Environmental Assessment of the Alaskan Continental Shelf

Quarterly Reports of Principal Investigators
October - December 1977

Volume II

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

VOLUME I

RECEPTORS (BIOTA)

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MARINE BIRDS

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DATA MANAGEMENT

Environmental Assessment of the Alaskan Continental Shelf

QUARTERLY REPORTS OF PRINCIPAL INVESTIGATORS
FOR OCTOBER - DECEMBER 1977

VOLUME II

Outer Continental Shelf Environmental Assessment Program

Boulder, Colorado

March 1978

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratory

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TRANSPORT

QUARTERLY REPORT

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Development and Operation of HF Ocean Current Mapping Radar Units

Principle Investigator: Donald E. Barrick

Submitted: January 6, 1978

Current Mapping Radar Program

Progress Report - 1 January 1978

I. Abstract

Some of the Alaskan surface-current observations and ground-truth comparisons were described in a special report to OCSEAP and BLM by Barrick. Since returning to Boulder, the current-mapping radar project personnel have been primarily concerned with the analysis and reduction of data from Lower Cook Inlet. Data from one twenty-four hour run has been reduced and maps have been made using the two-site processing techniques. A movie showing the animated sequencing of those current vectors with time has been produced. In addition, some temporal analysis of surface components versus space has been started.

II. Objectives

The objectives of the current mapping radar program for the following year as far as OCSEAP is concerned is to 1) complete analysis of some of the 1977 Lower Cook Inlet data and 2) return to another part of Cook Inlet (i.e., Augustine Island and Cape Douglas) and take surface current observations there.

III. Field Activities

No OCSEAP field activities for this quarter.

IV. Results

Appended at the end of this report are some surface current maps which have been processed with more sophisticated numerical techniques. The sites were at Seldovia and Anchor Point. Each arrow represents an average over a 3 x 3 km square. The velocity scale is 3 kts for a separation of one vector unit (i.e., tail to tail of adjacent vectors is 3 kts in magnitude).

In addition, plots showing a velocity component versus time are given for a few locations. A least-square fit of the sine and cosine term for a 12 and 24 hour period have been fit to the data and are plotted with the data.

V. Preliminary Interpretation of the Results

The first set of figures represent the spatial distribution of surface currents. The contours show regions of equal energy (i.e., $\frac{1}{2}(u^2 + v^2)$ where u is the N-S component and v is the E-W component). These contours are normalized to an arbitrary value. The time that the data were taken is given in bold numbers in the lower center; the date is shown in the lower right hand side.

02:30; The flow is almost zero with a small surface-current into Kachemak Bay at the North Entrance. There the velocity resolution appears to be much better than 25 cm/sec., but the contribution due to any vertical and horizontal shear may be important. B. Weber in our group is working on corrections that may give lower limits to the measurement resolution than 25 cm/sec.

03:30; The flow out of the inlet has increased considerably, with the maximum flow in a line almost West from Anchor Point.

04:00; The strength of the flow has increased considerably, with the maximum currents on the order of 0.5 m/sec.

06:00; There is a doubling of the flow rate compared to the 04:00 and the max, again just south of Anchor Point on a westerly line is about 1.0 m/sec. There is a small flow into the North end of Kachemak Bay.

08:00; The southward flow is decreasing and there does not appear to be any flow into Kachemak Bay.

08:30; We see a further decrease in the current with a null zone to the south of the center of radar coverage. There is a development of the northerly flow closer to Anchor Point with the main flow still to the south.

09:30; The southerly flow has decreased even more, the null zone still exists in about the same location, and the northerly flow near Anchor Point has increased in strength.

11:00; All the flow is toward the North, with a maximum to the S. W. of Anchor Point. The maximum velocity is about 0.5 m/sec.

12:30; The flow velocity has increased more, with the maximum now several km further to the S. W. W. of Anchor Point.

14:00; The flow is almost zero, with some flow into Kachemak Bay from the North and West.

14:30; The flow from the North is increasing, and at 15:00 has increased with the maximum about 20 km from Anchor Point to the S. W.

The second set of figures show a least square fit of $U_1 = A_1 \sin \omega_1 t + B_1 \cos \omega_1 t$ and $U_2 = A_2 \sin \omega_2 t\ B_2 \cos \omega_2 t$ where ω_1 and ω_2 corresponds to the 12 and 24 hour period respectively. The first figure shows each component separately for a distance x = 18 km, y = 30 km. (The origin is halfway between the radars and the x direction is parallel to a line from Seldovia to Anchor Point. Again, each vector is separated by 3 km.

The next figure shows a composite of $U_1 + U_2$ for the same location with the actual comparison of the measured surface currents. At this location, the comparison with this fit is quite good, although wind effects, etc. and other tidal frequencies can cause deviations from this type of least squares fit to the data.

The final figure shows the spatial variation along a constant line x = +9 km from a distance of y = 6 km to y = 39 km. There is a systematic change in the phase of the tides that is easily seen in this figure. The maximum deviation from the fit occurs at the maximum velocities.

IV. Problems Encountered/Recommended Changes

One of the major problems encountered is an interference signal. We are presently writing software to handle this and the data will be reprocessed when the programs are completed. The source of this interference is unknown at this time. It may be sky-wave or man-made. Whatever it is, it does not pose an insurmountable problem in the analysis of the data. What should be remembered is that some of the figures presented here may be altered in removing the interference. This interference did not appear in all of the data.

VII. Estimate of Funds Expanded from Oct. 1, 1977 to Dec. 31, 1977

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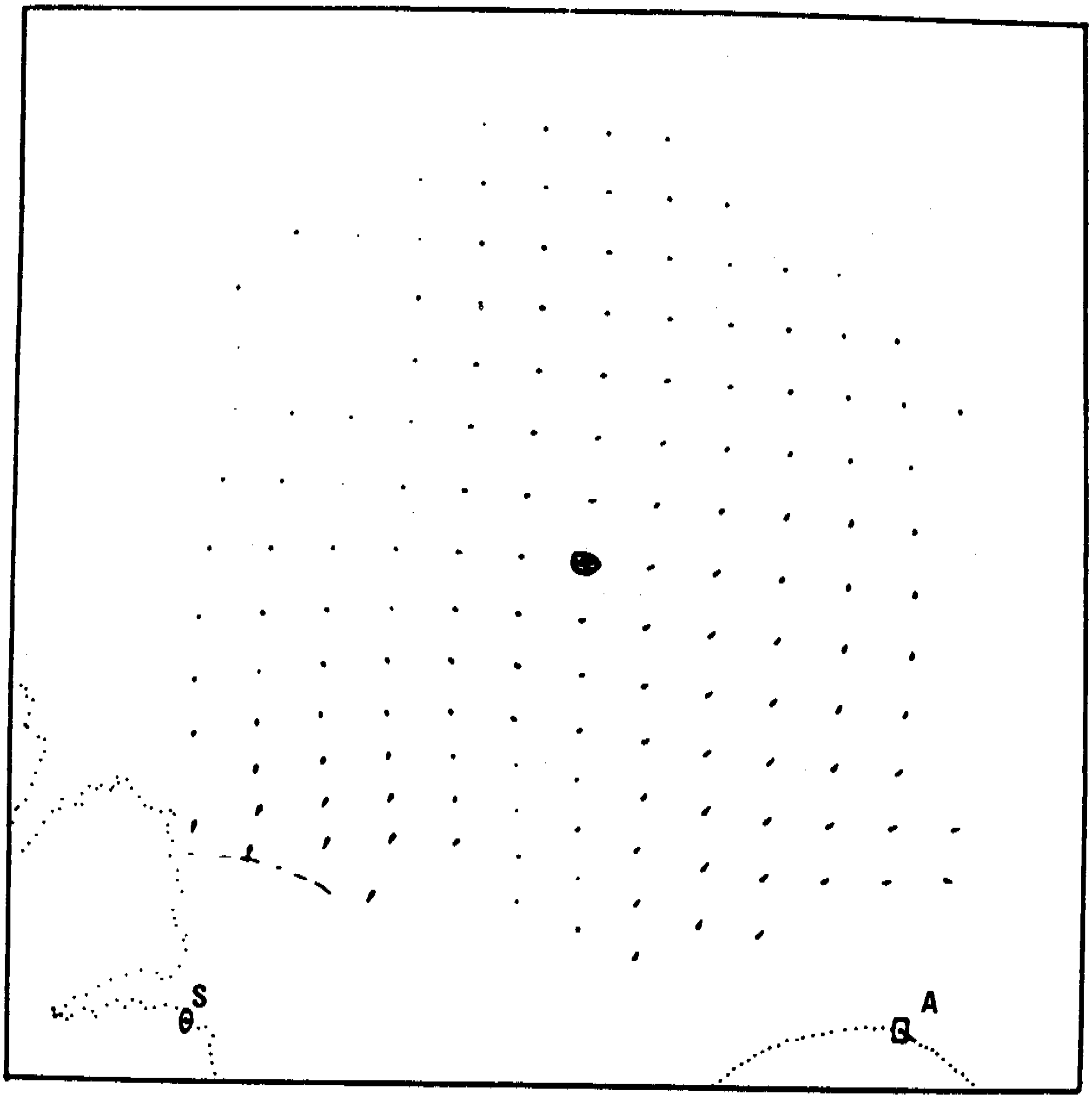

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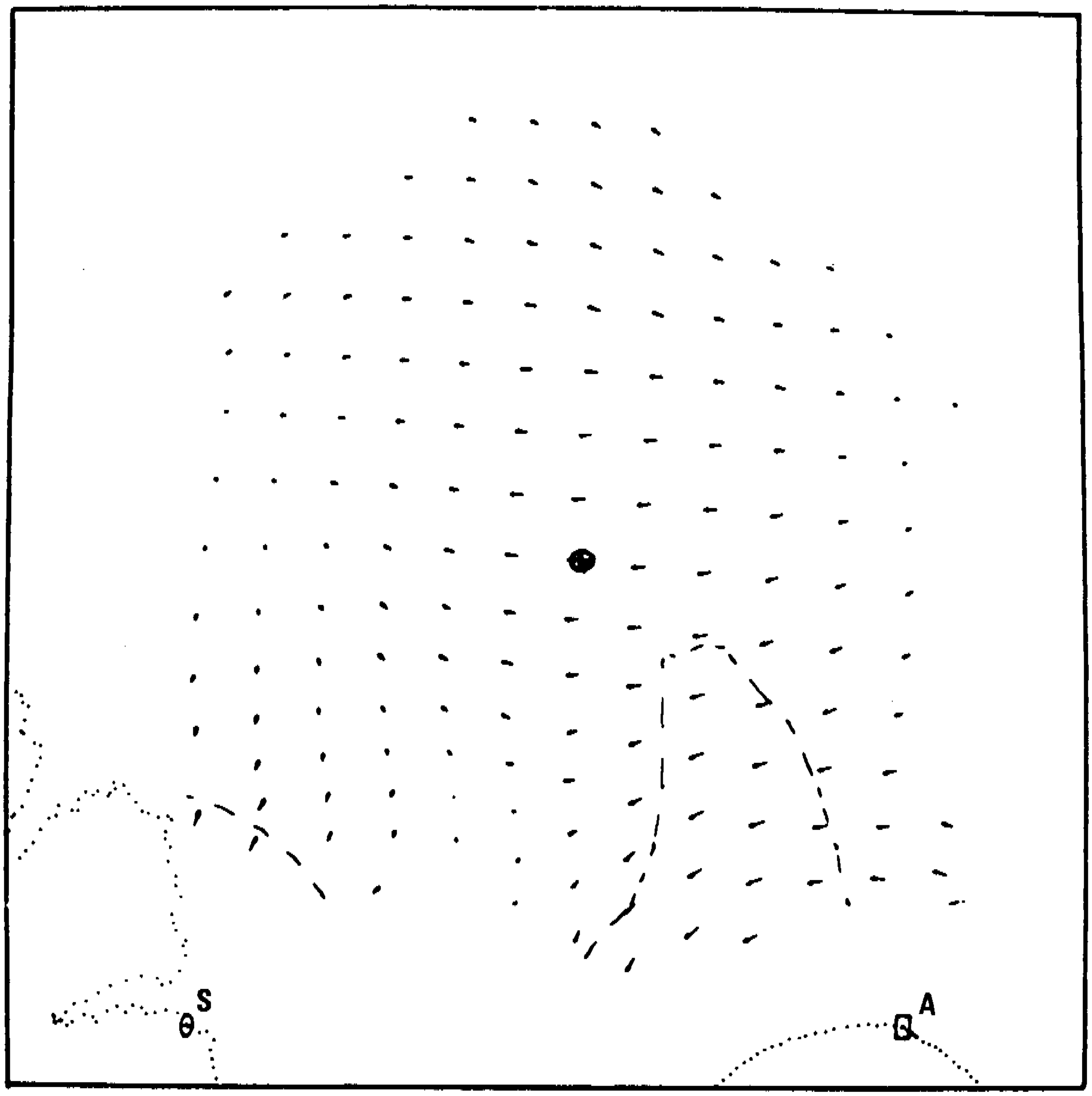

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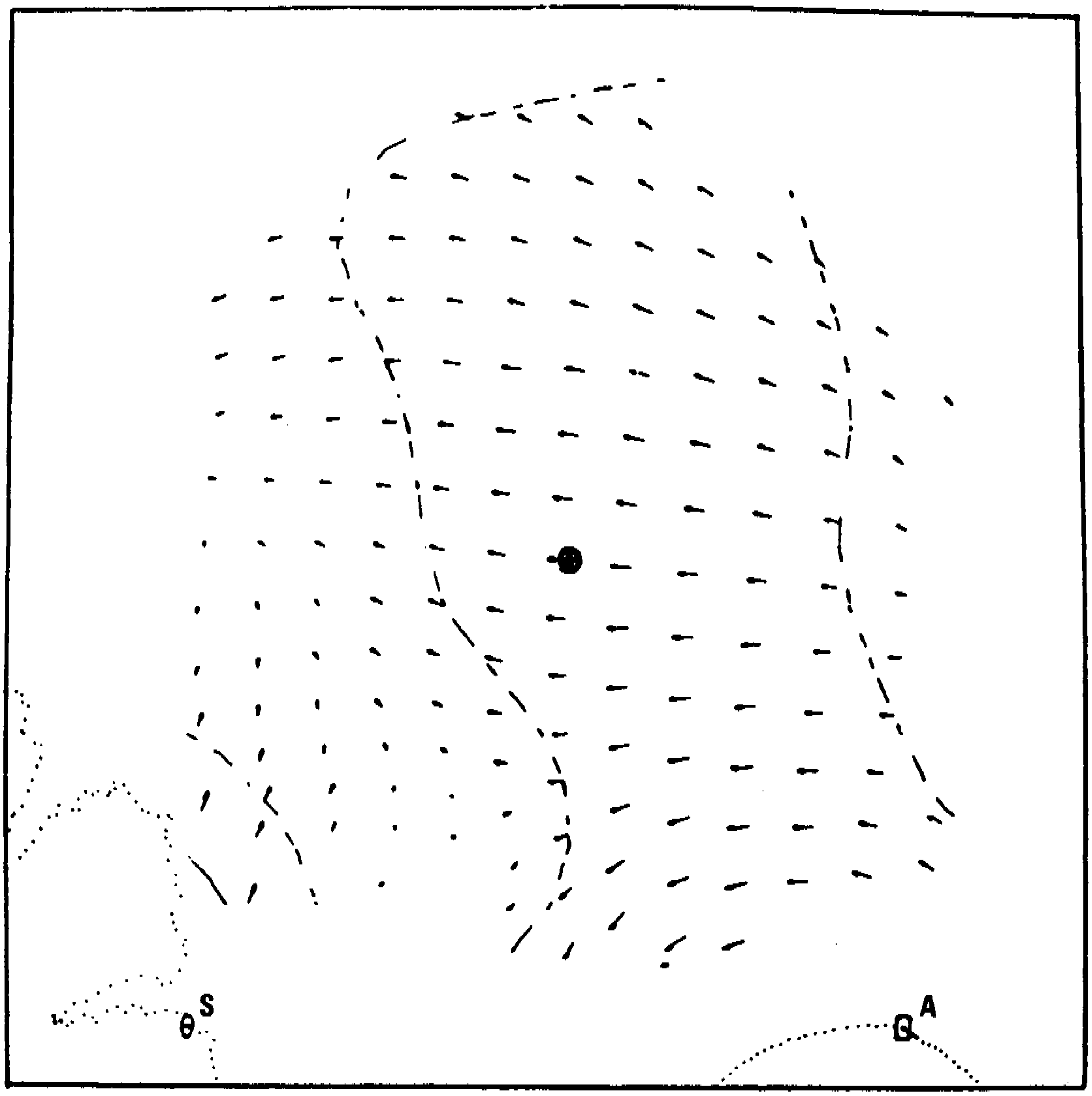

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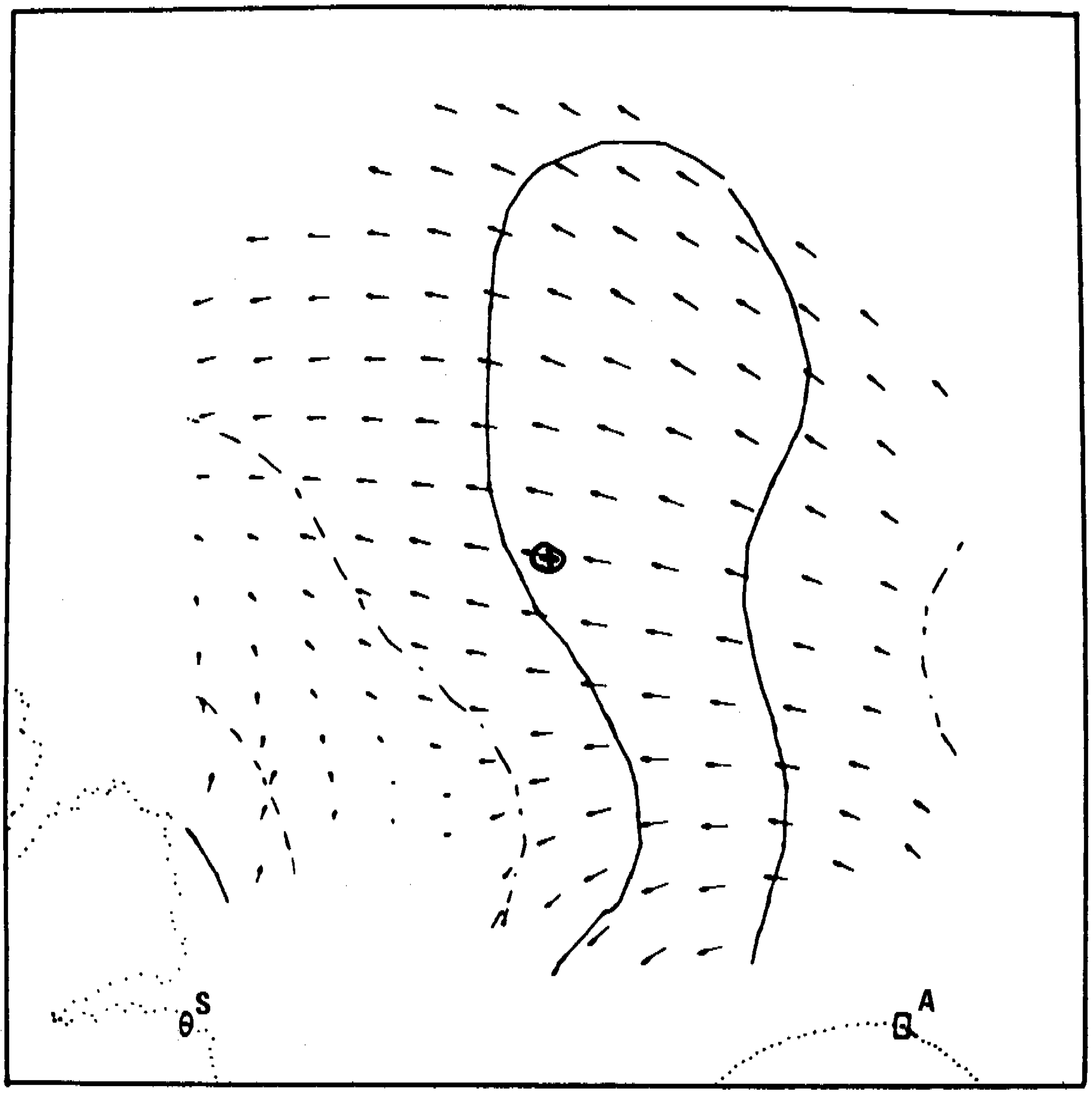

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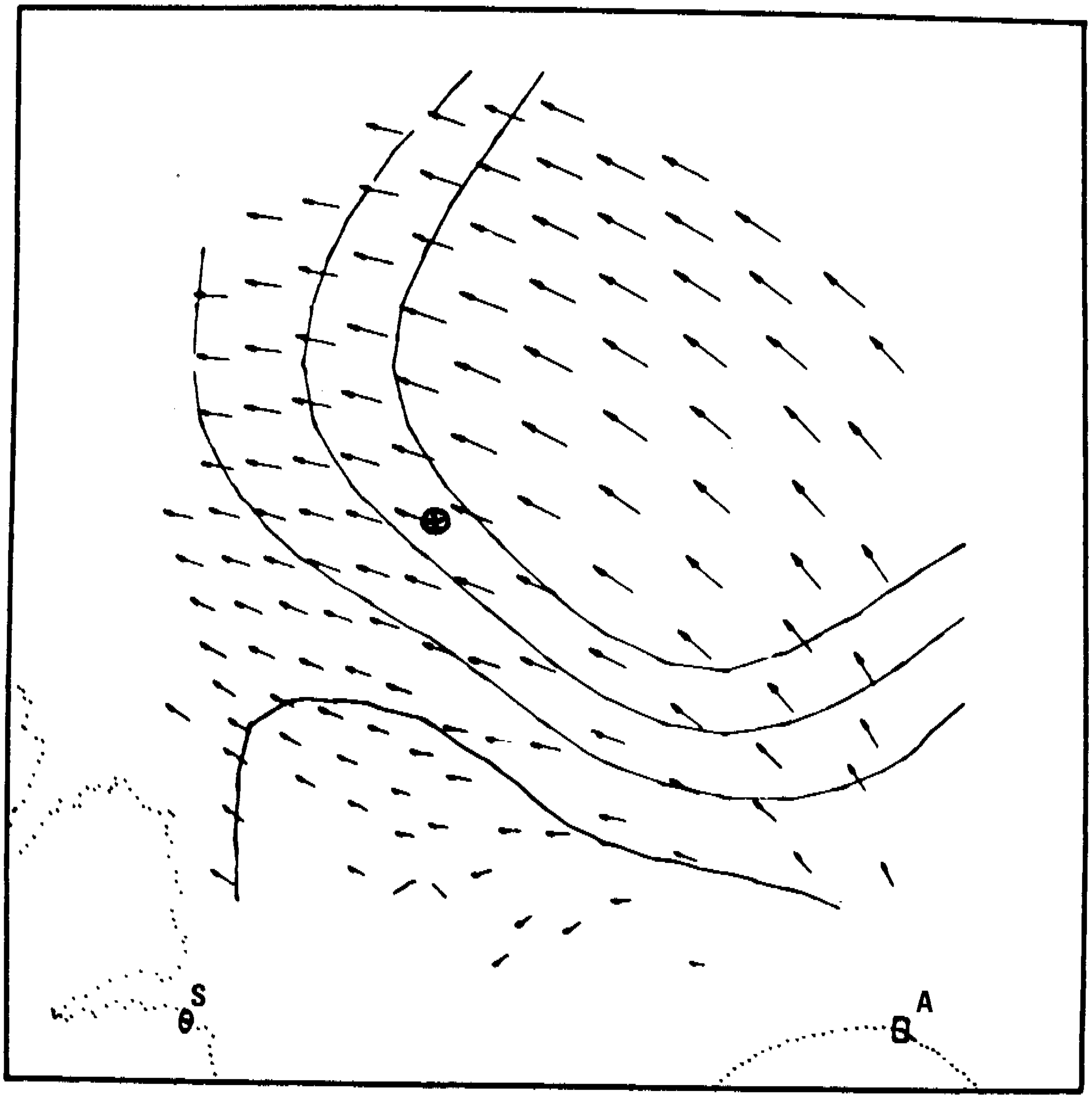

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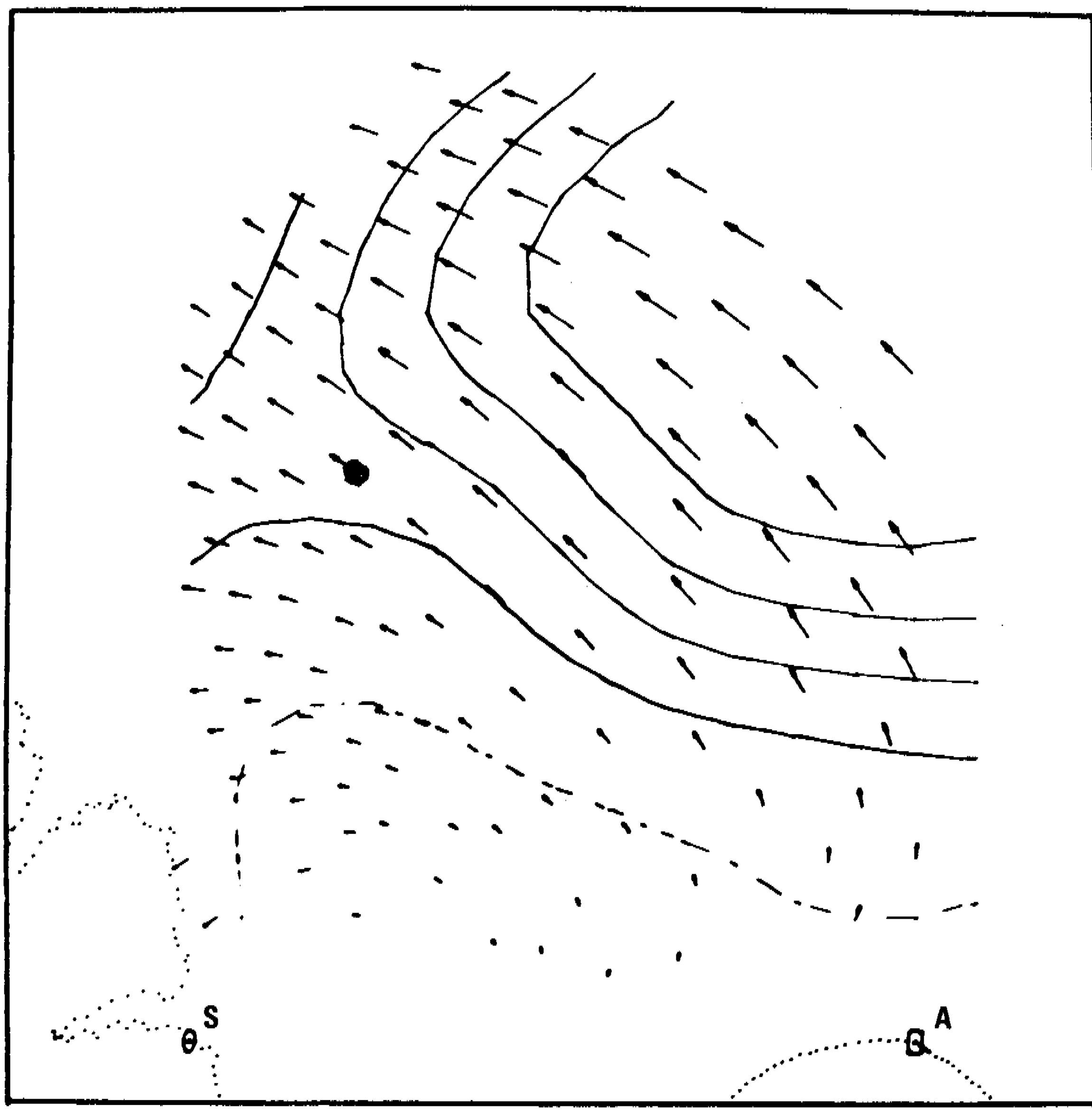

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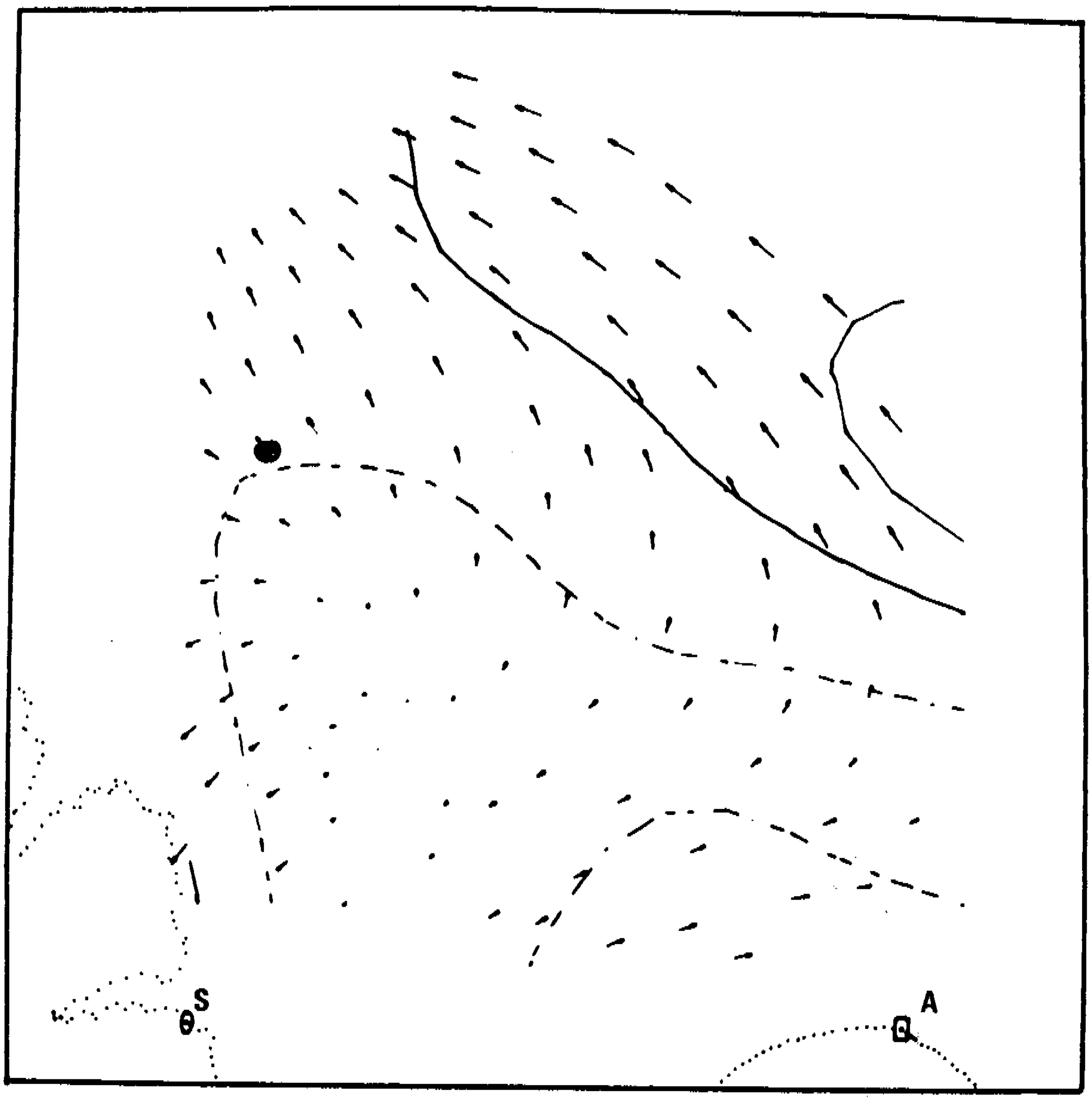

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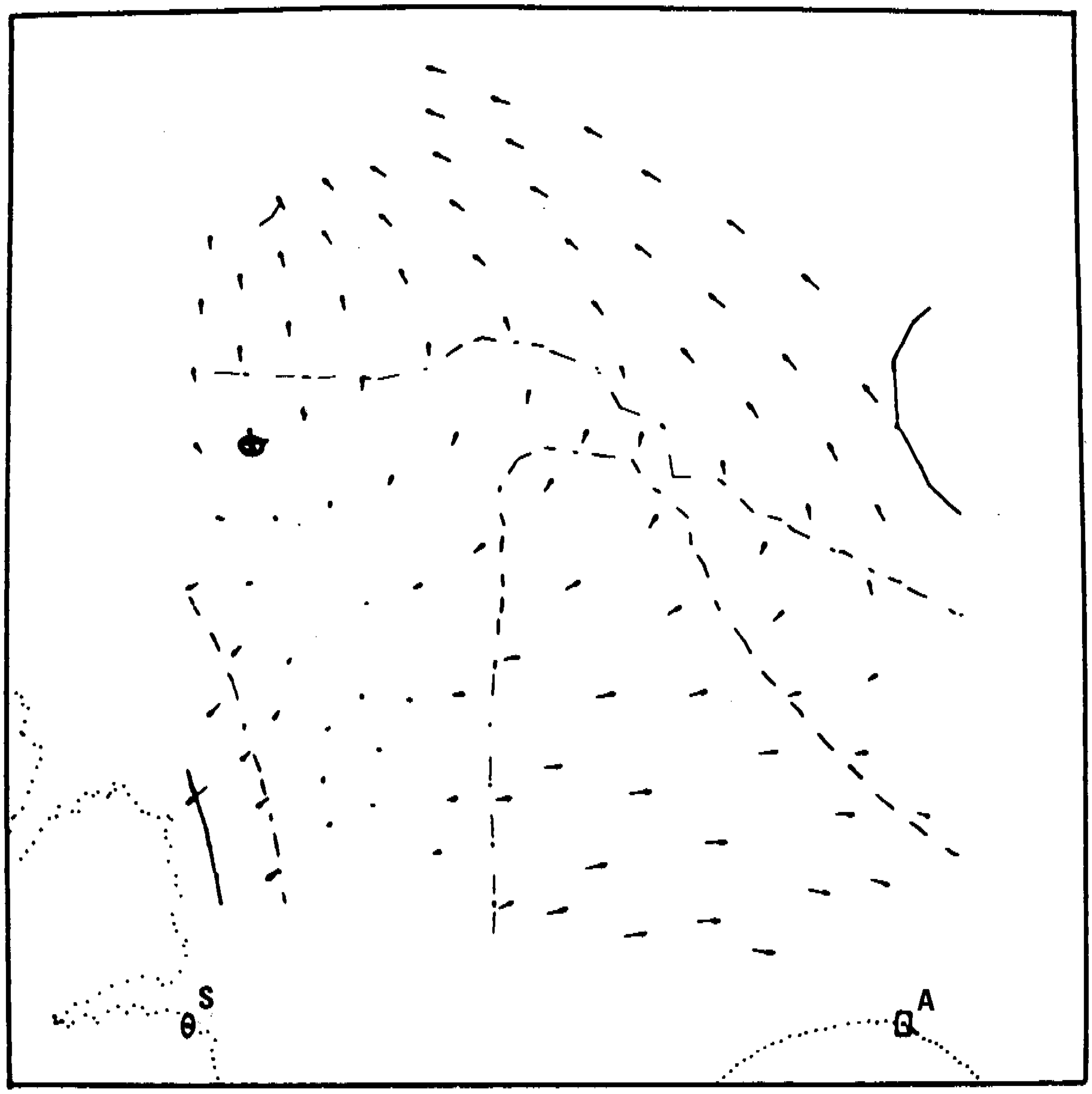

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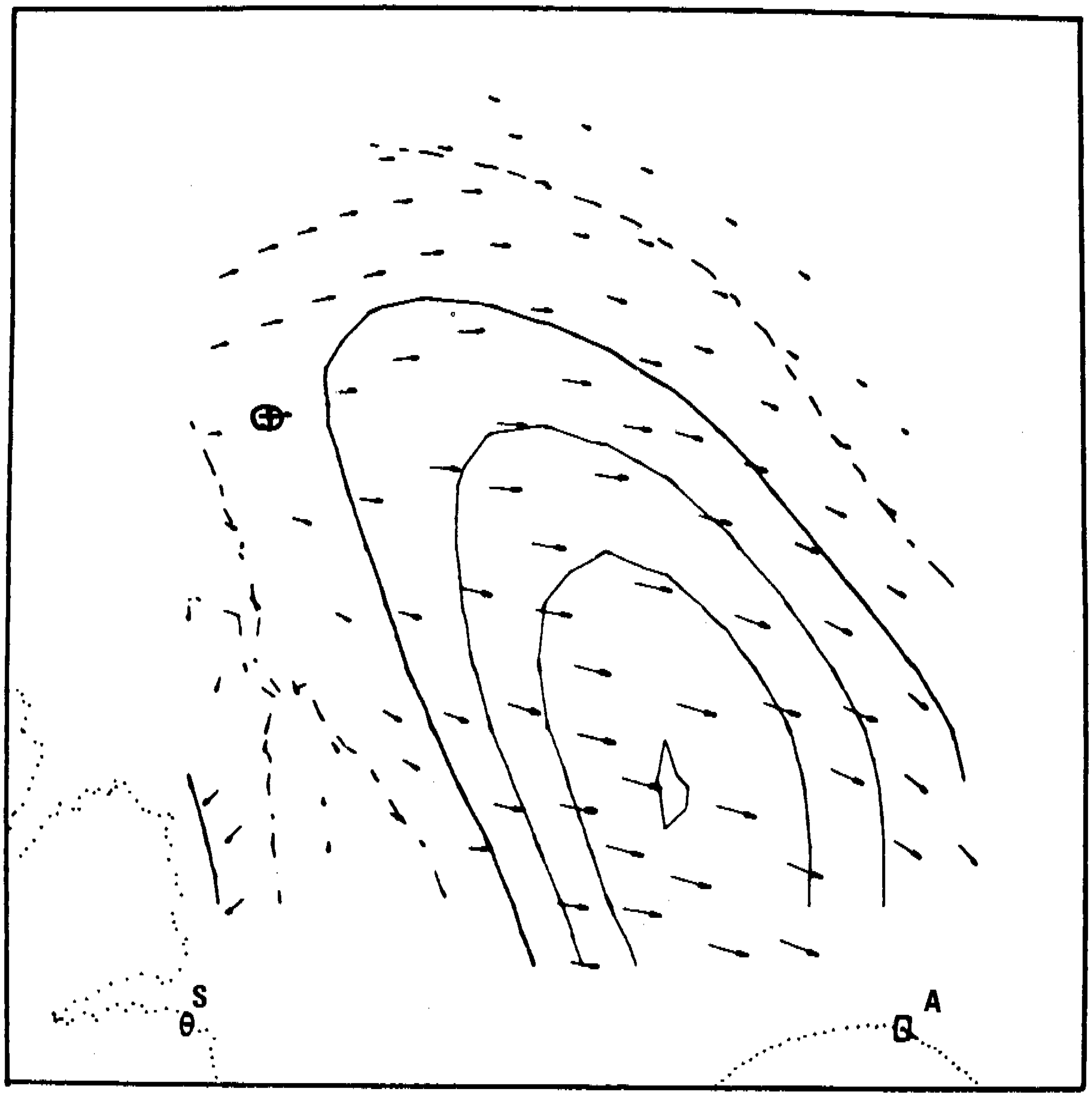

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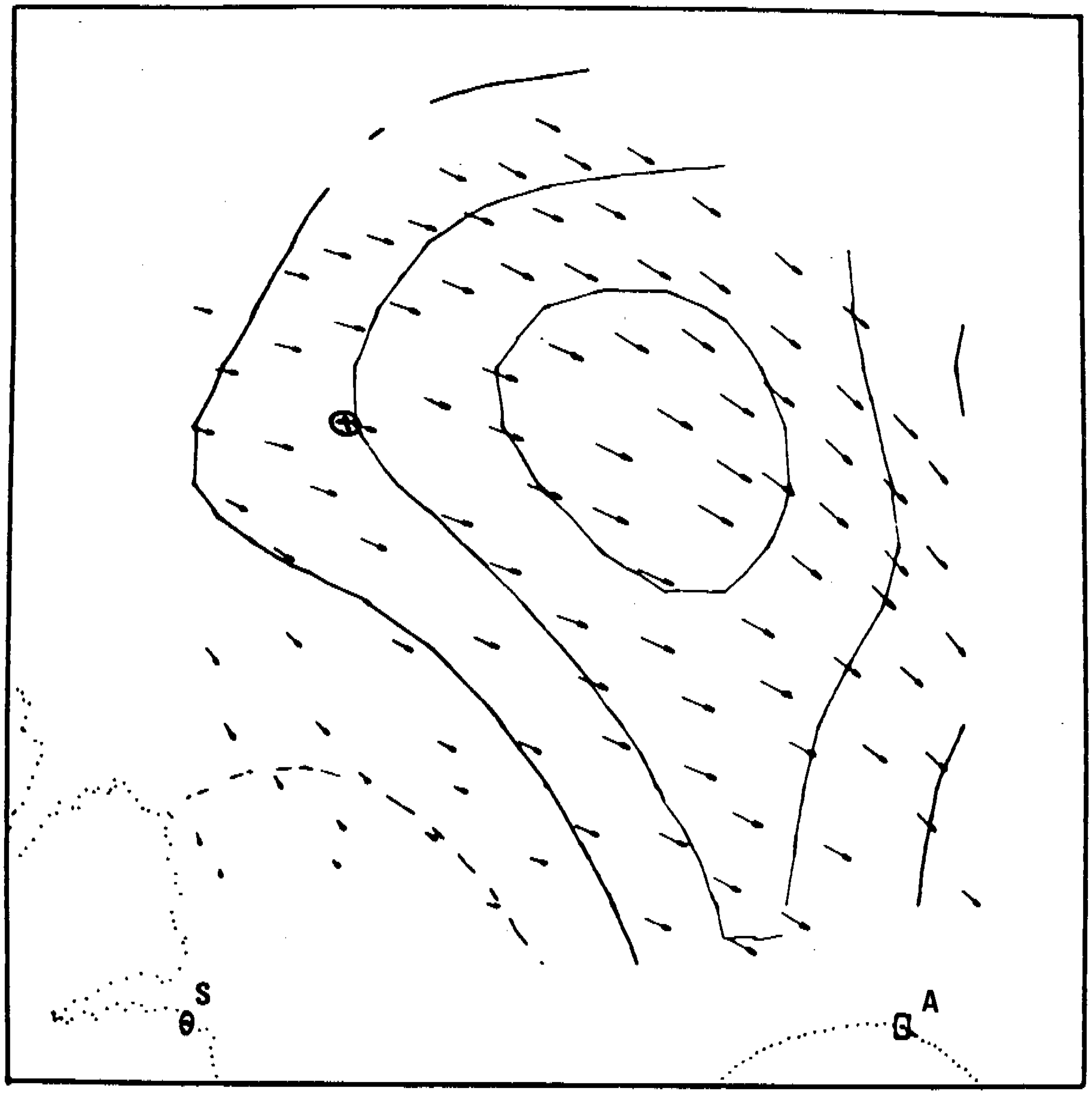

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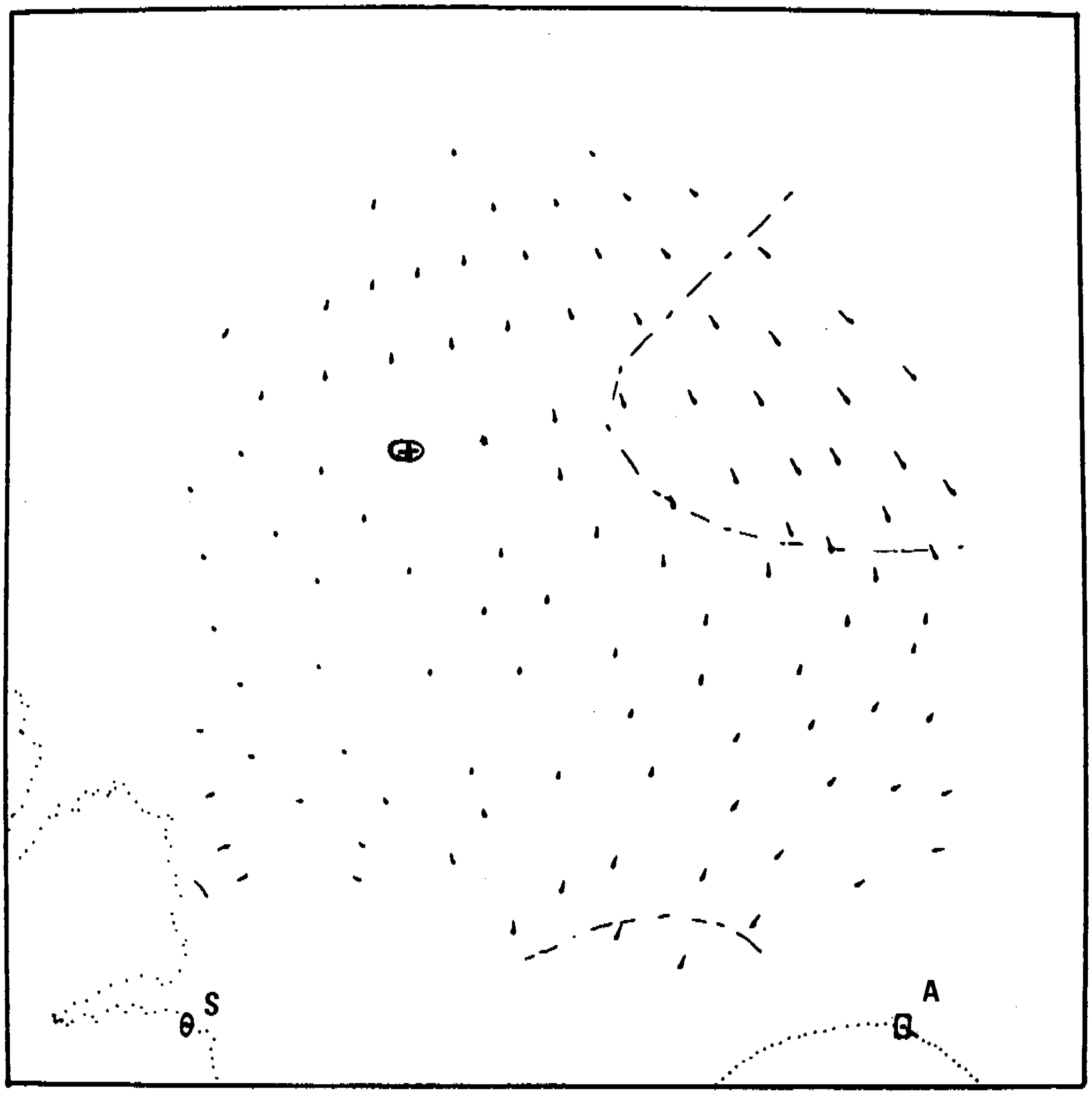

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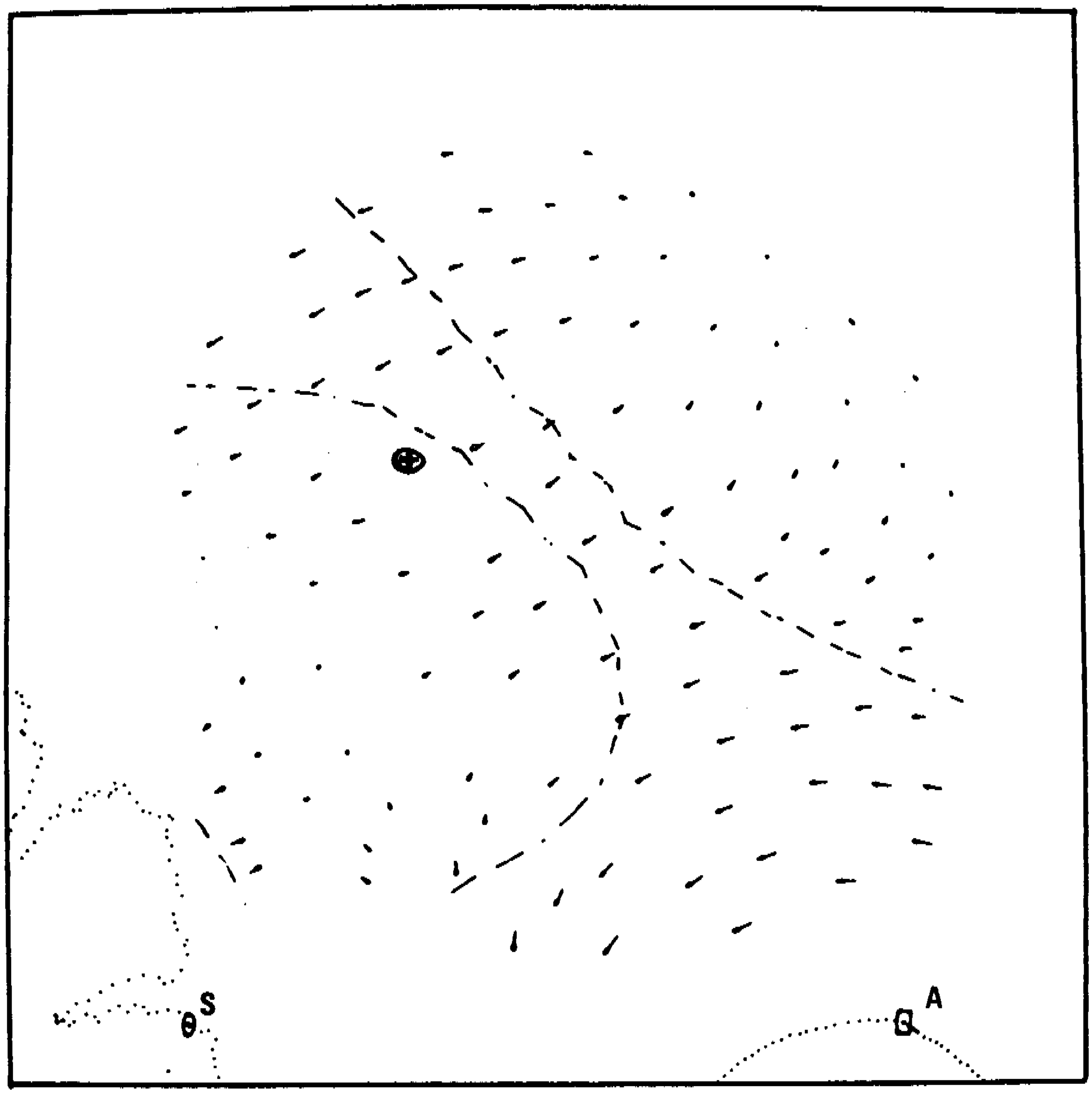

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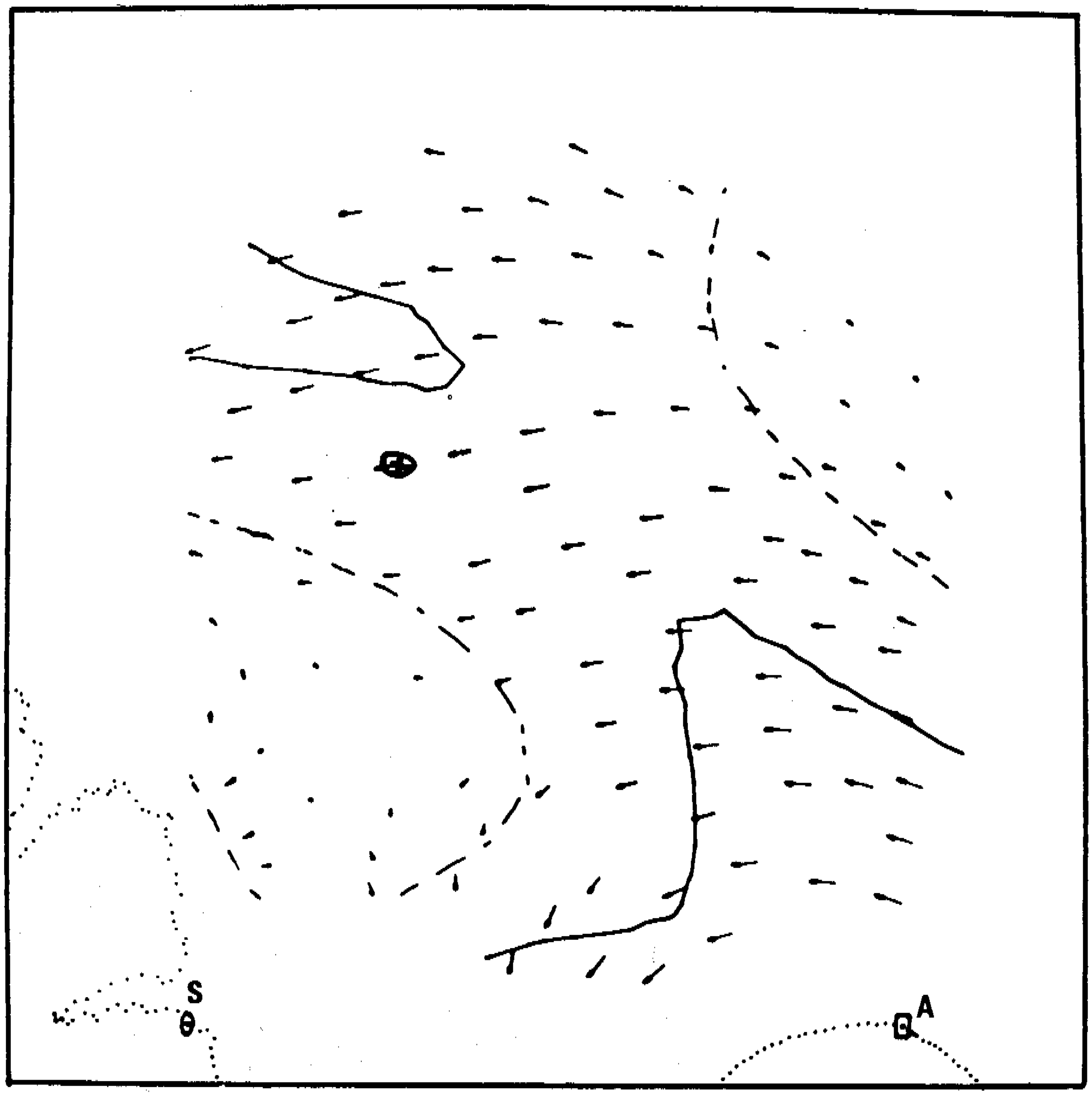

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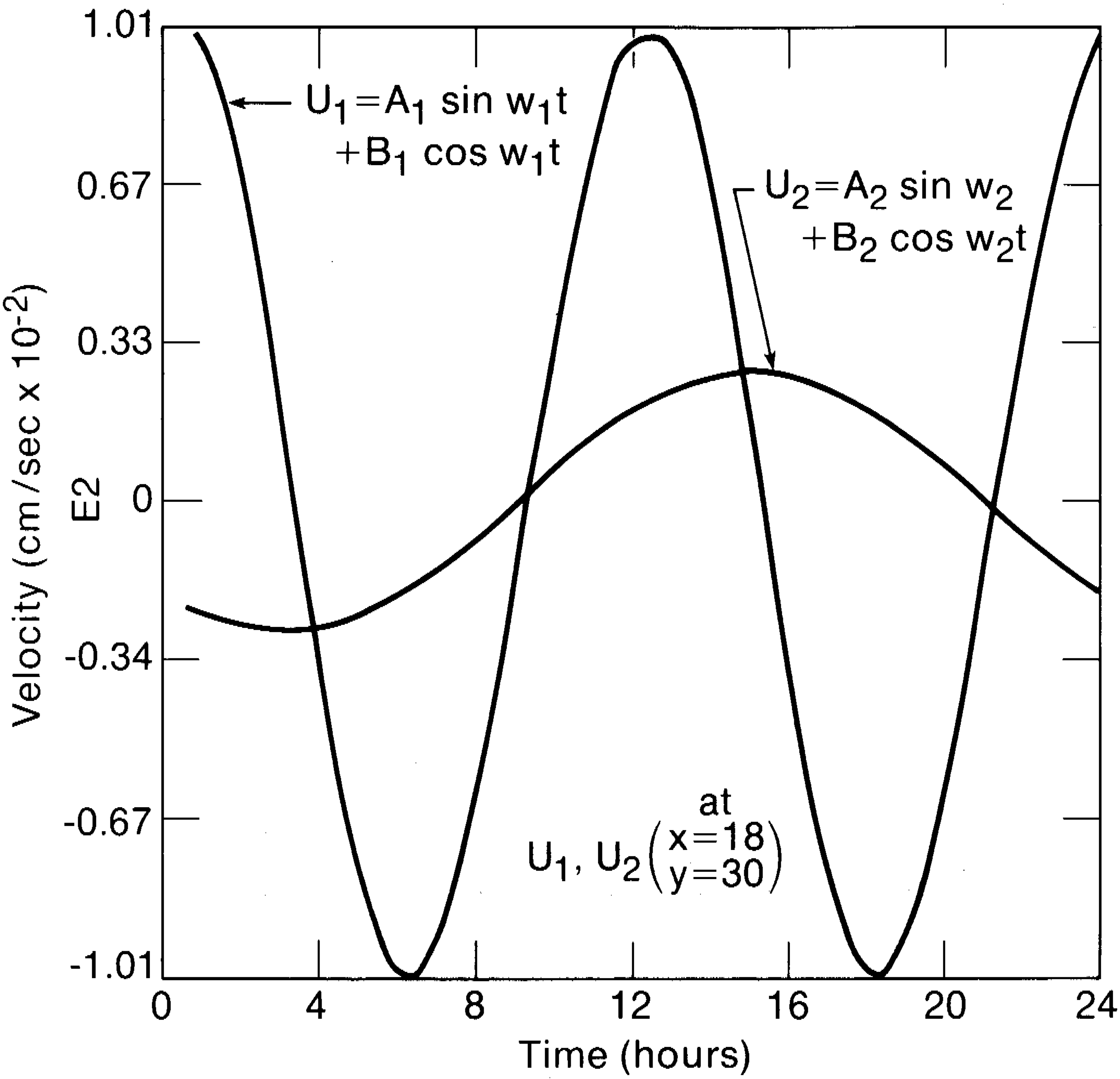
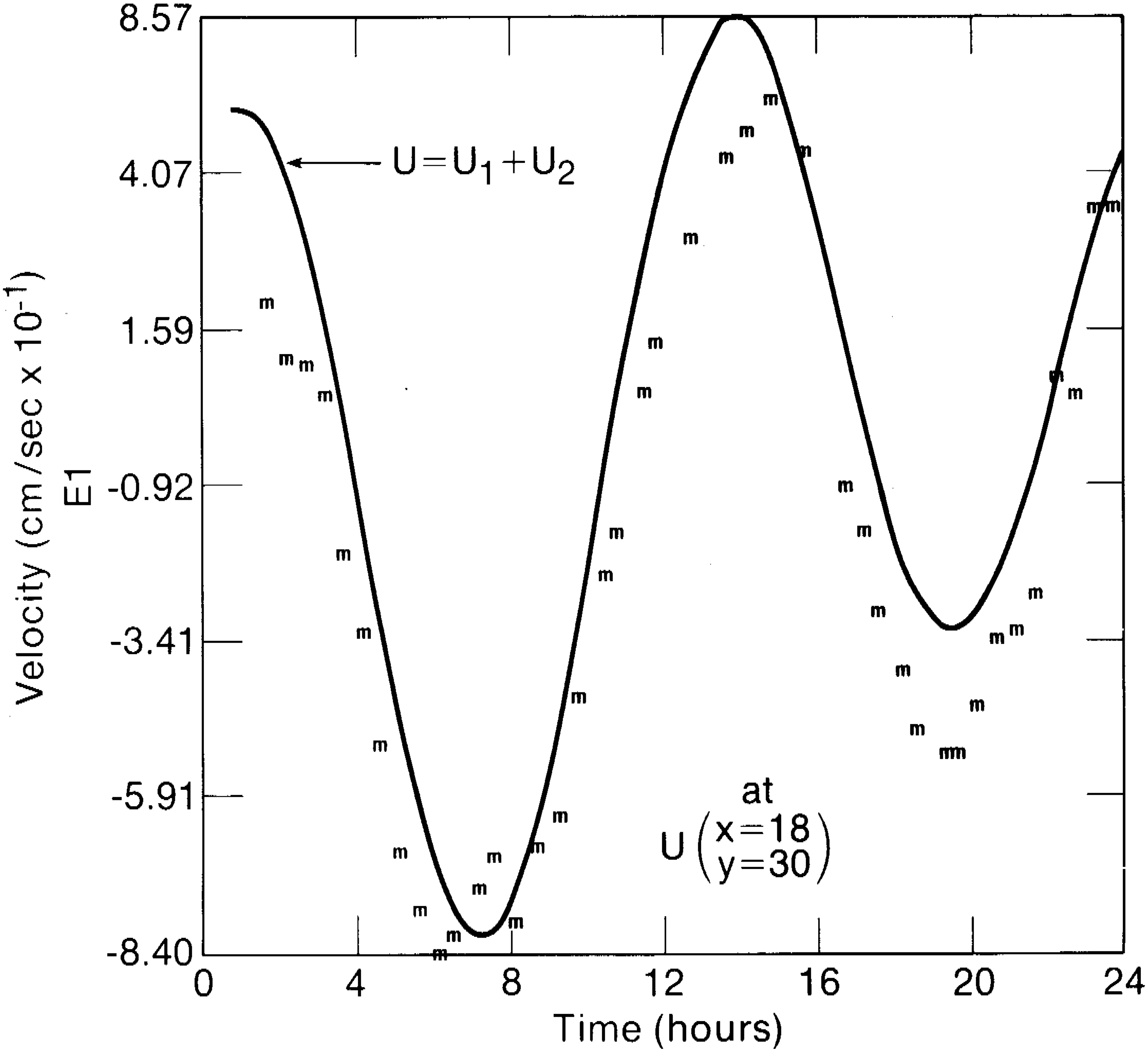
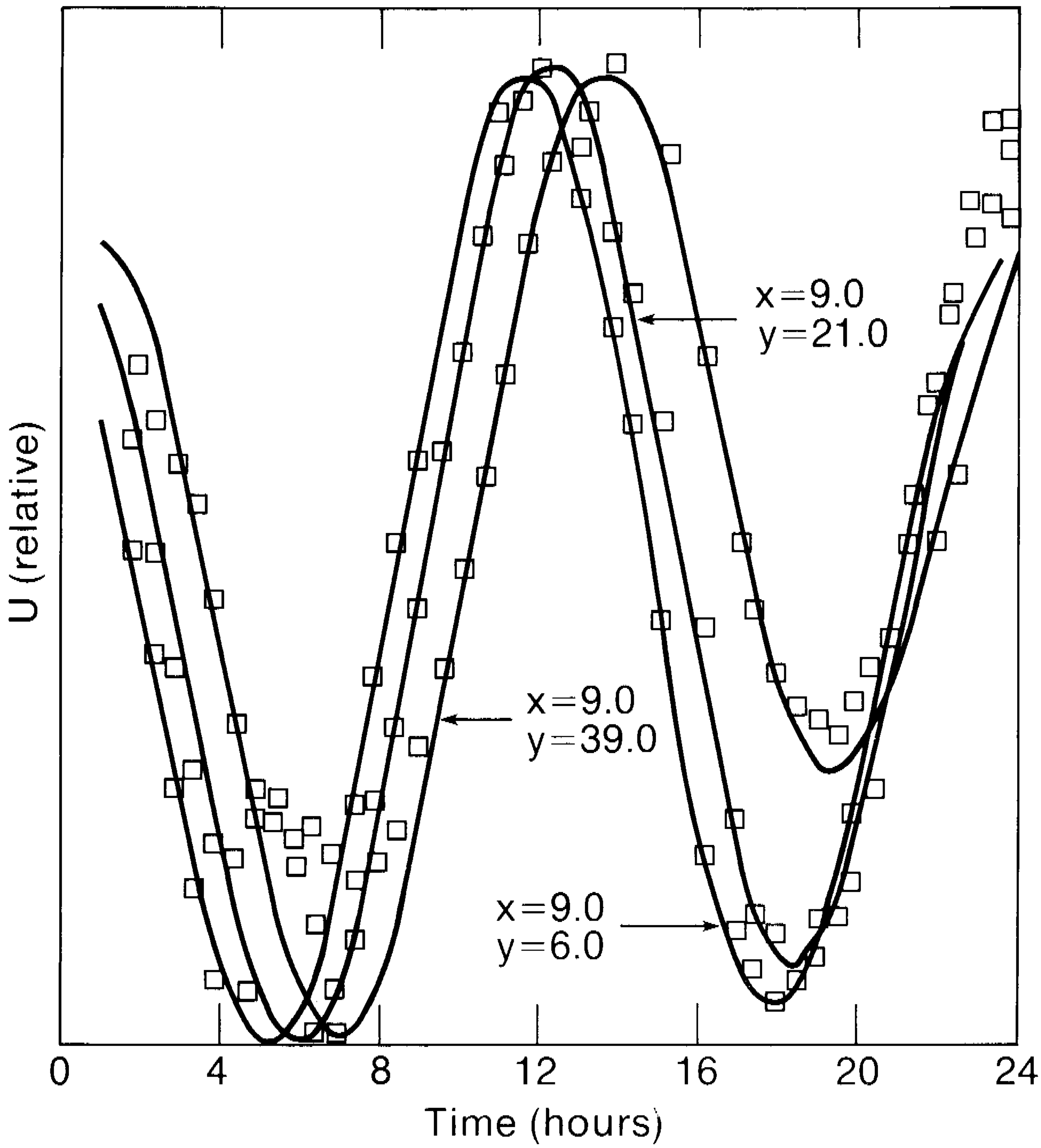


1.01
0.67
0.33
0
-0.34
-0.67
-1.01
Velocity (cm/sec x 10-2)
E2
$U_1 = A_1 \sin w_1 t$
$+ B_1 \cos w_1 t$
$U_2 = A_2 \sin w_2$
$+ B_2 \cos w_2 t$
at
$U_1, U_2 \binom{x=18}{y=30}$
0
4
8
12
16
20
24
Time (hours)


8.57
4.07
1.59
-0.92
-3.41
-5.91
-8.40
Velocity (cm/sec x 10^{-1})
E1
$U = U_1 + U_2$
at
$U \begin{pmatrix} x=18 \\ y=30 \end{pmatrix}$
0
4
8
12
16
20
24
Time (hours)



Spatial Variation of the U Component
□- data Solid Curves $U=U_1+U_2$

QUARTERLY REPORT

December 31, 1977

Research Unit #59

COASTAL MORPHOLOGY, OIL SPILL VULNERABILITY AND SEDIMENTOLOGY

-- NORTHERN GULF OF ALASKA --

Miles O. Hayes - Principal Investigator

Christopher H. Ruby - Co-Investigator

Coastal Research Division
Department of Geology
University of South Carolina

Contract No. 03-5-022-82

I. Quarter's Accomplishments:

This quarter's primary emphasis was placed on the completion of a final report for our work in the Gulf of Alaska. That final report has been completed and is presently being published as a technical report.

"Coastal Morphology, Sedimentation and Oil Spill Vulnerability - Northern Gulf of Alaska" (see list below).

Expected delivery date from the publisher is February 8, 1978. Copies will be forwarded to OCSEAP at that time. Additionally, two papers have been generated during this past quarter. The first paper (Ruby and Hayes, 1978), which is an offshoot of oil spill related research in the Gulf, will be published within the Proceedings of Coastal Zone '78, a symposium on the technical, environmental, socio-economic and regulatory aspects of coastal zone planning and management. That conference will be held in San Francisco, California during March 14-16, 1978. A preprint is included in the Appendix of this report.

The other paper (Nummedal et al. 1977) is a summary of the longshore transport dynamics along the beaches of the Gulf of Alaska. It was presented at the 4th International Conference on Port and Ocean Engineering under Arctic Conditions held in St. Johns, Newfoundland during September, 1977. It is presently in press to be published with the Proceedings of that Conference. A preprint is included in the Appendix of this report.

Thus, our work in the Gulf of Alaska is completed. All emphasis from our Alaska research personnel is now being directed at our study site in Kotzebue Sound. In summary, there are 6 papers and 3 abstracts which we feel represent the bulk of our research findings in the Gulf. They are as follows:

Primary Papers:

Boothroyd, J. C., (Co-principal investigator), Cable, M. S. and Levey, R. A., 1976, Coastal morphology and sedimentation, Gulf of Alaska (glacial sedimentation), in Environmental Assessment of the Alaskan Continental Shelf, P. I. Repts., Vol 12, Geology, pp. 87-213.

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. The role of ice as a modifier of the impacts and dispersal patterns of oil spills will receive particular emphasis. The interaction of ice and beachface dynamics is also of primary concern.

III. Field and Laboratory Activities:

No field work was done in either the Gulf of Alaska or the Kotzebue Sound area. Laboratory work was focused on sedimentological analysis of samples from Kotzebue Sound beaches and reduction of that data.

IV. Results:

The results are summarized under Section I of this report and are given in detail in the enclosed papers. The final report, as stated previously, is at the publishers and will be mailed as soon as it returns.

V. Interpretation of Results:

Interpretations are given in each of the individual papers enclosed in the Appendix.

Nummedal, D. and Stephen, M. F., 1976, Coastal dynamics and sediment transportation, northeast Gulf of Alaska, Tech. Rept. No. 9-CRD, Dept of Geology, Univ. of South Carolina, 148 p.

Hayes, M. O., Ruby, C. H., Stephen, M. F. and Wilson, S. J., 1976, Geomorphology of the southern coast of Alaska, Proc. 15th International Conf. of Coastal Eng., Vol. II, Honolulu, Hawaii, July, 1976, p. 1992-2008.

Nummedal, D., Stephen, M. F. and Ruby, C. H., 1977, Reconnaissance evaluation of longshore sediment transport, northeast Gulf of Alaska, 4th International Conf. on Port and Ocean Eng. under Arctic Conditions, St. Johns, Newfoundland, Sept., 1977, (in press).

Ruby, C. H., 1977, Coastal morphology, sedimentation and oil spill vulnerability northern Gulf of Alaska, Tech. Rept. No. 15-CRD, Dept. of Geology, Univ. of South Carolina, 223 p.

Ruby, C. H. and Hayes, M. O., 1978, Application of an oil spill vulnerability index to the Copper River delta, Alaska, Proceedings of Coastal Zone '78, San Francisco, Ca., March, 1978 (in press).

Abstracts with Programs:

Hayes, M. O. and Ruby, C. H., 1975, Barrier island development on a tectonically active delta, Copper River delta, Alaska, G.S.A. Annual Mtg., Vol. 7, No. 7, Salt Lake City, Utah, September, p. 1105.

Stephen, M. F., Hayes, M. O., Ruby, C. H. and Wilson, S. J., 1976, Littoral processes and geomorphic variability on a storm dominated, glacial shoreline, Malaspina Foreland, Gulf of Alaska, AAPG-SEPM Annual Mtg., New Orleans, La., April, pp. 119-120.

Hayes, M. O., Ruby, C. H., Stephen, M. F. and Wilson, S. J., 1976, Geomorphology of the southern coast of Alaska, Abstracts, 15th International Conf. on Coastal Eng., Honolulu, Hawaii, July, pp. 530-533.

Present activities include completion of sedimentological analysis of the Kotzebue Sound samples and submission of that data to NODC, as well as preparation for this spring's break-up study in the Sound. In our last quarterly report (October 1, 1977), we indicated that the oil spill vulnerability and morphology data would be submitted with this report. However, considering our funding extension for analysis of break-up and freeze-up in the Sound, we plan to delay that submission until the possible modifying factors imposed by ice can be investigated. Additionally, field preparations (collection and analysis of pertinent charts, maps, aerial photos, reports, and literature) are underway for this summer's field work on Kodiak Island.

APPENDIX

Preprints of two recent papers:

Nummedal, D., Stephen, M. F. and Ruby, C. H., 1977, Reconnaissance evaluation of longshore sediment transport, northeast Gulf of Alaska, 4th Inter. Conf. on Port and Ocean Eng. under Arctic Conditions, St. Johns, Newfoundland, Sept., (in press).

Ruby, C. H. and Hayes, M. O., 1978, Application of an oil spill vulnerability index to the Copper River delta, Alaska, Procs., Coastal Zone '78, San Francisco, Ca., March (in press).

OIL SPILL VULNERABILITY INDEX, COPPER RIVER DELTA

C. H. Ruby[1]
Miles O. Hayes[1]

ABSTRACT

An index has been devised that ranks the relative impacts of potential oil spills on coastal environments. The index is a sliding scale ranging from very low to very high risk environments and is based primarily on the relative longevity of spilled oil within each of ten subenvironments. Assuming only natural cleansing processes, the index considers both the differential biological impact and the influence of local physical processes on the distribution of spilled oil. Additionally, the potential for mechanized cleanup within the subenvironments has been analyzed.

This evaluation system has been developed after detailed field studies of three major oil spills and two minor spills in coastal areas with heavy winter ice. To apply the system to a given study site, a relatively rapid and inexpensive baseline study is initiated, which classifies the shoreline into geomorphic "type-areas". This classification is based on sediment type, littoral processes, tidal range and currents, gross biological productivity, local climatic conditions and general coastal morphology. The index is then applied by analogy to studies of spill behavior within similar type-areas at actual major spill sites.

The index provides information which enables cleanup programs to more efficiently deploy men and materials at a spill site. Use of the index will considerably enhance the probability of protecting high-risk coastal environments while reducing wasted efforts in areas which will be effectively and quickly cleaned by natural processes. Previous oil spills have resulted in a waste of large sums of money and manpower due to a general lack of knowledge regarding specific coastal areas and oil spill behavior within them. The application of this index can reduce much of that waste.

The index can be applied to any coastal area subject to hazardous liquid spills. The Copper River Delta, Alaska, a relatively complex coastal environment 70 km SSE of Valdez, is used here to demonstrate both the application of the Index and the logic behind the classification. It also demonstrates the direct applicability of this scheme to impact statements regarding pollutants in the coastal zone.

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Columbia, S. C. 29208

INTRODUCTION

As oil exploration and development continue to escalate in Alaska, the potential for oil spills within coastal environments increases. The Trans-Alaska Pipeline has opened a new era with regard to tanker transport of petroleum in Alaskan coastal waters. Tankers operating on a route between the west coast of the lower 48 states and Valdez will move through Prince William Sound, just west of the Copper River delta. In addition, exploration is rapidly advancing in the Gulf of Alaska itself. Any production or support facilities located in the Gulf will subject the adjacent shorelines to the possibility of oil spills. Single large spills, or chronically recurring small spills, could result in serious damage to these shoreline environments.

Gilmore et al. (1970) indicate that of 36 major spills studied, 75% were associated with vessels, 90% of which were carrying crude oils. The median volume of these spills was 25,000 barrels (1,050,000 gallons), for all spills exceeding 2,000 barrels. With the trend toward larger volume super tankers, the relative size of oil spills will increase proportionately. These figures support the very real possibility of a massive oil spill in the Gulf of Alaska.

Excluding the narrows at Valdez harbor, the Hinchinbrook Entrance between Hinchinbrook and Montague Islands is probably the most dangerous single zone on the tanker route (Fig. 1). The passage between the islands is slightly over 12 km wide. Seal Rocks, a shallow rocky area (minimum depth 10 m) occupies approximately the middle 1/3 of the entrance. This area is subject to extreme storms, poor visibility, unpredictable wind patterns and strong tidal currents. These conditions, in conjunction with the heavy tanker traffic expected in the area, make it a potential site for an oil spill.

This paper will analyze the potential impact of an oil spill in the Copper River delta area. A rapid method of coastal classification is described, which is then used to predict the variable impact of an oil spill on the wide variety of deltaic environments. The predictive data are then reduced into numerical form and result in the "Oil Spill Vulnerability Index". This Index ranks coastal environments in terms of their vulnerability to oil spills. It varies from low risk environments (1) which will be cleaned by natural processes within days to high risk environments (10), in which spilled oil may remain for more than 10 years. The methods described can be applied to any coastal zone. The resulting Index can greatly improve the design of oil-spill contingency plans, while providing considerable general information to policy makers for coastal areas.

POTENTIAL BIOLOGIC IMPACTS

The literature is replete with studies relating to biological damage resulting from oil spills or contact with petroleum products and their derivatives. This paper will not attempt to review that literature. However, there are a number of studies which relate directly to the oil spill problem in the Gulf of Alaska.

Nelson-Smith (1970), in a general overview, indicated that many varieties of finfish will actively avoid areas of oil contamination. Rice (1973) found, more specifically, that pink salmon fry would attempt to avoid water contaminated with Prudhoe Bay crude oil. This avoidance behavior could prove disastrous to the anadromous species in Alaskan waters. Hasler (1970) theorized that petro-products introduced into coastal areas could inhibit the territory recognition process used by salmon by providing false chemical clues or masking those clues already present. Even more pertinent is evidence that Alaskan fish and invertebrates may be more sensitive to crude oils than similar species from more temperate waters (Rice et al., 1976). In another study, Morrow (1973) demonstrated that even low concentrations of crude oil would induce mortality in juvenile coho and sockeye salmon. In studies by Mironov (1969), Kuhnhold (1970), and Corner et al. (1968), juvenile stages of various marine species were found to be 10-100 times more sensitive to pollutants than their respective adult forms. These studies all point to the very adverse effects of oil spills to anadromous species. In addition to direct lethal effects on adults, eggs, alevins and fry, spills interfere with breeding by creating an avoidance problem, or the inability of species to recognize their "home" stream.

Very little is known about the potential effects of oil spills on the large populations of mammals within the Gulf of Alaska. This is largely the result of the paucity of research on the effects of oil spills on sea mammals in general. Vank (1973) estimated that oil pollution was a major cause of seal deaths in Helgoland and on the Schleswig-Holstein coast. In a laboratory study by Geraci and Smith (1976), seals exposed for various durations to crude oil were found to develop eye problems, breathing disorders, elevated heartbeat and were ultimately incapacitated or killed. In the wild, given a large oil spill, these animals would have no choice but to surface through floating oil in order to breathe.

Marine invertebrates have been studied in considerable detail with regard to oil spill impacts, especially the communities of organisms on rocky shorelines and in tidal pools. Cowell (1971) found that limpets were very sensitive to crude oils with as many as 89% being killed after only one hour of exposure. Smith (1968) found that with crude oil and dispersant concentrations of 60 ppm, limpets could not attach themselves to the rock surfaces. In a number of other spill studies, limpets were found inverted at the bottom of tidal pools, apparently unable to attach. However, in a paper by Foster et al. (1971), it is stated that limpets appeared to be feeding on oil coating the rocks. Thus, there are still considerable discrepancies in research dealing with limpets.

Nelson-Smith (1971) stated that a 2% solution of crude oil was lethal to barnacles, while Crap et al. (1972) found that petro-products were extremely harmful to various species of polychaetes. Numerous studies point to the very high sensitivity of amphipods to spilled oil (Blumer et al., 1971; Baker, 1971). In some cases, they have been used as indicator species at spill sites. Karinen and Rice (1974) showed that the molting success of Tanner crabs was reduced by increased oil concentrations. Shaw et al. (1977) used Prudhoe Bay crude oil in experiments and found that clams would surface when oiled sea water was introduced. Finally, Brodersen et al. (1967) showed that adult Alaskan shrimp and crabs were quite sensitive to low concentration levels (0.24-1.96 ppm) of petroleum products and speculated that the cold water species may be more sensitive than warmer water species. The literature cited above is only a very small sample of the wide variety of research into lethal and sublethal effects of petroleum products on marine invertebrate species. There is still considerable work to be done, and areas of conflict remain. However, it is clear that oil spills definitely damage many species even at low concentration levels.

Plant life is also adversely affected by oil spills. Cowell (1971) estimated that 75-100% of salt marsh grasses coated with Torrey Canyon crude were killed. Foster et al. (1971) found that surf grasses were killed by direct coating and abrasion (smothering) by crude oils. Most studies indicate that plants are considerably more resistant than animal species but still susceptible, especially to direct coating.

Sea birds have been the most visible victims of oil spills, as they cannot recognize spilled oil on the water's surface. As a result, they are often found swimming in oil slicks, to the end that many thousands of birds have died by ingestion and loss of insulation through oil coating. The Gulf of Alaska has a very large bird population. It also serves as a molting area for many species of ducks and geese and is on the primary flight path of many migrating species.

The studies described above represent only a small portion of the extremely active research in the field of biological impacts of petroleum products. There can be no doubt that a major spill within the Gulf of Alaska will result in severe damage to the very abundant life there. Part of the purpose of the vulnerability index is to minimize this damage by pinpointing especially sensitive environments so that they can receive priority protection in the event of a spill.

COASTAL CLASSIFICATION

A rapid method of coastal classification has been developed by Hayes et al. (1973). This procedure, called the "Zonal Method", is an inexpensive coastal reconnaissance technique. After a given study area has been defined, pertinent charts, maps, geological data, oceanographic and weather information, and previous studies and literature are reviewed. The entire area is then photographed and described on tape from a small fixed-wing aircraft. Dominant transport directions, general coastal morphology, sediment distributions, and littoral process parameters are noted and are used to develop a first approximation basemap. Additionally, the shoreline is broken into specific subenvironments or zonal sites. A single representative site is selected for each zonal area. These sites are then studied in detail.

In general, the study of a zonal site consists of a number of line transects (profiles) across the active beach face and intertidal zone. These profiles are used to construct a 3-dimensional block diagram of the site. Sediment samples are collected along the profile lines at equally spaced intervals. Samples are later analyzed for texture and composition. Results of these analyses are synthesized by computer for comparison to sediment characteristics at actual spill sites. Sketches and ground and aerial photographs are made of the site and its principle morphological and biological components. Physical process parameters (waves, wind, currents etc.) are measured, and a tape recorded description of the site is made. Detailed study of a zonal site usually requires one full day for a team of three.

After the zonal sites have been described, a sediment sampling interval is established for the entire study area, usually 3-10 km. Closer spacing is used for particularly complex coastal zones. At each of the sampling sites, a single profile is measured. Three sediment samples are collected from the active beachface for later lab analysis (as above). Photo, sketch and taped descriptions are also made. Usually about four of these study sites can be completed within a 5 hour period surrounding the low tide. Thus, it is possible to complete up to 8 sites per day, depending on tides. A more detailed description of these methods and their application to the Gulf of Alaska is given by Ruby (1977).

When the field work has been completed and synthesized, a map is constructed which identifies various coastal subenvironments (Fig. 1). The amount of detail necessary for the development of reasonable baseline data for oil spill contingency plans varies from one area to another. However, as an example, 1216 km of lower Cook Inlet shoreline were classified in a 3 week period by a team of three (Hayes et al., 1977). Thus, these methods are quite rapid, yet detailed enough to provide the required data base to construct accurate environmental maps.

OIL SPILL CASE STUDIES

Two major oil spills have been studied in detail by our research group: 1) the VLCC Metula, which ran aground in the Strait of Magellan on August 9, 1974, spilling 53,000 tons of crude oil, and 2) the Urquiola, which ran aground and burned at the entrance to La Coruña harbor in N. W. Spain on May 12, 1976, spilling 100,000 tons of crude (approximately 75,000 tons of that quantity was burned). These two spills occurred in very different coastal environments.

The Strait of Magellan is dominated by very strong tidal currents (maximum spring tidal range is greater than 11 m) and by high winds but relatively low wave energy due to limited fetch. The land area is primarily remnant glacial topography which is very similar to much of the coastal plain on the Gulf of Alaska. In all, approximately 247 km of shoreline were affected by the Metula spill. These included sand and gravel beaches, marsh areas and broad boulder-cobble low-tide terraces, as well as high scarps and wave-cut platforms onto glacial deposits. The area was studied by our research group on three separate occasions.

The N. W. coast of Spain is a ria system (flooded river valleys). There are four major embayments or rias, each protected by adjacent peninsulas. The rias usually have a very well-developed marsh and tidal flat complex at their inner ends. Wave and tidal energies within the rias are low to moderate. However, on the exposed sections of coastline surrounding the rias and on the rock headlands protecting them, the wave energy is considerably higher. Most of the shorelines are relatively fine sand beaches in protected areas and exposed rock headlands. Over 215 km of these shorelines were impacted by the Urquiola spill.

In addition to these studies, three short term research trips were made to special interest spills: 1) Jakob Maersk oil spill in Oporto, Portugal, 2) the Buchard #65 spill in the frozen Buzzards Bay and 3) the Ethyl H. spill in the frozen Hudson River. These spills provided added detail to spill behavior in environments not found in either Spain or Chile. These studies have provided a data base for predicting oil spill behavior within various coastal environments. This data base, modified for specific local process parameters, has been used to develop the oil spill vulnerability index.

OIL SPILL VULNERABILITY INDEX

The Oil Spill Vulnerabiliy Index has been developed through analysis of the five spill areas described above and a literature search. It is based primarily on the relative longevity of spilled oil within each of 10 subenvironments (assuming only natural cleaning processes). Oil longevity has been found to be related to three parameters: 1) the nature of the sediments (especially relative grain size, 2) the intensity of the nearshore marine processes (wind direction and speed, waves and tidal range), and 3) general local climate. A fourth factor which can dramatically affect the impact of a spill, both directly and by alteration of the processes listed above, is the timing of the spill, especially with regard to the tidal range (spring vs. neap) and the season. Listed below are the 10 classes of the Index and the subenvironments which they represent. They are listed in order of increasing susceptibility to oil spills.

1. Straight, rocky headlands:

   High bedrock scarps are generally exposed to the highest wave energies. Reflecting waves prevent oil from coating the rock surfaces. Even when oiled, the intensity of wave action rapidly cleans them. Hinchinbrook and Kayak Islands are examples of this environment (Fig. 2). These islands have bedrock scarps hundreds of meters high plunging vertically into the sea. Intervention by man in the event of a spill is unnecessary.

2. Eroding wave-cut platforms:

   Wave energies on these flat platforms is quite high. Sediment is generally thin, covering the rock or till platform. These areas will generally be cleaned by natural processes within a few weeks at most. All areas of this type at the Metula spill site were clean after one year. Hinchinbrook and Kayak Islands have broad wave-cut platforms. No cleanup procedures are required for these areas. Biological activity can be quite high on these platforms especially when they are cut into bedrock.

3. Flat, fine-grained sandy beaches:

Fine-grained beaches are usually very flat and hard-packed. The fine-grained nature of the sediment prevents oil penetration to more than a few centimeters. Thus, the oil stays on the surface where it can be removed by road grading machinery or by natural processes. If left only to natural processes, these areas will be cleaned within a few months depending on the intensity of the waves. However, it is considered wise to remove oil mechanically if possible in order to avoid contamination of other areas by re-floated oils. The seaward sides of the Copper River delta barrier islands all fall into this category (Fig. 2). These islands will act as barriers to oil penetration into the back-barrier environments.

4. Steeper, medium-to-coarse grained sandy beaches:

The grain size of these beaches permits oil to penetrate deeper than the fine-grained beaches (still only a few centimeters). However, these beaches change rapidly, and sand may be deposited on top of the oil. Later, when the beach goes into an erosional stage, the oil will be re-exposed and released to pollute new areas. Oil was buried to depths of 100 cm within a few days on beaches of this type in Spain. Removal of oiled sediment by machinery in this situation is not advised, because it could result in serious erosional problems. Precisely this problem was encountered at the Arrow spill in Chedabucto Bay, Nova Scotia (Owens and Rashid, 1976). There are a number of isolated beaches of this type surrounding the Copper River delta.

5. Impermeable exposed tidal flats:

Tidal flats are generally water saturated and composed of extremely fine-grained sediments. Thus, oil penetration is virtually impossible. At the Urquiola spill site, oil was observed being refloated from tidal flats during rising tides. Tidal and wave energies will clean these areas although not as rapidly as on exposed beaches. The refloating of oil can result in recontamination of various nearby environments, and mechanized cleanup is considered impossible. These areas can have very dense communities of infauna and should be protected from oiling if at all possible. There are large tidal flat areas behind the Copper River delta barrier islands (Fig. 2).

6. Mixed sand and gravel beaches:

Oil penetration into beaches of this type can amount to several centimeters. Rates of burial are quite high (a few days in Spain). Attempts to remove deeply buried oil may result in severe erosion. Additionally, road grading machinery will have considerable difficulty due to the low bearing capacity of the sediments. In general, these areas have rather sparse biological productivity. It is recommended that these areas be left to natural cleaning when possible even though it may take a number of years. The berm-top overwash and low-tide terrace areas are especially prone to accumulate spilled oil. In that case, cleanup methods may be utilized just in those areas. There are a few pocket beaches of this type on Hinchinbrook and Kayak Islands.

7. Gravel beaches:

The large grain size of pure gravel beaches will permit considerable oil penetration (up to 45 cm in Spain). Rapid burial is also a problem. Once a gravel beach is oiled, it will be extremely difficult to clean without removing much of the beachface. Natural cleaning time will vary depending upon wave energies. In sheltered areas, many years will be required, especially in colder northern waters where biological degradation is slower (Cundell and Traxler, 1973; Robertson, 1972). Fortunately, these areas generally have relatively low density biological communities. There are a few small gravel beaches on Hinchinbrook and Kayak Islands.

8. Sheltered rocky headlands:

Oil tends to adhere to rough rocky surfaces. In areas sheltered from wave activity, oil coatings will remain for many years subject to slow chemical and biological degradation. These areas often have well developed communities of organisms and should be protected from oiling. Mechanized cleanup without harm to the attached flora and fauna is presently impossible. Areas of this type are absent from the immediate Copper River delta but are very common in nearby Prince William Sound.

9. Protected estuarine tidal flats:

Once oil reaches these quiet back-water areas, it will remain there for many years (more than 10 years in some cases). Natural cleaning processes are extremely slow. Mechanized cleanup without disturbing the abundant infaunal communities is impossible. These areas should receive priority protection from oiling. There are broad areas of sheltered tidal flats fronting the marshes behind the Copper River delta barrier islands.

10. Protected estuarine salt marshes:

Oil which is permitted to reach marsh areas will have long term deleterious impact. Physical, chemical and biogenic cleaning processes are very slow. The abundant floral and faunal assemblages are very sensitive to spilled oil. Mechanical cleanup techniques are very limited and usually harmful to the marsh ecosystem. At the *Metula* spill site, oil within marsh areas was essentially unchanged after 1½ years. Longevity is estimated at more than 10 years. There are extensive areas of salt marsh on the Copper River delta (Fig. 2).

APPLICATIONS TO THE NORTHERN GULF OF ALASKA

Using a combination of the vulnerability classification just described and a classification of coastal morphology described earlier, it is possible to delineate the coastal environments of the Copper River delta with respect to oil spill vulnerability. Generally, the delta is a high-risk area especially in the back-barrier environments. In addition, the entire study area is remote and almost inaccessible to standard cleanup operations. Of all the environments, the erosional shorelines in rock scarps on Hinchinbrook Island, Kayak Island and Wingham Island are most apt to be rapidly cleaned by natural processes. The marsh and tidal flat areas behind the barrier islands are extremely vulnerable areas. The remainder of the beaches are variable with potential effects depending essentially upon the wave energy and beach grain size. Oil burial can be a problem with these sand and gravel beaches because they change rapidly, going through repetitive cycles of erosion and deposition.

Using the ten morphological subdivisions just discussed, a risk classification has been devised. Oil longevity within these risk classifications is estimated as follows:

Risk Class	Longevity
1-2	A few days to a few weeks
3-4	One to six months
5-6	Less than twelve months
7-8	A year or two to as many as eight years
9-10	As many as ten years or more

Table 1 shows the results of this application to the delta.

TABLE 1

Km of shoreline	% of shoreline	Discussion	Risk Classification
110	16	Oil easily removed by wave erosion; some problems in areas of gravel accumulation and pocket beaches	1-2
166	24	Generally low-risk areas. Fine sands prevent penetration of oil. Possibility of oil burial.	3-4
195	28	Mud tidal flats do not permit deep penetration of the oil, but the low energies may require as much as a year to remove the oil. Sand and gravel beaches are prone to oil burial.	5-6
20	3	These areas include pure gravel beaches and sheltered rock headlands and cliffs. Oil will remain for periods of years.	7-8

Km of shoreline	% of shoreline	Discussion	Risk Classification
200	29	These highly sensitive marsh and tidal flat areas can retain oil for more than 10 years. In addition, these areas are of extreme biological importance.	9-10

CONCLUSIONS

Table 1 shows that of the 691 km of shoreline classified, 32% falls into the high risk categories of 7-10. Oil longevity within these areas is estimated to be a few years to more than 10 years. However, in some instances, certain natural physical processes may act to prevent or limit oil spills from penetrating into these high risk zones. For example, the Copper River delta barrier islands will act as natural barriers to spilled oil. Furthermore, fluvial flushing may prevent considerable portions of oil from contaminating these extremely sensitive back-barrier and marsh environments. Thus, these high risk areas must be analyzed in detail to determine the actual probability of spilled oil reaching them.

Finally, the remoteness and relative inaccessability vastly increases cleanup logistics problems. Within the area, there is only one small fishing town (Cordova, population: 3,000). Other than Cordova, equipped with a jet airport, the area is virtually uninhabited. Additionally, there are no roads connecting Cordova to the shorelines of the delta. Thus, any attempted mechanized cleanup of an oil spill will have to deal with rather severe transportation problems. All equipment will have to be transported considerable distances by air or ship to the spill site.

Figure 1 shows the study areas and the general morphological classification. Using that classification, Figure 2 was developed. It shows the risk classes of the coastal environments of the delta. The scale of these figures does not permit delineation of the full detail present on much larger basemaps. It is hoped that this type of research will be extended to other critical shorelines of the United States. With the addition of detailed biological basemaps, oil spill contingency planners will be able to make informed decisions regarding deployment of clean-up operations. These basemaps would also provide coastal zone managers with information to permit sound development programs.

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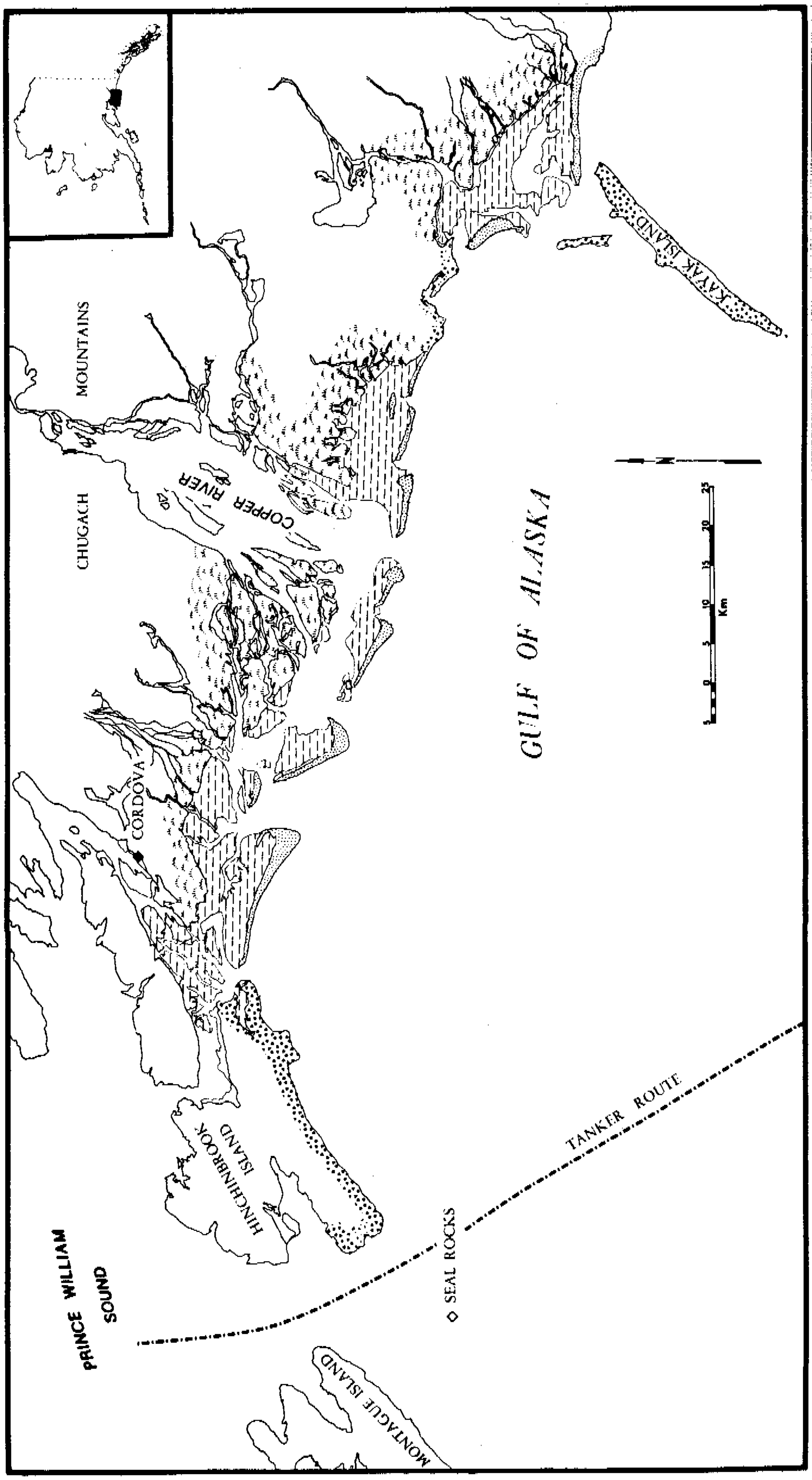
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TANKER ROUTE
MONTAGUE ISLAND
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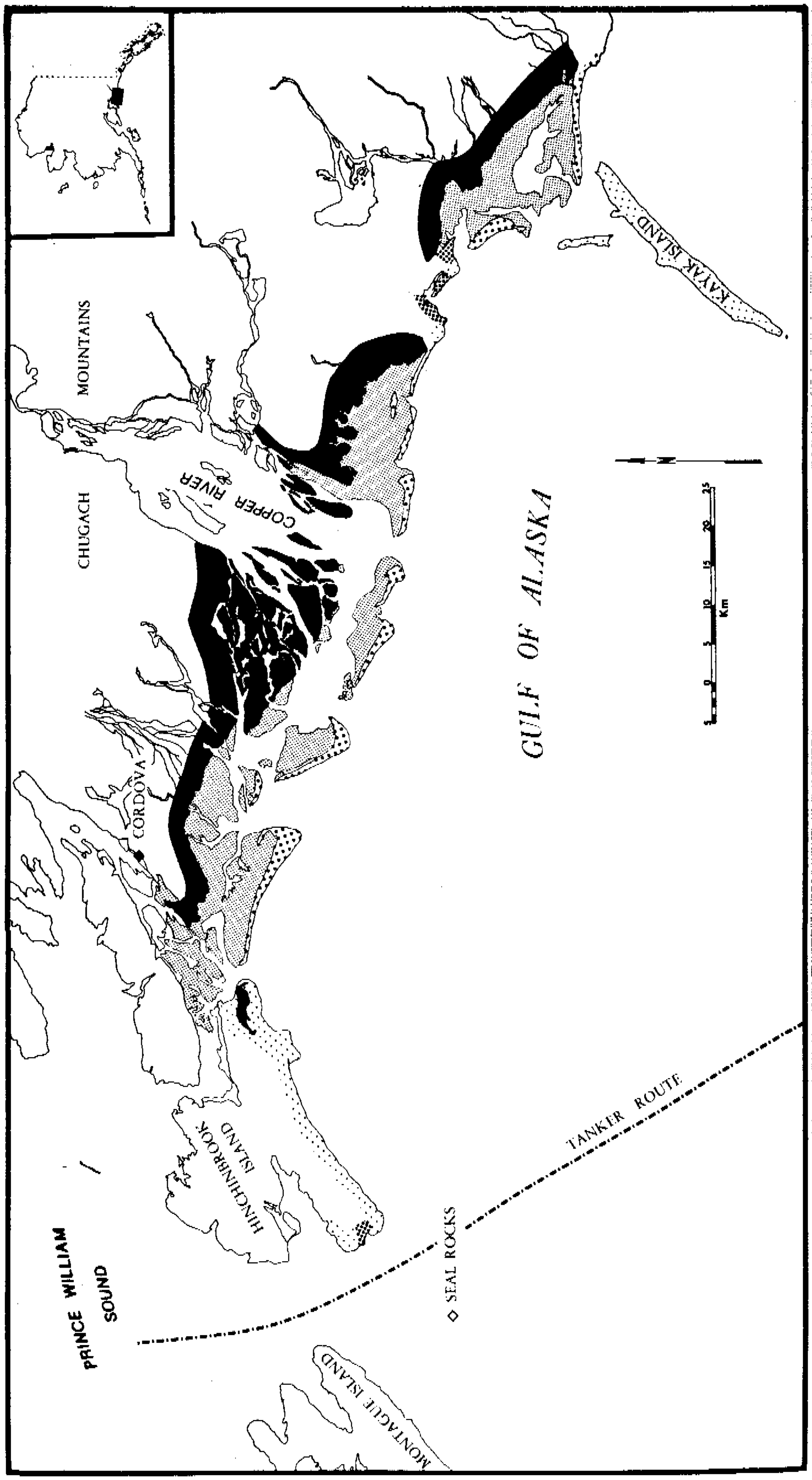
GEOMORPHIC CLASSIFICATION

- Bedrock Headlands, Scarps and Wave-Cut Platforms
- Barrier Islands and Fine Sand Beaches
- Exposed Tidal Flats
- Pure Gravel Beaches
- Protected Marshes and Tidal Flats

Figure 1. (opposite page) Map of study area on the Copper River delta and adjacent shorelines. The six primary barrier islands fronting the delta form an arc approximately 80 km in length. Landward of the barrier island chain is a broad sand-mud tidal flat zone fringed by an extensive salt marsh system. Just inland, there is the complex topography of the Chugach Mountains with associated glaciers and glacial drainage systems. The delta is enclosed by two uplifted bedrock islands (Kayak and Hinchinbrook). The shoreline of the islands is manifest primarily as high bedrock scarps; however, there are numerous sand and gravel pocket beaches. The location and configuration of these pocket beaches is the result of structural control within the bedrock. A broad wave-cut platform has been developed on the eastern shore of Kayak Island. The tanker route between the lower 48 states and Valdez, Alaska is shown to the left where it passes between Hinchinbrook and Kayak Islands into Prince William Sound. Note the position of Seal Rocks, a shallow rocky area (minimum depth 10 m). The key to the geomorphology appears directly above.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OIL SPILL VULNERABILITY RISK CLASS

CLASS	RESIDENCE TIME
1-2	A Few Days to a Few Weeks
3-4	One to Six Months
5-6	Less Than Twelve Months
7-8	A Year or Two to Eight Years
9-10	As Many as Ten Years or More

Figure 2. (opposite page) Map of the study area showing the application of the Oil Spill Vulnerability Index "Risk Classification". 32% of the shoreline environments fall into the high risk classes of 7-10 in which spilled oil may remain for more than 10 years. These high risk areas are generally found in the quieter water areas behind the barrier islands (marsh and tidal flat areas). Those areas are also of extreme biological importance. The more exposed coastal areas have received ratings of 1-6. These areas will be cleaned by natural processes rather rapidly. The key for risk classification is located immediately above.

RECONNAISSANCE EVALUATION OF LONGSHORE SEDIMENT TRANSPORT, NORTHEAST GULF OF ALASKA

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ABSTRACT

Aerial photographic reconnaissance combined with systematic sediment sampling and littoral process observations, delineated the following pattern of longshore sediment transport along the northeast Gulf coast of Alaska between Cape Yakataga and Yakutat: a net transport to the west between Cape Yakataga and Icy Cape, a nodal point at Icy Cape, net flux to the east along the western shore of Icy Bay past Claybluff Point, a westward net flux on the west Malaspina Foreland and Riou Spit, a nodal zone at Sitkagi Bluffs and net transport into Yakutat Bay all along its western shore.

Computations of wave energy flux from SSMO data for the coastal zone of the entire Gulf of Alaska demonstrate transport to the west or the northwest at all ocean facing beaches between Vancouver Island and Prince William Sound. The wave energy flux values, combined with refraction diagrams for the continental shelf of the northern Gulf of Alaska, form the basis for the estimation of longshore sediment transport rates. The annual net transport rate is found to range from about 1.4 million cubic meters to the west on the west Malaspina Foreland, to about 220,000 cubic meters to the east between Sitkagi Bluffs and the western shores of outer Yakutat Bay. The calculated transport pattern shows good correlation with the morphological observations.

INTRODUCTION

During the summer of 1975, the authors participated in an environmental geological study of the coastline of the northeast Gulf of Alaska as part of the Outer Continental Shelf Environmental Assessment Program of the National Oceanic and Atmospheric Administration, sponsored by the Bureau of Land Management. The study included mapping of the geology of the west Malaspina Foreland (Boothroyd et al.1976), a characterization of coastal morphology between Cape Yakataga and Dry Bay with emphasis on shoreline stability (Hayes et al. 1976; Ruby, 1977), and field measurements combined with theoretical studies of nearshore wave climate and sediment transportation (Nummedal and Stephen, 1976; Stephen et al. 1976).

This paper will assess the littoral drift direction indicators which were described and measured in the field and compare these to the results of theoretical predictions derived from a simple model of wave climate and refraction patterns on the adjacent continental shelf. Good correlation was observed between transport directions deduced

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from coastal morphology, sediment trends,observed nearshore currents and wave parameters, and directions computed from SSMO-derived wave data in the Gulf. We want to emphasize that, for many sections of the world's shoreline, the combination of a rapid, systematic morphological reconnaissance and sediment sampling, the zonal method (Hayes et al. 1973), and the construction of a simple shelf wave climate model based on ship wave observations summarized by the Naval Weather Service Command,provides an inexpensive, efficient, and reliable program for the acquisition of regional coastal engineering data.

LONG-TERM TRANSPORT TRENDS

The coastline of the northeast Gulf of Alaska between Cape Yakataga and Yakutat (Fig.3) encompasses the Malaspina Glacier and its associated outwash plains, the two glacially scoured embaymants of Icy and Yakutat Bays, and low-lying beach ridge plains east of Yakutat and to the west of Icy Cape. Sedimentary features reflecting long-term transport trends along this coastline include barriers and recurved spits, deflected river mouths, and cuspate forelands.

Between Icy Cape and Cape Yakataga, river mouth deflections demonstrate westward transport. Erosional cliffs at Icy Cape indicate the existence of a nodal point (Fig.1), and river mouths and prograding spits demonstrate transport to the northeast along the west shore of Icy Bay. The development of a cuspate foreland at Claybluff Point attests to the importance of waves generated within the Bay. Strong katabatic winds from the St. Elias Range generate waves propagating out Icy Bay. These waves, combined with strongly refracted ocean swell, account for the transport towards the northwest on the downdrift side of Claybluff Point. The much more intense transport towards the northeast on the exposed side of this foreland is caused by the effective Pacific swell (Fig.2).

The 6.6 km long Riou Spit, built since 1904 (Molnia, 1977), protects the east side of Icy Bay from the Pacific swell. Small wave built features formed by local waves charaterize the sheltered bay shore (Fig.4). Riou Spit itself, the erosional till bluffs at Point Riou and barrier spits deflecting the distributaries of the Old Yahtse and Yana Streams, demonstrate consistent westward transport along the west Malaspina Foreland (Fig.4). The gentle curvature of the foreland causes a decrease in transport intensity near its center. The shoreline from the western edge of Sitkagi Bluffs and some distance to the east appears to be a broad nodal zone, apparently subject to a long-term eastward transport by normal wave conditions as illustrated by the spits deflecting the distributaries of Manby and Alder Streams (Fig.5). Evidence exists, however, that transport during storms can be towards the west. Precut timbers from a barge which was wrecked off Alder Stream in November, 1974, have been dispersed downdrift of the wreck site in a westerly direction, opposite that of the dominant drift (Fig.7). The Kwik Stream fan delta has developed a series of barrier spits indicating transport into Yakutat Bay (Fig.6). Whereas the neoglacial moraine at the Icy Bay entrance (Molnia and Carlson, 1975) attenuates the Pacific swell, the deep entrance to Yakutat Bay has no such effect. As a consequence, longshore transport on the shores of Yakutat Bay is consistently directed into the bay. Transport directions derived by these morphological criteria are summarized by solid black arrows in figure 11.

Three to five sediment samples were obtained from each of 60 beach profiles surveyed between Cape Yakataga and Yakutat Bay. Trends in lithologic composition of beach gravels and mean sediment size are consistent with the transport patterns deduced from the morphology. Details on the sediment variability are presented in Ruby (1977).

LITTORAL PROCESS VARIABILITY

Field studies of littoral processes had two objectives: (1) to document the "instantaneous" spatial variability in nearshore wave conditions, and (2) to relate temporal changes in wave conditions at a given site to beach response. Only objective (1) pertains to this review of transport directions. Three days with stable weather and uniform offshore wave conditions were chosen for evaluation of the spatial process variability (23 July, 18 August, and 20 August, 1975). With a Cessna 182 airplane, capable of beach landings, four or five process-stations were sampled each day within a few hours around low tide. The results are summarized in Figure 8. Icy Cape was found to act as a nodal point with wave-generated longshore currents set into Icy Bay on its east side and set to the west on the ocean facing beach. Maximum wave heights were recorded at Icy Cape. On the west Malaspina Foreland, currents were consistently set to the west, and the wave heights were found to increase toward Riou Spit. On the east Malaspina Foreland, the nearshore currents were consistently set into the bay at Manby Point and stations farther east. At the Alder stream beach, however, currents in both directions were observed. Wave heights were generally lower at Many Point than at stations to the east or west.

The selection of days with nearly uniform offshore wave conditions permits these spatial differences in nearshore wave characteristics to be attributed to effects of beach slope, shoaling, refraction, and shoreline orientation.

SHELF WAVE CLIMATE

The Gulf of Alaska has one of the highest winter cyclone frequencies in the northern hemisphere (Pettersen, 1969). Cyclones generated on the North Pacific polar and arctic fronts generally travel east into the Gulf where the steep temperature-induced pressure gradients prevent their further passage across the Alaska and St. Elias Ranges. Cyclonic circulation in the Gulf enhanced by winds generated by the steep pressure gradient along the mountains causes dominant as well as prevailing winds to blow from the southeast along the entire North American west coast from Vancouver Island to Prince William Sound. Offshore, or westerly, winds prevail along the Gulf shores of the Alaskan peninsula and the Aleutians.

The shelf wave climate caused by this wind regime is expressed in terms of deep water wave energy flux values calculated for the eight major compass directions for each individual SSMO data square (Table 1). Ship wave observations, summarized by the U.S. Naval Weather Service Command were used for the calculations. Details can be found in Nummedal and Stephen (1976). The calculated wave climate is graphically portrayed in terms of the resultant wave energy flux vector for each data square (Fig. 9). This vector points north at Queen Charlotte and Sitka, northwest at Cordova, and northeast at Seward. This indicates a convergence of wave energy toward Prince William Sound. The direction of the resultant wave energy flux vector should correspond to the direction of net coarse sediment transport on an adjacent ocean beach not subject to topographically controlled local reversals. The SSMO data predict a net long-term transport toward the northwest along the North American coast from Vancouver to Cordova and, where beaches are present, a northeast transport from the Aleutians to the entrance of Prince William Sound. This pattern is in general agreement with that deduced by Silvester (1974) from geomorphology alone.

LONGSHORE SEDIMENT TRANSPORT RATES

Wave energy flux values for the Cordova SSMO data square, combined with wave refraction diagrams for 8, 12 and 16 sec. waves from the southwest, south and southeast (Nummedal and Stephen, 1976) were used to calculate the longshore wave energy flux along 4 approximately straight segments of the shoreline between Cape Suckling and Yakutat Bay. It is assumed that the longshore currents are predominantly generated by the momentum of the breaking wave, rendering the wave energy flux method (Galvin and Vitale, 1977) a valid tool for transport rate calculations. Calculated longshore energy flux and consequent transport rates for each shoreline segment, for each of the three deep water wave approach directions that have a significant onshore component, are summarized in Table 2 and graphically portrayed in Figure 10.

The gross sediment transport is seen to be fairly consistent for the four shoreline segments, ranging from 1.6 to 2.9 million cubic meters per year. The annual net transport rate, on the contrary, demonstrates great variability, ranging from 1.39 million cubic meters to the west on the west Malaspina Foreland to 220 thousand cubic meters toward the east on the Malaspina Foreland east of Sitkagi Bluffs. The results indicate that southeasterly waves are responsible for the bulk of the sediment transportation along the northern Gulf Coast of Alaska. This is to be expected in light of the wind regime previously discussed. Gross transport rates are higher than what is reported anywhere else along the shorelines of the United States (Wiegel, 1964).

SUMMARY AND CONCLUSIONS

1. A summary diagram is presented in Figure 11 to show longshore sediment transport directions on the Malaspina shores, deduced from observations of coastal morphology, sediment trends, littoral process observations and calculations based on SSMO data and wave refraction diagrams. Good agreement is noted between all indicators. The following pattern is evident: a net transport to the west between Cape Yakataga and Icy Cape, a nodal point at the Cape, net flux to the east along the western shore of Icy Bay past Claybluff Point, a westward net flux on the west Malaspina Foreland and Riou Spit, a nodal zone at Sitkagi Bluffs and net transport into Yakutat Bay.

2. The eastern shore of the Malaspina Foreland appears to be a region of dominant long-term transport to the east, interrupted by frequent storm reversals. The westward dispersal of timbers from the barge wreck and the near balance between calculated transport rates to the east and west both support this conclusion.

3. Calculated net transport rates, ranging up to 1.4 million cubic meters per year, are larger than those documented anywhere in the conterminous United States (Wiegel, 1964).

4. A combined systematic field reconnaissance, the zonal method, and an office study of the coastal wave climate was used to estimate sediment transport trends and rates on a broad regional scale. These inexpensively acquired coastal engineering data can be of great value in the early planning for coastal development.

ACKNOWLEDGEMENTS

This study was supported by the National Oceanic and Atmospheric Administration through contract no. 03-5-022-82, Miles O. Hayes and Dag Nummedal, Principal Investigators. Jon Boothroyd, Raymond Levey and Steve Wilson assisted in the field.

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TABLE 1

Deep Water Wave Energy Flux[1] Values for Gulf of Alaska SSMO Squares

Wave energy flux in units of $10^{10} \frac{ergs}{m \cdot s}$

Data Square	N	NE	E	SE	S	SW	W	NW
Vancouver	1.12	.39	1.45	5.01	4.44	3.07	4.21	4.37
Queen Charlotte	.83	.55	1.84	5.00	2.44	2.05	2.66	2.08
Sitka	.71	1.60	3.18	4.45	2.94	2.72	2.72	1.40
Cordova	.54	2.04	7.42	4.66	2.86	2.54	3.00	1.10
Seward	1.49	2.23	5.70	3.76	3.54	4.09	5.44	3.78
Kodiak	1.02	2.27	3.06	1.43	1.56	1.69	4.37	2.68
Unimak	2.30	1.64	2.23	1.78	3.25	4.53	6.46	5.28

[1] Since observed SSMO wave heights are supposed to be significant values, the quantities presented in this table are in effect wave energy flux factors.

TABLE 2

Longshore sediment transport rates on the northeast coast of the Gulf of Alaska, based on SSMO data for the time period 1963-1970. Positive sign indicates transport to the right (west); negative sign indicates transport to the left (east).

Wave Approach Direction	Deep Water Wave Energy Flux* $10^{10} \frac{ergs}{s \cdot m}$	Sediment transport rate in 10^6 m^3/yr for shoreline segment			
		1	2	3	4
Southeast	4.66	1.54	.98	1.15	.67
South	2.86	-.68	.21	.39	-.36
Southwest	2.54	-.63	-.81	-.15	-.53
Gross transport rate		2.85	2.00	1.69	1.56
Net transport rate		.23	.38	1.39	-.22

* For the Cordova SSMO data square

Figure 1. Oblique air photo of the coast from Icy Cape (foreground) to Cape Yakataga (background). The photo was taken on August 4, 1975, from 9000 feet.

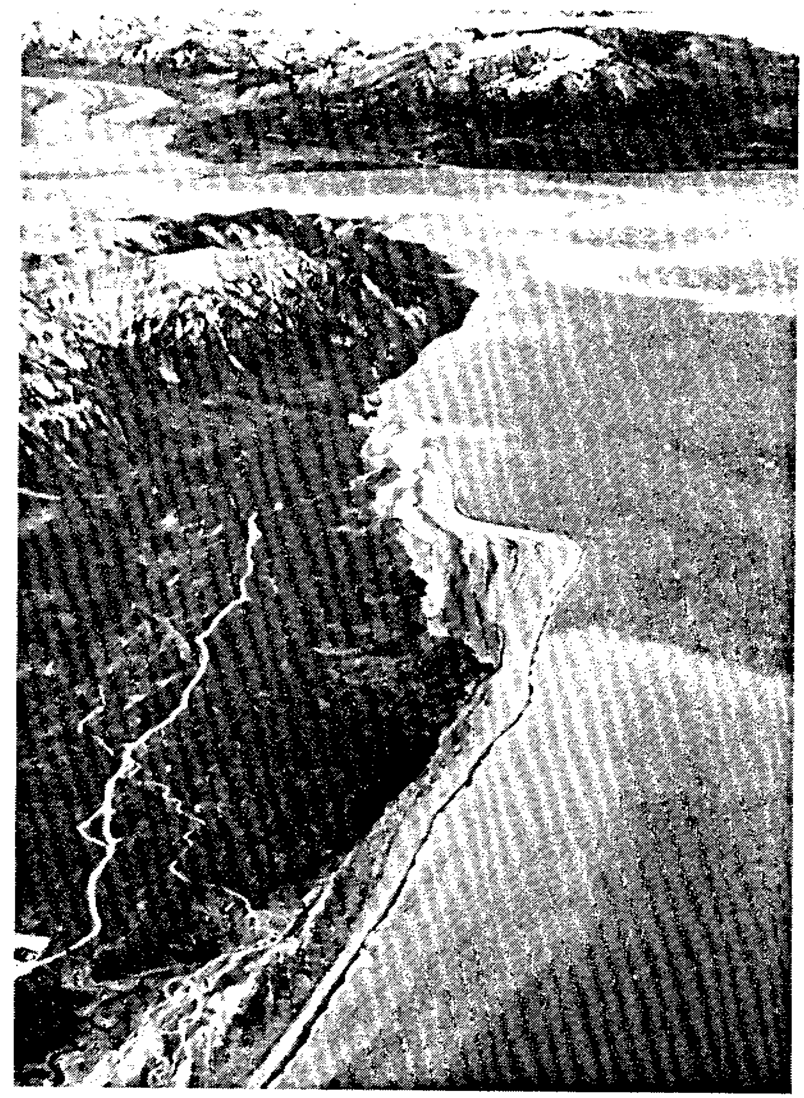


Figure 2. Oblique air photo of Claybluff Point (center) and the west side of Icy Bay. The Tyndall Glacier and Karr Hills are in the background. The photo was taken on August 4, 1975, from 9000 feet.

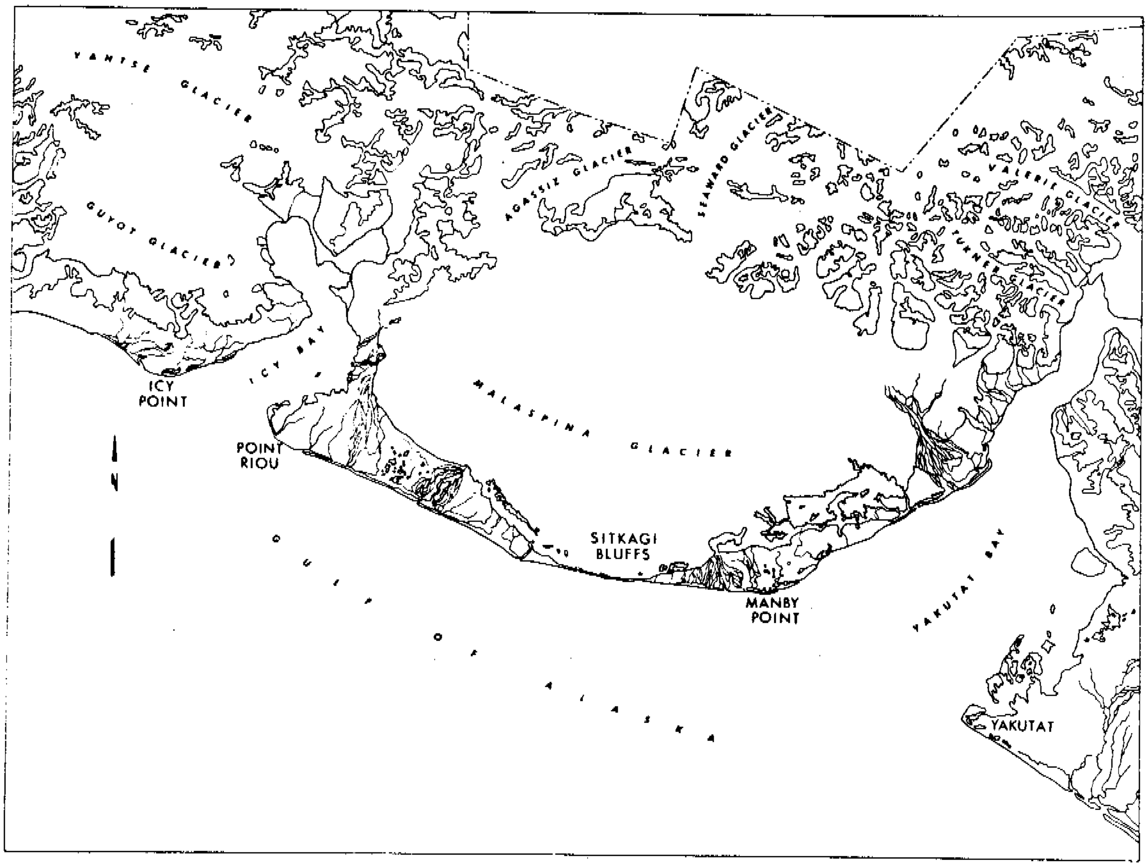


Figure 3. Location map of the study area on the northern Gulf coast of Alaska.

Figure 4. Oblique aerial view of the west Malaspina Foreland, looking east. Riou Spit is in the foreground, Point Riou is the first vegetated cliff, the Old Yahtse and Yana streams form the two wide outwash plains further east. Photo taken August 4, 1975, from 8000 ft.

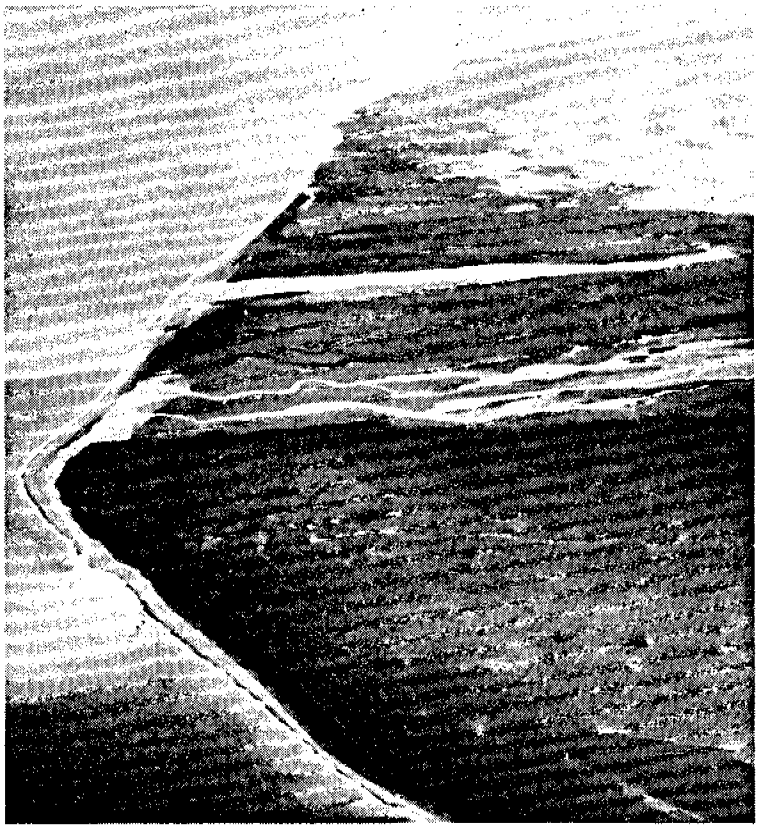


Figure 5. Oblique aerial view of the east Malaspina Foreland, looking west. Manby Point is in the foreground, Sitkagi Bluffs, Fountain Stream, and part of the Malaspina Glacier are visible in the background. The Manby and Alder Streams form the outwash plain. August 4, 1975.

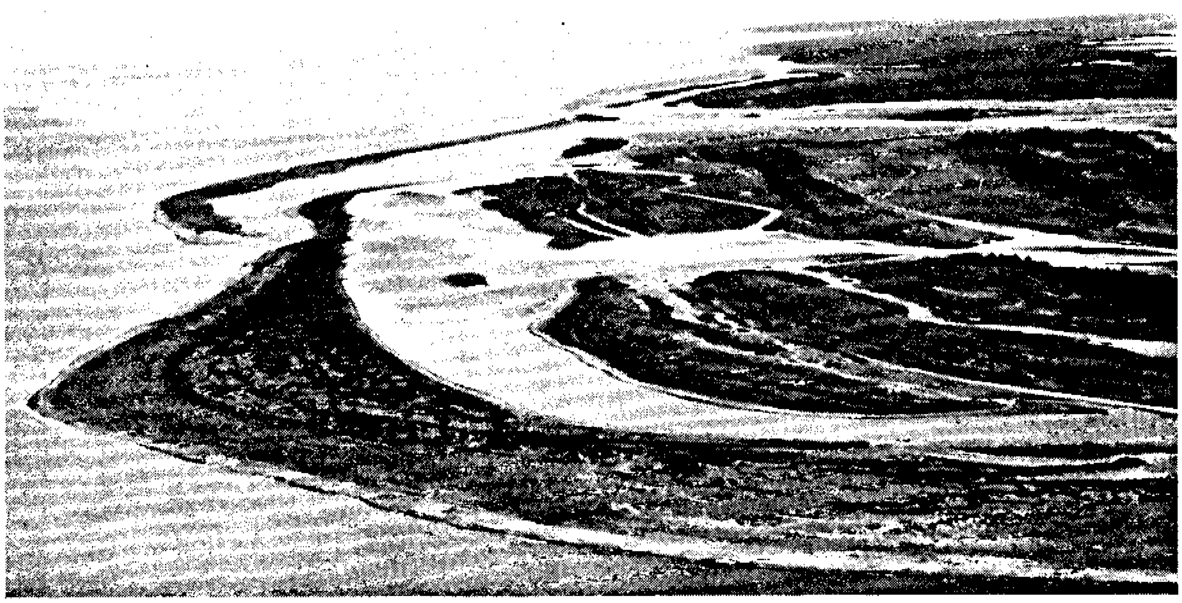


Figure 6. Oblique aerial view to the south of the prograding beach ridge plain of the Grand Wash River (Kwik Stream). Photo taken August 4, 1975 from 3000 feet. Note the suspended sediment plumes and the northeastward orientation of the barrier spits.

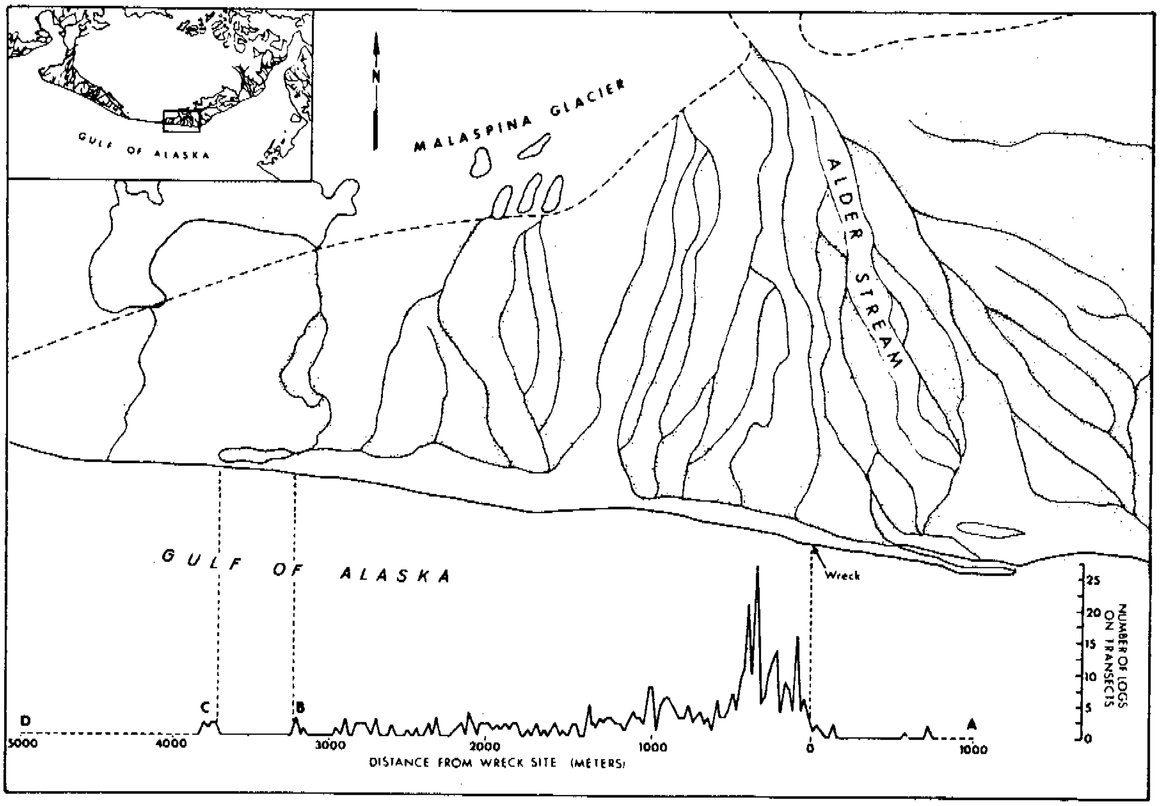


Figure 7. Map of the Alder Stream beach and outwash with a graph showing the distribution of timbers on the storm berm downdrift of the barge wreck.

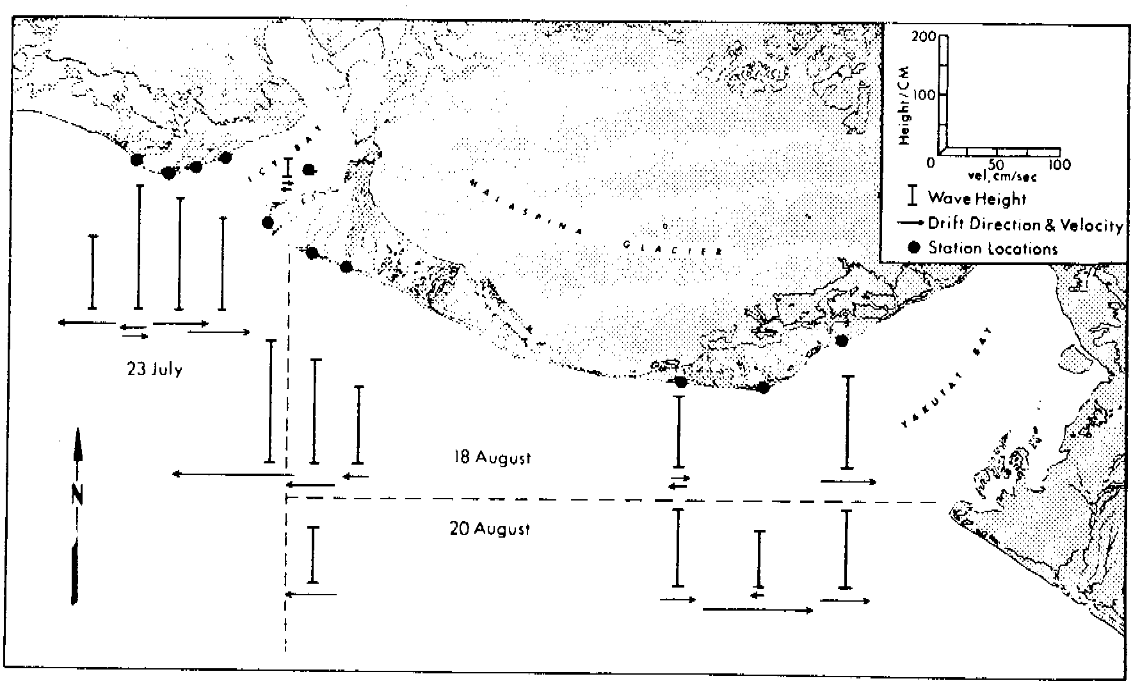


Figure 8. Wave height and longshore currents observed at process network stations on 23 July, 18 August, and 20 August, 1975. Measurements were made on days of regionally uniform offshore wave conditions.

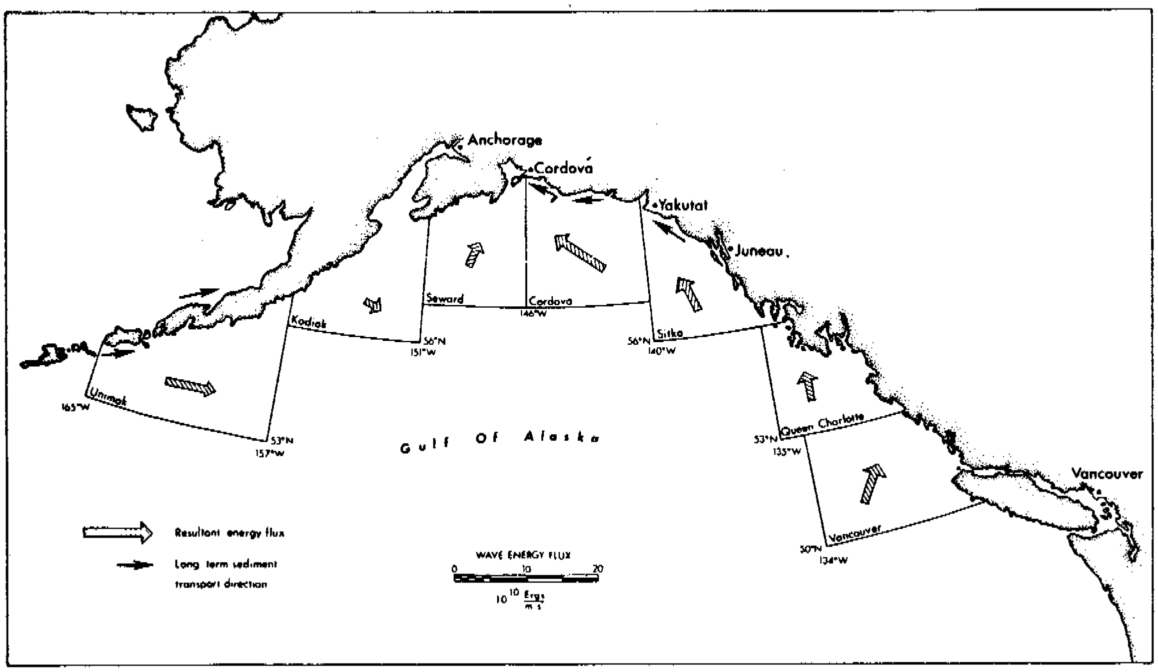


Figure 9. Direction of longshore sediment transportation based on large scale coastal geomorphic features and resultant wave energy flux distribution for the coastal areas of the Gulf of Alaska. Note the convergence of wave energy flux towards Prince William Sound.

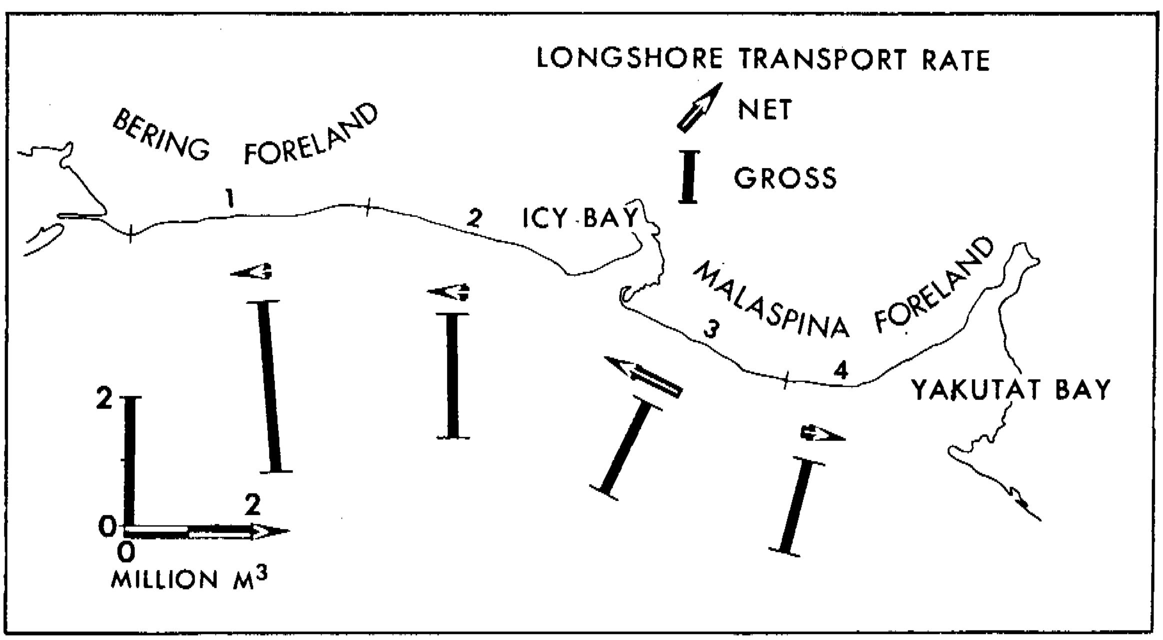


Figure 10. Summary diagram of computed longshore sediment transportation rates along the northeast coast of the Gulf of Alaska. Computations are based on local SSMO data and wave refraction diagrams.

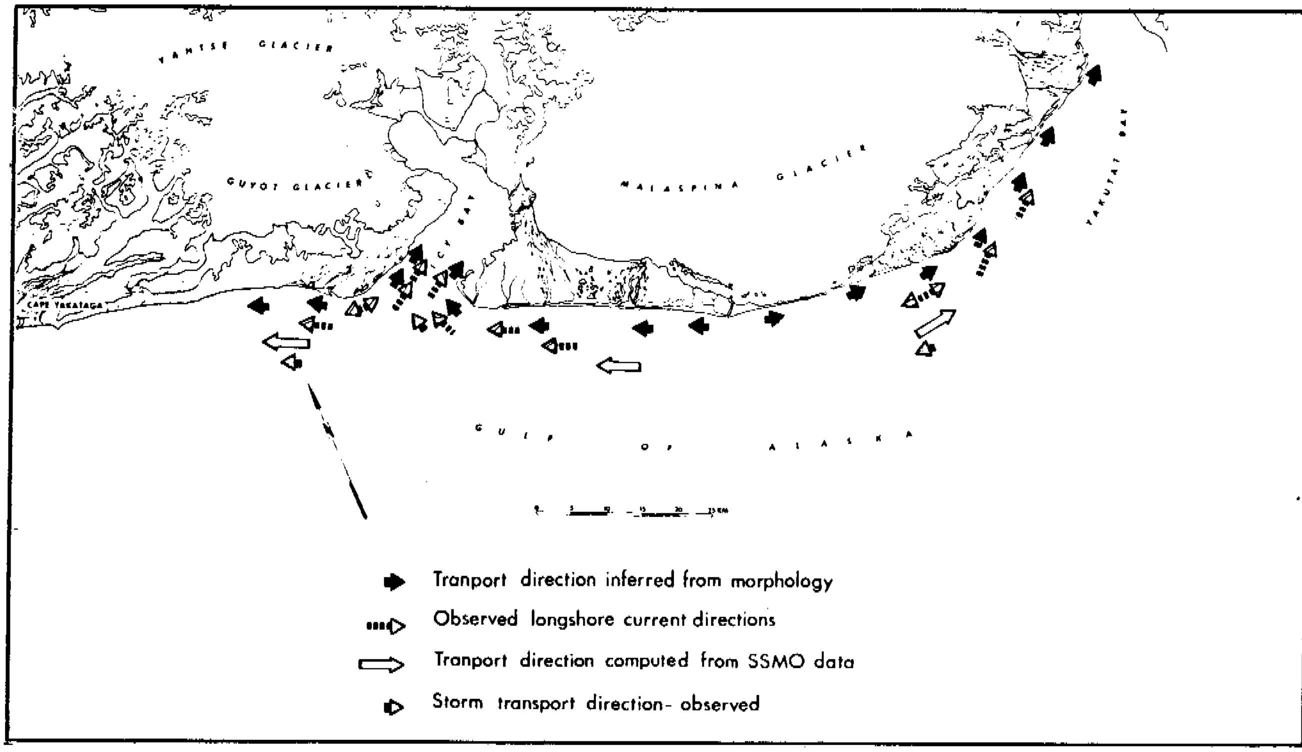


Figure 11. Summary of sediment transport directions along the shoreline the northeast Gulf of Alaska from Yakutat Bay to Cape Yakataga. Information is derived from observations of local coastal morphology, longshore current directions, transport patterns on storm generated features like high berms and washover terraces, and computations of longshore energy flux.

QUARTERLY REPORT

Contract #03-5-22-67, Task Order 6
Research Unit #87
Reporting Period: 1 October 1977-
30 December 1977
Number of pages: 1

THE INTERACTION OF OIL WITH SEA ICE IN THE BEAUFORT SEA

Seelye Martin

Department of Oceanography, WB-10
University of Washington
Seattle, Washington 98195

28 December 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 and Field Activities:

A. Field Activities: During the past quarter, we have began our preparations for our upcoming field trip in March 1978.

B. Laboratory Activities: Our work during the past quarter has been on the development of a model for wave and oil absorption by grease ice, and the role of grease and pancake ice at both the pack ice edge, and in the lee shore areas of Kotebue and Norton Sound, and Bristol Bay. As part of this work, we have developed a constitutive law for the behavior of grease ice, which shows that at low shear velocities, the viscosity of the grease ice increases; while at high shears, its viscosity approaches that of sea water.

We are looking at this ice from two aspects. First, being in part a highly viscous buoyant fluid, its distribution under wind and current forces may model how oil would spread in similar weather conditions. This is of interest because of its occurrence in the Kotzebue, Norton, Bristol Bay, and Saint George Basins. Since we can follow the distribution of grease ice in these basins from a combination of satellite, aircraft, and surface observations, we should be able to understand qualitatively how crude oil would behave under similar weather conditions.

Second, since the viscosity of grease changes with shear, we plan laboratory experiments on the small-scale interaction of grease ice and oil, where-in we suspect that a low viscosity oil which is swept into grease ice may be trapped on the surface at the boundary between the high and low viscosity grease ice. Knowledge of this sort will aid in the design of clean-up techniques and trajectory predictions for oil spilled in the Chukchi and Bering Seas.

III. Estimate of Funds Expended:

As of this date, we are 20% expended.

Sea Ice Thickness Profiling and
Under-Ice Oil Entrapment

Research Unit #88

by

Austin Kovacs

Corps of Engineers, U.S. Army
Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire

Presentation Reference:

Kovacs, A. (1977) "Sea Ice Thickness Profiling and Under-Ice Oil Entrapment", Proceedings of the 9th Annual Offshore Technology Conference in Houston, Texas, May 2-5, 1977, pp. 547-554.

January 1978

QUARTERLY REPORT

Contract No:

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

Research Unit No.:

91

Reporting Period:

1 October - 31 December 1977

Number of Pages:

3

Current Measurements in Possible Dispersal Regions of the Beaufort Sea

Knut Aagaard

Department of Oceanography
University of Washington
Seattle, Washington 98195

10 January 1978

Ref.: A78-4

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 modified on the Beaufort shelf.

II. Field Activities

These are described in the attached preliminary report, Ref. M77-122, Cruise W28.

III. Results, and IV Preliminary Interpretation of Results

Analysis of current records is continuing.

V. Problems Encountered

None beyond the routine ones described in the attached preliminary report.

VI. Estimate of funds expended by Department of Oceanography, University of Washington to 30 November 1977.

TOTAL ALLOCATION (5/16/75-9/30/78)			$282,674
A. Salaries, faculty and staff		$34,381	
B. Benefits		4,613	
C. Supplies & Expendable Equipment		34,931	
Floatation	$1,500		
D. Permanent Equipment		80,346	
Release	$6,369		
Current Meter	$8,256		

E.	Travel		$ 6,156	
F.	Computer		626	
G.	Other Direct Costs		28,930	
	Freight	$1,940		
	Duty & Customs Charges	$1,533		
H.	Indirect Costs		15,488	
			TOTAL	$205,471
			REMAINING BALANCE	$ 77,203

University of Washington

Department of Oceanography

Seattle, Washington 98195

Preliminary Report

University of Washington Participation in

NOAA Recovery/Deployment Phase of Cruise W28

Current Measurements in Possible Dispersal Regions of the Beaufort Sea

6 November - 17 November 1977

by

Clark Darnall

NOAA Contract 03-5-022-67, TA 3

Approved by:

Knut Aagaard, Research Associate Professor
Principal Investigator

George Anderson, Professor
Associate Chairman for Research

Ref: M77-122

CURRENT STUDIES ON BEAUFORT SEA SHELF

1. *Objectives*

To look at the time-dependent circulation and dynamics of the outer shelf and slope of the Beaufort Sea, by means of long-term Eulerian time-series current studies at selected locations, where the ice cover is not seasonally removed. Cruise W28 was a recovery/deployment phase of current meter studies.

2. *Narrative*

Mooring recovery phase

Two moorings deployed in April 1977 were to be recovered. They were located at 200 m and 1000 m depths. A prototype sub-surface data retrieval storage and telemetry system developed by the Applied Physics Laboratory, University of Washington, had been installed in the offshore mooring. Prior to attempting recovery of this mooring, we attempted to interrogate this unit. Due to ice conditions and shortness of daylight working hours, only the 200 m mooring was recovered. The acoustic transponder/release in the offshore (1000 m) mooring performed satisfactorily. We should be able to recover this mooring in the spring of 1978.

Mooring deployment phase

Two moorings were deployed in the same general area (30-40 mi. north of Lonely). The inshore mooring was deployed in 100 m with current meters at 65 m and 85 m. The mooring was equipped with a model 322 AMF acoustic transponder/release. The offshore mooring was in 192 m with current meters at 57 m and 177 m. This mooring also was equipped with an acoustic transponder/release.

A physical description and location of the moorings is in the Appendix.

The report of events is as follows:

November 6, 1977 S. Harding arrived Barrow.

November 7, 1977 F. Karig and C. Darnall arrived Barrow. We began assembling and checking out mooring equipment and instruments.

November 8, 1977, Weather, high thin overcast, temperature -20°C, winds N.W. at 6kt.

0935 AST - Darnall departed Barrow in NARL Cessna 180 N3467Y (Hoffman) for Lonely.
1015 - Landed Lonely.
1024 - Departed Lonely in NOAA helicopter N56RF (Labonty & Harrigan) to survey ice conditions in mooring area.
Ice conditions en route were near shore: many several-day-old refrozen leads, no open water, many large areas of smooth ice.
1100 - Landed in area of 1000 m mooring. There were no new leads, and ice appeared stable. Ice thickness - 12 to 16 inches.
1105 - Returning to Lonely.
1136 - Arrived Lonely. The NOAA helicopter would continue seal hunting operations out of Dead Horse and would return to Barrow on 10 November '77.

1155 - Departed Lonely in N3467Y (Hoffman).
1239 - Arrived Barrow.

November 9, 1977 Weather, high overcast, temperature -22°C, winds N.E. at 15 kt.
0900 AST - Karig and Harding departed Barrow in NARL twin otter N127RL (Walters) with anchors and flotation to be left at Lonely.
1130 - Returned Barrow.

November 10, 1977 Weather clear, temperature -19°C, light winds.
1300 AST - N56RF arrived from Dead Horse.
1615 - We started first record cycle on RCM-4 s.n. 437 and 660.

November 11, 1977 Weather clear, temperature -21°C, winds N.W. at 8 kt.
0844 AST - Karig, Harding and Darnall departed Barrow in N56RF (Labonty) and Harrigan). We were using one internal fuel bladder, so we could fly directly to the 100 m mooring site.
0939 - Landed at GNS position, 71°23'N, 152°30'W, sounding depth - 113 m.
0951 - Off.
1000 - Landed, sounding depth - 88 m.
1010 - Off, sunrise.
1011 - Landed, sounding depth - 100 m. Off-loaded deployment gear.
1045 - Harding departed in N56RF for Lonely to pick up anchors, float and fuel.
1210 - N56RF returned. GNS position 71°21.5'N, 152°29.3'W, 358°M, 30.1nm. from Lonely DEW site.
1232 - AMF 322 transponder/release s.n. 602290, receiver no. 5, transponder frequency 9.0 kHz, in the water.
1243 - RCM-4 s.n. 660 in the water.
1253 - RCM-4 s.n. 437 in the water. We heard transponder occasionally pinging.
1305 - Mooring in place. We loaded up.
1327 - Departed, returning directly to Barrow.
1430 - Arrived Barrow.
1440 - Sunset.
1745 - We started first record cycle on RCM-4 s.n. 1309, 1310.

November 12, 1977 Weather clear to the south, light snow, temperature -11°C, wind N.W. at 10 kt.
0830 AST - Karig, Harding, and Darnall departed Barrow in N56RF (Labonty, Harrigan).
0938 - Landed GNS position 71°31.1'N, 152°20.0'W, sounding depth - 183 m.
0948 - Off.
0953 - Landed GNS position 71°31.7'N, 152°15.0'W, sounding depth 192 m. We unloaded deployment gear.
1020 - Karig, in N56RF, returned to Lonely for anchors, floats and fuel.
1140 - N56RF returned. GNS position 71°31.8'N, 152°15.3'N, 359°M, 40.4nm from Lonely DEW site.
1217 - AMF 322 transponder/release s.n. 701072, receiver no. 2, transponder frequency 9.0 kHz, in the water.
1226 - RCM-4 s.n. 1310 in the water.
1254 - RCM-4 s.n. 1309 in the water.
1300 - Mooring in place.
1321 - Departed, returning directly to Barrow.
1425 - Arrived Barrow.
1600 - We prepared our diving and recovery gear.

November 13, 1977 Weather clear, temperature -28°C, winds N.N.E. at 6 kt.

0845 AST - Karig, Harding and Darnall departed Barrow in N56RF (Labonty, Harrigan) for 1000 m Spring 77 mooring site. Ice condition near mooring site: many new refrozen leads and many new open leads, approximately 20-30% open water.

1006 - Landed at GNS position 71°40.0'N, 152°10.1'W, winds 035°M at 14 kts, temperature -30°C, ice fog.

1017 - AMF transponder/release responded to first command at 1.9 km 312°M; unit also responded to timed pinger command, 1 pulse/2 sec for 60 sec.

1257 - After 8 relocations and transponder commands, we decided that the ice was moving too fast and was too unstable to attempt releasing the mooring. Our range and bearing to the mooring was 430 m, 100°M but was changing rapidly (i.e. ice was moving at ½ - 1 knot). We attempted to interrogate the APL data retrieval package. It would not respond to the turn-on command. Several attempts were made at different transducer depths, no reply.

1328 - Departed for Lonely to refuel and return to Barrow. Ice conditions inshore near 200 m mooring site were much better, no open water and few refrozen leads.

1528 - Arrived Barrow.

We decided to attempt to recover the 200 m Spring '77 mooring the following day.

November 14, 1977 Weather overcast to north and east, temperature -14°C, winds N.N.E. at 14 kt.

0818 AST - Harding, Karig and Darnall departed Barrow in N56RF (Labonty & Harrigan). We refueled at Lonely to give us more fuel for searching. There was considerable ice ridging at about 10-20 mi. north of Lonely.

1113 - Landed at GNS position 71°31.1'N, 152°11.3'W. AMF transponder/release replied to first transponder command range 1.66 km at 030°M. After several relocations/transponder interrogates, we calculated the ice to be moving at approximately ½ knot. Precise relocating was near impossible with this relative motion.

1257 - We sent the release command, and the unit replied with the release confirmation signal. The range and bearing held constant.

1430 - After 4 more relocations (two by helicopter, 2 on foot) we were within 40 m of the mooring (now resting against the bottom side of the ice). We dug our diving hole and started gearing up for the dive. It was now quite dark and we were working by flashlights.

1537 - Harding, Darnall began recovery dive.

1540 - Mooring was sighted (with help of underwater hand-held lights).

1547 - Divers out of water.

1555 - Mooring was recovered, and we loaded up.

1605 - Departed, returning directly to Barrow.

1711 - Arrived Barrow.

1730 - Opened the RCM-4s; s.n. 1315 had recorded for entire mooring duration, s.n. 1014 recorded approximately 1 month, and then it appeared that the battery had failed.

N56RF had only enough flight time before mandatory P.E. inspection to fly to Fairbanks with a reasonable safety margin. We decided that we would have to wait until spring of 1978 to recover the 1000 m Spring '77 mooring. We had accomplished more than we had expected this late in the fall and with the ice conditions as they were.

November 15 & 16, 1977 We tested our Arctic survival shelter and pack.

November 17, 1977 We returned to Seattle. This was the last day the sun would rise at Barrow until spring.

3. *Methods*

Deployment phase

The current meter moorings were designed and constructed at the Department of Oceanography, University of Washington, Seattle. The flotation was 28 in. O.R.E. steel spheres distributed along the mooring. The current meters were Aanderaa model RCM-4. The acoustic releases were AMF model 322. The mooring line was 1/2 in. diameter Nolaro using polyester fibers; it was premeasured, cut and loaded on aluminum reels with connecting links at all instrument and flotation points.

The deployment equipment consisted of a 10 ft. high A-frame, which holds the mooring line reel, and is used for an anchor-first, vertical deployment mode. Mechanical brakes and a stopper controlled the descent speed, and allowed the insertion of instruments. All components of the deployment system are of light-weight materials and can be broken down for helicopter-borne operations.

Recovery phase

An AMF model 301 ranging and bearing command system was used for precise relocation of the AMF model 322 releases. The divers used Unisuits, double 80 cu. ft. aluminum tanks with independent Poseidon regulators on each tank. Each diver was connected to a common tether line, and used U.S. Navy Diving Procedures and line signals.

4. *Personnel*

Fred Karig	Mechanical engineer	APL/University of Washington
Steve Harding	Research aide	Dept. of Oceanography/ U. of WA.
Clark Darnall	Oceanographer	Dept. of Oceanography/ U. of WA.
R. Labonty	Pilot	NOAA
Lt. W. Harrigan	Pilot	NOAA
R. DeHart	Mechanic	NOAA

Acknowledgements

Mr. Labonty and Lt. Harrigan's assistance in getting our operations on the ice, and their willingness to give us the maximum working time on the ice was greatly appreciated. The personnel of the Naval Arctic Research Lab and associated flight operations were very helpful in the accomplishment of our task.

APPENDIX A

Mooring locations:

Lonely 200 m mooring Spring 1977
71°31.1'N, 152°11.0'W

Lonely 1000 m mooring Spring 1977
71°40.4'N, 152°10.4'W

Lonely 100 m mooring Fall 1977
71°21.5'N, 152°29.3'W

Lonely 200 m mooring Fall 1977
71°31.8'N, 152°15.3'W

Flight time:

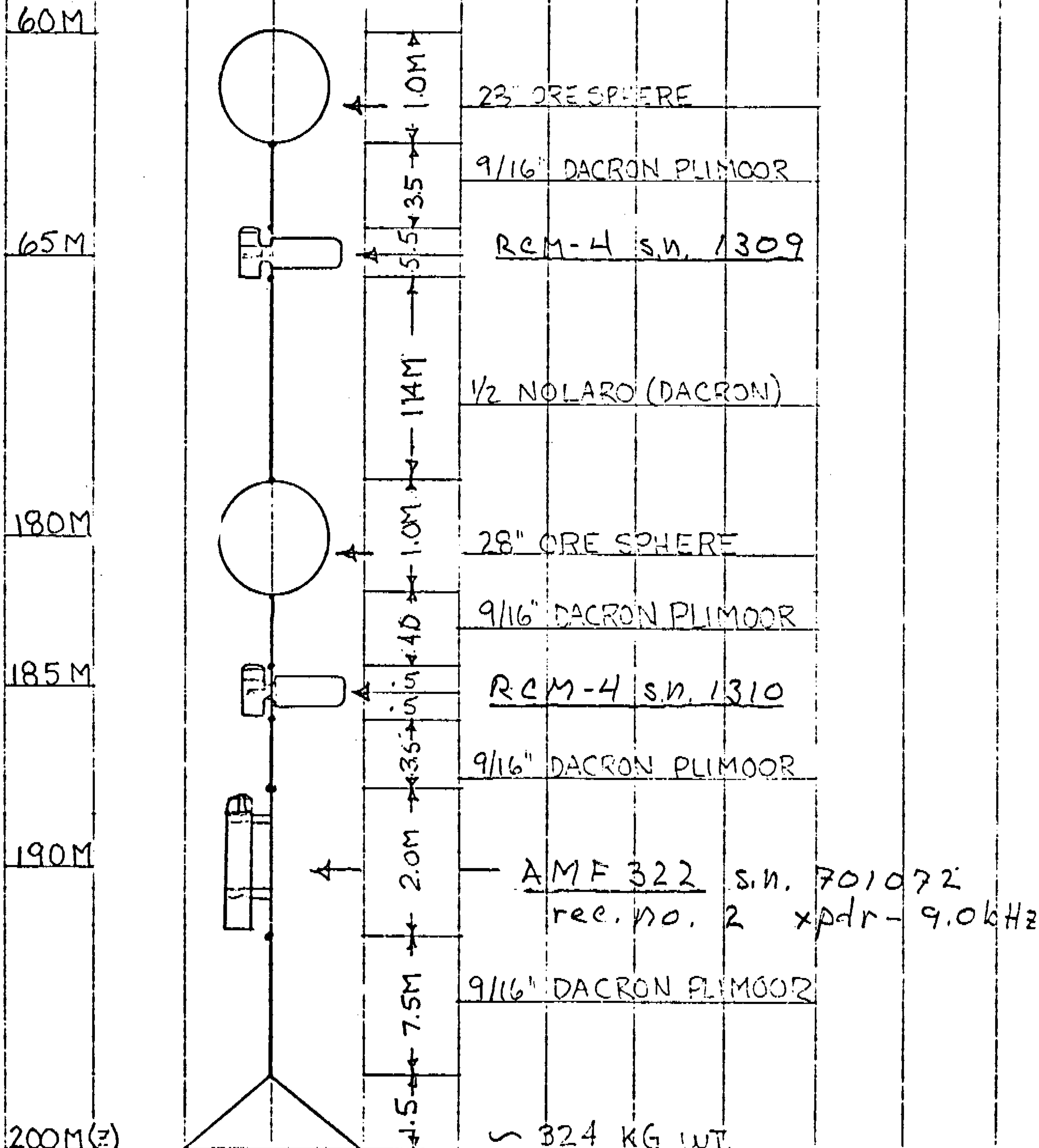
NARL fixed wing aircraft - 2 hrs. 34 mins.

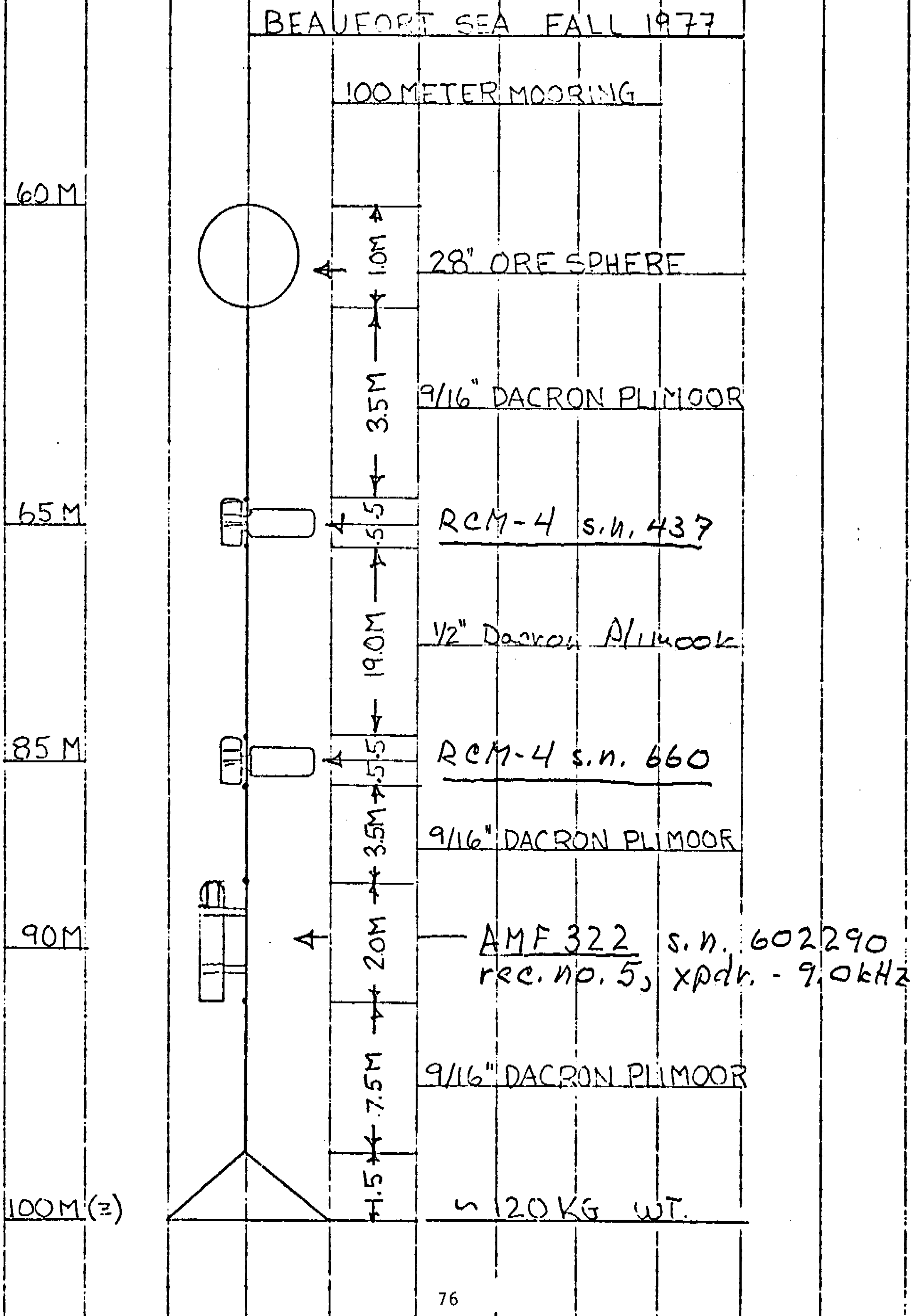
NOAA helicopter N56RF - 13 hrs. 46 mins.

APPENDIX - B

BEAUFORT SEA FALL 1977

200 METER MOORING




BEAUFORT SEA FALL 1977
100 METER MOORING
60 M
1.0M
28" ORE SPHERE
3.5M
9/16" DACRON PLIMOOR
65 M
.5
RCM-4 s.n. 437
19.0M
1/2" Dacron Plimoor
85 M
.5
RCM-4 s.n. 660
3.5M
9/16" DACRON PLIMOOR
90M
2.0M
AMF 322 s.n. 602290
rec. no. 5, xpdr. - 9.0kHz
7.5M
9/16" DACRON PLIMOOR
1.5
100M (≡)
~ 120 KG WT.

QUARTERLY REPORT

Contract #R7120846
#7120847

Research Unit #138

Reporting Period: 1 October 1977
31 December 1977

Number of Pages: 3

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

Dr. S. Hayes

Dr. J. D. Schumacher

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

January 1, 1978

I. TASK OBJECTIVES

-Eularian measurements of the velocity field at several positions and levels

-CTD measurements in Lower Cook Inlet, Kodiak, and Western Gulf region

-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:

Cruise reports are attached for the following cruises completed during this quarter.

1. SURVEYOR RP-4-SU-77B, Leg V, Cruise II
2. DISCOVERER RP-4-D1-77C, Leg II.
3. DISCOVERER RP-4-D1-77C, Leg III.
4. DISCOVERER RP-4-D1-77C, Leg IV.

B. Methods:

Plessey 9040 CTD

Plessey 8400 Digital Data Logger

Aanderaa RCM-4 current meters

PTG pressure temperature gauges

AMF releases

C. Sample Localities: (see cruise reports)

D. Data collected or analyzed:

1. A total of 15 moorings with current meters and/or pressure gauges were deployed. These will remain in place until March, 1979. Four moored arrays were recovered from the NEGOA region. A total of 545 CTD casts were made.

III. These data sets are being processed and analyzed.

IV. Problems encountered/recommended changes mooring SLS-24 failed to surface/ This mooring was subsequently found on the beach of Kayak Island. Equipment appeared in reasonable condition and data is being processed.

DATE: 12 October 1977

TO: Commanding Officer, NOAA Ship DISCOVERER

FROM: Carl Pearson, Oceanographer, PMEL, Chief Scientist

SUBJ: CRUISE REPORT, RP-4-DI-77C, LEG II, 3-12 October 1977

OBJECTIVES

LEG II initiates a physical oceanographic study of winter circulation patterns in lower Cook Inlet. These data will be used to help define processes of transport and dispersion of water-borne contaminants resulting from potential development of petroleum resources in lower Cook Inlet.

First priority of this study is the direct measurement of currents at various depths at 11 moored current meter array stations. Pressure gages installed on some of the current meter moorings will help examine the response of the sea level to meteorological events. As per the 28 September 1977 memo from Robert Charnell to George Lapiene, the original project instructions were changed to: 1) omit the proposed shallow water pressure gage deployments and add pressure gages to two of the current meter moorings; 2) to do the Cook Inlet CTD grid. In support of the current measurements, a grid of 159 CTD casts were to be taken to examine the physical properties of the water and to infer circulation from the density distribution. Figure 1 shows mooring and CTD locations.

In addition, a study of the seasonal variabilities of the vertical flux, distribution, and composition of suspended particulate matter was begun. To determine vertical flux, sediment traps were put on moorings C1, C4, and C11. A nephelometer on C11 will be used to determine in situ variability of suspended matter concentrations resulting from currents. A 24-hour station at C11 will aid in calibration of the nephelometer. The transect of six water sampling stations, F24-F29, will help provide a better picture of seasonal changes in particulate matter in the sediment trap study area.

ACCOMPLISHMENTS

All 11 moorings were successfully deployed (Appendix A), and all CTD stations occupied except a few which were eliminated either because they were redundant (in the same position as a mooring or water sample cast) or for reasons of navigationa safety. A total of 185 CTD casts were taken. Appendix B gives locations of CTD casts. Water samples and nephelometer traces were collected at stations F24-F29, at mooring sites C1, C4, and C11, and at the 24-hour time series station C11A. Eighty samples were collected for total suspended matter and 55 each for particula organic matter and trace major element analysis. Twenty-two nephelometer traces were recorded. Two gravity cores were taken at C1 and grab samples at C4 and C11 Samples collected were frozen for analysis at PMEL.

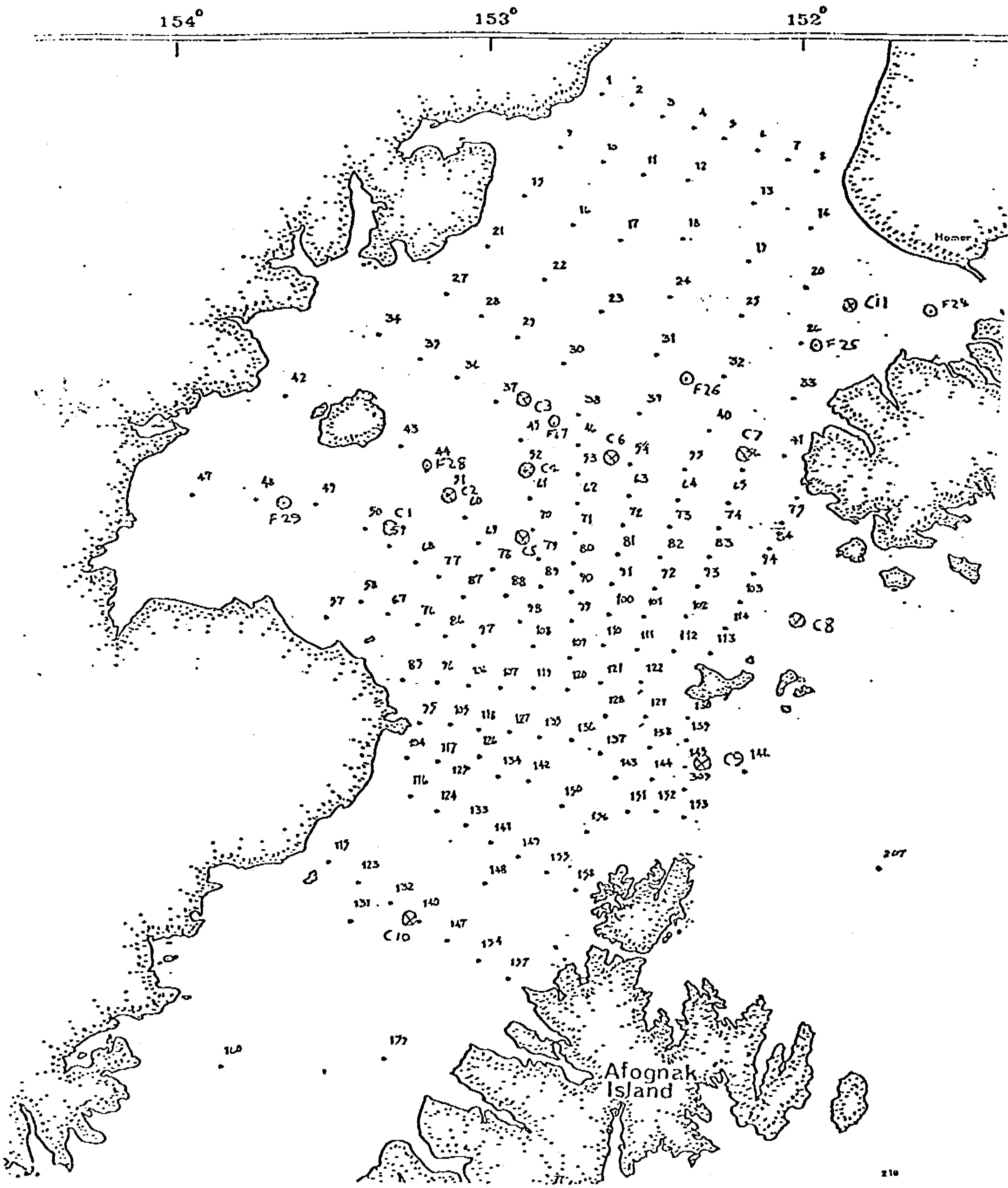
PERSONNEL

Carl Pearson	Chief Scientist, Oceanographer, PMEL
Jane Hannuksela	Oceanographer, PMEL
Bill Parker	Electronics Technician, PMEL
Marilyn Pizzello	Physical Science Technician, PMEL

ACKNOWLEDGEMENTS

We wish to thank the officers and crew of the DISCOVERER for their skill and efficiency in carrying out the varied operations of this LEG. In particular, we appreciate the efforts of LCDR Lilly in planning and the professional execution of these operations by the Deck and Survey Departments.

FIGURE 1



MOORING	POSITION LAT. °N LONG. °W	LORAN C SSL-9990	RCM UPPER LOWER	METER DEPTH METERS	TG S/N TYPE	RELEASE S/N RCVR.# TYPE	FLOAT(ORE) SIZE S/N	DEPTH METERS fm	GMT DATE TIME

APPENDIX A

C-4	59 16.9 152 54.0	y31861.18 z43806.28	1452 1672	18 63	229 T63A	603361 9 242	41" 524	84 46	JD 279 1920
C-3	59 24.2 152 53.2	y31821.44 z43841.79	2494 2359	21 51		601229 3 242	41" 456	59 32	279 2246
C-6	59 18.0 152 38.3	y31839.56 z43757.15	1817 1818	21 66		601629 6 242	41" 436	71 39	280 0119
C-7	59 19.1 152 11.8	y31806.83 z43668.57	2164 1986	15 60		700963 7 322	41" 439	71 39	281 1727
C-11	59 34.9 151 52.3	y31711.76 z43698.23	2267	36		702064 2 395	41" 659	40 22	281 2220

APPENDIX A

MOORING	POSITION LAT. °N LONG. °W	LORAN C SSL-9990	RCM UPPER LOWER	METER DEPTH METERS	TG S/N TYPE	RELEASE S/N RCVR.# TYPE	FLOAT(ORE) SIZE S/N	DEPTH METERS fm	GMT DATE TIME
C-8	59 02.5	y31881.63	1806	21		600929	41"	191	JD 277
	152 03.6	z43553.25	1681	66		1	661	105	0339
			1680	181		242			
C-9	59 47.25	y31972.00	1985	29	230	501883	41"	122	277
	152 16.3	z43498.51	1677	70	T63A	9	498	67	1738
			2159	112		242			
C-10	58 30.2	y32124.94	1683	23	232	503235	41"	170	277
	153 11.6	z43609.41	1982	68	T63A	10	525	93	2349
			1824	160		242			
C-1 [1]	59 10.8	y31919.38	1810	24		142	41"	42	278
	152 18.0	z43857.17	2512	38		1	458	23	1906
						242			
C-2	59 13.6	y31891.78	2355	26		600113	41"	64	278
	153 07.6	z43832.35	2498	56		8	497	35	2321
						242			
C-5	59 09.9	y31898.11	1804	16		601529	41"	128	279
	152 56.3	z43774.41	1981	61		5	499	70	1810
			2168	118		242			

[1] 2 sediment traps 10m. above bottom

APPENDIX B

CAST #	STATION #	LAT. °N	LONG. °W
001	C-8	59 02.6	152 04.4
002	66	59 13.8	152 02.7
003	75	59 11.1	152 02.9
004	84	59 09.3	152 07.1
005	94	59 06.4	152 10.4
006	103	59 03.4	152 12.6
007	114	59 00.4	152 14.4
008	113	58 59.7	152 16.6
009	112	58 57.4	152 24.9
010	130	58 50.2	152 21.7
011	139	58 49.0	152 22.4
012	145	58 46.9	152 23.1
013	309	58 44.5	152 22.5
014	153	58 41.6	152 22.1
015	146	58 46.9	152 11.5
016	C-9	58 47.4	152 19.5
017	157	58 24.8	152 56.5
018	154	58 27.1	153 01.7
019	147	58 28.4	153 08.4
020	140, C-10	58 30.5	153 12.5
021	132	58 32.5	153 19.5
022	131	58 30.6	153 27.2
023	123	58 35.5	153 23.8
024	115	58 36.3	153 29.5
025	116	58 43.9	153 15.0
026	124	58 41.8	153 10.5
027	133	58 40.4	153 04.5
028	141	58 38.8	152 59.3
029	148	58 34.8	153 01.1
030	149	58 37.1	152 55.0
031	155	58 35.6	152 48.2
032	158	58 34.6	152 44.8
033	156	58 3917	152 41.3
034	150	58 42.5	152 44.6
035	142	58 45.8	152 51.8
036	134	58 45.6	152 57.5
037	126	58 48.2	153 02.1
038	125	58 46.1	153 03.7
039	117	58 45.9	153 10.0
040	104	58 48.4	153 13.9
041	aborted		
042	aborted		
043	C-1	59 10.5	153 19.5
044	50	59 10.9	153 25.7
045	C-2	59 13.8	153 08.1
046	49	59 14.9	153 34.9
047	F-29	59 14.1	153 39.1
048	48	59 14.3	153 44.7
049	47	59 14.2	153 51.1
050	43	59 19.3	153 17.2

APPENDIX B

CAST #	STATION #	LAT. °N	LONG.°W
051	F-28	59 18.0	153 13.5
052	44	59 17.0	153 12.3
053	51	59 15.0	153 03.2
054	60	59 12.1	153 04.9
055	61	59 14.1	152 51.2
056	62	59 13.2	152 43.2
057	63	59 14.8	152 32.8
058	55	59 17.4	152 22.4
059	56	59 17.1	152 10.6
060	41	59 19.2	152 04.3
061	65	59 13.8	152 14.5
062	aborted	9	
063	74	59 11.5	152 16.4
064	73	59 12.1	152 26.8
065	64	59 14.4	152 25.1
066	C-5	59 10.1	152 55.0
067	C-4,52	59 16.7	152 53.3
068	45	59 20.2	152 53.7
069	C-3	59 23.9	152 53.6
070	53	59 16.3	152 43.2
071	C-6	59 18.0	152 37.8
072	42	59 25.3	153 25.3
073	aborted		
074	34	59 30.4	153 21.6
075	35	59 28.2	153 14.4
076	36	59 26.6	153 09.4
077	37	59 24.2	152 59.3
078	F-27	59 23.2	152 47.1
079	38	59 22.8	152 43.1
080	46	59 19.4	152 43.8
081	54	59 18.2	152 33.4
082	39	59 22.6	152 31.5
083	31	59 28.2	152 28.6
084	F-26	59 25.4	152 22.4
085	24	59 34.7	152 26.5
086	18	59 40.3	152 23.3
087	19	59 38.2	152 11.1
088	25	59 33.6	152 11.4
089	32	59 26.9	152 14.4
090	8	59 47.2	151 57.4
091	7	59 47.9	152 03.1
092	6	59 48.7	152 09.0
093	5	59 49.5	152 15.0
094	4	59 49.6	152 22.5
095	3	59 52.4	152 28.5
096	2	59 52.6	152 32.4
097	9	59 50.9	152 47.0
098	15	59 44.0	152 54.2
099	10	59 48.3	152 37.4
100	16	59 41.2	152 44.5

APPENDIX B

CAST #	STATION #	LAT. °N	LONG °W
101	17	59 40.1	152 34.1
102	11	59 46.4	152 30.9
103	12	59 46.2	152 20.3
104	13	59 43.5	152 08.4
105	14	59 40.8	151 58.1
106	20	59 35.2	151 58.8
107	F-25	59 30.0	151 57.4
108	26	59 29.6	152 01.0
109	40	59 20.4	152 17.5
110	C-7	59 18.0	152 13.0
111	33	59 25.0	152 01.2
112	F-24	59 33.7	151 35.5
113	C-11	59 33.6	151 50.9
114	C-11A-I	59 34.9	151 52.3
115	C-11A-II	59 34.9	151 52.1
116	C-11A-III	59 35.0	151 52.1
117	C-11A-IV	59 34.9	151 51.5
118	C-11A-V	59 35.0	151 52.0
119	C-11A-VI	59 34.9	151 52.1
120	C-11A-VII	59 34.7	151 52.9
121	C-11A-VIII	59 34.8	151 51.9
122	C-11A-IX	59 34.8	151 51.9
123	C-11A-X	59 34.8	151 52.2
124	C-11A-XI	59 34.8	151 52.0
125	C-11A-XII	59 34.8	151 51.9
126	C-11A-XIII	59 34.9	151 52.4
127	23	59 33.0	152 38.1
128	22	59 35.5	152 51.0
129	21	59 38.9	153 01.0
130	27	59 34.2	153 09.5
131	28	59 30.2	153 03.1
132	29	59 30.4	152 55.5
133	30	59 28.0	152 46.3
134	59	59 09.3	153 19.9
135	68	59 07.4	153 14.1
136	69	59 09.5	153 02.5
137	70	59 10.2	152 53.1
138	71	59 11.5	152 42.3
139	72	59 11.9	152 34.1
140	83	59 08.0	152 17.1
141	82	59 07.8	152 25.8
142	81	59 08.5	152 35.2
143	80	59 07.7	152 44.7
144	79	59 08.3	152 50.8
145	78	59 06.8	152 59.8
146	77	59 05.5	153 09.8
147	58	59 04.2	153 25.5
148	57	59 03.3	153 31.0
149	67	59 02.7	153 20.7

cast #	Station#	LAT. N	LONG. W
150	76	59° 01.2'	153° 14.5
151	86	59° 00.9'	153° 04.6'
152	87	59° 03.9'	153° 05.5'
153	88	59° 04.2'	152° 54.3'
154	89	59° 05.3'	152° 49.3'
155	90	59° 05.0	152° 42.2'
156	aborted		
157	91	59° 05.4'	152° 35.3'
158	92	59° 05.3'	152° 28.0'
159	93	59° 05.2'	152° 19.8'
160	102	59° 02.4'	152° 22.0'
161	101	59° 02.8'	152° 30.0'
162	100	59° 03.1'	152° 35.9'
163	107	58° 58.3'	152° 32.3'
164	110	58° 59.8'	152° 39.1'
165	99	59° 01.7'	152° 44.4'
166	109	58° 58.3'	152° 44.9'
167	108	58° 59.2'	152° 51.9'
168	98	59° 02.3'	152° 55.8'
169	97	58° 58.7'	153° 03.4'
170	85	58° 55.7'	153° 13.2'
171	96	58° 55.0'	153° 11.0'
172	106	58° 54.6'	153° 04.4'
173	107	58° 54.7'	152° 56.4'

cast #	station #	LAT. N	LONG. W
174	119	58° 55.0'	152° 48.8'
175	120	58° 54.4'	152° 44.5'
176	121	58° 55.1'	152° 37.1
177	122	58° 54.8'	152° 28.3'
178	129	58° 51.2'	152° 30.4'
179	128	58° 51.8'	152° 38.8'
180	95	58° 50.7'	153° 11.0'
181	105	58° 50.5'	153° 06.8'
182	118	58° 51.0'	153° 02.4'
183	127	58° 50.5'	152° 55.5'
184	135	58° 49.6'	152° 50.5'
185	136	58° 49.9'	152° 45.7'
186	137	58° 47.5'	152° 37.7'
187	143	58° 45.6'	152° 35.9'
188	151	58° 43.6'	152° 33.2'
189	152	58° 43.9'	152° 26.7'
190	144	58° 44.9	152° 28.3'
191	138	58° 48.7	152° 29.0'

Date: 21 October 1977

To : Commanding Officer
NOAA Ship DISCOVERER R102

From: Jim Schumacher, Chief Scientist, PMEL *Jim Schumacher*

Subj: Cruise Report, RP-4-DI-77C, Leg III, 13-21 October 1977

OBJECTIVES

Leg III was a continuation of field operations in support of PMEL's Gulf of Alaska physical oceanographic processess research program. The general objective of which is to describe and understand circulation in order to characterize advective and diffusive processes and examine their relation to water-borne substances resulting from petroleum development.

The specific objective of Leg III was the collection of hydrographic data from the shelf region off Kodiak Island. The CTD stations (see Figure A) were selected to provide data which would elucidate the following features during a fall/early winter regime:

1. The extent and characteristics of less saline, coastal flow along the Kenai Penninsula.

2. The possible bifurcation of Alaskan Current shelf-break waters in the Amatuli Trough region and the effect thereof on flow into the lower Cook Inlet/Shelikof Strait region.

3. The extent of stratification, in particular over the banks and the variability of such in both time and space.

CTD stations from the grid were also occupied to provide mass distribution data for numerical model efforts.

ACCOMPLISHMENTS

Although foul weather limited operations, it provided the opportunity to examine hydrographic properties before and after severe (25 ms^{-1} wind speeds and 8 to 10 meter seas) storm events. The band of coastal water was observed to be approximately 25 km wide in Section #1 (see Figure 1). Subsequent geostrophic flow calculations will result in baroclinic flow speeds. The first station re-occupied after a storm event (sta #316A) indicated an increase in heat content at this site (see Figure 2). During this event winds were generally from the south and were relatively warm, 7 to 8°C. Also shown in Figure 2 is the depth and spatial extent of the sigma-t = 26.5 gm/kg contour and the warm, subsurface core over the slope. It appears that some Alaskan Current waters do flow into Amatuli Trough, while the majority of transport is westward along the slope. The second storm event brought cold (2-3°C) dry air from the land; blowing generally toward the south. Two CTD stations (203 and 202.1) over Portlock Bank were re-occupied. As shown in Figure 3, there was a net loss of heat

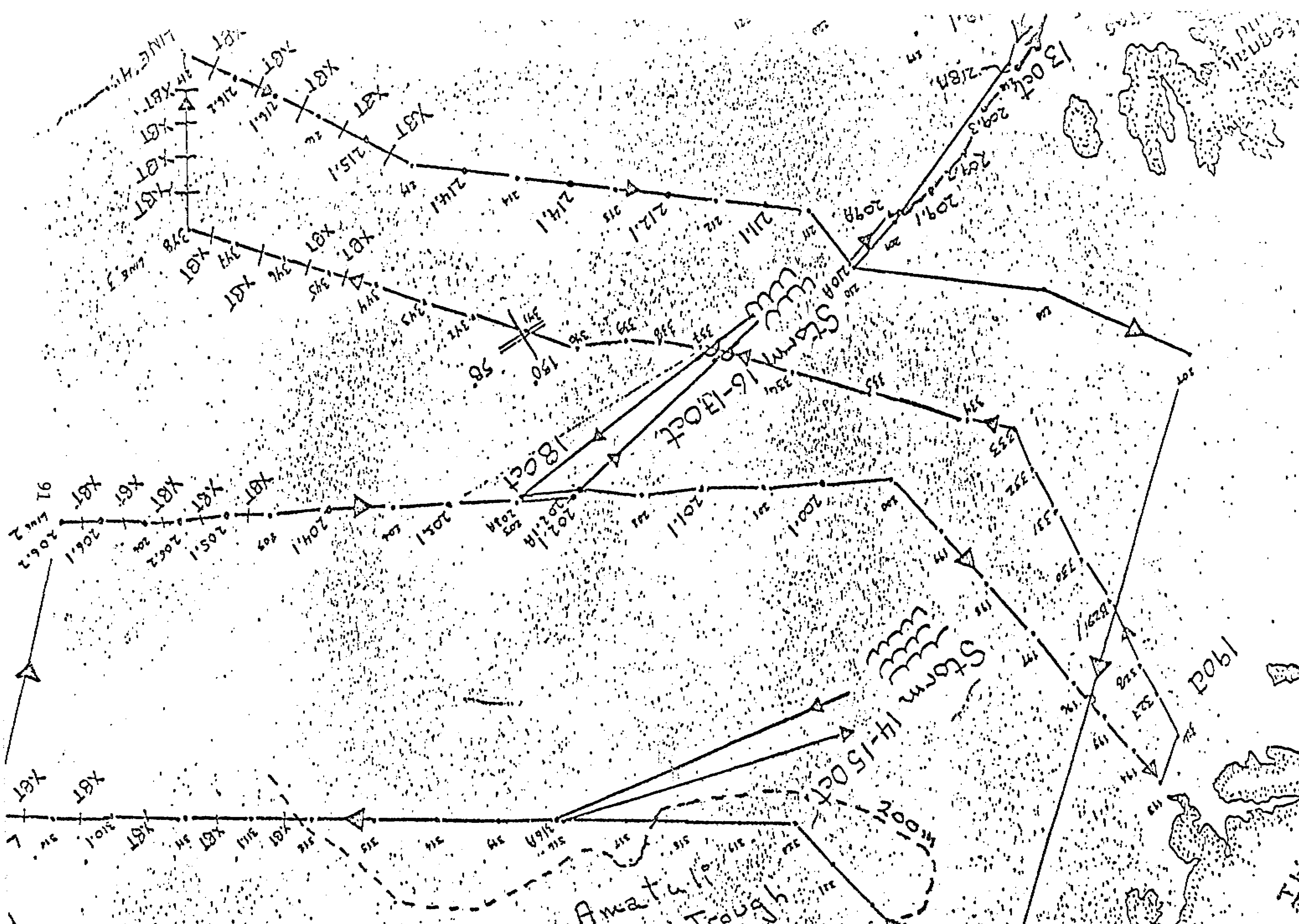


Figure A. Cruise track, LEG III 13-21 Oct 77 and a gain in salt content. Temperature data indicate a transition from a stratified water column with a gradient of 0.1°C/m across the thermocline (at sta. 202.1) to vertically homogeneous column after 31.5 hours. In all, 102 CTD casts were conducted and 23 XBT stations.

COMMENTS

PMEL has embarked on an extensive hydrographic study of waters around Kodiak Island. This effort is to continue through FY 78, with three more occupations of the approximately 450 CTD station grid. Therefore it is imperative that the OCSEAP Project Office, via whatever lines of supply, supply DISCOVERER with adequate quantities and correct types of expendable equipment, eg., pins and boots for the CTD cable terminations, so that operations may proceed with minimum loss of time to repairs and thereby attain maximum coverage of the grid.

PERSONNEL

Jim Schumacher, Chief Scientist/Principal Investigator, PMEL/ERL, NOAA.
Michael Grigsby, Physical Scientist, PMEL/ERL, NOAA.

ACKNOWLEDGEMENTS

We wish to thank all hands of DISCOVERER for their skill, efficiency and cooperation, often under harsh conditions, in carrying out Leg III operations. We further wish to applaude three particular aspects: a. the Daily Operational Plan provided by LCDR Kenneth Lilly, b. meteorological forecasts provided by NWS in Seattle and c. the timely processing of CTD data aboard the ship. Under the leadership of Captain Sidney Miller, the DISCOVERER is efficient and professional in its approach to field operations. It was our pleasure to have sailed on DISCOVERER.

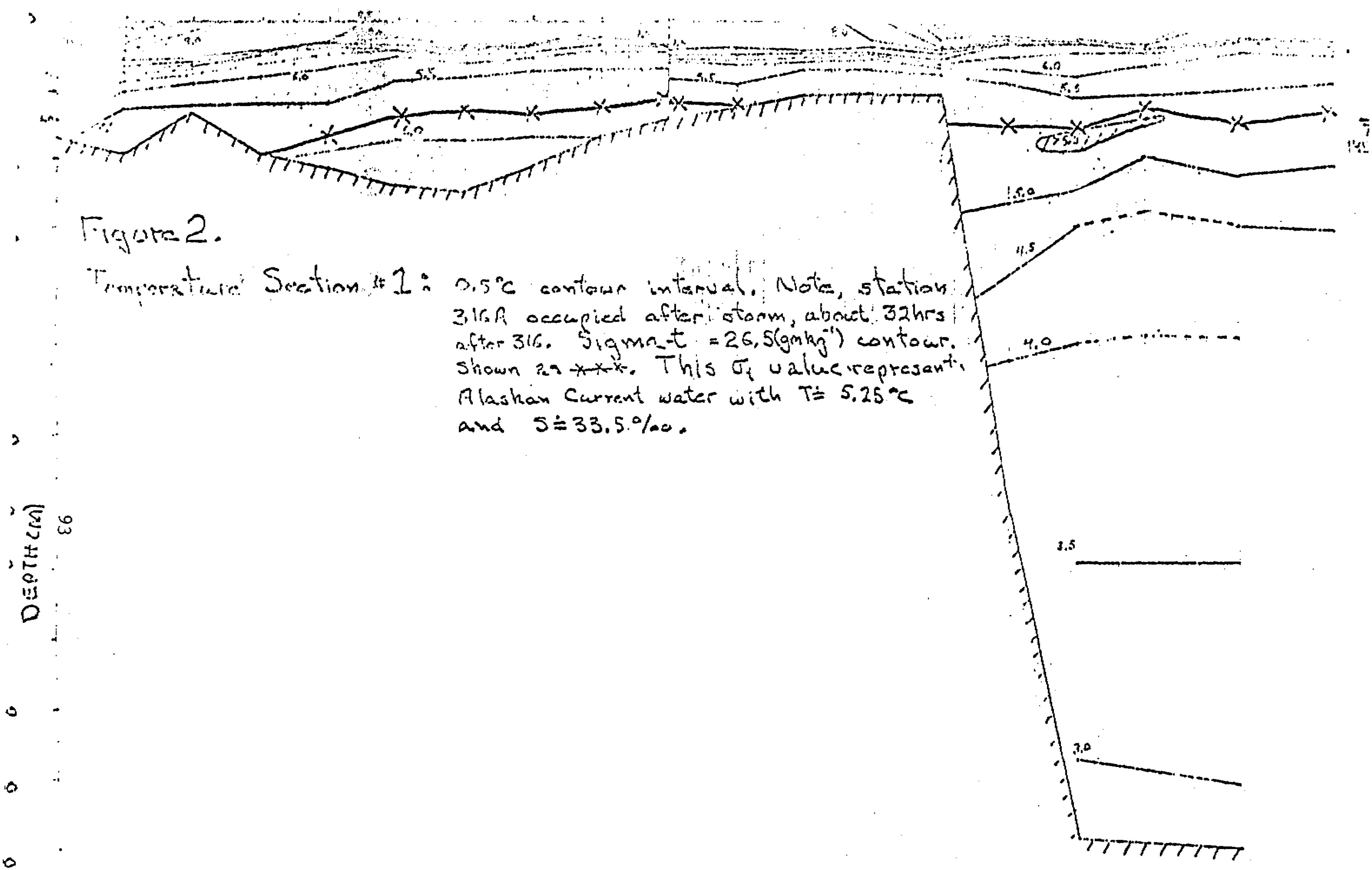


Figure 2.

Temperature Section #1: 0.5°C contour interval. Note, station 316A occupied after storm, about 32hrs after 316. Sigma-t = 26.5(gm kg⁻¹) contour. Shown as ×-×-×. This σ_t value represents Alaskan Current water with T ≐ 5.25°C and S ≐ 33.5 ‰.

Note: The above σ_t = 26.5 contour is 20m deeper than shown on Temper. Section #2

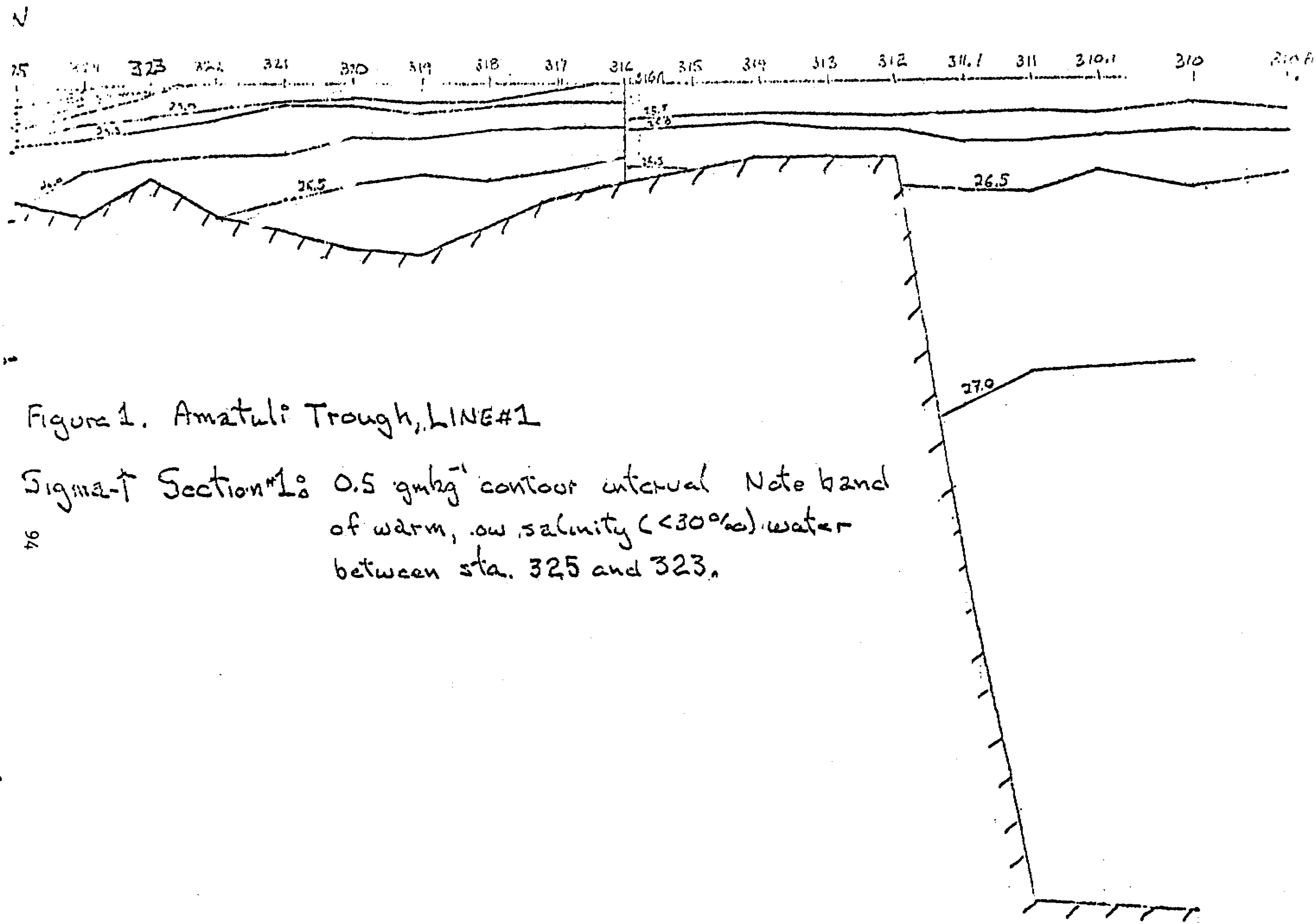


Figure 1. Amatuli Trough, LINE#1

Sigma-T Section #1: 0.5 gmkg⁻¹ contour interval. Note band of warm, low salinity (<30‰) water between sta. 325 and 323.

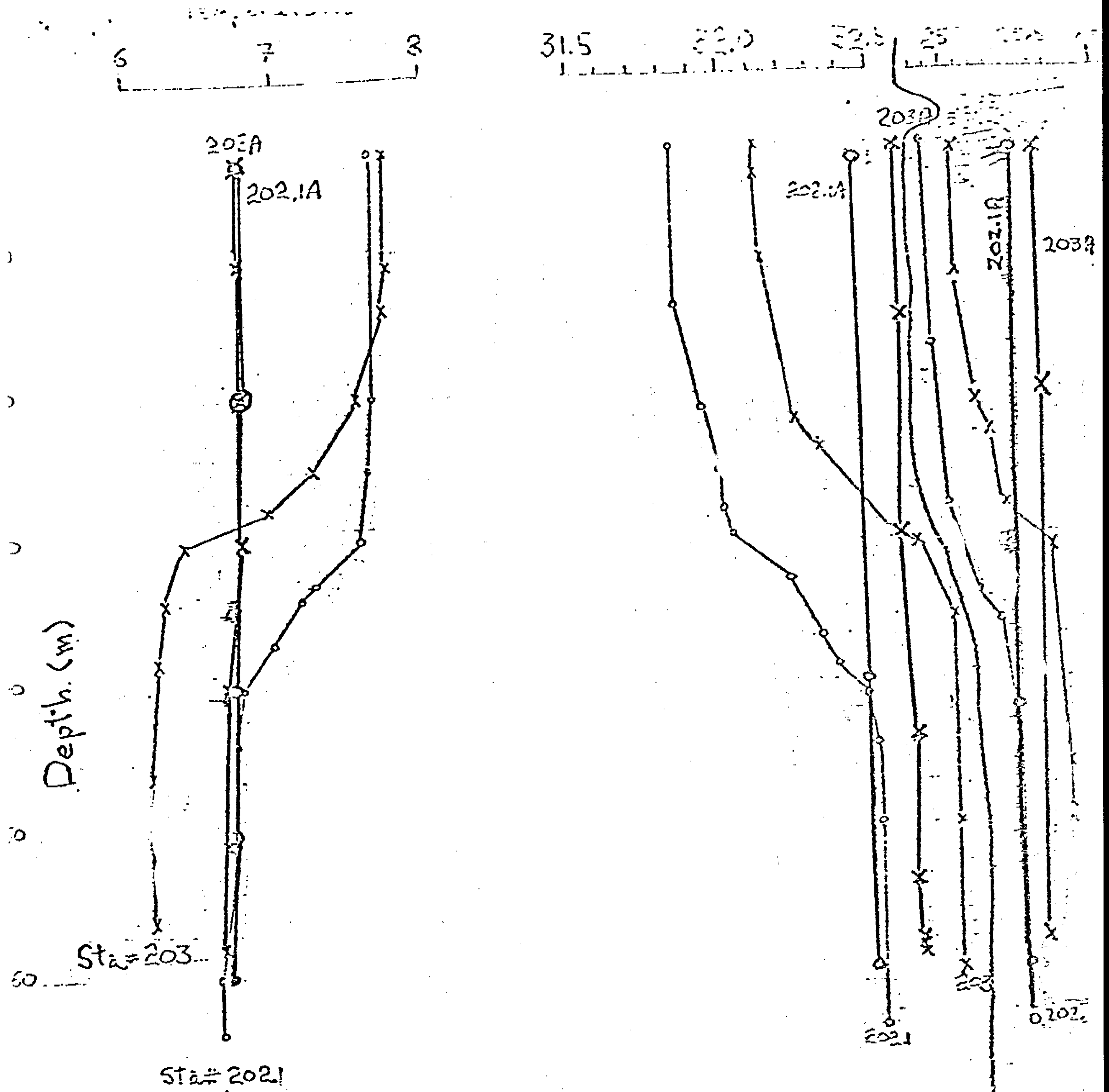


Figure 3. Comparison of vertical structure over Portlock Bank, before and after storm (Δt=41.5

[illegible]	[illegible]	1	[illegible]			
✓ 215	001					
✓ 209	002	2	58 11.1	151 12.3	139	CTD
✓ 210	003	3	58 12.5	151 00.0	98	CTD
✓ 208	004	4	58 24.2	151 26.4	164	CTD
✓ 207	005	5	58 36.1	151 46.1	154	CTD
✓ 325	006	6	59 21.5	150 06.4	170	CTD ‰
✓ 324	007	7	59 15.5	150 04.5	199	CTD
✓ 323	008	8	59 11.0	150 02.6	137	CTD
✓ 322	009	9	59 04.7	149 58.9	192	CTD
✓ 321	010	10	58 59.4	149 56.0	216	CTD
✓ 320	011	11	58 53.7	149 53.6	240	CTD ‰
✓ 319	012	12	58 51.4	149 45.8	243	CTD
✓ 318	013	13	58 47.6	149 35.7	209	CTD
✓ 317	014	14	58 45.3	149 27.4	186	CTD
✓ 316	015	15	58 41.2	149 18.9	141	CTD / [illegible]
✓ 316 A	016	16	58 41.6	149 17.9	146	CTD [illegible]
✓ 316A	016	17	58 41.7	149 18.4	146	CTD ‰
✓ 315	017	18	58 38.3	149 07.6	135	CTD
✓ 314	018	19	58 34.8	148 58.0	112	CTD
✓ 313	019	20	58 30.9	148 48.3	113	CTD
✓ 312	020	21	58 28.3	148 38.1	122	CTD
✓	021		58 26.6	148 32.7	159	XBT
✓ 311.1	022	22	58 24.4	148 26.6	677	CTD ‰
✓	023		58 23.4	148 22.9		XBT
✓ 311	024	23	58 21.6	148 19.0	1189	CTD
✓	025		58 20.3	148 12.7	1463	XBT
✓ 310.1	026	24	58 18.7	148 06.3	1302	CTD
✓	027		58 16.7	148 02.7	1262	XBT
✓ 310	028	25	58 13.9	147 59.1	2000	CTD
✓	029		58 11.8	147 52.3	1240	XBT
✓ 310A	030	26	58 09.9	147 42.5	2872	CTD
✓ 206.2	031	27	57 50.8	148 26.5	2250	CTD ‰
✓	032		57 52.0	148 30.5	1710	XBT
✓ 206.1	033	28	57 52.6	148 33.2	1737	CTD
✓	034		57 53.8	148 37.1	1435	XBT
✓ 206	035	29	57 54.7	148 41.0	1260	CTD
✓	036		57 55.8	148 44.3	1135	XBT
✓ 205.2	037	30	57 56.7	148 47.4	935	CTD

✓	038	31	57 57.1	148 53.3	398	CTD
✓ 205.1	039		57 59.9	148 57.7	164	XBT
✓	040	32	58 01.0	149 01.1	128	CTD ‰
✓ 205	041	33	58 03.2	149 10.8	112	CTD
✓ 204.1	042	34	58 07.2	149 21.9	132	CTD
✓ 204	043	35	58 09.6	149 30.5	109	CTD
✓ 203-1	044	36	58 13.4	149 42.3	102	CTD
✓ 203	045	37	58 15.5	149 50.9	118	CTD STORM ⇒ LAY LOST CALIB BOTTLE
✓ 202-1	046	38	58 13.5	149 43.0	60	CTD
✓ 203 A	047	39	58 15.5	149 52.0	64	CTD ‰
✓ 202-1A	048	40	58 19.5	150 03.6	53	CTD
✓ 202	049	41	58 21.9	150 12.9	64	CTD
✓ 201.1	050	42	58 26.2	150 21.4	77	CTD
✓ 201	051	43	58 28.8	150 34.5	79	CTD
✓ 200.1	052	44	58 32.3	150 45.5	144	CTD ‰
✓ 200	053	45	58 38.6	150 48.1	205	CTD
✓ 199	054	46	58 44.3	150 51.5	179	CTD
✓ 198	055	47	58 51.6	150 53.1	168	CTD
✓ 197	056	48	58 57.9	150 54.8	139	CTD
✓ 196	057	49	59 02.0	150 56.5	159	CTD ‰
✓ 195	058	50	59 06.7	150 58.4	157	CTD
✓ 194	059	51	59 09.7	150 58.7	65	CTD
✓ 193	060	52	59 07.7	151 06.1	80	CTD
✓ 326	061	53	59 03.3	151 06.2	103	CTD
✓ 327	062	54	58 59.6	151 06.0	163	CTD
✓ 328	063	55	58 53.0	151 06.2	182	CTD
✓ 329	064	56	58 47.8	151 06.3	144	CTD
✓ 330	065	57	58 43.3	151 06.0	175	CTD
✓ 331	066	58	58 38.5	151 05.9	185	CTD
✓ 332	067	59	58 33.0	151 06.9	166	CTD ‰
✓ 333	068	60	58 31.3	151 03.6	152	CTD
✓ 334	069	61	58 24.5	150 48.8	79	CTD
✓ 335	070	62	58 18.0	150 38.9	69	CTD
✓ 336	071	63	58 11.0	150 25.3	100	CTD
✓ 337	072	64	58 08.5	150 19.6	172	CTD ‰
✓ 338	073	65	58 06.5	150 15.5	236	CTD ‰
✓ 339	074	66	58 04.6	150 06.1	324	CTD
✓ 340	075					

Station	Ship's					
✓341	076	67	57 57.9	150 00.5	210	CTD
✓342	077	68	57 56.5	149 54.6	257	CTD
✓343	078	69	57 53.6	149 47.8	247	CTD ‰
✓344	079	70	57 48.5	149 41.8	284	CTD
✓	080		57 46.3	149 38.1	402	XBT
✓345	081	71	57 44.4	149 36.3	484	CTD
✓	082		57 42.3	149 31.8	597	XBT
✓346	083	72			648	CTD ABORTED WINCH
✓346	083	73	57 42 0	149 30.1	648	CTD
✓	084		57 38.8	149 25.9	1252	XBT
✓347	085	74	57 36.6	149 23.1	1395 *	CTD (650m)
✓	086		57 35.1	149 19.6	1710	XBT
✓348	087	75	57 33.9	149 16.8	1955*	CTD ‰ (650m)
✓	088		57 30.3	149 19.9	1975	XBT
✓	089		57 27.5	149 22.9	1912	XBT
✓	090		57 24.3	149 26.3	2176	XBT
✓	091		57 21.5	149 29.4	2094	XBT
✓217	092	76	57 18.3	149 32.8	2131	CTD (650m)
✓	093		57 21.0	149 36.0	1957	XBT
✓216.2	094	77	57 23.1	149 38.8	1860	CTD (650m)
	095		57 25.3	149 41.8	1774	XBT
✓216.1	096	78	57 26.8	149 44.4	1573	CTD (650m)
✓	097		57 28.7	149 46.9	1207	XBT
✓216	098	79	57 29.9	149 49.2	1134	CTD (650m)
✓	099		57 33.3	149 51.6	622	XBT
✓215.1	100	80/81	57 34.3 (33.8)	149 52.3 (53.1)	612	CTD ‰
	101		57 36.8	149 55.9	485	XBT
✓215	102	82	57 39.6	149 58.9	261	CTD
✓214.1	103	83	57 42.3	150 06.7	179	CTD
✓214	104	84	57 45.5	150 15.1	124	CTD
✓213.1	105	85	57 49.4	150 21.1	108	CTD
✓213	106	86	57 52.6	150 29.0	109	CTD
✓213	106	87	57 52.7	150 29.4	110	CTD ‰
✓212.1	107	88	57 56.4	150 36.1	133	CTD
✓212	108	89	57 59.2	150 43.4	123	CTD
✓211.1	109	90	58 02.7	150 49.0	148	CTD
✓211	110	91	58 05.6	150 58.6	118	CTD
✓210A	111	92	58 12.1	151 06.1	110	CTD ‰

Station	Sta[illegible]					
[illegible]	112	93	[illegible]	[illegible]		
209.1	113	94	58 11.7	151 18.8	168	CTD
209.2	114	95	58 08.7	151 27.9	157	CTD
209.3	115	96	58 06.1	151 35.0	137	CTD
218 A	116	97	58 03.3	151 44.8	167	CTD ‰
218.1	117	98	58 01.1	151 56.3	176	CTD
218.2	118	99	57 59.7	152 04.6	176	CTD
218.3	119	100	57 55.0	152 03.3	179	CTD
218.4	120	101	57 49.8	152 09.4	108	CTD
218.5	121	102	57 45.0	152 01.5	104	CTD ‰

DATE: 4 November 1977

TO: Commanding Officer, NOAA Ship DISCOVERER

FROM: Mr. Rick Miller, Chief Scientist, U of W/PMEL

Rick Miller

SUBJ: CRUISE REPORT, RP-4-DI-77C, LEG IV, 25 Oct. - 5 Nov. 1977

INTRODUCTION

Physical oceanographic studies as part of the Outer Continental Shelf Environmental Assessment Program (OCSEAP) in the Gulf of Alaska were the primary objectives of LEG IV of this cruise. Operations consisted of deployments of moored current meter and pressure gage arrays, CTD casts, and XBT measurements. The data collected will be used to help define the advective and dispersive processes in the flow regime over the Gulf of Alaska continental shelf and to provide base line data for trajectory models utilized in assessing the impact of energy development in this area. The major experiment deployed during this cruise was the Mitrofania Island Barotropic Response Study (MIBRS). Four moorings with bottom mounted pressure gages and current meters were deployed in order to study the response of the sea level to storms and the relationship between sea level and currents. CTD casts in this region defined the density field at the time of deployment.

After deployment of the four subsurface instrument arrays and completion of the CTD grid southeast of Mitrofania Island, the remainder of the cruise was a continuation of LEG III (13-21 Oct.). CTD and XBT observations were made in support of PMEL's Gulf of Alaska physical oceanographic processes research program. The objectives of the study were to obtain a better description and understanding of surface and subsurface current circulation in order to characterize advective and diffusive processes and to examine their relationships to water borne substances resulting from petroleum development. After completing the Mitrofania Island CTD stations, the ship proceeded to PMEL station 218 off the northeast coast of Kodiak Island. A total of 127 CTD casts and 24 XBT measurements were made on LEG IV.

SCIENTIFIC PERSONNEL

Mr. Rick Miller	U of W, Chief Scientist
Mr. Mike Grigsby	NOAA/PMEL

ACKNOWLEDGEMENTS

The DISCOVERER conducted all operations smoothly and efficiently with the result that the required operations were completed on schedule. The efforts of LCDR K. E. Lilly, Jr. are appreciated in coordinating all operations. Appreciation is extended to Boatswain W. Sherrill and his Deck Department for their deployment work on the moorings and to Chief Survey Technician L. Murray and the Survey Department for the CTD/XBT work. As has become customary on DISCOVERER, all operations are handled in a professional way that makes being part of the operation a pleasure.

MOORING INFORMATION SUMMARY

MOORING	ACTION	LAT °N	LONG °W	DEPTH	CURRENT METER(S)	PRESSURE GAGE
MI-A	DEPLOYED	55-47.4	158-39.0	71m	1	1
MI-B	DEPLOYED	55-25.1	157-58.8	110m	2	1
MI-C	DEPLOYED	54-54.4	157-21.5	250m	2	1
MI-D	DEPLOYED	55-45.6	157-58.8	118m	3	1

XBT MEASUREMENTS (LEG IV)

Ship Station No.	LAT (°N)	LONG (°W)	Type of Probe
54	57-26.6	150-23.5	T-6
56	57-23.1	150-17.3	T-6
58	57-19.5	150-09.1	T-6
60	57-15.1	150-03.5	T-6
62	57-10.5	149-58.1	T-6
64	57-04.5	149-49.2	T-6
69	56-48.6	150-50.1	T-6
71	56-53.3	150-56.8	T-6
73	56-59.5	151-02.9	T-6
75	57-04.3	151-06.7	T-6
88	57-00.0	151-27.1	T-6
90	56-55.4	151-22.5	T-6
92	56-50.5	151-17.8	T-6
94	56-45.3	151-13.8	T-6
96	56-41.8	151-09.9	T-6
103	56-29.6	151-38.7	T-4
105	56-34.1	151-42.5	T-4
107	56-38.4	151-45.8	T-4
109	56-43.2	151-49.1	T-4
124	56-28.6	152-26.3	T-4
126	56-23.0	152-23.2	T-4
128	56-19.6	152-18.6	T-4
130	56-15.3	152-13.3	T-4
150	55-52.5	153-43.5	T-4

CTD STATIONS

CAST NO.	STA NAME	LAT (°N)	LONG (°W)	DEPTH (M)
1	MI-A	55-47.5	158-38.7	73
2	MI-D	ABORTED		
3	MI-D	55-45.6	157-31.4	115
4	MI-B	55-25.7	157-59.2	113
5	MI-C	54-54.1	157-22.8	247
6	308	54-31.0	157-40.9	1784
7	307	54-35.6	157-46.5	1130
8	306	54-42.8	157-51.5	629
9	305	54-45.3	157-54.0	250
10	304	54-47.5	157-56.9	135
11	303	54-50.4	157-58.7	113
12	302	54-52.7	158-01.4	104
13	301	54-55.0	158-03.0	96
14	300	54-57.6	158-05.2	106
15	299	54-59.4	158-07.5	136
16	298	55-02.4	158-10.4	141
17	297	55-04.6	158-12.3	148
18	296	55-07.7	158-13.9	150
19	295	55-10.0	158-16.3	148
20	294	55-12.1	158-18.3	141
21	293	55-14.4	158-20.5	140
22	292	55-17.1	158-22.5	144
23	291	55-19.4	158-24.9	153
24	290	55-21.7	158-27.1	136
25	289	55-24.5	158-28.6	146
26	288	55-26.3	158-30.2	140
27	287	55-29.0	158-32.0	140
28	286	55-31.7	158-34.7	139
29	285	55-33.5	158-37.9	168
30	284	55-36.1	158-38.9	117
31	283	55-38.2	158-40.5	97
32	282	55-41.5	158-42.4	91
33	281	55-43.6	158-43.7	82
34	280	55-45.4	158-43.9	78
35	186	55-59.9	158-08.5	111
36	187	55-57.7	158-00.2	91
37	188	55-42.6	157-50.4	128
38	189	55-33.4	157-40.1	108
39	190	55-25.3	157-30.2	87
40	191	55-16.5	157-21.4	91
41	192	55-07.2	157-14.7	119
42	277	55-01.5	156-59.1	508
43	278	54-55.1	156-48.6	760
44	279	54-48.5	156-42.1	1637
45	279.1	54-43.2	156-28.2	2265
46	279.2	54-35.0	156-20.1	3920
47	218.5	55-45.1	152-01.0	106
48	218	58-03.7	151-44.7	168
49	219	57-55.7	151-34.3	71
50	220	57-48.4	151-22.7	59
51	221	57-44.8	151-10.4	71
52	222	57-39.2	150-55.6	80
53	223	57-34.1	150-39.7	101

CAST NO.	STA NAME	LAT (°N)	LONG (°W)	DEPTH (M)
54	224	57-28.0	150-26.1	210
55	225	57-24.6	150-21.6	403
56	226	57-21.6	150-12.7	595
57	226.1	57-17.3	150-06.9	1500+
58	226.2	57-13.3	150-00.1	1690
59	227	57-08.7	149-54.2	1570
60	227.1	57-03.5	149-48.0	2377
61	227.2	56-58.7	149-40.0	3840
62	349.2	56-40.3	150-43.8	3100
63	349.1	56-46.3	150-46.9	2377
64	349	56-50.3	150-53.8	1649
65	350	56-56.0	151-00.3	917
66	351	57-02.3	151-04.7	570
67	352	57-06.6	151-08.1	243
68	353	ABORTED		
69	353	57-12.2	151-16.4	151
70	354	57-16.2	151-18.0	152
71	355	57-21.9	151-22.9	152
72	356	57-26.7	151-25.4	164
73	357	57-31.6	151-33.2	142
74	358	57-34.8	151-41.5	117
75	359	57-36.7	151-53.2	165
76	229	57-30.7	151-56.3	96
77	230	57-17.0	151-42.6	63
78	231	57-05.8	151-35.5	129
79	231.1	57-02.6	151-29.6	166
80	232	56-57.9	151-26.0	600
81	232.1	56-52.6	151-20.7	905
82	233	46-48.2	151-16.0	905
83	233.1	56-43.4	151-11.6	1445
84	234	56-39.9	151-09.8	1591
85	234.1	56-30.3	151-04.3	4839
86	235	56-21.4	150-57.3	5175
87	242.2	56-15.5	151-30.7	4380
88	242.1	56-21.2	151-32.4	3658
89	242	56-25.8	151-37.6	3050
90	241.1	56-31.8	151-41.5	2130
91	241	56-34.6	151-4517	1445
92	240.1	56-40.9	151-48.2	402
93	240	56-45.4	151-50.1	141
94	239	56-54.9	151-57.7	86
95	238	57-02.8	152-08.4	75
96	237	57-10.1	152-18.4	82
97	236	57-18.9	152-28.5	97
98	243	57-03.4	152-51.4	90
99	244.3	56-59.9	152-42.6	148
100	244.2	56-56.0	152-36.0	168
101	244.1	56-52.3	152-32.4	170
102	244	56-47.8	152-29.6	174
103	246.2	56-41.8	152-29.5	176
104	245	56-41.9	152-05.9	42
105	246.1	56-37.7	152-29.2	160

CAST NO.	STA NAME	LAT (°N)	LONG (°W)	DEPTH (M)
106	246	56 32.0	152 29.4	239
107	247	56 24.5	152 24.7	335
108	248	56 21.9	152 21.8	535
109	249	56 18.1	152 17.6	1641
110	249.1	56 12.2	152,11.0	3840
111	250.6	56 54.7	152 56.1	137
112	250.5	56 57.1	158 00.9	132
113	250.4	56 55.5	153 09.5	177
114	250.3	56 52.8	153 20.1	174
115	250.2	56 45.2	153 16.5	133
116	250.1	56 41.5	153 15.3	159
117	250	56 41.9	153 27.7	110
118	251	56 59.5	153 16.2	150
119	252	56 30.5	153 11.6	97
120	253	56 24.7	153 04.7	31
121	254	56 19.5	153 00.4	59
122	255	56 17.0	152 59.3	143
123	256	52 11.0	152 53.7	1,955
124	258	56 23.1	154 15.0	56
125	259	56 14.9	154 07.2	132
126	260	54 07.6	153 56.1	198
127	261	55 58.2	153 45.3	106
128	262	55 54.2	153 51.0	407
129	263	55 48.8	153 38.3	1,000

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
NOAA Ship DISCOVERER

Date: 3 Nov. 1977

From: LCDR K. E. Lilly, Jr. KEL Jr
Field Operations Officer

To : ALL HANDS

OPERATIONAL PLAN--THUR. NIGHT/FRI., 3-4 NOV. 1977

As sure as the 7 o'clock wakeup, this leg is coming to an end. CTD/XBT operations will continue until tomorrow night around 2200 after which the ship will depart the working grounds to arrive at the Kodiak Fuel Pier at 0900 on 5 Nov.

ETA (Local)	ACTIVITY
2315	STN# 132 (250.6) no cb
2350	STN# 133 (250.5) w/CAL. BTLE.
0030/4 Nov	STN# 134 (250.4) no cb
0115	STN# 135 (250.3) no cb
0155	STN# 136 (250.2) no cb
0235	STN# 137 (250.1) w/CAL. BTLE.
0330	STN# 138 (250) no cb
0425	STN# 139 (251) no cb
0530	STN# 140 (252) no cb
0630	STN# 141 (253) w/CAL. BTLE.
0715	STN# 142 (254) no cb
0750	STN# 143 (255) no cb
0900	STN# 144 (256) no cb Deep cast over 1000m.
1340	STN# 145 (264) w/CAL. BTLE. Deep cast over 1000m.
----	STN# 146 XBT. T-4 halfway between 264 and 263.1.
1605	STN# 147 (263.1) no cb *Deep cast over 1000m.*
----	STN# 148 XBT. T-4 halfway between 263.1 and 263.
1730	STN# 149 (263) no cb Deep cast over 1000m.
----	STN# 150 XBT. T-4 halfway between 263 and 262.
1925	STN# 151 (262) no cb
2015	STN# 152 (261) w/CAL. BTLE.
2130	STN# 153 (260) w/CAL. BTLE. This is likely to be the last station.

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 we[illegible] 16 CTD stations that were not on the standard grid (stations 310 - 32[illegible].

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 ir 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 ackno ledged the release command, however it failed to surface. Further inte rogation several hours later indicated that the release was in the same position that it had been before firing. It is assumed that the moorin 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.

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

TABLE I

WESTERN GULF OF ALASKA STATION GRID

STATION	LAT. (N)	LONG. (W)	DEPTH (METER)
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 Gulf 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

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 1

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 2

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 2 (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: October 1 -
December 31, 1977

NUMERICAL STUDIES OF ALASKAN REGION

Jerry A. Galt
Principal Investigator

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

Quarterly Report

Research Unit: 140
Reporting Period Ending: 12/31/77
P.I.: Jerry A. Galt

Introduction

The modeling effort for this reporting period as described in the revised work statement of 11 October 1977 was progressing as four main-line developmental pieces. These sections and their proponents are as follows:

A. Diagnostic Model Graphics Development - Pease

C. Development of General Trajectory Model - Karpen

E. Meteorological Model Calibration and Synthesis of Met-program Observations - Overland

F. Development of Regional Wind Climatologies for Application to the Spill Trajectory Model - Overland

Status

A. Diagnostic Model Graphics Development - Milestones A1, A2, and A3 are about 90% complete. Some delays have developed in editing documentation but reports should be finished later this month.

C. Development of General Trajectory Model - Milestones C1 and C2 are completed. Progress on C3 is on schedule but hardware problems on the PDP 11/34 are interjecting delays in the programming.

E. Meteological Model Calibration and Synthesis of Met-program Observations - Milestone E1 is partially completed. All three geographic regions have been digitized but only the NEGOA region has a model grid set up. Milestones E2 and E3 have not been completed.

We have experienced down-time of large computer projects due to being forced by GSA to switch from the University of Washington computer to the ERL computer in Boulder.

F. Development of Regional Wind Climatologies for Application to the Spill Trajectory Model - Milestone F1 has been completed and work is ahead of schedule on F2 for the NEGOA region.

QUARTERLY REPORT

Contract No:

R 7120849

Research Unit No.:

141

Reporting Period:

1 October - 31 December 1977

Number of Pages:

2

Bristol Bay Oceanographic Processes

(B-BOP)

L. K. Coachman
T. H. Kinder

Department of Oceanography
University of Washington

J. D. Schumacher
R. L. Charnell

Pacific Marine Environmental Laboratory

30 December 1977

Ref: A78-2

TITLE: Bristol Bay Oceanographic Processes (B-BOP)

PI: Dr. L. K. Coachman
T. H. Kinder
Department of Oceanography
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3711 15th Ave NE
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Reprinting period: 1 October - 31 December 1977

I. Objectives

1. Determine spatial and temporal variability of the velocity field.

2. Determine sea level variability.

3. Examine meteorological forcing.

4. Determine hydrographic variability.

II. Field activities:

See attached cruise reports.

III. Results

We presented a poster paper, "Observations of a boundary front during the early summer: Bristol Bay, Alaska" by Schumacher, Kinder, Pashinski, and Charnell at the fall AGU meeting which was attended by Schumacher, Kinder, and Charnell. We have expanded the scope of this work, and are preparing a manuscript for journal submission.

Reed presented his paper, "Summer heat budget of the Eastern Bering Sea" at the same meeting. This manuscript is in review by the Journal of Geophysical Research.

A technical report, "The evolution of the hydrographic structure over the continental shelf near Bristol Bay, Alaska, during summer 1976" by Kinder, Schumacher, Tripp and Pashinski is in first draft, and should be completed during the coming quarter.

Coachman and Charnell are preparing a second paper, "Fine-structure and the transition zone in outer Bristol Bay, Alaska" as a sequel to their earlier paper on fine-structure.

IV. Estimate of Funds Expended (November 30, 1977) by Department of Oceanography, University of Washington

Allocation 10/1/77 to 12/31/77 $23,700

A.	Salaries, faculty and staff	$ 2,335
B.	Benefits	292
C.	Indirect Costs	1,214
D.	Supplies and other direct costs	10,967
E.	Equipment	-0-
F.	Travel	266
	Total Expenditures	15,074
	Remaining Balance	$ 8,626

Cooperation: We are cooperating with several research units as follows:

289 (Royer) Satellite photography usefully delineates the structural front which parallels the 50 m isobath.

435 (Leendertse) We provide hydrographic, current, and pressure data as requested.

217 (Hansen) We are attempting to integrate our hydrographic and moored instrument data with his drifter data.

206 (Vallier and Gardner) We are exchanging thoughts and data on the St. George Basin regime.

83 (Hunt) We are exchanging data, and attempting to correlate bird observations with the hydrography near the Pribilof Islands.

TO: S. C. Miller, Captain NOAA

FROM: R. K. Reed, NOAA/PMEL, Oceanographer

SUBJ: CRUISE REPORT, RP-4-DI-77C LEG I, 6-29 September 1977

OBJECTIVES

The flow of water is basic to understanding virtually all physical and biochemical processes in oceanic areas. Hence the highest priority of this investigation was the recovery of current meter arrays that had been previously deployed and the emplacement of new moorings to be recovered next year. The mooring sites were in the continental shelf areas south of the Alaska Peninsula, in Bristol Bay, and between the Pribilof Islands and Bering Strait. In order to supplement the direct current measurements, CTD casts were planned to examine physical properties and processes and infer circulation from the density distribution. Finally, a detailed survey of Kotzebue Sound was planned. Because of previous difficulty in resolving the processes of importance in this system, chemical measurements were made to provide information on the source and age of water masses.

ACCOMPLISHMENTS

The majority of observations planned for LEG I were obtained. CTD work in Bristol Bay enroute to Kodiak was not done. This was primarily the result of the unseasonably stormy weather encountered; almost three days working time was lost because of high seas and winds.

The PMEL current moorings recovered were: WGC3D, WGC1F, BC13D (both current meters missing because of obvious trawling), BC15C, BC2E (pressure gauge broke off after being sighted), and BC16A. In addition, NC18A was recovered after attempts had been made the previous month aboard the SURVEYOR. No trace was found of mooring BC17B; the release could not be interrogated, and the array was not sighted after firing. It is strongly suspected that this mooring was moved or damaged by trawling. All planned recoveries of University of Washington moorings (BC19A, BC18A, BC9C, and BC4E) were accomplished. Five moorings were deployed for PMEL, and four were deployed for the University of Washington; relevant data are given in Appendix A.

A total of 186 CTD casts were taken, and their locations are listed in Appendix B. In Kotzebue Sound, nutrient samples were taken at the surface and the bottom of each cast (84 total) for later analysis ashore, and 42 dissolved oxygen samples (obtained at the bottom of each cast) were analyzed aboard.

MISCELLANEOUS

Other scientific personnel aboard were R. Carlone, PMEL, electronics technician; V. Johnson, PMEL, trainee; R. Tripp, UW, Oceanographer (left ship at Nome on 20 September); and D. Ripley, UW, student helper. Performance of most of the actual work was carried out by shipboard personnel, however. On vessels as large as the DISCOVERER it is essential that tasks be clearly defined and well-organized; throughout the cruise it was apparent that this had been done, and the efforts and skill of the officers and crew are greatly appreciated. I would especially like to commend the deck department for their work on the moorings.

In general, the problems encountered were relatively minor. Approximately midway through the cruise, spurious signals became apparent on the analog traces from the CTD unit; various tests strongly suggested that the conductivity sensor had become magnetized. Arrangements were made to have a new unit sent to Nome, which was picked up on 20 September. At the same time a spare laboratory salinometer was received and subsequently used because of problems with bubbles in the cell of the original unit. Procedures were established to eliminate the recording of excessive data scans (which appreciably increases data processing costs) on the Plessey digital data logger at the start and end of CTD casts. A very strong quality control effort was made by shipboard personnel in monitoring CTD sensor performance in comparison with calibration data. For the extremely shallow casts in Kotzebue Sound, it was realized that the sonar pinger would not be effective in depth control. Consequently, depth frequency values were used, and this procedure was quite effective in allowing the sensors to reach within 1-2 meters of the bottom.

MOORING I.D. ORG.	POSITION LAT. LONG.	LORAN C ssl = 9990	RCM UPPER LOWER	METER DEPTH METERS	TG S/N TYPE	RELEASE S/N RCVR.# TYPE	FLOAT(ORE) SIZE S/N	DEPTH METERS fm	GMT DATE TIME
BC3D	55°17.7'N	x=18404.11	2510	17		180	41"	116.1	9 Sept 77
PMEL	165°29.7'W	y=34575.48	2509	97		#3	501	63.5	0310
		z=48207.02				242			
BC2F	57°02.4'N	x=18708.71	1678	19		501583	41"	65.0	10 Sept
PMEL	163°26.5'W	y=33805.65	2508	53		#4	438	35.5	2223
		z=47447.98				242			
BC4F	58°37.2'N	x=18622.92		18			28"	53.0	13 Sept
UW	168°22.2'W	y=33887.79		46	TG-3A	#8	535	29.0	0100
		z=49111.39				242			
BC21A	60°23.4'N	x=18208.79		28.5			28"	41.5	16 Sept
UW	169°11.2'W	y=32696.05			TG-3A	#8		22.7	1735
		z=48779.80				242			
BC20A	60°25.7'N	x=17913.23		22			28"	66	16 Sept
UW	171°05.7'W	y=32768.99		52	TG-3A	#3		36	2324
						242			
NC24A	61°48.4'N	x=17809.61		24		#7	28"	48.5	19 Sept
UW	170°26.1'W	y=31747.00		40		242		26.5	0018
		z=43619.74							
NC17B	62°53.1'N	y=30736.39	1812	17	242	501483	28"	47	19 Sept
PMEL	167°04.6'W	z=47762.47			TG-3A	#3	608	15	2214
						242			

MOORING I.D. ORG.	POSITION LAT. LONG.	LORAN C ssl = 9990	RCM UPPER LOWER	METER DEPTH METERS	TG S/N TYPE	RELEASE S/N RCVR.# TYPE	FLOAT(ORE) SIZE S/N	DEPTH METERS fm	GMT DATE TIME
NC23A	63°57.2'N	x=17968.39	1821	16		602561	28"	26	21 Sep
PMEL	166°09.4'W	y=29927.63				#10	669	14	0338
		z=47432.18				242			
NC12B	65°00.3'N	x=17581.62	1455	40	233	700663	28"	50	21 Sep
PMEL	169°00.7'W	y=29487.11			TG-3A	#4	670	27.5	1710
		z=47747.32				242			

APPENDIX

CAST #	STATION #	LAT.(°N)	LONG.(°W)
001	BC -13	55-44.0	165-23.0
002	BC -13	55-43.6	165-23.4
003	BC -13	55-44.0	165-23.6
004	BC -13	55-43.6	165-24.2
005	BC -13	55-44.0	165-23.4
006	BC -13	55-43.2	165-23.5
007	BC -13	55-43.9	165-23.5
008	BC -13	55-43.5	165-23.7
009	BC -13	55-43.7	165-24.3
010	BC -13	55-44.2	165-24.5
011	BC -13	55-43.9	165-22.7
012	BB -93.1	57-14.0	163-12.7
013	BB -93.2	57-16.1	163-09.6
014	BB -93.3	57-17.6	163-07.8
015	BB -93.4	57-19.6	163-05.5
016	BB -93.5	57-21.2	163-03.5
017	BB -93.6	57-22.6	163-01.5
018	BB -93.7	57-24.5	162-59.2
019	BB -93.8	57-26.3	162-57.0
020	BB -93.9	57-28.1	162-55.0
021	BB -93.10	57-29.5	162-53.2
022	BB -96.1	57-59.3	165-14.8
023	BB -96.2	58-02.1	165-10.2
024	BB -96.3	58-04.2	165-04.5
025	BB -96.4	58-07.1	165-00.1
026	BB -96.5	58-10.8	165-55.3
027	BB -96.6	58-13.1	165-49.6
028	BB -96.7	58-15.8	164-43.8
029	BB -96.8	58-18.4	164-39.7
030	BB -96.9	58-21.7	164-34.8
031	BB -96.10	58-24.2	164-27.9
032	BB -96.11	58-27.6	164-21.9
033	BB -96.12	58-30.4	164-16.8
034	BB -96.13	58-34.3	164-10.6
035	BB -96.14	58-35.5	164-07.1
036	BB -96.15	58-38.5	164-01.6
037	BB -96.16	58-41.4	163-56.3
038	BC -18	59-40.6	167-06.7
039	BB -141	59-47.0	167-34.4
040	BB -161	60-11.7	167-40.9
041	BB -162	60-18.0	168-18.0
042	BB -160	59-58.3	168-05.3
043	BB -159	59-45.0	168-30.8
044	BB -140	59-25.4	167-54.3
045	BC -9	59-11.3	167-39.7
046	BB -139	58-53.2	168-04.2
047	BC -4	58-37.4	168-21.4
048	BB -138	58-31.9	168-41.1
049	BB -137	58-04.8	169-03.8
050	BB -069	57-53.4	169-19.0

CAST #	STATION #	LAT.(°N)	LONG.(°W)
051	BB -057	57-28.3	169-50.1
052	BB -142	57-45.0	170-05.6
053	BB -143	58-02.7	170-24.2
054	BB -144	58-21.4	170-39.2
055	BB -145	58-39.2	170-53.1
056	BB -146	58-56.4	171-09.3
057	BB -147	59-15.3	171-26.3
058	BB -148	59-32.5	171-43.4
059	BB -149	59-49.8	171-59.7
060	BB -150	60-06.7	172-15.9
061	BB -151	60-17.2	171-50.3
062	BB -152	60-01.9	171-25.7
063,064*	BB -153	59-47.7	170-59.2
065	BB -154	59-31.8	170-35.7
066	BB -155	59-16.6	170-14.0
067	BB -156	59-02.7	169-49.1
068	BB -157	59-16.0	169-22.7
069	BB -158	59-30.5	168-58.3
070	BB -163	60-19.8	168-50.4
071	BC -21	60-23.3	169-12.5
072	BB -164	60-23.6	169-29.1
073	BB -165	60-24.0	170-06.0
074	BB -166	60-27.0	170-45.0
075	BC -20	60-25.8	171-05.9
076	BB -167	60-28.7	171-24.0
077	BB -168	60-30.7	171-59.5
078	BB -169	60-49.8	171-41.0
079	BB -170	61-04.4	171-26.4
080	BB -171	61-23.0	171-09.2
081	BB -172	61-05.9	170-46.7
082	BB -173	61-06.0	170-08.4
083	BB -174	61-05.9	169-31.0
084	BB -175	61-06.5	168-52.5
085	BB -176	61-06.6	168-17.3
086	BB -177	61-07.2	167-40.7
087	BB -178	61-07.1	167-01.3
088	BB -179	61-24.3	167-01.0
089	BB -180	61-42.5	166-52.0
090	BB -181	61-45.2	167-28.0
091	BB -182	61-47.1	168-08.1
092	BB -183	61-48.1	168-42.5
093	BB -184	61-50.0	169-19.0
094	BB -185	61-52.1	169-56.1
095	NC -24A	61-48.8	170-26.3
096	BB -186	61-39.0	170-54.8
097	BB -187	61-55.1	170-39.6
098	BB -188	62-10.9	170-29.1
099	BB -189	62-27.3	170-09.2
100	BB -190	62-40.3	169-54.3

*Recast taken on same station

CAST#	STATION #	LAT. (°N)	LONG. (°W)
101	BB-191	62-47.8	169-39.8
102	NC-12	62-43.6	167-21.3
103	NC-11	62-48.8	167-36.5
104	NC-10	62-54.6	167-51.8
105	NC-9	63-00.0	168-08.0
106	NC-8	63-05.3	168-22.4
107	NC-7	63-10.7	168-37.3
108	NC-13	62-39.5	167-08.2
109	NC-14	62-33.9	166-52.6
110	NC-15	62-29.7	166-39.8
111	NC-15.1	62-37.5	166-35.2
112	NC-15.2	62-39.1	166-22.7
113	NC-15.3	62-42.1	166-11.3
114	NC-15.4	62-44.7	165-59.4
115	NC-15.5	62-55.0	165-59.8
116	NC-15.6	63-06.4	166-00.6
117	NC-15.7	63-17.3	166-01.1
118	NC-15.8	63-25.8	166-00.4
119	NC-15.9	63-35.2	166-00.2
120	NC-15.10	63-44.5	165-59.2
121	NC-15.11	63-53.8	165-59.5
122	NC-15.12	64-02.6	166-00.3
123	NC-15.13	64-13.0	166-00.0
124	NC-15.14	64-23.2	166-00.4
125	NC-15.15	64-28.7	166-00.7
126	NC-63.1	66-40.5	165-00.0
127	NC-63	66-41.6	165-10.4
128	NC-64	66-59.9	165-15.4
129	NC-65	67-01.9	165-16.0
130	NC-66	67-11.1	164-52.1
131	Aborted		
132	NC-67	67-18.3	164-32.1
133	Aborted		
134	NC-68	67-22.9	164-12.9
135	Aborted		
136	NC-68.2	67-14.0	164-12.7
137	NC-70	67-04.9	164-24.0
138	NC-71	66-58.5	164-37.2
139	NC-72	66-50.8	164-42.8
140	NC-73	66-39.5	164-43.3
141	NC-74	66-40.8	164-09.3
142	NC-75	66-47.6	164-04.8
143	NC-76	66-55.5	165-54.3
144	NC-77	66-58.5	163-50.2
145	NC-77.1	66-59.0	163-31.9
146	NC-77.2	66-50.8	163-37.2
147	NC-77.3	66-44.4	163-48.1
148	NC-77.4	66-40.2	163-55.0
149	Aborted		
150	NC-80	66-39.5	163-37.0

CAST #	STATION #	LAT(°N)	LONG.(°W)
151	NC-79	66-47.5	163-24.1
152	NC-78.1	66-51.5	163-22.2
153	NC-78	66-56.9	163-15.0
154	NC-80.3	66-44.9	163-07.5
155	NC-80.2	66-42.0	163-13.0
156	NC-80.1	66-34.4	163-19.5
157	NC-81	66-31.9	163-13.8
158	NC-82	66-38.6	163-03.5
159	NC-83	66-41.2	162-56.5
160	NC-83.1	66-35.3	162-44.1
161	NC-85	66-29.6	162-46.0
162	NC-84.1	66-22.0	162-15.0
163	NC-89	66-19.6	162-17.4
164	NC-90	66-15.5	162-19.7
165	NC-88	66-18.7	162-31.0
166	NC-91	66-13.5	162-45.0
167	NC-87	66-19.8	162-52.9
168	NC-92	66-12.3	163-17.4
169	NC-86	66-22.5	163-21.8
170	NC-86.1	66-26.8	163-19.6
171	NC-86.2	66-30.5	162-57.5
172	NC-50	65-38.8	168-15.8
173	NC-51	65-39.1	168-23.5
174	NC-52	65-39.0	168-30.6
175	NC-53	65-38.1	168-39.6
176	NC-54	65-38.2	168-51.0
177	NC-55	65-38.4	168-58.4
178	NC-55.1	65-30.2	168-58.0
179	NC-55.2	65-26.5	169-08.9
180	NC-55.3	65-26.9	169-17.7
181	NC-55.4	65-28.8	169-26.3
182	NC-55.5	65-30.7	169-34.2
183	NC-55.6	65-33.3	169-42.1
184	NC-55.7	65-36.8	169-47.5
185	NC-55.8	65-40.7	169-51.6
186	NC-58.9	65-44.7	169-51.1

QUARTERLY REPORT

Contract No:

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

Research Unit No.:

151

Reporting Period:

1 October - 31 December 1977

Number of Pages:

2

STD Measurements in Possible Dispersal Regions of the Beaufort Sea

Knut Aagaard

Department of Oceanography
University of Washington
Seattle, Washington 98195

10 January 1978

Ref: A78-3

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.

V. Problems Encountered

None.

VI. Estimate of Funds Expended to 30 November 1977

TOTAL ALLOCATION (5/16/75-3/31/78):			$142,627
A.	Salaries, faculty and staff	$19,570	
B.	Benefits	2,317	
C.	Expendable Supplies & Equipment	5,168	
D.	Permanent Equipment	23,209	
E.	Travel	4,720	
F.	Computer	2,924	
G.	Other Direct Costs	27,855	
H.	Indirect Costs	9,557	
	TOTAL		95,320
	REMAINING BALANCE		47,307

QUARTERLY REPORT

Research Unit: #217
Reporting Period:
1 Oct. - 31 Dec. 1977
Number of pages: 1

Title: Lagrangian Surface Currents

Principal Investigator: D. V. Hansen

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

22 December 1977

I. Abstract

A minimum report is submitted at this time because two buoys of the May 1977 deployment of six are still transmitting but are nearing the end of their useful lifetimes. The results of this deployment continue as described in the previous quarterly report. Work is progressing smoothly on processing of previously collected data.

II. Objectives:

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

III. Activities:

Two of the six buoys deployed in the St. George Basin in Mid-May are still transmitting in Mid-December. Recent results are qualitatively similar to those reported in the last quarterly report and shown at the November review. In the interest of economy of technician and computer times smooth processing of these data will not be done until all data collection from this deployment is completed. Good progress is being made on processing of previously collected data preparatory to production of graphic data reports. Processed data plots have been transmitted to Dr. Roger and Mr. Pashinski for use in preparation of collaboration manuscripts.

Plans have been made with PMEL personel (Shumacher, Pashinski) for deployments to be made in March, June, and September of the coming year. Arrangements have been made for the NOAA Data Buoy Office to accept responsibility for procurement of the 10 new buoys required for the project.

IV. Results:

Nothing new to report this quarter.

V. Preliminary interpretation:

Nothing new to report this quarter.

VI. References: None

VII. Problems: None

VIII. Estimate of funds expended:

Considering funds made available to HDBO for new hardware procurement as expended, somewhat more than half of the FY 1978 funding has been used.

QUARTERLY REPORT

Contract #03-5-022-91

Research Unit #244

Reporting Period: Sept. 1 - Dec. 31, 1977

Number of Pages: 35

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

December 31, 1977

I. TASK OBJECTIVES

Work this quarter has concentrated on:

(a) continuing ice mapping for 1976 for the Beaufort coast,

(b) synoptic analysis of climatological conditions on the Chukchi Sea coast,

(c) initial evaluation of synoptic controls of pack ice impingement on the Beaufort Sea coast.

II. OFFICE ACTIVITIES

Personnel:

R. G. Barry - Principal Investigator

J. Rogers - Graduate Research Assistant

J. Reynolds - Graduate Research Assistant

B. Warmerdam - Graduate Research Assistant

G. Wohl - Graduate Research Assistant

III. DATA ANALYSED AND RESULTS

A. Ice Maps

Maps of ice conditions along the Beaufort Sea coast have now been completed for late winter through summer 1976 for the Barrow sector. These are included as Appendix 1 with accompanying descriptive notes. Mapping of the remaining two sectors on the Beaufort Sea coast for 1976 will be finished during the next quarter.

B. Synoptic Climatology of the Chukchi Sea Coast

1. Wind Regime at Kotzebue

Wind conditions along the Chuckchi coast have been examined in terms of their possible significance for summer ice severity. At Kotzebue, the wind regime exhibits a monsoonal pattern: easterly winds prevail from about mid-September to mid-May and westerly winds prevail from mid-May to mid-September. The summer westerlies are about 40-60% persistent at Kotzebue (Ramage, 1971), being commonly interrupted by strong opposing circulation systems. Kurashima (1968) includes Alaska south of the Brooks Range in his map of the monsoon regions of the world; the monsoonal pattern is not evident at the north slope stations of Barrow and Barter Island.

Analysis of individual years (1953-1976, except 1973) reveals that the mean date of onset of persistent summer westerlies at Kotzebue is May 16, but it is highly variable (Table 1). The physical process determining the onset of westerly winds here is not well understood. Two hypotheses could account for the monsoonal pattern: (1) the Arctic Front, which undergoes a northward march across Alaska during early summer, should cause a shift in prevailing wind direction from east to west winds in high (60-65°) latitudes (Kurashima, 1968); (2) the temperature difference between land and sea sets up a pressure gradient, causing onshore (westerly) winds at Kotzebue during summer and off-shore winds during winter.

There does not appear to be an evidence that the movement of the Arctic Front causes the monsoonal pattern of winds in Alaska. If the Arctic Front were responsible, one would expect there to be a progressive northward shift to summer westerly winds through Alaska each year. Preliminary analysis of winds at two stations (Unalakleet and Bethel) south of Kotzebue along the coast indicates that the wind shift takes place there, on average, a few days after the shift at Kotzebue, which cannot be possible if the Arctic Front hypothesis is correct. Barry (1967) mapped the median position of the Arctic Front for the years 1961-1965. The year 1964 was a year of very early westerly onset at Kotzebue (April 21), yet the mean position of the Arctic Front during April was south of Anchorage. Hence, the shift of the Arctic Front apparently does not explain the monsoonal wind pattern in Alaska.

There is evidence that land-sea temperature differences may determine the wind regime. Heating in interior Alaska (Fairbanks-Ft. Yukon area) sets up a thermal gradient during summer months (Figure 1). This gradient always is established by April, yet there is no relationship between the interior temperature (as represented by Fairbanks, which is in general highly representative of the interior temperature according to Haugen et al., 1971) and the date of west wind onset at Kotzebue (r = -0.13). There is, however, a weak relationship between the magnitude of the temperature difference between Kotzebue and Fairbanks and the onset date. The relationship is stronger in May (r = -0.54) than in April (r = -0.40). The coefficient in May is significant at the 95% level. The slightly later date of west wind onset at the southern stations would also be consistent with this hypothesis.

The frequency changes in the synoptic types of the Chukchi Sea grid were examined for the three weeks before and the three weeks after the date of onset of westerly winds at Kotzebue (Table 2). There is a significant decrease in types 2, 6, 12, 14, and 18; all but type 6 are basically cyclonic, with low pressure west of Alaska causing southerly and easterly winds at Kotzebue, and types 2 and 14 show high pressure in interior Alaska. There is a significant increase in types 5, 8, 15, 19, 21; most important are 5, 15, and 19, all of which have low pressure over interior Alaska and are associated with westerly winds. Types 8 and 21 have high pressure west of Alaska and are associated with northwest winds. This frequency change of types suggests that the formation of an interior surface heat low may be an important influence on the wind shift.

Thermal lows are generally associated with upper-level ridges that tend to enhance the lows by providing upper-level divergence and thus promoting lifting. Examination of the height of the 500 mb pressure surface on the actual shift dates for the years 1976 (May 4), 1975 (April 22), 1974 (May 12), 1970 (March 30), and 1969 (June 20) shows that there was generally ridging over interior Alaska and northwestern Canada, with troughs west and south of Alaska. Such a distribution is consistent with thermally-direct flow with surface westerlies along the central west coast of Alaska. Moreover, the trough and ridge positions are remarkably similar to those noted by Streten (1974) as causing anomalously high temperatures in interior Alaska (Figure 2). Hence, it is likely that a thermally-direct system of monsoonal winds is active in Alaska, but the precise relationship between the temperature field and the wind field is inadequately known, due mainly to a lack of a useful data base.

The importance of the westerly wind system to the work on this project is explained by the relationship between the date of onset of westerlies at Kotzebue and the severity of the summer (as indicated by accumulated thawing degree days). In general, the earlier the westerlies set in, the more severe will be the summer ($r = 0.67$, significant at the 99% level) (Figure 3). The wind field is an important feature of the circulation that can perhaps be used to forecast summer severity at Kotzebue. A general prediction can be made as early as June 1, based on the relationship in Figure 3. Because summer ice conditions are closely related to accumulated thawing degree days, a general forecast of ice conditions in the Chukchi Sea is thus possible.

The westerly onset dates also appear to be related to ice conditions in the Beaufort Sea. Barnett (1976) determined that the five worst ice years off Barrow (1955, 1960, 1964, 1970, and 1975) were also the five years in which the westerlies at Kotzebue set in earliest. It is unlikely that this is a direct causal relationship between these, since the penetration of the westerlies northward to Barrow is not related to the onset date of westerlies at Kotzebue, and in many years westerlies are not evident at Barrow. It is more likely that the behavior of the westerlies at Kotzebue and the Beaufort Sea ice conditions are both determined by some large-scale circulation feature, and thus early westerlies and bad ice years occur coincidently. Of note is the quasi-five-year return period in the Beaufort Sea ice record which matches the quasi-five-year return period of earliest westerlies at Kotzebue. Although probably impersistent, this may be useful for predicting ice conditions when combined with the statistical methods developed by Rogers (1977).

2. Temperatures at Kotzebue and Barrow

Correlation fields of pressure in relation to maximum daily temperature at Kotzebue and Barrow have been computed for July, 1955–1974, using the Chukchi type grid. Correlation fields of pressure can be interpreted in the same manner as composite difference charts, that is, for the source and direction of anomalous air flow at the reference station (Stidd, 1954). At Kotzebue, anomalously high summer maximum temperatures are the results of advection of warm interior air by easterly winds (Figure 4). Conversely, anomalously low summer temperatures result from advection of cool air from the Chukchi Sea by westerly winds. The major "center of action" for Kotzebue is located in the Beaufort Sea.

The Brooks Range apparently keeps warmth from the interior from reaching Barrow during the summer. At Barrow, anomalously high summer maximum temperatures are the result of advection of air from southerly latitudes by southwesterly winds passing west of the Brooks Range (Figure 5). Anomalously low temperatures result from cold air advection from the Beaufort Sea and Arctic Ocean by northerly winds. The major "center of action" for Barrow is over the western Chukchi Sea. It is important to note that the summer temperature regime of Barrow appears to be distinct from that of Alaska south of the Brooks Range, necessitating in-depth study of each area.

3. Sea-breeze effects at Barrow

An analysis of summer winds at Barrow demonstrates the influence of the land-sea temperature gradient on surface winds. This is detailed in a published note (Moritz, 1977) included here as Appendix 2.

C. Pack Ice Impingement on the Beaufort Sea Coast

Our analyses of Landsat imagery show that, although its decay rate is strongly affected by temperature conditions, the fast ice always disappears during the summer season. However, pack ice may also impinge on the coastal zone and this factor is the primary control of the navigation season.

Examination of the temperature record for summer 1975 at Barrow shows that it ranked as the eighth most severe (out of 55 summers) with a thawing degree day (TDD) total of 346 (Annual Report, 1977). The mean TDD value at Barrow is 532 with a standard deviation of 182, placing the 1955 figure only one standard from the mean. Yet 1975 was the most severe year in terms of the navigation season during this record. The pack did not accumulate mass during the 1975 summer, but it moved towards the coast as the shorefast ice ablated and broke up.

Tracks of the AIDJEX data buoys and manned camps show a general southeastward motion during the summer of 1975 in a region where westward motion is to be expected. Jayaweera (1977) reports anomalous northerly flow at

700 mb during that summer, which would account for the below normal temperature at Barrow and the onshore ice motion.

In order to make a more detailed study of the synoptic conditions we have obtained AIDJEX maps of surface pressure and geostrophic wind data for April-October 1975. These are being compared with the NMC analyses and our synoptic catalog which is currently being updated through 1976. It is planned to analyze the 1975 events in terms of their larger-scale synoptic controls and seasonal sequence and also, if feasible, to look at the historical ice records documented by Hunt and Naske as a guide to the temporal characteristics of similar conditions.

Table 1. Date of onset of persistent westerly winds at Kotzebue, 1953-1976

Year	Date	Year	Date
1976	May 4	1964	April 21
1975	April 22	1963	June 6
1974	May 12	1962	June 13
1973	Missing	1961	May 11
1972	June 10	1960	April 14
1971	June 7	1959	May 15
1970	March 30	1958	May 29
1969	June 20	1957	June 9
1968	May 12	1956	May 28
1967	May 10	1955	May 1
1966	May 3	1954	May 14
1965	June 9	1953	May 9

Mean date: May 16

Table 2. Frequency of Chukchi types three weeks before and three weeks after onset of westerly winds at Kotzebue, 1953-1974.

Type	Frequency Before Shift	Frequency After Shift	Absolute Change	Per Cent Change
1	170	142	-28	-16
2	75	34	-41	-55
3	12	22	+10	+83
4	25	28	+3	+12
5	17	44	+27	+159
6	8	4	-4	-50
7	6	6	0	0
8	5	12	+7	+140
9	17	23	+6	+35
10	3	5	+2	+67
11	21	14	-7	-33
12	8	4	-4	-50
13	24	18	-6	-25
14	10	4	-6	-60
15	1	15	+14	+1500
16	5	3	-2	-40
17	10	18	-8	+80
18	2	0	-2	-
19	3	11	+8	+267
20	2	2	0	0
21	2	4	+2	+100
22	0	2	+2	-
NT	9	20	+11	+122

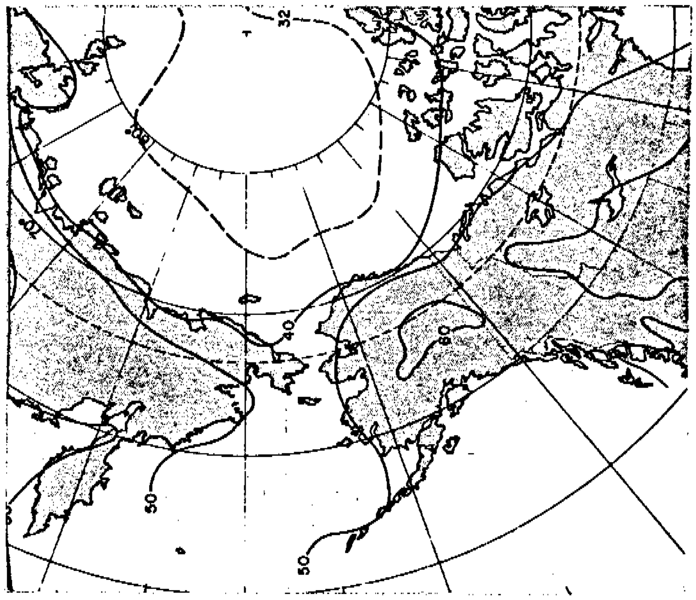

Figure 1. Mean daily temperature in Alaska and environs, July (after Wilson, 1969).

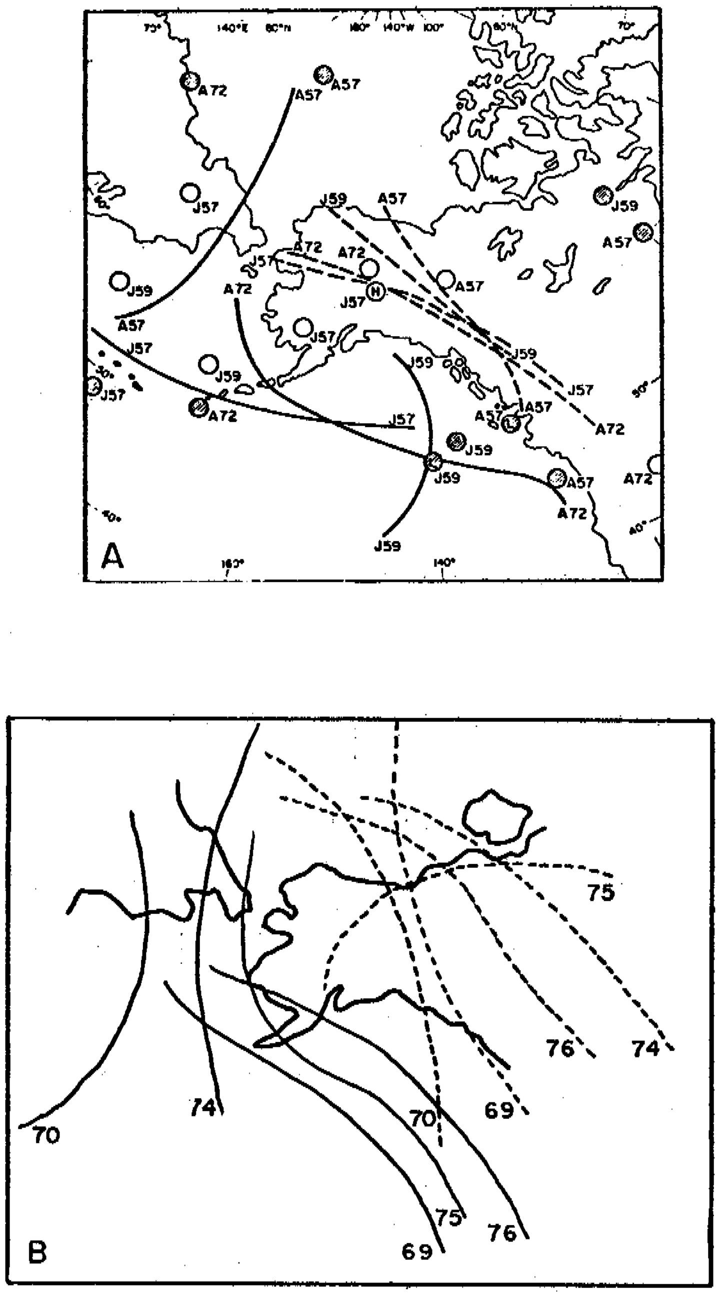

Figure 2. 500 mb trough and ridge positions on the day persistent westerlies set in at Kotzebue (B) are similar to those at 700 mb shown by Streten (1974) for warm summer months in the interior of Alaska.

Key: - - - - - ridge

——————— trough

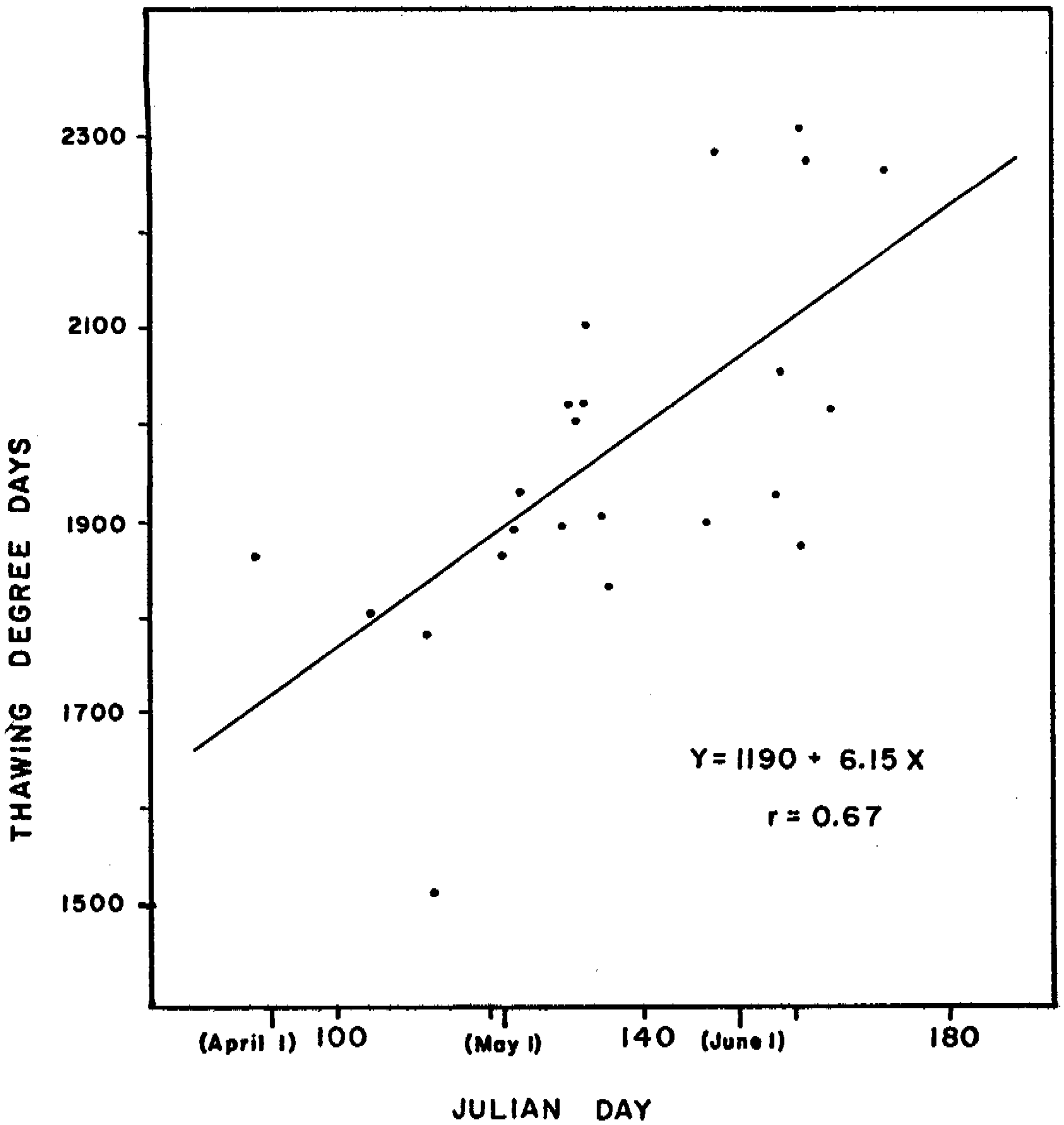

Figure 3. Date of westerly wind onset and accumulated thawing degree days at Kotzebue, 1953-1976 (except 1973). The outlier at approximately 1500 TDD represents the severe summer of 1975.

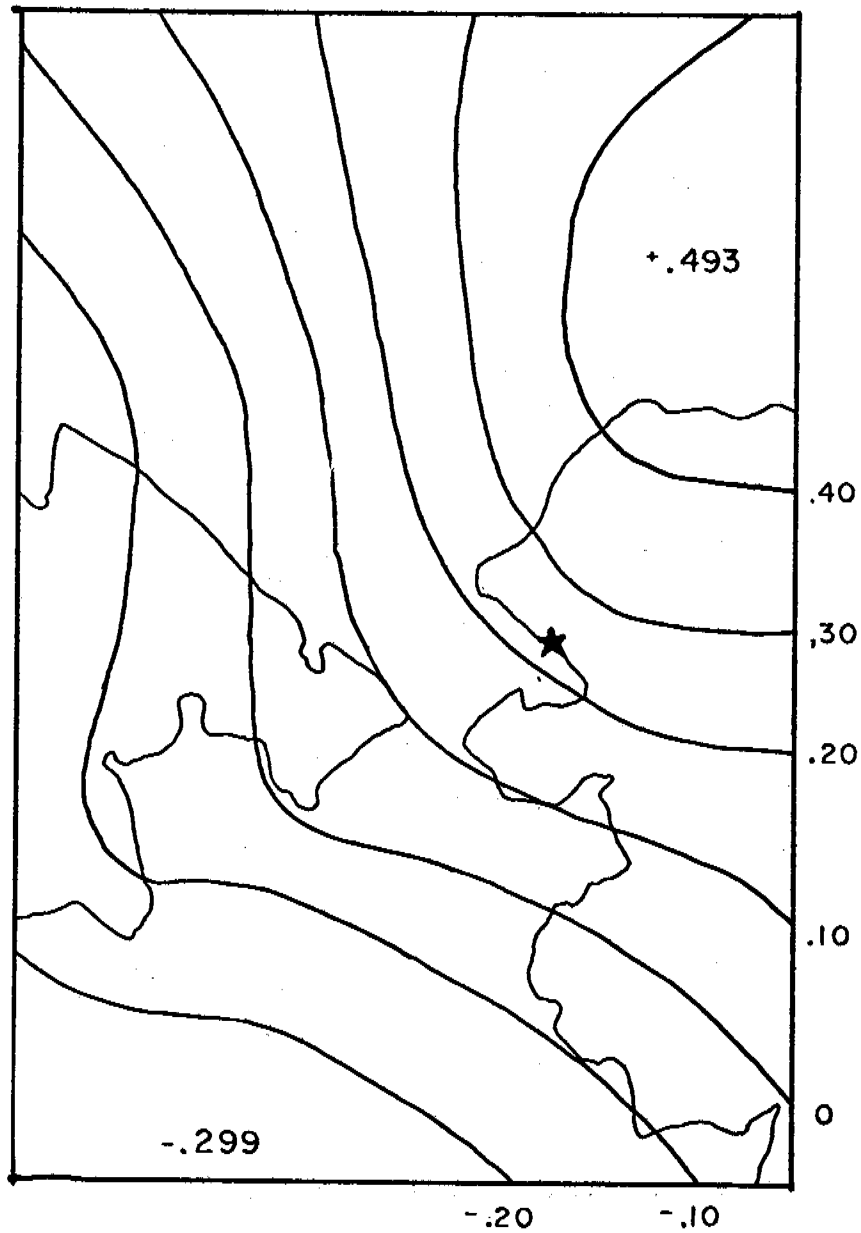

Figure 4. Correlation field of maximum temperature in July at Kotzebue (star) and surface pressure, 1955-1974.

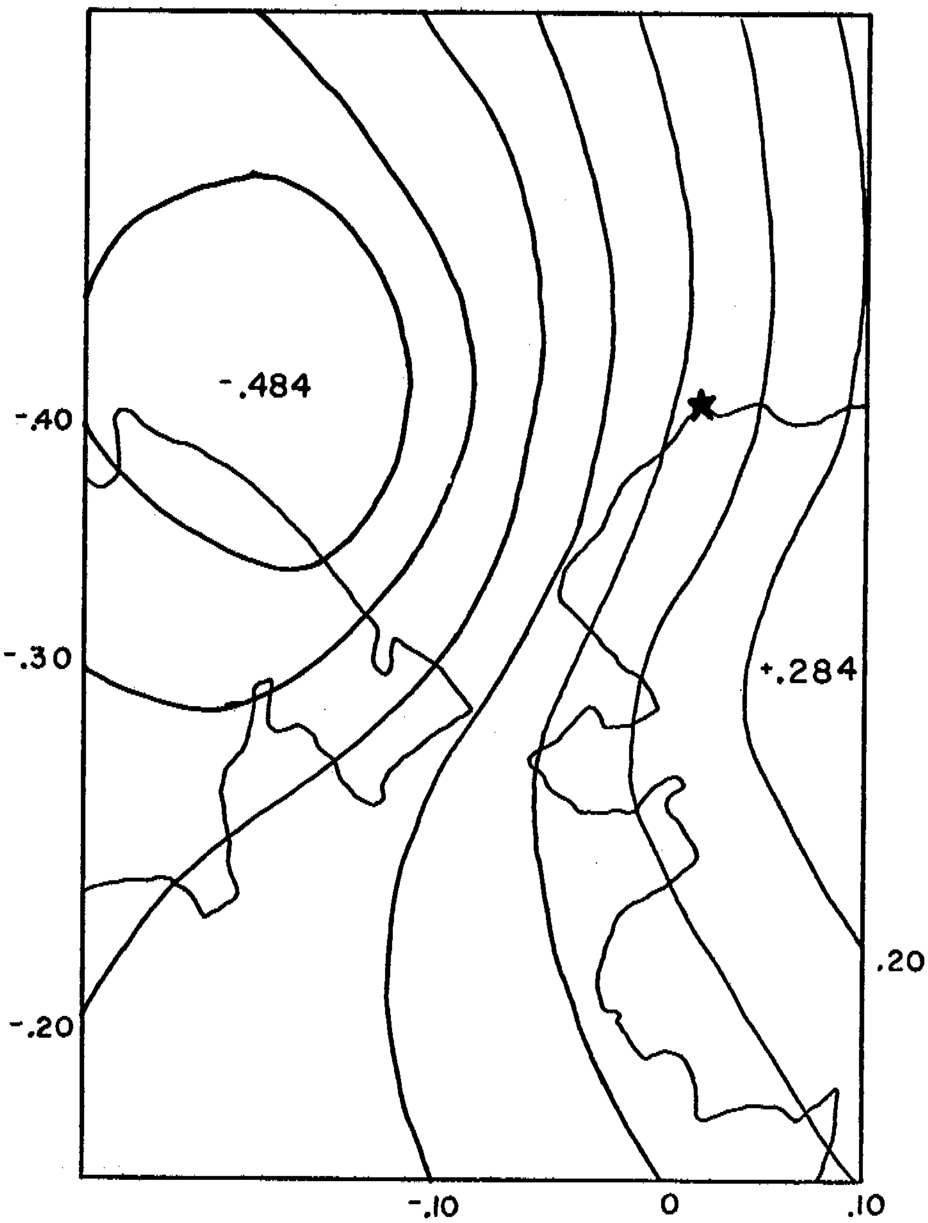

Figure 5. Correlation field of maximum temperature in July at Barrow (star) and surface pressure, 1955-1974.

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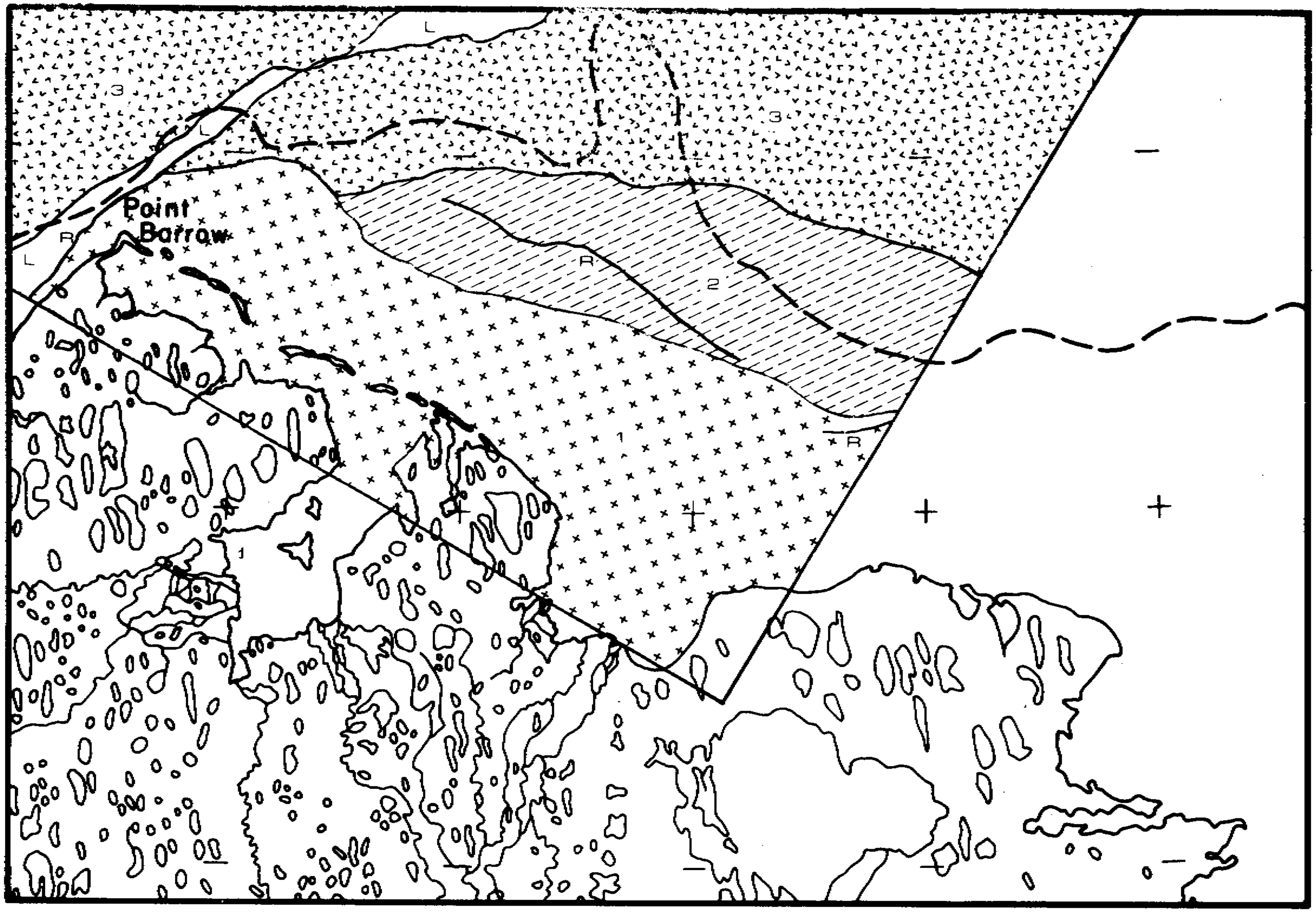
APPENDIX 1

Ice Maps for the Barrow Sector, Beaufort Sea Coast, 1976

25 February 1976: Scene E-2399-21420

In this winter scene, pack and fast ice are well consolidated with the exception of a large lead (L) approximately 5 to 10 km wide. This lead is located several km northwest of Pt. Barrow and extends in a northeasterly/southwesterly direction across the frame. Ridges (R) are present along the edge of the lead nearest Pt. Barrow. Three different zones are apparent in the ice. Smooth-looking, fairly light toned shorefast ice (1) extends 20 to 30 km from the coast. No major deformational features can be distinguished within this zone, although some ridging may be present along the seaward boundary. The pack ice (3) consists mainly of floes of various sizes in a matrix of darker toned ice. Zone 2 appears to be gradational between the other two zones. Apparently there are some floe-like objects in this zone, but they are much more indistinct than those in zone 3. However, the ice does not appear as homogeneous as that in zone 1. A ridge (R) is present in zone 2, possibly indicating a former continuous ice edge.

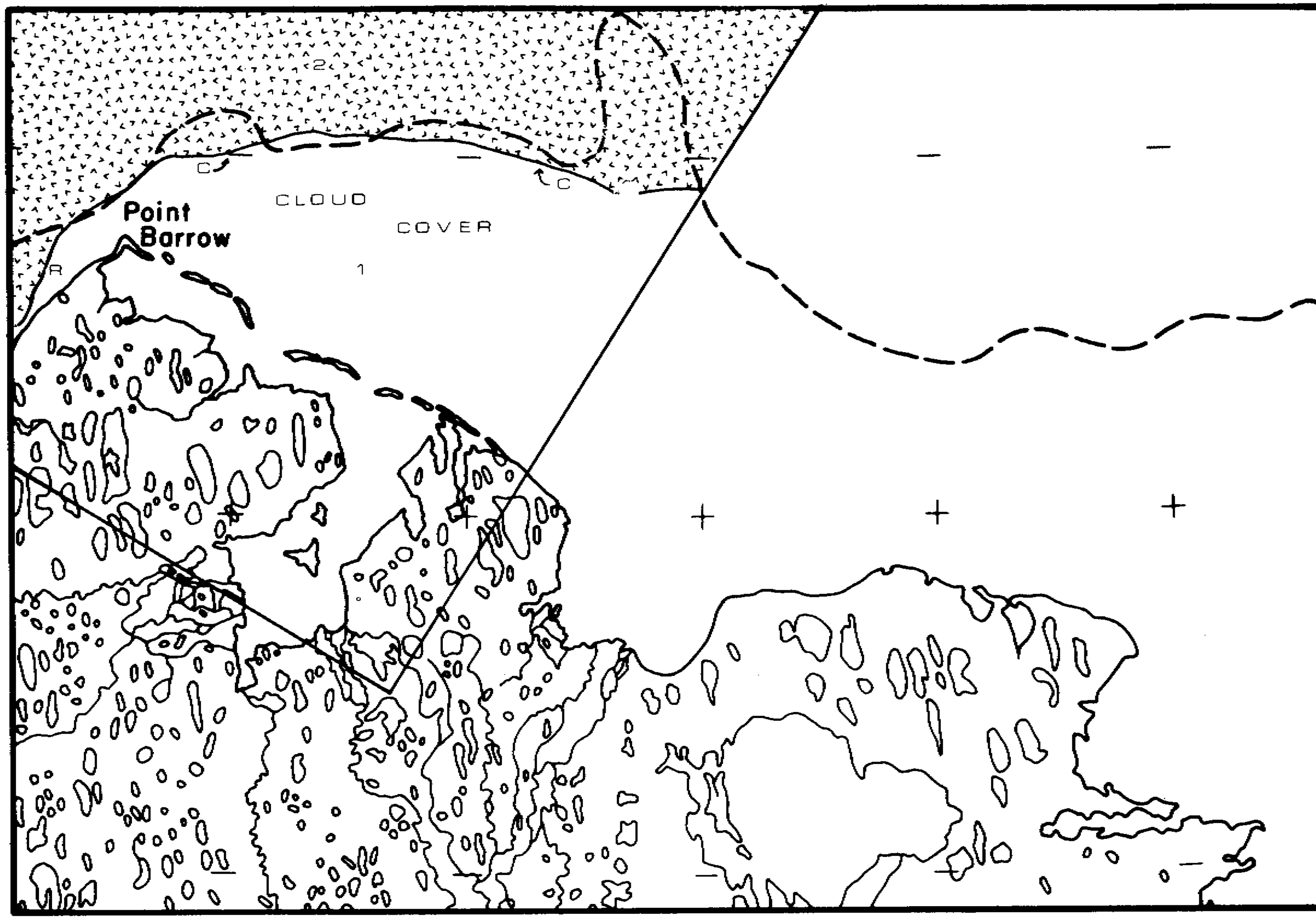


SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
BEAUFORT SEA COAST: BARROW SECTOR

25 February 1976

13 June 1976: Scene E-2508-21444

Cloud cover obstructs the view of nearly all of the continuous shore fast ice (1), so mapping within this area was impossible. However, the continous ice edge (C) is distinct. The pack ice (2) is quite consolidated although there are some fairly large areas of open water just seaward of the continous ice edge.



SHOREFAST SEA ICE

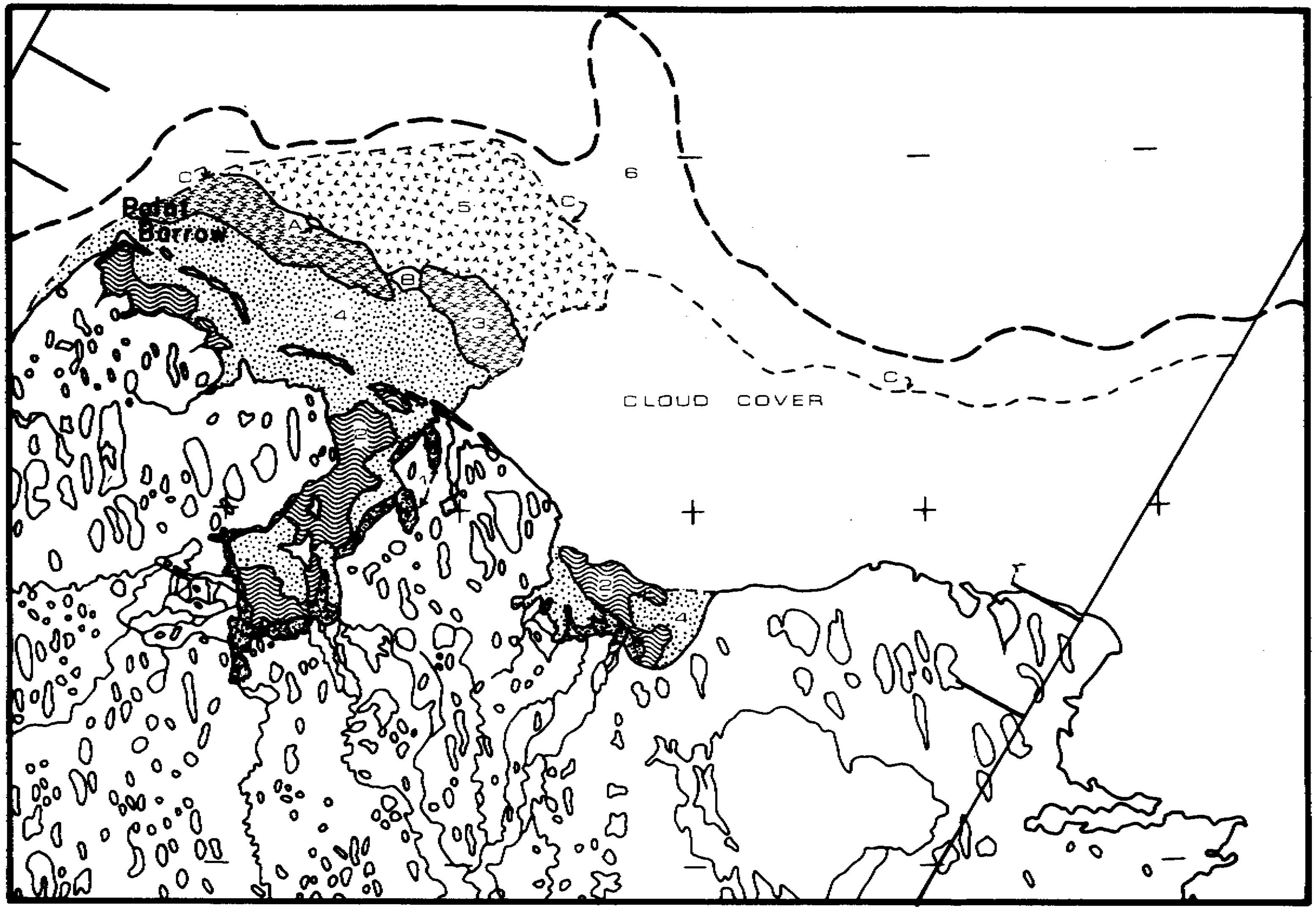
SURFACE MORPHOLOGICAL CHARACTERISTICS

BEAUFORT SEA COAST: BARROW SECTOR

13 June 1976

29 June 1976: Scenes E-2524-21331 and E-2524-21325

In this early summer scene, clouds cover much of the ice east of Smith Bay and nearly all of the pack ice. The continuous ice edge (C) is not clearly visible on this frame due to cloud cover; it has been mapped where possible by a dashed line. The continuous ice edge appears to have moved shoreward several km since 13 June. Some puddling and subsequent darkening of the continuous ice has occurred by this date, mainly in Dease Inlet, Smith Bay and shoreward of the barrier islands. Some open water (1) is present along the shore, especially at river mouths. Zone 2, which is the darkest toned, is the most heavily puddled ice. Zone 3, located approximately 20 km offshore, is also a fairly dark tone. This ice is of more uniform tone than that of zone 2, however. Two small areas, 2 to 3 km in diameter (designated A and B), of darker tone are located on the seaward edges of zone 3. The nature of this ice is uncertain; but perhaps grounded features, indistinguishable on these Landsat images, are responsible. Zone 4 consists of lighter toned, smooth-looking ice. This ice appears to be in an early stage of puddling, due to slight darkening in several areas. Zone 5 is fairly uniform, medium gray toned ice. The eastern boundary of this zone is uncertain due to cloud cover and is shown as a dashed line. Where visible, the pack ice (6) is fairly consolidated.



SHOREFAST SEA ICE

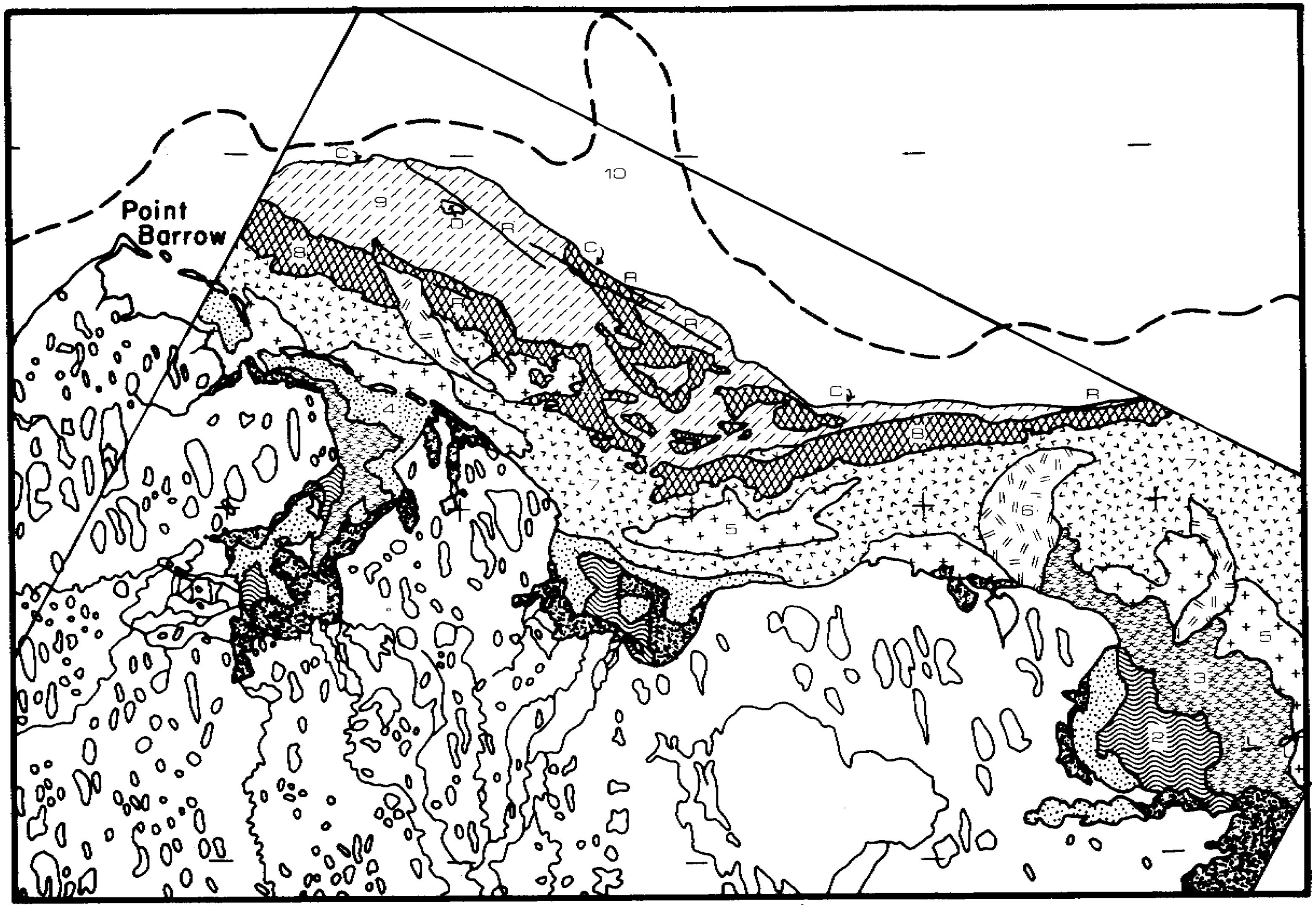
SURFACE MORPHOLOGICAL CHARACTERISTICS

BEAUFORT SEA COAST: BARROW SECTOR

29 June 1976

16 July 1976: Scene E-2541-21270

This frame covers the area from Iko Bay to Harrison Bay. There is more open water present (1) along the shoreline and in Dease Inlet and Iko, Smith and Harrison Bays than in the 29 June frame. The fast ice is still continuous, however, and there is a wide variation in puddling characteristics (zone 2-9). The pack ice (10) is quite consolidated, with the exception of an area of open water in the western part of the zone. The continuous ice edge (C) is fairly difficult to distinguish. Eight zones were delineated within the continuous ice. Zones 2 and 4 are composed of smooth, nearshore ice. Zone 2 is more heavily puddled and appears darker, while zone 4 is lighter toned and may be ice which has drained. Ice of mottled appearance, which is fairly dark-toned overall, composes zone 3. There are several leads (L) present within this zone in Harrison Bay. Zone 5 is also composed of ice of mottled tones, but it is quite light overall. Smooth-looking, medium gray-toned ice makes up zone 6. There is some variation in gray tone within zone 6, with the westernmost area being darker in tone, but the nature of the ice appears similar. Zone 7 covers a large area, extending across the frame. Overall the zone is a light tone, but there is some variation, mainly small areas of darker mottling. Zone 8 also covers a large area and consists of dark toned ice with some small areas of lighter mottling. There is some ridging (R) within this zone, mainly along the seaward boundary. The western end of zone 8 is coincident with zone 3 of the 29 June frame suggesting control by grounded ridges. Zone 9 is a fairly uniform medium gray tone, having some ridging (R) within it. An area of very dark tone (D), consisting of heavily puddled ice and/or open water, is present shoreward of a large ridge. The somewhat similar areas on the 29 June frame (A and B) are not present on the 16 July frame.



SHOREFAST SEA ICE

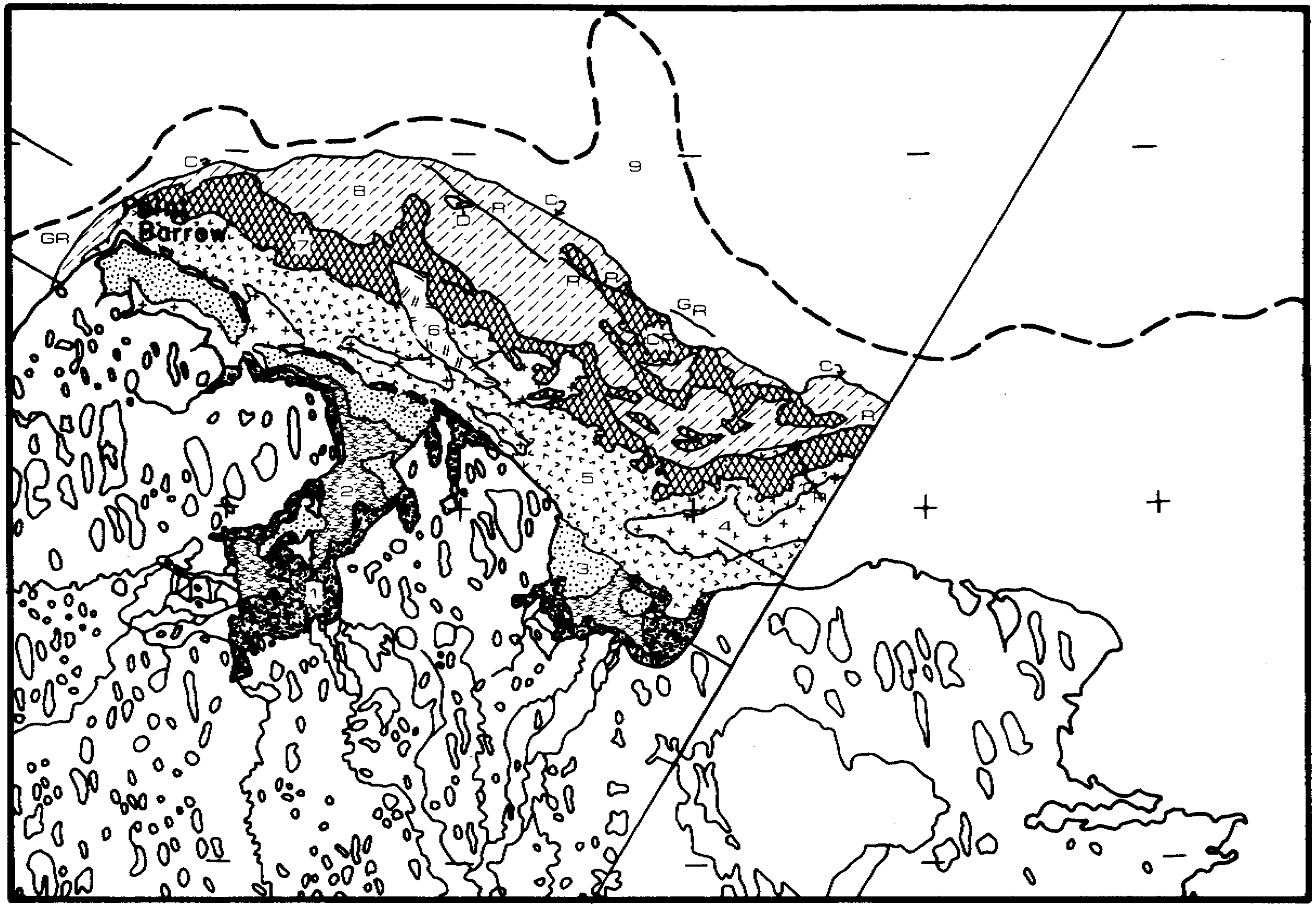
SURFACE MORPHOLOGICAL CHARACTERISTICS

BEAUFORT SEA COAST: BARROW SECTOR

16 July 1976

18 July 1976: Scenes E-21543-21382 and E-2543-21380

Very few changes have occurred in the ice since the previous frame (16 July) in the area of overlapping coverage. No ice movements can be observed between the two frames, but the ice is less consolidated in Dease Inlet and Smith Bay on the 18th. The continuous ice edge (C) is distinct on this frame. The pack ice (9) remains consolidated with the exception of open water along the shoreward edges in the western part of the zone. The fast ice remains continuous with a wide variety of puddling characteristics (zone 2-8). Open water (1) is present along the coast, especially in Dease Inlet and Smith Bay. Zones 2 and 3 are composed of smooth, nearshore ice. Zone 2 consists of darker, more rotten-looking ice, while in zone 3 the ice appears to have drained. Zone 4 is mottled ice of a fairly dark tone overall, while zone 5 is mottled ice with an overall light tone. There are a number of small, distinct areas of darker tone within zone 5, presumably due to increased melt. Smooth-looking, medium gray toned ice makes up zone 6. Zone 7 is composed of dark toned ice with a number of light toned linear features and some lighter mottling. There are several cracks (CR) in the seaward part of the zone, and it appears that the ice surrounding them will soon be part of the pack. Overall, zone 8 is a medium gray tone, although there is much tonal variation within this zone. There are several ridges (R) within this zone. The ridge system northwest of Pt. Barrow (GR) on the continous ice edge has remained stationary since the 25 February frame. Another ridge (GR), located just beyond the continuous ice edge north of Smith Bay, has also remained stationary since the 25 February frame. However, this ridge is not present on the next frame (2 August). The very dark toned areas (D) mentioned on the 16 July frame has remained in the same place, but now appears to be open water.

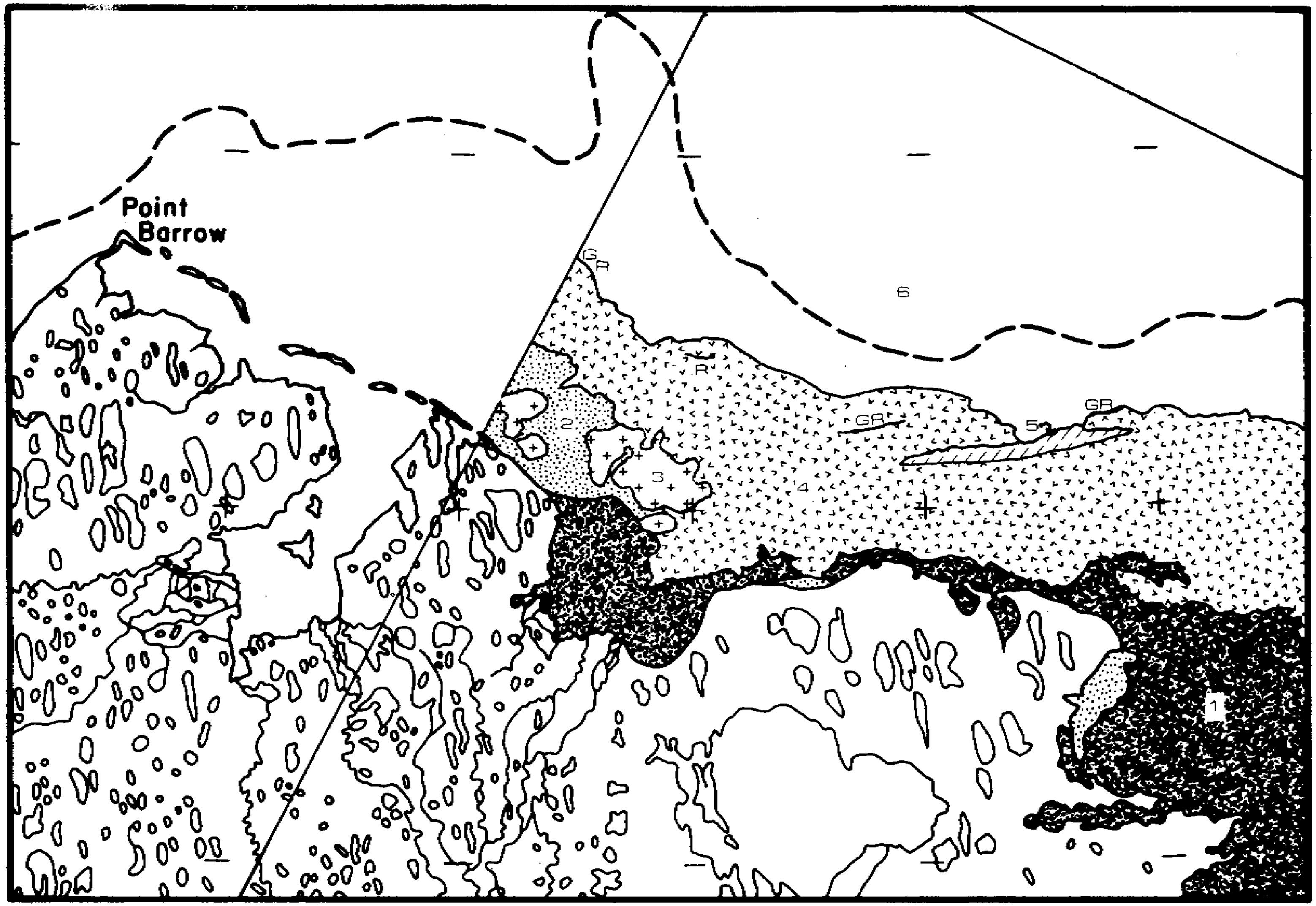


SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
BEAUFORT SEA COAST: BARROW SECTOR

18 July 1976

2 August 1976: Scene E-2558-21204

This late summer scene covers the area from Cape Simpson eastward. The fast ice is gone from Smith Bay and is nearly gone in Harrison Bay. Otherwise, the ice is still fairly close to shore, but appears quite uniformly rotten. Movements are very difficult to map because the ice has changed so much since the previous frame (18 July). Open water with small amounts of floating ice (less than 10%) is mapped as zone 1. Remnants of shorefast ice (2) are present in several places along the coast and consist of fairly dark gray, smooth-looking ice. Light toned, floe-like objects are mapped as zone 3. This ice appears to be smooth. Zone 5 is also light toned ice. This ice has remained stationary since at least the 16th of July. This ice was not mapped as a separate zone on the 16 July frame, because it did not appear significantly different from the ice to shoreward on this date. The remainder of the former continuous ice has been grouped as zone 4. The ice appears quite rotten overall, with many small areas of open water. There is a great deal of tonal variation within this zone. Four ridges have been mapped within zone 4. Three of them (GR) have not moved since the 16 July frame. The pack ice (6) is quite well consolidated on this date, but is also dark toned indicating extensive melt water, and the size of the floes is much smaller than on the 16th or 18th of July.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

BEAUFORT SEA COAST: BARROW SECTOR

2 August 1976

7 September 1976: Scene E-2594-21194 (not mapped)

On this frame, covering the area from Cape Simpson eastward, the continuous ice is completely gone. There is some loose pack ice located approximately 30 km offshore in approximately 40% concentration. No grounded features remained on this date.

APPENDIX 2

The following was submitted as part of this report:

Moritz, Richard E. (1977) "On a Possible Sea-breeze Circulation near Barrow, Alaska, Arctic and Alpine Research, Vol. 9, No. 4, pp. 427-431

Quarterly Report

Contract # 03-5-022-55
Research Unit # 250
Task Order # 11
Reporting Period: 10/1/77-12/31/77
Number of Pages: 2

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

Lewis H. Shapiro
William D. Harrison
Howard F. Bates
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

December 31, 1977

OCS COORDINATION OFFICE

Univeristy of Alaska

Quarterly Report for Quarter Ending December 31, 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:

During the past quarter, most of the effort on this project was devoted to preparation of a synthesis of the observations and data collected during the course of the program. This work is still in progress, and will be completed for inclusion in the annual report. In addition, some progress has been made in the study of the stress-related vibration of ice sheets, but no new results are available at present.

IV. Problems Encountered:

None

V. Esimtated Funds Expended: $10,000.

Quarterly Report

Contract #03-5-022-55
Research Unit # 257
Task Order #5/8
Reporting Period: 9/30/77 - 12/31/77
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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Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

December 31, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 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.

IV. Preliminary Interpretations:

The Beaufort and Chukchi Sea ice morphology maps have been used to identify areas with reasonably common morphology. These areas have been also interpreted as near shore ice hazard maps. These maps show the varying 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 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:

During this quarter we plan to continue our analysis of the 1976-77 ice season data, prepare for and attend the Beaufort Synthesis meeting and the Bering Synthesis meeting, and prepare our annual report.

VI. Problems Encountered/Recommended Changes: None

VII. Estimate of Funds Expended For This FY: 25%

VIII. Appendices: None

Quarterly Report

Contract #03-5-022-55
Research Unit #259
Task Order #259
Reporting Period: 9/30/77 - 12/31/77
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

December 31, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1977

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

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. and IV. Activities This Quarter:

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 was granted. The final report will be submitted in the near future.

V. Problems Encountered/Recommended Changes:

None.

VI. Estimate of Funds Expended:

$104,000.00 out of an extended total of $109,000.00.

Quarterly Report

Contract # 03-5-022-55
Research Unit # 265
Task Order # 6
Reporting Period: 10/1/77-12/31/7
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

December 31, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 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. The study of the one-dimensional, non-linear viscoelastic model for sea ice, described in the last annual report of this project, was continued with emphasis on finding a failure criterion for the model. In particular, the distortional strain energy criterion has been applied, with the assumption that failure occurs when that fraction of the applied stress-work which is conserved as elastic strain energy in the springs of the model, reaches some critical value. Using this criterion it is possible to calculate curves of the relationships of various parameters at failure for different loading conditions. Examples are strength vs. minimum-strain rate or time to minimum strain-rate for creep-rupture tests, and strength vs. strain-rate or loading rate for tests under those loading conditions. The relationships between parameters of the calculated curves closely follows the experimental results available from Peyton (1966). In addition, they are in good agreement with published results for polycrystalline fresh ice and for frozen soils.

   Study of the applicability of this failure criterion is still in progress, but should be completed in time for inclusion in the next annual report.

2. Based upon the results outlined above, the field program for the coming year has been revised to emphasize experiments required to test the predictions of the model. This in turn, resulted in the need to modify our strain measurement procedures and recording equipment. In addition, loading systems capable of instantaneously applying a high stress or a high constant stress-rate, to an in-situ sample, were also needed. These requirements have largely been met during the past quarter. Descriptions of these systems and their operation in the field will be included in the annual report.

IV. Problems Encountered:

None

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

QUARTERLY REPORT

Contract #03-5-022-55, Task 10
Research Unit #267
Reporting Period: October 1, 1977
to December 31, 1977
Number of Pages: 5

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

Albert E. Belon
Geophysical Institute
University of Alaska

December 31, 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: October 1 to December 31, 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 247 cloud-free Landsat scenes were selected and ordered from EDC at a total cost of $3944. 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. 193 NOAA scenes at a total cost of $2000.70 were acquired in 10" positive transparency format during the reporting period.

A catalog of remote-sensing data acquired during 1977 was prepared and distributed to OCSEAP investigators in November as OCSEAP Arctic Project Bulletin No. 17.

B. Operation and Maintenance of Data Processing Facilities

All the optical equipment for analysis of remote-sensing data was maintained operational and was used by OCSEAP investigators (see section D) during the reporting period.

A computer-driven film recorder (IGOR) is being tested for use by several remote-sensing projects at the Geophysical Institute. The IGOR recorder is used to produce black and white film products from remote-sensing data in digital magnetic tape format. Up to four channels of data can be simultaneously recorded on film ranging in size from 4x4" to 8x10". Current tests are being performed with Landsat data, although other data sources can also be used as input. The current mode of operation uses three IGOR channels to simultaneously record three registered Landsat images which can be subsequently reconstituted by photographic techniques to produce black and white or color images at the highest spatial and spectral resolution available in the original data.

The aerial cameras and film/paper processing equipment acquired on loan from several federal agencies in support of the OCSEAP-supported NARL airborne data acquisition has been checked. The aerial cameras appear to be in good condition but were received without either operation manuals or interconnecting electric cables. The latter will have to be constructed. The film/paper processing equipment was more of a disappointment. This equipment which was also received without operating manuals, is not in as good a condition as we were led to believe. The more serious problem is that it lacks attachments to handle roll film such as the NARL project will be producing. These accessories, if purchased rather than borrowed, would cost a minimum of $3500 and will require substantial time for installation and testing.

C. Development of Data Analysis and Interpretation Techniques

At this stage in the OCSEAP, the essential techniques have already been developed and are in use by investigators. The exception is our experimentation with the digital superimposition of two Landsat scenes from different dates which started during the last quarter in response to requirements of OCSEAP projects concerned with characterization of bird habitat on the North Slope coastal plain. Digital registration was accomplished this quarter. The two Landsat scenes selected to best differentiate vegetation development are from 18 July and 6 August 1976. The registered area of interest covers an area 24x12 km including Point Barrow. An eight channel digital magnetic tape was produced (2 registered scenes times 4 spectral bands). Training sets were selected to overlap ground-truth data acquired by OCSEAP investigators. Initial analysis of the eight-band tape offers promise that discrimination of coastal vegetation is enhanced by this combined multidate-multispectral analysis technique.

D. Assistance to OCS Investigators

Thirty-three OCS investigators made extensive use of our facilities and services during the reporting period. Their needs ranged from data searches and placement of data and work orders to utilization of data analysis equipment and cooperative studies.

Data purchases by OCS investigators totalled $4061 for orders placed to the National Ocean Survey for the magnificent aerial photography that NOS acquired for OCSEAP in summer 1977, $237 for orders placed to the EROS Data Center for Landsat data, and several hundred dollars in work orders for urgent or custom reproduction of selected data in our photographic laboratories. In addition most users performed analyses of library copies of data archived in our facility.

A display of remote-sensing imagery and products was prepared for the Bird and Mammal Review held in Fairbanks, 25-28 October, 1977. The display included samples of recently acquired imagery (SLAR, Landsat and aircraft photography); examples of computer analysis, surface circulation patterns and sea-ice mapping results.

Sea-ice investigators (Stringer, RU 257 and Burns/Shapiro, RU 230, 232, 248 and 249) and coastal geomorphology investigators (Cannon, RU 99) continued to be the most frequent and heavy users of our data and facilities. Examples of the range of users and their needs during the reporting period are:

Bill Sackinger, who asked for any remote-sensing imagery around his radar site at Barrow during the month of June. He looked through NOAA imagery and chose daily images through June 10, had enlargements made and sent to him. He later stopped in the office and we helped him locate areas on the NOAA imagery and looked through available Landsat data. We ordered two Landsat scenes which exceeded cloud specifications in hopes that they would be of use to him.

Steve Johnson, RU #467, LGL Ltd., Edmonton, Alberta, is involved in research in the Simpson Lagoon area of the Beaufort Sea. Last summer we looked for suitable daily NOAA images and sent them to him weekly. Now we are looking through Landsat images from June to November to find all available good imagery and have ordered copies for him.

David Drake - USGS, Menlo Park, after receiving the selected best Landsat scenes of the Bering Sea/Norton Sound area, has asked for a similar search for NOAA imagery of the area.

Don Fisk - National Marine Fisheries, Seattle, called and asked that we send him a complete set of catalogs of remote-sensing data.

Lee Lemericks, University of Alaska, is interested in using Landsat imagery to delineate surface characteristics of circulation patterns in the Norton Sound area under an OCS project.

Roger Hartz, USGS, Menlo Park, ordered all NOS aerial photography obtained this summer along the Chukchi and Beaufort Sea coasts.

Stu Rawlinson and Michael Moore, students of Jan Cannon's, spent considerable time looking at imagery of the Beaufort Sea coast in support of his OCS project.

Teri McClung and Lew Shapiro, used the color additive projector to view chips of radar imagery and also some Landsat scenes.

John Burns ordered slides of Landsat scenes for use in a talk he was giving on his OCS project concerned with the relationship of sea-mammals and sea-ice.

Kristina Ahlnas uses the NOAA imagery weekly in her work for Tom Royer involving the mapping of sea-surface temperatures.

Jan Cannon checks for new Landsat imagery regularly but also utilizes the NOS aerial photography and SLAR imagery for his OCS project.

Dr. Sharma looked at recent Landsat imagery of the Bering Sea and ordered copies of it for his studies of sea-surface circulation.

Ray Hadley, OCSEAP Coordinator in the University of Alaska Institute of Marine Science, and one of his visitors visited the remote sensing library to see what imagery was available here for OCS research.

Tom Osterkamp is a frequent user and keeps abreast of imagery useful to his OCS research on subsea permafrost.

Bruce Hasler, OCS, Anchorage District Office, visited our facility to become acquainted with what was available.

Dr. F. F. Wright, OCSEAP Juneau Project Office, asked for current imagery catalogs and also placed an order for Landsat imagery.

Many visitors of our facility are not formal OCSEAP investigators but their activities are related to OCSEAP and they are users of OCS remote-sensing data. Examples of such visitors are:

Russ Sorenson, Anchorage BLM, spent many hours looking at NOS map indices and ordered much imagery and a set of photo indices to aid in their coastal easement study.

Bill Fowler, BLM, ordered copies of all NOS photography within the NPR-A study area.

Dave Burbank, Alaska Dept. Fish & Game, asked for catalogs of latest remote-sensing imagery available. He also looked at the NOS aerial photography along the Bering, Chukchi and Beaufort Sea coasts. In the past year he has ordered much imagery to aid them in their work.

Weston Gardner, Research department of Mobil Oil Company, attended the Pecora Symposium in Sioux Falls, South Dakota and took special interest in a presentation made by Jan Cannon, RU #99. He asked for an index of SLAR imagery and any papers dealing with sea ice in the Beaufort Sea.

Reid Johnson, Geophysical Services, inqured about Landsat imagery available for the Beaufort Sea to aid in their winter seismic exploration work.

III. RESULTS

A catalog of all remote-sensing data (satellite and aircraft) acquired during 1977 was prepared as an update of previous catalogs and was distributed to all OCSEAP investigators in November 1977 as Arctic Project Bulletin No. 17.

Thirty-three OCSEAP investigators were assisted during the reporting period.

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

A. Problems encountered

Difficulties encountered by our and NARL's projects in the implementation of the OCSEAP airborne remote-sensing program and possible solutions will be discussed in early January with the OCSEAP Arctic Project Office.

B. Recommended change

Owing to increased responsibilities of the Principal Investigator in the administration of the Geophysical Institute it is likely that the renewal proposal for this project will be submitted in April under another P/I, John Miller, who also has extensive experience in remote-sensing. It is recommended that John Miller phase into the project during the next quarter in order to provide for a smooth overlap and continuation.

VI. ESTIMATE OF FUNDS EXPENDED

The estimated expenses of the project during the reporting period were approximately $10,000, of which $7,400 was for the purchase of remote-sensing data. In addition outstanding obligations totalling $18,000 were incurred for future purchases of remote-sensing data.

QUARTERLY REPORT

Contract #03-5-022-56
Recorder Unit #289
Task Order #19
Reporting Period 1 October-31 December 1977

Circulation and Water Masses in the Gulf of Alaska

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

31 December 1977

OCSEAP Quarterly Report - 1 October-31 December 1977

Thomas C. Royer
Institute of Marine Science
University of Alaska

I. Task Objectives

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

II. Field Activities

A. Cruises: DISCOVERER, DS005, 8-16 November and R/V ACONA, 8-15 November.

B. Scientific Party

DISCOVERER, D. Nebert, Chief Scientist
ACONA, J. Niebauer, Chief Scientist
D. Livingston, Graduate Student
W. Kopplin, Marine Technician
F. Waite, Marine Technician

C. Methods

DISCOVERER, CTD sampling
ACONA, STD sampling and current meter deployments

D. Sample Locations

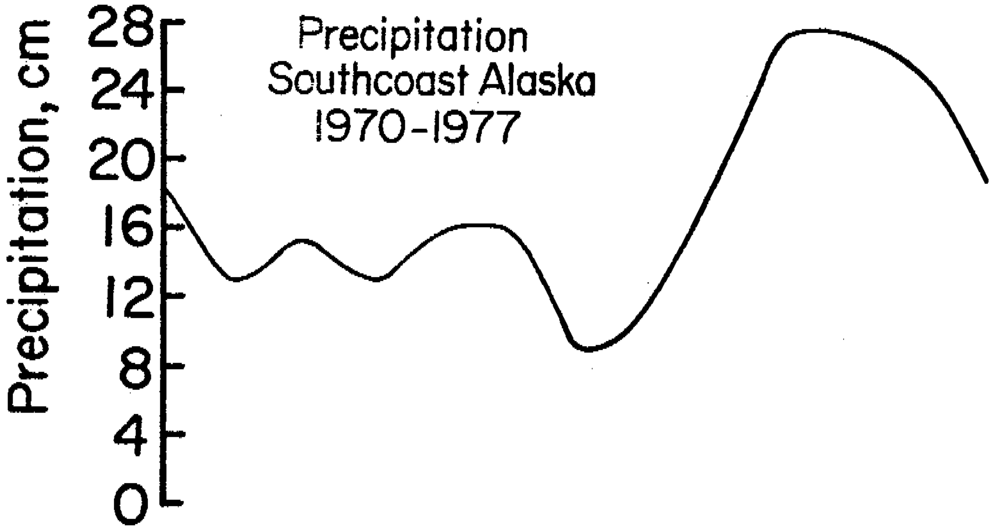
DISCOVERER, Kodiak Island Shelf and Seward Line.
ACONA, Prince William Sound and Hinchinbrook Entrance.

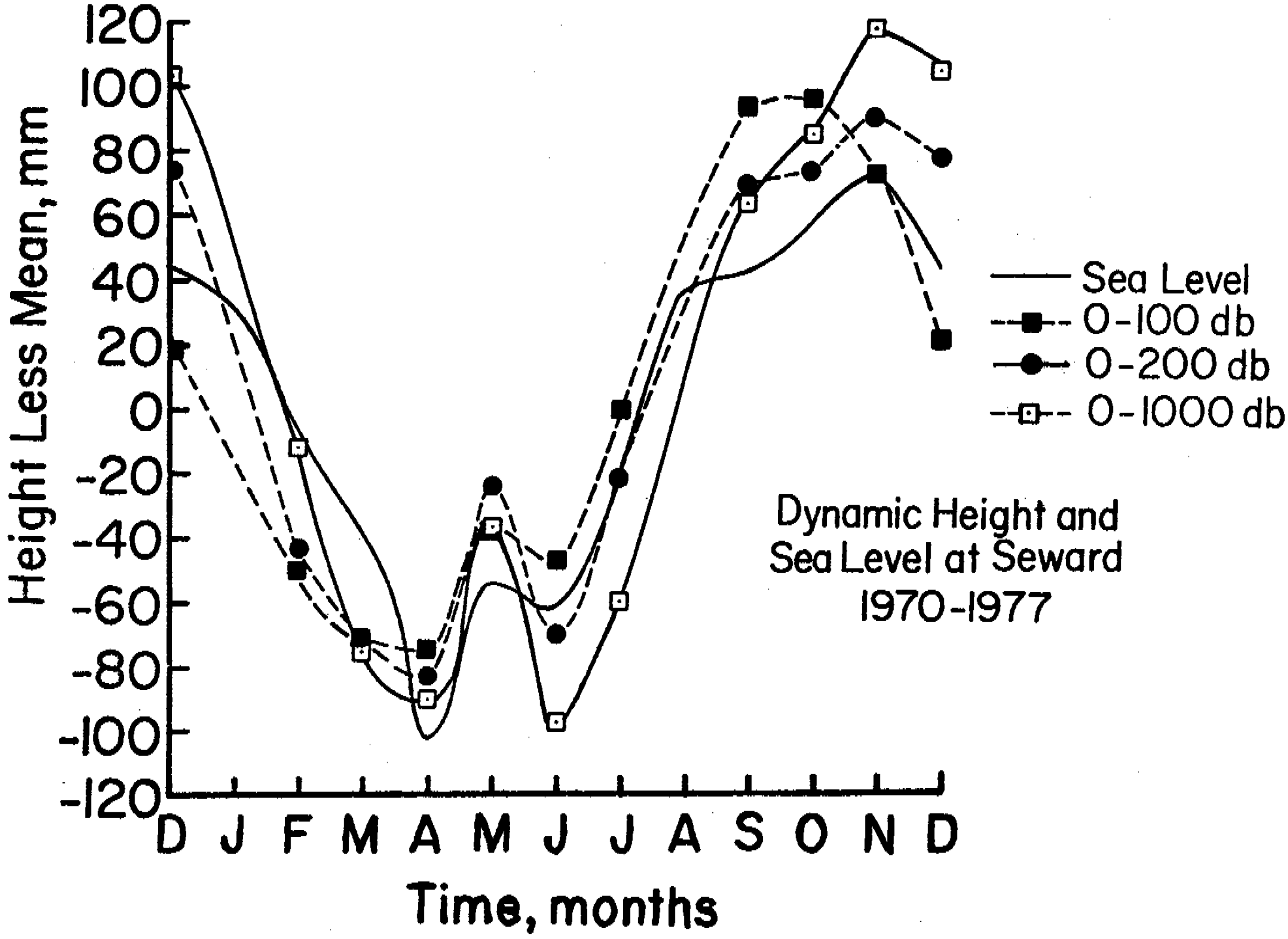
E. Data Collected

DISCOVERER, 94 CTD stations.
ACONA, STD stations and two current meter array deployments.

III. Results

A study of the sea level, dynamic height, precipitation and wind stress near Seward now enables the description of annual cycle of these variables (Fig. 1). The upper layer dynamic height (0-1000 db) has a maximum in September-October and minima in April and June with a sub-peak in May. The dynamic heights of the lower layers have peaks that are shifted toward the winter months. The (0-1000 db). It also appears that the barotropic component fluctuations are small here, since the sea level changes can be accounted for by the dynamic height changes. That is, the sea level slope does not change seasonally. Another result from this study is that gradient of dynamic height is well-correlated with precipitation.


Precipitation
Southcoast Alaska
1970-1977
Precipitation, cm
28
24
20
16
12
8
4
0


Height Less Mean, mm
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
D J F M A M J J A S O N D
Time, months
Sea Level
0-100 db
0-200 db
0-1000 db
Dynamic Height and
Sea Level at Seward
1970-1977

A numerical model of the circulation along the Seward line has been developed and tested. The current reversals observed at IMS 9 at certain times of the year can be duplicated in this model by altering the salinity at the outer end of the line. This simulates the coastal jet flow around Kayak Islands being trapped by the Alaska Stream.

IV. Preliminary Interpretation of Results

It is now conclusive that precipitation is the most important driving force over the continental shelf in the northern Gulf of Alaska. Peaks in current speeds are expected in mid to late fall with the highest currents due to precipitation in the upper layers. Beneath the upper layer, wind stress becomes important in controlling the circulation. Southeast Alaska and south coast Alaska are the regions of greatest rainfall with amounts decreasing toward Kodiak and offshore. The shelf circulation near Kodiak might be controlled by precipitation over the eastern portion of the Gulf of Alaska and then modified by the local winds.

V. Problems Encountered

The CTD accuracy problem has yet to be corrected, though we are now in the process of assisting with its definition. It should have been corrected with haste since there exist six months of CTD with known inaccuracies. It must be corrected prior to the upcoming field season.

The new ship schedule does not include any ship time for this research unit in the western Gulf of Alaska. Work in the western gulf was included in the work statement. It is important that the time series for this area continue, especially in light of it having different circulation characteristics from the eastern part.

QUARTERLY REPORT

Contract No. 03-5-022-56
Research Unit No. 347
Reporting Period: Oct. 1977
through Dec, 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

Dec. 21, 1977

Dec. 21, 1977

QUARTERLY REPORT

For the Period Ending Dec. 31, 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. The color keys and proofs of the first two volumes were available for checking the week of December 5 and they were checked at Boulder by Gene Cote of the AEIDC graphics staff by December 13. Volume III proofs should be checked by the end of December at AEIDC. Printing should begin immediately and the printing of all 3 volumes should be finished by the end of January 1978. The final product will have a sewn and glued binding with a plastic cover.

IV. N/A

V. N/A

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1977

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 25

PRINCIPAL INVESTIGATOR: Mr. James L. Wise

Period July 1, 1975 - December 31, 1977 (30 months)

	Total Budget	Expended	Remaining
Salaries & Wages	58,093	61,511	(3,418)
Staff Benefits	10,445	10,963	(518)
Equipment	-0-	-0-	-0-
Travel	2,540	2,708	(168)
Other	6,426	5,607	819
Total Direct	77,504	80,789	(3,285)
Indirect	30,551	31,920	(1,369)
Task Order Total	108,055	112,709*	(4,654)

*Preliminary cpst data, not fully processed.

QUARTERLY REPORT

Contract No. R7120848
RU: 367
Reporting Period:
1 October - 31 December 1977
Number pages: 10

Coastal Meteorology

R. Michael Reynolds

Pacific Marine Environmental Laboratory

28 December 1977

Task Title: Coastal Meteorology

PI: R. Michael Reynolds
NOAA/PMEL
3711 15th Avenue N. E.
Seattle, Washington 98105

Reporting Period - 1 October - 31 December 1977

I. Task Objectives

A. To characterize the regional wind field in three areas, Albatross Banks, Lower Cook Inlet, and Hichenbrook Entrance. To make measurements as necessary and analyze data sufficient to define mean seasonal circulations. Priority and emphasis will be placed on Lower Cook Inlet.

B. To relate observed over-water winds to winds computed by the meteorological model adapted from Lavoie under R. U. 140.

II. Field and Laboratory Activities

A. Cruises: None

B. Field Experiments: The two remote meteorological stations which were installed at Pt. Riou and Pt. Manby have been recovered and returned. These stations are undergoing repair and calibration in preparation for deployment in the LCI area.

C. Laboratory Activities:

1. An OCSEAP Physical Oceanography/Meteorology Review Meeting was held on 9-11 November and Providence Heights Education and Conference Center, Issaquah, Washington. Mr. Reynolds attended.

2. Mr. Reynolds and Mr. Hiester attended the ERL Mesoscale Modeling Workshop held 26-27 October in Boulder, Colorado. Mr. Reynolds presented a paper on model verification. Before leaving Boulder area Mr. Reynolds met with ERL scientists concerning possible programs involving the RFC instrumented aircraft in Alaska.

3. Mr. Hiester attended the NCAR sponsored workshop on cloud modeling held in Boulder on 24-25 October.

4. A review of the general wind fields in Lower Cook Inlet is well underway. Historical data is being collected and examined to derive seasonal wind patterns in the vicinity of Homer and Kenai. Ten years of historical data from Anchorage, Kenai, and Homer are included in this effort. Present data from the data buoys are being analyzed in the light of historical data.

5. Mr. Macklin visited several locations in Alaska. The purpose of the trip was to familiarize ourselves with facilities and persons from which data can be obtained. Weatherservice personnel, pilots, and ferry crew were included in the interviews. A summary of that trip is included at the end of this report.

APPENDIX

Coastal Meteorology FY77-78

TRIP REPORT

28 November to 3 December 1977

S. A. Macklin

Coastal Meteorology - Field Operations FY77-78

Information Assembled From Fact-Finding Trip to Alaska

Itinerary:

11/28/77 Fairbanks, Alaska

Geophysical Institute

11/29/77 Homer, Alaska

Federal Aviation Agency
National Weather Service
Kachemak Air Service, Inc.
Division of Marine Highways - Tustumena

11/30/77 Anchorage, Alaska

National Weather Service
Arctic Environmental Data Information Center
Bureau of Land Management, OCSEAP

12/2/77 Juneau, Alaska

Division of Marine Highways
National Weather Service
NOAA-OCSEAP Project Office

Geophysical Institute, Fairbanks

The purpose of this discussion was to research the possibility of integrating two PMEL remote weather stations into an existing Lower Cook Inlet seismic network telemetering to a data recording facility in Homer. G. I. personnel involved in the discussion were Jurgen Kienle (seismic P.I.), Dick Siegrist (Engineer) and Neil Davis (Deputy Director).

In order to make use of this net, three hurdles must be surmounted. First, the Cook Inlet network must be upgraded. The system was installed as an afterthought and the electronics employed are cast off from other projects. Each station will require an amp/vco,(perhaps) a mixer, new transmitter and recorder and two antennas. These costs will run between $5K and $10K. Second, the seismic data is recorded on 16 mm film, automatically processed, and delivered to Firbanks for analysis every 5 days. This scheme does not facilitate the analysis of meteorological data. Therefore it is advised that we provide our own data recording system - possibly data logger or Rustrak recorder. Third, the Institute's next scheduled trip to service the network is June, 1978. Thus for early 1978 installation, PMEL must provide transportation, meals and lodging, and labor costs for G.I. personnel to accomplish the hookup. Additional expenses are incurred for PMEL personnel travel and for helicopter charter. Because of these unanticipated extra costs for equipment and installation, it is likely that a more attractive alternative exists.

FAA/NWS, Homer Alaska

On November 29 I met with Ed Klott, FAA Station Chief, and Don Otto, FAA weather observer. The possibility of installation of a PMEL pressure sensor and hourly logging of its output value was discussed. Generally the idea was favorably received although proper channels need be followed. Winter is the slack season and the extra observation would pose no problem. In summer, however, there is much more air traffic. Hourly weather observations are conducted by Don Otto during the day and by Francie Walters (NWS) at night. Pressure measurements are made from the station altimeter. Wind observations are sometimes not representative of Kachemak Bay conditions.

Kachemak Air Service, Inc., Homer, Alaska

On a tip from Ed Klott, I met with Bill DeCreeft, a local pilot who has been flying Lower Cook Inlet for 13 years. Bill was very knowledgeable about local wind conditions, and offered the following comments.

During the late summer and fall there is often a strong west wind flowing through the Kamishak gap between the Aleutian Range and the Chigmit Mountains. He has on occasion observed 100 knot winds at Bruin Bay. This flow is often accompanied by water spout formation along the cliffs south of Contact Point and at Pedro Bay on Iliamna Lake and at Iniskin Bay north of Augustine Island. These winds apparently achieve their strong velocities from orographic channeling as they are observed to dissipate quickly after diverging into Cook Inlet, although they are still measurable at Augustine Island. All of the Geophysical Institute sites are sheltered from this wind except for those on Augustine Island. Mount St. Augustine itself generates fairly frequent katabatic winds (willi-wahs) and lee wake effects.

Winter drainage winds are not too pronounced in Lower Cook Inlet. The strong winds pouring out of Knik and Turnagain Arms are diminished south of the Forelands. Drainage winds often flow from upper Kachemak Bay and from Douglas Glacier on the west side. In the case of Kachemak Bay winds, the Homer hourlies might not be accurate.

Throughout the region (including Shelikof Strait) by far the most unpredictable (and damaging) winds arise from westerlies. The Barren Islands are particularly notorious for local violent winds.

In light of the above information, Bill DeCreeft suggests remote weather stations be installed at Bruin Bay and Augustine Island. Further information on Kamishak Bay winds can perhaps be obtained through conversation with a Seldovia fisherman, Joe Carlough (234-7642).

Division of Marine Highways, Alaska Ferry *Tustumena*

The *Tustumena* sails weekly between Seward and Homer via Kodiak in the winter, and in the summer season adds an additional Seward-Cordovia-Seward run. A few years back the Alaska ferries were instrumented (temperature, pressure, wind speed and direction) at the request of Lief Lie, MIC, NWS Juneau. The purpose of my visit to the *Tustumena* was to determine the frequency and reliability of meteorological observations conducted by the ship.

In the event of their shortcoming, a PMEL meteorological package can be installed during the Tustumena's January Puget Sound in-port.

I talked at length with Dave Renwick, 3rd Mate, one of the weather observers. He seemed highly competent, having spent many years as a weather observer, including a long stint aboard ocean station "N". The ship maintains a Bridge Log with entries of time, position, course (true and magnetic), wind speed, wind direction, pressure, temperature and weather description. These entries are logged at every course change (at least every 2 hours). In addition a log of Marine Coastal Weather Observations is kept with entries every four hours when in International Waters. Included are position, present weather, visibility, wind speed and direction, sea state, air temperature, barometric pressure, and pressure tendency. These observations are radioed to Kodiak and relayed from there to Anchorage NWS.

Wind speed and direction are measured by a standard NWS cup anemometer and wind vane with bridge dial indicators. When I was aboard, Renwick complained about inaccuracy of wind speed measurements (dial reads an estimated 15 knots too low). As a result, all wind speed entries in the log were in Beaufort force scale as determined by sea state observation!! Temperature is read from two indoor/outdoor thermometers, one on either side of the bridge. Both outdoor temperatures are sampled at observation time, the lower is recorded. Pressure is measured by an aneroid barometer calibrated yearly by Don Olson, Port Meteorologist, NWS Seattle.

The Tustumena's winter schedule (beginning March 1978) is as follows:

dep. Seward	Monday	0755
arr. Kodiak		2200
dep. Kodiak		2330
arr. Seldovia	Tuesday	1200
dep. Sledovia		1230
arr. Homer		1310
dep. Homer		1545
⋮		⋮
arr. Seward	Wednesday	1900

This schedule cannot, as a rule, be maintained by the Tustumena and several hours leeway must be allowed. Course changes in the study area occur at Tonki Cape, in the middle of the Barren Islands, at Dangerous Cape and in Kachemak Bay.

As the Tustumena is only in the study zone on Tuesdays it is impractical to devote a PMEL meteorological setup for ship-board installation. Providing that the existing instrumentation is serviced and operating, ship's observations should be adequate for our research purposes.

National Weather Service, Anchorage, Alaska

On November 30, 1977 I met with Ed Diemer, Chief Forecaster, and Gerry Morrell, Communications, to discuss the climate of the three study areas, data products, and AMOS availability.

Ed Diemer will be a very useful source of empirical methods for forecasting coastal winds. Various algorithms have been developed for the Barren Islands, Valdez, etc. Of all the study sites Albatross Banks is best predicted by the synoptic net. For flow from the N and NW surface winds are observed to die out at night, then pick up to their 850 mb value during the day.

Upper Cook Inlet (roughly from Anchorage to Kenai) exhibits strong seasonal orographic funneling of the surface air flow. Drainage winds flow S in the winter; the flow direction is reversed in the summer. These upper Cook Inlet winds are little affected by passage of synoptic disturbances in the Gulf of Alaska.

Lower Cook Inlet winds are more influenced by storms tracking through the Gulf. Besides this, streaming winds from the Kamishak Gap, drainage winds from the Kenai Mountains, Mount St. Augustine and Mount Douglas, and strong winds in the Barren Islands are dominant features of the Lower Cook Inlet wind field. The Barren Island winds are at times computed by multiplying the King Salmon-Kodiak pressure difference by five for cold air and by four for warm air!

Less information was offered on Hinchinbrook Entrance and Prince William Sound weather patterns. This body of water is horseshoed by mountains and glaciers to the east; north; and west and protected from the Gulf to the south by a chain of islands with elevation to 3,000 feet. Because of the fjord structure there are many pockets that are isolated from the regional circulation, only flushing under certain conditions. At Valdez, for example, air spills over into the airport with speeds approaching 50 knots when the 500 mb flow is from the N or NW at 50 knots or better. It is doubtful if this surface wind sustains as far as the tanker terminal. Twenty-five knot drainage winds are often observed at the Whittier dock when the 850 mb chart indicates warm air advection around a low pressure center. I have asked Diemer to prepare a list of forecasting "tricks" (with physical justification when possible) for the study areas.

PMEL will be provided with Xerox copies of hourly observations (and upper air soundings where applicable) of select stations beginning January 1, 1978. The copies will be mailed monthly for the following stations:

<u>Cook Inlet</u>:

Kodiak (NWS)
King Salmon (NWS)
Anchorage (NWS)
Iliamna (FAA-day/AMOS-night)
Kenai (FAA)
Homer (FAA-day/NWS-night)
Big River Lake (contract-day)
Shuyak Island (coastal winds)
2 Oil Rigs in North Cook Inlet

Hinchinbrook Entrance:

Valdez (NWS)
Cordova (FAA)
Whittier (contract)
Seward (contract-day)
Johnstone Point (contract)

The Shuyak Island coastal wind station is a Labarge satellite relay station providing wind data only. I have requested that NWS Anchorage install a pressure sensor. A similar unit will be installed on Naked Island, Prince William Sound, in early 1978.

Additional data is available from the AMOS stations at Middleton Island and Cape Hinchinbrook. This data is not archived and must be accessed each hour or it is lost. Gerry Morrell suggests that we request the MIC Seattle NWS to receive from Kansas City FAA an hourly collective of AMOS and coastal wind stations in our study areas. The central computer will automatically scan all data at a given time each hour (say minute 45) and group together under a collective heading those requested stations for teletype output in weattle. Hopefully this output can be filed and forwarded to us on a weekly or daily basis by NWS personnel. Cloyd Shirley, Kansas City FAA, (8-926-7191) can shed more light on this service.

The NWS instrumentation in Lower Cook Inlet is supervised by Wayne Henderson, Anchorage NWS. It is felt that the FAA pressure observations at Kenai, Homer, and Iliamna are as accurate as those from the upper-air stations. These FAA facilities employ an altimeter which is checked weekly against either a mercurial standard or a second altimeter.

Arctic Environmental Information and Data Center

Jim Wise has taken over the position vacated by Bill Serby's retirement. Little has been published on weather regimes of any of the study areas. There are 3 NWS papers on ice in Cook Inlet, a mediocre publication Alaskan Coastal Weather, and an oceanographic paper by Dave Burbank, Alaska State Department of Fish and Game, Circulation Studies in Kachemak Bay and Lower Cook Inlet, March 1977. Local climatological summaries are available for Homer, Valdez and Nodiale through NCC in Asheville. Revised Uniform Summary of Surface Weather Observations, an Air Force ETAC publication, is available for Kenai, Cordova, Kodiak, and Middleton Island. This gives annual and monthly summary and diurnal variations of wind, temperature and precipitation. Bill Brower, NCC Asheville, maintains an Alaska Climatic Weather file (RU#496) containing all observations. This can be a good source of marine observations. Dean Dale, EDS, can perhaps arrange near-real-time transmittal of this information. Brower can be reached at 8-677-0266. An interesting satellite photo (GIL 078:20-46:40 6125 V3F4474 18 Mar 76 N4 135 7E) shows visible flow through the Kamishak Gap.

Jim suspects there are drainage winds out of deeper valleys on the Kenai Peninsula, especially across Tustumena Lake. Pat Wennekens, AEIDC, recounted the tale of a plane flight he took from Homer to Kenai in late October. The normal route is to fly inland up the peninsula at 2500 feet. Because of strong drainage winds the plane had to fly around Anchor Point and up the coast to Kenai. During the flight the surface waves and water transport were observed to be westerly across the Inlet completely dominating the strong north-south current.

Bureau of Land Management, Anchorage

I talked with Jerry Imm, OCS, as Jim Seidel was in Seattle. Jerry pointed out the wind trajectory work based on Putnin's climate classification. This work is contained in the Final Environmental Impact Statement for Lower Cook Inlet, and is the logical springboard for our Lower Cook Inlet study.

With regard to access of data from oil companies, Jerry suggested contacting Dick Miller and Charles Phail of Dames and Moore. (Dames and Moore are contracted to forecast for the oil rigs.) The oil rig Ocean Ranger and one other are now on standby in Lower Cook Inlet awaiting startup of operations in February or March. Marathon, Phillips, and Arco were the big spenders in the tract.

Jerry also had a wind story to tell: In February 1976, he went to Lake Hood Airfield (just north of Anchorage). Just as he was arriving there was a freak wind storm of about 10 minutes duration. A wedge of cold dense air came from the Chugach Mountains and descended on the air field (an area of about 8 mile on a side). The wind socks, about 600 yards apart, were straight out and pointing at each other. The wings on about 30 aircraft were smashed downward or broken off completely, but none of the aircraft were broken loose from their diedowns.

Division of Marine Highways, Juneau, Alaska

I met with Herb Stetson, Port captain. I reported that it would probably not be necessary to mount any PMEL gear on the Tustumena.

Because the Division was changing buildings I did not have access to four years of weather logs from the Tustumena.

National Weather Service, Juneau, Alaska

I met beiefly with Lief Lie, MIC, to inform him of the Tustumena's anemometer problem. He will take care of it. I will board the Tustumena with Don Olson, Seattle, NWS, during the Puget Sound in-port this winter.

NOAA/OCSEAP Project Office, Juneau, Alaska

Here I discussed our field plan for the coming year with Mauri Pelto and George Lapiene. The NWS wind forecasting methods will be most helpful in predicting coastal winds. The proposed pressure net will provide added information for refining or expanding these methods. George agreed to help us get data from the oil rigs which are in LCI.

Implications to Field Operation: F4-1977-1978

Pressure Net:

Existing Stations --

1. Kodiak
2. King Salmon
3. Anchorage
4. Iliamna
5. Kenai
6. Homer
7. EB-39
8. Phillips oil rig
9. Big River Lake (occasional)
10. Tustumena (occasional)

An "nth" order polynomial fit requires $n.\frac{n+1}{2}$ reporting stations, thus

order	#stations
3	6
4	10
5	15

AIDJEX suggests 20% more stations than the minimum required. Without addition of PMEL pressure sensors we should have a solid 3rd order array. Should problems arise, additional sensors can be installed at Snug Harbor cannery on Chisik Island and at Chinitna Bay on the west side of Cook Inlet, and on the populated coast between Kenai and Homer.

The software can be run as often as each hour using boundary conditions derived from NWS charts or Fleet Numerical.

Occasional visits with a calibration standard to all sources are to be conducted near the beginning, middle and end of the field season.

A similar operation can be carried out in Prince William Sound using a 3rd order fit.

Remote Weather Stations

It has been decided to bypass the Geophysical Institute telemetry system in favor of purchase of two Aanderaa remote weather stations. These stations are capable of sampling hourly for a 6 month period without attendance.

They will be installed on the SW side of Augustine Island and at Contact Point on Bruin Bay. These sites will give excellent indication of Kamishak Gap winds and drainage winds from Mt. St. Augustine.

The Climatronic sensors are now free for installation in populated areas. Prime sites are Homer Spit and on the coast between Homer and Kenai.

Installation can be performed as early as March 1 at project expense or by NOAA helicopter in late April concurrent with installation of a portable laboratory on Iliamna Bay.

AR-1784-NOAA
DECEMBER 1977

PROGRESS REPORT
1 October 1977 - 1 December 1977
Research Unit #435

MODELING OF TIDES AND CIRCULATIONS OF THE BERING SEA

Prepared for: DEPARTMENT OF COMMERCE
(National Oceanic and Atmospheric Administration)

Contract No.: 03-6-022-35249

Progress Report

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

National Oceanic and Atmospheric Administration

October 1, 1977 - December 1, 1977

Jan J. Leendertse and Shiao-Kung Liu

This is the beginning of the second phase of the study. During this reporting period the emphasis of our efforts has been centered around the following areas:

1. The Bristol Bay model has been modified and re-schematized to incorporate the field data collection program scheduled for this fiscal year. The model realignment will also allow us to take full advantage of data obtained previously from the range of pressure gauges and current meters between Pribilof Island and Nunivak Island, as shown in Fig. 1.

2. In addition to the model realignment, both the horizontal and vertical grid structure of the Bristol Bay model have been rearranged. The new arrangement will allow us to obtain much more improvement in the vertical resolution (i.e., from 7 to 15 layers) to incorporate the recently obtained field data on the vertical non-uniformity of the Bay current system without sacrificing too much horizontal resolution. The new setup also makes the time integration procedure twice as efficient as compared to the previous version.

3. It is our intention to use the new version of our three-dimensional computational program for the simulation of both the Bristol Bay and Norton Sound models. This new version of the program gives an accurate account of the arbitrary bathymetry at each spatial grid location, thus allowing for more precise computation of wave propagation in the model. In the meantime, the accuracy of the calculated currents in the lower layers is expected to be improved.

4. On October 13, 1977 a meeting between the Project Officer, Mr. M. Pelto of OCSEAP in Juneau, and Dr. R. Charnell of the Pacific Marine Environmental Laboratory in Seattle and Rand's investigators was held in Santa Monica. At that meeting an overview of the progress of our investigation was presented and we discussed extensively our data requirements. It appears that these requirements will be met.

5. During the reporting period both investigators participated in the Physical Oceanography Workshop set up by the Outer Continental Shelf Environmental Assessment Program Office at Providence Heights, Washington during November 9-11, 1977. At that meeting results from Phase I of this study were presented. Aspects of investigator-data management interaction were discussed.

6. We are beginning to set up the Norton Sound model for running with the "variable bottom" version of the code. Some changes at the model's open boundary are expected.

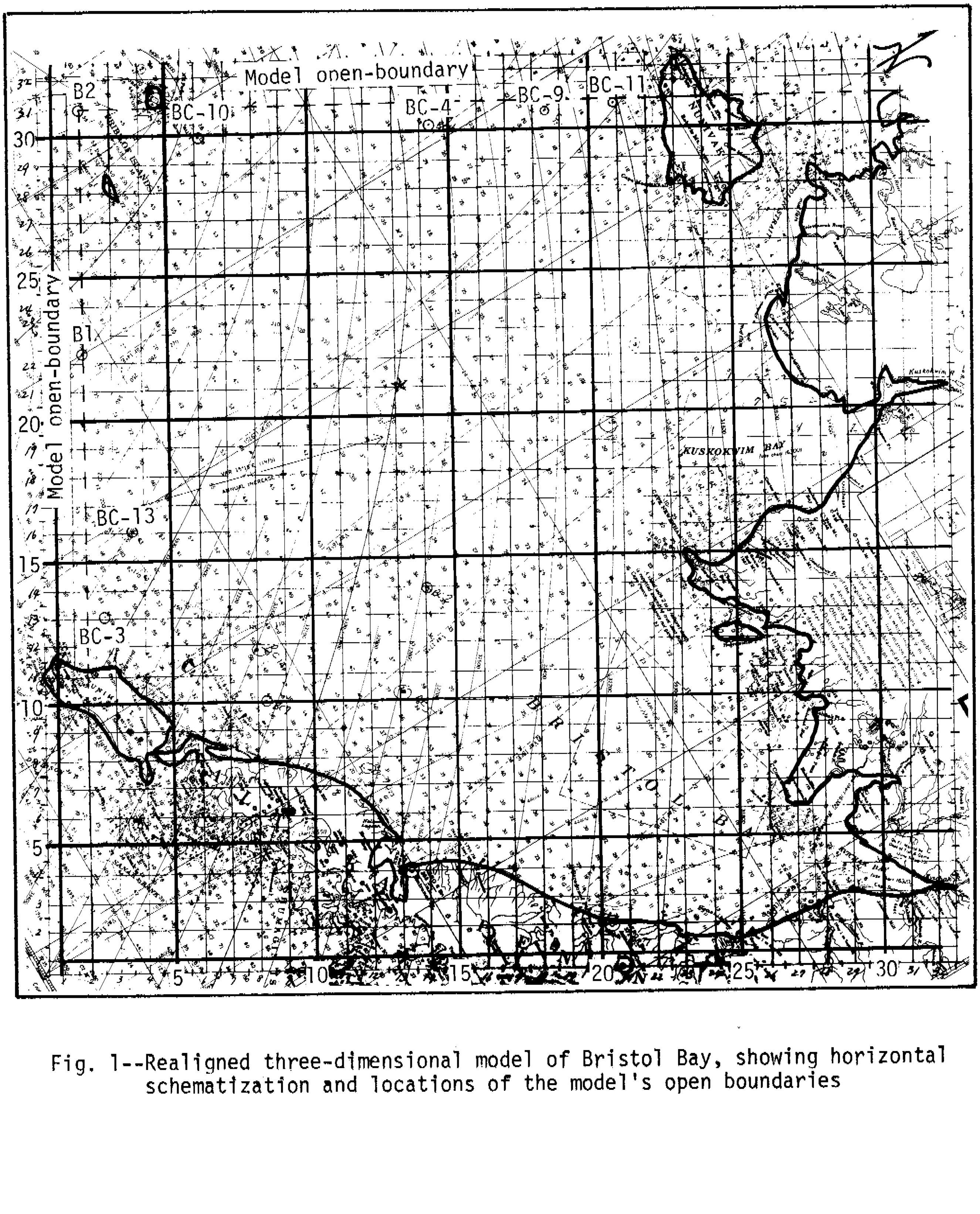


Fig. 1--Realigned three-dimensional model of Bristol Bay, showing horizontal schematization and locations of the model's open boundaries

QUARTERLY REPORT

Contract: 03-5-022-67 TO 11
Research Unit: 519
Reporting Period: 1 Oct. - 31 Dec. 1977
Number of pages: 5

COASTAL METEOROLOGY OF THE ALASKAN ARCTIC COAST

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Research Scientist

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1 January 1978

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

None.

III. Results

The atmospheric data is now being reduced. Sea breeze modeling is underway.

IV. Preliminary Interpretation of Results

1. Sea Breeze

Typical turning angles (α) for the calculated surface geostrophic wind vs. the measured 10-meter wind direction are 20°-60° counterclockwise. Pilot balloon data (Pingok Island) has shown anomalous α's of 110°-180° clockwise on 33% of the days during the August experiment. Rawinsonde data from Barter Island examined for the July-September 1976 time period indicated a 30% frequency of similar anomalies. This effect appears due to a persistent positive thermal gradient from sea to land (summer) coupled with a non-steady state sea breeze pulse occurring at maximum temperature gradient on relatively clear days. Due to the scale (mesoscale), frequency of occurrence and effect of this phenomenon on National Weather Service (NWS) predictions, a model incorporating these features should be implemented for areas along the Alaskan arctic coast.

2. Barrier Winds

Barrier wind analysis is proceeding; some results are shown and discussed here. At present it appears that Barter Island and Brownlow Point both experience the barrier flow as discussed by Schwerdtfeger. Figure 1 shows the point of measurement and the wind values for 3 May 1977. The symbols are U_N, Narwhal wind; U_{bw}, Brownlow wind; and U_{br}, Barter wind. In general, the barrier has the effect of contributing an offshore component to the flow at both Brownlow Point and Barter Island. It is likely that the local surface pressure field created orographically completely dominates the large-scale pressure field in the planetary boundary layer. Figure 2 shows wind data for several days in May, 1977. In the upper plot surface wind direction differences are shown between Narwhal Island, assumed to be unaffected by the barrier, and the other sites. The implicit assumption that all three sites should have the same undisturbed flow contributes perhaps 20° error to this analysis. This assumption will not be required when the geostrophic winds are computed. In the lower part of Figure 2 the Narwhal direction, Narwhal speed and Barter speed are shown. The Narwhal direction establishes two regimes of flow for about 240° and 70° during this period. Barter Island winds are shown affected by both wind regimes since they each have an onshore component while Brownlow winds are affected only on the northwesterly flow. This is consistent with the geography of the area. Barter speeds are generally slightly larger than Narwhal speeds in the period of 240° Narwhal flow.

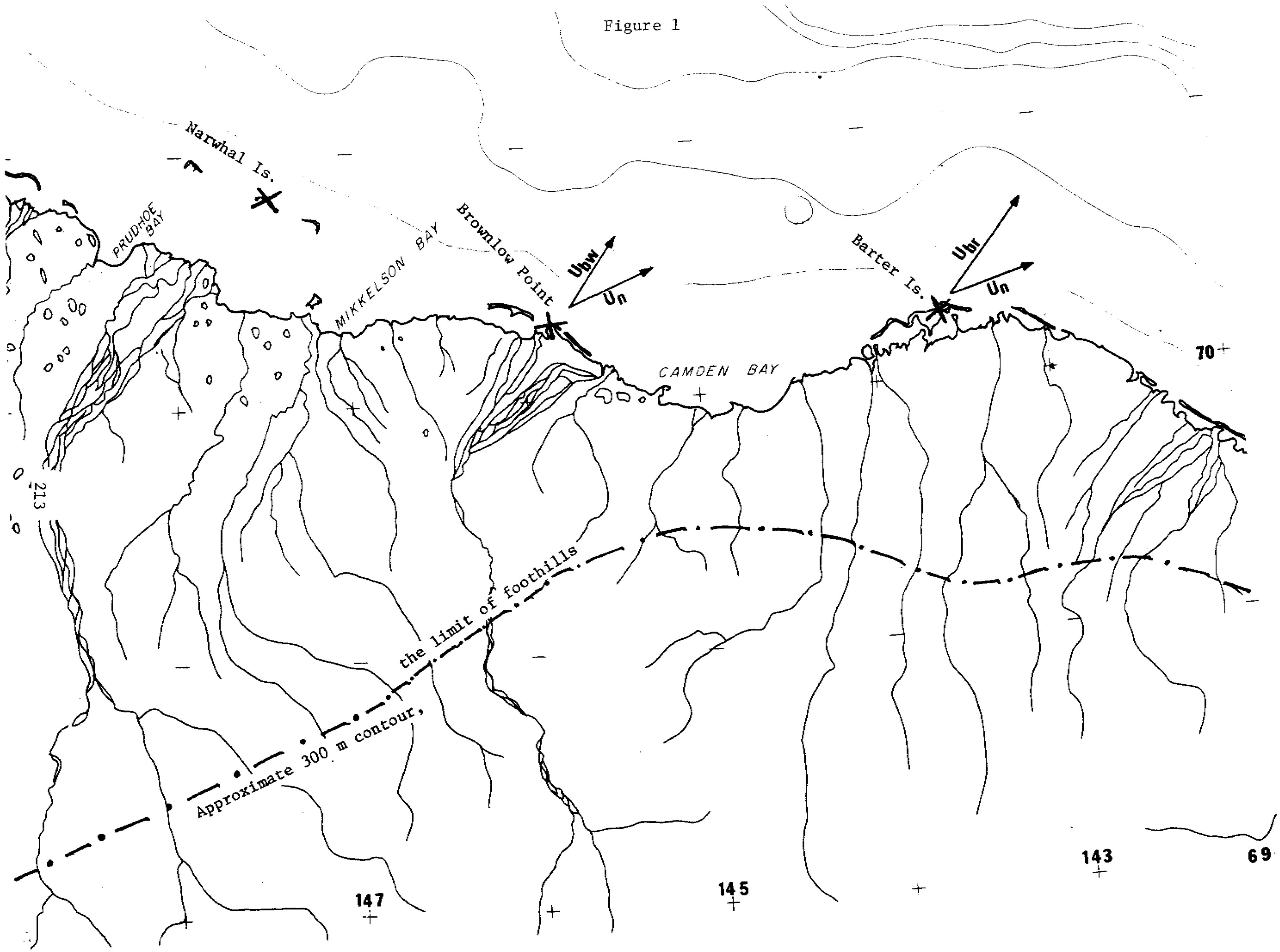
V. Problems Encountered and Recommended Changes

None.

VI. Estimate of Funds Expended

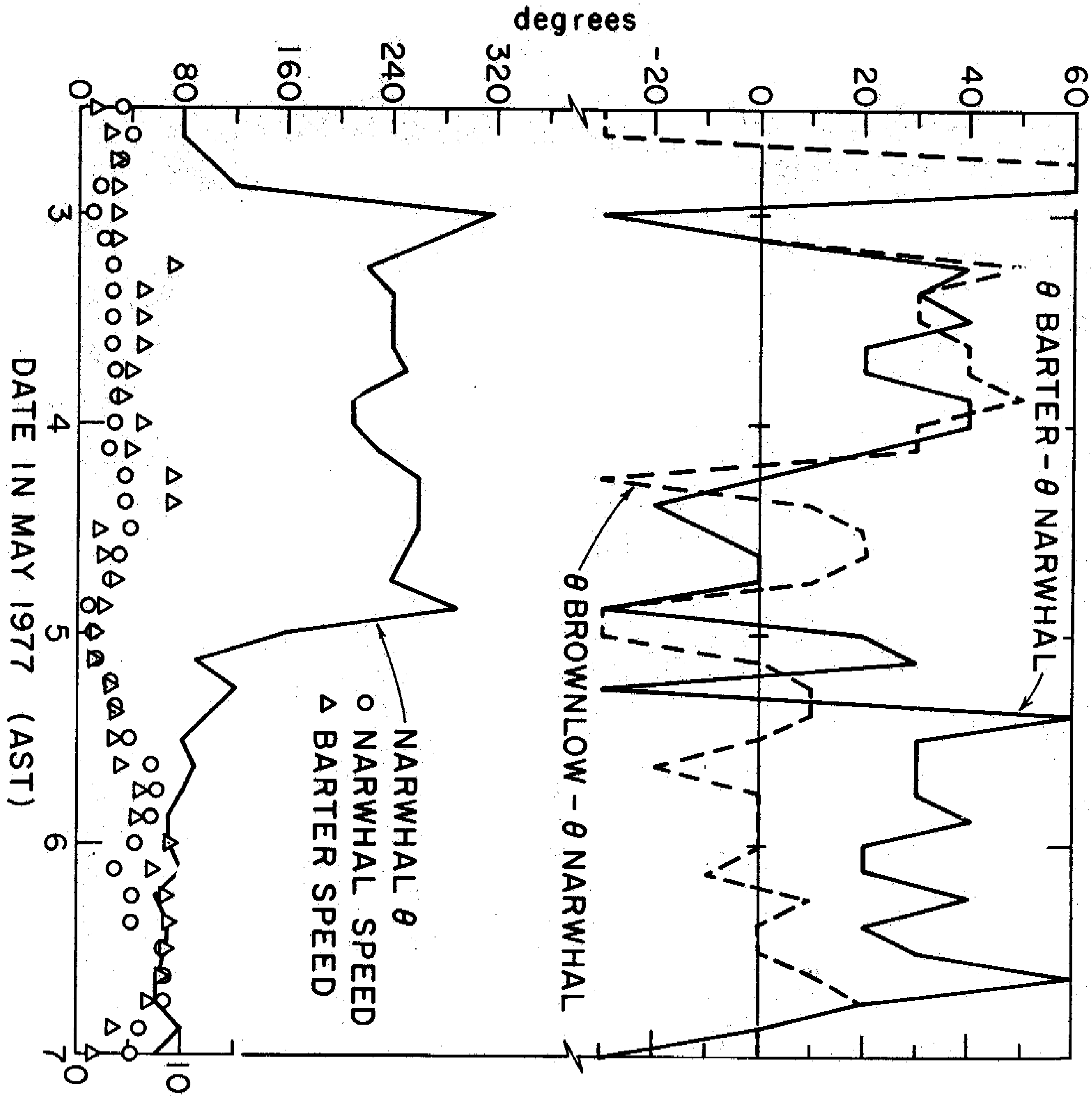
As of 1 January 1978, expenditures under this contract will come to $6,300.00 out of an allocation of $51,914.00

Figure 1



Narwhal Is.
PRUDHOE BAY
MIKKELSON BAY
Brownlow Point
Ubw
Un
Barter Is.
Ubr
Un
CAMDEN BAY
70
213
the limit of foothills
Approximate 300 m contour,
147
145
143
69

Figure 2


θ BARTER − θ NARWHAL
θ BROWNLOW − θ NARWHAL
NARWHAL θ
○ NARWHAL SPEED
△ BARTER SPEED
degrees
60
40
20
0
-20
320
240
160
80
0
3
4
5
6
7
DATE IN MAY 1977 (AST)
10
0
SPEED (m/sec)

Quarterly Report

Contract # 03-5-022-56
Research Unit # 526-77
Task Order # 13
Reporting Period: 10/1/77 - 12/31/77
Number of Pages: 4

CHARACTERIZATION OF THE NEARSHORE HYDRODYNAMICS OF AN ARCTIC BARRIER ISLAND-LAGOON SYSTEM

J. B. Matthews
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Geophysical Institute
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December 31, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 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.
None

B. Scientific Party.
N/A

C. Methods.
N/A

D. Sample Localities.

E. Data Collected or Analysed.

Analysis has proceeded on two magnetic tapes of current meter records and one tide gauge tape. Information on surface drifters has been received from field observers. The drifter recovery information is being analysed for possible trajectories and minimum daily speeds. Our data are being examined in the light of related data gathered by other research units.

III. Results:

Current meter 2169 and Tide gauge TG 196 were recovered from the channel between Spy and Leavitt Islands. The current meter recorded at 5 minute intervals from 8 August to 12 September 1977. The tide gauge recorded at 3.75 minute intervals for the period of 8 August 1977 to 16 September 1977.

Current meter 2169 had all sensors working for only 5 hours after deployment. Thereafter the speed sensor ceased to record. However the current direction did produce records as did the temperature and conductivity sensors. The first five hours' records showed a northwesterly flow declining from about 40 cm per second to zero and then a growing southeasterly and easterly current. This corresponded to a period during which the winds changed from westerly to easterly and later grew into a major storm. The anomalous current direction is probably the result of the meter recording the current in a deep channel curving around the Spy Island spit; the current is constrained to follow the channel. This interpretation is confirmed by the salinity and temperature observations which show fresher warmer coastal water leaving the lagoon and cold saline water entering through the channel. After about 10 days of strong easterly winds and an increase in sea level of about 1 m. we begin to see pulses of highly saline water (36-40^{o}/oo) leaving the lagoon.

The temperature records generally show warm water to be less saline than cold water except for the highly saline water in which no temperature characteristic is distinguishable from ambient. The temperature sensor on the tide gauge generally follows that of the current meter temperature sensor but with a lag of several hours. The lag probably results from the temperature sensor on the tide gauge being inside the case. Sea level records show levels changing by as much as a meter over several days as well as shorter term variations.

Current meter 2257 recovered from between Stump Island and the Arco Causeway recorded from 13 August 1977 to 16 September at 5 minute intervals. Errors were found to occur fairly regularly at 12 sample perioas for all sensors. Currents flowed into (southwards) and out of the lagoon with different wind and sea level conditions. The highest currents (>15 cm/sec) corresponded with inwards flowing water. Water flowed out of the lagoon only occasionally. Warm temperature (4-5^{o} C) was generally associated with less saline water (24-26^{o}/oo); cold temperatures (1-2^{o}C) with saline water (30-32^{o}/oo). Highly saline water (>32^{o}/oo) was not observed.

IV. Preliminary Interpretation of Results:

Coastal water of low salinity (< 28^{o}/oo) and high temperature (> 4^{o}) appears to stay close to the coastline and probably originates from the coastal rivers. The instrument between the Arco dock and Stump Island shows alternate pulses of coastal water and cold (<2^{o} C), saline (> 30°/oo) water flowing past it into the lagoon. Changes in wind direction appear to be associated with the current direction but the details are still being determined.

The water in the deep channel between Spy and Leavitt islands shows similar changes in water mass characteristics. However the warm (> 5° C) brackish water (24-26°/oo) is much warmer (up to 10°C) than any observed near the Arco dock. Moreover pockets of highly saline water were also observed in the 3rd week in August. The warmer water probably comes from the Colville river, the mouth of which is only a few kilometers from the instrument site.

The observation of highly saline water was not expected so late in the season. It does not appear to be of instrumental origin since all other sensors seem to operate satisfactorily at the same time and the conductivity sensor returns to lower 'normal' values repeatedly. The preliminary assessment is that pockets of hypersaline water may remain from the ice covered season and survive erosion by quite violent storms. Highly saline cold water overlain by warm brackish water is very stable and requires high values of velocity shear to raise the Richardson Number to critical values. It is unfortunate that the current speed sensor was inoperative during this time period. It is also regrettable that we do not have really detailed bathymetry of the lagoon to ascertain the existence, size and distribution of isolated pockets.

The tide gauge results are being corrected for barometric pressure provided by RU 526b. Tidal harmonic analyses will be run on the corrected data and the surge information extracted.

V. Problems Encountered / Recommended Changes:

The major problem encountered during this quarter is the lack of good bathymetric data on the Simpson Lagoon and entrances. It is also apparent that the lack of redundancy in the field instrumentation leads to frustrating data gaps in critical periods. To overcome these problems a good precision depth recorder for use in extremely shallow water from a small boat equipped with a good navigation device would be required. The redundancy problem could be solved by the acquisition of 8-10 more Aanderaa current meters equipped with pingers.

VI. Estimate of Funds Expended:

Approximately $115,000 remains of the total authorized budget.

QUARTERLY REPORT

Contract: 03-5-022-56
Research Unit: #529-77
Reporting Period: 10/1/77-12/31/77
Number of Pages: 12

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

31 December 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 other 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. LABORATORY ACTIVITIES

Laboratory work since October 1977 has included the analyses of the grain size distributions of Simpson Lagoon and some North Slope fluvial sediments that were collected in summer 1977. The conventional grain size statistical parameters for most of the lagoonal sediments have been computed.

In addition to the above, the clay mineral compositions of the less than 2 μm fractions of representative sediment samples from the Simpson Lagoon, Ugnuravik and Canning Rivers have been quantified. A suite of 80 bottom sediment samples have been selected from the Simpson Lagoon and the Continental Shelf area extending between Barter Island and Demarkation Point for baseline heavy metal, organic carbon, nitrogen and phosphorus analyses. These samples were oven-dried at 90°C. One split of the dried sample was finely pulverized and the other coarsely ground for the purpose of total and extractable heavy metal analyses respectively. Concentrations of vanadium in the "extractable" (or readily mobilized) fraction have been determined on 40 sediment samples of the Simpson Lagoon.

Currently analysis of the grain size distributions of the shelf sediments of the Barter Island - Demarkation Point area is in progress.

Between December 14 and 16, Dr. Naidu visited with Drs. Peter W. Barnes and Erk Reimnitz at the U.S. Geological Survey (Menlo Park) for consultation and to obtain splits from four vibrocore samples that were collected by the former two from the Simpson Lagoon. Splits of approximately 10-cm core sections were sampled and shipped to Fairbanks for stratigraphic analysis of lithology and coarse fractions.

Three size grades of sands (i.e., coarse, medium and fine size modes) have been separated by sieving from each of the gravelly-sand samples that were collected last summer from all the major barrier islands extending from the Demarkation Point to Point Barrow, as well as from all the major river beds of the North Slope of Alaska. Heavy minerals will be separated and studied from these sands.

Methods

Grain size distributions of the sediments were analyzed by the usual sieving-pipetting method, and the conventional statistical grain size parameters were computed after the formulae given by Folk and Ward (1957). Details on the procedure of clay mineral analysis have been included in Mowatt *et al.* (1974). Briefly, the clay minerals compositions were determined by X-ray diffraction on the < 2 μm fraction of sediments, and the method outlined by Biscaye (1965) was followed to quantify the various minerals.

Vanadium in the Acetic acid-Hydroxylamine hydrochloride extracts (Chester and Hughes, 1967) was analyzed by neutron activation analysis, using the isotope dilution technique. The latter technique is a slightly modified version of the one developed by Weiss *et al.* (1977). The TRIGA nuclear reactor at the University of California, Irvine, California was used for irradiation purposes. In addition to Dr. Naidu, Mike Sweeney (graduate student) participated in the analysis with technical help provided by Dr. H. V. Weiss of NOSC (San Diego).

III. WORKSHOP PARTICIPATION

Dr. Naidu participated in the OCSEAP-sponsored LGL modelling workshop at the University of British Columbia, Vancouver. Attempts were made to refine the previous Simpson Lagoon ecosystem model that was based on limited data. Presumably Dr. J. Truett of the LGL, Inc. will submit a detailed account of the entire proceedings of the workshop to the OCSEAP Office, and therefore no attempt is being made to duplicate that in this report.

IV. RESULTS

In Table 1 are included the statistical grain size parameters of the Simpson Lagoon bottom sediments.

The clay mineral compositions in the less than 2 μm size of the Simpson Lagoon sediments are included in Table 2. Results of the analysis on two samples of the Canning River clays show that the clay mineral assemblage in

TABLE I

STATISTICAL GRAIN SIZE PARAMETERS (AFTER FOLK AND WARD, 1957)
OF THE SIMPSON LAGOON BOTTOM SEDIMENTS

Sample #	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Md	M_Z	σ_I	Sk_I	K_G
SL877-1	1.5	2.80	93.53	3.21	0.47	1.780	1.53	1.42	-0.40	2.03
SL877-1A	1.5	0.0	83.21	14.95	1.84	2.250	2.73	1.21	0.63	2.85
SL877-1B	1.5	0.0	91.73	6.79	1.48	2.220	2.21	0.74	0.24	2.73
SL877-1C	1.5	0.0	89.77	8.44	1.79	2.260	2.27	0.89	0.31	3.19
SL877-1D	1.5	0.0	87.68	10.70	1.62	2.290	2.29	0.99	0.33	3.77
SL877-1E	1.5	0.0	86.34	12.54	1.12	2.280	2.33	0.91	0.34	2.99
SL877-2	1.8	0.0	95.79	3.44	0.78	1.740	1.72	0.62	-0.06	1.26
SL877-3	2.6	0.0	40.48	48.81	10.72	4.330	4.56	2.62	0.16	0.88
SL877-4	2.1	0.0	22.11	64.34	13.55	5.140	5.38	2.22	0.13	1.06
SL877-5A	1.8	0.0	34.35	60.38	5.27	4.250	4.52	1.57	0.35	1.09
SL877-5B	1.8	0.0	54.07	41.06	4.87	3.870	4.24	1.72	0.33	1.27
SL877-5C	1.8	0.0	48.60	45.91	5.49	4.040	4.44	1.70	0.38	1.20
SL877-5D	1.8	0.0	53.21	41.97	4.81	3.950	4.27	1.67	0.31	1.23
SL877-6	-	-	-	-	-	-	-	-	-	-
SL877-7	-	-	-	-	-	-	-	-	-	-
SL877-8	-	-	-	-	-	-	-	-	-	-
SL877-9	1.5	0.0	28.39	63.07	8.54	5.170	5.07	1.97	-0.00	0.92
SL877-10			N O		S A	M P	L E			
SL877-11	2.1	0.0	17.78	74.50	7.72	4.510	5.02	1.83	0.33	1.46
SL877-12	2.1	0.0	34.44	59.22	6.34	4.220	4.58	1.82	0.28	1.59
SL877-13	2.4	0.0	8.25	85.82	5.93	4.710	5.08	1.32	0.44	1.58
SL877-14	2.3	0.0	41.05	51.03	7.92	4.250	4.41	2.16	0.15	1.11
SL877-15	1.8	2.55	77.79	15.19	4.47	2.080	2.79	2.34	0.42	2.60
SL877-16	-	-	-	-	-	-	-	-	-	-
SL877-17	0.6	4.93	75.48	15.96	3.63	2.050	2.16	2.68	0.02	2.51
SL877-18	0.5	0.0	59.91	33.95	6.13	3.320	4.04	1.99	0.52	1.02
SL877-19	3.2	0.0	71.59	24.84	3.57	2.630	3.16	1.34	0.76	1.23
SL877-20	2.6	0.0	88.77	9.32	1.91	2.530	2.60	0.75	0.60	5.01
SL877-21A	-	-	-	-	-	-	-	-	-	-

TABLE I

CONTINUED

Sample #	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Md	M_z	σ_I	Sk_I	K_G
SL877-21B	2.9	0.0	18.53	69.62	11.85	5.270	5.40	2.04	0.13	1.10
SL877-21C	-	-	-	-	-	-	-	-	-	-
SL877-21D	2.9	0.0	20.08	70.11	9.81	5.000	5.20	2.06	0.15	1.23
SL877-22	2.4	0.0	11.89	81.63	6.48	4.670	5.10	1.36	0.50	1.41
SL877-23	2.4	0.0	27.00	66.73	6.27	4.810	4.61	2.09	-0.08	1.10
SL877-24	1.5	0.0	77.13	18.89	3.98	2.640	2.85	1.89	0.28	1.65
SL877-25A	2.6	0.0	67.93	27.84	4.23	2.320	3.29	2.10	0.65	1.03
SL877-25B	2.6	0.0	71.52	26.53	1.95	2.250	3.10	1.94	0.63	0.96
SL877-25C	2.6	0.0	66.19	28.96	4.85	2.460	3.39	2.14	0.63	0.88
SL877-26	3.0	0.0	21.95	72.18	5.88	4.370	4.96	1.51	0.52	1.40
SL877-27	3.0	0.0	22.06	71.43	6.51	4.38	4.77	1.64	0.41	1.32
SL877-28	2.7	0.0	16.20	73.48	10.32	4.84	5.38	1.68	0.45	1.00
SL877-29	2.4	0.0	25.22	64.85	9.93	4.66	4.96	2.22	0.17	1.17
SL877-30	1.1	0.0	80.40	18.60	0.99	1.92	2.41	1.47	0.41	1.28
SL877-31	-	-	-	-	-	-	-	-	-	-
SL877-32A	-	-	-	-	-	-	-	-	-	-
SL877-32B	-	-	-	-	-	-	-	-	-	-
SL877-32C	-	-	-	-	-	-	-	-	-	-
SL877-32D	-	-	-	-	-	-	-	-	-	-
SL877-33	2.1	0.0	54.33	37.55	8.11	2.730	3.92	2.34	0.68	0.66
SL877-34	-	-	-	-	-	-	-	-	-	-
SL877-35	-	-	-	-	-	-	-	-	-	-
SL877-36	2.1	0.0	42.71	47.80	9.49	4.400	4.63	2.27	0.22	0.77
SL877-37	2.3	0.0	40.88	51.69	7.43	4.350	4.43	2.10	0.15	0.85
SL877-38	2.3	0.0	28.98	59.63	11.39	4.740	4.83	2.45	0.09	0.93
SL877-39	2.0	0.0	39.80	48.30	11.89	4.390	4.51	2.75	0.06	0.85
SL877-40	1.5	0.0	76.98	19.22	3.80	2.440	2.84	1.79	0.41	2.03
SL877-UG1	0.8	0.0	62.75	31.74	5.51	3.250	3.56	1.98	0.31	1.52

TABLE II

WEIGHTED PEAK AREA PERCENTAGES (AFTER BISCAYE, 1965) OF CLAY MINERALS IN THE LESS THAN 2 MICRON FRACTION OF SIMPSON LAGOON SEDIMENTS

Sample #	Expandable	Illite	Kaolinite + Chlorite
SL877-2	5	67	28
SL877-6	8	59	33
SL877-9	4	63	33
SL877-13	14	54	32
SL877-14	3	66	31
SL877-21D	3	67	30
SL877-23	3	66	31
SL877-24	6	63	31
SL877-25D	11	60	29
SL877-5A	5	66	29
SL877-12	7	63	30
SL877-4	4	65	30
SL877-17	2	65	33
SL877-11	10	59	31
SL877-19	6	64	30
SL877-1D	6	63	31
SL877-7	2	71	27
SL877-20	10	57	33
SL877-29	5	68	27
SL877-26	13	54	33
SL877-22	10	60	30
SL877-3	9	55	36
SL877-1	Trace	71	29

that river consists predominantly of illite (82 and 84%) with lesser amounts of chlorite and kaolinite (16 and 18%) and no expandable phases. The Ugnuravik River clays have about 10% of expandable components with 59% of illite and 31% of chlorite and kaolinite. At this point in time slow X-ray scans have been made of the 3·5Å region of all clay samples in attempting to resolve the quantity of chlorite and kaolinite, and the actual calculations have yet to be made.

Table 3 shows the concentrations of vanadium in the readily extractable portion of the Simpson Lagoon sediments.

V. PRELIMINARY INTERPRETATION OF RESULTS

It would seem that most of the Simpson Lagoon sediments analyzed by us are constituted of poorly-sorted muddy sands with occasional gravel content. As it is to be expected, there is a general increase in the mud contents of sediments from the lagoon shores to the relatively deeper central portion of the lagoon.

Based on our knowledge of the clay mineral assemblages of the major rivers of the North Slope and the Simpson Lagoon, it would seem that the lagoon is predominantly impacted by sediments from the Kuparuk River. The only portion of the lagoon which receives identifiable amounts of the Colville River clays is the area situated on the northwest corner of the lagoon (south of the Spy Island). These conclusions are well substantiated by the observed turbid fluvial plume patterns in the continental margin of the North Slope.

TABLE III

VANADIUM CONCENTRATIONS (μg/g) IN ACETIC ACID - HYDROXYLAMINE HYDROCHLORIDE EXTRACTS (CHESTER AND HUGHES, 1967) OF SIMPSON LAGOON SEDIMENTS

Sample No.	Vanadium (μg/g)	Sample No.	Vanadium (μg/g)
SL877-1D	3·1	SL877-18	7·5
SL877-2	3·2	SL877-19(1)	1·9
SL877-3	6·1	SL877-19(2)	1·9
SL877-4	7·2	SL877-21D	7·0
SL877-4a	7·8	SL877-22	5·4
SL877-5A	4·9	SL877-24	4·0
SL877-5B	4·5	SL877-25C	4·3
SL877-5C	5·1	SL877-27	6·3
SL877-6	6·2	SL877-28	6·3
SL877-8	2·6	SL877-29	7·4
SL877-8a	2·4	SL877-30	1·8
SL877-9	5·1	SL877-31	7·5
SL877-11	6·5	SL877-32B	4·8
SL877-11a	6·1	SL877-33	4·3
SL877-13	5·7	SL877-37	5·1
SL877-14(1)	5·8	SL877-38	9·0
SL877-14(2)	4·9	SL877-40	3·6
SL877-14(3)	4·3	SL877-40(2)	2·5
SL877-15	5·0	Ugnuravik R.	3·8
SL877-17	4·0		

Analysis of the Canning River clays shows that those fluvial clays have quite a distinctive clay mineral assemblage, inasmuch as there are no expandable minerals and very little kaolinite. Earlier we have pointed out that the clays of the Colville, Kuparuk, Sagavanirktok and the Mackenzie Rivers have significant amounts of expandable clay minerals as well as kaolinite. In addition, the Canning fluvial clays (< 2 μm size) characteristically have considerable amounts of calcite. The only other fluvial clays from the North Slope which do have a little calcite are those from the Sagavanirktok River. Further, it would seem that the expandable components in the Sagavanirktok and Kuparuk Rivers, upon 1N K^+ saturation, and subsequent glycolation (and not subsequent to 1N Mg^{++} saturation and glycolation) collapse, indicating that the expandable components are most likely degraded (depotassicated) illites. However, the expandable phases of the Colville River clays, as has been shown earlier by us (Mowatt *et al.*, 1974) either do not collapse or collapse very little subsequent to 1N K^+ or Mg^{++} saturation and glycolation. The latter experiment suggests that the Colville clays have well-defined discrete smectite and/or mixed-layered smectitic phases in them. In conclusion, it would seem that the clay mineral assemblages of the various North Slope fluvial clays are significantly distinctive to be of potential use as natural tracers to identify the sources, transport pathways and depositional sites of fine-grained particles in the Beaufort Sea.

At this point in time we have not had the opportunity to analyze the vanadium data on sediment extracts.

VI. PROBLEMS EXCOUNTERED/RECOMMENDED CHANGES

Discussions with Drs. Peter W. Barnes and Erk Reimnitz of the U.S. Geological Survey have led us to believe that they are also concerned with temporal changes and growth of the barrier islands of the North Slope area. This study would constitute a part of their OCSEAP commitments. Additional information on barrier island morphology would be coming forth from Dr. Jan Cannon who is also an OCSEAP investigator. Consequently, no duplication of this effort will be made under our OCSEAP contract, and we will make the best use of the data gathered by the above investigators.

Earlier it was our feeling that the interpretation of the stratigraphic changes in both lithology and structure of the Simpson Lagoon cores would be a straight-forward simple effort, and that the recapitulation of the Holocene paleogeography of the North Slope Continental Margin area and thus the origin of the barrier islands would not be too difficult to follow. However, it would seem that the recent paleogeographic history of the Simpson Lagoon area has been quite complex, as indicated by the stratigraphic dissimilarities observed between the four cores that were collected from not too widely apart locations within the lagoon complex.

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QUARTERLY REPORT

Contract Number: 03-5-022-56
Research Unit: #530
Task Order: #6
Reporting Period: 10/1/77-12/31/77

THE ENVIRONMENTAL GEOLOGY AND GEOMORPHOLOGY OF THE BARRIER ISLAND - LAGOON SYSTEM ALONG THE BEAUFORT SEA COASTAL PLAIN FROM PRUDHOE BAY TO THE COLVILLE RIVER

Dr. P. Jan Cannon

December 31, 1977

QUARTERLY REPORT FOR THE QUARTER ENDING DECEMBER 22, 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 Colville River

Principal Investigator: Dr. P. Jan Cannon

I. Task Objectives

1. To determine the origin and evolution (geomorphic history) of the barrier islands and coastal lagoons. Future projections of the duration of the barrier islands, and of the coastal morphology are part of this objective.
2. To determine the source(s) of the gravel size materials that compose 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 plain such as the various streams, dune fields, ground patterns, thermokarst features, deltas, pingos, lugs, and lakes.
5. To construct a spacial and temporal model of the environmental geology of the region. This may include a geological hazards map.

II. Activities

A series of aerial reconnaissance flights were done during different times of the year to observe and document coastal processes and changes. The flights were as follows:

1. June 14, 1977 (Cannon): Ice breakup.
2. July 27, 1977 (Rawlinson): Mid summer; flight followed by several days of ground reconnaissance.
3. August 15, 1977 (Cannon, Rawlinson): Mid summer; flight followed by several days of ground reconnaissance.

4. October 1, 1977 (Cannon, Rawlinson): Freezeup.
5. November 22, 1977 (Rawlinson, Moore): Post freezeup.

The two periods of ground reconnaissance were for observing and documenting geologic and geomorphic occurrences and features, i.e., stratigraphy, lithologies, landforms, and erosional processes.

Office and lab work includes compilation and interpretation of available literature, composition of area geomorphic maps, work on a realistic island - lagoon origin model, and consideration of processes for a spacial and temporal model of the environmental geology.

The December LGL workshop was attended by a representative of the geomorphology group.

III. Results

General Flight Observations, June 14, 1977

1. Palinas were well developed at the mouths of the major rivers entering the Beaufort Sea.
2. Major rivers were open and running.
3. Ice was still present in the lagoon, showing signs of thermal decay and breakup. Near shore areas were generally ice free.
4. Spring - thaw overflow from the Kuparuk River extended to the offshore islands, and at the channels, past the islands. The estimated thickness averaged 0.02 m.
5. Spring - thaw overflow from the Colville River was extensive, reaching Thetis Island to the west. Eastward, the overflow did not extend beyond Oliktok Point. Estimated thicknesses range from 0.15 m to 0.05 m.
6. Strudle holes were abundant near the Colville delta. Organic material was being introduced into the lagoon through the strudle holes.
7. Ice shove mounds and ridges were very extensive on the seaward side of the offshore islands.

General Flight Observations, July 27, 1977

This flyover was for the purpose of familiarization of the area prior to landing for several days of ground reconnaissance.

1. All waters were open except for large, broken pack ice on the seaward side of the islands.
2. Ice shove features were present on all islands.

General Flight Observations, August 15, 1977

This flyover was of limited extent because of bad weather conditions and poor visibility from the aircraft. The flyover was also prior to landing for several days of ground reconnaissance and was not meant to cover the entire area.

General Flight Observations, October 1, 1977

1. The wind was from the southwest at 18 mph and thought to be responsible for enhanced exposure of generally submerged shoals.
2. No ice was present in the lagoon, however, some ice was beginning to form on the lagoon side of the islands near Prudhoe Bay.
3. All major rivers were running; block and pancake ice were present.
4. Seaward beaches of the islands were smooth; all ice shove features present during the summer were obliterated.
5. Seaward beaches were linear; the sinusoidal shape that developed during the late summer storm was obliterated.
6. Bar development was complete between Bodfish and Bertoncini Islands; the spit on the west end of Bertoncini Island extended almost to the unnamed tundra island near the east end of Pingok Island.
7. There was little beach development on the unnamed tundra island; wave impact was directly on the sediments underlying the tundra cover; clear ice was also visible within the sediments.

8. Pingok and Leavitt Islands were connected by a narrow bar.
9. The large ice shove mound observed on Spy Island during the summer was still present, indicating little or no wave wash over the island.

General Flight Observations, November 22, 1977

1. The lagoon was completely frozen over, with no apparent input from major rivers.
2. Seaward beaches exhibited considerable ice shove; fast ice was present from the ice shove ridges seaward.
3. The lagoon side of the islands exhibited slight ice shove, a fairly continuous small ridge parallel to the shoreline.
4. In some places it was impossible to ascertain the shape of the beach because of snow cover. Much of the pressure ice appeared to be grounded offshore.
5. Bar development was unchanged since October 1, i.e., much of the lagoon was closed off so that major exchange would occur only near the ends of the system.
6. The ice shove mound was still present on Spy Island.

Area and Volume

For the purpose of quantifying the data for input into the model, the east and west boundaries of the study area were set as the ARCO causeway and Oliktok Point respectively. The area of the barrier island - lagoon system is then, 238 km^2 (2.4×10^8 m^2). Assuming an average depth of the lagoon as 1.5 m, the volume of the system is 3.6×10^8 m^3.

Coastal Exposure and Erosion Rates

Using maps and sequential vertical photography the coast and the islands were differentiated into high and low topography and erosion rates calculated. The calculations were only of tundra covered areas. Considered were only the lagoon side of the islands, and the mainland; excluded were estuaries and delta systems. The exposure and erosion rates are as follows:

Coast

High Topography- 47 km, 1.1 m/yr

Low Topography- 35 km, 1.3 m/yr

Island

High Topography- 10 km, 1.5 m/yr

Low Topography- 4 km, 3.8 m/yr*

* Although this figure is a mean, it probably should be considered more as a spot reading because the low, actively eroding areas of the islands tend to be localized. A more realistic value is about 1.6 m/yr.

The total coastal exposure is 96 km. High topography is considered to average an aggregate thickness of 2.5 m, 0.5 m of tundra peat capping 2.0 m of silt, sand, gravel, and ice. Low topography is considered to average an aggregate thickness of 1.5 m, 0.5 m of tundra peat capping 1.0 m of silt, sand, gravel, and lesser amounts of ice.

Several questions arose from some investigators as to the validity of taking measurements directly from sequential vertical photography:

1. Would not the observed flucuations in sea level introduce error by physically putting the water line farther inland or farther offshore?
2. Would not the average coastal erosion rate value be artificially increased by taking measurements at points where drained lake beds had been inundated by the sea?

In all cases measurements were taken from an unchanged inland point to the top edge of the tundra capped cliff. Any water line variation would be on the beach or up the cliff, and would have no effect on the measurement.

Erosion rates would be artificially increased by considering inundated lake beds. For this reason, such areas were not included in the calculations.

Approximate Duration of the Tundra Islands

Erosion rates were calculated for the offshore islands and average 1.7 m/yr (this value includes the seaward side). The seaward side of the islands tend to erode slightly slower than does the lagoon side. The 1.7 m/yr figure was doubled to account for erosion from each side of the islands and the widest part of each island was measured. With this, tundra duration times are as follows:

Pingok Island-

Two Islands- 61 years

East Island- 184 years

West Island- 222 years

Bertoncini Island- 84 years

Bodfish Island- 176 years

Cottle Island- Not yet considered

Erosional Input Into the Barrier Island - Lagoon System

With the average coastal and island dimensions previously given, the total volume, and the volume of organic material introduced into the system are as follows:

Total- 2.6×10^5 m^3/yr

- (2.7×10^3 m^3/yr per kilometer of coastline)

Organics- 6.4×10^4 m^3/yr

- (6.6×10^2 m^3/yr per kilometer of coastline)

For the low and high topography areas respective minimums of 30% and 20% of the total volume are considered organic.

Densities of 2.0 g/cm^3 and 1.1 g/cm^3 for the inorganic and organic material respectively were used for determining the mass of the material introduced into the system by coastal erosion.

Total- 4.6×10^8 kg/yr

- (5.0×10^6 kg/yr per kilometer of coast)

Organics- 7.0×10^7 kg/yr

- (7.7×10^5 kg/yr per kilometer of coast)

River Input Into the Barrier Island - Lagoon System

Prior to ice breakup a large volume of material from the Kuparuk River is deposited on top of the sea ice within the lagoon. Little material from the Colville and Sagavanirktok Rivers reaches the lagoon.

To estimate the extent of coverage, LANDSAT imagery (Bands 4 and 7) was enlarged to 1:250,000 and enhanced on International

Imaging System equipment. An average thickness of 0.02 m is assumed for the material. Only 1.0% is assumed to be organic with a density of 1.1. The remainder is assumed to be inorganic with a density of 2.0. Results for the Kuparuk River is as follows:

Area of coverage- 54 km^2
Volume of total material- 1.08×10^6 m^3
Volume of inorganic material- 1.07×10^6 m^3
Mass of inorganic material- 2.14×10^9 kg
Volume of organic material- 1.08×10^4 m^3
Mass of organic material- 1.19×10^7 kg

IV. Preliminary Interpretation of Results

The following interpretations are based on results itemized in the quarterly report for the quarter ending September 30, 1977, on data gathered since that time, and on data received at the December workshop.

Erosion and Erosion Rates

Erosion of the Beaufort Sea coast is due to a combination of thermal and mechanical agents. Thermal erosion occurs during the summer months and has its greatest effect on the coastal cliffs. Ice and permafrost thaw, making the cliffs more susceptible to wind and wave impact. Erosion of the coast and islands is most active during storm periods and also seems structurally directed.

Variations in coastal erosion rates tend to be more a function of high versus low topography rather than protected versus unprotected coastline. Erosion rate values for areas on the lee side of high wind and wave impact are not significantly different from values for areas of direct exposure.

Although not included in the erosion rate averages, very high values (up to about 7 m/yr) were determined near the mouth of the Ugnuravik River.

Island erosion rates tend to be higher than mainland rates due to primarily the islands' two sides of attack. The seaward side of the islands tend to erode at a slower rate than the lagoon side because of wide beach development and a stabilizing dune ridge. Another consideration may be that a higher degree of solar radiation impacts south facing beach cliffs, i.e., island - lagoon cliffs, on any given summer day.

Duration of the Tundra Islands

The tundra islands are being eroded at relatively high rates. The degradation could possibly be slowed by erecting barriers to mechanical agents.

Without tundra covers the islands will probably remain as lag deposits left from the erosion of the tundra until clastic introduction decreases. Introduction of coarse clastic material seems unlikely over a geologically short period of time, and is therefore nonrenewable. The introduction of sand size material from river systems and coastal erosion cannot be excluded at this time. Any introduction of material to the islands, however, will eventually decrease as the coast retreats, and the offshore barrier islands will disappear.

Nutrient Input

Nutrient input into the system is primarily from two sources, erosion of the coast and introduction from river systems. Coastal erosion alone is sufficient to supply the system with nutrients. For the purpose of the model it was assumed that at any given time 50% of the total material was available for introduction into the system. This value, when cut to 10% (steady - state input) was still sufficient. Nutrient input from the Kuparuk River, although large at the time of breakup, seems to have little effect on the system because of the high flush rate in the lagoon.

Origin and Evolution of the Islands and the Coastal Plain

Material composing the coastal plain and offshore islands, at least west to the Simpson Lagoon area, represent a ground moraine from pre - Wisconsin Pleistocene glaciation. Supporting evidence is as follows:

1. Large numbers of lithologies, some with little resistance to fluvial and/or marine transport.
2. Angular clasts.
3. Surface striations (oriented) and polished surfaces on boulders.
4. Clast sizes from sand to boulder.
5. The fact that ice rafted material contributes little in terms of deposition.
6. Streams entering the area are of such low relief that transportation of coarse material is unlikely.
7. LANDSAT Imagery- low sun angle - moraines are visible almost to the coast. These moraines are probably Wisconsin in age.

The tundra islands are remnant features (in a sense, not true barrier islands) of the coastal plain which extended farther seaward. Indicators of this are the 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 removed leaving the constituent gravel as lag. As constructional features, the gravel islands probably receive sand size material eroded from local tundra - covered areas and from major rivers. Longshore transport cannot account for all the material. Large boulders found on the tundra - covered islands may be presently buried in the sand and gravel islands. Reworking processes would tend to bury the larger heavier clastics.

Source of Material

Most of the coarse clastic material is derived in situ from the tundra - covered areas. Initial sources for the material composing the moraine are now being considered. The fact that certain lithologies of coarse clastics increase in abundance eastward indicates an eastward provenance (probably the eastern Brooks Range). Whether or not the material is presently being transported has yet to be determined.

About 7% of the coarse clastic material found on the island beaches contain carboniferous fossils. All parts of the Brooks Range have carboniferous outcrops within the north slope drainage.

V. Problems Encountered

None.

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Research Unit # 531
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Number of pages: 4 pages + 1 figure

Oceanographic Processes in a Beaufort Sea Barrier Island-Lagoon System: Numerical Modelling and Current Measurements

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16 December 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

Participated in Beaufort Sea Barrier Island-Lagoon Modelling Workshop, University of British Columbia, December 1977.

A2. Laboratory Activities

Numerical Modelling

Two-dimensional modelling

Simpson Lagoon, taken as extending from Spy Island on the west to the Arco causeway on the east, was modelled using nonlinear hydrodynamic equations expressed in terms of sea level elevation and flow rate per unit width. The vertically integrated equations of motion and continuity are

$$\frac{\partial U}{\partial t} = - gD \frac{\partial H}{\partial x} + \gamma V + V - fQUD \tag{1}$$

$$\frac{\partial V}{\partial t} = - gD \frac{\partial H}{\partial y} - \gamma U + Y - fQVD \tag{2}$$

$$\frac{\partial H}{\partial t} + \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = R \tag{3}$$

in which x and y are horizontal coordinates; t = time ; U and V are the vertically integrated components of flow rate per unit width; g is gravity; H is the water level elevation relative to local mean sea level; D is the water depth; γ is the Coriolis parameter; f is a non-dimensional friction parameter; Q is the magnitude of the flow rate per unit width; R is the rainfall rate; and X and Y are the components of wind stress divided by the water density.

The computation scheme, which permits flooding of grid squares and flow over broad or short-crested wiers (e.g., causeways or thin islands), is a slight extension of that proposed by Reid and Bodine (1968). H , U and V are staggered in time and space in the manner first proposed by Hansen. The modelled region consists of a grid of 1 km × 2 km rectanges, 17 × 34 in number (see Figure 1). Depths range from 3 to 40 feet below mean sea level.

The main goal of the computations was the estimation of flow rates associated with steady winds covering an area greater than the 10 × 50 km lagoon. Since sea elevations around the lagoon for the various wind conditions are unknown, the decision was made to apply "flow-through" boundary conditions (no change of flow rate with distance) on the east and west boundaries, and to set H = 0 on the north boundary. (Ideally, the elevation along this boundary should be estimated before each run.) The model was run until a steady state had been reached - some 1000 time steps.

A limited number of cases have been run to date since the supporting current and particle-track plots have not yet been completed. Approximate replacement times for the water within that part of the lagoon lying between the causeway and Pingok Island (a volume, as modelled, of 0.31 km^3) have been calculated for four wind conditions:

Case	Wind from true	Speed m/s	Volume transport m^3/s	Replacement time hrs.
1	ESE	5	1000	86
2	ESE	20	4000	21.5
3	WNW	10	2500	34.5
4	NNE	10	1000	86

The replacement times are somewhat greater than those first calculated. Minor changes will result with calibration changes. The maximum associated changes in sea level inside Simpson Lagoon relative to an assigned sea level of zero some 10 km offshore are: set-down of 7 cm, set-down of 90 cm, set-up of 21 cm, and set-up of 16 cm, respectively, for cases 1, 2, 3, and 4.

Although we stress that the above replacement times are provisional, since they depend on the bottom-friction coefficient and on the formula used to evaluate the wind stress, the times are of interest in that they lie between one and four days, and in that the times are inversely proportional to the wind speed. The problem of computing flow rates associated with time-varying winds requires a new set of boundary conditions (applicable to long gravity waves) and has not yet been addressed; frequent changes in wind direction could significantly increase replacement times, resulting in longer residence times for marine organisms.

Reference

Reid, R. O. and B. R. Bodine: Numerical model for storm surges in Galveston Bay. *J. Waterways and Harbors Div., A.S.C.E.* (94) WW1, Feb. 1968, pp. 33-57.

B. Personnel

J. C. H. Mungall, R. Hann - Co-Principal Investigators
R. E. Whitaker, 3-D Modelling
C. Horne, Graduate Research Assistant

III. Results

Computed replacement times for the Lagoon water masses are still in the order of days. It is possible that the actual times may be larger on account of the transient (as opposed to steady) nature of the wind. Furthermore, the transit time of a water parcel following the landward shore of the lagoon may be longer than that of a parcel that goes along the center of the lagoon.

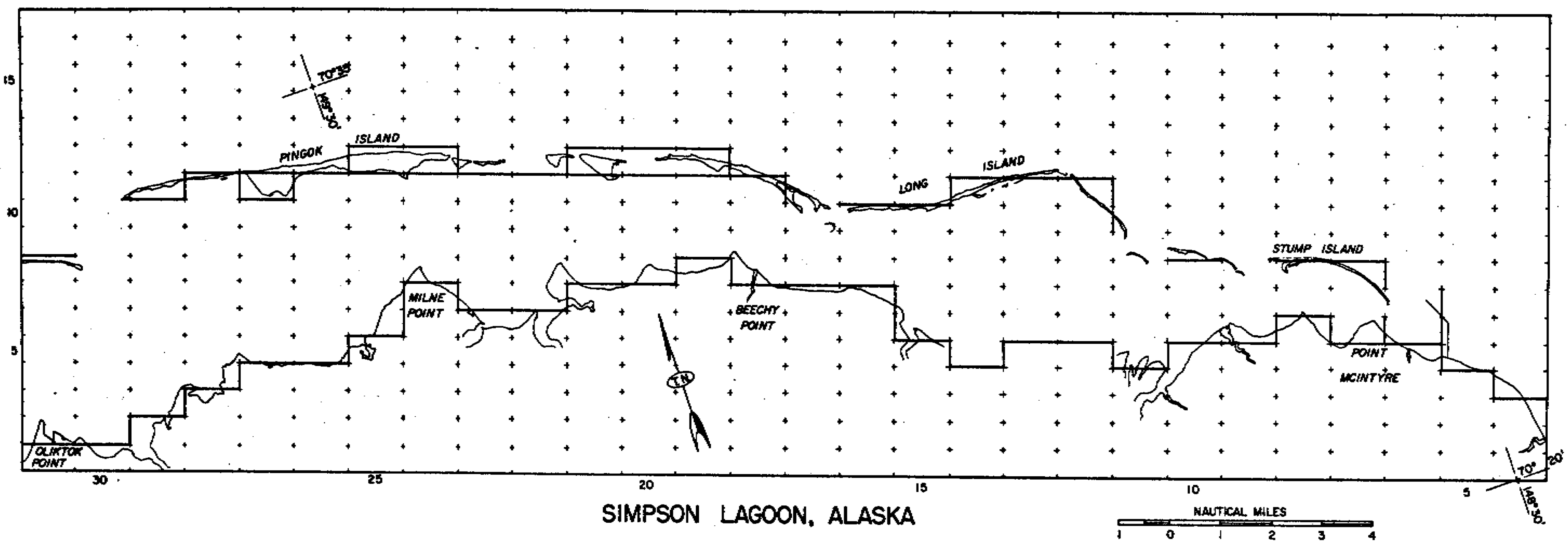

Figure 1. Grid scheme for Simpson Lagoon, Alaska. Crosses denote corners of 1 km × 2 km computational rectangles.

QUARTERLY REPORT

Research Unit # 536
Reporting Period: October 1 - December 31, 1977

Development and Operation of a Remote Sensing Data Acquisition Platform for OCS Studies

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Research Unit 536

REMOTE SENSING OF THE ENVIRONMENT

QUARTERLY REPORT

Oct - Dec 1977

The remote sensing program at NARL began with the hire and arrival of a trained and skilled technician as the Remote Sensing Coordinator (RSC) on 17 March 1977.

The program is being developed to conduct environmental assessment, in conjunction with ground truth, aerial photography and SLAR imagery, of spatial and temporal perturbation and changes occurring within the Arctic's terrestrial, littoral, estuarian, off-shore island and outer continental shelf marine environments. The first six months of the program have been spent amassing equipment for modification and installation into the NARL C117D aircraft; to select and prepare the aircraft as a remote sensing and data acquisition platform; and ground check the SLAR (APS/94D) and T-11 aerial mapping camera (AMC) for C117D 722NR installation. This past Quarter has been used to ferry the aircraft, equipment and crew to Tucson, AZ for final installation of the SLAR components and antenna before calibration of the equipment through 30 hours of image taking missions prior to the return of the crew and equipment to NARL Barrow, AK.

The RSC travelled a good deal during the first six months to obtain equipment and training in the use of it.

1. 23-30 Apr Michigan 11 International Symposium on Remote Sensing of the Environment.

2. 27 June-10 Jul Arizona Ft. Huachuca
California China Lake
Alaska OCSEAP

3. 17 Sep-10 Oct New Hampshire Ray & Leon Service School CRREL

4. 24 Oct-23 Nov Arizona Ft. Huachuca
28 Nov-12 Dec

5. 12 Dec to present New Hampshire Personal leave

Initially C117D 310 was designated to become the Remote Sensing aircraft. Due to mechanical and electrical problems 310 underwent a complete electrical rebuild and 722NR was assigned to the project. Engine problems on 722NR held the program back as both aircraft had to be taken to Whidby Island Naval Air Station for complete engine inspections. With the return of 722NR to NARL, the first to return, construction began toward the installation of remote sensing equipment, primarily the SLAR and air sampling tubes.

At this date modifications to the C-117D to allow air samples to be collected through a variety of port sizes from 1/8" to 4" I.D. have been completed.

A PRT-5 Radiometer was installed and temperature profiles of the ice-water interface were obtained for Dr. John Kelley's Gases in Sea Ice program.

In addition, the APS 94 SLAR has been ground checked and repaired for physical damage, mounted on pallets and was installed in the aircraft in preparation for the antenna installation and system checkout and calibration to be done at Ft. Huachuca, Arizona. Operation and maintenance manuals have been obtained from the Army Pub. Office for final tweeking of the obtained system.

On its flight to Arizona 722NR aperienced severe radio problems. Once outfitted with the SLAR 722NR was determined to cruise at 150 knots. The cruise speed of 310 is 160-5 knots because it has cleaner skin and is lighter. It has functioning radios, has 600/700+ hrs remaining on the two engines before majors are needed and has been retrofitted for more modern avionics. It has since been determined that 310 would be the better remote sensing aircraft. What in fact will happen is that 2-3 days will be necessary to exchange all equipment from 722NR to 310, but 722NR will then act as a back-up to the remote sensing program.

Presently, the aircraft, 722NR, is enroute back to NARL and is outfitted with a working and calibrated SLAR system. Monies have been obtained to update the navigational system to that of an Ontrack 3. The new system will be installed into 310 at the earliest possible date. Upon the return of the aircraft to NARL remote sensing missions will commense for OCS and the Weather Service.

2ND QUARTERLY PROGRESS REPORT
23RD JANUARY 1978
OCS RESEARCH UNIT #540

"Oil Spill Vulnerability of the Beaufort Sea Coast"

Dag Nummedal, Principal Investigator
Ian A. Fischer, Jeffrey S. Knoth, Co-Investigators

I. OBJECTIVES:

A. To characterize the mainland and barrier shoreline of the Beaufort Sea between Barrow and Demarcation Bay with respect to geomorphology and sedimentary environments.

B. To assess the retention potential for spilled hydrocarbons within the coastal environments.

C. To develop testable hypotheses on the initiation and development of the barrier island system.

D. To do a preliminary reconnaissance of the streams on the eastern part of the North Slope.

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Columbia, S. C. 29208

II. FIELD STUDIES:

A. 72 beach stations located both on the barrier islands and the mainland shore, between Lonely and Demarcation Bay, were sampled between August 18 and 26. Access to stations was gained by a Bell 206B helicopter rented from ERA. 12 additional stations were sampled at Prudhoe Bay between Heald Pt. and Pt. McIntyre on August 4 through 6. At the Barrow and Plover Spits, 11 stations were measured 3 times between August 7 and 28.

Reconnaissance sampling of the Sagavanirktok and Canning Rivers took place intermittently between August 15 and 26.

B. The scientific field party consisted of the principal investigator and the two co-investigators. David Hopkins and Roger Hartz (U.S. Geol. Survey, Menlo Park) helped in sample acquisition at Prudhoe Bay. Robert K. Fahnestock (SUNY, Fredonia) assisted in sampling the rivers and selected coastal stations.

C. Methods. 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 procedure 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 or two close-up photographs of the sediments were generally taken.

In the laboratory, the beach profile data were punched on computer cards and processed by an IBM 370/168 computer system with a Calcomp plotter for drafting of the profiles. The program is written by Cary Fico (University of South Carolina). The sediment samples were sieved by a Ro-Tap shaker and a standard set of sieves to determine weight frequency distributions. A computer program, written by James May (The Citadel, Charleston, S. C.) permits the calculation of all relevant statistical parameters and provides frequency and cumulative weight percent plots of the sample distributions.

Studies of rock fragment lithologies and mineralogy is planned for the near future.

D. Figure 1 shows the location of sample stations along the Beaufort Coast of Alaska. Inserts (at a larger scale) show the stations at Pt. Barrow and at Prudhoe Bay. Station coordinates (to the nearest second) are listed in Appendix 1.

A set of grain size-frequency data is enclosed as Appendix 2. Descriptive statistical parameters (calculated by the method of moments) for each sample have been summarized and are printed in Appendix 3.

III. RESULTS AND INTERPRETATION

A. Sediment size analysis. Any beach sediment sample represents a complex of different sources (parent populations) transported to the site by different wave energy conditions operating over different time scales. As each parent population moves down the beach, it is subjected to filtering both at the fine and coarse end of the distribution. The fines (e.g. muds and fine sands) will be winnowed out by wave action and carried offshore, while the coarse fraction (boulders and cobbles) will easily be worked deeply into the beach and move at a much slower rate than the sand/gravel fraction. Therefore, each component population will be filtered and better sorted, as it moves away from the source. If we deal with a single population, however, which started out as a unimodal distribution, then the same mode should be recognizable in sediment samples acquired further downdrift.

In addition to filtering through movement down the beach, there is also a mixing of populations from different sources. The sedimentary deposit at the updrift end of a given geomorphic unit (the source) may itself be a mixture. Offshore sources, fluvial input, aeolian transport, and erosional remnants may further complicate the grain size picture downdrift of this source. Therefore, the identification of transport directions based on beach sediment size characteristics requires a three-step analysis: (1) identification of one (or more) source areas, (2) determination of the size-frequency modes associated with the source(s), and (3) the recognition of the relative importance of these modes in samples obtained elsewhere in the transport system. This analysis will be illustrated by an example from a barrier island system on the Beaufort coast of Alaska.

B. A case study. The samples used for this study were obtained from the island chain extending from Flaxman Island on the east (sample BE 19) to Reindeer Island to the west (sample BE 28) (Fig. 1). As demonstrated in Figure 2, there is no obvious trend in mean size or sorting along the island chain, although the mean size trend could be interpreted as a fining away from two sources, one at Flaxman Island and a second at Stockton Island. The sorting parameter indicates no trends.

All sediment samples are polymodal. A review of the dominant modes (containing at least 10 percent of the total sediment sample) demonstrates that they are not randomly distributed. All sediment samples can be accounted for by four distinctive modes, a coarse mode at about -4ϕ (16 mm), a second mode at about -2.6ϕ (6 mm), a third at -1.3ϕ (2.5 mm) and a sand made at about 1.8ϕ (0.3 mm) (Fig. 3). The variability in beach sediments along the island chain can be explained by different relative contributions of these four modes. Mode 3 is present only to the west of Stockton Island (Table 1), which, together with the sudden coarsening at this same location (Fig. 2, top), is a strong indication of a new sediment source at this point. There is no morphologic evidence left of this source. Mode 1 shows a decrease in per cent contribution toward the west (Table 1). The other modes show no distinct trends. Morphologic evidence for overall transport to the west is abundant.

The applicability of this relatively simple modal analysis to sediment transport paths in this island chain suggests that it should be applied to the other barrier island systems as well.

Table 1. Sediment size variability from Flaxman to Reindeer Islands. Samples obtained at profile location B. Modal size in ϕ units.

Sample	Mode 1	%	Mode 2	%	Mode 3	%	Mode 4	%
19	-4.625	100		0		0		
20	-4.375	20	-2.875	30		0	1.125	50
21		0		0		0	1.625	100
22	-4,125	25	-2.625	15		0	1.875	60
23	-3.625	10		0		0	2.125	90
25	-3.875	10	-2.625	15	-1.375	75		0
26		0	-2.625	35	-1.375	65		0
27		0		0	-1.125	100		0
28	-4.125	10	-2.625	15	-1.375	15	1.875	60

C. Statistical parameters of grain size. Appendix 3 summarizes the statistics for 167 beach sediment samples (location in Figure 1). Summary statistics are reviewed with reference to Figures 4 to 7 (histograms) and Figures 8 to 13 (bivariate scatter plots). The average beach sediment size is -0.2ϕ (1.2 mm) which is substantially coarser than the typical value for temperate latitudes. The mean size of beach sand on the east coast of the U. S. ranges from about 0.6 mm at Long Island to a regional low of 0.3 mm in northeast Florida (Coastal Engineering Research Center, 1973, p. 4-23). The Beaufort coast frequency distribution (Fig. 4) is skewed to the left, demonstrating that a large number of samples are substantially coarser than the mean.

The mean of the sorting parameter is 1.3ϕ (Fig. 5) which would correspond to poorly-sorted sediments according to the scale suggested by Folk (1974, p. 46). The sorting distribution is bimodal with one mode at .53ϕ and another at 1.44ϕ. The former mode, indicative of moderately well-sorted sediments, is representative of relatively fine-grained beaches far from the sediment source area.

Most sample distributions are nearly symmetrical, as demonstrated by a mean skewness of -0.08 (Fig. 6). The mean kurtosis (moment measure) is 2.79 (Fig. 7).

The scatter plots provide some interesting insights when compared to previously published distributions. The distributions are particularly significant in that they represent a greater range in sediment composition than what is common to most beaches. The distribution of sorting (standard deviation) versus mean has basically the same shape as the one found for Padre Island, Texas (Hayes, 1965). In both cases, the pattern (Fig. 8) can be explained as due to the mixing of a fine and a coarse source population, both of which would be relatively well sorted. Samples with a more intermediate mean size are likely to represent a mixture of these two sources. Such mixtures would be polymodal and generally more poorly sorted. The pattern is the same whether one mixes two sand populations of modal size 2.4ϕ and 2.9ϕ (as on Padre Island) or multiple populations ranging in size from -4ϕ to +2.5ϕ (as on the Beaufort coast). Hayes et al. (1976) demonstrated a similar trend for the mixing of pebbles and fine sand in Cook Inlet, Alaska.

Figure 9 shows a scatter plot of skewness versus mean. A stretched sigmoidal pattern, again similar to that for Padre Island and Lower Cook Inlet, is apparent. The positive skewness of the coarse samples is due to the fine tail. Similarly, the negative skewness of the fine samples is contributed by the coarse tail. Samples which fall in the extreme lower right-hand corner of the scatter plot consist of a few large pebbles in well-sorted fine sand. The presence of sample points in the lower right hand corner of the graph, combined with their absence from the upper left, suggests an interesting characteristic concerning the hydraulics of beach sediment deposition: pebbles can be deposited in equilibrium with beach sand; whereas, sand cannot be in equilibrium on a pebble beach. A plot of skewness versus standard deviation (Fig. 11) displays an interesting triangular field. The larger standard deviation is associated with a symmetrical distribution; only well-sorted samples (small standard deviation) have a significant asymmetry. This is consistent with the concepts of modal mixing. When two (or multiple) modes are of equal proportion in the sample, the total distribution becomes symmetrical, and it will also have its maximum standard deviation. Plots of kurtosis versus mean (Fig. 10), standard deviation (Fig. 12) and skewness (Fig. 13) exhibit trends consistent with the concepts discussed above.

REFERENCES

Coastal Engineering Research Center, 1973, Shore Protection Manual: Govt. Printing Office, Washington, D. C.

Folk, R. L., 1974, Petrology of Sedimentary Rocks, Hemphill Publ. Co., Austin, Texas.

Hayes, M. O., 1965, Sedimentation on a semiarid wave-dominated coast (south Texas) with emphasis on hurricane effects: Ph.D. thesis, University of Texas (unpubl.).

Hayes, M. O., P. J. Brown and J. Michel, 1976, Coastal morphology and sedimentation, Lower Cook Inlet, Alaska: Tech. Rept. No. 12-CRD, Dept. of Geology, University of South Carolina, Columbia, S. C.

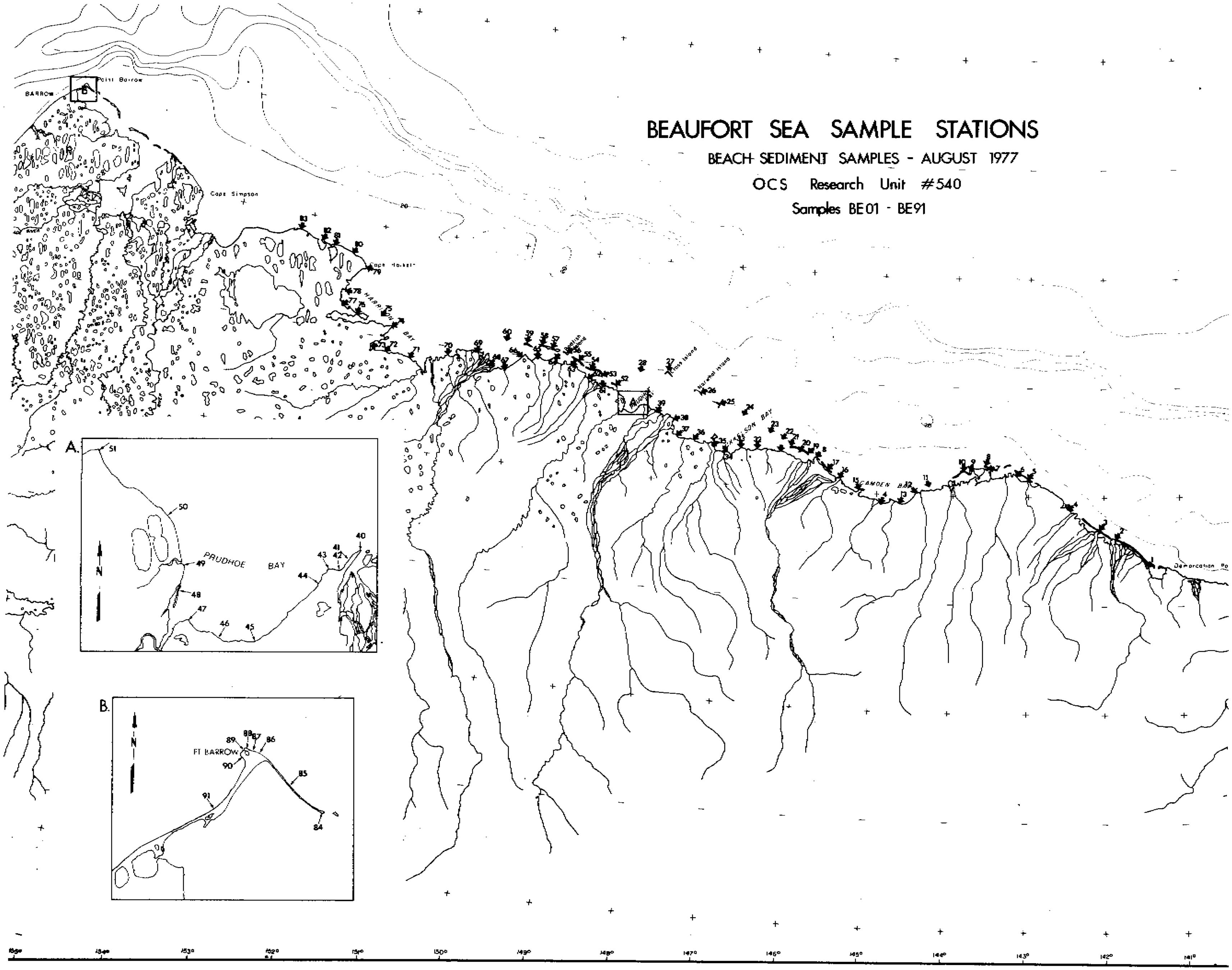

Figure 1. Location of beach sample stations along the Beaufort coast.

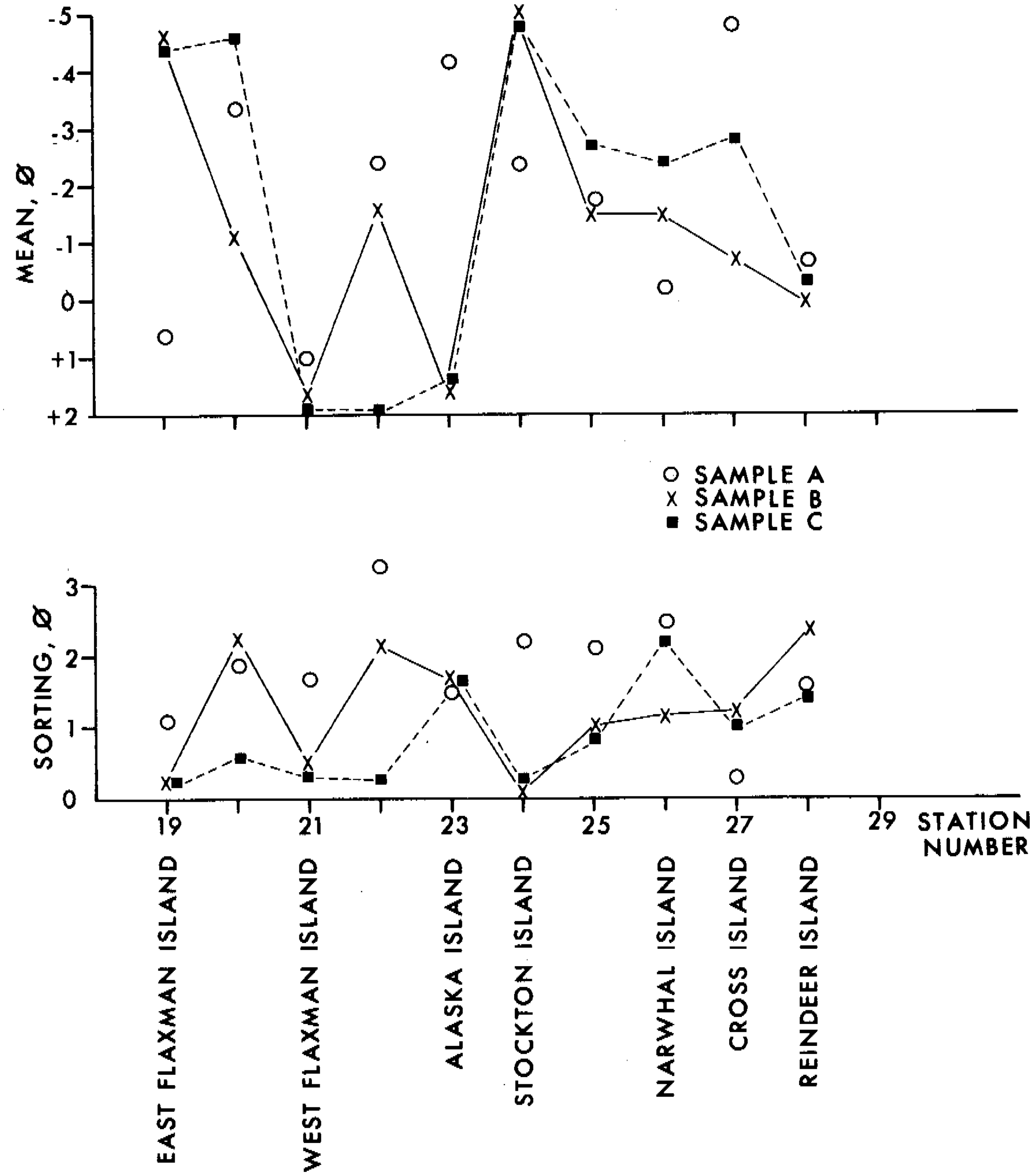

Figure 2. Variation in mean grain size and sorting along the barriers from Flaxman to Reindeer Islands.

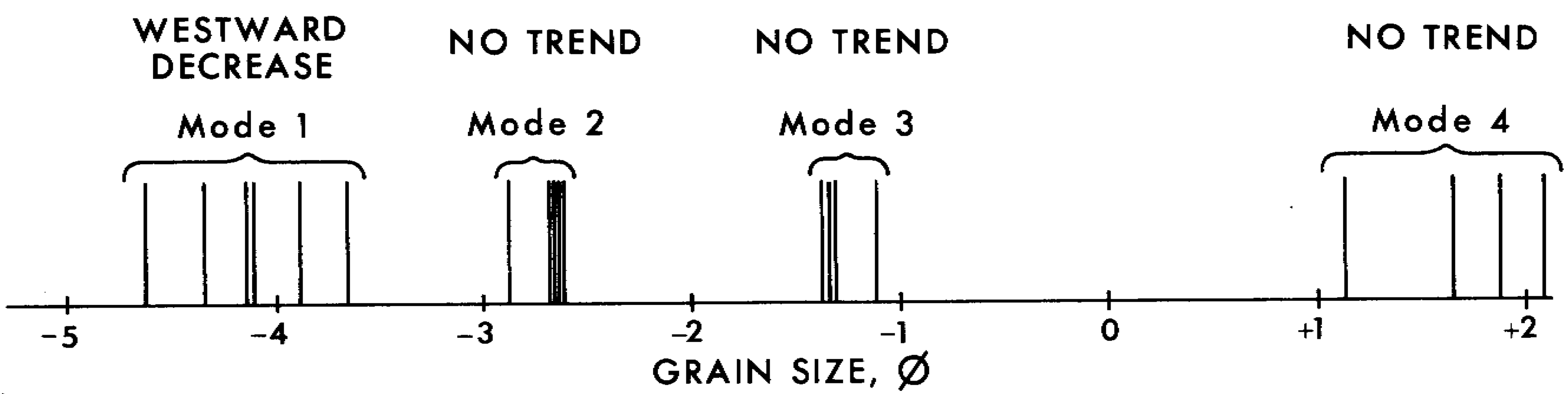

Figure 3. Distribution of grain size modes for beach samples between Flaxman and Reindeer Islands.

STATISTICS TABLE AND HISTOGRAM FOR MEAN

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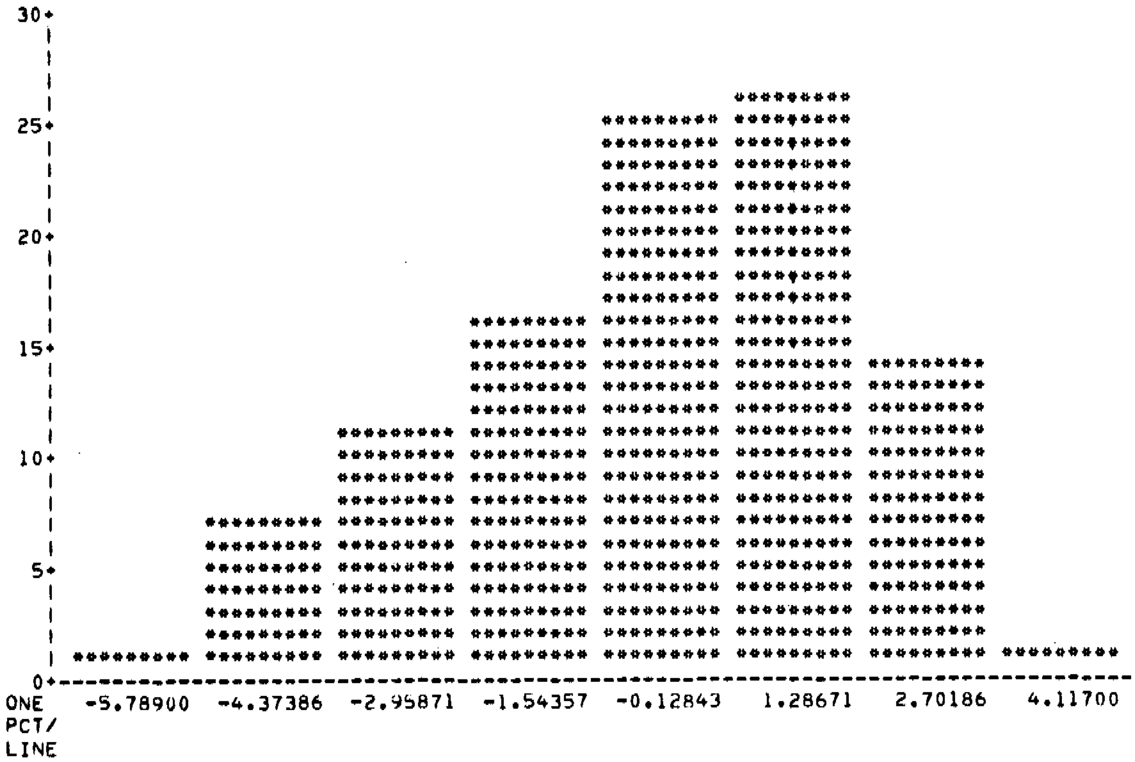

BEAUFORT SEA COAST BEACH SEDIMENT
DISTRIBUTION OF MEANS

Figure 4. Histogram of mean sediment size for the Beaufort beaches.

STATISTICS TABLE AND HISTOGRAM FOR STADE

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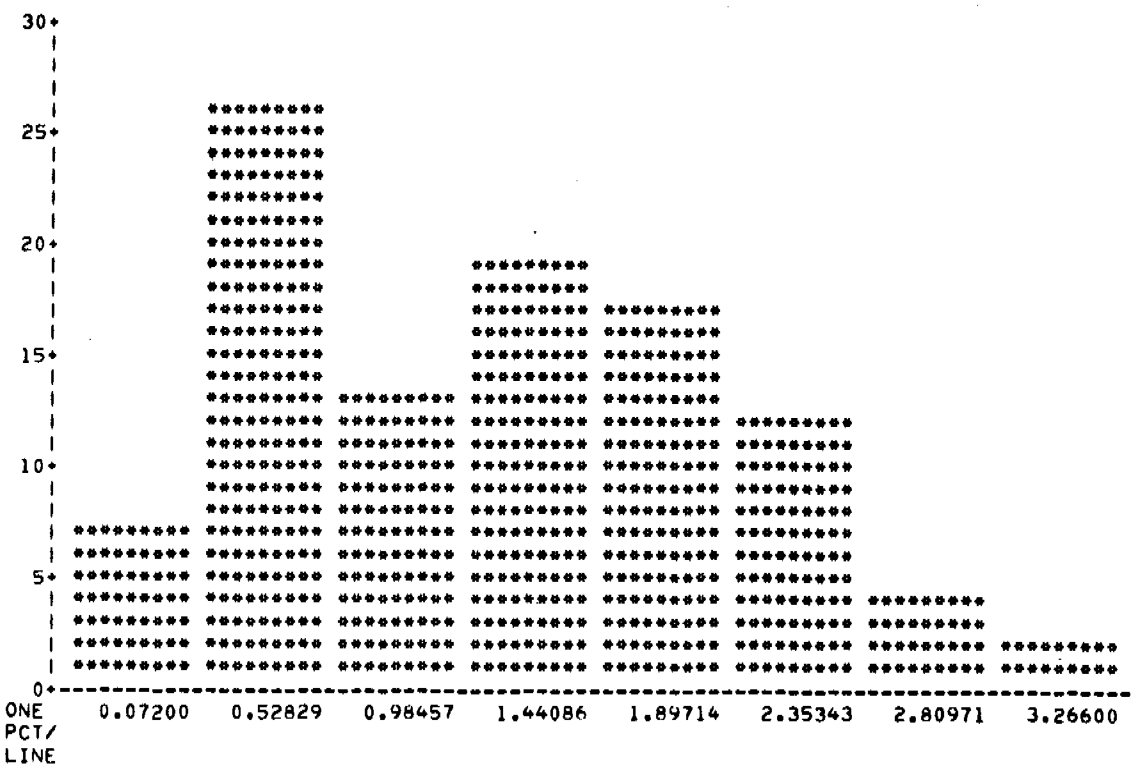

BEAUFORT SEA COAST BEACH SEDIMENT
DISTRIBUTION OF SORTING

Figure 5. Histogram of standard deviation.

STATISTICS TABLE AND HISTOGRAM FOR SKEW

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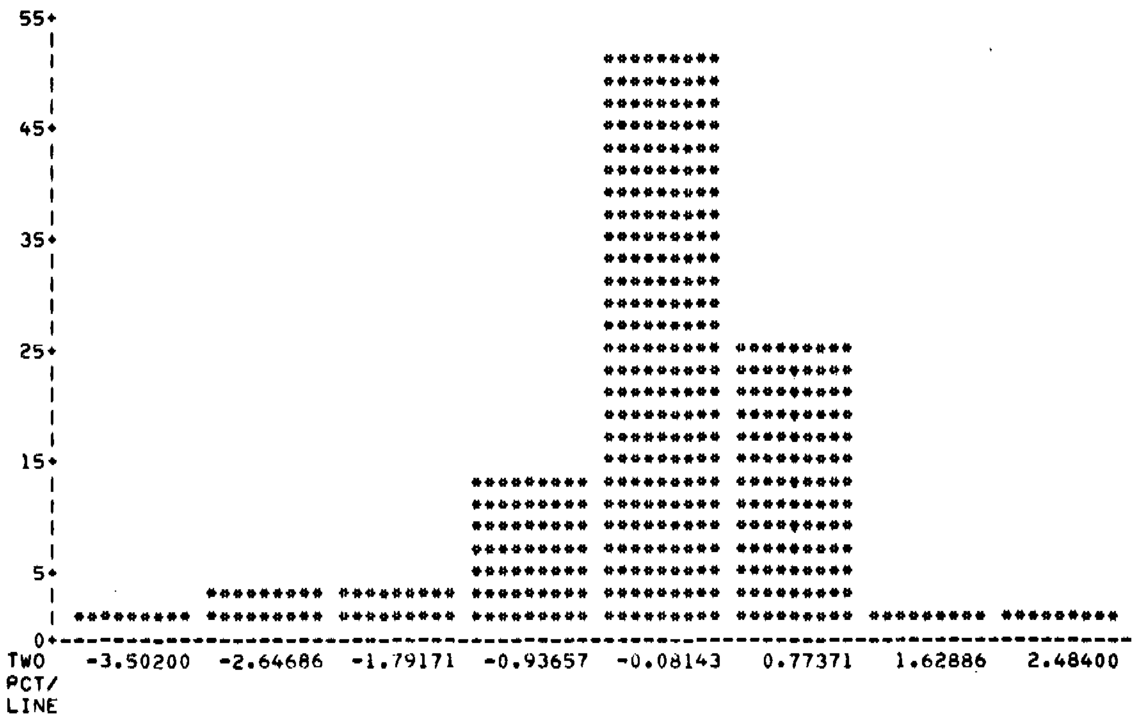

BEAUFORT SEA COAST BEACH SEDIMENT SKEWNESS DISTRIBUTION

Figure 6. Histogram of skewness.

STATISTICS TABLE AND HISTOGRAM FOR KURT

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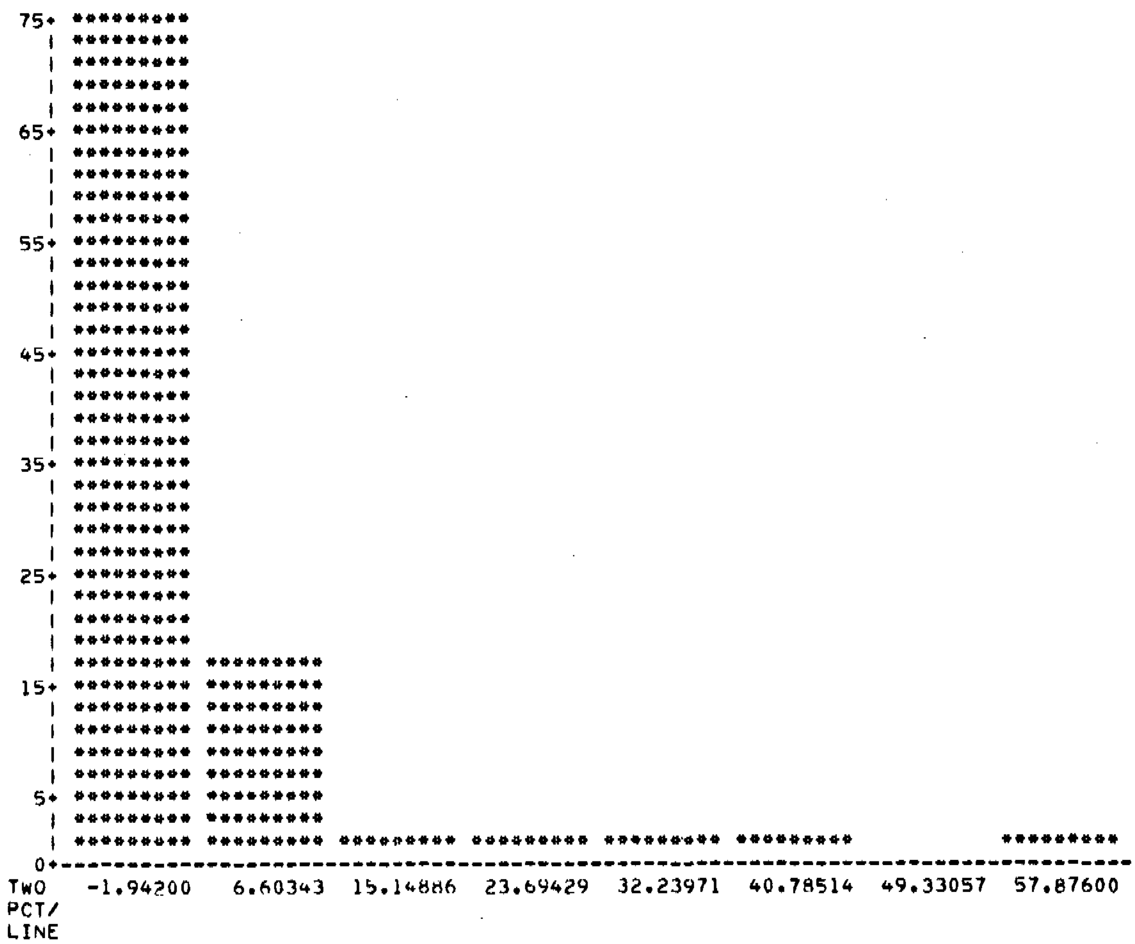
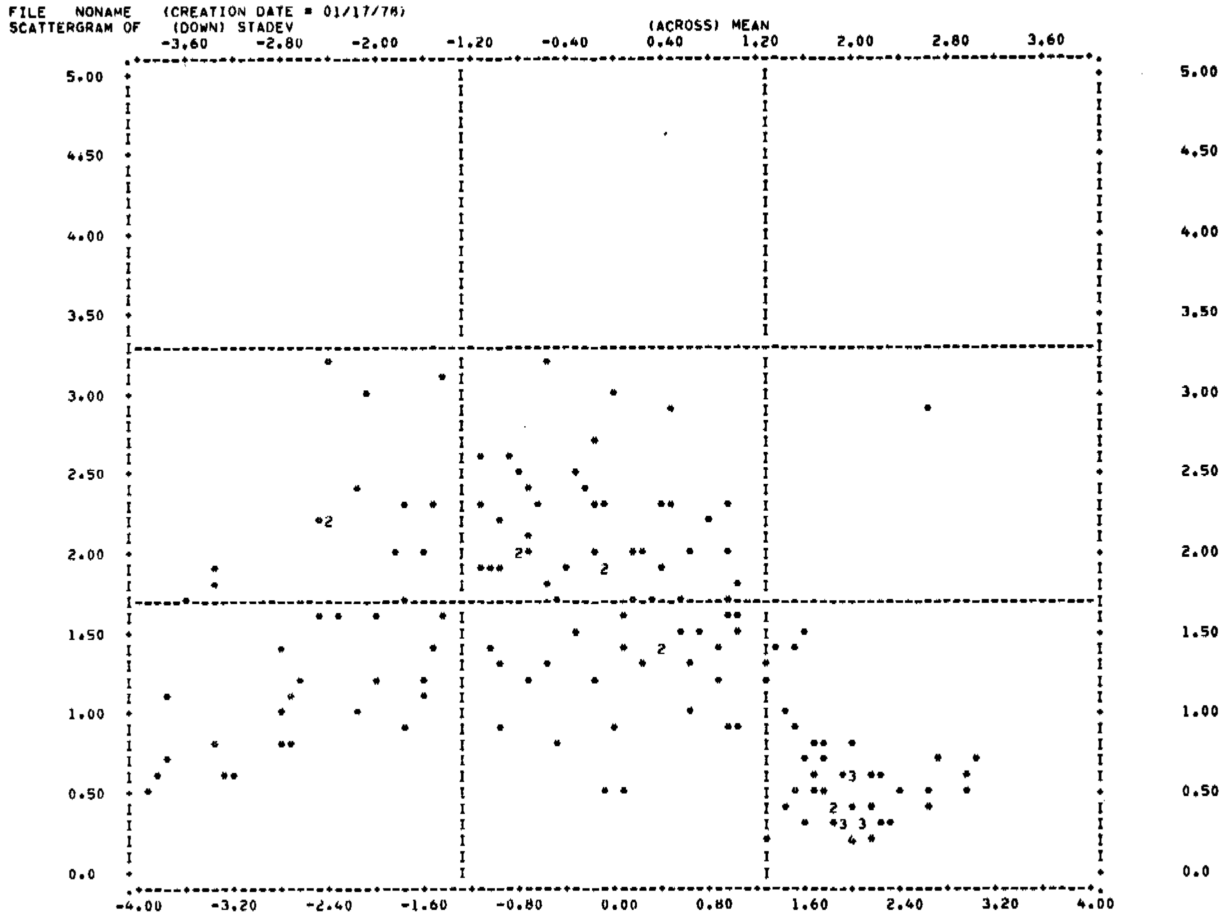


BEAUFORT SEA COAST BEACH SEDIMENT KURTOSIS DISTRIBUTION

Figure 7. Histogram of kurtosis.



STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES SPSSH - RELEASE 6.02 01/17/78

STATISTICS..

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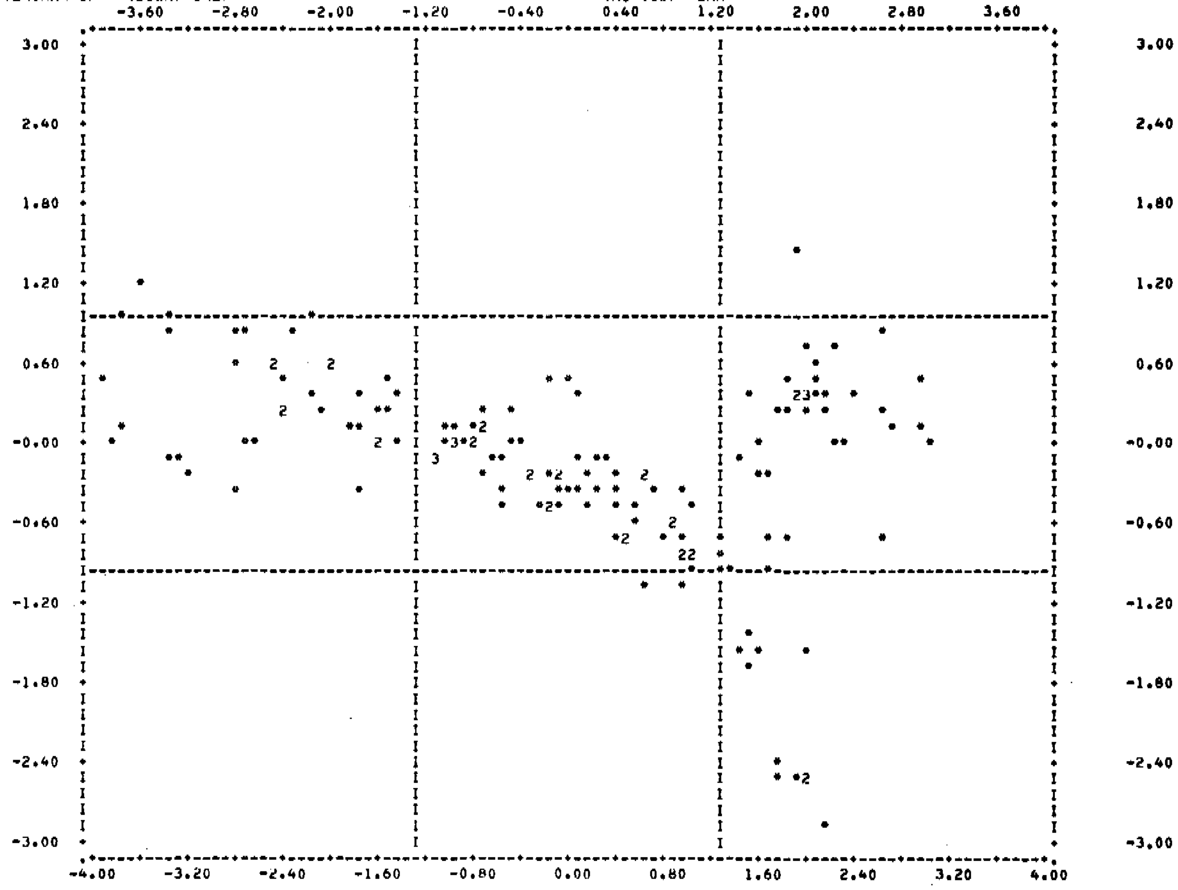
STD ERR OF EST -	0.70991	INTERCEPT (A) -	1.40619	SLOPE (B) -	-0.18263
PLOTTED VALUES -	158	EXCLUDED VALUES-	10	MISSING VALUES -	0

Figure 8. Scatter plot of standard deviation versus mean.

FILE NONAME (CREATION DATE = 01/17/78)
SCATTERGRAM OF (DOWN) SKEW (ACROSS) MEAN



STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES SPSSH - RELEASE 6.02 01/17/78

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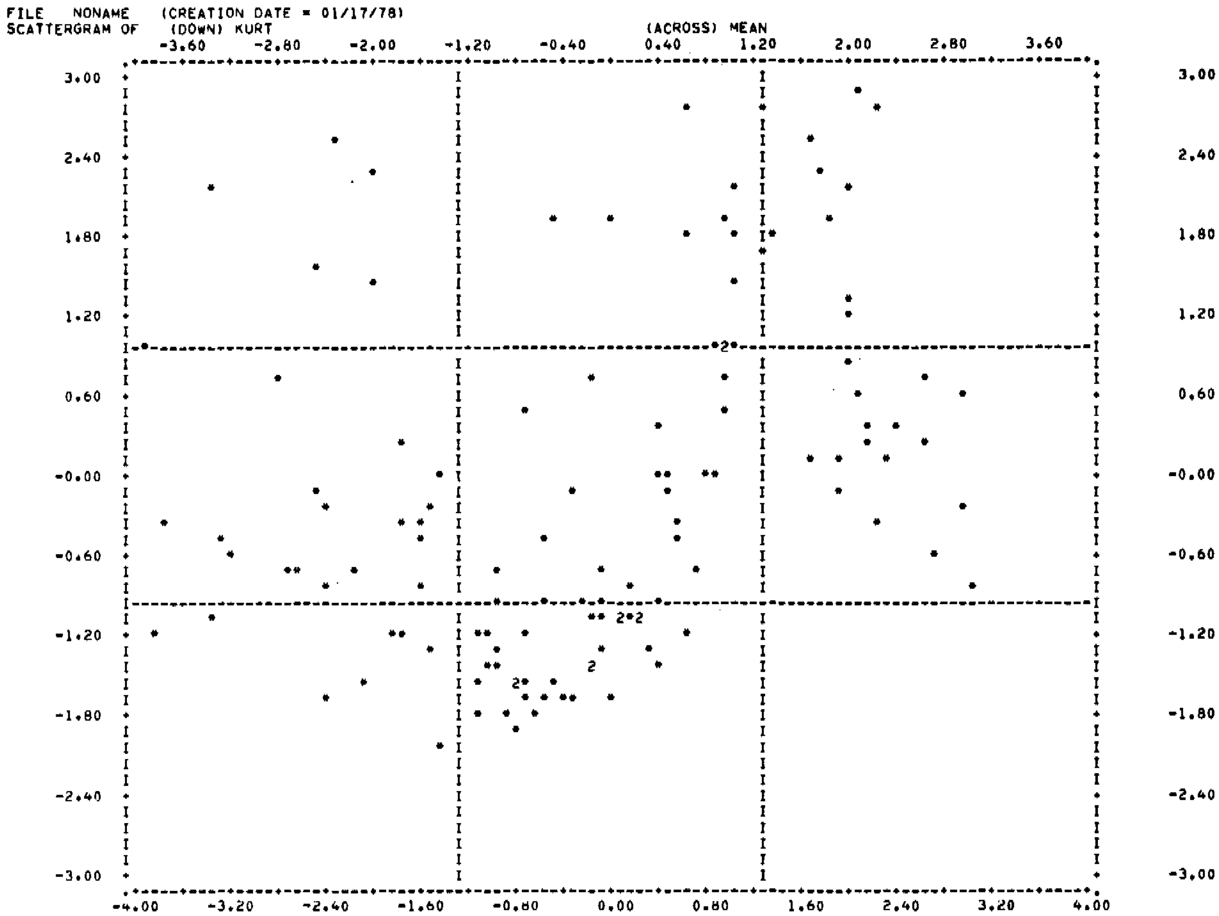
Figure 9. Scatter plot of skewness versus mean.



STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES SPSSH - RELEASE 6.02 01/17/78

STATISTICS..

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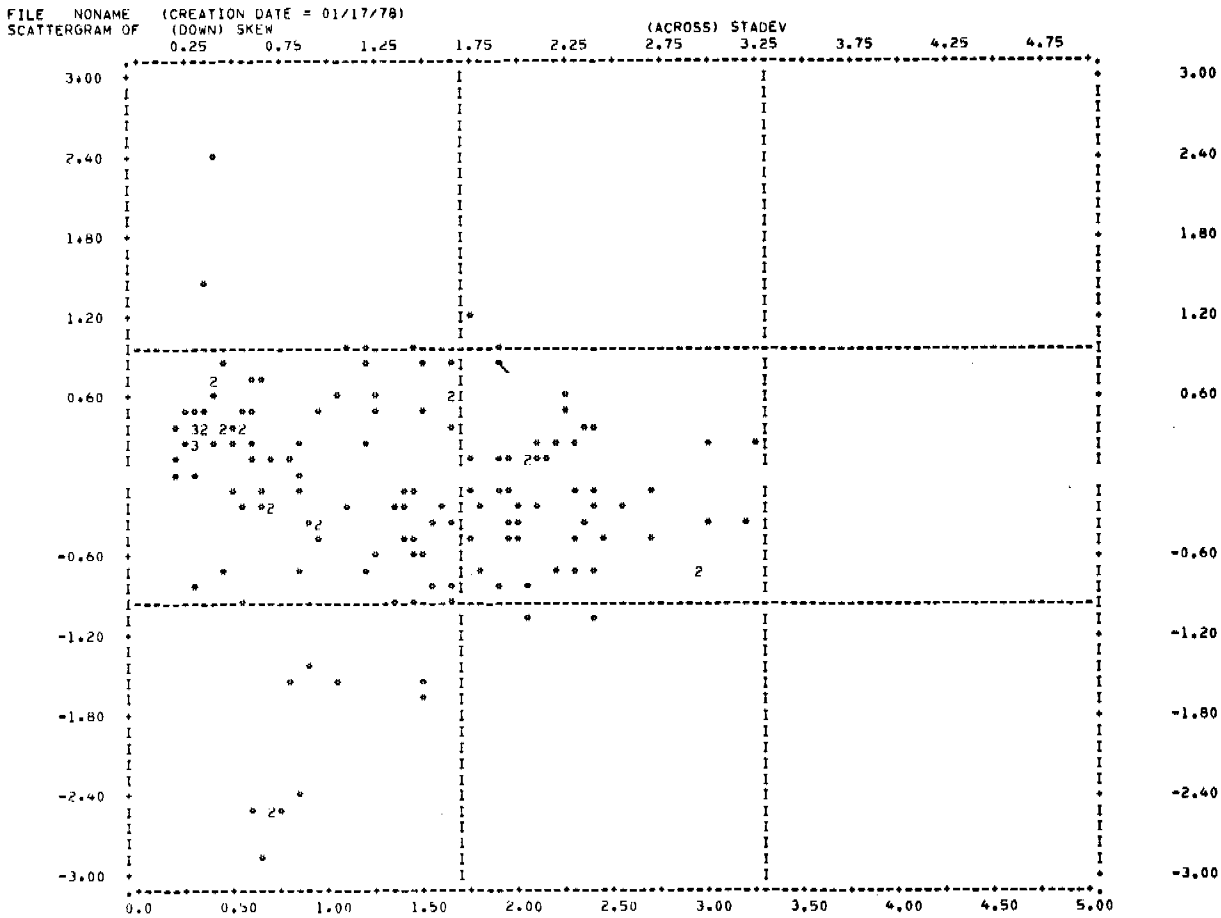
Figure 10. Scatter plot of kurtosis versus mean.



STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES SPSSH - RELEASE 6.02 01/17/78

STATISTICS..

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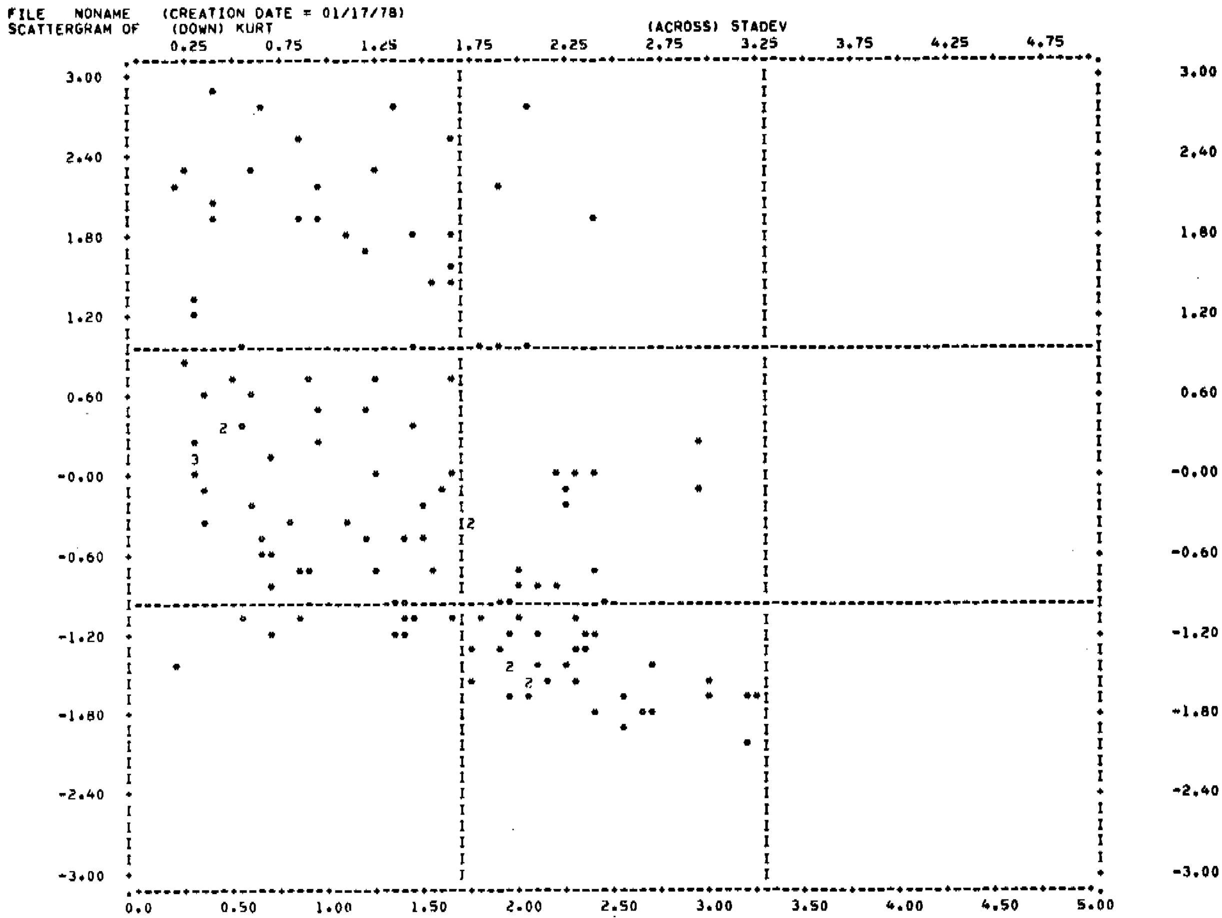
Figure 11. Scatter plot of skewness versus standard deviation.



STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES SPSSH - RELEASE 6.02 01/17/78

STATISTICS..

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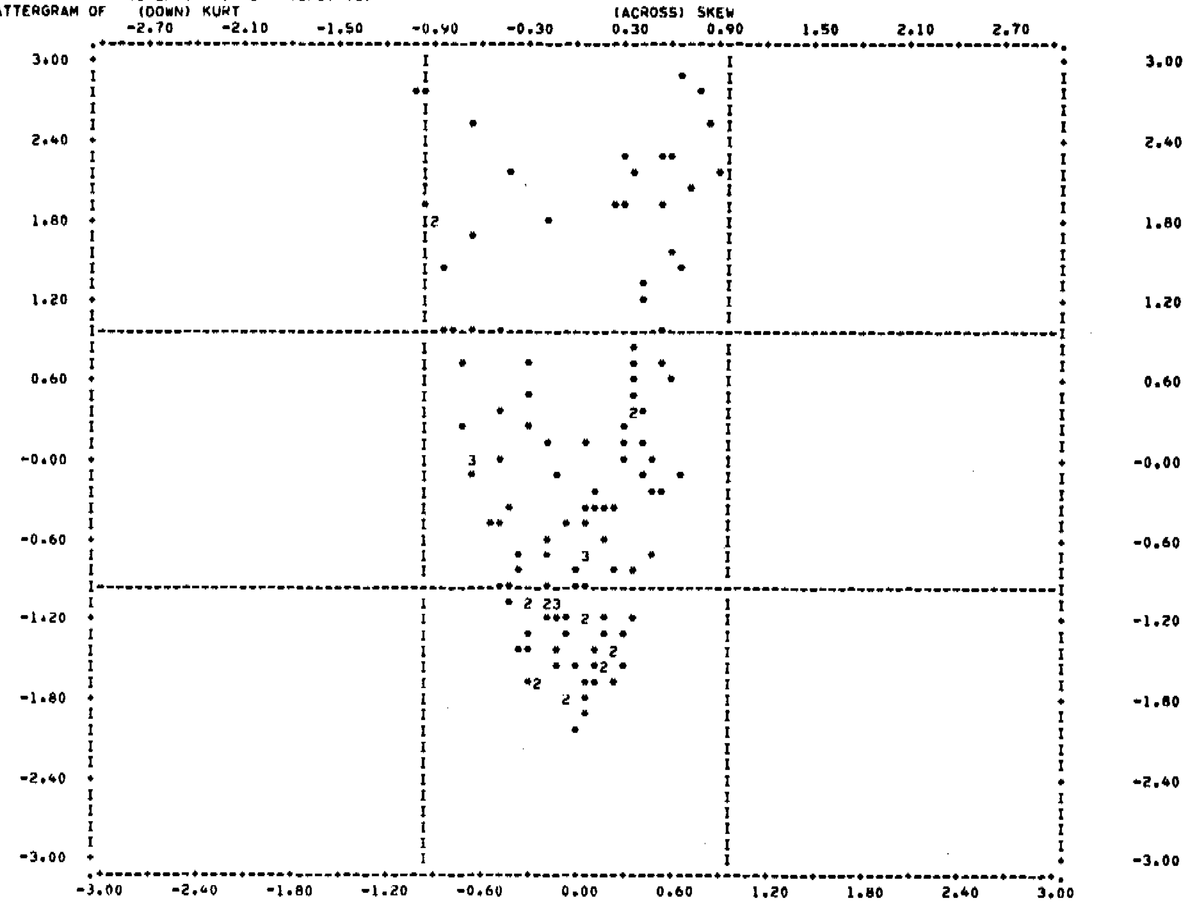
PLOTTED VALUES -	132	EXCLUDED VALUES-	36	MISSING VALUES -	0

Figure 12. Scatter plot of kurtosis versus standard deviation.

FILE NONAME (CREATION DATE = 01/17/78)
SCATTERGRAM OF (DOWN) KURT (ACROSS) SKEW



STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES SPSSH - RELEASE 6.02 01/17/78

STATISTICS..

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PLOTTED VALUES -	132	EXCLUDED VALUES-	36	MISSING VALUES -	0

Figure 13. Scatter plot of kurtosis versus skewness.

APPENDIX 1

Sample station coordinates

(For map location, see Figure 1)

BEAUFORT SEA STATION LOCATIONS

STATION	LATITUDE	LONGITUDE
BE01	69°42'22"	141°29'18"
BE02	69°48'34"	141°54'12"
BE03	69°51'31"	142°06'30"
BE04	69°57'51"	142°30'24"
BE05	70°04'06"	142°53'12"
BE06	70°05'04"	143°07'12"
BE07	70°08'54"	143°34'18"
BE08	70°08'00"	143°33'02"
BE09	70°07'41"	143°45'24"
BE10	70°06'58"	143°49'21"
BE11	70°02'40"	144°16'12"
BE12	70°01'00"	144°29'19"
BE13	69°58'01"	144°42'17"
BE14	69°57'31"	144°57'33"
BE15	70°00'52"	145°16'54"
BE16	70°03'58"	145°28'42"
BE17	70°06'16"	145°39'09"
BE18	70°09'38"	145°50'09"
BE19	70°10'33"	145°56'42"
BE20	70°11'42"	146°04'46"
BE21	70°12'10"	146°12'39"
BE22	70°13'57"	146°23'43"
BE23	70°13'58"	146°33'40"
BE24	70°18'19"	147°00'50"
BE25	70°21'26"	147°20'53"
BE26	70°23'41"	147°28'50"
BE27	70°29'50"	147°57'24"
BE28	70°29'09"	148°19'43"
BE29	70°08'08"	145°56'15"
BE30	70°08'44"	146°05'12"
BE31	70°10'35"	146°19'31"
BE32	70°11'09"	146°37'27"
BE33	70°10'56"	146°50'50"
BE34	70°09'13"	147°03'03"

STATION	LATITUDE	LONGITUDE
BE35	70°11'51"	147°15'00"
BE36	70°12'26"	147°33'15"
BE37	70°12'18"	147°42'03"
BE38	70°17'01"	147°46'33"
BE39	70°18'58"	147°57'49"
BE40	70°20'54"	148°12'00"
BE41	70°20'34"	148°12'50"
BE42	70°20'18"	148°14'15"
BE43	70°20'24"	148°14'44"
BE44	70°19'49"	148°15'38"
BE45	70°18'08"	148°21'15"
BE46	70°18'13"	148°24'21"
BE47	70°18'49"	148°27'13"
BE48	70°19'44"	148°27'52"
BE49	70°20'30"	148°27'24"
BE50	70°22'01"	148°28'54"
BE51	70°23'55"	148°35'00"
BE52	70°25'21"	148°36'35"
BE53	70°27'47"	148°47'54"
BE54	70°28'52"	148°56'20"
BE55	70°30'58"	149°08'16"
BE56	70°31'47"	149°15'01"
BE57A	70°33'28"	149°28'18"
BE57B	70°33'09"	149°28'42"
BE58	70°34'03"	149°38'42"
BE59	70°33'50"	149°51'03"
BE60	70°33'20"	150°08'54"

STATION	LATITUDE	LONGITUDE
BE61	70°24'00"	148°47'46"
BE62	70°26'40"	149°01'41"
BE63	70°29'17"	149°13'24"
BE64	70°30'36"	149°26'10"
BE65	70°29'55"	149°41'32"
BE66	70°29'23"	149°55'15"
BE67	70°26'04"	150°05'25"
BE68	70°26'44"	150°20'07"
BE69	70°29'45"	150°31'33"
BE70	70°27'51"	150°54'36"
BE71	70°25'36"	151°25'54"
BE72	70°26'13"	151°45'36"
BE73	70°27'16"	151°56'29"
BE74	70°33'25"	151°42'42"
BE75	70°34'38"	151°53'06"
BE76	70°35'11"	152°10'54"
BE77	70°36'30"	152°24'36"
BE78	70°40'56"	152°25'05"
BE79	70°48'13"	152°10'05"
BE80	70°51'52"	152°25'39"
BE81	70°53'06"	152°41'12"
BE82	70°54'48"	152°52'48"
BE83	70°55'31"	153°09'05"
BE84A	71°21'40"	156°21'33"
BE84B	71°21'40"	156°21'33"
BE85	71°22'24"	156°24'25"

STATION	LATITUDE	LONGITUDE
BE86	71°34'17"	156°37'13"
BE87	71°23'23"	156°27'47"
BE88	71°23'22"	156°28'20"
BE89	71°23'22"	156°28'35"
BE90	71°23'10"	156°28'42"
BE91A	71°21'29"	156°30'44"
BE91B	71°21'42"	156°31'16"

APPENDIX 3

Summary of statistical parameters

OBS	STATION	DATE	MEAN	STADE	SKEW	KURT
1	BE3A	.	0.587	1.736	-0.431	-0.290
2	BE3B	.	0.995	2.031	-0.783	1.012
3	BE3C	.	2.061	0.325	0.533	3.285
4	BE4A	.	-0.074	1.952	-0.451	-0.862
5	BE4B	.	-2.726	1.186	0.917	3.465
6	BE4C	.	1.313	0.278	-0.796	17.754
7	BE5A	.	0.263	1.388	-0.095	-1.025
8	BE5B	.	0.439	2.317	-0.671	0.103
9	BE5C	.	-1.094	1.937	-0.048	-1.168
10	BE6A	.	-3.234	0.657	-0.170	-0.532
11	BE6B	.	-1.593	1.206	0.088	-0.474
12	BE6C	.	-0.133	2.312	-0.406	-1.039
13	BE7A	.	-0.856	2.647	0.062	-1.717
14	BE7B	.	-2.338	1.628	0.864	2.522
15	BE7C	.	2.162	0.640	-2.764	40.107
16	BE8A	.	-3.748	1.181	1.023	5.195
17	BE8B	.	-3.908	0.526	0.533	0.998
18	BE9A	.	-1.096	2.683	-0.056	-1.787
19	BE9B	.	-2.191	1.097	0.966	5.179
20	BE9C	.	0.371	1.473	-0.455	0.390
21	B10A	.	1.032	0.933	-0.397	2.162
22	B10B	.	-2.795	0.880	-0.282	0.786
23	B10C	.	-0.013	0.968	0.561	1.965
24	B11A	.	2.190	0.463	0.378	0.478
25	B11B	.	2.242	0.342	0.047	-0.272
26	B11C	.	2.358	0.320	0.041	0.216
27	B12A	.	-4.364	0.427	0.392	0.407
28	B12B	.	-3.856	0.694	0.059	-1.128
29	B12C	.	0.195	2.001	-0.373	-0.798
30	B13A	.	-1.011	1.422	0.079	-1.105
31	B13B	.	-2.645	1.244	0.083	-0.702
32	B13C	.	0.086	0.535	0.433	3.913
33	B15A	.	1.601	0.354	0.021	4.186
34	B15B	.	-0.036	3.007	-0.280	-1.566
35	B15C	.	0.984	2.380	-0.986	2.008
36	B16A	.	2.942	0.615	0.597	0.704
37	B16B	.	2.652	0.468	0.863	3.533
38	B17A	.	0.974	0.946	-0.315	0.521
39	B17B	.	0.658	2.033	-1.046	2.793
40	B18A	.	0.874	1.450	-0.503	1.015
41	B18B	.	-0.584	3.204	-0.245	-1.652
42	B18C	.	1.717	0.684	-0.171	0.176
43	B19A	.	0.650	1.085	-0.176	1.818
44	B19B	.	-4.669	0.293	0.297	0.127
45	B19C	.	-4.613	0.289	0.306	0.116
46	B20A	.	-3.375	1.885	0.898	2.198
47	B20B	.	-1.102	2.313	-0.107	-1.514
48	B20C	.	-4.553	0.606	0.798	3.105
49	B21A	.	1.024	1.674	-0.879	1.885
50	B21B	.	1.693	0.526	-0.850	6.960
51	B21C	.	1.943	0.308	0.426	0.166
52	B22A	.	-2.374	3.266	0.259	-1.679
53	B22B	.	-1.616	2.086	0.242	-0.836
54	B22C	.	1.990	0.259	0.355	0.849

OBS	STATION	DATE	MEAN	STADE	SKEW	KURT
55	B23A	.	-4.174	1.434	1.043	3.974
56	B23B	.	1.626	1.524	-1.464	7.082
57	B23C	.	1.553	1.496	-1.663	9.842
58	B24A	.	-2.418	2.207	0.357	-0.737
59	B24B	.	-4.936	0.210	0.238	-1.382
60	B24C	.	-4.809	0.265	0.565	2.285
61	B25A	.	-1.826	2.098	0.157	-1.196
62	B25B	.	-1.800	0.962	-0.275	0.298
63	B25C	.	-2.735	0.857	0.066	-0.621
64	B26A	.	-0.214	2.441	-0.449	-0.861
65	B26B	.	-1.584	1.107	0.114	-0.298
66	B26C	.	-2.388	2.275	0.542	-0.175
67	B27A	.	-4.841	0.382	0.726	2.133
68	B27B	.	-0.695	1.224	0.342	0.578
69	B27C	.	-2.838	1.066	0.676	4.799
70	B28A	.	0.707	1.566	-0.358	-0.644
71	B28B	.	-0.064	2.373	-0.296	-1.258
72	B28C	.	-0.325	1.596	-0.139	-0.076
73	B29A	.	2.997	0.594	0.133	-0.135
74	B29C	.	2.645	0.518	0.331	0.761
75	B30B	.	-3.331	1.924	1.050	3.536
76	B31A	.	-2.819	1.483	0.896	3.200
77	B31B	.	-3.592	1.775	1.268	6.138
78	B31C	.	-5.789	0.387	2.484	36.329
79	B33B	.	-3.280	0.629	-0.086	-0.443
80	B33C	.	-3.340	0.868	-0.105	-1.070
81	B34A	.	-0.946	2.253	0.116	-1.438
82	B34B	.	-2.508	2.268	0.631	-0.010
83	34BB	.	0.553	1.513	-0.517	-0.363
84	34BC	.	-0.404	1.961	0.064	-1.571
85	B34C	.	1.850	0.436	-0.663	13.664
86	B36A	.	-0.774	2.064	0.003	-1.478
87	B36B	.	-0.308	2.559	-0.237	-1.565
88	B36C	.	1.758	0.833	-2.311	22.941
89	B37A	.	-1.544	2.304	0.283	-1.257
90	B37C	.	1.870	0.407	0.307	2.027
91	B38B	.	-1.796	2.367	0.389	-1.158
92	B38C	.	2.018	0.682	-3.502	57.876
93	BE41	.	2.231	0.656	0.805	2.779
94	BE47	.	2.004	0.690	-2.492	29.684
95	BE48	.	1.728	0.740	-2.433	29.172
96	BE49	.	0.351	1.743	-0.074	-1.231
97	B52A	.	-0.175	2.094	-0.126	-1.408
98	B52B	.	0.804	2.223	-0.672	0.021
99	B52C	.	-0.803	2.534	0.043	-1.821
100	B53A	.	-2.072	3.017	0.287	-1.550
101	B53B	.	-2.032	1.254	0.611	2.311
102	B53C	.	0.968	1.788	-0.679	1.067
103	54AA	.	-1.443	1.653	0.476	0.061
104	54AB	.	-0.078	0.527	-0.207	-1.016
105	54AC	.	0.422	1.967	-0.278	-1.430
106	54BA	.	-1.996	1.625	0.687	1.525
107	54BB	.	1.403	1.060	-1.446	7.682
108	54BC	.	0.475	2.377	-0.686	0.068

OBS	STATION	DATE	MEAN	STADE	SKEW	KURT
109	B55A	.	0.078	1.449	-0.095	-0.997
110	B55B	.	-3.742	0.788	0.210	-0.257
111	B55C	.	-1.523	1.485	0.480	-0.121
112	B56A	.	-0.737	2.412	-0.124	-1.111
113	B56B	.	-0.610	2.389	-0.055	-1.796
114	B56C	.	0.481	2.941	-0.680	-0.098
115	B57A	.	0.642	1.357	-0.169	-1.090
116	B57B	.	0.110	1.636	-0.277	-0.990
117	B57C	.	0.952	1.657	-0.746	0.789
118	57BA	.	1.574	0.702	-0.213	4.455
119	57BB	.	1.246	1.223	-0.653	1.772
120	B58A	.	-0.492	1.726	0.108	-1.485
121	B58B	.	-2.450	1.631	0.623	1.613
122	B58C	.	1.346	1.459	-0.912	1.851
123	B58X	.	-1.042	1.942	0.216	-1.335
124	B59A	.	-0.685	2.070	0.129	-1.584
125	B59B	.	-0.828	2.066	0.188	-1.442
126	B59C	.	1.033	1.876	-0.827	1.003
127	B60A	.	1.480	0.908	-1.438	9.883
128	B60B	.	-0.983	0.915	0.055	-0.703
129	B60C	.	0.870	1.227	-0.487	0.075
130	B61B	.	-0.752	2.175	0.152	-1.461
131	B61C	.	-0.578	1.397	-0.464	-0.362
132	B62A	.	1.069	1.566	-0.825	1.458
133	B62B	.	0.417	1.422	-0.194	-0.915
134	B62C	.	2.185	0.296	0.285	0.357
135	B63A	.	-1.734	1.736	0.229	-0.275
136	B63B	.	-0.194	2.707	-0.362	-1.344
137	B63C	.	1.888	0.697	-2.498	30.060
138	B64A	.	1.431	0.480	-0.003	8.965
139	B64B	.	1.260	1.349	-0.952	2.851
140	B64C	.	2.102	0.374	0.387	0.643
141	B66A	.	1.534	0.511	0.468	4.169
142	B66B	.	0.223	2.017	-0.315	-1.029
143	B66C	.	1.706	0.835	-0.656	2.550
144	B67A	.	2.750	0.721	0.163	-0.594
145	B67B	.	2.027	0.282	0.398	1.378
146	B67C	.	1.985	0.408	0.765	3.328
147	B72B	.	3.044	0.703	0.019	-0.749
148	B72C	.	2.013	0.214	0.363	2.223
149	B74A	.	1.873	0.346	0.480	3.025
150	B74B	.	2.409	0.565	0.384	0.419
151	B74C	.	1.721	0.584	0.298	2.311
152	B75A	.	1.903	0.329	1.442	15.155
153	B75B	.	-1.416	3.186	0.018	-1.942
154	B75C	.	2.653	2.961	-0.718	0.309
155	B76B	.	2.038	0.801	-1.555	16.688
156	B79A	.	2.080	0.390	0.635	2.987
157	B81A	.	-0.552	1.896	-0.019	-0.951
158	B81B	.	0.133	1.781	-0.190	-0.995
159	B81C	.	2.028	0.620	-2.496	39.416
160	B82A	.	-0.074	1.986	-0.153	-0.634
161	B82B	.	-2.191	2.419	0.473	-0.616
162	B82C	.	-0.493	0.874	0.270	1.935
163	B83A	.	2.023	0.284	0.419	1.238
164	B83B	.	-0.966	1.920	0.175	-1.306
165	B83C	.	1.949	0.342	0.429	-0.068
166	B85C	.	-0.162	1.237	0.570	0.756
167	91BC	.	-0.975	1.361	0.053	-0.915

QUARTERLY REPORT

Contract No:
R7120840
Research Unit No.:
541 (Previously 141E)
Reporting Period:
1 October - 31 December 1977
Number of Pages: 2

NORTON - CHUKCHI OCEANOGRAPHIC PROCESSES (N-COP)

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31 December 1977

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

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Report Period 1 October - 31 December 1977

I. Task Objectives:

1. Elucidation of the fluctuations in transport of the predominantly north flow through the system;

2. Verification and temporal and spatial description of the bifurcation of northward flow which takes place west of Pt. Hope;

3. Definition of temporal and spatial scales of the variability ubiquitous to the system and acquisition of data for a dynamical description;

4. Definition of circulations prevailing in Norton and Kotzebue sounds. These relatively shallow sounds on the east side of the system have been largely ignored in previous studies, the general circulation patterns within them are not well known; and

5. Clarification of interaction in the zone between the shelf regime of the northeastern (N-COP study area) and the southeastern Bering Sea (B-BOP study area).

II. Field and Laboratory Activities:

A. Cruises: None

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 has been completed and copies forwarded to the OCSEAP project office.

Investigators from this research unit participated in an OCSEAP physical oceanography workshop held in Issaquah, Washington in November, 1977.

Preliminary analysis of three of the over-winter current moorings in the northern Bering Sea region were carried out. Currents have for the first time been recorded beneath the northern Bering Sea and Bering Strait winter ice cover. These records were obtained 9 m above the bottom at two locations southeast of St. Lawrence Island and one location in the eastern channel of Bering Strait. They were recorded from September 1976-April 1977, bracketing the autumn-winter season. A net northward nontidal flow ($\sim$15 cm/s in Bering Strait and $\sim$5 cm/s southeast of St. Lawrence Island) occurred, giving the first direct confirmation of northward regional flow throughout the winter. Large (~50 cm/s) alternating north-south flow events having 2-5 day time scales were superposed on this northward flow, and were driven in part by local atmospheric disturbances. Tidal energy only amounted to $\sim$1% of the total 2.86 hour filtered variance energy in eastern Bering Strait, and $\sim$25% farther south. Nontidal events in Bering Strait were not always correlated with those farther south. Spectral analysis revealed a factor of two decrease in energy density throughout most frequency ranges examined (0.0336-1.9992 cpd) with the onset of local surface ice formation. Frequency bands between diurnal and semidiurnal tidal exhibited a five-fold decrease in energy density. This energy decrease can be explained qualitatively: the ice cover acts as a viscous upper boundary to 1) impede air-sea transfer of wind energy, and 2) attenuate water motions.

CTD data from the September oceanographic cruise to the Bering shelf region, including Norton Sound, are still being processed. Atmospheric pressure data from the northern Bering Sea are presently being digitized from barograph carts prior to processing and analysis. Processing/checking of the over-winter current record from the Chukchi Sea is still underway.

IV. Problems Encountered:

None

REFERENCE

Attention is called to the following article on permafrost studies:

Owens, E. H. and J. R. Harper (1977). "Frost-table and Thaw Depths in the Littoral Zone near Peard Bay, Alaska", Journal of the Arctic Institute of North America, Vol. 30, No. 3, pp. 155-168.

HAZARDS

HAZARDS

HAZARDS

QUARTERLY REPORT

Contract: 03-5-022-67
Research Unit: 98
Reporting Period: 1 Oct. - 31 Dec. 1977
Number of Pages: 3

DYNAMICS OF NEAR SHORE ICE

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I. TASK OBJECTIVES

The University of Washington under Task Order No. 5 of the NOAA Contract 03-5-022-67 agreed to deploy drifting buoys to gather data on the ice movement and atmospheric conditions in the region of the continental shelf of the Beaufort and Chukchi Seas. It was agreed that 4 buoys would be purchased and deployed to track the motion of the ice cover, with one of these buoys to contain a barometric pressure sensor to determine the atmospheric condition. Data from these buoys shall be interpreted to help explain the physical behavior of the ice in this region. This information will help to increase the geographic coverage of previous buoy deployment programs so that we might know more about different regions and will help to determine year to year variability of the ice behavior in the near shore environment.

II. FIELD AND LABORATORY ACTIVITIES

A. Field Trips Scheduled

None

B. Scientific Party

None

C. Methods

All buoys discussed in this report are sampled by the Random Access Measurement System on board Nimbus VI satellite. Data discussed in this report were not collected under the current year's contract but under that of the previous year (1977).

D. Sample Location

The final positions of all buoys deployed under the 1977 contract were reported in the previous quarterly report.

E. Data Collected or Analyzed

The final data from the buoys deployed in the 1977 contract have been sent to the OCSEAP Data Bank.

III. RESULTS

A data report on the time history of the buoy positions observed during the 1977 reporting period is being prepared.

Purchase Orders have been written to Polar Research Laboratory in Santa Barbara, California and to Paroscientific Instruments in Bellevue, Washington to purchase the required buoys and pressure sensor for deployment in the 1978 observation period. We have been in contact with these vendors to ensure that the hardware will be available in time for an early spring deployment and that the hardware will reliably provide the data required.

IV. PRELIMINARY INTERPRETATION OF THE RESULTS

None.

V. PROBLEMS ENCOUNTERED AND RECOMMENDED CHANGES

The schedule of milestones indicates that the Purchase Order was to be sent out approximately 1 November. Since the contract was not received by the University of Washington from NOAA until early December it was not possible to begin this contract as scheduled. However, by working closely with the vendors we believe that they shall be able to meet the delivery schedule of early February in spite of this delay.

VI. ESTIMATE OF FUNDS EXPENDED

As of 30 November 1977 actual expenditures under this contract total $224,965.00. The estimated obligations for December are anticipated to be approximately $600. The total purchase price contract for the 4 drifting buoys is $21,760.00 and the total purchase price for the Paroscientific Instruments barometric pressure sensor is $2,275.00. These costs include the estimated transportation charges to Barrow, Alaska.

Addendum to RU #98

MEASUREMENTS OF SEA ICE MOTION JANUARY 1977 TO SEPTEMBER 1977

by

A. S. Thorndike
AIDJEX

ABSTRACT

Several data buoys were deployed in the Beaufort and Chukchi Seas during the spring of 1977, as part of NOAA's Outer Continental Shelf Environmental Assessment Program. Data from these buoys (and from two buoys deployed during AIDJEX and still operating) have been edited and interpolated for presentation in this report.

In earlier papers and reports we have discussed the procedures for handling data from RAMS buoys--see references. Only a few additional remarks are required here.

1. The convention of numbering days sequentially from day 1 = 1 January 1975 as was done in the earlier reports has been replaced here with day numbers beginning with day 1 = 1 January 1977. A calendar is provided in Appendix 1.

2. Readers who have followed this business closely will note that no data have been reported for the last part of December 1976 and the first part of January 1977. Data do exist for this period for the two buoys R723 and R1003. They may be prepared at a later date.

3. For compactness, only daily positions are reported here. More complete data sets comprising position and velocity at 3-hour intervals are available from the AIDJEX Data Bank.

4. Several buoys crossed into the eastern hemisphere during this period. The tabulated longitude of these stations will change sign from -180°E to +180°E as a station moves westward across the 180° meridian.

ACKNOWLEDGMENT

This work was supported by the National Science Foundation grant entitled "Arctic Sea Ice Study" and numbered OPP76-10801, and 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. The OCSEAP contract with the AIDJEX office is entitled "Near Shore Ice" and is numbered 03-5-022-67.

REFERENCES

Thorndike, A. S., and J. Y. Cheung. 1977. AIDJEX measurements of sea ice motion, 11 April 1975 to 14 May 1976. AIDJEX Bulletin No. 35, pp. 1-49.

Thorndike, A. S., and J. Y. Cheung. 1977. Position data supplement No. 1. 14 May 76 - 30 November 76. Unpublished. Available from AIDJEX Data Bank.

Thorndike, A. S., and J. Y. Cheung. 1977. Measurements of sea ice motion determined from OCS data buoys, October 1975 to December 1976. Unpublished final report to OCSEAP-NOAA. Available from AIDJEX Data Bank.

Appendix. The following correspondence between calendar dates and day numbers may be useful.

date	day
1 January 77	1
1 February 77	32
1 March 77	60
1 April 77	91
1 May 77	121
1 June 77	152
1 July 77	182
1 August	213
1 September 77	244
1 October 77	274
1 November 77	305
1 December 77	335

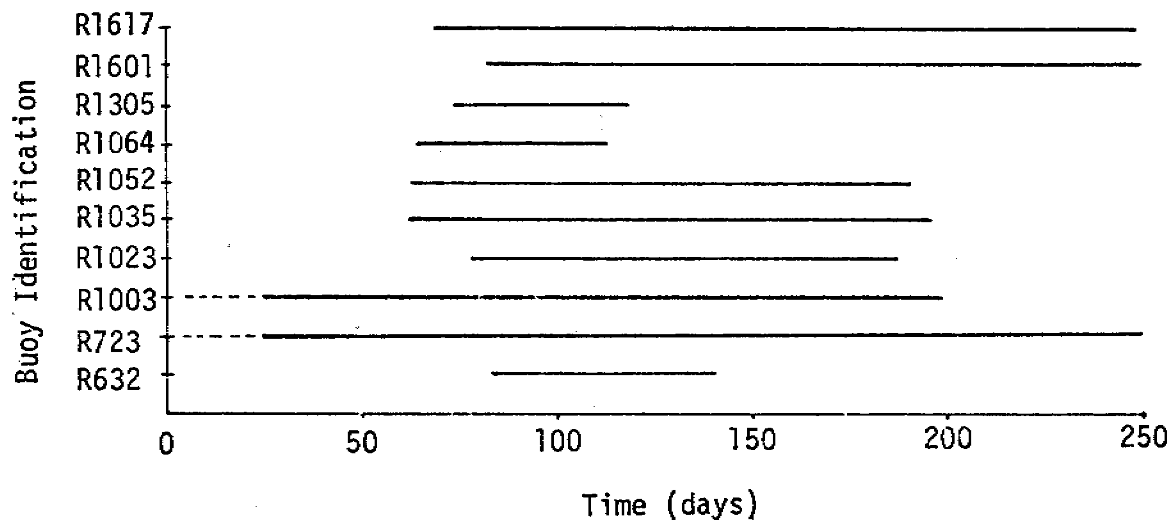
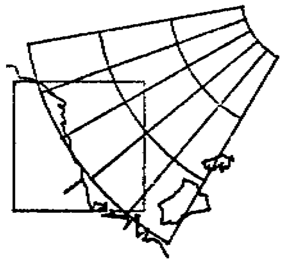


Figure 1. Time chart showing the interval of data reported for each buoy. The broken lines for buoys R723 and R1003 indicate times when data exist but are not reported here.



Buoy R632. Deployed
23 March '77; last data
30 May '77.

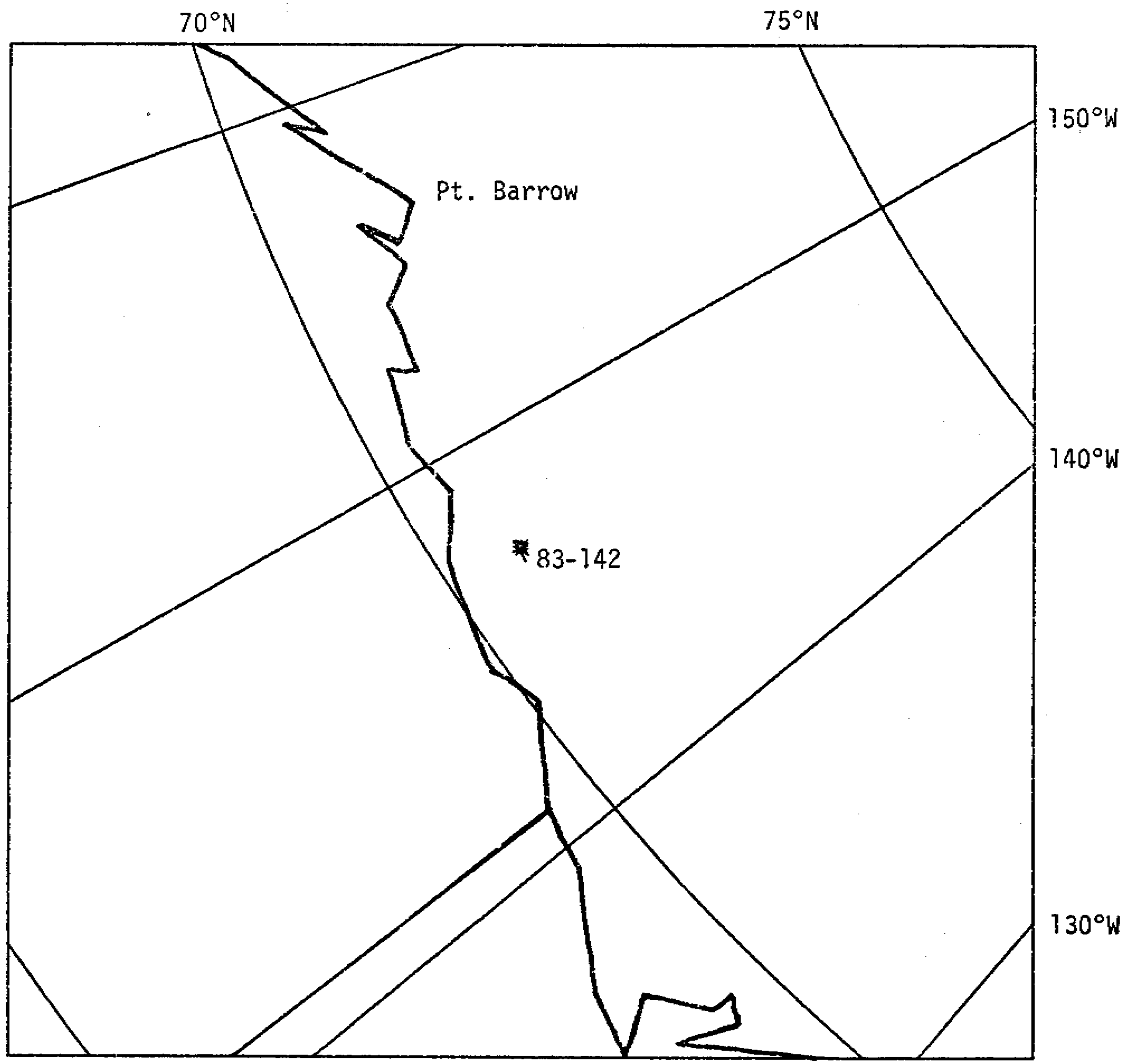
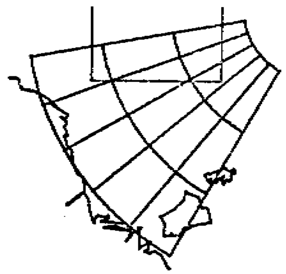
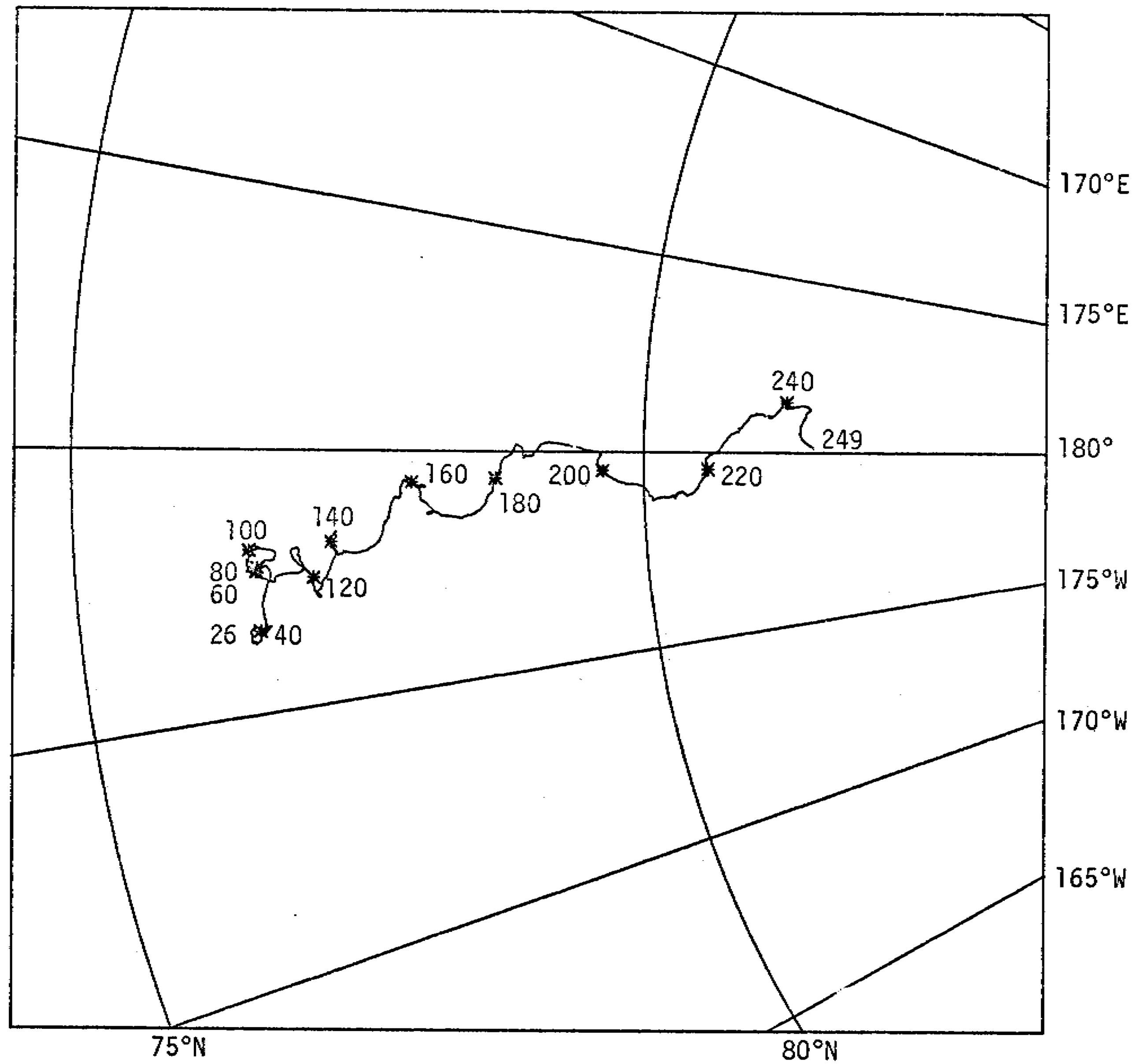
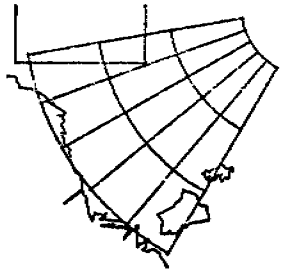


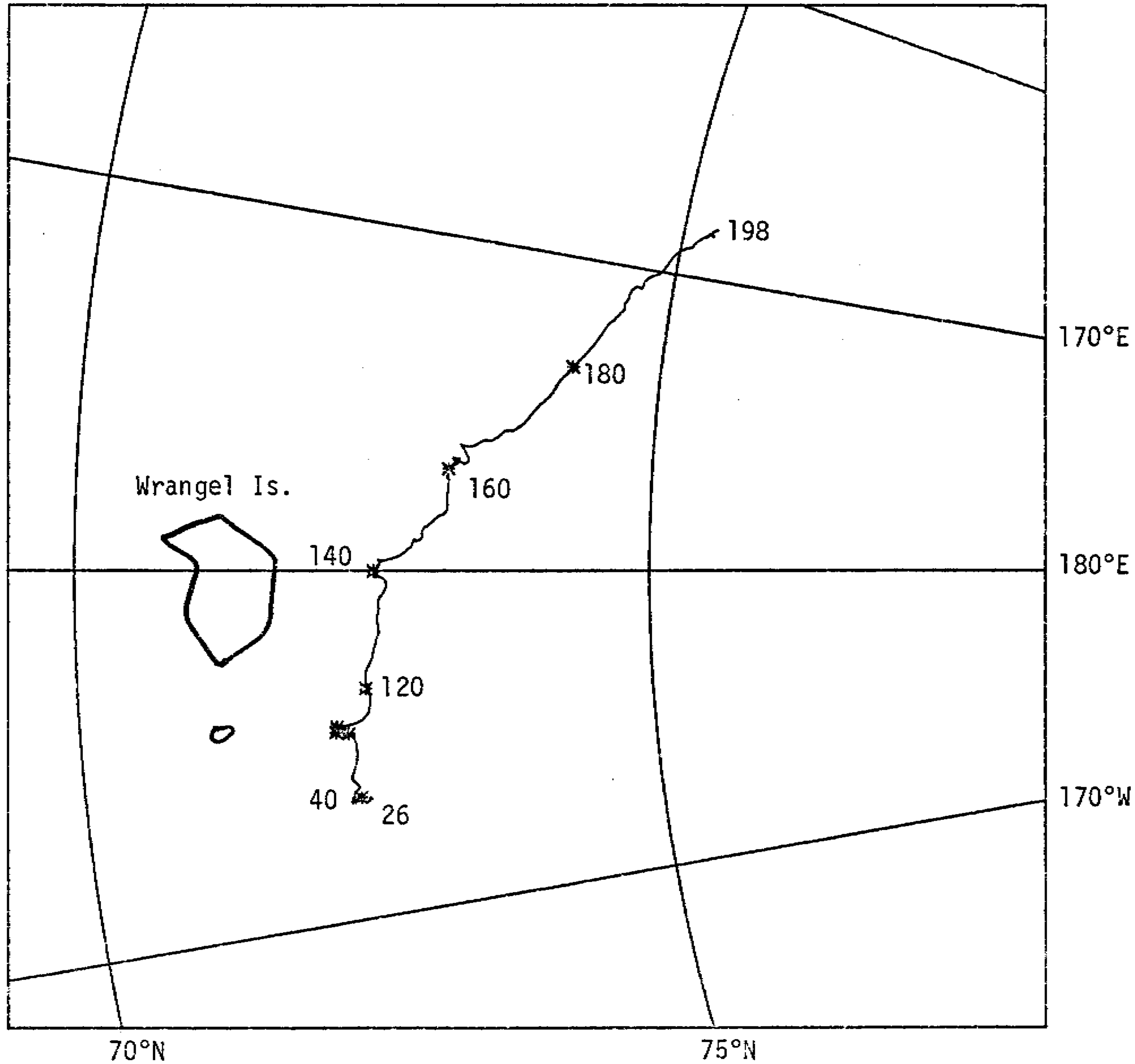
Figure 2. The trajectory of each station is plotted. A thumbnail sketch locates the plotted region with respect to the Alaskan coast. Asterisks indicate the positions at integral multiples of 20 days. The region is 1000 km x 1000 km aligned with the coordinate system described in Appendix 7 of AIDJEX Bulletin 35.



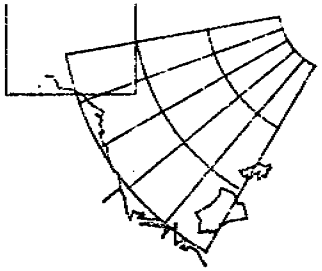


Buoy R723. Deployed 16 October '75. Known during AIDJEX as Site Y, or Station 66. Located at 77.2°N, 168.9°W on 1 December '76. Still operating as of 29 September '77 at 81.4°N, 175.4°E.

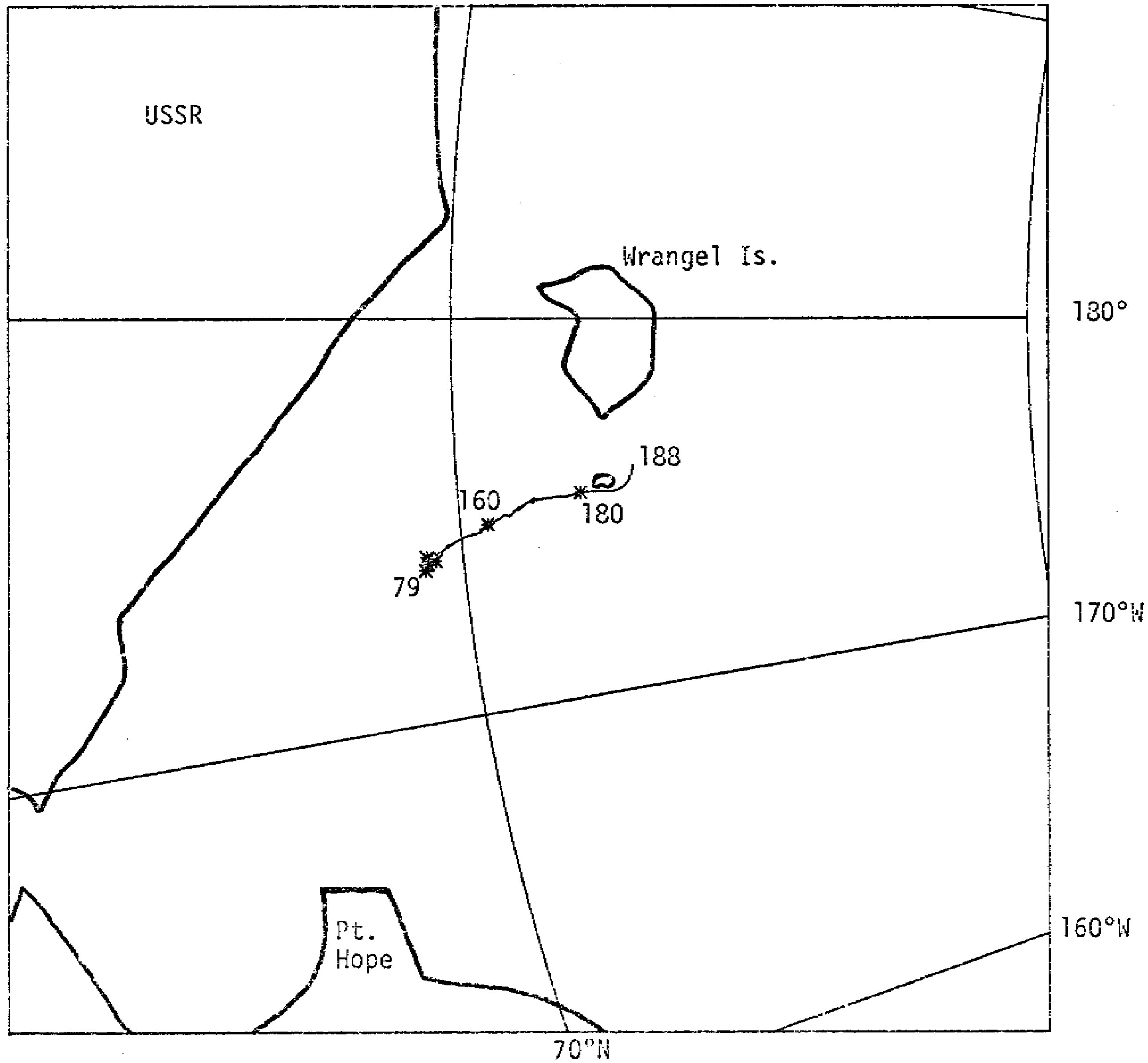


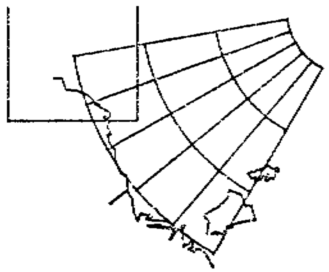


Buoy R1003. Deployed in spring 1975, at the same site as the AIDJEX NavSat buoy HF6. First good data 20 July '75, at 73.9°N, 141.6°W. On 1 Dec. '76 the buoy was located at 73.1°N, 167.0°W. Last good data on 24 July '77.

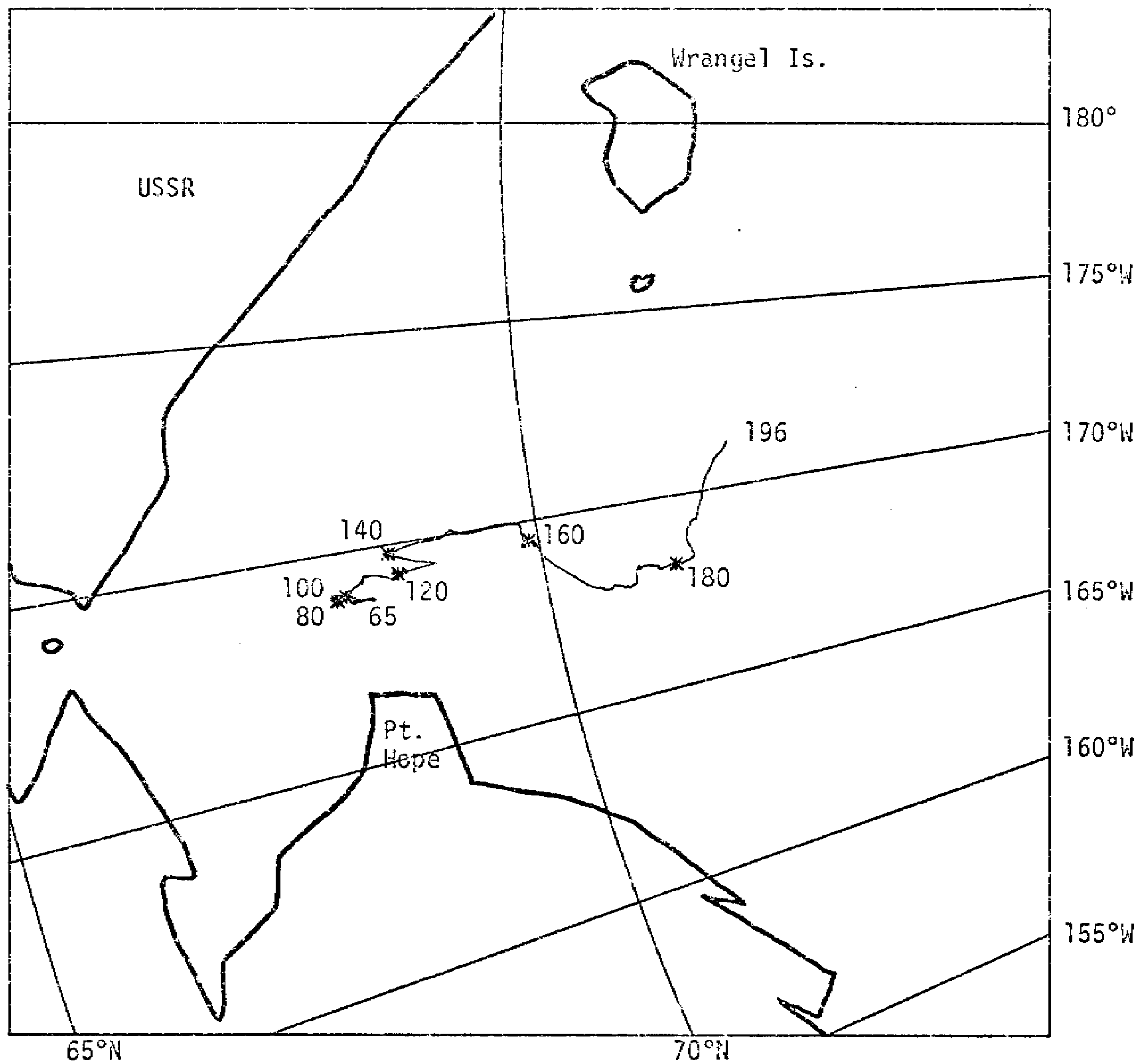


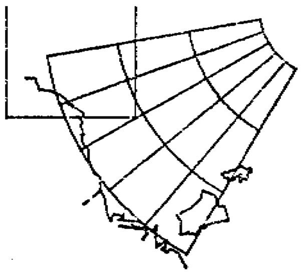
Buoy R1023. Deployed 13 March '77; last data 10 July '77.

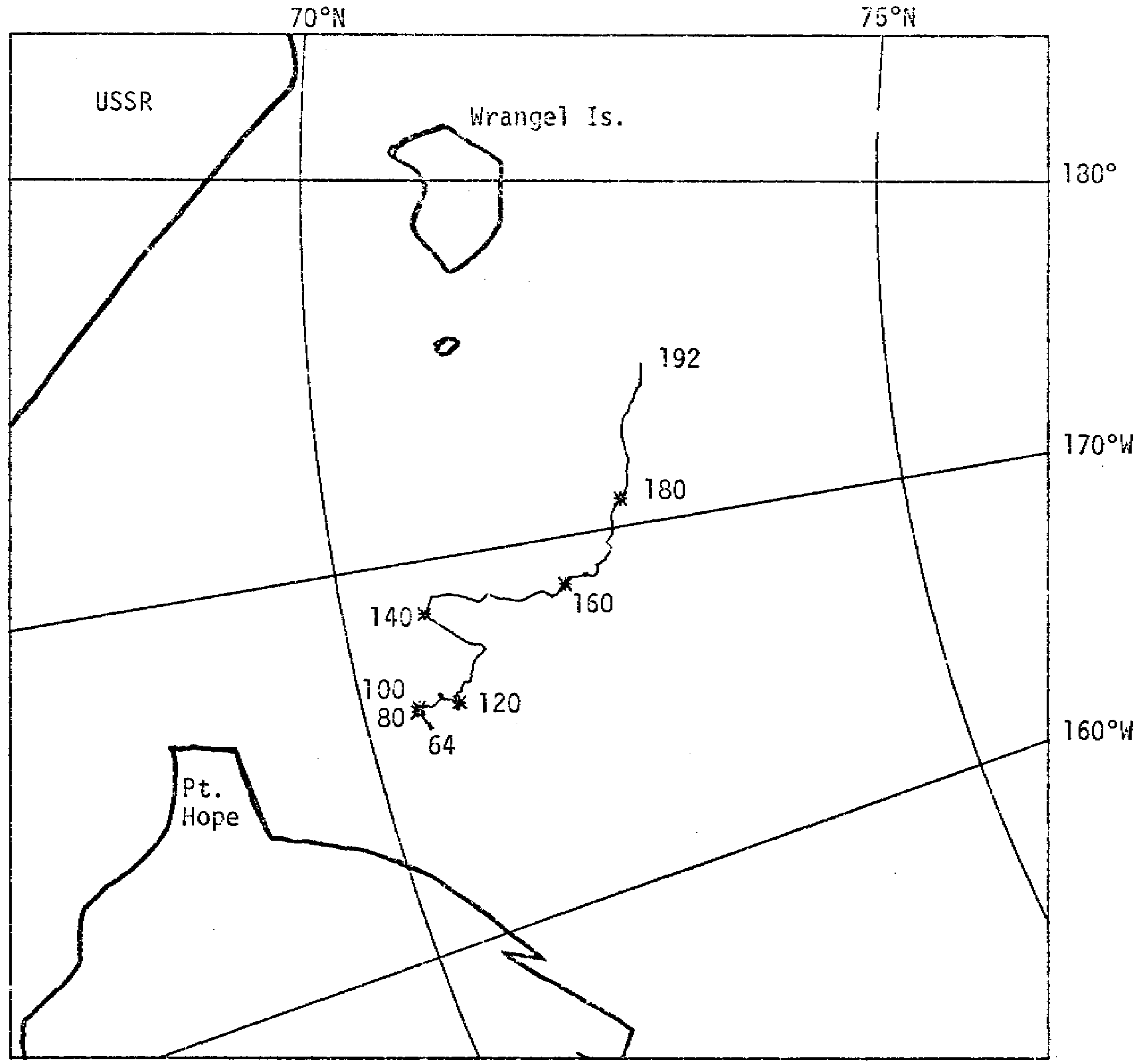




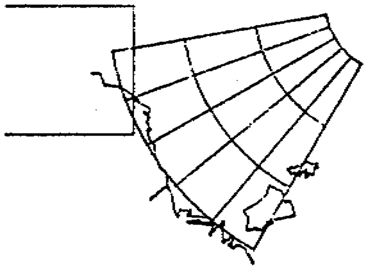
Buoy R1035. Deployed 4 March '77; last data 17 July '77.

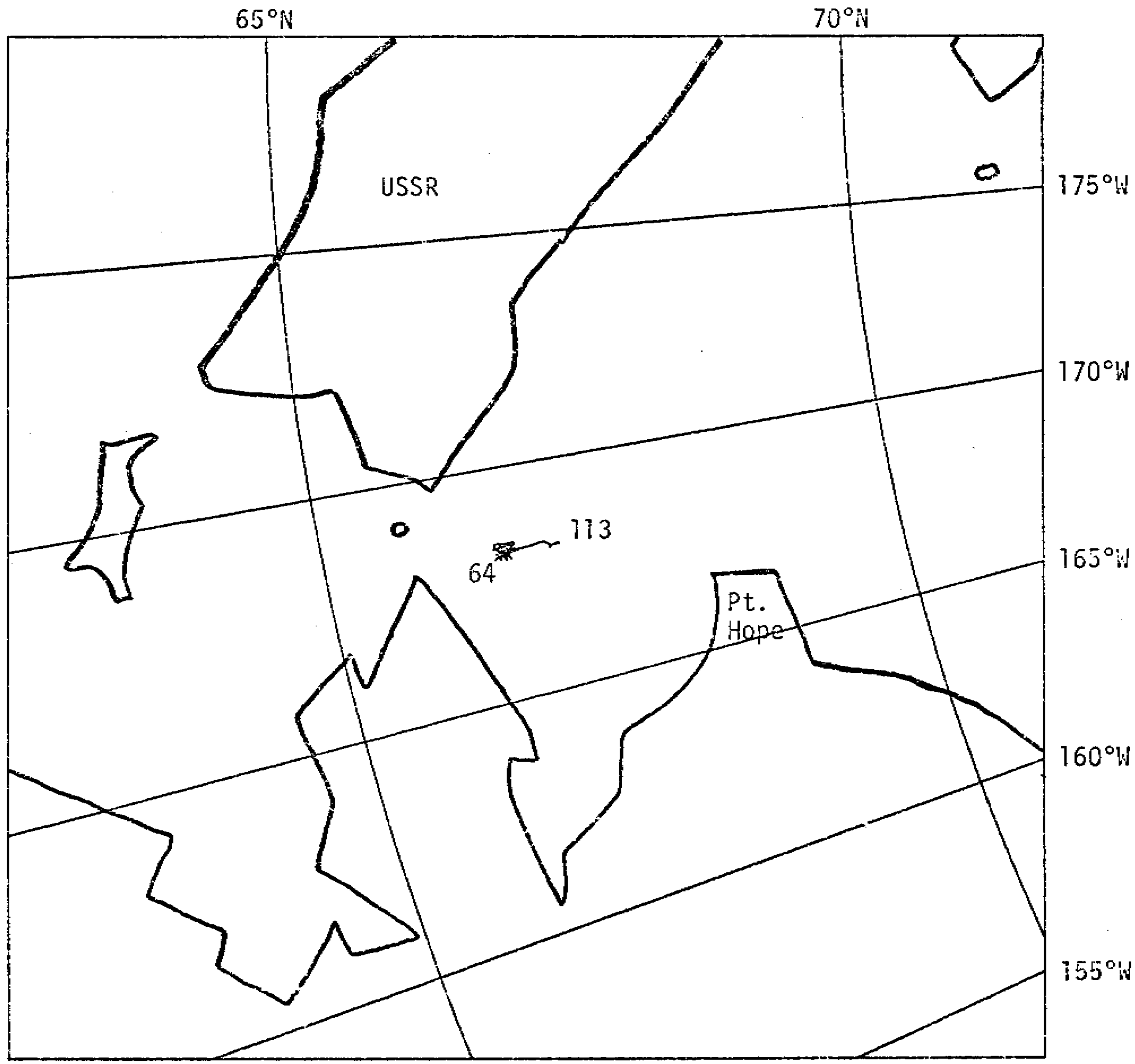




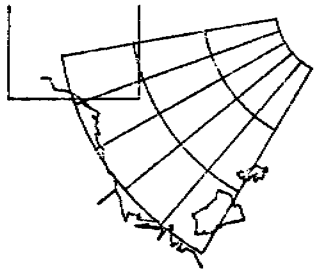


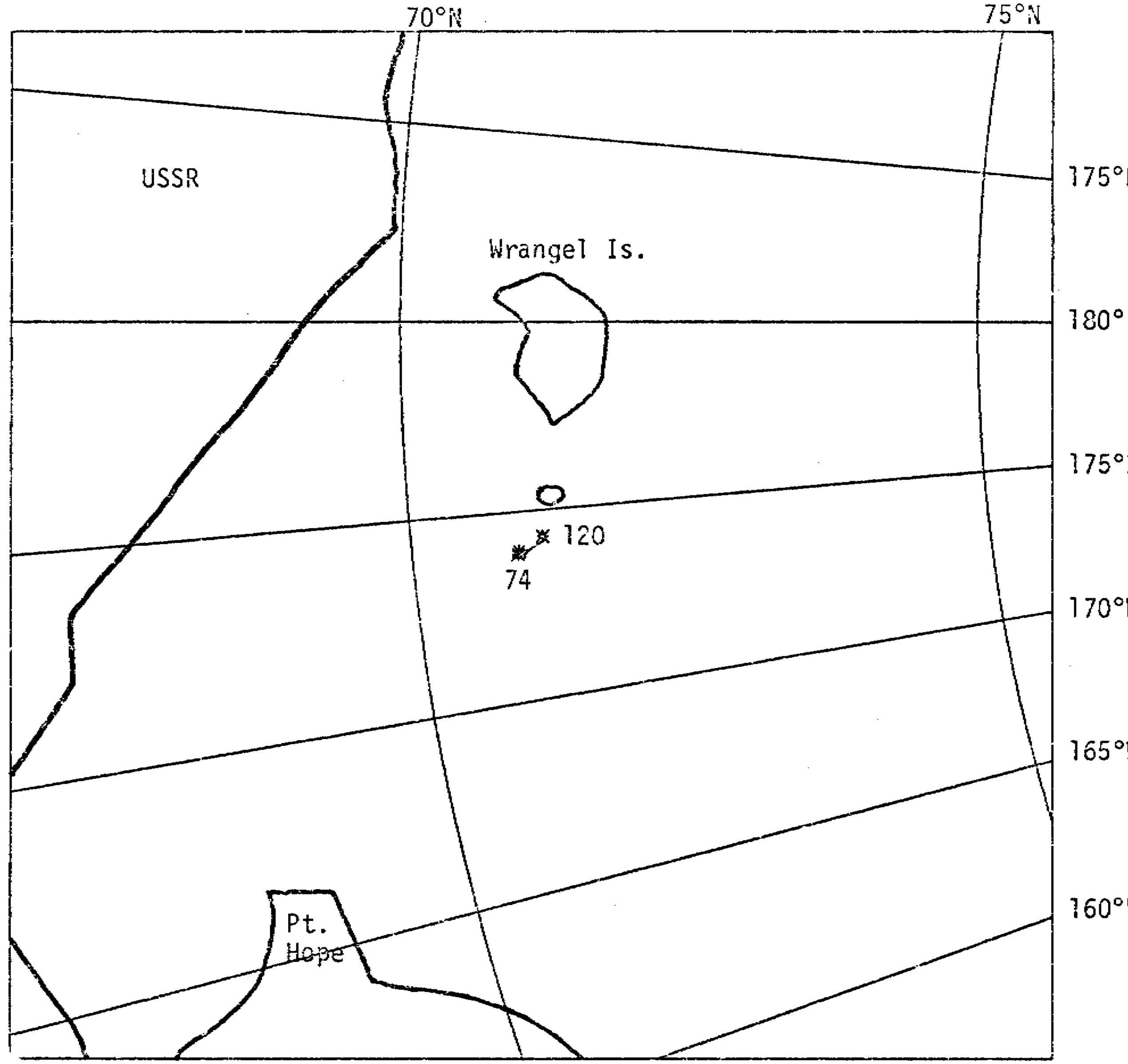
Buoy R1052. Deployed
3 March '77; last data
13 July '77.



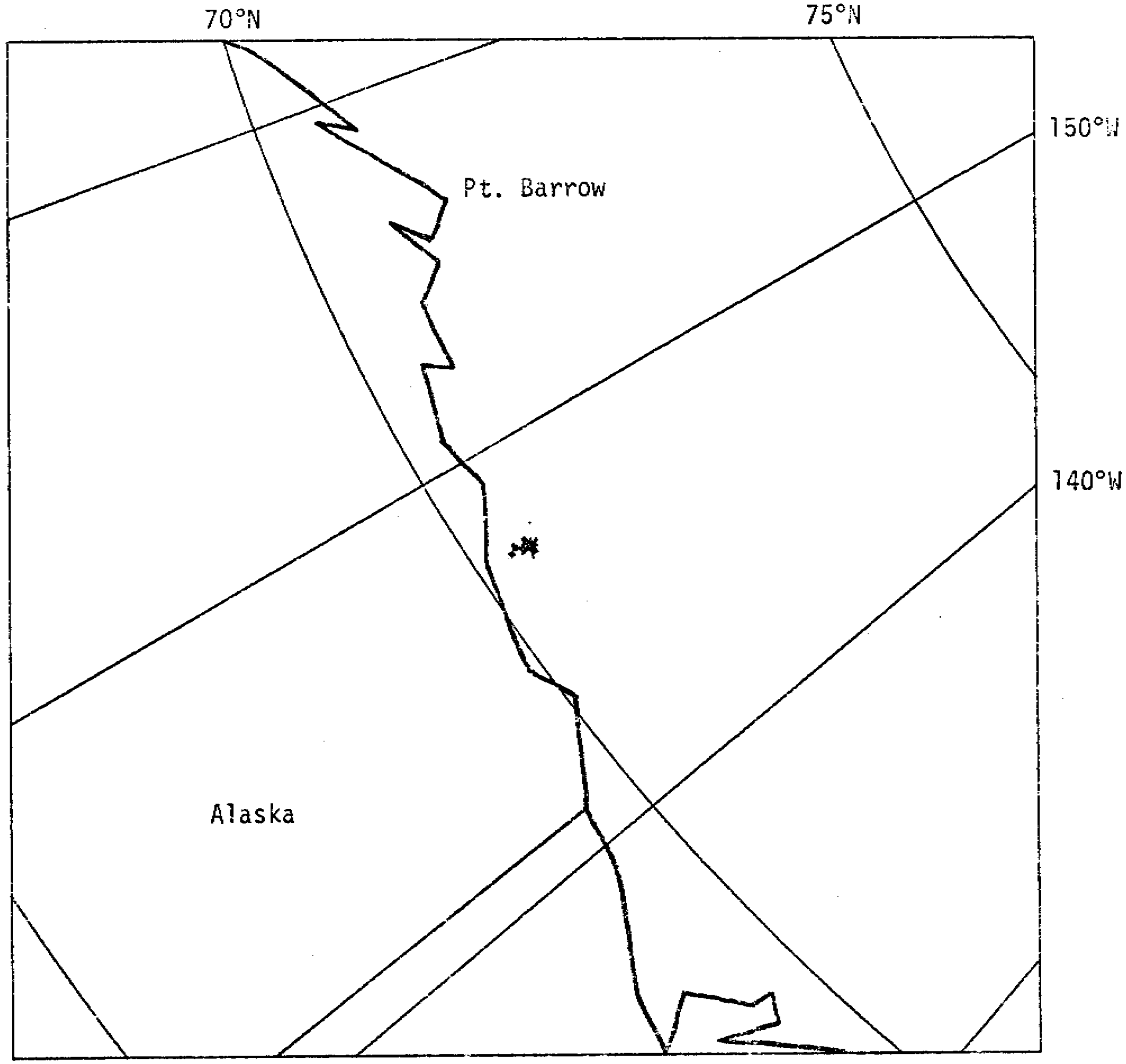


<u>Buoy R1064.</u> Deployed 4 March 1977; last data 25 April '77.

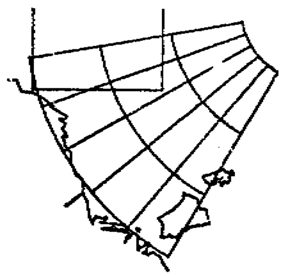


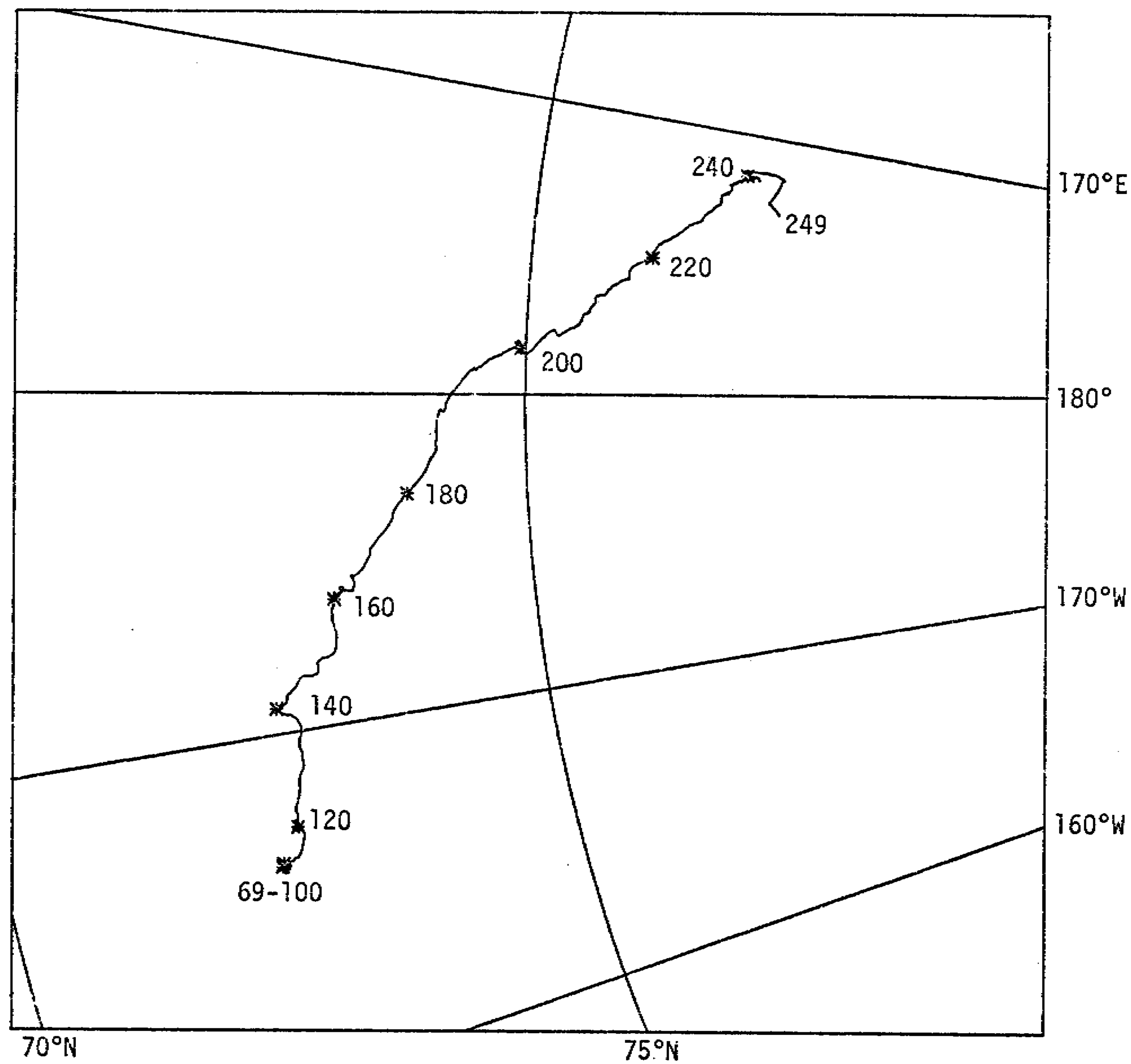


Buoy R1305. Deployed 14 March '77; last data 3 May '77.



Buoy R1601. Deployed 23 March '77. Still operating as of 29 September '77 at 70.3°N, 147.3°W. The motion of this buoy may be strongly constrained by small islands not shown in this sketch of the Alaskan coast.





Buoy R1617. Deployed 5 March '77. Still operating as of 29 September '77 at 76.4°N, 170.4°E.

TABLES

Daily estimated positions at 1200 GMT for data buoys. Errors in the estimated positions are typically 1 = 1000 m.

RAMS 632 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
81			101	70.720	-146.849	121	70.723	-146.924	141	70.711	-146.970	161		
82			102	70.710	-146.925	122	70.715	-146.922	142	70.725	-146.872	162		
83	70.710	-146.895	103	70.729	-146.923	123	70.714	-146.919	143			163		
84	70.730	-146.912	104	70.700	-146.972	124	70.722	-146.908	144			164		
85	70.722	-146.892	105	70.718	-146.942	125	70.728	-146.936	145			165		
86	70.716	-146.870	106	70.698	-146.936	126	70.719	-146.888	146			166		
87	70.712	-146.862	107	70.716	-146.980	127	70.721	-146.899	147			167		
88	70.719	-146.896	108	70.730	-146.906	128	70.724	-146.937	148			168		
89	70.716	-146.850	109	70.719	-146.905	129	70.728	-146.908	149			169		
90	70.718	-146.877	110	70.728	-146.936	130	70.711	-146.907	150			170		
91	70.716	-146.937	111	70.713	-146.919	131	70.720	-146.904	151			171		
92	70.718	-146.945	112	70.719	-146.922	132	70.719	-146.910	152			172		
93	70.725	-146.874	113	70.709	-146.943	133	70.720	-146.944	153			173		
94	70.722	-146.876	114	70.719	-146.921	134	70.722	-146.911	154			174		
95	70.726	-146.922	115	70.723	-146.931	135	70.715	-146.941	155			175		
96	70.723	-146.914	116	70.729	-146.879	136	70.722	-146.907	156			176		
97	70.717	-146.925	117	70.727	-146.875	137	70.720	-146.868	157			177		
98	70.736	-146.903	118	70.710	-146.924	138	70.730	-146.915	158			178		
99	70.735	-146.902	119	70.720	-146.934	139	70.725	-146.899	159			179		
100	70.714	-146.876	120	70.737	-146.918	140	70.713	-146.919	160			180		

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
21			71	76.514	-175.817	121	77.087	-174.931	171	78.211	-177.296	221	80.545	-179.413
22			72	76.521	-175.849	122	77.073	-174.781	172	78.278	-177.188	222	80.605	-179.939
23			73	76.508	-175.811	123	77.101	-174.324	173	78.379	-177.107	223	80.688	179.607
24			74	76.519	-175.841	124	77.130	-174.234	174	78.432	-177.139	224	80.757	179.057
25			75	76.512	-175.827	125	77.109	-174.400	175	78.511	-177.238	225	80.823	178.871
26	76.665	-173.265	76	76.513	-175.821	126	77.125	-174.491	176	78.562	-177.391	226	80.827	178.791
27	76.660	-173.216	77	76.539	-175.962	127	77.145	-174.627	177	78.605	-177.588	227	80.859	178.548
28	76.661	-173.219	78	76.559	-176.116	128	77.171	-174.897	178	78.632	-177.912	228	80.905	178.225
29	76.654	-173.192	79	76.550	-176.239	129	77.208	-175.112	179	78.669	-178.136	229	80.935	177.964
30	76.645	-173.151	80	76.539	-176.232	130	77.237	-175.391	180	78.691	-178.626	230	80.977	177.829
31	76.624	-173.053	81	76.527	-176.217	131	77.268	-175.679	181	78.736	-179.029	231	81.021	177.827
32	76.614	-173.039	82	76.525	-176.218	132	77.293	-175.649	182	78.761	-179.481	232	81.055	177.926
33	76.610	-173.070	83	76.524	-176.233	133	77.283	-176.051	183	78.814	-179.785	233	81.100	177.910
34	76.605	-173.080	84	76.521	-176.222	134	77.276	-176.204	184	78.853	-179.992	234	81.094	177.988
35	76.595	-173.014	85	76.520	-176.209	135	77.284	-176.374	185	76.873	179.848	235	81.107	178.028
36	76.589	-172.983	86	76.520	-176.221	136	77.297	-176.583	186	78.885	179.714	236	81.148	177.769
37	76.586	-172.977	87	76.561	-176.211	137	77.300	-176.725	187	78.903	179.693	237	81.196	177.382
38	76.585	-173.061	88	76.610	-176.236	138	77.290	-176.747	188	78.931	179.770	238	81.194	177.027
39	76.581	-173.070	89	76.620	-176.258	139	77.272	-176.621	189	78.947	179.984	239	81.242	176.981
40	76.585	-173.074	90	76.613	-176.308	140	77.249	-176.522	190	78.953	-179.725	240	81.230	176.990
41	76.559	-173.163	91	76.601	-176.294	141	77.263	-176.210	191	78.987	-179.808	241	81.249	177.199
42	76.510	-173.207	92	76.598	-176.332	142	77.293	-175.920	192	79.052	-179.960	242	81.236	177.318
43	76.496	-173.033	93	76.589	-176.294	143	77.330	-175.846	193	79.153	179.576	243	81.242	177.416
44	76.493	-172.918	94	76.696	-176.183	144	77.345	-175.885	194	79.249	179.598	244	81.353	177.277
45	76.496	-172.749	95	76.760	-176.005	145	77.374	-175.928	195	79.347	179.711	245	81.445	177.425
46	76.503	-172.704	96	76.734	-175.794	146	77.482	-175.858	196	79.440	179.786	246	81.412	177.736
47	76.518	-172.711	97	76.722	-175.769	147	77.633	-176.123	197	79.528	179.922	247	81.371	178.376
48	76.536	-172.678	98	76.689	-175.789	148	77.698	-176.536	198	79.622	-179.959	248	81.379	179.157
49	76.573	-172.840	99	76.659	-175.748	149	77.712	-176.847	199	79.608	-179.630	249	81.454	179.591
50	76.613	-173.095	100	76.618	-175.589	150	77.729	-177.082	200	79.615	-179.312	250		
51	76.635	-173.216	101	76.576	-175.491	151	77.740	-177.068	201	79.687	-178.861	251		
52	76.625	-173.598	102	76.582	-175.243	152	77.769	-177.328	202	79.807	-178.490	252		
53	76.627	-174.320	103	76.636	-175.129	153	77.787	-177.690	203	79.958	-178.351	253		
54	76.687	-175.005	104	76.711	-174.984	154	77.812	-177.996	204	80.042	-177.949	254		
55	76.704	-175.375	105	76.743	-175.000	155	77.848	-178.052	205	80.052	-177.803	255		
56	76.666	-175.582	106	76.753	-175.139	156	77.871	-178.128	206	80.072	-177.627	256		
57	76.633	-175.496	107	76.818	-175.215	157	77.870	-178.362	207	80.096	-177.569	257		
58	76.622	-175.488	108	76.941	-175.218	156	77.885	-178.590	208	80.161	-177.687	258		
59	76.625	-175.470	109	76.989	-175.328	159	77.907	-178.744	209	80.225	-177.669	259		
60	76.609	-175.391	110	76.938	-175.592	160	77.942	-178.717	210	80.248	-177.721	260		
61	76.554	-175.396	111	76.975	-175.778	161	78.004	-178.611	211	80.258	-177.754	261		
62	76.503	-175.434	112	76.967	-175.887	162	78.078	-178.458	212	80.266	-177.684	262		
63	76.508	-175.410	113	76.954	-175.911	163	78.079	-178.515	213	80.271	-177.636	263		
64	76.519	-175.469	114	76.970	-175.996	164	78.041	-178.456	214	80.288	-177.782	264		
65	76.509	-175.657	115	76.947	-176.201	165	78.044	-178.033	215	80.289	-177.849	265		
66	76.503	-175.804	116	76.905	-176.132	166	78.093	-177.777	216	80.333	-177.921	266		
67	76.514	-175.858	117	76.910	-175.859	167	78.150	-177.389	217	80.370	-177.765	267		
68	76.513	-175.816	118	76.948	-175.611	168	78.117	-177.304	218	80.420	-177.821	268		
69	76.516	-175.788	119	76.982	-175.496	169	78.104	-177.337	219	80.459	-178.046	269		
70	76.517	-175.829	120	77.051	-175.180	170	78.132	-177.402	220	80.539	-178.760	270		

RAMS 1003 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
21			61	72.303	-175.281	101	72.207	-175.360	141	72.614	179.947	181	74.303	173.140
22			62	72.240	-175.260	102	72.214	-175.358	142	72.659	179.759	182	74.421	172.495
23			63	72.237	-175.261	103	72.237	-175.364	143	72.671	179.691	183	74.488	172.040
24			64	72.230	-175.274	104	72.288	-175.439	144	72.641	179.697	184	74.569	171.651
25			65	72.213	-175.298	105	72.281	-175.462	145	72.651	179.686	185	74.612	171.425
26	72.477	-173.410	66	72.214	-175.324	106	72.280	-175.575	146	72.681	179.712	186	74.615	171.205
27	72.468	-173.429	67	72.221	-175.316	107	72.392	-175.597	147	72.831	179.550	187	74.636	171.005
28	72.466	-173.418	68	72.210	-175.319	108	72.489	-175.793	148	72.923	179.288	188	74.652	170.791
29	72.462	-173.389	69	72.208	-175.316	109	72.532	-176.082	149	72.948	179.084	189	74.711	170.620
30	72.455	-173.378	70	72.216	-175.349	110	72.537	-176.390	150	72.969	179.105	190	74.746	170.529
31	72.443	-173.342	71	72.219	-175.341	111	72.517	-176.528	151	73.012	179.026	191	74.816	170.185
32	72.427	-173.351	72	72.214	-175.309	112	72.503	-176.567	152	73.022	178.788	192	74.902	169.865
33	72.410	-173.382	73	72.209	-175.331	113	72.498	-176.532	153	73.075	178.635	193	75.025	169.159
34	72.402	-173.399	74	72.210	-175.314	114	72.497	-176.598	154	73.155	178.383	194	75.114	168.903
35	72.406	-173.371	75	72.209	-175.303	115	72.484	-176.610	155	73.234	178.147	195	75.184	168.630
36	72.404	-173.387	76	72.215	-175.334	116	72.466	-175.574	156	73.232	177.788	196	75.248	168.388
37	72.398	-173.410	77	72.215	-175.318	117	72.463	-176.543	157	73.236	177.510	197	75.290	168.270
38	72.393	-173.482	78	72.221	-175.449	118	72.469	-176.577	158	73.237	177.244	198	75.257	168.354
39	72.394	-173.468	79	72.237	-175.552	119	72.475	-176.575	159	73.228	177.172	199		
40	72.397	-173.461	80	72.234	-175.526	120	72.488	-176.611	160	73.227	177.030	200		
41	72.378	-173.462	81	72.229	-175.523	121	72.526	-176.650	161	73.267	176.856	201		
42	72.327	-173.422	82	72.231	-175.554	122	72.518	-176.712	162	73.315	176.675	202		
43	72.323	-173.440	83	72.236	-175.523	123	72.501	-176.655	163	73.313	176.603	203		
44	72.314	-173.363	84	72.240	-175.535	124	72.505	-176.632	164	73.264	176.599	204		
45	72.303	-173.331	85	72.226	-175.511	125	72.516	-176.692	165	73.279	176.669	205		
46	72.304	-173.351	86	72.232	-175.526	126	72.509	-176.731	166	73.330	176.709	206		
47	72.306	-173.349	87	72.243	-175.506	127	72.511	-176.971	167	73.379	176.743	207		
48	72.311	-173.480	88	72.247	-175.540	128	72.537	-177.228	168	73.393	176.552	208		
49	72.346	-173.657	89	72.244	-175.544	129	72.579	-177.539	169	73.331	176.192	209		
50	72.377	-173.783	90	72.241	-175.513	130	72.613	-177.953	170	73.338	176.197	210		
51	72.343	-173.934	91	72.243	-175.544	131	72.641	-178.233	171	73.382	176.212	211		
52	72.328	-174.027	92	72.238	-175.526	132	72.628	-178.535	172	73.491	176.074	212		
53	72.318	-174.034	93	72.235	-175.554	133	72.637	-178.763	173	73.567	175.991	213		
54	72.371	-174.435	94	72.283	-175.519	134	72.640	-178.999	174	73.681	175.736	214		
55	72.380	-175.138	95	72.314	-175.506	135	72.681	-179.330	175	73.748	175.651	215		
56	72.358	-175.375	96	72.264	-175.367	136	72.707	-179.674	176	73.843	175.443	216		
57	72.355	-175.353	97	72.273	-175.305	137	72.650	-179.842	177	73.935	174.995	217		
58	72.344	-175.349	98	72.266	-175.427	138	72.628	-179.865	178	74.028	174.609	218		
59	72.346	-175.361	99	72.241	-175.444	139	72.620	-179.872	179	74.101	174.211	219		
60	72.343	-175.338	100	72.237	-175.431	140	72.607	-179.959	180	74.183	173.747	220		

RAMS 1023 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
71			101	69.653	-173.744	131	69.762	-174.024	161	70.244	-174.773	191		
72			102	69.650	-173.729	132	69.759	-174.004	162	70.285	-174.793	192		
73			103	69.686	-173.796	133	69.756	-174.029	163	70.302	-174.813	193		
74			104	69.685	-173.843	134	69.760	-174.017	164	70.294	-174.814	194		
75			105	69.689	-173.823	135	69.762	-174.012	165	70.328	-174.855	195		
76			106	69.690	-173.817	136	69.787	-174.085	166	70.400	-174.959	196		
77			107	69.775	-173.922	137	69.765	-174.116	167	70.456	-174.952	197		
78			108	69.765	-173.909	138	69.752	-174.073	168	70.509	-175.074	198		
79	69.694	-173.891	109	69.778	-173.930	139	69.714	-174.053	169	70.522	-175.107	199		
80	69.695	-173.891	110	69.780	-173.938	140	69.686	-174.068	170	70.543	-175.127	200		
81	69.691	-173.886	111	69.764	-173.948	141	69.689	-174.106	171	70.590	-175.215	201		
82	69.690	-173.864	112	69.758	-173.946	142	69.696	-174.096	172	70.625	-175.251	202		
83	69.684	-173.879	113	69.760	-173.977	143	69.702	-174.107	173	70.641	-175.292	203		
84	69.684	-173.845	114	69.756	-173.973	144	69.691	-174.122	174	70.647	-175.233	204		
85	69.686	-173.856	115	69.765	-173.979	145	69.693	-174.135	175	70.656	-175.315	205		
86	69.691	-173.884	116	69.746	-173.938	146	69.699	-174.107	176	70.676	-175.285	206		
87	69.683	-173.864	117	69.756	-173.943	147	69.745	-174.151	177	70.700	-175.284	207		
88	69.690	-173.890	118	69.763	-173.973	148	69.761	-174.196	178	70.799	-175.302	208		
89	69.692	-173.884	119	69.764	-173.990	149	69.765	-174.162	179	70.916	-175.308	209		
90	69.694	-173.887	120	69.754	-173.959	150	69.796	-174.156	180	71.027	-175.346	210		
91	69.691	-173.889	121	69.764	-174.006	151	69.882	-174.347	181	71.138	-175.395	211		
92	69.690	-173.881	122	69.764	-174.003	152	69.884	-174.322	182	71.297	-175.365	212		
93	69.690	-173.880	123	69.752	-173.973	153	69.969	-174.429	183	71.406	-175.409	213		
94	69.696	-173.895	124	69.766	-173.986	154	70.110	-174.542	184	71.491	-175.590	214		
95	69.696	-173.859	125	69.755	-173.975	155	70.183	-174.580	185	71.500	-175.703	215		
96	69.690	-173.848	126	69.762	-173.976	156	70.173	-174.670	186	71.523	-175.790	216		
97	69.706	-173.810	127	69.750	-173.942	157	70.174	-174.667	187	71.522	-175.868	217		
98	69.713	-173.843	128	69.754	-173.980	158	70.207	-174.658	188	71.533	-175.937	218		
99	69.669	-173.817	129	69.759	-174.006	159	70.237	-174.717	189			219		
100	69.677	-173.806	130	69.755	-174.014	160	70.237	-174.750	190			220		

RAMS 1035 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
61			91	68.271	-168.999	121	68.753	-169.311	151	69.245	-170.096	181	71.178	-168.221
62			92	68.261	-169.035	122	68.727	-169.309	152	69.319	-170.015	182	71.229	-168.243
63			93	68.255	-168.983	123	68.707	-169.335	153	69.466	-169.950	183	71.263	-168.255
64			94	68.259	-168.959	124	68.716	-169.310	154	69.611	-170.015	184	71.305	-168.358
65	68.465	-168.814	95	68.257	-168.961	125	68.724	-169.269	155	69.769	-170.023	185	71.294	-168.439
66	68.508	-168.779	96	68.265	-168.974	126	68.739	-169.327	156	69.866	-169.905	186	71.271	-168.677
67	68.484	-168.834	97	68.265	-168.982	127	68.754	-169.291	157	69.866	-169.681	187	71.279	-169.031
68	68.414	-168.828	98	68.293	-168.984	128	68.757	-169.313	158	69.877	-169.398	188	71.317	-169.164
69	68.327	-168.801	99	68.246	-168.945	129	68.780	-169.321	159	69.845	-169.408	189	71.356	-169.291
70	68.329	-168.784	100	68.203	-168.920	130	68.813	-169.291	160	69.876	-169.494	190	71.396	-169.432
71	68.330	-168.801	101	68.184	-168.909	131	68.826	-169.310	161	69.968	-169.422	191	71.444	-169.750
72	68.341	-168.862	102	68.158	-168.982	132	68.827	-169.313	162	70.052	-168.940	192	71.479	-170.084
73	68.362	-168.845	103	68.147	-169.007	133	68.823	-169.295	163	70.279	-168.319	193	71.537	-170.439
74	68.390	-168.926	104	68.221	-169.043	134	68.821	-169.321	164	70.408	-168.017	194	71.585	-170.642
75	68.302	-168.968	105	68.245	-168.963	135	68.844	-169.308	165	70.464	-167.961	195	71.658	-170.911
76	68.265	-169.031	106	68.242	-169.024	136	69.055	-169.368	166	70.509	-167.898	196	71.721	-171.099
77	68.274	-169.021	107	68.329	-169.124	137	69.070	-169.391	167	70.556	-167.912	197		
78	68.271	-169.025	108	68.406	-169.231	138	69.019	-169.439	168	70.583	-167.965	198		
79	68.267	-169.022	109	68.436	-169.272	139	68.790	-169.652	169	70.645	-167.907	199		
80	68.265	-168.983	110	68.431	-169.255	140	68.699	-169.795	170	70.692	-167.860	200		
81	68.273	-168.997	111	68.425	-169.277	141	68.695	-169.795	171	70.733	-167.876	201		
82	68.262	-168.987	112	68.429	-169.241	142	68.706	-169.800	172	70.769	-167.943	202		
83	68.262	-169.004	113	68.453	-169.380	143	68.699	-169.812	173	70.775	-168.123	203		
84	68.260	-169.017	114	68.445	-169.358	144	68.705	-169.821	174	70.790	-168.265	204		
85	68.260	-168.964	115	68.603	-169.305	145	68.691	-169.789	175	70.824	-168.354	205		
86	68.262	-168.991	116	68.693	-169.186	146	68.691	-169.809	176	70.845	-168.296	206		
87	68.268	-168.992	117	68.730	-169.218	147	68.743	-169.833	177	70.920	-168.293	207		
88	68.274	-169.005	118	68.747	-169.284	148	68.808	-169.864	178	70.975	-168.251	208		
89	68.267	-169.002	119	68.751	-169.271	149	68.988	-169.933	179	70.992	-168.163	209		
90	68.268	-168.989	120	68.745	-169.265	150	69.150	-169.945	180	71.087	-168.200	210		

RAHS 1052 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
61			91	70.494	-166.274	121	70.835	-166.271	151	71.266	-168.813	181	72.597	-170.968
62			92	70.486	-166.274	122	70.808	-166.368	152	71.325	-168.706	182	72.644	-171.304
63			93	70.477	-166.235	123	70.792	-166.339	153	71.429	-168.596	183	72.652	-171.635
64	70.537	-165.727	94	70.481	-166.287	124	70.801	-166.304	154	71.547	-168.475	184	72.678	-171.910
65	70.522	-165.802	95	70.494	-166.364	125	70.812	-166.326	155	71.665	-168.572	185	72.662	-172.177
66	70.539	-165.827	96	70.487	-166.288	126	70.828	-166.401	156	71.745	-168.607	186	72.651	-172.474
67	70.520	-165.760	97	70.493	-166.127	127	70.838	-166.437	157	71.771	-168.559	187	72.660	-172.867
68	70.524	-165.747	98	70.513	-166.124	128	70.869	-166.474	158	71.814	-168.434	188	72.702	-173.191
69	70.519	-165.762	99	70.476	-166.203	129	70.915	-166.652	159	71.837	-168.429	189	72.751	-173.454
70	70.526	-165.685	100	70.466	-166.201	130	70.964	-166.670	160	71.913	-168.560	190	72.773	-173.525
71	70.520	-165.713	101	70.451	-166.154	131	71.004	-166.933	161	71.978	-168.802	191	72.823	-173.872
72	70.526	-165.824	102	70.447	-166.166	132	71.014	-167.022	162	72.030	-168.848	192	72.868	-174.198
73	70.513	-165.838	103	70.459	-166.239	133	71.034	-167.133	163	72.143	-168.799	193		
74	70.511	-165.871	104	70.482	-166.306	134	71.033	-167.134	164	72.136	-168.867	194		
75	70.496	-165.980	105	70.500	-166.233	135	71.042	-167.165	165	72.136	-168.816	195		
76	70.471	-166.135	106	70.502	-166.264	136	71.131	-167.337	166	72.161	-168.859	196		
77	70.469	-166.149	107	70.553	-166.256	137	71.127	-167.519	167	72.211	-168.751	197		
78	70.491	-166.206	108	70.613	-166.253	138	71.054	-167.592	168	72.246	-168.852	198		
79	70.483	-166.252	109	70.668	-166.347	139	70.878	-168.060	169	72.264	-169.015	199		
80	70.482	-166.260	110	70.697	-166.418	140	70.716	-168.542	170	72.245	-169.062	200		
81	70.476	-166.246	111	70.684	-166.520	141	70.711	-168.614	171	72.277	-169.079	201		
82	70.470	-166.265	112	70.667	-166.454	142	70.727	-168.697	172	72.314	-169.123	202		
83	70.478	-166.223	113	70.683	-166.465	143	70.753	-168.869	173	72.343	-169.207	203		
84	70.473	-166.215	114	70.676	-166.428	144	70.777	-168.955	174	72.376	-169.305	204		
85	70.475	-166.175	115	70.779	-166.250	145	70.775	-168.957	175	72.397	-169.542	205		
86	70.481	-166.196	116	70.818	-166.028	146	70.774	-168.973	176	72.412	-169.746	206		
87	70.457	-166.179	117	70.793	-166.006	147	70.824	-169.012	177	72.450	-170.034	207		
88	70.481	-166.238	118	70.798	-166.004	148	70.903	-169.015	178	72.458	-170.187	208		
89	70.476	-166.270	119	70.822	-166.103	149	71.040	-168.896	179	72.453	-170.340	209		
90	70.487	-166.265	120	70.823	-166.102	150	71.178	-168.684	180	72.527	-170.688	210		

RAMS 1064 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
61			81	66.594	-166.140	101	66.548	-168.157	121			141		
62			82	66.613	-168.176	102	66.539	-168.160	122			142		
63			83	66.596	-168.143	103	66.547	-168.186	123			143		
64	66.626	-168.307	84	66.595	-168.144	104	66.634	-168.192	124			144		
65	66.634	-168.296	85	66.596	-168.141	105	66.659	-168.156	125			145		
66	66.664	-168.297	86	66.596	-168.143	106	66.666	-168.191	126			146		
67	66.649	-168.346	87	66.604	-168.159	107	66.796	-168.200	127			147		
68	66.575	-168.292	88	66.605	-168.189	108	66.906	-168.235	128			148		
69	66.490	-168.282	89	66.606	-168.155	109	66.974	-168.160	129			149		
70	66.490	-168.267	90	66.606	-168.174	110	66.981	-168.139	130			150		
71	66.511	-168.286	91	66.619	-168.166	111	66.976	-168.109	131			151		
72	66.517	-168.379	92	66.594	-168.180	112	66.969	-168.073	132			152		
73	66.639	-168.314	93	66.590	-168.158	113	67.012	-168.131	133			153		
74	66.663	-168.342	94	66.588	-168.162	114			134			154		
75	66.554	-168.325	95	66.610	-168.172	115			135			155		
76	66.580	-168.204	96	66.602	-168.195	116			136			156		
77	66.604	-168.145	97	66.611	-168.188	117			137			157		
78	66.612	-168.154	98	66.641	-168.213	118			138			158		
79	66.599	-168.155	99	66.591	-168.158	119			139			159		
80	66.598	-168.152	100	66.549	-168.158	120			140			160		

RAMS 1305 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
71			81	70.935	-173.942	91	70.937	-173.978	101	70.909	-173.817	111	71.155	-174.314
72			82	70.927	-173.954	92	70.930	-173.941	102	70.910	-173.812	112	71.150	-174.260
73			83	70.927	-173.897	93	70.935	-173.957	103	70.941	-173.881	113	71.146	-174.338
74	70.934	-173.890	84	70.928	-173.969	94	70.967	-173.963	104	70.967	-173.893	114	71.147	-174.310
75	70.932	-173.878	85	70.932	-173.870	95	71.010	-173.943	105	70.961	-173.881	115	71.145	-174.315
76	70.931	-173.891	86	70.934	-173.892	96	70.962	-173.887	106	70.962	-173.924	116	71.121	-174.261
77	70.929	-173.929	87	70.920	-173.916	97	70.976	-173.806	107	71.065	-174.038	117	71.134	-174.247
78	70.932	-173.956	88	70.938	-173.952	98	70.962	-173.846	108	71.173	-174.223	118	71.140	-174.264
79	70.943	-173.955	89	70.936	-173.942	99	70.927	-173.908	109	71.173	-174.277	119	71.151	-174.356
80	70.931	-173.964	90	70.934	-173.947	100	70.930	-173.913	110	71.171	-174.292	120	71.147	-174.307

RAMS 1601 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
81			121	70.527	-147.252	161	70.525	-147.295	201	70.474	-147.355	241	70.357	-147.340
82			122	70.522	-147.291	162	70.516	-147.314	202	70.492	-147.401	242	70.342	-147.332
83	70.524	-147.358	123	70.532	-147.239	163	70.515	-147.341	203	70.510	-147.431	243	70.331	-147.338
84	70.523	-147.262	124	70.523	-147.261	164	70.520	-147.326	204	70.507	-147.259	244	70.331	-147.327
85	70.523	-147.297	125	70.517	-147.266	165	70.518	-147.275	205	70.496	-147.260	245	70.339	-147.372
86	70.529	-147.298	126	70.530	-147.277	166	70.517	-147.288	206	70.496	-147.234	246	70.328	-147.347
87	70.519	-147.295	127	70.515	-147.274	167	70.523	-147.315	207	70.506	-147.226	247	70.330	-147.329
88	70.524	-147.285	128	70.522	-147.296	168	70.527	-147.284	208	70.519	-147.395	248	70.331	-147.356
89	70.524	-147.303	129	70.521	-147.280	169	70.522	-147.276	209	70.509	-147.509	249	70.328	-147.338
90	70.523	-147.297	130	70.522	-147.322	170	70.530	-147.322	210	70.503	-147.469	250		
91	70.525	-147.271	131	70.529	-147.285	171	70.526	-147.279	211	70.500	-147.482	251		
92	70.526	-147.328	132	70.524	-147.278	172	70.528	-147.270	212	70.508	-147.484	252		
93	70.523	-147.261	133	70.525	-147.285	173	70.523	-147.305	213	70.493	-147.496	253		
94	70.524	-147.289	134	70.529	-147.314	174	70.525	-147.278	214	70.507	-147.497	254		
95	70.527	-147.269	135	70.537	-147.247	175	70.525	-147.288	215	70.494	-147.428	255		
96	70.526	-147.276	136	70.517	-147.275	176	70.503	-147.384	216	70.484	-147.337	256		
97	70.532	-147.308	137	70.526	-147.278	177	70.520	-147.306	217	70.492	-147.366	257		
98	70.535	-147.226	138	70.521	-147.311	178	70.524	-147.293	218	70.484	-147.356	258		
99	70.531	-147.229	139	70.521	-147.294	179	70.515	-147.309	219	70.482	-147.334	259		
100	70.521	-147.285	140	70.529	-147.301	180	70.527	-147.296	220	70.435	-147.215	260		
101	70.522	-147.279	141	70.526	-147.239	181	70.523	-147.291	221	70.437	-147.327	261		
102	70.522	-147.222	142	70.515	-147.256	182	70.520	-147.290	222	70.446	-147.323	262		
103	70.546	-147.284	143	70.511	-147.283	183	70.524	-147.307	223	70.440	-147.318	263		
104	70.530	-147.200	144	70.523	-147.271	184	70.523	-147.286	224	70.437	-147.336	264		
105	70.527	-147.266	145	70.527	-147.289	185	70.526	-147.274	225	70.436	-147.344	265		
106	70.524	-147.176	146	70.517	-147.292	186	70.528	-147.276	226	70.420	-147.406	266		
107	70.529	-147.227	147	70.517	-147.279	187	70.526	-147.300	227	70.416	-147.421	267		
108	70.526	-147.279	148	70.528	-147.297	188	70.516	-147.305	228	70.406	-147.405	268		
109	70.528	-147.259	149	70.518	-147.296	189	70.533	-147.245	229	70.393	-147.359	269		
110	70.527	-147.256	150	70.517	-147.293	190	70.516	-147.034	230	70.407	-147.441	270		
111	70.533	-147.259	151	70.517	-147.292	191	70.526	-147.098	231	70.384	-147.506	271		
112	70.524	-147.323	152	70.520	-147.299	192	70.502	-147.068	232	70.392	-147.502	272		
113	70.525	-147.243	153	70.522	-147.277	193	70.525	-147.325	233	70.391	-147.487	273		
114	70.521	-147.279	154	70.522	-147.303	194	70.521	-147.357	234	70.388	-147.484	274		
115	70.530	-147.292	155	70.521	-147.310	195	70.515	-147.444	235	70.395	-147.512	275		
116	70.524	-147.285	156	70.528	-147.279	196	70.510	-147.428	236	70.393	-147.482	276		
117	70.526	-147.266	157	70.528	-147.310	197	70.516	-147.411	237	70.385	-147.476	277		
118	70.517	-147.261	158	70.522	-147.266	198	70.508	-147.434	238	70.342	-147.301	278		
119	70.523	-147.212	159	70.527	-147.279	199	70.513	-147.432	239	70.353	-147.358	279		
[illegible]	70.528	-147.207	160	70.522	-147.262	200	70.512	-147.384	240	70.361	-147.299	280		

RAMS 1617 YR=1977

DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG	DAY	LAT	LONG
61			101	72.392	-166.194	141	72.630	-170.761	181	74.015	-177.061	221	76.075	174.909
62			102	72.382	-166.197	142	72.645	-170.778	182	74.121	-177.525	222	76.144	174.419
63			103	72.403	-166.180	143	72.690	-170.834	183	74.170	-177.870	223	76.282	173.998
64			104	72.438	-166.234	144	72.708	-170.873	184	74.223	-178.211	224	76.389	173.610
65			105	72.442	-166.274	145	72.723	-170.989	185	74.223	-178.464	225	76.453	173.455
66			106	72.451	-166.317	146	72.721	-171.037	186	74.229	-178.734	226	76.496	173.160
67			107	72.467	-166.293	147	72.786	-171.209	187	74.235	-179.060	227	76.559	172.897
68			108	72.570	-166.446	148	72.834	-171.403	188	74.248	-179.361	228	76.591	172.789
69	72.418	-166.067	109	72.623	-166.765	149	72.891	-171.578	189	74.274	-179.490	229	76.600	172.591
70	72.421	-166.076	110	72.650	-167.059	150	72.970	-171.549	190	74.309	-179.575	230	76.630	172.345
71	72.424	-166.066	111	72.624	-167.262	151	73.031	-171.685	191	74.342	-179.888	231	76.654	172.287
72	72.416	-166.079	112	72.617	-167.324	152	73.035	-171.925	192	74.413	179.766	232	76.669	172.212
73	72.418	-166.098	113	72.598	-167.286	153	73.067	-172.004	193	74.530	179.236	233	76.660	172.003
74	72.422	-166.122	114	72.600	-167.359	154	73.132	-172.055	194	74.596	179.137	234	76.687	171.940
75	72.415	-166.085	115	72.617	-167.373	155	73.207	-172.268	195	74.698	178.834	235	76.803	171.665
76	72.411	-166.108	116	72.590	-167.288	156	73.231	-172.641	196	74.789	178.666	236	76.882	171.534
77	72.411	-166.101	117	72.599	-167.217	157	73.216	-173.017	197	74.899	178.459	237	76.694	171.660
78	72.428	-166.205	118	72.581	-167.165	158	73.215	-173.278	198	74.933	178.314	238	[illegible]	171.577
79	72.426	-166.305	119	72.595	-167.168	159	73.213	-173.375	199	74.915	178.294	239	76.796	171.617
80	72.421	-166.311	120	72.604	-167.239	160	73.236	-173.635	200	74.943	178.299	240	76.799	171.942
81	72.417	-166.289	121	72.620	-167.300	161	73.268	-173.852	201	74.981	178.590	241	76.790	171.555
82	72.420	-166.306	122	72.602	-167.406	162	73.308	-173.943	202	75.082	178.382	242	76.760	171.442
83	72.410	-166.295	123	72.598	-167.389	163	73.329	-174.111	203	75.219	177.847	243	76.886	171.367
84	72.424	-166.330	124	72.606	-167.348	164	73.302	-174.067	204	75.277	177.956	244	77.089	171.452
85	72.405	-166.271	125	72.601	-167.382	165	73.309	-174.025	205	75.322	177.897	245	77.110	171.538
86	72.414	-166.286	126	72.616	-167.468	166	73.358	-173.986	206	75.372	177.761	246	77.068	171.985
87	72.432	-166.294	127	72.625	-167.655	167	73.410	-173.950	207	75.437	177.617	247	77.019	172.428
88	72.426	-166.298	128	72.648	-167.940	168	73.419	-174.052	208	75.488	177.271	248	77.021	172.530
89	72.424	-166.301	129	72.682	-168.200	169	73.426	-174.319	209	75.545	177.067	249	77.096	172.817
90	72.427	-166.299	130	72.703	-168.529	170	73.420	-174.430	210	75.582	176.810	250		
91	72.433	-166.303	131	72.747	-168.852	171	73.444	-174.422	211	75.585	176.653	251		
92	72.424	-166.311	132	72.768	-169.153	172	73.502	-174.541	212	75.613	176.530	252		
93	72.419	-166.298	133	72.773	-169.393	173	73.552	-174.771	213	75.674	176.467	253		
94	72.437	-166.292	134	72.761	-169.509	174	73.587	-174.960	214	75.693	176.306	254		
95	72.485	-166.302	135	72.777	-169.778	175	73.606	-175.182	215	75.716	176.225	255		
96	72.451	-166.226	136	72.803	-170.118	176	73.654	-175.398	216	75.748	176.134	256		
97	72.454	-166.132	137	72.763	-170.409	177	73.742	-175.730	217	75.800	175.978	257		
98	72.471	-166.223	138	72.713	-170.516	178	73.807	-176.035	218	75.869	175.863	258		
99	72.429	-166.291	139	72.648	-170.617	179	73.827	-176.274	219	75.873	175.534	259		
100	72.408	-166.228	140	72.613	-170.707	180	73.909	-176.670	220	76.005	175.155	260		

QUARTERLY REPORT

Research Unit #: 105
Reporting Period: October 1 - December 31, 1977

DELINEATION AND ENGINEERING CHARACTERISTICS OF PERMAFROST BENEATH THE BEAUFORT SEA

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In lieu of a quarterly report, CRREL Special Report 77-41 has been submitted, entitled "1977 CRREL-USGS Subsea Permafrost Program, Beaufort Sea, Alaska". Copies may be obtained by writing U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire 03755.

QUARTERLY REPORT

Research Unit #204
Number of Pages: 2
Report Period: 1 October - 31 December 1977

OFFSHORE PERMAFROST STUDIES, BEAUFORT SEA

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Research Unit #204: Quarterly Report, October-November-December, 1977

OFFSHORE PERMAFROST STUDIES, BEAUFORT SEA

I. Abstract of Highlights

Hopkins compiled a preliminary onshore-offshore cross-section showing distribution of sediments and permafrost in the Prudhoe Bay area. The cross-section shows that ice-rich permafrost is likely to be present within a few meters below the sea bottom at points as much as 17 km offshore and that gravel is available beneath 5 to 10 m of mud and clay at almost any point on the continental shelf within 17 km of shore in the Prudhoe Bay area.

II. Task Objective: D-9

III. Field and Laboratory Activities:

A-1. Field Activities: None

A-2. Laboratory Activities

Amino-acid analyses of mollusk fragments
Pick and prepare samples for radiocarbon dating
Sedimentological studies on borehole PB-6
Re-examine pebble lithology in marine-clay section of PB-2
Compile interpretive cross-sections

B. Scientific Party:

D. M. Hopkins, geologist and P.I.
R. E. Lewellen, geologist and chief driller
A. H. Lachenbruch, consultant on geothermal interpretations
K. M. McDougall, paleontologist, foraminifera
Joe Hazel, paleontologist, ostracodes
Gifford Miller, geologist, amino-acid dating
Peggy A. Smith, geologist, sedimentological studies on drill core

C. Methods of Analysis:

Radiocarbon dating, amino-acid racemization, pebble lithology and roundness counts, grain-size analyses, study of fossil foraminifera and ostracodes.

D. Sample Localities:

As in previous quarterly reports, seven offshore boreholes in the Prudhoe Bay area.

E. Data Collected or Analyzed:

Ostracodes identified for boreholes PB-1, 2, and 3
Preliminary identifications, counts, and paleoecological analyses completed for foraminifera in boreholes PB-5, 6, and 7, but not PB-8
Completed sedimentological studies on 8 core samples from PB-6

IV. & V. Results and Interpretation

Hopkins compiled a preliminary onshore-offshore cross-section showing distribution of sediments and permafrost in the Prudhoe Bay area. The cross-section shows that ice-rich permafrost is likely to be present within a few meters below the sea bottom at points as much as 17 km offshore and that gravel is available beneath 5 to 10 m of mud and clay at almost any point on the continental shelf within 17 km of shore in the Prudhoe Bay area.

VI. Budget: No funds received so none could be spent.

QUARTERLY REPORT

Contract:	RK6-6074
Research Unit:	205
Reporting period:	October - December, 1977
Number of Pages:	3 plus 3 Attachments

GEOLOGIC PROCESSES AND HAZARDS OF THE BEAUFORT SEA SHELF AND COASTAL REGIONS

Peter Barnes

Erk Reimnitz

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January 1, 1978

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 Quarterly Reports and project proposals.

II. Field and Laboratory Activities:

A. Ship and field trip schedule:

Leg II of the R/V KARLUK summer cruise ended in Nome in early October where the boat was removed from the water and winterized. The transit to Nome was hampered by bad weather and equipment malfunctions.

B. Scientific Party

E. Reimnitz	U.S. Geological Survey
L. Toimil	U.S. Geological Survey
H. Hill	U.S. Geological Survey
D. Maurer	U.S. Geological Survey
D. Thor	U.S. Geological Survey

C. Methods:

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, vibrocoring, diving observations, in-situ and sample observations of sediment salinity, and sediment strength, water samples, sediment profiling transducers, bottom plow, aerial photography and water level recorders.

D. Data Collected or Analyzed:

Data analysis is proceding in the following areas:

a)Surface sediment samples and core sediment samples have been analyzed for interstitial water salinities (See attachment A).

b)Near surface temperature data obtained from thermoprobes have been calculated and are reported on here (See Attachment B).

c) Precision bathymetry from the Colville delta front platform is being analyzed for comparison with earlier bathymetry and preliminary results are also reported (See Attachment C).

d) The forty plus cores which were taken this last summer are presently being opened, photographed, described, radiographed, and archived.

e) Reports are in preparation discussing the extent and importance of the 1970 storm surge, and another examining the significance of the change in shape and position of three of the barrier islands.

f) Computer analysis of precison navigation and bathymetry from data tapes is underway for a comparison of offshore shoal morphology between the 1955 surveys and the present day.

g) A significant number of bottom drifters released in the spring of this year off the delta of the Colville River have been returned and the drift rates and trajectories are being determined.

h) Several lines of side-scan data from off Barrow are being prepared for a mosaic and detailed analysis of gouge intensity.

E. Scientific Laboratory group:

Peter Barnes	Project Chief	U.S.G.S. Office of Marine Geology
Erk Reimnitz	Principal Investigator	U.S.G.S. Office of Marine Geology
Larry Toimil	Co-Investigator	U.S.G.S. Office of Marine Geology
Doug Maurer	Assistant	U.S.G.S. Office of Marine Geology
David McDowell	Assistant	U.S.G.S. Office of Marine Geology

III. Results:

Attachment A - Salinity of interstitial water of sea floor sediments, Beaufort Sea shelf

Attachment B - Sea floor temperatures, Beaufort Sea, Alaska

Attachment C - The 2-m bench of the Colville River delta, Alaska

IV. Preliminary interpretation of results:

Preliminary interpretation of results is given in the above-listed attachments to this Quarterly Report.

V. Problems encountered:

All three current meters and two of the three pressure gauges purchased by this project for use in the arctic have been lost during use on the inner Beaufort Sea Shelf.

Several budgetary and personnel constraints imposed by both NOAA/OCSEAP and USGS funding limitations will have a detrimental effect on the depth and thoroughness with which the project objectives can be studied and reported on.

VI. Estimate of Funds Expended:

NOAA/OSCEAP Funds	$ 4000
USGS Funds	$ 7500
Total	$11500

ATTACHMENT A

SALINITY OF INTERSTITIAL WATER OF SEA FLOOR SEDIMENTS, BEAUFORT SEA SHELF

by

Erk Reimnitz and Doug Maurer

In our annual report (Research Unit #205, 1 April 1977, Attachment A) and in U.S.G.S. Open File Report 77-416 (Reimnitz, et al., 1977) we have presented data on sediment porewater salinities, sea-floor temperatures, and on calculated freezing points for surficial material in the study area. For the study of offshore permafrost, or more specifically ice-bonding of sediments, data on the salinity of porewater is critical. Also for an understanding of bottom processes, as for example bed load transport, a knowledge of whether sediment grains are bonded by ice is very important, and this in turn is a function of porewater salinity. For these reasons we have continued to collect data on the salinity of interstitial water during the course of our field work, whenever it did not interfere with the achievement of our primary goals. Such new data is presented in this section.

The sediments analyzed were collected in one of three ways: using a van Veen grab sampler, using a small tube inserted into the bottoms of long vibrocores immediately after their retrieval, or by divers using a specially designed coring device 30 cm long (Table I). The analytical techniques used are as outlined in our annual report and by Reimnitz et al., (1977).

Nine stations were occupied in Prudhoe Bay on August 20, 1977. At these stations we collected bottom sediments by use of a grab sampler. Measurements made at each station include bottom water temperature and salinity (using a Beckman Salinometer), and sediment temperatures (using a thermister on a rod, which was driven a short distance into the bottom where the resistivity was measured by use of a digital volt-ohm meter). The resulting data are shown in figures 1 through 4.

The water temperatures and salinities show the influence of the Putuligayuk River supplying warm and fresh water to the Bay. On the day of the measurements winds were weak from the northeast. Under this condition relatively warm and fresh bay water seems to be flowing out of the channel toward the west dock, while open-shelf water of higher salinity and lower temperature enters the bay across the broad shallow sill between Heald Point and Gull Island (figures 1 and 2). From temperature and salinity measurements taken in the bay at other times earlier in the season we can rule out the possibility that the cold, saline water in the deepest part of the bay is a remnant from the previous winter.

The salinities of interstitial waters in surface sediments of Prudhoe Bay show a wide scatter in values, ranging from about 14 to 36 ppm. As expected, the surficial sediments near the mouth of Putuligayuk River are freshest.

Surficial sediment temperatures also show the influence of warm Putuligayuk River water entering the bay, and colder ocean water spilling across the shallow sill. Two meters below the southernmost station of the bay, measured only a few days later, the sediment temperature was close to 0^{o} C. (see attachment B in this report).

Sediment interstitial salinities and surface temperatures in the bay, taken about one month later in previous years and reported in our annual report (Attachment A) and by Reimnitz et al., (1977), show that they change rapidly during this time interval. Interstitial salinities, after termination of Putuligayuk River discharge and initiation of freeze-up, are higher, and surface sediment temperatures markedly lower (about 1^{o} C versus 6^{o} C).

Interstitial salinities of surficial sediment collected over the years by various techniques are shown in figure 6. Figure 5 shows their location relative to bathymetry and keys them to Table I. Excluding the three values taken farthest offshore, determined through different analytical procedures by Dr. Naidu of the University of Alaska, and the anomalous value of 91.8 ppm near the western part of the Colville Delta, the salinities were contoured. This contour pattern reflects the influence of the Colville, Putuligayuk and Sagavanirktok, the Saviovik, and the Canning rivers. The contour pattern may also be related to the previously reported westward deflection of freshwater plumes off the river mouths which is related to the general westward currents on the inner shelf. We do not know why the influence of the Kuparuk River is not reflected in the salinity values of surface sediments.

The cluster of highly varied salinity values in Harrison Bay, determined from samples collected in a diving operation, was taken during a very short time period in 1977. The sampling device used eliminated the chance of introducing seawater into the sediment sample. Furthermore, visual observations allowed us to select 'undisturbed' sites, away from recently ice-gouged terrain. Thus the large variations in interstitial salinities in a small area of apparently uniform oceanographic and sedimentalogic conditions must be explained in terms of high rates of ice gouging and related phenomena on the sea floor.

Interstitial salinities determined from subsamples of the bottoms of vibrocores are shown in figure 7. These values are representative of conditions up to 194 cm below the sea floor (see length of bars in figure 7, or Table I). They generally are much higher than surface salinity values. The highest sub-surface interstitial salinities, or the sharpest salinity gradients, are found at water depths shallower than 2 m. Here the fast ice during the latter part of the winter rests on the sea floor and causes freezing of interstitial water. Brine formation along such a surface, would tend to increase subsurface interstitial salinities as saline water is forced downward.

We believe that similar processes are partly responsible for the highly variable interstitial salinity conditions in Harrison Bay, pointed out above. Our studies of the rate of ice gouging (Reimnitz, et al., 1977, and Barnes, et al., 1977) have shown that the bottom is totally reworked every 50 to 80 years to an average depth below the sea floor of about 25 cm. During this process ice often remains long enough in contact with a particular spot on the sea floor to cause at least some freezing of interstitial waters and salt enrichment in the porewater of adjacent materials. Of course the physical processes of sediment mixing by ice bulldozing through bottom deposits, which, during some parts of the season have a high salinity gradient, will produce uneven interstitial salinity values on the sediment surface.

A plot of interstitial salinity values - surface and sub-surface combined - against water depth in meters is shown in figure 8. On this plot we distinguished between lagoon and open-shelf conditions by using different symbols, and also identified those salinity values obtained more than 1 meter below the sea floor. This plot demonstrates three generalizations that we can make from our data:

a) Interstitial salinity values for open-shelf surface sediments seaward of the 5 m isobath lie within a rather narrow range from 25 to 38 ppm, showing no depth dependence.

b) Extreme variations in sediment interstitial salinities are found at depths shallower than 2 m.

c) The highest salinities were found at depths over 1 m the surface, inshore of the 2 m isobath, in the zone of bottom-fast ice.

The extremely high salinity value of 91.8 ppm, obtained near the Colville Delta (figure 5 and Table I) in shallow water, is an anomaly. We have no reason to reject this data point, but are not prepared to give an interpretation. The remainder of the salinity values above that of normal seawater, and ranging up to 75 ppm, do not seem excessive, since similarly high values have been measured in shallow, lagoon waters below the floating fast ice.

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Reimnitz, Erk, Maurer, D.K., Barnes, P.W., and Toimil, L.J., 1977, Some physical properties of shelf surface sediments, Beaufort Sea, Alaska: U.S. Geol. Survey Open File Report No. 77-416

Barnes, P.W., Remnitz, Erk, and Drake, D.E., 1977, Marine environmental problems in the ice-covered Beaufort Sea shelf and coastal regions, Annual Report to Natl. Oceanic and Atmospheric Adm., Environmental Assessment of the Alaskan Continental Shelf; Principal Investigator's Reports, 16 pages and 10 attachments.

Reimnitz, Erk, Barnes, P.W., Toimil, L.J., and Melchior, John, 1977, Ice gouge recurrence and rates of sediment reworking, Beaufort Sea, Alaska: Geology Vol. 5, 405-408.

Barnes, P.W., Reimnitz, Erk, Drake, D.E., and Toimil, L.J., 1977, Miscellaneous hydrologic and geologic observations on the inner Beaufort Sea shelf, Alaska: U.S. Geol. Survey Open File Report 77-477, 95 p.

* DS - Diver held piston core
P - Hand driven core tube
V - Vibrocore subsample
SNAP - Snapper subsample

TABLE I Interstitial salinity of bottom sediments

Station #	Sample Type*	Location	Water Depth (M)	Depth Below Sediment Surface (cm)	Water Content Dry 0/0	(0/00) Interstitial Salinity	Sediment Description
1	DS-22	152°08.0'W 70°48.0'N	2	30	23	29.8	very stiff silty clay
2	DS-21	152°02.5'W 70°47.0'N	3	30	30	28.5	stiff silty clay
3	SNAP	151°36.2'W 70°36.7'N	4	5	-	30.6	very fine silty sand
4	P-1	151°20.9'W 70°26.7'N	1.5	5 30	27 -	91.8 39.8	very fine sand very fine silty sand
5	V-53	150°24.9'W 70°36.7'N	13	94	17	30.6	fine silty sand
6	DS-25	150°25.5'W 70°36.8'N	13	28	-	30.7	fine sandy silt
7	V-55	150°28.0'W 70°33.9'N	7	170	17	27.2	stiff clayey sandy silt
8	V-56	150°28.5'W 70°32.4'N	2.5	165	25	76.7	fine silty sand
9	P-2	150°34.5'W 70°30.3'N	0	20	-	10.5	clean medium sand
10	DS-26	150°23.4'W 70°36.4'N	11	20	19	35.1	soft silty clay
11	DS-27	150°18.4'W 70°35.3'N	10	20	-	31.5	fine silty sand
12	DS-24	150°15.1'W 70°34.7'N	8.5	30	-	28.5	organic-rich silt
13	V-59	150°11.8'W 70°27.7'N	1.3	184	31	69.1	organic-rich silt
14	V-51	149°56.4'W 70° 30.4'N	2	194	47	25.7	clean medium-fine sand
15	SNAP	149°42.7'W 70°32.2'N	3	5	30	31.0	soft sandy silty clay
16	V-49	149°30.8'W 70°32.4'N	3	5 156	- 46	29.3 54.0	organic-rich silt silty organic detritus
17	V-50	149°26.7'W 70°30.7'N	1.4	181	-	59.5	clean medium-fine sand

* DS - Diver held piston core
P - Hand driven core tube
V - Vibrocore subsample
SNAP - Snapper subsample

TABLE I Interstitial salinity of bottom sediments

Station #	Sample Type*	Location	Water Depth (M)	Depth Below Sediment Surface (cm)	Water Content Dry 0/0	(0/00) Interstitial Salinity	Sediment Description
18	DS-28	149°26.4'W 70°31.8'N	2.5	5 14 28	- - -	35.1 39.6 36.9	sandy silt fine silty sand sandy silt
19	SNAP	149°24.5'W 70°32.2'N	1.5	5	-	28.8	clean medium-coarse sand
20	DS-32	149°14.8'W 70°40.6'N	13.5	20	-	31.0	clean fine sand
21	V-48	149°14.2'W 70°30.4'N	2.5	5 172	- 36	32.1 48.2	organic-rich silt organic-rich silt
22	SNAP	149°07.7'W 70°30.2'N	2	5	-	27.7	organic-rich silt
23	DS-34	148°56.8'W 70°36.3'N	14	19	-	30.9	clean medium-coarse sand
24	DS-29	148°54.8'W 70°28.5'N	3	5 22	30 28	32.3 32.2	soft silty clay stiff silty clay
25	V-27	148°48.3'W 70°25.7'N	1.3	165	43	40.3	organic detritus with silt laminations
26	V-28	148°42.2'W 70°25.4'N	1	160	20	61.0	fine sandy silt
27	V-26	148°26.0'W 70°19.3'N	1.5	183	-	38.5	fine-medium silty sand
28	V-25	148°21.2'W 70°18.9'N	23	114	-	34.9	medium-coarse pebbly sand
29	V-38	148°17.5'W 70°29.3'N	4.6	32	14	47.7	fairly clean medium-fine sand
30	V-37	148°09.6'W 70°29.3'N	10	43	14	23.1	very stiff sandy silt
31	V-30	148°06.0'W 70°22.1'N	1.5	164	-	70.8	fine silty sand
32	V-29	148°00.2'W 70°24.0'N	5.5	64	23	30.5	very stiff silty clay
33	V-31	147°54.0'W 70°19.9'N	1.3	148	-	60.0	sandy silt
34	V-35	147°35.4'W 70°29.2'N	19	5 56	15 16	32.5 24.8	v. coarse sandy silty clay stiff, pebbly sandy silty clay
35	V-32	147°28.0'W 70°26.5'N	16.5	45	18	31.1	stiff silty clay

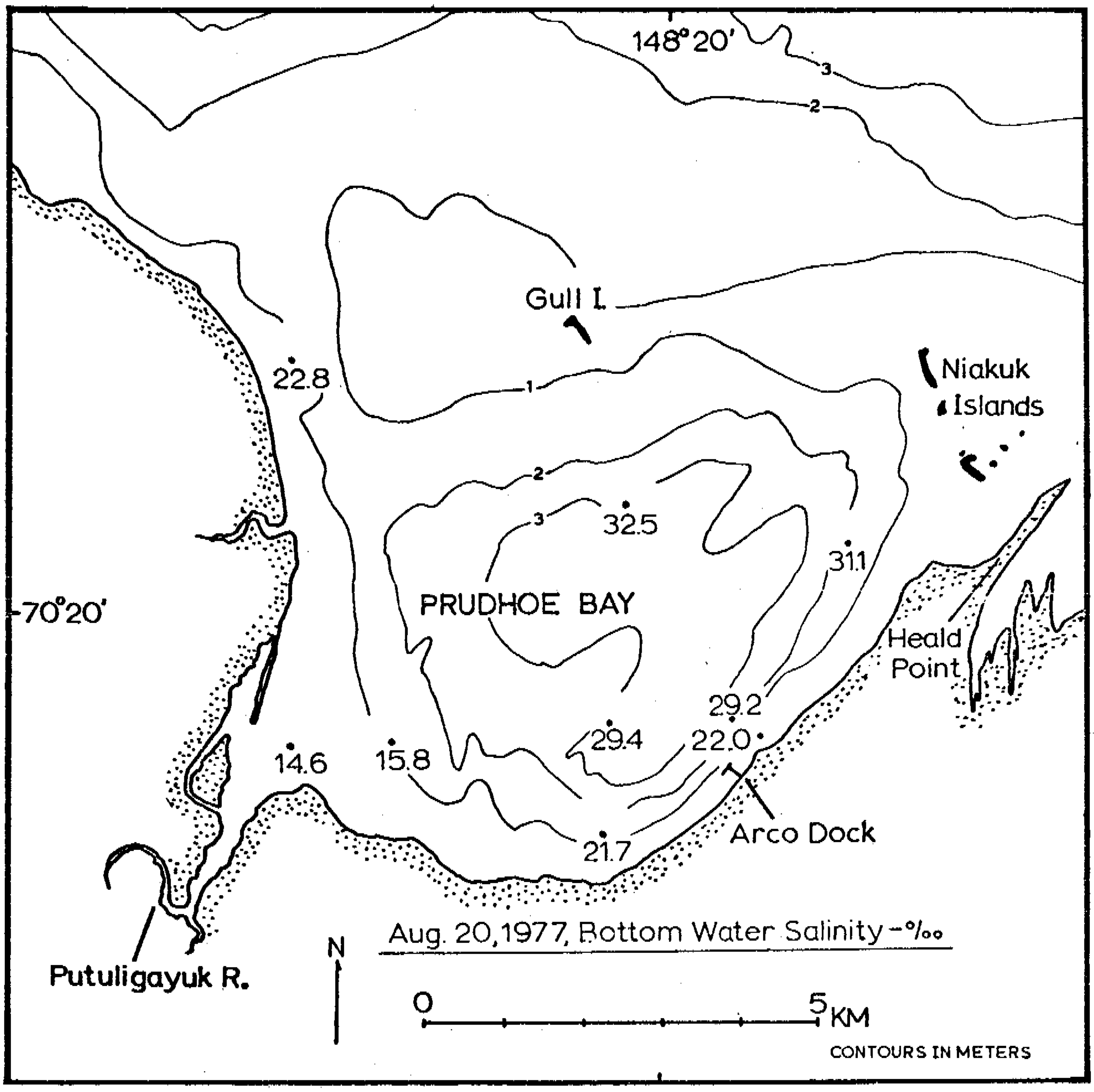

Figure 1 (Att. A)

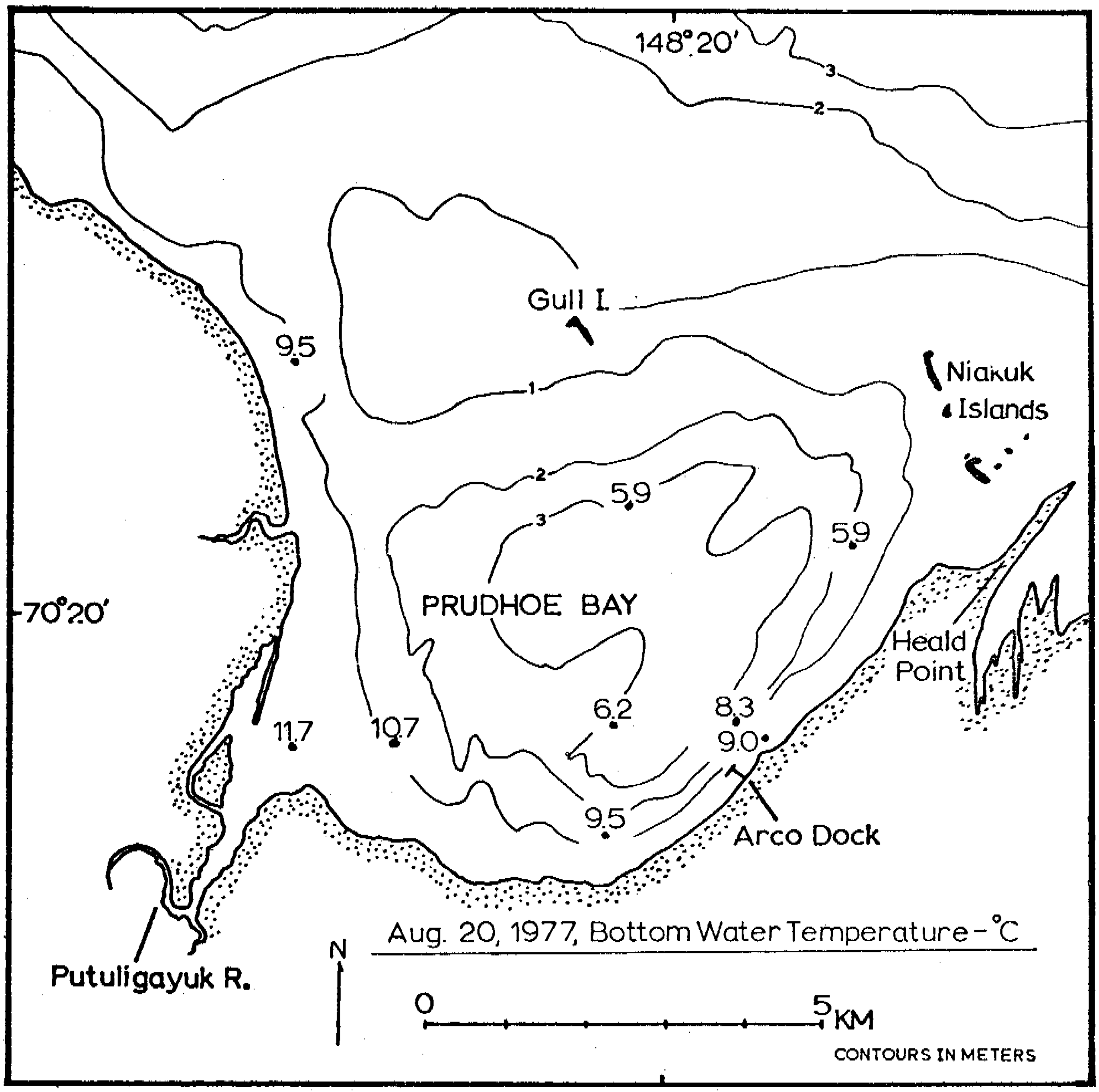
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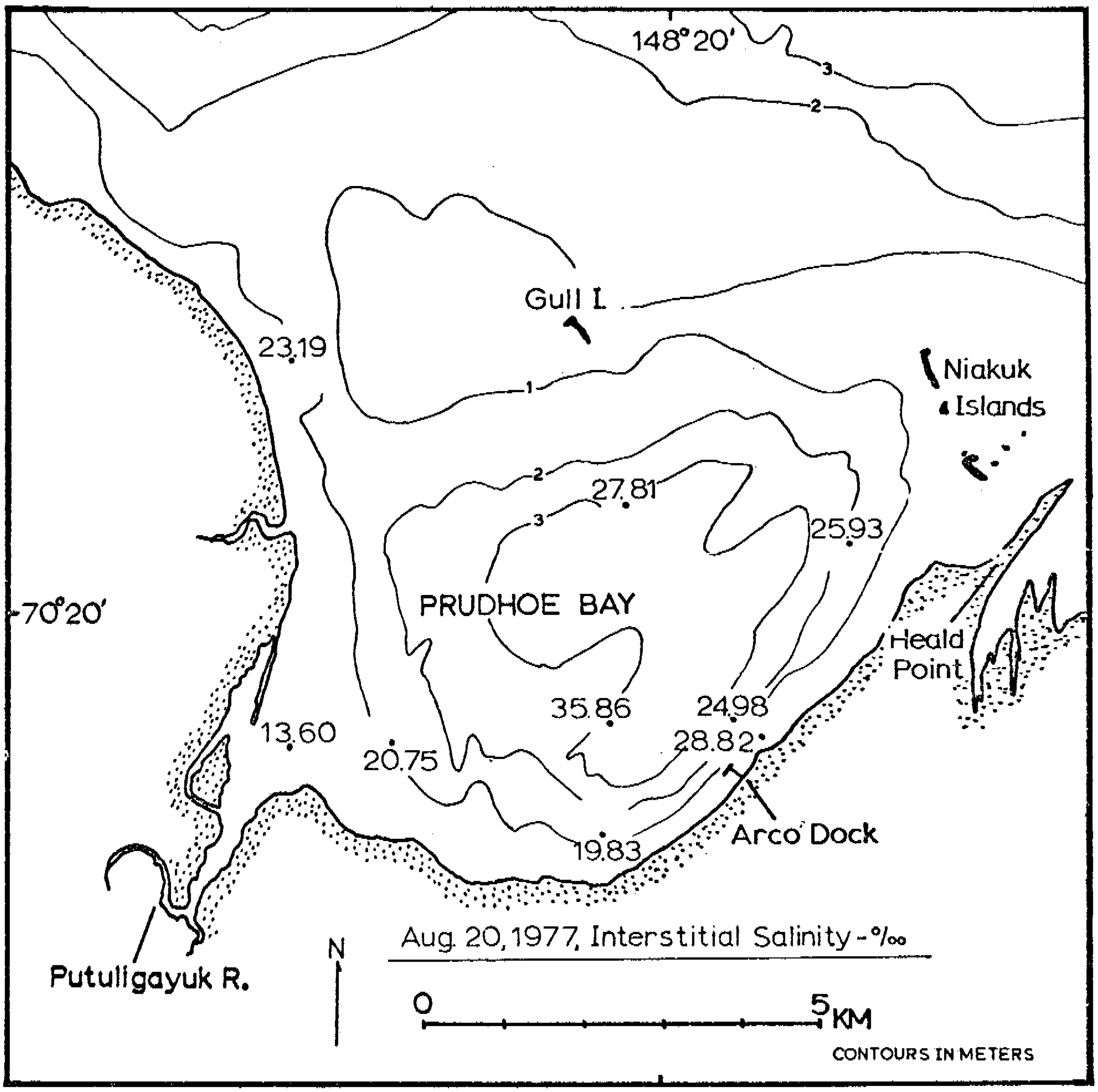
Fig. 2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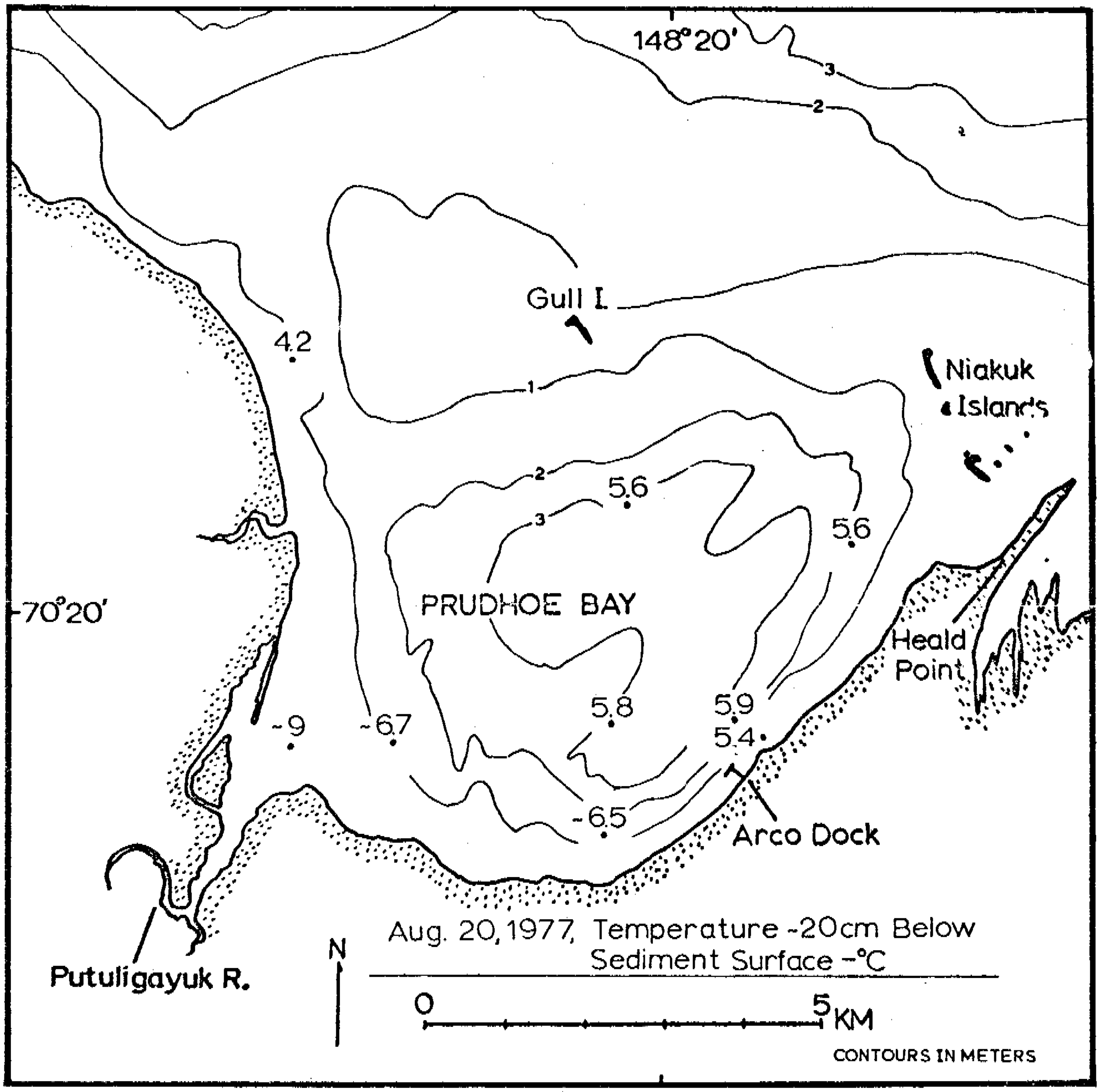
19.83
Putuligayuk R.
N
Aug. 20, 1977, Interstitial Salinity - ‰
0
5 KM
CONTOURS IN METERS

Fig. 3



148°20'
3
2
Gull I.
4.2
1
Niakuk
Islands
2
5.6
3
5.6
70°20'
PRUDHOE BAY
Heald
Point
5.8
5.9
~9
~6.7
5.4
~6.5
Arco Dock
Putuligayuk R.
N
Aug. 20, 1977, Temperature ~20cm Below
Sediment Surface ~°C
0
5 KM
CONTOURS IN METERS

Fig. 4

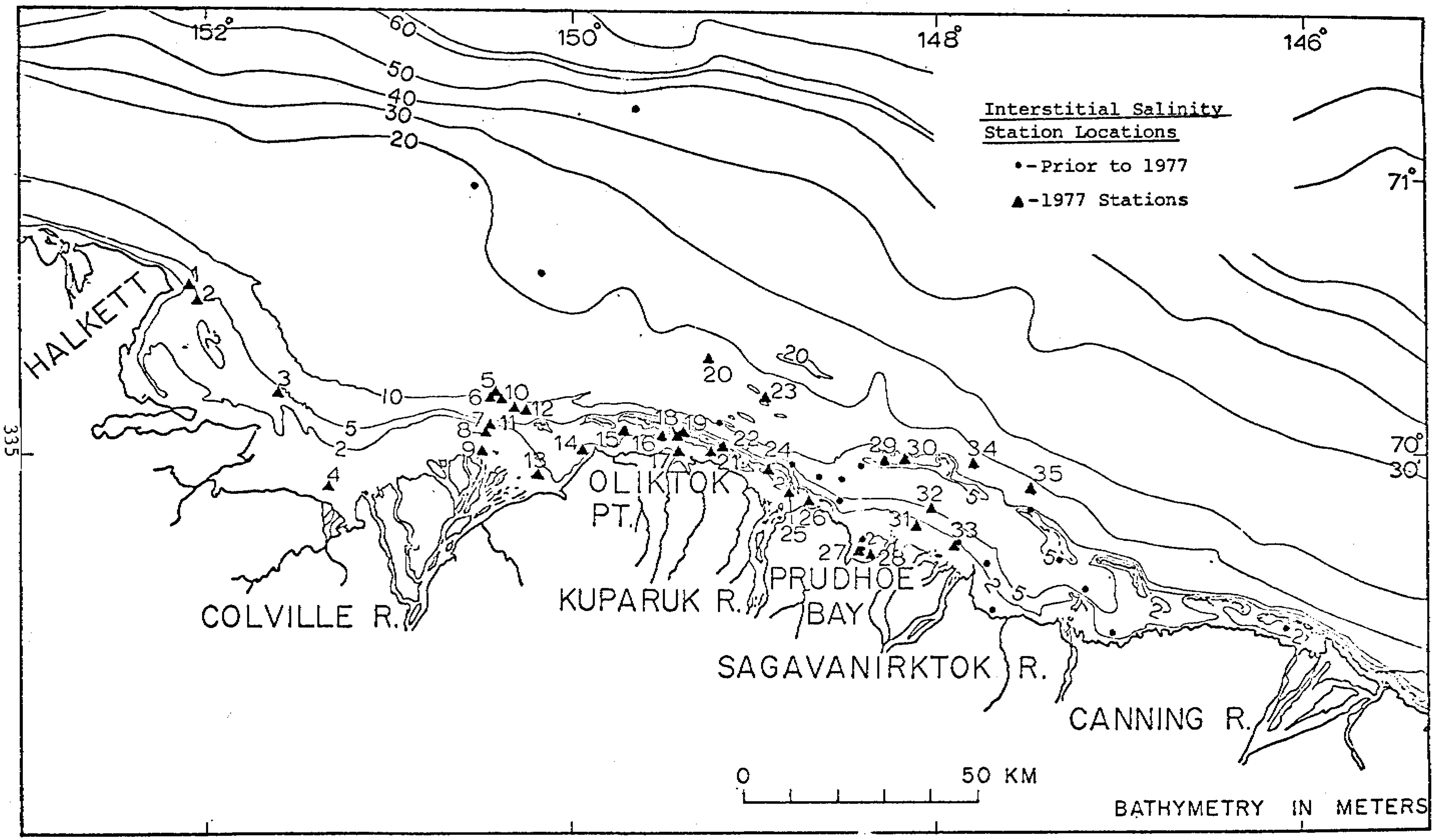


Figure 5. Numbered stations are listed in Table I, stations occupied prior to 1977 have been described in our Annual Report (1977), Attachment A and Reimnitz, et.al., 1977.

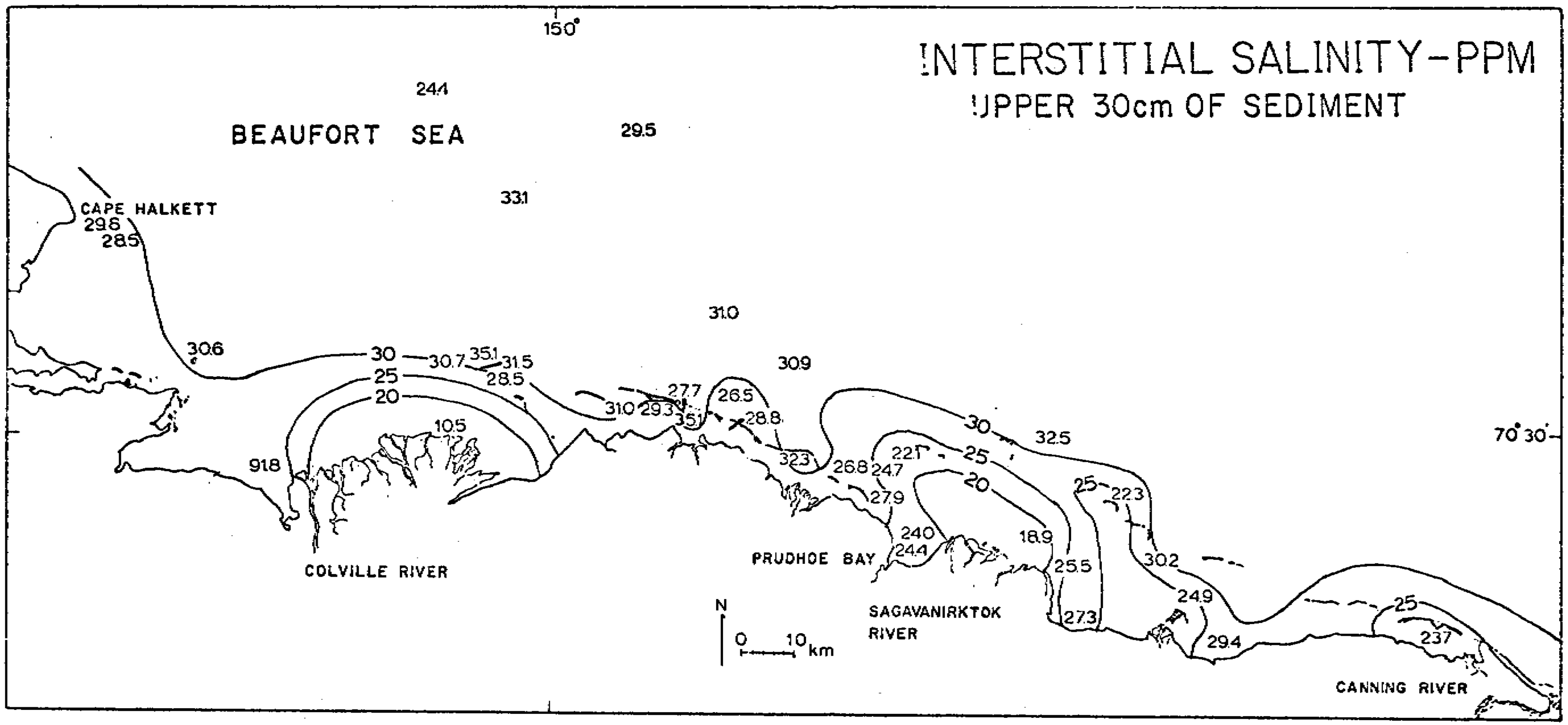
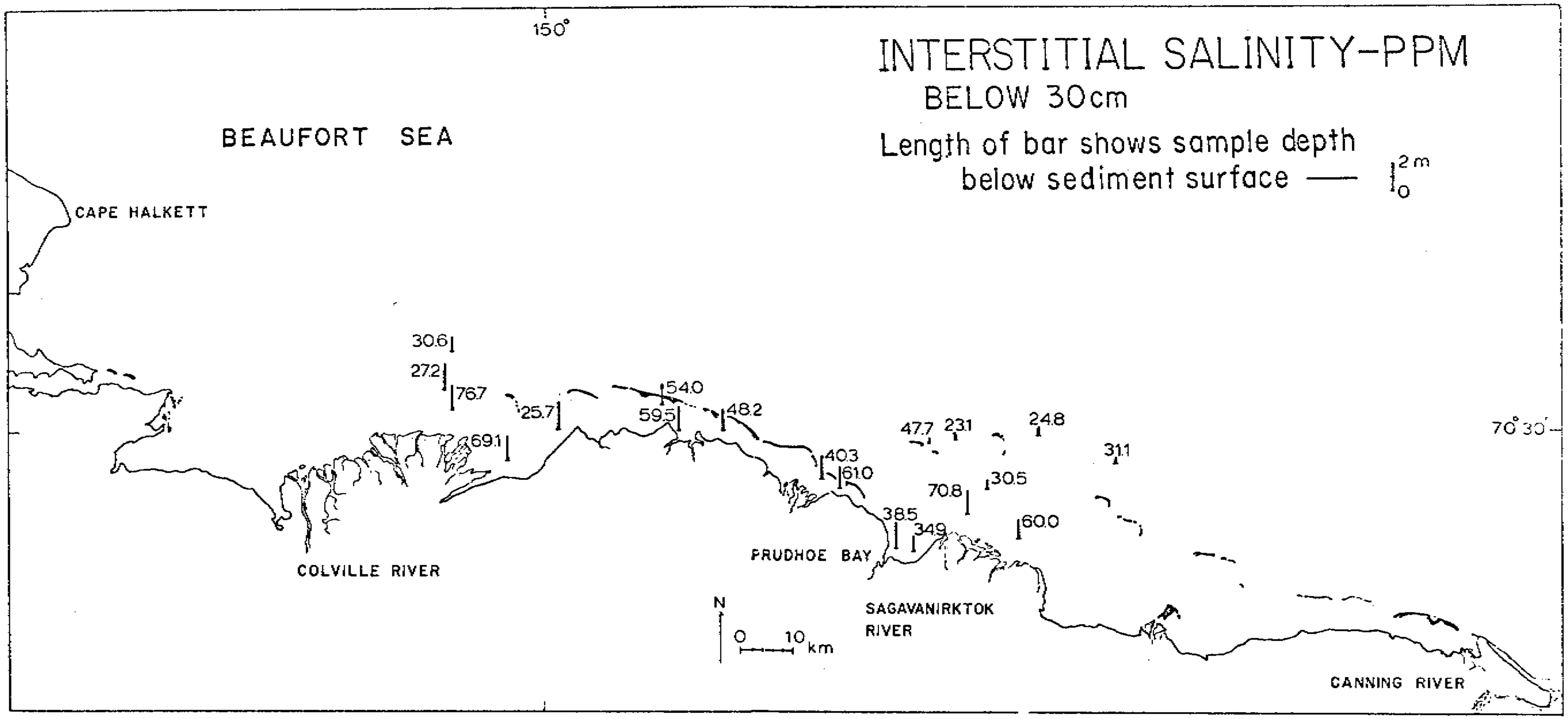

INTERSTITIAL SALINITY-PPM
UPPER 30cm OF SEDIMENT
150°
BEAUFORT SEA
CAPE HALKETT
COLVILLE RIVER
PRUDHOE BAY
SAGAVANIRKTOK RIVER
CANNING RIVER
70° 30'
N
0 10 km
24.4
29.5
33.1
29.6
28.5
30.6
31.0
30.9
30
25
20
30.7
35.1
31.5
28.5
10.5
91.8
31.0
29.3
35.1
27.7
26.5
28.8
32.3
26.8
24.7
27.9
22.1
24.0
24.4
18.9
25.5
27.3
32.5
22.3
30.2
24.9
29.4
23.7

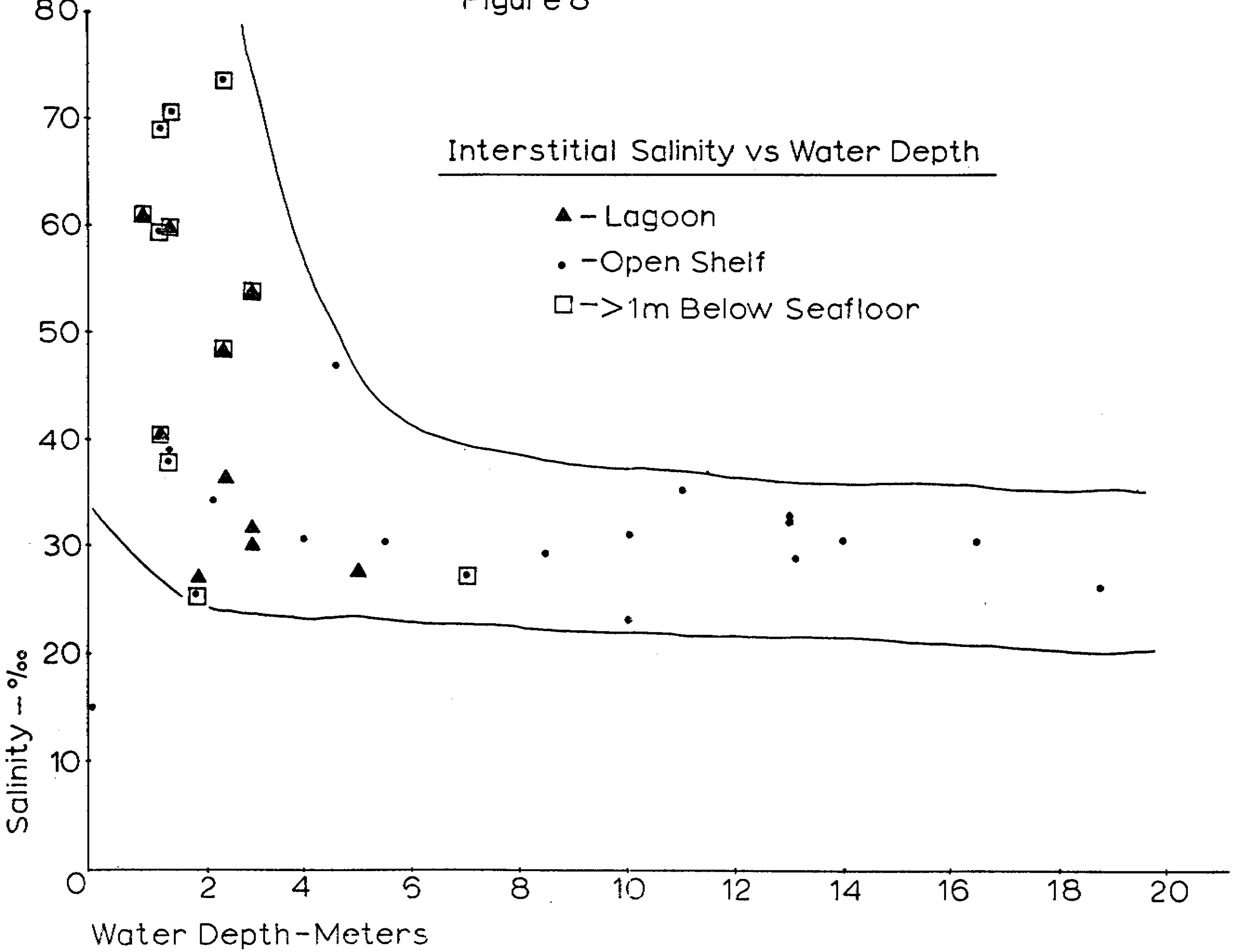
Figure 6.



150°
INTERSTITIAL SALINITY-PPM
BELOW 30cm
Length of bar shows sample depth
below sediment surface — 2 m 0
BEAUFORT SEA
CAPE HALKETT
30.6
27.2
76.7
25.7
54.0
59.5
48.2
69.1
47.7
23.1
24.8
31.1
40.3
61.0
30.5
70.8
38.5
34.9
60.0
70°30'
COLVILLE RIVER
PRUDHOE BAY
SAGAVANIRKTOK
RIVER
N
0
10 km
CANNING RIVER

Figure 7.

Figure 8



Interstitial Salinity vs Water Depth
▲ - Lagoon
• - Open Shelf
□ - >1m Below Seafloor
Salinity — ‰
Water Depth - Meters
80
70
60
50
40
30
20
10
0
2
4
6
8
10
12
14
16
18
20

ATTACHMENT B

SEA FLOOR TEMPERATURES, BEAUFORT SEA, ALASKA

by

Peter Barnes, David McDowell, and Erk Reimnitz

The thermal permafrost region of the inner Beaufort Sea shelf off northern Alaska is poorly understood, even with the considerable drilling and geophysical efforts of the last few years. (Lewellen, 1973, Osterkamp and Harrison, 1976, Lachenbruch and Marshall, 1977.) During the seven years of the Beaufort Sea work we have encountered near-surface seismic anomalies, bathymetric features, grounded sea ice occurences and other sea-floor characteristics which we thought might relate to anomalous thermal regimes and possibly permafrost. Thus, on numerous occasions we have attempted to measure sub-seafloor temperatures. In this brief report we present data gathered during the summers of 1973 and 1977 and compare it with earlier data (Remnitz and others, 1977). The results are insufficient or inconclusive to explain the anomalous sea-floor characteristics outlined above, but may be of use to other investigators.

The thermoprobe used in gathering the 1977 data consisted of a 2 meter long steel tube enclosing three thermistors at 1 m spacing. This tube was attached to a 2 meter T-bar which was driven into the bottom with a vibro-hammer. The resistances were read to the nearest ohm on a digital voltmeter, which allows for millidegree precision. Equalization times for dissipating driving disturbance ranged from 15 to 35 minutes but were generally 20 minutes. Extrapolation of resistance values obtained at 5-minute intervals suggest that 20-minute reading was on the order of 20 ohms above equilibrium readings. This would result in temperature readings about 0.1° to high. Bottom water temperatures were measured with a hand-held conductivity-temperature sensor with precision on the order of 0.1° and accuracies about 0.2°C. When the thermoprobe was not driven 2 m into the bottom, an additonal water temperature measurment was obtained from the upper thermistor on the probe.

Results from the August, 1977 stations showed a decreasing temperature profile with depth (Table I and figures 1 and 2). The shallow stations achieved the greatest penetrations and also the greatest positive (4.96°C) and negative (-2.32°C) sediment temperatures whereas the deep water stations had shallow penetration and a low range of negative temperature values. Near-bottom water temperatures were highest (9.1°C) in shallow water in bays and lagoons while lowest (-0.7°C) water temperatures were measured in deeper waters offshore (Table I).

The same kind of thermoprobe was used in late July of 1973 at five stations, three of which gave useful data (Table I, figure 2). All stations were in shallow water (less than 3.5 m) and all showed negative temperatures at 1 m. Compared to the 1977 data, the sediment temperatures are considerably colder for stations in similar environments while water temperatures are warmer. The 1973 stations were occupied about a month earlier than the 1977 stations.

A comparison of sediment temperatures 1 m below the sea floor determined from the 1977 temperature curves (figure 2), divides the stations into two distinct groups (figure 1). Inshore and in shallow water, temperatures were consistently above $0^{o}C$ and in most cases above $1^{o}C$ at 1 m below the sea floor. Offshore and in deeper water, temperatures were consistently below $0^{o}C$, and near $-1^{o}C$ at 1 meter below the sea floor. A similar division could be made using the near-bottom water temperatures; warm inshore values versus cold offshore.

In shallow water a comparison (figures 2 and 3) of the 1977 and 1973 data with temperature data reported earlier by us (Reimnitz and others, 1977) and with shallow sea-floor temperature data from other workers (Osterkamp and Harrison, 1976, Lachenbruch and Marshall, 1977), shows the different thermal character at different seasons in the Prudhoe Bay area. Data from April and May (May, 1972 thermoprobe and drill holes in 1975 and 1976) indicate increasing temperatures with depth in the upper 2-3 m of sediment, reflecting the winter heat loss at the sediment-ice or sediment-water interface. Late July 1973 data show temperature increases in the deeper parts of the upper 2 m of sediment but the surficial sediments and the overlying waters are very warm by comparison (Table I and figure 2). The late summer data of August, 1977 show decreasing temperatures with depth, reflecting the heat input from the overlying warm summer waters. With the onset of winter conditions and cooler inshore waters the shallow subsurface sediment temperatures begin to lower, as seen in the late Sepember, 1971 data (figure 3).

Further offshore, seasonal temperature contrast is apparently still present but of a much smaller magnitude. This is shown graphically in figure 4. If we consider that the data reported on here record the seasonal extremes in these two environments, then there is some indication that the temperatures on the shelf at 1 m below the sea floor in less than 3 m of water can be as low as $-2.5^{o}C$ in late winter but rise to a positive $1^{o}C$ or more in summer. Offshore in waters over 3 m deep, the seasonal range appears to be from about $-1.5^{o}C$ in winter to $-0.5^{o}C$ in summer at 1 m below the sea floor.

The shallow water data also suggest that sediment temperature respond rather quickly to the presence of sea ice implying that further offshore in areas of extensive grounding, such as in the stamukhi zone, heat may be being withdrawn at a significantly higher rate than elsewhere on the shelf. This, when coupled with the already cool sea-floor temperature, would aid in preserving relict permafrost (Lachenbruch and Marshall, 1977).

Conclusions:

1. Temperature gradients measured during the summer of 1973 and 1977 in shallow water show decreasing temperatures from the sediment surface downward reflecting seasonal influence of warm inshore waters.

2. The seasonal thermal effects noted at deeper stations on the inner shelf are believed to be much less pronounced than in shallow water.

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TABLE I

1973 and 1977 Beaufort Sea Thermoprobe Data

Thermoprobe Station	Water Depth	Maximum Thermistor Penetration	Equilibration Time	Upper – Middle – Bottom Thermistor			Bottom Water Temperature
1977, Late August							
26	1.5 m	1.87 m	21	7.97°C	2.56°C*	0.03°C	9.1°C
28	1.0 m	1.88 m	35	3.63	1.78	-2.32	2.7°C
30	1.5 m	1.68 m	20	5.53	2.74	-0.52	5.9°C
32	16.5 m	0.40 m	15		1.12	-0.997	-0.5°C
33	21.0 m	0.85 m	15	1.09	-0.53	-1.14	0.2°C
43	12.7 m	0.82 m	20	0.52	-0.92	-0.78	0.4°C
46	13.8 m	0.87 m	20	-0.92	-0.92	-0.57	0.7°C
48	2.5 m	2.17 m	20	4.96	2.82	1.10	5.2°C
49	3.0 m	2.20 m	20	4.40	2.09	0.03	4.7°C
57	2.0 m	2.00 m	20	4.01	1.35	-0.43	3.9°C
1973, Late July							
1	3.5 m	1.80 m	30	9.30°C	2.88°C	-0.43°C	10.3°C
2	3.0 m	1.85 m	15-45	5.08	-2.32	-2.17	10.0°C
4	3.0 m	2.14 m	<0	5.79	2.25	-2.18	7.8°C

*Underlined temperatures are sediment temperatures - others are water temperatures.

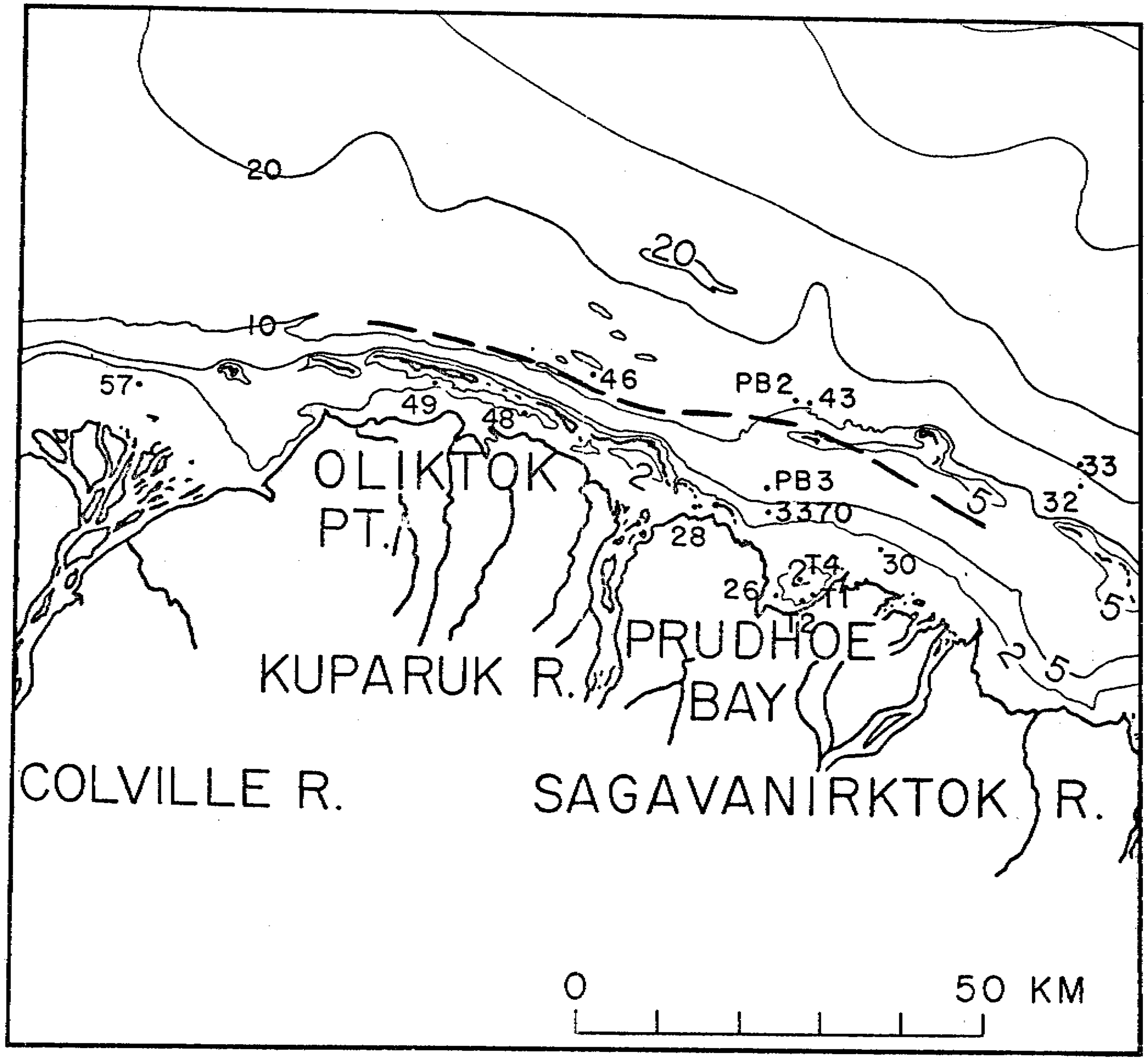

Figure 1. Location map showing 1973 and 1977 thermoprobe sites and drill holes (Lachenbruch and Marshall, 1977; Osterkamp and Harrison, 1976). The dashed line represents the approximate location of the 0°C isotherm at 1 meter below the sea floor (1977 data).

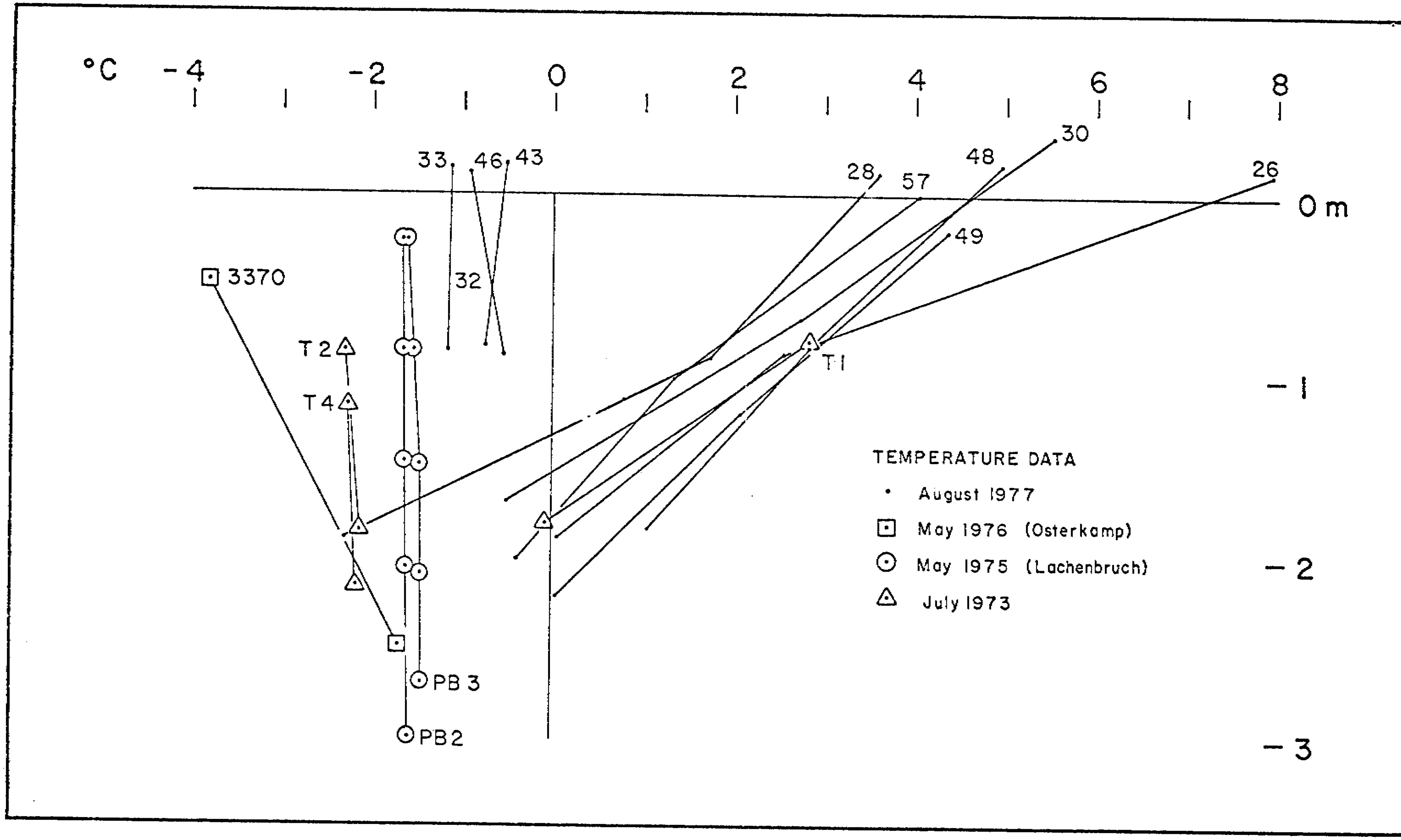

Figure 2. Sediment temperatures in the upper 3 meters of the sea bed. All values warmer than $0^{o}C$ on this graph occur in water depths less than 3 meters. Data sources: July, 1973 and August, 1977 - this report; 3370 - Osterkamp and Harrison, 1976; PB-2 and PB-3 - Lachenbruch and Marshall, 1977.

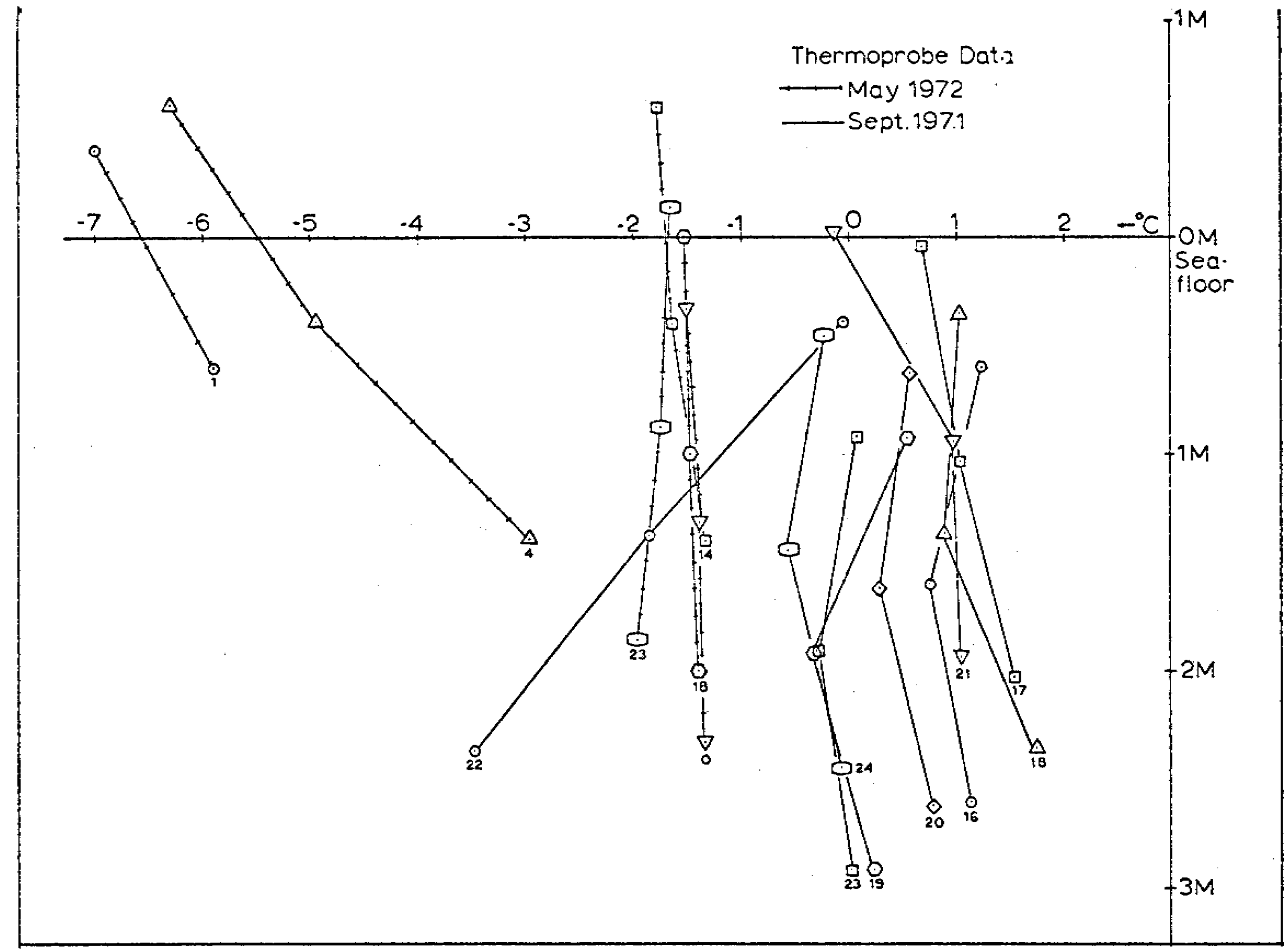

Figure 3. Termoprobe sediment temperatures for September, 1971 and May, 1972, from Reimnitz and others, 1977. Compare with Figure 2.

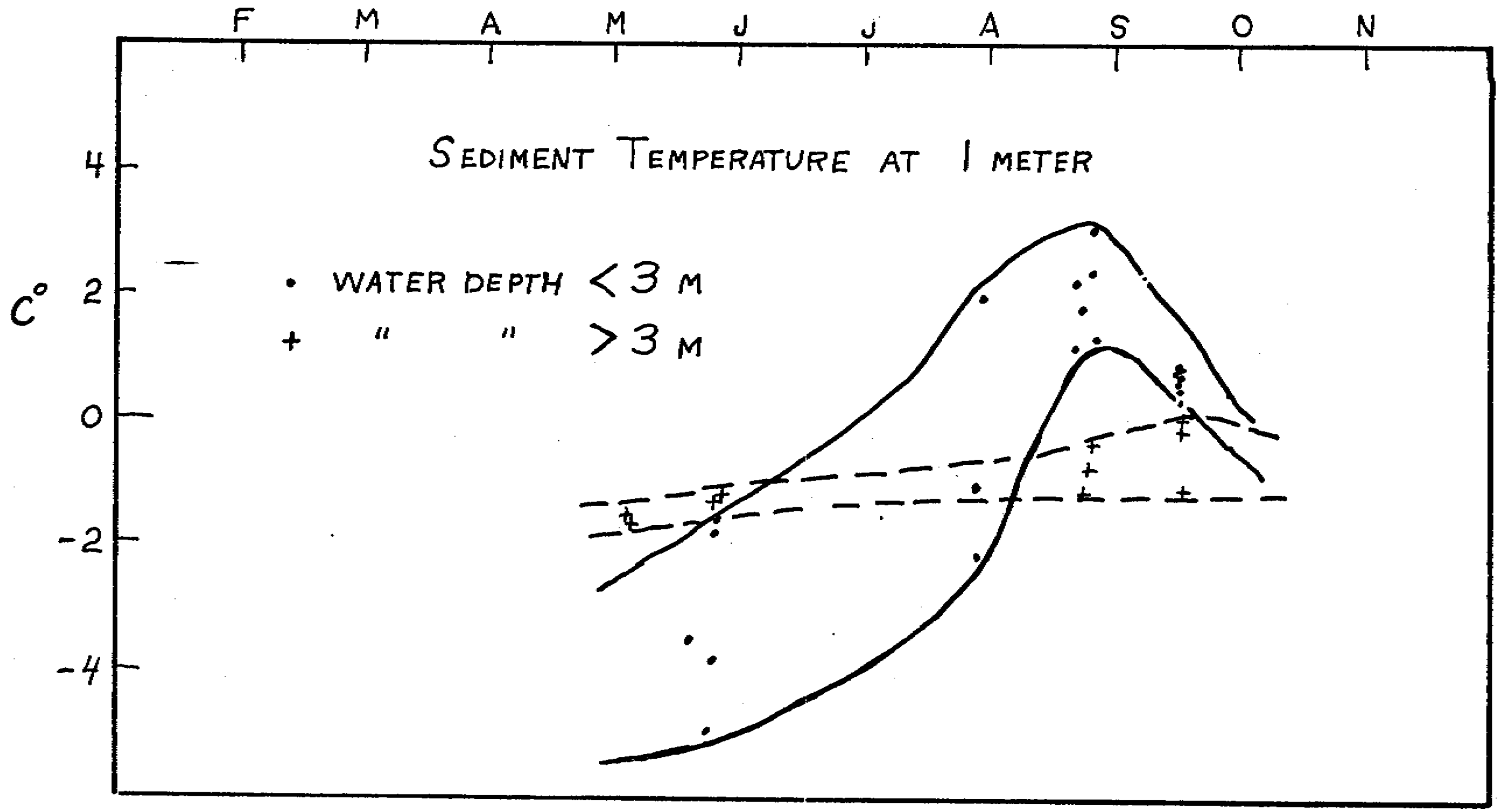

Figure 4. A comparison of the seasonal variation in seabed temperatures 1 meter below the sea floor from thermoprobe and drill hole temperature data, 1971-1977. Data sources in Table 1, Figures 2 and 3.

ATTACHMENT C

MORPHOLOGIC CHARACTER OF THE "2-m BENCH"; COLVILLE RIVER DELTA

by

Larry Toimil

Deltaic regions of Alaskan Beaufort Sea coast are commonly marked by a broad and flat bench developed shoreward of the 2-m isobath within the bottom-fast ice zone of Reimnitz et al.(1977). In most cases little bathymetric expression of a prograding delta front exists seaward of this so-called 2-m bench. This condition is particularly well developed off the Colville River Delta (figure 1) where it is not only marked by a conspicuous steepening of slope gradients seaward of the 2-m bench, but also by an abrupt change in the texture and lithologic character of sea bed deposits (from unstructured muds beyond the 4-m isobath to well-bedded sequences of fine sands, muds, and peats of the 2-m bench ((Barnes et al., 1977)). River sediments might be expected to accumulate inshore of the 2-m isobath and this in turn might be reflected in a relatively rapid progradition of the 2-m bench, as changes in the distal portions of the delta do not appear to be great. During spring breakup and flooding of the bottom-fast ice, drainage of flood waters is likely to be best developed and strudel scour of the sea bed (Reimnitz and Bruder, 1972) most intense at or just seaward of the 2-m bench. These factors together with the observations of Walker (1974), which show drastic seasonal changes in the physical nature of the waters overlaying the 2-m bench suggest that, in terms of ice, sediment transport, and thermal regimes this region is probably the most dynamic part of the inner shelf.

Presented here are a series of facsimile bathymetric profiles (figure 2) which serve to outline the general morphologic character of the 2-m bench developed off the distributaries of the Colville River. The profiles are corrected bathymetric records obtained using a narrow beam (8° cone angle) 200 kHz transducer coupled to a 7-inch Raytheon dry paper recorder. The system is capable of resolving sea bed relief of about 10 cm amplitude. Profiles A through U (figure 2) were obtained in early July, 1977, during the final stages of sea ice break-up. Ice conditions during this period prevented coverage of the westernmost portion of the study area which was later surveyed by the R/V KARLUK during September (profiles V thru Y, figure 2). In this presentation corrections have been applied for the draft carried by the transducer during the surveys. Profiles A thru U have also been normalized with respect to tidal sea level fluctuations, which varied over a range of 30 cm.

The geographic position of the transects shown in figure 1 were determined by fixes obtained using a del Norte range-range navigation system. Their location is considered accurate to within 25 m, except for transects V through Y where discrepancies in the location of trisponder stations resulted in overlapping ranges and poor fixes. The profiles of figure 2 have been keyed to the plotted transects of figure 1, arranged from east to west, and aligned along the 2-m isobath (indicated by black dots in figure 1).

Differences in the morphologic character of the bench are apparent, especially along it's outer perimeter. Profiles obtained east of transect I (figure 1) do not show the marked increase in slope gradients seaward of the 2-m isobath seen in the profiles collected along the central portion of the bench (J through T, figure 2). Nor do they reveal the irregular micro-relief characteristic of ice gouging which is well-developed across the central region of the bench. This may be explained in part by the protection offered the eastern portion by Thetis Island from the action of prevailing northeasterly wind-generated waves and ice push. It may also may also reflect higher rates of deposition for the eastern sector of the 2-m bench than elsewhere. This condition might be expected since at present the major proportions of suspensate carried by the Colville River to the coast is discharged through Kupigruak and Eastern Channels (Arnborg et al., 1967).

The processes responsible for the development of the subtle 0.5-m high ridge seen on the western side of the delta in profiles N,O,P,R,S,T,U, and V just inside the 2-m isobath are not so easily explained. Vibracores obtained across this ridge in the area of transect V show a surficial unit of well-sorted, relatively clean, fine sand thickening towards the ridge crest (Barnes et al., 1977, Cores PB76-21,11, and 23). The implications of this feature are uncertain and it's subtle nature does not allow accurate comparisons of it's present position with that of older data sets.

Along transects H through O the 2-m isobath corresponds well enough with a marked change in slope gradients to allow comparison of it's present position with that shown on U.S. Coast and Geodetic smooth sheet (8058) compiled in 1953. In making this comparison, one finds no detectable change in the position of the 2-m bench perimeter for the 24-year period between surveys. This finding, if representative, implies a relatively high degree of stability for the delta front as a whole and for the 2-m bench in particular. Such stability is surprising in light of the estimated 7.3 x 10^6 tons of inorganic suspended loads discharged annually by the Colville River (Arnborg et al.,1967) and the observed deltation processes operating over the 2-m bench. This raises the question as to what processes contribute to the apparent stability of the delta front, and what conditions might adversely affect this front.

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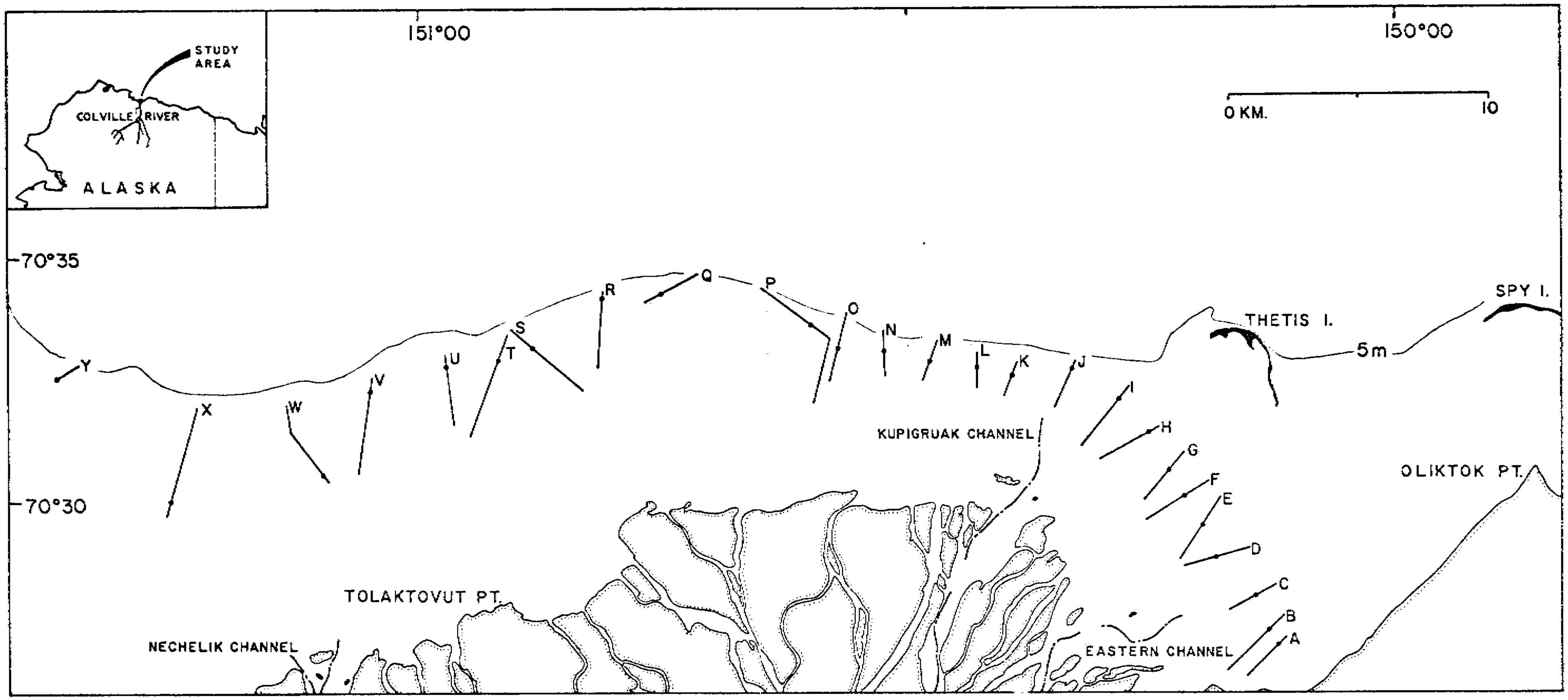

Figure 1. Location map showing the geographic position of bathymetric transects across the 2-m bench. The location of the 2-m depth isobath is indicated by black dots superimposed on the transects. The axis of both Kupigruak and Eastern Channels, represented by broken lines, were plotted from bathymetric data obtained during July 1 through 7, 1977. No bathymetric expression of the channels was found beyond where indicated.

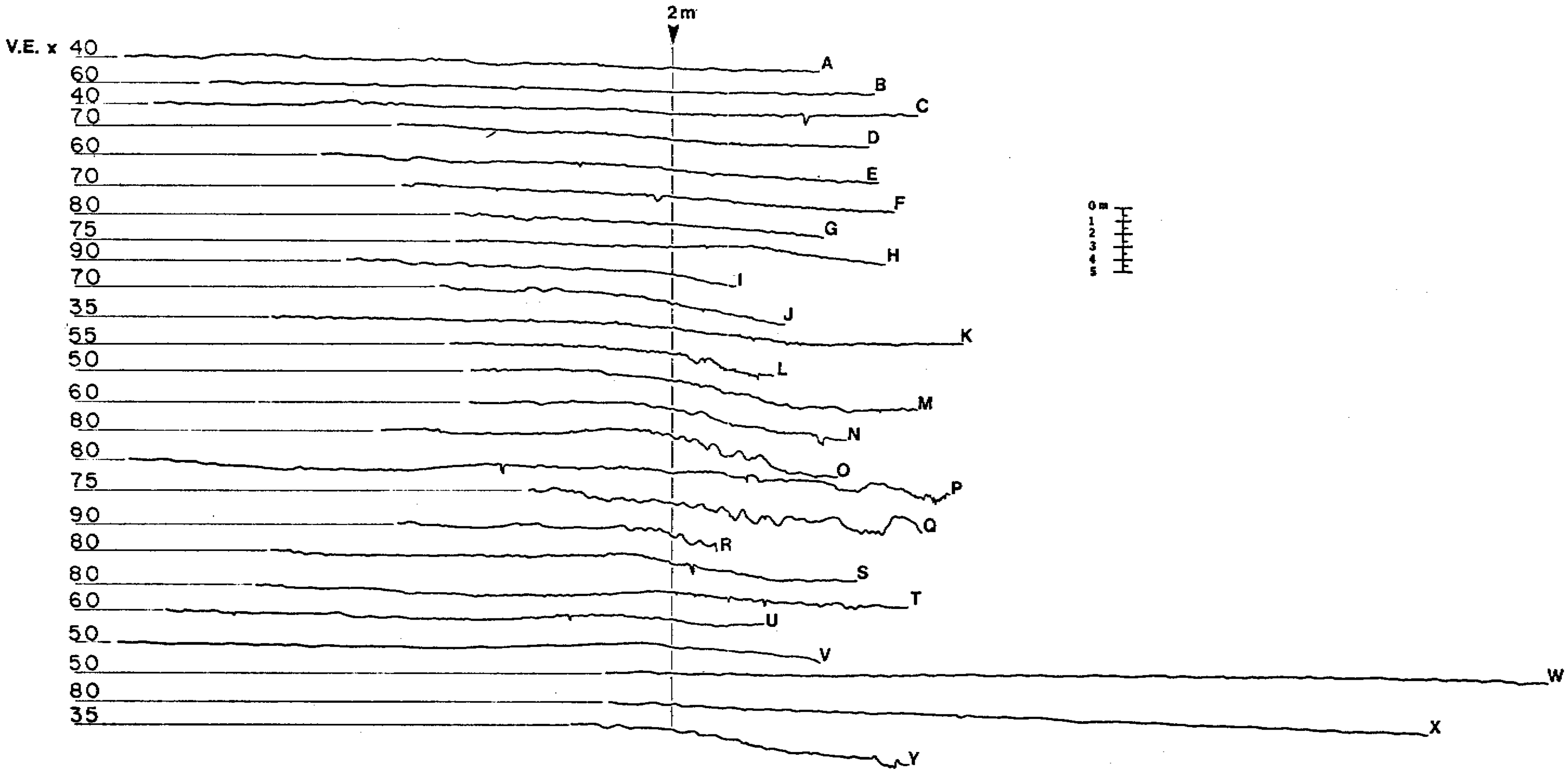

Figure 2. Showing facsimile bathymetric profiles depicting the general character of the 2-m bench. Individual profiles are keyed to transect lines of Figure 1. The sharp spike-like depressions seen in many of the transects are interpreted as strudel scours after Reimnitz et al. (1974).

Quarterly Report

Contract: RK6-6074
Research Unit: 206
Reporting Period: Eleventh Quarter
Number of pages: Three

Faulting and Slope Instability in the St. George Basin Area, Southern Bering Sea

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January, 1978

I. ABSTRACT OF HIGHLIGHTS OF QUARTER'S ACCOMPLISHMENTS

The eleventh quarter of RU2-6 was devoted to analyzing single-channel seismic reflection records and performing textural analyses of surface sediment samples collected during Cruise S6-77. The analyses should be completed by April, which will enable us to incorporate the new data into an annual report.

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 in the St. George Basin region of the Bering Sea continental margin.

III. FIELD OR LABORATORY ACTIVITIES

A. Ship or field trip schedule: None

B. Scientific party: None

C. Methods: Analyses of single-channel seismic reflection records and surface sediment samples are currently underway. Seismic records are predominantly 80 to 120 KJ sparker, 3.5 kHz, and 12 kHz profiles and some Uniboom and Minisparker profiles. Surface-sediment samples are being analyzed for grain-size distribution, carbon content, and heavy and light mineral components.

D. Sample Localities/Ship Tracklines

Figure 1 shows the tracklines for Cruise S6-77 and figure 2 shows the sampling localities occupied during that cruise.

E. Data Collected or Analyzed

Shipboard data were in transit from the ship at the time of our last quarterly report. The pertinent data collected on Cruise S6-77 are outlined below:

4 dredge hauls	41 CTD profiles
4 Van Veen grab samples	12 XBT stations
28 gravity cores	3600 n.m. 3.5 kHz profiles
8 bottom photograph stations	3600 n.m. 12 kHz profiles
6 hours sea-floor televisions	3600 n.m. continuous sea surface temperature and salinity records
27 current-meter stations	143 Van Dorn water-bottle casts
	2500 n.m. 80-120 KJ profiles
	1550 n.m. magnetic records
	4519 n.m. gravity data

IV. RESULTS

The 1977 annual report contained maps that showed major, surface, and minor faults. Symbols (e.g. circles and triangles) on those maps, were used to indicate the fault classification and offset. Figure 3 is an update of that map, showing inferred trends of the faults and fault zones. Major faults outline the borders of the St. George basin and Pribilof ridge and we infer that most of the other faults parallel those boundaries.

Sediment data from Cruise S6-77 will be incorporated with sediment data from Cruise S4-76 and will be part of the 1978 annual report.

V. PRELIMINARY INTERPRETATIONS OF RESULTS

It still is early to speculate on the implications of the data collected. Interpretations will be included in the 1978 annual report.

VI. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES

No major problems were encountered this quarter.

VII. ESTIMATE OF FUNDS EXPENDED

All funds expended.

VIII. BIBLIOGRAPHY

See last quarterly report.

Quarterly Report

Research Unit # 208
Reporting Period 10/1/77-12/30/77
Number of pages: 4

Yukon Delta Coastal Processes Study

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

February 28, 1978

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: N/A

B. Scientific party: N/A

C. Methods

1) Field Studies: N/A

2) Laboratory Studies:

   a) Radiocarbon analyses (completed) by Steve Robinson (U.S.G.S., Menlo Park, California)

   b) Pollen analysis (in progress) by Tom Ager (U.S.G.S., Reston, Virginia)

c) Heavy mineral analysis (completed) by Tracy Vallier (U.S.G.S., Menlo Park, California)

d) Study the distribution of different vegetation assemblages in relation to depositional environment and extent of development of permafrost

e) Sample analysis (in progress), including

(1) Short cores:

frozen, split, x-rayed and analyzed for grain size and composition

(2) Grab samples:

Analyzed for grain size and composition

f) Landsat and NOAA VHRR satellite imagery are being studied in conjunction with synoptic weather maps to determine seasonal variation in ice movement as well as map sub-ice channels along the delta margin.

D. Sample localities (Figure 1)

E. Data collected or analyzed

1) Number and types of samples collected: N/A

2) Number and type of analyses:

a) Textural analyses - 50 completed, 40 in progress

b) Radiocarbon dates - 14 completed

c) Pollen analysis - 60 completed (others in progress)

d) Heavy mineral analyses - 11 completed

e) Vegetation assemblages - 56 sites described

f) Forty-one (41) beach profiles have been plotted, and are presently being formatted to be put on mag tape

F. Milestone Chart and Data Submission Schedule

No changes

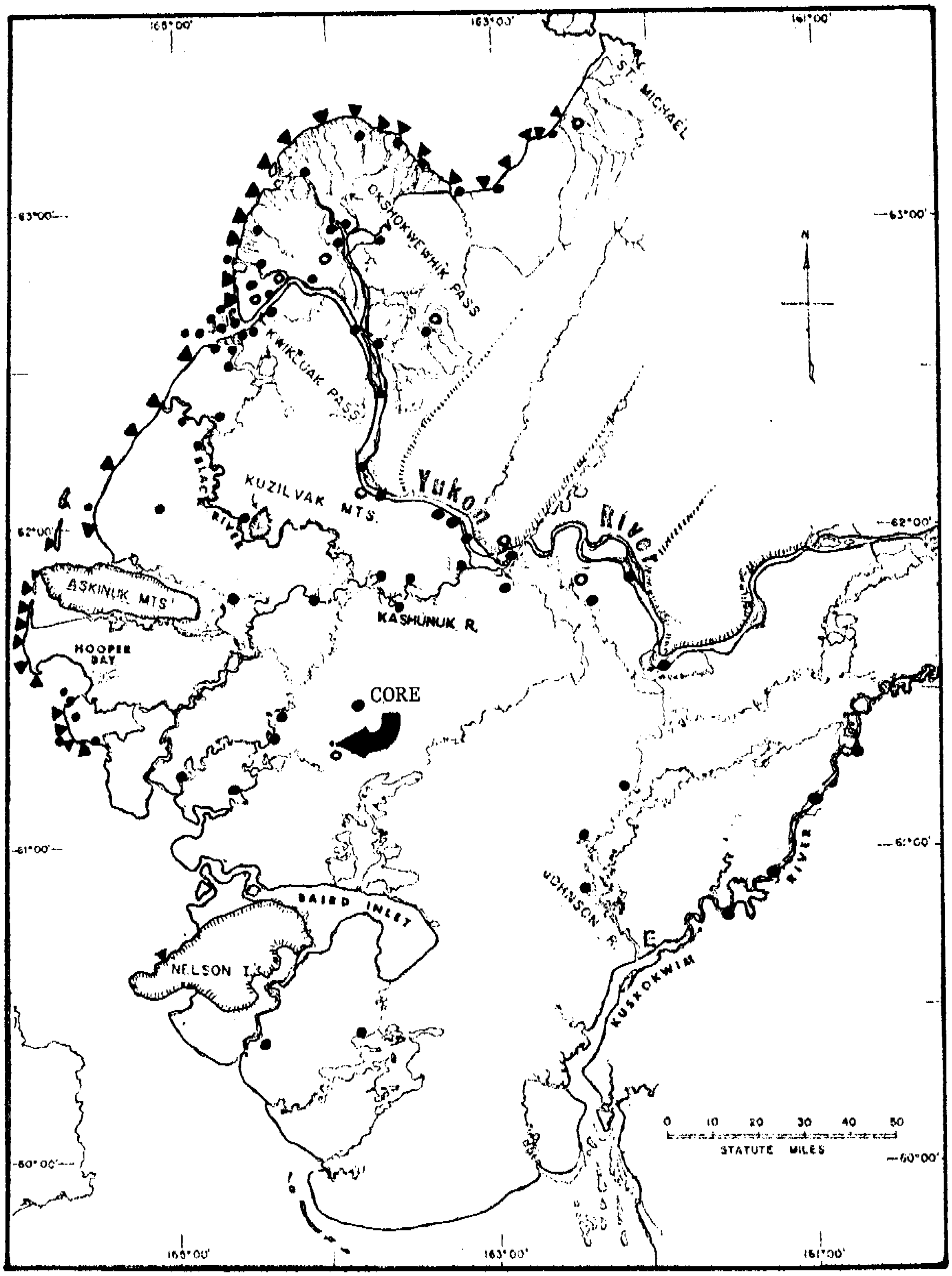

Figure 1: Location of sample stations. Triangle (▼) marks a coastal station with beach profiles, sediment and vegetation samples. Closed circle (●) marks grab samples or short cores for textural analysis or radiocarbon dating (includes some vegetation descriptions). Open circles (O) indicate only vegetation description.

III. Results and Interpretations

Most of the time this quarter has been spent in data analysis, hence little time has been spent interpreting those data beyond that already reported. Most of the interpretation will be presented in the annual report.

IV. Problems Encountered/Recommended Solutions

The main problem has been the fact that official notification of the continuation of my grant for FY78 was not received until February, 1978, thereby causing problems with purchasing equipment, etc. This has subsequently been taken care of. A more efficient system of notification of grants is needed, however.

QUARTERLY REPORT

Research Unit #: 210
Reporting Date: 1 October - 31 December 1977
Number of Pages: 7

EARTHQUAKE ACTIVITY AND GROUND SHAKING IN AND ALONG THE EASTERN GULF OF ALASKA

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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 Activities

A. Land Based Seismic Instrumentation

The final schematic diagrams for the new seismic amplifiers and voltage-control oscillators have been completed and printed circuit layout is now under way. If no major delays are encountered, the first units will be ready to install next summer.

B. Ocean Bottom Instrument Package

John Lahr spent four days at the USGS in Woods Hole, Massachusetts learning first-hand about the ocean bottom seismic system (OBS) being developed by Bruce Ambuter and discussing with him the particular scientific and logistic problems we expect to encounter in the Gulf of Alaska. The prototype ocean bottom systems operated well in the laboratory and the first underwater tests will be made in January after the Benthos acoustic recall system has been installed.

III. LABORATORY ACTIVITIES

A. Three new people have been added to our personnel to handle data processing. They are:

Kent Fogleman - Supervises and assists in routine procedures of data processing, including: Scanning and digitizing seismic films; and computer processing to obtain earthquake catalogs and maps.

Mary Ann Allan - Scanning, digitizing and locating earthquakes.

Suzanne Helton - Scanning, digitizing and locating earthquakes.

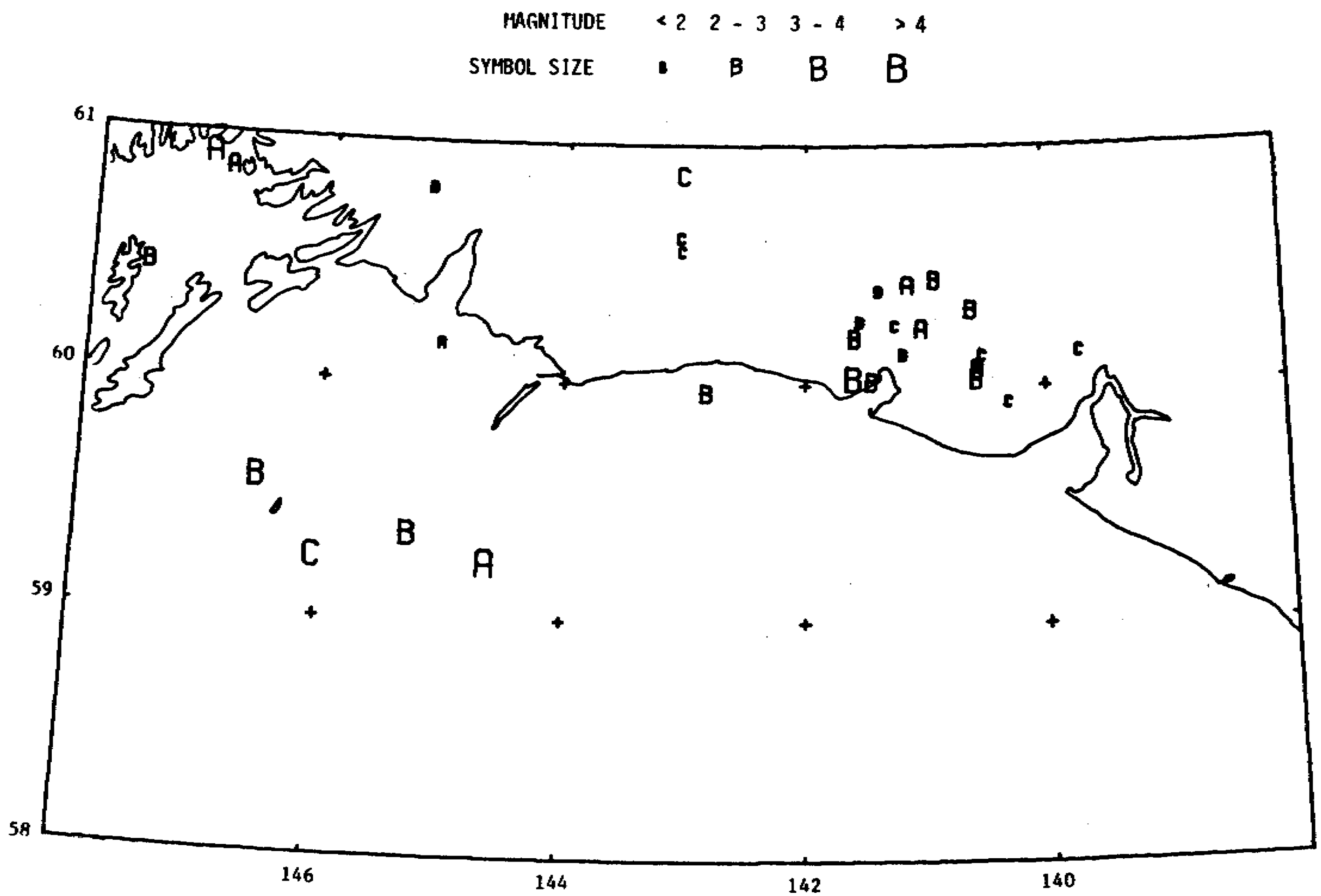
The present state of data processing is:

Scanning - Completed through June 1977, and for October 1977.

Digitizing - Completed through October 1976, and for October 1-14, 1977.

Locations - Completed through September 1976. Preliminary for October 1976 and October 1-14, 1977.

A preliminary catalog of earthquakes located in October, 1976 and during October 1-14, 1977 is presented in the Appendix, and the epicenters of these events are plotted in Figures 1 and 2.



EASTERN GULF OF ALASKA SEISMICITY

Figure 1. Map of earthquake epicenters from data from the USGS regional seismograph network, October, 1976.

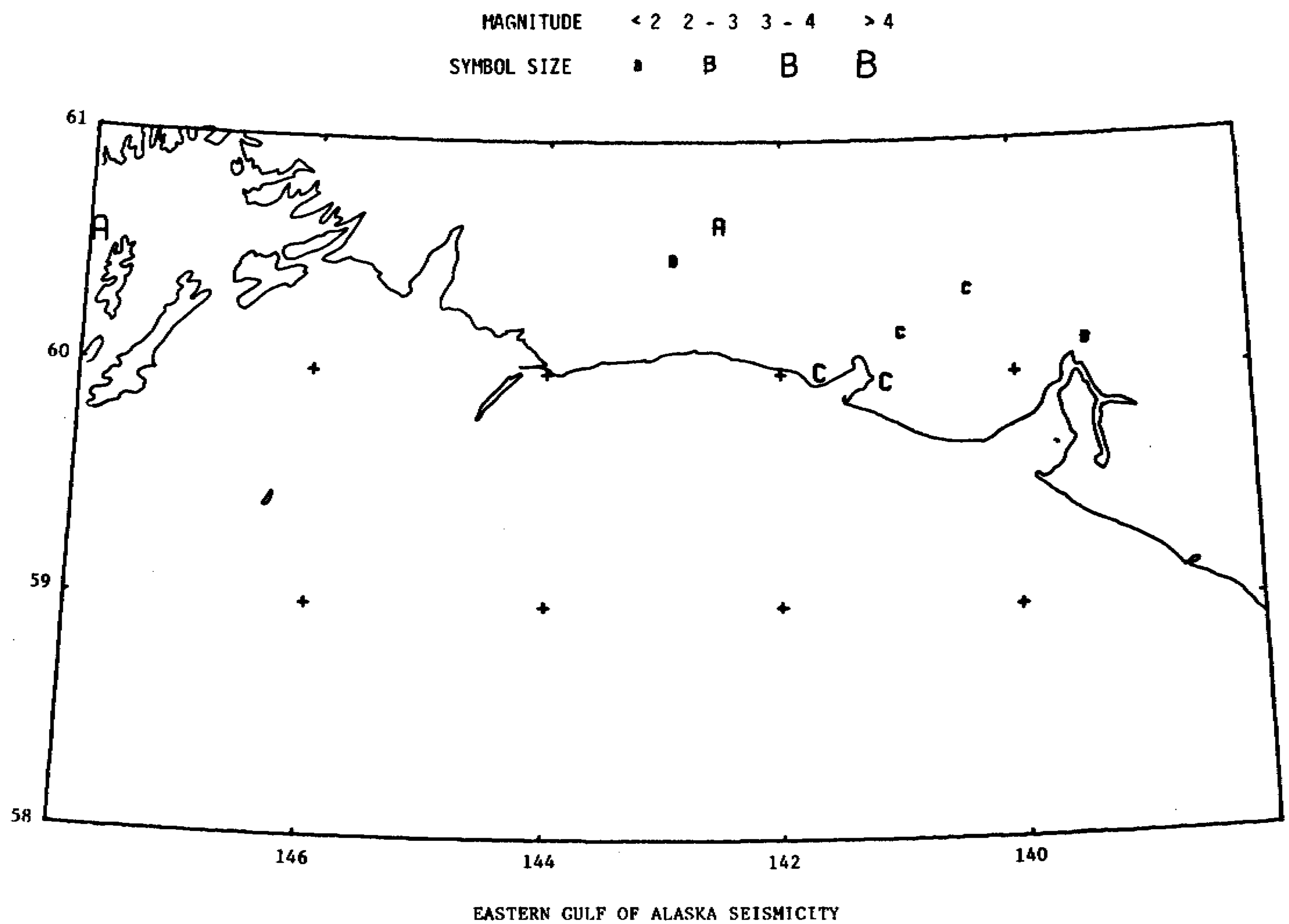


Figure 2. Map of earthquake epicenters from data from the USGS regional seismograph network, October 1-14, 1977.

B. A talk entitled Seismicity of Icy Bay, Alaska, by Christopher Stephens and John Lahr, was presented at the 1977 Fall Annual Meeting of the American Geophysical Union in San Francisco. Among the conclusions drawn about the seismicity near Icy Bay was that there is an apparent reversal of focal mechanism with depth. Earthquakes occurring at depths less than about 10 km have mechanisms consistent with thrusting on planes dipping steeply to the north, while earthquakes occurring at depths from about 10 to about 30 km have focal mechanisms that suggest a nearly opposite sense of relative motion. All of the results presented at the meeting will be published in a forthcoming paper.

APPENDIX

This appendix lists origin times, focal coordinates, magnitudes, and related parameters for earthquakes which occurred in the eastern Gulf of Alaska region. 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, duration magnitude of the earthquake.

(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) D3, epicentral distance in kilometers to the third closest station to the epicenter.

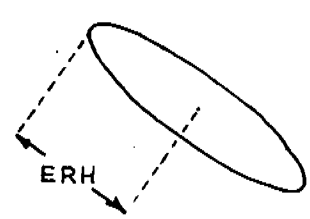
(9) RMS, root-mean-square error in seconds of the traveltime residuals:

$$RMS = \sum_i (R_{Pi}^2 + R_{Si}^2) / (NP + NS)$$

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.

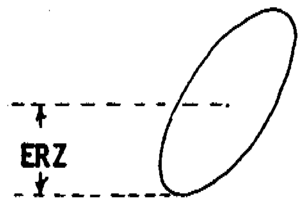
(10) ERH, largest horizontal deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the epicentral precision for an event. An upper limit of 99 km is placed on ERH.

Projection of ellipsoid onto horizontal plane:



(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. An upper limit of 99 km is placed on ERZ.

Projection of ellipsoid
onto vertical plane:



(12) Q, quality of the hypocenter. This index is a measure of the precision of the hypocenter and is calculated from ERH and ERZ as follows:

Q	ERH	ERZ
A	≤ 2.5	≤ 2.5
B	≤ 5.0	≤ 5.0
C	≤ 10.0	≤ 10.0
D	ALL OTHERS	

This quality symbol is used to denote each earthquake on epicenter maps.

EASTERN GULF OF ALASKA EARTHQUAKES

		ORIGIN	TIME	LAT N		LONG W		DEPTH	MAG	NP	NS	GAP	D3	RMS	ERH	ERZ	Q
1976		HR	MN SEC	DEG	MIN	DEG	MIN	KM				DEG	KM	SEC	KM	KM	
OCT	1	0 53	39.5	60	15.8	141	32.4	35.7	1.7	6	5	151	32	.76	4.9	2.6	B
	1	2 30	10.1	59	21.3	145	15.3	10.4	3.5	22	4	194	136	.55	4.4	1.9	B
	4	7 6	54.8	60	25.2	141	8.3	.1	2.0	8	3	170	39	.40	1.7	2.1	A
	4	8 29	23.9	60	18.9	140	36.6	.5	2.1	11	5	186	51	.67	1.5	2.8	B
	4	21 3	57.6	59	14.3	144	36.7	10.9	4.3	27	1	198	200	.47	1.7	2.4	A
	6	21 56	19.8	60	1.5	141	35.4	19.7	3.2	8	2	155	27	.63	3.6	2.0	B
	14	6 13	33.8	60	3.7	140	33.7	2.7	2.0	7	1	119	40	.63	1.9	2.8	B
	14	6 14	32.2	60	3.8	140	33.5	2.7	2.4	7	1	120	40	.51	1.8	2.8	B
	14	10 54	28.6	60	7.6	141	10.7	16.5	1.6	6	3	126	41	.36	3.2	2.2	B
	15	10 53	25.6	60	7.1	140	31.6	19.0	1.3	5	0	186	45	.23	4.8	5.3	C
	16	14 57	51.3	60	4.4	140	34.6	6.1	1.9	6	1	124	42	.54	2.6	5.0	C
	16	22 41	51.4	60	.8	141	26.5	13.6	2.2	8	0	162	19	.35	3.3	2.5	B
	19	5 35	53.4	59	15.0	146	1.5	46.5	3.3	20	1	290	145	.33	7.8	5.8	C
	21	9 0	36.7	60	33.3	143	2.0	3.6	1.8	4	2	186	188	.24	4.8	7.5	C
	20	10 14	36.2	60	55.0	147	2.9	25.5	3.5	18	0	74	46	.26	1.4	1.7	A
	20	20 8	31.3	60	36.7	143	2.6	13.6	1.6	3	2	225	164	.28	4.2	5.5	C
	22	12 53	44.1	60	14.2	141	1.6	17.2	2.3	11	1	149	41	.43	2.3	1.7	A
	22	16 25	35.5	60	11.7	141	34.9	43.2	2.0	9	1	137	29	.54	2.5	3.2	B
	22	17 56	12.1	60	8.3	139	42.8	16.8	1.1	4	3	247	55	.20	5.3	2.1	C
	23	20 28	38.7	59	55.6	140	18.5	12.2	1.1	4	2	245	59	.48	8.9	7.7	C
	24	15 16	42.3	60	48.3	145	9.6	15.2	1.6	10	2	118	102	.63	2.0	3.0	B
	26	4 24	3.6	60	52.6	143	1.7	28.2	2.9	19	3	98	76	1.00	4.3	5.2	C
	26	20 1	55.0	60	23.6	141	22.8	22.3	1.9	8	1	154	39	.88	2.7	3.8	B
	27	13 6	46.0	60	51.4	146	52.6	20.9	2.2	10	3	109	88	.46	2.3	2.1	A
	28	4 26	34.7	59	57.8	142	49.2	9.8	2.2	12	5	182	78	.92	2.6	1.9	B
	29	0 13	4.0	60	26.4	140	54.8	16.7	2.4	11	0	177	47	.36	3.1	2.6	B
	29	22 25	27.8	60	1.1	140	34.2	17.7	2.1	10	1	139	37	.62	2.9	1.8	B
	30	8 28	38.2	60	9.5	145	2.4	16.9	1.2	10	6	140	58	.26	2.0	1.1	A
	30	17 47	10.6	60	26.4	147	31.9	15.6	2.1	8	0	168	99	.30	3.9	4.2	B
	31	13 57	55.8	59	34.4	146	30.8	.1	3.2	15	2	141	129	.22	3.9	3.3	B
	31	23 14	20.4	60	14.9	141	14.9	19.1	1.4	7	2	142	30	.17	6.8	4.3	C

EASTERN GULF OF ALASKA EARTHQUAKES

		ORIGIN	TIME	LAT N		LONG W		DEPTH	MAG	NP	NS	GAP	D3	RMS	ERH	ERZ	Q
1977		HR	MN SEC	DEG	MIN	DEG	MIN	KM				DEG	KM	SEC	KM	KM	
OCT	2	0 39	19.8	60	.4	141	39.8	87.1	2.4	4	3	200	82	2.41	9.1	4.8	C
	3	7 32	12.5	60	21.5	140	23.2	15.0	1.5	6	5	230	75	.71	6.2	3.0	C
	3	14 43	50.1	60	7.4	139	22.8	16.2	1.7	5	5	253	51	.34	3.3	2.8	B
	3	22 35	5.0	59	57.8	141	5.9	10.5	2.0	3	3	221	138	.02	4.2	5.8	C
	6	5 19	18.3	60	10.4	140	58.0	35.8	1.8	3	3	194	122	.22	7.5	8.2	C
	6	13 12	11.4	60	29.5	142	55.4	9.1	1.8	7	6	125	113	.73	3.0	3.3	B
	10	5 42	.2	60	38.5	142	31.2	3.5	2.5	7	5	104	64	.96	1.8	2.5	A
	14	20 21	22.4	60	33.1	147	54.7	11.0	3.1	21	2	137	70	.52	1.2	1.4	A

QUARTERLY REPORT

Research Unit #: 212
Reporting Period: October 1 - December 31, 1977

FAULTING, INSTABILITY, EROSION AND DEPOSITION OF SHELF SEDIMENTS EASTERN GULF OF ALASKA

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Quarterly Report - R.U. 212
October 1977 - December 1977

FAULTING, INSTABILITY, EROSION AND DEPOSITION OF SHELF SEDIMENTS EASTERN GULF OF ALASKA

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I. Abstract of Highlights of Quarter's Accomplishments:

Presented papers at Geological Society of America annual meeting in Seattle, Washington, November, 1977 (see appendix).

Refined navigation from R/V GROWLER cruise, April - May, 1977, between Yakutat Bay and Kayak Island. Have begun analyzing seismic and bathymetric data from this cruise.

Measured sediment properties on cores collected on DISCOVERER cruise of late 1976. Data being analyzed.

Geotechnical cruise funded 100% by U.S.G.S. (Geologic and Conservation Division) in eastern Gulf of Alaska, October, 1977.

II. Task Objectives:

B-10 - Determine the types and characteristics of bottom sediments.
D-2 - Determine the types and extent of natural seafloor stability. Compile maps indicating relative susceptibility to instability hazards.
D-6 - Determine and map the distribution, mode of faulting, age of most recent movement, and magnitude of offset for major faults.

III. Field or Laboratory Activities:

Geotechnical Cruise to the eastern Gulf of Alaska on R/V SEA SOUNDER funded 100% by U.S.G.S. Data needed for continuing study of seafloor instability of continental shelf. Reports generated from these data will be utilized by U.S.G.S. Conservation Division and by the Bureau of Land Management in relation to decisions pertaining to exploration and development of the outer continental shelf.

Analyses of all cruise data, both geophysical and sedimentological are continuing. We have completed a report that includes detailed maps of the distribution of seafloor sediments, percentages of gravel, sand, silt and clay, and contoured values of mean and sorting of the bottom sediments (see appendix).

Four papers were presented at the annual meeting of the Geological Society of America held in Seattle, Washington, November 7-9, 1977. These papers are presently being prepared for publications (abstracts included in appendix).

IV. Results and Plans:

High quality, high resolution seismic reflection records (minisparker) were obtained in Yakutat and Icy Bays and in the nearshore zone of the eastern Gulf of Alaska between Dangerous River and Cape Suckling from the R/V GROWLER. These records are being studied and the results are being incorporated with data collected and synthesized in the previous years. These data will allow us to extend our mapping closer to the shore and will help bridge the data gap between on and offshore geologic knowledge.

Samples collected on the DISCOVERER cruise were obtained in the area of the northeastern Gulf of Alaska between Bering Trough and Yakutat Sea Valley. Vane shear and Tor vane measurements were made on the core samples. Moisture contents and bulk density samples were taken when possible. Size analyses of characteristic cores have been completed in the laboratory. These data will add to our growing knowledge of the seafloor characteristics in lease sale area 39. These data are being prepared for release in open-file format.

A piston coring cruise was successfully completed in October 1977 in the northeastern Gulf of Alaska between Montague Island and Yakutat Bay. Principle targets of study were areas of seafloor instability. Long cores will provide additional information about the physical properties of the poorly consolidated sediments and will add knowledge about the slump and slide processes active on this high energy seafloor. Hydrocarbon gradients were measured. This cruise was funded entirely by the U.S.G.S. because OCSEAP has informed us that they would not fund this study that we felt was vital to a better understanding of seafloor instability.

V. Preliminary Interpretation:

Samples and records are being analyzed (see appendix).

VI. Problems:

Reduction in funding has hampered the continuation of a study of seafloor hazards that we believe to be important for proper OCS management decisions.

VII. Estimate Funds Expended:

Twenty percent.

VIII. Publications and Oral Presentations:

During this past quarter, papers have been presented at a national meeting. In addition, several papers have been submitted for publications. These papers and abstracts are listed below and those that have been published are attached in Appendix A.

Bruns, Terry R., Carlson, Paul R., and Schwab, William C., 1977, Listric faults south of Kayak Island, northern Gulf of Alaska: Geological Society of America, Abstract with Programs, v. 9, p. 914.

Carlson, Paul R., Bruns, Terry R., Molnia, Bruce F., and Hampson, Jr., John C., 1977, Submarine valleyson the continental shelf, northeastern Gulf of Alaska: Geological Society of America, Abstract with Programs, v. 9, p. 921.

Carlson, Paul R. and Molnia, Burce F., in press, Submarine faults and slides on the continental shelf, northern Gulf of Alaska: Marine Geotechnology.

Carlson, Paul R., Molnia, Bruce F., Kittelson, Steven C., and Hampson, John C. Jr., 1977, Distribution of bottom sediments on the continental shelf, northern Gulf of Alaska: U.S. Geol. Survey miscellaneous field studies, MF-876, 13 p., 2 map sheets.

Molnia, Bruce F., 1977, Coastal morphology, erosion, and accretion of Gulf of Alaska coastline, Cape Suckling to Yakutat Bay: Geological Society of America, Abstract with Programs, v. 9, p. 1098.

Molnia, Bruce F. and Carlson, Raul R., in press, Surface sedimentary units of the northern Gulf of Alaska continental shelf: Am. Assoc. Petroleum Geologists Bull.

Molnia, Bruce F., Carlson, Paul R. and Bruns, Terry R., 1977, Large submarine slide in Kayak Trough, Gulf of Alaska, in Coates, D. (ed.), Landslides; Engineering geology reviews, Geol. Soc. America.

Yarus, Jeffrey M., Ehrlich, Robert, and Molnia, Bruce F., 1977, Bottom sediment circulation patterns in the Gulf of Alaska--Fourier grain shape analyses: Geological Society of America, Abstract with Programs, v. 9, p. 1236.

IX. Appendix A.

Bruns, Terry R., Carlson, Paul R., and Schwab, William C., 1977
LISTRIC FAULTS SOUTH OF KAYAK ISLAND, NORTHERN GULF OF ALASKA:
G.S.A., Abstract with Programs, v. 9, p. 914.

The outer edge of the continental shelf south of Kayak Island in the northern Gulf of Alaska, is the site of small surficial step faults underlain by deep-seated listric faults. Both surface and deep faults appear to result from growth on a shelf edge structural high. Shelf edge structures are inviting targets for exploration, but deep-seated faults are not always recognized. These faults could create conditions hazardous to drilling as on tracts over the structural high which was leased in OCS sale 39. The surficial step faults are found in two clusters covering areas of 100 and 124 km^2 in water depths of 150-225 m. The relief of individual scarps varies from 2-5 m. Some fault blocks show evidence of backward rotation; however, the most seismic records do not show seaward curvature of the slip planes. The slip planes can be traced to a depth of about 150 m on high resolution seismic reflection records and cut strata of Pleistocene age. The deep-seated faults, which are interpreted from multichannel seismic records, affect strata to a depth of 1 km. The faults appear to have curvilinear, concave-upward, slip surfaces. Rotation of the fault blocks has caused a wedge of material to be displaced seaward. These listric faults are discontinuously present over a distance of 50 km and cut Pleistocene and possible Pliocene age strata. Masses of slumped sediment are present on the continental slope adjacent to the area of faulting. The observed faulting and slumping appears to be a consequence of continued growth of underlying anticlinal structures causing uplift and gravity sliding of the overlying material. The surface faults may be due to settling within the seaward-moving sediment wedge.

Carlson, Paul R., Bruns, Terry R., Molnia, Bruce F., and Hampson, Jr., John C., 1977
SUBMARINE VALLEYS ON THE CONTINENTAL SHELF, NORTHEASTERN GULF OF ALASKA
G.S.A., Abstract with Programs, v. 9, p. 921.

The continental shelf of the northeastern Gulf of Alaska between Prince William Sound and Cross Sound is cut by at least eight major valleys. These submarine valleys (from west to east, Hinchinbrook Sea Valley, Egg Island Trough, Kayak Trough, Bering Trough, Pamplona Trough, Yakutat Sea Valley, Alsek Sea Valley, Cross Sound Sea Valley) and the adjacent shelf have been investigated using high- and medium-resolution seismic profiling (21,000 km of track lines) and surface sediment sampling ($\sim$ 550 samples). Evidence that these troughs or valleys owe their present morphology to glacial processes includes: 1) U-shaped cross sections, both surficial and at the top of the Pleistocene surface, 2) concave longitudinal sections commonly shoaling at their seaward end, 3) till-like sediments collected from the walls or outer shelf adjacent to the troughs, and 4) characteristic seismic reflectors typical of glacially derived strata. Depressions with tens of meters of relief have been detected on the Pleistocene subbottom erosional surface along the thalweg of these valleys. These depressions have been partially smoothed out by the seaward-thinning wedge of Holocene glacial flour (clayey silt) that is filling these valleys and blanketing the inner shelf at rates as high as 15 mm per year (based on ^{210}Pb measurements). Although glaciation played a dominant role in the modern morphology of these sea valleys, structural complexities may also influence it. For example, seismic records indicate that the depocenter of a shelf basin underlies the axis of the landward end of Yakutat Sea Valley. In addition, the numerous structural and topographic highs on the shelf (e.g. Tarr Bank, Kayak Island and Pamplona Ridge) may have influenced the flow directions of the glacial lobes.

Molnia, Bruce F., 1977
COASTAL MORPHOLOGY, EROSION, AND ACCRETION OF THE GULF OF ALASKA COASTLINE, CAPE SUCKLING TO YAKUTAT BAY:
G.S.A., Abstract with Programs, v. 9, p. 1098.

The 250 km-long Gulf of Alaska coastal area between Cape Suckling and Yakutat Bay consists of four morpho-geographical segments, each with a unique sedimentological regime and geologic character. The segments are: (1) Bering Glacier foreland; (2) Yakataga to Umbrella Reef; (3) Icy Bay mouth; and (4) Malaspina Glacier foreland. This entire region is subject to aperiodic tectonic uplifts and nonuniform isostatic readjustments.

The Bering Glacier foreland segment, characterized by broad, thick ($\sim$ 100 m) sandy-beach and outwash plains, has large wash-over fans that are offsetting stream mouths and burying forests. Rivermouth spits are accreting westward (max. 6 km/30 yrs), while the coastline is actively receding (max. rates > 20 m/yr). The Yakataga to Umbrella Reef segment is characterized by eroding bedrock outcrops or thin modern beaches. Behind the beaches is a receding erosional scarp, up to 6 m high. The Icy Bay mouth segment is the most dynamic and complicated, characterized by recent rapid deglaciation and shoreline erosion of as much as 4.5 km since 1922. Parts of the area are underlain by melting ice. Deposition at Point Riou Spit averages 5 x 10^6 m^3/yr. The Malaspina Glacier segment consists of eastern and western outwash forelands and a large recessional moraine at Sitkagi Bluffs. Sediment input from the stagnating Malaspina plus the erosional resistance of the moraine keep this shoreline essentially stable. Blizhni Point is the only major depositional area.

In spite of the active and continuous erosional processes, the Cape Suckling to Yakutat Bay coastal area is accretionary. Uplift of seafloor produces new coastal sections which, although immediately attacked by erosion, are subsequently uplifted beyond the zone of shoreline erosion. Hence, in the sense of geologic time, this coastline is accretionary, yet, in the instantaneous sense, it is recessional.

Yarus, Jeffrey M., Ehrlich, R., and Molnia, Bruce F., 1977
BOTTOM SEDIMENT CIRCULATION PATTERNS IN THE GULF OF ALASKA --
FOURIER GRAIN SHAPE ANALYSIS
G.S.A., Abstract with Progams, v. 9, p. 1236

Bottom sediment samples were collected from the Gulf of Alaska and environs in order to determine parameters of the sediment transporting bottom currents including velocity and direction. Samples from the near shore sediment sources can be distinguished from one another on the basis of quartz grain shape measured by the amplitudes of a Fourier series in closed form. Potential source areas include: the Copper, Bering and Alsek rivers, the Malaspina and Bering glacial drainages, Icy Bay and Yakutat Bay end moraines, Kayak Island, Middleton Island as well as subsea sources on the shelf. The submerged sources (Pamploma Ridge, Wessels Reef plus several Tertiary highs) are the result of glaciation and ongoing uplift of the shelf. Shape constrasts between these regions can be used to determine long term bottom circulation patterns assuming that sediment provinces defined by shape analysis are not Pleiostocene relics.

In the near shore zones (depths < 50 m) proportional contributions of the sources can be determined as sediment is swept westwards by long shore transport. Data from offshore samples (50 m - 200 m) suggest that bottom currents strong enough to transport sand are active and that some Tertiary-Pleistocene structural highs are yielding sediment. Preliminary data indicate a distinct change in shape at a specific size within the sand fraction. This may indicate that the coarser fraction ($> .25$ mm 2ϕ) might be relict whereas the finer sands and silts are in transport. If so, then this defines an upper limit of modern bottom shear stresses which in turn may be related to current velocity.

Molnia, Bruce F., Carlson, Paul R., and Bruns, Terry R., 1977
LARGE SUBMARINE SLIDE IN KAYAK TROUGH, GULF OF ALASKA
G.S.A., Reviews in Engineering Geology, v. 3, p. 137

ABSTRACT

Analyses of high-resolution seismic profiles have revealed the presence of a well-defined, massive submarine slide located at the north end of the Kayak Trough in the northern Gulf of Alaska. This slide is about 18 km long and 15 km wide, has a volume of about 5.9 km^3, and has moved down a 1° slope. Sediment from the upper 2 m of the slide consists of low-strength, greenish-gray clayey silt. Morphologically this slide is a classic example, with a well-preserved pull-apart scarp in the headward regions, a well-developed toe, disrupted internal bedding, and hummocky surface topography.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

APPENDIX A ADDENDUM

TO ACCOMPANY MAP MF-876 - can be obtained from: Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225.

DISTRIBUTION OF BOTTOM SEDIMENTS ON THE CONTINENTAL SHELF, NORTHERN GULF OF ALASKA

by

Paul R. Carlson, Bruce F. Molnia, Steven C. Kittelson and John C. Hampson, Jr.

INTRODUCTION

These reconnaissance maps show the distribution and relative proportions of major types of bottom sediment on the Gulf of Alaska continental shelf between Montague Island and Yakutat (fig. 1). This part of the shelf is 450 km long and ranges in width (shoreline to 200-m isobath) from about 80 km off the Copper River to less than 30 km off Kayak Island and encompasses an area of about 25,000 km^2. The shelf gradient ranges from 0°08' off the Copper River to 0°23' off Kayak Island to 0°12' off Icy Bay (fig. 1).

Morphology

Four major valleys or troughs are incised approximately perpendicular to shore; they are, from west to east, Hinchinbrook Sea Valley, Kayak Trough, Bering Trough and Yakutat Sea Valley (fig. 1). One elongate depression, Egg Island Trough, parallels the shoreline along the Copper River Delta. Positive relief features, from west to east, include Tarr Bank, Middleton and Kayak Islands and surrounding platforms, and Pamplona Ridge. The influence of each of these morphologic features must be considered in a study of erosional or depositional processes and the resulting distribution of sediment on the continental shelf.

On shore, the topography consists of a narrow coastal plain backed by the tectonically active, glaciated Chugach-St. Elias Mountains. The main breaks in these young, rugged mountains are valleys through which glaciers flow or flowed toward the sea. At the west end of the study area, the glacially fed Copper River annually carries a gigantic load of sediment--107 x 10^9 kilograms (Reimnitz, 1966)-- to the Gulf of Alaska. Two piedmont glaciers, Bering and Malaspina, extend nearly to the shoreline. From these massive glaciers numerous meltwater streams carry significant amounts of suspended matter--890 mg/l at the mouth of the Seal River that drains from Bering Glacier (R. Feely, oral commun. 1976)-- into the predominantly counter-clockwise circulation of the Alaskan Gyre (Reimnitz and Carlson, 1975). Two large bays, Icy and Yakutat, which were once the sites of large glaciers (Plafker and Miller, 1958), are incised in the coastline on either side of the Malaspina Glacier.

Geology and Structural Framework

Strata ranging from Paleocene well-indurated argillite and graywacke (Orca Group) to Pleistocene semiconsolidated siltstone and conglomeratic mudstone (upper part of the Yakataga Formation) crop out in the foothills, on the coastal plain, and on some of the islands and banks of the continental shelf (Plafker, 1967, 1974; Plafker and Addicott, 1976; Winkler, 1973; Molnia and Carlson, 1975a). Plafker (1967, 1971) has named this continental margin basin the Gulf of Alaska Tertiary Province. The Tertiary strata are complexly folded and faulted, probably as a consequence of Cenozoic interactions between the North American plate and the Pacific plate (Plafker, 1969, 1972; Plafker and others, 1975; Bruns and Plafker, 1975). Holocene unconsolidated mud, sand, and gravel unconformably overlie the wave-, stream-, and glacier-planed surface of Paleocene to Pleistocene rocks on the coastal plain as well as the continental shelf (Carlson and Molnia, 1975; Plafker and others, 1975).

Climatology and Oceanography

Weather in the Gulf of Alaska is influenced by two competing pressure systems, the Aleutian Low and the Pacific High (Dodimead and others, 1963; Royer, 1975). Severe westerly storms move through the region during the winter months when the Aleutian Low predominates. The cyclonic rotation of these storms creates strong easterly winds in the northern Gulf of Alaska. During the summer, the Pacific High becomes dominant, fair weather frequent, and the prevailing winds more southwesterly and more docile. The Ekman transport of shelf waters as a result of the wind stress produces strong downwelling in the winter and weak upwelling in the summer (Royer, 1975).

Water circulation in the Gulf of Alaska is forced by the westerly Subarctic Current that turns north as it nears the North American continent and flows into the gulf as the Alaskan Gyre. In response, the nearer shore Alaskan Stream flows counter-clockwise through the Gulf of Alaska at a speed of 16-20 cm/sec (Dodimead and others, 1963). Royer (1975) reports that an 18-cm/sec westward flowing surface current was monitored near Middleton Island in April 1972, on the basis of several sightings of a large propane tank.

Large storm waves estimated to be at least 15 m high (T. C. Royer, 1977) roll across the shelf throughout the winter seasons. These waves undoubtedly disturb the bottom even at the shelf edge (200 m deep). Strong bottom currents are believed to be active on highs such as Tarr Bank. Speculated additional forces include the little known internal waves that are being reported with increasing frequency as study of these phenomena intensifies.

Tsunamis are frequent visitors to the Alaskan shelves, generated either from regional or remote earthquakes. These long (400-km wavelength) waves devastate coastal structures (Plafker and others, 1969) and most certainly have some effect on the surface sediments on the shelf.

Purpose

These maps and pamphlet illustrate the physical characteristics of continental shelf sediments in the northern Gulf of Alaska. The data provide clues for unraveling the history of recent sedimentation. The amounts and modes of erosion, transportation, and deposition are important in evaluating the environmental hazards of this shelf, particularly as petroleum exploration accelerates. Benthic biologists relate occurrence of infauna and epifauna to sediment type. Geochemists must know the sediment types and characteristics in order to evaluate the distribution and absorption of metals and nonmetals and how these relate to the presence, absence, or spread of contaminants. Knowledge of the type of seafloor also is important in understanding the effects of oil spills as well as explaining concentrations of hydrocarbons. This report provides a preliminary look at the regional distribution of sediments and the active sedimentary processes.

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DATA COLLECTION

Sampling Techniques

Most of the data incorporated in this report were collected on seven cruises beginning September 1974. The type and amount of data collected on each cruise are shown on Table 1.

The sediment maps in this report are based primarily on analyses of sediment samples collected on the Cromwell and Discoverer cruises, supplemented by shipboard descriptions of sediments collected on the Acona and Sea Sounder cruises and by interpretations of seafloor stratigraphy from high-resolution seismic reflection profiles (Carlson and Molnia, 1975; Molnia and Carlson, 1975a). The seismic records were especially useful in providing continuity of interpretation across areas where the bottom samples were sparse. The seven cruises utilized various means of navigation including satellite, Loran A, Decca Hi-Fix, Raydist, Motorola Mini-Ranger, and radar. The location accuracy ranges from 0.25 to 1.5 km but averages about 0.5 km.

The sample sites are plotted on the sediment distribution map (sheet 1). Most of the samples were collected with VanVeen and Shipek grab samplers. Approximately one liter of sediment was retained for size analyses.

In addition to our data collected since 1974, we have used data generated by Wright (1972 a,b) for the Yakutat Bay region and by Reimnitz (1966) for the Copper River delta and prodelta region.

Laboratory Techniques

Size analyses of the sediment samples were obtained using sieves, 1/2 ϕ interval, for sand and gravel sizes (American Society for Testing Materials, 1972) and a hydrophotometer for silt and clay sizes (Jordan and others, 1971). Grain size classes follow Wentworth's (1922) classification: gravel > 2 mm, sand 2.00 - 0.062 mm, silt 0.062 - 0.004 mm and clay < 0.004 mm. Size parameters of mean and sorting were calculated using the formulas derived by Folk and Ward (1957). Samples that contained more than 5 percent gravel were of insufficient volume to give an accurate size representation (Schlee and Pratt, 1970; Krumbein and Pettijohn, 1938). The volume of sample needed to portray the coarsest gravels would have been too large for routine collections. Description of some of these sediments will be possible only with thorough observation of the seafloor by television or bottom camera.

A total of 41 samples was analyzed for carbon using the LECO combustion technique (Boyce and Bode, 1972). The samples were chosen to represent variations in sediment types throughout the study area.

Representative samples of the two dominant sediment types, clayey silt and gravelly mud, were tested for geotechnical properties. Twenty-eight samples were analyzed for Atterberg limits using the ASTM modified methods suggested by Richards (1974). Vane shear measurements (Richards, 1961; Kravitz, 1970; Monney, 1974) were made on subsamples of 16 box cores. The subsamples were collected by pushing an 8.5-cm (inside diameter) plastic core-liner into the top surface of the box core and then cutting the liner out of the sample at the time the box core was slabbed. The miniature vane shear measurements were made in the laboratory, about six months after the cruise, on the cores that were confined by the liner and a tight fitting core cap at the bottom of the subsample. The hand-crank vane shear apparatus (Wykeham Farrance Eng. Ltd.) was rotated at a rate of about 90°/min (Monney, 1974).

SEDIMENT DATA

Sediment distribution

The map showing distribution of sediment types (sheet 1) is based on a modified version of Shepard's (1954) and Folk's (1954) sediment classifications. The samples were located on ternary diagrams on the basis of percentages of gravel, sand, silt, and clay. Samples containing more than 1 percent gravel were located on the gravel-sand-mud triangle and all others on the sand-silt-clay triangle (sheet 1). They were then plotted on the map as one of seven sediment types defined on the ternary diagrams. Because of the relatively few samples in some of the categories defined by Shepard (1954) and Folk (1954), we have combined some groups and thus simplified the distribution map. Several areas are shown as bed-rock because of the rugged, irregular surface of the seafloor, a lack of internal reflectors on high-resolution seismic profiles, and our inability to obtain samples of sediment despite multiple attempts.

Table 1.--Cruises in the northern Gulf of Alaska

Cruise	Date	Type and Amount of Data	
R/V Thompson ---------------	9/74-10/74	High-resolution seismic	- 6500 km
NOAA Surveyer --------------	4/75-5/75	---------------do.-----------	- 5000 km
NOAA Cromwell---------------	6/75	Gravity cores and grab samples	- 400 samples
M/V Green ------------------	6/75-8/75	High-resolution seismic	- 2250 km
NOAA Discoverer ------------	10/75	Grab samples	- 37 samples
R/V Acona ------------------	4/76	High-resolution seismic	- 700 km
		Grab samples	- 58 samples
		Seabed photographs	- 14 stations
R/V Sea Sounder -----------	6/76	High-resolution seismic	- 2300 km
		Grab samples and cores	- 86 samples
		Seafloor television	- 11 locations

Seismic profiles and maps of sedimentary units (Molnia and Carlson, 1975a), an isopach of Holocene sediments (Carlson and Molnia, 1975), and bathymetry (Molnia and Carlson, 1975b) were used to supplement textural data and to modify boundaries between sediment types.

The dominant sediment in this high-energy environment is clayey silt (sheet 1). Clayey silt is especially prevalent east of Kayak Island, mantling much of the shelf except the nearshore area between Yakataga and Yakutat, the Kayak Island platform, the crest and flanks of Pamplona Ridge, and the outermost shelf. West of Kayak Island clayey silt dominates in Kayak and Egg Island Troughs, in Hinchinbrook Sea Valley, and on the outer shelf except on the Middleton Island platform and Tarr Bank.

The second most common sediment is gravelly mud (sheet 1), which covers most of Tarr Bank and Pamplona Ridge and is present along much of the shelf edge east of Kayak Island.

Sand predominantes in the nearshore zone especially near the Copper River and the Malaspina Glacier (sheet 1). Our sampling grid does not extend close enough to shore near the Bering Glacier to determine whether or not that part of the nearshore zone contains significant quantities of sand.

Gravel and Sand

The percentages of gravel in the northern Gulf of Alaska are variable, ranging from almost 75 percent of some samples to a trace of largely granule-size particles in others. The principal areas of gravel accumulation are on the Tarr Bank - Middleton Island platform, on the top and flanks of Pamplona Ridge, and on the moraines at the mouths of Yakutat Bay and Icy Bay (sheet 2A). Cumulative percent curves of the gravelly sediment (fig. 2) shows their overall size characteristics.

The dominant percentages of gravel are in the range of 10-25 percent on the west side of Tarr Bank and around Middleton Island. On the east side of Tarr Bank, the 1-10 percent range dominates. On Pamplona Ridge the dominant gravel range is 25-50 percent, decreasing to 1-25 percent at the landward end. At the mouth of Yakutat Bay many of the morainal samples contain more than 50 percent gravel. In addition, small patches of gravel are located along the flanks of the Yakutat Sea Valley.

The highest concentrations of sand (many samples are more than 90 percent sand) occur along the continually changing barrier islands that are prograding westward at the mouth of the Copper River (Reimnitz, 1966) (sheet 2B). Most of the sand, whether from barrier island or tidal channel, is moderately well-sorted, medium to fine sand (fig. 2). Hayes (1976) has classified the mineralogically immature sand of the barrier islands as litharenite, containing about equal parts of quartz and metamorphic rock fragments. Other areas of sand dominance are the nearshore zone both east and west of the Malaspina Glacier and a patch on the floor of Yakutat Sea Valley.

Tarr Bank samples also have a relatively high sand content ranging from 10-50 percent with most of the samples in the 25-35 percent range. The Kayak Island platform is covered by sediment of a fairly high sand content with samples at the southwest end consisting of as much as 88 percent sand.

The high sand and gravel content at the surface of Tarr Bank is a measure of the great energy of storm waves. As the severe winter storms move through the area, they generate large waves and strong bottom currents that extensively rework the bottom sediment on banks and shoals. The generally high energy over these bathymetric highs, in addition to winnowing the bottom sediment, also retards deposition of the fine fraction. Underwater television observations of Tarr Bank during the R/V Sea Sounder cruise (6/76) showed widely diverse seafloor deposits ranging from large boulders and cobbles, to shell hash and granules, to sand, to muddy gravels. The gravels, where more concentrated, were probably deposited as ground moraine at some time in the Pleistocene when glaciers apparently covered much on the shelf (Molnia, 1977). Those samples with pebbles scattered throughout the mud, classic diamictons (fig. 2), represent dual sedimentation processes. The mud was probably deposited in environments similar to those of today, by meltwater streams carrying great quantities of glacial flour into the gulf. The pebbles are dropstones, probably ice-rafted glacial debris. This sedimentary environment must have existed throughout much of the Tertiary, according to Plafker and Addicott (1976) who describe thick outcrops of Yakataga Formation (Miocene to Holocene) that contain multiple sequences of conglomeratic mudstone.

The moderately well-sorted sands of the nearshore zone characterize a dynamic environment. The internal wave action combined with storm waves and longshore currents resuspend or keep the fine particles in suspension, and the Alaskan Stream and Gyre transport them westward.

The high sand content in the entrance between Hinchinbrook and Montague Islands (10-50 percent) and between Hinchinbrook Island and the mainland to the east (more than 50 percent) suggests transport of sand from the Copper River system along shore and into Prince William Sound. Tidal action in the entrance probably winnows the fines from this sandy sediment. The concept of sediment transport into Prince William Sound is reinforced by high-resolution seismic profiles that show a wedge of Holocene sediment building into the sound and also by satellite imagery that shows plumes of suspended matter being transported into the sound (Reimnitz and Carlson, 1975; Sharma and others, 1974).

Silt and Clay

The highest concentrations of silt (as much as 80 percent) occur east of Kayak Island, especially seaward of the Malaspina and Bering Glaciers (sheet 2C). Much of the shelf in this area is blanketed by clayey silt (sheet 1), which can be attributed largely to the vast quantities of glacial flour supplied by the glaciers during the melt season. Figure 2 shows the cummulative size curves of this type of sediment.

West of Kayak Island, the highest concentrations of silt (60-72 percent) are found in Kayak and Egg Island Troughs and in Hinchinbrook Sea Valley.

Areas with low silt percentages are the bathymetric highs, Tarr Bank, Middleton and Kayak Island platforms, and Pamplona Ridge. Isolated places such as Yakutat Sea Valley and the nearshore zones of the entire region where sand or gravel content is high also contain bottom sediments low in silt.

The pattern of silt distribution around Kayak Island agrees with patterns of suspended sediment-laden water visible on satellite imagery. This agreement suggests that the nearshore currents, influenced by the Alaskan Gyre, play a significant role in the transport of glacial flour over the continental shelf in the northern Gulf of Alaska.

The highest concentrations of clay (30-50 percent) occur in Egg Island Trough, Kayak Trough, Hinchinbrook Sea Valley, and on much of the shelf between Kayak Island and Pamplona Ridge (sheet 2D), a distribution similar to that of silt (sheet 2C).

Low clay contents occur in the sediments east of Pamplona Ridge and are a result of the exceptionally high silt content. The lowest percentage of clay (less than 10 percent) is in the nearshore zone where the percentage of sand is very high. Other areas that are fairly low (10-20 percent) in clay-size sediments are located on Pamplona Ridge and around Middleton Island.

Clay-size sediments are not so prevalent on the northern Gulf of Alaska shelf as on shelves in other parts of the world (fig. 3). The primary reason for this deficiency is that the source sediment is largely glacial flour, which appears to be dominated by the silt fraction (fig. 3). In addition, the high wave energy in this dynamic environment may keep the clay in suspension and aid its transport off the shelf into the abyssal depths. In some bays, however, the energy is low enough to allow the clay-size fraction to settle out of suspension. For example, Wright (1972a) reported sediments from parts of Yakutat Bay with as much as 85 percent clay-size particles.

A uniform assemblage of clay minerals is present in the shelf sediments of the northern Gulf of Alaska. Chlorite and illite are dominant, averaging 51 percent and 37 percent, respectively, in 87 samples analyzed; kaolinite (10 percent) and montmorillonite (2 percent) round out the clay mineral suite (Molnia and Fuller, in press). Griffin, Windom, and Goldberg (1968) reported high illite (58 percent) and chlorite (36 percent) contents in the suspended load of the Copper River. They attributed the high chlorite concentrations found at high latitudes to the effects of low-intensity weathering processes and glacial transport.

Mean and sorting

Calculations of mean size (measure of central tendency) and sorting (standard deviation) of the sediment size curves were made using Folk and Wards (1957) formulas. Mean phi (ϕ) ranges from -2.8 for the lag gravel on the Middleton Island platform to 8.0 for the clayey silt in Egg Island Trough (sheet 2E). The degree of sorting ranges from moderately well sorted (less than 1) to very poorly sorted sediment (as high as 9) (sheet 2F).

Variations in mean grain size and sorting in general parallel the distribution of sediment types in that discrete areas of sand, gravel and muddy gravel, and silt are evident on both maps (sheet 2E and F). The concentrations of these end products are repeated by the percentage maps (sheet 2A-D). The most prevalent mean phi size, 6-8 ϕ (clayey silt), is most common east of Kayak Island where much of the shelf surface is composed of sediment in this mean size. West of Kayak Island, the 6-8 mean phi size is found throughout Egg Island and Kayak Troughs and in Hinchinbrook Sea Valley. These distributions emphasize the ubiquitious nature of this silty component of the sediments and the prevalence of glacial flour.

On Tarr Bank, Middleton Island platform and Pamplona Ridge two ranges of mean phi (less than 4 ϕ and 4-6 ϕ) prevail. These areas are dominated by gravel and gravelly mud. Across the entire Copper River prodelta, a 10-km-wide band of fine sand with a mean of less than 4 ϕ is bordered seaward by a narrower band of sandy silt with a mean of 4-6 ϕ. The same type of coarse to fine sequence exists around Kayak Island and in the nearshore zone between Yakataga and the Malaspina Glacier. Sediments of 4-6 mean phi size occur on the landward sides of some of the Copper River barrier islands. These fines have accumulated because the islands provide shelter from high-energy waves.

The degree of sediment sorting provides insight into sedimentation processes. The moderately well sorted sediments, primarily medium to fine sand (fig. 2 and sheet 2F) located along the nearshore zone throughout the entire study area, are evidence of the winnowing action of the bottom currents and of breaking waves in shallow water. Seaward of the moderately well sorted sediment, the sediment grades from poorly (1-2) to very poorly (more than 2) sorted (sheet 2F). Some poorly sorted sediments are deposited in the shadow zones behind the barrier islands. The bulk of the samples, which are clayey silts (predominantly glacial flour) that blanket much of the continental shelf, plot in the very poorly sorted category ranging from 2-3, and most are above 2.6. The most poorly sorted sediments (more than 3 with some as high as 7-9) are found on Tarr Bank, Pamplona Ridge, at the mouth of Yakutat Bay and at sporadic sample localities at the edge of the shelf (sheet 2F). Many of these extremely poorly sorted sediments (fig. 2) are till-like and others are gravelly or pebbly muds. Some of the poorly sorted muddy gravels are probably glacial moraine. Most of the gravelly muds, however, are probably a composite of glacial flour (clayey silt) and ice-rafted pebbles.

Carbon (carbonate and organic)

Of the 40 samples analyzed, the sandy samples contained the least carbon, as carbonate or organic carbon, ranging from 0.1 to 0.5 percent. The muddy samples contained somewhat greater quantities of both carbonate and organic carbon but were all low. The highest carbonate carbon measured was 2.14 percent from a gravelly mud collected on Tarr Bank, and the highest organic carbon content was 0.82 percent from a clayey silt sampled near the south end of Kayak Island. Ranges for the various sediment types analyzed are listed in Table 2.

Comparison plots of carbonate and organic carbon versus mean phi size (fig. 4) show considerable scatter, but if the individual sediment types are identified, a cluster of clayey silts marked by low carbon content is noticeable, especially on the carbonate carbon graph (fig. 4a). The sandy samples show a slight increase in both carbonate and organic carbon content with a decrease in mean particle size.

Engineering properties

Tests for Atterberg limits and vane shear strength were run on selected samples. The physical property tests were run about six months after sample collection, but the samples were well sealed, and we assume that they contained most of their original moisture. The moisture contents at time of analysis ranged from 24-90 percent of the dry weight of the sediment (table 3). In most of the clayey silt samples, the moisture content is greater than the liquid limit, suggesting highly sensitive soil. The plastic and liquid limits are both rather low, less than 30 and 50, respectively (table 3).

On a graph of the relation of plasticity index to liquid limit (fig. 5), all of the Gulf of Alaska samples plot along the A-line of Casagrande (1948), which represents an empirical boundary between typical inorganic clay (above A-line) and typical inorganic silt (below A-line). However, unlike many terrestrial soils (Casagrande, 1948), the

Alaskan shelf samples plot on both sides of the A-line. These samples are classified as clayey silts of low plasticity.

Laboratory vane shear tests were run on a few box core samples. The peak shear strengths were very low, ranging from 1 to 9 kilopascals (0.01-0.09 tons/ft^2). The gravelly muds were slightly stronger than the clayey silts (fig. 6), but in both types the peak shear strength decreased as moisture contents increased.

STRATIGRAPHY

The compex areal patterns of surface sediment on the continental shelf reflect multiple sediment sources and processes. Some of the sediment has been transported and reworked over the last several thousand years, and some is being introduced today.

On the basis of a study of high-resolution seismic profiles and bottom samples, a simplified stratigraphy of sedimentary units has been developed (Molnia and Carlson, 1975a; Carlson and Molnia, in press). The units and their characteristics are shown in table 4.

Table 2.--Carbonate carbon and organic carbon for selected samples from the northern Gulf of Alaska continental shelf.

Sediment type	No. of samples	Carbonate carbon (%) Range	Carbonate carbon (%) Ave.	Organic carbon (%) Range	Organic carbon (%) Ave.
Gravelly mud ----	11	0.26-2.14	0.91	0.33-0.71	0.59
Clayey silt -----	23	0.12-0.82	0.32	0.30-0.82	0.60
Silty sand ------	6	0.11-0.49	0.19	0.11-0.51	0.25

Table 3.--Atterberg limits for sediments on continental shelf in northern Gulf of Alaska

[Percents dry weight of sediment]

Sediment	No. of Samples	Plastic limit (%) Range	Plastic limit (%) Ave.	Liquid limit (%) Range	Liquid limit (%) Ave.	Natural water content (%) Range	Natural water content (%) Ave.	Plasticity index (%) Range	Plasticity index (%) Ave.
Clayey silt -----	22	17.0-29.3	23.8	23.9-50.8	39.3	24.1-90.2	52.8	6.1-23.5	15.6
Gravelly mud ----	6	17.0-29.7	23.9	22.7-47.8	36.3	30.9-54.4	41.6	5.7-18.1	12.4

Table 4.--Marine sedimentary units on the continental shelf of the northern Gulf of Alaska
[Modified from Carlson and Molnia, in press]

Unit	Seismic reflection characteristics	Description
Holocene sediments	Relatively horizontal and parallel reflectors except for disrupted reflectors where slumped.	Olive to gray underconsolidated clayey silt; moderately sorted medium to fine sand in nearshore zone; interlayered sand and mud units in transition zone.
Holocene end moraines	Discontinuous, irregular reflectors, very irregular surface morphology.	Olive to gray unsorted unstratified heterogeneous mixture of clay, silt, sand, and gravel.
Quaternary glacial-marine sediments	Very irregular confused, distorted reflectors	Olive to gray pebbly mud, sandy shelly mud, and sandy gravel.
Paleocene to Pleistocene sedimentary rocks	Well-developed reflectors indicating folded, faulted, and truncated lithified sedimentary strata.	Semi- to well-indurated pebbly and sandy mud, siltstone, and sandstone.

These stratigraphic units are all present at or near the seafloor on various parts of the shelf. The Holocene sediments form a blanket or wedge that thins seaward but covers much of the shelf. Positive relief features - Tarr Bank, the Middleton and Kayak Island platforms, Pamplona Ridge and parts of the outermost shelf - are not covered. These features are constructed primarily of Paleocene to Pleistocene sedimentary rocks and in many places are covered by a relatively thin layer (2-10 m) of Quaternary glacial-marine sediments. Small, thin (1-3 m) patches of Holocene sediment have been sampled at isolated spots on these features (Carlson and Molnia, 1975). Both the Miocene to Pleistocene and the Quaternary units (table 2) have many of the characteristics of the Yakataga Formation (Plafker and Addicott, 1976), and, indeed, both may be members of that unit. Regional tectonism has uplifted, folded, and faulted these units, and they have been partially eroded since the last glacial advance.

The Holocene sediments are those materials that have been deposited since the last major glacial advance. Included in the Holocene deposits, in addition to sand, silt and clay, now being deposited on the shelf, are morainal sediments seaward of the Bering Glacier, Icy Bay, and Yakutat Bay.

SEDIMENTATION PROCESSES

Agents of transport that carried the surficial sediments to their present sites included ice, both glaciers and icebergs; currents, including longshore, surface, and bottom; waves including storm, seismic, and internal; mass movement, both slumps and slides; streams and rivers; and wind.

Glacial deposits.--The muddy gravels found on bathymetric highs and at the edge of the shelf are relict, till-like deposits, similar to those mapped by Miller (1953) on Middleton Island. Similar muddy conglomerates occur onshore in the Yakataga Formation (Plafker and Addicott, 1976). This coarse debris offshore probably was deposited during the Pleistocene when lobes of the massive piedmont glaciers extended to the shelf edge. As these glaciers retreated to near the present-day shoreline, outwash or stratified drift was probably being deposited on the shelf. Subsequently, sea level rose to near its present position and icebergs calved from the tidal glaciers and floated in the shelf waters. Gravel and sand frozen into the icebergs was randomly dropped onto the glacial flour that was accumulating on the shelf. The resulting pebbly or gravelly mud (diamicton) makes up a significant part of the modern-day highs, Tarr Bank, Middleton Island platform and Pamplona Ridge. Uplift of these positive relief features and the winnowing action of waves and currents have kept the diamictons from being covered by the fine sediment that is being deposited elsewhere on the shelf.

Postglacial deposits.--The modern sediment being deposited on the continental shelf of the northern Gulf of Alaska is principally clayey silt. However, in the very nearshore areas moderately well-sorted sand and coarse silt are being deposited. The source of most of this sediment is principally the Copper River and secondarily the large glaciers that reach almost to the sea along much of the shoreline of the northern gulf. The sediment is carried to the ocean and then transported westward by the dominating Alaskan Gyre. Wind is a less important but significant transporter of fine sediment, especially the wind that during the fall and winter months, frequently howls down the Copper River gorge at speeds as great as 160 km/hr. (Reimnitz, 1966). This wind picks up significant amounts of fine sediment from the flood plain of the braided Copper River and carries it seaward across the shelf, as much as 40 - 50 km offshore (Carlson, Molnia and Reimnitz, 1976; Post, 1976). The silt, whether wind blown or current transported, settles through the water column and blankets the area. The wedge of sediment is thickest close to shore, reaching thicknesses of more than 300 m southeast of the Copper River and more than 200 m seaward of the Malaspina Glacier (Carlson and Molnia, 1975). This silt and clayey silt thins and pinches out over Tarr Bank and Pamplona Ridge and over scattered places near the shelf edge.

Rates of modern sediment accumulation based on ^{210}Pb analyses of samples from two of our box cores range from 17 mm/yr for mud on the inner shelf near the Copper River prodelta to 2 mm/yr for sediments on the outer shelf near Middleton Island (Charles Holmes, U.S. Geol. Survey, written commun., 1977). If we assume that the Holocene sediment seaward of the Copper River averages 150-200 m in thickness on the inner shelf and has been accumulating for about 10,000 years, the rate of accumulation would be 15-20 mm/yr, equivalent to that obtained with the ^{210}Pb technique.

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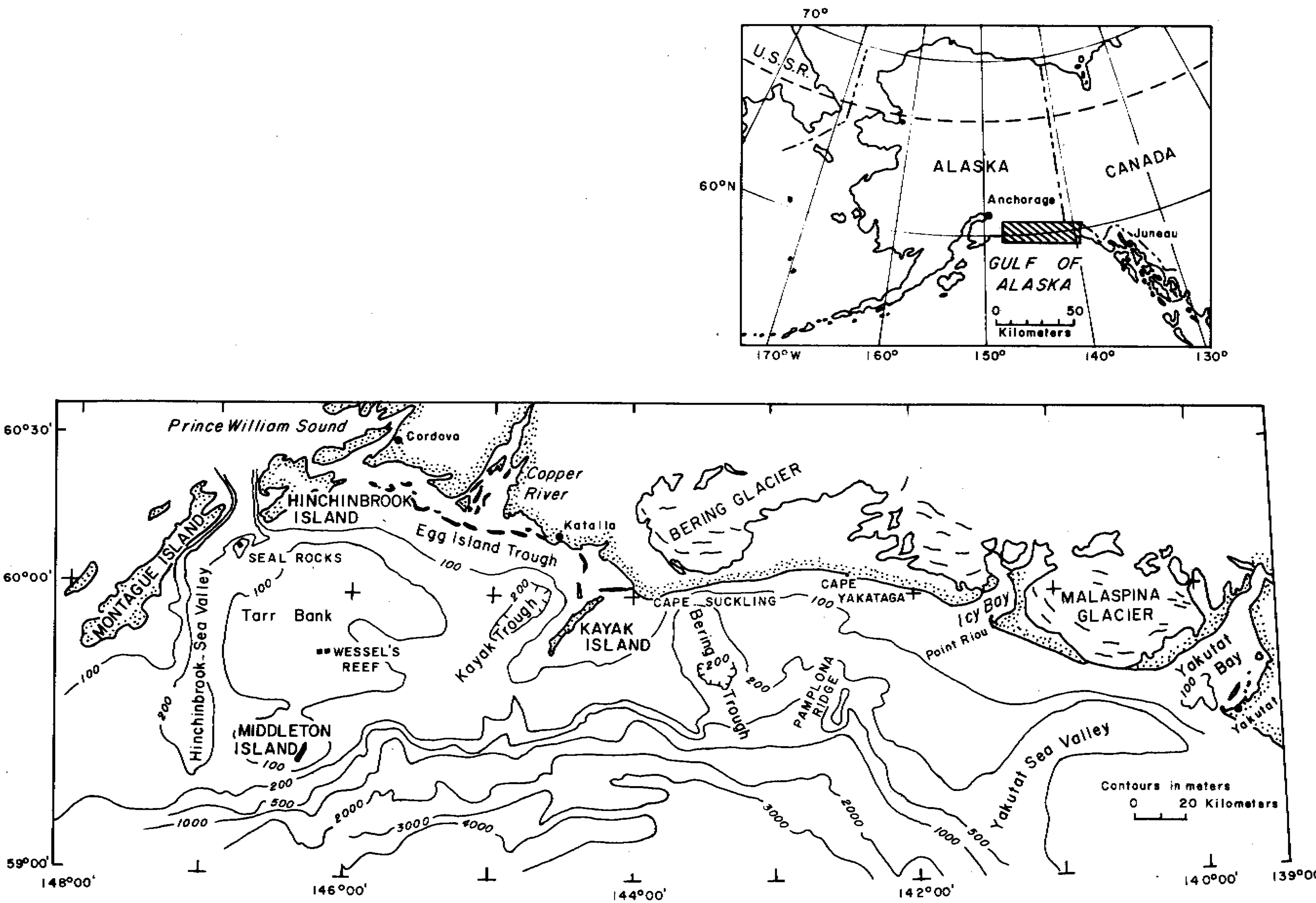

Figure 1. Location map of study area, modified from Molnia and Carlson (1975).

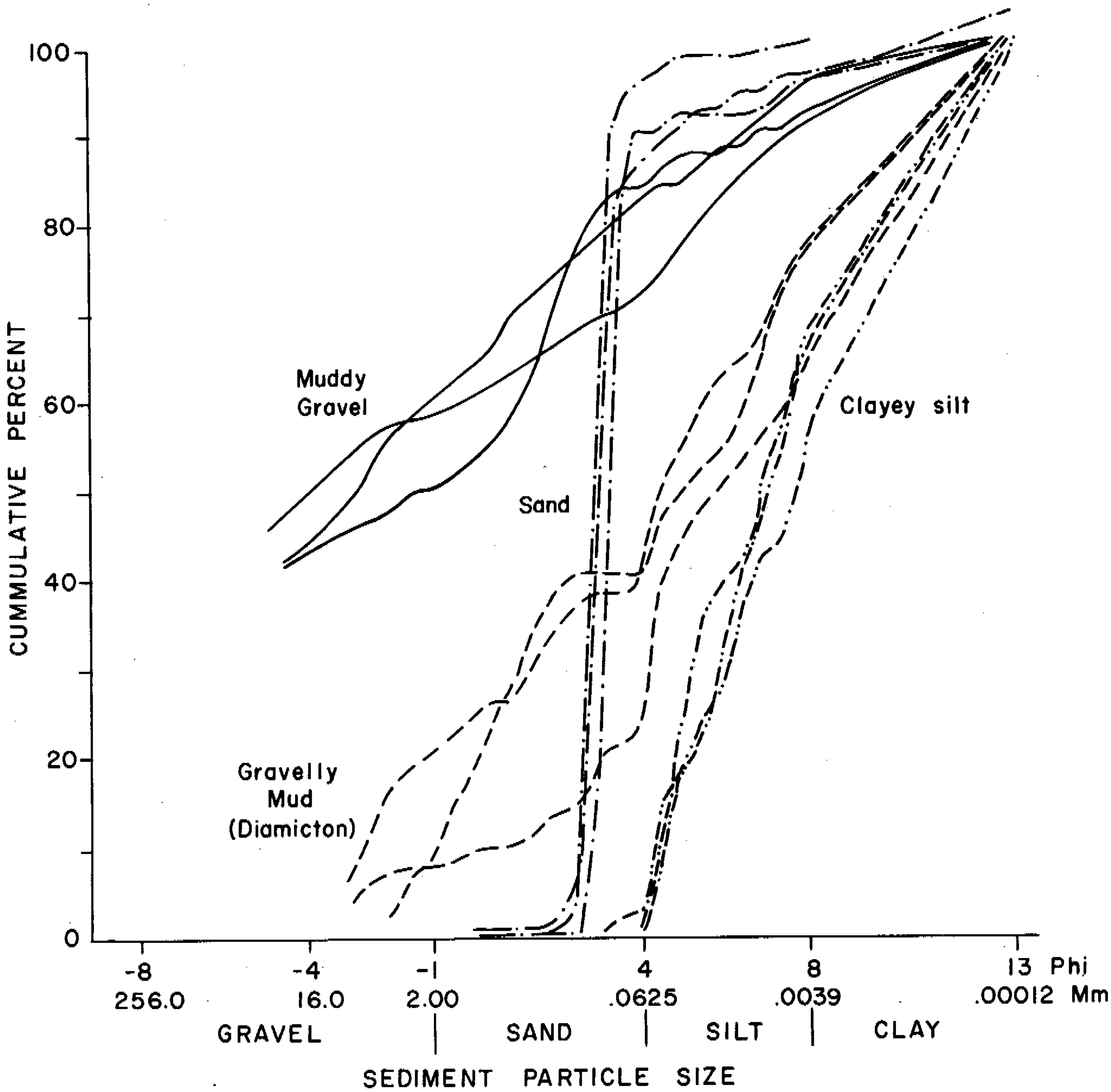

Figure 2. Cumulative curves of the dominant sediment types.

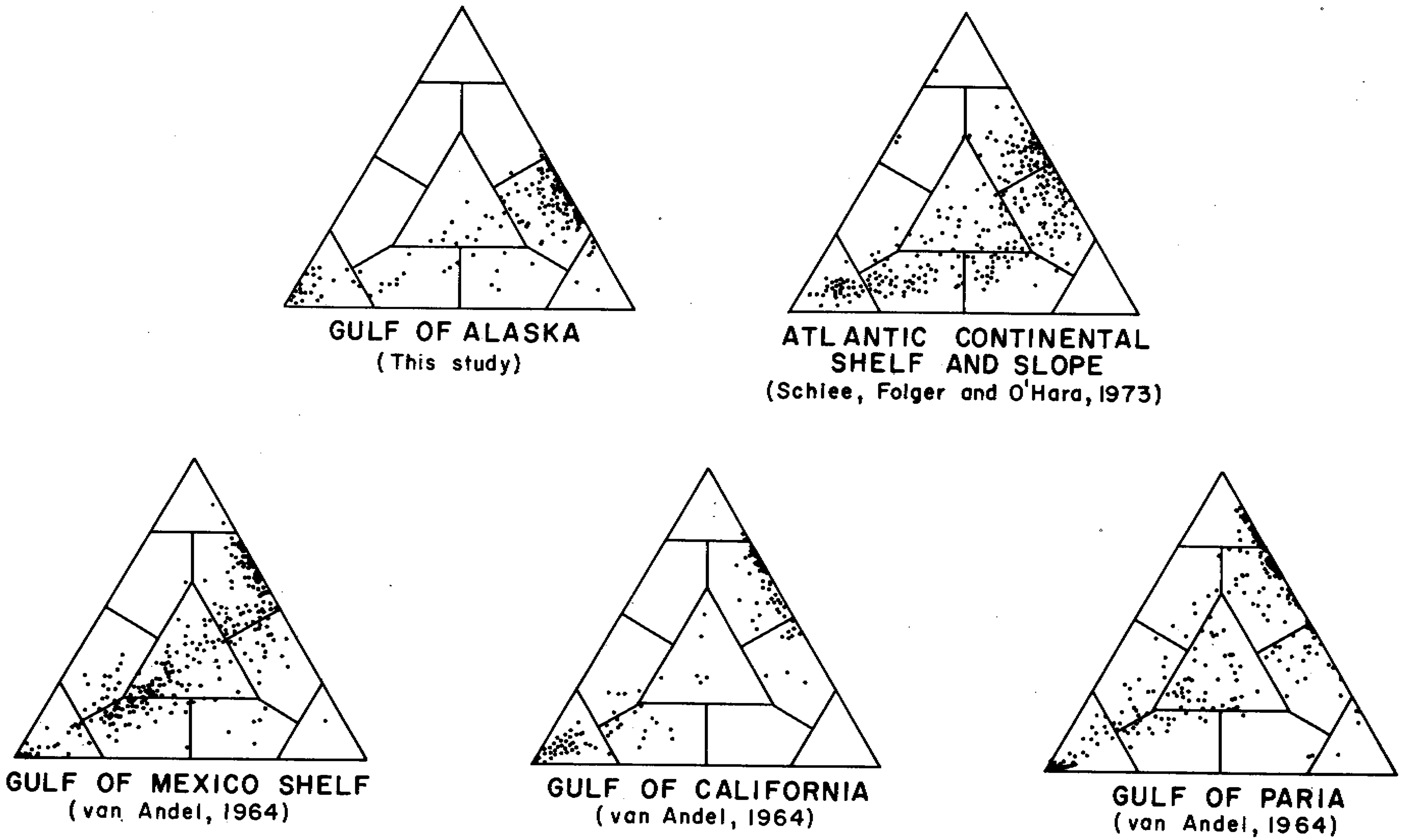

Figure 3. Ternary textural diagrams of sediment from the Gulf of Alaska, Gulf of California, Gulf of Paria, Gulf of Mexico and the U.S. Atlantic continental shelf and slope.

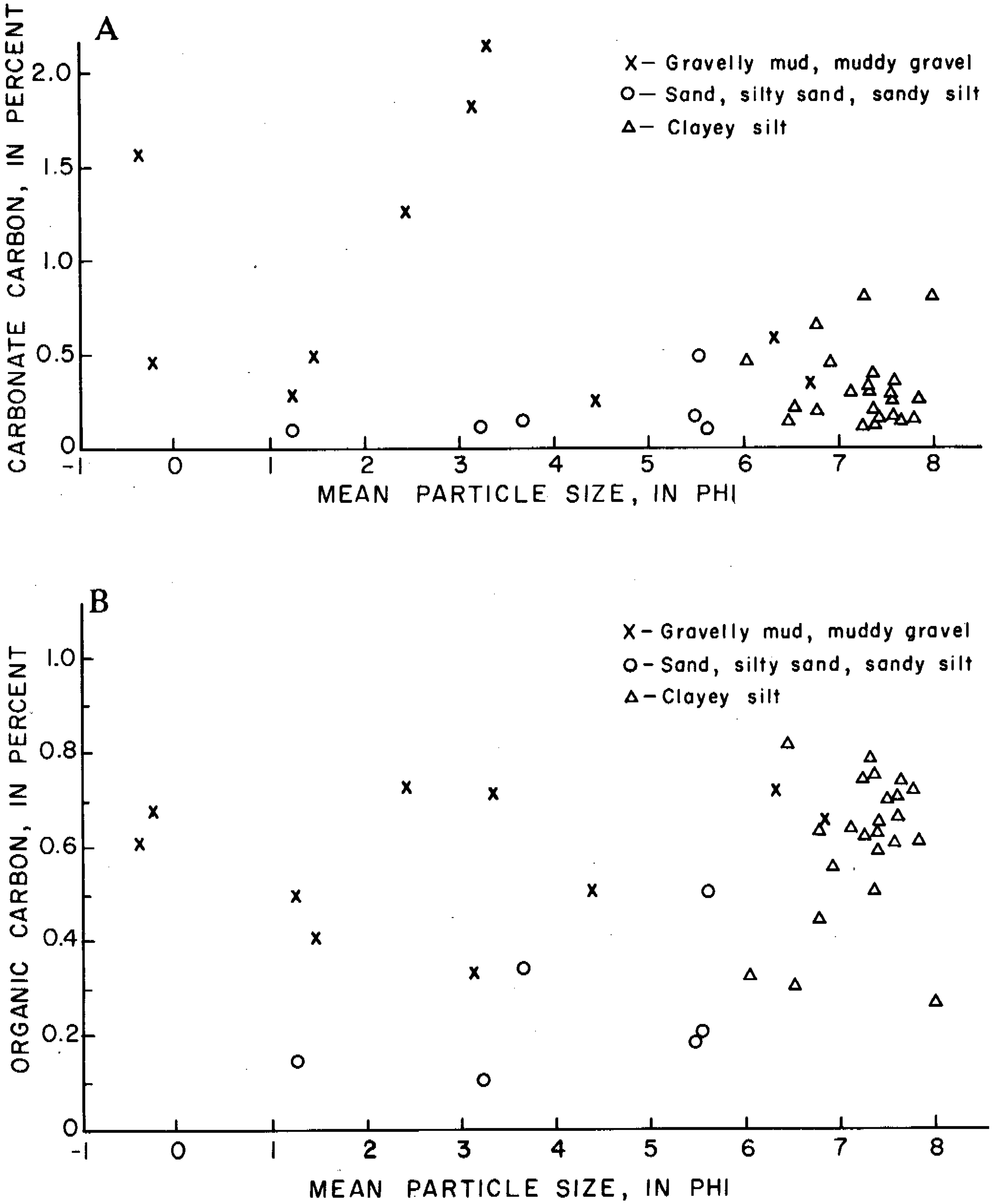

Figure 4. Mean phi sediment size compared to percent A) carbonate carbon and B) organic carbon.

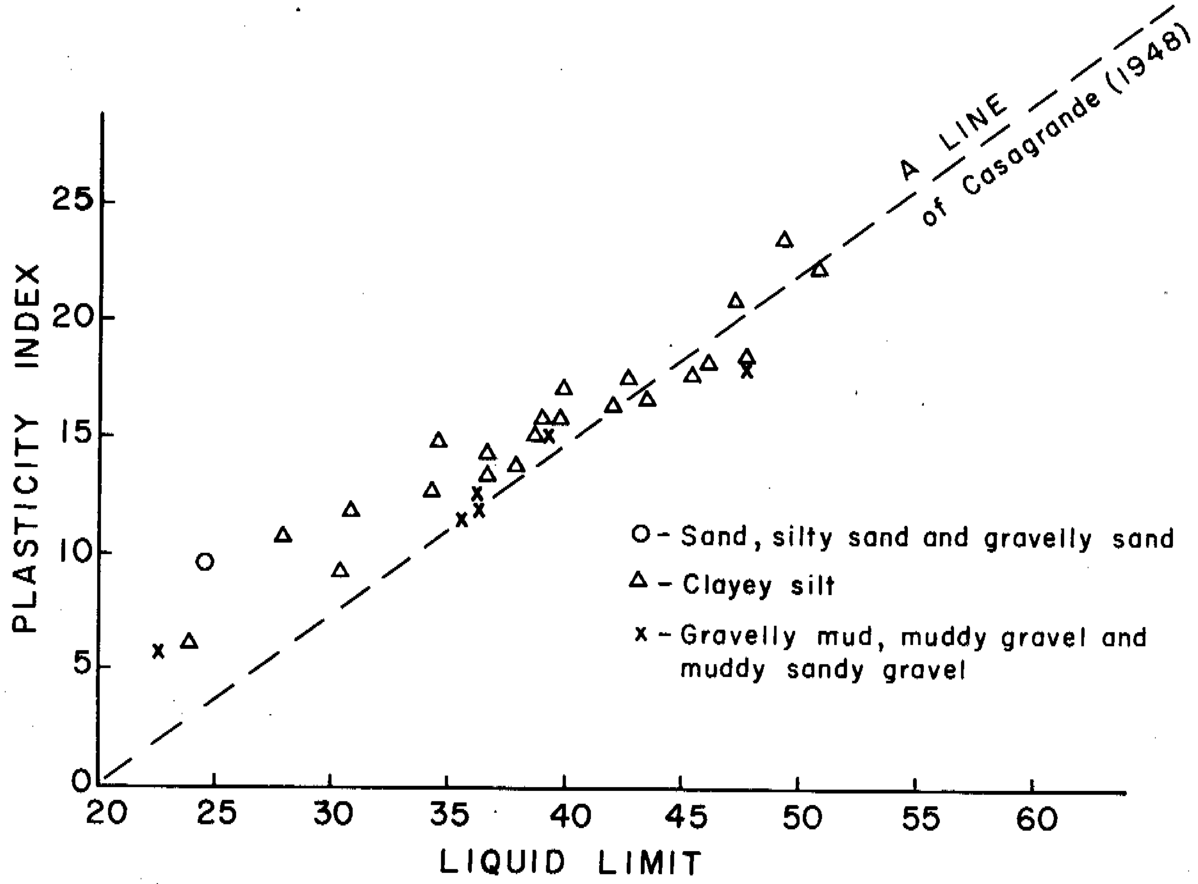

Figure 5. Plasticity index plotted against Liquid limit of surface samples from continental shelf.

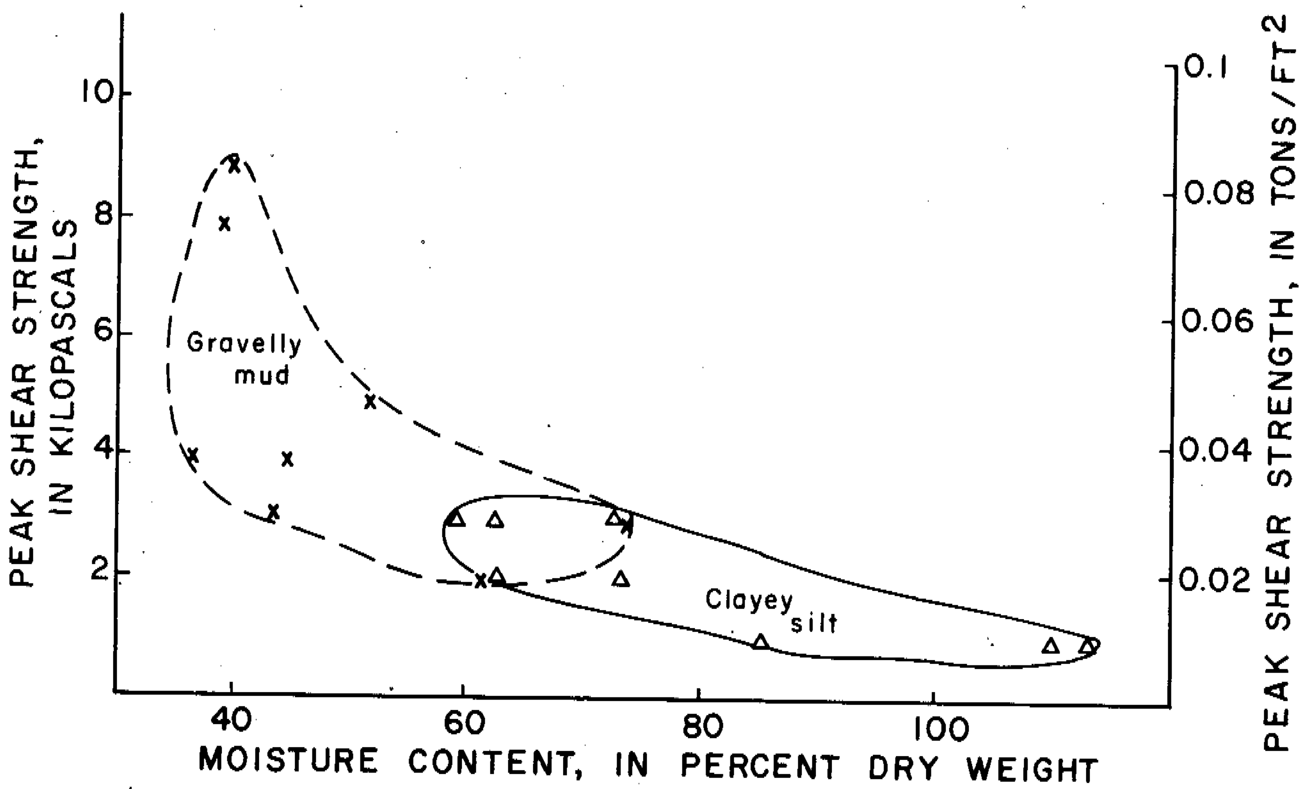

Figure 6. Peak shear strength (laboratory vane shear) versus moisture content of northern Gulf of Alaska shelf sediment.

Quarterly Report

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Research Unit #251
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Reporting Period: 9/30/77 - 12/31/77
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SEISMIC AND VOLCANIC RISK STUDIES WESTERN GULF OF ALASKA

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OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1977

Project Title: Seismic and Volcanic Risk Studies--Western Gulf of Alaska

Contract Number: 03-5-022-55

Task Order Number: C1

Principal Investigators: H. Pulpan, J. Kienle

I. Abstract

The seismic system operated under this contract is continuing to work well. Hypocenter data from the three month period from July through September 1977 indicate a number of clusters of seismic activity not previously observed.

II. Task Objectives

It is the purpose of this research to determine the seismicity of the lower Cook Inlet, Kodiak, and Alaska Peninsula and to evaluate the seismic risk to onshore and offshore development and also to evaluate eruption or potential volcanic risk of Redoubt and Augustine Volcanoes in Cook Inlet.

III. Field Activities

There was no field activity except for two servicing trips to the central recording site of Homer. The seismic station at Homer was put back into operation after equipment from this station, borrowed for spares during the summer servicing, was returned. The seismic network was performing well. Two of the 27 station system are presently inoperative. The reason for these outages are presently not known. Table 1 and 7 give a listing of the seismic stations and the percent of downtime for these stations during the report period, respectively.

IV. Results and Preliminary Interpretation

Appendix 1 and 2 give the listing of hypocenters and plots of epicenters, respectively, for the time period from July 1 through September 31, 1977. Listings and plots are given in two groups: One includes all events that could be located while the second group lists only the best located events termed class 1 events (see appendix for the criteria for class 1 events).

Activity in the Kodiak-Alaska Peninsula area appears to be much higher than in previous three month periods, but is a reflection of the good performance of the network during this time span. The lower Cook Inlet activity shows the usual cluster of mostly intermediate depth events near Mt. Iliamna. This activity is associated with the Benioff Zone there. The cluster of shallow events near Mt. Douglas, is somewhat to the south of a previously observed cluster that started to be active in early 1976. The new cluster started in July 1977 and was rather intense through September. The largest magnitude of these events was 2.5.

A new cluster of shallow seismicity is appearing near Mt. Mageik, a volcano, with a maximum magnitude event of 2.9. Because of the lower reliability of the Kodiak Peninsula area portion of the network previously, it is not possible to tell whether this cluster did, indeed, start in July 1977.

A cluster of events also occured near the station at Deadman Bay on Kodiak Island. The largest event was one of magnitude 3.7.

A series of events occured off the south coast of Kodiak, in an area that was highly active during the 1964 earthquake after shock activity and has since produced a number of above magnitude 5 shocks. The largest event during the 3 month period was a magnitude 4.8 event.

Finally, a cluster of shallow magnitude 1.5-2.5 events is apparent on the Alaska Peninsula where the Ukinrek Maars were formed in April 1977.

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 1

Percent Downtime of Seismic Stations

Station	October 1 - December 31, 1977
AUF	0
AUK	0
AUM	0
AUP	100[1]
BMT	0
CDA	0
CHI	0
CHO	0
DMB	100[1]
FLP	0
HOM	10[2]
MAA	0
MCN	0
OPT	0
PNM	0
PUB	0
RAI	0
RED	0
SHU	0
SII	0
SKS	0
SPL	0
UKL	0
YCB	0

1. Signal lost late August, 1977.
2. Sensor removed for use as spare during service period. Was reinstalled during October.

Table 2

Percent downtime of seismic stations - October 1 - December 31, 1977

APPENDIX 1

HYPOCENTER LISTINGS FOR COOK INLET, KODIAK, AND ALASKA PENINSULA

July through September, 1977

Table A1-1	Class 1 events
Table A1-2	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 N).

(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 A1-1	Cook Inlet, western Gulf of Alaska Class 1 events
Table A1-2	Cook Inlet, western Gulf of Alaska All events

Class 1 events have the following quality parameters:

RMS	≤	1 sec
ERZ	≤	10 km
ERH	≤	10 km
NP	≥	5

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	DAY	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUL	1	0	27	54.7	59	51.5	152	34.3	86.6	2.9	10	189	43	0.35	6.6	6.2	D
	1	13	58	42.2	60	8.7	153	56.4	5.0	1.9	3	238	71	0.08	0.	0.	C
	1	22	12	42.1	57	49.0	154	32.5	5.0	2.3	3	148	86	0.	0.	0.	C
	3	11	25	40.9	60	0.8	154	36.6	5.0	2.0	3	287	87	0.03	0.	0.	C
	3	11	54	50.8	58	14.2	156	14.0	37.1	2.8	9	252	152	0.85	22.4	9999.9	D
	3	13	0	40.4	59	37.1	152	45.0	89.0	2.0	4	231	27	0.	0.	0.	C
	3	16	32	14.0	60	8.9	152	4.8	86.2	2.7	13	131	48	0.40	7.0	9.2	C
	3	17	28	31.9	58	53.8	154	31.3	125.6	2.3	7	162	29	0.37	6.7	10.5	D
	4	3	38	41.3	58	54.8	150	36.9	5.0	2.8	6	256	167	0.52	16.8	898.9	D
	4	7	56	8.8	60	6.8	152	2.7	43.6	2.5	5	235	52	0.58	35.8	143.4	D
	4	17	15	33.3	59	49.8	153	5.4	149.6	2.8	9	156	21	0.20	4.6	4.9	C
	4	21	3	36.7	60	4.6	152	56.2	114.8	3.9	28	87	39	0.67	3.3	4.4	C
	5	11	19	30.0	59	27.5	150	39.6	35.0	2.8	9	257	146	0.62	15.6	835.7	D
	5	13	33	47.5	59	33.1	152	42.4	99.0	2.7	10	179	31	0.30	5.1	4.9	D
	5	14	4	57.6	60	10.2	152	27.8	105.3	2.7	7	212	32	0.25	10.1	10.6	D
	5	14	26	10.0	59	14.9	152	25.4	92.5	2.4	8	190	54	0.35	7.7	10.2	D
	5	16	44	13.4	56	51.0	154	47.1	5.0	2.2	3	238	49	0.02	0.	0.	C
	6	3	17	22.8	60	5.8	155	13.7	5.0	2.0	3	305	122	0.09	0.	0.	C
	6	3	59	33.9	59	45.4	155	9.0	5.0	2.2	4	277	90	0.53	0.	0.	D
	6	7	59	56.7	60	15.9	153	41.8	3.5	2.0	4	239	53	0.60	0.	0.	D
	6	15	14	35.8	60	1.2	154	0.5	5.0	1.5	3	231	59	0.01	0.	0.	C
	7	1	24	10.5	60	5.6	155	38.9	5.0	1.9	3	313	144	0.15	0.	0.	C
	7	11	38	54.4	57	36.6	155	51.8	0.3	2.8	4	167	46	1.04	0.	0.	D
	7	17	16	39.3	60	21.2	151	46.6	81.8	2.5	6	162	55	0.21	8.1	10.7	D
	7	17	39	37.1	57	21.9	151	49.2	41.2	2.8	5	247	58	0.20	12.2	3.5	D
	8	5	56	53.1	60	38.5	153	49.8	5.0	2.4	3	286	63	0.02	0.	0.	C
	8	7	45	9.4	60	27.0	153	25.7	5.0	2.3	3	276	36	0.47	0.	0.	D
	8	8	33	12.3	59	39.9	153	18.7	141.3	3.6	15	161	4	0.40	7.4	5.2	D
	8	8	38	10.3	59	58.4	153	35.5	122.7	2.2	4	203	41	0.	0.	0.	C
	8	9	41	34.2	60	1.0	153	7.0	153.9	3.1	14	172	41	0.27	5.5	3.9	D
	8	13	49	32.8	56	53.3	155	11.6	0.4	2.0	5	203	60	0.53	9.9	44.0	D
	8	15	16	27.8	58	8.7	154	30.3	86.7	2.4	9	105	79	0.20	1.9	5.7	C
	8	17	11	51.4	57	52.3	156	35.3	9.3	1.1	4	201	6	0.	0.	0.	C
	8	19	2	3.9	59	39.1	152	50.5	101.0	2.2	6	172	21	0.17	6.0	6.6	D
	8	19	59	40.4	61	6.3	150	42.2	69.1	4.5	13	90	63	0.49	3.8	8.4	B
	8	20	57	35.1	59	56.8	152	31.1	106.7	3.2	7	205	51	0.26	11.2	9.4	D
	8	23	39	27.7	60	25.7	154	27.6	5.0	2.3	3	296	93	0.05	0.	0.	C
	9	6	13	40.3	58	2.4	151	42.4	28.9	2.9	8	245	56	0.70	17.5	7.7	D
	9	9	41	10.8	56	56.8	153	9.3	32.7	2.6	6	212	51	0.19	3.7	3.0	D
	9	10	11	25.6	56	55.8	154	2.8	29.2	1.2	4	175	18	0.	0.	0.	C
	9	10	43	30.2	58	25.5	153	52.2	9.0	1.9	4	330	77	0.24	0.	0.	C
	9	13	9	55.2	61	9.3	152	35.2	0.6	3.1	7	277	82	0.75	37.3	42.2	D
	9	14	12	1.8	59	32.8	153	38.9	126.7	2.4	7	174	25	0.08	3.1	2.2	C
	9	22	31	30.3	59	28.9	155	45.8	5.0	1.9	3	321	133	0.12	0.	0.	C
	9	23	36	9.9	59	33.9	151	39.0	5.0	1.9	5	241	89	0.31	9.8	702.3	D

Table 1-1

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUL 10	0	58	3.4	62	5.1	149	10.3	28.5	3.1	9	113	53	0.31	3.6	4.5	C
10	3	43	41.9	58	54.2	151	39.4	36.4	4.1	21	161	108	0.60	3.1	668.2	D
10	6	37	6.9	59	49.9	153	15.4	36.5	3.4	9	166	197	0.61	8.1	816.2	D
10	8	27	10.9	59	28.7	151	57.2	58.2	2.6	8	213	74	0.13	2.0	4.8	C
10	9	27	26.7	57	30.3	155	48.9	5.0	2.6	4	220	67	0.40	0.	0.	D
10	10	35	4.9	57	50.1	155	11.6	5.0	2.2	3	149	65	0.	0.	0.	C
10	21	51	16.6	56	36.8	155	16.9	5.0	2.0	4	243	67	0.29	0.	0.	C
11	4	51	13.9	58	50.1	150	58.3	29.0	3.2	8	247	148	0.72	19.1	9999.9	D
11	10	31	44.9	60	28.0	154	9.0	5.0	1.8	3	292	76	0.32	0.	0.	D
11	11	19	21.2	59	55.7	152	54.2	128.2	3.3	13	149	35	0.37	7.6	5.4	D
11	13	34	10.1	60	1.7	152	42.2	126.8	3.1	11	132	43	0.34	5.8	4.8	C
11	12	28	59.7	55	55.4	155	32.1	22.5	2.1	4	152	9	0.29	0.	0.	C
11	12	37	58.0	58	1.5	150	1.3	1.1	2.5	4	289	149	0.06	0.	0.	C
11	15	29	28.6	56	13.4	154	32.7	5.0	0.	3	301	43	0.	0.	0.	C
11	18	47	19.8	58	10.0	154	10.2	74.4	2.3	7	185	60	0.13	2.5	4.9	D
11	23	9	1.4	59	25.5	154	16.2	5.0	1.5	3	253	36	0.01	0.	0.	C
12	1	39	3.0	59	56.8	153	26.7	155.5	2.4	4	191	34	0.01	0.	0.	C
12	1	44	53.8	59	33.2	152	31.5	81.4	2.5	4	250	41	0.	0.	0.	C
12	6	19	47.8	58	9.1	153	40.9	5.0	2.2	3	256	32	0.23	0.	0.	C
12	6	40	40.3	58	7.4	153	34.5	5.0	2.1	3	250	25	0.06	0.	0.	C
12	17	19	47.1	59	15.4	153	40.8	30.3	2.9	10	158	136	0.74	7.8	952.7	D
13	8	19	33.4	59	59.0	153	11.2	57.8	2.1	4	175	36	0.	0.	0.	C
13	9	42	18.2	60	18.5	153	51.1	5.0	2.6	4	250	60	0.52	0.	0.	D
13	12	41	20.6	60	8.3	153	55.8	5.0	2.2	4	236	66	0.58	0.	0.	D
13	14	28	52.3	57	43.7	154	44.1	57.6	2.6	4	138	44	0.	0.	0.	C
13	23	7	48.1	59	36.1	152	59.4	99.6	2.1	4	212	14	0.02	0.	0.	C
13	23	15	19.0	57	18.8	153	20.8	36.2	2.5	4	225	70	0.	0.	0.	C
14	10	47	9.9	55	9.2	155	29.5	30.3	4.3	11	254	76	0.32	7.5	3.4	D
14	13	59	33.4	59	55.0	152	20.7	62.1	2.6	6	171	60	0.33	11.2	17.1	D
14	11	20	3.2	54	37.2	155	41.4	39.6	2.8	6	324	236	0.23	78.3	393.9	D
14	11	45	2.9	54	49.3	155	37.9	43.9	4.3	5	322	272	0.28	107.4	626.8	D
14	13	59	48.7	58	48.0	153	54.4	5.0	2.5	4	273	93	0.70	0.	0.	D
14	18	53	28.2	57	26.0	153	34.9	131.1	2.8	4	268	44	0.01	0.	0.	C
15	2	6	14.9	61	37.8	150	51.5	59.4	3.5	29	70	52	0.98	4.2	9.4	C
15	3	34	3.7	57	50.4	156	31.7	133.2	2.1	6	268	3	0.70	69.7	106.6	D
15	8	20	45.4	58	28.0	155	39.8	1.6	3.1	5	250	153	0.91	2.1	4.9	D
15	13	27	7.9	56	57.9	153	39.7	37.1	2.4	6	158	22	0.09	1.3	0.9	C
16	9	9	48.3	56	50.2	153	33.2	48.5	1.9	4	193	37	0.	0.	0.	C
16	14	42	34.6	57	24.1	156	14.8	114.2	0.	11	103	36	0.27	4.2	8.6	C
16	22	0	56.4	59	55.4	152	38.2	90.4	3.9	20	79	55	0.85	4.7	10.4	C
17	19	34	16.3	57	41.7	155	47.7	5.0	1.8	5	199	50	0.36	34.9	86.2	D
18	2	32	10.8	58	5.6	154	51.2	5.0	2.2	5	185	74	0.92	17.6	9999.9	D
18	16	32	13.1	57	12.9	155	53.2	5.0	0.	3	264	66	0.17	0.	0.	C
18	20	17	19.6	59	54.2	152	57.6	122.8	4.0	19	89	58	0.33	2.0	2.7	B
19	2	42	11.7	60	59.2	152	23.9	133.0	3.9	26	64	66	0.57	2.6	5.1	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUL	19	9	43	51.1	57	7.6	153	55.7	35.3	1.7	4	140	4	0.	0.	0.	C
	19	11	41	46.4	58	39.5	153	39.9	89.4	2.7	12	93	58	0.47	3.6	8.2	C
	19	14	26	7.9	57	13.6	153	48.3	5.0	1.2	3	176	18	0.	0.	0.	C
	19	16	31	46.1	56	19.5	153	58.0	32.5	2.6	5	293	29	0.09	6.7	1.2	D
	19	17	16	36.5	59	34.2	153	26.8	110.9	1.7	9	123	26	0.29	3.6	5.7	C
	19	17	23	37.4	57	0.5	144	55.5	5.0	3.9	7	322	462	0.93	137.9	707.0	D
	19	18	39	15.9	56	34.4	154	35.2	0.4	2.3	4	234	24	0.55	0.	0.	D
	19	23	17	4.3	58	31.2	151	12.8	5.0	2.9	7	233	108	0.76	15.9	28.3	D
	20	2	18	23.5	58	59.7	151	3.2	52.6	3.0	7	240	61	0.50	13.3	21.7	D
	20	3	47	5.7	57	26.3	154	23.7	5.0	1.8	3	172	47	0.04	0.	0.	C
	20	10	33	22.6	58	26.2	154	36.0	5.0	1.8	3	229	89	0.	0.	0.	C
	20	10	39	30.7	57	21.4	155	0.8	5.0	2.4	4	212	55	0.52	0.	0.	D
	20	12	5	55.0	57	43.4	155	22.5	34.2	2.2	4	304	95	0.01	0.	0.	C
	20	13	24	26.8	54	19.0	161	16.7	33.6	5.4	9	188	191	0.64	7.8	706.3	D
	20	13	40	8.8	56	38.3	154	31.0	38.8	2.4	4	267	22	0.	0.	0.	C
	20	15	52	43.9	57	43.8	152	32.3	5.0	1.4	3	252	52	0.01	0.	0.	C
	20	18	5	54.0	60	4.4	152	27.0	103.6	4.4	22	72	42	0.74	4.2	6.3	C
	20	21	27	48.7	53	55.0	156	35.5	26.4	3.4	4	337	390	0.66	0.	0.	D
	21	2	19	58.6	55	52.8	157	44.8	32.3	3.6	19	234	103	0.34	4.6	3.1	D
	21	5	4	17.8	61	6.4	152	20.3	153.5	3.1	13	167	80	0.49	5.6	6.8	D
	21	5	30	26.7	60	13.5	152	27.8	115.6	2.8	10	188	27	0.32	8.0	9.9	D
	21	5	52	11.4	59	34.3	152	57.4	103.1	1.7	5	133	37	0.	0.1	0.1	C
	21	6	40	29.6	60	59.2	150	48.9	1.3	3.3	11	138	124	0.68	5.2	23.0	D
	21	11	31	40.3	57	4.7	154	54.4	2.5	2.7	4	246	57	0.23	0.	0.	C
	21	18	7	40.3	59	54.4	153	22.6	162.0	3.6	27	76	63	0.97	5.1	7.4	C
	21	21	43	12.9	57	49.0	155	59.0	5.0	2.9	3	311	131	0.45	0.	0.	D
	21	22	30	28.4	57	24.5	153	32.5	156.5	3.5	4	154	39	0.56	0.	0.	D
	22	5	57	1.8	61	7.7	150	11.1	21.9	4.0	22	128	97	0.89	5.2	5.4	D
	22	6	52	20.0	59	46.5	153	0.1	138.8	2.8	8	147	18	0.69	15.1	19.6	D
	22	8	3	21.8	57	59.2	156	38.3	0.0	1.3	4	238	16	0.03	0.	0.	C
	22	8	17	21.3	58	4.5	157	0.9	4.6	1.9	5	282	39	0.02	1.1	0.4	C
	22	9	48	4.5	59	30.8	152	20.1	5.0	2.0	3	191	43	0.	0.	0.	C
	22	18	24	45.6	59	51.2	152	49.8	122.3	2.8	6	138	31	0.82	21.6	27.4	D
	23	1	3	23.7	59	15.8	153	32.9	118.9	3.1	12	100	10	0.78	8.4	13.0	C
	23	2	1	57.3	60	4.1	151	19.1	5.0	1.9	3	257	68	0.04	0.	0.	C
	23	2	23	1.2	59	49.3	153	12.1	115.7	2.7	7	187	18	0.29	7.5	9.5	D
	23	4	27	42.8	59	24.5	154	37.6	374.0	2.8	4	306	68	0.40	0.	0.	D
	23	7	41	41.4	60	3.9	154	48.4	5.0	1.7	3	294	99	0.10	0.	0.	C
	23	11	17	7.5	59	42.7	152	26.0	78.5	2.8	14	85	45	0.50	3.6	4.8	B
	23	11	54	20.1	58	1.7	155	7.9	0.1	2.0	5	235	36	0.71	53.3	179.5	D
	23	14	39	31.0	59	45.9	152	9.9	5.0	2.1	3	160	46	0.	0.	0.	C
	23	14	58	14.0	60	0.9	152	0.4	5.0	1.8	3	202	61	0.01	0.	0.	C
	24	4	2	0.6	59	45.1	155	10.1	5.0	2.1	3	306	109	0.	0.	0.	C
	24	5	21	32.2	60	25.6	155	13.9	5.0	2.3	3	310	135	0.04	0.	0.	C
	24	14	50	15.9	59	44.7	152	4.4	5.0	2.1	5	165	41	0.83	42.3	97.1	D

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUL	24	15	36	22.9	59	44.3	152	18.1	78.6	2.3	4	145	50	0.	0.	0.	C
	24	19	56	43.3	59	28.0	152	6.3	62.7	1.9	4	170	29	0.01	0.	0.	C
	24	21	48	18.7	59	41.0	151	48.6	40.8	1.9	4	184	26	0.03	0.	0.	C
	24	22	11	36.8	56	42.3	155	2.6	7.8	2.0	4	226	55	0.25	0.	0.	C
	25	1	55	6.5	59	47.6	155	2.9	5.0	2.4	3	302	103	0.	0.	0.	C
	25	1	56	33.8	60	10.7	152	42.7	108.6	2.5	4	148	27	0.	0.	0.	C
	25	7	13	7.7	56	52.0	154	53.3	5.0	1.8	4	248	54	0.53	0.	0.	D
	25	8	28	6.0	58	40.8	153	43.4	0.6	1.8	8	140	54	0.27	2.6	14.8	D
	25	13	12	33.2	59	34.5	153	13.3	121.9	2.5	12	130	8	0.46	7.3	7.6	C
	25	16	8	42.5	57	39.7	156	8.7	54.8	1.8	4	320	97	0.	0.	0.	C
	25	19	23	7.5	59	49.1	152	10.5	5.0	1.7	3	165	51	0.	0.	0.	C
	25	20	22	2.9	59	39.1	152	3.8	5.0	1.5	3	151	33	0.01	0.	0.	C
	26	3	37	2.8	60	1.0	152	26.0	5.0	1.2	3	164	48	0.	0.	0.	C
	26	4	0	32.6	59	53.5	152	43.8	102.0	2.2	6	131	38	0.22	5.6	7.7	C
	26	7	1	6.3	58	45.6	153	57.3	8.8	2.1	7	140	40	0.55	5.8	843.5	D
	26	13	3	9.1	59	49.2	152	13.3	5.0	1.9	3	162	53	0.	0.	0.	C
	26	18	39	21.5	62	34.4	148	48.5	19.9	4.6	20	53	88	0.75	3.5	4.8	D
	27	7	7	54.6	57	38.7	155	41.9	36.6	2.9	4	176	52	0.	0.	0.	C
	27	7	0	49.4	58	8.5	155	30.8	1.3	2.8	5	263	131	0.90	36.9	101.7	D
	27	7	27	3.2	58	27.8	151	53.0	5.0	2.9	3	217	87	0.	0.	0.	C
	27	17	43	48.9	60	18.6	152	18.3	91.4	2.9	9	156	28	0.24	4.7	5.0	C
	28	0	56	59.2	59	22.5	152	46.0	67.9	2.2	4	263	33	0.	0.	0.	C
	28	1	15	47.2	62	20.8	151	32.1	13.3	3.1	14	74	177	0.96	6.4	13.3	D
	28	1	49	20.5	56	55.5	153	46.6	5.0	2.0	3	154	21	0.	0.	0.	C
	28	13	56	44.5	59	15.7	152	4.2	5.0	2.1	3	296	74	0.29	0.	0.	C
	28	18	5	21.1	60	26.8	151	19.7	29.1	2.5	8	178	79	0.81	18.4	15.3	D
	29	2	15	0.5	57	5.4	154	20.5	5.0	1.8	3	236	23	0.01	0.	0.	C
	29	2	23	36.6	59	42.5	153	12.2	97.7	2.2	6	180	6	0.06	7.1	2.3	D
	29	2	53	58.8	59	49.9	153	3.0	114.3	2.6	10	167	22	0.28	5.0	5.3	D
	29	5	17	21.7	54	56.5	159	33.0	26.9	3.7	6	340	401	0.63	437.1	898.9	D
	29	11	36	48.7	58	40.0	153	42.3	2.5	1.9	6	140	74	0.14	1.9	236.3	D
	29	16	10	15.8	57	5.9	153	56.7	27.7	2.0	5	112	1	0.03	0.5	0.8	C
	29	16	32	33.7	59	43.7	152	15.9	92.2	2.6	8	210	55	0.62	18.9	20.5	D
	29	17	49	58.3	59	23.6	152	39.9	80.0	2.5	11	189	39	0.33	6.8	6.2	D
	29	19	18	10.5	57	8.9	152	20.5	31.9	2.5	6	265	44	0.08	3.7	1.2	D
	29	20	19	5.9	56	37.0	153	17.7	7.5	1.7	4	251	54	0.45	0.	0.	D
	30	2	53	36.7	58	54.4	152	9.1	63.9	2.4	4	292	86	0.02	0.	0.	C
	30	9	31	53.0	55	41.0	157	33.5	2.3	2.5	5	245	65	0.85	30.4	65.3	D
	30	10	23	9.0	58	15.4	152	34.4	38.4	2.3	6	158	40	0.29	5.2	3.7	D
	30	11	9	57.7	56	26.9	156	13.4	78.0	2.4	5	129	78	0.21	4.7	15.8	D
	30	15	7	3.8	59	47.5	151	17.9	5.0	2.3	4	297	107	0.11	0.	0.	C
	30	18	8	48.7	59	35.5	153	54.1	5.0	1.9	3	257	39	0.02	0.	0.	C
	31	0	56	36.3	58	12.5	150	36.8	2.9	2.8	9	258	111	1.04	20.1	32.0	D
	31	13	15	31.0	57	12.1	154	27.7	23.1	1.8	5	185	17	0.92	41.2	24.7	D
AUG	1	11	45	10.6	57	16.0	153	50.4	5.0	1.2	3	185	21	0.	0.	0.	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	DAY	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
AUG	1	15	50	45.4	59	11.5	152	46.0	422.7	3.5	4	293	38	0.76	0.	0.	D
	1	17	33	46.2	57	43.4	154	24.2	74.9	2.2	5	148	45	0.08	2.2	8.1	D
	1	19	13	40.9	59	32.5	154	6.7	5.0	1.8	3	315	45	0.01	0.	0.	C
	1	21	52	53.7	58	56.7	152	20.0	74.9	2.4	5	235	75	0.85	14.4	37.1	D
	2	2	21	41.2	58	42.7	151	58.9	100.1	2.4	5	258	23	0.25	30.0	31.2	D
	2	6	42	26.7	57	58.2	156	39.2	2.4	1.4	4	235	16	0.14	0.	0.	C
	2	7	35	30.3	58	58.5	150	55.6	96.8	3.2	4	319	145	0.01	0.	0.	C
	2	8	46	29.2	59	30.5	152	29.5	82.9	2.3	4	259	51	0.	0.	0.	C
	2	13	53	52.6	58	23.8	153	32.8	90.0	2.7	9	106	74	0.17	2.0	5.9	C
	3	2	52	17.3	58	52.9	154	30.0	395.8	3.3	4	287	137	0.92	0.	0.	D
	3	3	38	42.1	52	57.1	158	22.3	5.0	3.9	5	321	412	0.80	299.3	9999.9	D
	3	7	6	11.4	57	4.6	154	17.8	41.1	2.1	4	151	20	0.	0.	0.	C
	3	7	36	32.8	59	19.3	153	14.3	109.2	2.8	7	134	8	0.39	12.9	9.9	C
	3	14	52	44.1	57	11.7	153	46.4	44.9	2.5	4	153	16	0.03	0.	0.	C
	3	19	36	18.8	58	38.3	152	28.7	52.7	2.8	6	134	7	0.34	13.4	11.7	C
	4	8	44	27.2	55	6.7	153	11.4	30.9	3.6	14	286	171	0.33	11.9	386.6	D
	4	10	3	49.8	58	41.4	152	12.0	56.0	2.3	7	234	11	0.27	9.3	6.3	D
	4	11	31	57.3	57	15.3	155	31.5	28.8	1.8	5	227	54	0.27	9.1	5.4	D
	4	15	10	24.7	59	28.4	152	55.5	106.2	3.3	33	109	26	0.52	2.4	2.8	C
	4	20	14	32.0	58	21.0	154	18.0	89.8	2.8	12	145	74	0.25	2.3	6.3	D
	4	22	56	7.7	58	47.9	151	42.9	63.0	3.3	24	162	41	0.39	2.1	3.9	C
	4	23	40	15.7	61	23.3	150	2.3	36.2	2.8	16	131	30	0.76	4.8	3.3	C
	5	4	11	28.7	60	56.1	150	27.3	48.8	3.2	23	134	59	0.61	3.6	11.7	C
	5	9	43	3.7	59	53.1	152	55.2	104.0	3.0	13	148	60	0.42	6.7	5.9	D
	5	20	29	44.0	58	38.5	152	3.6	50.5	3.3	17	154	16	0.33	2.0	3.1	C
	5	22	24	2.0	57	48.9	154	4.4	5.0	1.8	3	211	60	0.01	0.	0.	C
	6	3	17	52.0	57	16.1	153	51.8	5.0	1.5	3	185	21	0.	0.	0.	C
	6	4	45	41.8	59	50.4	152	6.8	5.0	2.1	4	262	74	0.13	0.	0.	C
	6	9	12	46.5	57	41.1	155	39.9	105.7	3.1	11	102	13	0.25	3.0	4.7	C
	6	11	39	5.6	58	58.7	153	37.9	5.0	1.5	3	206	83	0.	0.	0.	C
	6	11	41	4.5	59	16.9	154	38.1	166.7	3.1	13	102	31	0.44	5.2	6.3	C
	6	12	10	23.0	56	56.3	151	1.6	39.6	3.8	12	290	126	0.61	30.8	748.7	D
	6	17	24	13.0	58	10.5	155	18.1	6.0	3.0	10	105	46	0.52	3.3	6.6	D
	7	0	4	48.5	57	23.0	153	44.0	5.0	2.4	3	218	35	0.01	0.	0.	C
	7	1	11	44.9	58	25.4	154	46.3	5.0	2.7	8	101	82	0.24	1.7	332.6	D
	7	3	40	57.5	57	12.9	155	0.6	2.7	2.0	4	189	26	0.91	0.	0.	D
	7	3	45	19.9	59	7.0	153	21.1	11.0	1.7	4	135	28	0.12	0.	0.	C
	7	4	28	49.9	61	5.1	151	13.3	2.3	3.5	20	112	91	0.97	4.0	14.0	D
	7	12	43	9.8	59	36.8	152	33.7	117.1	2.8	4	245	56	0.06	0.	0.	C
	8	5	41	35.7	57	15.6	153	6.7	5.0	1.5	3	255	10	0.	0.	0.	C
	8	7	15	11.0	59	5.1	157	30.6	18.8	2.7	4	341	134	0.30	0.	0.	D
	8	7	37	11.3	60	10.3	153	6.7	162.3	3.7	34	74	33	0.61	2.9	4.1	C
	8	11	55	2.0	57	21.5	153	6.6	58.0	2.6	7	135	21	0.19	3.6	5.9	C
	8	13	23	41.4	57	30.9	155	16.3	71.0	2.2	7	165	32	0.81	13.8	19.2	D
	8	18	8	39.7	57	4.6	153	56.0	36.5	3.7	26	115	2	0.74	3.4	2.3	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
AUG	9	2	16	54.9	57	52.7	156	37.6	8.9	1.5	5	208	8	0.05	1.2	0.8	C
	9	2	29	14.5	59	45.3	152	53.1	92.6	1.8	5	161	50	0.08	21.1	34.6	D
	9	2	47	58.7	59	38.4	151	45.2	32.1	2.3	5	230	95	0.10	7.7	127.7	D
	9	10	27	41.5	59	56.8	153	12.4	139.5	2.4	7	143	58	0.11	2.7	5.1	D
	9	12	37	48.5	58	39.8	153	4.3	1.5	1.6	4	119	42	0.69	0.	0.	D
	9	23	9	12.3	62	5.6	152	32.8	5.0	3.2	3	246	187	0.05	0.	0.	C
	9	23	10	40.2	62	6.7	152	28.6	5.0	3.1	6	172	145	0.27	3.5	471.9	D
	10	3	15	26.2	57	22.5	155	2.9	54.9	2.2	5	170	25	0.19	5.9	5.9	D
	10	3	26	54.3	60	2.7	153	23.2	179.5	3.2	14	133	53	0.39	4.9	4.5	C
	10	6	20	27.2	56	56.9	154	23.1	3.6	1.9	4	177	30	0.	0.	0.	C
	10	9	35	56.0	56	24.2	152	40.0	32.6	4.8	24	203	88	0.57	5.9	3.0	D
	10	10	25	4.4	57	13.4	155	28.7	29.1	2.2	10	101	52	0.73	5.3	5.9	C
	10	11	14	58.9	56	19.9	152	37.5	34.5	3.5	19	250	96	0.78	11.0	4.6	D
	10	12	27	22.6	57	24.0	154	37.8	43.1	2.8	16	43	7	0.95	4.7	8.6	C
	10	17	38	26.2	56	1.4	151	54.9	2.9	3.0	6	275	145	0.82	24.0	36.9	D
	11	10	31	48.2	57	40.2	152	54.1	6.2	2.3	4	120	25	0.06	0.	0.	C
	11	21	47	45.3	56	53.9	153	53.7	5.0	2.3	3	146	21	0.01	0.	0.	C
	12	14	36	57.8	57	6.2	153	55.5	40.2	1.9	4	148	2	0.	0.	0.	C
	12	15	30	14.2	59	46.3	153	17.0	5.0	1.8	3	188	43	0.07	0.	0.	C
	12	19	28	15.3	61	33.1	151	14.0	71.4	3.6	22	79	72	0.51	2.7	7.2	C
	13	15	25	31.8	56	42.7	154	59.1	5.0	2.1	3	268	52	0.	0.	0.	C
	14	6	2	49.4	58	23.6	155	59.5	163.9	3.0	6	224	74	0.25	14.5	26.1	D
	14	6	49	45.7	58	25.1	156	3.8	169.1	3.3	9	228	78	0.19	6.6	7.5	D
	15	0	52	9.9	59	51.4	153	22.5	149.3	2.9	8	145	52	0.19	4.3	7.2	D
	15	6	54	41.9	60	4.2	152	54.5	142.1	2.4	7	158	39	0.25	7.2	12.0	D
	15	10	14	21.4	58	41.8	153	36.4	5.0	1.9	4	150	56	0.04	0.	0.	C
	15	12	26	18.1	58	41.3	153	36.8	5.0	1.5	4	151	57	0.05	0.	0.	C
	15	16	46	35.0	58	42.7	153	35.7	5.1	1.9	4	148	55	0.	0.	0.	C
	15	17	45	11.6	57	14.0	150	59.0	29.6	3.8	14	232	107	0.50	7.2	4.0	D
	15	18	31	46.6	58	47.7	152	55.4	67.1	2.4	8	116	38	0.27	3.2	5.4	C
	15	20	59	26.9	56	48.6	155	17.7	5.0	2.2	3	241	70	0.11	0.	0.	C
	16	6	32	16.7	58	41.6	153	37.5	5.8	2.0	9	84	29	0.46	3.1	5.4	C
	16	11	49	16.7	58	42.3	152	27.0	60.6	2.1	4	151	10	0.	0.	0.	C
	16	11	54	30.5	57	1.7	153	57.6	35.4	2.0	4	120	53	0.	0.	0.	C
	17	15	19	1.4	59	58.0	152	43.5	101.5	2.8	7	163	50	0.43	15.1	10.5	D
	17	15	59	40.1	56	38.7	158	39.5	89.9	3.6	10	167	1	0.87	20.2	22.8	D
	17	20	45	28.2	59	29.6	152	14.6	5.0	2.3	3	200	69	0.	0.	0.	C
	17	23	40	7.8	57	50.7	156	13.0	135.5	3.4	7	214	62	0.15	4.0	5.0	D
	18	9	36	2.6	59	6.1	153	23.4	9.1	2.2	7	136	18	0.74	6.4	5.5	D
	18	14	18	42.6	59	48.7	153	46.0	144.2	2.8	4	227	50	0.02	0.	0.	C
	18	15	3	11.5	57	8.6	153	50.1	58.6	2.8	9	111	45	0.26	3.0	6.1	C
	18	15	14	22.0	57	7.1	153	53.9	30.6	1.9	9	112	5	0.30	2.4	2.3	C
	18	19	13	22.4	58	33.9	153	46.8	2.5	1.7	5	153	64	0.80	14.9	26.4	D
	19	4	28	58.2	61	56.2	150	5.4	35.5	3.1	19	54	33	0.77	5.1	5.3	C
	19	9	8	4.9	61	55.8	150	6.1	35.6	2.9	18	47	33	0.81	5.4	5.6	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
AUG	19	9	13	36.7	60	27.0	152	42.1	135.2	2.9	6	306	5	0.14	10.4	12.8	D
	19	11	59	47.1	58	38.3	153	49.4	5.0	1.3	3	172	55	0.30	0.	0.	C
	19	16	7	54.2	57	42.5	153	14.2	5.0	1.3	3	164	39	0.	0.	0.	C
	19	19	20	56.2	59	9.3	153	46.0	113.1	2.3	5	137	25	0.13	9.2	16.1	D
	20	3	23	45.4	58	10.2	154	3.8	38.2	2.0	6	134	54	0.66	10.6	9.5	C
	20	4	47	34.5	58	40.9	153	38.3	5.0	1.9	6	153	56	0.37	4.3	634.6	D
	20	5	9	48.1	59	23.7	153	29.3	5.0	2.0	3	207	107	0.	0.	0.	C
	20	9	1	50.7	59	4.2	153	14.1	5.0	1.4	3	206	55	0.	0.	0.	C
	20	12	12	55.7	61	41.5	151	17.8	67.6	2.7	13	93	75	0.49	3.6	10.5	C
	20	16	33	15.4	58	31.5	152	21.8	49.0	2.3	7	191	11	0.28	7.5	6.6	D
	20	17	53	17.5	57	9.2	155	14.5	4.8	0.	8	99	41	0.27	2.1	4.1	C
	20	22	16	46.9	55	42.6	153	22.8	5.0	2.5	3	326	107	0.58	0.	0.	D
	21	0	10	39.7	58	15.5	151	38.6	5.0	2.0	4	260	58	0.32	0.	0.	D
	21	7	10	14.3	59	23.4	153	30.5	5.0	1.9	3	208	107	0.	0.	0.	C
	21	11	2	10.9	60	24.5	153	33.9	8.4	1.8	4	144	43	0.10	0.	0.	C
	21	12	40	16.2	57	47.4	152	30.7	40.4	1.6	4	160	4	0.	0.	0.	C
	21	15	4	12.5	57	31.8	156	32.7	5.0	2.0	3	307	179	0.13	0.	0.	C
	21	15	34	37.7	59	57.1	153	2.5	145.3	3.3	22	108	54	0.54	3.2	5.3	C
	21	21	34	12.7	59	45.5	153	12.4	136.9	2.4	5	167	43	0.23	12.1	11.5	D
	22	0	7	38.2	58	8.4	153	40.1	61.6	3.0	9	137	31	0.17	2.1	3.4	C
	22	2	49	56.7	61	11.8	150	49.9	39.2	2.9	10	117	71	0.63	5.5	5.2	C
	22	10	40	15.9	57	36.4	154	22.5	5.0	2.3	3	241	88	0.	0.	0.	C
	22	10	54	36.9	58	33.8	153	41.1	79.2	2.3	4	203	63	0.	0.	0.	C
	22	11	24	46.2	57	11.9	155	8.5	88.0	2.3	5	153	34	0.08	3.7	7.9	D
	22	18	52	37.9	59	53.3	153	5.6	147.5	3.4	13	146	61	0.37	4.6	6.6	D
	23	1	11	30.9	59	34.5	153	20.5	119.3	2.3	7	156	21	0.27	5.6	6.9	D
	23	6	28	31.3	57	47.9	153	14.7	45.6	2.0	5	101	29	0.08	3.7	8.5	D
	23	7	43	24.3	60	11.9	150	57.3	23.5	2.6	4	284	103	0.16	0.	0.	C
	23	12	29	13.4	57	14.5	156	46.0	11.1	3.2	9	165	18	0.70	8.6	7.3	D
	23	13	48	41.0	57	42.1	153	58.2	5.0	2.0	3	186	57	0.	0.	0.	C
	23	20	53	34.0	59	53.1	153	19.0	161.6	3.0	9	144	57	0.18	4.0	5.9	D
	23	21	50	39.3	59	55.9	153	28.1	137.3	2.2	4	220	62	0.01	0.	0.	C
	24	0	26	50.9	59	10.2	152	15.4	5.0	2.1	4	197	60	0.81	0.	0.	D
	24	1	30	8.8	60	13.3	152	51.1	157.3	3.0	6	160	22	0.12	5.2	7.8	D
	24	2	14	10.0	59	38.7	151	34.9	5.0	2.3	3	245	104	0.	0.	0.	C
	24	3	17	0.4	59	25.1	152	29.9	5.0	1.8	3	202	103	0.	0.	0.	C
	24	6	47	48.2	57	6.1	153	24.3	5.0	1.2	3	218	20	0.	0.	0.	C
	24	13	58	52.6	58	48.9	153	8.4	3.8	1.4	4	130	50	0.	0.	0.	C
	24	15	13	49.7	57	15.4	157	16.2	114.7	2.4	5	161	29	0.08	3.1	3.8	D
	24	17	31	13.8	59	34.4	153	32.0	131.2	2.1	5	168	27	0.07	3.3	4.9	D
	24	17	54	19.9	59	48.8	153	31.4	134.6	2.0	4	186	79	0.08	0.	0.	C
	24	20	7	5.9	60	20.4	153	34.4	5.0	1.3	3	218	45	0.17	0.	0.	C
	24	23	16	10.0	58	53.3	152	53.4	5.0	1.3	3	164	42	0.	0.	0.	C
	24	23	50	24.6	59	13.0	152	2.5	28.8	1.9	4	212	83	0.23	0.	0.	C
	25	0	25	55.8	58	1.7	154	10.8	5.0	1.7	3	196	60	0.	0.	0.	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
AUG 25	2	23	37.7	60	14.2	152	57.4	174.0	2.7	7	153	22	0.11	4.4	6.9	C
25	12	31	55.0	59	5.9	154	23.9	133.3	2.4	6	145	56	0.10	2.3	4.2	C
25	16	5	17.6	57	51.0	154	10.0	5.0	1.7	3	223	64	0.01	0.	0.	C
25	16	55	43.6	59	40.5	151	45.4	33.7	2.2	5	230	100	0.90	140.3	133.1	D
25	17	42	37.5	59	56.1	153	12.5	150.0	3.0	17	164	59	0.39	3.8	3.4	D
25	18	14	12.0	59	49.4	154	6.8	5.0	2.2	3	244	99	0.05	0.	0.	C
26	0	27	32.5	59	27.5	152	49.3	97.1	2.4	7	162	31	0.23	4.0	5.1	C
26	3	11	32.0	57	53.7	154	32.5	5.0	2.1	4	180	59	0.34	0.	0.	D
26	7	6	48.9	59	28.7	152	41.4	15.1	1.5	4	252	39	0.	0.	0.	C
26	7	27	18.3	60	34.2	153	3.9	152.3	3.1	16	95	23	0.52	4.0	5.8	C
26	7	48	41.3	57	24.2	154	49.7	43.3	2.2	8	134	14	0.33	3.6	4.4	C
26	9	53	56.0	59	18.8	152	53.9	111.9	2.2	7	154	30	0.14	2.3	4.1	C
26	10	11	45.5	59	50.0	153	11.0	141.8	2.8	7	157	57	0.33	7.9	11.1	D
26	10	43	48.3	59	2.9	152	47.3	89.7	2.2	8	151	48	0.19	2.6	3.9	C
26	12	59	41.6	57	4.8	153	57.2	33.4	1.8	4	114	50	0.	0.	0.	C
26	13	6	29.6	57	21.6	156	11.2	81.2	2.6	9	146	39	0.23	2.9	3.1	C
26	13	49	42.0	59	53.3	151	10.6	37.2	2.6	5	256	106	0.56	32.0	9999.9	D
26	20	53	27.8	58	42.6	153	35.5	5.0	1.7	4	148	56	0.01	0.	0.	C
26	23	43	56.8	58	40.6	153	38.6	2.5	1.8	4	154	74	0.37	0.	0.	D
26	23	49	41.2	58	42.8	153	35.4	5.5	1.4	4	148	55	0.04	0.	0.	C
27	2	1	50.5	58	42.6	153	35.7	5.8	1.9	4	149	55	0.05	0.	0.	C
27	2	31	45.8	56	50.8	155	5.2	5.0	2.3	3	267	60	0.03	0.	0.	C
27	3	51	46.3	56	38.1	151	36.3	23.0	4.0	19	236	107	0.50	7.6	3.6	D
27	5	50	16.1	58	43.0	153	35.4	5.0	1.9	3	149	72	0.	0.	0.	C
27	5	59	34.8	58	42.1	153	36.3	5.0	1.6	3	150	73	0.	0.	0.	C
27	6	58	25.2	59	5.7	152	1.4	74.6	1.9	4	212	55	0.	0.	0.	C
27	8	55	8.4	57	12.6	155	40.6	79.1	2.0	6	199	63	0.26	7.0	14.2	D
27	10	40	6.1	58	51.2	155	39.8	5.0	2.2	3	286	120	0.22	0.	0.	C
27	13	11	35.1	58	20.4	155	19.2	125.2	1.9	4	245	64	0.02	0.	0.	C
27	15	0	10.8	56	40.7	158	11.6	48.9	3.0	6	159	30	0.52	54.5	117.2	D
27	15	42	19.9	58	8.4	155	59.9	141.0	2.6	6	210	22	0.15	7.2	10.5	D
27	17	7	10.4	58	42.7	153	35.7	5.0	1.8	3	148	72	0.01	0.	0.	C
27	19	23	14.9	59	54.3	153	10.6	130.6	2.4	6	169	59	0.23	9.2	11.9	D
28	3	33	38.0	59	47.0	153	9.1	131.7	2.2	6	163	47	0.24	8.8	9.1	D
28	4	26	5.3	57	51.9	154	46.6	7.7	1.8	4	180	45	0.02	0.	0.	C
28	5	13	52.9	59	21.4	153	29.2	111.3	2.1	5	154	49	0.08	2.2	3.9	C
28	7	47	27.7	57	33.4	152	27.7	45.6	1.7	4	225	21	0.	0.	0.	C
28	11	33	28.0	59	15.1	153	53.5	151.5	2.3	6	149	24	0.09	4.5	7.2	C
28	12	13	45.8	58	43.9	153	45.4	1.5	2.1	4	173	48	0.22	0.	0.	C
28	12	33	10.9	54	31.1	153	41.2	18.6	3.2	11	300	190	0.32	20.1	399.0	D
28	14	41	54.4	59	51.5	153	22.0	157.5	3.2	13	179	54	0.27	4.6	3.7	D
29	9	23	29.2	59	17.3	153	35.4	116.6	2.4	6	141	10	0.12	3.8	5.2	C
29	10	1	27.8	58	9.4	153	38.7	60.1	2.2	8	61	30	0.23	2.5	5.4	B
29	12	6	41.3	55	6.5	157	36.5	38.7	3.2	4	288	117	0.28	0.	0.	C
29	19	10	41.2	60	48.2	152	54.7	0.4	2.8	6	247	43	0.64	15.3	23.8	D

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
AUG 29	19	44	0.9	56	52.9	157	12.0	78.5	2.3	5	178	24	0.14	7.9	11.3	D
30	3	10	3.7	59	52.3	153	33.8	151.6	2.4	5	193	30	0.06	4.9	4.6	D
30	6	0	6.8	60	2.3	152	55.1	105.1	2.6	8	157	43	0.20	4.1	5.4	C
30	8	8	46.6	57	23.0	152	4.2	31.7	3.1	10	241	47	0.45	10.0	3.3	D
30	8	12	13.3	57	25.3	152	10.1	30.7	2.7	7	247	41	0.33	9.5	3.0	D
30	8	23	37.7	56	9.8	157	23.8	56.3	3.2	14	196	45	0.42	5.6	8.5	D
30	9	32	49.7	60	26.5	153	29.9	5.0	2.0	3	275	40	0.27	0.	0.	C
30	11	9	6.9	59	39.2	151	28.8	5.0	1.9	3	249	98	0.	0.	0.	C
30	17	27	40.8	57	46.6	152	51.0	5.0	1.2	3	138	21	0.	0.	0.	C
30	19	27	8.8	60	15.3	152	34.1	123.7	2.9	9	208	21	0.38	8.1	8.0	D
30	20	7	59.9	59	42.8	152	31.1	100.1	3.7	30	80	40	0.55	2.6	3.8	C
30	20	45	0.3	56	21.8	152	42.7	31.6	3.8	20	233	92	0.42	5.8	2.6	D
30	20	47	24.0	56	9.2	152	17.7	7.4	3.6	7	261	178	0.27	23.2	12.5	D
30	21	36	29.0	58	25.4	154	53.2	5.0	1.6	5	106	85	0.21	2.9	480.1	D
30	23	28	3.3	57	53.2	156	37.2	7.7	1.8	9	191	8	0.54	5.5	3.0	D
30	23	38	22.9	57	52.9	156	40.0	7.1	1.6	6	215	10	0.25	4.0	2.5	D
31	1	59	25.7	57	4.6	153	56.1	5.0	2.1	3	135	51	0.	0.	0.	C
31	4	52	29.8	57	53.0	154	23.8	5.0	1.8	3	242	62	0.06	0.	0.	C
31	4	59	58.3	58	48.5	153	5.9	5.0	1.5	3	160	47	0.	0.	0.	C
31	6	17	47.1	60	35.6	151	7.6	5.0	2.3	3	304	92	0.39	0.	0.	D
31	8	26	40.1	60	17.0	152	52.5	129.4	2.6	8	150	16	0.38	8.5	10.7	D
31	10	34	7.9	59	31.5	153	22.1	120.2	2.1	5	190	16	0.36	25.4	21.1	D
31	10	58	23.9	57	42.9	155	25.4	67.6	1.9	5	174	8	0.12	4.7	4.4	D
31	17	3	42.7	56	43.9	154	54.0	5.0	1.5	3	260	48	0.01	0.	0.	C
31	18	34	18.1	58	3.8	154	11.1	5.0	1.7	4	181	60	0.98	0.	0.	D
31	19	36	46.0	60	14.1	151	53.4	117.0	2.7	6	255	52	0.30	15.8	20.4	D
31	18	38	47.5	57	53.1	156	37.5	8.6	1.6	4	271	8	0.11	0.	0.	C
31	19	50	9.8	57	9.6	155	13.4	3.4	2.1	4	179	40	0.03	0.	0.	C
31	21	12	34.5	59	51.1	155	12.7	5.0	1.7	3	305	113	0.	0.	0.	C
31	22	12	29.2	57	49.1	153	24.9	70.1	2.6	12	66	30	0.28	2.5	4.5	B
31	23	12	18.0	57	53.2	156	33.2	5.0	0.9	3	257	5	0.	0.	0.	C
SEP 1	5	56	36.4	58	43.0	155	14.5	158.7	2.6	9	140	73	0.27	6.2	16.4	D
1	6	55	57.0	57	46.1	154	36.5	69.7	2.0	12	82	48	0.24	1.7	3.4	B
1	7	9	7.0	61	51.9	152	32.3	38.4	2.9	16	157	142	1.68	11.8	9999.9	D
1	12	26	55.4	57	2.8	153	57.2	37.3	1.7	4	118	52	0.	0.	0.	C
1	13	30	15.3	60	7.4	153	8.2	160.3	3.4	21	151	38	0.49	4.6	4.3	C
1	13	48	35.0	58	18.4	154	51.0	5.0	2.1	7	98	71	0.17	1.4	265.3	D
1	15	3	25.6	59	56.6	153	7.4	128.4	2.1	6	183	56	0.18	9.2	9.8	D
1	17	59	6.9	57	43.4	153	31.1	43.1	1.2	5	104	15	0.01	0.2	0.3	C
1	21	34	12.5	57	52.9	156	41.7	3.3	1.1	4	219	12	0.	0.	0.	C
1	21	38	45.8	64	33.9	160	6.8	1.3	3.9	13	84	77	1.03	5.5	40.0	D
1	23	10	42.7	57	45.1	154	22.9	66.7	1.8	4	153	36	0.	0.	0.	C
2	0	6	34.7	59	37.1	153	1.1	108.2	1.9	5	167	79	0.06	2.8	3.7	D
2	0	33	23.9	58	11.3	151	31.9	34.9	1.9	7	260	68	0.43	14.1	4.0	D
2	1	13	17.8	59	45.5	152	33.3	107.6	2.2	6	184	39	0.13	5.2	5.6	D

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	MN	TIME 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 2	1	54	27.6	60	25.0	153	28.0	9.7	1.5	4	229	38	0.15	0.	0.	C
2	3	20	20.9	60	9.7	152	55.1	150.9	2.8	15	154	29	0.39	5.7	6.2	D
2	5	39	19.3	56	32.2	155	52.4	33.3	1.9	5	180	76	0.22	0.1	0.	C
2	6	29	19.3	56	41.6	154	59.8	8.5	1.7	4	239	52	0.11	0.	0.	C
2	9	6	38.6	58	32.0	154	24.8	1.1	2.5	17	90	64	0.64	2.4	21.2	D
2	9	59	56.4	58	44.2	153	55.7	11.7	1.6	7	164	33	0.48	5.1	730.0	D
2	10	6	33.1	59	38.6	151	51.1	34.1	1.6	5	234	77	0.27	41.7	35.1	D
2	14	54	19.6	58	55.8	152	23.2	46.5	1.6	4	207	33	0.	0.	0.	C
2	17	3	59.0	57	45.5	152	43.4	3.2	1.3	4	153	13	0.62	0.	0.	D
2	17	40	16.5	57	38.8	155	49.5	55.6	1.9	4	145	23	0.64	0.	0.	D
2	18	36	55.8	60	30.2	153	17.7	5.0	1.7	3	285	30	0.12	0.	0.	C
2	19	30	46.2	57	29.5	156	18.0	5.0	1.2	3	197	34	0.01	0.	0.	C
2	19	57	53.7	56	55.4	157	2.9	21.7	2.1	5	183	35	0.48	25.5	23.6	D
2	20	35	27.2	58	33.9	154	0.7	99.8	2.2	10	98	60	0.21	2.1	5.1	C
2	20	41	8.1	59	47.8	153	35.1	141.5	1.9	7	210	25	0.08	3.5	2.9	D
2	22	26	59.7	59	50.6	154	47.1	5.0	1.9	3	294	90	0.	0.	0.	C
2	23	59	33.0	60	25.4	153	50.8	5.0	1.8	3	281	59	0.03	0.	0.	C
3	3	3	48.3	60	39.8	153	37.8	1.3	1.6	4	268	54	0.21	0.	0.	C
3	3	58	15.2	62	2.6	151	57.6	2.9	0.	10	184	118	1.51	10.9	40.1	D
3	7	47	24.0	56	21.4	156	38.4	27.5	2.3	6	124	36	0.50	10.6	12.6	C
3	13	34	49.1	59	38.5	153	1.3	108.0	1.7	4	152	11	0.	0.	0.	C
3	20	23	25.3	60	13.4	151	15.0	36.7	2.7	7	273	86	0.43	19.7	7.8	D
3	21	33	6.5	58	42.6	152	34.0	74.8	2.2	9	130	15	0.22	3.1	3.7	C
3	22	3	45.9	60	45.1	151	18.2	15.0	2.2	5	309	88	0.82	83.7	7.3	D
4	0	56	34.7	59	1.0	153	40.4	34.3	1.6	4	158	10	0.10	0.	0.	C
4	3	36	21.6	56	59.9	154	30.6	5.0	1.7	3	191	38	0.01	0.	0.	C
4	4	40	29.4	56	29.4	154	6.5	33.8	2.4	7	290	9	0.25	6.5	2.4	D
4	6	53	17.0	56	5.5	158	43.4	46.7	2.7	13	264	62	0.74	45.9	78.6	D
4	9	51	11.4	58	40.2	153	34.0	1.2	1.3	6	177	31	0.26	2.4	12.2	C
4	10	15	26.8	59	16.8	153	8.8	85.8	1.8	7	138	41	0.12	2.1	2.9	C
4	11	41	23.3	58	10.9	151	52.7	5.0	1.4	4	246	56	0.34	0.	0.	D
4	12	17	48.8	60	7.3	152	33.6	118.9	2.2	6	195	35	0.12	7.0	7.2	D
4	12	46	18.3	57	53.2	156	38.6	9.1	1.4	4	275	9	0.08	0.	0.	C
4	12	42	38.2	60	2.2	153	21.8	156.3	2.5	7	212	43	0.11	6.2	5.2	D
4	14	30	42.4	59	44.7	151	32.1	5.0	1.4	4	249	96	0.27	0.	0.	C
4	15	54	51.8	58	31.7	152	58.8	5.0	1.4	3	162	38	0.	0.	0.	C
4	16	39	26.7	58	43.4	153	51.1	3.5	1.7	7	136	31	0.26	2.4	3.7	C
4	22	18	39.5	60	11.3	151	54.8	38.6	2.0	5	250	54	0.50	113.7	78.8	D
4	22	45	37.6	59	50.7	153	27.8	146.5	2.7	5	211	25	0.02	1.6	1.4	C
5	0	2	47.1	59	9.1	152	18.2	60.9	2.1	5	193	58	0.01	0.4	0.5	C
5	5	14	26.2	59	54.4	152	0.1	5.0	1.0	3	225	71	0.	0.	0.	C
5	5	45	16.4	59	35.2	152	46.8	96.1	1.6	5	167	26	0.05	2.2	2.1	C
5	6	35	1.0	56	38.9	153	42.9	5.0	1.7	3	217	30	0.10	0.	0.	C
5	10	28	25.3	59	57.8	153	29.9	178.4	2.6	10	162	37	0.11	2.5	3.7	C
5	20	24	32.8	61	20.8	150	43.1	25.1	3.1	11	125	56	0.91	8.2	7.2	D

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	DAY	ORIGIN HR	ORIGIN MN	TIME SEC	LAT N DEG	LAT N MIN	LONG W DEG	LONG W MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
SEP	5	21	31	10.1	58	22.2	154	43.5	5.0	1.6	5	131	86	0.14	2.1	319.0	D
	6	22	12	57.1	58	22.9	154	47.8	0.6	2.0	10	100	80	0.64	3.5	48.8	D
	6	1	29	21.0	59	25.2	153	7.4	101.4	2.2	7	143	19	0.11	2.2	2.3	C
	6	1	42	58.0	57	56.6	153	15.8	41.6	2.5	12	80	14	0.26	1.7	2.7	B
	6	5	36	31.5	58	41.4	153	34.6	5.0	1.3	3	204	29	0.	0.	0.	C
	6	5	48	35.4	58	7.8	153	5.3	51.0	2.5	6	233	8	0.13	4.7	3.9	D
	6	6	18	43.2	60	4.9	152	49.5	121.4	1.9	4	166	37	0.02	0.	0.	C
	6	6	51	23.0	56	46.0	157	47.3	146.0	2.8	4	330	177	0.21	0.	0.	C
	6	8	43	24.4	57	4.8	155	26.8	10.3	2.1	7	166	77	0.87	9.5	9999.9	D
	6	9	24	15.3	59	25.1	153	0.4	82.9	2.0	6	150	25	0.23	7.8	8.3	D
	6	13	30	20.0	61	15.9	151	49.8	92.9	2.6	11	177	107	0.49	5.8	9.5	D
	6	17	21	34.7	59	17.1	153	42.3	115.0	2.5	6	222	16	0.18	8.8	9.2	D
	6	18	21	33.2	57	56.7	154	32.6	5.0	2.0	3	256	50	0.01	0.	0.	C
	6	18	38	7.0	59	51.9	152	50.5	39.4	2.1	5	165	61	0.45	96.4	151.7	D
	7	0	34	51.8	61	8.6	151	32.1	61.6	2.5	8	165	105	0.57	10.1	21.3	D
	7	2	43	21.9	59	36.9	151	10.9	1.5	2.2	7	181	115	0.75	11.2	120.1	D
	7	4	7	28.3	60	10.2	152	33.3	109.9	2.2	7	212	30	0.11	3.6	4.6	D
	7	7	15	4.5	59	11.3	153	29.6	99.0	2.9	14	117	16	0.23	2.2	2.8	B
	7	12	15	57.3	59	31.4	153	5.0	121.4	1.9	4	172	16	0.14	0.	0.	C
	7	12	25	36.6	58	42.0	153	36.0	8.0	1.4	4	150	28	0.	0.	0.	C
	7	13	38	19.1	60	20.6	152	12.0	98.6	2.3	5	271	32	0.06	5.8	4.9	D
	7	14	34	29.1	58	9.5	155	20.0	0.2	2.8	9	99	44	0.91	6.0	39.9	D
	7	14	38	49.2	58	10.8	155	27.0	5.0	2.1	4	213	106	0.81	0.	0.	D
	7	15	32	50.1	58	30.2	154	36.8	19.5	1.8	4	192	70	0.70	0.	0.	D
	7	17	48	36.8	60	1.1	152	45.8	105.5	3.1	22	115	44	0.45	2.9	3.7	C
	7	18	11	13.5	59	35.1	153	37.0	130.3	2.2	7	175	23	0.08	3.6	3.0	C
	7	22	23	5.5	59	24.0	152	56.9	96.0	2.2	8	177	29	0.27	4.4	5.4	C
	8	16	2	53.2	59	5.4	152	25.7	56.3	1.6	4	182	51	0.	0.	0.	C
	8	19	4	2.8	58	40.7	153	37.9	0.3	2.5	9	109	31	0.42	3.0	17.1	C
	8	19	14	52.6	58	42.0	153	35.4	8.3	1.6	5	149	28	0.04	0.8	0.9	C
	8	20	2	16.7	58	10.1	155	26.5	5.0	2.2	6	213	104	0.40	7.4	695.1	D
	8	21	30	4.2	57	42.3	155	51.7	7.5	2.8	17	48	21	0.60	2.3	2.9	D
	8	23	15	23.3	57	50.3	153	14.1	65.1	2.2	5	134	25	0.04	1.0	1.5	C
	9	1	35	25.5	60	7.1	152	50.3	121.6	2.7	13	128	33	0.37	4.6	4.9	C
	9	1	49	9.7	59	25.4	152	36.2	90.4	2.2	8	175	42	0.19	3.6	4.8	C
	9	4	43	41.6	59	22.7	153	6.7	119.6	1.8	4	172	31	0.02	0.	0.	C
	9	4	50	14.7	60	17.6	152	38.5	140.4	2.4	5	202	15	0.09	10.2	12.4	D
	9	7	5	13.8	59	49.3	154	8.8	167.3	2.3	4	334	102	0.18	0.	0.	C
	9	7	42	57.7	59	39.8	153	11.2	126.2	2.2	6	142	2	0.12	6.2	6.3	D
	9	14	23	37.3	60	10.8	152	44.1	109.7	2.3	6	177	26	0.04	1.5	1.3	C
	9	14	47	36.4	59	50.3	155	11.7	5.0	1.6	3	305	112	0.	0.	0.	C
	9	15	22	24.5	58	41.6	153	36.7	8.0	1.4	5	125	29	0.11	1.8	2.8	C
	9	15	58	56.7	62	13.0	149	28.6	33.8	4.2	22	51	66	0.51	2.5	2.6	C
	9	18	3	48.4	60	7.3	151	32.6	5.0	1.8	3	259	75	0.	0.	0.	C
	9	18	21	12.9	58	56.3	152	26.0	5.0	1.3	3	202	35	0.01	0.	0.	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	MN	TIME 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 10	0	22	32.0	58	11.0	155	21.5	0.4	2.5	13	108	46	0.65	3.1	20.9	D
10	1	54	27.7	59	47.4	152	58.0	127.1	2.8	4	319	21	0.	0.	0.	C
10	7	31	47.1	58	43.1	153	34.6	9.0	2.1	10	85	26	0.44	2.8	4.4	C
10	12	11	25.4	59	59.3	153	28.4	153.0	2.3	5	215	39	0.04	3.3	3.0	D
10	12	21	24.1	58	42.1	153	36.7	8.4	1.5	5	138	28	0.11	1.9	2.5	C
10	12	58	17.2	58	10.9	155	17.2	13.0	1.6	5	135	101	0.31	4.5	702.2	D
10	14	32	46.3	58	16.5	154	50.6	65.3	1.9	4	250	85	0.02	0.	0.	C
10	16	5	33.3	58	48.4	152	56.7	62.2	2.0	8	117	37	0.15	1.9	2.7	B
10	17	6	51.9	59	2.5	153	37.9	7.1	1.5	6	133	11	0.11	1.2	1.3	B
10	17	8	8.7	59	0.4	153	36.8	12.7	1.6	4	147	7	0.23	0.	0.	C
10	17	54	18.6	57	14.2	155	23.6	50.9	2.8	16	115	47	1.19	6.7	19.3	C
11	0	51	44.1	59	1.8	153	37.9	9.0	1.7	6	126	10	0.16	1.6	1.4	B
11	2	7	23.8	59	3.5	153	58.6	124.4	2.4	11	94	13	0.25	2.9	4.2	C
11	7	0	6.6	58	42.2	153	37.2	11.3	2.5	10	83	28	0.54	3.3	700.5	D
11	8	42	38.0	58	14.0	151	38.1	5.0	2.9	7	256	60	0.44	13.3	675.0	D
11	12	38	54.4	59	2.2	153	37.0	10.0	1.4	4	133	10	0.	0.	0.	C
11	18	22	37.5	59	2.0	153	37.4	8.9	1.7	6	129	10	0.12	1.2	1.0	B
12	10	49	11.4	58	34.2	152	33.8	55.2	2.1	6	129	14	0.26	5.9	6.6	C
12	15	38	49.2	56	10.0	152	14.2	9.8	2.5	4	275	127	0.20	0.	0.	C
12	23	53	57.6	57	49.9	156	21.5	140.4	2.4	7	151	14	0.26	11.3	19.3	D
13	4	25	31.7	57	45.9	156	12.2	132.3	2.6	10	81	7	0.57	12.4	19.3	C
13	8	9	40.7	59	17.0	153	18.1	113.8	2.5	9	130	9	0.25	3.8	4.3	C
13	9	16	38.7	57	3.0	153	59.3	32.1	1.9	7	115	50	0.19	1.9	2.0	B
13	11	24	28.7	57	53.6	156	32.1	5.0	0.4	3	248	4	0.	0.	0.	C
13	18	36	48.4	56	53.5	154	24.7	5.0	2.1	3	185	39	0.	0.	0.	C
13	20	27	41.4	58	43.4	152	37.5	72.5	2.7	11	126	19	0.35	3.8	4.9	C
13	23	14	6.9	59	38.2	151	26.8	5.0	2.1	6	250	100	0.71	19.5	9999.9	D
13	23	53	43.2	60	7.6	152	10.5	44.4	2.3	7	229	46	0.57	16.3	53.0	D
14	0	32	46.2	59	37.1	151	29.1	5.0	1.6	4	243	98	0.47	0.	0.	D
14	0	47	25.9	55	11.5	154	20.7	29.4	2.9	5	293	106	0.20	87.2	28.8	D
14	1	40	44.4	58	43.2	151	42.0	33.7	2.1	7	247	39	0.38	10.7	4.9	D
14	3	22	15.3	60	2.9	153	6.0	136.3	2.9	13	156	44	0.30	5.2	4.7	D
14	6	47	43.4	58	9.6	156	15.8	6.4	2.6	11	181	13	0.19	1.6	1.6	C
14	16	51	11.2	56	20.3	157	23.3	49.1	2.9	9	164	53	0.48	5.2	11.7	D
14	19	49	27.2	58	37.8	152	37.7	5.0	1.3	3	146	16	0.	0.	0.	C
15	4	49	19.4	60	0.2	152	25.8	103.9	2.8	6	201	50	0.36	15.7	16.4	D
15	14	35	7.9	59	44.8	152	33.9	90.4	2.2	6	183	38	0.05	1.9	2.4	C
15	17	40	56.6	60	1.0	153	20.6	153.1	2.7	7	190	41	0.12	5.1	6.8	D
15	21	15	36.8	60	0.1	153	19.6	5.0	1.7	3	216	55	0.01	0.	0.	C
15	21	21	10.3	60	10.3	153	7.7	143.7	2.6	7	204	33	0.24	14.8	13.0	D
15	21	50	42.3	58	42.5	153	48.0	0.2	1.7	5	180	31	0.16	3.0	15.6	D
17	5	23	0.4	58	29.0	156	38.5	226.7	3.4	14	213	70	0.38	7.6	11.6	D
17	6	52	32.1	56	5.6	154	37.4	38.9	2.1	5	206	58	0.07	3.4	1.2	D
17	10	34	19.0	58	2.9	155	37.6	213.4	3.0	4	302	143	0.51	0.	0.	D
17	11	28	18.2	59	34.7	152	47.8	92.9	2.2	7	165	25	0.09	1.5	2.0	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	ORIGIN MN	TIME SEC	LAT N DEG	LAT N MIN	LONG W DEG	LONG W MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
SEP 17	13	37	23.1	59	26.1	153	14.9	5.0	1.8	3	196	103	0.	0.	0.	C
17	15	42	39.5	60	51.3	150	52.2	1.3	3.7	22	133	83	0.85	4.4	21.2	D
17	16	56	14.2	59	33.3	152	23.8	74.5	2.0	4	191	48	0.	0.	0.	C
17	18	26	28.4	60	51.5	152	47.7	166.8	4.5	33	63	49	0.69	3.1	5.3	C
17	20	57	36.0	60	26.2	152	1.8	39.4	2.3	6	278	41	0.73	379.7	145.8	D
17	22	5	8.1	57	31.9	155	43.0	64.3	1.9	6	119	29	0.45	10.0	18.4	C
18	1	5	33.1	60	20.6	152	2.2	107.4	3.5	32	77	41	0.75	3.3	6.1	C
18	3	44	23.9	59	31.5	152	58.2	113.2	2.4	6	175	33	0.24	10.3	10.5	D
18	11	18	51.6	58	22.9	154	10.7	76.7	2.3	6	178	74	0.13	2.7	7.7	D
18	12	25	10.4	59	43.0	153	14.7	127.6	2.3	4	319	7	0.14	0.	0.	C
18	19	25	58.1	59	47.8	152	0.2	5.0	2.0	3	220	70	0.	0.	0.	C
19	0	2	29.7	58	31.8	152	55.6	5.0	1.9	3	239	35	0.	0.	0.	C
19	8	7	37.8	59	52.4	152	51.9	105.0	4.2	27	70	32	0.41	2.0	2.9	B
19	10	7	5.1	56	46.3	153	45.7	38.4	2.8	10	184	34	0.34	3.7	1.8	D
19	13	38	25.2	57	11.0	155	43.2	5.0	2.1	6	116	66	0.75	8.1	9999.9	D
19	15	30	9.1	56	27.4	153	33.3	30.3	2.2	4	266	40	0.	0.	0.	C
19	22	18	24.4	60	7.4	152	27.3	102.5	3.8	39	75	37	0.46	1.9	2.9	B
19	22	28	35.8	58	14.7	151	21.1	12.7	2.0	4	265	72	0.29	0.	0.	C
20	2	29	5.8	62	40.4	149	40.0	36.4	2.9	15	132	114	0.35	2.4	405.3	D
20	4	20	51.9	57	17.2	154	17.0	38.6	3.2	15	75	21	0.49	2.7	1.9	B
20	4	54	34.7	59	55.8	152	42.2	109.7	1.7	5	176	42	0.05	3.5	4.1	D
20	6	18	39.5	60	1.6	153	52.3	217.2	3.2	16	165	55	0.34	4.6	4.4	D
20	7	10	45.7	59	32.3	154	28.4	194.1	2.6	7	277	51	0.07	5.0	6.6	D
20	14	56	36.4	60	5.2	151	56.1	5.0	1.7	4	240	59	0.78	0.	0.	D
21	14	49	53.9	56	25.7	152	43.1	25.1	4.1	23	201	84	0.56	5.8	3.0	D
21	18	2	21.4	57	0.7	152	43.4	26.7	2.8	7	298	27	0.22	11.6	1.9	D
21	18	18	49.1	58	36.9	152	25.3	57.6	1.9	4	199	75	0.	0.	0.	C
21	18	59	1.4	59	42.2	151	1.2	5.0	2.1	3	265	124	0.	0.	0.	C
21	20	30	50.3	59	13.8	152	13.3	40.2	1.8	4	237	67	0.	0.	0.	C
21	21	7	14.3	57	41.6	154	16.0	5.0	1.9	3	209	45	0.01	0.	0.	C
22	14	23	5.1	57	10.9	154	45.7	46.7	3.5	17	96	18	0.40	2.1	3.9	C
23	6	48	56.4	56	50.8	156	28.8	55.6	2.9	10	107	65	0.73	6.3	23.2	C
23	8	46	4.3	58	11.0	155	21.6	8.1	2.7	6	138	104	0.49	5.5	34.8	D
23	11	14	6.9	58	49.3	153	37.9	5.0	1.7	3	283	16	0.43	0.	0.	D
23	11	20	49.9	58	50.3	153	38.3	5.0	2.0	3	278	14	0.34	0.	0.	D
23	11	47	12.2	55	21.2	158	38.4	14.9	3.6	12	285	143	0.45	15.8	5.2	D
23	14	19	37.8	60	7.6	154	27.3	5.0	1.6	3	284	86	0.24	0.	0.	C
23	16	54	5.4	60	4.9	153	51.0	5.0	1.7	3	254	59	0.11	0.	0.	C
23	22	37	44.4	60	45.4	150	40.1	35.3	3.6	22	139	80	0.51	2.8	2.9	D
24	2	10	35.8	60	7.1	153	1.8	136.2	3.2	15	146	36	0.48	5.5	5.7	D
24	6	40	13.6	59	20.3	153	27.6	126.7	2.6	8	143	2	0.16	4.9	7.1	C
25	5	34	2.3	58	40.5	154	28.6	119.6	2.1	6	225	50	0.07	4.0	2.8	D
25	6	29	20.9	59	12.6	153	47.1	103.0	2.0	4	150	24	0.04	0.	0.	C
25	6	39	30.1	56	28.8	156	36.5	93.3	2.7	4	300	103	0.01	0.	0.	C
25	9	4	10.5	59	39.7	152	45.1	103.1	2.6	9	169	27	0.37	6.5	7.2	D

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	MN	TIME 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 25	17	58	6.9	58	11.1	155	21.1	1.3	2.1	6	201	60	0.52	11.2	46.9	D
25	18	6	58.4	56	51.4	156	9.5	36.6	1.9	5	246	74	0.47	39.5	27.4	D
25	19	5	47.4	59	4.2	152	37.7	66.5	2.2	8	165	51	0.20	2.8	4.0	D
26	1	23	27.0	57	42.3	156	40.9	134.6	2.6	16	163	20	0.21	2.2	2.7	C
26	2	39	11.0	58	5.5	154	36.8	86.4	2.8	11	126	64	0.20	1.8	4.7	B
26	12	51	7.6	59	22.1	153	25.8	108.4	2.4	8	267	3	0.34	14.8	15.9	D
26	15	50	14.9	60	3.2	152	49.6	113.5	2.1	5	166	40	0.04	3.5	3.4	D
26	18	22	21.5	60	13.0	153	0.8	154.0	3.6	26	85	26	0.60	3.2	4.4	C
27	3	17	34.7	58	34.1	154	39.6	118.8	3.5	21	110	101	0.29	1.7	3.4	B
27	10	30	54.0	59	13.2	153	37.4	4.5	2.5	4	305	132	0.08	0.	0.	C
27	11	13	5.9	59	57.4	153	28.1	134.0	2.2	4	213	36	0.	0.	0.	C
27	12	6	25.1	60	6.1	150	31.0	5.0	2.7	3	307	129	0.01	0.	0.	C
27	12	52	34.1	58	8.0	150	31.9	31.3	3.2	13	206	123	0.61	7.0	6.2	D
27	13	17	47.5	58	49.9	154	48.2	139.9	2.5	11	122	45	0.31	3.4	6.9	C
28	3	52	52.2	58	41.9	153	37.1	10.7	2.3	9	141	29	0.58	4.4	781.5	D
28	4	52	29.9	59	35.1	152	53.3	117.8	2.5	9	160	20	0.25	5.6	6.5	D
28	10	31	43.5	59	38.1	151	46.5	65.6	3.1	10	153	82	0.54	7.2	19.7	D
28	14	10	32.4	58	9.7	154	4.5	83.8	1.9	4	222	48	0.	0.	0.	C
28	15	37	9.9	59	11.7	153	30.0	5.0	1.7	3	206	53	0.	0.	0.	C
29	5	24	5.0	57	47.6	154	40.9	29.7	3.0	6	109	51	0.78	27.2	37.8	C
29	13	50	37.9	59	10.0	154	25.1	5.0	2.1	3	178	14	0.	0.	0.	C
30	8	12	0.2	59	20.9	152	29.1	70.3	2.8	8	196	53	0.37	7.3	8.2	D
30	16	25	41.7	58	47.4	153	37.1	0.9	2.2	6	146	19	0.19	2.8	12.2	C
30	20	36	52.8	58	47.4	153	29.4	1.8	1.5	4	186	18	0.14	0.	0.	C
30	22	51	57.5	59	16.1	151	42.9	30.7	2.7	6	224	95	0.47	14.0	9.1	D
30	23	7	14.1	59	48.5	153	25.6	148.4	2.3	5	179	20	0.06	5.0	5.0	D

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	ORIGIN MN	TIME SEC	LAT N DEG	LAT N MIN	LONG W DEG	LONG W MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUL 1	0	27	54.7	59	51.5	152	34.3	86.6	2.9	10	189	43	0.35	6.6	6.2	D
3	16	32	14.0	60	8.9	152	4.8	86.2	2.7	13	131	48	0.40	7.0	9.2	C
4	17	15	33.3	59	49.8	153	5.4	149.6	2.8	9	156	21	0.20	4.6	4.9	C
4	21	3	36.7	60	4.6	152	56.2	114.8	3.9	28	87	39	0.67	3.3	4.4	C
5	13	33	47.5	59	33.1	152	42.4	99.0	2.7	10	179	31	0.30	5.1	4.9	D
8	8	33	12.3	59	39.9	153	18.7	141.3	3.6	15	161	4	0.40	7.4	5.2	D
8	9	41	34.2	60	1.0	153	7.0	153.9	3.1	14	172	41	0.27	5.5	3.9	D
8	15	16	27.8	58	8.7	154	30.3	86.7	2.4	9	105	79	0.20	1.9	5.7	C
8	19	2	3.9	59	39.1	152	50.5	101.0	2.2	6	172	21	0.17	6.0	6.6	D
8	19	59	40.4	61	6.3	150	42.2	69.1	4.5	13	90	63	0.49	3.8	8.4	B
9	9	41	10.8	56	56.8	153	9.3	32.7	2.6	6	212	51	0.19	3.7	3.0	D
9	14	12	1.8	59	32.8	153	38.9	126.7	2.4	7	174	25	0.08	3.1	2.2	C
10	0	58	3.4	62	5.1	149	10.3	28.5	3.1	9	113	53	0.31	3.6	4.5	C
10	8	27	10.9	59	28.7	151	57.2	58.2	2.6	8	213	74	0.13	2.0	4.8	C
11	11	19	21.2	59	55.7	152	54.2	128.2	3.3	13	149	35	0.37	7.6	5.4	D
11	13	34	10.1	60	1.7	152	42.2	126.8	3.1	11	132	43	0.34	5.8	4.8	C
11	18	47	19.8	58	10.0	154	10.2	74.4	2.3	7	185	60	0.13	2.5	4.9	D
14	10	47	9.9	55	9.2	155	29.5	30.3	4.3	11	254	76	0.32	7.5	3.4	D
15	2	6	14.9	61	37.8	150	51.5	59.4	3.5	29	70	52	0.98	4.2	9.4	C
15	8	20	45.4	58	28.0	155	39.8	1.6	3.1	5	250	153	0.91	2.1	4.9	D
15	13	27	7.9	56	57.9	.53	39.7	37.1	2.4	6	158	22	0.09	1.3	0.9	C
16	14	42	34.6	57	24.1	156	14.8	114.2	0.	11	103	36	0.27	4.2	8.6	C
18	20	17	19.6	59	54.2	152	57.6	122.8	4.0	19	89	58	0.33	2.0	2.7	B
19	2	42	11.7	60	59.2	152	23.9	133.0	3.9	26	64	66	0.57	2.6	5.1	C
19	11	41	46.4	58	39.5	153	39.9	89.4	2.7	12	93	58	0.47	3.6	8.2	C
19	16	31	46.1	56	19.5	153	58.0	32.5	2.6	5	293	29	0.09	6.7	1.2	D
19	17	16	36.5	59	34.2	153	26.8	110.9	1.7	9	123	26	0.29	3.6	5.7	C
20	18	5	54.0	60	4.4	152	27.0	103.6	4.4	22	72	42	0.74	4.2	6.3	C
21	2	19	58.6	55	52.8	157	44.8	32.3	3.6	19	234	103	0.34	4.6	3.1	D
21	5	4	17.8	61	6.4	152	20.3	153.5	3.1	13	167	80	0.49	5.6	6.8	D
21	5	30	26.7	60	13.5	152	27.8	115.6	2.8	10	188	27	0.32	8.0	9.9	D
21	5	52	11.4	59	34.3	152	57.4	103.1	1.7	5	133	37	0.	0.1	0.1	C
21	18	7	40.3	59	54.4	153	22.6	162.0	3.6	27	76	63	0.97	5.1	7.4	C
22	5	57	1.8	61	7.7	150	11.1	21.9	4.0	22	128	97	0.89	5.2	5.4	D
22	8	17	21.3	58	4.5	157	0.9	4.6	1.9	5	282	39	0.02	1.1	0.4	C
23	2	23	1.2	59	49.3	153	12.1	115.7	2.7	7	187	18	0.29	7.5	9.5	D
23	11	17	7.5	59	42.7	152	26.0	78.5	2.8	14	85	45	0.50	3.6	4.8	B
25	13	12	33.2	59	34.5	153	13.3	121.9	2.5	12	130	8	0.46	7.3	7.6	C
26	4	0	32.6	59	53.5	152	43.8	102.0	2.2	6	131	38	0.22	5.6	7.7	C
26	18	39	21.5	62	34.4	148	48.5	19.9	4.6	20	53	88	0.75	3.5	4.8	D
27	17	43	48.9	60	18.6	152	18.3	91.4	2.9	9	156	28	0.24	4.7	5.0	C
29	2	23	36.6	59	42.5	153	12.2	97.7	2.2	6	180	6	0.06	7.1	2.3	D
29	2	53	58.8	59	49.9	153	3.0	114.3	2.6	10	167	22	0.28	5.0	5.3	D
29	16	10	15.8	57	5.9	153	56.7	27.7	2.0	5	112	1	0.03	0.5	0.8	C
29	17	49	58.3	59	23.6	152	39.9	80.0	2.5	11	189	39	0.33	6.8	6.2	D

Table A1-2

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUL	29	19	18	10.5	57	8.9	152	20.5	31.9	2.5	6	265	44	0.08	3.7	1.2	D
	30	10	23	9.0	58	15.4	152	34.4	38.4	2.3	6	158	40	0.29	5.2	3.7	D
AUG	1	17	33	46.2	57	43.4	154	24.2	74.9	2.2	5	148	45	0.08	2.2	8.1	D
	2	13	53	52.6	58	23.8	153	32.8	90.0	2.7	9	106	74	0.17	2.0	5.9	C
	4	10	3	49.8	58	41.4	152	12.0	56.0	2.3	7	234	11	0.27	9.3	6.3	D
	4	11	31	57.3	57	15.3	155	31.5	28.8	1.8	5	227	54	0.27	9.1	5.4	D
	4	15	10	24.7	59	28.4	152	55.5	106.2	3.3	33	109	26	0.52	2.4	2.8	C
	4	20	14	32.0	58	21.0	154	18.0	89.8	2.8	12	145	74	0.25	2.3	6.3	D
	4	22	56	7.7	58	47.9	151	42.9	63.0	3.3	24	162	41	0.39	2.1	3.9	C
	4	23	40	15.7	61	23.3	150	2.3	36.2	2.8	16	131	30	0.76	4.8	3.3	C
	5	9	43	3.7	59	53.1	152	55.2	104.0	3.0	13	148	60	0.42	6.7	5.9	D
	5	20	29	44.0	58	38.5	152	3.6	50.5	3.3	17	154	16	0.33	2.0	3.1	C
	6	9	12	46.5	57	41.1	155	39.9	105.7	3.1	11	102	13	0.25	3.0	4.7	C
	6	11	41	4.5	59	16.9	154	38.1	166.7	3.1	13	102	31	0.44	5.2	6.3	C
	6	17	24	13.0	58	10.5	155	18.1	6.0	3.0	10	105	46	0.52	3.3	6.6	D
	8	7	37	11.3	60	10.3	153	6.7	162.3	3.7	34	74	33	0.61	2.9	4.1	C
	8	11	55	2.0	57	21.5	153	6.6	58.0	2.6	7	135	21	0.19	3.6	5.9	C
	8	18	8	39.7	57	4.6	153	56.0	36.5	3.7	26	115	2	0.74	3.4	2.3	C
	9	2	16	54.9	57	52.7	156	37.6	8.9	1.5	5	208	8	0.05	1.2	0.8	C
	9	10	27	41.5	59	56.8	153	12.4	139.5	2.4	7	143	58	0.11	2.7	5.1	D
	10	3	15	26.2	57	22.5	155	2.9	54.9	2.2	5	170	25	0.19	5.9	5.9	D
	10	3	26	54.3	60	2.7	153	23.2	179.5	3.2	14	133	53	0.39	4.9	4.5	C
	10	9	35	56.0	56	24.2	152	40.0	32.6	4.8	24	203	88	0.57	5.9	3.0	D
	10	10	25	4.4	57	13.4	155	28.7	29.1	2.2	10	101	52	0.73	5.3	5.9	C
	10	12	27	22.6	57	24.0	154	37.8	43.1	2.8	16	43	7	0.95	4.7	8.6	C
	12	19	28	15.3	61	33.1	151	14.0	71.4	3.6	22	79	72	0.51	2.7	7.2	C
	14	6	49	45.7	58	25.1	156	3.8	169.1	3.3	9	228	78	0.19	6.6	7.5	D
	15	0	52	9.9	59	51.4	153	22.5	149.3	2.9	8	145	52	0.19	4.3	7.2	D
	15	17	45	11.6	57	14.0	150	59.0	29.6	3.8	14	232	107	0.50	7.2	4.0	D
	15	18	31	46.6	58	47.7	152	55.4	67.1	2.4	8	116	38	0.27	3.2	5.4	C
	16	6	32	16.7	58	41.6	153	37.5	5.8	2.0	9	84	29	0.46	3.1	5.4	C
	17	23	40	7.8	57	50.7	156	13.0	135.5	3.4	7	214	62	0.15	4.0	5.0	D
	18	9	36	2.6	59	6.1	153	23.4	9.1	2.2	7	136	18	0.74	6.4	5.5	D
	18	15	3	11.5	57	8.6	153	50.1	58.6	2.8	9	111	45	0.26	3.0	6.1	C
	18	15	14	22.0	57	7.1	153	53.9	30.6	1.9	9	112	5	0.30	2.4	2.3	C
	19	4	28	58.2	61	56.2	150	5.4	35.5	3.1	19	54	33	0.77	5.1	5.3	C
	19	9	8	4.9	61	55.8	150	6.1	35.6	2.9	18	47	33	0.81	5.4	5.6	C
	20	16	33	15.4	58	31.5	152	21.8	49.0	2.3	7	191	11	0.28	7.5	6.6	D
	20	17	53	17.5	57	9.2	155	14.5	4.8	0.	8	99	41	0.27	2.1	4.1	C
	21	15	34	37.7	59	57.1	153	2.5	145.3	3.3	22	108	54	0.54	3.2	5.3	C
	22	0	7	38.2	58	8.4	153	40.1	61.6	3.0	9	137	31	0.17	2.1	3.4	C
	22	2	49	56.7	61	11.8	150	49.9	39.2	2.9	10	117	71	0.63	5.5	5.2	C
	22	11	24	46.2	57	11.9	155	8.5	88.0	2.3	5	153	34	0.08	3.7	7.9	D
	22	19	52	37.9	59	53.3	153	5.6	147.5	3.4	13	146	61	0.37	4.6	6.6	D
	23	1	11	30.9	59	34.5	153	20.5	119.3	2.3	7	156	21	0.27	5.6	6.9	D

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN HR	MN	TIME SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
AUG	23	6	28	31.3	57	47.9	153	14.7	45.6	2.0	5	101	29	0.08	3.7	8.5	D
	23	12	29	13.4	57	14.5	156	46.0	11.1	3.2	9	165	18	0.70	8.6	7.3	D
	23	20	53	34.0	59	53.1	153	19.0	161.6	3.0	9	144	57	0.18	4.0	5.9	D
	24	1	30	8.8	60	13.3	152	51.1	157.3	3.0	6	160	22	0.12	5.2	7.8	D
	24	15	13	49.7	57	15.4	157	16.2	114.7	2.4	5	161	29	0.08	3.1	3.8	D
	24	17	31	13.8	59	34.4	153	32.0	131.2	2.1	5	168	27	0.07	3.3	4.9	D
	25	2	23	37.7	60	14.2	152	57.4	174.0	2.7	7	153	22	0.11	4.4	6.9	C
	25	12	31	55.0	59	5.9	154	23.9	133.3	2.4	6	145	56	0.10	2.3	4.2	C
	25	17	42	37.5	59	56.1	153	12.5	150.0	3.0	17	164	59	0.39	3.8	3.4	D
	26	0	27	32.5	59	27.5	152	49.3	97.1	2.4	7	162	31	0.23	4.0	5.1	C
	26	7	27	18.3	60	34.2	153	3.9	152.3	3.1	16	95	23	0.52	4.0	5.8	C
	26	7	48	41.3	57	24.2	154	49.7	43.3	2.2	8	134	14	0.33	3.6	4.4	C
	26	9	53	56.0	59	18.8	152	53.9	111.9	2.2	7	154	30	0.14	2.3	4.1	C
	26	10	43	48.3	59	2.9	152	47.3	89.7	2.2	8	151	48	0.19	2.6	3.9	C
	26	13	6	29.6	57	21.6	156	11.2	81.2	2.6	9	146	39	0.23	2.9	3.1	C
	27	3	51	46.3	56	38.1	151	36.3	23.0	4.0	19	236	107	0.50	7.6	3.6	D
	28	3	33	38.0	59	47.0	153	9.1	131.7	2.2	6	163	47	0.24	8.8	9.1	D
	28	5	13	52.9	59	21.4	153	29.2	111.3	2.1	5	154	49	0.08	2.2	3.9	C
	28	11	33	28.0	59	15.1	153	53.5	151.5	2.3	6	149	24	0.09	4.5	7.2	C
	28	14	41	54.4	59	51.5	153	22.0	157.5	3.2	13	179	54	0.27	4.6	3.7	D
	29	9	23	29.2	59	17.3	153	35.4	116.6	2.4	6	141	10	0.12	3.8	5.2	C
	29	10	1	27.8	58	9.4	153	38.7	60.1	2.2	8	61	30	0.23	2.5	5.4	B
	30	3	10	3.7	59	52.3	153	33.8	151.6	2.4	5	193	30	0.06	4.9	4.6	D
	30	6	0	6.8	60	2.3	152	55.1	105.1	2.6	8	157	43	0.20	4.1	5.4	C
	30	8	8	46.6	57	23.0	152	4.2	31.7	3.1	10	241	47	0.45	10.0	3.3	D
	30	8	12	13.3	57	25.3	152	10.1	30.7	2.7	7	247	41	0.33	9.5	3.0	D
	30	8	23	37.7	56	9.8	157	23.8	56.3	3.2	14	196	45	0.42	5.6	8.5	D
	30	19	27	8.8	60	15.3	152	34.1	123.7	2.9	9	208	21	0.38	8.1	8.0	D
	30	20	7	59.9	59	42.8	152	31.1	100.1	3.7	30	80	40	0.55	2.6	3.8	C
	30	20	45	0.3	56	21.8	152	42.7	31.6	3.8	20	233	92	0.42	5.8	2.6	D
	30	23	28	3.3	57	53.2	156	37.2	7.7	1.8	9	191	8	0.54	5.5	3.0	D
	30	23	38	22.9	57	52.9	156	40.0	7.1	1.6	6	215	10	0.25	4.0	2.5	D
	31	10	58	23.9	57	42.9	155	25.4	67.6	1.9	5	174	8	0.12	4.7	4.4	D
	31	22	12	29.2	57	49.1	153	24.9	70.1	2.6	12	66	30	0.28	2.5	4.5	B
SEP	1	6	55	57.0	57	46.1	154	36.5	69.7	2.0	12	82	48	0.24	1.7	3.4	B
	1	13	30	15.3	60	7.4	153	8.2	160.3	3.4	21	151	38	0.49	4.6	4.3	C
	1	15	3	25.6	59	56.6	153	7.4	128.4	2.1	6	183	56	0.18	9.2	9.8	D
	1	17	59	6.9	57	43.4	153	31.1	43.1	1.2	5	104	15	0.01	0.2	0.3	C
	2	0	6	34.7	59	37.1	153	1.1	108.2	1.9	5	167	79	0.06	2.8	3.7	D
	2	1	13	17.8	59	45.5	152	33.3	107.6	2.2	6	184	39	0.13	5.2	5.6	D
	2	3	20	20.9	60	9.7	152	55.1	150.9	2.8	15	154	29	0.39	5.7	6.2	D
	2	5	39	19.3	56	32.2	155	52.4	33.3	1.9	5	180	76	0.22	0.1	0.	C
	2	20	35	27.2	58	33.9	154	0.7	99.8	2.2	10	98	60	0.21	2.1	5.1	C
	2	20	41	8.1	59	47.8	153	35.1	141.5	1.9	7	210	25	0.08	3.5	2.9	D
	3	21	33	6.5	58	42.6	152	34.0	74.8	2.2	9	130	15	0.22	3.1	3.7	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	DAY	ORIGIN HR	MN	TIME 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	4	4	40	29.4	56	29.4	154	6.5	33.8	2.4	7	290	9	0.25	6.5	2.4	D
	4	10	15	26.8	59	16.8	153	8.8	85.8	1.8	7	138	41	0.12	2.1	2.9	C
	4	12	17	48.8	60	7.3	152	33.6	118.9	2.2	6	195	35	0.12	7.0	7.2	D
	4	12	42	38.2	60	2.2	153	21.8	156.3	2.5	7	212	43	0.11	6.2	5.2	D
	4	16	39	26.7	58	43.4	153	51.1	3.5	1.7	7	136	31	0.26	2.4	3.7	C
	4	22	45	37.6	59	50.7	153	27.8	146.5	2.7	5	211	25	0.02	1.6	1.4	C
	5	0	2	47.1	59	9.1	152	18.2	60.9	2.1	5	193	58	0.01	0.4	0.5	C
	5	5	45	16.4	59	35.2	152	46.8	96.1	1.6	5	167	26	0.05	2.2	2.1	C
	5	10	28	25.3	59	57.8	153	29.9	178.4	2.6	10	162	37	0.11	2.5	3.7	C
	5	20	24	32.8	61	20.8	150	43.1	25.1	3.1	11	125	56	0.91	8.2	7.2	D
	6	1	29	21.0	59	25.2	153	7.4	101.4	2.2	7	143	19	0.11	2.2	2.3	C
	6	1	42	58.0	57	56.6	153	15.8	41.6	2.5	12	80	14	0.26	1.7	2.7	B
	6	5	48	35.4	58	7.8	153	5.3	51.0	2.5	6	233	8	0.13	4.7	3.9	D
	6	9	24	15.3	59	25.1	153	0.4	82.9	2.0	6	150	25	0.23	7.8	8.3	D
	6	13	30	20.0	61	15.9	151	49.8	92.9	2.6	11	177	107	0.49	5.8	9.5	D
	6	17	21	34.7	59	17.1	153	42.3	115.0	2.5	6	222	16	0.18	8.8	9.2	D
	7	4	7	29.3	60	10.2	152	33.3	109.9	2.2	7	212	30	0.11	3.6	4.6	D
	7	7	15	4.5	59	11.3	153	29.6	99.0	2.9	14	117	16	0.23	2.2	2.8	B
	7	13	38	19.1	60	20.6	152	12.0	98.6	2.3	5	271	32	0.06	5.8	4.9	D
	7	17	48	36.8	60	1.1	152	45.8	105.5	3.1	22	115	44	0.45	2.9	3.7	C
	7	18	11	13.5	59	35.1	153	37.0	130.3	2.2	7	175	23	0.08	3.6	3.0	C
	7	22	23	5.5	59	24.0	152	56.9	96.0	2.2	8	177	29	0.27	4.4	5.4	C
	8	19	14	52.6	58	42.0	153	35.4	8.3	1.6	5	149	28	0.04	0.8	0.9	C
	8	21	30	4.2	57	42.3	155	51.7	7.5	2.8	17	48	21	0.60	2.3	2.9	D
	8	23	15	23.3	57	50.3	153	14.1	65.1	2.2	5	134	25	0.04	1.0	1.5	C
	9	1	35	25.5	60	7.1	152	50.3	121.6	2.7	13	128	33	0.37	4.6	4.9	C
	9	1	49	9.7	59	25.4	152	36.2	90.4	2.2	8	175	42	0.19	3.6	4.8	C
	9	7	42	57.7	59	39.8	153	11.2	126.2	2.2	6	142	2	0.12	6.2	6.3	D
	9	14	23	37.3	60	10.8	152	44.1	109.7	2.3	6	177	26	0.04	1.5	1.3	C
	9	15	22	24.5	58	41.6	153	36.7	8.0	1.4	5	125	29	0.11	1.8	2.8	C
	9	15	58	56.7	62	13.0	149	28.6	33.8	4.2	22	51	66	0.51	2.5	2.6	C
	10	7	31	47.1	58	43.1	153	34.6	9.0	2.1	10	85	26	0.44	2.8	4.4	C
	10	12	11	25.4	59	59.3	153	28.4	153.0	2.3	5	215	39	0.04	3.3	3.0	D
	10	12	21	24.1	58	42.1	153	36.7	8.4	1.5	5	138	28	0.11	1.9	2.5	C
	10	16	5	33.3	58	48.4	152	56.7	62.2	2.0	8	117	37	0.15	1.9	2.7	B
	10	17	6	51.9	59	2.5	153	37.9	7.1	1.5	6	133	11	0.11	1.2	1.3	B
	11	0	51	44.1	59	1.8	153	37.9	9.0	1.7	6	126	10	0.16	1.6	1.4	B
	11	2	7	23.3	59	3.5	153	58.6	124.4	2.4	11	94	13	0.25	2.9	4.2	C
	11	18	22	37.5	59	2.0	153	37.4	8.9	1.7	6	129	10	0.12	1.2	1.0	B
	12	10	49	11.4	58	34.2	152	33.8	55.2	2.1	6	129	14	0.26	5.9	6.6	C
	13	8	9	40.7	59	17.0	153	18.1	113.8	2.5	9	130	9	0.25	3.8	4.3	C
	13	9	16	38.7	57	3.0	153	59.3	32.1	1.9	7	115	50	0.19	1.9	2.0	B
	13	20	27	41.4	58	43.4	152	37.5	72.5	2.7	11	126	19	0.35	3.8	4.9	C
	14	3	22	15.3	60	2.9	153	6.0	136.3	2.9	13	156	44	0.30	5.2	4.7	D
	14	6	47	43.4	58	9.6	156	15.8	6.4	2.6	11	181	13	0.19	1.6	1.6	C

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	MN	TIME 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 15	14	35	7.9	59	44.8	152	33.9	90.4	2.2	6	183	38	0.05	1.9	2.4	C
15	17	40	56.6	60	1.0	153	20.6	153.1	2.7	7	190	41	0.12	5.1	6.8	D
17	6	52	32.1	56	5.6	154	37.4	38.9	2.1	5	206	58	0.07	3.4	1.2	D
17	11	28	18.2	59	34.7	152	47.8	92.9	2.2	7	165	25	0.09	1.5	2.0	C
17	19	26	28.4	60	51.5	152	47.7	166.8	4.5	33	63	49	0.69	3.1	5.3	C
18	1	5	33.1	60	20.6	152	2.2	107.4	3.5	32	77	41	0.75	3.3	6.1	C
18	11	18	51.6	58	22.9	154	10.7	76.7	2.3	6	178	74	0.13	2.7	7.7	D
19	8	7	37.8	59	52.4	152	51.9	105.0	4.2	27	70	32	0.41	2.0	2.9	B
19	10	7	5.1	56	46.3	153	45.7	38.4	2.8	10	184	34	0.34	3.7	1.8	D
19	22	18	24.4	60	7.4	152	27.3	102.5	3.8	39	75	37	0.46	1.9	2.9	B
20	4	20	51.9	57	17.2	154	17.0	38.6	3.2	15	75	21	0.49	2.7	1.9	B
20	4	54	34.7	59	55.8	152	42.2	109.7	1.7	5	176	42	0.05	3.5	4.1	D
20	6	18	39.5	60	1.6	153	52.3	217.2	3.2	16	165	55	0.34	4.6	4.4	D
20	7	10	45.7	59	32.3	154	28.4	194.1	2.6	7	277	51	0.07	5.0	6.6	D
21	14	49	53.9	56	25.7	152	43.1	25.1	4.1	23	201	84	0.56	5.8	3.0	D
22	14	23	5.1	57	10.9	154	45.7	46.7	3.5	17	96	18	0.40	2.1	3.9	C
23	22	37	44.4	60	45.4	150	40.1	35.3	3.6	22	139	80	0.51	2.8	2.9	D
24	2	10	35.8	60	7.1	153	1.8	136.2	3.2	15	146	36	0.48	5.5	5.7	D
24	6	40	13.6	59	20.3	153	27.6	126.7	2.6	8	143	2	0.16	4.9	7.1	C
25	5	34	2.3	58	40.5	154	28.6	119.6	2.1	6	225	50	0.07	4.0	2.8	D
25	9	4	10.5	59	39.7	152	45.1	103.1	2.6	9	169	27	0.37	6.5	7.2	D
25	19	5	47.4	59	4.2	152	37.7	66.5	2.2	8	165	51	0.20	2.8	4.0	D
26	1	23	27.0	57	42.3	156	40.9	134.6	2.6	16	163	20	0.21	2.2	2.7	C
26	2	39	11.0	58	5.5	154	36.8	86.4	2.8	11	126	64	0.20	1.8	4.7	B
26	15	50	14.9	60	3.2	152	49.6	113.5	2.1	5	166	40	0.04	3.5	3.4	D
26	18	22	21.5	60	13.0	153	0.8	154.0	3.6	26	85	26	0.60	3.2	4.4	C
27	3	17	34.7	58	34.1	154	39.6	118.8	3.5	21	110	101	0.29	1.7	3.4	B
27	12	52	34.1	58	8.0	150	31.9	31.3	3.2	13	206	123	0.61	7.0	6.2	D
27	13	17	47.5	58	49.9	154	48.2	139.9	2.5	11	122	45	0.31	3.4	6.9	C
28	4	52	29.9	59	35.1	152	53.3	117.8	2.5	9	160	20	0.25	5.6	6.5	D
30	8	12	0.2	59	20.9	152	29.1	70.3	2.8	8	196	53	0.37	7.3	8.2	D
30	23	7	14.1	59	48.5	153	25.6	148.4	2.3	5	179	20	0.06	5.0	5.0	D

APPENDIX 2

EPICENTER LOCATION MAPS FOR OCTOBER THROUGH DECEMBER, 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 size of the letters is proportional to the magnitude of the event.

The following is a list of figures:

Figure	Caption
A2-1	Cook Inlet, all events
A2-2	Cook Inlet, class 1 events
A2-3	Kodiak-Alaska Peninsula, all events
A2-4	Kodiak-Alaska Peninsula, class 1 events

Class 1 events have the following quality parameters (see Appendix 2 for definition):

RMS $\leq$ 1 sec
ERZ $\leq$ 10 km
ERH $\leq$ 10 km
NP $<$ 5

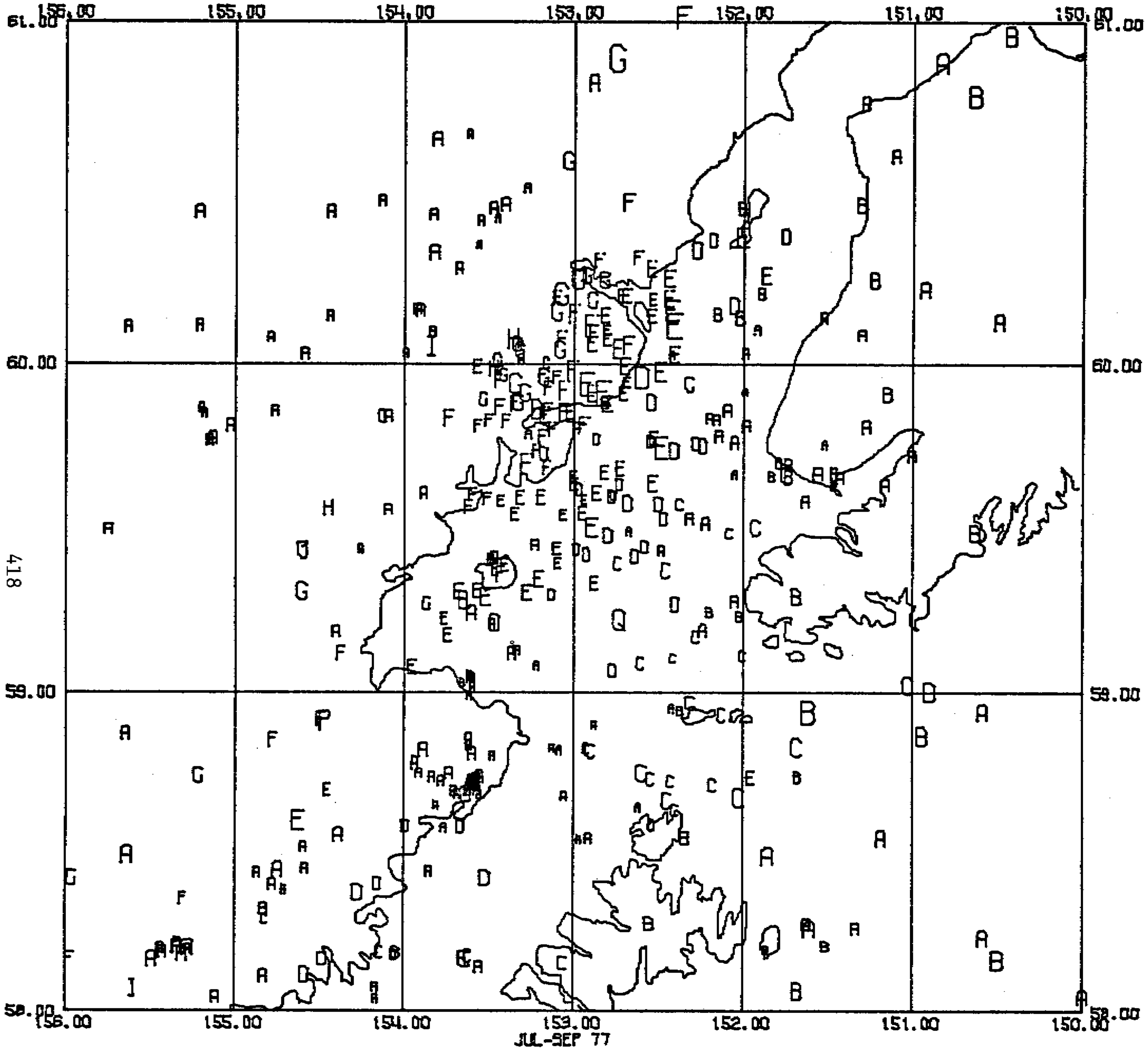

Fig. A2-1 Cook Inlet, all events

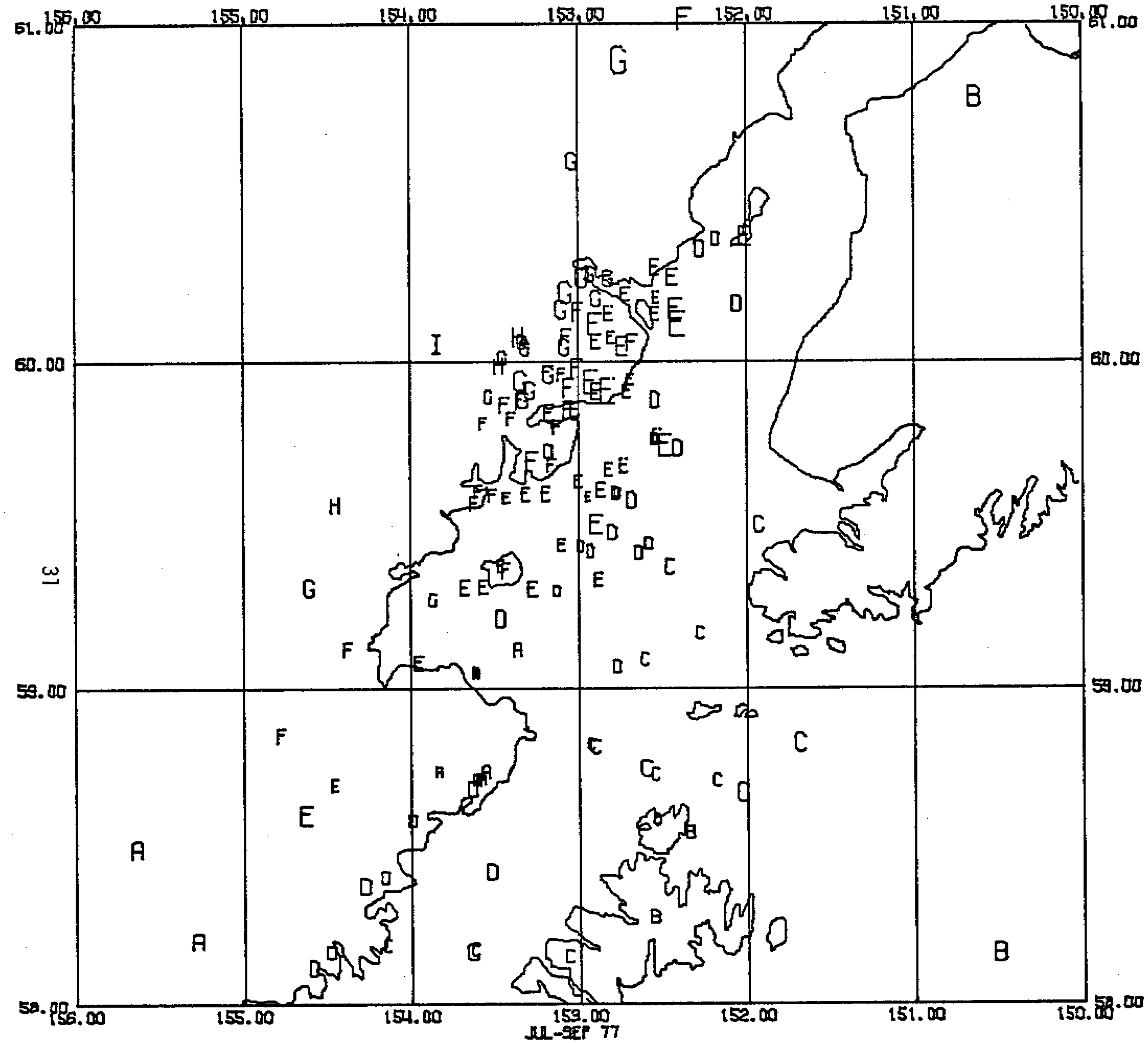

Fig. A2-2 Cook Inlet, class 1 events

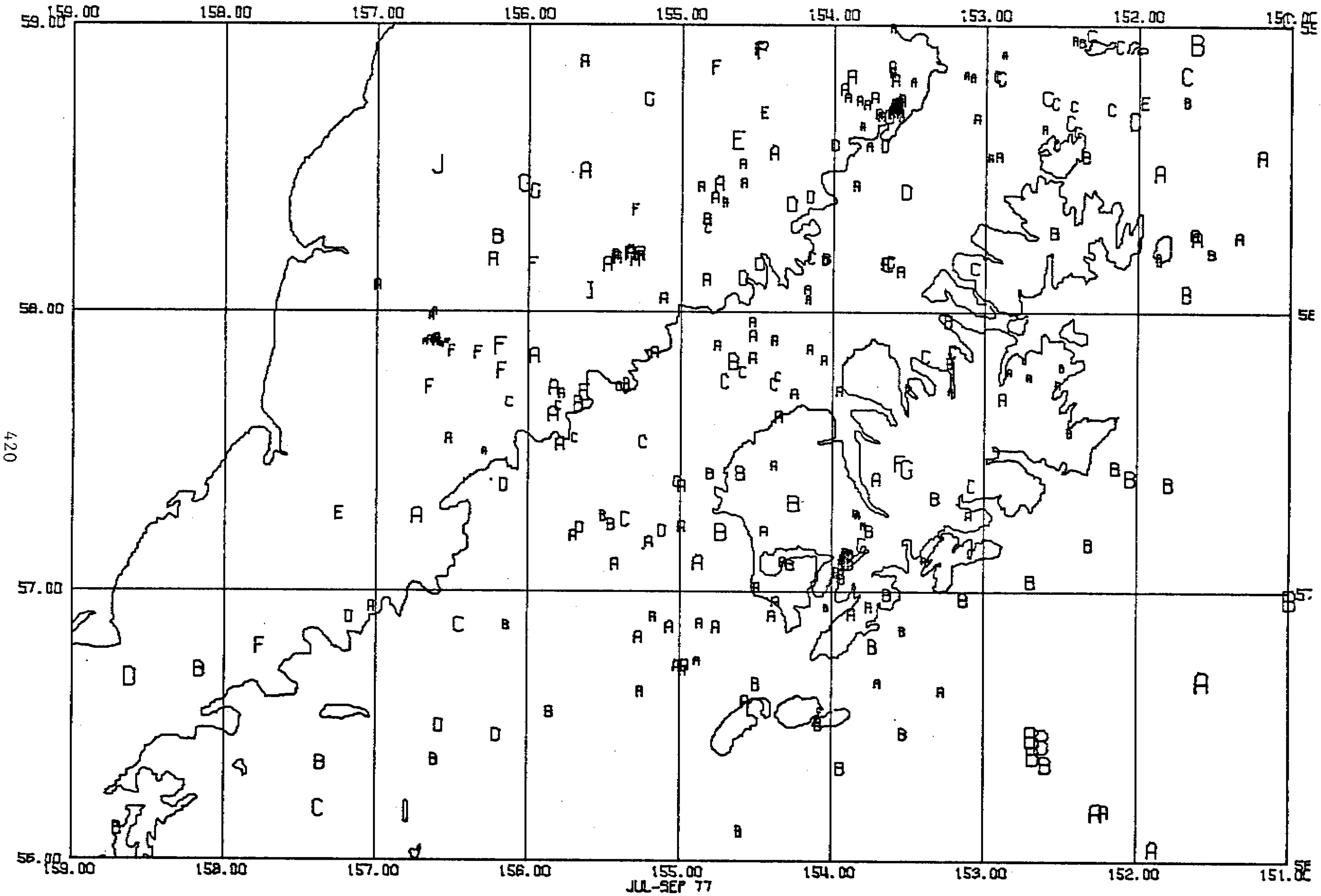

Fig. A2-3 Alaska Peninsula, Kodiak--all events

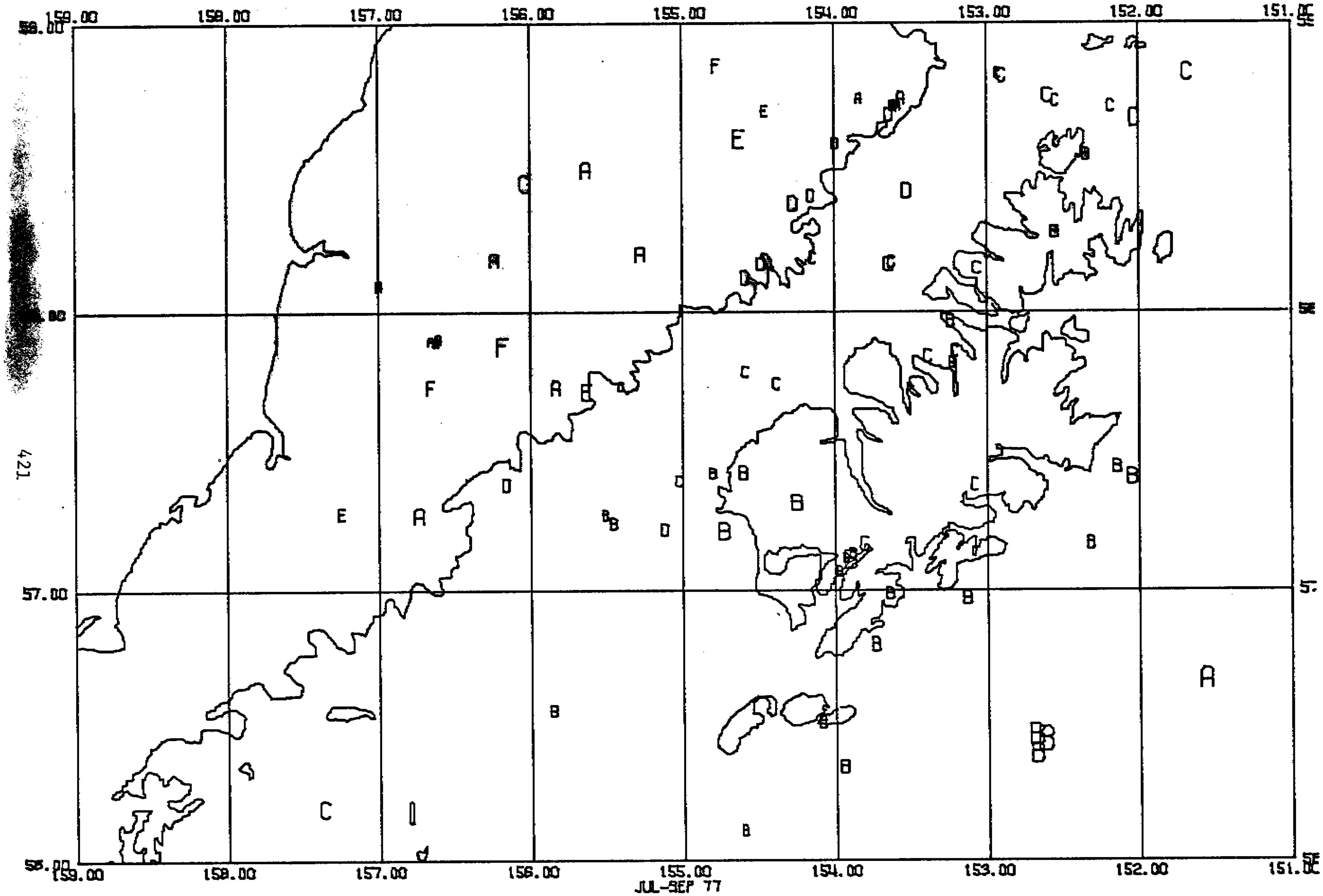

Fig. A2-4 Alaskan Peninsula, Kodiak--class 1 events

QUARTERLY REPORT

Contract #03-5-022-55
Research Unit # 253
Task Order # 1
Reporting Period: 10/1/77 - 12/31/77
Number of Pages: 4

SUBSEA PERMAFROST:
PROBING, THERMAL REGIME AND DATA ANALYSIS

T. E. Osterkamp
W. D. Harrison
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

December 31, 1977

OCS COORDINATION OFFICE
University of Alaska

Quarterly Report for Quarter Ending December 31, 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 light-weight probing techniques and appropriate data analysis (D-9).

II. Field and Laboratory Work:

No field work was done this quarter. Laboratory work consisted of testing and calibration of our salinity apparatus and our hydraulic conductivity probes. We have recalibrated our thermistor probes. We are also redesigning some of our field equipment and developing the experimental design for a hole far offshore at Prudhoe Bay.

III. Results and Interpretation:

Our data reduction is more than 75% completed and we will present the data along with pertinent discussion and interpretation in our next quarterly report. A preliminary graph of temperature profiles at various distances offshore at Tekegakrok Point is shown in Figure 1.

We offer the following comments, based on a preliminary interpretation of our data, which may be of use and interest to other investigators:

1. Kotzebue Hole

Temperatures measured just under the ice cover and at the sea bed imply that a layer of fresher water of unknown thickness, characteristics and distribution exists under the ice cover at Kotzebue. It is assumed that this water comes primarily from the Noatak and Kobuk Rivers. The implications of this fresher water for water supply for offshore drill rigs and for the city of Kotzebue could be significant. The mean annual sea bed temperature there is about +3°C with a negative temperature gradient. These results imply that the rivers feeding into Kotzebue Sound may exert a strong local influence on the temperature and salinity fields in the water column and in the subsea sediments.

2. Tekegakrok Point

We have found a thawed layer at hole 575 from 2.3 m to 5.5 m below the sea bed. This appears to be an annual effect similar to what we have observed at Prudhoe Bay. If so, the implication for artificial islands is that something like 3-4 m of surface material may become ice-bonded during the first winter. This type of information is needed to assess some of the problems of artificial islands for use as drilling platforms.

IV. Problems:

None.

V. Funds expended:

$197,202.42 as of November 30, 1977.

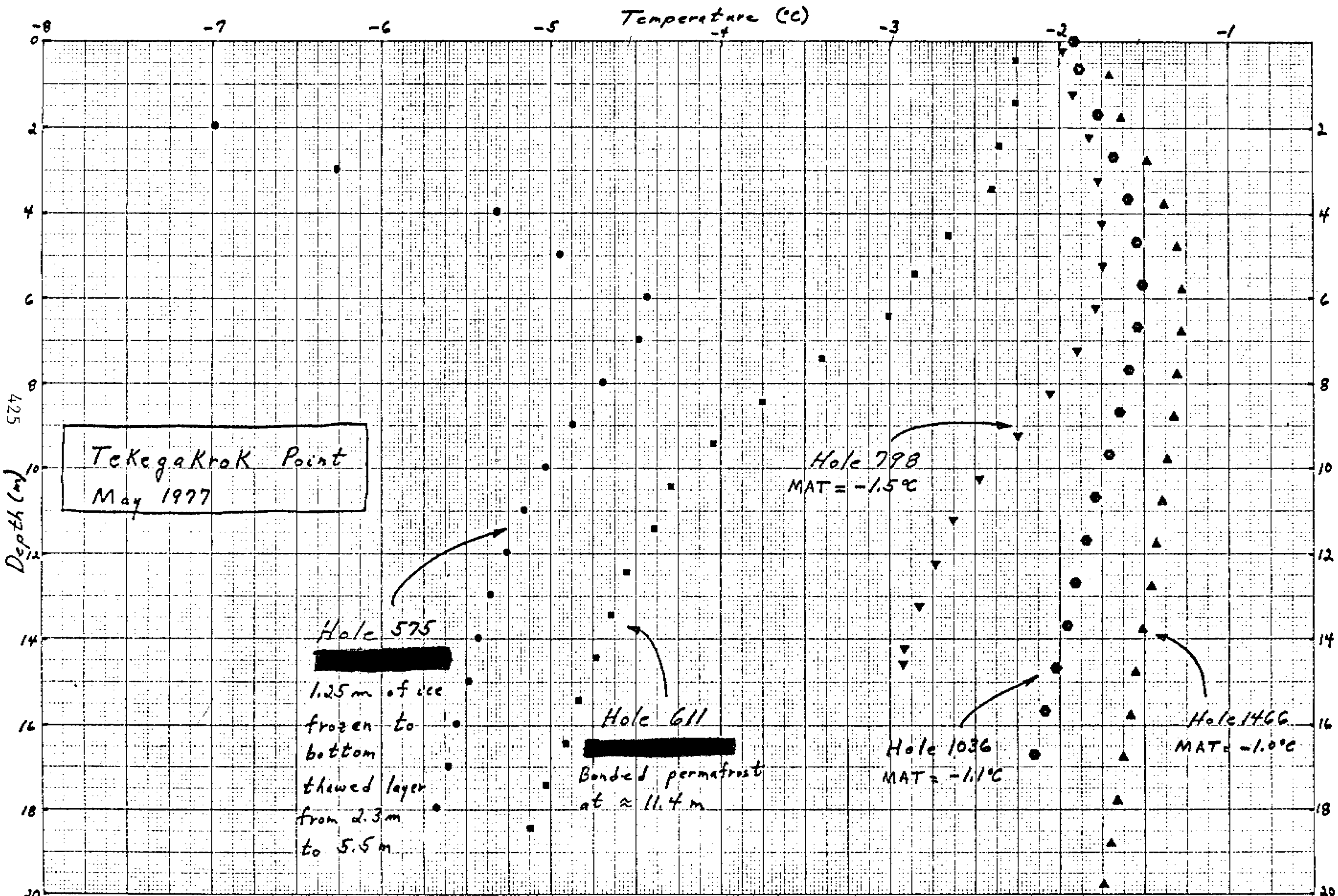

Figure 1

TO 771117

Quarterly Report

Contract #03-5-022-55
Research Unit #271
Report Period: October 1 - December 31, 1977
Number of Pages: 4

BEAUFORT SEACOAST PERMAFROST STUDIES

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(907) 272-5522

December 31, 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: None.

III. Results: Many of the refraction lines taken near Prudhoe Bay have been reduced to time distance plots. The two examples shown in Figure 1 are lines 15-12 and 15-13 respectively. The high velocities observed in the fast materials are seen to be significantly different. This difference is attributed to a difference in local surface slope at the two locations. If a value of 3000 ms^{-1} is used as an expected value, the refracting surface slope can be calculated. This calculation gives a slope of 7.8 degrees downward away from shore for line 15-12 and 2.4 degrees upward away from shore for line 15-13. These results are in general agreement with slopes reported as in previous work.

Figure 2 is a plot of the depth to the high velocity refractors observed over 12km of line which runs approximately South to North offshore from the Sag River toward Cross Island. The line was made from twenty-seven individual refraction records similar to Figure 1. The average depth to the high velocity refractor is seen to be between 20 and 30 meters. The refractor is apparently discontinuous near shore and essentially horizontal. The individual refraction points have been connected by straight lines in the figure to suggest an approximate surface although it is understood that this is only an approximation.

IV. Preliminary interpretation of results: Although the data have not all been interpreted at this time, a few conclusions can be tentatively drawn. Communication with Dave Hopkins (RU 473) indicates a rough correlation between the extent of high velocity refractors observed at depths of 20 to 30 meters offshore with consolidated clays. Presently three lines with a length of 10 - 15 km have been run in a North-South direction. Two of these have not shown continuous high velocity refractors while the third, shown in Figure 2, does show high velocity refractors. Thus, while there is good evidence that frozen materials exist at distance from 6 to 20 km offshore in some locations, this is not always the case. Presently the general characteristics of the permafrost are not well known and it may be that coastal factors such as rivers, bays and offshore islands contribute to the apparently complex behavior.

V. Problems encountered/recommended changes: None.

VI. Estimate of funds expended to date: $137,000.

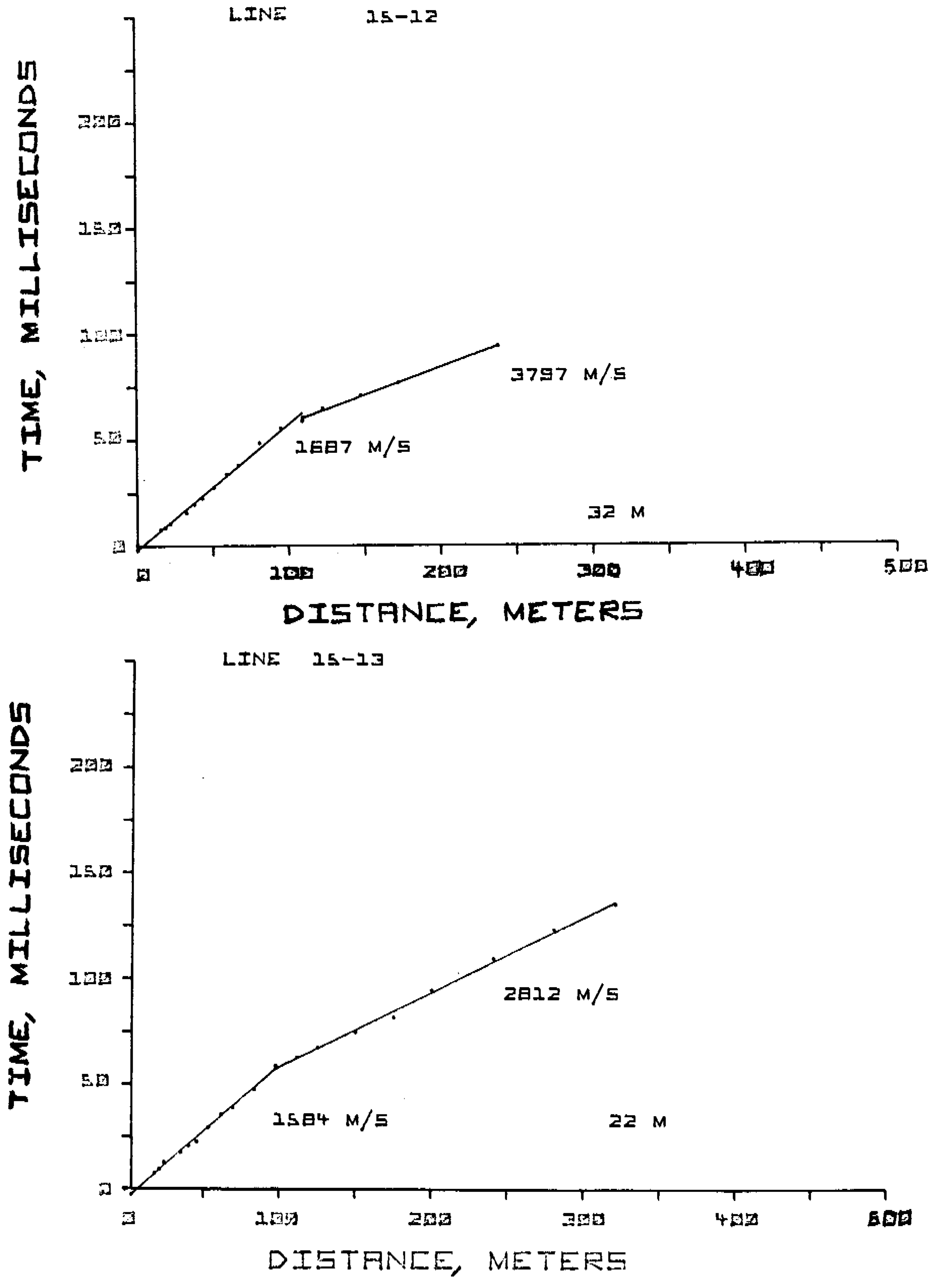


Figure 1 - Two time-distance plots of seismic refraction data taken near Prudhoe Bay.

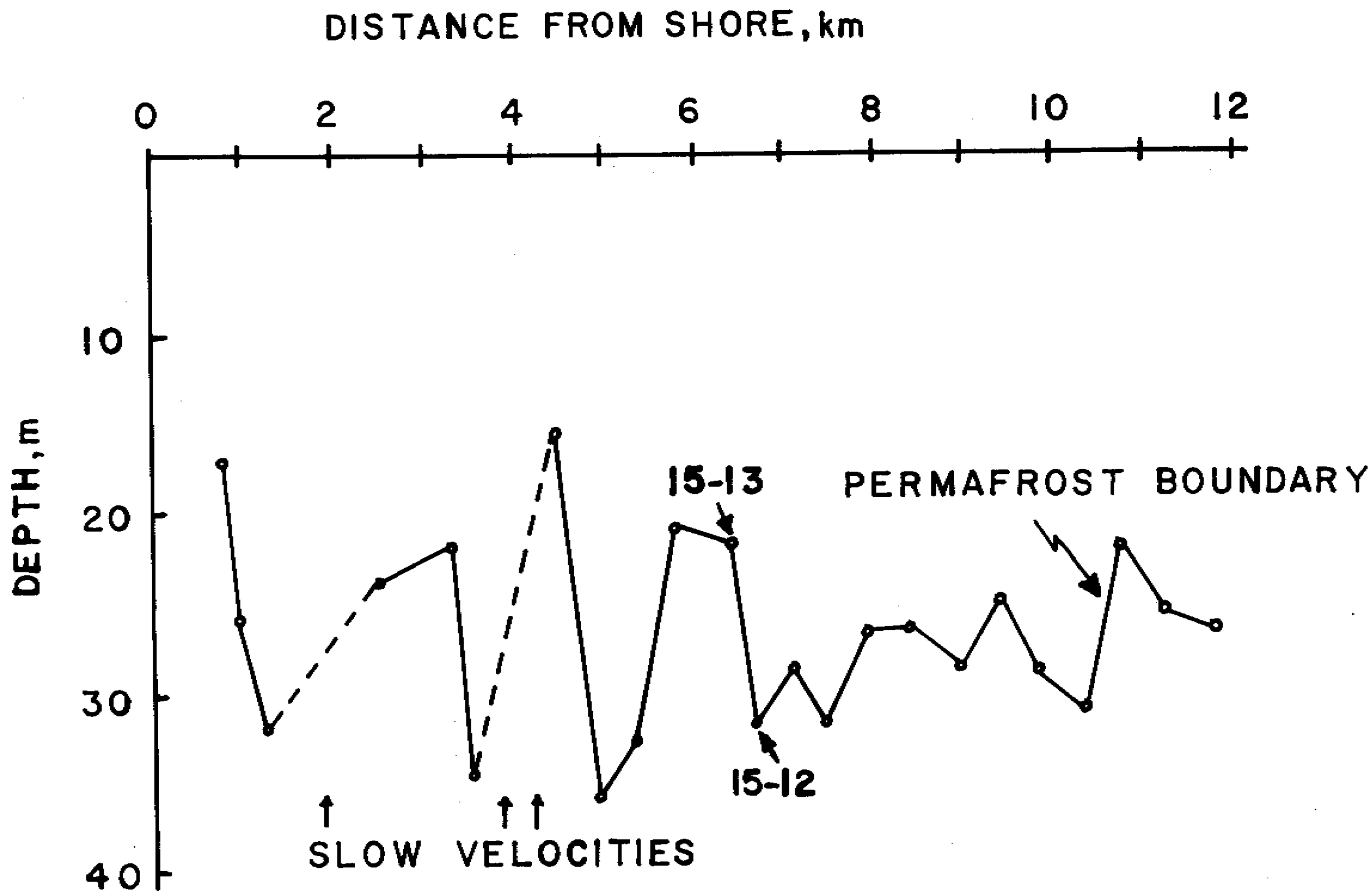


Figure 2 - Plot of approximate depths to the fast refractors versus the distance along a line running from the mouth of Sag River toward Cross Island.

QUARTERLY REPORT

Contract: #03-5-022-56
Research Unit: # 290
Task Order: #3
Reporting Period: 10/1/77-12/31/77
Number of pages: 3

BENTHOS-SEDIMENTARY SUBSTRATE INTERACTIONS

Dr. Charles M. Hoskin

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

December 1977

I. Task Objectives

This work is to provide grain size data for samples from lower Cook Inlet submitted by OCSEAP investigators. These data will identify those places which accumulate fine-grained sediment which may be ingested by benthic organisms.

II. Field Activities

None.

Laboratory Activities

Samples from Cook Inlet have not been received. A final report of work done in the southeastern Bering Sea is being prepared. There are 25 stations for which paired grain size and macrobenthos data are available (see attached map). Correlation coefficients were calculated by computer for grain size modes through the range 63-300 μm for all species occurring at 2.5 percent by weight or more. Computations were made for percent by number, percent by weight, number/m^2 and weight of a given species/m^2. Illustrative materials will include (1) a map of the geographic distribution of grain size modes, (2) a table for all correlation coefficients, and (3) scatter diagrams for selected species of number of individuals/m^2 and weight of a given species/m^2. Tabular data will be presented for quality control of the grain size data.

Ms. G. H. Kris Tommos continues her mineralogical studies of these samples, and has been working on point-counting of the sand fraction, and heavy mineral analysis. These data will be part of her MS thesis in Oceanography.

III. Results

A total of 544 correlation coefficients were computed for 136 species. The highest r value found was 0.77; eleven r values greater than 0.50 were found for number of individuals/m^2 and eleven r values greater than 0.50 were found for weight of a given species/m^2.

IV. Problems Encountered

None.

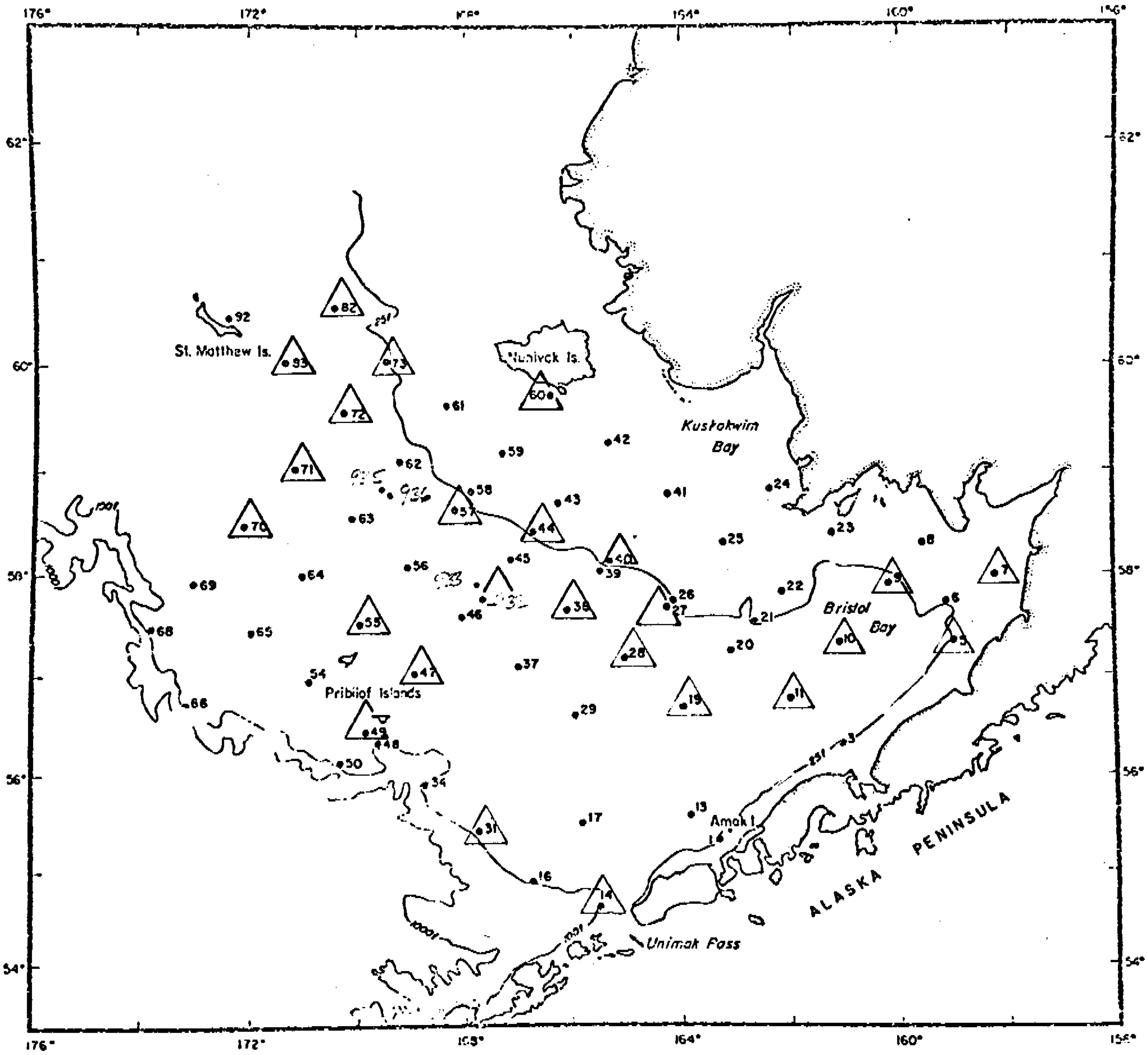


Figure 1. Index map of the southeastern Bering Sea, showing location of van Veeb grab stations.

- size data only (n = 41)
- size and macrobenthos data (n = 25)

QUARTERLY REPORT

Research Unit #: 327
Number of Pages: 12
Reporting Period: October 1 - 31 December 1977

SHALLOW FAULTING, BOTTOM INSTABILITY, AND MOVEMENT OF SEDIMENT IN LOWER COOK INLET AND WESTERN GULF OF ALASKA

Monty A. Hampton
Arnold H. Bouma

U. S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

December 20, 1977

I. Highlights of Quarter's Accomplishments:

At sea in lower Cook Inlet and western Gulf of Alaska from September 14 to October 10, 1977. Since returning to our offices in Menlo Park, routine analyses have begun, including grain-size measurements and inspection of high-resolution seismic reflection records, side-scanning sonar records, 70 mm underwater photographs, and underwater TV tapes. Goals of the ongoing analyses are to better understand the dynamics of bedforms in lower Cook Inlet, to trace sediment dispersal patterns on the Kodiak shelf, and to determine the engineering properties of volcanic ash-bearing sediments on the Kodiak shelf.

II. Task Objectives:

Assessment of the geologic hazards of lower Cook Inlet and the western Gulf of Alaska continental shelf; in particular the identification and mapping of active surface faults and areas of sediment instability.

III. Field or Laboratory Activities:

See the attached Preliminary Cruise Report for the following:

A. Ship schedule
B. Scientific party
C. Methods
D. Sample locations
E. Data collected

IV. Results:

Replotting of tracklines in lower Cook Inlet and plotting locations of bottom photographs. We are also plotting the phenomena visible on the side scan sonar records after which correlations can be made in areas with sufficient density of tracklines in order to establish size and shapes of individual bedform fields.

Grain-size measurements, inspection of geophysical and visual-format records, and measurement of geotechnical properties of ash-bearing sediments are all ongoing. No results of these analyses are yet available.

VI. Auxiliary Material:

A. Papers in preparation or in print:

Bouma, A. H., and Hamptom, M. A., 1976, Preliminary report on the surface and shallow subsurface geology of lower Cook Inlet and Kodiak Shelf, Alaska: U.S. Geological Survey Open-File Report 76-695, 36 p., 9 maps.

Bouma, A. H., and Hampton, M. A., 1976, Large sandwaves and other bedforms in lower Cook Inlet, Alaska (abstract): Conference on Marine Slope Stability, Louisiana State University, Oct. 14 and 15, 1976.

Bouma, A. H., Hampton, M. A., and Orlando, R. C., 1977, Sandwaves and other bedforms in lower Cook Inlet, Alaska: Marine Geotechnology, v. 21, in press.

Bouma, A. H., Hampton, M. A., Wennekens, M. P., and Dygas, J. A.. 1977, Large dunes and other bedforms in lower Cook Inlet, Alaska: Preprints 1977 Offshore Technology Conference, Paper 2737, p. 79-85.

Bouma, A. H. Hampton, M. A., Frost, T. P., Torresan, M. E., Orlando, R. C., and Whitney, J. W., 1977, Bottom characteristics of lower Cook Inlet, Alaska: U.S. Geological Survey Open-File Report 77- , 91 p.

Bouma, A. H., Hampton, M. A., Rappeport, M. L., Whitney, J. W., Teleki, P. G., and Orlando, R. C., 1978, Movement of sandwaves in lower Cook Inlet: submitted to Offshore Technology Conference.

Hampton, M. A., and Bouma, A. H., 1976, Seismic profiles of lower Cook Inlet and Kodiak Shelf, R/V SEA SOUNDER, June-July, 1976: U.S. Geological Survey Open-File Report 76-848, 36 p., 4 maps, 9 rolls.

Hampton, M. A., and Bouma, A. H., 1977, Seismic reflection records showing stable and unstable slopes near the shelf break, western Gulf of Alaska: U.S. Geological Survey Open-File Report 77-702, 31 p.

Hampton, M. A., and Bouma, A. H., 1977, Slope instability near the shelf break, western Gulf of Alaska: Marine Geotechnology, v. 2, in press.

Hampton, M. A., Bouma, A. H., and Frost, T. P., 1977, Volcanic ash in surficial sediments of the Kodiak shelf - an indicator of sediment dispersal patterns: submitted to Marine Geology.

Hampton, M. A., Bouma, A. H., and Torresan, M. E. 1977, Surface microtextures on quartz and grains from the lower Cook Inlet, Alaska: submitted to Geology.

Hampton, M. A., Bouma, A. H., Sangrey, D. A., Carlson, P. R., Molnia, B. F., and Clukey, E. C., 1978, Quantitative study of slope instability in Gulf of Alaska: submitted to Offshore Technology Conference.

Hein, J. R., Bouma, A. H., and Hampton, M. A., 1977, Distribution of clay minerals in lower Cook Inlet and Kodiak Shelf sediment, Alaska: U.S. Geological Survey Open-File Report 77-581, 17 p.

VII. Problems Encountered/Recommended Expended:

Weather-related to problems were significant during this year's ship operations.

VIII. Estimate of Funds Expended:

About one quarter of the available funds.

CRUISE REPORT

OF THE
BRANCH OF MARINE GEOLOGY
U.S. GEOLOGICAL SURVEY, MENLO PARK, CA

FOR

CRUISE -S7-77-WG-

GENERAL CRUISE INFORMATION

AREA: W. GULF OF ALASKA / S. COOK INLET, KODIAK SHELF, SHUMAGIN IS

SHIP: R/V SEA SOUNDER

CHIEF SCIENTIST(S): ARNOLD BOUMA / MONTY HAMPTON

TYPE OF DATA
COLLECTED: GEOPHYSICAL, GEOLOGICAL, HYDROGRAPHIC

CRUISE DATES:	LOCAL DATE/TIME*	TIME(JD/GMT)	PORT
START CRUISE:	14 SEP 7 8 HRS	257/17 8	LV KODIAK, AK
END CRUISE:	10 OCT 7 0 HRS	283/17 0	SEWARD AK, END CRUZ

PORT STOPS:

1.	ARRIVE:	16 SEP 723 HRS	259/1723	ARRIVE HOMER, AK
	LEAVE:	17 SEP 457 HRS	260/1457	LEAVE HOMER, AK
2.	ARRIVE:	18 SEP 845 HRS	261/1845	ARRIVE IN HOMER, AK
	LEAVE:	18 SEP 1253 HRS	261/2253	DEPART HOMER
3.	ARRIVE:	21 SEP 7 0 HRS	264/17 0	ARRIVE IN HOMER
	LEAVE:	22 SEP 8 4 HRS	265/18 4	DEPART PORT HOMER
4.	ARRIVE:	25 SEP 930 HRS	268/1930	ARRIVE (HOME)-R
	LEAVE:	27 SEP 9 0 HRS	270/19 0	LEAVE HOMER START LEG 2
5.	ARRIVE:	29 SEP 5 0 HRS	272/15 0	IN PORT KODIAK, AK
	LEAVE:	29 SEP 13 1 HRS	272/23 1	LEAVE PORT KODIAK, AK

* EXPRESSED IN LOCAL STANDARD TIME.

	HOURS	DAYS & HOURS
TOTAL UNDERWAY TIME:	517	21 DAYS 13 HRS
TOTAL PORT TIME:	106	4 DAYS 10 HRS

PERSONNEL LIST

NAME	AFFIL	DUTIES	ABOARD	ASHORE
MCCLENAGHEN, ALAN		SHIP CAPTAIN		
SHEPPARD, HOWARD ON BOAR		CHIEF ENGINEER		
JOHANNESEN,ORNULF ABOARD		CHIEF MATE		
HAMPTON, MONTY		CHIEF SCIENTST	254/19 0	
BOUMA, ARNOLD		CHIEF SCIENTST	254/19 0	283/17 0
FROST, THOMAS		GEOLOGIST	254/19 0	269/17 0
COLBURN, IVAN		GEOLOGIST	254/19 0	269/17 0
BATSON, RAY		GEOLOGIST	254/19 0	264/18 0
MCTIGUE, DAVID		GEOLOGIST	254/19 0	283/17 0
SWENSON, PHYLLIS		GEOLOGIST	254/19 0	283/17 0
RAPPEPORT, MEL		GEOLOGIST	254/19 0	269/17 0
PARSON, CHUCK		GEOLOGIST	254/19 0	269/17 0
DYGAS, JOE		GEOLOGIST	254/19 0	260/1445
THURSTON, DENNIS		GEOLOGIST	254/19 0	260/1445
GUTMACHER, CHRIS		GEOLOGIST	254/19 0	283/17 0
TELEKI, PAUL		GEOLOGIST	260/1445	268/2030
WHITNEY, JOHN		GEOLOGIST	260/1445	268/2030
SCHWAB, BILL		GEOLOGIST	261/17 0	269/17 0
ORLANDO, ROBERT		GEOLOGIST	261/2250	269/17 0
BRITCH, BOB		GEOLOGIST	261/2250	264/13 0
TORRESAN, MICHAEL		GEOLOGIST	261/2250	
BALTIERRA, JOHN		GEOLOGIST	261/2250	269/17 0
SWEET, BILL		GEOLOGIST	269/17 0	283/17 0
KOSKI, RANDY		GEOLOGIST	269/17 0	283/17 0
TURNER, BRUCE		GEOLOGIST	269/17 0	283/17 0
SANGREY, DWIGHT		GEOLOGIST	269/17 0	283/17 0
TANNER, GORDON		ELECTRONICS T	254/19 0	283/17 0
NOVAK, BOB		ELECTRONICS T	269/17 0	283/17 0
STEVENSON, ANDREW		MECHANICAL T	254/19 0	283/17 0
IRWIN, BARRY		NAVIGATOR	254/19 0	283/17 0
CLUKEY, ED		UNSP INVESTIGATR	269/17 0	283/17 0

EQUIPMENT SYSTEMS USED

NAVIGATIONAL	GEOPHYSICAL	GEOLOGICAL	HYDROGRAPHICAL
LORAN C	DIGITRACK	PISTON CORE	TRANSMISSOMETER
MINIRANGER	SNGL CHANL ARCER	GRAVITY CORE	TEMP/SALINOMETER
INTEGRATED NAV	UNIBOOM	SOUTAR GRAB	EXP BATHY THERMO
	MINISPARKER	SEAFLOOR CAMERA	HYD CURRENT METR
	SIDE SCAN SONAR	TELEVISION	
	3.5KH BATHYMETR	PENETROMETER	
	12KH BATHYMETRY	HYDROPLAST. CORE	
	SHIPBOARD GRAVTY		

DATA COLLECTED

GEOPHYSICAL

DATA TYPE OR SYSTEM	RECORDING MEDIUM	TRACKLINE KILOMETERS	TRACKLINE N. MILES	RECORDING TIME(HRS)	ROLL,REEL LIST QTY
SNGL CHANL ARCER	ANL PAPER ROLL	1213.1	655.0	117.9	4
UNIBOOM	ANL PAPER ROLL	774.6	418.2	85.6	13
MINISPARKER	ANL PAPER ROLL	507.7	274.1	56.9	3
SIDE SCAN SONAR	ANL PAPER ROLL	742.3	401.1	85.7	28
3.5KH BATHYMETRY	ANL PAPER ROLL	3758.7	2029.5	395.7	27
12KH BATHYMETRY	ANL PAPER ROLL	3350.6	1809.2	355.8	25
BATHYMETRY + NAV	DIGIT MAG TAPE	3966.7	2141.9	591.3	7
	PRINTR LISTING	3272.6	1767.1	600.5	4
SHIPBOARD GRAVTY	DIGIT MAG TAPE	1512.7	816.8	187.9	6
	ANL PAPER ROLL	1269.7	685.6	169.4	5

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	21	10	0	10	0
PISTON CORE	1	1	0	1	0
HYDROPLAST. CORE	1	0	0	0	0
SOUTAR GRAB	40	23	7	16	0
TOTALS	63	34	7	27	0

GEOLOGICAL/HYDROLOGICAL (ANALOG)

DATA TYPE OR SYSTEM	RECORDING MEDIUM	RECORDING TIME(HRS)	NUMBER OF TAPES, ROLLS,LISTS,ETC.
TELEVISION	ANLOG MAG TAPE	4.8	4
SEAFLOOR CAMERA	PHOTOGRAPH	4.9	3
TEMP/SALINOMETER	ANL PAPER ROLL	497.6	4

NUMERICAL OBSERVATION

DATA TYPE OR SYSTEM	NUMBER OF READINGS	TAKEN OVER HOW MANY STATIONS
PENETROMETER	3	2

NAVIGATIONAL

DATA TYPE OR SYSTEM	RECORDING MEDIUM	NUMBER OF TAPES, ROLLS, LISTS, ETC.
DR NAV PLOT/LAB	MAP OR PLOT	19
MINIRANGER	PRINTR LISTING	4
DR NAV PLOT/BRIG	MAP OR PLOT	2

OPERATIONS INFORMATION

STATION DATA   STATIONS OCCUPIED: 51,   TOTAL TIME ON STATION: 69.0 HRS,

TRACKLINES   TRACKLINES RUN: 102,   TOTAL TRACKLINE TIME: 254.6 HRS,

CUMULATIVE TRACKLINE DISTANCE: 2733.7 KM / 1476.1 N. MILES

DEPLOYMENTS

SIDE SCAN MARK 4 / EXP BATHY THERMO 1

SHIP: R/V SEA SOUNDER CRUISE LOCATOR: S7-77-WG
ID -YR-AREA

CHIEF
SCIENTIST: BOUMA / HAMPTON

JUL. DAY	TIME (GMT)	CRUISE/DATA INFO RECORD. MEDIUM	SEQNCE NUMBER	DATA STATUS/ INSTITUTE	PERSONNEL, PORTS, EQUIPMENT DESCRIPTION LINE#	OR: STA./SHOT PT.#	WATER DEPTH UNCOR.	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DATA DESCRIPTION, COMMENTS OR OBSERVATIONS
		GRAVITY CORE		SAMPLE ATTEMPTS								
258	951.0	SAMPLE	201G1	NO RECO	L#	STN/SP# 201	0126 M	58	40.83	-152	13.19	GRAV ON BOTTOM
258	1454.0	SAMPLE	203G1	RECOVERY	L#	STN/SP# 203	0149 M	58	46.38	-153	2.54	1 METER OF MUD
273	7 2.0	SAMPLE	215G1	RECOVERY	L#	STN/SP# 215	0115 M	57	11.38	-152	25.88	19 CM. SHELL AND ASH SAN
273	1459.0	SAMPLE	218G1	NO RECO	L#	STN/SP# 218	0097 M	56	51.40	-152	3.52	ON BOTTOM
273	2320.0	SAMPLE	221G1	RECOVERY	L#	STN/SP# 221	0191 M	56	41.41	-151	51.86	57CM. SAND & CLY,PEB SAN
274	146.0	SAMPLE	222G1	RECOVERY	L#	STN/SP# 222	0942 M	56	36.90	-151	46.47	10 CM MUDDY,SANDY GRAVEL
274	2147.0	SAMPLE	223G1	RECOVERY	L#	STN/SP# 223	1302 M	56	45.70	-151	32.91	ON STONE
274	22 8.0	SAMPLE	223G2	NO RECO	L#	STN/SP# 223	1303 M	56	45.46	-151	32.78	GRAV ON BOTTOM
274	2347.0	SAMPLE	223G3	NO RECO	L#	STN/SP# 223	1303 M	56	45.38	-151	32.78	GRAV ON BOTTOM
275	044.0	SAMPLE	224G1	RECOVERY	L#	STN/SP# 224	0992 M	56	47.59	-151	33.00	270 CM. OLIVE GREEN MUD
275	738.0	SAMPLE	225G1	RECOVERY	L#	STN/SP# 225	0601 M	56	47.87	-151	37.46	GRAV ON BOTTOM
275	849.0	SAMPLE	226G1	NO RECO	L#	STN/SP# 226	0351 M	56	48.28	-151	40.79	GRAV ON BOTTOM
275	9 7.0	SAMPLE	226G2	NO RECO	L#	STN/SP# 226	0370 M	56	48.06	-151	40.00	GRAV #2 ON BOTTOM
275	1432.0	SAMPLE	227G1	NO RECO	L#	STN/SP# 227	0370 M	57	5.63	-151	13.97	ON BOTTOM NO RECOVERY
275	1444.0	SAMPLE	227G2	NO RECO	L#	STN/SP# 227	0366 M	57	5.64	-151	14.08	ON BOTTOM NO RECOVERY
276	027.0	SAMPLE	231G1	RECOVERY	L#	STN/SP# 231	0182 M	57	24.29	-151	22.35	GRAV ON BOTTOM
276	1535.0	SAMPLE	232G1	NO RECO	L#	STN/SP# 232	0260 M	57	22.06	-150	35.97	ON BOTTOM
278	2327.0	SAMPLE	239G1	RECOVERY	L#	STN/SP# 239	0975 M	57	51.00	-149	7.86	3 METERS LONG
279	253.0	SAMPLE	240G1	RECOVERY	L#	STN/SP# 240	1415 M	57	48.35	-149	5.39	GRAV ON BOTTOM LONG CORE
279	516.0	SAMPLE	241G1	NO RECO	L#	STN/SP# 241	0572 M	57	41.45	-149	38.94	ON BOTTOM
279	526.0	SAMPLE	241G2	NO RECO	L#	STN/SP# 241	0556 M	57	41.39	-149	39.03	PEBBLY SAND INCORE CATCH
		PISTON CORE		SAMPLE ATTEMPTS								
275	426.0	SAMPLE	224P1	RECOVERY	L#	STN/SP 224	1034 M	56	46.50	-151	34.84	415 CM.
		HYDROPLAST. CORE		SAMPLE ATTEMPTS								
273	2257.0	SAMPLE	221H1	NO RECO	L#	STN/SP# 221	0173 M	56	41.41	-151	51.40	HYDROPLASTIC CORE
		SOUTAR GRAB		SAMPLE ATTEMPTS								
258	730.0	SAMPLE	200S1	NO RECO	L#	STN/SP# 200	0163 M	58	36.58	-151	50.09	VANV ON BOTTOM
258	739.0	SAMPLE	200S2		L#	STN/SP# 200	0160 M	58	36.77	-151	50.25	PEBBLY MEODY SAND
258	1016.0	SAMPLE	201S1	RECOVERY	L#	STN/SP# 201	0126 M	58	41.20	-152	14.19	PEBBLY MUDDY SAND
258	1218.0	SAMPLE	202S1	RECOVERY	L#	STN/SP# 202	0190 M	58	44.54	-152	41. [illegible]	FULL SANDY MUD
258	1622.0	SAMPLE	204S1	RECOVERY	L#	STN/SP# 204	0164 M	58	51.35	-152	54.17	PEBBLY MUDDY SAND
258	1830.0	SAMPLE	205S1	RECOVERY	L#	STN/SP# 205	0118 M	58	58.84	-153	16.35	SOUTAR GRAB SAMPLE
271	1656.0	SAMPLE	213S1	RECOVERY	L#	STN/SP# 213	0063 M	59	29.64	-152	28.38	1/2 FULL CLEAN SAND
271	1719.0	SAMPLE	214S1	RECOVERY	L#	STN/SP# 214	0063 M	59	27.96	-152	26.48	ON BOTTOM
273	938.0	SAMPLE	216S1	RECOVERY	L#	STN/SP# 216	0096 M	57	6.01	-152	20.60	15 CM SAND & VOLANIC ASH
273	1117.0	SAMPLE	217S1	RECOVERY	L#	STN/SP# 217	0075 M	57	0.64	-152	11.03	10 CM SANDY SILTY MUD
273	2057.0	SAMPLE	219S1	RECOVERY	L#	STN/SP# 219	0079 M	56	42.61	-151	53.55	SANDY GRAVEL VOLC. ASH
273	2142.0	SAMPLE	220S1	NO RECO	L#	STN/SP# 220	0062 M	56	43.74	-151	55.90	ON BOTTOM

SHIP: R/V SEA SOUNDER CRUISE LOCATOR: S7-77-WG
ID -YR-AREA

CHIEF
SCIENTIST: BOUMA / HAMPTON

JUL. DAY	TIME (GMT)	CRUISE/DATA INFO RECORD. MEDIUM	SEQNCE NUMBER	DATA STATUS/ INSTITUTE	PERSONNEL,PORTS,EQUIPMENT DESCRIPTION OR: LINE#	STA./SHOT PT.#	WATER DEPTH UNCOR.	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DATA DESCRIPTION,COMMENTS OR OBSERVATIONS
		SOUTAR GRAB		SAMPLE ATTEMPTS (CONTINUED)								
273	2147.0	SAMPLE	220S2	NO RECO	L#	STN/SP# 220	0062 M	56	43.76	-151	55.94	ON BOTTOM
273	2154.0	SAMPLE	220S3	NO RECO	L#	STN/SP# 220	0061 M	56	43.78	-151	55.91	ON BOTTOM
273	22 3.0	SAMPLE	220S4	RECOVERY	L#	STN/SP# 220	0062 M	56	43.81	-151	55.83	32CM & 5 CM.DIAM.BOULDER
274	2254.0	SAMPLE	223S1	RECOVERY	L#	STN/SP# 223	1303 M	56	45.09	-151	33.36	10CM. SILTY MUD, WORMS
275	1512.0	SAMPLE	227S1	NO RECO	L#	STN/SP# 227	0358 M	57	5.76	-151	13.99	ON BOTTOM NO RECOVERY
275	1656.0	SAMPLE	227S2	RECOVERY	L#	STN/SP# 22‾	0372 M	57	5.59	-151	13.97	12CM.GRAY,SILTY,SNDY CLA
275	18 4.0	SAMPLE	228S1	RECOVERY	L#	STN/SP# 228	0185 M	57	7.51	-151	15.20	12 CM. GRAVELLY SAND
275	1944.0	SAMPLE	229S1	RECOVERY	L#	STN/SP# 229	0172 M	57	14.21	-151	20.03	2-3CM SILTY SAND,SNDY SL
276	033.0	SAMPLE	234S2	NO RECO	L#	STN/SP# 234	0094 M	57	24.35	-151	22.51	SOUTAR ON BOTTOM
276	1558.0	SAMPLE	232S1	RECOVERY	L#	STN/SP# 232	0262 M	57	22.02	-150	35.89	SMALL SAMPLE SAND, GRAVE
276	1610.0	SAMPLE	232S2	NO RECO	L#	STN/SP# 232	0262 M	57	22.11	-150	35.62	SMALL SAMPLE SAND, GRAVE
276	1748.0	SAMPLE	233S1	NO RECO	L#	STN/SP# 233	0618 M	57	17.88	-150	34.87	ON BOTTOM NO RECOVERY
276	1811.0	SAMPLE	233S2	NO RECO	L#	STN/SP# 233	0633 M	57	17.66	-150	[illegible].16	ON BOTTOM NO RECOVERY
276	1835.0	SAMPLE	233S3	NO RECO	L#	STN/SP# 233	0650 M	57	17.46	-150	35.72	ON BOTTOM NO RECOVERY
276	2249.0	SAMPLE	234S1	RECOVERY	L#	STN/SP# 234	0093 M	57	31.54	-150	49.42	SMALL AMOUNT GRAVELLYSAN
277	350.0	SAMPLE	235S1	NO RECO	L#	STN/SP# 235	0258 M	57	31.19	-150	18.05	SUTR ON BOTTOM
277	1444.0	SAMPLE	236S1	NO RECO	L#	STN/SP# 236	0230 M	58	4.11	-149	28.59	ON BOTTOM PRETRIP
277	15 2.0	SAMPLE	236S2	RECOVERY	L#	STN/SP# 236	0230 M	58	4.16	-149	28.20	20CM. SANDY MUD-MUDDY SN
277	1652.0	SAMPLE	237S1	NO RECO	L#	STN/SP# 237	0134 M	57	57.35	-149	40.57	ON BOTTOM PRETRIP
279	557.0	SAMPLE	241S1	NO RECO	L#	STN/SP# 241	0595 M	57	41.35	-149	38.70	ON BOTTOM-DIDNOT TRIGGER
279	626.0	SAMPLE	241S1	RECOVERY	L#	STN/SP# 241	0606 M	57	41.29	-149	39.16	1/2 FULL
279	921.0	SAMPLE	242S1	RECOVERY	L#	STN/SP# 242	0300 M	57	31.33	-150	16.62	20% REC. MUDDY FINE SAND
279	1249.0	SAMPLE	243S1	RECOVERY	L#	STN/SP# 243	0190 M	57	48.49	-150	1.19	MUDDY SAND OVER MEDIUM S
279	14 1.0	SAMPLE	244S2	NO RECO	L#	STN/SP# 244	0257 M	57	51.65	-149	50.87	ON BOTTOM
279	14 6.0	SAMPLE	244S1	NO RECO	L#	STN/SP# 244	0256 M	57	51.53	-149	50.80	ON BOTTOM NO TRIGGER
279	1438.0	SAMPLE	244S3	RECOVERY	L#	STN/SP# 244	0257 M	57	51.72	-149	50.93	ON BOTTOM 11 CM. SAND
279	1557.0	SAMPLE	245S1	RECOVERY	L#	STN/SP# 245	0135 M	57	57.61	-149	39.66	GRAVEL OVER MUDDY SAND
279	19 9.0	SAMPLE	246S1	RECOVERY	L#	STN/SP# 246	0134 M	58	12.76	-149	13.41	21 CM. GRAVELY SAND
		TELEVISION		ANLOG MAG TAPES								
263	516.0	REEL	1	START	L#	STN/SP# 206	0066 M	59	28.49	-152	41.73	CAMERA ON BOTTOM
263	544.0		1	OFF	L#	STN/SP# 206	0000	59	28.49	-152	43.01	CAMERA UP WINCH PROBLEM
263	546.0		1	ON	L#	STN/SP# 206	0000	59	28.60	-152	42.83	CAMERA ON BOTTOM
263	616.0	REEL	1	END	L#	STN/SP# 206	0000	59	30.20	-152	40.11	VIDEO TAPE RAN OUT
263	857.0	REEL	2	START	L#	STN/SP#	0000	59	32.84	-152	38.86	
263	10 7.0		2	OFF	L#	STN/SP#	0064 M	59	31.69	-152	37.62	
270	2210.0		2	ON	L#	STN/SP# 209	0042 M	59	33.82	-151	56.28	CAMERA ON BOTTOM
270	2247.0		2	OFF	L#	STN/SP# 209	0039 M	59	33.69	-151	57.82	CAMERA OFF BOTTOM
271	029.0		2	ON	L#	STN/SP# 210	0044 M	59	33.32	-152	9.82	CAMERA ON BOTTOM
271	047.0	REEL	2	END	L#	STN/SP# 210	0044 M	59	33.03	-152	10.65	CAMERA OFF BOTTOM
271	135.0	REEL	3	START	L#	STN/SP# 211	0071 M	59	33.16	-152	16.24	CAMERA ON BOTTOM
271	138.0		3	OFF	L#	STN/SP# 211	0000	59	33.28	-152	16.17	NO FLASH CAMERA UP
271	1252.0		3	ON	L#	STN/SP# 212	0064 M	59	31.08	-152	33.42	BOTTOM 0-131
271	1351.0	REEL	3	END	L#	STN/SP# 212	0068 M	59	31.34	-152	31.35	131-1007 OFF BOTTOM
278	9 3.0	REEL	4	START	L#	STN/SP# 238	0191 M	57	56.29	-150	10.28	ON BOTTOM STEVENSON TRGH

SHIP: R/V SEA SOUNDER CRUISE LOCATOR: S7-77-WG
ID -YR-AREA

CHIEF
SCIENTIST: BOUMA / HAMPTON

JUL. DAY	TIME (GMT)	CRUISE/DATA INFO RECORD. MEDIUM	SEQNCE NUMBER	DATA STATUS/ INSTITUTE	PERSONNEL,PORTS,EQUIPMENT DESCRIPTION OR: LINE#	STA./SHOT PT.#		WATER DEPTH UNCOR.	LATITUDE DEG MIN	LONGITUDE DEG MIN	DATA DESCRIPTION,COMMENTS OR OBSERVATIONS
		TELEVISION		ANLOG MAG TAPES (CONTINUED)							
278	943.0	REEL	4	END	L#	STN/SP#	238	0200 M	57 55.97	-150 10.08	CAMERA OFF BOTTOM
		SEAFLOOR CAMERA		PHOTOGRAPHS							
263	516.0	PHOTO	1	START	L#	STN/SP#	206	0066 M	59 28.49	-152 41.73	DROP 1 2628-2713 86 FRAM
263	544.0		1	OFF	L#	STN/SP#	206	0000	59 28.49	-152 43.01	
263	546.0		1	ON	L#	STN/SP#	206	0000	59 28.60	-152 42.83	DROP 2 2719-2855 136 FRM
263	625.0	PHOTO	1	END	L#	STN/SP#	206	0000	59 30.37	-152 40.20	CAMERA UP TO DEVELP FILM
263	857.0	PHOTO	2	START	L#	STN/SP#	206	0000	59 32.84	-152 38.86	CAMERA IN H2O 2880-2927?
263	10 7.0		2	OFF	L#	STN/SP#	206	0064 M	59 31.69	-152 37.62	CAMERA UP
270	2210.0			ON	L#	STN/SP#		0042 M	59 33.82	-151 56.28	
270	2247.0			OFF	L#	STN/SP#		0039 M	59 33.69	-151 57.82	
271	029.0		2	ON	L#	STN/SP#		0044 M	59 33.32	-152 9.82	2880 - 2927 FRAMES ?
271	047.0		2	OFF	L#	STN/SP#		0044 M	59 33.03	-152 10.65	
271	135.0		2	ON	L#	STN/SP#		0071 M	59 33.16	-152 16.24	2933-2987 FRAMES ?
271	138.0	PHOTO	2	END	L#	STN/SP#		0000	59 33.28	-152 16.17	NO FLASH CAMERA UP
271	1252.0	PHOTO	3	START	L#	STN/SP#		0064 M	59 31.08	-152 33.42	3008 - 3072 FRAMES ?
271	1351.0		3	OFF	L#	STN/SP#		0068 M	59 31.34	-152 31.35	
278	9 3.0		3	ON	L#	STN/SP#		0191 M	57 56.29	-150 10.28	3111 - 3170 FRAMES ?
278	943.0	PHOTO	3	END	L#	STN/SP#		0200 M	57 55.97	-150 10.08	
		PENETROMETER		NUM.OBSRVATIONS							
275	1011.0	READINGS	1	RECOVERY	L#	STN/SP#	226	0370 M	56 48.12	-151 40.52	ON BOTTOM PENETROMETER
275	1044.0	READINGS	2	RECOVERY	L#	STN/SP#	226	0346 M	56 47.96	-151 41.16	ON BOTTOM PENETROMETER
279	10 1.0	READINGS	1	START	L#	STN/SP#	242	0280 M	57 31.29	-150 17.35	ON BOTTOM
		SIDE SCAN MARKER		DEPLOYMENTS							
260	20 8.0	NUMBER	SS1		L#	STN/SP#	SS1	0063 M	59 30.63	-152 39.28	SIDESCAN MARKER ON BOTTM
260	2121.0	NUMBER	SS2		L#	STN/SP#	SS2	0057 M	59 29.99	-152 35.18	SIDESCAN MARKER ON BOTTM
260	2220.0	NUMBER	SS3		L#	STN/SP#	SS3	0065 M	59 25.62	-152 35.09	SIDESCAN MARKER ON BOTTM
260	2254.0	NUMBER	SS4		L#	STN/SP#	SS4	0067 M	59 25.10	-152 39.12	SIDESCAN MARKER ON BOTTM
		HYD CURRENT METR		DEPLOYMENTS							
261	655.0	NUMBER	1	END	L#	STN/SP#		0000	59 30.16	-152 40.13	CURRENT METER ON BOTTOM

SHIP: R/V SEA SOUNDER

CRUISE LOCATOR: S7-77-WG (ID -YR-AREA)

CHIEF SCIENTIST: BOUMA / HAMPTON

JUL. DAY	TIME (GMT)	CRUISE/DATA INFO RECORD. MEDIUM	CRUISE/DATA INFO SEQNCE NUMBER	DATA STATUS/ INSTITUTE	PERSONNEL, PORTS, EQUIPMENT DESCRIPTION OR: LINE#	STA./SHOT PT.#	WATER DEPTH UNCOR.	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DATA DESCRIPTION, COMMENTS OR OBSERVATIONS
		EXP BATHY THERMO		DEPLOYMENTS								
277	351.0	NUMBER XBT	1	RECOVERY	L#	STN/SP# 235	0258 M	57	31.17	-150	18.08	XBT LAUNCHED
		TEMP/SALINOMETER ANL PAPER ROLLS										
258	446.0	ROLL	1	START	L# 202	STN/SP#	0000	58	35.4	-151	23.68	
259	17 0.0		1	OFF	L#	STN/SP#	0000	59	36.19	-151	24.18	
260	1458.0		1	ON	L#	STN/SP#	0000	59	36.04	-151	24.32	
261	17 0.0		1	OFF	L#	STN/SP#	0000	59	33.05	-151	10.06	
261	2256.0		1	ON	L#	STN/SP#	0000	59	36.02	-151	24.29	
264	153.0	ROLL	1	END	L#	STN/SP#	0000	59	8.50	-152	26.99	
264	159.0	ROLL	2	START	L#	STN/SP#	0000	59	8.93	-152	26.91	
264	751.0		2	OFF	L#	STN/SP#	0000	59	37.24	-151	24.25	
266	117.0		2	ON	L# 244	STN/SP#	0000	59	33.86	-152	7.44	
266	2 8.0		2	OFF	L# 244	STN/SP#	0000	59	34.14	-152	0.62	
266	317.0		2	ON	L# 245	STN/SP#	0000	59	35.01	-152	0.72	
269	2322.0		2	OFF	L#	STN/SP#	0000	59	35.71	-151	23.73	
270	19 3.0		2	ON	L#	STN/SP#	0000	59	35.94	-151	24.00	
272	1622.0	ROLL	2	END	L#	STN/SP#	0000	57	49.12	-152	28.64	
272	1635.0	ROLL	3	START	L#	STN/SP#	0000	57	49.12	-152	28.73	
279	1521.0	ROLL	3	END	L#	STN/SP#	0000	57	54.36	-149	45.78	
279	1528.0	ROLL	4	START	L#	STN/SP#	0000	57	55.23	-149	44.24	
282	17 0.0	ROLL	4	END	L#	STN/SP#	0000	60	5.95	-149	25.21	

CRUISE REPORT

OF THE
BRANCH OF MARINE GEOLOGY
U.S. GEOLOGICAL SURVEY, MENLO PARK, CA

FOR

CRUISE -S7-77-WG-

GENERAL CRUISE INFORMATION

AREA: W. GULF OF ALASKA / S. COOK INLET, KODIAK SHELF, SHUMAGIN IS

SHIP: R/V SEA SOUNDER

CHIEF SCIENTIST(S): ARNOLD BOUMA / MONTY HAMPTON

TYPE OF DATA
COLLECTED: GEOPHYSICAL , GEOLOGICAL , HYDROGRAPHIC

CRUISE DATES:	LOCAL DATE/TIME*	TIME(JD/GMT)	PORT
START CRUISE:	14 SEP 7 8 HRS	257/17 8	LV KODIAK, AK
END CRUISE:	10 OCT 7 0 HRS	283/17 0	SEWARD AK, END CRUZ

PORT STOPS:

1.	ARRIVE:	16 SEP 723 HRS	259/1723	ARRIVE HOMER, AK
	LEAVE:	17 SEP 457 HRS	260/1457	LEAVE HOMER, AK
2.	ARRIVE:	18 SEP 845 HRS	261/1845	ARR VE IN HOMER, AK
	LEAVE:	18 SEP 1253 HRS	261/2253	DEPART HOMER
3.	ARRIVE:	21 SEP 7 0 HRS	264/17 0	ARRIVE IN HOMER
	LEAVE:	22 SEP 8 4 HRS	265/18 4	DEPART PORT HOMER
4.	ARRIVE:	25 SEP 930 HRS	268/1930	ARRIVE (HOME)-R
	LEAVE:	27 SEP 9 0 HRS	270/19 0	LEAVE HOMER START LEG 2
5.	ARRIVE:	29 SEP 5 0 HRS	272/15 0	IN PORT KODIAK, AK
	LEAVE:	29 SEP 13 1 HRS	272/23 1	LEAVE PORT KODIAK, AK

* EXPRESSED IN LOCAL STANDARD TIME.

	HOURS	DAYS & HOURS
TOTAL UNDERWAY TIME:	517	21 DAYS 13 HRS
TOTAL PORT TIME:	106	4 DAYS 10 HRS

QUARTERLY REPORT

Contract: RK6-6074

Research Unit: RU-429

Reporting Period: 1 October, 1977 - 1 January, 1978

Faulting, Sediment Instability, Erosion and Deposition Hazards of Norton Sea Floor

Devin R. Thor

Hans Nelson

Pacific-Arctic Branch of Marine Geology

345 Middlefield Road

Menlo Park, California 94025

December, 1977

Activities this quarter included the continuing reduction, interpretation, and presentation of data collected on the S5-77-BS cruise, and preparation for the 1978 cruise in Norton Sound with R/V KARLUK and R/V SEA SOUNDER.

Analysis of 1977 sonographs has just been completed and the preparation of maps from these data is now underway. Maps will show distribution, density, and trend of ice gouging, and distribution and density of sea floor craters. Evaluation reports of these phenomena are in preparation and will be included in the annual report and submitted for publicaton in scientific journals this coming spring.

A large, (9 km diameter) shallow, subsurface, gas cap (<100-m) that leaks thermogenic hydrocarbons (petroleum-derived) at isolated locations on the sea floor 50 km south of Nome has been outlined by utilizing high-reolution geophysics records and organic geochemical analysis. A report of this potential petroleum resource and sea-floor hazard is in preparation for the Annual Report and the 1978 Offshore Technology conference.

Data also has been summarized to explain large shallow (<1-m deep) sea-floor depressions (ca 100-m diameter) apparently formed by current scour. This information is being prepared for the annual report and future publication.

Preparations for the KARLUK cruise included Devin Thor spending two weeks helping to bring the boat down from Prudhoe Bay to Nome, Alaska. Besides the complicated logistics involved with planning a small boat operation such as the KARLUK, we are preparing equipment and operating procedures for the scuba diving program which will be a part of the KARLUK work. Special diver-operated coring devices for sediment and gas sampling are being built. Data from this program will help us understand sea-floor cratering (pock marks) which are world-wide in distribution, but have been only superficially studied.

A poster session on Geologic Hazards of Norton Basin was presented at the Geological Society of America annual meeting in Seattle, Washington, November 7 - 9, 1977.

QUARTERLY REPORT

Contract RK6-6074
Research Unit: 430
Reporting Period:
1 Oct 1977 -
31 Dec 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

December 31, 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: 10 Oct 1977 - 13 Oct 1977 (4 days)
2. vessel: R/V S.P. LEE
3. location: Norton Sound, Northern Bering Sea
4. purpose: recovery of two GEOPROBE tripod systems

B. Scientific party

1.	D. Cacchione	-	USGS (Menlo Park)
2.	D. Drake	-	USGS (Menlo Park)
3.	M. Holmes	-	USGS (Seattle)
4.	D. Scholl	-	USGS (Menlo Park)
5.	T. McCulloh	-	USGS (Seattle)
6.	B. Ruppel	-	USGS (Seattle)
7.	J. Johnson	-	USGS (Seattle)
8.	C. Meeder	-	USGS (Seattle)
9.	K. Parolski	-	USGS (Woods Hole)
10.	T. Cutler	-	USGS (Anchorage)
11.	G. Tate	-	USGS (Menlo Park)
12.	C. Totman	-	USGS (Menlo Park)
13.	P. Wiberg	-	USGS (Menlo Park)
14.	J. Erickson	-	USGS (Menlo Park)
15.	G. Barker	-	USGS (Menlo Park)
16.	G. Asuncion	-	USGS (Menlo Park)
17.	J. Nicholson	-	USGS (Menlo Park)

C. Methods

Following successful recovery of the two GEOPROBE tripods, the instruments and electronics systems were thoroughly checked on board ship to assure proper operation. At that time it was discovered that multiple component problems in the electronics of GEOPROBE system #2 caused only intermittent operation and early failure of that data acquisition system. GEOPROBE system #1, however, appeared to record data successfully for the entire 80 day deployment period.

The cassette tape was immediately taken to PMEL, Seattle where it was translated onto 7 track computer tape with the assistance of Dr. David Halpern and Mr. Paul Freitag. The USGS, Menlo Park has recently ordered a tape translation unit from SEA DATA Corporation so that future tape translation can be accomplished in our facilities. The cassette tape had fewer than 0.1% error records, and the data stream has been easily decoded.

The 7 track computer tape containing the GEOPROBE data, generated at PMEL, Seattle, was then converted to a 9 track tape at USGS, Menlo Park for compatibility with the Multics Computer System. Each of the sensor data was then checked for errors, corrected using simple interpolation schemes and plotted as a time series. Calibration data for each of the GEOPROBE sensors derived both prior to the deployment and after the equipment returned to Menlo Park, has been applied to the raw data values. These calibrated values will be used in future reports.

Standard statistical values and preliminary time series analysis of each sensor output have been computed and recorded. Time series analysis of the sensor outputs is still in progress.

The quality of the photographs from each GEOPROBE system were disappointing because of high turbidity levels near the sea floor. Analysis of the photographs is still in progress; however, because of the poor light conditions, the photographs will not provide the kind of data on sediment movement and bed configuration that was anticipated.

Shipboard data collected during the July 1977 cruise on the R/V SEA SOUNDER in Norton Sound and during Hans Nelson's cruise to outer Norton Basin are still being analyzed. Concentration values for over 150 samples of suspended sediments have been determined and plotted, and distribution charts of suspended sediments (inorganic/organic) have been drawn. Other analyses of the suspended matter including chemical, textural, and remote sensing data are being carried out.

D. Sample Locations

The quarterly report of this project for the period 1 July 1977 - 30 September 1977 contains a sample location chart. The GEOPROBE stations were taken at:

	Lat.	Long.
GEOPROBE #1:	64-00.1N	165-30.0W
GEOPROBE #2:	64-09.0N	163-21.0W

E. Data Collected and Analyzed

A summary of the shipboard data collected during our July cruise was given in the previous quarterly report. Station samples typically included water bottles (suspended sediment samples), light transmission profiles, current meter profiles, C-T-D cast.

The GEOPROBE data tape contains the following types of information:

Basic data (hourly samples)	Burst data (taken once) per second for 60 seconds, once per hour
current speed	current speed (4)
current direction	current direction (4)
total bottom pressure	pressure (1)
bottom temperature (2)	
light transmission	
light scattering	

(the numbers in parenthesis indicate the number of sensors).

III. Results

A. Suspended Sediment

The results of our initial field sampling of suspended particulate matter in September-October 1976 supported the following conclusions:

1. Land-derived organic and inorganic particulate matter contributed by the Yukon River controls the composition of the suspended matter throughout Norton Sound. Plankton is an important component in the surface water only in the northern portion of the Sound and to the west in the Alaskan Coastal Current.

2. Yukon silt and clay settles into the near-bottom layer of the water column principally within 50 to 150 km of the delta. Consequently, the flow of the lower portion of the Norton Sound water column is most important to the transport and fate of Yukon sediment.

3. Based upon the surface and near-bottom distributions of suspended matter, two significant pathways of advective sediment transport were identified. One of these pathways was clearly shown by plumes of relatively turbid water stretching northwestward from the vicinity of the delta and across the "mouth" of Norton Sound. The second pathway involves nearshore flow in a counter-clockwise sense around the margin of the Sound.

4. The water column in Norton Sound in the late summer was strongly two-layered owing to the local production of warm, low salinity surface water. The density interface between these layers was particularly sharp in the eastern cul-de-sac of Norton Sound. Water in the lower layer of the cul-de-sac was colder (2-4°C) and more saline (32-33‰) than any known water type on the shelf of the Northern Bering Sea (during summer months). Muench et al. (R.U. 141) have suggested that this unique bottom water is a topographically-isolated remnant of winter convection. Suspended matter concentrations in the eastern cul-de-sac in 1976 were surprisingly uniform but also relatively high (~6-7 mg/l). The uniformity of concentrations indicated that horizontal mixing and processes of diffusion are significant in the cul-de-sac, whereas communication between the inner and outer portions of the Sound may be limited. Further study of the hydrography of Norton Sound was planned for July 1977.

During July 1977 we deployed two GEOPROBE systems, three PMEL current meter moorings (Muench, R.U. 141) and occupied 27 stations for measurements of conductivity, temperature, light transmission, current speed and direction and water sample collection for suspended matter separations. In addition, during the following SEA SOUNDER cruise (H. Nelson, chief scientist) samples were collected at stations off Port Clarence, in the Bering Strait and north of Saint Lawrence Island. In all over 50 stations were occupied for suspended matter sampling and more than 200 water samples were filtered for subsequent suspended matter analyses. Laboratory processing is in progress and should be nearly completed by June 1978.

In order to supplement our shipboard sampling program, we have assembled and partially analyzed available LANDSAT images provided by A. Belon, University of Alaska. Although sequences of images with low cloud cover are the exception in the northern Bering, these data have substantially aided our studies of surface water transport and the dispersal of Yukon River fine sediment. While we will not reproduce satellite images in this report, several of the following conclusions draw heavily on the imagery data.

Suspended matter distributions at the surface and near the bottom in July 1977 (Figs. 1 and 2) were quite similar to the distributions present in late September 1976 (refer to OCSEAP annual report April 1977, R.U. 430). However, absolute concentrations of total suspended matter at all locations in July 1977 were significantly lower except in the surface water of the eastern cul-de-sac where concentrations were similar to those measured in 1976. It is likely that the observed differences, which are largest near the delta, are caused by variations in the transport of suspended matter within 20-40 km of the delta shoreline. Satellite data suggest that circulation near the delta and in the western portion of Norton Sound is strongly influenced by fluctuations in the strength of the northward-flowing Alaskan Coastal Current; fluctuations which are related to atmospheric pressure changes (Coachman et al., 1975).

At present our analysis of the suspended matter, C-T-D, and current meter data collected in July 1977 is approximately 75% completed. The emerging picture of suspended matter transport is generally compatible with conclusions presented by Muench et al. (in press). However, we suspect that relatively short-term changes in circulation patterns in the Sound as well as differences in flow between the upper and lower water layers may be highly significant. It is premature to attempt a thorough discussion of these problems at this point.

B. Bottom Sediment Dynamics

The digital data collected with GEOPROBE system #1 south of Nome have been translated from cassette to 9 track computer compatible tape through the cooperative efforts of Dr. David Halpern and Mr. Paul Freitag, PMEL, Seattle. The data have subsequently been analyzed for errors, corrected, and plotted as time series variables using the Honeywell multics computer at the USGS, Menlo Park. Examples of the data plots are given in this section. Similar plots for the entire 80 day experimental period are available, and will be presented in the annual report.

In Figure 3 data obtained with the rotor/vane current meter are plotted for the period July 28 - August 16, 1977. Hourly speed values plotted in the upper graph of Figure 3 represent rotor counts over the sample interval (basic sample interval = 1 hour). The counts are converted to speed values through a calibration formula. The plot of current direction is derived from single samples of the vane taken once each basic sample interval. The plots of E-W and N-S current are derived from conversion of the polar current measurements (s = speed, θ = direction) to Cartesian form:

$$\pm u = s \sin \theta$$

$$\pm v = s \cos \theta$$

where +u and -u are east and west components, respectively, and +v and -v are north and south components, respectively.

The hourly averages of current speed and direction clearly depict the dominance of the tidal components in the current field. Peak tidal current speeds of 32 cm/sec occur during the spring tidal period (July 28 and July 30 and again on August 12). These current speeds, measured at 1.8 m above the sea floor, are probably significant in producing local resuspension of the surface sediments in this area. The character of the vane record is distinctly tidal, with a preferred E-W component. Note that the vane most often swings through north rather than south in its apparent tidal oscillation.

The tide in this area is of the mixed type, with a strong semi-diurnal periodicity as indicated by the current speed data in Figure 1 and in the pressure data (not shown). The E-W speed component is definitely diurnal; the semi-diurnal motion is chiefly contributed by the N-S speed component.

The E-W current speeds are both more energetic and more regular than the "noisier", low amplitude N-S tidal components. The spring-neap tidal cycle is readily apparent in the plot of E-W currents.

Figure 4 presents the statistics for the rotor/vane current measurements. The mean speed of 10.63 cm/sec over the 80-day experimental period is significant for net transport of bottom materials. The dominance of the v component suggests a large, net advective flux toward the north. The non-tidal current represented by the "sticks" in Figure 3 has a net flow of about 10 cm/sec toward the north.

The histograms of speed and direction in Figure 4 indicate the dominant measured currents toward the NE and NW, a result of the strongly polarized E-W tidal flow.

Figure 5 is a data plot containing the same type of information as Figure 3 except that this figure is for September 6 - September 26. The most obvious significant feature in this data is the striking sustained period of non-tidal current during the period September 13-15. This anamalous period of high current is correlated with a surface storm that transitted the area about that time. Surface winds at Nome reached 40 knots in gusts. The bottom current is generally toward the North, the E-W tidal component is very weak throughout and subsequent to the storm period.

Other data show that the storm period is associated with very high levels of near-bottom turbidity. The more normal period dominated by tidal currents are less turbid; however, the turbidity does show a definite correlation with tidal flow (low turbidity and cold water occur periodically every 24 hours).

The electromagnetic current meter data show that during the storm, wave currents of up to 25 cm/sec occur at the sea floor.

IV. Preliminary Interpretation of Results

1. Tidal currents normally produce periodic bottom stresses high enough to resuspend the bed materials.

2. Turbidity and temperature variations at a level about 2 m above the bed have a distinct diurnal periodicity, probably caused by horizontal E-W tidal advection.

3. Episodic storms generate sustained bottom currents and significant wave currents that produce substantial increases in bottom turbidity. These increase are probably caused by local resuspension and horizontally advected suspended materials.

V. Problems encountered

A. GEOPROBE system #2 suffered a critical tape-electronics, problem that prevented recovery of the digital data. Photographs from both GEOPROBE camera systems are indistinct due to the high levels of suspended materials near the sea floor. These high levels are probably a result of the generally high suspended loads in addition to the periodically generated resuspension by tidal currents.

B. Nome is a very difficult staging area for a major oceanographic cruise. The logistics of air freight are extremely unpredictable; cargo (and people) must be accounted for at every way point. Wein Alaska Airlines was on strike during the entire cruise period; reduced flight schedules added to the normally irritating situations.

Additionally, during the instrument recovery phase in October, Drs. Drake and Cacchione were unable to ferry out to the R/V LEE which was at anchor a short distance offshore. Moderate winds (20-30 knots) created a local sea state that prevented small boat operations from the Nome boat docks to ships anchored offshore. This situation necessitated the scientific party that was on board (including our Branch Chief, Dr. David Scholl) to accomplish the recovery of both GEOPROBE tripods.

The vagaries of weather, freight, and Nome hospitality render even the best of plans inadequate. The recommended change is to provide Nome with a ship pier.

VI. Estimate of funds expended.

Funds were expended for:

1) recovery of GEOPROBE systems;
2) data analysis;
3) instrument refurbishment and calibration;
4) new construction (GEOPROBE #3)

About 30 per cent of the funds for the Lower Cook Inlet work (FY 78) have been allocated toward the field experiment.

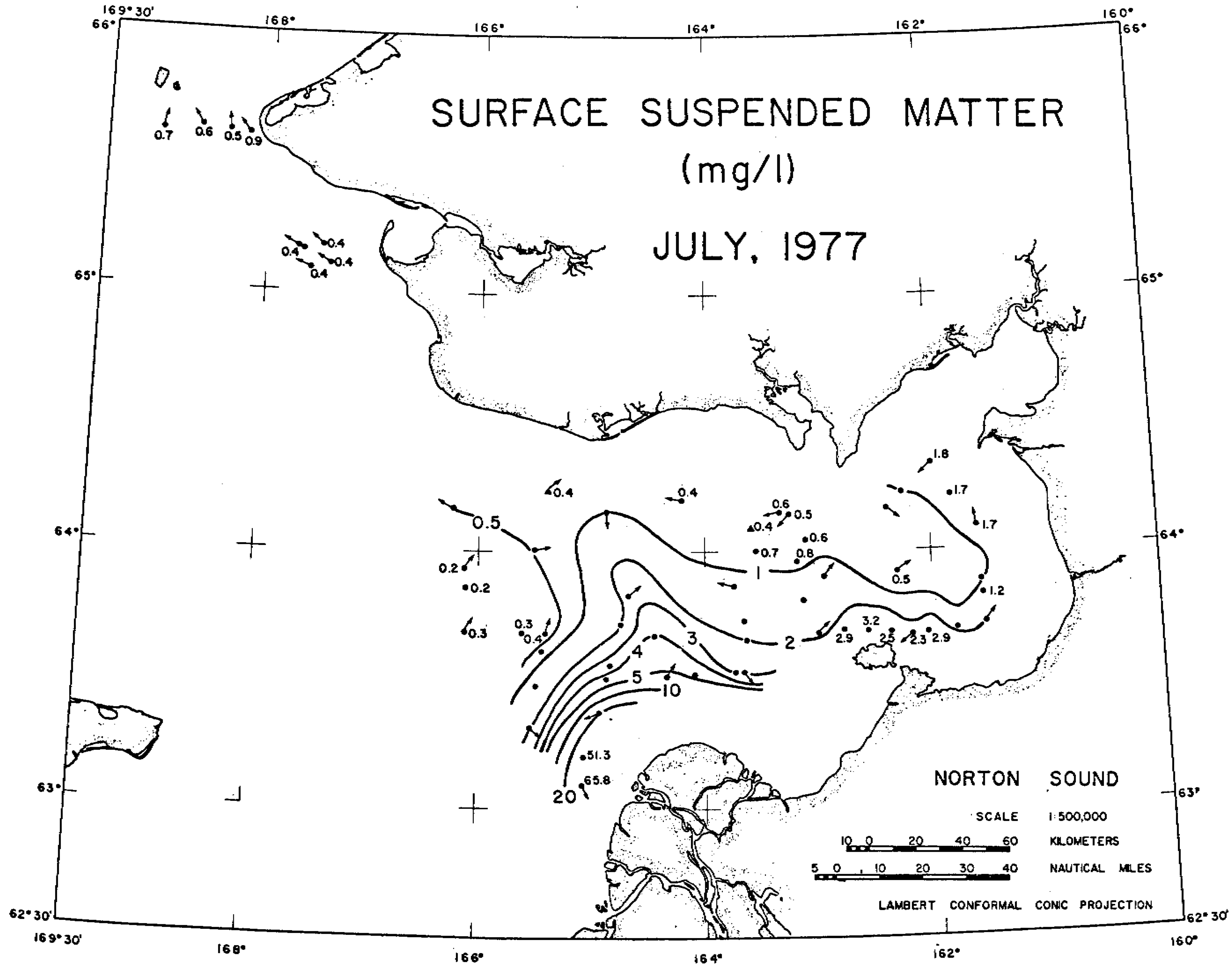

SURFACE SUSPENDED MATTER
(mg/l)
JULY, 1977
NORTON SOUND
SCALE 1:500,000
KILOMETERS
NAUTICAL MILES
LAMBERT CONFORMAL CONIC PROJECTION
169°30'
168°
166°
164°
162°
160°
66°
65°
64°
63°
62°30'

Figure 1

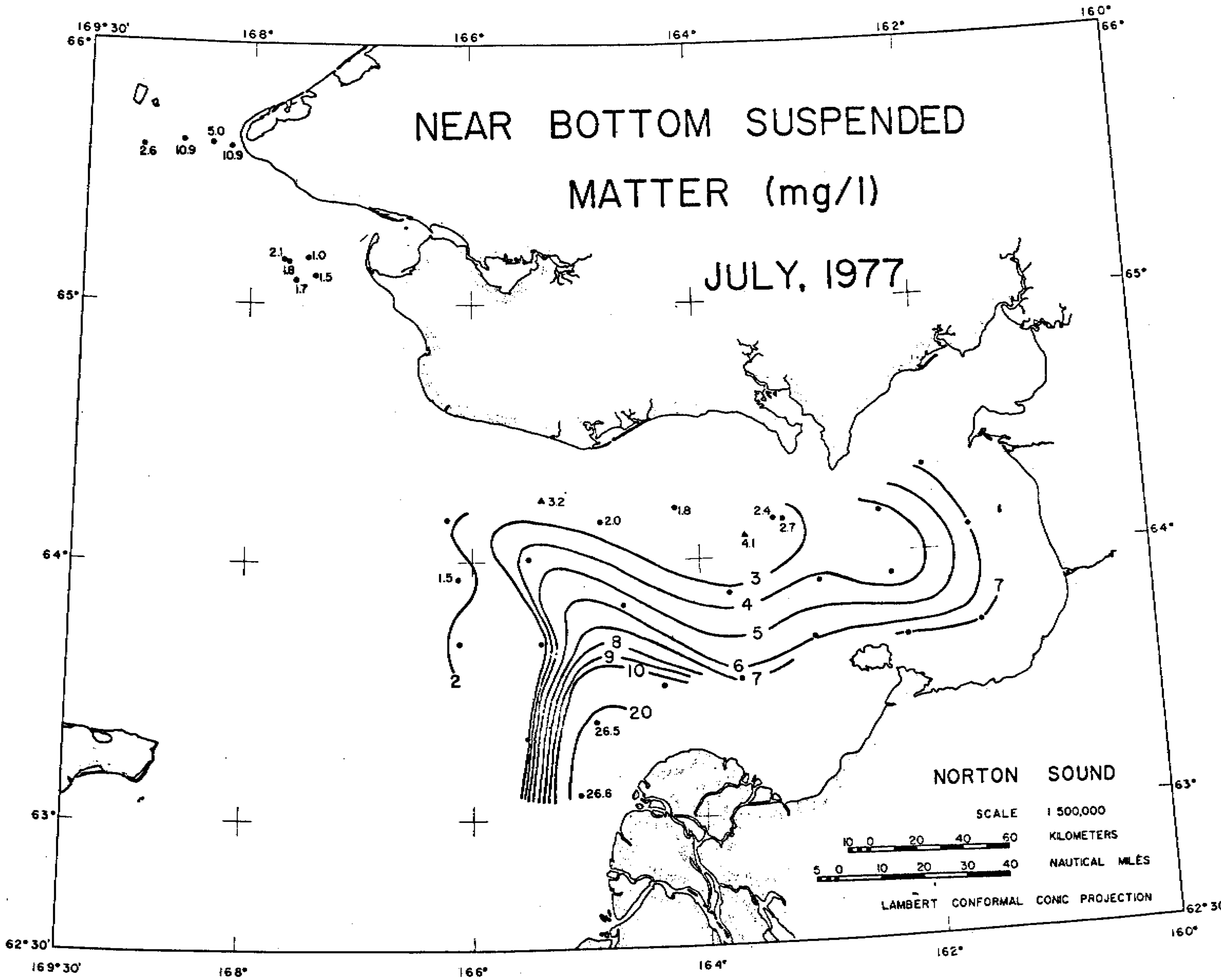

NEAR BOTTOM SUSPENDED
MATTER (mg/l)
JULY, 1977
NORTON SOUND
SCALE 1:500,000
10 0 20 40 60 KILOMETERS
5 0 10 20 30 40 NAUTICAL MILES
LAMBERT CONFORMAL CONIC PROJECTION
169°30'
168°
166°
164°
162°
160°
66°
65°
64°
63°
62°30'
2.6
10.9
5.0
10.9
2.1
1.0
1.8
1.5
1.7
3.2
2.0
1.8
2.4
2.7
4.1
1.5
26.5
26.6
2
3
4
5
6
7
8
9
10
20

Figure 2

TIME SERIES OF VECTOR AVERAGED CURRENTS AT GEOPROBE, NOR SND 77
LOCATION = LAT 64 00N, LONG 165 00W, DEPTH = 17.5 METERS
OBSERVATION PERIOD = 0000 28 JUL 77 TO 2300 16 AUG 77 (20.0 DAY
AVERAGING INTERVAL = 1.0 HOURS (1 POINTS)

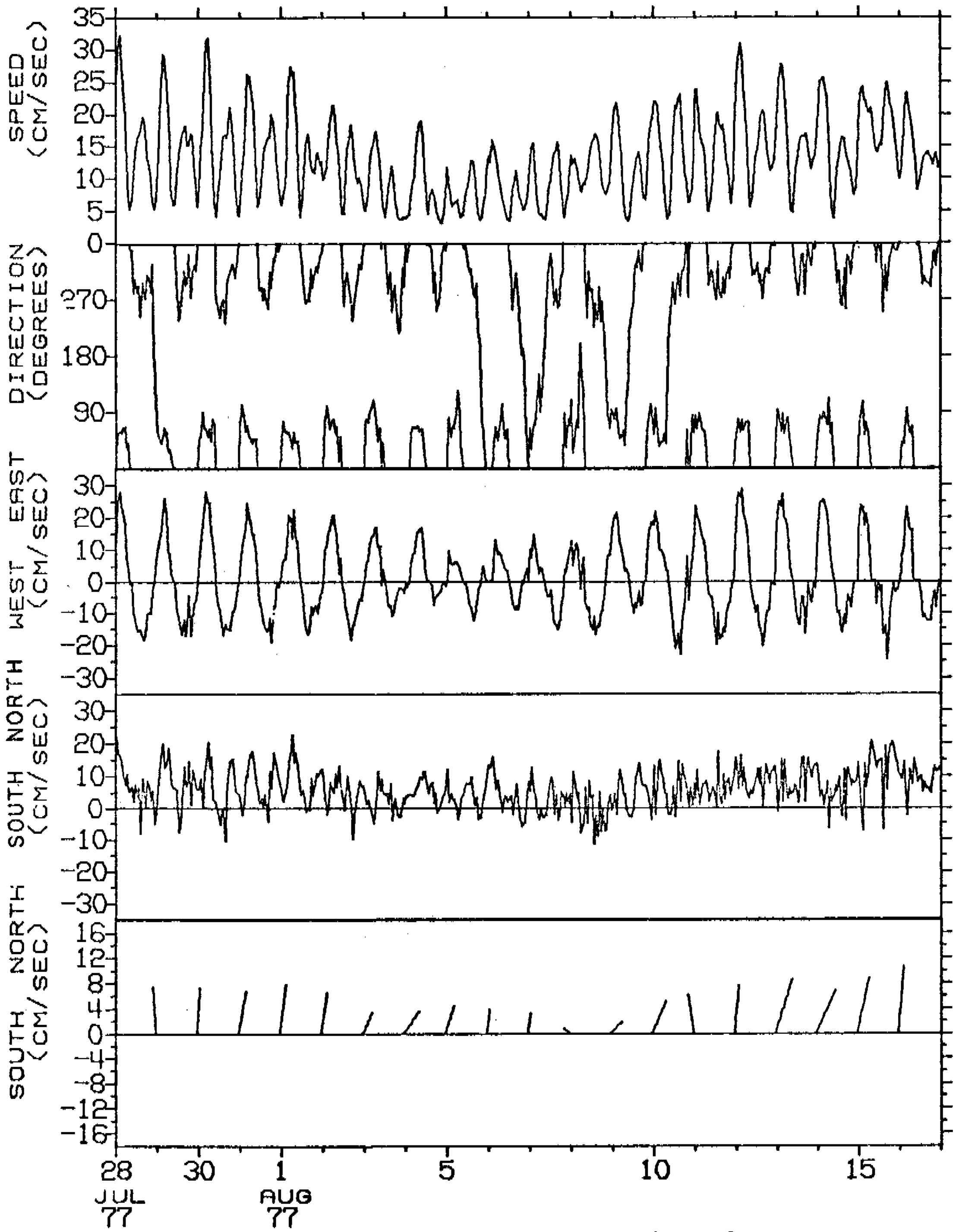
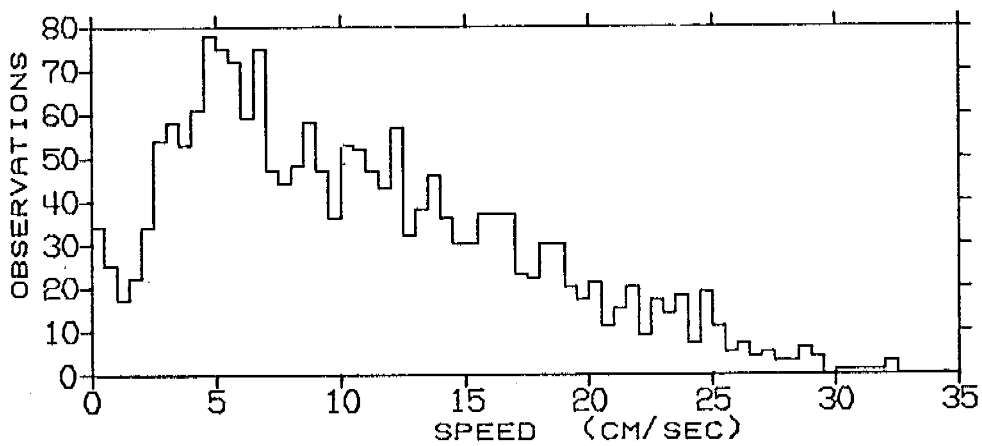


Figure 3

STATISTICS AND HISTOGRAMS OF CURRENTS AT GEOPROBE, NOR SND 77
LOCATION = LAT 64 00N, LONG 165 00W, DEPTH = 17.5 METERS
OBSERVATION PERIOD = 0000 8 JUL 77 TO 2300 25 SEP 77 (80.0 DAYS
N = 1920 DT = 1.00 HOURS, UNITS = (CM/SEC)

	MEAN	VARIANCE	ST-DEV	SKEW	KURT	MAX	MIN
S	10.63	44.73	6.69	0.662	2.778	32.28	0.00
U	0.50	96.76	9.84	0.375	3.201	30.63	-24.35
V	4.79	37.73	6.14	0.343	3.460	25.08	-17.16

S = SPEED
U = EAST-WEST COMPONENT OF VELOCITY, EAST =POSITIVE U
V = NORTH-SOUTH COMPONENT OF VELOCITY, NORTH = POSITIVE V



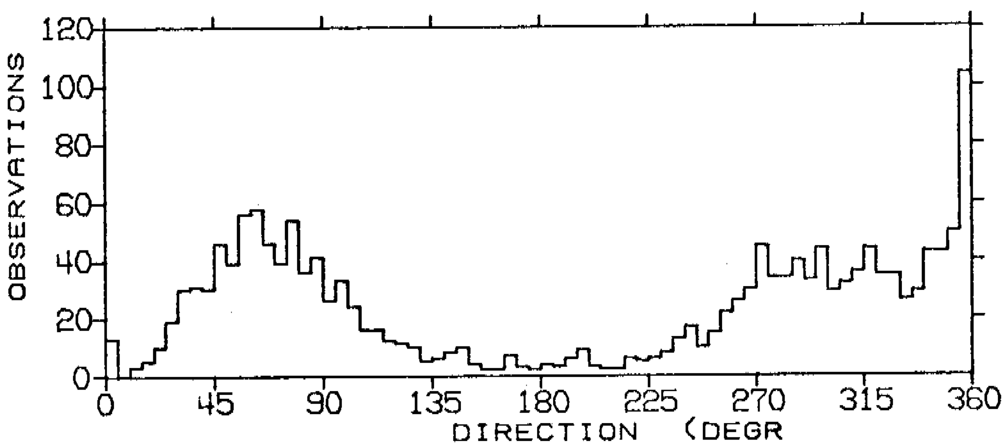


Figure 4

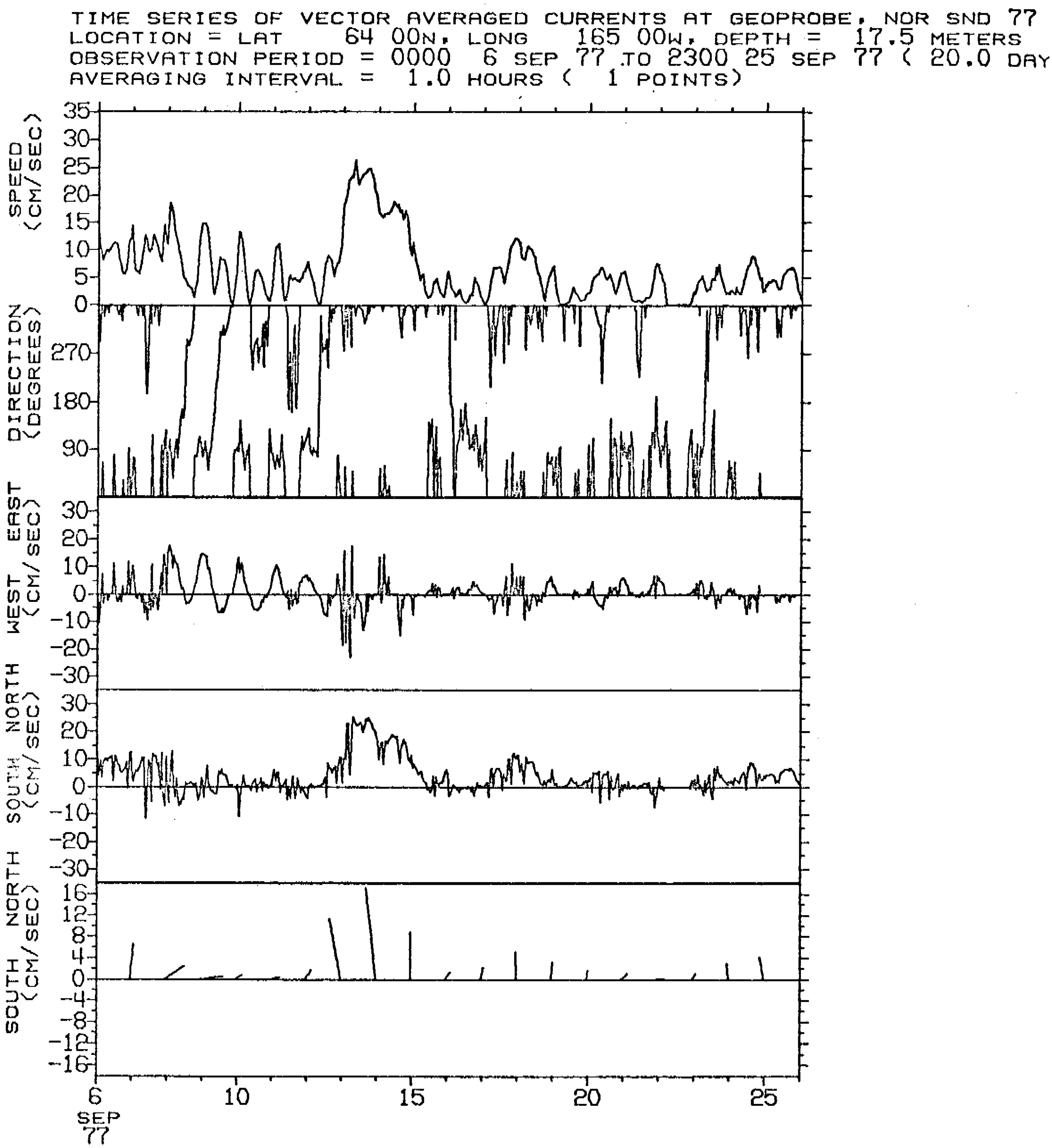

TIME SERIES OF VECTOR AVERAGED CURRENTS AT GEOPROBE, NOR SND 77
LOCATION = LAT 64 00N, LONG 165 00W, DEPTH = 17.5 METERS
OBSERVATION PERIOD = 0000 6 SEP 77 TO 2300 25 SEP 77 (20.0 DAY
AVERAGING INTERVAL = 1.0 HOURS (1 POINTS)
SPEED (CM/SEC)
DIRECTION (DEGREES)
WEST EAST (CM/SEC)
SOUTH NORTH (CM/SEC)
SOUTH NORTH (CM/SEC)
SEP 77

Figure 5

QUARTERLY REPORT

Research Unit #: 431
Reporting Period: October 1 - December 31, 1977

Title: Coastal Processes and Morphology of the Alaska Bering Sea Coast

Principle Investigators: Asbury H. Sallenger
John R. Dingler
Ralph Hunter

Agency: U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

I. Highlights

Comparisons of vertical aerial photographs from before and after the severe November, 1974 storm showed that tundra bluffs in the vicinity of Nome were eroded as much as 45 m. In the Safety Sound area, giant cusps spaced 340m apart were destroyed by the storm and were replaced by giant cusps spaced 590 m apart. This resulted in a complex pattern of shoreline erosion and accretion.

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

Date: October 7-15

Scientific Party: A. Sallenger, C. Fletcher, C. Peterson, D. Klise.

Activities: Remonitored beach/nearshore profiles in the Nome and Port Clarence areas.

Sample Locations: 24 beach/nearshore profiles in the Nome/Safety Lagoon areas; 8 beach/nearshore profiles in the Port Clarence/Brevig Lagoon areas.

Data Collected: 32 beach/nearshore profiles; these will be compared to previous measurements.

IV. Results

A. Comparisons of vertical aerial photography from before and after the November, 1974 storm were completed. During this event 1-2 m high bluffs east of Nome were eroded as much as 45m. West of Nome higher bluffs (3-4 m) were eroded as much as 18m. Shoreline changes were complex. Giant cusps spaced 340m apart were destroyed during the storm and were replaced by giant cusps spaced 590m. Resulting shoreline changes ranged from approximately 60m accretion to approximately 30m erosion. Data and more complete discussion will be included in our final report.

B. The beach/nearshore profile data are presently being reduced.

V. Problems:

None.

VI. Estimate of Funds Expended.

<u>All</u>.

QUARTERLY REPORT

Research Unit #: 473
Reporting Period: October 1 -
December 31, 1977

SHORELINE HISTORY OF CHUKCHI AND BEAUFORT SEAS AS AN AID TO PREDICTING OFFSHORE PERMAFROST CONDITIONS

David M. Hopkins
Principal Investigator

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345 Middlefield Road
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Research Unit #473: Quarterly Report, October-November-December, 1977

SHORELINE HISTORY OF CHUKCHI AND BEAUFORT SEAS AS AN AID TO PREDICTING OFFSHORE PERMAFROST CONDITIONS

I. Abstract of Highlights:

Ancient marine deposits exposed on and near the coast of the Beaufort Sea can be resolved to identify an ancient interglacial shoreline and barrier-island chain which can be traced discontinuously from Barrow Village to Prudhoe Bay. The barrier chain is an important source of sand and gravel for modern beaches and barrier islands. Differences in elevation of the crest indicate that Prudhoe Bay has subsided at least 4 meters in the last 120,000 years.

R. W. Hartz has completed a map classifying the coast of NPRA according to morphology and rate of coastal retreat. The map will be included in the Annual Report.

D. M. Hopkins summarized the results of OCSEAP-supported offshore permafrost studies for the NAS Committee on Permafrost. His report is included here.

II. Task Objective: D-9

III. Field and Laboratory Activities

A-1. Field activities: none

A-2. Laboratory activities

Prepare fossil bones for identification
Prepare radiocarbon samples for identification
Conduct amino-acid analyses of fossil mollusks
Complete pebble-lithology counts

B. Scientific party

D. M. Hopkins, geologist and P.I.
R. W. Hartz, geologist
R. E. Nelson, geologist

C. Methods of analysis

Map analysis, literature survey, and compilation of field data to determine coastal morphology, rates of coastal retreat, and height of maximum storm surge.

Pollen analysis of recent pollen rain to support interpretation of pollen spectra in ancient samples.

Analyze fossil pollen, marine mollusks, and microfaunas, and undertake radiocarbon dating and amino-acid racemization studies in order to establish dating of various Pleistocene events and character of Pleistocene environment.

Counts of pebble lithology in order to ascertain sources of nourishment of beaches and barrier bars and to determine directions of sediment transport.

D. Sample localities

About 400 data-collection sites, visited during 1976 and 1977, between Icy Cape and Canning River.

E. Data collected or analyzed

Completed lithologic counts for 100 pebble samples
Completed palynological analysis of about 12 recent samples
Compiled map of morphology and rates of coastal retreat for entire coast of NPRA from Icy Cape to Colville River.

IV. & V. Results and Interpretation

Joint efforts of John W. Williams, David Carter, and the Hopkins-Hartz-Nelson-Smith party resulted in the recognition of an ancient shoreline, occupied during the last interglacial high-sea-level interval about 120,000 years ago, which can be traced from the vicinity of Barrow Village eastward to Prudhoe Bay.

The shoreline intersects the present coast at Barrow Village, where it is the remnant of a mainland beach. Farther west, it becomes a low, discontinuous ridge of pebbly sand or sandy gravel which is probably an ancient barrier chain. The ridge extends eastward north of Lake Teshekpuk and thence through the peninsula north of Kogru River and through the Eskimo Islands. After a long gap, the ancient barrier chain is represented by Pleistocene remnants preserved on Pingok Bertoncini, Bodfish, and Cottle Island. The ridge probably intersected the present coast somewhere near Point McIntyre, and extends eastward under land areas to intersect the coast again near Central Compressor Station on the west shore of Prudhoe Bay.

This discontinuous Pleistocene shoreline is a major source for gravel on the modern beaches where it lies near or at the present coastline, and is itself a possible candidate for gravel mining. Thetis and Stump Islands, among others, probably originated by complete erosion of segments of this ancient Pleistocene barrier chain, but have now retreated several kilometers landward since complete erosion of the original Pleistocene remnants.

In most places, the crest of the Pleistocene ridge lies five to seven meters above present sea level, but the crest grows lower approaching Prudhoe Bay and lies less than a meter above sea level at Central Compressor Station. Tectonic subsidence of four to six meters during the last 100,000 years is suggested for Prudhoe Bay.

The Pleistocene shoreline cannot be recognized east of Prudhoe Bay. It lies inland and is probably completely buried by Pleistocene alluvium and outwash gravel eastward from Prudhoe Bay.

B. New map classifying coast of NPRA

R. W. Hartz completed a map and short text on the coastal morphology of NPRA from Icy Cape to the Colville River. The map and text are being reproduced and will be included in the 1978 Annual Report, and also in a USGS document on environment of NPRA, which was also prepared for BLM. The map was presented and explained at a public meeting on environmental studies in NPRA held in Anchorage in early December.

The map shows that the entire Arctic coast is undergoing rapid coastal retreat, even under pristine natural conditions. The coast of the Beaufort Sea, however, is retreating much more rapidly than the coast of the Chukchi Sea in the NPRA area.

C. Summary of OCSEAP permafrost studies in Prudhoe Bay area presented to the Permafrost Committee of NAS/NRC

D. M. Hopkins was asked to review OCSEAP-supported offshore permafrost studies in the Prudhoe Bay area before the National Academy of Science Permafrost Committee at a meeting held in San Francisco on December 5, 1977. The report may be useful in planning continuing coastal and permafrost studies, so it is reproduced here.

VI. Budget: No funds received so none could be spent.

SUMMARY OF OFFSHORE PERMAFROST RESEARCH DISCUSSED AT COMMITTEE ON PERMAFROST MEETING DECEMBER 5, 1977

David Hopkins of the United States Geological Survey, Menlo Park, CA, reviewed some of the results during the last three years of the offshore permafrost studies supported by the Outer Continental Shelf Environmental Assessment Program, funded by BLM and managed by NOAA.

The major effort has been concentrated in the Prudhoe Bay area. A joint USGS-CRREL-Arctic Research, Inc. crew consisting of Paul Sellmann, Edwin Chamberlain, Herbert Ueda, Hopkins, and Robert Lewellen has completed nine boreholes ranging from 12 to 70 m deep. Thermal logs and lithologic, geochronologic, soils-engineering, and pore-water geochemistry studies have yielded considerable data on the distribution of ice-bonded permafrost, pore-water salinities, and geologic and thermal history. Scott Blouin and Donald Garfield (CRREL) devised a sled-mounted and tractor-towed hydraulic probe and used it to measure penetration resistance of sediments to depths of 10 or 15 m below bottom; ground-temperature profiles were obtained in about half of their 30 probe holes. Augurs, probes, and jetting devices have been used by Tom Osterkamp and Will Harrison (Geophysical Institute, University of Alaska, Fairbanks) to obtain additional data on soil temperatures and depths to ice-bonded permafrost. These boreholes and probes were aligned along three lines: one extends from Discovery Well near the base of ARCO West Dock 17 km seaward to and beyond Reindeer Island, a second extends from the middle of Prudhoe Bay northward through the shoal connecting Gull and the Niakuk Islands, and a third, cross line extends from Stump Island 10 km eastward parallel to the coast to a site off the mouth of the Sagavanirktok River.

The borehole and probe studies have been supplemented by seismic-reflection and seismic-refraction determinations by James Rogers (University of Alaska, Anchorage) of the depth to the top of ice-bonded permafrost; these geophysical studies have been conducted aboard the R/V LOON in cooperation with Erk Reimnitz and Peter Barnes (U.S.G.S.). Rogers has also attempted to determine the distribution of shallow ice-bonded permafrost beneath the barrier islands in the Prudhoe Bay area, using a hammer seismograph.

These interrelated studies have shown that ice-bonded permafrost is present throughout the continental shelf to and beyond the 15-m isobath in the Prudhoe Bay area; permafrost is probably generally present throughout the Beaufort Sea, in fact, to water depths of at least 20 m. The top of ice-bonded permafrost has an irregular, rugged, and presently unpredictable relief of several tens of meters. Geophysical studies indicate that ice-bonded permafrost is present at the surprisingly shallow depths of 5 m below the sea floor in many places, but it lies as deep as 150 m in others. Permafrost may be completely lacking in some areas as large as one or two kilometers in diameter. Some years ago, about 40 m of ice-bonded permafrost was penetrated between depths of 90 and 130 m in one deep hole; no other data is available on the thickness of the ice-bonded layer in submerged areas near Prudhoe Bay.

Pore water salinities differ significantly from one place to another. Pore water in gravel commonly has the salinity of sea water, but more saline brines have been encountered in one borehole where the top of the ice-bonded layer was unexpectedly deep. Another borehole encountered nearly fresh pore water in clay a short distance below the sea bottom.

The observed differences in the depth to the top of the ice-bonded layer are partly related to differences in pore-water salinities but differences in thermal history may also be important. Prudhoe Bay and possibly some other areas where ice-bonded permafrost is deep or absent are sites that once lay beneath relatively warm, fresh-water thaw lakes prior to submergence. An unexpectedly complicated history of local vertical crustal movements may also be involved in the very irregular depth of thaw.

The ice content of the relict, ice-bonded permafrost beneath the sea floor is unknown. However, several observations in the Prudhoe Bay area suggest the possibility that as much as 10 meters of subsidence may have taken place as a consequence of deep thawing beneath a larger thermokarst lake or beneath newly submerged areas after transgression of the shoreline. If the observations are correctly interpreted, they suggest that excess ground ice in gravel extends to depths of 50 m or more in the Prudhoe Bay area.

Seismic studies show that only the wider parts of the barren barrier islands of Beaufort Sea are underlain at shallow depth by firmly ice-bonded permafrost (shallow permafrost is no doubt also present in the areas of Pleistocene sediment that form the core of some of the older islands such as Pingok and Cottle Islands). Island areas underlain at shallow depth by recent firmly ice-bonded permafrost (in contra-distinction to the relict permafrost found at greater depth beneath sea floor and barrier islands alike) are readily recognized by the presence of frost-cracks; these areas are also old enough so that a few salt-tolerant plants have become established. Thermal calculations indicate, however, that recent ice-bearing permafrost should be expected beneath even the younger parts of the actively migrating barrier islands; evidently brine pockets or incomplete bonding in ice-bearing permafrost is responsible for the low seismic velocities and lack of frost-cracking in these young areas.

The OCSEAP permafrost studies confirm Canadian studies that have shown that permafrost is widespread on the Beaufort Sea continental shelf; they show that ice-bonded permafrost is present at surprisingly shallow depths and that the ice content may be much higher than had been anticipated. Subsea permafrost conditions must be carefully assessed in planning, designing, and siting bottom-founded and buried structures, especially pipelines for hot oil. The factors involved in this irregular distribution of ice-bonded permafrost are still very poorly understood, and we are still far from being able to predict the potential problem areas and far from being able to evaluate the seriousness of shallow ice-bonded permafrost as a geologic hazard in those areas where it is known to exist.

QUARTERLY REPORT

Contract #03-05-022-55
Research Unit # 483
Task Order # 12
Reporting Period: 10/1/77 -
12/31/77
Number of Pages: 3

EVALUATION OF EARTHQUAKE ACTIVITY AROUND NORTON AND KOTZEBUE SOUNDS

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University of Alaska
Fairbanks, Alaska 99701

December 31, 1977

I. Task Objectives:

1. Complete residual field works by checking or replacing electronic components located inside RCA buildings at field sites.

2. Scale daily film records and computer process the data for the evaluation of the level of seismic activity in and around the study area.

II. Field and Laboratory Activities:

1. The RCA buildings at the field sites are heavily instrumented for communication purposes. Some equipment radiate signals of high wattage which occassionally interfere with the seismic signal. However, we have overcome the difficulties from these sources by adopting proper bandpass filters. Since RCA is a growing concern in Alaska, it frequently changes the instrumental setups in its buildings at field sites and cause deterioration of the signal-to-noise ratio of the seismic signal. After repeated changes of the electronic packages of the seismic setups, we have stabilized the microwave telemetry of the seismic signal. For the last several months, the seismic signal of desirable quality could be recorded without any loss of data.

2. The two horizontal-component seismographic system added to the vertical-component station at Kotzebue to monitor icequakes failed to function normally after ground freezeups. We attribute this to the level change to the sensitive detectors. We are in the process of correcting the situation.

3. The data gathered during 1977 have been scaled and large portions have been punched on cards for processing on computer.

III. Results:

1. The results of a preliminary computer run for the earthquake data gathered by all the networks operated by the Geophysical Institute during 3 months (July through September) of 1977 are summarized in the enclosed bulletin. This does not represent the entire seismic activity occurred during the three months, particularly, in Beaufort Sea around Barton Island and around Seward Peninsula. Detailed analyses of the data for these two areas are in progress.

2. A swarm of icequakes that occurred during the month of November, 1977, have been monitored. The data represent this sequence detected by the vertical-component detector at Kotzebue. A qualitative comparison between the wave trains recorded for this sequence and those recorded by the same station during January through March, 1977 appear very similar. Detailed analyses of the icequakes data are in progress.

IV. Preliminary Interpretation: None

V. Problems Encountered: None

VI. Estimate of Funds Expended: $17,000

QUARTERLY REPORT

A GEOGRAPHIC BASED INFORMATION MANAGEMENT SYSTEM FOR PERMAFROST IN THE BEAUFORT AND CHUKCHI SEAS.

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Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado 80309

October - December, 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 Quarterly Report (July - September 1977) and this Quarterly Report (continuation)

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* Chapters included in Annual Report 1976-1977

*** Chapters included in Quarterly Report (July-September, 1977)

**** Chapters included in this Report

I. Task Objectives

The content of this Quarterly 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 submarine permafrost origin and development, such as Quaternary Arctic history, are under consideration.

II. Summary of Results

According to the first objective connected with the data management system, we have continued to compile source data maps. These maps include salinity and temperature of the sea water at the maximal sampling depth for the Beaufort and Chukchi Seas. The distribution of the data we used for the Beaufort Sea was shown in the last report. Shown here is the distribution of data for the Chukchi Sea (Fig. 1, Table 1). This report contains the following source maps, in a scale of 1:1,000,000 generated by a CDC 7600 computer:

1) Temperature of the sea water at the maximal sampling depth (interval of $1^{o}C$),
2) Salinity of the sea water at the maximal sampling depth (interval of $1^{o}/oo$),
3) Proximity of the sampling depth to the bottom in %,
4) Temperature of the Beaufort Sea water at the maximal sampling depth (interval of $0.2^{o}C$).

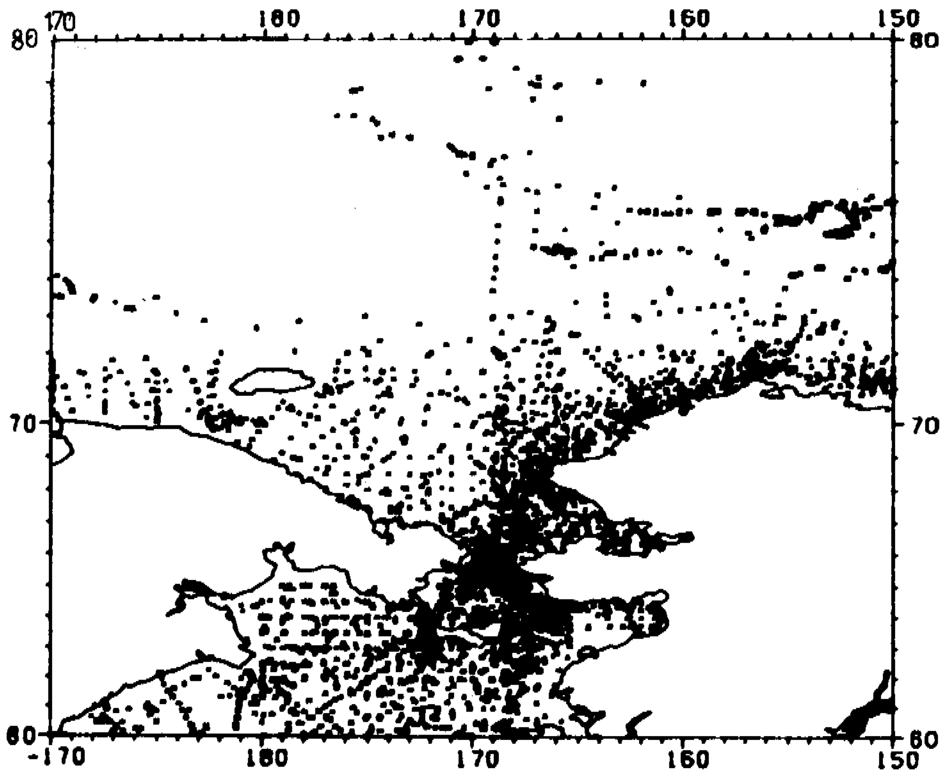


Figure 1. Distribution of observations

Months 1 to 12 Years 1900 to 1977 4582 Total station count

Table 1. Distribution of observations by month — Chukchi Sea

Month	Number	Sampling Depth (m)	Bottom (M)	Temp. (C°)	Salinity (°/oo)
1	2	2	1	2	2
2	1	1	1	1	1
3	1	1	1	1	1
4	12	12	12	12	12
5	41	41	3	3	14
6	28	28	28	28	26
7	215	215	171	215	206
8	1957	1957	1913	1957	1947
9	1230	1213	1196	1228	1227
10	213	213	213	209	208
11	26	26	26	18	22
12	2	2	2	2	2
Total	3718	3709	3567	3764	3668

All these source maps are included in this report. The division of the 1,000,000 scale maps for Quarterly Report is shown in Figure 2.

After many different experiments we found that a 2-dimensional first or second order polinomal interpolation seems to give the best results. The numerical scheme follows. If we wish to calculate the value of some physical or geological feature at points M (Xo,Yo), we first limit our considerations to the domain p'={(Xi,Yi)}, which satisfies the condition:

$$\sqrt{(x_0-x_i)^2+(y_0-y_i)^2} \leq R \quad (1)$$

In other words, the point M is inside the circle of radius R. Each point (Xi,Yi) has a special value Pi, which is increases when (Xi,Yi) is near (Xo,Yo) and decreases otherwise. At the point M (XoYo) the value is equal to 1. We take the point M as an origin of coordinates. The value of the fraction in each point inside our domain (1) can be approximated by polinom of 2nd or 1st degree,

$$Q_2(x,y) = C_0+C_1x+C_2y+C_3x^2+C_4xy+C_5y^2$$

or

$$Q_1(x,y) = C_0+C_1x+C_2y$$

We will now show how to calculate the unknown coefficients $C_0, C_1, C_2, C_3, C_4, C_5$ in the case of second order polinom. This is done by using the least squares numerical method, needed are such coefficents which will give the minimum to the sum

$$S = \sum_{i=1}^{N} P_i \left(C_0+C_1x_i+C_2y_i+C_3x_i^2+C_4x_iy_i+C_5y_i^2-\varphi_i\right)^2$$

Where N is number of observations inside the circle of radius R, (Xi,Yi) are coordinates of the given observations and φ_i are the values of the function (salinity, temperature, depth) at these points. In order to obtain a minimum of S we must take the derivatives of this expression with regard to C_0, C_1, C_2, C_3, C_4 and C_5 and obtain 6 linear equations, which are called normal equations:

$$\frac{ds}{dc_0} = \frac{ds}{dc_1} = \frac{ds}{dc_2} = \frac{ds}{dc_3} = \frac{ds}{dc_4} = \frac{ds}{dc_5} = 0$$

$$\begin{cases} C_0\sum p_i + C_1\sum p_i x_i + C_2\sum p_i y_i + C_3\sum p_i x_i^2 + C_4\sum p_i x_i y_i + C_5\sum p_i y_i^2 = \sum p_i \varphi_i \\ C_0\sum p_i x_i + C_1\sum p_i x_i^2 + C_2\sum p_i x_i y_i + C_3\sum p_i x_i^3 + C_4\sum p_i x_i^2 y_i + C_5\sum p_i x_i y_i^2 = \sum p_i x_i \varphi_i \\ C_0\sum p_i y_i + C_1\sum p_i x_i y_i + C_2\sum p_i y_i^2 + C_3\sum p_i x_i^2 y_i + C_4\sum p_i x_i y_i^2 + C_5\sum p_i y_i^3 = \sum p_i x_i \varphi_i \\ C_0\sum p_i x_i^2 + C_1\sum p_i x_i^3 + C_2\sum p_i x_i^2 y_i + C_3\sum p_i x_i^4 + C_4\sum p_i x_i^3 y_i + C_5\sum p_i x_i^2 y_i^2 = \sum p_i x_i^2 \varphi_i \\ C_0\sum p_i x_i y_i + C_1\sum p_i x_i^2 y_i + C_2\sum p_i x_i y_i^2 + C_3\sum p_i x_i^3 y_i + C_4\sum p_i x_i^2 y_i^2 + C_5\sum p_i x_i y_i^3 = \sum p_i x_i y_i \varphi_i \\ C_0\sum p_i y_i^2 + C_1\sum p_i x_i y_i^2 + C_2\sum p_i y_i^3 + C_3\sum p_i x_i^2 y_i^2 + C_4\sum p_i x_i y_i^3 + C_5\sum p_i y_i^4 = \sum p_i y_i^2 \varphi_i \end{cases}$$

Remembering that M (X_o Y_o) is the origin of the coordinates, we have only to find Co and then $\varphi(X_o, Y_o) = C_o$. When calculating the value of the needed function at point M we need only move to the next point and repeat the above calculations.

The value of Pi is a function of the distance

$$d_i = \sqrt{(x_i - x_o)^2 + (y_i - y_o)^2}$$

and must equal zero when di = R and equal 1, when $d_i = 0$.

In our calculations we have chosen the expression:

$$P_i = \begin{cases} \left(\dfrac{R^2 - d_i^2}{d_i^2}\right)^2 & d_i \neq 0 \\ 1 & d_i = 0 \end{cases}$$

The radius R was chosen as R = 25.ΔX, but it is very important to be sure that at least six observations are inside the circle when using a second order interpolation and three observations for a first order. Generally all calculations were done with second order polinomials, but occasionally, as a test, we used first order, and usually the results were almost the same. However, second order has given a smoothed contour.

The analysis of these maps and the maps that will be generated during January-April 1978 shall be given together with our Annual Report.

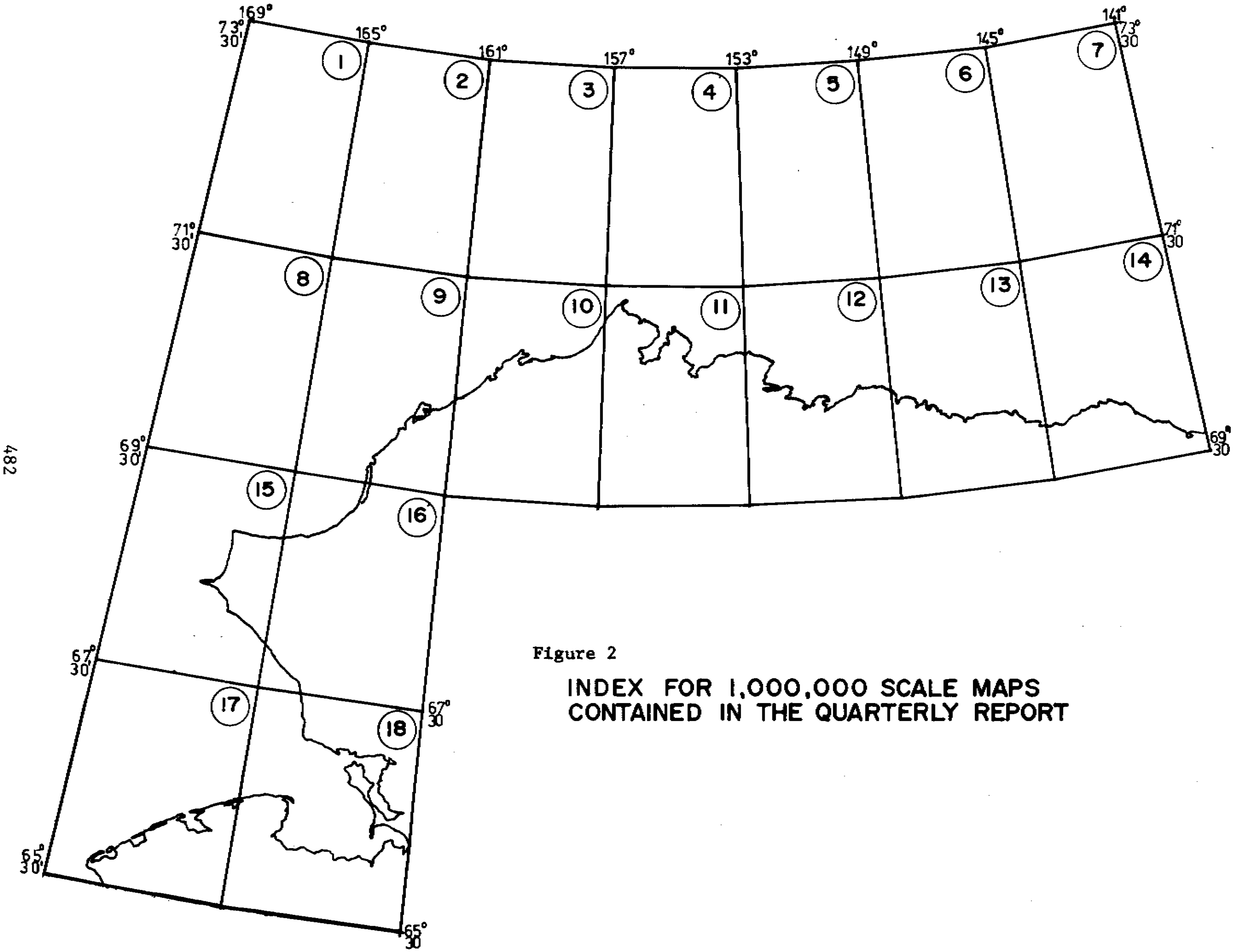


Figure 2

INDEX FOR 1,000,000 SCALE MAPS
CONTAINED IN THE QUARTERLY REPORT

CHUKCHI SEA
BEAUFORT SEA

RESEARCH UNIT 516 OCSEAP
NOAA INSTAAR 1977

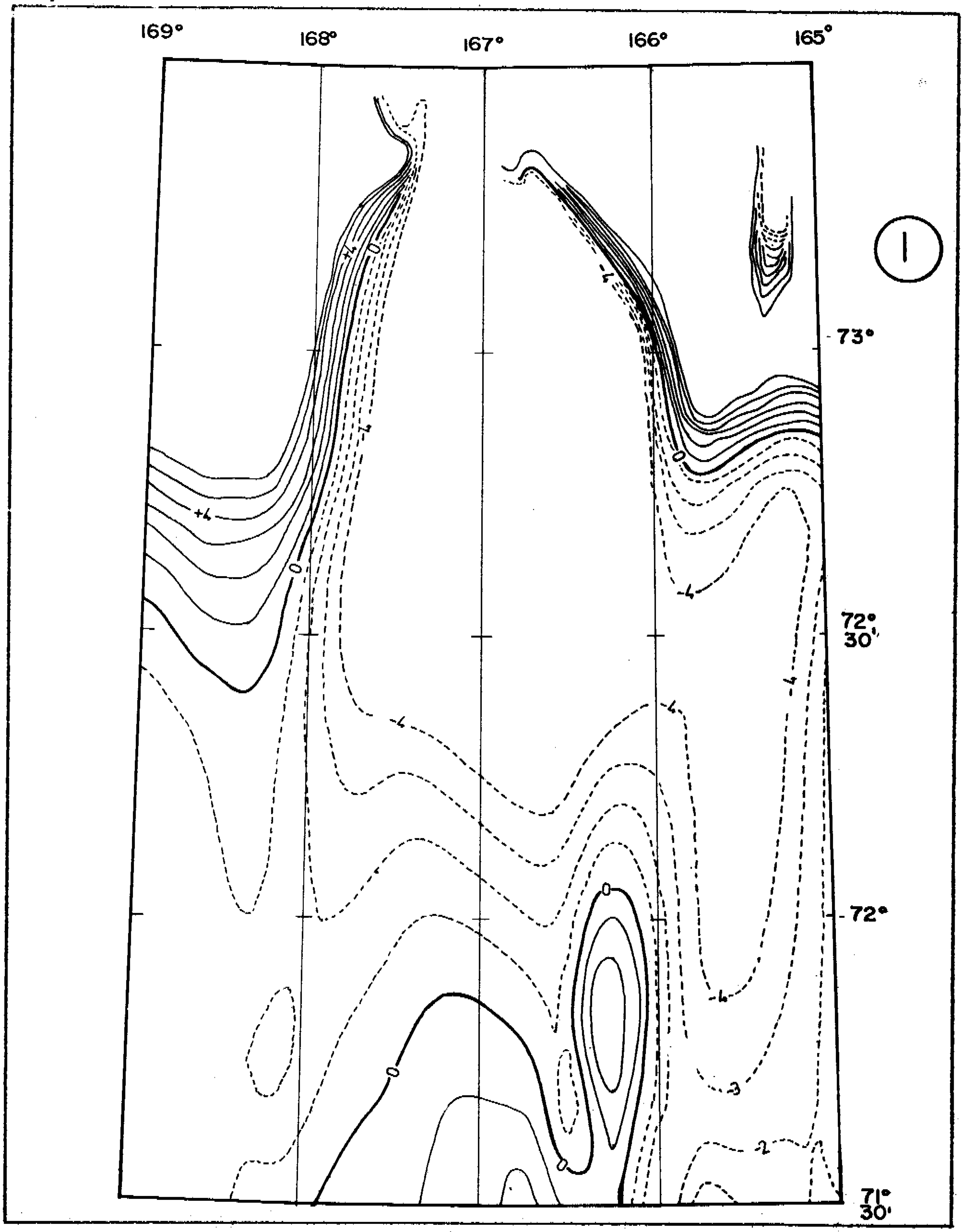
TEMPERATURE OF THE SEA WATER AT THE MAXIMAL SAMPLING DEPTH

A SOURCE MAP FOR SUBMARINE PERMAFROST PREDICTION

TEMPERATURE — -4° TO +6°C
INTERVAL OF 1°C
SCALE — 1:1,000,000

GEOGRAPHIC BASED INFORMATION MANAGEMENT SYSTEM FOR PERMAFROST IN THE CHUKCHI AND BEAUFORT SEAS

temperature



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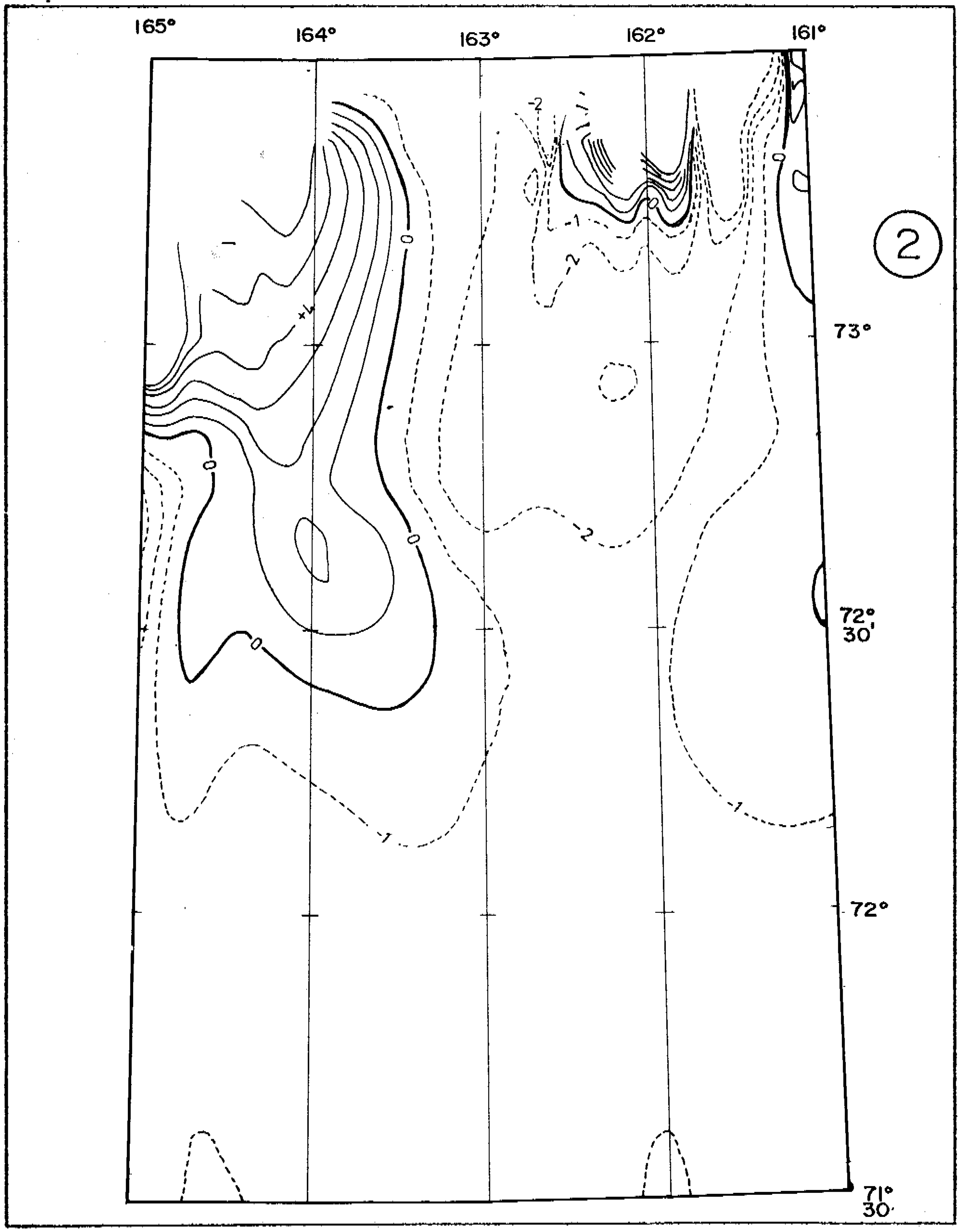

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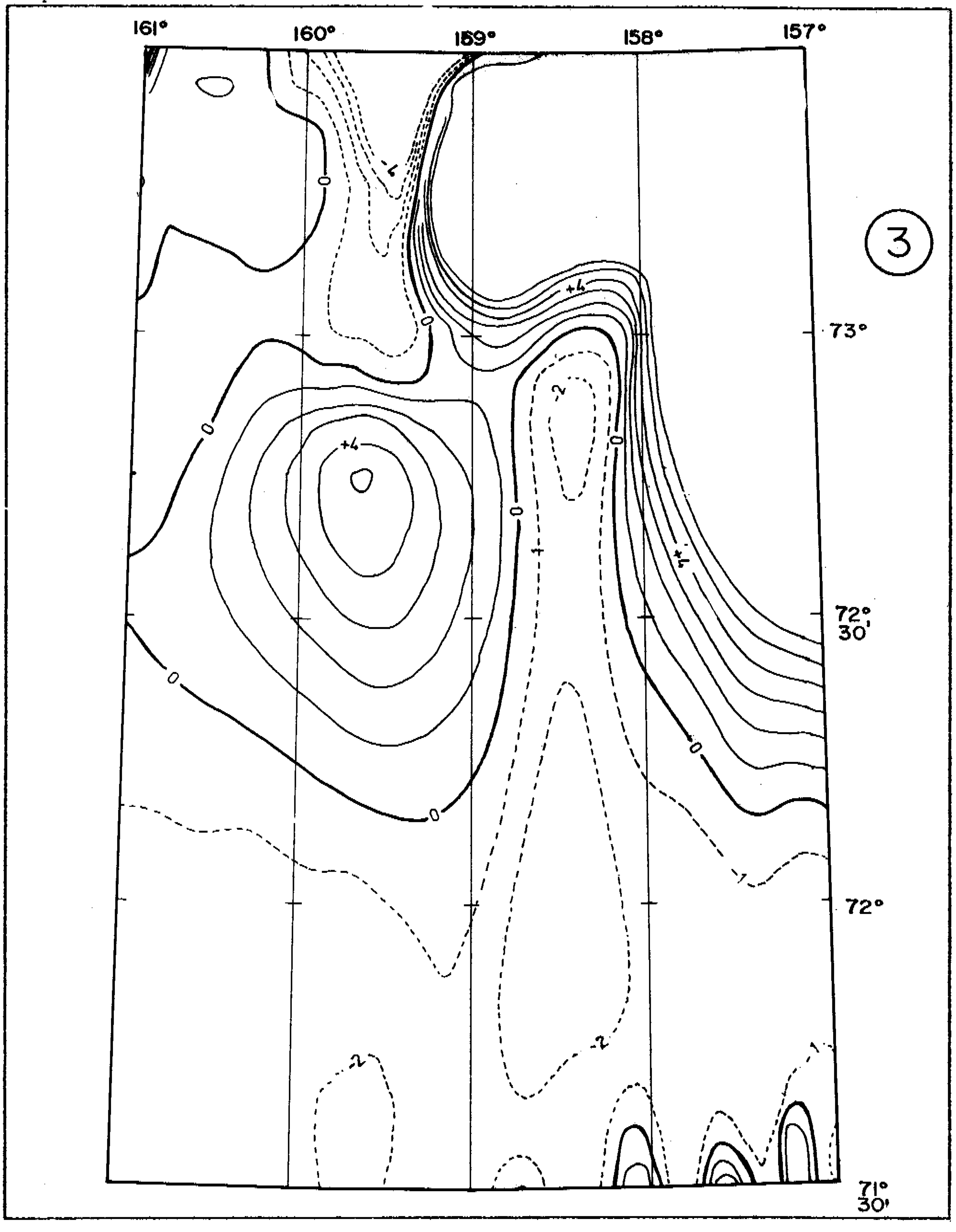

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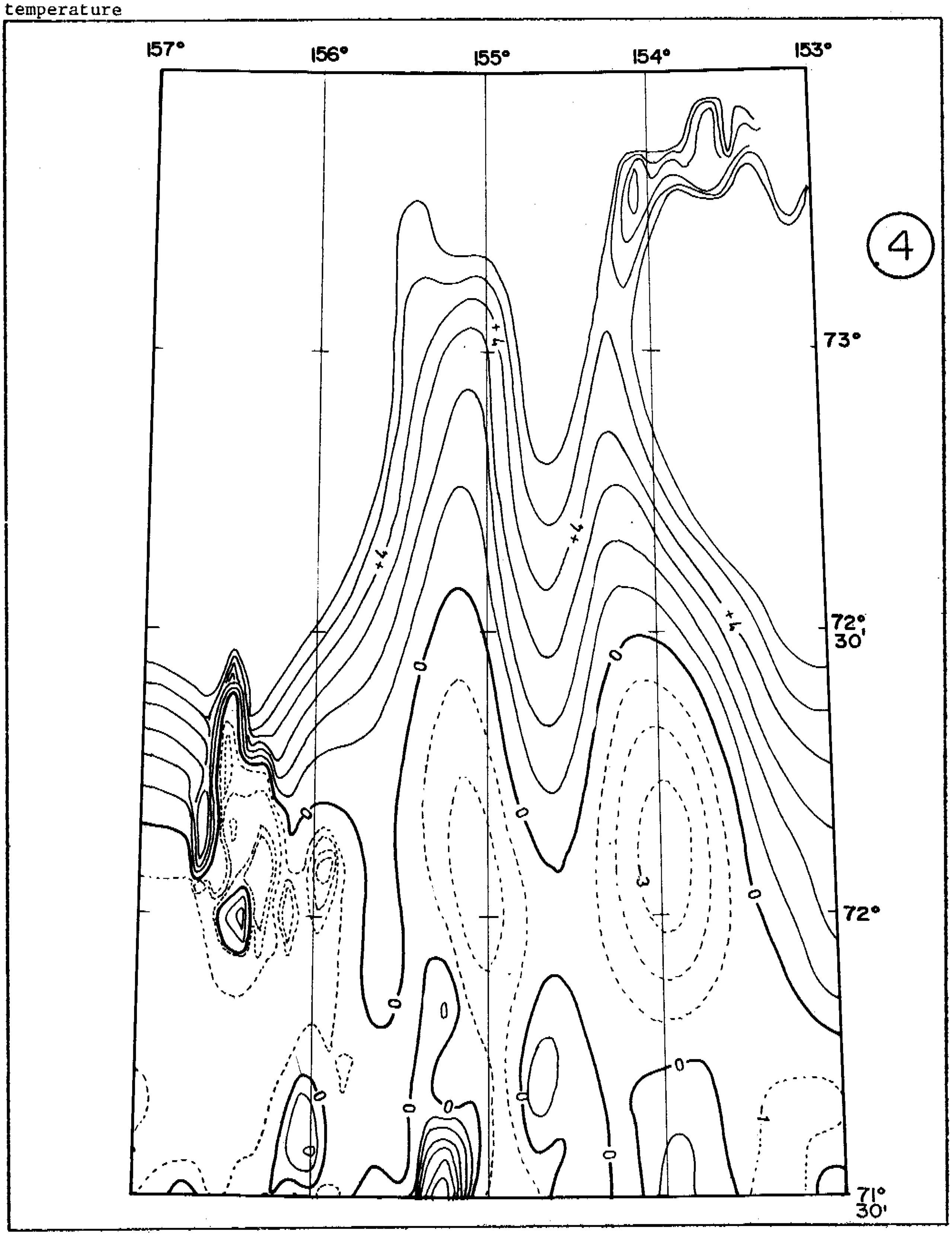

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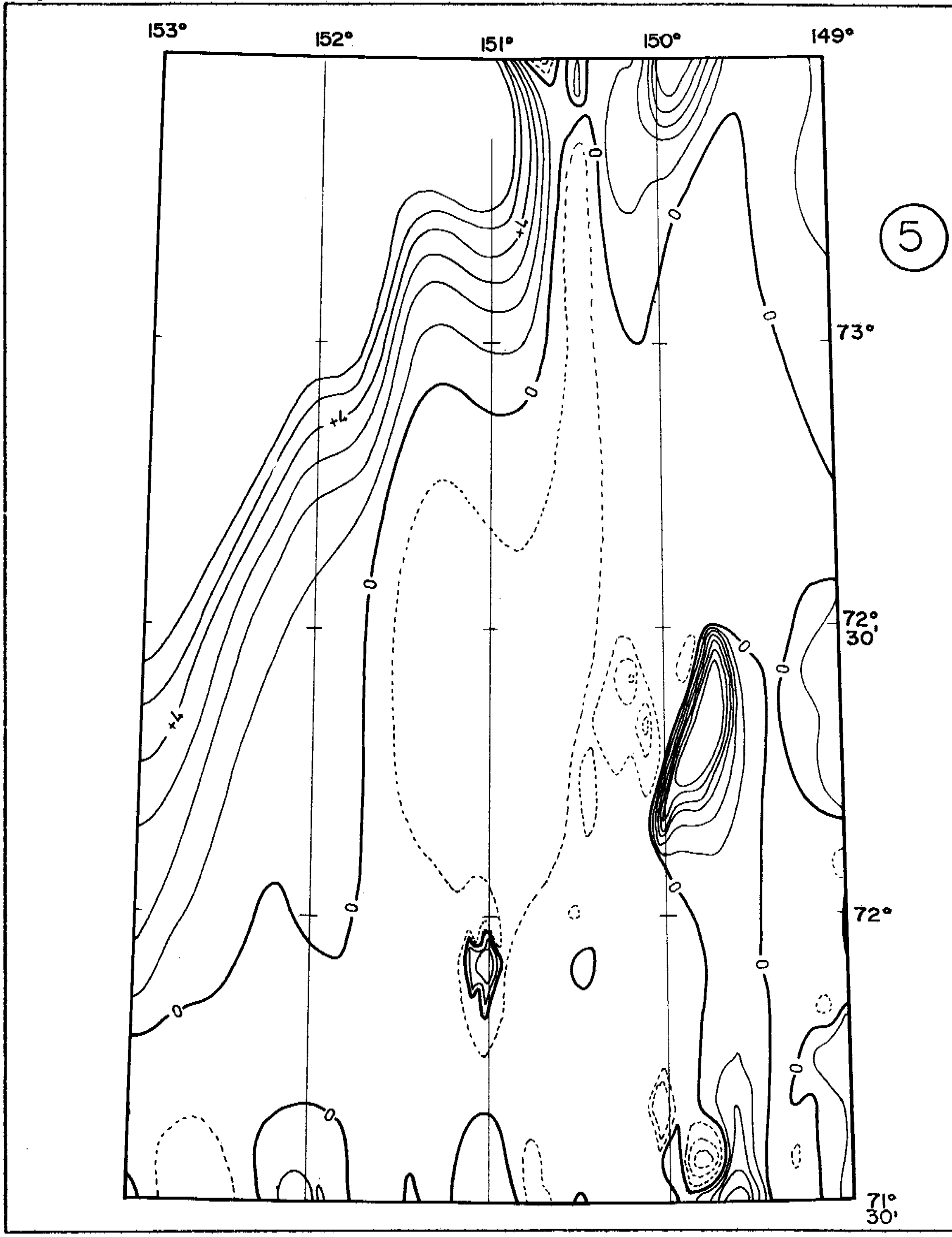

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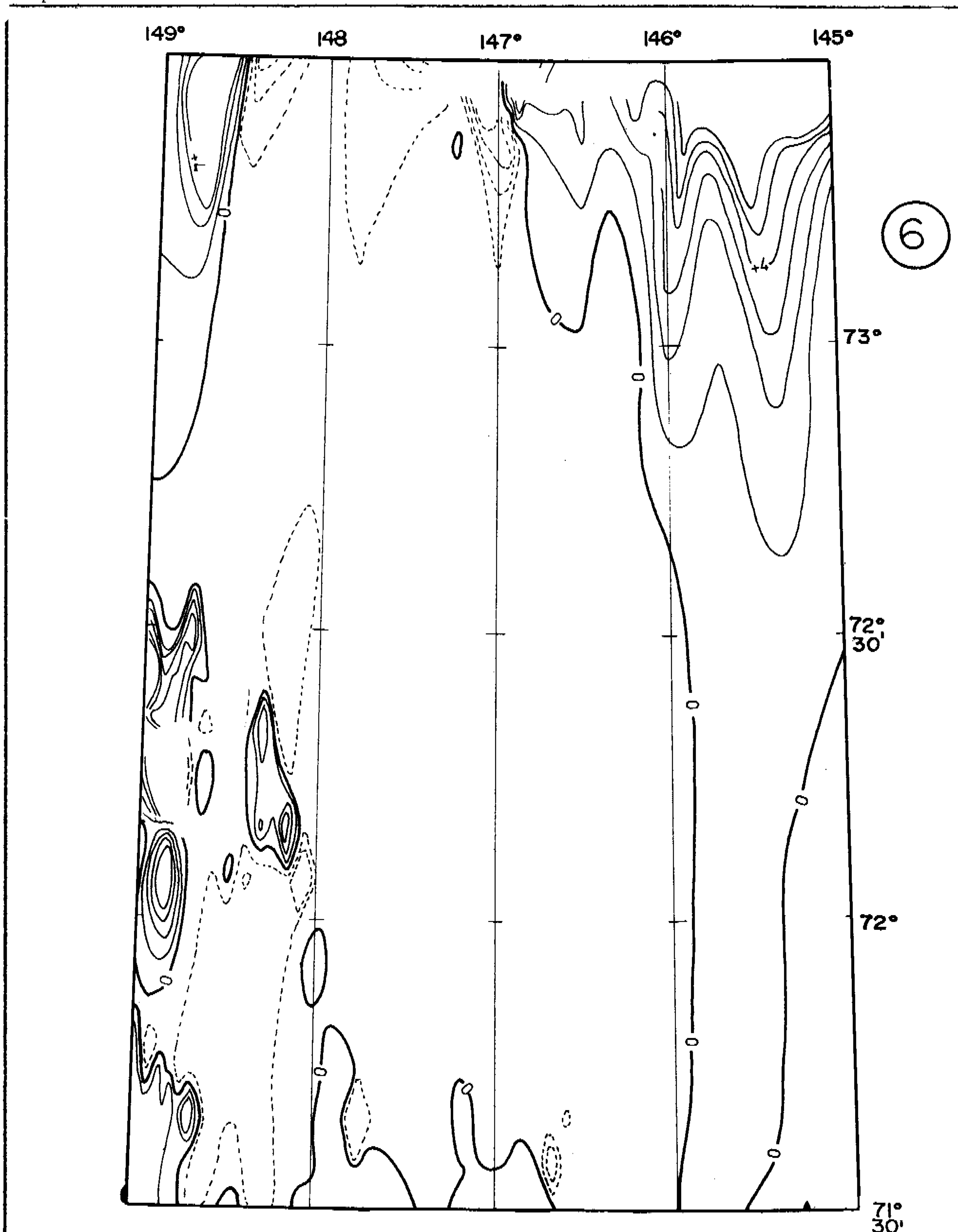

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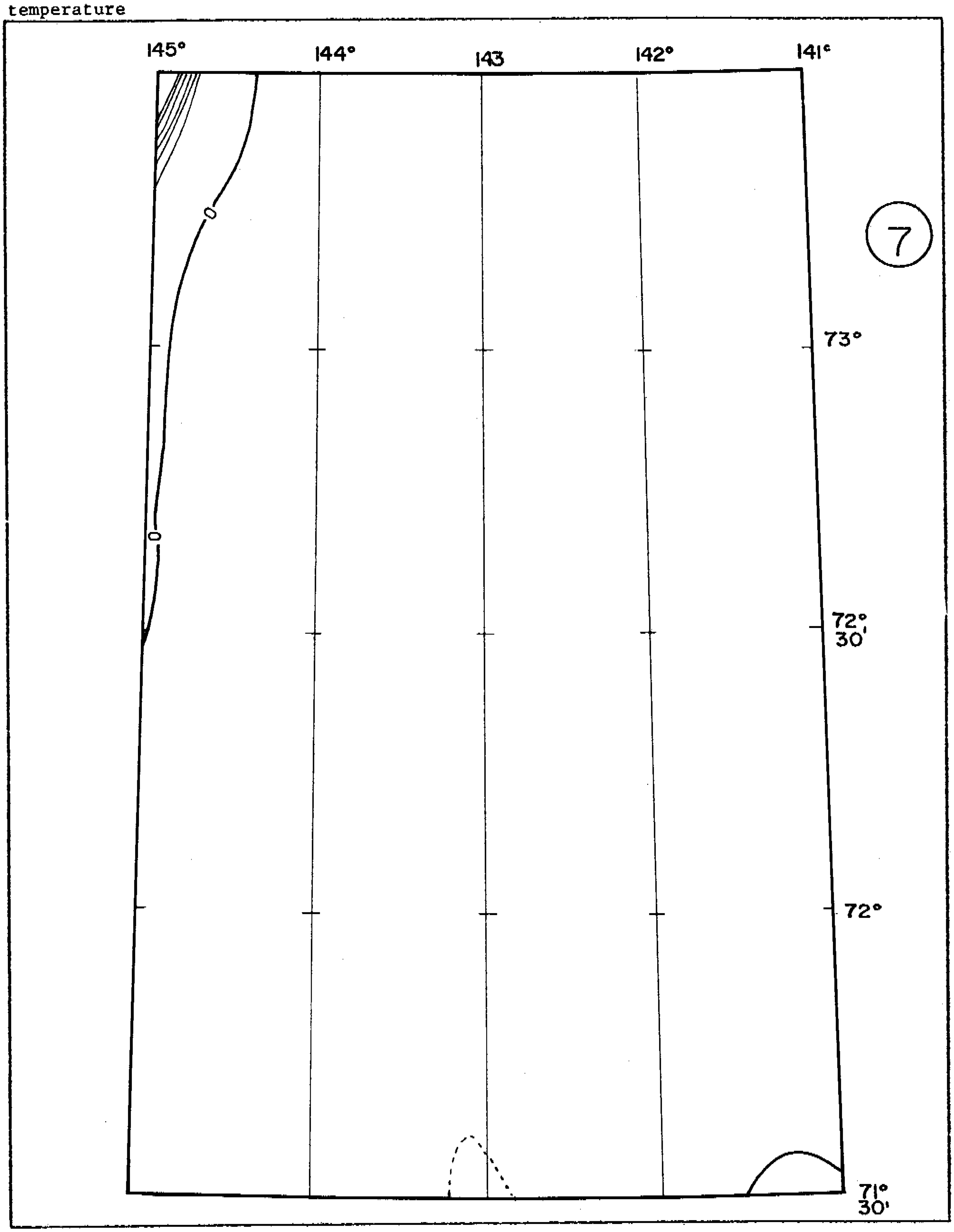

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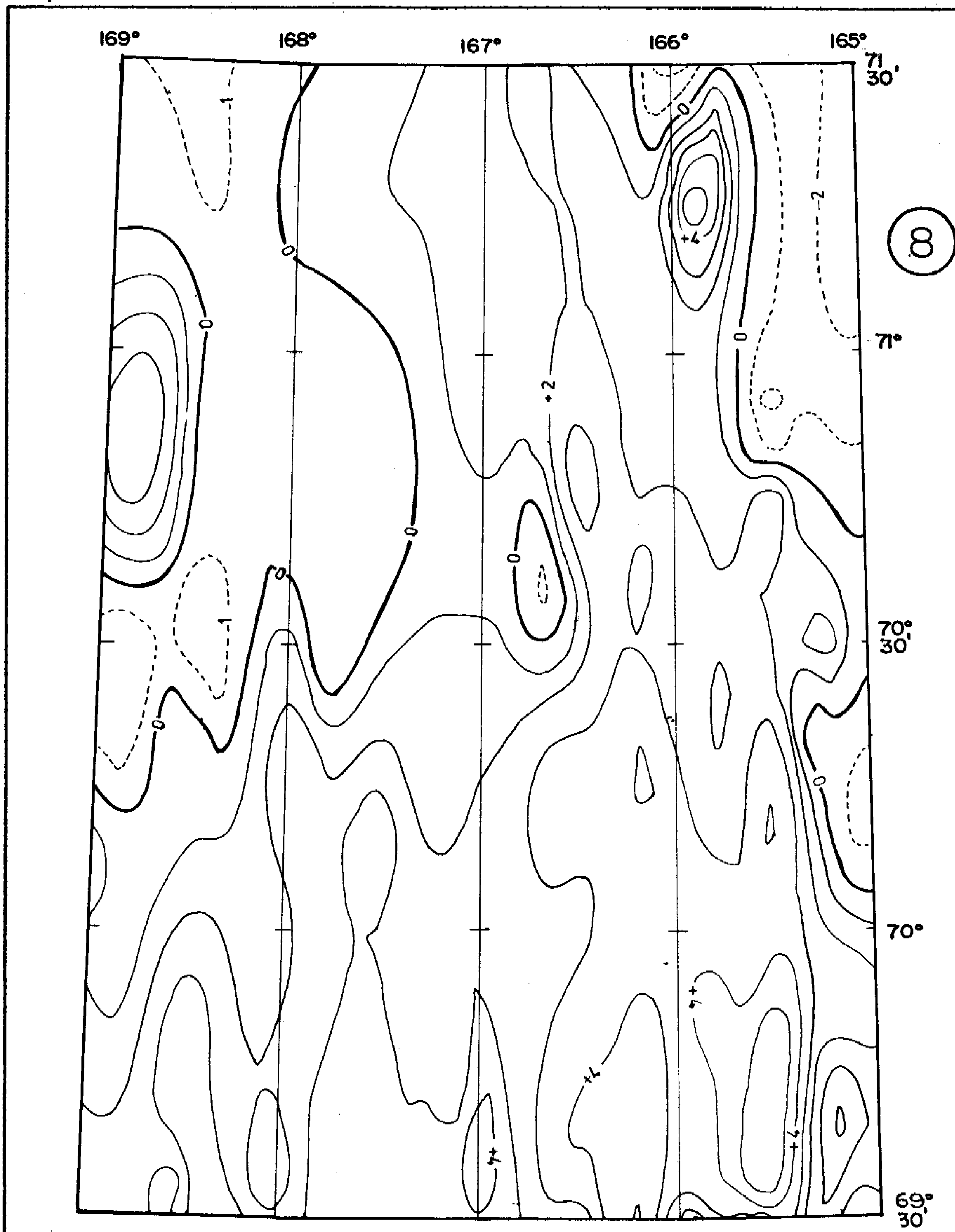

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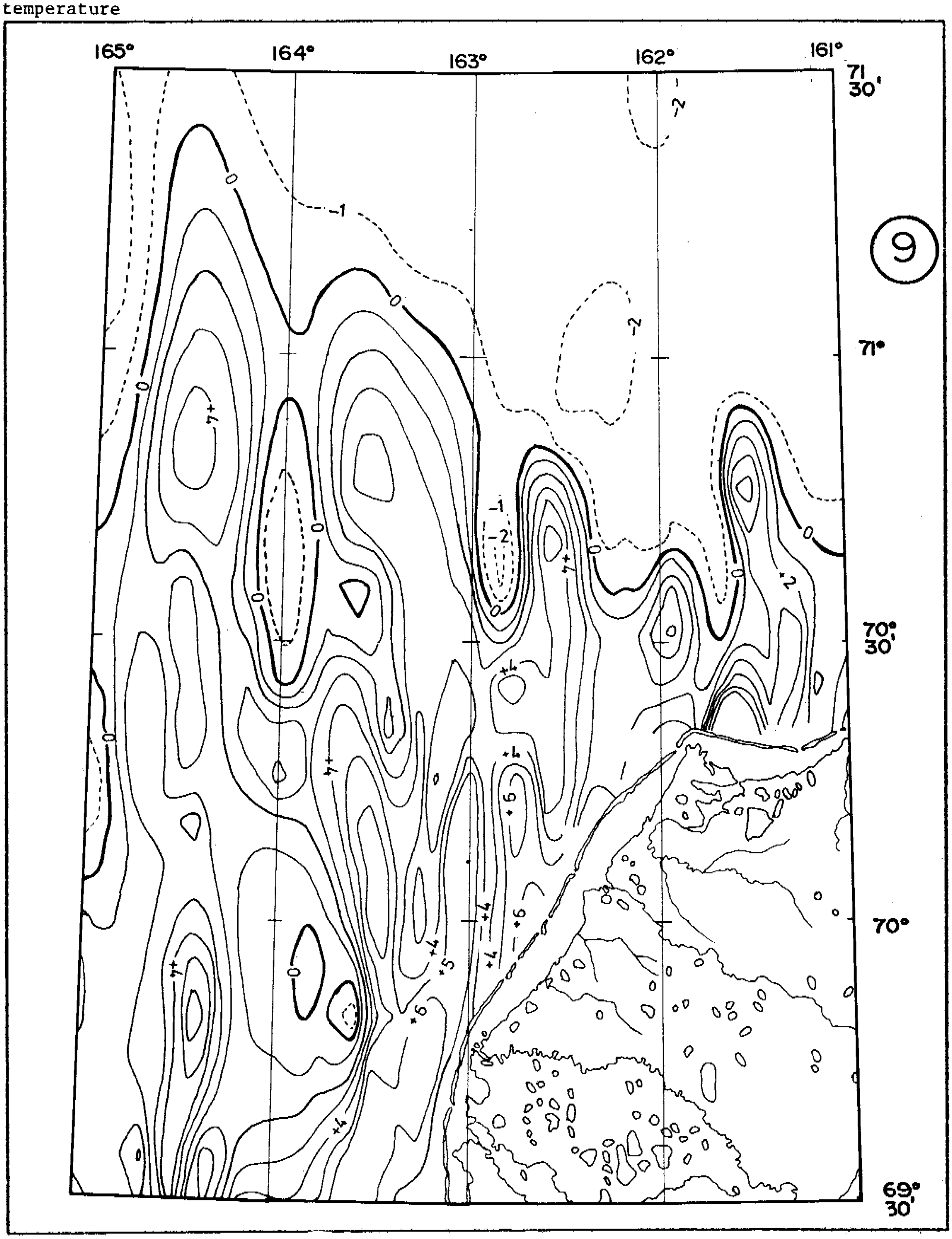

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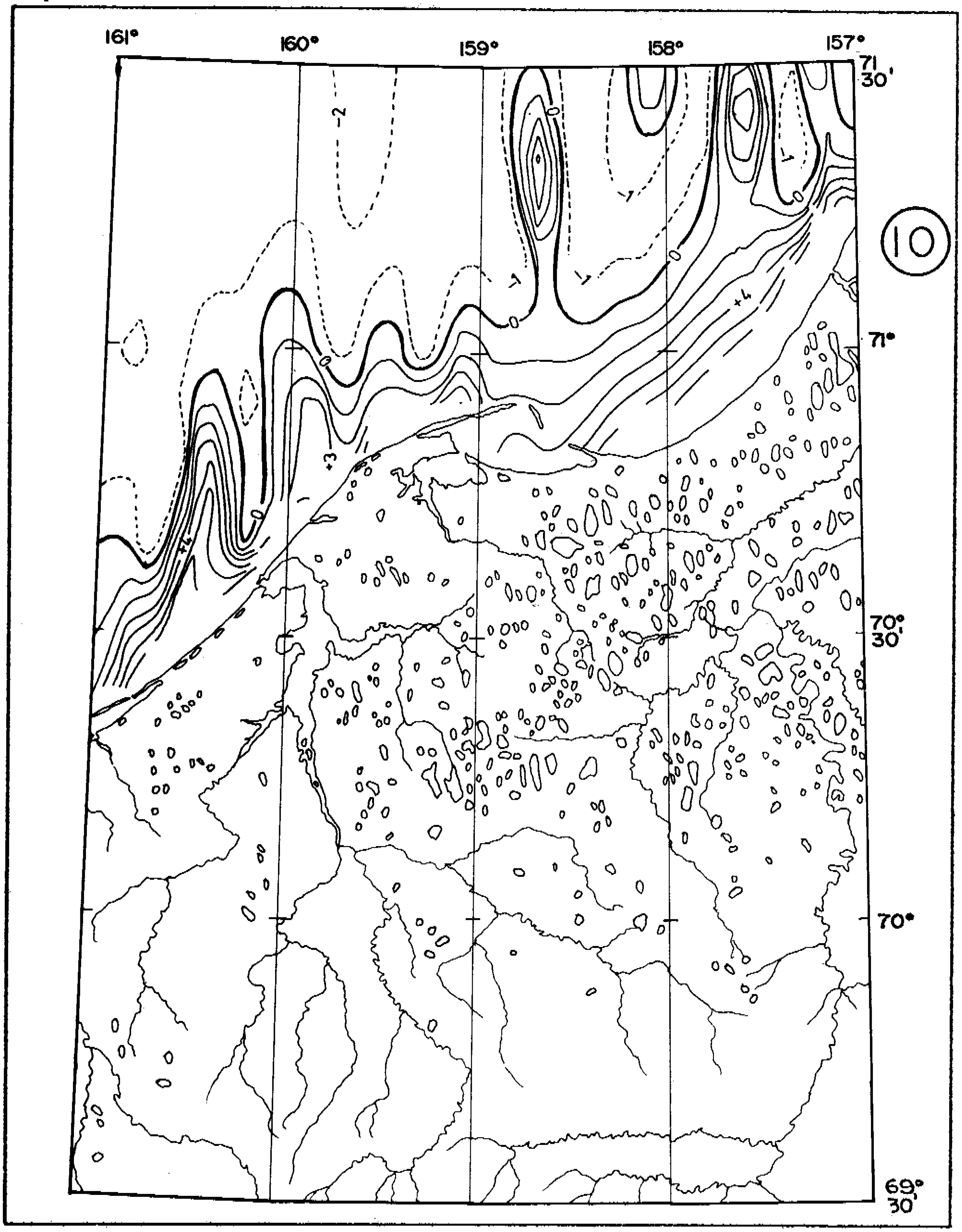

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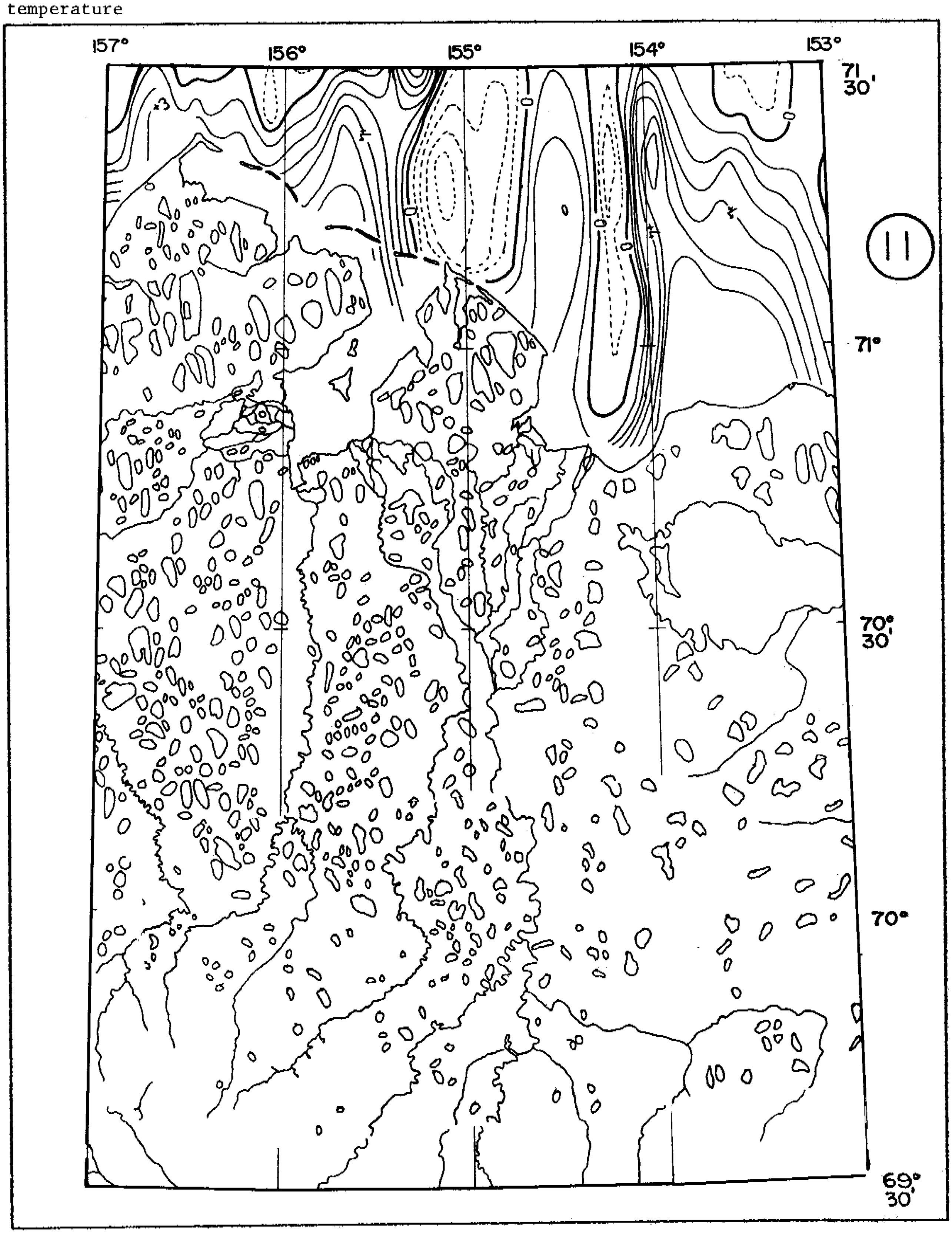

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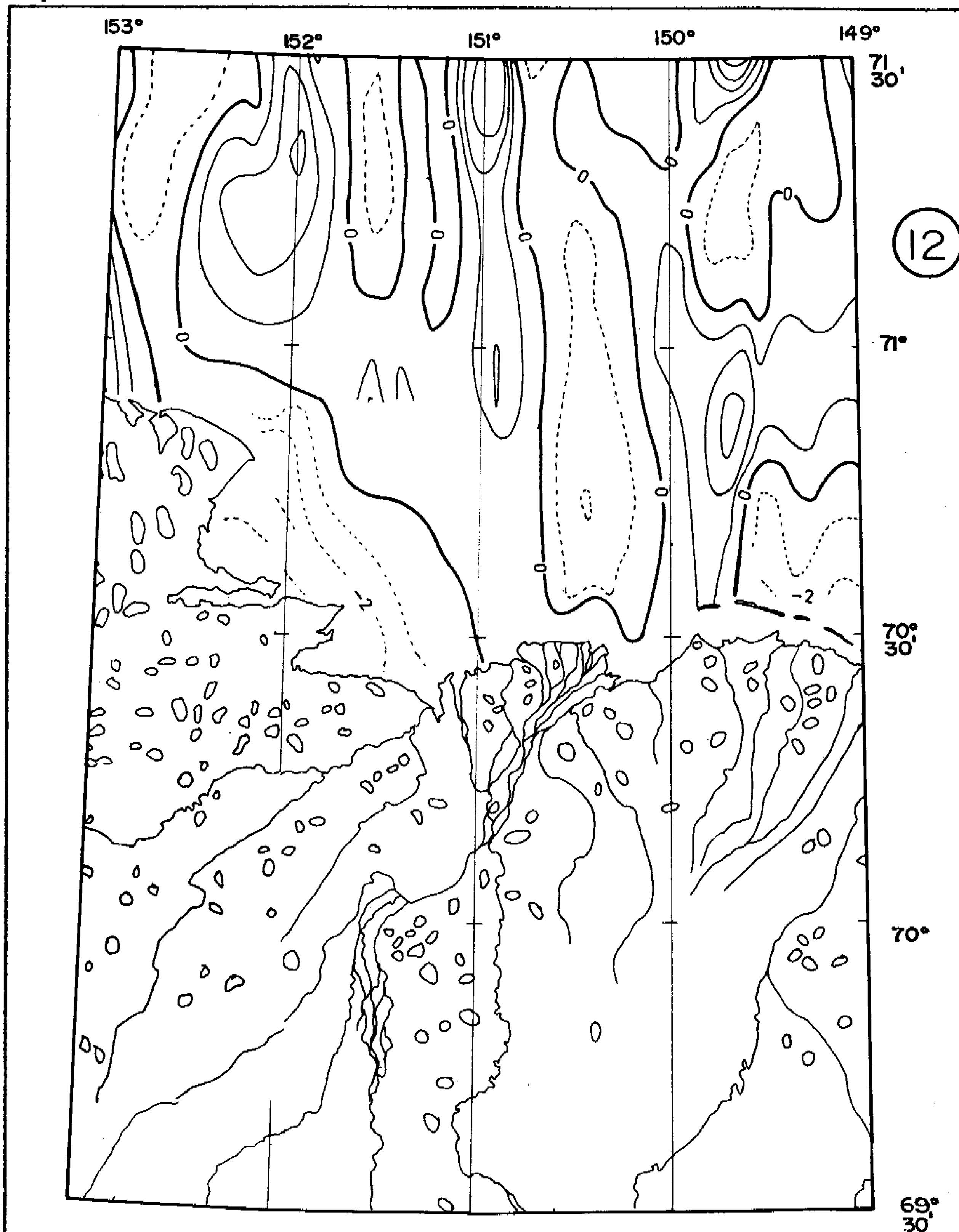

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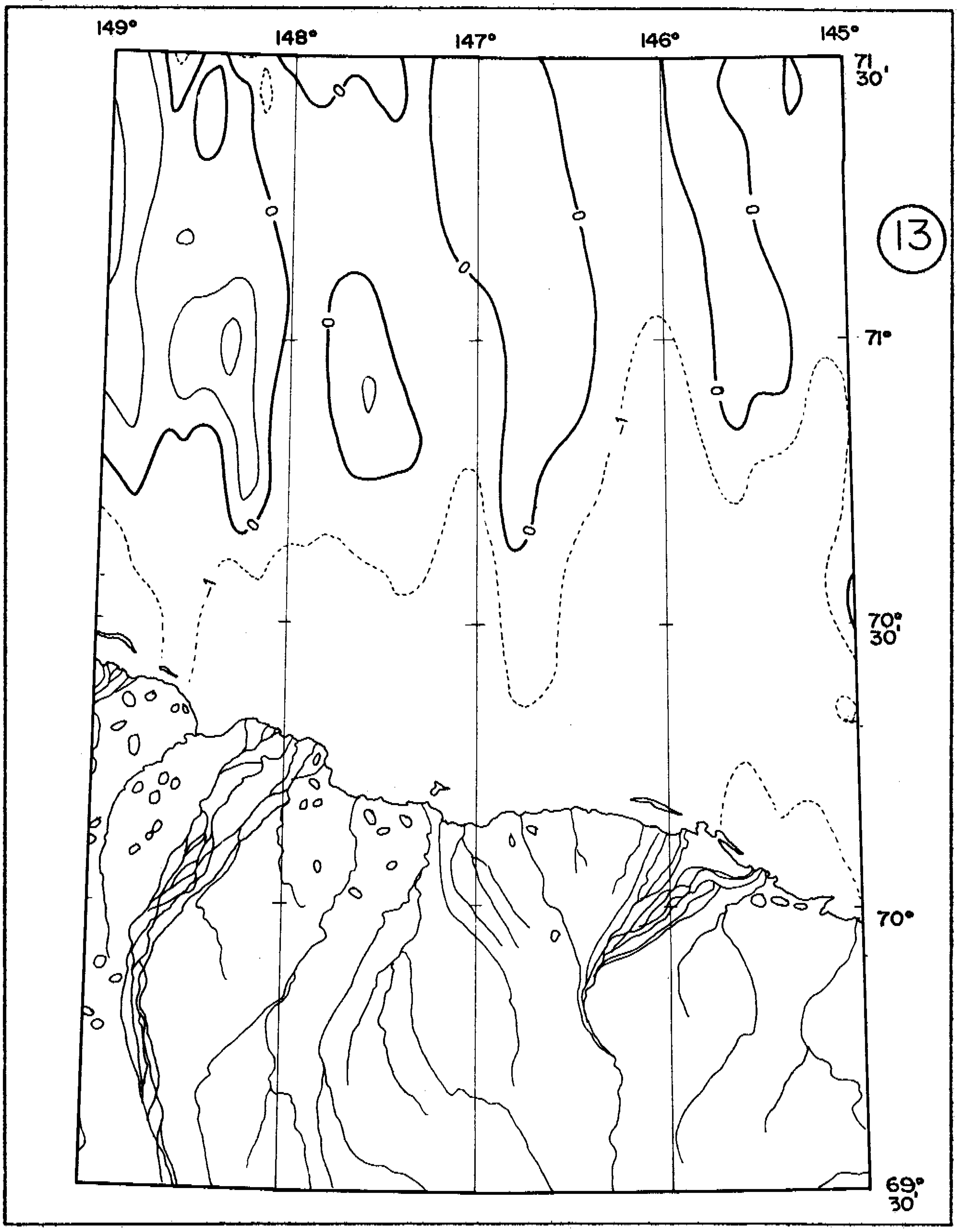

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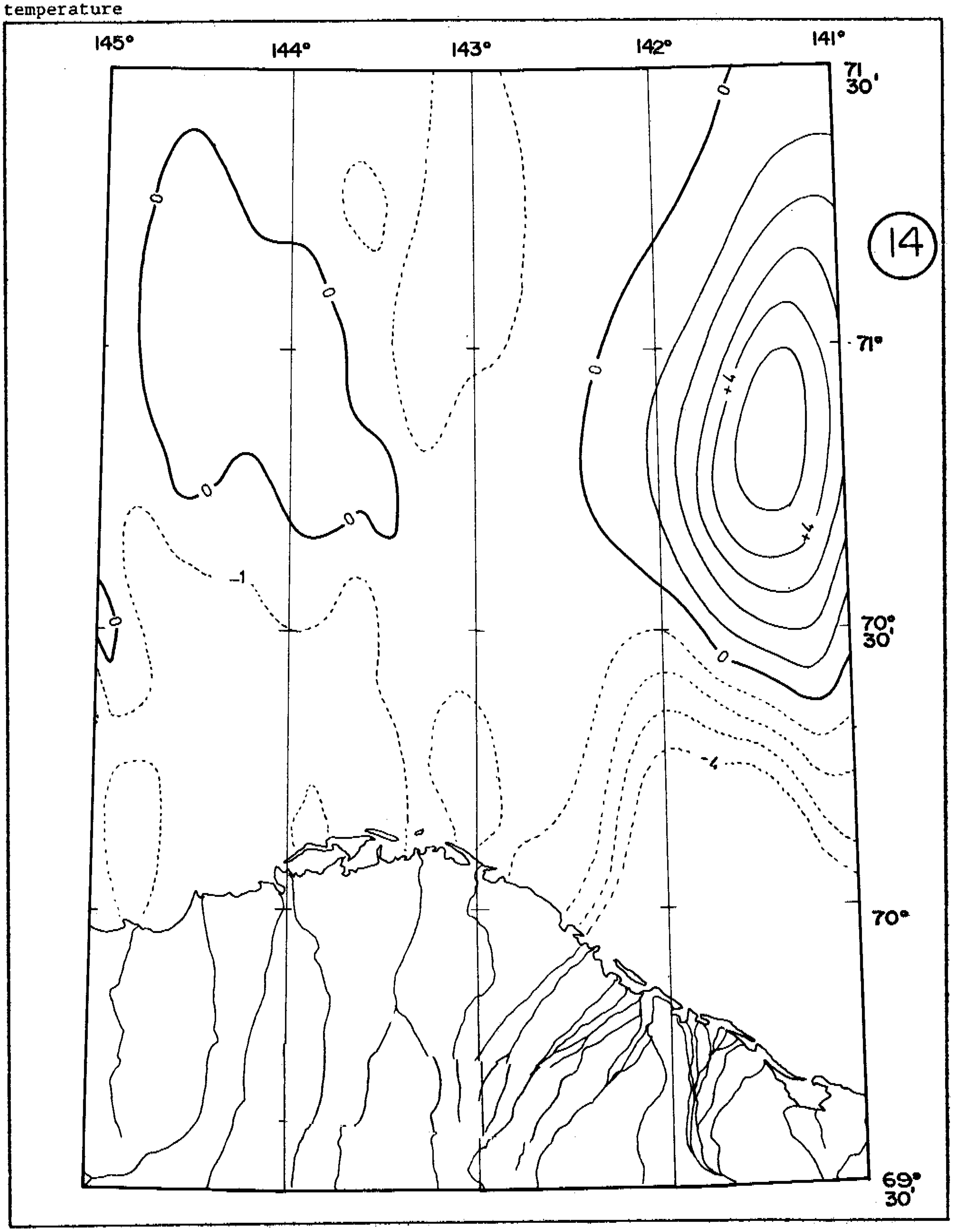

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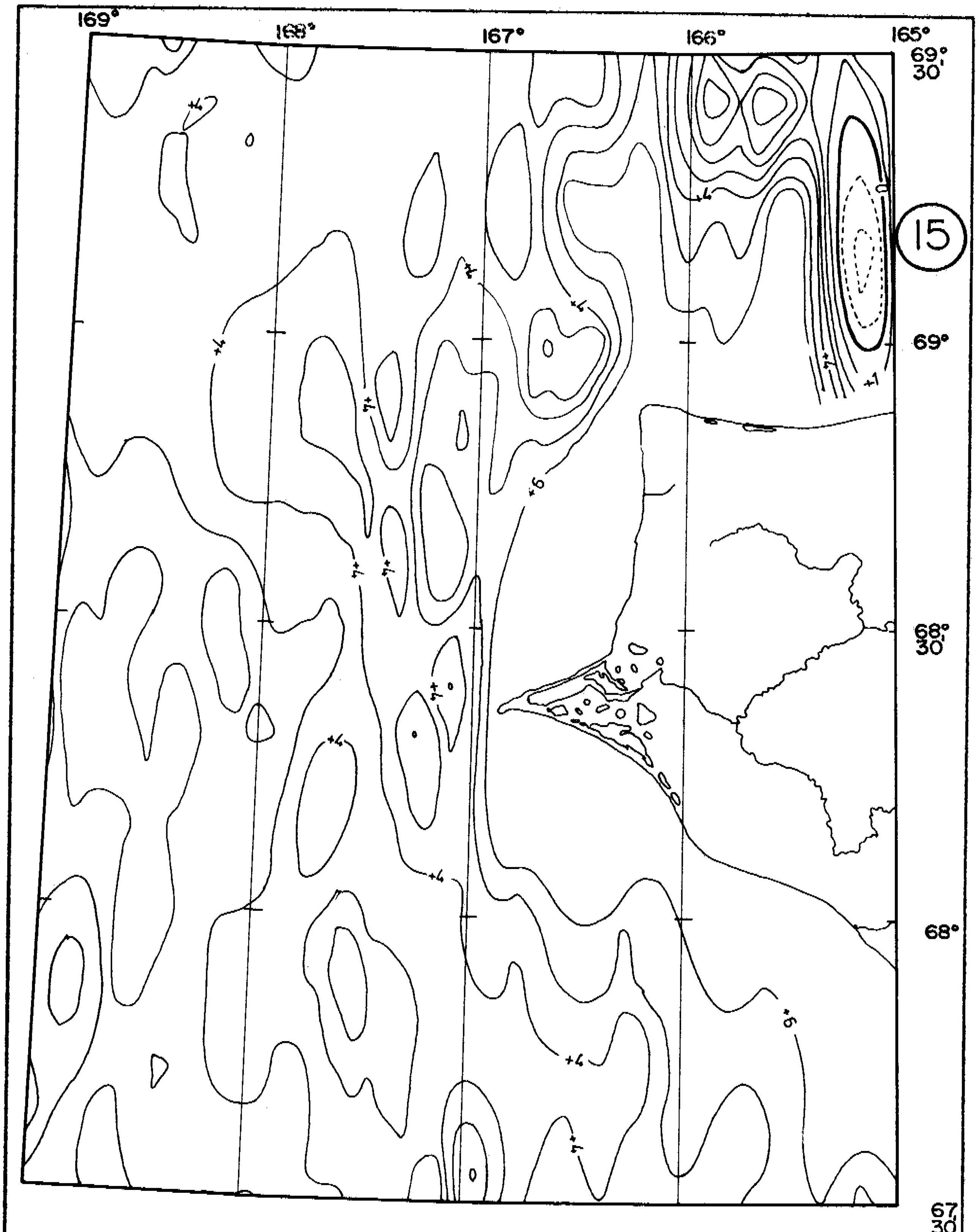

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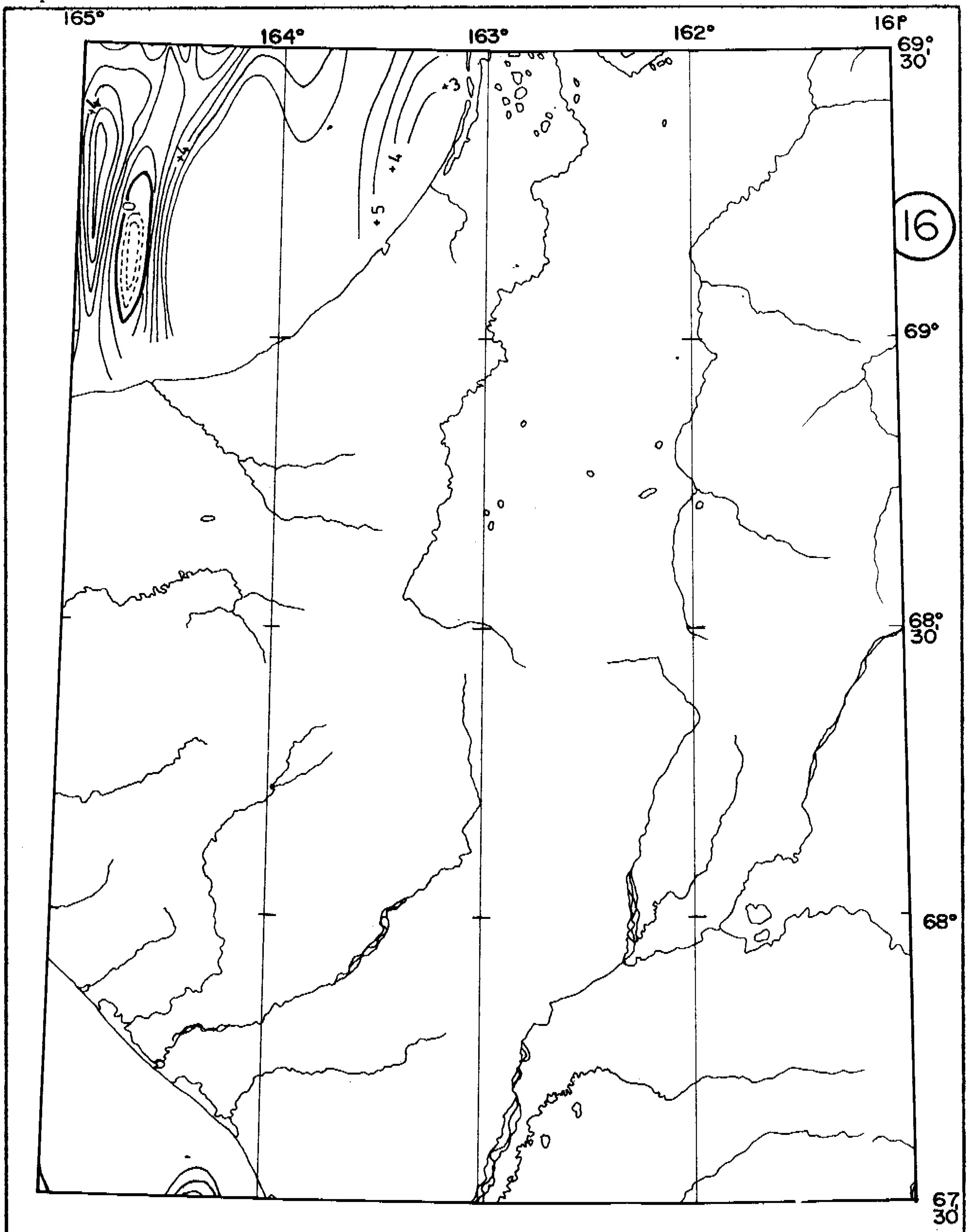

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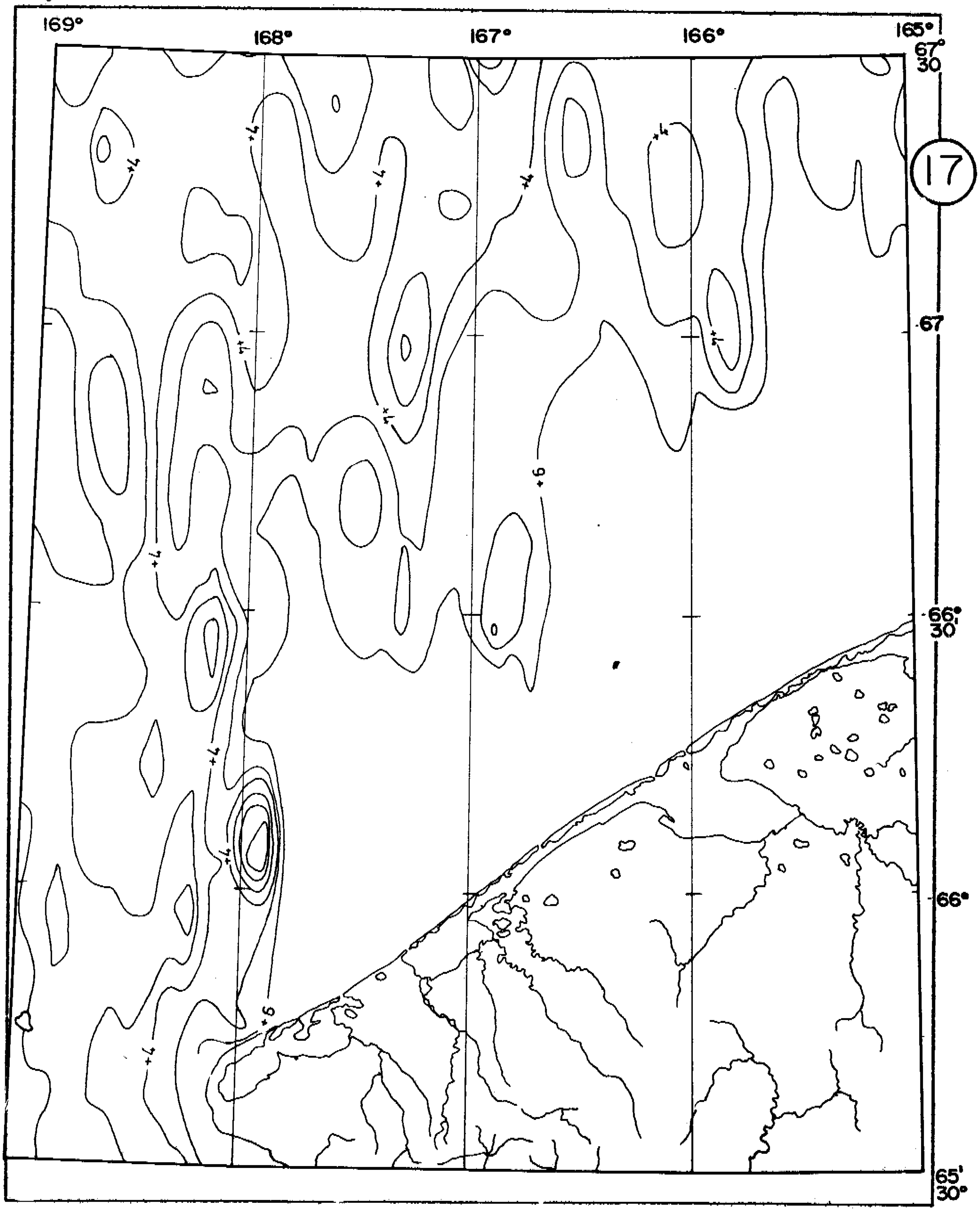

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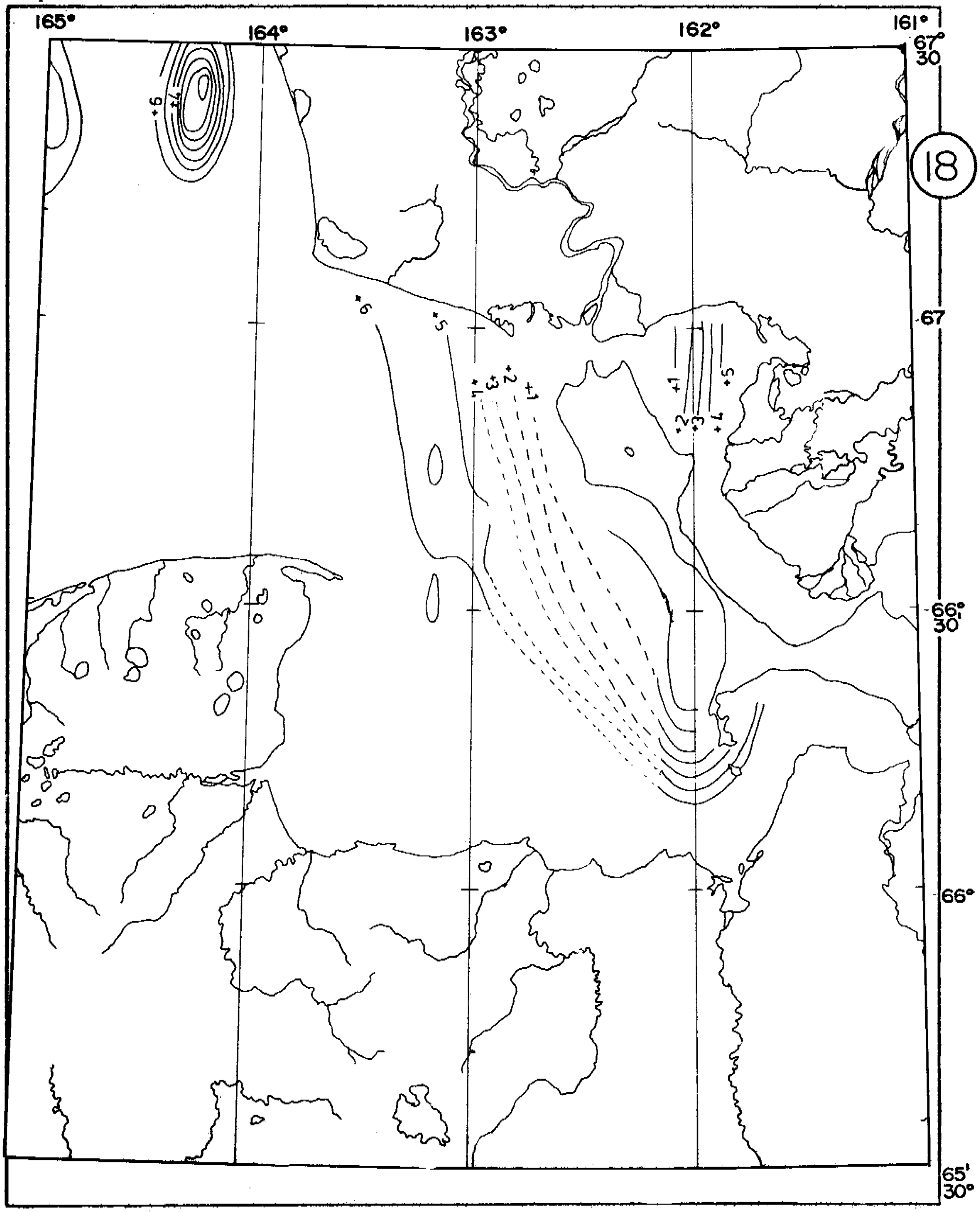


CHUKCHI SEA
BEAUFORT SEA

RESEARCH UNIT 516 OCSEAP
1977

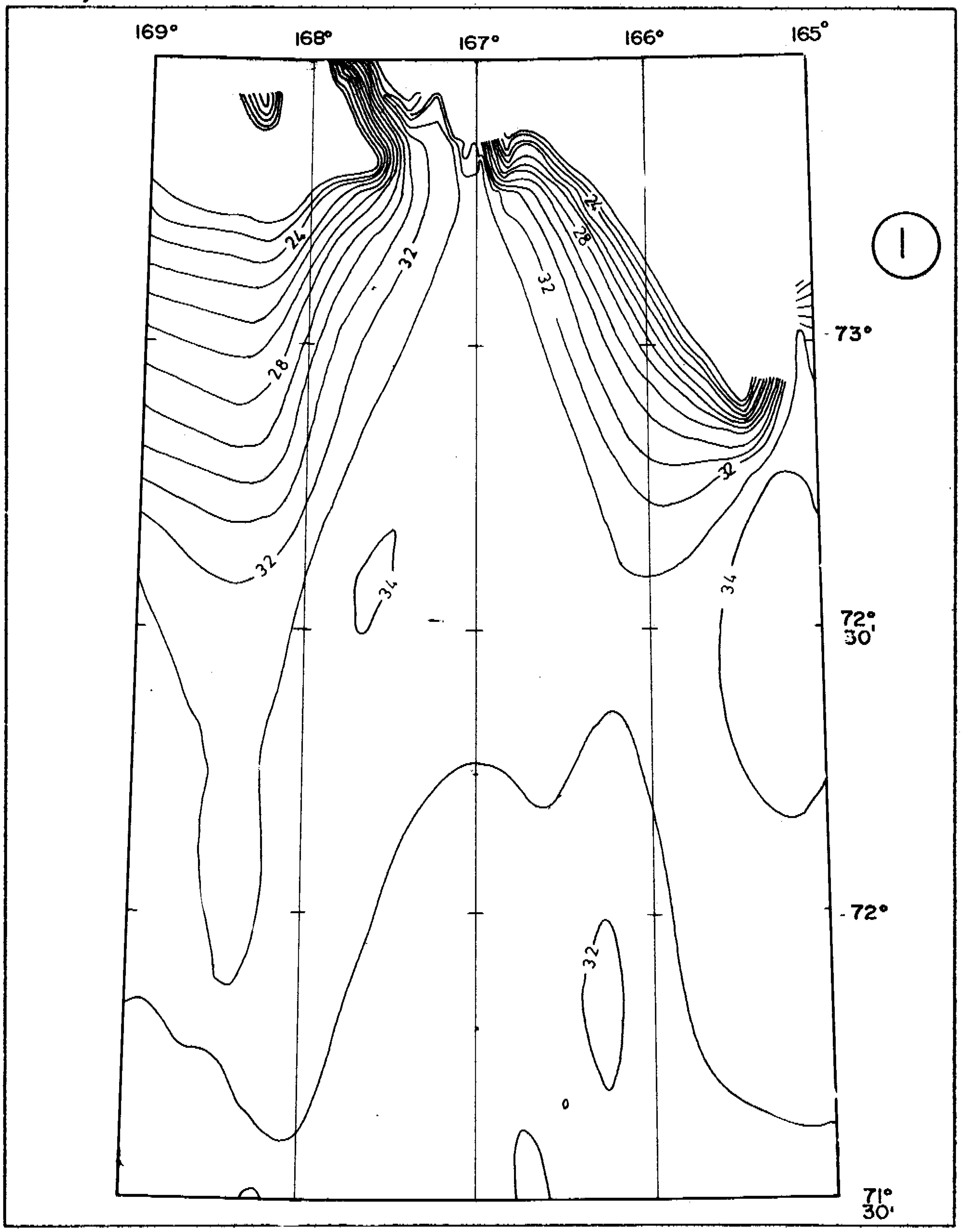
SALINITY OF THE SEA WATER AT THE MAXIMAL SAMPLING DEPTH

A SOURCE MAP FOR SUBMARINE PERMAFROST PREDICTION

SALINITY — 22 TO 36‰
INTERVAL OF 1‰
SCALE — 1:1,000,000

GEOGRAPHIC BASED INFORMATION MANAGEMENT SYSTEM
FOR PERMAFROST IN THE CHUKCHI AND BEAUFORT SEAS

salinity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167°
166°
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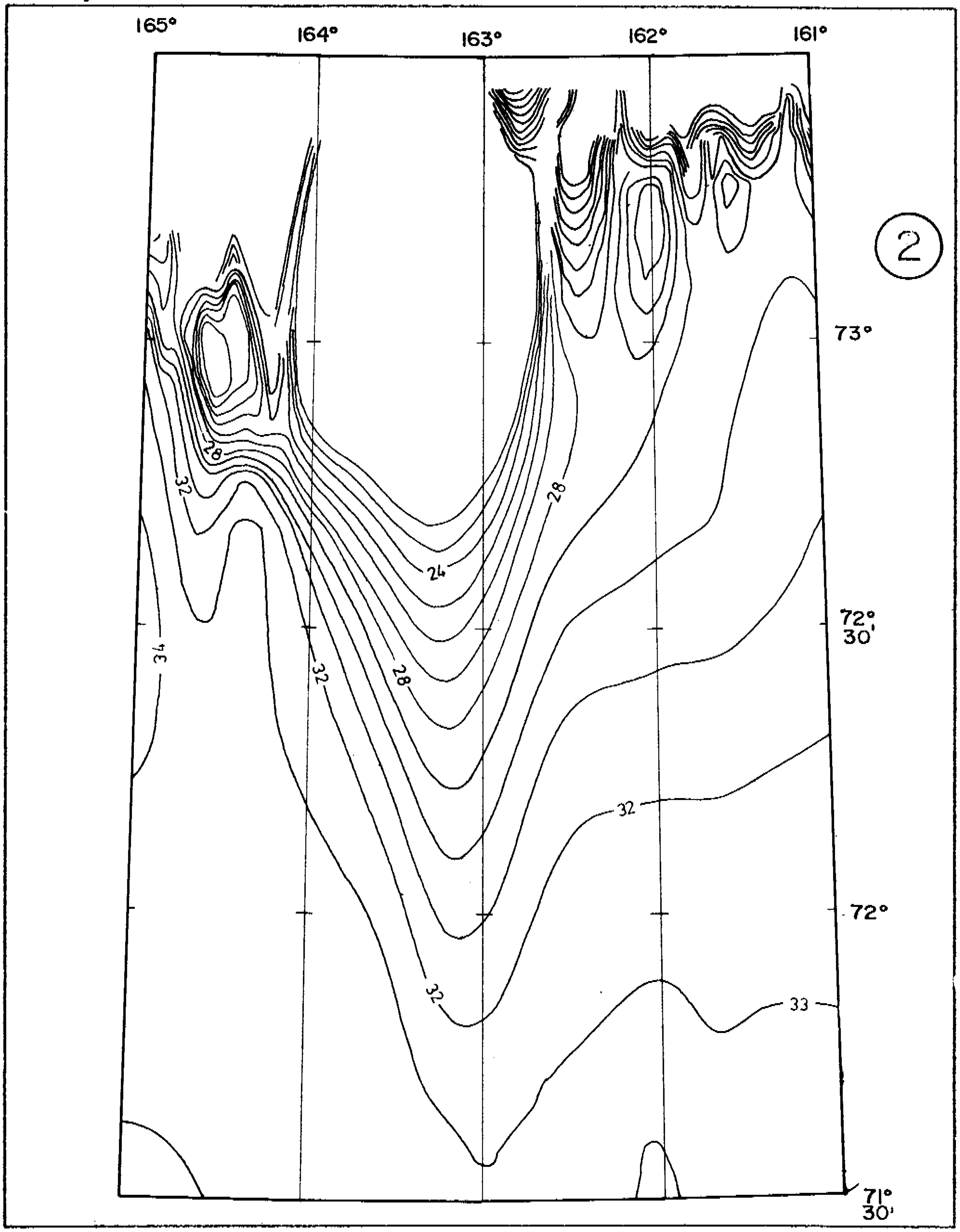
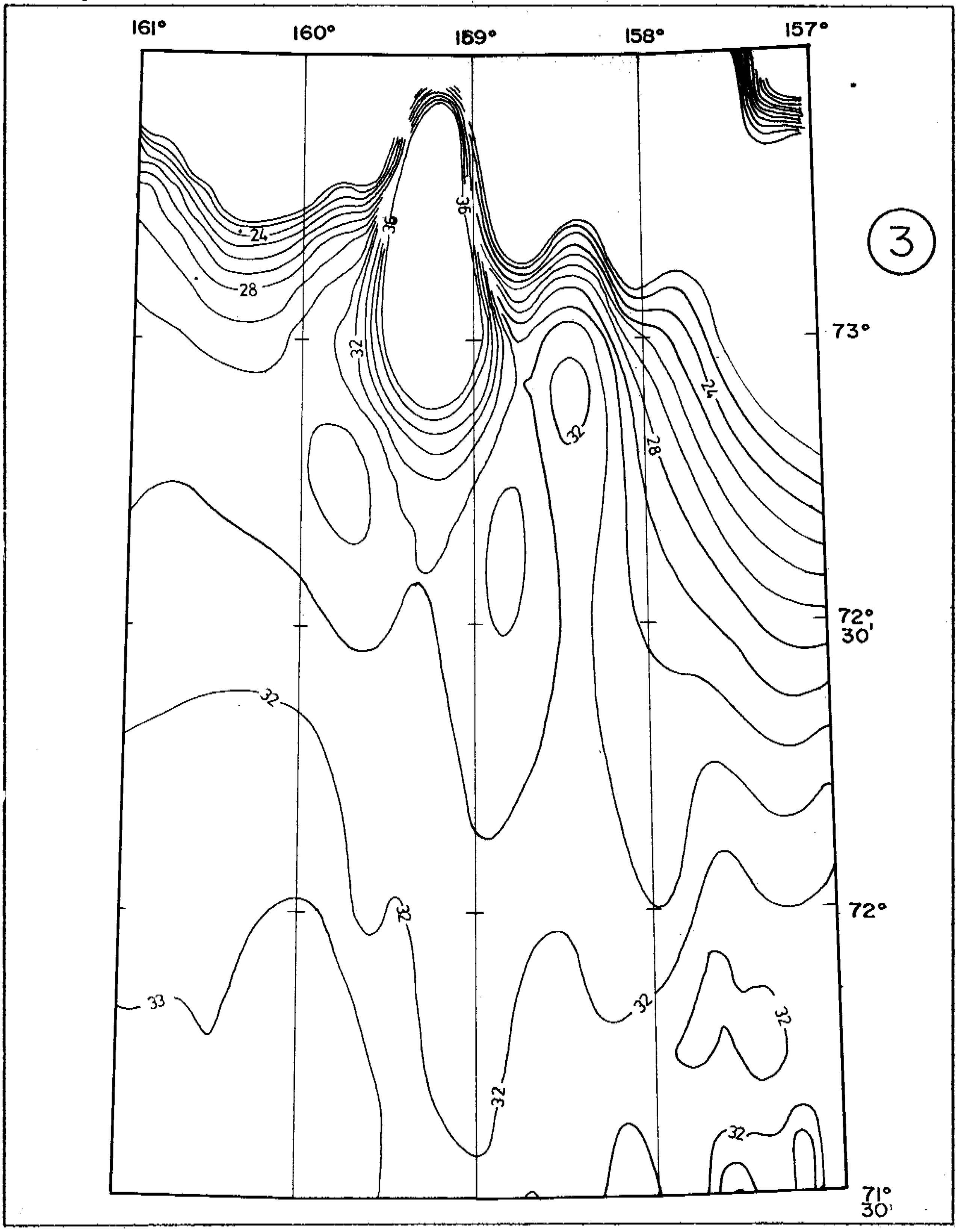
1

salinity



salinity



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159°
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3
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32
36
36
32
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32
32
71°
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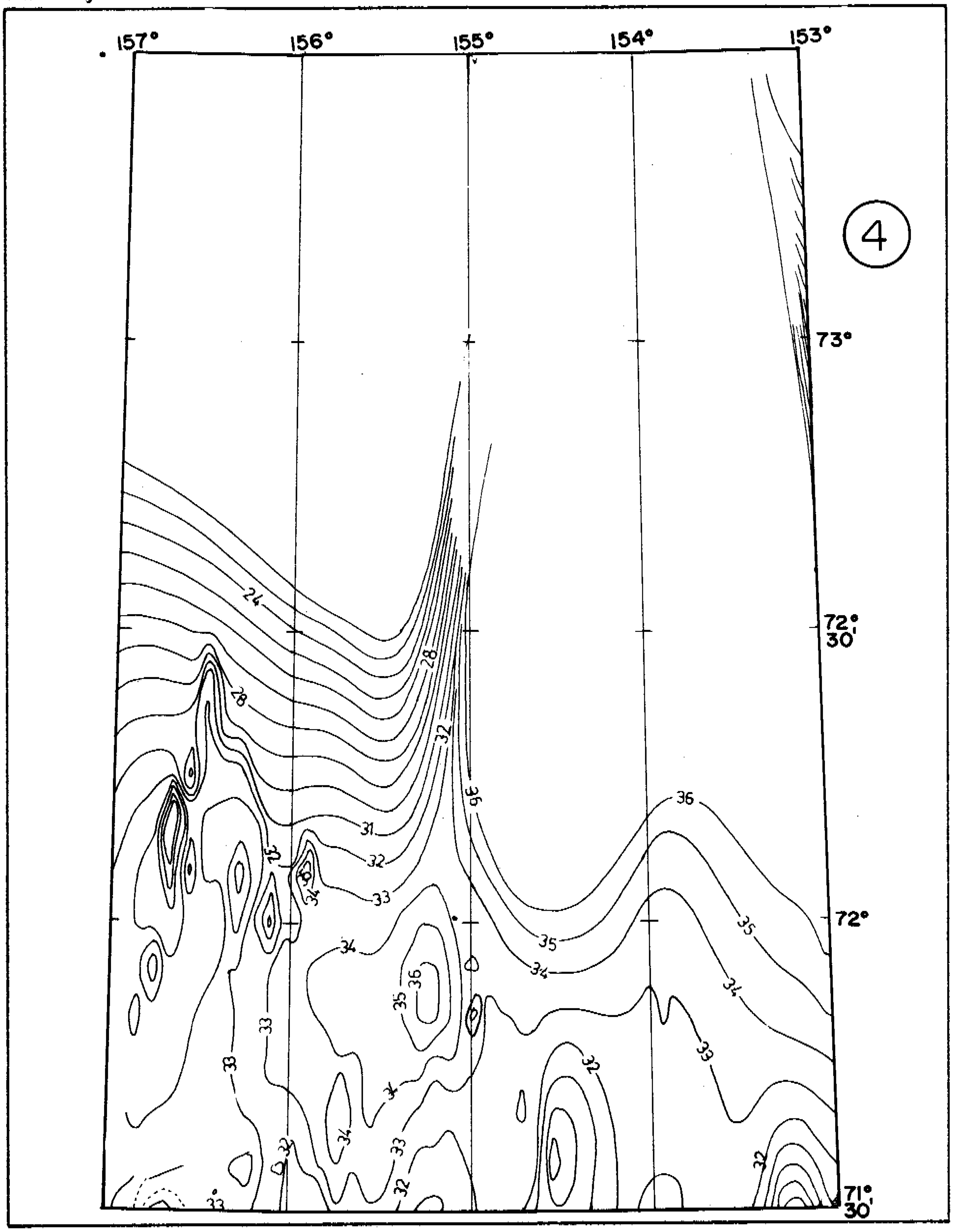
salinity



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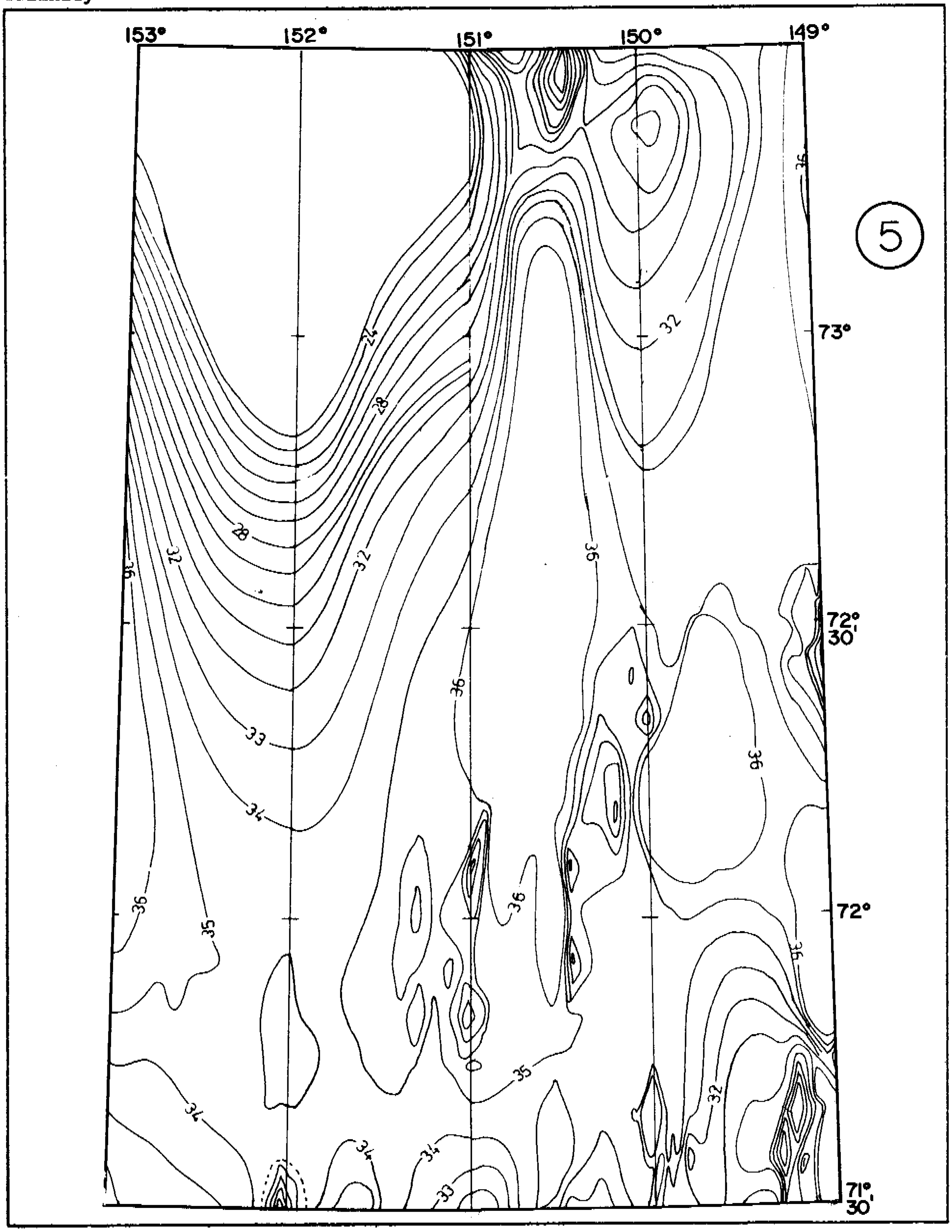
salinity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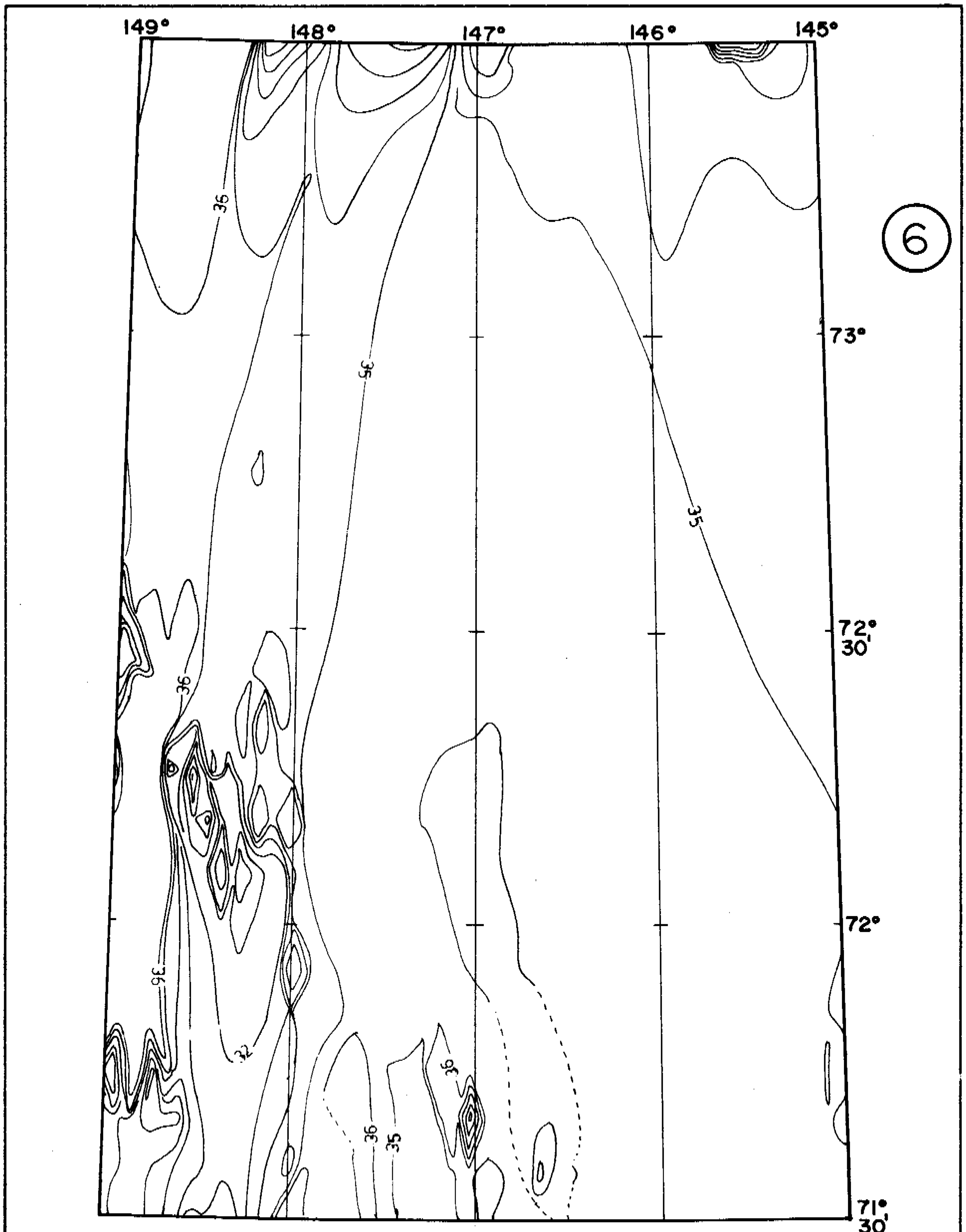
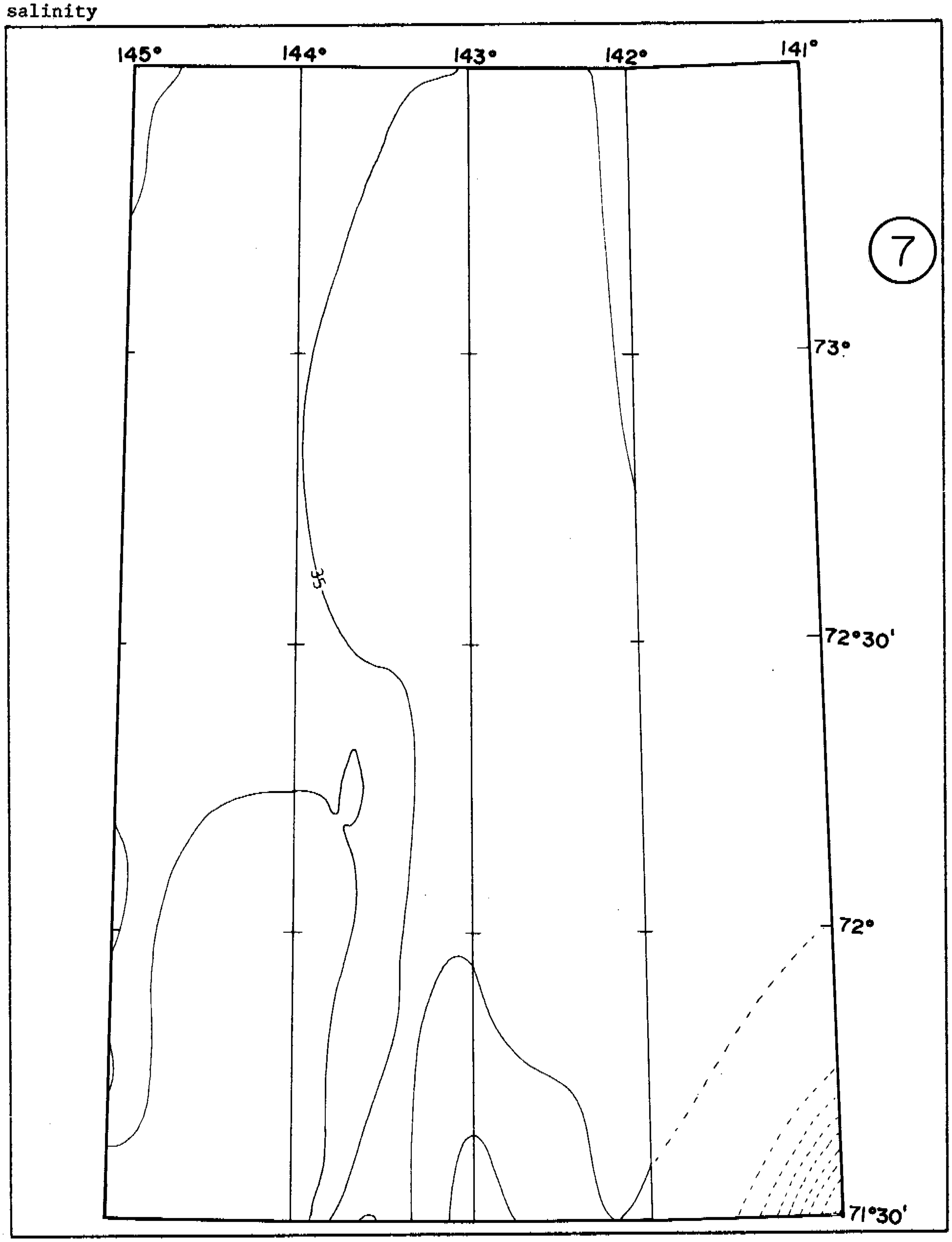
salinity



salinity



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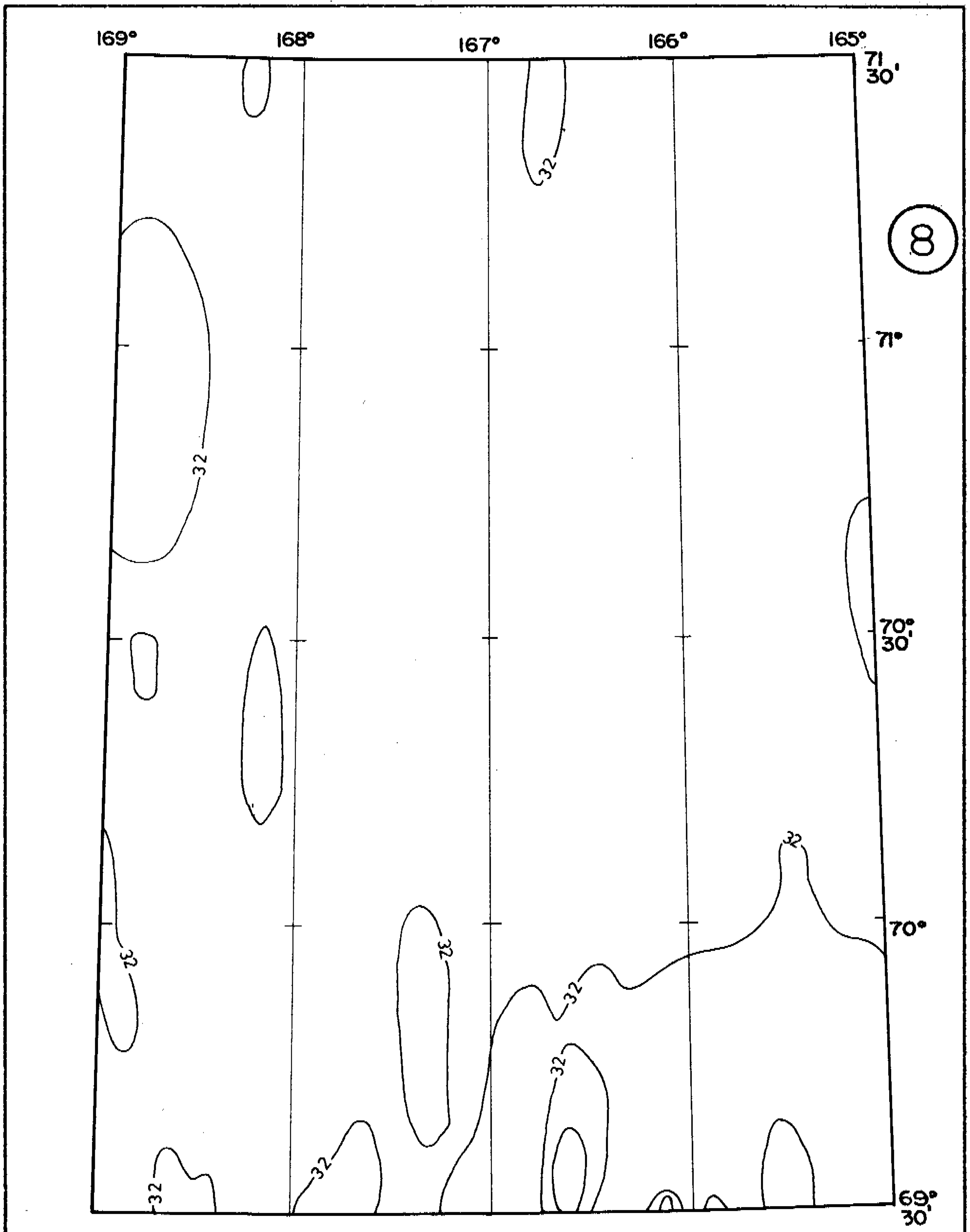
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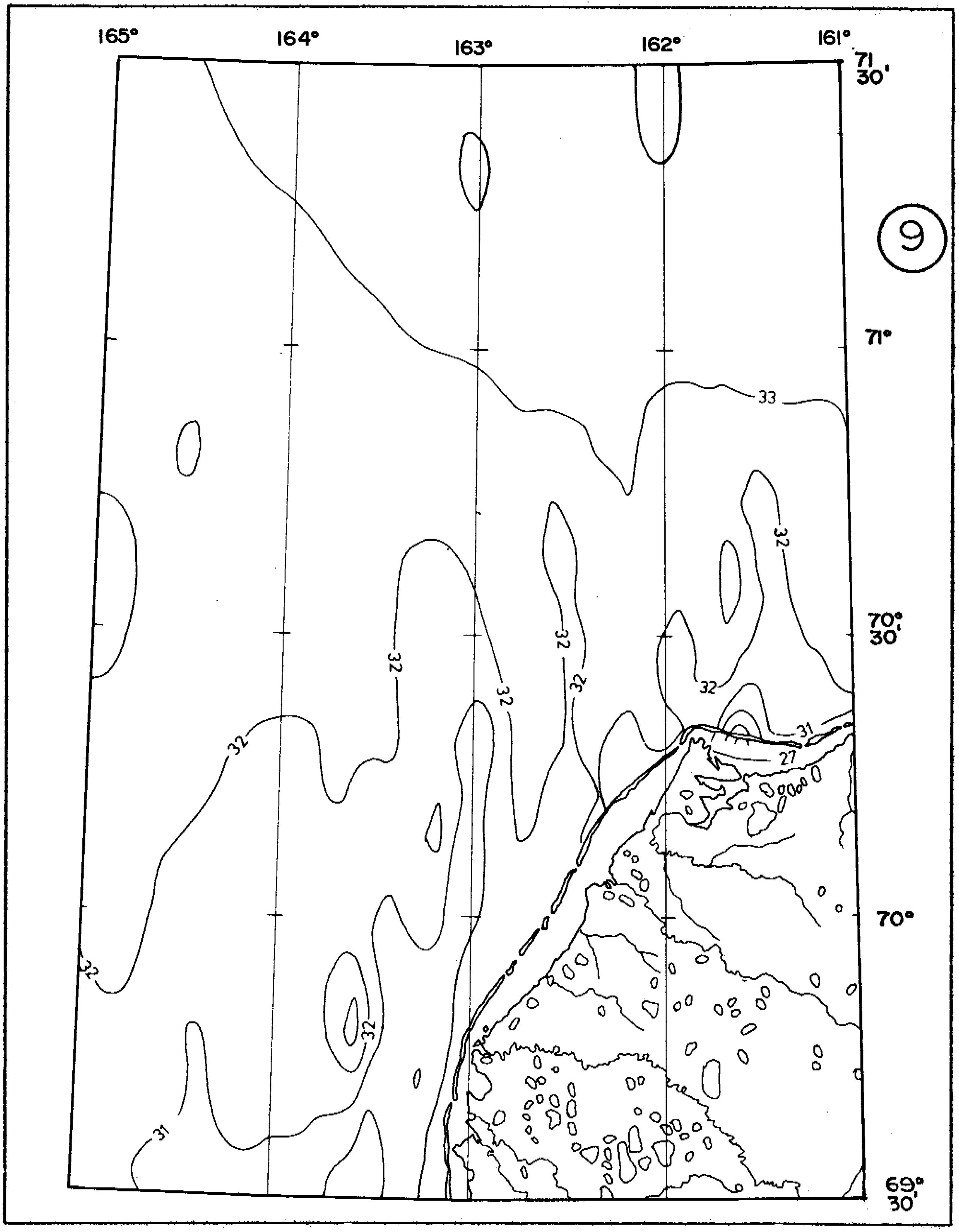
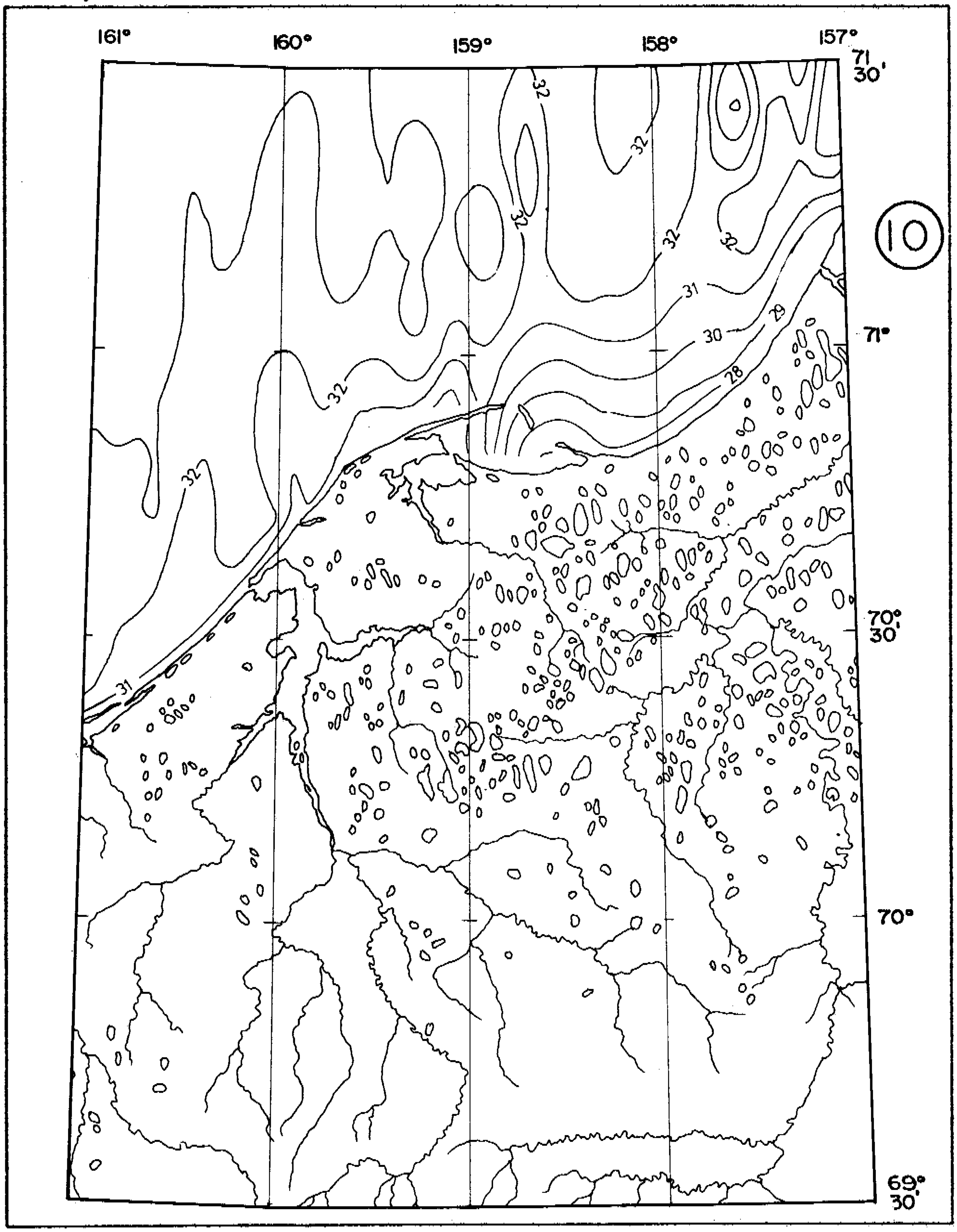
32

salinity



salinity



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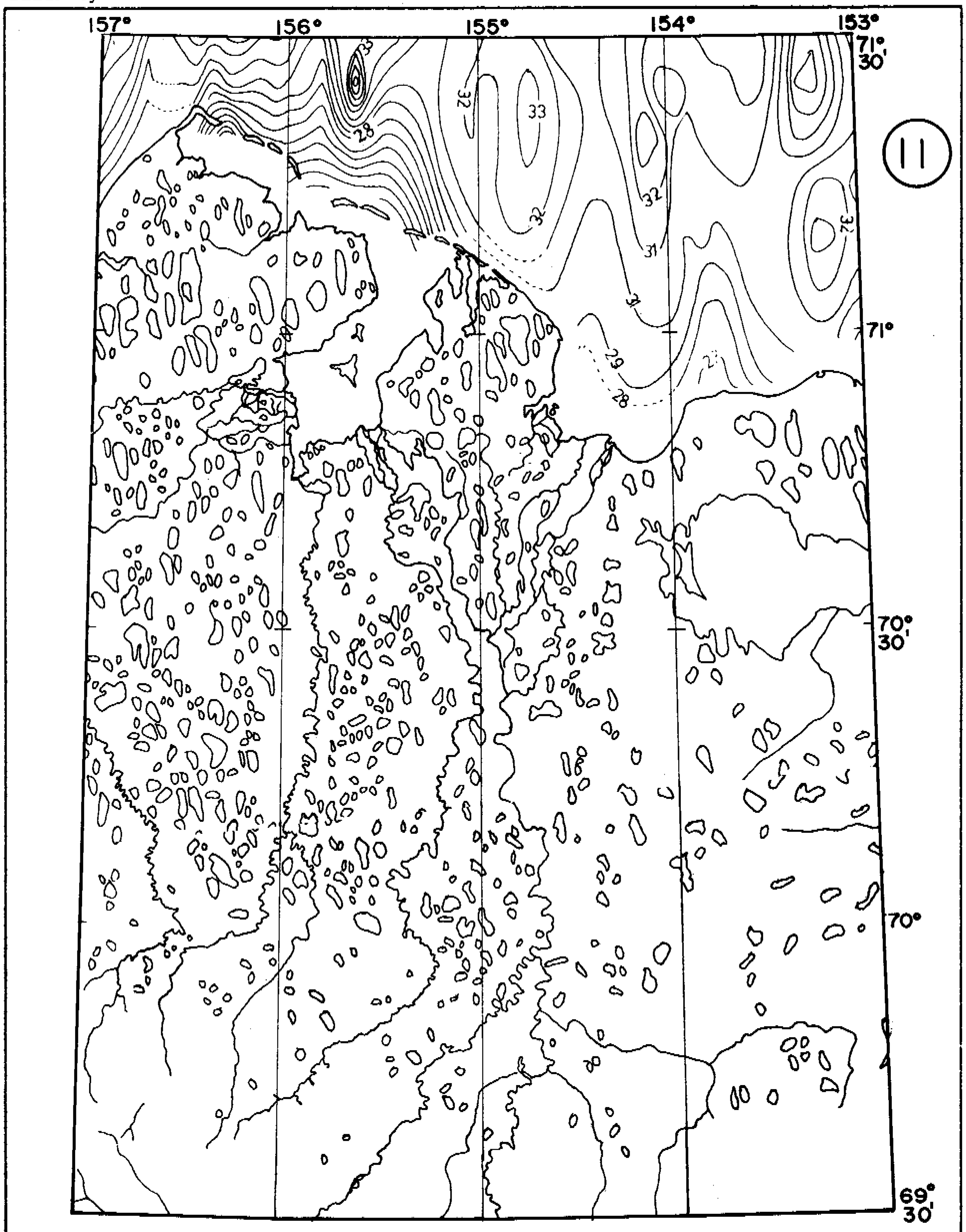
salinity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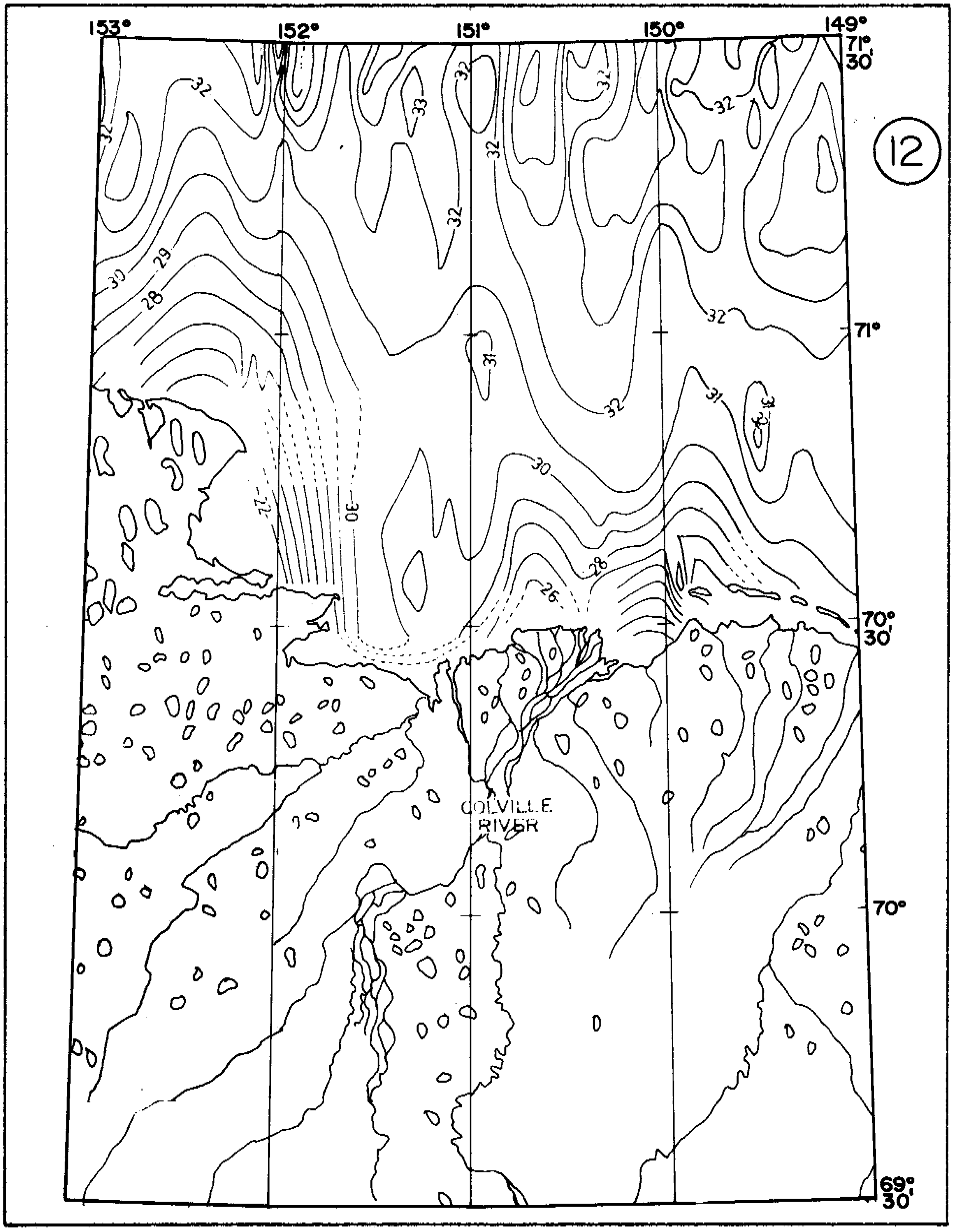
salinity


153°
152°
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149°
71° 30'
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70°
69° 30'
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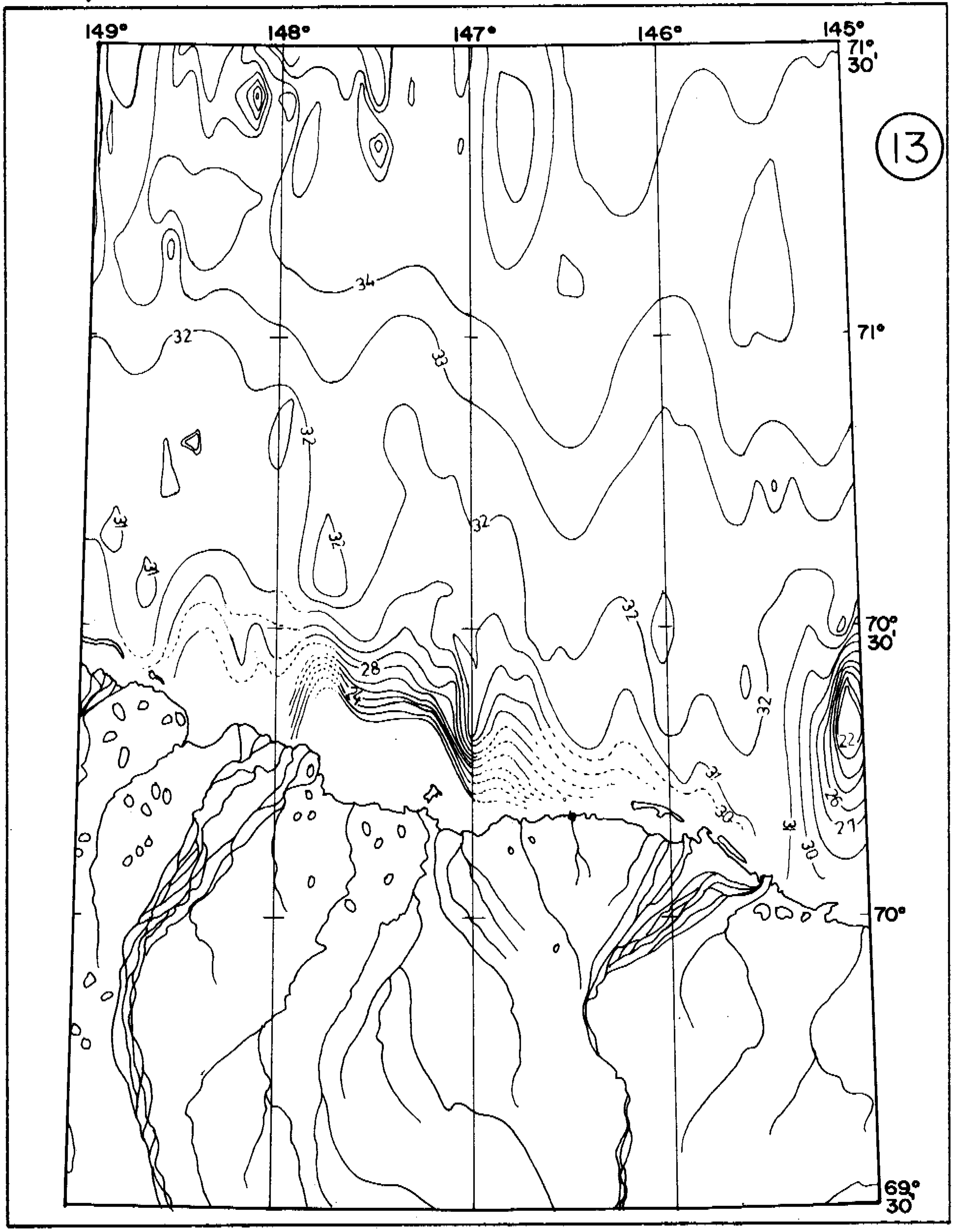
26
COLVILLE RIVER

salinity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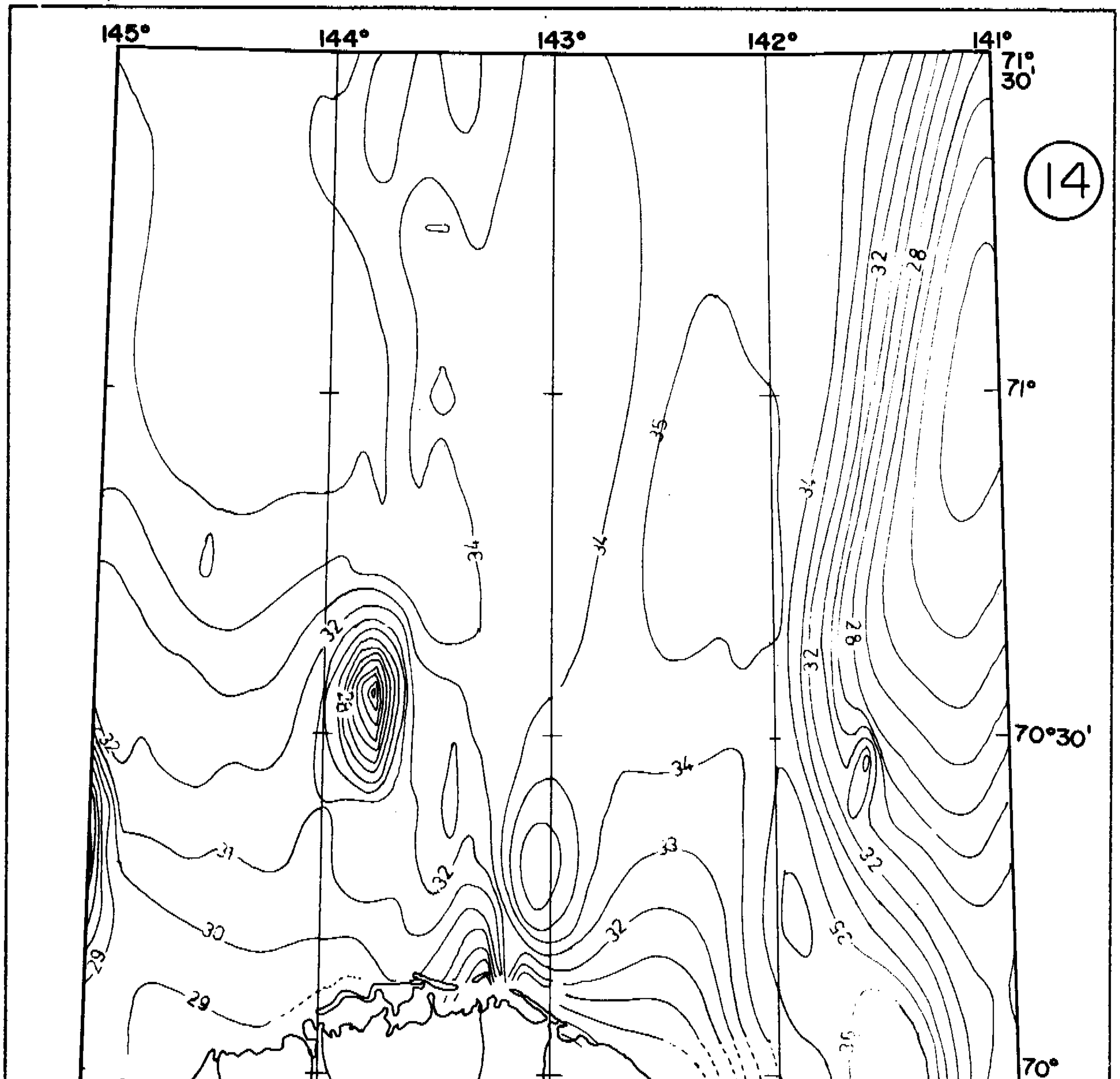
salinity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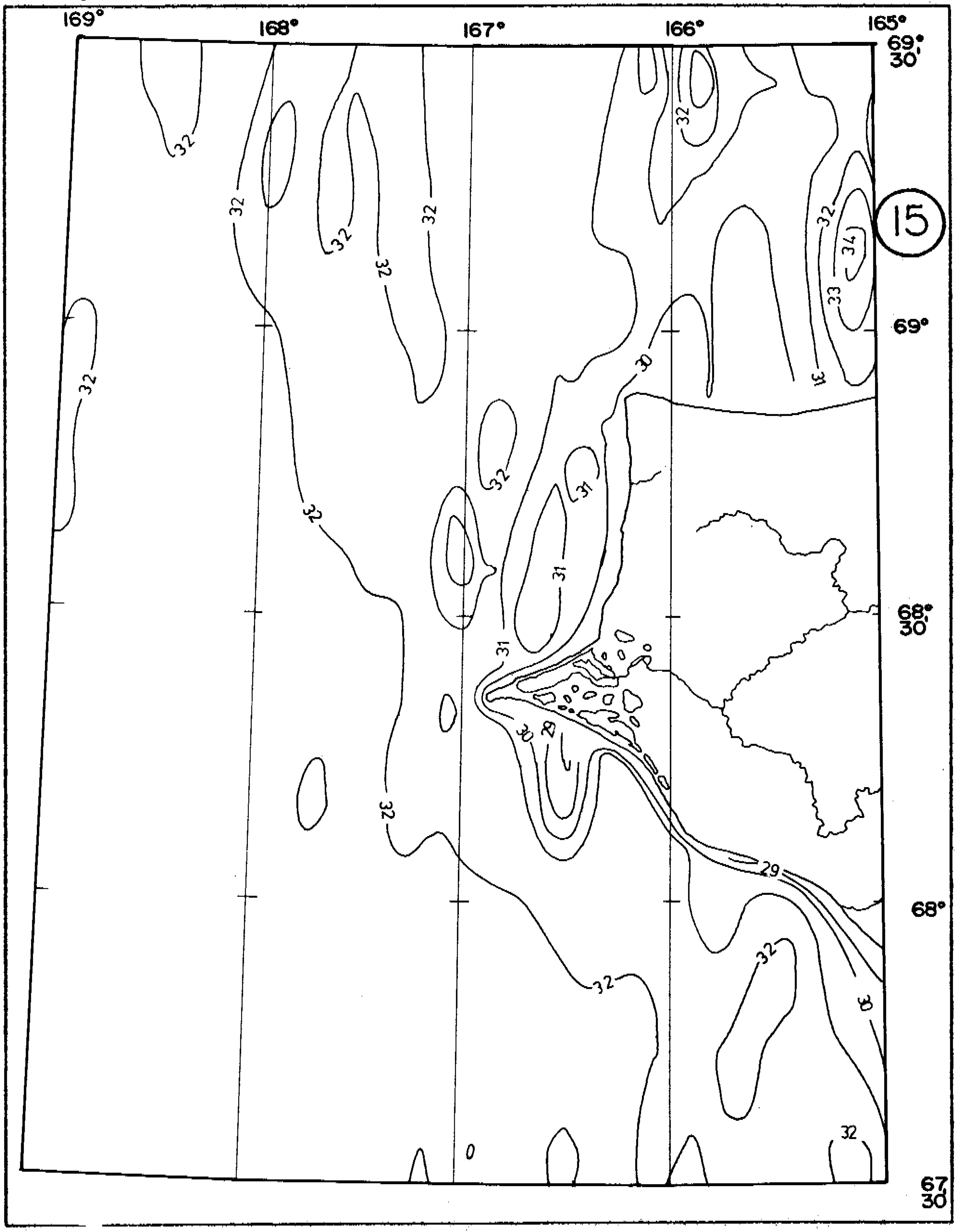
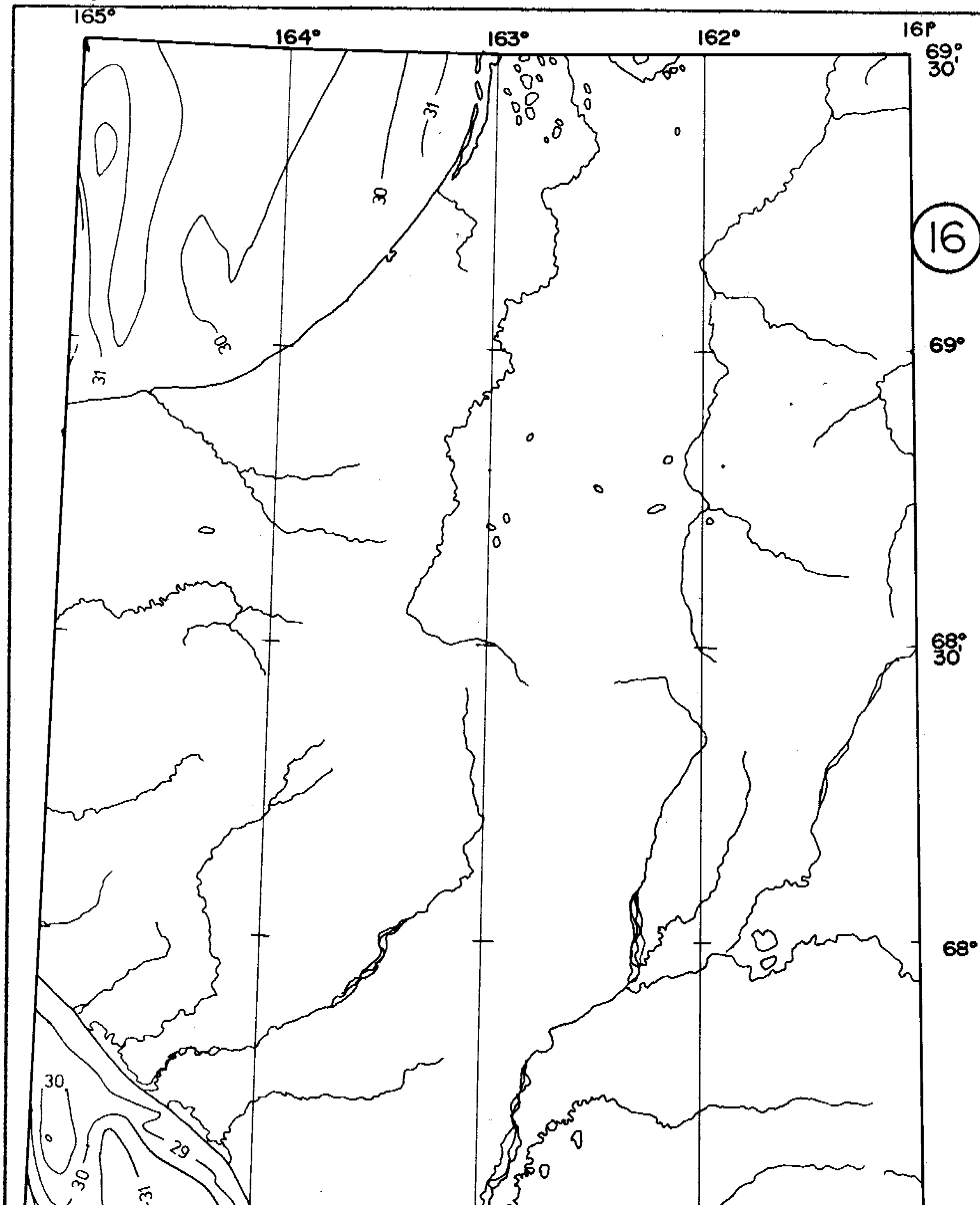
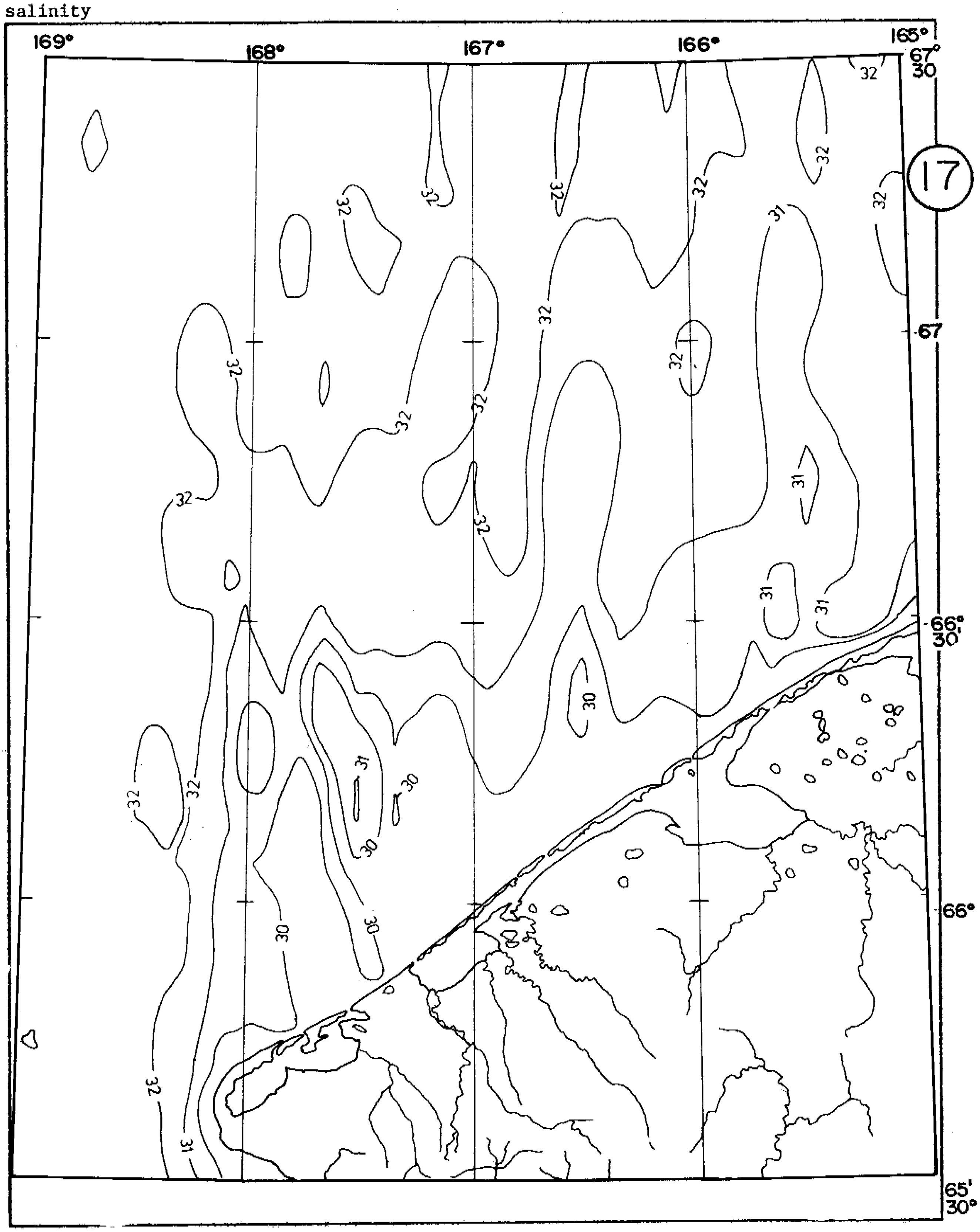
salinity



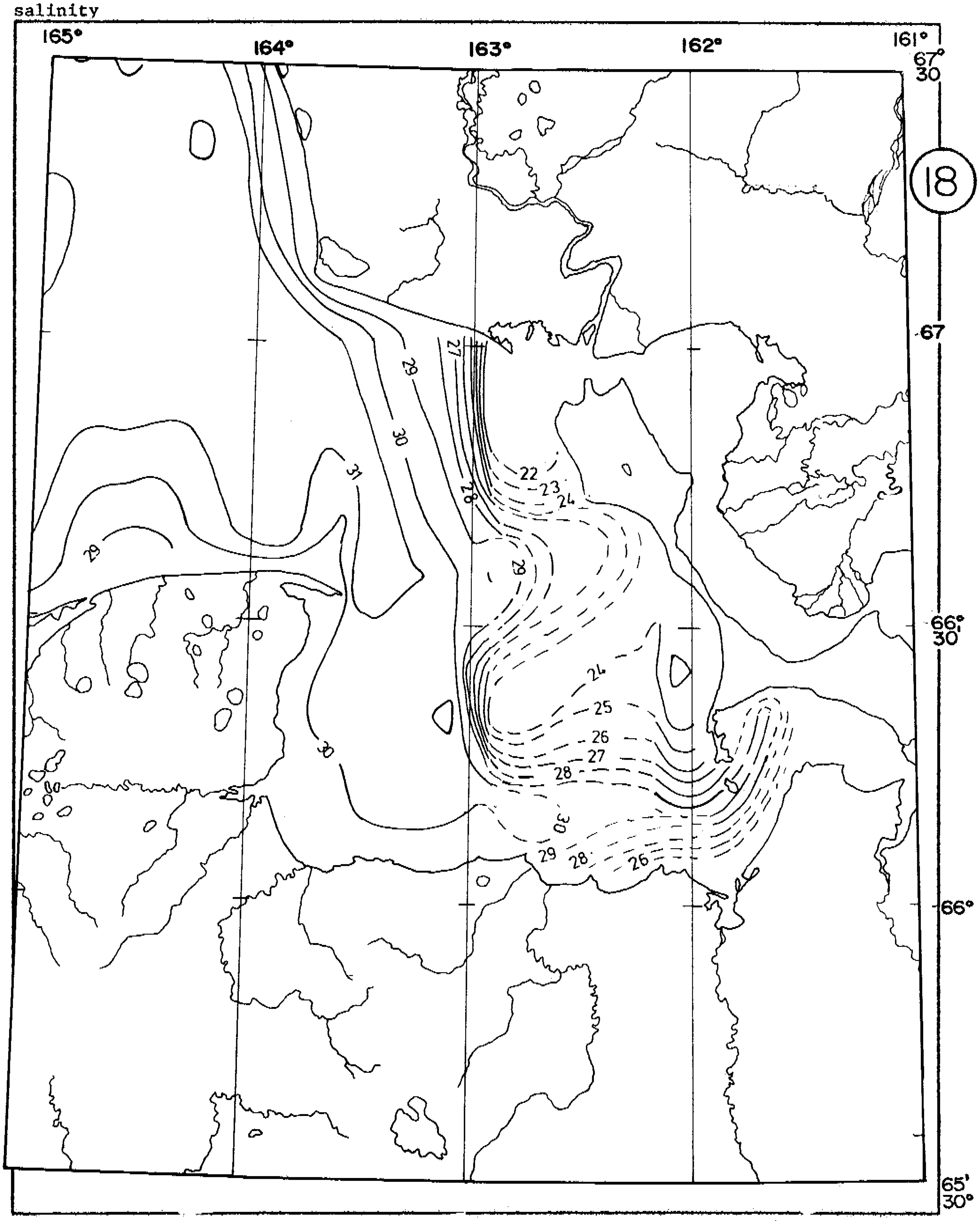
salinity



salinity



salinity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BEAUFORT SEA
CHUKCHI SEA

RESEARCH UNIT 516 OCSEAP
NOAA INSTAAR 1977

PROXIMITY OF THE MAXIMAL SAMPLING DEPTH TO THE BOTTOM IN %

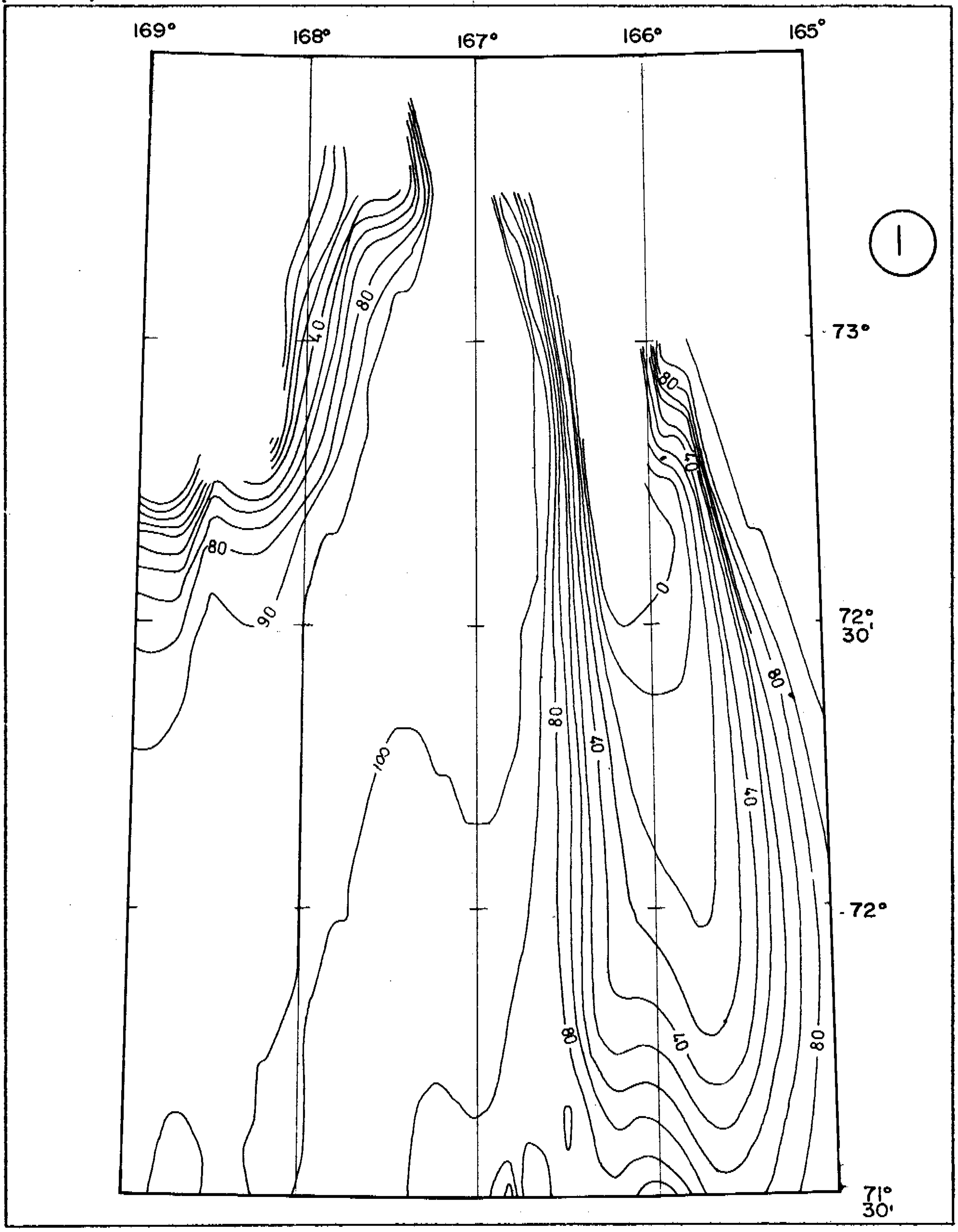
A SOURCE MAP FOR SUBMARINE PERMAFROST PREDICTION

0 TO 100 % (SAMPLING DEPTH = BOTTOM IS 100%)
INTERVAL OF 10 %

SCALE— 1: 1,000,000

GEOGRAPHIC BASED INFORMATION MANAGEMENT SYSTEM FOR PERMAFROST IN THE CHUKCHI AND BEAUFORT SEAS

proximity



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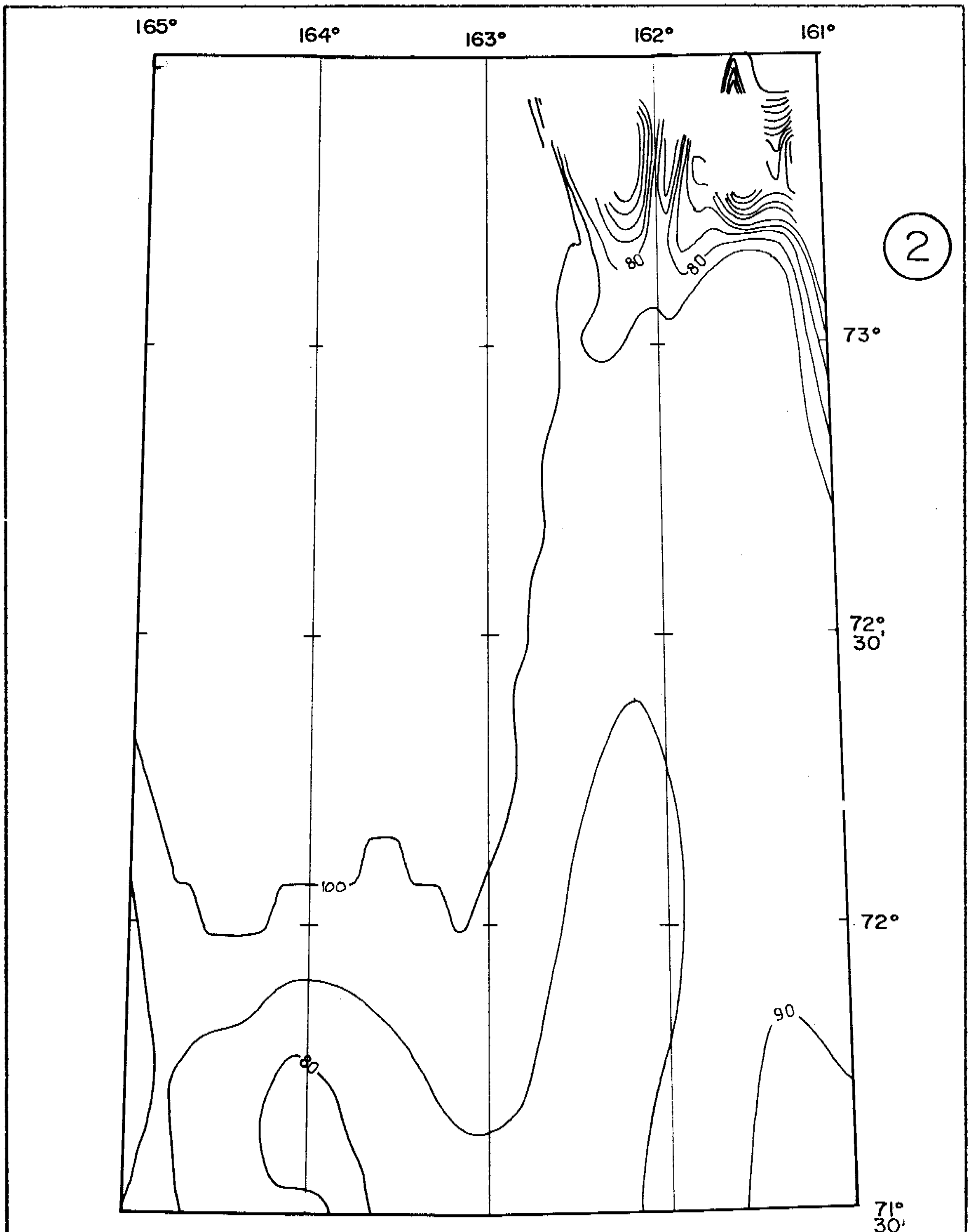
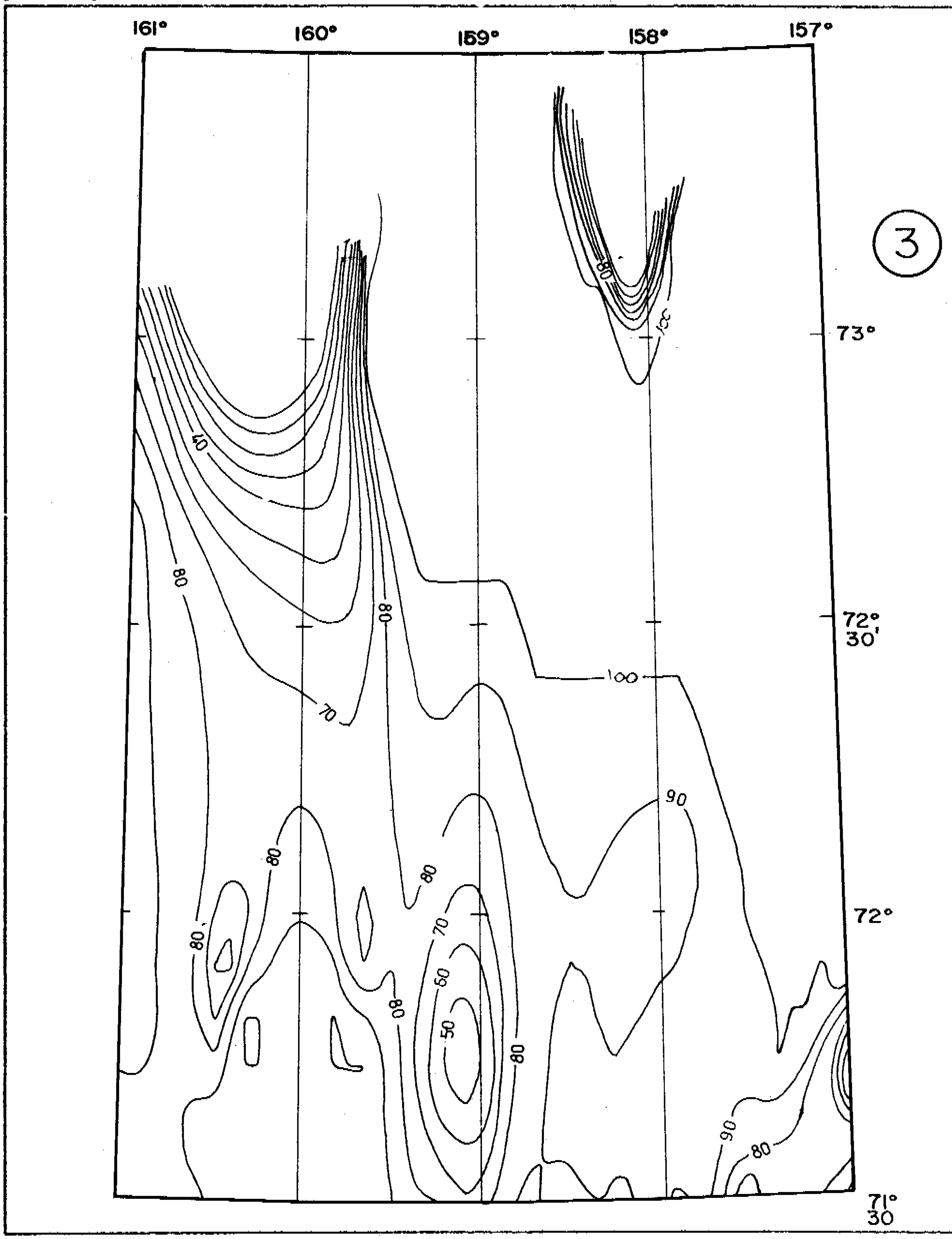
proximity



proximity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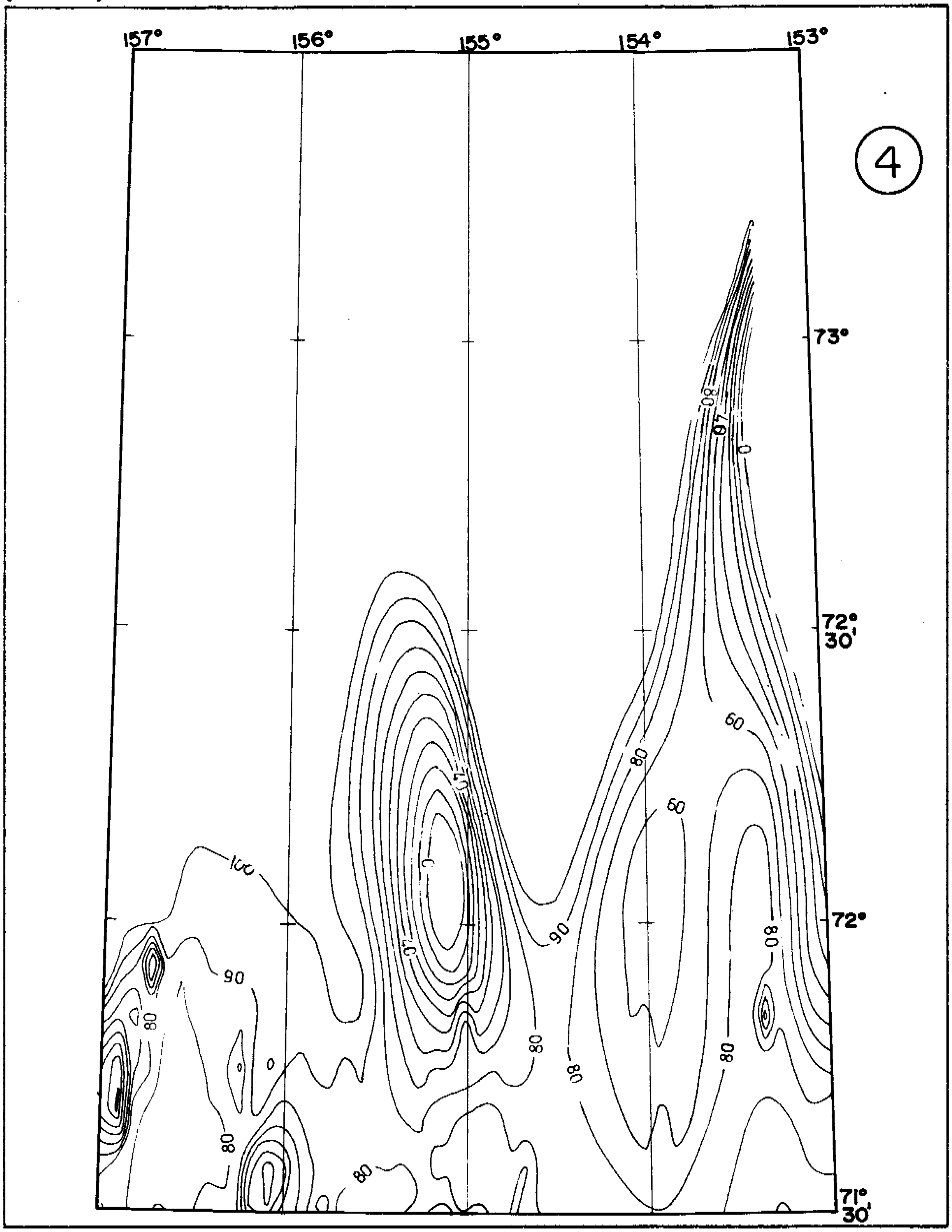
proximity



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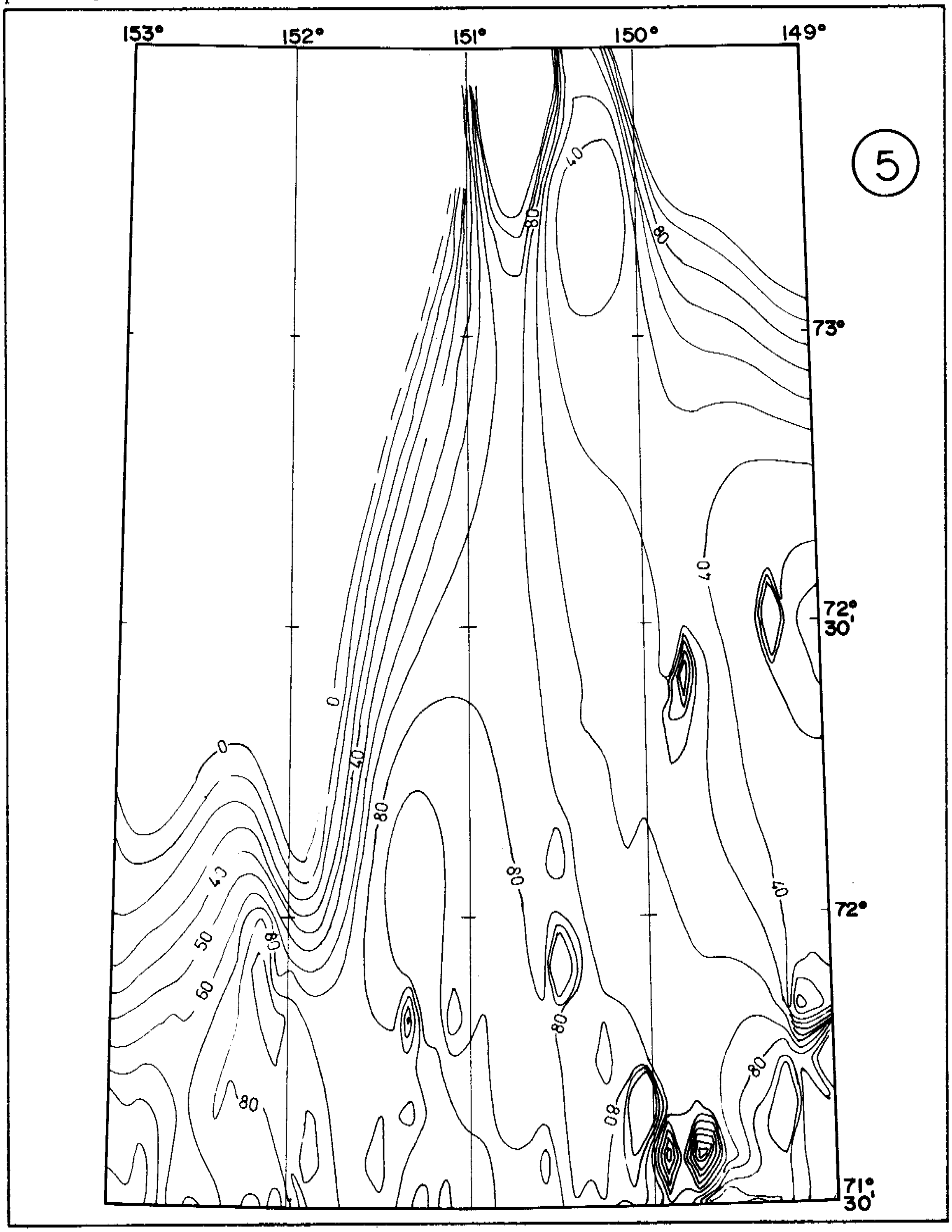

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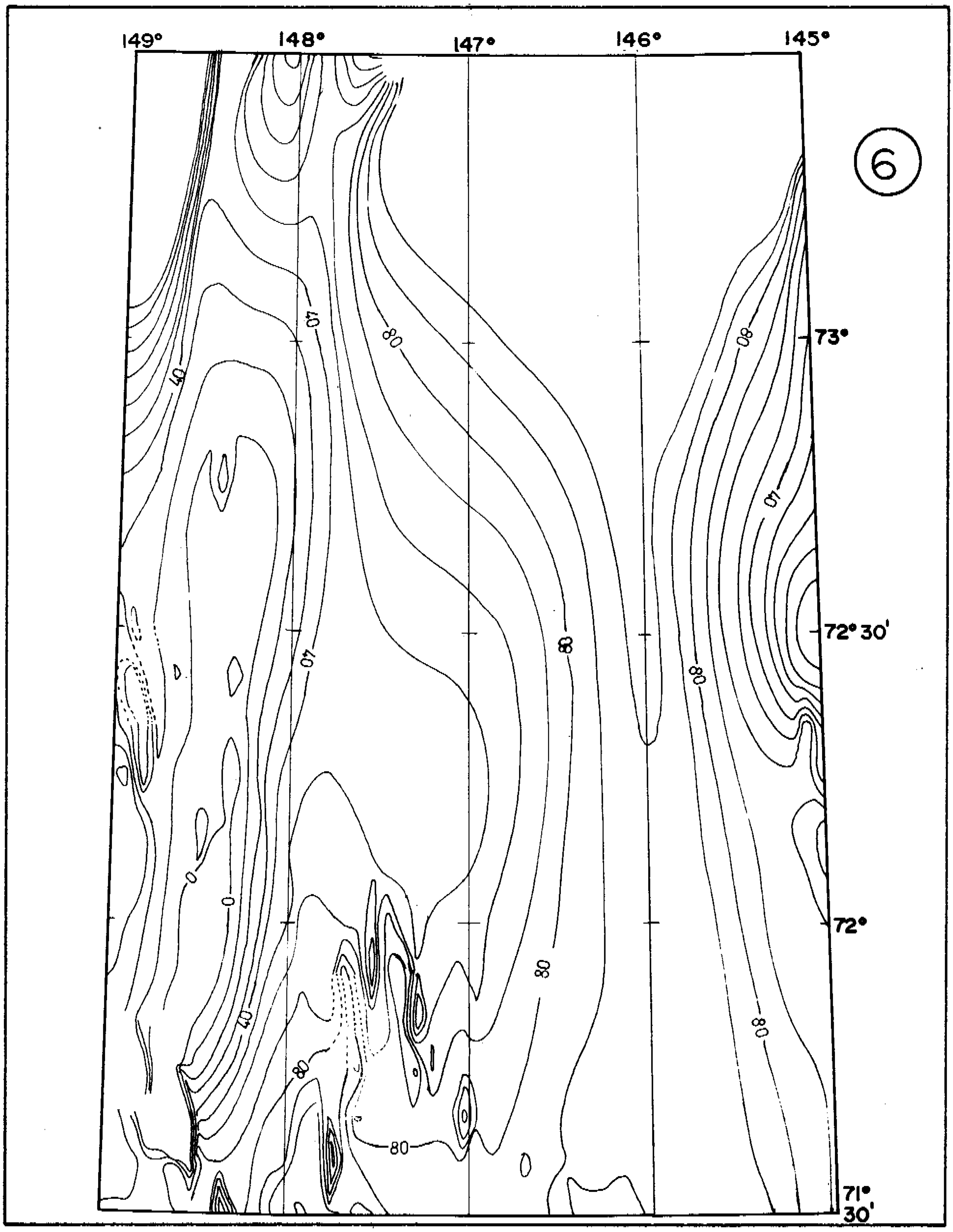

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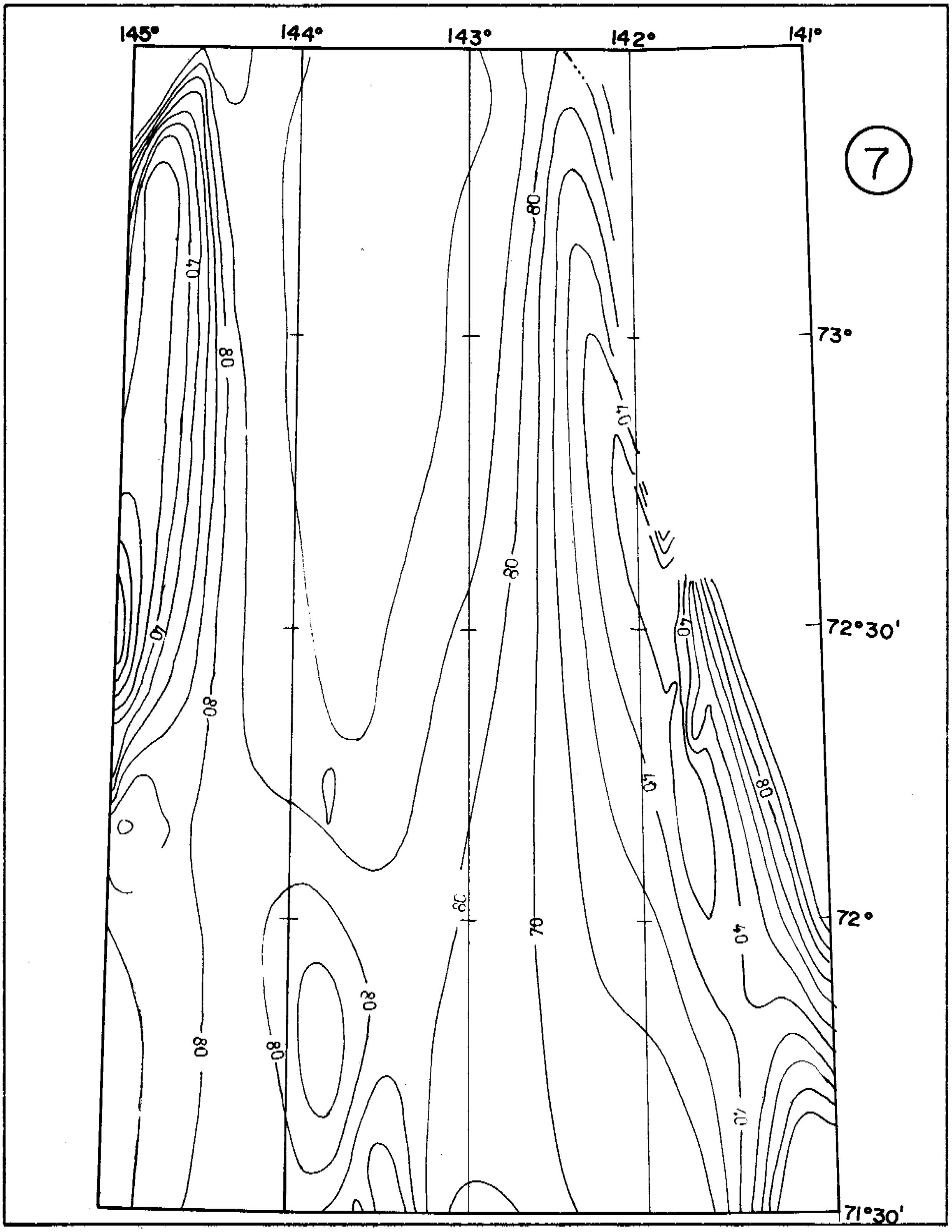
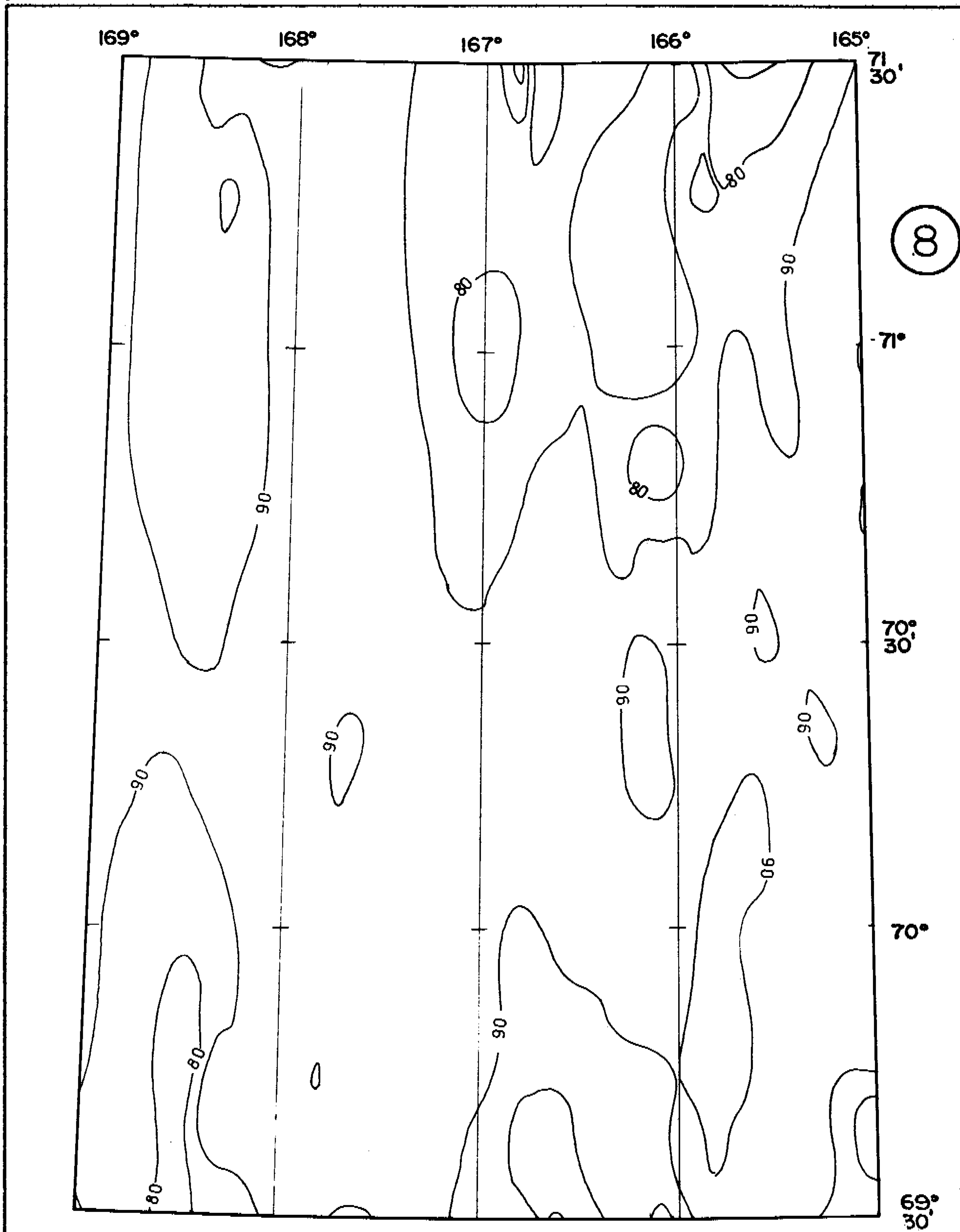
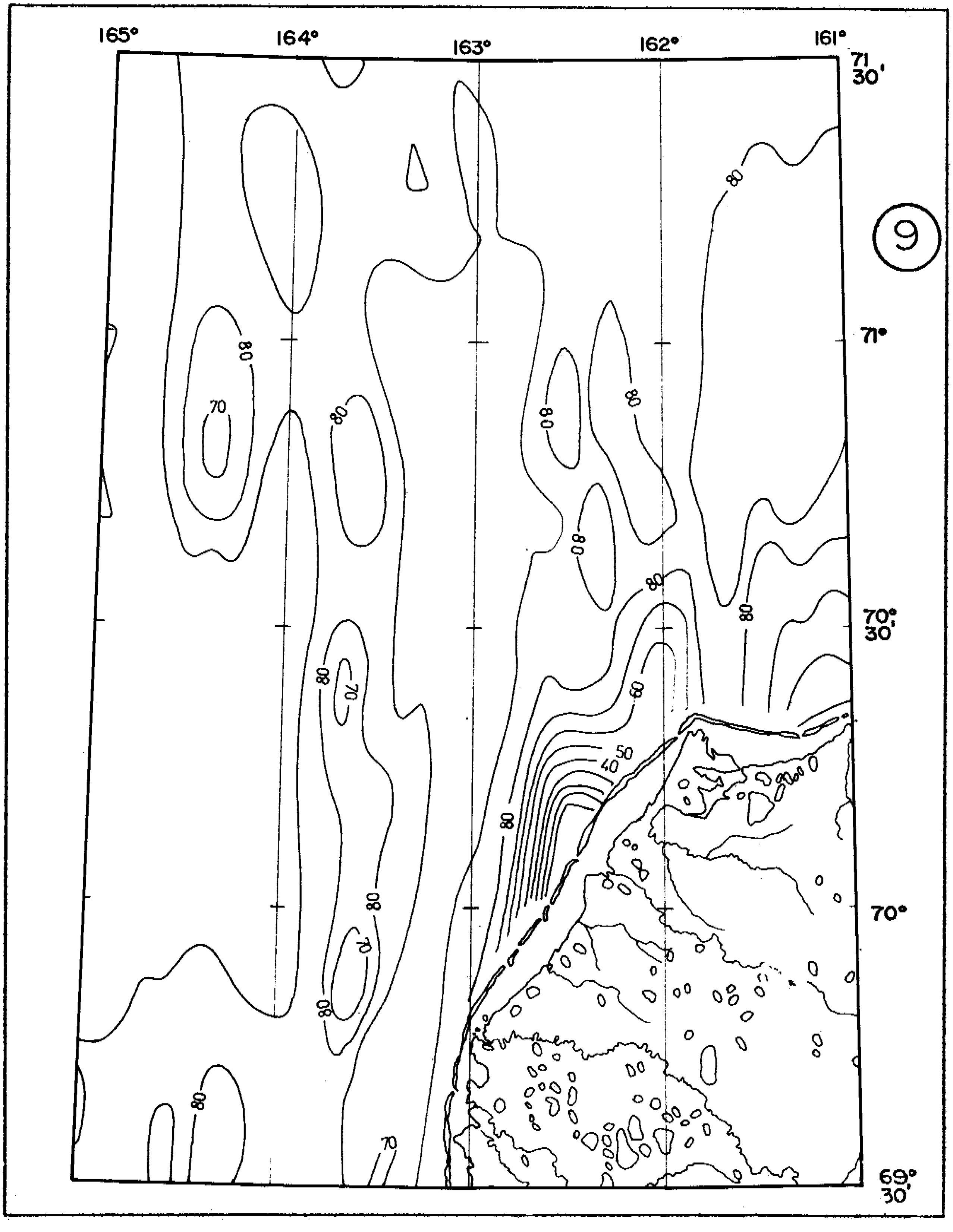


proximity



salinity



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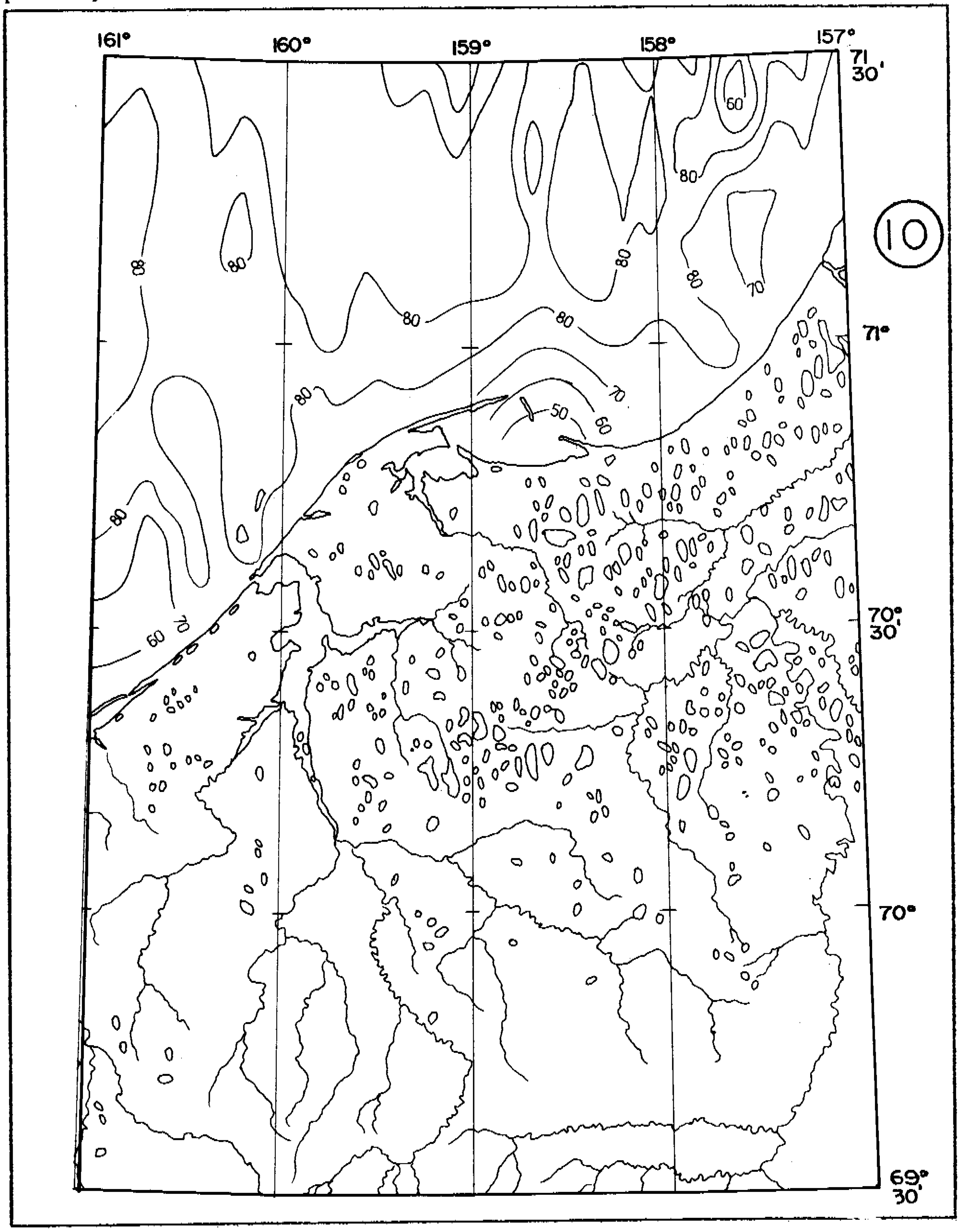
proximity



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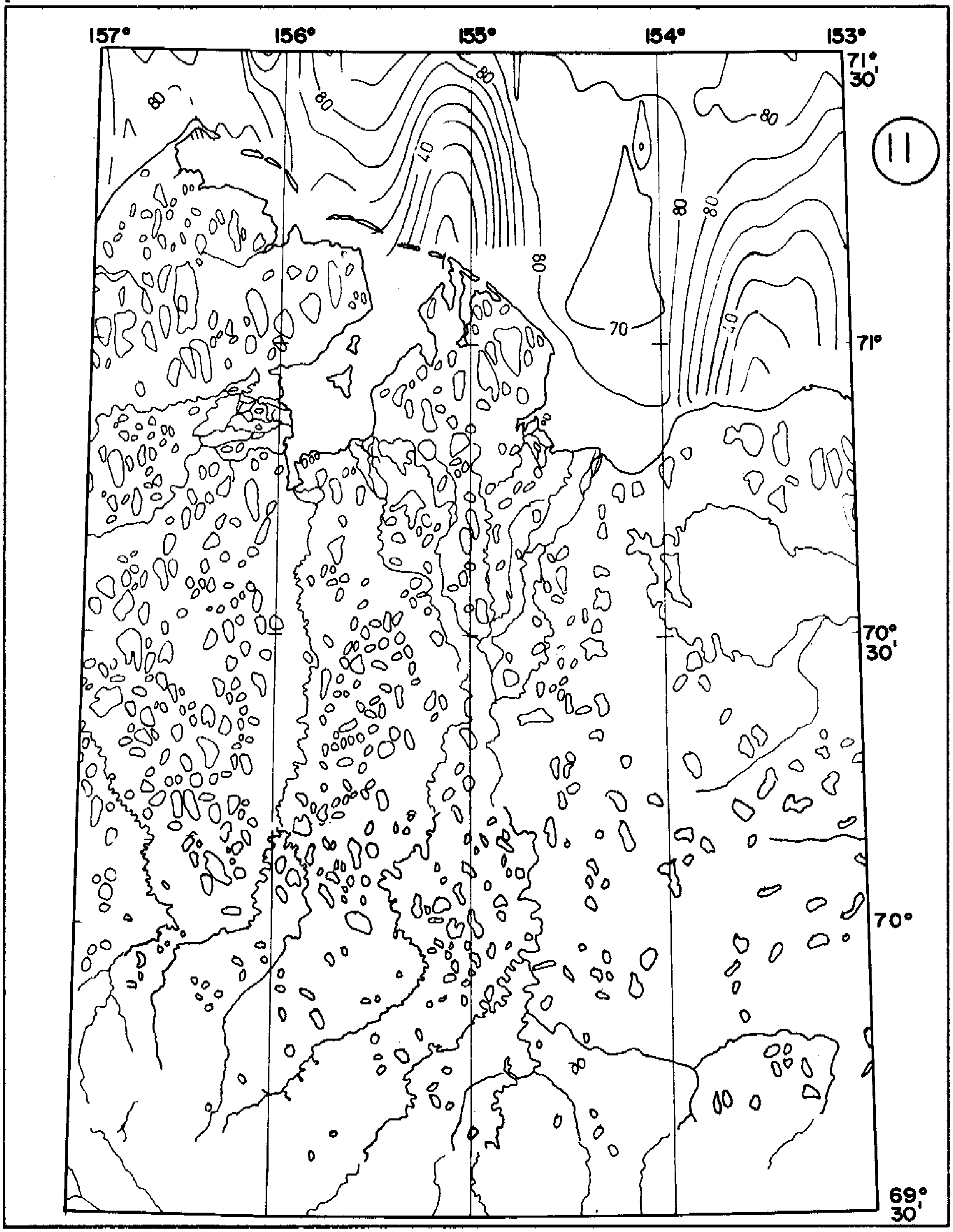

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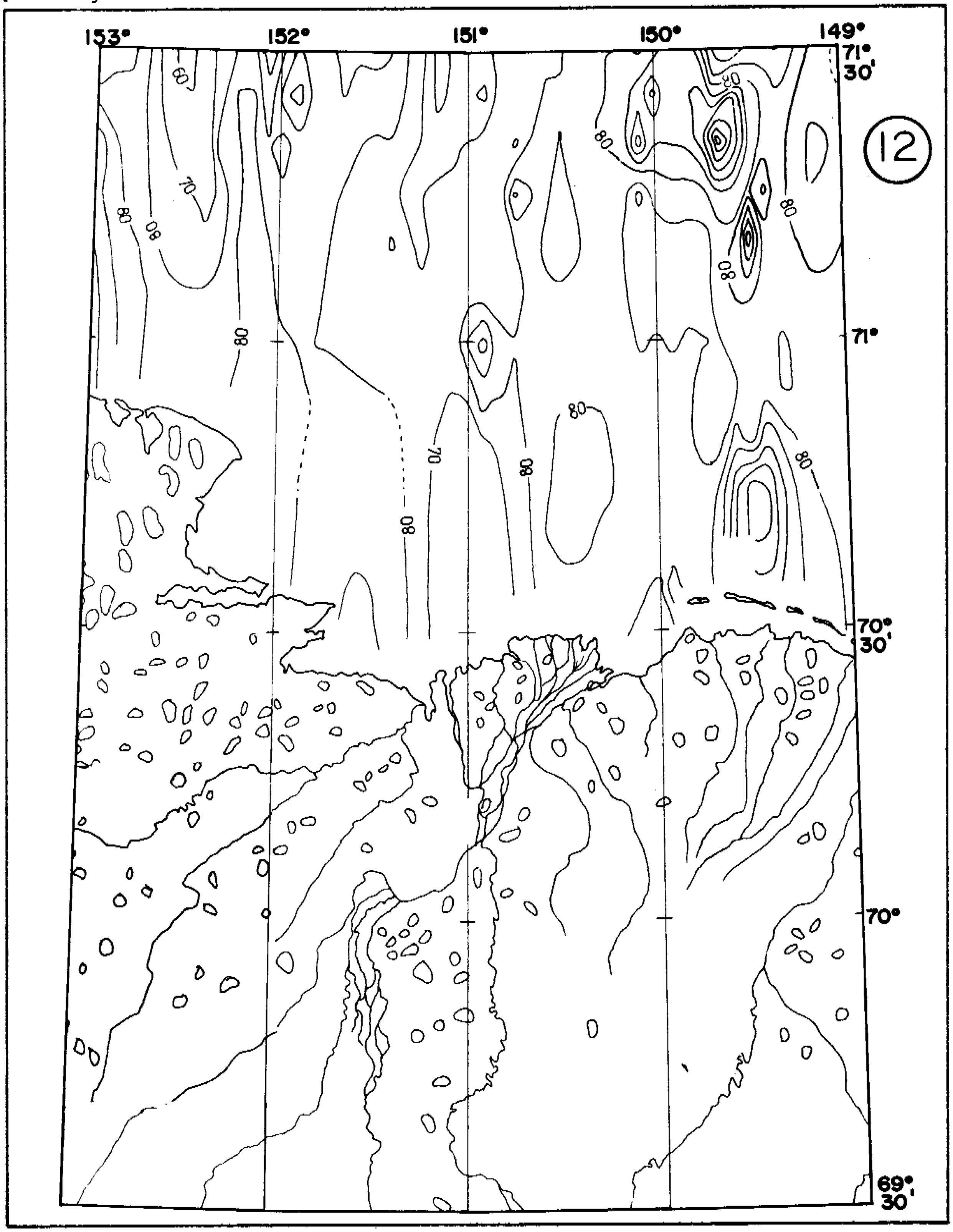

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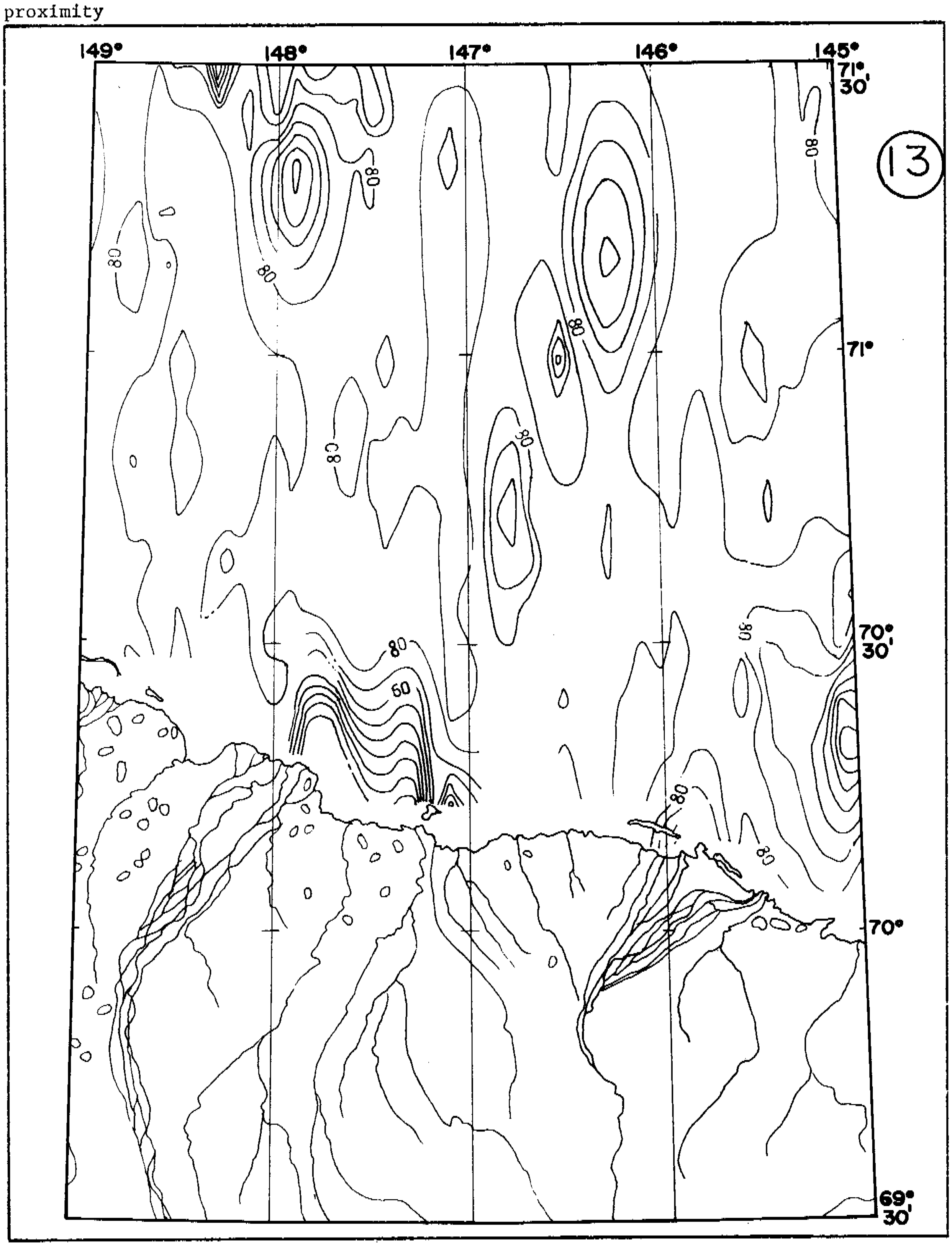

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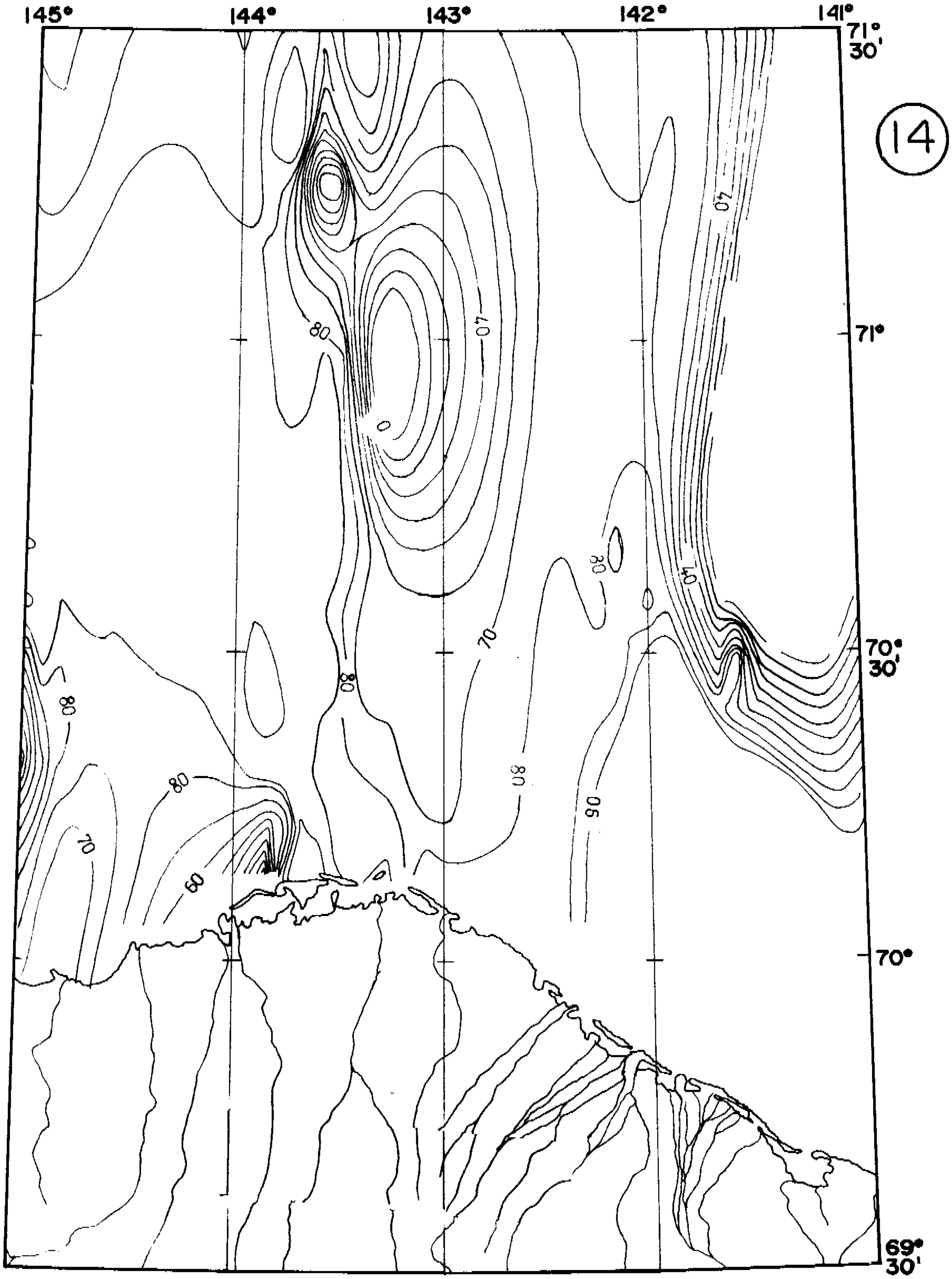
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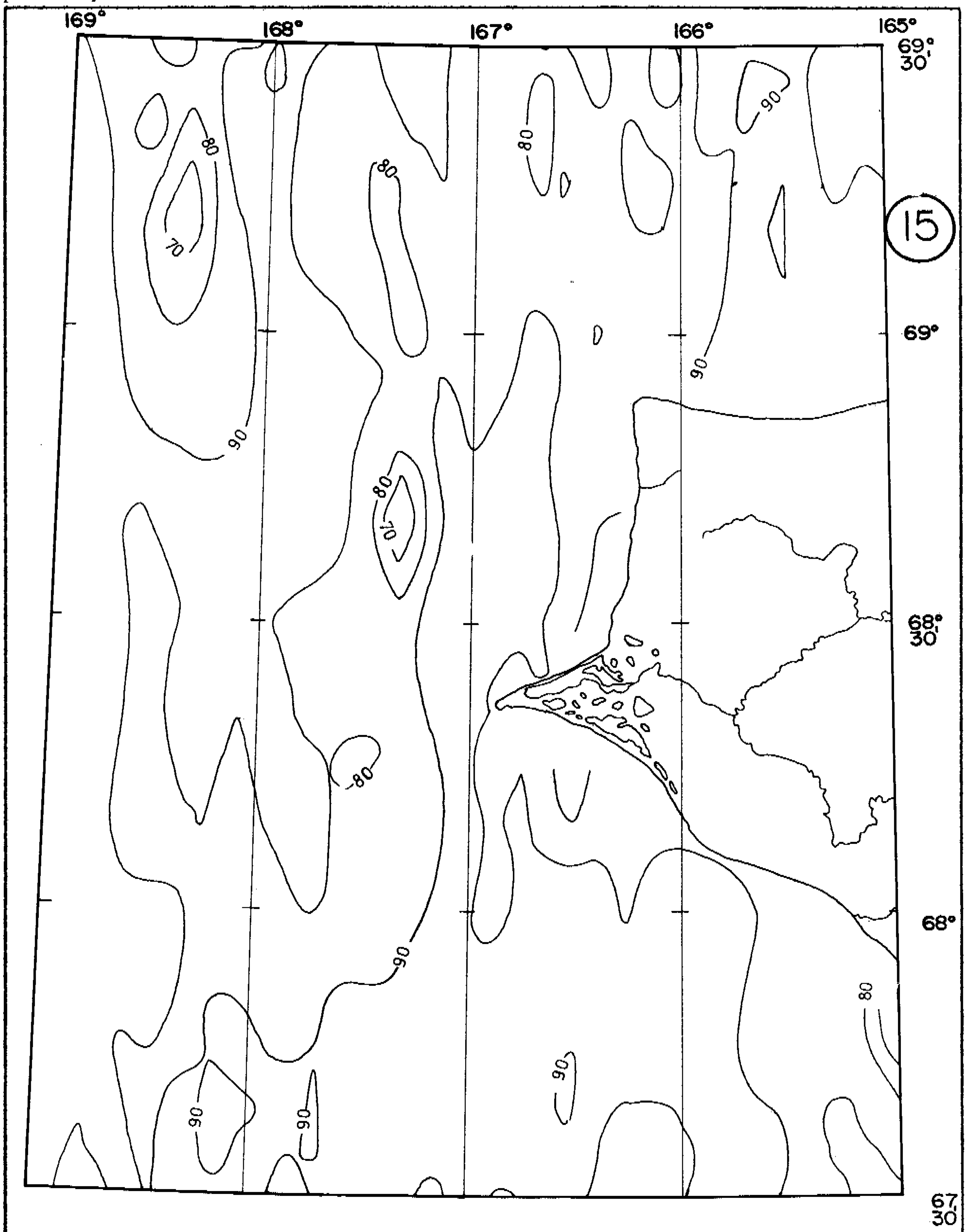

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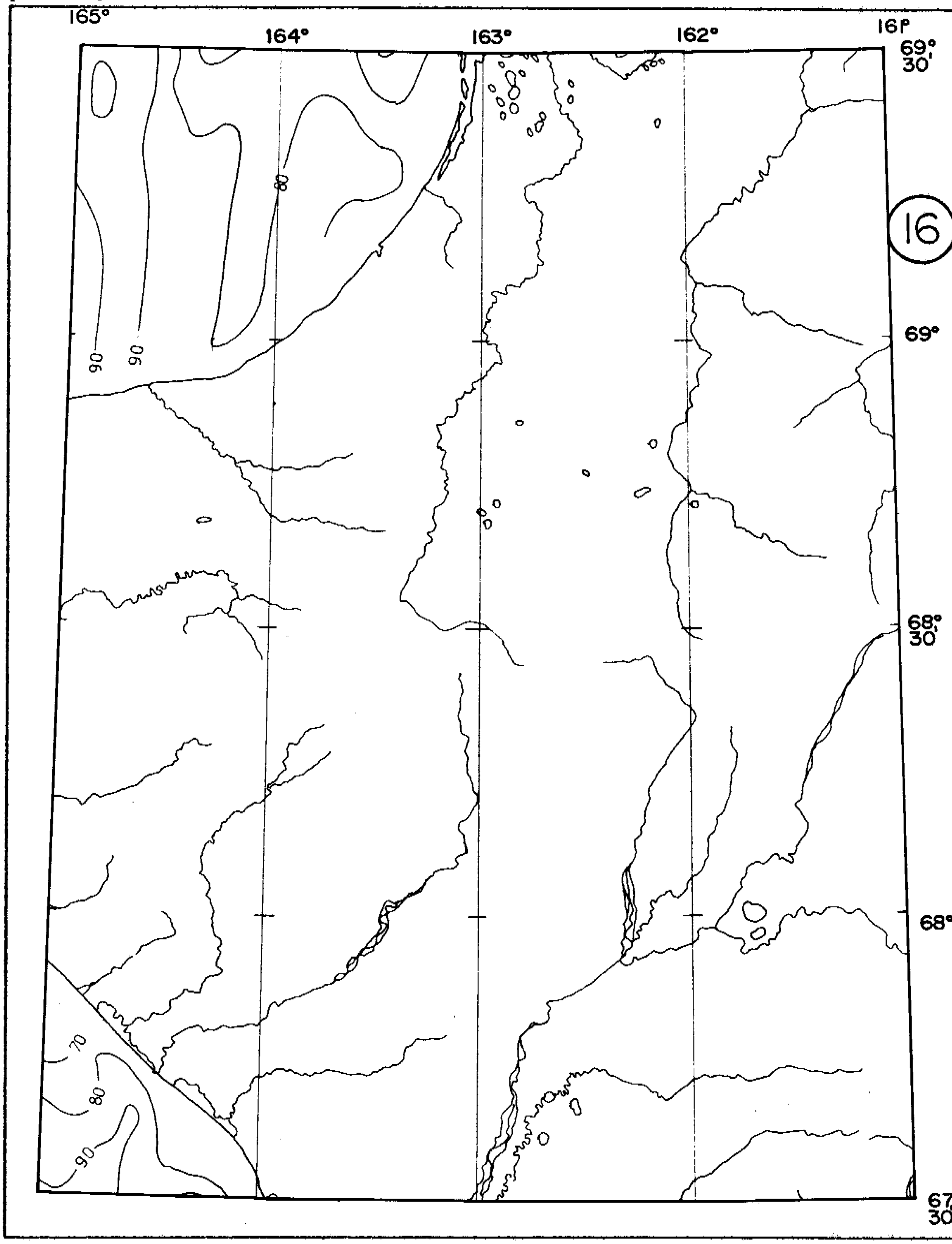

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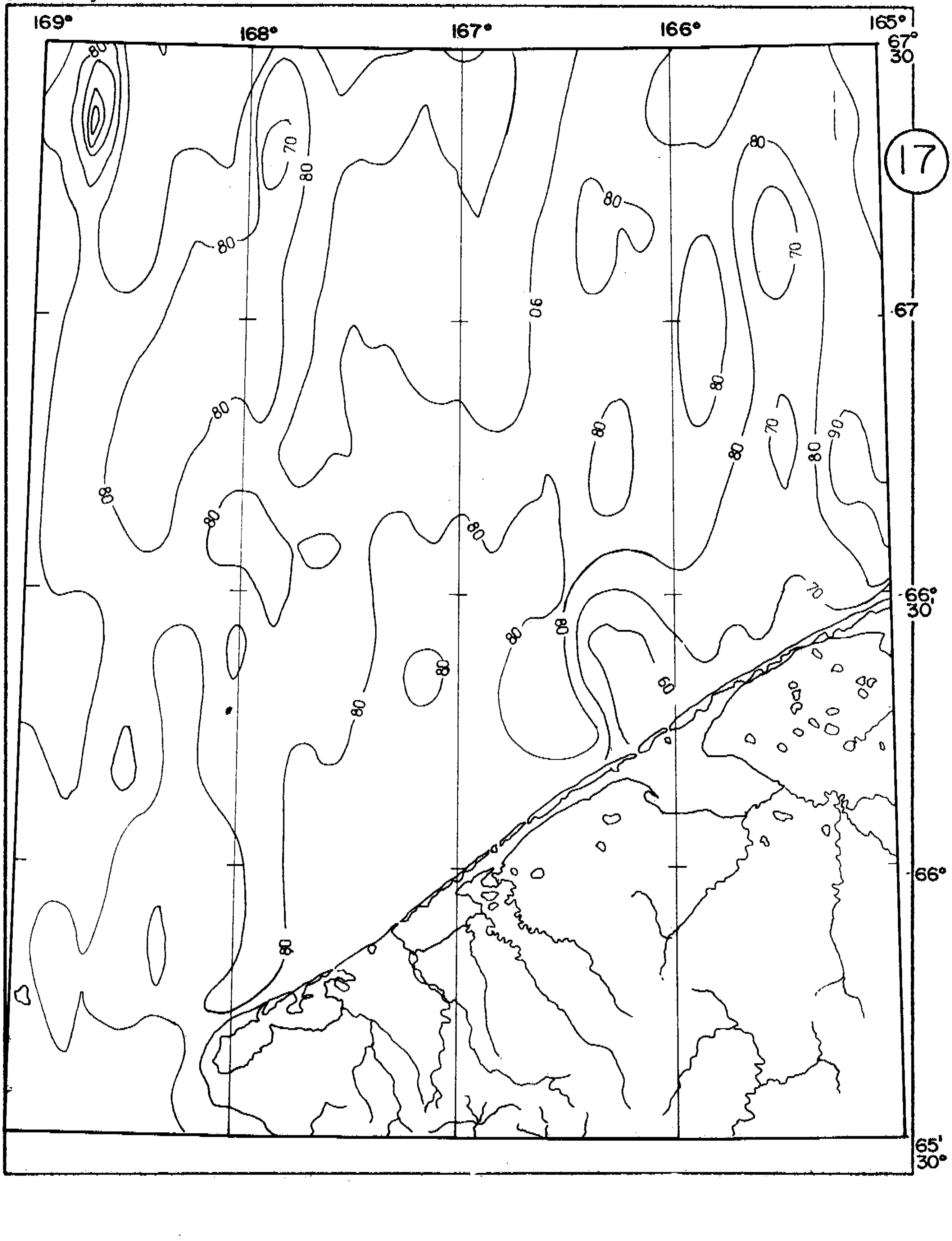

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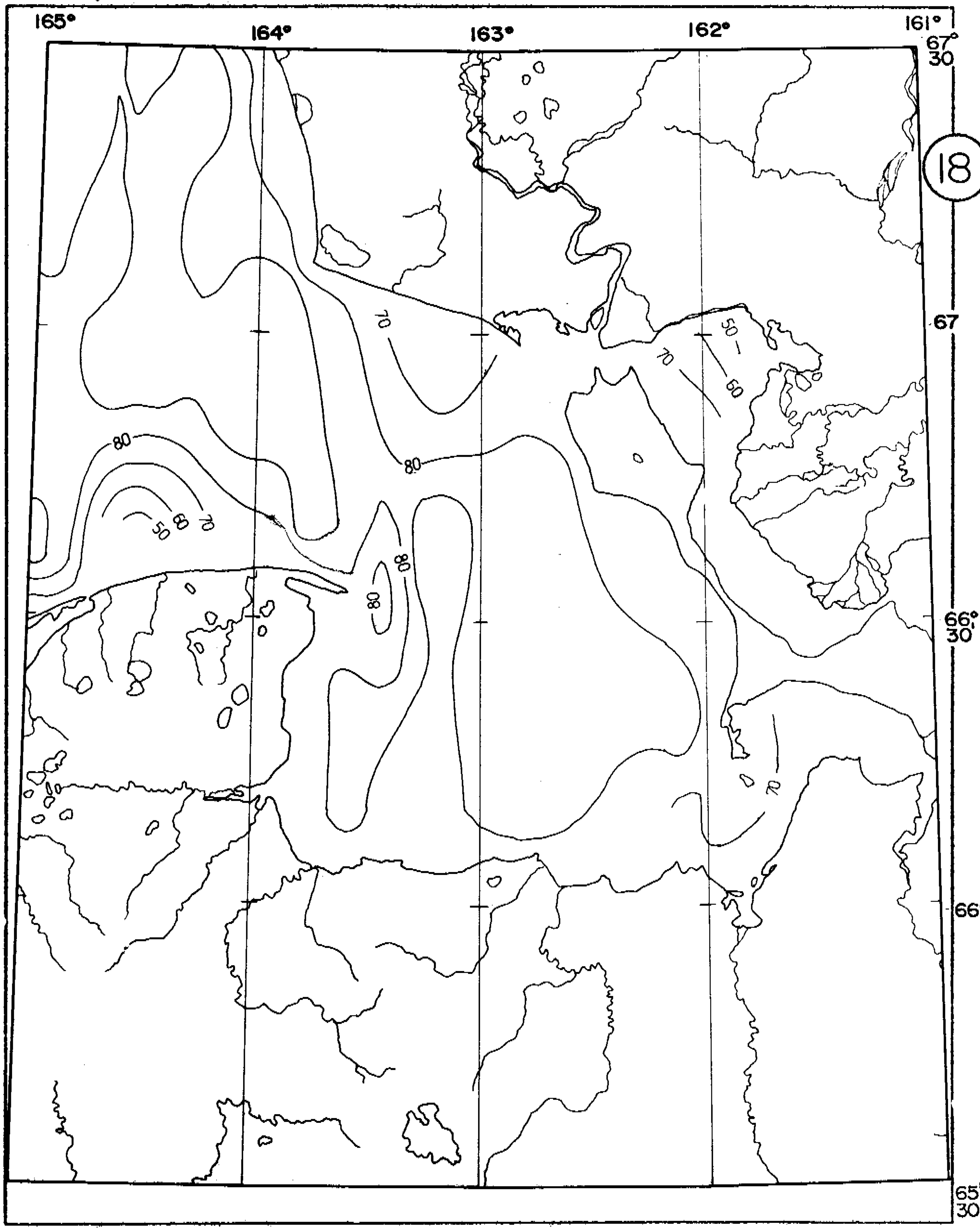


BEAUFORT SEA

RESEARCH UNIT 516 OCSEAP
NOAA INSTAAR 1977

TEMPERATURE OF THE SEA WATER AT THE MAXIMAL SAMPLING DEPTH

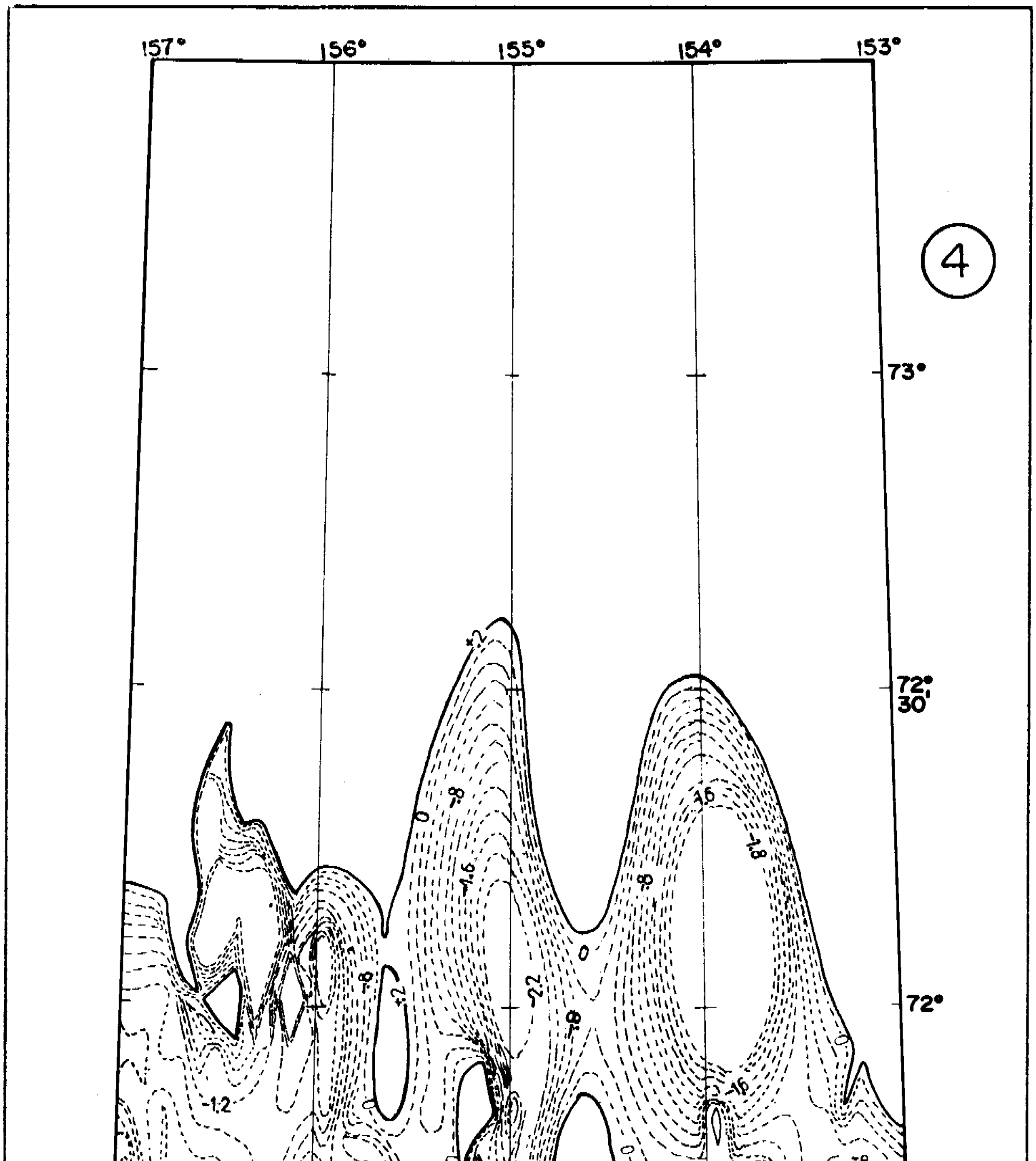
A SOURCE MAP FOR SUBMARINE PERMAFROST PREDICTION

TEMPERATURE — -2.2° TO +0.2°C
INTERVAL OF 0.2°C

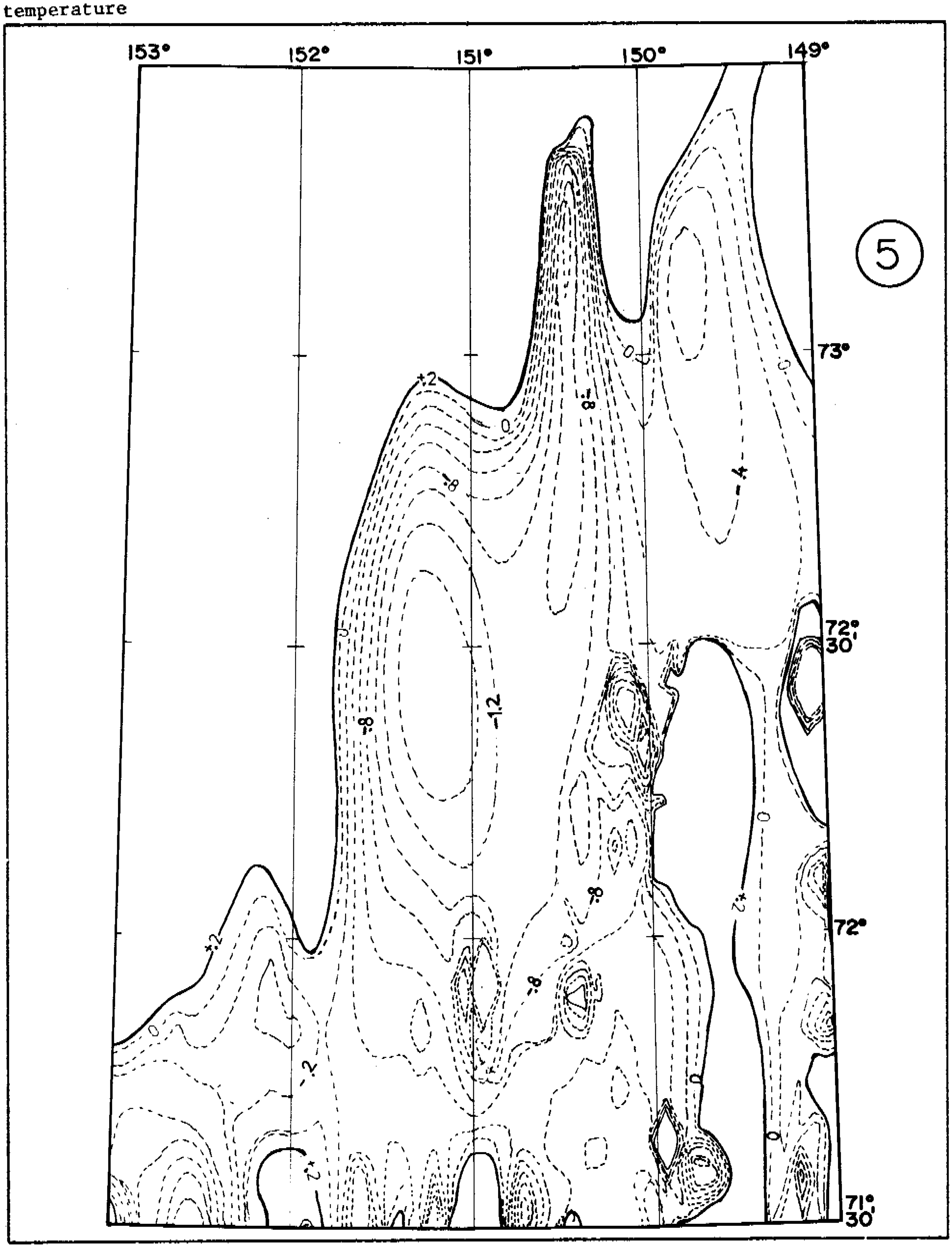
SCALE — 1: 1,000.000

GEOGRAPHIC BASED INFORMATION MANAGEMENT SYSTEM FOR PERMAFROST IN THE CHUKCHI AND BEAUFORT SEAS

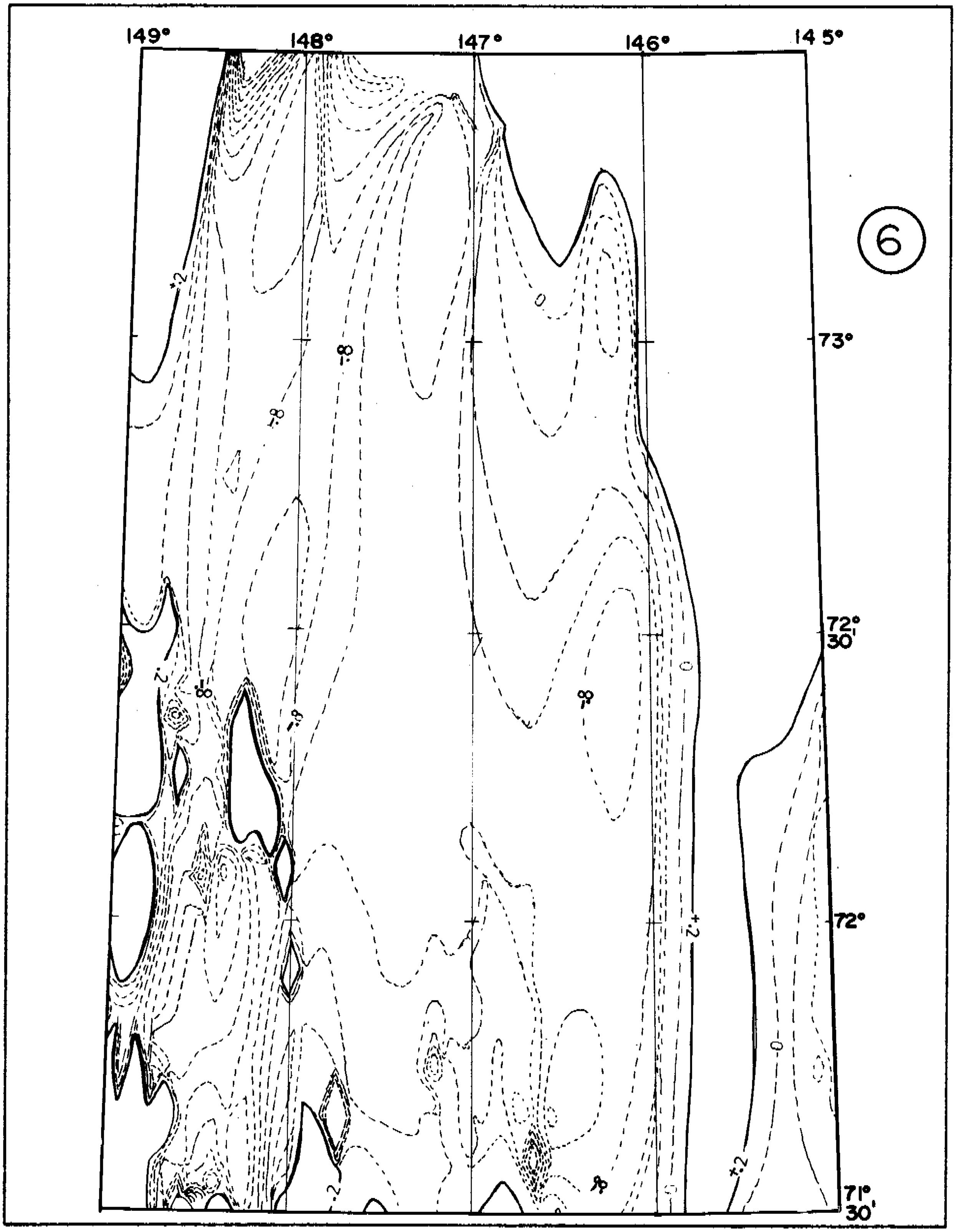
temperature



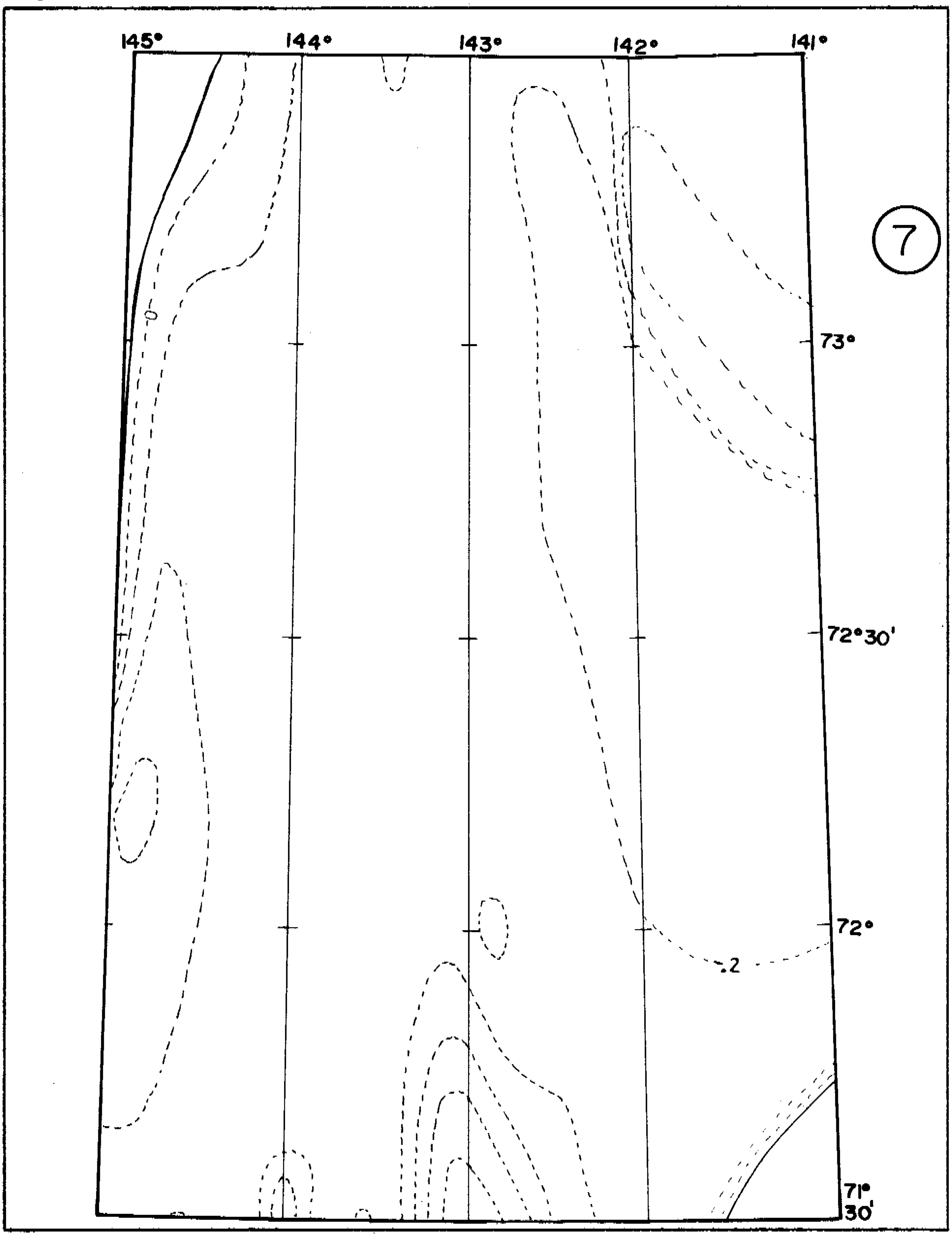
temperature



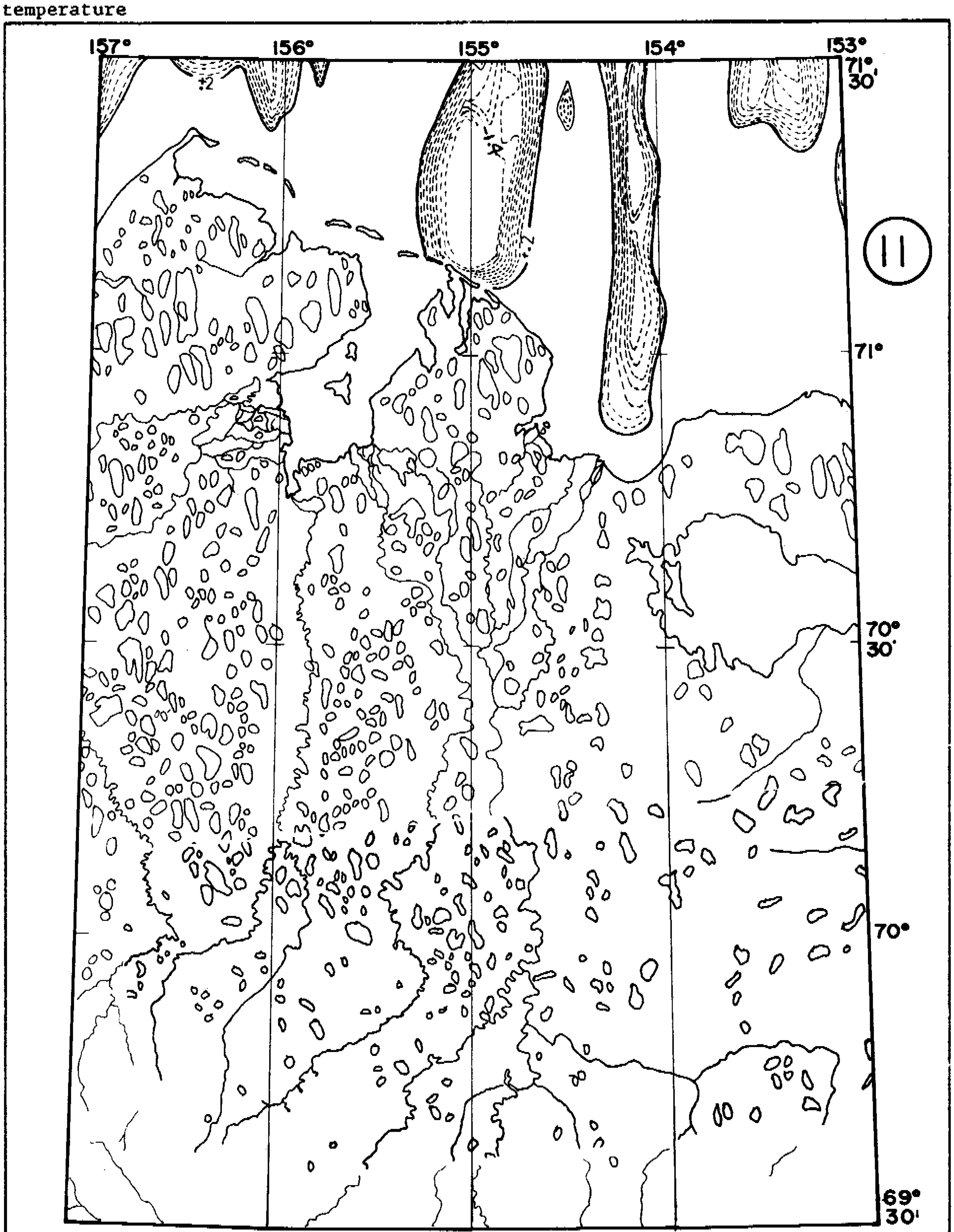
temperature



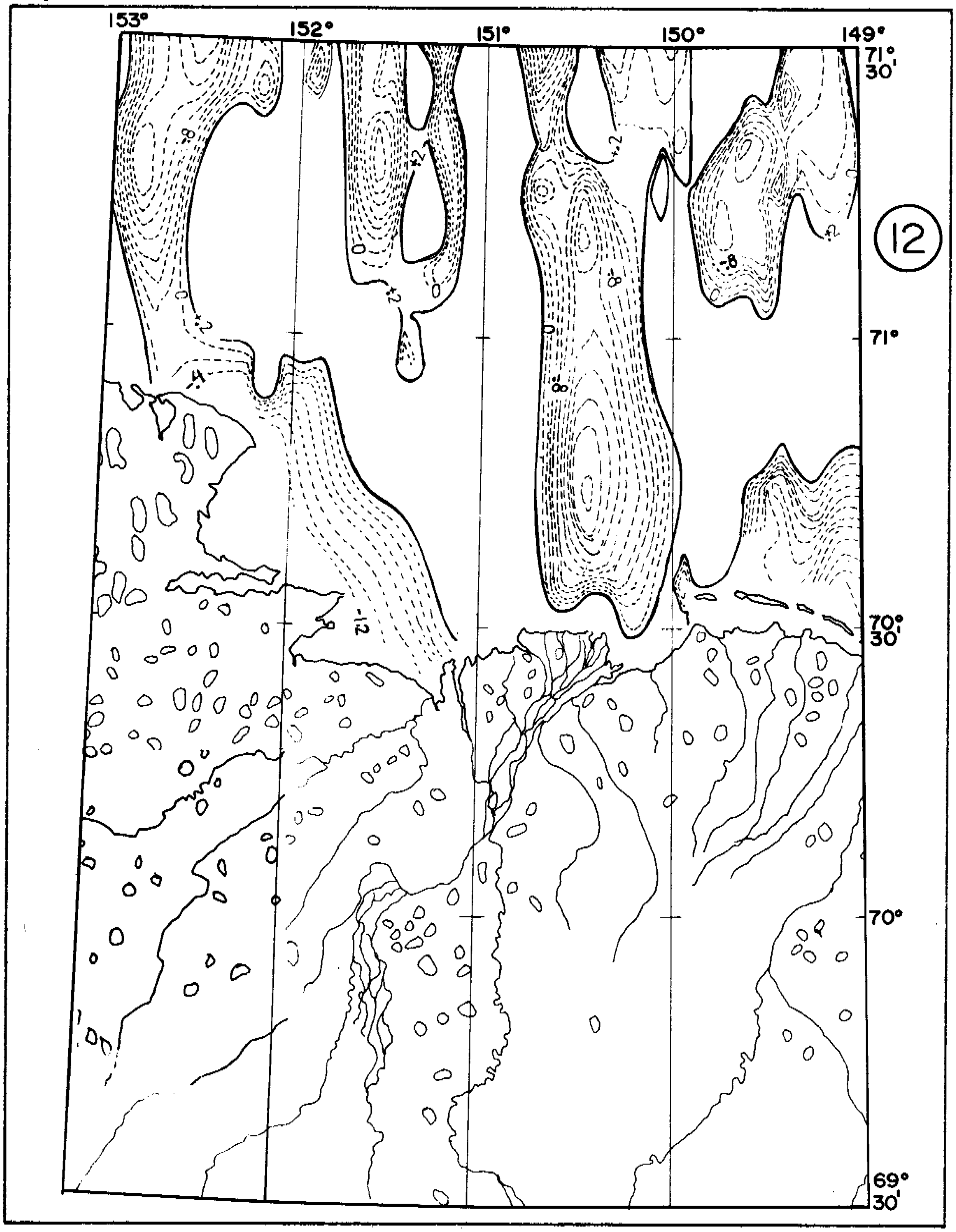
temperature



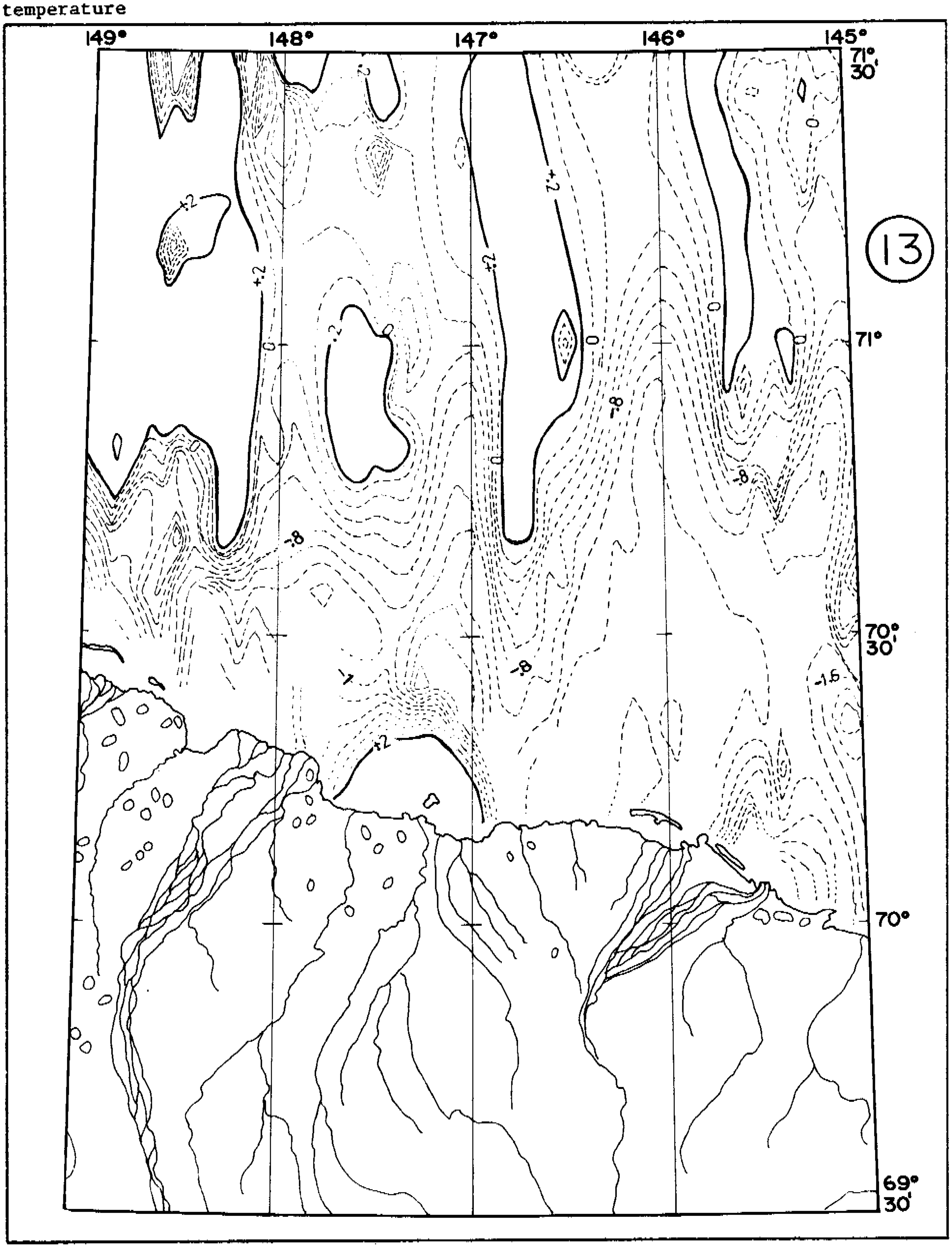
temperature



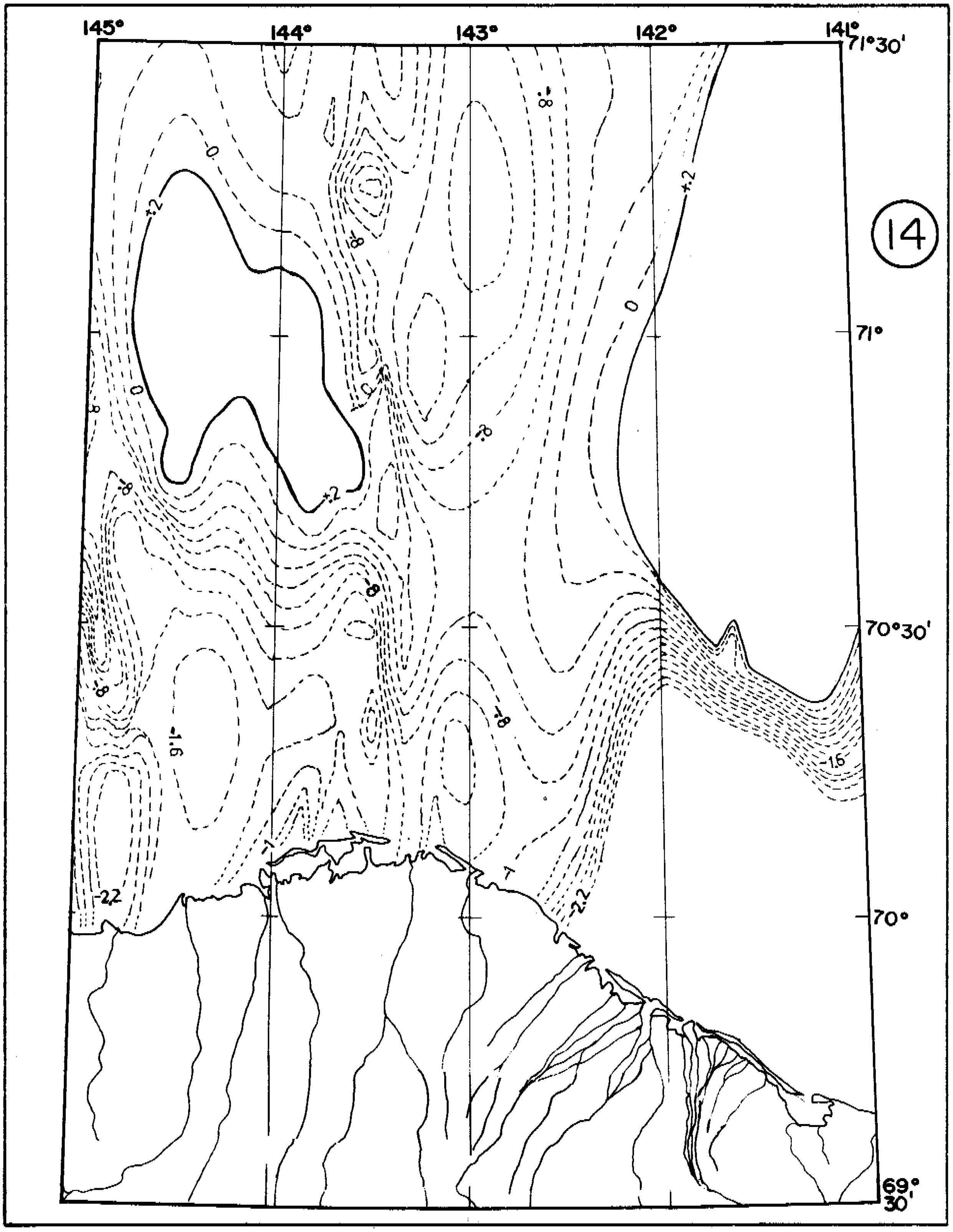
temperature



temperature



temperature



Submarine Permafrost on Arctic

Shelf of Eurasia

(Continuation)

Chapter D. History of development, paleogeographic conditions (continuation).

The assumptions of glaciologists who consider the low position of the Arctic Ocean level as only a result of a glacieustatic process are summarized, for instance, by S. Strelkov (322-325), and here illustrated by Fig. 73-75. The map and two curves show the location of the Arctic Ocean shoreline in the Pleistocene according to this scientist's conclusion. The Eurasiatic shelf is shown as being exposed during glaciation, including the maximal one (Illinoian). The amplitude of the shoreline oscillations reached 400-450 m in the Kara Sea (minus 250 for Samara glaciation time (Illinoian) and plus 200 for the boreal (Sangamon) transgression. The -250 m is related to the Ziryan glaciation (early Wisconsin), and changes of the shoreline position along the Arctic coast (Fig. 75) is explained as a result of tectonics.

Figures 76-78 and Table 16 show the data about sea-level-stillstands and fluctuations during the last galciation and the Holocene in the Laptev Sea according to Soviet and American data gathered and analyzed by M.L. Holmes and I.S. Creager (1974). Their proposed sea level curve of the Laptev Sea for the period 17,500 - 13,500 B.P. looks similar to some other World Ocean curves, but a radiocarbon date for core 137 (depth 103-117 cm) does not correspond to this curve and, together with core 144 and 143, shows a lowering of the level after the last glaciation maximum (about 18,000 y.a.) The authors explain this fact by the contamination of core 137 by inactive carbon.

The history of the shelf development is always considered when Russian geologists are trying to evaluate the extension and thickness of submarine permafrost. A typical example is the work of A.I. Chehovsky (1972 (62)) on offshore permafrost in Kara Sea. In this work the problems of permafrost development (or the negative temperature zone on the areas with porous water of high mineralization) is considered on the Kara Sea shelf down to 200 m in

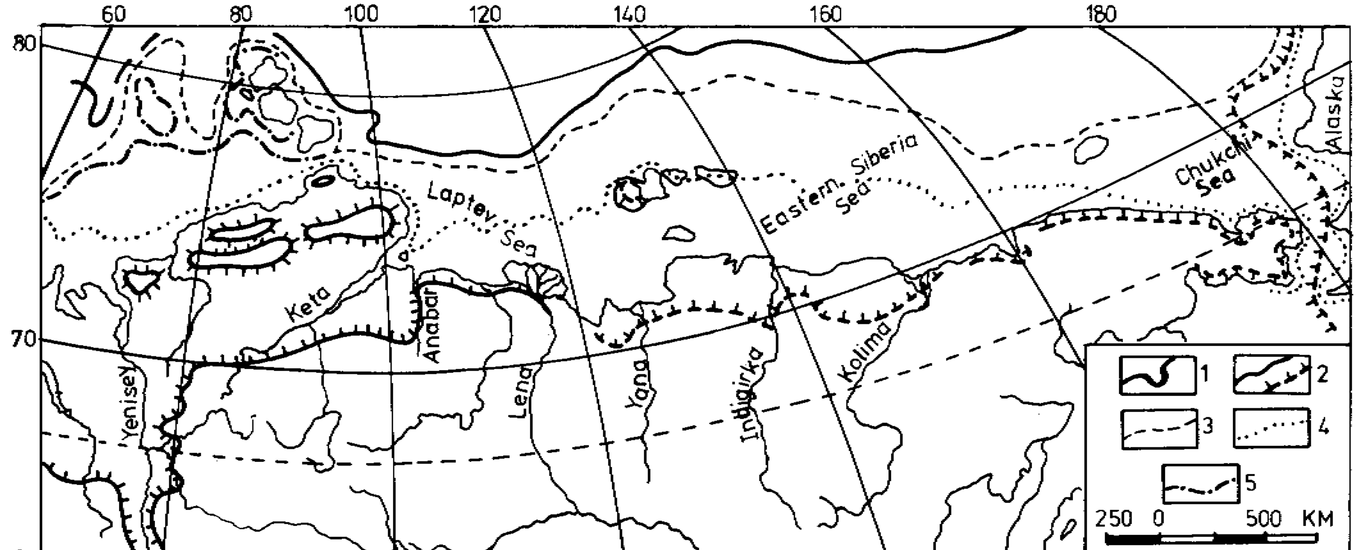


Figure 73

MAP OF THE LOCATION FOR THE ARCTIC SEA SHORELINE DURING THE QUATERNARY PERIOD. COMPILED BY S.A. STRELKOV, 1965.

1). Position of the Arctic Ocean shoreline during the maximum glaciation (Illinoian)

2). Established (a) and postulated (b) position of the shoreline during the boreal transgression (Sangamon)

3). Position of the shoreline before and during the Zyranskoye glaciation (early Wisconsin)

4). Position of shoreline during the Karginskoye period (mid Wisconsin interstade)

5). Position of the Kara Sea shoreline during the Sartanskoye period (Wisconsin)

Figure 74 SHORELINE OSCILLATION IN THE KARA SEA AFTER STRELKOV,1965

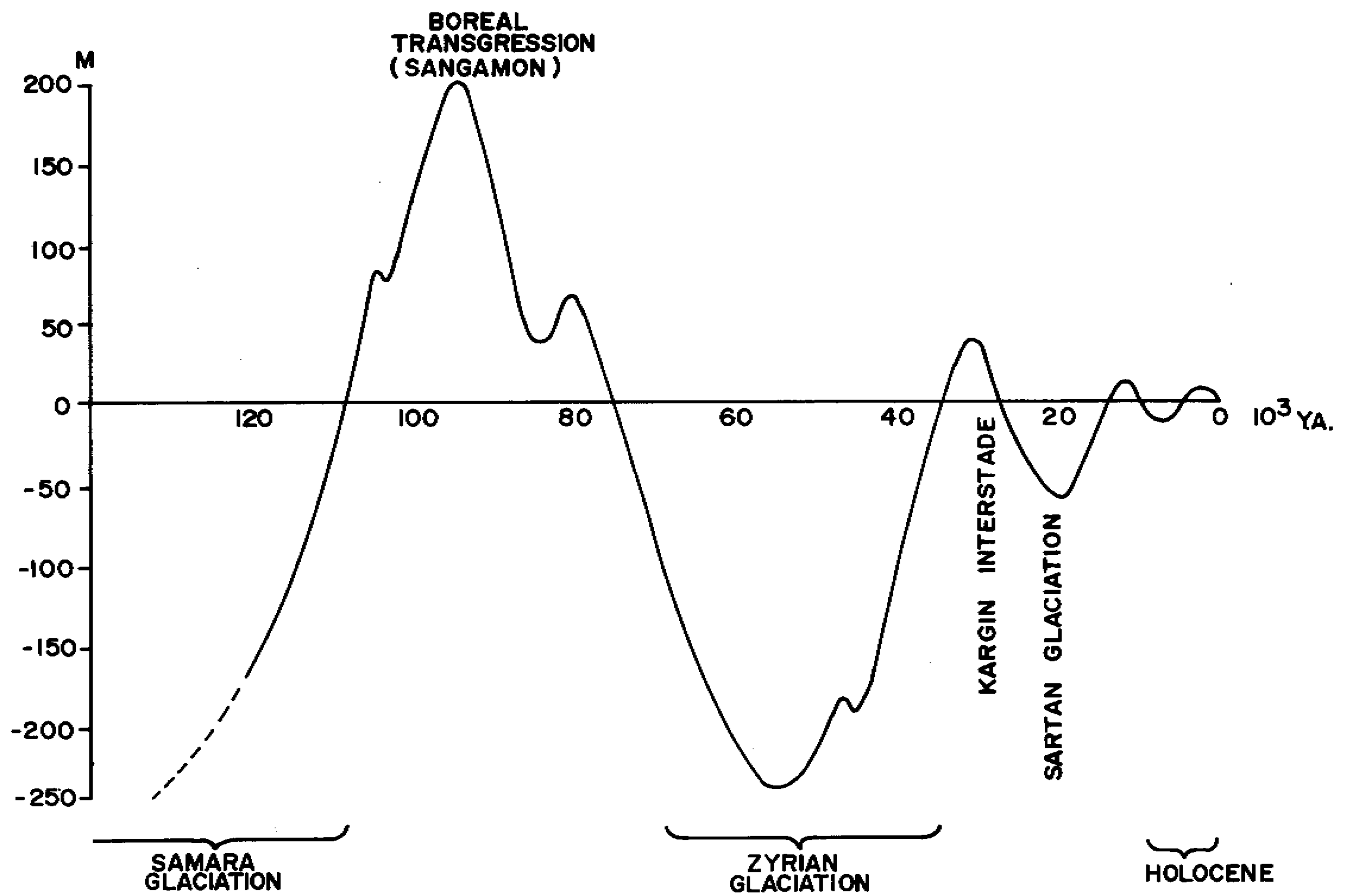
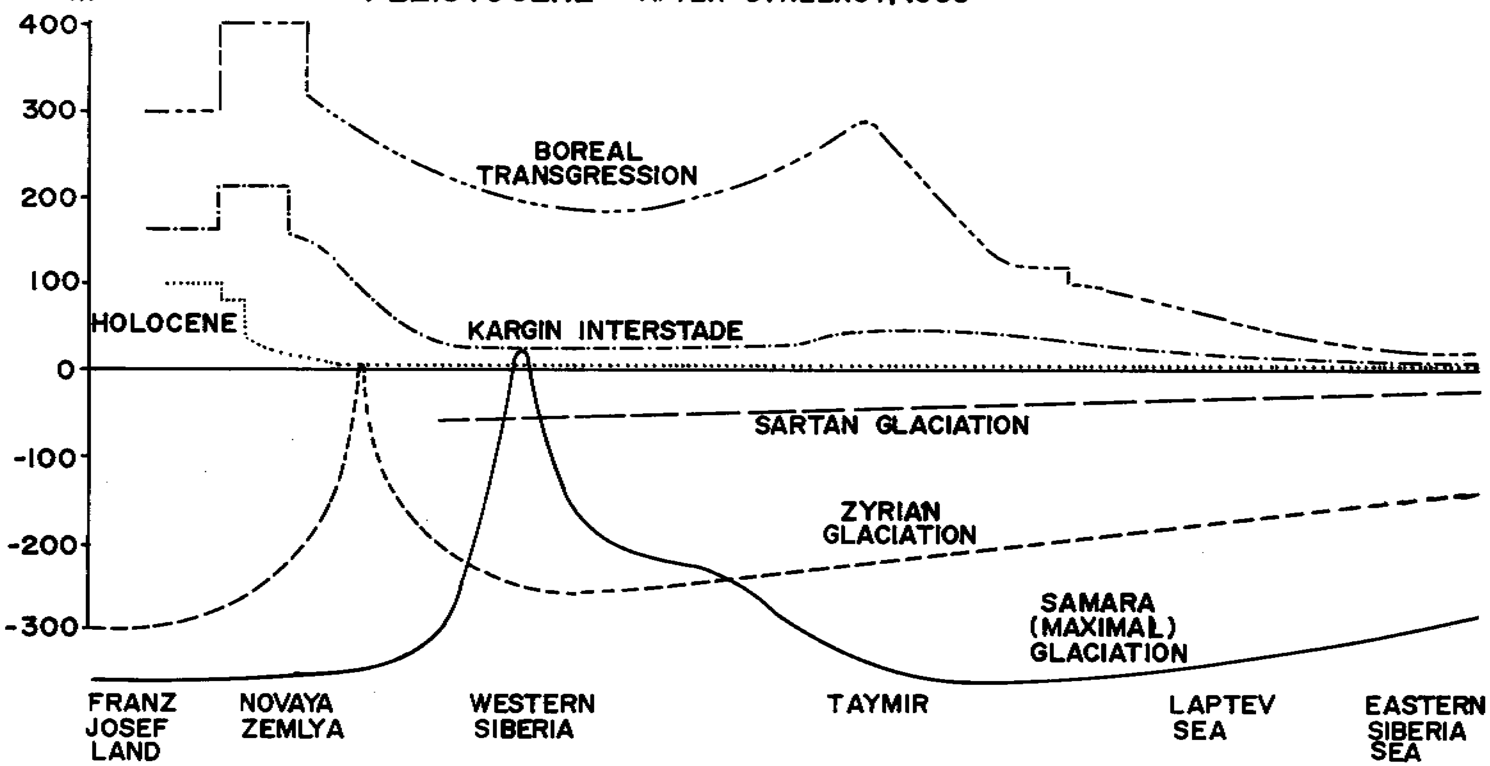


Figure 75

CHANGE IN THE POSITION OF THE ARCTIC SEAS SHORELINE DURING THE PLEISTOCENE AFTER STRELKOV, 1965



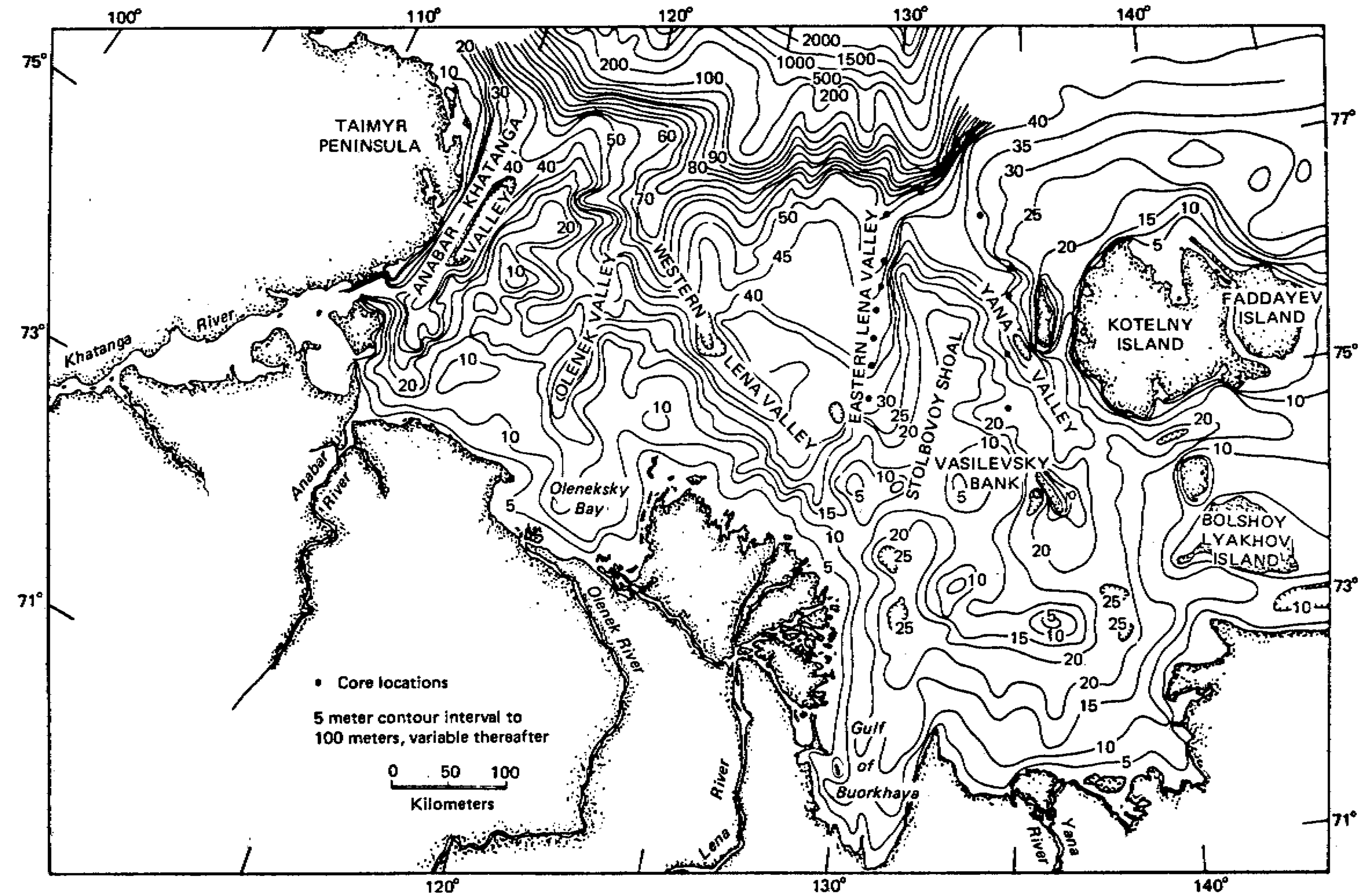


Figure 76 Bathymetric chart of the Laptev Sea.

After M. L. Holmes and J. S. Creager, 1974

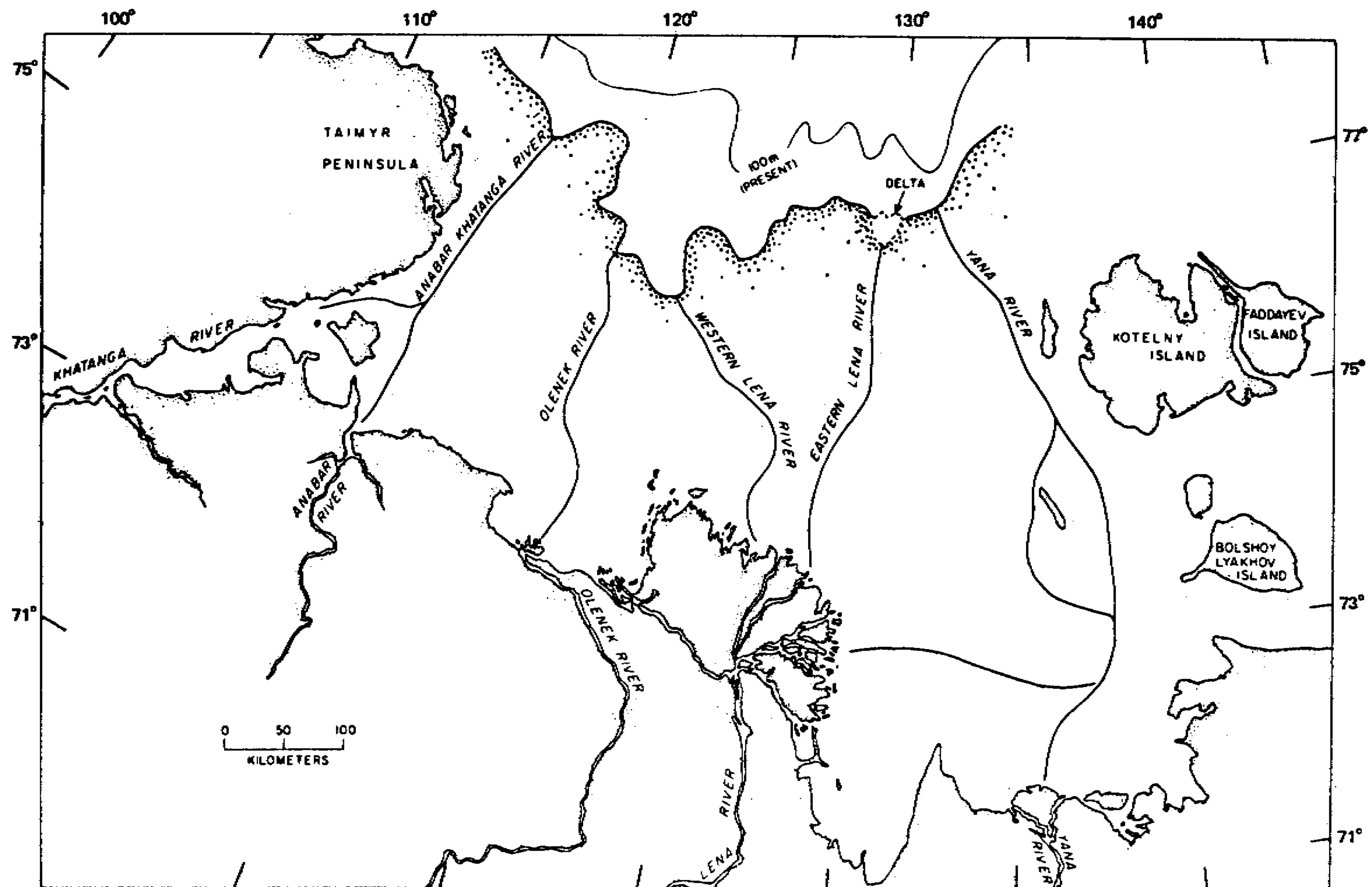


Figure 77 Paleogeography of the Laptev Sea at about 15,000 years B.P.

After M. L. Holmes and J. S. Creager, 1974

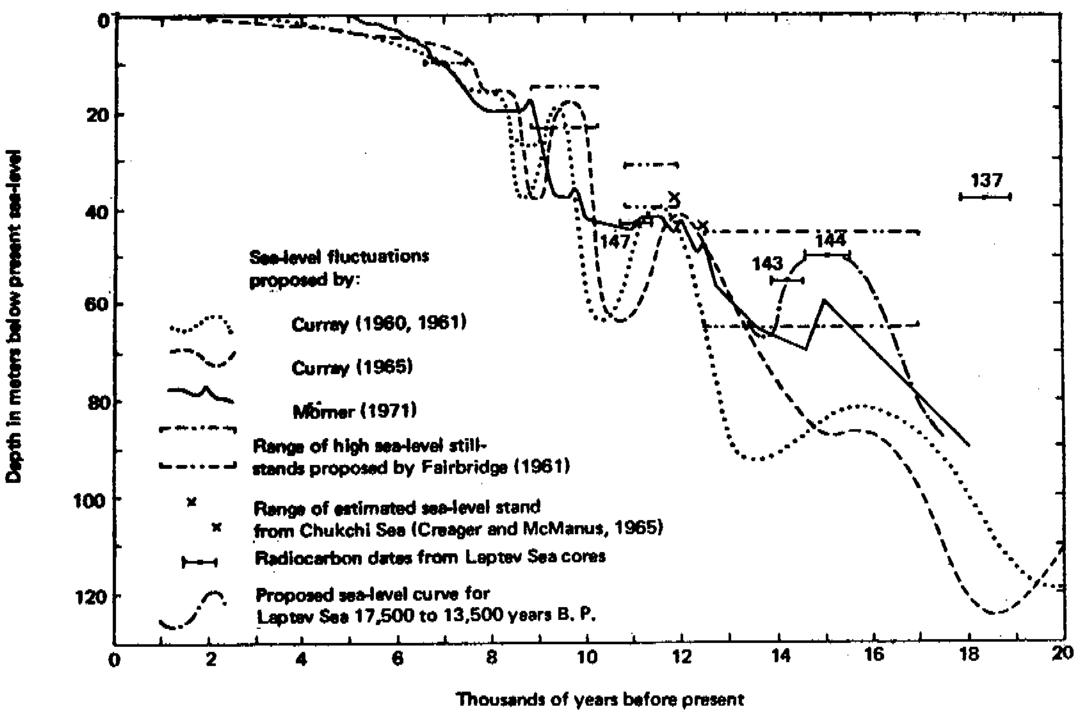


Figure 78 Sea-level stillstands and fluctuations during late Pleistocene and Holocene times. After M. L. Holmes and J. S. Creager, 1974

TABLE 16. CARBON—14 DATES AND SEDIMENTATION INTENSITIES

CORE	DEPTH IN CORE (CM)	RADIOCARBON AGE (YEARS B.P.)	AVERAGE SEDIMENTATION INTENSITY (mg/cm /yr)*
137	3—17	8410 ± 230	9
	103—117	18,400 ± 540	
143	24—32	14,200 ± 370	2**
144	3—20	6050 ± 200	
147	44—64	15,000 ± 460	
	89—102	11,040 ± 310	15**

* Based on elapsed time between dates.
** Assumed surface interval (3 to 20 cm) date 6000 yr B.P.

After M. L. Holmes and J. S. Creager, 1974

depth. The present temperature conditions for permafrost formation on the whole of the Kara Sea shelf are different from the conditions of the sea sector with a water depth of 1-2 m. The shallow areas freeze to the bottom during the winter. The winter temperature of the deposits reach (-4.2^{o}) - (-5.5^{o}) at a depth of 3-4 m from the bottom (the water depth of 1-2 m). It is low enough for the shelf area to be influenced by the rivers' thermal inflow. If the thermal conditions of the shelf at 1-2 m depth depends on climatic conditions, the thermal regime and extension of submarine permafrost deeper will be connected with such factors as the bottom relief, temperature and salinity of the sea water; and these factors contribute along with the history of the shelf development in Pleistocene and Holocene.

The Kara Sea shelf relief is very irregular with vast shallow areas and deep depressions. In the middle of the sea, at about the 80 meridian, the central Kara upland extends with an average depth of 50 - 100 m. The East Novozemelskaya depression, with a depth down to 500 m is situated along the east coast of Novozemelskaya. The trenches Santa Anna and Voronin are to the west and east of the central Kara upland and are located in the sub-meridian direction up to 79^{o}. The hydrological regime of the Kara Sea is defined by a small amount of solar radiation, of cold water inflow from the arctic basin, relatively low penetration of water from Atlantic basin and considerable salinification of surface water due to run off of the Ob and Enisey Rivers. The bottom roughness has also a strong affect on the water mass circulation.

The water mass of the Arctic basin and Kara Sea is inhomogeneous in its physical characteristics, and consist of several kinds of water differing from one another by some characteristic pecularities. In the Kara Sea shelf area one can define three principal water mass categories: Arctic, Atlantic and river water. Arctic water formation is connected with migration of Atlantic water, water of Pacific Ocean, river water and water from Arctic basin melting ice, and in addition, the hydrometeorologic processes occurring in the sea affect them. Atlantic water inflow in the Kara Sea, with the warm Gulf Stream currents, occur at a depth from 200 to 800 m in the Arctic basin. The river water occurs as far as the Yamal and Gydan Peninsulas. The river water influence exists in the Kara Sea up to 75°N. Their deepest penetration is limited by warm water intermixing.

The considered area was under epeirogenic movement of different directions in the Quaternary period, but the major one, according to A. Chehovsky, was extremely slow subsidence. From the viewpoint of A. Chehovsky, the north part of the low-land was inundated by the Arctic basin water several times. The predominance of negative movement shows that almost all the present-day Kara Sea shelf during the Quaternary period was under water. This is why, according to A. Chehovsky, the permafrost, which can be compared with thick permafrost found today in the northern part of Western Siberia, could not be formed. During this subsidence, there were some positive movements. The maximum amplitude (range) of positive tectonic movement took place at the beginning of the Holocene (Kuzin, 1961 (194)). The sea regression led to the draining of the shelf down to a depth of 15-20 m. Therefore, most of the shallow shelf sectors, which were coming out of the sea water at the beginning of the Holocene, had favorable climatic conditions for forming permafrost of considerable thickness. This thick permafrost formation under the Kara Sea shelf could also take place during glaciations. The author thinks that the total Kara Sea ice thickness was increased during the glaciation epoch when perennial ice was occupying all the area of the present day shelf. V. Zubakov (1972 (409)) considers this ice connected with the ice-shelf subformation, which corresponds in appearance to the coastal zone glaciation with typical development of both ground ice and sea ice.

In severe climatic conditions, the ice on the shelf forms from surface precipitation and from the freezing sea water below the surface. As a result of mutual growth, the ice can go down to 200 m in depth. One can assume that the Kara Sea ice thickness during glaciation attained 500-800 m, depending on the shelf depth. At the present time such ice thickness can be observed in the Antarctic (Shackleton and Ross Ice Shelves). The "extremel point of view", expressed by M. Grosswald (1970), is that the (shelf) ice thickness of Barents Sea and, in part, the Kara Sea reached 1800-2000 m during glaciation. A. Chehovsky supposes that the necessary conditions for forming ice 800 m thick existed on the Kara Sea shelf during the Ziryan glaciation (earlier Wisconsin). The climatic conditions were probably very severe on the whole present-day Kara Sea water area, and analogous to Greenland and Antarctica. One can assume that the average annual temperature could go down to -30^{o} to $-35^{o}C$. Simple calculations show that under the geothermical gradient of about 3^{o} the permanent thickness can reach 400-700 m. Maximum permafrost thicknesses were formed under shallow shelf areas as they have less ice thickness and therefore the lowest temperature at the bottom. After the ice regression and inundation of the shelf area for sea water with a negative temperature (approximately 35,000-50,000 years ago) and ground freezing stopped and melting began because of the heat flow. Thawing would continue until complete permafrost disappearance. In an area with positive bottom temperature, it is only a question of time. Under the negative bottom temperatures the thawing would continue as far as the thickness comes into conformity with these temperatures. Considering only the heat going for phase change from ice to water, the decrease in permafrost thickness can be calculated this way:

$$g_t \lambda_t = \frac{Q_p H}{T}$$

where g_t – geothermical gradient of the thawing zone (0.030 gr/m)

λ_t – coefficient of the thermoconductivity $\left(1{,}1 \frac{\text{KCAL}}{\text{M HOUR GRADE}}\right)$

Q_p – phase change heat (24000 $\frac{\text{k cal}}{\text{m}^3}$)

T – thawing time (50,000 YEARS)

H – the value of the perennial melting from below (M)

The calculations of A. Chehovsky show that during 50,000 years, about 500 m of permafrost could be thawed.

Analyzing the conditions of the permafrost existence in the Kara Sea and using for the division of the shelf such characteristics as:

1) the different kinds of water distribution,

2) morphology of the bottom shelf,

3) history of the paleogreographical development,

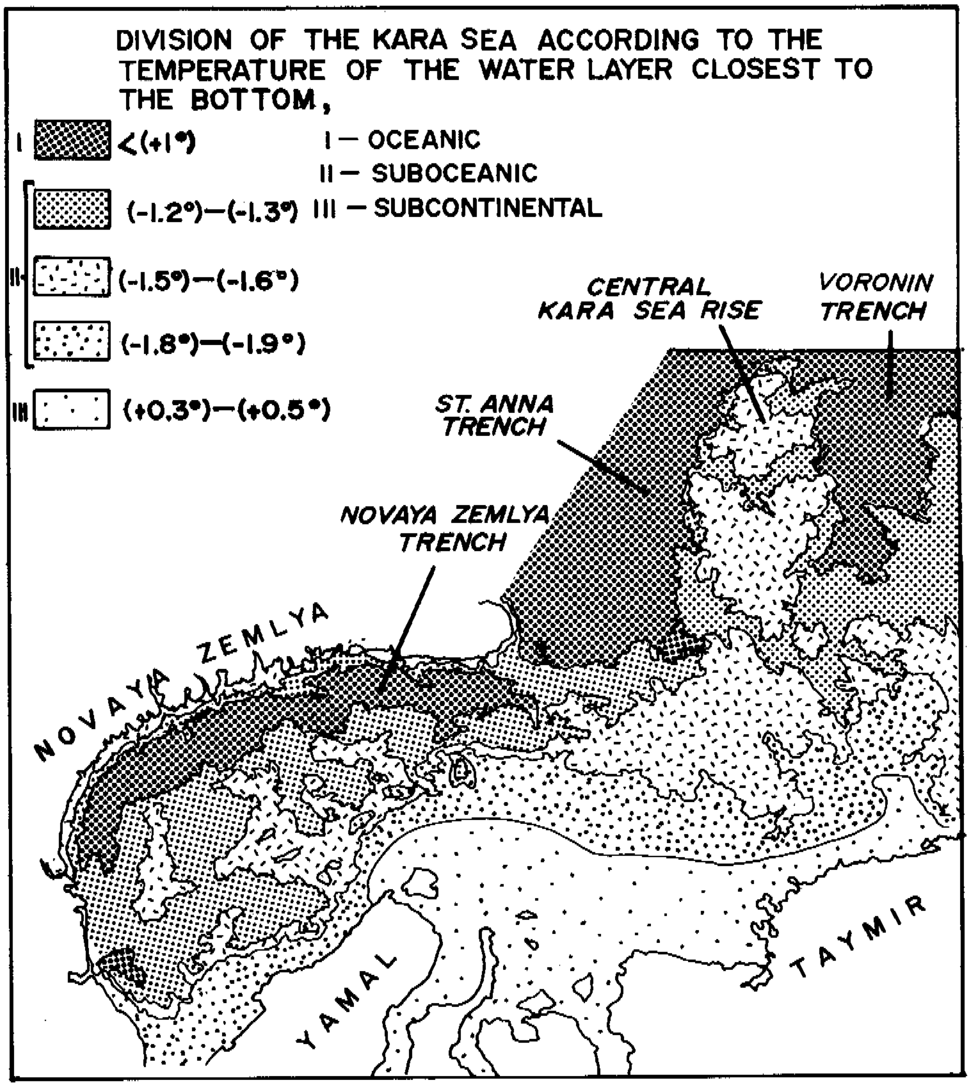
A. Chehovsky made the following division of the Kara Sea shelf (Fig. 79):

I. Oceanic region: Includes the St. Anna and Voronin trenches and Novya-Zemelskaya depression with depths of more than 200 m. The bottom of these depressions is formed by non-wave accumulation processes and they have flat, practically horizontal surfaces. The water filling them can be then characterized with distinctive stratification according to the temperature and salinity.

Arctic Water can be divided into three layers:

1. The water layer at the depth of 50 m has a uniform (in a vertical direction) negative temperature and a salinity of 29 to 32^{o}/oo. For this layer the convective mixture of water and also the Arctic Basin sea ice influence on the temperature regime and salinity is typical.

Figure 79


DIVISION OF THE KARA SEA ACCORDING TO THE TEMPERATURE OF THE WATER LAYER CLOSEST TO THE BOTTOM,
I <(+1°)
I — OCEANIC
II — SUBOCEANIC
III — SUBCONTINENTAL
(-1.2°)—(-1.3°)
II (-1.5°)—(-1.6°)
(-1.8°)—(-1.9°)
III (+0.3°)—(+0.5°)
CENTRAL KARA SEA RISE
VORONIN TRENCH
ST. ANNA TRENCH
NOVAYA ZEMLYA TRENCH
NOVAYA ZEMLYA
YAMAL
TAYMIR

2. Below the first layer, within 50-100 m, there are waters with increasing salinity (up to 34°/oo). These waters have formed on the Arctic basin continental slope.

3. At depths from 100 m to 200 m, there are waters with a salinity of about 35°/oo. The water temperature of this layer forms under the influence of Atlantic water and the second layer waters.

Atlantic Water exists at depths of more than 200 m. It can be characterized by a positive temperature and salinity of about 35°/oo. This water flows to the Kara Sea along the St. Anna and Voronin trenches. Each water layer temperature for the oceanic region is presented in Table 17. Obviously, during the whole Quaternary period the bottom water layer temperatures of the ocean depression were positive. Therefore permafrost could not have formed at the bottom.

II. Suboceanic region: Occupies the shelf with a depth of 20 to 200 m. In the eastern and western parts and also above the "Kara highland" the predominate depths are 50 to 100 m. The forming of the suboceanic bottom relief is mostly linked with an abrasion process. The tectonic subsidence caused the displacement of these surfaces from the wave affecting zone to greater depths.

The whole oceanic region can be characterized by negative temperatures of the bottom water layer. Temperature and water salinity to a depth of 100 m completely correspond to the waters of the first and second layers of oceanic region. Water occurring below 100 m has considerably lower temperatures, which approach the freezing temperature of water with similar salinity (Table 18). Permafrost can occur on the bottom of the suboceanic region. The thicknesses could be in accordance with present-day bottom temperature conditions or even greater. This situation probably can take place on the

Table 17. Dependence of Salinity and Temperature with the sea Depth in the "Oceanic Region".

Sea Depth (M)	0-50	50-100	100-200	200
Salinity (‰)	29-30	33-34	35-36	35
Temperature (C°)	(-1.2)-(-1.3)	(-1.5)-(1.6)	(-0.4)-(-0.6)	<(+1.0)

Table 18. Dependence of Salinity and Temperature with the sea depth in the "Suboceanic Region".

Sea Depth(m)	0-50	50-100	100-200
Salinity (‰)	29-30	33-34	35-36
Temperature(C°)	(-1.2)-(-1.3)	(-1.5)-(-1.6)	(-1.8)-(-1.9)

Table 19 Thickness of the submarine permafrost in the "suboceanic region" of the shelf.

Sea Depth (m)	0-50	50-100	100-200
Temperature (C°)	(-1.2)-(-1.3)	(-1.5)-(-1.6)	(-1.8)-(-1.9)
Submarine Permafrost Thickness (m)	100-150	60-80	80-100

shelf area from depths of 20 to 50 m. During the conditions of the shelf glaciation epoch such areas could have the greatest thickness of permafrost (600-650 m). During the post-Zyrian period, permafrost of about 500 m in thickness could have thawed. Therefore the present-day permafrost thickness in this part of the shelf can be found as a difference between thicknesses which were developed during the Zyrian period and were thawed after that time. This thickness is about 100-150 m. In the rest of the suboceanic shelf region the permafrost thicknesses depend on present-day bottom temperature conditions. Permafrost thicknesses for different sea depth are shown in Table 19.

III. Subcontinental region: Situated to the north from the Yamal and Gydan peninsulas, and occupying a large part of the Yamal-Gydansky bank to a 20 m depth. One can here define the present-day abrasion and abrasion-accumulation surfaces. Abrasion surfaces form on the zone of wave influence and occur at depths of 15-20 m. In the coastal part of the shelf, the sedimentation of clastic material is derived from the river's drift or shore abrasion. The abrasion-accumulation surfaces form here and are covered by relatively thick layers of consolidated sands. The temperature and salinity of the water is affected by the Ob-Enisey current. The water of this current warms (+6 to +8^{o}C) with a salinity of 10 - 15^{o}/oo. The Ob-Enisey current keeps an extremely large reserve of the advective heat caused by continental run-off. In the winter the water of Ob-Enisey current drops to minus 0.4 - 0.6^{o}C, which corresponds to freezing for water with a salinity of 10 - 15^{o}/oo. The calculated average annual temperatures are +0.3, +0.5^{o}C. As mentioned above, the influence of the Ob-Enisey current is limited by the depth of 10 m (to the north from Yamal and Gydan Peninsulas). This isobath was taken by A. Chehovsky as a border between the subcontinental and suboceanic regions.

Permafrost in the subcontinental region has both Pleistocene as well as Holocene age. Its formation is connected with Zyrian glaciation and with beginning of the Holocene, when part of the shelf areas had the characteristic of littoral plains. The present-day geothermal conditions of the bottom give the possibility to assume that there is no permafrost here now. The permafrost relict layer occurs deeply from the bottom in this region and its formation is connected with the Zyrian glaciation. The base of the frozen layer in this region is 150-200 m. During the winter the bottom temperature in the subcontinental region has minus 0.4, - 0.6^{o}C, affecting the formation of the seasonal permafrost of small thickness. Proceeding on the basis of the point of view described in his article and taking into account the Kara Sea paleogeographical development and the performed calculations, A. Chehovsky came to the following conclusions about permafrost and its thickness in the defined regions:

1) in the oceanic region permafrost is absent,
2) in the suboceanic region permafrost exists under the sea bottom,
3) in the subcontinental region permafrost exists at considerable depths from the bottom,
4) in a large part of the shelf, permafrost thicknesses correspond to the present-day bottom temperature conditions. Shallow shelf areas, to 50 m in depth (subcontinental part of suboceanic region), have an abnormally great thickness of permafrost, which does not correspond to the present day temperature conditions. Here the present degradation of frozen rocks takes place now.
5) the greatest permafrost thickness (up to 150 m) should be expected in the suboceanic regions to a depth of 50 m.

To be continued.

List of Figures

List of Tables

Financial Status

Amount dispersed since the beginning of work . . . . $ 55,037

Amount dispersed Fourth Quarter (October-December, 1977) . $ 15,880

DATA MANAGEMENT

DATA MANAGEMENT

QUARTERLY REPORT

Research Unit 362

Quarter Ending - 15 December 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

January 1, 1978

DIGITAL DATA

A total of 146 data sets (excluding resubmissions) were received by NODC and NGSDC this quarter. A total of 92 data sets were 'final processed' during the quarter; 58 data sets are in a 'hold' status awaiting additional Project Office and/or P.I. information or possible resubmissions. The distribution and status of all OCSEAP digital data received to date is as follows:

	Received	Finaled	In Hold	In Processing
Biological	621	278	51	292*
Physical	194	147	5	42
Chemical	31	9	0	22
Geological	6	2	2	2
	852	436	58	358

* The large number of biological data sets in processing is attributed in part to a 131 multifile data set that must be reprocessed due to resubmission and to several multifile data sets of 40, 35 and 25 files that have recently been received.

The data sets received for each file type during this quarter and the distribution by lease areas are shown in Table 1.

TABLE 1. Distribution of Data Sets Received between 9/16/77 and 12/15/77.

File Type-Format Name	Total	Lease Area Code								
		1	2	3	4	5	6	7	8	9
015 - Current Meter	6	5	-	-	1	-	-	-	-	-
017 - Pressure Gauge	1	1	-	-	-	-	-	-	-	-
021 - Trace Metals	3	1	1	3	1	-	1	-	1	-
022 - STD Data	12	1	2	1	6	1	5	2	4	-
023 - Fish Resource	4	-	-	4	4	-	4	4	4	4
024 - Zooplankton	7	7	7	-	-	-	-	-	-	-
028 - Phytoplankton	2	-	-	-	2	-	2	-	-	-
029 - Primary Productivity	2	-	-	-	2	-	2	-	-	-
030 - Intertidal Data	3	2	-	3	-	-	-	-	-	-
032 - Benthic Organisms	8	-	-	5	-	3	-	-	-	-
033 - Marine Bird Sighting	35	-	-	-	-	35	-	8	-	-
034 - Marine Bird-Land Census	1	-	-	-	-	-	-	1	-	1
035 - Marine Bird Colony	26	-	-	-	25	-	-	1	-	1
037 - Feeding Flock	8	8	8	8	8	-	8	-	8	-
043 - Light Hydrocarbons	2	-	2	2	-	-	-	-	-	-
056 - Lagrangian Meas.	9	1	-	1	-	8	-	-	-	-
061 - Trace Elements	15	8	3	2	4	1	5	-	-	1
072 - Beach Profiles	1	1	-	-	-	-	-	-	-	-
073 - Grain Size Analysis	1	1	-	-	-	-	-	-	-	-
	146									

Lease Area Code
1 - NEGOA
2 - Lower Cook
3 - Kodiak
4 - St. George
5 - Beaufort
6 - Bristol
7 - Norton
8 - Aleutians
9 - Chuckchi

DATA REPORTS

A total of 32 data reports were received from the Project Offices this quarter. The reports are entered in the data tracking system which identifies the appropriate lease areas for each report. The distribution by discipline and lease area is shown in Table 2.

TABLE 2. Distribution of Data Reports Received Between September 16 and December 15, 1977.

Discipline	Total	Lease Area Code 1	2	3	4	5	6	7	8	9	General
Mammals	4	-	-	-	-	3	1	3	1	3	-
Birds	6	-	-	-	-	2	-	3	-	3	-
Fish/Plankton/Intertidal	6*	2	4	2	-	2	-	-	-	-	-
Chemistry/Microbiology/Effects	5	-	-	-	-	-	1	-	-	-	4
Physical Ocean./Meteorology	1	-	-	-	-	1	-	-	-	-	-
Geology/Geophysics	2	1	-	-	-	2	-	-	-	-	-
Sea Ice/Permafrost	7	-	-	-	-	7	-	1	-	4	-
Maps/Charts/Analog Data and General Reports	1	1	1	1	-	1	-	-	-	-	-
	32										

* Four of these reports were indicated by the Juneau Project Office to contain relevant data that will not become part of the digital data base - the reports are retained by the Project Office.

ROSCOPS

A total of 63 ROSCOPs were received this quarter. A total of 367 have been received to date for OCSEAP cruises and surveys. ROSCOPs for this quarter were received by the following:

USGS - 3
USFWS - 15
PMEL - 1
NMFS - 1
ADF&G - 6
Dames & Moore - 4
Univ. of California - 2
Univ. of Alaska - 3
Oregon State University - 23
Univ. of Washington - 2
Univ. of South Carolina - 1
Univ. of Houston - 1
Johns Hopkins - 1

DATA REQUESTS

The following is the list of the major requests received and/or being worked on during this quarter. Requests for the Data Catalog, new taxonomic codes and other routine information such as copies of data formats are not included in this list.

Data Received	Date Completed	Requestor/Description
8/30	Partial	Johnson (Arctic Project) - Completion of requests delayed by BLM and Project Office requests - bottom temperature product requires new software development.
9/20	9/23	Lt. Nelson (NOAA/EDS) - Selected OCSEAP current meter data (015) inventory for Gulf of Alaska data from PMEL.
9/30	10/11	Cava (Juneau P.O.) - Copies of subsets of taxonomic code by marine invertebrates and fishes for Jerry Sanger (USFWS).
9/21	11/17	Pelto (Juneau P.O.) - Plot to scale a portion of NOS chart 16013 for overlays.
10/17	10/25	Lt. Nelson (NOAA/EDS) - NODC inventory of all current meter data for Gulf of Alaska.
10/24	11/8	Pease (PMEL) - Replacement tape of data for file ID IMS812 - previous tape sent was not readable.
10/24	11/8	Hadley (IMS) - Replacement tape of data for file ID IMS810 - previous tape sent was not readable.
10/26	Partial	Hadley (IMS) - Selected stations and file types located in Kodiak lease area - completion delayed due to higher priority requests.
11/8	Partial	Becker (Juneau P.O.) - Monthly inventories in Lower Cook for Hazard, Transport, Biological and Chemical data. Preliminary inventory list/plots sent 11/15. Microbiological file descriptions sent 12/1. Retrievals from data files are underway - should complete request this month - delay due to BLM request.

Data Received	Date Completed	Requestor/Description
11/11	11/21	Patten (Johns Hopkins) - Tape copy of his FY 75-76 033/035 marine bird data - original punched cards keypunched by NODC also returned to Patten.
11/18	12/12	Fischer (Boulder) and Gottlieh (BLM) - Inventory of Beaufort Sea species submitted by OCSEAP investigators. Plot and list of all species to family level obtained from DIP files and sent to BLM by Federal Express 11/22. List to species level of taxonomic code required retrieval from specific data files. Species list included birds, mammals and fish with separate lists for prey and predator. Additional monthly plots of available data, above species list and copy of list on magnetic tape forwarded to BLM by Federal Express on 12/12.
11/22	-	Hadley (IMS) - Tape copy of STD data (022) for file ID RA-75 (RU 138).
11/23	11/30	Black (Providence College, R.I.) - Information on Aleutian volcanic activity and effects on biota - copy of appropriate OCSEAP task descriptions forwarded through Wayne Fischer.
11/30	11/30	MacDowell (Resource Marketing Svc.) - Information on Beaufort Sea bathymetry and geophysics - referred to NGSDC after discussion OCSEAP data catalog.

NGSDC has serviced several requests for the Alaskan area which included digital earthquake data and analog seismic profiles from OCSEAP studies.

FORMAT DEVELOPMENT

A format 'FACT' sheet, documenting all format modifications and code additions, was distributed to all OCSEAP data management personnel on November 28. Investigators requesting changes were notified of the approved fields and codes to be used. Modifications to 6 formats, 2 new codes and additions to 13 existing codes were completed during the quarter. A series of modifications to the ice record for file type 033 also were agreed upon to enable Mike Crane's office to process Divoky's marine bird sighting data that contained ice information but not in the OCSEAP format.

The digitizing of all OCSEAP codes in a format compatable with the NODC computer system is underway in Mike Crane's office. All codes will be processed on diskettes with a copy forwarded to NODC for incorporation in the data base and for output products.

A review of the USFWS proposed format - Marine Bird, Analysis of Production, was completed and comments forwarded to Dr. Lensink on October 17 with copies of the comments to OCSEAP personnel. The major point of the memo was that the acceptance of summary data that differed from the data currently being received for OCSEAP marine birds will require a Program Office decision before this type of data can be included in the data base.

No further action on formats developed or modified in the past quarter (July-September) has been taken by the Program or Project Offices. The decision to review format actions at the Program level has altered the present system of approval and distribution of formats. Consequently formats distributed in September (File types 025, 027, 038, 057, 063) have not yet been approved or formally distributed to investigators.

DATA PROCESSING

The procedures described in the previous quarterly report have been implemented. Check programs using range checks (where data are available) are being forwarded to the Project Offices together with preliminary inventories of most data parameters. A memo describing each step in NODC's processing of OCSEAP data was distributed to all OCSEAP data management personnel on November 14. An abstruct of this memo is planned by the Arctic Project Office for their "Bulletin". Copies of available check programs and listings of all parameters currently included in NODC inventories also were distributed to data management personnel in November.

Efforts are underway to create archive tapes for each file type vice each data set with all data included in these tapes undergoing similar checking procedures and processing File types 043 (Light Hydrocarbons) and 029 (Primary Productivity) have been completed to date; file type 015 (Current Meter data) is now being processed in a similar manner. Other physical and chemical data files are planned for completion in the following order:

Trace Metals in Water (021)
Lagrangian Measurements (056)
Trace Elements (061)

Further guidance concerning the necessity of creating archive tapes for Pressure Gauge (017) and Wind data (101) will be provided by the Program Office. STD data (022) will be treated separately as NODC has existing quality controls for these data once they are converted to an NODC 'standard' format. Similar processing of geology file types - Beach Profiles (072), Grain Size Analysis (073), and Permafrost (075) - will be discussed with NGSDC personnel in the near future. Priorities for processing all biological data files will be provided by Program Office personnel. Memos describing the 043 and 029 range checking and possible data errors have been distributed to OCSEAP data management personnel and to the appropriate

OCSEAP investigators or data processors.

Efforts to convert the check programs to run on the new NODC mini-computer are underway. Discussions to determine the most effective means to provide similar programs to Mike Crane's and Dean Dale's offices are continuing.

DATA PRODUCT DEVELOPMENT

Selected products are being prepared for discussion at the Lower Cook data synthesis meeting in Anchorage in January, 1978. Improvements and new versions of rotary plots and time series plots are included in this development. Samples of 'product types' using file type 043 (Light Hydrocarbons) and file type 040 (Marine Bird Habitat) also are being completed. Both of these file types contain significant amounts of data in Lower Cook.

A detailed explanation of one way to compute marine bird distribution and relative abundance using file type 033 data was received from US Fish and Wildlife personnel in Anchorage. It is planned to develope this scheme for providing one type of product from the Bird Sighting data files.

DATA CATALOG AND INVENTORIES

All copies of the first edition of Part I of the OCSEAP Data Catalog have been distributed. The last ten copies were requested by private industry and university libraries. Records in the data inventories and data tracking system are being reviewed and updated where necessary as these files will be used to generate the first version of Part II of the catalog and an updated version of Part I. Part II will consist of a computer listing sorted by file type and lease area for all data sets received by the EDS data centers. Identification of the investigators, their affliation and the number of stations or observations in each data set will be included. The new catalog is planned for completion by January 1978.

Meetings in October with Program Office personnel established the format and information to be included in Part II of the catalog. A recent innovation is the interface of the DIP files with the tracking system to obtain exact cruise dates for the catalog. Cruise dates in the tracking system generally come from ROSCOPs and the Data Documentation form that accompanies each data set. These dates often indicate cruise periods but not the actual sampling dates.

A file of OCSEAP earthquake epicenter data (file type 401 in the data catalog) has been completed by NGSDC and will be included in the new catalog, as well as updated microbiology information (file type 402) held at the National Institutes of Health.

Preliminary instructions for access to DIP have been distributed to Program Office personnel. The completion of a users manual for access to DIP and the data tracking system has been delayed due to other priorities including the new version of the data catalog and efforts to complete archive files of OCSEAP data.

No modifications were made to the data tracking system this quarter. Approximately 150 new records and 2100 updates and changes were entered in the system during the quarter.

TAXONOMIC CODE

The taxonomic code newsletter (No. 5) was distributed to OCSEAP management and investigators in October. Included with the newsletter was a list of the bibliographic references used by Dr. Mueller to construct the hierarchy of the file. Requests for copies of the NODC code and additional codes continue to be received at NODC with Dr. Elaine Collins answering these requests.

MEETINGS

October

Mike McCann - met with Program Office personnel in Boulder to discuss data inventory accessions and data catalog.

Mary Hollinger - attended the OCSEAP Marine Bird and Mammal meeting in Fairbanks and discussed taxonomic code developments with Dr. Mueller.

Bob Stein - met with Program Office personnel in Boulder to discuss heavy hydrocarbon format development.

November

Audet - met with new BLM-Washington representative of Alaskan OCS program.

Visit by Francesca Cava and Herb Bruce to NODC to discuss various aspects of data management and data processing.

Audet - met with Sam Patten and Wayne Fischer to discuss data products and key entry techinques.

December

Meetings between Doug Wolfe, Wayne Fischer and NODC personnel to discuss data product development and data compenduim products.

All September meetings were documented in the previous quarterly report.

ADMINISTRATIVE

Rod Combellick has moved from NGSDC to take a position as the Geology data tracker for the Juneau Project Office. Bruce Grant is the NGSDC contact for all OCSEAP activities.

PROBLEMS

The most apparent problem at NODC is the lack of adequate resources (manpower) to respond in a timely manner to all data requests while at the same time concentrate on the development of new data products for OCSEAP. The priorities established for requests often results in relatively simple requests from investigators being delayed while more important requests from the OCSEAP offices and BLM are answered.

The lack of specific information and documentation for some OCSEAP office and BLM requests has resulted in much of the time taken to answer request simply in understanding what is really needed by the requestor.

The lack of a replacement for Rod Combellick is hindering processing and other NGSDC activities concerned with OCSEAP data.

Quarterly Report

Contract Number: 03-7-022-35139
Research Unit Number: 527
Reporting Period: 10/1/77 - 12/31/77
Number of Pages: 8 (plus enclosures)

OCSEAP Data Processing Services

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1 January 1978

Background and Objectives

The OCSEA Program encompasses a wide variety of investigations dealing with monitoring and assessing environmental parameters. One requirement of this program involves the submission of data collected in this fashion to national archiving centers. Data submitted are to be quality controlled and coded in a format suitable to the archiving centers. Much of this data flow is monitored by the Juneau Project Office (JPO).

As part of the task of monitoring data flow, JPO seeks assurance of data quality through data validation and data product development. It is in this framework that data processing services are provided by this research unit.

In order to carry out these procedures, use is made of an information management system known as the MARMAP Information System (MIS).

Past Work

This work began in March 1977 and early work was primarily concerned with the evolution and implementation of quality control procedures for file type 033 ("Ship and Aircraft Census - Marine Birds") data from several principal investigators. The majority of data received to date were received during the period prior to that covered by the present quarterly report, and served to identify those areas of quality control which required attention in the adaptation of the MIS for this work or in the generation of new procedures especially for this work. Production work was also begun during that time and expanded as indicated below during the present reporting period.

Current Work

Several activities have been pursued during the quarter ending 31 December 1977, and are described below.

1. Preparation of Field Operation Status Report (FOSREPT)

   The relatively large number of field operations associated with this work, and the inherent time-line events associated with its processing have created the need for a readily available and easily updated status report. A file of data needed for the report has been created, and is updated using available MIS programs. The file is accessed by the program FOSREPT to produce the desired product. A current issue is included with this quarterly report.

2. Modification of LOGLIST

When work was begun of file type 033 data, the program LOGLIST, which generates a formatted listing of a data file complete with error citations, listed that data in a text-like fashion. It became desirable, during the evolution of appropriate quality control procedures for this work, to have data displayed in a columnar fashion, with field acronyms listed at the head of each column. This change was made, but resulted in a somewhat awkward limitation of total data field size to one 132-column page width. During this quarter, this limitation has been greatly minimized by the further modification of this program such that the total data field width of a given record can now be five 132-column pages wide (giving approximately 550 data characters), and can be expanded further if the need arises. As before, the program is table-driven from a master table.

3. Summary of File Type 033 Data Validation Procedures

Throughout this work the need has arisen for a summary report which describes the procedures found necessary in order to validate file type 033 data collected in the OCSEA Program. These procedures have been referenced elsewhere in letters, reports, etc., but have not been available in a readily accessible form. This report, enclosed, is aimed at providing that availability. While it states those procedures now in effect, it should not be viewed as the final version of the procedures, as changes and/or additions are made quite frequently (see, for example, item 7 below).

4. Code Validation Activities

File Type 033 contains data fields (fields in which the entries are actual data numbers, such as latitude or longitude) and code fields (fields in which the entries are letters and/or numbers which represent an observation, such as use of a number to represent cumulonimbus clouds, for example). Early Fish and Wildlife Service (FWS) codes for use with file type 033 differed dramatically from those approved by the National Oceanic Data Center (NODC), the archival center for data of this type. One of the data validation procedures described in the report referenced in (3) above consists of conversion of FWS codes to NODC codes. In several instances, no NODC counterparts were available for FWS codes, and in other instances, a particular FWS code did have a counterpart by definition, but it was a different letter or number code in NODC. The third case also exists, in which the codes used by FWS were the same character and definition used by NODC. The latter case poses no problems. The second case requires a number or character conversion during the overall conversion process. The first case, however, presents a significant problem. Resolution of this problem has been made by consultation between Mssrs. Jim Audet and Bob Stein of NODC, the appropriate PI, and this office. This has resulted in the enhancement of NODC-approved codes for several code groups, and should not present a significant problem upon receipt of data from new field operations. Distribution of enhanced code groups is to be made by NODC.

5. Quality Control Products - Mailed (see FOSREPT)

During this quarter, 2 tapes were received containing data from a total of 9 field operations. The first tape contained data from 5 field operations, and was coded in FWS format. The second contained data from 4 field operations, and was coded in a slightly modified NODC format (non NODC-specified bird name abbreviations were coded in columns 84-87 of card type 5). The two quality control products CODEPULL and LOGLIST were generated from these and several other field operations received earlier, giving a total of 53 of each product mailed to appropriate principal investigators (PI's) during the period. This brings the total to 99 of each of these products mailed to PI's, representing all the data received to date.

6. Quality Control Products - Received (see FOSREPT)

Several CODEPULL and LOGLIST products were mailed during both this period and during the development period. Of this total, 60 CODEPULL and 67 LOGLIST products were received during this quarter, bringing the total of each type received to 79. Of those received to date, 2 are in NODC format, and 77 are in FWS format.

7. Field Operation Data-Editing (see FOSREPT)

To date, the interactive programs EDITLOG and FLDFILL have been used to edit data from 12 field operations. After this editing was completed CODEPULL and LOGLIST were rerun to verify the corrections and to determine if other corrections were necessary. If no further corrections were required, the data were certified as having passed the "final check". Of the 12 data sets edited, 5 required no further work, and 7 were either discussed with and returned to the appropriate PI for resolution.

8. Field Operation Data - Quality Control Completed (see FOSREPT)

Of the 5 field operation data sets which passed the final check, 2 were already in NODC format, and were sent to NODC, completing the series of data validation steps presently in effect for this work. Subsequent conversation with Mssrs. Jim Audet and Bob Stein of NODC has led to the conclusion that some additional changes need to be made in other data sets to be mailed to that site. These are in addition to the steps described in Figure 5 of the "OCSEAP Data Validation Procedures" above, and include the following:

a) Leading zeros will be inserted in the station, latitude, longitude, date, time, sequence number, and ship's heading fields.

b) Fields with embedded "+" or "-" signs will be adjusted such that the sign is in the column immediately preceeding left-most significant figure in the field.

c) Any data beyond column 83 of the NODC format will be removed.

d) Blanks will replace leading zeros in the bottom depth, number of individuals, ship's speed, and height of observer's eyes above sea level fields.

The other 3 data sets which passed the final check are now ready for conversion from FWS to NODC format. Work is proceeding on this final step at the present time. It involves setting up routines described in "OCSEAP Data Validation Procedures", as ammended above.

9. A Problem Tape

Data is typically received by this RU in the form of magnetic tapes. Some are accompanied by Data Definition Forms (DDF's) which help in establishing the parameters necessary for reading the tape. When no DDF or other notation is available, a trial and error technique is often necessary for the establishment of appropriate parameters. The variety of recording schemes encountered to date is shown in Table 1.

One tape in particular has presented the most difficulty. According to the DDF, the tape named CANADA1 contains data from eight field operations. Only one could be found. Several schemes have been attempted in an effort to find other data on the tape, but have proved unsuccessful. The tape has been returned to the JPO for resolution.

Table 1 Tape Characterizations

Tape Name	7 or 9 Track	Density (BPI)	Parity	Code	Number of Field Ops.	Number of Files	Data Format	Record Format	Block Size	Logical Record Length	DDF Received
ALASKA1-9	9	800	odd	EBCDIC	*	2*	FWS	u	4000	80	yes (1,2,7) no (3-6,8,9)
ALASKA10	9	800	odd	EBCDIC	2	2	NODC	u	83	83	yes
ALASKA11	9	800	odd	EBCDIC	4	1	NODC	u	128	87**	yes
OREGON1	7	800	even	BCD	12	12	NODC	u	80	80	no
CANADA1	9	1600	odd	EBCDIC	1***	1***	FWS	u	80	80	yes

* The number of Field Operations varies with the particular tape. All operations are coded in the second file on each tape. The first file is empty on each tape.

** Records are blank filled.

*** DDF indicates 8 Field Operations on tape.

Notation is made of this event, not to draw attention to any one source of data, but rather to point out one of a variety of activities which are not self-evident in other reports or procedures describing this work. Many events such as this one occur, and are philosophically lumped under the general topic of "unforseen delays".

10. Format Changes

There have evolved some relatively minor changes in the NODC-approved format for File Type 033 data during this last quarter. The format was previously coded as five different eighty column card types. The following changes have been made by NODC, and will form a part of the validation steps carried by this RU.

Card Type 1:

Columns 81-83 Transect Width (tens of meters)

Card Type 5:

Column 81 Substrate Type--An existing NODC code group now added to this file type.

Code	Definition
Blank	No information
0	Indeterminable
1	Mud
2	Sand
3	Shell
4	Small rocks
5	Medium rocks
6	Large rocks
7	Bed rock
8	Wood
9	Tide pool
A	Dirt
B	Scree
C	Vegitation
D	Clay
E	Peat

Code	Definition
F	Gravel
G	Boulders
H	Combinations (see text)
J	Talus
K	Volcanic ash

Column 82 Cover--An existing NODC code group now added to this file type.

Code	Definition
Blank	No information
0	Indeterminable
1	Elymus
2	Hordeum
3	Festuca
4	Epilobium
5	Achillea
6	Salix
7	Sambucus
8	Alnus
9	Ribes
A	Mosses
B	Mixed forb
C	Mixed grass
D	Detritus (organic)
E	Drift log
F	Debris (man-made)
G	Carex
H	Poa
J	Other (see text)
K	Iris Sestosa

Column 83 Outside zone

Code	Definition
0	Bird within counting zone (transect width)
1	Ship follower
2	Bird seen outside of counting zone during a transect or survey
3	Bird seen within ½-hour before or after a transect or survey
4	Bird on or over land seen during a transect or survey
5	Bird on or over land seen before or after a transect or survey
6	Bird found on ship before or after a transect or survey

OCSEAP DATA VALIDATION PROCEDURES
For File Type 033

In order to provide data validation for the File Type 033 data from the OCSEAP Project, four areas need consideration. These include card type validation, data range and relational parameter checking, and format, code, or unit conversion. Since this is a multi-card type file, the card type designation must first be verified (an incorrect value would lead to the improper interpretation of remaining fields on that card), along with the occurrence and sequencing of card types. 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. 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 on interrelated 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 NODC format, the necessary format changes must be carried out.

Card type designation and sequencing, and valid code field contents are checked in a program called CODEPULL. First the card type is verified. This must be between one and five, and certain other fields are also checked for further verification (ex. - a type five card must have a taxonomic code and a sequence number). Extra cards and missing cards are detected with the sequencing routine. This checks that the cards are in order, that each station has a unique one card followed by a unique two card, and that there are no duplicated or skipped sequence numbers. Then the appropriate code tables are called, and each code of each code field is compared with the appropriate table containing all valid codes for that field.

The output from CODEPULL is a listing of the file in order by station number. Any errors detected are flagged with a brief descriptive message, including a record count for ease in correcting, and, in the case of a bad code, a string of asterisks under the field. Following the file listing is a summary of all the codes used for each code field and their definitions. For a bad code, the record in which it appeared replaces the definition. Figure 1 is a list of the code groups checked and Figure 2 is a portion of a CODEPULL listing.

Data range and relational checking are done in a program called LOGLIST. This verifies the data coded as raw numbers, rather than as codes. The contents of the data fields are first checked for numerics, signs, and leading zeros and then compared to upper and lower limits appropriate to each field. In some cases the value of one field is dependent on the value of another field and these relational checks are also made.

Figure 1
File Type 033 Code Groups Validated

	Field	FWS Columns	NODC Columns
Card Type 1			
	Platform Type	67-68	69
	Ship Activity	70	71
	Sampling Technique	69	70
	Collection Code	-	72
	Zone Scheme	-	73
	Angle of View	-	74
	Observation Conditions	-	75
	Speed Type	60	-
	O.B.S. Region	28-30	-
	Observer Location	74	-
Card Type 2			
	Wind Direction	-	45-46
	Swell Direction	-	50-51
	Sea State	-	49
	Weather	16-17	55-56
	Cloud Type	-	57
	Cloud Amount	-	58
	Water Color	-	59
	Visibility	18	61
	Sun Direction	-	62
	Glare Intensity	61	63
	Glare Area	62	64
	Moon Phase	-	68
	Tide Height	-	69
	Debris	-	80
	Observation Conditions	19	-
	Turbidity	-	63
Card Type 3			
	Ice Cover	16,23,35	16,22
	Ice Pattern/Description	17, 24	32
	Ice Type	18, 25	17, 23
	Ice Form	19,26,34	18, 24
	Ice Relief	20, 27	19, 25
	Ice Thickness	21, 28	20, 26
	Ice Melting Stage	22, 29	21, 27
	Open Water Type	30	28
	Ice Direction	31, 36	29, 33
	Distance	32,37,40	30, 34
	Lead/Polyna Width	33, 39	31
	Ship in Lead/Polyna Location	38	-
	Collection Code	41,42,43	35,36,37
	Mammal Trace	44, 45	38, 39
	Pond Size	-	49
Card Type 5			
	Age Class	50	32
	Sex	51	33
	Color Phase	52	34
	Plumage	53	35
	Molt	54	36

Figure 1 (cont.)

Field	FWS Columns	NODC Columns
Counting Method	-	42
Reliability	-	43
Distance Measurement Type	-	44
Association Type	55-56	50
Behavior	46-47	56-57
Special Marks	62	58
Bird Condition	63	59
Food Source Association	-	60
Debris	74	71
Oil	-	72
Habitat	-	76,77
Substrate Type	-	81
Cover Code	-	82
Outside Zone	-	83
Text Flag	77	-

Figure 2

Sample CODEPULL Listing

CODEPULL consists of two major sections.

Figure 2A is a page from the first section showing how the file is listed. It is sorted by Station, Card Type and Sequence Number and has dotted lines dividing the Stations. The errors flagged are "Bad Card Type" because the Card Type 4 has no sequence number; "Bad Sequence Number" because the sequence number field is not numeric; and "Bad Code" because the code entered is invalid.

Figure 2B is a portion of the second section. This first gives a summary of the number of each type of record found in the file, then a list of the codes used and appropriate definitions. For an invalid code the definition is replaced by the record number in which it appeared. This can be seen for the Weather Code on Card Type 2.

Figure 2A

```
                                   ***** CODEPULL *****

                                     FOR CRUISE FW7032


               THE MARMAP INFORMATION SYSTEM        OCSEAP - GULF OF ALASKA PROJECT


     *** CODEPULL - CRUISE FW7032

--------------------------------------------------------------------------------------------------------------
                              033FW70321 1073595250N1492600W7705232105               10+09 1119  6     4      30
                              033FW70322 1073 260                           2      03
RECORD #    3
TYPE 4 #    1  BAD CARD TYPE -->
                              033FW70324 1073 WAY UP BACK SIDE. SEE FIELD NOTES.

RECORD #    4
TYPE 4 #    2  BAD SEQUENCE# -->
                              033FW70324 1073 KIWH ALL 3 VERY GREY BACKS ONE FEMALE WITH NOTCH IN DORSAL HALF
                              033FW70325 1073  91290106               1                                 001  0
                              033FW70325 1073  9128020301             1                                 002  0
                              033FW70325 1073  9129010502             2                                 003  2
                              033FW70325 1073  9218021601      1      1          001                    004  0
                              033FW70325 1073  9218021601      2      4          001                    005  0
--------------------------------------------------------------------------------------------------------------
                              033FW70321 1173595130N1492615W7705232115               10+09 1120  6     4      30
RECORD #   11
TYPE 2 #    2  BAD CODE -->   033FW70322 1173 256    + 81               2      03
                                                                                   **
                              033FW70325 1173  9129011302             2     10     20                   001  0
                              033FW70325 1173  9128020301             1            20                   002  0
                              033FW70325 1173  9129010301             4     10     20                   003  0
                              033FW70325 1173  91290106               2     10     20                   004  0
--------------------------------------------------------------------------------------------------------------
                              033FW70321 1273595000N1492730W7705232125               10+09 1118  6     4      30
                              033FW70322 1273 256    + 84               2      03
                              033FW70325 1273  9128020103             1     09     20                   001  0
                              033FW70325 1273  9129010301             8     09     20                   002  0
                              033FW70325 1273  9127070301             3            20                   003  0
                              033FW70325 1273  9109030201             2            61                   004  0
                              033FW70325 1273  91290106               2            20                   005  0
--------------------------------------------------------------------------------------------------------------
                              033FW70321 1373594800N1492715W7705232135               10+09 1118  6     3      30
RECORD #   24
TYPE 2 #    4  BAD CODE -->   033FW70322 1373 265                       3      03
                                                                                   **
                              033FW70325 1373  9128020103             4     09     20                   001  0
                              033FW70325 1373  9129011401             2     09     20                   002  0
                              033FW70325 1373  9129011302             2            03                   003  0
                              033FW70325 1373  91290103               3     10     20                   004  0
                              033FW70325 1373  9129010601             2            03                   005  0
--------------------------------------------------------------------------------------------------------------
                              033FW70321 1473594600N1492715W7705232145               10+09 1118  6     3      30
                              033FW70322 1473 220                       3      03
                              033FW70325 1473  9129011401             1            20                   001  0
                              033FW70325 1473  9128020301             1            20                   002  0
                              033FW70325 1473  912901                 5            20                   003  0
                              033FW70325 1473  9128020103             1            20                   004  0
                              033FW70325 1473  91290103               2            20                   005  0
--------------------------------------------------------------------------------------------------------------
                              033FW70321 1573594430N1492715W7705232155               10+09 1118  6     3      30
                              033FW70322 1573  91    + 78               3      03
                              033FW70325 1573  9129011401             5     09     20                   001  0
                              033FW70325 1573  9129011401             9            01                   002  0
                              033FW70325 1573  9218022001             1                                 003  2
                              033FW70325 1573  9128020103             1            20                   004  0
                              033FW70325 1573  9129011302             2     09     20                   005  0
```

Figure 2B

***** SUMMARY *****

FOR CRUISE FW7032

2219 TOTAL RECORDS

277 TYPE 1 RECORDS
277 TYPE 2 RECORDS
0 TYPE 3 RECORDS
6 TYPE 4 RECORDS
1659 TYPE 5 RECORDS

0 RECORDS WITH AN INVALID TYPE

RECORD TYPE 1

CODE FIELD: PLATFORM TYPE - NODC(1:69)

CODES	COMMENT
BLANK	-

CODE FIELD: SAMPLING TECHNIQUE - NODC(1:70) - FWS(1:69)

CODES	COMMENT
BLANK	-

CODE FIELD: SHIP ACTIVITY - NODC(1:71)

CODES	COMMENT
BLANK	-

CODE FIELD: COLLECTION CODE (PHOTOS TAKEN) - NODC(1:72)

CODES	COMMENT
BLANK	-

CODE FIELD: ZONE SCHEME (TRANSECT WIDTH) - NODC(1:73)

CODES	COMMENT
BLANK	-

CODE FIELD: ANGLE OF VIEW - NODC(1:74)

CODES	COMMENT
BLANK	-

CODE FIELD: OBSERVATION CONDITIONS - NODC(1:75)

CODES	COMMENT
4	AVERAGE
3	POOR
2	MARGINAL
7	EXCELLENT
6	GOOD
5	FINE
BLANK	-

Figure 2B (cont.)

RECORD TYPE 2

CODE FIELD: WIND & SWELL DIRECTION - NODC(2:45-46)(2:50-51)

CODES	COMMENT
BLANK	-
31	305-314 DEG.
14	135-144 DEG.

CODE FIELD: SEA STATE - NODC(2:49)

CODES	COMMENT
2	SMOOTH-WAVELET
3	SLIGHT
4	MODERATE
1	CALM-RIPPLED
0	CALM-GLASSY
BLANK	-

CODE FIELD: WIND & SWELL DIRECTION - NODC(2:45-46)(2:50-51)

CODES	COMMENT
BLANK	-

CODE FIELD: WEATHER - NODC(2:55-56) - FWS(2:16-17)

CODES	COMMENT
03	CLOUDS GENERALLY FORMING OR DEVELOPING
0	*** 000011 000024 000045 000051 000690 000721
68	RAIN OR DRIZZLE AND SNOW, SLIGHT
00	CLOUD DEVELOPMENT NOT OBSERVED OR NOT OBSERVABLE
71	CONTINUOUS FALL OF SNOW FLAKES, SLIGHT
61	RAIN, NOT FREEZING, CONTINUOUS, SLIGHT
41	FOG OR ICE FOG IN PATCHES
43	FOG OR ICE FOG, SKY INVISIBLE, THINNING DURING LAST HOUR

CODE FIELD: CLOUD TYPE - NODC(2:57)

CODES	COMMENT
BLANK	-
3	ALTOCUMULUS

CODE FIELD: CLOUD AMOUNT - NODC(2:58)

CODES	COMMENT
BLANK	-

CODE FIELD: WATER COLOR - NODC(2:59)

CODES	COMMENT
BLANK	-

CODE FIELD: VISIBILITY - NODC(2:61) - FWS(2:18)

CODES	COMMENT
BLANK	-

CODE FIELD: COMPASS DIRECTION (SUN) - NODC(2:62)

CODES	COMMENT
BLANK	-

CODE FIELD: GLARE INTENSITY - NODC(2:63) - FWS(2:61)

CODES	COMMENT
BLANK	-

CODE FIELD: GLARE AREA - NODC(2:64) - FWS(2:62)

CODES	COMMENT
BLANK	-

LOGLIST prints a columnular listing for each card type. The columns are identified by a three character field code defined prior to the data listing. The record number is listed on the left and any errors detected are flagged in the diagnostics section on the right. A totally blank field is indicated by a row of dots and imbedded blanks by an asterisk. Figure 3 is a list of the limit and relational checks made and Figure 4 is a portion of a LOGLIST listing.

These outputs are sent to the Principal Investigator for correcting. He checks the diagnostic messages and the data and marks any necessary corrections directly on the listing. These are returned to us and the updates made to the file with an interactive program called EDITLOG. Then CODEPULL and LOGLIST are rerun for final verification.

Finally the data is converted to NODC format (if it was coded in another format) and submitted to NODC. Format conversion is done with a program called CONVPROG. Many different operations are carried out at this point. For example, data fields are moved from one place to another on a given card, or onto a different card; units are converted and rounded or truncated, or converted to codes; and codes are converted to those equivalent codes acceptable to NODC. Figure 5 is a list of the special conversion routines carried out.

All of these programs form part of the MARMAP Information System. Their operation is directed by a Master System Table (MST). The MST has an entry for each field of each card type in a file. This contains all the information needed for processing, including field code, data type, position, upper limit, lower limit, relational checking and conversion routines. The programs therefore are data independent and readily adaptable to any file type.

Figure 3
Limits and Relational Checks

Note: Entries apply to both FWS and NODC unless otherwise noted.

Card Type 1

Longitude should be between 120 and 180 degrees.
Hemisphere should be "w" and Time Zone "+".
Date: Day between 1 and 31, month between 1 and 12.
Time: Hour between 0 and 23, minutes between 1 and 59.
Elapsed Time should be between 0 and 30 minutes.
FWS Heading between 0 and 359 degrees. (NODC between 00 and 35).
FWS Speed between 0 and 15 knots when platform type is ship.
FWS Speed greater than 5 knots when transect type is 71.

Card Type 2

FWS Wind Direction between 0 and 360 degrees. (NODC uses a code).
Wind Speed between 0 and 50 knots.
Swell Height between 0 and 25 feet.
Sea Surface Temperature between -2°C and +10°C.
Wet and Dry Bulb Temperature between -10°C and +70°C.
Wet Bulb Temperature should be less than or equal to Dry Bulb Temperature.
Temperatures are also checked for signs, numerics, and leading zeros.
Barometric Trend should not be coded when Barometric Pressure is blank.
Salinity between 20°/oo and 34°/oo.
Thermocline Depth between 0 and 100 meters.

Card Type 3

Excess Sediment, Ice Algae, or Other Features fields should be blank. (FWS only)

Card Type 5

Taxonomic Code between 88 and 92.
FWS Direction of Flight between 1 and 12 o'clock (NODC between 0 and 35 degrees).
FWS Begin Zone should be less than End Zone.
FWS Begin Zone and End Zone between 0 and 30 when Transect Type is 71 or 78 (unless BZN coded 97-99).
FWS Begin Zone and End Zone between 0 and 60 when Transect Type is 70 or 77 (unless BZN coded 97-99).

Figure 4

Sample LOGLIST Listing

LOGLIST lists the data for each card type individually. Fields in each record are then keyed by acronym codes.

Figure 4A shows the header page and the list of acronym definitions.

Figure 4B is a page from the data listing of Card Type 1. Blank data fields are depicted by a series of dots as in the LTD and LNG fields while leading or imbedded blanks appear as asterisks as in the SPD and HGT fields. The diagnostics are flagged with the messages at the right. Here the HED field is out of range because it should be between 0 and 35 degrees.

Figure 4A

***** LOGLIST *****

FOR CRUISE FW7032

CALL FILE ********

CARD TYPE 1

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

Figure 4A (cont.)

*** LOGLIST - CRUISE FW7032 - CALL FILE ******** - CARD TYPE 1

ACRONYM DEFINITIONS

STA	STATION
LAT	START LATITUDE
LON	START LONGITUDE
DEG	DEGREES (SUBFIELD OF LON)
DAT	DATE - YYMMDD
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
TZS	TIME ZONE SIGN
TZN	TIME ZONE NUMBER
SPD	SPEED MADE GOOD
HED	COURSE MADE GOOD
HGT	HEIGHT OF OBS. EYES (ABOVE SEA)
PLT	PLATFORM TYPE
SMP	SAMPLING TECHNIQUE
ACT	SHIP ACTIVITY
PHO	PHOTOS TAKEN
TRW	TRANSECT WIDTH
ANG	ANGLE OF VIEW
OBC	OBSERVATION CONDITIONS
DIS	DISTANCE MADE GOOD

ACRONYM DEFINITIONS

WTP	WATCH TYPE
TRN	TRANSECT WIDTH

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 4B

*** LOGLIST - CRUISE FW7022 - CALL FILE ******** - CARD TYPE 1

	STA	LAT	LON	DAT	TIM	LTD	LNG	ELT	TZS	TZN	SPD	HEO	HGT	PLT	SMP	ACT	PHO	TRW	ANG	OBC	DIS	WTP	TRN	DIAGNOSTICS
52	*7279	565358N	1523630W	770528	1950	....	....	10	+	09	**9	36	**8	.	.	.	.	.	.	6	....	.	*30	* HED FIELD OUTSIDE *
53	*7379	565408N	1523518W	770528	2000	....	....	10	+	09	**9	36	**8	.	.	.	.	.	.	6	....	.	*30	* HED FIELD OUTSIDE *
54	*7478	565537N	1523458W	770528	2010	....	....	10	+	09	**9	36	**8	.	.	.	.	.	.	7	....	.	*30	* HED FIELD OUTSIDE *
55	*7578	565712N	1523446W	770528	2020	....	....	10	+	09	**9	35	**8	.	.	.	.	.	.	7	....	.	*30	
56	*7679	565850N	1523508W	770528	2030	....	....	10	+	09	**9	35	**8	.	.	.	.	.	.	7	....	.	*30	
57	*7779	570022N	1523530W	770528	2040	....	....	10	+	09	**9	35	**8	.	.	.	.	.	.	7	....	.	*30	
58	*7878	570155N	1523554W	770528	2050	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	7	....	.	*30	
59	*7978	570309N	1523712W	770529	2100	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	7	....	.	*30	
60	*8079	570418N	1523823W	770528	2110	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
61	*8178	570548N	1523948W	770528	2120	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
62	*8279	570706N	1524106W	770528	2130	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
63	*8378	570830N	1524236W	770528	2140	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	4	....	.	*30	
64	*8479	571000N	1524044W	770528	2150	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	5	....	.	*30	
65	*8578	571116N	1524524W	770528	2200	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	5	....	.	*30	
66	*8678	571242N	1524648W	770528	2210	....	....	10	+	09	**9	33	**8	.	.	.	.	.	.	5	....	.	*30	
67	*8777	571707N	1525048W	770529	0400	....	....	20	+	09	**0	..	**4	.	.	.	.	.	.	7	....	.	*60	
68	*8873	571448N	1525027W	770529	1737	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	
69	*8973	571310N	1525025W	770529	1747	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	
70	*9073	571124N	1525028W	770529	1757	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	
71	*9179	570942N	1525030W	770529	1807	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
72	*9278	570757N	1525100W	770529	1817	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
73	*9378	570612N	1525200W	770529	1827	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
74	*9479	570315N	1525250W	770529	1837	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
75	*9578	570255N	1525326W	770529	1847	....	....	10	+	09	*10	19	...	.	.	.	.	.	.	5	....	.	*30	
76	*9678	570114N	1525345W	770529	1857	....	....	10	+	09	*10	19	**4	.	.	.	.	.	.	5	....	.	*30	
77	*9779	565925N	1525345W	770529	1907	....	....	10	+	09	*10	18	**4	.	.	.	.	.	.	5	....	.	*30	

Figure 5

Conversion Routines

Card Type 1

Latitude - convert tenths of minutes to seconds and add hemisphere.
Longitude - convert tenths of minutes to seconds.
Date - add decade in year field.
Speed - tenths of knots to whole knots.
Course - truncate three digits into two digits.
Height of observers eyes - convert feet to meters.
Observation conditions - move from card type two to card type one.
Platform Type - convert FWS code to NODC code.
Ship Activity - convert FWS code to NODC code.

Card Type 2

Bottom Depth - convert fathoms to meters.
Barometric Pressure - truncate leftmost digits.
Swell Height - tenths of feet to whole meters.
Wind Direction - convert degrees to NODC code.
Temperatures - move signs to a position adjacent to digits.

Card Type 3

Collection Code - convert FWS code to NODC code.

Card Type 5

Taxonomic Code - blank fill trailing doublets.
Time - convert tenths of minutes to whole minutes.
Direction of Flight -convert clock position relative to ship to degrees and add Course Heading from card type 1 for compass direction.
Association Type - convert FWS code to NODC code.

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