Program Work Statements

Environmental Assessment of the Alaskan Continental Shelf

Volume 7 - Geology

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

U. S. DEPARTMENT OF INTERIOR
Bureau of Land Management

CONTENTS - GEOLOGY

WORK STATEMENT (Research Unit #16)

I. TITLE: Seismotectonic analysis of the seismic and volcanic hazards in the Pribilof Islands - Eastern Aleutian Islands region of the Bering Sea.

II. PRINCIPAL INVESTIGATOR:

John Davies
Lamont-Doherty Geological Observatory
Columbia University
Palisades, New York 10964

III. GEOGRAPHICAL AREA AND INCLUSIVE DATES:

Bering Sea: Pribilof Islands, Eastern Aleutian Arc

May 15, 1975 - June 30, 1975
July 1, 1975 - September 30, 1976

IV. COST SUMMARY:

FY 1975	FY 1976
$52,349	$71,793

V. PROPOSED RESEARCH:

A. We propose a detailed seismotectonic study of the Pribilof Islands - Eastern Arc region. This study includes an analysis of the present seismicity of the region to identify active fault zones and other regions of high seismic risk, an evaluation of the deformation of the Shumagin Islands, seismic gap zone, and the seismic activity of Makushin, Akutan, and Pavlof volcanos. The primary emphasis is therefore on task D-5.

There is presently only a limited quantity of data available from a small seismic network which has been operated in the Shumagin Islands region. Other than this data there is no other data available with which to perform detailed seismicity studies in the proposed study area. It will be possible to make preliminary identifications of active zones by September 30, 1976. The amount of deformation within the Shumagin gap zone and its significance in terms of the possiblity of a major earthquake may be difficult to access within this short time span; however, the effort should be begun. The present activity of Akutan, Makushin, and Pavlof volcanos will be known. These studies, with the exception of the geodetic measurements, are similar and complementary to seismic and volcanic hazards work proposed by the University of Alaska and the USGS in the Gulf of Alaska. They will be coordinated with these other studies. The marine geophysical work of the USGS may identify structures offshore which can be correlated with active faults or zones seen in the seismicity studies here proposed.

B. We propose to reorganize and augment the present seismic network which we presently operate in this region under ERDA support. We will add a short period seismograph in the Pribilof Islands. We will relocate two stations in the Dutch Harbor vicinity so that Makushin and Akutan volcanos can be monitored. We will purchase and install telemetry equipment which will allow all of the stations in the Cold Bay - Shumagin Islands area to be recorded on a single Develoccuder. The data from all of these seismic stations will be used to more precisely locate earthquake hypocenters than is possible with the World Wide Standard Seismographic Network. The data from stations located on or near volcanos will be used to determine the present level of activity of these volcanos.

We will increase the frequency and the redundancy of our geodetic leveling measurements in the Shumagin Islands region. These leveling data will allow us to begin to access the tectonic strains accumulation in the Shumagin seismic gap. This information is important because it will aid our interpretation and evaluation of the potential for a major earthquake in the gap.

VI. INFORMATION PRODUCTS:

We will produce earthquake catalogs, seismicity maps and hypocenter cross sections. These will be analyzed to identify active faults or other high seismic risk areas. We will produce seismic frequency plots for Makushin Akutan, and Pavlof volcanos. We will analyze the geodetic leveling data in terms of tectonic strain accumulation in this Shumagin seismic gap.

VII. DATA OR SAMPLE EXCHANGE INTERFACES:

The primary data required of other investigators by this study will be arrival time information in the form of phase cards from the Senedi-Kodiak network of the University of Alaska. This data exchange has been discussed and will best proceed on an informal basis. We will require the services of NGSDC to provide WWSSN film chips, perhaps Russian stations for occasional events which are large enough to allow world wide first motion study. We may also require plots of historic seismicity maps for the study region as an aid to interpretations of the detailed seismicity maps which we will produce. We may also require their plotting services for data produced by this study.

It is suggested that data inventories be provided to general data banks, rather than individual events data since it would be wasteful to include this specialized data in a general data bank.

VIII. SAMPLE ARCHIVAL REQUIREMENTS:

Lamont-Doherty will archive the original seismograms and films accrrued in their seismic archive.

IX. SCHEDULE:

Seismic data will be continuously recorded. Films and seismograms will be mailed weekly from field sites to Lamont where they will be routinely read. Analysis of the data will depend upon acquisition rate, but probably will be carried out toward the end of the funding period, i.e. Fall of 1976.

X. EQUIPMENT:

See budget and logistic list.

XI. LOGISTICS REQUIREMENT:

Helicopter time (about 2 hours per day)

1. Port Moller - 2 days
2. Shumagin Islands - 5 days
3. Cold Bay - 6 days
4. Cape Senichef - 1 day
5. Dutch Harbor - 3 days

XII. COST:

See attached list.

WORK STATEMENT RU 59

I. TITLE: Coastal Morphology and Sedimentation, Gulf Coast of Alaska

II. PRINCIPAL INVESTIGATOR: Miles O. Hayes, Ph.D.
Jon C. Boothroyd, Ph.D.

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Dry Bay to Cape Yakataga (includes Yakutat Bay and Icy Bay)

IV. COST SUMMARY: FY75 ($37,545) FY76 ($36,984)

V. PROPOSED RESEARCH

A. Background and Objectives

1. The major emphasis of this project falls under Task D4 to evaluate present rates of change in coastal morphology, with particular emphasis on rates and patterns of man-induced changes. 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.

2. Except for past research carried out by our group (described under Methods below), the only other information available includes:

(a) General morphological maps compiled from aerial photographs (e.g., Plafker and Miller, 1958; Post).

(b) Ground observations of a reconnaissance nature, most of which were made 50 or more years ago.

3. Information required to meet the task objective:

(a) Measurement of beach profiles and resurveying zonal study localities.

(b) Collection of sediment samples.

(c) Measurement of sediment size and gradients of the streams.

(d) Bottom profiles in nearshore areas.

(e) Low-altitude oblique aerial photography; vertical aerial photographs.

(f) Ground observations of features observed on vertical and oblique photography.

(g) Short-term process measurements of wave height, period and approach direction, wind speed and direction, and longshore currents.

(h) High-altitude, high-resolution color infrared photography of the study area (stereo coverage).

4. All of these requirements can be met and reported on by 30 September 1976, provided the color infrared photography is made available to us by 1 October 1975.

5. Dr. Jan Cannon's study (Research Unit #99) is closely related to our research. It is our understanding that he is compiling three maps: 1) geological hazards, 2) coastal plan landforms, and 3) beach materials. We would provide geological ground truth data and quantitative information on beach sedimentation to supplement his maps. He will provide aerial photographs and imagery to supplement our ground interpretations.

B. Methods

1. The only data relating specifically to the coastal geomorphology and sedimentation (particularly active processes) of this area were collected by our research group during the period 1969-1971. The following information is readily available to us:

(a) Published Data: Gustavson (1974), Boothroyd (1972), Hayes and others (1973), Boothroyd and Ashley (1975), Gustavson (1975). These are data published by our group based on previous work carried out in the study area.

(b) Unpublished Data: Grain size analyses of approximately 400 sediment samples from survey beach profiles (approximately 100), surveyed maps of the beach zone (20), approximately 500 oblique aerial photographs, preliminary facies maps of glacial stream outwash plains based on 1948-1970 vertical aerial photography.

(c) Other Published Data: Miller (1971), Plafker and Miller (1958), Tarr and Martin (1914), Russell (1842; 1894).

(d) Other Unpublished Data: Austin Post photographs and vertical air photography of selected areas obtained over the past 30 years.

2. Field studies would be carried out in the summer of 1975 by a six man field crew using a fixed-wing aircraft (Cessna 180 capable of beach landings). One three-man crew would concentrate on regional sedimentation trends (beach sampling; process measurements), and a second three-man crew would be stationed relatively permanently in the Icy Bay area in order to examine in detail the geology of the

shoreline of the Bay and to concentrate on quantitative aspects of sedimentation along the shoreline of the Bay and the Malaspina Foreland. The following information would be gathered:

(a) Permanent Beach Profiles: The fifteen permanent beach profiles established in February-March, 1970[1], would be relocated and resurveyed twice, once at the beginning and once at the end of the field season. These data would be compared with the data of 1969-1971 in order to obtain quantitative measurements of volumes of sediment eroded or deposited at the fifteen permanent stations during this time interval. This information, combined with aerial photograph interpretation, would allow us to make predictions concerning future rates of shoreline erosion and deposition along much of the study area.

(b) Zonal Study: In effect, the zonal study conducted during the summer of 1975, with the following modifications:

1) We would concentrate our efforts in the Dry Bay to Cape Yakataga area.

2) As many as possible of the original zonal sites would be relocated and resurveyed in order to assess changes over the past five years. This would probably be possible for approximately nine of the eighteen original sites.

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[1] During the summer of 1970, eighteen sites thought to be representative of the region were studies in detail (i.e., block diagrams of a segment of the beach were surveyed, photographs were taken, detailed grain size measurements were made, etc.). Also, sediments were sampled at ninety stations along the beach.

3) New zonal sites (approximately nine) would be located in the Dry Bay to Cape Yakataga area in order to carefully define the regional morphological patterns of that area.

4) Sediment sampling would be repeated at the permanent beach profiles and at the resurveyed zonal sites.

5) Process measurements would be made at each zonal site (e.g., measurements of wave period, wave height, and longshore current velocity).

6) Sampling of the beach sediments in the Dry Bay to Cape Yakataga area would be carried out. Samples would be collected at 1-2 km intervals in order to construct a sediment dispersal diagram.

C. Glacial Sedimentation

1. Longitudinal transects of selected braided streams to measure clast (pebble) size and stream gradient (stations occupied at 100-500 m intervals). Bay types and bed forms will also be observed and recorded at each station.

2. Location of probable subsurface ice area is identified by low-altitude aerial observations.

3. Ground inspection of probable subsurface ice areas identified from the air.

4. Location of probable soil creep of areas of slow mass movement as identified by low-altitude aerial observations.

5. Ground inspection of probable soil creep areas identified from the air.

6. Detailed studies of inactive sandiers (glacial outwash plains) in order to identify possible past glacier-burst channels.

7. Measurement of closely space (½ km intervals) bottom profiles off the deltas in Icy Bay and Yakutat Bay out to depths of 20 m in order to determine:

(a) General configuration and slope of delta fronts;

(b) The location of slumps.

8. Detailed examination of the margin of the Malaspina ice sheet to determine if any portions of the glacier are surging.

9. No animal or plant species will be studied.

10. All samples collected in the field would be analyzed for grain size with the Hydraulic Equivalent Sediment Analyzer (HESA), a 200 cm settling tube in the Coastal Research Division Laboratory at the University of South Carolina. These data, combined with the earlier data, would be used to construct a sediment distribution map of the entire beach zone of the study area.

VI. INFORMATION PRODUCTS

The following information products would be available at the end of the project:

A. Environmental Map: The area would be photographed in detail from the air at least twice during the field season. These oblique aerial photographs, in combination with all available vertical photographs, ERTS imagery, etc., would be used to construct a detailed map of the regional coastal morphology. This work would be carried out in cooperation with Dr. P. Jan Cannon of the Department of Geology, University of Alaska. Our environmental map would show areas of erosion, accretion, and stability (with rates of change recorded where possible.

Generalized facies mapping of the sandur plains would be carried out utilizing vertical aerial photographs and 1:63,300 topographic maps where available. These maps and photos would be augmented by oblique photos taken by the present investigators in 1969, 1970, and 1971, and by additional photography obtained under the proposed new study.

The facies maps would be at two scales: 1) general maps at a scale of 1:125,000, and 2) detailed maps at a scale of 1:63,360 or larger if possible. Maps would be similar to Plafker and Miller (1958) and Miller (1971) but would specifically include more detail on variation in sandur plains and vegetation cover. These maps would also document changes which have occurred since the latest published maps. This is particularly important in the area surrounding Icy Bay.

B. Wave Energy Distribution: Summary of Synoptic Meteorological Observations (SSMO data), available from the National Climatic Center, Asheville, North Carolina, hindcast wave data from surface synoptic charts, and wave observations obtained during the study period would be used to determine the deep water wave energy flux distribution in the Gulf of Alaska. By means of these data and constructed nearshore wave refraction diagrams, the longshore component of wave energy flux would be determined along the shoreline of the Dry Bay to Cape Yakataga area.

C. Final Report: The final report will include a summary of many of the critical environmental parameters of the coastal zone of southern Alaska between Dry Bay and Cape Yakataga. These

parameters include the following:

1) Active Streams;

2) Glacial Till;

3) Buried Ice Blocks;

4) General Soil Categories;

5) Zones of Erosions;

6) Zones of Accretion;

7) Areas Threatened by Glacier Bursts;

8) Process Distribution (i.e., wave dominances vs. tidal dominances).

These properties will be summarized on the environmental map. The detailed data of the zonal studies will be illustrated with ground and aerial photographs, three-dimensional block diagrams, and other detailed illustrations. The report will include recommendation concerning critical environmental problems discovered in the study area. An attempt will be made to determine, where possible, questions of regional importance, such as dominant direction of longshore sediment transport and the processes that are dominant in shaping the coastal morphology (e.g., coastal storms, aeolian processes, etc.). A bibliography and evaluation of work already completed in the area will be included in the report.

VII.DATA OR SAMPLE EXCHANGE INTERFACES

We will interact chiefly with Jan Cannon, University of Alaska, in the manner described above.

VII. SAMPLE ARCHIVAL REQUIREMENTS

None.

IX.SCHEDULE

1. Field Work

(a) Party of 3 plus pilot: 20 May to 1 July 1975. This party will resurvey beach profiles and collect sediment samples and do zonal studies from Hinchinbrock Island to Icy Point. Ninety stations will be sampled on 5 km spacing. In addition, the 18 permanent beach profile stations will be surveyed both at the beginning and the end of the field season. Also, 18 zonal sites will be revisited and possibly resurveyed.

(b) Party of 3: 1 June to 15 August 1975. This party will conduct glacial sedimentology studies out of test camps. These studies will focus on the shoreline at Icy Bay and Yakataga Bay and the Malaspina Foreland.

(c) Party of 3: 1 July to 31 August 1975. This party will conduct beach process studies. These will concentrate between Cape Yakataga and Dry Bay.

2. Laboratory Work (Will be conducted at the University of South Carolina)

(a) Sediment Analysis: Grain size analysis of 400 sediment samples teken during field season will be conducted between 1 July and 31 August 1975.

(b) Computer Wave Analysis: Will be conducted between 31 August 1975 and 1 May 1976.

(c) Map Construction: Will be conducted between 31 August 1975 and 1 May 1976.

3. Reports

(a) Preliminary report on regional coastal geomorphology and sedimentation by 31 December 1975.

(b) Preliminary report on geological hazards by 31 November 1975.

(c) Report on regional wave energy distribution by 1 May 1976.

(d) Final summary report by 30 September 1976.

The following equipment will be used:

1) 3 Honda ATC 90's

2) 1 15 ft. Zodiac rubber boat with 50 A.P. outboard engine plus 15 H.P. emergency engine.

3) Weather station (wind, barometric pressure, temperature - continuously recording).

4) Bottom profiler (Bludworth EM-130SS).

5) Theodolite and supporting surveying equipment.

6) Price current meter.

7) Miscellaneous 35 mm cameras, 16 mm movie camera, Polaroid camera.

A. Aircraft (We will arrange.)

Aircraft requirements are limited to fixed-wing aircraft (Cessna 180). Preliminary contact has been made with Gulf Air Taxi in Yakutat to provide the following services:

1. 325 hours total @ $70/hour - $22,750.00.

2. May 20 - July 1 (42 days) - 1 airplane and pilot full-time; 3 hour/day minimum or 126 hours.

3. June 1 - August 31 - 1 airplane part-time for a minimum of 199 total hours.

4. We will pay subsistence for pilots when away from Yakutat on an actual expense basiss.

Contingency funds for flying time are included in the budget-$1,875,000.

B. Housing (We will arrange.)

The following housing arrangements have been tentatively arrived at.

1. FAA house at Cape Yakataga (1 June to 31 August) or National Weather Service House in Yakutat wh available (tentative dates (1 June to 30 June).

2. Field camp (tents in various locations (1 June to 31 August).

One field crew will occupy a house and one a field camp at any given time.

XII. COST

The following two pages (12 and 13) give the final revised figures for our contract. Information on the breakdown of funds between FY75 and FY76 are not available to us at this time. Please make these corrections.

ALASKA MARINE ENVIRONMENTAL ASSESSMENT PROGRAM
WORK STATEMENT (Research Unit 99)

I. TITLE:

The Environmental Geology and Geomorphology of the Gulf of Alaska Coastal Plain

II PRINICPAL INVESTIGATOR:

Dr. P. Jan Cannon
Assistant Professor of Geology
Department of Geology
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7809
SS#: 441-42-6636

III GEOGRAPHIC AREA AND INCLUSIVE DATES

Gulf of Alaska April 1, 1975 - Sept 30, 1976

IV COST SUMMARY

FY 1975 through June 30, 1975	FY 1976 July 1, 1975-Sept 30, 1976
$4,433	$25,634

V PROPOSED RESEARCH:

A. Background and Objectives

The following are the objectives of this research:

1. To produce three maps, with explanations, which will display certain baseline data necessary for an environmental assessment of the coastal plain section of the Gulf of Alaska. The maps will be produced at a scale of 1:63,360. (See Map 1, Map 2, and Map 3 below).

Map 1. Environmental Geologic Hazards and Shoreline Stability

This map will indicate the extent of possible environmental geologic hazards such as storm flooding, seismic sea waves, landslides, ice falls, and outburst flooding. This map will also indicate the relative stability of the shoreline as determined by quantitative data from other projects and landform analysis.

Map 2. Major Coastal Plain Landforms

This map will locate, identify, and describe the various coastal landforms. The explanation will indicate the origin of the particular landform types, the possible lifetime or

stability of each particular landform type, and the economic importance of each landform type.

Map 3. Major Beach Materials

This map will indicate the distribution of beach materials that will be important in an environmental assessment of the coastal zone.

2. To produce a report on the application of side-looking airborne radar (SLAR) imagery to the environmental geologic mapping of coastal zones. This report will also contain a comparison of SLAR imagery with aerial photography and satellite imagery. (See Report below).

Report. Application of Radar Imagery (SLAR) to the Environmental Geologic Mapping of Coastal Zones

This report will demonstrate the capabilities of radar imagery in environmental geologic and geomorphic mapping of coastal zones, and will evaluate other available remote sensing data for their potential to coastal zone mapping.

3. To construct an annotated mosaic of the area from SLAR imagery. The scale of this annotated mosaic is yet to be determined. (See Mosaic below).

Mosaic. Annotated SLAR Mosaic of Coastal Zone

This annotated mosaic constructed from the radar imagery (SLAR) will be used to present an explanation of the unique view provided by the radar imagery.

B. Methods

The following lists sequentially the methods planned to produce each of these products:

Map 1, Environmental Geologic Hazards and Shoreline Stability

1. Evaluate existing literature and correspond with on going projects in the area.

2. Search for and interpret any existing raw data on erosion and deposition.

3. Comparison of sequential mapping of coastal areas.

4. Identification of major shoreline processes.

5. Evaluation of historical records.

6. Identification of the materials which comprise the shoreline features.

7. Interpretation of the origin or source(s) of the beach materials.

8. Comparison of sequential ERTS imagery.

9. Field observations and measurements of shoreline changes from previous and current studies.

10. Interpretation of the shoreline morphostratigraphy.

Map 2. Major Coastal Plain Landforms

This map will locate, identify, and describe the various coastal landforms. The explanation will indicate the origin of the particular landform types, the possible lifetime or stability of each particular landform type, and the economic importance of each landform type. The explanation will also relate the general wildlife habitat to each particular type of major landform. The information to be displayed on this map will be gathered by the following methods:

1. Use of existing maps.

2. Use of existing aerial photographs.

3. Interpretation of acquired high-altitude aerial photographs (approximately 62,500 feet AGL).

4. Interpretation of acquired side-looking airborne radar imagery (SLAR).

5. Ground reconnaissance of difficult areas.

Map 3. Major Beach Materials

This map will indicate the distribution of beach materials of a certain nature that will be important in an environmental assessment of the Gulf of Alaska coastal zone. This map will indicate the general nature of the beach materials which is related to the information presented in the other two maps. The nature of the beach materials has an extremely important economic value. The information of this map will be obtained by the following methods.

1. Communication with other projects being performed in the area.

2. Photogeologic interpreations.

3. Interpreation of side-looking airborne radar imagery (SLAR).

4. Ground sampling.

VI INFORMATION PRODUCTS

A. Three maps necessary for an environmental assessment of the coastal plain of the Gulf of Alaska.

B. A report on the application of SLAR to environmental geologic mapping of the coastal plain.

C. An annotated mosaic of the coastal plain from SLAR imagery.

VII DATA OR SAMPLE EXCHANGE INTERFACES

1. Side-looking airborne radar imagery (SLAR) of coast, low altitude K-band required as soon as possible (5-1-75 to 9-1-75). Side-looking airborne radar imagery (SLAR) will have to be provided by NASA or some other support aircraft (USGS Mohawk - what their LOU put down). SLAR is more important to project than high-altitude photography.

2. High altitude aerial photographs, from U-2 or RB-57 aircraft, taken at 62,500 feet AGL, Color and Color IR from RC-8 or other comparable 6-inch focal length camera (5-1-75 to 9-1-75).

   High altitude photographs would have to be provided by NASA, the U-2 or RB-57.

VIII SAMPLE ARCHIVAL REQUIREMENTS

No archival required

IX SCHEDULE

1. Reconnaissance and data collection 6-1-75 to 9-1-75.

2. Review and assimilate collected data and prepare first draft of maps 9-1-75 to 6-30-76.

3. Field checking of problem areas and map units 6-1-75 to 9-1-76.

4. Complete final draft of maps 7-1-76 to 9-30-76.

5. Maps and report completed 9-30-76.

X EQUIPMENT REQUIREMENTS

None

XI LOGISTIC REQUIREMENTS

None

105
WSD

WORK STATEMENT (Research Unit #105)

I. TITLE: Delineation of Subsea Permafrost and its Engineering Characteristics in the Beaufort Sea

II. PRINCIPAL INVESTIGATORS

R. Berg
S. Blouin
E. Chamberlain
A. Kovacs
P. Sellmann

III. GEOGRAPHIC AREA AND INCLUSIVE DATES

Beaufort Sea - FY 1975: through June 30, 1975
FY 1976: July 1, 1975 - Sept. 30, 1976

IV. COST SUMMARY

	FY 1975 through June 30, 1975	FY 1976 July 1, 1975 - Sept. 30, 1976
Salaries	$ 3730	$ 55445
Technical Support	1710	25745
Equipment and Services	1000	35770
Travel	600	9800
Drilling Contract	140000	
Overhead	2960	53240
	$150,000	$180,000

V. PROPOSED RESEARCH

A. Background and objectives

Permafrost has been found to exist beneath the sea floor along the coast of the Beaufort Sea. Safe design of offshore oil exploration and recovery facilities require that the occurrence, thickness, and engineering characteristics of subsea permafrost be determined (Geological Hazards, Tasks D-8, D-9, and D-10).

PRELIMINARY

An offshore permafrost map will evolve from the use of several complementary exploration techniques, such as sampling and drilling, seismic and electromagnetic surveys, and thermal modeling. The unique engineering characteristics of subsea permafrost must be defined from measurements in-situ, on undisturbed cores and on reconstituted laboratory samples.

Programs addressing specific aspects are being proposed by the USGS (Menlo Park), the Geophysical Institute, University of Alaska, and CRREL.

The objectives of work proposed herein are two-fold:

1) to work towards the development of a map portraying the occurrence and depth of subsea permafrost in the Beaufort Sea and evaluating the hazards imposed by these unique conditions;

2) to work towards the quantification of the engineering characteristics of subsea sediments in the Beaufort Sea, and their relation to temperature, sediment type, ice content and salinity, and as appropriate, the hydrocarbon contents.

These objectives will be pursued through the following program:

1. Sampling and Drilling

Drilling and sampling are the only means that can lead to unambiguous data on temperature, sediment type, the degree of ice bonding, ice content and salinity. Drilling and sampling are required to determine in detail the physical properties, phase composition, and the temperature of the material. Geophysical methods can only provide relative data, which require correlation to ground truth from boreholes. Also when changes, e.g. in observed seismic velocity, are correlated to borehole observation, the reliance that can be placed in geophysical data is enhanced.

The drilling program we propose is a cooperative effort by the USGS (Menlo Park) and USACRREL. The two main objectives are to assess the distribution of permafrost and its relationship to the Quaternary geologic history of the Beaufort Sea Shelf. The data to be obtained consists of temperature measurements and actual samples of the material which constitute the stratigraphic section. A portion of the sampling requirements can be satisfied with samples acquired in a disturbed state, but for certain tests, undisturbed sampling must be aimed for. It is proposed to rent a Becker drill capable of both rotary and drive sampling, and drilling is planned initially for near Prudhoe Bay. Also a resonant coring system may be tested to obtain shallow (<50 ft) samples.

* BLM-NOAA, Environmental Assessment of the Gulf of Alaska, Southeastern Bering and Beaufort Sea, inclosure to letter to prospective principal investigators, from John H. Robinson, April 11, 1975.

2. Determination of Material Properties

The first facilities to be built off the northern coast of Alaska are likely to be associated with the discovery, production, and transportation of petroleum. The structures most likely to be influenced by the presence of subsea permafrost are pipelines, wellbores, pile-founded platforms, and gravity structures. The safe design of such structures requires information about critical engineering properties. We proposed to obtain these engineering characteristics. Also some down-borehole in-situ measurements are proposed.

2a. Index Properties

The samples and cores obtained from drilling must be analyzed and catalogued to make full use of the large investment in the drilling program. Laboratory analysis of the field data of the cooperative drilling program will be performed at the following three locations:

1) at the drill site

2) at the USGS in Menlo Park, CA, and University of Alaska (chemical)

3) at CRREL in Hanover, NH.

Examples of index properties that are proposed to be determined at CRREL are: specific gravity, grain-size distribution, bulk density and dry density, and Atterberg limits.

2b. Laboratory Studies

Index properties such as density, salinity and grain-size distribution are often not directly used in engineering design calculations, but experience and previous investigations have established relations between these index properties and engineering characteristics such as strength and consolidation parameters.

The subsea permafrost is an unknown environment and a new start has to be made in relating index parameters to engineering characteristics; this involves conducting laboratory investigations of strength and consolidation as a function of sediment type, salinity, and temperature on undisturbed cores and reconstituted samples.

3. Soviet Literature

Offshore permafrost is not confined to the United States ,but Canadian and Russian programs in this area are also known to exist. CRREL has in the past compiled world-wide bibliographies of permafrost work and continues to do

so. Also CRREL has established contacts with Russian permafrost experts. We propose to review and compile special bibliographies for offshore permafrost research and development.

B. Methods

A technical plan for the different aspects of the proposal follows:

1. Sampling and Drilling

This effort is centered around a month-long drilling program planned for the spring of FY 76 in the Prudhoe Bay area, and is the basis for a joint study proposed by the U.S. Geological Survey and CRREL. It will consist of a study designed to test drilling and sampling techniques, methods of sample recovery, to formulate routine methods of data collection, and to set a framework for obtaining engineering, geological, and thermal parameters for this potentially unique subsea permafrost setting.

The sea ice will be used as a stable platform from which holes will be drilled in the vicinity of the sites shown on Figure 1. These provisional sites were selected on the basis of nearly 1800 kilometers of high resolution seismic profiles already acquired by the USGS and the University of Alaska during the summer of 1974. The drill holes will enhance the value of the seismicdata in that they provide direct correlation between velocity and stratigraphy.

The proposed first-year field work includes the drilling of four to seven holes 100 m in depth. This effort will be restricted to the Prudhoe Bay area which will provide general information of regional importance and its location near a major logistics support center makes it a practical site.

CRREL's program will have a dual role in the overall study: 1) it is respo sible for arranging for and developing the drilling techniques for both the CRREL and USGS technical programs, and 2) support our own technical program concerned with determination of engineering properties of the subsea materials.

The primary drill sites indicated in Figure 1 lie on a line approximately normal to the coast and the location of an onshore hole with thermal data acquired for a number of years lies on an extension of the line. This information will provide control for offshore conditions in a situation where the seas have been transgressing onto the land. The line BB' is of secondary priority and will be drilled if time, conditions, and funds permit. This line will be used to assess the effects of relatively warm fresh river water on a permafrost setting. The southernmost holes will be drilled where ice is not in contact with the bottom, eliminating this parameter as a potential variable in a complex thermal setting. The exact location of the drill holes will be based on the seismic studies mentioned earlier. The seismic records will provide a means to extrapolate the drill hole data over a larger regional setting.

The sampling and drilling effort will employ a range of drilling and sampling techniques so as to test a large range of techniques for acquiring samples in an undisturbed state. These techniques will vary as a function of the lithology of the material. The equipment for drilling and sampling will be tested in a range of natural conditions. Therefore, it is planned to employ drilling equipment that has both the potential to drive sample as well as rotary drill.

The costs for this part of the program are difficult to determine because of dramatic increases in costs of all drilling related equipment. The costs quoted in this proposal are based on a drilling contract with equipment that is currently available and at current prices.

2. Determination of Material Properties

2a. Index Properties

Samples and cores obtained from the drilling program will be analyzed and catalogued at the drill site where properties such as visible ice content and density will also be determined. Other tests such as those for thermal conductivity ~~and trace metal content~~ will be conducted by the USGS in Menlo Park, CA.

The bulk of the index tests, however, will be conducted at USACRREL in Hanover, NH. These tests include, but are not limited to, grain-size distribution, total water content, density, specific gravity, salinity, the Atterberg limits, unfrozen water content, and organic content. The index properties obtained will provide a file of data for offshore sediments of selected locations and will be used to establish relations for predicting the strength and consolidation characteristics of offshore permafrost. The work will be performed by technicians in the well-equipped CRREL Soils Laboratory. A limited number of samples obtained from 1975 drilling programs can also be accommodated. These include the University of Alaska samples from this spring's Prudhoe drilling and the ONR-NSF sampling from Barrow eastward by Lewellen.

2b. Laboratory Studies

Mechanical properties such as shear strength, compressibility and thaw-consolidation will be performed in the CRREL Soils Laboratory. Initial tests will be performed on cored samples from Pt. Barrow and Cape Simpson obtained by ONR supported offshore drilling program (Lewellen). It is anticipated that these samples will be acquired without charge. The results of these tests will be used to evaluate equipment and as a base for designing a more extensive testing program of the undisturbed core to be obtained at other locations, such as Prudhoe Bay, by the USGS-CRREL drilling program.

The strength and consolidation parameters will be determined as functions of, and correlated with sediment type, salinity, temperature, pressure, density, and moisture content for a range of undersea permafrost samples. Also techniques will be employed to correlate mechanical properties to more readily obtainable information such as index properties, blow count, seismic and electrical resistivity data, and other data obtainable from down-hole measurements.

To guide and supplement the laboratory work, an ongoing literature survey will be conducted on the mechanical properties of undersea permafrost. Feedback between laboratory requirements and drilling and probing capabilities will be continuously revised. It is anticipated that existing laboratory apparatus at CRREL will be adequate to perform tests, but slight modification may be necessary.

2c. Soviet Literature

The study of subsea permafrost is relatively new, particularly in North America. Workers within North America are maintaining close contact with one another, particularly through the Canadian and proposed U.S. Beaufort Sea projects. However, we are aware of several studies and workers within the Soviet Union. There are several Soviet accounts of the subsea permafrost. It is proposed to undertake a comprehensive review and analysis of past and current Soviet literature on subsea permafrost and related coastal processes, and where appropriate, translate selected materials for general dissemination. To accomplish this, Dr. George Swinzow, CRREL specialist in Soviet permafrost literature, will undertake a special literature study assisted by our Cold Regions Bibliographic Project personnel at the Library of Congress.

VI. INFORMATION PRODUCTS

Anticipated results of this study include:

1. Some unambiguous data on the temperature profile, the degree of ice bonding, sediment type and salinity of the permafrost at some selected offshore locations.

2. The initiation of a map portraying the occurrence and depth of subsea permafrost in the Beaufort Sea and evaluating the hazards imposed by these conditions.

3. A file of data on index and engineering properties of offshore sediments at selected locations.

4. The quantification of the engineering characteristics of subsea sediments in the Beaufort Sea and their relation to index properties.

5. An annotated bibliography of offshore permafrost research development, exploration and construction.

This information will be transmitted in the form of technical reports at the end of Fiscal Years 75 and 76.

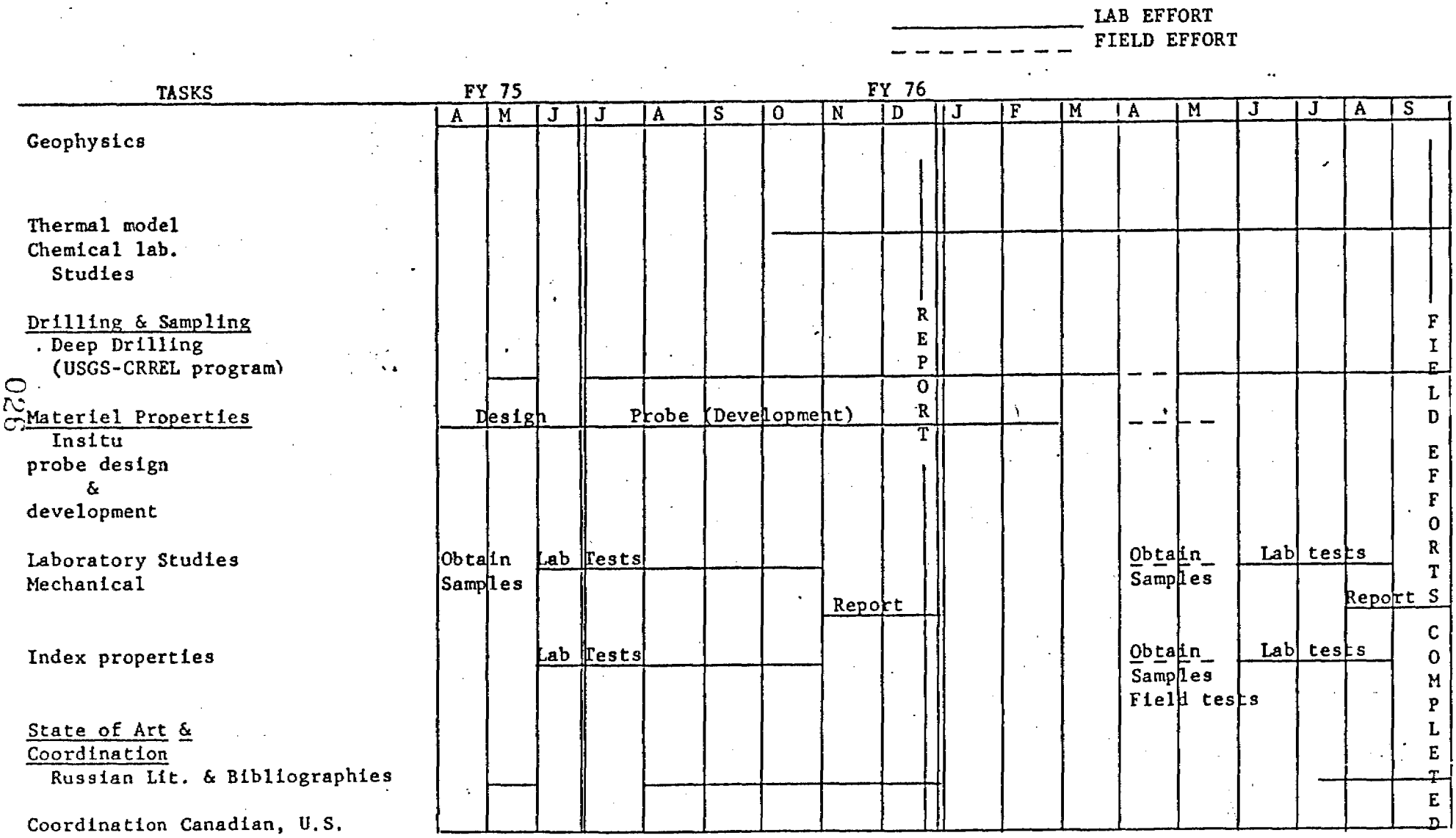
VII. DATA OR SAMPLE EXCHANGES

Samples will be obtained in FY 75 from Lewellen's drilling program in the Barrow area and the University of Alaska program in the Prudhoe Bay area.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

No special requirements are required. CRREL will be responsible for shipping of all required samples.

IX. SCHEDULE USA CRREL SUBSEA PERMAFROST PROGRAM, BEAUFORT SEA



X. EQUIPMENT REQUIREMENTS

XI. LOGISTICS REQUIREMENTS*

Time:	Spring 1976; 45 days approximately mid-March to late April 76
Location:	Prudhoe Bay; operating out of Pt. McIntyre possibly Prudhoe
Vehicles:	adequate ground or air transportation from Deadhorse to McIntyre oversnow-ice tracked vehicles** CRREL Bombardier snow machine (2 each) - shared with USGS subproject
Personnel:	2 men for 20 days at McIntyre; remainder time on ice with contractor supplied facilities or CRREL camper
Helicopter:	30 hours during period in cooperation with USGS requirement
~~Gas:~~ Fuel:	7500 gallons of diesel for drilling contract and support
Other:	D-6 catepillar for moving heavy drilling equipment on ice** (possibly available from CRREL)

* To be supplied by NOAA logistical support unless indicated by **

** Requires transport Fairbanks to Prudhoe Bay

WORK STATEMENT

Research Unit #152/154

I. TITLE: Distribution, Composition and Transport of Suspended Particulate Matter in the Gulf of Alaska and Southeastern Bering Shelf

II. PRINCIPAL INVESTIGATORS: Dr. Richard A. Feely
Dr. Joel D. Cline

III. GEOGRAPHICAL AREAS:

Gulf of Alaska - 1 July 1975 - 30 September 1976

Bering Sea - 1 April 1975 - 30 June 1975

1 July 1975 - 30 September 1976

IV. COST:

Gulf of Alaska - 150K

Southeastern Bering Shelf - 150K

PRELIMINARY

DATE: May 8, 1975

V. PROPOSED RESEARCH

A. Background and Objectives

Historical Background - Gulf of Alaska

There is very little published information about the distribution of suspended particulate matter in the Gulf of Alaska.

Reimnitz (1966) studied the sedimentation history and lithology of sediments from the Copper River Delta. He estimated the particulate matter supply of the Copper River to be 107 x 10^6 tons/yr which mostly consists of fine grain sands and silts.

Sharma et al. (1974) compared some surface particulate matter distributions taken during February 24-28, 1973 between Kenai Peninsula and Kayak Island with ERTS multispectral scanner images of the same region which were obtained on October 12, 1972 and August 14, 1973. The ERTS images show that the Copper River and Bering Glacier provide most of the sediment load to this region. The westward flowing Alaska current deflects the Copper River plume to the west. The suspended matter moves along the coast with some material entering Prince William Sound through the passages on either side of Hinchinbrook Island and the remaining material is carried along the southeast shore of Montague Island. The plume of suspended matter from Bering Glacier is carried to the west by the Alaska current until it reaches Kayak Island where it is deflected to the south.

The Gulf of Alaska is a unique geological setting in which suspended particulate matter is supplied to the Gulf from a variety of sources, i.e., rivers, glaciers, tidal inlets and oceanic sources. Turbid plumes of fine grained glacial flour extend offshore over large portions of the Gulf and

in some cases maintain their integrity for considerable periods of time. Trace elements and petroleum hydrocarbons, which may be released during drilling and transportation operations, tend to adsorb onto the surfaces of suspended particles and are deposited along with the particles. Therefore, we need to study the distribution, composition and transport of suspended particulate matter in the Gulf of Alaska in order to evaluate the possible environmental impact of petroleum development in this region.

Historical Background - Southeastern Bering Shelf

There is very little published information about the distribution and composition of suspended particulate matter in the southern and southeastern Bering Shelf regions.

Sharma et al. (1974) compared some particulate matter distributions taken during June-July 1973 in the southern Bering Sea and Bristol Bay area with ERTS-1 multispectral scanner images of the same area which were obtained on October 2, 1972. The surface contours of suspended load distributions indicate several regions of relatively turbid water which originate from a variety of sources. These turbid regions include:

(1) A region of turbid water which is north of the Aleutian Islands. This is probably due to the high level of primary productivity that is the result of the mixing of nutrient-rich deep water with the Alaskan Stream which flows into the Bering Sea from the south.

(2) A region of turbid water which extends south from Kuskokwim Bay and west from northern Bristol Bay. This plume probably represents suspended matter derived from the Kuskokwim River from the North and the Kvichak and Nushagak Rivers from the east.

(3) A region of slightly turbid water extended to the southwest from Bristol Bay which probably represents suspended matter derived from Kvichak and Nushagak Rivers.

The ERTS imagery indicates that the Nushagak River is a major source for particulate matter in the Bristol Bay area. The suspended particles from the Kvichak and Nushagak Rivers are carried to the west by the prevailing counterclockwise current. Sharma et al. (op. cit.) state that although the river plumes remain close to shore, offshore transport of material in suspension is probably brought about by tidal currents.

There is only a small amount of information about the chemical composition of the suspended matter in the southern and southeastern Bering Sea. Loder (1971) studied the distribution of particulate organic carbon (POC) north of Unimak Pass and found high POC concentrations (221-811 µg C/liter) in the thermally stabilized upwelled water north of the Unalaska Islands. Lower POC concentrations were found north of Unimak Island and west of Akutan Pass which presumably were due to current mixing.

Tsunogai et al. (1974) studied the distribution and composition of particulate matter from six stations in the south central and southeastern Bering Sea. They found the highest concentrations of particulate matter occurred at 20 to 30 meters depth which appeared to be due to the high productivity and the slow decomposition of organic matter just below the surface. The organic portion of the suspended matter was about 67 percent for the samples from the Bering Sea and 80 percent for the samples south of the Aleutian Islands in the northern North Pacific.

El Wardani (1960) studied the distribution of organic phosphorus in the Bering Sea, Aleutian trench and the Gulf of Alaska. He demonstrated that organic phosphorus in the upper 200 m of the water column bears an inverse relationship to inorganic phosphorus. Below 200 m no detectable organic phosphorus was found.

Objectives

The primary objective of the suspended matter program in these areas will be to address task B-11 (characterize physically and chemically sediment influx, transport and deposition) of the Study Plan. In the course of this program we will address portions of tasks A-33 (trace elements in suspended particulate matter) and A-34 (particulate nutrients in suspended particulate matter). In order to accomplish these tasks we will initiate an integrated field program, beginning FY 76, which will be conducted simultaneously with the biological program under J. Larrance and D. Damkaer in the Gulf of Alaska and the geochemical program under D. Burrell in the Bering Sea. The field program for suspended particulate matter will consist of three cruises in the northeastern Gulf and one cruise in the northwestern Gulf. Two cruises in the Bering Sea are anticipated.

Sample collection will occur concurrently with STD-nephelometer hydrocasts such that particulate matter distributions will be related to the hydrography. Water samples will be collected in 10-liter PVC Model 1070 Drop-Top Niskin® bottles and filtered through preweighed 0.40 μm Nuclepore® filters. The fitters will be washed with three 10-ml aliquots of deionized filtered water, dried in a desiccator, stored in plastic petri dishes, and frozen to reduce bacterial activity. At the laboratory the filters will be reweighed on a seven-place Cahn® Model 4700 Electrobalance. Additional water samples will be filtered through appropriate filters for the determination of organic carbon and nitrogen.

It is expected that the suspended matter program will utilize approximately 1-2 hours per station for the sample collection. This includes the time required for the STD-nephelometer hydrocast plus the time required for the collection of 10-liter water samples from the rosette sampler. There will also be an additional time requirement of approximately five hours between stations for sample processing (i.e., filtrations).

A second aspect of the suspended matter program will be concerned with the processes of sediment resuspension and redeposition. Observations of light scattering profiles from the Gulf of Alaska have indicated evidence of near bottom turbidity layers which may be due to resuspension of bottom sediments. The erosion and transport of bottom sediments are expected to be related to the action of near bottom currents. These currents are presumably influenced mainly by the actions of waves, tides and storm surges.

To determine how these processes affect the near bottom distribution of particulate matter we will deploy a small mooring in the eastern Gulf at approximately 100 m depth. The mooring will contain an Aanderaa® current meter and a nephelometer located within 10 meters of the bottom. The mooring will be maintained for approximately two months and recovered under the direction of J. Schumacher of PMEL.

B. Methods

The major (C, N, Mg, Al, Si, K, Ca, Ti, and Fe) and trace (Cr, Mn, Cu, Ni, Zn and Pb) element chemistry of the particulate matter will be determined by X-ray fluorescence. This technique has been used successfully for the determination of the major inorganic elements in particulate matter in coastal and deep water environments and the techniques are fairly well established (Cann and Winter, 1971, and Baker and Piper, 1975). Recent advances in this field have lowered the minimum detectable limits to such an extent that many trace elements in particulate matter can be analyzed routinely.

The organic carbon and nitrogen content of suspended particulate matter has been shown to be a valuable indicator of terrestrial and marine sources of organic matter in the coastal waters of Alaska (Loder, 1971). Specifically, Loder and Hood (1972) have used the C/N ratio of particulate matter to distinguish terrestrial, glacial, estuarine and marine-derived sources or organic matter, and from this analysis, trajectories of suspended loads may be elucidated.

Particulate organic carbon and nitrogen will be analyzed by the micro-Dumas combustion method, employing a Hewlett Packard® model 185B C-H-N analyzer (Sharp, 1974). Particulate matter will be removed from one liter volumes by vacuum filtration (precombusted 0.45 μm glass or silver filters; Sharp, 1974; Gordon and Sutcliffe, 1974) and the carbon and nitrogen combusted to CO_2 and N_2. After separation by standard gas-solid chromatography (GC), the gases are quantitatively determined by thermal conductivity (TC). Sample analysis time is about 10 minutes.

Standardization will be effected with EDTA, acetanilide (Sharp, 1974) and nicotinic acid, the latter two are NBS standards. These results will be corroborated by direct GC analysis of CO_2 and N_2.

In order to insure the reliability of the analytical results we anticipate close coordination and cooperation with the sedimentary geochemists. We have discussed this at length with the geochemists from the University of Alaska and we have concluded that a cooperative intercalibration program including: (1) free exchange of samples for comparison of analytical results and (2) free exchange of information concerning analytical techniques will best serve this purpose. It may be advisable to include into the intercalibration program other geochemists involved in similar BLM sponsored programs.

VI. INFORMATION PRODUCTS

The field data from the first year program will be arranged into a tabular format and submitted to EDS on IBM cards. In addition, distribution maps and cross-sections will be prepared for the final report. The final report will also contain narrative descriptions of the distribution, composition and transport of suspended matter in the study region.

VII. DATA OR SAMPLE EXCHANGE INTERFACES

The suspended matter program will require information from portions of the geological and physical oceanography programs. Detailed maps of the bathymetry and sediment types should be made available to us as soon as possible. We also need data on the chemical and mineralogical composition of the sediments as well as grain size distributions.

We will also need detailed descriptions of the circulation patterns. Special emphasis should be placed on net water mass transport through the study region.

The particulate matter program has a need for some additional information of a supportive nature which could be supplied by EDS or similar information service. The information includes:

1) Monthly discharge rates of the major Alaskan rivers
2) Historical information on the major and trace element composition of dissolved and particulate matter in the Alaskan rivers
3) Detailed ERTS multispectral scanner images (green band, 0.5-0.6 μm and red band, 0.6-0.7 μm) of the study area -- especially during the field season.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

We presently do not have any sample archival plans.

IX. SCHEDULES

The following diagram shows the projected cruise schedule for the suspended matter program in the Gulf of Alaska and Bering Sea.

AREA AND PROJECT	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NEGOA				⊢	⊣					⊢	⊣		⊢	⊣	
Current meters & nephelometer						H			H						
NWGOA														⊢	⊣
Southeastern Bering Shelf		⊢	⊣									⊢	⊣		
Ship-time Days		14		21		1			1	21		21		21	21

Table 1. Ship time request in the NE and NW Gulf of Alaska and Southeastern Bering Shelf

An estimation of the schedule of delivery of information after each cruise is as follows.

(1) Suspended Matter Distributions: 2-3 months after each cruise

(2) Major Element Chemistry of Suspended Matter: 4-5 months after each cruise

(3) Trace Element Chemistry of Suspended Particulate Matter: 6-8 months after each cruise

Milestones

(1) First 90-day period

a) Set up laboratory and equipment
b) Begin development of the nephelometers
c) Prepare for first cruise

(2) Second 90-day period

a) Finish laboratory set-up and check out procedures for the analysis of suspended matter
b) Conduct fall cruises
c) Begin analysis of samples from the fall cruise

(3) Third 90-day period

a) Prepare preliminary reports on the results from the first cruise
b) Prepare for spring cruise
c) Complete analyzing samples from fall cruises

(4) Fourth 90-day period

a) Conduct spring cruise
b) Begin analysis of samples from spring cruises
c) Prepare for summer cruises

(5) Fifth 90-day period

a) Conduct summer cruise
b) Continue analysis of samples from the spring cruise
c) Prepare preliminary report on data from spring cruises

(6) Sixth 90-day period

a) Complete analysis of all samples
b) Prepare final report.

X. EQUIPMENT REQUIREMENTS

Since a considerable amount of equipment will either have to be built or adapted to meet certain requirements for this program, a certain amount of lead time prior to the cruises will be required for equipment development. The following is our best estimate of the amount of time required (beginning from the time funds are received at PMEL) for development of the most important equipment items.

1. Nephelometer (to be used on STD-hydrocasts) . . . . . 6 months
2. Nephelometer (to be used on current meter mooring) . . . 8 months
3. Filtration Equipment . . . . . 3 months
4. X-ray Fluorescence Unit . . . . . 3 months

XI. LOGISTICS REQUIREMENTS

Vessel facility requirements

The vessel used must provide the following facilities:

1. Approximately 100 sq ft of laboratory space which includes
   - work bench (10' x 2') with drawers and cabinets for storing supplies. The work benches should be equipped with a sink that supplies deionized water.
   - work space (10' x 4') with at least 72" clearance for the filtration rack in one of the laboratories.
   - the laboratory must be located on the main deck with good access to the sampling area.

2. Deck space

   - space is needed on the open main deck for the deployment of the nephelometer and sample bottles.

3. Storage space

   - for gear: about 20 sq ft of deck space
   - for samples: 10 cu ft of freezer space

4. Electric power

   - in laboratories: three double receptacles in each laboratory supplying 110V, 60 Hz current.

5. Scientific personnel

   - four to six scientists will accompany these cruises to conduct the suspended matter program.

6. Small boat requirements

   - in order to collect samples in and around the major rivers which are not navigable by the research vessel, a small work boat (16-25 ft), equipped with a hand winch, will be required for deployment from the research vessel.

7. Helicopter requirements

   - in the event that deployment of a work boat from the research vessel is not feasible (i.e., the rivers are not navigable), then a helicopter may be required for sample collection. Approximately 4-5 days of helicopter time during each field season for each area is required for this work.

8. Sampling Protocol

	NEGOA	NWGOA	BERING
Sampling Events	Fall 1975 Spring 1976 Summer 1976	Fall 1976	Fall 1975 Spring 1976
Nominal distance between stations	30 km	20 km	60 km
Number of vertical stations (approximate)	48	35	32
Number of standard depths (approximate)	7	7	7
Number of surface stations	0	35	32
Total number of samples (approximate)	336	280	256
Wire time (est.)[1]	48 hrs	70 hrs	64 hrs
Time between vertical stations	5 hrs	5 hrs	5 hrs
Personnel	4-5	4-5	4-5

[1]Based on the estimate of time required to make a 200 m rosette sampler cast

9. Contingency Plans

In the event that during the course of this program unforeseen opportunities arise which will allow us to collect additional samples without additional cost to the total program, we reserve the right to do so upon approval of the program office.

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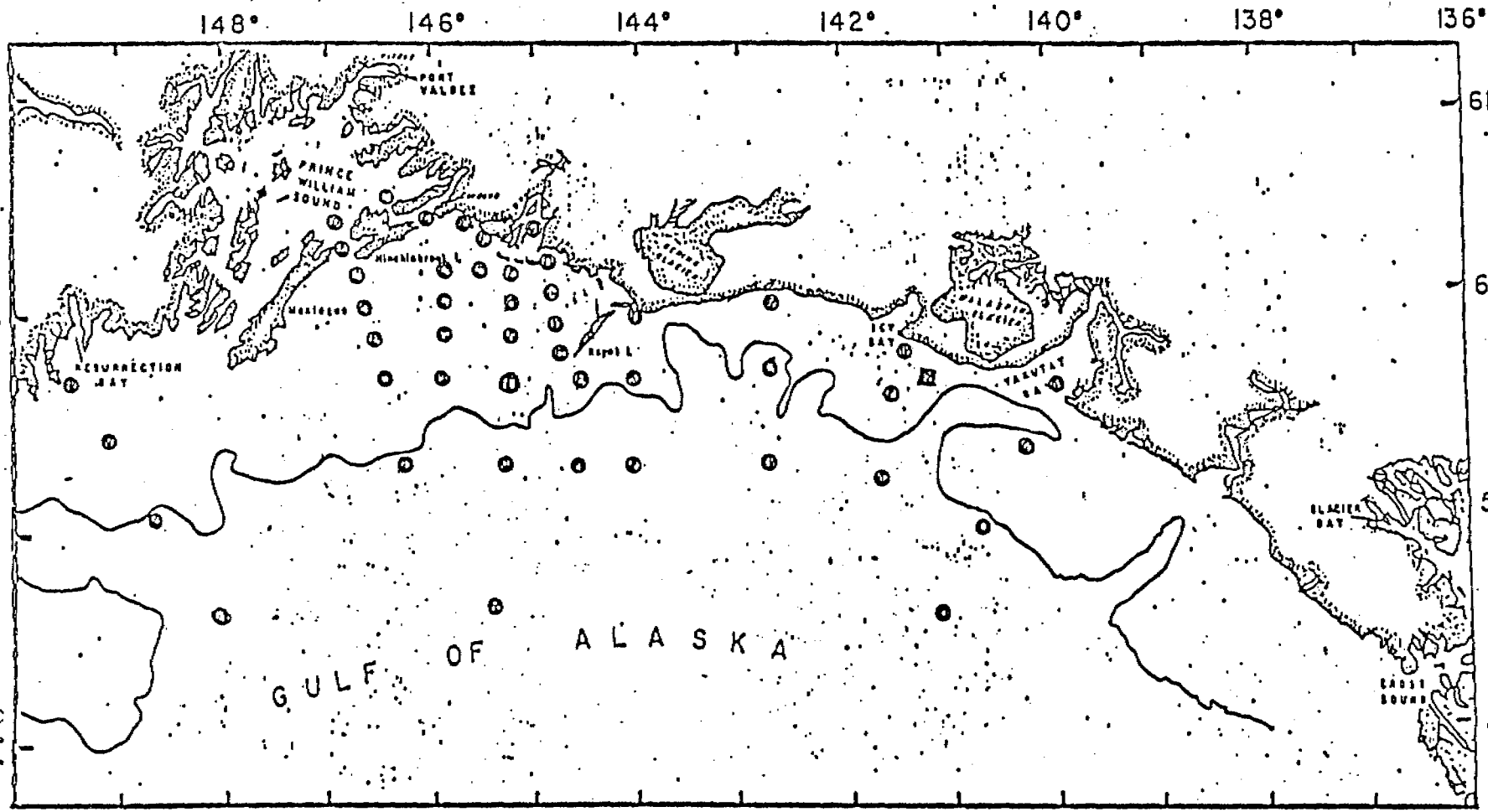
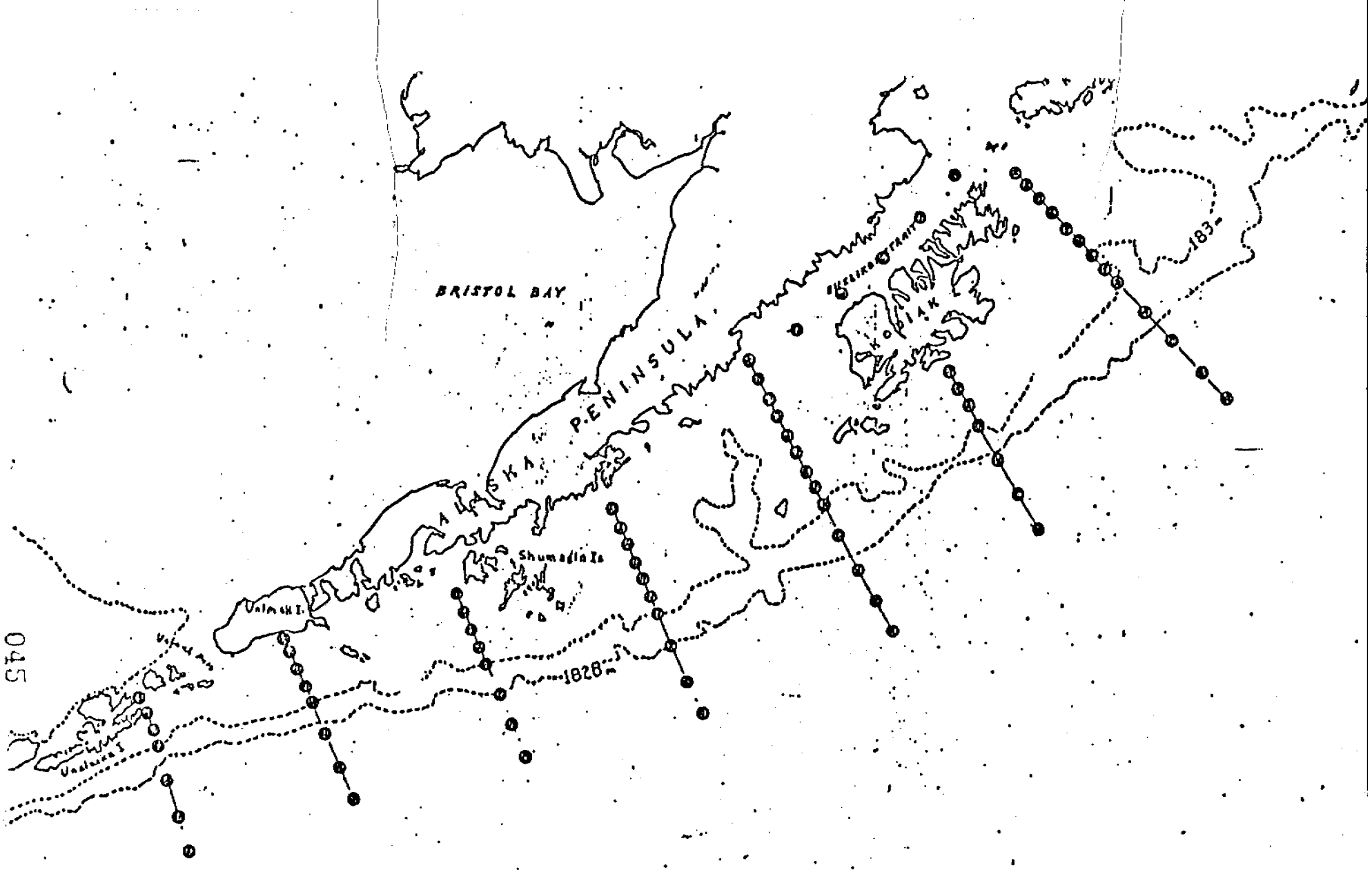


Proposed locations of the particulate matter stations (●) and the bottom mooring (▣).



Proposed locations of the particulate matter stations in the Northwest Gulf.

WORK STATEMENT (Research Unit #204) (G)

I. Title: OFFSHORE PERMAFROST STUDIES, BEAUFORT SEA

II. Principal Investigators: Peter Barnes
Erk Reimnitz

III. Geographic Area and Inclusive Dates: Beaufort Sea (Prudhoe Bay)
Project will initiate with funding in FY75 and continue through September, 1976.

IV. Costs: FY75 (10.0) FY76 (90.0)

V. Proposed Research:

A. Background

Task References
Primary Emphasis, D-8
Secondary Related Studies, A-33, B-10, 11, 12, D-2, 9, 10, 12, 13

State of Knowledge - Information Needed

A knowledge of the distribution and character of permafrost is fundamental to engineering problems related to offshore drilling and oil production and to the interpretation of seismic exploration studies. Especially important to pipelines, drill rigs, and docking facilities, is the distribution of ice in the upper 10 to 50 meters of seafloor. But, in fact, little is known about offshore permafrost, its distribution, properties, and dynamics of formation. Offshore, the potential consequences of structural failure are even greater in terms of loss of human life, environmental damage, and costs, than on land.

Prediction of the extent of offshore permafrost requires a knowledge of the thermal regime, the past position of the shoreline, of water depths at various times in the past, and of former air temperatures when the site lay exposed during periods of low sea level. Furthermore, because distribution of modern permafrost is affected by circulation of brine through the sediment, it is necessary to know the lateral extent and continuity of permeable layers, and this requires knowledge of the general geology.

Related research will be carried out by Robert Lewellen, Arctic Research, Littleton, Colorado (mostly in the Barrow area); Paul Sellman and other associates at CRREL; Jim Rogers and associates at the University of Alaska and by Tom Osterkamp and William Harrison also of the University of Alaska. A coordination meeting is planned for early July, 1975, in Menlo Park to work out detailed coordination of activities.

B. Proposed Research (Sampling and Analysis

This work statement covers the USGS part of a joint agency effort between the U. S. Geological Survey and the U. S. Army Cold Regions Research and Engineering Laboratory (CRREL). (See also Research Unit #105). CRREL will drill a series of 4-7 holes along two transects perpendicular to the shore from Prudhoe Bay, Alaska. These holes will be drilled to a depth of about 150 m during the late winter and early spring of 1976, using the sea ice as a platform. (See

attached map). Continuous coring will be attempted in all holes drilled. Extrapolation of core hole data by geophysical means will be attempted using USGS and the University of Alaska seismic reflection and refraction data. The sampling scheme is based on the need to extend onshore and nearshore data (Osterkamp and Harrison) offshore and to compare thermal regimes off a lagoon, barrier island (Line A-A^1) and off a delta (Line B-B^1).

The USGS will perform the following three activities:

1. Thermal Logging and Modeling: In the holes to be drilled, the USGS will log temperatures to milli-degree accuracy and thereby determine the undisturbed equilibrium temperatures. Samples will be obtained for thermal conductivity measurements and for determination of the abundance and freezing characteristics of the interstital fluid. An attempt will be made to combine these data with regional information on shoreline and climatic history, sea-bed temperature, distribution of sediments, and onshore geothermal information to provide an interim model for the thermal regime of the sub-bottom sediments and the likely distribution of ice within them.

2. Geological History Determination: Examination of core samples and cuttings will yield information on stratigraphy and lithology of the shelf sediments. Standard sedimentary techniques will be used to determine the depositional environments represented in the stratigraphic section. In order to make maximum use of the bore holes, the drill cores or cuttings

will be sampled for their fossil content, especially mollusks, foraminifers, ostracodes, and pollen.

3. Geochemical Analysis: The USGS will also conduct a limited geochemistry effort. Between two and four samples will be taken from each core and analyzed for their chemical content. Analysis will be made for carbonates and organic exertion; other constituents to be analyzed will be determined at the next permafrost meeting this July.

VI. Information Products

The following information products are expected to result from this coordinated permafrost research program if the drilling is a success.

1. Preliminary maps showing the distribution of permafrost, its depth, and the presence or absence of ice-bonded permafrost.
2. Analysis of depositional history of shelf sediments, paleoclimatology, sealevel history, paleo-geography.
3. Crossections of cores showing stratigraphy, sediment types, lithology, geochemistry, salinity and ice content.
4. Crossections of cores showing temperature gradients.
5. Calculations on the thickness of the permafrost.
6. A thermal model.

VII. Data or Sample Exchange Interfaces

The only anticipated data or sample exchange will occur within the coordinated USGS-CRREL-University of Alaska program. The products are not required by other investigators to our knowledge.

IX. Sample Archival Requirements

Data will be in the form of well logs, thermal gradients, fannual lists, sediment analysis and other essentially narrative on analog

format. With successful coring capability, we hope to obtain 50% core recovery on each hole, or up to 250 m of core material.

IX. Schedule

Sample acquisition will occur during April, 1976. Prior to that time, several planning meetings are planned, the first one for July, 1975. Analysis of data will start with field observations and will result in a report of results of the drilling operation. Reports detailing the analysis of field data and samples will necessarily follow completion of lab tests during the summer of 1976. It is anticipated that an additional study year will be required to adequately address this task.

X. Equipment Requirements

The geothermal group in Menlo Park plans to develop a near surface thermal probe for use during and following the on-ice field program.

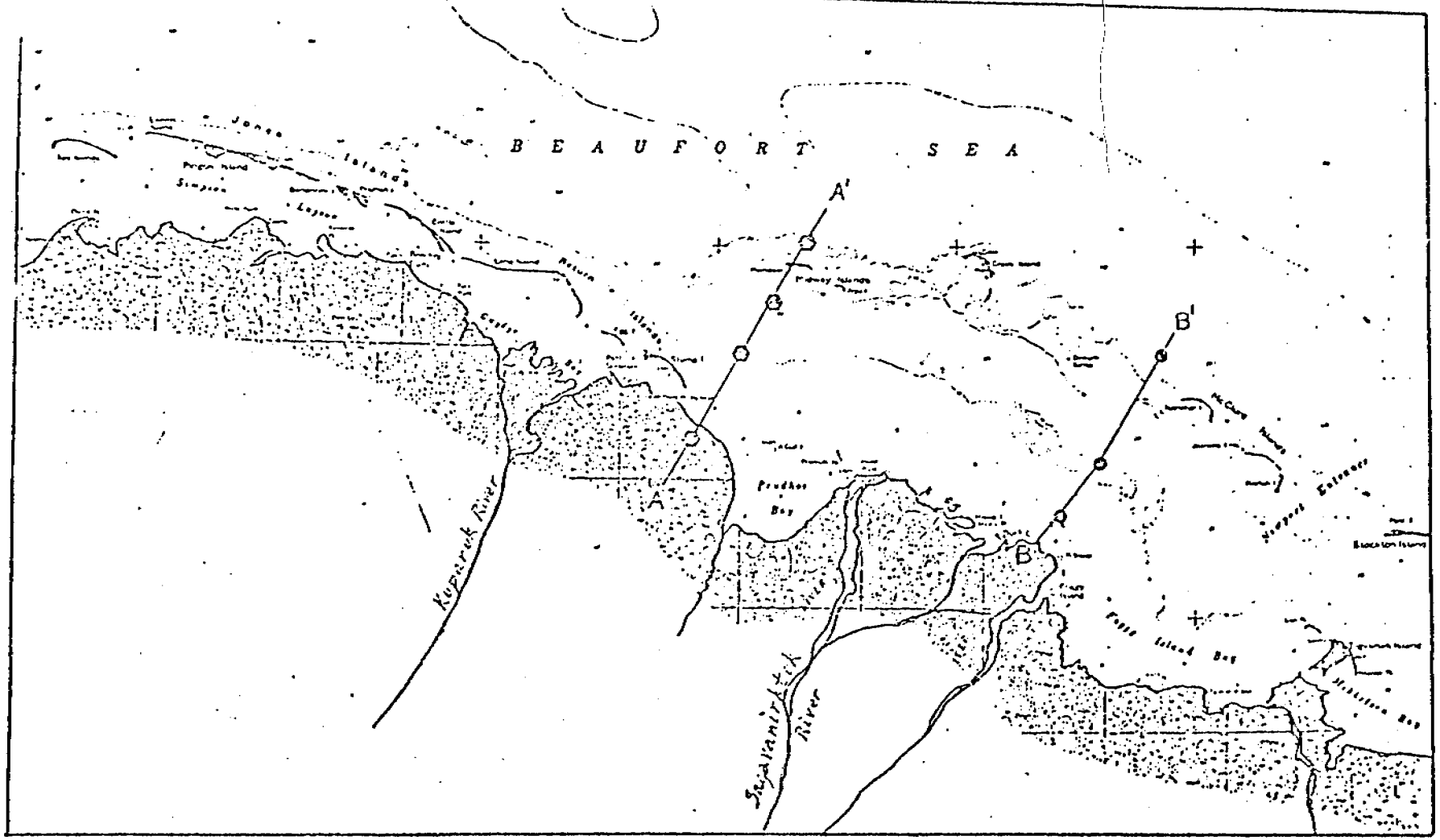
XI. Logistics Requirements

Logistics: The drilling will take place on the sea ice on a line from Pt. McIntyre to Reindeer Island during the month of April, 1976. Both helicopter and fixed wing aircraft support will be required to locate routes for moving drilling equipment on the ice and to provide aerial reconnaissance and photography of the area. About 35 hours of flight time will be required. A shore based facility with an expediter and radio communications in the Prudhoe Bay area would be extremely helpful to the project. It is anticipated that a considerable volume of samples and equipment may

have to be shipped for this project. Lodging for 1-2 people will be needed in Prudhoe Bay off and on during the field period (April, 1976).

Other logistics requirements are outlined in the CRREL Proposal and Work Statement.

Special Problems: Geochemical studies and determination of the engineering properties of the drill hole data are considered in a proposal from the Cold Regions Research and Engineering Laboratory. The actual drilling expenses, which comprise the largest part of the overall project costs, are also present in the CRREL proposal.



PRIMARY DRILL SITES

SECONDARY DRILL SITES

Figure 1

Scale

0 5 10 15 20 25 Km

WORK STATEMENT (Research Unit #205)

I. TITLE: Marine Environmental Problems in the Ice Covered Beaufort Sea Shelf and Coastal Regions.

II. PRINCIPAL INVESTIGATORS: Peter Barnes
Erk Reimnitz
David Drake

III. GEOGRAPHIC AREA AND INCLUSIVE DATES:

Beaufort Sea and Coast, part of a continuing study from the present through September, 1976.

IV. COST SUMMARY:

FY 1975	FY 1976
$165,529	$35,165

V. PROPOSED RESEARCH

A. Background

1. Task references

primary emphasis - B-11
secondary emphasis - A-29,33; B-2,3,10,8,12,13; D-1,2,4,8, 10,11,12,13

2. State of knowledge - (background information needed) - The marine environment of the Arctic shelf poses special problems to offshore development. Compared to unique Arctic processes and phenomena related to cold temperatures and the predominant influence of sea ice; faulting, tectonic activity, and sea floor instability are environmentally of lower concern. Five years of study have provided a basic understanding of these unique factors, but many important aspects of them have yet to be addressed. For example, a major process to be understood is that of ice gouging, in particular, maximum scour depth, recurrence rate, depth distribution, and the relation of gouging to ice regime. Another is the spring flooding of the fast ice with river water, a hazard to operations and a process that could greatly affect dispersal of pollutants. The growth of the fast ice, and its vertical fluctuation with tides and surges, sets up currents that not only influence sedimentary processes, but also the dispersal of pollutants. The interaction of the shear zone with the continental margin, its effects on oceanographic circulation, sediment dispersal,

and shelf profile, must be understood. The shear zone is a formidable barrier to offshore development, and shipping, and appears to be an important key to an understanding of the shelf ecosystem. The distribution, depth, and nature of offshore permafrost is another unknown, a phenomenon that will affect offshore construction activity.

This work statement requests funds to allow the USGS to accelerate their ongoing research projects in the Beaufort Sea in order to meet the NOAA/BLM time table for information products. These funds will be used to hire additional technicians and purchase new equipment to enable the production of a better research product and a quicker schedule than originally planned.

The following is a list of the most important topics which we are going to address during the next two years. Many of these are questions raised on the basis of our past investigations, and apparently hold the key to an understanding of the seasonal cycle in the marine environment. These study topics primarily address tasks outlined under sediment transport and geologic hazards, but are very closely interrelated and interdependent with other tasks set forth under Baselines (benthos, chemical baselines), Transport Processes (water mass movement, physical and chemical processes, ice dynamics), and Hazards (ice forces, severe oceanic events).

(1) Processes of ice gouging, in particular the repetitive rates at which gouging occurs and the extent to which it occurs outside of the area of our past investigations. Repetitive side scan sonar surveys with precise navigational control, direct diving observations, and a deep-tow package with underwater television and a high frequency subbottom profiler, will be used in the study of repetitive rates of gouging.

(2) Shelf sediment transport regime, including ice-rafting, river effluents and bottom reworking and resuspension by ice and benthos, using a large variety of techniques.

(3) Offshore permafrost, using seismic refraction techniques during the summer season to delineate the upper surface.

(4) The fast-ice zone, and its influence on nearshore current circulation, bedforms, sediment transport, permafrost, and on river discharge.

(5) The shear zone between the coastal ice and the offshore pack ice, and its influence and/or relationship to bathymetry,

thermal effects on the sea floor, ice gouging, and winter current regime, tides, and sediment transport. Some of the studies on this topic can be done during summer operations, but winter operations using specific recording instrument packages are required, and should be coordinated with programs in other scientific disciplines, which also use remote sensing techniques.

(6) Coastal erosion and its relationship to the formation of offshore islands and the stability of the coastal marine environment.

(7) Shelf oceanography, related to the sedimentary environment. This includes upwelling in the coastal zone, the dispersal of highly saline (60 o/oo) and cold (-5°C) water generated in shallow embayments, lagoons, and river mouths during the winter, and possibility of anchor ice formation as a factor in the sedimentary environment. Much of the necessary data must be gathered through recording instrument packages during winter-operations, such as the planned permafrost drilling venture.

(8) The apparent lack of deltaic sedimentation near river mouths in the Arctic, and the unique marine aspects of Arctic rivers in general. Seismic reflection surveys will be extended up into the major river channels. Instrument packages, including current-, temperature-, salinity-, and tide-sensors shall be used to monitor specific nearshore locations throughout the winter.

(9) Pleistocene stratigraphy and geologic history, from a combined analysis of available sediment and seismic data, the expected drill hole data, and 2-m long vibro-corer samples.

Approximately 20-50% of the task objective can be met and reported on by September, 1976. However, the USGS will have a continuing program to study the Arctic seas albiet at a much reduced level of funding and effort.

3. Related research

(1) Offshore permafrost studies, Beaufort Sea

(2) Study of shearzone dynamics on the Beaufort Sea shelf north of Alaska; Cold Regions Research and Engineering Laboratory - Austin Kovacs and others.

(3) Arctic Ice Dynamics Joint Experiment: Division of Marine Resources, University of Washington.

B. Methods

Because oil drilling and production during the next several years will probably not extend seaward of the seasonal fast-ice zone, and because existing data in this area are sparse, the proposed summer operations for the next two seasons focus on the shelf region shoreward of the shear zone (10-30m). The Geological Survey is constructing a shallow-draft research vessel the R/V KARLUK, especially adapted for independent operations on the inner shelf.

During the summer of 1975, we plan to commence working in the Kotzebue area by mid-July, follow the retreating ice around Barrow, and proceed eastward as far as Flaxman Island. The KARLUK will be winterized at Prudhoe Bay.

Equipment that will be operated routinely from the KARLUK includes bottom sampling and coring gear, water-salinity, temperature, and turbidity sensors, fathometers, a high resolution seismic system, underwater television, and a side-scan sonar. Precision navigation will be maintained. This equipment will be used in a reconnaissance survey between Kotzebue and Harrison Bay, thereby broadening our data base for Arctic areas. A brief study will be made off Barrow, to delineate ice gouge features and possible gravel deposits for construction needs.

Between Barrow and Prudhoe Bay, a seismic refraction system will be used (in cooperation with the Institute of Geophysics of the University of Alaska) to search for high-velocity layers that may be related to permafrost.

Topical problems listed earlier, and in the appendix, will be investigated during the remainder of the summer between Harrison Bay and Flaxman Island: here we have considerable background information. Current meters will be implanted on the open shelf, later to be moved into very shallow water prior to freeze-up. Special techniques to be used during the second half of the summer will include (a) repetitive sonar and fathometer surveys of ice gouges, (b) diving observations and bottom photography, (c) measurements of sediment thicknesses within ice gouges by combined use use of narrow beam echo-sounder, a near-bottom tow package incorporating sub-bottom profiler and television, and a vibrocorer capable of obtaining two-meter long cores. River delta sediments will also be examined with cores and or sediment profiler.

A similar field operation, but with more focus on topical problems, will be conducted in 1976. This work will also involve an extension of the study area east to coordinate with Canadian studies.

The temporal and spacial sampling scheme will be dictated by real time ice conditions and by weather constraints. Sampling locales will often be selected on the basis of profiling, side scan sonar, TV or other real time observations. Sample variance, from station to station, will be determined by remotely sensed geophysical means by use of sediment profilers, bathymetry, side scan sonar, bottom television, or diver observations.

Sample analysis and data reduction will follow standard techniques previously used and will generally follow those summarized in Reimnitz and Barnes (1974); and in Barnes and Reimnitz (1974).

VI. INFORMATION PRODUCTS

1. Maps of ice gouge density, trends, and maximum gouge depth.

2. Comparisons of ice gouge distribution, and evaluation of ice hazards.

3. Delineation of offshore gravel resources for construction purposes.

4. Map of the distribution, thickness, and nature of Holocene marine sediments for foundation assessment.

5. Long term records of inner shelf bottom currents and water temperature and sedimentary processes aimed at defining pollutant trajectories.

6. Knowledge of shelf sediment transport regime, including ice-rafting, river effluents and bottom reworking and re-suspension by ice and benthos, for assessing dispersal of pollutants.

7. Knowledge of what controls the location of the shear zone, its effects on oceanographic and sedimentologic processes, and of how fixed engineering structures will affect the configuration of the zone.

8. Provide background information for the understanding of coastal processes, coastal erosion and delta progradation in the high Arctic.

VII. DATA OR SAMPLE EXCHANGE INTERFACES

Date will be needed on ice distribution, circulation, river input, sediment geochemistry and benthos as soon as they are available for aid in reaching task objectives.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

Data will generally be in the form of analog records, subbottom reflection records, side scan sonar, underwater TV, diving observations,

bottom photography, suspended sediments, temperature, salinities, currents, and coring.

IX. SCHEDULE

- Sample acquistion for this program will be undertaken during the ice free season (mid-July to mid-September) during both CY 1975 and CY 1976. If ice conditions permit, up to 1000 km of track and sampling lines will be run on transects parallel and perpendicular to coast.

- Information delivery products will be in the form of a cruise report following each field operation in CY 1975 and CY 1976. Scientific reports and maps will be delivered following data analysis and completion of data products.

X. EQUIPMENT REQUIREMENTS

List of major equipment already available for the R/V KARLUK operation:

EG&G subbottom profiling system (Uniboom)
EG&G side scan sonar
Simrad depth recorder
Decca 916 radar
Grab sampling devices
Transmissiometer
Salinity and temperature probe
Two recording current meters and temperature recorders
Deck readout current meter
Diving gear and underwater camera
Shear vane for soil strength measurements
Skiff and outboard motor
Diver held box core samplers
Sextant and taffrail log
Raytheon narrow-beam fathometer

New equipment to be purchased using NOAA/BLM funds:

Vibrocore sampling device (capability for 2 m long cores)
Multi-user precision navigation system
Underwater television system with video tape recorder
Transceiver, 7.5 KhZ transducer, and digitizer for Raytheon Recorder

Equipment to be provided by University of Alaska (for 2 week survey):

Seismic refraction system

XI. LOGISTICS

USGS Supplied

The 42-foot Research Vessel KARLUK will be available for this project during the summers of 1975 and 1976. Since it cannot pass Barrow

before early August, it will be used for coastal studies between Kotzebue and Barrow starting July 15, 1975.

Other Requirements

- Ice reconnaissance Pt. Hope to Cape Halket, July 20-August 15, est. 10-20 hours. Fixed wing during transit of KARLUK thru these regions.
- Radio communications with Barrow
- Fuel cache - 300-500 gallons, Arctic Diesel at Icy Cape DEW site.
- Housing for 1-2 men at NARL for about one week around the first of August.
- Arctic Diesel fuel (up to 1,000 gallons), water, perishable supplies; and ammenities from NARL for 4-5 men around the first of August.
- An expediter with communications at Prudhoe to arrange and/or pick up USGS purchased food, fuel, water, parts and miscellaneous supplies (est. 5 man days)

Additional logistics requirements for the CY 1976 field season are anticipated such as ice reconnaissance and expediter at Prudhoe, however, as much of the 1976 field program will be dictated by results of the 1975 program these requirements cannot be spelled out at this time.

APPENDIX A

Barnes and Reimnitz
Marine Environmental Problems

General Background Information

Investigations of the marine geology and sedimentary processes of the continental shelf and shores of the Chukchi and Beaufort Seas in northern Alaska were initiated in 1970. Many aspects have been cooperative efforts with federal and state agencies and universities. The primary goal of the program has been to understand the processes that are unique to Arctic shelves and their sedimentary environment, where sea ice plays an important role. Our specific objectives have included: 1) a definition of the character of the bottom materials, including permafrost; 2) a study of the present sediment transport and depositional mechanisms; and 3) studies of the Holocene and Pleistocene geologic record.

Our results to date have clearly established drifting ice as a major factor in the marine geologic and sedimentologic environment of Arctic shelves (best summarized in Reimnitz and Barnes, 1975). A rudimentary framework for the processes and related sedimentologic record over the entire shelf width has been established. Utilizing this framework a conceptual model has been developed which relates the relative importance of ice and water as dynamic agents to depth and distance from the coast (Barnes and Reimnitz, 1975). It is believed that the two areas of most intense sedimentologic activity occur along the coast and at the shear between the coastal ice and the arctic pack ice. Ice is deformed and stirs bottom sediments, permits conductive thermal transfer between the atmosphere and the seafloor where grounded, inhibits free discharge of river water during spring, re-suspends sediments and transports sediments by bulldozing and rafting.

Processes related to the fast-ice flooding by rivers during the late spring flood, have a strong influence on the inner shelf sedimentary environment of the Beaufort Sea shelf. Drainage through strudel and subsequent underflow scour and reshape the bottom in the region off arctic deltas. However, little sediment is transported at this time and conditions for ice rafting sediments great distances of the inner shelf are unfavorable. Seismic studies have shown only a thin layer of Holocene sediments manteling the entire width of the continental shelf, thus the scarcity of modern deltaic sediments near Arctic River mouths remains an enigma. These same studies show that the Holocene sedimentary section is reworked by ice gouging, currents, and strudel scour obliterating most of the bedding features.

In many areas of the inner shelf, bottom sediment temperatures are below 0° C, however, ice bonded sediments have not been encountered, perhaps due to the presence of saline interstitial waters.

Geochemical studies of sediments in parts of the eastern Chukchi and western Beaufort Seas show no evidence for anomolous values of selected heavy metals at this point in time.

WORK STATEMENT (Research Unit #206)

I. TITLE: Faulting and Slope Instability in the Saint George Basin Area, and Immediately Adjacent Continental Shelf and Upper Continental Slope of the Southern Bering Sea

II. PRINCIPAL INVESTIGATOR: T. L. Vallier

III. GEOGRAPHIC AREA AND INCLUSIVE DATES:

St. George Basin Area, Southern Bering Sea

June, 1975 through September 30, 1976

IV. COST SUMMARY:

FY 1975	FY 1976
$16,000	$99,000

V. PROPOSED RESEARCH:

A. Background and Objectives

The proposed research is designed to outline and document problems related to seafloor instability along the outer continental shelf and upper continental slope of the St. George Basin area, Southern Bering Sea. This area includes the St. George and Amak Basins, the Bering and Pribiloff submarine canyons, and the outer shelf and upper slope that flanks them. Major environmental concerns in this regime are associated with active faulting and slope instability. The area nearest the Alaska Peninsula, Amak Basin, is subject to frequent earthquakes; some seismicity also occurs in the St. George Basin. Fault scarps have been discovered on the seafloor in the St. George Basin area indicating recent tectonic deformation. The shelf edge is cut by gigantic submarine canyons, and both the canyon walls and the shelf edge are zones of active slumping; some slumps are of massive size. Thick accumulations (+10 meters) of relatively young thixotropic sediment, suspected along the shelf edge in old buried river channels and in canyon heads, add to slope instability. Slumping and active faulting along the shelf edge may be associated with the release of natural gas and oil, although no seeps have been reported.

There is very little existing data. The information that has been collected consists of less than a dozen geophysical lines (relection, magnetic and gravity profiles), bathymetry, and some sediment samples. Only enough is known to outline problems.

In order to properly evaluate the environmental hazards posed by aspects of seafloor instability and faulting, both geophysical and sedimentological data are required. At least two months

of ship time are scheduled in two cruises. The first, of at least one month duration, will take place in September and October, 1975, and the second, of similar length, is planned for the late Spring or early summer of 1976. The first cruise will be principally an underway high resolution geophysical survey with some bottom sampling.

Critical areas of study are the St. George and Amak Basins, and parts of the adjacent Pribiloff and Bering submarine canyons, the outer continental shelf and upper continental slope. Continuous high resolution seismic and magnetic profiling will be combined with side-scan profiling (in selected areas). Sediments and rocks will be sampled in specific areas on a problem-oriented basis, for example across faults, in canyons, and across the upper part of the continental slope.

The second cruise will continue high resolution seismic and magnetic profiling, but will be more concerned with sediment sampling and detailed geophysical surveys of specific areas. Both cruises, to the degree possible, will be coordinated with proposed studies of other investigators who are concerned with details of sediment distributions, dynamics, and related currents. Also, close coordination is planned with on-shore studies of seismicity and volcanic activity.

The extent to which these requirements can be met and reported on by September of 1976 is 25 to 50 percent. With good weather and otherwise successful cruises, this could be raised to 75 percent.

Related programs are being coordinated with investigators at the University of Washington and the University of Alaska, particularly with regards to sediment distribution and sediment dynamics.

B. Methods

All available data will be used to complete this project. Most are now accessible and other data will become available during the next year.

The temporal and spatial sampling scheme must be developed as the preliminary cruise data are analyzed and interpreted. The tentative cruise tracks have been planned for the 1975 cruise, which shows at least fifteen crossings of the St. George Basin area and tracks across canyons and parallel to the shelf edge with a total of about 3,000 nautical miles of tracks. These tracks will be modified both before and during the cruise in order to collect data for solving specific problems, some of which may not even be identified at the present time. The 1976 tracks are not yet planned, but sediment sampling certainly will play a large part in the cruise .

High resolution geophysical gear will be extensively employed. Ship tracks are planned on a grid-like pattern, but are also designed to address problems that will be identified as work progresses. Sediment

sampling devices are gravity, box, and possibly vibra cores, grab samples, and dredges. Side-scan surveys will be combined with bottom photography and television camera studies to investigate areas of potential slumping, faulting, and extensive bottom trawling.

VI. INFORMATION PRODUCTS:

Data from these cruises, combined with data from other sources, will be used to generate interpretive reports and maps which will delineate sea floor instability, hazards, and faults in the St. George Basin area. Specific maps will show zones of active and potential gas and oil seeps. During the latter part of the investigations, a sediment distribution map will be prepared if adequate coordination can be maintained with other investigators.

VII. DATA OR SAMPLE EXCHANGE INTERFACES:

This investigation needs data on sediment dynamics, sediment mechanics, and sediment dispersed, both past and present, in order to answer questions on sediment stability and movement. Data and sample exchanges are planned with other investigators, particularly from the University of Alaska, and University of Washington, with the aim of answering some or all of these questions. The seismic magnetic and bathymetric profiles collected during this investigation, plus splits from the sediment samples, certainly will be needed by other investigators, probably within the same time framework.

VIII. SAMPLE ARCHIVAL REQUIREMENTS:

None is anticipated at the present time. However, requirements may change as work progresses.

IX. SCHEDULE:

First Cruise: Profiles and sediment samples should be accessible by Febraury 1, 1976. Some preliminary interpretations, both as maps and as written reports should be ready by May 1, 1976.

Second cruise: Profiles and sediment samples should be accessible by September 30, 1976. Interpretative reports and maps based on the second cruise will not be ready by that date but should be prepared by March 1, 1977.

Important interfaces between research groups at the University of Washington and the University of Alaska and any other groups deemed important will be maintained during that time interval.

X. EQUIPMENT REQUIREMENTS:

State-of-the-art navigational and geophysical equipment will be used including LORAN C and satellite navigation and high resolution gear which includes a 3.5 Khz mini-sparker, uni-boom, and a 160 Kj arcer,

along with a side scan sonar. Also included will be bottom photography equipment including a television camera system for the second cruise. Bottom sampling devices will be corers, grab samples, and dredges. The television camera system and piston and vibra-corers probably will be available only on the second cruise.

XI. LOGISTICS REQUIREMENTS:

Logistic requirements will be met by the U.S. Geological Survey inasmuch as possible. Ship expenses are requested for the R/V Less. See item XII for figures.

WORK STATEMENT

(Research Unit #208)

I. TITLE: Yukon Delta Coastal Processes Study

II. PRINCIPAL INVESTIGATORS: William R. Dupré
D. M. Hopkins
U. S. Geological Survey
Menlo Park, CA 94025

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Northern Bering Sea
1 July 1975 - 30 September 1976

IV. COST SUMMARY:

FY1975	FY1976
Through 6/30/75	7/1/75 - 9/30/76
Not Funded	Science $13,850
	Logistics 1,150
	Total $15,000

V. PROPOSED RESEARCH

A. Background and Objectives

This study responds to Task D4 -- Evaluate present rates of change along the 250-km shoreline of the Yukon-Kuskokwim Delta; locate areas where coastal morphology is changing rapidly and establish rate of change; and evaluate possible effects of future human activities. In particular, establish cause and frequency of large-scale diversions which have resulted in large changes in the position of the mouths of the Yukon and Kuskokwim Rivers, in order to predict likelihood of future changes and extent to which man's activities and intervention may precipitate or inhibit such a change.

Task B10 - Determine the types and characteristics (grain size distribution, mineralogy) of suspended and bed load sediment brought to the Bering Sea by the Yukon and the Kuskokwim Rivers; estimate annual mass introduced to sea and mass stored on delta and on beaches.

Task D6 - Determine and map distribution, mode of faulting, age of most recent movement, and magnitude of major faults extending across the delta and onto the submerged shelf.

Despite its size and its important role in the sediment budget and hydraulic regime of the Bering Sea, the Yukon-Kuskokwim Delta is a virtually unknown area, and no studies of the type proposed here have ever been conducted. It is covered by a very generalized geologic map published at a scale of 1:500,000, nearly 20 years ago (Conrad and Hoare, 1957) and parts are

covered by bedrock oriented maps prepared by J. M. Hoare and published at scale 1:250,000 between 1960 and 1965. C. H. Nelson has conducted a study of the mercury content of bottom sediments in the mouth of the Kuskokwim River in 1973. All of these studies were conducted by the USGS.

The Water Resources Division of the U. S. Geological Survey established stream gaging stations on the lower Yukon and Kuskokwim River, and daily measurements are now being made of stream flow and water level, and samples are being collected for granulometric analysis of suspended sediment and bed load. These measurements have been in progress for less than a year. No mineralogical studies of the sediments have been undertaken.

Information required to accomplish objectives:

1. Data on historic changes in shoreline and channel position and morphology.

2. Position of pre-historic shorelines, abandoned distributaries, and sub-deltas, and age when these were active.

3. Mineralogical and grain-size analyses and estimates of total volume of suspended and bed load sediments of Yukon and Kuskokwim Rivers.

4. Mineralogical and grain-size analyses and estimates of total mass of modern and ancient beaches and sub-deltas.

5. Data on thickness of Holocene Delta in many places.

6. Field observations of hydrology, sediment trajectories, and dynamics of erosion and deposition along distributaries and at the delta front at various flood stages and storm conditions and <u>especially</u> during the spring break-up.

B. Methods

1. Library research to find old as well as recent maps, photographs, traveller's accounts, air photos, and ERTS photos in order to determine the position and significance of different distributaries and of the shoreline at as many points in time as possible.

2. Obtain USGS-WRD data on granulometry and estimates of mass of suspended and bed load sediment in Yukon and Kuskokwim Rivers, and obtain aliquets or duplicate samples for mineralogical study.

3. Study ERTS photos and ccmpare them with USGS-WRD data on discharge as a means of establishing the extent of water coverage and turbidity plumes at different flood stages and for possible information on dynamics of the spring break-up flood.

4. Seven-to-ten days of fieldwork to seek samples that will characterize the sediments and provide radiocarbon-dating on modern and ancient shoreline deposits and modern and ancient sub-deltas. During this period, gain an idea of dynamic processes of erosion and deposition at the delta front and along distrubutary channels.

5. If time permits, establish a few bench marks from which future shoreline changes can be measured.

6. If supplemental funding can be obtained, return to the field for 10 days in May, 1976, in order to observe hydrology and sediment dispersal during the spring break-up flood.

This is a pilot study, and samples cannot be randomized. Sampling sites will be chosen primarily on the basis of their promise to yield useful geochronological information.

Analytical work will consist of standard granulometric measurements and radiocarbon age-assays, and some mineralogical studies of limited scope.

This study will interface with ongiong studies of sediment distribution and movement on the Northern Bering Shelf (C. H. Nelson, USGS), studies of total sediment budget of Yukon River (Nelson, USGS, McManus, University of Washington), studies of correlation between sediment type and benthic found in S. E. Bering Sea (Skip Hoskins, University of Alaska), and studies of suspended particulate matter in the southeastern Bering Sea (Richard Feely and Joel Cline, PMEL/NOAA).

VI. INFORMATION PRODUCTS

Map and supporting text giving the following information:

Areas of active progradation and active shoreline retreat.
Position of former shoreline and distributary channels at several past times within the last 100 years (historic record) and within last 5000 years (geologic record).

Position and boundaries of sub-deltas and estimates of their ages.
Position of past major diversions of main stem of Yukon River.
Location, character, and age of fault traces.
Location and age of radiocarbon-dated samples.
Locations and character of granulometry samples.
Location and description of bench marks for measuring future shoreline changes.

VII. SAMPLE ARCHIVE

Principal Investigators will collect approximately 100 samples and will hold them for five years and then discard unless otherwise requested.

VIII. SCHEDULE

5/26/75 - 5/31/75 -	Dupré and Hopkins at USGS in Menlo Park for planning of logistics
6/1/75 - 7/31/75 -	Photo-interpretation and literature search
8/1/75 - 8/15/75 -	Field Work
8/16/75 - 5/1/76 -	Photo-interpretation, analytical work, and compilation
5/2/76 - 5/15/76 -	Hopefully, in Alaska for observation of break-up flood
5/16/76 - 6/30/76 -	Prepare report
7/1/76 - 9/30/76 -	Process and reproduce report
9/30/76 -	Submit Final Report

IX. EQUIPMENT REQUIREMENTS: None

X. LOGISTICS REQUIREMENTS

We need seven days fixed-wing or helicopter time and could use up to 30 days support time in Bethel-Hooper Bay-St. Mary's-St. Michael area of Western Alaska. We have budgeted for seven days charter time, but if NOAA can provide air support at no charge to project, more money can be devoted to salary time for Dupré or to a visit for spring break-up.

WORK STATEMENT (Research Unit #209)

I. TITLE: Fault History of Pribilof Islands and its Relevance to Bottom Stability in St. George Basin

II. PRINCIPAL INVESTIGATOR: David M. Hopkins

III. GEOGRAPHIC AREA AND INCLUSIVE DATES:

Pribilof Islands (Southern Bering Sea)

May, 1975 through September, 1976

IV. COST SUMMARY:

FY 1975	FY 1976
$5,500	$44,500

V. PROPOSED RESEARCH:

A. Background

This work statement is directed at the following objectives:

1. Determine and map distribution, mode of faulting, age of most recent movement, and magnitude of offset for major faults extending from sea floor onto the Pribilof Islands (Task D-6).

2. Summarize existing knowledge (unpublished) on frequency of volcanic eruptions on and near the Pribilof Islands (Task D-5).

3. Evaluate rates of change in coastal morphology (Task D-4).

State of knowledge:

1. Barth, T.E.W., 1955, "Geology of the Pribilof Islands, Alaska", U.S. Geological Survey Bulletin 1142-5. Presents general map of faults and volcanic vents on Pribilof Islands, scale 1:250,000.

2. Unpublished geologic map of Pribilof Islands, by D. M. Hopkins, scale 1:25,000. Includes detailed map and generalized age classification of faults, volcanic vents, individual lava flows, sand dunes, old shorelines, and young beach deposits.

Information needed:

Samples and radiocarbon and potassium-argon analyses that will establish more precisely the age of eruptions, fault movements and shoreline erosion and progradation.

Time table:

The study will be completed and reports submitted on or before September 30, 1976.

Related research:

"Faulting and slope instability in the St. George Basin area, Southern Bering Sea", T. Vallier, P.I.

B. Method

All relevant existing information, published and unpublished, is already in the files of the P.I. and will be incorporated into the final reports.

Sampling program is geochronological, and sample sites will be chosen because of their potential usefulness in establishing the age of faulting and volcanism or rates of shoreline changes. Sampling adequacy can and will be evaluated on the basis of replicability of results of analysis of duplicate samples and concordance between geochronological results and geological stratigraphy. Between 25 - 50 stations will be sampled with at least one sample taken per station. These stations will be distributed along the coast of each of the two islands in areas where faults cut little lava flows on sand dunes so that the age of the fault can be determined by measuring the age of the lava flow or the age of the organic matter in the sand dunes. Procedures for evaluating accuracy and uncertainty of radiocarbon and K/Ar age estimates have been standardized for more than a decade and are well-known to earth scientists.

No living animal or plant species will be studied.

VI. INFORMATION PRODUCTS

Map at scale 1:50,000 showing volcanic vents and fissures and active faults on the Pribilof Islands, classified according to the age of last activity, and a brief text giving estimates of frequency of and time of most recent eruptions and fault movements.

Map at scale 1:50,000 showing areas of shoreline progradation and erosion and brief text giving estimates or rates of change.

Geochronological results will be reported in Radiocarbon and in archival publication for K/Ar dating.

VII. INTERFACES:

T. Vallier plans cruise tracks near the Pribilof Islands in order to establish the continuity between faults recognized offshore and onshore and extent offshore of volcanic areas. My field work will be completed 7/1/75 and his cruise will take place 9/75. We will meet in mid-July for final planning session in order to plan optimal cruise tracts.

VIII. Five to twenty radiocarbon samples and 10 to 50 K/Ar samples will be collected. Radiocarbon samples may be completely consumed but if not, P.I. proposes to retain unused splits of both radiocarbon +K/Ar for at least five years. Splits can be made available to other investigators or submitted to EDS/NODC if desired.

IX. SCHEDULE:

6/16/75-6/30/75	Field work in Pribilofs
7/15/75	Coordination meetings with Vallier
9/75	Vallier cruise in Pribilof-St. George Basin area.
3/1/76	Completion of analytical work and data compilation
9/30/76	Submittal of completed reports

Vallier and I will conduct weekly coordination sessions, 10/75 through 5/76.

X. EQUIPMENT REQUIREMENTS:

None

XI. LOGISTICS REQUIRED:

Transportation by commercial airlines except I have requested to share charter from St. Paul Island to St. George Island with Aleut Corporation and to share charter from St. George Island to King Salmon, Alaska with National Marine Fisheries Service (NOAA). Transportation on the islands will be partly with locally rented vehicles, but mostly on foot.

WORK STATEMENT

(Research Unit #210)

I. TITLE: Earthquake Activity and Ground Shaking in and along the Eastern Gulf of Alaska

II. PRINCIPAL INVESTIGATORS: Robert A. Page
John C. Lahr
U. S. Geological Survey
Menlo Park, CA 94025

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Gulf Coast of Alaska
1 July 1975 - 30 September 1976

IV. COST SUMMARY

	FY76
Science	$115,000
Logistics	30,000
Total	$145,000

V. PROPOSED RESEARCH

A. Background and 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. Tasks D-5, 6 and 7 are of primary emphasis.

Currently little is known about potential earthquake hazards in the eastern Gulf of Alaska and adjacent onshore areas. The region is a zone of tranistional tectonics between strike-slip faulting in southeast Alaska and oceanic subduction along the Kenai Peninsula, Kodiak Island and the Alaska Peninsula. The continental shelf area between Kayak Island and Cross Sound is recognized as a transient gap in the circum-Pacific belt of recent

seismicity and is thought to be one of the most likely sites for a future major (magnitude 7 or larger) earthquake in southern coastal Alaska. A major aim of the proposed research will be to develop an understanding of what geologic structures in the seismic gap have generated and are capable of generating damaging earthquakes.

A second aim of the proposed research is to obtain recordings of strong ground motion close to the zone of energy release in a major earthquake. Currently no such records have ever been obtained within 40 km of a magnitude 7 earthquake or within more than 100 km of a magnitude 8 earthquake. Without such information there is currently a disturbing uncertainty in regard to the nature of the ground shaking that causes major damage.

Information required to meet the research objectives include computer relocations of historic earthquakes, historic earthquake reports, computer locations and focal mechanism solutions of current earthquakes, and locations of offshore faults. All of these requirements can be met fully, or at least mostly, by September 30, 1976.

The proposed research is closely coordinated with the offshore fault investigations of the U.S. Geological Survey; information generated by either study will be made available to the other to assist in the interpretation of geologic hazards. The principal investigators are in close communication with investigators at the Geophysical Institute of the University of Alaska and at the Lamont-Doherty Geological Observatory of Columbia University who are studying seismicity and seismic hazards in the Kodiak Island and Alaska Peninsula-southern Bering Sea regions.

B. Methods

Seismically active offshore faults will be delineated by two techniques. First, small offshore and coastal earthquakes will be located from data recorded by the onshore seismograph network. Second, recent and historic earthquakes large enough to be recorded at distant seismographs will be relocated to minimize location errors using standard computer techniques, such as the master-event technique. Both techniques have been successfully used by the USGS in studying offshore earthquake sequences off the coast of southeast Alaska.

The critical review of historic earthquake activity in the eastern Gulf of Alaska region will include relocation of earthquakes to minimize location errors, as discussed above, and examination of felt reports and earthquake observations to better understand the locations and mechanisms, frequency of occurrence, and tectonic significance of historic earthquakes.

VI. INFORMATION PRODUCTS:

1. Catalogs and maps of earthquakes as small as magnitude 2.0 for the continental shelf and coastal areas in the eastern Gulf of Alaska.

2. Scientific report(s) evaluating seismic hazards in the eastern Gulf of Alaska in terms of expectable earthquakes and capable faults on the basis of current small earthquake activity, historic moderate and large earthquake activity, and submarine faults identified by marine geophysical surveys.

3. Strong-motion records for ground shaking from offshore earthquakes of magnitude 6 and greater in the continental shelf area of the Gulf of Alaska between Cross Sound and the Shumagin Islands.

VII. DATA OR SAMPLE EXCHANGE INTERFACES:

All of our seismic data is routinely shared with NOAA and this practice will continue. The data is also available for the use of other interested parties.

Magnetic tapes of recorded earthquake hypocenters, origin times, depths, and magnitudes will be submitted to the Juneau Project Office for archival.

VIII. SAMPLE ARCHIVAL REQUIREMENTS:

Films and magnetic tapes of raw seismic data recorded in part with these funds will be stored at the National Center for Earthquake Research, U.S.G.S., Menlo Park, CA.

Magnetic tapes with recorded earthquake hypocenters, origin times, depths and magnitudes will be archived within the Environmental Data Service of NOAA.

Any strong-motion records obtained in this program will be archived, processed and disseminated by the Seismic Engineering Branch of the U.S. Geological Survey through the data retrieval and dissemination program funded by the National Science Foundation under the RANN Program.

IX. SCHEDULE:

	Date
Catalog and Map of Historic Earthquake Data	July 1975
Catalog and Map of Earthquakes as small as magnitude 2.0 for October 1974 - June 1975	Dec. 1975

Magnetic tape of earthquakes for archival:

July 1975 - Sept. 1975	Dec. 1975
Oct. 1975 - Dec. 1975	Mar. 1976
Jan. 1976 - Mar. 1976	June 1976
Apr. 1976 - June 1976	Sept.1976
July 1976 - Sept. 1976	Dec. 1976

X. EQUIPMENT REQUIREMENTS:

Standard seismograph equipment for recording strong ground motion and for recording of small local earthquakes will be utilized. Twelve strong-motion accelerographs will be deployed in the summer of 1975. Eight short-period telemetering seismographs will be installed in the summer of 1976.

XI. LOGISTICS REQUIREMENTS:

28 days - Helicopter Charter

Location	Dates (To be arranged)
Yakutat Bay to Cordova	June through August 1975
Cross Sound to Cordova	June through August 1976

Helicopter requirement: Two men and 250 lbs. gear plus pilot and fuel to 8000 ft elevation.

The USGS can arrange to meet the helicopter requirements but will need an estimated $30,000 in funding support to do so.

WORK STATEMENT

(Research Unit #212)

I. TITLE: Erosion and Deposition of Shelf Sediments: Eastern Gulf of Alaska

II. PRINCIPAL INVESTIGATORS: Bruce F. Molnia
Paul R. Carlson
U. S. Geological Survey
Menlo Park, CA 94025

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Eastern Gulf of Alaska
1 July 1975 - 30 September 1976

IV. COST SUMMARY:

	FY 1976
Geology	$ 88,093
Logistics	52,000
Total	$140,093

V. PROPOSED RESEARCH

A. Background and Objectives
Tasks: B-10, B-11

The continental shelf of the eastern Gulf of Alaska is a very dynamic environment. Rivers and streams carry vast quantities of glacial silt and clay to this shelf, which is affected by strong, longshore currents, frequent periods of high energy storm waves, and occasional seismic sea waves (tsunamis). If this area is to be a safe one for petroleum production, the physical characteristics and dynamic nature of the shelf sediments must be carefully studied. The stability and maintenance of drilling rigs, production platforms, pipelines, and shoreline based facilities are all affected by the erosional and depositional hazards of this high energy shelf. For all practical purposes, adequate sediment data are not available for the OCS leasing areas in the eastern gulf.

We estimate that between 25 and 50% of this knowledge can be obtained and reported on by 30 September 1976.

Related research in the Gulf of Alaska includes Research Units #216 (Faulting and Instability of Shelf Sediments), #59 (Coastal Morphology and Sedimentation), #99 (Geology and Geomorphology), and #152 (Distribution, Composition, and Transport of Suspended Particulate Matter).

B. Methods

In order to locate problem areas of either excessive erosion, deposition or sediment by-passing, a defining sediment sampling program is proposed for the period July 1975 - September 1976. Seafloor deposits will be collected with box, piston, vibra and gravity cores. Sample locations will be initially selected based on: high-resolution seismic profiles and side-scan sonar records (see related Proposal Research Unit #216) especially in proposed areas for lease. Sample collection will also be based on experience gained in the course of the work.

Samples collected will be described and analyzed for physical parameters (mean size and sorting), sedimentary structures (which will provide clues to processes active on the seafloor), and composition.

VI. INFORMATION PRODUCTS

1. Analyses and maps of distribution of surface sediment types.

2. Analyses and maps of major areas of erosion, deposition and sediment by-passing.

3. Maps of sediment size variations and other sediment parameters (mean, sorting, % gravel, sand and mud).

4. Analyses and maps delineating areas of principle sedimentary structures and surface bedforms.

5. Analyses and maps of primary sedimentary sources and sinks (i,e., sediment budget).

6. Interpretative papers considering the dynamics of the major sedimentary processes affecting the shelf.

VII. DATA OR SAMPLE EXCHANGE INTERFACE

Comparisons will be made between distribution of bottom sediments and near-surface (suspended) sediments studied by Feely and Cline (Research Unit #152). Selected samples collected by Feely and Cline will be X-rayed to determine clay mineral content of the suspended sediments (and) to compare to the mineralogy of the bottom sediments. Splits of selected box core samples will be collected for University of Alaska benthic biologists (Feder, Research Unit #281).

VIII. SAMPLE ARCHIVAL REQUIREMENTS

Sample archiving will be done in house.

IX. SCHEDULE

Our sampling will be based on careful analysis of the seismic reflection profiles and upon experinece gained during the course of the study. We will comply with the data acquisition format and schedule to the best of our ability.

X. EQUIPMENT REQUIREMENTS

Precision navigation is vital to assure accurate location of sediment samples. A Loran-C or sonar-doppler system, will be utilized with satellite navigation providing backup, especially for those stations at or near the outer limits of navigation controls.

A 3.5 KHz system (or uniboom) will provide the needed stratigraphic information to assure propoer placement of core samples. This seismic system will, hopefully, involve a hull-mounted transducer and thus will not have to be hauled in at each sampling station. Other systems that will be used include a mini-sparker, to resolve the full thickness of thicker sediment bodies and a side scan sonar to provide information about the surface texture and structure of important sediment masses.

The type of corer used, i.e., box, piston, vibra, gravity or dart, will depend on the sediment type and thickness. A large, high speed winch (20,000 lbs pulling strength; line-out speeds of > 100 m/min; ½" wire rope at least 3,000 metres in length; large, movable A-frame) must be used, one equipped with a sensitive tensiometer.

XI. LOGISTICS REQUIREMENTS

When: Sometime during June through September, to take advantage of best weather season.

Where: Eastern Gulf of Alaska from Cross Sound to Montague Island (136 W-148 W).

How: Ships needed.

20 days - (USGS operated and specially equipped)
15 days - small inshore vessel (charter or lease)

WORK STATEMENT

(Research Unit #216)

I. TITLE: Faulting and Instability of Shelf Sediments: Eastern Gulf of Alaska

II. PRINCIPAL INVESTIGATORS: Paul R. Carlson
Bruce F. Molnia
U. S. Geological Survey
Menlo Park, CA 94025

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Eastern Gulf of Alaska
1 July 1975 - 30 September 1976

IV. COST SUMMARY:

	FY1976
Geology	$123,649
Logistics	40,000
Total	$163,649

V. PROPOSED RESEARCH

A. Background and Objectives
Tasks: D-2, D-6

The tectonically active nature of the eastern Gulf of Alaska makes it imperative to closely examine the seafloor on the continental shelf before petroleum activities commence. Major earthquakes will occur that may damage installations on the shelf or along the coast. Hazards include ground shaking, fault displacement, and tectonic warping, and ground failure (e.g., 1964 at Valdez and Seward). Numerous onshore faults (several of which have been active in the past century) have been mapped to the shoreline of the Gulf of Alaska. It is not known if these continue across the shelf. It is, therefore, imperative that offshore faults be mapped and a determination made regarding magnitude and age of offset. A second and related hazard is that of ground failure, such as submarine slumps or slides. The thick sequences of unconsolidated sediment which are being deposited off rivers (e.g., Copper River) and streams draining this glaciated region are susceptible to failure caused by earthquakes or by agitation related to storm waves, seismic sea waves (tsunamis), and the nebulous internal waves. Ground failure can also result if these water saturated sediments are overloaded by continuing deposition or by improperly designed and overloaded man-made structures. In order to make environmentally safe decisions, knowledge is therefore needed about the distribution, thickness, and type of these unconsolidated sediments.

We estimate that between 25 and 50% of this knowledge can be obtained and reported on by 30 September 1976.

Related research in the Gulf of Alaska includes Research Units #327 (Faulting and Instability of Shelf Sediments: Western Gulf of Alaska), #210 (Earthquake Activity and Ground Shaking along the Eastern Gulf of Alaska), and #212 (Erosion and Deposition of Shelf Sediments: Eastern GUlf of Alaska).

B. Methods

Very little marine geological or geophysical data of a non-proprietary nature has been gathered in the Gulf of Alaska. However, reconnaissance lines of high resolution reflection profiles have recently been run across part of the OCS lease area (Montague Island to Icy Bay) in the eastern Gulf. Additional reconnaissance lines will be run between Cross Sound and Icy Bay in April and May, 1975. These data, when fully interpreted, will provide a base of knowledge for subsequent detailed profiling.

Faults that have been observed on one or more crossings will be traced to determine the strike and offset characteristics of the fault zone. This tracking will include, in addition to high resolution seismic profiling, selected lines of side-scan sonar to determine the character and continuity of surface rupture, Dart cores and box cores will be collected in approporiate areas where the age of the sediment broken by faulting might be determinable.

High resolution reflection profiles also will be obtained over areas thought to be most prone to slumping or sliding. These areas include those of thick sediment accumulation and relatively steep slopes, such as the submarine extension of the Copper River Delta, the margin of the depression west of Kayak Island, the continental shelf slope-break throughout the OCS area, and the flanks of several sea valleys that are incised into the shelf. Selected piston cores, box cores and vibra cores will be collected in these areas of high potential for bottom failure. These cores will be used to determine the physical properties of the sediment.

In order to trace faults and identify areas of sediment instability in very shallow water (<15m) a small boat (<100' long) operation also will be conducted.

Standard geological and geophysical analyses of the seismic reflection profiles and core samples will be completed. Sediment cores will be analyzed for particle size, composition and sedimentary structure.

VI. INFORMATION PRODUCTS

1. Maps of faults, surface and near surface.

2. Isopach map of "modern" sediment.

3. Maps of sediment slumps and potential slumps or slides.

4. Maps of surficial sediment distribution.

5. Precision map of seafloor topographic features.

6. Hazards map - fault zones, slumps, etc.

7. Interpretation to accompany the maps noted above.

VII. DATA OR SAMPLE EXCHANGE INTERFACES

We will maintain dialogues with Page and Lahr (Research Unit #210) and the Western Gulf of Alaska team (Research Unit #327) with regard to their studies of seismicity and ground failure respectively.

We will also work closely with USGS land-based geologists in order to relate onshore faulting and geologic framework and stratigraphy to geologic hazards encountered in the Gulf of Alaska OCS area.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

Sample archiving will be done in house. However, storing of magnetic tapes and analog records will be required for public availability.

IX. SCHEDULE

Our sampling will be based on careful analysis of our seismic reflection profiles and upon experience gained during the course of the study. We will comply with the data acquisiton format and schedule to the best of our ability.

X. EQUIPMENT REQUIREMENTS

Precision navigation is of prime importance to this study. Satellite navigation and/or Loran C, and/or a sonar-doppler system will be provided on a USGS operated and specially equipped vessel.

High resolution seismic profiling will be accomplished with a 3.5 KHz transducer and an 800 Joule mini-sparker system. The sparker has good resolution, operates well even in rough seas, and is compact; therefore, it can be used in a small boat (50-100') which will allow us to follow faults in very shallow water (<15m).

An EG&G side-scan sonar system will be deployed over selected areas to provide needed "three-dimensional" profiles of fault zones. This system also is compact and therefore useable in the planned small boat operation, as well as on board larger vessels.

Sampling from the larger vessels will be done with piston, dart, vibra, and box corers, all of which require high speed (<100 m/min.) winches with at least 3000 meters of ½" wire. Sampling also will be conducted from the small boat; by necessity only lighter equipment will be operated.

XI. LOGISTICS REQUIREMENTS

Because of weather conditions, the best time to carry out these operations in the Cross Sound to Montague Island area is June through September. Fifteen days on a larger vessel (Class II or III) and 15 days on smaller inshore vessles will be needed. Because of man-power and equipment problems, these cruises cannot be simultaneous. Vessels will be manned and operated by USGS.

JUN 3 0 1975

RESEARCH UNIT #251

WORK STATEMENT

I. TITLE: Seismic and Volcanic Risk Studies - Western Gulf of Alaska

II. PRINCIPAL INVESTIGATORS:
Hans Pulpan - SS#: 337-40-5563
Juergen Kienle - SS#: 574-20-0499
Geophysical Institute
University of Alaska
Fairbanks, AK 99701
(907) 479-7424

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Western Gulf of Alaska (Lower Cook Inlet Kodiak Semidi Islands). 1 July 1975 - 30 September 1976

IV. COST SUMMARY:

FY75	FY76
$36,890	$146,827

V. PROPOSED RESEARCH

A. Background and Objectives

The Gulf of Alaska is an area of extremely high seismic and volcanic risk. The seismic and volcanic activity is the consequence of plate convergence, the Pacific crustal plate underthrusting the North American plate in a northwesterly direction along the Aleutian Island arc and its extension into mainland Alaska. Large earthquakes occur regularly in this area. The most recent major earthquake was the March 27, 1964, Prince William Sound Earthquake (M=8.5), which also generated a major tsunami. The rupture, as outlined by the aftershock zone, extended from Prince William Sound to the southwestern end of Kodiak Island. The adjacent crustal blocks to the southwest (Semidi-Shumagin Islands) and to the east (Yakataga) of the 1964 rupture zone are identified seismic gaps, i.e. regions where substantial seismic strain was not released through a major earthquake for quite some time, and hence are likely sites for the next major earthquake. Recognizing the high risk in these gaps and the unique seismotectonic problems of the area in general, regional seismic networks were installed in the past few years by the USGS (southcentral and southeastern Alaska), Columbia University (Shumagin Islands), and the University of Alaska (Lower Cook Inlet - Semidi Islands). These networks are complemented by the seismic stations of the NOAA tsunami warning system. All four agencies cooperate closely through data exchange and logistic support.

Simultaneously, with the above effort, the University of Alaska has begun to study the activity state and potential environmental hazard of two selected Cook Inlet volcanoes, Redoubt and Augustine. Both volcanoes pose a considerable threat to oil development in that area. Augustine, an island volcano, has generated a series of three tidal waves during eruptive activity in 1883, which crossed the entire lower Cook Inlet arriving at English Bay on the Kenai Peninsula with maximum amplitudes of 25-30 feet. Violent eruptions in 1964 culminated in the extrusion of a lava plug dome, 230 meters in height. The volcano poses a very serious threat to any exploration or drilling operation on the island itself.

The research programs associated with the above networks attempt to develop a better understanding of the fundamental tectonic and volcanic processes associated with plate convergence and also to provide the basis for developing an earthquake prediction capability. The logistic difficulties and high costs of operation have resulted in a rather moderate pace toward obtaining enough data to achieve our goals. However, the existing instrumentation and studies in this area provide an excellent backbone for an expansion of high seismic arrays, very much suited for the assessment of the seismic and volcanic hazards to oil development activities on the Outer Continental Shelf.

We propose to investigate these risks on the continental shelf section located between the lower Cook Inlet and the Semidi Islands. The objectives of the investigation are:

1. Determination of the seismicity of the area and its relationship to large and small scale tectonic structure, (Task D-7). The emphasis would be on the delineation of active on-and offshore faults and the determination of their mode of deformation through fault plate solutions. This will partly compliment the high resolution seismic reflection profiles work of task D-6 (Research Unit #327). We propose to add eleven short period seismic stations to the existing network in order to lower the present detection threshold to magnitude 2 - 3 earthquakes. Six stations would be installed on Kodiak Island, two in the lower Cook Inlet, and three in the Katmai-Alaska Peninsula area. The most accurate hypocenter locations would be obtained for the lower Cook Inlet and the Katmai-Shelikof Strait-Kodiak region. The location quality of offshore foci will suffer from the one-sided station distribution, which cannot be improved without expensive ocean bottom seismometry. Results from the improved network will be combined with hypocentermaps based on historic earthquakes (Task D-5) in coordination with Research Unit #352. If necessary, the historic hypocenters would be relocated using improved crustal models based on all available data (seismic and marine geophysical).

2. Monitor the microearthquake activity (an indicator of eruption potential) of two active volcanoes in Cook Inlet, Augustine and Redoubt.

B. Methods

Signals from existing and proposed stations will be transmitted to the University of Alaska's recording site at Homer, via VHF telemetry links and telephone lines, following presently employed techniques and will be recorded on two film recorders (develocorder). A computer program, HYPO, developed by the U.S.G.S. and presently in use at the seismology lab, will be used for the hypocenter determination. Fault plane solutions will be obtained for selected events in order to determine the mode of faulting of seismically active faults.

VI. INFORMATION PRODUCTS

1. Epicenter maps of the specified area at a much higher resolution than presently available.

2. Fault plane solutions for selected events.

3. Plots of frequency of occurrence of earthquake activity of Augustine and Redoubt Volcanoes.

VII. DATA OR SAMPLE EXCHANGE

The following Data will be requested from EDS:

1. Hypocenter locations (maps and listings) of historic events.

2. 70 mm film chips of selected events recorded over the WWSS.

3. Marine geophysical plots (gravity, magnetics, reflection seismic) of the Gulf of Alaska.

We will solicit EDS's help to produce epicenter maps and cross-sections from the earthquake data catalogue accumulated during the contract period.

VII. SPECIAL ARCHIVAL REQUIREMENTS: None

~~IX~~ SCHEDULE

Installation:

Late summer - fall, 1975:	6 Kodiak Stations 2 Cook Inlet Stations
Spring - summer, 1976:	3 Katmai - Alaska Peninsula Stations
Data Acquisition:	Continuous after installation of the seismic arrays

Data Analysis: Continuous

Milestones: Quarterly hypocenter catalogues

Interfacing with other programs: Tasks D-5 and D-6

X. EQUIPMENT REQUIREMENTS:

Eleven remote seismic stations will be purchased.

XI. LOGISTIC REQUIREMENTS

Helicopter support (Jet Ranger) will be required for both installation and maintenance of the seismic array. We estimate a total flying time of about 60 hours will be needed.

ALASKA MARINE ENVIRONMENTAL ASSESSMENT PROGRAM
WORK STATEMENT (Research Unit 253/255/256)

JUN 3 0 1975

I. TITLE: Offshore Permafrost - Drilling, Boundary Conditions, Properties, Processes and Models

II. PRINCIPAL INVESTIGATORS: Dr. T. E. Osterkamp - SS#: 357-28-7107
Dr. W. D. Harrison - SS#: 554-70-4301

Address: Geophysical Institute
University of Alaska
Fairbanks, AK 99701

III. GEOGRAPHIC AREA AND INCLUSIVE DATES:

Beaufort Sea - April 1, 1975 to September 30, 1976

IV. COST SUMMARY:

FY 1975	FY 1976
through June 30, 1975	July 1, 1975 - September 30, 1976
$44,302	$45,698

V. PROPOSED RESEARCH:

A. Background and Objectives

We propose a comprehensive program to study offshore permafrost in the Beaufort Sea. It will focus on the following three activities:

(1) A near shore drilling program in spring 1975, with an emphasis on conditions near the shore.

(2) Determination of the properties of sea-bottom sediments in shallow water areas (<5 m) which are particularly important to offshore permafrost; specifically, temperature, salt content and sediment characteristics. These provide essential boundary conditions for models.

(3) Preliminary laboratory and theoretical work necessary for an understanding of the permafrost regime, with an emphasis on the coupling of chemical to thermal processes.

This proposal is directed at the following tasks in NOAA's proposal to BLM.

Primary Tasks: D-8 and D-9
Secondary Tasks: B-10, B-11, D-2, A-33 and A-34

1. Present State of Knowledge

Drilling at Barrow confirmed subsea permafrost in Elson Lagoon and near the barrier islands. Both the drilling and seismic work indicate that this permafrost is not ice-bonded.

The oil industry has reported bonded subsea permafrost in Prudhoe Bay and near Stump Island. This has recently been confirmed by the Principal Investigator.

Subsea permafrost distribution, character, boundary conditions, physical and mechanical properties, and its relation to geologic setting, currents and soil types are still unknown.

2. Information Required to Meet Objectives

(a) Drilling, sampling and core analysis.
(b) Thermal and chemical boundary conditions obtained on a seasonal basis.
(c) Experiments on salt water infiltration into permafrost.
(d) A predictive model based on the above information and including effects of geologic setting, currents and shoreline history.

3. What Will be Done by September 30, 1976?

(a) Drilling, sampling and core analysis at selected sites near Prudhoe Bay.
(b) Thermal and chemical boundary conditions for 1.25 years at selected sites near Prudhoe Bay.
(c) A preliminary investigation of the permeability of permafrost to sea water.
(d) Thermal properties of a few selected cores.
(e) A conceptual model will be constructed and some limiting cases solved. The framework for a coupled mass and energy transport model will be developed.

4. Related Research

This work has been coordinated with that of USGS, CRREL, R. Lewellen and other investigators (eg. Naidu, Univ. of Alaska). We have also discussed our proposed work with industry representatives and have obtained drilling data (logs) on subsea permafrost and temperature data from a deep well located next to the beach at Prudhoe Bay.

B. Methods

(a) Use of Available Information

See A.1 and A.4 above. Seismic information from Dr. Rogers, Univ. of Alaska and USGS will also be used.

(b) Sampling Strategy Methods and Analysis

Drilling Drilling in the Alaskan Beaufort Sea to study offshore permafrost began with Lewellen's continuing project near Barrow. Next year, a large-scale USGS-CRREL project is planned for Prudhoe Bay. The University of Alaska also has a modest Sea Grant/AOGA funded project planned for Prudhoe Bay this year. NOAA's BLM assessment studies will augment the latter project.

Work will be done in the vicinity of Pt. McIntyre. One hole will be drilled in each of several representative areas: where the ice does not freeze to the bottom, where it does, and on the beach. On shore, two adjacent shallow holes will be attempted for a preliminary permeability experiment. Of all holes drilled, at least one hole will be about 50 m deep, the others shallower.

Concentration will be on these near-shore areas because several different regimes are represented, and to avoid overlap with the USGS-CRREL project, which will drill further out.

Drilling will be done by the Alaska State Highway Department materials laboratory. They have had wide experience in soil sampling in cold regions, and have the laboratory capability to perform a range of standard soil tests.

Equipment will be transported to Prudhoe Bay by the highway department. Drilling will begin late in April and will continue for about 14 days, drilling about 10 hours a day. Drilling will be by standard rotary methods usually using bentonite mud as the circulating medium in order to minimize contamination of the samples with sea water. Equipment will be available for standard penetration tests, as will split tube samplers, shelby tubes, split tube rotary samplers, and core barrels.

The drilling crew will consist of three men, one of whom will be the geologist logging the hole. Harrison and Osterkamp will also be present.

In situ temperature will be measured by probing into the bottom of the hole. The success of this procedure will depend upon the hardness of the material and the stability of the hole. An attempt will be made to place a thermistor cable in the deepest hole.

JUN 3 0 1975

Thermal and Chemical Boundary Conditions The presence and characteristics of offshore permafrost are determined by factors which include the mean annual sea bottom temperature and salinity, the nature of the sub-sea material, sea-level and shoreline history, ocean currents and geological setting. This part of the proposal addresses the first and, to some extent, the second of these factors. The sea-bottom temperature and salinity are the essential boundary conditions for the coupled heat and mass transfer models which are needed to describe the distribution of permafrost with depth, area and time (described below under "Properties, Processes, and Models").

Efforts will be limited to water depths under 5 meters. These shallow water areas may extend up to 15 km from the coast and include all the major bays and areas inshore of the barrier islands.

Since the temperature and salinity vary widely over the year, measurements will be made several times during the year, probably in February, May, August and November.

During the initial April 1-June 30 reconnaissance, work is planned in the vicinity of Pt. McIntyre, mostly with simple equipment which is being developed as part of the University of Alaska Sea Grant Project on Offshore Permafrost. The full-scale program will be carried out during the July 1, 1975-September 30, 1976 period. At least one line of stations seaward from Pt. McIntyre and ~ 30 km lines to the east and west are planned. Other stations will be occupied as time and conditions permit.

Most of the work will be done on the fast ice by two men using snow machines and sleds. Site location will be by Brunton compass and snow-machine odometer. Precise location by theodolite and distance ranger may be attempted if warranted by rapid facies change. A small outboard motor boat will be used for summer work.

Temperature in ice, water and soil will be measured with the thermistor sensors using a precision Wheatstone Bridge. A 50 m thermistor cable will be installed offshore and a 15-20 m cased hole will be drilled on the beach for temperature logging. This will be done in connection with the drilling described in "Drilling" above. For soil temperature measurements a hollow metal rod will be driven into the soil and a thermistor probe inserted through it. For soil samples, a lightweight tripod, cathead, hammer and drive sampler will be used in addition to hand driven samplers and grab samplers. Past experience indicates depths of 5-10 m can be attained in fine-grained unbonded soils but much less in gravel. The pore water salinity, pore water chemistry, and the routine index and mechanical properties of a few selected soil samples will also be determined.

Properties, Processes, and Models Under the development of Lachenbruch and others, the application of the principles of Fourier heat conduction to the on-shore permafrost regime has enjoyed considerable success. Although this can serve as a guide, it is likely that a more complicated framework will be necessary for the interpretation, and ultimately, prediction, of the off-shore regime. This is because the infiltration of brine, the diffusion of salt, and the requirements of phase equilibrium probably cause a significant coupling of thermal, chemical and hydrologic processes.

The following list includes the input for a fairly complete boundary value model of the off-shore permafrost regime:

(1) An understanding of the processes, their coupling, and relative importance.

(2) Material properties, particularly those governing mass transport rates. The thermal properties are much better known.

(3) Geothermal heat flux. This is fairly well known.

(4) Shoreline history, and the associated problem of sedimentary processes off-shore.

(5) Distribution of ocean bottom temperature and salinity with area and time, preferably below the depth of seasonal fluctuations, probably 5 or 10 m.

(6) Some idea of temperature and salinity distribution with depth before ocean transgression. In fairly recently flooded areas we already have some idea of this temperature.

Other information, such as the present day distribution of temperature with depth, is also important. On-shore it has been used to deduce something about the history of surface temperature, which is the analogue of (5) above. (5) was addressed in "Thermal and Chemical Boundary Conditions" of this proposal; (1) and (2) are addressed here.

Because the boundary conditions are not yet well-known, nor the processes understood, it is not now feasible to construct a numerical model of off-shore permafrost. It is necessary instead to consider restricted classes of coupled thermal, chemical and hydrological processes and models. Our reason for doing this now is that serious experimental efforts in the Alaska Beaufort Sea are beginning, and such considerations point out just what measurements need to be made. For example, preliminary work illustrates how the evolution of the off-shore regime may be controlled by mass transport processes, with the conventional thermal properties having only a second order effect.

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Emphasis will be on studying processes and their interaction, rather than on detailed numerical calculation.

The scope of this work is severely limited by the available funding. In order for a realistic model to evolve, these simple models need to be synthesized and up-dated as more field data become available. Funds from the NSF Arctic Off-Shore Program will be sought for this.

Some in situ field experiments and laboratory experiements focusing on the thermal and chemical transport processes are necessary for understanding the offshore permafrost regime. These include:

(1) The in situ investigation of the permeability of the permafrost to sea water.

(2) The investigation of the infiltration of salt water into core materials.

(3) Thermal properties--conductivity, effective heat capacity, ice content and freezing point depression.

(4) Hydrologic properties, particularly the hydraulic conductivity.

All of these experiements will not be possible at the available level of OCS funding and only a preliminary investigation of (1) is proposed. Thermal properties will be measured on a few selected cores using Sea Grant funds and additional funding will be sought for (2), (3), and (4) from the NSF Arctic Offshore Program and the University of Alaska Sea Grant Program.

VI. INFORMATION PRODUCTS

All field data, laboratory results and theoretical analysis will be presented in reports, in graphical form or using tables and charts. Raw data will be in the form of log-book entries and vertical cross section core plots.
Specific products will include:

(1) Depth of the top of the bonded permafrost below the ocean bottom, if present, in all bore holes near Prudhoe Bay.

(2) Salinity and temperature on a seasonal basis near the bore holes, and temperature profile in some bore holes.

(3) Bore hole logs and characterization of selected core samples extracted from the bore holes.

(4) Soil characterization of the sea bottom sediments near the bore holes.

(5) A discussion of the processes, their coupling, and relative importance in a model of offshore permafrost.

VII. DATA OR SAMPLE EXCHANGE

We anticipate doing salinity and possibly other measurements on USGS-CRREL cores and therefore need samples from them.

We will also need temperature profiles and soil analysis information from USGS-CRREL and R. Lewellen's drilling projects.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

We will store our cores at the Geophysical Institute, University of Alaska. These cores will be available to other investigators.

IX. SCHEDULE

Spring, 1975 - Near shore drilling and sampling in water < 5 m in depth to avoid overlap with the USGS-CRREL drilling program. Temperature, salinity and ice content will be determined to obtain the thermal and chemical boundary conditions.

Summer, 1975 - Near shore bottom temperature measurements and bottom sampling. Sample analysis.

Fall, 1975 - Near shore bottom temperature measurements and shallow sampling. Sample analysis and modeling efforts.

Winter, 1976 - Near shore bottom temperature measurements and shallow sampling. Sample analysis and modeling efforts.

Spring, 1976 - Near shore bottom temperature measurements and shallow sampling. Sample analysis and modeling efforts.

Summer, 1976 - Complete analysis and write reports.

The experience we obtain by drilling and sampling in Prudhoe Bay will be of importance to the Spring, 1976, efforts of USGS-CRREL. Their samples and data will be of interest to us for salinity analysis and for our theoretical work.

X. EQUIPMENT REQUIREMENTS

Our equipment can be purchased or constructed at the University of Alaska.

XI. LOGISTICS REQUIREMENTS

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April 15-May 20, 1975 - Our requirements have been satisfied.

July 20-30, 1975 - (a) Food and lodging, two men, Prudhoe Bay.
(b) Small outboard powered boat (an 18'-22' Boston Whaler with 2-20HP engines is ideal).
(c) Transportation from lodging area to boat mooring area (preferably the new dock).

October 20-30, 1975 - (a) Food and lodging, two men, Prudhoe Bay.
(b) Transportation from lodging area to new dock.
(c) Over-ice transportation - snow machines or tracksters.
(Odometers would be desirable on these vehicles).

February 18-28, 1976 - (a) Food and lodging, two men, Prudhoe Bay.
(b) Transportation from lodging area to new dock.
(c) Over-ice transportation - snow machines or tracksters.

April 20-30, 1976 - (a) Food and lodging, two men, Prudhoe Bay.
(b) Transportation from lodging area to new dock.
(c) Over-ice transportation - snow machines or tracksters.
(d) Plus three days helicopter time - 30 hours (4 place helicopter).

JUN 30 1975

Seacoast

WORK STATEMENT (Research Unit #271)

I. Title: Beaufort Seacoast Permafrost Studies, May 1, 1975

II. ~~Principal Investigator~~: James C. Rogers
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
(907) 272-5522
SS#: 574-14-2391

III. Geographical Area: Alaskan Beaufort Sea Coast with emphasis at Prudhoe Bay and Point Barrow

Inclusive Dates: April 30, 1975 - Sept 20, 1976

IV. Cost Summary

FY 1975 - $80K

The budget, through June 30, 1975, is designed to provide for acquisition of seismic refraction equipment that will be used during the field programs during 1975 and 1976. University of Alaska Sea Grant funds will be used to provide salaries during the 1975 field work program. Additional funds will be sought for subsequent data analysis and for the 1976 field season from the Alaska Sea Grant program and also from industry.

V. Proposed Research

A. Background and Objectives

The known oil reserves along the Beaufort Sea Coast coupled with a national need to develop these resources have focused increased attention on the distribution and character of permafrost in that area. Of particular concern to this project is the comparatively unknown areas offshore and along the barrier islands. Recently priorities have been established for attacking the problem area and a high priority was established for mapping the distribution of offshore permafrost.

The work statement outlines a study of coastal offshore permafrost which utilizes seismic refraction techniques to probe the ocean bottom along the Alaskan Beaufort Sea Coast. It will provide information relevant to task D-8 in NOAA's proposal to BLM. Recent work has demonstrated the value of

this method for mapping bonded permafrost offshore (Rogers, et al, 1975; Hunter, 1974; Hunter and Hobson, 1974) while previous work demonstrated its value on bonded permafrost studies onshore (Roethlisberger, 1972, Hobson, 1962).

The most important parameter to be determined in this study is the distribution of offshore permafrost. Also, the depth to the top of the bonded permafrost beneath the ocean floor, and its thickness, are sought. Presently there are many indications of permafrost offshore in the Canadian Arctic, but the conditions offshore in Alaska are relatively unknown. This study seeks to fill that gap. Using the equipment purchased in this program, data will be gathered which will be of immediate and practical value in determining the distribution and nature of offshore permafrost existing today. An objective is compilation of the above parameters for use by other principal investigators, as well as appropriate agencies and industries.

The distribution study will primarily focus on the Prudhoe Bay area with secondary emphasis at Pt. Barrow. In addition, a transect of the Beaufort Sea Coast will be made from Pt. Barrow to determine subbottom permafrost occurrence.

The truncation of permafrost beneath the ocean is of interest, particularly the shape of the frozen-nonfrozen boundary. Thus, the second major objective is the determination of the shape of this boundary near Barrow and Prudhoe Bay. These results will provide valuable information for refinement and testing of thermal models.

The third major objective is to provide information to support drilling programs including those of the University of Alaska, CRREL, and the USGS. Drilling provides good information on bottom conditions only near the drill hole. It is possible, using the seismic technique, to extend such information to areas remote from the drill site, by correlating seismic refraction data at the drill site and at the remote locations. Moreover, the seismic data can be used to suggest areas for drilling investigations. Thus the seismic refraction data obtained in August of 1975 will be valuable information for the spring 1976 drilling planned by the USGS and CRREL. It will also extend the information gained by the University of Alaska drilling in May of 1975.

It should be emphasized that OCS support is for acquisition, installation, and checkout of seismic equipment. Actual field data acquisition, data reduction, and report preparation is contingent upon support from other sources as mentioned in XII--Cost Summary.

B. Methods

The seismic refraction data will be produced in the form of ship transects. Data will be taken from the USGS boat KARLUK, through the cooperation of Drs. E. Reimnitz and P. Barnes of the USGS. Initial measurements will be made in the vicinity of Barrow for testing purposes. Additional coastal refraction work will be undertaken to complement offshore permafrost studies already made in the area (Rogers, et al, 1975; Lewellen, 1974). The equipment configuration and data reduction methods will be similar to those of Hunter (1974).

Following this work, selected lines will be run along the coast from Barrow to Prudhoe Bay. Refraction line grids will be also run in interesting areas as the two week measurement period permits. Several lines will be run in the vicinity of Prudhoe Bay to complement drilling efforts in that area which have been completed or which are planned.

VI. Information Products

The primary result of the seismic refraction work will be bonded permafrost distribution information along the Beaufort Sea Coast. It is anticipated that a complete picture of the distribution would require thousands of miles of seismic lines. However, a number on the order of a few hundred miles of lines is realistic for the first field season. These data coupled with drilling information should provide initial distribution information. A second field season using seismic techniques coupled with core drilling will enable further refinement of the distribution map and determination of the shape of the bonded permafrost - ocean bottom interface. It will be possible near Barrow and Prudhoe Bay to couple drilling and seismic work. This should result in "ground truth" for the seismic work as well as allowing extension of the drilling information on soil properties away from the drilling sites using seismic techniques. Three levels of data will be output:

1. analog refraction data
2. time distance plots of (1)
3. geographical plots of (2) with interpretation

These data will only give information on the depth to the upper boundary of the bonded permafrost.

VII. Data Exchange Interfaces

Drilling information from W. Harrison and T. Osterkamp will be utilized for the refraction work in Prudhoe Bay while drilling information from R. I. Lewellen will be used near Pt. Barrow.

The refraction data will be provided to these investigators and to CRREL and USGS for further drilling.

VIII. Sample Archival Requirements

There will be no samples which require archiving.

IX. Schedule

Equipment acquisition and assemply	May 1, 1975 - July 15, 1975
Deployment and installation on Karluk	July 15, 1975 - Aug 3, 1975
Field Work	Aug 3, 1975 - Aug 17, 1975
Data Analysis	Aug 3, 1975 - Oct 15, 1975
Report writing - first season report	Oct 15, 1975 - Nov 30, 1975
Modification of Equipment	Apr 15, 1976 - July 15, 1976
Second Field Season	Aug 1, 1976 - Aug 15, 1976
Data Analysis	Aug 1, 1976 - Sept 1, 1976
Final Report Production	July 15, 1976 - Sept 30, 1976

X. Equipment Requirements

Extensive seismic equipment will be purchased as detailed in XII Costs.

XI. Logistics Requirements

Conversations with the U.S. Geological Survey (Peter Barnes and others) have demonstrated the need and feasibility of making seismic refraction measurements along the Beaufort Sea coast from their 42-foot boat Karluk during the 1975 summer season. Benefits obtained from such an arrangement include close scientific cooperation and minimization of duplicate costs for expensive vessel time and navigation systems. Present plans call for the vessel to arrive at Barrow from the Bering Sea around August 1st where the seismic refraction equipment will be installed.

The seismic equipment is relatively compact and light with the exception of the cable handling equipment. However, none of it should present major problems for shipment and installation at NARL, Barrow. Some of this equipment will be leased and some purchased. The Karluk (a 42-foot research vessel) will be furnished by the USGS. Field work at Barrow will require 36-man days at NARL while the work along the coast and at Prudhoe Bay will be done from the Karluk. Specific requirements include:

A. Point Barrow - July 15 - August 3, 1975

1. Food and lodging for 36 man days
2. Transportation support (truck)

B. Prudhoe Bay - August 15 - August 20, 1975

1. Food and lodging for 15 man days
2. Transportation support (truck)

ALASKA MARINE ENVIRONMENTAL ASSESSMENT PROGRAM
WORK STATEMENT (Research Unit #291)

I Title: Benthos-Sedimentary Substrate Interactions

II Principal Investigator: Dr. Charles M. Hoskin, Associate Professor
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701
SS#: 297-28-5942

III Geographic Area and inclusive Dates:

Bering Sea April 1, 1975 to September 30, 1976

IV Cost Summary:

FY 1975 through June 30, 1975	FY 1976 July 1, 1975-Sept 30, 1976
$1,835	$43,791

V Proposed Research:

A. Background and Objectives

This work relates to Task B-10; types and characteristics of bottom sediments. The goal of this work is to provide baseline data, relating the physical (grain-size) nature of the sediment substrate to the benthos of the southern Bering Sea.

B. Methods

Samples for analysis will be obtained from the Feder-Carey benthos sampling program using Van Veen grabs. Sampling variance will be measured by replicate analysis for selected stations. Hoskin will perform the grain-size analysis on over 60 samples from 60 stations following the procedures of Folk (1970); sieves for gravel and sand (>0.0625 mm) and pipet analysis for silt and clay (<0.0625 mm).

VI Information Products:

Results of grain-size analysis will be reported, using a format and description in common with Creager's University of Washington group and the USGS. The main product envisaged will be diagrams (models) relating the distribution and abundance of grain-size modes to the abundance and distribution of the benthos from Feder and Carey's analyses.

VII Data Sample Interfaces:

Samples will be required from Feder and Carey's benthos program.

VIII Archiving:

Creager has the largest archive of bottom sediment (about 900), and has requested splits of the 60 samples used in this work.

IX Schedule:

Leg II of the June 1975 cruise of R/V Discoverer will be involved with the Van Veen grab program. This is being scheduled and coordinated by Dr. Howard Feder, of the University of Alaska.

X Equipment:

No special equipment is needed

XI Logistics:

No special requirements. Samples will be obtained from the Feder-Carey benthos program.

WORK STATEMENT (Research Unit #327)

I. TITLE: Faulting and instability of shelf sediments, western Gulf of Alaska

II. PRINCIPAL INVESTIGATORS: Monty Hampton and (1) to be named

III. GEOGRAPHIC AREA AND INCLUSIVE DATES:

Western Gulf of Alaska (i.e. west of Montague Island)

Through June, 1975 and July 1, 1975 - September 30, 1976

IV. COST SUMMARY:

FY 1975	FY 1976	
$60,000	$91,000	
	76,000	Logistics
	$167,000	

V. PROPOSED RESEARCH:

A. Background

Active tectonism in the western Gulf of Alaska poses severe environmental hazards to petroleum production activites. Major earthquakes are likely that could wreak havoc with offshore platforms, pipelines, and coastal installations. In addition to fault displacement and ground shaking, ground failure is also likely (e.g. during the 1964 earthquake, extensive seafloor slumping occurred at Seward). Very little is known about the distribution and displacement history of faults that may cut the shelf and upper slope of the western Gulf of Alaska. Even less is known about the thickness and physical properties of recent sediments on this shelf.

A planned summer 1975 cruise (USGS contract vessel) will provide rather widely spaced reconnaissance lines across the shelf between Montague and Shumagin Islands. High-resolution acoustic profiles will provide preliminary data bout fault locations, offsets, and some indication as to probable age. Knowledge will also be gleaned from these profiles regarding the distribution and thickness of late Quaternary sediment and the location of areas of potential ground failure. These profiles will provide a base of knowledge for more detailed seismic profiling to be carried out in the summer of 1976.

The information needed to meet the objectives of this task are high-resolution seismic profiles and selected bottom samples and cores. Profiles must be gathered with state-of-the-art equipment and the best navigation or ship positioning possible. Geologic, stratographic and structural analyses of the seafloor will be based on these profiles, which will also guide a sampling program aimed at providing information relative to the age of faulting and the late Neogene history of seafloor stability.

Although high-resolution reflection profiles will be gathered during the summer months of 1975 (contracted work with Geophysical Services, Inc.) these will be limited to widely spaced lines positioned for resource assessment studies. No samples will be taken. A major effort will be made to collect closer-spaced data in the summer season of 1976, an effort that will be guided by the regional information gathered during the GSI-contract cruise of 1975. Thus, by September 1976, the reconaissance level data base will be in hand for the first time. We suspect that between 25-50% of the data needed to fulfull the task will be available for study by the end of the first funding cycle (i.e. September, 1976).

Essential studies to this task are: Research Unit Nos. 16, Seismic and volcanic hazards; 210, Earthquake Activity and Ground Shaking along the Eastern Gulf of Alaska; 251, Seismic and Volcanic Risk Studies, Western Gulf of Alaska; 216, Faulting and Instability of Shelf Sediments, Eastern Gulf of Alaska - Cross Sound to Montague Island; and 212, Erosion and Deposition of Shelf Sediments in the Eastern Gulf of Alaska. Excellent coordination and cooperation is anticipated.

B. Methods

Little data, either geophysical or geological exists for the bulk of the western Gulf of Alaska - especially west of Kodiak Island, seaward of the Alaska Peninsula. Nonetheless, a thorough search will be made for published data pertinent to the task assignment, and unpublished records (some are available from USGS files, and possibly also from Lamont-Doherty Geological Observatory) as well. Prior to the start of the 1976 cruise all extant information should be in hand. Persuasive arguments may also free some industry proprietary information.

The 1976 cruise, approximately 1000 line miles (or more), will trace faults in detail using high-resolution seismic profiling gear. Selected lines of side scan sonar will be run to determine the extent of surface rupture and selected dart cores and box cores will be collected to aid in the determination of the relative age of the faulting.

High-resolution reflection profiles also will be collected over probable areas of potential ground failure (e.g., areas of high sedimentation on steep or relatively steep slopes). Sites will be selected for piston, box, and vibra cores in order to determine the physical parameters and internal structures of suspected and recognized unstable sediment masses.

Seismic reflection lines will be positioned to delineate and map the areal distribution of faults that displace the sea floor and those that subcrop beneath a cover of late Neogene deposits. It will not be possible to position many (most?) of these lines until after the reconaissance information has been interpreted. There is no clear-cut way to predict the location, strike and displacement characteristics of faults and significant slumps prior to the start of the work on the amount of data needed to resolve these questions. Hence, the growing body of data will dictate the field procedures to be employed next. Without question however, several thousand miles of line will be involved, and perhaps as many as several hundred samples.

Analytical methods will be those typically employed to stratographically and structurally resolve high resolution profiles. Sediment samples and sediment cores will be examined for evidence relevent to the age of slumped or displaced masses of sediment and offset stratographic units. Necessary evidence includes sediment characterization numeralogical composition, and dating via radiogenic methods or perhaps the more difficult amino-acid degradation cycle. Shallow sab-sea floor boring may be necessary, and, in many areas, perhaps essential. Funds for a sea floor drilling program have not been requested.

VI. INFORMATION PRODUCTS:

The following products, which include a descriptive as well as an interpretative text, will be supplied in fulfillment of the task.

1. Analyses and maps of surface and nearsurface faults.
2. Analyses and maps of sediment slumps and potential slumps or slides.
3. Analyses and distribution of maps of surficial sediment types.
4. Hazards map--fault zones and zones of potential and actual ground failure--and interpretative analyses.

VII. DATA OR SAMPLE EXCHANGE INTERFACES:

Seismic reflector profiles, regardless of type or quality, collected by other investigators, will be useful to this task assignment. Information relevant to the distribution of sediment types is also needed. Both seismic and sediment data are needed early in FY 1976 and thereafter. Detailed epicenter plots are needed, especially for magnitude 3 and 4 quakes, and lesser shocks, if possible. Products of the research carried out under this task assignment will be useful to those researchers involved in biological and sediment dynamics studies, and those involved in seismicity studies.

VIII. SAMPLE ARCHIVAL REQUIREMENTS:

No special archiving procedures are envisioned other than the storage of magnetic tapes and copies of reflection profiles. The details of these procedures are presently being worked out between EDS and USGS personnel.

IX. SCHEDULE:

Seismic reflection profiles adequate to delineate characteristics of the sea floor pertinent to its stability will be initially collected during the summer months of 1975. Approximately 800 line miles (possibly more) will be secured by contractual arrangement with GSI. Tentatively these lines will be evenly spaced between Montague Island and Unimak Island, crossing the shelf approximately normal to its regional trend. Approximately twice as many line miles of seismic data will be collected in 1976 in areas outlined for more detailed study by the 1975 investigatons. Sediment samples will not be taken until the 1976 cruise. It is not possible to say at this time how many (or what type) samples will be necessary to fulfill the task of determining the essential aspects of the faulting and instability of shelf sediments. Optimum sampling density, location, and procedures will be developed as an outgrowth of the reconaissance level interpretations in this area.

Interfaces with other research groups, in particular those identified above (under background), will be maintained at all times. Close working relations will be especially important with comparable studies being conducted in the eastern Gulf of Alaska and the Bering Sea. A USGS operated and specially outfitted vessel will be scheduled in support of these sister programs.

X. EQUIPMENT REQUIREMENTS:

As far as can be foreseen, all equipment requirements will be met by the U.S. Geological Survey. Besides a vessel specially outfitted to conduct geological environmental studies on the Alaskan OCS specialized equipment that will be employed include the following:

1. Precision - onboard navigation system
2. Side scan sonar
3. Hull-mounted 3.5 khz and Unibacm transducers
4. Mini-sparker
5. 30 Kj (or larger) arches
6. 12 Kc (or higher) fathometer

XI. LOGISTICS REQUIREMENTS:

It is planned that the USGS will supply all necessary logistics as far as ship operations are concerned. However, circumstances may arise that would require assistance in conducting some or most of the field studies. It seems certain that fixed-wing and helicopter support will be requested for the 1976 field season, but the amount will not

be known until this program is underway and problems requiring this support are identified. An example of such a problem would be the tracing faults toward and beyond islands rising about the shelf floor. Transportation to these islands for the purpose of geologic mapping would then be requested.

WORK STATEMENT (Research Unit #352)

I. SEISMICITY OF THE BEAUFORT SEA, BERING SEA AND GULF OF ALASKA.

II. PRINCIPAL INVESTIGATOR: Herbert Meyers, Deputy Chief, Solid Earth Data Services Division, National Geophysical and Solar-Terrestrial Data Center, EDS, NOAA, Boulder, Colorado, Phone 303-499-1000, Ext. 6521.

III. GEOGRAPHIC AREA AND INCLUSIVE DATES. Beaufort Sea, Bering Sea and Gulf of Alaska, April 75 through September 76.

IV. COST SUMMARY.

FY 76 $25.0 K

V. PROPOSED RESEARCH.

A. Background and objectives. This project relates directly to tasks D5, D7, and D13. Secondary emphasis of the project relates to task D6.

The state of Alaska is one of the World's major seismic regions. It accounts for about 5% of the world's earthquake activity. Most of the earthquake activity in this region occurs in a zone several hundred kilometers mile along the northern rim of the Gulf of Alaska and parelelling the southern Coast of Alaska and the Aleutian chain. Northern Alaskan in the Beaufort Basin region have minor seismic activity. Western Alaska near the Chukchi Sea and Norton Basin regions has minor seismic activity. Moderate seismic activity occurs in the southern BeringSea region near Bistol Bay Basin and St. George Basin has moderate seismic activity. However, seismic and tsunami risks are present even in the areas of low seismic activity from larger earthquakes which may occur in a highly active Gulf of Alaska and Aleutian regions.

Very little is known about the relationships among earthquake magnitudes, earthquake intensities, ground accelerations, and distances from epicenters for the Alaska region. Also, there is essentially no information available about the response of ocean structures during earthquakes. Although earthquake activity in Alaska in greater than in any other state, only few of the shocks have cause severe damage because of the absence of large population centers.

Prior to the development of a magnitude scale based purely on instrumental records, earthquakes were compared by their intensity, a rating assigned by an experienced observer using a descriptive scale that indicates the degree of shaking at a specific place. Since the beginning of the 20th Centruy, a relatively complete history of the larger earthquakes of Alaska has been obtained instrumentally and magnitudes have been computed for the majority of them. During the period 1899-1964, the locations of eight events of magnitude greater than 8, fifty-six between magnitude 7 and 8, and two hundred thirty-four events with magnitudes between 6 and 7, have been determined for Alaska and the Aleutian Islands (Figure 1).

Two of the eight earthquakes of magnitude $\geq$ 8.0 (1899-1964) occurred in the Aleutian Islands region, outside of the scope of this review. The other events are summarized below.

In September 1899, the Yakutat Bay area experienced two of the notable earthquakes of the last century. Available seismograms from these events, though few have enabled estimates of magnitude of 8.3 and 8.6, respectively (Richter, 1958). Another shock in the same area measures 7.8 on the Richter magnitude scale. The largest earthquake (September 10, 1899, 21 hours GMT) raised the shoreline over a considerable length, and at one point there was an uplift of 47 feet 4 inches, one of the greatest vertical movements known.

On October 9, 1900, a great earthquake occurred in or near the Chugach Mountains. The epicenter of this event remains uncertain, but intensity data place it in the St. Elias Range or the Chugach Mountains. Instrument data enable a magnitude estimate of 8.3. Intensity data are VII to VIII at Kodiak, VI to VII at Skagway, and VI at Whitehorse, Yukon Territory, Canada. It is estimated that this event was felt in an area of at least 120,000 square miles.

The NGSDC digital file of instrumentally located earthquakes contains approximately 10,000 events for the Alaskan region. Although the file contains data beginning about 1900, the bulk of the events are for the last 25 years. In addition to the digital file, there are descriptive reports dating back to 1928 which describe the effects of earthquakes on population and the developed areas of the Alaskan regions. Both of these files will be supplemented with data and information from additional sources to permit the preparation of seismic histories, epicenter plots, and recurrence rates for a period long enough to represent the seismicity of the region concerned. A final report will be available on or before September 30, 1976, which will depict the seismicity of the region in a variety of formats.

B. METHODS. The instrumental information for 10,000 earthquakes in conjunction with descriptive reports on the effects of the earthquakes on the surrounding regions (intensity reports) will be used to derive recurrence rates as a function of geography and magnitude. The effects will be computed according to a standard model relating maximum intensities as a function of magnitude, depth and distance for various geological regimes in the area. This will be an extension of work now being performed by NGSDC involving the development of recurrence curves which show the number of times each earthquake intensity will be felt within each one degree area for the 48 conterminous states. To accomplish this task for Alaska, it will be necessary to assign intensity values to earthquake reports (felt information) which previously had no assigned intensity; digitize the entire intensity file for the Alaskan region; deduce or derive magnitudes for those earthquakes now in the file without an assigned magnitude; supplement existing digital files with data from other

sources. NGSDC is now the national repository for both instrumental and felt reports for earthquakes in the U.S. and its territories. Much of the data already resides in the files of NGSDC and we have many cooperating agents throughout the country who will be able to provide us with supplemental information relating to Alaska.

VI. INFORMATION PRODUCTS. A variety of epicenter plots will be prepared which depict the occurrence of earthquakes according to depths, magnitudes, and time intervals. Descriptive reports will be prepared which document the occurrence and effect of tsunamis in the region. Where sufficient information exists, isoseismal maps will be prepared for significant earthquakes which have occurred in the region. Computer printout summaries of all earthquakes for the region will be prepared both chronologically and geographically by one degree squares.

VII. DATA OR SAMPLE EXCHANGE INTERFACES. The results from any strong motion seismic record generated in the area would be useful in testing and calibrating magnitude and intensity versus distance relationships. Relocation of hypocenters or recalulation of magnitudes performed by other investigators, particularly for some of the older earthquakes would be a useful input to the project.

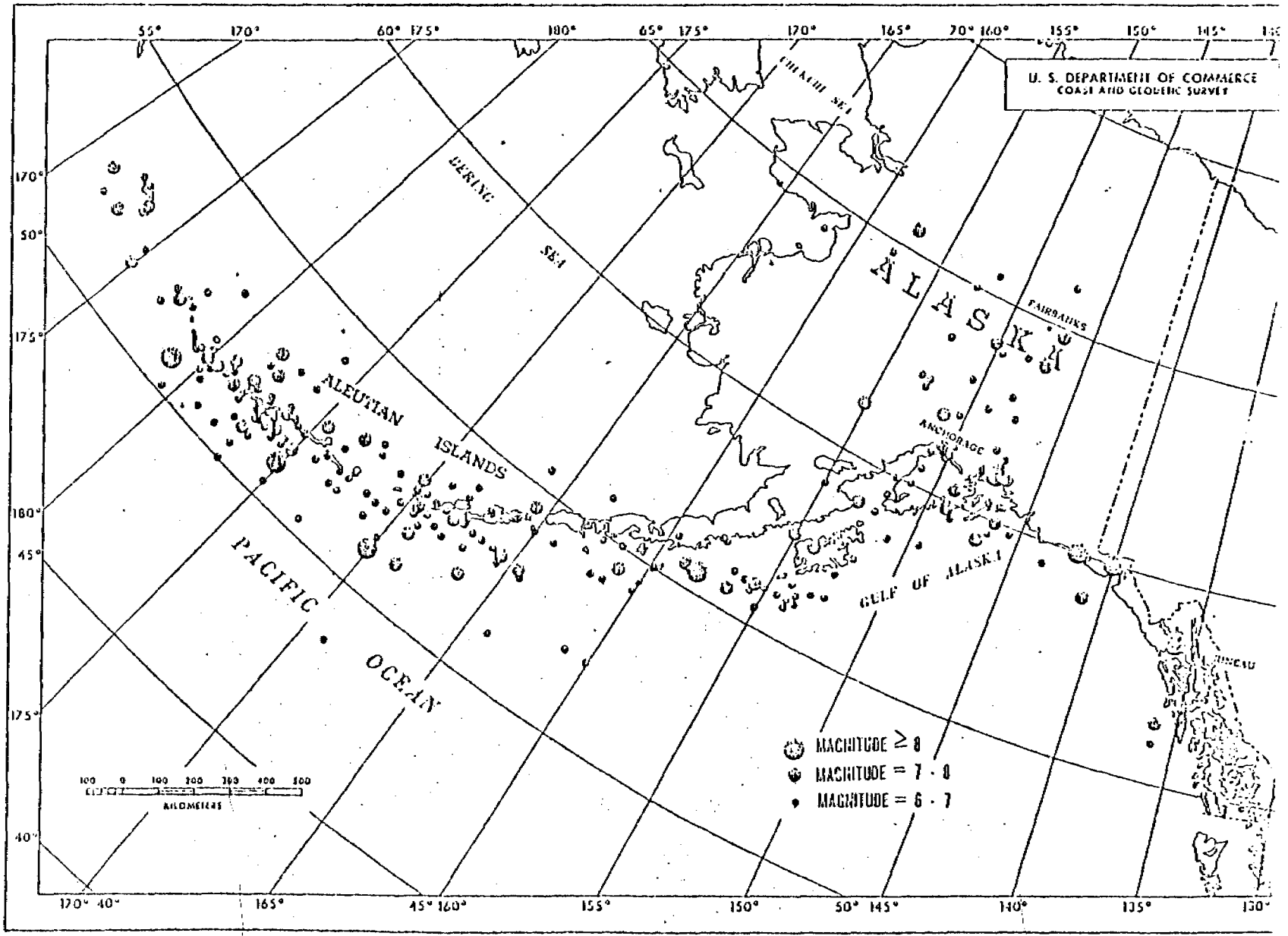
VIII. SAMPLE ARCHIVAL REQUIREMENTS. No requirements exist.

IX. SCHEDULE:

July 1, 1975	Begin computer coding all felt information from data in files.
September 1975	Coding completed.
June 1976	Coding of additional felt information and instrumental data for other sources completed.
September 1976	Final report and product preparation completed.

X. EQUIPMENT REQUIREMENTS. None.

XI. LOGISTICS REQUIREMENTS. None.


U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
BERING SEA
CHUKCHI SEA
ALASKA
FAIRBANKS
ANCHORAGE
ALEUTIAN ISLANDS
PACIFIC OCEAN
GULF OF ALASKA
MAGNITUDE ≥ 8
MAGNITUDE = 7 - 8
MAGNITUDE = 6 - 7
KILOMETERS
170°
50°
175°
180°
45°
40°
55°
60°
65°
70°
160°
155°
150°
145°
140°
135°
130°

WORK STATEMENT (Research Unit #407)

I. TITLE: A Study of Beaufort Sea Coastal Erosion, Northern Alaska

II. PRINCIPAL INVESTIGATOR: Robert Lewellen

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Point Barrow to Demarcation Point, Alaska

IV. COST SUMMARY:

FY 1975 through June 30, 1975	FY 1976 July 1, 1975 - Sept. 30, 1976
none	$18,000

V. PROPOSED RESEARCH

A. Background and objectives

1. Related tasks - D-3 and D-4

2. Present state of knowledge - The present state of knowlege in this area is adequate; the information has just never been compiled in final form or completely published.

3. Information required to meet task objectives - The information required to meet the task objectives exists on the photographic prints of past aerial photography missions of the Alaskan coast, bathymetric data, field notes by the author of this proposal, and selected literature by Hume, Lewellen, Wiseman, Short, and Schalk. The main requirement is the sequential photography taken randomly since 1945.

4. Extent to which these requirements can be met by Sept. 30, 1976 - The entire study and compilation of maps and report will be completed by September 30, 1976.

5. Related research - Related research has been carried out in the past by Hume, Schalk, Short, and Wiseman. The P.I. knows these people personally and maintains, routinely, a close contact for scientific purposes.

B. Methods

1. Efforts to use existing data - The P.I. has in hand all of the published and unpublished materials, documents, and data

relative to this study; these items are routinely used in relation to the subsea permafrost project (AINA-ONR 454).

2. Sampling scheme - The temporal sampling scheme is a function of when sequentail aerial photography or gound measurements exist. This coverage is adequate. Spatially, the coverage is essentially continuous from Point Barrow to Demarcation Point. Samples will be taken in every site where sequential comparisons can be made. This will average about one sample point per mile of coastline. The statistics of measurement errors inherent in these techniques will be presented.

3. Methods of analysis - Standard air photo navigational techniques; any standard reference on air photo interpretation will do -- American Society of Photogrammetry for example.

VI. INFORMATION PRODUCT

The information will be displayed on a series of six or seven coastal maps along with a detailed illustrated interpretive report.

VII. DATA ON SAMPLE EXCHANGE INTERFACES

None required.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

Nothing anticipated.

IX. SCHEDULE

Compilation and drafting will be completed in final form by September 30, 1976.

X. EQUIPMENT REQUIREMENTS

None

XI. LOGISTICS REQUIREMENTS

None