Program Work Statements

Environmental Assessment of the Alaskan Continental Shelf

Volume 6 – Physical Oceanography and Meteorology

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

U. S. DEPARTMENT OF INTERIOR
Bureau of Land Management

CONTENTS - PHYSICAL OCEANOGRAPHY

(Research Unit #48)

WORK STATEMENT

TITLE: Development and Operation of Coastal HF Current-Mapping Radar Units

PRINCIPAL INVESTIGATOR: Dr. Donald E. Barrick
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NOAA/ERL
Boulder, Colorado 80302

GEOGRAPHIC AREA & INCLUSIVE DATES: Beaufort and Gulf of Alaska Seacoasts, Summer, Fall, Winter of 1976

Cost Summary: FY 1975 $ 240 K
FY 1976 $ 40 K

PROPOSED RESEARCH:

A. Background and Objectives

The primary task which describes the emphasis of the expected results from the proposed program is B-2; i.e., determination of near-surface circulation patterns which can be used to predict the transport of floating petroleum-related pollutants. Tasks which are of secondary impact with respect to this effort are B-3, B-4, B-5, and B-6; in particular, these "restricted" water areas between the coast and ice edge, and also in estuaries and fiords, will be investigated because of the unique circulation patterns which can develop in such areas. With respect to B-6, we would propose to use our system to map near-surface water circulation during any planned oil-spill experiment, in order to compare our predictions of oil dispersion with actual observations.

At present, the only techniques available for measurement of near-surface ocean currents (which transport floating spills) in coastal waters is to optically track the movements of floats or dyes from an airborne platform. Hence, data on surface circulation in coastal waters (out to 60 km), especially in the bays and restricted areas, are presently extremely sparse. In order to develop accurate predictive techniques, it is necessary to correlate observed circulation patterns with the geophysical driving forces, such as winds, waves, storms, tides, geostrophic flows, and coastal/bottom topography. Very little of this has been done in general, and none in the Gulf of Alaska/Beaufort seacoast areas.

The primary objectives of the proposed program are twofold: (i) to implement a proven concept into a transportable, easily assembled and operated unit pair capable of producing a current map at the site in real time, and to calibrate the system as to its accuracy; (ii) to operate the radars at coastal areas of interest along the Beaufort and Gulf of Alaska seacoasts in support of the BLM/ERL Alaskan Continental Shelf environmental assessment program. To these ends, the only information required is a series of recommendations on where these coastal operating areas should be; the field teams will be prepared to operate the units during 1976 at any appropriate sites, within the constraints of time and money. Areas especially appropriate would include regions around potential oil-bearing strata, and in particular, confined areas such as bays and estuaries in which the impact of spills can be more severe and where other near-surface current-measurement techniques are inappropriate.

It is presently planned that by September 30, 1976, the first objective will have been completely accomplished. It is also anticipated that most of the planned operations included in the second objective will have been completed by that date, and that reports describing the findings will be in proce

There are several other investigations with which data correlation and exchange should occur; this will only be meaningful during the operational data-gathering phase of our program, namely, the summer, fall, and winter of 1976. We plan to correlate our observed near-surface circulation patterns along the Gulf of Alaska seacoast with tidal and long-wave/storm effects thus the results of Drs. Galt, Laevastu and Hansen would be very useful to us during our overlapping operational periods. In addition, a two-way data exchange should ensue between our program and the numerical modeling investigation of Dr. Galt, since his measurements and predictions of larger-scale circulation in the Beaufort Sea and the Gulf of Alaska will complement nicely our closer-in finer-scale circulation measurements.

B. Methods

One of the chief features of the current-mapping radar units being developed is their ability to produce a utilitarian final product, on-site, in near-real time: namely, a hard-copy map of near-surface current vectors. This map is readily interpretable in the sense that it will show the coastline, the location of the two radar sites, a distance scale, optional latitude/longitude lines, and labels identifying the date, time of measurements, sea state, duration of the measurements, number of samples used in the averaging process, and any other meteorological/geophysical details which the operator deems worth noting. The length and direction of the current vectors at each of the regular gridpoints (whose spacing is selectable by the operator) produces a readily interpretable picture of the circulation pattern in the coverage area. Thus the map is ready for immediate correlation with other parameters, such as tidal, meteorological, or geophysical conditions at the time of the measurement.

Of course, the data used to produce the map will also be stored on floppy discs and/or tapes for later special statistical analyses and/or additional map reproduction. The important point to be made here, however, is that the system is being designed so that the information which is presently believed to be the most important final product will be available immediately in the field. Hence, time-consuming data crunching and interpretation at the home laboratory -- an attendant part of most field experiments -- is not required here. These maps will, of course, be disseminated in report form, as well as archived with NODC/EDS (National Ocean Data Center) for interested secondary users.

The typical spatial resolution planned for the current maps is 3 km (although finer resolution will be possible if desired in more restricted coastal areas). The maps can display the vectors at any grid-point spacing. (Actually, vectors every 3 km will in most cases fill the map with too much data for ready interpretation, and hence a coarser display grid would be selected.) The temporal sampling interval (i.e., the time between sequential operating periods, and, hence consecutive maps) can be as small as one hour. The temporal schedule selected should be based upon the phenomenon with which the circulation is to be correlated. For example, the system should be operated at two-hourly intervals with the advent and passage of a storm through the Beaufort Sea area. From these two-hourly maps (spanning, say, a period of three days), one will be able to predict quite accurately the transport and dispersion of an oil spill during a storm. The current-vector data used to produce the maps can be integrated in time (with a two-hour increment) to actually produce a second type of map: one showing the actual trajectory of a surface particle. Routine tidal effects, on the other hand, would normally require a map only every six hours for correlation purposes.

The final report covering operations in a given area will include more than just a compendium of maps. Interpretation of the circulation patterns in terms of driving phenomena will be undertaken, and where applicable, trajectory predictions will be included. Where other independent experiments have been conducted in the same area, correlations and comparisons with those data will be made. Thus the reader will be able to obtain an understanding, not just of typical circulation patterns in a given region, but how these patterns vary with expected meteorological and tidal conditions. This will in turn permit assessment by many diverse groups of the impact of planned oil operations in the particular coastal area.

INFORMATION PRODUCTS

The first type of information produced on this program will be a report detailing the design, operation, and maintenance of the planned radar units. Included will be a summary of the checkout/calibration phase, in which the observed current-measuring accuracies will be listed. These will be determined -- possibly in the Gulf-of-Mexico in conjunction with the NOAA Data Buoy Office -- by comparisons with near-surface current measurements from other sources, such as buoys, floats, and dye markers.

The second type of information produced will be reports summarizing and interpreting measured circulation patterns for a given area (i.e., around the radar locations). The content of such reports was described in detail in the preceding section; they will include not only copies of all of the current maps, but also interpretations and correlations with the relevant meteorological/tidal phenomena.

DATA INTERCHANGES

The section on Proposed Research mentioned the various other projects with which data exchanges are desirable. It should be emphasized that our program will actually require no data from other investigators for an adequate presentation/interpretation of our results. Where other projects are being conducted in our operating areas (several of which were mentioned in a previous section), we will attempt to establish a data exchange program. We will, of course, be pleased to provide both our raw current maps (as soon as they are produced on site), as well as our area reports, to any other interested investigators who we feel would benefit from our data. All data, including both the current maps and reports, will be forwarded to EDS/NODC for archival within 120 days of acquisition.

SAMPLE ARCHIVAL REQUIREMENTS

Other than the hard-copy maps of current vectors and the project reports which will be sent to EDS/NODC, no special archival requirements for materials, samples, or documents exist for this program.

SCHEDULE

31 December 1975: One radar unit pair constructed and ready for checkout/calibration.

31 March 1976 : Calibration of unit pair completed (presently planned to take place in the Gulf of Mexico near the NOAA Data Buoy Office towers).

15 May 1976 : Final modifications to the radar unit hardware/software completed (in Boulder).

1 June 1976 : Begin operations along the Gulf of Alaska coast.

31 August 1976 : Report completed on design, operation, and maintenance of HF current-mapping radar systems.

1 November 1976 : Operations along the Beaufort/Gulf of Alaska seacoasts completed.

Reports containing circulation maps and their interpretation will be completed within one month after the termination of operations at a given seacoast location.

EQUIPMENT REQUIREMENTS

Considerations involving special equipment are closely related to logistics requirements, and are discussed in the subsequent section.

LOGISTICS REQUIREMENTS

Approximately $40 K of the total budget is reserved for field operations along the Beaufort/Gulf of Alaska seacoasts. This will provide for approximately five months of operations, which includes two engineers in the field to man one of the two station pairs (one man is required at each of the two units comprising a pair). The exact duration and amount of the operations possible will depend upon the locations at which operations are conducted, and the nature of the logistics required for the sites selected. Every attempt will be made to: (1) select operating locations around which a knowledge of the coastal circulation is of prime importance, but (ii) locate the actual radar units such that special and expensive logistics requirements will not exist. It would be very desirable where possible to locate a given station such that: (i) there is access by road to the site selected on the beach; ii) power is available in the immediate vicinity from other sources (i.e., 115 volt A/C, 20 amps, 2 kW per station); (iii) food and shelter is available in the immediate vicinity (i.e., within 20 miles). These requirements could all be met, for example, if sites are selected at or close to villages or other experiment stations. If operations are required in desolate seacoast areas, it is possible that helicopter transport of the gear to the sites will be necessary, along with temporary shelter and food provisioning for the desired operating period; a portable gasoline generator will be required at each station in this event also. Hence these logistics requirements will be considered as final decisions are being made as to the field site locations for the operations.

(Research Unit #81)

WORK STATEMENT

I. TITLE: Beaufort Shelf Surface Currents

II. PRINCIPAL INVESTIGATOR: G. L. HUFFORD, Oceanographer
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Research and Development Center
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(203)-445-8501

III. BEAUFORT SEA COASTAL ZONE, August 1975 - June 1976

IV. COST SUMMARY:

FY 1975

THROUGH 30 JUNE 1975

TOTAL: $37,200

V. PROPOSED RESEARCH:

The proposed work will address the following study plan tasks: (1) determine the Beaufort Sea shelf current patterns and develop the capability to predict the transport of petroleum-related pollutants during open water season (Task B-2); and (2) determine the nature of the surface transport process at the pack ice edge on the outer shelf during open season (Task B-5).

The discovery of oil reserves along the nothern coasts of Alaska and Canada has assigned significant economic importance to these coastal areas, and offshore drilling on the continental shelf is certain to be undertaken within the next few years. With the drilling comes the increasing possibility of a major oil spill into the coastal waters. During the open season initially, the movement of oil would be determined primarily by the local shelf current. Thus knowledge of the surface water motions in the northern Alaskan shelf region is of both economic and environmental interest. However, our understanding of the water motions on the Beaufort Sea shelf is crude at the most.

Objective: The objective of this proposal is to determine the surface current patterns and to develop a model capable of predicting surface water motions on the Beaufort Sea continental shelf. The region of specific interest is between Point Barrow (156° 30'W) and Demarcation Point (142°W). Surface water for this project will be defined as the upper meter. The surface current model is based on data collected by means of an airborne surface current measurement system. The heart of the system is an air-deployed expendable surface current probe that will give surface current speed and direction information. The probe is launched from a helicopter from less than 50 feet of altitude. After deployment, the helicopter then attains an altitude of 600 to 1,000 feet and a photograph is taken of the resulting dye patches released from the probe on the water's surface. Personnel on the aircraft record the aircraft altitude and heading for future analysis of the photograph. Since the actual current speed and direction will be taken from the photographs collected, the camera, of course, plays a very important part in the technique. The ship will take continuous weather measurements. Portable weather stations will also be set up along the coast during the study.

Since an icebreaker will be used as a logistic base, advantage will be made of the fact that the ship must steam from Barrow east to Demarcation Point and back again. The coastal area can be sampled going in and coming out.

The geographical area of interest is approximately 300 miles long and 40 miles wide. It is felt that eighty transects (each 40 miles long measured from shore) whose positions are determined by random number is sufficient coverage to give necessary information for determining the surface current. Ten probes will be used on each transect. Probe drop locations will also be determined by random number. By randomizing the sample procedure the collected data will be free of spacial bias. It is estimated that each transect will take 2 1/2 hours to complete. The total project would require a total of 200 hours of helicopter time. To successfully sample this region of the Beaufort Sea, an area where the ice pack can encroach at any time, it is necessary that an icebreaker with its two helicopters be used for this study. A cruise of two weeks is considered sufficient to do this work. The best time is in August when the ice has retreated its maximum to the north.

It is expected that with the sampling program conducted during August 1975, the results of this study as a report will be available June 1976. The data in the form of current speed and direction and wind speed and direction (IBM cards) will be supplied to EDS within 120 days of acquisition.

VI. SCHEDULE:

Conduct Sampling Program on USCGC GLACIER	15 August - 2 September 1975
Supply Data to EDS	January 1976
Final Report	June 1976

VII. LOGISTICS

An icebreaker (USCGC GLACIER) will be used as the logistic base. The ship's helicopters will be used to deploy the expendable surface current probes and recover the data. The ship and helicopter time have already been approved for this summer by the U.S. Coast Guard. Accommodations have also already been arranged with NARL Barrow, Alaska, for intermediate stop overs getting on and off the ship.

VIII. EQUIPMENT REQUIREMENTS:

It is imperative that purchase of the expendable surface current probes be made by 1 May 1975 since there is a 90 day delivery delay. It is requested that all funds for this proposal be supplied from FY75 monies.

WORK STATEMENT

(Research Unit #91)

I. Title: Current Measurements in Permanently Ice-Covered Areas of the Beaufort Sea Using Acoustic Data Retrieval

II. Co-Principal Investigators: Knut Aagaard, Department of Oceanography and Dean P. Haugen, Applied Physics Laboratory, University of Washington Seattle, WA 98195

III. Geographic Area and Inclusive Dates:

1 April 1975 - 30 September 1976

IV. Cost Summary:

FY 1975 through 30 June 1975	FY 1976 1 July 1975 - 30 September 1976
$75,000	$100,000

V. Proposed Research:

A. Background and objectives

1. The objective is to provide long-term Eulerian time series of currents at selected locations on the outer shelf and slope of the Beaufort Sea, where the ice cover may not be seasonally removed. The measurements are aimed at contributing to the accomplishment of task elements B-2 - B-4, relating to the circulation and dynamics of the outer shelf and slope.

2. Such measurements have not been made in permanently ice-covered areas. However, we do know that the mean flow seaward of the shelf break is westward, while an eastward flow (probably intermittent) prevails on the outer shelf. Strong flow prevails in Barrow Canyon and may be either up- or down-canyon. Storm surges and related events are probably more important that tides in effecting changes of short-time scale.

3. While the total number of mooring locations is of necessity small, we can over the long term expect time series of length and quality adequate to provide very good spectral resolution up to at least semi-diurnal frequency, as well as descriptions of the mean flow at these locations over a variety of intervals, and descriptions of major or unusual current events.

4. By 30 September 1976 all current meters will have been deployed for at least 5 months, and several cycles of data retrieval should have been accomplished. It is likely that the early data processing will be well along, but because of the large raw data volume we cannot expect spectral estimates and other detailed time-series descriptions until some time after the end of calendar 1976.

5. Those persons investigating transport processes or modeling of water and ice, or requiring environmental background information or water movement, will require or benefit from time series current descriptions as described.

B. Methods

1. Results of the time series and other analyses will be fitted and compared to what is known of the mean flow field, its variations, and the regional tidal regime.

2. A 20-minute sampling mode is ample for the spectral resolution required, and is also consistent with data storage and power requirements. The sampling will extend through the contract year, providing records of 5-7 months duration. Should circumstances

at the end of the contract year indicate the desirability of further extending the deployment and monitoring period, appropriate decisions can be made then. The limitations of time and funds dictate the construction and deployment of three mooring systems with two current meters each. One system will be installed in Barrow Canyon, at about 71°37'N, 155°47'W, in approximate water depth 200 m, in order to examine at its point of entry the flow moving onto the Beaufort Sea shelf from the southwest. This is water of Bering Sea origin. The system is conveniently located for initial intense monitoring. The two other systems will be deployed at about 150°W, one on the outer shelf and one on the slope, to obtain time series representative of the outer shelf and slope regimes. The offshore meters are expected to be in the mean westward flow and the inshore meters in the eastward flow. The current meters will be spaced optimally below about 100 m beneath the sea surface to insure their being out of reach of drifting ice. Temporal variance of the measured currents will be calculated by normal time series methods, using Fourier transforms.

3. Besides the variance analysis indicated above, we anticipate calculations of vector means and trends over various time scales, and examination of unusual or special current events with emphasis on their cause or origin.

VI. Information Products:

If all systems operate successfully there will be six long time series current records: two from northeast of Barrow in the canyon, two from the outer shelf, and two from the continental slope, the last four being on about the Oliktok meridian. The information format will be temporal analyses of means and variances, as described above.

VII. Data or Sample Exchange Interfaces:

The above information will be required by persons working on transport processes and modeling (possibly also by biologists, chemists, and geologists needing environmental background information) as soon as processing and standard analyses are completed.

VIII. Sample Archival Requirements:

All archiving can be done on computer cards, or magnetic tape in a format specified by the Project Office.

IX. Schedule:

April-July 1975	ordering of equipment with long lead time, design activities
June-September 1975	prototype fabrication
October-December 1975	checkout and testing of prototype
December 1975 - March 1976	fabrication of two additional systems
January 1976	final system checkout and field trials of prototype system in Puget Sound
late February-early March 1976	deployment of first system northeast of Barrow
March 1976	intensive monitoring of first system
late April 1976	deployment of second and third systems on Oliktok meridian
April-May 1976	begin routine monitoring of all systems as logistics permit, and begin processing of returned data
30 September 1976	technical report
31 January 1977	final report (data report based on accomplished analyses, and summary of work through contract year)

X. Equipment Requirements

Each instrumentation system will comprise an anchor, an acoustic anchor release (AMF 242), a string of two RCM-4 current meters, and a data buoy housing a power supply, a digital tape recorder, timing and control electronics, and acoustic telecommunication subsystems. The data buoy and associated systems will be developed and built at the University of Washington. The current meters provide current speed, direction and temperature in digital format. Sampling will be done under control from the data buoy, and sensor data will be sent to the data buoy via cable where it will be formatted for recording on magnetic tape. Sufficient power will be provided for two years of operation and sufficient tape capacity for eight months at a sample rate of once every 20 minutes.

The acoustic telecommunication system will comprise a command receiver, a data transmitter, and a transponder/pinger to assist in localization and recovery. Tone-code modulated commands will be decoded in the command receiver to control pinger operation, data transmission, and the magnetic tape transport. Data will be transmitted using high-bit rate, phase-shift keying techniques permitting quick transfer of the data from the buoy to the surface. The transponder/pinger will act as a transponder to received interrogation pulses and as a free-running pinger under acoustic control from the surface.

Data will be stored in digital form on a small low-power cassette recorder. Tape capacity will permit over two million bits of information to be stored on the tape. This is sufficient to store data from eight months with 20-minute samples of several sensors. Data can be recovered whenever a site visit is possible. Although data from up to eight months can be stored, more frequent site visits are scheduled to lessen the chances of significant loss of data, and to more nearly achieve real-time retrieval.

Normal navigation and radar fixes from the Alaskan coast is probably adequate to locate within acoustic communication range of a buoy (about 2 kilometers), although inertial navigation instrumentation in the aircraft would certainly be a definite advantage. If necessary, after arriving at the site, a portable sonar direction finder operating with the buoy transponder can be used to establish a final position close over the buoy. This will provide a direct communication path free of multi-path interference. It is envisioned that data can be transferred at a 10 kHz bit-rate, making possible a complete data transfer cycle in a few minutes.

Equipment needed for deployment includes portable winch and quadrupod, and hole-cutting equipment.

The first system will be deployed in late February-early March and the next two in late April, as previously discussed.

XI. Logistic Requirements:

Exclusive of helicopter staging time we require 2 periods of working time for installation. For the first installation, about 25 nautical miles from Barrow, one day of flying should suffice. For the second installation (two moorings), we anticipate two days of flying (one day for each mooring) in an area extending 50-60 nautical miles north of Oliktok. Additionally we require helicopter time on an opportunity basis to monitor the systems. For the system near Barrow an initial 2-4 week period of monitoring once or twice a week is desired, with only an hour or so being required for the actual on-ice work. Subsequently, interrogation and monitoring of this and the two systems north of Oliktok should be accomplished on an average of once every two months, actual on-site time required again being about an hour.

Recovery of the systems, whether decided to be at the end of the contract year or at a later extended time, will probably be attempted using helicopter support, in which case 1-2 days can be expected to be required for each mooring. Alternatively, should recovery be attempted during a summer of extremely favorable ice conditions, it can be accomplished by ship, and again only about one day per mooring should be necessary.

Additionally we require lodging for 4 persons during the two periods of deployment, including 2-3 days at Barrow before and after each deployment for staging purposes, i.e., for a total of 4 persons x 9 days/trip x 2 trips = 72 person-days during deployment operations; lodging during the initial intense monitoring period for two persons for 2-4 weeks; lodging during routine monitoring procedures, 2 persons x 5 days/trip x 3 trips = 30 person-days; and lodging during recovery, 4 persons x 8 days/trip x 1 trip = 32 person-days. At NARL we will require use of a heated, wired space for assembly and testing of equipment prior to the two deployments, and during the monitoring operations. We shall need transportation between NARL and the helicopter rendezvous point.

We request all the above requirements to be arranged by NOAA.

ALASKA MARINE ENVIRONMENTAL ASSESSMENT PROGRAM
WORK STATEMENT (Research Unit #111)

I. TITLE:

Seasonability and Variability of Streamflow Important to Alaskan Nearshore Coastal Areas

II. PRINCIPAL INVESTIGATOR:

Robert F. Carlson, Director and Professor Hydrology
Institute of Water Resources
University of Alaska
Fairbanks, Alaska 99701
SS#: 395-40-5203

III. GEOGRAPHIC AREA AND INCLUSIVE DATES:

Bering Sea, Gulf of Alaska, Beaufort Sea June 1, 1975-Sept 30, 1976

IV. COST SUMMARY:

FY 1975	FY 1976
through June 30, 1975	July 1, 1975-Sept 30, 1975
$4,245	$46,127

V. PROPOSED RESEARCH:

A. Background and Objectives

The freshwater flow from Alaska's many coastal streams are an important factor in understanding the local circulation and transport patterns of the outer continental shelf and nearshore zone. Although many of these streams have streamflow quantity and sediment concentration measurements from a number of years as a result of the USGS, Water Resources Division, measurement program, neither the seasonability or the year to year variability has been adequately examined. Also, because of the very sparse nature of Alaskan streamflow data and the extreme heterogeneity of the land mass, indicies of seasonability and variability must be related to stream basin parameters to allow for meaningful extrapolation to ungaged streams.

The work of this proposal is expected to be important to the project tasks which are attempting to examine circulation, transport, ice phenomena, and biota which are affected by freshwater and sediment inputs.

The overall objective of the proposed work is to determine and assess the characteristics of coastal streams important to offshore development activities. This general objective will be met through the following subobjectives:

1. Examination of important seasonal characteristics of streamflow such as breakup data, freezeup data, and flow variation throughout the year.

2. Characterize the way in which the streamflow varies from year to year.

3. Relate the indices of seasonability and variability to areal basin characterisitics.

4. Examine the manner in which sediment concentration varies throughout the year and from year to year, particularly in the way that it is tied to streamflow quantity.

The US Geological Survey has carried out the streamflow measurement and sediment concentration program for a number of years. The degree of coverage and the length of record varies throughout the coastal area but is generally longer and more dense in the Gulf of Alaska, less dense in the Bering Sea, and nearly absent on the Beaufort Sea. The Geological Survey and others have carried out a certain number of statistical summaries but these generally relate very general information such as average annual flow. To date, an adequate and complete study on the variability and seasonability of streamflow and sediment concentrations have not been carried out nor is an adequate estimation available at the present time.

The study will rely on information acquired by the Geological Survey for streamflow and sediment. The study will also supplement this data from available satellite images of the NOAA 2 and 3 series and the ERTS series, particularly in regard to understanding the areal variations of streamflow characterisitics and disappearance and accumulation of snow-cover.

We expect to have formulated our basic analysis plan and have it executed on most of the available stream records by September 30, 1976. However, because of the extremely small length of many Alaskan streamflow records it is important that the estimates continually be updated as new information becomes available for the entire length of the OCS Environmental Assessment program. If a particular lack of information is noted as a result of this analysis, recommendations will be made to acquire additional streamflow information by the US Geological Survey and the new information will be incorporated into the estimation scheme.

We know of no directly related research being carried out by others. The project will collaborate closely with the information gathering activities of the US Geological Survey, Water Resources Division.

B. Methods

The analysis effort of this task will depend nearly entirely on already acquired published and unpublished materials. We expect the source to be the published records of the Geological Survey and various unpublished notes and records of the Geological Survey. The available satellite imagery of the ERTS and NOAA 2 and 3 series will also be used.

The first phase of the work will concentrate on analyzing past records of the Geological Survey and other records as may be available and will include examining the satellite imagery of the ERTS 2 and NOAA 3 series. Records will be compiled in such a form as to have immediate availability to other phases of the outer continental shelf environmental assessment program.

We will perform appropriate analysis to determine important characteristics of streamflow seasonability. Each available record will be examined year by year to determine such features as the dates of breakup and freezeup, length of rise of the spring flood, approxiamte distribution of streamflow between base flow, rainfall, snowmelt and magnitude and number of flood peaks throughout the year. Simple models which assess and account for the storage and release capability of most large river basins will be examined and used to explain portions of the data.

Once the seasonal characteristics of each year of streamflow are determined and adequately explained, the next step will examine the way in which key characterisitics vary from year to year. Although we do not expect the length of the record to permit an adequate examination of periodicities which allow for extrapolation to the future, we do expect to be able to explain the seasonability characteristics with some simple statistical models. The next step of analysis will be to relate both the seasonability and variability characteristics of each individual stream to its stream basin characterisitcs. Our experience has indicated that the area of the basin is usually the most dominate one and seldom does the sparse data array in Alaska permit valid statistical justification for inclusion of other streamflow characteristics. Nevertheless, the basis for areal dependence of various flow characterisitics is important and will be thoroughly examined. When areal dependence is detected, the models thus derived can be used as a basis for extrapolation to ungaged or poorly understood areas. Also, this phase of the work may lead to recommendations for further measurement on the part of the Geological Survey Water Resources Division.

An important feature of describing both the temporal and spatial characterisitics of the seasonability and variability parameters will be an analysis of the available satellite imagery of the ERTS 2 and NOAA 3 series. The most useful part of this analysis will be an examination of the way in which the snowcover accumulates and disappears to allow for appropriate inferences of the nature and timing of various sources of the streamflow hydrograph. When necessary, models will be derived which depend on other parts of the hydrological system such as precipitation, evaporation and storage patterns.

An important part of the research effort will be an examination of available sediment concentration data. Again the variability and seasonability of the sediment concentration data will be examined for available records. As most sediment data is available in terms of concentration, an estimation of the total sediment input into the coastal area will depend quite closely on the streamflow quantity analysis program, particularly in regard to estimation of future events.

VI. INFORMATION PRODUCTS:

The first stage of the research will include intermediate data compilation, collection and publication which should have immediate usefulness to other phases of the environmental assessment effort. Because many of the streamflow characteristics are basic driving mechanisms for many nearshore processes, an attempt will be made to design the output of the examination in such a way to meet the data needs of the other assessment efforts. The information generated should be of particular interest to Jan Cannon in his work on coastal Morphology and with whom this work will be closely coordinated. The final results will be stated both in a deterministic and statistical fashion. Results will be available in qualitative, quantitative, graphical and deterministical form. Other users will have available information on such characteristics as expected date of breakup, expected date of freezeup, date of maximum sediment discharge and other important features of the streamflow regime.

In particular, graphs and tabulations will be provided which show the mean runoff and probability of extreme variations from the mean for streams discharging into estuaries likely to be impacted by oil development. These include, for example, the Copper, Kvichak, Nushagak, Kuskokwin, Colville, and Kuparuk River. We will provide data inputs to oil spill scenarios developed by other workers whose estuarine circulation models are affected by the influx of fresh water.

The figures and calculations will be based on those of the 30-50 streams gaged by the U.S. Geological Survey which have records of sufficient length to allow analysis of their statistics. For basins with less than adequate gage data, discharge curves will be estimated by use of models which use such data as are available. Estimations of precision will be provided for all cases.

VII. DATA OR SAMPLE EXCHANGE INTERFACES:

This project should not need data or samples from other investigators. We will depend almost entirely on available published and unpublished records of the U.S. Geological Survey, Water Resources Division, for streamflow and sediment data. If sediment concentrations should be acquired directly by other parts of the environmental assessment program, then such data could be used by this project.

We expect the product of this research to be required by others as they need to understand many offshore processes which depend on freshwater or sediment concentration, particularly in the vicinity of the many large streams in all three study areas. We expect the bulk of this information to be used by other parts of the physical oceanography program and some parts of the biological assessment program and by some parts of the program attempting to understand ice breakup patterns.

We also expect to make use of satellite imagery from the ERTS and NOAA satellites. We expect this information to be made available through arrangements already arrived at with on-going projects at the University of Alaska, Fairbanks. If additional areal photography should become available as a result of the environmental assessment program, particularly of coastal basins in regard to snow disappearance and accumulation, such information could be used by this project.

VIII. SAMPLE ARCHIVAL REQUIREMENTS:

We do not expect any archival requirements for this project.

IX. SCHEDULE:

The schedule for the project is envisioned as follows:

June 1, 1975 to August 30, 1975

Assessment and acquisition of available data and satellite imagery.
Design of analysis program.

September 1, 1975 to March 31, 1975

Analysis of seasonability and year to year variability for for streamflow records selected for analysis.
Examination and prelimiary assessment of strategies for areal streamflow models and variability description of sediment data.

April 1, 1976 to June 30, 1976

Completion and documentation of variability, seasonability and areal analysis of streamflow and sediment data.
Preparation of preliminary report and documentation.

July 1, 1976 to September 30, 1976.

Preparation of final report and recommendation for additional assessment and updating of variability, seasonability and areal models.

Information delivery milestones are as follows:

November 30, 1975

Listing of data matrix which has been assembled and acquired in preparation for the analysis program

June 30, 1976

Delivery of draft report and explanation of seasonability, variability, areal models of sediment and streamflow.

September 30, 1976

Delivery of final report and recommendations for further work and assessment of new data as it becomes available. Recommendations for updating of analysis models.

X. EQUIPMENT REQUIREMENTS:

We do not expect to need any special equipment for this project.

XI. LOGISTICS REQUIREMENTS:

We do not expect any special vessel, lodging or other logistics support. The project may schedule and make several site visits to certain areas to provide additional information on the nature of stream basins. All travel requirements will be arranged with our institution.

(Research Unit #138/139/147)

WORK STATEMENT

I. Title: Gulf of Alaska Study of Mesoscale Oceanographic Processes (GAS-MOP)

II. Co-Principal Investigators:

Dr. Stanley P. Hayes
Physical Oceanographer
Ocean-Atmosphere Response Studies Project
Pacific Marine Environmental Laboratory
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(206) 543-5276

Dr. James D. Schumacher
Physical Oceanographer
Estuarine and Environmental Dynamics Group
Pacific Marine Environmental Laboratory
University of Washington, WB-10
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(206) 442-4958

III. Region: Gulf of Alaska
1 May 1975 - 30 September 1976

IV. Cost Summary:

FY 75 (-30 June 1975)	$145,200
FY 76 (1 July 1975 - 30 September, 1976)	254,800
Total	$400,000

V. PROPOSED RESEARCH:

A. Background and Objectives

The field studies proposed here investigate mesoscale circulation. This work will be carefully coordinated with other complimentary facets of the BLM sponsored Gulf of Alaska study. Together with meteorological studies, additional density field and current measurements and the proposed numerical modeling, this will form a coherent program that will attempt to characterize intermediate scale advective and diffusive processes within the study area. This research addresses Task B-2 and to a limited degree Task B-11.

Intermediate scale circulation in coastal areas can be roughly described as quasi-geostrophic. This means that the currents will respond locally to winds (resulting in Ekman flows and surface layer transports), sea surface slopes (resulting in barotropic currents), and the distribution of the density variations (resulting in a baroclinic contribution to the currents). In addition to the local forcing external factors will cause components of the current that are not controlled by local forcing, such as tidal currents and shelf waves. These various components of the flow interact with each other and the local geometry to give the observed currents. From a theoretical point of view the observed time dependent currents can not be accurately forecast using simple boundary conditions and first principles. On the other hand a purely phenominological description of the circulational is impractical for several reasons. First of all it would be prohibitively expensive to acquire the density of data required to do an adequate job, and secondly it would be impossible to describe events that had not been experienced and documented. These difficulties suggest that some combination of mutually supportive theoretical and observational studies be carried out. Clearly parameters that can be related to local forcing must be measured i.e. winds, density distributions and sea surface elevations. In addition strategically placed current meter moorings are required to document the resulting flow. From these observations causal relationships can be formulated. These then will provide the basis for more refined experimental design, development of environmental models and ultimately lead to the ability to forecast regional conditions from a limited amount of environmental data.

The continued current meter and STD measurements and the initial bottom pressure measurements which are detailed in this work statement are required to meet these objectives. Only a "first look" analysis with preliminary inferences on causal relationships can be anticipated by September 30, 1976. This is particularly true for the sea surface slope experiment since this will be the first such field experiment.

The proposed research is conveniently divided into two integrated and carefully coordinated segments each under the direction of one of the principal investigators. The first segment covers moored current meter installations under the direction of Dr. Schumacher and the second segment deals with sea surface slopes under the direction of Dr. Hayes. Both segments of the study will require some STD measurements in conjunction with the instrument deployments. This will be on a finer space scale and shorter time scale than the larger STD grid that has been proposed

(T. Royer, U. of Alaska) for the entire area. The increased spatial and temporal resolution which we propose is necessary in order to determine the importance of high frequency, small scale processes.

B. Methods

<u>Direct Current Measurements</u>

Only a minimal amount of research has been conducted in the Gulf of Alaska, with the most comprehensive physical oceanographic study being presently completed under the first year of the BLM-NEGOA program. This data will be used as an information base for the present study. In addition, weather information and satellite photographs will be analyzed to determine surface wind stress which will aid in the interpretation of the direct current meter measurement program.

Direct current measurements are required to describe the spatial and temporal variability of the circulation. This information supports general circulation studies, investigations of mixing processes, and suspended sediment transport (Tasks B-2 and B-11). Direct velocity measurements are required to establish the correlation between the sea surface slope variations and the velocity field. Additionally, the direct measurements combined with inferred velocities calculated from STD data establish the geostrophic and non-geostrophic components in the baroclinic flow.

A total of five moored current meter buoys (Fig. 1 shows typical mooring) are proposed for this study. In some cases additional instrumentation e. g. bottom pressure gauges and an nephelometer will also be on the mooring.

STA-62 The position in the NE Gulf of Alaska is indicated in Figure 2. This station has been maintained continuously.

since October 1974. It will provide long-term estimates of the statistics of the velocity. These are required in order to calculate mean velocities and to examine the stationary of the statistics. This buoy in about 200 m of water will have Aanderaa current meters at 20, 30, 50 m depths and at 10 m above the bottom. The mooring will provide key data for comparing sea surface slopes with the velocity field.

STA-63A The position is indicated on Figure 2. This is a short term (3 months) array using the equipment from station 3. It will further study the sea surface slope correlation with the velocity field and support the suspended sediment transport proposal.

STA-C71 The position in the NW Gulf of Alaska is indicated in Figure 3. The array contains two Aanderaa current meters at 20 and 50 m depths. This is a preliminary study of the velocity field in this area of the Gulf. The mooring will be maintained continuously to begin monitoring the long term statistics. A bottom pressure gauge will also be moored.

STA-C72 The position is indicated on Figure 3. The current meter array is the same as on C71. Again a preliminary study in the western Gulf of Alaska will be obtained.

In support of these direct current meter measurements STD stations will be taken at the deployment and recovery times. Additionally, 25 hour anchor stations will be taken at each current meter location. Regional STD coverage will be provided by University of Alaska portion of the program.

The processing and presentation of the STD data generally follows the procedures and formats used during the first year of PMEL's NEGOA program, and used in previous reports (Halpern, 1972; Halpern and Holbrook, 1973; Halpern, Holbrook, and Reynolds, 1974). The current meter data will be analyzed and presented in the same format as in the present PMEL'NEGOA program (software and theory of these analysis appear in Halpern's series of reports).

Sea Surface Slope Experiment

The sea surface slope determines the barotropic velocity field in the same manner that the density field from STD stations determines the baroclinic velocity field. On continental shelves the response of the ocean circulation to wind forcing is expected to have a large barotropic component particularly in winter. The bottom pressure measurements are required in order to establish the dynamics of the circulation (Task B-2).

The proposed sea surface slope program consists of an array in the NEGOA area and a pilot study in the NWGOA area. The array experiment is a follow up to the pilot study now in progress off Icy Bay (i.e., mooring 63-1/2). The proposed array contains six bottom mounted pressure/temperature recorders deployed along two lines as shown in Figure 2. The lines extend from the 50 m to the 250 m contour. The array will permit the determination of sea surface slope variations in both the on/off shore and along shore directions. These pressure measurements will be made in conjunction with the current meter arrays at 62, 63, 63A. The current meter arrays are described above. The objectives of the bottom pressure array, co-orginated with the current meter array, are:

A. LINE 1

1. Region of relatively flat/smooth topography

2. Offshore/onshore sea surface slope

(i) Spacial scale of the sea surface slope.

(ii) Calculate alongshore geostrophic currents from sea surface slope and compare with measured currents.

(iii) Time scale of set-up of slope.

(iv) Tidal analysis

(v) Shelf waves, quasi-geostrophic waves, eddies.

B. LINE 2

1. Alongshore sea surface slope

(i) Investigate as a function of offshore distance.

(ii) Effects of bottom topography between lines 1 and 2.

(iii) Calculate onshore/offshore geostrophic flow.

2. Offshore-onshore sea surface slope

(i) Offshore scale (see (i) above).

(ii) Dependence of slope on water depth compared to distance offshore.

The data from the array will provide a phenomenological description of the sea surface slope and the resultant barotropic velocity field. Time scales from 15 min to 1 year will be obtained to resolve the spectrum of the variability including seasonal effects. The description will be obtained in an area with topographic features common to many segments of the Gulf of Alaska shelf. Future experiments will test the description under various topographic and oceanic situations.

In the NWGOA area, a pilot study is designed to provide initial data on the sea surface slope variability in a new region. The experiment consists of a single bottom-mounted pressure/temperature recorder on mooring C71. The sea surface slope will be monitored between this station and the surface tide gauge at Kodiak. The pilot study information combined with the data from the array experiment will be used to design a more complete experiment for the NWGOA area. Additionally, the combined bottom pressure and moored velocity measurements will be useful to shelf circulation models.

In order to compare the baroclinic slopes with the measured sea surface slopes, STD stations will be occupied at each pressure site at deployment and recovery.

The geographical coverage of the sea surface slope program will be extended by the bottom pressure measurement off Seward which has been proposed by T. Royer (U. of Alaska). Frequent discussions and comparison of data sets are anticipated.

The measured bottom pressure will be analysed in conjunction with NOS collected coastal tide data at Yakutat and Kodiak. Wind and meteorological data from these locations as well as Middleton Island will be required.

The data analysis will develop as the experiment progresses. The initial processing to data report stage will follow the Halpern, Holbrook, and Reynolds (1973, 1974) format for scaler variables. Subsequent processing will separate the tidal from the non-tidal components. The first approach to this will probably use complex demodulation techniques (Perkins, 1970) to determine the tidal signals. These will be subtracted from the measured series to obtain the residual nontidal component. Processing programs for complex demodulation have been developed at PMEL by Halpern and Holbrook (e.g. Halpern, 1974).

Having obtained a time series of the nontidal bottom pressure variations, the coherence between the elements in the array will be examined. The techniques for this analysis in frequency space are discussed in Halpern (1973). The coherence between the elements in the array will be examined.

The coherence estimates will be used to test the adequacy of the sampling array (e.g. Carter, et al., 1973; Webster, 1972). Additionally the coherence and phase are fundamental in determining the propagation characteristics of pressure disturbances.

The coherent pressure sensors will be differenced to obtain the pressure gradient. Geostrophy will be assumed in order to estimate the barotropic velocity fluctuations. A variety of statistical and analytical procedures will be employed to measure the significance of possible causal relationships.

VI. INFORMATION PRODUCTS

Direct Current Measurements

The following presentations of the current meter data have been selected as being the most descriptive for a wide variety of users. For each current meter there will be five pages of data presentation which include standard statistics, speed and direction histograms, time series of v and v components of velocity, progressive vector diagrams and spectra of the velocity.

Speeds and directions will be grouped into 1.5 cm/sec and 6^o intervals, respectively. These data are presented as the actual number of observations in each interval. Time series plots are the hourly averages of the u and v components of velocity (east and north respectively).

Progressive vector diagrams will be constructed by vector addition of the hourly averaged east and north components of velocity. The plots begin with a circle and are marked every 24 hours by an asterisk. The diagrams do not represent real water particle trajectories since the observations were taken at a single point, but they do give an indication of the longer period fluctuations at that point. The scales of the diagrams are adjusted so all plots are the same size.

The velocity (temperature, salinity, and pressure when the meters are equipped with these sensors) time histories will be transformed to the frequency (spectral) representation by a fast Fourier transform algorithm (FFT) (Halpern, *et al.*, 1973) and plotted on a log-log grid. The left plot is the spectral estimates of the north and east components, and the spectra of the sum - of the two components is shown in the right-hand plot, with rotary spectra appearing below these.

Sea Surface Slope Experiment

The data on bottom pressure and temperature variations will be published in data reports with a summary of relevant statistical parameters. See Halpern, Holbrook, and Reynolds (1974) for an example. The analysis and scientific discussion of the data will appear in refereed journal articles and in technical reports.

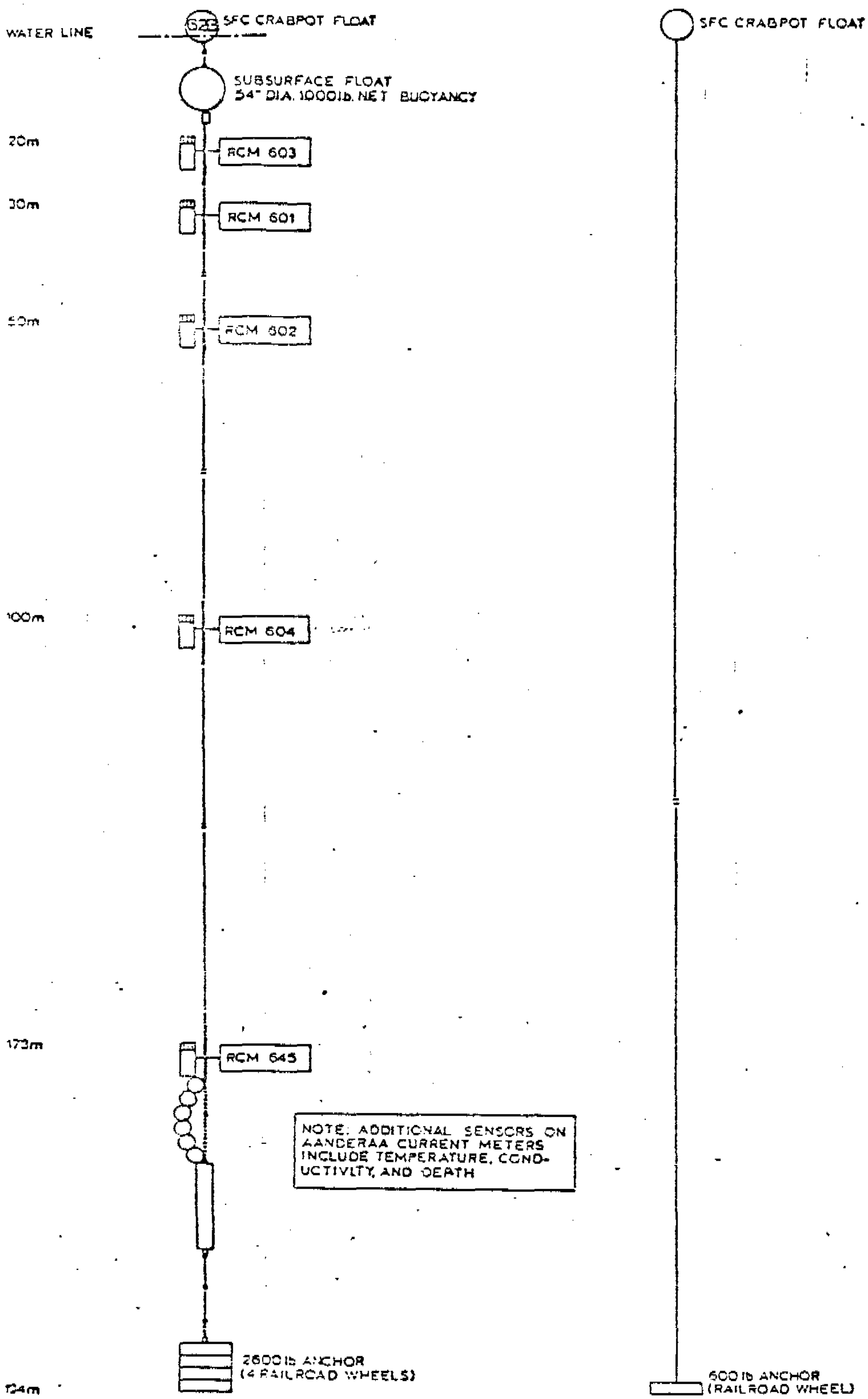
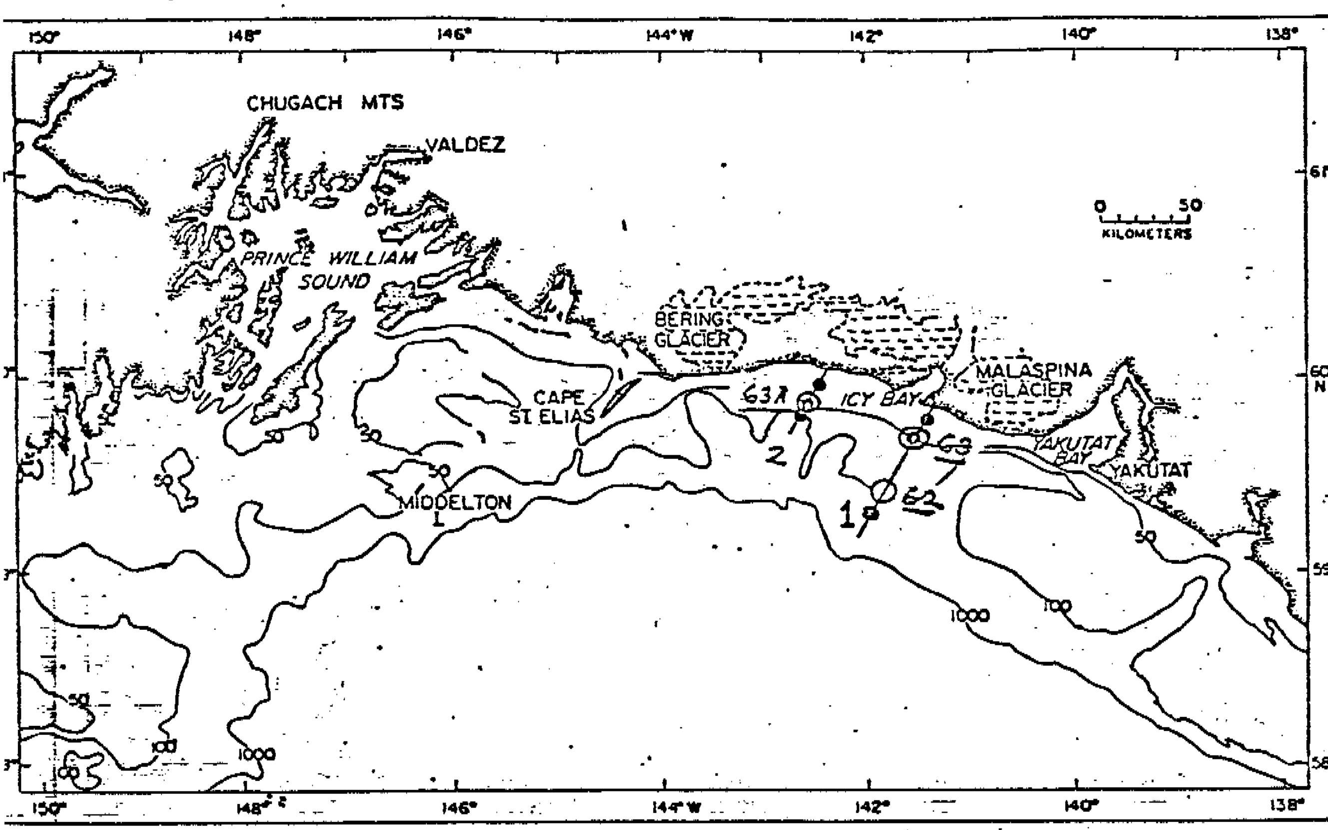


Figure 4. Mooring diagram showing details of subsurface buoy 62B and nearby witness buoy.



igure 2, Array configuration in the NE Gulf of Alaska. Circles represent current meter moorings. Dots represent bottom pressure gauges. 62, 63, 63A are the current meter moorings. Mooring 62 is a long term mooring. Mooring 63 will be in place during the winter quarter, (Dec 75 - Mar 76) mooring 63A will be in place during the summer quarter (June - Aug 76). Lines 1 and 2 comprise the bottom pressure array. Line 1 will be maintained continuously from Dec 75; Line 2 will be maintained continuously from March 76.

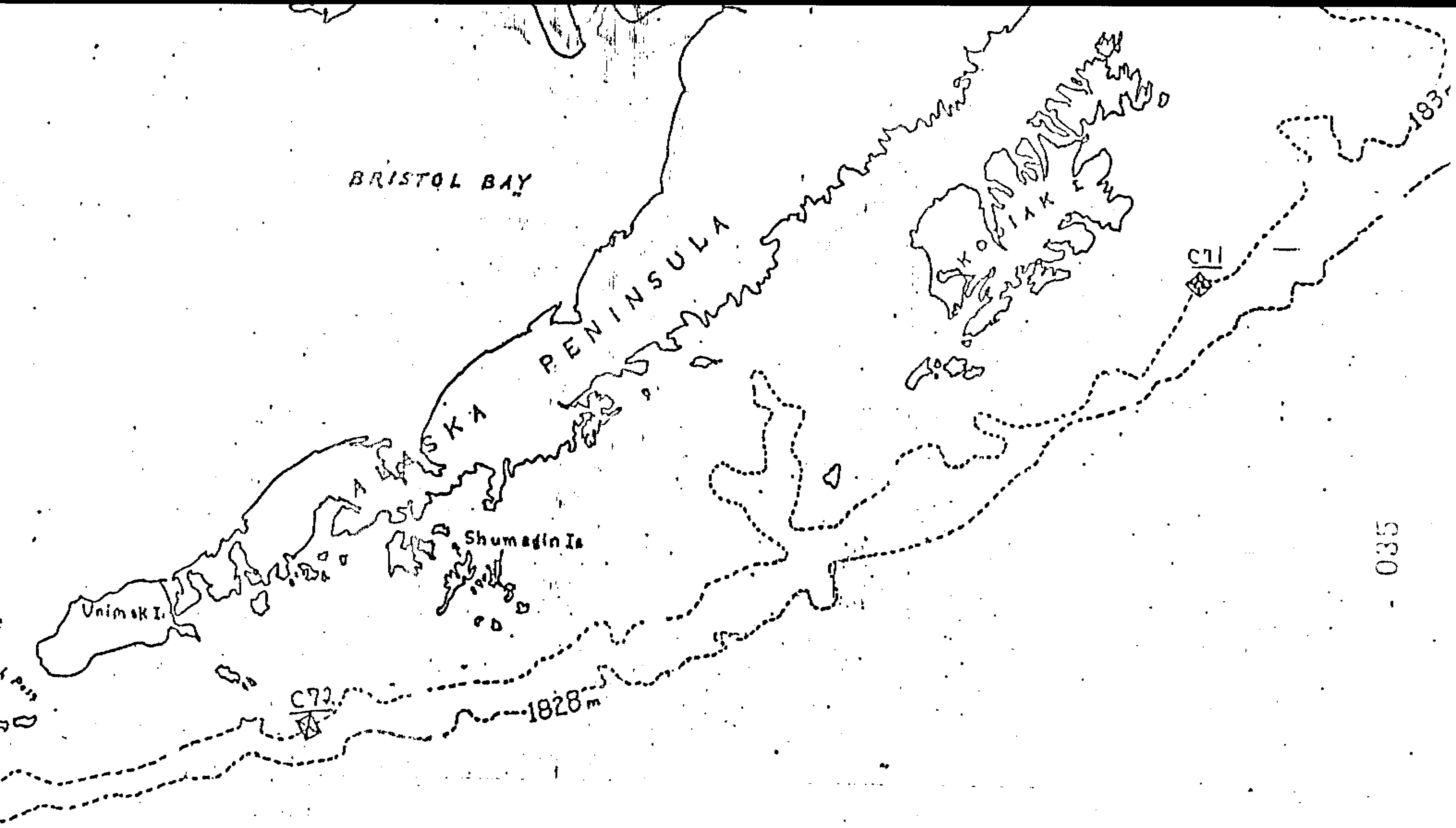


Figure 2. Proposed moorings in the NW Gulf of Alaska. The boxes are moorings. C71 has a pressure gauge as well as current meters.

035

VII. DATA OR SAMPLE EXCHANGE INTERFACES

The direct current meter measurements will be required by any investigators desiring information regarding general circulation and in particular the sea-slope study and as "ground truth" velocities to compare with the diagnostic modeling study.

Data on the meteorological conditions, hourly winds, hourly atmospheric pressure, and coastal tidal data for the Yakatat-Middleton Island region are required. Data from EB-33 are required. These data are required for the duration of the experiment. Analysis would be facilitated if the data could be supplied in 4-month pieces. This environmental data could then be analyzed along with the pressure gauge data.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

7-track magnetic tape in standard Holbrook format will supplied.

IX. SCHEDULE

See ship schedule in Table 1. This gives the deployment and recovery of instrumentation.

Direct Current Measurements

Date	Milestones
December 1975	Data report - STD & current meters STA 62E C71A & C72A
March 1976	Data report - Current meters STA 62F, C71B & C72B

Date	Milestones
June 1976	Data report - STD & current meters STA 62G, C71C & C72c.
September 1976	Data report - STD & current meters STA 62H, C71D & C72D
November 1976	Data report - STD & current meters STA 62I, C71E & C72E
February 1977	STD & current meters STA 62J, C71F & C72F

Sea Surface Slope Experiment

Date	Milestones
May 1975	Recover Aanderaa gauge (TG-2A). Post cruise calibration. Order equipment, supplies and materials to construct 5 pressure temperature gauges.
June	Engineering Study with protype pressure temperature gauge (PTG-100) and Aanderaa gauges (TG-2A). Oregon Coast deployment.
July	Order equipment, supplies and materials to construct 5 additional PTG's.
September	All parts for 5 PTG's have arrived. Assemble and calibrate units.
December	Deploy 3 PTG's on Icy Bay line 1. Line 1 will be continuously maintained from this time on.
January 1976	Continue construction and calibration of PTG's.

Date	Milestones
March	Deploy Icy Bay line 2 with 3 PTG's.
April	Deploy PTG at C71 NWGOA.
June	Replace line 1.
September	Replace line 2. Recover C71 PTG.
December	Replace line 1 in Icy Bay. A one year record of sea surface slope has now been obtained.

Each unit will be calibrated prior to each deployment and after each recovery. Data reports, technical reports, and other reports will be published irregularly.

X. EQUIPMENT REQUIREMENTS

All deployed instrumentation has been covered in the above schedules.

XI. LOGISTIC REQUIREMENTS

The ship schedule in Table 1 lists the required ship time. Cruises of five or six consecutive days are required for mooring work and a small number of STD stations in the vicinity of each mooring.

April 22, 1975

Clarification of the Work Statement of Dr. S. P. Hayes and Dr. J. D. Schumacher in the Gulf of Alaska

Data required from other sources:

This task requires the following meteorological and oceanographic data sets:

1. Hourly winds and atmospheric pressure values at Yakatat, Kodiak, Middleton Island, and EB-33.
2. Hourly water level at Yakatat, Cordova, and Kodiak.

These data are required for the duration of the experiment. Analysis would be facilitated if the data could be supplied in monthly pieces with no more than a 2-month lag (e.g., January data arrives April 1). The data can be simply lists of numbers or cards or 7-track magnetic tape.

(Research Unit #140/146/149/31)

WORK STATEMENT

I. NUMERICAL STUDIES OF ALASKAN REGION

II. PRINCIPAL INVESTIGATOR:

J. A. Galt (206) 442-4598
Pacific Marine Environmental Laboratory, NOAA
3711 - 15th Avenue N.E.
Seattle, Washington 98105

III. GEOGRAPHIC AREAS:

Segment I - Gulf of Alaska

Segment II - Bering Sea

Segment III - Beaufort Sea

IV. COST SUMMARY

	FY 75	FY 76
Gulf of Alaska	0	72.4K
Bering Sea	0	60.4K
Beaufort Sea	0	30.0K
Total		162.8K

V. PROPOSED RESEARCH

Introduction

Numerical modeling techniques can be productively used in a variety of ways to support environmental studies. In order to identify areas that offer the greatest potential for supportive interaction, it is appropriate to outline some of the salient features of the study plan. This then should point to some key areas where modeling efforts should be concentrated.

In formulating an environmental assessment study it is clear a priori that any research program that attempts to describe the actual complexities of a natural environment will require a variety of investigative techniques. Various time and space scales will interact with certain processes being dominant at some instances while at other times entirely different dynamic regimes may control the observed distribution of parameters. With this as a preamble, it is not surprising that a single well defined experiment cannot be expected to address a significant portion of the issues raised in an environmental assessment study. Quite the contrary, studies to describe ecosystems and formulate viable alternatives for environmental utilization are typically multifaceted with components overlapping scientific disciplines and calling on the talents of a relatively large number of experts and projects. It is within the framework of this consortium approach that the fundamental questions must be addressed, the research must be carried out, and the data compiled. Obviously one of the first tasks amenable to numerical modeling techniques would be the integration of collected data. Numerical models that use the observational data collected by various investigators and provides interpretations consistent with known dynamical constraints are thus suggested.

A second characteristic of regional environmental assessment studies that can be identified a priori is that the available field data will be sparse. This will be true in two ways. First of all, there is never enough money available to collect uniform data sets that span the region of interest. The best defined experiments tend to look at specific processes in a localized area. This is of course as it should be if a quantitative understanding of controlling dynamics is required and available funds are limited. Even if great care is taken in designing nested sets of experiments there will still be spatial gaps in the available data. The field data will also inevitably be sparse in a temporal sense, or to put it another way it will lack historical perspective. This will become particularly apparent when one tries to consider the chronic build-up of pollutants or the statistics of extreme events. This then identifies a second major area where numerical modeling will be useful. Once dynamical models have been developed and verified with local experiments they can be used to extrapolate the implications of the observed dynamics into regions where the data are sparse. If carefully done, this will optimize the return on actual data that are collected and may in some cases make it possible to obtain historical statistics by hindcasting with limited available data (for example, meteorological data applied to the storm surge problem).

Gulf of Alaska

Basically, three numerical modeling studies are proposed for the Gulf of Alaska region.

The first will be based on the diagnostic model that has been developed under the present NEGOA contract (B-1) (B-2) (B-4) (D-13). To date, a theoretical description of the model equations has been completed and by the end of the present contract representative test data will have been run through the model with the results presented in the form of current patterns for the NEGOA region. The extension of the study will focus on three specific goals: 1) The numerical model program will be standardized and documented in a format that will allow its immediate application to any other regional study where appropriate data is available. Along with appropriate documentation the model will be configured to take combinations of direct current measurements and pressure gauge data as boundary input. Standard output options will be maps of the dynamic topography of the sea surface, Ekman wind drift currents, total surface currents and integrated total transport. 2) The model will be tested using a wide variety of input conditions, derived both from artificial and geophysical data. The fundamental dynamic representations and numerical techniques used in the model will be checked to obtain estimates of accuracy and the range applicability potentially possible with the model. And 3) the data collected through the effort of the physical oceanography subprogram will be used in the model to investigate as many flow conditions as can be represented. These results will be collected and presented as a series of current distribution scenarios.

The second proposed numerical modeling study for the region will be aimed at the development of a stocastic model for the observed variations in the wind and current measurements (B-4) (B-2) (D-13). This model will use the long period current meter and wind field data to obtain statistical representations for the time variations of the flow. The time dependent stocastic representations of the flow can then be used to simulate those portions of the advective fields which are neither deterministic (in the sense that present techniques cannot forecast them) or small enough scale so that they can be treated as diffusive. The currents from this type model will complement the ones obtained from the diagnostic model and the sum of the two fields can then be used as a more complete representation of the advective regime.

The third proposed model study for this region will initiate the development of a distribution of variables model (B-4) (B-8) (D-13). This model will require current and mixing data as input and will calculate the advective and diffusive changes of constituents in the water. Basically this will solve the mass budget equation. The first phase of the study will consider the two dimensional spreading of a surface contaminant, thus simulating the early trajectory to be expected from an oil spill. A variety of environmental situations will be simulated and the results of the other model studies as well as available field data will be incorporated into the formulations. Subsequent model development will examine the distributions expected for constituents that spread in three dimensions as well as components that are non-conservative. The long term objective of this model development is to formulate a model that can contribute to a quantitative description of a general constituent within the water column. In these later stages cooperation with other subprograms (for example, suspended sediment and plankton studies) is anticipated. In this way it may be possible to simulate some more general environmental parameter distributions and potential system interactions.

Bering Sea

This numerical modeling program will be made up of two components. The first will begin the initial diagnostic model simulations of the Bristol Bay region of the Bering Sea (B-1) (B-2) (B-4). The basic model formulation used will be identical to the diagnostic model developed for the Gulf of Alaska study. For the first few exploratory runs the model can be run with historical STD or Nansen bottle data supplying the density information. Boundary conditions on the pressure and currents can be approximated with the understanding that some range of parameters will have to be investigated. This exploration will add valuable insights into the dynamic response of the system. As the observational program begins to accumulate field data it will be incorporated into the model studies.

The second component of the proposed study will be the development of a baroclinic general circulation model for the Bering Sea. This will be a relatively modest study focusing attention primarily on two key dynamic processes that are thought to be relevant to the circulation of the Bering Sea shelf: 1) To investigate the dynamic implications of the seasonal wind stress variations of an order of magnitude that occur in the western Bering Sea (these are comparable to the changes that drive the monsoon currents in the Indian Ocean) and 2) to study the transfer of momentum and vorticity across the shelf break and to estimate to what extent the shelf circulation is driven by currents forced in deep water.

Beaufort Sea

At the present time a large scale investigation of Arctic Ice Dynamics is being conducted by the AIDJEX group. One component of the study deals with the development and testing of a large scale model of pack ice (B-4) (B-12). The first task proposed in this study is to conduct a careful review of the AIDJEX modeling efforts and to identify to what extent the ice models can be adapted to address the smaller scale coastal regions that are relevant to the BLM study. After the present work has been analyzed, critical gaps in the coastal ice-ocean circulation problem will be identified and these can be used to focus future proposals on facets of the problem that can be most profitably attacked. A second component of the proposed research will be to review tidal and storm surge models for potential adaptation to the Beaufort Sea shelf region (B-12) (B-14). The fundamental physics represented in this type model are those described by the so-called long wave equations. These equations have been successfully used in hundreds of locations to forecast tidal and storm surge phenomena. In some respects a Beaufort Sea model could be a standard adaptation of these equations to the local geometry. Not entirely so, however, for in this region there are several variants on the standard problems. In particular, the tides are very small and the major variations in sea level seem to be associated with seiche or surge effects. Another factor that will require careful attention is the deep ocean outer boundary (this is not an uncommon problem for storm surge models and has been approached many times before; all the same it generally cannot be handled in a routine manner). The final factor that will require special attention is the ice cover. The extent to which there is open water in the shallow water adjacent shore and the amount of stress that can be transmitted through the ice cover and will both be very significant parameters in determining coastal surges. Available models will be very carefully analyzed and evaluated in terms of incorporating appropriate representations of these processes.

VI. INFORMATION PRODUCTS - BY REGION AND COMPONENT

Gulf of Alaska

1) Diagnostic Model (Application and Development). This model is primarily designed to look at long term average flow condition giving estimate of something like monthly mean flow.

Expected products

a) The model will be applied to the Gulf of Alaska data collected during the previous cruises of the program (STD program, current meter program, pressure gauge program, NWS weather, and whatever detailed weather comes out of Dr. Laevastu's study). In addition, various sets of artificial data will be input into the model to illustrate the dynamics of the flow and investigate special situations. The final product will be a report presenting a number of environmental scenarios.

b) The computer software for the model will be consolidated and documented so that a package containing a technical description and Fortran IV listing will be available in report form. Step by step instructions for applying the model to arbitrary data sets will make the model available to study all BLM regions with a minimum of development and set-up effort.

2) Development of stocastic representations for time dependent wind and current transport. This model will represent the advective effects of variations in the current field. The model will generate current fields with statistical characteristics matching those obtained from direct observations.

Expected product

A numerical representation (computer subroutine) will be developed that simulates regional advective effects in a manner consistent with actual observations from current meters and Lagrangian drogues.

3) Development of Distribution of Variables Model. This model will simulate the distribution of pollutants including the effects of advection and diffusion. For input data it will use the current fields from the

diagnostic model (steady mean flow), the stocastic model (time dependent-non deterministic flow) and the HN model (tidal flow) as well as weather data from NWS and Dr. Laevastu's study.

Expected product

a) Initial formulation of the model with technical report describing processes and numerical techniques.

b) Additional technical report documenting preliminary tests of the model for distributions of surface pollutants in the NEGOA area.

Bering Sea

1) Initial use of diagnostic modeling in the Bristol Bay area. This will use the model developed in the Gulf of Alaska on Bristol Bay data as it becomes available.

Expected product

A few documented runs, or applications of the model to simulate circulation in Bristol Bay. A report will document progress and results.

2) Baroclinic GCM (General Circulation Model) for the Bering Sea. This model will focus attention on the exchange processes across the shelf break as well as the implication of the large variations in seasonal wind stress.

Expected product

By the end of the contract period the model will have been configured for the Bering Sea. Analysis of supporting data for initialization and the defining of forcing functions will be completed and the first test runs to check model characteristics will be carried out. A report will document progress and results.

Beaufort Sea:

Review of Ice Modeling of AIDJEX and careful analysis of ice cover as it affects storm surge models. This will be a technical literature review and analysis of the state-of-the-art incorporation of sea ice in ocean models.

Expected product

A report documenting ice models and the potential effects of ice on existing models. Recommendations for continued development and numerical experiments will be included in the report.

VII. DATA INTERFACES

The modeling studies will be closely coordinated with field studies as is indicated in section V.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

Model results will be carefully documented in report form.

IX. SCHEDULE

Model development and modification will depend to some extent on recruiting results for key personnel. Which facets of the work will be initially carried out will again depend on key personnel, but also on the expected availability of field data to formulate boundary conditions and test model results.

Brief progress reports will be delivered to the project office quarterly and major modeling results will be presented in report form.

Documented program listings will be made available wherever appropriate.

X. EQUIPMENT REQUIREMENTS

None

XI. LOGISTICS REQUIREMENTS

Computer facilities -- tentatively at the computer center at the University of Washington.

Final

WORK STATEMENT (Research Unit #141/145/148)

I. BRISTOL BAY OCEANOGRAPHIC PROCESSES (B-BOP)

II. Dr. James D. Schumacher
Pacific Marine Environmental Laboratory, ERL
3711 - 15th Avenue N.E.
Seattle, Washington 98105

Dr. L. K. Coachman
Department of Oceanography, WB-10
University of Washington
Seattle, Washington 98195

III. BERING SEA, 1 JULY 1975 - 30 SEPTEMBER 1976

IV. COST SUMMARY

FY 1975 through 30 June 1975	FY 1976 1 July 1975 - 30 September 1976
$229,576	$370,424

V. PROPOSED RESEARCH

A. Background and Objectives

1. The objective of this study is to aid elucidation of the circulation pattern in the study area (B2) by obtaining long-term Eulerian current and sea level measurements. The measurements and their analysis will in addition support Tasks B-4, B-5, B-11 and E-2. Task B-1, review of literature and data on the circulation, will support analysis of the data.

2. Few direct current measurements have been made in the area, and most ideas of the circulation pattern are inferred from the distribution

of water properties or are based on ship drift information. It is known that the flow along the continental slope to the southwest of the study region is to the northwest and that there is a net transport from the Bering Sea shelf north through Bering Strait. The tidal components of the flow are probably significant.

3. Long term Eulerian current and sea level measurements, supported by STD surveys, will permit an examination of the Bristol Bay flow regime.

4. All data from the sensors will have been recovered by 30 September 1976. However, because of the quantity of the data and the complexity of the analysis required, a final report will not be completed by this time. Technical reports will be issued about 90 days after each data recovery.

5. Direct liaison with other groups maintaining sea level and current meter moorings will be necessary to coordinate analysis. Many investigators will require a general picture of the flow regime. Therefore, the data will be rapidly analyzed to provide general features such as velocity time plots and progressive vector diagrams.

B. Methods

Weather information and satellite photographs will be analyzed to determine surface wind stress which will aid in the interpretation of the direct current meter measurement program.

Direct current measurements are required to describe the spatial and temporal variability of the circulation. This information supports general circulation studies, investigations of mixing processes, and suspended sediment transport (Tasks B-2 and B-11). Direct velocity measurements are required to establish the correlation between the sea surface slope variations and the velocity field. Additionally, the direct measurements combined with inferred velocities calculated from STD data establish the geostrophic and non-geostrophic components in the baroclinic flow.

The hydrographic survey has been designed as a pilot 17 STD station line (see Figure 3) to be occupied three times and an expanded 102 STD station grid (see Figure 4) to be occupied three times (using two ships) during the intensive field operations (summer FY 76). The station locations for the 102 station grid have been selected in conjunction with proposed chemical oceanographic studies. The pilot grid will cover approximately 1200 nautical miles and the expanded grid 3300 nautical miles.

The station grid in Bristol Bay will focus attention on the complex circulation over this shelf region caused in part by river effluent into the eastern end of the bay, water transport through Unimak Pass, and oceanic conditions found off the western edge of the shelf. Station spacing in this region is on an approximately 25 x 25 nautical mile square grid. North of Bristol Bay, where the circulation is expected to be less relevant to immediate problems in potential lease areas, the grid is to be expanded to 50 x 50 nautical miles. Due to the length of this station grid and the need for synopticity, two ships will be required to run the grid. Four 25-hour STD time-series stations are to be occupied near station BC1 (September and June) and BC2 (August and September) to examine typical magnitude of short period baroclinic fluctuations in the density field.

The hydrographic program will sample temperature and salinity distributions at each station using an STD recorder. Density fields will be computed and the baroclinic component to the flow calculated. Section plots of the data will be examined and estimates obtained for static stability as well as mixing processes. If water masses can be differentiated, long period advective effects can be estimated. The calculated density information will also be the primary input to the diagnostic modeling efforts.

All components of the program will be carefully coordinated and feature an approach that nests scales in both time and space. During the initial studies a large scale grid of three moored instrument packages will be deployed and renewed on approximately a three-month schedule. Each of these instrument packages will include two Aanderaa current meters and an Aanderaa pressure gauge (BC1, BC2 and BC 3 -- Figure 2). A tentative deployment schedule for these moorings is: (1) early September 1975, late November 1975, early March 1976, and June 1976. During the periods when these moorings are deployed the reconnaissance STD survey will be carried out including 17 stations (Figure 3). The data from this large scale study will provide a historical perspective for the velocity and density fields as well as sea level data that can be analyzed for tidal and storm surge components.

During the summer of 1976 the study will be intensified with increased resolution along the inflow and outflow boundaries and in a triangular array in central Bristol Bay. Six additional current meter moorings each with two Aanderaa meters will be deployed for the period from June 1976 to September 1976 (BC4, BC5, BC8, and BC9 -- Figure 2). Four additional moorings with pressure gauges will be deployed around the perimeter of the region to better define the barotropic pressure gradients and tie together the current meter and density field measurements (BC10, BC11, BC12, and BC13 -- Figure 2). These moorings will also be deployed during the intensified summer of 1976 study.

Data from all segments of the program will be coordinated with modeling studies (Galt and Favorite) and synthesized into data reports that will be available through the project office to all interested investigators.

Details of the mooring designs and techniques of data reduction will be similar to those used in the BLM sponsored studies in the Gulf of Alaska. The processing and presentation of the STD data generally follow the procedures and formats used during the first year of PMEL's NEGOA program, and used in previous reports (Halpern, 1972; Halpern and Holbrook, 1973; Halpern, Holbrook, and Reynolds, 1974). The current meter data will be analyzed and presented in the same format as in the present PMEL NEGOA program (software and theory of these analyses appear in Halpern's series of reports).

VI. INFORMATION PRODUCTS

The following presentations of the current meter data have been selected as being the most descriptive for a wide variety of users. For each current meter there will be five pages of data presentation which include standard statistics, speed and direction histograms, time series of v and v components of velocity, progressive vector diagrams and spectra of the velocity.

Speeds and directions will be grouped into 1.5 cm/sec and 6° intervals, respectively. These data are presented as the actual number of observations in each interval. Time series plots are the hourly averages of the u and v components of velocity (east and north respectively.

Progressive vector diagrams will be constructed by vector addition of the hourly averaged east and north components of velocity. The plots begin with a circle and are marked every 24 hours by an asterisk. The diagrams do not represent real water particle trajectories since the observations were taken at a single point, but they do give an indication of the longer period fluctuations at that point. The scales of the diagrams are adjusted so all plots are the same size.

The velocity (temperature, salinity, and pressure) time histories will be transformed to the frequency (spectral) representation by a fast Fourier transform algorithm (FFT) (Halpern et al., 1973) and plotted on a log-log grid. The left plot is the spectral estimates of the north and east components, and the spectra of the sums of the two components is shown in the right-hand plot, with rotary spectra appearing below these.

Together with the STD data, which will be presented in the same format as in the present PMEL-NEGOA project, these data will be presented as data reports.

VII. DATA EXCHANGE INTERFACES

The current meter and STD measurements will be required by any investigators desiring information regarding general circulation and in particular the sea-slope study and as "ground truth" velocities to compare with the diagnostic modeling studies.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

Original current meter tapes and translated, edited and corrected STD tapes will be forwarded to EDS/NODC.

Current meter records of speed and direction, pressure recorder and STD data will be transcribed to the format specified by the Project Office and submitted to the Project data base.

IX. SCHEDULE

See Figure 1 for field operations schedule.

Date	Milestone
March 76	Data Report - Analyzed data from moorings BC1 - BC3 and reconnaissance STD study - Cruise 1
June	Data Report - Analyzed data from moorings BC1 - BC3 and reconnaissance STD study - Cruise 2
September	Data Report - same as above - Cruise 3 and detailed STD study Cruise 4
October	Data Report - detailed STD study - Cruise 5
December	Final Data Report - Analyzed data from mooring BC1 - BC13 - Cruise 4

XI. LOGISTICS REQUIREMENTS

See Figure 1 for all shiptime requirements all vessels should be CLASS I or CLASS III ships.

REFERENCES

Halpern, D., 1972: STD observations in the northeast Pacific near 47°N, 128°W (August/September 1971). NOAA Tech. Mem. ERL-POL-2, U. S. Government Printing Office, 26 pp.

Halpern, D. and J. R. Holbroook, 1973: STD measurements off the Oregon coast, July/August 1972. CUEA Data Rept. 4, Department of Oceanography, University of Washington, Seattle, 381 pp.

Halpern, D., J. R. Holbrook and R. M. Reynolds, 1973: Physical oceanographic observations made by the Pacific Oceanographic Laboratory off the Oregon coast during July and August 1972. CUEA Tech. Rept. 3, Department of Oceanography, University of Washington, Seattle, 205 pp.

Halpern, D., Holbrook, J. R., Reynolds, R. M., (1974). A compilation of wind, current, and temperature measurements: Oregon, July and August 1973. CUEA Tech. Rept. 6, Department of Oceanography, University of Washington, Seattle, 190 pp.

Operations \ Date	J (1975)	A	S	O	N	D	J (1976)	F	M	A	M	J	J	A	S
Moorings BC1, BC2, BC3			X		X				X			X			X
Reconnaissance STD Study			X		X				X						
Current Meter Moorings BC4, BC5, BC6, BC7, BC8 and BC9												X			X
Pressure Gauge Moorings BC10, BC11, BC12 and BC13												X			X
Detailed STD Study												X		X	X
Ship Time (days) 1st Ship			9		9				9			24		9	24
Ship Time (days) 2nd Ship												7		7	7
Cruise No			1		2				3			4		5	6

final mooring recovery

Figure 1

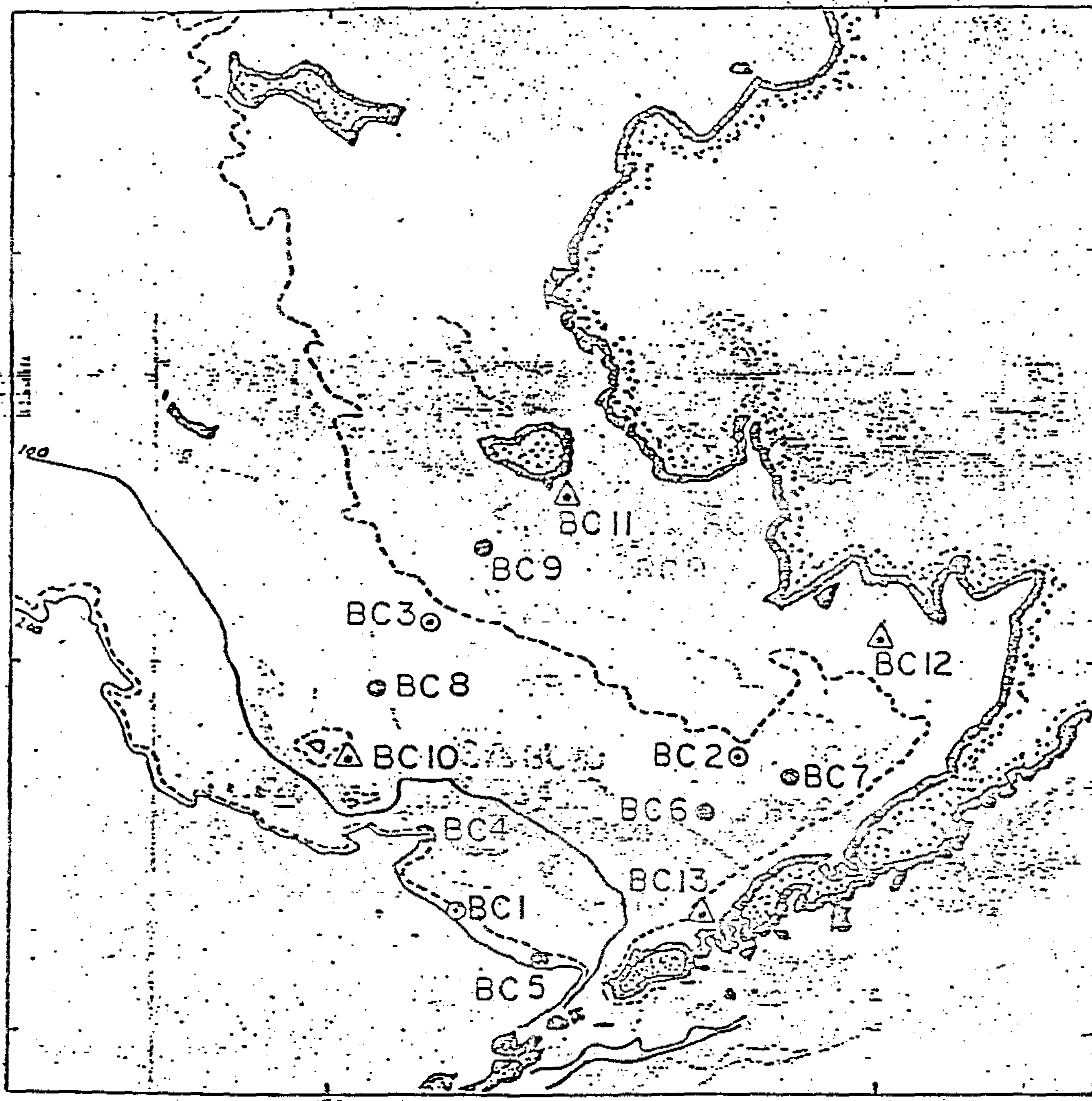

BC11
BC9
BC3
BC8
BC10
BC12
BC2
BC7
BC6
BC4
BC13
BC1
BC5
100
62
58
54
170
160

Figure 2

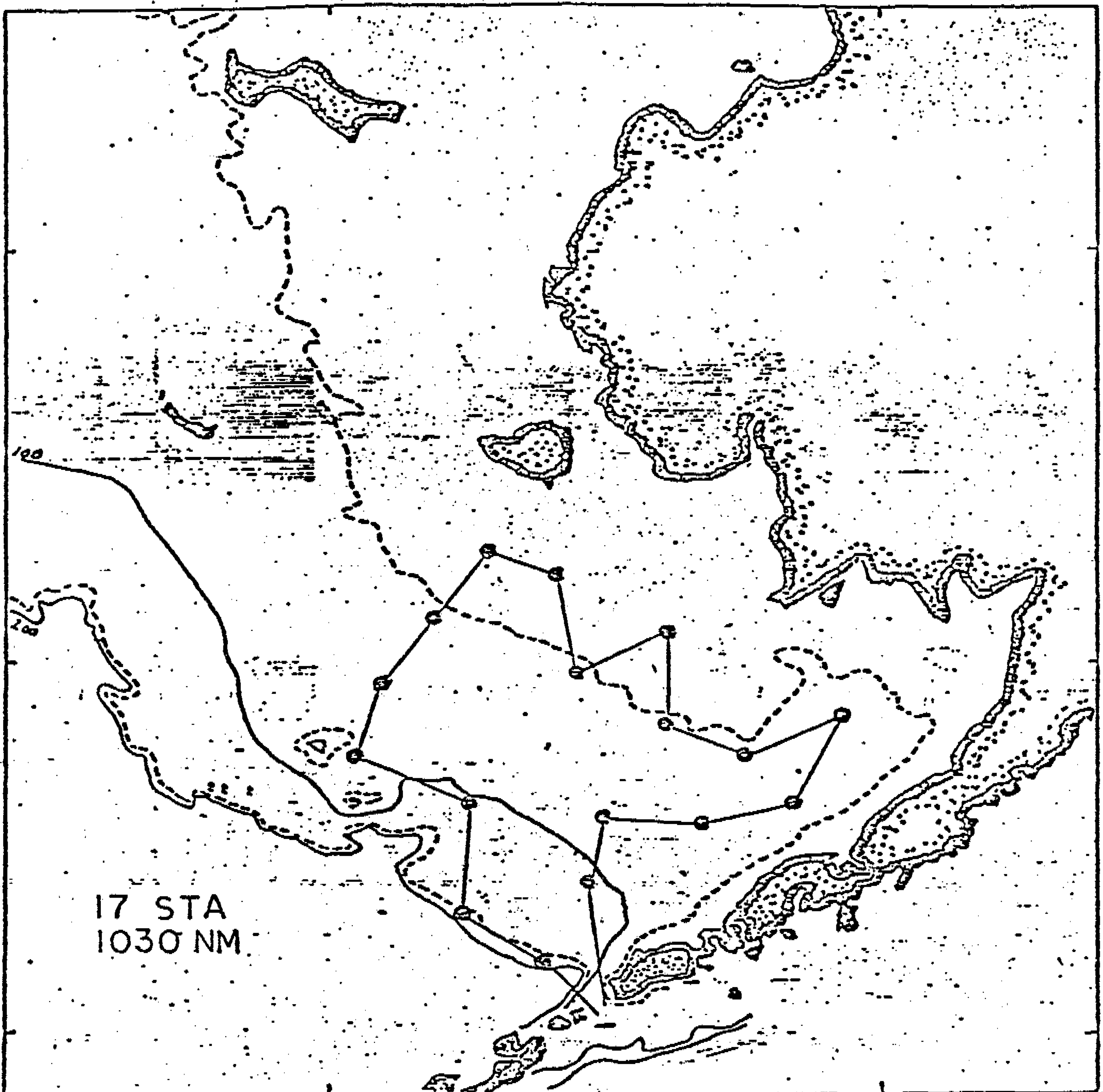


Figure 3

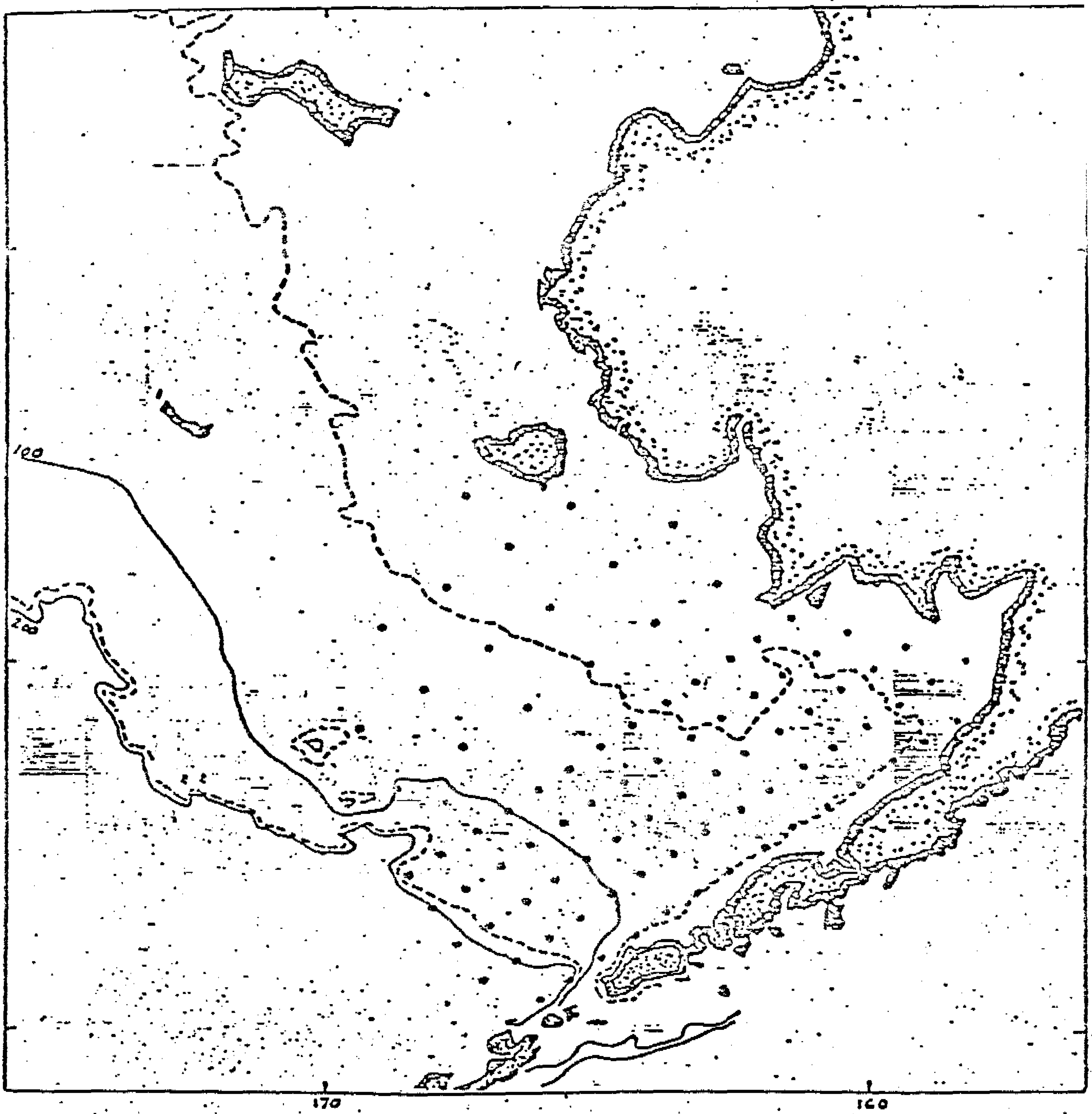


Figure 4

November 75	9 days	
March 76	9 days	
June 76	Re ship:	24 days
	Re ship:	7 days
August 76	Re ship:	9 days
	Re ship:	7 days
September 76	Re ship:	24 days
	Re ship:	7 days

WORK STATEMENT

(Research Unit #151)

I. Title: STD Mappings of the Beaufort Sea Shelf

II. Principal Investigator: Knut Aagaard, Research Associate Professor
Department of Oceanography, University of Washington, Seattle, WA 98195

III. Geographic Area and Inclusive Dates: Beaufort Sea, 1 April 1975-30 September 1976.

IV. Cost Summary

FY 1975	FY 1976
through 30 June 1975	1 July 1975 - 30 September 1976
$23,700	$28,026

V. Proposed Research:

A. Background and objectives

1. The objective is to provide seasonably distributed temperature-salinity mappings of the Beaufort Sea shelf and the dynamically related region of the slope. Such mappings are an essential pre-requisite to, and component of, all physical oceanographic studies of the shelf, and of modeling for both shelf circulation and ice dynamics. Specifically, the mappings are necessary input for the accomplishment of task elements B-2 - B-4.

2. Except for the brief ice-free period during summer, hydrographic sections have never been taken in this area.

3. The objective can reasonably be met by three synoptic sequences of three representative STD sections extending across the shelf and out over the slope. These mappings then in turn provide internal density field input and tracer information for task elements B-2 - B-4.

4. Processed temperature, salinity, and density sections can be reported out by 30 September 1976 for the fall and late winter. Sections for the spring may require a few months beyond this date to be fully processed.

5. Those persons conducting research on transport processes and modeling (both water and ice) require some or all of the temperature, salinity and density fields described above. In addition, the field work for the ice coring program proposed by Dr. Seelye Martin will be closely coordinated with the present work with respect to logistics and personnel.

B. Methods

1. Except for the brief summer period there are no suitable data presently available. The relatively few summer data that do exist have been exhaustively studied in the literature and provide a base for comparison.

2. The presently unsampled period extends through fall, winter, and spring. We shall conduct one survey during each of these seasons, as light and flying conditions reasonably and safely permit. Summer sampling indicates that a reasonable spatial representation can be had by running three sections each time, normal to the coast at the approximate longitudes 142°W, 147°W, and 153°W. The sections will extend across the shelf and out over the slope, with 8 stations comprising each section, giving a typical station spacing along the section of about 8 nautical miles. By taking advantage of a high-grade digitally-recording profiling system, in a portable configuration and carried aboard a helicopter, we can under reasonable conditions readily run each survey in 8 days. This is certainly

a synoptic time scale for the major features of the shelf circulation, and it provides ample vertical resolution.

3. On each cast the STD sounder will be standardized by attaching a water sampling bottle with reversing thermometers to the armored cable directly above the sensor. The salinity samples will then be analyzed by portable salinometer at NARL, Barrow at the end of each survey before returning to Seattle. The STD tapes will be processed at the University of Washington; the conductivity signal digitally converted to salinity; density and dynamic anomalies calculated; and the sections plotted. These are standard analyses and processing procedures.

VI. Information Products:

There will be three high-resolution sections of temperature, salinity, density, and dynamic anomaly during each of fall, winter and spring. The sections cross the northern Alaskan shelf at the western end, the middle and the eastern end, i.e., about 200 km apart. The products will be in the form of reproducable figures with a narrative. All the supporting STD data will be archived in the project's data base in a format coordinated with the project office.

VII. Data or Sample Exchange Interfaces:

The above information will be required by persons working on transport processes and modeling (possibly also by biologists, chemists, and geologists needing environmental background information) as soon as processing is completed.

VIII. Sample Archival Requirements:

All archiving can be done on computer cards, tape, disc, or paper storage.

IX. Schedule:

By: 1 December 1975	finish first STD survey
1 April 1976	finish second STD survey
1 May 1976	provide processed and completed sections from first survey
20 June 1976	finish third STD survey
1 September 1976	provide processed and completed sections from second survey
1 December 1976	provide processed and completed sections from third survey
1 January 1977	provide final report and summary of the above work

The corresponding field phases of Seelye Martin's ice sampling program will be accomplished by the 1 December 1975, 1 April 1976, and 20 June 1976 dates.

X. Equipment Requirements:

The profiling will be done with a Plessy 9400 CTD. We will log the data directly on computer compatible magnetic tape using a Plessey 8400 system. Additionally, we will utilize a DC analog output driving a XYY' plotter for on-site monitoring purposes. We also require a portable winch for cable drive, generators for power for the profiling system, armored single-conductor cable, ice augers, tripod and similar small equipment and tools. These items will be deployed on the three surveys, during October-November, February-March, and May-June.

XI. Logistics Requirements:

Exclusive of helicopter staging time, we require 3 periods of working time in the southern Beaufort Sea, each period of 8 days duration (3 lines x 8 stations per line, @ 3 stations per day = 8 days), distributed as follows:

Period	Helicopter time (days)
October-November 1975	8
February-March 1976	8
May-June 1976	8
Total	24 days

The working area extends to about 60 nautical miles from the coast, along 3 lines at about 142°W, 147°W and 153°W. Total weight of equipment to be carried in helicopter is about 750 pounds. We also require lodging during this period for three persons, preceeded and followed by 2 days each at NARL, Barrow for purposes of staging and for processing of field samples, i.e., for a total of 3 persons x 12 days/trip x 3 trips = 108 person-days. At NARL we will require use of a heated, wired room with stable temperature conditions for 2 days each trip (2 days/trip x 3 trips = 6 days) for purposes of salinity analysis. We require transportation between NARL and the helicopter rendezvous point. Standard survival gear for helicopter use also needs to be supplied. We request all the above requirements to be arranged by NOAA.

FINAL

Research Unit #217

WORK STATEMENT

I. TITLE: Lagrangian Surface Current Measurements in the Gulf of Alaska Outer Continental Shelf

II. PRINCIPAL INVESTIGATOR: Donald V. Hansen
NOAA/AOML
Miami, FL

III. GEOGRAPHIC AREA AND INCLUSIVE DATES: Gulf of Alaska

IV. COST SUMMARY: FY76
$98,000

V. PROPOSED RESEARCH:

This work unit addresses Task B-2, Determination of Evaluation Patterns and Development of Knowledge Needed for Prediction of Transport of Petroleum Related Pollutants. In particular, it is planned to acquire Lagrangian current measurement data. Some small amount of circulation data is presently available for the Gulf of Alska OCS, but no detailed Lagrangian data suitable construction of scenario of oil spill events on Lagrangian statistical functions is presently available.

The information needed to meet task objectives are primarily time/position data to be derived from face-drifting buoys. The extent to which the data acquisition, computation, and reporting can be completed by September, 1976, cannot be stated definitely without knowing the residence time of buoys in the project area. A long residence time implies later completion but better statistics. A reasonable guess is that results can be reported three months after the final buoy deployments. If initial deployment can be made in Summer, 1975, and a quarterly deployment schedule maintined, it should be possible to complete and report all work by 30 September 1976.

This work is related to the moored current meter and STD work. Deployment strategy and locations are to be guided by previous year's result from moored current meter. Buoy deployments should be made simultaneously with STD cruises, and interpretation of results requires information on the lateral shear profile from the diagnostic model.

Such data of this type as exists at present have already been used to guide design of this project. No further use of existing data is envisaged.

It is expected that the general movement of water over the OCS is to the west. In order to maximize coverage and residence time in the project area, deployments are planned in the eastern portion of the project area. Quarterly deployments of these buoys will be made along a cross-shelf line of STD stations to provide seasonal and cross-shelf coverage. This is an experimental project from which sampling adequacy cannot be estimated before the fact. Three separate measures of sampling adequacy are possible after the fact. They are the number of data points (days) to the first zero-crossing of the Lagrangian correlation functions, the ratio of the residence time of buoys in the area to the first zero crossing, and ratio of current energy to noise of the sampling system.

The position data will be smoothed and interpolated to uniform time intervals by least square polynominal fitting. Time series of Lagrangian velocity components will be computed by differencing and correlation will be computed by standard methods. A seasonal time integration then provides appropriate tensor dispersions coefficients.

VI. INFORMATION PRODUCTS

Information products will consist of time, series of time, position, and environmental data time series in magnetic tape format for each buoy deployed. Lagrangian time correlative functions characteristic of the region will be computed on a seasonal basis. Computation of Lagrangian space correlations will be attempted, but are not likely to be well determined by this number of buoys. All of the above will be summarized in hard copy, and the entire drift experience will be produced in motion picuture film format.

VII. DATA OR SAMPLE EXCHANGE INTERFACES

Surface current data from part current meter moorings will be used to modify deployment strategy. Information from this research and the seasonal mean flow will be required for pollution dispersion modelling.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

No material archiving is required.

IX. SCHEDULE

It is proposed to deploy buoys on an approximately quarterly basis. Data collection will continue autonomously for as long as the buoys remain operational in the project area. A reasonable estimate of residence time in the greater Gulf of Alaska OCS is 100 days. We expect to obtain raw data from NASA within 10 days of collection and should be processed within another 50 days. Partial results can be obtained while collection is in progress if required. A target project calendar is as follows:

Initial Deployment (3 buoys)	Summer, 1975
Second Deployment (3 buoys)	Fall, 1975
Third Deployment (3 buoys)	Winter, 1975
Final Deployment (3 buoys)	Spring, 1976
Final Report	Fall, 1976

This sequence is a block determined primarily by geophysical time sealer. For logistic reasons, it can be delayed as a block, but for technical reasons it cannot be advanced. The most important interface with other projects is that deploymnets should be coincident with STD cruises, if possible.

X. EQUIPMENT REQUIREMENTS

The principal equipment requirement is for remote-trashable buoy hardware. This is to be provided by the Principal Investigator and collaborations. Scheduling as described under IX above.

XI. LOGISTICS REQUIREMENTS

This project requires minimum logistics support. A small amount of time and space aboard ship will be required for buoy deployment. It is required to be able to carry four buoys approximately 15 feet long and weighing approximately 200 pounds. A berth for one accompanying scientist will be required. It is desired to load the buoys aboard ship in Seattle, if possible.

WORK STATEMENT

(Research Unit #235)

PREPARATION OF HYDRODYNAMICAL-NUMERICAL AND 3-PARAMETER SMALL-MESH ATMOSPHERIC MODELS FOR COASTAL WATERS IN GULF OF ALASKA

PRINCIPAL INVESTIGATOR: T. Laevastu
Environmental Prediction Research Facility (EPRF)
Naval Postgraduate School, Monterey, CA 93940

COST SUMMARY

(1)	Salaries and Partial Government Overhead (20%).........	$17.6K
(2)	Subcontract (Compass Systems, Inc)......................	6.2K
(3)	Computer Time (AEC)......................................	9.1K
(4)	Climatology Preparation (NMFS)...........................	4.3K
(5)	Travel to Seattle and Consultation (Dr. Bengtsson)......	2.8K
	Total.......	$40.0K

INTRODUCTION

EPRF has optimized multilayer HN models and has applied them to various coastal and open ocean problems, including pollution and oil spill movement prediction. (Ref. 1 and 2 as examples)

There remain a few problems to test and solve within these models, specially in three respects:

(a) detailed verification of the models
(b) coupling of the HN models with small-mesh atmospheric models
(c) inclusion of the "Danish diffusion" subroutines into the models for application of oil spill movement prediction.

The Alaskan Marine Environmental Assesment Program (AMEAP) offers an unique opportunity to successfully solve these problems and to provide useful analyses/prediction models.

TASK 1. PREPARATION OF HYDRODYNAMICAL-NUMERICAL (HN) MODELS FOR THE COASTAL WATERS FROM UNIMAK PASS TO SITKA.

In order to reproduce the currents and transport and diffusion-dispersion processes in this relatively complex coastal region with HN models, it is necessary that the models have a relatively fine mesh.

It is proposed to program three overlapping models with a grid size of about 10 km (Figure 1). The HN models will be multilayer models which can, however, be run in single layer mode. This would save computer time in operational use such as in the case of oil spill movement prediction. The bathymetry as well as climatological density structure (T, S) will be digitized in the model grids. The first task will be accomplished with a small subcontract to Compass Systems Inc. and the latter task will be performed by Pacific Environmental Group of NMFS of NOAA.

The open boundaries will be described using available tidal harmonics from various coastal mareograph stations and empirical transfer functions.

The verification and tuning of the model will be effected with current recordings which are expected to become available with the present BLM-NOAA project.

The three models will be augmented with a two-dimensional "Danish diffusion" subroutine for oil spill movement prediction. The atmospheric driving forces will be derived from the small-mesh 3-parameter atmospheric model described in Task 2.

Most of the debugging of the programs and numerical climatology preparation will be done on medium size computers (CDC 3100) available in EPRF for which no renumeration is required. However, time will be required for production runs on the CDC 7600 computer at Laurence Radiation Laboratory (AEC), Berkeley.

TASK 2. PREPARATION OF SMALL-MESH METEOROLOGICAL 3-PARAMETER MODEL FOR GULF OF ALASKA COASTAL AREAS.

The coastal winds are often different than those over the land or those farther off-shore. This is due to intense sea-air interaction in the coastal region and to the effects of coastal mountains. All oceanographic models, and especially oil spill movement prediction models, require accurate input of the wind fields which are not available from presently used numerical atmospheric models. Therefore, a very small-mesh special model is required. Preliminary investigations indicate that the Bengtsson 3-parameter model, (Ref. 3) available in EPRF, can be adapted for the coastal areas to obtain the coastal wind peculiarities. However, the adaption of this model requires additional work on the inclusion of the feedback of energy from the ocean to atmosphere as well as some consultation with the originator of the model, Dr. Bengtsson (who is presently the Deputy Director of the European Center for Medium Range Forecasting). The initial-guess field for this model will be obtained from hemispheric numerical analysis/forecasts of NMC and FNWC. The reanalysis of initial state will include the available coastal stations (marked on Figure 1) and synoptic ship reports as available. It is anticipated that part of the cost of this model development will be carried by funds available to EPRF.

COORDINATION

The work on the tasks listed above will be closely coordinated with PMEL (Dr. Galt), NMFS (Dr. Favorite) in Seattle, and possibly by one EPRF scientific staff member, working limited time in Seattle. Other coordination will be effected as directed by the project manager in NOAA.

DELIVERABLE PRODUCTS

The following products will be delivered as a result of this project:

(1) Program decks in FORTRAN with necessary climatological data for all 4 programs.

(2) Program documentation and running instructions.

(3) Reports with output examples and available verification and testing results.

PERSONNEL, SCHEDULE

(1) The scientific-technical leader of the proposed project will be Dr. T. Laevastu, Head, Oceanography Department, EPRF. The following members of this department will participate in the project.

Mr. S. Larson

Mr. K. Rabe

Mr. J. Harding

(2) Dr. L. Bengtsson will serve as a consultant on the Task 2 of this project.

(3) The duration of the project is estimated to be 8 months beginning about 1 May 1975. Estimated completion date is 1 December 1975.

June 30, 1975

ALASKA MARINE ENVIRONMENTAL ASSESSMENT PROGRAM
WORK STATEMENT (Research Unit #289)

I. Title: Mesoscale Currents and Water Masses in the Gulf of Alaska

II. Principal Investigator: Dr. Thomas C. Royer
Associate Professor
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7835
SS#: 375-40-3978

III. Geographic Area and Inclusive Dates:

Gulf of Alaska, July 1, 1975 - September 30, 1975

IV. Cost Summary:

FY 1975 through June 30, 1975	FY 1975 July 1, 1975 through Sept 30, 1975
	$292,386

V. Proposed Research:

A. Background and objectives

The primary tasks which this work statement will deal with are: B-1, summarize and evaluate existing literature and published data related to circulation and transport, and B-2, determine circulation patterns and develop the capability to predict the transport. Secondary emphasis will be placed on: B-4, test and evaluate potentially applicable circulation models for special areas such as those that are environmentally sensitive or restricted circulation, such as fjords, to compare predicted oil spill trajectories and concentrations with those inferred from field experiments carried out in these areas, and D-13, synthesize existing literature to provide analysis of the frequency, intensity and effects of extreme oceanic events.

The first comprehensive hydrographic data for the northern Gulf of Alaska were obtained in 1926 with follow-up cruises in several following years. Until the mid-1950's, there existed a serious gap in the regional hydrographic data which was briefly filled at that time. However, until 1970 no expeditions had occupied stations during more than one season in any one year so that estimates of annual cycles of hydrographic parameters in the Gulf of Alaska were not possible. During the period 1970-1972, a station line crossing the shelf out of Seward was occupied eight times at irregular intervals giving the first estimate of the annual cycles of water properties (Royer, 1975). In addition, the shoreward station (59°50.2'N, 149°30.5'W) has been occupied 23 times since 1970, which provides reasonable estimates of these annual cycles at that point. Other investigators such as Plathotnik (1963), Namias (1968), Fleming (1958), Dodimead, Favorite and Hirano (1963) have described some aspects of the meteorological and oceanographic regime for the region.

In general, the region is characterized by a westward (cyclonic) surface flow of about 1/2 knot. The temperature-salinity characteristics are seasonally altered over the entire depth of the shelf. The controlling atmospheric pressure system changes from a strong low in winter to a weak high in summer. The wind speed not only changes intensity by an order of magnitude but the direction is reversed seasonally. Extreme cooling, precipitation and runoff also influence the water mass characteristics at various times of the year. However, probably the single most important cause of the seasonal circulation variance is the changing of the wind stress.

It is proposed that the seasonal baroclinic geostrophic circulation and transport be calculated for the Gulf of Alaska shelf region. Temperature-salinity versus depth data will be required to fulfill this work. The geostrophic currents will be determined from STD (salinity-temperature-depth) data gathered on a quarterly basis along an established grid (See Figure 1). Direct current meter measurements will also be obtained at approximately 58°41.1'N, 148°21.6'W for the purpose of "adjusting" our reference level for the geostrophic computations and to give the barotropic current component. This station will be a permanent mooring during the contract period. Sea surface slope between the installation and shoreline will be measured using coastal tide data and a bottom pressure gauge at the current meter site. Extension of the station grid into Prince William Sound will provide input for circulation investigations for that region as requested by the biologists.

Marine weather conditions for the Gulf of Alaska will be required for the work. The parameters of wind speed and direction, air temperature, humidity and precipitation will be required on a daily basis for the study region. The data obtained from coastal observations are of marginal quality due to local effects. Emphasis will be placed on meteorological data from environmental data buoys such as EB-03 and EB-33 and on observations from Middleton Island. A minimum requirement would be daily observations with 6 hourly observations preferred. In addition to the raw meteorological data, calculated quantities such as the Fofonoff-type computations or upwelling indices (Bakun, 1973) will be required to be correlated with the observed current fields.

The termination of this fiscal year's field program in August 1976, will allow the final graphic output of the data except the current meter data to be available by 30 September 1976. A quantitative report will be available on all data with the exception of data from the final field expedition which will be reported in a qualitative sense only. This field program is being coordinated with other physical oceanographic investigations. The data gathered by this project will be used as input for the hydrodynamic modelling program. The grid, therefore, will have to be coordinated with the modellers. The historical data review will be used to search for anomalous features during the field programs and as aid in describing the circulation of the region. The upwelling indices computed by Bakun will be used, as previously described. Small scale studies carried out by other principal investigators will provide input on time and space scales for the region and give some estimates of confidence intervals for the regional STD measurements. Interchange of data with the Lagrangian drifter program will be required to achieve a more complete vertical current profile since conditions prohibit deployment of a current meter in the upper twenty meters of water. These interchanges are expected to occur on a 1-1 basis and will be spurred by the principal investigator's scientific interests. It is expected that the derived salinity, temperature, density and current fields will be available for other principal investigators such as the chemists, biologists and geologists.

Coordination between field investigators will also be enhanced through the use of a common platform, the ships operating in the region. Logistics and operations will be coordinated between PI's on the project.

B. Methods

The temperature-salinity data will be used to compute density fields from which the baroclinic geostrophic current field for each shelf transect will be calculated. Using available current meter data from this and other segments of the OCS project, the reference level will be obtained using the barotropic current component. Using water mass analysis techniques, (T-S diagrams) circulation for the region will be described both on the shelf and just offshelf. Attention must be directed toward the near shelf and deep ocean circulation since it serves as a source for water on the shelf at various times of the year and its dynamics influence the shelf circulation. In comparison to other OCS regions, very little is known about this deep ocean circulation and it will be necessary to have our sampling program overlap this region. (See Figure 1) The proposed transect lines for the western portion of the study area are approximately 150 nautical miles long with a station spacing of approximately 15 nautical miles on the shelf and 8 nautical miles near the shelf break. These sections join the standard sections (P2, P7, P8, P9) occupied by the U.S. Coast Guard on a quarterly basis. Data from the NEGOA study indicate that this might be a better sampling scheme than that of the NEGOA study due to the small (10-20 n.m) scale of features found near the shelf break in that study.

It is not proposed to alter the NEGOA grid, however, since the station spacing is not that critical. The temporal spacing necessary for the STD grid is quarterly to avoid aliasing problems from the annual cycle. The surface spatial sampling interval will be checked using IR satellite data to provide scale lengths of surface temperature anomalies. The short period variance of the STD data will be estimated from 25-hour station data gathered by other principal investigators.

The current meters will sample at twenty-minute intervals which is based on the capacity of the recording system for a three-month installation. The array will be replaced quarterly and will provide a continuous time series of current at five depths (20, 30, 50, 100 and 10 meters above the bottom) for the period from approximately August 1975 through August 1976.

The literature will be reviewed for materials directly applicable to this study. NODC and EDS archived data will be used to provide a historical data base for sea level, oceanographic and meteorological data.

VI. Information Products

The raw STD and current meter data will be available to other principal investigators upon request. Cross-section of the temperature, salinity, density and geostrophic currents will be prepared for each transect sampled. Surface plots and flow streamlines will be constructed where applicable. The parameter time series will be subjected to spectral analysis and standard displays such as histograms, current versus time, frequency spectra, and progressive vector diagrams will be prepared. Data listings will also be made.

VII. Data or Sample Exchange Interfaces

Current meter data from other investigators will be required on a 120-day schedule for comparison with the geostrophic computations. Wind stress fields and/or the upwelling indices (Bakun and Favorite) will be required on a 90-day delay basis. Temperature and salinity versus depth will be accepted at any time from other principal investigators. It is expected that the cross-sections and data listings will be required by the biologists, chemists and geologists on a 60-day notice in addition to use by other physical oceanographers.

VIII. Sample Archival Requirements - None

IX. Schedule

Approximate Cruise Schedule

August 1975
November 1975
February 1976
May 1976
August 1976

This schedule is similar to that agreed upon by the physical oceanographic group in April 1975. Cross-sections and data listings to be made available 60 days after the termination of the cruises. Analysis will be made within 120 days after the cruise.

X. Equipment Requirements

Five additional current meters will be required for the permanent current meter installation planned. It is expected that the ships will provide STD's, reversing thermometers, Nansen bottles and surface water sampling equipment. The Institute of Marine Science will provide the ten current meters needed to establish the current meter array contingent on a 1 July 1975 delivery date by the manufacturer.

It is expected that the National Ocean Survey will reinstall and maintain the coastal tide station at Seward before August 1975 since this requirement is necessary for the sea level slope computations. IMS can maintain and operate the gauge on a cost reimbursed basis. It is recommended that the NWS installation on Middelton Island be upgraded in the immediate future to provide better, more reliable weather information, which should include radiosonde measurements.

XI. Logistics Requirements

Ship time requirements are for 105 days with 10 days in the eastern gulf and 11 days in the western gulf each quarter (5 cruises). (See IX Schedule)

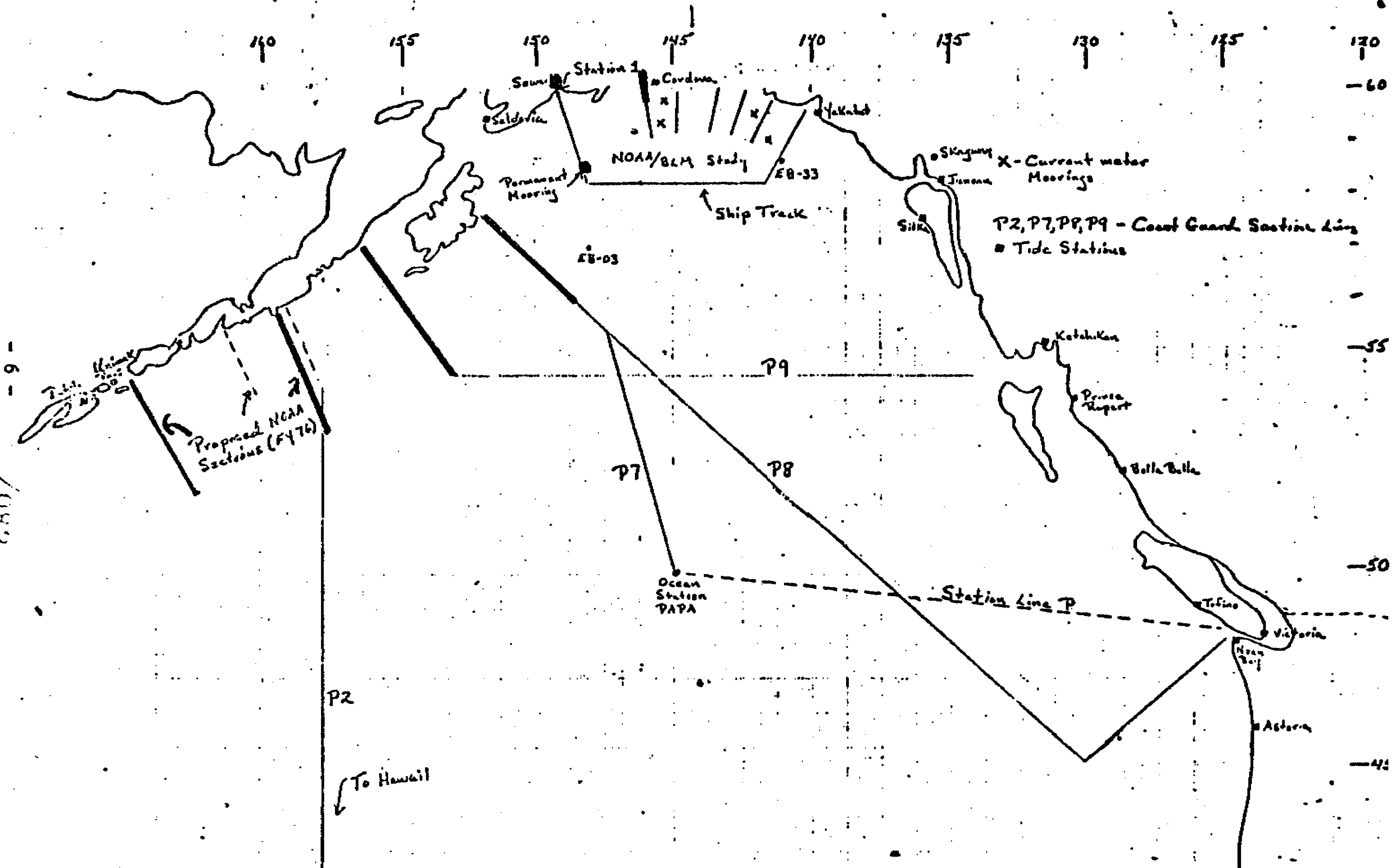

160
155
150
145
140
135
130
125
120
60
55
50
45
Station 1
Cordova
Seldovia
Yakutat
NOAA/BLM Study
EB-33
Permanent Mooring
Ship Track
EB-03
Skagway
Juneau
Sitka
X - Current meter Moorings
P2, P7, P8, P9 - Coast Guard Section Line
Tide Stations
Ketchikan
Prince Rupert
Bella Bella
Tofino
Victoria
Neah Bay
Astoria
Ocean Station PAPA
Station Line P
P9
P8
P7
P2
To Hawaii
Proposed NOAA Sections (FY76)

Figure 1

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Dodimead, A. J., F. Favorite and T. Hirano (1963) Review of oceanography of the subarctic region. In: Salmon of the North Pacific Ocean, Part II. International North Pacific Fisheries Commission, Bull. No. 13, 195 pp.

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June 30, 1975

ALASKA MARINE ENVIRONMENTAL ASSESSMENT PROGRAM
WORK STATEMEN (Research Unit #307)

I. Title:

Historical and Statistical Oceanographic Data Analysis and Ship of Opportunity Program

II. Principal Investigator:

Robin D. Muench
Assistant Professor
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701
SS#: 007-40-2365

III. Geographic Area and Inclusive Dates:

Gering Sea April 1, 1975 through Sept 30, 1976

IV. Cost Summary:

FY 1975	FY 1976
through June 30, 1975	July 1, 1975-Sept 30, 1976
$10,367	$81,439

V. Proposed Research

A. Background and objectives

This research will be addressed toward clarification of processes responsible for water and pollutant transport in the southeastern Bering Sea region. These transport processes are responsible for and will exert a primary control over biological and chemical distributions in the study area, in addition to transporting pollutants. Transport processes define areas which are subject to contamination from a given source of pollutants.

The present state of knowledge of oceanographic processes in the study area is very poor. This shallow, broad shelf region is very strongly affected by local winds as driving forces for currents and mixing. The interrelation between winds and water motion here is however but poorly understood. Tidal currents, as well as winds, contribute to mixing by turbulent processes. The general circulation on the southeastern Bering Sea shelf is generally believed to be northerly during the summer. During the winter, the flow direction is uncertain due to lack of measurements. The seasonal ice cover during winter moves southward with prevailing winds, opposed to a possible northerly water flow. There is no information available on details of the regional circulation.

The regional hydrographic structure is dominated by the interaction of water conditioned on the shallow shelf, water which has been advected eastward from the Bering Sea basin and water advected northward from the Gulf of Alaska through passes in the Aleutian Islands. This results in a larger summer structure when a low temperature layer lies below about 30 m depth over most of the shelf and is overlain by warmer water. The low temperature layer apparently is a remnant of the preceding winter's cold convection layer.

Virtually nothing is known however, about the dynamics of this layer, including water motion and mixing processes.

During the winter the water becomes vertically well mixed due to thermohaline convection. Too few winter data are however available to estimate regional or year-year variation in these convective processes. There is, in particular, no information during winter from the ice covered region save for some scattered icebreaker stations which are inadequate for determining the field of temperature and salinity.

To summarize, the present state of knowledge about the southeastern Bering Sea can only be classified as poor. Little is known of the distribution of temperature and salinity at a given time. Nothing is known of year-year variation and nothing is known of the circulation.

Information to be obtained under this research will contribute toward delineation of the circulation, temperature and salinity fields in the study region. In particular, all available temperature and salinity data, along with the few observations of dissolved oxygen and nutrients which are available, will be compiled and used to qualitatively discuss mixing and circulation processes. To describe in detail and quantitatively the circulation will require a program of direct current measurements and detailed measurement of the temperature and salinity distribution. These detailed measurements are to be carried out by other OCS research projects. In order to plan an effective detailed sampling plan, input from this research in the form of mean seasonal distribution of temperature and salinity will be essential. Therefore, while information from this project will be insufficient to clearly delineate circulation, mixing processes and the distribution of variables, general fields will be determined and these will moreover be necessary as input into future, more detailed programs.

This research will be sufficient to define the large-scale distribution of variables for each season, with the exception of winter when too few data are available, seasonal variation and long-term variations. It is hoped that the ship of opportunity program will provide an ongoing source of data which will help fill holes in the existing data and thus aid in delineating distribution of variables. This in turn will serve as input to future detailed circulation and mixing studies.

It is anticipated that, by September 1976, compilation of historical information will be complete and listings will be available. If desired, these can be plotted and presented in the same format as for the ongoing Gulf of Alaska data collection program. In addition, the results of statistical analyses will be available, including spatial and temporal distribution of variables. Some qualitative circulation information will be available. It will not be possible to provide detailed information on circulation based on this research, but input will have been provided to programs addressed to this study.

Related research is being carried on both within and outside the OCS program. Of major significance are the direct current measurements and more detailed temperature and salinity measurements proposed within the OCS program. Information from this research will be supplied directly to investigators involved with these studies. This will be done on a 1-1 basis, since all investigators are able to contact each other personally. Close coordination will take place between the ship of opportunity program and any detailed research.

Ongoing research is being carried out by Japanese parties. The data from these efforts will be obtained as part of the ship of opportunity program.

It is hoped that it will be possible to provide some input into cruise and sampling patterns, in these cases.

An additional project is the U.S. National Science Foundation PROBES project (Processes and Resources on the Bering Sea Shelf) on which the P.I. of this project is also an investigator. Cooperation on a 1-1 basis with this project will be sought.

B. Methods

Existing data have been or will be acquired from NODC or from individual organizations or investigators, particularly in the case of foreign data. The acquisition has already commenced, as NODC data listings from the Bering Sea have been obtained under the auspices of separate projects.

A literature search has been carried out, and pertinent publications are already in hand. Information contained in these materials has been synthesized into the research plan. A great deal of the data are, however, unpublished and largely unanalyzed. These fall into the statistical analysis portion of this research as discussed below.

Inasmuch as this project will use available data and ships of opportunity, the sampling problem is not particularly pertinent. Exceptions are cases where input into ship of opportunity sampling can be had. In this case, sampling must be chosen to obtain the densest spatio-temporal temperature and salinity samples available which are still compatible with other programs being carried out from the vessel. Dense sampling will allow attempts at delineating small-scale features in the hydrographic structure which will be of interest to planned detailed sampling programs. All measurements will have "state-of-the-art" accuracy.

The historical data will be analyzed using standard statistical methods to determine any long-term variations in heat of salt content of the water. Spatial plots of temperature and salinity will be constructed to aid in evaluating large-scale mixing processes and their seasonal variations. Temperature-salinity analyses will be used to deduce, if possible, general circulation patterns. In such shallow water there is however some room for error in these analyses. All these methods are standard physical oceanographic analysis techniques which may be found in any physical oceanographic text or reference work.

VI. Information Products

Primary products from this research will include listings of all available temperature, salinity, oxygen and nutrient data from the study area. Plots of mean areal distribution (by season) will be prepared except in situations where data are inadequate for a meaningful plot (as for the winter months). Long-term variations in heat and salt content will be presented in graphical form for different areas and different water strata.

It is anticipated, in addition to the above routine products, that some publication will become available as a result of this research. Such papers might deal with interpretation of the data; for example, circulation and mixing processes. Since at this time the exact potential for such research given the constraints of available data is unknown, nature and availability of such publications must remain uncertain.

Data resulting from participation in ship-of-opportunity cruises will be supplied in the standard format which has been developed elsewhere within the OCS program. These data will be supplied as soon after the cruises as readily available, in the form of data reports.

VII. Data or Sample Exchange Interfaces

All temperature, salinity, dissolved oxygen and nutrient data gathered from the study region during this research will be incorporated into the statistical analyses and are needed as soon as available. Within the OCS projects, it should be possible to obtain this data on a 1-1 basis from other principal investigators prior to archiving.

It is expected that information from this research will be of interest to most other investigators in the study area, particularly in the context of planning more detailed future studies. This information will be supplied to the maximum extent possible on a 1-1 basis. If the demand for information makes this unfeasible, information will have to be supplied through the EOS archiving system. Rapidity of information will generally be of utmost importance within the context of a rather ambitious overall planning effort/ field program. In light of the constantly evolving nature of the field program, placing of specific dates on information transfer is however felt to be premature.

A specification will be written for the acquisition of data by ships of opportunity whenever possible in order to maximize the accuracy of results. The specification will include calibration procedures, station procedures and output format requirements.

"Preferred" cruise tracks and schedules of desired tracks will be prepared for use by the Project Office. These tracks will be used in ship scheduling and planning by the Project Office to fill in data gaps in time and space and as analyses of results show a need.

VIII. Sample Archival Requirements

No samples requiring archival will be obtained from this project.

IX. Schedule

Since the only sample acquisition contemplated will be carried out via an unstructures (time-wise) ship of opportunity program, it is impossible to provide a sample acquisition schedule. Preliminary data analysis will be carried out at a rate sufficient to provide data to NODC within 120 days of acquisition, as specified for OCS projects.

Information resulting from the statistical data analysis will be provided at the conclusion of this research in September 1976. Sub-portions of this analysis of interest to other OCS investigators will be provided on a 1-1 basis as available. It must be stressed that close communication between investogators is an essential function to assure maximum effectiveness of this research inasmuch as these results may aid future planning. Other than this, results will be presented in a report format in timely fashion. Brief project reports can be delivered to the Project Office on a quarterly basis.

X. Equipment Requirements

The only equipment required will be a remote computer terminal necessary for processing of data. This piece of equipment is required immediately, inasmuch as acquisition of historical data has already commenced.

XI. Logistics Requirements

No logistics support will be needed specifically for this project, inasmuch as the ship of opportunity program utilizes already available logistics.

WORK STATEMENT

(Research Unit #335)

I. TITLE

Transport of Pollutants in the vicinity of Prudhoe Bay

II. PRINCIPAL INVESTIGATOR

Richard J. Callaway
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Pacific Northwest Environmental Research Laboratory
Environmental Protection Agency
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Corvallis, Oregon 97330
(503) 752-4211, Ext. 369

III. GEOGRAPHIC AREA AND INCLUSIVE DATES

Beaufort Sea - June 30, 1975 - September 30, 1976

IV. COST SUMMARY

FY 1975 through June 30, 1975	FY 1976 July 1, 1975 - September 30, 1976
$29,085	$19,310

V. PROPOSAL RESEARCH

Objectives: This research is intended to determine the transport of pollutants based on the computed velocity field. Pollutants envisioned are those associated with offshore drilling operations and construction projects. Initially, the currents will be computed from knowledge of local wind structure, river runoff and offshore tides as input boundary values.

Pursuant to this, two offshore tide gauges will be installed to record data for 29 days. An Aanderra current meter will be installed with each tide gauge.

VI. PROPOSED RESEARCH

A. Background and Objectives:

Relevant Tasks: This research addresses tasks B-1, B-2, and B-4.

Information Available and Required: Some information on all aspects of currents, winds, tides and runoff is available in the Beaufort Sea area concerned, but not in sufficient detail on the time frame envisioned. Topographic charts form the basis of the schematization of numerical simulation of bottom topography. The soundings are not overwhelming; since topography influences the shallow circulation, this may affect the fine grid model computations. The dynamics of the shelf circulation are not too well-developed for any of the worlds seas much less the remote Beaufort Sea in question.

Although the data base is lamentable, the use of simulation models comes into one of its more productive modes as a numerical experimentation tool. Various environmental conditions likely to exist can be input; verification with existing data can be attempted, leading to insight on the probable magnitude of various driving forces.

Related Research: Related research in the area concerns proposed circulation studies to be carried out by Dr. Carlson on river inputs, Dr. Searby on surface current measurements and Dr. Aagaard on currents and STD measurements. Dr. Galt's work on numerical modeling will also serve as a check on aspects of this work. The river runoff data and winds are part of the input requirements for the model.

Dr. Hufford's work on surface currents is especially relevant; therefore this work will be very closely coordinated with his. The proposed tidal boundary information to be supplied by this Principal Investigator is a function of the weather; a possibility exists that all the tide instrumentation could be wiped out. Since winds are the prime driving force this may not be as catastrophic as it appears; at any rate numerical experiments will be conducted at an early stage to test the sensitivity of the model to tides, winds and river inflow separately and together.

Data Time Frame: Assuming wind and river flow data as available and tides can be measured for a 29 day period in the ice-free season of 1975, the program will be completed by September 30, 1976. If the tides cannot be measured in 1975 but in 1976, then a six-months delay is anticipated. A reduced study could be carried out describing the results of numerical experimentation in the absence of direct tidal measurements. Quarterly reports will be made, showing progress, including results of preliminary runs on the computer.

B. Methods

Archived Data: Generally available information on file in atlases. technical reports, topographic charts will be used for initial gross grid model runs. Data previously collected by university of Alaska and Washington personnel will be used as input and verification data where possible. This will require on-site visits at an early stage. The Environmental Data Services will be requested to access data by specific parameter, time series, and season.

Callaway and Ditsworth (1973) described the installation of tide recorders at distances of 20 and 80 nautical miles offshore in New York Bight. Tidal constituents were obtained through Fourier analysis of 15 and 29 day records. The data were digitized from the analog record at our laboratory, plotted and checked visually and processed by the NOAA tidal analysis group.

The computer model to be used was initially developed by Hansen at the University of Hamburg for analysis of tide in the North Sea and other areas. Later versions were used by Laevastu at the U.S. Navy Postgraduate School in Monterey, California. The model used here was programmed by Bauer (1974) and consists of three layers in the two horizontal dimensions. Earlier version of the model have been and are being used by Laevastu at the Environmental Prediction Research Facility in California.

Note that the convective acceleration terms are not included here. These terms will be included for later runs as it is anticipated that they will be of importance in the vicinity of varying topography.

Transport can be extracted over a given time period by summing currents over a section. Flushing time is then computed by noting the residence time within sections. The program also provides for introduction of instantaneous or continuous "pollutants". The source area is one or more grids. The path of river influence can thus be traced although the computer time for this can be quite large. For rivers near the boundaries this is not a feasible solution as the concentration at the boundary has to be specified--which assumes one knows in advance what one is trying to predict.

Sampling Scheme: The sampling scheme envisioned here is fairly straight forward requiring a continuous time-series of tidal elevations at the boundaries of the numerical grid (fig. 1). The grid is determined by: computer size, numerical step size, water depth (both as to core requirement and instrumentation depth limit) and the detail required and permitted. The grid size must be large enought to allow numerical inaccuracies to be filtered out in the vicinity of the boundaries, i.e., the interior solution is the one of interest.

The tidal elevations are sampled every two minutes to provide an almost continuous record. The tide recorders will be Bass Engineering devices which are based on a design by Filloux. Present plans call for installation at the locations shown in figure 1.

The data will be processed as described below to extract the phases and amplitude of the principal harmonics. These are then used to synthesize a representative Fourier series of tidal fluctuation at the model boundaries. Phase lags between inshore and offshore boundaries are adjusted linearly or parabolically along the boundary.

Winds will be input as constant over the whole grid or, if needed, two or more wind fields will be input. Time variation of wind can also be introduced. Wind data will be taken from that available during the tide data sampling period.

River input data will be adjusted to a velocity of flow over a given grid(s) area. Constant flow will be used; if highly variable flow exists this can also be introduced.

Methods of Analysis: Callaway (1973) described some numerical experiments on pollution in a coastal zone with three open boundaries, Laevastu and Callaway (1974) presented results of simulation of computed currents, tidal elevations, and dispersion in New York Bight.

Examples of some trial runs on the Beaufort area around Prudhoe Bay are given in the appendix.

VII. INFORMATION PRODUCTS

If the tide gauges function and are recovered, the data will be analyzed as described above. The data herein will be similar to that shown in figure 2.

The numerical experimentation and Beaufort Sea runs will be included in a separate publication, perhaps the Journal of Physical Oceanography.

The computer program, flow diagram, example input and output--hence a user's manual--will be published.

The final report will include one or more scenarios including winds and other conditions representative of realistic conditions followed by a prediction of trajectory and concentration of hypothetical spill. If desired, the Project Office can specify the location of the spill and the winds for the scenario.

VIII. DATA OR SAMPLE EXCHANGE INTERFACE

Other Data: This has been discussed before in Section V-A, Related Research. The time frame is during the ice-free season when current measurements are being made, i.e., wind and runoff data are needed in conjunction with tides and currents.

The final stage of verification of the model runs will require comparison with the STD and current data to be collected by Hufford. (This will be available January 1976.)

As shown in the appendix, computer tests are underway and the program is operational for some preliminary investigations. Modifications to the program will be undertaken for inclusion of the convective acceleration terms and for "tide flat" exposure, the latter phenomenon occurring when offshore winds drive out water in shallow areas. Results of these preliminary runs will be made a part of the first quarterly report.

XI. EQUIPMENT REQUIREMENTS

5 tide recorders

4 or more current meters

moorings, with a minimum of 250-lb anchors.

The scheduling is for installation and retrieval within 29 days during the ice-free season.

XII. LOGISTICS REQUIREMENTS

Installation of the offshore facilities is relatively simple, requiring only a boom to lift the gear over (about 500 pounds). Recovery is simpler as the anchor is sacrificed. It is assumed a NOAA or CG vessel will be available for this. It is hoped that the EPA people involved will not have to remain aboard ship any longer than necessary during the field installation and recovery periods. If possible, a helicopter will be used.

IX. SAMPLE ARCHIVAL REQUIREMENTS

Duplicates of tide recorder analog tapes will be made as well as of all computer runs. All current meter data will be similarly archived. If digital current meters are employed, the data will be transcribed to magnetic tape in a format specified by the Project Office.

X. SCHEDULE

A schedule of events will be submitted to the Project Office at the beginning of work and thereafter will be updated with each Quarterly Report.

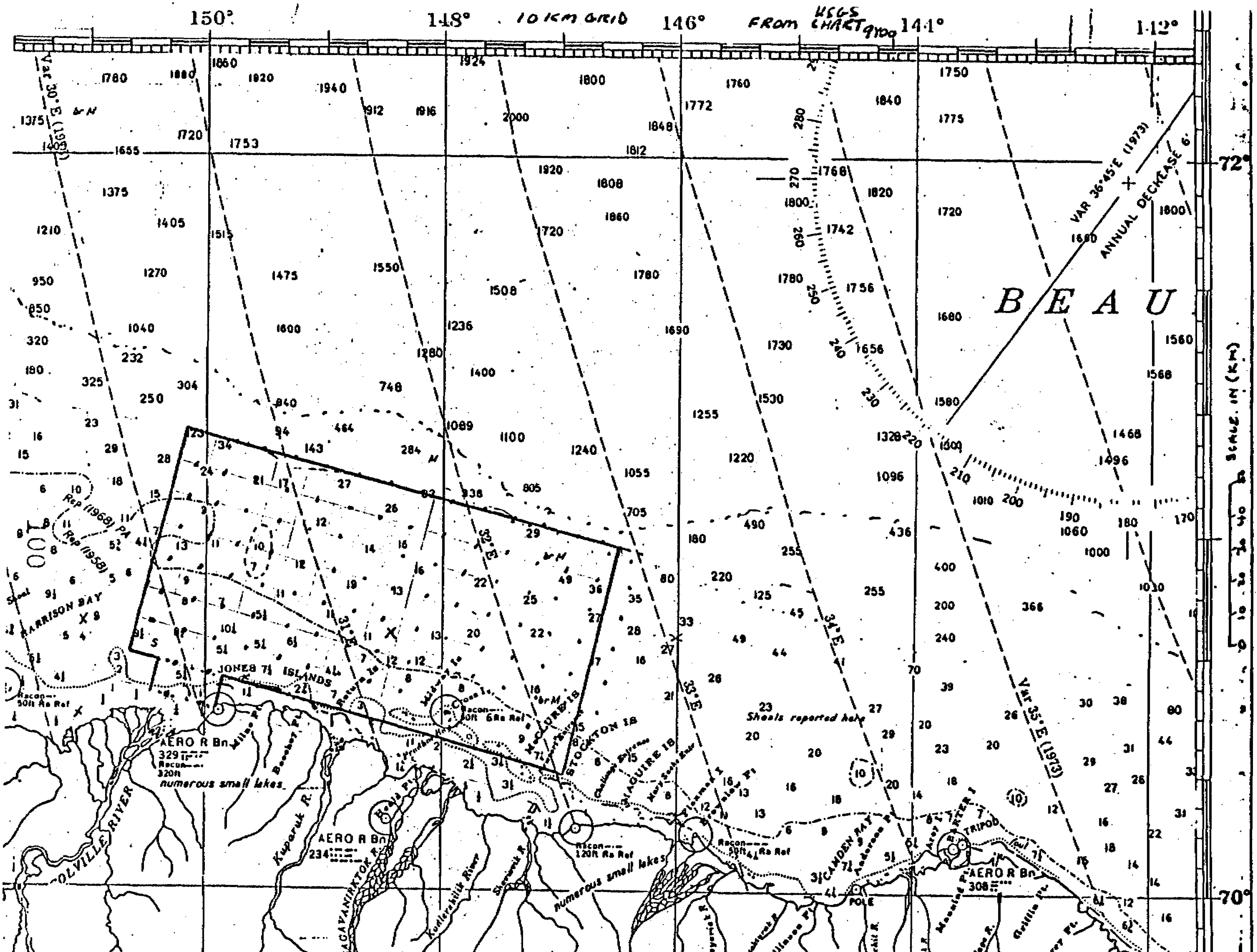
Data processing and computer runs will be done at Corvallis. Preparation of AMF releases and tide recorders will be done at Corvallis, again at Barrow and finally on board ship. There is an 8-hour steaming time from Barrow to the first installation (~71°N, 151°W) about 1 hour is needed per installation.

In short, all instruments are to be in place, recording simultaneously for a period of 29 days in the ice-free season. If instruments malfunction, 15-day records can be salvaged for the harmonic analysis.

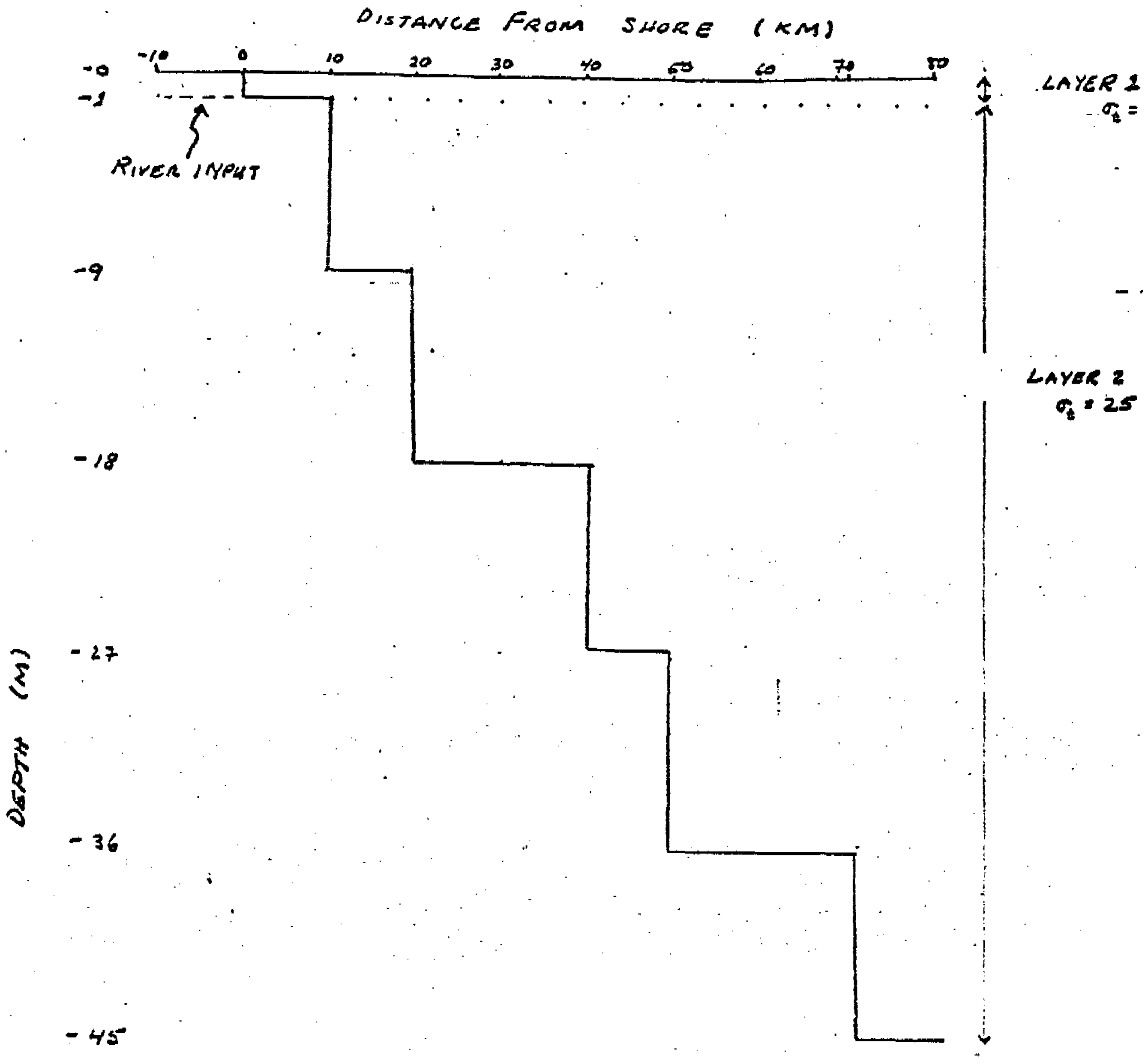
Upon recovery of the data about 3-4 months are required to process, edit and digitize the records. The data will be forwarded to the Project Office in the prescribed format. The data will be available from the EDS Project data base by February 1, 1976. All data would be available for computer runs by February 1, 1976, and possibly before then. Hopefully, wind and runoff data will also be available. I believe that whatever the conditions of these latter data, personal, prepublication examinations will allow sufficient data to be available for input to the computer runs.

Lodging will be required in Barrow or a DEW line station prior to loading equipment aboard ship (or helicopter) and while testing and assembling the equipment.

Anticipate one week for two people prior to installation of equipment. One man will supervise recovery. He will require three days at Barrow to pack and ship equipment.



150°
148°
10 KM GRID
146°
FROM USGS CHART
144°
142°
72°
70°
B E A U
VAR 36°45'E (1973)
ANNUAL DECREASE 6'
Var 35°E (1973)
Shoals reported here
HARRISON BAY
JONES ISLANDS
McCLURE IS
STOCKTON IS
MAGUIRE IS
CAMDEN BAY
TRIPOD
POLE
AERO R Bn
numerous small lakes
COLVILLE RIVER
Kuparuk R.
SAGAVANIRKTOK R.
SCALE IN (KM)



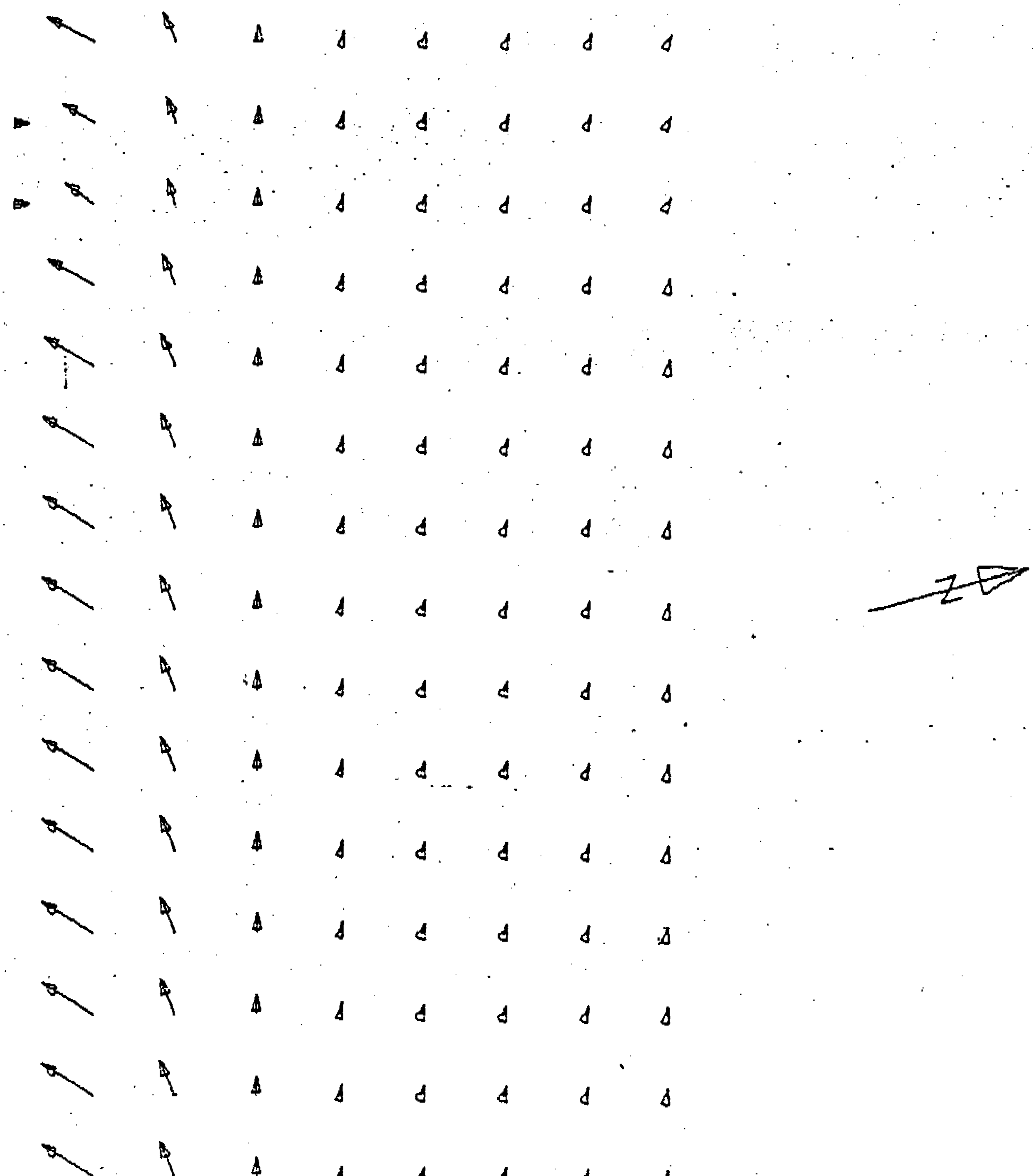
CROSS SECTION OF SLOPED BOTTOM

VERTICAL TO HORIZONTAL EXAGERATION = 2500:1

FLOW 100(CM/SEC/IN) TIME 14400 SEC UPPER LAYER

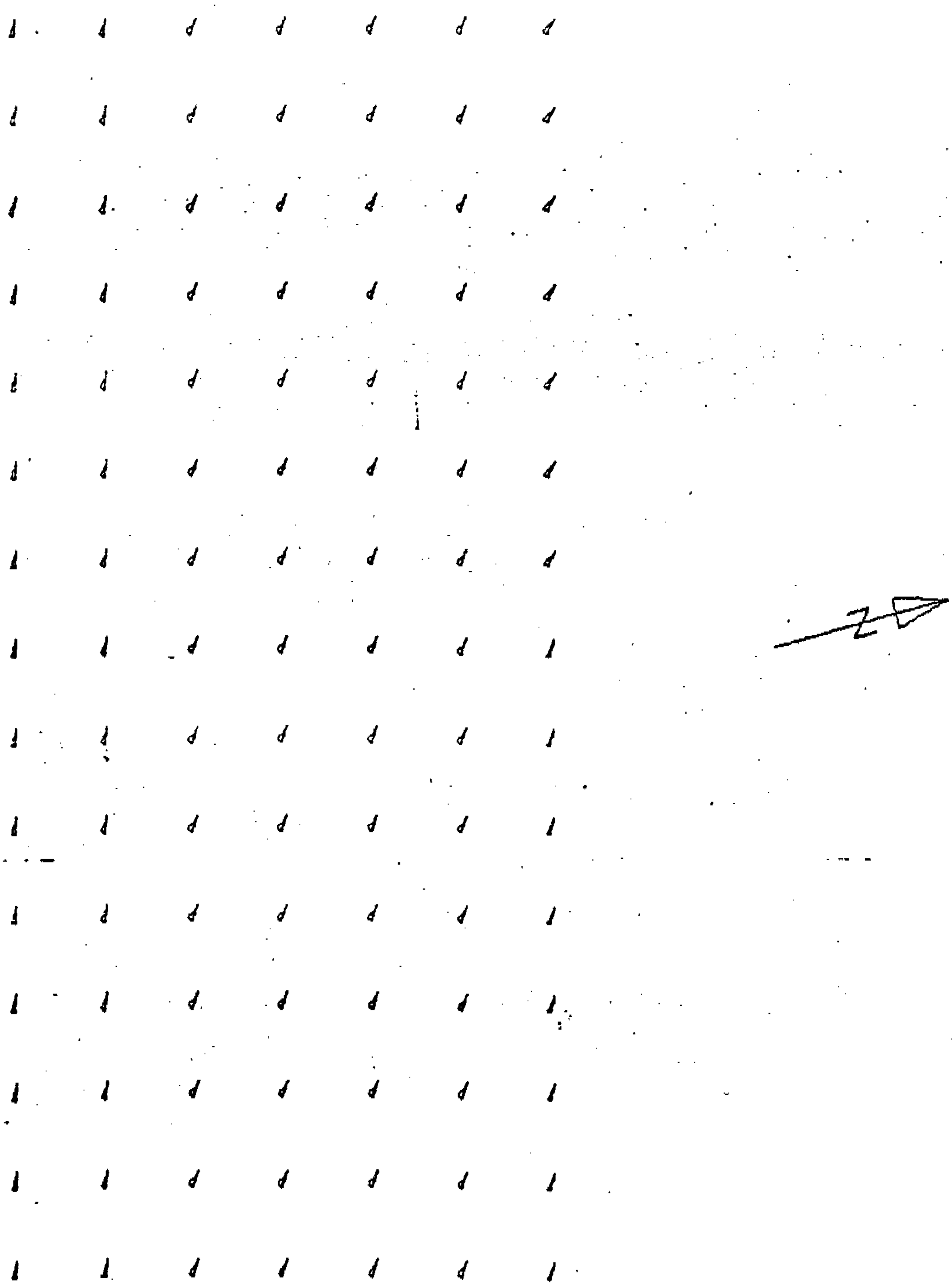
RIVER

MODEL NO 7



SLOPING BOTTOM,M2 TIDE, RIVER INPUT AT 10CM/SEC
BEAUFORT SEA SHELF MODEL-007A

FLOW 100(CM/SEC/IN)   TIME   14400 SEC   LAYER lower



SLOPING BOTTOM,M2 TIDE, RIVER INPUT AT 10CM/SEC
BEAUFORT SEA SHELF MODEL-007A

MODEL NO

ENCLOSURE #1

FINAL

OCSEP Work Statement
RU 347

I. Title

Marine Climatology of the Gulf of Alaska and the Bering and Beaufort Seas

II. Principal Investigators

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Comm: (704) 258-2850/ext 765

III. Geographic Area and Inclusive Dates

Marine area bound by 50°-80°N and 130°W-180°. Work to be done during FY 76 and FY 77 (7/1/75 - 9/30/77).

IV. Cost Summary

FY 1976 7/1/75 - 9/30/76	FY 1977 10/1/76 - 9/30/77
$110,700	$110,000
NCC - 74.5	NCC - 77.3
AEIDC - 36.2	AEIDC - 32.7

V. Proposed Research

The NCC and the AEIDC propose to do a joint study and analysis of climatological conditions on the marine and coastal areas of all of Alaska.

The objective is to determine and publish the present knowledge of the climatological conditions of that portion of the Alaskan waters and the near coastal areas that are important to the development of the outer continental shelf.

VI. Information Product

The climatological evaluation will be in the form of an atlas for each of the three selected coastal zone areas of Alaska; the Gulf of Alaska, Bering Sea, and Beaufort Sea (see attached Provisional Contents of Atlas). Each atlas will contain about 240 pages, of which 168 will be 3-color maps, displaying isopleths and graphs; included will be a few tables and a descriptive narrative of the atlas contents.

VII. Data and Sample Exchange Interfaces

The climatological analyses of the Alaskan waters will be based on surface marine and selected coastal land station data presently contained in NCC digital data base and "off-the-shelf" records within NCC and AEIDC.

The contents of these atlases will be of interest to other investigators in the study area, particularly in the context of planning more detailed future studies. In addition, the atlases would serve as an envirommental guide in planning, constructing and operating permanent offshore facilities.

VIII, IX, X, XI. Not applicable

XII. Cost

See attached:

1. NCC/AEIDC Budget;

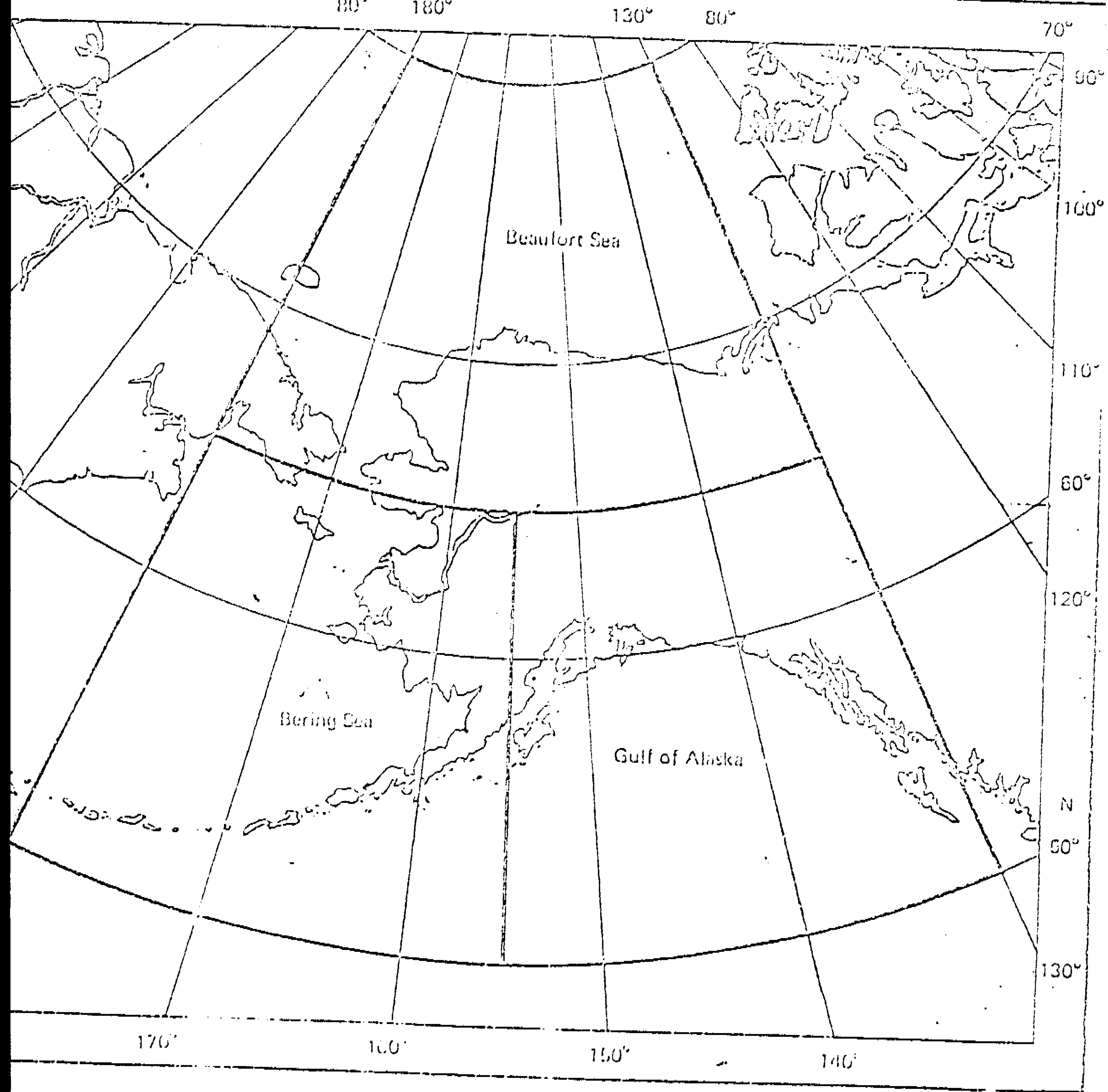
2. Atlas Milestones/Project Calendar.

PROPOSED

ALASKAN COASTAL ZONE ATLAS

Provisional

TABLE OF CONTENTS

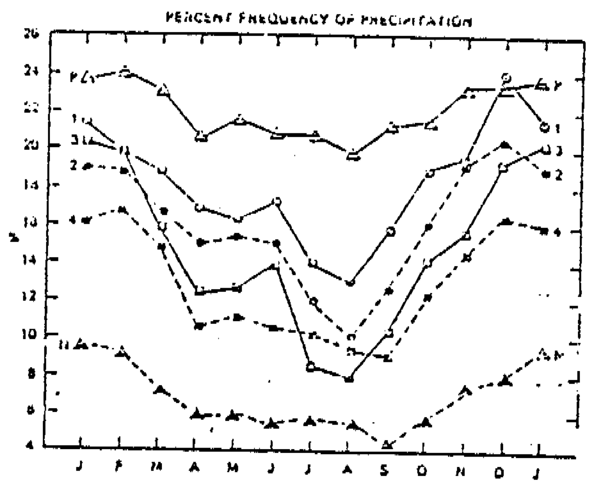

80°
180°
130°
80°
70°
90°
100°
Beaufort Sea
110°
60°
120°
Bering Sea
Gulf of Alaska
N
50°
130°
170°
160°
150°
140°

Detailed Provisional Contents of Alaskan Coastal Climatology Atlas *

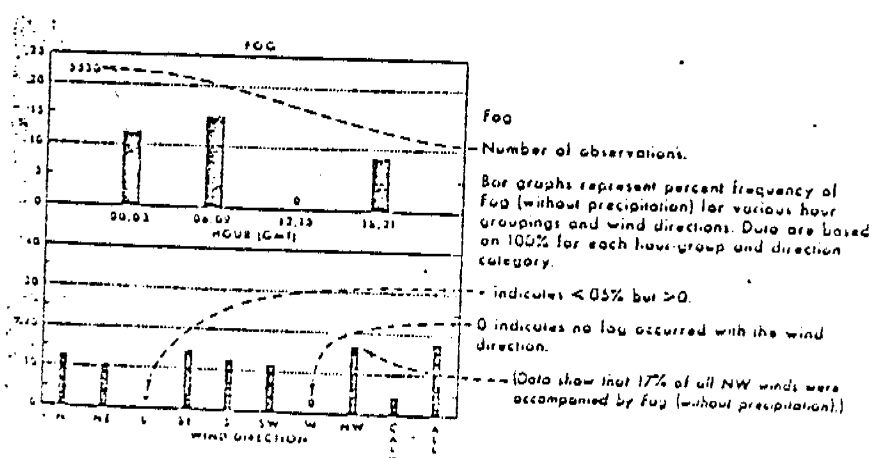
I. Introduction Material
Foreword, Introduction, Geographic Reference Chart

II. General Climatology
Items of special interest are covered here.

A. Annual march of selected elements include monthly graphs to show annual variations of such items as cloud cover, visibility, fog, precipitation, air temperature, sea surface temperature, waves, wind and sea level pressure. A sample graph appears below:



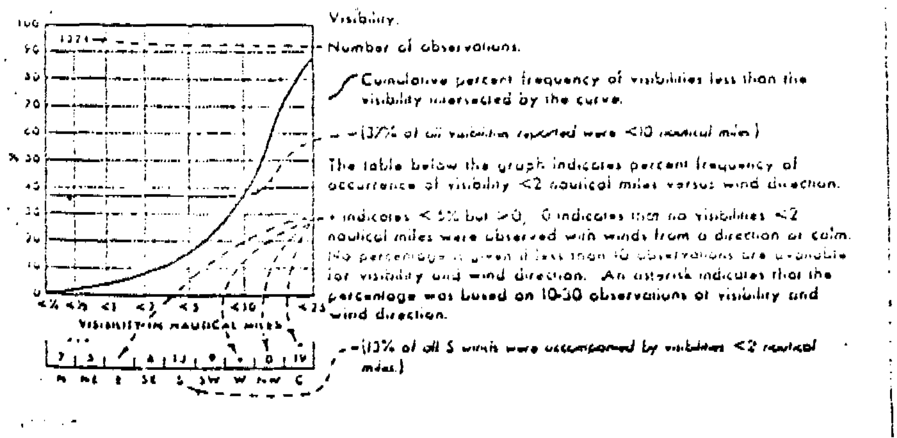
B. Fog information for fog-prone areas (If fog is extremely prevalent, fog material is covered in the "Climatic Charts" section).



*Sample graphs are based on dummy data and are not necessarily representative of U.S. Coastal Areas.

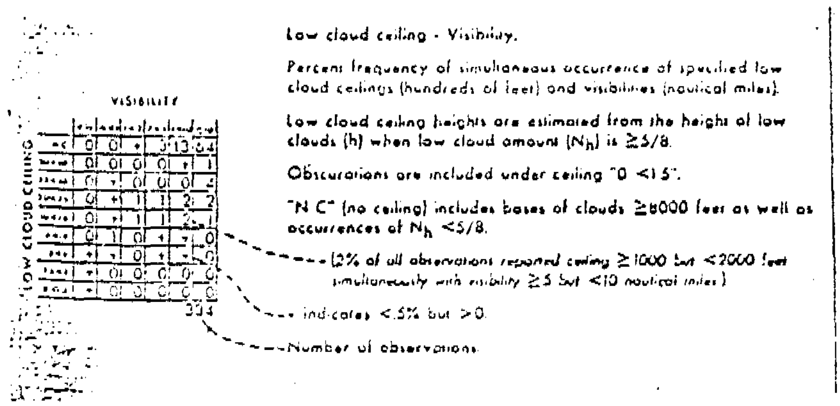
Isopleths: Percent frequency of total cloud amount 2/8.
Percent frequency of low cloud amount 5/8.

B. Visibility - Wind Direction

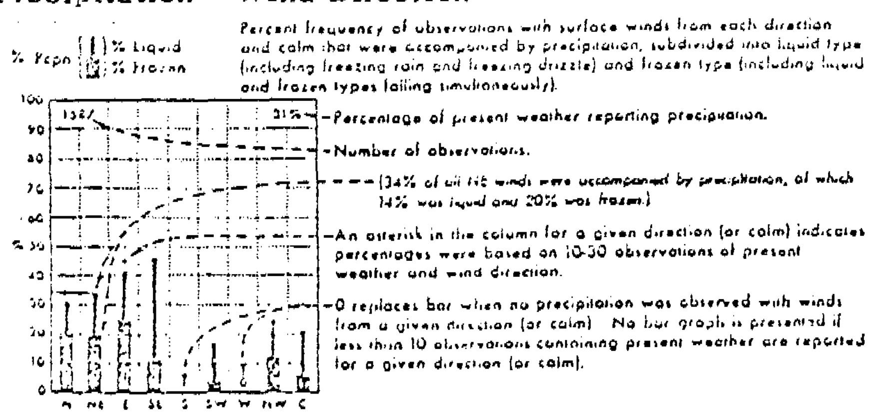


Isopleths: Percent frequency of visibility < 2 nautical miles.
Percent frequency of visibility ≥ 5 nautical miles.

C. Low Cloud Ceiling - Visibility

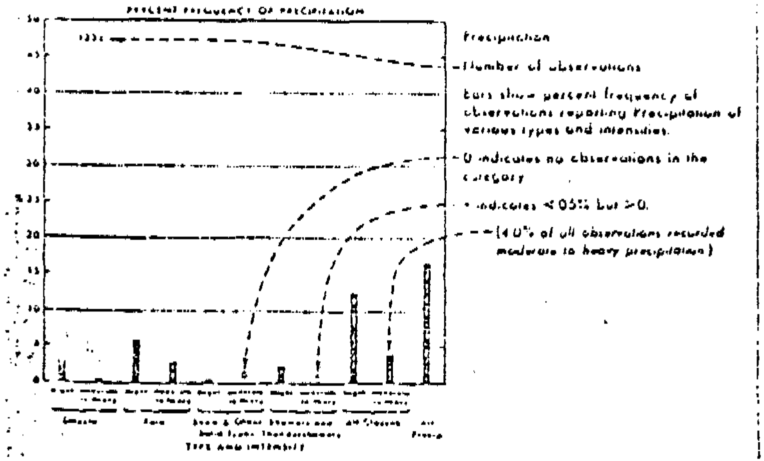


D. Precipitation - Wind Direction



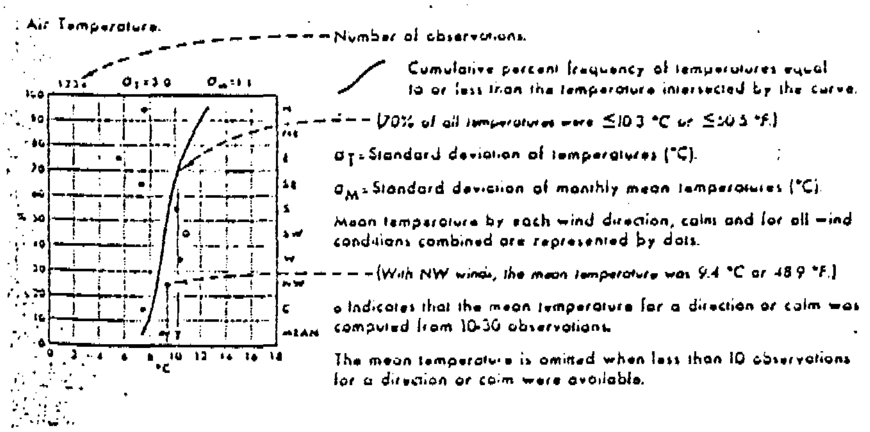
Isopleths: Percent frequency of precipitation. (Note-display monthly mean precipitation values at selected coastal stations).

E. Precipitation Types



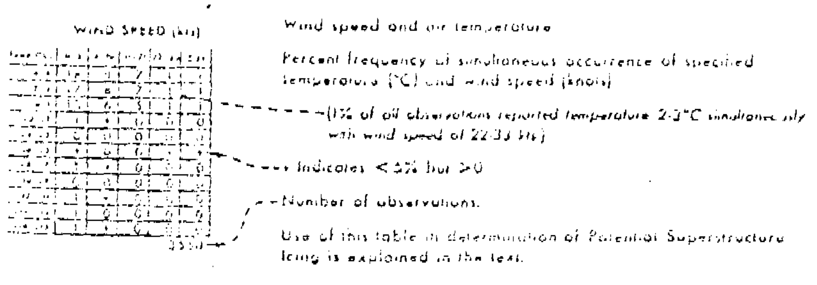
Isopleths: Percent frequency of frozen precipitation. (Note-display monthly mean snowfall amounts at selected coastal stations).

F. Air Temperature - Wind Direction



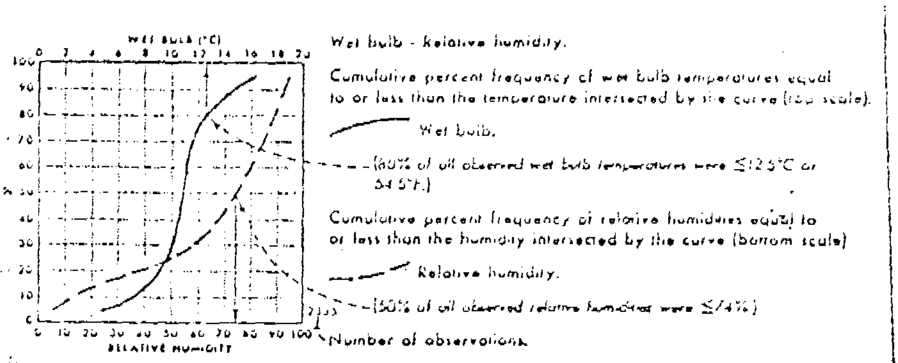
Isopleths: Mean Air Temperature

G. Air Temperature - Wind Speed



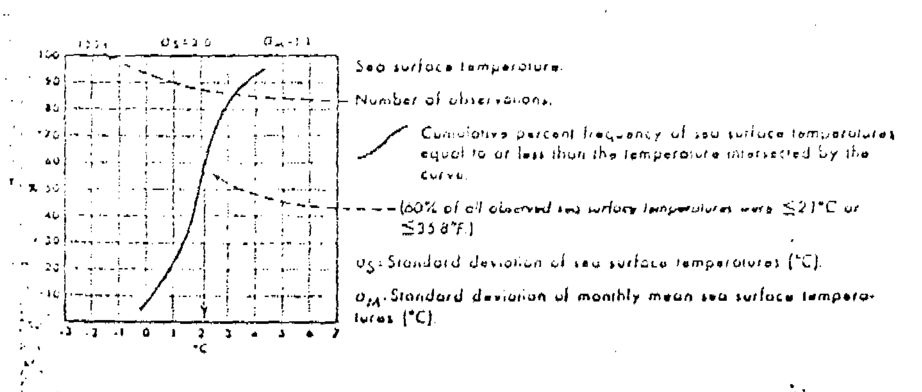
Isopleths: 1% and 99% air temperatures.

H. Wet Bulb Temperature - Relative Humidity



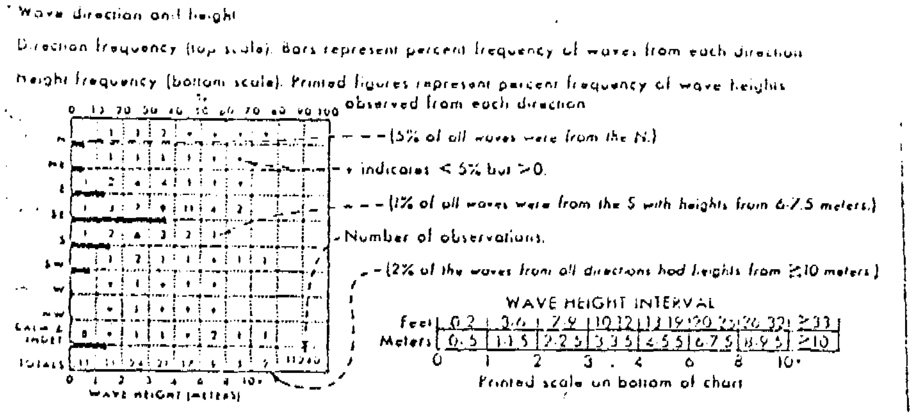
Isopleths: Percent frequency of Temperature-Humidity Index (THI) ≥ 24°C.

I. Sea Surface Temperature



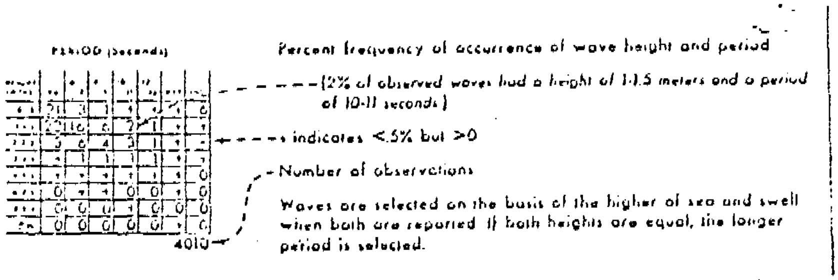
Isopleths: Mean 1% and 99% Sea Surface Temperature

J. Wave Height - Direction



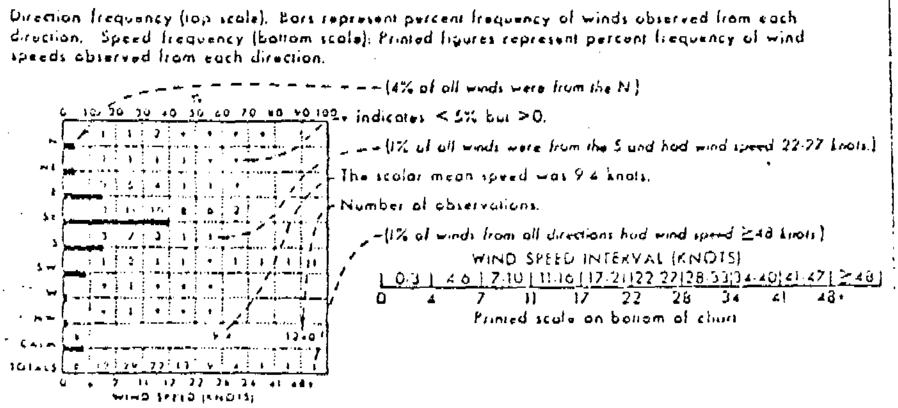
Isopleths: Percent frequency of waves less than 1.5 meters.
Percent frequency of waves less than 2.5 meters.

K. Wave Height - Period



Isopleths: Percent frequency of waves ≥ 3.5 meters.
Percent frequency of waves ≥ 6.0 meters.
(Note-display observed extreme wave heights at observation points).

L. Wind Speed - Direction

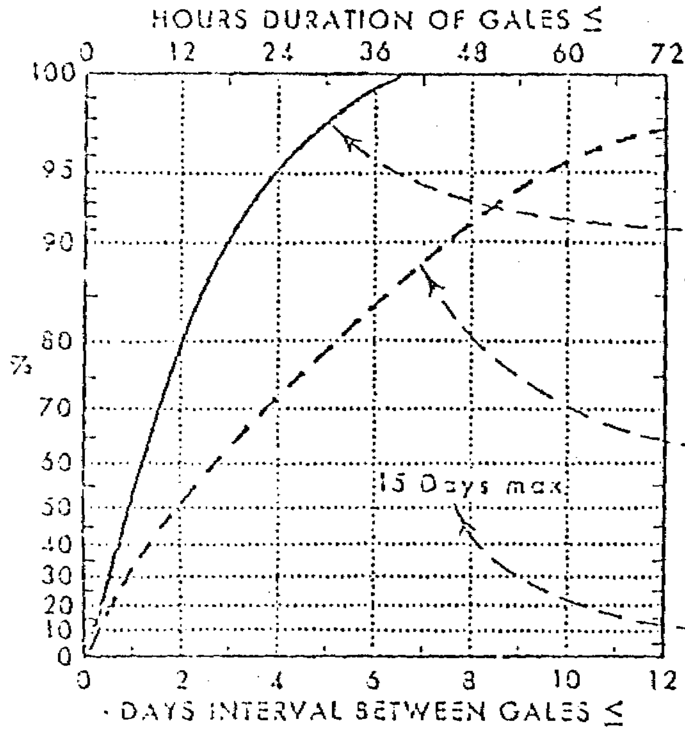


Isopleths: Scalar mean wind speed. (Note-display observed extremes at observation points).

M. Sea Level Pressure
Graphs: Percent frequency of sea level pressure similar to the sea surface temperature graphs.

Isopleths: Mean sea level pressure. (Note-display primary/ secondary storm tracks).

N. Hours Duration of Gales - Days Interval Between Gales
(see attached page)



Hours duration of gales - Days interval between gales.

Cumulative percent frequency of hours duration of gales equc or less than the number of hours intersected by the solid cur (based on gales which began in this month).

---(*98% of gales had a duration ≤30 hours.*)

Cumulative percent frequency of days interval between gales equal to or less than the number of days intersected by the broken curve (based on gales which ended in this month).

---(*88% of gales were followed by another gale in 7 days or less.*

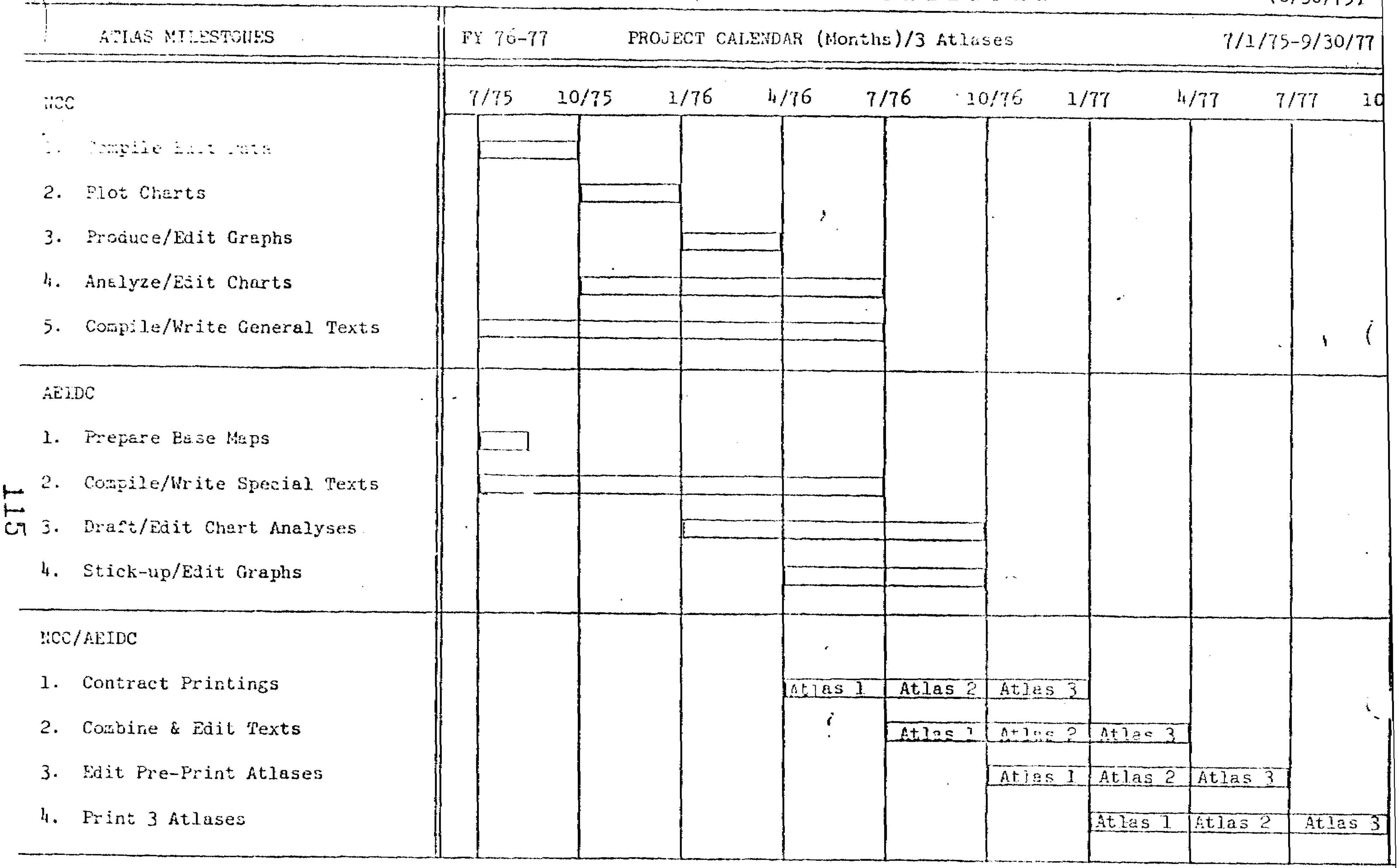
The maximum value(s) of hours duration and/or days interval be displayed when the graph limits are exceeded.

---(*100% of gales were followed by another gale in 15 days or les*

Where observations of gales are few, cumulative percent frequ cies of hours duration of gales and days interval between gale are provided in tables.

Percentage frequency of gale force winds (≥34 k

REVISED ATLAS MILESTONES/PROJECT CALENDAR (6/30/75)



The total cost for the combined efforts of NCC and AEIDC to prepare the three Atlases for Printing is $160.7K. The three areas will be done as one effort to insure continuity of analysis.

ENCLOSURE #3

UNIVERSITY OF ALASKA

MEMORANDUM

TO: Bill Searby DATE: July 14, 1975

FROM: Gene Cote G.C.

SUBJECT: Format refinements on the Climatic Atlas Series.

The printing estimates reflect two major points: 1. The relatively large size of the book and 2. A relatively expensive type of binding. Large size is the main factor for if size were reduced the binding as well as the printing would cost less.

The problem with a simple scale reduction is that in order to get the size small enough to realize printing economy the typset graphs, which in our initial concept overprint the map, would be too small for legibility. The isobars, which also overprint the map, are sufficiently generalized to permit a substantial reduction, however.

I would propose two alternates, both of which involve some scale reduction. I will pursue with the printer an alternate binding for the original format size but, based upon past experience, I'm not optimistic of substantial savings. Again it's the size working against us since any binding for a book that large must be hand rather than machine manufactured.

The first scale reduction alternate would be to simply take the map as is, with isobars and typeset graphs and reduce it down to the limit permitted by the graphs. Since the graphs contain relatively fine line work they can't be reduced much. The resulting format size, while a bit smaller than the original size, would probably not be small enough to save substantial printing cost.

The second alternate would be to depart substantially from the original format and separate the graphs from the map. The page size would be determined by the maximum space required by the graphs when aligned in compact columns. The map, since it lends itself to substantial reduction, would then be scaled down to the page size required for the graphs. Data continuity would be maintained by organizing material into a two page spread with the map and isobars on one side and the graphs pertaining to that particular map on the facing page. This approach would reduce the book to approximately half of its original size and should save substantially on printing cost.

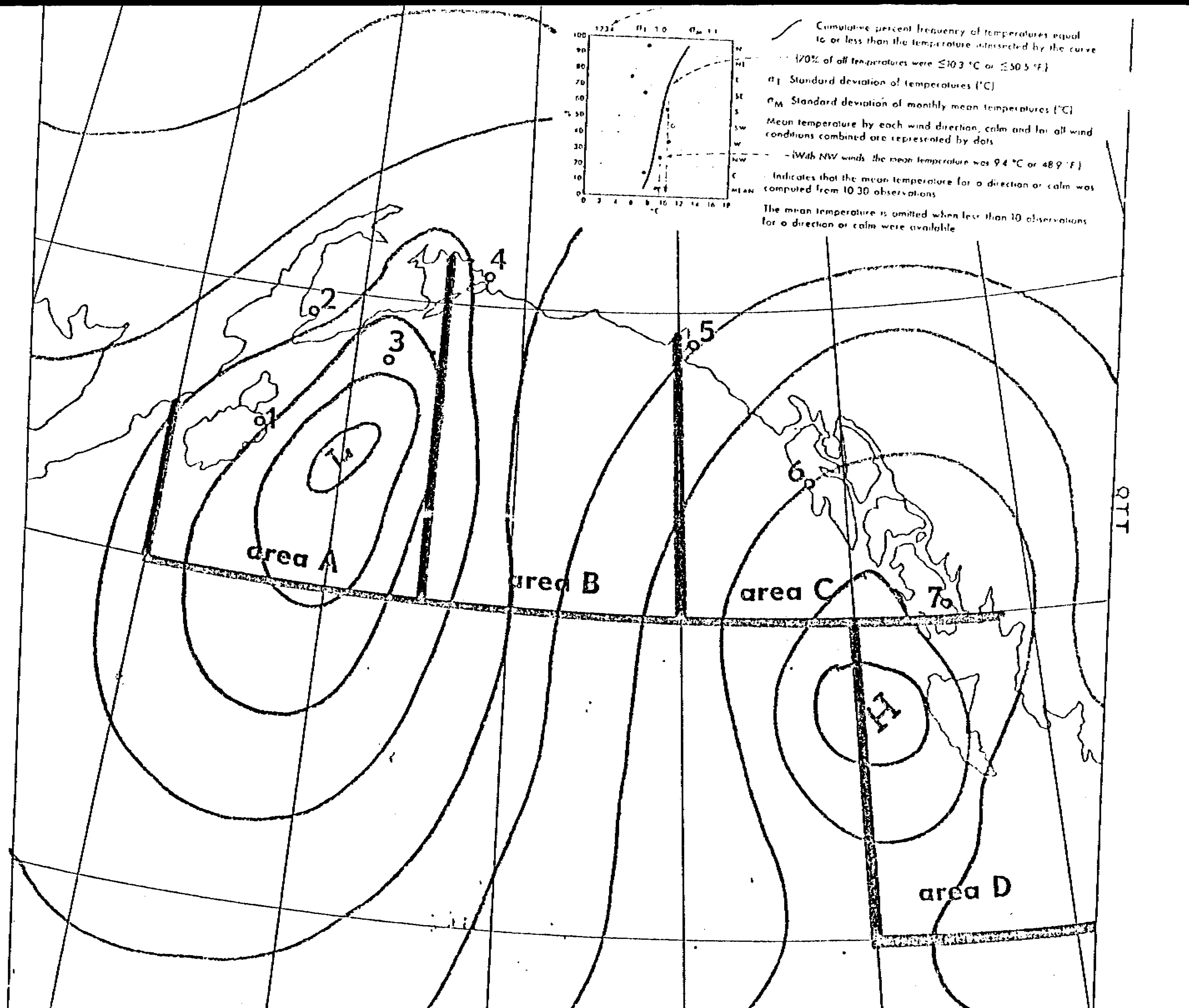
I have included a sample spread to be forwarded to Bill Brower. The scale which resulted is approximately one half of the original format size for a map scale of approximately 1:10,000,000. I feel that, graphically, this results in a readily legible map considering the generality of data likely to be shown. The graphs maintain their legibility since they are not reduced at all. The only possible objection is the relation between a specific graph and it's corresponding data station or area on the map. I personally don't feel this is a significant problem as long as the two corresponding pages face each other and the graphs are numerically keyed to the map. This sample is a rough mock-up only and final map scale, page size and so on would have to be pinned down at a later time based upon the maximum number and maximum size of graphs which must appear on any one page.

This approach would double the number of pages per book but since a 50% reduction in linear dimensions results in a 75% reduction in area there would be more pages printed simultaneously on a single sheet of paper, thus fewer press passes, thus printing economy. The added bonus is that the smaller format size would permit lower cost binding, regardless of what binding type is used.

I will now revise the specifications to incorporate the format size change and again approach printers for estimates. I will also request estimates on alternate bindings on the original format size along with reduced press runs, also on the original size.

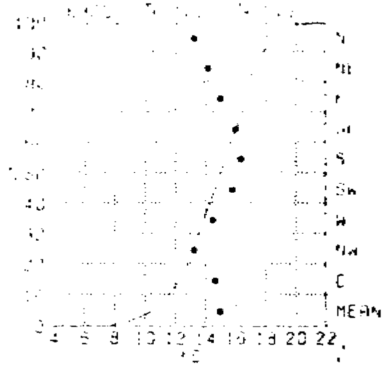
My one hesitation at this point is about the graphs. We are assuming that the computer print-outs supplied to us will be camera ready and of reproduction quality. Any additional work we would have to do on the graphs would add considerably to our estimated costs. I would suggest verifying at an early date the exact nature of the computer printed graphs to insure compatibility with our production techniques.

cc: Bill Brower, NCC

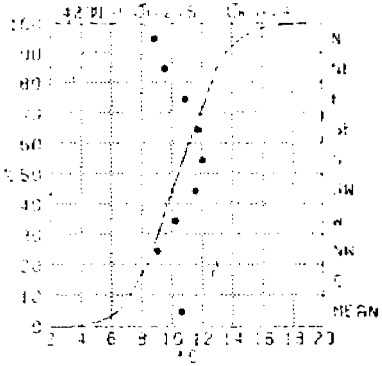

Cumulative percent frequency of temperatures equal to or less than the temperature intersected by the curve
(70% of all temperatures were ≤10.3 °C or ≤50.5 °F)
σ_T Standard deviation of temperatures (°C)
σ_M Standard deviation of monthly mean temperatures (°C)
Mean temperature by each wind direction, calm and for all wind conditions combined are represented by dots
(With NW winds the mean temperature was 9.4 °C or 48.9 °F)
Indicates that the mean temperature for a direction or calm was computed from 10-30 observations
The mean temperature is omitted when less than 10 observations for a direction or calm were available
1
2
3
4
5
6
7
L
H
area A
area B
area C
area D

WIND DIRECTION

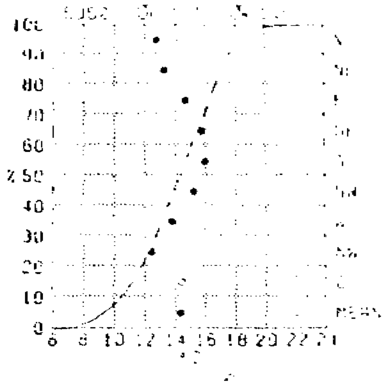
AREA **1**



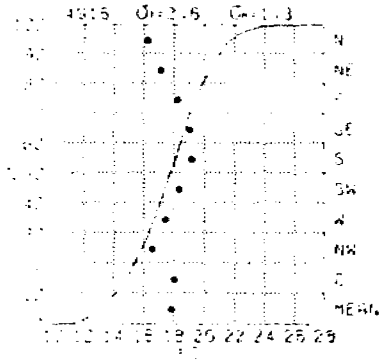
AREA **2**



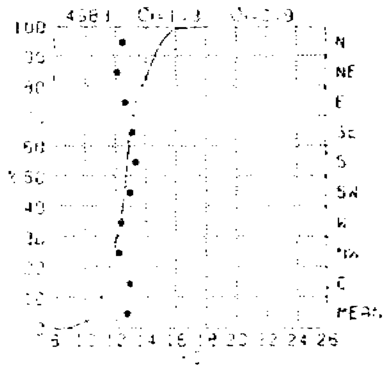
AREA **3**



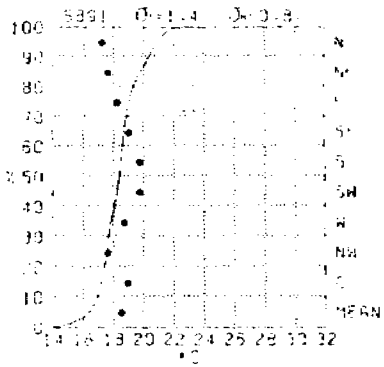
AREA **4**



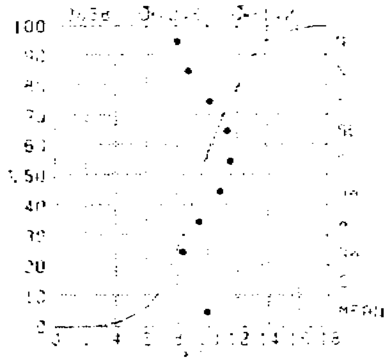
OWS P **5**



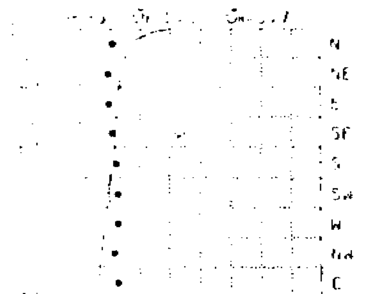
OWS **6**



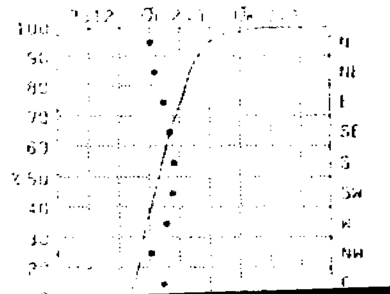
AREA **7**



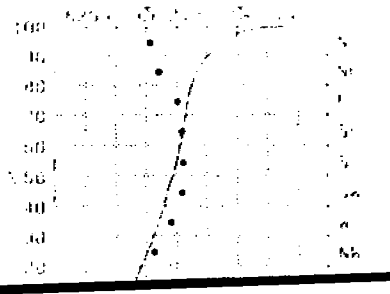
OWS N **A**



AREA **B**



AREA **C**



AREA **D**

WORK STATEMENT

(Research Unit #357)

I. TITLE

Physical oceanography of the Gulf of Alaska

II. CO-PRINCIPAL INVESTIGATORS

F. Favorite, NOAA, NMFS, NWFC
Seattle, WA 98112
(206) 442-7754

J. H. Johnson, NOAA, NMFS, PEG
Monterey, CA 93940
(408) 373-3331

III. GEOGRAPHIC AREA AND INCLUSIVE DATES

Central Gulf of Alaska
1 April 1975 - 30 September 1976

IV. COST SUMMARY

Personnel	$16.4 K
Equipment	14.9 K
Other	13.7 K
Total	$45.0 K

V. PROPOSED RESEARCH

A. Background and objectives

This study is intended to satisfy the requirements of Task B-1 -- Summarize and evaluate existing literature and unpublished data related to circulation and transport.

The present state of knowledge of circulation and transport in this area is quite fragmentary. Although it is generally accepted that northward flow into the gulf stems from the divergence of the Subarctic Current, the location of this divergence zone, the factors causing the divergence, and the seasonal and annual fluctuations in transport are not well known. Winter intensification of winds results in increased water transport, but the nature of this flow, particularly at the head of the gulf, and its effect on the containment or seaward discharge of coastal runoff are not clear.

B. Methods

Standard methods of water mass identification and processes associated with general distributions of variables will be used to initially characterize oceanographic conditions. There are numerous atlases of annual and monthly mean properties and such presentations will not be duplicated. Rather, we will investigate quasi-synoptic data to ascertain the variability in conditions that has occurred in the area, and ascertain probable causes through studies of other physical data. Once relations between actual observed conditions and physical processes have been ascertained then historical records of sea level and wind-stress data will be utilized to infer possible extreme conditions in the distribution of variables and in flow.

VI. INFORMATION PRODUCTS

The ultimate product of this study will be an in-depth summary of the present state of our knowledge of the physical oceanography of the Gulf of Alaska. A number of subsidiary products will be generated that should be useful to various Principal Investigators. These may include: ranges of water properties to be expected, characteristic oceanographic domains, maximum and minimum flow conditions (Ekman and total transports), and variations in circulation and upwelling patterns. Predictive indices and primitive model solutions will also be investigated.

VII. DATA OR SAMPLE EXCHANGE INTERFACES

Station data in the NODC Geofile as of December 1972 are already available to us. It will be necessary to acquire an updated tape (unless it is more economical to acquire a completely new tape). Vertical array summaries by 1 X 1° squares are also needed. These data will be required by June 1975.

We already have access to mean monthly sea level pressures dating back to 1899 which will be used for transport studies. NCC may be contacted to ascertain if any useable data on mean winds are available. Sea level data from coastal stations for the period 1972-75 will be requested from the appropriate NOAA division.

VIII. SAMPLE ARCHIVAL REQUIREMENTS

None

IX. SCHEDULE

The schedule will depend upon receipt and processing of data. Because we are working rather independently, are not participating in a field program and will have an initial draft prepared in less than a year, perhaps a detailed schedule is not necessary. It is expected that all analyses will be essentially complete by January 1976, the draft by April 1976, review by June 1976, and corrections and/or additions by August 1976.

X. EQUIPMENT REQUIREMENTS

No field equipment will be purchased or deployed. Laboratory data display and analysis equipment will be purchased from Tektronix. These components are available through GSA contractual agreements and no delays in acquisition are anticipated.

XI. LOGISTICS REQUIREMENTS

None