# Environmental Assessment of the Alaskan Continental Shelf

Quarterly Reports of Principal Investigators for July - September 1978

Volume II

Outer Continental Shelf Environmental Assessment Program
Boulder, Colorado 80303

December 1978

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

**U.S. DEPARTMENT OF INTERIOR**
Bureau of Land Management

## DISCLAIMER

The National Oceanic and Atmospheric Administration (NOAA) does not approve, recommend, or endorse any proprietary product or proprietary material mentioned in this publication. No reference shall be made to NOAA or to this publication furnished by NOAA in any advertising or sales promotion which would indicate or imply that NOAA approves, recommends, or endorses any proprietary product or proprietary material mentioned herein, or which has as its purpose an intent to cause directly or indirectly the advertised product to be used or purchased because of this publication.

VOLUME 2

CONTENTS

| | Page |
|---|---|
| CONTAMINANT BASELINES | 1 |
| HAZARDS | 187 |
| TRANSPORT | 367 |
| DATA MANAGEMENT | 593 |

## CONTAMINANT BASELINES

Contents


| RU# | PI | Agency | Title | Page |
|---|---|---|---|---|
| 152 | Feely, R., et al. | PMEL/NOAA, Seattle, WA | Transport Mechanisms and Hydrocarbon Adsorption Properties of Suspended Matter in Lower Cook Inlet | 3 |
| 153 | Cline, J. Feely, R. | PMEL/NOAA, Seattle, WA | Identification of Natural and Anthropogenic Petroleum Sources in the Alaskan Shelf Areas Utilizing Low Molecular Weight Hydrocarbons | 33 |
| 162 | Burrell, D. | Inst. of Marine Science, Fairbanks, AK | Distribution and Dynamics of Heavy Metals in Alaskan Shelf Environment Subject to Oil Development | 80 |
| 275 | Shaw, D.G. | Inst. of Marine Science, Fairbanks, AK | Hydrocarbons: Natural Distribution and Dynamics on the Alaskan Outer Continental Shelf | 171 |
| 480 | Kaplan, I.R., et al. | Univ. of Calif. Los Angeles, CA | Characterization of Organic Matter Sediments from Cook Inlet, Norton Sound, Kodiak Shelf and Beaufort Sea | 173 |
| 506 | Robertson, D. Abel, K. | Battelle Lab., Richland, WA | Natural Distribution of Trace Metals and Environmental Background in Three Alaska Shelf Areas | 182 |

Quarterly Report

| | |
|---|---|
| Research Unit: | #152 |
| Reporting Period: | 7/1/78-9/30/78 |
| Number of Pages: | 30 |
| Principal Investigators: | Richard A. Feely |
| | Joel D. Cline |

# Transport Mechanisms and Hydrocarbon Adsorption Properties of Suspended Matter in Lower Cook Inlet

Prepared by

Richard A. Feely, Joel D. Cline and Gary J. Massoth

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

September 30, 1978

## I. Task Objectives

The major objectives of the Lower Cook Inlet suspended matter program include: (1) determination of the seasonal variability of the vertical fluxes, the distribution, and the composition of suspended particulate matter in areas of contrasting sedimentation and productivity; (2) participation in an interdisciplinary study of the partitioning of several trace element species among their major reservoirs; and (3) investigation of the physical processes and mechanisms controlling the accommodation of petroleum hydrocarbons with respect to Lower Cook Inlet suspended matter.

## II. Field and Laboratory Activities

### A. Field Activities

1. Ship Schedule
   a. DISCOVERER Cruise RP-4-DI-78A-III (4-17 May 1978)
   b. MILLER FREEMAN Cruise RP-4-MF-78A-II (19 May-4 June 1978)
   c. DISCOVERER Cruise RP-4-DI-78B-II (22 August-6 September 1978)
2. Participants from PMEL
   a. Dr. Richard Feely, Oceanographer
   b. Mr. Gary Massoth, Oceanographer
   c. Ms. Jane Hannuksela, Oceanographer
   d. Mr. William Landing, Research Assistant, UW
   e. Mr. Rundy Dyer, Research Aid, UW
   f. Mr. Anthony Paulson, Oceanographer

3. Methods

a. Particulate Matter--Water samples were collected in General Oceanics 1070 10L PVC Top-Drop Niskin bottles from preselected depths. Nominally these included: 0-2 m, 10 m, 20 m, 40 m, 60 m, 80 m, and 5 meters above the bottom. Aliquots were drawn within one-half hour after collection from each sample and vacuum filtered through preweighed 0.4 um pore diameter Nuclepore polycarbonate filters for total suspended matter concentration determinations and multielement particulate composition analysis. Samples were also filtered through 0.45 um pore diameter Selas silver filters for particulate carbon and nitrogen analyses. All samples were rinsed with three 10 mL aliquots of deionized and membrane filtered water, placed in individual petri dishes with lids slightly ajar for a 24-hour desiccation period over sodium hydroxide and then sealed and stored (silver filters frozen) for subsequent laboratory analysis.

b. Bottom Sediment--Bottom sediment samples were collected with a Shipek grab sampler, a three-inch gravity corer equipped with a plastic core liner, and a HAPS corer. Five gravity corer samples and all HAPS corer samples were sectioned into 1 cm segments upon collection and frozen in individual plastic bags. All remaining bottom sediment samples were immediately frozen and returned to the laboratory intact.

c. Nephelometry--The vertical distribution of suspended matter was determined with a continuously recording integrating analog nephelometer. The instrument was interfaced with the ship's CTD system using the sound velocity channel (14-16 KHz). Continuous vertical profiles of forward light scattering were obtained in analog form on a Hewlett Packard 7044 X-Y recorder.

d. Conductivity (Salinity), Temperature, and Depth--These standard hydrographic data were acquired with a Plessy Model 9040 Environmental Profiling System (CTD probe) and a Model 8400 digital data logger using 7-track, 200 B.P.I. magnetic tape. Temperature and salinity calibration data were provided by NOAA ship personnel from discrete water samples utilizing reversing thermometers and a bench salinometer, respectively. Signals from the CTD system and the nephelometer were also simultaneously interfaced with the ship's data acquisition system. This resulted in computer listings of continuous (uncorrected) data for conductivity, temperature, depth, salinity, sigma-t, and light scattering for all vertical sampling stations.

e. Sediment Trap/Vertical Particulate Flux Studies--During cruise RP-4-MF-78A-II (19 May-4 June 1978) three moorings, each supporting one set of tandem sediment traps located 10 m above the bottom, were deployed along a transect line extending from Kamishak Bay to Kachemak Bay in lower Cook Inlet. The sediment trap capture period was set (trap closure to be activated by self-contained timers approximately 80 days after deployment) to obtain a long-term average of the particulate vertical flux mass (rate) and composition. Recovery of the sediment traps is scheduled for October 1978.

4. Station Locations

Figure 1 shows the locations of suspended matter stations occupied during Cruise RP-4-DI-78A-III (4-17 May 1978) and RP-4-MF-78A-II (19 May-4 June 1978) in lower Cook Inlet. Stations ST-1, ST-2 and ST-3 were the only positions occupied during the latter cruise which was conducted entirely for sediment trap deployment operations. The station locations for the late summer cruise (RP-4-DI-78B-II, 22 August-6 September 1978) in lower Cook Inlet and Shelikof Strait are shown in Figure 2. The additional stations in Shelikof Straits were occupied to identify the regions where suspended matter from lower Cook Inlet is deposited.

5. Samples and Data Collected

We have completed both interdisciplinary cruises scheduled for FY 78 in lower Cook Inlet. During the first cruise (RP-4-DI-78A-III, 4-17 May 1978), 283 suspended particulate matter samples, five gravity and HAPS corer samples, 59 nephelometer profiles and 72 CTD profiles were collected. In addition, nine suspended matter samples were processed in support of hydrocarbon studies conducted in upper Cook Inlet (Cline: RU 153). A total of 12 stations were occupied including two 48-hour time series studies at stations CB-7 and CB-9 (Figure 1). During the summer cruise (RP-4-DI-78B-II, 22 August-6 September 1978) a total of 22 stations were occupied in Cook Inlet and Shelikof Strait and 280 suspended matter samples and 7 sediment cores were collected. A single time-series station was occupied at station CB-10 (Figure 2).

B. Laboratory Activities

1. Sample and Data Status

Analysis of samples and data collected on cruises RP-4-DI-78A-III (4-17 May) and RP-4-DI-78B-II (22 August-6 September 1978) are currently underway and will be discussed in a future report.

2. Hydrocarbon-Suspended Matter Interaction Studies

a. Methods

The preliminary objective of the sediment/oil interaction study was to establish the loading characteristics of Cook Inlet suspended matter relative to a typical Cook Inlet crude oil. The particular approach used was designed to evaluate the quantity of petroleum that might be adsorbed to indigenious particles, assuming that particles and oil would achieve rapid equilibrium with each other. Experiments were conducted in seawater near 32°/oo and 10°C. Equilibration times were set for one hour in these preliminary observations.

Suspended matter was recovered from near Kalgin Island (station 4) with a Sorvall SS-3 continuous flow centrifuge.

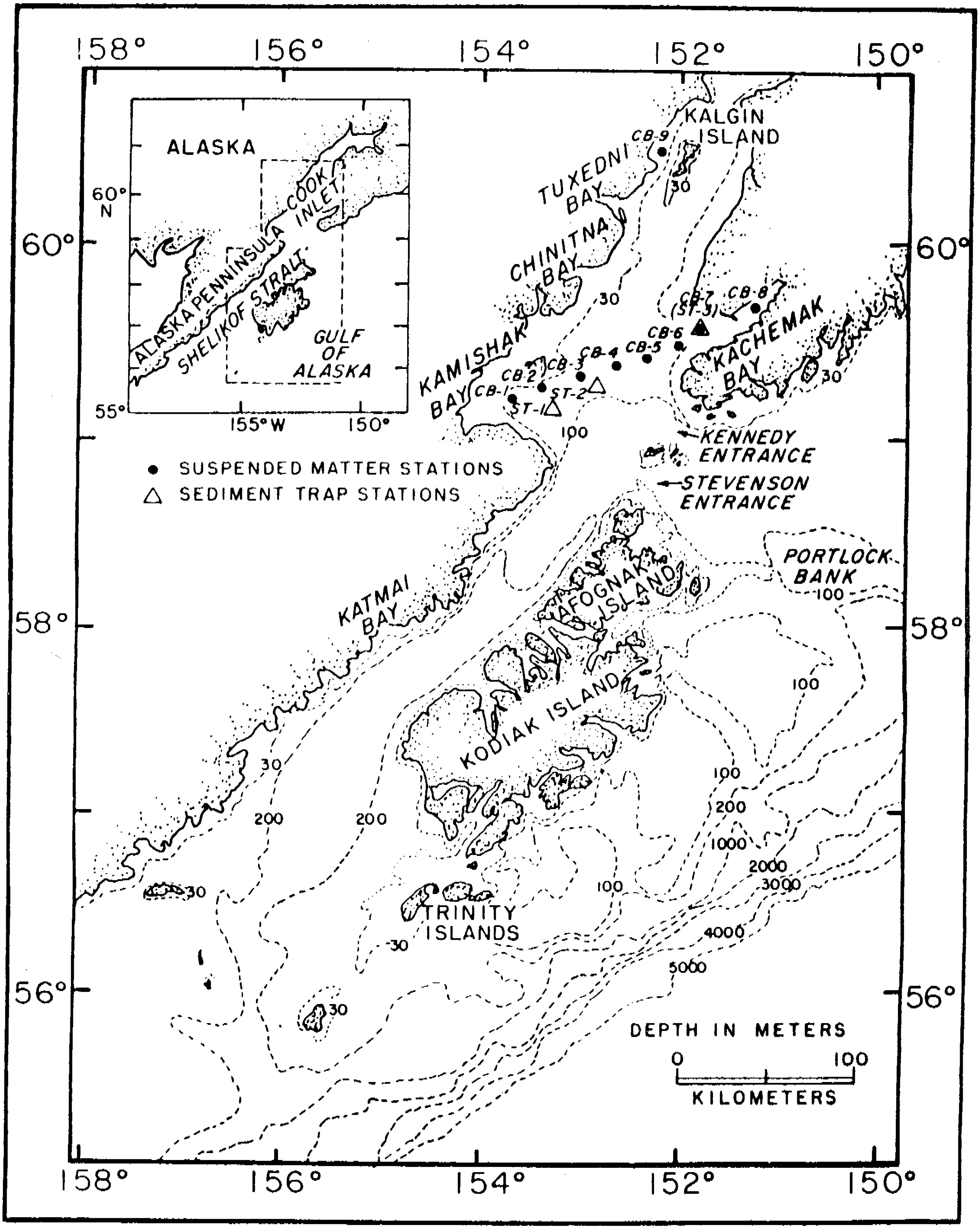



Figure 1. Locations of suspended matter and sediment trap stations occupied in lower Cook Inlet (Cruises RP-4-Di-78A-III, 4-17 May 1978 and RP-4-MF -78A-II, 19 May - 4 June 1978).

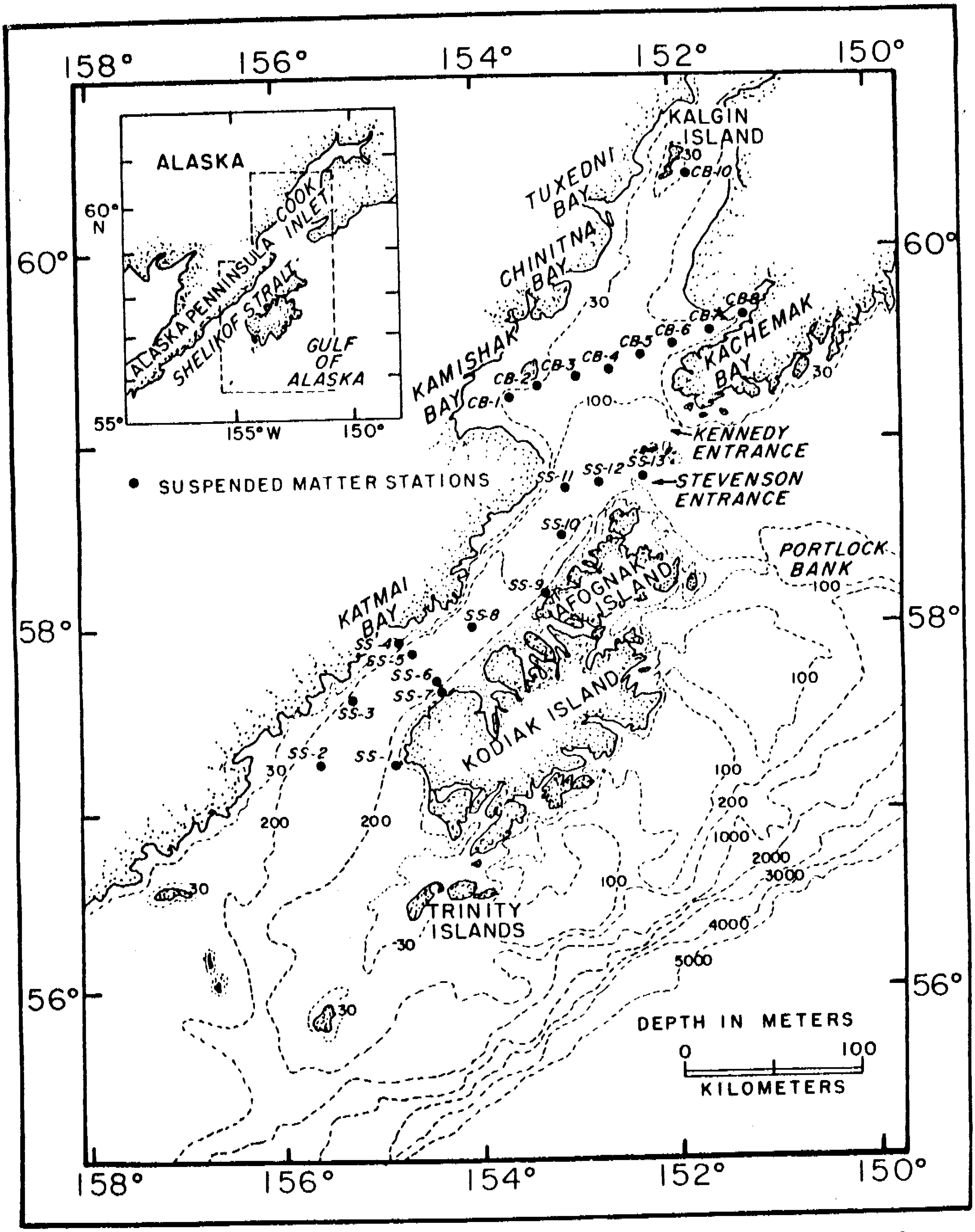



Figure 2. Locations of suspended matter stations occupied in lower Cook Inlet (Cruise RP-4-Di-78B-II, 22 August - 6 September 1978).

Previous testing of this recovery technique has shown that more than 95% of all particles greater than 0.4 um are sedimented as computed from mass differences between the source water and the centrifuge effluent (Baker et al., 1978). Small organic particles are not efficiently retained because of the relatively low density. In upper Cook Inlet, the relatively low abundance of organic matter would negate any significant compositional fractionation occurring as the result of the centrifugation process.

After recovery, the sediment was transferred to a clean jar, fitted with an aluminum foil top, frozen, and returned to the laboratory. Water was removed from the sediment by freeze drying, resulting in a fine dry powder which was subsequently used in the agglutinization study.

The loading characteristics of Cook Inlet suspended matter was investigated under controlled laboratory conditions. Approximately 50 mg suspended sediment (dry weight) was added to 800 mℓ of filtered Cook Inlet seawater ($S \simeq 32°/oo$) in a 1-liter separatory funnel. To this was added varying quantities of crude oil, resulting in initial loading factors (mg oil/mg sediment) ranging from 0.17 to 1.7. Prior to the addition of the oil, the water temperature was decreased to the desired experimental value. The mixture was shaken gently for 1 hour to simulate natural mixing conditions, but not severe enough to generate frothing or air bubbles on the solution.

After one hour, the separatory funnels were allowed to stand vertically in the water bath for 1-3 hours to promote settling of the oil/sediment flocs. These were removed carefully with a small bore pipette and transferred to a 25 mm filtration apparatus. The oil was separated from the sediment particles by dissolving in methylene chloride and retaining the inorganic material on 0.4 um Selas® silver filter. The preweighed filters were dried at 110°C and the residual weight determined. Excess water was removed via pipette and sodium sulfate and the volume of methylene chloride reduced to 2 mℓ in a concentrator tube.

The remaining mixture in the separatory funnel is made up of emulsified oil, surface slick (in some instances), oil adsorbed to the walls of the separatory funnel, and oil adsorbed to suspended particles that did not settle. This mixture was extracted with 20% ethyl ether/methylene chloride solution to recover the remaining oil. A total of 3-20 mℓ aliquots of the solvent mixture was used to effect the extraction. This fraction (referred to as the water accommodated oil) and the previous fraction, both were reduced to a 2 mℓ volume in a concentrator tube and a 25 uℓ aliquot taken for gravimetry. Both extracts were saved for future GC analyses.

Prior to actual experimentation, oil recovery efficiencies were conducted. It was determined that approximately 15% of the total oil was lost during concentration step (presumably volatiles). Extraction of approximately 20 mg Cook Inlet crude oil from 800 mℓ of seawater was effectively carried out with the previous solvent mixture with total recoveries better than 95% after correction for evaporative losses. When sediment is added to oil-water mixture, the extraction efficiency decreases in proportion to the amount of oil present. This experimental artifact will be discussed below.

Because both the seawater and sediment contain extractable organics, separate tests were made to determine the amount of organics that would be included in the lipid fraction. We assumed that no partitioning of the organics occurred in the mixture and simply corrected the final oil recoveries based on sediment and water recoveries in each fraction. In actuality, the distribution of the natural organics is affected by the addition of petroleum to the system, but no serious consequences arise since the concentration of oil was usually much greater than the combined amounts of extractable organics from the water and sediment. The exception is the case where only 8.4 mg of oil was added.

In order to compare particle size distributions of Cook Inlet suspended matter with the oil-suspended matter aggregates, samples of each were subjected to microscopic analysis utilizing a scanning electron microscope for the particulate samples and a light microscope for the oil-suspended matter aggregates and the techniques outlined by Feely (1976). For the particulate samples small volumes of seawater (250-500 mℓ) were filtered through 0.4 um Nuclepore filters, washed with three 10 mℓ portions of deionized filtered water and stored in plastic petri dishes. In the laboratory the filters were cut into 5 mm squares and mounted onto aluminum stubs. The stubs were placed into a sputter coater and coated with Au. Five stubs were prepared from each filter. The stubs were placed into a ISI Super Mini Sem II scanning electron microscope and were observed at a manification of 1000X.

For the oil-suspended matter aggregates, aliquots of samples from the interaction studies were placed onto a microscope slide and observed with an AO Model 3025TU Epi-LUME microscope at a magnification of 150X. Photo micrographs were made from the microscope images. Approximately 20 micrographs from each sample were used for particle counting and sizing.

b. Results and Discussion

1. Hydrocarbon-suspended matter interaction experiments

The oil loading experiments conducted at 10°C using a representative crude oil from Cook Inlet were completed this summer. In these studies, the concentration of sediment was varied from 62.5 to 250 mg/L; the oil from 10 to 525 mg/L. Filtered seawater from Cook Inlet or Puget Sound was used in the experiment.

The results of the study are documented in Table 1 and depicted graphically in Figures 3 and 4. In general, accommodated oil increases with increase in the concentration of oil up to an apparent saturation point (Figure 3). The maximum amount of oil accommodated was 11% of the sediment weight (50 mg), but decreased to 6.5% in the case of 100 mg sediment added (Table 1). Provisionally this is attributed to a stabilization of the oil emulsion at elevated concentration of sediment as first observed by Huang and Elliott (1977). Below this critical mass of sediment oil is adsorbed to the surface of particles from coalescing oil droplets and is subsequently sedimented to the bottom of the container. Near the critical mass (in this case 125 mg/L), the microscopic oil droplets are stabilized by the surface adsorption of detrital particles, thus prohibiting the condensation of the oil droplets. This suggests that only oil droplets greater than a critical size may interact with particles and be accommodated. Because of the imprecision of the replicate experiments, additional work will be required in order to document the authenticity of these observations.

Several additional features are apparent in Table 1. In column 2, the recovery of sediment is compared to the original concentration. It appears that increased concentrations of oil facilitate the flocculation or better, the sedimentation of detrital particles. One explanation for this phenomenon can be readily gleaned from the velocity settling equation of Stokes

$$v = \frac{k(\rho_m - \rho_l)r^2}{u}, \qquad (1)$$

where $k = 2g/9$, $\rho_m - \rho_l$ is the density difference between the oiled particles and the fluid, r is the particle radius (or aggregate), and u is the dynamic viscosity. If we assume the same average density for discrete spherical ocluded particles and aggregates of these particles, the settling velocity will increase by the square of the radius. This simplified picture ignores the interstitial pore space created by close packing of spheres, but qualitatively the effect is the same. In brief, the higher concentrations of oil lead to aggregate formation with more rapid settling of the aggregates (i.e., greater percentage of sediment recovered after one hour of settling).

The second feature observed involves the total recovery of oil (see column 4). Detailed studies of recovery efficiency show that Prudhoe Bay crude oil can be quantitatively recovered from seawater mixtures when its concentration exceeds 20 mg/L. As is readily apparent in Table 1 quantitative recovery of this particular oil from seawater mixtures is marginal, particularly at oil concentrations below 40 mg/L. Higher concentrations of sediment appear to improve the recovery. Whereas

Prudhoe Bay crude oil was quantitatively extracted with 3 - 20 mℓ aliquots of dichloromethane, a mixture of dichloromethane (80%) and diethyl ether (20%) was needed to achieve these marginal efficiencies. It appears that compositional factors inherent in the Cook Inlet oil preclude its efficient recovery from seawater mixtures. The difficulty is pronounced at low concentration of oil and suggests that current procedures utilizing $CH_2Cl_2$ to extract hydrocarbons from the waters of Cook Inlet may be inadequate. Work is continuing on this problem in the laboratory.

## Preliminary Model

Sufficient information is now available to attempt a preliminary hypothesis concerning the adsorption of Cook Inlet crude oil on indigeneous suspended matter. An examination of Figure 3 shows that accommodation is a function of oil concentration, asymptotically approaching a constant value. This behavior is suggestive of a process similar to the Langmuir adsorption isotherm, however the observations belie a mono-molecular adsorption process. The premise upon which this model is proposed is based on the concept that adsorption of oil by particles is controlled by a critical volume and the concentration of oil. Initially only small particles ( < 5u) are effective adsorbers if oil, but later these small oiled particles may coalesce into aggregates.

The critical volume of an emulsified oil drop is governed by its chemical and physical properties. An example of this is shown in Figure 5, where oil droplet size is given as a function of dynamic viscosity. These data are from Huang and Elliott (1977) and represent 3 typical crude oils. Note that droplet size ranges from 1 to 5 um for a 3-fold change in viscosity. Restated, the working hypothesis is that particles less than the critical volume are efficient scrubbers of oil, whereas larger particles are much less efficient.

If the sediment particles are critically small, the quantity of oil adsorbed may result in particle buoyancy. This consequence is shown in Figure 5. For graphical purposes, the mean density of an oiled particle ( m) is given as a function of the radius ratio, where $r_2$ is the radius of the uncontaminated particle and $r_1$ is the oiled particle. The density of the oil was assumed to be 0.85 g $cm^{-3}$, that of the particle was 2.5 g $cm^{-3}$. Also shown is the critical density ($\rho_{crit}$), below which the particle becomes buoyant.

In order to keep the model relatively simple at this stage, assume that all particles are of spheres of uniform size and density. By definition, their radius, r, is less than $r_{crit}$, which must be determined. The adsorption reaction may be represented simply:

$$O + M \rightleftharpoons O(M), \qquad (2)$$

where O is the liquid oil, M is the adsorbate, and O(M) is the adsorbed phase. The equilibrium premise stated above may be written as

$$K = v_o/v_x \; C \;, \qquad (3)$$

Table 1. Sediment accommodated oil as a function of sediment (50, 100, and 200 mg) and oil concentrations (8-422 mg). The suspended sediment was recovered from Cook Inlet with a continuous flow centrifuge. Reactions were carried out at 10°C in 800 ml of filtered Cook Inlet seawater. The number of replicate experiments are shown in parentheses.

| Amount of Oil Added (mg) | Sed. Recovered Lower Layer (%) | Oil Recovered Lower Layer (%) | Total Oil Recovered (%) | Loading $\frac{\text{mg oil}}{\text{mg sed}}$ |
|---|---|---|---|---|
| | | 50 mg | | |
| 8.45 (5) | 70.0 ± 3.03 | 3.8 ± .84 | 31.4 ± 6.84 | .0090 ± .0023 |
| 16.9 (7) | 61.3 ± 9.27 | 4.4 ± 1.40 | 39.7 ± 8.42 | .0251 ± .0077 |
| 42.25 (4) | 53.7 ± 10.81 | 3.0 ± 2.00 | 52.2 ± 5.56 | .0465 ± .0212 |
| 84.50 (4) | 64.2 ± 4.79 | 3.0 ± 0.00 | 64.2 ± 12.20 | .0784 ± .0066 |
| 169.0 (3) | 59.5 ± 6.45 | 2.4 ± .75 | 68.2 ± 17.93 | .1113 ± .0200 |
| 422.50 (3) | 56.7 ± 7.77 | 1.4 + .11 | 78.7 ± 9.29 | .1101 ± .0400 |
| | | 100 mg | | |
| 16.9 (4) | 73.0 ± 1.83 | 11.02 ± 1.21 | 41.70 ± 13.30 | .0258 ± .003 |
| 42.25 (4) | 70.2 ± 2.63 | 3.87 ± 1.63 | 56.7 ± 2.99 | .0232 ± .009 |
| 84.50 (4) | 71.0 ± 2.71 | 2.20 ± 0.42 | 81.0 ± 2.71 | .0266 ± .005 |
| 169.0 (4) | 68.7 ± 1.15 | 2.37 ± 0.93 | 97.0 ± 1.99 | .0584 ± .024 |
| 422.5 (4) | 69.5 ± 1.91 | 1.06 ± 0.16 | 92.0 ± 8.27 | .0652 ± .008 |
| | | 200 mg | | |
| 16.9 (4) | 74.7 ± 2.63 | 12.2 ± 6.73 | 52.2 ± 4.27 | .0181 ± .004 |
| 42.25 (4) | 77.0 ± 2.16 | 11.4 ± 1.74 | 71.3 ± 3.20 | .0313 ± .004 |
| 84.50 (4) | 75.5 ± 6.86 | 11.5 ± 3.63 | 77.0 ± 8.50 | .0635 ± .017 |
| 169.0 (4) | 78.5 ± 1.91 | 5.7 ± 0.72 | 92.0 ± 5.29 | .0616 ± .006 |
| 422.5 (4) | 71.0 ± 8.37 | 3.3 ± 0.67 | 88.0 ± 6.06 | .1008 ± .018 |

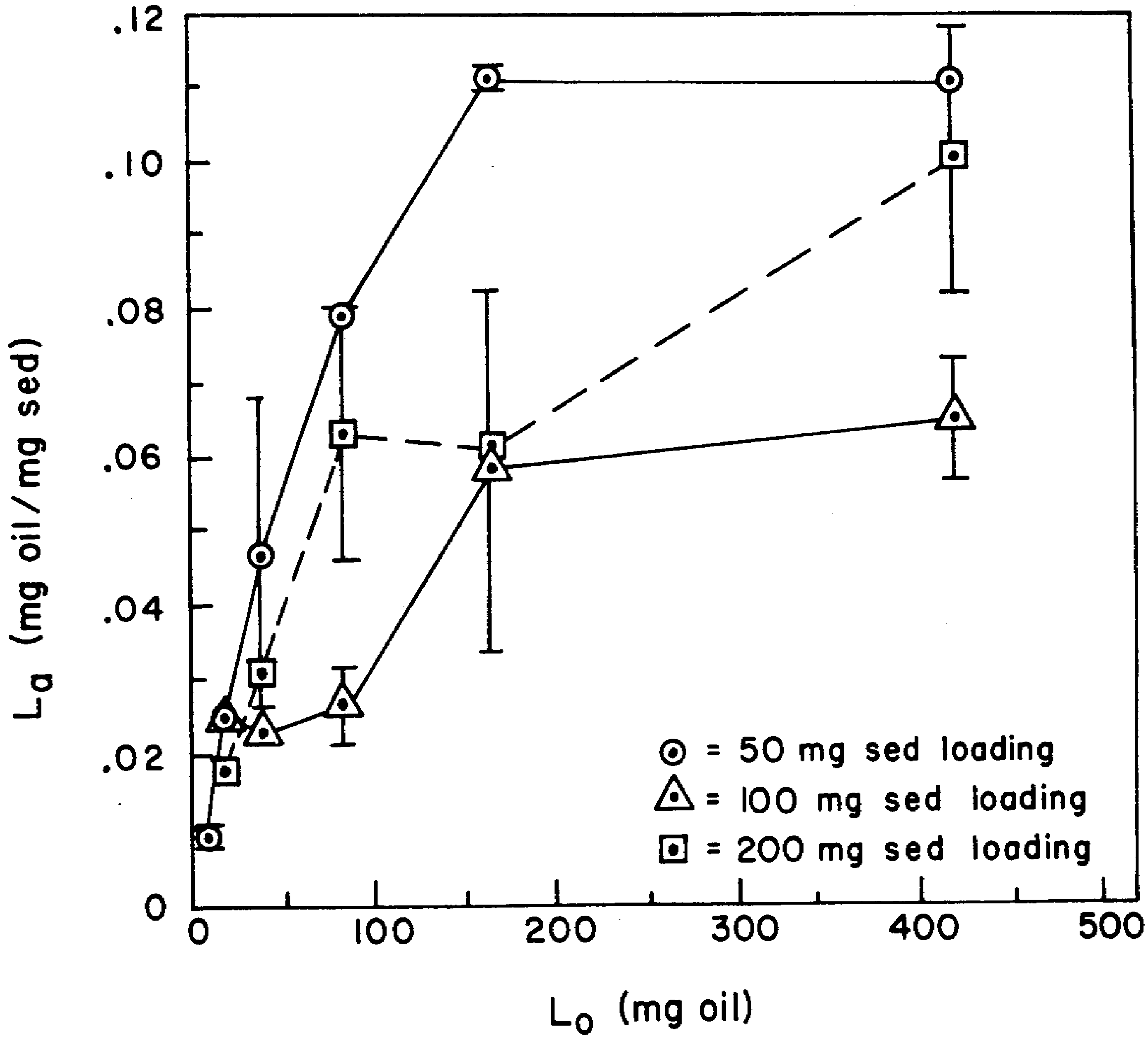



Figure 3. Oil loading as a function of oil and sediment concentrations. All experiments were conducted at 10°C in 800 ml of filtered Cook In!et seawater. The reaction was allowed to run for 1 hour

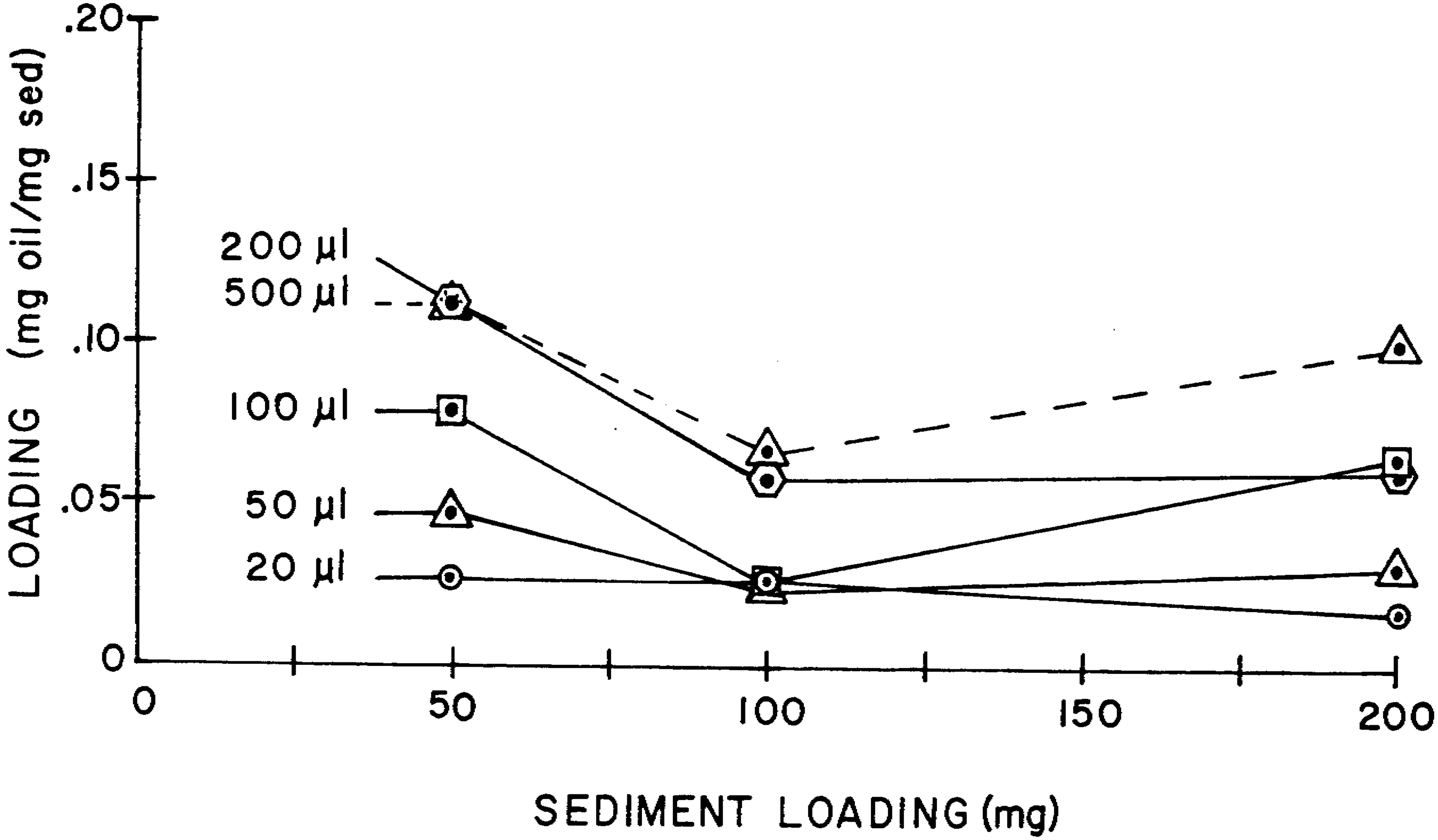



Figure 4. Oil loading as a function of sediment concentration. Note the minimum in settled oil at 100 mg sediment loading. See text for explanation.

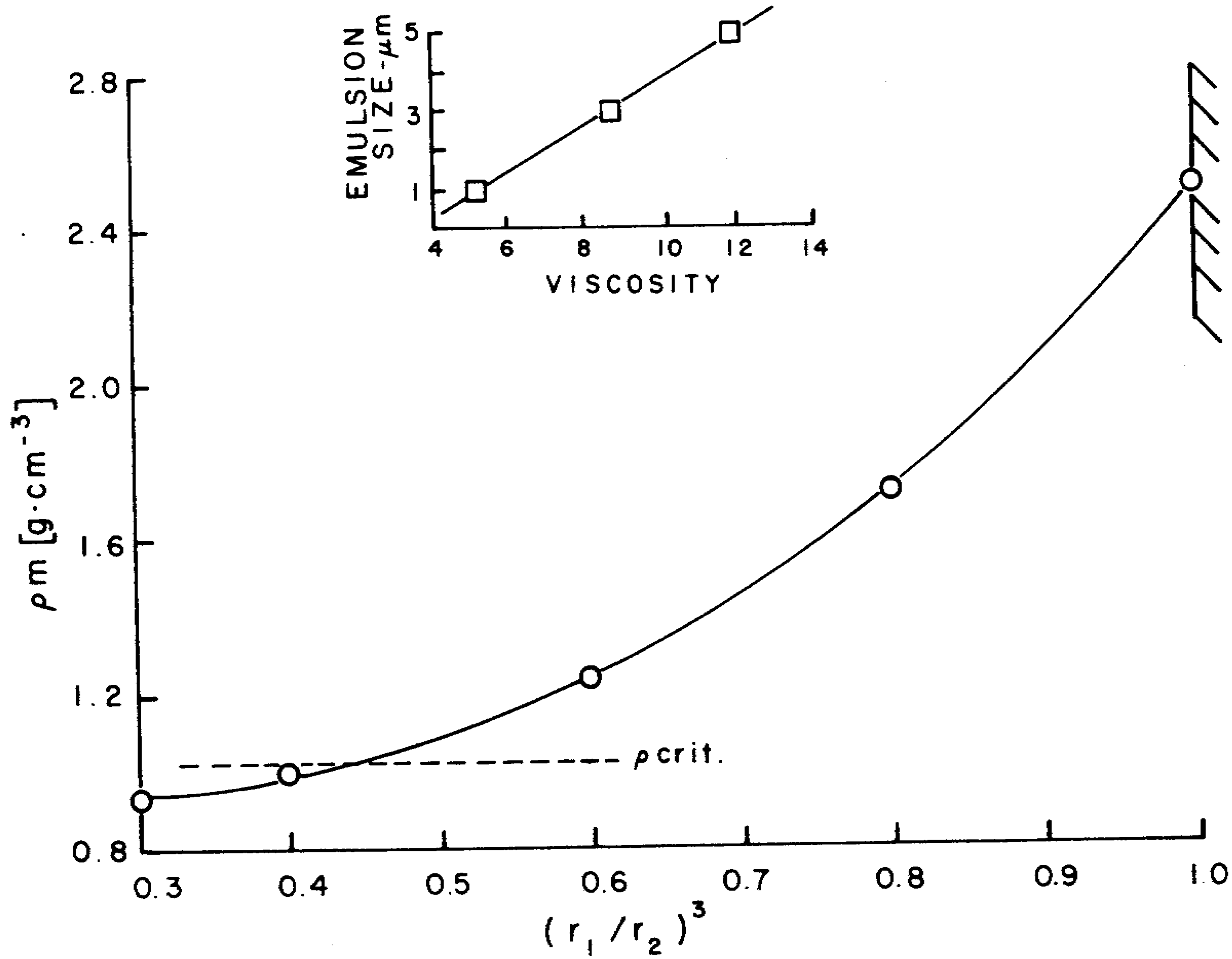



Figure 5. Relationship between the mean particle density ($\rho m$) and the raduis ratio ($r_1/r_2$). The raduis of the contaminated particle is $r_2$, whereas that of the oiled particle is $r_1$. The assumed density of the oil and sediment particles are 0.85 and 2.5g $cm^{-3}$ respectively. The inset shows the relationship between emulsion droplet size and kinematic viscosity for three crude oils (Huang and Elliott, 1977).

where $v_o$ is the volume of adsorbed oil, $v_x$ is the remaining volume, and C is the concentration of oil added. If we define a critical volume, $v^*$

$$v^* = v_o + v_x \tag{4}$$

Equation (3) is the model to be tested. Rearranging equation (3) we obtain

$$KC = v_o/v_x \tag{5a}$$

or

$$KC = v_o/(v^* - v_o) \tag{5b}$$

If the mass of adsorbed oil is proportional to the adsorbed volume of oil

$$m = k'v_o \tag{6}$$

where k' is a constant of proportionality. Normalizing the volumes by setting $\theta' = v_o/v^*$ and substituting equation (6) into equation (5b), we obtain:

$$m = b'\theta' = \frac{b'kc}{1 + kc} \tag{7}$$

Solving for the mass of adsorbed oil, equation (7) becomes upon rearrangement

$$m = \frac{b'kc}{1 + kc} \tag{8a}$$

To test the model equation (8a) is linearized by inversion to obtain

$$1/m = {}^1/k' + {}^1/k'KC. \tag{8b}$$

Application of the model to the data in Table is shown in Figure 6. In the care of 100 mg sediment loading, the data are badly scattered, not well behaved, and were not regressed. Given the level of uncertainty in the original data, the plots are quite linear and show that these results are not inconsistent with the model, <u>but do not prove it</u>!

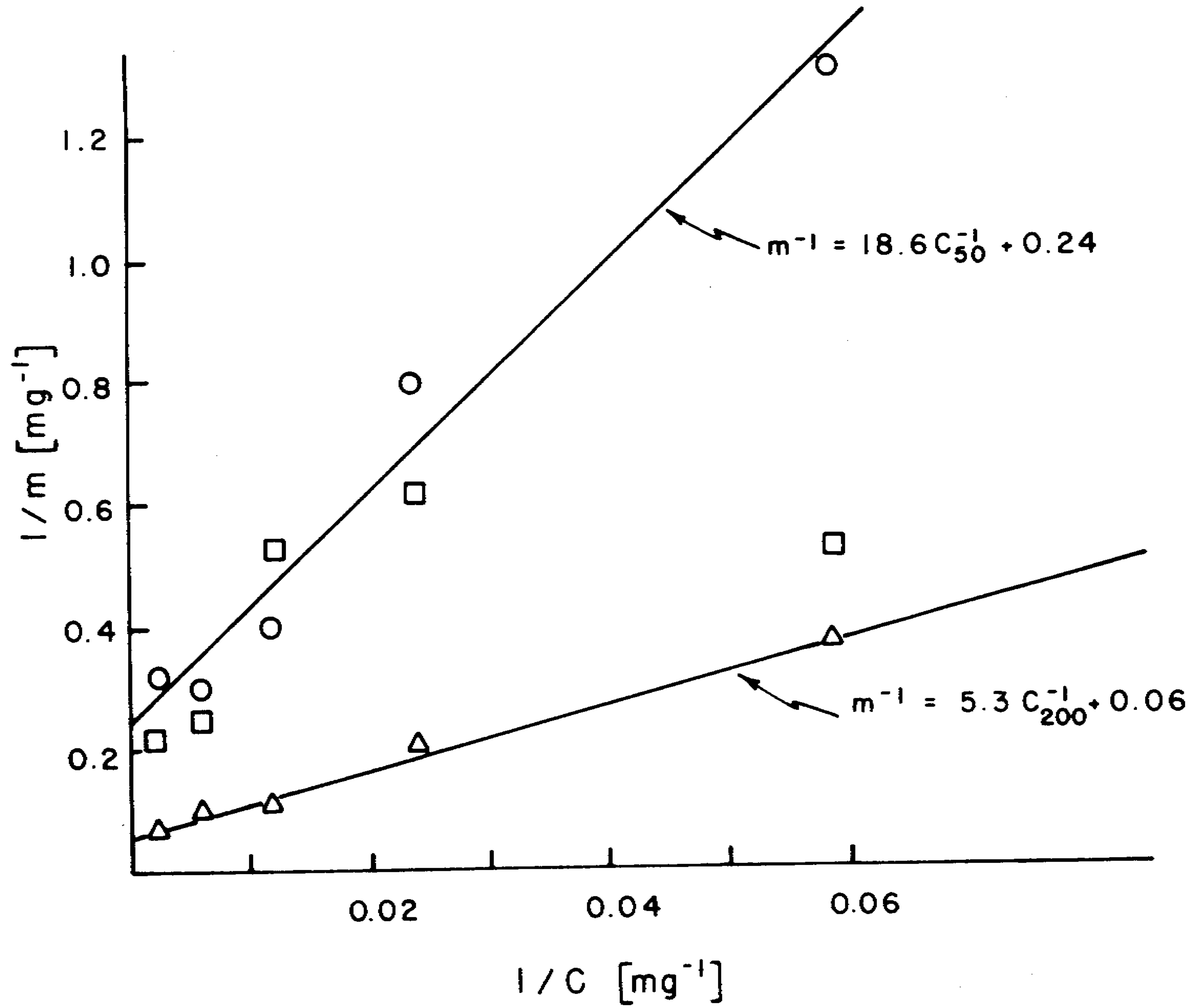



Figure 6. The relationship between the mass of adsorbed oil and the initial concentration of oil as a function of the initial loading of sediment. Only the 50 and 200 mg sediment loadings were regressed. See the text for a discussion of the results and Table 1 for a compilation of adsorption parameters.

The reason for plotting the data in this fashion was to obtain a measure of the equilibrium constant K and the proportionality constant $k'$. These calculations are summarized in Table 2.

Table 2. A summary of calculated adsorption constants for Cook Inlet suspended sediment and crude oil.

| Sediment mg | $k$ $mg^{-1}$ | $k'$ mg | $k^*$ - |
|---|---|---|---|
| 50 | 0.013 | 4.1 | 0.082 |
| 200 | 0.012 | 10.4 | 0.082 |

It is readily noted that k the equilibrium constant is independent of sediment concentration, indicating that the adsorption is a function of particle surface area or critical volume. When normalized to the mass of sediment, the proportionality constant $k^*$ is invariant also.

For the experimental conditions stated, k was found to be invariant, thus the fraction of the critical volume can be calculated for each oil concentration independently of the sediment concentration. Returning to equation (7), the fraction of the critical volume used is $\Theta' = KC/(1 + kc)$. For initial oil concentrations of 16.9 mg and 422 mg respectively, the volume fraction was 17% and 83%.

The model developed above assumes equilibrium between spherical particles of uniform density and a well dispersed oil. The experiment was not conducted in a fashion to represent a well dispersed oil phase, but rather to duplicate a normal mixing situation in Cook Inlet. These preliminary results show that both sediment concentration and oil concentration play a role in the quantity of oil that may be transported by sediment. For dilute suspensions of sediment, the equilibrium state may be achieved only after a longer period of time (i.e., t > 1 hr).

While these preliminary results are tantalizing, for detailed studies are needed to confirm our hypotheses. For example, particle size determinations need to be made in both the surface slick and the sedimented phase. Emulsion particle size also needs to addressed and how it relates to the adsorption phenomenon.

While observations bear out the fact that oil is adsorbed to particles, the mechanisms describing such a relationship is not known. Our preliminary studies have shown that particle size and chemistry are important, but of equal merit is the chemistry of the oil itself. Comparison of Prudhoe Bay and Cook Inlet crude oils show large differences in their adsorptive behavior. However, through such models as proposed above, common behavior patterns between different oils and adsorbates may become more apparent.

2. Sedimentation of oil-suspended matter aggregates

In order to examine some of the physical properties of the oil-suspended matter aggregates relative to the suspended matter from Lower Cook Inlet, samples of each were subjected to particle size analysis utilizing both a light microscope (AO 3025TU Epi LUME) and a scanning electron microscope (ISI Super Mini SEM II) and the procedures outlined by Feely (1976) as described previously in this report. The results of these studies are presented in Figure 7. The size distribution of the ambient suspended matter indicates particles which range between 0.1 and 35.0 um with a median diameter of 1.9 um. In contrast the oil-suspended matter

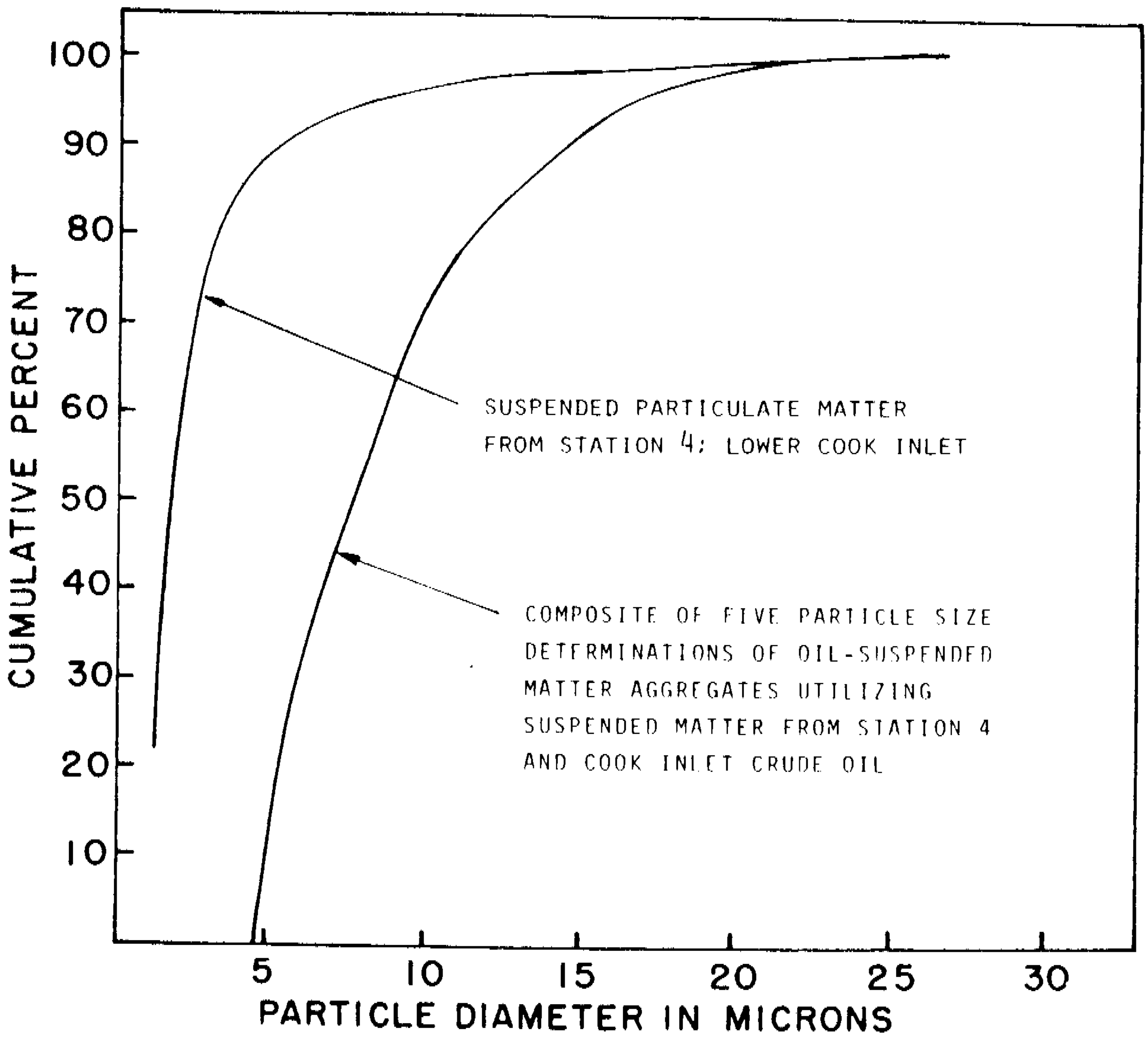



Figure 7. Particle size distribution curves for near-surface suspended matter from station 4 in Lower Cook Inlet (Cruise RP-4-Di-77A-IV, 4-16 April 1977) and oil-suspended matter aggregates resulting from the laboratory interaction studies.

aggregates range between 5.0 and 45 um with a median diameter of 7.5 um. The oil-suspended matter aggregates were spherical in appearance and contained numerous fine particles. Increased oil loadings in the laboratory experiments did not appear to significantly change the resulting particle size distributions of the aggregates, although the range of oil loadings was small (20-500 uℓ). These results suggest the oil-suspended matter aggregates maintain an optimal size distribution which is independent of the oil loadings. Therefore unless rapid resolubilization of oil occurs during settling, the aggregates would be expected to settle at rates which are proportional to their size and density.

Lerman et al. (1974) have examined settling equations for particles of various shapes and densities and have developed a modified form of Stoke's Law which can be used to calculate settling velocities of oil-suspended matter aggregates if the size and shape of the aggregates and the amount of accommodated oil are known. For oil-suspended matter aggregates having approximately sherical shapes in seawater, the equation for the settling velocity of the aggregates can be written as:

$$v_s = 1.45 \times 10^4 ( \rho_s - \rho_w ) r^2 \qquad (9)$$

where $v_s$ is the settling velocity in cm $sec^{-1}$, $\rho_s$ is the bulk density of the aggregates, $\rho_w$ the density of seawater in g $cm^{-3}$, and r is the radius of the aggregates. Figure 8 shows the calculated settling velocities for oil-suspended matter aggregates of various sizes and bulk densities. From the accommodation studies it is apparent that bulk densities for accommodated oils ranges between 2.4-2.6 g $cm^{-3}$ (0-11% accommodated oil). The data for the size analysis of the oil-suspended matter aggregates indicates that greater than 98% of the aggregates range between 2 and 10 um in radius.

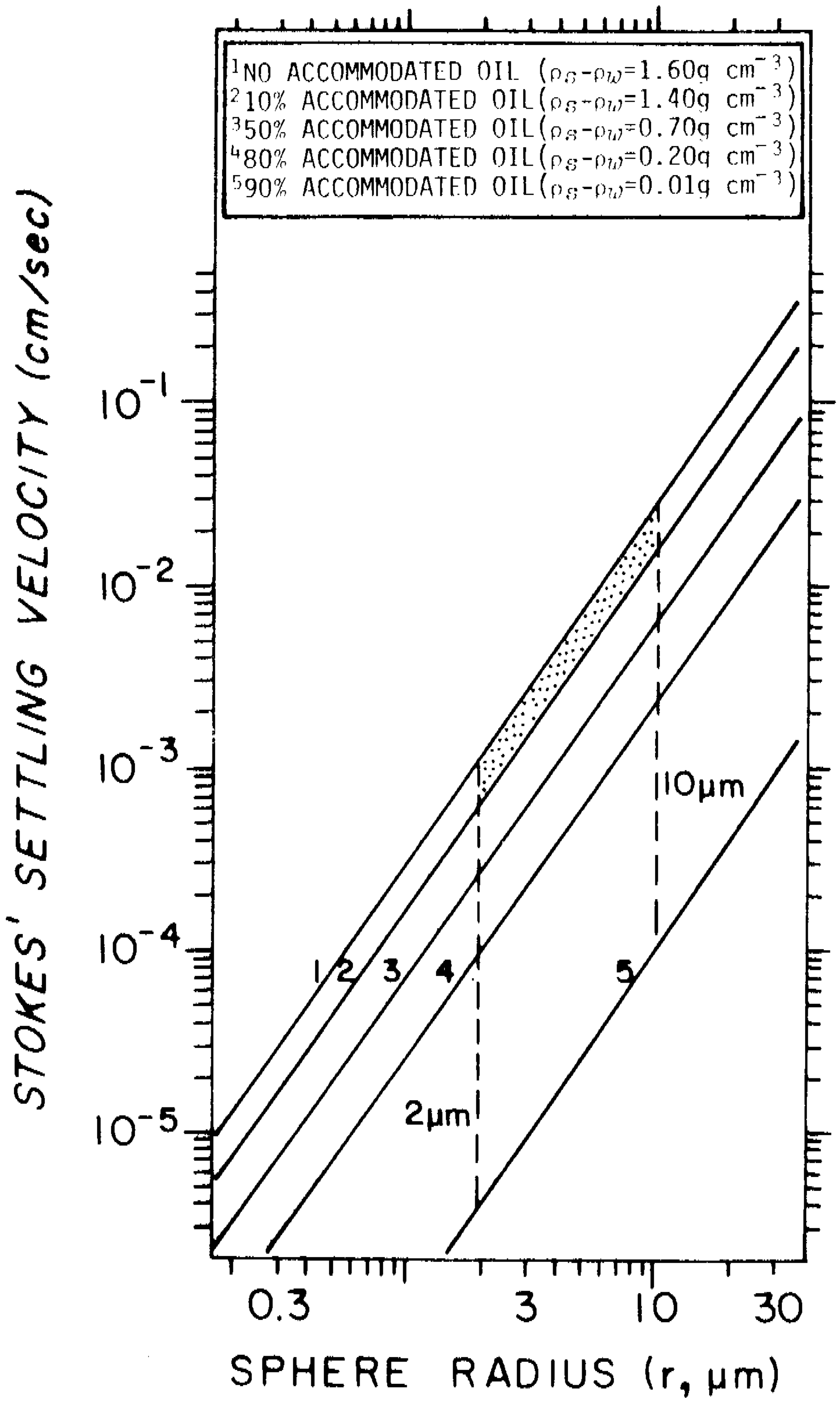



Figure 8. Calculated settling velocities of oil-suspended matter aggregates with varying amounts of accommodated oil. The shaded area represents the range of settling velocities calculated for aggregates resulting from the interaction studies.

Therefore, the settling velocities of the oil-suspended matter aggregates are calculated to range between $70 \times 10^{-4}$ and $3.5 \times 10^{-2}$ cm $sec^{-1}$ (shaded area in Fig. 8). This means that in the absence of vertical turbulence and dissolution processes, it would take approximately between 6 and 330 days for the oil-suspended matter aggregates to fall through a 200 meter water column. Since depths in lower Cook Inlet approximately range between 0 and 170 meters, the estimate of 330 days represents a maximum settling time for oil-suspended matter aggregates in the water column. These estimates are based on laboratory studies with fresh oil. However, in natural waters the highest components of the oil will be lost to the surrounding atmosphere and water via evaporation and dissolution processes, hence increasing the bulk density of the aggregates. Thus, the settling velocities of the oil-suspended matter aggregates should increase with time, making their overall settling times within the water column even shorter than the values predicted from the laboratory studies. However, it should be pointed out that lower Cook Inlet is a very dynamic system with horizontal and vertical turbulence occurring throughout the region. Therefore, further refinement of the aforementioned estimates of settling times for the oil-suspended matter aggregates cannot be made without some consideration of the hydraulics of the system.

## III. Problems Encountered

We have no significant problems to report at this time.

## REFERENCES


Baker, E. T., J. D. Cline, R. A. Feely and J. Quan. (1978) Seasonal distribution, trajectory studies, and sorption characteristics of suspended matter in northern Puget Sound Region. MESA Rept., ERL/NOAA/EPA, 140 p.

Feely, R. A. (1976) "Evidence for aggregate formation in a nepheloid layer and its possible role in the sedimentation of particulate matter," Marine Geol., 20:M7-M13.

Huang, C. P., and H. A. Elliott. (1977) "The stability of emulsified crude oils as affected by suspended particles. In: Fate and Effects of Petroleum Hydrocarbons in Marine Organisms and Ecosystems," D. A. Wolfe, ed. Pergamon Press, New York.

Lerman, A., D. Lal and M. F. Dacey. (1974) "Stokes' Settling and Chemical Reactivity of suspended particles in natural waters." In: Suspended Solids in Water, R. J. Gibb, Ed., Plenum Press, New York, 17-48.

IV. Estimate of Funds Expended

| | Allocated | Expended | Balance |
|---|---|---|---|
| Salaries and Overhead | \$108.7 K | \$108.7 K | \$ 0.0 K |
| Travel and Shipping | 8.3 | 8.3 | 0.0 |
| Equipment | 12.0 | 12.0 | 0.0 |
| Publications, Reports and Data Processing | 1.7 | 1.7 | 0.0 |
| Other Direct Costs | 6.7 | 6.7 | 0.0 |
| | \$137.4 K | \$137.4 K | \$ 0.0 K |

QUARTERLY REPORT

Research Unit: 153

Reporting Period: 1 June - 30 Sept 1978

Number of Pages: 46

# Identification of Natural and Anthropogenic Petroleum Sources in the Alaskan Shelf Areas Utilizing Low Molecular Weight Hydrocarbons


Prepared by

Joel Cline and Richard Feely

Pacific Marine Environmental Laboratory

7600 Sand Point Way N.E.

Seattle, Washington 98115

## I Task Objectives

During the past year, site specific studies were carried out in Cook Inlet relative to the sources of low molecular weight hydrocarbons. The research has focused on the biological production of LMWH in Kachemak Bay and the apparent sources of anthropogenic hydrocarbons in upper Cook Inlet, specifically in Trading Bay. In the past our effort was devoted to the characterization and distributions of the low molecular weight aliphatic fraction ($C_1$-$C_4$), but this year the program was upgraded to include LMW aromatics, including $C_2$-benzenes. The objective is to identify unique LMW aromatics associated with production activities in upper Cook Inlet as a part of a longer term monitoring strategy. Because of low biological input levels and high solubility, these components are strong candidates for unique identifiers.

The characterization of biologically produced hydrocarbons is being emphasized in Lower Cook Inlet where primary productivity is much greater. This effort is focusing on the ratios of saturates to unsaturates being produced during biological activity. Without this knowledge, it is not known how the LMWH present in crude oil will differ from the ambient condition. As an ancillary segment of this program, surficial bottom sediments are being analyzed for LMW aliphatics in order to characterize the benthic source.

In order to assess the significance of suspended solid transport of petroleum, relatively large quantities of suspended matter are recovered and analyzed for the heavier petroleum fraction. These sediments were obtained from a site near Kalgin Island, a point near the probable source in Trading Bay. In support of study to identify the source, it is also our aim to evaluate the vertical transport of petroleum-like hydrocarbons by analyzing material collected in moored sediment traps. These studies are performed cooperatively with Dr. Feely of this facility (R.U. 152).

## II Field Schedule

A. Ship Schedule

The distributions, abundances, and sources of LMW aliphatics and aromatics were evaluated in LCI during May and August of this year. Both sets of observations were conducted aboard the R/V DISCOVERER.

| Date | Cruise No. |
|---|---|
| May 4-17, 1978 | RP-4-DI-78AIII |
| Aug. 26 - Sept. 6, 1978 | RP-4-DI-78BII |

B. Scientific Compliment

The scientific party employed in the LMWH during the May cruise was:

Dr. Joel Cline, Project Leader, NOAA

Mr. Anthony Young, Oceanographer, NOAA

Mr. Charles Katz, Grad. Student, U.W.

Ms. Susan Hamilton, Grad. Student, U.W.

During the August cruise, the scientific compliment included:

Dr. Joel Cline, Cruise Leader, NOAA

Mr. Anthony Young, Oceanographer, NOAA

Ms. Joyce Quan, Phy. Sci. Tech., NOAA

Mr. Charles Katz, Grad. Student, U.W.

Ms. Susan Hamilton, Grad. Student., U.W.

C. Methods

1. LMW Aliphatics

LMWHs are stripped from a 1-ℓ volume of seawater using modified procedure recommended by Swinnerton and Linnenbom (1967). A diagram of the gas phase extractor is shown in Figure 1. Although the system actually used by us is somewhat simpler in detail than that reflected in Figure 1, the principal remains the same.

Chromatography of the components is effected on a column of Poropak$^R$ Q (4' x 3/16"), 60-80 mesh, in series with a small column of activated alumina (3/16" x 2") impregnated with 1% silver nitrate by weight. This dual column configuration results in sharper peaks, better separation of olefins, and reduced component retention times. Chromatography of LMWH components through $C_4$ is accomplished in less than 6 minutes. Detection of the component hydrocarbons as they emerge from the column is performed with a flame ionization detector.

2. LMW Aromatics

Aromatics were stripped from solution in an analogous fashion (T = 70°C) and trapped on Tenax GC$^R$, which does not retain water. The LMW aromatics were backflushed off the Tenax column at 25°C and chromatographed on a column of Chromosorb 102 (6' x 1/8" i.d.). In May the separations of LMW aromatics was effected 5% SP-1200/1.75% Bentone 34 on 100/120 mesh Supelcoport. These chromatograms, which will be shown later, did not effectively separate the LMW aromatics from the heavier alkanes ($C_6$+), thus the Chromosorb 102 column

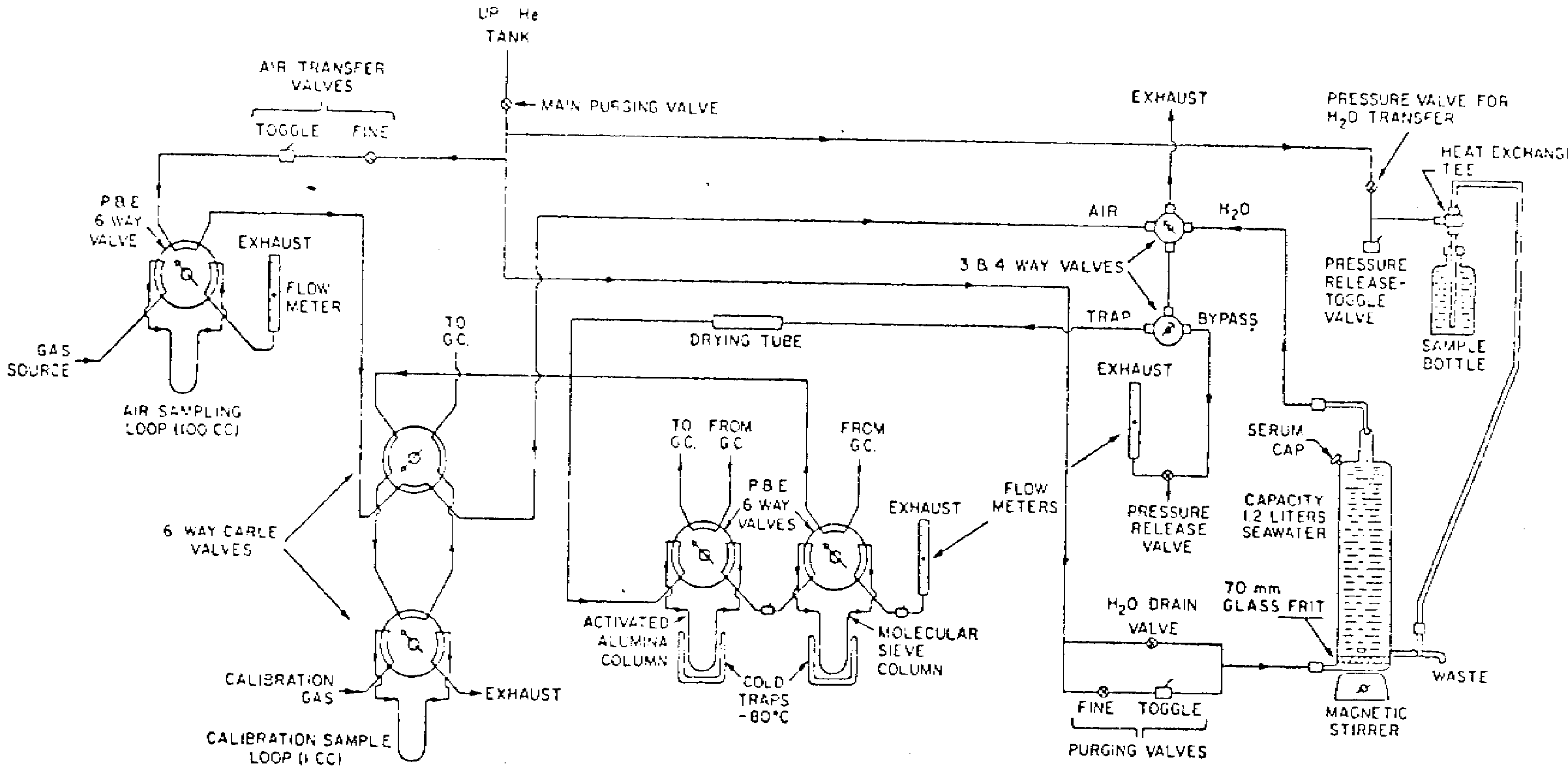



Figure 1. Low molecular weight hydrocarbon extraction system (Swinnerton and Linnenbom, 1967; Swinnerton et al., 1968). The extraction system shown is a recent modification given to us by Mr. R. Lamontagne of the Naval Research Laboratories, Washington, D. C.

was used this summer. A schematic diagram of the aromatic stripping apparatus is reflected in Figure 2, but does not show the chromatographic column.

3. Aliphatic and Aromatic Analysis of Suspended Matter

Suspended matter collected from the traps and by continuous flow centrifugation was analyzed according to the procedures established by MacLeod *et al.* (1976). Briefly, an appropriate weight of sediment (1-10 g) is dewatered with methanol, then extracted with a methylene chloride/methanol mixture for 18-24 hours in a ball mill tumbler. The extraction is repeated and the washings and extracts combined. Additional dewatering is accomplished and removal of particulates and humic material is effected by passing the extracts through a small bed of silica gel and washing with methlene chloride. The eluate is concentrated to approximately 2 mℓ. At this point the sample is chromatographed on silica gel to separate the aliphatic and aromatic fractions; sulfur is removed from each fraction. After concentration of each fraction to approximately 0.2 mℓ, the two samples are ready for GC and/or GC-MS analyses.

D. Station Locations

The location of the sampling points is reflected in Figures 3 and 4. In LCI, time series stations were occupied at CB-7, CB-9 and CB-10. Because of the shortened nature of the August cruise, time series stations CB-7 and CB-9 were not occupied. In addition CB-10 was moved to a point just east of Kalgin Island on the 10 fathom isobath.

The grid shown in Figure 4 was traversed in a small vessel (Miss Vicki Ann - Homer), while the DISCOVERER was on anchor station. The small

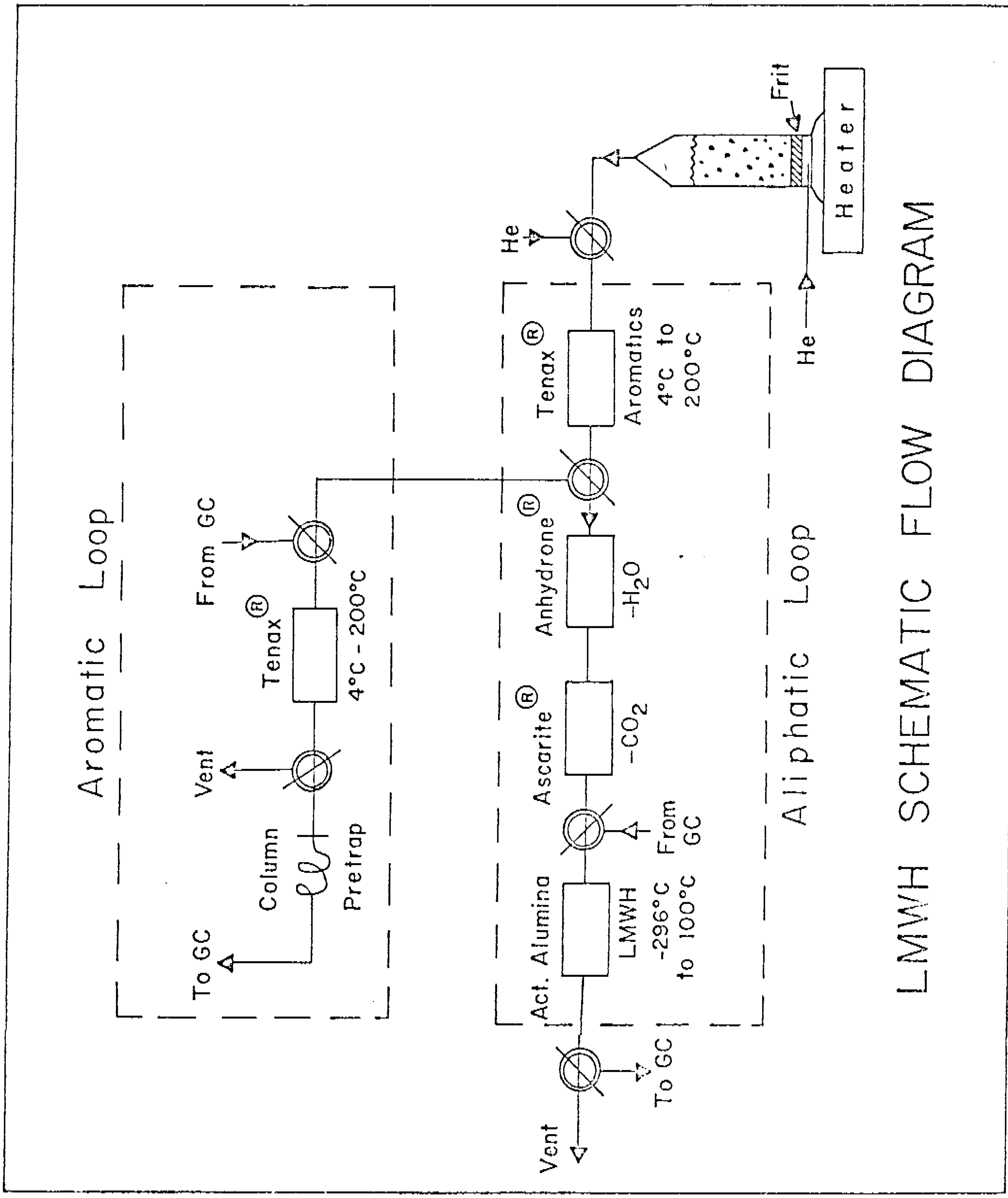



Figure 2. LMWH Schematic flow diagram. Note that aromatics are retained on Tenax[R] at 4°C and eluted at 200°. Nominally, 1ℓ volumes are stripped.

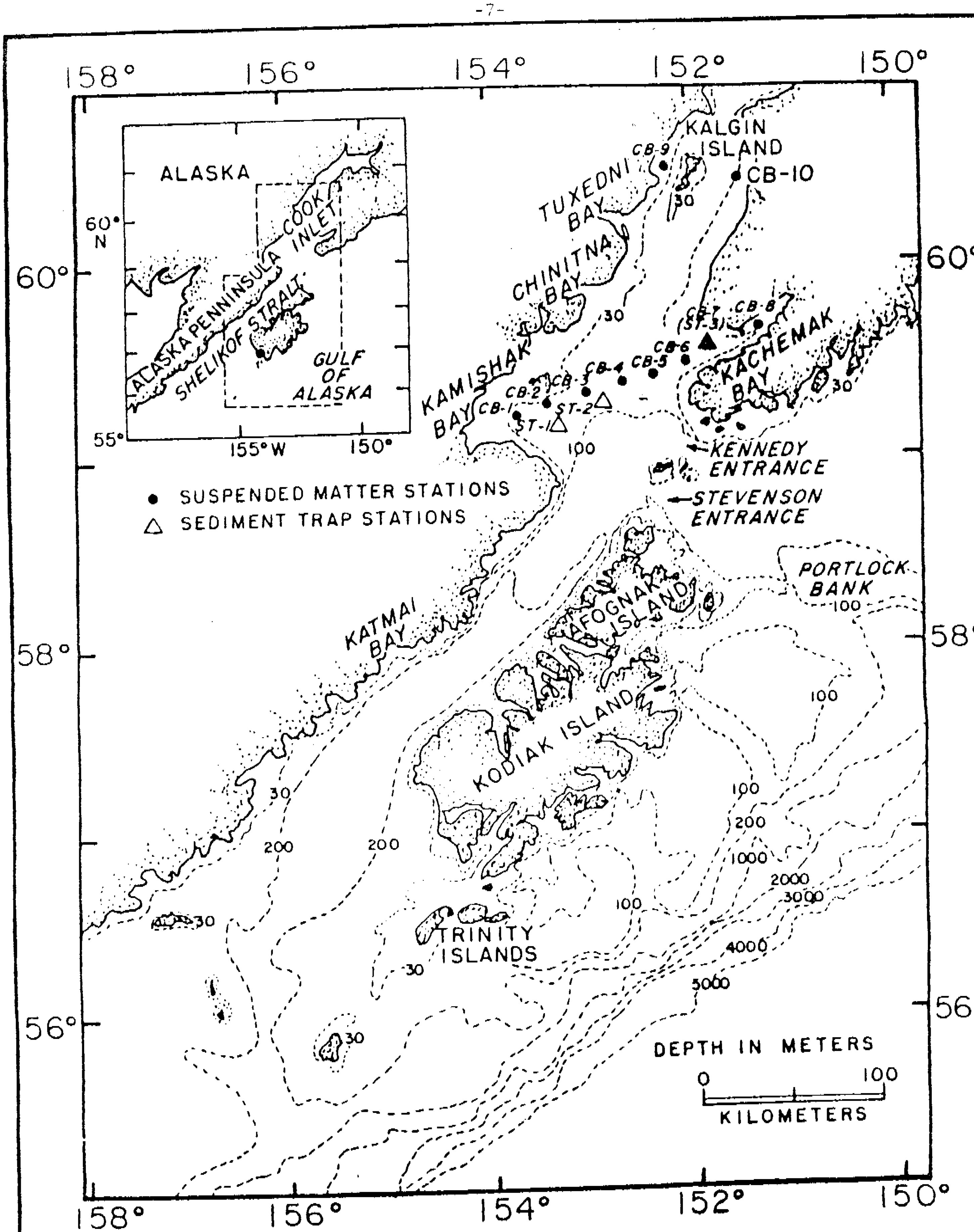



Figure 3. The location of sampling stations in LCI. Sediment trap stations ST-1 and ST-2 were not sampled for hydrocarbons.

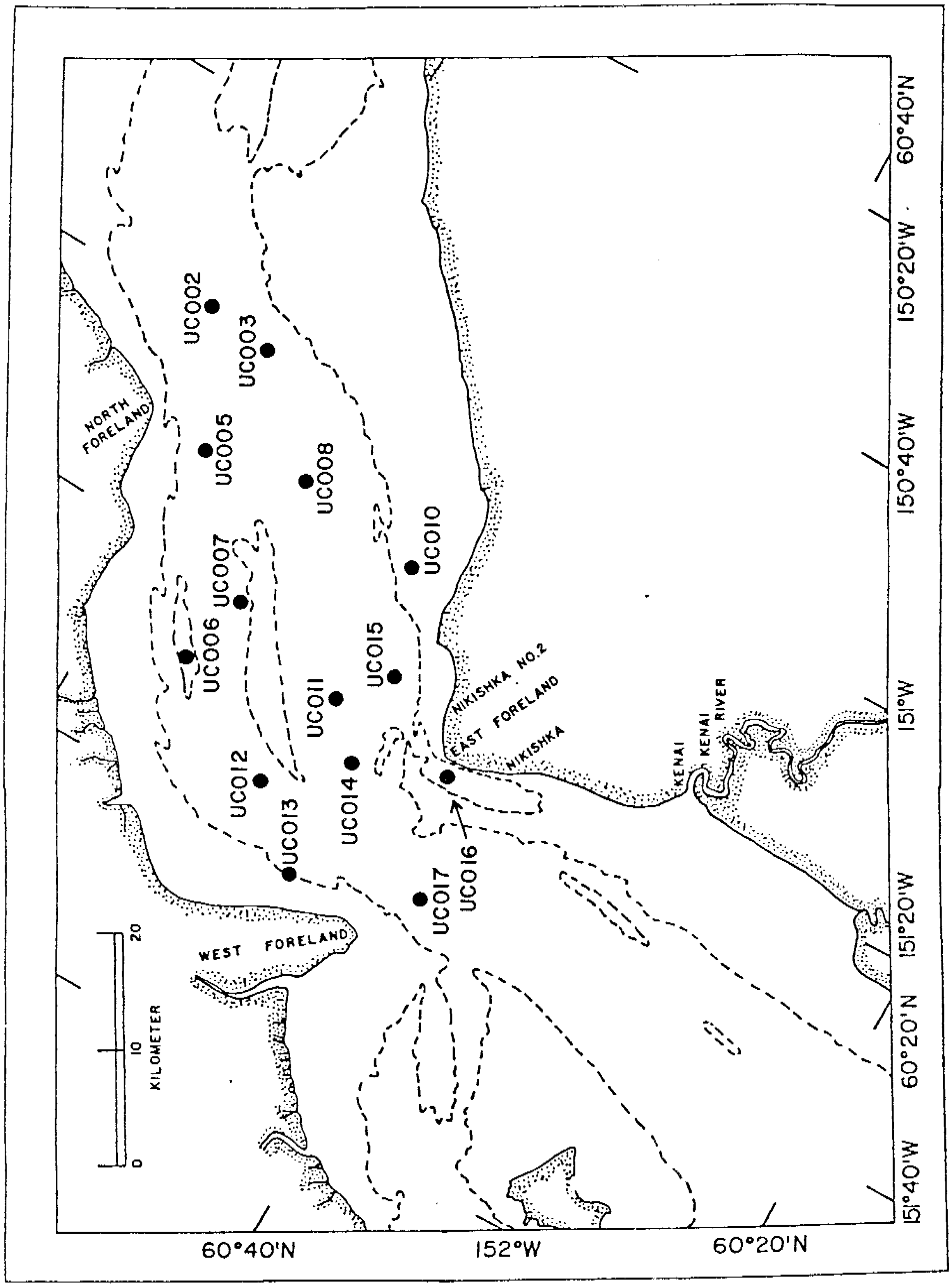



Figure 4. The location of stations sampled in Upper Cook Inlet during May 1978.

boat operation required 2 days to complete.

## III Data Collected and/or Analyzed

### 1. Lower Cook Inlet (May 1978)

| SAMPLE TYPE | COLLECTED | ANALYZED |
|---|---|---|
| Aliphatics - water | 158 | 158 |
| - biological | 26 | 26 |
| Aromatics - water | 30 | 18 |
| Aliphatics in sediments | 2 cores attempted | 0 |
| Suspended Sediments | 8 | 2 |

Stations Occupied: 30

Trackline: Approximately 200 n.mi.

### 2. Lower Cook Inlet (August 1978)

| SAMPLE TYPE | COLLECTED | ANALYZED |
|---|---|---|
| Aliphatics - water | 88 | 88 |
| - biological | 48 | 48 |
| Aromatics - water | 24 | not completed |
| LMW Aliphatics - sediments | 5 | 4 |
| Heavy hydrocarbons - susp. matter | 8 | not completed |

Stations Occupied: 25

Trackline: Approximately 200 n.mi.

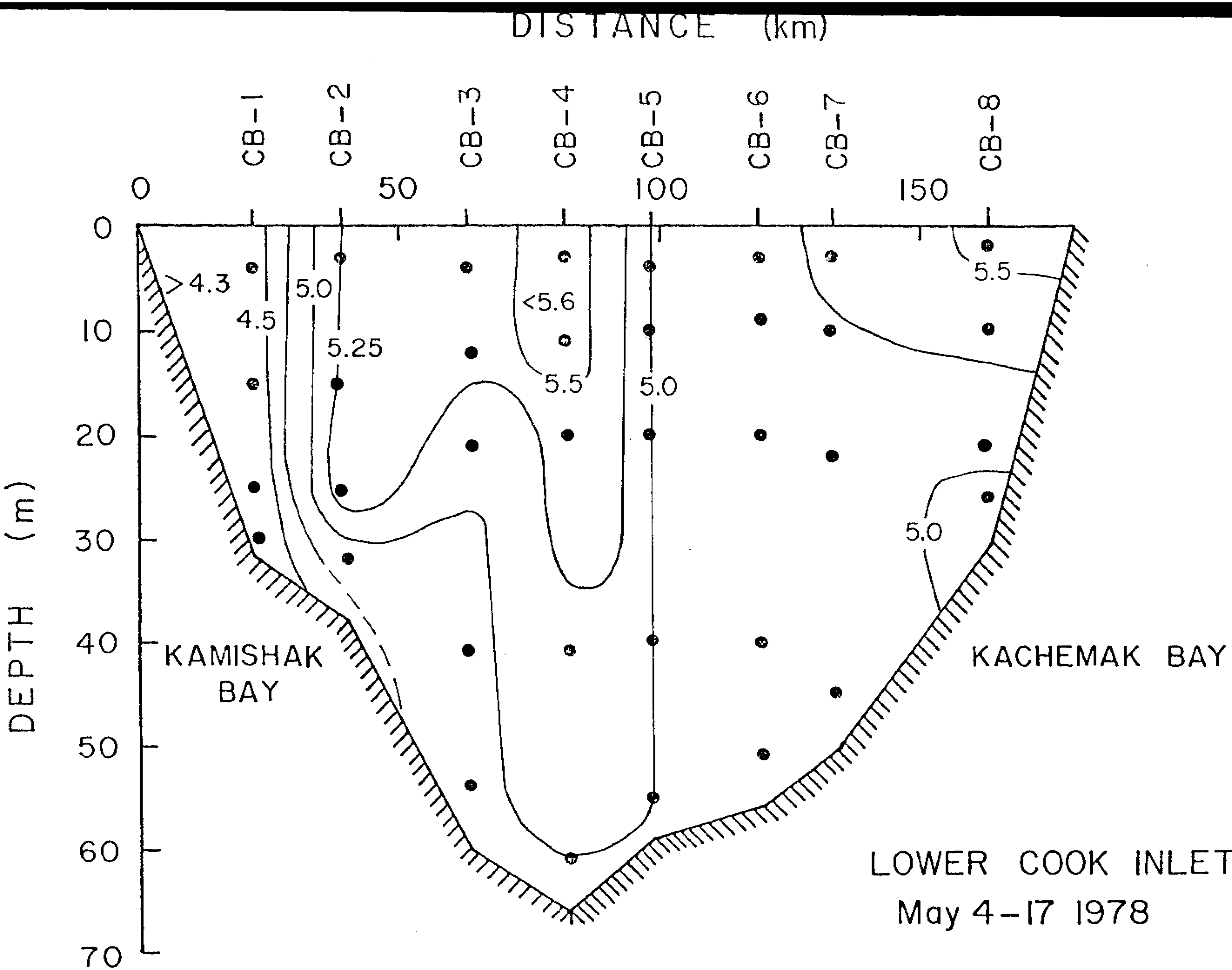



Figure 5. The vertical distribution of temperature, °C, along the transect between Kamishak (CB-1) and Kachemak Bay (CB-8).

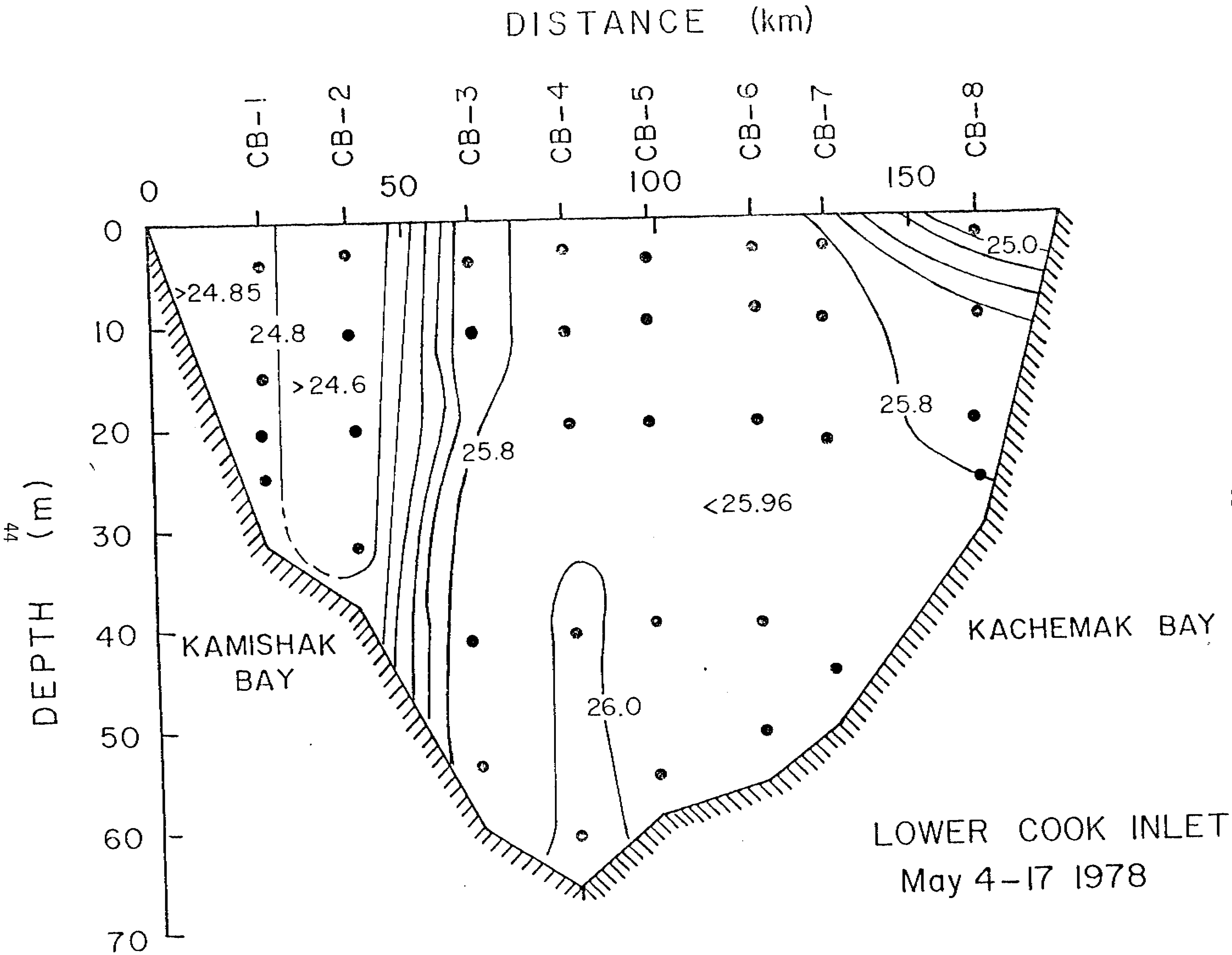



Figure 6. The vertical density structure in terms of $\sigma_t$ along the transect between Kamishak (CB-1) and Kachemak Bays (CB-8).

## IV Results and Discussion

During the past year, two cruises to LCI were completed, although the results from the August visit are not sufficiently processed to include them in this report. Similarly, a complete presentation of our biological studies is not ready at this time because some of the nutrient and biological data are not available. It is our intention to provide a seasonal comparison of hydrocarbon distributions and biological indicators at the next reporting period. This will also include a summary of our past work in LCI.

What will be presented at this time are our observations taken in May of this year and will include the Transect, Time Series, and Upper Cook Inlet subprograms.

### Kamishak-Kachemak Bay Transect

Cook Inlet is a partially mixed estuary, which during May was laterally inhomogeneous and vertically unstratified. These features, which are characteristic of a wide, tidally-mixed estuary, are reflected in Figures 5 and 6. The sectional temperature distribution shows relatively cold water in Kamishak Bay whereas some local warming of the surface waters is apparent in Kachemak Bay. The temperature of the incoming seawater was presumably near 5°C. Lateral inhomogeniety is evident in Figure 6, where, with the exception of Kachemak Bay, the isopycnals are vertical. At the time of the measurements, stratification was developing in Coal Bay (sta. CB-8) due to solar insolation and/or local runoff.

The distribution of dissolved methane is analogous to that of density (Figure 7), although dominant sources of methane are apparent in both Kamishak and Kachemak Bays. The largest concentration of methane observed was near the bottom at CB-8, where more than 1500 nℓ/ℓ (STP) was present

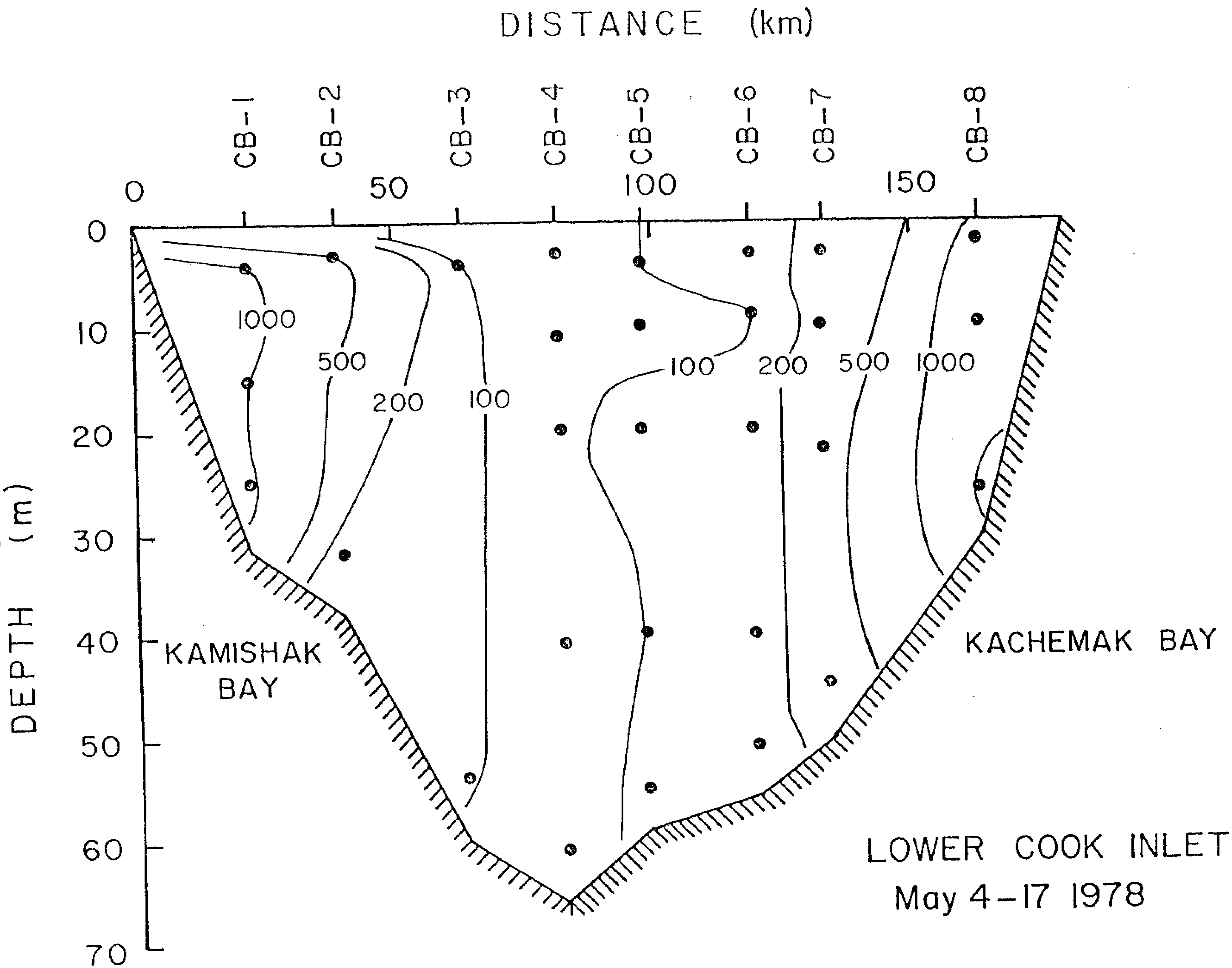



Figure 7. The vertical distribution of dissolved methane (nℓ/ℓ, STP) along the Transect between Kamishak and Kachemak Bays.

Although significant production was occurring at CB-7 during these observations, the major contribution of methane appears to be the organic-rich sediments found in the area. A similar situation exists in Kamishak Bay, where concentrations of methane exceeding 1000 nℓ/ℓ (STP) were encountered. Incoming seawater was characterized by concentrations of methane near 100 nℓ/ℓ (Figure 7).

The vertical distribution of dissolved ethane and ethene is revealed in Figure 8 and 9. In general, the concentration of ethane was less than 1 nℓ/ℓ, with the exception of a single sample in Kamishak Bay ($C_2H_6$ = 1.7 nℓ/ℓ). Under normal circumstances little attention would be given to a single value, but this particular area has shown anomalous hydrocarbon assemblages on previous visits (Cline, 1977). The alleged petroleum seeps near Cape Douglas represent a possible source for ethane, but our measurements are inconclusive at this point. If there is a submarine seep in this area its effect is subtle and its location is probably in shallow water. The high concentrations of ethane observed in Kachemak Bay are correlated with elevated levels of ethene (see Figure 9) in the surface layers. Both these gases are biogenic and/or photochemical in origin. Studies currently under way will hopefully discern the origin of ethene.

A strong source of ethene is apparent in Kachemak Bay and is presumably related to accelerating plant production. Values greater than 2.0 nℓ/ℓ (STP) were observed in the surface waters at stations CB-7 and CB-8. In Kamishak Bay, concentrations of ethene were uniformly near 0.8 nℓ/ℓ. The recent data taken in August of this year shows high concentrations of ethene in the surface layers, analogous to that observed in July of 1977. Biological production was slightly lower in August compared to May, thus

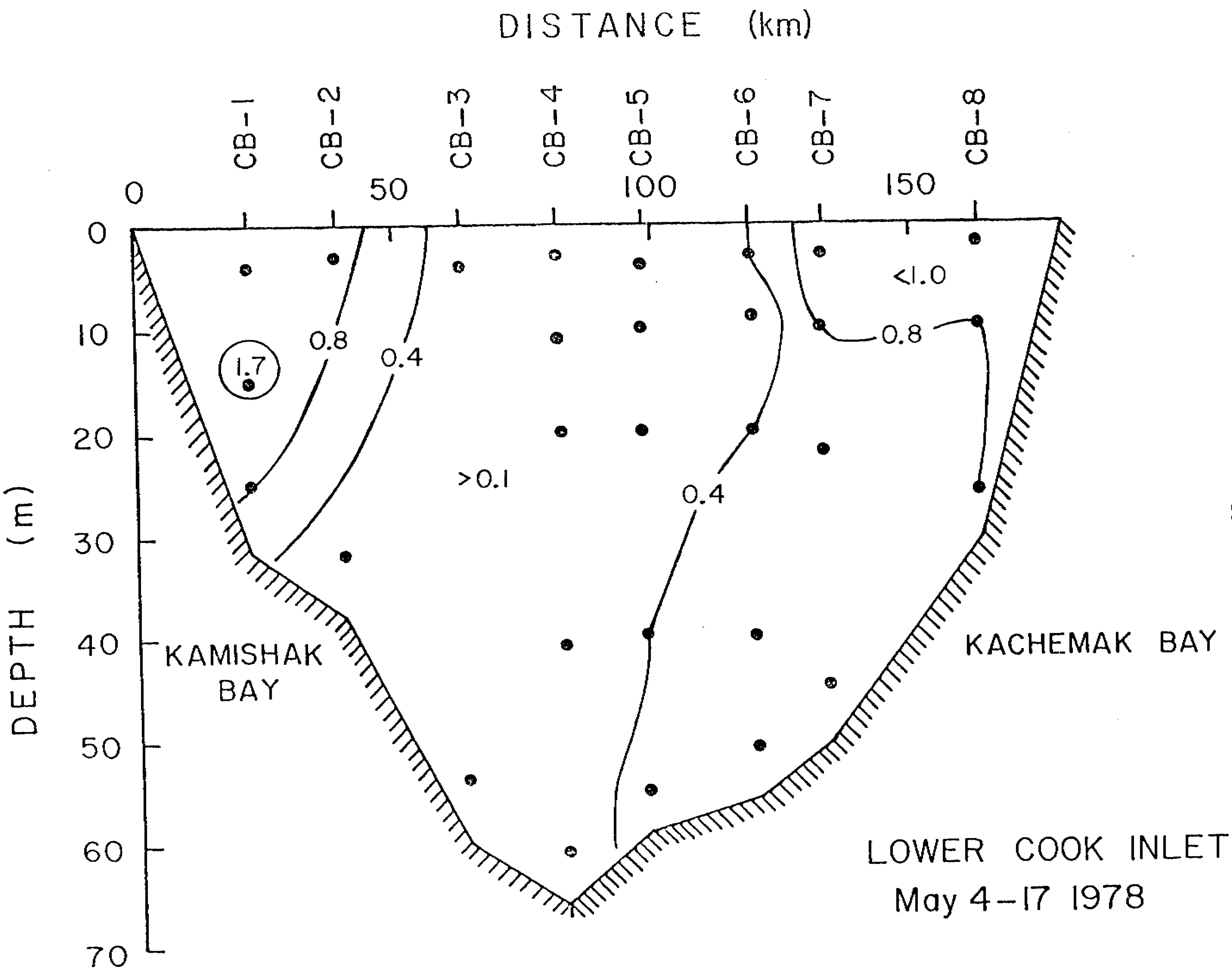



Figure 8. The vertical distribution of ethane in nℓ/ℓ along a transect between Kachemak and Kamishak Bays. Note the high value at station CB-1 (15m).

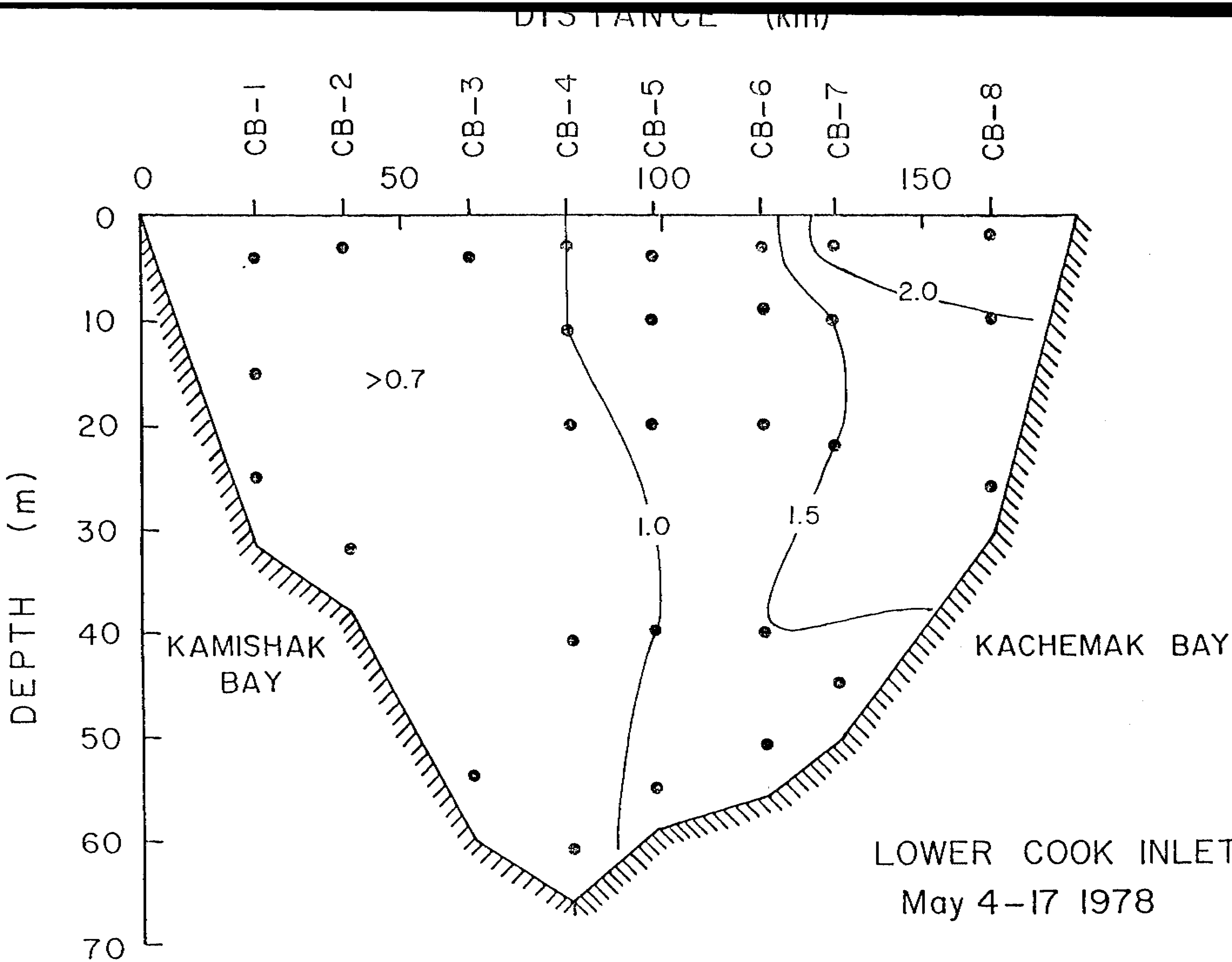



Figure 9. The vertical distribution of ethene in nℓ/ℓ (STP) along the transect between Kamishak and Kachemak Bays. Concentrations greater than 2.0 nℓ/ℓ were observed in Kachemak Bay.

the production of ethene may be limited by the availability of light. More data will be available by the next reporting period with which to come to a more definitive conclusion.

In Figure 10 is shown the biogenic $C_2$ index ratio ($C_{2:0}/C_{2:1}$) for the transect. With the exception of the single sample in Kamishak Bay, the values cluster around $0.4 \pm 0.1$, indicating that the proportions of ethene to ethane represent a biological source. Ratios greater than 1 for values of ethane and ethene > 1 nℓ/ℓ signify a significant thermogenic contribution. This ratio presumably does not hold in anoxic waters (Hunt, 1972), where the saturated hydrocarbons are more prevalent.

Upper Cook Inlet

Measurements of LMWH were made above the Forelands in May 11 and 12. Observations were conducted from a small shallow draft vessel. Two depths were sampled at each station for both aliphatics and aromatics. Samples were preserved with 200 mg $NaN_3$ and subsequently analyzed aboard the R/V DISCOVERER within 5 days.

The near surface distribution of dissolved methane is reflected in Figure 11. The highest methane concentration (1560 nℓ/ℓ) was observed in Trading Bay with a zonal decrease toward the east. Minimum values less than 200 nℓ/ℓ were observed on the east side of the inlet. Because of large tidal mixing, no vertical stratification was apparent, resulting in a uniform hydrocarbon distribution with depth. Surface concentrations of methane decreased uniformly in all directions away from the apparent locus in Trading Bay.

In Figure 12 is shown the surface distribution of ethane in nℓ/ℓ. The highest surface concentration of ethane observed was 8.3 nℓ/ℓ near

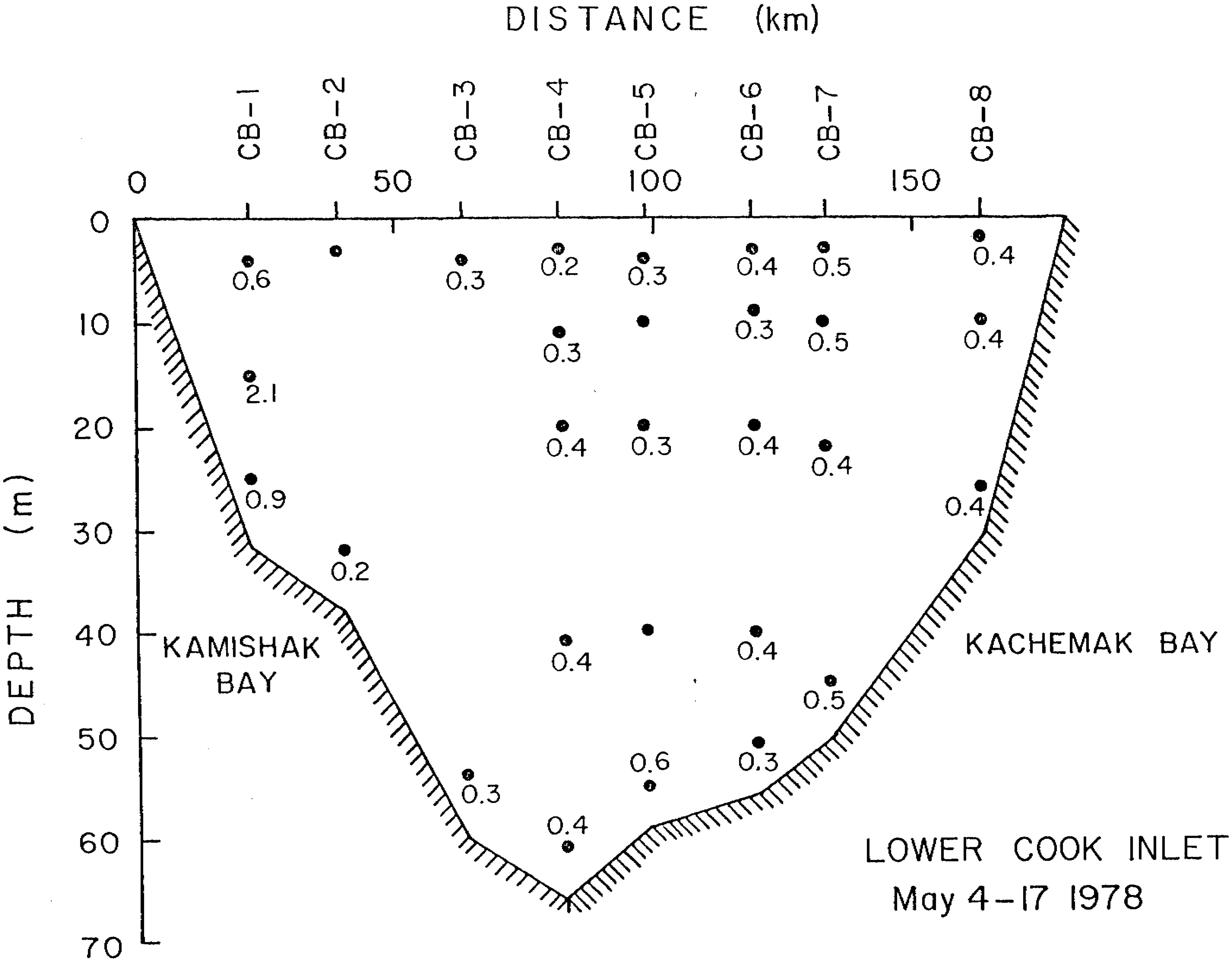



Figure 10. Biological $C_2$ ($C_{2:0}/C_{2:1}$) index ratio for stations occupied along the transect between Kamishak and Kachemak Bays. A ratio of ethane to ethene less than unity signifys a biological composition.

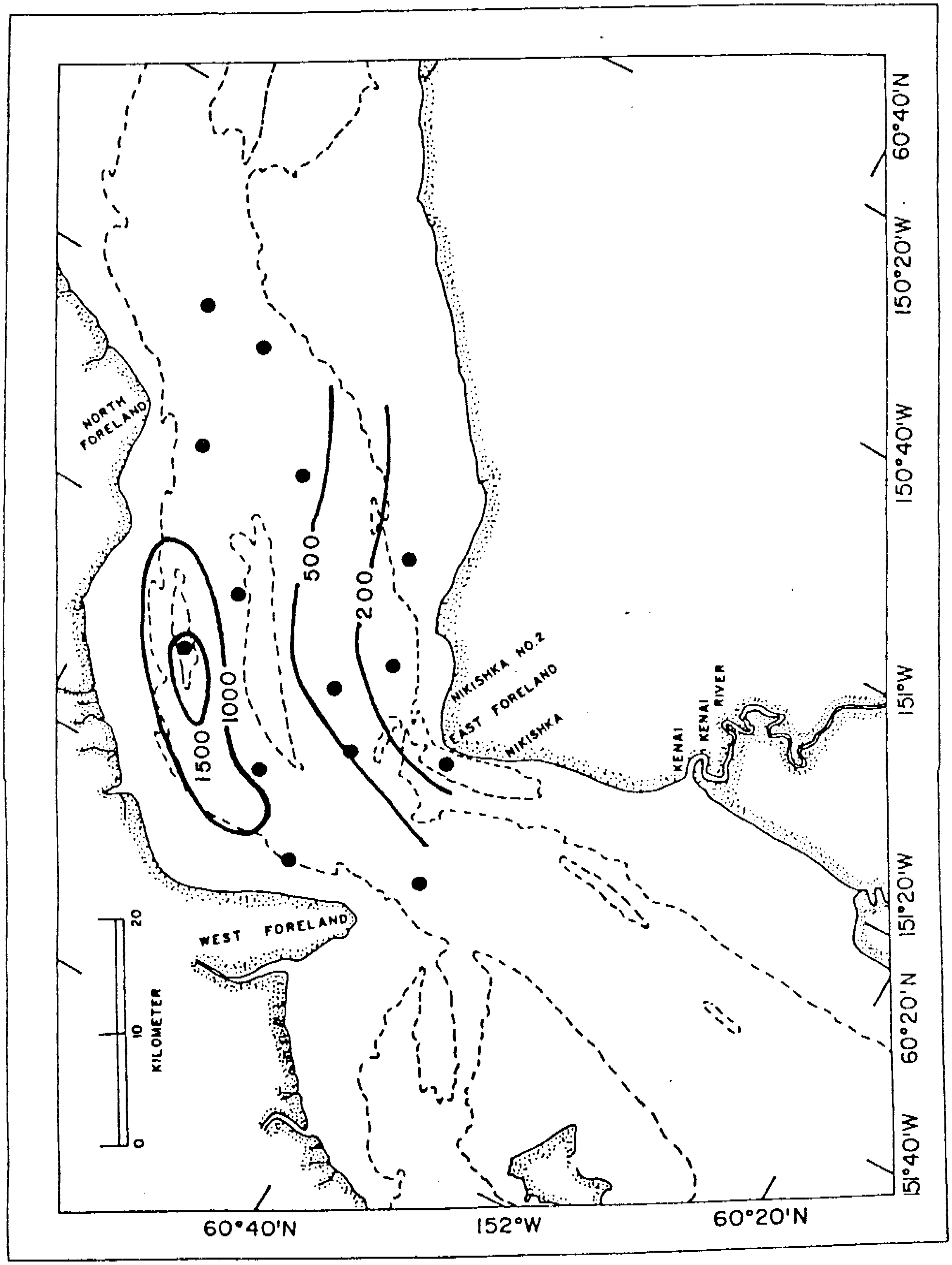



Figure 11. Surface distribution of methane (nℓ/ℓ) in upper Cook Inlet during May 12-13, 1978. The highest concentration of dissolved methane was observed over the shoal area west of Middle Ground Shoal.

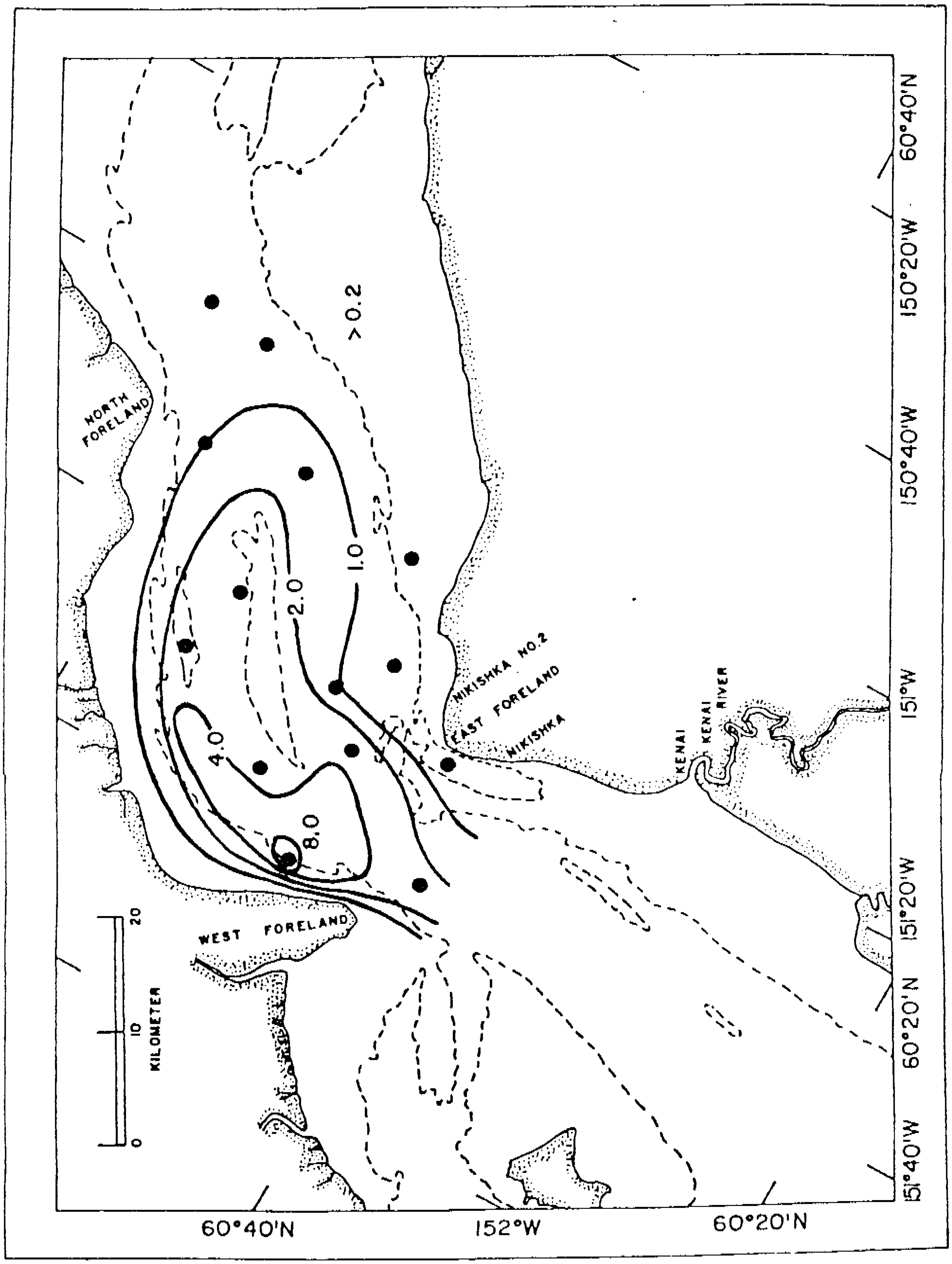



Figure 12. Surface distribution of ethane (nℓ/ℓ) in upper Cook Inlet during May 12-13, 1978. The contour shapes suggest a clockwise circulation through Trading Bay.

the West Foreland. Concentrations of ethane were greater than 2 nℓ/ℓ in all of Trading Bay. Not unlike that observed for dissolved methane, the lowest concentrations of ethane were observed north and east of Trading Bay. Background levels were 0.2 to 0.4 nℓ/ℓ north of the apparent source.

In contrast, the concentration of ethene was rather invariant throughout the entire region (Figure 13). The surface values ranged from 0.2 to 0.6 nℓ/ℓ; the mean was 0.3 nℓ/ℓ. The relatively low concentrations of ethene suggest minimal biological input or low light levels, or both. The abundance of suspended matter in this region of the inlet would further inhibit the penetration of light.

Not unlike that observed in the case of ethane, the surface concentration of a propene was higher in Trading Bay relative to surrounding areas (Figure 14). The highest concentration was 4.4 nℓ/ℓ near the West Foreland. Concentrations diminished toward north, reaching minimum values of 0.2 nℓ/ℓ. Again the strongest signature was at station UC013.

During last year's investigation aboard the R/V ACONA, a source of LMW aliphatics was tentatively identified in Trading Bay (Cline *et al.*, 1978). With greater station density, the source of aliphatics appears confined to Trading Bay as suspected, although the precise location of the source is not known. During the May cruise, stations were sited north of the North Foreland in order to assess any contribution from the extensive intertidal sediments. These data confirm our original hypothesis that these gases are of thermogenic origin or the sediments in Trading Bay are biologically unique.

A preliminary attempt was made to correlate the occurrence of LMW aliphatics and existing platforms and/or pipelines. These comparisons are

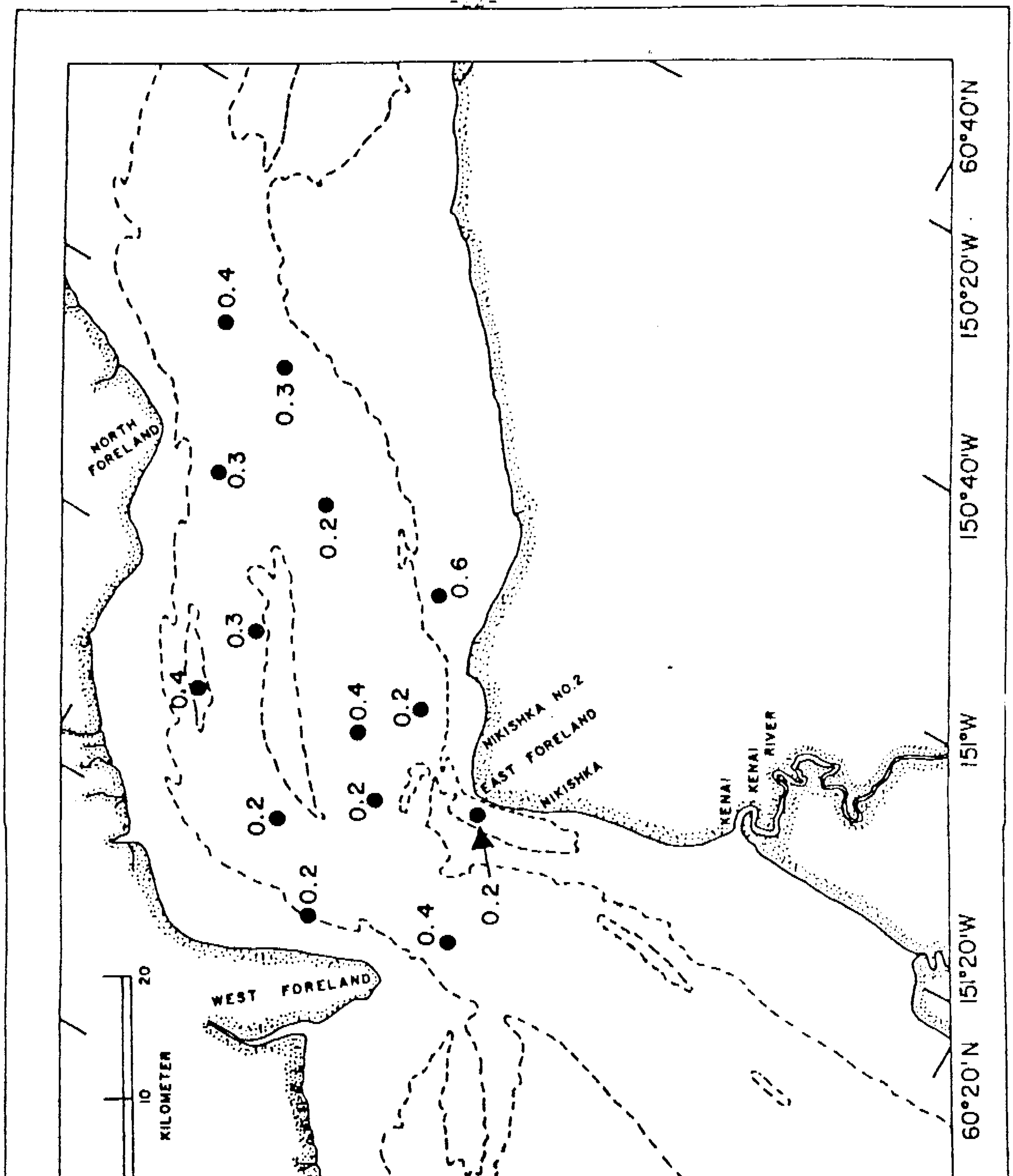



Figure 13. Surface distribution of ethene (nℓ/ℓ) in upper Cook Inlet during May 12-13, 1978.

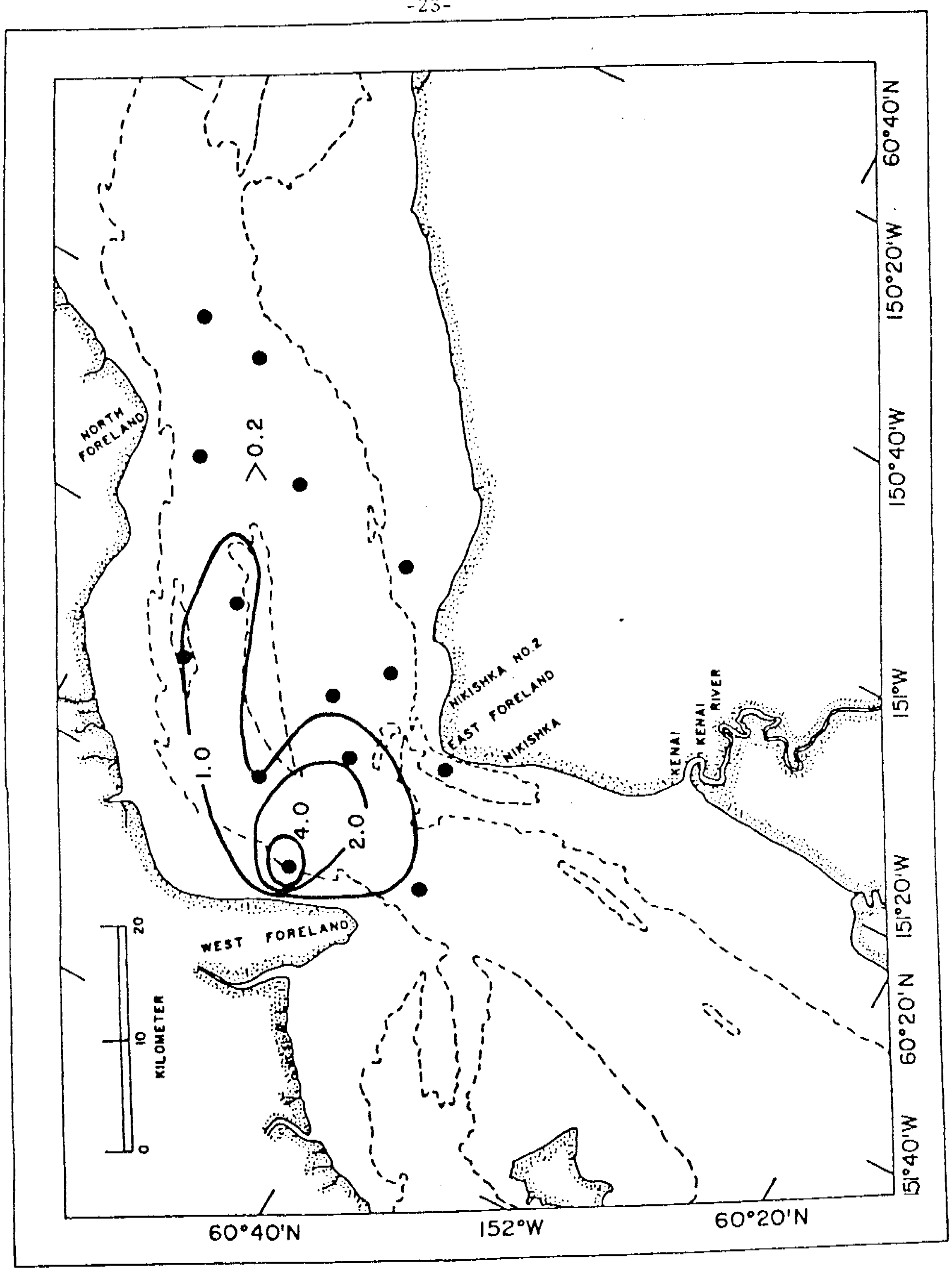



Figure 14. The surface distribution of dissolved propane in upper Cook Inlet during May 12-13, 1978.

shown in Figure 15. The locations of structures and pipelines are approximate and were taken from hydrographic chart 16660 dated October 18, 1975. Not shown, however, are numerous capped wells, particularly in the region of Trading Bay. The highest concentration of ethane and propane were found approximately 5 km south of the southern-most platform. Two wells, apparently capped, are within 2 km of the locus of gaseous hydrocarbons. A closer scrutiny of the chart reveals numerous wells near the 10 fathom curve in Trading Bay. If the mean drift of the current is clockwise, the actual source of LMW hydrocarbons could be west of the existing platforms. Unfortunately no sampling was conducted in that region. It is also conceivable that natural gas seeps in the area are the major source of gaseous hydrocarbons.

Selected water samples also were analyzed for low molecular weight aromatic compounds. Numerous analytical difficulties were encountered, consequently only a few samples were analytically credible. The major problems encountered included incomplete stripping of aromatics from solution, contamination, and a complex arrray of naturally-occurring low boiling point hydrocarbons. In the procedure adopted in May, the aromatics were sorbed on Tenax[R] at about 4°C, then eluted at 250°C. Under the conditions of the purge and trap procedure pentane and heavier aliphatics are also retained and would co-elute with benzene.

In Figure 16 are shown the chromatograms of the LMW aliphatics (A) and aromatics (B). Also shown is the chromatogram (C) of the "aromatics" present in the carrier gas and associated plumbing. The dominant feature of the aliphatic fraction is the large abundance of methane, followed by ethane and propane. In contrast, the aromatic fraction (B) reflects a

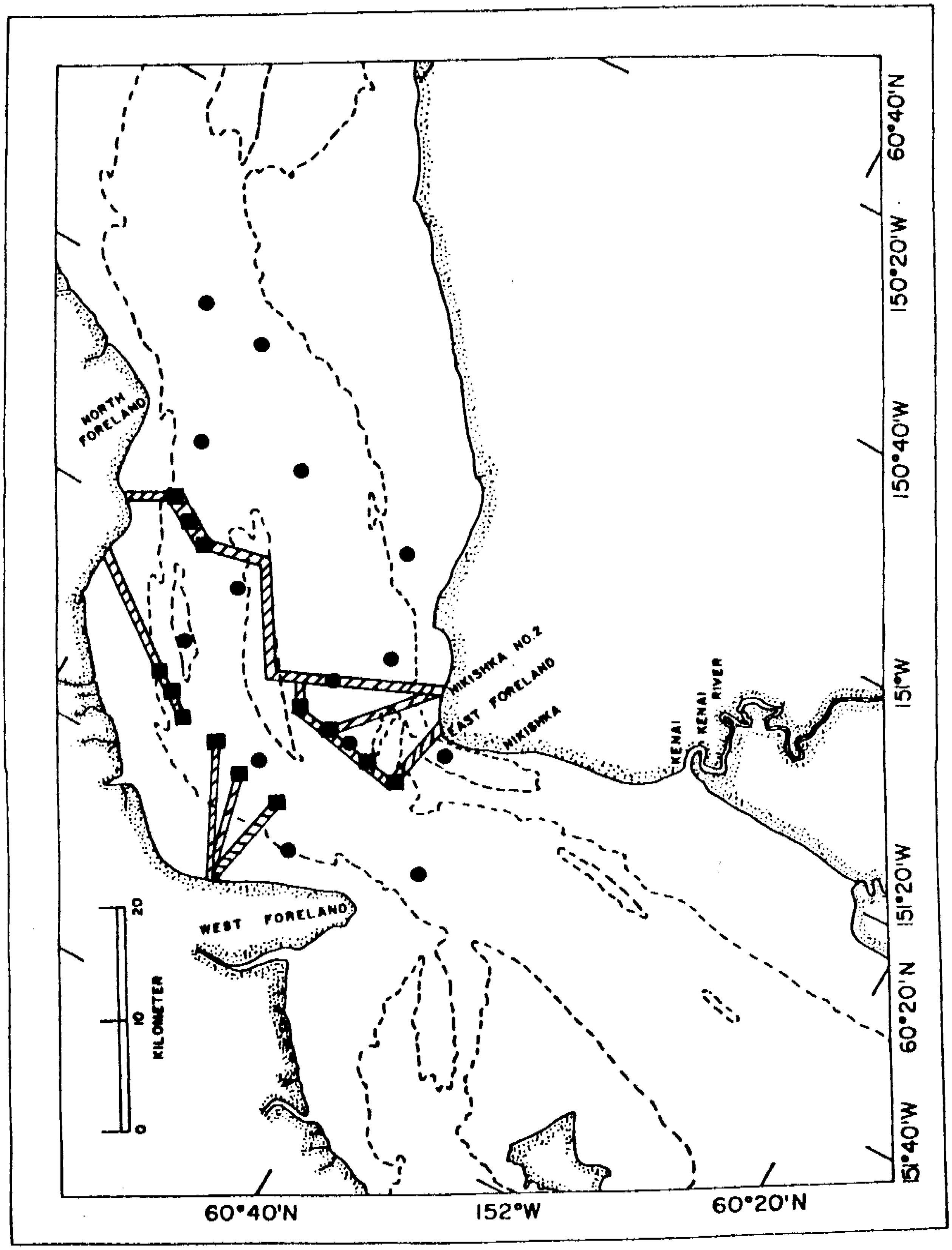



Figure 15. The location of stations ( ● ), platforms ( ■ ), and pipelines (▨▨▨) in upper Cook Inlet. The locations are approximate and were taken from hydrographic chart 16660 dated Oct. 18, 1975.

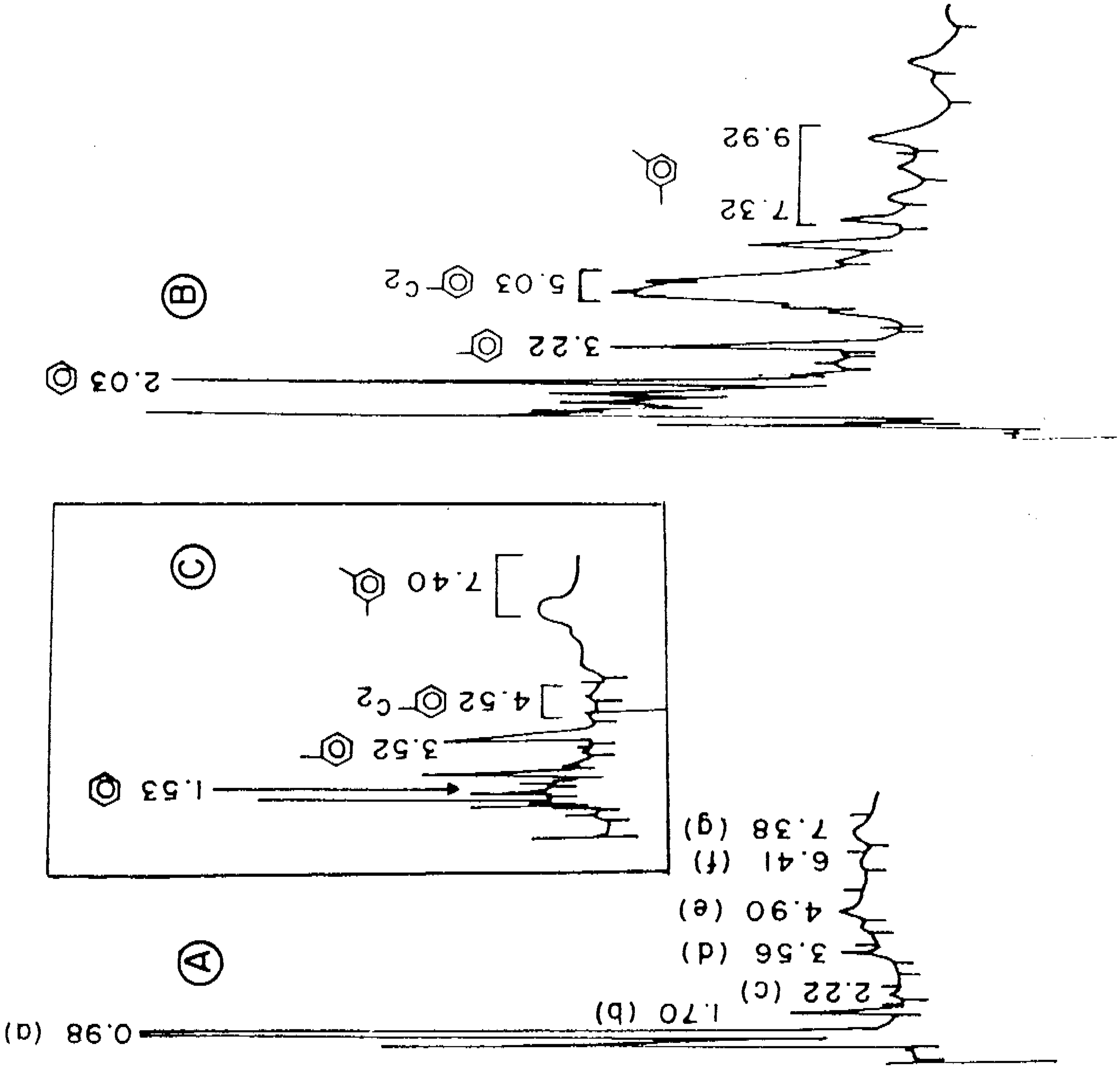



Figure 16. The chromatographic traces of LMW aliphatics (A) and aromatics (B). The compounds identified in the aliphatic fraction include methane (a), ethane (b), ethene (c), propane (d), propene (e), iso- and n-butanes (f & g). Probable identification of aromatic compounds is shown by symbols. A carrier blank is reflected in (C).

high degree of complexity, particularly in the boiling point range below benzene. Because of the complexity in the number of compounds present, retention indices are not totally reliable in identifying individual compounds. However, numerous standards were run and the tentative identification given on the figure represent our best guess. The "aromatic" chromatogram reflects numerous peaks that were not resolved by the column, many of them eluting prior to benzene. Toluene was apparently present as well as $C_2$-benzenes having the boiling point and molecular structure similar to ethyl benzene. Some evidence for the presence of xylenes also is depicted in Figure 16.

The chromatographic traces of the aliphatic and aromatic fractions taken from the surface waters at station UC006 are shown in Figure 17. As before, the dominant aliphatics include the saturates since biological productivity in this region is presumably minimal. The arene fraction shows a preponderance of a compound tentatively identified as benzene with lesser amounts of $C_2$-benzenes and xylenes. Compounds eluting before benzene are unresolved by this column and may reflect the presence of hexanes.

By way of comparison, the chromatographic traces of the aliphatic and aromatic fractions from station CB-05 are shown in Figure 18. This was a near-bottom sample. The aliphatic trace shows an increase in the unsaturates such as ethene (c) and propene(e), and the total absence of butanes. Similarly, the arene fraction is less complex in the neighborhood of benzene, but equally as complex at higher retention indices (see Figures 15 and 16). Although we have tentatively identified the peak at 3.55 minutes as toluene, it was present in our blanks and appears to be present in the sample as well.

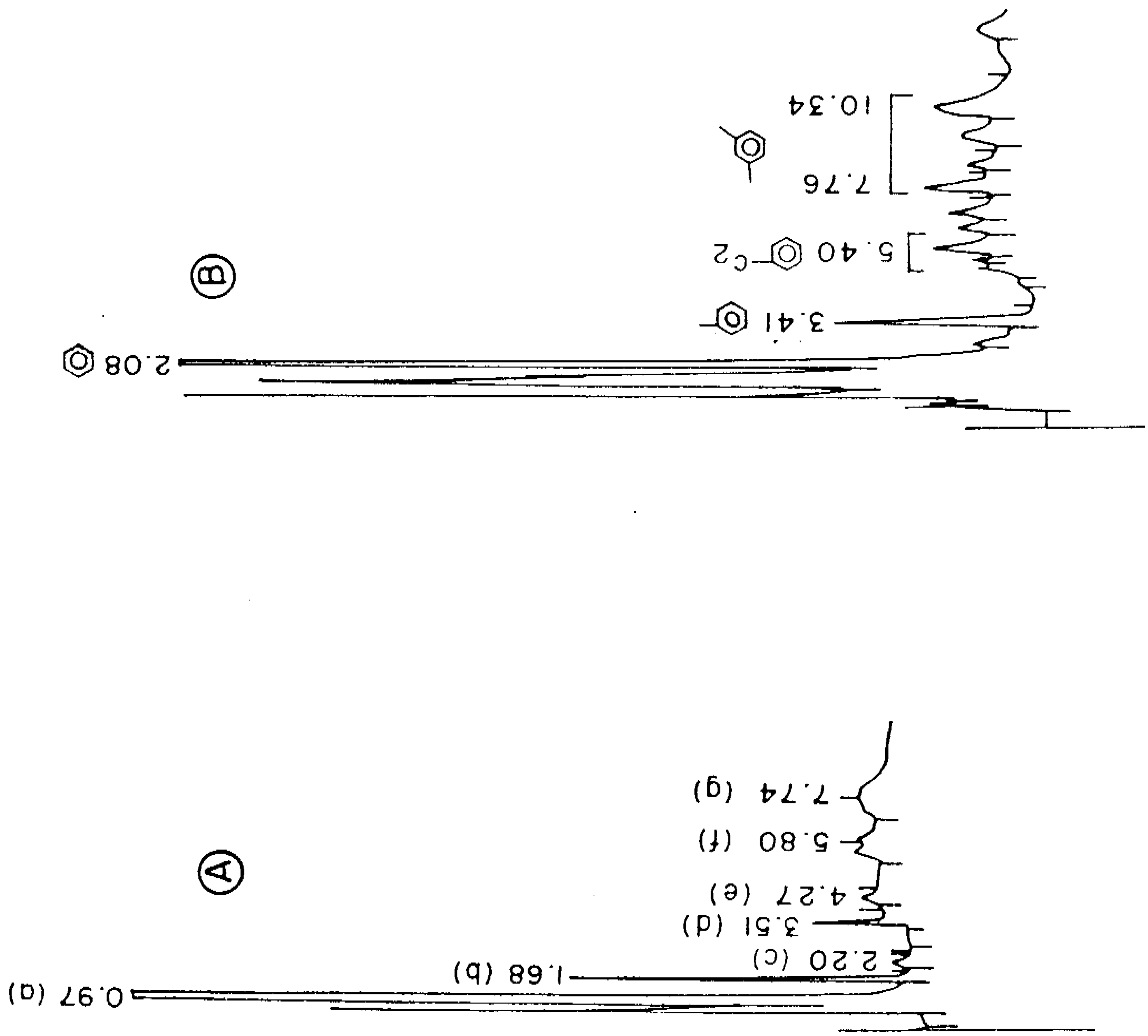



Figure 17. The chromatographic trace of the aliphatic fraction (A) and the aromatic fraction (B) taken from the surface at station UC006. Identification of the aliphatic peaks is given in Figure 16.

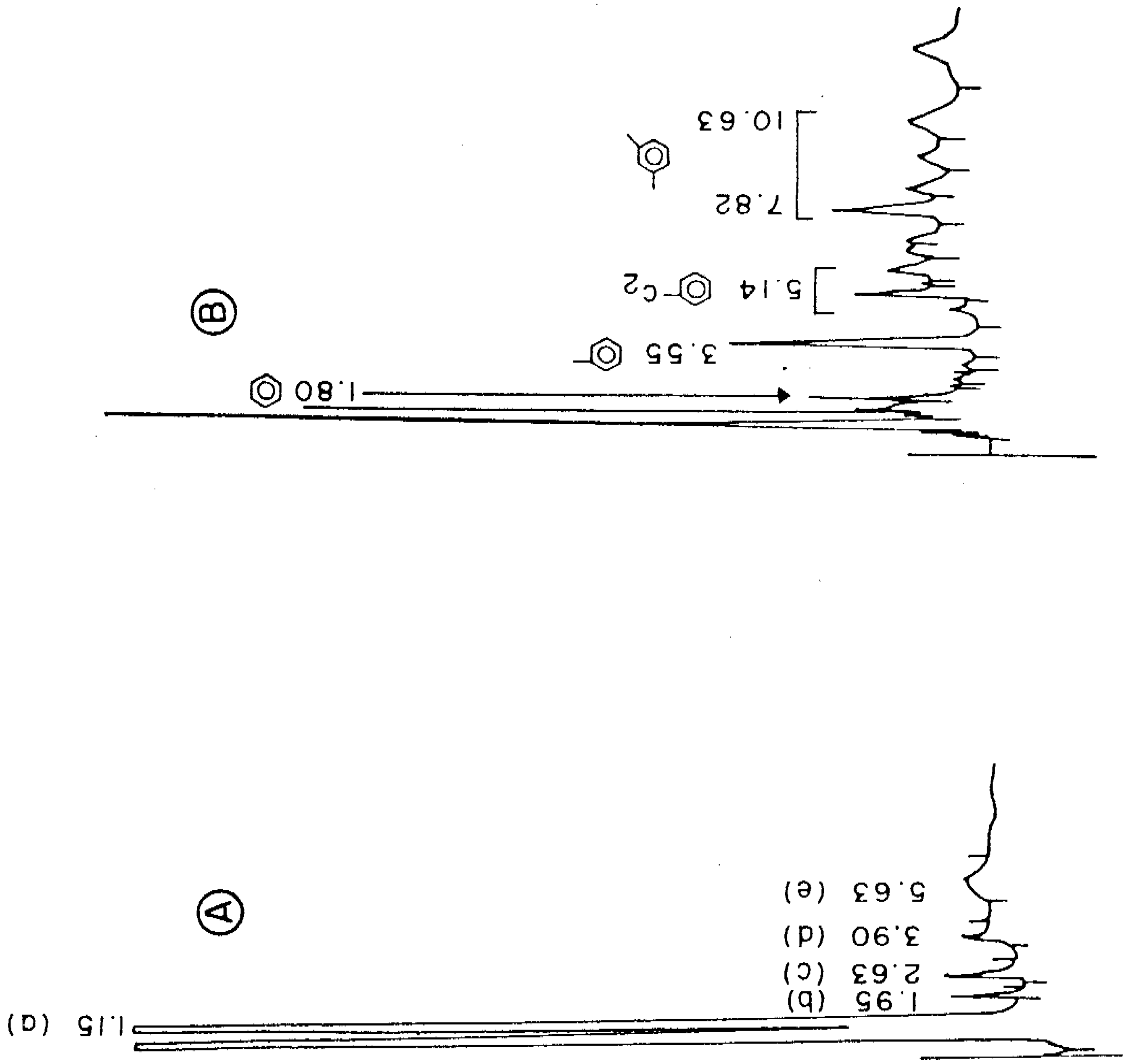



Figure 18. Chromatographic trace of the LMW aliphatic (A) and aromatic fractions (B) from station CB-05 in lower Cook Inlet. The sample was taken from approximately 5m off the bottom. Peak identification is the same as that given in Figure 16.

Time Series Observations

During the May cruise, time series observations were conducted at stations CB-7, CB-9, and CB-10. Depending on the time available, the measurements were conducted every 4 or 6 hours for periods up to 48 hours. For the sake of brevity, only stations CB-7 and CB-10 will be discussed at this time.

Station CB-7 is located in Kachemak Bay and because of its location, represents the most biologically active site that was visited. The variation in temperature and salinity at 3m and 44m is shown in Figure 19. These depths represent average values as no attempt was made to position the rosette precisely during each cast. In Figure 19, the diurnal tidal signature is quite evident in the surface layers and to a lesser extent at depth. Over the 48 hour period salinities varied from 31.7 to 31.8°/₀₀. Temperature was more variable, ranging from 5° to 6°C, the major difference due to pulses of warm water emanating from Kachemak Bay (i.e., Coal Bay).

A similar time variation of dissolved methane at 3m and 44m is shown in Figure 20. As expected, the concentration of methane near the bottom was greater than that observed in the surface layers and reflects the contribution from the bottom and the volatilization across the air-sea interface. The diurnal tidal signal is evident, reflecting the significance of the source waters. The organic-rich sediments prevalent in Kachemak Bay, and in particular, Coal Bay, is probably enriching the bottom waters with methane. The time-concentration profile for methane was symmetrically periodic in the near-bottom waters, ranging from 300 to 450 nℓ/ℓ. With the exception of the high concentration of methane observed at 0800 hours (local) on May 7, the surface concentrations varied from 200-300 nℓ/ℓ.

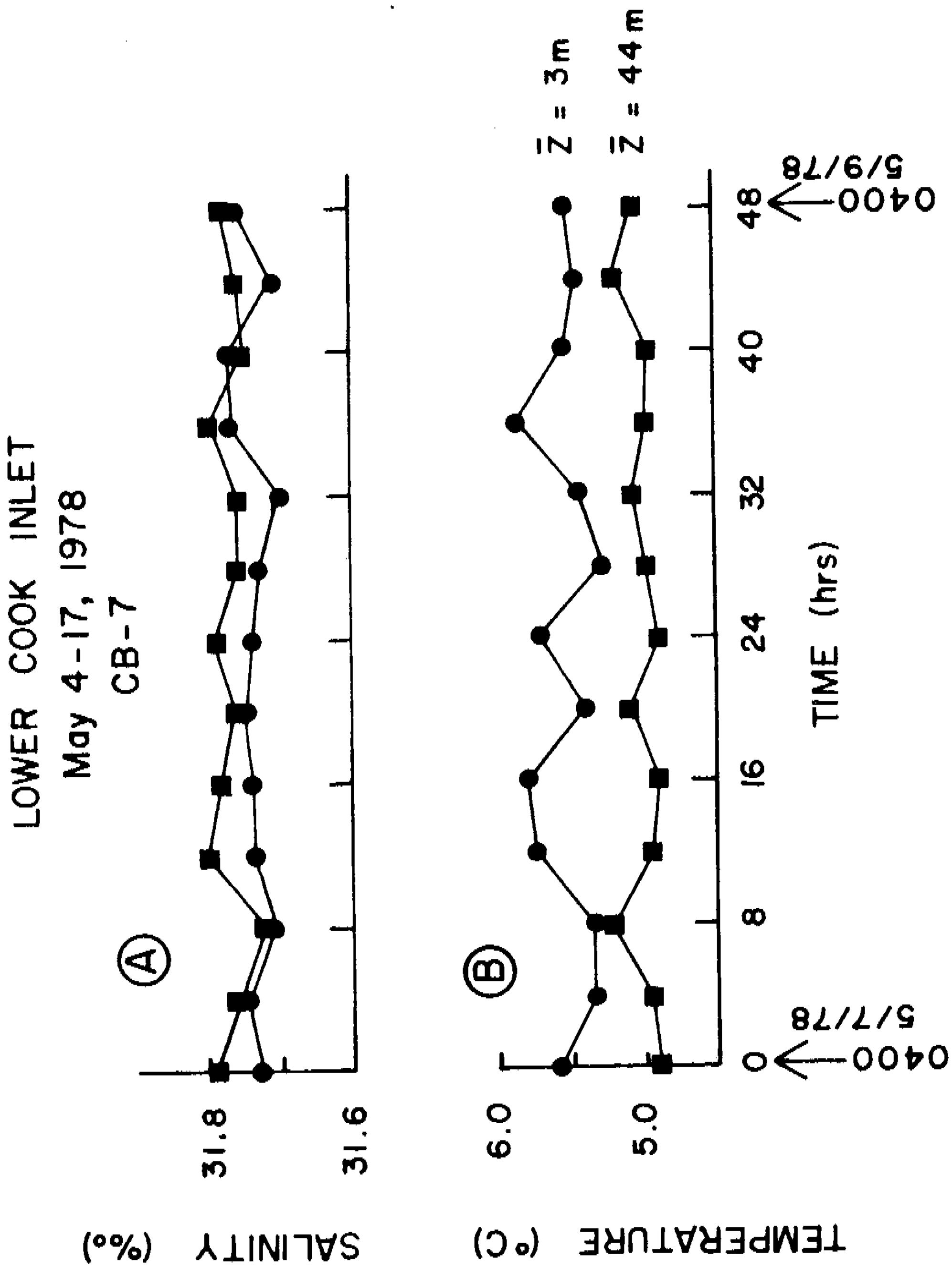



Figure 19. Diurnal temperature (B) and salinity (A) variations at station CB-7 during the period May 7-9, 1978. Surface values ( ● ) were nominally taken at 3m; near bottom samples ( ■ ) at 44m.

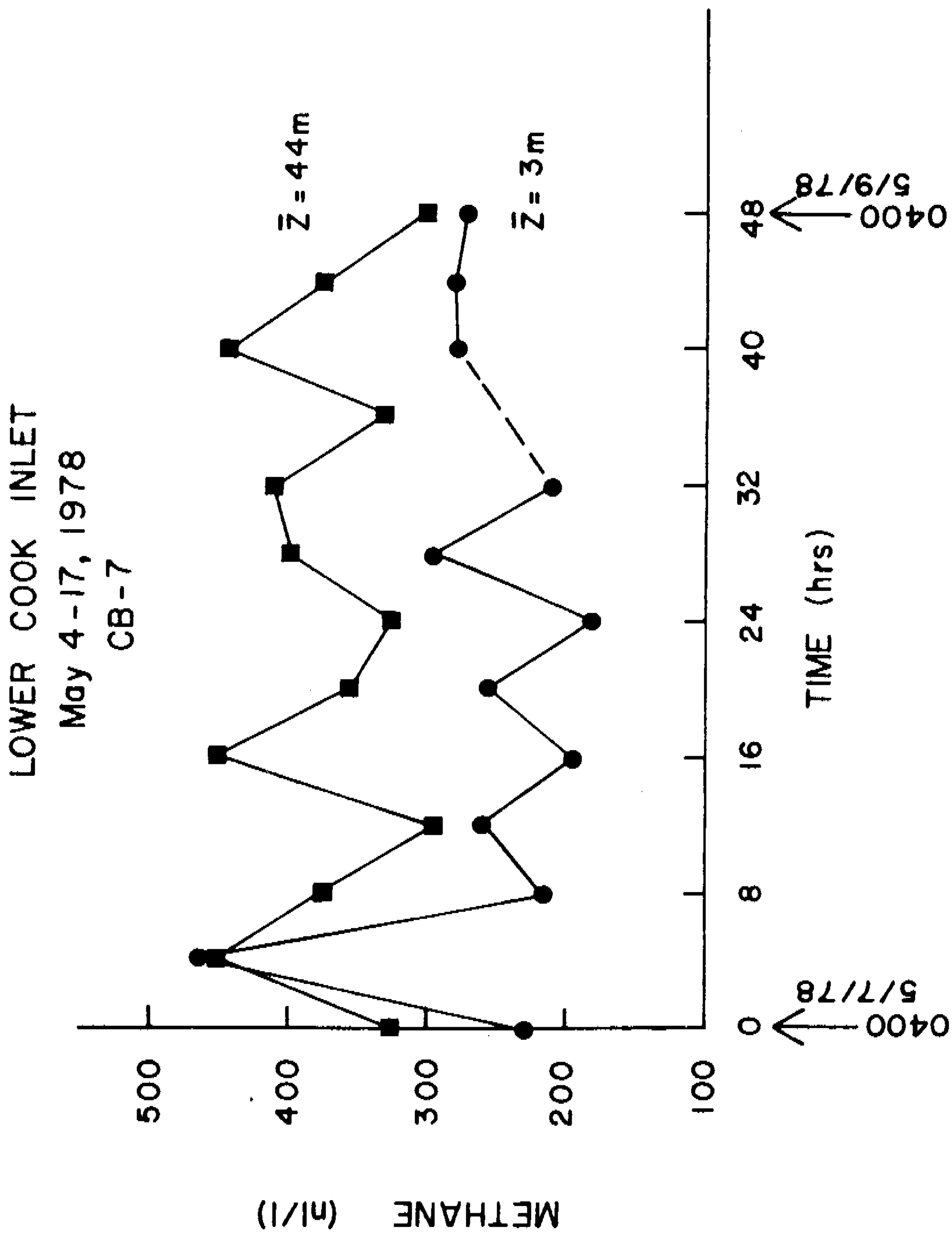



Figure 20. Diurnal changes in the concentration of dissolved methane at station CB-7 during the period May 7-9, 1978. Surface concentrations ( ● ) were nominally measured at 3m; near bottom concentrations ( ■ ) at 44m.

A reduced source and volatilization across the sea surface are the principle causes of reduced concentrations in the surface layers.

In the past, two indicator ratios have been used to characterize sources of LMW hydrocarbons. This includes the methane to ethane plus propane ratio and the ratio of ethane to ethene. For station CB-7, these ratios are depicted in Figure 21. In this presentation the ratio of methane to ethane plus propane was adjusted to exclude the contribution of methane arising from the solution of air, or the equilibrium solubility concentration (C*). In the surface layers $R_1$ remains constant at 200 with the exception of the measurements made during the first eight hours of the time series. The high ratio is the result of the high concentration of methane observed (see Figure 20), which may have been related to local contamination from the ship's holding tanks (see Dr. Griffiths' letter dated June 12, 1978). In the near-bottom waters, $R_1$ varied between 200 and 400, representing a range of values typical of biogenic sources. In the upper part of Figure 21, the ratio of ethane to ethene ($R_2$) is presented. With the exception of two measurements made during the first 12 hours, the ratio in both the surface waters and at depth are constant at 0.5. Again, this value is typical for well aerated waters prevalent over the Alaskan shelf areas. A value less than 1 is indicative of biological sources.

Station CB-10 was located to the east of the main channel adjacent to Kalgin Island (see Figure 3). Because of the shortness of time, this station was only occupied for 30 hours. The temperature and salinity variations are shown in Figure 22. Stratification was minimal due to large vertical turbulence, resulting in a uniform distribution of properties with depth. During the cource of the measurements, salinity varied from 29.1 to 29.6°/₀₀,

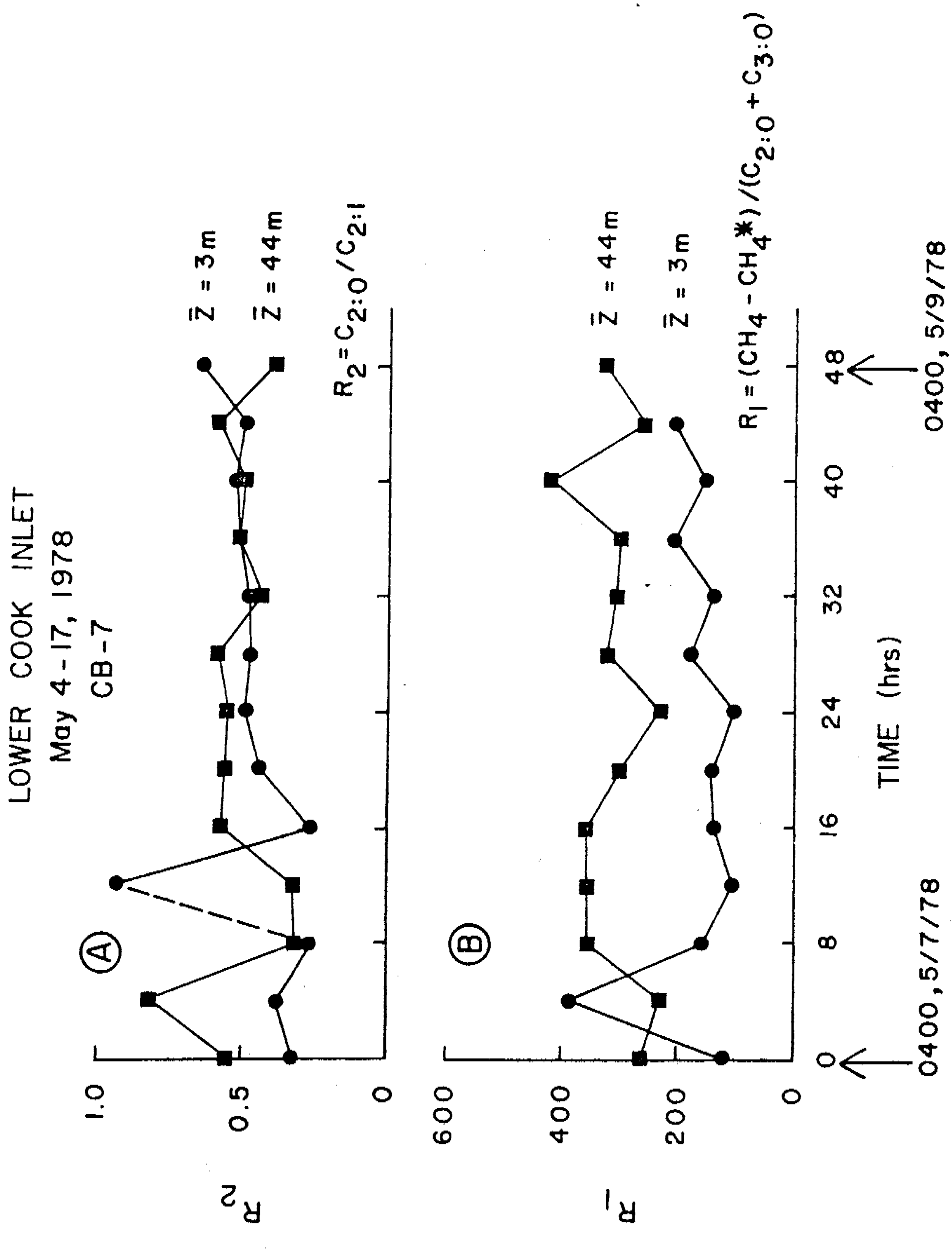



Figure 21. The diurnal variation in the ratio of ethane to ethene (A) and the methane to ethane plus propane ratio (B) for station CB-7. The ratios were computed for the nominal depths of 3m and 44m. The ratio $R_1$ has been adjusted to exclude the solution of methane from air by subtracting the equilibrium solubility concentration $CH_4^*$

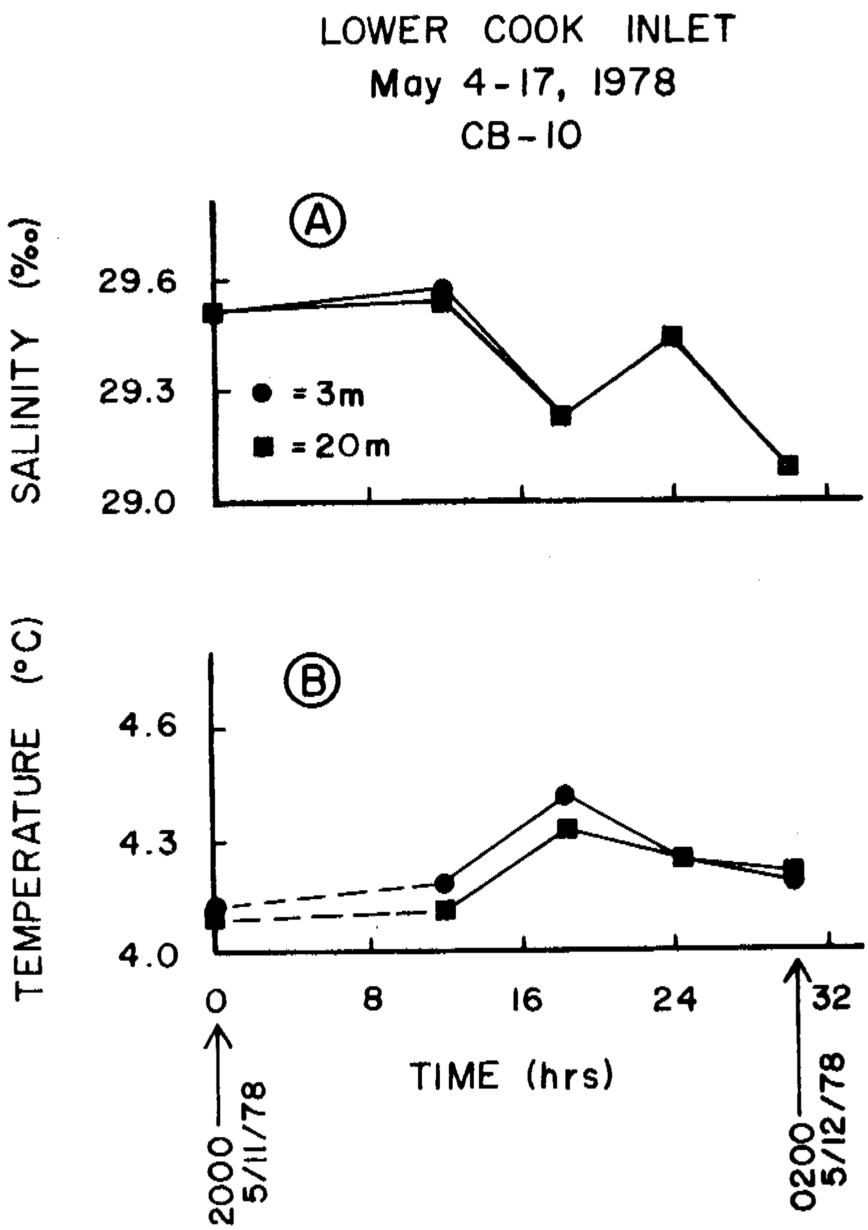



Figure 22. The diurnal temperature (B) and salinity (A) variation at station CB-10. Observations were nominally conducted at 3m ( ● ) and 20m ( ■ ).

whereas temperature ranged from 4.1 to 4.4°C. The diurnal tidal signature was muted, but present.

The time variation profile for dissolved methane and ethane is shown in Figure 23. Methane varied from 300 to 400 nℓ/ℓ and showed little tidal effects or depth variation. With the exception of the measurement made at 0200 hours 5/12/78, the concentration of ethane was $\leq 0.5$ nℓ/ℓ. Because of the station location, water sampled at CB-10 was largely derived from the east side of Cook Inlet and did not reflect the elevated concentrations of ethane and propane found in Trading Bay (see Figures 12 and 14). In August, the station was moved to a point just east of Kalgin Island. The preliminary examination of these data show surges of ethane- and propane-rich water from upper Cook Inlet.

While station CB-10 in May was located away from the principle flow from upper Cook Inlet, some lateral mixing occurred. In Figure 24 is reflected the diurnal variation in the ethane/ethene ratio (A) and the ratio of methane to ethane plus propane (B). Whereas $R_1$ ranges from a low of 400 to a high of nearly 800, the biogenic $C_2$ index ratio ($R_2$) ranges from 2 to 9. The abundance of ethane relative to ethene is indicative of a thermogenic source of hydrocarbons. Whereas the ratio of saturated hydrocarbons ($R_1$) is high, suggesting a biological source, the $C_2$ index ratio is greater than 1 and strongly indicates either a thermogenic source of hydrocarbons or hydrocarbons which have originated from anoxic waters or sediments. Information provided earlier demonstrates clearly that the latter is not the case. In the case of incipient detection of a petroleum source, the $C_2$ index ratio is significantly diagnostic.

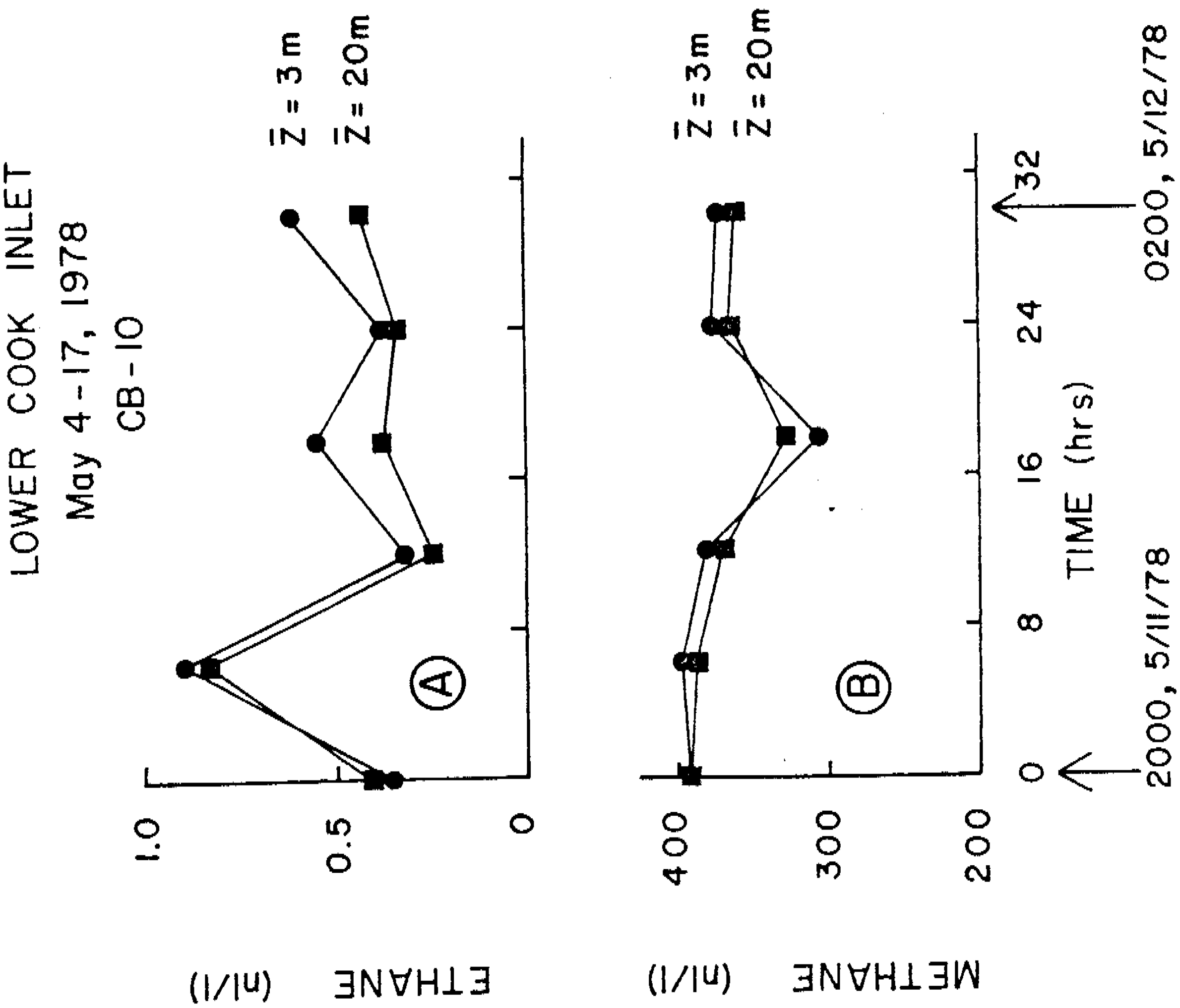



Figure 23. The diurnal variation of dissolved methane (A) and ethane (B) at station CB-10. Sampling was nominally conducted at 3m and 20m.

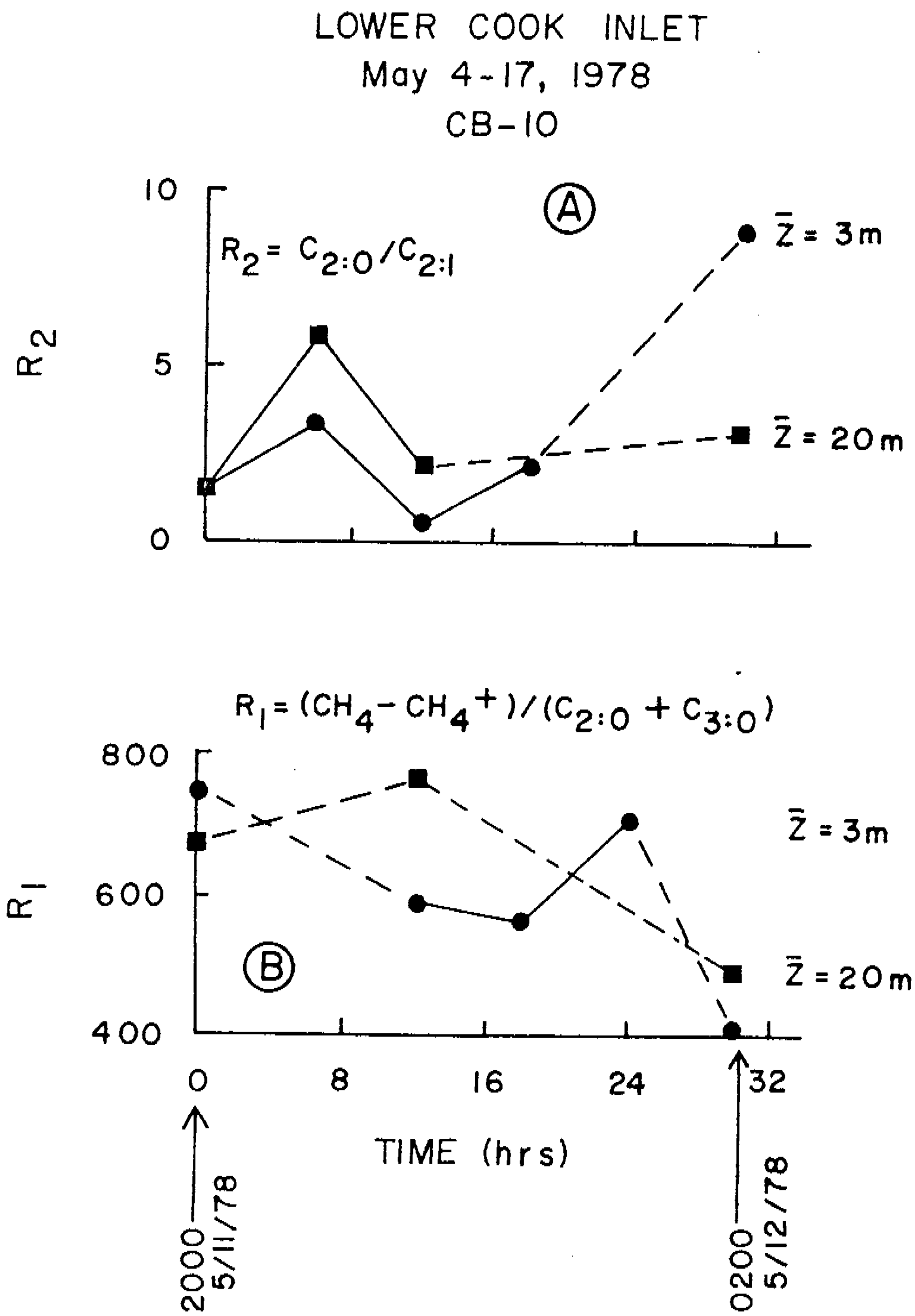



Figure 24. The diurnal variation of the ethane to ethene ratio (A) and the ratio of methane to ethane plus propane (B) at station CB-10. The sampling depths were nominally at 3m and 20m. See Figure 21 for the definition of $R_1$.

Particulate Hydrocarbons

In May, suspended matter samples were collected every 6 hours at station CB-7, CB-9, and CB-10. These samples are currently being analyzed, with emphasis on the material collected at CB-10. Preliminary analysis of one subsample from CB-10 has been completed and will be discussed below. It is stressed that these results are preliminary in nature, and may be altered slightly before the next reporting period.

The chromatographic trace of the heavy n-alkane fraction is shown in Figure 25. The dominant feature of the chromatogram is the abundance of alkanes in the $C_{25}$ to $C_{31}$ carbon range, with a strong odd-even prevaling character. In this boiling point fraction, the concentration of individual saturates ranges from 120 to 500 ng/g dry weight sediment (Table 1). At the low end, the dominant alkanes were $C_{15}$, $C_{17}$, pristane, and $C_{19}$, the concentrations ranging from 30-60 ng/g. The overall odd-even concentration ratio was 2.0. The relatively strong odd-even dominance evident in the boiling fraction greater than $C_{20}$ reflects probable input from plant waxes, although this interpretation is provisional. It is conceivable that modest amounts of petroleum-derived Hc may be masked by the more prevalent terrestrially-derived H.C.

The location of CB-10 during May was not ideal in terms of monitoring the material flux from upper Cook Inlet. Samples taken in August should be more representative, based on our preliminary examination of the LMW aliphatic data. Also, it now appears that significant concentrations of hydrocarbons may be associated with terrestrially derived detrital material, thus analyses should be made of the source materials (i.e., riverine suspended matter).

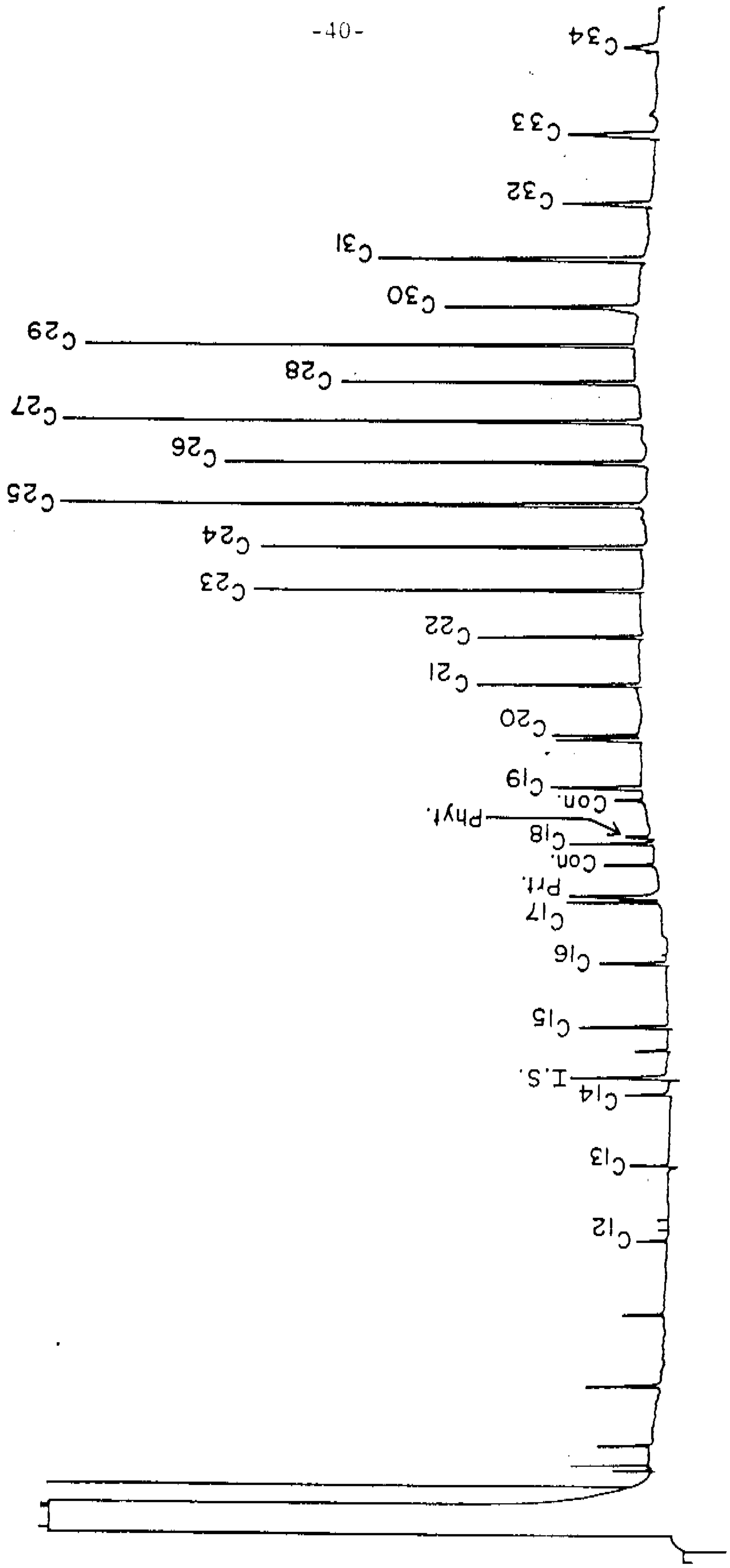



Figure 25. Chromatogram of the n-alkane fraction extracted from suspended matter collected at station CB-10 in May 1978. The internal standard was hexa-methylbenzene. Concentrations of individual n-alkanes is reported in Table 1.

TABLE 1. Concentration of normal alkanes and the isoprenoid hydrocarbons pristane and phytane at stations CB-10 in May 1978. The sample was collected over a 12 hour period (38.5g dry weight), homogenized, then split into two fractions. The values below represent the mean of these fractions.

| Normal Alkane | Concentration (ng/g) |
|---|---|
| $C_{12}$ | 7 |
| $C_{13}$ | 10 |
| $C_{14}$ | 14 |
| $C_{15}$ | 29 |
| $C_{16}$ | 24 |
| $C_{17}$ | 55 |
| Pristane | 63 |
| $C_{18}$ | 33 |
| $C_{19}$ | 14 |
| Phytane | 42 |
| $C_{20}$ | 32 |
| $C_{21}$ | 67 |
| $C_{22}$ | 68 |
| $C_{23}$ | 180 |
| $C_{24}$ | 170 |
| $C_{25}$ | 310 |
| $C_{26}$ | 170 |
| $C_{27}$ | 500 |
| $C_{28}$ | 120 |

TABLE 1. Continued

| Normal Alkane | Concentration (ng/g) |
|---|---|
| $C_{29}$ | 240 |
| $C_{30}$ | 130 |
| $C_{31}$ | 270 |
| $C_{32}$ | 79 |
| $C_{33}$ | 89 |
| $C_{34}$ | 65 |

$\Sigma$ODD = 1783

$\Sigma$EVEN = 912

Based on a preliminary comparison between our measurements and those performed by MacLeod *et al.*, (1976) on intertidal beach sediments taken near Port Angeles and Dungeness Bay in Washington, the composition and concentrations of individual alkanes falls between the polluted sediments obtained near Port Angeles and those obtained from Dungeness Bay, a relatively clean environment. Because the latter reasurements were made in relatively coarse beach sands, presumably low in organic matter, the concentrations of hydrocarbons associated with suspended matter may represent natural background levels. Measurements of particulate organic carbon and nitrogen from upper Cook Inlet show the suspended matter to be 0.3-0.7% carbon by weight, with the atom C/N ratio about 13. Typical marine samples are usually less than 10, which indicates a large abundance of terrestrially-derived organic matter.

## V References Cited


Cline, J.D. 1977. Distribution of light hydrocarbons, $C_1$-$C_4$, in the northeast Gulf of Alaska, Lower Cook Inlet, Southeastern Bering Shelf, Norton Sound and Southeastern Chukchi Sea pp. 180-268. In: *Environmental Assessment of the Alaskan Continental Shelf, Vol. 13. Contaminant Baselines*, NOAA/ERL, Boulder Co.

Cline, J.D., R. Feely, A. Young. 1978. Identification of Natural and Anthropogenic petroleum sources in the Alaskan shelf areas utilizing low molecular weight hydrocarbons. *In: Environmental Assessment of the Alaskan Continental Shelf*, submitted as Annual Report.

Hunt, J.M. 1972. Hydrocarbon geochemistry of Black Sea. *In: The Black Sea - Geology, Chemistry and Biology*, E.T. Degens and D.A. Ross [eds.], AAPG Memoir, Vol. 20.

## VI Problems Encountered

The major problem encountered during the May and August cruises involved the analysis of waters for LMW aromatics. Contamination, poor extraction efficiencies, and the complexity of compounds present in the volatile gas fraction presented severe analytical difficulties. Some of these problems were resolved prior to the August cruise, but not all. While such questions as contamination, trapping procedures, standardization, and extraction efficiencies can be resolved, the complexity of compounds present in seawater presents an insurmountable problem to conventional g.c. analysis. For next year's program a request has been made to implement g.c.-m.s. measurements in the field. Since this has not been attempted before, we anticipate difficulties. However, if sufficient development time is available and stable power requirements can be obtained, some success should be realized in one year.

## VII Estimate of Funds Expended

| | Allocated | Expended to Date | Balance |
|---|---|---|---|
| Salaries | $87,990 | $ 87,990 | $ 0 |
| Major Equipment | 800 | 800 | 0 |
| Expendables | 5,500 | 5,500 | 500 |
| Travel | 4,640 | 4,640 | 0 |
| Shipping | 1,000 | 800 | 200 |
| Publications | 4,000 | 4,000 | 0 |
| Contracts | 1,600 | 1,200 | 400 |
| Totals | $105,780 | $ 104,680 | $1,100 |

QUARTERLY REPORT

Contract: #03-5-022-56
Research Unit: #162
Task Order: #12
Reporting Period: 7/1/78-9/30/78
Number of Pages: 91

# DISTRIBUTION AND DYNAMICS OF HEAVY METALS IN ALASKAN SHELF ENVIRONMENT SUBJECT TO OIL DEVELOPMENT

Dr. David C. Burrell
Principal Investigator
Professor of Marine Science

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

September 1978

TABLE OF CONTENTS

LIST OF TABLES. . . . . . . . . . . . . . . . . . . . . . . . . . . iii

LIST OF FIGURES . . . . . . . . . . . . . . . . . . . . . . . . . . v

I. TASK OBJECTIVES . . . . . . . . . . . . . . . . . . . . . . . . 1

II. FIELD WORK . . . . . . . . . . . . . . . . . . . . . . . . . 1

III. RESULTS . . . . . . . . . . . . . . . . . . . . . . . . . . 7

IV. PRELIMINARY INTERPRETATION. . . . . . . . . . . . . . . . . . . . . 24

V. PROBLEMS ENCOUNTERED. . . . . . . . . . . . . . . . . . . . . . . 37

APPENDIX I - Resurrection Bay - R/V *Acona* Cruise No. 253 - November 1977 (Hydrographic Data). . . . . . . . . . . . . . . . . . . . . . 38

APPENDIX II - Resurrection Bay - R/V *Acona* Cruise No. 256 - February 1978 (Hydrographic Data). . . . . . . . . . . . . . . . . . . . . . 41

APPENDIX III - Resurrection Bay - R/V *Acona* Cruise No. 260 - April 1978 (Hydrographic Data). . . . . . . . . . . . . . . . . . . . . . 46

APPENDIX IV - Resurrection Bay - R/V *Acona* Cruise No. 262 - July 1978 (Hydrographic and Nutrient Data) . . . . . . . . . . . . . 55

APPENDIX V - Heavy Metal Contents of Bering Sea Seals . . . . . . . . 64

## LIST OF TABLES


TABLE I. Resurrection Bay - R/V *Acona* No. 262, 10-11 July 1978 - Operations. . . . . . . . . . . . . . . . . . . . 2

TABLE II. Lower Cook Inlet - OSS *Discoverer*, 29 August-2 September 1978 - Operations. . . . . . . . . . . . . 4

TABLE III. Lower Cook Inlet - OSS *Surveyor*, 3-17 November 1977 - Heavy Metal Contents of Tanner Crab. . . . . . . . . 8

TABLE IV. Lower Cook Inlet - OSS *Discoverer*, 4-16 May 1978 - Particulate Sediment Geochemistry at Time Series Station CB-7, Kachemak Bay . . . . . . . . . . . . . 11

TABLE V. Lower Cook Inlet - OSS *Discoverer*, 4-16 May 1978 - Particulate Sediment Geochemistry at Time Series Station CB-9, Redoubt Bay. . . . . . . . . . . . . . 12

TABLE VI. Lower Cook Inlet - OSS *Discoverer*, 29 August-2 September 1978 - Particulate Sediment Geochemistry at Time Series Station CB-10 . . . . . . . . . . . . 13

TABLE VII. Resurrection Bay - R/V *Acona* No. 254, December 1977 - Chemistry of Particulate Sediment (mg/g) - Station RES 2.5 . . . . . . . . . . . . . . . . . . . . . . . 14

TABLE VIII. Resurrection Bay - R/V *Acona* No. 254, December 1977 - Particulate Sediment Geochemistry (w/V) - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . . . . 15

TABLE IX. Resurrection Bay - R/V *Acona* No. 254, December 1977 - Particulate Sediment Metal/Al Ratios - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . . . . 16

TABLE X. Resurrection Bay - R/V *Acona* No. 254, December 1977 - Water Column Chemistry at Station RES 2.5. . . . . . 17

TABLE XI. Resurrection Bay - R/V *Acona* No. 260, April 1978 - Chemistry of Particulate Sediment (mg/g) - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . . . . 18

TABLE XII. Resurrection Bay - R/V *Acona* No. 260, April 1978 - Particulate Sediment Geochemistry (w/V) - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . . . . 19

TABLE XIII. Resurrection Bay - R/V *Acona* No. 260, April 1978 - Particulate Sediment Metal/Al Ratios - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . . . . 20

LIST OF TABLES (continued)

TABLE XIV. Resurrection Bay - R/V *Acona* No. 262, July 1978 - Particulate Sediment Geochemistry (w/V) - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . . . . . 21

TABLE XV. Resurrection Bay - R/V *Acona* No. 262, July 1978 - Chemistry of Particulate Sediment (mg/g) - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . . . . . 22

TABLE XVI. Resurrection Bay - Seasonal Suspended Sediment Load - Station RES 2.5. . . . . . . . . . . . . . . . . . . . . 23

TABLE XVII. Cadmium Content of Pure Bacteria Culture under Various Oiling Conditions. . . . . . . . . . . . . . . 35

## LIST OF FIGURES


FIGURE 1. Station locations for tanner crab samples of Table III. Lower Cook Inlet; *Surveyor*, 3-17 November 1977. . . . . . . . . . . . . . . . . . . . . . . . . 9

FIGURE 2. Manganese contents of organic association function of Resurrection Bay sediment. *Acona* 260, April 1978; Station RES 2.5 . . . . . . . . . . . . . . . . . . . . 10

FIGURE 3. Particulate Mn and Al (μg/g). Station RES 2.5; November 1977 . . . . . . . . . . . . . . . . . . . . . . 25

FIGURE 4. Particulate Mn and Al (μg/g). Station RES 2.5; April 1978. . . . . . . . . . . . . . . . . . . . . . . . 26

FIGURE 5. Metal/Al ratios of particulate sediment. Station RES 2.5; November 1977. . . . . . . . . . . . . . . . . . 27

FIGURE 6. Metal/Al ratios of particulate sediment. Station RES 2.5; April 1978 . . . . . . . . . . . . . . . . . . . 28

FIGURE 7. Seasonal particulate load distribution at Station RES 2.5 . . . . . . . . . . . . . . . . . . . . . . . . . 29

FIGURE 8. Seasonal particulate organic carbon distributions at Station RES 2.5 . . . . . . . . . . . . . . . . . . . . 30

FIGURE 9. Distribution of interstitial water Mn and Fe. Station RES 2.5; May 1978. Data provided by D. T. Heggie . . . 32

FIGURE 10. Results of oiling experiment. . . . . . . . . . . . . . 33

FIGURE 11. Relationship between the optical density parameter and actual dry weight of separated biomass. . . . . . . . . 34

FIGURE 12. Growth curve. . . . . . . . . . . . . . . . . . . . . . . 36

## I. TASK OBJECTIVES

The primary objective of this program is to research natural pathways of potentially toxic heavy metals to and through Alaskan Shelf and coastal marine biota (with emphasis on commercially important benthic species) and hence to determine and predict changes likely to result from oil industry activity in this marine zone. Ancillary components of this work include: (1) characterizing the heavy metal inventories of the water, sediment and indigenous biota in those geographical areas for which no background data exist; (2) determining non-biological pathways (rates and routes under both natural and stressed conditions) of the heavy metals as these affect the availability of metals to the organisms; (3) toxicity effects of selected heavy metals to animals which are of major commercial importance under Alaskan environmental conditions.

## II. FIELD WORK

### A. Field Work

1. Resurrection Bay (Lower Cook Inlet Project)
   R/V *Acona* No. 262, 10-11 July 1978
   Personnel: T. Owens
   M. Robb
   D. Weihs

   Summer survey of hydrography, nutrient distributions and other chemical parameters as shown in Table I. The primary object of this cruise was to research the distribution of heavy metals in the water column as related to suspended sediment load, nutrient distributions, dissolved and particulate organic carbon, etc. The overall aim, as for previous cruises, is to research the factors which determine the flux of heavy metals to and from the sediments and hence to predict the effects of anthropogenic perturbations of the natural system.

TABLE I

RESURRECTION BAY
R/V *ACONA* NO. 262, 10-11 JULY 1978
OPERATIONS

| Station | Depth (m) | Operations |
|---|---|---|
| RES 2 | 223 | Hydro, STD, Spectrex, nutrients |
| RES 5 | 264 | Hydro, STD, Spectrex, nutrients |
| RES 4 | 257 | Hydro, STD, Spectrex, nutrients |
| RES 3 | 289 | Hydro, STD, Spectrex, nutrients |
| RES 2.5 | 287 | Hydro, STD, Spectrex, Part. load, TM, POC, DOC, nutrients |

2. Lower Cook Inlet
OSS *Discoverer* 29 August-2 September 1978
Personnel: D. Weihs
M. Robb

The primary purpose of this cruise was to collect the samples for heavy metal analysis at the single time series station requested by OCSEAP Boulder. Operations as given in Table II.

A second major objective of this sampling trip was to obtain fresh supplies of live *Macoma balthica* for use in the aquaria metal uptake experiments.

B. Scientific Parties

As noted above.

C. Field Collection Methods

As discussed in 1977-78 Annual Report.

D. Sample Localities

As stated in Tables

E. Laboratory and Analysis Program

1. Revised procedure for obtaining standardized chemical extracts from sediments.

At the beginning of the OCS program we utilized the method of Chester and Hughes (1967; 25% acetic acid + 1 M hydroxylamine hydrochloride) to obtain a single extract for heavy metal analysis. This procedure removes acid leachable and reducible metals and is widely utilized. Later in the program we received a BLM mandate to standardize with other BLM-OCS operations in the contiguous states and hence to use a 25% acetic acid extract only. This current contract period we have cooperated with PMEL to devise and utilize yet a third standardized scheme. This leaching procedure, details of which are given below, is based on that of Malo (1977) and involves a two-step procedure to (a) release metals organically bound and (b) weakly bound inorganic associates.

TABLE II

LOWER COOK INLET
OSS *DISCOVERER*, 29 AUGUST-2 SEPTEMBER 1978
OPERATIONS

| Station | Hours | Operations |
|---|---|---|
| CB 10 | 0 | TM Poc Doc |
| | 6 | TM Poc Doc |
| | 12 | TM Poc Doc |
| | 18 | TM Poc Doc |
| | 24 | TM Poc Doc |

Details of the method used in our laboratory follow. The starting material is freeze dried sediment.

a. $H_2O_2$ extraction:

i. Place triplicate 0.5 g sub-samples into 50 ml poly centrifuge tubes.

ii. Add 5 ml 10% Ultrax $H_2O_2$ and heat in 50°C water bath for 48 hrs.

iii. Centrifuge at 1500 rpm for 1 hr and decant supernatant into tared 50 ml capped plastic beakers.

iv. Add 5 ml $H_2O$ to pellet, repeat from step (iii) twice more combining supernatants.

v. Approximating volume of supernatants, acidify with Ultrex HCl to 0.3 N.

vi. Weigh solution to detemine dilution and filter through 0.45 μm Nuclepore membrane into small plastic vial.

vii. Analyze solution via atomic absorption.

b. 0.3 N HCl extraction:

i. Add 5 ml Ultrex 0.3 N HCl to above pellet and heat on 90°C water bath for 30 min.

ii. Centrifuge for 1 hr at 1500 rpm and decant supernatant into tared 50 ml capped plastic beakers.

iii. Add further 5 ml aliquot of 0.3 N Ultrex HCl to pellet and repeat extraction step twice more combining supernatants.

iv. Filter solution through 0.45 HA Millepore membrane into small plastic vial and analyze via atomic absorption spectrophotometry.

2. To date summary of laboratory-aquaria experiments on role of marine microorganism mobilization of heavy metals.

The first sediment and *Macoma* collections were made in Resurrection Bay in November 1977. Over the period December 1977 - January 1978 the first solution-bacteria-clam cadmium transfer experiment was run. The results of this have been reported in the 1977-78 Annual Report.

It was clear from this initial experiment on a mixed marine heterotrophic population that the large number of operating variables pertaining during the solution-bacteria uptake portion of the experiment prevented detailed interpretation of the data although it was clear that very large concentration factors for, in this case, cadmium were involved.

The first experimental design modification - isolation of a pure culture from the natural marine population - was undertaken over the period February-March. A white G-negative rod culture (suspected marine pseudomonad) was isolated and chosen as the test organism.

Oiling experiment: A pure culture broth was prepared using the procedures described in the 1977-78 Annual Report. Colonies were subjected to Prudhoe Bay crude at concentrations of 100, 500 and 1000 ppm for 20, 43 and 125 hrs. The objective of this experiment was to see: (a) whether the presence of oil affected the growth patterns; (b) whether indigenous contents of some test heavy metal (in this case cadmium) would be affected by growth in an oiled medium. Results and discussion are given in a following section.

This latter experiment also incorporated a correlation of weight of bacteria (dry weight spun down from 500 ml of medium) *versus* optical density.

Population growth: In June of this year a detailed growth rate experiment was run. The objective of this experiment was to characterize the growth phases of the pure culture used, and also to determine the effect of the presence of 0.1 ppm cadmium in the growth medium. This latter modification gave the growth stage of maximum metal uptake.

Second stable cadmium uptake and transfer experiment: In late August a second solution-bacteria-clam transfer experiment was initiated using the pure culture and certain experimental design changes suggested by the intervening experiments. Results of this experiment will be included in a subsequent report.

## III. RESULTS

### A. Heavy Metal Contents of Benthos

Additional data for tanner crab samples collected on Lower Cook Inlet on the 3-17 November 1977 *Surveyor* cruise are given in Table III. Relevant station locations for these samples are shown in Figure 1.

### B. Heavy Metal Contents of Sediment Extracts

Heavy metal contents of the organic-association extract for a Resurrection Bay core profile are shown in Figure 2.

### C. Environmental Data for NEGOA Specific Study Sites

These series of data are essential ancillary information required to interpret the heavy metal distribution data. Hydrographic data for R/V *Acona* cruise No. 253 (November 1977) are given in Appendix I; R/V *Acona* No. 256 (February 1978) in Appendix II; R/V *Acona* No. 260 (April 1978) in Appendix III. Appendix IV gives hydrographic and nutrient data for *Acona* cruise No. 262 (July 1978).

### D. Lower Cook Inlet - Time Series Data

Geochemical data for stations CB-7 and CB-9 occupied on the *Discoverer* cruise 4-16 May 1978 are given in Tables IV and V. Preliminary data for station CB-10 taken on the *Discoverer* cruise of 29 August-2 September 1978 are given in Table VI.

### E. Natural Flux of Heavy Metals in Alaskan Fjord Estuaries

This project is presently emphasizing water column and sediment data at Resurrection Bay station RES 2.5. Geochemical data obtained to date for the time period December 1977 are given in Tables VII-X; for April 1978 in Tables XI-XIII; for July 1978 in Tables XIV and XV. Seasonal suspended load data for this station are given in Table XVI.

TABLE III

LOWER COOK INLET
OSS *SURVEYOR*, 3-17 NOVEMBER 1977
HEAVY METAL CONTENTS OF TANNER CRAB (μm/g dry weight)

| Station # | Sample | Cd | Cu | Ni | Zn |
|---|---|---|---|---|---|
| 5 | | 0.10 ± 0.08 | 57.4 ± 0.6 | Contam. | 58 ± 12 |
| 41 | B | 0.45 ± 0.3 | 57.3 ± 3.0 | " | 70[a] |
| | C | 0.45 ± 0.08 | 48.8 ± 7.3 | " | 28 ± 17 |
| | D | 0.57 ± 0.4 | 45.9 ± 2.0 | " | 22 ± 2 |
| | E | 0.6[a] | 110.7[a] | " | 132[a] |
| 35 | A | 0.36 ± 0.3 | 85.5 ± 2.3 | " | 109 ± 6 |
| | B | 0.18 ± 0.1 | 72.3 ± 4.6 | " | 27 ± 9 |
| 62 | C | 0.4[a] | 33.9[a] | " | 37[a] |
| | F | 0.22 ± 0.06 | 67.4 ± 4.0 | " | 66 ± 2 |
| 53 | C | 0.25 ± 0.05 | 28.7 ± 4.0 | " | 19 ± 3 |

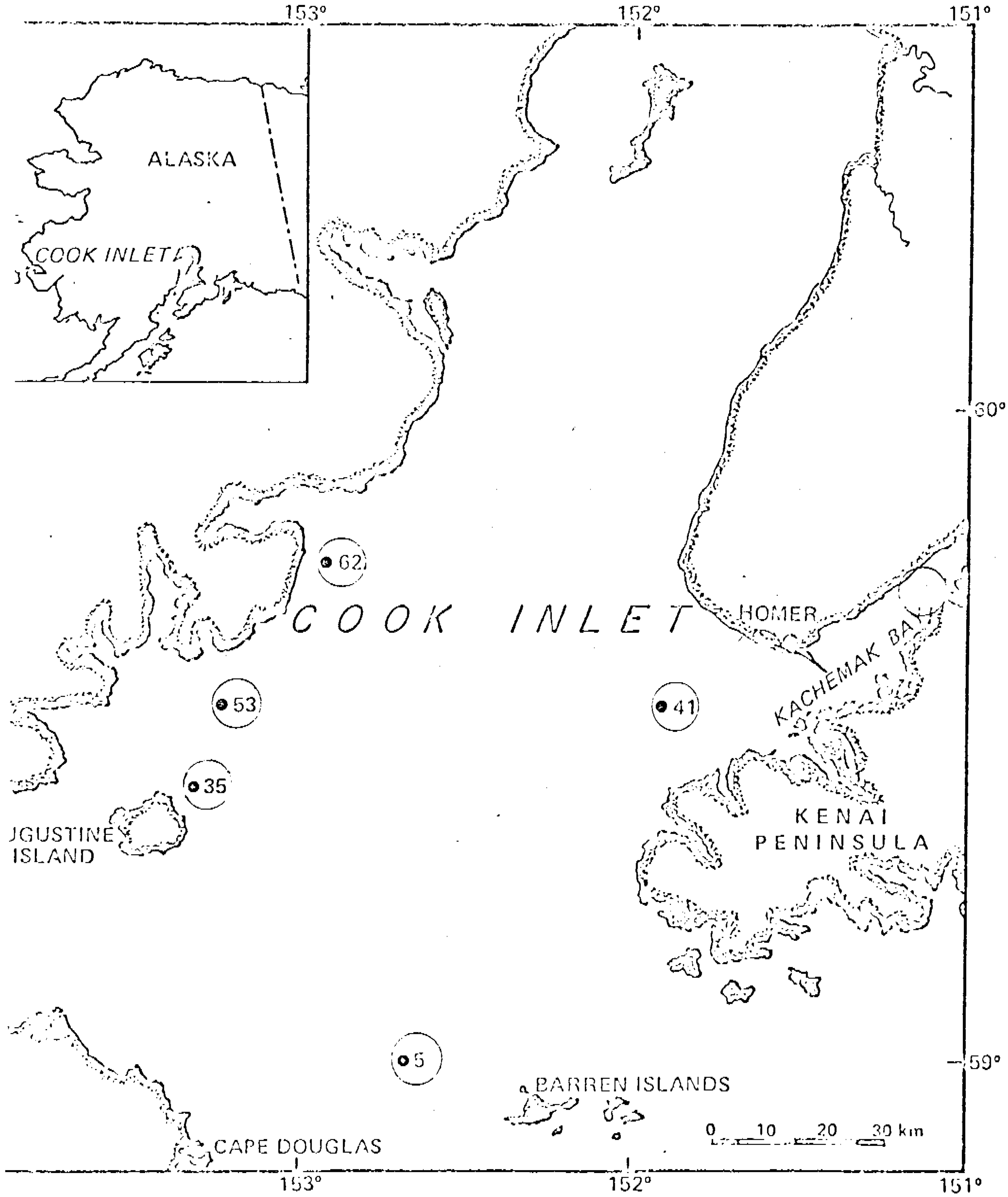



Figure 1. Station locations for tanner crab samples of Table III. Lower Cook Inlet; *Surveyor*, 3-17 November 1977.

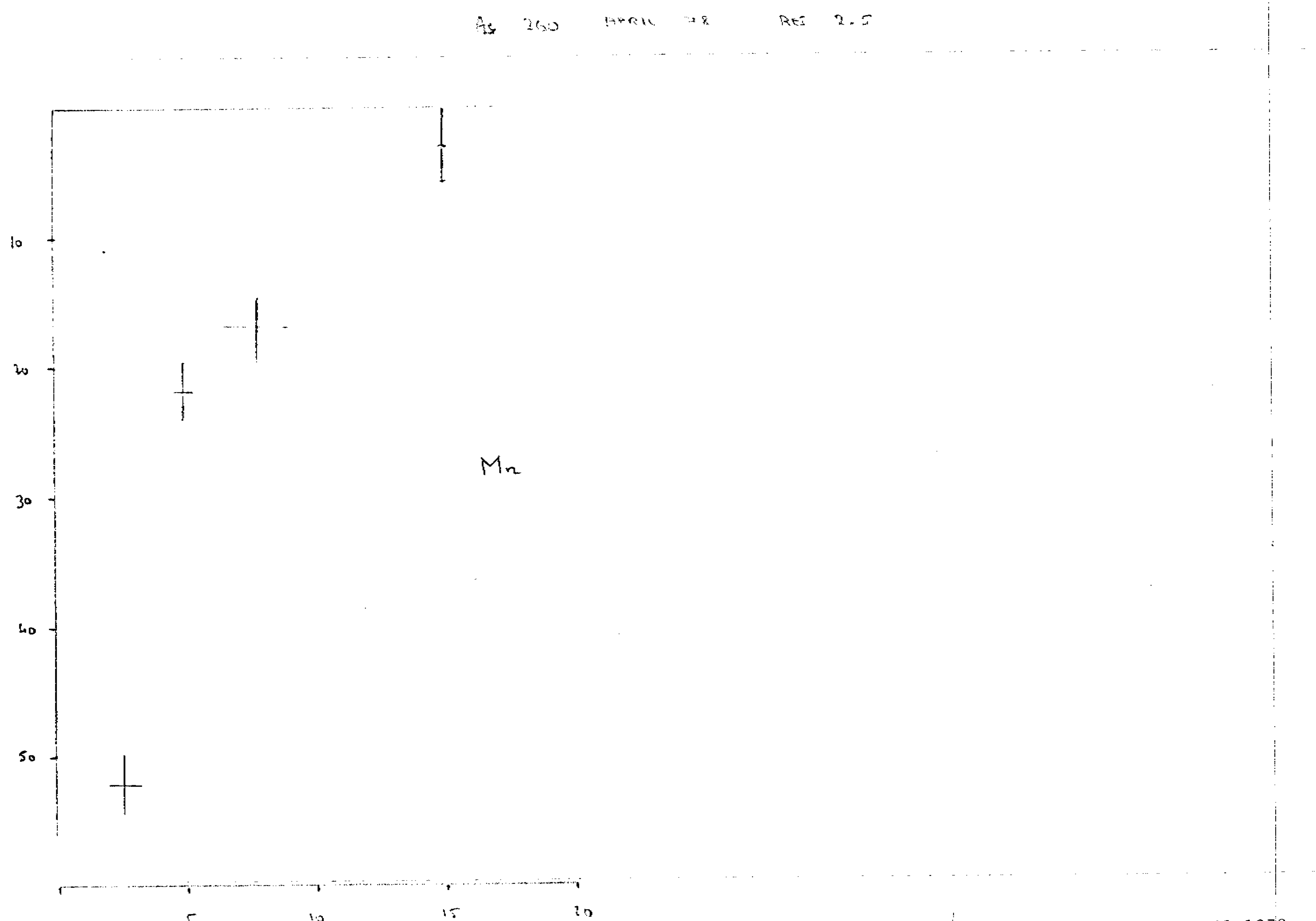



Figure 2. Manganese contents of organic association function of Resurrection Bay sediment. *Acona* 260, April 1978; Station RES 2.5.

TABLE IV

LOWER COOK INLET
OSS *DISCOVERER*, 4-16 MAY 1978
PARTICULATE SEDIMENT GEOCHEMISTRY AT TIME SERIES
STATION CB-7, KACHEMAK BAY

| Hour | Depth | Sediment load | Copper (µg/kg) | Mercury (ng/kg) | Manganese (µg/kg) | POC (µg/ℓ) |
|---|---|---|---|---|---|---|
| 0 | surface | | 0.52 | 29 | 0.58 | lost |
| 0 | deep | | 0.54 | 33 | 0.63 | lost |
| 6 | surface | | 0.59 | 13 | 0.54 | lost |
| 6 | deep | | 0.26 | 17 | 0.49 | lost |
| 12 | surface | | 0.68 | 18 | 0.49 | lost |
| 12 | deep | | 0.57 | 28 | 0.50 | lost |
| 18 | surface | | 0.82 | 20 | 0.48 | lost |
| 18 | deep | | 0.28 | 12 | 0.40 | lost |
| 26 | surface | | 0.72 | 18 | 0.40 | lost |
| 26 | deep | | 0.30 | 11 | 0.40 | 174 |
| 30 | surface | | 0.34 | 15 | 0.49 | - |
| 30 | deep | | 0.28 | 11 | 0.46 | - |
| 36 | surface | | 0.34 | 17 | 0.42 | - |
| 36 | deep | | 0.35 | 15 | 0.41 | - |
| 42 | surface | | 0.33 | 13 | 0.37 | - |
| 42 | deep | | 0.42 | 13 | 0.39 | - |

TABLE V

LOWER COOK INLET
OSS *DISCOVERER*, 4-16 MAY 1978
PARTICULATE SEDIMENT GEOCHEMISTRY AT TIME SERIES
STATION CB-9, REDOUBT BAY

| Hour | Depth | Sediment load | Copper (μg/kg) | Mercury (ng/kg) | Manganese (μg/kg) | POC* (μg/ℓ) |
|---|---|---|---|---|---|---|
| 0 | surface | | 0.67 | 13 | | 479 |
| 0 | deep | | 0.65 | 20 | | >1320 |
| 6 | surface | | 0.56 | >100 | | 304 |
| 6 | deep | | 0.63 | 34 | | 1453 |
| 12 | surface | | 1.04 | 30 | | 310 |
| 12 | deep | | 0.69 | 54 | | 579 |
| 18 | surface | | 0.76 | 26 | | 524 |
| 18 | deep | | 0.79 | 37 | | >1400 |
| 24 | surface | | 0.66 | 19 | | 671 |
| 24 | deep | | 0.94 | 63 | | 1265 |
| 30 | surface | | 0.79 | 15 | | - |
| 30 | deep | | 0.72 | 9 | | - |
| 36 | surface | | 0.67 | 19 | | - |
| 36 | deep | | 0.65 | 14 | | - |
| 42 | surface | | 0.57 | 25 | | - |
| 42 | deep | | 0.81 | 25 | | - |

*single determination

TABLE VI

LOWER COOK INLET
OSS *DISCOVERER*, 29 AUGUST - 2 SEPTEMBER 1978
PARTICULATE SEDIMENT GEOCHEMISTRY AT TIME SERIES
STATION CB-10

| Hour | Depth | POC (μg/ℓ) |
|---|---|---|
| 0 | surface | 369[a] |
| 0 | deep | 1500 ± 600 |
| 6 | surface | 303 ± 46 |
| 6 | deep | >2700[a] |
| 12 | surface | 867 ± 177 |
| 12 | deep | >2700[a] |
| 18 | surface | 153 ± 39 |
| 18 | deep | 2429 ± 8 |
| 24 | surface | 650 ± 43 |
| 24 | deep | 446 ± 32 |

[a]single determinations

TABLE VII

RESURRECTION BAY
R/V *ACONA* No. 254, DECEMBER 1977
CHEMISTRY OF PARTICULATE SEDIMENT (mg/g)
STATION RES 2.5

| Depth (m) | Mn | V | Al | POC |
|---|---|---|---|---|
| 10 | 3.20 ± .08 | 0.25 ± .07 | 71.8 ± 2.6 | 207 ± 1 |
| 30 | 3.64 ± .59 | 0.23 ± .03 | 93.6 ± 7.2 | 193 ± 24 |
| 70 | 4.53 ± .10 | 0.27 ± .03 | 94.9 ± 14.2 | 219 ± 108 |
| 110 | 5.23 ± .54 | 0.17 ± .05 | 78.4 ± 10.9 | 158 ± 12 |
| 130 | 3.33[a] | 0.18[a] | 58.9[a] | 133 ± 53 |
| 150 | 2.51[a] | 0.13[a] | 56.2[a] | 54 ± 24 |
| 170 | 3.78 ± .39 | 0.21 ± .03 | 70.0 ± 9.0 | 38 ± 6 |
| 190 | 1.97[a] | 0.10[a] | 51.8[a] | 62 ± 9 |
| 210 | 3.71 ± .24 | 0.19 ± .03 | 76.6 ± 4.3 | 63 ± 9 |
| 230 | 4.36 ± .36 | 0.19 ± .01 | 72.2 ± 0.7 | 31[a] |
| 250 | 5.80 ± .33 | 0.21 ± .02 | 78.8 ± 0.9 | 53 ± 6 |
| 260 | 6.78 ± .29 | 0.20 ± .01 | 77.3 ± 4.4 | 200[a] |
| 270 | 5.63 ± .24 | 0.17 ± .01 | 69.5 ± 3.2 | 193 ± 42 |
| 280 | 6.12 ± 1.14 | 0.20 ± .04 | 79.6 ± 18.8 | [444 ± 284] |
| 285 | 3.93 ± .08 | 0.16 ± .01 | 67.6 ± 2.2 | 128 ± 87 |

[a]Single determinations

TABLE VIII

RESURRECTION BAY
R/V *ACONA* No. 254, DECEMBER 1977
PARTICULATE SEDIMENT GEOCHEMISTRY (w/V)
STATION RES 2.5

| Depth (m) | Part. Sed. (mg/ℓ) | POC (μg/ℓ) | Al (μg/ℓ) | Mn (μg/ℓ) | V (μg/ℓ) |
|---|---|---|---|---|---|
| 10 | | 37 ± 0.2 | 12.7 ± 0.7 | 0.57 ± .02 | 0.04 ± .01 |
| 30 | | 35 ± 4 | 16.3 ± 3.1 | 0.62 ± .07 | 0.04 ± .01 |
| 70 | | 40 ± 19 | 17.7 ± 5.2 | 0.83 ± .14 | 0.05 ± .01 |
| 110 | | 25 ± 2 | 12.1 ± 0.2 | 0.81 ± .01 | 0.03 ± .01 |
| 130 | See | 31 ± 12 | 11.9[a] | 0.67[a] | 0.04[a] |
| 150 | separate | 24 ± 11 | 25.6[a] | 1.14[a] | 0.06[a] |
| 170 | table | 16 ± 2 | 28.3 ± 1.2 | 1.54 ± .03 | 0.09 ± .01 |
| 190 | | 47 ± 7 | 43.0[a] | 1.64[a] | 0.09[a] |
| 210 | | 39 ± 6 | 49.8 ± 1.1 | 2.33 ± .04 | 0.12 ± .01 |
| 230 | | 13[a] | 35.6 ± 7.0 | 2.12 ± .27 | 0.10 ± .02 |
| 250 | | 32 ± 4 | 48.0 ± 2.2 | 3.76 ± .31 | 0.13 ± .02 |
| 260 | | 116[a] | 44.4 ± 1.3 | 3.90 ± .17 | 0.12 ± .01 |
| 270 | | 149 ± 33 | 53.3 ± 2.7 | 4.33 ± .24 | 0.17 ± .01 |
| 280 | | [347 ± 220] | 60.7 ± 9.5 | 4.68 ± .51 | 0.15 ± .02 |
| 285 | | 176 ± 119 | 92.3 ± 2.8 | 5.37 ± .23 | 0.22 ± .01 |

[a]Single determinations

TABLE IX

RESURRECTION BAY
R/V *ACONA* No. 254, DECEMBER 1977
PARTICULATE SEDIMENT METAL/Al RATIOS
STATION RES 2.5

| Depth (m) | Mn/Al x $10^3$ | V/Al x $10^4$ |
|---|---|---|
| 10 | 44.5 | 34.6 |
| 30 | 38.6 | 24.4 |
| 70 | 48.6 | 28.6 |
| 110 | 67.1 | 20.9 |
| 130 | 56.6 | 31.1 |
| 150 | 44.7 | 23.7 |
| 170 | 42.4 | 29.7 |
| 190 | 38.1 | 19.8 |
| 210 | 46.8 | 23.1 |
| 230 | 60.3 | 26.7 |
| 250 | 73.6 | 26.0 |
| 260 | 87.7 | 25.2 |
| 270 | 81.1 | 24.8 |
| 280 | 77.4 | 25.1 |
| 285 | 58.2 | 23.9 |

TABLE X

RESURRECTION BAY
R/V *ACONA* No. 254, DECEMBER 1977
WATER COLUMN CHEMISTRY AT STATION RES 2.5

| Depth (m) | DOC (mg C/ℓ) |
|---|---|
| 10 | 0.52 ± 0.08 |
| 30 | 0.70 ± 0.14 |
| 70 | 0.37 ± 0.04 |
| 110 | 0.57 ± 0.14 |
| 130 | 0.34 ± 0.15 |
| 150 | 0.36 ± 0.02 |
| 170 | 0.24 ± 0.02 |
| 190 | 0.40 ± 0.05 |
| 210 | 0.74 ± 0.15 |
| 230 | 0.42 ± 0.17 |
| 250 | 1.05 ± 0.63 |
| 260 | 4.87 ± 0.70 |
| 270 | [7.9] |
| 280 | 0.53 ± 0.25 |
| 285 | 1.40 ± 0.19 |

TABLE XI

RESURRECTION BAY
R/V *ACONA* No. 260, APRIL 1978
CHEMISTRY OF PARTICULATE SEDIMENT (mg/g)
STATION RES 2.5

| Depth (m) | Mn | V | Al | POC |
|---|---|---|---|---|
| 10 | 0.57 ± .01 | 0.05 ± .01 | 18.41 ± 0.57 | 318 |
| 30 | 1.44 ± .09 | 0.11 ± .01 | 44.08 ± 0.58 | 190 |
| 70 | 2.75 ± .29 | 0.41 ± .20 | 89.09 ± 1.66 | 60.4 ± 9.4 |
| 110 | 2.92 ± .09 | 0.21 ± .01 | 86.90 ± 0.60 | 60.8 ± 8.7 |
| 170 | 2.18 ± .09 | 0.17 ± .03 | 82.79 ± 6.75 | 60.2 ± 6.5 |
| 190 | 1.80 ± .09 | 0.18 ± .01 | 76.39 ± 0.12 | 49.8 ± 3.0 |
| 210 | 1.62 ± .06 | 0.19 ± .02 | 79.32 ± 0.32 | 45.6 ± 0.5 |
| 230 | 1.90 ± .26 | 0.20 ± .01 | 79.00 ± 0.02 | 23.7 ± 0.5 |
| 250 | 2.38 ± .26 | 0.19 ± .02 | 75.04 ± 7.86 | 133.5 ± 57.0 |
| 260 | 2.74 ± .03 | 0.21 ± .01 | 76.68 ± 0.58 | 65.9 ± 25.2 |
| 270 | 5.32 ± .30 | 0.22 ± .01 | 83.03 ± 2.20 | 44.3 ± 5.0 |
| 280 | 6.06 ± .10 | 0.23 ± .01 | 81.65 ± 0.65 | 36.7 ± 0.5 |
| 285 | 5.30 ± .21 | 0.19 ± .03 | 74.76 ± 2.46 | 83.1 ± 49.4 |

TABLE XII

RESURRECTION BAY
R/V *ACONA* No. 260, APRIL 1978
PARTICULATE SEDIMENT GEOCHEMISTRY (w/V)
STATION RES 2.5

| Depth (m) | Part. Sed. (mg/ℓ) | POC (μg/ℓ) | Al (μg/ℓ) | Mn (μg/ℓ) | V (μg/ℓ) |
|---|---|---|---|---|---|
| 10 | | 418 | 24.23 ± 0.66 | 0.75 ± .01 | 0.07 ± .01 |
| 30 | | 93 | 21.73 ± 1.26 | 0.71 ± .02 | 0.05 ± .01 |
| 70 | | 26 ± 4 | 38.51 ± 2.51 | 1.19 ± .18 | 0.18 ± .10 |
| 110 | | 26 ± 4 | 37.54 ± 2.24 | 1.26 ± .03 | 0.09 ± .01 |
| 170 | | 32 ± 3 | 42.36 ± 0.57 | 1.12 ± .07 | 0.09 ± .02 |
| 190 | See | 24.6 ± 1.5 | 37.79 ± 4.05 | 0.89 ± .06 | 0.09 ± .01 |
| 210 | separate | 27.5 ± .3 | 47.71 ± 1.24 | 0.98 ± .06 | 0.12 ± .01 |
| 230 | table | 15.7 ± .3 | 52.44 ± 2.33 | 1.26 ± .12 | 0.13 ± .01 |
| 250 | | 106 ± 46 | 58.84 ± 0.94 | 1.86 ± .04 | 0.14 ± .01 |
| 260 | | 50 ± 20 | 58.56 ± 5.44 | 2.10 ± .23 | 0.16 ± .01 |
| 270 | | 26 ± 3 | 48.61 ± 0.21 | 3.11 ± .08 | 0.13 ± .01 |
| 280 | | 31.1 ± .4 | 69.36 ± 1.05 | 5.15 ± .13 | 0.21 ± .01 |
| 285 | | 92 ± 55 | 82.86 ± 5.95 | 5.87 ± .36 | 0.22 ± .05 |

TABLE XIII

RESURRECTION BAY
R/V *ACONA* NO. 260, APRIL 1978
PARTICULATE SEDIMENT METAL/Al RATIOS
STATION RES 2.5

| Depth (m) | Mn/Al x $10^3$ | V/Al x $10^4$ |
|---|---|---|
| 10 | 30.9 | 25.5 |
| 30 | 32.6 | 24.1 |
| 70 | 30.7 | 45.5 |
| 110 | 33.5 | 24.3 |
| 170 | 26.4 | 20.7 |
| 190 | 23.5 | 23.6 |
| 210 | 20.4 | 24.3 |
| 230 | 24.0 | 25.4 |
| 250 | 31.6 | 24.5 |
| 260 | 35.7 | 27.0 |
| 270 | 64.0 | 25.8 |
| 280 | 74.2 | 28.4 |
| 285 | 70.8 | 25.3 |

TABLE XIV

RESURRECTION BAY
R/V *ACONA* No. 262, JULY 1978
PARTICULATE SEDIMENT GEOCHEMISTRY (w/V)
STATION RES 2.5

| Depth (m) | Part. Sed. (mg/ℓ) | POC (μg/ℓ) |
|---|---|---|
| 10 | | 652 |
| 30 | | 309 ± 53 |
| 70 | | 59 ± 17 |
| 110 | | 251 ± 46 |
| 170 | See | 97 ± 1 |
| 190 | separate | 42 ± 10 |
| 210 | table | 110 ± 1 |
| 230 | | 65 ± 16 |
| 250 | | 208 ± 35 |
| 260 | | 33 ± 1 |
| 270 | | 58 ± 8 |
| 280 | | 60 ± 12 |

TABLE XV

RESURRECTION BAY
R/V *ACONA* No. 262, JULY 1978
CHEMISTRY OF PARTICULATE SEDIMENT (mg/g)
STATION RES 2.5

| Depth (m) | POC |
|---|---|
| 10 | 756 |
| 30 | 363 ± 62 |
| 70 | 211 ± 59 |
| 110 | 323 ± 59 |
| 170 | 162 ± 2 |
| 190 | 72 ± 17 |
| 210 | 168 ± 2 |
| 230 | 94 ± 23 |
| 250 | 348 ± 58 |
| 260 | 52 ± 1 |
| 270 | 88 ± 12 |
| 280 | 56 ± 11 |

TABLE XVI

RESURRECTION BAY
SEASONAL SUSPENDED SEDIMENT LOAD (mg/ℓ)
STATION RES 2.5

| Depth (m) | *Acona* No. 256 December 1977 | *Acona* No. 260 April 1978 | *Acona* No. 262 July 1978 |
|---|---|---|---|
| 10 | 0.18 ± .01 | 1.32 ± .01 | 0.862 ± .017 |
| 30 | 0.18 ± .04 | 0.49 ± .02 | 0.849 ± .043 |
| 70 | 0.18 ± .03 | 0.43 ± .02 | 0.281 ± .004 |
| 110 | 0.16 ± .02 | 0.43 ± .02 | 0.778 ± .068 |
| 130 | 0.22 ± .02 | | |
| 170 | 0.45 ± 0 | 0.52 ± .05 | 0.595 ± .012 |
| 190 | 0.41 ± .04 | 0.49 ± .05 | 0.582 ± .006 |
| 210 | 0.76 ± .07 | 0.60 ± .01 | 0.651 ± .048 |
| 230 | 0.63 ± .03 | 0.66 ± .03 | 0.696 ± .042 |
| 250 | 0.40 ± .01 | 0.79 ± .07 | 0.598 ± .007 |
| 260 | 0.61 ± .02 | 0.76 ± .08 | 0.634 ± .064 |
| 270 | 0.58 ± .05 | 0.59 ± .02 | 0.662 ± .135 |
| 280 | 0.77 ± .07 | 0.85 ± .01 | 1.072 ± .072 |
| 285 | 0.79 ± .03 | 1.11 ± .04 | |

F. Aquaria Experiments on Food Chain Transfers of Heavy Metals

See following section.

G. Heavy Metal Contents of Bering Sea Marine Mammals

The final results of this one-year sub-project are given in Appendix V.

## IV. PRELIMINARY INTERPRETATION

### A. Natural Flux of Heavy Metals in Alaskan Fjord Estuaries

As explained previously, the deep basins of these fjords appear to function as ideal natural environments for the study of benthic boundary reactions. We are interested in the transport of chemicals to this interface; chemical transformations within the sediment; the potential flux of elements back into the water column; the role of microorganisms in transferring chemicals from this reservoir to the food web (see next section); and the likely impact of man introduced pollutants on these natural reactions.

We are currently working intensively at station RES 2.5 in Resurrection Bay. Only partial data are available at this time.

Following the observations of marked gradients for "soluble" manganese at the base of the water column (positive to the interface) in Yakutat Bay, discussed in the previous Annual Report, we have tended to concentrate efforts on this element. Figures 3 and 4 show fractions of Mn and Al in the particulate sediment (mg/g; vertical profiles). Metal/Al ratio plots as shown in Figures 5 and 6 may be taken to represent oxide/alumino-silicate distributions of particulates in the column. The marked increase in this ratio at the base of the column may be tentatively interpreted as indicating a gradient of solid phase Mn(IV) towards the boundary. (The reversal at the very base of the column may probably be safely attributed to a sampling artifact: disturbance of the bottom sediment by the weight or fish. In this context the increase in suspended load at the bottom shown in Figure 7 should be noted. In other estuarine environments natural bottom resuspension would be expected, but not here, and not in the oceanographic winter. However, natural or otherwise, dilution of the column sediment by alumino-silicate rich resuspended sediment seems likely.) Figure 8 shows the particulate organic carbon distributions at the same station and seasons.

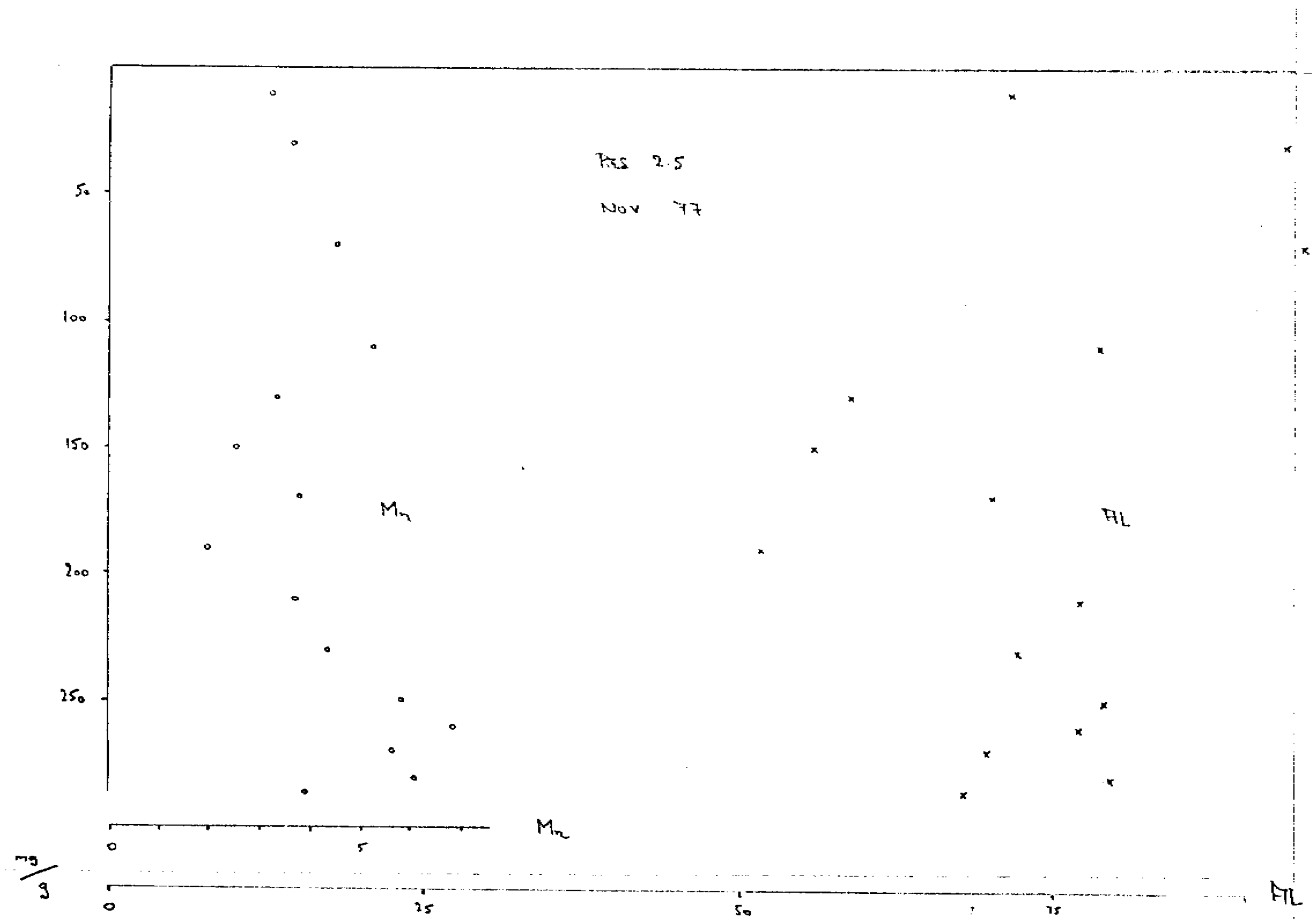



Figure 3. Particulate Mn and Al (μg/g). Station RES 2.5; November 1977.

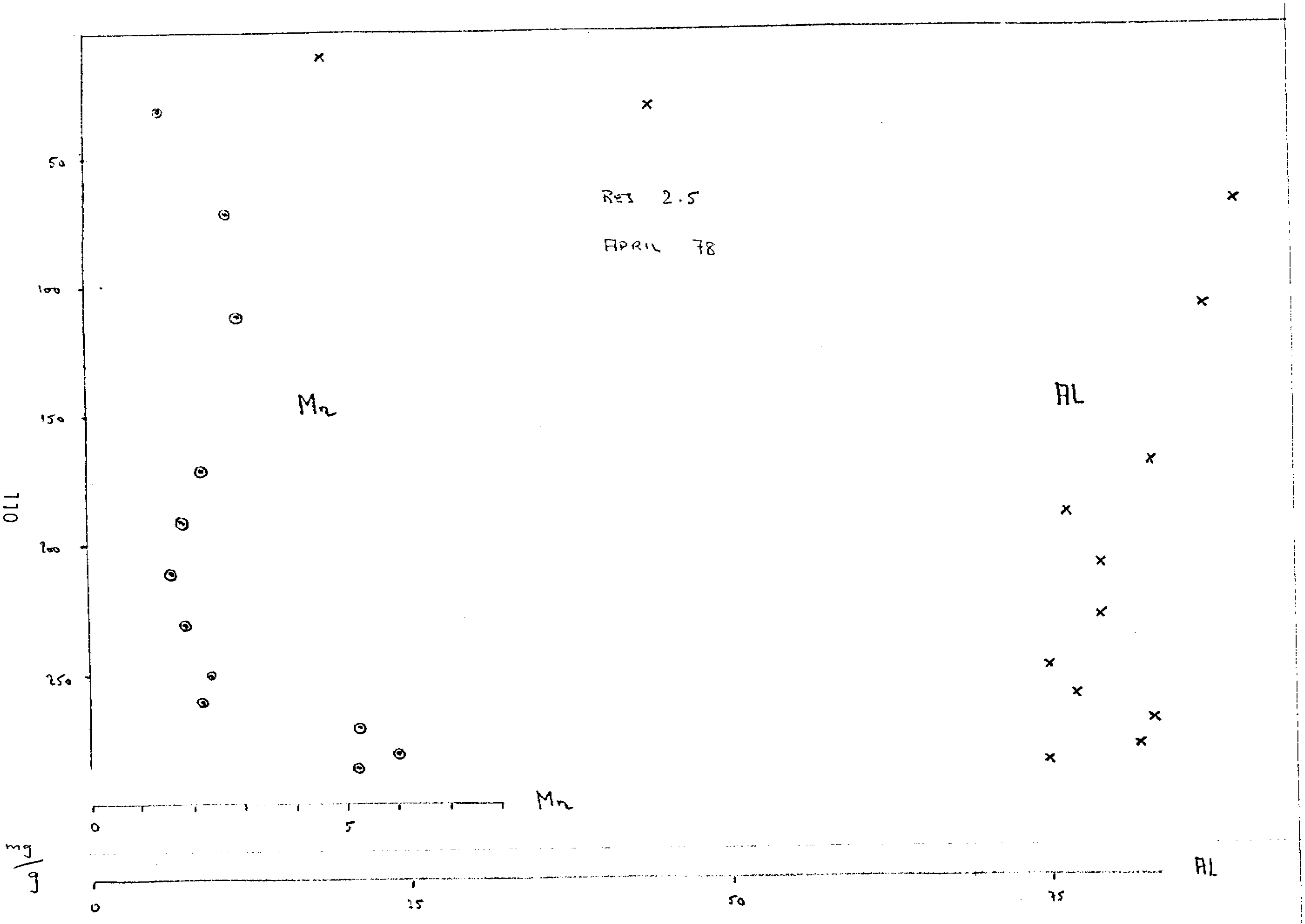



Figure 4. Particulate Mn and Al (μg/g). Station RES 2.5; April 1978.

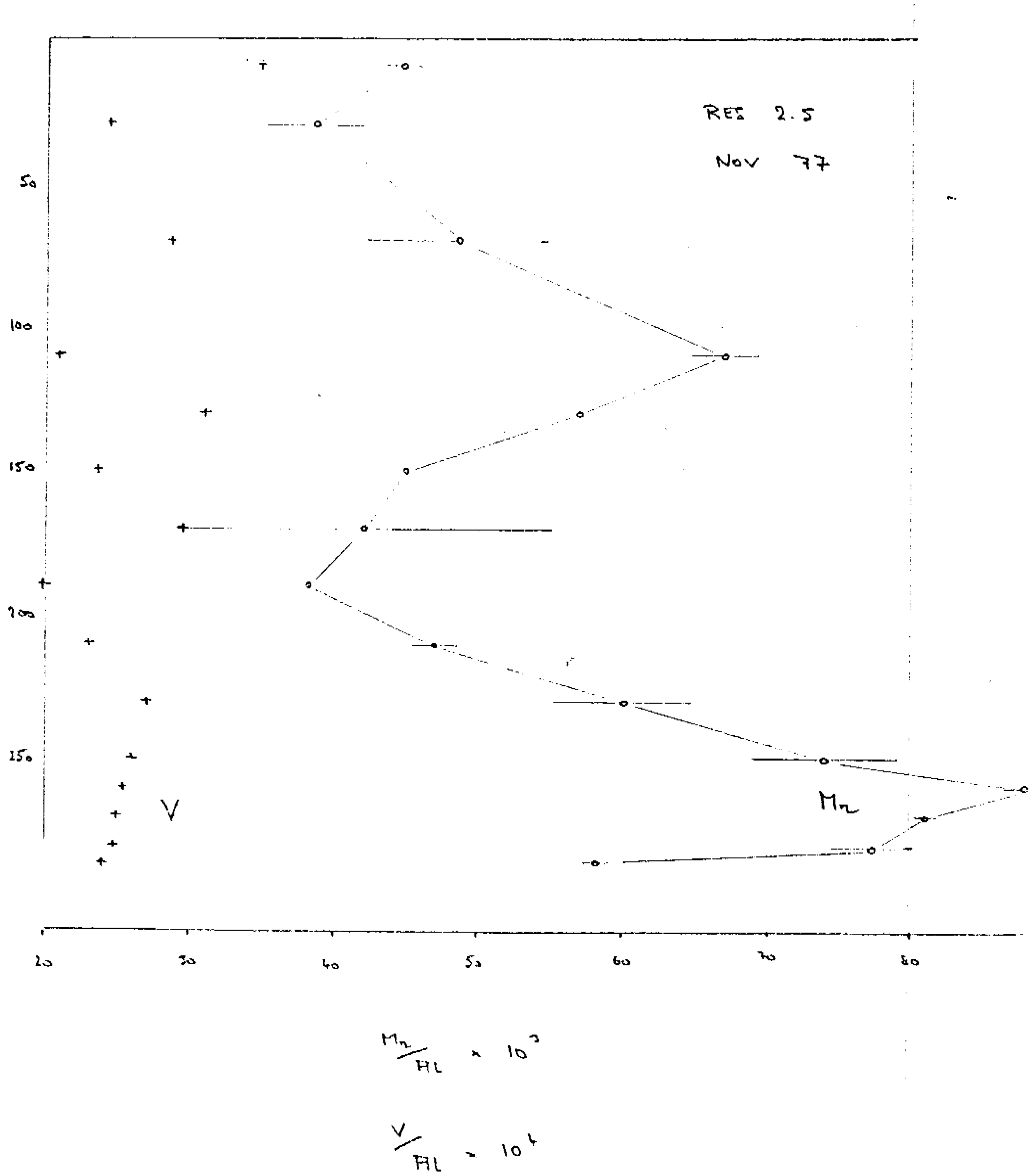



Figure 5. Metal/Al ratios of particulate sediment. Station RES 2.5; November 1977.

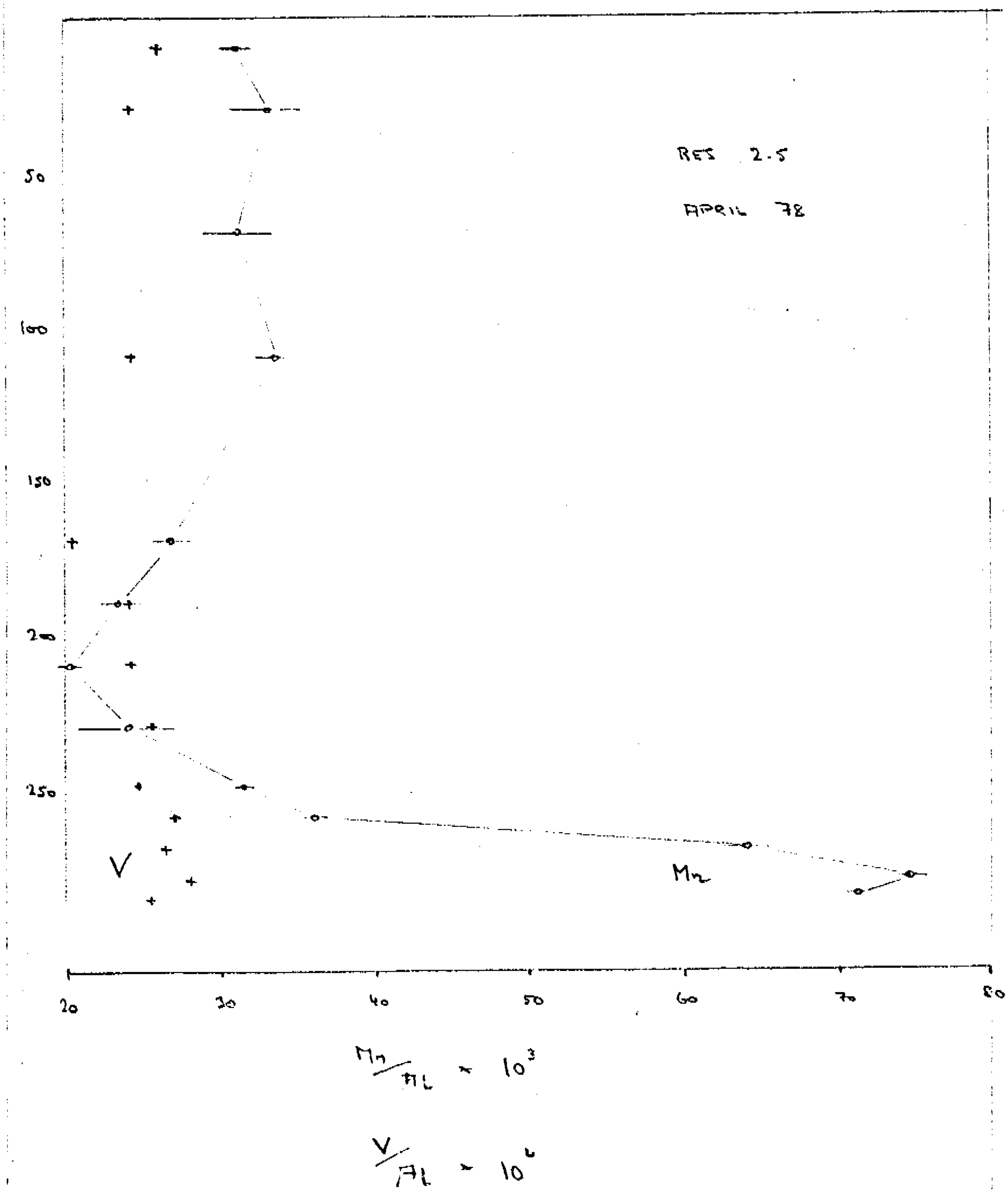



Figure 6. Metal/Al ratios of particulate sediment. Station RES 2.5; April 1978.

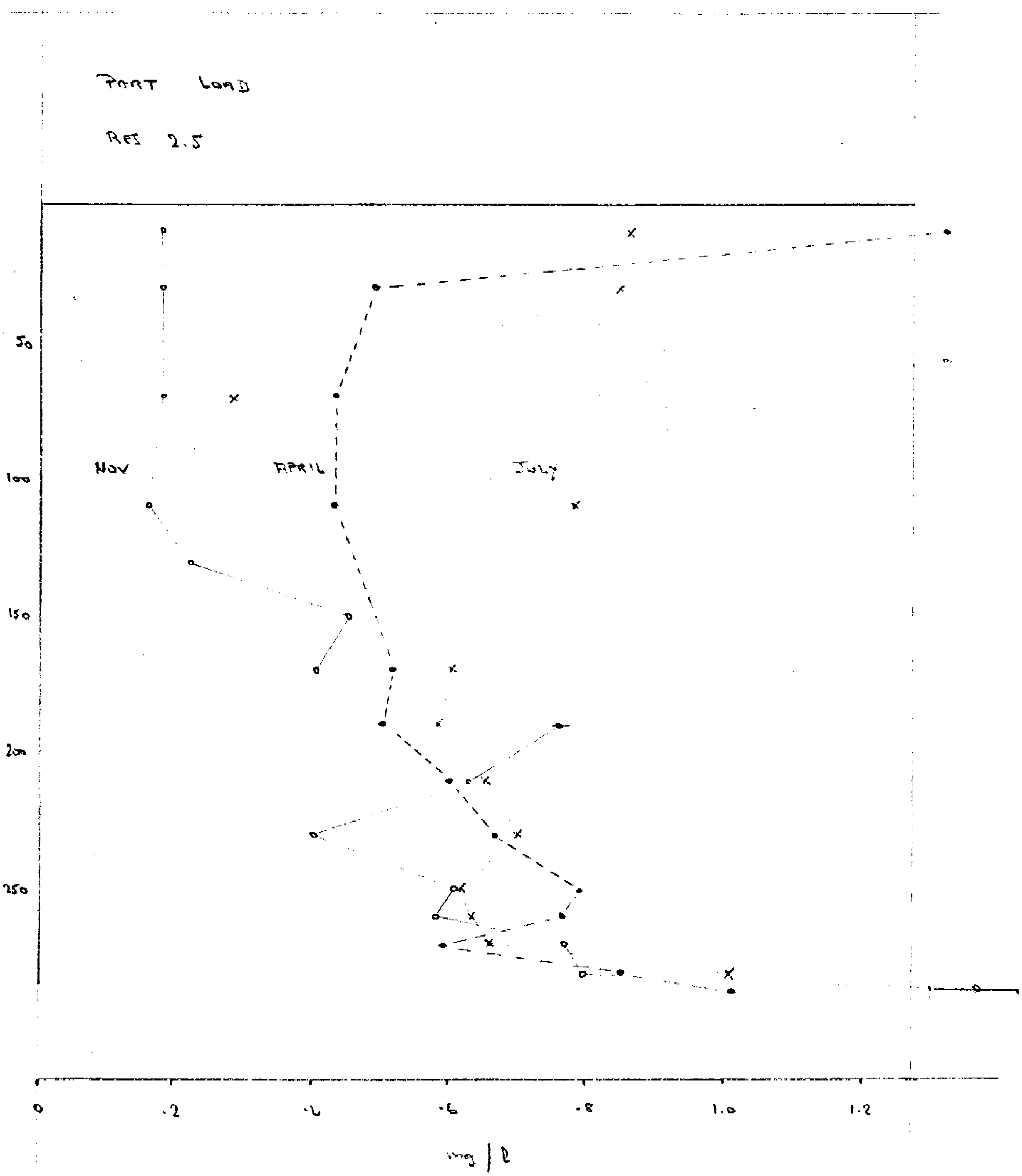



Figure 7. Seasonal particulate load distribution at Station RES 2.5.

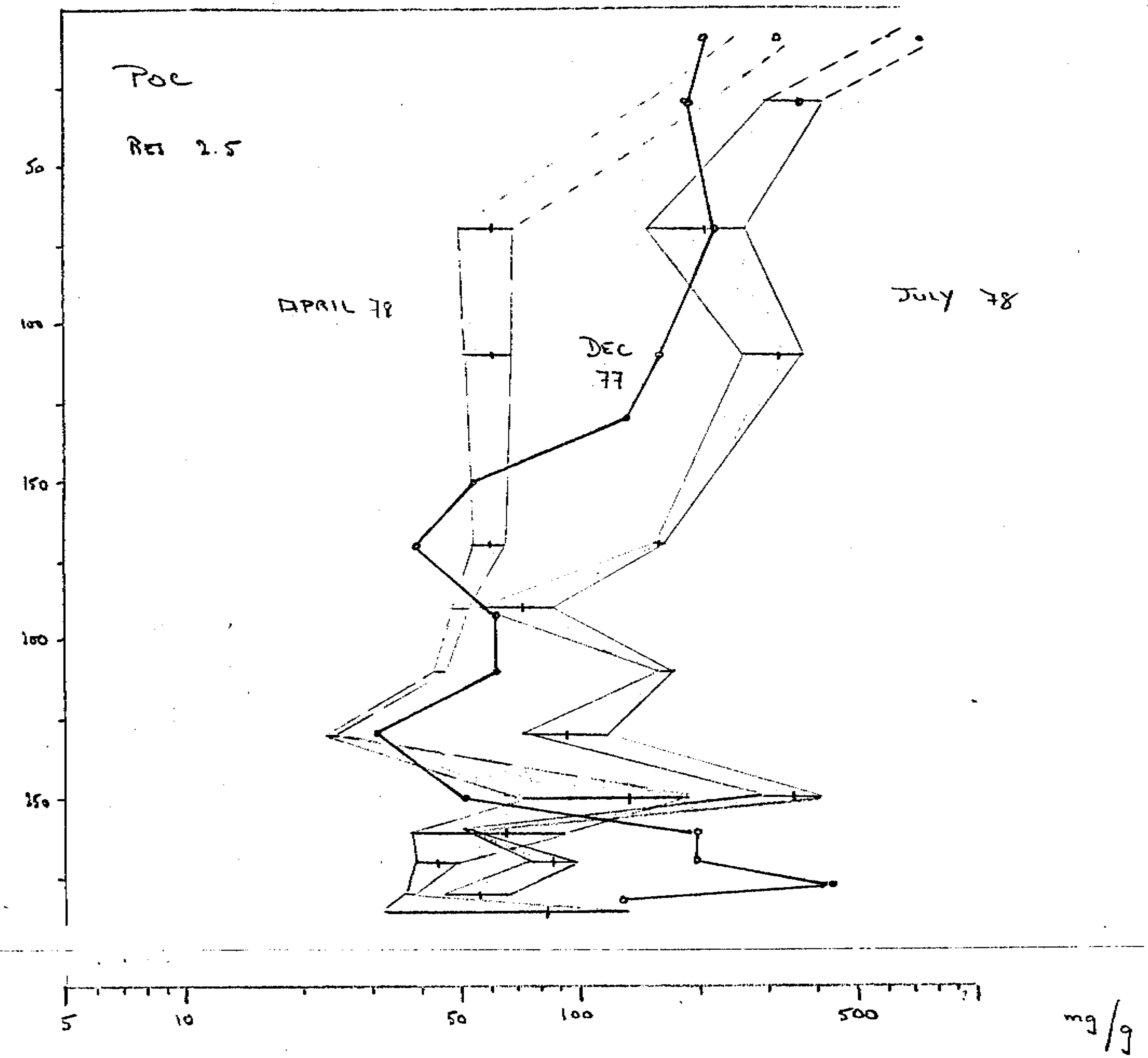



Figure 8. Seasonal particulate organic carbon distributions at Station RES 2.5.

A gradient of particulate Mn and soluble/colloidal manganese towards the sediment interface argues for a substantial flux of this metal out of the sediments. It is not intended to discuss sediment/interstitial water geochemistry here in any detail, neither is much of our own sediment data available yet. However, Figure 9, from an old data set, illustrates the distribution of "soluble" interstitial water manganese and iron at this station. Oxidation and immobilization of iron in the upper part of the sediment is apparent; this sequence is not shown in the manganese profile.

B. Aquaria Experiments on Food Chain Transfers of Heavy Metals

Figure 10 illustrates the results of the oiling experiment described above. There is no significant difference of biomass (optical density) with time between control populations of the G-negative rod culture and cultures grown in media oiled as shown. Figure 11 illustrates the relationship between the optical density parameter and actual dry weight of separated biomass. The cadmium content of the bacteria - as an example of heavy metal behavior during hydrocarbon stress - was also monitored during the course of this experiment as shown in Table XVII. This was "natural content" i.e. no extra Cd was added to the growth medium. The overall values are unusually high, and this is probably a function of the particular sediment extract added to the broth; however, there is no evidence for systematic changes in this content during the course of the experiment.

Figure 12 illustrates a detailed growth curve for the isolated culture and also behavior with 0.1 ppm cadmium added to the growth medium. Cadmium delays growth; but there is no effect on the final steady state phase (The illustration is misleading in this respect since space limitations have required a cut-off at 30 hours; the two growth curves come together a little later.)

We originally reported significant transfer of cadmium from bacteria to clams. The interpretation of this original experiment was complicated because of the number of variables involved and new mass balance

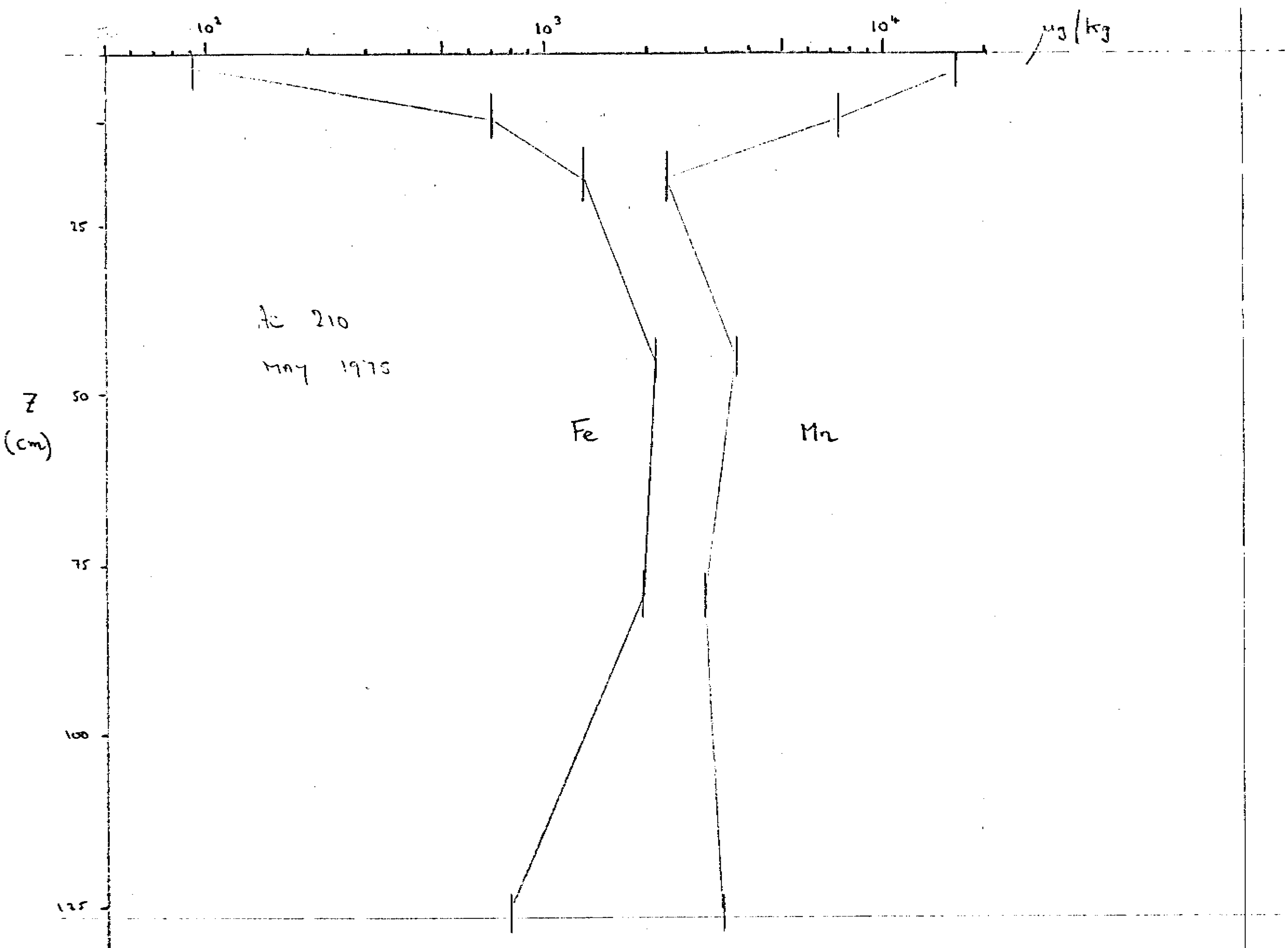



Figure 9. Distribution of interstitial water Mn and Fe. Station RES 2.5; May 1978.
Data provided by D. T. Heggie.

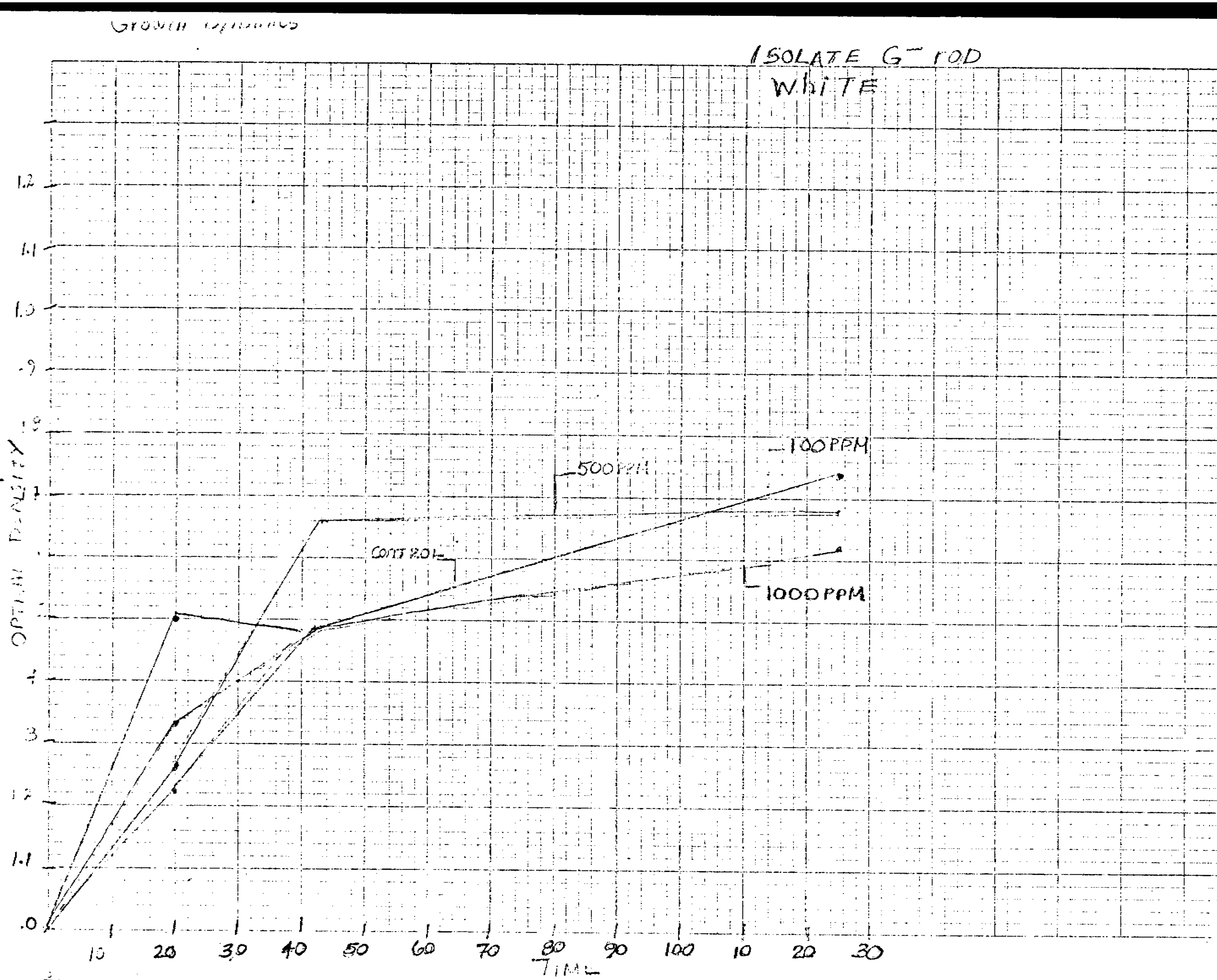



Figure 10. Results of oiling experiment.

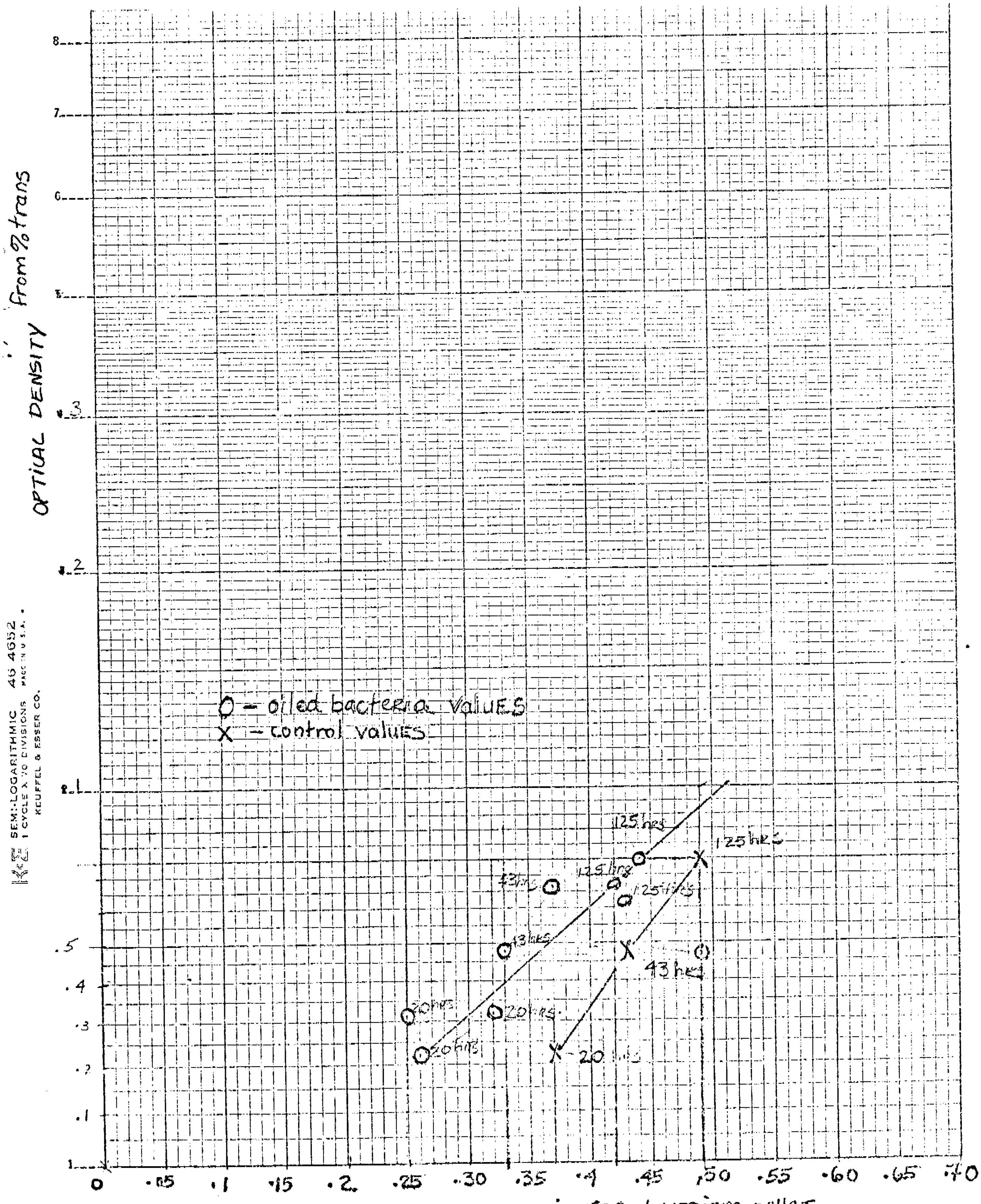



Figure 11. Relationship between the optical density parameter and actual dry weight of separated biomass.

TABLE XVII

CADMIUM CONTENT OF PURE BACTERIA CULTURE UNDER VARIOUS OILING CONDITIONS

| Sample No. | Conc of crude in growth medium (ppm) | Elapsed population growth time (hrs) | Cadmium content of bacteria (μg/g) |
|---|---|---|---|
| 1 | control | 20 | 2.8 |
| | 500 | 20 | 6.3 |
| | 1000 | 20 | - |
| 2 | control | 43 | 3.6 |
| | 100 | 43 | 3.8 |
| | 500 | 43 | 3.8 |
| | 1000 | 43 | 4.8 |
| 3 | control | 125 | 4.2 |
| | 100 | 125 | 3.3 |
| | 500 | 125 | 3.2 |
| | 1000 | 125 | 2.2 |

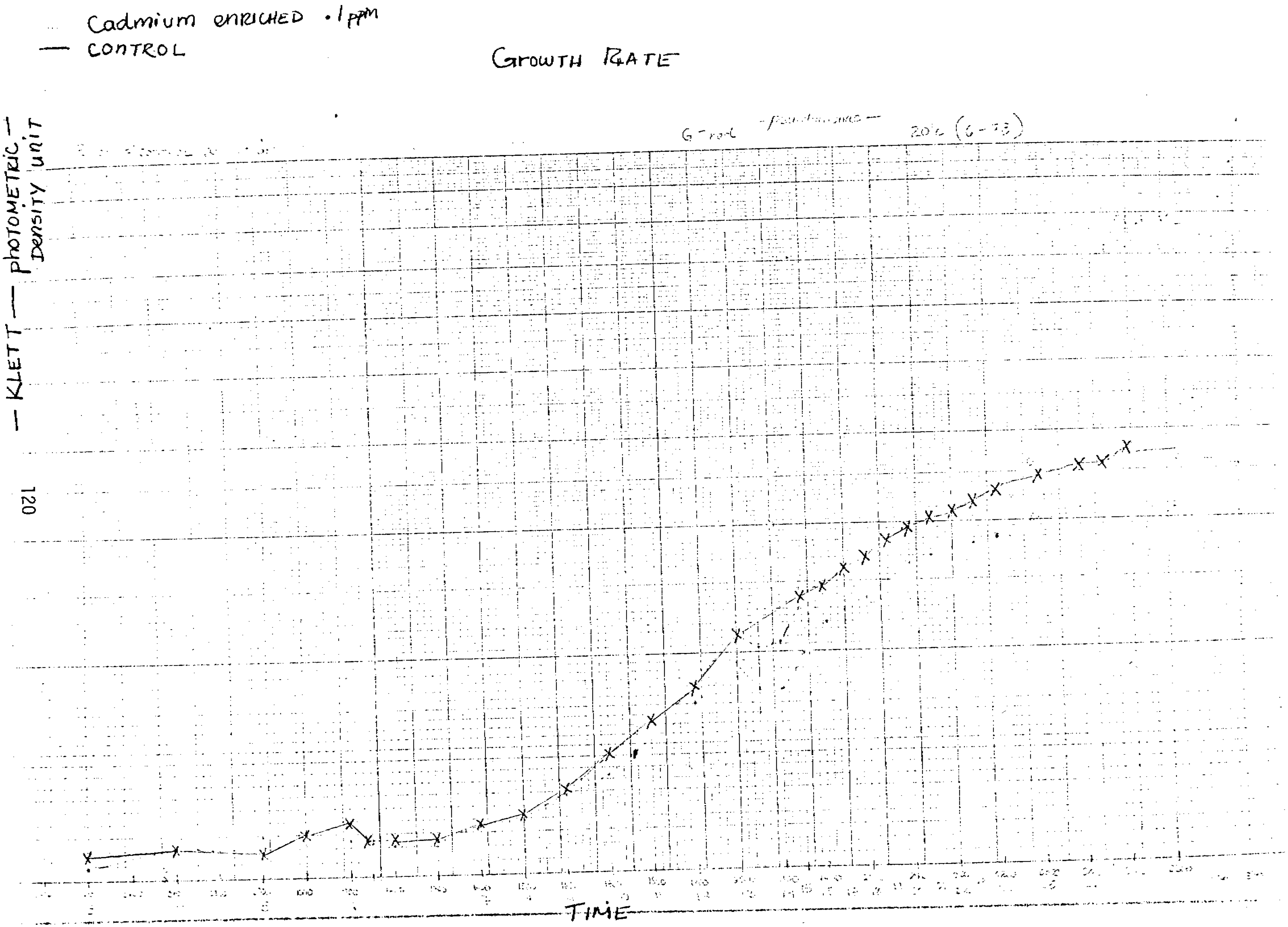



Figure 12. Growth curve.

assessments show that these initial results cannot unequivocally support our earlier conclusions. This experiment is being repeated at the present time with the separated culture and with special emphasis on transfer of sufficient bacterial biomass to give measurable Cd uptake by the clams. The experimental design is quite difficult because of analysis detection limitations; a third experiment is being planned using radio tracers.

## V. PROBLEMS ENCOUNTERED

1. We have experienced an incredible amount of equipment down-time this quarter. In particular the plasma furnace has been inoperable over most of this period. It has been returned to the manufacturer but so far without notable signs of improvement. This has caused us to postpone the Lower Cook Inlet biota analysis, not just for the latest cruise (August), but also for the three previous cruises as well. The atomic absorption spectrophotometer has also malfunctioned but this has been fixed, as has the distilled water system. The new Spectrex size analysis instrument has, in spite of considerable effort, never performed satisfactorily. This machine has also been returned to the manufacturers for service but, at this time, we suspect fundamental design problems.

2. Activation analysis has also been delayed because of malfunction of the University of California reactor. It is hoped to complete this phase of the program during the next quarter.

3. We have expended a considerable amount of effort in designing the sediment extract scheme described earlier. We were delayed for a long period because of non-arrival of Ultrex chemicals but this part of the program is now operating smoothly.

4. Both of our special trace metal sampling bottles were damaged beyond repair during the August *Discoverer* cruise.

APPENDIX I

Resurrection Bay

R/V *Acona* Cruise No. 253

November 1977

Hydrographic Data

AC CRUISE 253 CONSECUTIVE STATION NO. 33. RES2.5 17/11/77
19.0 HOURS GMT

LATITUDE = 60 1.2N LONGITUDE = 149 21.5W SONIC DEPTH = 289 M

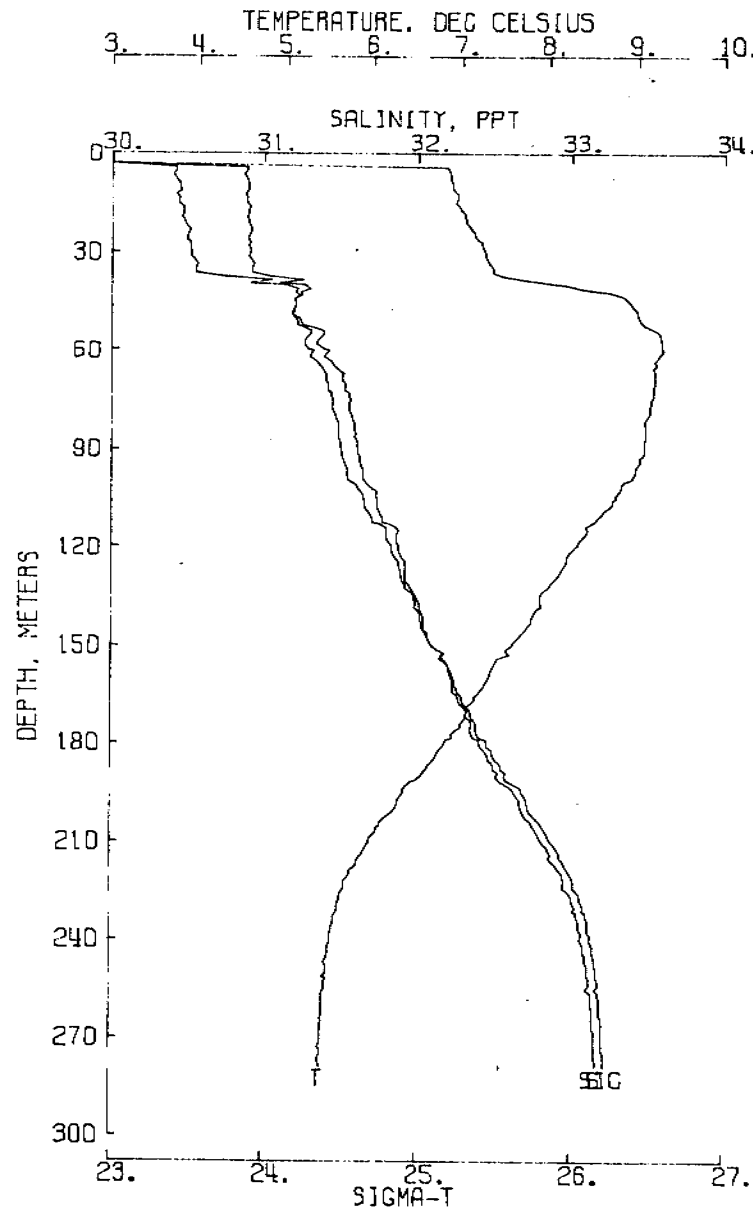
1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS .
CLOUD AMOUNT --- (8) ---8/8 TOTAL .
VISIBILITY --- (6) ---4-10 KM

| | DIRECTION | SPEED |
|---|---|---|
| WIND | 0 - 0 DEGR | 15 KNOTS |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 0 - 0 DEGR | 0.2 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | |
|---|---|---|
| TEMPERATURES -DRY = 0.6 DEGR C. | BAROMETRIC PR. =1032.1 MB | |
| -WET = DEGR C. | TRANSPARENCY = M | |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 2.0 | -1.67 | 26.585 | 21.38 | 0.013 |
| 1.0 | -1.66 | 26.585 | 21.38 | 0.006 |
| 5.0 | 6.84 | 30.419 | 23.88 | 0.027 |
| 10.0 | 6.88 | 30.447 | 23.90 | 0.047 |
| 15.0 | 6.94 | 30.432 | 23.88 | 0.068 |
| 20.0 | 7.04 | 30.469 | 23.89 | 0.088 |
| 25.0 | 7.16 | 30.494 | 23.90 | 0.108 |
| 30.0 | 7.27 | 30.528 | 23.91 | 0.128 |
| 35.0 | 7.36 | 30.551 | 23.92 | 0.148 |
| 40.0 | 8.18 | 31.140 | 24.26 | 0.167 |
| 45.0 | 8.92 | 31.210 | 24.21 | 0.186 |
| 50.0 | 9.02 | 31.230 | 24.21 | 0.205 |
| 60.0 | 9.30 | 31.421 | 24.32 | 0.241 |
| 70.0 | 9.26 | 31.531 | 24.42 | 0.277 |
| 75.0 | 9.17 | 31.559 | 24.44 | 0.295 |
| 80.0 | 9.12 | 31.571 | 24.46 | 0.312 |
| 90.0 | 9.09 | 31.612 | 24.50 | 0.347 |
| 100.0 | 8.96 | 31.644 | 24.56 | 0.382 |
| 125.0 | 8.19 | 31.917 | 24.87 | 0.463 |
| 150.0 | 7.57 | 32.092 | 25.10 | 0.538 |
| 175.0 | 6.98 | 32.354 | 25.38 | 0.607 |
| 200.0 | 6.25 | 32.680 | 25.73 | 0.668 |
| 250.0 | 5.47 | 33.122 | 26.17 | 0.769 |




CRUISE 253 STATION 33

AC CRUISE 253 CONSECUTIVE STATION NO. 32. RES 5 17/11/77
17.5 HOURS GMT

LATITUDE = 59 50.7N LONGITUDE = 149 28.0W SONIC DEPTH = 265 M

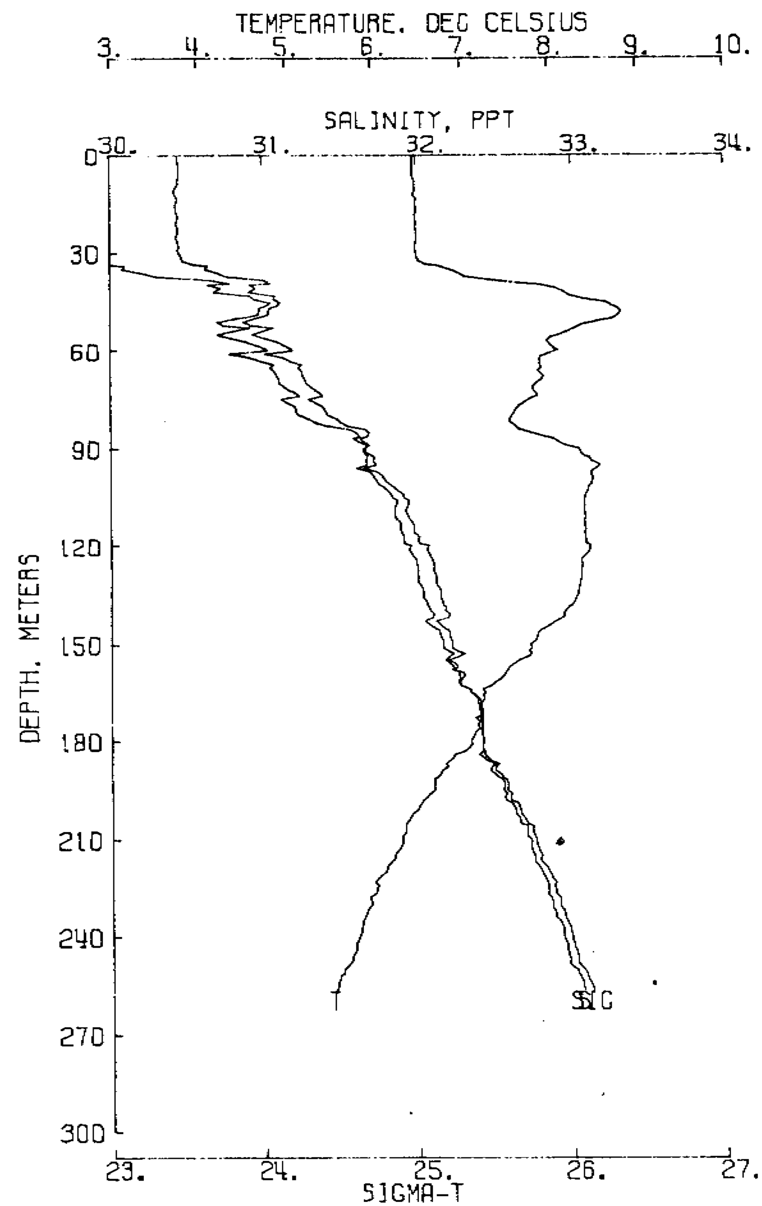
1-DIGIT WEATHER CODE IS (X2) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (6) ---STRATOCUMULUS .
CLOUD AMOUNT --- (8) ---8/8 TOTAL .
VISIBILITY --- (7) ---10-20 KM

| | DIRECTION | SPEED |
|---|---|---|
| WIND | 335 - 344 DEGR | 26 KNOTS |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 335 - 344 DEGR | 1.0 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| TEMPERATURES | | | |
|---|---|---|---|
| -DRY = | -1.1 DEGR C. | BAROMETRIC PR. = | 1031.1 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 2.0 | 6.46 | 29.799 | 23.44 | 0.009 |
| 1.0 | 6.46 | 29.799 | 23.44 | 0.004 |
| 5.0 | 6.46 | 29.823 | 23.46 | 0.022 |
| 10.0 | 6.49 | 29.793 | 23.43 | 0.045 |
| 15.0 | 6.49 | 29.796 | 23.43 | 0.067 |
| 20.0 | 6.49 | 29.803 | 23.44 | 0.089 |
| 25.0 | 6.50 | 29.802 | 23.44 | 0.112 |
| 30.0 | 6.50 | 29.833 | 23.46 | 0.134 |
| 35.0 | 6.86 | 30.085 | 23.61 | 0.156 |
| 40.0 | 7.89 | 30.641 | 23.91 | 0.176 |
| 45.0 | 8.67 | 31.039 | 24.11 | 0.196 |
| 50.0 | 8.74 | 30.826 | 23.94 | 0.215 |
| 60.0 | 8.10 | 31.030 | 24.19 | 0.254 |
| 70.0 | 7.85 | 31.104 | 24.28 | 0.292 |
| 75.0 | 7.79 | 31.108 | 24.30 | 0.310 |
| 80.0 | 7.57 | 31.238 | 24.43 | 0.327 |
| 90.0 | 8.34 | 31.673 | 24.66 | 0.361 |
| 100.0 | 8.50 | 31.794 | 24.73 | 0.394 |
| 125.0 | 8.37 | 32.105 | 24.99 | 0.472 |
| 150.0 | 7.79 | 32.219 | 25.17 | 0.545 |
| 175.0 | 7.17 | 32.413 | 25.40 | 0.613 |
| 200.0 | 6.50 | 32.613 | 25.65 | 0.676 |
| 250.0 | 5.64 | 33.029 | 26.08 | 0.784 |




CRUISE 253 STATION 32

APPENDIX II

Resurrection Bay

R/V *Acona* Cruise No. 256

February 1978

Hydrographic Data

AC CRUISE 256 ON WECOMA STATION NO. 1, RES2.5 16/ 2/78
20.1 HOURS GMT

LATITUDE = 60 1.0N LONGITUDE = 149 22.0W SONIC DEPTH = 289 M

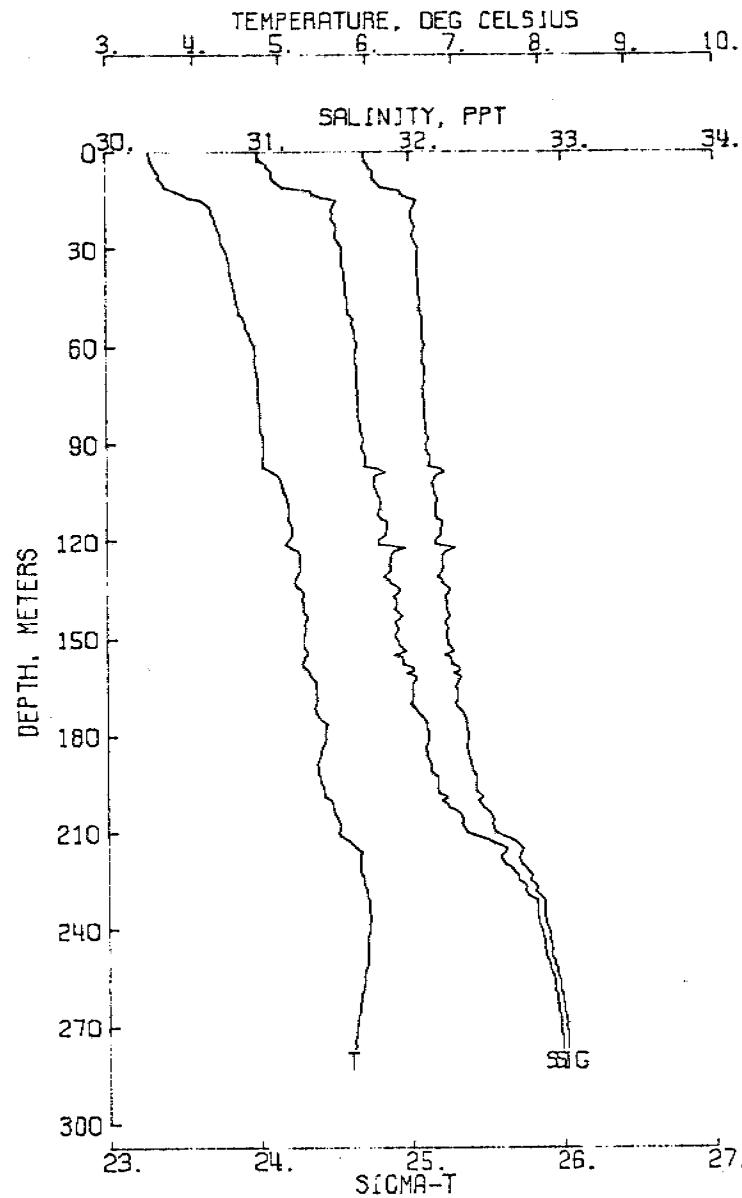
1-DIGIT WEATHER CODE IS (6) AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED .
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- (6) ---4-10 KM

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 0 - 0 DEGR | KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 0 - 0 DEGR | 0.0 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | |
|---|---|---|
| TEMPERATURES -DRY = 4.4 DEGR C. | BAROMETRIC PR. =1003.5 MB | |
| -WET = DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 3.49 | 30.995 | 24.69 | 0. |
| 1.0 | 3.49 | 30.995 | 24.69 | 0.003 |
| 5.0 | 3.56 | 31.055 | 24.73 | 0.016 |
| 10.0 | 3.48 | 31.112 | 24.77 | 0.032 |
| 15.0 | 4.09 | 31.512 | 25.05 | 0.048 |
| 20.0 | 4.23 | 31.498 | 25.01 | 0.062 |
| 25.0 | 4.30 | 31.511 | 25.02 | 0.077 |
| 30.0 | 4.36 | 31.555 | 25.05 | 0.092 |
| 35.0 | 4.41 | 31.551 | 25.05 | 0.106 |
| 40.0 | 4.45 | 31.573 | 25.06 | 0.121 |
| 45. | 4.49 | 31.590 | 25.07 | 0.136 |
| 50.0 | 4.53 | 31.593 | 25.07 | 0.150 |
| 60.0 | 4.70 | 31.650 | 25.09 | 0.179 |
| 70.0 | 4.74 | 31.650 | 25.09 | 0.208 |
| 75.0 | 4.75 | 31.646 | 25.09 | 0.223 |
| 80.0 | 4.76 | 31.656 | 25.09 | 0.237 |
| 90.0 | 4.82 | 31.694 | 25.11 | 0.266 |
| 100.0 | 4.97 | 31.770 | 25.16 | 0.294 |
| 125.0 | 5.23 | 31.862 | 25.21 | 0.365 |
| 150.0 | 5.26 | 31.909 | 25.24 | 0.434 |
| 175.0 | 5.44 | 32.095 | 25.36 | 0.501 |
| 200.0 | 5.57 | 32.205 | 25.44 | 0.567 |
| 250.0 | 5.99 | 32.902 | 25.94 | 0.681 |




CRUISE 256 STATION 1

AC CRUISE 256 CONSECUTIVE STATION NO. 2, RES003 16/ 2/78
21.3 HOURS GMT

LATITUDE = 6? 59.0N LONGITUDE = 149 20.5W SONIC DEPTH = 290 M

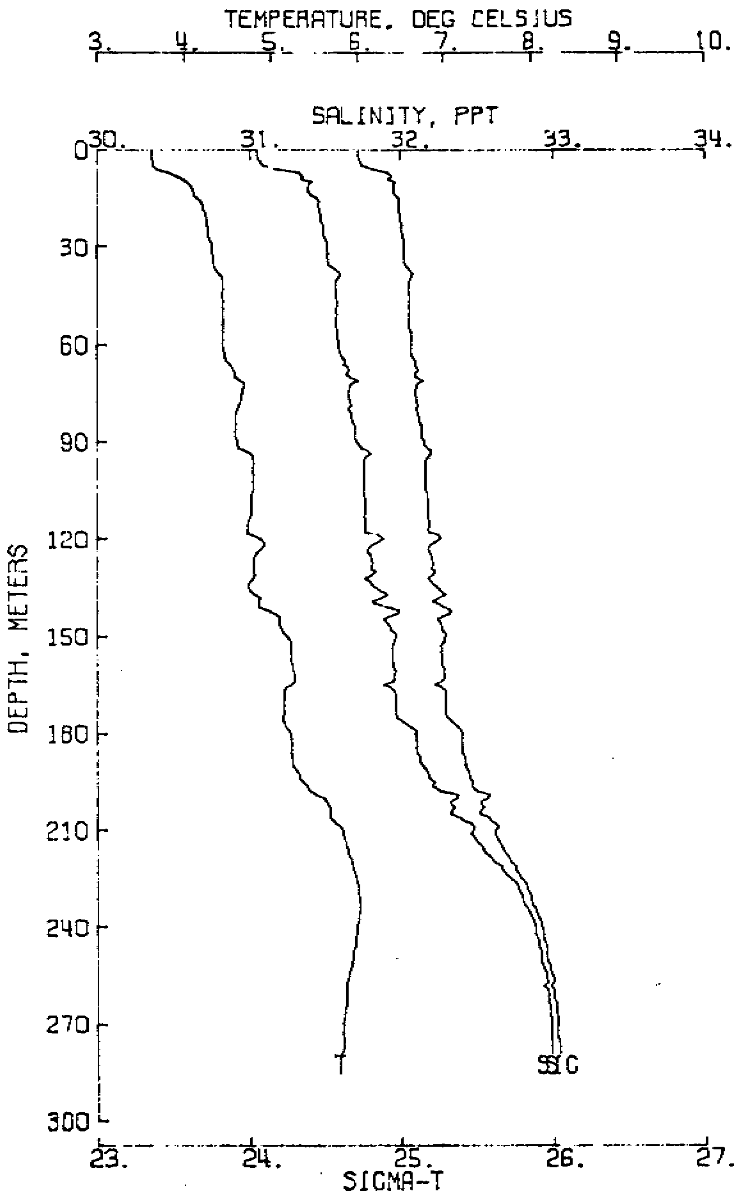
1-DIGIT WEATHER CODE IS (6) AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED,
VISIBILITY --- (6) ---4-10 KM

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 335 - 344 DEGR | ? KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 335 - 344 DEGR | 0.5 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 4.4 DEGR C. | BAROMETRIC PR. = | 1003.5 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 3.41 | 31.040 | 24.71 | 0. |
| 1.0 | 3.62 | 31.044 | 24.72 | 0.003 |
| 5.0 | 3.62 | 31.078 | 24.74 | 0.016 |
| 10.0 | 4.03 | 31.407 | 24.97 | 0.032 |
| 15.0 | 4.15 | 31.452 | 24.99 | 0.047 |
| 20.0 | 4.24 | 31.470 | 25.00 | 0.062 |
| 25.0 | 4.27 | 31.490 | 25.00 | 0.076 |
| 30.0 | 4.31 | 31.511 | 25.02 | 0.091 |
| 35.0 | 4.34 | 31.522 | 25.03 | 0.106 |
| 40.0 | 4.44 | 31.568 | 25.06 | 0.121 |
| 45.0 | 4.42 | 31.570 | 25.06 | 0.135 |
| 50.0 | 4.43 | 31.568 | 25.06 | 0.150 |
| 60.0 | 4.44 | 31.586 | 25.07 | 0.179 |
| 70.0 | 4.59 | 31.656 | 25.11 | 0.208 |
| 75.0 | 4.67 | 31.652 | 25.10 | 0.222 |
| 80.0 | [illegible] | 31.648 | 25.10 | 0.237 |
| 90.0 | 4.55 | 31.705 | 25.15 | 0.265 |
| 100.0 | 4.75 | 31.756 | 25.17 | 0.293 |
| 125.0 | 4.81 | 31.800 | 25.20 | 0.363 |
| 150.0 | 5.17 | 31.964 | 25.29 | 0.432 |
| 175.0 | 5.12 | 31.976 | 25.31 | 0.500 |
| 200.0 | 5.42 | 32.368 | 25.56 | 0.565 |
| 250.0 | 5.94 | 32.918 | 25.96 | 0.678 |




CRUISE 256 STATION 2

NC CRUISE 256 CONSECUTIVE STATION NO. 3. RES004 16/ 2/78
22.2 HOURS GMT

LATITUDE = 59 54.6N LONGITUDE = 149 24.5W SONIC DEPTH = 260 M

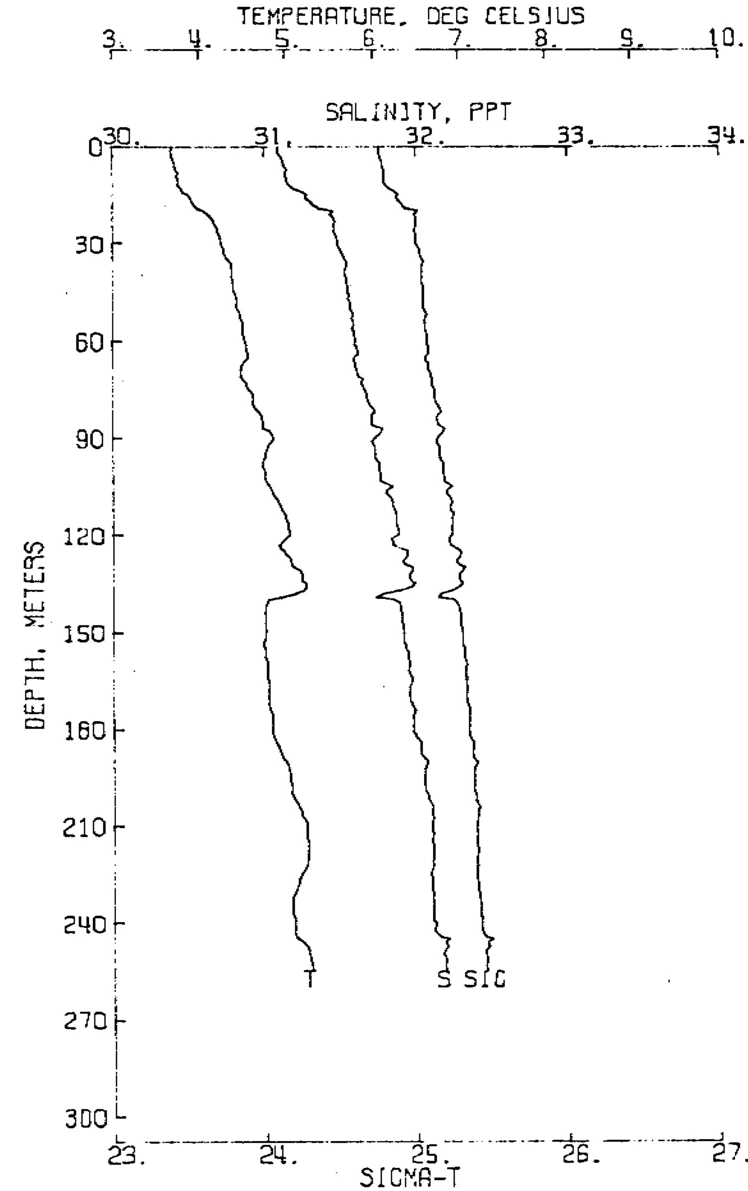
1-DIGIT WEATHER CODE IS (X) AND INDICATES CONTINUOUS LAYER
CLOUD TYPE --- (7) ---STRATU .
CLOUD AMOUNT --- (8) ---8/8 TOTAL .
VISIBILITY --- (7) ---10-20 KM

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 335 - 344 DEGS | 5 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 0 - 0 DEGS | 2.0 M. | SECS |
| SWELL | - DEGS | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 4.4 DEG C. | BAROMETRIC PR. = | 1003.5 MB |
| -WET = | DEG C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 3.49 | 31.093 | 24.75 | 0. |
| 1.0 | 3.49 | 31.096 | 24.75 | 0.003 |
| 5.0 | 3.71 | 31.123 | 24.77 | 0.016 |
| 10.0 | 3.75 | 31.148 | 24.79 | 0.032 |
| 15.0 | 3.97 | 31.292 | 24.88 | 0.048 |
| 20.0 | 4.09 | 31.459 | 25.01 | 0.063 |
| 25.0 | 4.21 | 31.458 | 24.99 | 0.078 |
| 30.0 | 4.26 | 31.492 | 25.01 | 0.093 |
| 35.0 | 4.36 | 31.546 | 25.05 | 0.107 |
| 40.0 | 4.38 | 31.538 | 25.04 | 0.122 |
| 45.0 | 4.41 | 31.550 | 25.05 | 0.137 |
| 50.0 | 4.44 | 31.544 | 25.05 | 0.151 |
| 60.0 | 4.53 | 31.599 | 25.07 | 0.181 |
| 70.0 | 4.43 | 31.617 | 25.09 | 0.210 |
| 75.0 | 4.56 | 31.657 | 25.11 | 0.224 |
| 80.0 | 4.62 | 31.699 | 25.14 | 0.238 |
| 90.0 | 4.95 | 31.724 | 25.14 | 0.267 |
| 100.0 | 4.74 | 31.759 | 25.18 | 0.295 |
| 125.0 | 4.97 | 31.939 | 25.29 | 0.364 |
| 150.0 | 4.74 | 31.920 | 25.30 | 0.432 |
| 175.0 | 4.93 | 31.982 | 25.34 | 0.499 |
| 200.0 | 5.07 | 32.069 | 25.39 | 0.565 |
| 250.0 | 5.25 | 32.171 | 25.45 | 0.696 |




CRUISE 256 STATION 3

?? CRUISE 256 OCEANOGRAPHIC STATION NO. 4, RES005 16/ 2/78
23.5 HOURS GMT

LATITUDE = 5? 50.?N LONGITUDE = 149 28.0W. SONIC DEPTH = 263 M

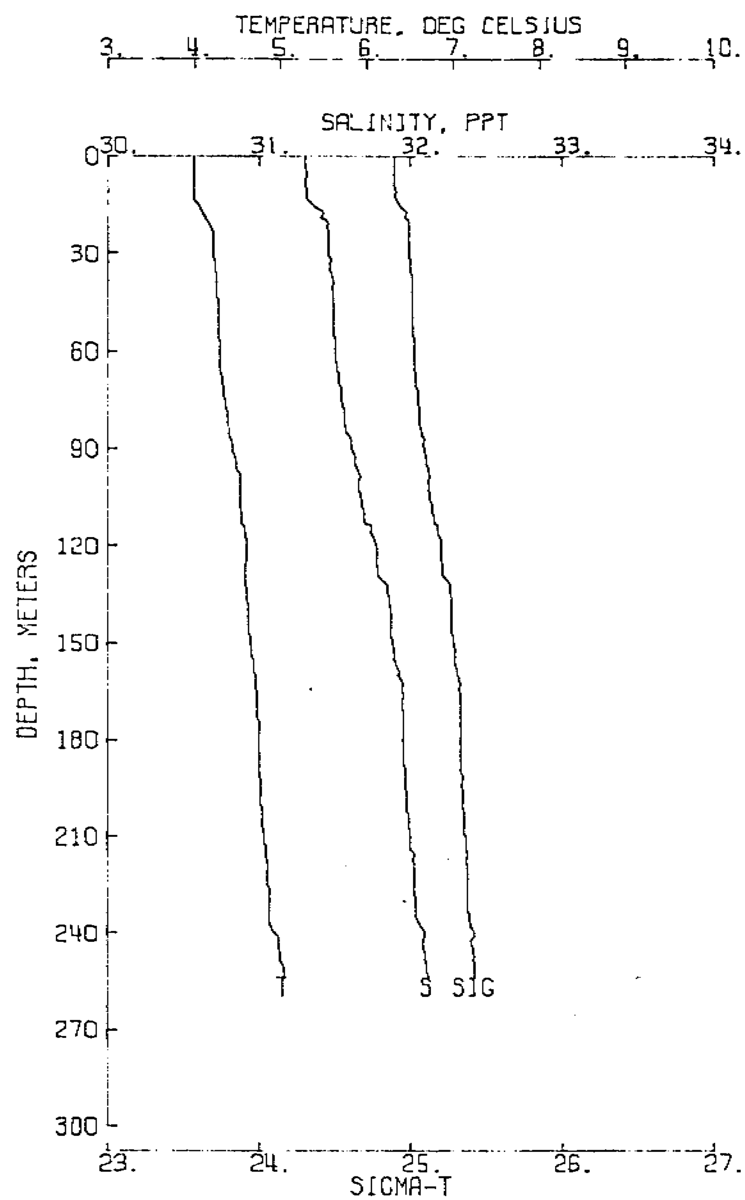
1-DIGIT WEATHER CODE IS (X?) AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- (6) ----4-10 KM

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | ?5 - 54 DEGR | 25 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 145 - 154 DEGR | 2.? M. | SECS |
| SWELL | - DEGR | ?. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 4.4 DEGR C. | BAROMETRIC PR. = | MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 3.[illegible] | 31.304 | 24.89 | 0. |
| 1. | 3.9[illegible] | 31.304 | 24.89 | 0.003 |
| 5.0 | 3.9[illegible] | 31.316 | 24.90 | 0.015 |
| 10. | 3.9[illegible] | 31.311 | 24.90 | 0.031 |
| 15.0 | 4.04 | 31.345 | 24.92 | 0.046 |
| 20.0 | 4.15 | 31.449 | 24.99 | 0.061 |
| 25.0 | 4.2[illegible] | 31.453 | 24.99 | 0.076 |
| 30.0 | 4.22 | 31.456 | 24.99 | 0.091 |
| 35.0 | 4.24 | 31.475 | 25.00 | 0.106 |
| 40.0 | 4.24 | 31.457 | 25.01 | 0.121 |
| 45.0 | 4.27 | 31.490 | 25.01 | 0.136 |
| 50.0 | 4.27 | 31.493 | 25.01 | 0.150 |
| 60.0 | 4.2[illegible] | 31.507 | 25.02 | 0.180 |
| 70.0 | 4.32 | 31.530 | 25.04 | 0.210 |
| 75.0 | 4.35 | 31.543 | 25.05 | 0.224 |
| 80.0 | 4.37 | 31.548 | 25.06 | 0.239 |
| 90.0 | 4.44 | 31.614 | 25.09 | 0.268 |
| 100.0 | 4.5[illegible] | 31.642 | 25.12 | 0.297 |
| 125.0 | 4.5[illegible] | 31.776 | 25.21 | 0.367 |
| 150.0 | 4.64 | 31.885 | 25.29 | 0.436 |
| 175.0 | 4.74 | 31.949 | 25.33 | 0.503 |
| 200.0 | 4.7[illegible] | 31.977 | 25.35 | 0.570 |
| 250.0 | 5.02 | 32.107 | 25.42 | 0.701 |




CRUISE 256 STATION 4

APPENDIX III

Resurrection Bay

R/V *Acona* Cruise No. 260

April 1978

Hydrographic Data

AC CRUISE 260 CONSECUTIVE STATION NO. 23. RES002 23/ 4/78
15.2 HOURS GMT

LATITUDE = 60 3.5N LONGITUDE = 149 23.4W SONIC DEPTH = 193 M

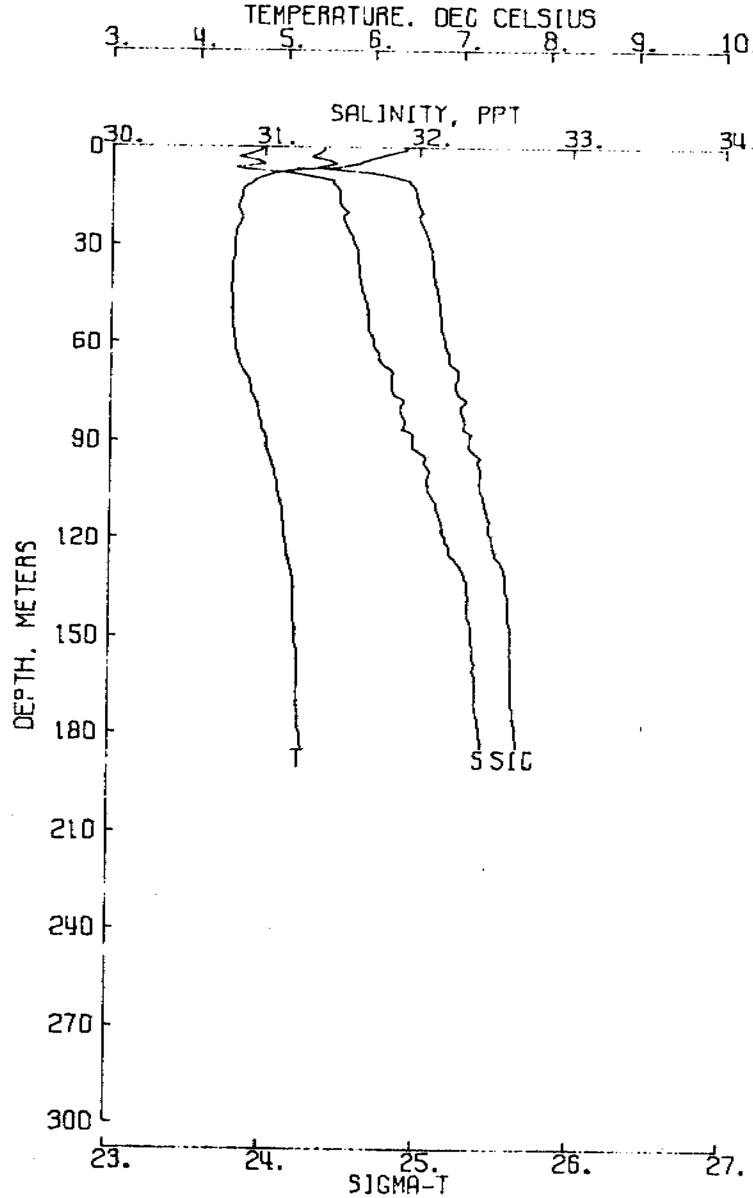
1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS ,
CLOUD AMOUNT --- (6) ---6/8 ,
VISIBILITY --- (7) ---10-20 KM

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 175 - 184 DEGR | 10 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 175 - 184 DEGR | 0.3 M. | SECS |
| SWELL | - DEGR | M. | SECS |

TEMPERATURES -DRY = 5.6 DEGR C. BAROMETRIC PR. =1014.5 MB
-WET = DEGR C. TRANSPARENCY = M

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 6.33 | 30.979 | 24.38 | 0. |
| 1.0 | 6.33 | 30.979 | 24.38 | 0.004 |
| 5.0 | 5.80 | 30.996 | 24.46 | 0.018 |
| 10.0 | 4.63 | 31.443 | 24.94 | 0.035 |
| 15.0 | 4.48 | 31.478 | 24.98 | 0.050 |
| 20.0 | 4.47 | 31.538 | 25.03 | 0.065 |
| 25.0 | 4.43 | 31.535 | 25.03 | 0.079 |
| 30.0 | 4.40 | 31.586 | 25.07 | 0.094 |
| 35.0 | 4.39 | 31.603 | 25.09 | 0.109 |
| 40.0 | 4.38 | 31.614 | 25.10 | 0.123 |
| 45.0 | 4.37 | 31.645 | 25.12 | 0.137 |
| 50.0 | 4.38 | 31.674 | 25.15 | 0.152 |
| 60.0 | 4.42 | 31.719 | 25.18 | 0.180 |
| 70.0 | 4.56 | 31.834 | 25.25 | 0.208 |
| 75.0 | 4.61 | 31.843 | 25.26 | 0.221 |
| 80.0 | 4.69 | 31.886 | 25.28 | 0.235 |
| 90.0 | 4.79 | 31.964 | 25.33 | 0.262 |
| 100.0 | 4.89 | 32.073 | 25.41 | 0.288 |
| 125.0 | 5.03 | 32.224 | 25.51 | 0.352 |
| 150.0 | 5.13 | 32.360 | 25.61 | 0.412 |
| 175.0 | 5.17 | 32.402 | 25.64 | 0.472 |




CRUISE 260 STATION 23

AC CRUISE 260 CONSECUTIVE STATION NO. 24, RES025 24/ 4/78
7.5 HOURS GMT

LATITUDE = 61 1.2N LONGITUDE = 149 21.5W SONIC DEPTH = 291 M

1-DIGIT WEATHER CODE IS (X6) AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED,
VISIBILITY --- (6) ---4-10 KM

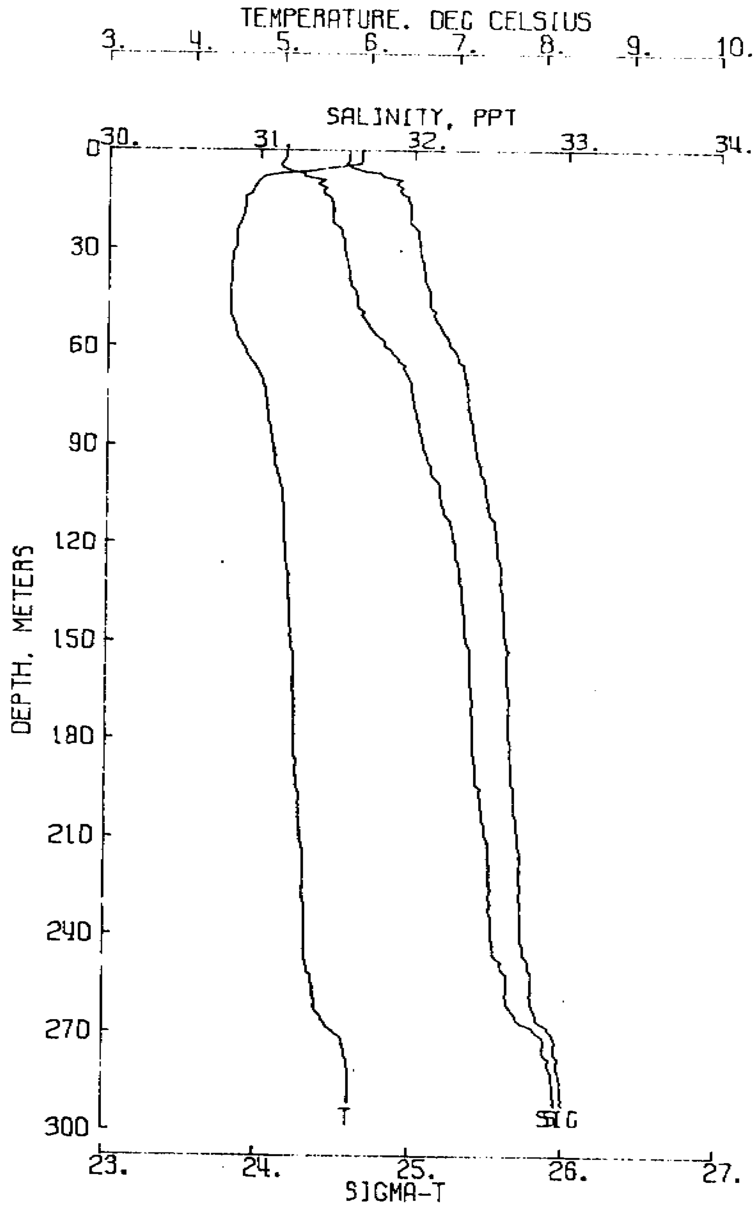
| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 175 - 184 DEGR | 5 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 0 - 0 DEGR | M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 5.6 DEGR C. | BAROMETRIC PR. = | 1015.2 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 5.90 | 31.164 | 24.58 | 0. |
| 1.0 | 5.90 | 31.164 | 24.58 | 0.003 |
| 5.0 | 5.58 | 31.134 | 24.59 | 0.017 |
| 10.0 | 4.70 | 31.367 | 24.87 | 0.033 |
| 15.0 | 4.56 | 31.464 | 24.96 | 0.048 |
| 20.0 | 4.52 | 31.472 | 24.97 | 0.063 |
| 25.0 | 4.47 | 31.531 | 25.02 | 0.078 |
| 30.0 | 4.43 | 31.544 | 25.04 | 0.093 |
| 35.0 | 4.40 | 31.566 | 25.06 | 0.107 |
| 40.0 | 4.40 | 31.586 | 25.07 | 0.122 |
| 45.0 | 4.40 | 31.627 | 25.11 | 0.136 |
| 50.0 | 4.41 | 31.661 | 25.13 | 0.151 |
| 60.0 | 4.56 | 31.819 | 25.24 | 0.179 |
| 70.0 | 4.78 | 31.979 | 25.35 | 0.206 |
| 75.0 | 4.82 | 31.996 | 25.36 | 0.219 |
| 80.0 | 4.84 | 32.015 | 25.37 | 0.232 |
| 90.0 | 4.90 | 32.070 | 25.41 | 0.258 |
| 100.0 | 4.97 | 32.146 | 25.46 | 0.284 |
| 125.0 | 5.05 | 32.288 | 25.56 | 0.346 |
| 150.0 | 5.13 | 32.365 | 25.61 | 0.407 |
| 175.0 | 5.17 | 32.403 | 25.64 | 0.466 |
| 200.0 | 5.23 | 32.464 | 25.68 | 0.525 |
| 250.0 | 5.35 | 32.600 | 25.78 | 0.640 |






CRUISE 260 STATION 24

AC CRUISE 260 CONSECUTIVE STATION NO. 21, RES25A 23/ 4/78
13.8 HOURS GMT

LATITUDE = 61 1.2N LONGITUDE = 149 23.0W SONIC DEPTH = 285 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- ( ) ---NOT RECORDED ,
CLOUD AMOUNT --- (6) ---6/8 ,
VISIBILITY --- (6) ---4-10 KM

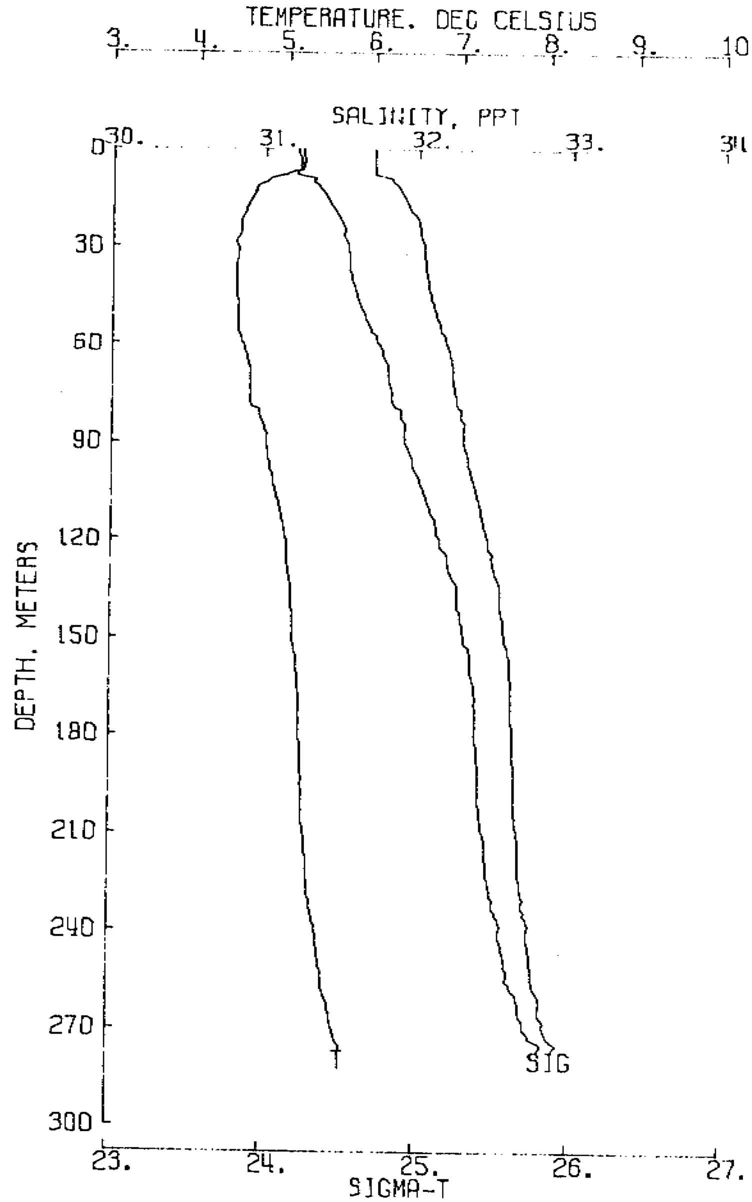
| | DIRECTION | SPEED |
|---|---|---|
| WIND | 185 - 194 DEGR | 7 KNOTS |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 0 - 0 DEGR | M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | |
|---|---|---|
| TEMPERATURES -DRY = 5.0 DEGR C. | BAROMETRIC PR. =1014.2 MB |
| -WET = DEGR C. | TRANSPARENCY = M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 5.17 | 31.210 | 24.70 | 0. |
| 1.0 | 5.17 | 31.210 | 24.70 | 0.003 |
| 5.0 | 5.17 | 31.212 | 24.70 | 0.016 |
| 10.0 | 4.74 | 31.315 | 24.83 | 0.032 |
| 15.0 | 4.58 | 31.402 | 24.91 | 0.048 |
| 20.0 | 4.50 | 31.472 | 24.97 | 0.063 |
| 25.0 | 4.47 | 31.512 | 25.01 | 0.078 |
| 30.0 | 4.44 | 31.543 | 25.04 | 0.093 |
| 35.0 | 4.43 | 31.552 | 25.04 | 0.107 |
| 40.0 | 4.42 | 31.568 | 25.06 | 0.122 |
| 45.0 | 4.43 | 31.597 | 25.08 | 0.136 |
| 50.0 | 4.44 | 31.642 | 25.11 | 0.151 |
| 60.0 | 4.50 | 31.747 | 25.19 | 0.179 |
| 70.0 | 4.58 | 31.807 | 25.23 | 0.207 |
| 75.0 | 4.59 | 31.829 | 25.25 | 0.221 |
| 80.0 | 4.68 | 31.896 | 25.29 | 0.234 |
| 90.0 | 4.76 | 31.925 | 25.31 | 0.261 |
| 100.0 | 4.83 | 32.000 | 25.36 | 0.288 |
| 125.0 | 5.01 | 32.193 | 25.49 | 0.352 |
| 150.0 | 5.10 | 32.311 | 25.58 | 0.414 |
| 175.0 | 5.17 | 32.389 | 25.63 | 0.473 |
| 200.0 | 5.21 | 32.422 | 25.65 | 0.533 |
| 250.0 | 5.43 | 32.604 | 25.77 | 0.648 |






CRUISE 260 STATION 21

AC CRUISE 260 CONSECUTIVE STATION NO. 22. RES25B 23/ 4/78
14.2 HOURS GMT

LATITUDE = 60 1.2N LONGITUDE = 149 20.6W SONIC DEPTH = 285 M

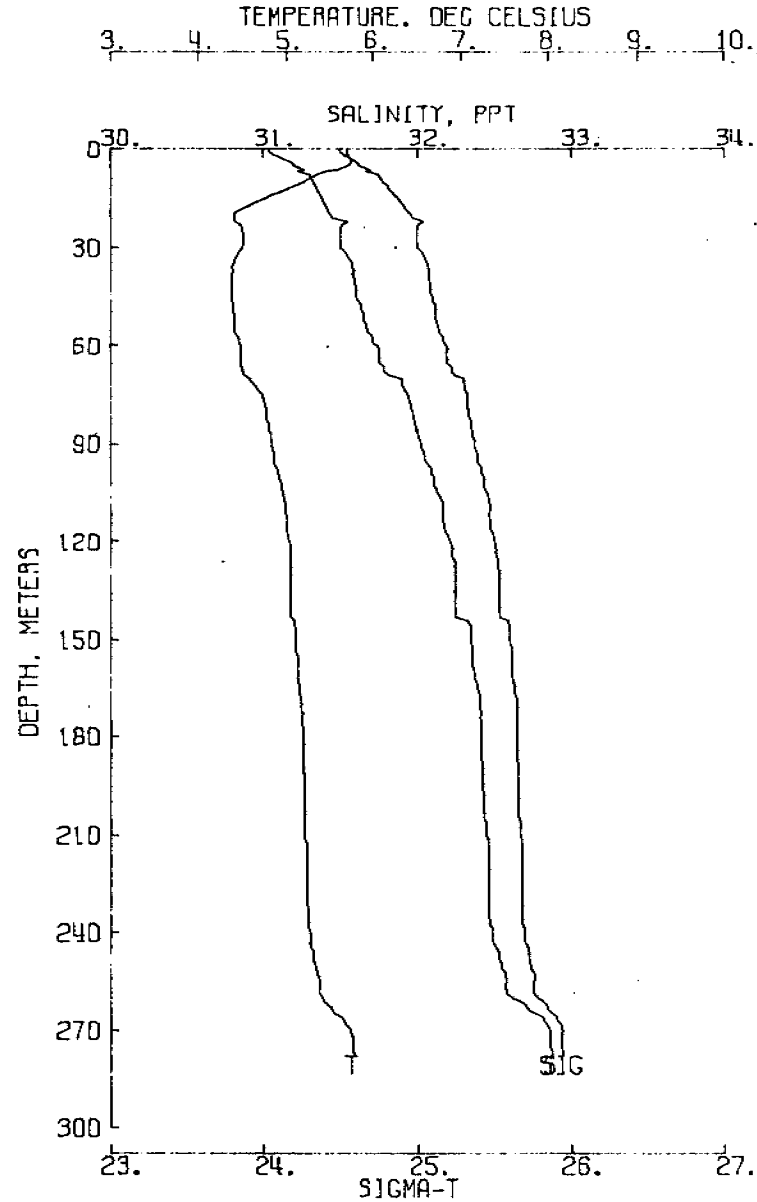
1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- (6) ---STRATOCUMULUS
CLOUD AMOUNT --- (7) ---7/8
VISIBILITY --- (6) ---4-10 KM

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 175 - 184 DEGR | 9 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 175 - 184 DEGR | 0.2 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 5.0 DEGR C. | BAROMETRIC PR. = | 1014.2 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 5.70 | 31.032 | 24.50 | 0. |
| 1.0 | 5.70 | 31.032 | 24.50 | 0.003 |
| 5.0 | 5.73 | 31.191 | 24.62 | 0.017 |
| 10.0 | 5.19 | 31.320 | 24.78 | 0.033 |
| 15.0 | 4.76 | 31.378 | 24.87 | 0.049 |
| 20.0 | 4.41 | 31.428 | 24.95 | 0.064 |
| 25.0 | 4.51 | 31.495 | 24.99 | 0.079 |
| 30.0 | 4.50 | 31.496 | 24.99 | 0.094 |
| 35.0 | 4.40 | 31.572 | 25.06 | 0.109 |
| 40.0 | 4.39 | 31.586 | 25.08 | 0.123 |
| 45.0 | 4.38 | 31.603 | 25.09 | 0.138 |
| 50.0 | 4.41 | 31.639 | 25.12 | 0.152 |
| 60.0 | 4.48 | 31.734 | 25.18 | 0.180 |
| 70.0 | 4.58 | 31.894 | 25.30 | 0.208 |
| 75.0 | 4.72 | 31.938 | 25.32 | 0.222 |
| 80.0 | 4.78 | 31.955 | 25.33 | 0.235 |
| 90.0 | 4.84 | 32.019 | 25.37 | 0.261 |
| 100.0 | 4.92 | 32.107 | 25.43 | 0.287 |
| 125.0 | 5.05 | 32.231 | 25.52 | 0.351 |
| 150.0 | 5.11 | 32.347 | 25.60 | 0.412 |
| 175.0 | 5.18 | 32.412 | 25.65 | 0.472 |
| 200.0 | 5.20 | 32.437 | 25.66 | 0.531 |
| 250.0 | 5.32 | 32.549 | 25.74 | 0.648 |




CRUISE 260 STATION 22

AC CRUISE 260 CONSECUTIVE STATION NO. 20. RES003 23/ 4/78
12.6 HOURS GMT

LATITUDE = 59 59.0N LONGITUDE = 149 20.5W SONIC DEPTH = 292 M

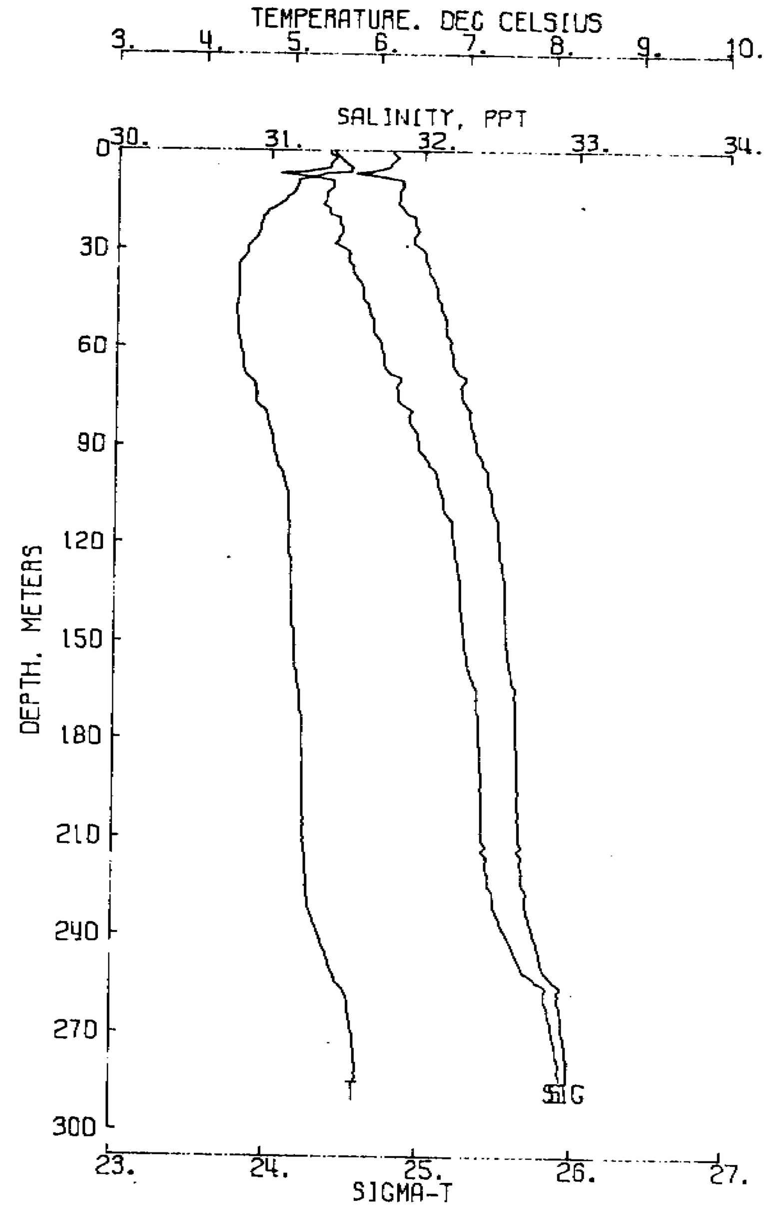
1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 175 - 184 DEGR | 5 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 0 - 0 DEGR | M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 5.6 DEGR C. | BAROMETRIC PR. = | 1014.0 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 5.48 | 31.376 | 24.79 | 0. |
| 1.0 | 5.48 | 31.376 | 24.79 | 0.003 |
| 5.0 | 5.67 | 31.376 | 24.77 | 0.016 |
| 10.0 | 5.04 | 31.404 | 24.86 | 0.032 |
| 15.0 | 4.90 | 31.361 | 24.84 | 0.048 |
| 20.0 | 4.64 | 31.449 | 24.94 | 0.063 |
| 25.0 | 4.61 | 31.456 | 24.95 | 0.078 |
| 30.0 | 4.48 | 31.504 | 25.00 | 0.093 |
| 35.0 | 4.39 | 31.537 | 25.04 | 0.108 |
| 40.0 | 4.38 | 31.583 | 25.07 | 0.123 |
| 45.0 | 4.37 | 31.614 | 25.10 | 0.137 |
| 50.0 | 4.37 | 31.661 | 25.14 | 0.152 |
| 60.0 | 4.41 | 31.720 | 25.18 | 0.180 |
| 70.0 | 4.56 | 31.869 | 25.28 | 0.207 |
| 75.0 | 4.61 | 31.842 | 25.26 | 0.221 |
| 80.0 | 4.72 | 31.923 | 25.31 | 0.235 |
| 90.0 | 4.80 | 31.983 | 25.35 | 0.261 |
| 100.0 | 4.93 | 32.100 | 25.43 | 0.288 |
| 125.0 | 5.00 | 32.229 | 25.52 | 0.351 |
| 150.0 | 5.06 | 32.287 | 25.56 | 0.412 |
| 175.0 | 5.15 | 32.378 | 25.62 | 0.473 |
| 200.0 | 5.17 | 32.403 | 25.64 | 0.532 |
| 250.0 | 5.52 | 32.681 | 25.82 | 0.648 |




CRUISE 260 STATION 20

AC CRUISE 260 CONSECUTIVE STATION NO. 19. RES3.5 23/ 4/78
12.1 HOURS GMT

LATITUDE = 59 57.9N LONGITUDE = 149 20.7W SONIC DEPTH = 195 M

1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

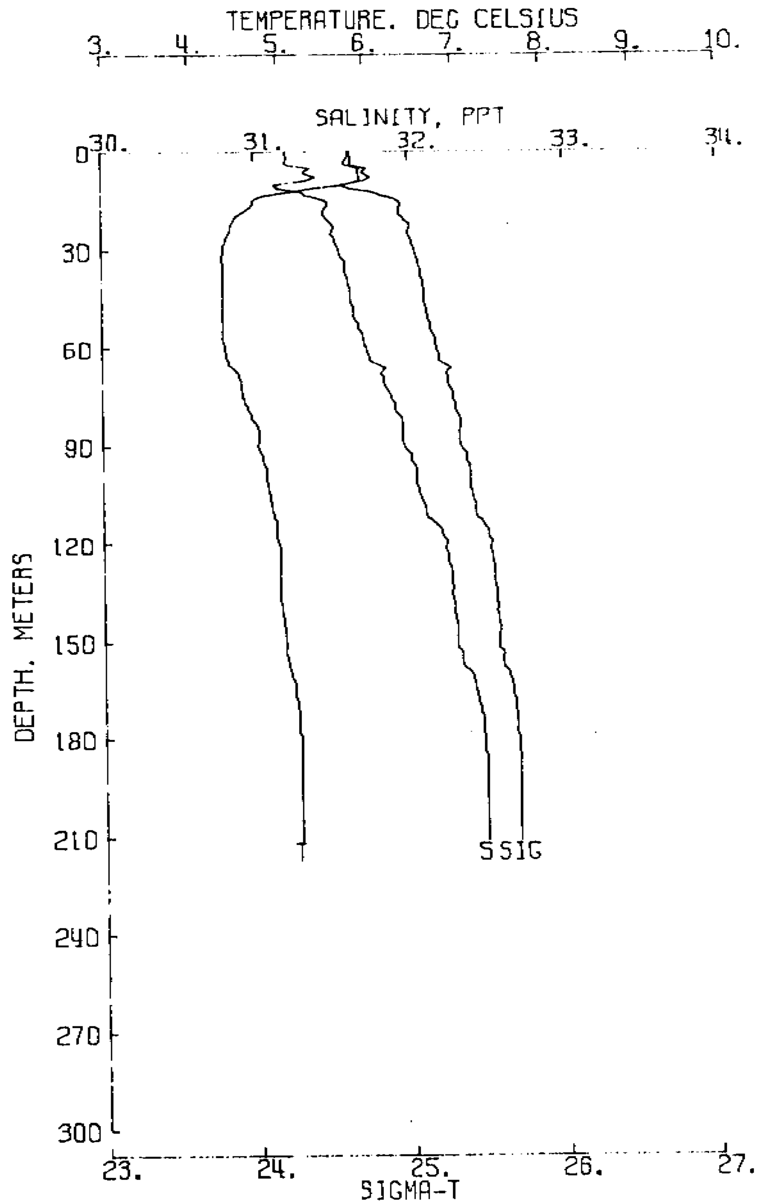
| | DIRECTION | SPEED |
|---|---|---|
| WIND | - DEGR | KNOTS |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 0 - 0 DEGR | M. | SECS |
| SWELL | - DEGR | M. | SECS |

TEMPERATURES -DRY = 5.6 DEGR C. BAROMETRIC PR. =1014.0 MB
-WET = DEGR C. TRANSPARENCY = M

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 5.91 | 31.206 | 24.62 | 0. |
| 1.0 | 5.81 | 31.206 | 24.62 | 0.003 |
| 5.0 | 5.95 | 31.367 | 24.73 | 0.017 |
| 10.0 | 5.77 | 31.125 | 24.56 | 0.033 |
| 15.0 | 4.73 | 31.470 | 24.95 | 0.049 |
| 20.0 | 4.53 | 31.462 | 24.96 | 0.064 |
| 25.0 | 4.44 | 31.495 | 25.00 | 0.079 |
| 30.0 | 4.38 | 31.547 | 25.05 | 0.094 |
| 35.0 | 4.37 | 31.585 | 25.08 | 0.108 |
| 40.0 | 4.38 | 31.609 | 25.10 | 0.123 |
| 45.0 | 4.38 | 31.618 | 25.10 | 0.137 |
| 50.0 | 4.39 | 31.646 | 25.12 | 0.151 |
| 60.0 | 4.40 | 31.727 | 25.19 | 0.180 |
| 70.0 | 4.59 | 31.846 | 25.26 | 0.207 |
| 75.0 | 4.61 | 31.883 | 25.29 | 0.221 |
| 80.0 | 4.68 | 31.925 | 25.31 | 0.234 |
| 90.0 | 4.77 | 31.971 | 25.34 | 0.261 |
| 100.0 | 4.98 | 32.045 | 25.39 | 0.287 |
| 125.0 | 5.01 | 32.247 | 25.53 | 0.351 |
| 150.0 | 5.06 | 32.301 | 25.57 | 0.412 |
| 175.0 | 5.22 | 32.464 | 25.68 | 0.472 |
| 200.0 | 5.23 | 32.484 | 25.70 | 0.529 |






CRUISE 260 STATION 19

AC CRUISE 260 CONSECUTIVE STATION NO. 18, RES004 23/ 4/78
10.7 HOURS GMT

LATITUDE = 59 54.7N LONGITUDE = 149 24.5W SONIC DEPTH = 263 M

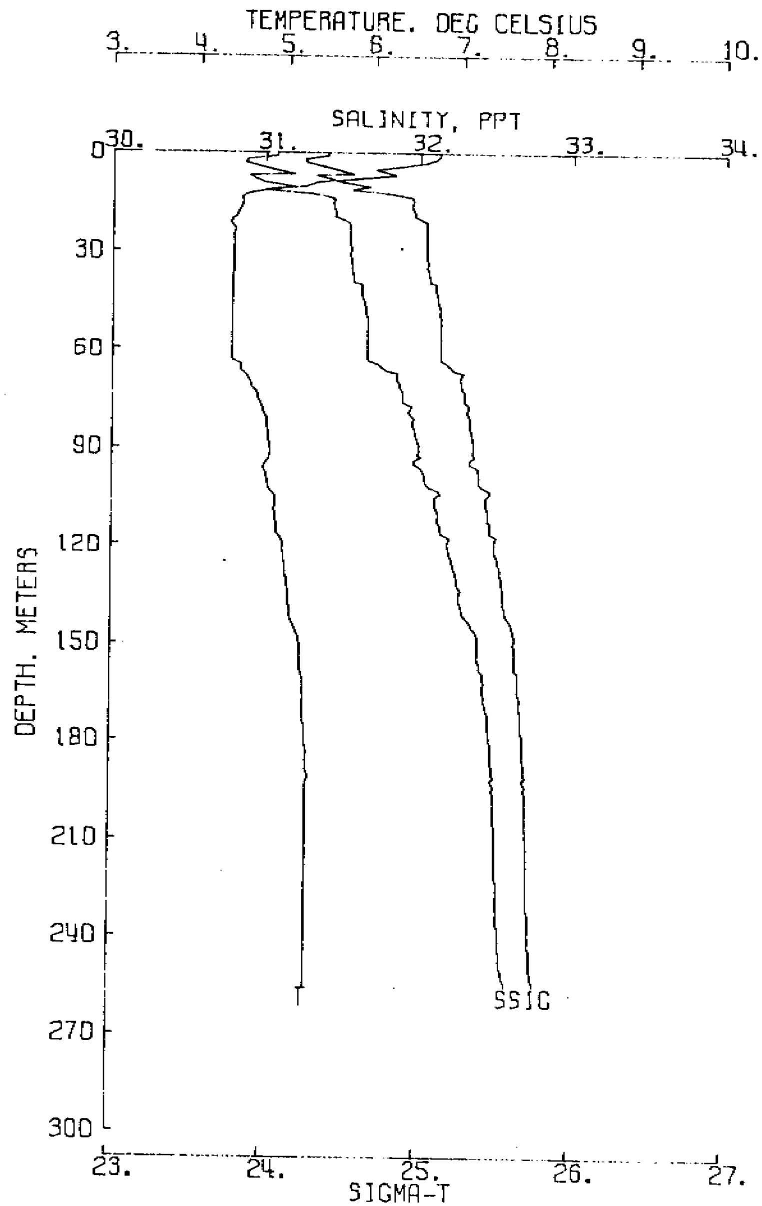
1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 165 - 174 DEGR | 5 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 165 - 174 DEGR | 0.3 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 6.1 DEGR C. | BAROMETRIC PR. = | 1013.8 MB |
| -WET = | . DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 6.72 | 31.063 | 24.40 | 0. |
| 1.0 | 6.72 | 31.063 | 24.40 | 0.004 |
| 5.0 | 6.01 | 31.049 | 24.48 | 0.018 |
| 10.0 | 5.20 | 31.182 | 24.67 | 0.035 |
| 15.0 | 4.48 | 31.441 | 24.95 | 0.051 |
| 20.0 | 4.36 | 31.495 | 25.01 | 0.066 |
| 25.0 | 4.39 | 31.553 | 25.05 | 0.081 |
| 30.0 | 4.39 | 31.556 | 25.05 | 0.095 |
| 35.0 | 4.38 | 31.558 | 25.05 | 0.110 |
| 40.0 | 4.36 | 31.619 | 25.11 | 0.125 |
| 45.0 | 4.36 | 31.640 | 25.12 | 0.139 |
| 50.0 | 4.37 | 31.662 | 25.14 | 0.153 |
| 60.0 | 4.37 | 31.670 | 25.14 | 0.182 |
| 70.0 | 4.58 | 31.873 | 25.28 | 0.209 |
| 75.0 | 4.68 | 31.902 | 25.30 | 0.223 |
| 80.0 | 4.74 | 31.938 | 25.32 | 0.236 |
| 90.0 | 4.81 | 31.999 | 25.36 | 0.263 |
| 100.0 | 4.77 | 32.042 | 25.40 | 0.289 |
| 125.0 | 4.99 | 32.224 | 25.52 | 0.353 |
| 150.0 | 5.16 | 32.389 | 25.63 | 0.414 |
| 175.0 | 5.23 | 32.466 | 25.68 | 0.473 |
| 200.0 | 5.25 | 32.509 | 25.72 | 0.531 |
| 250.0 | 5.25 | 32.562 | 25.76 | 0.646 |




CRUISE 260 STATION 18

AC CRUISE 260 CONSECUTIVE STATION NO. 17, RES005 23/ 4/78
9.1 HOURS GMT

LATITUDE = 59 59.7N LONGITUDE = 149 28.0W SONIC DEPTH = 267 M

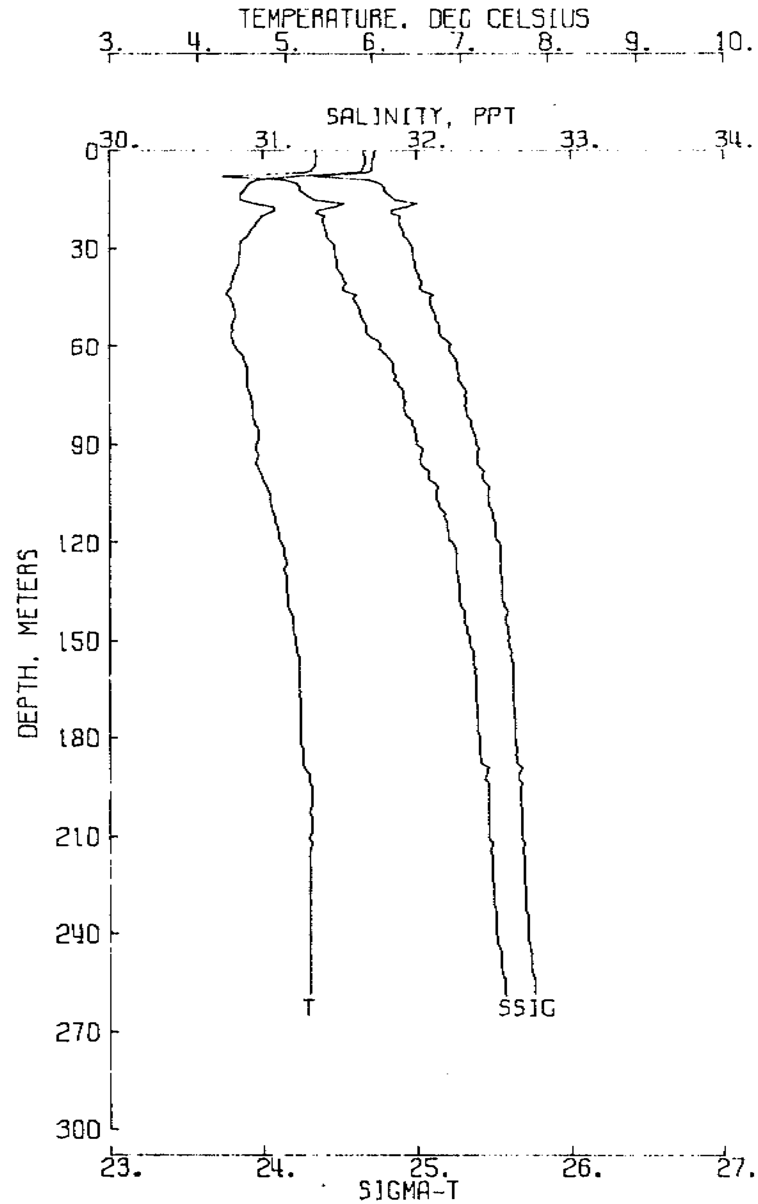
1-DIGIT WEATHER CODE IS (X1) AND INDICATES PARTLY CLOUDY
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- ( ) ---NOT RECORDED

| | DIRECTION | SPEED |
|---|---|---|
| WIND | 165 - 174 DEGR | 5 KNOTS |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 165 - 174 DEGR | 0.3 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 6.7 DEGR C. | BAROMETRIC PR. = | 1013.5 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 5.90 | 31.343 | 24.72 | 0. |
| 1.0 | 5.90 | 31.343 | 24.72 | 0.003 |
| 5.0 | 5.91 | 31.332 | 24.71 | 0.016 |
| 10.0 | 4.59 | 31.216 | 24.76 | 0.033 |
| 15.0 | 4.49 | 31.330 | 24.86 | 0.049 |
| 20.0 | 4.72 | 31.398 | 24.89 | 0.064 |
| 25.0 | 4.58 | 31.413 | 24.92 | 0.079 |
| 30.0 | 4.48 | 31.471 | 24.98 | 0.095 |
| 35.0 | 4.46 | 31.482 | 24.99 | 0.109 |
| 40.0 | 4.40 | 31.528 | 25.03 | 0.124 |
| 45.0 | 4.38 | 31.589 | 25.08 | 0.139 |
| 50.0 | 4.42 | 31.636 | 25.11 | 0.153 |
| 60.0 | 4.43 | 31.774 | 25.22 | 0.182 |
| 70.0 | 4.56 | 31.855 | 25.27 | 0.209 |
| 75.0 | 4.60 | 31.909 | 25.31 | 0.222 |
| 80.0 | 4.62 | 31.926 | 25.32 | 0.236 |
| 90.0 | 4.67 | 32.004 | 25.38 | 0.262 |
| 100.0 | 4.73 | 32.075 | 25.43 | 0.288 |
| 125.0 | 5.00 | 32.254 | 25.54 | 0.351 |
| 150.0 | 5.12 | 32.336 | 25.59 | 0.412 |
| 175.0 | 5.17 | 32.393 | 25.63 | 0.472 |
| 200.0 | 5.29 | 32.463 | 25.67 | 0.531 |
| 250.0 | 5.27 | 32.548 | 25.74 | 0.647 |




CRUISE 260 STATION 17

APPENDIX IV

Resurrection Bay

R/V *Acona* Cruise No. 262

July 1978

Hydrographic and Nutrient Data

AC CRUISE 262 CONSECUTIVE STATION NO. 2. RES2.0 11/ 7/78
17.7 HOURS GMT

LATITUDE = 60 3.5N LONGITUDE = 149 23.4W SONIC DEPTH = 223 M

1-DIGIT WEATHER CODE IS (X6) AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- (6) ---4-10 KM

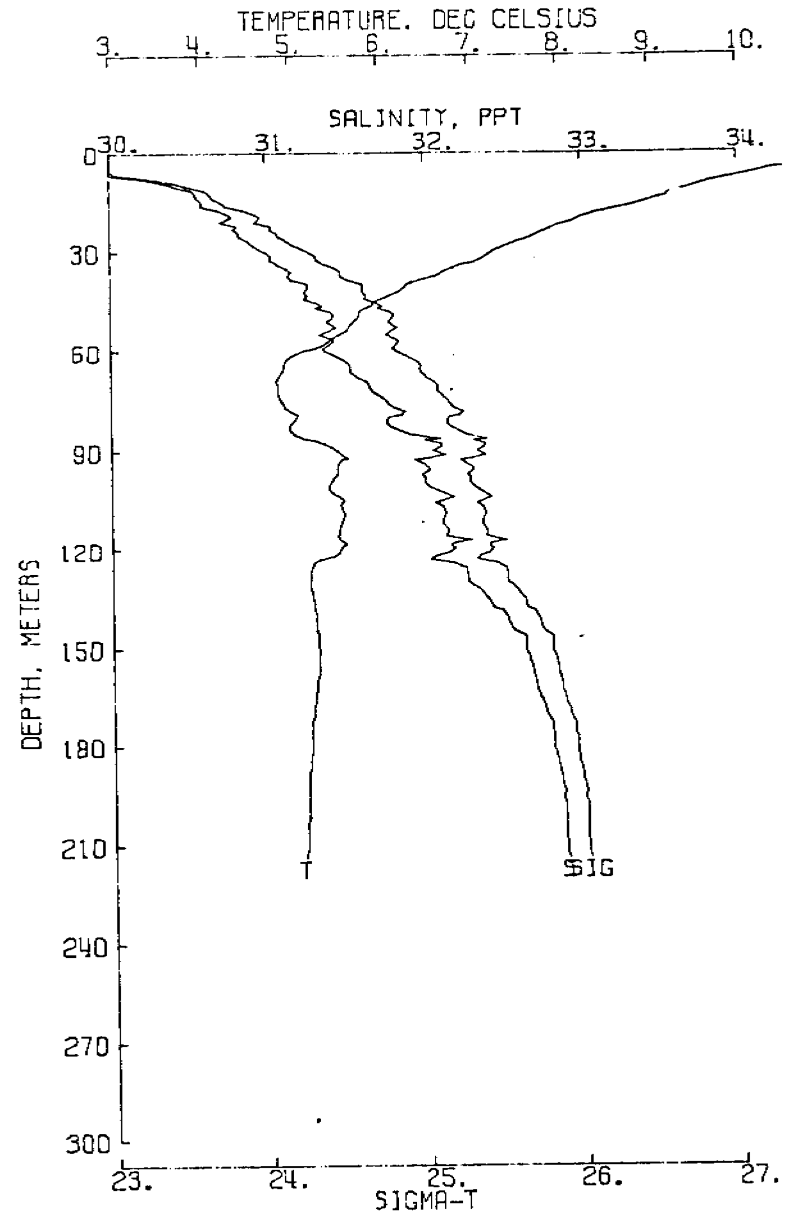
| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | 175 - 184 DEGR | 10 KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 175 - 184 DEGR | 0.2 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 11.1 DEGR C. | BAROMETRIC PR. = | 1012.8 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 11.42 | 28.379 | 21.60 | 0. |
| 1.0 | 11.42 | 28.379 | 21.60 | 0.006 |
| 5.0 | 10.38 | 29.752 | 22.84 | 0.030 |
| 10.0 | 9.57 | 30.421 | 23.49 | 0.053 |
| 15.0 | 8.97 | 30.600 | 23.73 | 0.074 |
| 20.0 | 8.24 | 30.758 | 23.96 | 0.095 |
| 25.0 | 7.74 | 30.829 | 24.08 | 0.114 |
| 30.0 | 7.28 | 30.993 | 24.27 | 0.133 |
| 35.0 | 6.83 | 31.124 | 24.43 | 0.151 |
| 40.0 | 6.33 | 31.266 | 24.61 | 0.168 |
| 45.0 | 5.94 | 31.304 | 24.68 | 0.185 |
| 50.0 | 5.76 | 31.414 | 24.79 | 0.201 |
| 60.0 | 5.15 | 31.362 | 24.82 | 0.233 |
| 70.0 | 4.87 | 31.649 | 25.08 | 0.263 |
| 75.0 | 4.91 | 31.755 | 25.16 | 0.277 |
| 80.0 | 5.09 | 31.774 | 25.15 | 0.291 |
| 90.0 | 5.52 | 32.052 | 25.32 | 0.319 |
| 100.0 | 5.43 | 32.002 | 25.29 | 0.346 |
| 125.0 | 5.23 | 32.217 | 25.49 | 0.411 |
| 150.0 | 5.30 | 32.634 | 25.81 | 0.470 |
| 175.0 | 5.21 | 32.800 | 25.95 | 0.524 |
| 200.0 | 5.16 | 32.877 | 26.02 | 0.576 |






CRUISE 262 STATION 2

AC CRUISE 262 CONSECUTIVE STATION NO. 4. RES 5 11/ 7/78
20.5 HOURS GMT

LATITUDE = 59 50.7N LONGITUDE = 149 27.9W SONIC DEPTH = 264 M

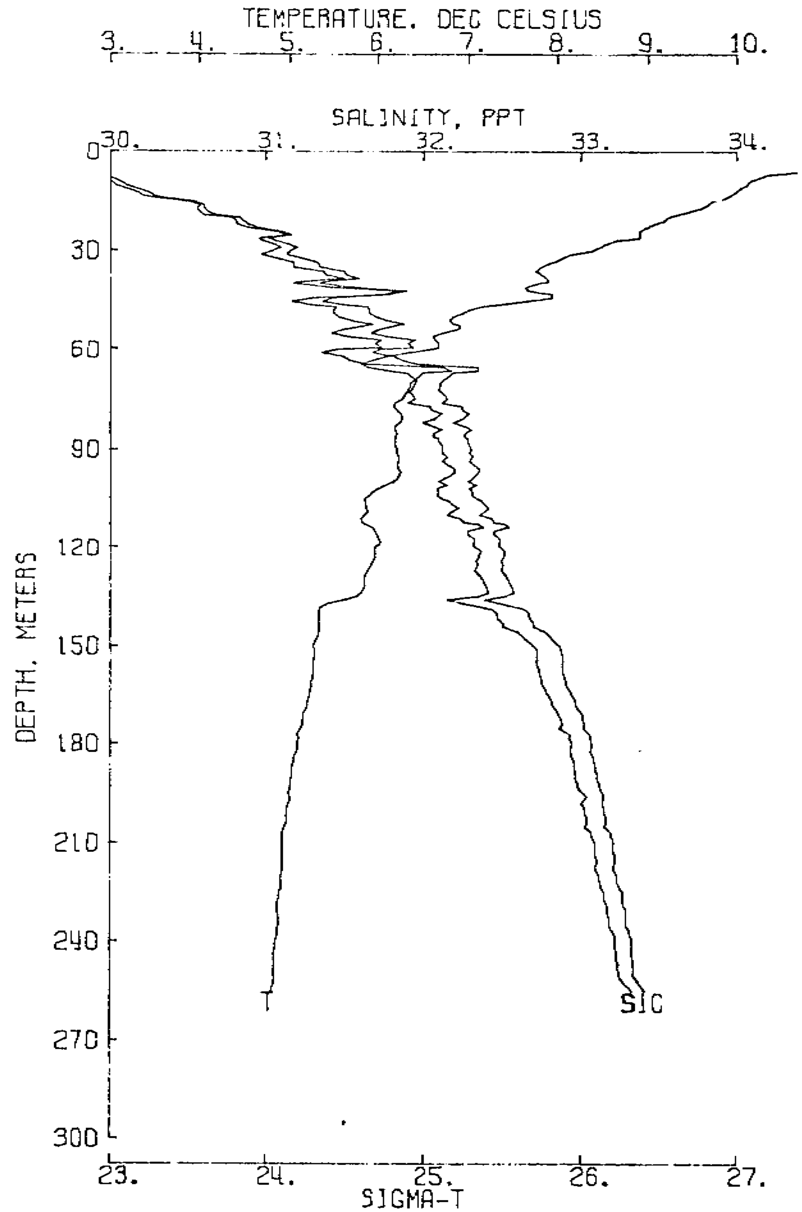
1-DIGIT WEATHER CODE IS (X5) AND INDICATES DRIZZLE
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- (5) ---2-4 KM

| | DIRECTION | SPEED | | |
|---|---|---|---|---|
| WIND | - DEGR | KNOTS | | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 175 - 184 DEGR | 1.0 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | |
|---|---|---|
| TEMPERATURES -DRY = 11.1 DEGR C. | BAROMETRIC PR. =1011.9 MB |
| -WET = DEGR C. | TRANSPARENCY = M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 12.05 | 25.955 | 19.62 | 0. |
| 1.0 | 12.05 | 25.955 | 19.62 | 0.008 |
| 5.0 | 10.96 | 29.473 | 22.53 | 0.033 |
| 10.0 | 10.11 | 30.039 | 23.11 | 0.058 |
| 15.0 | 9.72 | 30.507 | 23.54 | 0.081 |
| 20.0 | 9.22 | 30.782 | 23.83 | 0.102 |
| 25.0 | 8.92 | 31.142 | 24.16 | 0.122 |
| 30.0 | 8.39 | 31.028 | 24.15 | 0.141 |
| 35.0 | 7.81 | 31.176 | 24.35 | 0.160 |
| 40.0 | 7.79 | 31.176 | 24.35 | 0.177 |
| 45.0 | 7.65 | 31.162 | 24.36 | 0.194 |
| 50.0 | 6.82 | 31.468 | 24.71 | 0.211 |
| 60.0 | 6.63 | 31.459 | 24.72 | 0.243 |
| 70.0 | 6.41 | 31.904 | 25.10 | 0.272 |
| 75.0 | 6.27 | 31.945 | 25.15 | 0.286 |
| 80.0 | 6.27 | 32.105 | 25.28 | 0.300 |
| 90.0 | 6.20 | 32.122 | 25.30 | 0.328 |
| 100.0 | 6.16 | 32.097 | 25.28 | 0.354 |
| 125.0 | 5.92 | 32.346 | 25.51 | 0.419 |
| 150.0 | 5.28 | 32.707 | 25.87 | 0.479 |
| 175.0 | 5.12 | 32.872 | 26.02 | 0.531 |
| 200.0 | 4.97 | 33.024 | 26.15 | 0.580 |
| 250.0 | 4.83 | 33.245 | 26.34 | 0.670 |




CRUISE 262 STATION 4

AC CRUISE 262 CONSECUTIVE STATION NO. 5, RES 4 11/ 7/78
21.8 HOURS GMT

LATITUDE = 5? 54.7N LONGITUDE = 149 24.0W SONIC DEPTH = 257 M

1-DIGIT WEATHER CODE IS (X) AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- (5) ---2-4 KM

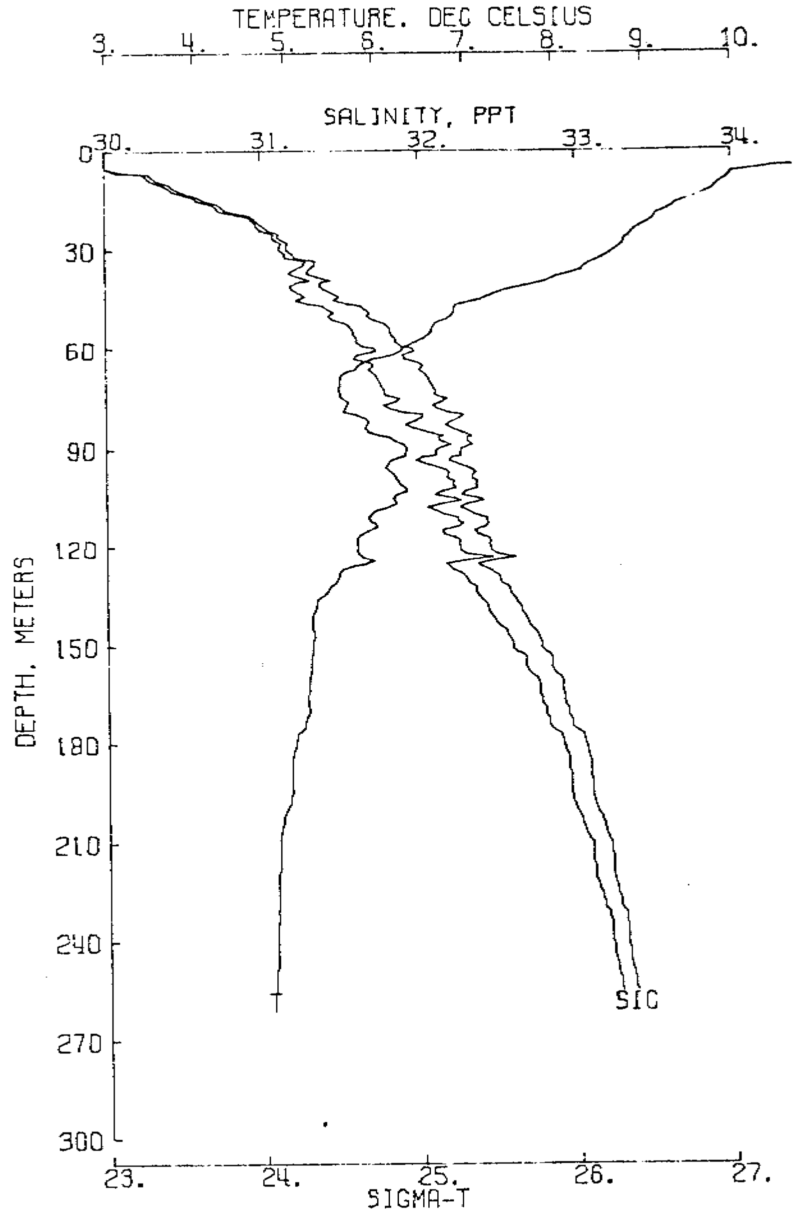
| | DIRECTION | SPEED | |
|---|---|---|---|
| WIND | - DEGR | KNOTS | |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 175 - 184 DEGR | 1.0 M. | SECS |
| SWELL | - DEGR | M. | SECS |

TEMPERATURES -DRY = 11.1 DEGR C. BAROMETRIC PR. =1011.2 MB
-WET = DEGR C. TRANSPARENCY = M

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 11.85 | 26.536 | 20.11 | 0. |
| 1.0 | 11.85 | 26.536 | 20.11 | 0.008 |
| 5.0 | 10.50 | 29.792 | 22.86 | 0.033 |
| 10.0 | 9.86 | 30.380 | 23.42 | 0.056 |
| 15.0 | 9.52 | 30.591 | 23.64 | 0.078 |
| 20.0 | 9.16 | 30.916 | 23.94 | 0.099 |
| 25.0 | 8.90 | 31.084 | 24.12 | 0.118 |
| 30.0 | 8.71 | 31.110 | 24.16 | 0.137 |
| 35.0 | 8.36 | 31.260 | 24.33 | 0.156 |
| 40.0 | 7.92 | 31.241 | 24.38 | 0.174 |
| 45.0 | 7.17 | 31.215 | 24.46 | 0.191 |
| 50.0 | 6.87 | 31.422 | 24.66 | 0.208 |
| 60.0 | 6.31 | 31.708 | 24.96 | 0.240 |
| 70.0 | 5.61 | 31.750 | 25.07 | 0.270 |
| 75.0 | 5.64 | 31.879 | 25.17 | 0.284 |
| 80.0 | 5.78 | 32.028 | 25.27 | 0.298 |
| 90.0 | 6.37 | 32.115 | 25.27 | 0.325 |
| 100.0 | 6.26 | 32.218 | 25.37 | 0.353 |
| 125.0 | 5.87 | 32.163 | 25.37 | 0.418 |
| 150.0 | 5.30 | 32.589 | 25.77 | 0.478 |
| 175.0 | 5.18 | 32.830 | 25.98 | 0.531 |
| 200.0 | 4.98 | 32.991 | 26.13 | 0.580 |
| 250.0 | 4.85 | 33.265 | 26.36 | 0.670 |






CRUISE 262 STATION 5

AC CRUISE 262 CONSECUTIVE STATION NO. 6, RES 3 11/ 7/78
23.0 HOURS GMT

LATITUDE = 59 59.0N LONGITUDE = 149 20.5W SONIC DEPTH = 289 M

1-DIGIT WEATHER CODE IS (X6) AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED.
VISIBILITY --- (4) ---1-2 KM

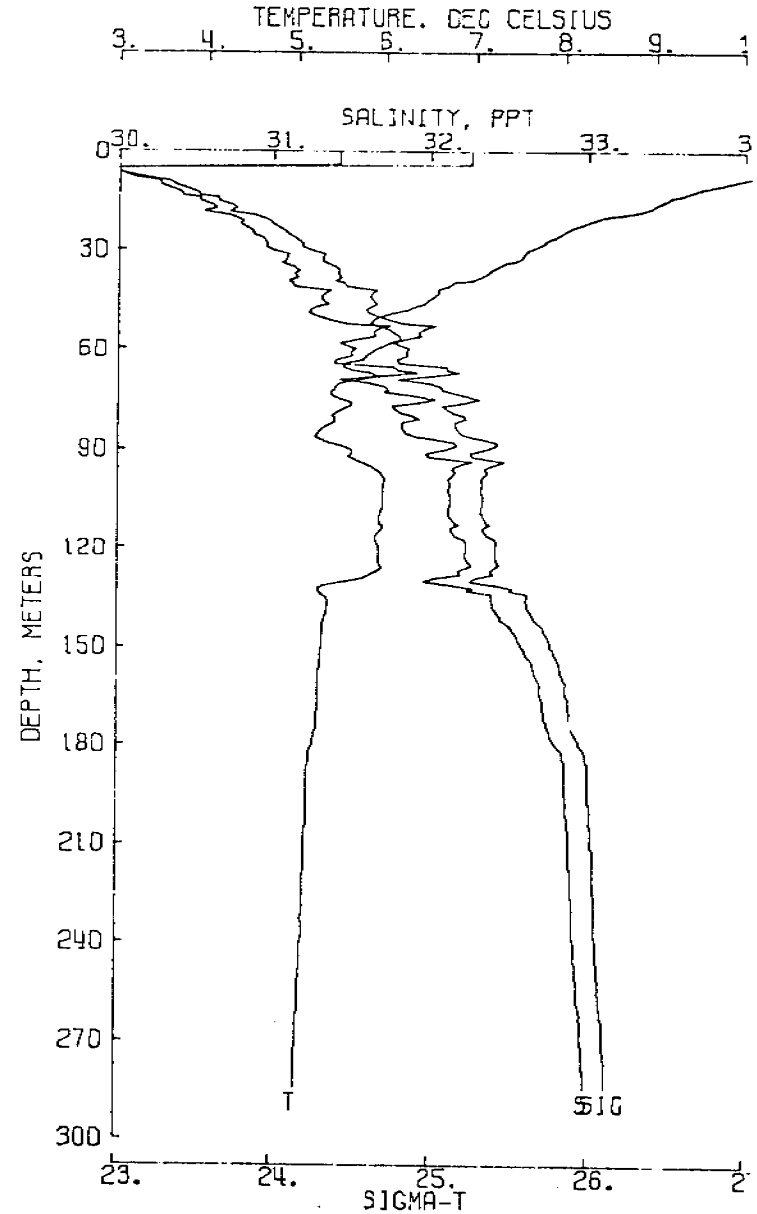
| | DIRECTION | SPEED |
|---|---|---|
| WIND | 175 - 184 DEGR | 7 KNOTS |

| | DIRECTION | HEIGHT | PERIOD |
|---|---|---|---|
| SEA | 175 - 184 DEGR | 0.2 M. | SECS |
| SWELL | - DEGR | M. | SECS |

| | | | |
|---|---|---|---|
| TEMPERATURES -DRY = | 11.1 DEGR C. | BAROMETRIC PR. = | 1010.0 MB |
| -WET = | DEGR C. | TRANSPARENCY = | M |

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 12.50 | 32.261 | 24.41 | 0. |
| 1.0 | 12.50 | 32.261 | 24.41 | 0.004 |
| 5.0 | 12.18 | 26.712 | 20.18 | 0.020 |
| 10.0 | 9.69 | 30.272 | 23.36 | 0.046 |
| 15.0 | 9.11 | 30.522 | 23.64 | 0.068 |
| 20.0 | 8.43 | 30.747 | 23.92 | 0.088 |
| 25.0 | 7.94 | 30.871 | 24.09 | 0.108 |
| 30.0 | 7.56 | 31.002 | 24.24 | 0.127 |
| 35.0 | 7.24 | 31.115 | 24.37 | 0.145 |
| 40.0 | 6.77 | 31.115 | 24.44 | 0.163 |
| 45.0 | 6.46 | 31.314 | 24.63 | 0.180 |
| 50.0 | 5.95 | 31.288 | 24.67 | 0.196 |
| 60.0 | 5.89 | 31.522 | 24.86 | 0.228 |
| 70.0 | 5.47 | 31.612 | 24.98 | 0.258 |
| 75.0 | 5.50 | 32.026 | 25.31 | 0.272 |
| 80.0 | 5.40 | 31.875 | 25.20 | 0.286 |
| 90.0 | 5.62 | 32.078 | 25.33 | 0.314 |
| 100.0 | 5.97 | 32.110 | 25.32 | 0.341 |
| 125.0 | 5.93 | 32.252 | 25.43 | 0.407 |
| 150.0 | 5.28 | 32.580 | 25.77 | 0.468 |
| 175.0 | 5.23 | 32.748 | 25.91 | 0.522 |
| 200.0 | 5.13 | 32.871 | 26.02 | 0.573 |
| 250.0 | 5.06 | 32.939 | 26.08 | 0.674 |






CRUISE 262 STATION 6

AC CRUISE 262 CONSECUTIVE STATION NO. 7. RES2.5 12/ 7/78
0.2 HOURS GMT

LATITUDE = 60 1.2N LONGITUDE = 149 21.5W SONIC DEPTH = 287 M

1-DIGIT WEATHER CODE IS (X() AND INDICATES RAIN
CLOUD TYPE --- ( ) ---NOT RECORDED
CLOUD AMOUNT --- ( ) ---NOT RECORDED,
VISIBILITY --- (5) ---2-4 KM

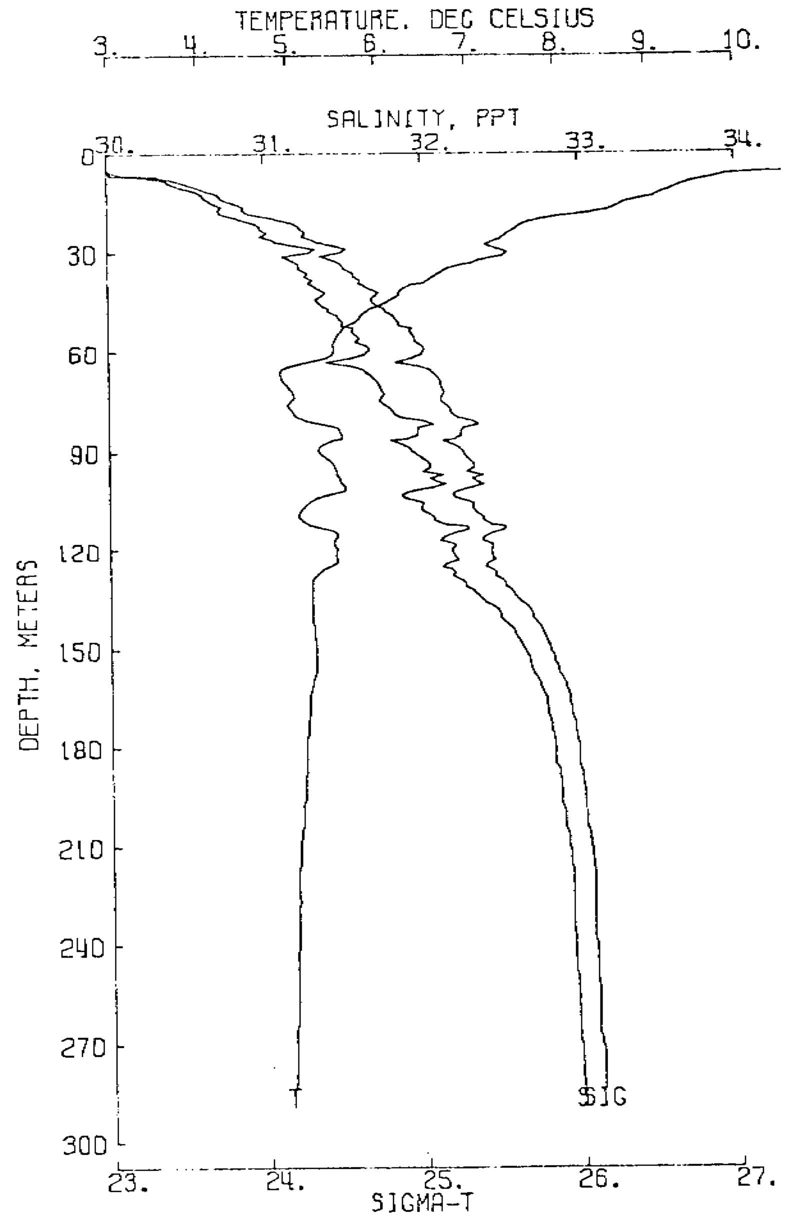
| | DIRECTION | | SPEED | |
|---|---|---|---|---|
| WIND | - | DEGR | KNOTS | |

| | DIRECTION | | HEIGHT | PERIOD |
|---|---|---|---|---|
| SEA | 0 - 0 | DEGR | M. | SECS |
| SWELL | - | DEGR | M. | SECS |

TEMPERATURES -DRY = 12.2 DEGR C. BAROMETRIC PR. =1009.7 MB
-WET = DEGR C. TRANSPARENCY = M

| DEPTH METERS | TEMPERATURE DEG C | SALINITY PPT | SIGMA-T | DELTA-D DYN M |
|---|---|---|---|---|
| 0. | 12.52 | 25.315 | 19.04 | 0. |
| 1.0 | 12.52 | 25.315 | 19.04 | 0.009 |
| 5.0 | 11.52 | 28.545 | 21.72 | 0.040 |
| 10.0 | 9.36 | 30.472 | 23.57 | 0.064 |
| 15.0 | 8.76 | 30.672 | 23.81 | 0.085 |
| 20.0 | 7.88 | 30.847 | 24.08 | 0.105 |
| 25.0 | 7.44 | 30.971 | 24.23 | 0.124 |
| 30.0 | 7.45 | 31.288 | 24.48 | 0.141 |
| 35.0 | 6.79 | 31.214 | 24.51 | 0.159 |
| 40.0 | 6.38 | 31.295 | 24.63 | 0.176 |
| 45.0 | 6.09 | 31.338 | 24.69 | 0.192 |
| 50.0 | 5.80 | 31.471 | 24.83 | 0.208 |
| 60.0 | 5.51 | 31.654 | 25.01 | 0.239 |
| 70.0 | 4.99 | 31.721 | 25.12 | 0.268 |
| 75.0 | 5.02 | 31.723 | 25.12 | 0.282 |
| 80.0 | 5.11 | 31.864 | 25.22 | 0.297 |
| 90.0 | 5.34 | 31.937 | 25.25 | 0.324 |
| 100.0 | 5.60 | 32.140 | 25.38 | 0.351 |
| 125.0 | 5.44 | 32.123 | 25.39 | 0.417 |
| 150.0 | 5.30 | 32.639 | 25.81 | 0.476 |
| 175.0 | 5.19 | 32.815 | 25.96 | 0.529 |
| 200.0 | 5.13 | 32.890 | 26.03 | 0.581 |
| 250.0 | 5.05 | 32.956 | 26.09 | 0.680 |

144




CRUISE 262 STATION 7

AC-262,RES-03-005

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 1501.00 | 17.381 | 0.447 | 5.974 | 2.731 | 0.133 | 2.598 |
| 10 | 1502.00 | 8.518 | 0.647 | 2.915 | 0.782 | 0.108 | 0.675 |
| 20 | 1503.00 | 10.761 | 0.744 | 3.767 | 2.700 | 0.219 | 2.481 |
| 30 | 1504.00 | 12.188 | 0.888 | 3.656 | 4.645 | 0.314 | 4.331 |
| 50 | 1505.00 | 16.631 | 1.141 | 3.950 | 9.104 | 0.727 | 8.377 |
| 75 | 1506.00 | 19.477 | 1.247 | 3.496 | 11.238 | 0.345 | 10.893 |
| 100 | 1507.00 | 27.574 | 1.455 | 1.578 | 16.806 | 0.303 | 16.502 |
| 150 | 1508.00 | 35.920 | 1.857 | 1.264 | 22.563 | 0.108 | 22.455 |
| 200 | 1509.00 | 35.750 | 2.065 | 1.127 | 26.752 | 0.132 | 26.620 |
| 250 | 1510.00 | 45.089 | 2.195 | 1.041 | 30.670 | 0.183 | 30.487 |

AC-262,RES-03-004

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 1511.00 | 8.055 | 0.109 | 2.185 | 0.627 | 0.065 | 0.563 |
| 10 | 1512.00 | 8.950 | 0.464 | 2.061 | 1.409 | 0.192 | 1.217 |
| 20 | 1513.00 | 13.819 | 0.746 | 3.135 | 3.949 | 0.249 | 3.700 |
| 30 | 1514.00 | 13.507 | 0.820 | 3.588 | 4.623 | 0.278 | 4.344 |
| 50 | 1515.00 | 35.796 | 1.283 | 5.062 | 15.923 | 0.762 | 15.161 |
| 75 | 1516.00 | 24.911 | 1.363 | 1.501 | 16.570 | 0.375 | 16.194 |
| 100 | 1517.00 | 26.055 | 1.401 | | 15.810 | 0.399 | 15.411 |
| 150 | 1518.00 | 36.335 | 1.770 | | 22.026 | 0.100 | 21.926 |
| 200 | 1519.00 | 41.086 | 1.924 | | 26.320 | 0.089 | 26.232 |
| 250 | 1520.00 | 47.612 | 2.105 | | 29.857 | 0.148 | 29.709 |

AC-262,RES-03-003

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 1521.00 | 12.163 | 0.050 | | 0.326 | 0.044 | 0.282 |
| 10 | 1522.00 | 6.306 | 0.324 | | 0.780 | 0.087 | 0.693 |
| 20 | 1523.00 | 9.212 | 0.583 | | 2.885 | 0.212 | 2.672 |
| 30 | 1524.00 | 10.628 | 0.723 | | 4.367 | 0.322 | 4.045 |
| 50 | 1525.00 | 14.811 | 1.087 | | 9.391 | 1.142 | 8.249 |
| 75 | 1526.00 | 25.918 | 1.479 | | 14.247 | 0.353 | 13.894 |
| 100 | 1527.00 | 27.231 | 1.624 | | 14.328 | 0.413 | 13.915 |
| 150 | 1528.00 | 37.627 | 1.967 | | 19.763 | 0.145 | 19.618 |
| 200 | 1529.00 | 43.233 | 1.892 | | 22.386 | 0.156 | 22.230 |
| 250 | 1530.00 | 34.855 | 1.540 | | 20.824 | 0.348 | 20.476 |

AC-262,RES-03-02.5

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 10 | 1531.00 | 7.851 | 0.508 | | 1.188 | 0.380 | 0.808 |
| 30 | 1532.00 | 13.170 | 0.922 | | 5.483 | 0.117 | 5.366 |
| 70 | 1533.00 | 25.301 | 1.527 | | 16.970 | 0.116 | 16.853 |
| 110 | 1534.00 | 29.094 | 1.631 | | 18.262 | 0.116 | 18.147 |
| 170 | 1535.00 | 38.777 | 1.891 | | 22.881 | 0.126 | 22.755 |
| 190 | 1536.00 | 40.051 | 1.942 | | 23.850 | 0.460 | 23.390 |
| 210 | 1537.00 | 42.886 | 1.988 | | 24.926 | 0.098 | 24.828 |
| 230 | 1538.00 | 43.593 | 2.039 | | 25.679 | 0.103 | 25.576 |
| 250 | 1539.00 | 43.235 | 2.003 | | 25.674 | 0.102 | 25.571 |
| 260 | 1540.00 | 42.451 | 1.984 | | 25.452 | 0.102 | 25.350 |
| 270 | 1541.00 | 41.596 | 2.032 | | 26.232 | 0.101 | 26.130 |
| 280 | 1542.00 | 41.628 | 1.890 | | 25.578 | 0.101 | 25.477 |

AC-256, RES-2.5

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 3481.00 | 22.046 | 1.013 | 0.309 | 13.794 | 0.080 | 13.744 |
| 10 | 3482.00 | 25.744 | 1.248 | 0.254 | 16.094 | 0.106 | 16.018 |
| 20 | 3483.00 | 25.418 | 1.260 | 0.317 | 16.181 | 0.108 | 16.103 |
| 30 | 3484.00 | 26.081 | 1.271 | 0.368 | 16.269 | 0.096 | 16.203 |
| 50 | 3485.00 | 25.437 | 1.258 | 0.530 | 15.941 | 0.116 | 15.855 |
| 75 | 3486.00 | 25.711 | 1.259 | 0.394 | 16.083 | 0.080 | 16.033 |
| 100 | 3487.00 | 26.692 | 1.288 | 0.246 | 16.530 | 0.054 | 16.506 |
| 150 | 3488.00 | 21.530 | 0.970 | 0.098 | 13.187 | 0.029 | 13.189 |
| 175 | 3489.00 | 28.969 | 1.342 | 0.198 | 17.950 | 0.060 | 17.920 |
| 200 | 3490.00 | 31.326 | 1.456 | 0.635 | 19.171 | 0.054 | 19.147 |
| 225 | 3491.00 | 36.965 | 1.607 | 0.300 | 22.495 | 0.044 | 22.481 |
| 250 | 3492.00 | 33.745 | 1.392 | 0.158 | 20.314 | 0.003 | 20.341 |
| 275 | 3493.00 | 51.385 | 2.254 | 0.059 | 30.581 | 0.034 | 30.577 |

AC-256, RES-004

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 3494.00 | 25.682 | 1.237 | 0.041 | 15.979 | 0.080 | 15.929 |
| 10 | 3495.00 | 25.638 | 1.241 | 0.117 | 16.398 | 0.088 | 16.340 |
| 20 | 3496.00 | 25.806 | 1.239 | 0.130 | 16.237 | 0.085 | 16.181 |
| 30 | 3497.00 | 36.917 | 1.347 | 0.312 | 20.335 | 0.085 | 20.280 |
| 50 | 3498.00 | 25.896 | 1.253 | 0.170 | 16.273 | 0.065 | 16.238 |
| 75 | 3499.00 | 48.689 | 1.325 | 0.245 | 23.442 | 0.034 | 23.438 |
| 100 | 3500.00 | 26.727 | 1.257 | 0.016 | 16.696 | 0.042 | 16.685 |
| 150 | 3501.00 | 29.331 | 1.350 | 0.135 | 18.194 | 0.047 | 18.178 |
| 175 | 3502.00 | 29.958 | 1.358 | 0.130 | 18.475 | 0.049 | 18.456 |
| 200 | 3503.00 | 23.808 | 1.021 | 0.523 | 14.496 | 0.049 | 14.477 |
| 225 | 3504.00 | 24.965 | 1.175 | 0.150 | 15.192 | 0.029 | 15.193 |
| 250 | 3505.00 | 30.816 | 1.434 | 0.015 | 18.792 | 0.052 | 18.770 |

*

AC-260,RES-02-005

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 3676.00 | 1.630 | 0.144 | | 0.468 | 0.086 | 0.382 |
| 10 | 3677.00 | 17.297 | 0.920 | | 8.833 | 0.257 | 8.576 |
| 20 | 3678.00 | 4.472 | 0.500 | | 0.811 | 0.083 | 0.728 |
| 30 | 3679.00 | 18.259 | 1.130 | | 10.446 | 0.281 | 10.165 |
| 50 | 3680.00 | 25.587 | 1.304 | | 14.349 | 0.233 | 14.115 |
| 75 | 3681.00 | 30.432 | 1.536 | | 17.548 | 0.251 | 17.297 |
| 100 | 3682.00 | 30.239 | 1.502 | | 17.540 | 0.240 | 17.300 |
| 150 | 3683.00 | 28.840 | 1.453 | | 17.296 | 0.231 | 17.064 |
| 200 | 3684.00 | 27.724 | 1.460 | | 17.170 | 0.233 | 16.937 |
| 250 | 3685.00 | 28.808 | 1.453 | | 17.422 | 0.234 | 17.188 |

AC-260,RES-02-004

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 3686.00 | 9.526 | 0.460 | | 3.830 | 0.235 | 3.595 |
| 10 | 3687.00 | 16.216 | 0.901 | | 9.004 | 0.236 | 8.768 |
| 20 | 3688.00 | 23.474 | 1.204 | | 13.123 | 0.237 | 12.885 |
| 30 | 3689.00 | 24.062 | 1.193 | | 13.403 | 0.250 | 13.153 |
| 50 | 3690.00 | 27.771 | 1.289 | | 16.304 | 0.349 | 15.955 |
| 75 | 3691.00 | 30.275 | 1.458 | | 17.422 | 0.148 | 17.274 |
| 100 | 3692.00 | 31.465 | 1.495 | | 18.161 | 0.160 | 18.001 |
| 150 | 3693.00 | 27.579 | 1.387 | | 14.118 | 0.102 | 14.016 |
| 200 | 3694.00 | 28.637 | 1.432 | | 17.178 | 0.136 | 17.042 |
| 250 | 3695.00 | 26.218 | 1.363 | | 14.424 | 0.170 | 14.254 |

AC-260,RES-02-02.5

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 3601.00 | 13.811 | 0.032 | | 4.767 | 0.194 | 4.573 |
| 10 | 3602.00 | 26.435 | 0.641 | | 13.957 | 0.188 | 13.769 |
| 30 | 3603.00 | 30.756 | 1.243 | | 17.794 | 0.178 | 17.616 |
| 70 | 3604.00 | 32.310 | 1.486 | | 18.224 | 0.178 | 18.046 |
| 110 | 3605.00 | 31.984 | 1.555 | | 18.897 | 0.205 | 18.672 |
| 170 | 3606.00 | 31.764 | 1.633 | | 18.813 | 0.216 | 18.598 |
| 190 | 3607.00 | 22.887 | 1.583 | | 11.564 | 0.134 | 11.430 |
| 210 | 3608.00 | 26.676 | 1.069 | | 14.752 | 0.243 | 14.509 |
| 230 | 3609.00 | 28.372 | 1.294 | | 16.182 | 0.325 | 15.857 |
| 250 | 3610.00 | 28.684 | 1.524 | | 16.666 | 0.243 | 16.423 |
| 260 | 3611.00 | 29.564 | 1.447 | | 17.448 | 0.216 | 17.232 |
| 270 | 3612.00 | 30.728 | 1.487 | | 17.959 | 0.249 | 17.710 |
| 280 | 3613.00 | 30.792 | 1.522 | | 18.037 | 0.188 | 17.849 |
| 285 | 3614.00 | 28.407 | 1.509 | | 17.142 | 0.303 | 16.839 |

AC-260,RES-02-002

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 3707.00 | 0.672 | 0.001 | | 0.391 | 0.071 | 0.320 |
| 10 | 3708.00 | 22.558 | 0.978 | | 11.130 | 0.203 | 10.926 |
| 20 | 3709.00 | 24.007 | 1.093 | | 12.378 | 0.204 | 12.174 |
| 30 | 3710.00 | 26.910 | 1.270 | | 14.951 | 0.216 | 14.735 |
| 50 | 3711.00 | 31.304 | 1.409 | | 15.064 | 0.294 | 14.770 |
| 75 | 3712.00 | 29.950 | 1.451 | | 17.178 | 0.169 | 17.009 |
| 100 | 3713.00 | 30.405 | 1.572 | | 17.507 | 0.109 | 17.397 |
| 150 | 3714.00 | 33.096 | 1.621 | | 19.350 | 0.099 | 19.250 |
| 180 | 3715.00 | 33.267 | 1.622 | | 19.327 | 0.106 | 19.221 |

AC-260,RES-02-003

| DEPTH | BOTTLE NUMBER | [SILICATE](SD) | [PHOS.](SD) | [AMMONIA](SD) | [SUM NITR.](SD) | [NITRITE](SD) | [NITRATE](SD) |
|---|---|---|---|---|---|---|---|
| 0 | 3696.00 | 1.234 | 0.037 | | 0.584 | 0.083 | 0.502 |
| 10 | 3697.00 | 1.370 | 0.109 | | 0.265 | 0.062 | 0.203 |
| 20 | 3698.00 | 16.869 | 0.734 | | 7.678 | 0.194 | 7.484 |
| 30 | 3699.00 | 21.192 | 0.785 | | 9.278 | 0.124 | 9.154 |
| 50 | 3700.00 | 28.247 | 1.287 | | 15.907 | 0.251 | 15.656 |
| 75 | 3701.00 | 30.228 | 1.391 | | 17.182 | 0.164 | 17.018 |
| 100 | 3702.00 | 31.570 | 1.495 | | 17.808 | 0.132 | 17.676 |
| 150 | 3703.00 | 32.522 | 1.604 | | 18.732 | 0.160 | 18.572 |
| 200 | 3704.00 | 31.949 | 1.494 | | 18.737 | 0.090 | 18.647 |
| 250 | 3705.00 | 42.587 | 2.072 | | 25.068 | 0.086 | 24.983 |
| 280 | 3706.00 | 51.983 | 2.539 | | 27.939 | 0.081 | 27.858 |

*BYE

# APPENDIX V

## HEAVY METAL CONTENTS OF BERING SEA SEALS

# HEAVY METAL CONTENTS OF BERING SEA SEALS

David C. Burrell

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

Contribution No. XXX, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
Paper presented at 29th Alaska Science Conference, Fairbanks, Alaska. August 1978.

## INTRODUCTION

This communication is based on base-line studies performed as part of the BLM/NOAA Outer Continental Shelf Environmental Assessment Program for Alaska and hence unfortunately consists of unintegrated survey work lacking the direction and cohesiveness generally associated with scientific projects. Nevertheless, we have obtained a number of precisely analysed heavy metal data for an area — the central Bering Sea — which is of considerable economic importance and current oceanographic interest, and for which very little chemical characterization exists.

The major portion of this work concerns heavy metal contents of various seal tissue samples. These distributions are considered within the context of the environmental base-lines determined for water and sediments within coincident and adjacent portions of the Bering Sea.

## ANALYSIS TECHNIQUES

All biota and sediment samples considered here have been analysed for selected heavy metals spectrophotometrically. The major limitations on analytical precision for both classes of sample is connected with the dissolution step and inter-element matrix effects. The problem of oxidation of the tissue samples without loss of volatile metals was addressed here by low temperature ashing in an oxygen plasma furnace. The residues from this step were then treated with Ultrex nitric acid in a teflon digestion bomb prior to graphite furnace atomic spectrometric analysis. Standard curves run with each batch were prepared by adding standards to a matrix prepared in bulk for each type of tissue sample. NBS standards were carried through with each batch to monitor accuracy.

Only chemical extracts of sediments have been determined in this study as a very rough measure of bioavailability. The extractant used — 25 percent v/v acetic acid — was mandated by the contracting agency. Metal concentrations thus determined were lower than would have been given by the more conventional mixed acid-reducing treatment but the latter has only the virtue of more universal use since several studies (Luoma and Jenne, 1976, for example) have shown little correlation between "bioavailability", as evidenced by measured uptake, and various chemical leaching treatments.

Soluble seawater trace metal data constitutes only a very minor component of this particular report. The very stringent sampling strategy needed has been discussed in detail by Burrell (1978). Final analysis was by differential pulse anodic stripping voltammetry.

## ENVIRONMENTAL DATA

Using the very careful sampling procedures referenced above, a number of water samples were collected from the U.S.S.R. Hydromet Vessel *Volna* on the stations shown in Figure 1 in July-August 1977. Coincidently, many of these localities cover that portion of the Alaskan Shelf west of Nunivak Island from which the seal specimens discussed below has been collected the previous spring.

To date, soluble copper and lead values have been determined and Figure 2 shows the mean ranges for over 100 samples collected through the water column. These closely conform with distributions given previously for the Gulf of Alaska and elsewhere. Since mean soluble concentrations

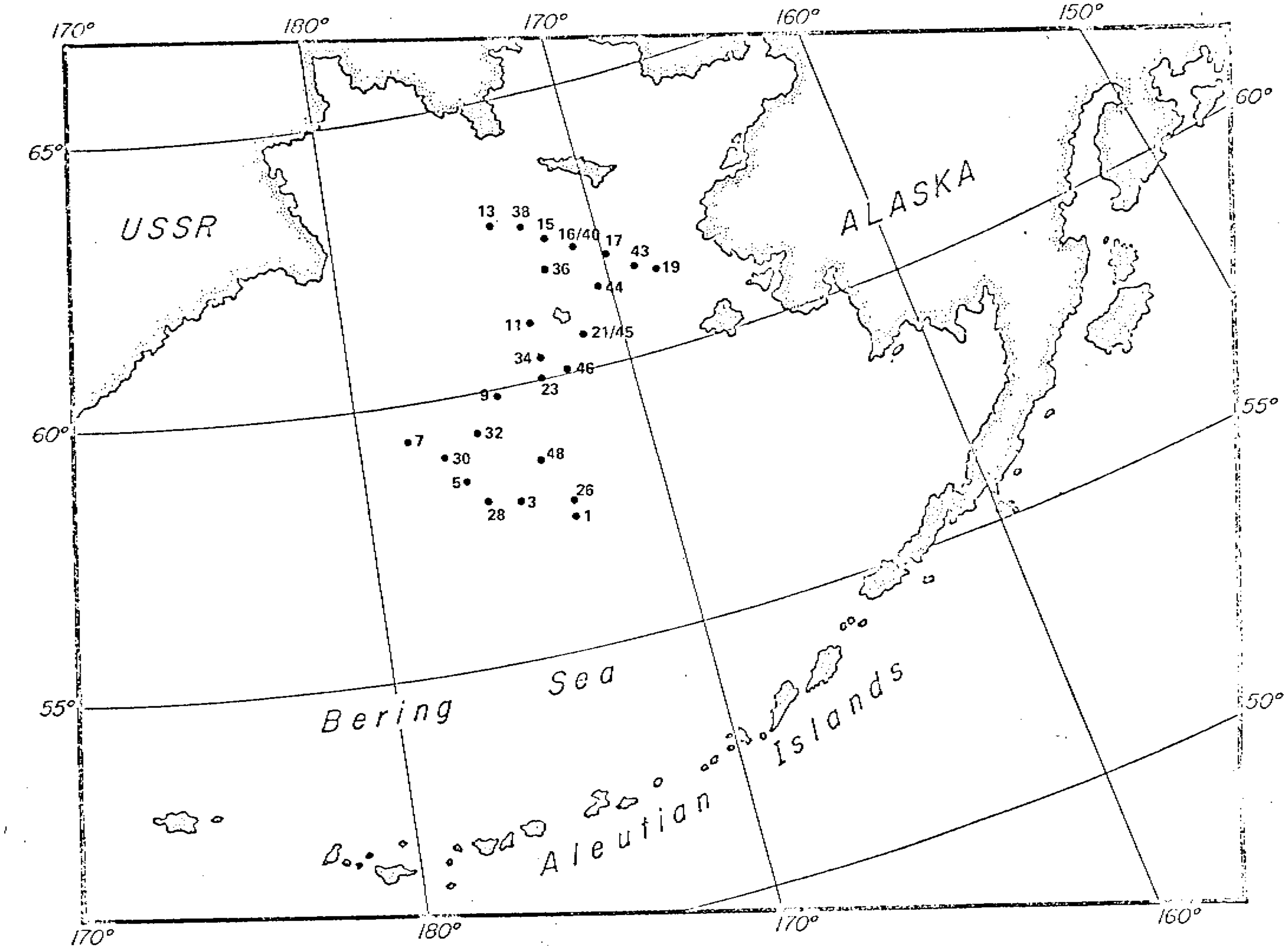



Figure 1. Stations occupied by U.S.S.R. hydromet vessel *Volna* July-August 1977.

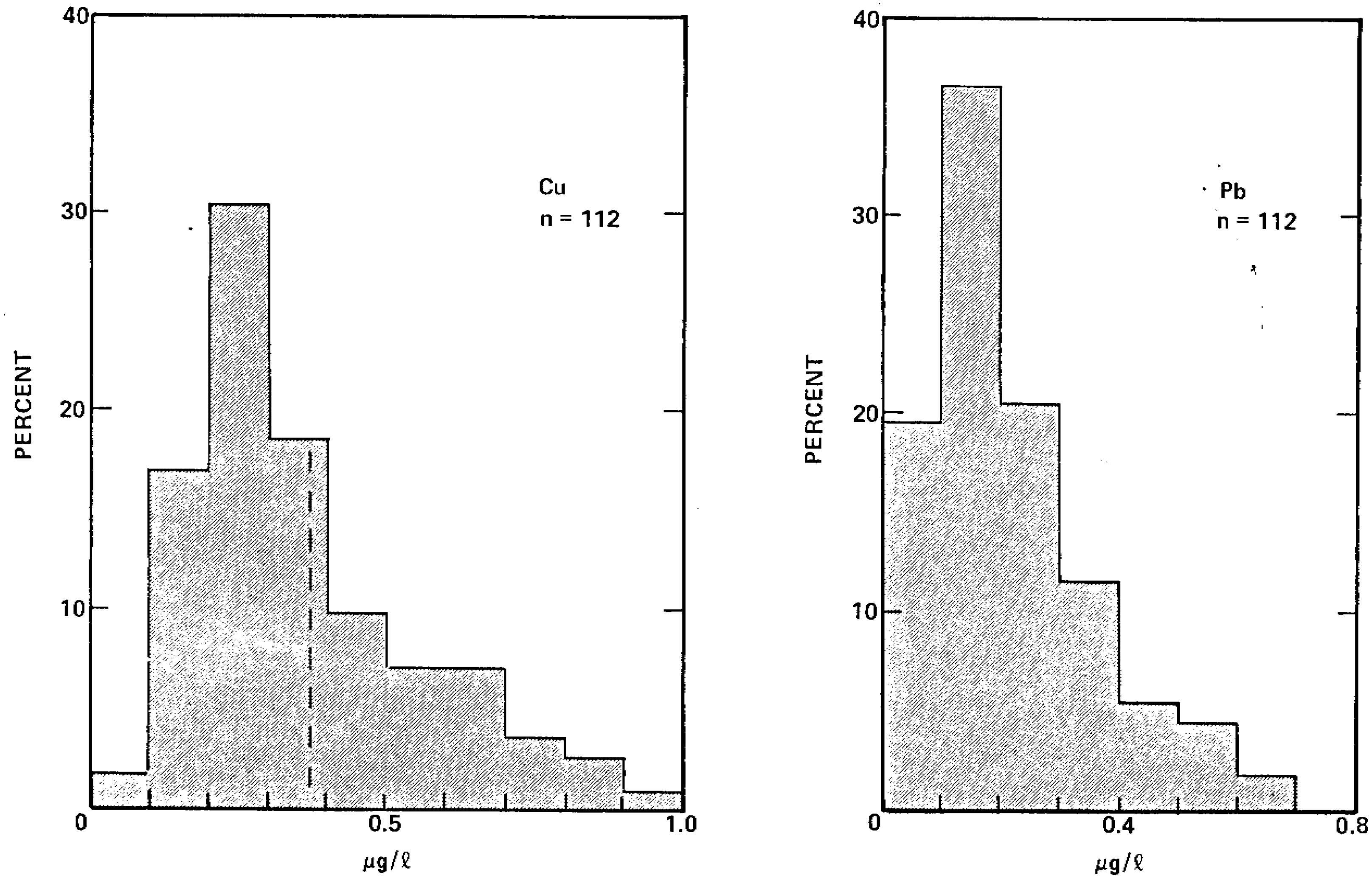



Figure 2. Mean ranges for soluble copper and lead concentrations for samples collected from the surface and adjacent to the bottom at the stations given in Figure 1. (D. T. Heggie, analyst)

should only vary between narrow limits in the open ocean, this would be expected. However, it is only recently that nanogram ranges have been suggested for these metals: our data supports such levels for unpolluted open ocean water and at the same time add confidence to their accuracy. Although we have good soluble data for these two metals only, there is no evidence for any anomolous trends and it is expected that the concentrations of other trace metals in solution will show the same low ranges given in earlier publications for the Gulf of Alaska (e.g., Burrell, 1978).

With regard to the "available" metal contents of Bering Sea surficial sediments, we have data for coarsely spaced grids of stations in Norton Sound and in the southern portion of the Bering Sea, which includes most of the geographic area from which the seals analysed in this study were harvested. Figures 3 and 4 illustrate the distribution of mud-sized material over this region and Table I lists acid-extractable contents of a number of metals from the Norton Sound samples. It is immediately apparent that these sediments are relatively coarse grained; considerably more so than the areas south of the Aleutian Chain. And, since extractable metal contents are a function of the grain size, these latter contents are similarly depressed and, for the most part below the analytical detection limits. Table II for example, shows correlations between concentrations of extracted metals and the content of mud-sized sediment for Norton Sound.

## HEAVY METAL CONTENTS OF MARINE MAMMALS

Figure 5 shows the localities of sacrificed seal samples collected on two separate cruises in March-April and May-June of 1977.

The original objective of this project was to look for statistical differences between the heavy metal contents of four species of seal which

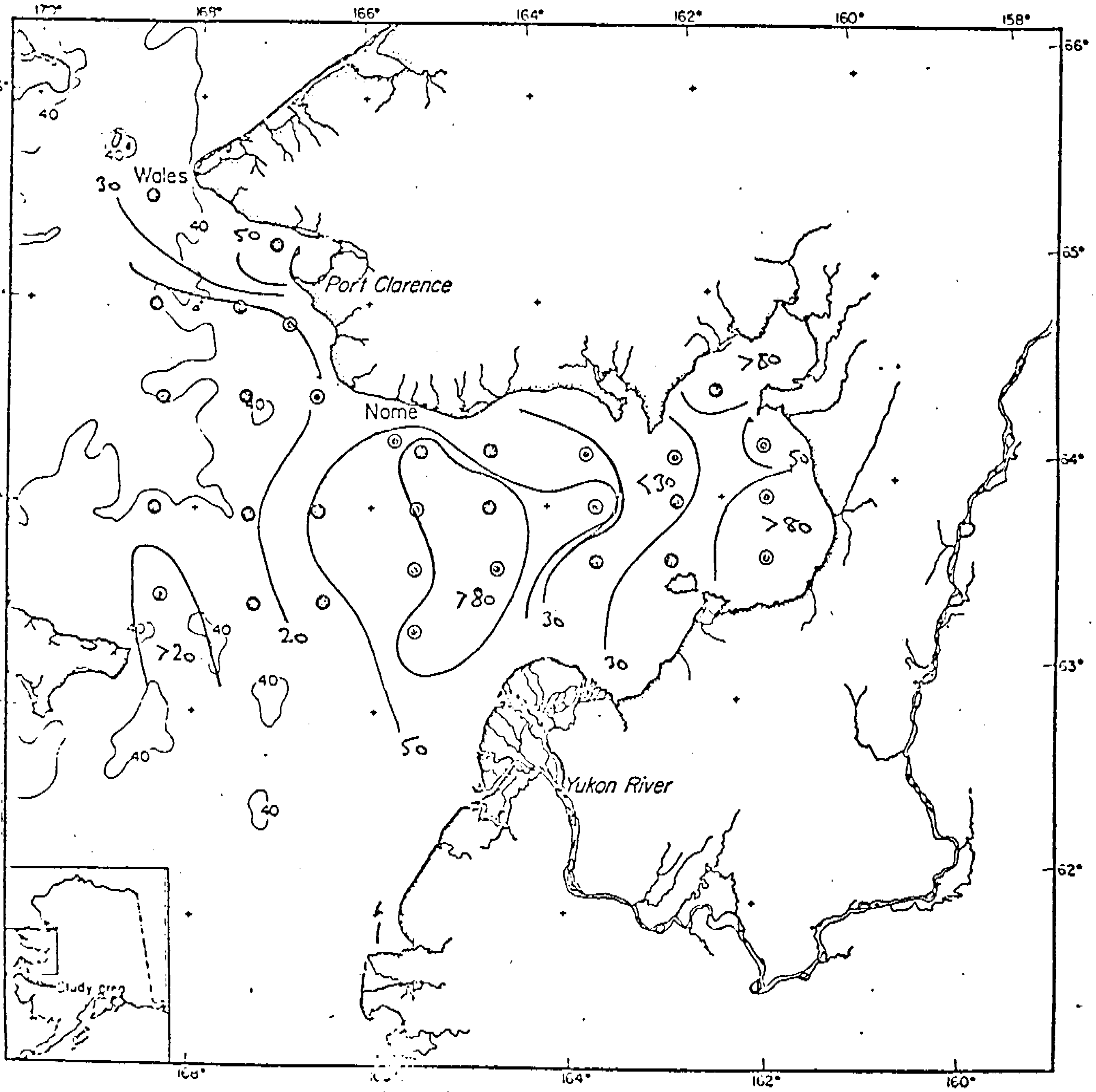



Figure 4. Northern Bering Sea: Norton Sound. Weight percent of mud-sized fraction of superficial sediment. (C. Tommos, analyst)

TABLE I

NORTON SOUND

OSS *Discoverer* - September 1976

Heavy metal contents of sediment extracts (μg/g) and clay + silt %

| # | Clay/silt (%) | Cd | Cu | Ni | Zn | Fe | Mn |
|---|---|---|---|---|---|---|---|
| 1 | 22.1 | <0.1 | <0.3 | <1.3 | 6.2 | 746 | 8 |
| 4 | 87.0 | <0.1 | 0.5 | 2.5 | 5.0 | 3050 | 48 |
| 5 | 64.3 | <0.1 | 0.5 | 2.9 | 5.0 | 2843 | 86 |
| 6 | 86.4 | <0.1 | 2.0 | 3.3 | 5.7 | 3084 | 121 |
| 9 | 89.0 | <0.1 | 1.1 | 4.3 | 8.0 | 4250 | 79 |
| 12D | 59.5 | <0.1 | 0.6 | 1.4 | 5.1 | 1609 | 230 |
| 13 | 81.9 | <0.1 | 0.5 | 1.8 | 6.0 | 2086 | 283 |
| 15 | 81.9 | <0.1 | <0.3 | <1.3 | 5.1 | 1779 | 75 |
| 17 | 85.6 | 0.1 | 2.2 | 4.2 | 9.1 | 2961 | 193 |
| 20 | 35.2 | <0.1 | <0.3 | <1.3 | 3.5 | 966 | 58 |
| 21 | 21.5 | <0.1 | 0.3 | <1.3 | 3.5 | 1219 | 52 |
| 23 | 43.8 | <0.1 | 0.6 | 1.8 | 6.6 | 2066 | 70 |
| 26 | 17.6 | <0.1 | <0.3 | <1.3 | 2.5 | 565 | 60 |
| 28A | 14.8 | <0.1 | <0.3 | <1.3 | 2.5 | 745 | 20 |

TABLE II

NORTON SOUND

*Discoverer* -- September 1976

Heavy metal extract data and grain size correlation coefficients

| | S + C | Fe | Mn | Zn | Ni | Cu |
|---|---|---|---|---|---|---|
| Silt and Clay | | 0.86 | 0.53 | 0.67 | 0.73 | 0.62 |
| Fe | | | 0.27 | 0.71 | 0.98 | 0.84 |
| Zn | | | | | 0.76 | 0.84 |
| Ni | | | | | | 0.85 |

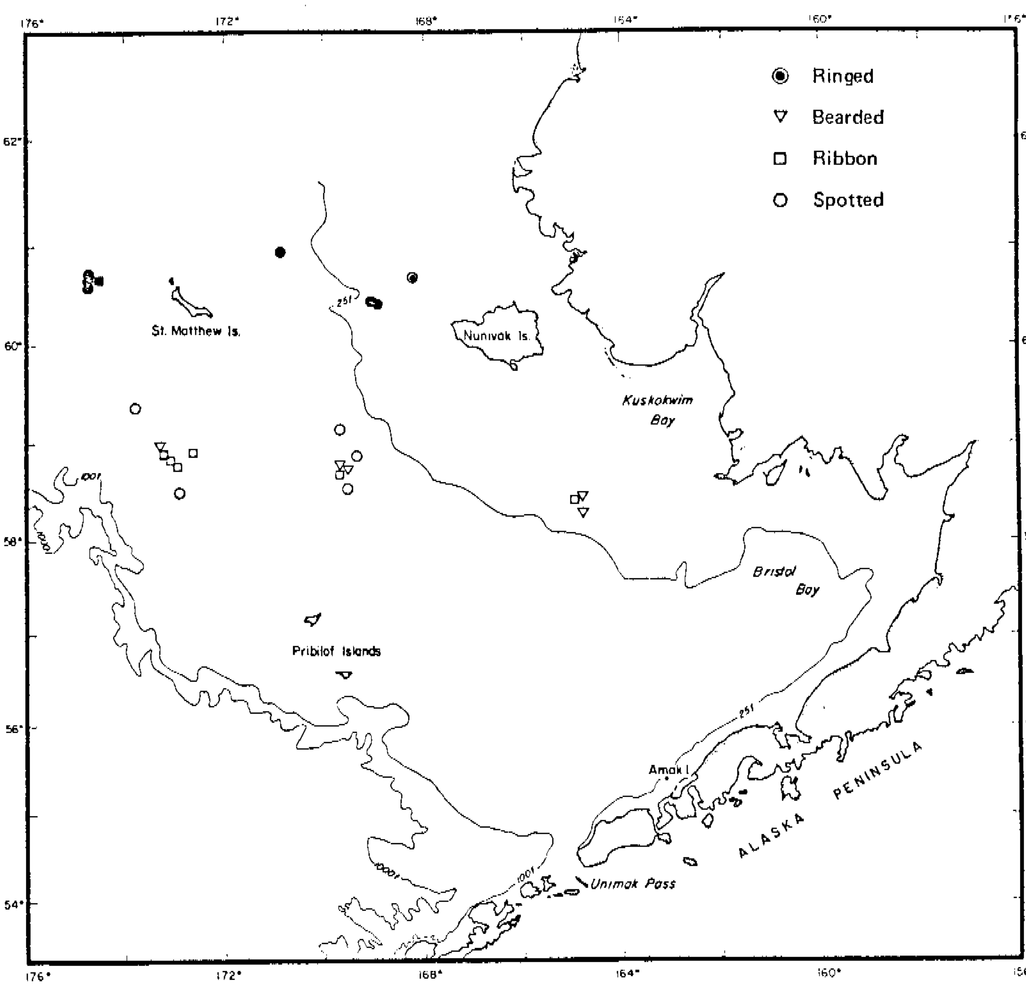



Figure 5. Localities of seal samples collected on *Surveyor* cruise March-April 1977 and *Discoverer* cruise May-June 1977.

were thought to have distinctive feeding habits. Our data are largely for ribbon, spotted and bearded seal samples (Tables III and IV) which were believed to feed predominantly on fish and benthos, pelagic fish, and invertebrate benthos respectively. Unfortunately it was not found feasible to obtain representative food species at the time of collection of the mammals. Nor were stomach contents suitable for either identification for analysis: in many cases it was found that the animals had starved for a number of days. The biological investigators also found the seals to be largely opportunistic feeders who would eat what was available, so that diet differentiation by species, where it occurred, was only noted where there was adequate choice.

For most of the individuals collected we have analysed for cadmium, nickel, copper, and zinc in muscle, liver and kidney tissue and these data, as means of duplicate determinations, are given in Tables V and VI. Table VII gives accuracy and precision information relating to this batch of numbers.

As noted above, marked differences in heavy metal contents as a reflection of transfer from a particular type of food would not be expected. Nevertheless, Table VIII lists some possible trends based on this very limited sample batch.

It appears likely that the spotted seals have the lowest overall metal contents and, yet more tentatively, bearded the highest. The former are considered to be largely consumers of fin fish, whereas the bearded seals consume large quantities of benthic invertebrates. Since the benthos concentrates metal more than pelagic communities this possible trend is of interest. Clearly more positive correlation would require not only a considerably larger number of specimens of one specific species but also concurrent food species or, preferably, fresh stomach contents.

TABLE III

BERING SEA

O.S.S. *Surveyor* 31 March - 27 April 1977

Seal samples collected for heavy metal analysis

| Sample # | Latitude (N) | Longitude (W) | Species | Sex | Weight (kg) | Age (yrs) |
|---|---|---|---|---|---|---|
| 1 | 58°51.0 | 173°08.0 | Ribbon | F | 39.5 | 1 |
| 2 | 58°51.0 | 173°08.0 | Ribbon | M | 102.0 | - |
| 3 | 58°56.0 | 172°40.0 | Ribbon | M | 81.8 | 4 |
| 4 | 58°45.6 | 172°55.4 | Spotted | M | 35.0 | 1 |
| 5 | 59°00.6 | 173°15.0 | Bearded | F | 181 | 6+ |
| 6 | 58°53.0 | 173°07.0 | Ribbon | M | 107.3 | 15 |
| 7 | 58°43.9 | 169°32.9 | Bearded | M | 232 | 12 |
| 8 | 58°48.5 | 169°41.0 | Bearded | F | 227 | 12+ |
| 10 | 59°06.3 | 169°41.3 | Spotted | F | 41.8 | 1 |
| 11 | 58°24.7 | 164°52.3 | Ribbon | F | 98.6 | 3 |
| 16 | 58°21.3 | 164°49.7 | Bearded | F | 204.5 | 2 |
| 17 | | | Walrus | F | | |
| 28 | 58°54.2 | 169°13.6 | Spotted | M | 89.9 | 6 |
| 29 | 58°40.1 | 169°40.3 | Ribbon | M | 59.9 | 3 |
| 30 | 58°34.8 | 169°28.8 | Spotted | M | 84.0 | 7 |
| 32 | 59°22.5 | 173°43.0 | Spotted | M | 118.0 | 17 |

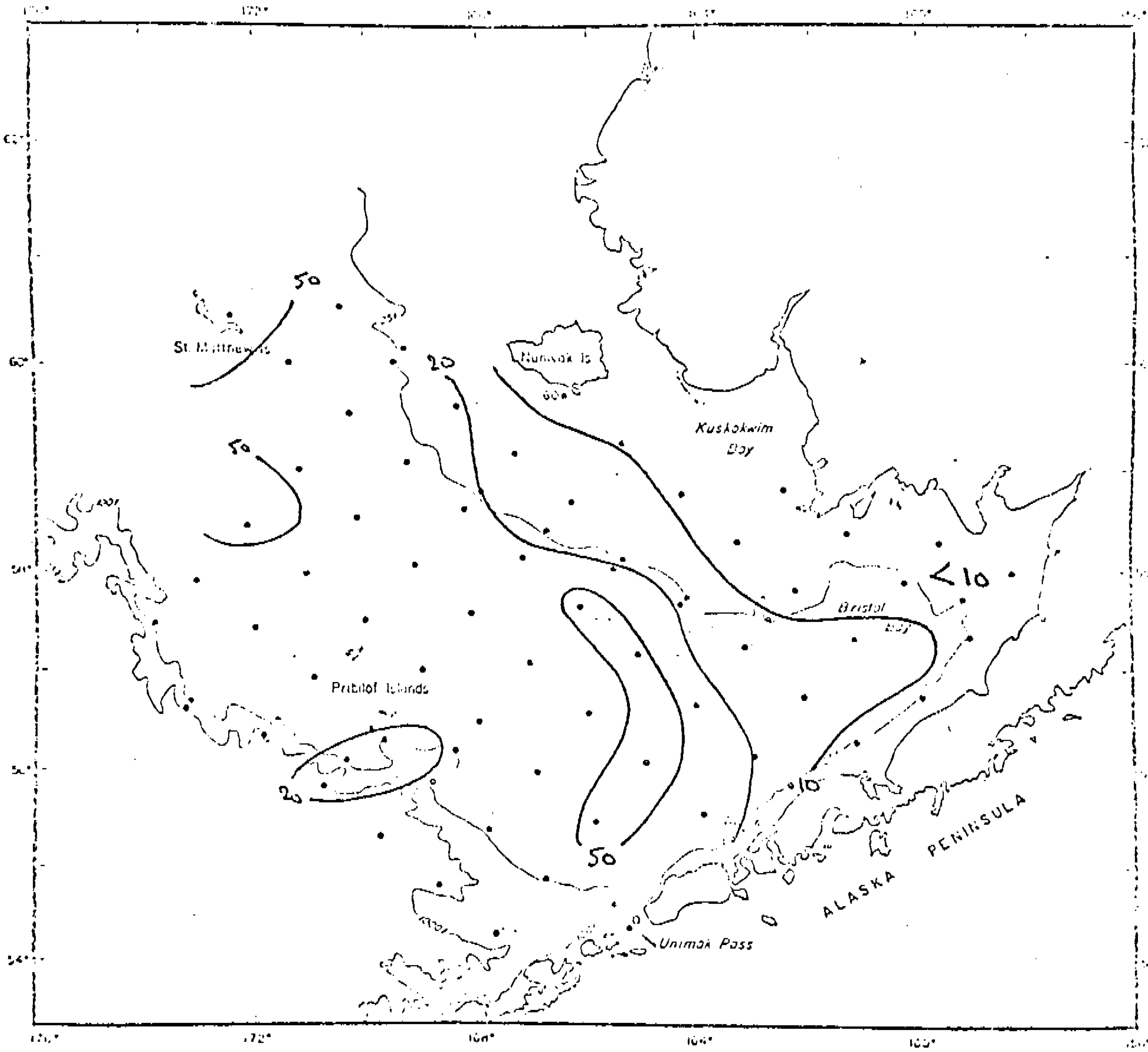



Figure 3. South Bering Sea weight percent of mud-sized fraction of superficial sediment. (C. Tommas, analyst)

TABLE IV

BERING SEA

O.S.S. *Discoverer* 25 May - 5 June 1977

Seal samples collected for heavy metal analysis

| Sample # | Latitude (N) | Longitude (W) | Species | Sex | Weight (kg) | Age (yrs) |
|---|---|---|---|---|---|---|
| 1 | 60°37.7 | 174°27.2 | Ribbon | M | 80.0 | 10 |
| 2 | 60°36.3 | 174°37.5 | Spotted | F | 57.7 | 10 |
| 3 | 60°36.3 | 174°37.5 | Spotted | M | 45.5 | 0.3 |
| 5 | 60°36.3 | 174°37.5 | Spotted | M | 49.1 | 2 |
| 7 | | | Ribbon | M | 73.6 | 7 |
| 8 | 60°26.5 | 168°55.8 | Spotted | F | 55.0 | 4 |
| 10 | 60°24.2 | 169°49.8 | Spotted | M | 68.6 | 5 |
| 13 | 60°35.9 | 168°10.1 | Ringed | M | 8.7 | 1 |
| 15 | 60°56.6 | 170°48.3 | Spotted | F | 37.7 | <1 |

TABLE V

BERING SEA

O.S.S. *Surveyor* 31 March - 27 April 1977

Heavy metal contents of seal tissue (μg/g dry weight)

| Sample | Species | Tissue | Cd[a] | Ni[a] | Cu[a] | Zn[a] |
|---|---|---|---|---|---|---|
| 01 | Rib | muscle | 0.13 ± 0.01 | 2.5 ± 0.4 | 6.7 ± 0.5 | 37 ± 12 |
| | | liver | 6.4 ± 0.1 | 2.6 ± 0.9 | 16.5 ± 0.2 | 169 ± 7 |
| | | kidney | 53.0 ± 0.3 | 2.8 ± 0.2 | 19.4 ± 0.1 | 149 ± 1 |
| 02 | Rib | muscle | 0.3 (c) | 1.3 (c) | 4.4 ± 0.6 | 50 ± 0 |
| | | liver | 8.7 ± 1.2 | 1.3 (c) | 16.5 ± 3.5 | 8 ± 2 |
| | | kidney | 20.1 ± 4.5 | 0.5 ± 0 | 16.5 ± 3.5 | 102 ± 22 |
| 03 | Rib | muscle | 0.25 ± 0 | 8.3 ± 1.0 | 5.5 ± 0 | 54 ± 2 |
| | | liver | 6.4 ± 0.1 | 2.2 ± 0.4 | 26.9 ± 1.3 | 140 ± 15 |
| | | kidney | 34.5 (c) | 3.0 (c) | 16.0 (c) | 98 (c) |
| 04 | S | muscle | 0.14 ± 0.01 | 3.0 ± 0.2 | 6.7 ± 1.3 | 51 ± 9 |
| | | liver | 0.4 ± 0.1 | 2.5 ± 0.2 | 25.0 ± 2.5 | 116 ± 51 |
| | | kidney | 16.7 ± 0.2 | 2.4 ± 0.4 | 44 ±13 | 113 ± 23 |
| 05 | B | muscle | 0.8 ± 0.1 | 2.8 ± 0.3 | 7 ± 2 | 175 ± 25 |
| | | liver | 21.0 ± 0.5 | 1.3 ± 0.1 | 36.5 (c) | 182 ± 2 |
| | | kidney | 16.0 ± 2.0 | 2.0 ± 0.1 | 28.5 ± 0 | 163 ± 3 |
| 06 | Rib | muscle | 0.47 ± 0.01 | 5.8 ± 0 | 6.8 ± 0.8 | 18 ± 6 |
| | | liver | 11.4 ± 0.1 | 0.9 ± 0.2 | 29.0 ± 2.5 | 100 ± 10 |
| | | kidney | 33.4 ± 0 | 1.2 ± 0.2 | 17.5 ± 0.3 | 48 ± 0 |
| 07 | B | muscle | 0.57 ± 0.04 | 2.8 ± 0.2 | <5 (b) | 147 ± 20 |
| | | liver | 22.2 ± 1.3 | 0.8 ± | 22.8 ± 0.2 | 170 ± 17 |
| | | kidney | 22.5 ± 2.0 | 1.3 ± 0.3 | 40 ± 6 | 160 ± 15 |
| 08 | B | muscle | 1.26 ± 0 | 1.2 ± 0.1 | 7.6 ± 0 | 40 ± 1 |
| | | liver | 41.1 ± 0.9 | 0.5 ± 0 | 44.1 ± 2.4 | 87 ± 3 |
| | | kidney | 17.4 ± 0.1 | 1.5 ± 0.1 | 28.1 ± 0.6 | 110 ± 1 |
| 10 | S | muscle | 1.5 ± 1.0 | 2.4 ± 0.2 | 11 ± 3 | 52.5± 0 |
| | | liver | 0.6 ± 0.1 | 8.1 ± 1.6 | 18 ± 4 | 213 ± 7 |
| | | kidney | 44.3 ± 0.7 | <1.0 (b) | 24.5 (c) | 183 (c) |
| 11 | Rib | muscle | 0.24 ± 0.02 | <0.5 (b) | 16.5 ± 3.5 | 140 ± 5 |
| | | liver | 35 ±15 | <0.5 (b) | 13.8 ± 1.2 | 15 ± 10 |
| | | kidney | 16 (c) | <0.5 (b) | 19 ± 6 | 8 ± 3 |

TABLE V (Continued)

| Sample | Species | Tissue | Cd[a] | Ni[a] | Cu[a] | Zn[a] |
|---|---|---|---|---|---|---|
| 16 | B | muscle | 1.13 ± 0.07 | 4.8 ± 0.2 | 6.9 ± 0.6 | 60 ± 10 |
| | | liver | 5.3 ± 0.6 | 5.4 ± 1.1 | 37.6 ± 1.6 | 228 ± 3 |
| | | kidney | 108.7 ± 0.5 | 6.2 ± 0.2 | 34.7 ± 0.2 | 110 ± 20 |
| 17 | Walrus | muscle | 1.50 ± 0.25 | 2.4 ± 0.5 | 6.3 ± 1.3 | 43 ± 8 |
| | | liver | 26.0 ± 1.0 | 1.6 ± 0.3 | 41.6 ± 0.4 | 99 ± 1 |
| | | kidney | 26.5 ± 1.0 | <1.0 (b) | 27.7 ± 0 | 96 ± 1 |
| 28 | S | muscle | 0.11 ± 0.01 | <0.5 (b) | 6.4 ± 0.05 | 68 ± 1 |
| | | liver | 4.5 ± 0.05 | <0.5 (b) | 16.4 ± 0.1 | 136 ± 1 |
| | | kidney | – – | – – | – – | – – |
| 29 | Rib | muscle | 0.70 ± 0.03 | <0.5 (b) | 1.7 ± 0 | 74 ± 2 |
| | | liver | 17.0 ± 0.3 | <0.5 (b) | 5.2 ± 1.4 | 130 ± 3 |
| | | kidney | 37 ± 5 | <0.5 (b) | 5.2 ± 1.3 | 92 ± 14 |
| 30 | S | muscle | 0.16 ± 0.04 | <0.5 (b) | 4.0 ± 0.1 | 133 ± 0 |
| | | liver | 7.3 ± 0.2 | <0.5 (b) | 18.5 ± 0.2 | 160 ± 0 |
| | | kidney | 34 ± 5 | <0.5 (b) | 15 ± 2.5 | 120 ± 17 |
| 32 | S | muscle | 0.17 ± 0.01 | <0.5 (b) | 1.1 ± 0.1 | 62 ± 9 |
| | | liver | 15.9 ± 0.8 | <0.5 (b) | 17.1 ± 0.9 | 125 ± 23 |
| | | kidney | 49 ± 7 | <0.5 (b) | 4 ± 2.5 | 110 ± 32 |

a = mean of duplicate determinations
b = duplicate determinations
c = single determinations

TABLE VI

BERING SEA

O.S.S. *Discoverer* 25 May - 5 June 1977

Heavy metal contents of seal tissue (μg/g dry weight)

| Sample | Species | Tissue | Cd[a] | Ni[a] | Cu[a] | Zn[a] |
|---|---|---|---|---|---|---|
| 01 | Rib | muscle | 0.29 ± 0.04 | 0.5 ± 0.1 | 4.6 ± 0.1 | 96 ± 5 |
| | | liver | 3.2 ± 0.9 | <0.5 (b) | 6 ± 3 | 185 ± 15 |
| | | kidney | <0.3 (b) | 1.3 ± 0.5 | 10 ± 1 | 197 ± 6 |
| 02 | S | muscle | 1.3 (c) | <0.5 (b) | 3.9 ± 0.5 | 18.2 ± 1.1 |
| | | liver | 2.48 ± 0.02 | <0.5 (b) | 11 ± 3 | 23.3 ± 0.2 |
| | | kidney | <0.5 (c) | <0.5 (b) | 25.5 ± 0 | 22 ± 2 |
| 03 | S | muscle | 0.29 ± 0.07 | 2 ± 1 | 7.6 ± 0.8 | 87 ± 7 |
| | | liver | 1.85 ± 0.15 | 2.5 ± 0 | 16.5 ± 0.1 | 114 ± 1 |
| | | kidney | 11.0 (c) | 1.4 (c) | 24.0 (c) | 93 ± 25 |
| 05 | S | muscle | 0.6 (c) | <0.5 (b) | 2.2 ± 0.7 | 7.5 ± 1 |
| | | liver | 0.99 ± 0.01 | <0.5 (b) | 2.3 ± 0.1 | 10 ± 1 |
| | | kidney | <0.5 (c) | <0.5 (b) | 23 ± 3 | 13 ± 1 |
| 08 | S | muscle | 0.08 ± 0 | <0.5 (b) | 6.5 ± 0.5 | 62 ± 3 |
| | | liver | 1.9 ± 0.4 | <0.5 (b) | 44.3 ± 0.3 | 101 ± 15 |
| | | kidney | 1.52 ± 0.02 | <0.5 (b) | 29 ± 3 | 83 ± 3 |
| 10 | S | muscle | 0.24 ± 0 | 2.4 ± 0 | 7.1 ± 0.9 | 123 ± 2 |
| | | liver | 2.6 ± 0.4 | 1.8 ± 0.2 | 20.3 ± 0 | 109 ± 5 |
| | | kidney | 11 ± 4 | 0.9 ± 0.1 | 12 ± 3 | 103 ± 9 |
| 11 | Ring | muscle | 0.19 ± 0.01 | 0.6 ± 0.1 | 9.5 ± 0 | 135 ± 0 |
| | | liver | 5.0 (c) | <0.5 (b) | 25 (c) | 72 ± 2 |
| | | kidney | 2.52 ± 0.04 | 0.7 ± 0.1 | 10 (c) | 227 ± 13 |
| 15 | S | muscle | 0.17 ± 0.05 | 1.4 ± 0.8 | 6.9 ± 0.1 | 80 ± 1 |
| | | liver | 3.1 ± 0.4 | 2.1 ± 0.2 | 18.5 ± 1.5 | 134 ± 9 |
| | | kidney | 13.1 ± 0.1 | 3.8 ± 0.3 | 16.1 ± 0.1 | 123 ± 1 |
| 07 | Rib | muscle | 0.27 ± 0.01 | <0.5 (b) | 3.3 ± 0.7 | 116 ± 7 |
| | | liver | 3.0 ± 0.2 | 17.5 ± 0 | 2.5 (c) | 115 ± 5 |
| | | kidney | 5.5 ± 0 | <0.5 (b) | 10 ± 1 | 138 ± 3 |

a = mean of duplicate determinations
b = duplicate determinations
c = single determinations

TABLE VII

BERING SEA

Marine mammal analysis program - precision and accuracy
($\mu g/g$ dry weight ± one standard deviation)

a. NBS Standard # 1571 orchard leaves.

| Element | n | This Study | NBS Certified |
|---|---|---|---|
| Cd | 3 | 0.15 ± 0.06 | 0.11 ± 0.02 |
| Ni | 4 | 1.4 ± 0.03 | 1.3 ± 0.2 |
| Cu | 7 | 10.5 ± 3 | 12 ± 1 |
| Zn | 7 | 25 ± 5 | 25 ± 3 |

b. NBS Standard # 1577 bovine liver.

| Element | n | This Study | NBS Certified |
|---|---|---|---|
| Cd | 3 | 0.31 ± 0.07 | 0.27 ± 0.04 |
| Ni | 4 | 0.9 ± 0.08 | -- |
| Cu | 3 | 150 ± 30 | 193 ± 10 |
| Zn | 8 | 120 ± 20 | 130 ± 10 |

TABLE VIII

HEAVY METAL DISTRIBUTIONS IN SEAL TISSUE

FROM BERING SEA - SPRING 1977

Cadmium

1. Concentrations in the kidneys of ribbon seals greater than in spotted or bearded
2. Higher cadmium contents in the muscle tissue of bearded seals than in ribbon or spotted
3. Liver contents of spotted seals relatively low
4. Liver contents of bearded seals relatively high

Nickel

Muscle contents generally higher than liver or kidneys

Copper

Spotted seal kidneys generally higher than liver, but reverse trend for ribbon and bearded seals

Zinc

1. Muscle contents of bearded (and possibly spotted) seals higher than ribbon
2. Concentration of zinc higher in livers than in kidneys of all species

Liver and kidney contents shown generally elevated contents of these metals, as would be expected. Enhancements of cadmium in these organs are notably high, but the general lack of comparable reference data does not permit comment as to whether these are unusually so. Olafson and Thompson (1974) have reported on the isolation of metallothioneins from seal livers, and have suggested that the biosynthesis of such cadmium-binding protein acts primarily as a detoxification mechanism in these, as in terrestrial mammals. Assuming that these complexes serve no other metabolic function then the presence of such hepatic complexes implies toxic ambient marine levels of these metals (notable cadmium, but also mercury and zinc).

The mean kidney content of cadmium for all the analysed samples is around 24 ppm dry weight: a "critical" liver concentration in man has been estimated at around 200 ppm. Kerfoot and Jacobs (1976) have echoed earlier models in which a daily intake of some 50 μg Cd/day will produce the observed mean body burden of around 30 mg, which would vary approximately correspond to a "critical organ" concentration of around 50 ppm. Estimates such as these assume a long residence time for cadmium in the mammalian tissue: this is one of the chief health hazards of this metal. There appears to be no correlation of liver and kidney contents of metals with the age of the animals given in this report, however. For the muscle tissue there is a suspicion of increasing contents, especially of zinc, with age but, in general, assumption of relatively short residence times with varying organ contents reflecting recent eating habits is attractive. (Note also that liver cadmium contents, for example, of the May samples are generally lower than those taken in April). We have here, however, for too few individuals of any one species or age group to permit anything approaching a vigorous statistical analysis.

ACKNOWLEDGEMENTS

This work was supported by BLM/NOAA Contract No. 03-5-022-56. The soluble copper and lead data were determined by D. T. Heggie. F. Fay and L. Shultz collected the seal samples. T. Manson and D. Weihs performed the chemical analyses and C. Tommos the sediment size analysis.

## REFERENCES


Burrell, D.C. 1978. Annual report to OCSEAP. Unpublished report, Institute of Marine Science, University of Alaska. 292 p.

Luoma, S.N. and E. A. Jenne. 1976. Factors affecting the availability of sediment-bound cadmium to the estuarine, deposit feeding clam, *Macoma balticia*. pp. 283-290. *In* C.E. Cushing, ed., Radioecology and energy resources, Ecological Soc. Amer. Special Publ. No. 1.

Kerfoot, W.B. and S.A. Jacobs. 1976. Cadmium accrual in combined wastewater treatment-aquaculture system. *Environ. Sci. Tech.* 10:662.

Olafson, R. W. and J. A. J. Thompson. 1974. Isolation of heavy metal binding proteins from marine vertebrates. *Mar. Biol.* 28:83.

QUARTERLY REPORT

Contract: #03-5-022-57
Research Unit: #275
Task Order: #5
Reporting Period: 7/1/78-9/30/78
Number of Pages: 2

# HYDROCARBONS: NATURAL DISTRIBUTION AND DYNAMICS ON THE ALASKAN OUTER CONTINENTAL SHELF


Principal Investigator

D. G. Shaw

Institute of Marine Science
University of Alaska
Fairbanks, Alaska


September 1978

## I. FIELD ACTIVITIES

A. Collection of water, particulate matter and plankton was carried out in late August in Cook Inlet from the NOAA Ship *Discoverer*. One time series station was occupied in the lower inlet and a series of transects were made in the vicinity of upper inlet production platforms.

B. Biological materials for baseline hydrocarbon analysis were collected in the nearshore Beaufort Sea during a cruise of the R/V *Alumiak*. We had planned to collect sediment cores for follow analyses of the aromatic hydrocarbons that had previously been observed in grab samples. However, this effort was unsuccessful because of insufficient penetration by the available gravity corer. This was a joint effort with A. S. Naidu. He is now investigating the possibility of obtaining drill cores this winter.

## II. LABORATORY ACTIVITIES

Laboratory work has been somewhat curtailed in order to man field parties and allow vacations. As the quarter ends, lab work is picking up again without any major instrumental or methodological problems.

QUARTERLY REPORT

TO

U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

July 1, 1978 to September 30, 1978

# CHARACTERIZATION OF ORGANIC MATTER IN SEDIMENTS FROM COOK INLET, NORTON SOUND, KODIAK SHELF AND BEAUFORT SEA

Contract No. 03-6-022-35250, R.U. No. 480

I.R. Kaplan

M.I. Venkatesan

S. Brenner

J. Bonilla

Institute of Geophysics and Planetary Physics

University of California

Los Angeles, California 90024

September 30, 1978

Field Activity

Mr. Dave Winter and Mr. Dave Meredith from our group participated in the August/September, 1978 cruises of the R.V. DISCOVERER in Lower Cook Inlet. Sixteen samples for gas and seventeen samples for heavy molecular weight hydrocarbons were collected from Cook Inlet and Shelikof Strait.

Laboratory Activity

1. The analysis of all the samples collected in 1976 and 1977 have been completed including the GC of aliphatic and aromatic fractions. Data reduction of the GC results have been completed and enclosed herewith. GC-MS analysis of selected samples will be performed in the next few months.

2. Interlaboratory calibration samples were received. Three samples have been separated into aliphatic and aromatic fractions. The gas chromatograph has been out of order for the last six weeks and the fractions have not been run on the GC. As soon as the samples are run, results will be sent.

3. One of the 18 samples collected in Spring, 1978 was lost. The remaining 17 samples have been extracted and 15 have been column chromatographed into aliphatic and aromatic fractions. Gravimetric data is summarized in Table 7.

Table 1a. Aliphatic Hydrocarbon Concentrations (ng/g) in Norton Sound Sediment Samples, 1977 Cruise (Part I: $n$-$C_{17}$-$n$-$C_{24}$)

| Station | $n$-$C_{17}$ | Pristane | $n$-$C_{18}$ | Phytane | $n$-$C_{19}$ | $n$-$C_{20}$ | $n$-$C_{21}$ | $n$-$C_{22}$ | $n$-$C_{23}$ | $n$-$C_{24}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 34 0-2 cm | n.d. | n.d. | n.d. | n.d. | 0.9 | 1.2 | 3.2 | 3.3 | 7.7 | 3.3 |
| 35 0-2 cm | 1.4 | 2.4 | 1.5 | n.d. | 3.2 | 4.0 | 13.2 | 13.4 | 39.8 | 17.2 |
| 39 surf | 0.2 | 0.3 | 0.3 | n.d. | 0.7 | 0.8 | 1.8 | 2.0 | 5.1 | 2.8 |
| 41 surf | n.d. | n.d. | n.d. | n.d. | 1.3 | 1.8 | 6.0 | 6.1 | 18.0 | 8.8 |
| 42 surf | 1.7 | 3.2 | 1.8 | n.d. | 9.7 | 7.1 | 23.7 | 22.3 | 63.8 | 27.8 |
| 43 0-2 cm | 1.2 | 1.3 | 1.2 | n.d. | 3.5 | 3.9 | 12.1 | 11.8 | 1.6 | 14.2 |
| 44 0-2 cm | n.d. | n.d. | 0.6 | n.d. | 1.7 | 2.5 | 9.2 | 14.3 | 34.5 | 22.3 |
| 48 surf | 4.0 | 5.6 | 5.1 | n.d. | 16.7 | 17.3 | 66.3 | 43.3 | 136.5 | 47.5 |
| 14 IK 0-3 cm | 4.4 | n.d. | 4.6 | n.d. | 11.1 | 13.1 | 42.3 | 36.8 | 104.2 | 42.7 |
| 17 0-3 cm | 2.7 | n.d. | 4.5 | n.d. | 14.6 | 18.3 | 63.0 | 55.3 | 149.3 | 59.2 |
| 17SV 0-3 cm | n.d. | n.d. | n.d. | n.d. | 22.7 | 15.6 | 54.5 | 49.2 | 138.0 | 53.6 |
| 17 IK 160cm | n.d. | n.d. | n.d. | n.d. | 3.1 | 6.2 | 23.0 | 25.4 | 72.4 | 32.1 |

Table 1b. Aliphatic Hydrocarbon Concentrations (ng/g) in Norton Sound Sediment Samples, 1977 Cruise (Part II: $n$-$C_{25}$-$n$-$C_{34}$)

| Station | $n$-$C_{25}$ | $n$-$C_{26}$ | $n$-$C_{27}$ | $n$-$C_{28}$ | $n$-$C_{29}$ | $n$-$C_{30}$ | $n$-$C_{31}$ | $n$-$C_{32}$ | $n$-$C_{33}$ | $n$-$C_{34}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 34 0-2 cm | 8.6 | 3.2 | 18.9 | 2.9 | 14.9 | 1.4 | 14.7 | 0.9 | 4.9 | n.d. |
| 35 0-2 cm | 52.2 | 16.9 | 117.8 | 16.5 | 95.4 | 10.4 | 101.0 | 6.6 | 32.3 | 2.6 |
| 39 surf | 7.8 | 3.0 | 19.6 | 3.1 | 17.0 | 0.4 | 19.2 | 1.3 | 6.2 | 0.7 |
| 41 surf | 24.7 | 8.8 | 49.5 | 8.6 | 41.1 | 4.0 | 41.2 | 2.4 | 11.6 | n.d. |
| 42 surf | 79.7 | 27.1 | 170.2 | 27.5 | 142.8 | 16.0 | 148.1 | 10.2 | 45.2 | 3.2 |
| 43 0-2 cm | 41.6 | 14.2 | 88.6 | 13.5 | 70.2 | 7.6 | 69.4 | 4.6 | 21.9 | 2.0 |
| 44 0-2 cm | 34.1 | 13.0 | 49.5 | 6.3 | 28.4 | 0.9 | 22.8 | n.d. | 6.4 | n.d. |
| 48 surf | 185.1 | 39.1 | 459.0 | 39.4 | 260.8 | 14.7 | 190.7 | 9.9 | 59.6 | n.d. |
| 14 IK 0-3cm | 129.9 | 35.9 | 284.8 | 32.6 | 201.6 | 18.1 | 186.8 | 11.7 | 62.5 | n.d. |
| 17 0-3 cm | 180.5 | 53.7 | 409.0 | 46.8 | 292.4 | 26.1 | 268.0 | 16.1 | 87.3 | 6.6 |
| 17SV 0-3cm | 166.1 | 45.0 | 367.6 | 40.3 | 256.2 | 18.4 | 223.8 | 12.1 | 71.7 | n.d. |
| 17 IK 160cm | 96.7 | 28.4 | 218.7 | 26.5 | 176.6 | 16.1 | 163.9 | 7.6 | 49.9 | n.d. |

n.d. = not determined, too low to be calculated accurately.

Table 2. Characteristic Parameters for Norton Sound Hydrocarbons (1977 Cruise)

| Station | $\frac{\text{Non-Saponifiable Fr.}}{\text{Organic Carbon}}$ (x $10^{-4}$) | $\frac{\text{Alkanes}}{\text{Org. Carbon}}$ ($x10^{-4}$) | $\frac{\text{Pristane}}{n\text{-}C_{17}}$ | $\frac{\text{Phytane}}{n\text{-}C_{18}}$ | $\frac{\text{Pristane}}{\text{Phytane}}$ | $\frac{\text{Odd}}{\text{Even}}$ |
|---|---|---|---|---|---|---|
| 34 (0-2 cm) | 39.3 | 0.75 | 1.38 | 0.14* | 2.0* | 4.55 |
| 35 (0-2 cm) | 170.7 | 0.87 | 1.67 | 0.22* | 7.0* | 5.15 |
| 39 (Surf) | 2.1 | 0.24 | 1.44 | 0.33* | 2.5* | 5.35 |
| 41 (Surf) | 115.5 | 0.53 | 1.0* | 0.25* | 4.0* | 4.78 |
| 42 (Surf) | 357.1 | 2.60 | 1.82 | 0.25* | 5.5* | 4.78 |
| 43 (0-2 cm) | 39.0 | 0.64 | 1.06 | 0.16* | 6.5* | 4.22 |
| 44 (0-2 cm) | 65.5 | 0.48 | 1.44 | 0.13* | 6.0* | 3.21 |
| 48 (Surf) | 19.6 | 0.38 | 1.38 | 0.17* | 5.0* | 6.37 |
| 14 IK (0-3 cm) | 242.6 | 4.37 | 0.55 | 0.23* | 3.1* | 5.26 |
| 17 (0-3 cm) | 79.6 | 2.04 | 2.03 | 0.19* | 1.3* | 5.12 |
| 17 SV (0-3 cm) | 206.0 | 6.40 | 0.5* | 0.17* | 2.0* | 5.67 |
| 17 IK (160 cm) | 34.4 | 1.91 | 0.5* | 0.17* | 4.0* | 5.34 |

* Approximate values based on measured peak heights.

Table 3a. Aliphatic Hydrocarbon Concentrations (ng/g) in Beaufort Sea Sediment Samples, 1976 Cruise (Part I: $n-C_{15}-n-C_{23}$)

| Station * | $n-C_{15}$ | $n-C_{16}$ | $n-C_{17}$ | Pristane | $n-C_{18}$ | Phytane | $n-C_{19}$ | $n-C_{20}$ | $n-C_{21}$ | $n-C_{22}$ | $n-C_{23}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27.39 | 29.1 | 46.9 | 27.5 | 53.1 | 19.3 | 84.4 | 86.8 | 136.2 | 118.3 | 221.6 |
| 2 | n.d. | 13.1 | 26.9 | 15.6 | 30.0 | 11.9 | 45.5 | 46.1 | 68.2 | 59.6 | 105.2 |
| 3 | n.d. | 17.3 | 47.7 | 28.2 | 63.8 | 18.8 | 105.9 | 104.4 | 176.4 | 146.4 | 314.1 |
| 4 | 45.2 | 59.5 | 96.3 | 62.9 | 94.4 | 30.9 | 126.0 | 121.9 | 173.9 | 152.9 | 270.3 |
| 5 | 30.0 | 35.9 | 60.5 | 40.1 | 64.3 | 19.0 | 98.0 | 94.4 | 164.4 | 140.7 | 278.4 |
| 6 | 33.3 | 39.2 | 62.9 | 37.2 | 69.8 | 20.5 | 119.0 | 111.2 | 186.5 | 196.9 | 469.5 |
| 7 | 36.5 | 39.2 | 53.9 | 37.9 | 47.3 | 14.8 | 63.6 | 56.9 | 95.2 | 90.5 | 200.8 |
| 8 | 35.3 | 45.6 | 77.4 | 52.8 | 77.4 | 21.1 | 112.2 | 107.5 | 157.4 | 181.1 | 409.2 |
| 9 | 29.6 | 36.0 | 61.4 | 37.0 | 69.3 | 21.4 | 110.3 | 105.1 | 194.4 | 158.9 | 342.9 |
| 10 | 27.9 | 32.4 | 69.5 | 41.7 | 79.2 | 22.1 | 127.3 | 122.4 | 197.6 | 214.3 | 530.0 |
| 11 | 30.5 | 34.4 | 47.2 | 34.7 | 39.2 | 20.8 | 52.6 | 48.5 | 43.2 | 77.4 | 186.2 |

Table 3b. Aliphatic Hydrocarbon Concentrations (ng/g) in Beaufort Sea Sediment Samples, 1976 Cruise (Part II: $n-C_{24}-n-C_{34}$)

| Station* | $n-C_{24}$ | $n-C_{25}$ | $n-C_{26}$ | $n-C_{27}$ | $n-C_{28}$ | $n-C_{29}$ | $n-C_{30}$ | $n-C_{31}$ | $n-C_{32}$ | $n-C_{33}$ | $n-C_{34}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 109.7 | 238.7 | 81.0 | 429.4 | 91.5 | 506.5 | 49.9 | 460.6 | 40.2 | 151.2 | 23.9 |
| 2 | 51.1 | 112.2 | 30.3 | 202.2 | 42.5 | 276.3 | n.d. | 247.9 | n.d. | 85.7 | n.d. |
| 3 | 129.8 | 324.1 | 89.0 | 5.3 | 0.8 | 6.0 | 0.4 | 5.5 | 0.3 | n.d. | n.d. |
| 4 | 128.7 | 263.0 | 72.3 | 418.2 | 84.6 | 540.4 | n.d. | 474.5 | n.d. | n.d. | n.d. |
| 5 | 123.8 | 298.8 | 83.8 | 444.0 | 89.6 | 526.7 | 25.1 | 444.9 | 22.7 | 161.0 | n.d. |
| 6 | 197.1 | 489.2 | 160.2 | 764.2 | 132.3 | 739.4 | 83.2 | 754.8 | 23.8 | 270.6 | n.d. |
| 7 | 88.2 | 214.4 | 66.4 | 324.2 | 58.7 | 316.3 | 34.9 | 298.5 | 11.6 | 105.3 | n.d. |
| 8 | 170.1 | 431.7 | 115.7 | 640.1 | 94.8 | 650.2 | 38.3 | 593.0 | 31.9 | 199.6 | n.d. |
| 9 | 144.2 | 342.4 | 119.3 | 526.5 | 93.6 | 555.4 | 58.2 | 527.3 | 17.2 | 190.0 | 21.7 |
| 10 | 203.9 | 529.5 | 148.4 | 773.8 | 134.8 | 790.8 | 63.4 | 750.1 | 37.3 | 250.6 | n.d. |
| 11 | 71.4 | 232.2 | 35.7 | 316.0 | n.d. | 256.7 | n.d. | 250.4 | n.d. | 92.3 | n.d. |

n.d. = not determined, too low to be calculated accurately.

* = all samples are surface; 11 is bulk.

Table 4. Characteristic Parameters for Beaufort Sea Hydrocarbons (1976 cruise)

| Station | $\frac{\text{Non-saponifiable fr.}}{\text{Organic carbon}}$ $(x10^{-4})$ | $\frac{\text{Alkanes}}{\text{Org. C}}$ $(x10^{-4})$ | $\frac{\text{Pristane}}{n\text{-}C_{17}}$ | $\frac{\text{Phytane}}{n\text{-}C_{18}}$ | $\frac{\text{Pristane}}{\text{Phytane}}$ | $\frac{\text{Odd}}{\text{Even}}$ |
|---|---|---|---|---|---|---|
| 1 | 127.1 | 3.41 | 0.59 | 0.36 | 1.60 | 3.37 |
| 2 | 176.4 | 2.03 | 0.58 | 0.40 | 1.32 | 4.29 |
| 3 | 201.8 | 1.75 | 0.59 | 0.29 | 1.82 | 1.78 |
| 4 | 242.5 | 4.43 | 0.65 | 0.33 | 2.04 | 3.37 |
| 5 | 197.5 | 3.91 | 0.66 | 0.30 | 2.11 | 3.58 |
| 6 | 229.3 | 4.91 | 0.59 | 0.29 | 1.82 | 3.57 |
| 7 | 167.2 | 2.88 | 0.70 | 0.31 | 2.55 | 3.25 |
| 8 | 379.1 | 10.88 | 0.68 | 0.27 | 2.50 | 3.83 |
| 9 | 296.1 | 5.53 | 0.60 | 0.31 | 1.73 | 3.53 |
| 10 | 350.0 | 8.17 | 0.60 | 0.28 | 1.89 | 3.91 |
| 11 | 216.2 | 3.67 | 0.73 | 0.53 | 1.67 | 5.00 |

Table 5a. Aliphatic Hydrocarbon Concentrations (ng/g) in Kodiak Shelf Sediment Samples, 1976 Cruise (Part I: n-$C_{15}$-n-$C_{23}$)

| Station* | n-$C_{15}$ | n-$C_{16}$ | n-$C_{17}$ | Pristane | n-$C_{18}$ | Phytane | n-$C_{19}$ | n-$C_{20}$ | n-$C_{21}$ | n-$C_{22}$ | n-$C_{23}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | 2.2 | 2.3 | 3.4 | 5.9 | 2.9 | 0.7 | 3.7 | 3.0 | 4.1 | 3.4 | 4.2 |
| 57 | 0.7 | 1.1 | 1.9 | 6.2 | 1.9 | 0.6 | 2.7 | 2.1 | 2.4 | 2.1 | 2.6 |
| 60 | 3.7 | 3.8 | 5.9 | 15.8 | 7.2 | 2.0 | 10.6 | 10.5 | 12.1 | 11.4 | 13.5 |
| 68 | 2.2 | 1.5 | 2.7 | 10.4 | 2.8 | 1.0 | 6.0 | 4.5 | 8.7 | 4.7 | 6.6 |
| 72 | n.d. | n.d. | 1.3 | n.d. | 1.5 | n.d. | 4.3 | 5.8 | 22.1 | 21.7 | 61.8 |
| 75 | 0.5 | 0.6 | 1.0 | 3.9 | 1.1 | 0.3 | 1.6 | 1.2 | 1.5 | 1.4 | 1.6 |
| 80 | 0.1 | 0.1 | 0.2 | 0.4 | 0.2 | 0.1 | 0.5 | 0.5 | 0.8 | 0.6 | 0.8 |
| 80' | 0.5 | 0.5 | 1.1 | 5.7 | 1.1 | 0.3 | 1.7 | 1.4 | 2.0 | 1.5 | 1.9 |
| 81 | 6.0 | 4.4 | 7.8 | 30.4 | 8.5 | 2.8 | 15.6 | 13.3 | 21.9 | 16.0 | 22.8 |
| 87 | n.d. | n.d. | n.d. | n.d. | 0.2 | n.d. | 0.5 | 0.5 | 1.1 | 0.7 | 1.1 |
| 92 | 17.0 | 11.8 | 20.1 | 43.0 | 20.7 | 6.7 | 39.3 | 29.2 | 48.9 | 32.8 | 46.1 |
| 93 | 2.4 | 1.6 | 3.0 | 10.4 | 3.0 | n.d. | 5.5 | 4.9 | 10.0 | 8.2 | 12.7 |
| 97 | 1.7 | 1.6 | 4.5 | 10.0 | 6.2 | 6.2 | 14.0 | 12.1 | 21.2 | 15.4 | 21.8 |
| 98 | 3.1 | 2.4 | 4.3 | 8.8 | 4.4 | n.d. | 7.9 | 6.0 | 8.9 | 6.8 | 9.5 |
| 130 | 2.9 | 3.0 | 4.7 | 9.2 | 6.4 | 2.1 | 10.7 | 11.1 | 11.6 | 11.7 | 13.2 |

Table 5b. Aliphatic Hydrocarbon Concentrations (ng/g) in Kodiak Shelf Sediment Samples, 1976 Cruise (Part II: n-$C_{24}$-n-$C_{34}$)

| Station* | n-$C_{24}$ | n-$C_{25}$ | n-$C_{26}$ | n-$C_{27}$ | n-$C_{28}$ | n-$C_{29}$ | n-$C_{30}$ | n-$C_{31}$ | n-$C_{32}$ | n-$C_{33}$ | n-$C_{34}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | 3.4 | 4.6 | 2.7 | 6.3 | 3.3 | 7.9 | 2.6 | 9.4 | 1.4 | 3.3 | 1.1 |
| 57 | 2.1 | 3.5 | 2.3 | 4.8 | 2.1 | 4.8 | 0.8 | 3.5 | n.d. | 1.1 | n.d. |
| 60 | 11.2 | 14.7 | 9.9 | 17.9 | 10.7 | 23.1 | 7.2 | 23.5 | 5.7 | 9.6 | 5.8 |
| 68 | 4.7 | 8.4 | 4.4 | 15.5 | 6.2 | 12.7 | 3.6 | 13.8 | 22.8 | 1.3 | 4.1 |
| 72 | 26.5 | 79.5 | 25.4 | 143.8 | 19.5 | 110.4 | 21.5 | 104.8 | 1.6 | n.d. | 16.0 |
| 75 | 1.3 | 1.4 | 0.9 | 1.9 | 0.4 | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| 80 | 0.6 | 0.9 | 0.6 | 1.3 | 0.6 | 1.1 | 0.3 | 1.5 | 0.2 | 0.5 | 0.1 |
| 80' | 1.3 | 1.8 | 1.0 | 2.9 | 1.5 | 3.3 | 0.7 | 3.3 | 0.5 | 1.3 | 0.5 |
| 81 | 14.3 | 23.2 | 14.0 | 37.5 | 16.7 | 38.0 | 10.3 | 40.0 | 7.9 | 14.3 | 4.5 |
| 87 | 0.9 | 1.5 | 0.8 | 3.1 | 1.2 | 2.9 | 0.7 | 2.5 | 0.4 | 1.1 | n.d. |
| 92 | 31.7 | 60.1 | 32.9 | 105.3 | 47.2 | 100.8 | 23.1 | 104.8 | 174.5 | 11.3 | 7.8 |
| 93 | 10.5 | 20.6 | 12.1 | 40.0 | 14.5 | 39.6 | 9.6 | 43.6 | 6.3 | 15.4 | 3.0 |
| 97 | 15.7 | 30.7 | 17.0 | 60.9 | 21.5 | 59.7 | 14.3 | 67.3 | 109.7 | 5.5 | 4.3 |
| 98 | 6.8 | 13.5 | 6.8 | 24.9 | 7.7 | 24.5 | 4.3 | 27.5 | n.d. | 8.6 | n.d. |
| 130 | 11.5 | 15.5 | 11.8 | 19.7 | 12.1 | 19.2 | 8.7 | 19.2 | 1.8 | 8.1 | 3.1 |

* Samples are 0-2 cm, except 80', which is 2-4 cm; n.d. = not determined; too low to be calculated accurately.

Table 6. Characteristic Parameters for Kodiak Shelf Hydrocarbons (1976 Cruise)

| Station ** | Non-Saponifiable Fr. / Organic Carbon (x $10^{-4}$) | Alkanes / Org. Carbon (x $10^{-4}$) | Pristane / n-$C_{17}$ | Phytane / n-$C_{18}$ | Pristane / Phytane | Odd / Even |
|---|---|---|---|---|---|---|
| 52 | 124.2 | 0.24 | 1.7 | 0.9 | 2.3 | 1.9 |
| 57 | 78.6 | 0.14 | 3.2 | 1.3 | 2.4 | 1.9 |
| 60 | 121.6 | 0.77 | 2.6 | 0.5 | 6.1 | 1.7 |
| 68 | 115.8 | 0.29 | 3.9 | 0.4 | 10.4 | 1.7 |
| 72 | 96.9 | 2.89 | 0.5* | 0.2* | 3.0* | 3.8 |
| 75 | 100.7 | 0.08 | 4.0 | 0.3 | 12.2 | 0.8 |
| 80 | 37.1 | 0.03 | 2.5 | 0.3 | 6.2 | 2.1 |
| 80' | n.a. | n.a. | 5.2 | 0.3 | 17.7 | 1.8 |
| 81 | 142.3 | 0.74 | 3.9 | 0.3 | 10.8 | 2.1 |
| 87 | 64.9 | 0.04 | 2.2* | 0.3* | 4.5* | 2.6 |
| 92 | 111.9 | 0.87 | 2.1 | 0.3 | 6.4 | 1.3 |
| 93 | 25.8 | 0.27 | 3.4 | 0.3* | 2.8* | 2.6 |
| 97 | 40.3 | 0.21 | 2.2 | 0.3 | 4.0 | 1.3 |
| 98 | 95.4 | 0.09 | 2.0 | 0.0 | 6.0 | 2.8 |
| 130 | 40.2 | 0.24 | 1.9 | 0.3 | 4.4 | 1.5 |

* Approximate values based on measured peak heights.
** Samples are 0-2 cm except 80', which is 2-4 cm.
n.a. = not available

Table 7. Cook Inlet Sediment Samples (1978 - Spring Cruise)

| Station* No. | Latitude (N) | Longitude (N) | Depth (m) | Nonsapon. Fr. (ppm) | Aliphatic Fr. (ppm) | Aromatic Fr. (ppm) |
|---|---|---|---|---|---|---|
| 201 | 59°12.5' | 153°52.6' | 22 | 39.09 | 4.49 | 3.24 |
| 203 | 59°05.8' | 153°29.5' | 38 | --analysis not complete -- | | |
| 204 | 59°13.7' | 153°39.4' | 34 | 44.51 | 2.12 | 1.91 |
| 211 | 59°26.1' | 153°37.5' | 19 | 20.41 | 1.27 | 1.26 |
| 212 | 59°32.6' | 153°20.9' | 26 | 20.09 | 1.58 | 1.42 |
| 213 | 59°29.9' | 153°14.0 | 33 | 16.06 | 1.14 | 1.27 |
| 214 | 59°17.9' | 153°13.2' | 53 | 25.83 | 1.41 | 1.35 |
| 233 | 59°48.9' | 152°55.6' | 14 | 32.24 | 2.27 | 2.06 |
| 234 | 59°38.2' | 152°56.4' | 38 | 13.86 | 0.99 | 0.61 |
| 245 | 60°07.8' | 152°16.7' | 46 | 11.01 | 1.17 | 1.01 |
| 247 | 59°58.3' | 152°34.1' | 20 | 7.97 | 1.02 | 0.87 |
| 255 | 60°18.8' | 151°37.0' | 42 | 57.07 | 1.45 | 14.10 |
| 265 | 60°34.7' | 151°49.5' | 16 | 95.09 | 28.81 | 8.74 |
| 370 | 58°17.0' | 154°02.6' | 112 | 51.76 | 3.09 | 3.66 |
| 380 | 58°38.4' | 153°26.0' | 57 | -- analysis not complete -- | | |
| 390 | 58°53.5' | 153°11.0' | 170 | 27.77 | 2.13 | 2.56 |
| 394 | 58°51.3' | 153°08.2' | 171 | 42.59 | 2.06 | 3.83 |

* All samples are 0-2 cm.

Research Unit # 506
Report Period: May 1-Sept. 30, 1978

Quarterly Report

# NATURAL DISTRIBUTION OF TRACE METALS AND ENVIRONMENTAL BACKGROUND IN THREE ALASKA SHELF AREAS

David E. Robertson
Keith H. Abel

Battelle, Pacific Northwest Laboratories
Richland, Washington

QUARTERLY REPORT FOR PERIOD ENDING SEPTEMBER 30, 1978

Project Title: Natural Distribution of Trace Metals and Environmental Background in Three Alaska Shelf Areas

Principal Investigators: David E. Robertson and Keith H. Abel
Battelle, Pacific Northwest Laboratories
Richland, Washington 99352

## I. Task Objectives

The primary objective of this study is to determine environmental baseline concentrations of selected heavy metals in seawater (both dissolved and suspended fractions) in selected marine "indicator" organisms and in the sediments of the Alaskan Outer Continental Shelf (OCS) study area.

The research plan that we have formulated is coordinated and in conjunction with the studies being conducted by Dr. D. C. Burrell of the University of Alaska and Dr. Richard Feely of PMEL. Our contribution is an integral part of the sampling and analysis program of these groups. We will complement their work by measuring those heavy metals most amenable to neutron activation analysis. Of the total suite of elements considered of prime importance to this study (As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Zn, V, Ag, Ba, Co, Fe and Mn), we will concentrate our efforts on the analyses of V, Mn, Fe and Cr in seawater, biota, and sediments. We will, however, be measuring additional elements which are automatically detected by the instrumental neutron activation analysis method we will employ.

## II. Field or Laboratory Activities

Participation in two field cruises constituted the main activities during this period. David A. Cochran participated on the 4 May 78 to 15 May 78 leg of the Discoverer in the Cook Inlet area. Seawater (suspended and dissolved fractions) and HAPS sediment cores were collected (see accompanying table). A total of 31 seawater samples and 5 HAPS cores were taken.

Keith H. Abel participated on the 25 August 78 to 05 September 78 leg of the Discoverer, also in the Cook Inlet area. Seawater and HAPS sediment cores were collected (see accompanying table). A total of 20 water samples and 17 sediment samples were collected. Seven of the water samples were taken at a time series station (CB-10) at 8-hour intervals to determine temporal variations in trace metal concentrations.

The sediment samples are presently being analyzed for "available" trace metals using the leaching procedure agreed upon with Drs. Feely and Burrell. This procedure involves an initial leaching with a dilute solution of hydrogen peroxide to free organic matter. This is followed by leaching with 0.3 N HCl to free trace metals which are weakly bound to inorganic phases. We will concentrate our efforts on measuring V, Mn, Fe and Cr; however, we will be able to measure additional elements which we feel are important to this study, such as Al, Ca, Ba, Co, Sc, As and Sb.

The seawater samples are being analyzed for V and Mn, both in the soluble and particulate phases.

## III. Results and Discussion

The results and the significance of the analyses now being performed will be presented in our final report to NOAA which will be completed in December, 1978. In this report we will summarize all of the data which have been gathered during the course of our participation in the Alaskan OCS program, and present our final interpretation of the data.

## IV. Problems Encountered

No major problems have been encountered during this period. Both cruise legs were very successful and all samples desired were collected.

## V. Estimate of Funds Expended

As of September 29, 1978, $32,357 of the $37,820 have been spent. The remaining $5,563 will be used to complete the analyses of samples collected on the May and August cruises and to prepare our final report.

SEDIMENT AND SEAWATER SAMPLING LOCATIONS

NOAA SHIP DISCOVERER - GULF OF ALASKA

4 May 1978 - 15 May 1978

The purpose of this sampling trip was to collect water and sediment samples for trace metal analysis. The trip started at Homer, AK and at selected sites samples were taken. The water samples were filtered and acidified with the exception of six grab samples which were taken with a polyethylene bucket thrown from the ship into undisturbed water. These samples were then acidified with Ultrex HCl. The sediment samples were sectioned and halved with one-half going to Gary Massoth at PMEL. The other half was sealed in a polyethylene jar and frozen.

| Station | Latitude | Longitude | Depth(m) | Sed. | $H_2O$ | |
|---|---|---|---|---|---|---|
| CB-1 | 59° 13.7' | 153° 40.1' | 31 | X | S,B | |
| CB-7 | 59° 35.4' | 151° 45.9' | 51 | X | S,B | G |
| CB-5 | 59° 25.0' | 152° 20.5' | 72 | | S,B | |
| CB-7 mid channel | 59° 3 & 4' | 151° 37.0' | 78 | X | S,B | |
| CB-8 | 59° 39.3' | 151° 16.7' | 53 | X | S,B | |
| CB-6 | 59° 30.0 | 152° 00.4' | 60 | | S,B | |
| CB-10 | 60° 31.5 | 151° 30.9' | 24 | | S,B | |
| CB-9 | 60° 28.2' | 152° 12.2' | 38 | | S,B | G |
| CB-2 | 59° 16.7' | 153° 19.1' | 38 | | S,B | G |
| ST-1 | 59° 10.9' | 153°,19.3' | 38 | | S.B | G |
| CB-3 | 59° 19.8' | 152° 59.6' | 60 | X | S | |
| ST-2 | 59° 16.6' | 152° 52.7' | 88 | | S,B | G |
| CB-9 | 59° 24.1' | 152° 39.4' | 65 | | S,B | G |

SEDIMENT AND SEAWATER SAMPLING
LOCATIONS - NOAA SHIP DISCOVERER

Gulf of Alaska
25 August 1978 - 05 September 1978

Occupied transect from Coal Bay to St. Augustine Island (CB-8 thru CB-1)

Occupied time series station for 48 hr in Upper Cook Inlet by Kalgin Island (CB-9)

Occupied suspended sediment stations in Shelikof Strait (SS-13 thru SS-1)

| Station | Latitude | Longitude | Bottom Depth | Water Depth | HAPS Core |
|---|---|---|---|---|---|
| CB-8 | 59° 39.4' | 151° 16.6' | 29M | 15M | 0-2 cm |
| CB-7 | 59° 33.3' | 151° 39.6' | 82M | 77M | 0-2 cm |
| CB-6 | 59° 30.0' | 152° 00.4' | 60M | 20M | 0-2 cm |
| CB-5 | 59° 26.3' | 152° 19.6' | 75M | 30M | 0-2 cm |
| CB-4 | 59° 22.6' | 152° 39.6' | 62M | 15M | 0-2 cm |
| CB-3 | 59° 20.7' | 153° 00.4' | 62M | 20M | Shipek |
| CB-2 | 59° 16.5' | 153° 20.7' | 38M | 20M | 0-2 cm |
| CB-1 | 59° 14.4' | 153° 40.1' | 30M | 15M | 0-2 cm |
| CB-10 | 60° 22.8' | 151° 51.5' | 20M | 15M t=0 hr | |
| CB-10 | " | " | 20M | 15M t=8hr | |
| CB-10 | " | " | 20M | t=16 hr | |
| CB-10 | " | " | 20M | t=24 hr | |
| CB-10 | " | " | 20M | t=32 hr | |
| CB-10 | " | " | 20M | t=40 hr | |
| CB-10 | " | " | 20M | t=48 hr | |
| SS-11 | 58° 45.8' | 153° 08.5' | 186M | 145M | 0-2 cm |
| SS-13 | 58° 47.1' | 152° 23.1' | 150M | 147M | 0-2 cm |
| SS-10 | 58° 28.5' | 153° 11.1' | 172M | -- | 0-2 cm |
| SS-8 | 58° 00.5' | 154° 03.2' | 200M | -- | 0-2 cm |
| SS-5 | 57° 52.2' | 154° 44.0' | 269M | -- | 0-2 cm |
| SS-4 | 57° 55.7' | 154° 49.3' | 136M | 131M | 0-2 cm |
| SS-6 | 57° 42.4' | 154° 29.2' | 206M | 201M | 0-2 cm |
| SS-2 | 57° 16.9' | 155° 37.3' | 278M | 273M | 0-2 cm |
| SS-1 | 57° 16.1' | 154° 53.2' | 107M | -- | 0-2 cm |

HAZARDS

Contents


| RU# | PI | Agency | Title | Page |
|---|---|---|---|---|
| 59 | Hayes, M. et al. | Univ. of South Carolina, Columbia, SC | Oil Spill Vulnerability, Coastal Morphology and Sedimentation of Kodiak Island, Kotzebue Sound and the Beaufort Coast | 189 |
| 87 | Martin, S. | Univ. of Wash., Seattle, WA | The Interaction of Oil with Sea Ice in the Beaufort Sea | 194 |
| 88 | Kovacs, A. Weeks, W. | CRREL, Hanover, NH | Dynamics of Near Shore Ice | 230 |
| 98 | Colony, R. | Univ. of Wash., Seattle, WA | Dynamics of Near Shore Ice | 234 |
| 105 | Sellman, P. Chamberlain, E. et al. | CRREL, Hanover, NH | Delineation and Engineering Characteristics of Permafrost Beneath the Beaufort Sea | 241 |
| 204 | Hopkins, D. et al. | U.S.G.S., Menlo Park, CA | Offshore Permafrost Studies and Shoreline History of Chukchi and Beaufort Seas as an aid to Predicting Offshore Permafrost Conditions | 243 |
| 205 | Barnes, P. Reimnitz, E. | U.S.G.S., Menlo Park, CA | Marine Environmental Problems in the Ice-Covered Beaufort Sea Shelf and Coastal Regions | 246 |
| 206 | Vallier, T. Gardner, J. | U.S.G.S., Menlo Park, CA | Faulting and Slope Instability in the St. George Basin Area, Southern Bering Sea | 251 |
| 210 | Lahr, J. Stephens, C. | U.S.G.S., Menlo Park, CA | Earthquake Activity and Ground Shaking in and along the Eastern Gulf of Alaska | 254 |
| 251 | Pulpan, H. Kienle, J. | Geophysical Inst., Fairbanks, AK | Seismic and Volcanic Risk Studies Western Gulf of Alaska | 281 |
| 253 | Osterkamp, T. Harrison, W. | Geophysical Inst., Fairbanks, AK | Subsea Permafrost, Probing, Thermal Regime and Data Analysis | 330 |
| 271 | Rogers, J. Morak, J. | Geophysical Inst., Fairbanks, AK | Beaufort Seacoast Permafrost Studies | 332 |

| RU# | PI | Agency | Title | Page |
|---|---|---|---|---|
| 290 | Hoskin, C.<br>Burrell, D. | Inst. of Marine Science, Fairbanks, AK | Sediment Size Analysis | 335 |
| 327 | Hampton, M.<br>Bouma, A. | U.S.G.S., Menlo Park, CA | Shallow Faulting, Bottom Instability and movement of sediment in Lower Cook Inlet and Western Gulf of Alaska | 340 |
| 430 | Cacchione, D.<br>Drake, D. | U.S.G.S., Menlo Park, CA | A. Bottom and Near-Bottom Sediment, Dynamics in Norton Basin, B. Bottom and Near-Bottom Sediment, Dynamics in Lower Cook Inlet, C. Sediment Transport during Wintertime Conditions, Northern Bering Sea | 351 |
| 431 | Sallenger, A. | U.S.G.S., Menlo Park, CA | Coastal Processes and Morphology of the Bering Sea Coast of Alaska | 360 |
| 483 | Biswas, N. | Geophysical Inst., Fairbanks, AK | Evaluation of Earthquake Activity around Norton and Kotzebue Sounds | 362 |
| 516 | Vigdorchik, M. | INSTAAR, Boulder, CO | A Geographic Based Data Management System for Permafrost in the Beaufort and Chukchi Seas | 365 |

QUARTERLY REPORT

October 1, 1978

RU 59

Task D-4

# Oil Spill Vulnerability, Coastal Morphology and Sedimentation of Kodiak Island, Kotzebue Sound and the Beaufort Coast

Principal Investigator: Miles O. Hayes

Co-investigators: Dag Nummedal, Christopher Ruby

Coastal Research Division, Department of Geology
University of South Carolina, Columbia, South Carolina 29208

# I. ABSTRACT

Coastal Research Division field teams carried out three field studies during the summer of 1978. A four-week program on Kodiak Island resulted in 128 profile and sample sites set up at a 15 km spacing on the shorelines of the island archepelago. The NOAA helicopter N56RF was used as a platform for most of this work. Aerial photo surveys were made over the entire shoreline between sample sites in order to apply a uniform coastal classification which is presently being used as a data base for the assignment of shoreline oil spill vulnerability. Approximately 200 sediment samples were collected. They have already been analyzed in our Sedimentology Laboratory, and data are now being transferred to magnetic tape (sent under separate cover).

A two-week field program in Kotzebue Sound - Chukchi Sea followed the Kodiak work. All permanent profile sites (44) set up during the summer of 1976 were re-established for comparative analysis. All sediment samples collected (approx. 150) have been analyzed and recorded on magnetic tape. A final report for this area is expected to be ready in December, 1978.

Finally, a week of field work was completed along the shoreline between Barrow and Lonely on the Beaufort coast, in order to complete a project started last summer encompassing the shoreline from Barrow to Demarcation Pt. Sample sites (35) were set at a 5 km spacing along both lagoon and barrier shorelines. Samples are presently being analyzed and will be submitted with a final report this December. Emphasis during the next quarter will be placed on the completion of the final reports for Kotzebue Sound and the Beaufort Coast.

# II. TASK OBJECTIVES

The major emphasis of this project falls under Task D-4, which is to: evaluate present rates of change in coastal morphology, with particular emphasis on rates and patterns of man-induced changes and locate areas where coastal morphology is likely to be changed by man's activities and evaluate the effect of these changes, if any. The relative susceptibility of different coastal areas will be evaluated especially as they relate to potential oil spill impacts.

## III. FIELD AND LABORATORY ACTIVITIES:

### A. Field Trip Schedule

Part I - Kodiak Island

1. 18 June 1978 - 15 July 1978

2. Air support: Approximately 80 hours in N56RF helicopter.
   Approximately 20 hours in chartered Jet Ranger III (Maritime Helicopters, Homer, AK).
   Approximately 20 hours in chartered Maule (Island Air Service, Kodiak, AK).

3. Scientific Party:

   18 June - 28 June

   a. Miles O. Hayes - director of field activities.
   b. Kennith Finkelstein - field assistant.
   c. Peter J. Reinhart - field assistant.

   28 June - 14 July 1967

   a. Christopher H. Ruby - director of field activities.
   b. Kennith Finkelstein - field assistant.
   c. Peter J. Reinhart - field assistant.

Part II - Kotzebue Sound-Chukchi Sea

1. 15 July 1978 - 25 July 1978

2. Air support: Approximately 30 hours in a chartered Maule (Matson Air Service, Kotzebue, AK.
   Two hours in twin Beech to set up base camp (Matson Air Service, Kotzebue, AK).

3. Scientific Party:

   15 July - 21 July 1978

   a. Christopher H. Ruby - director of field activities.
   b. Peter J. Reinhart - field assistant.
   c. Kennith Finkelstein - field assistant

21 July - 25 July 1978

a. Christopher H. Ruby - director of field activities.
b. Peter J. Reinhart - field assistant

Part III. University of Alaska

1. 26 July 1978 - 28 July 1978

2. Analysis and acquisition of various types of imagery and consultation with colleagues.

3. Scientific Party:

   a. Christopher H. Ruby
   b. Peter J. Reinhart

Part IV. Beaufort Coast

1. 10 August 1978 - 15 August 1978

2. Air support : N56RF - NOAA helicopter. Approximately 20 hours.

3. Scientific Party:

   a. Christopher H. Ruby - director of field activities.
   b. Peter J. Reinhart - field assistant.

Note: All above scientific personnel are members of the Coastal Research Division of the Department of Geology, University of South Carolina, Columbia, S. C.

B. Methods

1. Kodiak Study Site

The island shoreline was divided into 128 separate sample sites. Each site is 15 km apart. These sites were photographed and described on tape, sampled for beach sediment grain size, composition, sorting, shape, etc. At 65 sites, a beach profile was measured and a sketch made in addition to the above. Gross biologic productivity and distribution has been described. The surrounding geomorphology has been used to make inferences regarding recent historic changes (i.e. progradation, erosion, seismic movements, etc.). Areas of specific interest or importance have been analyzed in considerably greater detail.

2. Kotzebue Sound Study Site:

The 44 permanent beach profiles established during the summer of 1976 have been re-occupied to determine short-term (2 year) changes. The remainder of the field work was concentrated on the barrier island complex between Cape Prince of Wales and Cape Espenberg. Analysis of the numerous wash-through channels will be used to estimate the frequency and intensity of barrier overtopping during storms. These data will be compared to estimates based on analysis of weather data. Nearshore bathymetry of offshore bar systems has been investigated using a Bloodworth fathometer.

3. Beaufort Sea Study Site

The coastal segment between Lonely and Pt. Barrow has been divided into study sites 5 km apart on both mainland beaches and barrier island shorelines. The types of data collected are similar to number 1 (above).

D. Data Collection and Analysis

1. Approximately 500 sediment samples were collected and have been analyzed for grain shape and composition.
2. Over 200 profile sites have been measured.
3. More than 5000 ground and aerial photographs were taken.
4. 20 hours of taped morphology and spill vulnerability information were made during over-flights.

IV. Results:

This past quarter's primary emphasis was placed on the collection of field data and the physical analysis of the sediment samples collected. Additionally, the profile data as well as the sediment data has been reduced by computer and stored on magnetic tape.

QUARTERLY REPORT

Contract # 03-5-22-67, Task Order 6
Research Unit #87
Reporting Period: 7/1/78 - 9/30/78
Number of Pages: 37

# THE INTERACTION OF OIL WITH SEA ICE IN THE BEAUFORT SEA

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

27 September 1978

I. Task Objectives:

To understand the small scale interaction of petroleum and sea ice in the Beaufort Sea. Our eventual aim is to predict how an oil spill or well blow-out might interact with the mobile pack ice of the Arctic Ocean.

II. Laboratory Activities:

During the past quarter, we ran three experiments on the interaction of Prudhoe Bay crude oil with sea ice. Because one of these experiments is still in progress, we will submit a detailed report on our results in the following quarter. The experiments concerned first, the interaction of oil and grease ice; second, the pumping of oil through a field of nearly-circular ice pancakes; and third, the interaction of oil with simulated multi-year ice. We will discuss these experiments in the above order.

In the first experiment, we grew in a wave field a layer of grease ice which was about 120 mm thick. We then poured 250 ml of oil on the surface of the mixture of waves and grease ice. Subsequently, the majority of the oil remained on the grease ice surface in a contained patch while the turbulence in the wave field broke some of the oil into small droplets, which were advected down into the grease ice interior.

In the second experiment, we grew in a wave field a field of nearly-circular pancakes with 150 mm diameters over a 120 mm thick grease ice layer. While the wave generator was on, we released beneath the ice about 500 ml of Prudhoe Bay crude oil. The oil slowly rose through the grease ice into the cracks around the pancakes, where the oscillating motion of the pancakes pumped the oil laterally around the pans. The oscillations also pumped some oil onto the ice surface. The oil spread until it affected an area measuring about 1 $m^2$. At the end of the experiment we cut up the ice to find that about 20% of the oil was accessible to the surface either within the cracks or on the ice surface; while the remainder was frozen in beneath the pancakes.

The third experiment on the fate of oil under multi-year ice took about 5 weeks to run. In this experiment, we first grew a 100 mm thick sheet of first year ice in our tank. We then warmed the room up for a 5 day period and let the ice desalinate. To simulate the melting of surface snow, we also added a 2 mm thick layer of fresh water to the ice surface. We then refroze the ice sheet and allowed it to grow an additional 20 mm. At this point, we released 500 ml of Prudhoe Bay crude oil beneath the ice, where it primarily collected into two pools each measuring about 100-150 mm in diameter. This oil was next allowed to freeze in until it was no longer visible from below.

We then performed two warm-up experiments on the oil-ice mixture. In the first, we left our laboratory almost totally in the dark but warmed the room up to +5°C. Using a thermistor chain frozen into the ice, we followed the warming of the ice; also a flash camera photographed the ice at 1 hour intervals. We found that even as the interior ice temperature approached 0°C and a melt pond formed on the ice surface, that the oil remained trapped at depth.

Therefore, we re-cooled the ice and added a simulated 'sun' above the ice sheet. Using a Kipp radiometer, we adjusted the output of this 'sun' so that at the ice surface, the incident radiation was about equal to that in the summer Arctic on a cloudy day. We then warmed up the room to +2°C and turned on the sun. We found that energy absorbed by the oil through the ice caused the ice above the oil to rot and after a period of about 18 hours the oil was released onto the melt pond surface above where the oil was trapped. The oil, however, migrated upward only a negligible amount; most of the release came from the actual melting down of the surface ice to the level of the trapped oil.

III. Other Work:

We attach a copy of a field report by Jane Bauer on the ice edge properties in the Bering Sea as observed from the SURVEYOR in February 1978.

IV. Estimate of Funds Expended:

As of this date, we are 99% expended.

Field Observations of Medium and Small Scale Features of the Bering Sea Ice Edge in February 1978

A report from BLM/NOAA Contract No. 03-5-022-67,
Task Order No. 6, Research Unit #87,
Principal Investigator, Seelye Martin

by

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

25 August 1978

ABSTRACT

Satellite images often show band-like structures occurring within the ice edge zone of the Bering Sea. Direct observations of these ice bands were made in February, 1978 from the NOAA ship SURVEYOR. The ice bands are composed of many ice cakes with slush and grease ice between the cakes. These bands appear to be aligned nearly perpendicular to the wind, with the windward edge being somewhat diffuse. Smaller scale bands of grease ice and small ice bits form in a direction generally parallel to the wind which suggests they may result from Langmuir circulation. Grease ice also appears in the leed of ice cakes during increased winds or decreased temperatures. At the southern-most edge of the ice, wave action is apparent, and ice cakes break apart into smaller "chunks." The width of this southern-most edge is primarily dependent upon the strength of the wind and swell. The features of the ice edge zone appear to be in constant transition and result from the interactions of the ice, air and water.

## 1. INTRODUCTION

In the Bering Sea, the ice edge zone, which lies between the open water and the winter pack ice, is a region of interaction among ice, air and water. Satellite images show that within this zone, band-like structures often occur which have widths of several kilometers and lengths of tens of kilometers. Certain of these band-like structures were discussed by Muench and Charnell (1977) and labeled as medium-scale features. They suggest that the bands might be caused by northerly winds and the presence of roll vortices in the atmospheric boundary layer.

Figure 1, a LANDSAT-2 image (180 x 180 $km^2$), shows a region of the ice edge zone in the Bering Sea which contains these ice bands. When bands occur, the ice edge zone often appears to have a width of 30-50 km and may be wider than 80 km, as in the bottom left corner of the figure. Clouds representative of roll vortices can also be seen in the bottom right corner. One problem with satellite visible imagery occurs when southerly winds, associated with low pressure systems in the western half of the Bering Sea, cover the area with clouds, so that few good pictures result. Thus, ground-truth data is most helpful to verify satellite data and to get an idea of what happens when the area is under clouds.

An opportunity to make direct observations of these ice bands arose in February 1978. These observations, made from the NOAA ship SURVEYOR while on an OCSEAP cruise from 13 February to 1 March (see Figure 2a,b) have provided information about the ice bands, plus other small-scale interactions occurring within this zone. The medium-scale ice bands will be the first topic discussed, followed by discussions of smaller-scale observations and lastly, of observations concerning the southern-most edge of the ice band region. As atmospheric conditions are relevant to the discussions, Figure 3 shows surface pressure maps obtained from FNWC broadcasts received onboard the SURVEYOR. The contour interval is 4 mb. The maps shown are for the three days, 23-25 February, on which the SURVEYOR was in or near the ice at approximately 58° N latitude and 165° 20' W longitude. These maps show that the predominant winds in this region were southeasterly and that the region was covered by clouds during most of this time. ERTS salellite imagery for these days contains nearly 90% cloud cover, so that the ice edge is nearly invisible on these images.

## 2. DISCUSSION

### I. Medium-Scale Bands

The ice bands are composed of ice cakes ranging in size from one to ten meters in diameter. Figures 4-7 show examples of these cakes, surrounded by grease ice and slush. As can be seen, the amount of ice cover varies within these bands. Figure 4 was taken in the afternoon on 23 February--an overcast day with easterly winds of approximately $8\,m\,s^{-1}$ and an air temperature of about 0.6°C. The large, rectangular cake in the foreground is about 3 m in length. Figures 5 and 6a were taken on the partly cloudy morning of 25 February with southeasterly winds of $3\text{-}4\,m\,s^{-1}$ and air temperature near 0.5°C. These two photos were taken while in a band approximately 3 kilometers in width. The walrus in the center of Figure 5 gives an idea of scale, and a rafted ice cake, which represents one of the larger floes (8-9 m in length) seen within these bands, appears in Figure 6a. A CTD cast was made here, station B-BOP (Bristol-Bay Oceanographic Processes) 996.2, with the analog trace showing the water column (46 m) to be isothermal at -1.65°C. (The CTD data was obtained from Thomas H. Kinder of the Department of Oceanography at the University of Washington.) The gaps between ice cakes contained mostly slush and some smaller "chunks" of ice. Whenever ice cakes collided, pieces of slush and slices of darker ice rose to the surface as shown in Figure 6b, which is a close-up of interactions caused by the bow of the ship. The dark slab in the center is a slice of ice which rose to the surface after the bow of the ship had broken an ice cake. Much of the slush had also just risen to the surface, giving the impression that the ice was gradually melting. Figure 7, taken about 90 minutes after 5 and 6a, also gives an impression of melting ice. The winds were now from slightly south of east at 4-6 $m\,s^{-1}$, and the air temperature was +1°C. The surface water temperature in the open water to the south of Figure 7 was -1.60°C, or .05°C warmer than in the previous ice band. (Figure 7 shows the southern edge of the next band.) The amount of slush between cakes is less, with more grease ice and open water appearing. The greater distance between ice cakes is somewhat typical of the windward edge of these bands and will be pointed out in other figures. Many walrus, as in Figure 7, were seen lounging on ice floes near the edges of these ice bands, suggesting that this is a region of biological productivity and shelter for marine mammals. Thus, Figures 4 through 7 present a good description of the consistency of these band-like structures of ice, and Figure 8 presents a summary of these major features.

An opportunity to view these bands from a helicopter arose on the afternoon of 23 February. Unfortunately, visibility was only 6 to 7 kilometers. Winds were easterly at 6-7 $m\,s^{-1}$, and a 1 m swell came from the south. The air temperature was +1°C. The helicopter flew some 18 km directly north from the ship at an altitude of 925 m, turned and flew back to the ship. Our northern most position was 58° 02.0' N and 165° 26.0' W, and ice bands of varying shapes and sizes were visible during the entire flight. Figures 9-13 show examples of these band-like structures. Knowing the helicopter direction-of-flight and swell direction, it is possible to estimate wind and swell directions on each of these photographs. The wavy arrows show swell direction, and the straight arrows show the wind direction. Notice that in most cases the wind is roughly perpendicular to the bands, and in Figures 9 and 10a, the two southern-most photos, the windward side of each band is less well defined. Also notice that the band widths appear to be 5 to 8 times the swell wavelength. Figure 10b was taken looking straight down at the mass of ice cakes which appear in the foreground of Figure 10a. The ice cakes in Figure 10b appear to have their longest sides aligned from left to right, or nearly perpendicular to the wind. (Though there was some camera angle above the perpendicular, it was small enough that the distortion from top to bottom should be small near the bottom of the photo. This implies that the ratio of width to length of each ice cake viewed is approximately the true value.) This implies that the ice cakes within these bands do align with a preferential direction which appears to be either perpendicular to the wind, nearly parallel to the swell, or some combination of the two. Figures 11-13 show no small-scale features, but do show various alignments of these bands. The band in Figure 11b is the third band from the bottom of Figure 11a. These bands each have two well-defined edges and appear somewhat parallel to each other. Figures 12 and 13 show bands of varying width and direction, with sections appearing either perpendicular to the swell or perpendicular to the wind. In all cases, these bands of ice cakes appear similar to the band-like structures seen on the satellite imagery.

A closer look was obtained when the helicopter returned to the ship, Figure 14a. The SURVEYOR is 89.3 m in length, which gives an idea of scale. The wind was across its deck from the left, and swell is from the top of the picture. Upon circling to land, Figure 14b was taken from an altitude of approximately 60 m. The larger cakes are about 6 meters in length. Notice there are small wind waves at the top of the picture but not at the bottom. This could result from several factors: the ice damping out the waves, the ice shielding the water from wind effects, the appearance of grease ice on the water surface leeward of the ice, or some combination of these. Again, the major axis of each larger cake appears to be aligned in nearly the same direction, approximately perpendicular to the wind. However, as no swell is visible in the photo, one cannot gain insight into how the swell interacts with this small band of ice cakes.

This ground-truth data presents an idea of the consistency of these bands seen on satellite imagery. It also shows that these bands can occur during cyclonic disturbances in the atmosphere. The cyclonic disturbances had a large-scale effect on the system also. The ice edge on 25 February was found much farther to the north than had been reported a week earlier. It is not known whether the movement of the edge was due to melting or whether the ice was blown to the northwest. In either case, the edge did move to the northwest during the cyclonic disturbances and the ice bands persisted.

II. Small-scale Bands

While in the vicinity of the sea ice, bands of a much smaller scale, 1-3 meters in width, were also observed to form. These bands generally contained grease ice and smaller bits of ice, and formed approximately parallel to the wind. These bands appeared to form when either the air temperature fell or the wind increased. Figures 15a and b were taken at sunset on an evening of light, easterly winds and swell. About an hour before sunset, the air temperature was 0°C and fell to -1°C shortly after sunset. The bands in these photos are quite visible. Figure 13a was taken facing the setting sun, and Figure 15b looks away from the sun. The presence of these bands is more apparent in Figure 15a, and leads to the question of whether these bands actually formed during this time or became visible due to the angle of the sun's rays.

Grease ice bands also became quite visible as the wind increased. Figures 16a and b were taken after the wind increased from $4\ m\ s^{-1}$ (several hours earlier) to $10\ m\ s^{-1}$. The air temperature was +0.6°C. Figure 16a looks downwind while 16b looks upwind. Again, from visual observations, it is impossible to determine whether the grease ice or slush actually formed during this event or whether the wind, through increased cooling or something such as Langmuir circulation, created conditions that brought grease ice to the surface from below. Another possibility, if the ice cakes are melting, is that grease ice forms from the fresher meltwater of the ice, thus explaining its presence in the vicinity of the ice cakes.

Figures 17 and 18 present a closer look at grease ice appearing on the leeward side of the ice cakes. In Figure 17, a thin film of grease ice is to the left of the cake and occurs in the wind shadow of the ice. It also appears to damp out some of the capillary waves caused by a $4\,m\,s^{-1}$ wind. In 18, the grease ice appears in the foreground of the photo, away from the walrus. Here, no damping effect is visible, but the wind waves are also larger due to a stronger wind, $8\,m\,s^{-1}$. Again, it cannot be said whether the grease ice is forming or conditions for viewing it are improved.

III. Southern-most Ice Edge

The most fascinating area is the southern-most edge of the sea ice, which is unlike the edges of most of the bands as it contains many small "chunks" of ice and few ice cakes. Figures 19-21 are representative of the southern-most edge. As the ship approached the ice from the south, small pieces of widely-scattered ice first appeared and later became more frequent and larger. Figures 19-23 were taken shortly after sunrise with light winds ($3\ m\ s^{-1}$) and swell (0.5 m), both from the southeast. The air temperature was 0°C. Grease ice and some open water are visible between the ice pieces. Figure 19 looks north toward an ice band while Figure 20 looks west along a strip of ice chunks. Figure 21 is a shot of these chunks, looking directly down from 12 m above the water. The ice cake on the front right is about 1 m in diameter. Most of the chunks are widest below the surface with a thin neck and a slightly wider top. The neck appears to be a result of wave erosion at the water surface. Figure 22, taken 20 minutes after 19 and 20, again looks west at scattered ice chunks. The water surface temperature here was -1.65°C. The surface was covered by grease ice and slush which can be seen in Figure 23. The photograph, taken 3 meters above the surface, shows slush and small bits of ice with some grease ice to the right. This is typical of the surface coverage between the ice chunks when the air temperature is near the freezing point.

Upon leaving the southern-most ice band, atmospheric conditions were quite changed. The wind was slightly north of easterly and increasing to 15-20 $m\,s^{-1}$. Swell of 1 to 2 meters was from the east with wind waves of one meter. The air temperature had dropped to 0°C from a maximum during the day of +1.1°C. The slush between ice cakes became much thicker, and swell was felt about 1 km into the ice band. Figures 24 and 25, taken while leaving the ice, both look from inside the ice band toward the southern-most ice edge. The crack running across the center of Figure 24 formed from the waves interacting with the ice. The crack grew every time a wave passed under, with ice on one side rising on the crest and ice on the other falling with the trough. Figure 25 was taken nearer to the edge and close to the region where ice cakes were seen to break into chunks due to the interaction caused by the waves and wind. These chunks were generally less than 0.5 meters in diameter above the surface, were no longer flat on top, and were mostly wider below the surface. This region was observed to extend some 200 m into the ice band.

With the stronger winds and waves, the width of the "chunk" zone decreased, most likely resulting from the wind and waves "herding" the chunks together. Other factors may be that some of the southern-most chunks melted during the warmer hours or were blown into warmer water to melt. As can be seen in Figure 26, the zones of breakup are fairly distinct under these conditions. There is the region of ice cakes and thick slush, the area where active break-up is occurring, a region of many "chunks" and some slush, and lastly the edge of scattered chunks with grease ice and open water between them. The width of these latter two regions appeared to decrease with increasing wind, while the amount of interaction appeared dependent on the size of the swell.

## 3. CONCLUSIONS

These ground-truth observations provide information about medium and small scale features within the ice edge zone in the southeastern Bering Sea. As the better observations were from a helicopter, data concerning these features were obtained only for one set of atmospheric and oceanic conditions. The effects from swell and wind on these bands are still unknown. Noticably, the bands were not in steady state, but appeared to be continuously in transition. Thus, viewing these bands under different conditions or obtaining a time series of measurements would increase understanding of the physical processes involved.

The small-scale features also appeared to be in continuous transition. The growth and melting of grease ice and the appearance of slush was a dominant feature within the ice cake bands and in the open water between them. The frequency of ice cover may play a major role in heat transfer and be important to the biological development of the region. The interactions at the southernmost ice edge appeared to be dynamic processes. A better understanding of these processes could be useful in determining the location of the ice edge and would enhance the understanding of interactions among ice, air and water.

The ice edge zone is an active region which is continuously in a state of transition. It is here that ice, air and water all directly interact. It is known to be a region of strong biological productivity and shelters many marine mammals. An understanding of processes here would enhance ice studies and air-sea interaction studies elsewhere, as well as aid forecasts for shipping, and yield better understanding of "herding" mechanisms of pollutants, such as oil. These present observations are only a beginning to a description of the ice edge zone and the processes involved here.

## ACKNOWLEDGMENTS

I thank Dr. Seelye Martin for suggesting and arranging my participation in the SURVEYOR cruise and for his invaluable assistance in preparing this report. I also thank Dr. Gunter Weller for arranging the funding of my participation in the cruise. Also, I thank Dr. Thomas H. Kinder and the personnel of the NOAA ship SURVEYOR for their assistance and cooperation during the field work. This work was primarily supported by BLM/NOAA Contract No. 03-5-022-67, Task Order No. 6, RU #87, and partly by NSF Grant Number OCE74-13339.

## REFERENCES

Muench, R.D., and Charnell, R.L., 1977: "Observations of Medium-Scale Features Along the Seasonal Ice Edge in the Bering Sea." Journal of Physical Oceanography, Vol. 7, No. 4, pp. 602-606.

## FIGURE CAPTIONS

1. A LANDSAT-2 image (180 x 180 $km^2$) of a region of the ice edge zone in the Bering Sea containing medium-scale ice bands.

2. Cruise track and CTD station locations for NOAA ship SURVEYOR, 13 February - 28 February 1978.

3. Surface pressure maps for Bering Sea and Gulf of Alaska for 22-25 February 1978.

4. Ice cakes, surrounded by slush and grease ice, which compose these ice bands. The rectangular cake in the foreground is about 3 m in length.

5. Ice band consisting of ice cakes, surrounded by slush and grease ice. Notice the walrus in the center of the picture.

6. The ship in an ice band. (6a) shows the bow with several cakes ahead. (6b) shows slush and slices of ice rising to the surface after contact with the bow of the ship.

7. Ice cakes, grease ice, and open water near the edge of an ice band. Notice the family of walrus on one of the larger cakes.

8. Schematic diagram of the major features of the ice band.

9. View of an ice band from a helicopter at an altitude of 925 m. Straight arrow shows wind direction, and wavy arrow shows swell direction.

10. Looking nearly straight down at ice cakes in an ice band. Arrows are as in Figure 9.

11. See caption for Figure 9. Black is due to edges of the window in the helicopter.

12. See caption for Figure 9.

13. See caption for Figure 9.

14. Returning to the ship. (14a) the ship is 89 m in length. (14b) taken from an altitude of 60 m. Notice the lack of capillary waves in the foreground. Arrows are same as in Figure 9.

15. Small-scale bands forming on the surface. (15a) bands of grease ice, forming parallel to the wind. (15b) bands of small pieces of ice and grease ice forming parallel to the wind.

16. Slush and grease ice appearing in stronger winds. (16a) looks upwind while (16b) looks downwind.

17. Grease ice on the leeward side (left) of the ice cake.

18. Slush and grease ice downwind of an ice cake. A walrus is just leaving the cake.

19. Pieces of ice, grease ice, and open water representing the southern-most edge of the ice.

20. Another picture of the southern-most ice edge, looking along a strip of ice chunks.

21. Chunks of ice as seen from 12 m above the water surface.

22. Another picture of scattered ice chunks as seen along the southern-most edge. This was taken 20 minutes after Figures 19 and 20.

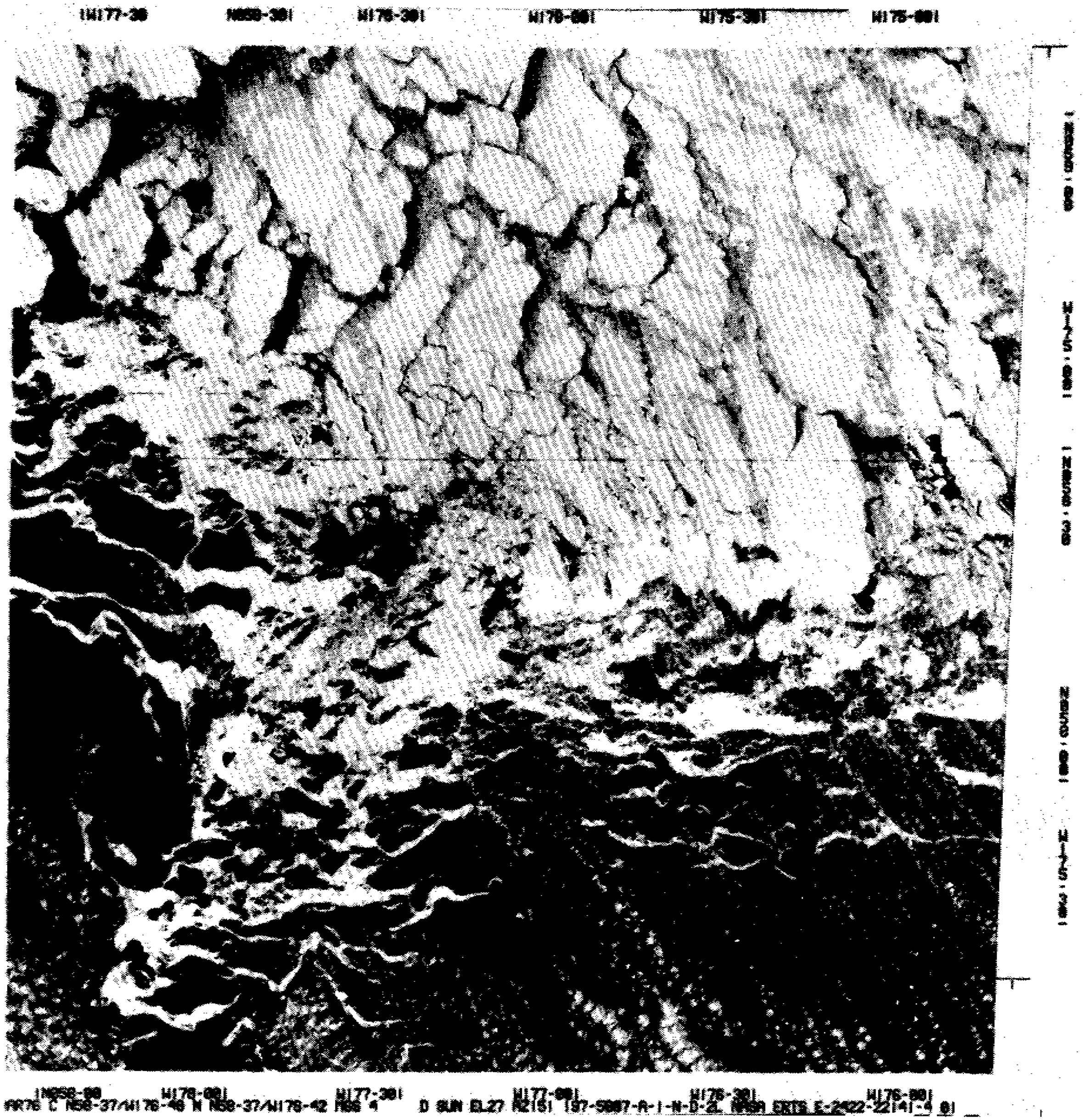
23. A close-up of the grease ice and slush found between the pieces of ice seen in Figure 22.

24. The southern-most ice edge, looking south. The crack in the ice, located in the middle of the picture, formed as a result of wave action.

25. Looking from within an ice band towards the southern-most ice edge.

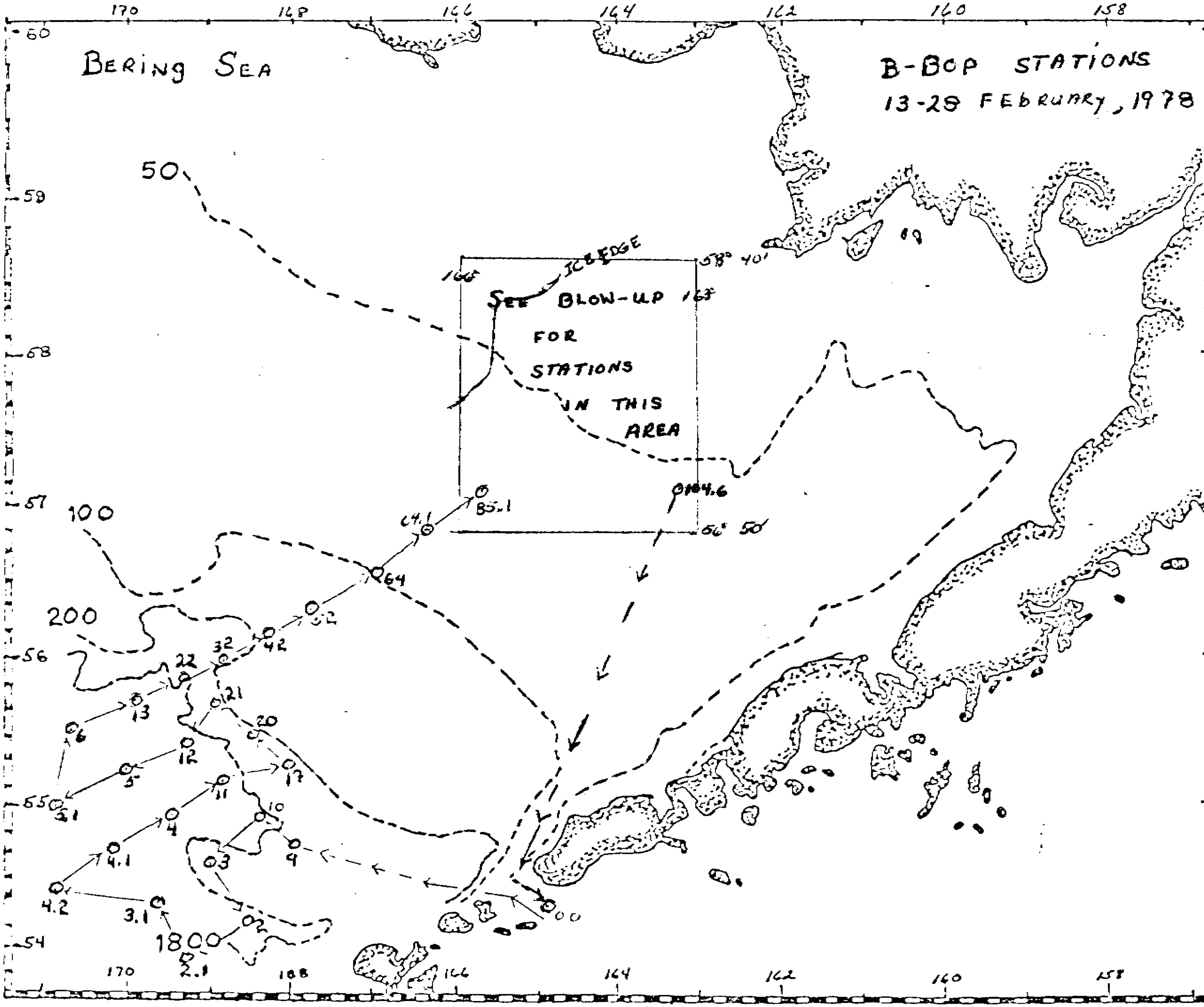
26. Schematic diagram of the southern-most ice edge and the transition to an ice band.

1

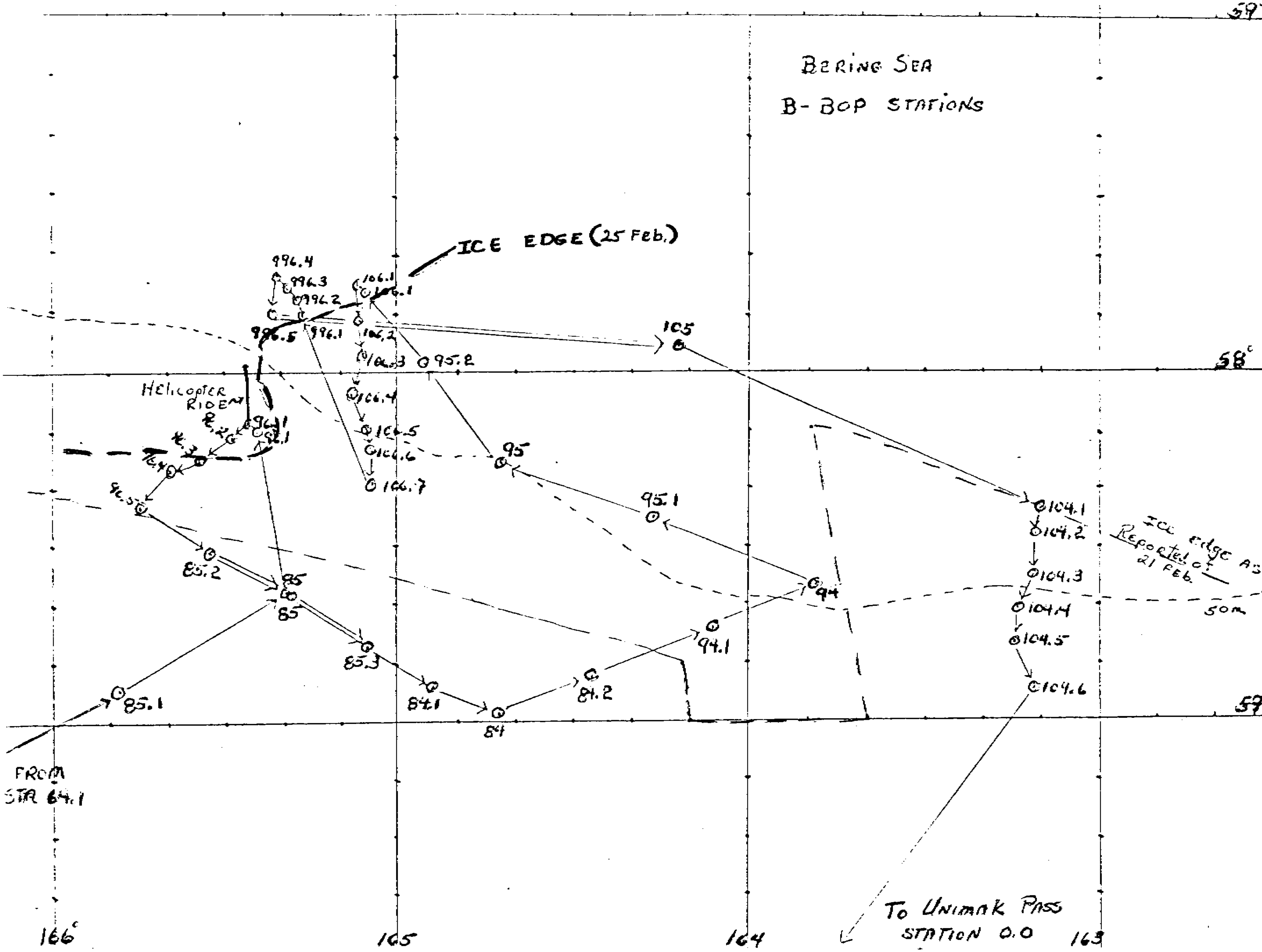


2A



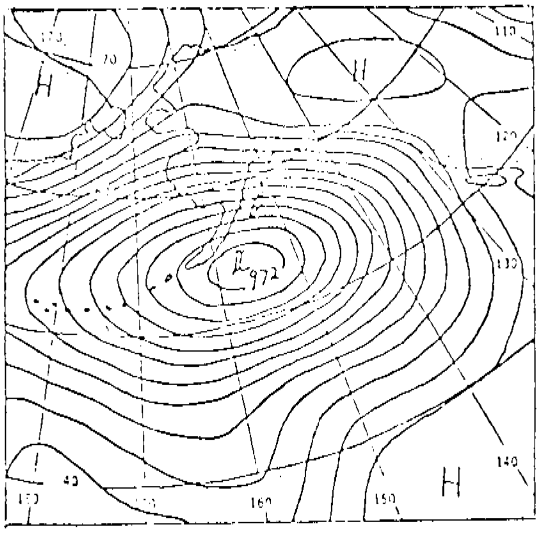

BERING SEA
B-BOP STATIONS
13-28 FEBRUARY, 1978
ICE EDGE
SEE BLOW-UP FOR STATIONS IN THIS AREA
58° 40'
56° 50'
50
100
200
1800

2 B

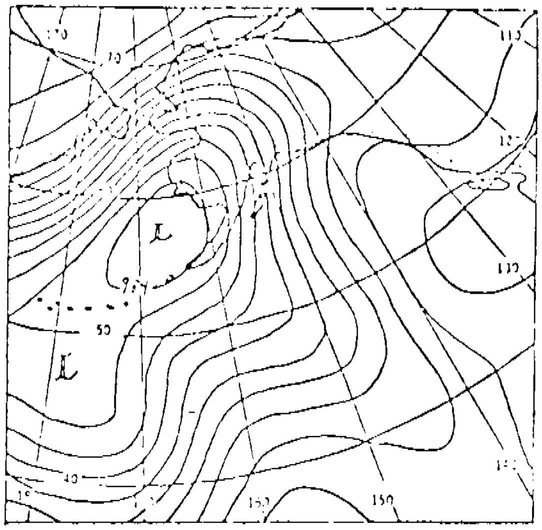


BERING SEA
B-BOP STATIONS
ICE EDGE (25 Feb.)
Helicopter RIDE
Ice edge as Reported of 21 Feb.
50m
FROM STA 64.1
To Unimak Pass
STATION 0.0
59°
58°
57°
166°
165
164
163
105
95
95.1
95.2
94
94.1
84
84.1
84.2
85
85.1
85.2
85.3
104.1
104.2
104.3
104.5
104.6
106.1
106.2
106.4
106.5
106.6
106.7
996.1
996.2
996.3
996.4
996.5

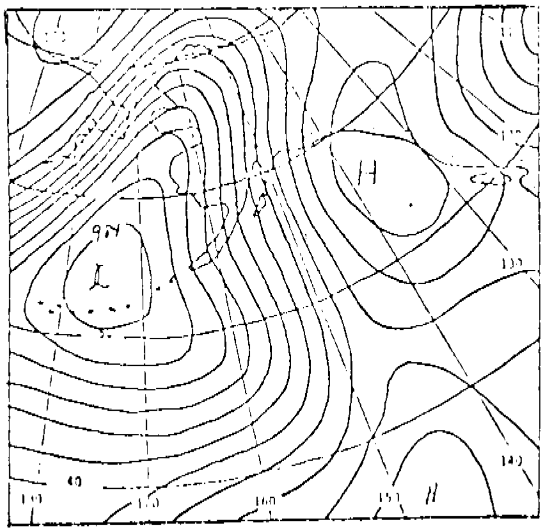
3



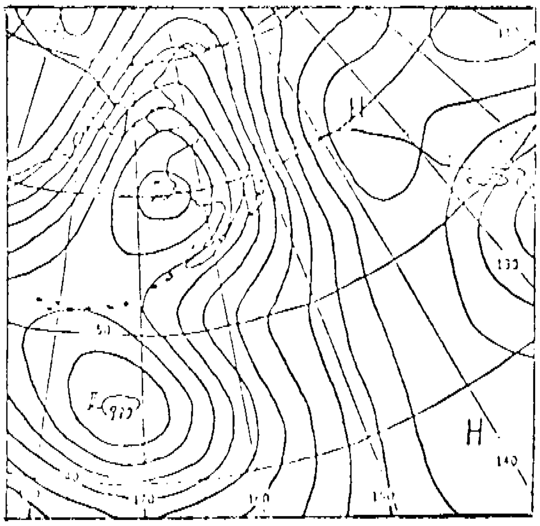

00Z 22 February 1978




00Z 23 February 1978




00Z 24 February 1978



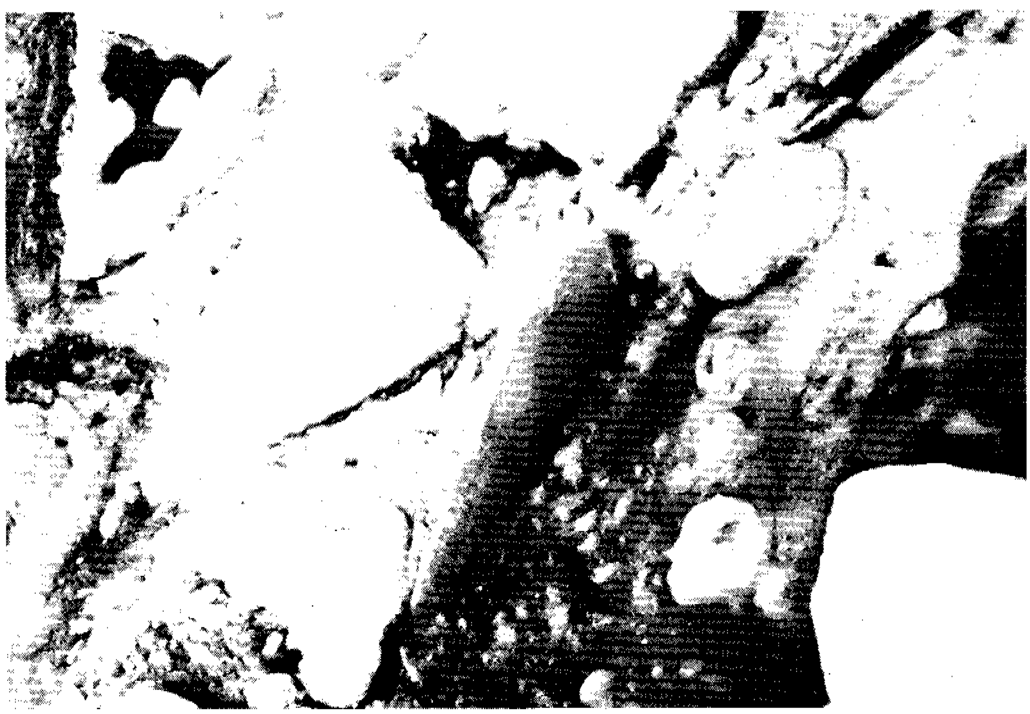

12Z 25 February 1978

4

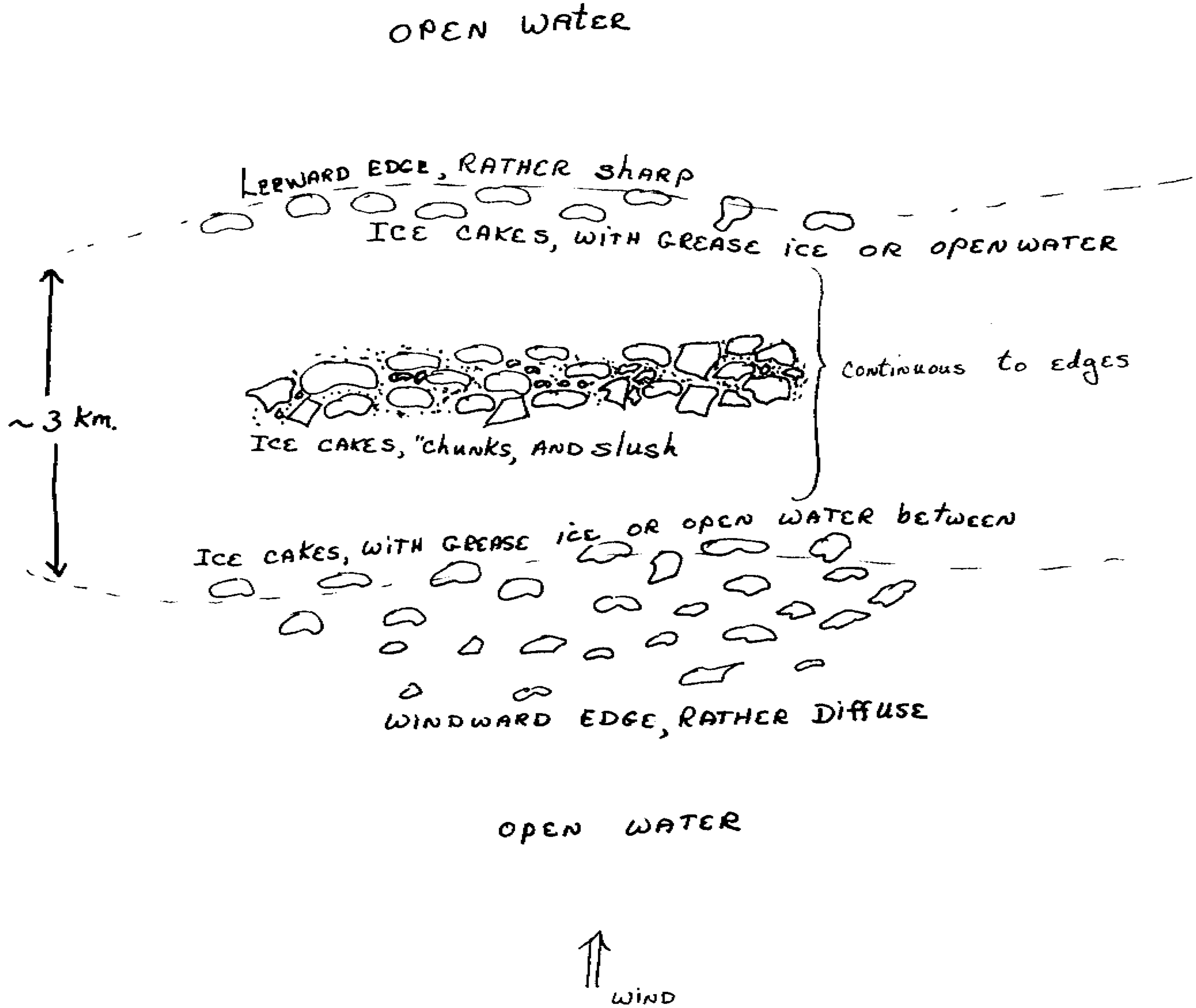
5

6A

6B

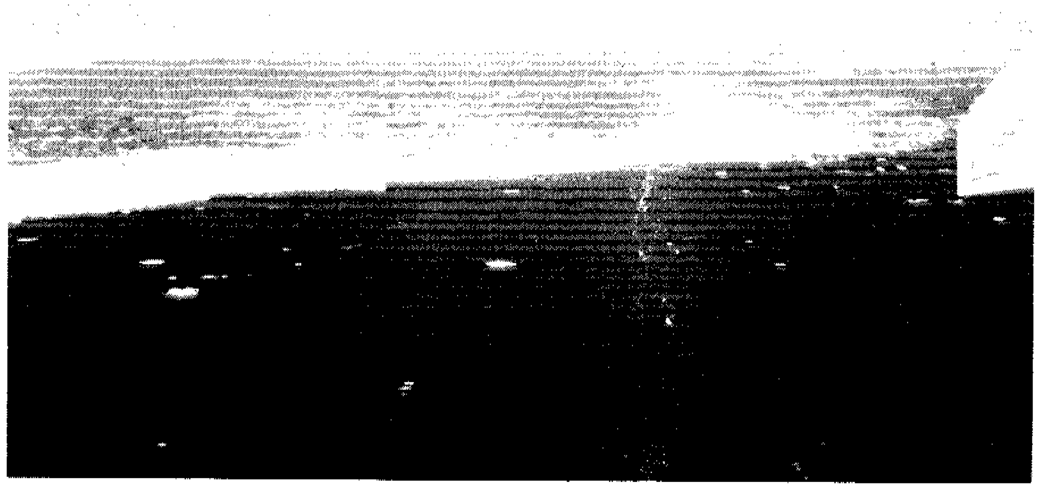


8


OPEN WATER
LEEWARD EDGE, RATHER SHARP
ICE CAKES, WITH GREASE ICE OR OPEN WATER
~3 km.
Continuous to edges
ICE CAKES, "chunks, AND slush
ICE CAKES, WITH GREASE ICE OR OPEN WATER between
WINDWARD EDGE, RATHER DIFFUSE
OPEN WATER
WIND

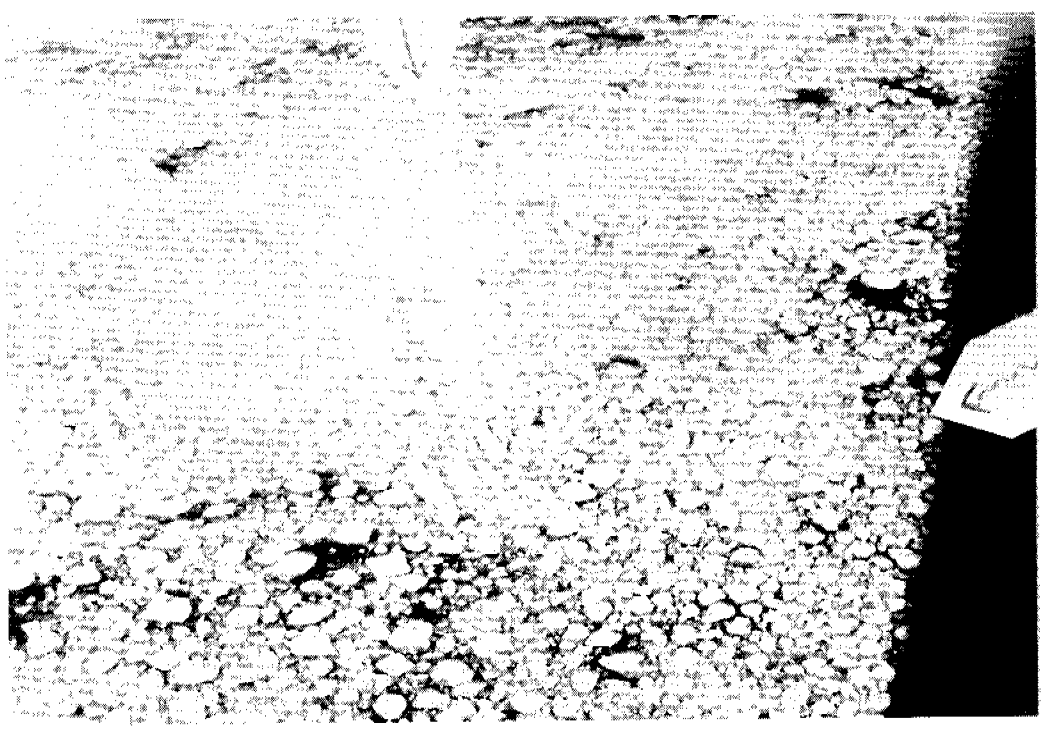
7

9

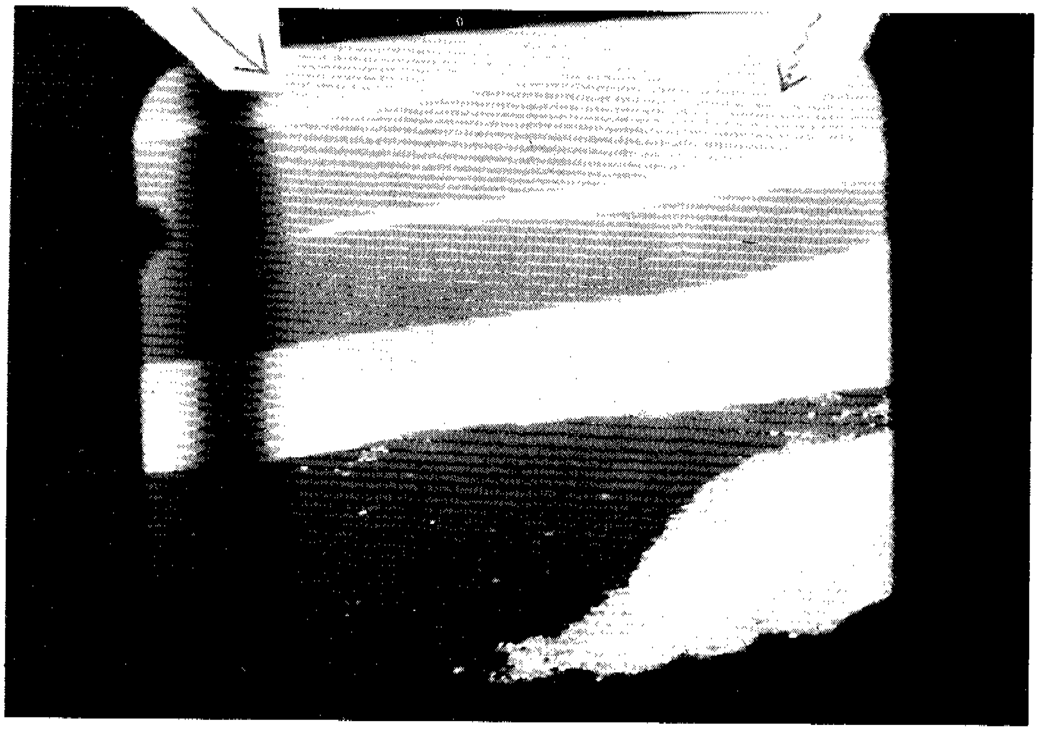


10
A

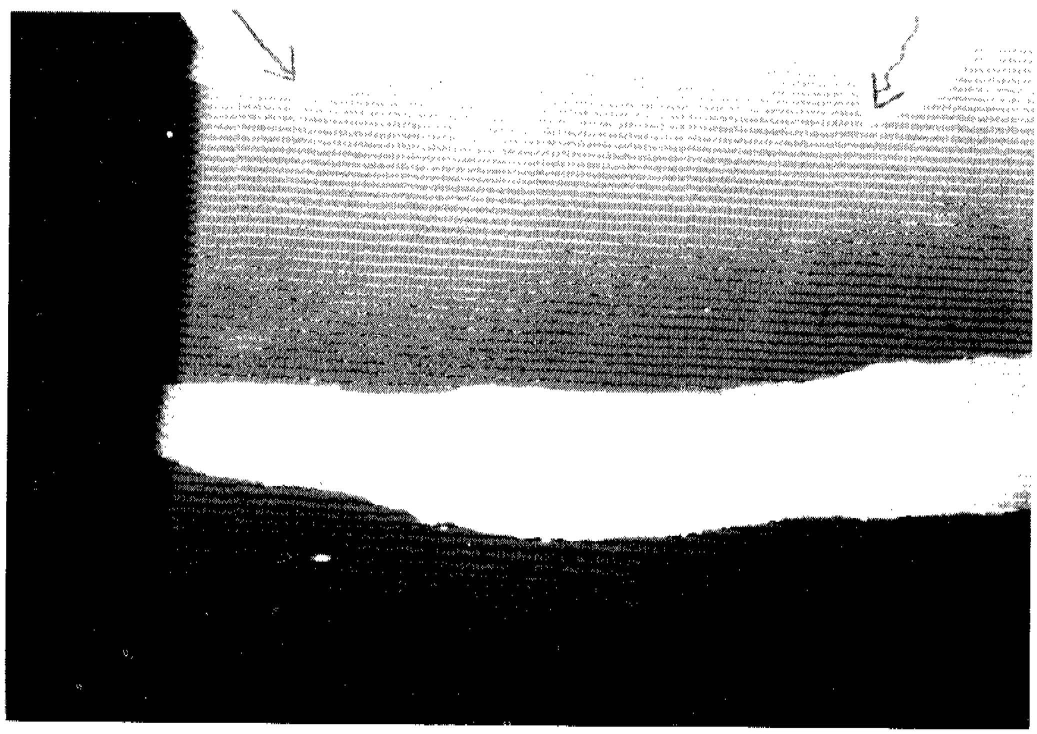
10
B



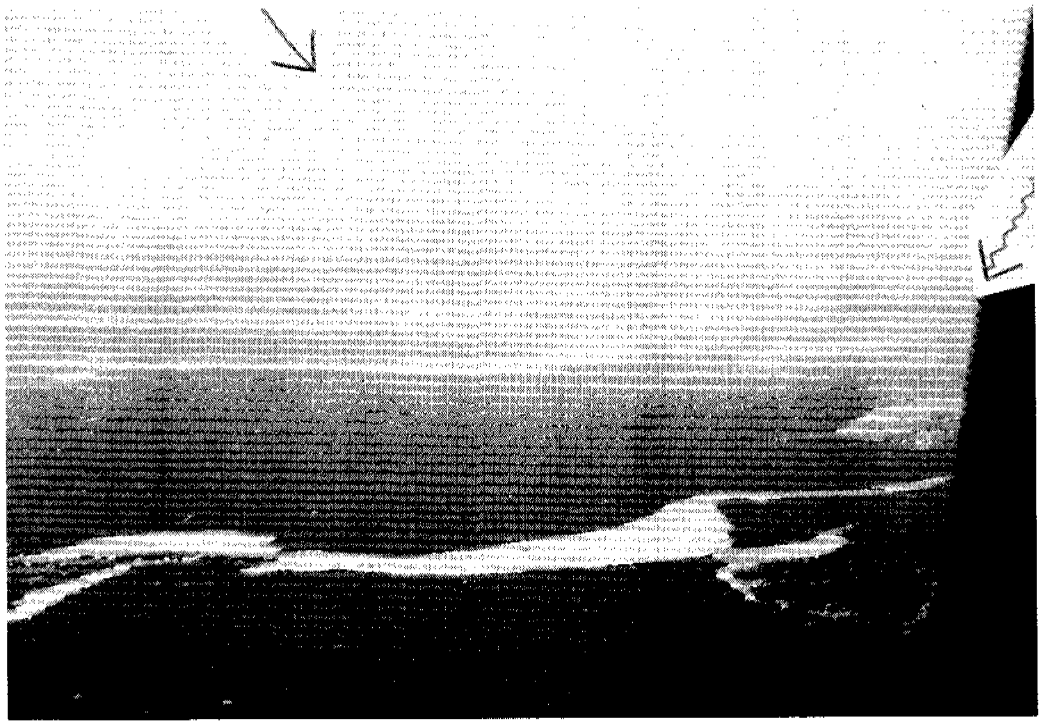
11 A



11 B



12



13

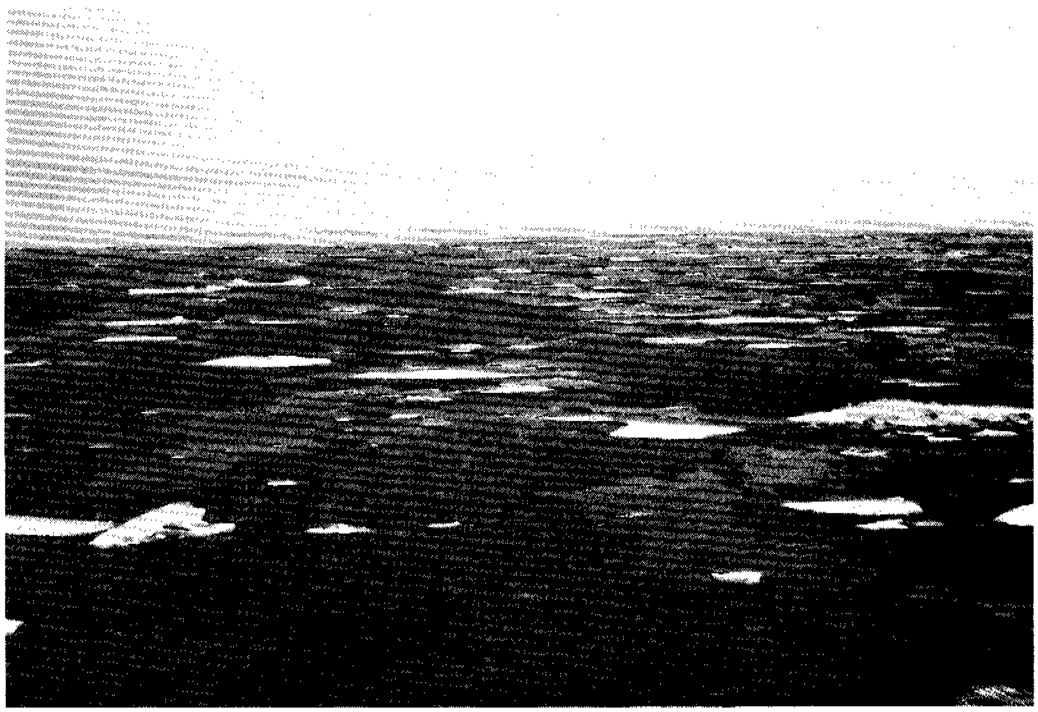
14
A

14
B

15 A

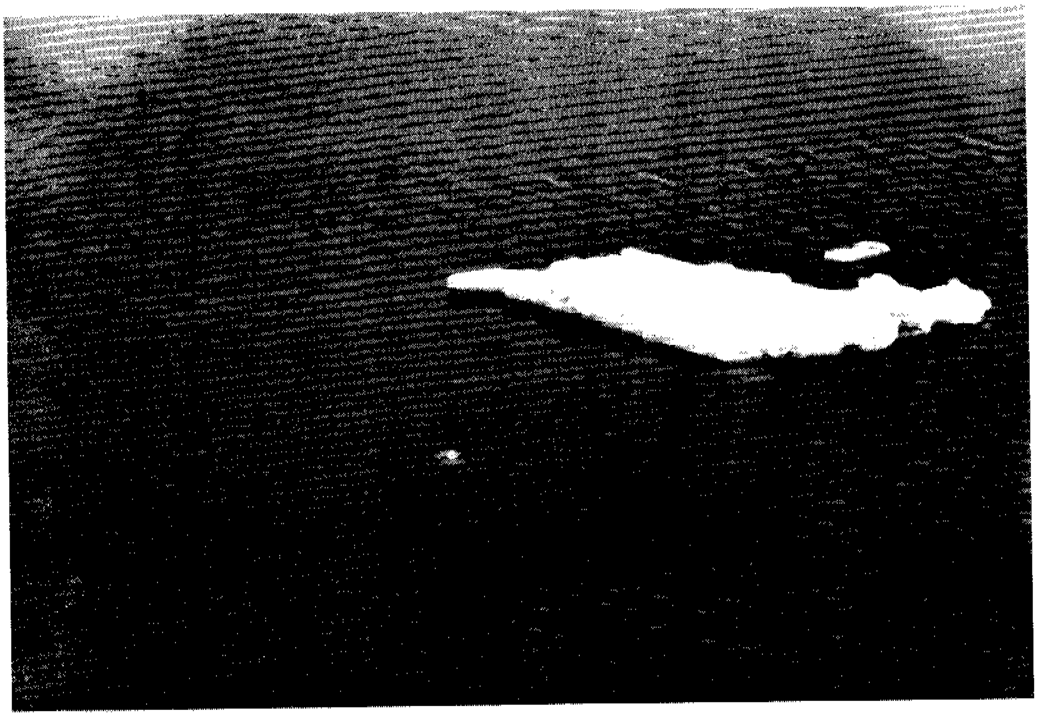
15 B

16
A

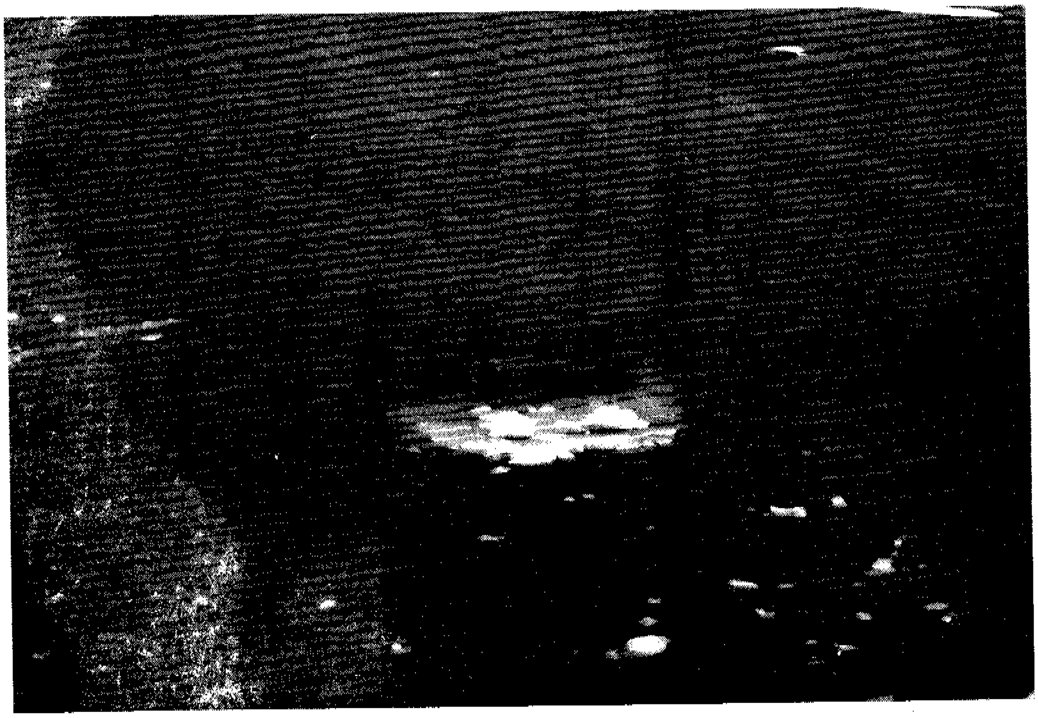


16
B

17

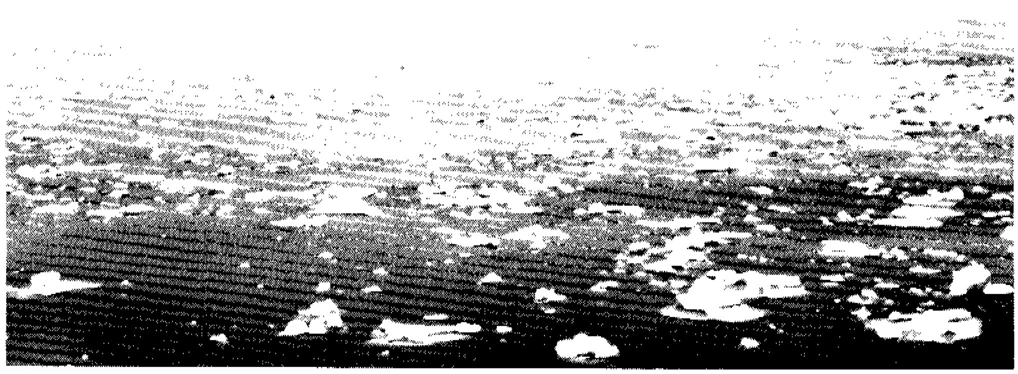


18



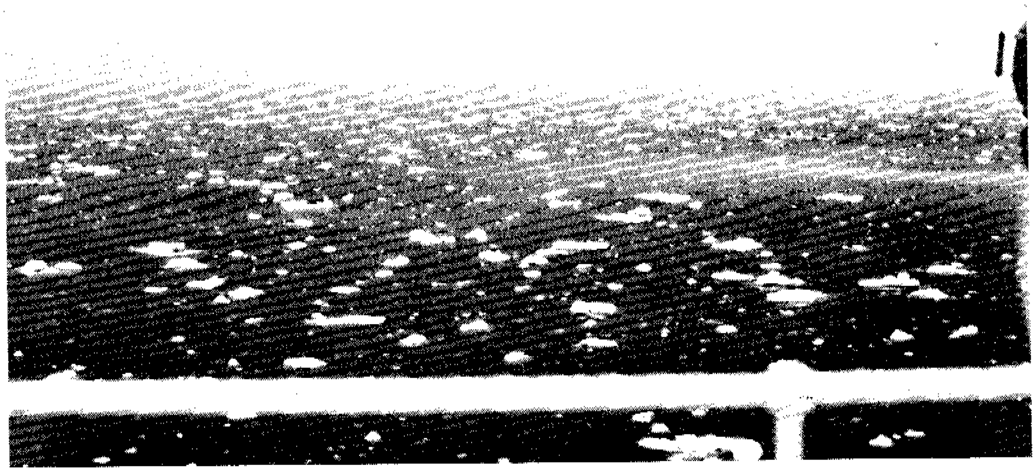
19

20

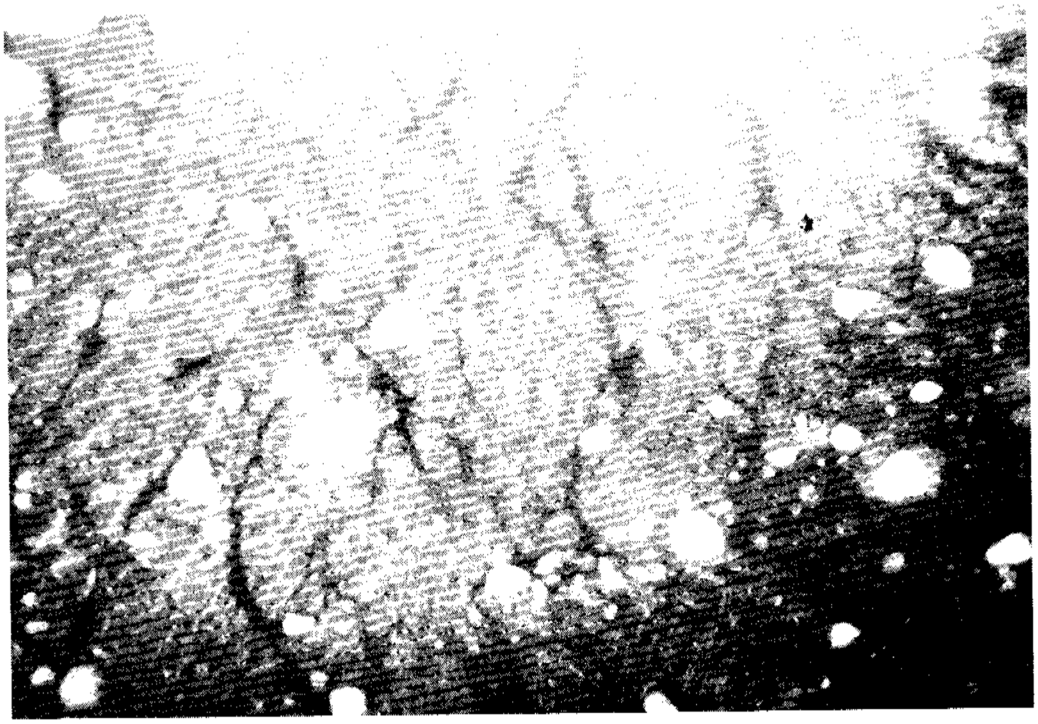


21

22



23

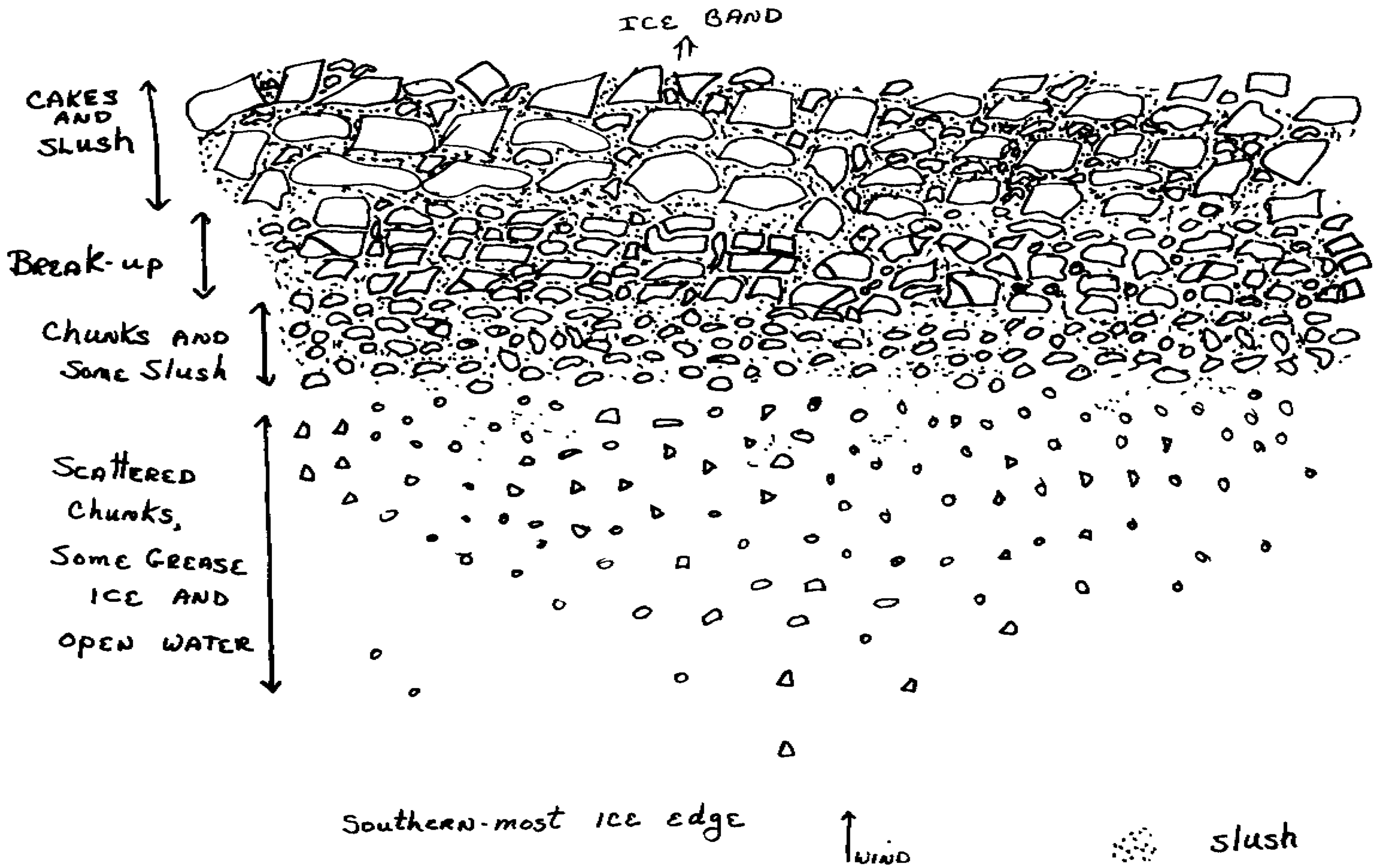


24

25

229

26



ICE BAND
CAKES AND SLUSH
Break-up
Chunks and Some Slush
Scattered Chunks, Some Grease Ice and Open Water
Southern-most ice edge
WIND
slush

QUARTERLY REPORT

R.U.#88: Dynamics of Near-shore Ice
P.O.: 01-5-022-1651
Reporting Period: 1 July 1978 to 30 September 78
Number of Pages: 4

# DYNAMICS OF NEAR - SHORE ICE

Principal Investigators: A. Kovacs and W. F. Weeks

Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755

20 October 1978

I. Task objectives

The purpose of this project is to:

a. study the motion of the fast ice and near-shore ice north of Prudhoe Bay and in the vicinity of the Bering Strait,

b. make observations on major ice deformation features that occur near the edge of the pack ice/fast ice boundary,

c. explore the use of a pulsed radar system to measure the characteristics of sea ice,

d. study the internal structure of near-shore sea ice,

e. characterize the spatial and temporal variations in sea ice pressure ridging via the use of laser profilometry and side-looking airborne radar (SLAR).

II. Field and/or Laboratory Activities

No field studies were carried out during this quarter.

A report entitled "Sea Ice Ridging Over the Alaskan Continental Shelf" was completed and submitted to the Journal of Geophysical Research for publication.

A report on shore ice piling is in an advanced stage of preparation. Preparations to investigate fall ice pile-ups along the Beaufort Sea coast are being made.

A report entitled "Ice Related Environmental Problems" has been prepared for the Environmental Working Group of the Commission on Offshore Energy Technology, Marine Board, NRC.

A cooperative report which addresses the interrelationship between the internal structure and the physical and mechanical properties of fast sea ice at Barrow, Alaska is in preparation. Involved are CRREL, USGS, Institut für Geophysik, University of Münster, Germany, and the Institute of Low Temperature Science, Japan.

A report dealing with studies of crystal alignments in the fast ice along the Arctic coast of Alaska, between Shishmaref Lagoon and Camden Bay is in preparation.

Parts were secured to make repairs to the Tin City radar. The radar is expected to become operational in November.

III. New Results

A new ice pile-up has been observed southeast of Pt. Barrow. This formation consists of ice 16 cm thick. The ice advanced 25 m inland and piled to a height of 2.5 m.

A laser profile line made by NASA in March 1978 extending seaward from Cross Island shows significantly different results than did a line run during the same period in 1976. The 1978 line shows the most heavily ridged area to be the first 20 km section (adjacent to Cross Island) which the 1976 data has the roughest area being 20 to 40 km seaward. Visual observations during both years in the area agree with this and also make note of the fact that much less multi-year ice was present near shore in 1978.

The status of recent reports is as follows:

a. Kovacs, A. (1978), Radar profile of a multi-year pressure ridge. Arctic, Vol. 31, No. 1.

b. Kovacs, A. Remote detection of water under ice covered lakes on the North Slope of Alaska. Accepted for publication in Arctic.

c. Kovacs, A. and Sodhi, D.S., Shore ice pile-up and ride-up (field observations, models, theoretical analyses). In preparation.

d. Tucker, W.B., III, Weeks, W.F., and Frank, M. Sea ice ridging over the Alaskan continental shelf. Submitted for publication in the Journal of Geophysical Research.

IV. Estimate of Funds Expended (as of 30 September 1978).

| | ORIGINAL | EXPENDED | REMAINING |
|---|---|---|---|
| Narwhal Island | $64,949 | $64,949 | $0 |
| Bering Strait/Remote Sensing | $76,433 | $76,433 | $0 |
| Ice Conditions of the Beaufort and Chukchi Seas | $31,994 | $31,994 | $0 |

QUARTERLY REPORT

Contract: 03-5-022-67
Research Unit: 98
Reporting Period: 1 July - 30 Sept. 1978
Number of Pages: 7

# DYNAMICS OF NEAR SHORE ICE

Roger Colony

Polar Science Center
Division of Marine Resources
University of Washington
Seattle, Washington 98105

September 20, 1978

## I. TASK OBJECTIVES

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

## II. FIELD AND LABORATORY ACTIVITIES

### A. Field Trips Scheduled

None

### B. Scientific Party

None

### C. Methods

All buoys discussed in this report are sampled by the Random Access Measurement System on board Nimbus VI satellite.

### D. Sample Location

Four data buoys were deployed in March 1978 over the continental shelf in the Beaufort and Chukchi Seas from east of Point Barrow to Cape Lisbourne.

### E. Data Collected or Analyzed

The latitude and longitude of the four buoys have been monitored since March 1978. Atmospheric pressure data is being collected from one of the buoys.

## III. RESULTS

The satellite data is received weekly from NASA, Goddard Space Flight Center. The proceedure is to decode the NASA data, sort the appropriate buoy platform numbers, make a long track correction to position, edit bad fixes, and smooth and interpolate the position and pressure time series. Figures 1-3 show latitude and longitude time series from the edited position data. The pressure data has not yet been processed. The smoothing and interpolation proceedure has not been done. The data is for the period June-August.

## IV. PRELIMINARY INTERPRETATION OF THE RESULTS

None

## V. PROBLEMS ENCOUNTERED AND RECOMMENDED CHANGES

Buoy 1003 stopped reporting at the end of June and buoy 1301 stopped reporting at the end of July. The cause of failure to report is not known, however a certain mortality rate was expected. Buoys 413 and 425 continue to report through mid-September. During July and August NASA was converting their software and reporting methods to the new Nimbus-7 satellite. The magnetic tapes for this period are not complete but there is assurance that this data will be recovered. NASA has announced that there will be no RAMS data for a three to four week period beginning 15 September. This data will be irretrievably lost. This again is due to the launch of Nimbus-7. This is unfortunate because I was planning to use the inertial motion in the buoys as a measure of the internal stress in the ice. Inertial motions are generally prevalent from July to October. Good drift data is expected from buoy 413 and 425 for the fall period.

## VI. ESTIMATE OF FUNDS EXPENDED

As of 30 September 1978 actual expenditures under this contract total about $269,514.81. The estimated obligations for October are anticipated to be $4,400.

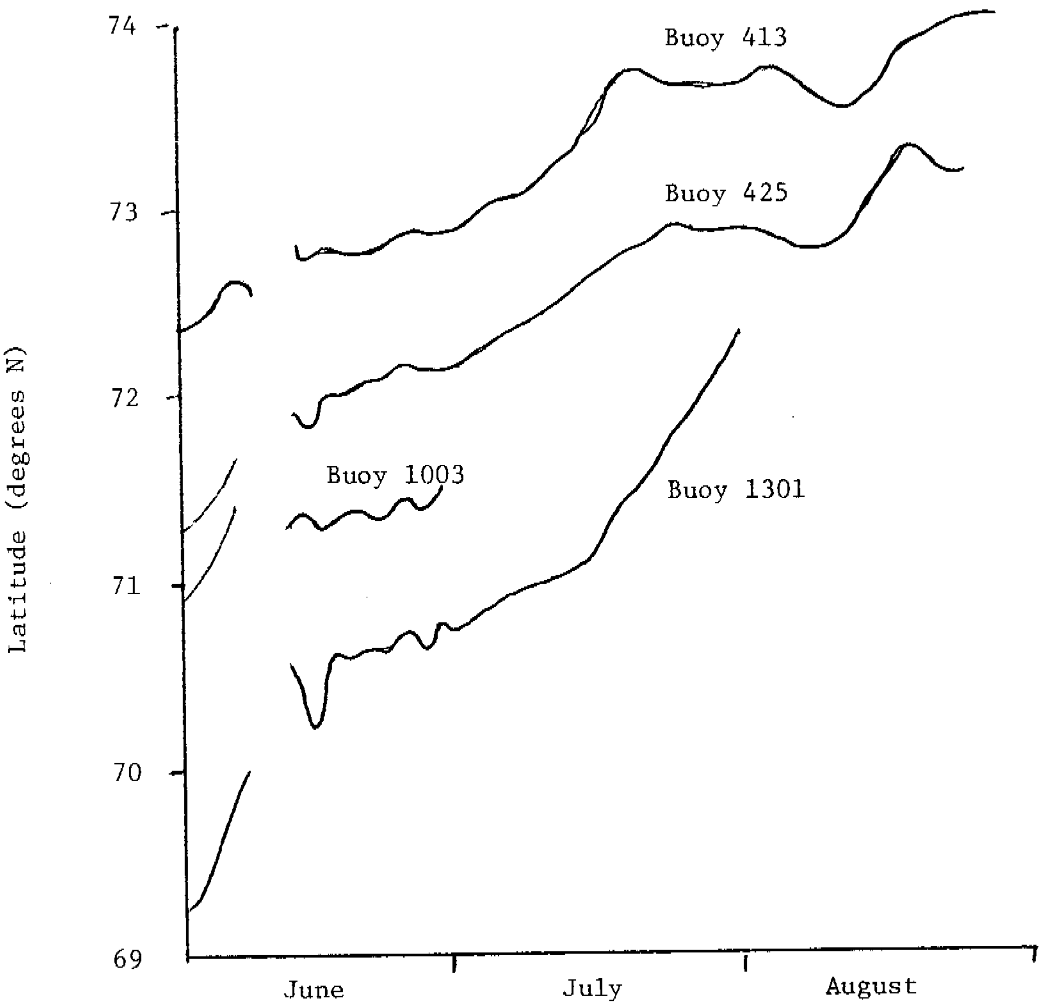



Figure 1. Time series of latitude.

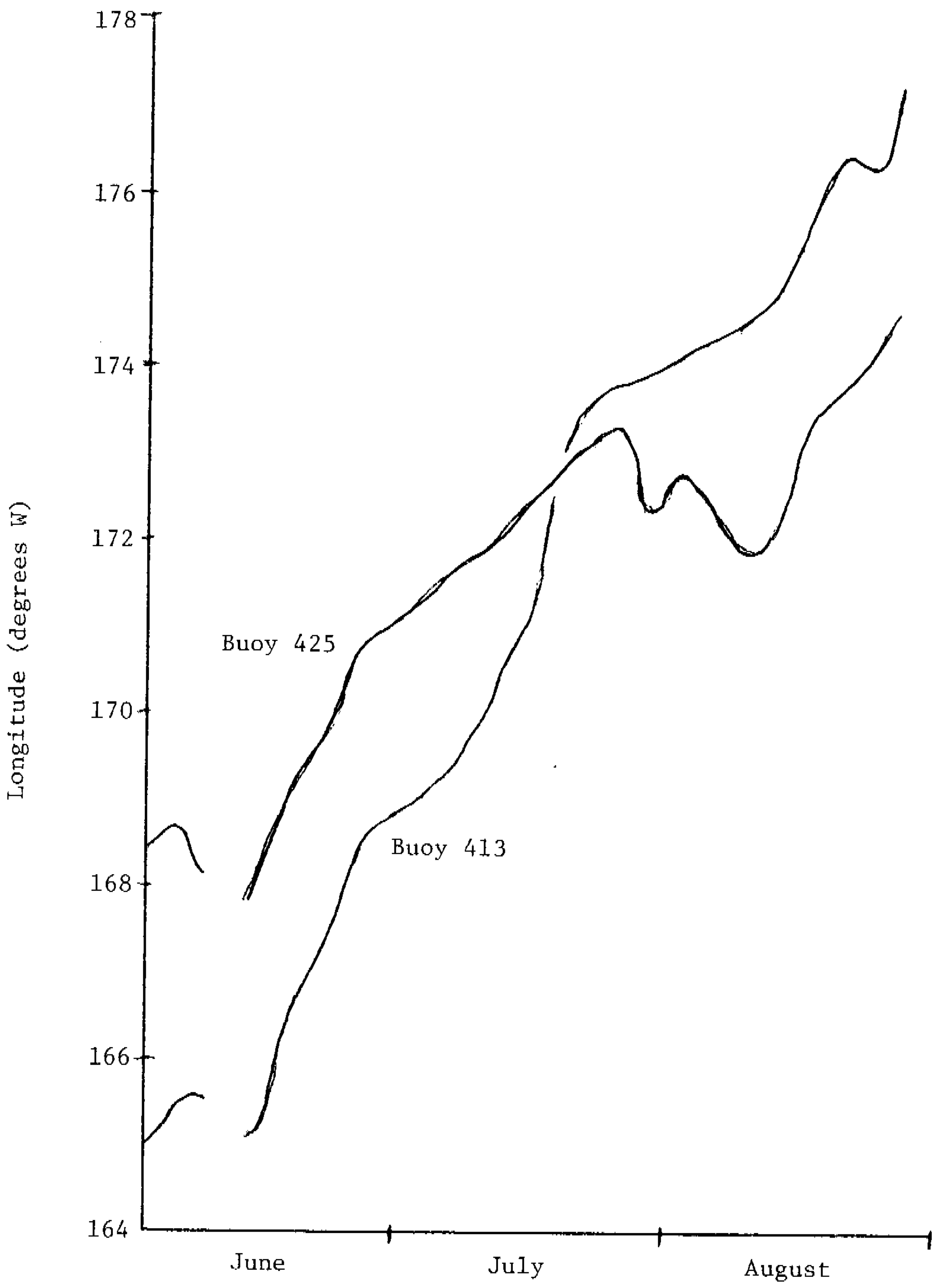



Figure 2. Time series of longitude.

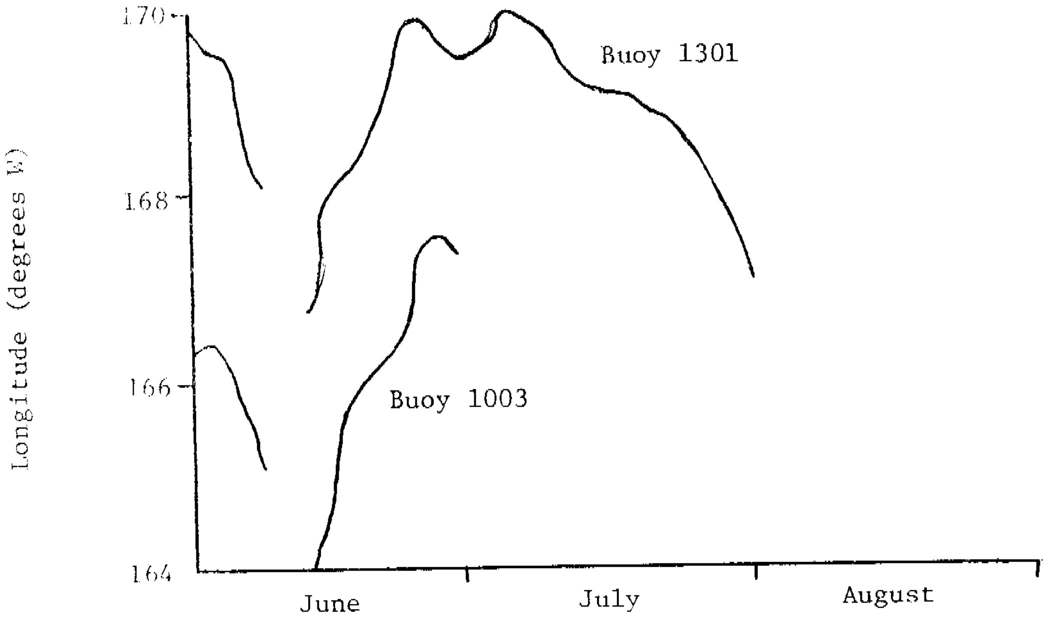



Figure 3. Time series of longitude.

Research Unit No. - 105
Reporting Period - 1 July 1978
Number of Pages - 30 September 1978

Quarterly Report
to

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Arctic Projects Office
Fairbanks, Alaska

# DELINEATION AND ENGINEERING CHARACTERISTICS OF PERMAFROST BENEATH THE BEAUFORT SEA

Principal Investigators:
P. V. Sellmann
E. Chamberlain

Associate Investigators:
S. Arcone
S. Blouin
A. Delaney
I. Iskandar
F. Page

September 30, 1978

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

## I. TASK OBJECTIVES:

The project will attempt to provide regional data on permafrost distribution in the Beaufort Sea. This will be done by reprocessing and examining commercially available seismic records for an indication of the position of the top of bonded permafrost. Analysis of drill cores and other available supplementary data will also be carried out, with no drilling done as part of this year's program.

## II. - IV. FIELD AND LABORATORY ACTIVITIES:

With completion of all engineering property analysis and data interpretation of probe records efforts were spent combining the results of the two years of studies into formal CRREL reports. The results of the drilling and engineering studies are being grouped into one report. The final version of the report covering the penetrometer studies is now complete. Preliminary copies of data and drafts of these reports are available on request. Funds were obligated at the beginning of this quarter for processing of 560 km of commercial offshore seismic data. This data was not available by the end of the quarter although delivery was assured for the second week of October. If this data is as promising as preliminary inspection indicates, an additional order will be placed for other available records.

A considerable number of inquiries were received concerning all aspects of our subsea-permafrost studies from contractors planning to bid on the Beaufort Sea Permafrost program proposed by the Conservation Division of the U.S. Geological Survey. Two meetings were also attended at OCSEAP request during this quarter, the Fairbanks Ice/Permafrost Review meeting and the Contractors preproposal meeting for the USGS Permafrost study.

## V. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES:

The study of commercial seismic records has suffered from the delays in receiving the processed records from the original field tapes. As a result, additional effort was placed on finalizing previous studies. With the seismic data now being processed and an assured delivery date, no immediate problems seem to exist.

## VI. ESTIMATE OF FUNDS OBLIGATED:

All of this year's funds were obligated.

Research Unit # 204
Report Period: July-Sept. 1978

Quarterly Report

# OFFSHORE PERMAFROST STUDIES AND SHORELINE HISTORY OF CHUKCHI AND BEAUFORT SEAS AS AN AID TO PREDICTING OFFSHORE PERMAFROST CONDITIONS

D.M. Hopkins et al.

United States Geological Survey
Menlo Park, California

Research Units 204 & 473: Quarterly Report, July-August-September, 1978

# OFFSHORE PERMAFROST STUDIES AND SHORELINE HISTORY OF CHUKCHI AND BEAUFORT SEAS AS AN AID TO PREDICTING OFFSHORE PERMAFROST CONDITIONS

## I. Abstract of Highlights

The lithology of pebble samples collected along the beaches of southwestern Harrison Bay indicates they were derived from a Brooks Range source. A very old spindrift line (+150 yrs.) was observed atop the bluffs along the southwest coast of Harrison Bay between benchmark Harrison and benchmark Vista. The elevation of this old spindrift-line is 4.0 to 4.5 m above sea level, at least a meter higher than spindrift deposited during the 1970 storm surge.

## II. Task Objectives: D-9

## III. Field or Laboratory Activities

A. Fieldwork on the Beaufort Sea coast was conducted between August 13 and September 19, 1978. Four field camps were established in transit along the coast of Harrison Bay. Utilizing an inflatable boat we examined and sampled many new locations between Atigaru Point and Oliktok Point.

B. Scientific Party:

D. M. Hopkins, geologist and Principal Investigator
R. W. Hartz, geologist and Co-Investigator
J. R. Garst, student/geological field assistant

C. Methods of Analysis:

Synthesis of field observations
Study of maps and air photos

D. Sample Localities:

Many new localities along the coast of Harrison Bay.

E. Data Collected or Analyzed:

Lithologic pebble counts
Granulometry samples
Radiocarbon dates on 1977 and 1976 samples
Identification of recent and fossil mollusks

IV & V. Results and Interpretation

A very old and discontinuous driftwood line was found partially buried atop the bluffs between benchmark Harrison and benchmark Vista on the southwest shore of Harrison Bay. Logs up to 5 cm across and 30 cm in length were found incorporated into the turf, they are badly decomposed and tend to crumble upon touch which leads us to believe that the driftwood was deposited by a storm surge that occurred more than 150 years ago. The elevation of this old driftwood line is from 4.0 to 4.5 m above sea level, at least 1.0 to 1.5 m higher than the storm surge of 1970, believed to be highest surge of the last century (Reimnitz and Maurer, 1978).

Only three sample locations yielded pebbles of sufficient size and quantity to fit the parameters of our lithological pebble counts. The lithology of these samples indicates that they were originally derived from a Brooks Range source.

The results of radiocarbon dates on samples collected during 1976 and 1977 have been received, and their interpretation will be forthcoming in our next Quarterly Report or presented as an interim report. We are also preparing a report on recent and fossil mollusks of the Beaufort Sea, which will accompany the radiocarbon report.

VI. Problems Encountered

Although we received assurances that our request for a field radio would be fulfilled, no field communication system was available upon our arrival at NARL. We were left in the field without communication with NARL base when the party chief was stricken by pneumonia and needed immediate medical attention. Thanks to smoke grenades and luck we were able to signal a low-flying aircraft which ferried us to NARL. Several days of fieldwork were lost while waiting for a plane to come within range of our smoke grenades.

The rigorous demands of remote field camps and harsh weather conditions prior to freeze up tended to impede field activities.

VII. Estimate of Funds Expended to Date: All funds expended.

VIII. Bibliography

Reimnitz, Erk, and Maurer, D. K., 1978, Storm surges in the Alaskan Beaufort Sea: U.S. Geological Survey Open File Report 78-593, 25 p.

QUARTERLY REPORT

Contract: RK6-6074
Research unit: 205
Reporting period: July 1 - September 30, 1978

# MARINE ENVIRONMENTAL PROBLEMS IN THE ICE-COVERED BEAUFORT SEA SHELF AND COASTAL REGIONS


Peter Barnes

Erk Reimnitz

Pacific-Arctic Branch of Marine Geology
345 Middlefield Road
Menlo Park, California 94025


1 October, 1978

Quarterly Report, 1 October, 1978 - RU: 205, Barnes and Reimnitz

Preparation for, and execution of, field activities has consumed most of the project effort in the last quarter. No insurmountable problems nor changes in program plans or goals occurred in the last quarter.

FIELD ACTIVITIES:

Field studies on the R/V KARLUK took place during the months of August and September in the area from Barrow to Flaxman Island.

SCIENTIFIC PARTY:

P. Barnes - U.S. Geological Survey, Geologist
E. Reimnitz - U.S. Geological Survey, Geologist
D. Maurer - U.S. Geological Survey, Research Assistant
D. Fox - U.S. Geological Survey, Research Assistant
J. Nicholson - U.S. Geological Survey, Electronics Technician
H. Hill - U.S. Geological Survey, Electronics Technician

PRELIMINARY OBSERVATIONS:

Resurvey of bottom areas studied in detail in previous years illustrates some marked differences since last year's survey. The most striking change in water depths less than 10 m is the increase in the abundance of hydraulic bedforms and the sediment infilling of ice gouge features. Extensive open water during the latter half of the 1977 summer and early fall gave rise to abnormally large waves and swell which could account for the change in bottom character. Thus previous estimates of gouge recurrence rates and incision depth are too low.

A very distinct ice gouge less than two years old was studied by direct diving observations. The gouge, at a depth of 12 m, is about 10 m wide, flat floored, about 50 cm deep, with flanking ridges of soft mud up to 80 cm high. The long term average rate of sediment deposition in this area of the Beaufort Sea shelf is about 6 cm/100 yr, and we therefore were surprised to find 25 to 30 cm of new sediment fill in the two year old gouge. The depth of the new fill was easily measured along several transects by penetrating the fill by hand to a very firm, original gouge floor. The lower 20 cm of the fill offered some resistance to penetration by hand, while the upper 5 to 10 cm of the fill was soupy, with a high water content.

These observations have several important implications for ice gouge studies, and for designers of marine pipelines:

1. Gouges on the shelf are rapidly filled and eliminated. These fill deposits are narrow and string-shaped.

2. A part of the new fill must originate from reworking or erosion of the seafloor adjacent to the gouge, and does not represent settling out from suspensions of new sediment added by rivers and coastal erosion.

3. The average gouge observed on the shelf at any time is young, perhaps less than 10 to 20 years.

4. The incision depth of gouges on the shelf, as determind from fathometer records, is far less than the original incision depth, with deep incisions filling more rapidly than shallow ones.

5. Stakes were driven into and adjacent to the gouge [illegible]. future studies on the rate of sediment infilling.

**PLEASE LIMIT ABSTRACT TO THIS PAGE ONLY**

| | |
|---|---|
| OTC | '78 |
| Session | |
| Date Received | |

PAPER TITLE Presence of major Beaufort Sea shoal revealed through sea ice studies


PRINCIPAL AUTHOR Erk Reimnitz TELEPHONE 856-7004
COMPANY U. S. Geological Survey TELEX
MAILING ADDRESS 345 Middlefield Road
CITY & STATE Menlo Park, California ZIP 94025 COUNTRY U.S.A.
CO-AUTHOR Douglas Maurer
COMPANY United States Geological Survey
MAILING ADDRESS 345 Middlefield Road
CITY & STATE Menlo Park, California ZIP 94025 COUNTRY U.S.A.
NOTE: ATTACH SEPARATE SHEET FOR ADDITIONAL AUTHORS (please see attached sheet)


Note to Authors: The OTC Program Committee will evaluate papers solely on the basis of information supplied on this form. Preference will be given to papers providing specific information in each of the four areas of the data reporting form as outlined in the section entitled "Submittal of Papers".


Six years of satellite data and observations from vessels and aircraft show that ice dynamics, the occurrence of major ice features, and overall ice zonation on the Beaufort Sea shelf are strongly influenced by ice interaction with shoals. On a broad scale this is seen in the correspondence of a belt of charted shoals with the outer edge of the fast ice zone. Recognition of this relationship led to the concept of stamukhi zone -- a mid-shelf belt of grounded pressure ridges and hummock fields on shoals sheltering the inner shelf. It also led to the recent discovery and survey of a 17-km-long, up to 10-meter-high shoal on the poorly charted shelf off the Prudhoe Bay oil field. This feature, called Stamukhi Shoal, lies next to charted shoals that may not exist now, and it may have formed as a result of ice-related processes. A series of Landsat images representing views of sea ice during several winters and summers show a striking correlation between ice features and the west end of Stamukhi Shoal as surveyed in 1977.

Gravel, a resource in high demand in the petroleum development of the Arctic Shelf, appears to be a major component of the shoals. However, Stamukhi Shoal helps protect the inner shelf and coast from ice pressure and is instrumental in determining the extent of the fast ice, and thereby the extent of areas readily developed for petroleum in the near future. Its mining as a gravel borrow therefore would seem unadvisable.




Please separate and mail to OTC Headquarters

**PLEASE LIMIT ABSTRACT TO THIS PAGE ONLY**

OTC ________ PC78 ________
Session ________
Date Received ________

PAPER TITLE Sub-ice morphology and oil entrapment potential determined from side-scan sonar observations, Prudhoe Bay, Alaska


PRINCIPAL AUTHOR Peter W. Barnes, TELEPHONE (415) 856-7008
COMPANY U.S. Geological Survey TELEX ________
MAILING ADDRESS 345 Middlefield Road MS99
CITY & STATE Menlo Park, California ZIP 94025 COUNTRY USA
CO-AUTHOR Erk Reimnitz,
COMPANY U. S. Geological Survey
MAILING ADDRESS 345 Middlefield Road MS99
CITY & STATE Menlo Park, California ZIP 94025 COUNTRY USA


NOTE: ATTACH SEPARATE SHEET FOR ADDITIONAL AUTHORS Please see additional authors under abstract.

Note to Authors: The OTC Program Committee will evaluate papers solely on the basis of information supplied on this form. Preference will be given to papers providing specific information in each of the four areas of the data reporting form as outlined in the section entitled "Submittal of Papers".


The three-dimensional morphology of the sub-ice surface is thought to be an influence on seabed morphology in shallow water and is a containment factor when a sub-ice petroleum spill pools against the underside of the ice. Investigations have shown that sea bed morphology is not affected by sub-ice morphology. On the other hand, oil concentrations on the sub-ice surface will consistantly occur underneath the elongate snow ridges of the sastrugi pattern.

In early May, 1978, upward directed side-scanning sonar was towed along the undersurface of the undeformed fast ice at three sites in the Prudhoe Bay area. At each of the sites - protected bay, open lagoon, and tidal channel - trenches were cut through the ice parallel and perpendicular to the northeast-southwest snowdrift pattern called sastrugi. Along these trenches snow depth, ice thickness, and ice draft were measured. Snow depth correlated with ice thickness; snow ridges coinciding with thinner ice. The areal patterns reinforced the correlation. The elongate sub-ice ridge and troughs with relief up to 30 cm paralleled the surface sastrugi pattern on a wave length of 10- to 20-m. Diving observations indicated a smaller set of depressions 1 cm or less in depth, oriented parallel to the ice crystal fabric. Under-ice morphology did not correlate with water depth, oceanographic environment, or sediment character.



ADDITIONAL CO-AUTHORS:

Lawrence J. Toimil, Harding and Lawson
San Rafael, CA 94902, Telephone (415) 472-1400

Harry R Hill, U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

Quarterly Report

Contract: RD6-6074
Research Unit: 206
Reporting Period: Fourteenth Quarter
Number of pages: Two

# Faulting and Slope Instability in the St. George Basin Area, Southern Bering Sea

T. L. Vallier and J. V. Gardner
Pacific-Arctic Branch of Marine Geology
U.S. Geological Survey
Menlo Park, California 94025

October 1, 1978

## I. ABSTRACT OF HIGHLIGHTS OF QUARTER'S ACCOMPLISHMENTS

We have completed all textural analyses from Cruise S6-77 and most of the detailed analyses of single-channel seismic reflection records. These data will be incorporated into the final report that is due in May of 1979. We have been working on open-file reports and outside publications to make certain that the data are available to the public.

## II. TASK OBJECTIVES

The objectives of this project are to map the distribution and types of faults and to outline the areas of potentially unstable sediment in the St. George Basin region of the Southern Bering Sea continental margin.

## III. FIELD OR LABORATORY ACTIVITIES

A. Ship or field trip schedule: None

B. Scientific party: None

C. Methods: Analyses of single-channel seismic reflection records are continuing, particularly in the area around the Pribilof Islands. Seismic records are predominantly 80 and 120 KJ sparker, 3.5 kHz, and 12 kHz profiles and some Uniboom and Minisparker profiles.

D. Sample Localities/Ship Tracklines

The last cruise in the area was S6-77 in August and September of 1977 (see Quarterly Report of January 1978 for tracklines and sample locations).

E. Data collected or Analyzed

No shipboard data were collected. New data from shore lab investigations will be incorporated in the final report.

IV. RESULTS

No results are given in this report. A synthesis of the data from this project will be given in our final report.

V. PRELIMINARY INTERPRETATIONS OF RESULTS

Major interpretations have not changed since our 1978 Annual Report.

VI. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES

No major problems were encountered this quarter.

VII. ESTIMATE OF FUNDS EXPENDED

All funds have been expended.

VIII. Bibliography

See 1978 Annual Report.

QUARTERLY REPORT FOR THE PERIOD

1 JULY - 30 SEPTEMBER 1978

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

RESEARCH UNIT: 210

PRINCIPAL INVESTIGATORS: John C. Lahr
Christopher Stephens

PREPARED BY: Christopher Stephens
John Roger
John C. Lahr

## I. ABSTRACT OF HIGHLIGHTS

The major goal for the field season this year was the replacement of 10 or more "NCER 202" seismic electronic field units with the newly developed "NCER A1 VCO."* In addition, a new filter bridge telephone interface was developed, and a new radio panel for the receive site in Yakutat was fabricated.

Preliminary earthquake locations for the period October-December 1977 are also presented.

## II. TASK OBJECTIVES

Objectives:

1) Tabulate the locations and magnitudes of all significant earthquakes earthquakes in the NEGOA region.
2) Prepare focal mechanism solutions to aid in interpreting the tectonic processes active in the region.
3) Identify both offshore and onshore faults that are capable of generating earthquakes.
4) Assess the nature of the strong ground shaking associated with large earthquakes in the NEGOA.
5) Evaluate the observed seismicity in close cooperation with OCSEAP Research Units 16 and 251 towards development of an earthquake prediction capability in the NEGOA.
6) Compile and evaluate frequency vs. magnitude relationships for seismic activity within and adjacent to the study areas.

## III. FIELD AND LABORATORY ACTIVITIES

### A. FIELD ACTIVITIES

#### 1. Background

One of the most severe problems which we have faced over the past years has been the marginal operation of the "202" seismic electronics. Frequency drift was the most obvious problem with several unsuccessful efforts made to stabilize these units. Another serious defect was lack of a calibration cycle and limited dynamic range. Maintenance of the electronics also presented problems, as each channel had to be specially tuned, requiring a different VCO for each frequency. In addition, operation from an expensive stable-voltage battery was necessary, thus complicating the field set up. The A1 VCO is a high performance seismic amplifier and analog telemetry unit designed to improve upon the previously used "202" units. The problems corrected by the A1 unit include:

a) Stable frequency -- crystal reference operation which guarantees frequency drift of less than 1 Hz over the $-20^{o}F$ to $+80^{o}F$ temperature range.

b) Calibration cycle -- the unit calibrates itself and the geophone once each day. Figure 1 contains a calibration cycle recorded in the field with explanations.

* The NCER A1 VCO contains 3 components: a voltage controlled oscillator (VCO), a calibrator and a preamplifier.


Figure 1. Example of a typical calibration cycle for a Al VCO unit. Site: CVA Date: 17 August 1978

c) Gain ranging -- the unit automatically reduces the gain for large seismic events, giving an extra 20db of dynamic range.

d) Tuning -- the frequency for each channel is synthesized using a phase-locked loop, and the sine wave output is constructed using digital techniques. Al units can be tuned to any channel by setting one rotary switch.

e) Power source -- since operation is crystal referenced, battery voltage does not significantly affect center-frequency, so operation from the high capacity, but unregulated air cell batteries is possible.

This description covers only the main highlights of the Al VCO. A comprehensive Open-File Report on the unit is being prepared which will contain more detailed information and specifications.

## 2. INSTRUMENT DEVELOPMENT

### Al VCO

A student was hired to help with parts procurement to insure delivery on our tight schedule. Concurrently, the design and loading of the printed circuit (PC) boards was awarded to outside vendors. Another student was hired to perform thorough and time consuming environmental tests. Special testing equipment was designed and used to allow operation and monitoring of each unit while subjected to temperatures of from $-50^{o}$ to $+100^{o}C$. A portable calibration decoder was designed and built to verify calibration codes and aid in the field operations. Each unit was packaged in a rugged water proof enclosure with a special external connector to simplify field installation.

A special summing amplifier for multiplexing the various radio and Al VCO signals was designed and built.

### FILTER BRIDGE

The new filter bridge was designed to ease monitoring of seismic signals, to provide better filtering and to interface more compatibly with phone company equipment, both electronically and visually. Four of these units were built for shipment to Alaska.

### YAKUTAT RADIO PANEL

A radio panel with preamplifiers for each receiver was constructed The panel should also ease maintenance.

## 3. FIELD OPERATIONS

All seismic stations were visited and put into working order. At 18 of the 30 stations supported in part by OCSEAP new Al units were installed. To date we are not aware of any failures in the Al electronics and all units have been performing well.

Other activities at stations include:

CVA -- Installed new cable to satellite station, rewired receiver pit

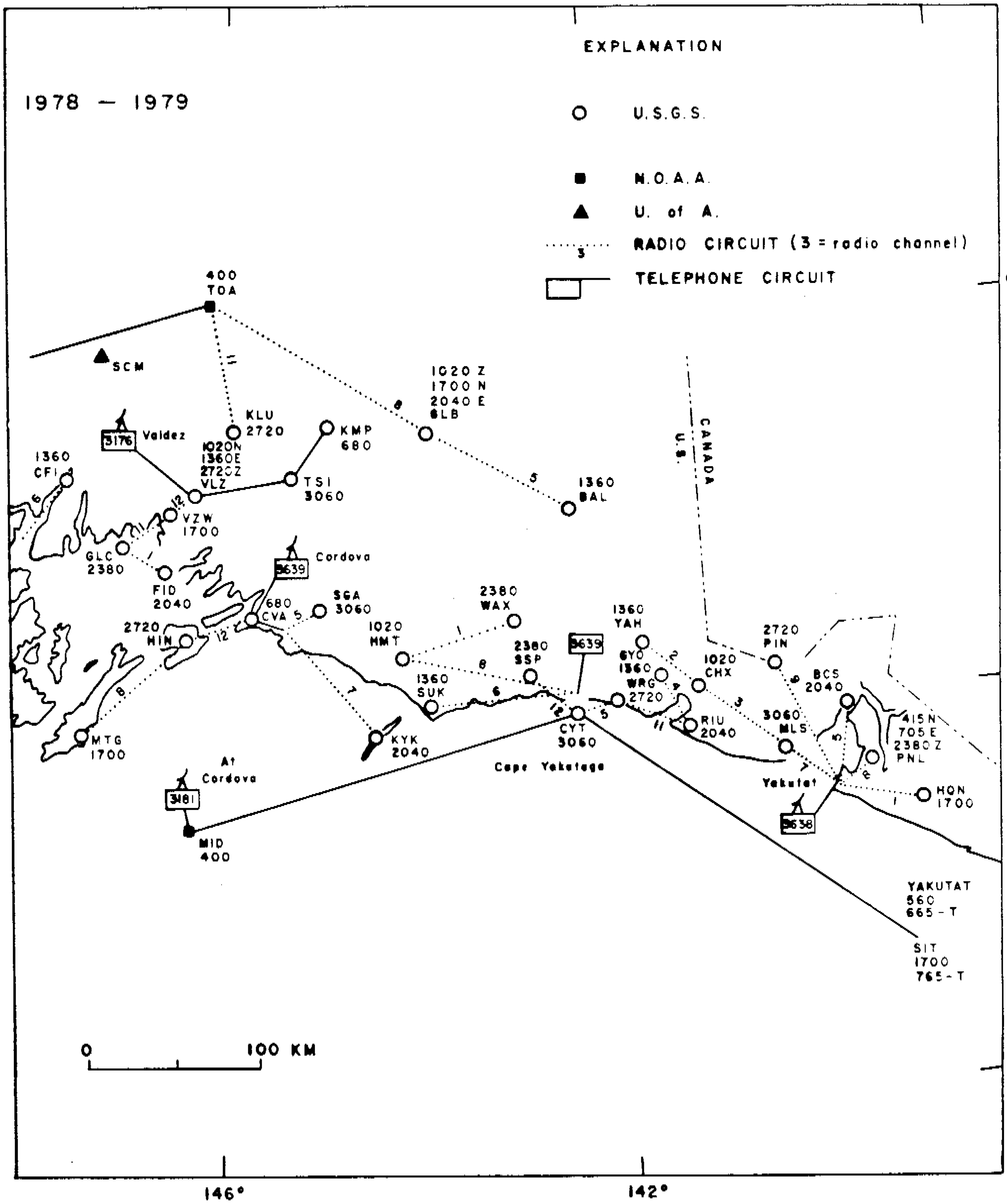



Figure 2. Map of USGS and other seismic stations in southeastern Alaska. The USGS stations east of 148°W are maintained with support from OCSEAP.

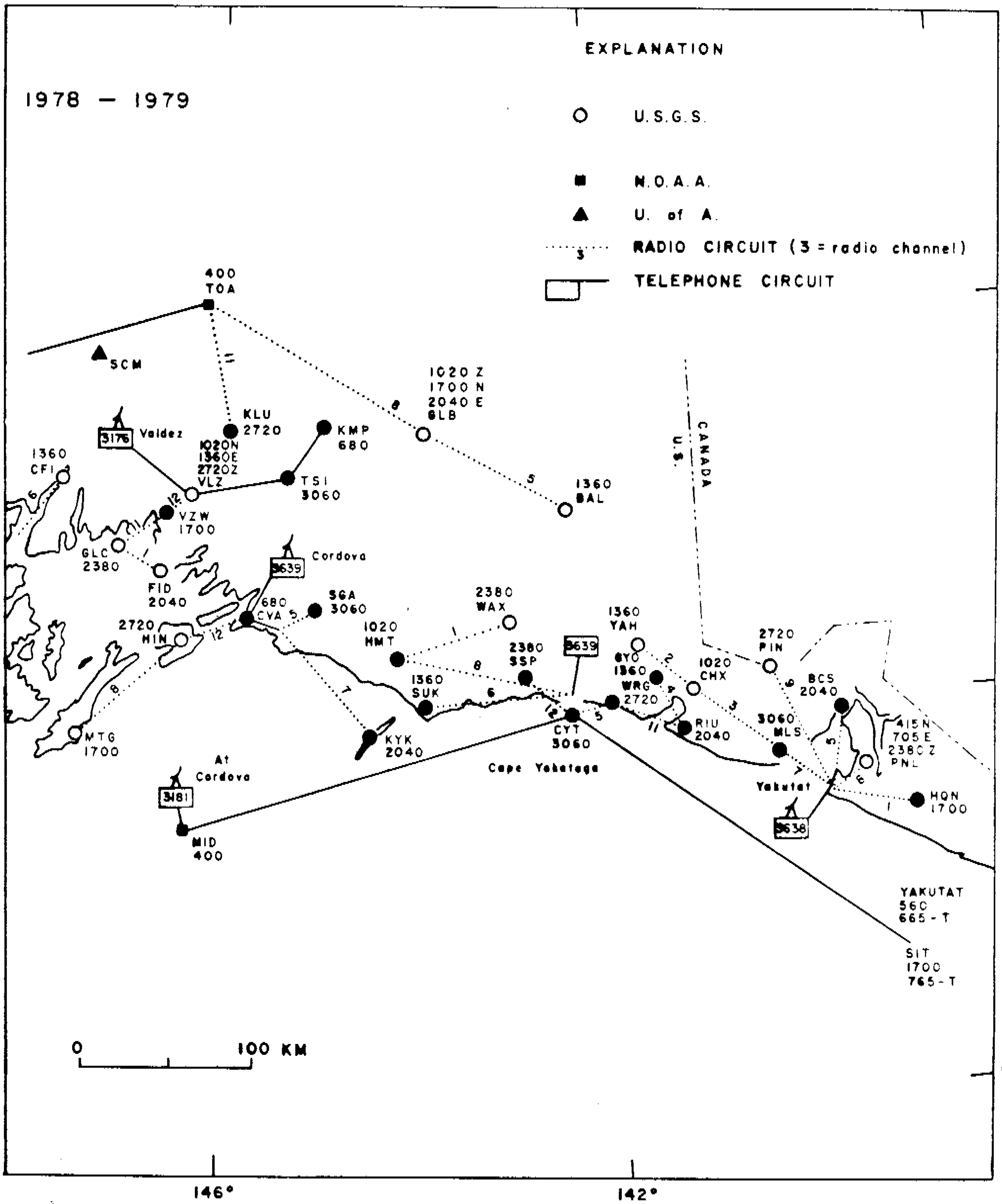



Figure 3. Map (modified from Figure 2) showing the USGS seismic stations at which A1 VCO units and modified boxes are installed (solid circles).

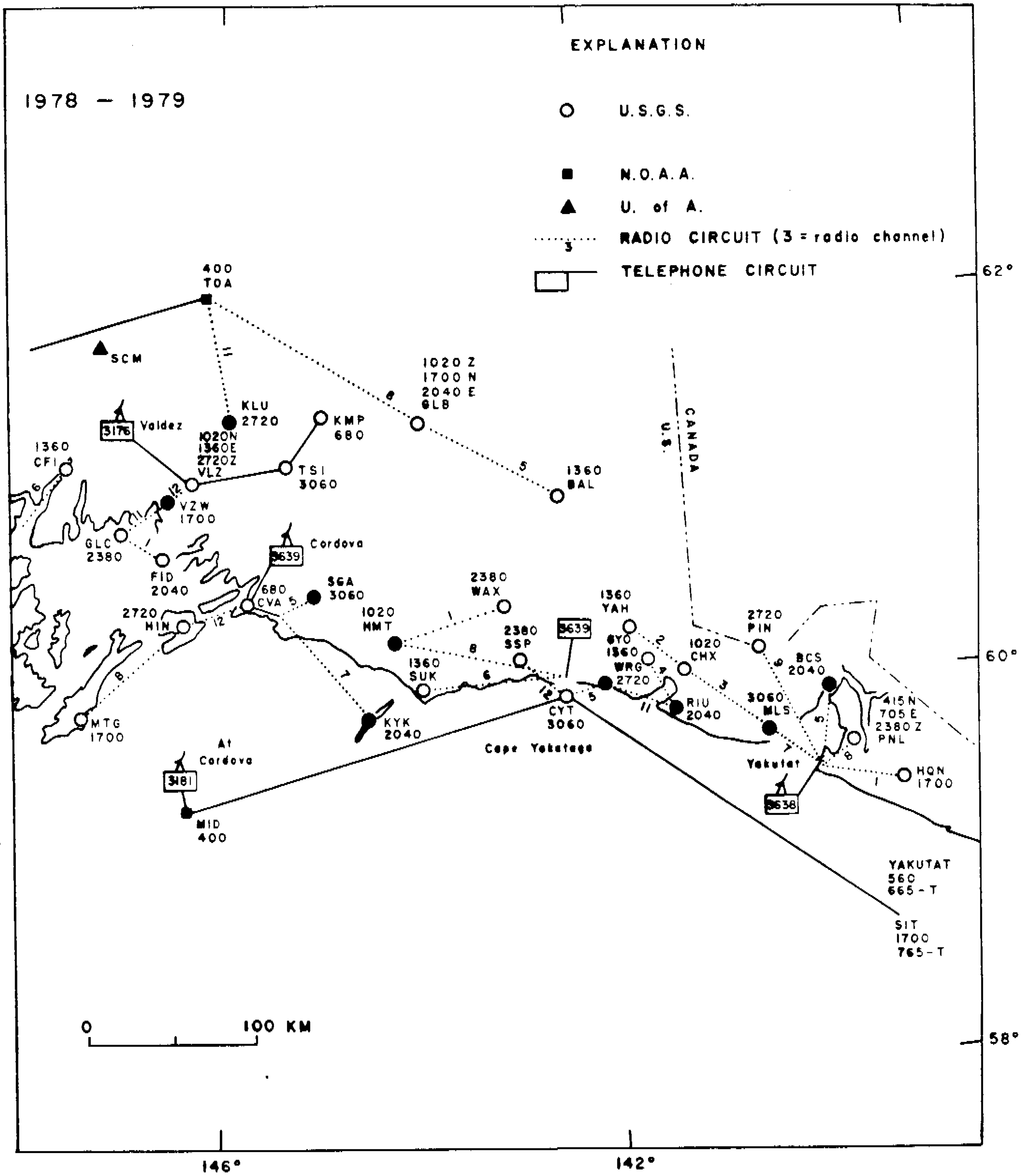



Figure 4. Map (modified from Figure 3) showing the USGS seismic stations at which air cells are installed (solid circles).

and buried cable into station.

YKG -- Moved to hilltop from old site near ocean. This was done to reduce background seismic noise.

Yakutat -- Converted over to phone line from receive point to satellite station. This should improve data quality over the old radio link.

B. SCIENTIFIC AND FIELD PARTY

1.) Laboratory

John Lahr, USGS, Geophysicist, Project Chief
Christopher Stephens, USGS, Geophysicist
Kent Fogleman, USGS, Geophysicist
Mary Ann Allan, USGS, Physical Science Aid
Suzanne Helton, USGS, Physical Science Aid
Richard Archdeacon, USGS, Physical Science Aid
Mark Smetana, USGS, Physical Science Aid
Tom Cleese, USGS, Physical Science Aid
Tom Walker, USGS, Physical Science Aid

2.) Field

John Roger, USGS, Electronics Engineer, July 6 - September 24
John Lahr, Geophysicist, July 26 - August 11
Marion Salsman, USGS, Physical Science Technician, stationed in Alaska.

C. LABORATORY ANALYSIS

The routine processing of data has been facilitated by implementation of a new earthquake data processing program which was developed by the U.S. Geological Survey for use on the Honeywell Multics Computer. The program is used to organize and make corrections to seismic data.

On a trial basis, the routine data processing has been reorganized in a manner that will allow final determinations of earthquake parameters within two weeks of the date that film data is received in Menlo Park. Thus, the data from each quarter can be made available to OCSEAP within a month after the quarter has ended. Under the new procedure, the data for October-December, 1978 should be available to OCSEAP by January, 1979.

D. SAMPLE LOCALITIES

A map of seismic stations operated by the U.S. Geological Survey in the eastern Gulf of Alaska from October through December 1977 is shown in Figure 5. A list of the station locations is given in Table 1.

E. DATA COLLECTED OR ANALYZED

A map and tabulations of preliminary earthquake locations along the eastern Gulf of Alaska for October through December 1977 are presented in the Appendix.

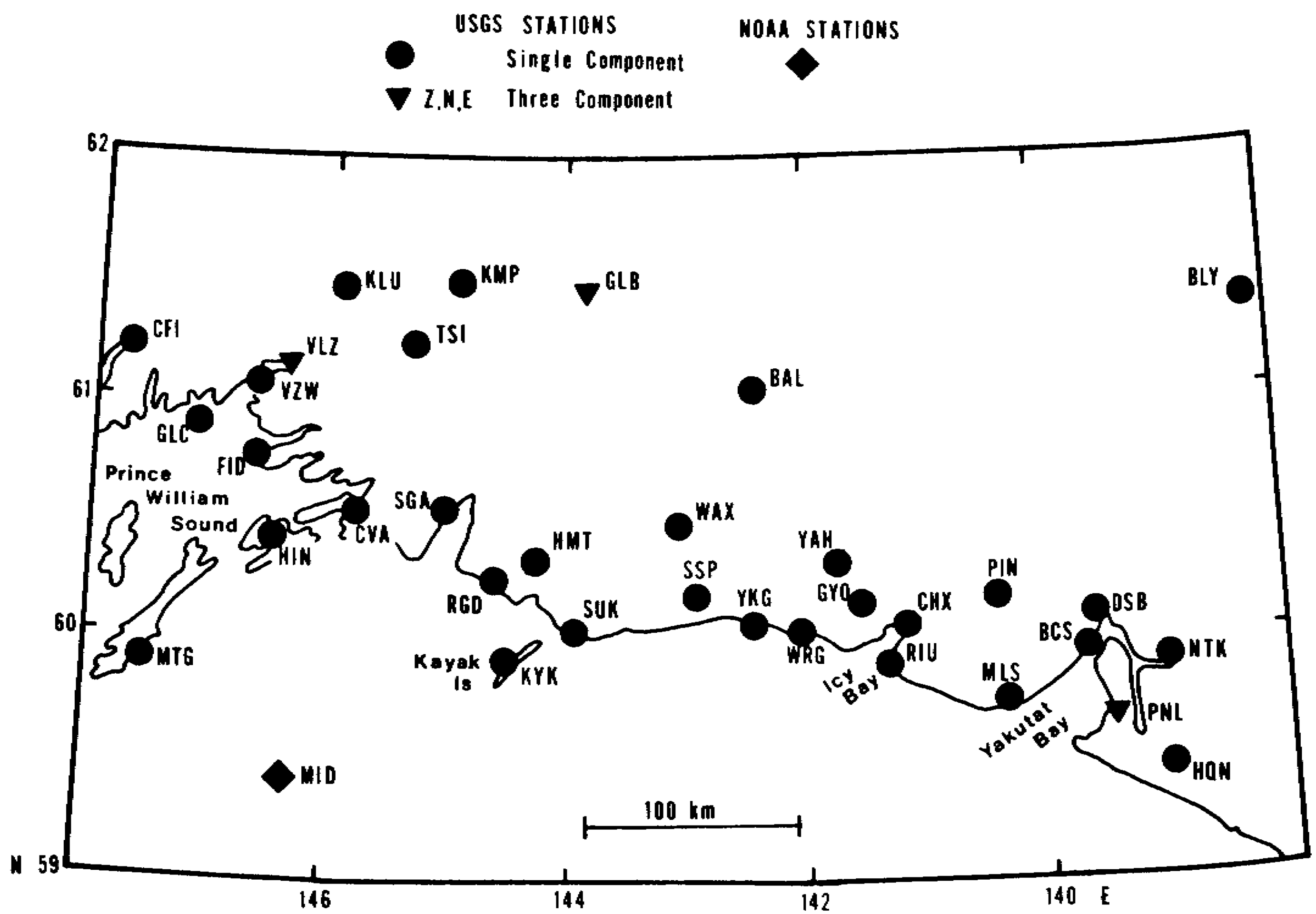



Figure 5. Seismic stations operating in southeastern Alaska during October-December 1977.

## TABLE 1

USGS SEISMIC STATIONS SUPPORTED IN PART BY OCSEAP AND OPERATED DURING OCTOBER - DECEMBER 1977

| STA CODE | STATION NAME | LAT N DEG MIN | LONG W DEG MIN | ELEV M | TDLY SEC | MAG @ 1HZ |
|---|---|---|---|---|---|---|
| BAL | Baldy | 61 2.17 | 142 20.67 | 1300 | 0.00 | 117000 |
| BCS | Bancas Point | 59 56.90 | 139 37.00 | 10 | 0.30 | 29700 |
| CFI | College Fiord | 61 10.96 | 147 45.99 | 2 | 0.00 | 117000 |
| CHX | Chaix Hills | 60 4.00 | 141 7.10 | 793 | 0.30 | 59400 |
| CVA | Cordova | 60 32.79 | 145 44.96 | 90 | 0.30 | 59400 |
| FID | Fidalgo | 60 43.73 | 146 35.79 | 488 | 0.30 | 234000 |
| GLB | Gilahina Butte | 61 26.51 | 143 48.63 | 845 | 0.00 | 234000 |
| GLC | Glacier Is. | 60 53.44 | 147 4.35 | 3 | 0.30 | 117000 |
| GYO | Guyot Hills | 60 8.70 | 141 28.29 | 183 | 0.30 | 117000 |
| HIN | Hinchinbrook | 60 23.81 | 146 30.10 | 611 | 0.30 | 234000 |
| HMT | Mt. Hamilton | 60 20.19 | 144 15.64 | 620 | 0.30 | 117000 |
| HQN | Harlequin Lake | 59 27.10 | 138 52.62 | 372 | 0.30 | 117000 |
| KLU | Klutina | 61 29.57 | 145 55.21 | 1012 | 0.00 | 234000 |
| KMP | Kimball Pass | 61 30.78 | 145 1.09 | 1143 | 0.30 | 117000 |
| KYK | Kayak Is. | 59 52.10 | 144 31.39 | 375 | 0.30 | 59400 |
| MLS | Malaspina | 59 45.80 | 140 9.00 | 2 | 0.30 | 14700 |
| MTG | Montague Is. | 59 54.71 | 147 29.82 | 31 | 0.30 | 59400 |
| PIN | Pinnacle | 60 5.80 | 140 15.40 | 975 | 0.30 | 59400 |
| PNL | Peninsula | 59 40.12 | 139 23.82 | 579 | 0.30 | 59400 |
| RIU | Riou | 59 52.70 | 141 13.70 | 15 | 0.30 | 7400 |
| SGA | Sherman Glacier | 60 30.07 | 145 12.42 | 424 | 0.30 | 59400 |
| SSP | Sunshine Point | 60 10.80 | 142 50.30 | 732 | 0.30 | 117000 |
| SUK | Suckling Hills | 60 4.60 | 143 47.00 | 427 | 0.30 | 117000 |
| TSI | Tsina | 61 13.57 | 145 20.24 | 1113 | 0.30 | 117000 |
| VLZ | Valdez | 61 7.89 | 146 19.92 | 10 | 0.30 | 7400 |
| VZW | Valdez West | 61 3.54 | 146 33.24 | 796 | 0.30 | 234000 |
| WAX | Waxell Ridge | 60 27.00 | 142 51.10 | 975 | 0.30 | 0 |
| WRG | White River Glcr | 60 2.27 | 142 1.90 | 550 | 0.30 | 29700 |
| YAH | Yahtse | 60 21.80 | 141 44.70 | 2135 | 0.30 | 59400 |
| YKG | Yakataga | 60 4.20 | 142 25.33 | 60 | 0.30 | 7400 |

This table lists geographical coordinates and other pertinent information for USGS seismic stations in southeastern Alaska. TDLY is the telephone delay in seconds. The magnification (MAG) of the vertical component seismometer is given at 1 Hz.

## IV. and V. RESULTS AND PRELIMINARY INTERPRETATION

### Seismicity south of Yakutat Bay

Interests for lease sales in the NEGOA have recently focused on areas south and southeast of Yakutat Bay. As a preliminary step to assessing the seismic hazard associated with this area, a brief review of a recent sequence of earthquake activity is presented below.

The USGS seismic network in southeastern Alaska was installed in the summer of 1974. Earlier that year, three earthquakes with local magnitudes that ranged from 4.1-4.4 occurred about 60 km south of Yakutat Bay. From September 1974 to September 1976, the USGS network was used to locate 21 more earthquakes in the same area (Figure 6). The magnitudes of the earthquakes ranged from about 0.6 to 3. Results from marine geophysical exploration of this area (Molnia, et al., 1978) show that this sequence of earthquakes occurred within 20 km of an apparently northeast trending zone that is characterized by a series of 3-5 meter scarps (Figure 7). A magnitude 7 earthquake occurred in 1908 near the southwest end of this zone and within 60 km of the recent sequence of activity.

The earthquakes shown in Figure 6 were relocated using a master event technique. The scatter in the distribution of the epicenters is considerably smaller than that from the original locations. The apparent north-south trend in the relocated epicenters is attributed to location errors, and it is possible that all of the earthquakes occurred on a single fault. The depth of the earthquakes cannot be well determined because they are located over 60 km from the nearest station.

Although the number of earthquakes located in this area has decreased since 1974, it is possible that small earthquakes are continuing to occur here. A network of ocean bottom seismometers (OBS), such as the one suggested in Figure 7, is necessary to detect and accurately locate these earthquakes.

## VI. PROBLEMS ENCOUNTERED AND RECOMMENDATIONS

Maintaining the continuity of station operation remains as one of the major problems of data collection. A discussion of some of the factors affecting station operation and data transmission is presented below:

### RADIOS

A problem as severe as that experienced with the old "202" electronics has been radio reception. In many cases, especially during the winter, poor reception seriously degrades the seismic information. The modified Motorola HT-200 radio we currently use appears to be a poor choice for Alaskan conditions in general and our network in particular. We are investigating other options, including increasing the transmitted power. Three evaluation radios have already been ordered (with increased output power) and should be installed in the Yakutat area by November 1978. We hope to be closer to a solution to this serious problem by next summer.

In the meantime, an effort has been made to optimize reception given the present radios. Each transmitter was tuned for maximum power and

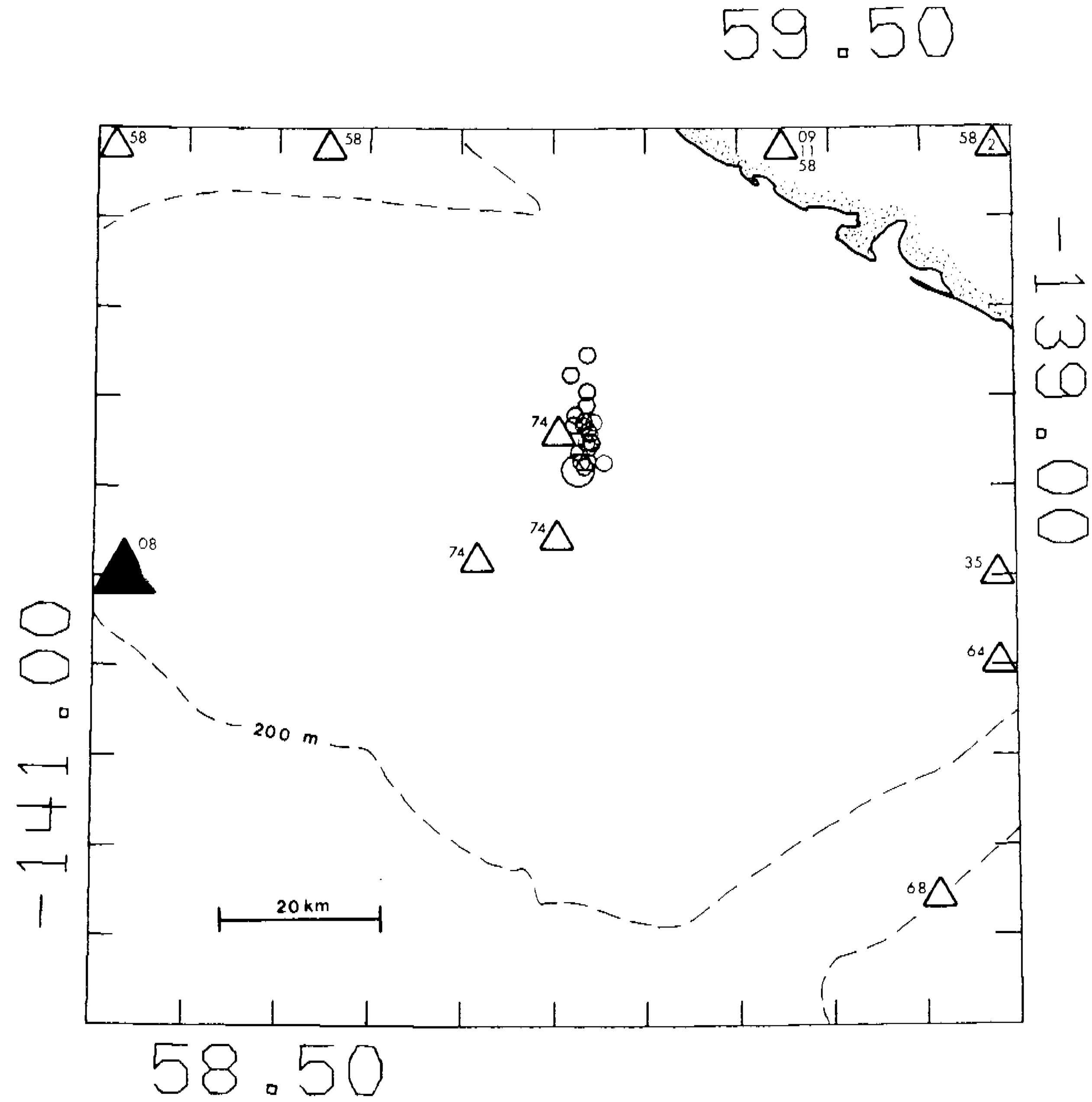



Figure 6. Map showing earthquake epicenters from PDE (triangles) and USGS (circles) in the region immediately south of Yakutat Bay. The numbers next to the PDE epicenters correspond to the year in which the earthquake occurred. The large solid triangle shows the epicenter of a magnitude 7 earthquake which occurred in 1908. The USGS seismic network in southeastern Alaska was installed after the three PDE-located earthquakes occured in 1974. The 21 USGS-located earthquakes shown here were relocated using a master-event technique. The apparent north-south trend in the epicenters may be due to location error.

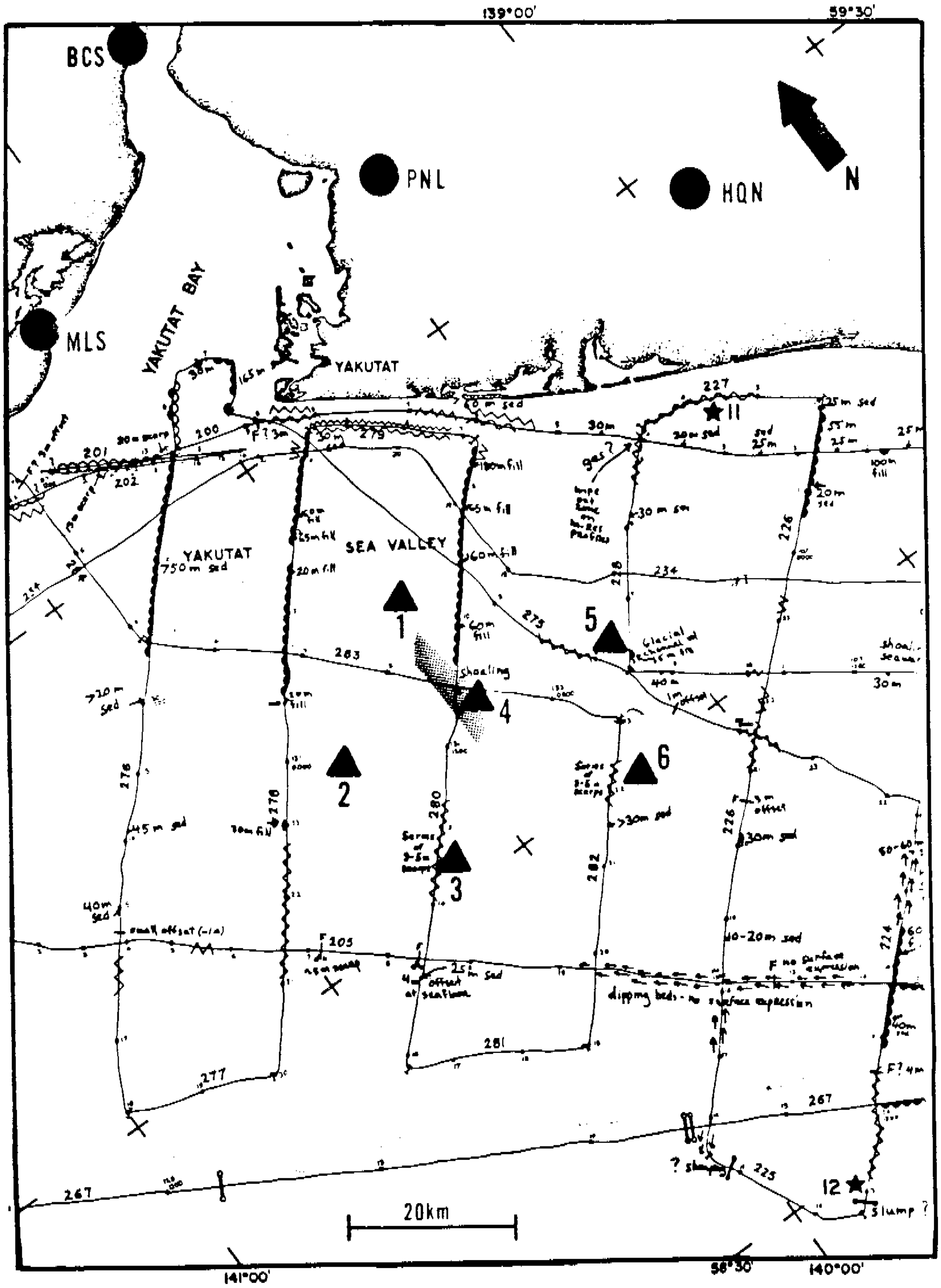



Figure 7. Map showing the proposed locations for deployment of USGS/NOAA ocean bottom seismometers (triangles) south of Yakutat Bay. Current land-based seismic stations operated by the USGS are shown as circles. Stippled area near station 4 encloses the epicenters of 21 relocated earthquakes shown in Figure A5. (Base map after Molnia, et al,1978.)

preamplifiers were installed in Yakutat to increase the incoming signal strength. These preamplifiers, along with their receivers, were mounted to a panel designed in Menlo Park and installed in Yakutat in August.

## ANTENNA SYSTEM

In the past, Yagi antennas mounted on 1-1/2" electrical conduit have been employed. During the winter, many of the installations were destroyed due to icing and wind. In an effort to solve this problem, 2" water pipe masts were installed with log-periodic antennas. The log-periodic antennas have proven to be more durable than the Yagis, but the masts seem to be too long for our guying system. To improve on this set up, shorter masts of 2" water pipe have been installed at VZW and PIN. In addition, an effort was made to bury the base of the mast at least 18" below the surface of the ground. This should provide greater stability.

Another experiment along a different line, but aimed at the same problem, has been tried. At HIN a plywood shelter for the transmit antenna was installed. Although the shelter itself withstood the winter, several problems with this approach have become evident.

a) The plywood weathered and splintered and nails rusted and worked out. This resulted in a weakened shelter.

b) The radio at HIN got flooded, since the shelter did not adequately protect the radio from moisture.

c) The UHF cable at a station west of this network which had a similar structure installed was chewed up and almost destroyed by an animal.

The basic idea here is to protect the antennas from detuning due to snow and also to provide a degree of protection. This approach is still being evaluated.

To increase the chance of success for the experiment the shelter at HIN was moved 1/5 kilometer to the edge of a steep hill overlooking Cordova.

## BEARS

Animals, especially bears, seriously damage several of our sites each year. Below is a list of recent damage due to animals:

SGS -- Pulled sensor out of ground three times.
SUK -- ransacked site.
SSP -- pulled sensor out of ground twice and destroyed radio cable twice.
WRG -- destroyed radio cable twice.
RIU -- ransacked site.
MLS -- broke radio cable.
BCS -- ransacked site.
PNL -- pulled sensors out of ground twice.
HQN -- pulled sensor out of ground once.
GLB -- possible damage to cables due to bear.

It appears that although bears are good diggers, destruction can be prevented if culverts are deeply buried. The ransacked sites were reinstalled more securely and have not been damaged in the same way since.

Damage to radios and their cables occurred when the radio was strapped to a tree limb. At SSP, WRG, MLS and RIU steel boxes were strapped to a tree with the radio inside. At the WRG and RIU the cables are protected with steel-flex conduit. There was one bear attack on the radio at SSP with only slight damage, but not affecting data transmission. AT MLS, which had no steel flex protection, the UHF cable was broken. It appears the steel box is a good solution to this type of bear problem but the steel flex cable must also be used. An advantage of this type of installation, in addition to security from bears, is ease of maintenance as compared to having the radios in a sealed waterproof plastic tube strapped to a tree.

Finally, when a bear digs up the sensor, the station becomes insensitive seismically. This is a recurring problem at certain sites. Although bears are curious, they appear to lack motivation when food is not a possibility. The placing of a difficult obstacle above the sensor may stop this kind of activity, and this approach will be taken at problem sites next summer.

## STANDARDIZATION OF FIELD INSTALLATION

This summer almost all stations were rewired in the same manner. This standardization should reduce maintenance time at these stations in the future.

## FILTER BRIDGES

Filter bridges are used to frequency multiplex our signals before connection to a phone line. A newly designed bridge with a meter and speaker for monitoring purposes and a better filter was installed at Yakutat. In addition, there are warning lights to indicate improper carrier level.

## VIII. REFERENCES

Eaton, J. P., M. E. O'Neill, and J. N. Murdock (1970). Aftershocks of the 1966 Parkfield-Cholame, California, earthquake: a detailed study, Bull. Seism. Soc. Am. 60, 1151-1197.

Lee, W. H. K., and J. C. Lahr (1972). HYPO71: a computer program for determining hypocenter, magnitude, and first motion pattern of local earthquakes, U.S. Geological Survey, Open-File Report, 100 p.

Lee, W. H. K., R. E. Bennett, and K. L. Meagher (1972). A method of estimating magnitude of local earthquakes from signal duration, U. S. Geological Survey, Open-File Report, 28 p.

Molnia, B. F., P. R. Carlson, and L. H. Wright, 1978, Geophysical data from the 1975 cruise of the NOAA ship SURVEYOR in northern Gulf of Alaska, Interpretation of data Cross Sound to Yakutat Bay, U.S. Geological Survey Open-File Map 78-209.

PAPERS IN PRESS

Fogleman, K., C. Stephens, J. C. Lahr, S. Helton, and M. Allan (1978). Catalog of earthquakes in southern Alaska, October-December 1977, U. S. Geological Survey, Open-File Report.

# APPENDIX

Preliminary earthquake locations along the Eastern Gulf of Alaska for the period October through December 1977

This appendix lists origin times, focal coordinates, magnitudes, and related parameters for earthquakes which occurred in the eastern Gulf of Alaska region. The following data are given for each event:

(1) Origin time in Universal Time (UT): date, hour (HR), minute (MN), and second (SEC). To convert to Alaska Standard Time (AST) subtract ten hours.

(2) Epicenter in degrees and minutes of north latitude (LAT N) and west longitude (LONG W).

(3) DEPTH, depth of focus in kilometers.

(4) MAG, magnitude of the earthquake.

(5) NP, number of P arrivals used in locating earthquake.

(6) NS, number of S arrivals used in locating earthquake.

(7) GAP, largest azimuthal separation in degrees between stations.

(8) D3, epicentral distance in kilometers to the third closest station to the epicenter.

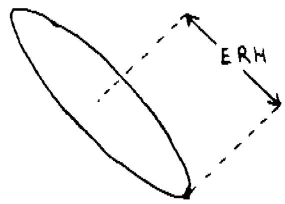
(9) RMS, root-mean-square error in seconds of the traveltime residuals:

$$RMS = \sqrt{\sum_i (R^2_{Pi} + R^2_{Si}) \,/\, (NP + NS)}$$

where $R_{Pi}$ and $R_{Si}$ are the observed minus the computed arrival times of P and S waves respectively at the i-th station.

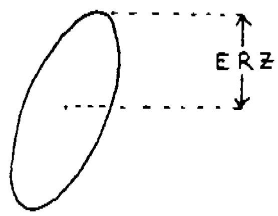
(10) ERH, largest horizontal deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the epicentral precision for an event. An upper limit of 99 km is placed on ERH.

Projection of ellipsoid
onto horizontal plane:




(11) ERZ largest vertical deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the depth precision for an event. An upper limit of 99 km is placed on ERZ.

Projection of ellipsoid
onto vertical plane:




(12) Q, quality of the hypocenter. This index is a measure of the precision of the hypocenter and is calculated from ERH and ERZ as follows:

| Q | ERH | ERZ |
|---|---|---|
| A | $\leq$ 2.5 | $\leq$ 2.5 |
| B | $\leq$ 5.0 | $\leq$ 5.0 |
| C | $\leq$ 10.0 | $\leq$ 10.0 |
| D | $\geq$ 10.0 | $\geq$ 10.0 |

This quality symbol is used to denote each earthquake on epicenter maps.

All earthquakes were located using the following horizontally layered velocity model:

| Layer | Depth to Top (km) | P velocity (km/sec) |
|---|---|---|
| 1 | 0 | 2.75 |
| 2 | 0.01 | 6.0 |
| 3 | 20 | 7.0 |
| 4 | 32 | 8.2 |

This model was developed by minimizing the travel-time residuals for a group of earthquakes near Valdez. It is considered a reasonable model but not necessarily the optimum model for this region. Further modifications and refinements to the model will undoubtedly take place in the future as more data are gathered.

Whenever possible S-phase arrivals are used in addition to P-phase arrivals. The S-phase velocity is assumed to equal (P-velocity)/1.78 in each layer of the velocity model.

Magnitudes are determined from the signal duration or the maximum trace amplitude. Eaton and others (1970) approximate the Richter local magnitude, whose definition is tied to maximum trace amplitudes recorded on standard horizontal Wood-Anderson torsion seismographs, by an amplitude magnitude based on maximum trace amplitudes recorded on high-gain, high-frequency vertical seismographs such as those operated in the Alaskan network. The amplitude magnitude XMAG used in this catalog is based on the work of Eaton and his co-workers and is given by the expression (Lee and Lahr, 1972)

$$\mathrm{XMAG} = \log_{10} A - B_1 + B_2 \log_{10} D^2 \qquad (1)$$

where A is the equivalent maximum trace amplitude in millimeters on a standard Wood-Anderson seismograph, D is the hypocentral distance in kilometers, and $B_1$ and $B_2$ are constants. Differences in the frequency response of the two seismograph systems are accounted for in calculating A; however, it is assumed that there is no systematic difference between the maximum horizontal ground motion and the maximum vertical motion. The terms $-B_1 + B_2 \log_{10} D^2$ approximate Richter's $-\log_{10} A_0$ function (Richter, 1958, p. 342), which expresses the trace amplitude for a zero-magnitude as a function of epicentral distance ($\Delta$). For small local earthquakes in central California, $B_1 = 0.15$ and $B_2 = 0.80$ for $\Delta = 1$ to 200 km and $B_1 = 3.38$ and $B_2 = 1.50$ for $\Delta =$ 200 to 600 km.

For small, shallow earthquakes in central California, Lee and others (1972) express the duration magnitude FMAG at a given station by the relation

$$\mathrm{FMAG} = -\,0.87 + 2.00 \log_{10} \tau + 0.0035\,\Delta \qquad (2)$$

where $\tau$ is the signal duration in seconds from the P-wave onset to the point where the peak-to-peak trace amplitude on the Geotech Model 6585 film viewer falls below 1 cm, and $\Delta$ is the epicentral distance in kilometers.

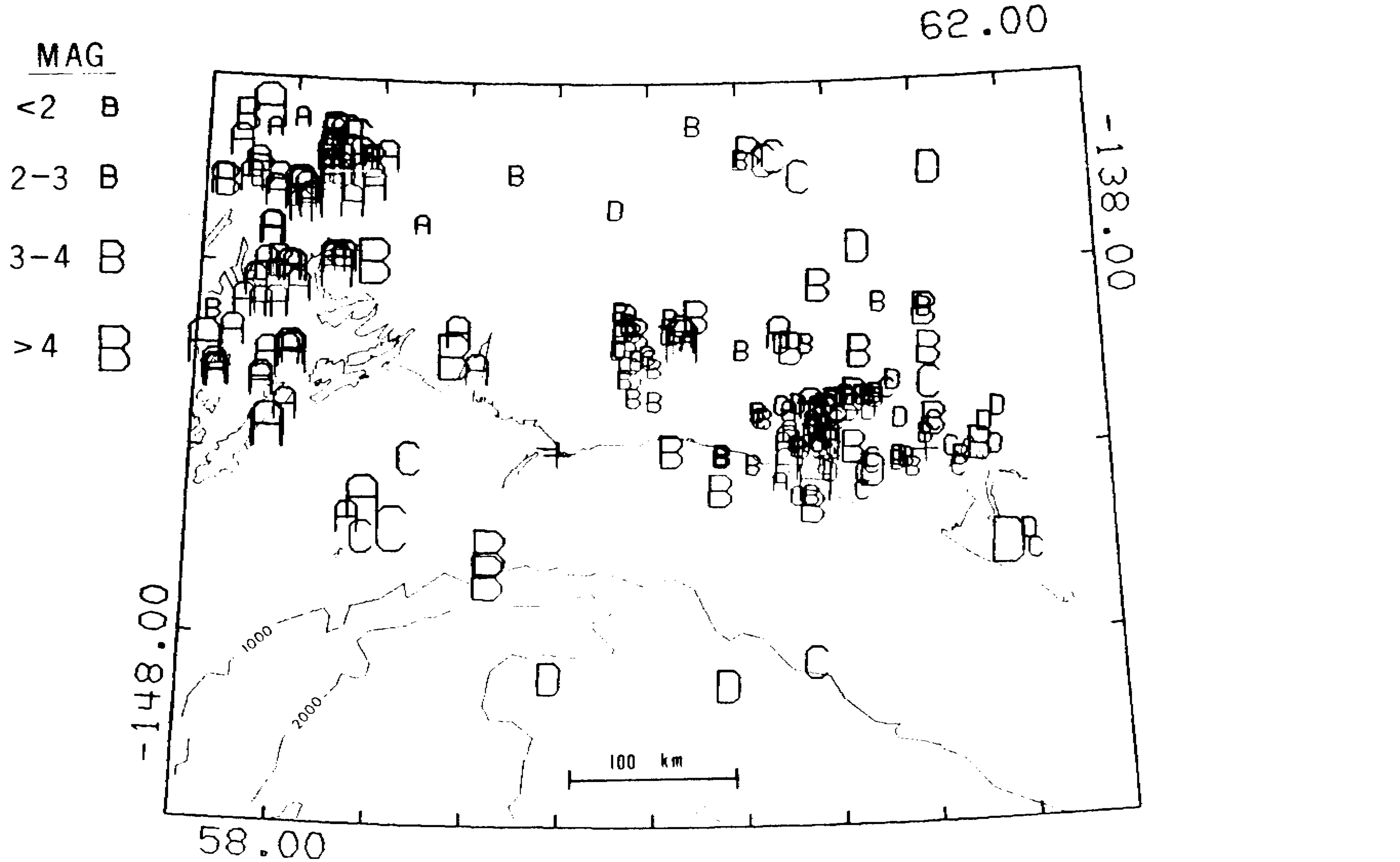
Comparison of XMAG and FMAG estimates from equations (1) and (2) for 77 Alaskan shocks in the depth range 0 to 150 km and in the magnitude range 1.5 to 3.5 reveals a systematic linear decrease of FMAG relative to XMAG with increasing focal depth. We use the following equation, including a linear dependence on depth term:

$$FMAG = - 1.15 + 2.0 \log_{10}\tau + 0.007z + 0.0035 \Delta , \quad (3)$$

where z is the focal depth in kilometers. Incorporating the depth term in the calculation of FMAG was found to be necessary for Alaskan data.

The magnitude preferentially assigned to each earthquake in this catalog is the mean of the FMAG (equation 3) estimates obtained for USGS stations. The XMAG estimate is given when no FMAG determinations could be made. For shocks larger than about magnitude 3.0, XMAG cannot be determined because the maximum trace amplitudes are off-scale or the traces are too faint to read. For many shocks smaller than about magnitude 2.0, the trace amplitude drops below 1 cm peak-to-peak between the P and S arrivals and FMAG is not determined.

Many of the earthquakes recorded by the stations occur outside of the network, so it is difficult to establish good depth control for these events. The procedure for locating all earthquakes is to first fix the depth and determine the optimal epicentral location, and then allow the depth to vary. Frequently for earthquakes which occur outside of the network little or no improvement to the solution is found when the depth is allowed to vary. The result is that the distribution of the depths of the final hypocentral solutions may be biased toward the initial trial depth and may not reflect the true depth of the earthquakes. The trial depth used for the earthquakes occurring in the fourth quarter of 1977 was 15 km.




EASTERN GULF OF ALASKA SEISMICITY OCTOBER-DECEMBER 1977

Figure 8. Map of earthquake epicenters determined by the USGS seismic network in southeastern Alaska for the fourth quarter of 1977. The symbol corresponds to the quality of the hypocenter solution (for description see text) and the size is proportional to magnitude.

EASTERN GULF OF ALASKA EARTHQUAKES

| 1977 | ORIGIN TIME HR | MN | SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NP | NS | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OCT 2 | 0 | 39 | 22.8 | 60 | 36.8 | 142 | 32.8 | 8.9 | 1.9 | 5 | 5 | 109 | 52 | 0.83 | 1.2 | 2.7 | B |
| 2 | 3 | 14 | 21.0 | 60 | 35.2 | 142 | 34.6 | 22.0 | 1.7 | 4 | 5 | 106 | 52 | 0.38 | 1.5 | 2.5 | B |
| 2 | 21 | 26 | 21.9 | 61 | 20.8 | 146 | 49.5 | 23.1 | 2.0 | 11 | 6 | 90 | 52 | 0.35 | 1.0 | 2.2 | A |
| 3 | 7 | 32 | 12.6 | 60 | 20.1 | 140 | 23.9 | 15.3 | 1.5 | 5 | 5 | 227 | 75 | 0.24 | 6.3 | 2.8 | C |
| 3 | 14 | 43 | 50.3 | 60 | 8.0 | 139 | 21.2 | 5.3 | 1.6 | 4 | 4 | 255 | 61 | 0.33 | 4.6 | 41.2 | D |
| 3 | 22 | 35 | 4.6 | 60 | 32.7 | 139 | 55.3 | 12.2 | 2.1 | 3 | 3 | 231 | 143 | 0.41 | 4.3 | 2.7 | B |
| 5 | 18 | 22 | 53.6 | 61 | 43.6 | 146 | 33.8 | 10.9 | 2.3 | 19 | 13 | 110 | 67 | 0.49 | 1.0 | 2.8 | B |
| 6 | 5 | 19 | 18.3 | 60 | 10.4 | 140 | 58.0 | 35.8 | 1.9 | 3 | 3 | 194 | 122 | 0.22 | 7.5 | 8.2 | C |
| 6 | 13 | 12 | 10.6 | 60 | 28.0 | 142 | 56.6 | 0.5 | 1.7 | 7 | 7 | 173 | 118 | 0.50 | 2.7 | 2.6 | B |
| 8 | 20 | 16 | 57.8 | 60 | 44.5 | 142 | 28.7 | 25.9 | 2.2 | 8 | 7 | 140 | 142 | 0.45 | 4.4 | 3.6 | B |
| 10 | 5 | 41 | 52.9 | 60 | 40.0 | 142 | 38.9 | 5.3 | 2.5 | 9 | 4 | 94 | 68 | 0.68 | 1.6 | 2.2 | A |
| 13 | 6 | 37 | 17.8 | 61 | 38.8 | 147 | 39.1 | 17.1 | 2.5 | 20 | 7 | 120 | 52 | 0.40 | 1.1 | 1.3 | A |
| 14 | 20 | 21 | 22.5 | 60 | 33.2 | 147 | 54.9 | 14.4 | 3.2 | 28 | 4 | 137 | 70 | 0.46 | 1.2 | 1.2 | A |
| 17 | 23 | 24 | 20.8 | 61 | 31.2 | 146 | 20.9 | 26.7 | 2.3 | 17 | 6 | 86 | 51 | 0.32 | 1.6 | 2.4 | A |
| 22 | 15 | 12 | 39.0 | 61 | 42.3 | 146 | 35.5 | 7.7 | 2.4 | 23 | 14 | 109 | 65 | 0.64 | 0.9 | 1.2 | A |
| 23 | 2 | 37 | 41.0 | 61 | 19.5 | 146 | 48.4 | 20.7 | 2.0 | 23 | 10 | 77 | 51 | 0.36 | 0.9 | 2.0 | A |
| 24 | 11 | 13 | 56.3 | 61 | 35.4 | 145 | 57.9 | 19.3 | 2.5 | 28 | 11 | 109 | 53 | 0.65 | 0.9 | 1.1 | A |
| 24 | 14 | 43 | 7.9 | 61 | 23.2 | 147 | 12.6 | 17.8 | 2.4 | 27 | 11 | 86 | 67 | 0.42 | 1.1 | 1.2 | A |
| 25 | 11 | 2 | 51.8 | 60 | 52.6 | 146 | 54.2 | 20.6 | 2.3 | 26 | 13 | 104 | 28 | 0.50 | 1.0 | 1.4 | A |
| 25 | 23 | 42 | 44.6 | 61 | 26.2 | 146 | 34.3 | 19.8 | 2.0 | 21 | 11 | 82 | 42 | 0.44 | 1.2 | 1.2 | A |
| 27 | 4 | 10 | 16.9 | 60 | 27.2 | 144 | 54.0 | 18.0 | 2.5 | 21 | 11 | 156 | 100 | 0.23 | 2.1 | 2.0 | A |
| 27 | 21 | 1 | 35.4 | 60 | 32.1 | 143 | 0.9 | 2.1 | 1.7 | 9 | 7 | 120 | 67 | 0.31 | 3.3 | 4.5 | B |
| 27 | 12 | 34 | 59.1 | 60 | 46.7 | 147 | 19.1 | 14.3 | 2.7 | 28 | 10 | 131 | 52 | 0.43 | 1.2 | 1.1 | A |
| 29 | 7 | 14 | 39.4 | 60 | 11.3 | 141 | 8.5 | 0.1 | 2.2 | 17 | 7 | 137 | 39 | 0.62 | 2.2 | 3.3 | B |
| 30 | 10 | 51 | 58.8 | 60 | 4.3 | 141 | 7.0 | 8.2 | 3.4 | 24 | 2 | 119 | 22 | 0.59 | 1.3 | 1.1 | A |
| 30 | 12 | 15 | 7.3 | 61 | 24.3 | 146 | 56.2 | 18.0 | 3.1 | 32 | 8 | 96 | 55 | 0.40 | 1.0 | 1.1 | A |
| NOV 1 | 2 | 22 | 0.1 | 61 | 26.9 | 147 | 10.8 | 20.4 | 2.1 | 23 | 13 | 93 | 59 | 0.42 | 1.0 | 2.0 | A |
| 1 | 19 | 45 | 0.5 | 60 | 48.1 | 140 | 27.5 | 0.3 | 1.8 | 9 | 7 | 240 | 92 | 0.41 | 1.8 | 2.5 | B |
| 1 | 22 | 0 | 0.9 | 60 | 32.4 | 146 | 56.3 | 20.0 | 2.4 | 35 | 8 | 50 | 62 | 0.40 | 1.1 | 1.9 | A |
| 1 | 22 | 41 | 30.0 | 60 | 54.0 | 141 | 7.4 | 0.0 | 2.1 | 17 | 4 | 205 | 86 | 0.45 | 1.7 | 3.2 | B |
| 2 | 6 | 9 | 47.4 | 60 | 13.4 | 141 | 48.9 | 0.0 | 1.7 | 10 | 6 | 96 | 24 | 0.30 | 1.1 | 4.2 | B |
| 2 | 6 | 48 | 31.9 | 61 | 29.2 | 147 | 23.1 | 20.0 | 2.3 | 12 | 7 | 97 | 62 | 0.29 | 1.4 | 4.0 | B |
| 2 | 10 | 6 | 35.1 | 60 | 31.3 | 146 | 58.0 | 10.3 | 3.4 | 26 | 7 | 82 | 94 | 0.52 | 1.3 | 1.6 | A |
| 2 | 17 | 5 | 33.1 | 61 | 24.5 | 146 | 51.9 | 24.0 | 2.3 | 10 | 7 | 139 | 54 | 0.28 | 1.7 | 2.2 | A |
| 3 | 7 | 12 | 44.5 | 61 | 47.1 | 147 | 34.9 | 20.0 | 2.6 | 10 | 9 | 151 | 69 | 0.36 | 1.5 | 3.7 | B |
| 3 | 9 | 23 | 26.1 | 61 | 33.7 | 145 | 7.5 | 42.8 | 2.4 | 15 | 13 | 98 | 56 | 0.35 | 1.7 | 3.7 | B |
| 3 | 14 | 19 | 1.0 | 60 | 31.9 | 146 | 59.6 | 10.7 | 2.4 | 22 | 14 | 158 | 92 | 0.44 | 1.3 | 1.4 | A |
| 3 | 15 | 39 | 21.4 | 60 | 43.7 | 143 | 15.7 | 0.2 | 2.0 | 13 | 6 | 76 | 65 | 0.46 | 1.8 | 3.1 | B |
| 3 | 20 | 10 | 10.4 | 60 | 31.3 | 145 | 9.1 | 15.1 | 3.2 | 16 | 7 | 126 | 94 | 0.29 | 3.0 | 1.7 | B |
| 4 | 15 | 53 | 13.7 | 61 | 6.3 | 140 | 39.9 | 33.0 | 2.5 | 3 | 2 | 264 | 116 | 0.16 | 5.4 | 99.0 | D |
| 7 | 21 | 32 | 47.8 | 60 | 35.3 | 142 | 40.2 | 12.5 | 1.7 | 5 | 3 | 122 | 53 | 0.08 | 9.1 | 6.4 | C |
| 8 | 21 | 8 | 7.5 | 60 | 17.2 | 140 | 31.9 | 17.2 | 1.9 | 9 | 4 | 185 | 62 | 0.17 | 3.6 | 2.1 | B |
| 8 | 21 | 31 | 51.6 | 60 | 0.1 | 141 | 13.8 | 2.0 | 2.1 | 7 | 2 | 107 | 103 | 0.28 | 3.8 | 4.2 | B |
| 8 | 22 | 48 | 19.8 | 61 | 37.4 | 141 | 51.9 | 0.5 | 2.1 | 7 | 5 | 247 | 141 | 0.16 | 4.7 | 2.6 | B |
| 9 | 1 | 35 | 53.8 | 60 | 18.5 | 140 | 31.5 | 15.4 | 1.9 | 11 | 8 | 179 | 64 | 0.24 | 3.3 | 1.7 | B |

EASTERN GULF OF ALASKA EARTHQUAKES (CONTINUED)

| 1977 | ORIGIN TIME HR MN | SEC | LAT N DEG MIN | LONG W DEG MIN | DEPTH KM | MAG | NP | NS | GAP DEG | D3 KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NOV 9 | 12 41 | 21.3 | 60 5.7 | 141 12.8 | 8.5 | 2.0 | 15 | 5 | 120 | 42 | 0.31 | 1.4 | 1.8 | A |
| 10 | 1 36 | 32.4 | 61 2.5 | 146 31.8 | 20.2 | 2.1 | 12 | 9 | 116 | 48 | 0.33 | 1.7 | 2.0 | A |
| 11 | 5 59 | 20.4 | 60 31.0 | 147 12.9 | 8.7 | 2.0 | 18 | 16 | 154 | 80 | 0.63 | 2.4 | 1.7 | A |
| 12 | 2 15 | 56.8 | 60 59.6 | 146 29.5 | 15.1 | 3.0 | 18 | 10 | 114 | 64 | 0.62 | 1.2 | 1.3 | A |
| 12 | 3 38 | 49.8 | 60 3.3 | 141 12.1 | 3.2 | 1.6 | 8 | 2 | 115 | 46 | 0.33 | 2.9 | 6.1 | C |
| 13 | 1 47 | 13.7 | 61 36.7 | 146 23.7 | 32.8 | 2.2 | 13 | 9 | 90 | 56 | 0.30 | 1.4 | 5.1 | C |
| 13 | 13 13 | 2.5 | 60 39.1 | 141 34.2 | 7.5 | 2.1 | 13 | 4 | 175 | 60 | 0.36 | 1.7 | 2.3 | A |
| 13 | 17 46 | 49.4 | 60 58.9 | 147 1.5 | 20.0 | 2.4 | 18 | 11 | 113 | 41 | 0.43 | 1.2 | 1.4 | A |
| 13 | 19 43 | 58.0 | 60 53.9 | 147 23.3 | 29.4 | 2.6 | 21 | 12 | 141 | 47 | 0.44 | 1.4 | 1.3 | A |
| 14 | 2 47 | 40.1 | 60 14.4 | 141 7.7 | 8.9 | 1.3 | 7 | 6 | 145 | 51 | 0.38 | 2.3 | 3.6 | B |
| 14 | 6 0 | 7.8 | 60 59.1 | 147 1.9 | 21.7 | 2.5 | 21 | 10 | 113 | 41 | 0.38 | 1.3 | 1.9 | A |
| 14 | 13 15 | 42.3 | 61 29.3 | 141 18.1 | 1.8 | 2.2 | 4 | 4 | 252 | 134 | 0.21 | 4.7 | 6.4 | C |
| 14 | 15 2 | 45.8 | 60 1.2 | 141 0.2 | 20.4 | 1.6 | 5 | 3 | 217 | 56 | 0.27 | 6.0 | 5.2 | C |
| 14 | 22 49 | 44.0 | 60 42.6 | 143 13.6 | 7.6 | 1.9 | 9 | 5 | 97 | 77 | 0.62 | 1.7 | 2.6 | B |
| 16 | 2 30 | 13.9 | 61 0.4 | 147 7.2 | 20.3 | 2.0 | 15 | 10 | 118 | 42 | 0.43 | 1.6 | 2.8 | B |
| 16 | 9 7 | 46.4 | 59 51.7 | 141 13.0 | 12.4 | 3.0 | 17 | 1 | 161 | 50 | 0.41 | 2.1 | 1.2 | A |
| 16 | 15 37 | 43.0 | 60 47.2 | 147 9.2 | 19.8 | 2.7 | 24 | 11 | 135 | 55 | 0.49 | 1.7 | 2.0 | A |
| 17 | 10 6 | 8.4 | 61 46.2 | 142 29.2 | 25.0 | 1.9 | 5 | 5 | 274 | 137 | 0.42 | 4.1 | 3.1 | B |
| 17 | 10 50 | 28.2 | 61 30.3 | 144 29.7 | 20.4 | 1.3 | 7 | 4 | 154 | 55 | 0.40 | 3.5 | 3.9 | B |
| 17 | 20 30 | 11.7 | 61 43.9 | 146 33.7 | 19.6 | 2.3 | 18 | 10 | 111 | 58 | 0.49 | 1.1 | 1.7 | A |
| 19 | 3 10 | 50.6 | 60 39.7 | 143 9.9 | 0.4 | 1.6 | 8 | 6 | 94 | 61 | 0.38 | 1.4 | 4.6 | B |
| 21 | 5 2 | 19.9 | 61 25.3 | 146 56.3 | 7.9 | 2.3 | 27 | 11 | 98 | 52 | 0.48 | 0.8 | 1.3 | A |
| 21 | 18 14 | 24.2 | 61 2.6 | 146 24.1 | 17.2 | 2.1 | 18 | 10 | 56 | 37 | 0.56 | 1.0 | 0.9 | A |
| 22 | 21 6 | 28.3 | 60 17.2 | 142 56.7 | 10.8 | 1.5 | 8 | 5 | 90 | 52 | 0.32 | 3.6 | 3.9 | B |
| 23 | 1 21 | 44.3 | 60 32.6 | 140 41.3 | 0.2 | 2.0 | 13 | 6 | 197 | 62 | 0.23 | 1.8 | 4.2 | B |
| 23 | 3 27 | 14.5 | 61 21.0 | 146 49.3 | 21.1 | 2.2 | 19 | 14 | 80 | 51 | 0.47 | 0.8 | 2.0 | A |
| 23 | 10 29 | 26.5 | 60 59.4 | 147 0.8 | 22.3 | 2.3 | 26 | 15 | 58 | 37 | 0.41 | 1.1 | 1.2 | A |
| 23 | 15 35 | 50.3 | 60 3.3 | 141 10.2 | 3.5 | 1.8 | 15 | 6 | 115 | 47 | 0.46 | 1.3 | 2.6 | B |
| 23 | 21 56 | 10.5 | 60 3.0 | 141 9.2 | 11.8 | 2.2 | 16 | 5 | 117 | 47 | 0.42 | 1.6 | 1.5 | A |
| 24 | 0 41 | 25.7 | 61 43.6 | 147 15.4 | 14.2 | 1.8 | 10 | 9 | 134 | 71 | 0.36 | 1.4 | 2.1 | A |
| 24 | 1 16 | 48.4 | 60 3.7 | 141 9.2 | 2.3 | 1.8 | 12 | 9 | 117 | 40 | 0.29 | 1.5 | 2.6 | B |
| 24 | 13 47 | 8.1 | 60 34.0 | 143 20.0 | 0.2 | 1.4 | 4 | 3 | 259 | 75 | 0.11 | 4.1 | 99.0 | D |
| 24 | 22 26 | 54.4 | 60 18.4 | 140 45.7 | 38.1 | 2.5 | 4 | 4 | 177 | 116 | 0.06 | 8.8 | 14.7 | D |
| 25 | 9 5 | 50.1 | 61 11.3 | 147 14.6 | 1.0 | 2.2 | 17 | 10 | 74 | 40 | 0.48 | 1.5 | 2.3 | A |
| 25 | 9 57 | 22.8 | 60 7.4 | 147 11.4 | 3.6 | 3.2 | 32 | 8 | 110 | 91 | 0.44 | 1.3 | 1.5 | A |
| 25 | 14 16 | 45.4 | 60 30.6 | 143 7.6 | 0.9 | 1.8 | 9 | 8 | 163 | 78 | 0.32 | 2.4 | 3.3 | B |
| 26 | 7 2 | 39.2 | 61 13.7 | 145 32.2 | 18.0 | 1.8 | 13 | 7 | 97 | 44 | 0.44 | 1.5 | 1.1 | A |
| 26 | 10 45 | 1.7 | 60 33.5 | 141 58.9 | 25.7 | 1.5 | 9 | 8 | 139 | 54 | 0.23 | 1.6 | 2.6 | B |
| 26 | 12 48 | 29.7 | 61 36.6 | 146 35.7 | 21.2 | 2.2 | 13 | 14 | 110 | 59 | 0.37 | 1.5 | 3.7 | B |
| 26 | 13 21 | 43.6 | 61 36.0 | 146 15.7 | 23.7 | 2.2 | 14 | 11 | 93 | 62 | 0.36 | 1.2 | 2.3 | A |
| 26 | 13 56 | 37.2 | 61 30.9 | 139 49.3 | 0.1 | 2.9 | 5 | 2 | 281 | 177 | 0.47 | 23.0 | 28.7 | D |
| 26 | 21 4 | 30.0 | 61 36.1 | 141 34.9 | 0.1 | 2.4 | 5 | 5 | 255 | 146 | 0.24 | 6.0 | 3.4 | C |
| 27 | 0 7 | 1.7 | 61 34.7 | 141 41.7 | 0.4 | 2.1 | 4 | 3 | 252 | 141 | 0.19 | 6.8 | 4.3 | C |
| 27 | 0 10 | 31.0 | 61 47.1 | 146 57.1 | 11.9 | 1.9 | 12 | 8 | 137 | 73 | 0.32 | 1.7 | 2.2 | A |
| 27 | 12 32 | 45.6 | 61 39.7 | 146 19.9 | 35.0 | 3.0 | 20 | 6 | 91 | 59 | 0.40 | 1.5 | 5.3 | C |

EASTERN GULF OF ALASKA EARTHQUAKES (CONTINUED)

| 1977 | ORIGIN TIME HR | MN | SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NP | NS | GAP DEG | D3 KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NOV 27 | 16 | 5 | 48.2 | 59 | 56.2 | 141 | 5.8 | 14.2 | 1.2 | 3 | 2 | 231 | 113 | 0.07 | 20.9 | 10.8 | D |
| 27 | 19 | 53 | 33.8 | 60 | 22.9 | 140 | 20.0 | 32.7 | 1.4 | 3 | 3 | 229 | 132 | 0.09 | 13.0 | 29.9 | D |
| 28 | 6 | 42 | 28.1 | 60 | 43.9 | 147 | 50.7 | 12.3 | 1.9 | 7 | 5 | 169 | 68 | 0.28 | 2.0 | 2.7 | B |
| 28 | 15 | 11 | 8.1 | 59 | 58.3 | 145 | 37.0 | 17.6 | 2.7 | 10 | 7 | 203 | 132 | 0.28 | 5.1 | 5.3 | C |
| 28 | 21 | 26 | 29.0 | 60 | 18.1 | 140 | 41.1 | 18.2 | 1.3 | 4 | 4 | 182 | 121 | 0.08 | 9.0 | 7.1 | C |
| 29 | 0 | 53 | 54.8 | 61 | 33.8 | 146 | 28.2 | 30.2 | 2.2 | 14 | 13 | 99 | 56 | 0.41 | 1.1 | 1.1 | A |
| 29 | 3 | 14 | 33.7 | 60 | 7.6 | 147 | 9.7 | 4.1 | 3.2 | 32 | 5 | 118 | 104 | 0.35 | 1.2 | 1.6 | A |
| 29 | 12 | 26 | 48.3 | 59 | 52.9 | 140 | 42.0 | 5.2 | 1.5 | 4 | 2 | 252 | 135 | 0.02 | 8.7 | 7.0 | C |
| 29 | 14 | 21 | 52.2 | 59 | 59.1 | 142 | 14.5 | 2.9 | 1.3 | 11 | 7 | 181 | 40 | 0.25 | 2.5 | 2.2 | A |
| 29 | 16 | 22 | 13.0 | 60 | 38.6 | 142 | 36.4 | 0.2 | 2.9 | 21 | 6 | 97 | 57 | 0.47 | 1.0 | 1.7 | A |
| 29 | 16 | 37 | 23.1 | 59 | 60.0 | 142 | 13.0 | 4.4 | 1.9 | 7 | 6 | 232 | 40 | 0.27 | 2.6 | 3.0 | B |
| 29 | 19 | 35 | 0.3 | 61 | 29.1 | 146 | 34.9 | 20.6 | 2.0 | 14 | 10 | 86 | 72 | 0.37 | 1.0 | 2.7 | B |
| 29 | 21 | 6 | 36.5 | 61 | 20.7 | 146 | 20.7 | 24.9 | 2.4 | 13 | 8 | 70 | 56 | 0.30 | 1.3 | 1.6 | A |
| 30 | 5 | 7 | 34.4 | 61 | 27.2 | 147 | 29.9 | 10.8 | 2.9 | 23 | 4 | 92 | 59 | 0.46 | 1.3 | 1.8 | A |
| 30 | 8 | 12 | 10.6 | 60 | 1.2 | 142 | 46.0 | 10.7 | 2.7 | 7 | 4 | 253 | 41 | 0.37 | 3.8 | 1.8 | B |
| 30 | 10 | 25 | 44.7 | 61 | 31.4 | 146 | 35.0 | 19.9 | 2.3 | 16 | 11 | 90 | 69 | 0.43 | 1.1 | 1.5 | A |
| 30 | 13 | 8 | 56.3 | 59 | 59.1 | 142 | 12.7 | 3.8 | 1.7 | 7 | 3 | 219 | 41 | 0.23 | 4.9 | 3.2 | B |
| 30 | 14 | 2 | 26.8 | 61 | 26.0 | 146 | 6.2 | 26.2 | 2.3 | 17 | 8 | 68 | 47 | 0.36 | 1.3 | 1.5 | A |
| 30 | 14 | 9 | 40.5 | 59 | 48.5 | 142 | 14.6 | 19.3 | 2.6 | 3 | 4 | 286 | 29 | 0.32 | 4.3 | 2.0 | B |
| 30 | 17 | 12 | 16.1 | 60 | 15.2 | 140 | 58.0 | 0.8 | 2.0 | 8 | 4 | 155 | 45 | 0.31 | 2.2 | 5.2 | C |
| 30 | 17 | 14 | 27.7 | 60 | 5.7 | 141 | 2.9 | 22.7 | 1.3 | 4 | 3 | 194 | 49 | 0.11 | 10.1 | 6.2 | D |
| 30 | 19 | 44 | 4.7 | 60 | 47.5 | 147 | 30.5 | 22.1 | 2.8 | 10 | 6 | 152 | 74 | 0.35 | 2.2 | 2.2 | A |
| 30 | 22 | 13 | 54.9 | 61 | 1.6 | 146 | 4.2 | 21.9 | 3.1 | 17 | 5 | 87 | 56 | 0.25 | 1.4 | 2.7 | B |
| DEC 2 | 16 | 48 | 26.4 | 60 | 39.2 | 145 | 6.4 | 5.5 | 2.5 | 27 | 6 | 58 | 82 | 0.30 | 1.1 | 1.6 | A |
| 2 | 17 | 40 | 18.6 | 60 | 15.9 | 141 | 22.6 | 15.6 | 1.9 | 4 | 2 | 138 | 65 | 0.35 | 10.3 | 11.6 | D |
| 2 | 23 | 29 | 32.3 | 60 | 21.7 | 139 | 56.0 | 0.1 | 2.4 | 9 | 3 | 272 | 90 | 0.49 | 5.5 | 4.6 | C |
| 3 | 1 | 24 | 40.5 | 60 | 10.5 | 140 | 15.9 | 17.2 | 1.4 | 3 | 1 | 227 | 149 | 0.21 | 86.8 | 48.0 | D |
| 3 | 20 | 39 | 29.9 | 58 | 45.3 | 142 | 11.7 | 21.3 | 2.9 | 14 | 5 | 275 | 147 | 0.36 | 24.5 | 40.7 | D |
| 4 | 20 | 3 | 59.5 | 59 | 54.1 | 139 | 39.5 | 2.3 | 1.4 | 4 | 2 | 153 | 40 | 0.18 | 4.2 | 7.4 | C |
| 5 | 0 | 5 | 10.5 | 61 | 28.6 | 146 | 35.8 | 19.9 | 2.7 | 13 | 6 | 112 | 94 | 0.49 | 1.6 | 1.8 | A |
| 5 | 0 | 47 | 1.3 | 60 | 36.5 | 142 | 38.5 | 5.3 | 3.1 | 16 | 9 | 95 | 50 | 0.58 | 1.0 | 1.6 | A |
| 5 | 3 | 24 | 31.1 | 59 | 42.9 | 141 | 15.1 | 11.9 | 2.0 | 11 | 5 | 183 | 57 | 0.33 | 3.1 | 2.2 | B |
| 5 | 6 | 4 | 47.0 | 59 | 50.8 | 141 | 35.6 | 15.3 | 1.4 | 9 | 8 | 218 | 34 | 0.47 | 2.4 | 1.4 | A |
| 5 | 14 | 24 | 31.3 | 60 | 41.3 | 143 | 10.0 | 0.5 | 1.3 | 10 | 5 | 139 | 59 | 0.26 | 1.8 | 5.3 | C |
| 5 | 19 | 7 | 53.1 | 60 | 1.1 | 139 | 24.8 | 1.1 | 2.2 | 9 | 4 | 234 | 49 | 0.47 | 5.0 | 3.0 | B |
| 5 | 20 | 21 | 36.2 | 59 | 56.8 | 140 | 18.7 | 3.9 | 1.7 | 6 | 2 | 155 | 60 | 0.34 | 3.0 | 3.9 | B |
| 5 | 20 | 37 | 24.0 | 59 | 58.3 | 140 | 17.5 | 1.2 | 1.0 | 7 | 1 | 192 | 68 | 0.00 | 9.0 | 98.7 | D |
| 6 | 0 | 33 | 52.1 | 58 | 52.5 | 141 | 15.9 | 15.0 | 2.6 | 12 | 6 | 278 | 138 | 0.29 | 6.9 | 6.1 | C |
| 6 | 10 | 56 | 44.8 | 61 | 35.3 | 146 | 38.2 | 31.8 | 2.2 | 18 | 11 | 98 | 50 | 0.36 | 1.2 | 2.1 | A |
| 7 | 22 | 22 | 27.5 | 59 | 56.1 | 140 | 35.8 | 5.3 | 1.7 | 4 | 2 | 236 | 128 | 0.10 | 7.6 | 4.2 | C |
| 7 | 22 | 42 | 15.9 | 59 | 54.0 | 140 | 35.5 | 3.2 | 2.1 | 3 | 2 | 259 | 159 | 0.07 | 9.4 | 12.8 | D |
| 7 | 22 | 42 | 40.1 | 60 | 24.6 | 147 | 47.2 | 13.7 | 2.6 | 26 | 11 | 158 | 85 | 0.42 | 2.0 | 1.4 | A |
| 7 | 22 | 45 | 44.7 | 59 | 45.4 | 146 | 6.6 | 9.0 | 3.7 | 36 | 3 | 112 | 90 | 0.28 | 1.4 | 1.7 | A |
| 7 | 22 | 50 | 36.4 | 59 | 58.1 | 140 | 35.0 | 13.5 | 1.7 | 7 | 2 | 159 | 74 | 0.33 | 5.7 | 4.2 | C |
| 7 | 22 | 58 | 23.9 | 60 | 12.6 | 141 | 4.9 | 1.3 | 2.1 | 8 | 2 | 142 | 47 | 0.25 | 3.8 | 6.2 | C |

EASTERN GULF OF ALASKA EARTHQUAKES (CONTINUED)

| 1977 | ORIGIN TIME HR | MN | SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NP | NS | GAP DEG | D3 KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEC 8 | 1 | 33 | 54.5 | 60 | 35.8 | 142 | 43.6 | 15.7 | 1.8 | 7 | 5 | 97 | 53 | 0.31 | 2.8 | 2.5 | B |
| 8 | 22 | 31 | 9.1 | 60 | 14.4 | 146 | 59.8 | 13.4 | 2.8 | 25 | 5 | 107 | 77 | 0.54 | 1.4 | 1.9 | A |
| 11 | 4 | 7 | 42.9 | 61 | 31.9 | 147 | 25.5 | 20.6 | 2.3 | 21 | 6 | 103 | 57 | 0.39 | 1.1 | 2.0 | A |
| 11 | 9 | 52 | 5.6 | 60 | 1.9 | 140 | 47.3 | 7.3 | 2.0 | 11 | 5 | 153 | 65 | 0.45 | 3.1 | 2.7 | B |
| 12 | 8 | 0 | 44.5 | 59 | 32.8 | 146 | 6.6 | 43.6 | 2.7 | 17 | 4 | 155 | 134 | 0.60 | 3.5 | 7.4 | C |
| 12 | 11 | 3 | 48.8 | 60 | 13.1 | 140 | 36.7 | 8.2 | 1.8 | 5 | 2 | 165 | 63 | 0.24 | 24.0 | 19.5 | D |
| 12 | 11 | 7 | 14.5 | 59 | 47.8 | 140 | 42.7 | 13.5 | 1.8 | 5 | 2 | 243 | 85 | 0.25 | 8.6 | 3.2 | C |
| 12 | 18 | 3 | 49.0 | 60 | 12.7 | 139 | 12.0 | 17.5 | 1.5 | 5 | 2 | 252 | 62 | 0.50 | 10.4 | 8.1 | D |
| 12 | 18 | 50 | 45.9 | 60 | 35.3 | 141 | 16.4 | 2.2 | 1.2 | 7 | 5 | 184 | 77 | 0.27 | 1.[illegible] | 4.3 | B |
| 12 | 22 | 27 | 55.5 | 61 | 11.5 | 147 | 13.1 | 12.5 | 2.5 | 18 | 6 | 92 | 62 | 0.60 | 1.4 | 1.2 | A |
| 13 | 11 | 29 | 41.7 | 60 | 35.6 | 141 | 32.9 | 3.3 | 1.3 | 6 | 6 | 169 | 66 | 0.31 | 1.8 | 24.4 | D |
| 13 | 11 | 46 | 11.7 | 60 | 24.1 | 147 | 46.6 | 5.8 | 2.8 | 31 | 6 | 101 | 86 | 0.38 | 1.4 | 1.6 | A |
| 13 | 17 | 1 | 51.6 | 59 | 56.6 | 141 | 31.0 | 13.3 | 2.2 | 13 | 2 | 153 | 31 | 0.35 | 1.9 | 1.8 | A |
| 14 | 8 | 23 | 27.6 | 60 | 26.2 | 147 | 47.7 | 11.8 | 2.3 | 14 | 11 | 201 | 83 | 0.44 | 2.2 | 1.8 | A |
| 14 | 14 | 2 | 47.0 | 60 | 58.8 | 146 | 55.0 | 20.6 | 2.7 | 16 | 12 | 109 | 38 | 0.42 | 1.6 | 1.8 | A |
| 14 | 14 | 5 | 46.6 | 59 | 35.6 | 145 | 47.1 | 0.1 | 3.2 | 12 | 9 | 217 | 177 | 0.23 | 5.3 | 3.4 | C |
| 14 | 14 | 8 | 53.1 | 61 | 25.8 | 147 | 46.7 | 27.8 | 2.2 | 9 | 6 | 162 | 34 | 0.35 | 2.9 | 1.7 | B |
| 14 | 17 | 46 | 24.3 | 60 | 59.8 | 147 | 16.8 | 16.0 | 2.1 | 8 | 5 | 125 | 53 | 0.25 | 2.5 | 1.6 | A |
| 15 | 23 | 49 | 20.1 | 59 | 57.7 | 140 | 13.1 | 4.7 | 1.9 | 8 | 5 | 152 | 73 | 0.32 | 2.4 | 2.7 | B |
| 16 | 5 | 17 | 1.7 | 60 | 39.1 | 143 | 8.2 | 0.4 | 2.7 | 14 | 10 | 68 | 61 | 0.42 | 1.6 | 2.7 | B |
| 16 | 5 | 47 | 51.2 | 61 | 19.2 | 143 | 22.0 | 18.9 | 1.2 | 5 | 4 | 180 | 21 | 0.26 | 47.2 | 10.7 | D |
| 16 | 14 | 11 | 26.2 | 60 | 2.9 | 141 | 11.4 | 0.8 | 1.1 | 9 | 4 | 114 | 47 | 0.19 | 2.1 | 82.1 | D |
| 16 | 14 | 12 | 45.1 | 60 | 1.3 | 141 | 21.4 | 23.1 | 1.2 | 4 | 3 | 164 | 62 | 0.12 | 4.3 | 3.9 | B |
| 17 | 5 | 20 | 22.6 | 60 | 11.3 | 141 | 44.8 | 18.0 | 1.3 | 3 | 3 | 137 | 23 | 0.04 | 2.0 | 4.6 | B |
| 17 | 5 | 56 | 54.5 | 60 | 45.2 | 139 | 57.2 | 0.2 | 2.2 | 10 | 8 | 235 | 107 | 0.58 | 3.2 | 4.7 | B |
| 17 | 6 | 9 | 46.9 | 60 | 23.8 | 147 | 45.4 | 11.6 | 2.6 | 17 | 11 | 219 | 87 | 0.53 | 2.2 | 1.3 | A |
| 17 | 9 | 13 | 49.3 | 61 | 11.0 | 147 | 14.3 | 13.3 | 2.4 | 18 | 8 | 85 | 30 | 0.45 | 1.2 | 1.4 | A |
| 17 | 15 | 13 | 2.5 | 60 | 59.1 | 146 | 57.9 | 22.7 | 2.8 | 36 | 11 | 57 | 35 | 0.44 | 1.0 | 1.0 | A |
| 18 | 5 | 16 | 58.6 | 59 | 32.7 | 138 | 56.1 | 3.6 | 1.6 | 3 | 1 | 203 | 59 | 0.11 | 27.8 | 56.5 | D |
| 18 | 6 | 56 | 44.6 | 60 | 3.7 | 141 | 33.1 | 14.2 | 1.7 | 16 | 10 | 124 | 27 | 0.38 | 1.3 | 1.1 | A |
| 18 | 8 | 16 | 58.2 | 60 | 9.5 | 141 | 6.2 | 17.3 | 1.5 | 9 | 9 | 133 | 48 | 0.33 | 2.4 | 1.2 | A |
| 18 | 9 | 17 | 52.3 | 60 | 38.5 | 142 | 47.2 | 1.3 | 1.4 | 5 | 3 | 139 | 52 | 0.23 | 3.0 | 26.5 | D |
| 18 | 17 | 51 | 57.0 | 60 | 15.5 | 141 | 2.7 | 10.4 | 1.0 | 6 | 4 | 190 | 47 | 0.27 | 7.0 | 10.7 | D |
| 18 | 21 | 52 | 12.6 | 60 | 0.7 | 139 | 43.6 | 17.8 | 1.3 | 5 | 3 | 211 | 42 | 0.26 | 5.6 | 1.7 | C |
| 19 | 8 | 19 | 12.5 | 59 | 56.6 | 141 | 53.1 | 3.6 | 1.3 | 8 | 6 | 217 | 48 | 0.37 | 2.7 | 3.4 | B |
| 19 | 9 | 1 | 0.3 | 60 | 21.6 | 147 | 16.6 | 14.1 | 2.6 | 27 | 16 | 113 | 86 | 0.58 | 1.1 | 1.3 | A |
| 19 | 13 | 53 | 27.1 | 60 | 37.6 | 147 | 36.9 | 14.0 | 2.0 | 24 | 16 | 144 | 63 | 0.59 | 1.5 | 1.0 | A |
| 19 | 19 | 55 | 15.5 | 61 | 18.3 | 146 | 55.6 | 20.4 | 2.3 | 26 | 16 | 77 | 47 | 0.33 | 0.9 | 2.0 | A |
| 20 | 20 | 51 | 45.9 | 61 | 35.0 | 141 | 57.2 | 0.0 | 1.9 | 8 | 5 | 244 | 135 | 0.37 | 4.6 | 1.1 | B |
| 20 | 22 | 26 | 1.9 | 60 | 34.0 | 141 | 26.3 | 8.6 | 2.0 | 10 | 5 | 172 | 58 | 0.31 | 1.8 | 2.8 | B |
| 21 | 7 | 24 | 39.5 | 60 | 15.3 | 140 | 50.5 | 0.1 | 2.1 | 13 | 5 | 160 | 47 | 0.38 | 1.8 | 3.5 | B |
| 21 | 13 | 37 | 2.9 | 59 | 54.6 | 140 | 9.9 | 3.1 | 1.7 | 6 | 4 | 200 | 78 | 0.16 | 4.9 | 4.6 | B |
| 21 | 21 | 3 | 23.0 | 61 | 30.4 | 146 | 27.5 | 25.1 | 2.3 | 14 | 7 | 84 | 69 | 0.39 | 1.3 | 2.2 | A |
| 21 | 22 | 19 | 40.8 | 60 | 37.1 | 143 | 15.7 | 1.9 | 2.0 | 9 | 7 | 76 | 68 | 0.46 | 1.6 | 2.6 | B |
| 22 | 7 | 50 | 3.5 | 60 | 14.7 | 140 | 57.8 | 0.2 | 2.4 | 7 | 3 | 240 | 104 | 0.28 | 3.8 | 3.3 | B |

## EASTERN GULF OF ALASKA EARTHQUAKES (CONTINUED)

| 1977 | ORIGIN TIME HR MN | SEC | LAT N DEG MIN | LONG W DEG MIN | DEPTH KM | MAG | NP | NS | GAP DEG | D3 KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEC 22 | 13 21 | 56.8 | 59 29.3 | 139 9.7 | 25.0 | 3.3 | 7 | 1 | 317 | 92 | 0.07 | 78.7 | 11.8 | D |
| 22 | 16 35 | 4.5 | 60 3.0 | 141 6.7 | 0.0 | 2.0 | 10 | 6 | 116 | 47 | 0.35 | 1.3 | 3.5 | B |
| 22 | 17 18 | 0.8 | 60 46.2 | 143 18.9 | 0.8 | 1.8 | 5 | 4 | 124 | 79 | 0.17 | 1.7 | 3.3 | B |
| 22 | 21 31 | 0.9 | 60 11.4 | 141 48.2 | 24.9 | 1.9 | 5 | 4 | 226 | 87 | 0.14 | 6.7 | 3.0 | C |
| 23 | 0 19 | 34.2 | 60 22.9 | 147 16.2 | 17.8 | 2.7 | 29 | 12 | 93 | 86 | 0.40 | 1.2 | 1.3 | A |
| 23 | 2 54 | 12.2 | 61 35.1 | 146 35.6 | 24.4 | 2.6 | 21 | 12 | 101 | 62 | 0.32 | 1.1 | 1.8 | A |
| 23 | 15 38 | 22.1 | 60 8.9 | 141 12.2 | 10.6 | 1.7 | 8 | 5 | 148 | 53 | 0.32 | 2.5 | 2.0 | B |
| 23 | 20 22 | 42.7 | 60 9.8 | 139 54.2 | 5.5 | 2.2 | 11 | 5 | 108 | 69 | 0.33 | 4.7 | 2.8 | B |
| 23 | 22 50 | 55.8 | 61 35.0 | 146 9.0 | 27.0 | 1.9 | 11 | 9 | 98 | 58 | 0.42 | 1.0 | 1.3 | A |
| 24 | 0 59 | 8.2 | 60 15.6 | 141 14.2 | 4.5 | 2.0 | 9 | 6 | 146 | 57 | 0.33 | 1.6 | 2.3 | A |
| 24 | 3 24 | 14.0 | 60 3.9 | 141 30.0 | 14.5 | 2.8 | 23 | 2 | 119 | 26 | 0.44 | 1.3 | 0.9 | A |
| 24 | 6 48 | 2.2 | 59 54.0 | 141 3.2 | 3.2 | 1.3 | 3 | 4 | 189 | 117 | 0.18 | 10.4 | 13.0 | D |
| 24 | 10 57 | 24.1 | 60 2.3 | 141 23.3 | 13.8 | 1.5 | 6 | 3 | 166 | 41 | 0.18 | 3.0 | 1.7 | B |
| 24 | 21 47 | 21.5 | 60 30.8 | 142 50.7 | 8.0 | 1.2 | 4 | 2 | 170 | 68 | 0.06 | 8.1 | 9.0 | C |
| 25 | 1 11 | 23.5 | 59 20.4 | 144 44.3 | 14.4 | 3.1 | 29 | 18 | 188 | 98 | 0.34 | 2.7 | 1.7 | B |
| 25 | 3 7 | 49.1 | 60 10.4 | 141 13.6 | 14.6 | 1.2 | 9 | 7 | 132 | 36 | 0.40 | 1.8 | 1.1 | A |
| 25 | 9 2 | 14.3 | 60 45.9 | 139 57.0 | 0.5 | 1.8 | 9 | 7 | 228 | 126 | 0.42 | 2.9 | 2.4 | B |
| 25 | 20 53 | 4.6 | 60 1.8 | 141 23.6 | 19.8 | 1.3 | 5 | 4 | 181 | 42 | 0.17 | 3.6 | 1.9 | B |
| 26 | 5 13 | 29.8 | 59 46.4 | 141 24.5 | 3.1 | 1.3 | 8 | 5 | 239 | 68 | 0.20 | 2.9 | 7.2 | C |
| 26 | 7 33 | 26.9 | 60 24.6 | 143 16.0 | 0.5 | 1.8 | 9 | 8 | 173 | 80 | 0.37 | 1.6 | 3.2 | B |
| 26 | 7 36 | 30.8 | 60 26.6 | 143 12.4 | 1.7 | 2.7 | 12 | 9 | 146 | 79 | 0.28 | 1.6 | 2.8 | B |
| 27 | 12 50 | 50.0 | 61 2.8 | 146 28.7 | 18.2 | 1.9 | 18 | 11 | 75 | 36 | 0.52 | 1.0 | 0.6 | A |
| 27 | 15 10 | 38.4 | 61 32.1 | 146 35.9 | 24.1 | 2.3 | 19 | 13 | 105 | 67 | 0.38 | 1.3 | 1.8 | A |
| 28 | 4 38 | 26.0 | 60 9.0 | 139 53.9 | 0.2 | 1.3 | 6 | 5 | 222 | 87 | 0.25 | 6.1 | 5.8 | C |
| 28 | 19 42 | 54.7 | 59 38.8 | 146 16.7 | 7.0 | 2.8 | 24 | 14 | 107 | 112 | 0.24 | 1.7 | 1.5 | A |
| 29 | 6 53 | 8.7 | 59 28.5 | 144 43.7 | 17.7 | 3.4 | 32 | 9 | 176 | 21 | 0.24 | 2.9 | 1.7 | B |
| 29 | 16 18 | 3.4 | 59 26.3 | 138 52.8 | 13.0 | 1.5 | 4 | 3 | 307 | 70 | 0.44 | 9.5 | 1.3 | C |
| 29 | 17 12 | 45.2 | 60 43.9 | 142 45.7 | 4.8 | 1.1 | 7 | 6 | 107 | 69 | 0.36 | 1.0 | 2.9 | B |
| 29 | 18 28 | 38.7 | 60 7.5 | 141 28.7 | 2.9 | 1.1 | 7 | 4 | 175 | 68 | 0.22 | 1.6 | 2.3 | A |
| 29 | 20 0 | 26.0 | 60 18.0 | 140 36.8 | 20.6 | 1.6 | 9 | 5 | 174 | 63 | 0.23 | 4.0 | 3.4 | B |
| 29 | 21 48 | 18.7 | 61 41.0 | 146 26.6 | 24.0 | 3.6 | 31 | 5 | 99 | 62 | 0.47 | 0.9 | 1.5 | A |
| 29 | 22 18 | 41.7 | 61 50.5 | 147 20.6 | 18.9 | 3.2 | 26 | 14 | 150 | 76 | 0.45 | 1.2 | 1.7 | A |
| 29 | 23 29 | 15.6 | 60 39.1 | 143 19.0 | 9.4 | 1.0 | 4 | 3 | 141 | 69 | 0.10 | 2.7 | 5.8 | C |
| 30 | 3 36 | 55.6 | 60 0.5 | 139 15.0 | 0.4 | 1.5 | 4 | 4 | 241 | 57 | 0.20 | 2.0 | 99.0 | D |
| 30 | 3 37 | 6.9 | 58 47.9 | 144 5.0 | 32.3 | 2.5 | 5 | 7 | 265 | 211 | 0.16 | 7.0 | 99.0 | D |
| 30 | 4 9 | 46.3 | 60 3.2 | 141 10.0 | 16.2 | 1.0 | 9 | 7 | 115 | 47 | 0.18 | 2.7 | 1.9 | B |
| 30 | 5 37 | 35.5 | 59 46.5 | 141 15.4 | 10.2 | 1.4 | 3 | 3 | 232 | 153 | 0.15 | 4.5 | 4.8 | B |
| 30 | 10 30 | 22.9 | 60 5.1 | 139 59.6 | 6.4 | 1.6 | 9 | 5 | 180 | 57 | 0.22 | 3.1 | 2.6 | B |
| 30 | 19 12 | 2.6 | 60 15.5 | 141 33.5 | 11.7 | 1.1 | 3 | 3 | 213 | 175 | 0.15 | 7.6 | 5.6 | C |
| 30 | 20 58 | 38.0 | 60 18.4 | 143 10.3 | 0.2 | 1.8 | 9 | 9 | 157 | 79 | 0.44 | 2.0 | 2.9 | B |
| 31 | 3 3 | 11.3 | 59 57.5 | 139 37.7 | 13.6 | 0.7 | 4 | 4 | 210 | 38 | 0.34 | 3.0 | 2.6 | B |
| 31 | 6 4 | 58.8 | 61 25.9 | 147 49.5 | 20.6 | 2.3 | 22 | 14 | 82 | 50 | 0.50 | 1.3 | 1.8 | A |
| 31 | 10 37 | 27.9 | 60 13.7 | 141 28.9 | 15.4 | 1.3 | 9 | 7 | 130 | 27 | 0.24 | 2.5 | 1.2 | A |
| 31 | 17 28 | 35.9 | 60 18.3 | 140 50.4 | 11.9 | 1.3 | 9 | 8 | 176 | 50 | 0.51 | 2.1 | 2.1 | A |

Quarterly Report

Contract #: 03-5-022-55
Research Unit #: 251
Task Order #: C1
Reporting Period: 07/01/78 - 09/30/78
Number of Pages:

# SEISMIC AND VOLCANIC RISK STUDIES
# WESTERN GULF OF ALASKA


H. Pulpan
J. Kienle

Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701


September 30, 1978

# TABLE OF CONTENTS

I. ABSTRACT

II. TASK OBJECTIVES

III. FIELD AND LABORATORY ACTIVITIES

IV. RESULTS AND PRELIMINARY INTERPRETATION

TABLES

FIGURES

APPENDIX 1

APPENDIX 2

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Period Ending September 30, 1978

| | |
|---|---|
| Project Title: | Seismic and Volcanic Risk Studies Western Gulf of Alaska |
| Contract Number: | 03-5-022-55 |
| Task Order Number: | C1 |
| Principal Investigators: | H. Pulpan, J. Kienle |

## I. Abstract

The main emphasis during this report period was upon field operation. The annual service of the seismic network took place and field expeditions were staged to Augustine and Redoubt Volcanoes.

## II. Task Objectives

It is the purpose of this research to determine the seismicity of lower Cook Inlet, Kodiak Island, and the Alaska Peninsula, and to evaluate the seismic risk to onshore and offshore development and also to evaluate eruption potential and volcanic risk of Redoubt and Augustine Volcanoes in Cook Inlet.

## III. Field Activities

### A. Field Trip Schedules

#### 1. Volcanology

June 19-28, 1978: Volcanological studies on Augustine Volcano, field trip sponsored by U.S. Geological Survey, Conservation Division, Anchorage Office.

July 3-13, 1978: Glaciological studies on "North Glacier", Redoubt Volcano. Accommodations and helicopter support courtesy of Cook Inlet Pipeline Company, Drift River Tanker Terminal.

Aug. 31-Sept. 2, 1978: Relocation of seismic station on summit of Augustine Volcano (new station AUM that replaces AUP), installation of repeater at Augustine station AUF, repair of Shuyak (SHU) repeater at Augustine station AUK. Annual servicing of Redoubt seismic station (RED).

Relocation of one building left by NOAA ERL/WPL, Boulder, Colorado, at SE shore of Augustine Island to a new site on the western flank of the volcano.

Sept. 11-16, 1978: Glaciologic and volcanologic field studies on "North Glacier", Drift River Valley, and around the footslopes (up to 4,000 feet) of Redoubt Volcano.

2. Seismology

Depart Fairbanks for King Salmon. Preparation for service at King Salmon.

June 26 Can not work as helicopter is in Kodiak for maintenance

27 Visit stations; BMT, MRS, FLP, PUB: Dropped batteries heavy hardware needed for service stopped flying early as pilot had flown in from Kodiak this A.M. and had logged 8 hours flying.

28 Visit stations, CDA, MCN, OPT. Dropped batteris and heavy hardware. Returned to King Salmon due to fuel leak in Helicopter. Repaired fuel line the same day. Returned to Augustine Volcanoe.

28 Visit stations AUI. Attempted service but ran out of daylight. Removed unit and carried it back to camp.

29 Visit station AUI-Completed service. AUM-started service-heavy wind and rain damaged equipment-removed for repair at camp.

30 Visit stations: AUF, completed service; AUM-reinstalled equipment and completed service. Couldn't reach AUP due to cloud cover.

July 1 Could not reach AUP due to bad weather; CDA-serviced station; MCN-serviced station; OPT-completed station service.

2 Could not reach AUP due to cloud cover, not enough fuel to reach RED; returned to King Salmon.

July 3 Pilot sick, didn't work at any stations this day.

4 Holiday-problems getting fuel, bad weather; pilot decides risk too excessive to fly

5 Visit Stations: PUB-completed service; FLP-could not land due to rain and high wind, picked up geologic samples near MRS station; MRS-only partially finished before weather worsened-pilot request we return to King Salmon before we get stuck. Having problems with fuel regulations (linear activator) in aircraft and rpm is not stable on takeoff.

6 Helicopter down for maintenance-aircraft repaired late afternoon weather very bad-rain and wind-attempted MRS, FLP but couldn't land.

7 Visit stations UKL-completed service, FLP-completed service, MRS-completed service-rain and terrible weather.

8 Pilot sick today. Feeling better late afternoon, aircraft float leaking air-held up to repair same. Attempted BLM-rain/wind couldn't land.

9 Pilot sick A.M., feeling better afternoon: Helicopter governor problems more delay. Attempted BLM: Rain/wind got stuck overnight in helicopter by falling ceiling and wind.

10 Pilot sick after returning to King Salmon.

11 Pilot sick/weather bad

12 Pilot sick/weather bad

13 Pilot OK/Helicopter broke during run-up (Hydraulic leak) then voltage regulator failure then linear actuator failure. Ordered parts.

14 Parts arrive late afternoon: Visit station BMT-completed service

15 Visit station YCB: Got called off station by F.A.A. requesting use of aircraft for search and rescue effort. Returned YCB, completed service. PNM-problems locating station, getting dark when we arrived-did not complete service. Helicopter must be returned for service/inspection.

22 Arrive Kodiak/problems with helicopter/didn't arrive today.

23 Aircraft not in Kodiak

24 Aircraft not in Kodiak (fuel leak)

25 Aircraft not in Kodiak/chartered fixed wing to drop batteries and heavy hardware.

| | | |
|---|---|---|
| July | 26 | Aircraft not in Kodiak/chartered fixed wing to drop other batteries and hardware. |
| | 26 | Helicopter from Homer arrives late P.M. Visit station Spruce Island, Cape Chiniak, UGAK island: Drop batteries and heavy hardware. Ran out of daylight. |
| | 27 | Visit stations: DMB-completed service, SII-completed service, SKD completed service but transmitter has low power output. UGK-completed service. |
| | 28 | Terrible weather most part of day. Visit stations SPL-completed service, MMC-completed service, RAI- completed service. |
| | 29 | Visit stations. SHU-completed service, Spruce Island-cleared landing area, completed station service. |
| | 30 | Weather bad all day-can not fly. |
| | 31 | Problem with helicopter voltage regulator loose most of day ≈ 3 P.M. visited SKD and replaced transmitter with another with better power output visited UGK to install new receiver from SKD. |
| Aug | 1 | Visit station CHI-completed service however seismometer was damaged during relocation and broke our spare while unloading equipment from aircraft. Service visit complete. |
| Aug | 17 | Arrive Homer |
| | 18 | Depart Homer for Kodiak to do island stations/weather goes bad enroute turn back at SII but drop batteries and heavy hardware there. |
| | 19 | Weather bad all day. |
| | 20 | High winds and turbulence attempted flight to SitKiniak-turned back. |
| | 21 | Visit station: CHO completed service, CHI completed service |
| | 22 | Weather bad all day. |
| | 23 | Visit station SII-installed strong motion equipment, reset levels from CHI station receiver. |
| | 23 | SKD visit-replaced VCO unit that was putting harmonics into the circuit. |
| | 23 | SHU visit-installed new equipment fiberglass box to replace rusted container there, also new VCO and transmitter. |

Aug 31 Met NOAA chopper in Kenai-visit station AUP-removed equipment. Installed new station AUH and serviced, AUF-serviced station but receiver from AUH is very noisy. AUK-replaced bad receiver

Sept 1 Visit station: RED-completed service, returned AUH and replaced transmitter, returned AUF and replaced receiver for AUH.

2 CDA visit: (repaired station which was destroyed by a bear). PUB visit: reset levels from MMC receiver.

3 Weather bad attempted PNM, too much rain and fog to service electronic equipment.

4 MRS visit-station OK, confidence check (have been receiving erratic signals).

PNM: Serviced station, YCB: Relocated seismometer and reset levels. BLM: Reset all receiver levels and balanced mixers.

B. Scientific Parties

| | |
|---|---|
| Augustine Volcano: June 19-28, 1978 | J. Kienle, Co-Principal Investigator, U. of Alaska<br>J. Whitney, U.S.G.S. Conservation Division, Anchorage<br>M. Lynch, U.S.G.S. Conservation Division, Anchorage<br>D. Thurston, U.S.G.S. Conservation Division, Anchorage |
| Augustine & Redoubt Volcanoes: Aug. 31-Sept. 2, 1978 | J. Kienle, Co-Principal Investigator, U. of Alaska<br>R. Foster, Technician, U. of Alaska |
| Redoubt Volcano: July 3-13, 1978 | R. Motyka, Graduate Student, U. of Alaska<br>P. MacKeith, Graduate Student, U. of Alaska<br>R. March, Field Assistant, U. of Alaska |
| Sept. 11-16, 1978: | J. Kienle, Co-Principal Investigator, U. of Alaska<br>C. Benson, Glaciologist, U. of Alaska<br>R. Forbes, Petrologist, U. of Alaska<br>P. MacKeith, Graduate Student, U. of Alaska |

Seismic Station Service

| | |
|---|---|
| Jun 26 to Jul 3: | R. Foster, Electronic Technician<br>S. Estes<br>J. Pender; Student help |
| Jul 4 to Jul 16: | R. Foster<br>J. Pender |
| Jul 22 to Aug 1: | R. Foster<br>J. Pender |
| Aug 17 to Aug 23: | R. Foster |
| Aug 31 to Sept 2: | J. Kienle<br>R. Foster |
| Sept 2 to Sept 4: | R. Foster |

C. Methods

The Redoubt and Augustine studies involved petrologic sampling, sample collection for $C^{14}$ age dating, tree coring, offshore dredging, temperature logging of pyroclastic flow drill hole, installation of glacier ablation poles, surveying.

D. Sample Locations

Augustine and Redoubt Volcanoes, Cook Inlet.

IV. and V. Results and Preliminary Interpretation:

A. Volcanology

Augustine Volcano: One of the principal geologic hazards offshore Augustine Volcano are pyroclastic avalanches and associated nueés ardentes (glowing clouds). Virtually all of the terrane lying between the 500 foot contour line and the seashore at Augustine's western, northern and eastern flank consists of pyroclastic avalanche debris. Federal OCS lease sale blocks lie only 3 miles (4.8 km) from the eastern shore line of Augustine Island and blocks 10 km offshore were leased during the recent sale.

Three lobate, hummocky bathymetric features, that morphologically resemble the Burr Point (north shore) pyroclastic avalanche terrane, can be seen to extend about 2 to 4 km offshore on the northeastern and southwestern flanks of Augustine Volcano and 2.5 km off the Northwest Island (NOS-NOAA hydrographic survey H-9073, Vicinity of Augustine Island, advance information data sheet, subject to office review). The same data sheet also reveals a large, flat wedge-shaped submarine platform that extends 8 km offshore, west of the island and seems to be bound by an erosional scarp.

In June, 1978, a joint field team of U.S. Geological Survey geologists from the Conservation Division, Anchorage Office and the University of Alaska investigated the suspected offshore pyroclastic avalanches on the east side of Augustine and tried to establish their relationship to onshore pyroclastic avalanche outcrops. Dredging material from the hummocky terrane offshore with a home-made small dredge and using a Zodiac raft proved to be not very successful. The few small pebbles that were recovered, however, were all andesitic. Later, ocean bottom TV footage acquired aboard the Sea Sounder (OCSEAP, RU 327) showed very active sea life in rough hummocky terrane, that we interpret to be the distant end of pyroclastic avalanches. However, to date, we still do not have a representative rock specimen from the offshore flows confirming their suspected volcanic nature. Onshore, the eastern coast of Augustine, in contrast to the western shoreline, consists of a steep erosional scarp with good outcrop, about 50 feet (15 m) high. These outcrops have been mapped by Detterman (1973) as andesitic to rhyodacitic lava flows but we found them to be andesitic-dacitic debris avalanches and lahars that could well be the onshore equivalents of the suspected offshore avalanches. The flows were overlain by a well developed soil profile. We recovered old wood from the pyroclastic flow - soil layer interface, which we have submitted for $C^{14}$-dating. This date should give us a minimum age of the underlying debris flow unit.

We also extracted 10 wood cores from Sitka spruce trees growing on pyroclastic avalanches and lahars on the northwestern and western shoreline of the volcano in an attempt to establish a minimum age for these flows. The samples are now being processed.

Unfortunately, we had no time or funds to investigate the large submarine platform that extends 8 km offshore west of the volcano. This platform could be of glacial, sedimentary or volcanic origin. If it is volcanic it is probably different from the debris flows discussed above. The material that makes up the platform is less chaotic and seismically quite transparent. It is possible that this platform represents volcanic flow material (basalts, hyaloclastites or ash flows) that was deposited in the earlier eruptive history of the volcano. David Johnston from the U.S. Geological Survey's Field Geochemistry and Geophysics Branch, Menlo Park, California, this year discovered the first basaltic material that was ever found on Augustine. He discovered three outcrops of hyaloclastites, implying subaqueous emplacement, on the southern flank of Augustine.

How far offshore pyroclastic flow associated nueés ardentes (glowing clouds with temperatures of order 600 to 800°C and velocities of order 150-200 km/hr) would travel is difficult to assess. Mt. Pelée on Martinique Island, West Indies, is morphologically and in terms of its eruptive style very similar to Augustine Volcano. During the 1902 eruptions, glowing clouds obliterated the city of St. Pierre and all of its 30,000 inhabitants. Anderson and Flett (1903) report that several glowing clouds travelled as far as about 5 miles (8 km) offshore after travelling 4 miles (6.5 km) down the 4428 foot high flank of the volcano (Augustine's summit is now, after 1976 eruptions, 4100 feet high).

In summary, we find that most historic and recent prehistoric debris flows at Augustine travelled to distances of about 7 to 10 km from the summit. Submarine flows extend to distances of 2 to 4 km from the shoreline on the east side of the island and of 2.5 km from the shoreline of the Northwest Island. A very large platform of unknown, but possibly volcanic origin extends about 8 km offshore on the west side of the volcano. Since this platform is such a major feature of the Augustine structure we feel it should be investigated next year. Based on comparisons with a similar volcano in the West Indies (Mt. Pelée) glowing clouds (temperature 600-800°C, velocity 150-200 km/hr) associated with the pyroclastic debris avalanches could easily travel to distances of 15 km from the summit vent or 10 km (6.2 miles) offshore on the northeast side of the volcano, i.e., just reaching recently sold leases.

Redoubt Volcano: Unlike Augustine Volcano, the much higher peak of Redoubt (10,197 feet) is heavily glaciated. The principal hazards of this volcano are flash floods. During the January, 1966, eruptions excessive meltwater accumulated in the summit crater (1 x 1.6 km in size, at an elevation of 8,000 to 8,500 feet) and then drained catastrophically. The crater water outburst caused the Drift River to break up in mid-winter and 2 separate flash floods reached the mouth of the river. Such flooding poses a threat to the Drift River Tanker Terminal.

Another hazard arises from the fact that the glacier that descends from the summit crater due north, henceforth called the "North Glacier", could dam up the Drift River. If an advance occurs, the valley would get blocked creating a lake that could drain catastrophically.

The glaciologic study of the past summer was an effort to assess the state of the North Glacier. In early July a party of three installed an array of 15 survey stakes over the lower portion of the glacier where it begins to fan out. In addition, 2 baseline benchmarks and 4 photo-control points were established in the area. In late July, North Pacific Aerial Surveys obtained vertical photo coverage of the North Glacier, which will be used to construct a detailed topographic map of the glacier.

Most of the glacier is heavily covered with surface moraine and volcanic ejecta but it was possible to install a horizontal ablation stake in the river cut wall of ice at the terminus.

A party of four revisited to North Glacier terminus in September to resurvey the glacier terminus, the 15 survey stakes and to measure the baseline. The resurvey gave us the first data on the glacier movement of the lower 3 km over a period of about 2 months (Figure 1).

The dynamics of a glacier are not constant throughout the year but usually show the fastest motion and almost all the ablation during the summer months. Therefore, our survey covering early July to middle of September does not give a complete picture of the state of the North Glacier. We intend to resurvey the glacier next summer (1979).

Ablation: Most of the terminus lobe is covered with a layer of moraine and volcanic ejecta often up to 2 m thick. Under these conditions no direct ablation measurements were possible. However, near the river and at the ice fall (Figure 1) measurements were taken. The former showed that the vertical ice cliff melted back 4.4 m, while at the latter a pole that in July was sunk 4 m into the ice had melted out completely by September.

Horizontal ice motion: In all parts of the lowest 1.5 km, the motion was between 2 and 3 m/yr (.33 to .5 m measured in 2 months). At a distance of 2.5 km from the river it was 66 m/yr on the west side and 2 m/yr on the east side, while at the icefall, 3 km from the river, one stake recorded a motion of 192 m/yr.

Vertical ice motion: In direct correspondence with the above results, the areas of slowest motion showed that the ice was thinning while the area of faster movement on the west side was thickening.

Interpretation: The rate of melting at the terminus is 4.4 m horizontally, which at the moment is balanced by an about 3 m per year advance. This is supported by the observation that the ice in the lower 1.5 km seems to be thinning. However, the effect on the glacier of the 1966 eruption has not yet reached the lower portions of the glacier and we must observe ice motion and thickening higher up. On the west side of a rock outcrop near the icefall (Figure 1), there is sufficient motion to transport a large quantity of ice. The effect is showing at stakes C1 and C2. This area must be carefully watched in successive years to determine whether or not a pulse or wave of ice is travelling down glacier that might eventually reach the glacier terminus. Since it is impossible to install stakes higher up the glacier because it is totally broken up, we need to follow glacier motion above the icefall (2,000 foot level) by repeated aerial photography.

Based on our ground geodetic surveys of the summit crater in July 1977, North Pacific Aerial Surveys has now produced a preliminary photogrammetric ice surface map (1:3,000) of the Redoubt Crater and North Glacier down to an elevation of 3,000 feet. Future mapping is planned to link up the high and low level surveys.

Comparisons are being made between 1977 aerial photography and 1954 U.S.G.S. photography to determine changes which have occurred due to the eruption in 1966.

Simultaneous with the glaciologic field work in September petrologic handspecimens were collected from the lower (below 4,000 feet) northern and western flanks of the volcano. Poor weather prohibited any collections higher on the volcano. Thin sections are now being prepared for petrologic analysis.

## References

Anderson, T. and J. S. Flett, 1903, Report on the eruptions of the Soufriere, in St. Vincent, in 1902, and on a visit to Montagne Pelee, in Martinique - Part 1, Phil. Trans. of the Royal Soc. of London, Series A, Vol. 200, pp. 353-553, p.

Detterman, R. L., 1973, Geol. Map of the Iliamna B-2 Quadrangle, Augustine Island, Alaska.

## B. Seismicity

Only routine data analysis was performed during the report period, on account of the emphasis that was put upon the servicing of the seismic network. Monthly epicenter maps and hypocenter listings are given for the time period, June through August 1978 in Appendix 1 and 2, respectively. Seismicity does not show any unusual occurances. Cummulative epicenter maps for the time period January through June 1978 are also given in Appendix 1. These confirm the general seismicity picture derived from previous years:

1. High level shallow (0-50 km) seismic activity, off the south coast of Kodiak Island. The cluster of events (Fig A1-1) there is largely due to the M=5.8 event of April 12, 1978 and its aftershocks.

2. High level intermediate depth (50-150 km) seismic activity in the Mt. Illiamna area.

3. High level of micro seismic activity in the area of the Ukinrek Naars. This activity occurs in a swarm type fashion usually lasting for a few days. An extremely intense swarm occurred in July 1978, when 75 events occurred on July 12 and July 13. The largest of the events was one of magnitude 2.5.

4. Shallow micro earthquake activity volcanoes such as Snowy Mt., Magiek and Mt. Katmai. Augustine Volcanoe, however, has been essentially devoid of any activity.

Appendix 1

Epicenter Location Maps

This appendix shows plots of epicenters for January 1978 and February 1978. Triangles with three-letter codes show the locations of seismic stations. The one-letter code shows the epicenter location with the following depth code:

| | |
|---|---|
| A | $0 \leq 25$ |
| B | $26 \leq 50$ |
| C | $51 \leq 100$ |
| D | $101 \leq 125$ |
| E | $126 \leq 150$ |
| F | $151 \leq 175$ |
| G | $176 \leq 200$ |
| etc. | |

The size of the letters is proportional to the magnitude of the event. The size of the numerals giving ten geographic coodinate corresponds to magnitude 2.

The following is a list of figures:


| Figure | Caption |
|---|---|
| A1-1 | Alaska Peninsula-Kodiak, all events, January-June 1978 |
| A1-2 | Alaska Peninsula-Kodiak, Class 1 events, January-June 1978. |
| A1-3 | Cook Inlet, all events, January-June 1978 |
| A1-4 | Cook Inlet class 1 events, January-June 1978 |
| A1-5 | Alaska Peninsula-Kodiak June 1978, all events |
| A1-6 | Alaska Peninsula-Kodiak, July 1978 all events |
| A1-7 | Alaska Peninsula-Kodiak, August 1978, all events |
| A1-8 | Cook Inlet, June 1978, all events |
| A1-9 | Cook Inlet, July 1978, all events |
| A1-10 | Cook Inlet, August 1978, all events |

UNIVERSITY OF ALASKA

LOWER COOK INLET, KODIAK ISLAND,

AND ALASKA PENINSULA SEISMIC NETWORK

JULY 1978

| STATION NAME | CODE | LATITUDE (NORTH) | LONGITUDE (WEST) | ELEVATION (METERS) | COMPONETS |
|---|---|---|---|---|---|
| AUGUSTINE IS. FLOW | AUF | 59 23.27 | 153 27.45 | 166 | SPZ |
| AUGUSTINE IS. KAMISHAK | AUI | 59 20.05 | 153 25.62 | 259 | SPZ |
| AUGUSTINE IS. MOUND | AUM | 59 22.26 | 153 21.17 | 106 | SPZ |
| AUGUSTINE IS. DOME H | AUH | 59 21.73 | 153 25.23 | 1033 | SPZ |
| BLUE MOUNTIAN | BLM | 58 02.8 | 156 20.2 | 548 | SPZ |
| CAPE DOUGLAS | CDA | 58 57.32 | 153 31.77 | 386 | SPZ |
| CHIRIKOF ISLAND | CHI | 55 48.5 | 155 38.6 | 250 | SPZ |
| CHOWIET ISLAND | CHW | 56 02.0 | 156 42.7 | 160 | SPZ |
| DEADMAN BAY | DMB | 57 05.23 | 153 57.63 | 300 | SPZ |
| FEATHERLY PASS | FLP | 57 42.7 | 156 15.9 | 485 | SPZ |
| HOMER | HOM | 59 39.50 | 151 38.60 | 198 | SPZ |
| MAARS | MRS | 57 51.40 | 153 04.82 | 131 | SPZ |
| MCNEIL RIVER | MCN | 59 06.06 | 154 11.99 | 273 | SPZ |
| MIDDLE CAPE | MMC | 57 20.00 | 154 38.1 | 340 | SPZ |
| OIL POINT | OPT | 59 39.16 | 153 13.78 | 625 | SPZ |
| PINNACLE MOUNTIAN | PNN | 56 48.3 | 157 35.0 | 442 | SPZ |
| PUALE BAY | PUB | 57 46.4 | 155 31.0 | 280 | SPZ |
| RASPBERRY ISLAND | RAI | 58 03.63 | 153 09.55 | 520 | SPZ |
| REDOUBT VOLCANO | RED | 60 25.14 | 152 46.32 | 1067 | SPZ |
| SHUYAK ISLAND | SHU | 58 37.68 | 152 20.93 | 34 | SPZ |
| SITKINAK ISLAND | SII | 56 33.60 | 154 10.92 | 500 | SPZ,SPE-W |
| SITKALIDAK ISLAND | SKD | 57 09.85 | 153 04.82 | 135 | SPZ |
| SPIRIDON LAKE | SPL | 57 45.55 | 153 46.28 | 600 | SPZ |
| UGASHIK LAKE | UKL | 57 24.1 | 156 51.3 | 410 | SPZ |
| YELLOW CREEK BLUFF | YCB | 56 38.9 | 158 40.9 | 320 | SPZ |



Table 1

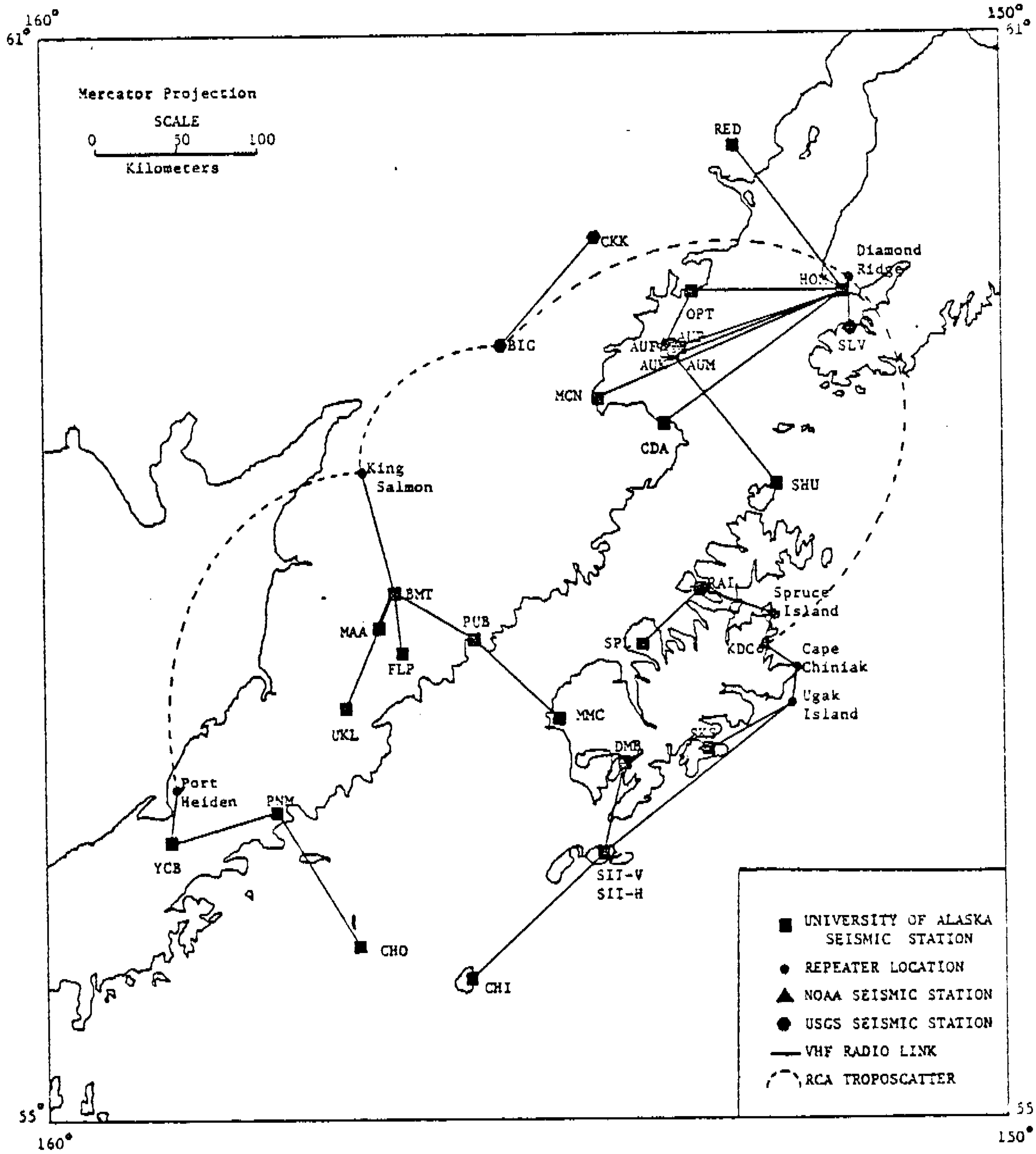





Fig. 1. Layout of Seismic system before 1978 annual service

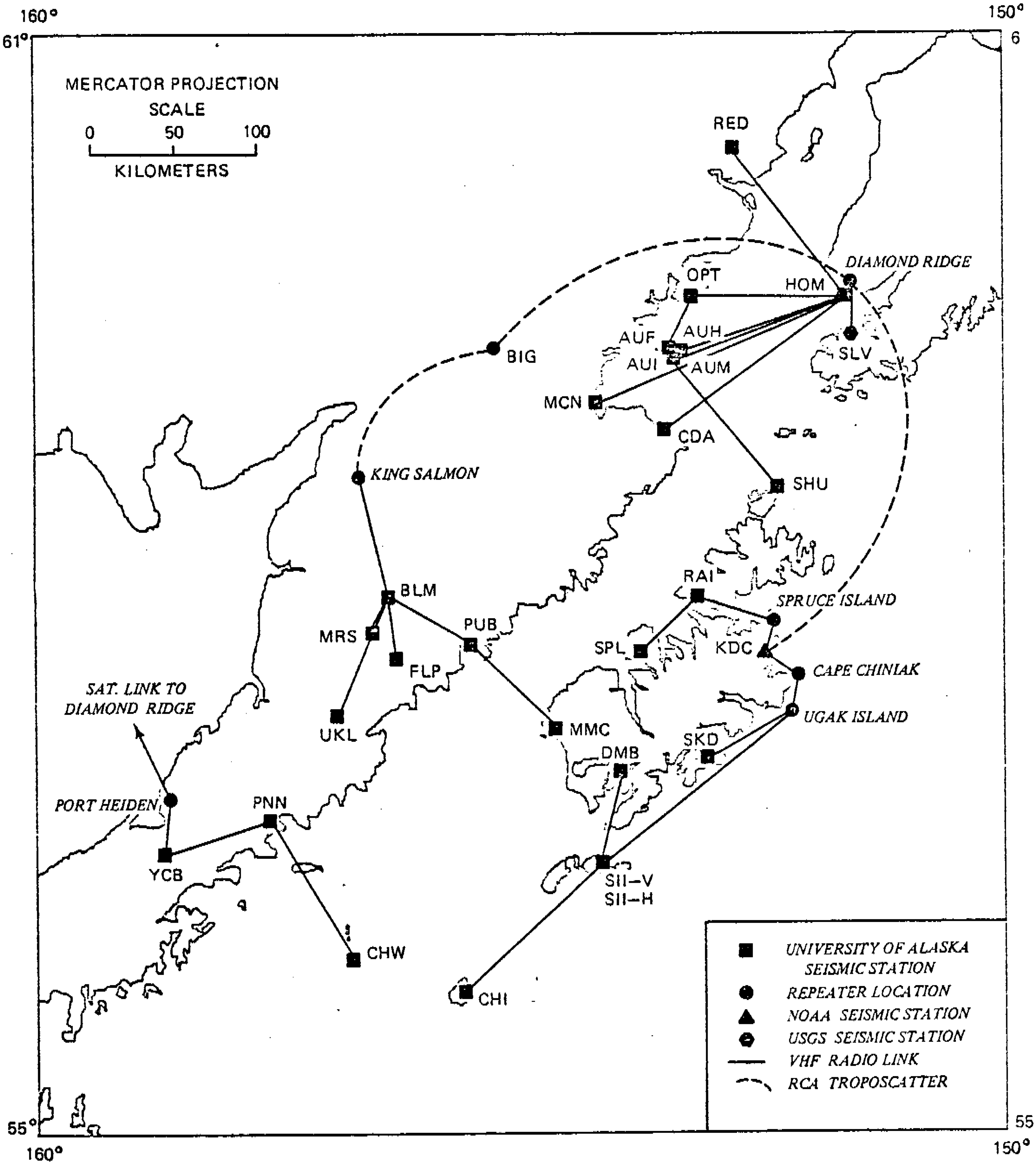





Fig. 2. Layout of Seismic system after 1978 annual service

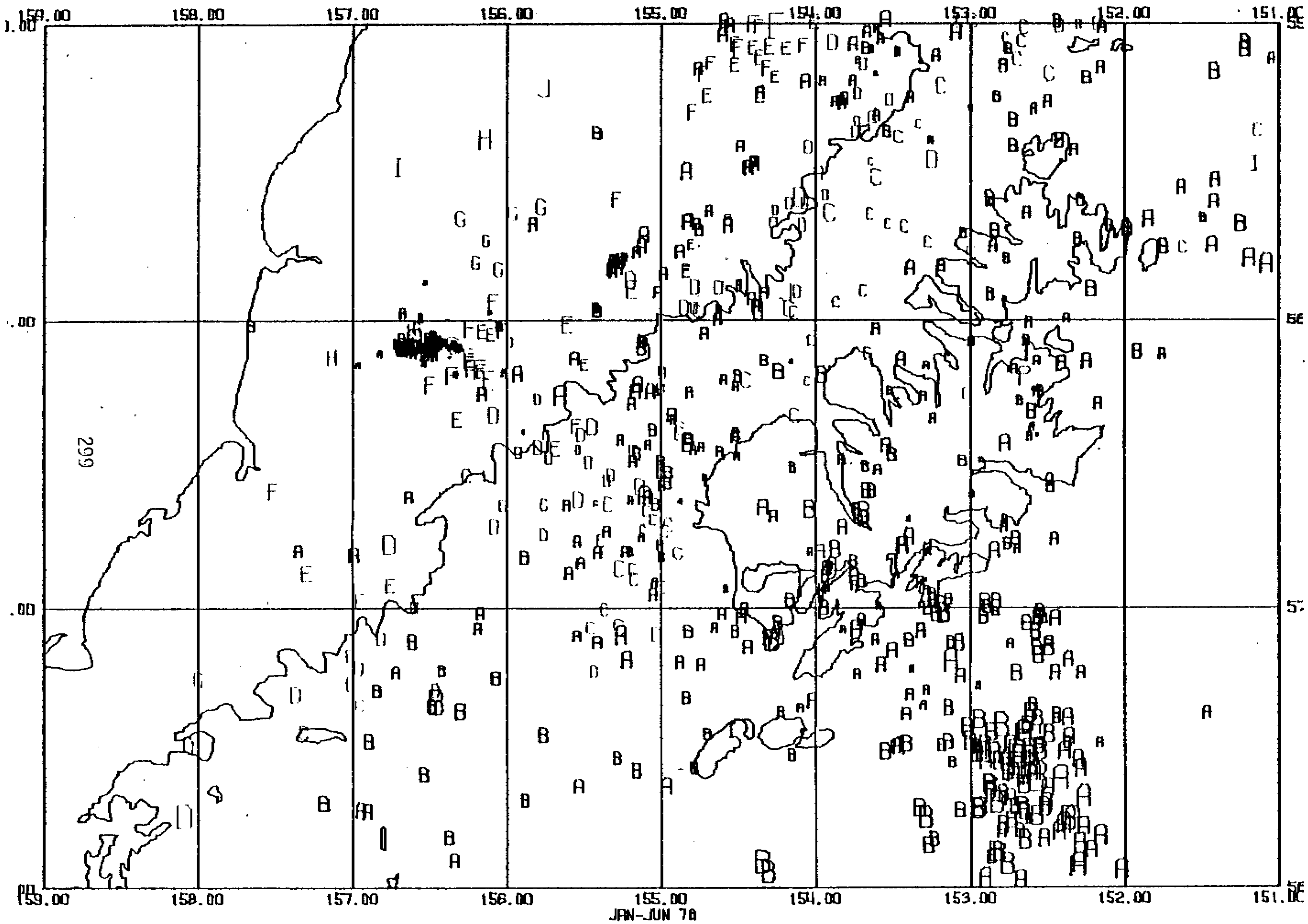
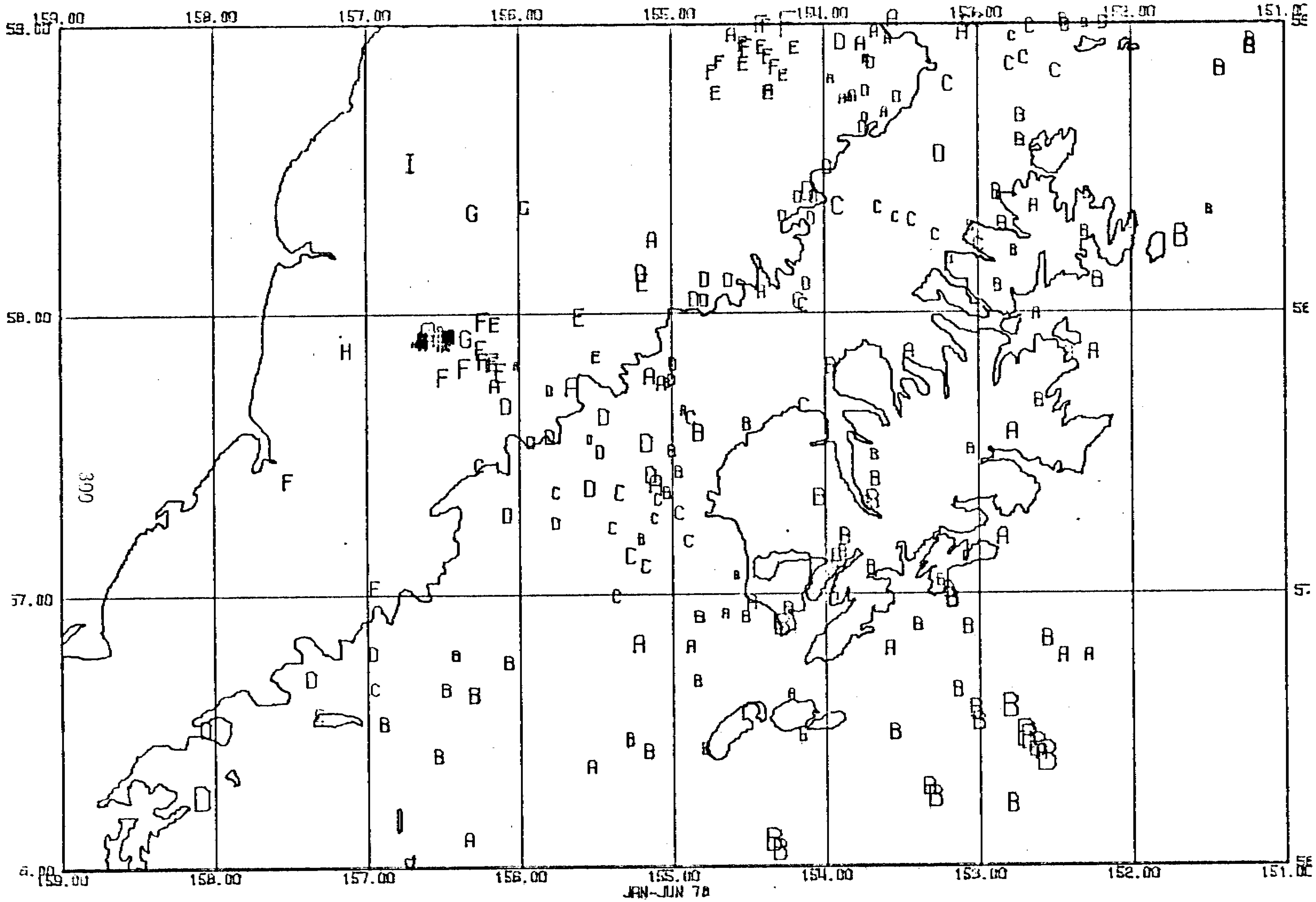



Fig. A 1-1, Epicenter Map, Alaska Peninsula, January-June 1978, all locatable events




300

Fig. A 1-2. Epicenter Map, Alaska Peninsula-Kodiak, January-June 1978, class 1 events

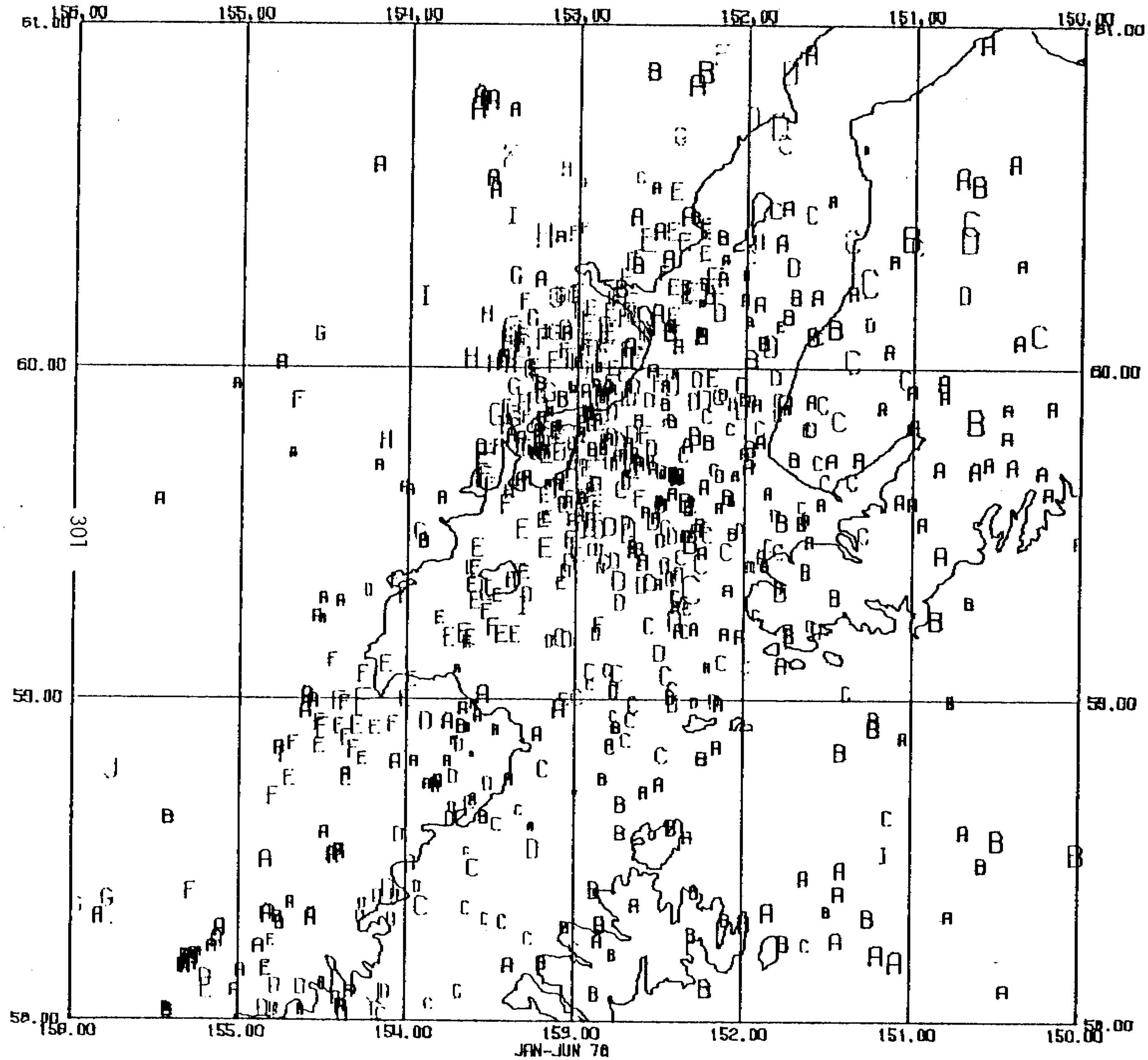



Fig. A 1-3, Epicenter Map, Cook Inlet, January-June 1978 all locatable events

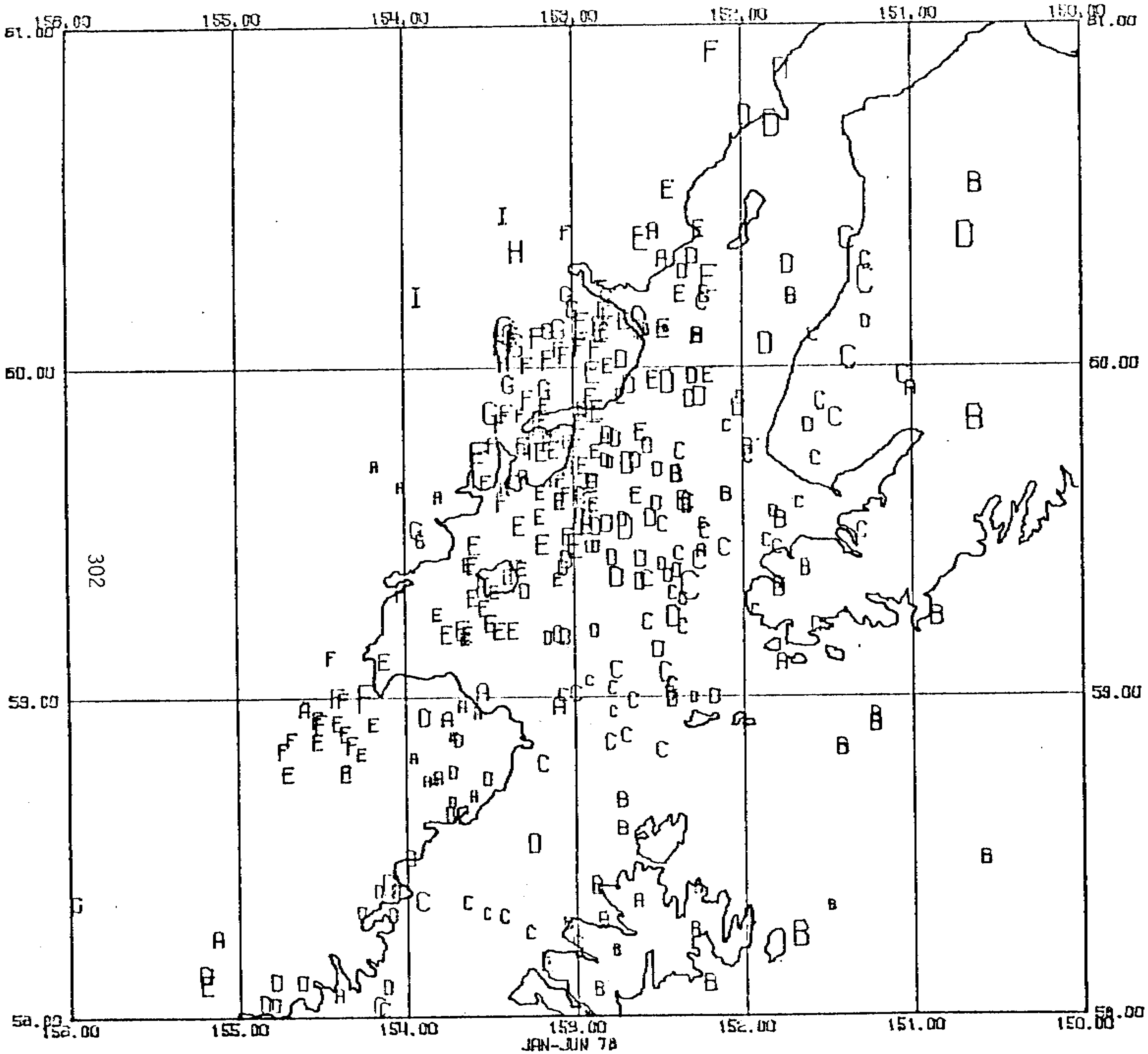
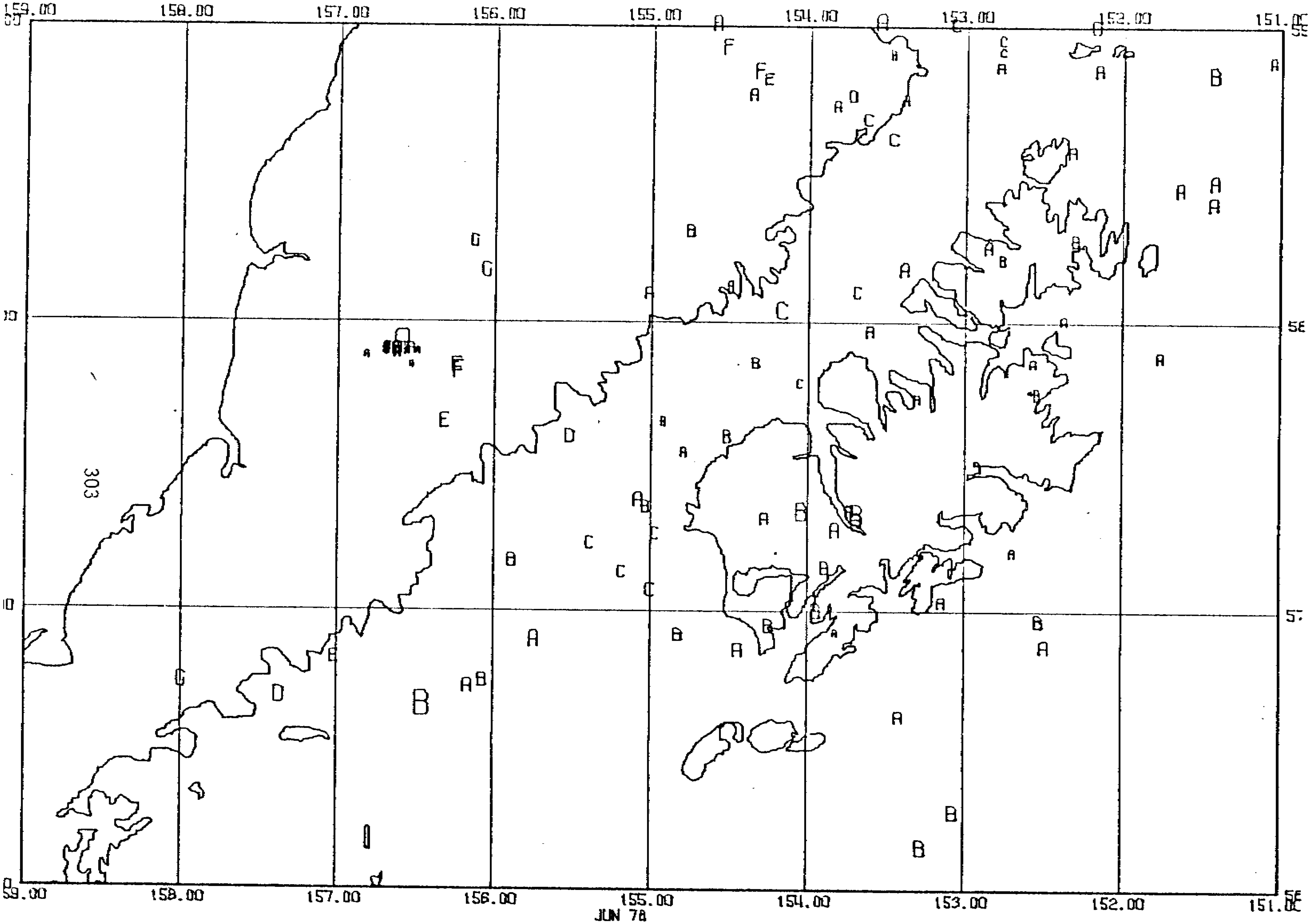



Fig A 1-4, Epicenter Map, Cook Inlet, January-June 1978, class 1 events




303

Fig. A 1-5, Epicenter Map, Alaska Peninsula-Kodiak, June 1978, all locatable events

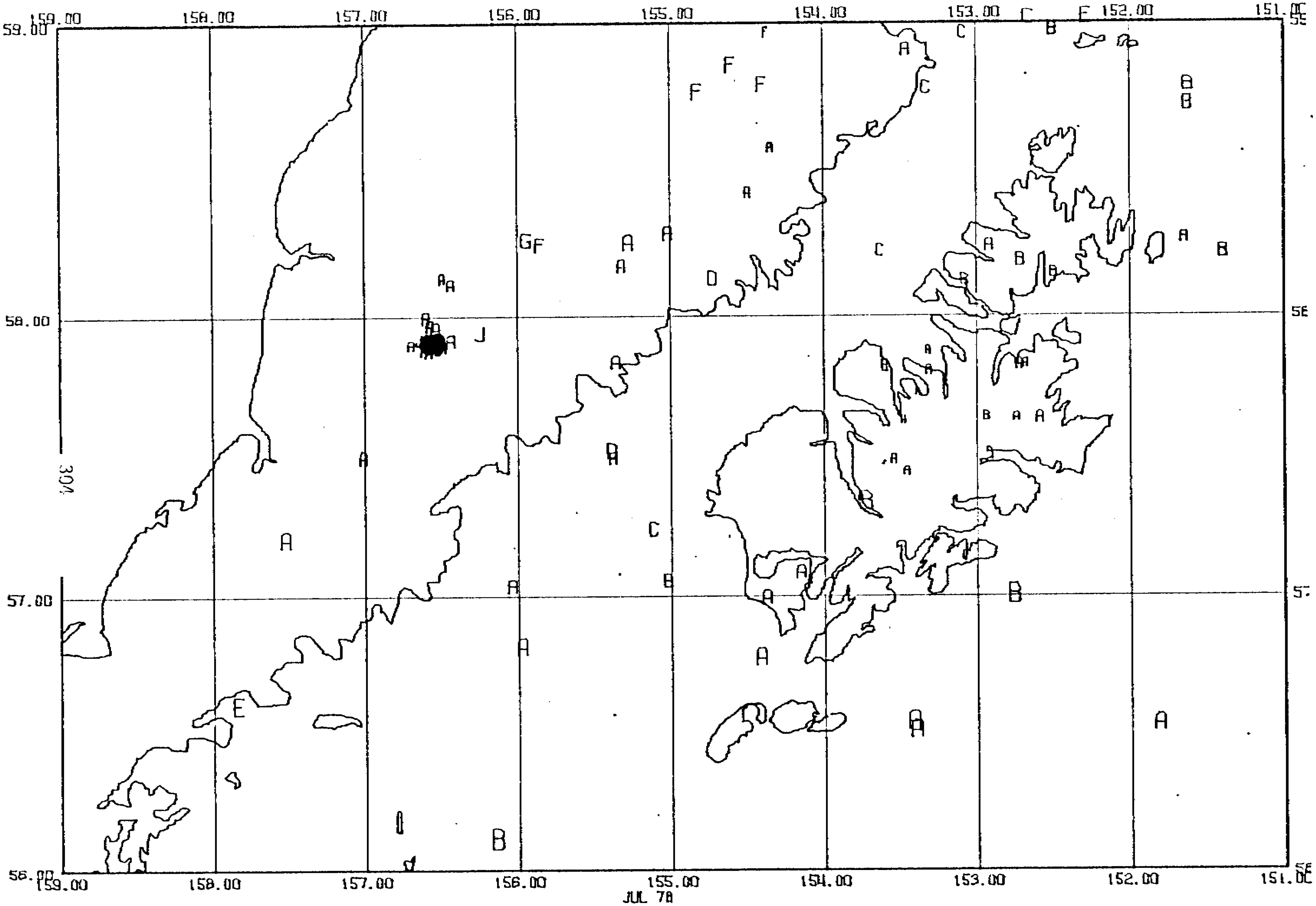



Fig. A 1-6, Epicenter Map, Alaska Peninsula-Kodiak, July 1978, all locatable events

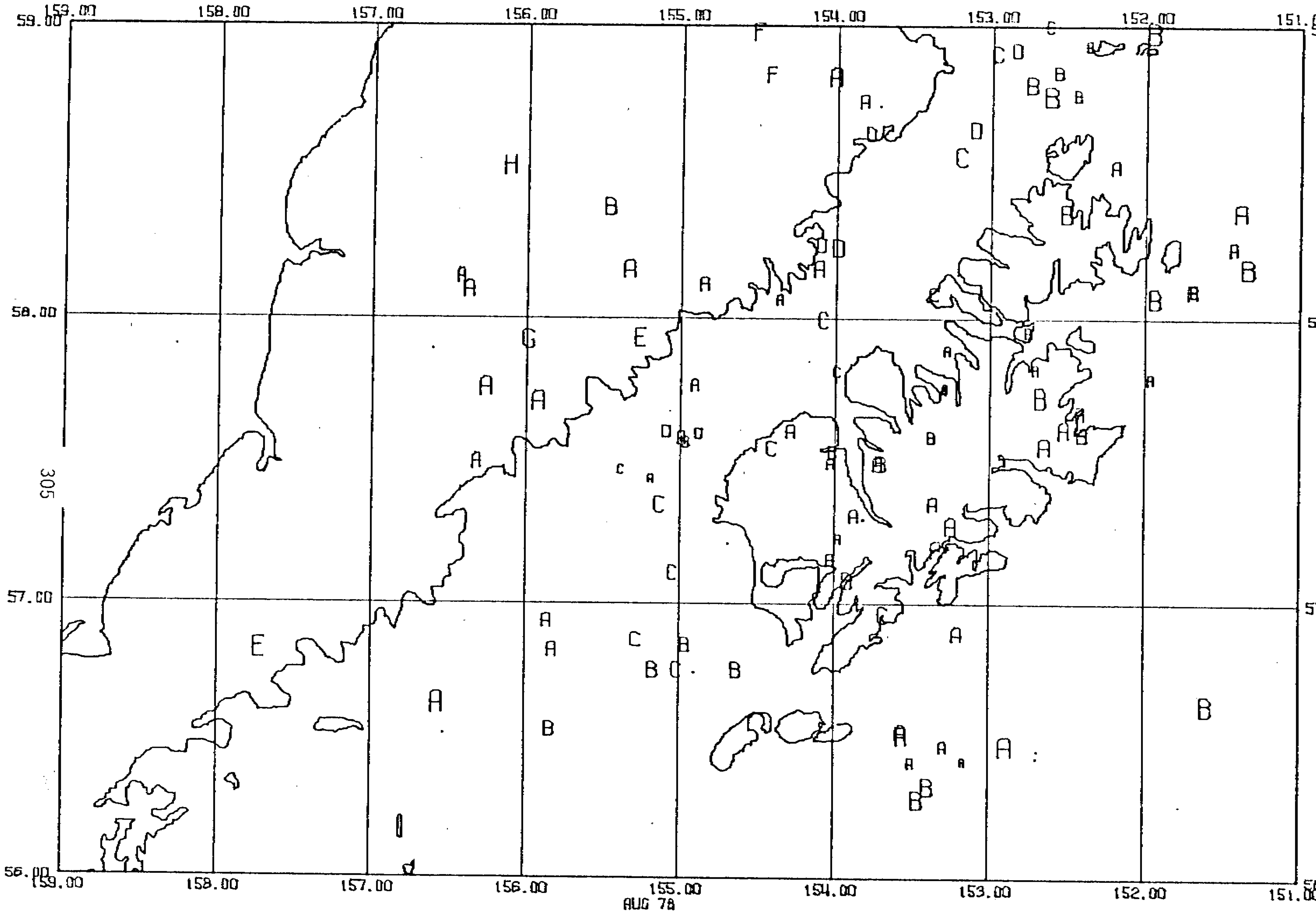



Fig. A 1-7, Epicenter Map, Alaska Peninsula-Kodiak, August 1978, all locatable events

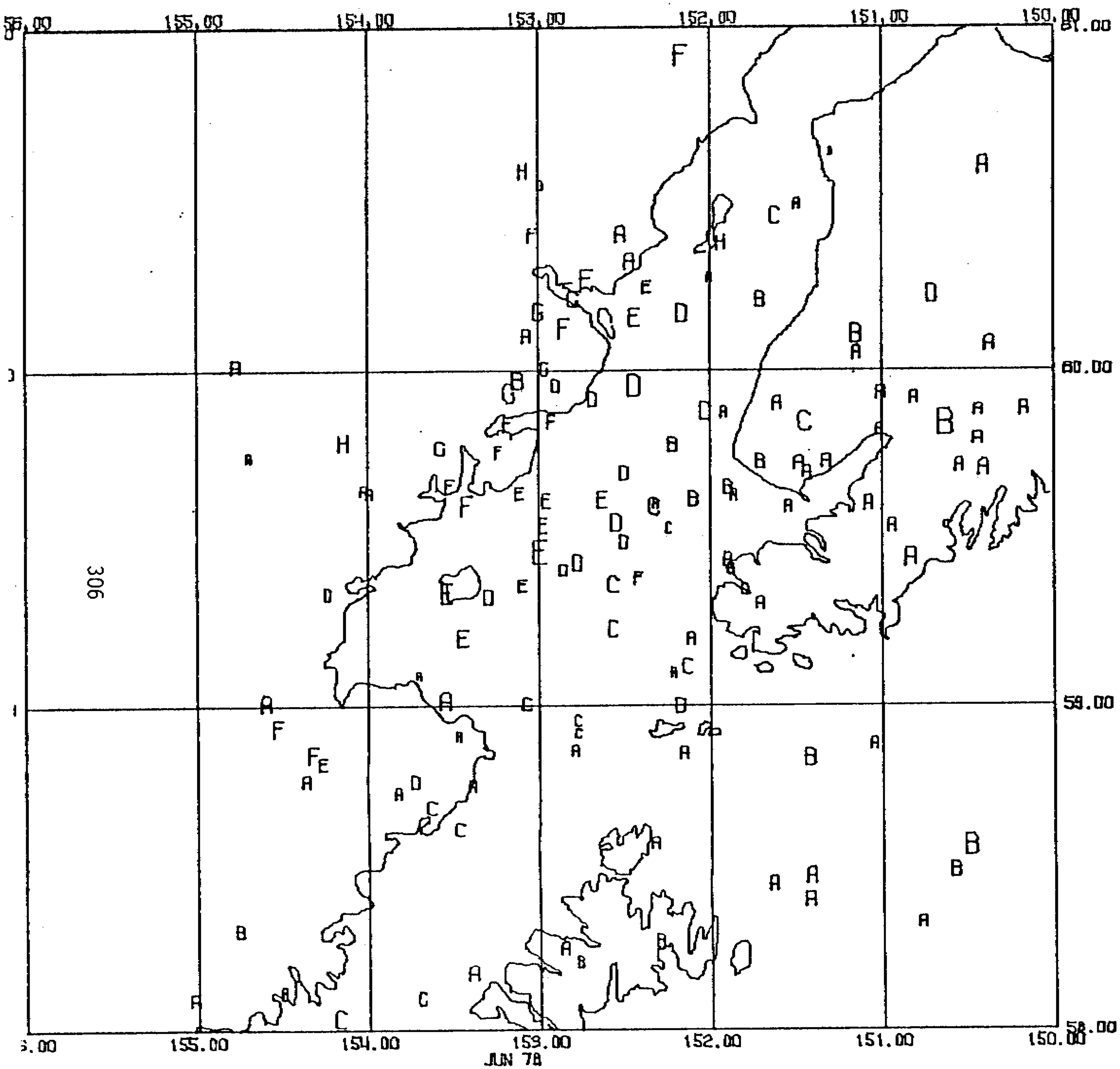



Fig. A 1-8, Epicenter Map, Cook Inlet, June 1978, all locatable events

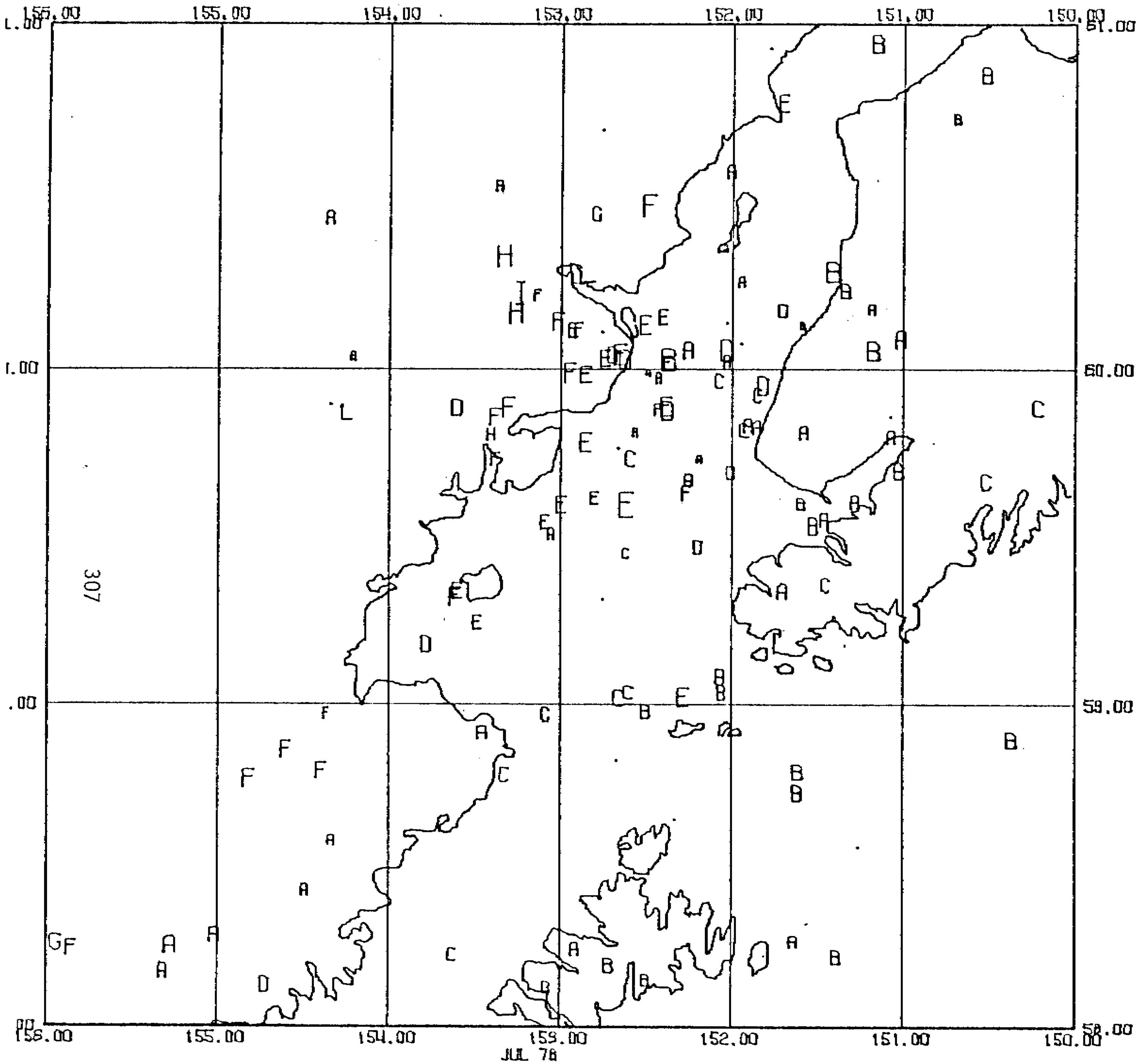



Fig. A 1-9, Epicenter map, Lower Cook Inlet, July 1978, all locatable events

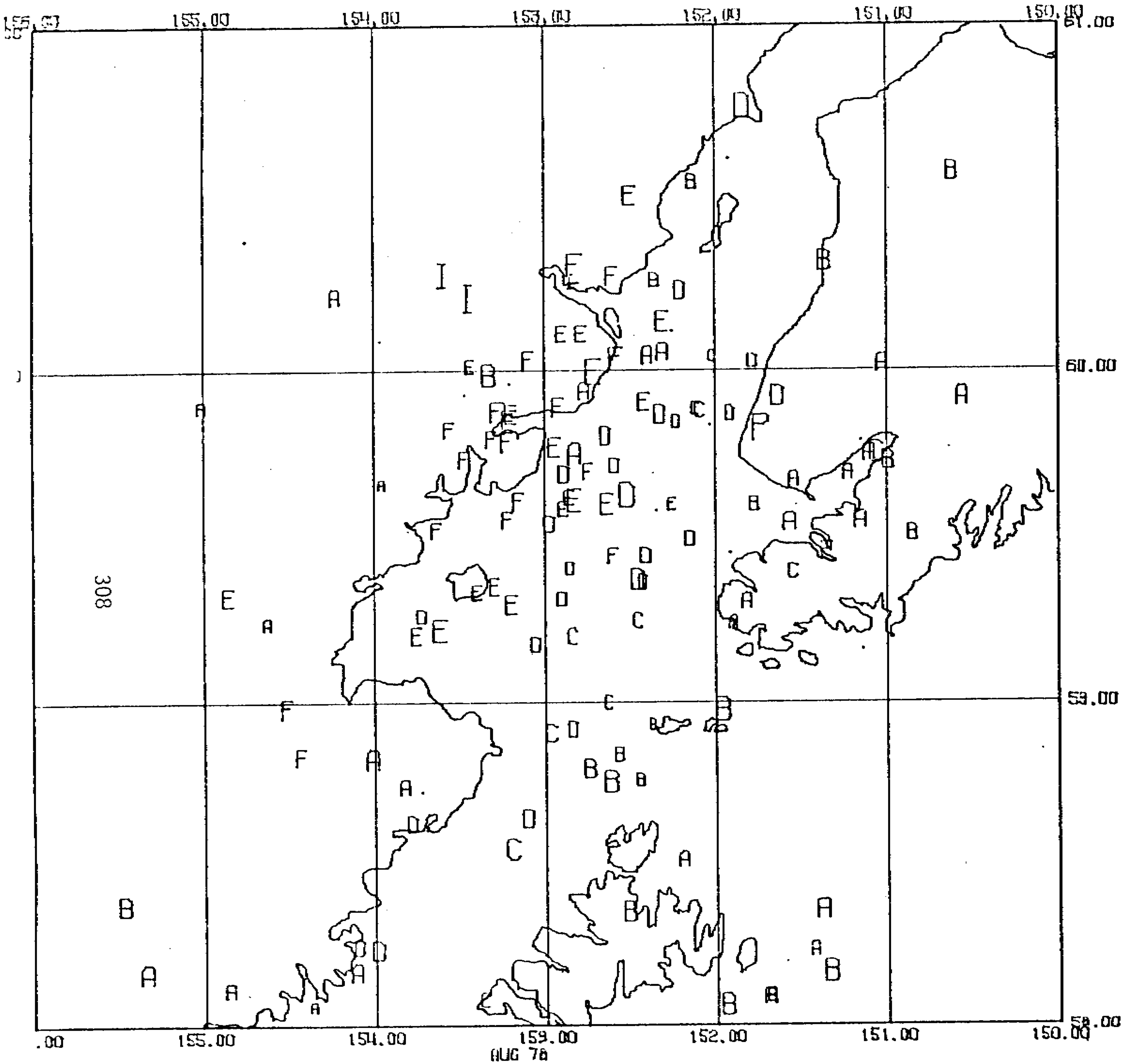



Fig. A 1-10, Epicenter Map, Lower Cook Inlet August 1978, all locatable events

Appendix 2

Hypocenter Listings for Cook Inlet,
Kodiak, and Alaska Peninsula

Table A1-1 All Events

June-August, 1978

This appendix lists origin times, focal coordinates, magnitudes, and related parameters for earthquakes which occurred in the lower Cook Inlet, Kodiak, and Alaska Peninsula areas. The following data are given for each event:

(1) Origin time in Greenwich Civil Time (GCT): date, hour (HR), minute (MN), and second (SEC). To convert to Alaska Standard Time (AST), subtract ten hours.

(2) Epicenter in degrees and minutes of north latitude (LAT N ) and west longitude (LONG N).

(3) DEPTH, depth of focus in kilometers.

(4) MAG, magnitude of the earthquake. A zero means not determined.

(5) NO, number of P arrivals used in locating earthquake.

(6) GAP, largest azimuthal separation in degrees between stations.

(7) DM, epicentral distance in kilometers to the closest station to the epicenter.

(8) RMS, root-mean-square error in seconds of the travel time residuals:

$$RMS = \sum_i (R^2_{Pi} + R^2_{Di}) / (NP + NS)$$

Where $R_{Pi}$ and $R_{Si}$ are the observed minus the computed arrival times of P and S waves, respectively, at the i-th station.

(9) ERH, largest horizontal deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the epicentral precision for an event.

(10) ERZ, largest vertical deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the depth precision for an event.

(11) Q, quality of the hypocenter. This index is a measure of the precision of the hypocenter and is the average of two quantitites, QS and QD, defined below:

| QS | RMS (sec) | ERH (km) | ERZ (km) |
|---|---|---|---|
| A | < 0.15 | ≤ 1.0 | ≤ 2.0 |
| B | < 0.30 | ≤ 2.5 | ≤ 5.0 |
| C | < 0.50 | ≤ 5.0 | |
| D | Others | | |

QD is rated according to the station distribution as follows:

| QD | NO | GAP | DMIN |
|---|---|---|---|
| A | ≥ 6 | ≤ 90° | ≤ DEPTH or 5 km |
| B | ≥ 6 | ≤ 135° | ≤ 2x DEPTH or 10 km |
| C | ≥ 6 | ≤ 180° | ≤ 50 km |
| D | Others | | |

The following table is included:

Table A1-1 Cook Inlet, western Gulf of Alaska
All Events

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | ORIGIN HR | MN | TIME SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUN 1 | 10 | 9 | 34.5 | 58 | 35.7 | 153 | 29.4 | 53.9 | 2.5 | 4 | 276 | 62 | 0. | 0. | 0. | C |
| 1 | 12 | 33 | 0.3 | 59 | 42.1 | 151 | 30.3 | 1.1 | 2.3 | 5 | 249 | 97 | 0.32 | 12.0 | 719.9 | D |
| 1 | 18 | 54 | 57.8 | 60 | 33.5 | 151 | 55.1 | 33.1 | 2.3 | 4 | 279 | 49 | 0.13 | 0. | 0. | C |
| 1 | 21 | 25 | 22.1 | 57 | 59.6 | 152 | 23.2 | 5.0 | 1.5 | 3 | 274 | 28 | 0.34 | 0. | 0. | D |
| 2 | 0 | 55 | 43.1 | 61 | 4.8 | 150 | 58.9 | 31.5 | 2.6 | 14 | 148 | 114 | 0.76 | 6.2 | 5.1 | D |
| 2 | 6 | 5 | 35.7 | 58 | 4.8 | 153 | 42.7 | 70.5 | 2.2 | 4 | 202 | 32 | 0. | 0. | 0. | C |
| 2 | 7 | 0 | 35.0 | 59 | 54.7 | 151 | 1.6 | 2.6 | 2.3 | 5 | 270 | 112 | 0.40 | 0.2 | 0.4 | D |
| 2 | 9 | 39 | 40.6 | 58 | 44.2 | 153 | 24.6 | 5.0 | 1.9 | 3 | 175 | 25 | 0.02 | 0. | 0. | C |
| 2 | 13 | 20 | 50.3 | 59 | 35.3 | 152 | 58.8 | 116.2 | 2.4 | 6 | 176 | 15 | 0.08 | 9.9 | 4.6 | D |
| 2 | 14 | 15 | 58.4 | 58 | 53.6 | 153 | 29.2 | 0.2 | 1.6 | 4 | 196 | 49 | 0.02 | 0. | 0. | C |
| 2 | 15 | 10 | 34.4 | 58 | 50.7 | 152 | 48.4 | 5.0 | 1.9 | 3 | 301 | 43 | 0.35 | 0. | 0. | D |
| 2 | 19 | 11 | 34.8 | 60 | 34.2 | 151 | 20.6 | 5.0 | 1.8 | 4 | 288 | 80 | 0.04 | 0. | 0. | C |
| 2 | 20 | 1 | 23.0 | 56 | 43.1 | 158 | 1.5 | 159.6 | 2.9 | 4 | 332 | 191 | 0.25 | 0. | 0. | C |
| 3 | 0 | 15 | 1.1 | 59 | 41.0 | 150 | 25.8 | 2.9 | 2.7 | 7 | 267 | 154 | 0.89 | 15.1 | 38.0 | D |
| 3 | 0 | 53 | 19.7 | 59 | 18.8 | 154 | 15.3 | 90.0 | 2.1 | 4 | 261 | 51 | 0.01 | 0. | 0. | C |
| 3 | 2 | 25 | 14.2 | 59 | 12.3 | 152 | 35.7 | 69.2 | 2.7 | 7 | 124 | 47 | 0.23 | 3.2 | 5.6 | C |
| 4 | 7 | 5 | 56.4 | 60 | 5.1 | 153 | 5.4 | 10.7 | 2.3 | 4 | 298 | 48 | 0.27 | 0. | 0. | C |
| 4 | 11 | 5 | 22.8 | 59 | 35.5 | 152 | 7.5 | 40.3 | 2.5 | 6 | 159 | 28 | 0.25 | 5.3 | 3.2 | D |
| 4 | 11 | 31 | 15.3 | 59 | 23.1 | 152 | 52.4 | 77.6 | 1.9 | 4 | 221 | 32 | 0.06 | 0. | 0. | C |
| 4 | 11 | 32 | 29.0 | 58 | 59.3 | 153 | 34.6 | 5.3 | 3.3 | 9 | 91 | 37 | 0.45 | 3.8 | 6.0 | C |
| 4 | 11 | 53 | 45.7 | 58 | 11.4 | 152 | 47.1 | 47.3 | 2.2 | 6 | 169 | 26 | 0.38 | 7.1 | 8.6 | D |
| 4 | 11 | 57 | 20.6 | 59 | 10.6 | 153 | 28.3 | 100.1 | 2.9 | 9 | 154 | 17 | 0.27 | 5.9 | 4.6 | D |
| 4 | 16 | 31 | 46.3 | 60 | 2.0 | 151 | 10.1 | 5.0 | 2.2 | 5 | 272 | 98 | 0.54 | 16.1 | 35.0 | D |
| 4 | 20 | 10 | 44.3 | 59 | 45.6 | 154 | 10.1 | 180.6 | 0. | 11 | 252 | 54 | 0.63 | 18.9 | 21.0 | D |
| 5 | 9 | 55 | 58.6 | 56 | 50.3 | 154 | 28.0 | 11.5 | 2.6 | 6 | 199 | 35 | 0.16 | 2.4 | 271.4 | D |
| 5 | 13 | 27 | 30.3 | 57 | 18.0 | 154 | 17.8 | 7.4 | 2.2 | 4 | 178 | 20 | 0.43 | 0. | 0. | D |
| 5 | 14 | 2 | 43.1 | 59 | 44.4 | 153 | 15.3 | 133.8 | 1.9 | 4 | 189 | 9 | 0.01 | 0. | 0. | C |
| 5 | 16 | 11 | 37.3 | 60 | 15.7 | 152 | 1.0 | 5.0 | 1.6 | 3 | 232 | 45 | 0.01 | 0. | 0. | C |
| 5 | 17 | 9 | 42.9 | 59 | 31.1 | 149 | 8.8 | 11.5 | 2.9 | 6 | 285 | 137 | 0.03 | 1.9 | 2.6 | C |
| 5 | 17 | 53 | 5.8 | 60 | 31.8 | 153 | 0.1 | 163.3 | 1.7 | 4 | 304 | 17 | 0.02 | 0. | 0. | C |
| 5 | 18 | 43 | 4.6 | 59 | 35.3 | 152 | 39.1 | 101.7 | 0. | 11 | 86 | 33 | 0.31 | 4.0 | 5.4 | B |
| 5 | 19 | 31 | 56.2 | 60 | 14.0 | 152 | 44.7 | 129.4 | 3.6 | 12 | 143 | 20 | 0.37 | 8.4 | 10.8 | D |
| 5 | 20 | 9 | 55.7 | 58 | 44.6 | 153 | 45.0 | 75.8 | 2.3 | 5 | 146 | 26 | 0.04 | 1.8 | 3.1 | C |
| 5 | 20 | 28 | 34.6 | 59 | 34.7 | 151 | 6.1 | 9.3 | 2.5 | 7 | 248 | 120 | 0.68 | 31.9 | 92.1 | D |
| 6 | 6 | 21 | 33.8 | 58 | 52.0 | 151 | 3.9 | 5.0 | 1.9 | 4 | 303 | 142 | 0.17 | 0. | 0. | C |
| 6 | 12 | 1 | 29.8 | 58 | 7.1 | 148 | 54.3 | 69.6 | 3.2 | 4 | 338 | 216 | 0.09 | 0. | 0. | C |
| 6 | 15 | 28 | 33.5 | 58 | 45.0 | 154 | 22.7 | 1.7 | 2.1 | 5 | 238 | 40 | 0.06 | 1.8 | 1.4 | C |
| 6 | 19 | 42 | 19.4 | 57 | 50.3 | 156 | 32.7 | 5.0 | 1.1 | 3 | 258 | 3 | 0.31 | 0. | 0. | D |
| 6 | 22 | 49 | 53.1 | 59 | 35.2 | 152 | 20.0 | 5.0 | 1.6 | 4 | 189 | 44 | 0.15 | 0. | 0. | C |
| 7 | 12 | 37 | 47.9 | 59 | 55.3 | 152 | 28.5 | 96.9 | 0. | 27 | 73 | 51 | 0.42 | 2.1 | 2.6 | B |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | | ORIGIN HR | MN | TIME SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUN | 8 | 6 | 36 | 34.7 | 60 | 11.1 | 151 | 43.7 | 38.5 | 2.7 | 6 | 240 | 63 | 0.07 | 7.9 | 2.7 | D |
| | 8 | 7 | 5 | 1.9 | 59 | 46.5 | 150 | 27.7 | 2.9 | 2.3 | 6 | 281 | 147 | 0.53 | 25.4 | 53.6 | D |
| | 8 | 10 | 42 | 12.4 | 56 | 53.7 | 154 | 50.9 | 41.0 | 2.3 | 8 | 221 | 50 | 0.35 | 7.2 | 3.2 | D |
| | 8 | 11 | 31 | 14.9 | 56 | 54.8 | 153 | 50.2 | 5.0 | 1.4 | 3 | 255 | 53 | 0.01 | 0. | 0. | C |
| | 8 | 16 | 56 | 27.5 | 60 | 25.8 | 151 | 38.9 | 53.7 | 3.0 | 6 | 269 | 62 | 0.30 | 34.5 | 45.1 | D |
| | 8 | 16 | 57 | 40.1 | 60 | 4.7 | 151 | 10.5 | 38.2 | 3.3 | 8 | 263 | 96 | 0.80 | 23.2 | 9999.9 | D |
| | 9 | 3 | 42 | 26.1 | 56 | 36.2 | 153 | 26.2 | 2.3 | 2.4 | 4 | 245 | 46 | 0.19 | 0. | 0. | C |
| | 9 | 4 | 24 | 28.8 | 56 | 15.1 | 153 | 6.0 | 36.2 | 3.0 | 5 | 285 | 75 | 0.16 | 15.8 | 2.7 | D |
| | 9 | 6 | 51 | 33.9 | 59 | 18.2 | 153 | 34.2 | 113.6 | 3.4 | 14 | 142 | 8 | 0.21 | 2.2 | 2.6 | C |
| | 9 | 7 | 0 | 42.4 | 59 | 21.6 | 152 | 26.3 | 130.5 | 2.1 | 4 | 243 | 55 | 0.06 | 0. | 0. | C |
| | 9 | 8 | 43 | 30.0 | 59 | 27.8 | 152 | 31.8 | 79.2 | 2.4 | 4 | 261 | 44 | 0.01 | 0. | 0. | C |
| | 9 | 9 | 22 | 11.4 | 60 | 42.5 | 151 | 33.5 | 5.0 | 2.2 | 3 | 296 | 73 | 0.52 | 0. | 0. | D |
| | 9 | 10 | 34 | 55.4 | 58 | 54.4 | 154 | 33.2 | 137.9 | 2.9 | 7 | 198 | 29 | 0.17 | 4.8 | 8.8 | D |
| | 9 | 12 | 51 | 1.7 | 58 | 59.3 | 154 | 37.3 | 0.4 | 2.7 | 8 | 213 | 27 | 0.28 | 5.5 | 12.5 | D |
| | 9 | 13 | 55 | 14.0 | 59 | 53.9 | 150 | 50.1 | 5.0 | 2.2 | 3 | 283 | 63 | 0.01 | 0. | 0. | C |
| | 9 | 16 | 47 | 34.5 | 57 | 43.9 | 152 | 33.8 | 45.3 | 2.2 | 4 | 154 | 4 | 0.40 | 0. | 0. | D |
| | 9 | 18 | 10 | 33.8 | 59 | 34.0 | 153 | 26.9 | 146.5 | 3.1 | 9 | 162 | 15 | 0.18 | 3.5 | 4.4 | C |
| | 9 | 22 | 24 | 10.7 | 60 | 32.3 | 153 | 22.8 | 64.4 | 3.2 | 8 | 174 | 36 | 1.10 | 5.0 | 6.3 | D |
| | 10 | 1 | 46 | 51.8 | 58 | 54.1 | 152 | 47.3 | 60.9 | 1.6 | 4 | 157 | 39 | 0. | 0. | 0. | C |
| | 10 | 2 | 55 | 19.9 | 59 | 24.7 | 150 | 51.7 | 5.4 | 3.2 | 7 | 265 | 41 | 0,45 | 13.4 | 8.0 | D |
| | 10 | 3 | 21 | 41.1 | 58 | 15.2 | 152 | 19.0 | 36.7 | 2.2 | 6 | 193 | 41 | 0.39 | 8.6 | 4.3 | D |
| | 10 | 4 | 45 | 36.9 | 59 | 36.8 | 153 | 7.8 | 111.1 | 2.1 | 5 | 145 | 7 | 0.15 | 10.8 | 13.7 | D |
| | 10 | 5 | 4 | 27.5 | 58 | 56.1 | 152 | 47.6 | 64.9 | 2.1 | 7 | 94 | 42 | 0.23 | 2.9 | 4.6 | C |
| | 10 | 5 | 37 | 2.4 | 57 | 45.3 | 152 | 35.6 | 5.0 | 0.8 | 3 | 141 | 6 | 0. | 0. | 0. | C |
| | 10 | 8 | 23 | 59.8 | 57 | 53.3 | 156 | 38.3 | 8.9 | 0. | 15 | 176 | 9 | 0.29 | 1.8 | 1.1 | C |
| | 10 | 8 | 29 | 17.2 | 57 | 53.2 | 156 | 33.5 | 5.9 | 2.2 | 4 | 258 | 5 | 0.07 | 0. | 0. | C |
| | 10 | 8 | 30 | 21.1 | 57 | 53.0 | 156 | 37.1 | 8.2 | 2.3 | 4 | 270 | 8 | 0.14 | 0. | 0. | C |
| | 10 | 8 | 33 | 53.3 | 57 | 52.5 | 156 | 38.9 | 8.2 | 2.0 | 5 | 211 | 9 | 0.15 | 3.6 | 2.4 | D |
| | 10 | 8 | 54 | 30.9 | 57 | 53.3 | 156 | 42.5 | 0.6 | 1.2 | 4 | 222 | 13 | 0.06 | 0. | 0. | C |
| | 10 | 9 | 7 | 30.4 | 57 | 54.2 | 156 | 42.2 | 5.0 | 1.3 | 4 | 225 | 13 | 0.44 | 0. | 0. | D |
| | 10 | 9 | 14 | 49.8 | 57 | 53.3 | 156 | 38.8 | 9.7 | 2.1 | 6 | 213 | 10 | 0.17 | 2.8 | 1.3 | D |
| | 10 | 9 | 54 | 14.2 | 57 | 53.0 | 156 | 39.4 | 8.3 | 1.0 | 4 | 214 | 26 | 0. | 0. | 0. | C |
| | 10 | 10 | 6 | 11.0 | 59 | 52.9 | 151 | 37.7 | 5.0 | 2.2 | 4 | 243 | 87 | 0.36 | 0. | 0. | D |
| | 10 | 10 | 49 | 22.5 | 59 | 54.3 | 153 | 12.0 | 152.5 | 0. | 17 | 162 | 28 | 0.37 | 4.9 | 6.1 | C |
| | 10 | 14 | 43 | 40.4 | 56 | 51.2 | 152 | 30.8 | 24.0 | 2.5 | 8 | 314 | 48 | 0.22 | 18.1 | 3.4 | D |
| | 10 | 16 | 6 | 21.3 | 58 | 28.1 | 150 | 36.1 | 32.1 | 2.7 | 10 | 252 | 103 | 0.27 | 5.6 | 2.6 | D |
| | 10 | 16 | 31 | 38.4 | 57 | 53.4 | 156 | 34.2 | 5.0 | 1.0 | 3 | 261 | 6 | 0.03 | 0. | 0. | C |
| | 10 | 16 | 32 | 13.2 | 57 | 53.0 | 156 | 41.7 | 2.0 | 2.3 | 4 | 219 | 12 | 0.06 | 0. | 0. | C |
| | 10 | 17 | 5 | 49.2 | 57 | 53.4 | 156 | 30.4 | 5.0 | 0.8 | 3 | 226 | 3 | 0. | 0. | 0. | C |
| | 10 | 19 | 35 | 11.6 | 60 | 14.3 | 146 | 27.0 | 29.4 | 0. | 18 | 223 | 202 | 0.52 | 6.3 | 594.8 | D |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | DAY | ORIGIN HR | ORIGIN MN | TIME SEC | LAT N DEG | LAT N MIN | LONG W DEG | LONG W MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUN | 11 | 7 | 53 | 21.2 | 58 | 48.7 | 151 | 26.7 | 40.5 | 0. | 18 | 169 | 56 | 0.33 | 2.2 | 1.5 | D |
| | 11 | 11 | 16 | 52.5 | 59 | 51.5 | 151 | 56.3 | 5.0 | 2.0 | 6 | 226 | 76 | 1.25 | 26.0 | 9999.9 | D |
| | 11 | 17 | 32 | 30.7 | 60 | 28.4 | 151 | 30.6 | 5.0 | 1.9 | 3 | 288 | 69 | 0.75 | 0. | 0. | D |
| | 11 | 18 | 31 | 7.1 | 57 | 53.3 | 156 | 42.9 | 1.8 | 1.8 | 4 | 223 | 13 | 0.03 | 0. | 0. | C |
| | 11 | 19 | 17 | 19.7 | 60 | 46.3 | 145 | 57.4 | 35.1 | 3.1 | 4 | 340 | 375 | 1.26 | 0. | 0. | D |
| | 11 | 21 | 4 | 33.1 | 59 | 4.6 | 155 | 2.5 | 5.0 | 2.2 | 3 | 287 | 83 | 0.46 | 0. | 0. | D |
| | 11 | 22 | 27 | 40.9 | 59 | 37.5 | 154 | 2.4 | 3.9 | 1.7 | 5 | 257 | 45 | 0. | 0.2 | 0.1 | C |
| | 12 | 0 | 26 | 50.7 | 58 | 51.6 | 144 | 22.2 | 5.0 | 4.3 | 7 | 325 | 417 | 1.11 | 165.4 | 963.7 | D |
| | 12 | 1 | 16 | 8.1 | 56 | 55.6 | 154 | 16.1 | 35.6 | 2.5 | 6 | 116 | 41 | 0.18 | 2.4 | 2.3 | B |
| | 12 | 1 | 45 | 29.8 | 58 | 14.9 | 156 | 9.5 | 159.1 | 2.3 | 6 | 278 | 24 | 0.14 | 11.3 | 13.7 | D |
| | 12 | 7 | 13 | 40.7 | 56 | 39.9 | 157 | 23.7 | 86.3 | 2.9 | 8 | 191 | 19 | 0.35 | 6.9 | 9.0 | D |
| | 12 | 7 | 24 | 51.3 | 56 | 48.7 | 157 | 2.3 | 109.2 | 2.2 | 4 | 329 | 66 | 0.12 | 0. | 0. | C |
| | 12 | 7 | 30 | 39.6 | 59 | 48.2 | 150 | 40.1 | 40.5 | 0. | 31 | 161 | 57 | 0.46 | 2.5 | 1.7 | D |
| | 12 | 8 | 7 | 44.2 | 59 | 55.8 | 149 | 59.8 | 29.5 | 3.1 | 10 | 281 | 102 | 0.34 | 12.4 | 4.9 | D |
| | 12 | 8 | 42 | 59.2 | 59 | 51.8 | 150 | 11.6 | 7.1 | 2.3 | 4 | 309 | 156 | 0. | 0. | 0. | C |
| | 12 | 15 | 28 | 44.9 | 60 | 42.1 | 149 | 8.6 | 4.1 | 3.1 | 5 | 309 | 201 | 0.33 | 63.9 | 10.4 | D |
| | 12 | 16 | 16 | 31.4 | 60 | 3.4 | 150 | 23.8 | 0.8 | 2.6 | 4 | 308 | 137 | 0. | 0. | 0. | C |
| | 12 | 21 | 3 | 41.4 | 59 | 59.0 | 152 | 59.4 | 172.5 | 2.5 | 5 | 340 | 39 | 0.02 | 8.3 | 15.6 | D |
| | 12 | 21 | 18 | 49.5 | 59 | 45.3 | 152 | 14.4 | 30.2 | 2.6 | 5 | 232 | 48 | 0.27 | 12.2 | 6.9 | D |
| | 13 | 1 | 58 | 42.4 | 59 | 4.8 | 153 | 43.0 | 6.2 | 1.4 | 4 | 133 | 17 | 0. | 0. | 0. | C |
| | 13 | 5 | 18 | 17.5 | 58 | 6.3 | 154 | 30.7 | 5.0 | 1.7 | 3 | 206 | 79 | 0. | 0. | 0. | C |
| | 13 | 7 | 50 | 54.1 | 57 | 38.3 | 154 | 56.4 | 7.5 | 1.7 | 5 | 133 | 37 | 0.10 | 1.7 | 1.9 | C |
| | 13 | 8 | 59 | 53.1 | 58 | 59.1 | 153 | 5.9 | 70.1 | 2.5 | 12 | 108 | 25 | 0.47 | 4.3 | 6.1 | C |
| | 13 | 10 | 28 | 51.9 | 57 | 7.7 | 153 | 54.8 | 37.6 | 2.5 | 6 | 109 | 49 | 0.29 | 3.9 | 3.1 | C |
| | 13 | 12 | 23 | 42.1 | 59 | 56.6 | 153 | 8.7 | 39.3 | 3.0 | 7 | 314 | 209 | 0.73 | 112.0 | 9999.9 | D |
| | 13 | 14 | 56 | 26.6 | 59 | 23.5 | 151 | 53.5 | 5.0 | 1.6 | 5 | 275 | 81 | 0.28 | 17.1 | 619.2 | D |
| | 13 | 15 | 4 | 12.7 | 57 | 37.7 | 156 | 21.0 | 122.3 | 2.9 | 5 | 159 | 10 | 0.12 | 11.3 | 15.7 | D |
| | 14 | 9 | 38 | 5.9 | 58 | 39.8 | 153 | 39.1 | 69.2 | 2.4 | 7 | 143 | 33 | 0.38 | 8.1 | 11.2 | D |
| | 14 | 11 | 27 | 18.2 | 60 | 49.6 | 151 | 2.8 | 5.0 | 2.3 | 3 | 307 | 104 | 0.90 | 0. | 0. | D |
| | 15 | 10 | 54 | 21.0 | 59 | 37.8 | 153 | 32.7 | 129.4 | 2.6 | 8 | 202 | 17 | 0.06 | 1.7 | 1.8 | C |
| | 15 | 12 | 36 | 34.6 | 59 | 42.2 | 151 | 43.9 | 29.3 | 2.7 | 8 | 227 | 84 | 0.83 | 32.1 | 28.3 | D |
| | 15 | 22 | 38 | 50.6 | 59 | 56.0 | 152 | 55.1 | 94.7 | 2.2 | 4 | 159 | 35 | 0. | 0. | 0. | C |
| | 15 | 23 | 1 | 52.3 | 58 | 48.1 | 154 | 17.1 | 119.4 | 2.2 | 10 | 145 | 33 | 0.13 | 2.0 | 4.0 | C |
| | 16 | 2 | 30 | 55.8 | 57 | 53.2 | 156 | 30.6 | 5.0 | 1.3 | 3 | 230 | 3 | 0. | 0. | 0. | C |
| | 16 | 3 | 18 | 22.9 | 57 | 53.4 | 156 | 34.2 | 5.0 | 0.4 | 3 | 261 | 6 | 0.03 | 0. | 0. | C |
| | 16 | 5 | 14 | 1.4 | 60 | 17.9 | 152 | 29.6 | 3.4 | 2.8 | 7 | 200 | 20 | 0.21 | 5.1 | 9.0 | D |
| | 16 | 5 | 45 | 11.1 | 60 | 33.9 | 153 | 6.6 | 192.3 | 2.6 | 6 | 291 | 24 | 0.14 | 11.6 | 17.0 | D |
| | 16 | 12 | 13 | 46.9 | 57 | 14.9 | 154 | 59.8 | 65.5 | 2.4 | 4 | 316 | 23 | 0.05 | 0. | 0. | C |
| | 16 | 22 | 0 | 42.9 | 60 | 22.8 | 153 | 3.4 | 136.9 | 2.3 | 5 | 230 | 16 | 0.05 | 4.8 | 4.7 | D |
| | 17 | 0 | 40 | 55.0 | 58 | 33.4 | 152 | 20.7 | 2.5 | 2.2 | 5 | 253 | 73 | 0.13 | 6.8 | 300.2 | D |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | | ORIGIN HR | MN | TIME SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUN | 18 | 0 | 5 | 37.3 | 57 | 49.6 | 156 | 16.3 | 119.8 | 2.6 | 7 | 91 | 12 | 0.23 | 8.7 | 14.9 | C |
| | 18 | 0 | 51 | 40.4 | 57 | 34.9 | 154 | 32.0 | 48.0 | 2.3 | 5 | 126 | 28 | 0.07 | 4.2 | 6.2 | D |
| | 18 | 8 | 7 | 35.1 | 60 | 8.4 | 152 | 11.8 | 98.1 | 3.3 | 11 | 196 | 44 | 0.41 | 8.2 | 10.5 | D |
| | 18 | 10 | 14 | 35.9 | 60 | 13.6 | 152 | 23.3 | 114.7 | 2.1 | 4 | 196 | 30 | 0. | 0. | 0. | C |
| | 18 | 10 | 16 | 27.9 | 60 | 22.7 | 152 | 32.8 | 18.8 | 2.7 | 7 | 218 | 13 | 0.32 | 5.9 | 5.8 | D |
| | 18 | 13 | 16 | 29.8 | 56 | 43.4 | 156 | 5.8 | 37.1 | 2.7 | 10 | 192 | 88 | 0.26 | 2.9 | 2.5 | D |
| | 18 | 14 | 23 | 42.8 | 58 | 49.5 | 154 | 20.6 | 126.6 | 2.7 | 10 | 152 | 31 | 0.19 | 2.6 | 3.9 | C |
| | 18 | 15 | 14 | 23.5 | 60 | 52.9 | 146 | 57.8 | 10.0 | 3.4 | 17 | 202 | 107 | 0.59 | 5.6 | 12.9 | D |
| | 18 | 15 | 16 | 59.3 | 57 | 19.8 | 153 | 45.5 | 10.4 | 2.2 | 5 | 156 | 44 | 0.26 | 4.5 | 586.3 | D |
| | 18 | 17 | 19 | 46.1 | 59 | 48.4 | 151 | 1.9 | 5.0 | 1.9 | 6 | 267 | 118 | 0.50 | 21.1 | 51.8 | D |
| | 18 | 21 | 3 | 9.0 | 58 | 0.5 | 154 | 12.1 | 70.3 | 0. | 14 | 88 | 37 | 0.18 | 1.3 | 3.2 | B |
| | 18 | 21 | 58 | 58.4 | 59 | 31.0 | 152 | 34.6 | 77.8 | 3.1 | 11 | 91 | 39 | 0.33 | 3.3 | 5.5 | C |
| | 19 | 2 | 56 | 48.0 | 58 | 13.8 | 152 | 52.4 | 5.0 | 2.2 | 3 | 236 | 25 | 0.05 | 0. | 0. | C |
| | 19 | 3 | 42 | 9.9 | 58 | 26.4 | 148 | 7.7 | 5.0 | 3.7 | 10 | 294 | 268 | 1.63 | 99.5 | 9999.9 | D |
| | 19 | 4 | 8 | 30.7 | 57 | 12.8 | 155 | 25.0 | 55.5 | 2.5 | 5 | 191 | 49 | 0.05 | 2.0 | 2.5 | C |
| | 19 | 4 | 34 | 16.7 | 60 | 5.9 | 152 | 52.8 | 128.7 | 3.2 | 11 | 156 | 36 | 0.28 | 6.2 | 7.7 | D |
| | 19 | 6 | 10 | 39.9 | 59 | 30.7 | 150 | 57.7 | 12.2 | 2.3 | 6 | 263 | 129 | 0.79 | 53.4 | 51.9 | D |
| | 19 | 9 | 53 | 49.7 | 58 | 22.7 | 151 | 26.9 | 5.0 | 2.6 | 4 | 268 | 93 | 0.15 | 0. | 0. | C |
| | 19 | 13 | 50 | 15.8 | 57 | 17.3 | 153 | 43.1 | 37.9 | 2.9 | 4 | 166 | 40 | 0. | 0. | 0. | C |
| | 19 | 16 | 22 | 27.6 | 57 | 19.8 | 153 | 45.0 | 11.2 | 1.8 | 5 | 156 | 44 | 0.26 | 4.4 | 581.9 | D |
| | 19 | 17 | 0 | 2.2 | 59 | 20.3 | 153 | 6.9 | 102.8 | 2.2 | 6 | 172 | 17 | 0.12 | 4.5 | 3.1 | C |
| | 19 | 18 | 21 | 7.4 | 59 | 53.4 | 152 | 42.5 | 77.0 | 2.6 | 7 | 130 | 39 | 0.77 | 13.5 | 19.5 | C |
| | 19 | 18 | 43 | 3.9 | 59 | 40.6 | 151 | 27.3 | 5.0 | 2.1 | 5 | 250 | 99 | 0.50 | 18.8 | 9999.9 | D |
| | 20 | 1 | 28 | 15.5 | 57 | 9.1 | 155 | 54.4 | 27.3 | 2.6 | 5 | 206 | 63 | 0.31 | 9.5 | 11.4 | D |
| | 20 | 2 | 2 | 54.7 | 59 | 36.9 | 154 | 0.0 | 16.5 | 1.8 | 4 | 285 | 43 | 0.01 | 0. | 0. | C |
| | 20 | 2 | 30 | 10.8 | 56 | 37.3 | 156 | 29.8 | 49.3 | 0. | 16 | 213 | 69 | 1.30 | 15.1 | 66.2 | D |
| | 21 | 5 | 59 | 49.5 | 59 | 36.4 | 151 | 52.8 | 5.0 | 2.0 | 5 | 289 | 76 | 0.25 | 21.3 | 566.1 | D |
| | 21 | 8 | 31 | 11.5 | 57 | 11.7 | 152 | 42.7 | 5.0 | 1.4 | 3 | 249 | 22 | 0.20 | 0. | 0. | C |
| | 21 | 8 | 32 | 30.8 | 59 | 17.9 | 153 | 19.0 | 92.9 | 2.7 | 7 | 97 | 7 | 0.14 | 4.2 | 6.7 | C |
| | 21 | 11 | 5 | 37.0 | 58 | 8.8 | 156 | 4.9 | 153.0 | 2.9 | 6 | 244 | 49 | 0.17 | 13.0 | 13.3 | D |
| | 21 | 11 | 31 | 49.2 | 60 | 8.8 | 153 | 2.0 | 161.8 | 3.1 | 9 | 186 | 56 | 0.21 | 4.2 | 4.9 | D |
| | 21 | 11 | 58 | 8.6 | 60 | 11.0 | 152 | 49.3 | 167.8 | 2.8 | 5 | 190 | 26 | 0.03 | 4.7 | 6.0 | D |
| | 21 | 15 | 4 | 7.1 | 60 | 34.6 | 150 | 26.1 | 0.8 | 3.0 | 4 | 322 | 129 | 0.05 | 0. | 0. | C |
| | 21 | 15 | 11 | 6.7 | 57 | 48.2 | 156 | 15.9 | 128.3 | 3.1 | 9 | 133 | 10 | 0.25 | 7.0 | 9.9 | C |
| | 21 | 16 | 39 | 31.0 | 57 | 0.8 | 153 | 10.0 | 23.5 | 2.1 | 4 | 310 | 17 | 0. | 0. | 0. | C |
| | 21 | 19 | 42 | 41.7 | 59 | 17.1 | 151 | 43.6 | 5.0 | 2.1 | 5 | 236 | 94 | 0.79 | 25.6 | 9999.9 | D |
| | 21 | 22 | 58 | 42.6 | 59 | 25.4 | 153 | 1.9 | 119.6 | 0. | 26 | 84 | 19 | 0.32 | 1.8 | 2.0 | B |
| | 21 | 23 | 4 | 28.6 | 59 | 44.7 | 153 | 35.9 | 159.0 | 2.4 | 6 | 288 | 23 | 0.06 | 9.1 | 11.8 | D |
| | 21 | 23 | 8 | 35.3 | 58 | 27.1 | 151 | 26.3 | 5.0 | 2.6 | 6 | 218 | 99 | 0.42 | 8.2 | 735.7 | D |
| | 21 | 23 | 51 | 19.5 | 56 | 7.4 | 153 | 18.1 | 33.4 | 3.0 | 7 | 296 | 73 | 0.29 | 24.7 | 3.8 | D |
| | 22 | 7 | 32 | 23.5 | 59 | 24.0 | 152 | 47.8 | 83.8 | 2.7 | 8 | 183 | 36 | 0.31 | 8.2 | 8.0 | D |
| | 22 | 17 | 5 | 13.6 | 57 | 50.7 | 152 | 35.1 | 5.0 | 1.6 | 3 | 208 | 12 | 0.02 | 0. | 0. | C |
| | 22 | 19 | 33 | 39.5 | 59 | 51.8 | 150 | 27.2 | 20.8 | 1.9 | 4 | 304 | 143 | 0.08 | 0. | 0. | C |
| | 22 | 23 | 31 | 50.4 | 59 | 24.8 | 151 | 55.2 | 5.0 | 2.1 | 4 | 276 | 78 | 0.15 | 0. | 0. | C |

# COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | | ORIGIN HR | MN | TIME SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUN | 23 | 2 | 32 | 26.3 | 59 | 42.5 | 151 | 20.7 | 2.3 | 2.4 | 5 | 255 | 112 | 0.36 | 15.4 | 810.8 | D |
| | 23 | 23 | 45 | 12.0 | 57 | 15.5 | 153 | 51.2 | 5.0 | 2.7 | 3 | 177 | 47 | 0. | 0. | 0. | C |
| | 24 | 5 | 58 | 24.2 | 57 | 57.1 | 153 | 37.5 | 5.0 | 2.1 | 3 | 205 | 30 | 0. | 0. | 0. | C |
| | 24 | 15 | 5 | 57.5 | 57 | 52.3 | 156 | 50.0 | 6.4 | 1.3 | 4 | 235 | 20 | 0.23 | 0. | 0. | C |
| | 24 | 15 | 26 | 13.9 | 59 | 5.7 | 152 | 9.4 | 72.0 | 2.6 | 7 | 156 | 53 | 0.30 | 6.2 | 16.7 | D |
| | 24 | 19 | 15 | 38.8 | 59 | 20.0 | 152 | 35.6 | 74.2 | 2.9 | 10 | 112 | 43 | 0.34 | 3.7 | 5.7 | C |
| | 24 | 20 | 34 | 17.0 | 59 | 40.2 | 152 | 31.7 | 80.9 | 2.6 | 9 | 184 | 39 | 0.20 | 7.0 | 9.5 | D |
| | 24 | 20 | 52 | 12.5 | 57 | 32.1 | 154 | 48.3 | 5.0 | 1.8 | 3 | 147 | 24 | 0. | 0. | 0. | C |
| | 24 | 23 | 17 | 58.9 | 58 | 31.3 | 150 | 24.9 | 36.8 | 0. | 11 | 255 | 125 | 0.34 | 8.2 | 430.2 | D |
| | 25 | 3 | 55 | 54.9 | 58 | 42.8 | 153 | 50.6 | 0.3 | 1.9 | 4 | 183 | 32 | 0.01 | 0. | 0. | C |
| | 25 | 17 | 29 | 57.6 | 57 | 6.9 | 155 | 12.6 | 53.9 | 2.3 | 4 | 233 | 42 | 0. | 0. | 0. | C |
| | 25 | 18 | 42 | 21.1 | 59 | 34.0 | 152 | 21.2 | 68.7 | 2.9 | 9 | 89 | 41 | 0.35 | 3.8 | 6.4 | B |
| | 25 | 20 | 41 | 28.2 | 58 | 50.0 | 152 | 10.5 | 5.0 | 2.3 | 5 | 188 | 78 | 0.24 | 4.3 | 531.2 | D |
| | 26 | 4 | 46 | 49.2 | 57 | 21.8 | 155 | 6.2 | 17.2 | 2.5 | 6 | 172 | 28 | 0.36 | 6.5 | 16.9 | D |
| | 26 | 14 | 56 | 32.4 | 58 | 18.9 | 150 | 47.3 | 5.0 | 1.9 | 3 | 284 | 142 | 0.56 | 0. | 0. | D |
| | 26 | 22 | 0 | 59.7 | 59 | 59.6 | 154 | 47.4 | 5.0 | 2.4 | 3 | 293 | 95 | 0.02 | 0. | 0. | C |
| | 27 | 6 | 57 | 4.4 | 56 | 58.5 | 153 | 58.3 | 39.0 | 0. | 7 | 127 | 48 | 0.30 | 3.6 | 2.7 | C |
| | 27 | 23 | 40 | 56.8 | 55 | 32.3 | 154 | 11.4 | 31.6 | 0. | 10 | 266 | 113 | 0.31 | 11.5 | 4.8 | D |
| | 28 | 5 | 41 | 53.7 | 59 | 49.6 | 152 | 56.4 | 130.5 | 2.2 | 4 | 197 | 25 | 0. | 0. | 0. | C |
| | 28 | 6 | 32 | 42.4 | 57 | 43.2 | 153 | 19.0 | 5.0 | 1.8 | 3 | 153 | 27 | 0. | 0. | 0. | C |
| | 28 | 10 | 23 | 0.8 | 59 | 51.0 | 152 | 3.2 | 93.6 | 3.1 | 9 | 165 | 31 | 0.23 | 3.8 | 5.5 | C |
| | 28 | 12 | 39 | 36.6 | 56 | 52.4 | 155 | 46.0 | 5.0 | 2.8 | 7 | 133 | 85 | 1.24 | 10.8 | 9999.9 | D |
| | 28 | 12 | 49 | 54.3 | 58 | 58.7 | 152 | 12.1 | 81.9 | 2.6 | 8 | 154 | 65 | 0.25 | 3.3 | 8.0 | D |
| | 28 | 17 | 39 | 35.3 | 57 | 3.0 | 155 | 1.7 | 51.5 | 2.7 | 5 | 206 | 39 | 0.26 | 10.1 | 10.3 | D |
| | 28 | 18 | 33 | 26.8 | 59 | 49.1 | 151 | 28.8 | 60.3 | 3.3 | 7 | 235 | 20 | 0.18 | 5.2 | 5.0 | D |
| | 28 | 22 | 1 | 11.3 | 59 | 10.9 | 152 | 8.1 | 5.0 | 2.1 | 5 | 255 | 72 | 0.19 | 8.4 | 427.2 | D |
| | 29 | 3 | 2 | 42.3 | 59 | 47.5 | 149 | 9.4 | 16.6 | 2.7 | 4 | 326 | 140 | 0. | 0. | 0. | C |
| | 29 | 4 | 45 | 37.3 | 57 | 18.7 | 154 | 4.2 | 39.6 | 3.5 | 12 | 150 | 34 | 0.29 | 2.3 | 1.4 | C |
| | 29 | 8 | 53 | 7.8 | 60 | 30.3 | 151 | 54.4 | 30.7 | 2.8 | 4 | 273 | 48 | 0.44 | 0. | 0. | D |
| | 29 | 12 | 18 | 35.4 | 57 | 20.5 | 155 | 3.2 | 40.7 | 2.3 | 5 | 182 | 25 | 0.03 | 0.9 | 0.4 | C |
| | 29 | 13 | 20 | 18.0 | 59 | 41.6 | 150 | 34.3 | 5.0 | 2.3 | 3 | 301 | 146 | 0.22 | 0. | 0. | C |
| | 29 | 20 | 58 | 20.8 | 59 | 30.8 | 152 | 59.8 | 108.2 | 2.4 | 5 | 224 | 20 | 0.11 | 8.8 | 12.9 | D |
| | 30 | 3 | 4 | 19.0 | 57 | 34.8 | 155 | 32.5 | 98.9 | 2.4 | 5 | 247 | 21 | 0.14 | 13.0 | 18.1 | D |
| | 30 | 4 | 43 | 14.7 | 56 | 56.5 | 152 | 33.1 | 34.4 | 2.6 | 8 | 279 | 40 | 0.40 | 26.0 | 2.8 | D |
| | 30 | 6 | 2 | 20.5 | 59 | 34.5 | 151 | 33.8 | 2.2 | 1.8 | 5 | 244 | 94 | 0.32 | 11.1 | 721.9 | D |
| | 30 | 6 | 29 | 36.0 | 60 | 11.9 | 150 | 43.8 | 79.4 | 2.9 | 7 | 280 | 78 | 0.28 | 16.2 | 9.4 | D |
| | 30 | 13 | 48 | 9.9 | 57 | 46.3 | 154 | 4.6 | 54.6 | 1.9 | 4 | 281 | 18 | 0.01 | 0. | 0. | C |
| | 30 | 14 | 31 | 57.4 | 59 | 37.5 | 151 | 55.1 | 39.3 | 2.5 | 5 | 222 | 100 | 0.56 | 26.5 | 9999.9 | D |
| | 30 | 18 | 13 | 43.7 | 60 | 26.0 | 152 | 8.1 | 37.2 | 3.4 | 6 | 256 | 35 | 0.35 | 49.8 | 23.7 | D |
| | 30 | 22 | 33 | 56.6 | 59 | 49.0 | 153 | 12.0 | 133.6 | 2.5 | 6 | 166 | 18 | 0.10 | 6.0 | 4.4 | D |
| | 30 | 23 | 22 | 15.4 | 55 | 49.9 | 148 | 52.7 | 5.0 | 3.8 | 13 | 306 | 298 | 0.50 | 35.2 | 594.9 | D |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | DA | HR | MN | TIME SEC | LAT DEG | LAT MIN | LONG DEG | LONG MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL | 1 | 5 | 24 | 2.9 | 60 | 1.1 | 152 | 43.2 | 97.4 | 2.7 | 4 | 176 | 44 | 0.03 | 0. | 0. | C |
| | ~~1~~ | ~~5~~ | ~~59~~ | ~~5.6~~ | ~~60~~ | ~~33.3~~ | ~~152~~ | ~~1.9~~ | ~~2.1~~ | ~~2.2~~ | ~~4~~ | ~~279~~ | ~~43~~ | ~~0.41~~ | ~~0.~~ | ~~0.~~ | ~~D~~ |
| | 1 | 7 | 52 | 17.6 | 60 | 1.6 | 154 | 13.5 | 5.0 | 1.4 | 3 | 272 | 69 | 0.03 | 0. | 0. | C |
| | 1 | 7 | 55 | 32.0 | 58 | 46.2 | 154 | 25.3 | 125.0 | 2.6 | 9 | 156 | 39 | 0.16 | 2.3 | 3.7 | C |
| | 1 | 13 | 10 | 49.6 | 59 | 17.7 | 153 | 38.6 | 128.7 | 3.0 | 11 | 145 | 13 | 0.18 | 2.7 | 3.2 | C |
| | 1 | 16 | 53 | 52.5 | 59 | 25.0 | 151 | 18.2 | 9.1 | 2.1 | 4 | 254 | 109 | 0.29 | 0. | 0. | C |
| | 1 | 20 | 46 | 51.8 | 57 | 12.9 | 155 | 6.7 | 65.6 | 2.8 | 8 | 189 | 33 | 0.36 | 5.9 | 7.1 | D |
| | 2 | 1 | 36 | 27.4 | 60 | 15.2 | 151 | 26.7 | 31.9 | 3.6 | 6 | 261 | 75 | 0.15 | 5.8 | 1.9 | D |
| | ~~2~~ | ~~4~~ | ~~45~~ | ~~47.8~~ | ~~59~~ | ~~13.3~~ | ~~155~~ | ~~52.5~~ | ~~146.7~~ | ~~2.6~~ | ~~5~~ | ~~244~~ | ~~61~~ | ~~0.02~~ | ~~2.2~~ | ~~3.0~~ | ~~C~~ |
| | 2 | 8 | 47 | 54.5 | 60 | 31.0 | 153 | 22.8 | 5.0 | 1.9 | 3 | 287 | 35 | 0.45 | 0. | 0. | D |
| | 2 | 10 | 26 | 40.8 | 60 | 49.7 | 150 | 32.5 | 35.8 | 2.8 | 6 | 284 | 130 | 0.40 | 26.8 | 695.1 | D |
| | ~~2~~ | ~~11~~ | ~~54~~ | ~~5.7~~ | ~~60~~ | ~~9.7~~ | ~~151~~ | ~~11.9~~ | ~~5.0~~ | ~~1.6~~ | ~~3~~ | ~~267~~ | ~~79~~ | ~~0.10~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| | 2 | 16 | 35 | 57.3 | 57 | 37.4 | 152 | 57.4 | 25.4 | 1.8 | 4 | 125 | 31 | 0. | 0. | 0. | C |
| | 2 | 16 | 50 | 53.5 | 59 | 34.2 | 153 | 1.5 | 104.7 | 2.8 | 8 | 89 | 14 | 0.30 | 5.6 | 5.8 | C |
| | 3 | 2 | 15 | 52.1 | 59 | 57.6 | 152 | 26.6 | 5.0 | 1.7 | 3 | 158 | 54 | 0. | 0. | 0. | C |
| | 3 | 5 | 37 | 53.2 | 59 | 55.3 | 151 | 51.0 | 79.0 | 3.3 | 10 | 206 | 52 | 0.33 | 5.3 | 5.6 | D |
| | 3 | 6 | 38 | 41.3 | 60 | 25.7 | 152 | 49.1 | 154.1 | 2.5 | 5 | 276 | 2 | 0.21 | 17.2 | 19.8 | D |
| | 3 | 20 | 16 | 46.9 | 57 | 48.6 | 152 | 44.4 | 6.6 | 1.9 | 4 | 157 | 16 | 0.77 | 0. | 0. | D |
| | ~~4~~ | ~~[illegible]~~ | ~~6~~ | ~~57.9~~ | ~~58~~ | ~~12.1~~ | ~~153~~ | ~~39.5~~ | ~~65.[illegible]~~ | ~~2.4~~ | ~~5~~ | ~~267~~ | ~~33~~ | ~~0.08~~ | ~~6.6~~ | ~~5.7~~ | ~~D~~ |
| | 4 | 14 | 58 | 47.3 | 60 | 1.4 | 152 | 3.7 | 87.4 | 3.6 | 9 | 198 | 59 | 0.23 | 3.6 | 3.9 | D |
| | 4 | 17 | 46 | 3.4 | 60 | 11.2 | 153 | 16.6 | 200.0 | 4.0 | 8 | 221 | 38 | 0.13 | 5.4 | 6.3 | D |
| | ~~5~~ | ~~1~~ | ~~35~~ | ~~47.3~~ | ~~61~~ | ~~56.9~~ | ~~149~~ | ~~46.6~~ | ~~5.6~~ | ~~0.~~ | ~~13~~ | ~~201~~ | ~~49~~ | ~~0.52~~ | ~~8.4~~ | ~~8.4~~ | ~~D~~ |
| | 5 | 6 | 48 | 51.7 | 60 | 0.5 | 152 | 2.9 | 5.0 | 1.9 | 3 | 197 | 60 | 0. | 0. | 0. | C |
| | 5 | 6 | 35 | 46.8 | 59 | 47.9 | 152 | 34.8 | 5.0 | 1.5 | 3 | 132 | 40 | 0.01 | 0. | 0. | C |
| | 5 | 19 | 17 | 48.8 | 60 | 3.8 | 151 | 2.5 | 2.0 | 2.9 | 5 | 276 | 103 | 0.45 | 133.9 | 306.1 | D |
| | 5 | 21 | 6 | 9.4 | 58 | 53.6 | 153 | 28.7 | 10.4 | 2.4 | 7 | 173 | 53 | 0.26 | 3.8 | 401.2 | D |
| | 6 | 5 | 11 | 18.9 | 60 | 12.0 | 153 | 9.7 | 139.2 | 1.8 | 4 | 218 | 32 | 0. | 0. | 0. | C |
| | 6 | 14 | 52 | 23.5 | 59 | 42.8 | 153 | 24.1 | 124.6 | 1.9 | 4 | 199 | 11 | 0. | 0. | 0. | C |
| | ~~7~~ | ~~[illegible]~~ | ~~11~~ | ~~54.1~~ | ~~60~~ | ~~16.9~~ | ~~152~~ | ~~56.6~~ | ~~164.1~~ | ~~3.3~~ | ~~8~~ | ~~190~~ | ~~21~~ | ~~0.21~~ | ~~7.8~~ | ~~9.1~~ | ~~D~~ |
| | 7 | 18 | 11 | 26.2 | 59 | 47.4 | 151 | 36.1 | 5.0 | 2.4 | 3 | 288 | 92 | 0.04 | 0. | 0. | C |
| | 8 | 0 | 54 | 59.6 | 58 | 51.9 | 150 | 23.8 | 45.1 | 2.9 | 5 | 262 | 95 | 0.24 | 16.5 | 89.7 | D |
| | ~~8~~ | ~~[illegible]~~ | ~~42~~ | ~~41.2~~ | ~~59~~ | ~~39.1~~ | ~~152~~ | ~~16.0~~ | ~~14.[illegible]~~ | ~~1.9~~ | ~~5~~ | ~~129~~ | ~~35~~ | ~~0.75~~ | ~~11.7~~ | ~~999.9~~ | ~~D~~ |
| | 8 | 8 | 47 | 8.1 | 58 | 24.3 | 154 | 30.6 | 5.0 | 2.0 | 6 | 239 | 83 | 0.34 | 11.0 | 595.5 | D |
| | 8 | 9 | 34 | 16.9 | 60 | 6.6 | 152 | 45.6 | 107.9 | 0. | 6 | 152 | 34 | 0.09 | 4.5 | 14.0 | C |
| | 8 | 12 | 52 | 29.9 | 60 | 14.4 | 151 | 57.8 | [illegible] | 1.8 | 4 | 230 | 48 | 0.65 | 0. | 0. | D |
| | 8 | 14 | 21 | 19.1 | 60 | 52.0 | 149 | 33.4 | 5.0 | 0. | 18 | 163 | 84 | 0.58 | 4.5 | 9.8 | D |
| | 8 | 18 | 15 | 4.4 | 59 | 40.3 | 151 | 3.0 | 40.9 | 2.7 | 6 | 252 | 122 | 0.51 | 19.0 | 890.6 | D |
| | 9 | 6 | 6 | 44.9 | 59 | 54.0 | 151 | 52.8 | 64.5 | 2.4 | 4 | 201 | 50 | 0. | 0. | 0. | C |
| | ~~9~~ | ~~12~~ | ~~52~~ | ~~37.4~~ | ~~57~~ | ~~41.6~~ | ~~153~~ | ~~20.0~~ | ~~[illegible]~~ | ~~1.5~~ | ~~4~~ | ~~139~~ | ~~24~~ | ~~0.11~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| | 9 | 22 | 31 | 23.0 | 60 | 0.3 | 152 | 46.1 | 113.7 | 2.9 | 25 | 141 | 46 | 0.41 | 3.3 | 3.0 | C |
| | 9 | 22 | 50 | 11.7 | 59 | 59.8 | 152 | 29.8 | 5.0 | 1.0 | 3 | 155 | 51 | 0. | 0. | 0. | C |
| | ~~10~~ | ~~0~~ | ~~7~~ | ~~55.3~~ | ~~57~~ | ~~54.8~~ | ~~155~~ | ~~16.5~~ | ~~244.2~~ | ~~3.0~~ | ~~4~~ | ~~331~~ | ~~149~~ | ~~0.20~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| | 10 | 10 | 39 | 24.7 | 60 | 5.6 | 152 | 57.3 | 123.1 | 2.6 | 7 | 178 | 37 | 0.40 | 11.1 | 16.0 | D |
| | 10 | 15 | 3 | 46.0 | 57 | 52.2 | 156 | 34.4 | 5.6 | 1.0 | 3 | 269 | 5 | 0.01 | 0. | 0. | C |
| | 10 | 16 | 5 | 2.3 | 57 | 53.2 | 156 | 37.1 | 5.0 | 1.0 | 3 | 278 | 8 | 0.01 | 0. | 0. | C |

JUNE 1978-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | ORIGIN HR | MN | TIME SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUNE 10 | 14 | 40 | 21.3 | 57 | 56.5 | 156 | 37.1 | [illegible] | 2.3 | 5 | 255 | 15 | 0.09 | 8.7 | 4.9 | D |
| 10 | 17 | 8 | 27.1 | 57 | 53.5 | 156 | 30.9 | [illegible] | 0. | 6 | 191 | 4 | 0.22 | 3.1 | 1.5 | D |
| 10 | 18 | 19 | 25.2 | 59 | 46.6 | 151 | 5.4 | [illegible] | 2.3 | 6 | 265 | 117 | 0.45 | 26.8 | 106.0 | D |
| 10 | [illegible] | 30 | 16.3 | 56 | 30.7 | 151 | 50.7 | 5.0 | 3.2 | 5 | 276 | 104 | 0.42 | 58.9 | 188.1 | D |
| 10 | 22 | 42 | [illegible] | 57 | 53.4 | 156 | 32.0 | 10.1 | 2.4 | 6 | 194 | 4 | 0.17 | 2.4 | 1.1 | C |
| 10 | 23 | 5 | 54.3 | 57 | 53.9 | 156 | 38.8 | 2.1 | 0.8 | 4 | 215 | 10 | 0. | 0. | 0. | C |
| 10 | 23 | 13 | 12.4 | 57 | 25.9 | 153 | 28.3 | 5.0 | 1.6 | 3 | 192 | 38 | 0.01 | 0. | 0. | C |
| 11 | [illegible] | 59 | 42.6 | 60 | [illegible] | [illegible] | 42.3 | 27.1 | 1.6 | 4 | 306 | 117 | 0.17 | 0. | 0. | C |
| 11 | 2 | 32 | 27.3 | 59 | 29.5 | [illegible] | 4.5 | [illegible] | 1.9 | 8 | 172 | 20 | 0.20 | 3.3 | 4.6 | C |
| 11 | [illegible] | 47 | 58.8 | 60 | 6.9 | 151 | 36.2 | [illegible] | 1.5 | 4 | 241 | 50 | 0.43 | 0. | 0. | D |
| 11 | [illegible] | 17 | [illegible] | 61 | 52.7 | [illegible] | 2.1 | [illegible] | 0. | 8 | 222 | 57 | 0.88 | 15.5 | 71.8 | D |
| 11 | 13 | 33 | [illegible] | 60 | [illegible] | 152 | 35.9 | [illegible] | 1.1 | 3 | 146 | 38 | 0. | 0. | 0. | C |
| 11 | 14 | 59 | [illegible] | 62 | 3.8 | [illegible] | 14.1 | [illegible] | 0. | 14 | 100 | 28 | 0.62 | 4.6 | 4.6 | C |
| 11 | 15 | 43 | 54.0 | 60 | 55.8 | 151 | 47.1 | 3.7 | 0. | 7 | 222 | 203 | 0.80 | 66.9 | 66.4 | D |
| 11 | [illegible] | 51 | [illegible] | [illegible] | [illegible] | [illegible] | 4.6 | [illegible] | 0. | 4 | 270 | 38 | 0. | 0. | 0. | C |
| 11 | [illegible] | 49 | 18.3 | 59 | 40.1 | 152 | 1.9 | 89.4 | 2.3 | 9 | 119 | 21 | 0.24 | 3.7 | 5.2 | C |
| 11 | [illegible] | 37 | 11.0 | 57 | 37.0 | 153 | 29.7 | 5.0 | 1.4 | 3 | 160 | 22 | 0. | 0. | 0. | C |
| 12 | [illegible] | 40 | [illegible] | 57 | [illegible] | [illegible] | [illegible] | [illegible] | 2.3 | 4 | 204 | 7 | 0. | 0. | 0. | C |
| 12 | 4 | 4 | 3.7 | 57 | [illegible] | [illegible] | 36.8 | [illegible] | 1.4 | 4 | 208 | 8 | 0. | 0. | 0. | C |
| 12 | 4 | 34 | 33.4 | 57 | [illegible] | [illegible] | 35.1 | [illegible] | 2.3 | 3 | 201 | 6 | 0.01 | 0. | 0. | C |
| 12 | [illegible] | 36 | [illegible] | 57 | [illegible] | [illegible] | 36.9 | [illegible] | 2.1 | 4 | 209 | 8 | 0.06 | 0. | 0. | C |
| 12 | 7 | 24 | [illegible] | 57 | 53.4 | 156 | 36.6 | 1.3 | 2.0 | 4 | 208 | 8 | 0.03 | 0. | 0. | C |
| 12 | [illegible] | 5 | 32.8 | 57 | 53.0 | 156 | 35.8 | 5.0 | 1.1 | 3 | 204 | 7 | 0.01 | 0. | 0. | C |
| 12 | [illegible] | 30 | 49.1 | 57 | 53.2 | 156 | 36.8 | 2.0 | 2.2 | 4 | 208 | 8 | 0. | 0. | 0. | C |
| 12 | [illegible] | 45 | [illegible] | 57 | 53.3 | [illegible] | 37.4 | [illegible] | 2.7 | 4 | 209 | 8 | 0. | 0. | 0. | C |
| 12 | [illegible] | 59 | 23.3 | 57 | 53.4 | 156 | 32.6 | 5.0 | 1.2 | 3 | 255 | 4 | 0. | 0. | 0. | C |
| 12 | [illegible] | 44 | 20.4 | 57 | 52.9 | 156 | 35.6 | 5.0 | 2.0 | 3 | 203 | 6 | 0. | 0. | 0. | C |
| 12 | [illegible] | 46 | 17.7 | 57 | [illegible] | 156 | 32.9 | [illegible] | 2.6 | 4 | 196 | 4 | 0. | 0. | 0. | C |
| 12 | 9 | 53 | 33.1 | 57 | 53.2 | 156 | 37.0 | 1.1 | 2.4 | 4 | 208 | 8 | 0.04 | 0. | 0. | C |
| 12 | 10 | 20 | 7.0 | 57 | 53.1 | 156 | 36.1 | 2.8 | 2.1 | 4 | 205 | 7 | 0. | 0. | 0. | C |
| 12 | [illegible] | 46 | [illegible] | 57 | 52.6 | 156 | 33.7 | 6.6 | 2.5 | 4 | 197 | 4 | 0. | 0. | 0. | C |
| 12 | 13 | 54 | 40.1 | 57 | 52.8 | 156 | 36.5 | 4.3 | 2.4 | 4 | 206 | 7 | 0. | 0. | 0. | C |
| 12 | 14 | 5 | 22.3 | 57 | 53.4 | 156 | 37.5 | 2.8 | 2.1 | 4 | 210 | 8 | 0. | 0. | 0. | C |
| 12 | 14 | 5 | 59.7 | 59 | 31.4 | 153 | 7.1 | 104.4 | 2.2 | 9 | 104 | 15 | 0.35 | 5.1 | 8.0 | C |
| 12 | 15 | 26 | [illegible] | 57 | 53.3 | 156 | 36.0 | 5.1 | 1.3 | 4 | 206 | 7 | 0. | 0. | 0. | C |
| 12 | 16 | 27 | 44.0 | 57 | 53.3 | 156 | 37.3 | 4.8 | 2.0 | 4 | 209 | 8 | 0. | 0. | 0. | C |
| 12 | 18 | 22 | 24.0 | 59 | 26.0 | 152 | 38.2 | 72.6 | 1.7 | 5 | 140 | 41 | 0.05 | 3.1 | 6.3 | D |
| 12 | 20 | 55 | [illegible] | 57 | [illegible] | 156 | 35.4 | 5.0 | 2.2 | 3 | 201 | 6 | 0.01 | 0. | 0. | C |
| 12 | 21 | 30 | 2.8 | 57 | 53.2 | 156 | 37.3 | 1.0 | 2.1 | 4 | 209 | 8 | 0. | 0. | 0. | C |
| 12 | 21 | 42 | 56.8 | 57 | 53.0 | 156 | 37.2 | 0.0 | 2.3 | 4 | 208 | 8 | 0.01 | 0. | 0. | C |
| 12 | 21 | 52 | 17.2 | 57 | 53.1 | 156 | 36.2 | [illegible] | 2.0 | 4 | 205 | 7 | 0. | 0. | 0. | C |
| 12 | 21 | 53 | 24.7 | 57 | 53.5 | 156 | 36.4 | 0.2 | 2.5 | 4 | 208 | 8 | 0.06 | 0. | 0. | C |
| 12 | 21 | 59 | 51.6 | 57 | 53.1 | 156 | 36.1 | 2.0 | 1.0 | 4 | 205 | 7 | 0. | 0. | 0. | C |
| 12 | 22 | 19 | 15.7 | 57 | 53.2 | 156 | 35.1 | 1.6 | 2.4 | 4 | 203 | 6 | 0.05 | 0. | 0. | C |
| 12 | 22 | 31 | 4.7 | 57 | 53.3 | 156 | 32.1 | 8.0 | 2.3 | 6 | 194 | 4 | 0.23 | 3.2 | 1.6 | D |

## COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | ORIGIN TIME HR MN | SEC | LAT N DEG MIN | LONG W DEG MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ~~JUL 12~~ | ~~22 39~~ | ~~11.1~~ | ~~57 53.2~~ | ~~156 35.3~~ | ~~5.0~~ | ~~1.1~~ | ~~3~~ | ~~264~~ | ~~6~~ | ~~0.08~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 12 | 22 44 | 21.6 | 57 53.4 | 156 34.3 | 5.0 | 0.9 | 3 | 261 | 6 | 0.07 | 0. | 0. | C |
| 12 | 22 49 | 23.5 | 57 53.4 | 156 31.8 | 8.6 | 2.4 | 6 | 194 | 4 | 0.27 | 3.8 | 1.9 | D |
| 12 | 23 10 | 26.9 | 57 52.9 | 156 31.5 | 8.1 | 2.4 | 6 | 191 | 3 | 0.22 | 3.0 | 1.5 | D |
| ~~12~~ | ~~23 27~~ | ~~54.4~~ | ~~57 52.4~~ | ~~156 35.4~~ | ~~3.6~~ | ~~2.3~~ | ~~4~~ | ~~203~~ | ~~6~~ | ~~0.01~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 12 | 23 37 | 25.5 | 57 53.2 | 156 35.1 | 1.6 | 2.1 | 4 | 203 | 6 | 0.05 | 0. | 0. | C |
| 12 | 23 44 | 51.7 | 57 53.0 | 156 31.4 | 9.4 | 2.3 | 6 | 191 | 3 | 0.20 | 2.7 | 1.4 | D |
| ~~12~~ | ~~23 50~~ | ~~5.6~~ | ~~57 53.1~~ | ~~156 36.1~~ | ~~4.7~~ | ~~2.0~~ | ~~4~~ | ~~205~~ | ~~7~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 0 46 | 0.3 | 57 53.1 | 156 31.6 | 8.0 | 2.2 | 6 | 192 | 3 | 0.19 | 2.6 | 1.3 | D |
| 13 | 0 57 | 27.8 | 57 52.9 | 156 31.5 | 8.1 | 2.3 | 6 | 191 | 3 | 0.22 | 3.0 | 1.5 | D |
| ~~13~~ | ~~3 24~~ | [illegible] | ~~57 26.6~~ | ~~153 36.1~~ | ~~34.0~~ | ~~0.~~ | ~~7~~ | ~~283~~ | ~~70~~ | ~~0.17~~ | ~~12.8~~ | ~~3.6~~ | ~~D~~ |
| 13 | 4 5 | 33.9 | 57 53.5 | 156 35.3 | 6.9 | 1.1 | 4 | 205 | 7 | 0. | 0. | 0. | C |
| 13 | 4 8 | 47.3 | 57 53.3 | 156 29.4 | 5.0 | 0.6 | 3 | 207 | 3 | 0. | 0. | 0. | C |
| 13 | 4 9 | 55.3 | 57 53.6 | 156 31.2 | 9.9 | 2.2 | 5 | 192 | 4 | 0.21 | 4.1 | 2.0 | D |
| ~~13~~ | ~~4 18~~ | ~~37.7~~ | ~~57 53.7~~ | ~~156 35.7~~ | ~~7.1~~ | ~~1.5~~ | ~~4~~ | ~~206~~ | ~~7~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 4 26 | 56.7 | 57 53.2 | 156 33.3 | 7.0 | 1.8 | 4 | 198 | 5 | 0. | 0. | 0. | C |
| 13 | 5 8 | 14.6 | 57 53.3 | 156 34.9 | 6.5 | 2.2 | 4 | 203 | 6 | 0. | 0. | 0. | C |
| ~~13~~ | ~~5 38~~ | [illegible] | ~~57 53.1~~ | ~~156 34.9~~ | ~~7.5~~ | ~~2.5~~ | ~~4~~ | ~~202~~ | ~~6~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 5 46 | 7.0 | 57 53.6 | 156 34.0 | 7.6 | 2.4 | 4 | 201 | 6 | 0. | 0. | 0. | C |
| 13 | 6 32 | 19.0 | 57 53.4 | 156 34.1 | 7.5 | 1.0 | 4 | 201 | 6 | 0. | 0. | 0. | C |
| ~~13~~ | ~~6 56~~ | ~~25.4~~ | ~~57 53.5~~ | ~~156 35.4~~ | ~~6.0~~ | ~~2.2~~ | ~~4~~ | ~~205~~ | ~~7~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 7 11 | 2.2 | 57 54.2 | 156 32.2 | 13.6 | 2.3 | 5 | 198 | 19 | 0.02 | 0.4 | 0.4 | C |
| 13 | 7 21 | 31.2 | 57 53.3 | 156 35.4 | 6.6 | 2.2 | 4 | 204 | 7 | 0. | 0. | 0. | C |
| 13 | 7 30 | 27.1 | 57 53.4 | 156 33.4 | 8.3 | 2.1 | 4 | 198 | 5 | 0. | 0. | 0. | C |
| ~~13~~ | ~~7 57~~ | ~~21.3~~ | ~~57 52.7~~ | ~~156 35.0~~ | ~~7.1~~ | ~~2.3~~ | ~~4~~ | ~~202~~ | ~~6~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 7 58 | 56.1 | 57 52.4 | 156 30.3 | 8.0 | 2.0 | 4 | 186 | 2 | 0. | 0. | 0. | C |
| 13 | 9 14 | 56.0 | 57 54.0 | 156 32.7 | 10.4 | 2.1 | 6 | 199 | 5 | 0.25 | 3.6 | 1.7 | D |
| ~~13~~ | ~~10 39~~ | ~~27.1~~ | ~~57 54.8~~ | ~~156 35.8~~ | ~~9.1~~ | ~~2.4~~ | ~~4~~ | ~~263~~ | ~~11~~ | ~~0.01~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 10 46 | 24.0 | 57 52.1 | 156 35.9 | 5.7 | 1.0 | 4 | 201 | 6 | 0. | 0. | 0. | C |
| 13 | 10 47 | 59.3 | 57 53.3 | 156 36.7 | 5.0 | 2.3 | 4 | 208 | 8 | 0. | 0. | 0. | C |
| ~~13~~ | ~~10 59~~ | ~~3.6~~ | ~~57 53.7~~ | ~~156 36.3~~ | ~~5.7~~ | ~~2.5~~ | ~~4~~ | ~~208~~ | ~~8~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 11 2 | 33.3 | 57 53.1 | 156 35.0 | 6.2 | 2.2 | 4 | 202 | 6 | 0. | 0. | 0. | C |
| 13 | 11 41 | 43.2 | 57 53.5 | 156 27.2 | 6.2 | 2.5 | 9 | 158 | 4 | 0.57 | 4.4 | 2.8 | D |
| 13 | 12 2 | 2.3 | 57 53.6 | 156 34.5 | 7.8 | 1.9 | 4 | 202 | 6 | 0. | 0. | 0. | C |
| ~~13~~ | ~~12 15~~ | ~~37.3~~ | ~~57 53.7~~ | ~~156 35.8~~ | ~~7.1~~ | ~~1.2~~ | ~~4~~ | ~~207~~ | ~~7~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 12 27 | 30.8 | 57 53.5 | 156 35.3 | 6.9 | 0.6 | 4 | 205 | 7 | 0. | 0. | 0. | C |
| 13 | 12 32 | 59.3 | 57 53.8 | 156 34.0 | 8.8 | 2.1 | 5 | 202 | 6 | 0.11 | 2.3 | 1.2 | C |
| ~~13~~ | ~~12 45~~ | ~~47.5~~ | ~~57 53.9~~ | ~~156 36.1~~ | ~~5.9~~ | ~~1.2~~ | ~~4~~ | ~~209~~ | ~~8~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 12 57 | 32.2 | 57 53.7 | 156 35.2 | 7.0 | 1.3 | 4 | 205 | 7 | 0. | 0. | 0. | C |
| 13 | 13 2 | 57.1 | 57 53.5 | 156 35.9 | 6.9 | 1.1 | 4 | 206 | 7 | 0. | 0. | 0. | C |
| ~~13~~ | ~~13 24~~ | [illegible] | ~~57 25.2~~ | ~~153 36.5~~ | ~~34.5~~ | ~~0.~~ | ~~7~~ | ~~93~~ | ~~33~~ | ~~0.27~~ | ~~3.5~~ | ~~3.2~~ | ~~C~~ |
| 13 | 13 33 | 36.4 | 57 53.7 | 156 35.7 | 5.7 | 2.3 | 4 | 206 | 7 | 0. | 0. | 0. | C |
| 13 | 13 42 | 19.0 | 57 53.5 | 156 37.2 | 5.2 | 1.1 | 4 | 210 | 8 | 0. | 0. | 0. | C |
| 13 | 13 47 | 49.7 | 57 52.8 | 156 34.4 | 8.0 | 1.1 | 4 | 203 | 6 | 0. | 0. | 0. | C |
| ~~13~~ | ~~13 48~~ | [illegible] | ~~57 53.9~~ | ~~156 37.7~~ | ~~5.7~~ | ~~2.2~~ | ~~4~~ | ~~212~~ | ~~9~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |

319

320

[illegible] GULF OF ALASKA EARTHQUAKES

| DAY | HR | MN | SEC | LAT DEG | LAT MIN | LONG DEG | LONG MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 36.3 | [illegible] | 2.3 | 4 | 204 | 3 | 0. | 0. | 0. | C |
| 13 | 12 | 57 | 31.2 | 57 | [illegible] | [illegible] | 23.3 | [illegible] | 2.2 | 5 | 199 | 5 | 0.05 | 1.0 | 0.6 | C |
| 13 | [illegible] | 43 | [illegible] | 57 | [illegible] | [illegible] | 35.9 | [illegible] | 2.3 | 4 | 206 | 7 | 0. | 0. | 0. | C |
| 13 | [illegible] | 4 | [illegible] | 57 | [illegible] | [illegible] | 24.7 | [illegible] | 2.9 | 11 | 101 | 56 | 0.17 | 1.5 | 2.8 | B |
| 13 | [illegible] | 16 | [illegible] | 57 | [illegible] | [illegible] | 36.0 | [illegible] | 2.2 | 3 | 251 | 6 | 0.01 | 0. | 0. | C |
| 13 | [illegible] | 14 | [illegible] | [illegible] | [illegible] | [illegible] | 33.5 | [illegible] | 2.5 | 4 | 249 | 9 | 0. | 0. | 0. | C |
| 13 | [illegible] | [illegible] | [illegible] | 57 | [illegible] | [illegible] | 37.0 | [illegible] | 1.1 | 4 | 209 | 8 | 0.10 | 0. | 0. | C |
| 14 | [illegible] | [illegible] | [illegible] | 57 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 4 | 206 | 7 | 0. | 0. | 0. | C |
| 14 | 14 | 27 | [illegible] | 57 | [illegible] | [illegible] | 40.4 | 1.3 | 1.0 | 4 | 219 | 11 | 0.02 | 0. | 0. | C |
| 14 | 14 | 37 | 44.0 | 60 | 7.7 | [illegible] | 25.6 | 103.7 | 2.5 | 14 | 130 | 37 | 0.42 | 8.2 | 7.2 | C |
| 14 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 49.4 | [illegible] | 2.3 | 4 | 185 | 23 | 0.02 | 0. | 0. | C |
| 15 | 11 | 58 | [illegible] | 57 | [illegible] | [illegible] | 34.0 | [illegible] | 1.0 | 4 | 202 | 6 | 0. | 0. | 0. | C |
| 15 | 12 | 21 | [illegible] | [illegible] | [illegible] | [illegible] | 39.5 | [illegible] | 4.4 | 31 | 79 | 34 | 0.35 | 1.6 | 1.8 | B |
| 15 | [illegible] | 8 | [illegible] | 60 | [illegible] | [illegible] | 3.0 | [illegible] | 1.0 | 4 | 242 | 40 | 0.49 | 0. | 0. | D |
| 15 | [illegible] | 22 | [illegible] | [illegible] | [illegible] | [illegible] | 27.0 | [illegible] | 1.6 | 5 | 239 | 49 | 0. | 2.1 | 1.0 | C |
| 15 | 13 | 33 | [illegible] | 61 | 41.4 | 151 | 3.2 | 2.5 | 2.7 | 13 | 164 | 102 | 1.93 | 16.7 | 56.6 | D |
| 15 | [illegible] | 19 | [illegible] | [illegible] | [illegible] | [illegible] | 14.4 | 54.2 | 2.8 | 20 | 168 | 81 | 0.43 | 3.6 | 9.5 | D |
| 15 | [illegible] | 22 | [illegible] | [illegible] | [illegible] | [illegible] | 34.2 | [illegible] | 1.7 | 4 | 202 | 6 | 0. | 0. | 0. | C |
| 15 | [illegible] | 55 | [illegible] | 57 | [illegible] | [illegible] | 34.9 | [illegible] | 1.7 | 4 | 204 | 7 | 0. | 0. | 0. | C |
| 15 | [illegible] | 8 | [illegible] | [illegible] | [illegible] | [illegible] | 32.3 | [illegible] | 2.7 | 11 | 263 | 61 | 0.17 | 4.4 | 3.5 | D |
| 16 | 2 | 13 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 2.0 | 5 | 242 | 91 | 0.35 | 30.8 | 27.7 | D |
| 16 | 1 | 51 | [illegible] | 61 | [illegible] | [illegible] | 29.1 | 5.0 | 1.9 | 8 | 153 | 53 | 0.39 | 5.0 | 13.0 | D |
| [illegible] | 4 | 39 | [illegible] | 60 | [illegible] | 152 | 55.2 | 133.3 | 2.4 | 12 | 159 | 37 | 0.26 | 5.3 | 7.2 | D |
| 16 | [illegible] | 18 | 31.2 | [illegible] | [illegible] | [illegible] | [illegible] | 5.0 | 0. | 4 | 346 | 470 | 0.37 | 0. | 0. | D |
| 16 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 37.8 | [illegible] | 0.3 | 4 | 213 | 9 | 0. | 0. | 0. | C |
| 16 | [illegible] | 54 | [illegible] | 57 | [illegible] | 155 | 25.5 | [illegible] | 2.5 | 4 | 205 | 7 | 0. | 0. | 0. | C |
| 16 | [illegible] | 43 | [illegible] | [illegible] | [illegible] | [illegible] | 21.3 | [illegible] | 1.9 | 5 | 209 | 60 | 0.34 | 5.7 | 20.5 | D |
| 16 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 2.4 | 4 | 198 | 5 | 0. | 0. | 0. | C |
| 16 | [illegible] | 31 | [illegible] | 57 | [illegible] | 156 | 32.4 | 10.0 | 2.4 | 4 | 196 | 5 | 0. | 0. | 0. | C |
| 17 | [illegible] | 4 | [illegible] | 57 | [illegible] | 156 | 33.3 | [illegible] | 2.2 | 4 | 200 | 5 | 0. | 0. | 0. | C |
| 17 | [illegible] | 20 | [illegible] | 61 | [illegible] | [illegible] | 16.3 | [illegible] | 2.5 | 4 | 326 | [illegible] | 0.45 | 0. | 0. | D |
| 17 | [illegible] | 23 | [illegible] | 57 | [illegible] | 156 | 24.5 | [illegible] | 1.0 | 4 | 202 | 6 | 0. | 0. | 0. | C |
| 17 | [illegible] | 45 | [illegible] | 57 | [illegible] | [illegible] | 35.9 | [illegible] | 0.9 | 4 | 206 | 7 | 0. | 0. | 0. | C |
| 17 | [illegible] | 36 | [illegible] | 56 | [illegible] | 156 | 24.0 | 3.5 | 2.7 | 4 | 228 | 47 | 0.16 | 0. | 0. | C |
| 17 | [illegible] | 3 | [illegible] | 59 | [illegible] | [illegible] | 16.5 | 203.2 | 2.6 | 4 | 302 | 62 | 0.31 | 0. | 0. | D |
| 17 | [illegible] | 37 | [illegible] | 59 | 43.2 | 152 | 12.0 | 5.0 | 1.3 | 3 | 161 | 32 | 0. | 0. | 0. | C |
| [illegible] | [illegible] | 24 | [illegible] | 57 | [illegible] | 155 | 31.6 | [illegible] | 2.3 | 5 | 194 | 4 | 0.13 | 2.5 | 1.3 | D |
| [illegible] | [illegible] | 16 | [illegible] | [illegible] | [illegible] | [illegible] | 33.6 | [illegible] | 2.4 | 7 | 207 | 5 | 0.37 | 4.6 | 2.1 | D |
| [illegible] | [illegible] | 36 | [illegible] | 59 | 47.1 | 153 | 25.9 | [illegible] | 2.0 | 4 | 245 | 13 | 0.01 | 0. | 0. | C |
| 18 | [illegible] | 25 | [illegible] | 59 | 57.4 | 154 | 23.0 | 130.1 | 1.6 | 5 | 228 | 19 | 0.15 | 13.7 | 14.5 | D |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 151 | 43.6 | [illegible] | 2.3 | 7 | 236 | 54 | 0.15 | 5.4 | 7.6 | D |
| 18 | 21 | 18 | [illegible] | 61 | 58.5 | [illegible] | 0.7 | [illegible] | 0. | 16 | 68 | 63 | 0.50 | 3.3 | 4.8 | D |
| 18 | 21 | 55 | [illegible] | 58 | 14.9 | 151 | 39.7 | 7.6 | 2.1 | 4 | 318 | 74 | 0.31 | 0. | 0. | D |
| 18 | 22 | 15 | [illegible] | 57 | 28.3 | 157 | 2.0 | 16.3 | 2.6 | 4 | 170 | 53 | 2.24 | 0. | 0. | D |
| [illegible] | [illegible] | 12 | [illegible] | [illegible] | [illegible] | [illegible] | 59.8 | 104.1 | 0. | 18 | 107 | 34 | 0.22 | 1.8 | 1.9 | B |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | ORIGIN TIME HR | MN | SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL 19 | 9 | 14 | 7.7 | 61 | 1.0 | 152 | 4.3 | 92.6 | 3.5 | 14 | 151 | 76 | 0.55 | 5.1 | 10.7 | D |
| 19 | 9 | 32 | 1.9 | 56 | [illegible] | 151 | 14.7 | [illegible] | 0. | 16 | 220 | 135 | 0.53 | 7.7 | 25.7 | D |
| 19 | 12 | 17 | 48.6 | 59 | 57.5 | 152 | 52.9 | 104.5 | 2.9 | 7 | 157 | 39 | 0.41 | 9.4 | 13.1 | D |
| 19 | 12 | 40 | 13.6 | 58 | 6.4 | 154 | 44.9 | 87.3 | 2.7 | 9 | 121 | 69 | 0.72 | 7.0 | 19.8 | C |
| 19 | 13 | 15 | 44.3 | 59 | 57.5 | 152 | 59.0 | 129.7 | 3.5 | 9 | 170 | 36 | 0.37 | 8.1 | 10.8 | D |
| 19 | 16 | 4 | 23.2 | 57 | 51.6 | 156 | 27.7 | 1.6 | 1.9 | 4 | 205 | 8 | 0.33 | 0. | 0. | D |
| 19 | 17 | 44 | 21.3 | 60 | 49.1 | 162 | 57.2 | 5.0 | 0. | 3 | 340 | 493 | 0.99 | 0. | 0. | D |
| 19 | 18 | 54 | 32.8 | 61 | 12.9 | 149 | 58.6 | 13.4 | 0. | 13 | 135 | 53 | 0.67 | 5.5 | 6.3 | D |
| 19 | 21 | 50 | [illegible] | 61 | [illegible] | 147 | 12.4 | [illegible] | 0. | 9 | 282 | 99 | 0.50 | 16.9 | 17.5 | D |
| 19 | 23 | 27 | 35.5 | 59 | 0.8 | 152 | 5.1 | 37.9 | 2.6 | 8 | 166 | 58 | 0.23 | 3.0 | 2.9 | D |
| 20 | 0 | 31 | 55.4 | 57 | 47.6 | 153 | 19.8 | 5.0 | 1.6 | 3 | 149 | 26 | 0. | 0. | 0. | C |
| 20 | [illegible] | 15 | 27.1 | 60 | 26.6 | 153 | 21.1 | [illegible] | 3.8 | 7 | 251 | 14 | 0.51 | 24.7 | 31.6 | D |
| 20 | 5 | 9 | 51.4 | 56 | 58.2 | 152 | 47.4 | 29.0 | 3.8 | 7 | 306 | 27 | 0.51 | 19.9 | 4.8 | D |
| 20 | 5 | 18 | 45.6 | 58 | 49.5 | 152 | 40.1 | 65.4 | 0. | 12 | 134 | 51 | 0.26 | 2.4 | 7.5 | C |
| 20 | 5 | 44 | [illegible] | 60 | 41.5 | 152 | 45.3 | 155.0 | 0. | 30 | 85 | 30 | 0.74 | 3.8 | 5.7 | C |
| 20 | 6 | 56 | 55.6 | 56 | 34.1 | 155 | 22.6 | 2.5 | 0. | 4 | 143 | 73 | 1.21 | 0. | 0. | D |
| 20 | 7 | 24 | 26.8 | 56 | 31.1 | 153 | 27.0 | 5.0 | 3.7 | 5 | 253 | 45 | 0.67 | 328.9 | 437.3 | D |
| 20 | 8 | 27 | 1.2 | 56 | 29.2 | 153 | 25.8 | 8.6 | 3.5 | 5 | 258 | 47 | 0.68 | 40.6 | 999.9 | D |
| 20 | 8 | 48 | 7.5 | 57 | [illegible] | 156 | 35.6 | 1.6 | 1.7 | 4 | 206 | 7 | 0.15 | 0. | 0. | C |
| 20 | 9 | 28 | 13.7 | 57 | 53.3 | 156 | 35.4 | 5.0 | 1.8 | 3 | 265 | 6 | 0.16 | 0. | 0. | C |
| 20 | 12 | 40 | 45.6 | 60 | 12.2 | 151 | 21.6 | 35.6 | 2.6 | 5 | 262 | 62 | 0.46 | 44.1 | 5.4 | D |
| 20 | 18 | 2 | 25.8 | 58 | 15.8 | 155 | 2.4 | 5.0 | 2.6 | 5 | 153 | 93 | 0.35 | 5.5 | 782.1 | D |
| 20 | 20 | 11 | 47.9 | 59 | 19.0 | 153 | 27.7 | 121.5 | 2.6 | 10 | 148 | 11 | 0.22 | 6.6 | 4.6 | D |
| 20 | 23 | 2 | 31.9 | 59 | 60.0 | 153 | 24.7 | 146.6 | 2.9 | 7 | 180 | 22 | 0.10 | 4.8 | 4.0 | C |
| 20 | 23 | 43 | 45.6 | 58 | 59.7 | 152 | 41.1 | 63.1 | 2.9 | 9 | 198 | 48 | 0.38 | 7.3 | 12.1 | D |
| 21 | 4 | 35 | 53.6 | 59 | 14.1 | 155 | 58.1 | 154.3 | 2.9 | 8 | 231 | 30 | 0.28 | 12.9 | 14.5 | D |
| 21 | 6 | 10 | 9.0 | 60 | 4.6 | 151 | 56.7 | 69.6 | 0. | 25 | 106 | 49 | 0.54 | 2.5 | 4.4 | C |
| 21 | 6 | 31 | 13.1 | 57 | 53.8 | 156 | 33.3 | 9.8 | 1.7 | 4 | 200 | 6 | 0. | 0. | 0. | C |
| 21 | 9 | 41 | 37.1 | 60 | 17.0 | 153 | 22.2 | [illegible] | 3.9 | 20 | 156 | 35 | 0.42 | 5.0 | 4.2 | C |
| 21 | 11 | 19 | 14.9 | 57 | 3.8 | 154 | 10.5 | 1.8 | 2.6 | 4 | 197 | 56 | 0.10 | 0. | 0. | C |
| 21 | 16 | 19 | 44.7 | 58 | 8.4 | 156 | 27.2 | 5.0 | 2.1 | 3 | 300 | 8 | 0.01 | 0. | 0. | C |
| 21 | 22 | 14 | [illegible] | 57 | [illegible] | 155 | 20.1 | 37.6 | 0. | 14 | 87 | 99 | 0.30 | 1.7 | 353.9 | D |
| 22 | 0 | 23 | 21.3 | 57 | 53.4 | 156 | 33.2 | 9.3 | 2.2 | 4 | 198 | 5 | 0. | 0. | 0. | C |
| 22 | 3 | 41 | 53.1 | 58 | 6.8 | 156 | 30.8 | 5.3 | 2.2 | 3 | 308 | 12 | 0.07 | 0. | 0. | C |
| 22 | 4 | 9 | 54.4 | 57 | 52.6 | 156 | 32.9 | 8.0 | 2.1 | 4 | 194 | 4 | 0. | 0. | 0. | C |
| 22 | 5 | 15 | 16.4 | 57 | 28.3 | 153 | 33.6 | 5.0 | 2.0 | 3 | 199 | 34 | 0. | 0. | 0. | C |
| 22 | 6 | 29 | 11.9 | 58 | 13.4 | 152 | 56.1 | 5.0 | 2.3 | 3 | 177 | 59 | 0.07 | 0. | 0. | C |
| 22 | 7 | 15 | 46.6 | 57 | 53.0 | 156 | 32.8 | 9.5 | 2.6 | 4 | 196 | 4 | 0. | 0. | 0. | C |
| 22 | 7 | 45 | 49.1 | 57 | [illegible] | 156 | 33.2 | [illegible] | 1.9 | 4 | 199 | 5 | 0. | 0. | 0. | C |
| 22 | 8 | 2 | 4.1 | 60 | 44.7 | 151 | 44.1 | 107.4 | 3.1 | 4 | 299 | 67 | 0.12 | 0. | 0. | C |
| 22 | 8 | 42 | 30.9 | 57 | 52.8 | 156 | 33.7 | 9.6 | 2.2 | 4 | 197 | 5 | 0. | 0. | 0. | C |
| 22 | [illegible] | 1 | [illegible] | 57 | 52.3 | 156 | [illegible] | [illegible] | 2.0 | 4 | 199 | 3 | 0. | 0. | 0. | C |
| 22 | [illegible] | 14 | [illegible] | 57 | [illegible] | 156 | 32.0 | [illegible] | 2.4 | 4 | 195 | 4 | 0. | 0. | 0. | C |
| 22 | 11 | 8 | 53.2 | 57 | 53.4 | 156 | 33.6 | 9.4 | 2.4 | 4 | 199 | 5 | 0. | 0. | 0. | C |
| 22 | 11 | 16 | 17.8 | 57 | 47.8 | 156 | 22.7 | 11.1 | 2.6 | 5 | 144 | 53 | 0.87 | 20.2 | 999.9 | D |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | ORIGIN HR | TIME MN | SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL 19 | 8 | 14 | 7.7 | 61 | 1.0 | 152 | 4.3 | 92.6 | 3.5 | 14 | 151 | 76 | 0.55 | 5.1 | 10.7 | D |
| ~~19~~ | ~~9~~ | ~~32~~ | ~~1.9~~ | ~~56~~ | ~~24.5~~ | ~~151~~ | ~~14.7~~ | ~~1.2~~ | ~~0.~~ | ~~16~~ | ~~220~~ | ~~135~~ | ~~0.53~~ | ~~7.7~~ | ~~25.7~~ | ~~D~~ |
| 19 | 12 | 17 | 48.6 | 59 | 57.5 | 152 | 52.9 | 104.5 | 2.9 | 7 | 157 | 39 | 0.41 | 9.4 | 13.1 | D |
| 19 | 12 | 40 | 13.6 | 58 | 6.4 | 154 | 44.9 | 87.3 | 2.7 | 9 | 121 | 69 | 0.72 | 7.0 | 19.8 | C |
| 19 | 13 | 15 | 44.3 | 59 | 57.5 | 152 | 59.0 | 129.7 | 3.5 | 9 | 170 | 36 | 0.37 | 8.1 | 10.8 | D |
| 19 | 14 | 4 | 28.2 | 57 | 51.6 | 156 | 37.7 | 1.9 | 1.9 | 4 | 205 | 8 | 0.33 | 0. | 0. | D |
| 19 | 17 | 44 | 21.3 | 60 | 45.1 | 162 | 57.2 | 5.0 | 0. | 3 | 340 | 493 | 0.99 | 0. | 0. | D |
| 19 | 18 | 54 | 32.8 | 61 | 19.9 | 149 | 58.6 | 13.4 | 0. | 13 | 135 | 53 | 0.67 | 5.5 | 6.3 | D |
| ~~19~~ | ~~20~~ | ~~50~~ | ~~43.9~~ | ~~60~~ | ~~56.5~~ | ~~147~~ | ~~12.4~~ | ~~9.2~~ | ~~0.~~ | ~~9~~ | ~~282~~ | ~~99~~ | ~~0.50~~ | ~~16.9~~ | ~~17.5~~ | ~~D~~ |
| 19 | 23 | 27 | 35.5 | 59 | 0.8 | 152 | 5.1 | 37.9 | 2.6 | 8 | 166 | 58 | 0.23 | 3.0 | 2.9 | D |
| 20 | 0 | 31 | 55.4 | 57 | 47.6 | 153 | 19.8 | 5.0 | 1.6 | 3 | 149 | 26 | 0. | 0. | 0. | C |
| ~~20~~ | ~~3~~ | ~~15~~ | ~~27.1~~ | ~~60~~ | ~~24.4~~ | ~~152~~ | ~~21.1~~ | ~~139.6~~ | ~~3.8~~ | ~~7~~ | ~~251~~ | ~~14~~ | ~~0.51~~ | ~~24.7~~ | ~~31.6~~ | ~~D~~ |
| 20 | 5 | 9 | 51.4 | 56 | 58.2 | 152 | 47.4 | 29.0 | 3.8 | 7 | 306 | 27 | 0.51 | 19.9 | 4.8 | D |
| 20 | 5 | 18 | 45.6 | 59 | 40.5 | 152 | 40.1 | 65.4 | 0. | 12 | 134 | 51 | 0.26 | 2.4 | 7.5 | C |
| 20 | 5 | 44 | 32.5 | 60 | 41.5 | 152 | 45.3 | 155.9 | 0. | 30 | 85 | 30 | 0.74 | 3.8 | 5.7 | C |
| 20 | 6 | 56 | 55.6 | 56 | 34.1 | 155 | 22.6 | 2.6 | 0. | 4 | 143 | 73 | 1.21 | 0. | 0. | D |
| 20 | 7 | 24 | 24.9 | 56 | 31.1 | 153 | 27.0 | 5.0 | 3.7 | 5 | 253 | 45 | 0.67 | 328.9 | 437.3 | D |
| 20 | 8 | 27 | 1.2 | 56 | 29.2 | 153 | 25.8 | 8.6 | 3.5 | 5 | 258 | 47 | 0.68 | 40.6 | 999.9 | D |
| ~~20~~ | ~~9~~ | ~~49~~ | ~~1.4~~ | ~~57~~ | ~~53.7~~ | ~~156~~ | ~~35.6~~ | ~~1.7~~ | ~~1.7~~ | ~~4~~ | ~~206~~ | ~~7~~ | ~~0.15~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 20 | 9 | 29 | 13.7 | 57 | 53.3 | 156 | 35.4 | 5.0 | 1.8 | 3 | 265 | 6 | 0.16 | 0. | 0. | C |
| 20 | 12 | 40 | 48.6 | 60 | 12.2 | 151 | 21.6 | 35.6 | 2.6 | 5 | 262 | 62 | 0.46 | 44.1 | 8.4 | D |
| ~~20~~ | ~~15~~ | ~~2~~ | ~~25.9~~ | ~~58~~ | ~~15.8~~ | ~~155~~ | ~~2.4~~ | ~~5.0~~ | ~~2.6~~ | ~~5~~ | ~~158~~ | ~~93~~ | ~~0.35~~ | ~~5.5~~ | ~~782.1~~ | ~~D~~ |
| 20 | 20 | 11 | 47.9 | 59 | 19.0 | 153 | 37.7 | 121.5 | 2.6 | 10 | 148 | 11 | 0.22 | 6.6 | 4.6 | D |
| 20 | 23 | 2 | 31.9 | 59 | 50.0 | 153 | 24.7 | 146.6 | 2.9 | 7 | 180 | 22 | 0.10 | 4.8 | 4.0 | C |
| 20 | 23 | 43 | 45.6 | 58 | 59.7 | 152 | 41.1 | 63.1 | 2.9 | 9 | 198 | 48 | 0.38 | 7.3 | 12.1 | D |
| 21 | 4 | 35 | 53.6 | 58 | 14.1 | 155 | 58.1 | 154.9 | 2.9 | 8 | 231 | 30 | 0.28 | 12.9 | 14.5 | D |
| 21 | 6 | 10 | 9.0 | 60 | 4.6 | 151 | 56.7 | 69.6 | 0. | 25 | 106 | 49 | 0.54 | 2.5 | 4.4 | C |
| 21 | 6 | 31 | 19.1 | 57 | 53.6 | 156 | 33.3 | 9.5 | 1.7 | 4 | 200 | 6 | 0. | 0. | 0. | C |
| ~~21~~ | ~~7~~ | ~~41~~ | ~~37.1~~ | ~~60~~ | ~~17.8~~ | ~~153~~ | ~~22.2~~ | ~~192.2~~ | ~~3.9~~ | ~~20~~ | ~~156~~ | ~~35~~ | ~~0.42~~ | ~~5.0~~ | ~~4.2~~ | ~~C~~ |
| 21 | 11 | 19 | 14.9 | 57 | 3.8 | 154 | 10.5 | 1.8 | 2.6 | 4 | 197 | 56 | 0.10 | 0. | 0. | C |
| 21 | 16 | 19 | 44.7 | 58 | 5.4 | 156 | 27.2 | 5.0 | 2.1 | 3 | 300 | 8 | 0.01 | 0. | 0. | C |
| ~~21~~ | ~~22~~ | ~~14~~ | ~~52.1~~ | ~~57~~ | ~~4.6~~ | ~~155~~ | ~~20.1~~ | ~~32.6~~ | ~~0.~~ | ~~14~~ | ~~87~~ | ~~99~~ | ~~0.30~~ | ~~1.7~~ | ~~353.9~~ | ~~D~~ |
| 22 | 0 | 23 | 21.3 | 57 | 53.4 | 156 | 33.2 | 9.2 | 2.2 | 4 | 198 | 5 | 0. | 0. | 0. | C |
| 22 | 3 | 41 | 53.1 | 58 | 6.8 | 156 | 30.8 | 5.0 | 2.2 | 3 | 308 | 12 | 0.07 | 0. | 0. | C |
| 22 | 4 | 9 | 54.4 | 57 | 52.6 | 156 | 32.9 | 8.0 | 2.1 | 4 | 194 | 4 | 0. | 0. | 0. | C |
| 22 | 5 | 15 | 16.4 | 57 | 25.3 | 153 | 33.6 | 5.0 | 2.0 | 3 | 199 | 34 | 0. | 0. | 0. | C |
| 22 | 5 | 29 | 11.9 | 58 | 13.4 | 152 | 56.1 | 5.0 | 2.3 | 3 | 177 | 59 | 0.07 | 0. | 0. | C |
| 22 | 7 | 15 | 46.6 | 57 | 53.0 | 156 | 32.8 | 9.5 | 2.6 | 4 | 196 | 4 | 0. | 0. | 0. | C |
| ~~22~~ | ~~7~~ | ~~45~~ | ~~49.1~~ | ~~57~~ | ~~53.7~~ | ~~156~~ | ~~33.2~~ | ~~10.5~~ | ~~1.9~~ | ~~4~~ | ~~199~~ | ~~5~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 22 | 8 | 2 | 4.1 | 60 | 44.7 | 151 | 44.1 | 102.4 | 3.1 | 4 | 299 | 67 | 0.12 | 0. | 0. | C |
| 22 | 8 | 42 | 30.0 | 57 | 52.8 | 156 | 33.7 | 8.6 | 2.2 | 4 | 197 | 5 | 0. | 0. | 0. | C |
| ~~22~~ | ~~9~~ | ~~1~~ | ~~15.1~~ | ~~57~~ | ~~52.3~~ | ~~156~~ | ~~31.9~~ | ~~[illegible]~~ | ~~2.0~~ | ~~4~~ | ~~199~~ | ~~3~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 22 | 9 | 14 | 55.0 | 57 | 52.2 | 156 | 33.0 | 9.2 | 2.4 | 4 | 195 | 4 | 0. | 0. | 0. | C |
| 22 | 11 | 8 | 53.2 | 57 | 53.4 | 156 | 33.6 | 9.4 | 2.4 | 4 | 199 | 5 | 0. | 0. | 0. | C |
| 22 | 11 | 16 | 17.3 | 57 | 38.8 | 155 | 22.7 | 11.1 | 2.6 | 5 | 144 | 53 | 0.37 | 20.2 | 999.9 | D |

## COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1978 | ORIGIN HR | MN | TIME SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL 22 | 17 | 53 | [illegible] | 57 | 53.6 | 156 | 33.8 | [illegible] | 1.8 | 4 | 200 | 5 | 0. | 0. | 0. | C |
| 22 | 17 | 57 | 51.7 | 59 | 26.8 | 152 | 13.3 | 85.1 | 2.3 | 4 | 250 | 61 | 0.16 | 0. | 0. | C |
| 22 | 15 | 9 | 23.5 | 57 | 53.1 | 156 | 31.4 | 10.6 | 2.7 | 6 | 191 | 3 | 0.17 | 2.4 | 1.2 | C |
| 22 | 18 | 25 | 21.3 | 58 | 57.4 | 152 | 31.7 | 40.8 | 2.6 | 7 | 217 | 57 | 0.21 | 9.1 | 3.9 | D |
| 22 | 21 | 25 | 32.3 | 60 | 25.2 | 154 | 22.4 | [illegible] | 2.2 | 3 | 294 | 88 | 0. | 0. | 0. | C |
| 22 | 21 | 27 | 23.7 | 58 | 56.0 | 154 | 37.7 | 129.2 | 2.8 | 9 | 233 | 64 | 0.11 | 8.2 | 3.4 | D |
| 22 | 21 | 33 | 42.5 | 60 | 0.6 | 152 | 41.5 | 109.3 | 3.8 | 25 | 88 | 45 | 0.43 | 2.4 | 2.8 | B |
| 22 | 23 | 11 | 57.9 | 57 | 9.3 | 153 | 48.6 | 99.6 | 2.8 | 6 | 212 | 27 | 0.08 | 7.6 | 3.6 | D |
| 22 | 23 | 55 | 50.6 | 58 | 13.5 | 155 | 18.2 | 1.3 | 3.1 | 6 | 206 | 51 | 0.47 | 4.6 | 18.9 | D |
| 23 | 0 | 37 | 37.3 | 56 | 47.2 | 156 | 0.2 | 2.3 | 3.2 | 5 | 246 | 85 | 0.09 | 3.4 | 8.0 | D |
| 23 | [illegible] | 21 | 51.9 | 57 | 52.0 | 156 | 42.7 | 1.3 | 1.9 | 4 | 221 | 13 | 0.01 | 0. | 0. | C |
| 23 | 10 | 15 | 6.9 | 59 | 51.6 | 153 | 36.1 | 96.0 | 2.9 | 4 | 229 | 32 | 0. | 0. | 0. | C |
| 23 | 10 | 30 | 13.0 | 59 | 51.5 | 152 | 25.1 | 113.4 | 3.5 | 10 | 135 | 48 | 0.47 | 8.7 | 11.6 | C |
| 23 | 15 | 30 | 23.6 | 58 | 44.3 | 154 | 50.9 | 133.3 | 3.2 | 6 | 253 | 55 | 0.21 | 14.1 | 18.0 | D |
| 23 | 15 | 39 | 53.3 | 60 | 7.0 | 152 | 16.9 | 7.6 | 2.9 | 6 | 172 | 50 | 0.89 | 10.3 | 999.9 | D |
| 23 | 19 | 21 | 48.1 | 59 | 18.9 | 151 | 43.8 | 6.0 | 2.6 | 5 | 236 | 92 | 0.78 | 23.7 | 999.9 | D |
| 23 | 23 | 35 | 14.8 | 61 | 33.1 | 150 | 35.6 | 37.0 | 2.9 | 9 | 128 | 77 | 0.51 | 5.1 | 5.4 | D |
| 24 | 5 | 57 | 27.2 | 59 | 56.6 | 152 | 6.6 | 65.7 | 2.3 | 6 | 184 | 24 | 0.27 | 16.6 | 11.6 | D |
| 24 | 10 | 11 | 11.4 | 59 | 13.5 | 153 | 30.7 | 117.3 | 2.3 | 4 | 197 | 13 | 0.08 | 0. | 0. | C |
| 24 | 11 | 28 | 9.1 | 60 | 6.0 | 152 | 32.3 | 113.1 | 3.3 | 9 | 155 | 37 | 0.16 | 4.0 | 9.5 | C |
| 24 | 17 | 14 | 20.7 | 58 | 45.9 | 151 | 36.6 | 35.7 | 2.0 | 4 | 324 | 110 | 0.01 | 0. | 0. | C |
| 24 | 15 | 29 | 49.4 | 59 | 53.7 | 154 | 20.5 | 5.0 | 0. | 4 | 333 | 389 | 0.14 | 0. | 0. | C |
| 24 | 15 | 7 | 11.7 | 57 | 10.4 | 157 | 33.2 | 0.2 | 3.4 | 5 | 189 | 41 | 0.08 | 1.3 | 4.6 | C |
| 24 | 23 | 51 | 9.8 | 59 | 18.8 | 152 | 44.9 | 85.9 | 0. | 17 | 126 | 35 | 0.43 | 3.3 | 3.6 | C |
| 25 | 1 | 5 | 34.6 | 56 | 44.8 | 156 | 26.6 | 0.1 | 3.3 | 5 | 208 | 26 | 0.46 | 41.9 | 139.3 | D |
| 25 | [illegible] | 54 | 17.0 | 59 | 45.1 | 152 | 53.1 | 101.6 | 3.3 | 6 | 125 | 22 | 0.07 | 2.1 | 8.0 | C |
| 25 | 13 | 54 | 31.2 | 60 | 6.7 | 153 | 2.7 | 139.5 | 3.1 | 5 | 192 | 37 | 0.20 | 19.7 | 66.9 | D |
| 25 | 16 | 49 | 11.4 | 58 | 55.5 | 152 | 19.7 | 5.0 | 0. | 8 | 161 | 77 | 0.28 | 2.6 | 392.9 | D |
| 25 | 20 | 56 | 9.7 | 59 | 47.7 | 151 | 57.1 | 70.9 | 2.5 | 6 | 257 | 73 | 0.09 | 22.1 | 24.2 | D |
| 25 | 21 | 22 | 39.7 | 60 | 0.0 | 152 | 23.7 | 108.0 | 2.3 | 4 | 242 | 51 | 0. | 0. | 0. | C |
| 25 | 21 | 52 | 11.7 | 59 | 41.3 | 153 | 20.0 | 145.6 | 3.2 | 12 | 176 | 23 | 0.21 | 4.5 | 5.1 | C |
| 26 | 7 | 53 | 53.3 | 59 | 36.3 | 152 | 17.4 | 125.7 | 2.4 | 5 | 309 | 53 | 0.06 | 17.6 | 23.4 | D |
| 26 | 11 | 24 | 4.1 | 59 | 42.3 | 152 | 37.2 | 65.1 | 2.9 | 8 | 195 | 34 | 0.12 | 8.1 | 11.2 | D |
| 26 | 13 | 15 | 43.1 | 59 | 20.1 | 151 | 28.3 | 53.2 | 2.3 | 4 | 321 | 105 | 0. | 0. | 0. | C |
| 26 | 15 | 4 | 27.1 | 59 | 33.6 | 151 | 15.8 | [illegible] | 0. | 15 | 179 | 103 | 0.58 | 5.3 | 6.7 | D |
| 26 | 16 | 34 | 59.6 | 59 | 48.5 | 151 | 52.3 | 5.0 | 2.2 | 3 | 259 | 41 | 0.02 | 0. | 0. | C |
| 26 | 18 | 0 | 4.0 | 60 | 8.1 | 153 | 17.7 | 179.4 | 3.5 | 7 | 284 | 53 | 0.15 | 19.2 | 21.3 | D |
| 26 | 19 | 1 | 47.2 | 58 | 9.1 | 155 | 20.3 | 0.6 | 2.4 | 8 | 133 | 43 | 0.64 | 4.7 | 27.3 | D |
| 26 | 20 | 21 | 53.9 | 57 | 59.7 | 152 | 24.3 | 38.6 | 3.8 | 20 | 83 | 208 | 0.59 | 3.1 | 657.6 | D |
| 27 | 4 | 58 | 25.3 | 58 | 11.5 | 151 | 25.0 | 40.6 | 2.7 | 5 | 276 | 80 | 0.20 | 15.3 | 447.1 | D |
| 27 | [illegible] | 38 | 32.0 | 59 | 60.0 | 155 | 39.1 | 95.6 | 3.3 | 9 | 263 | 50 | 0.33 | 22.2 | 20.9 | D |
| 27 | 13 | 35 | 3.7 | 57 | 48.9 | 152 | 42.0 | 6.6 | 1.7 | 4 | 166 | 14 | 1.04 | 0. | 0. | D |
| 27 | 14 | 41 | 25.5 | 56 | 5.0 | 156 | 10.8 | 46.1 | 4.0 | 8 | 203 | 33 | 0.42 | 9.3 | 13.6 | D |
| 27 | 16 | 32 | 26.7 | 57 | 18.4 | 153 | 45.8 | 32.6 | 3.7 | 13 | 121 | 44 | 0.26 | 2.0 | 1.8 | B |
| 28 | 6 | 26 | 17.9 | 57 | 48.0 | 153 | 37.4 | 40.6 | 2.2 | 4 | 161 | 9 | 0.01 | 0. | 0. | C |

# COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| DATE | ORIGIN HR | ORIGIN MN | TIME SEC | LAT DEG | LAT MIN | LONG DEG | LONG MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JUL 28 | 7 | 30 | [illegible] | 60 | 7.9 | 152 | 2.0 | 35.[illegible] | 0. | 11 | 102 | 57 | 0.98 | 7.6 | 6.8 | C |
| ~~28~~ | ~~1[illegible]~~ | ~~9~~ | [illegible] | [illegible] | [illegible] | ~~15[illegible]~~ | ~~21.3~~ | ~~74.7~~ | ~~2.5~~ | ~~5~~ | ~~167~~ | ~~24~~ | ~~0.21~~ | ~~4.4~~ | ~~4.9~~ | ~~C~~ |
| 28 | 13 | 16 | 1[illegible].5 | 61 | 32.7 | 14[illegible] | 44.3 | 2.[illegible] | 0. | 4 | 217 | 21 | 0.08 | 0. | 0. | C |
| 28 | 13 | 31 | 21.7 | 58 | 5.2 | 153 | 6.1 | 48.0 | 2.2 | 5 | 272 | 5 | 0.30 | 6.7 | 6.3 | D |
| 28 | 1[illegible] | 49 | 42.8 | 58 | 7.6 | 152 | 31.0 | 40.1 | 2.3 | 4 | 279 | 38 | 0.36 | 0. | 0. | D |
| 28 | 17 | 12 | 4.4 | 57 | 26.[illegible] | 153 | 56.5 | 5.1 | 1.5 | 3 | 159 | 30 | 0. | 0. | 0. | C |
| 29 | 1 | 47 | 11.8 | 57 | 43.1 | 153 | 23.8 | 5.0 | 1.2 | 3 | 143 | 22 | 0. | 0. | 0. | C |
| 29 | 11 | 1 | 31.1 | 57 | 37.0 | 152 | 26.8 | 4.[illegible] | 2.2 | 5 | 183 | 16 | 0.16 | 6.3 | 9.0 | D |
| ~~29~~ | ~~1[illegible]~~ | ~~40~~ | [illegible] | ~~57~~ | [illegible] | ~~15[illegible]~~ | ~~24.1~~ | ~~17.[illegible]~~ | ~~2.4~~ | ~~5~~ | ~~149~~ | ~~34~~ | ~~0.24~~ | ~~2.2~~ | ~~346.1~~ | ~~C~~ |
| 29 | 15 | 22 | 1.3 | 59 | 3.9 | 152 | 37.6 | 73.5 | 2.4 | 5 | 213 | 52 | 0.03 | 1.0 | 2.4 | C |
| 29 | 16 | 25 | 32.5 | 59 | 50.9 | 152 | 24.2 | 97.9 | 3.1 | 10 | 231 | 47 | 0.14 | 7.3 | 8.5 | D |
| ~~29~~ | ~~22~~ | ~~14~~ | [illegible] | [illegible] | [illegible] | ~~14[illegible]~~ | ~~44.4~~ | ~~34.[illegible]~~ | ~~0.~~ | ~~5~~ | ~~334~~ | ~~148~~ | ~~0.21~~ | ~~152.9~~ | ~~463.9~~ | ~~D~~ |
| 29 | 22 | 20 | 24.0 | 59 | 3.9 | 152 | 5.4 | 5.0 | 2.5 | 6 | 229 | 53 | 0.62 | 29.1 | 50.2 | D |
| 30 | [illegible] | 31 | 16.6 | 59 | 48.6 | 151 | 55.8 | 2.7 | 2.5 | 4 | 256 | 42 | 0.16 | 0. | 0. | C |
| 30 | 4 | 42 | 1[illegible] | 58 | [illegible].7 | 152 | 18.8 | 105.[illegible] | 3.1 | 4 | 302 | 70 | 0. | 0. | 0. | C |
| 30 | 6 | 40 | 57.0 | 59 | 5[illegible].5 | 15[illegible] | 6.1 | 63.6 | 2.6 | 5 | 176 | 40 | 0.09 | 4.5 | 12.1 | D |
| 30 | 6 | 15 | 39.7 | 56 | 34.6 | 157 | 52.0 | 102.1 | 3.2 | 4 | 149 | 30 | 0. | 0. | 0. | C |
| 30 | 7 | 28 | 35.6 | 60 | 55.0 | 151 | 11.0 | 39.7 | 3.2 | 15 | 124 | 103 | 0.63 | 4.8 | 740.3 | D |
| ~~30~~ | ~~1[illegible]~~ | ~~6~~ | [illegible] | ~~61~~ | ~~12.[illegible]~~ | ~~15[illegible]~~ | ~~29.6~~ | ~~134.[illegible]~~ | ~~4.5~~ | ~~16~~ | ~~170~~ | ~~88~~ | ~~0.55~~ | ~~5.7~~ | ~~9.0~~ | ~~D~~ |
| 30 | 1[illegible] | 34 | 41.[illegible] | 59 | [illegible] | 151 | 29.0 | 5.0 | 2.3 | 5 | 247 | 99 | 0.52 | 18.2 | 999.9 | D |
| 30 | 23 | 47 | 5[illegible].3 | 59 | 3[illegible].3 | 151 | 33.1 | 23.0 | 2.9 | 6 | 220 | 4 | 0.75 | 7.2 | 6.9 | D |
| ~~31~~ | ~~11~~ | ~~9~~ | [illegible] | ~~57~~ | ~~37.4~~ | ~~15[illegible]~~ | ~~45.2~~ | ~~5.[illegible]~~ | ~~1.5~~ | ~~3~~ | ~~227~~ | ~~54~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 31 | 1[illegible] | 57 | 17.1 | 60 | 1.3 | 151 | 12.3 | 26.5 | 3.4 | 4 | 338 | 120 | 0.22 | 0. | 0. | C |
| 31 | 1[illegible] | 35 | 22.4 | 57 | 1.8 | 155 | 2.6 | 40.7 | 2.6 | 5 | 231 | 41 | 0.29 | 12.2 | 4.0 | D |
| 31 | 14 | 48 | 33.1 | 58 | 42.0 | 151 | 39.0 | 42.1 | 2.9 | 12 | 202 | 86 | 0.35 | 3.6 | 422.8 | D |
| 31 | 1[illegible] | 9 | 35.6 | 57 | 0.9 | 156 | 3.7 | 1.5 | 2.5 | 6 | 169 | 64 | 1.35 | 11.6 | 68.8 | D |
| 31 | 21 | 54 | 56.3 | 58 | 10.1 | 152 | 44.2 | 42.4 | 2.5 | 5 | 279 | 27 | 0.06 | 11.4 | 7.0 | D |
| AUG 1 | 4 | 16 | [illegible].6 | 57 | 2[illegible].1 | 15[illegible] | 20.8 | 5.0 | 2.8 | 4 | 201 | 149 | 0.69 | 0. | 0. | D |
| ~~1~~ | [illegible] | ~~21~~ | [illegible] | [illegible] | [illegible] | ~~15[illegible]~~ | ~~33.5~~ | ~~7[illegible].7~~ | ~~4.2~~ | ~~9~~ | ~~182~~ | ~~38~~ | ~~0.36~~ | ~~11.3~~ | ~~15.3~~ | ~~D~~ |
| 1 | 7 | 19 | 14.4 | 60 | 11.5 | 154 | 15.3 | 5.0 | 2.8 | 5 | 254 | 83 | 0.55 | 24.8 | 999.9 | D |
| 1 | 1[illegible] | 31 | 32.0 | 58 | 58.7 | 152 | 39.4 | 55.2 | 2.5 | 5 | 219 | 50 | 0.09 | 3.0 | 6.5 | D |
| ~~1~~ | ~~1[illegible]~~ | ~~20~~ | [illegible] | ~~60~~ | [illegible] | ~~151~~ | ~~48.5~~ | [illegible] | ~~2.5~~ | ~~5~~ | ~~216~~ | ~~39~~ | ~~0.16~~ | ~~9.3~~ | ~~16.1~~ | ~~D~~ |
| 1 | 1[illegible] | 10 | 59.7 | 59 | 24.6 | 152 | 16.9 | 102.2 | 2.2 | 5 | 213 | 54 | 0.04 | 5.4 | 5.0 | D |
| 1 | 1[illegible] | 18 | 21.2 | 59 | 35.6 | 152 | 53.2 | 102.6 | 2.6 | 5 | 181 | 20 | 0.11 | 6.0 | 5.7 | D |
| 1 | 1[illegible] | 37 | 46.7 | 56 | 44.9 | 154 | 54.1 | 50.5 | 0. | 9 | 186 | 48 | 0.33 | 4.6 | 9.4 | D |
| 1 | 20 | 41 | 55.6 | 57 | 32.6 | 154 | 59.2 | 49.8 | 2.3 | 6 | 133 | 40 | 0.09 | 1.6 | 3.2 | B |
| 2 | 3 | 32 | 45.3 | 58 | 13.0 | 151 | 27.1 | 5.0 | 2.6 | 5 | 263 | 102 | 0.95 | 42.5 | 999.9 | D |
| 2 | [illegible] | 43 | 35.4 | 60 | 33.2 | 150 | 38.6 | 39.0 | 3.2 | 7 | 301 | 114 | 0.31 | 25.5 | 473.5 | D |
| ~~2~~ | ~~1[illegible]~~ | ~~39~~ | [illegible] | ~~58~~ | [illegible] | ~~151~~ | ~~43.2~~ | [illegible] | ~~2.9~~ | ~~7~~ | ~~216~~ | ~~58~~ | ~~0.63~~ | ~~10.9~~ | ~~9.6~~ | ~~D~~ |
| 2 | 14 | 59 | 21.1 | 56 | 36.2 | 156 | 36.4 | 5.0 | 3.9 | 4 | 216 | 125 | 1.83 | 0. | 0. | D |
| 2 | 16 | 45 | 15.1 | 59 | 14.2 | 153 | 44.7 | 93.6 | 2.5 | 6 | 152 | 21 | 0.18 | 7.6 | 10.0 | D |
| ~~2~~ | ~~21~~ | ~~6~~ | ~~[illegible].5~~ | ~~57~~ | [illegible] | ~~15[illegible]~~ | ~~33.0~~ | ~~21.[illegible]~~ | ~~3.2~~ | ~~6~~ | ~~204~~ | ~~19~~ | ~~0.17~~ | ~~7.4~~ | ~~13.7~~ | ~~D~~ |
| 2 | 21 | 38 | 3.5 | 59 | 31.5 | 153 | 14.5 | 130.9 | 2.7 | 7 | 157 | 14 | 0.17 | 7.9 | 9.8 | D |
| 2 | 22 | 36 | 10.1 | 54 | 25.9 | 155 | 10.6 | 38.6 | 3.9 | 4 | 295 | 305 | 0.78 | 0. | 0. | D |
| 3 | 6 | 33 | 31.9 | 59 | 47.2 | 151 | 9.2 | 74.1 | 0. | 22 | 153 | 31 | 0.36 | 2.4 | 3.0 | C |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1976 | ORIGIN TIME HR | MN | SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | [illegible] | 11 | [illegible] | [illegible] | [illegible] | 153 | 33.2 | 66.1 | 2.6 | 8 | 115 | 13 | 0.13 | 1.7 | 2.4 | D |
| 3 | 18 | 16 | 27.5 | 59 | 18.5 | 153 | 25.3 | 109.4 | 2.5 | 9 | 157 | 2 | 0.28 | 8.1 | 6.1 | D |
| 3 | 17 | 7 | 27.6 | 59 | 16.0 | 153 | 13.5 | 107.7 | 3.2 | 4 | 207 | 13 | 0. | 0. | 0. | C |
| 3 | 19 | 31 | 55.7 | 59 | 23.0 | 152 | 52.6 | 96.7 | 2.3 | 10 | 180 | 31 | 0.27 | 6.4 | 5.4 | D |
| 4 | [illegible] | 0 | 52.0 | 59 | 55.6 | 153 | 28.1 | [illegible] | 0. | 15 | 180 | 33 | 0.33 | 5.4 | 6.4 | D |
| 4 | [illegible] | 44 | 21.2 | 59 | 33.9 | 152 | 40.2 | 111.9 | 3.5 | 4 | 289 | 33 | 0. | 0. | 0. | C |
| 4 | [illegible] | 44 | [illegible] | 58 | 56.6 | 151 | 59.6 | 41.7 | 3.9 | 12 | 171 | 63 | 0.33 | 2.5 | 402.1 | D |
| 4 | [illegible] | 7 | [illegible] | [illegible] | 12.3 | 150 | 23.0 | [illegible] | [illegible] | 8 | 210 | 67 | 0.38 | 6.6 | 20.2 | D |
| 4 | 6 | 17 | 3.5 | 60 | 14.8 | 152 | 38.3 | 131.1 | 3.3 | 9 | 161 | 20 | 0.19 | 5.8 | 8.0 | D |
| 4 | [illegible] | 13 | 59.9 | 59 | 47.6 | 148 | 38.8 | 37.5 | 0. | 19 | 114 | 136 | 0.84 | 4.3 | 940.2 | D |
| 4 | [illegible] | 59 | [illegible] | 57 | 18.9 | 154 | 10.1 | [illegible] | 3.2 | 5 | 189 | 32 | 0.21 | 10.8 | 10.1 | D |
| 4 | 13 | 27 | [illegible] | 57 | 12.9 | 154 | 38.7 | 5.4 | 2.3 | 5 | 302 | 28 | 0.05 | 7.9 | 1.7 | D |
| 4 | 14 | 0 | [illegible] | 59 | 17.5 | 154 | 53.1 | 118.0 | 3.0 | 6 | 247 | 83 | 0.06 | 15.9 | 4.8 | D |
| 4 | 15 | 6 | 26.0 | 56 | 41.5 | 155 | 50.9 | 5.0 | 2.8 | 7 | 159 | 89 | 0.93 | 10.8 | 999.9 | D |
| 4 | 17 | 42 | [illegible] | 56 | [illegible] | 154 | 19.2 | [illegible] | 2.8 | 6 | 179 | 57 | 0.37 | 6.2 | 21.1 | D |
| 4 | 19 | 0 | 25.3 | 58 | 57.0 | 154 | 32.7 | 135.3 | 3.4 | 6 | 254 | 58 | 0.12 | 12.4 | 9.5 | D |
| 4 | 19 | 36 | [illegible] | 59 | 40.2 | 151 | 15.0 | 12.4 | 2.5 | 4 | 329 | 111 | 0.03 | 0. | 0. | C |
| 4 | 22 | 21 | [illegible] | [illegible] | 12.5 | 154 | 1.2 | [illegible] | 3.3 | 7 | 153 | 52 | 0.21 | 3.3 | 6.9 | D |
| 5 | [illegible] | 1 | 2.3 | 56 | 27.1 | 152 | 55.6 | 5.0 | 3.9 | 5 | 269 | 78 | 0.20 | 10.8 | 439.2 | D |
| 5 | [illegible] | 22 | 28.3 | 59 | 13.2 | 151 | 55.0 | 5.0 | 2.3 | 5 | 266 | 87 | 0.84 | 43.7 | 999.9 | D |
| 5 | [illegible] | 23 | [illegible] | 59 | [illegible] | 151 | 50.5 | 2.6 | 2.8 | 5 | 215 | 25 | 0.87 | 18.5 | 39.3 | D |
| 5 | [illegible] | 14 | 41.5 | 59 | 39.7 | 152 | 54.9 | 95.0 | 2.9 | 5 | 179 | 17 | 0.12 | 18.0 | 8.9 | D |
| 5 | 12 | 26 | [illegible] | 58 | 13.4 | 154 | 7.7 | 91.8 | 2.8 | 7 | 222 | 55 | 0.05 | 1.3 | 2.2 | C |
| 5 | 15 | 30 | 58.3 | 59 | 59.6 | 151 | 3.2 | 2.0 | 3.1 | 8 | 273 | 106 | 0.47 | 23.3 | 49.4 | D |
| 5 | [illegible] | 49 | 27.4 | [illegible] | [illegible] | 153 | 23.6 | [illegible] | 2.1 | 8 | 199 | 65 | 0.56 | 15.7 | 87.9 | D |
| 5 | 17 | 55 | 32.3 | 58 | 36.1 | 153 | 48.7 | 87.1 | 2.8 | 10 | 137 | 42 | 0.15 | 2.1 | 3.8 | C |
| 5 | [illegible] | 56 | [illegible] | 59 | 19.3 | 153 | 19.3 | 104.7 | 2.9 | 11 | 96 | 5 | 0.26 | 3.8 | 4.1 | C |
| 5 | 21 | 14 | [illegible] | 57 | [illegible] | 154 | 23.9 | 37.4 | 2.4 | 4 | 114 | 31 | 0. | 0. | 0. | C |
| 5 | 23 | 19 | [illegible] | 60 | 44.1 | 151 | 52.6 | 90.4 | 4.3 | 19 | 144 | 60 | 0.49 | 3.9 | 5.7 | D |
| 6 | [illegible] | 12 | 31.4 | 58 | 31.1 | 153 | 13.6 | 71.3 | 3.5 | 9 | 180 | 51 | 0.17 | 3.2 | 4.1 | D |
| 6 | 1 | 22 | [illegible] | 57 | [illegible] | 153 | 25.7 | [illegible] | 2.9 | 6 | 232 | 20 | 0.46 | 1.1 | 0.5 | C |
| 6 | 1 | 47 | [illegible] | 60 | 29.0 | 152 | 31.9 | 124.9 | 3.3 | 6 | 306 | 15 | 0.25 | 22.5 | 22.5 | D |
| 6 | 2 | 18 | [illegible] | 59 | 38.9 | 151 | 34.2 | 19.1 | 2.7 | 6 | 245 | 93 | 0.57 | 23.5 | 22.8 | D |
| 6 | 4 | 40 | [illegible] | 59 | 53.3 | 150 | 35.3 | 5.0 | 3.3 | 4 | 302 | 134 | 0.08 | 0. | 0. | C |
| 6 | [illegible] | 29 | [illegible] | [illegible] | 4.3 | 151 | 42.4 | 47.6 | 2.5 | 4 | 266 | 53 | 0. | 0. | 0. | C |
| 6 | 6 | 38 | [illegible] | 58 | 4.1 | 156 | 24.4 | 20.4 | 3.0 | 7 | 208 | 62 | 0.39 | 5.5 | 5.9 | D |
| 6 | 13 | 19 | 25.5 | 56 | 31.1 | 155 | 51.9 | 33.2 | 2.8 | 7 | 220 | 110 | 0.26 | 5.6 | 404.3 | D |
| 6 | 11 | 17 | [illegible] | [illegible] | 1.9 | 151 | 58.4 | [illegible] | 3.9 | 5 | 272 | 44 | 0.26 | 13.9 | 3.3 | D |
| 6 | 13 | 28 | [illegible] | 59 | 51.6 | 152 | 57.3 | [illegible] | 3.4 | 10 | 172 | 27 | 0.24 | 6.8 | 5.4 | D |
| 6 | 14 | 12 | 55.3 | 57 | 7.9 | 154 | 3.1 | 14.3 | 2.5 | 6 | 164 | 7 | 0.10 | 1.7 | 2.4 | C |
| 6 | 14 | 22 | [illegible] | 59 | 47.2 | 151 | 46.6 | [illegible] | 4.6 | 4 | 327 | 83 | 0. | 0. | 0. | C |
| 6 | 15 | 44 | 44.7 | 58 | 25.4 | 146 | 9.7 | 5.0 | 4.4 | 6 | 333 | 380 | 0.21 | 57.1 | 194.5 | D |
| 6 | 17 | 13 | 37.5 | 57 | 43.6 | 156 | 17.5 | 8.0 | 3.6 | 5 | 226 | 2 | 0.04 | 1.9 | 0.4 | C |
| 6 | 20 | 6 | 55.6 | 57 | 33.3 | 155 | 1.0 | 5.0 | 2.6 | 3 | 214 | 33 | 0.13 | 0. | 0. | C |
| 6 | [illegible] | 57 | [illegible] | 58 | 7.0 | 155 | 27.1 | 9.7 | 2.6 | 5 | 267 | 10 | 0.02 | 1.3 | 0.2 | C |

COOK INLET-[illegible] [illegible] ALASKA EARTHQUAKES

| DATE | | HR | MN | TIME SEC | LAT DEG | LAT MIN | LONG DEG | LONG MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 7 | 2 | 7 | 21.[illegible] | 60 | 37.1 | 151 | 55.2 | 82.1 | 0. | 21 | 115 | 51 | 0.53 | 3.8 | 5.7 | C |
| | ~~7~~ | [illegible] | ~~59~~ | ~~4.[illegible]~~ | [illegible] | [illegible] | [illegible] | ~~0.1~~ | [illegible] | ~~2.8~~ | ~~6~~ | ~~223~~ | ~~28~~ | ~~0.25~~ | ~~12.7~~ | ~~15.1~~ | ~~D~~ |
| | 7 | 9 | 19 | 46.0 | 59 | 17.3 | 152 | 55.5 | 76.6 | 2.5 | 5 | 266 | 29 | 0. | 0.2 | 0.2 | C |
| | 7 | 5 | 43 | 33.6 | 57 | 52.5 | 156 | 1.2 | 151.0 | 3.6 | 4 | 300 | 134 | 0.03 | 0. | 0. | C |
| | 7 | 6 | 20 | 41.2 | 59 | 13.3 | 152 | 28.8 | 71.9 | 2.6 | 7 | 230 | 52 | 0.62 | 19.8 | 25.1 | D |
| | 7 | 9 | 58 | 1[illegible].9 | 59 | 2[illegible].3 | 152 | 29.4 | 7[illegible].2 | 3.5 | 12 | 114 | 49 | 0.36 | 5.8 | 10.8 | C |
| | 7 | 11 | 3 | 1.[illegible] | 60 | 14.5 | 152 | 22.9 | 42.[illegible] | 2.6 | 4 | 195 | 29 | 0.57 | 0. | 0. | D |
| | 7 | 12 | 39 | 4[illegible].[illegible] | 56 | 56.[illegible] | 154 | 18.6 | 69.6 | 2.9 | 7 | 229 | 68 | 0.11 | 2.9 | 3.9 | D |
| | ~~8~~ | [illegible] | ~~19~~ | ~~3[illegible].7~~ | ~~57~~ | [illegible] | ~~152~~ | ~~46.3~~ | ~~131.[illegible]~~ | ~~2.5~~ | ~~5~~ | ~~187~~ | ~~25~~ | ~~0.42~~ | ~~68.7~~ | ~~40.2~~ | ~~D~~ |
| | 8 | 6 | 4 | 31.1 | 58 | 44.4 | 152 | 28.1 | 37.7 | 2.4 | 5 | 231 | 65 | 0.03 | 1.6 | 0.6 | C |
| | 8 | 9 | 30 | [illegible].2 | 61 | 20.9 | 146 | 49.5 | 33.[illegible] | 0. | 30 | 151 | 60 | 0.46 | 2.2 | 2.0 | D |
| | [illegible] | ~~17~~ | ~~35~~ | ~~5[illegible].1~~ | ~~59~~ | [illegible] | ~~153~~ | ~~13.8~~ | ~~11[illegible].1~~ | ~~3.2~~ | ~~7~~ | ~~192~~ | ~~29~~ | ~~0.31~~ | ~~8.3~~ | ~~9.5~~ | ~~D~~ |
| | 8 | 15 | 22 | 21.6 | 59 | 16.3 | 152 | 52.1 | 70.[illegible] | 2.8 | 5 | 209 | 35 | 0.22 | 17.5 | 17.4 | D |
| | 8 | 1[illegible] | 35 | 21.1 | 58 | 48.3 | 154 | 27.5 | 127.[illegible] | 2.9 | 7 | 163 | 36 | 0.30 | 6.1 | 12.1 | D |
| | 8 | 23 | 27 | 5[illegible].2 | 57 | [illegible].4 | 154 | 2.5 | 42.[illegible] | 2.6 | 6 | 110 | 32 | 0.09 | 1.1 | 2.1 | B |
| | 9 | 3 | 16 | [illegible].9 | 59 | 44.7 | 148 | 31.7 | 35.6 | 4.6 | 18 | 197 | 175 | 0.88 | 8.6 | 997.9 | D |
| | 9 | 7 | 11 | 29.3 | 56 | 55.7 | 155 | 42.8 | 64.3 | 3.2 | 6 | 159 | 23 | 1.09 | 22.6 | 30.5 | D |
| | 9 | 7 | 45 | 3[illegible].3 | 59 | 34.4 | 152 | 52.2 | 112.3 | 4.1 | 27 | 75 | 22 | 0.37 | 2.0 | 2.1 | B |
| | ~~9~~ | ~~7~~ | ~~56~~ | [illegible] | ~~60~~ | ~~12.3~~ | ~~152~~ | ~~14.3~~ | [illegible] | ~~3.4~~ | ~~7~~ | ~~202~~ | ~~38~~ | ~~0.29~~ | ~~9.5~~ | ~~11.8~~ | ~~D~~ |
| | 9 | 15 | 43 | [illegible].9 | 57 | [illegible]2.4 | 155 | 17.7 | [illegible] | 1.7 | 4 | 135 | 22 | 0.15 | 0. | 0. | C |
| | 10 | [illegible] | 26 | 36.4 | 57 | 57.9 | 154 | 6.6 | 63.[illegible] | 2.9 | 5 | 182 | 30 | 0.03 | 0.7 | 1.1 | C |
| | ~~10~~ | ~~6~~ | ~~10~~ | ~~5[illegible].7~~ | ~~57~~ | [illegible] | ~~153~~ | ~~26.5~~ | [illegible] | ~~2.9~~ | ~~5~~ | ~~230~~ | ~~17~~ | ~~0.20~~ | ~~53.3~~ | ~~74.9~~ | ~~D~~ |
| | 10 | 7 | 52 | 27.5 | 56 | 18.3 | 153 | 25.2 | 34.8 | 3.5 | 8 | 282 | 55 | 0.33 | 12.4 | 2.6 | D |
| | 10 | 12 | 36 | 53.7 | 56 | 36.0 | 151 | 37.9 | 39.5 | 3.8 | 9 | 284 | 108 | 0.58 | 27.9 | 776.2 | D |
| | 10 | 14 | 1 | 31.4 | 60 | 22.9 | 154 | 45.0 | 13.4 | 0. | 21 | 133 | 93 | 0.61 | 2.9 | 3.7 | D |
| | 10 | 14 | 14 | 5[illegible].1 | 58 | 5.6 | 154 | 52.6 | 5.0 | 2.6 | 4 | 209 | 75 | 0.52 | 0. | 0. | D |
| | 10 | 15 | 45 | [illegible].4 | 57 | 27.8 | 153 | 45.0 | 11.[illegible] | 2.6 | 4 | 132 | 32 | 0.04 | 0. | 0. | C |
| | 10 | 16 | 6 | 37.3 | 61 | 5.4 | 151 | 26.3 | 39.6 | 2.8 | 15 | 134 | 102 | 0.44 | 3.3 | 517.9 | D |
| | ~~10~~ | ~~21~~ | ~~42~~ | [illegible] | ~~56~~ | [illegible] | ~~153~~ | ~~40.6~~ | [illegible] | ~~0.~~ | ~~13~~ | ~~272~~ | ~~81~~ | ~~0.51~~ | ~~12.6~~ | ~~5.7~~ | ~~D~~ |
| | 11 | 1 | 25 | 33.6 | 60 | 14.5 | 152 | 52.1 | 204.1 | 2.3 | 4 | 347 | 68 | 0.07 | 0. | 0. | C |
| | 11 | 2 | 45 | 41.0 | 61 | 10.5 | 151 | 44.1 | 176.9 | 3.7 | 4 | 324 | 101 | 0.21 | 0. | 0. | C |
| | ~~11~~ | ~~3~~ | ~~49~~ | [illegible] | ~~58~~ | ~~27.6~~ | ~~152~~ | ~~12.9~~ | ~~15.0~~ | ~~2.5~~ | ~~4~~ | ~~247~~ | ~~73~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| | 11 | 9 | 0 | 17.8 | 60 | 34.3 | 147 | 50.3 | 13.4 | 3.9 | 16 | 217 | 143 | 0.61 | 6.6 | 5.6 | D |
| | 11 | 10 | 59 | 33.7 | 59 | 10.5 | 153 | 47.0 | 108.4 | 2.9 | 9 | 139 | 25 | 0.15 | 4.7 | 5.0 | C |
| | 11 | 13 | 44 | 26.[illegible] | 57 | 55.9 | 152 | 46.2 | 31.7 | 2.2 | 4 | 199 | 26 | 0.31 | 0. | 0. | D |
| | 11 | 20 | 32 | 47.2 | 59 | 24.9 | 152 | 26.2 | 91.[illegible] | 2.8 | 5 | 240 | 52 | 0.03 | 21.1 | 13.8 | D |
| | 11 | 22 | 43 | 59.4 | 58 | 1.4 | 154 | 8.3 | 8.0 | 3.1 | 8 | 109 | 47 | 0.17 | 1.2 | 246.0 | C |
| | 12 | [illegible] | 41 | 46.7 | 56 | 43.9 | 150 | 12.2 | 32.1 | 3.0 | 4 | 318 | 75 | 0.21 | 0. | 0. | C |
| | ~~12~~ | ~~21~~ | ~~45~~ | [illegible] | ~~57~~ | ~~36.5~~ | ~~154~~ | ~~54.1~~ | [illegible] | ~~2.6~~ | ~~4~~ | ~~284~~ | ~~31~~ | ~~0.69~~ | ~~0.~~ | ~~0.~~ | ~~D~~ |
| | 13 | 0 | 38 | 59.3 | 57 | 4.9 | 155 | 4.4 | 53.2 | 2.8 | 6 | 203 | 38 | 0.17 | 4.9 | 4.5 | D |
| | 13 | 1 | 41 | 56.1 | 59 | 43.0 | 152 | 51.7 | 5.0 | 3.9 | 3 | 253 | 68 | 0.09 | 0. | 0. | C |
| | ~~13~~ | ~~4~~ | ~~7~~ | ~~35.4~~ | ~~59~~ | ~~54.7~~ | ~~152~~ | ~~47.9~~ | ~~5.0~~ | ~~3.0~~ | ~~3~~ | ~~236~~ | ~~56~~ | ~~0.06~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| | 13 | 6 | 29 | 57.8 | 56 | 54.8 | 155 | 52.9 | 5.0 | 2.7 | 7 | 183 | 80 | 0.90 | 9.9 | 100.0 | D |
| | 13 | 8 | 5 | 27.0 | 56 | 43.8 | 155 | 2.9 | 57.1 | 3.0 | 5 | 236 | 71 | 0.01 | 0.5 | 0.9 | C |
| | 13 | 11 | 29 | 33.7 | 55 | 36.1 | 157 | 18.3 | 16.6 | 4.0 | 5 | 311 | 135 | 0.61 | 281.0 | 32.7 | D |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| 1973 | ORIGIN HR | MN | TIME SEC | LAT N DEG | MIN | LONG W DEG | MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ~~13~~ | ~~11~~ | ~~59~~ | ~~[illegible]~~ | ~~57~~ | ~~47.8~~ | ~~154~~ | ~~6.6~~ | ~~50.0~~ | ~~1.9~~ | ~~4~~ | ~~242~~ | ~~14~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 13 | 20 | 57 | 40.7 | 60 | 15.8 | 146 | 34.7 | 39.4 | 3.5 | 5 | 338 | 419 | 0.37 | 157.8 | 321.7 | D |
| 13 | 21 | 13 | 18.4 | 59 | 49.4 | 152 | 15.2 | 93.6 | 2.4 | 7 | 240 | 58 | 0.11 | 7.9 | 5.4 | D |
| 14 | 1 | 25 | 4.6 | 60 | 4.9 | 152 | 55.8 | 115.9 | 2.9 | 9 | 160 | 38 | 0.23 | 5.4 | 8.5 | D |
| ~~14~~ | ~~1~~ | ~~59~~ | ~~[illegible]~~ | ~~49~~ | ~~10.2~~ | ~~153~~ | ~~29.6~~ | ~~206.3~~ | ~~4.9~~ | ~~27~~ | ~~108~~ | ~~59~~ | ~~0.45~~ | ~~3.0~~ | ~~3.9~~ | ~~C~~ |
| 14 | 2 | 8 | 55.6 | 57 | 12.6 | 153 | 60.0 | 3.2 | 1.8 | 4 | 119 | 13 | 0.18 | 0. | 0. | C |
| 14 | 4 | 52 | 8.7 | 60 | 0.3 | 153 | 7.3 | 149.5 | 3.0 | 7 | 172 | 39 | 0.13 | 10.6 | 12.7 | D |
| ~~14~~ | ~~7~~ | ~~51~~ | ~~[illegible]~~ | ~~58~~ | ~~2.9~~ | ~~154~~ | ~~22.7~~ | ~~6.5~~ | ~~1.8~~ | ~~4~~ | ~~282~~ | ~~48~~ | ~~0.15~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 14 | 10 | 40 | 14.3 | 60 | 1.3 | 152 | 25.6 | 5.0 | 3.0 | 5 | 156 | 48 | 0.71 | 14.0 | 34.2 | D |
| 14 | 19 | 26 | 49.8 | 59 | 50.1 | 152 | 1.7 | 87.9 | 0. | 9 | 165 | 29 | 0.19 | 4.1 | 8.8 | C |
| ~~14~~ | ~~2?~~ | ~~4~~ | ~~11.1~~ | ~~59~~ | ~~47.7~~ | ~~154~~ | ~~2.8~~ | ~~5.0~~ | ~~3.4~~ | ~~3~~ | ~~286~~ | ~~34~~ | ~~0.33~~ | ~~0.~~ | ~~0.~~ | ~~D~~ |
| 14 | 21 | 14 | 15.3 | 60 | 1.6 | 152 | 20.5 | 8.3 | 3.2 | 5 | 165 | 49 | 0.56 | 8.8 | 999.9 | D |
| 15 | 13 | 24 | 53.0 | 56 | 48.9 | 150 | 40.1 | 19.1 | 4.3 | 9 | 289 | 151 | 0.34 | 19.0 | 7.7 | D |
| 15 | 19 | 22 | 50.1 | 59 | 20.4 | 152 | 27.2 | 84.0 | 2.5 | 7 | 143 | 51 | 0.24 | 9.8 | 17.0 | D |
| ~~15~~ | ~~21~~ | ~~24~~ | ~~[illegible]~~ | ~~57~~ | ~~42.5~~ | ~~155~~ | ~~29.6~~ | ~~134.0~~ | ~~2.8~~ | ~~9~~ | ~~176~~ | ~~16~~ | ~~0.12~~ | ~~4.8~~ | ~~3.4~~ | ~~C~~ |
| 16 | 2 | 38 | 37.3 | 59 | 20.7 | 148 | 23.5 | 2.7 | 3.5 | 9 | 308 | 187 | 0.35 | 33.9 | 21.0 | D |
| 16 | 15 | 8 | 13.7 | 59 | 50.4 | 153 | 18.7 | 142.3 | 3.8 | 4 | 198 | 21 | 0.05 | 0. | 0. | C |
| ~~16~~ | ~~17~~ | ~~17~~ | ~~[illegible]~~ | ~~56~~ | ~~43.9~~ | ~~154~~ | ~~39.6~~ | ~~38.9~~ | ~~2.9~~ | ~~6~~ | ~~195~~ | ~~35~~ | ~~0.26~~ | ~~4.7~~ | ~~2.4~~ | ~~D~~ |
| 16 | 17 | 11 | 24.3 | 57 | 27.0 | 155 | 24.6 | 70.6 | 1.9 | 4 | 163 | 58 | 0. | 0. | 0. | C |
| 16 | 20 | 15 | 59.[illegible] | 57 | 44.5 | 153 | 18.4 | 5.0 | 1.6 | 3 | 154 | 27 | 0. | 0. | 0. | C |
| ~~16~~ | ~~2?~~ | ~~16~~ | ~~[illegible]~~ | ~~59~~ | ~~44.?~~ | ~~152~~ | ~~58.5~~ | ~~111.7~~ | ~~3.5~~ | ~~12~~ | ~~102~~ | ~~17~~ | ~~0.27~~ | ~~2.9~~ | ~~3.4~~ | ~~C~~ |
| 17 | 9 | 46 | 30.6 | 58 | 19.4 | 152 | 32.7 | 33.5 | 3.7 | 6 | 154 | 46 | 0.14 | 2.4 | 2.1 | C |
| 17 | 12 | 48 | 42.0 | 57 | 17.2 | 153 | 53.9 | 5.0 | 2.3 | 3 | 189 | 22 | 0. | 0. | 0. | C |
| 17 | 13 | 29 | 27.3 | 59 | 28.1 | 152 | 10.4 | 99.9 | 2.7 | 5 | 142 | 33 | 0.27 | 25.5 | 32.7 | D |
| ~~17~~ | ~~14~~ | ~~47~~ | ~~[illegible]~~ | ~~55~~ | ~~25.7~~ | ~~155~~ | ~~43.2~~ | ~~35.1~~ | ~~0.~~ | ~~4~~ | ~~266~~ | ~~222~~ | ~~0.92~~ | ~~0.~~ | ~~0.~~ | ~~D~~ |
| 17 | 15 | 45 | 33.7 | 58 | [illegible].3 | 151 | 22.1 | 34.5 | 3.8 | 6 | 228 | 79 | 0.43 | 13.0 | 6.6 | D |
| 17 | 22 | 52 | 12.7 | 59 | 52.3 | 155 | 1.6 | 5.0 | 2.2 | 3 | 301 | 103 | 0. | 0. | 0. | C |
| ~~18~~ | ~~4~~ | ~~32~~ | ~~[illegible]~~ | ~~57~~ | ~~51.2~~ | ~~152~~ | ~~40.6~~ | ~~10.3~~ | ~~3.4~~ | ~~6~~ | ~~133~~ | ~~27~~ | ~~0.17~~ | ~~4.3~~ | ~~5.0~~ | ~~D~~ |
| 18 | 18 | 52 | 27.8 | 59 | 45.3 | 153 | 14.7 | 133.5 | 0. | 28 | 96 | 11 | 0.59 | 3.4 | 3.6 | C |
| 19 | 0 | 36 | 6.5 | 59 | 31.2 | 151 | 11.0 | 22.4 | 3.1 | 6 | 257 | 116 | 0.71 | 103.8 | 104.2 | D |
| ~~19~~ | ~~2~~ | ~~57~~ | ~~5.0~~ | ~~58~~ | ~~24.6~~ | ~~151~~ | ~~24.7~~ | ~~3.9~~ | ~~3.4~~ | ~~5~~ | ~~271~~ | ~~91~~ | ~~0.40~~ | ~~7.5~~ | ~~17.4~~ | ~~D~~ |
| 19 | 3 | 52 | 57.4 | 57 | 9.6 | 153 | 22.3 | 5.0 | 3.3 | 7 | 168 | 17 | 1.32 | 11.7 | 12.0 | D |
| 19 | 3 | 58 | 55.6 | 56 | 26.5 | 152 | 41.5 | 22.4 | 0. | 12 | 263 | 84 | 0.51 | 11.9 | 5.3 | D |
| 19 | 4 | 3 | 9.5 | 57 | 14.7 | 153 | 16.8 | 21.4 | 3.2 | 5 | 150 | 15 | 0.72 | 25.1 | 23.9 | D |
| ~~19~~ | ~~4~~ | ~~9~~ | ~~34.5~~ | ~~57~~ | ~~19.5~~ | ~~153~~ | ~~23.3~~ | ~~0.8~~ | ~~2.7~~ | ~~5~~ | ~~127~~ | ~~25~~ | ~~0.49~~ | ~~3.2~~ | ~~16.7~~ | ~~D~~ |
| 19 | 7 | 4 | 54.4 | 59 | 30.9 | 151 | 35.9 | 24.8 | 3.2 | 6 | 242 | 93 | 0.38 | 32.4 | 34.8 | D |
| 19 | 7 | 50 | 13.7 | 56 | 47.8 | 157 | 45.5 | 103.3 | 3.9 | 13 | 168 | 10 | 0.28 | 4.4 | 4.6 | C |
| ~~19~~ | ~~11~~ | ~~59~~ | ~~[illegible]~~ | ~~59~~ | ~~11.6~~ | ~~153~~ | ~~39.1~~ | ~~113.3~~ | ~~3.8~~ | ~~11~~ | ~~126~~ | ~~21~~ | ~~0.23~~ | ~~4.6~~ | ~~4.2~~ | ~~C~~ |
| 19 | 15 | 45 | 45.4 | 57 | 40.5 | 155 | 57.5 | 21.5 | 3.7 | 6 | 187 | 28 | 0.12 | 2.1 | 1.8 | C |
| 19 | 18 | 31 | 25.2 | 57 | 34.7 | 155 | 6.8 | 94.2 | 2.5 | 5 | 292 | 39 | 0.05 | 9.2 | 10.3 | D |
| ~~19~~ | ~~21~~ | ~~28~~ | ~~25.2~~ | ~~59~~ | ~~57.6~~ | ~~154~~ | ~~11.9~~ | ~~139.3~~ | ~~0.~~ | ~~14~~ | ~~120~~ | ~~34~~ | ~~0.37~~ | ~~4.1~~ | ~~4.8~~ | ~~C~~ |
| 20 | 12 | 39 | 50.4 | 58 | 43.3 | 152 | 39.1 | 41.0 | 3.8 | 6 | 152 | 79 | 0.31 | 5.1 | 529.8 | D |
| 21 | 2 | 0 | 44.9 | 57 | 34.6 | 154 | 18.6 | 5.0 | 2.7 | 3 | 196 | 33 | 0. | 0. | 0. | C |
| 21 | 8 | 14 | 41.5 | 57 | 41.2 | 152 | 42.6 | 37.0 | 3.8 | 4 | 145 | 14 | 0. | 0. | 0. | C |
| ~~21~~ | ~~[illegible]~~ | ~~47~~ | ~~59.7~~ | ~~60~~ | ~~1.3~~ | ~~152~~ | ~~2.3~~ | ~~69.4~~ | ~~2.2~~ | ~~5~~ | ~~194~~ | ~~46~~ | ~~0.46~~ | ~~17.3~~ | ~~22.5~~ | ~~D~~ |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| DATE | HR | MN | SEC | LAT DEG | LAT MIN | LONG DEG | LONG MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 5 | 59 | 1?.? | 57 | 1?.? | 153 | 49.1 | 5.0 | 0.6 | 3 | 192 | 24 | 0. | 0. | 0. | C |
| ~~21~~ | ~~1~~ | ~~14~~ | [illegible] | ~~57~~ | [illegible] | ~~15?~~ | ~~36.6~~ | [illegible] | ~~0.~~ | ~~12~~ | ~~176~~ | ~~28~~ | ~~0.45~~ | ~~3.5~~ | ~~3.9~~ | ~~C~~ |
| 22 | ? | 20 | ?.7 | 61 | 43.8 | 152 | 0.7 | 34.7 | 4.6 | 24 | 93 | 153 | 0.81 | 3.4 | 884.7 | D |
| 22 | ? | 27 | 5?.4 | 53 | 4?.9 | 153 | 46.4 | 37.9 | 3.4 | 9 | 131 | 73 | 0.26 | 2.3 | 1.8 | B |
| 22 | 16 | 9 | 2?.? | 59 | 34.7 | 153 | 20.6 | 5.0 | 0. | 4 | 185 | 40 | 0.20 | 0. | 0. | C |
| 22 | 17 | 12 | 1?.9 | 60 | 4.9 | 152 | 48.8 | 109.1 | 2.9 | 4 | 158 | 37 | 0. | 0. | 0. | C |
| 22 | 18 | 52 | 2?.? | 57 | ?.1 | 153 | 56.9 | 29.2 | 3.2 | 5 | 221 | 4 | 0.02 | 0.6 | 0.3 | C |
| 22 | 19 | 45 | 2?.? | 60 | 16.3 | 152 | 51.9 | 135.1 | 4.2 | 18 | 149 | 17 | 0.31 | 3.4 | 2.8 | C |
| ~~22~~ | ~~22~~ | ~~7~~ | [illegible] | [illegible] | ~~2?.7~~ | ~~151~~ | ~~54.7~~ | [illegible] | ~~0.~~ | ~~19~~ | ~~109~~ | ~~18~~ | ~~0.36~~ | ~~1.9~~ | ~~2.7~~ | ~~C~~ |
| 22 | 22 | 52 | 23.3 | 59 | 51.9 | 152 | 8.4 | 57.7 | 2.4 | 4 | 174 | 53 | 0. | 0. | 0. | C |
| 23 | 4 | 23 | 1?.6 | 5? | ??.7 | 152 | 59.9 | 72.1 | 3.1 | 7 | 134 | 56 | 0.24 | 5.1 | 12.0 | C |
| ~~23~~ | [illegible] | ~~20~~ | ~~1?.2~~ | ~~60~~ | ~~?.7~~ | ~~152~~ | ~~20.8~~ | ~~116.1~~ | ~~3.7~~ | ~~7~~ | ~~177~~ | ~~41~~ | ~~0.19~~ | ~~5.0~~ | ~~7.1~~ | ~~D~~ |
| 23 | 11 | 13 | 4?.3 | 59 | 61.4 | 152 | 37.1 | 99.1 | 2.7 | 9 | 100 | 34 | 0.31 | 4.4 | 6.6 | C |
| 23 | 12 | 45 | 4?.? | 59 | 2?.7 | 153 | 39.5 | 131.5 | 2.6 | 4 | 242 | 22 | 0. | 0. | 0. | C |
| 23 | 19 | 49 | 17.? | 59 | ?7.3 | 152 | 45.6 | 118.0 | 4.6 | 10 | 184 | 42 | 0.23 | 7.7 | 5.8 | D |
| 24 | 1 | 31 | 4?.? | 59 | 47.4 | 148 | 39.1 | 30.4 | 4.9 | 21 | 114 | 136 | 0.87 | 4.2 | 972.4 | D |
| 24 | 6 | 9 | ?.4 | 59 | 25.0 | 152 | 37.8 | 133.0 | 2.6 | 7 | 156 | 59 | 0.23 | 9.7 | 17.1 | D |
| 24 | ? | 45 | 5?.6 | 59 | 5?.7 | 152 | 52.0 | 74.6 | 2.8 | 7 | 197 | 58 | 0.23 | 12.3 | 12.3 | D |
| ~~24~~ | ~~1?~~ | ~~?~~ | [illegible] | ~~57~~ | [illegible] | ~~15?~~ | ~~12.5~~ | ~~5.0~~ | ~~1.6~~ | ~~3~~ | ~~310~~ | ~~83~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 24 | 12 | 14 | 5?.? | 56 | ?1.9 | 153 | 14.1 | 11.0 | 2.9 | 4 | 284 | 34 | 0.15 | 0. | 0. | C |
| 24 | 1? | 39 | 30.4 | 59 | ??.4 | 152 | 21.2 | 80.? | 3.2 | 8 | 137 | 44 | 0.08 | 1.3 | 2.0 | C |
| ~~24~~ | ~~1?~~ | ~~?~~ | ~~51.7~~ | [illegible] | [illegible] | ~~15?~~ | ~~2?.9~~ | ~~37.?~~ | ~~3.3~~ | ~~9~~ | ~~255~~ | ~~112~~ | ~~0.72~~ | ~~23.4~~ | ~~966.1~~ | ~~D~~ |
| 24 | 15 | 4 | 13.3 | 59 | 46.1 | 153 | 20.3 | 131.? | 2.8 | 6 | 170 | 14 | 0.03 | 1.7 | 1.5 | C |
| 24 | 16 | 10 | 1?.5 | 59 | ?.1 | 153 | 4.9 | 85.7 | 2.5 | 9 | 173 | 28 | 0.40 | 18.7 | 10.3 | D |
| 24 | 17 | 15 | 31.2 | 59 | 37.0 | 153 | 7.8 | 85.9 | 3.1 | 8 | 162 | 62 | 0.14 | 2.7 | 5.1 | D |
| 25 | 4 | 9 | 45.1 | 59 | ?7.0 | 153 | 21.6 | 29.? | 3.8 | 11 | 152 | 210 | 0.70 | 9.1 | 874.1 | D |
| 25 | ? | 9 | 24.9 | 60 | 31.? | 152 | 9.2 | 35.3 | 2.5 | 4 | 274 | 36 | 0.15 | 0. | 0. | C |
| 25 | ? | 47 | 2?.? | 60 | 6.9 | 152 | 15.1 | 16.1 | 0. | 5 | 186 | 44 | 0.15 | 51.7 | 628.1 | D |
| ~~25~~ | ~~1?~~ | ~~?5~~ | [illegible] | ~~5?~~ | [illegible] | ~~153~~ | ~~27.4~~ | ~~109.2~~ | ~~2.3~~ | ~~4~~ | ~~220~~ | ~~39~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 25 | 15 | 35 | 2?.8 | 57 | 27.7 | 153 | 43.7 | 31.0 | 3.0 | 5 | 103 | 33 | 0.13 | 2.1 | 8.1 | D |
| 25 | 17 | 2 | 5?.3 | 58 | ?.2 | 155 | 22.1 | 8.6 | 3.3 | 9 | 164 | 41 | 0.30 | 2.4 | 406.3 | C |
| ~~25~~ | ~~17~~ | ~~7~~ | ~~1?.6~~ | [illegible] | ~~6?.4~~ | ~~151~~ | ~~7.9~~ | ~~13.?~~ | ~~3.0~~ | ~~7~~ | ~~251~~ | ~~118~~ | ~~0.16~~ | ~~11.4~~ | ~~12.8~~ | ~~D~~ |
| 26 | ? | 21 | 1?.? | 59 | 3?.5 | 153 | 58.4 | 4.4 | 1.8 | 4 | 256 | 40 | 0.36 | 0. | 0. | D |
| 26 | 4 | 16 | 1?.? | 59 | 25.6 | 151 | 22.8 | 139.0 | 3.0 | 4 | 341 | 107 | 0.03 | 0. | 0. | C |
| 26 | 4 | 17 | 33.7 | 58 | 2?.1 | 156 | 9.0 | 198.9 | 3.6 | 6 | 314 | 161 | 0.15 | 37.9 | 33.8 | D |
| 26 | 4 | 36 | 7.3 | 60 | 30.1 | 147 | 21.5 | 5.0 | 4.6 | 4 | 322 | 297 | 0.17 | 0. | 0. | C |
| 26 | 5 | 15 | 46.? | 56 | 27.9 | 153 | 18.6 | 5.0 | 2.3 | 3 | 271 | 54 | 0.16 | 0. | 0. | C |
| 26 | 7 | 59 | ?.5 | 59 | 53.3 | 151 | 40.5 | 90.1 | 3.7 | 6 | 222 | 25 | 0.05 | 1.5 | 2.1 | C |
| ~~26~~ | ~~11~~ | ~~52~~ | ~~2?.5~~ | ~~5?~~ | ~~56.5~~ | ~~152~~ | ~~40.5~~ | ~~85.?~~ | ~~3.1~~ | ~~5~~ | ~~225~~ | ~~34~~ | ~~0.06~~ | ~~22.9~~ | ~~8.8~~ | ~~D~~ |
| 26 | 11 | 54 | 33.3 | 56 | 25.1 | 153 | 10.6 | 5.0 | 1.6 | 3 | 280 | 63 | 0.21 | 0. | 0. | C |
| 26 | 12 | 39 | 37.0 | 57 | 44.8 | 154 | 55.6 | 5.0 | 2.1 | 5 | 164 | 68 | 1.10 | 20.8 | 999.9 | D |
| ~~26~~ | ~~14~~ | ~~37~~ | ~~?.4~~ | ~~57~~ | ~~41.8~~ | ~~151~~ | ~~1.4~~ | ~~3?.?~~ | ~~3.3~~ | ~~7~~ | ~~254~~ | ~~124~~ | ~~0.74~~ | ~~21.5~~ | ~~999.9~~ | ~~D~~ |
| 26 | 17 | 13 | 52.0 | 59 | 34.3 | 151 | 47.9 | 43.1 | 2.7 | 5 | 284 | 81 | 0.06 | 23.9 | 201.5 | D |
| 26 | 21 | 18 | 44.8 | 58 | 43.1 | 153 | 50.8 | 1.4 | 2.6 | 7 | 157 | 47 | 0.14 | 4.5 | 20.8 | C |
| 26 | 22 | 3 | 47.2 | 59 | 48.6 | 153 | 14.6 | 149.2 | 3.9 | 10 | 164 | 17 | 0.33 | 8.1 | 7.2 | D |

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

| DATE | ORIGIN TIME HR MN | SEC | LAT N DEG MIN | LONG W DEG MIN | DEPTH KM | MAG | NO | GAP DEG | DM KM | RMS SEC | ERH KM | ERZ KM | Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ~~27~~ | ~~[illegible] 14~~ | ~~[illegible]~~ | ~~[illegible]~~ | ~~14[illegible] 1.3~~ | ~~[illegible]~~ | ~~0.~~ | ~~4~~ | ~~[illegible]~~ | ~~463~~ | ~~0.72~~ | ~~0.~~ | ~~0.~~ | ~~D~~ |
| 27 | 5 58 | 54.[illegible] | 59 20.1 | 152 35.6 | 41.1 | 2.5 | 5 | 205 | 74 | 0.16 | 7.1 | 355.5 | D |
| 27 | 6 0 | 1[illegible] | 57 43.3 | 152 43.6 | [illegible].3 | 2.1 | 5 | 157 | 15 | 0.78 | 45.2 | 48.4 | D |
| 27 | 7 27 | 3[illegible].3 | 59 38.6 | 156 52.6 | 39.7 | 2.8 | 7 | 252 | 134 | 0.43 | 12.2 | 654.1 | D |
| ~~27~~ | ~~7 41~~ | ~~[illegible]~~ | ~~59 22.2~~ | ~~151 34.6~~ | ~~51.1~~ | ~~2.6~~ | ~~4~~ | ~~274~~ | ~~32~~ | ~~0.13~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 27 | [illegible] 47 | 3[illegible].1 | 56 31.7 | 156 31.3 | 13.[illegible] | 0.[illegible] | 10 | 84 | 56 | 0.21 | 5.8 | 11.6 | D |
| 27 | 1 3 | [illegible].1 | 57 42.9 | 151 5.7 | 62.3 | 3.0 | 6 | 275 | 31 | 0.18 | 15.7 | 12.2 | D |
| ~~27~~ | ~~10 52~~ | ~~[illegible]~~ | ~~[illegible]~~ | ~~15[illegible] 21.1~~ | ~~[illegible]~~ | ~~4.4~~ | ~~9~~ | ~~264~~ | ~~123~~ | ~~0.32~~ | ~~45.5~~ | ~~47.3~~ | ~~D~~ |
| 27 | 11 37 | 5[illegible].6 | 59 60.8 | 151 56.3 | 85.3 | 2.5 | 4 | 272 | 75 | 0.03 | 0. | 0. | C |
| 27 | 1[illegible] 38 | 37.0 | 57 28.3 | 154 2.7 | 2.1 | 2.0 | 4 | 140 | 36 | 0. | 0. | 0. | C |
| ~~27~~ | ~~1[illegible] 26~~ | ~~[illegible]~~ | ~~[illegible]~~ | ~~151 58.9~~ | ~~[illegible]~~ | ~~2.0~~ | ~~4~~ | ~~290~~ | ~~30~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 27 | 2[illegible] 51 | 1[illegible] | 59 5[illegible] | 152 27.1 | 111.3 | 3.2 | 5 | 239 | 50 | 0.09 | 46.3 | 20.2 | D |
| [illegible] | 1[illegible] 30 | 4[illegible] | 59 3[illegible].5 | 152 55.1 | 122.5 | 2.6 | 6 | 177 | 20 | 0.19 | 8.5 | 9.5 | D |
| [illegible] | 1[illegible] 28 | 5[illegible].3 | 57 46.2 | 153 19.0 | 5.0 | 1.5 | 3 | 153 | 27 | 0. | 0. | 0. | C |
| ~~[illegible]~~ | ~~16 57~~ | ~~[illegible]~~ | ~~[illegible]~~ | ~~154 26.3~~ | ~~[illegible]~~ | ~~2.9~~ | ~~4~~ | ~~201~~ | ~~23~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 28 | 2[illegible] 28 | 16.9 | 59 48.0 | 153 34.9 | 137.3 | 2.5 | 4 | 189 | 25 | 0. | 0. | 0. | C |
| 29 | [illegible] 26 | 5[illegible].0 | 60 58.3 | 147 0.2 | 5.0 | 0. | 6 | 289 | 133 | 0.47 | 140.7 | 172.6 | D |
| ~~29~~ | ~~7 11~~ | ~~21.[illegible]~~ | ~~[illegible]~~ | ~~152 43.5~~ | ~~1.[illegible]~~ | ~~0.~~ | ~~14~~ | ~~154~~ | ~~75~~ | ~~0.73~~ | ~~5.9~~ | ~~28.2~~ | ~~D~~ |
| 29 | 2[illegible] 45 | 5[illegible].7 | 60 17.4 | 151 23.7 | 36.0 | 3.7 | 5 | 272 | 77 | 0.35 | 135.7 | 57.5 | D |
| [illegible] | 2[illegible] 6 | 4[illegible].6 | 60 14.5 | 153 38.4 | 20[illegible] | 4.5 | 18 | 122 | 52 | 0.33 | 2.7 | 3.7 | C |
| ~~30~~ | ~~1[illegible] 26~~ | ~~1[illegible]~~ | ~~57 [illegible]~~ | ~~153 11.0~~ | ~~13[illegible].7~~ | ~~3.0~~ | ~~7~~ | ~~176~~ | ~~8~~ | ~~0.14~~ | ~~5.9~~ | ~~3.8~~ | ~~D~~ |
| 30 | 21 6 | 1[illegible].7 | 60 6.2 | 152 37.0 | 127.5 | 3.9 | 13 | 146 | 47 | 0.31 | 4.1 | 4.7 | C |
| 31 | [illegible] 54 | 35.3 | 57 54.1 | 155 17.8 | 113.6 | 3.3 | 6 | 300 | 74 | 0.35 | 28.5 | 23.4 | D |
| 31 | 1 6 | 44.1 | 56 26.6 | 153 31.2 | 5.0 | 1.9 | 3 | 275 | 44 | 0.14 | 0. | 0. | C |
| ~~31~~ | ~~1 14~~ | ~~3[illegible]~~ | ~~56 30.7~~ | ~~153 35.5~~ | ~~[illegible]~~ | ~~2.9~~ | ~~3~~ | ~~255~~ | ~~36~~ | ~~0.~~ | ~~0.~~ | ~~0.~~ | ~~C~~ |
| 31 | 1 15 | 3[illegible] | 56 29.7 | 153 35.3 | 5.0 | 3.4 | 4 | 259 | 37 | 0.41 | 0. | 0. | D |
| 31 | 1 21 | 2[illegible] | 56 1[illegible] | 153 29.5 | 37.2 | 3.5 | 4 | 294 | 54 | 0. | 0. | 0. | C |
| ~~31~~ | ~~17 57~~ | ~~1[illegible]~~ | ~~[illegible] 1.[illegible]~~ | ~~15[illegible] 7.2~~ | ~~57.3~~ | ~~2.6~~ | ~~5~~ | ~~262~~ | ~~66~~ | ~~0.13~~ | ~~53.9~~ | ~~44.8~~ | ~~D~~ |
| 31 | 2[illegible] 44 | 3[illegible] | 59 45.3 | 153 15.3 | 126.3 | 3.3 | 9 | 164 | 11 | 0.19 | 6.9 | 4.8 | D |

QUARTERLY REPORT

Contract #02-5-022-55
Research Unit #253
Task Order #1
Reporting Period: 1/7/78 - 30/9/78
Number of Pages: 2

# SUBSEA PERMAFROST

## PROBING, THERMAL REGIME AND DATA ANALYSIS

T. E. Osterkamp
W. D. Harrison
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

Reference: Iskandar, I.K., Osterkamp, T.E. and Harrison, W.D., Chemistry of Interstitial Water from the Subsea Permafrost, Prudhoe Bay, Alaska, Third International Conference on Permafrost, Edmonton, Alberta, Canada, 10-13 July, 1978, pp. 92-98.

October 1978

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Period Ending September 30, 1978

Project Title: Subsea Permafrost: Probing, Thermal Regime and Data Analysis

Contract Number: 03-5-022-55

Task Order Number: 1

Principal Investigators: T. E. Osterkamp and W. D. Harrison

I. Task Objectives:

To determine the subsea permafrost regime in selected near-shore areas in the Beaufort Sea using lightweight probing techniques and appropriate data and analysis (D-9).

II. Field and Laboratory Work:

Permafrost conditions on the Barrier Islands were investigated by two men during the period August 19-25, 1978. Holes were jetted into Reindeer, Stump and Cottle Islands. These islands were chosen as being representative of a range of island morphologies, and because seismic data had been obtained by Rogers and Morack either on each island or nearby offshore. The holes are still being logged for temperature. The data from this work, and from our main field project in April - May are still being analyzed.

III & IV. Results and Interpretation:

In progress

V. Problems:

None

VI. Funds Expended:

$278,689.16 as of August 31, 1978.

Quarterly Report

Contract #03-5-022-55
Research Unit #271
Report Period: 14th Quarter
Ending Sept. 30
Number of Pages: 2

# BEAUFORT SEACOAST PERMAFROST STUDIES

James C. Rogers
John L. Morack
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
(907) 272-5522

September 30, 1978

I. Task Objectives: The objectives of this study are to develop an understanding of the nature and distribution of offshore permafrost along the Alaska Beaufort Seacoast. Also of interest is the distribution of permafrost beneath the barrier islands. Emphasis is placed upon seismic methods but close cooperation with others using thermal, chemical and geological methods is an important part of the work.

II. Field Work: A 21 foot Boston Whaler was used for the first time this year and over 300 seismic records were taken. This is the highest number yet gathered in a season.

Marine lines were run in the eastern end of Simpson Lagoon and between Beechey Point and Cottle Island. Additional lines were run both east and west of Gull Island in Prudhoe Bay and in between Narwhal Island and the mainland. Refraction lines were also run using a hammer seismograph on Reindeer Island adjacent to holes drilled and temperature logged by Harrison and Osterkamp.

III. Results: Data analysis is continuing, approximately one half of the records have been scaled data plotting and analysis will be accomplished in the following quarter.

IV. Preliminary Interpretation of Results: The data taken on Reindeer Island support our earlier conclusion that to depths of at least 10 meters beneath the Island continuous bonded materials do not exist.

Ice bonded velocities have been observed in the eastern end of Simpson Lagoon but in the vicinity of Cottle Island none were observed. Our conclusion is that either bonded materials are absent in this area or they are deeper than the penetration depth of our equipment (approximately 40 meters).

V. Problems Encountered/Recommended Changes: Difficulty with a leased positioning system precluded exact location of the offshore lines. An examination of the applicability of a small boat radar is being made to determine if such a system could be used to provide navigational and hence data position information.

VI. Estimate of Funds Spent to Date: $ 170,000.00

# QUARTERLY REPORT

Contract: #03-5-022-56
Research Unit: #290
Task Order: #3
Reporting Period: 7/1/78-9/30/78
Number of pages: 5

# SEDIMENT SIZE ANALYSIS

Dr. Charles Hoskin
Dr. David Burrell

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

September 1978

## I. TASK OBJECTIVES

There have been two principle objectives in this program. The work on benthos-sedimentary substrate interactions has been largely completed and was reported on in the Annual Report. The final objective is concerned with physical parameters and mineral composition of surface sediments from the southeastern Bering Sea continental shelf. These are being examined in order to determine the environmental processes operating in this region. This investigation will define the character, trends, and variations of the surface sediments; suggest source areas by, for example, comparing the geology of the catchment, areas of drainage systems and the various mineral assemblages of the sediments in the study area; distinguish between modern, palimpsest, and relict sediments by means of sediment texture and mineralogy; and, by interpretation, will delineate the influences of environmental forces on the sediment distribution.

## II. FIELD AND LABORATORY ACTIVITIES

### A. Field Work

None for this R.U. this quarter

### B. Scientific Parties

N/A

### C. Field Collection Methods

N/A

### D. Sample Localities

N/A

E. Laboratory and Analysis Program

1. Grain size analysis of sediments has been done in the laboratory following the procedures of Hoskin (1976). Statistical parameters have been generated from the size analyses using a University of Washington computer program.

2. Thin sections have been made from each sand fraction following impregnation with artificial resin.

3. Heavy mineral separation by gravity settling in a brominated hydrocarbon liquid has been accomplished.

4. X-ray diffraction of the heavy mineral assemblage of each sample has been completed.

5. LANDSAT imagery has been studied in order to trace sediment source and movement.

6. By correlating the results of these sedimentological studies with data obtained from physical oceanographic reports, principal water masses and circulation patterns that influence mineral transport will be determined.

III. RESULTS

1. Heavy Mineral Analysis
X-ray Diffraction

X-ray diffraction patterns have been obtained for the heavy mineral assemblage of each sample with the objective of characterizing the samples in order to group them according to their gross diffraction patterns which, in turn, correspond to petrographic groups. Preliminary study shows that the mineralogy of these sediments reflects the energy regime of the shelf.

2. Satellite Imagery

Satellite imagery of the study area taken during various seasons and years have been examined. It has been determined that rivers are primary sediment sources and that suspended sediment is transported in a net counterclockwise direction along the northern coast of the Alaska Peninsula, into Bristol Bay, then northward, closely following the coast until reaching the Nushazak and Kirchak rivers, where the suspended sediment then extends out to 35 km beyond the Nushagak Peninsula. Generally, however, the concentration of offshore suspended sediment is low until the flow reaches the Kuskokwim Bay.

3. Grain-size Analysis

Granulometric analyses have been completed and statistical parameters such as mean grain size, sorting, skewness, kurtosis, percentage gravel, percentage sand, percentage silt, percentage clay, sand/mud ratio, and size class have been generated from the size analysis. Factor analyses on the sediment textural data have yet to be run.

4. Petrographic Analysis

Thin-sections have been made from each sand fraction following impregnation with artificial resin. These are being examined by petrographic microscope. Point counting has yet to be completed.

5. Biological Studies

Relationships have been sought between sediment and the benthos (Dr. C. M. Hoskin, Benthos-Sedimentary Substrate Interactions, Summary

Report, January 1978). The problem of biological correlation with sediment type will be considered further.

## IV. PRELIMINARY INTERPRETATION

No discussion of the results is included in this quarterly report. These data will be summarized and discussed in a M.S. thesis.

## V. PROBLEMS ENCOUNTERED

No major problems were encountered this quarter.

4th QUARTERLY REPORT

July - September, 1978

OCSEAP RU 327

Shallow faulting, bottom instability, and movement of sediment in lower Cook Inlet and Western Gulf of Alaska.

Principal investigators:

Monty A. Hampton
Arnold H. Bouma

U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

Submitted:

September 29, 1978

I. Highlights of Quarter's Accomplishments:

A cruise was conducted in lower Cook Inlet and western Gulf of Alaska from August 2 - August 22, 1978. Since returning from the cruise we started to recompute our cruise tracks, study the records, and bottom television tapes.

II. Task Objectives:

Assessment of the geologic hazards of lower Cook Inlet and the western Gulf of Alaska continental shelf; in particular the identification and mapping of active surface faults, gas-charged sediments, and areas of sediment instability.

III. Field or Laboratory Activities:

A. Ship schedule: see table I
B. Scientific party: see table II
C. Methods and kilometers of data collected: see table III
D. Sample locations: see table IV
E. Other data collected: see table V

IV. Results:

Lower Cook Inlet (see attached sheets)

Kodiak Shelf (see attached sheets)

VI. Auxiliary Material:

none

LOWER COOK INLET

This summer's fieldwork in lower Cook Inlet had seven objectives: 1) rerun some industrial track lines, 2) add coverage to a selected area in which investigations started last year, 3) identify the nature of certain bedforms observed on side scan sonar records, 4) study the nature of the bedform-free zone north of the bathymetric ramp, 5) collect some samples at selected locations, 6) study sediment transport over a number of bedforms, and 7) conduct a pilot study off Augustine Island.

BBN, now McClelland Engineers, conducted a presale survey in 1973. The data are of proprietary nature. In anticipation of partial release we reran a number of selected tracks using the same preplotted navigation system. A letter dated September 10, 1978 from McClelland now allows us to use the lines we requested. Rerunning those track lines allows us to study if navigation and/or changes of large bedforms occurred during the 1973-78 time period.

In 1977 we started a detailed survey in an E-W zone off Anchor Point with the idea in mind that this zone contains all pertinent bedforms encountered in lower Cook Inlet, and that a high density data gathering survey would provide us better answers to understanding problems than a lower density survey over the entire area would do. We were very successfull in this operation. We now can study the different bedforms, the characteristics of bedform field boundaries, relation between bedform type and bathymetry, and characteristics of sediment motion of pertinent bedforms. A few 1977 lines were partially rerun to study changes. Plans for 1979 are to rerun more lines to study temporal changes.

It is difficult to obtain a true picture of the surface morphology, sediment characteristics, and height of bedforms when studying side scan sonar records. This summer considerable time was spent utilizing bottom television and camera to obtain the desired ground truth. Some of our original interpretations had to be changed drastically when we observed that many of the smaller bedforms were lower than thought so far and that reflectivity differences were not due to local slope but due to coarseness differences of the material. We think we also got a handle on the larger bedforms but more study of the TV tapes is needed and additional checks have to be made next year.

The bedform- free zone north of the bathymetric ramp in central lower Cook Inlet indeed is void of bedforms. Locally small ripples are present but most of the seafloor at the study site is characterized by a pebbly-shelly rough bottom.

We collected a number of samples at certain bedforms to help in the hydrodynamic studies on these forms. In addition a few samples were collected in areas we have insufficient coverage to make a sediment distribution map. Laboratory analyses and plotting of data will tell us if more samples are required.

We studied sediment transport over some of the larger bedforms, especially near the site of Cacchione's GEOPROBE. Vertical current profiles and TV studies were used to select the proper time in a tidal cycle to carry out dispersal studies. However, shiphandling problems and a few mechanical difficulties prevented us from obtaining results. We noticed, however, that most sediment transport over the bottom took place during the last hours of any tidal cycle during spring tides.

A brief pilot study was conducted off the east side of Augustine Island to see if a vessel the size of the R/V SEA SOUNDER and the normal equipment she carries will provide data on lava flows. The effort was unsuccessful. The water depth is too shallow and the bottom has too many peaks to move a vessel that size in that area. We did not distinguish much on the seismic records. Sampling is difficult in such a hard bottom and TV work is dangerous running the risk of loosing equipment.

KODIAK SHELF

This year's work on the Kodiak Shelf had three objectives: 1) to study in detail a surficial fault and determine the recency of movement, 2) take samples from areas that show evidence of gas-charged sediments, 3) search for areas of slope instability on the steep walls at the mouth of Sitkinak Trough.

The fault chosen for study has been correlated on seismic reflection records for at least 60 km along the northern parts of middle and northern Albatross Banks and Chiniak Trough. It shows a small but distinct seafloor offset in some places and trends across mapable sedimentary units perhaps as young as late Pleistocene. This year, we ran a tight grid across the fault, utilizing Uniboom, 3.5 kHz, and side-scanning sonar. Our purpose was to characterize the "freshness" of the fault scarp's appearance, therefore allowing us to make qualitative deductions as to its age, and to locate sites that, through TV observations and sampling, might allow us to make quantitative age estimates. Shipboard analysis of the records showed no areas that looked promising to fulfill our goals, and under the constraints of a tight cruise schedule, we temporarily terminated the project pending detailed analysis of the records back in the office, which will determine the future work on this topic.

Areas chosen for study of gas-charged sediments included a site near the head of Chiniak Trough and portions of middle Albatross Bank and Kiliuda Trough. A sample taken at the Chiniak Trough site contained bubble-phase gas, probably of biogenic origin. The other locations preliminarily show some anomalous concentrations of gas, although not high enough to be in bubble phase. Correlation of gas concentration with seismic-reflection signature will be made, and further field work on gas-charged sediments is planned for next year.

Three seismic-reflection lines were run across the mouth of Sitkinak Trough, in an area of the steepest seafloor slopes on the Kodiak Shelf. Thick accumulations of sediments were detected in the troughs, and sampling showed them to be sandy muds, commonly with abundant siliceous microfauna. No evidence of sediment sliding was found on the survey lines, which correlates with our earlier work that shows no significant slope instability on the Kodiak Shelf. However, slumping in the general area of Sitkinak Trough has been reported by Self and Mahmood (1977), although precise locations were not given.

Literature cited:

Self, G.W., and Mahmood, A., 1977, Assessment of relative slope stability of Kodiak Shelf, Alaska, using high-resolution acoustic profiling data: Marine Geotechnology, v. 2, p. 333-347.

TABLE I

Ship Schedule

| Cruise dates | Local date/time | | Time (JD/GMT) | Port |
|---|---|---|---|---|
| Start cruise | 2 Aug. | 0530 hrs | 214/1530 | LV Homer, AK |
| Port stop | 10 Aug. | 1310 hrs | 222/2310 | AR Homer, AK |
| " " | 11 Aug. | 1307 hrs | 223/2307 | LV Homer, AK |
| End cruise | 22 Aug. | 0530 hrs | 234/1530 | AR Kodiak, AK |

Total underway time: 18 days 23 hrs (455 hrs)

Total port time: 0 days 23 hrs

---

TABLE II

Scientific Party

| | |
|---|---|
| Bouma, Arnold | Chief scientist |
| Hampton, Monty | Chief scientist |
| Swenson, Phyllis | Geologist, data curator |
| Rappeport, Mel | Geologist |
| Schwab, Bill | " |
| Rubin, Dave | " |
| Torresan, Mike | " |
| Garrison, Louis | " |
| Whitney, John | " |
| Combellick, Rod | " |
| Sangrey, Dwight | Civil engineer |
| Turner, Bruce | Geologist |
| Redden, George | Chemist |
| Kestly, Dave | Electrical engineer |
| Clukey, Ed | Civil engineer |
| Orlando, Bob | Geologist, navigator |
| Gibbons, Helen | " " |
| Garlow, Rich | " " |

TABLE III

Methods and amount of data collected

Equipment systems used:

| Navigational | Geophysical | Geological | Hydrographical |
|---|---|---|---|
| Satellite | Uniboom | Gravity core | Current meter |
| Loran C | Single channel arcer | Grab sampler | |
| Mini Ranger | 3.5 kHz bathymetry | Television | |
| | 12 kHz bathymetry | Seafloor camera | |
| | Side-scanning sonar | | |
| | Shipboard magnetometer | | |

Data collected:

| Geophysical system | Trackline distance (nautical miles) |
|---|---|
| Single channel arcer | 320 |
| Uniboom | 638 |
| 3.5 kHz bathymetry | 412 |
| 12 kHz bathymetry | 1869 |
| Side-scanning sonar | 435 |
| Shipboard magnetometer | 11 |

| Sampling device | Sampling attempts | Samples recovered |
|---|---|---|
| Gravity core | 43 | 35 |
| Grab sampler | 26 | 21 |

| Visual format system | Number of tapes/rolls |
|---|---|
| Television | 8 |
| Seafloor camera | 15 |

| Hydrographical system | Number of stations | Number of readings |
|---|---|---|
| Current meter | 3 | 28 |

TABLE IV

Sample locations

| Station number | Location | Operations |
|---|---|---|
| 300 | 59°35.9'N, 152°03.4'W | TV, camera, grab sample |
| | 59°34.2'N, 153°02.0'W | |
| 301 | 59°35.3'N, 152°12.7'W | TV, camera |
| | 59°35.6'N, 152°13.0'W | |
| 302 | 59°35.8'N, 152°18.8'W | TV, camera |
| | 59°36.6'N, 152°18.1'W | |
| 303 | 59°33.5'N, 152°35.6'W | TV, camera |
| | 59°31.5'N, 152°36.3'W | |
| 304 | 59°31.6'N, 152°29.8'W | TV, camera |
| | 59°31.4'N, 152°32.7'W | |
| 305 | 59°30.8'N, 152°30.0'W | Grab sample |
| 306 | 59°30.8'N, 152°30.0'W | Grab sample |
| 307 | 59°32.5'N, 152°29.8'W | Grab sample |
| 308 | 59°31.4'N, 152°28.9'W | TV, camera |
| | 59°32,3'N, 152°28.2'W | |
| 309 | 59°30.7'N, 152°30.9'W | TV, camera |
| | 59°31.0'N, 152°29.8'W | |
| 310 | 59°31.0'N, 152°29.9'W | Grab sample |
| 311 | 59°30.6'N, 152°30.3'W | Grab sample |
| 312 | 59°30.4'N. 152°30.4'W | Grab sample |
| 313 | 59°27.4'N, 152°38.6'W | Current meter, |
| | 59°27.4'N, 152°38.6'W | TV, camera |
| 314 | 59°27.0'N, 152°37.8'W | Current meter, |
| | 59°26.4'N, 152°40.4'W | TV, camera, |
| | | Gravity core |

TABLE IV (Cont'd)

Sample locations

| Station number | Location | Operations |
|---|---|---|
| 315 | 59°25.7'N, 153°19.3'W | Gravity core |
| 316 | 59°21.9'N, 153°13.7'W | Gravity core |
| 317 | 59°23.1'N, 153.18.8'W<br>59°23.6'N, 153°19.4'W | TV, camera |
| 318 | 59°09.9'N, 153°38.5'W | Grab sample |
| 319 | 59°13.6'N, 153°38.5'W | Grab sample |
| 320 | 59°17.3'N, 152°38.6'W<br>59°19.0'N, 152°42.3'W | Grab sample,<br>TV, camera |
| 321 | 59°22.8'N, 152°38.0'W | Grab sample |
| 322 | 59°31.1'N, 152°38.4'W | Grab sample |
| 323 | 59°30.9'N, 152°38.8'W | Grab sample |
| 324 | 59°32.5'N, 152°31.3'W<br>59°32.8'N, 152°30.8'W | Current meter,<br>TV, camera |
| 325 | 59°33.0'N, 152°25.2'W<br>59°33.0'N, 152°25.3'W | TV, camera |
| 326 | 59°32.8'N, 152°25.3'W | Grab sample |
| 327 | 59°33.8'N, 152°25.0'W | Grab sample |
| 328 | 58°27.9'N, 153°16.2'W | Gravity core |
| 329 | 57°39.0'N, 151°58.0'W | Gravity core |
| 330 | 58°01.0'N, 150°50.6'W | Gravity core |
| 331 | 57°33.2'N, 147°38.2'W | Gravity core |
| 332 | 57°39.34'N, 148°12.2'W | Gravity core |
| 333 | 57°38.5'N, 148°45.4'W | Gravity core |

TABLE IV (Cont'd)

Sample locations

| Station number | Location | Operations |
|---|---|---|
| 334 | 57°33.0'N, 148°57.4'W | Gravity core |
| 335 | 57°28.3'N, 149°04.1'W | Gravity core |
| 336 | 57°46.6'N, 149°02.1'W | Gravity core |
| 337 | 57°00.3'N, 149°44.9'W | Gravity core |
| 338 | 57°08.9'N, 150°06.6'W | Gravity core |
| 339 | 57°14.2'N, 150°17.5'W | Gravity core |
| 340 | 57°17.5'N, 150°24.9'W | Gravity core |
| 341 | 56°59.0'N, 152°21.5'W | Gravity core, grab sample |
| 342 | 56°55.8'N, 152°15.4'W<br>56°55.8'N, 152°15.3'W | Gravity core,<br>grab sample |
| 343 | 56°39.4'N, 153°04.7'W | Gravity core |
| 344 | 56°39.5'N, 153°05.6'W | Gravity core |
| 345 | 56°36.1'N, 153°10.0'W | Gravity core |
| 346 | 56°36.2'N, 153°17.5'W | Gravity core |
| 347 | 56°36.8'N, 153°17.9'W | Gravity core |
| 348 | 56°37.7'N, 153°18.9'W | Gravity core |
| 349 | 56°38.5'N, 153°20.0'W | Gravity core |
| 350 | 56°46.2'N, 153°10.0'W | Gravity core |
| 351 | 56°46.9'N, 153°11.0'W | Gravity core |
| 352 | 56°42.2'N, 153°10.9'W | Gravity core |
| 353 | 56°39.9'N, 153°11.1'W | Gravity core |

TABLE IV (Cont't)

Sample locations

| Station number | Location | Operations |
|---|---|---|
| 354 | 56°37.9'N, 153°16.3'W | Gravity core, grab sample |
| 355 | 56°08.5'N, 153°29.4'W | Gravity core |
| 356 | 56°05.6'N, 153°31.3'W | Gravity core |
| 357 | 56°07.6'N, 153°38.5'W | Gravity core |
| 358 | 56°47.0'N, 153°11.7'W | Gravity core |
| 359 | 56°46.5'N, 153°10.6'W | Gravity core |

QUARTERLY REPORT

Contract RK-6-6074
Research Unit: 430
Reporting Period:
1 July 1978 -
30 Sept 1978

A. Bottom and Near-Bottom Sediment Dynamics in Norton Basin

B. Bottom and Near-Bottom Sediment Dynamics in Lower Cook Inlet

C. Sediment Transport during Wintertime Conditions, Northern Bering Sea

David A. Cacchione
David E. Drake

Pacific-Arctic Branch of Marine Geology
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

October 1, 1978

A. Bottom and Near-Bottom Sediment Dynamics in Norton Basin

I. Task Objectives

A. Development of quantitative relationships between bottom velocity shear and induced sediment entrainment for specific sites in Norton Sound.

B. Estimation of near-bottom sediment flux at various locations in Norton Sound, with particular attention to the movements of Yukon River materials.

C. Comparison of bottom sediment movements during quiescent and stormy periods at specific sites in Norton Sound.

D. Monitoring of bottom currents and light scattering/transmission (within two meters of the sea floor) to enable prediction of sediment and pollutant flux vectors at future times.

E. Measurement of near-surface and near-bottom suspended sediment distribution in Norton Basin.

II. Field and Laboratory Activities

A. No ship cruises or field trips were made during this quarter.

B. Scientific Party: not applicable.

C. Methods:

1. Laboratory analysis of data collected during calendar year 1977 on R/V SEA SOUNDER and with the GEOPROBE tripod are continuing. Two scientific journal articles are currently in preparation that describe (1) the suspended sediment transport system in the eastern portion of the Northern Bering Sea; and (2) storm-generated bottom transport in Norton Sound, respectively.

D. Sample locations - Detailed sample location and trackline charts were shown in the annual report for RU 430 (1 April 1978).

E. Data Collected and Analyzed - A complete list of data are given in the annual report (1 April 1978).

III. Results

The final report for this work is in preparation. It will include findings that will be reported in two scientific journal articles that are in the last stages of preparation. These results show that infrequent storms which transect the eastern Northern Bering Sea and Norton Sound during the ice-free months generate widespread resuspension of bottom sediments and strong, persistent northward transport of materials. At the GEOPROBE site located about 30 n.m. south of Nome, a storm which occurred in September, 1977 caused significant increases in concentrations at 2 m above the sea floor (from 5 mg/l to about 150 mg/l) and strong northerly bottom currents (about 25-30 cm/sec) for about 4 days.

During non-storm periods, tidal currents during spring tides generate bottom stresses that are high enough to entrain the local sediment. Neap tidal currents appear to be insufficient to cause initial movement. This situation suggests that the bottom sediment pattern in western Norton Sound, is controlled in the long term by tidal energy. Storms perturb this relationship, and induce large quantities of sediment removal.

IV. Preliminary Interpretation of Results

During storms, substantial erosion of the sea floor over large portions of western Norton Sound can occur. This erosion could be an important consideration in future development of seafloor installations and pipelines. During non-storm times, deposition seems to occur during neap tides; whereas, some minor erosion and transport of bottom materials occurs during periods of spring tides.

The shallow depths and recent sediment cover provided by the proximal Yukon source suggest that large amplitude waves generated during storms can cause widespread resuspension of the sea floor. Wave-generated stress, when combined with those due to wind-driven and tidal currents, exceed the critical values needed to initiate motion of the bottom sediment. These excess stresses will cause substantial transport and removal of the surficial materials during these times.

V. Problems - None.

VI. Estimate of Funds Expended: 95%

B. Bottom and Near-Bottom Sediment Dynamics in Lower Cook Inlet

I. Task Objectives

This study addresses the overall objective of evaluating geologic hazards associated with erosion and deposition on the seafloor and of characterizing bottom sediment dynamics. Specific objectives in Lower Cook Inlet are:

1. To provide a spatial and temporal description of bottom sediment transport, with particular emphasis on the areas of large sand waves.

2. To develop estimates of bottom sediment flux related to high energy events such as storms and tides.

3. To relate the magnitude of bedshear to the initiation of bottom sediment movement for each sedimentary environment.

4. To provide detailed descriptions of seafloor physiography and surface sediment characteristics in selected areas of observation.

5. To describe changes in the surface character of the seafloor over relatively long duration (at least one month).

## II. Field and Laboratory Activities

### A. Schedule

1. dates: depart Seward, Alaska - 24 July 1978
   arrive Homer, Alaska - 31 July 1978
2. vessel: R/V SEA SOUNDER
3. location: Lower Cook Inlet
4. purpose: deploy GEOPROBE tripods and conduct sampling and geophysical surveys to accomplish task objectives.

### B. Scientific party

1. D. Cacchione
2. D. Drake
3. A. Bouma
4. M. Hampton
5. J. Gardner
6. J. Nicholson
7. R. Patrick
8. E. Clukey
9. W. Schwab
10. R. Wilson
11. G. Barker
12. G. Tate
13. C. Totman
14. P. Wiberg
15. R. Garlow
16. C. Madison
17. M. Rappeport

### C. Methods

Two GEOPROBE tripods were deployed in an area of large amplitude sand waves (heights of about 3 meters) in central Lower Cook Inlet. The plan was to emplace two tripods on a single sand wave, one near the crest, the other in the trough. A detailed side-scan sonar and bathymetric survey was conducted prior to the launch sequence. Both GEOPROBE tripods were preset to record over a 3 day period, with a relatively high basic sampling interval of 7.5 minutes selected in each system. The electromagnetic current sensors (4 per tripod) were preset to make 180 sequential measurements, once per second, on the 7.5 minute basic interval.

GEOPROBE #1 (G1) was launched successfully during decreasing flood current in 64 m water depth at 2000 local time on 25 July 1978. GEOPROBE #2 (G2) was launched successfully near the crest of a large sand wave in 59 m water depth at 1646 local time on 26 July 1978. The second launch took place about 150 meters northwest of G1. The position of G1 and G2 relative to the bottom features were checked using the 12 kHz bathymetric system on R/V SEA SOUNDER and the acoustic transponders on the tripods. The tripods were located on the bathymetric recorder and marked. It appears that we were able to position the GEOPROBE on the same sand wave at the desired crest-trough separation.

Site surveys in the vicinity of the GEOPROBE locations were conducted to obtain detailed bathymetric, morphologic, and sediment data. The surveys included 3.5 kHz, 12 kHz and side-scan sonar profiling; bottom sampling; suspended sediment sampling; current, light transmission and C-T-D profiles. Two anchor stations were occupied for about 24 hours each near the tripod sites.

Recovery of both GEOPROBES provided some extra excitement. The primary recovery system on both tripods failed to function properly. On G1 the electrolytic corrosion process that is the basis for the acoustic release mechanism did not completely corrode the support wire, preventing the buoyancy package from returning the retrieval line to the surface. The suspected cause for this failure was a low power supply to the release section. The buoyancy package and retrieval line on G2 also failed to surface on command. In this case we later determined that the acoustic release had operated properly, but the bottom drag line, laid out as a back-up recovery line, had fouled the buoyancy package.

In both instances we were able to locate the tripods precisely using the acoustic ranging mode of the transponders. Both tripods were recovered intact after several hours of dragging for the bottom recovery lines using a large grapnel. No damage to either system occurred due to the dragging operation.

After recovering both tripods we then replenished batteries, film and tape on G1, reset the basic sampling interval to one hour, and redeployed G1 in the vicinity of the previous two deployments. The camera was set to take one picture every 4 hours. We intended to have this GEOPROBE system operate for about 80 consecutive days. (Recovery is scheduled for mid-October).

D. Sample Locations

The bathymetric chart, Fig. 1, compiled earlier by Bouma and Hampton (RU 432) shows the approximate location of the GEOPROBE sites. Table 1 lists the station and deployment locations with water depths.

E. Data Collected and Analyzed

Table 1 outlines the data collected during the July cruise. The two GEOPROBE data tapes and photographs recovered during that cruise are presently being processed and analyzed. Initial inspection shows that the GEOPROBE photographs are excellent and show extreme contrasts in surface character at the two proximal sites. The cassette data tapes have been read and are being converted to 9-track computer compatible tapes.

III. Results: Too early to report.

IV. Preliminary Interpretation of Results: None

V. Problems Encountered: None, except for the failure of the GEOPROBE recovery systems described in II. above.

VI. Estimate of funds expended: $108,000

C. Sediment Transport during Wintertime Conditions, Northern Bering Sea

I. Task Objectives

To determine the quantity and composition of suspended matter in Norton Sound during the winter season and use this information to assess processes and pathways of sediment transport.

II. Field and Laboratory Activities

A. Field work was completed in February-March 1978. Work during the past quarter has focused on the distribution of suspended matter in the sound and analyses of the texture and composition of the particulate matter recovered from ice and water samples.

B. Methods - Combustion analysis, polarizing and scanning electron microscopy, x-ray diffraction.

C. See Annual report RU 430, April 1978 and Cruise Report prepared by Clarke H. Darnall for helicopter cruise W-29.

III. Results

1. The suspended matter within Norton Sound in February 1978 was predominantly fine to medium terrigenous silt resuspended from the Yukon prodelta which extends across the mouth of the Sound. Plankton constituted <10% of the suspended matter in Norton Sound.

2. Within 75 km of the delta at depths <15 m the suspended matter contained substantial amounts of coarse silt and some very fine sand; this coarse material was present throughout the water column at two stations.

3. Plankton, predominantly pillbox and spindle-draped diatoms, was progressively more abundant away from the delta. In fact, the suspended matter at stations west of Nome and off Port Clarence contained 30-50% siliceous plankton.

4. As indicated in our July report, the concentrations of suspended matter in the Sound during the winter were similar to those observed in July 1977. A more careful analysis and comparison of ice-free and ice-covered TSM values confirms this observation. In the summer the bulk of the terrigenous to the lower portion of the water column, whereas the vertical distribution is essentially uniform in the winter.

5. Microscope examination of the particulate matter present in the pack ice shows that the sediment is composed of >95% terrigenous silt with one exception. The exception was obtained on our Port Clarence transect and contained approximately 40% diatoms and 60% fine inorganic silt.

6. The texture of the material frozen into the pack ice was typically coarser than material in suspension at a given station. Nevertheless, the pack ice sediment is predominantly silt with no more than 10% very fine sand.

IV. Preliminary Interpretation of Results

The data show that there is no decrease in the amount of suspended sediment in the western portion of Norton Sound during the winter season relative to concentrations observed during "fairweather" (calm seas and light winds) conditions in the summer. Since the effects of wind and wave-induced currents are of little or no significance in the winter, it is clear that the tidal plus mean currents are sufficient to erode the bottom sediments and maintain high levels of suspended matter.

The texture of the sediment in the pack ice suggests that this material was incorporated in the ice from suspension rather than through adfreezing of material from direct bottom contact. The fact that several of the ice samples taken from distinctive layers in the pack ice contained more sediment/volume than is present near the Yukon Delta in the summer strongly suggests that such layers were formed during high energy winter events which occurred when the ice was near the delta.

Further work is underway to pinpoint sources of the sediment in the pack ice and to identify the winter storms which may have been responsible for resuspending this material. This analysis may lead to an estimate of rates of ice movement in Norton Sound.

V. Problems Encountered: None

VI. Estimate of funds expended: 95%

TABLE 1: Station Operations Summary

| Station No. | Location (Lat./Long.) | Depth (m) | Events (No. OC Times) |
|---|---|---|---|
| 1 | 58°39.4'N 151°13.4'W | 190 | Grav |
| 2 | 59°27.6'N 152°38.6'W | 74 | TV, CAM, CM$^{(3)}$, GEOPROBE 1 |
| 3 | 59°27.4'N 152°37.9'W | 56 | TV, CAM, CM$^{(6)}$, CTD$^{(8)}$, VANV, TRANS(6), GEOPROBE 2, SS |
| 4 | 59°32.1'N 152°15.9'W | 65 | TV(7), CAM(6), SS, TRANS(8), CM(8), CTD(6), VANV |
| 5 | 59°27.4'N 152°37.8'W | 57 | VANV |
| 6 | 59°27.6'N 152°38.4'W | 60 | VANV |
| 7 | 59°27.6'N 152°38.4'W | 59 | VANV |
| 8 | 59°27.6'N 152°38.3'W | 58 | TV(8), CAM(8), SS, TRANS(9), CTD(10), CM(7) |
| 9 | 59°27.5'N 152°37.1'W | 56 | GEOPROBE 3, TV, CAM, VANV |

Key:
- GRAV = Gravity Core
- TV = Underwater Television Tapes
- CAM = 70 mm Camera Photographs
- CM = Current Meter Profiles
- CTD = Conductivity-Temperature-Depth Profiles
- SS = Suspended Sediment Samples
- TRANS = Transmissometer Profiles
- VANV = Bottom Samples

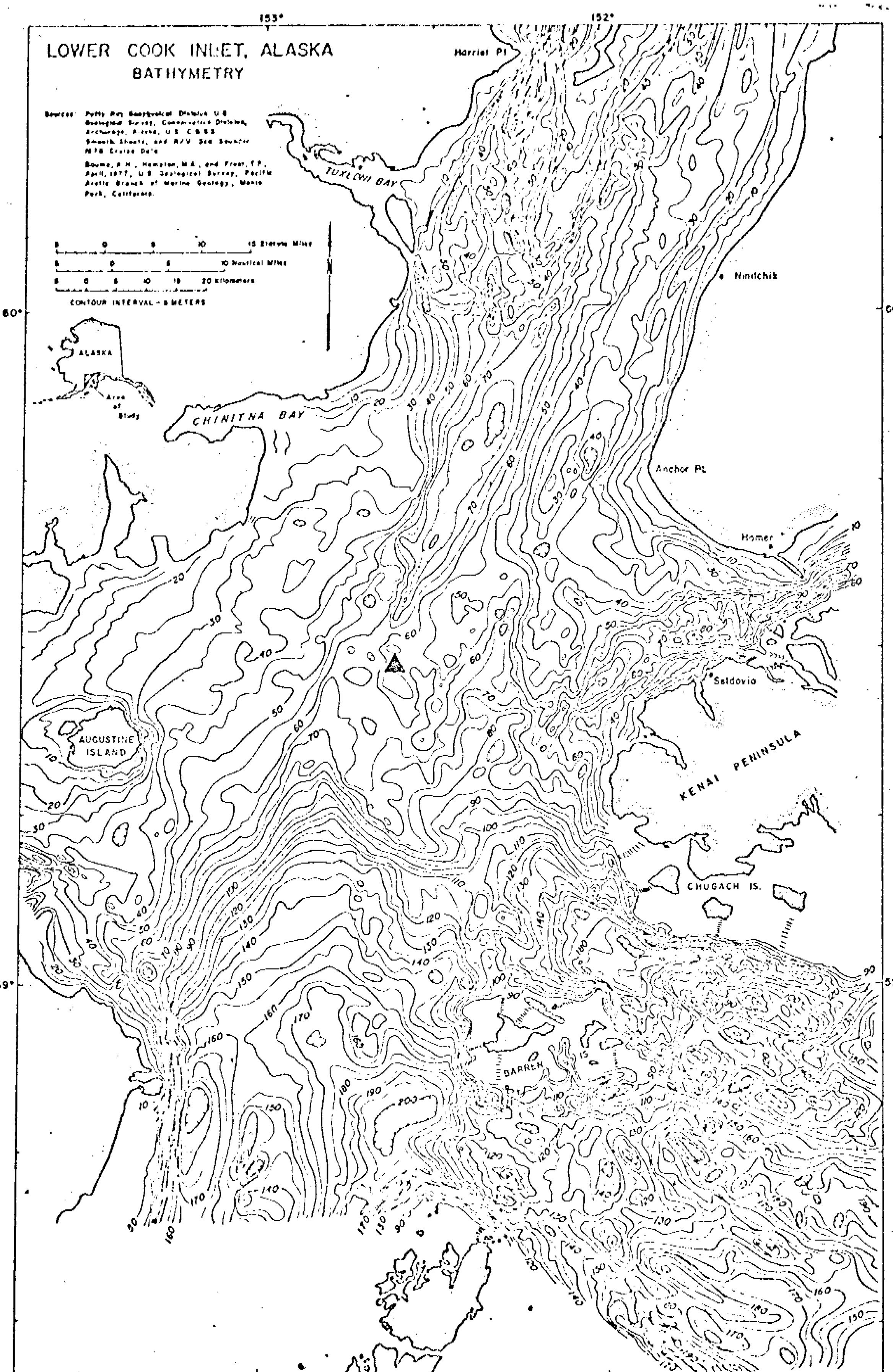



Figure 1. Bathymetric chart of Lower Cook Inlet (courtesy of A. Bouma and M. Hampton) showing GEOPROBE sites (▲).

Quarterly Report
July-September 1978
Research Unit 431

# Coastal Processes and Morphology of the Bering Sea coast of Alaska

Asbury H. Sallenger
U.S. Geological Survey
Menlo Park, California 94025

November 8, 1978

I. Abstract

We are continuing the reduction of our data taken during FY 77. We plan to submit our Final Report by December 31, 1978.

II. Objectives

1. To complete reduction and analysis of data gathered during the FY 77 field season. These data include:

   A. Measurements of wave height, period and approach direction in the vicinity of Nome

   B. Beach profiles and sediment samples from Pavlov and Cold Bays, Alaska Peninsula

   C. Beach and nearshore profile data along the northern Bering Sea coast of Alaska

2. Completion of a wave model for the November, 1974 storm in the northern Bering Sea

III. Field Activities

None

IV. Results

Results will be presented in Final Report.

V. Problems Encountered/Recommended Changes

We stated in our FY 78 proposal that our Final Report would be submitted at the end of the fiscal year. We now plan to submit the Final Report within 90 days following the end of the contract period.

VI. Estimate of Funds Expended

All

QUARTERLY REPORT

Contract #03-05-022-55
Research Unit # 483
Task Order # 12
Reporting Period: 07/1/78-
09/30/78

# EVALUATION OF EARTHQUAKE ACTIVITY AROUND NORTON AND KOTZEBUE SOUNDS

N. N. Biswas
L. Gedney
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

October 1, 1978

OCS COORDINATION OFFICE
University of Alaska

Quarterly Report for Quarter Ending September 30, 1978

| | |
|---|---|
| Project Title: | Evaluation of Earthquake Activity Around Norton and Kotzebue Sounds |
| Contract Number: | 03-05-022-55 |
| Task Order Number: | 12 |
| Principal Investigators: | N. N. Biswas and L. Gedney |

I. Task Objectives:

1. Service field sites of seismographic stations of the network.

2. Routine scaling of daily seismic data gathered by the seismographic network.

II. Field and Laboratory Activities;

1. The primary activity during the past quarter was to prepare, plan, test field equipment and to service the field sites. All the field sites have been serviced successfully except the station located at Savoonga on St. Lawrence Island. The details are given below.

2. The 3-component (vertical, north-south and east-west) station at Kotzebue was located at the White Alice site. Since this site will be phased out by RCA during the fourth quarter of 1978, the seismographic station at Kotzebue has been relocated about three miles north at the Air Force (AC & W) site. Arrangements to telemeter the data from this site to the Kotzebue earth station by the regular telephone line has been completed. To overcome the levelling problem encountered in the past with the horizontal-component seismometers (Geotech S-1300), these conventional instruments have been replaced by three non-level sensitive seismometers (Geotech S-500) at Kotzebue.

3. The seismographic station (GMA) at the White Alice site on Granite Mountain was operated by the Alaska Tsunami Warning Center of NOAA. This station provided seismic coverage to the eastern side of the study area. However, the White Alice site at the above location was phased out during the end of the second quarter of 1978, which resulted in the termination of the seismographic station there. To improve the seismic gap caused from this source, a new remote station has been located just north of Candle which is located near the southern coast of Kotzebue Sound. The signal from this station is telemetered by VHF to Kotzebue.

4. The operational remote station (DMA) of the network at Devil Mountain, has been serviced.

5. The other stations of the network located at Unalakleet (UNL), Anvil Mountain (ANV) and Tin City (TNA) have been serviced.

6. All the stations mentioned above have been calibrated; the calibrations have been carried out under the operating conditions and the relevent data have been successfully transmitted to the central recording site at Fairbanks.

7. The station (SVG) of the network at Savoonga could not be serviced during the present field work. On visiting the site, it was found that RCA has installed a TV-transmitter near the electronic package of the seismographic system. The transmitter is capable of superposing RF noise on the seismic signal. To overcome this difficulty, it is planned to relocate the electronic package of the seismic system during December, 1978, incorporating necessary RF shielding to eliminate future problems.

8. From the beginning of 1979, the data from the network will be recorded at Nome instead of at Fairbanks to overcome the difficulties caused by the recent lease-rate increase of microwave data telemetry links. Arrangements with the Northern Community College at Nome have been finalized to install the recorder there. The acquisition of the necessary recording system is progressing satisfactorily.

9. The rescaling and computer processing of seismic data for some events gathered from January 1976 through June 1978 by the northeast Alaskan network are in progress.

10. The sealing of the daily data from the western Alaska network has been maintained up-to-date. The computer processing of these data is continuing routinely.

III. Results: None.

IV. Preliminary Interpretation: None.

V. Problems Encountered: None.

VI. Estimate of the Funds Expended: $80,000.

Research Unit #516
Reporting Period: July-Sept. 1978

Quarterly Report

# A GEOGRAPHIC BASED DATA MANAGEMENT SYSTEM FOR PERMAFROST IN THE BEAUFORT AND CHUKCHI SEAS

M. Vigdorchik
INSTAAR
University of Colorado
Boulder, Colorado

QUARTERLY PROGRESS REPORT - JULY-SEPTEMBER, 1978 - R.U. 516

A geographic based data management system for permafrost in the Beaufort and Chukchi seas

M. Vigdorchik, INSTAAR, University of Colorado

I. Task Objectives: The first principal objective was to develop a computerized system which would aid in predicting the distribution and characteristics of off-shore permafrost. The second objective was to undertake a comprehensive review and analysis of past and current Soviet literature on subsea permafrost and related natural processes.

II. Summary of Results: According to the first objective, the system has been developed. We have completed the compilation of the computerized maps in 1:000,000 scale. Twenty-nine maps were made, including source, derived and composite maps, and a composite map showing the areas suitable for submarine permafrost development on the shelf of the Beaufort and Chukchi seas. According to the computerized analysis of the environmental data for that shelf, the submarine permafrost could have a sporadic extension, mostly in the limits of isobath 120 m. A high probability of subsea permafrost exists in the northern Chukchi Sea, to the east from Point Barrow, to the north and north-west from Prudhoe Bay, and in the eastern part of the American Beaufort Sea shelf. During the July-September period, the analysis "Submarine Permafrost on Arctic Shelf of Eurasia," based on the recent Russian investigations, was also completed. All these results will be placed in the Final Report.

III. Financial Status: Amount dispersed since the beginning of the work - $100,000

Amount dispersed third quarter (July-September, 1978) - $ 14,043

## TRANSPORT

Contents


| RU# | PI | Agency | Title | Page |
|---|---|---|---|---|
| 48 | Barrick, D. | U.S.G.S., Menlo Park, CA | Development and Operation of HF Ocean Current Mapping Radar Units | 369 |
| 91 | Aagaard, K. | Univ. of Wash. Seattle, WA | Current Measurements in Possible Dispersal Regions of the Beaufort Sea | 371 |
| 141 | Coachman, L. Kinder, T. et al. | PMEL, Seattle, WA | Bristol Bay Oceanographic Processes | 374 |
| 208 | Dupre, W. | Univ, of Houston, Houston, TX | Yukon Delta Coastal Processes Study | 426 |
| 217 | Hansen, D. | NOAA, Miami, FL | Langrangian Surface Current Observations for OCSEAP - Alaska | 431 |
| 244 | Barry, R. | INSTAAR, Boulder, CO | Study of Climatic Effects on Ice Extent and its Seasonal Decay Along the Beaufort Sea and the Chukchi Sea Coasts | 443 |
| 250 | Shapiro, L. Harrison, W. | Geophysical Inst., Fairbanks, AK | Mechanics of Origin of Pressure Ridges, Shear Ridges, and Hummock Fields in Landfast Ice | 456 |
| 257 | Stringer, W. | Geophysical Inst., Fairbanks, AK | Morphology of Beaufort, Chukchi and Bering Seas Near Shore Ice Conditions by Means of Satellite and Aerial Remote Sensing | 458 |
| 265 | Shapiro, L. | Geophysical Inst., Fairbanks, AK | *In-situ* Measurements of the Mechanical Properties of Sea Ice | 462 |
| 267 | Belon, A. | Geophysical Inst., Fairbanks, AK | Operation of an Alaskan Facility for Applications of Remote-Sensing Data to OCS Studies | 464 |
| 289 | Royer, T. | Inst. of Marine Science, Fairbanks, AK | Circulation and Water Masses in the Gulf of Alaska | 469 |
| 435 | Leendertse, J. Liu, S. | Rand Corp. Santa Monica,CA | Modeling of Tides and Circulations of the Bering Sea | 473 |
| 519 | Leavitt, E. | Univ. of Wash. Seattle, WA | Coastal Meteorology of the Alaskan Arctic Coast | 483 |

| RU# | PI | Agency | Title | Page |
|---|---|---|---|---|
| 526 | Matthews, J. | Geophysical Inst., Fairbanks, AK | Characterization of the Nearshore Hydrodynamics of an Arctic Barrier Island-Lagoon System | 486 |
| 529 | Naidu, A. | Inst. of Marine Science, Fairbanks, AK | Sediment Characteristics, Stability, and Origin of the Barrier Island-Lagoon Complex, North Arctic Alaska | 491 |
| 530 | Cannon, P. | Univ. of AK, Fairbanks, AK | The Environmental Geology and Geomorphology of the Barrier Island-Lagoon System along the Beaufort Sea Coastal Plain from Prudhoe Bay to the Colville River | 519 |
| 531 | Mungall, J.<br>Whitaker, R. | Texas A&M Univ. College Station, TX | Oceanographic Processes in a Beaufort Sea Barrier Island-Lagoon System: Numerical Modeling and Current Measurements | 522 |
| 541 | Coachman et al. | Univ. of Wash. Seattle, WA | Norton Sound-Chukchi Sea Oceanographic Processes (N-COP) | 536 |
| 562 | Kovacs, A. | CRREL, Hanover NH | Oil Pooling Under Sea Ice | 584 |
| 567 | Coon, M.<br>Pritchard, R. | Flow Res. Co. Kent, WA | The Transport and Behavior of Oil Spilled In and Under Sea Ice | 587 |
| 568 | Schultz, L. | ARCTEC, Inc. Columbia, MD | The Transport and Behavior of Oil Spilled In and Under Sea Ice-Task 1 | 590 |

QUARTERLY REPORT

Project No.: RWOOOO R7120858

Research Unit: No. 48

Reporting Period: July 1, 1978 thru September 31, 1978

No. of Pages: 2

# Development and Operation of HF Ocean Current Mapping Radar Units

Principal Investigator: Donald E. Barrick

Submitted: December 1, 1978

## Surface Current Mapping Radar Program

Progress Report - 30 September 1978

### I. Abstract

One radar was operated at the Southern part of Augustine Island, the other was operated at the Western tip of Cape Douglas.

Tests and observations were made for a period of three weeks, with continuous two-site data recorded every three hours over an eight day period.

### II. Objectives

The objective of the current radar mapping program for this period was to obtain surface current data in the area between the West of Augustine Island and Cape Douglas. This was done successfully and some of it will be reduced, analyzed and interpreted the second half of the 1979 fiscal year, dependent upon negotiations with OCSEAP.

### III. Field Activities

At the end of June 1978, the CODAR system was deployed and operated at Cape Douglas, Alaska for tests and surface current observations. The system worked very successfully under extremely bad weather conditions, i.e., heavy rains and 30-50 knot winds during much of this time. Continuous data were taken for eight days from both sites at least every three hours and every 1.5 hours over a two day period. The reporting quarter ended while the RU48 group was still in the field.

### IV. Results

No OCSEAP results have been processed by this quarter's end.

### V. Preliminary Interpretation of the Results

Preliminary looks at currents made in the field indicate they are generally smaller in magnitude in this region by some 50% than on the Eastern side near Anchor Point and Seldovia.

### VI. Problems Encountered/Recommended Changes

Most of the hardware technical problems have been solved. What is needed now is time to stay out of the field and analyze the data. Much time must be spent solving problems of removing noise from the data and interpreting the results. Erratic funding is the biggest roadblock in accomplishing these goals.

### VII. Estimate of Funds Expended from July 1 - 1978 to September 20, 1978

$25,000

# QUARTERLY REPORT

Contract No.:

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

Research Unit No.:

91

Reporting Period:

1 July - 30 September 1978

Number of Pages:

3

# Current Measurements in Possible Dispersal Regions of the Beaufort Sea

Knut Aagaard

Department of Oceanography
University of Washington
Seattle, Washington 98195

28 September 1978

I. Objectives

The objective of this work has been to obtain long-term Eulerian time series of currents at selected locations on the outer shelf of the Beaufort Sea. Such measurements are necessary to describe and understand the circulation on the outer shelf. It is this circulation which transports and disperses the plankton, substances of biological and geological consequence, and pollutants. The water motion also influences the ice distribution and drift. The current time series must be long enough to define the important temporal scales of motion.

II. Field Activities

Attempts are discussed below in V.

III. Results, and IV. Preliminary Interpretation of Results

Analysis of current records is continuing.

V. Problems Encountered

Five moorings are presently deployed. We made a concerted effort to recover them this summer by ship, but a series of ship failures, along with poor ice conditions, prevented us from getting near the moorings. As the reliable battery life time of the releases is now being approached, it is critical that the moorings be pulled via a helicopter operation in October. Planning for this is underway.

VI. Estimate of Funds Expended to 31 August 1978.

| | | | |
|---|---|---|---|
| TOTAL ALLOCATION 10/1/77 - 9/30/78 | | | $94,132 |
| 1. | Salaries, faculty & staff | $ 7,514 | |
| 2. | Benefits | 1,157 | |
| 3. | Indirect Costs | 3,907 | |
| 4. | Supplies & Other Direct Costs | 45,160 | |
| 5. | Equipment | 14,058 | |
| 6. | Travel | 3,869 | |
| | TOTAL EXPENDITURES | $75,665 | |
| | REMAINING BALANCE | | $18,467 |

QUARTERLY REPORT

Contract No.:

03-5-022-67, TO 4

Research Unit No.:

141/149

Reporting Period:

1 July - 30 September 1978

Number of Pages:

51

# BRISTOL BAY OCEANOGRAPHIC PROCESSES

L. K. Coachman
T. H. Kinder

Department of Oceanography
University of Washington
Seattle, Washington 98195

J. D. Schumacher
R. L. Charnell

Pacific Marine Environmental Laboratory
3711 15th Ave. NE
Seattle, Washington 98105

30 September 1978

A78-20

Title: Bristol Bay Oceanographic Processes (B-BOP)

Principal Investigators: L. K. Coachman
T. H. Kinder

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

J. D. Schumacher
R. L. Charnell

Pacific Marine Environmental Laboratory
3711 15th Ave. NE
Seattle, WA 98105

PERIOD: 1 July - 30 September 1978

I. Objectives:

1. To elucidate water movement and hydrographic structure in the project area.

II. Field Activities:

See attachemnt.

III. and IV. Results and Preliminary Interpretation

"On lateral water mass interaction - a case study, Bristol Bay, Alaska" by Coachman and Charnell has been accepted by *Journal of Physical Oceanography.*

"A structural front over the continental shelf of the southeastern Bering Sea" by Schumacher, Kinder, Pashinski, and Charnell has been accepted by *Journal of Physical Oceanography.*

Four talks are scheduled for the Alaskan shelf session at the western American Geophysical Union Meeting in December:

"Observation of a baroclinic eddy in the Southeastern Bering Sea" by Kinder, Schumacher, and Hansen; and

"Mean and low frequency flow over the continental shelf of the southeast Bering Sea during summer" by Schumacher, Kinder, Hansen, and Pashinski; and

"Oceanography of Arctic Shelves" by Coachman; and

"Transition zone and finestructure between shelf and off-shore water" by Charnell and Coachman.

V. Problems. None.

OBSERVATION OF A BAROCLINIC EDDY IN THE SOUTHEASTERN BERING SEA

T. H. Kinder (Dept. of Oceanography, Univ. of Washington, WB-10, Seattle, WA. 98195)
J. D. Schumacher (PMEL/NOAA, Seattle, WA. 98105)
D. V. Hansen (AOML/NOAA, Miami, FL. 33149)

Shallow (18 m) drogues, released during May 1977 and tracked by satellite, delineated an eddy in the southeastern Bering Sea. Located above complex topography (depth range: 200 m - 3000 m), the eddy had a diameter of about 150 km and had speeds of 7 to 16 cm/s at 50 km from its center. A CTD survey during July defined the eddy from 200 m to 1500 m depth in temperature and salinity distributions, but no hydrographic evidence for the eddy existed at the surface. A geostrophic calculation referenced to 1500 m agreed qualitatively with the drogue data, and accounted for all but 2 to 4 cm/s of the drogue speeds. This suggests that the 1500 m reference level, coincident with our deepest data, was too shallow. Examination of the TS correlation showed that the water at the eddy's core was the same as that at its periphery, in contrast with a cyclonic ring observed nearby in July 1974.

A second CTD survey in February 1978 showed that the eddy had dissipated or moved, as no trace of it remained. An earlier STD survey of the region in summer 1971 had not shown either a ring like that seen in 1974 or an eddy like that seen in 1977. In spite of the ubiquitous inclusion of permanent eddies and steady currents in Bering Sea circulation schemes, recent evidence from synoptic data suggests that the hydrographic and velocity fields are highly variable on scales of 50 to 100 km and a few weeks to a few years.

1. 033762KINDER

2. 1978 Fall AGU Meeting

3. Oceanography

4. Oceanography of Alaskan Shelves

5. No

6. No

7. 0%

8. Same as 1.

MEAN AND LOW FREQUENCY FLOW OVER THE CONTINENTAL SHELF OF THE SOUTHEAST BERING SEA DURING SUMMER

J. D. Schumacher (PMEL/NOAA/ERL, 3711 15th Ave. NE, Seattle, Washington 98105
T. H. Kinder (Oceanography Dept., University of Washington, WB-10, Seattle, Washington 98105
D. V. Hansen (AOML, 15 Rickenbacker Causeway, Miami, Florida 33149)
D. Pashinski (PMEL/NOAA/ERL, 3711 15th Ave. NE, Seattle, Washington 98105)

We present CTD, current meter and satellite tracked drifter data collected over the southeast Bering Sea shelf during summer 1976. These data did not show the organized flow regimes that have been presented in various atlases and circulation schemes. Instead, these data show that two distinct hydrographic and current domains existed: a stratified central shelf domain located seaward of the fifty meter isobath in which the mean velocity was weak ($\sim$0.5 cm/s), and a well-mixed coastal domain which exhibited stronger mean flow ($\sim$3.0 cm/s). Although 90 to 95% of the variance was tidal, correlations between low pass filtered (35 hour) current records from the lower mixed layer of the central shelf domain were $r \sim 0.65$ and $r \sim 0.50$ over horizontal separations of 30 to 60 km respectively. We found good agreement between observed mean flow and geostrophic calculations, suggesting that the horizontal density gradient between the two domains drives the flow in the coastal domain. Winds during the summer were light ($\sim$5m/s) and variable. Correlations between winds and currents were generally not significant statistically. During a two day period in late July when wind speeds exceeded 10 m/s, however, current records and drifter trajectories indicated a strong current response ($\sim$1% of the wind speed) in the central shelf domain.

1. 023972SCHUMACHER
2. 1978 Fall Meeting
3. Oceanography
4. Oceanography of Alaskan Shelves
5. No
6. No
7. 0%
8. Bill to: PMEL/NOAA
   Building #264 (Tower)
   7600 Sandpoint Way N.E.
   Seattle, Washington 98115
9.

TRANSITION ZONE AND FINESTRUCTURE BETWEEN SHELF AND OFF-SHORE WATER

R. L. Charnell (PMEL/NOAA/ERL, 3711 15th Avenue N.E., Seattle, Washington 98105)
L. K. Coachman (Department of Oceanography, WB-10, University of Washington, Seattle, Washington 98195)

Transition zones between the two water masses (shelf and off-shore) at a shelf break are generally relatively narrow (25-50 km) and characterized by a single strong gradient (front) in some horizontal properties; e.g. salinity. A basic feature of the lateral water mass interaction in this zone is finestructure. Observations from outer Bristol Bay in the Southeast Bering Sea, show a broader transition zone with strong gradients forming an inner and outer front. This interaction zone is approximately 100-150 km wide and is characterized by mid-water-column finestructure with a spectrum of scale sizes. Vertical mixing energy within the zone appears low, which results in persistence of interleaving signatures induced by horizontal interaction of the two adjacent water masses. Outer Bristol Bay conditions allow enhanced examination of the processes of water mass mixing.

1. 001984CHARNELL
2. 1978 Fall Meeting
3. Oceanography
4. Oceanography of Alaskan shelves
5. No
6. No
7. None
8. Bill to: PMEL/NOAA
   Building #264 (Tower)
   7600 Sandpoint Way N.E.
   Seattle, Washington 98115
9.

APPENDIX A

University of Washington
Department of Oceanography
Seattle, Washington 98195

Preliminary Report

# University of Washington Participation in NOAA SHIP *Discoverer* Cruise RP-4-DI-78B, Leg I

Bristol Bay Oceanographic Processes RU 141

Norton-Chukchi Oceanographic Processes RU 541

10 July - 3 August 1978

by

Richard B. Tripp

NOAA Contract 03-5-022-67, TO 4 & TO 14

Approved by:

L. K. Coachman, Professor
Principal Investigator

George C. Anderson, Professor
Associate Chairman for Research

Ref: M78-53

BRISTOL BAY OCEANOGRAPHIC PROCESSES
NORTON-CHUKCHI OCEANOGRAPHIC PROCESSES

## 1. *Objectives*

This study is a joint program with the Pacific Marine Environmental Laboratory (PMEL), ERL, NOAA to provide: 1) water mass circulation information over the eastern and northeastern Bering Sea shelf region; 2) verification of the fluctuation in the northward transport through Bering Strait; 3) data on temporal and spatial scales of eddies ubiquitous to the system; 4) data to refine our understanding of key dynamic processes within the system; 5) data to augment our understanding of the circulation within Norton Sound; and 6) some basis for predictive or diagnostic models of ecosystem response to loading by petroleum and petroleum by-products. These data are for the Outer Continental Shelf Environmental Assessment Program (OCSEAP).

The Leg I portion of Cruise RP-4-DI-78B, of the NOAA ship *Discoverer* was directed towards accomplishing this research. The objectives of this cruise were:

1) The deployment of three Nimbus satellite-tracked drift buoys south of Kodiak Island for the NEGOA project.

2) The recovery of nine current meter and pressure gauge moorings in the Eastern and Northeastern Bering Sea, that were deployed in September 1977.

3) The deployment of twelve current meter and pressure gauge moorings at selected sites in the Eastern and Northeastern Bering Sea and Norton Sound to: 1) refine our understanding of the dynamic processes; 2) provide data for the tidal model of RU 435; and 3) examine the front between Nunivak Island and the Pribilof islands. The recovery of these moorings is planned for September 1978.

4) A series of C-T-D stations selected sites to monitor the seasonal change within the system.

5) A thorough examination of the front along the 50 meter contour between the Pribilof islands and Nunivak Island by: 1) a series of closely spaced XBT's and CTD's across the front over a 25-hour period to study the behavior of the front during a tidal cycle; 2) two 25-hour time series near mooring FX-1A utilizing the CTD.

6) The collection and analysis of nutrient samples in Norton Sound and the Northeastern Bering Sea to aid in the examination of the water masses within this area.

## 2. *Cruise Track and Narrative*

The NOAA ship *Discoverer* departed the Pt. Wells fuel dock Seattle Washington at 2316 GMT, 10 July 1978 and proceeded towards Kodiak, Alaska.

Surface drifters to be tracked by the Nimbus satellite were deployed nearing Kodiak Island at the following locations:

1) Drifter No. 561 at latitude 56-55.8 North, longitude 150-11.9 West at 0852 GMT, 14 July 1978.

2) Drifter No. 753 at latitude 57-02.0 North, longitude 150-04.9 West at 0927 GMT, 14 July 1978.

3) Drifter No. 400 at latitude 57-02.1 North, longitude 150-18.2 West at 1001 GMT, 14 July 1978.

At 1805 GMT, 14 July 1978 we docked alongside the marginal pier, U.S. Coast Guard Base, Kodiak, Alaska. We departed Kodiak, Alaska 0252 GMT, 15 July 1978 and proceeded to the survey area.

1) Station BC-3D PMEL — Latitude 55-17.7 North, longitude 165-29.7 West. Released at 2204 GMT, and recovered at 2303 GMT, 16 July 1978. This mooring consisted of current meters at 17 meters and 97 meters water depth. There was moderate growth on float and first meter. However, rotor was free to turn. Very little data, if any, from upper current meter.

The C-T-D sampling program between mooring locations was initiated. A summary of C-T-D stations accomplished can be found in attachment A. A summary of samples collected for nutrient analysis can be found in attachment B.

2) Station BC-2F PMEL — Latitude 57-02.4 North, longitude 163-26.5 West. Released at 1732 GMT 17 July 1978. The mooring did not surface. We ran a grid around the area and concluded that the mooring was either fouled up or had lost its floatation. We could hear the pinger of the acoustic release without the command unit. An indication that the mooring was within ∿150 ft. of the ship. We returned to the site two hours later with the same results.

3) Station BC-4F UW — Latitude 58-37.2 North, longitude 168-22.2 West. Interrogated at different sites with no response. Returned to original site and fired at 1911 GMT, 18 July 1978. No sighting. We ran a one-mile grid encompassing the GP with no contact established with the mooring.

A line (60 miles long) of C-T-D stations at 10 n. mile intervals were occupied across the front. XBT's were taken at 2.5 n. mile intervals between C-T-D stations to aid in positioning the front. The XBT's are listed in attachment C.

4) Station FX-2A US — Deployed 0115 GMT, 19 July 1978 in 43 meters water depth. This mooring consists of a current meter at 20 meters and a pressure gauge at 42 meters water depth. This mooring was deployed in mostly homogeneous water.

5) Station BC-4G UW — Deployed 03.5 GMT, 19 July 1978 in 53 meters water depth. This mooring consists of current meters at 18 meters and 46 meters, and a pressure gauge at 52 meters water depth. This mooring was deployed in an area which had a sharp thermal structure.

Another line of C-T-D stations at 10 n.m. intervals (with XBT's in between) were taken parallel and 3.9 n.m. from the first line. The first line was then rerun from the NE-SW direction.

6) Station FX-1A UW — Deployed 0019 GMT, 20 July 1978 in 47.7 meters water depth. This mooring consists of current meters at 16 meters and 38 meters water depth. This mooring is ∿9 n.m. from BC-4G and ∿12 n.m. from FX-2A.

7) Station FX-3A UW — Deployed 0054 GMT, 20 July 1978 in 46 meters water depth. This mooring consists of current meters at 14 meters and 36 meters water depth. This mooring is 4.6 n.m. from FX-1A.

8) Station BC-21A UW — Latitude 60-23.4 N, longitude 169-11.2 W. Released at 1717 GMT, and recovered 1744 GMT, 20 July 1978. This mooring consisted of a current meter at 28.5 meters and a pressure gauge at 40.5 meters water depth.

Station BC-21B UW — Deployed 1809 GMT, 20 July 1978 in 41 meters water depth. This mooring consists of current meters at 20 meters and 32 meters water depth.

9) Station BC-20A UW — Latitude 60-25.7 N, longitude 171-05.2 W. Released at 2353 GMT, 20 July 1978 and recovered 0015 GMT, 21 July 1978. This mooring consisted of current meters at 22 meters and 52 meters and a pressure gauge at 65 meters water depth.

Station BC-20B UW — Deployed 0049 GMT, 21 July 1978 in 65 meters water depth. This mooring consists of current meters at 20 meters and 32 meters water depth.

10) Station NC-24A UW — Latitude 61-48.4 N, longitude 170-26.1 W. Released at 1716 GMT and recovered 1734 GMT, 21 July 1978. This mooring consisted of current meters at 24 meters and 40 meters water depth.

Station NC-24B UW — Deployed 1810 GMT, 21 July 1978 in 47.5 meters water depth. This mooring consists of current meters at 19 meters and 39 meters water depth.

11) Station LD-2 PMEL — Deployed 0458 GMT, 22 July 1978 in 28 meters water depth. This mooring consists of a current meter at 24.5 meters and a pressure gauge at 26 meters water depth. Additional geostrophic positioning information obtained by radar is:

| | | |
|---|---|---|
| Northeast Cape | 5.20 n.m. | 63-13.3 N |
| Punuk Island | 10.1 n.m. | 168-34.5 W |
| Direct point of land | 3.8 n.m. | |

12) Station LD-1 PMEL — Deployed 1849 GMT, 22 July 1978 in 14 meters water depth. This mooring consists of a current meter at 10.5 meters and a pressure gauge at 12 meters water depth.

13) Station NC-17B PMEL — Latitude 62-53.1 N. longitude 167-04.6 W. Released at 2308 GMT, and recovered at 2319 GMT, 22 July 1978. This mooring consisted of a current meter at 17 meters and a pressure gauge at 26 meters water depth.

14) Station LD-3 PMEL — Deployed 0831 GMT, 23 July 1978 in 37 meters water depth. This mooring consists of a current meter at 33.5 meters water depth.

15) Station LD-4 PMEL — Deployed 1821 GMT, 23 July 1978 in 20 meters water depth. This mooring consists of a current meter at 16.5 meters and a pressure gauge at 18 meters water depth.

16) Station NC-12B PMEL — Latitude 65-00.3 N, longitude 169-00.7. Interrogated 2314 GMT, 23 July 1978 with no response. The release command was made with no results. A grid of interrogations and firings were made around the deployment site with no contact ever established.

17) Station NC-23A PMEL — Latitude 63-57.2 N, longitude 166-09.4 W. Released at 2007 GMT, and recovered at 2016 GMT, 24 July 1978. This mooring consisted of a current meter at 16 meters water depth.

18) Station LD-5 UW — Deployed 1335 GMT, 25 July 1978 in 27.4 meters water depth. This mooring consists of a current meter at 20 meters and a pressure gauge at 26.4 meters water depth. The radar bearing from the deployment site to Cape Darby is 022.8° at a distance of 12 miles.

All pertinent information regarding the mooring deployments can be found in attachment D. Mooring designs are shown in figure 2 (PMEL) and figure 3 (UW).

At 2110 GMT, 25 July 1978 we proceeded towards Nome to offload mail and scientific equipment. Moderate seas precluded offloading of all scientific equipment. At 0440 GMT, 26 July 1978 we returned to the C-T-D survey area.

The survey was interrupted to evacuate an ill crew member at St. Paul Island. We then returned to the area of the front paralleling the 50 m isobath which separates the well-mixed coastal domain from the two-layered central shelf domain.

A 27 n.m. section, 1 n.m. northwest of moorings FX-2A, FX-1A and BC-4G was occupied four times over a 25-hour period to examine the frontal direction with the stage of the tide. Each section had a C-T-D spacing of 4.5 n.m., which were augmented by XBT's at 1.5 n.m. intervals.

Two 25-hour C-T-D time series were accomplished near Mooring FX-1A to examine the behavior of the front at one location over a tidal cycle.

On completion of the second anchor station at 2320 GMT, 30 July 1978 the NOAA ship *Discoverer* proceeded toward Adak, Alaska. At 1904 GMT, 2 August 1978 the ship was alongside the fuel pier, U.S. Navy Base, Adak, Alaska. A total of 5,055 nautical miles were logged on Leg I of this cruise, all of which were in slight seas.

3. *Methods*

Aanderaa RCM-4 current meters were employed on each mooring, set to record data (current speed and direction, temperature, conductivity and pressure) at a sampling interval of 30 minutes (PMEL) or 20 minutes (UW). The UW meters do not have a conductivity or pressure sensor.

An Aanderaa TG-2A or TG-3A pressure gauge was housed in an anchor wire on moorings BC-4G, FX-2A and LD-5. The pressure gauge was attached to the acoustic release on PMEL moorings LD-1, LD-2 and LD-4. The sampling interval for all the pressure gauges was 15 minutes.

C-T-D casts were taken on each hydrographic section utilizing a Plessy Model 9040 profiling system S/N 6219 with a Model 8400 data logger. Data were stored on a 7-track magnetic tape for reduction ashore by PMEL. In order to determine field calibration factors for the conductivity and temperature sensors, a nisken bottle was mounted on the rosette sampler 1 meter above the sensors.

The salinity samples collected were analyzed aboard ship on a Guildline Model 8400 Autosal. SN 43-166.

Nutrient samples were frozen and will return with the ship to Seattle (November 1978). At that time they will be analyzed at the University of Washington for phosphate, silicate, nitrate and nitrite.

4. *Personnel*

| | | |
|---|---|---|
| R. B. Tripp | Principal Oceanographer | University of Washington Chief Scientist |
| Steve Harding | Research Aide | " |
| Rich Spicer | Graduate Student | " |
| Mike Grigsby | Oceanographer | PMEL/ERL/NOAA |
| Warren J. Houck | Professor | Humboldt State University |
| Ed Boulby | Biologist | NWAFC |
| Dennis Pippenger | " | NWAFC |

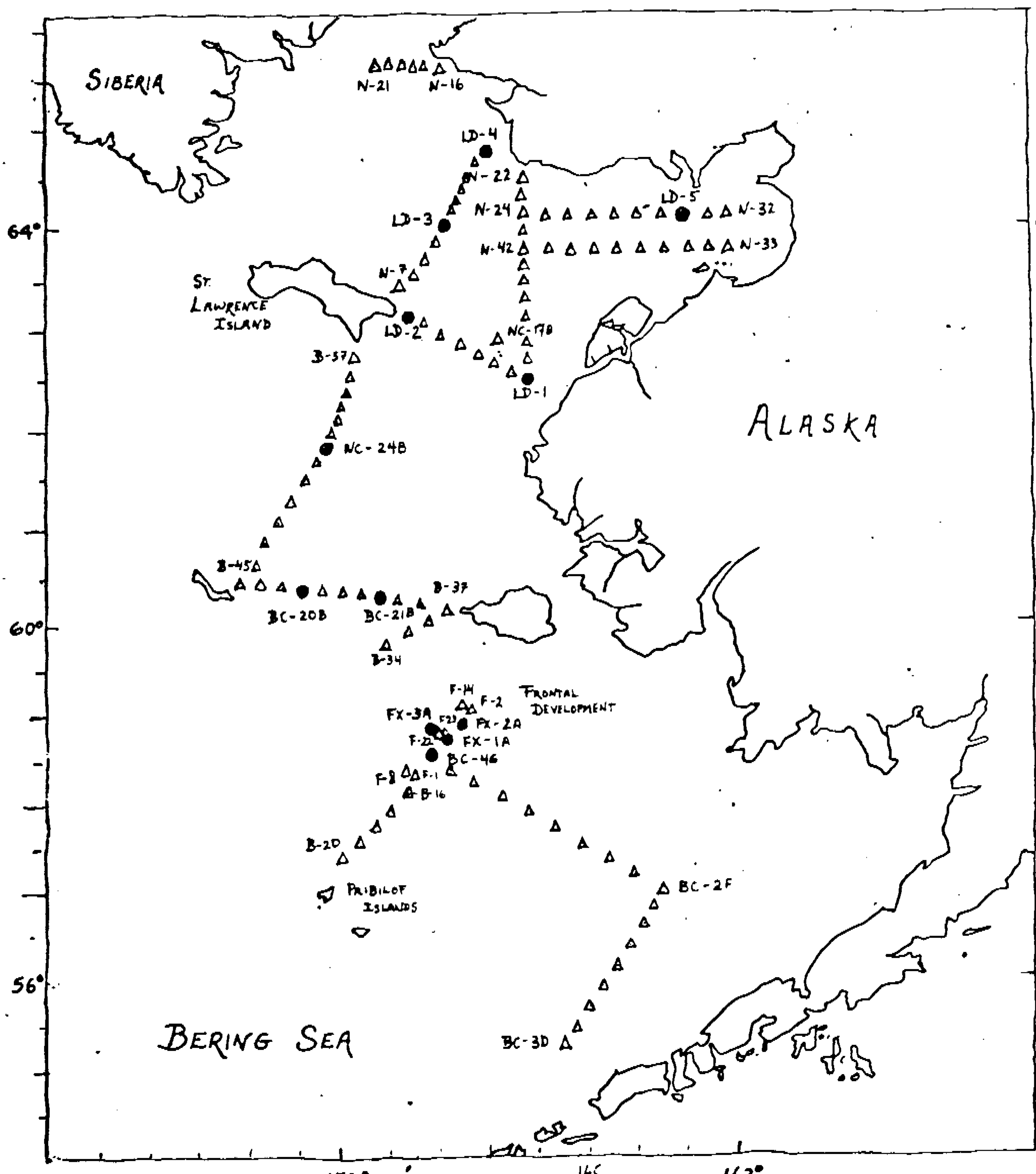
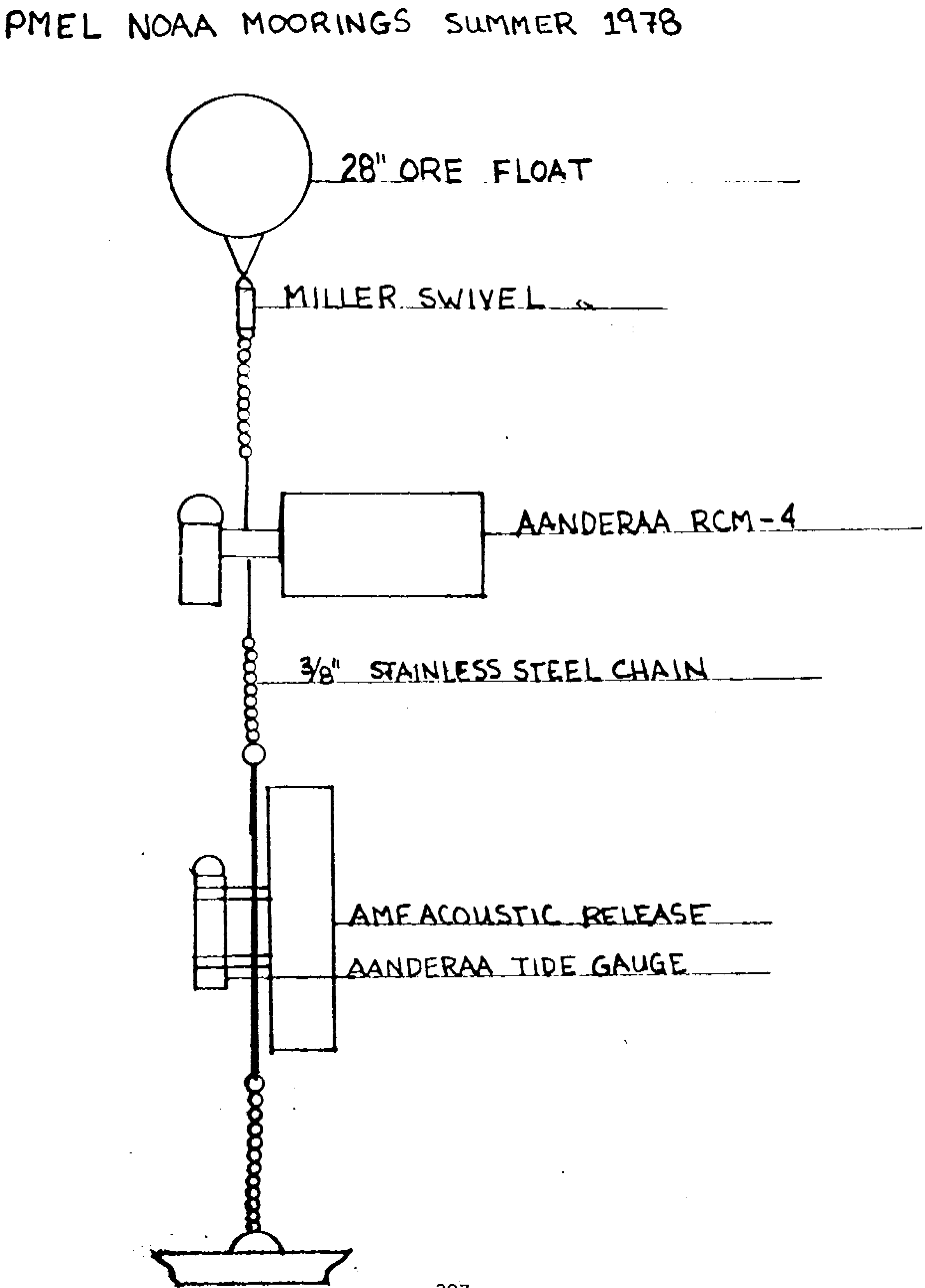

SIBERIA
ALASKA
ST. LAWRENCE ISLAND
BERING SEA
PRIBILOF ISLANDS
FRONTAL DEVELOPMENT
N-21
N-16
LD-4
N-22
LD-5
N-24
N-32
LD-3
N-42
N-33
N-7
LD-2
NC-17B
LD-1
B-37
NC-24B
B-45
B-37
BC-20B
BC-21B
B-34
F-14
F-2
FX-3A
FX-2A
F-22
FX-1A
BC-46
F-8
F-1
B-16
B-20
BC-2F
BC-3D
64°
60°
56°
170°
165
162°

Figure 1.

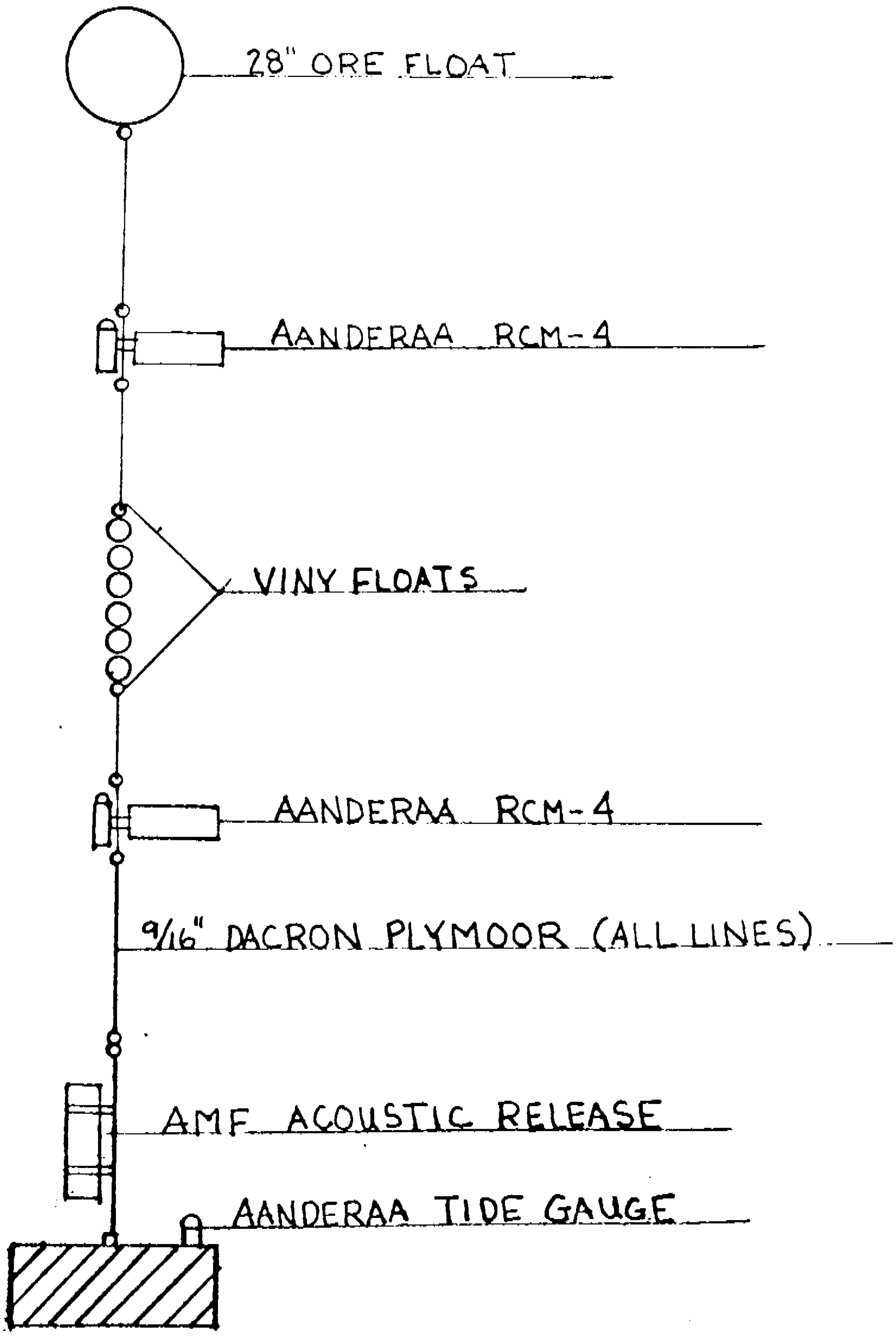
Figure 2.



PMEL NOAA MOORINGS SUMMER 1978
28" ORE FLOAT
MILLER SWIVEL
AANDERAA RCM-4
3/8" STAINLESS STEEL CHAIN
AMF ACOUSTIC RELEASE
AANDERAA TIDE GAUGE

Figure 3.

# BRISTOL BAY SUMMER 1978
## TYPICAL MOORING DESIGN




UNIVERSITY OF WASHINGTON
DEPARTMENT OF OCEANOGRAPHY

ATTACHMENT A

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 1 | BC-3D | 0049 | 17 | 55-18.3 | 165-30.6 | 110 | 113 |
| 2 | B-1 | 0255 | | 55-30.4 | 165-12.3 | 105 | 107 |
| 3 | B-2 | 0440 | | 55-42.5 | 164-59.5 | 92 | 96 |
| 4 | B-3 | 0632 | | 55-57.6 | 164-44.7 | 88 | 91 |
| 5 | B-4 | 0803 | | 56-08.2 | 164-31.4 | 85 | 87 |
| 6 | B-5 | 0941 | | 56-20.5 | 164-16.1 | 83 | 84 |
| 7 | B-6 | 1125 | | 56-34.4 | 164-01.1 | 74 | 78 |
| 8 | B-7 | 1317 | | 56-49.0 | 163-43.8 | | 73 |
| 9 | BC-2F | 1945 | | 57-02.6 | 163-27.3 | 58 | 64 |
| 10 | B-8 | 2218 | | 57-15.3 | 164-05.3 | 59 | 64 |
| 11 | B-9 | 0044 | 18 | 57-28.6 | 164-45.5 | | 62 |
| 12 | B-10 | 0246 | | 57-38.3 | 165-16.4 | 56 | 62 |
| 13 | B-11 | 0445 | | 57-47.9 | 165-45.7 | 51 | 58 |
| 14 | B-12 | 0644 | | 57-57.7 | 166-16.5 | 56 | 58 |
| 15 | B-13 | 0841 | | 58-07.1 | 166-49.2 | | 58 |
| 16 | B-14 | 1030 | | 58-17.7 | 167-19.9 | 50 | 54 |
| 17 | B-15 | 1216 | | 58-27.4 | 167-48.7 | 47 | 53 |
| 18 | F-1 | 1532 | | 58-19.0 | 168-52.8 | 62 | 65 |
| 19 | F-3 | 1649 | | 58-26.2 | 168-39.1 | 60 | 64 |
| 20 | F-4 | 1800 | | 58-34.3 | 168-27.5 | 51 | 56 |
| 21 | F-5 | 2158 | | 58-41.5 | 168-15.2 | 43 | 49 |
| 22 | F-6 | 2314 | | 55-48.8 | 168-01.3 | 39 | 43 |
| 23 | BC-4G | 0333 | 19 | 58-37.2 | 168-21.5 | 48 | 53 |
| 24 | F-8 | 0557 | | 58-20.5 | 169-00.0 | 61 | 65 |
| 25 | F-9 | 0713 | | 58-28.7 | 168-46.2 | 58 | 64 |
| 26 | F-10 | 0819 | | 58-36.0 | 168-34.2 | 52 | 58 |
| 27 | F-11 | 0928 | | 58-43.1 | 168-22.4 | 45 | 49 |
| 28 | F-12 | 1040 | | 58-50.9 | 168-09.8 | 36 | 44 |
| 29 | F-13 | 1156 | | 58-58.8 | 167-56.6 | 34 | 40 |
| 30 | F-14 | 1316 | | 59-06.5 | 167-41.8 | 35 | 40 |
| 31 | F-2 | 1408 | | 59-03.5 | 167-34.6 | 35 | 40 |

ATTACHMENT A
(page 2)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 32 | F-7 | 1524 | | 58-56.1 | 167-49.4 | 35 | 40 |
| 33 | F-6 | 1638 | | 58-49.2 | 168-02.2 | 40 | 45 |
| 34 | F-5 | 1748 | | 58-40.8 | 168-15.5 | 45 | 50 |
| 35 | F-4 | 1859 | | 58-33.3 | 168-28.9 | 52 | 56 |
| 36 | F-3 | 2001 | | 58-26.2 | 168-41.7 | 58 | 62 |
| 37 | F-1 | 2105 | | 58-19.0 | 168-53.2 | 60 | 65 |
| 38 | FX-3A | 0113 | 20 | 58-47.7 | 168-13.6 | | 46 |
| 39 | B-34 | 0638 | | 59-48.4 | 169-02.4 | 38 | 44 |
| 40 | B-35 | 0809 | | 59-56.2 | 168-38.0 | | 40 |
| 41 | B-36 | 0947 | | 60-04.4 | 168-14.6 | 22 | 32 |
| 42 | B-37 | 1129 | | 60-12.9 | 167-48.6 | 25 | 31 |
| 43 | B-38 | 1250 | | 60-16.1 | 168-16.6 | 26 | 31 |
| 44 | B-39 | 1455 | | 60-20.3 | 168-41.6 | 30 | 36 |
| 45 | BC-21B | 1827 | | 60-23.8 | 169-10.5 | 37 | 40 |
| 46 | B-40 | 1953 | | 60-23.8 | 169-39.1 | 40 | 45 |
| 47 | B-41 | 2111 | | 60-23.9 | 170-06.7 | 43 | 51 |
| 48 | B-42 | 2229 | | 60-24.9 | 170-34.8 | 54 | 59 |
| 49 | BC-20B | 0105 | 21 | 60-25.3 | 171-05.4 | 60 | 65 |
| 50 | B-43 | 0222 | | 60-25.2 | 171-30.5 | 60 | 65 |
| 51 | B-44 | 0338 | | 60-26.5 | 171-55.8 | 57 | 62 |
| 52 | B-45 | 0451 | | 60-26.1 | 172-15.9 | 53 | 58 |
| 53 | B-46 | 0627 | | 60-40.0 | 171-59.8 | 57 | 62 |
| 54 | B-47 | 0805 | | 60-52.0 | 171-41.5 | 56 | 64 |
| 55 | B-48 | 0939 | | 61-05.3 | 171-25.7 | 52 | 58 |
| 56 | B-49 | 1112 | | 61-17.6 | 171-10.3 | 44 | 51 |
| 57 | B-50 | 1242 | | 61-30.0 | 170-52.3 | 44 | |
| 58 | B-51 | 1417 | | 61-41.1 | 170-37.1 | | 47 |
| 59 | NC-24B | 1827 | | 61-48.4 | 170-25.3 | 42 | 47 |
| 60 | B-52 | 1931 | | 61-58.3 | 170-20.2 | 43 | 48 |
| 61 | B-53 | 2038 | | 62-07.1 | 170-12.6 | 41 | 44 |
| 62 | B-54 | 2143 | | 62-16.9 | 170-06.0 | | 41 |

ATTACHMENT A
(page 3)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 63 | B-55 | 2246 | | 62-25.8 | 170-00.3 | 31 | 36 |
| 64 | B-56 | 2354 | | 62-36.0 | 169-51.2 | 33 | 38 |
| 65 | B-57 | 0106 | 22 | 62-45.7 | 169-45.7 | 36 | 42 |
| 66 | LD-2 | 0614 | | 63-13.3 | 168-34.5 | 22 | 28 |
| 67 | N-1 | 0739 | | 63-06.4 | 168-16.0 | 34 | 38 |
| 68 | N-2 | 0911 | | 63-01.3 | 167-55.1 | 18 | 22 |
| 69 | N-3 | 1048 | | 62-55.2 | 167-35.2 | 24 | 25 |
| 70 | N-4 | 1308 | | 62-48.9 | 167-14.8 | 34 | 38 |
| 71 | N-5 | 1511 | | 62-43.3 | 166-53.9 | 29 | 33 |
| 72 | LD-1 | 2002 | | 62-30.5 | 166-07.6 | 12 | 14 |
| 73 | N-6 | 2125 | | 62-37.6 | 166-36.2 | 20 | 22 |
| 74 | NC-17B | 2338 | | 62-53.0 | 167-05.0 | 22 | 26 |
| 75 | N-7 | 0344 | 23 | 63-28.2 | 168-48.5 | 17.5 | 26 |
| 76 | N-8 | 0506 | | 63-36.5 | 168-35.0 | 25 | 31 |
| 77 | N-9 | 0613 | | 63-43.9 | 168-24.4 | 30 | 33 |
| 78 | N-10 | 0728 | | 63-53.3 | 168-09.1 | 31 | 33 |
| 79 | LD-3 | 0845 | | 64-00.5 | 168-00.1 | 35 | 37 |
| 80 | N-11 | 0953 | | 64-08.1 | 167-46.6 | 32 | 36 |
| 81 | N-12 | 1116 | | 64-16.0 | 167-35.5 | 28 | 31 |
| 82 | N-13 | 1238 | | 64-24.6 | 167-22.1 | 24 | 30 |
| 83 | N-14 | 1401 | | 64-33.9 | 167-08.7 | 24 | 27 |
| 84 | N-15 | 1549 | | 64-41.7 | 166-55.4 | 20 | 24 |
| 85 | LD-4 | 1703 | | 64-46.1 | 166-50.0 | 18 | 20 |
| 86 | N-21 | 0437 | 24 | 65-26.7 | 169-20.8 | 45 | 51 |
| 87 | N-20 | 0539 | | 65-27.5 | 167-04.1 | 51 | 55 |
| 88 | N-19 | 0637 | | 65-27.2 | 168-46.2 | 52 | 55 |
| 89 | N-18 | 0741 | | 65-27.3 | 168-25.8 | 53 | 58 |
| 90 | N-17 | 0841 | | 65-27.4 | 168-06.1 | 38 | 40 |
| 91 | N-16 | 0932 | | 65-27.0 | 167-54.5 | 30 | 34 |
| 92 | N-22 | 1621 | | 64-25.9 | 166-09.7 | 26 | 29 |
| 93 | N-23 | 1727 | | 64-16.8 | 166-10.9 | 20 | 24 |
| 94 | N-24 | 1830 | | 64-07.8 | 166-08.5 | 18 | 21 |

ATTACHMENT A
(page 4)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 95 | NC-23A | 2024 | | 63-57.2 | 166-09.2 | 19 | 24 |
| 96 | N-42 | 2131 | | 63-46.2 | 166-10.5 | 21 | 27 |
| 97 | N-41 | 2246 | | 63-47.3 | 165-43.4 | 17 | 21 |
| 98 | N-40 | 0002 | 25 | 63-47.1 | 165-16.5 | 14 | 17 |
| 99 | N-39 | 0118 | | 63-47.0 | 164-50.2 | 12 | 16 |
| 100 | N-38 | 0238 | | 63-47.0 | 164-21.5 | 10 | 16.5 |
| 101 | N-37 | 0355 | | 63-47.5 | 163-55.3 | 11 | 16 |
| 102 | N-36 | 0526 | | 63-47.0 | 163-27.9 | 13 | 16 |
| 103 | N-35 | 0645 | | 63-46.7 | 162-58.2 | 15 | 17 |
| 104 | N-34 | 0803 | | 63-47.0 | 162-31.2 | 15 | 16.5 |
| 105 | N-33 | 0905 | | 63-46.8 | 162-05.5 | 14 | 15 |
| 106 | N-32 | 1056 | | 64-06.3 | 162-06.1 | 14 | 18 |
| 107 | N-31 | 1209 | | 64-07.0 | 162-33.0 | 16 | 20 |
| 108 | LD-5 | 1349 | | 64-08.4 | 163-01.0 | 24 | 27 |
| 109 | N-30 | 1507 | | 64-07.3 | 163-29.3 | 19 | 22 |
| 110 | N-29 | 1623 | | 64-07.2 | 163-56.0 | 19 | 22 |
| 111 | N-28 | 1746 | | 64-07.0 | 164-25.3 | 20 | 21 |
| 112 | N-27 | 1857 | | 64-07.0 | 164-51.0 | 16 | |
| 113 | N-26 | 2006 | | 64-07.1 | 165-17.2 | 17 | 18 |
| 114 | N-25 | 0624 | 26 | 64-06.7 | 165-43.0 | 18 | 20 |
| 115 | NC-23A | 0801 | | 63-57.2 | 166-10.1 | 22 | 25 |
| 116 | N-42 | 0917 | | 63-47.2 | 166-09.8 | 25 | 27 |
| 117 | N-43 | 1023 | | 63-37.7 | 166-08.9 | 21 | 26 |
| 118 | N-44 | 1142 | | 63-27.0 | 166-08.8 | 20 | 24 |
| 119 | N-45 | 1247 | | 63-17.3 | 166-09.5 | 20 | 24 |
| 120 | N-46 | 1400 | | 63-07.5 | 166-09.2 | | 22 |
| 121 | N-47 | 1509 | | 62-57.0 | 166-09.7 | 18 | 21 |
| 122 | N-48 | 1626 | | 62-45.9 | 166-08.7 | 17 | 20 |
| 123 | N-6 | 1805 | | 62-37.0 | 166-36.9 | | 22 |
| 124 | B-20 | 2359 | 27 | 57-22.2 | 169-57.8 | 59 | 63 |
| 125 | B-19 | 0135 | 28 | 57-34.4 | 169-40.4 | 65 | 71 |
| 126 | B-18 | 0305 | | 57-46.8 | 169-25.1 | 60 | 65 |

ATTACHMENT A
(page 5)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 127 | B-17 | 0442 | | 57-58.3 | 169-06.6 | 60 | 64 |
| 128 | B-16 | 0611 | | 58-11.8 | 168-53.7 | 62 | 67 |
| 129 | F-15 | 1043 | | 58-55.7 | 167-51.9 | 37 | 42 |
| 130 | F-16 | 1133 | | 58-52.0 | 167-59.6 | 38 | 43 |
| 131 | F-17 | 1216 | | 58-48.5 | 168-04.9 | 40 | 45 |
| 132 | F-18 | 1259 | | 58-44.9 | 168-10.8 | 43 | 47 |
| 133 | F-19 | 1401 | | 58-41.4 | 168-15.7 | 44 | 49 |
| 134 | F-20 | 1449 | | 58-37.3 | 168-22.4 | 49 | 53 |
| 135 | F-21 | 1532 | | 58-34.7 | 168-27.3 | 50 | 55 |
| 136 | F-15 | 1806 | | 58-55.8 | 167-53.3 | 35 | 40 |
| 137 | F-16 | 1857 | | 58-51.9 | 168-00.3 | 37 | 42 |
| 138 | F-17 | 1937 | | 58-48.4 | 168-05.9 | 39 | 44 |
| 139 | F-18 | 2014 | | 58-45.8 | 168-11.0 | 42 | 46 |
| 140 | F-19 | 2101 | | 58-41.8 | 168-16.6 | 44 | 49 |
| 141 | F-20 | 2148 | | 58-38.7 | 168-22.5 | 46 | 51 |
| 142 | F-21 | 2235 | | 58-35.3 | 168-27.5 | 48 | 55 |
| 143 | F-15 | 0143 | 29 | 58-54.4 | 167-53.9 | 35 | 42 |
| 144 | F-16 | 0228 | | 58-51.9 | 167-58.6 | 37 | 42 |
| 145 | F-17 | 0317 | | 58-48.6 | 168-03.9 | 39 | 44 |
| 146 | F-18 | 0403 | | 58-45.6 | 168-10.3 | 40 | 47 |
| 147 | F-19 | 0451 | | 58-42.0 | 168-15.7 | 43 | 47 |
| 148 | F-20 | 0537 | | 58-38.9 | 168-21.7 | 49 | 52 |
| 149 | F-21 | 0628 | | 58-35.1 | 168-27.6 | 50 | 55 |
| 150 | F-15 | 0907 | | 58-55.7 | 167-53.6 | 35 | 40 |
| 151 | F-16 | 0955 | | 58-52.2 | 167-59.7 | 35 | 42 |
| 152 | F-17 | 1040 | | 58-48.6 | 168-04.8 | 40 | 44 |
| 153 | F-18 | 1127 | | 58-45.5 | 168-10.2 | 41 | 47 |
| 154 | F-19 | 1217 | | 58-41.8 | 168-16.4 | 44 | 49 |
| 155 | F-20 | 1307 | | 58-38.5 | 168-22.3 | 47 | 51 |
| 156 | F-21 | 1404 | | 58-34.8 | 168-28.1 | 50 | 56 |
| 157 | F-22 | 1611 | | 58-43.8 | 168-11.0 | 43 | 47 |

ATTACHMENT A
(page 6)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 158 | F-22 | 1708 | | 58-43.9 | 168-11.6 | 42 | 47 |
| 159 | F-22 | 1808 | | 58-43.7 | 168-10.5 | 42 | 47 |
| | | | Anchor Station 1 | | | | |
| 160 | F-22 | 1904 | 29 | 58-43.9 | 168-10.3 | 44 | 47 |
| 161 | | 1918 | | | | 45 | 47 |
| 162 | | 1934 | | | | 45 | |
| 163 | | 1949 | | | | 45 | |
| 164 | | 2004 | | | | 44 | |
| 165 | | 2032 | | | | 44 | |
| 166 | | 2100 | | | | 44 | |
| 167 | | 2130 | | | | 44 | |
| 168 | | 2200 | | | | 44 | |
| 169 | | 2230 | | | | 43 | |
| 170 | | 2300 | | | | 44 | |
| 171 | | 2330 | | | | 44 | |
| 172 | | 0000 | 30 | | | 45 | |
| 173 | | 0030 | | | | 44 | |
| 174 | | 0059 | | | | 44 | |
| 175 | | 0100 | | | | 43 | |
| 176 | F-22 | 0203 | | 58-43.9 | 168-10.3 | 44 | 47 |
| 177 | | 0233 | | | | 44 | |
| 178 | | 0300 | | | | 44 | |
| 179 | | 0332 | | | | 44 | |
| 180 | | 0402 | | | | 44 | |
| 181 | | 0429 | | | | 44 | |
| 182 | | 0459 | | | | 44 | |
| 183 | | 0533 | | | | 45 | |
| 184 | | 0601 | | | | 45 | |
| 185 | | 0631 | | | | 45 | |
| 186 | | 0702 | | | | 44 | |
| 187 | | 0732 | | | | 45 | |
| 188 | | 0801 | | | | 44 | |

ATTACHMENT A
(page 7)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 189 | | 0832 | | | | 44 | |
| 190 | | 0902 | | | | 45 | |
| 191 | | 0931 | | | | 45 | |
| 192 | | 1000 | | | | 44 | |
| 193 | | 1032 | | | | 44 | |
| 194 | | 1100 | | | | 44 | |
| 195 | | 1130 | | | | 44 | |
| 196 | | 1200 | | | | 44 | |
| 197 | | 1230 | | | | 45 | |
| 198 | | 1300 | | | | 43 | |
| 199 | | 1330 | | | | 44 | |
| 200 | | 1402 | | | | 42 | |
| 201 | F-22 | 1433 | 30 | 58-43.9 | 168-10.3 | 42 | 47 |
| 202 | | 1503 | | | | 42 | |
| 203 | | 1531 | | | | 44 | |
| 204 | | 1603 | | | | 42 | |
| 205 | | 1635 | | | | 43 | |
| 206 | | 1701 | | | | 42 | |
| 207 | | 1730 | | | | 42 | |
| 208 | | 1802 | | | | 45 | |
| 209 | | 1832 | | | | 44 | |
| 210 | | 1901 | | | | 44 | |
| 211 | | 1916 | | | | 44 | |
| 212 | | 1931 | | | | 44 | |
| 213 | | 1947 | | | | 44 | |
| 214 | | 2002 | | | | 45 | |
| | | | Anchor Station 2 | | | | |
| 215 | F-23 | 2200 | 30 | 58-47.9 | 168-04.3 | 40 | 45 |
| 216 | | 2215 | | | | 40 | |
| 217 | | 2230 | | | | 41 | |
| 218 | | 2245 | | | | 41 | |

ATTACHMENT A
(page 8)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 219 | | 2259 | | | | 40 | |
| 220 | | 2330 | | | | 40 | |
| 221 | | 0000 | 31 | | | 40 | |
| 222 | | 0030 | | | | 40 | |
| 223 | | 0100 | | | | 40 | |
| 224 | | 0130 | | | | 40 | |
| 225 | F-23 | 0159 | | 58-47.9 | 168-04.3 | 40 | 45 |
| 226 | | 0230 | | | | 40 | |
| 227 | | 0302 | | | | 40 | |
| 228 | | 0333 | | | | 40 | |
| 229 | | 0400 | | | | 40 | |
| 230 | | 0432 | | | | 40 | |
| 231 | | 0501 | | | | 40 | |
| 232 | | 0530 | | | | 41 | |
| 233 | | 0601 | | | | 43 | |
| 234 | | 0633 | | | | 43 | |
| 235 | | 0700 | | | | 42 | |
| 236 | | 0731 | | | | 43 | |
| 237 | | 0803 | | | | 43 | |
| 238 | | 0832 | | | | 43 | |
| 239 | | 0900 | | | | 44 | |
| 240 | | 0929 | | | | 43 | |
| 241 | | 1000 | | | | 41 | |
| 242 | | 1030 | | | | 41 | |
| 243 | | 1059 | | | | 41 | |
| 244 | | 1130 | | | | 41 | |
| 245 | | 1200 | | | | 41 | |
| 246 | | 1230 | | | | 42 | |
| 247 | | 1300 | | | | 41 | |
| 248 | | 1330 | | | | 43 | |
| 249 | | 1401 | | | | 40 | |

ATTACHMENT A
(page 9)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 250 | F-23 | 1430 | 30 | 58-47.9 | 168-04.3 | 40 | 45 |
| 251 | | 1501 | | | | 41 | |
| 252 | | 1533 | | | | 40 | |
| 253 | | 1602 | | | | 40 | |
| 254 | | 1631 | | | | 40 | |
| 255 | | 1700 | | | | 40 | |
| 256 | | 1729 | | | | 40 | |
| 257 | | 1802 | | | | 43 | |
| 258 | | 1831 | | | | 44 | |
| 259 | | 1903 | | | | 44 | |
| 260 | | 1931 | | | | 44 | |
| 261 | | 2000 | | | | 44 | |
| 262 | | 2030 | | | | 44 | |
| 263 | | 2100 | | | | 45 | |
| 264 | | 2129 | | | | 43 | |
| 265 | | 2200 | | | | 41 | |
| 266 | | 2215 | | | | 38 | |
| 267 | | 2230 | | | | 41 | |
| 268 | | 2245 | | | | 41 | |
| 269 | | 2300 | | | | 41 | |

ATTACHMENT B
(page 1)

Nutrient Sample Summary

| CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) | CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) |
|---|---|---|---|---|---|---|---|
| 18 | F-1 | DI-1 | DI-2 (62) | 70 | N-4 | DI-48 | DI-49 (34) |
| 19 | F-3 | 3 | 4 (60) | 71 | N-5 | 50 | 51 (33) |
| 20 | F-4 | 6 | 5 (51) | 72 | LD-1 | 52 | 53 (12) |
| 21 | F-5 | 7 | 8 (43) | 73 | N-6 | 54 | 55 (20) |
| 22 | F-6 | 9 | 10 (39) | 74 | NC-17B | 56 | 57 (22) |
| 23 | BC-4G | 11 | 12 (48) | 75 | N-7 | 58 | 59 (18) |
| 24 | F-8 | 13 | 14 (61) | 76 | N-8 | 60 | 61 (24) |
| 25 | F-9 | 15 | 16 (58) | 77 | N-9 | 62 | 63 (30) |
| 26 | F-10 | 17 | 18 (52) | 78 | N-10 | 64 | 65 (31) |
| 27 | F-11 | 19 | 20 (49) | 79 | LD-3 | 66 | 67 (35) |
| 28 | F-12 | 21 | 22 (44) | 80 | N-11 | 68 | 69 (32) |
| 29 | F-13 | 23 | 24 (34) | 81 | N-12 | 70 | 71 (28) |
| 30 | F-14 | 25 | 26 (35 | 82 | N-13 | 72 | 73 (25) |
| 31 | F-2 | 28 | 27 (35) | 83 | N-14 | 74 | 75 (27) |
| 32 | F-7 | 29 | 30 (38) | 84 | N-15 | 76 | 77 (20) |
| 33 | F-6 | 31 | 32 (40) | 86 | N-21 | 78 | 79 (45) |
| 34 | F-5 | 33 | 34 (45) | 87 | N-20 | 80 | 81 (51) |
| 35 | F-4 | 35 | 36 (52) | 88 | N-19 | 82 | 83 (52) |
| 36 | F-3 | 37 | 38 (58) | 89 | N-18 | 84 | 85 (53) |
| 37 | F-1 | 39 | 40 (60) | 90 | N-17 | 86 | 87 (38) |
| 66 | LD-2 | | 41 (22) | 91 | N-16 | 88 | 89 (30 |
| 67 | N-1 | 42 | 43 (34) | 92 | N-22 | 90 | 91 (26) |
| 68 | N-2 | 44 | 45 (18) | 93 | N-23 | 92 | 93 (20) |
| 69 | N-3 | 46 | 47 (24) | 94 | N-24 | 94 | 95 (18) |

ATTACHMENT B
(page 2)

| CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) | CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) |
|---|---|---|---|---|---|---|---|
| 95 | NC-23A | DI-96 | DI-97 (19) | 120 | N-46 | DI-147 | DI-148 (22) |
| 96 | N-42 | 98 | 99 (21) | 121 | N-47 | 149 | 150 (18) |
| 97 | N-41 | 100 | 101 (17) | 122 | N-48 | 151 | 152 (20 |
| 98 | N-40 | 102 | 103 (14) | 123 | N-6 | 153 | 154 (22) |
| 99 | N-39 | 104 | 105 (14) | 124 | B-20 | 155 | 156 (59) |
| 100 | N-38 | 106 | 107 (10) | 125 | B-19 | 157 | 158 (65) |
| 101 | N-37 | 108 | 109 (16) | 126 | B-18 | 159 | 160 (60) |
| 102 | N-36 | 110 | 111 (13) | 127 | B-17 | 161 | 162 (60) |
| 103 | N-35 | 112 | 113 (15) | 128 | B-16 | 163 | 164 (62) |
| 104 | N-34 | 115 | 116 (15) | 129 | F-15 | 165 | 166 (37) |
| 105 | N-33 | 117 | 118 (14) | 130 | F-16 | 167 | 168 (38) |
| 106 | N-32 | 119 | 120 (16) | 131 | F-17 | 169 | 170 (40) |
| 107 | N-31 | 121 | 122 (18) | 132 | F-18 | 171 | 172 (43) |
| 108 | LD-5 | 123 | 124 (27) | 133 | F-19 | 173 | 174 (49) |
| 109 | N-30 | 125 | 126 (22) | | | | |
| 110 | N-29 | 127 | 128 (22) | 135 | F-21 | 175 | 176 (50) |
| 111 | N-28 | 129 | 130 (20) | 136 | F-15 | 177 | 178 (35) |
| 112 | N-27 | 131 | 132 (16) | 137 | F-16 | 179 | 180 (38) |
| 113 | N-26 | 133 | 134 (17) | 138 | F-17 | 181 | 182 (40) |
| 114 | N-25 | 135 | 136 (20) | 139 | F-18 | 185 | 184 (42) |
| 115 | NC-23A | 137 | 138 (25) | 140 | F-19 | 185 | 186 (44) |
| 116 | N-42 | 139 | 140 (27) | 141 | F-20 | 187 | 188 (48) |
| 117 | N-43 | 141 | 142 (22) | 142 | F-21 | 189 | 190 (51) |
| 118 | N-44 | 143 | 144 (20) | 143 | F-15 | 191 | 192 (38) |
| 119 | N-45 | 145 | 146 (20) | 144 | F-16 | 193 | 194 (36) |

ATTACHMENT B
(page 3)

| CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) |
|---|---|---|---|
| 145 | F-17 | DI-195 | DI-196 (40) |
| 146 | F-18 | 197 | 198 (40) |
| 147 | F-19 | 199 | 200 (44) |
| 148 | F-20 | 201 | 202 (47) |
| 149 | F-21 | 203 | 204 (50) |
| 150 | F-15 | 205 | 206 (36) |
| 151 | F-16 | 207 | 208 (39) |
| 152 | F-17 | 209 | 210 (40) |
| 153 | F-18 | 211 | 212 (41) |
| 154 | F-19 | 213 | 214 (44) |
| 155 | F-20 | 215 | 216 (45) |
| 156 | F-21 | 217 | 218 (54) |

ATTACHMENT C

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 1 | 1720 | 18 | 58-29.0 | 168-35.3 | 60 |
| 2 | 1728 | | 58-30.3 | 168-33.6 | 60 |
| 3 | 1740 | | 58-32.2 | 168-30.9 | 60 |
| 4 | 1836 | | 58-36.1 | 168-24.5 | 55 |
| 5 | 2125 | | 58-37.9 | 168-20.7 | 51 |
| 6 | 2137 | | 58-39.5 | 168-18.1 | 49 |
| 7 | 2226 | | 58-43.3 | 168-12.3 | 48 |
| 8 | 2240 | | 58-45.0 | 168-07.8 | 46 |
| 9 | 2253 | | 58-46.9 | 168-04.5 | 46 |
| 10 | 2342 | | 58-50.9 | 167-58.8 | 44 |
| 11 | 2354 | | 58-52.9 | 167-54.6 | 42 |
| 12 | 0005 | 19 | 58-54.5 | 167-51.1 | 42 |
| 13 | 0026 | | 58-56.2 | 167-48.3 | 42 |
| 14 | 0739 | | 58-30.5 | 168-42.9 | 64 |
| 15 | 0748 | | 58-31.8 | 168-40.7 | 60 |
| 16 | 0800 | | 58-33.8 | 168-37.4 | 62 |
| 17 | 0847 | | 58-37.9 | 168-31.3 | 55 |
| 18 | 0859 | | 58-39.7 | 168-28.1 | 53 |
| 19 | 0911 | | 58-41.5 | 168-25.1 | 47 |
| 20 | 0956 | | 58-45.3 | 168-18.4 | 48 |
| 21 | 1008 | | 58-47.0 | 168-15.0 | 48 |
| 22 | 1020 | | 58-48.7 | 168-11.7 | 45 |
| 23 | 1110 | | 58-52.9 | 168-06.4 | 42 |
| 24 | 1123 | | 58-54.8 | 168-03.1 | 42 |
| 25 | 1135 | | 58-56.6 | 167-59.9 | 42 |
| 26 | 1558 | | 58-58.3 | 167-53.5 | 42 |
| 27 | 1611 | | 58-51.4 | 167-56.6 | 42 |
| 28 | 1624 | | 58-49.3 | 168-02.0 | 42 |
| 29 | 1710 | | 58-45.7 | 168-05.6 | 45 |
| 30 | 1719 | | 58-44.2 | 168-08.2 | 46 |
| 31 | 1729 | | 58-42.8 | 168-11.2 | 46 |
| 32 | 1815 | | 58-39.2 | 168-18.4 | 51 |
| 33 | 1827 | | 58-37.2 | 168-21.9 | 53 |
| 34 | 1838 | | 58-35.4 | 168-25.1 | 55 |
| 35 | 1923 | | 58-31.6 | 168-31.8 | 60 |

ATTACHMENT C
(page 2)

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 36 | 1933 | | 58-30.0 | 168-34.6 | 61 |
| 37 | 1945 | | 58-28.0 | 168-36.1 | 63 |
| 38 | 0013 | 20 | 58-42.7 | 168-09.2 | 47 |
| 39 | 0041 | | 58-46.8 | 168-12.0 | 47 |
| 40 | 1108 | 28 | 58-54.4 | 167-54.7 | 42 |
| 41 | 1120 | | 58-53.0 | 167-57.5 | 43 |
| 42 | 1152 | | 58-51.0 | 168-01.2 | 43 |
| 43 | 1201 | | 58-49.8 | 168-03.0 | 43 |
| 44 | 1236 | | 58-47.3 | 168-06.8 | 46 |
| 45 | 1245 | | 58-46.2 | 168-08.8 | 48 |
| 46 | 1319 | | 58-43.9 | 168-12.2 | 49 |
| 47 | 1330 | | 58-42.5 | 168-14.8 | 50 |
| 48 | 1431 | | 58-38.6 | 168-19.7 | 50 |
| 49 | 1503 | | 58-37.2 | 168-22.3 | 53 |
| 50 | 1512 | | 58-35.9 | 168-25.3 | 54 |
| 51 | 1831 | | 58-54.6 | 167-56.6 | 42 |
| 52 | 1839 | | 58-53.4 | 167-58.7 | 42 |
| 53 | 1914 | | 58-50.7 | 168-02.4 | 44 |
| 54 | 1921 | | 58-49.8 | 168-03.9 | 44 |
| 55 | 1955 | | 58-47.3 | 168-08.0 | 46 |
| 56 | 2001 | | 58-46.6 | 168-09.3 | 46 |
| 57 | 2035 | | 58-44.6 | 168-13.1 | 47 |
| 58 | 2044 | | 58-43.4 | 168-14.6 | 48 |
| 59 | 2121 | | 58-40.9 | 168-18.8 | 50 |
| 60 | 2130 | | 58-40.0 | 168-20.7 | 51 |
| 61 | 2210 | | 58-37.6 | 168-24.0 | 53 |
| 62 | 2219 | | 58-36.5 | 168-25.6 | 55 |
| 63 | 0204 | 29 | 58-54.3 | 167-55.3 | 42 |
| 64 | 0213 | | 58-53.1 | 167-57.0 | 42 |
| 65 | 0251 | | 58-50.7 | 168-00.7 | 44 |
| 66 | 0259 | | 58-49.7 | 168-02.5 | 44 |
| 67 | 0339 | | 58-47.5 | 168-06.2 | 47 |
| 68 | 0348 | | 58-46.6 | 168-08.5 | 47 |

ATTACHMENT C
(page 3)

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 69 | 0424 | | 58-44.4 | 168-12.1 | 47 |
| 70 | 0433 | | 58-43.3 | 168-14.1 | 47 |
| 71 | 0513 | | 58-40.9 | 168-17.7 | 49 |
| 72 | 0522 | | 58-39.8 | 168-20.1 | 49 |
| 73 | 0559 | | 58-37.8 | 168-23.9 | 53 |
| 74 | 0610 | | 58-36.4 | 168-26.1 | 54 |
| 75 | 0928 | | 58-54.6 | 167-55.5 | 40 |
| 76 | 0939 | | 58-53.4 | 167-57.8 | 42 |
| 77 | 1014 | | 58-51.1 | 168-01.3 | 43 |
| 78 | 1023 | | 58-50.0 | 168-03.0 | 43 |
| 79 | 1101 | | 58-47.7 | 168-06.5 | 45 |
| 80 | 1111 | | 58-46.6 | 168-08.4 | 46 |
| 81 | 1148 | | 58-44.4 | 168-12.2 | 47 |
| 82 | 1200 | | 58-43.1 | 168-14.5 | 48 |
| 83 | 1241 | | 58-40.7 | 168-18.5 | 50 |
| 84 | 1252 | | 58-39.5 | 168-20.7 | 51 |
| 85 | 1330 | | 58-37.3 | 168-24.3 | 53 |
| 86 | 1341 | | 58-36.1 | 168-26.4 | 55 |
| 87 | 2008 | 30 | 58-43.9 | 168-10.3 | 47 |
| 88 | 2034 | | 58-44.5 | 168-08.9 | 48 |
| 89 | 2039 | | 58-45.1 | 168-08.1 | 48 |
| 90 | 2044 | | 58-45.6 | 168-07.2 | 47 |
| 91 | 2048 | | 58-46.1 | 168-06.5 | 47 |
| 92 | 2052 | | 58-46.6 | 168-05.8 | 46 |
| 93 | 2056 | | 58-47.1 | 168-05.1 | 46 |
| 94 | 2100 | | 58-47.6 | 168-04.4 | 46 |
| 95 | 2104 | | 58-48.1 | 168-03.7 | 45 |
| 96 | 2108 | | 58-48.6 | 168-03.0 | 44 |
| 97 | 2112 | | 58-49.1 | 168-02.3 | 44 |
| 98 | 2330 | 31 | 58-47.0 | 168-06.5 | 46 |
| 99 | 2335 | | 58-46.3 | 168-08.0 | 46 |
| 100 | 2340 | | 58-45.8 | 168-09.5 | 47 |
| 101 | 2345 | | 58-45.0 | 168-11.1 | 47 |

ATTACHMENT C
(page 4)

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 102 | 2350 | 31 | 58-44.3 | 168-12.7 | 48 |
| 103 | 2355 | | 58-43.7 | 168-14.2 | 48 |
| 104 | 0000 | Aug. 1 | 58-43.0 | 168-15.8 | 48 |
| 105 | 0005 | | 58-42.0 | 168-17.3 | 49 |
| 106 | 0010 | | 58-41.8 | 168-18.9 | 51 |
| 107 | 0015 | | 58-41.1 | 168-20.5 | 51 |

ATTACHMENT D

Mooring Deployment Summary

| Mooring ID | Time GMT | Date GMT 1978 | Latitude North | Longitude West | Water Depth Meters | Instrumentation Depths | Loran - c rates x-rate | y-rate | z-rate | Receiver Channel No. |
|---|---|---|---|---|---|---|---|---|---|---|
| FX-2A UW | 0115 | 19 | 58-52.0 | 167-56.5 | 43 | cm 20 m<br>PG 42 m | | 33667.25<br>33666.90 | 48907.38 | 10 |
| BC-4G UW | 0315 | 19 | 58-37.0 | 168-21.6 | 53 | cm 18 m<br>cm 46 m<br>PG 52 m | | 33889.20 | 49107.73 | 7 |
| FX-1A UW | 0019 | 20 | 58-42.8 | 168-09.5 | 47.7 | cm 16 m<br>cm 38 m | | 33798.60 | 49017.89 | 6 |
| FX-3A UW | 0054 | 20 | 58-47.4 | 168-13.1 | 46 | cm 14 m<br>cm 36 m | | 33754.00 | 49013.59 | 5 |
| BC-21B UW | 1809 | 20 | 60-23.9 | 169-10.4 | 41 | cm 20 m<br>cm 32 m | 18209.15 | 32689.65 | | 1 |
| BC-20B UW | 0049 | 21 | 60-25.6 | 171-05.1 | 65 | cm 20 m<br>cm 32 m | 17914.56 | 32772.98 | | 2 |
| NC-24B UW | 1810 | 21 | 61-48.3 | 170-26.0 | 47 | cm 19 m<br>cm 39 m | 17810.19 | 31746.9 | | 4 |
| LD-2 PMEL | 0558 | 22 | 63-13.2 | 168-34.8 | 28 | cm 24.5 m<br>PG 26 m | 17840.66 | 30594.40 | | 1 |
| LD-1 PMEL | 1949 | 22 | 62-30.3 | 166-07.2 | 14 | cm 10.5 m<br>PG 12 m | 18170.22 | 30961.86 | | 10 |
| LD-3 PMEL | 0831 | 23 | 64-00.4 | 168-00.0 | 37 | cm 33.5 m | 17796.71 | 29981.49 | | 7 |
| LD-4 PMEL | 1821 | 23 | 64-46.6 | 166-49.6 | 20 | cm 16.5 m<br>PG 18 m | 17806.26 | 29342.46 | | 1 |
| LD-5 UW | 1335 | 25 | 64-08.3 | 163-00.2 | 27.4 | cm 20 m<br>PG 26.4 m | 18156.46 | 29899.90 | 46824.61 | 4 |

## APPENDIX B

University of Washington
Department of Oceanography
Seattle, Washington 98195

Preliminary Report

# University of Washington Participation in NOAA Ship *Discoverer* Cruise RP-4-DI-78B, Leg III

Bristol Bay Oceanographic Processes RU 141

Norton-Chukchi Oceanographic Processes RU 541

10 - 29 September 1978

by

Richard B. Tripp

NOAA Contract 03-5-022-67, TO 4 & TO 14

Approved by:

L. K. Coachman, Professor
Principal Investigator

George C. Anderson, Professor
Associate Chairman for Research

Ref: M78-56

BRISTOL BAY OCEANOGRAPHIC PROCESSES

NORTON-CHUKCHI OCEANOGRAPHIC PROCESSES

## 1. *Objectives*

This study is a joint program with the Pacific Marine Environmental Laboratory (PMEL), ERL, NOAA to provide:

1) water mass circulation information over the eastern and northeastern Bering Sea shelf region.

2) verification of the fluctuation in the northward transport through Bering Strait.

3) data on temporal and spatial scales of eddies ubiquitous to the system

4) data to refine our understanding of key dynamic processes within the system.

5) more data to augment our understanding of the circulation within Norton Sound.

6) some basis for predictive or diagnostic models of ecosystem response to loading by petroleum and petroleum by-products.

The Leg III portion of this cruise was directed toward finalizing some of this research. This was the last scheduled cruise associated with this program. The specific objectives of this cruise were:

1) The recovery of twelve current meter and pressure gauge moorings in the eastern and northeastern Bering Sea, that were deployed in July 1978.

2) C-T-D stations at selected sites to minotor the seasonal change within the system.

3) An examination of the structural front paralleling the 50-meter isobath prior to retrieval of the four moorings.

4) The collection and analysis of nutrient samples from selected sites as an aid in examining the circulation.

5) A series of C-T-D stations around the Pribilof Islands in conjunction with the RU 83 program to correlate bird observations with physical parameters near the front around the islands.

6) A series of drags in an attempt to retrieve some of the previous lost moorings which failed to surface.

## 2. *Cruise Track & Narrative*

The NOAA ship *Discoverer* departed Kodiak, Alaska at 1800 GMT, 10 September 1978 and proceeded to the survey area (Figures 1 & 2).

1) Station BC-21B UW — Latitude 60°23.9'N, longitude 169°10.4'W. Released at 0555 GMT and recovered at 0615 GMT, 13 September 1978. This mooring consisted of current meters at 20 meters and 32 meters water depth.

The C-T-D program was initiated at this time. All CTD stations accomplished are listed in attachment A.

2) Station BC-20B UW — Latitude 60°25.6N, longitude 171-05.1W. Released at 1803 GMT, and recovered at 1855 GMT, 13 September 1978. This mooring consisted of current meters at 19 meters and 51 meters water depth. We encountered a slight problem during this retrieval. The top current meter was hung up on the ship's rudder post for a time, resulting in the loss of the current meter rotor and vane.

3) Station NC-24B UW — Latitude 61-48.3N, longitude 170-26.0W. Released at 0049 GMT and recovered at 0109 GMT, 14 September 1978. This mooring consisted of current meters at 19 meters and 39 meters water depth.

4) Station LD-1 PMEL — Latitude 62-30.3N, longitude 166-07.2W. Released at 1719 GMT, and recovered at 1729 GMT, 14 September 1978. This mooring consisted of a current meter at 10.5 meters, and a pressure gauge at 12 meters water depth.

5) Station LD-2 PMEL — Latitude 63-13.2N, longitude 168-34.8W. Released at 2326 GMT, 14 September 1978 and recovered at 0007 GMT, 15 September 1978. This mooring consisted of a current meter at 24.5 meters and a pressure gauge at 26 meters water depth.

6) Station LD-3 PMEL — Latitude 64-00.4N, longitude 166-49.6W. Released at 0359 GMT, and recovered at 0404 GMT, 15 September 1978. This mooring consisted of a current meter at 33.5 meters water depth. There was growth around bearing on current meter. Also, the current meter was 125° out of alignment with reference.

7) Station LD-5 UW — Latitude 64-08.3N, longitude 163-00.2W. No contact was made with this mooring. A grid of one mile interrogations was done around the deployment site with no positive results. Also, a line of one-mile interrogations was done from 69-09.7N; 163-38'W to 69-09.6'N; 163-10.0'W with negative results. A drag was accomplished around the deployment site with no success.

8) Station NC-22A PMEL — Latitude 63-40.8W, longitude 163-01.8W. We had tried unsuccessfully to retrieve this mooring in August 1977. We now dragged the area, hitting something but failed to retrieve anything.

9) Station LD-4 PMEL — Latitude 64-46.6N, longitude 166-49.6W. Released at 1721 GMT, and recovered at 1736 GMT. This mooring consisted of a current meter at 16.5 meters and a pressure gauge at 18 meters water depth. There was heavy growth on the instrumentation.

We proceeded toward Bering Strait to attempt recovery of a Japanese mooring deployed 24 July 1978. The position was latitude 65-46.5N, and longitude 168-35.5W with a Radar Bearing to Fairway Rock 202°/9.60 n.m. On arrival at the mooring site, the seas were too heavy to attempt dragging operations, so C-T-D stations were occupied in Bering Strait until the following morning.

At 1700 GMT, 17 September we commenced dragging operations. We completed the drag at 1857 GMT with no positive results other than retrieving some large rocks.

An attempt was made to interrogate NC-16A, lost in Bering Strait the previous year. However, no response was obtained.

Taking C-T-D stations en route, we returned to an area around moorings FX-1A, FX-2A, FX-3A and BC-4G to examine the structural front over a 25-hour tidal cycle.

A line of (27 n.m.) C-T-D stations were occupied at 4.5 n.m. intervals across the front. XBT's were taken at 15. n.m. intervals between the C-T-D stations. XBT information can be found in attachment B. Nutrient samples were drawn at the surface and at bottom - 5 meters on all C-T-D casts associated with the frontal experiment (attachment C). Only XBT's were taken on the fourth crossing of the front, as the weather deteriorated.

10) Station BC-4G — Latitude 58-37.0N. longitude 168-21.6W. Released 1748 GMT and recovered at 1820 GMT, 20 September 1978. This mooring consisted of current meters at 18 meters & 46 meters, and a pressure gauge at 52 meters water depth.

11) Station FX-1A — Latitude 58-42.8N, longitude 168-09.5W. Released 1914 GMT, and recovered 2004 GMT, 20 September 1978. This mooring consisted of current meters at 16 meters and 38 meters water depth.

12) Station FX-3A — Latitude 58-47.4N, longitude 168-13.1W. Released 2153 GMT, and recovered 2226 GMT, 20 September 1978. This mooring consisted of current meters at 14 meters and 36 meters water depth.

13) Station FX-2A — Latitude 58-52.0N, longitude 167-56.5W. Released 2344 GMT, 20 September 1978 and recovered at 0012 GMT, 21 September 1978. This mooring consisted of a current meter at 20 meters, and a pressure gauge at 42 meters water depth.

XBT's were taken around the front until the following morning. No CTD's were taken due to heavy seas.

At 1957 GMT, 21 September 1978 we arrived at the deployment site of mooring BC-4F. Again there was no response to interrogation. Heavy seas prevented our planned drag of the area.

C-T-D's were taken on a line toward St. Paul Island, where we were scheduled to take aboard the bird observers.

At 1940 GMT, 22 September 1978 the University of California bird program commenced around the Pribilof Islands.

A series of C-T-D's and XBT's were taken around the islands to examine the water column as it changes from stratified to homogeneous near the Pribilof Islands. Five lines of stations extending out from St. Paul Island, and two lines extending out from St. George Island were accomplished. Nutrient samples were collected at 10 meters and bottom minus 5 meters water depth. In addition one hydrographic station in the stratified water column was sampled at eight depths and one hydrographic station in the well-mixed region was sampled at six depths.

At 0652 GMT, 27 September 1978 the survey in the Pribilof area was terminated and the ship proceeded toward Kodiak, Alaska. At 1800 GMT, 29 September 1978 the ship was alongside the fuel pier at the U.S. Coast Guard Station, Kodiak, Alaska. A total of 3155.5 nautical miles were steamed on Leg III of this cruise.

3. *Methods*

Aanderaa RCM-4 current meters were employed on each of the recovered moorings. The meters were set to record data (current speed and direction, temperature, conductivity, and pressure) at a sampling interval of 30 minutes (PMEL) or 20 minutes (UW). The UW meters do not have a conductivity or pressure sensor.

Aanderaa TG-2A or TG-3A pressure gauges were utilized on moorings BC-4G, FX-2A, LD-1, LD-2 and LD-4. The sampling interval for all the pressure gauges was 15 minutes.

C-T-D casts were taken on each hydrographic station utilizing a Plessy Model 9040 profiling system S/N 6219 with a model 8400 data logger. Data were stored on a 7-track magnetic tape for reduction ashore by PMEL. There was a problem with the data logger during this leg. No temperatures were recorded on the Plessy system. However, temperatures were recorded on the ship's DAS and will be retrieved when the ship returns to Seattle.

In order to determine field calibration factors for the conductivity and temperature sensors, a niskin bottle was mounted on the rosette sampler 1-meter above the sensors.

The salinity samples collected were analyzed aboard ship on a Guildline Model 8400 Autosal N/N 43-166.

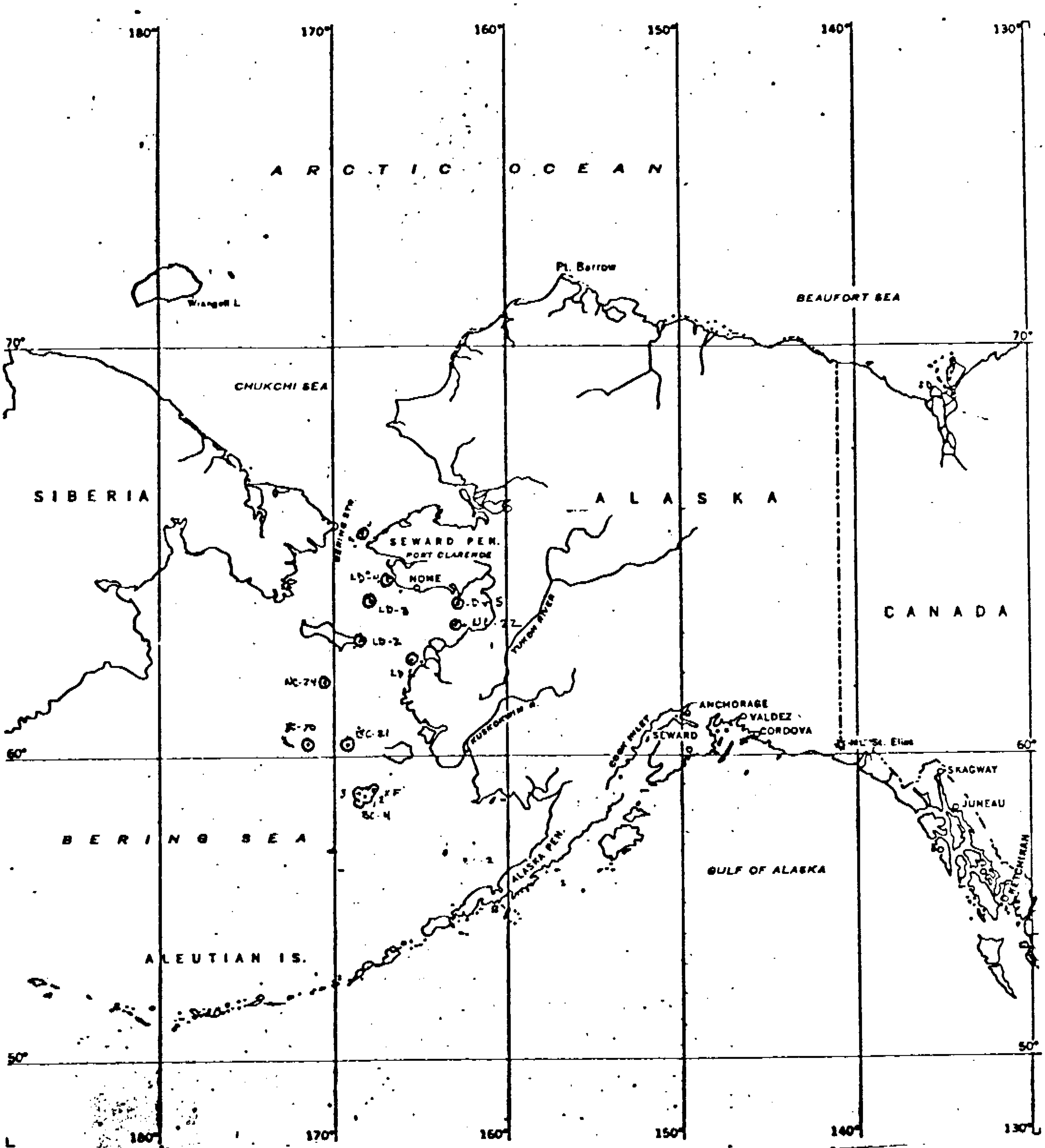
Nutrient samples were frozen and will return with the ship in November 1978. At that time they will be analyzed at the University of Washington.

XBT's utilized on this cruise were T-10 (0-200 meter) type.

4. *Personnel*

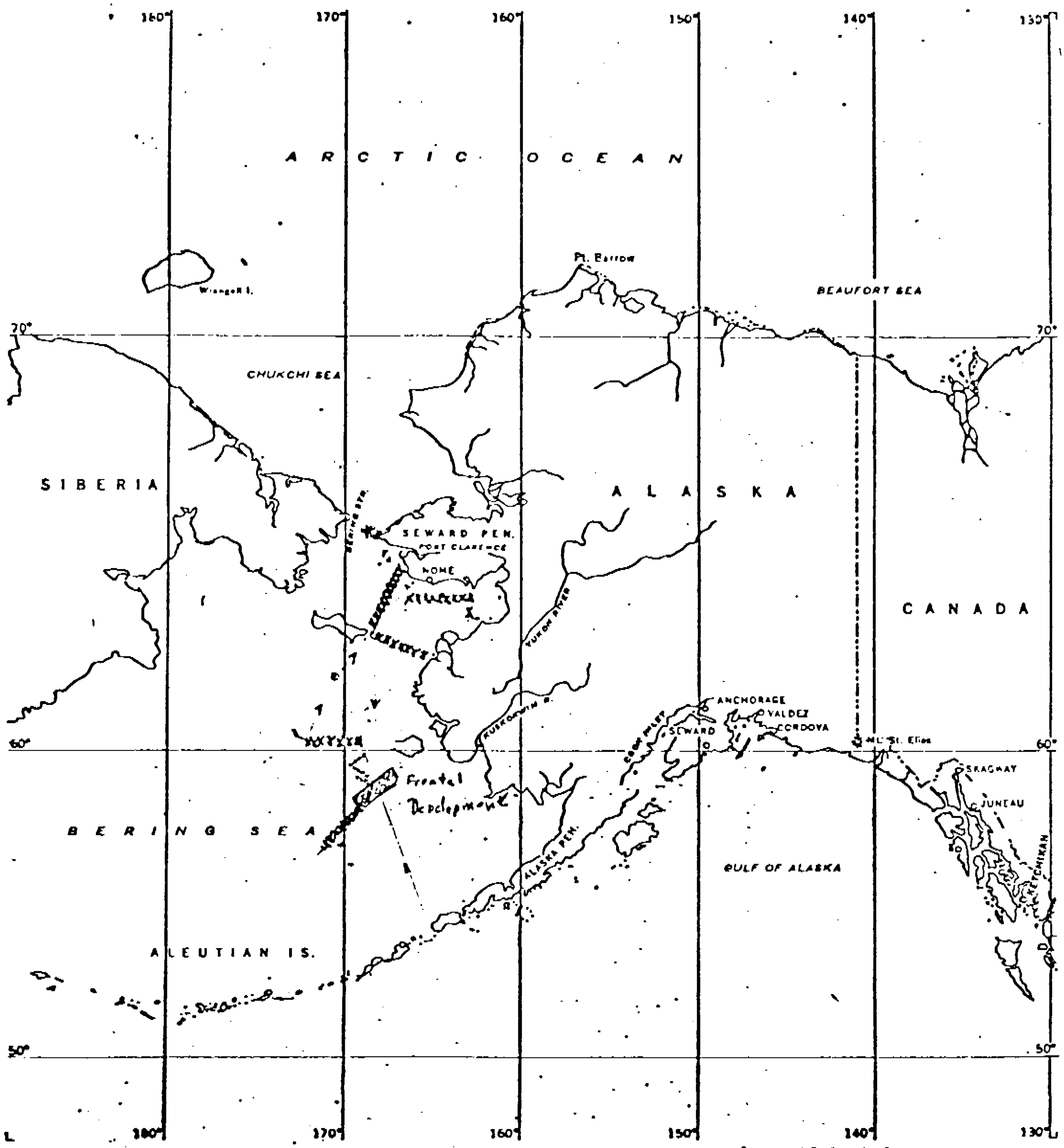
| | | |
|---|---|---|
| R. B. Tripp | Principal Oceanographer | University of Washington |
| Tore Lein-Mathison | Student | " |
| Dave Pashinski | Physical Scientist | PMEL-NOAA |
| Kristine Newby | Biologist | NMFS |
| Elizabeth Hacker | Biologist | NMFS |
| *Maura Naughton | Biologist | University of California, Irvine |
| *Bill Rodstrom | Biologist | " |
| **Ron Squibb | Biologist | " |

* Joined ship 9/22
** Joined ship 9/27




Mooring Locations RP4-DI-78B Leg III.

Figure 1.




CTD & XBT Sections RP4-DI-78B Leg III.

Figure 2.

ATTACHMENT A

C-T-D Station Summary

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 1 | BC-21B | 0629 | 13 | 60-23.4 | 169-10.7 | 37 | 42 |
| 2 | B-40 | 0755 | | 60-23.9 | 169-37.5 | 41 | 45 |
| 3 | B-41 | 0916 | | 60-23.7 | 170-06.7 | 49 | 53 |
| 4 | B-42 | 1031 | | 60-25.2 | 170-34.8 | 55 | 60 |
| 5 | BC-20B | 1200 | | 60-26.0 | 171-05.1 | 61 | 65 |
| 6 | B-43 | 1313 | | 60-25.2 | 171-30.4 | 60 | 67 |
| 7 | B-44 | 1431 | | 60-26.1 | 171-54.5 | 55 | 64 |
| 8 | B-45 | 1520 | | 60-28.8 | 172-05.9 | 53 | 67 |
| 9 | N-1 | 0843 | 14 | 63-05.9 | 168-16.9 | 35 | 40 |
| 10 | N-2 | 0957 | | 63-01.0 | 167-55.2 | 18 | 21 |
| 11 | N-3 | 1057 | | 62-54.7 | 167-35.6 | 19 | 27 |
| 12 | N-4 | 1201 | | 62-48.8 | 167-15.7 | 35 | 37 |
| 13 | N-5 | 1305 | | 62-42.7 | 166-54.9 | 27 | 32 |
| 14 | N-6 | 1436 | | 62-36.6 | 166-36.1 | 18 | 23 |
| 15 | LD-1 | 1648 | | 62-30.2 | 166-08.7 | 10 | 15 |
| 16 | LD-2 | 0024 | 15 | 63-13.0 | 168-35.0 | 25 | 28 |
| 17 | LD-3 | 0417 | | 64-00.5 | 167-59.6 | 8.2 | 12 |
| 18 | N-24 | 0819 | | 64-06.9 | 166-07.9 | 18 | 21 |
| 19 | N-25 | 0929 | | 64-06.9 | 165-41.5 | 15 | 20 |
| 20 | N-26 | 1032 | | 64-06.8 | 165-15.6 | 14 | 18 |
| 21 | N-27 | 1139 | | 64-06.7 | 164-51.2 | 14 | 18 |
| 22 | N-28 | 1247 | | 64-06.8 | 164-24.3 | 16 | 22 |
| 23 | N-29 | 1405 | | 64-07.0 | 163-55.8 | 17 | 22 |
| 24 | N-30 | 1510 | | 64-06.9 | 163-29.5 | 17 | 22 |
| 25 | LD-5 | 1634 | | 64-08.1 | 163-00.0 | 21 | 30 |
| 26 | LD-4 | 1750 | 16 | 64-47.1 | 166-49.9 | 15 | 24 |
| 27 | N-50 | 0112 | 17 | 65-38.2 | 168-14.3 | 33 | 38 |
| 28 | N-51 | 0212 | | 65-39.1 | 168-22.1 | 43 | 49 |
| 29 | N-52 | 0255 | | 65-37.9 | 168-32.8 | 45 | 53 |
| 30 | N-53 | 0332 | | 65-37.9 | 168-39.9 | 44 | 51 |
| 31 | N-54 | 0413 | | 65-38.1 | 168-50.1 | 43 | 49 |

ATTACHMENT A
(page 2)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 32 | N-55 | 0447 | | 65-38.1 | 168-57.1 | 42 | 47 |
| 33 | N-54 | 0532 | | 65-38.2 | 168-49.1 | 45 | 50 |
| 34 | N-53 | 0613 | | 65-38.4 | 168-39.4 | 44 | 49 |
| 35 | N-52 | 0650 | | 65-38.2 | 168-32.2 | 47 | 53 |
| 36 | N-51 | 0740 | | 65-38.2 | 168-22.1 | 45 | 50 |
| 37 | N-50 | 0821 | | 65-38.5 | 168-13.2 | 34 | 44 |
| 38 | N-55 | 1017 | | 65-38.5 | 168-57.8 | 37 | 45 |
| 39 | N-54 | 1052 | | 65-38.0 | 168-48.8 | 45 | 49 |
| 40 | N-53 | 1133 | | 65-38.2 | 168-39.5 | 44 | 49 |
| 41 | N-52 | 1210 | | 65-38.3 | 168-32.0 | 48 | 53 |
| 42 | N-51 | 1249 | | 65-38.7 | 168-22.5 | 44 | 51 |
| 43 | N-50 | 1331 | | 65-38.4 | 168-14.5 | 31 | 40 |
| 44 | LD-4 | 0242 | 18 | 64-46.6 | 166-49.5 | 15 | 20 |
| 45 | N-15 | 0342 | | 64-40.8 | 166-58.5 | 20 | 25 |
| 46 | N-14 | 0441 | | 64-33.1 | 167-10.6 | 22 | 27 |
| 47 | N-13 | 0551 | | 64-24.5 | 167-22.4 | 24 | 29 |
| 48 | N-12 | 0657 | | 64-16.0 | 167-35.7 | 27 | 31 |
| 49 | N-11 | 0806 | | 64-07.6 | 167-46.5 | 31 | 36 |
| 50 | LD-3 | 0910 | | 64-00.4 | 167-59.1 | | 37 |
| 51 | N-10 | 1018 | | 63-53.1 | 168-09.2 | 30 | 34 |
| 52 | N-9 | 1125 | | 63-45.0 | 168-21.7 | 30 | 33 |
| 53 | N-8 | 1241 | | 63-36.0 | 168-34.4 | 28 | 33 |
| 54 | N-7 | 1349 | | 63-28.4 | 168-49.0 | | 27 |
| 55 | F-15 | 1228 | 19 | 58-55.7 | 167-53.2 | 38 | 42 |
| 56 | F-16 | 1310 | | 58-52.7 | 167-58.2 | 37 | 42 |
| 57 | F-17 | 1354 | | 58-49.5 | 168-04.2 | 37 | 43 |
| 58 | F-18 | 1441 | | 58-45.8 | 168-09.8 | 39 | 47 |
| 59 | F-19 | 1523 | | 58-42.8 | 168-15.3 | 45 | 49 |
| 60 | F-20 | 1617 | | 58-39.1 | 168-21.0 | 47 | 52 |
| 61 | F-21 | 1704 | | 58-35.9 | 168-26.3 | 50 | 54 |
| 62 | F-15 | 1945 | | 58-35.8 | 167-52.1 | 38 | 42 |

ATTACHMENT A
(page 3)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 63 | F-16 | 2032 | | 58-52.9 | 167-58.2 | 39 | 42 |
| 64 | F-17 | 2115 | | 58-49.4 | 168-02.9 | 39 | 43 |
| 65 | F-18 | 2206 | | 58-45.3 | 168-08.8 | 42 | 45 |
| 66 | F-19 | 2256 | | 58-42.2 | 168-14.5 | 45 | 49 |
| 67 | F-20 | 2351 | | 58-38.7 | 168-21.2 | 47 | 51 |
| 68 | F-21 | 0031 | 20 | 58-35.7 | 168-26.4 | 50 | 54 |
| 69 | F-15 | 0327 | | 58-56.0 | 167-52.7 | 33 | 42 |
| 70 | F-16 | 0420 | | 58-52.8 | 167-57.9 | 35 | 42 |
| 71 | F-17 | 0507 | | 58-49.2 | 168-03.5 | 39 | 44 |
| 72 | F-18 | 0606 | | 58-45.8 | 168-09.5 | 42 | 47 |
| 73 | F-19 | 0652 | | 58-42.7 | 168-15.0 | 44 | 49 |
| 74 | F-20 | 0755 | | 58-39.3 | 168-21.1 | 46 | 51 |
| 75 | FX-2A | 0136 | 21 | 58-51.6 | 167-58.6 | 33 | 40 |
| 76 | B-58 | 2251 | | 58-29.4 | 168-35.1 | 57 | 62 |
| 77 | B-59 | 0002 | 22 | 58-23.3 | 168-48.5 | 58 | 64 |
| 78 | B-60 | 0113 | | 58-15.9 | 169-01.2 | 61 | 65 |
| 79 | B-61 | 0227 | | 58-08.8 | 169-15.5 | 61 | 67 |
| 80 | B-62 | 0344 | | 58-01.3 | 169-27.2 | 63 | 67 |
| 81 | B-63 | 0456 | | 57-54.0 | 169-41.9 | 63 | 69 |
| 82 | B-64 | 0607 | | 57-46.7 | 169-54.5 | 64 | 70 |
| 83 | B-65 | 0720 | | 57-39.4 | 170-07.5 | | 71 |
| 84 | B-66 | 0833 | | 57-32.0 | 170-19.4 | 65 | 70 |
| 85 | B-67 | 0945 | | 57-25.0 | 170-32.9 | 65 | 69 |
| 86 | B-68 | 1059 | | 57-17.4 | 170-46.3 | 73 | 78 |
| 87 | B-69 | 1210 | | 57-10.0 | 170-59.9 | 82 | 87 |
| 88 | P-1 | 2317 | | 57-05.9 | 168-59.3 | 72 | 77 |
| 89 | P-2 | 0232 | 23 | 56-34.2 | 169-24.8 | 57 | 66 |
| 90 | P-3 | 0536 | | 56-35.3 | 168-29.6 | 105 | 109 |
| 91 | P-4 | 1645 | | 57-09.9 | 170-04.6 | 26 | 29 |
| 92 | P-5 | 1852 | | 57-09.4 | 169-29.2 | 62 | 69 |
| 93 | P-6 | 2116 | | 57-34.8 | 168-30.9 | 64 | 71 |

ATTACHMENT A
(page 4)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 94 | P-7 | 0020 | 24 | 57-17.2 | 170-10.6 | 31 | 36 |
| 95 | P-8 | 0125 | | 57-14.4 | 170-25.3 | 43 | 51 |
| 96 | P-9 | 0510 | | 57-48.4 | 170-26.4 | 64 | 71 |
| 97 | P-10 | 0801 | | 57-32.0 | 170-25.6 | | 72 |
| 98 | P-11 | 2348 | | 57-12.5 | 170-28.4 | 54 | 60 |
| 99 | P-12 | 0512 | 25 | 57-12.7 | 172-05.4 | 104 | 108 |
| 100 | P-13 | 0944 | | 56-47.5 | 171-10.1 | 107 | 111 |
| 101 | P-14 | 1238 | | 57-05.8 | 170-27.2 | 40 | 45 |
| 102 | P-15 | 1938 | | 56-38.9 | 170-28.5 | 106 | 107 |
| 103 | P-16 | 2257 | | 56-39.3 | 169-25.3 | 58 | 64 |
| 104 | P-17 | 0424 | 26 | 55-39.5 | 169-26.2 | 289 | 2505 |
| 105 | P-18 | 0751 | | 56-05.7 | 169-27.2 | 235 | 240 |
| 106 | P-19 | 1143 | | 56-12.3 | 170-24.4 | 116 | 119 |
| 107 | P-20 | 1510 | | 55-49.7 | 170-54.7 | 502 | 2500 |
| 108 | P-21 | 2201 | | 56-38.0 | 169-52.4 | 78 | 82 |
| 109 | P-22 | 0507 | 27 | 55-59.5 | 168-51.4 | 500 | 914 |

ATTACHMENT B

XBT Station Summary

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 1 | 1252 | 19 | 58-54.7 | 167-54.8 | 42 |
| 2 | 1258 | | 58-53.8 | 167-56.0 | 42 |
| 3 | 1333 | | 58-51.6 | 168-00.2 | 43 |
| 4 | 1340 | | 58-50.6 | 168-01.7 | 43 |
| 5 | 1421 | | 58-48.1 | 168-06.3 | 45 |
| 6 | 1429 | | 58-47.0 | 168-07.7 | 46 |
| 7 | 1502 | | 58-44.9 | 168-11.3 | 47 |
| 8 | 1513 | | 58-43.5 | 168-13.5 | 48 |
| 9 | 1554 | | 58-41.6 | 168-17.2 | 49 |
| 10 | 1605 | | 58-40.2 | 168-19.2 | 51 |
| 11 | 1641 | | 58-38.1 | 168-22.2 | 53 |
| 12 | 1650 | | 58-37.0 | 168-23.9 | 54 |
| 13 | 2011 | | 58-54.5 | 167-54.1 | 42 |
| 14 | 2019 | | 58-53.6 | 167-55.7 | 42 |
| 15 | 2056 | | 58-51.5 | 168-00.0 | 44 |
| 16 | 2105 | | 58-50.3 | 168-01.6 | 44 |
| 17 | 2143 | | 58-47.8 | 168-04.9 | 46 |
| 18 | 2153 | | 58-46.5 | 168-06.8 | 46 |
| 19 | 2229 | | 58-44.2 | 168-11.1 | 47 |
| 20 | 2236 | | 58-43.3 | 168-12.6 | 48 |
| 21 | 2330 | | 58-40.9 | 168-16.6 | 50 |
| 22 | 2335 | | 58-39.9 | 168-18.6 | 51 |
| 23 | 0014 | 20 | 58-37.3 | 168-23.3 | 53 |
| 24 | 0018 | | 58-36.8 | 168-24.2 | 53 |
| 25 | 0355 | | 58-55.0 | 167.54.4 | 42 |
| 26 | 0402 | | 58-54.0 | 167-55.7 | 42 |
| 27 | 0440 | | 58-51.7 | 167-59.5 | 42 |
| 28 | 0450 | | 58-50.4 | 168-01.3 | 44 |
| 29 | 0539 | | 58-47.7 | 168-05.0 | 46 |
| 30 | 0550 | | 58-46.6 | 168-07.3 | 46 |
| 31 | 0629 | | 58-44.8 | 168-11.2 | 49 |
| 32 | 0638 | | 58-43.7 | 168-12.9 | 49 |
| 33 | 0726 | | 58-41.9 | 168-16.3 | 50 |

ATTACHMENT B
(page 2)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 34 | 0740 | | 58-40.3 | 168-19.1 | 52 |
| 35 | 0828 | | 58-38.3 | 168-22.7 | 53 |
| 36 | 0837 | | 58-37.0 | 168-24.5 | 55 |
| 37 | 0848 | | 58-35.7 | 168-26.4 | 55 |
| 38 | 1230 | | 58-55.8 | 167-52.6 | 41 |
| 39 | 1241 | | 58-55.4 | 167-54.1 | 42 |
| 40 | 1254 | | 58-53.7 | 167-56.9 | 42 |
| 41 | 1259 | | 58-43.0 | 167-58.1 | 42 |
| 42 | 1308 | | 58-51.8 | 168-00.0 | 43 |
| 43 | 1317 | | 58-50.6 | 168-01.9 | 44 |
| 44 | 1326 | | 58-49.4 | 168-03.9 | 44 |
| 45 | 1336 | | 58-48.0 | 168-06.5 | 45 |
| 46 | 1344 | | 58-47.1 | 168-07.9 | 45 |
| 47 | 1353 | | 58-45.9 | 168-09.9 | 45 |
| 48 | 1401 | | 58-44.9 | 168-11.2 | 46 |
| 49 | 1410 | | 58-43.8 | 168-13.2 | 48 |
| 50 | 1419 | | 58-42.6 | 168-15.8 | 48 |
| 51 | 1427 | | 58-41.6 | 168-17.3 | 49 |
| 52 | 1435 | | 58-40.5 | 168-19.3 | 50 |
| 53 | 1443 | | 58-39.5 | 168-20.9 | 50 |
| 54 | 1452 | | 58-38.3 | 168-22.7 | 51 |
| 55 | 1502 | | 58-36.9 | 168-24.9 | 53 |
| 56 | 1510 | | 58-35.9 | 168-26.4 | 55 |
| 57 | 0231 | 21 | 58-52.4 | 168-07.6 | 44 |
| 58 | 0308 | | 58-53.4 | 168-16.5 | 45 |
| 59 | 0343 | | 58-54.3 | 168-26.1 | 46 |
| 60 | 0417 | | 58-55.3 | 168-35.4 | 47 |
| 61 | 0450 | | 58-56.1 | 168-43.2 | 49 |
| 62 | 0526 | | 58-57.2 | 168-52.8 | 51 |
| 63 | 0603 | | 59-01.7 | 168-49.9 | 49 |
| 64 | 0644 | | 59-04.9 | 168-56.8 | 48 |

ATTACHMENT B
(page 3)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 65 | 0729 | | 59-08.0 | 169-05.3 | 50 |
| 66 | 0812 | | 59-10.4 | 169-12.8 | |
| 67 | 0906 | | 59-14.3 | 169-21.2 | 53 |
| 68 | 0954 | | 59-17.1 | 169-28.1 | 55 |
| 69 | 1028 | | 59-19.5 | 169-28.2 | 55 |
| 70 | 1108 | | 59-22.8 | 169-20.8 | 51 |
| 71 | 1141 | | 59-25.9 | 169-15.8 | 49 |
| 72 | 1232 | | 59-30.9 | 169-10.3 | 47 |
| 73 | 1314 | | 59-35.1 | 169-05.8 | 44 |
| 74 | 1719 | 23 | 57-09.6 | 170-01.5 | 35 |
| 75 | 1724 | | 57-09.4 | 170-00.2 | 49 |
| 76 | 1730 | | 57-09.1 | 169-57.6 | 45 |
| 77 | 1736 | | 57-09.1 | 169-55.8 | 53 |
| 78 | 1742 | | 57-09.2 | 169-53.9 | 53 |
| 79 | 1751 | | 57-09.4 | 169-50.9 | 53 |
| 80 | 1758 | | 57-09.4 | 169-48.3 | 55 |
| 81 | 1805 | | 57-09.5 | 169-45.9 | 52 |
| 82 | 1810 | | 57-09.5 | 169-44.1 | 52 |
| 83 | 1816 | | 57-09.5 | 169-41.9 | 51 |
| 84 | 1828 | | 57-09.5 | 169-37.6 | 50 |
| 85 | 1840 | | 57-09.5 | 169-33.2 | 60 |
| 86 | 2150 | | 57-34.1 | 169-33.6 | 72 |
| 87 | 2206 | | 57-32.4 | 169-37.8 | 71 |
| 88 | 2225 | | 57-30.2 | 169-42.8 | 71 |
| 89 | 2233 | | 57-29.3 | 169-44.8 | 69 |
| 90 | 2248 | | 57-27.8 | 168-48.6 | 66 |
| 91 | 2304 | | 57-25.9 | 169-52.9 | 66 |
| 92 | 2310 | | 57-25.2 | 169-54.5 | 64 |
| 93 | 2316 | | 57-24.6 | 169-56.1 | 62 |
| 94 | 2322 | | 57-23.9 | 169-57.7 | 64 |
| 95 | 2330 | | 57-22.4 | 169-59.7 | 64 |

ATTACHMENT B
(page 4)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 96 | 2336 | | 57-22.3 | 170-01.2 | 62 |
| 97 | 2343 | | 57-21.5 | 170-02.8 | 59 |
| 98 | 2348 | | 57-20.8 | 170-04.2 | 57 |
| 99 | 2354 | | 57-20.1 | 170-05.7 | 53 |
| 100 | 0000 | 24 | 57-19.3 | 170-07.3 | 55 |
| 101 | 0006 | | 57-18.7 | 170-08.8 | 51 |
| 102 | 0012 | | 57-18.0 | 170-10.3 | 49 |
| 103 | 0213 | | 57-15.4 | 170-25.4 | 56 |
| 104 | 0224 | | 57-17.6 | 170-25.4 | 64 |
| 105 | 0236 | | 57-20.0 | 170-25.3 | 68 |
| 106 | 0240 | | 57-28.0 | 170-25.3 | 68 |
| 107 | 0248 | | 57-22.3 | 170-25.2 | 68 |
| 108 | 0256 | | 57-23.9 | 170-25.2 | 68 |
| 109 | 0300 | | 57-24.6 | 170-25.2 | 68 |
| 110 | 0308 | | 57-26.1 | 170-25.2 | 68 |
| 111 | 0315 | | 57-27.5 | 170-25.3 | 68 |
| 112 | 0330 | | 57-30.5 | 170-25.4 | 71 |
| 113 | 0342 | | 57-32.4 | 170-25.5 | 71 |
| 114 | 0353 | | 57-34.9 | 170-25.6 | 71 |
| 115 | 0405 | | 57-37.5 | 170-25.6 | 71 |
| 116 | 0420 | | 57-40.3 | 170-25.6 | 73 |
| 117 | 0433 | | 57-42.8 | 170-25.8 | 73 |
| 118 | 0450 | | 57-46.1 | 170-25.8 | 75 |
| 119 | 0010 | 25 | 57-12.7 | 170-31.1 | 59 |
| 120 | 0017 | | 57-12.8 | 170-33.3 | 59 |
| 121 | 0025 | | 57-12.9 | 170-35.8 | 62 |
| 122 | 0034 | | 57-12.9 | 170-38.6 | 68 |
| 123 | 0042 | | 57-13.1 | 170-41.2 | 78 |
| 124 | 0050 | | 57-13.2 | 170-43.6 | 79 |
| 125 | 0058 | | 57-13.2 | 170-46.1 | 79 |
| 126 | 0106 | | 57-13.2 | 170-48.3 | 79 |
| 127 | 0115 | | 57-13.3 | 170-51.3 | 81 |

ATTACHMENT B
(page 5)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 128 | 0124 | | 57-13.2 | 170-54.1 | 84 |
| 129 | 0140 | | 57-13.2 | 170-59.3 | 89 |
| 130 | 0153 | | 57-13.1 | 171-03.2 | 91 |
| 131 | 0210 | | 57-13.1 | 171-08.7 | 93 |
| 132 | 0228 | | 57-13.0 | 171-13.8 | 99 |
| 133 | 0240 | | 57-12.9 | 171-18.4 | 100 |
| 134 | 0310 | | 57-13.0 | 171-28.3 | 102 |
| 135 | 0340 | | 57-12.9 | 171-38.1 | 104 |
| 136 | 0410 | | 57-12.8 | 171-48.0 | 107 |
| 137 | 0440 | | 57-12.7 | 171-58.0 | 107 |
| 138 | 1014 | | 56-48.9 | 171-06.3 | 116 |
| 139 | 1028 | | 56-50.6 | 171-02.4 | 112 |
| 140 | 1042 | | 56-52.4 | 170-58.5 | 108 |
| 141 | 1054 | | 56-53.9 | 170-55.1 | 106 |
| 142 | 1106 | | 56-55.5 | 170-51.7 | 104 |
| 143 | 1118 | | 56-56.0 | 170-48.4 | 102 |
| 144 | 1124 | | 56-57.7 | 170-46.7 | 100 |
| 145 | 1132 | | 56-58.8 | 170-44.5 | 95 |
| 146 | 1140 | | 56-59.8 | 170-42.3 | 91 |
| 147 | 1148 | | 57-00.8 | 170-40.2 | 88 |
| 148 | 1156 | | 57-01.8 | 170-37.8 | 82 |
| 149 | 1202 | | 57-02.4 | 170-36.0 | 80 |
| 150 | 1208 | | 57-03.1 | 170-34.2 | 77 |
| 151 | 1214 | | 57-03.8 | 170-32.3 | 77 |
| 152 | 1220 | | 57-04.6 | 170-30.7 | 73 |
| 153 | 1226 | | 57-05.3 | 170-29.0 | 55 |
| 154 | 1740 | 26 | 55-55.0 | 170-46.7 | 2500 |
| 155 | 1810 | | 55-58.3 | 170-43.0 | 2500 |
| 156 | 1820 | | 56-01.3 | 170-39.3 | 1800 |
| 157 | 1833 | | 56-03.3 | 170-36.7 | 1800 |
| 158 | 1900 | | 56-07.5 | 170-30.8 | 144 |
| 159 | 1925 | | 56-11.8 | 170-25.7 | 121 |

ATTACHMENT B
(page 6)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 160 | 1938 | | 56-13.8 | 170-22.8 | 118 |
| 161 | 1949 | | 56-15.6 | 170-20.1 | 115 |
| 162 | 2000 | | 56-17.4 | 170-17.5 | 112 |
| 163 | 2012 | | 56-19.4 | 170-15.0 | 112 |
| 164 | 2025 | | 56-21.8 | 170-12.7 | 111 |
| 165 | 2034 | | 56-23.5 | 170-11.1 | 110 |
| 166 | 2040 | | 56-24.6 | 170-10.0 | 109 |
| 167 | 2046 | | 56-25.6 | 170-08.9 | 108 |
| 168 | 2052 | | 56-26.7 | 170-07.8 | 109 |
| 169 | 2100 | | 56-28.2 | 170-06.2 | 106 |
| 170 | 2108 | | 56-29.3 | 170-05.0 | 104 |
| 171 | 2112 | | 56-30.3 | 170-04.1 | 104 |
| 172 | 2120 | | 56-31.7 | 170-02.6 | 100 |
| 173 | 2126 | | 56-32.8 | 170-01.4 | 99 |
| 174 | 2134 | | 56-34.0 | 169-59.9 | 97 |
| 175 | 2140 | | 56-35.0 | 169-58.0 | 97 |
| 176 | 2146 | | 56-35.9 | 169-56.4 | 95 |
| 177 | 2152 | | 56-36.9 | 169-54.7 | 91 |
| 178 | 0100 | 27 | 56-35.6 | 169-51.6 | 86 |
| 179 | 0106 | | 56-34.7 | 169-50.0 | 86 |
| 180 | 0113 | | 56-33.7 | 169-48.3 | 82 |
| 181 | 0120 | | 56-32.7 | 169-46.6 | 78 |
| 182 | 0127 | | 56-31.8 | 169-45.2 | 80 |
| 183 | 0133 | | 56-30.7 | 169-43.5 | 81 |
| 184 | 0140 | | 56-29.7 | 169-41.9 | 84 |
| 185 | 0147 | | 56-28.7 | 169-40.2 | 86 |
| 186 | 0153 | | 56-27.8 | 169-38.6 | 88 |
| 187 | 0200 | | 56-26.7 | 169-36.9 | 93 |
| 188 | 0206 | | 56-25.9 | 169-35.3 | 99 |
| 189 | 0218 | | 56-24.1 | 169-32.5 | 116 |
| 190 | 0230 | | 56-22.3 | 169-29.5 | 129 |
| 191 | 0242 | | 56-20.5 | 169-26.5 | 140 |

ATTACHMENT B
(page 7)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 192 | 0254 | | 56-18.7 | 169-23.8 | 173 |
| 193 | 0306 | | 56-16.9 | 169-20.7 | 219 |
| 194 | 0318 | | 56-15.2 | 169-17.6 | 194 |
| 195 | 0330 | | 56-13.5 | 169-14.5 | 262 |
| 196 | 0400 | | 56-09.1 | 169-06.8 | 440 |
| 197 | 0430 | | 56-04.4 | 168-59.3 | 580 |
| 198 | 0500 | | 55-59.7 | 168-52.1 | 988 |

ATTACHMENT C

Nutrient Sample Summary

| CTD Cast No. | Ref. No. | Sample No. (depth) | Sample No. (depth) | CTD Cast No. | Ref. No. | Sample No. (depth) | Sample No. (depth) |
|---|---|---|---|---|---|---|---|
| 55 | F-15 | FR-1 (38) | FR-2 (Sfc) | 94 | P-7 | 53 (31) | 54 (10) |
| 56 | F-16 | 3 (37) | 4 (Sfc) | 95 | P-8 | 55 (43) | 56 (30) |
| 57 | F-17 | 5 (37) | 6 (Sfc) | | | 57 (20) | 58 (15) |
| 58 | F-18 | 7 (39) | 8 (Sfc) | | | 59 (10) | 60 (5) |
| 59 | F-19 | 9 (45) | 10 (Sfc) | 96 | P-9 | 61 (64) | 62 (55) |
| 60 | F-20 | 11 (47) | 12 (Sfc) | | | 63 (45) | 64 (30) |
| 61 | F-21 | 13 (50) | 14 (Sfc) | | | 65 (20) | 66 (15) |
| 62 | F-15 | 15 (38) | 16 (Sfc) | | | 67 (10) | 68 (5) |
| 63 | F-16 | 17 (39) | 18 (Sfc) | 97 | P-10 | 69 (67) | 70 (10) |
| 64 | F-17 | 19 (39) | 20 (Sfc) | 98 | P-11 | 71 (54) | 72 (10) |
| 65 | F-18 | 21 (42) | 22 (Sfc) | 99 | P-12 | 73 (104) | 74 (10) |
| 66 | F-19 | 23 (45) | 24 (Sfc) | 100 | P-13 | 75 (107) | 76 (10) |
| 67 | F-20 | 25 (47) | 26 (Sfc) | 101 | P-14 | 77 (40) | 78 (10) |
| 68 | F-21 | 27 (50) | 28 (Sfc) | 102 | P-15 | 79 (106) | 80 (10) |
| 69 | F-15 | 29 (33) | 30 (Sfc) | 103 | P-16 | 81 (58) | 82 (10) |
| 70 | F-16 | 31 (35) | 32 (Sfc) | 104 | P-17 | 83 (289) | 84 (10) |
| 71 | F-17 | 33 (39) | 34 (Sfc) | 105 | P-18 | 85 (213) | 86 (10) |
| 72 | F-18 | 35 (42) | 36 (Sfc) | 106 | P-19 | 87 (116) | 88 (10) |
| 73 | F-19 | 37 (44) | 38 (Sfc) | 107 | P-20 | 89 (502) | 90 (10) |
| 74 | F-20 | 39 (46) | 40 (Sfc) | 108 | P-21 | 91 (79) | 92 (10) |
| 88 | P-1 | FR-41 (68) | FR-42 (10) | 109 | P-22 | 93 (500) | 94 (10) |
| 89 | P-2 | 43 (57) | 44 (10) | | | | |
| 90 | P-3 | 45 (105) | 46 (10) | | | | |
| 91 | P-4 | 47 (26) | 48 (10) | | | | |
| 92 | P-5 | 49 (62) | 50 (10) | | | | |
| 93 | P-6 | 51 (64) | 52 (10) | | | | |

Quarterly Report

Research Unit # 208
Reporting Period 7/1/78-9/30/78
Number of pages:

# Yukon Delta Coastal Processes Study

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

9/29/78

QUARTERLY REPORT

I. Task Objectives

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

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

2) Study the hydrology and sediment input of the Yukon and Kuskokwim Rivers as they largely determine the sediment budget of the northern Bering Sea. (Task B-11, B2).

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

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

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

II. Field and Laboratory Activities

A. Field trip schedule: July 15-August 2, 1978

B. Scientific Party:

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

2) Dr. Henry S. Chafetz - Department of Geology, University of Houston

3) John Klein - Department of Geology, University of Houston

4) Jerry Wagstaff - Department of Geology, University of Houston

5) Dr. Thomas Ager - U.S. Geological Survey, Reston, Virginia

C. Methods

1) Field Studies:

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

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

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

d) Core volcanic lake sediments for pollen and ash analysis.

e) Core selected areas to study peat formation in delta plain.

2) Laboratory Studies:

a) Radiocarbon dates completed by University of Texas Radiocarbon Lab.

b) Textural and mineralogic analysis of sediments (in progress).

c) Pollen and peat analysis (in progress).

D. Sample localities

(see figure 1)

E. Data collected or analysed

1) Number and types of samples/observations

a) Short cores for textural and mineralogical analysis - 60

b) Grab samples for textural analysis - 40

c) Grab samples for possible radiocarbon dating - 16

d) Grab samples for pollen analysis - 9

e) Vegetation assemblages - 40 (approximately)

f) Beach profiles and associated process measurements - 25

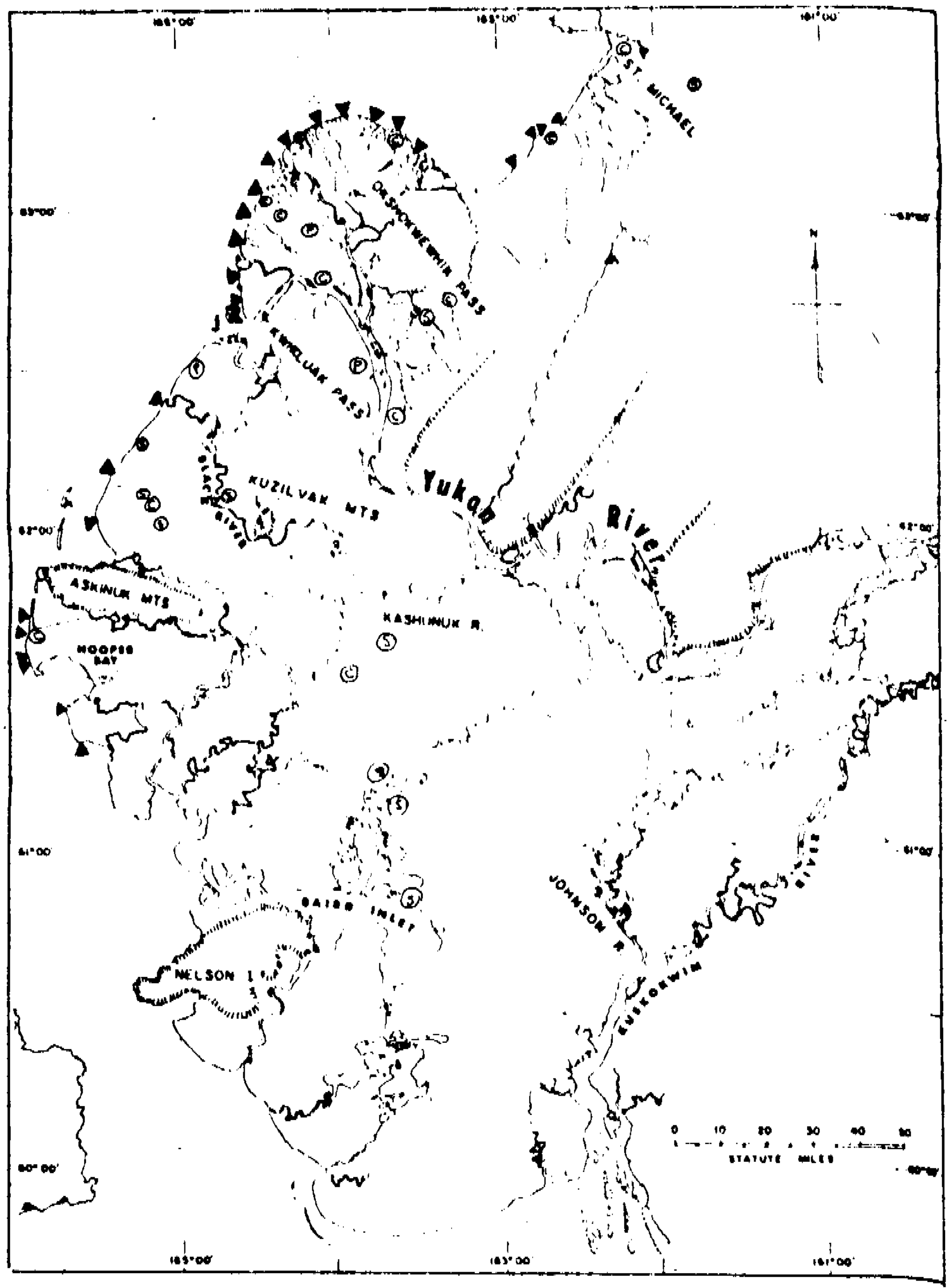



Figure 1: Location of sample localities

Ⓟ pollen sample

Ⓒ short cores (20 cm - 3m)

Ⓢ radiocarbon or textural sample

▼ coastal station:

includes beach profiling, sediment sampling, waves and salinity measurements.

III. Results and interpretation

None of the field data has been studied as preparations are presently being made to spend January to August in Menlo Park completing the final report. A preliminary study of ice movement in Norton Sound has been finished using Landsat imagery, and will be included in the annual report. In addition radiocarbon dates from samples collected last year have just been completed, and suggest that the rate of ice-wedge formation in the northern part of the delta region is <u>much</u> faster than previously expected. Ice wedges up to a meter in width formed during the interval between approximately 5,000 B.P. and 3,300 B.P. Smaller ice wedges are forming today.

IV. Problems encountered/Recommended solutions

The only serious problem encountered this quarter was the inability to re-locate a number of markers set up along the coast last year. In some cases they were removed by erosion or local fishermen; others were obscured by tall coastal grass. Some of the metal stakes were completely flattened by ice, suggesing that ice movement constitutes a significant geologic hazard, even hundreds of meters inland from the coast.

Other less serious problems involved the lack of fuel available and a limit on the number of hours available on the helicopter, thereby limiting the work to the northern part of the study area.

# QUARTERLY REPORT

Research Unit: #217
Reporting Period:
1 April - 30 September 1978

Principal Investigator: D. V. Hansen

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

10 October 1978

I. Objective: To obtain and interpret Lagrangian surface current data in the Gulf of Alaska and S.E. Bering Sea areas.

II. Activities: During this period, two deployments of five buoys each were made from OCSEAP vessels in the Gulf of Alaska, Kodiak region. Buoy deployment days were as follows:

Buoy I.D. 1473 deployed 23 May
Buoy I.D. 1775 deployed 23 May
Buoy I.D. 1450 deployed 23 May
Buoy I.D. 1466 deployed 26 May
Buoy I.D. 1421 deployed 27 May
Buoy I.D. 1203 deployed 24 July
Buoy I.D. 1161 deployed 24 July
Buoy I.D. 1157 deployed 24 July
Buoy I.D. 1142 deployed 24 July
Buoy I.D. 1220 deployed 24 July

These buoys were deployed at the locations shown in Figure 1, and have been tracked through the NIMBUS-6/RAMS system through the Summer. Four are still being received at the end of the reporting period.

III. Results:

Only preliminary results can be reported at this time due to delays in receipt of data from NASA resulting from transition to a new data service contractor, and some impacts of testing the NIMBUS-G satellite which will be orbitted in the near future. Such results as are available are summarized in Figures 1 to 9. The five buoys deployed in May were all refurbished and repowered hulls relict from prior operations. Some were believed to be relatively unseaworthy, and none had drogue loss sensors. Buoy I.D. 1473 (Figure 1), deployed east of Kennedy Entrance initially moved toward the entrance, then moved southward, passing east of Afognak Island, to ground on Cape Chiniak after about five weeks. Buoy 1775 (Figure 2), deployed about 100 km NW of 1473 passed through the Kennedy Entrance to describe a primarily cyclonic eddy motion in lower Cook Inlet, ultimately moving SW through the Shelikof Strait, to terminate transmission about 100 km SW of Kodiak Island after nearly three months. Buoy 1450, deployed between 1775 and 1473 (Figure 3), initially moved toward the Kennedy Entrance, but ceased transmission after less than a week. Buoys 1421 (Figure 4) and 1466 (Figure 5) were deployed south of the others, generally about 150 and 200 km east of Afognak and Kodiak Islands respectively. Both entered northern Shelikof Strait through the Kennedy Entrance. Buoy 1466 grounded on northern Kodiak Island after only 10 days, and 1421 grounded and is still transmitting from Cape Douglas after eddying around in lower Cook Inlet for a substantially greater length of time.

Overall, the buoys deployed in May exhibited a systematic pattern of cyclonic movement and flow into the Kennedy Entrance, and westward in the Shelikof Strait.

The buoys deployed in late July were of the newer PRL design and all contained drogue loss sensors. The telemetry indicates that drogue survival has been good. Buoy 1161, deployed close off Pye Island, grounded there almost immediately (Figure 6), and is still transmitting from its grounded location. Buoy 1203 was received for only about two days, with inconclusive results. Buoy 1142 (Figure 7), deployed west of Kennedy Entrance has moved westward, but at speeds on the order of 1-2 km/day and may still be functioning. Buoy 1157, deployed only a few miles southwast of 1142, has moved steadily to the southwest at speeds of about 10 km/day (Figure 8), and is being received from several miles southeast of Kodiak Island at the end of the reporting period. Buoy 1220 was deployed farthest offshore of the July group, and appears to have been deployed directly in the Alaska Stream, for it has been moving consistently southwestward, parallel to the Alaska Peninsula at speeds of 20-40 km/day (Figure 9). Overall, the buoys deployed in July behaved significantly differently from those deployed in May. In August, the flow within 100 km SE of the Kenai Peninsula appeared to be remarkably sluggish, and farther offshore an apparently rather smooth transition was made to mean current approaching one knot in the Alaska Stream.

IV. Interpretation of Results: None at this time.

V. Problems: During the latter part of the period and currently, this research unit has been troubled by the conditions that must be accepted as part of the price of participation in an experimental satellite project. Unavoidable delays of over a month have been occasioned by a change of data service contractor at GSFC. This data backlog has now been caught up with no lasting impact on the project. More serious problems are associated with system tests of the NIMBUS-G satellite scheduled for launch in late October. The NIMBUS-6 RAMS used for this research unit will be put into a dormant mode for about 10-15 days around the launch time for NIMBUS-G. There is also a problem peculiar to the Alaska area that is impacting the project. NIMBUS-G system testing is interrupting data transmission from buoys within the direct readout range of the Alaska receiving station. Because of these problems, it has been decided to defer launching of further buoys until the January cruise of the NOAA SURVEYOR, by which time these difficulties are expected to have passed.

VI. Estimate of funds expended: FY 1978 funding was expended as planned. This research unit is <u>not</u> funded in FY 1979.

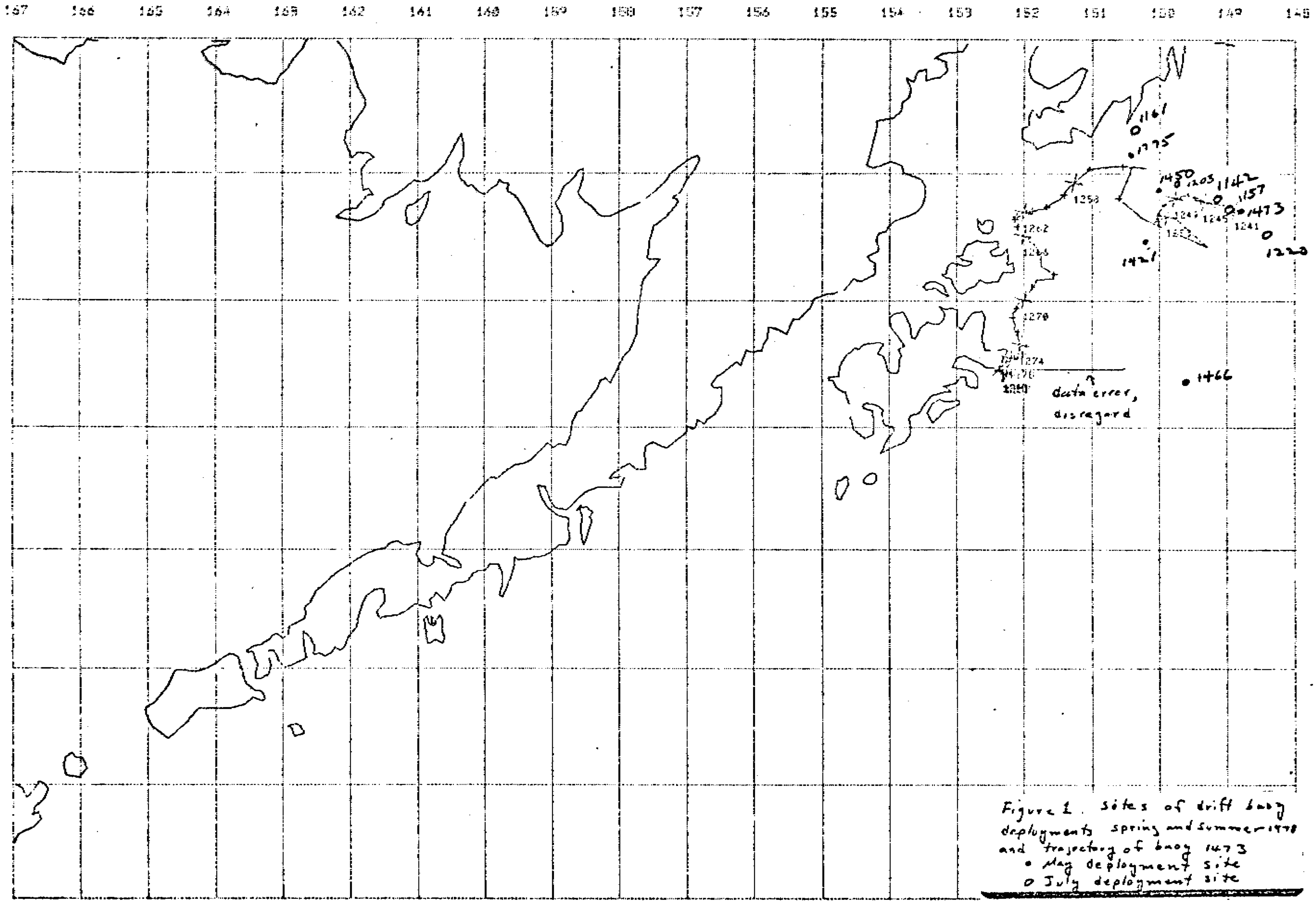



Figure 1. Sites of drift buoy deployments spring and summer 1978 and trajectory of buoy 1473
• May deployment site
o July deployment site

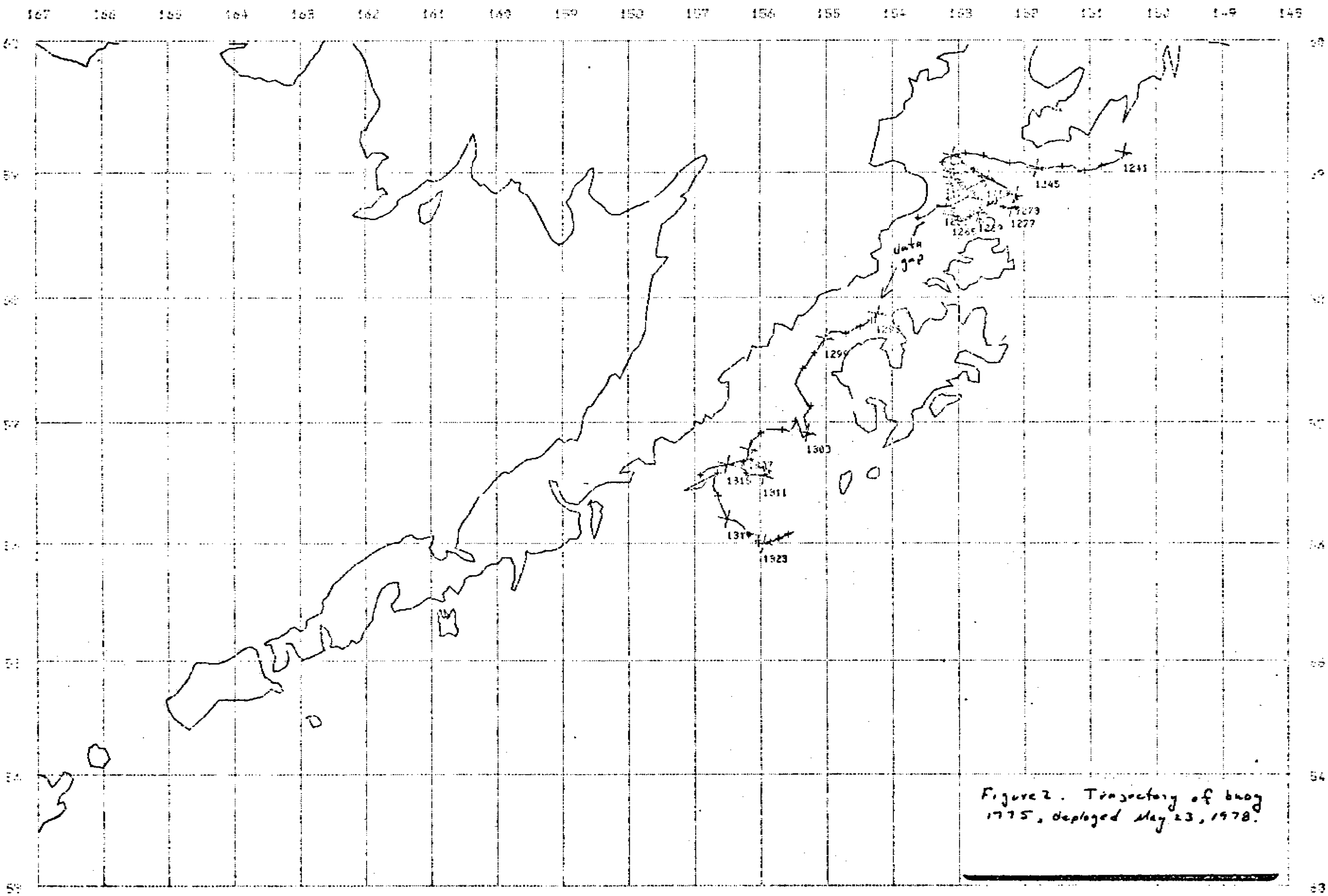



Figure 2. Trajectory of buoy 1775, deployed May 23, 1978.

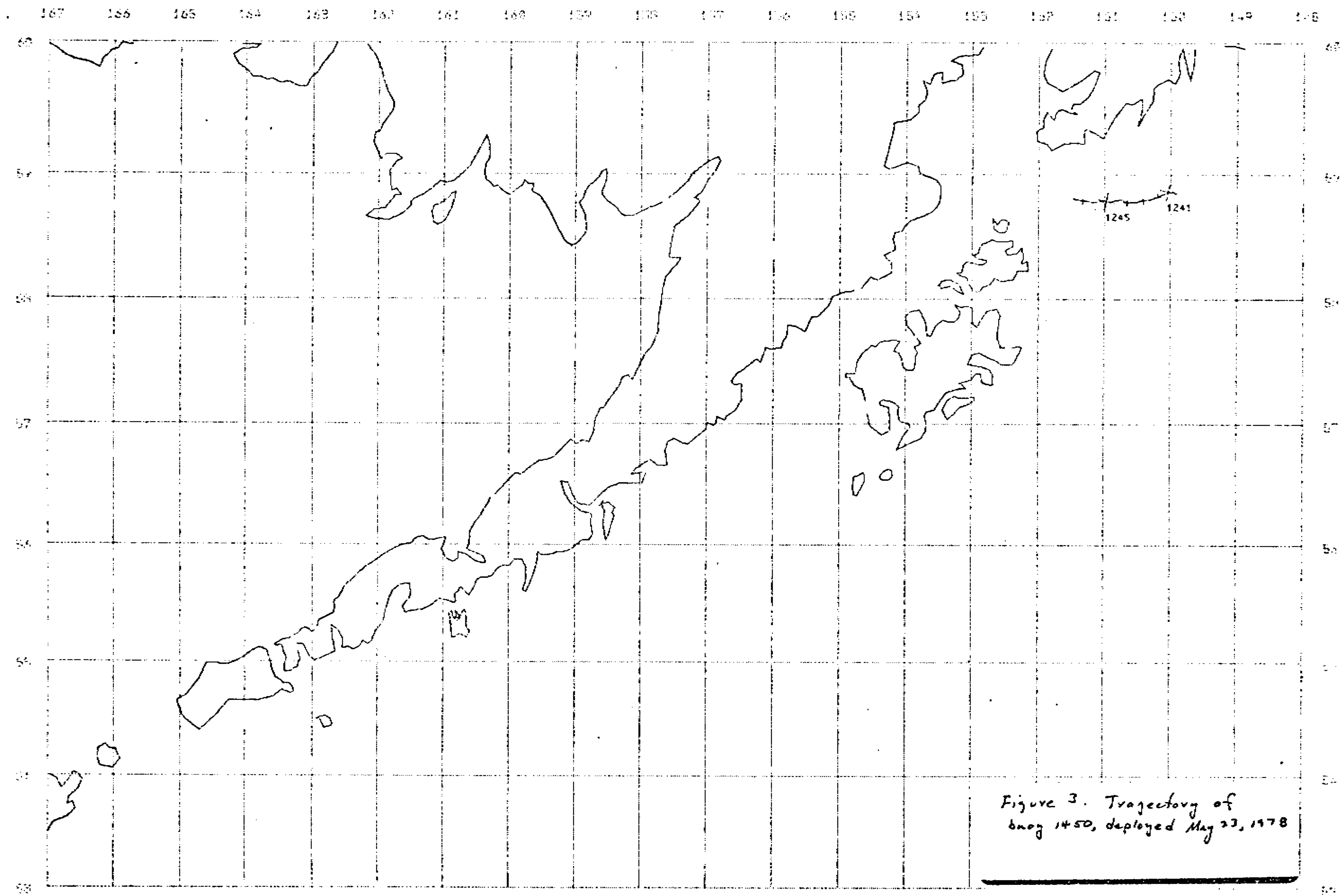



Figure 3. Trajectory of buoy 1450, deployed May 23, 1978

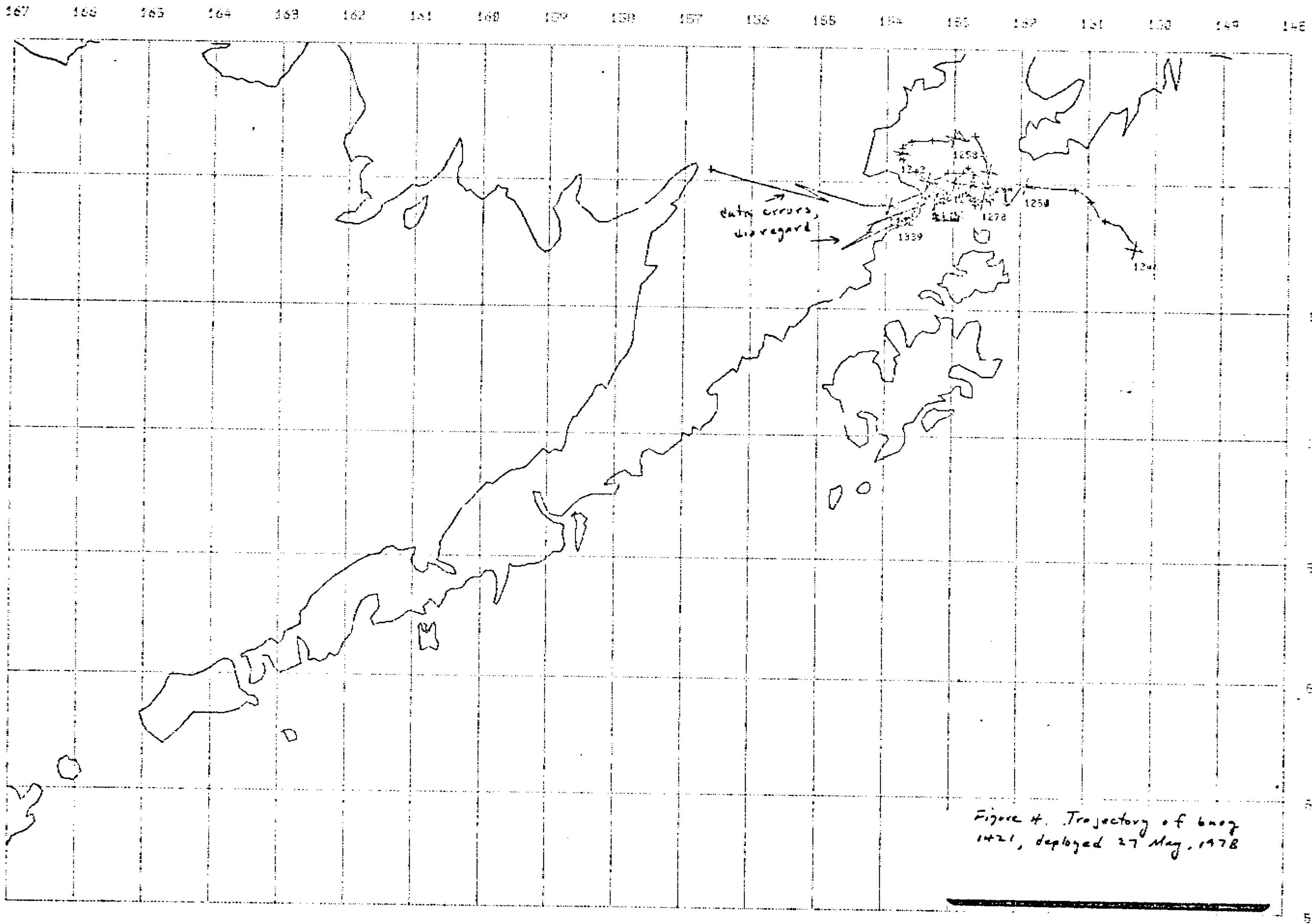



Figure 4. Trajectory of buoy 1421, deployed 27 May, 1978

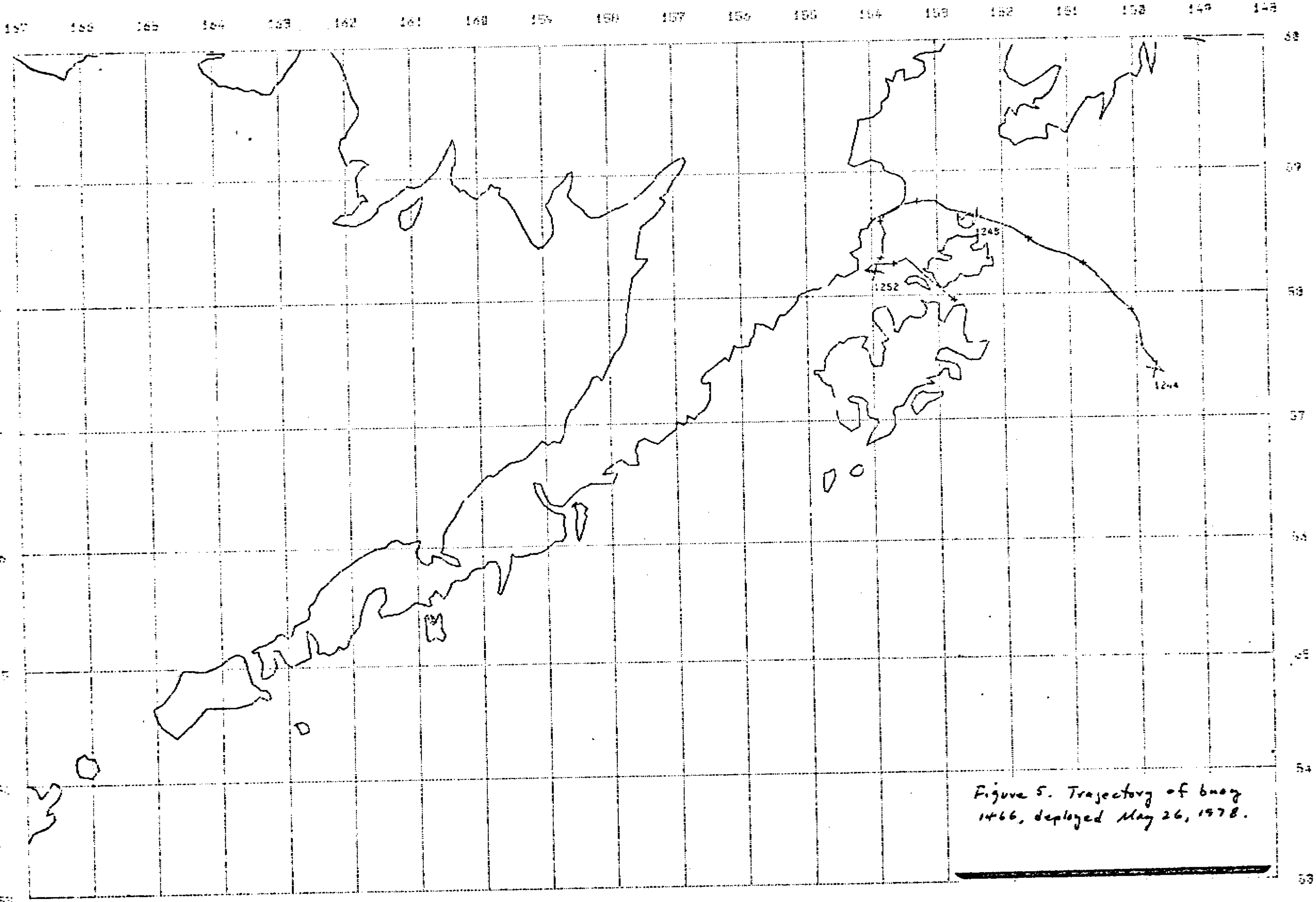



Figure 5. Trajectory of buoy 1466, deployed May 26, 1978.

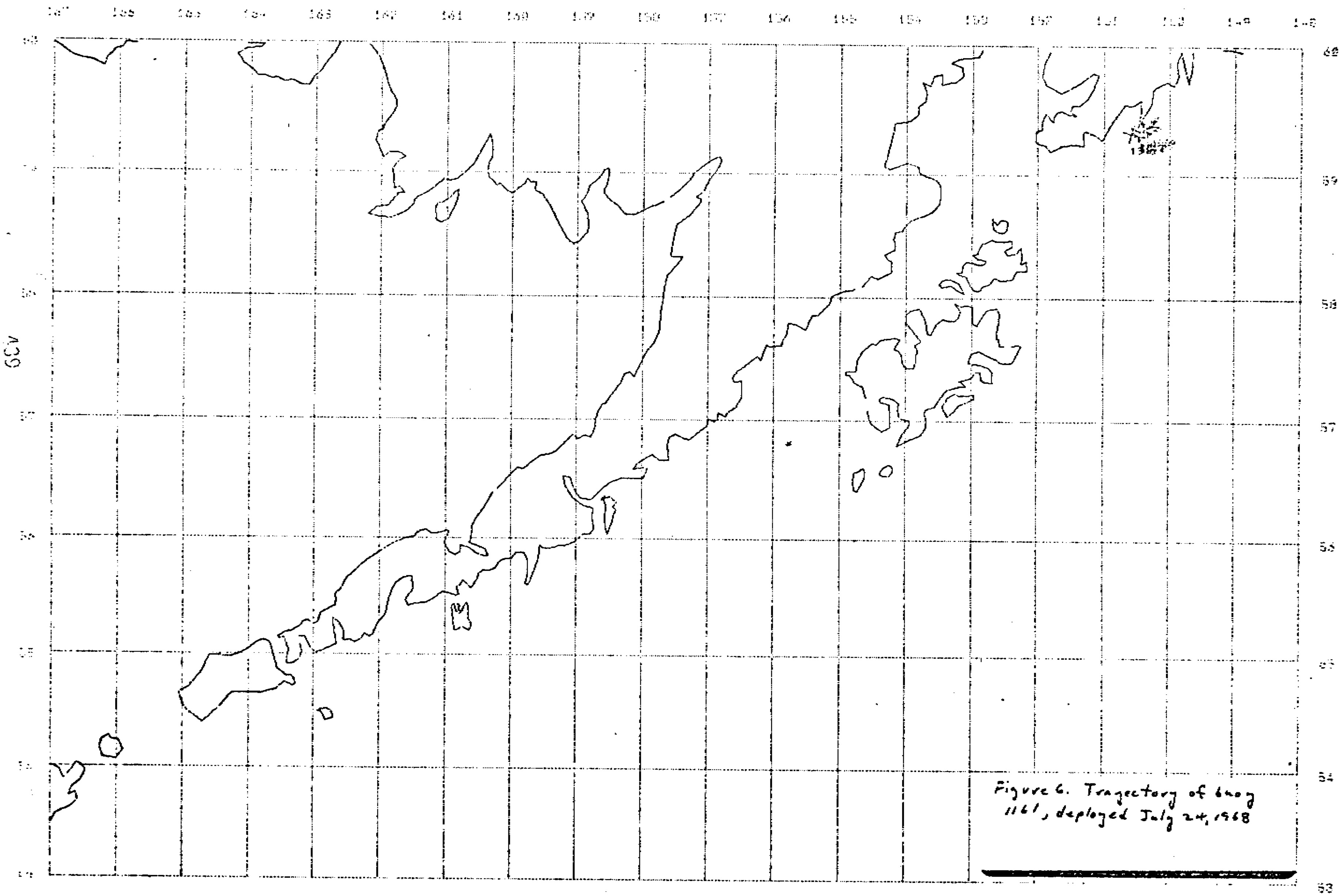



Figure 6. Trajectory of buoy 1161, deployed July 24, 1968

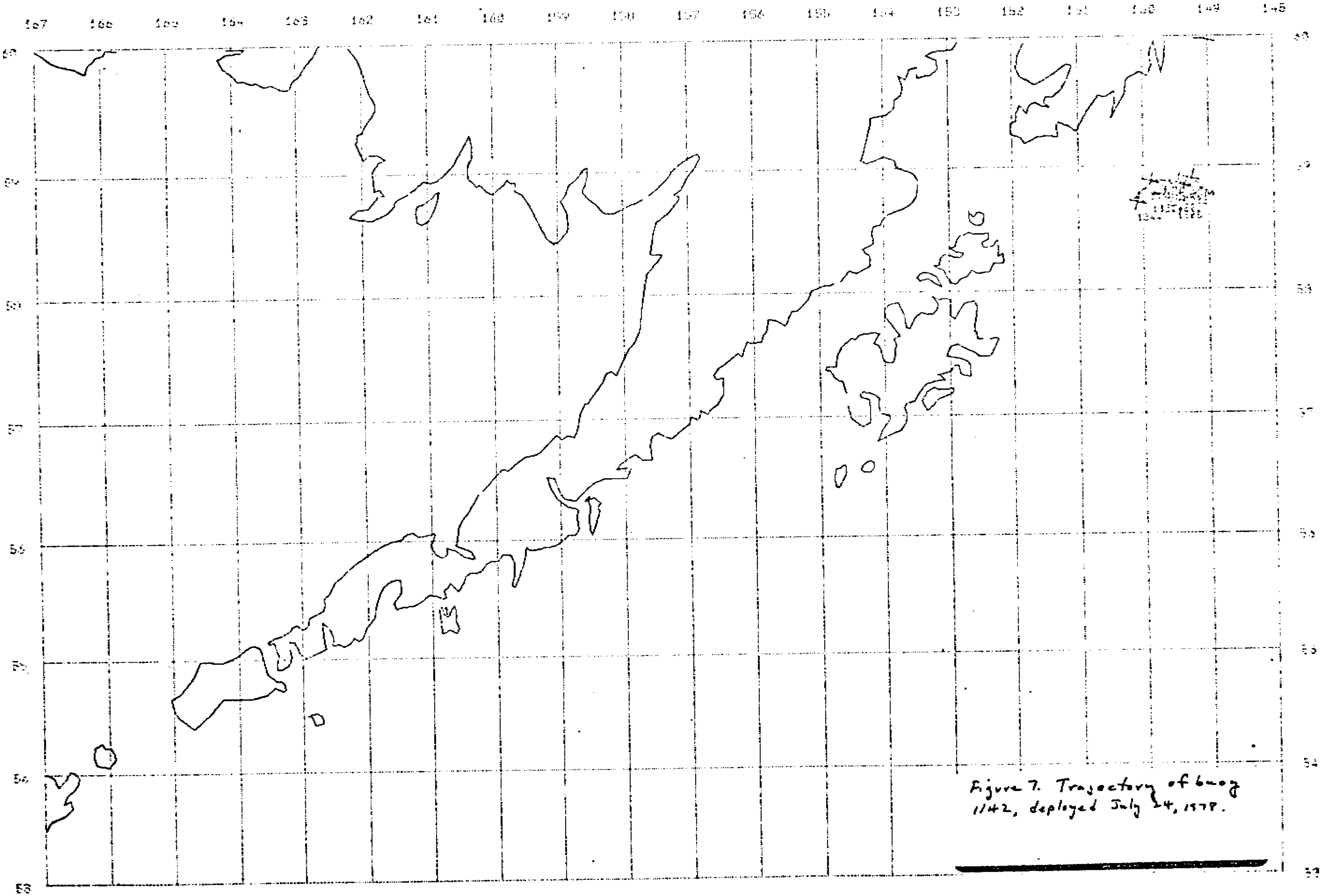


Figure 7. Trajectory of buoy 1142, deployed July 24, 1978.

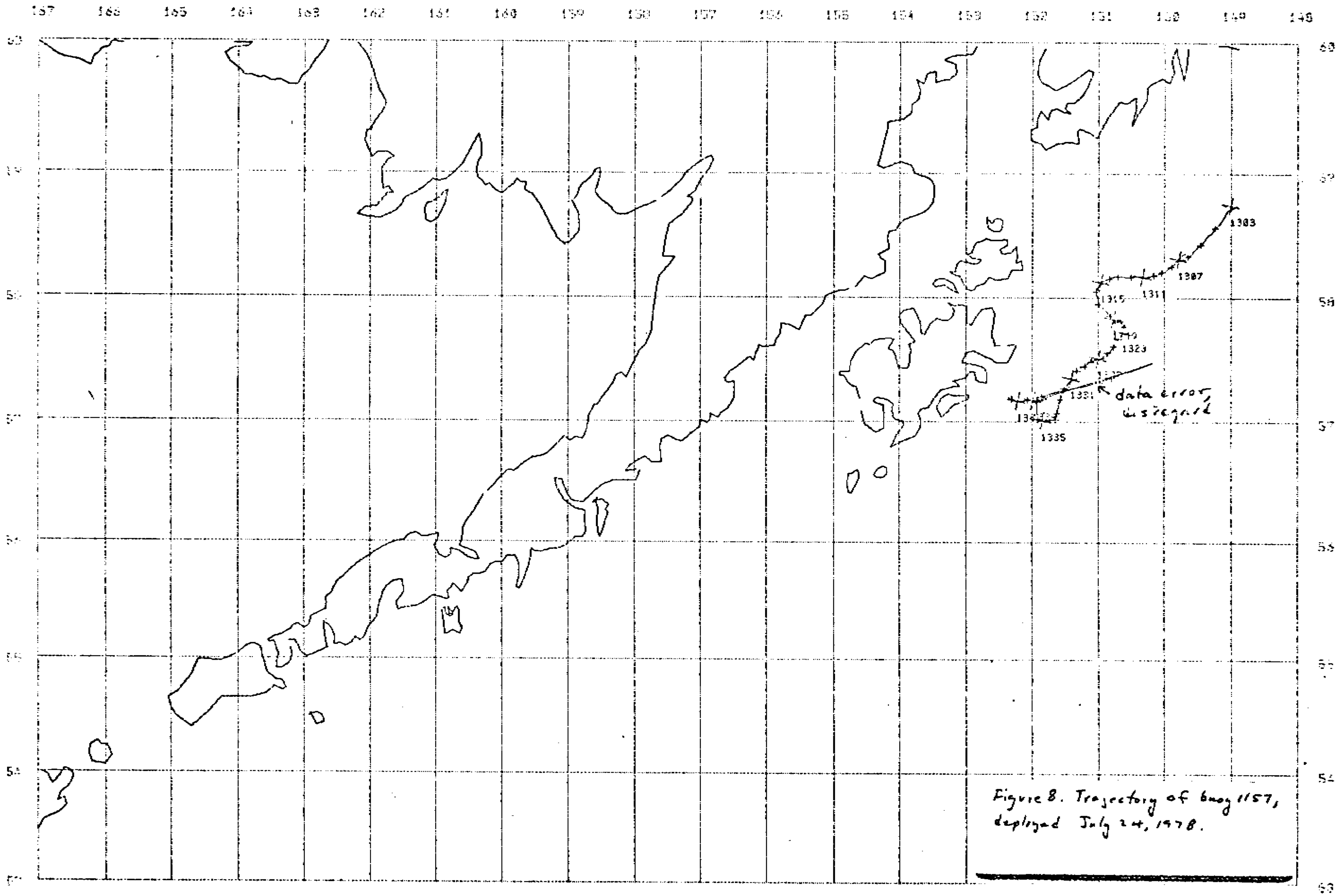



Figure 8. Trajectory of buoy 1157, deployed July 24, 1978.

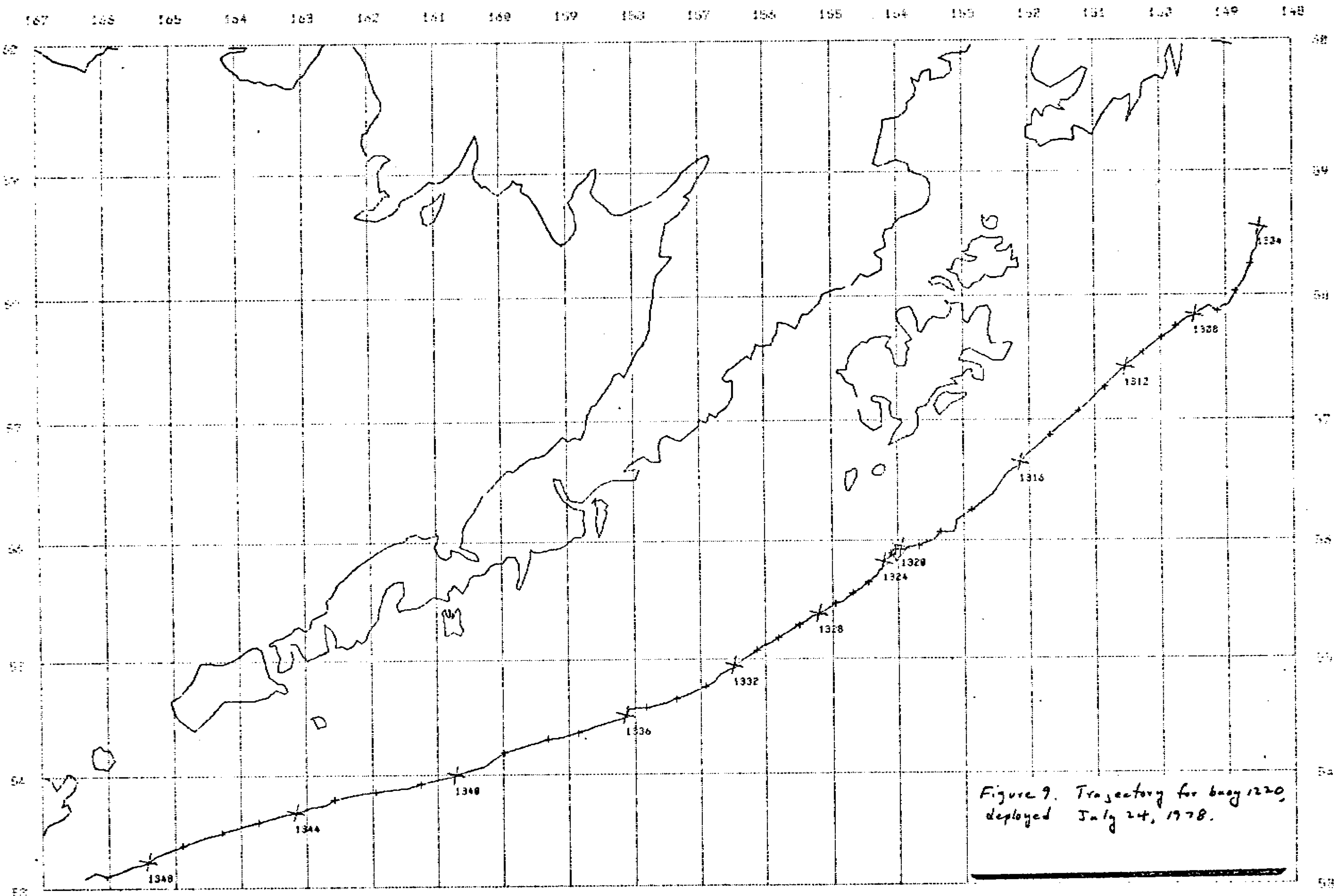



Figure 9. Trajectory for buoy 1220, deployed July 24, 1978.

QUARTERLY REPORT

Contract #03-5-022-91

Research Unit #244

Reporting Period: July 1 - Sept. 30, 1978

Number of Pages: 13

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

Principal Investigator

R. G. Barry

Professor of Geography

Institute of Arctic and Alpine Research

University of Colorado

Boulder, Colorado 80309

September 30, 1978

I. Task Objectives

Specific objectives of the final stages of this project on climatic effects on fast ice conditions are concerned with completing various studies of synoptic climatological characteristics over the two coastal areas. These data relate to possible variability in the ice regime.

II. Office Activities

a) Personnel

| | | | | |
|---|---|---|---|---|
| R. G. Barry, Principal Investigator | | | | |
| J. C. Rogers, Graduate | Research | Assistant | (1/2 time) | |
| G. Wohl, | " | " | " | (1/4 time until 10 Aug.) |
| B. Warmerdam, | " | " | " | (1/2 time) |
| Jane Reynolds, | " | " | " | (1/4 time) |

b) Meetings/Publications

R. G. Barry attended the OCSEAP Ice and Permafrost Review meeting in Fairbanks, 3 August, and reported on the project.

G. M. Wohl successfully defended his M.A. thesis based on work for the project titled:

"A study of sea ice conditions and synoptic climatology for the for the Beaufort Sea Coast of Alaska" (Univ. of Colorado, Boulder, 1978, 166 pp) (Abstract attached)

III. DATA ANALYZED AND RESULTS

Synoptic Climatology of the Beaufort Sea

1. Comparison of Summer Temperatures at Barrow and Barter Island

The mean summer temperature at Barter Island is consistently higher than at Barrow. June, July and August mean temperatures at Barter Island are $34.1^{o}$, $40.0^{o}$, and $38.9^{o}$F compared to $33.0^{o}$, $38.7^{o}$, and $37.6^{o}$F at Barrow. For 1957-75 (1957 is the beginning of the data set in this study) Barter

Island has a mean total of 576 thawing degree-days (TDDs) compared to 498 at Barrow. However, during some summer months, and occasionally over the entire summer, the mean temperature at Barrow is higher than at Barter Island. The Beaufort Sea synoptic types were used to determine if there were any major changes in the circulation types associated with months when Barrow was warmer than Barter Island or months when Barter Island was substantially warmer than Barrow.

The months chosen for the Barter Island warmer than Barrow case were selected only if Barter Island had an excess over Barrow of at least 39 TDD's in July and August and 33 TDD's in June. There are nine months, mainly Julys, when Barter Island is (much) warmer than Barrow and 8 when Barrow is warmer than Barter Island; these are shown in Table 1. Table 2 shows the total and mean frequencies of the synoptic types, and compares them with the mean frequency expected for the particular combinations of Junes, Julys, and Augusts shown in Table 1.

The results indicate some differences, particularly for the more frequent synoptic types. For the Barter Island warmer than Barrow case, synoptic types 2 and 5 are more frequent than average (by 1 1/2 and 1 day per month, respectively) while type 1 is less frequent by 1 day per month. Type 6 is also slightly less frequent than average. At Barrow type 2 is associated with southwesterly (overland) airflow, type 5 with westerly (over ice) airflow, and types 1 and 6 with northeasterly (over ice) airflow during a majority of the summer days (Table 2, page 8, March 31, 1977 annual report). This suggests that only type 2 is associated with above normal temperatures which agrees with Moritz's (1978, chap. 6) results for Julys. (It is assumed here that the same holds for June and August).

For Barrow warmer than Barter Island the mean frequencies of occurrence (compared with average) are the reverse of the foregoing case. Type 1 is now more frequent, as is type 6, and types 2 and 5 are less frequent than average. Despite this reversal the results are not clear-cut. For example, types 2 and 5, which vary together in mean frequency compared to average, are not of the same sign of temperature anomaly. The situation is clarified by examining Table 3. Columns 1 and 2 of Table 3 indicate whether each of the 4 types became either more or less frequent than normal with change in the temperature pattern between the two stations. Columns 3 and 4 indicate the actual temperature departures from normal for the four synoptic types at Barrow and Barker Island during July (Moritz, 1978).

Considering the temperature departures for the types at the 2 stations together with the changes in frequency of the types, a pattern emerges. Thus, types 2, 5, and 6 change frequency between the two temperature cases in accordance with the relative temperature anomalies (columns 3 and 4). Table 3 shows that:

a) types 2 and 5, are <u>warmer</u> at Barter Island and <u>more frequent</u> during periods when Barter Island is much warmer than Barrow.

b) type 6, which is <u>colder</u> at Barter Island, is <u>less frequent</u> when Barter Island is much warmer than Barrow.

c) the situation in a) and b) above will reverse for the Barrow warmer than Barter Island case.

While type 1 does not fit this pattern, the temperature anomalies associated with it at the two stations differ by only $0.2^{\circ}C$.

These results suggest that the cases when Barter Island is much warmer than Barter Island, can be explained by reversals in frequency of the major synoptic types and by the temperature departures from normal associated with those types at each station. Further analysis of these results showing the within-type temperature and frequency variance are in progress.

2. <u>Relation of temperature anomalies at Barrow to Synoptic Type Frequencies</u>

The role of the contribution of the Chukchi synoptic types to the temperature departure characteristics of the cold summers at Barrow has been investigated. The two factors involved are changes in frequencies of the types and within-type temperature changes during cold years. To investigate the relative importance of each of these factors, the temperature and frequency characteristics of the types during warm and cold Julys at Barrow were examined by the same methodology outlined in the last quarterly report. The warm Julys at Barrow occurred in 1957, 1962, 1966, 1968, 1971, 1972; then mean temperature departure from normal was +2.0°F. The cold Julys at Barrow occurred in 1959, 1960, 1963, 1967, 1969, 1970; their mean temperature departure from normal was -2.2°F.

For each type, three components of the overall temperature change ($\Delta\bar{T}$) at Barrow are computed:

(1) $(\Delta Fi)\ (Ti)\ /n$

(2) $(Fi)\ (\Delta Ti)\ /n$

(3) $(\Delta Fi)\ (\Delta Ti)\ /n$

where Fi = the frequency of type i during warm Julys

ΔFi = the change in frequency of type i between warm Julys and cold Julys

$Ti$ = the mean temperature departure of type i during warm Julys

$\Delta Ti$ = the change in mean temperature departure of type i between warm Julys and cold Julys

$n$ = the total number of days in each July set (186).

Component (1) is the term due to changes in type frequency; component (2) is the term due to within-type temperature changes; component (3) is an error correction term. The results of the computations are shown in Table 4.

The most important component overall is the within-type temperature change, which would have accounted for about 75% of $\Delta\bar{T}$ if the frequency of each type had remained constant. Of the nineteen types that occurred in both warm and cold Julys, fifteen had lower mean temperatures during cold Julys. In most cases, the change in frequency counteracted the effect of the change in temperature for a particular type, so component (3) was positive.

The most important types contributing to $\Delta\bar{T}$ were, in order of importance, 2, 12, 10, NT, 1, and 3 which together accounted for about 75% of the change (Table 5). This is roughly similar to the important types affecting July temperature at Kotzebue, although in this case type 2 is considerably more important. Of these, only type 10 contributed mainly through change in frequency.

Although within-type temperature changes were most important, frequency changes also occurred, and would have accounted for about 40% of $\Delta\bar{T}$ if the temperature of each type had remained constant. Types 10, 2, 9, and 12 underwent the most significant frequency changes.

Some of the possible reasons for large within-type temperature changes were discussed in the last annual report, including inconsistency of the typing scheme, sea-surface temperature changes, local changes, and changes in the persistence of the types.

At Barrow, the Chukchi types 2 and 12 are the warmest of those that occur regularly; these are cyclones in the Bering Sea and Strait region steering very warm air from the North Pacific northward to to Barrow. They occur on about 30% of the days in warm Julys; together with types 7 and 9, which are similar but in which the cyclones are located farther north, 48% of the days in warm Julys are accounted for. During cold Julys, the frequency of these types is only one-half that of warm Julys; they are replaced by an increased frequency of types 10 and 3, which are cold types. Type 10 is a cyclone in the Beaufort Sea that steers cold air southward and westward from the Arctic pack ice to Barrow (mean T $\simeq$ 33$^{o}$F); type 3, with blocking high pressure in the Bering Sea plus far northern cyclonic activity, steers cool air eastward to Barrow. These two types represent northern storms moving in the polar basin, as opposed to storms moving up from the Pacific--the normal Bering Strait track appears to be infrequent during cold Julys. Types 3 and 10 occur 26% of the days in cold Julys, but only one-half that frequently in warm Julys (Table 6).

IV. -

V. Problems/Recommended Changes. None

VI. Estimate of Funds Remaining. $11,500

Table 1. Summer months when Barter Island was much warmer than Barrow and when Barrow was warmer than Barter Island. Numbers in parenthesis indicate the number of thawing degree days ($^{o}F$) in excess.

| Barter Island much warmer than Barrow | Barrow warmer than Barter Island |
|---|---|
| July 1958 (220) | July 1965 ( 65) |
| July 1963 ( 96) | July 1972 (104) |
| July 1966 (118) | July 1974 ( 43) |
| July 1967 ( 93) | Aug. 1959 ( 50) |
| July 1969 (124) | Aug. 1962 ( 38) |
| July 1971 ( 81) | Aug. 1972 ( 36) |
| Aug. 1957 (124) | Aug. 1974 (153) |
| Aug. 1961 ( 87) | June 1959 ( 72) |
| Aug. 1963 (108) | |
| Mean = (117) | Mean = ( 70) |

Table 2. Total and Mean Frequency (Days) of synoptic types for months when Barter Island is much warmer than Barrow and for Barrow warmer than Barter Island.

| Synoptic type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total frequency for Barter Island warmer (9 months) | 26 | 76 | 2 | 16 | 33 | 24 | 2 | 16 | 2 | 5 | 5 | 2 | 2 | 7 | 24 | 5 | 8 | 4 | 6 | 1 | 6 |
| Total frequency for Barrow warmer (8 months) | 43 | 39 | 10 | 18 | 16 | 30 | 8 | 22 | 5 | 2 | 5 | 4 | 1 | 7 | 11 | 6 | 2 | 1 | 3 | 1 | 7 |
| Mean frequency per month, Barter Island warmer | 3 | 8½ | * | 2 | 4 | 2½ | * | 2 | * | ½ | ½ | * | * | 1 | 2½ | ½ | 1 | ½ | 1 | * | 1 |
| Mean frequency for 6 Julys and 3 Augusts | 4 | 7 | 1 | 2 | 3 | 3 | 1 | 1½ | ½ | ½ | * | * | * | 1 | 2½ | 1 | ½ | ½ | * | * | 1 |
| Mean frequency per month, Barrow warmer | 5½ | 5 | 1 | 2 | 2 | 4 | 1 | 3 | ½ | * | ½ | ½ | * | 1 | 1½ | 1 | * | * | ½ | * | 1 |
| Mean frequency for 1 June, 3 Julys, 4 Augusts | 4½ | 6 | 1 | 2½ | 3 | 3 | ½ | 1½ | ½ | ½ | * | ½ | * | 1 | 2 | ½ | ½ | ½ | * | * | ½ |

Table 3. Changes in frequency of types of pressure pattern in relation to temperature conditions at Barter Island and Barrow.

| Beaufort Sea Pressure Type | Barter Island Warmer Than Barrow | Barrow Warmer Than Barter Island | Mean Barter Island Temperature Anomaly (°C) | Mean Barrow Temperature Anomaly (°C) |
|---|---|---|---|---|
| Type 1 (NE flow) | Less frequent | More frequent | -1.5 | -1.7 |
| Type 2 (SW flow) | More frequent | Less frequent | 1.6 | 1.0 |
| Type 5 (W flow) | More frequent | Less frequent | -1.4 | -2.1 |
| Type 6 (NE flow) | Less frequent | More frequent | -1.2 | -0.3 |

Table 4. Components of Temperature Difference Between Warm and Cold Julys at Barrow According to Chukchi Pressure Types (see text). Units $^{o}F$.

| Type | Component 1 | Component 2 | Component 3 | ΔT |
|---|---|---|---|---|
| 1 | -.09 | -.15 | -.11 | -.35 |
| 2 | -.51 | -.88 | +.58 | -.81 |
| 3 | +.01 | -.20 | -.12 | -.31 |
| 4 | -.05 | -.01 | +.03 | -.03 |
| 5 | .00 | -.25 | +.11 | -.14 |
| 6 | +.05 | -.06 | +.02 | +.01 |
| 7 | 0 | +.07 | 0 | +.07 |
| 8 | +.01 | -.14 | +.02 | -.11 |
| 9 | -.21 | +.23 | -.12 | -.10 |
| 10 | -.40 | -.01 | -.01 | -.42 |
| 11 | +.06 | -.10 | -.13 | -.17 |
| 12 | -.17 | -.62 | +.20 | -.59 |
| 13 | -.08 | -.34 | +.17 | -.25 |
| 14 | -.03 | +.05 | +.05 | +.07 |
| 15 | -.03 | -.10 | -.06 | -.19 |
| 16 | -.04* | 0 | 0 | -.04 |
| 17 | +.10 | -.01 | +.01 | +.10 |
| 18 | 0 | +.02 | 0 | +.02 |
| 19 | -.08* | 0 | 0 | -.08 |
| 20 | 0 | -.02 | 0 | -.02 |
| 21 | -.11* | 0 | 0 | -.11 |
| 22 | - | - | - | - |
| NT | +.11 | -.33 | -.15 | -.37 |
| MD | - | - | - | - |
| TOTALS | -1.46 | -2.85 | +.49 | -3.82 |

Table 5. Percentage of mean temperature difference between warm and cold Julys at Barrow accounted for by individual pressure types (Chukchi catalog).

| Type | Percent | Cumulative Percent | Major Component of Difference |
|---|---|---|---|
| 2 | 21.2 | 21.2 | Both |
| 12 | 15.4 | 36.6 | ΔT |
| 10 | 11.0 | 47.6 | ΔF |
| NT | 9.7 | 57.3 | ΔT |
| 1 | 9.2 | 66.5 | Both |
| 3 | 8.1 | 74.6 | Both |
| 13 | 6.5 | 81.1 | ΔT |
| 15 | 5.0 | 86.1 | Both |
| 11 | 4.4 | 90.5 | Both |
| 5 | 3.7 | 94.2 | ΔT |
| Others | 5.8 | 100.0 | - |

Table 6. Characteristics of some important Chukchi pressure types at Barrow in July.

| Type | Fw (%) | Fc (%) | Mean Temperature Departure ($^oF$) | Surface Wind Direction | Geostrophic Flow |
|---|---|---|---|---|---|
| 2 | 18.8 | 6.5 | +2.9 | E | S |
| 9 | 14.0 | 6.5 | +3.4 | E | S |
| 12 | 11.8 | 8.1 | +2.3 | E/SW | SW |
| 1 | 5.9 | 10.2 | -3.7 | E | E |
| 3 | 9.7 | 15.6 | -1.3 | W | W |
| 10 | 3.2 | 10.8 | -5.5 | W | NW |

Key: Fw - frequency in warm Julys
Fc - frequency in cold Julys

Wohl, Gary M. (M.A., Geography)

A Study of Sea Ice Conditions and Synoptic Climatology for the Beaufort Sea Coast of Alaska

Thesis directed by Professor Roger G. Barry

Satellite imagery is used to identify the source of sea ice near Point Barrow that blocked navigation to Prudhoe Bay in the summer of 1975. Southward movement of the pack ice was found to be responsible, rather than the persistence of shorefast ice into the late summer. Meteorological conditions that are associated with sea ice conditions along the Beaufort Sea coast of Alaska are examined through a synoptic typing scheme covering all of Alaska. A comparison of National Weather Service (NWS) pressure data with an independent data set from the Arctic Ice Dynamics Joint Experiment (AIDJEX) for 1975 shows the pressure distribution depicted over the Beaufort Sea on NWS maps to be inaccurate. The theory and measurement of sea ice movement is discussed and the applicability of the AIDJEX model to forecasting is examined. Due to poor forecasting of pressure fields over the polar regions the AIDJEX model will be of limited applicability. The frequency of synoptic types showed only low correlations with ice conditions since the types are defined by the pressure distribution taken from NWS data. A separate attempt to redefine the types using a limited pressure data set covering the northern part of Alaska and the Beaufort Sea (but not including southern Alaska) gave no improvement. Recommendations for further study are included.

Signed ______________________
Faculty member in charge of thesis

Quarterly Report

Contract #: 03-5-022-55
Research Unit #: 250
Task Order #: 11
Reporting Period: 6/30/78-
9/30/78
Number of Pages: 2

# Mechanics of Origin of Pressure Ridges, Shear Ridges, and Hummock Fields in Landfast Ice

by

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

October 17, 1978

OCS COORDINATION OFFICE
University of Alaska

Quarterly Report for Quarter Ending
September 30, 1978

I. Task Objectives

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

II. Schedule

Analysis

III. Results

1. A paper on the beach and barrier island overrides which occurred during the winter of 1977-78 in the Point Barrow area, was presented at the meeting of the northwest section of the American Geophysical Union in September 1978. A manuscript of the paper is presently in preparation and will be issued as a report of the Geophysical Institute, University of Alaska, within the coming quarter.

2. A series of interviews with Eskimo people who formerly resided on the Beaufort Sea coast was completed during the past quarter. These have been translated and the material is currently being organized into manuscript form and will be available during the coming quarter.

IV. Problems Encountered

None

V. Estimated funds expended:

$5,000.00

Quarterly Report

Contract #03-5-022-55
Research Unit #258/257
Task Order # 5/8
Reporting Period: 6/30/78-9/30/78
Number of Pages: 3

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

Dr. W. J. Stringer
Assistant Professor of Applied Science
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

September 30, 1978

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending September 30, 1978

Project Title: Morphology of Beaufort, Chukchi and Bering Seas Near Shore Ice Conditions by Means of Satellite and Aerial Remote Sensing.

Contract Number: 03-5-022-55

Task Order Number: 8

Principal Investigator: W. J. Stringer

## I. Task Objectives:

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

## II. Field and Laboratory Schedule:

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

## III. Results:

This is the last reporting quarter for this research unit. A no-cost extension has been granted until November 30, 1978 with the final report due at that time rather than six months following the end of the contract.

## IV. Preliminary Interpretations:

No new preliminary interpretations were made this quarter. In the past quarterly and annual reports a great number of preliminary interpretations were reported. None of these were questioned or challenged. From this, it is safe to presume that no serious problems exist with these interpretations as they progress to final interpretation status.

V. Plans for Next Reporting Period: Submit final report.

VI. Problems Encountered/Recommended Changes: None.

VII. Estimate of Funds Expended: 99%

VIII. Appendices: None.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
Boulder, Colorado 80302

OCS Arctic Project Office
611 Elvey - Geophysical Inst.
University of Alaska
Fairbanks, AK. 99701

October 24, 1978

MEMO

TO: Rudy Engelmann

FROM: Bill Stringer Bill

SUBJECT: WMO Remote Sensing of Sea Ice Meeting

Because of the Orcas Island Oceanography Review Meeting I was unable to attend the entire WMO meeting. However, I was there for the part which would do me the most good: the presentation of the Russian SLAR data. The main value to me is outlined in the following statements:

1. In general, their SLAR looks no different from ours. To me, this means that although they have been in the business of using SLAR for aiding navigation in ice for approximately ten years, the data presentation mode they find useful is essentially the same as OCSEAP has been using.

2. They rely on manual interpretation which is highly dependent on the skill and training of the observers. The technique is basically pattern recognition identifying general ice types and roughness.

3. To us, and our use of SLAR, it is important that they stressed that identification of individual features is highly aspect sensitive and that ridges which can be identified on imagery obtained when flying on one azimuth cannot always be identified on imagery obtained when flying at right angles to that azimuth. This agrees with my own observations and may be a very important limitation to the use of SLAR on an operational basis for hazards assessment by petroleum companies.

As you may know already, Ted Flesher has arranged with the Army to obtain SLAR imagery of the Beaufort Sea next week. The experience gained at the WMO workshop should help me in working with Ted and the Army toward obtaining some useful data about ice freeze-up conditions and processes the Beaufort Sea.

WS/djb

QUARTERLY REPORT

Contract #03-05-022-55
Research Unit #265
Task Order #6
Reporting Period: 06/30/78 - 09/30/78
Number of Pages: 2

# *IN-SITU* MEASUREMENTS OF THE MECHANICAL PROPERTIES OF SEA ICE

Lewis H. Shapiro
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

October 18, 1978

OCS COORDINATION OFFICE
University of Alaska

Quarterly Report for Quarter Ending September 30, 1978

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

Contract Number: 03-05-022-55

Task Order Number: 6

Principal Investigator: Lewis H. Shapiro

I. Task Objectives:

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

II. Schedule:

Data Reduction

III. Results:

Most of the work during the past quarter was devoted to reducing data in preparation for analysis. This involved developing computer procedures for reading raw data, making the required calculations, and printing and plotting the results. This has been accomplished, and approximately one-half the data has been reduced. This phase of the work should be completed within one month, after which analysis will begin.

IV. Preliminary Interpretation:

None

V. Problems Encountered:

None

VI. Estimate of Funds Expended:

$10,000

# Q U A R T E R L Y   R E P O R T

Contract #03-5-022-55, Task 10
Research Unit #267
Reporting Period: July 1, 1978
to September 30, 1978
Number of Pages: 4

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

Albert E. Belon
Geophysical Institute
University of Alaska

September 30, 1978

# OPERATION OF AN ALASKAN FACILITY

# FOR APPLICATIONS OF REMOTE-SENSING DATA TO OCS STUDIES

Principal Investigator: Albert E. Belon
Affiliation: Geophysical Institute, University of Alaska
Contract: NOAA #03-5-022-55, Task 10
Research Unit: #267
Reporting Period: July 1 to September 30, 1978

## I. TASK OBJECTIVES

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

## II. LABORATORY ACTIVITIES

### A. Operation of the Remote-Sensing Data Library

We continued to search periodically for new Landsat imagery of the Alaskan coastal zone entered into the EROS Data Center (EDC) data base. As a result, 230 Landsat scenes were selected and ordered from EDC at a total cost of $3,656. These data products, which are gradually received from EDC, complete our files of Landsat data from the launch of the first satellite, July 26, 1972. This imagery is ordered in the following formats:

-70mm positive transparency of MSS, spectral band 5

-9 inch print of MSS, spectral band 7

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

The processing backlog at the EROS Data Center is gradually improving and data orders are beginning to arrive regularly. Although still a little slower than normal, orders are now being received in approximately 8 weeks from acquisition of the data by the satellites.

We continued to receive and catalog daily copies of NOAA satellite imagery of Alaska in both the visible and infrared spectral bands under a standing order with the NOAA/NESS Fairbanks Satellite Data Acquisition Station. 276 NOAA scenes at a total cost of $3,257 were acquired in 10" positive transparency format during the reporting period.

B. Operation and maintenance of data processing facilities

Near-real-time satellite imagery is now available to OCS investigators through the Remote-Sensing Data Library. Air Force weather satellite imagery (DMSP) is received at Elmendorf Air Force Base near Anchorage and shipped daily to the Geophysical Institute. NOAA-5 weather satellite imagery is also available on a same-day basis. Landsat quick-look data, from select scenes, is received from Canadian sources two or three days after acquisition. These new data products are made possible through a State-funded project to evaluate the utility of near-real-time satellite imagery to Alaskan problems. OCS has made use of this data primarily to determine sea-ice conditions in the Beaufort Sea (RU's 6, 205 & 526).

C. Development of data analysis and interpretation techniques

Permission has been received from the NASA Earth Resources Laboratory, Bay St. Louis, Mississippi, to use special computer programs they have developed to measure shore line length and classify suspended sediment distribution from remote sensing data. Our project is looking into the possibility of performing such an analysis of Simpson Lagoon in cooperation with several RU's conducting studies in the area.

D. Assistance to OCS investigators

Nineteen OCS investigators utilized our facilities during this reporting period, many of them repeatedly. Additionally several visitors, though not formal OCSEAP investigators, used our facility for OCSEAP-related activities. Approximately 40 people made extensive use of our services for either OCSEAP or OCSEAP-related projects. Some of these users and their activities are:

Peter Connors, RU-172, Bodega Marine Lab., used the Zoom Transfer Scope to transfer information from NOS aerial photographs to maps. He used photos he had purchased as well as transparencies from our files.

Jan Cannon, RU-530, periodically checks through the latest imagery and orders those scenes useful to his OCS investigation.

Juergen Kienle, RU-251, looked at and ordered NOAA imagery of a volcanic eruption on Kamchatka Peninsula.

Kristina Ahlnas (Royer, RU-289) looks through daily NOAA and DMSP imagery to aid in ordering specialized products of these data.

Christopher Ruby and Peter Reinhardt (Hayes, RU-59) of the University of South Carolina, spent several days in our facility looking through Landsat, NOAA and NOS imagery and placed several orders for data of their study areas.

Gene Ruff (Carey, RU-6) checked the latest NOAA imagery to determine ice conditions before going into the field to pursue their studies in the Beaufort Sea.

Peter Craig, RU-467, LGL Ltd., browsed through available Landsat images from 1977 and 1978 and ordered several of his study area in Simpson Lagoon.

Erk Reimnitz, RU-205, USGS - Menlo Park, looked through the latest imagery of the Beaufort Sea and was interested in the latest ice conditions. Copies of that day's DMSP imagery were given to him and prints made from imagery received after his departure were sent to him.

Dr. Naidu, RU-529, browsed through Landsat images of Simpson Lagoon and ordered copies of several scenes. He also checked on dates of satellite coverage for that area so that he could coordinate field sampling with satellite passes. We are now looking for the imagery for those dates and thus far two scenes have been entered into the data base and should be available for his use very shortly.

David Mason, RU-356, browsed through our library and ordered several images which he picked up on his return from doing field work.

Brendan Kelly, (Shapiro RU-250) looked through NOAA imagery to correlate ice data already compiled to the satellite imagery.

Harold Mortensen, Seattle Fisheries, looked through all the available Landsat data for Iliamna and ordered several images.

Kris Tommos (RU-290) is conducting a data search and analysis of Landsat imagery of Bristol Bay to evaluate sea-surface circulation.

Craig Wiese, Sea Grant Office, ordered several Landsat images and U-2 aerial photographs of the Cordova area.

Faye Alexiev, Research Design of Anchorage, ordered U-2 aerial photography of the offshore islands in the Beaufort Sea to use in her study for the North Slope Borough.

Fred Sorenson, U.S.F.&W.S. asked for our assistance in choosing NOAA satellite data from June 1977 through July 1978. Mr. Sorensen is involved in a project that is tracking a radio-collared polar bear in its trek across the Chukchi Sea. He knows the geographic location of the bear for given dates but needed the satellite data to give him information on ice conditions which may have influenced the bear's activities. A search was made and order placed for available NOAA imagery for him.

Don Schell (RU-537) examined Landsat imagery of the Beaufort Sea coast and ordered several images to measure the shoreline length between Barrow and Prudhoe Bay.

David Lapp and George Comfort, Arctic Canada Ltd., came in to look for historical ice data for the Prudhoe to Demarcation Point area. Catalogs listing available data in our library were given to them and the imagery was made available for their use.

III. RESULTS

A report, produced by RU's 267 and 258, was released in September by the OCSEAP Arctic Project Office. The report incorporates part of the RU 267 annual report and an article by RU's 267 and 258 in Arctic Project Bulletin No. 20 to illustrate, by means of historical Landsat imagery and sea-ice morphology maps, the seasonal sequence of sea-ice and sea-surface conditions from fall freeze-up to summer break-up in the 1979 Beaufort lease sale area.

A new catalog of remote-sensing data is being compiled and will be published in October. Because of the delay in receiving data for the entire Spring 1978, the distribution of the catalog, originally scheduled for August, was delayed until now.

No significant problems were encountered this reporting period.

VI. ESTIMATE OF FUNDS EXPENDED

The estimated expenses of the project during the reporting period were approximately $30,000, plus $4,000 in outstanding obligations for standing orders for Landsat and NOAA satellite imagery.

# QUARTERLY REPORT

Contract: 03-5-022-56
Research Unit: #289
Task Order No.: #19
Reporting Period: 7/1/78-9/30/78
Number of Pages: 4

# CIRCULATION AND WATER MASSES IN THE GULF OF ALASKA

Thomas C. Royer
Associate Professor of Marine Science and
Physical Oceanography
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

1 October 1978

## I. TASK OBJECTIVES THIS QUARTER

The general objectives of this proposed research are:

A. To better define the exchange of water between Prince William Sound and the Gulf of Alaska and the circulation on the adjacent shelf.

B. To monitor, archive and analyze satellite imagery for Alaskan coastal waters. To make this imagery available to other OCSEAP investigator and to assist them with their interpretation of these data.

C. To participate in the synthesis of all physical oceanographic data from the NEGOA area.

D. To continue to analyze (as time permits) the annual and interannual variability of hydrographic properties in the lease areas and adjacent waters.

## II. FIELD AND LABORATORY ACTIVITIES

A cruise aboard the R/V *Acona* in the northern Gulf of Alaska and Prince William Sound was carried out from 31 July through 12 August 1978. One-hundred forty-five STD stations were occupied with some discrete Nansen bottles sampling done for calibration. The Seward line was occupied twice during the cruise to give estimates of short term temporal variations. A purpose of the closely spaced grid is to serve as an input to the numerical model developed by J. Galt.

Another cruise on the R/V *Acona* commenced on 17 September and is scheduled to terminate on 4 October. The plans call for occupying the station grid between Kayak Island and Seward and within Prince William Sound. Current meter arrays in Montague Strait, Hinchinbrook Entrance and new Middleton Island will be recovered. Arrays will be redeployed in Montague Strait and Hinchinbrook Entrance.

## III. RESULTS

A synthesis report was begun for the NEGOA area. Progress on the report was retarded by late contributions of the PI's. Instead of distributing the report prior to the October physical oceanographers' meeting, a first draft will be distributed at that meeting.

Written reports have now been received from all PI's except from Galt who presented his orally. This discussion with Galt proved to be especially helpful in the synthesis.

A Master's thesis on the Middleton Island winds was completed by David Livingstone. An important conclusion of that work is that the upwelling indices as determined by Bakun are only close to those determined from the actual wind data at Middleton Island in the summer. In winter, Bakun overestimates, by a large margin, the downwelling effects. Livingstones findings appear to be consistent with coastal sea level observations.

Analysis continues on the Seward line data and current measurements at IMS9. It appears that the location of the array was such that the data do not represent the complete circulation pattern for that transect. Instead, numerous eddies propagated by the array, which appears typical for that location. A number of eddies are present in the hydrographic cross-sections.

Transports for all eighty transects that have been taken by RU 289 have now been compiled and their analysis has begun. Limited results show that the annual signal in the Alaska current (if there is an annual signal) does not occur in winter as was previously assumed, but instead, later in the year. The magnitudes of the mean and annual fluctuations are similar to those found using historical data. The annual changes in the baroclinic transports on the shelf have been determined and their driving mechanisms can be explained in most situations.

Current meter data for the Prince William Sound entrances and exits shows inflow, with tidal modification, in Hinchinbrook Entrance and similar outflow from Montague Strait. Rapid flows were measured at the bottom of these locations. Analysis of these data has just begun.

## IV. PROBLEMS

As mentioned previously, lack of submission of information for the synthesis report was a serious problem. This was further aggravated by a cruise in the last half of September where the PI was chief scientist. Similarly, negotiations for next years' funding were interrupted because of this cruise. At this stage, the contract office is attempting to have about the same amount of field work done next year as during the past year with increased analysis at 40% of this years funding. Some modifications to either the work statement or funding level must be done in the next quarter.

Research Unit # 435
Reporting Period: July 1-Oct. 31, 1978

Quarterly Report

# MODELING OF TIDES AND CIRCULATIONS OF THE BERING SEA

J. J. Leendertse
S. K. Liu

Rand Corp.
Santa Monica, California

Progress Report

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

National Oceanic and Atmospheric Administration

July 1, 1978 - October 31, 1978

J. J. Leendertse and S. K. Liu

During the reporting period our effort has been in carrying out the final prediction and verification run of the three-dimensional model of Bristol Bay and St. George Basin and the preparation of a Working Note describing the setup, adjustment and verification of this model (Ref. 1).

After the model's adjustment phase, which was reported in the previous progress report, the period between 16-19 July 1976 was selected for verifying the predictability of the model and the establishment of a set of predictive parameters.

During the model's verification period, observed currents at four locations have been compared to the computed values, located nearest to those current meter deployments. Details of the comparison and analysis are presented in our final report (Ref. 1). To demonstrate the model's predictability, comparisons made at four stations are presented in Figs. 1 through 4. Figure 1 contains four graphs. Graph A gives the water level at grid point (14,14) from dynamic computation. Graph B illustrates the computed east/west current components at four depths at this grid location, plotted together with the hourly observed east/west current component at station BC-2 (see insert map) measured at a 20-meter depth. Graph C gives similar comparisons, but for the north/south velocity components. These computed values agree quite well with the reported average values. Some uncertainties still exist. These uncertainties include the true horizontal location of the station. Depth values in the model are schematized according to the published navigation chart, which may not represent the true local depth. Local depth of the mixed layer may also be slightly different from the modeled value. Finally, the predicted water level at the model's open boundary also contains certain random and systematic errors which would affect the computed results. Graph D contains six curves representing the computed vertical velocity components at six selected layers. The vertical velocity of these layers not only reveals tide-induced vertical displacements, but also contains instabilities induced by the vertical stratification. The dynamic behavior of each layer is closely related to the local vertical densimetric Froude number and the Brunt-Väisälä frequency. A more detailed discussion on the vertical dynamic behavior is presented in Ref. 1. Figure 2 gives similar comparison graphs for station BC-5. In this figure, the currents are plotted as magnitudes and direction. The computed currents in the lower layers agree quite well with the observed values, whereas surface currents are in general higher than the computed magnitudes--particularly at their maximum range. The predicted current directions are excellent (Graph C). Some of the underestimates in the surface currents at this particular location may be traced to the low turbulent energy content. This is indicated by the dichotomic velocity distribution in the vertical (Graph D). Notice the lack of vertical velocity gradients in the bottom layers as compared to the similar graph in Fig. 1.

The next figure (3) represents the comparison at station BC-14, which is located very close to the Alaskan Peninsula. The computed currents agree well with the observed values, particularly for the east-west component. The vertical motions due to wind and tides increase the turbulence intensity close to the southern boundary and the salinity and temperature distributions are nearly homogeneous. Vertical displacements are very large, resulting in a vertically near-homogeneous structure.

Good agreement is also found at station BC-15 (Fig. 4). This station is shallower than the previous three stations. Vertical displacements of water columns show pronounced instabilities (Graph D), yet the magnitude is only about one-third of that at station BC-14.

The tidal propagation within the modeled area may be illustrated by a set of three-dimensional plots from the results of the hydrodynamic computation. A period of 12 hours of the verification period, from 0200 hour to 1400 hour June 18, 1976, is selected to demonstrate the movement of the water surface in the modeled area. Figure 5 illustrates the rising and falling of the water surfaces in the modeled area at three-hour intervals as they would be seen by a spectator looking from the north toward the Alaska Peninsula. Higher tidal harmonics superimposed on the principal lunar and solar components are also evident. It should be pointed out that the result would be different if the computation were to be carried out assuming a homogeneous density structure. This is due primarily to the different vertical shear structures induced by the vertical density gradient and the modification of the horizontal pressure gradient caused by the variations in the horizontal density distribution.

The computed co-tidal charts for the diurnal and semidiurnal components are presented in Figs. 6 and 7. These results are derived from 51 hours of computed results by means of 2-D Fourier transformation. They are compared to the observed charts for the K1 and M2 components derived from long-term data compiled by NOAA. Both the phase and the location of amphidromic points agree well with the observed chart. It seems our bottom friction coefficient is still somewhat on the high side.

During the reporting period the investigators participated in the OCSEAP Physical Oceanography/Meteorology Workshop at Orcas Island, Washington, in October.

In the following month it is planned to prepare a formal report on the work described so far under the contractual agreements with NOAA, and subsequently start with the adjustment of the Norton Sound model.

## Reference

1. Liu, S. K., and J. J. Leendertse, "A Three-Dimensional Model for Estuaries and Coastal Seas: Volume VI, Bristol Bay Simulations," The Rand Corporation, WN-10327-NOAA, September 1978.

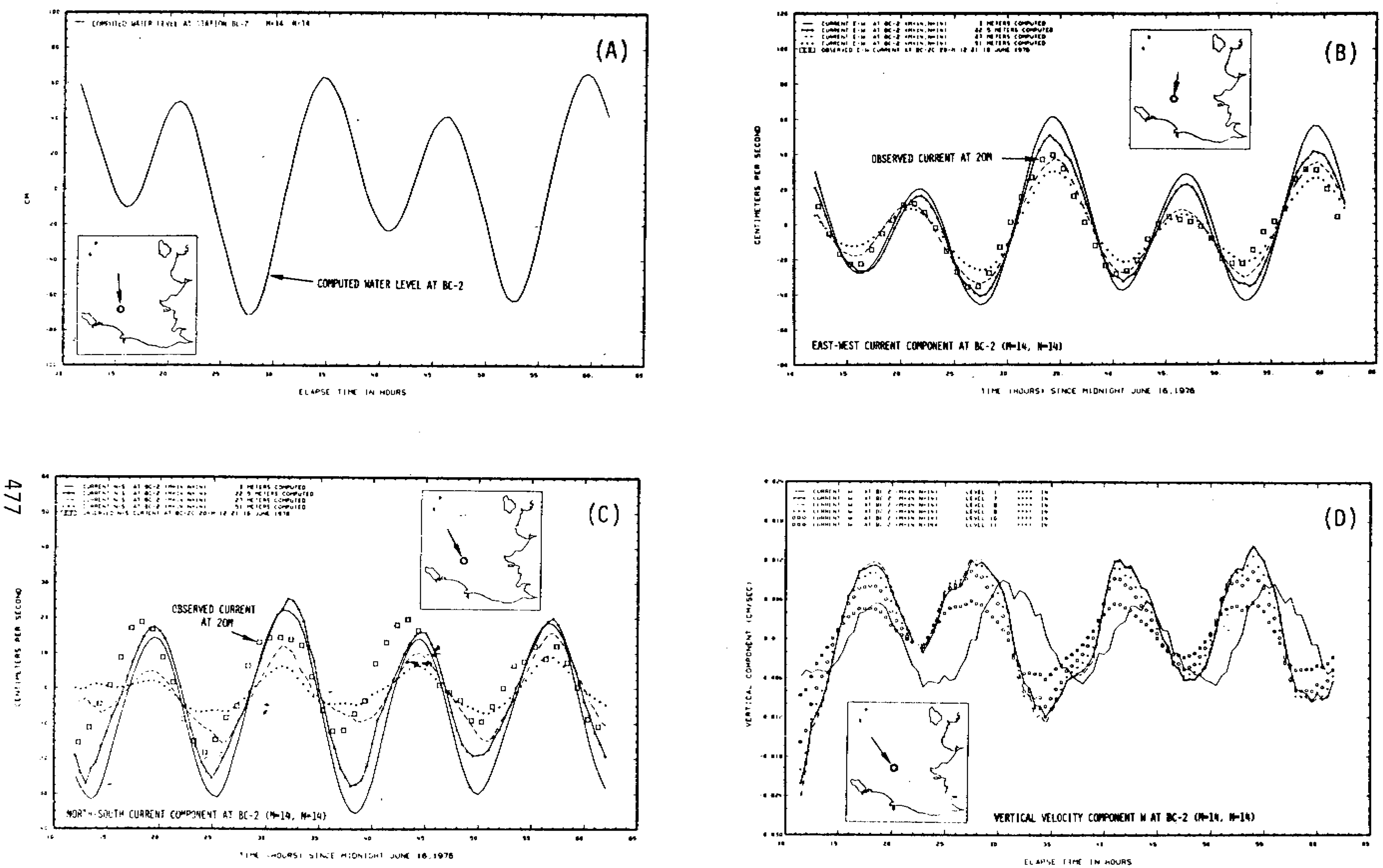



Fig. 1 --Comparison between the computed and the observed current component at a given location (B and C) together with the local water level (A) and vertical velocity component at six selected levels (D) during the period 0000 16 June through 1400 18 June 1976.

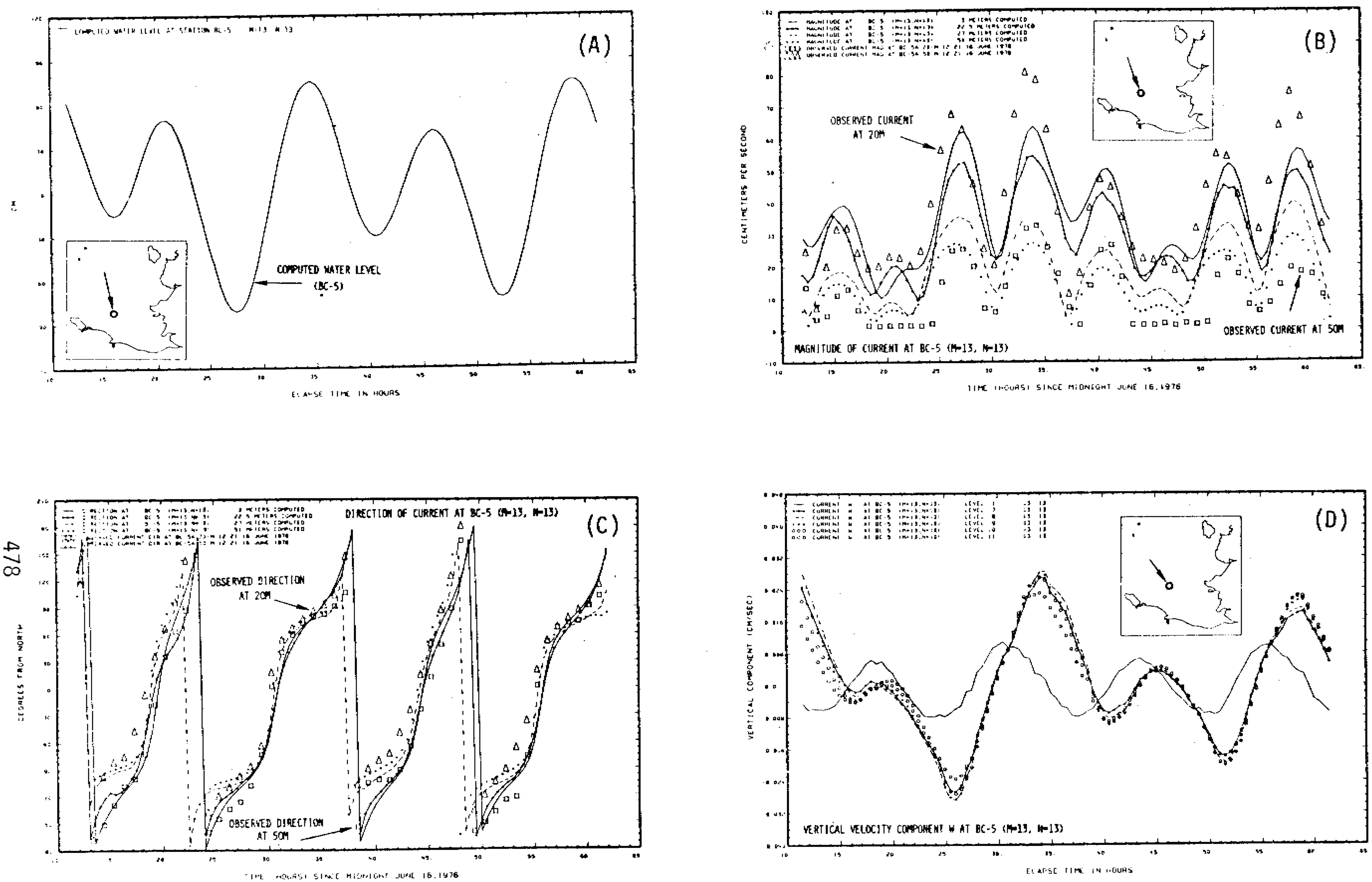



Fig. 2 --Comparison between the computed and the observed current speed and direction (B and C) together with the local water level (A) and vertical velocity component at six selected levels (D) during the period 0000 16 June through 1400 18 June 1976

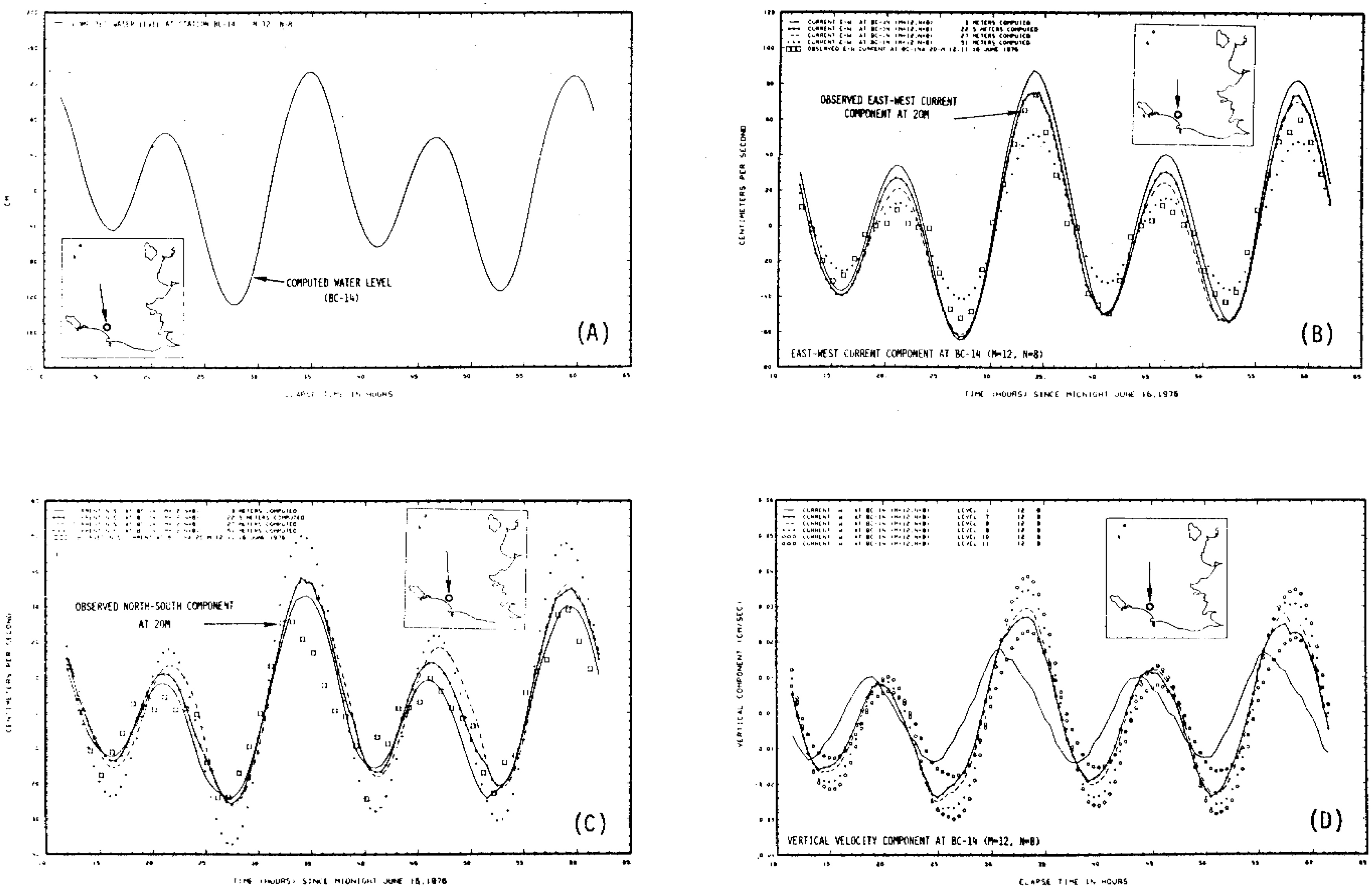



Fig. 3 --Comparison between the computed and the observed current components at a given location (B and C) together with the local water level (A) and vertical velocity component at six selected levels (D) during the period 0000 hr 16 June through 1400 18 June 1976.

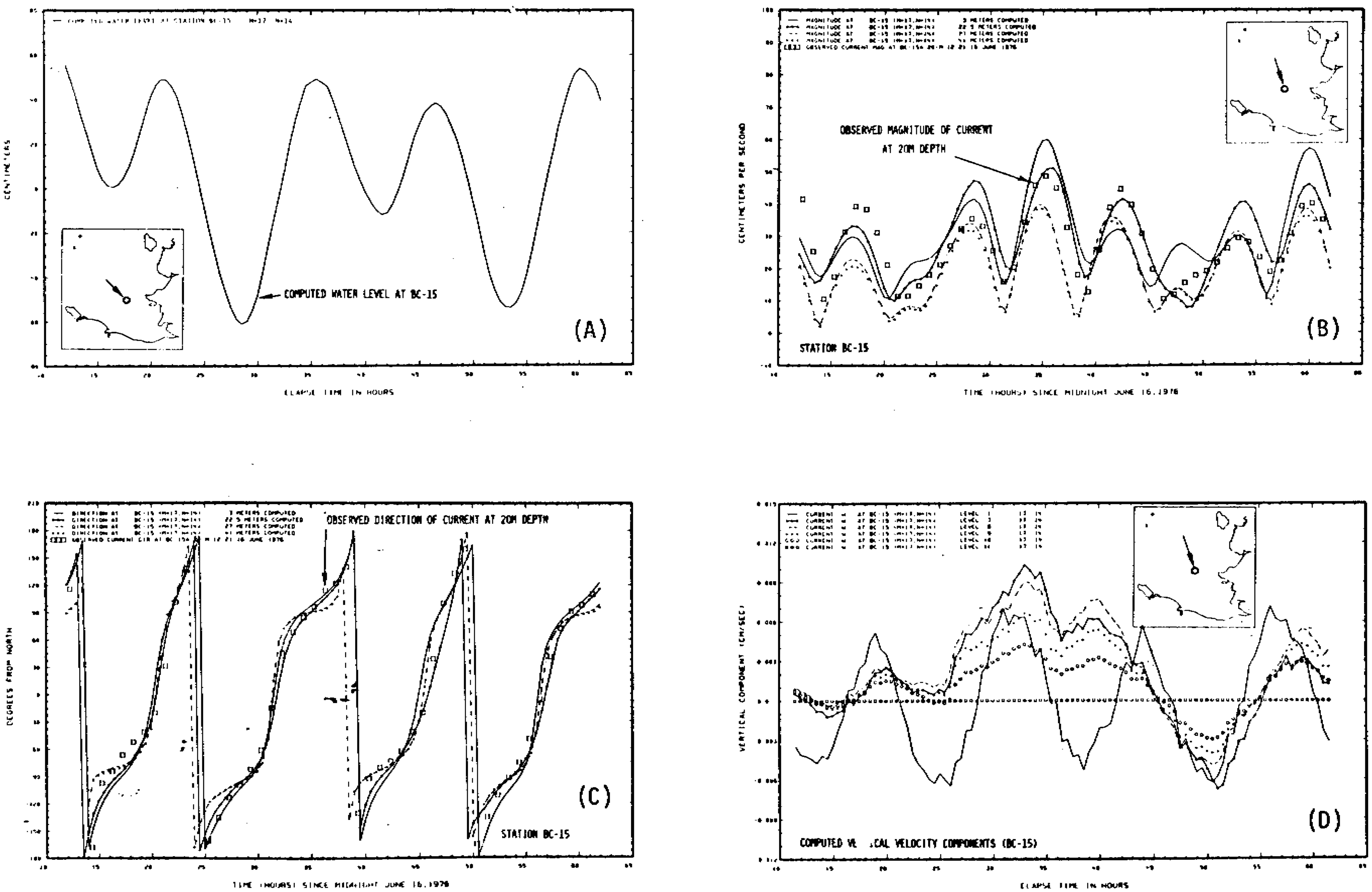



Fig. 4 --Comparison between the computed and the observed current speed and direction (B and C) together with the local water level (A) and vertical velocity component at six selected levels (D) during the period 0000 16 June through 1400 18 June 1976.

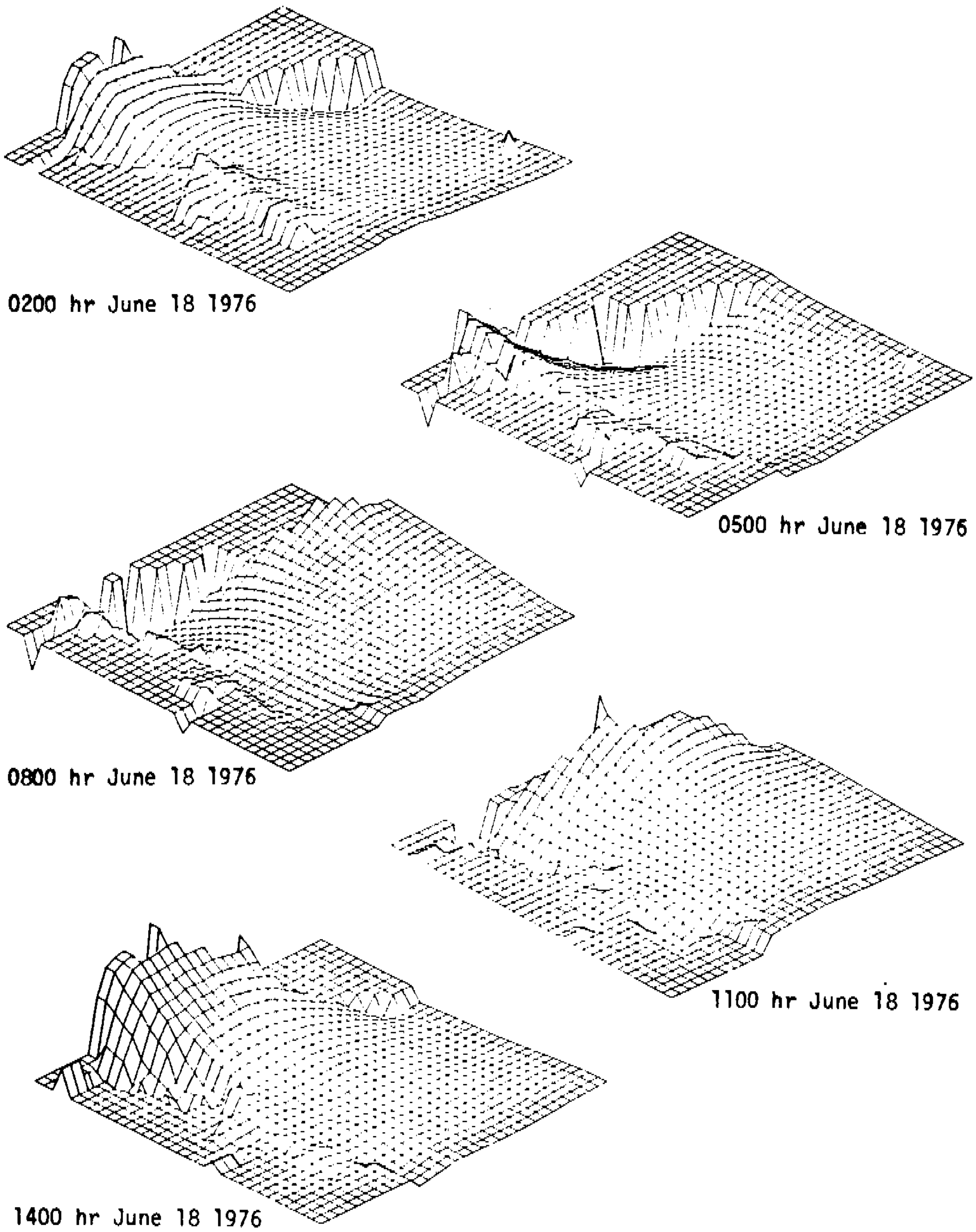



Fig. 5 Three-dimensional plots of the computed water surface movement in the modeled area during a 12-hour period in the verification run. Higher tidal harmonics superimposed on the principal lunar and solar components are evident.

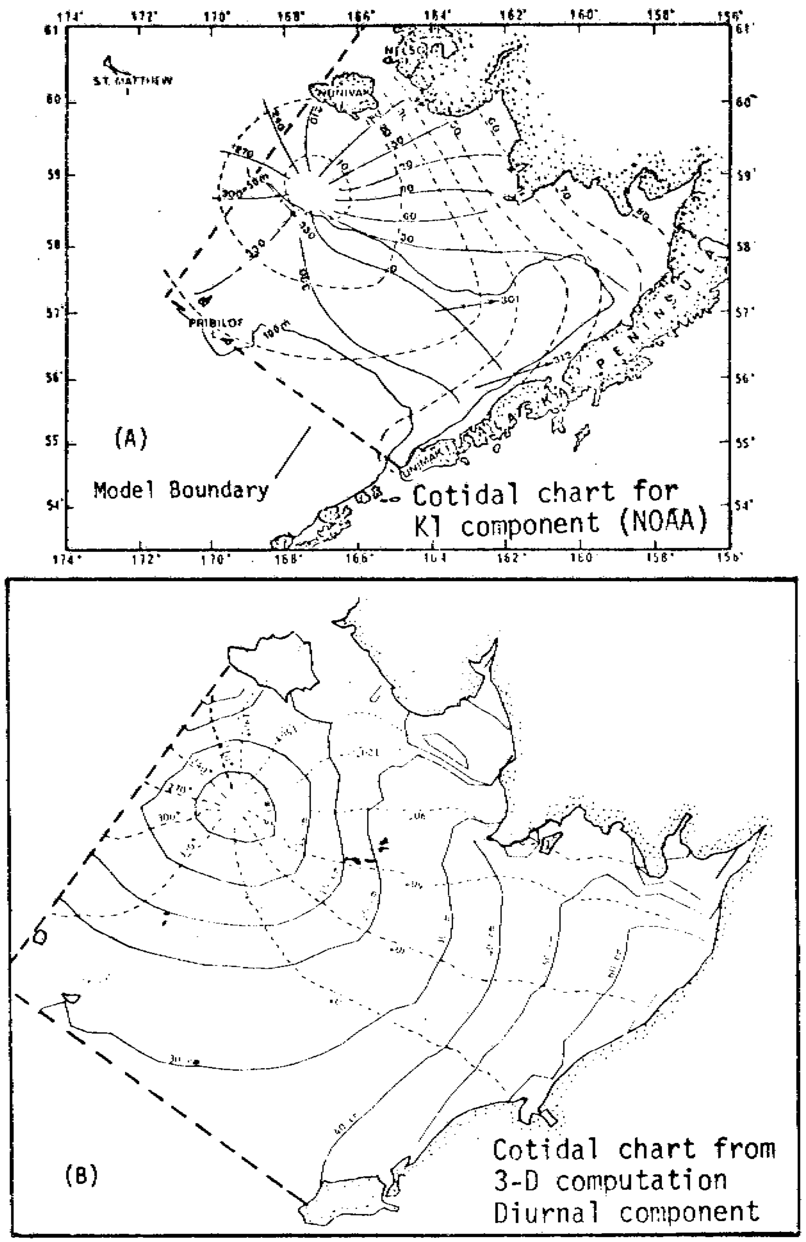

ST. MATTHEW I.
NUNIVAK
NELSON
PRIBILOF
100m
UNIMAK I.
ALASKA PENINSULA
(A)
Model Boundary
Cotidal chart for
K1 component (NOAA)
(B)
Cotidal chart from
3-D computation
Diurnal component

Fig. 6

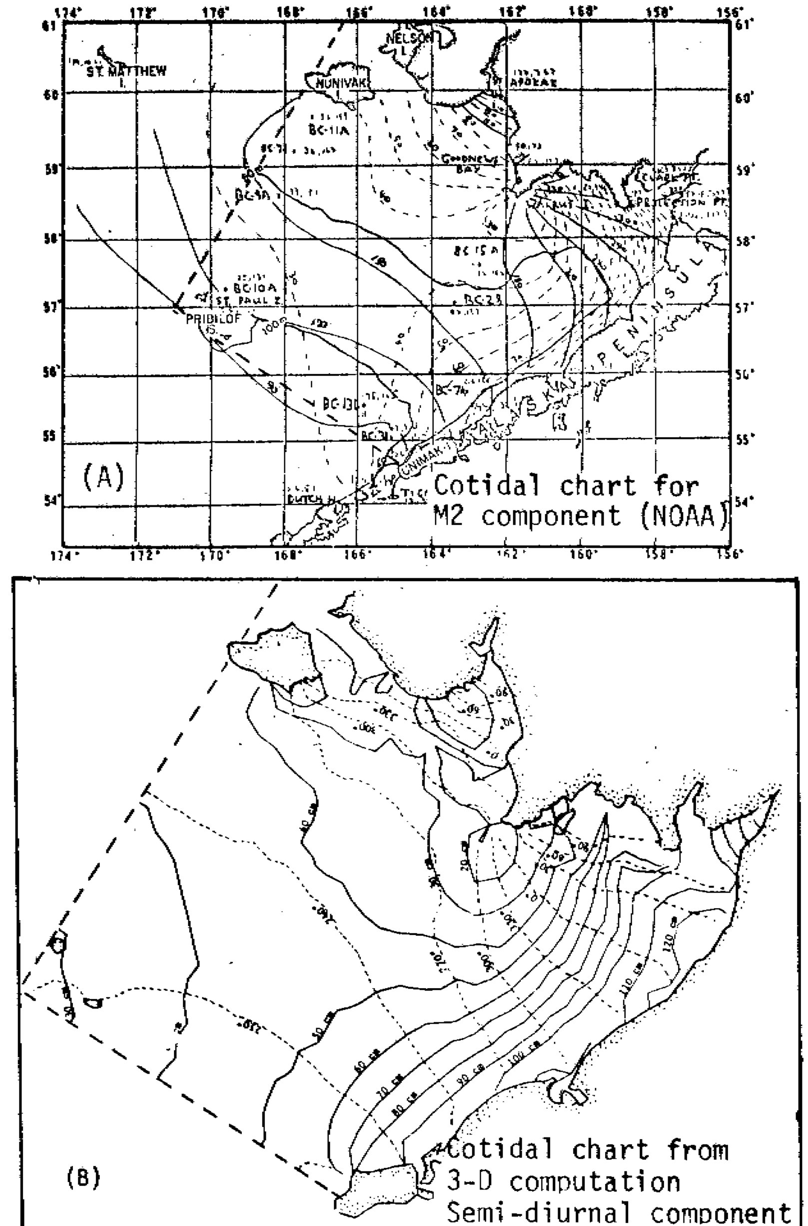

ST. MATTHEW I.
NUNIVAK
NELSON I.
APOKAK
GOODNEWS BAY
CAPE PEIRCE
PRIBILOF IS.
ST. PAUL
DUTCH H.
UNIMAK I.
ALASKA PENINSULA
(A)
Cotidal chart for
M2 component (NOAA)
(B)
Cotidal chart from
3-D computation
Semi-diurnal component

Fig. 7

QUARTERLY REPORT

Contract: 03-5-022-67 TO 13
Research Unit: 519
Reporting Period 1 July - 30 September 1978
Number of Pages: 3

# COASTAL METEOROLOGY OF THE ALASKAN ARCTIC COAST

Eric Leavitt
Research Scientist

Polar Science Center
Division of Marine Resources
University of Washington
Seattle, Washington 98195

1 October 1978

## I. Task Objectives

The objectives of this program are to measure and model mesoscale processes in the surface winds of the Beaufort Sea Coast. Any attempt to understand oceanic circulation and resultant pollutant trajectories must include a description of air stress forcing by the surface winds.

## II. Field and Laboratory Activities

### A. Field Trip Schedule

A field trip was taken from 14 July to 3 September 1978.

### B. Scientific Party

The scientific party consisted of R. Andersen of the Polar Science Center, University of Washington.

### C. Methods

Wind speed, wind direction, and temperature at 10 meters were measured by MRI model 701 recording weather stations. Atmospheric pressure was recorded by Weather Measure B211 microbarographs calibrated by Negretti and Zambra Precision Digital Barometers.

### D. Sample locations and E. Data Collected

1. Wind speed, wind direction and temperature at 10 meters
   a) Milne Point, 17 July to 31 August 1978
   b) Cottle Island, 20 July to 31 August 1978
   c) Cross Island, 20 July to 28 July and 14 August to 2 September 1978

2. Atmospheric pressure
   a) Deadhorse (FAA Tower), 19 July to 1 September 1978
   b) Milne Point, 18 July to 1 September 1978
   c) Oliktok, 22 July to 1 September 1978
   d) Umiat, 21 July to 1 September 1978

## III. Results

A. 1978 atmospheric data is now being reduced.

B. Sea breeze process modeling is continuing.

C. Spectrum analysis is being applied to data from the 1976 and 1977 field seasons.

IV. Preliminary Interpretation of Results

The sea breeze model has been modified in 4 major ways:

A. Second order perturbations terms arise from the horizontal advection expression in the momentum equations are now included.

B. A variable boundary layer has been added through adjustment of the eddy diffusivity terms.

C. Sub-grid scale motion is simulated by spatial filtering.

D. A synoptic wind field from the east or west can be introduced at any time during the model run.

The above modifications have resulted in a better comparison of measured 10 meter winds to model winds and have shown that the sea breeze influence is essentially confined to a coastal zone of $\pm 30$ km on each side of the shore.

V. Problems Encountered and Recommended Changes

Much of the data continuity of the 1978 field program is due to bush pilot Jim Helmricks and his Cessna 206 floatplane. He is the most available, dependable, and safest pilot on the North Slope.

VI. Estimate of Funds Expended

As of 1 October 1978, expenditures under this contract will come to $43,615 out of an allocation of $51,914.

QUARTERLY REPORT

Contract #: 03-5-022-55
Research Unit #: 526-77
Task Order #: 13
Reporting Period: 7/1/78 - 9/30/78
Number of Pages: 4

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

J.B. Matthews
Associate Professor of Marine Science
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

September 30, 1978

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter ending September 30, 1978

Project Title: Characterization of the Nearshore Hydrodynamics of an Arctic Barrier Island-Lagoon System

Contract Number: 03-5-022-55

Task Order Number: 13

Prinicipal Investigator: J. B. Matthews

I. Task Objectives:

A. To review estuarine lagoon hydrodynamics

B. Summarize knowledge of Simpson Lagoon.

C. Produce numerical predictions of Simpson Lagoon circulation under various environmental conditions.

D. Plan and execute a field program to verify the numerical model computations.

E. Produce circulation, flow and water quality estimates for use by ecological modeling group.

II. Field or Laboratory Activities:

A. Ship or Field Schedule:

1. 21 July 1978-29 July 1978 Prudhoe Bay
2. 28 August 1978-25 September 1978 Prudhoe Bay
3. 20 September 1978-22 September 1978 Prudhoe Bay

B. Scientific Party:

1. Kee Soo Nam
J. B. Matthews
Garry Meltvedt

2. Garry Meltvedt
Stuart Rawlinson

3. Stuart Rawlinson
Carol Baron

C. Methods:

A new technique of helicopter deployment of tide gauge and current meter instrument packages during the open water season and their subsequent recovery was successfully attempted. One frame previously deployed through the ice was located using an underwater pinger location system. The instruments were recovered from this frame and replaced by divers and surface marker buoys attached to aid the recovery at the end of the open-water season.

All deployments used the pipe frames tried during the previous field season. Pinger locators and protective zinc anodes were used in all cases. The frames are ideal for the shallow waters of Simpson Lagoon where conventional taut wire moorings are impossible to use and where even shallow draft ships cannot ply.

Location of instruments was determined to give as much information as possible on the flow of water along the arctic coast in the open water season and to determine water flow in and out of the Simpson Lagoon. An array off Milne Point was deployed for coordinated work with Dr. Naidu's (RU 529) sediment dynamics work and Dr. Mungall's (RU 531) continuous monitoring work. Dr. Kozo and Leavitt (RU 519) coordinated meteorological data stations for maximum benfit to our work.

D. Sample Localities:

Instrument locations are shown in figure 1. The array at SIM 29C (Egg Island Channel) was serviced and maintained. 10 current meters and 6 tide gauges were operated in the open water season at the 11 sites shown.

E. Data Collected or Analyzed:

Data tapes were recovered from all instruments. Data previously recovered from SIM 29C for the period 13 May-26 May 1978 has been edited.

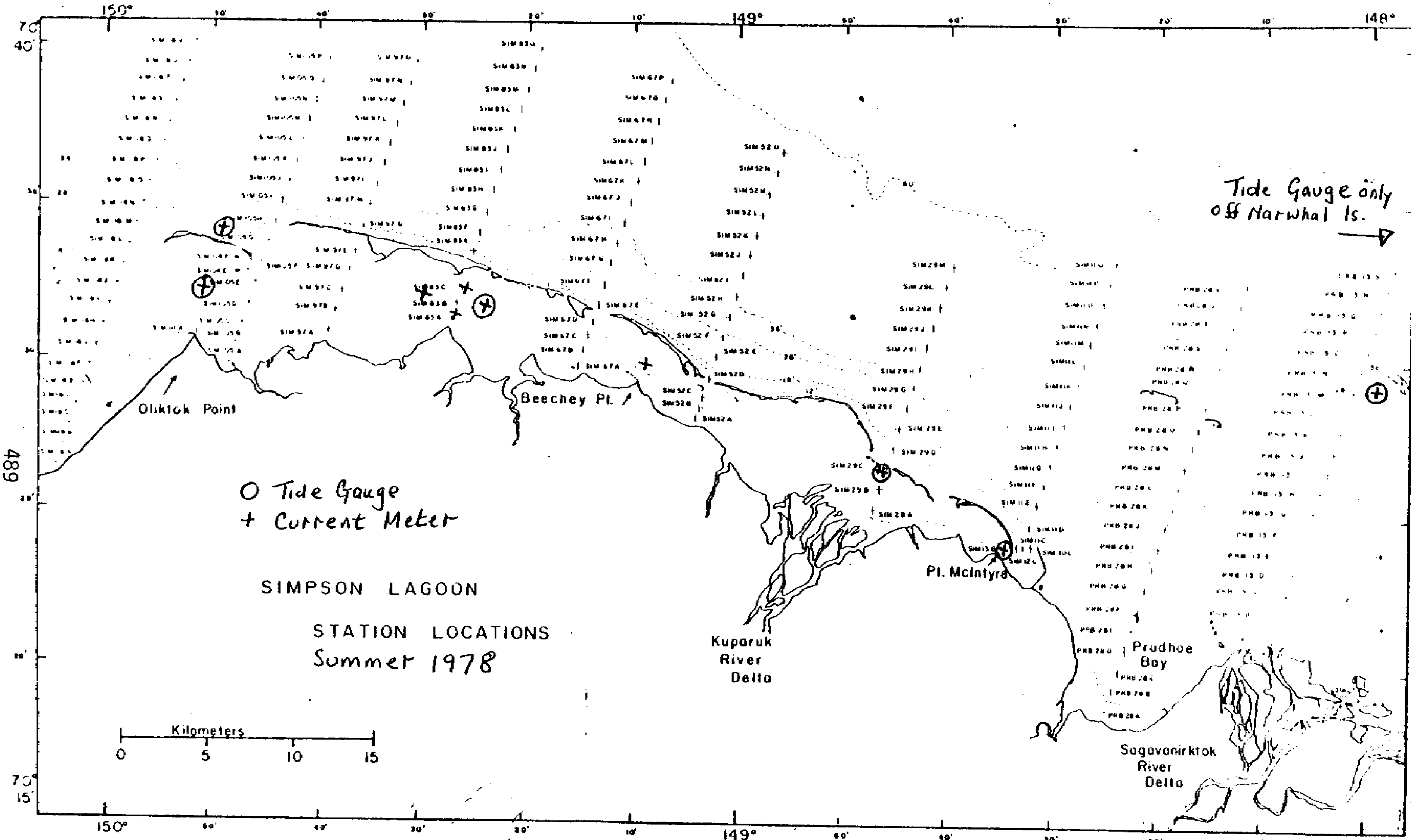



FIGURE 1. RU526 Instrument location Summer 1928

Some bad data were removed from the first part of the record.

III. Results:

Preliminary analysis indicates that the salinity in Egg Island Channel fell steadily from 43.5% on 13 May to 34% on 8 June when the Kuparuk River appeared to overflow. The water temperature was steady near -2.0°C until 8 June when it rose to 0°C. The current sensor was not working for much of the period. Dr. Matthews and Mr. Meltvedt, when they dived on the instrument, on 26 July 1978, found a pebble on top of the rotor. The rotor began turning when it was removed. It is assumed that the pebble was deposited during the spring overflow from the Kuparuk River. Data from the other instruments are not available at this time.

IV. Preliminary Interpretation of Results:

No conclusions can be drawn from the data at present since it is not analyzed for most of the instruments. However the Egg Island channel data suggests that unusually high salinity and low temperatures persist throughout the lagoon to the barrier islands until flushed by the river runoff.

V. Problems Encountered/Recommended Changes:

Helicopter deployment and recovery of instrument packages proved to be highly successful. Help was received from LGL scientists in recovering one array. Divers had to be used to locate and recover another array which became tangled by its locator buoy on a passing ice floe. It is recommended that further use be made of helicopters and divers rather than ships in similar operations.

VI. Estimate of Funds Expended:

All funds are expended. There may be a small cost overrun resulting from a larger field program than anticipated.

QUARTERLY REPORT

Contract: #03-5-022-56
Research Unit: #529-77
Task Order: #33
Reporting Period: 7/1/78-9/30/78
Number of Pages: 8

# SEDIMENT CHARACTERISTICS, STABILITY, AND ORIGIN OF THE BARRIER ISLAND-LAGOON COMPLEX, NORTH ARCTIC ALASKA

A. S. Naidu
Principal Investigator
Assistant Professor in Marine Science

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

September 1978

## TABLE OF CONTENTS


I. TASK OBJECTIVES. . . . . . . . . . . . . . . . . . . . . . . . . 1

II. LABORATORY ACTIVITIES. . . . . . . . . . . . . . . . . . . . . 1

Analytical Methods . . . . . . . . . . . . . . . . . . . . . 2

III. RESULTS. . . . . . . . . . . . . . . . . . . . . . . . . . . 2

IV. DISCUSSION . . . . . . . . . . . . . . . . . . . . . . . . . 2

Comments . . . . . . . . . . . . . . . . . . . . . . . . . 3

REFERENCES . . . . . . . . . . . . . . . . . . . . . . . . . 4


## LIST OF TABLES


TABLE I. Statistical grain size parameters (after Folk and Ward, 1957) of the Simpson Lagoon bottom sediments. Data revised since Annual Report, March 1978. . . . . . . . . 5

TABLE II. Concentrations (μg/g) of iron, manganese and zinc in acetic acid-hydroxylamine hydrochloride extracts (Chester & Hughes, 1967) of Simpson Lagoon bottom sediments. . . . . . . . . . . . . . . . . . . . . . . . 7

TABLE III. Concentrations (μg/g) of iron, manganese, zinc and copper in acetic acid-hydroxylamine hydrochloride extracts (Chester & Hughes, 1967) of Beaufort Sea bottom sediments . . . . . . . . . . . . . . . . . . . . 8

## I. TASK OBJECTIVES

The primary objective of this program is to collect all basic data on the size distribution, mineralogy, and certain biologically "critical" chemical attributes of sediments of the barrier island-lagoon complex of north arctic Alaska. In addition, research is being directed to assess the long-term directions of alongshore transport of sediments along the Beaufort Sea coast. The other objective of this program is to collect lithological and chemical baseline data from the contiguous area of the continental shelf of the Beaufort Sea. The chief purpose of this latter effort will be to fill in the small data gaps that exist on shelf sediments, principally between Barter Island and Demarcation Point.

## II. LABORATORY ACTIVITIES

Considerable portion of our time during the latter two months of the quarter concerning this report was spent in making preparations for the summer field season, and collecting additional field data from the Simpson Lagoon area and in the Beaufort Sea (refer to the Field and Cruise Report - Summer 1978, submitted separately to the OCSEAP Office). In July 1978, laboratory work included analysis of manganese and zinc concentrations on Simpson Lagoon sediment extracts. Additionally, iron, manganese, zinc and copper concentrations were analyzed on extracts of sediments from the continental shelf and slope and abyssal region of the Beaufort Sea.

The entire grain size distribution data pertaining to the Simpson Lagoon sediments submitted by us earlier to OCSEAP (refer to Naidu's Annual Report, March 1978) had to be revised, because of certain errors incorporated in the computer program.

An updated station location map has been prepared on the OCSEAP supplied base map for the Beaufort Sea. We are in the process of plotting individually all textural, mineralogical and chemical baseline data on the above base map.

### Analytical Methods

The sediment extracts are assumed to represent the 'readily mobilized' chemical fractions from sediments, and were obtained following the technique elaborated by Chester and Hughes (1967). The heavy metal analysis on the extracts were accomplished by atomic absorption spectrophotometry, using a Perkin-Elmer 603 unit.

## III. RESULTS

The revised data on statistical grain size parameters of Simpson Lagoon bottom sediments are presented in Table I. This revised data are being simultaneously submitted to Mr. Ray Hadley of the OCSEAP Data Processing Office, Fairbanks, for his onward action.

The concentrations of the various metals analyzed in sediment extracts of the Simpson Lagoon and Beaufort Sea sediments are shown in Tables 2 and 3.

## IV. DISCUSSION

It would seem that the relatively higher concentrations of manganese and zinc in the sediment extracts of the Beaufort Sea are related to the possible lower rate of sedimentation in the open sea and/or to the generally more finer nature of sediment particles, as compared to the Simpson Lagoon sediments. Some of these possibilities are being examined in detail and will be discussed in a later report.

Comments

As mentioned in the Field and Cruise Report - Summer 1978, our main effort in the field was directed to the collection of data complementary to the Sediment Dynamics Sphere (SDS) experiment in the Simpson Lagoon. However, at this point in time we have no idea how successful the experiment was. It is to be noted that the SDS instrumented package on the tripod was toppled over, and possibly also dragged, during the operation involving positioning the tripod in the Simpson Lagoon. The stabilizing anchors of the R/V *Natchik* accidentally caught the tripod's ground line, as the vessel was moving out after emplacing the tripod in the lagoon water. In case no data or limited data have been gathered on the SDS, as a consequence of this accident, it is strongly recommended by us that the tripod experiment be repeated in 1979 summer. Needless to emphasize that without adequate data on sediment dynamics and related hydrodynamic parameters, it would be most difficult to predict impacts of anthropogenic activities that may result in changes in sediment budgets and implication of the latter on modification of the lagoon ecosystem.

## REFERENCES

Chester, R. and M. J. Hughes. 1967. A chemical technique for the separation of ferro-manganese minerals, carbonate minerals and absorbed trace elements from pelagic sediments. *Chemical Geol.* 2:249-262.

Folk, R. L. and W. C. Ward. 1957. Brazos River bar - a study in the significance of grain size parameters. *J. Sedimentary Petrology* 27:3-26.

TABLE I

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

Data revised since March 1978. Refer to RU #529-77 Annual Report (March 1978) for sample locations

| Sample # | Depth (m) | % gravel | % sand | % silt | % clay | Md | $M_z$ | $\sigma_I$ | $Sk_I$ | $K_G$ |
|---|---|---|---|---|---|---|---|---|---|---|
| SL877-1A | 1.5 | - | 80.6 | 14.5 | 4.9 | 2.3 | 2.8 | 1.6 | .70 | 3.6 |
| 1B | 1.5 | - | 88.9 | 6.6 | 4.4 | 2.2 | 2.3 | 1.2 | .39 | 4.6 |
| 1C | 1.5 | - | 86.9 | 8.2 | 4.9 | 2.3 | 2.3 | 1.2 | .41 | 4.7 |
| 1D | 1.5 | - | 83.4 | 10.2 | 6.5 | 2.3 | 2.75 | 1.8 | .69 | 5.6 |
| 1E | 1.5 | - | 82.5 | 12.0 | 5.5 | 2.3 | 2.75 | 1.7 | .67 | 4.6 |
| 2 | 1.8 | - | 93.0 | 3.3 | 3.7 | 1.8 | 1.7 | 1.2 | .28 | 3.3 |
| 3 | 2.6 | - | 35.0 | 45.2 | 19.8 | 4.6 | 5.3 | 3.2 | .32 | 0.86 |
| 4 | 2.1 | - | 19.4 | 56.5 | 24.1 | 5.5 | 6.1 | 2.9 | .30 | 1.1 |
| 5A | 1.8 | - | 35.2 | 52.8 | 12.0 | 4.3 | 4.8 | 2.3 | .46 | 1.4 |
| 5B | 1.8 | - | 48.9 | 37.1 | 14.0 | 4.0 | 4.7 | 2.5 | .51 | 1.4 |
| 5C | 1.8 | - | 44.4 | 42.0 | 13.6 | 4.1 | 4.85 | 2.4 | .54 | 1.3 |
| 5D | 1.8 | - | 48.9 | 38.6 | 12.5 | 4.0 | 4.7 | 2.4 | .52 | 1.5 |
| 6 | 2.0 | - | 31.8 | 51.0 | 17.2 | 4.6 | 5.2 | 2.8 | .33 | 1.2 |
| 7 | 0.9 | 13.3 | 78.9 | 3.7 | 4.1 | 2.1 | 1.5 | 2.3 | -.44 | 2.2 |
| 8 | 0.3 | 3.2 | 71.0 | 17.3 | 8.5 | 2.65 | 2.8 | 2.8 | .18 | 2.25 |
| 9 | 1.5 | - | 24.7 | 54.9 | 20.4 | 5.5 | 5.9 | 2.9 | .27 | 1.2 |
| 11 | 2.1 | - | 15.7 | 65.9 | 18.4 | 4.8 | 5.8 | 2.65 | .52 | 1.5 |
| 12 | 2.1 | - | 30.6 | 52.6 | 16.8 | 4.3 | 5.3 | 2.7 | .52 | 1.6 |
| 13 | 2.4 | - | 7.7 | 79.5 | 12.8 | 4.8 | 5.5 | 2.0 | .58 | 1.9 |
| 14 | 2.3 | - | 38.3 | 47.6 | 14.1 | 4.4 | 4.8 | 2.7 | .30 | 1.2 |
| 15 | 1.8 | 2.2 | 72.7 | 13.0 | 12.1 | 2.3 | 3.5 | 3.1 | .61 | 1.9 |
| 17 | 0.6 | 8.7 | 67.0 | 15.0 | 9.2 | 2.1 | 2.6 | 3.4 | .22 | 2.9 |
| 18 | 0.5 | - | 54.7 | 31.0 | 14.3 | 3.4 | 4.5 | 2.7 | .65 | 1.2 |
| 19 | 3.2 | - | 67.4 | 23.4 | 9.2 | 2.7 | 3.5 | 2.0 | .81 | 1.7 |
| 20 | 2.6 | - | 85.2 | 9.0 | 5.8 | 2.5 | 2.7 | 1.2 | .71 | 6.8 |
| 21A | 2.9 | - | 17.0 | 59.6 | 23.4 | 5.6 | 6.3 | 2.8 | .36 | 1.1 |
| 21B | 2.9 | - | 16.5 | 61.9 | 21.6 | 5.6 | 6.1 | 2.7 | .32 | 1.2 |
| 21C | 2.9 | - | 22.1 | 59.5 | 18.4 | 5.1 | 5.6 | 2.6 | .31 | 1.2 |
| 21D | 2.9 | - | 18.0 | 62.6 | 19.4 | 5.3 | 5.9 | 2.7 | .33 | 1.3 |
| 22 | 2.4 | - | 11.0 | 75.4 | 13.6 | 4.8 | 5.5 | 2.0 | .60 | 1.6 |
| 23 | 2.4 | - | 24.8 | 61.3 | 13.9 | 5.0 | 5.05 | 2.7 | .12 | 1.8 |
| 24 | 1.5 | - | 71.8 | 19.0 | 9.2 | 2.55 | 3.4 | 2.7 | .53 | 1.7 |
| 25A | 2.6 | - | 63.8 | 26.1 | 10.1 | 2.4 | 3.5 | 2.6 | .71 | 1.05 |
| 25B | 2.6 | - | 66.8 | 24.8 | 8.4 | 2.3 | 3.4 | 2.65 | .72 | 1.2 |
| 25C | 2.6 | - | 61.9 | 27.1 | 11.0 | 2.6 | 3.7 | 2.7 | .67 | 1.0 |

TABLE I

CONTINUED

| Sample # | Depth (m) | % gravel | % sand | % silt | % clay | Md | $M_z$ | $\sigma_I$ | $Sk_I$ | $K_G$ |
|---|---|---|---|---|---|---|---|---|---|---|
| SL877-26 | 2.9 | - | 20.3 | 66.7 | 13.0 | 4.2 | 5.2 | 2.1 | .75 | 1.5 |
| 27 | 3.0 | - | 19.8 | 64.3 | 15.9 | 4.4 | 5.3 | 2.4 | .62 | 1.4 |
| 28 | 2.7 | - | 14.3 | 64.9 | 20.8 | 5.2 | 6.0 | 2.5 | .52 | 1.1 |
| 29 | 2.4 | - | 22.3 | 57.3 | 20.4 | 5.1 | 5.7 | 3.0 | .31 | 1.2 |
| 30 | 1.1 | - | 78.2 | 18.1 | 3.7 | 2.0 | 2.5 | 1.65 | .47 | 1.3 |
| 31 | 2.6 | - | 10.5 | 64.2 | 25.3 | 6.0 | 6.6 | 2.7 | .32 | 1.1 |
| 32A | 2.3 | - | 32.6 | 48.3 | 19.1 | 5.2 | 5.3 | 3.0 | .16 | 0.84 |
| 32B | 2.3 | - | 16.6 | 58.9 | 24.5 | 6.45 | 6.4 | 2.8 | .02 | 1.2 |
| 32C | 2.3 | - | 26.2 | 53.6 | 20.2 | 5.6 | 5.6 | 3.05 | .11 | 0.96 |
| 32D | 2.3 | - | 33.6 | 48.5 | 17.9 | 5.3 | 5.3 | 3.0 | .12 | 0.83 |
| 33 | 2.1 | - | 49.2 | 34.0 | 16.8 | 4.3 | 4.8 | 3.0 | .34 | 0.83 |
| 34 | 1.5 | - | 98.2 | 0.75 | 1.1 | 2.0 | 2.0 | .61 | .13 | 1.0 |
| 35 | 2.0 | - | 44.2 | 39.4 | 16.4 | 4.5 | 5.1 | 2.75 | .41 | 0.98 |
| 36 | 2.1 | - | 39.4 | 44.0 | 16.6 | 4.7 | 5.05 | 2.8 | .29 | 0.85 |
| 37 | 2.3 | - | 37.7 | 47.6 | 14.7 | 4.5 | 4.9 | 2.7 | .30 | 1.0 |
| 38 | 2.3 | - | 26.2 | 53.8 | 20.0 | 5.0 | 5.4 | 3.1 | .22 | 1.1 |
| 39 | 2.0 | - | 35.5 | 43.0 | 21.5 | 4.8 | 5.2 | 3.5 | .18 | 0.90 |
| 40 | 1.5 | - | 69.2 | 17.3 | 13.5 | 2.5 | 3.7 | 2.9 | .64 | 1.8 |
| UG-1 | 0.8 | - | 56.4 | 28.5 | 15.1 | 3.4 | 4.4 | 3.0 | .55 | 1.5 |

TABLE II

CONCENTRATIONS OF IRON, MANGANESE AND ZINC IN ACETIC ACID-HYDROXYLAMINE HYDROCHLORIDE EXTRACTS (CHESTER & HUGHES, 1967) IN SIMPSON LAGOON SEDIMENTS

Refer to RU #529-77 Annual Report for station locations

| Sample # | Iron µg/g | Manganese µg/g | Zinc µg/g |
|---|---|---|---|
| SL877-1 | 1100 | 56 | 11 |
| 2 | 1400 | 94 | 8 |
| 3 | 3400 | 250 | 32 |
| 4 | 6000 | 364 | 37 |
| 5 | 2700 | 180 | 28 |
| 6 | 2700 | 210 | 39 |
| 8 | 1200 | 113 | 23 |
| 9 | 3100 | 360 | 31 |
| 11 | 2700 | 120 | 44 |
| 13 | 4100 | 326 | 68 |
| 14 | 3300 | 228 | 33 |
| 15 | 1800 | 136 | 37 |
| 17 | 1600 | 116 | 25 |
| 18 | 3200 | 55 | 38 |
| 19 | 1500 | 53 | 16 |
| 21 | 4300 | 181 | 30 |
| 22 | 4150 | 159 | 26 |
| 24 | 1100 | 60 | 20 |
| 25 | 2650 | 86 | 26 |
| 27 | 3400 | 158 | 50 |
| 28 | 6850 | 105 | 21 |
| 29 | 3500 | 135 | 67 |
| 30 | 800 | 49 | 8 |
| 31 | 3400 | 163 | 30 |
| 32 | 2400 | 212 | 29 |
| 33 | 2400 | 212 | 24 |
| 37 | 2850 | 96 | 40 |
| 38 | 2650 | 79 | 24 |
| 40 | 550 | 61 | 21 |
| Average | 2800 | 152 | 31 |

TABLE III

CONCENTRATIONS OF IRON, MANGANESE, ZINC AND COPPER IN ACETIC ACID-HYDROXYLAMINE HYDROCHLORIDE EXTRACTS (CHESTER & HUGHES, 1967)

Refer to RU #529-77 Annual Report for station locations

| Sample # | Depth (m) | Iron $10^4$ x μg/g | Manganese μg/g | Zinc μg/g | Copper μg/g |
|---|---|---|---|---|---|
| GLA77-$5_1$ | 3593 | 97 | 4400 | 32 | 22 |
| $5_2$ | 3593 | 109 | 4500 | 34 | 24 |
| $5_3$ | 3593 | 98 | 4550 | 33 | 22 |
| 7 | 3566 | 89 | 2800 | 31 | 20 |
| 8 | 2048 | 94 | 4950 | 30 | 15 |
| 12 | 22 | 35 | 139 | 22 | 6 |
| 15 | 54 | 50 | 440 | 25 | 10 |
| 17 | 51 | 60 | 340 | 29 | 9 |
| 18 | 80 | 36 | 515 | 16 | 5 |
| 19 | 146 | 39 | 178 | 28 | 8 |
| 22 | 32 | 41 | 160 | 21 | 7 |
| 23 | 109 | 52 | 344 | 34 | 13 |
| 24 | 51 | 34 | 378 | 14 | 5 |
| 25 | 38 | 27 | 126 | 16 | 5 |
| 26 | 20 | 30 | 119 | 15 | 5 |
| 30 | 1829 | 85 | 13100 | 26 | 10 |
| 31 | 28 | 36 | 148 | 19 | 6 |
| 32 | 42 | 27 | 137 | 18 | 6 |
| 40 | 24 | 79 | 309 | 28 | 8 |
| 42 | 149 | 30 | 77 | 22 | 5 |
| Averages of shelf (< 65 m) sediments | | 42 | 230 | 21 | 8 |

FIELD AND CRUISE REPORT - SUMMER 1978

Contract #03-5-022-56
Research Unit #529-77
Task Order: 33
Reporting Period: 7/30/78-9/4/78
Number of Pages: 10

# SEDIMENT CHARACTERISTICS, STABILITY, AND ORIGIN OF THE BARRIER ISLAND-LAGOON COMPLEX, NORTH ARCTIC ALASKA

A. S. Naidu
Principal Investigator
Assistant Professor of Marine Science

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

October 1, 1978

# I. INTRODUCTION

The 1978 field season was started on July 30, 1978, and came to a close on September 4, 1978. The field program was divided into two phases. The primary task during the first phase was to supervise and assist emplacement of the instrumented package of the Sediment Dynamics Sphere (SDS) in the Simpson Lagoon, as well as to collect periodic water and sediment samples from the experimental site. This latter work relates to our study of sediment dynamics in the Simpson Lagoon area, which is being pursued under a separate subcontract from Naidu (R.U. 529) to Dr. L. H. Larsen of the University of Washington (Seattle). Milne Point was the site of the base camp for the above operations.

The second phase of the field work consisted of participation by A. S. Naidu in the ice-breaker cruise of the USCGC *Northwind* in the Beaufort Sea.

## Personnel

The following table indicates the period of time spent by various personnel at different field operations during summer 1978.

| Personnel | Dates | Base of Operation |
|---|---|---|
| A. S. Naidu | 7/31 to 8/2, 1978 | Helmerick's Camp |
| A. S. Naidu and J. G. Clough | 8/2 to 8/17, 1978 | Milne Point, Simpson Lagoon |
| J. M. Haney | 8/15 to 8/17, 1978 | USCGC *Northwind* |
| A. S. Naidu | 8/17 to 8/25, 1978 | USCGC *Northwind* |
| J. M. Haney | 8/17 to 9/4, 1978 | Milne Point |
| L. Larsen* | 8/5 to 8/10, 1978 | Milne Point |
| G. Peterson* | 8/5 to 8/12, 1978 | Milne Point |

*Participants from the University of Washington, Seattle; R. U. 529 Subcontractors.

## II. SAMPLES, SAMPLE LOCATION, AND FIELD OPERATIONS DURING PHASE I

In continuation of our geological-geochemical program relating to the Simpson Lagoon and adjacent marine environment, water samples from four locations each from the Colville and Kuparuk Rivers were collected to study the nature of terrigenous input. Additionally, representative lagoon water samples were collected from a number of stations in the Simpson Lagoon. The stations for the latter collection were established along four transects across the width of the lagoon, between Oliktok and Beechy Points. All these water samples were filtered within a few hours after collection through Nuclepore filtering pads, using a vacuum pump and a glass filtering unit. The filtered waters were preserved in 10% Ultrex $HNO_3$ acid medium for a suite of heavy metal analysis by Dr. H. V. Weiss of NOSC (San Diego). Dr. Weiss participated in all fluvial and part of the lagoon sample collection. Jim Helmerick's camp on the Colville Delta was used as the base camp for the fluvial sampling.

Our original plan had called for emplacement of the Sediment Dynamics Sphere (SDS) in the Simpson Lagoon on August 5, 1978. However, due to breakdown of the R/V *Alumiak* the SDS experiments could not be started before a week past the scheduled date. The instrumented tripod package was located at a site (Lat. 70° 32.2'N and Long. 149° 27.5'W) off the Milne Point in the Simpson Lagoon in 9 feet of water. The instrument was placed to measure wave-current parameters, record nephelometer and temperature readings, as well as take time-lapse photographs of the substrate bed form from August 11, 1978. The SDS was finally retrieved on September 7, 1978 using an ERA helicopter. The emplacement of the tripod in water with the aid of the R/V *Natchik* was quite cumbersome, and was marred by toppling over of the tripod accidentally as it got caught by one of the stabilizing anchors of the vessel. The tripod was eventually uprighted, but whether the instrumented package and other units satifactorily functioned or not during the duration of the experiment is not known as of this time.

In order to achieve *in situ* field calibration of the nephelometer on the tripod twice a day at some precisely noted time water samples were collected via a Niskin bottle from the tripod experimental site. These water samples were retrieved from the surface and from approximately 1 m water depth - the depth at which the nephelometer was located on the tripod. A one-litre aliquot of each of the water samples was filtered under vacuum through preweighed Nuclepore (pore diameter 0.4 μ) filter membranes. The suspensates thus collected on the pads were stored in a freezer before transfer to Fairbanks.

In attempting to establish criteria, based on ground truth, to estimate the distribution of suspended particles representative samples of surficial waters were collected from several known locations covering the Simpson Lagoon. These sample collections synchronized with the dates of orbital passage of one of the two Landsat Satellites, namely Landsat I and Landsat II, over the Simpson Lagoon region on August 6-7 and August 15-16, 1978. One litre of these water samples were filtered, at the base camp (Milne Point), through preweighed Nuclepore (0.4 μ pore diameter) filter membranes.

Surficial sediment samples of the Simpson Lagoon were collected at six different days from the SDS tripod experimental site. The purpose of this collection was to check the variations in the composition of the bed-load and the current-wave parameters in the Simpson Lagoon. The surficial sediments were retrieved from the top 1.5 cm section of core samples collected by a manual coring unit operated from a Boston Whaler.

Two days were spent in examining the stratigraphy of the tundra bluffs on the Pingok and Bodfish Islands, and collecting rock chips of large boulders on the Bodfish beaches. The latter effort was a continuation of our past attempts to elucidate the sources and mechanism of transport of boulders on the North Slope coast. Samples of mud from a few seemingly 'marker' and continuous horizons within the bluffs were collected. Sedimentological analysis of these mud samples and a detailed study of the boulders would seem to have significant implication in the understanding of the paleogeographic history of the North Slope continental margin region.

Attempts were made to obtain long (>2 m) gravity core samples from the Simpson Lagoon, using a 800-lb coring unit from the R/V *Natchik*. The purpose of this effort was to obtain cores for dating the various horizons by the $^{210}Pb$ method and ultimately estimating the rate of sedimentation in the Simpson Lagoon. The coring operation was not quite successful; it was only possible to retrieve cores of 25 cm maximum length. Because of the presence of stiff underlying clays, the penetration of the gravity corer was limited. However, it would seem that using the $^{210}Pb$ technique we should still be able to obtain some meaningful sedimentation rate data on the short cores. At each station at least two core samples were obtained. One of the samples was preserved in the liner for $^{210}Pb$ dating, while the second one was used to express out interstitial waters at 5 cm core sections. The interstitial waters which were expressed out under nitrogen pressure, were preserved in a freezer until ready for transfer to Fairbanks.

## III. PHASE II OF FIELD WORK (i.e., USCGC *Northwind* Cruise)

The following was the primary objective of the geological-geochemical program in the first phase (August 14-25) of the 1978 cruise of the USCGC *Northwind*:

a. to collect water samples from various depths of the Beaufort Sea, and to separate the suspended particulate matter in the water samples. The investigation on suspended particles constitutes an extension marineward of the mineralogical and chemical studies on similar particles from the Simpson Lagoon and adjacent deltaic regions of the North Slope of Alaska.

b. to collect a few gravity and box core samples in the 'marine facies' of the Colville Delta for the purpose of determining the rate of comtemporary sedimentation in the above area, using the $^{210}Pb$ dating technique. Such samples are considered more suitable than other core types because of their assumed undisturbed nature.

c. to collect water samples at various depths at a station in the continental shelf off the current oil lease area, for the purpose of analyzing a suite of heavy metals. This sample collection was at the request of Dr. Herbert V. Weiss of NOSC, San Diego, and relates to his OCSEAP heavy metal baseline program in the Beaufort Sea.

### Sample Collection and Onboard Processing

A total of 12 stations were occupied in the first phase of the cruise (See Table 1 for station locations and water depths). At each of the stations a set of three water samples were collected. In fact, these samples consisted of 2-litre aliquot splits of water subsamples taken from Dr. Rita Horner's Niskin hydrocast samples. The sampling depths were selected

TABLE I

LOCATIONS AND WATER DEPTHS OF STATIONS OCCUPIED DURING THE FIRST LEG OF THE 1978 USCGC *NORTHWIND* CRUISE IN THE BEAUFORT SEA

| Stations | Longitude W | Latitude N | Water Depth (m) |
|---|---|---|---|
| St. #1 | 150°14' | 71°11' | 45 |
| St. #3 | 149°17' | 70°58.5' | 41 |
| St. #4 | 146°05' | 70°19.8' | 33 |
| St. #5 | 148°20.2' | 70°36.2' | 22 |
| St. #6 | 148°11' | 70°55' | 40 |
| St. #7 | 149°54' | 71°05.5' | 24 |
| St. #8 | 150°52.9' | 71°03.6' | 23 |
| St. #9 | 151°51.3' | 71°11.1' | 29 |
| St. #10 | 152°51' | 71°05' | 23 |
| St. #11 | 152°47.7' | 71°19.8' | 55 |
| St. #12 | 152°41.1' | 71°21.6' | 99 |

arbitrarily. The first, second and third samples were from the 0-5 m, middle and lower-most Niskin hydrocasts, respectively. Each of the 2-litre water samples was filtered through preweighed Nuclepore filter membrane (pore size being 0.4 μm), using a standard vacuum filtering system. After filtration the suspensates on the pads were washed with distilled deionized water to remove any seawater associated with them. To minimize bacterial degradation the filter pads were stored in a freezer. An aliquot of 2-litre, rather than 1-litre, water sample was filtered each time in order to ensure that adequate amounts of suspensates are available for accurate clay mineral as well as organic carbon-nitrogen analyses.

Water samples for heavy metal analysis were collected at a site (70° 58.5'N and 149° 17.0'W) over the Beaufort Sea continental shelf. Again, the set of these three samples were from near the surface (3 m), middle (20 m) and bottommost (35 m) hydrocasts at the above station. Each of the water samples was filtered through specially clean glass filtering units, taking utmost care to avoid metal contamination. The filtered water samples were stored in polybottles to which Ultrex $HNO_3$ acid was added (in the proportion of one part acid and 10 parts water) as a preservant. These samples were shipped to Dr. Weiss from Fairbanks.

In attempting to retrieve suitable core samples for $^{210}Pb$ dating purpose, a series of gravity core samples were taken. However, with the exception at one station none of the gravity core samples were long enough to be suitable for the above dating. Many plastic core liners were lost, presumably because of the relatively stiff nature of the substratum. A core sample of 75 cm was retrieved at a station off the N.E. Colville Delta (71° 00'N and 149° 59.5'W). At this same station an excellent box core sample of 45 cm length was also taken. These two samples should be suitable specimens for $^{210}Pb$ dating. Preliminary examination of the core sample in the plastic liner showed no evidence of bioturbation or ice-gouging reworking. Both the cores have been preserved in the original containers (e.g., plastic liner and stainless steel box), taking all precautions to avoid any possible disturbance of the sediment sequences.

In addition to the above samples, suitable splits of all Smith-McIntyre grab samples collected by Mr. Gene Ruff during the cruise, were provided to us for detailed grain size and organic carbon analyses. To minimize bacterial degradation these sediment samples were preserved in the freezer until departure from the ship.

Excellent cooperation and help was provided by the ship's Officers and crew members. Living quarters were comfortable, but the laboratory space in the ship and at Milne Point was quite limited.

FIELD AND CRUISE REPORT - SUMMER 1978

Contract #03-5-022-56
Research Unit #529-77
Task Order: 33
Reporting Period: 7/30/78-9/4/78
Number of Pages: 10

# SEDIMENT CHARACTERISTICS, STABILITY, AND ORIGIN OF THE BARRIER ISLAND-LAGOON COMPLEX, NORTH ARCTIC ALASKA

A. S. Naidu
Principal Investigator
Assistant Professor of Marine Science

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

October 1, 1978

## I. INTRODUCTION

The 1978 field season was started on July 30, 1978, and came to a close on September 4, 1978. The field program was divided into two phases. The primary task during the first phase was to supervise and assist emplacement of the instrumented package of the Sediment Dynamics Sphere (SDS) in the Simpson Lagoon, as well as to collect periodic water and sediment samples from the experimental site. This latter work relates to our study of sediment dynamics in the Simpson Lagoon area, which is being pursued under a separate subcontract from Naidu (R.U. 529) to Dr. L. H. Larsen of the University of Washington (Seattle). Milne Point was the site of the base camp for the above operations.

The second phase of the field work consisted of participation by A. S. Naidu in the ice-breaker cruise of the USCGC *Northwind* in the Beaufort Sea.

### Personnel

The following table indicates the period of time spent by various personnel at different field operations during summer 1978.

| Personnel | Dates | Base of Operation |
|---|---|---|
| A. S. Naidu | 7/31 to 8/2, 1978 | Helmerick's Camp |
| A. S. Naidu and J. G. Clough | 8/2 to 8/17, 1978 | Milne Point, Simpson Lagoon |
| J. M. Haney | 8/15 to 8/17, 1978 | USCGC *Northwind* |
| A. S. Naidu | 8/17 to 8/25, 1978 | USCGC *Northwind* |
| J. M. Haney | 8/17 to 9/4, 1978 | Milne Point |
| L. Larsen* | 8/5 to 8/10, 1978 | Milne Point |
| G. Peterson* | 8/5 to 8/12, 1978 | Milne Point |

*Participants from the University of Washington, Seattle; R. U. 529 Subcontractors.

## II. SAMPLES, SAMPLE LOCATION, AND FIELD OPERATIONS DURING PHASE I

In continuation of our geological-geochemical program relating to the Simpson Lagoon and adjacent marine environment, water samples from four locations each from the Colville and Kuparuk Rivers were collected to study the nature of terrigenous input. Additionally, representative lagoon water samples were collected from a number of stations in the Simpson Lagoon. The stations for the latter collection were established along four transects across the width of the lagoon, between Oliktok and Beechy Points. All these water samples were filtered within a few hours after collection through Nuclepore filtering pads, using a vacuum pump and a glass filtering unit. The filtered waters were preserved in 10% Ultrex $HNO_3$ acid medium for a suite of heavy metal analysis by Dr. H. V. Weiss of NOSC (San Diego). Dr. Weiss participated in all fluvial and part of the lagoon sample collection. Jim Helmerick's camp on the Colville Delta was used as the base camp for the fluvial sampling.

Our original plan had called for emplacement of the Sediment Dynamics Sphere (SDS) in the Simpson Lagoon on August 5, 1978. However, due to breakdown of the R/V *Alumiak* the SDS experiments could not be started before a week past the scheduled date. The instrumented tripod package was located at a site (Lat. 70° 32.2'N and Long. 149° 27.5'W) off the Milne Point in the Simpson Lagoon in 9 feet of water. The instrument was placed to measure wave-current parameters, record nephelometer and temperature readings, as well as take time-lapse photographs of the substrate bed form from August 11, 1978. The SDS was finally retrieved on September 7, 1978 using an ERA helicopter. The emplacement of the tripod in water with the aid of the R/V *Natchik* was quite cumbersome, and was marred by toppling over of the tripod accidentally as it got caught by one of the stabilizing anchors of the vessel. The tripod was eventually uprighted, but whether the instrumented package and other units satifactorily functioned or not during the duration of the experiment is not known as of this time.

In order to achieve *in situ* field calibration of the nephelometer on the tripod twice a day at some precisely noted time water samples were collected via a Niskin bottle from the tripod experimental site. These water samples were retrieved from the surface and from approximately 1 m water depth - the depth at which the nephelometer was located on the tripod. A one-litre aliquot of each of the water samples was filtered under vacuum through preweighed Nuclepore (pore diameter 0.4 μ) filter membranes. The suspensates thus collected on the pads were stored in a freezer before transfer to Fairbanks.

In attempting to establish criteria, based on ground truth, to estimate the distribution of suspended particles representative samples of surficial waters were collected from several known locations covering the Simpson Lagoon. These sample collections synchronized with the dates of orbital passage of one of the two Landsat Satellites, namely Landsat I and Landsat II, over the Simpson Lagoon region on August 6-7 and August 15-16, 1978. One litre of these water samples were filtered, at the base camp (Milne Point), through preweighed Nuclepore (0.4 μ pore diameter) filter membranes.

Surficial sediment samples of the Simpson Lagoon were collected at six different days from the SDS tripod experimental site. The purpose of this collection was to check the variations in the composition of the bed-load and the current-wave parameters in the Simpson Lagoon. The surficial sediments were retrieved from the top 1.5 cm section of core samples collected by a manual coring unit operated from a Boston Whaler.

Two days were spent in examining the stratigraphy of the tundra bluffs on the Pingok and Bodfish Islands, and collecting rock chips of large boulders on the Bodfish beaches. The latter effort was a continuation of our past attempts to elucidate the sources and mechanism of transport of boulders on the North Slope coast. Samples of mud from a few seemingly 'marker' and continuous horizons within the bluffs were collected. Sedimentological analysis of these mud samples and a detailed study of the boulders would seem to have significant implication in the understanding of the paleogeographic history of the North Slope continental margin region.

Attempts were made to obtain long (>2 m) gravity core samples from the Simpson Lagoon, using a 800-lb coring unit from the R/V *Natchik*. The purpose of this effort was to obtain cores for dating the various horizons by the $^{210}Pb$ method and ultimately estimating the rate of sedimentation in the Simpson Lagoon. The coring operation was not quite successful; it was only possible to retrieve cores of 25 cm maximum length. Because of the presence of stiff underlying clays, the penetration of the gravity corer was limited. However, it would seem that using the $^{210}Pb$ technique we should still be able to obtain some meaningful sedimentation rate data on the short cores. At each station at least two core samples were obtained. One of the samples was preserved in the liner for $^{210}Pb$ dating, while the second one was used to express out interstitial waters at 5 cm core sections. The interstitial waters which were expressed out under nitrogen pressure, were preserved in a freezer until ready for transfer to Fairbanks.

## III. PHASE II OF FIELD WORK (i.e., USCGC *Northwind* Cruise)

The following was the primary objective of the geological-geochemical program in the first phase (August 14-25) of the 1978 cruise of the USCGC *Northwind*:

a. to collect water samples from various depths of the Beaufort Sea, and to separate the suspended particulate matter in the water samples. The investigation on suspended particles constitutes an extension marineward of the mineralogical and chemical studies on similar particles from the Simpson Lagoon and adjacent deltaic regions of the North Slope of Alaska.

b. to collect a few gravity and box core samples in the 'marine facies' of the Colville Delta for the purpose of determining the rate of comtemporary sedimentation in the above area, using the $^{210}Pb$ dating technique. Such samples are considered more suitable than other core types because of their assumed undisturbed nature.

c. to collect water samples at various depths at a station in the continental shelf off the current oil lease area, for the purpose of analyzing a suite of heavy metals. This sample collection was at the request of Dr. Herbert V. Weiss of NOSC, San Diego, and relates to his OCSEAP heavy metal baseline program in the Beaufort Sea.

### Sample Collection and Onboard Processing

A total of 12 stations were occupied in the first phase of the cruise (See Table 1 for station locations and water depths). At each of the stations a set of three water samples were collected. In fact, these samples consisted of 2-litre aliquot splits of water subsamples taken from Dr. Rita Horner's Niskin hydrocast samples. The sampling depths were selected

TABLE I

LOCATIONS AND WATER DEPTHS OF STATIONS OCCUPIED DURING THE FIRST LEG OF THE 1978 USCGC *NORTHWIND* CRUISE IN THE BEAUFORT SEA

| Stations | Longitude W | Latitude N | Water Depth (m) |
|---|---|---|---|
| St. #1 | 150°14' | 71°11' | 45 |
| St. #3 | 149°17' | 70°58.5' | 41 |
| St. #4 | 146°05' | 70°19.8' | 33 |
| St. #5 | 148°20.2' | 70°36.2' | 22 |
| St. #6 | 148°11' | 70°55' | 40 |
| St. #7 | 149°54' | 71°05.5' | 24 |
| St. #8 | 150°52.9' | 71°03.6' | 23 |
| St. #9 | 151°51.3' | 71°11.1' | 29 |
| St. #10 | 152°51' | 71°05' | 23 |
| St. #11 | 152°47.7' | 71°19.8' | 55 |
| St. #12 | 152°41.1' | 71°21.6' | 99 |

arbitrarily. The first, second and third samples were from the 0-5 m, middle and lower-most Niskin hydrocasts, respectively. Each of the 2-litre water samples was filtered through preweighed Nuclepore filter membrane (pore size being 0.4 μm), using a standard vacuum filtering system. After filtration the suspensates on the pads were washed with distilled deionized water to remove any seawater associated with them. To minimize bacterial degradation the filter pads were stored in a freezer. An aliquot of 2-litre, rather than 1-litre, water sample was filtered each time in order to ensure that adequate amounts of suspensates are available for accurate clay mineral as well as organic carbon-nitrogen analyses.

Water samples for heavy metal analysis were collected at a site (70° 58.5'N and 149° 17.0'W) over the Beaufort Sea continental shelf. Again, the set of these three samples were from near the surface (3 m), middle (20 m) and bottommost (35 m) hydrocasts at the above station. Each of the water samples was filtered through specially clean glass filtering units, taking utmost care to avoid metal contamination. The filtered water samples were stored in polybottles to which Ultrex $HNO_3$ acid was added (in the proportion of one part acid and 10 parts water) as a preservant. These samples were shipped to Dr. Weiss from Fairbanks.

In attempting to retrieve suitable core samples for $^{210}Pb$ dating purpose, a series of gravity core samples were taken. However, with the exception at one station none of the gravity core samples were long enough to be suitable for the above dating. Many plastic core liners were lost, presumably because of the relatively stiff nature of the substratum. A core sample of 75 cm was retrieved at a station off the N.E. Colville Delta (71° 00'N and 149° 59.5'W). At this same station an excellent box core sample of 45 cm length was also taken. These two samples should be suitable specimens for $^{210}Pb$ dating. Preliminary examination of the core sample in the plastic liner showed no evidence of bioturbation or ice-gouging reworking. Both the cores have been preserved in the original containers (e.g., plastic liner and stainless steel box), taking all precautions to avoid any possible disturbance of the sediment sequences.

In addition to the above samples, suitable splits of all Smith-McIntyre grab samples collected by Mr. Gene Ruff during the cruise, were provided to us for detailed grain size and organic carbon analyses. To minimize bacterial degradation these sediment samples were preserved in the freezer until departure from the ship.

Excellent cooperation and help was provided by the ship's Officers and crew members. Living quarters were comfortable, but the laboratory space in the ship and at Milne Point was quite limited.

Quarterly Report

Contract 03-5-022-56
Research Unit #530
Task Order #34
Reporting Period 7/1/78 - 9/30/78

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

Dr. P. Jan Cannon
Department of Geology
University of Alaska
Fairbanks, Alaska 99701

September 30, 1978

# QUARTERLY REPORT FOR QUARTER ENDING SEPTEMBER 30, 1978

Project Title: The Environmental Geology and Geomorphology of the Barrier Island - Lagoon System Along the Beaufort Sea Coastal Plain from Prudhoe Bay to the Colville River

Principal Investigator: Dr. P. Jan Cannon

## I. Task Objectives

1. To determine the origin and evolution (geomorphic history) of the barrier islands and the coastal lagoons.

2. To determine the source(s) of the gravel size materials that make up the barrier islands.

3. To determine the stability of the barrier island - lagoon system in respect to natural processes and man induced effects.

4. To determine the magnitude of the geomorphological relationships between the barrier island - lagoon system and the landforms of the coastal plain such as the various streams, dune fields, ground patterns, thermokarst features, deltas, pingos, lugs and lakes.

5. To construct a spatial and temporal model of the environmental geology of the region.

## II. Activities

Performed field trips and aerial reconnaissance flights of the study area.

1. Made low-altitude aerial reconnaissance flight of lease area during break-up observing and documenting the intensity and magnitude of important geomorphic processes.

2. In mid-July made a high-altitude aerial reconnaissance of entire coastal plain. Flight was at 35,000 feet above MSL in NASA Convair 990.

3. During the last week of July made field investigations of small streams which enter into the lagoon system, and a low-altitude aerial reconnaissance of part of the coastal plain drained by the small streams.

4. During August several on the ground field inspections were made of various areas around the lagoon system.

5. Several low-altitude aerial reconnaissance flights were made throughout the lease area and the adjacent coastal plain in order to obtain documentation and new spatial information.

6. A search was started for new remote sensing information of the lease area.

7. Intermediate-altitude, enhanced aerial photography was made of parts of the study area.

III. Results

1. The sequence of various events during break-up was different than that of prior years.

2. Documentation of various physiographic features indicated that there is a range of coastal and lake shoreline morphologies.

3. Transportation logistics worked out very well.

4. Pertinent data was obtained of entire lease area and the adjacent coastal plain.

IV. Preliminary Interpretation of Results

There has not been enough time since the end of the field work to do much interpretation of the data collected. One thing that can be ascertained as of now is that there appears to exist sufficient supplies of aggregate for development on the coastal plain. Also, both the Colville and the Canning Rivers bring down large amounts of wood to the lease area from the Brooks Range. Chunks of peat and tundra mat are brought down from all major streams to the lagoon system adding to that derived from erosion of the coastline.

V. Problems Encountered/Recommended Changes

The only problems encountered were weather problems related to intermediate-altitude aerial photography. If the photography gathered this field season is of significant value, more time will be allocated to the acquiring of such data next summer.

Contract # 03-8-022-35182
Research Unit # 531
Reporting Period: 1 July 1978-30 September 1978
Number of Pages: 13

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

Principal Investigators:

J. C. H. Mungall
Kinnetic Laboratories, Inc.
One Potrero Street
Santa Cruz, CA 93060
408/425-1474

Robert E. Whitaker
Department of Oceanography
Texas A&M University
College Station, TX 77843
713/845-7432

21 October 1978

## A. Field or Laboratory Activities

### 1. Summer Field Program - Simpson Lagoon, Alaska

A considerable amount of data was obtained during the 1978 field program. Figure 1 shows the salinities obtained near the Milne Point Camp and west of Milne Point from 22 July through 7 August 1978. The bottom panels show the winds as sampled at the Milne Point Camp. Temperatures and conductivities from these two locations were also obtained. Monitoring of the water temperature, conductivity and salinity continued through 22 August off the Milne Point Camp.

Figures 2 and 3 give the surface temperatures and salinities observed during a float-plane survey on 28 July and a helicopter survey on 5 August 1978. These distributions agree qualitatively with observations from previous field programs.

On 8 August 1978 an instrumented mini-tower was erected off the Milne Point Camp in water approximately 6 feet deep. Sensors on the tower provided data on the water characteristics, the horizontal current components and waves. The simultaneous current meter and wave gage data are in analog (continuous) and digital (discrete) form. The analog data are being analyzed at Texas A&M while the digital data are being treated at Kinnetic Laboratories. In addition to the common time-series analysis we will attempt to obtain wave direction spectra from the current and wave data.

NUMBER PERTAINS TO START OF DAY

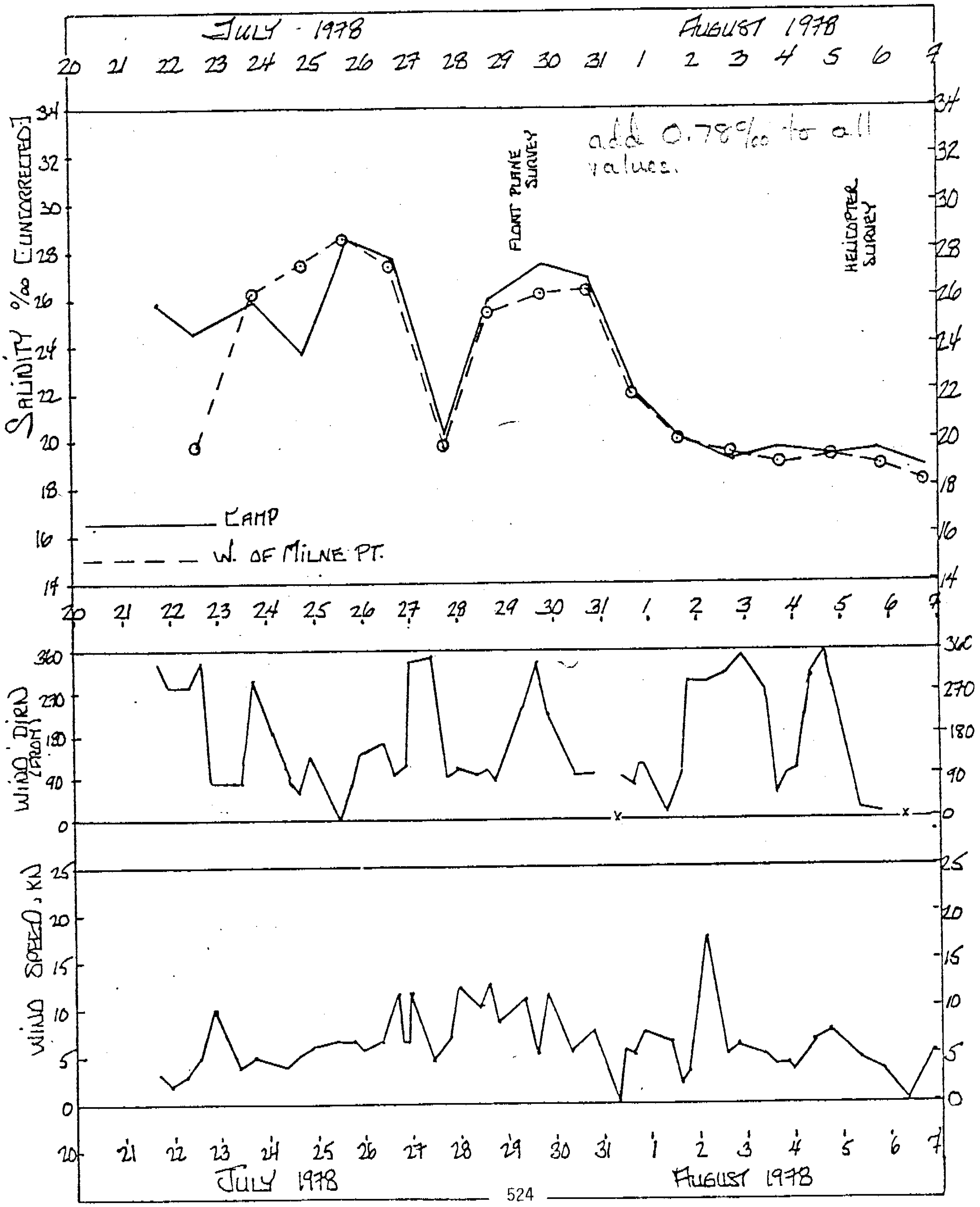





Figure 1. Salinities and winds.

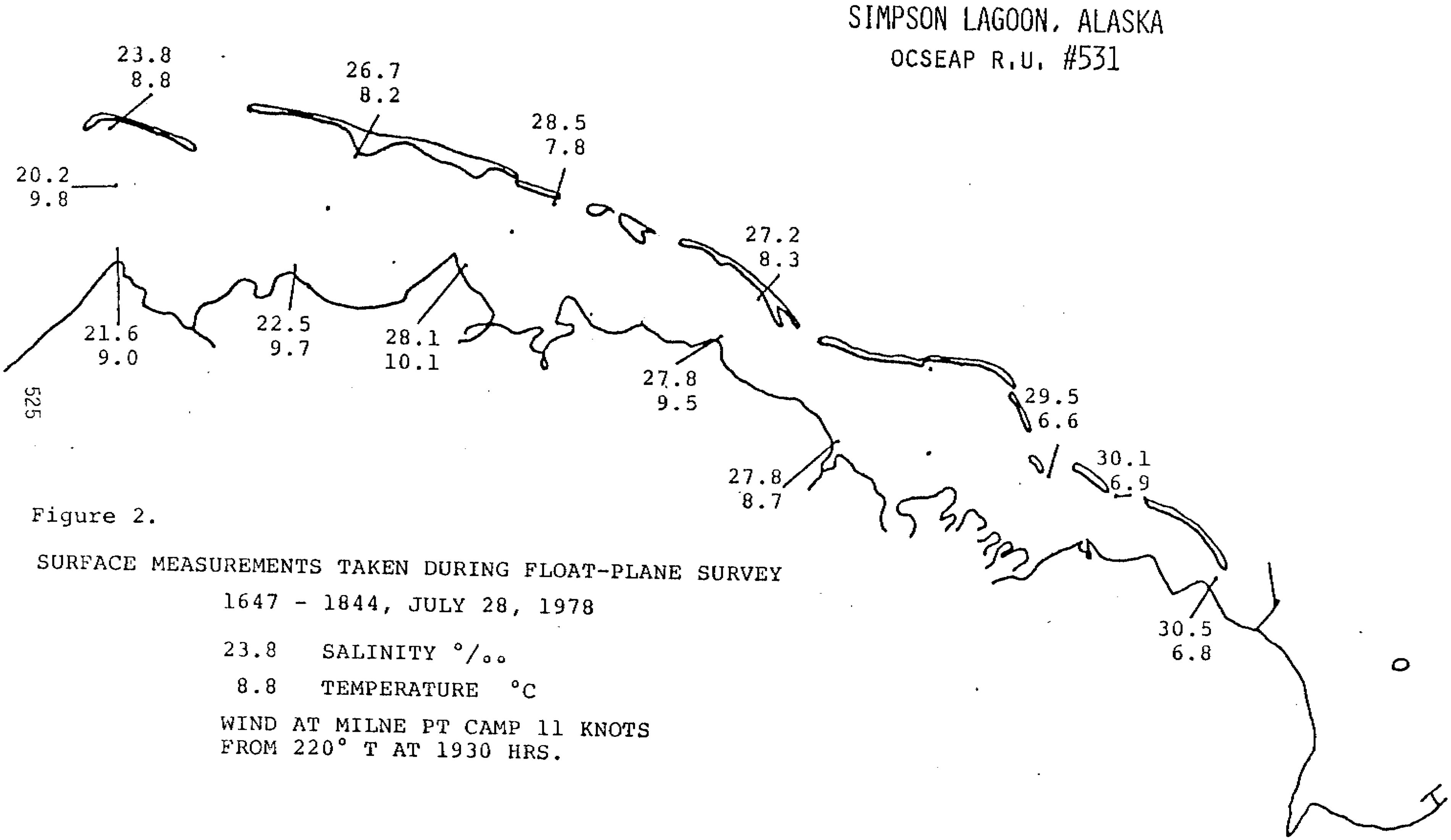



Figure 2.

SURFACE MEASUREMENTS TAKEN DURING FLOAT-PLANE SURVEY

1647 - 1844, JULY 28, 1978

23.8 SALINITY °/₀₀

8.8 TEMPERATURE °C

WIND AT MILNE PT CAMP 11 KNOTS
FROM 220° T AT 1930 HRS.

SIMPSON LAGOON, ALASKA
OCSEAP R.U. #531

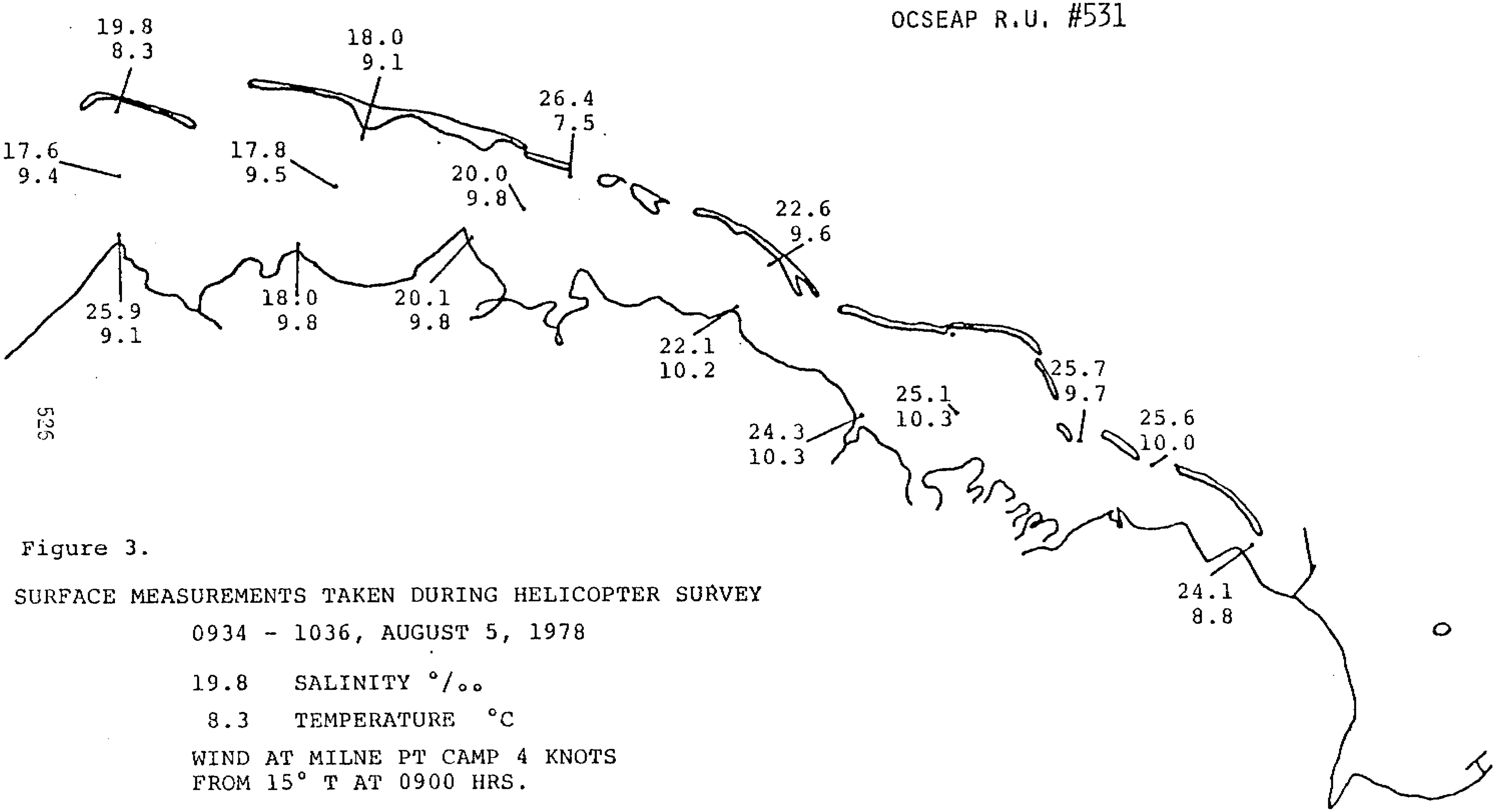



Figure 3.

SURFACE MEASUREMENTS TAKEN DURING HELICOPTER SURVEY
0934 - 1036, AUGUST 5, 1978

19.8 SALINITY °/₀₀
8.3 TEMPERATURE °C

WIND AT MILNE PT CAMP 4 KNOTS
FROM 15° T AT 0900 HRS.

Currents were also directly observed during the 1978 field season by "tracking" drouged drifters emitting keyed radio signals. Two radio direction-finding (RDF) stations provided azimuthal readings for triangulation. Two drifter configurations were utilized; one set was drogued at 10 m depth for offshore applications and the other set was drogued at 1 m for use within the lagoon proper.

Several attempts were made, with superior assistance provided by LGL personnel, to monitor the currents offshore and in Simpson Lagoon. Two of these attempts were failures due to malfunctions in one of the RDF station receivers. After considerable difficulty repairs to the faulty set were made and the third attempt to obtain Lagrangian data was successful.

Figures 4 through 8 show the five preliminary individual trajectories derived from ob servations obtained during the period 1200/20 August 1978 through 0000/22 August 1978. The buoys are identified by the manufactorer's number to avoid confusion. Notice that each buoy is represented by a different symbol. The sequential numbers give the order of the observations, which occurred at 3-hour intervals. Zero implies the point of deployment. A dashed line indicates a data gap. The two RDF stations are shown as "dots" at Milne Point and on Pingok Island near 149°36'W.

Locating the buoys was accomplished by obtaining

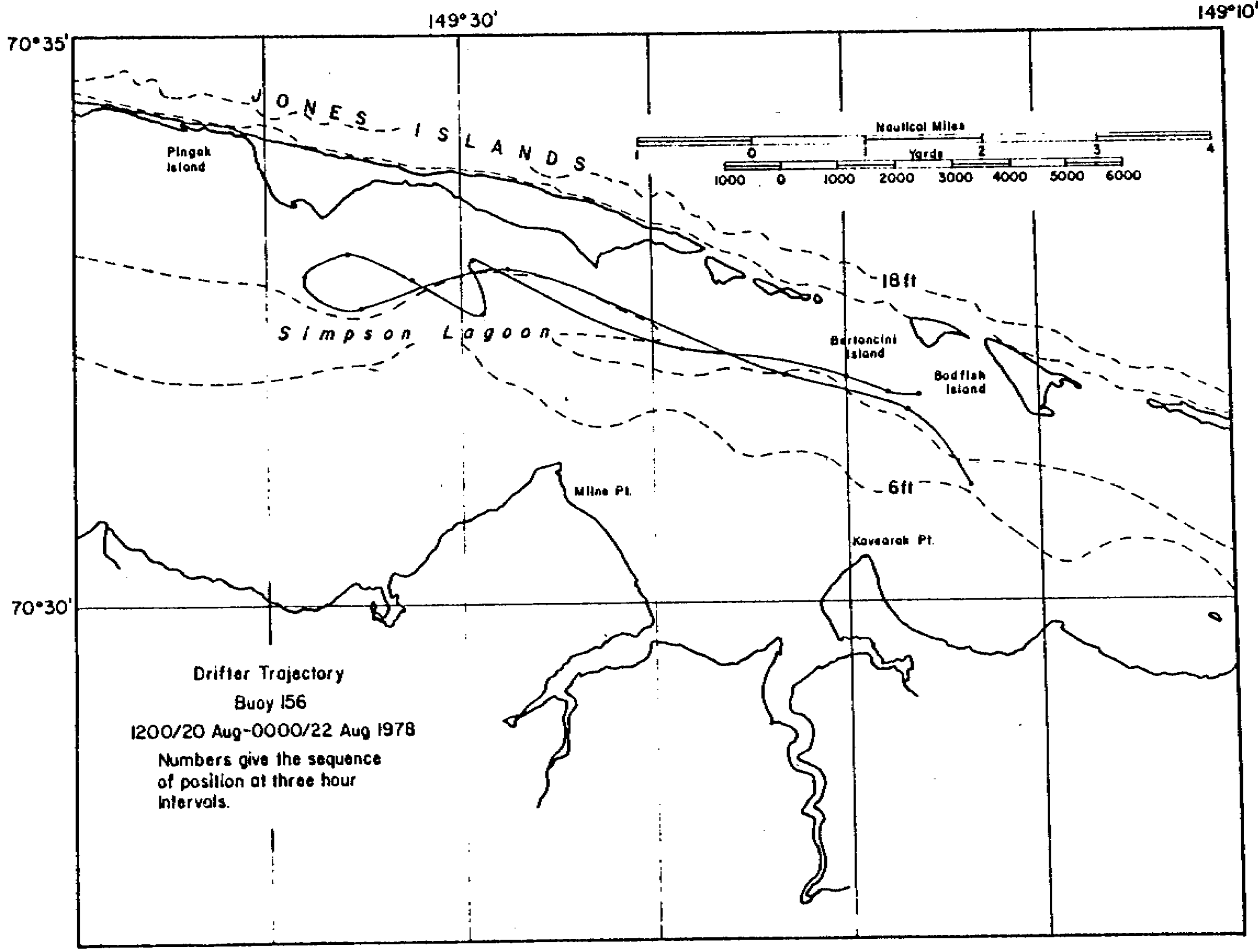
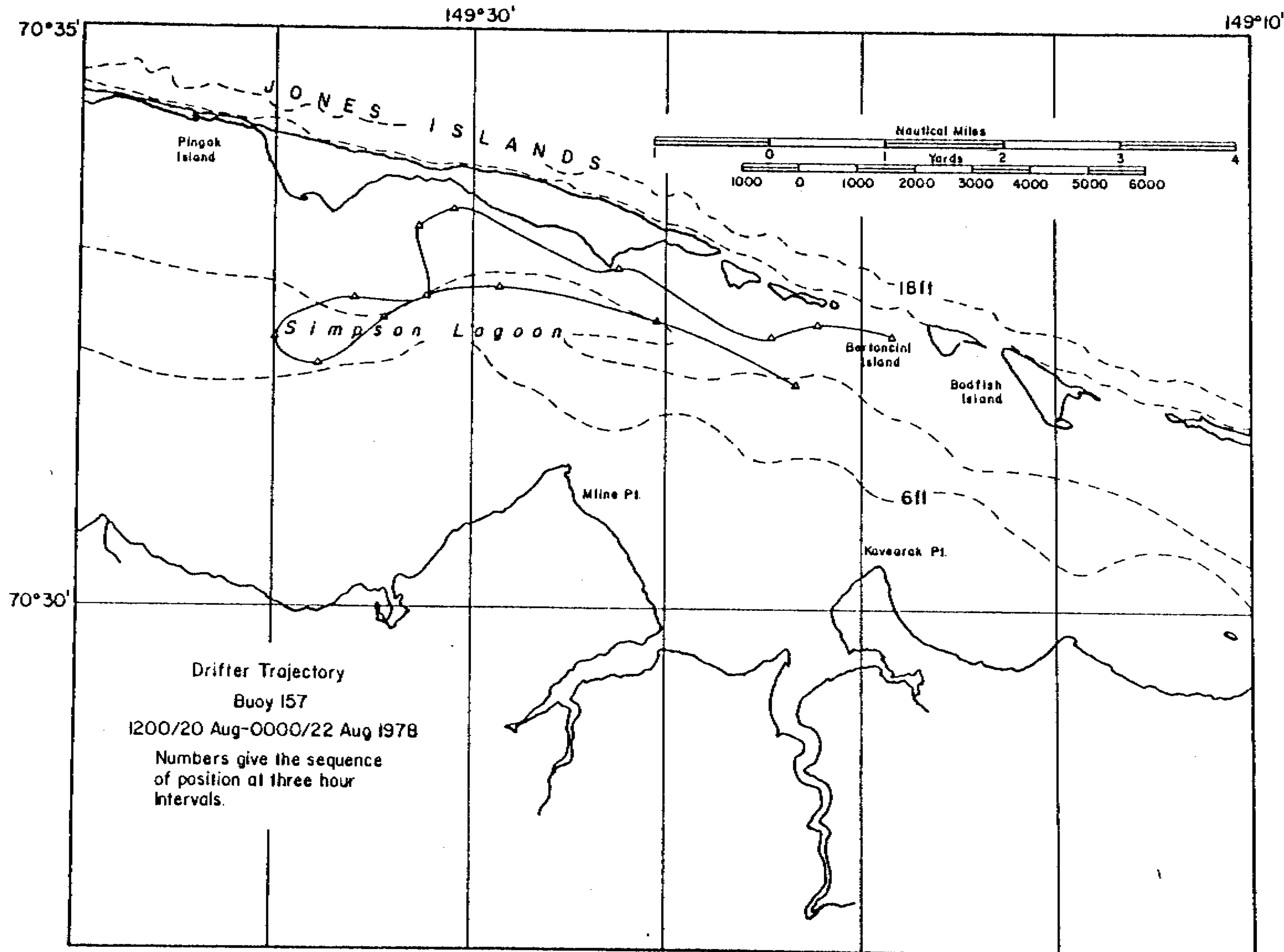

149°30'
149°10'
70°35'
70°30'
JONES ISLANDS
Pingok Island
Nautical Miles
0
1
2
3
4
Yards
1000
0
1000
2000
3000
4000
5000
6000
18 ft
Simpson Lagoon
Bertoncini Island
Bodfish Island
6 ft
Milne Pt.
Kavearak Pt.
Drifter Trajectory
Buoy 156
1200/20 Aug-0000/22 Aug 1978
Numbers give the sequence
of position at three hour
intervals.

Figure 4.



70°35'
149°30'
149°10'
70°30'
JONES ISLANDS
Pingok Island
Nautical Miles
1 0 1 2 3 4
Yards
1000 0 1000 2000 3000 4000 5000 6000
Simpson Lagoon
18ft
Bertoncini Island
Bodfish Island
Milne Pt.
6ft
Kavearak Pt.
Drifter Trajectory
Buoy 157
1200/20 Aug-0000/22 Aug 1978
Numbers give the sequence of position at three hour intervals.


Figure 5.

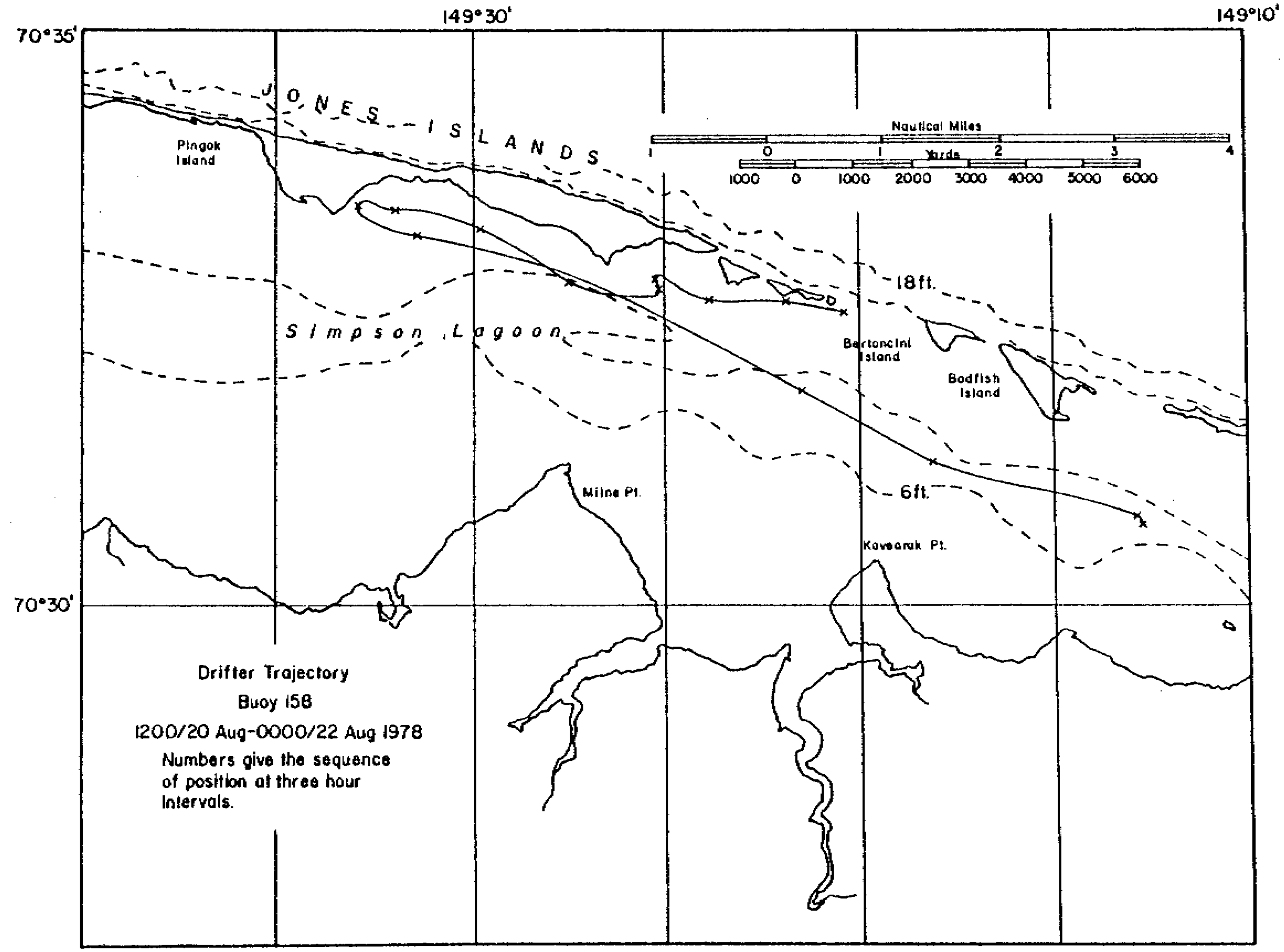

149°30'
149°10'
70°35'
70°30'
JONES ISLANDS
Pingok Island
Nautical Miles
1 0 1 2 3 4
Yards
1000 0 1000 2000 3000 4000 5000 6000
18ft.
Simpson Lagoon
Bertoncini Island
Badfish Island
6ft.
Milne Pt.
Kavearak Pt.
Drifter Trajectory
Buoy 158
1200/20 Aug-0000/22 Aug 1978
Numbers give the sequence
of position at three hour
intervals.

Figure 6.

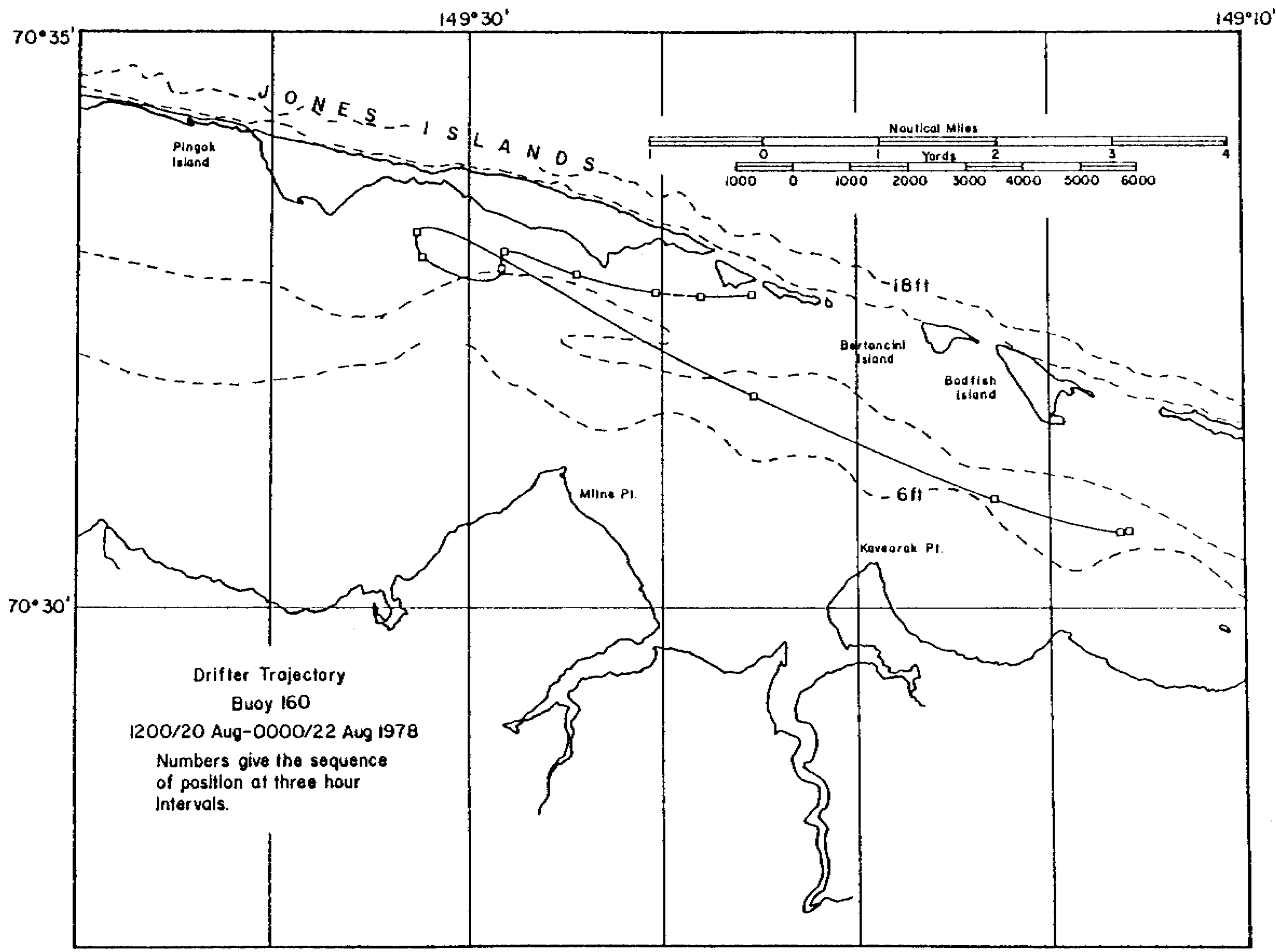

70°35'
149°30'
149°10'
JONES ISLANDS
Pingok Island
Nautical Miles
1 0 1 2 3 4
Yards
1000 0 1000 2000 3000 4000 5000 6000
18ft
Bertoncini Island
Bodfish Island
Milne Pt.
6ft
Kavearak Pt.
70°30'
Drifter Trajectory
Buoy 160
1200/20 Aug-0000/22 Aug 1978
Numbers give the sequence of position at three hour intervals.

Figure 7.

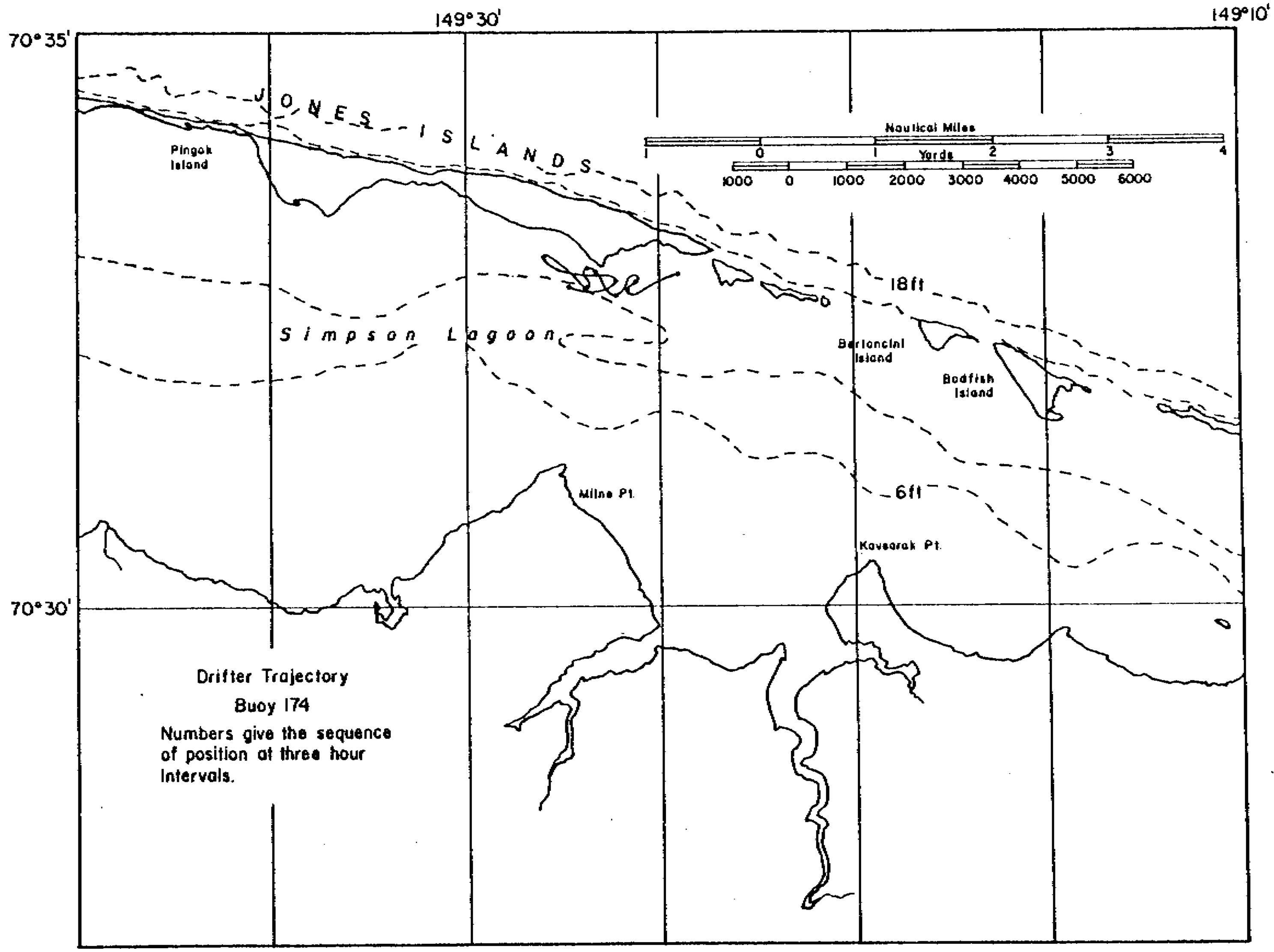

149°30'
149°10'
70°35'
70°30'
JONES ISLANDS
Pingok Island
Nautical Miles
1 0 1 2 3 4
Yards
1000 0 1000 2000 3000 4000 5000 6000
18ft
Simpson Lagoon
Bertoncini Island
Bodfish Island
Milne Pt.
6ft
Kavearak Pt.
Drifter Trajectory
Buoy 174
Numbers give the sequence of position at three hour intervals.

Figure 8.

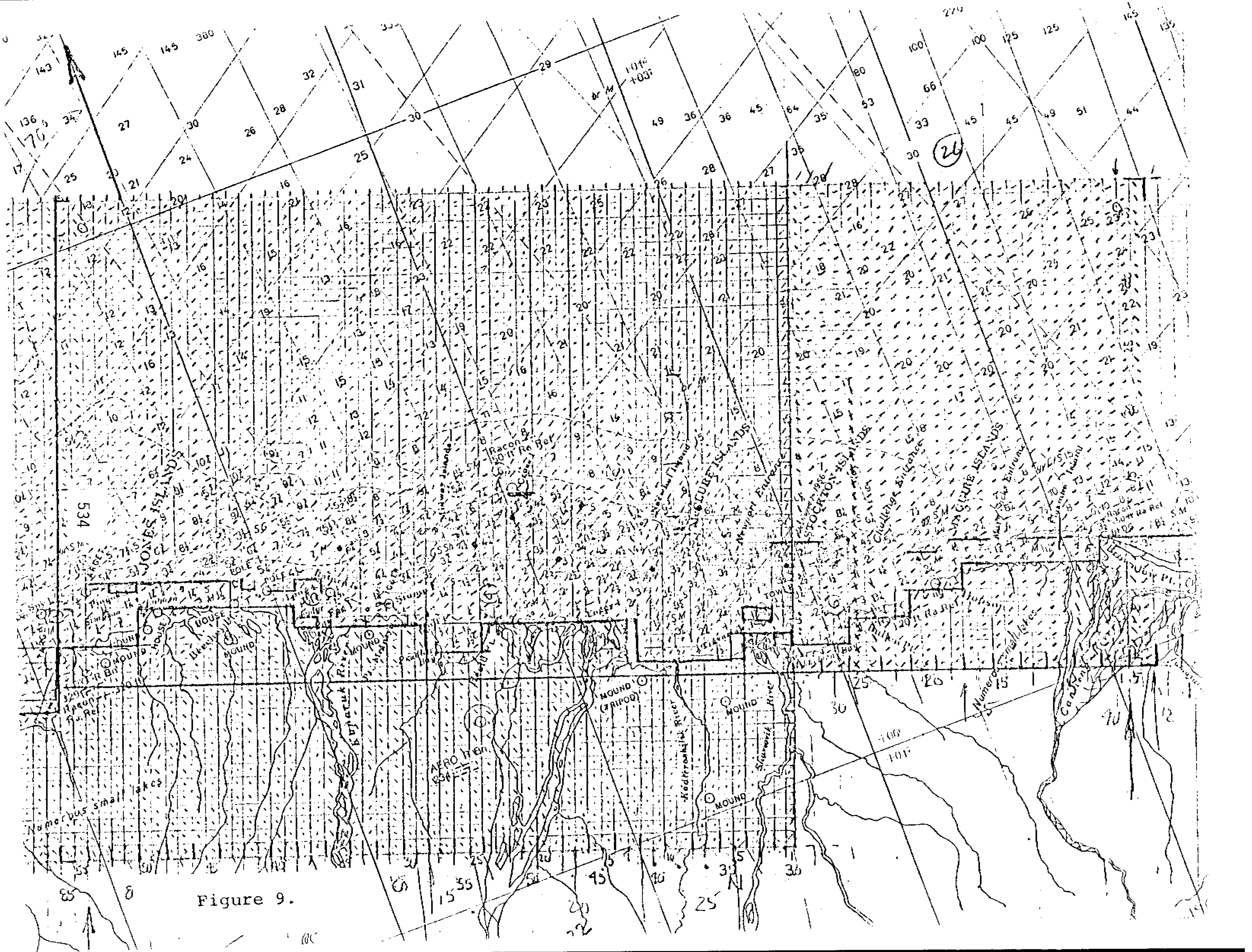
measurements of the appropriate bearing angles at the two RDF stations. The measurements were taken at 3-hour intervals starting at 1200/20 August 1978. Two sets of bearing angles were recorded at the stipulated times for each buoy by alternately rotating a loop antenna clockwise and counterclockwise and observing the radio signal extinction (audio) angle. Each data set was filtered by discarding those bearings differing from the mean by more than twice the computed standard deviation. The first and second statistical moments were then recomputed and the mean of the two bearings was plotted.

Generally, the drifters, with the exception of buoy 174, move westward from the deployment sites until approximately 0600/21 August. They then rapidly reverse direction. These trajectories are correlated with the Milne Point Camp wind data which show the wind direction changing from east to west between 0300 and 0600/21 August 1978. A time-lag of 1½-2 hours is indicated. The erratic and small displacements of buoy 174 suggest the drifter had run aground. No further comment on this drifter will be made.

Notice that while all the drifters respond to a changing wind their behavior is not identical. Buoy 160 is the only member to move clockwise in reversing direction.

2. Numerical Modeling

At the request of the LBM-OCS Anchorage office the



JONES ISLANDS
McCLURE ISLANDS
STOCKTON ISLANDS
Newport Entrance
Challenge Entrance
Numerous small lakes
Kuparuk River
AERO Lt Bn
MOUND
MOUND (TRIPOD)
HOUSE
Racon
POLE
534


Figure 9.

three-space model was applied to the nearshore Beaufort Sea area to obtain surface wind-driven flows for oil-spill trajectory calculations.

The established 2 × 2 km grid was situated too far west necessitating the formation of a new network. Figure 9 shows a portion of the old grid and the new 4 × 2 km grid extending from slightly east of Brownlow Point westward to Oliktok Point. Ten oil-spill locations (shown as dots) were specified by BLM-OCS. Average wind speeds for the periods July-August and October-November were used for excitation. The eight points of the compass served as the wind direction.

These computations constitute an extensive set and caused a considerable financial drain of project funds.

B. Status of Field Equipment

The two RDF sets borrowed for the 1978 field season have been returned intact to the Atlantic Environmental Group of the National Marine Fisheries Service in Narragansett, Rhode Island.

Nine of the unused drifters are in storage at the OCS Mukluk Camp. All of the remaining equipment, save one General Oceanics flow meter at Texas A&M, is in storage at Kinnetic Laboratories in Santa Cruz, California.

C. Estimate of Funds Expended

| | |
|---|---|
| Total expenditures to 30 September 1978 | $ 88,138.96 |
| Outstanding encumberances | 7,671.38 |
| Unencumbered balance | 17,306.66 |

QUARTERLY REPORT

Contract No.:

03-5-022-67, TO 1

Research Unit No.:

541

Reporting Period:

1 July - 30 September 1978

Number of Pages:

48

# NORTON SOUND - CHUKCHI SEA OCEANOGRAPHIC PROCESSES

# (N-COP)

L. K. Coachman
K. Aagaard
T. H. Kinder

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

30 September 1978

TITLE: Norton Sound - Chukchi Sea Oceanographic Processes (N-COP)

PRINCIPAL INVESTIGATORS: L. K. Coachman
K. Aagaard
T. H. Kinder

Department of Oceanography
University of Washington
Seattle, WA 98195

PERIOD: 1 July - 30 September 1978

I. Objectives: To elucidate the water flow and hydrographic structure in the study area.

II. Field Activities: See attachment.

III. Results and Preliminary Interpretation.

Two talks are scheduled for the western American Geophysical Union meeting in December:

"Oceanography of Arctic Shelves" by Coachman; and "Low frequency components of flow in the Bering Strait System", by Tripp, Coachman, Aagaard, and Schumacher.

V. Problems: none.

LOW FREQUENCY COMPONENTS OF FLOW IN THE BERING STRAIT SYSTEM

Richard B. Tripp
L. K. Coachman
K. Aagaard (all at: Dept. of Oceanography, University of Washington, Seattle, WA. 98195)
J. D. Schumacher (PMEL/NOAA, Seattle, WA. 98105)

During 1976-77 we had eleven current meter moorings deployed between St. Lawrence Island and Cape Lisburne in the Southern Chukchi Sea. The records span periods of seven to eleven months. Nine of these meters were within the general northward flow of Pacific water into the Arctic Ocean; two from east of St. Lawrence Island, one from Bering Strait proper, and six from a line extending across the southern Chukchi Sea west from Cape Lisburne. The long period (more than a few days) components of flow from these measurements are analyzed and discussed with regard to a) time scales of major changes in the northward transport, b) correlations in the flow field, and c) the regional variability and correlations in the temperature field.

1. 015341TRIPP
2. 1978 Fall Meeting
3. Oceanography
4. Oceanography of Alaskan Shelves
5. No
6. No
7. 0%
8. Bill to:

   Norton Chukchi Oceanographic Processes
   (20-3401)
   Dept. of Oceanography
   WB-10
   Univ. of Washington
   Seattle, WA 98195
9. To be furnished later

APPENDIX A

University of Washington
Department of Oceanography
Seattle, Washington 98195

Preliminary Report

University of Washington Participation in

NOAA SHIP *Discoverer* Cruise RP-4-DI-78B, Leg I

Bristol Bay Oceanographic Processes RU 141

Norton-Chukchi Oceanographic Processes RU 541

10 July - 3 August 1978

by

Richard B. Tripp

NOAA Contract 03-5-022-67, TO 4 & TO 14

Approved by:

L. K. Coachman, Professor
Principal Investigator

George C. Anderson, Professor
Associate Chairman for Research

Ref: M78-53

BRISTOL BAY OCEANOGRAPHIC PROCESSES
NORTON-CHUKCHI OCEANOGRAPHIC PROCESSES

1. *Objectives*

This study is a joint program with the Pacific Marine Environmental Laboratory (PMEL), ERL, NOAA to provide: 1) water mass circulation information over the eastern and northeastern Bering Sea shelf region; 2) verification of the fluctuation in the northward transport through Bering Strait; 3) data on temporal and spatial scales of eddies ubiquitous to the system; 4) data to refine our understanding of key dynamic processes within the system; 5) data to augment our understanding of the circulation within Norton Sound; and 6) some basis for predictive or diagnostic models of ecosystem response to loading by petroleum and petroleum by-products. These data are for the Outer Continental Shelf Environmental Assessment Program (OCSEAP).

The Leg I portion of Cruise RP-4-DI-78B, of the NOAA ship *Discoverer* was directed towards accomplishing this research. The objectives of this cruise were:

1) The deployment of three Nimbus satellite-tracked drift buoys south of Kodiak Island for the NEGOA project.

2) The recovery of nine current meter and pressure gauge moorings in the Eastern and Northeastern Bering Sea, that were deployed in September 1977.

3) The deployment of twelve current meter and pressure gauge moorings at selected sites in the Eastern and Northeastern Bering Sea and Norton Sound to: 1) refine our understanding of the dynamic processes; 2) provide data for the tidal model of RU 435; and 3) examine the front between Nunivak Island and the Pribilof islands. The recovery of these moorings is planned for September 1978.

4) A series of C-T-D stations selected sites to monitor the seasonal change within the system.

5) A thorough examination of the front along the 50 meter contour between the Pribilof islands and Nunivak Island by: 1) a series of closely spaced XBT's and CTD's across the front over a 25-hour period to study the behavior of the front during a tidal cycle; 2) two 25-hour time series near mooring FX-1A utilizing the CTD.

6) The collection and analysis of nutrient samples in Norton Sound and the Northeastern Bering Sea to aid in the examination of the water masses within this area.

2. *Cruise Track and Narrative*

The NOAA ship *Discoverer* departed the Pt. Wells fuel dock Seattle Washington at 2316 GMT, 10 July 1978 and proceeded towards Kodiak, Alaska.

Surface drifters to be tracked by the Nimbus satellite were deployed nearing Kodiak Island at the following locations:

1) Drifter No. 561 at latitude 56-55.8 North, longitude 150-11.9 West at 0852 GMT, 14 July 1978.

2) Drifter No. 753 at latitude 57-02.0 North, longitude 150-04.9 West at 0927 GMT, 14 July 1978.

3) Drifter No. 400 at latitude 57-02.1 North, longitude 150-18.2 West at 1001 GMT, 14 July 1978.

At 1805 GMT, 14 July 1978 we docked alongside the marginal pier, U.S. Coast Guard Base, Kodiak, Alaska. We departed Kodiak, Alaska 0252 GMT, 15 July 1978 and proceeded to the survey area.

1) Station BC-3D PMEL — Latitude 55-17.7 North, longitude 165-29.7 West. Released at 2204 GMT, and recovered at 2303 GMT, 16 July 1978. This mooring consisted of current meters at 17 meters and 97 meters water depth. There was moderate growth on float and first meter. However, rotor was free to turn. Very little data, if any, from upper current meter.

The C-T-D sampling program between mooring locations was initiated. A summary of C-T-D stations accomplished can be found in attachment A. A summary of samples collected for nutrient analysis can be found in attachment B.

2) Station BC-2F PMEL — Latitude 57-02.4 North, longitude 163-26.5 West. Released at 1732 GMT 17 July 1978. The mooring did not surface. We ran a grid around the area and concluded that the mooring was either fouled up or had lost its floatation. We could hear the pinger of the acoustic release without the command unit. An indication that the mooring was within ∿150 ft. of the ship. We returned to the site two hours later with the same results.

3) Station BC-4F UW — Latitude 58-37.2 North, longitude 168-22.2 West. Interrogated at different sites with no response. Returned to original site and fired at 1911 GMT, 18 July 1978. No sighting. We ran a one-mile grid encompassing the GP with no contact established with the mooring.

A line (60 miles long) of C-T-D stations at 10 n. mile intervals were occupied across the front. XBT's were taken at 2.5 n. mile intervals between C-T-D stations to aid in positioning the front. The XBT's are listed in attachment C.

4) Station FX-2A US — Deployed 0115 GMT, 19 July 1978 in 43 meters water depth. This mooring consists of a current meter at 20 meters and a pressure gauge at 42 meters water depth. This mooring was deployed in mostly homogeneous water.

5) Station BC-4G UW — Deployed 03.5 GMT, 19 July 1978 in 53 meters water depth. This mooring consists of current meters at 18 meters and 46 meters, and a pressure gauge at 52 meters water depth. This mooring was deployed in an area which had a sharp thermal structure.

Another line of C-T-D stations at 10 n.m. intervals (with XBT's in between) were taken parallel and 3.9 n.m. from the first line. The first line was then rerun from the NE-SW direction.

6) Station FX-1A UW — Deployed 0019 GMT, 20 July 1978 in 47.7 meters water depth. This mooring consists of current meters at 16 meters and 38 meters water depth. This mooring is ∿9 n.m. from BC-4G and ∿12 n.m. from FX-2A.

7) Station FX-3A UW — Deployed 0054 GMT, 20 July 1978 in 46 meters water depth. This mooring consists of current meters at 14 meters and 36 meters water depth. This mooring is 4.6 n.m. from FX-1A.

8) Station BC-21A UW — Latitude 60-23.4 N, longitude 169-11.2 W. Released at 1717 GMT, and recovered 1744 GMT, 20 July 1978. This mooring consisted of a current meter at 28.5 meters and a pressure gauge at 40.5 meters water depth.

Station BC-21B UW — Deployed 1809 GMT, 20 July 1978 in 41 meters water depth. This mooring consists of current meters at 20 meters and 32 meters water depth.

9) Station BC-20A UW — Latitude 60-25.7 N, longitude 171-05.2 W. Released at 2353 GMT, 20 July 1978 and recovered 0015 GMT, 21 July 1978. This mooring consisted of current meters at 22 meters and 52 meters and a pressure gauge at 65 meters water depth.

Station BC-20B UW — Deployed 0049 GMT, 21 July 1978 in 65 meters water depth. This mooring consists of current meters at 20 meters and 32 meters water depth.

10) Station NC-24A UW — Latitude 61-48.4 N, longitude 170-26.1 W. Released at 1716 GMT and recovered 1734 GMT, 21 July 1978. This mooring consisted of current meters at 24 meters and 40 meters water depth.

Station NC-24B UW — Deployed 1810 GMT, 21 July 1978 in 47.5 meters water depth. This mooring consists of current meters at 19 meters and 39 meters water depth.

11) Station LD-2 PMEL — Deployed 0458 GMT, 22 July 1978 in 28 meters water depth. This mooring consists of a current meter at 24.5 meters and a pressure gauge at 26 meters water depth. Additional geostrophic positioning information obtained by radar is:

| | | |
|---|---|---|
| Northeast Cape | 5.20 n.m. | 63-13.3 N |
| Punuk Island | 10.1 n.m. | 168-34.5 W |
| Direct point of land | 3.8 n m. | |

| | | |
|---|---|---|
| 12) | Station LD-1 PMEL | Deployed 1849 GMT, 22 July 1978 in 14 meters water depth. This mooring consists of a current meter at 10.5 meters and a pressure gauge at 12 meters water depth. |
| 13) | Station NC-17B PMEL | Latitude 62-53.1 N. longitude 167-04.6 W. Released at 2308 GMT, and recovered at 2319 GMT, 22 July 1978. This mooring consisted of a current meter at 17 meters and a pressure gauge at 26 meters water depth. |
| 14) | Station LD-3 PMEL | Deployed 0831 GMT, 23 July 1978 in 37 meters water depth. This mooring consists of a current meter at 33.5 meters water depth. |
| 15) | Station LD-4 PMEL | Deployed 1821 GMT, 23 July 1978 in 20 meters water depth. This mooring consists of a current meter at 16.5 meters and a pressure gauge at 18 meters water depth. |
| 16) | Station NC-12B PMEL | Latitude 65-00.3 N, longitude 169-00.7. Interrogated 2314 GMT, 23 July 1978 with no response. The release command was made with no results. A grid of interrogations and firings were made around the deployment site with no contact ever established. |
| 17) | Station NC-23A PMEL | Latitude 63-57.2 N, longitude 166-09.4 W. Released at 2007 GMT, and recovered at 2016 GMT, 24 July 1978. This mooring consisted of a current meter at 16 meters water depth. |
| 18) | Station LD-5 UW | Deployed 1335 GMT, 25 July 1978 in 27.4 meters water depth. This mooring consists of a current meter at 20 meters and a pressure gauge at 26.4 meters water depth. The radar bearing from the deployment site to Cape Darby is 022.8° at a distance of 12 miles. |

All pertinent information regarding the mooring deployments can be found in attachment D. Mooring designs are shown in figure 2 (PMEL) and figure 3 (UW).

At 2110 GMT, 25 July 1978 we proceeded towards Nome to offload mail and scientific equipment. Moderate seas precluded offloading of all scientific equipment. At 0440 GMT, 26 July 1978 we returned to the C-T-D survey area.

The survey was interrupted to evacuate an ill crew member at St. Paul Island. We then returned to the area of the front paralleling the 50 m isobath which separates the well-mixed coastal domain from the two-layered central shelf domain.

A 27 n.m. section, 1 n.m. northwest of moorings FX-2A, FX-1A and BC-4G was occupied four times over a 25-hour period to examine the frontal direction with the stage of the tide. Each section had a C-T-D spacing of 4.5 n.m., which were augmented by XBT's at 1.5 n.m. intervals.

Two 25-hour C-T-D time series were accomplished near Mooring FX-1A to examine the behavior of the front at one location over a tidal cycle.

On completion of the second anchor station at 2320 GMT, 30 July 1978 the NOAA ship *Discoverer* proceeded toward Adak, Alaska. At 1904 GMT, 2 August 1978 the ship was alongside the fuel pier, U.S. Navy Base, Adak, Alaska. A total of 5,055 nautical miles were logged on Leg I of this cruise, all of which were in slight seas.

3. *Methods*

Aanderaa RCM-4 current meters were employed on each mooring, set to record data (current speed and direction, temperature, conductivity and pressure) at a sampling interval of 30 minutes (PMEL) or 20 minutes (UW). The UW meters do not have a conductivity or pressure sensor.

An Aanderaa TG-2A or TG-3A pressure gauge was housed in an anchor wire on moorings BC-4G, FX-2A and LD-5. The pressure gauge was attached to the acoustic release on PMEL moorings LD-1, LD-2 and LD-4. The sampling interval for all the pressure gauges was 15 minutes.

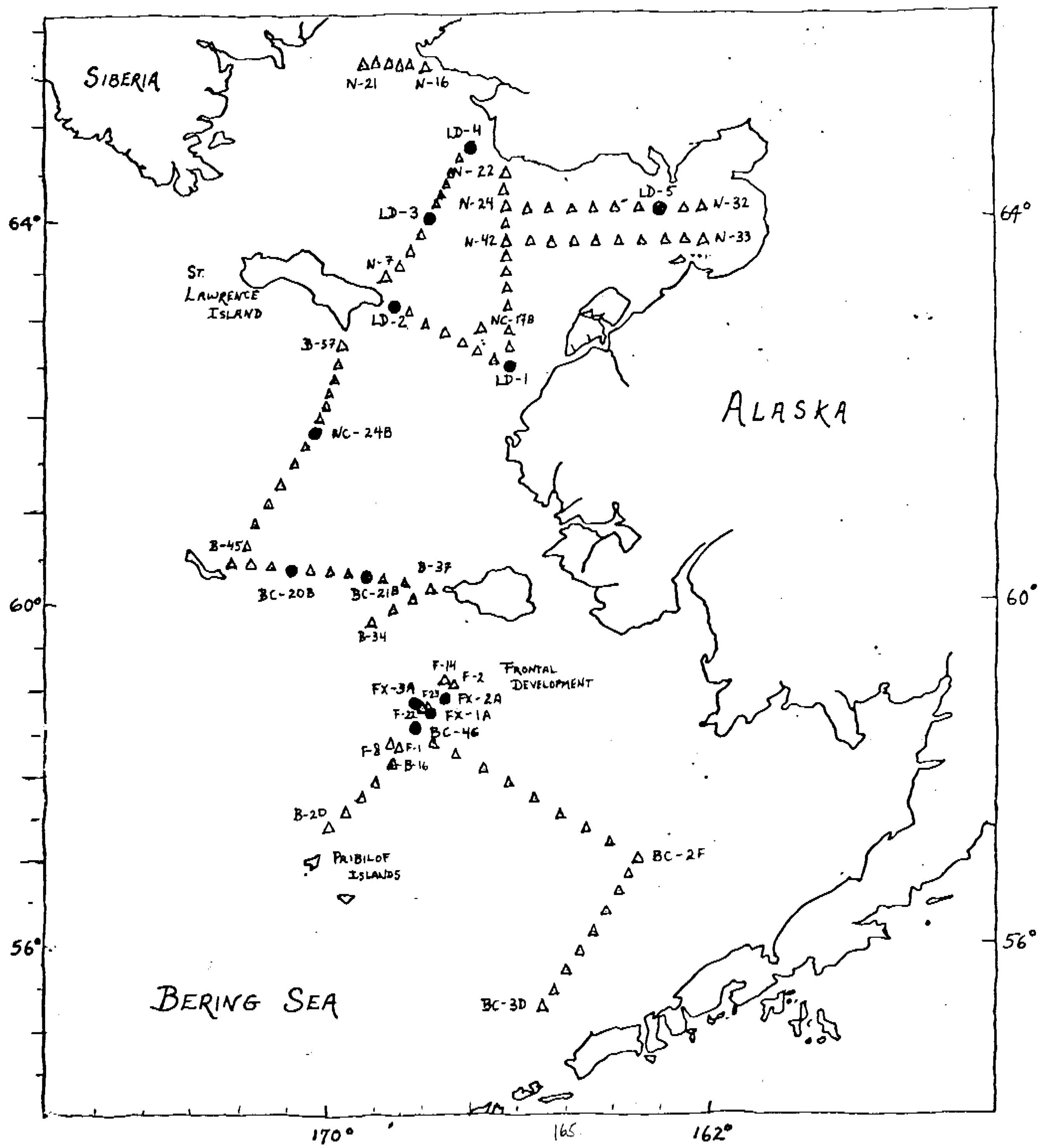
C-T-D casts were taken on each hydrographic section utilizing a Plessy Model 9040 profiling system S/N 6219 with a Model 8400 data logger. Data were stored on a 7-track magnetic tape for reduction ashore by PMEL. In order to determine field calibration factors for the conductivity and temperature sensors, a nisken bottle was mounted on the rosette sampler 1 meter above the sensors.

The salinity samples collected were analyzed aboard ship on a Guildline Model 8400 Autosal. SN 43-166.

Nutrient samples were frozen and will return with the ship to Seattle (November 1978). At that time they will be analyzed at the University of Washington for phosphate, silicate, nitrate and nitrite.

4. *Personnel*

| | | |
|---|---|---|
| R. B. Tripp | Principal Oceanographer | University of Washington Chief Scientist |
| Steve Harding | Research Aide | " |
| Rich Spicer | Graduate Student | " |
| Mike Grigsby | Oceanographer | PMEL/ERL/NOAA |
| Warren J. Houck | Professor | Humboldt State University |
| Ed Boulby | Biologist | NWAFC |
| Dennis Pippenger | " | NWAFC |



SIBERIA
N-21
N-16
LD-4
N-22
LD-5
LD-3
N-24
N-32
N-42
N-33
64°
N-7
ST. LAWRENCE ISLAND
LD-2
NC-17B
B-57
LD-1
ALASKA
NC-24B
B-45
B-37
BC-20B
BC-21B
60°
B-34
F-14
F-2
FRONTAL DEVELOPMENT
FX-3A
F23
FX-2A
F-22
FX-1A
BC-46
F-8
F-1
B-16
B-20
PRIBILOF ISLANDS
BC-2F
56°
BERING SEA
BC-3D
170°
165
162°


Figure 1.

**Figure 2.**

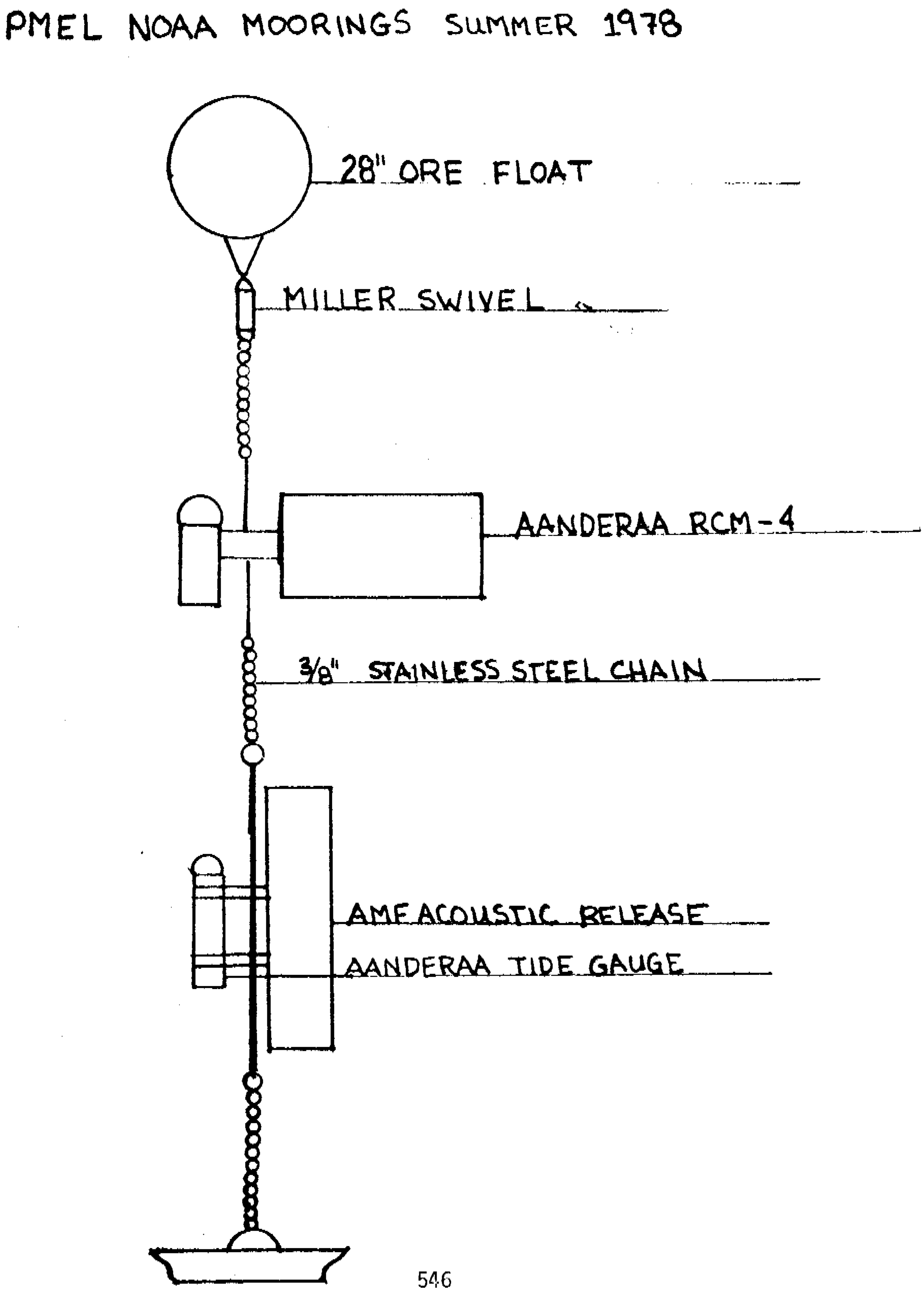
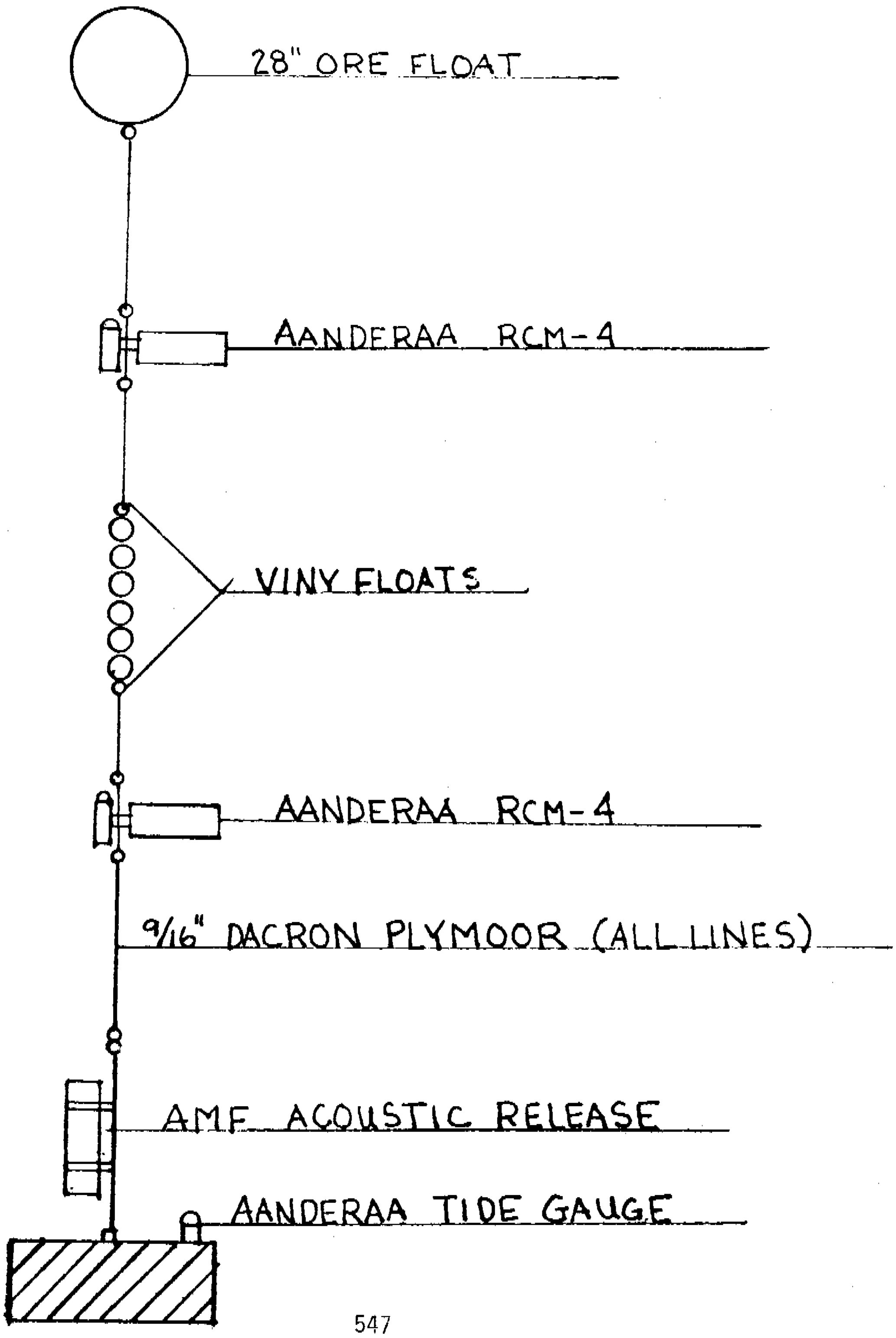

PMEL NOAA MOORINGS SUMMER 1978
28" ORE FLOAT
MILLER SWIVEL
AANDERAA RCM-4
3/8" STAINLESS STEEL CHAIN
AMF ACOUSTIC RELEASE
AANDERAA TIDE GAUGE

Figure 3.

BRISTOL BAY SUMMER 1978
TYPICAL MOORING DESIGN






UNIVERSITY OF WASHINGTON
DEPARTMENT OF OCEANOGRAPHY

ATTACHMENT A

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 1 | BC-3D | 0049 | 17 | 55-18.3 | 165-30.6 | 110 | 113 |
| 2 | B-1 | 0255 | | 55-30.4 | 165-12.3 | 105 | 107 |
| 3 | B-2 | 0440 | | 55-42.5 | 164-59.5 | 92 | 96 |
| 4 | B-3 | 0632 | | 55-57.6 | 164-44.7 | 88 | 91 |
| 5 | B-4 | 0803 | | 56-08.2 | 164-31.4 | 85 | 87 |
| 6 | B-5 | 0941 | | 56-20.5 | 164-16.1 | 83 | 84 |
| 7 | B-6 | 1125 | | 56-34.4 | 164-01.1 | 74 | 78 |
| 8 | B-7 | 1317 | | 56-49.0 | 163-43.8 | | 73 |
| 9 | BC-2F | 1945 | | 57-02.6 | 163-27.3 | 58 | 64 |
| 10 | B-8 | 2218 | | 57-15.3 | 164-05.3 | 59 | 64 |
| 11 | B-9 | 0044 | 18 | 57-28.6 | 164-45.5 | | 62 |
| 12 | B-10 | 0246 | | 57-38.3 | 165-16.4 | 56 | 62 |
| 13 | B-11 | 0445 | | 57-47.9 | 165-45.7 | 51 | 58 |
| 14 | B-12 | 0644 | | 57-57.7 | 166-16.5 | 56 | 58 |
| 15 | B-13 | 0841 | | 58-07.1 | 166-49.2 | | 58 |
| 16 | B-14 | 1030 | | 58-17.7 | 167-19.9 | 50 | 54 |
| 17 | B-15 | 1216 | | 58-27.4 | 167-48.7 | 47 | 53 |
| 18 | F-1 | 1532 | | 58-19.0 | 168-52.8 | 62 | 65 |
| 19 | F-3 | 1649 | | 58-26.2 | 168-39.1 | 60 | 64 |
| 20 | F-4 | 1800 | | 58-34.3 | 168-27.5 | 51 | 56 |
| 21 | F-5 | 2158 | | 58-41.5 | 168-15.2 | 43 | 49 |
| 22 | F-6 | 2314 | | 55-48.8 | 168-01.3 | 39 | 43 |
| 23 | BC-4G | 0333 | 19 | 58-37.2 | 168-21.5 | 48 | 53 |
| 24 | F-8 | 0557 | | 58-20.5 | 169-00.0 | 61 | 65 |
| 25 | F-9 | 0713 | | 58-28.7 | 168-46.2 | 58 | 64 |
| 26 | F-10 | 0819 | | 58-36.0 | 168-34.2 | 52 | 58 |
| 27 | F-11 | 0928 | | 58-43.1 | 168-22.4 | 45 | 49 |
| 28 | F-12 | 1040 | | 58-50.9 | 168-09.8 | 36 | 44 |
| 29 | F-13 | 1156 | | 58-58.8 | 167-56.6 | 34 | 40 |
| 30 | F-14 | 1316 | | 59-06.5 | 167-41.8 | 35 | 40 |
| 31 | F-2 | 1408 | | 59-03.5 | 167-34.6 | 35 | 40 |

ATTACHMENT A
(page 2)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 32 | F-7 | 1524 | | 58-56.1 | 167-49.4 | 35 | 40 |
| 33 | F-6 | 1638 | | 58-49.2 | 168-02.2 | 40 | 45 |
| 34 | F-5 | 1748 | | 58-40.8 | 168-15.5 | 45 | 50 |
| 35 | F-4 | 1859 | | 58-33.3 | 168-28.9 | 52 | 56 |
| 36 | F-3 | 2001 | | 58-26.2 | 168-41.7 | 58 | 62 |
| 37 | F-1 | 2105 | | 58-19.0 | 168-53.2 | 60 | 65 |
| 38 | FX-3A | 0113 | 20 | 58-47.7 | 168-13.6 | | 46 |
| 39 | B-34 | 0638 | | 59-48.4 | 169-02.4 | 38 | 44 |
| 40 | B-35 | 0809 | | 59-56.2 | 168-38.0 | | 40 |
| 41 | B-36 | 0947 | | 60-04.4 | 168-14.6 | 22 | 32 |
| 42 | B-37 | 1129 | | 60-12.9 | 167-48.6 | 25 | 31 |
| 43 | B-38 | 1250 | | 60-16.1 | 168-16.6 | 26 | 31 |
| 44 | B-39 | 1455 | | 60-20.3 | 168-41.6 | 30 | 36 |
| 45 | BC-21B | 1827 | | 60-23.8 | 169-10.5 | 37 | 40 |
| 46 | B-40 | 1953 | | 60-23.8 | 169-39.1 | 40 | 45 |
| 47 | B-41 | 2111 | | 60-23.9 | 170-06.7 | 43 | 51 |
| 48 | B-42 | 2229 | | 60-24.9 | 170-34.8 | 54 | 59 |
| 49 | BC-20B | 0105 | 21 | 60-25.3 | 171-05.4 | 60 | 65 |
| 50 | B-43 | 0222 | | 60-25.2 | 171-30.5 | 60 | 65 |
| 51 | B-44 | 0338 | | 60-26.5 | 171-55.8 | 57 | 62 |
| 52 | B-45 | 0451 | | 60-26.1 | 172-15.9 | 53 | 58 |
| 53 | B-46 | 0627 | | 60-40.0 | 171-59.8 | 57 | 62 |
| 54 | B-47 | 0805 | | 60-52.0 | 171-41.5 | 56 | 64 |
| 55 | B-48 | 0939 | | 61-05.3 | 171-25.7 | 52 | 58 |
| 56 | B-49 | 1112 | | 61-17.6 | 171-10.3 | 44 | 51 |
| 57 | B-50 | 1242 | | 61-30.0 | 170-52.3 | 44 | |
| 58 | B-51 | 1417 | | 61-41.1 | 170-37.1 | | 47 |
| 59 | NC-24B | 1827 | | 61-48.4 | 170-25.3 | 42 | 47 |
| 60 | B-52 | 1931 | | 61-58.3 | 170-20.2 | 43 | 48 |
| 61 | B-53 | 2038 | | 62-07.1 | 170-12.6 | 41 | 44 |
| 62 | B-54 | 2143 | | 62-16.9 | 170-06.0 | | 41 |

ATTACHMENT A
(page 3)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 63 | B-55 | 2246 | | 62-25.8 | 170-00.3 | 31 | 36 |
| 64 | B-56 | 2354 | | 62-36.0 | 169-51.2 | 33 | 38 |
| 65 | B-57 | 0106 | 22 | 62-45.7 | 169-45.7 | 36 | 42 |
| 66 | LD-2 | 0614 | | 63-13.3 | 168-34.5 | 22 | 28 |
| 67 | N-1 | 0739 | | 63-06.4 | 168-16.0 | 34 | 38 |
| 68 | N-2 | 0911 | | 63-01.3 | 167-55.1 | 18 | 22 |
| 69 | N-3 | 1048 | | 62-55.2 | 167-35.2 | 24 | 25 |
| 70 | N-4 | 1308 | | 62-48.9 | 167-14.8 | 34 | 38 |
| 71 | N-5 | 1511 | | 62-43.3 | 166-53.9 | 29 | 33 |
| 72 | LD-1 | 2002 | | 62-30.5 | 166-07.6 | 12 | 14 |
| 73 | N-6 | 2125 | | 62-37.6 | 166-36.2 | 20 | 22 |
| 74 | NC-17B | 2338 | | 62-53.0 | 167-05.0 | 22 | 26 |
| 75 | N-7 | 0344 | 23 | 63-28.2 | 168-48.5 | 17.5 | 26 |
| 76 | N-8 | 0506 | | 63-36.5 | 168-35.0 | 25 | 31 |
| 77 | N-9 | 0613 | | 63-43.9 | 168-24.4 | 30 | 33 |
| 78 | N-10 | 0728 | | 63-53.3 | 168-09.1 | 31 | 33 |
| 79 | LD-3 | 0845 | | 64-00.5 | 168-00.1 | 35 | 37 |
| 80 | N-11 | 0953 | | 64-08.1 | 167-46.6 | 32 | 36 |
| 81 | N-12 | 1116 | | 64-16.0 | 167-35.5 | 28 | 31 |
| 82 | N-13 | 1238 | | 64-24.6 | 167-22.1 | 24 | 30 |
| 83 | N-14 | 1401 | | 64-33.9 | 167-08.7 | 24 | 27 |
| 84 | N-15 | 1549 | | 64-41.7 | 166-55.4 | 20 | 24 |
| 85 | LD-4 | 1703 | | 64-46.1 | 166-50.0 | 18 | 20 |
| 86 | N-21 | 0437 | 24 | 65-26.7 | 169-20.8 | 45 | 51 |
| 87 | N-20 | 0539 | | 65-27.5 | 167-04.1 | 51 | 55 |
| 88 | N-19 | 0637 | | 65-27.2 | 168-46.2 | 52 | 55 |
| 89 | N-18 | 0741 | | 65-27.3 | 168-25.8 | 53 | 58 |
| 90 | N-17 | 0841 | | 65-27.4 | 168-06.1 | 38 | 40 |
| 91 | N-16 | 0932 | | 65-27.0 | 167-54.5 | 30 | 34 |
| 92 | N-22 | 1621 | | 64-25.9 | 166-09.7 | 26 | 29 |
| 93 | N-23 | 1727 | | 64-16.8 | 166-10.9 | 20 | 24 |
| 94 | N-24 | 1830 | | 64-07.8 | 166-08.5 | 18 | 21 |

ATTACHMENT A
(page 4)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 95 | NC-23A | 2024 | | 63-57.2 | 166-09.2 | 19 | 24 |
| 96 | N-42 | 2131 | | 63-46.2 | 166-10.5 | 21 | 27 |
| 97 | N-41 | 2246 | | 63-47.3 | 165-43.4 | 17 | 21 |
| 98 | N-40 | 0002 | 25 | 63-47.1 | 165-16.5 | 14 | 17 |
| 99 | N-39 | 0118 | | 63-47.0 | 164-50.2 | 12 | 16 |
| 100 | N-38 | 0238 | | 63-47.0 | 164-21.5 | 10 | 16.5 |
| 101 | N-37 | 0355 | | 63-47.5 | 163-55.3 | 11 | 16 |
| 102 | N-36 | 0526 | | 63-47.0 | 163-27.9 | 13 | 16 |
| 103 | N-35 | 0645 | | 63-46.7 | 162-58.2 | 15 | 17 |
| 104 | N-34 | 0803 | | 63-47.0 | 162-31.2 | 15 | 16.5 |
| 105 | N-33 | 0905 | | 63-46.8 | 162-05.5 | 14 | 15 |
| 106 | N-32 | 1056 | | 64-06.3 | 162-06.1 | 14 | 18 |
| 107 | N-31 | 1209 | | 64-07.0 | 162-33.0 | 16 | 20 |
| 108 | LD-5 | 1349 | | 64-08.4 | 163-01.0 | 24 | 27 |
| 109 | N-30 | 1507 | | 64-07.3 | 163-29.3 | 19 | 22 |
| 110 | N-29 | 1623 | | 64-07.2 | 163-56.0 | 19 | 22 |
| 111 | N-28 | 1746 | | 64-07.0 | 164-25.3 | 20 | 21 |
| 112 | N-27 | 1857 | | 64-07.0 | 164-51.0 | 16 | |
| 113 | N-26 | 2006 | | 64-07.1 | 165-17.2 | 17 | 18 |
| 114 | N-25 | 0624 | 26 | 64-06.7 | 165-43.0 | 18 | 20 |
| 115 | NC-23A | 0801 | | 63-57.2 | 166-10.1 | 22 | 25 |
| 116 | N-42 | 0917 | | 63-47.2 | 166-09.8 | 25 | 27 |
| 117 | N-43 | 1023 | | 63-37.7 | 166-08.9 | 21 | 26 |
| 118 | N-44 | 1142 | | 63-27.0 | 166-08.8 | 20 | 24 |
| 119 | N-45 | 1247 | | 63-17.3 | 166-09.5 | 20 | 24 |
| 120 | N-46 | 1400 | | 63-07.5 | 166-09.2 | | 22 |
| 121 | N-47 | 1509 | | 62-57.0 | 166-09.7 | 18 | 21 |
| 122 | N-48 | 1626 | | 62-45.9 | 166-08.7 | 17 | 20 |
| 123 | N-6 | 1805 | | 62-37.0 | 166-36.9 | | 22 |
| 124 | B-20 | 2359 | 27 | 57-22.2 | 169-57.8 | 59 | 63 |
| 125 | B-19 | 0135 | 28 | 57-34.4 | 169-40.4 | 65 | 71 |
| 126 | B-18 | 0305 | | 57-46.8 | 169-25.1 | 60 | 65 |

ATTACHMENT A
(page 5)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 127 | B-17 | 0442 | | 57-58.3 | 169-06.6 | 60 | 64 |
| 128 | B-16 | 0611 | | 58-11.8 | 168-53.7 | 62 | 67 |
| 129 | F-15 | 1043 | | 58-55.7 | 167-51.9 | 37 | 42 |
| 130 | F-16 | 1133 | | 58-52.0 | 167-59.6 | 38 | 43 |
| 131 | F-17 | 1216 | | 58-48.5 | 168-04.9 | 40 | 45 |
| 132 | F-18 | 1259 | | 58-44.9 | 168-10.8 | 43 | 47 |
| 133 | F-19 | 1401 | | 58-41.4 | 168-15.7 | 44 | 49 |
| 134 | F-20 | 1449 | | 58-37.3 | 168-22.4 | 49 | 53 |
| 135 | F-21 | 1532 | | 58-34.7 | 168-27.3 | 50 | 55 |
| 136 | F-15 | 1806 | | 58-55.8 | 167-53.3 | 35 | 40 |
| 137 | F-16 | 1857 | | 58-51.9 | 168-00.3 | 37 | 42 |
| 138 | F-17 | 1937 | | 58-48.4 | 168-05.9 | 39 | 44 |
| 139 | F-18 | 2014 | | 58-45.8 | 168-11.0 | 42 | 46 |
| 140 | F-19 | 2101 | | 58-41.8 | 168-16.6 | 44 | 49 |
| 141 | F-20 | 2148 | | 58-38.7 | 168-22.5 | 46 | 51 |
| 142 | F-21 | 2235 | | 58-35.3 | 168-27.5 | 48 | 55 |
| 143 | F-15 | 0143 | 29 | 58-54.4 | 167-53.9 | 35 | 42 |
| 144 | F-16 | 0228 | | 58-51.9 | 167-58.6 | 37 | 42 |
| 145 | F-17 | 0317 | | 58-48.6 | 168-03.9 | 39 | 44 |
| 146 | F-18 | 0403 | | 58-45.6 | 168-10.3 | 40 | 47 |
| 147 | F-19 | 0451 | | 58-42.0 | 168-15.7 | 43 | 47 |
| 148 | F-20 | 0537 | | 58-38.9 | 168-21.7 | 49 | 52 |
| 149 | F-21 | 0628 | | 58-35.1 | 168-27.6 | 50 | 55 |
| 150 | F-15 | 0907 | | 58-55.7 | 167-53.6 | 35 | 40 |
| 151 | F-16 | 0955 | | 58-52.2 | 167-59.7 | 35 | 42 |
| 152 | F-17 | 1040 | | 58-48.6 | 168-04.8 | 40 | 44 |
| 153 | F-18 | 1127 | | 58-45.5 | 168-10.2 | 41 | 47 |
| 154 | F-19 | 1217 | | 58-41.8 | 168-16.4 | 44 | 49 |
| 155 | F-20 | 1307 | | 58-38.5 | 168-22.3 | 47 | 51 |
| 156 | F-21 | 1404 | | 58-34.8 | 168-28.1 | 50 | 56 |
| 157 | F-22 | 1611 | | 58-43.8 | 168-11.0 | 43 | 47 |

ATTACHMENT A
(page 6)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 158 | F-22 | 1708 | | 58-43.9 | 168-11.6 | 42 | 47 |
| 159 | F-22 | 1808 | | 58-43.7 | 168-10.5 | 42 | 47 |
| | | | Anchor Station 1 | | | | |
| 160 | F-22 | 1904 | 29 | 58-43.9 | 168-10.3 | 44 | 47 |
| 161 | | 1918 | | | | 45 | 47 |
| 162 | | 1934 | | | | 45 | |
| 163 | | 1949 | | | | 45 | |
| 164 | | 2004 | | | | 44 | |
| 165 | | 2032 | | | | 44 | |
| 166 | | 2100 | | | | 44 | |
| 167 | | 2130 | | | | 44 | |
| 168 | | 2200 | | | | 44 | |
| 169 | | 2230 | | | | 43 | |
| 170 | | 2300 | | | | 44 | |
| 171 | | 2330 | | | | 44 | |
| 172 | | 0000 | 30 | | | 45 | |
| 173 | | 0030 | | | | 44 | |
| 174 | | 0059 | | | | 44 | |
| 175 | | 0100 | | | | 43 | |
| 176 | F-22 | 0203 | | 58-43.9 | 168-10.3 | 44 | 47 |
| 177 | | 0233 | | | | 44 | |
| 178 | | 0300 | | | | 44 | |
| 179 | | 0332 | | | | 44 | |
| 180 | | 0402 | | | | 44 | |
| 181 | | 0429 | | | | 44 | |
| 182 | | 0459 | | | | 44 | |
| 183 | | 0533 | | | | 45 | |
| 184 | | 0601 | | | | 45 | |
| 185 | | 0631 | | | | 45 | |
| 186 | | 0702 | | | | 44 | |
| 187 | | 0732 | | | | 45 | |
| 188 | | 0801 | | | | 44 | |

ATTACHMENT A
(page 7)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 189 | | 0832 | | | | 44 | |
| 190 | | 0902 | | | | 45 | |
| 191 | | 0931 | | | | 45 | |
| 192 | | 1000 | | | | 44 | |
| 193 | | 1032 | | | | 44 | |
| 194 | | 1100 | | | | 44 | |
| 195 | | 1130 | | | | 44 | |
| 196 | | 1200 | | | | 44 | |
| 197 | | 1230 | | | | 45 | |
| 198 | | 1300 | | | | 43 | |
| 199 | | 1330 | | | | 44 | |
| 200 | | 1402 | | | | 42 | |
| 201 | F-22 | 1433 | 30 | 58-43.9 | 168-10.3 | 42 | 47 |
| 202 | | 1503 | | | | 42 | |
| 203 | | 1531 | | | | 44 | |
| 204 | | 1603 | | | | 42 | |
| 205 | | 1635 | | | | 43 | |
| 206 | | 1701 | | | | 42 | |
| 207 | | 1730 | | | | 42 | |
| 208 | | 1802 | | | | 45 | |
| 209 | | 1832 | | | | 44 | |
| 210 | | 1901 | | | | 44 | |
| 211 | | 1916 | | | | 44 | |
| 212 | | 1931 | | | | 44 | |
| 213 | | 1947 | | | | 44 | |
| 214 | | 2002 | | | | 45 | |
| | | | Anchor Station 2 | | | | |
| 215 | F-23 | 2200 | 30 | 58-47.9 | 168-04.3 | 40 | 45 |
| 216 | | 2215 | | | | 40 | |
| 217 | | 2230 | | | | 41 | |
| 218 | | 2245 | | | | 41 | |

ATTACHMENT A
(page 8)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 219 | | 2259 | | | | 40 | |
| 220 | | 2330 | | | | 40 | |
| 221 | | 0000 | 31 | | | 40 | |
| 222 | | 0030 | | | | 40 | |
| 223 | | 0100 | | | | 40 | |
| 22[illegible] | | 0130 | | | | 40 | |
| 225 | F-23 | 0159 | | 58-47.9 | 168-04.3 | 40 | 45 |
| 226 | | 0230 | | | | 40 | |
| 227 | | 0302 | | | | 40 | |
| 228 | | 0333 | | | | 40 | |
| 229 | | 0400 | | | | 40 | |
| 230 | | 0432 | | | | 40 | |
| 231 | | 0501 | | | | 40 | |
| 232 | | 0530 | | | | 41 | |
| 233 | | 0601 | | | | 43 | |
| 234 | | 0633 | | | | 43 | |
| 235 | | 0700 | | | | 42 | |
| 236 | | 0731 | | | | 43 | |
| 237 | | 0803 | | | | 43 | |
| 238 | | 0832 | | | | 43 | |
| 239 | | 0900 | | | | 44 | |
| 240 | | 0929 | | | | 43 | |
| 241 | | 1000 | | | | 41 | |
| 242 | | 1030 | | | | 41 | |
| 243 | | 1059 | | | | 41 | |
| 244 | | 1130 | | | | 41 | |
| 245 | | 1200 | | | | 41 | |
| 246 | | 1230 | | | | 42 | |
| 247 | | 1300 | | | | 41 | |
| 248 | | 1330 | | | | 43 | |
| 249 | | 1401 | | | | 40 | |

ATTACHMENT A
(page 9)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 250 | F-23 | 1430 | 30 | 58-47.9 | 168-04.3 | 40 | 45 |
| 251 | | 1501 | | | | 41 | |
| 252 | | 1533 | | | | 40 | |
| 253 | | 1602 | | | | 40 | |
| 254 | | 1631 | | | | 40 | |
| 255 | | 1700 | | | | 40 | |
| 256 | | 1729 | | | | 40 | |
| 257 | | 1802 | | | | 43 | |
| 258 | | 1831 | | | | 44 | |
| 259 | | 1903 | | | | 44 | |
| 260 | | 1931 | | | | 44 | |
| 261 | | 2000 | | | | 44 | |
| 262 | | 2030 | | | | 44 | |
| 263 | | 2100 | | | | 45 | |
| 264 | | 2129 | | | | 43 | |
| 265 | | 2200 | | | | 41 | |
| 266 | | 2215 | | | | 38 | |
| 267 | | 2230 | | | | 41 | |
| 268 | | 2245 | | | | 41 | |
| 269 | | 2300 | | | | 41 | |

ATTACHMENT B
(page 1)

Nutrient Sample Summary

| CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) | CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) |
|---|---|---|---|---|---|---|---|
| 18 | F-1 | DI-1 | DI-2 (62) | 70 | N-4 | DI-48 | DI-49 (34) |
| 19 | F-3 | 3 | 4 (60) | 71 | N-5 | 50 | 51 (33) |
| 20 | F-4 | 6 | 5 (51) | 72 | LD-1 | 52 | 53 (12) |
| 21 | F-5 | 7 | 8 (43) | 73 | N-6 | 54 | 55 (20) |
| 22 | F-6 | 9 | 10 (39) | 74 | NC-17B | 56 | 57 (22) |
| 23 | BC-4G | 11 | 12 (48) | 75 | N-7 | 58 | 59 (18) |
| 24 | F-8 | 13 | 14 (61) | 76 | N-8 | 60 | 61 (24) |
| 25 | F-9 | 15 | 16 (58) | 77 | N-9 | 62 | 63 (30) |
| 26 | F-10 | 17 | 18 (52) | 78 | N-10 | 64 | 65 (31) |
| 27 | F-11 | 19 | 20 (49) | 79 | LD-3 | 66 | 67 (35) |
| 28 | F-12 | 21 | 22 (44) | 80 | N-11 | 68 | 69 (32) |
| 29 | F-13 | 23 | 24 (34) | 81 | N-12 | 70 | 71 (28) |
| 30 | F-14 | 25 | 26 (35 | 82 | N-13 | 72 | 73 (25) |
| 31 | F-2 | 28 | 27 (35) | 83 | N-14 | 74 | 75 (27) |
| 32 | F-7 | 29 | 30 (38) | 84 | N-15 | 76 | 77 (20) |
| 33 | F-6 | 31 | 32 (40) | 86 | N-21 | 78 | 79 (45` |
| 34 | F-5 | 33 | 34 (45) | 87 | N-20 | 80 | 81 (51) |
| 35 | F-4 | 35 | 36 (52) | 88 | N-19 | 82 | 83 (52) |
| 36 | F-3 | 37 | 38 (58) | 89 | N-18 | 84 | 85 (53) |
| 37 | F-1 | 39 | 40 (60) | 90 | N-17 | 86 | 87 (38) |
| 66 | LD-2 | | 41 (22) | 91 | N-16 | 88 | 89 (30 |
| 67 | N-1 | 42 | 43 (34) | 92 | N-22 | 90 | 91 (26) |
| 68 | N-2 | 44 | 45 (18) | 93 | N-23 | 92 | 93 (20) |
| 69 | N-3 | 46 | 47 (24) | 94 | N-24 | 94 | 95 (18) |
| 95 | NC-23A | DI-96 | DI-97 (19) | 120 | N-46 | DI-147 | DI-148 (22) |
| 96 | N-42 | 98 | 99 (21) | 121 | N-47 | 149 | 150 (18) |
| 97 | N-41 | 100 | 101 (17) | 122 | N-48 | 151 | 152 (20 |
| 98 | N-40 | 102 | 103 (14) | 123 | N-6 | 153 | 154 (22) |
| 99 | N-39 | 104 | 105 (14) | 124 | B-20 | 155 | 156 (59) |
| 100 | N-38 | 106 | 107 (10) | 125 | B-19 | 157 | 158 (65) |

ATTACHMENT B
(page 2)

| CTD Cast No. | Ref. No. | Surface Sample No. | Sample No. (depth - m) |
|---|---|---|---|
| 101 | N-37 | 108 | DI -109 (16) |
| 102 | N-36 | 110 | 111 (13) |
| 103 | N-35 | 112 | 113 (15) |
| 104 | N-34 | 115 | 116 (15) |
| 105 | N-33 | 117 | 118 (14) |
| 106 | N-32 | 119 | 120 (16) |
| 107 | N-31 | 121 | 122 (18) |
| 108 | LD-5 | 123 | 124 (27) |
| 109 | N-30 | 125 | 126 (22) |
| 110 | N-29 | 127 | 128 (22) |
| 111 | N-28 | 129 | 130 (20) |
| 112 | N-27 | 131 | 132 (16) |
| 113 | N-26 | 133 | 134 (17) |
| 114 | N-25 | 135 | 136 (20) |
| 115 | NC-23A | 137 | 138 (25) |
| 116 | N-42 | 139 | 140 (27) |
| 117 | N-43 | 141 | 142 (22) |
| 118 | N-44 | 143 | 144 (20) |
| 119 | N-45 | 145 | 146 (20) |
| 145 | F-17 | DI-195 | DI-196 (40) |
| 146 | F-18 | 197 | 198 (40) |
| 147 | F-19 | 199 | 200 (44) |
| 148 | F-20 | 201 | 202 (47) |
| 149 | F-21 | 203 | 204 (50) |
| 150 | F-15 | 205 | 206 (36) |
| 151 | F-16 | 207 | 208 (39) |
| 152 | F-17 | 209 | 210 (40) |
| 153 | F-18 | 211 | 212 (41) |
| 154 | F-19 | 213 | 214 (44) |
| 155 | F-20 | 215 | 216 (45) |
| 156 | F-21 | 217 | 218 (54) |
| 126 | B-18 | 159 | 160 (60) |
| 127 | B-17 | 161 | 162 (60) |
| 128 | B-16 | 163 | 164 (62) |
| 129 | F-15 | 165 | 166 (37) |
| 130 | F-16 | 167 | 168 (38) |
| 131 | F-17 | 169 | 170 (40) |
| 132 | F-18 | 171 | 172 (43) |
| 133 | F-19 | 173 | 174 (49) |
| 135 | F-21 | 175 | 176 (50) |
| 136 | F-15 | 177 | 178 (35) |
| 137 | F-16 | 179 | 180 (38) |
| 138 | F-17 | 181 | 182 (40) |
| 139 | F-18 | 185 | 184 (42) |
| 140 | F-19 | 185 | 186 (44) |
| 141 | F-20 | 187 | 188 (48) |
| 142 | F-21 | 189 | 190 (51) |
| 143 | F-15 | 191 | 192 (38) |
| 144 | F-16 | 193 | 194 (36) |

ATTACHMENT C

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 1 | 1720 | 18 | 58-29.0 | 168-35.3 | 60 |
| 2 | 1728 | | 58-30.3 | 168-33.6 | 60 |
| 3 | 1740 | | 58-32.2 | 168-30.9 | 60 |
| 4 | 1836 | | 58-36.1 | 168-24.5 | 55 |
| 5 | 2125 | | 58-37.9 | 168-20.7 | 51 |
| 6 | 2137 | | 58-39.5 | 168-18.1 | 49 |
| 7 | 2226 | | 58-43.3 | 168-12.3 | 48 |
| 8 | 2240 | | 58-45.0 | 168-07.8 | 46 |
| 9 | 2253 | | 58-46.9 | 168-04.5 | 46 |
| 10 | 2342 | | 58-50.9 | 167-58.8 | 44 |
| 11 | 2354 | | 58-52.9 | 167-54.6 | 42 |
| 12 | 0005 | 19 | 58-54.5 | 167-51.1 | 42 |
| 13 | 0026 | | 58-56.2 | 167-48.3 | 42 |
| 14 | 0739 | | 58-30.5 | 168-42.9 | 64 |
| 15 | 0748 | | 58-31.8 | 168-40.7 | 60 |
| 16 | 0800 | | 58-33.8 | 168-37.4 | 62 |
| 17 | 0847 | | 58-37.9 | 168-31.3 | 55 |
| 18 | 0859 | | 58-39.7 | 168-28.1 | 53 |
| 19 | 0911 | | 58-41.5 | 168-25.1 | 47 |
| 20 | 0956 | | 58-45.3 | 168-18.4 | 48 |
| 21 | 1008 | | 58-47.0 | 168-15.0 | 48 |
| 22 | 1020 | | 58-48.7 | 168-11.7 | 45 |
| 23 | 1110 | | 58-52.9 | 168-06.4 | 42 |
| 24 | 1123 | | 58-54.8 | 168-03.1 | 42 |
| 25 | 1135 | | 58-56.6 | 167-59.9 | 42 |
| 26 | 1558 | | 58-58.3 | 167-53.5 | 42 |
| 27 | 1611 | | 58-51.4 | 167-56.6 | 42 |
| 28 | 1624 | | 58-49.3 | 168-02.0 | 42 |
| 29 | 1710 | | 58-45.7 | 168-05.6 | 45 |
| 30 | 1719 | | 58-44.2 | 168-08.2 | 46 |
| 31 | 1729 | | 58-42.8 | 168-11.2 | 46 |
| 32 | 1815 | | 58-39.2 | 168-18.4 | 51 |
| 33 | 1827 | | 58-37.2 | 168-21.9 | 53 |
| 34 | 1838 | | 58-35.4 | 168-25.1 | 55 |
| 35 | 1923 | | 58-31.6 | 168-31.8 | 60 |

ATTACHMENT C
(page 2)

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 36 | 1933 | | 58-30.0 | 168-34.6 | 61 |
| 37 | 1945 | | 58-28.0 | 168-36.1 | 63 |
| 38 | 0013 | 20 | 58-42.7 | 168-09.2 | 47 |
| 39 | 0041 | | 58-46.8 | 168-12.0 | 47 |
| 40 | 1108 | 28 | 58-54.4 | 167-54.7 | 42 |
| 41 | 1120 | | 58-53.0 | 167-57.5 | 43 |
| 42 | 1152 | | 58-51.0 | 168-01.2 | 43 |
| 43 | 1201 | | 58-49.8 | 168-03.0 | 43 |
| 44 | 1236 | | 58-47.3 | 168-06.8 | 46 |
| 45 | 1245 | | 58-46.2 | 168-08.8 | 48 |
| 46 | 1319 | | 58-43.9 | 168-12.2 | 49 |
| 47 | 1330 | | 58-42.5 | 168-14.8 | 50 |
| 48 | 1431 | | 58-38.6 | 168-19.7 | 50 |
| 49 | 1503 | | 58-37.2 | 168-22.3 | 53 |
| 50 | 1512 | | 58-35.9 | 168-25.3 | 54 |
| 51 | 1831 | | 58-54.6 | 167-56.6 | 42 |
| 52 | 1839 | | 58-53.4 | 167-58.7 | 42 |
| 53 | 1914 | | 58-50.7 | 168-02.4 | 44 |
| 54 | 1921 | | 58-49.8 | 168-03.9 | 44 |
| 55 | 1955 | | 58-47.3 | 168-08.0 | 46 |
| 56 | 2001 | | 58-46.6 | 168-09.3 | 46 |
| 57 | 2035 | | 58-44.6 | 168-13.1 | 47 |
| 58 | 2044 | | 58-43.4 | 168-14.6 | 48 |
| 59 | 2121 | | 58-40.9 | 168-18.8 | 50 |
| 60 | 2130 | | 58-40.0 | 168-20.7 | 51 |
| 61 | 2210 | | 58-37.6 | 168-24.0 | 53 |
| 62 | 2219 | | 58-36.5 | 168-25.6 | 55 |
| 63 | 0204 | 29 | 58-54.3 | 167-55.3 | 42 |
| 64 | 0213 | | 58-53.1 | 167-57.0 | 42 |
| 65 | 0251 | | 58-50.7 | 168-00.7 | 44 |
| 66 | 0259 | | 58-49.7 | 168-02.5 | 44 |
| 67 | 0339 | | 58-47.5 | 168-06.2 | 47 |
| 68 | 0348 | | 58-46.6 | 168-08.5 | 47 |

ATTACHMENT C
(page 3)

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 69 | 0424 | | 58-44.4 | 168-12.1 | 47 |
| 70 | 0433 | | 58-43.3 | 168-14.1 | 47 |
| 71 | 0513 | | 58-40.9 | 168-17.7 | 49 |
| 72 | 0522 | | 58-39.8 | 168-20.1 | 49 |
| 73 | 0559 | | 58-37.8 | 168-23.9 | 53 |
| 74 | 0610 | | 58-36.4 | 168-26.1 | 54 |
| 75 | 0928 | | 58-54.6 | 167-55.5 | 40 |
| 76 | 0939 | | 58-53.4 | 167-57.8 | 42 |
| 77 | 1014 | | 58-51.1 | 168-01.3 | 43 |
| 78 | 1023 | | 58-50.0 | 168-03.0 | 43 |
| 79 | 1101 | | 58-47.7 | 168-06.5 | 45 |
| 80 | 1111 | | 58-46.6 | 168-08.4 | 46 |
| 81 | 1148 | | 58-44.4 | 168-12.2 | 47 |
| 82 | 1200 | | 58-43.1 | 168-14.5 | 48 |
| 83 | 1241 | | 58-40.7 | 168-18.5 | 50 |
| 84 | 1252 | | 58-39.5 | 168-20.7 | 51 |
| 85 | 1330 | | 58-37.3 | 168-24.3 | 53 |
| 86 | 1341 | | 58-36.1 | 168-26.4 | 55 |
| 87 | 2008 | 30 | 58-43.9 | 168-10.3 | 47 |
| 88 | 2034 | | 58-44.5 | 168-08.9 | 48 |
| 89 | 2039 | | 58-45.1 | 168-08.1 | 48 |
| 90 | 2044 | | 58-45.6 | 168-07.2 | 47 |
| 91 | 2048 | | 58-46.1 | 168-06.5 | 47 |
| 92 | 2052 | | 58-46.6 | 168-05.8 | 46 |
| 93 | 2056 | | 58-47.1 | 168-05.1 | 46 |
| 94 | 2100 | | 58-47.6 | 168-04.4 | 46 |
| 95 | 2104 | | 58-48.1 | 168-03.7 | 45 |
| 96 | 2108 | | 58-48.6 | 168-03.0 | 44 |
| 97 | 2112 | | 58-49.1 | 168-02.3 | 44 |
| 98 | 2330 | 31 | 58-47.0 | 168-06.5 | 46 |
| 99 | 2335 | | 58-46.3 | 168-08.0 | 46 |
| 100 | 2340 | | 58-45.8 | 168-09.5 | 47 |
| 101 | 2345 | | 58-45.0 | 168-11.1 | 47 |

ATTACHMENT C
(page 4)

| XBT No. | Time GMT | Day/GMT July 1978 | Latitude North | Longitude West | Water Depth |
|---|---|---|---|---|---|
| 102 | 2350 | 31 | 58-44.3 | 168-12.7 | 48 |
| 103 | 2355 | | 58-43.7 | 168-14.2 | 48 |
| 104 | 0000 | Aug. 1 | 58-43.0 | 168-15.8 | 48 |
| 105 | 0005 | | 58-42.0 | 168-17.3 | 49 |
| 106 | 0010 | | 58-41.8 | 168-18.9 | 51 |
| 107 | 0015 | | 58-41.1 | 168-20.5 | 51 |

ATTACHMENT D

Mooring Deployment Summary

| Mooring ID | Time GMT | Date GMT 1978 | Latitude North | Longitude West | Water Depth Meters | Instrumentation Depths | Loran - c rates x-rate | y-rate | z-rate | Receiver Channel No. |
|---|---|---|---|---|---|---|---|---|---|---|
| FX-2A<br>UW | 0115 | 19 | 58-52.0 | 167-56.5 | 43 | cm 20 m<br>PG 42 m | | 33667.25<br>33666.90 | 48907.38 | 10 |
| BC-4G<br>UW | 0315 | 19 | 58-37.0 | 168-21.6 | 53 | cm 18 m<br>cm 46 m<br>PG 52 m | | 33889.20 | 49107.73 | 7 |
| FX-1A<br>UW | 0019 | 20 | 58-42.8 | 168-09.5 | 47.7 | cm 16 m<br>cm 38 m | | 33798.60 | 49017.89 | 6 |
| FX-3A<br>UW | 0054 | 20 | 58-47.4 | 168-13.1 | 46 | cm 14 m<br>cm 36 m | | 33754.00 | 49013.59 | 5 |
| BC-21B<br>UW | 1809 | 20 | 60-23.9 | 169-10.4 | 41 | cm 20 m<br>cm 32 m | 18209.15 | 32689.65 | | 1 |
| BC-20B<br>UW | 0049 | 21 | 60-25.6 | 171-05.1 | 65 | cm 20 m<br>cm 32 m | 17914.56 | 32772.98 | | 2 |
| NC-24B<br>UW | 1810 | 21 | 61-48.3 | 170-26.0 | 47 | cm 19 m<br>cm 39 m | 17810.19 | 31746.9 | | 4 |
| LD-2<br>PMEL | 0558 | 22 | 63-13.2 | 168-34.8 | 28 | cm 24.5 m<br>PG 26 m | 17840.66 | 30594.40 | | 1 |
| LD-1<br>PMEL | 1949 | 22 | 62-30.3 | 166-07.2 | 14 | cm 10.5 m<br>PG 12 m | 18170.22 | 30961.86 | | 10 |
| LD-3<br>PMEL | 0831 | 23 | 64-00.4 | 168-00.0 | 37 | cm 33.5 m | 17796.71 | 29981.49 | | 7 |
| LD-4<br>PMEL | 1821 | 23 | 64-46.6 | 166-49.6 | 20 | cm 16.5 m<br>PG 18 m | 17806.26 | 29342.46 | | 1 |
| LD-5<br>UW | 1335 | 25 | 64-08.3 | 163-00.2 | 27.4 | cm 20 m<br>PG 26.4 m | 18156.46 | 29899.90 | 46824.61 | 4 |

APPENDIX B

University of Washington
Department of Oceanography
Seattle, Washington 98195

Preliminary Report

# University of Washington Participation in NOAA Ship *Discoverer* Cruise RP-4-DI-78B, Leg III

Bristol Bay Oceanographic Processes RU 141

Norton-Chukchi Oceanographic Processes RU 541

10 - 29 September 1978

by

Richard B. Tripp

NOAA Contract 03-5-022-67, TO 4 & TO 14

Approved by:

L. K. Coachman, Professor
Principal Investigator

George C. Anderson, Professor
Associate Chairman for Research

Ref: M78-56

BRISTOL BAY OCEANOGRAPHIC PROCESSES

NORTON-CHUKCHI OCEANOGRAPHIC PROCESSES

1. *Objectives*

This study is a joint program with the Pacific Marine Environmental Laboratory (PMEL), ERL, NOAA to provide:

1) water mass circulation information over the eastern and northeastern Bering Sea shelf region.

2) verification of the fluctuation in the northward transport through Bering Strait.

3) data on temporal and spatial scales of eddies ubiquitous to the system

4) data to refine our understanding of key dynamic processes within the system.

5) more data to augment our understanding of the circulation within Norton Sound.

6) some basis for predictive or diagnostic models of ecosystem response to loading by petroleum and petroleum by-products.

The Leg III portion of this cruise was directed toward finalizing some of this research. This was the last scheduled cruise associated with this program. The specific objectives of this cruise were:

1) The recovery of twelve current meter and pressure gauge moorings in the eastern and northeastern Bering Sea, that were deployed in July 1978.

2) C-T-D stations at selected sites to minotor the seasonal change within the system.

3) An examination of the structural front paralleling the 50-meter isobath prior to retrieval of the four moorings.

4) The collection and analysis of nutrient samples from selected sites as an aid in examining the circulation.

5) A series of C-T-D stations around the Pribilof Islands in conjunction with the RU 83 program to correlate bird observations with physical parameters near the front around the islands.

6) A series of drags in an attempt to retrieve some of the previous lost moorings which failed to surface.

## 2. *Cruise Track & Narrative*

The NOAA ship *Discoverer* departed Kodiak, Alaska at 1800 GMT, 10 September 1978 and proceeded to the survey area (Figures 1 & 2).

1) Station BC-21B UW — Latitude 60°23.9'N, longitude 169°10.4'W. Released at 0555 GMT and recovered at 0615 GMT, 13 September 1978. This mooring consisted of current meters at 20 meters and 32 meters water depth.

The C-T-D program was initiated at this time. All CTD stations accomplished are listed in attachment A.

2) Station BC-20B UW — Latitude 60°25.6N, longitude 171-05.1W. Released at 1803 GMT, and recovered at 1855 GMT, 13 September 1978. This mooring consisted of current meters at 19 meters and 51 meters water depth. We encountered a slight problem during this retrieval. The top current meter was hung up on the ship's rudder post for a time, resulting in the loss of the current meter rotor and vane.

3) Station NC-24B UW — Latitude 61-48.3N, longitude 170-26.0W. Released at 0049 GMT and recovered at 0109 GMT, 14 September 1978. This mooring consisted of current meters at 19 meters and 39 meters water depth.

4) Station LD-1 PMEL — Latitude 62-30.3N, longitude 166-07.2W. Released at 1719 GMT, and recovered at 1729 GMT, 14 September 1978. This mooring consisted of a current meter at 10.5 meters, and a pressure gauge at 12 meters water depth.

5) Station LD-2 PMEL — Latitude 63-13.2N, longitude 168-34.8W. Released at 2326 GMT, 14 September 1978 and recovered at 0007 GMT, 15 September 1978. This mooring consisted of a current meter at 24.5 meters and a pressure gauge at 26 meters water depth.

6) Station LD-3 PMEL — Latitude 64-00.4N, longitude 166-49.6W. Released at 0359 GMT, and recovered at 0404 GMT, 15 September 1978. This mooring consisted of a current meter at 33.5 meters water depth. There was growth around bearing on current meter. Also, the current meter was 125° out of alignment with reference.

7) Station LD-5 UW — Latitude 64-08.3N, longitude 163-00.2W. No contact was made with this mooring. A grid of one mile interrogations was done around the deployment site with no positive results. Also, a line of one-mile interrogations was done from 69-09.7N; 163-38'W to 69-09.6'N; 163-10.0'W with negative results. A drag was accomplished around the deployment site with no success.

8) Station NC-22A PMEL — Latitude 63-40.8W, longitude 163-01.8W. We had tried unsuccessfully to retrieve this mooring in August 1977. We now dragged the area, hitting something but failed to retrieve anything.

9) Station LD-4 PMEL — Latitude 64-46.6N, longitude 166-49.6W. Released at 1721 GMT, and recovered at 1736 GMT. This mooring consisted of a current meter at 16.5 meters and a pressure gauge at 18 meters water depth. There was heavy growth on the instrumentation.

We proceeded toward Bering Strait to attempt recovery of a Japanese mooring deployed 24 July 1978. The position was latitude 65-46.5N, and longitude 168-35.5W with a Radar Bearing to Fairway Rock 202°/9.60 n.m. On arrival at the mooring site, the seas were too heavy to attempt dragging operations, so C-T-D stations were occupied in Bering Strait until the following morning.

At 1700 GMT, 17 September we commenced dragging operations. We completed the drag at 1857 GMT with no positive results other than retrieving some large rocks.

An attempt was made to interrogate NC-16A, lost in Bering Strait the previous year. However, no response was obtained.

Taking C-T-D stations en route, we returned to an area around moorings FX-1A, FX-2A, FX-3A and BC-4G to examine the structural front over a 25-hour tidal cycle.

A line of (27 n.m.) C-T-D stations were occupied at 4.5 n.m. intervals across the front. XBT's were taken at 15. n.m. intervals between the C-T-D stations. XBT information can be found in attachment B. Nutrient samples were drawn at the surface and at bottom - 5 meters on all C-T-D casts associated with the frontal experiment (attachment C). Only XBT's were taken on the fourth crossing of the front, as the weather deteriorated.

10) Station BC-4G — Latitude 58-37.0N. longitude 168-21.6W. Released 1748 GMT and recovered at 1820 GMT, 20 September 1978. This mooring consisted of current meters at 18 meters & 46 meters, and a pressure gauge at 52 meters water depth.

11) Station FX-1A — Latitude 58-42.8N, longitude 168-09.5W. Released 1914 GMT, and recovered 2004 GMT, 20 September 1978. This mooring consisted of current meters at 16 meters and 38 meters water depth.

12) Station FX-3A — Latitude 58-47.4N, longitude 168-13.1W. Released 2153 GMT, and recovered 2226 GMT, 20 September 1978. This mooring consisted of current meters at 14 meters and 36 meters water depth.

13) Station FX-2A — Latitude 58-52.0N, longitude 167-56.5W. Released 2344 GMT, 20 September 1978 and recovered at 0012 GMT, 21 September 1978. This mooring consisted of a current meter at 20 meters, and a pressure gauge at 42 meters water depth.

XBT's were taken around the front until the following morning. No CTD's were taken due to heavy seas.

At 1957 GMT, 21 September 1978 we arrived at the deployment site of mooring BC-4F. Again there was no response to interrogation. Heavy seas prevented our planned drag of the area.

C-T-D's were taken on a line toward St. Paul Island, where we were scheduled to take aboard the bird observers.

At 1940 GMT, 22 September 1978 the University of California bird program commenced around the Pribilof Islands.

A series of C-T-D's and XBT's were taken around the islands to examine the water column as it changes from stratified to homogeneous near the Pribilof Islands. Five lines of stations extending out from St. Paul Island, and two lines extending out from St. George Island were accomplished. Nutrient samples were collected at 10 meters and bottom minus 5 meters water depth. In addition one hydrographic station in the stratified water column was sampled at eight depths and one hydrographic station in the well-mixed region was sampled at six depths.

At 0652 GMT, 27 September 1978 the survey in the Pribilof area was terminated and the ship proceeded toward Kodiak, Alaska. At 1800 GMT, 29 September 1978 the ship was alongside the fuel pier at the U.S. Coast Guard Station, Kodiak, Alaska. A total of 3155.5 nautical miles were steamed on Leg III of this cruise.

## 3. *Methods*

Aanderaa RCM-4 current meters were employed on each of the recovered moorings. The meters were set to record data (current speed and direction, temperature, conductivity, and pressure) at a sampling interval of 30 minutes (PMEL) or 20 minutes (UW). The UW meters do not have a conductivity or pressure sensor.

Aanderaa TG-2A or TG-3A pressure gauges were utilized on moorings BC-4G, FX-2A, LD-1, LD-2 and LD-4. The sampling interval for all the pressure gauges was 15 minutes.

C-T-D casts were taken on each hydrographic station utilizing a Plessy Model 9040 profiling system S/N 6219 with a model 8400 data logger. Data were stored on a 7-track magnetic tape for reduction ashore by PMEL. There was a problem with the data logger during this leg. No temperatures were recorded on the Plessy system. However, temperatures were recorded on the ship's DAS and will be retrieved when the ship returns to Seattle.

In order to determine field calibration factors for the conductivity and temperature sensors, a niskin bottle was mounted on the rosette sampler 1-meter above the sensors.

The salinity samples collected were analyzed aboard ship on a Guildline Model 8400 Autosal N/N 43-166.

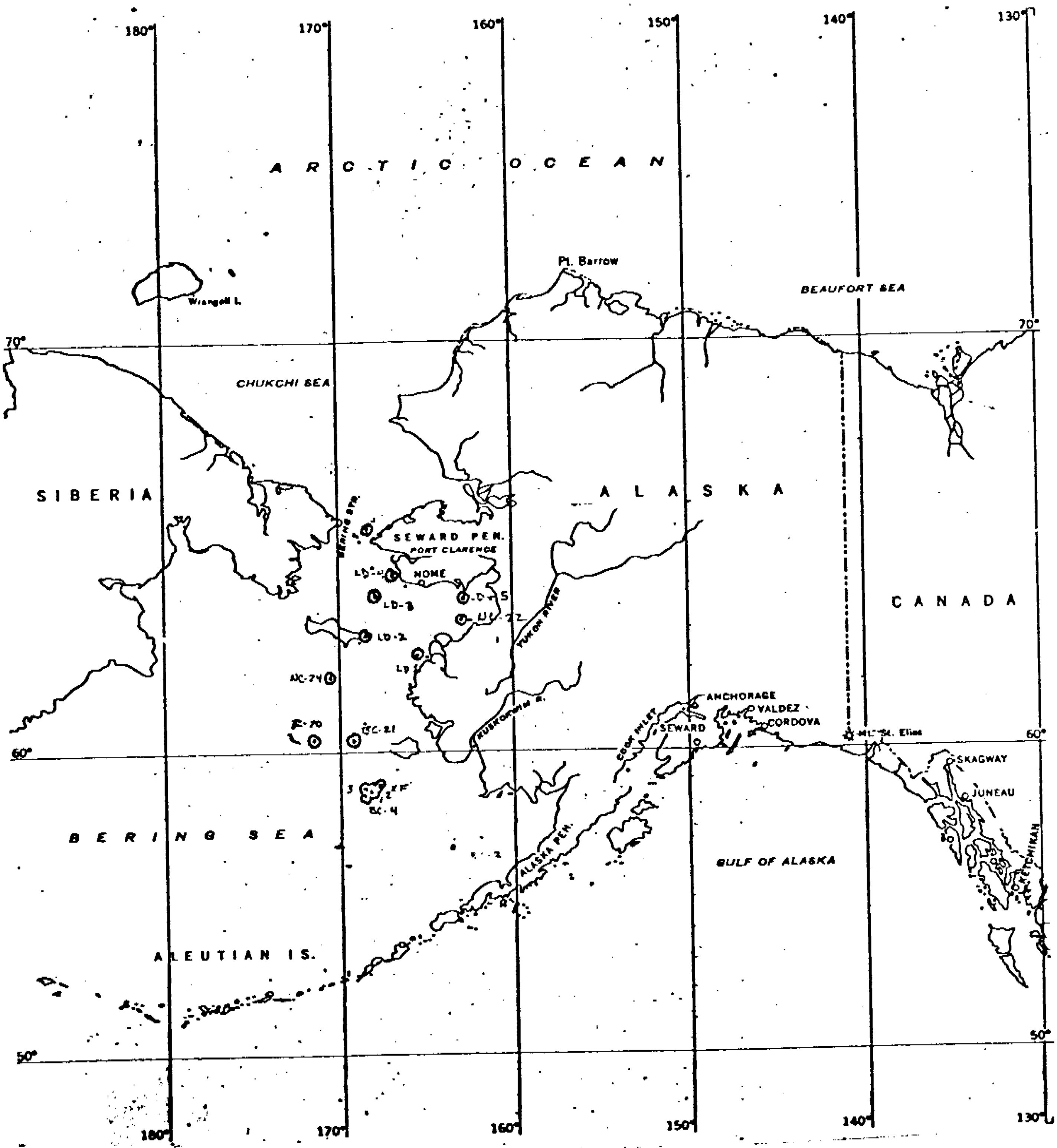
Nutrient samples were frozen and will return with the ship in November 1978. At that time they will be analyzed at the University of Washington.

XBT's utilized on this cruise were T-10 (0-200 meter) type.

4. *Personnel*

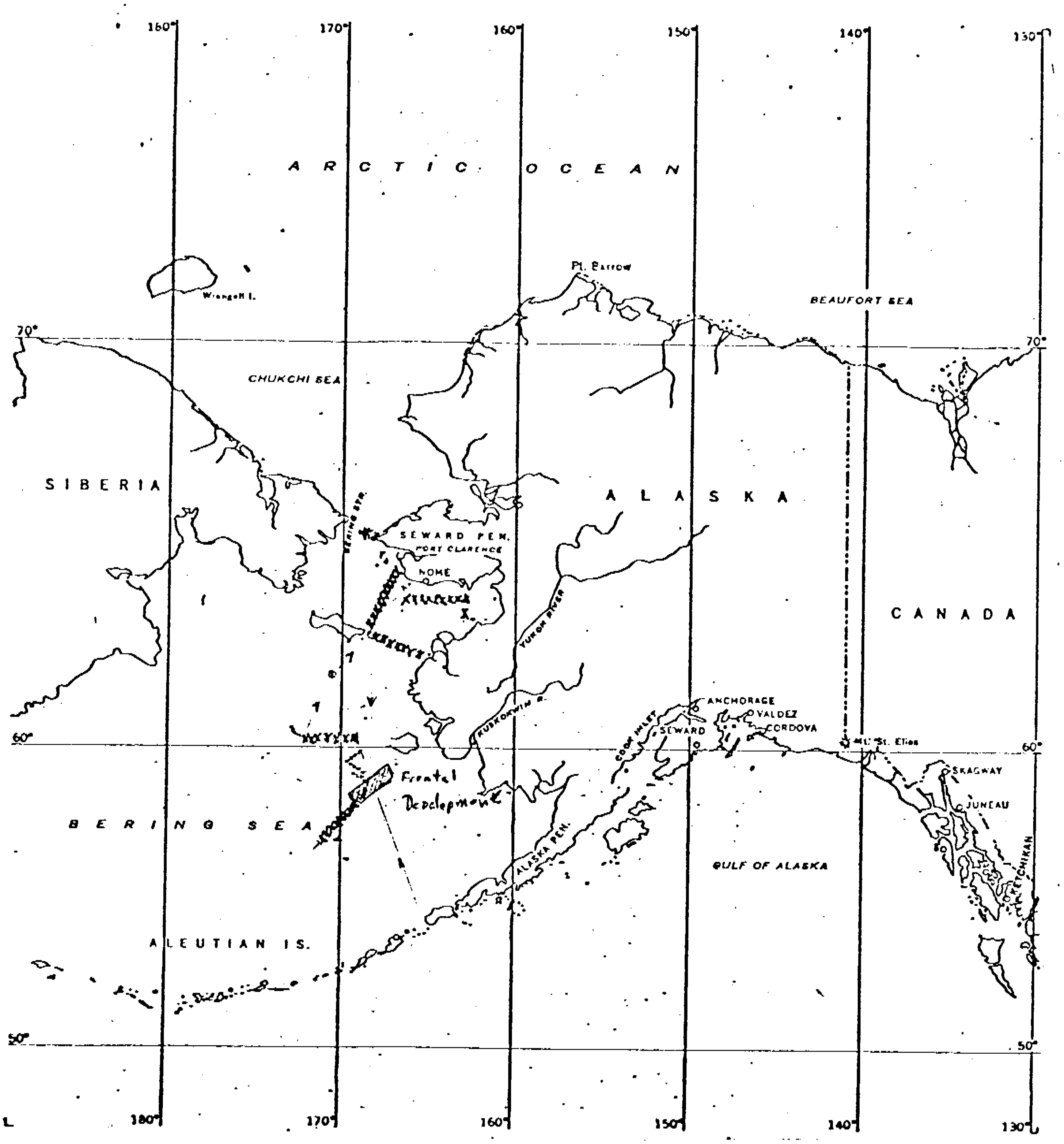
| | | |
|---|---|---|
| R. B. Tripp | Principal Oceanographer | University of Washington |
| Tore Lein-Mathison | Student | " |
| Dave Pashinski | Physical Scientist | PMEL-NOAA |
| Kristine Newby | Biologist | NMFS |
| Elizabeth Hacker | Biologist | NMFS |
| *Maura Naughton | Biologist | University of California, Irvine |
| *Bill Rodstrom | Biologist | " |
| **Ron Squibb | Biologist | " |

* Joined ship 9/22
** Joined ship 9/27




Mooring Locations RP4-DI-78B Leg III.

Figure 1.




CTD & XBT Sections RP4-DI-78B Leg III.

**Figure 2.**

ATTACHMENT A

C-T-D Station Summary

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept. 1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 1 | BC-21B | 0629 | 13 | 60-23.4 | 169-10.7 | 37 | 42 |
| 2 | B-40 | 0755 | | 60-23.9 | 169-37.5 | 41 | 45 |
| 3 | B-41 | 0916 | | 60-23.7 | 170-06.7 | 49 | 53 |
| 4 | B-42 | 1031 | | 60-25.2 | 170-34.8 | 55 | 60 |
| 5 | BC-20B | 1200 | | 60-26.0 | 171-05.1 | 61 | 65 |
| 6 | B-43 | 1313 | | 60-25.2 | 171-30.4 | 60 | 67 |
| 7 | B-44 | 1431 | | 60-26.1 | 171-54.5 | 55 | 64 |
| 8 | B-45 | 1520 | | 60-28.8 | 172-05.9 | 53 | 67 |
| 9 | N-1 | 0843 | 14 | 63-05.9 | 168-16.9 | 35 | 40 |
| 10 | N-2 | 0957 | | 63-01.0 | 167-55.2 | 18 | 21 |
| 11 | N-3 | 1057 | | 62-54.7 | 167-35.6 | 19 | 27 |
| 12 | N-4 | 1201 | | 62-48.8 | 167-15.7 | 35 | 37 |
| 13 | N-5 | 1305 | | 62-42.7 | 166-54.9 | 27 | 32 |
| 14 | N-6 | 1436 | | 62-36.6 | 166-36.1 | 18 | 23 |
| 15 | LD-1 | 1648 | | 62-30.2 | 166-08.7 | 10 | 15 |
| 16 | LD-2 | 0024 | 15 | 63-13.0 | 168-35.0 | 25 | 28 |
| 17 | LD-3 | 0417 | | 64-00.5 | 167-59.6 | 8.2 | 12 |
| 18 | N-24 | 0819 | | 64-06.9 | 166-07.9 | 18 | 21 |
| 19 | N-25 | 0929 | | 64-06.9 | 165-41.5 | 15 | 20 |
| 20 | N-26 | 1032 | | 64-06.8 | 165-15.6 | 14 | 18 |
| 21 | N-27 | 1139 | | 64-06.7 | 164-51.2 | 14 | 18 |
| 22 | N-28 | 1247 | | 64-06.8 | 164-24.3 | 16 | 22 |
| 23 | N-29 | 1405 | | 64-07.0 | 163-55.8 | 17 | 22 |
| 24 | N-30 | 1510 | | 64-06.9 | 163-29.5 | 17 | 22 |
| 25 | LD-5 | 1634 | | 64-08.1 | 163-00.0 | 21 | 30 |
| 26 | LD-4 | 1750 | 16 | 64-47.1 | 166-49.9 | 15 | 24 |
| 27 | N-50 | 0112 | 17 | 65-38.2 | 168-14.3 | 33 | 38 |
| 28 | N-51 | 0212 | | 65-39.1 | 168-22.1 | 43 | 49 |
| 29 | N-52 | 0255 | | 65-37.9 | 168-32.8 | 45 | 53 |
| 30 | N-53 | 0332 | | 65-37.9 | 168-39.9 | 44 | 51 |
| 31 | N-54 | 0413 | | 65-38.1 | 168-50.1 | 43 | 49 |

ATTACHMENT A
(page 2)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 32 | N-55 | 0447 | | 65-38.1 | 168-57.1 | 42 | 47 |
| 33 | N-54 | 0532 | | 65-38.2 | 168-49.1 | 45 | 50 |
| 34 | N-53 | 0613 | | 65-38.4 | 168-39.4 | 44 | 49 |
| 35 | N-52 | 0650 | | 65-38.2 | 168-32.2 | 47 | 53 |
| 36 | N-51 | 0740 | | 65-38.2 | 168-22.1 | 45 | 50 |
| 37 | N-50 | 0821 | | 65-38.5 | 168-13.2 | 34 | 44 |
| 38 | N-55 | 1017 | | 65-38.5 | 168-57.8 | 37 | 45 |
| 39 | N-54 | 1052 | | 65-38.0 | 168-48.8 | 45 | 49 |
| 40 | N-53 | 1133 | | 65-38.2 | 168-39.5 | 44 | 49 |
| 41 | N-52 | 1210 | | 65-38.3 | 168-32.0 | 48 | 53 |
| 42 | N-51 | 1249 | | 65-38.7 | 168-22.5 | 44 | 51 |
| 43 | N-50 | 1331 | | 65-38.4 | 168-14.5 | 31 | 40 |
| 44 | LD-4 | 0242 | 18 | 64-46.6 | 166-49.5 | 15 | 20 |
| 45 | N-15 | 0342 | | 64-40.8 | 166-58.5 | 20 | 25 |
| 46 | N-14 | 0441 | | 64-33.1 | 167-10.6 | 22 | 27 |
| 47 | N-13 | 0551 | | 64-24.5 | 167-22.4 | 24 | 29 |
| 48 | N-12 | 0657 | | 64-16.0 | 167-35.7 | 27 | 31 |
| 49 | N-11 | 0806 | | 64-07.6 | 167-46.5 | 31 | 36 |
| 50 | LD-3 | 0910 | | 64-00.4 | 167-59.1 | | 37 |
| 51 | N-10 | 1018 | | 63-53.1 | 168-09.2 | 30 | 34 |
| 52 | N-9 | 1125 | | 63-45.0 | 168-21.7 | 30 | 33 |
| 53 | N-8 | 1241 | | 63-36.0 | 168-34.4 | 28 | 33 |
| 54 | N-7 | 1349 | | 63-28.4 | 168-49.0 | | 27 |
| 55 | F-15 | 1228 | 19 | 58-55.7 | 167-53.2 | 38 | 42 |
| 56 | F-16 | 1310 | | 58-52.7 | 167-58.2 | 37 | 42 |
| 57 | F-17 | 1354 | | 58-49.5 | 168-04.2 | 37 | 43 |
| 58 | F-18 | 1441 | | 58-45.8 | 168-09.8 | 39 | 47 |
| 59 | F-19 | 1523 | | 58-42.8 | 168-15.3 | 45 | 49 |
| 60 | F-20 | 1617 | | 58-39.1 | 168-21.0 | 47 | 52 |
| 61 | F-21 | 1704 | | 58-35.9 | 168-26.3 | 50 | 54 |
| 62 | F-15 | 1945 | | 58-35.8 | 167-52.1 | 38 | 42 |

ATTACHMENT A
(page 3)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 63 | F-16 | 2032 | | 58-52.9 | 167-58.2 | 39 | 42 |
| 64 | F-17 | 2115 | | 58-49.4 | 168-02.9 | 39 | 43 |
| 65 | F-18 | 2206 | | 58-45.3 | 168-08.8 | 42 | 45 |
| 66 | F-19 | 2256 | | 58-42.2 | 168-14.5 | 45 | 49 |
| 67 | F-20 | 2351 | | 58-38.7 | 168-21.2 | 47 | 51 |
| 68 | F-21 | 0031 | 20 | 58-35.7 | 168-26.4 | 50 | 54 |
| 69 | F-15 | 0327 | | 58-56.0 | 167-52.7 | 33 | 42 |
| 70 | F-16 | 0420 | | 58-52.8 | 167-57.9 | 35 | 42 |
| 71 | F-17 | 0507 | | 58-49.2 | 168-03.5 | 39 | 44 |
| 72 | F-18 | 0606 | | 58-45.8 | 168-09.5 | 42 | 47 |
| 73 | F-19 | 0652 | | 58-42.7 | 168-15.0 | 44 | 49 |
| 74 | F-20 | 0755 | | 58-39.3 | 168-21.1 | 46 | 51 |
| 75 | FX-2A | 0136 | 21 | 58-51.6 | 167-58.6 | 33 | 40 |
| 76 | B-58 | 2251 | | 58-29.4 | 168-35.1 | 57 | 62 |
| 77 | B-59 | 0002 | 22 | 58-23.3 | 168-48.5 | 58 | 64 |
| 78 | B-60 | 0113 | | 58-15.9 | 169-01.2 | 61 | 65 |
| 79 | B-61 | 0227 | | 58-08.8 | 169-15.5 | 61 | 67 |
| 80 | B-62 | 0344 | | 58-01.3 | 169-27.2 | 63 | 67 |
| 81 | B-63 | 0456 | | 57-54.0 | 169-41.9 | 63 | 69 |
| 82 | B-64 | 0607 | | 57-46.7 | 169-54.5 | 64 | 70 |
| 83 | B-65 | 0720 | | 57-39.4 | 170-07.5 | | 71 |
| 84 | B-66 | 0833 | | 57-32.0 | 170-19.4 | 65 | 70 |
| 85 | B-67 | 0945 | | 57-25.0 | 170-32.9 | 65 | 69 |
| 86 | B-68 | 1059 | | 57-17.4 | 170-46.3 | 73 | 78 |
| 87 | B-69 | 1210 | | 57-10.0 | 170-59.9 | 82 | 87 |
| 88 | P-1 | 2317 | | 57-05.9 | 168-59.3 | 72 | 77 |
| 89 | P-2 | 0232 | 23 | 56-34.2 | 169-24.8 | 57 | 66 |
| 90 | P-3 | 0536 | | 56-35.3 | 168-29.6 | 105 | 109 |
| 91 | P-4 | 1645 | | 57-09.9 | 170-04.6 | 26 | 29 |
| 92 | P-5 | 1852 | | 57-09.4 | 169-29.2 | 62 | 69 |
| 93 | P-6 | 2116 | | 57-34.8 | 168-30.9 | 64 | 71 |

ATTACHMENT A
(page 4)

| Consec. Cast No. | Ref. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | CTD Depth (m) | Water Depth (m) |
|---|---|---|---|---|---|---|---|
| 94 | P-7 | 0020 | 24 | 57-17.2 | 170-10.6 | 31 | 36 |
| 95 | P-8 | 0125 | | 57-14.4 | 170-25.3 | 43 | 51 |
| 96 | P-9 | 0510 | | 57-48.4 | 170-26.4 | 64 | 71 |
| 97 | P-10 | 0801 | | 57-32.0 | 170-25.6 | | 72 |
| 98 | P-11 | 2348 | | 57-12.5 | 170-28.4 | 54 | 60 |
| 99 | P-12 | 0512 | 25 | 57-12.7 | 172-05.4 | 104 | 108 |
| 100 | P-13 | 0944 | | 56-47.5 | 171-10.1 | 107 | 111 |
| 101 | P-14 | 1238 | | 57-05.8 | 170-27.2 | 40 | 45 |
| 102 | P-15 | 1938 | | 56-38.9 | 170-28.5 | 106 | 107 |
| 103 | P-16 | 2257 | | 56-39.3 | 169-25.3 | 58 | 64 |
| 104 | P-17 | 0424 | 26 | 55-39.5 | 169-26.2 | 289 | 2505 |
| 105 | P-18 | 0751 | | 56-05.7 | 169-27.2 | 235 | 240 |
| 106 | P-19 | 1143 | | 56-12.3 | 170-24.4 | 116 | 119 |
| 107 | P-20 | 1510 | | 55-49.7 | 170-54.7 | 502 | 2500 |
| 108 | P-21 | 2201 | | 56-38.0 | 169-52.4 | 78 | 82 |
| 109 | P-22 | 0507 | 27 | 55-59.5 | 168-51.4 | 500 | 914 |

ATTACHMENT B

XBT Station Summary

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 1 | 1252 | 19 | 58-54.7 | 167-54.8 | 42 |
| 2 | 1258 | | 58-53.8 | 167-56.0 | 42 |
| 3 | 1333 | | 58-51.6 | 168-00.2 | 43 |
| 4 | 1340 | | 58-50.6 | 168-01.7 | 43 |
| 5 | 1421 | | 58-48.1 | 168-06.3 | 45 |
| 6 | 1429 | | 58-47.0 | 168-07.7 | 46 |
| 7 | 1502 | | 58-44.9 | 168-11.3 | 47 |
| 8 | 1513 | | 58-43.5 | 168-13.5 | 48 |
| 9 | 1554 | | 58-41.6 | 168-17.2 | 49 |
| 10 | 1605 | | 58-40.2 | 168-19.2 | 51 |
| 11 | 1641 | | 58-38.1 | 168-22.2 | 53 |
| 12 | 1650 | | 58-37.0 | 168-23.9 | 54 |
| 13 | 2011 | | 58-54.5 | 167-54.1 | 42 |
| 14 | 2019 | | 58-53.6 | 167-55.7 | 42 |
| 15 | 2056 | | 58-51.5 | 168-00.0 | 44 |
| 16 | 2105 | | 58-50.3 | 168-01.6 | 44 |
| 17 | 2143 | | 58-47.8 | 168-04.9 | 46 |
| 18 | 2153 | | 58-46.5 | 168-06.8 | 46 |
| 19 | 2229 | | 58-44.2 | 168-11.1 | 47 |
| 20 | 2236 | | 58-43.3 | 168-12.6 | 48 |
| 21 | 2330 | | 58-40.9 | 168-16.6 | 50 |
| 22 | 2335 | | 58-39.9 | 168-18.6 | 51 |
| 23 | 0014 | 20 | 58-37.3 | 168-23.3 | 53 |
| 24 | 0018 | | 58-36.8 | 168-24.2 | 53 |
| 25 | 0355 | | 58-55.0 | 167.54.4 | 42 |
| 26 | 0402 | | 58-54.0 | 167-55.7 | 42 |
| 27 | 0440 | | 58-51.7 | 167-59.5 | 42 |
| 28 | 0450 | | 58-50.4 | 168-01.3 | 44 |
| 29 | 0539 | | 58-47.7 | 168-05.0 | 46 |
| 30 | 0550 | | 58-46.6 | 168-07.3 | 46 |
| 31 | 0629 | | 58-44.8 | 168-11.2 | 49 |
| 32 | 0638 | | 58-43.7 | 168-12.9 | 49 |
| 33 | 0726 | | 58-41.9 | 168-16.3 | 50 |

ATTACHMENT B
(page 2)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 34 | 0740 | | 58-40.3 | 168-19.1 | 52 |
| 35 | 0828 | | 58-38.3 | 168-22.7 | 53 |
| 36 | 0837 | | 58-37.0 | 168-24.5 | 55 |
| 37 | 0848 | | 58-35.7 | 168-26.4 | 55 |
| 38 | 1230 | | 58-55.8 | 167-52.6 | 41 |
| 39 | 1241 | | 58-55.4 | 167-54.1 | 42 |
| 40 | 1254 | | 58-53.7 | 167-56.9 | 42 |
| 41 | 1259 | | 58-43.0 | 167-58.1 | 42 |
| 42 | 1308 | | 58-51.8 | 168-00.0 | 43 |
| 43 | 1317 | | 58-50.6 | 168-01.9 | 44 |
| 44 | 1326 | | 58-49.4 | 168-03.9 | 44 |
| 45 | 1336 | | 58-48.0 | 168-06.5 | 45 |
| 46 | 1344 | | 58-47.1 | 168-07.9 | 45 |
| 47 | 1353 | | 58-45.9 | 168-09.9 | 45 |
| 48 | 1401 | | 58-44.9 | 168-11.2 | 46 |
| 49 | 1410 | | 58-43.8 | 168-13.2 | 48 |
| 50 | 1419 | | 58-42.6 | 168-15.8 | 48 |
| 51 | 1427 | | 58-41.6 | 168-17.3 | 49 |
| 52 | 1435 | | 58-40.5 | 168-19.3 | 50 |
| 53 | 1443 | | 58-39.5 | 168-20.9 | 50 |
| 54 | 1452 | | 58-38.3 | 168-22.7 | 51 |
| 55 | 1502 | | 58-36.9 | 168-24.9 | 53 |
| 56 | 1510 | | 58-35.9 | 168-26.4 | 55 |
| 57 | 0231 | 21 | 58-52.4 | 168-07.6 | 44 |
| 58 | 0308 | | 58-53.4 | 168-16.5 | 45 |
| 59 | 0343 | | 58-54.3 | 168-26.1 | 46 |
| 60 | 0417 | | 58-55.3 | 168-35.4 | 47 |
| 61 | 0450 | | 58-56.1 | 168-43.2 | 49 |
| 62 | 0526 | | 58-57.2 | 168-52.8 | 51 |
| 63 | 0603 | | 59-01.7 | 168-49.9 | 49 |
| 64 | 0644 | | 59-04.9 | 168-56.8 | 48 |

ATTACHMENT B
(page 3)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 65 | 0729 | | 59-08.0 | 169-05.3 | 50 |
| 66 | 0812 | | 59-10.4 | 169-12.8 | |
| 67 | 0906 | | 59-14.3 | 169-21.2 | 53 |
| 68 | 0954 | | 59-17.1 | 169-28.1 | 55 |
| 69 | 1028 | | 59-19.5 | 169-28.2 | 55 |
| 70 | 1108 | | 59-22.8 | 169-20.8 | 51 |
| 71 | 1141 | | 59-25.9 | 169-15.8 | 49 |
| 72 | 1232 | | 59-30.9 | 169-10.3 | 47 |
| 73 | 1314 | | 59-35.1 | 169-05.8 | 44 |
| 74 | 1719 | 23 | 57-09.6 | 170-01.5 | 35 |
| 75 | 1724 | | 57-09.4 | 170-00.2 | 49 |
| 76 | 1730 | | 57-09.1 | 169-57.6 | 45 |
| 77 | 1736 | | 57-09.1 | 169-55.8 | 53 |
| 78 | 1742 | | 57-09.2 | 169-53.9 | 53 |
| 79 | 1751 | | 57-09.4 | 169-50.9 | 53 |
| 80 | 1758 | | 57-09.4 | 169-48.3 | 55 |
| 81 | 1805 | | 57-09.5 | 169-45.9 | 52 |
| 82 | 1810 | | 57-09.5 | 169-44.1 | 52 |
| 83 | 1816 | | 57-09.5 | 169-41.9 | 51 |
| 84 | 1828 | | 57-09.5 | 169-37.6 | 50 |
| 85 | 1840 | | 57-09.5 | 169-33.2 | 60 |
| 86 | 2150 | | 57-34.1 | 169-33.6 | 72 |
| 87 | 2206 | | 57-32.4 | 169-37.8 | 71 |
| 88 | 2225 | | 57-30.2 | 169-42.8 | 71 |
| 89 | 2233 | | 57-29.3 | 169-44.8 | 69 |
| 90 | 2248 | | 57-27.8 | 168-48.6 | 66 |
| 91 | 2304 | | 57-25.9 | 169-52.9 | 66 |
| 92 | 2310 | | 57-25.2 | 169-54.5 | 64 |
| 93 | 2316 | | 57-24.6 | 169-56.1 | 62 |
| 94 | 2322 | | 57-23.9 | 169-57.7 | 64 |
| 95 | 2330 | | 57-22.4 | 169-59.7 | 64 |

ATTACHMENT B
(page 4)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 96 | 2336 | | 57-22.3 | 170-01.2 | 62 |
| 97 | 2343 | | 57-21.5 | 170-02.8 | 59 |
| 98 | 2348 | | 57-20.8 | 170-04.2 | 57 |
| 99 | 2354 | | 57-20.1 | 170-05.7 | 53 |
| 100 | 0000 | 24 | 57-19.3 | 170-07.3 | 55 |
| 101 | 0006 | | 57-18.7 | 170-08.8 | 51 |
| 102 | 0012 | | 57-18.0 | 170-10.3 | 49 |
| 103 | 0213 | | 57-15.4 | 170-25.4 | 56 |
| 104 | 0224 | | 57-17.6 | 170-25.4 | 64 |
| 105 | 0236 | | 57-20.0 | 170-25.3 | 68 |
| 106 | 0240 | | 57-28.0 | 170-25.3 | 68 |
| 107 | 0248 | | 57-22.3 | 170-25.2 | 68 |
| 108 | 0256 | | 57-23.9 | 170-25.2 | 68 |
| 109 | 0300 | | 57-24.6 | 170-25.2 | 68 |
| 110 | 0308 | | 57-26.1 | 170-25.2 | 68 |
| 111 | 0315 | | 57-27.5 | 170-25.3 | 68 |
| 112 | 0330 | | 57-30.5 | 170-25.4 | 71 |
| 113 | 0342 | | 57-32.4 | 170-25.5 | 71 |
| 114 | 0353 | | 57-34.9 | 170-25.6 | 71 |
| 115 | 0405 | | 57-37.5 | 170-25.6 | 71 |
| 116 | 0420 | | 57-40.3 | 170-25.6 | 73 |
| 117 | 0433 | | 57-42.8 | 170-25.8 | 73 |
| 118 | 0450 | | 57-46.1 | 170-25.8 | 75 |
| 119 | 0010 | 25 | 57-12.7 | 170-31.1 | 59 |
| 120 | 0017 | | 57-12.8 | 170-33.3 | 59 |
| 121 | 0025 | | 57-12.9 | 170-35.8 | 62 |
| 122 | 0034 | | 57-12.9 | 170-38.6 | 68 |
| 123 | 0042 | | 57-13.1 | 170-41.2 | 78 |
| 124 | 0050 | | 57-13.2 | 170-43.6 | 79 |
| 125 | 0058 | | 57-13.2 | 170-46.1 | 79 |
| 126 | 0106 | | 57-13.2 | 170-48.3 | 79 |
| 127 | 0115 | | 57-13.3 | 170-51.3 | 81 |

ATTACHMENT B
(page 5)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 128 | 0124 | | 57-13.2 | 170-54.1 | 84 |
| 129 | 0140 | | 57-13.2 | 170-59.3 | 89 |
| 130 | 0153 | | 57-13.1 | 171-03.2 | 91 |
| 131 | 0210 | | 57-13.1 | 171-08.7 | 93 |
| 132 | 0228 | | 57-13.0 | 171-13.8 | 99 |
| 133 | 0240 | | 57-12.9 | 171-18.4 | 100 |
| 134 | 0310 | | 57-13.0 | 171-28.3 | 102 |
| 135 | 0340 | | 57-12.9 | 171-38.1 | 104 |
| 136 | 0410 | | 57-12.8 | 171-48.0 | 107 |
| 137 | 0440 | | 57-12.7 | 171-58.0 | 107 |
| 138 | 1014 | | 56-48.9 | 171-06.3 | 116 |
| 139 | 1028 | | 56-50.6 | 171-02.4 | 112 |
| 140 | 1042 | | 56-52.4 | 170-58.5 | 108 |
| 141 | 1054 | | 56-53.9 | 170-55.1 | 106 |
| 142 | 1106 | | 56-55.5 | 170-51.7 | 104 |
| 143 | 1118 | | 56-56.0 | 170-48.4 | 102 |
| 144 | 1124 | | 56-57.7 | 170-46.7 | 100 |
| 145 | 1132 | | 56-58.8 | 170-44.5 | 95 |
| 146 | 1140 | | 56-59.8 | 170-42.3 | 91 |
| 147 | 1148 | | 57-00.8 | 170-40.2 | 88 |
| 148 | 1156 | | 57-01.8 | 170-37.8 | 82 |
| 149 | 1202 | | 57-02.4 | 170-36.0 | 80 |
| 150 | 1208 | | 57-03.1 | 170-34.2 | 77 |
| 151 | 1214 | | 57-03.8 | 170-32.3 | 77 |
| 152 | 1220 | | 57-04.6 | 170-30.7 | 73 |
| 153 | 1226 | | 57-05.3 | 170-29.0 | 55 |
| 154 | 1740 | 26 | 55-55.0 | 170-46.7 | 2500 |
| 155 | 1810 | | 55-58.3 | 170-43.0 | 2500 |
| 156 | 1820 | | 56-01.3 | 170-39.3 | 1800 |
| 157 | 1833 | | 56-03.3 | 170-36.7 | 1800 |
| 158 | 1900 | | 56-07.5 | 170-30.8 | 144 |
| 159 | 1925 | | 56-11.8 | 170-25.7 | 121 |

ATTACHMENT B
(page 6)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 160 | 1938 | | 56-13.8 | 170-22.8 | 118 |
| 161 | 1949 | | 56-15.6 | 170-20.1 | 115 |
| 162 | 2000 | | 56-17.4 | 170-17.5 | 112 |
| 163 | 2012 | | 56-19.4 | 170-15.0 | 112 |
| 164 | 2025 | | 56-21.8 | 170-12.7 | 111 |
| 165 | 2034 | | 56-23.5 | 170-11.1 | 110 |
| 166 | 2040 | | 56-24.6 | 170-10.0 | 109 |
| 167 | 2046 | | 56-25.6 | 170-08.9 | 108 |
| 168 | 2052 | | 56-26.7 | 170-07.8 | 109 |
| 169 | 2100 | | 56-28.2 | 170-06.2 | 106 |
| 170 | 2108 | | 56-29.3 | 170-05.0 | 104 |
| 171 | 2112 | | 56-30.3 | 170-04.1 | 104 |
| 172 | 2120 | | 56-31.7 | 170-02.6 | 100 |
| 173 | 2126 | | 56-32.8 | 170-01.4 | 99 |
| 174 | 2134 | | 56-34.0 | 169-59.9 | 97 |
| 175 | 2140 | | 56-35.0 | 169-58.0 | 97 |
| 176 | 2146 | | 56-35.9 | 169-56.4 | 95 |
| 177 | 2152 | | 56-36.9 | 169-54.7 | 91 |
| 178 | 0100 | 27 | 56-35.6 | 169-51.6 | 86 |
| 179 | 0106 | | 56-34.7 | 169-50.0 | 86 |
| 180 | 0113 | | 56-33.7 | 169-48.3 | 82 |
| 181 | 0120 | | 56-32.7 | 169-46.6 | 78 |
| 182 | 0127 | | 56-31.8 | 169-45.2 | 80 |
| 183 | 0133 | | 56-30.7 | 169-43.5 | 81 |
| 184 | 0140 | | 56-29.7 | 169-41.9 | 84 |
| 185 | 0147 | | 56-28.7 | 169-40.2 | 86 |
| 186 | 0153 | | 56-27.8 | 169-38.6 | 88 |
| 187 | 0200 | | 56-26.7 | 169-36.9 | 93 |
| 188 | 0206 | | 56-25.9 | 169-35.3 | 99 |
| 189 | 0218 | | 56-24.1 | 169-32.5 | 116 |
| 190 | 0230 | | 56-22.3 | 169-29.5 | 129 |
| 191 | 0242 | | 56-20.5 | 169-26.5 | 140 |

ATTACHMENT B
(page 7)

| Consec. No. | Time GMT | Day/GMT Sept.1978 | Latitude North | Longitude West | Water Depth (m) |
|---|---|---|---|---|---|
| 192 | 0254 | | 56-18.7 | 169-23.8 | 173 |
| 193 | 0306 | | 56-16.9 | 169-20.7 | 219 |
| 194 | 0318 | | 56-15.2 | 169-17.6 | 194 |
| 195 | 0330 | | 56-13.5 | 169-14.5 | 262 |
| 196 | 0400 | | 56-09.1 | 169-06.8 | 440 |
| 197 | 0430 | | 56-04.4 | 168-59.3 | 580 |
| 198 | 0500 | | 55-59.7 | 168-52.1 | 988 |

ATTACHMENT C

Nutrient Sample Summary

| CTD Cast No. | Ref. No. | Sample No. (depth) | Sample No. (depth) |
|---|---|---|---|
| 55 | F-15 | FR-1 (38) | FR-2 (Sfc) |
| 56 | F-16 | 3 (37) | 4 (Sfc) |
| 57 | F-17 | 5 (37) | 6 (Sfc) |
| 58 | F-18 | 7 (39) | 8 (Sfc) |
| 59 | F-19 | 9 (45) | 10 (Sfc) |
| 60 | F-20 | 11 (47) | 12 (Sfc) |
| 61 | F-21 | 13 (50) | 14 (Sfc) |
| 62 | F-15 | 15 (38) | 16 (Sfc) |
| 63 | F-16 | 17 (39) | 18 (Sfc) |
| 64 | F-17 | 19 (39) | 20 (Sfc) |
| 65 | F-18 | 21 (42) | 22 (Sfc) |
| 66 | F-19 | 23 (45) | 24 (Sfc) |
| 67 | F-20 | 25 (47) | 26 (Sfc) |
| 68 | F-21 | 27 (50) | 28 (Sfc) |
| 69 | F-15 | 29 (33) | 30 (Sfc) |
| 70 | F-16 | 31 (35) | 32 (Sfc) |
| 71 | F-17 | 33 (39) | 34 (Sfc) |
| 72 | F-18 | 35 (42) | 36 (Sfc) |
| 73 | F-19 | 37 (44) | 38 (Sfc) |
| 74 | F-20 | 39 (46) | 40 (Sfc) |
| 88 | P-1 | FR-41 (68) | FR-42 (10) |
| 89 | P-2 | 43 (57) | 44 (10) |
| 90 | P-3 | 45 (105) | 46 (10) |
| 91 | P-4 | 47 (26) | 48 (10) |
| 92 | P-5 | 49 (62) | 50 (10) |
| 93 | P-6 | 51 (64) | 52 (10) |
| 94 | P-7 | 53 (31) | 54 (10) |
| 95 | P-8 | 55 (43) | 56 (30) |
| | | 57 (20) | 58 (15) |
| | | 59 (10) | 60 (5) |
| 96 | P-9 | 61 (64) | 62 (55) |
| | | 63 (45) | 64 (30) |
| | | 65 (20) | 66 (15) |
| | | 67 (10) | 68 (5) |
| 97 | P-10 | 69 (67) | 70 (10) |
| 98 | P-11 | 71 (54) | 72 (10) |
| 99 | P-12 | 73 (104) | 74 (10) |
| 100 | P-13 | 75 (107) | 76 (10) |
| 101 | P-14 | 77 (40) | 78 (10) |
| 102 | P-15 | 79 (106) | 80 (10) |
| 103 | P-16 | 81 (58) | 82 (10) |
| 104 | P-17 | 83 (289) | 84 (10) |
| 105 | P-18 | 85 (213) | 86 (10) |
| 106 | P-19 | 87 (116) | 88 (10) |
| 107 | P-20 | 89 (502) | 90 (10) |
| 108 | P-21 | 91 (79) | 92 (10) |
| 109 | P-22 | 93 (500) | 94 (10) |

Quarterly Report

R.U. #562 Oil Pooling Under Sea Ice
NOAA RD. No. RK-8-0065
Report Period: 1 July - 30 Sept. 1978

# OIL POOLING UNDER SEA ICE

Principal Investigator: A. Kovacs

US Army Corps of Engineers
Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755

I. Task Objectives:

The purpose of this project is to:

a. Determine the cause of the significant relief which exists under the fast ice.

b. Measuring the variation in the relief under fast ice using impulse radar.

c. Determine if the under ice relief is a series of individual pockets or consists of long rills.

d. Estimate the quantity of oil which could pool up in the under ice depressions should oil be released under the ice cover.

e. Use impulse radar to study the electromagnetic properties and anisotropy of sea ice.

II. Laboratory Activities:

During the past quarter, field data were reduced and various reports initiated or completed.

III. New Results:

Reduction of impulse radar data has again shown that maximum reflector signal strength occurs when the antenna E-field is orientated parallel to the prefered horizontal c-axes azimuthal orientation of the bottom ice. The latter orientation has again been found to align with the prevailing under ice current. The data shows that the surface reflection coefficient is a function of surface ice brine volume, i.e. surface reflectivity increases with surface brine volume. Also the effective dielectric constant was found to increase with the bulk ice cover brine volume. The center frequency of the electromagnetic energy reflected from the ice bottom decreased with increasing brine volume.

Impulse radar sounding data collected during the profiling of a snow free runway site on the fast ice has been reduced and corrected for profiling travel speed variations. The area profiled is 200 m long by 20 m wide. The under ice relief shows significant variations up to 48 cm. The maximum thickness measured was 1.83 m and the minimum was 1.35 m. The data will be used to construct an under ice contour map and to estimate the volume in the depressions available for oil containment should oil be released under the ice cover.

IV. Reports Submitted for Publication:

Kovacs, A. and Morey, R. M., Radar Anisotropy of Sea Ice Due to Prefered azimuthal Orientation of the Horizontal C-axes of Ice Crystals, to be published in Journal of Geophysical Research.

V. Funding:

| | |
|---|---|
| Funded at | $26,000 |
| Spent | 26,000 |
| Remainder | 0 |

QUARTERLY REPORT

03-78-DO-1-61

Research Unit: 567

Reporting Period: 1 July - 30 September 1978

Number of Pages: 2

# THE TRANSPORT AND BEHAVIOR OF OIL SPILLED IN AND UNDER SEA ICE

Max D. Coon

R. S. Pritchard

Flow Research Company
A Division of Flow Industries, Inc.
21414-68th Avenue South
Kent, Washington 98031

I. Abstract:

This is the second quarterly report for this project and the main accomplishment has been in determining trajectory for sea ice in the Beaufort and Chukchi Seas. Also the problem of major breakout of ice from the Chukchi into the Bering Sea has been studied.

II. Task Objectives:

The goal of the proposed work is to determine the locations to which oil spilled in or under the ice cover near Prudhoe Bay, Alaska, would be transported and to determine the behavior of the oil as the ice cover moves and deforms. Two separate tasks have been given Flow Industries. First, to determine a range of velocity fields which might be taken by the ice cover on the continental shelves of the Beaufort and Chukchi Seas by numerical modeling and synthesis of the results with manned and drifting station data. These velocity fields shall represent the climatological mean (or most probable) and extremes. As part of this task major breakouts of the ice from the Chukchi into the northern Bering Sea shall be considered. The second task is for the overall management of the program as well as to determine the likely trajectory and destination points for oil in several hypothetical scenarios by combining the relevant information obtained.

III. Field or Laboratory Activities:

None.

IV. Results:

One of the main data sets to be used as input for the calculation of most probable and extreme trajectories are the surface pressure data from the National Meteorological Center obtained through NCAR. This data set covering the time period from 1946-1975 has been obtained on tape and unpacked to give the necessary data for the Beaufort and Chukchi Seas.

In our original plan, trajectory calculations for the summer and early fall would be done with large scale free drift utilizing the NCAR data. To this end an evaluation of the large free drift calculation has been made utilizing data from AIDJEX and a report has been drafted. For winter data the trajectory from ice camps and buoys was examined with the hope that the motions would be small enough that they could be ignored. The winter drift data has been examined and a report has been drafted. However the data does not support our original supposition that the motions are small and we must reconsider the determination of winter trajectories.

The problem of determining conditions under which sea ice can break out from the Chukchi Sea into the Bering Sea has been considered. The stress and velocity conditions which will allow breakout have been determined. And a report is being drafted.

V. Preliminary Interpretation of Results:

None.

VI. Auxiliary Materials:

None.

VII. Problems Encountered/Recommended Changes:

None.

VIII. Estimate of Funds Expended:

The estimated expenditure under this contract through 30 September 1978 is $78,750.

QUARTERLY REPORT

Contract No.: 03-78-B01-62
Research Unit: 568
Reporting Period: 1 July-30 September 1978
Number of Pages: 2

# THE TRANSPORT AND BEHAVIOR OF OIL SPILLED IN AND UNDER SEA ICE-TASK 1

Lawrence A. Schultz

ARCTEC, Incorporated
9104 Red Branch Road
Columbia, Maryland 21045

September 11, 1978

## I. TASK OBJECTIVES

The objective of Task 1 of the program is to determine by field and laboratory experiments the physical processes by which spilled oil gets incorporated in, and transported in and under, sea ice. The objectives of three subtasks are further stated as follows:

Subtask 1.1: To determine how and at what rates oil moves upward through multi-year ice to the surface.

Subtask 1.2: To determine how and at what rates oil gets incorporated into pressure ridges formed from ice of various thicknesses.

Subtask 1.3: To determine how oil of different viscosities spreads and is moved by ocean currents under sea ice with different underside roughness characteristics.

## II. FIELD OR LABORATORY ACTIVITIES

### A. Ship or Field Trip Schedule

None

### B. Scientific Party

None

### C. Methods

Not Applicable

### D. Sample Localities

Not Applicable

### E. Data Collected or Analyzed

Not Applicable

## III. RESULTS

During this quarter, the preliminary preferred formulations for the various oil-ice interaction phenomena of interest were reviewed with consultants, Dr. Seelye Martin in the case of vertical migration, and Dr. Timothy Kao in the case of horizontal transport. The preferred formulations are now being revised in accord with their comments. Work on the preferred formulations will be completed in the next quarter.

The major effort during this quarter consisted of making preparations and plans for the horizontal transport tests to be conducted in ARCTEC's Ice Flume. The detailed Test Plan was completed and issued in early September. Preliminary testing in the flume will begin on 18 September. All testing in the flume is scheduled for completion in the next quarter.

## IV. PRELIMINARY INTERPRETATION OF RESULTS

Not Applicable

## V. PROBLEMS ENCOUNTERED AND RECOMMENDED CHANGES

None

## VI. ESTIMATE OF FUNDS EXPENDED

As of 30 September, it is estimated that approximately $35,000. will have been expended for the work of Task 1. It is estimated that the work will be completed on budget.

## DATA MANAGEMENT

Contents


| RU# | PI | Agency | Title | Page |
|---|---|---|---|---|
| 362 | Audet, J. | NOAA/EDS/NODC Washington, DC | OCSEAP Data Base Management Support | 594 |
| 497 | Crane, M. Hickok, D. | NOAA/EDS/NODC Anchorage, AK | OCSEAP Alaskan Data Processing Facility | 604 |
| 527 | Petersen, H. | Univ. of RI Kingston, RI | OCSEAP Data Processing Services | 623 |
| 563 | Eschmeyer, W. | Calif. Academy of Sciences, San Francisco, CA | Archival of Voucher Specimens of Biological Materials Collected Under the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Support | 662 |

QUARTERLY REPORT

Research Unit 362

Quarter Ending - 15 September 1978

OCSEAP DATA BASE MANAGEMENT SUPPORT

Submitted by: John J. Audet
Principal Investigator
National Oceanographic Data Center
Environmental Data and Information Service
National Oceanic and Atmospheric Administration

October 1, 1978

## DIGITAL DATA

A total of 192 data sets were received by NODC this quarter; three digital data sets (two in the non-OCSEAP epicenter format) and four analog record submissions were received by NGSDC. A total of 38 data sets were final processed. This was supplemented by a large number of data sets that were reviewed for potential data problems, especially taxonomic codes, using new NODC data checking programs.

The number of data sets in a hold status has increased from the last quarter. This total includes all file type 035 data, file type 033 data for RU 196, file type 027 data for RU 481 and unreadable file type 015 data tapes from RU 138/141; which amounts to 204 data sets. Another 107 data sets, which have been subjected to the NODC check programs, consist of a variety of taxonomic code and other corrections requiring information from the investigators.

The distribution and status of all OCSEAP digital data received to date is as follows:

| | Received | Finaled | In Hold | In Processing |
|---|---|---|---|---|
| Biological | 1030 | 589 | 257[A] | 184 |
| Physical | 293 | 188 | 42[B] | 63 |
| Chemical | 36 | 15 | 0 | 21 |
| Geological | 7 | 3 | 3 | 1 |
| | 1366 | 795 | 302 | 269 |

A - Includes all 035 (Marine Bird Colony) data awaiting a decision on conversion to the new file type 135, 027 (Marine Mammal Sighting) data awaiting information from the investigator and 033 (Marine Bird Sighting) data sent through Crane to obtain correct information from the investigator.

B - Includes unreadable tapes with 29 file IDs of 015 (Current meter) data that have been requested for resubmission.

The totals are slightly different from those in the summary for the tracking system because of last-minute entries for data sets finaled; an additional 15 data sets were finaled on September 15.

The distribution of data by lease areas for all data sets received this quarter is shown in Table 1.

Table 1. Distribution of Data Sets received between June 16 and September 15, 1978.

| File Type/Format | Total | Lease Area Code 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 015 - Current Meters | 15 | 10 | - | - | 1 | 1 | 1 | 1 | - | 4 |
| 017 - Pressure Gauge | 1 | - | - | - | - | - | - | 1 | - | 1 |
| 022 - STD/CTD | 9 | 5 | 2 | 2 | 4 | - | 4 | - | - | - |
| 025 - Mammal Specimen | 7 | - | - | - | 1 | 1 | 1 | 3 | - | 3 |
| 026 - Mammal Sighting II | 1 | - | 1 | - | - | - | - | - | - | - |
| 027 - Mammal Sighting I | 133 | 28 | - | 25 | 12 | 1 | 15 | 6 | 12 | 4 |
| 030 - Intertidal Data | 11 | 2 | 1 | 1 | 1 | 3 | 1 | - | - | 3 |
| 032 - Benthic Organisms | 4 | - | - | - | 4 | - | 4 | - | - | - |
| 035 - Bird Colony | 1 | - | - | - | - | - | - | - | - | 1 |
| 043 - Hydrocarbons | 1 | - | 1 | 1 | - | - | 1 | - | - | - |
| 056 - Lagrangian Currents | 6 | - | - | - | 6 | - | 3 | - | - | - |
| 073 - Grain Size Analysis | 1 | - | - | - | - | 1 | - | - | - | - |
| 101 - Wind Data | 2 | - | - | - | - | 2 | - | - | - | - |
| | 192 | | | | | | | | | |

Lease Area Code

1 - NEGOA
2 - Lower Cook
3 - Kodiak
4 - St. George
5 - Beaufort
6 - Bristol Bay
7 - Norton
8 - Aleutians
9 - Chukchi

## DATA REPORTS

A total of 22 data reports and other documents were received and filed by NODC or indicated by the Project Offices as containing data appropriate for inclusion in the data base. The reports are entered in the tracking system and includes the relevant lease areas for each report. The distribution of data reports received this quarter by discipline is as follows:

| | | |
|---|---|---|
| Marine Mammals | 3 | |
| Marine Birds | 3 | |
| Trace Metals/Hydrocarbons | 2 | |
| Ice | 1 | |
| Geology/Geophysics | 13 | (includes four analog data submissions and one track chart). |

A total of 304 data reports have been entered in the tracking system to date.

## ROSCOPS

A total of 64 ROSCOPs were received this quarter. A total of 524 have been received to date for OCSEAP cruises and surveys. ROSCOPs were received this quarter from the following:

| | |
|---|---|
| PMEL | 6 |
| USFWS | 6 |
| NWAFC | 1 |
| ADF&G | 24 |
| Univ. Alaska | 5 |
| Univ. Washington | 1 |
| Univ. California | 4 |
| Univ. Houston | 1 |
| Lamont-Doherty | 15 |
| Dames and Moore | 3 |

Several ROSCOPs included multiple agencies resulting in a slightly higher total when individually listed.

DATA REQUESTS

The following is a list of the major requests received and/or being processed this quarter. Individual requests for routine information such as copies of data formats or new taxonomic codes are not included in this list.

| Date Received | Data Completed | Request/Comments |
|---|---|---|
| 1/24/78 | 6/17/78 | Program Office/SAI - Completed first set of draft products for annual technical summary report - more details under 'Data Products'. |
| 6/6/78 | 7/10/78 | Peter Craig (LGL/LTD) - Inventory of fish resource data and copy of RU 233 data - requested through Toni Johnson. |
| 6/7/78 | 6/28/78 | Cava (JPO) - Distribution of all OCSEAP data sets by lease area for data received through June 15. |
| 6/13/78 | 7/10/78 | Cava (JPO) - Sample listing of temperature values for file type 030 (RU 78). |
| 5/22/78 | 6/8/78, 8/11/78, 8/25/78 | Pease (PMEL) - New version of IMS STD/CTD data (22 file IDs) forwarded on 9 magnetic tapes to Boulder computer facility on 8/11/78 after first tape specs not compatible - station plots for each file ID and DDFs sent to Pease 8/25/78. |
| 6/7/78 | 8/15/78 | Lowry (ADF&G) - Formatted listing of selected file type 032 parameters for Bering/Chukchi areas (3 data sets) - plots to be forwarded as soon as possible. |
| 6/8/78 | 8/14/78 | Thibodeaux (LSU) - Listing of Beaufort STD/CTD data collected by RU 151. |

| | | |
|---|---|---|
| 8/1/78 | 9/6/78 | Cava (JPO) - Sample listing of data records for file IDs SU001/SU002 file type 028 - (RU 427). |
| 8/1/78 | Partial | Program Office/SAI - Physical and biological products for annual technical summary report - discussed under 'Data Products'. |
| 8/2/78 | 8/8/78 | NMFS/Kodiak - Current meter data for summer months for St. George area. |
| 8/11/78 | 8/14/78 | Czerniak (Tetra Tech) - Copy of all OCSEAP formats and Parts I and II of the Data Catalog. |
| 8/15/78 | 9/7/78 | Cava (JPO) - Check run for all file type 035 (Bird Colony) data to identify potential problems for conversion to new 135 format. |
| 8/21/78 | 8/29/78 | Dohl (Univ. Calif.-Santa Cruz) - Copies of OCSEAP mammal formats and NODC taxonomic codes. (requested through Crane). |
| 8/28/78 | 9/15/78 | Rabin (Univ. Washington) - Copies of OCSEAP zooplankton format (024) and NODC taxonomic codes (requested through Cava). |
| 8/28/78 | ______ | Jou (Flow Research Inc.) - Data on ice movement in the Beaufort Sea. |
| 8/29/78 | ______ | Cava (JPO) - Updated list of OCSEAP PI address list and 'wallchart' listing - to be forwarded with quarterly report version of tracking system. |
| 9/12/78 | 9/18/78 | Pelto (JPO) - Listing, inventory and magnetic tape of archival Nansen/STD data for area east of NEGOA lease area - Tape to Charnell (PMEL) |

| | | |
|---|---|---|
| 9/13/78 | ——— | Lowry (ADF&G) - Modification to 6/7 request to list shrimp to species level - earlier request only to family level. |

PRODUCT DEVELOPMENT

A request was received on August 1 from SAI for the following products to be included in the annual technical summary report:

1. Seasonal charts of shearwater observations in the Kodiak area.

2. Seasonal charts of grey whale sightings for all lease areas.

3. Seasonal charts of walruses sighted in the Bering Sea differentiated by classes of behavior characteristics (water, land or ice activities).

4. Seasonal contour charts of temperature and salinity for surface and 25 meters for Bristol Bay and St. George Basin.

5. Lagrangian drift plots for Bristol, St. George, Kodiak and NEGOA with time ticks and begin and end dates included.

6. Current meter displays for southeastern Bering with tidal currents filtered from the data.

Base chart and area limit comparisons were completed for six of the nine lease areas on August 22 for this request. Discrepencies between several of the SAI bases and the NODC computer plots were resolved after SAI corrected their scale information.

Draft plots of shearwater and grey whale plots were completed and forwarded to SAI on September 11. Individual months rather than seasons were required to improve data presentations for spring observations for shearwaters.

The request was modified by SAI to plot temperature/salinity contours and walrus activity plots on single base charts which included several lease areas. Grey whale sightings also were plotted on one base chart for all lease areas. These products and the Lagrangian drift plots are expected to be completed by the end of September.

Current meter presentations are waiting a response to our memo of August 9.

A memo was forwarded to Bob Farentinos on September 14 discussing the products forwarded to date and the status of the remaining products. Several options were offered for improving the shearwater plots.

## FORMAT DEVELOPMENT

A draft copy of all current OCSEAP formats have been entered on the WYLBUR system to allow for on-line retrieval and more timely updates of formats and codes. Copies of this version of the formats were distributed at the Asilomar data management meeting. File type 135, the new Bird Colony format, will be included as soon as all codes and definitions have been completed by Program Office personnel.

Core data parameters will be identified by Program and Project Office personnel for each format and these parameters will be indicated on the WYLBUR version of the formats. A parameter check list for RU prepared by Mike Crane will be used to help Program/Project management to identify these 'core parameters'. A summary also will be prepared by NODC for all data received to date for each file type that lists the frequency that each parameter has been used by all OCSEAP investigators.

An updated version of all format codes was completed using Crane's original digital version of these codes. A final review of this new version will be completed by September and then incorporated in Part III of the Data Catalog.

A 'FACT' sheet for modifications to formats and codes completed during June, July and August was distributed to OCSEAP data management and investigators on September 12.

## DATA PROCESSING

Approximately 140 data sets plus all the 035 data and 75 file type 033 data sets for RU 196 have been reviewed during the quarter using new data checking programs which include taxonomic code summaries.

Programs for retrieval of codes for OCSEAP formats has been completed and will provide information concerning codes required for each file type and the file types needing specific codes as well as a list of accepted values and definitions for each code.

Master tape documentation has been completed for file types 028 (Phytoplankton) and 101 (Wind Data) and is nearing completion for 024 (Zooplankton). A list of all OCSEAP STD/CTD data (file type 022) that have been merged also has been distributed. These data are not being subjected as a group to checking procedures as additional checking and editing will be completed later as part of NODC quality controls for 'standard' data.

Coding forms were completed for file type 044 (Hydrocarbons II) and pads of the forms delivered to John Calder and each investigator as designated by the Program Office.

## DATA CATALOGS AND INVENTORIES

Parts I and II of the OCSEAP Data Catalog were distributed to all OCSEAP and BLM offices, to NOAA User Panel members and over 150 OCSEAP investigators. A copy of the OCSEAP data request form was included with each mailing. A computerized mailing list, which will be available for future mailings of OCSEAP information was generated as a subset of the NODC mailing list.

Part III of the Catalog, Format descriptions and codes, will be distributed in draft form to OCSEAP personnel in October.

## TAXONOMIC CODES

An updated version of the NODC taxonomic code was completed and distributed to all OCSEAP investigators in mid-June. A newsnote was distributed on June 29 concerning Species Group codes. A memo indicating NODC policy and OCSEAP recommendations concerning the use of these species group codes will be completed and distributed before October 1.

## ADMINISTRATIVE

The OCSEAP data management meeting at Asilomar included NODC employees Picciolo, Noe, Audet, Falk, liaison personnel Crane and Ross and Loughridge from NGSDC.

A mini-data management meeting was held in Boulder on August 15-17 to discuss revision of work statements, new data checking procedures, taxonomic code conversions and a review of data products that should be within and outside the scope of the data base research units. Mike Crane, Elaine Collins and Jim Audet attended from NODC; Carol Potter and Peter Sloss from NGSDC attended the first day's meetings.

Mike Crane spent the week following the Boulder meeting at NODC resolving problems concerning Arctic investigators, data checking procedures and FY 79 work statement revisions.

Quarterly Report

RU Contract No.
497 - - - - - -
370 03-5-022-56

Reporting Period 1 July 78
30 September 78

Pages 19

OCSEAP Alaskan Data Processing Facility

Michael L. Crane

David M. Hickok

30 September 1978

## I. Introduction

The Outer Continental Shelf Environmental Assessment Program has a special responsibility to future users, making available the fundamental measurements collected during the lifetime of the program. To meet this challenge, the OCSEA Program established a digital data base at the National Oceanographic Data Center. The arrangement with the data base encompasses data base services, data management support and technical data processing.

The OCSEAP reserved the responsibility of managing the data as a management prerogative and to implement this responsibility, in part, the OCSEAP has contracted the University of Alaska, AEIDC and the EDIS to jointly provide professional data management assistance. In partial fulfillment of these commitments, the AEIDC and the EDIS Alaskan Liaison Officer have established a facility providing project management support, digital data base support, and originator support. The vital links between each component are reinforced by the rigorous application of professional standards in data processing. The high standard which the Anchorage Data Processing Facility maintains has contributed to the efficient resolution of data management problems. This report summarizes the major accomplishments of the facility from 1 July to 30 September 1978.

## II. Description of Tasks

The specific tasks for data processing support are outlined in the guidance letters during calendar years 1977 and 1978. As modified by recent agreements, the major spheres are project management support, OCSEAP data base assistance, and principal investigator assistance. These are extended in support of the overall OCSEAP data management objectives. The execution of the duties of this facility are guided by the directives of project management, and the activities are coordinated with the data base or investigator as appropriate. In Anchorage the scope of the data supporting role is limited to the areas of data entry and data control. Specifically, data are entered on IBM diskettes and certain categories of data are checked with a minicomputer. Reports and data management papers are submitted to the OCSEA Program as required. When investigators require data entry services or require design of coding procedures, the Anchorage facility has the data entry personnel to assist the investigator plus the resources of a graphic production section of AEIDC. When the OCSEAP data base requires additional resources for creation of special files or executing checking programs, the Anchorage facility has the capability to respond in a timely and professional manner. When OCSEAP management requires special data management services, the Anchorage facility can efficiently implement the desired service. The liaison functions between each component are an integral part of the service capability.

The facility maintains strong ties to OCSEAP management and to the data base. The Anchorage Data Processing Facility provides the local Alaskan service, important to the data management mission of the OCSEA Program.

## III. Methods

Because the types of activities cover a wide spectrum, the operating procedures must be flexible and powerful. The principal attributes of the facility has been adaptability and timeliness. The IBM diskette technology has allowed the rapid implementation of new procedures. The benefits of this media have not been exhausted and the promises of continued efficiency are reinforced daily.

To assist the investigators, the IBM workstation allows both data entry and data editing (or corrections). Data sets can be partitioned discretely, copies are easily made, and data sets can be converted to tape effectively. Coding forms have been developed for investigators to prevent data entry errors. Data processing requirements are described to investigators as required. During this period, data for RU 241 Schneider was entered and edited on this system. Corrections were made to marine mammal specimen data for RU 229 Pitcher, RU 230 Burns, and RU 243 Calkins. Taxonomic sorts and listings by record type has complemented the checking of bird data for the RU 337 USF&WS.

It is difficult to determine if the data checking requirements are a project support activity or a data base support activity. The reason is the results from the checking procedures have direct benefit to the data base by reducing errors but the executive summaries and relational checks are OCSEAP management requirements. The benefit to the investigator is a more powerful error flagging capacity. It is clear that data corrected by the facility will reduce the cost of processing data, reduce the time of data delivery to the data base, and eliminate potential data management problems for OCSEAP management.

To achieve this goal, the facility envokes rigorous control procedures coupled to check programs on a minicomputer. The procedures include data preparation, data copying, documentation review and precise recordkeeping. The procedures include the design and execution of the checking programs. Because the process enjoys continuous review at each stage, the various activities can be arranged to fit the complications imposed by untimely delays. The delays will be discussed in a later section. The programming language of the minicomputer is powerful, efficient and manageable. Data checking will be the dominant activity in FY 79.

Check programs are designed to identify structural errors, cataloging errors, code errors, range errors, and relational errors. An exhaustive set of programs have been written to check for errors, to display predator-prey relationships, to summarize the fields used, and to select all records for each specimen according to a special criteria created by the user. These programs interact with the user and with the data on file type 025. A similar series is planned for file type 023, fish resource assessments, for file type 031, bird specimens and food habits, and for file type 032, benthic biology.

There are activities which support the data base directly. Review of check program results for RU 196 Divoky and RU 003 Arneson have been initiated this period at the request of Mr. John J. Audet, the NODC OCSEAP Data Coordinator. Conversion of taxonomic codes to the NODC code is another direct data base support task. Code conversion programs have been written for the minicomputer; file type 025 has been completed and file type 023 has been drafted.

Review of the food habits information of file type 023 has noted a deficiency. This review is a joint support task for the data base and OCSEAP management.

The "Parameter Checklist" was completed this period at the request of Ms. Cava and Ms. Johnson. The task is a sample of the support given to OCSEAP management. Data processing activities have also been initiated at the request of OCSEAP management. A data tape from LGL, Limited was converted to diskette and printed. After inspecting the file for 033 data, a logical error was discovered. The data from file type 023 was checked by programs ID 023, CD 023 and BL 023 and the results will be sent to Ms. Johnson. All data will be converted to tape and forwarded as instructed.

For the Arctic Project Office additional services are provided. The data tracking system is monitored as new data sets are received and updates to the DTS are recommended. The spectrum of services for project management is by far the most varied. The arrangement between the University of Alaska and the NODC Alaskan Liaison Officer allows the full range of services. The balance between management and data processing is the mechanism.

## IV. Status of Processing

The following tables were generated to define the current status in data processing. The first table indicates the data sets during this quarter which are or were active data sets. The second table indicates the status of 025 processing. The programs identified in the table for file type 025 were discussed in the report submitted last quarter. The third table indicates the status of check program development for file type 023.

## V. Significant Events

* The "Parameter Checklist" was completed, delivered, and updated during this period.

* Seven data sets of file type 025 data were submitted to the data base on behalf of RU 230 Burns.

* Revised work statement submitted this period.

* Nine programs have been written to check file type 025 data, four utilities programs and three programs for file type 023 data.

* Data from RU 467 LGL, Ltd. was reviewed this period.

* Ten data sets were received by RU 337 Lensink for taxonomic code review, record type accuracy and data content review. Service to terminate at end of quarter.

* All 025 data has been checked response from the investigators is required.

* Attended two major data management meetings this period.

## VI. Problems

As indicated in previous sections, the potential impact of delays will interfere with the timely execution of activities. The delay in response by investigators to check runs extends the time to process each data set. The delay from the project offices for the design of special check programs will impact the programming effort and the checking effort also. Procedures and deadlines indicated in the milestone chart in the renewal proposal are contingent upon the timely input as required. The procedural arrangements for delivery of data for checking have been negotiated with the data base managers. Until all programs for a given file type are written, no checking can be completed.

Because the guidance for next year's budget has been reduced from last year's, services to investigators will be dramatically reduced. The assistance to RU 337 Lensink will not be part of the OCSEAP sponsored activities. This reduction may increase the processing time for Dr. Petersen RU 527 because the errors in record type and taxonomic codes will not be monitored before shipment. The successful replacement of data from RU 240 Schneider will not be available to OCSEAP in FY 79 if similar situations develop.

The food habits data in file type 023 should be reviewed for consistency with other disciplines. Because the Anchorage facility is concentrating on the feeding file types, a uniform standard among the disciplines would maximize the utility of the data. The lack of uniformity would complicate the integration of data into a fabric of food webs embracing all disciplines.

Date entry services will be provided to RU 229 Pitcher and RU 243 Calkins. If these coding forms are received before 1 January 1979, there will be sufficient time to complete the task before the staff level is reduced to meet the funding level.

TABLE 1

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 003 | ARNESON | 040 | FG7604 | 78/08/02 | 77/03/10 | A/C | 76/05/01 | 76/05/09 | 1575 & 2607 |
| 003 | ARNESON | 040 | FG7606 | 78/08/02 | 77/03/10 | A/C | 76/05/17 | 76/05/20 | 1577 & 2610 |
| 003 | ARNESON | 040 | FG7603 | 78/08/02 | 77/03/10 | A/C | 76/02/22 | 76/03/24 | 1574 & 2608 |
| 003 | ARNESON | 040 | FG7608 | 78/08/02 | 77/03/10 | A/C | 76/07/24 | 76/07/25 | 1579 & 2609 |
| 003 | ARNESON | 040 | FG7610 | 78/08/02 | 77/03/10 | A/C | 76/06/16 | 76/06/17 | 1581 & 2612 |
| 003 | ARNESON | 040 | FG7703 | 78/08/02 | 77/12/23 | | | | |
| 003 | ARNESON | 040 | FG7704 | 78/08/02 | 77/12/23 | | | | |
| 003 | ARNESON | 040 | FG7705 | 78/08/02 | 77/12/23 | | | | |
| 003 | ARNESON | 040 | FG7706 | 78/08/02 | 77/12/23 | A/C | 77/05/06 | 77/05/07 | 3881 |
| 003 | ARNESON | 040 | FG7708 | 78/08/02 | 77/12/23 | A/C | 77/05/13 | 77/05/13 | 3883 |
| 003 | ARNESON | 040 | FG7707 | 78/08/02 | 77/12/23 | A/C | 77/05/10 | 77/05/12 | 3882 |
| 003 | ARNESON | 040 | FG7709 | 78/08/02 | 77/12/23 | AVON RAFT | 77/06/18 | 77/07/14 | 4293 |
| 003 | ARNESON | 040 | FG7602 | 78/08/02 | | AIRCRAFT | | | |
| 003 | ARNESON | 040 | FG7801 | 78/08/02 | | AIRCRAFT | | | |
| 003 | ARNESON | 040 | FG7802 | 78/08/02 | | AIRCRAFT | | | |
| 196 | DIVOKY | 033 | 1SR376 | 78/07/12 | 78/02/23 | SU76AI | 76/03/15 | 76/04/01 | 5191 |
| 196 | DIVOKY | 033 | 1SR476 | 78/07/12 | 78/02/23 | SU76AII | 76/04/12 | 76/04/30 | 5192 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 196 | DIVOKY | 033 | 2PD976 | 78/07/12 | 78/01/04 | ON FOOT | 76/09/13 | 76/09/15 | 5012 |
| 196 | DIVOKY | 033 | 3C0676 | 78/07/12 | 78/03/16 | ON FOOT | 76/06/16 | 76/06/30 | 5210 |
| 196 | DIVOKY | 033 | 2CL676 | 78/07/12 | 78/01/04 | ON FOOT | 76/06/25 | 76/06/28 | 5017 |
| 196 | DIVOKY | 033 | 2GL976 | 78/07/12 | 78/02/23 | USCG GLACIER | 76/09/20 | 76/10/02 | 5194 |
| 196 | DIVOKY | 033 | 2GLA76 | 78/07/12 | 78/02/23 | USCG GLACIER | 76/10/03 | 76/10/15 | 5193 |
| 196 | DIVOKY | 033 | 2BI776 | 78/07/12 | 78/02/23 | BURTON ISLAND | 76/07/22 | 76/07/28 | 5197 |
| 196 | DIVOKY | 033 | 2BW076 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/01 | 76/10/12 | 5040 |
| 196 | DIVOKY | 033 | 2KL676 | 78/07/12 | 78/01/04 | FOOT/SMALL BOAT | 76/06/23 | 76/06/23 | 5035 |
| 196 | DIVOKY | 033 | 2KL776 | 78/07/12 | 78/01/04 | FOOT/SMALL BOAT | 76/07/06 | 76/07/20 | 5037 |
| 196 | DIVOKY | 033 | 2BW776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/18 | 76/07/19 | 5024 |
| 196 | DIVOKY | 033 | 3PP776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/08 | 76/07/12 | 5019 |
| 196 | DIVOKY | 033 | 2WR676 | 78/07/12 | 78/01/04 | ON FOOT | 76/06/28 | 76/07/06 | 5018 |
| 196 | DIVOKY | 033 | 2IC676 | 78/07/12 | 78/01/04 | ON FOOT | 76/06/21 | 76/06/29 | 5016 |
| 196 | DIVOKY | 033 | 2WR976 | 78/07/12 | 78/01/04 | ON FOOT | 76/09/13 | 76/09/14 | 5013 |
| 196 | DIVOKY | 033 | 2UP776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/25 | 76/07/26 | 5026 |
| 196 | DIVOKY | 033 | 2CB776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/12 | 76/07/16 | 5020 |
| 196 | DIVOKY | 033 | 2CL976 | 78/07/12 | 78/01/04 | ON FOOT | 76/09/21 | 76/09/27 | 5058 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 196 | DIVOKY | 033 | 2IC976 | 78/07/12 | 78/01/04 | ON FOOT | 76/09/09 | 76/09/12 | 5033 |
| 196 | DIVOKY | 033 | 2IC876 | 78/07/12 | 78/01/04 | ON FOOT | 76/08/07 | 76/08/13 | 5029 |
| 196 | DIVOKY | 033 | 2PD776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/30 | 76/08/06 | 5028 |
| 196 | DIVOKY | 033 | 3A1976 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/09/07 | 76/09/07 | 4800 |
| 196 | DIVOKY | 033 | 3A2976 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/09/18 | 76/09/18 | 4801 |
| 196 | DIVOKY | 033 | 3A3976 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/09/23 | 76/09/23 | 4802 |
| 196 | DIVOKY | 033 | 3A1A76 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/10/04 | 76/10/04 | 4787 |
| 196 | DIVOKY | 033 | 3A2A76 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/10/13 | 76/10/13 | 4788 |
| 196 | DIVOKY | 033 | 2A3976 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/09/23 | 76/09/23 | 4818 |
| 196 | DIVOKY | 033 | 2A4976 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/09/28 | 76/09/28 | 4819 |
| 196 | DIVOKY | 033 | 2A1A76 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/10/13 | 76/10/13 | 4820 |
| 196 | DIVOKY | 033 | 2A1B76 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/11/06 | 76/11/06 | 4821 |
| 196 | DIVOKY | 033 | 3A1676 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/06/04 | 76/06/04 | 4790 |
| 196 | DIVOKY | 033 | 3A2676 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/06/12 | 76/06/12 | 4791 |
| 196 | DIVOKY | 033 | 3A3676 | 78/07/12 | 77/11/10 | AERIAL/CESSNA 180 | 76/06/17 | 76/06/17 | 4792 |
| 196 | DIVOKY | 033 | 3A2776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/07 | 76/07/07 | 4793 |
| 196 | DIVOKY | 033 | 3A3776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/15 | 76/07/15 | 4794 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 196 | DIVOKY | 033 | 3A4776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/20 | 76/07/20 | 4795 |
| 196 | DIVOKY | 033 | 3A5776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/28 | 76/07/28 | 4796 |
| 196 | DIVOKY | 033 | 3A6776 | 78/07/12 | 77/11/10 | AERIAL/SINGLE OTTER | 76/07/30 | 76/07/30 | 4797 |
| 196 | DIVOKY | 033 | 3A1876 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/08/12 | 76/08/12 | 4798 |
| 196 | DIVOKY | 033 | 3A2876 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/08/19 | 76/08/19 | 4799 |
| 196 | DIVOKY | 033 | 3AL876 | 78/07/12 | 78/02/23 | RV ALUMIAC | 76/08/19 | 76/08/31 | 5199 |
| 196 | DIVOKY | 033 | 2BW576 | 78/07/12 | 78/01/04 | ON FOOT | 76/05/06 | 76/06/03 | 5034 |
| 196 | DIVOKY | 033 | 3OK676 | 78/07/12 | 78/01/04 | ON FOOT | 76/06/07 | 76/06/15 | 5014 |
| 196 | DIVOKY | 033 | 3PB876 | 78/07/12 | 78/01/04 | SMALL BOAT | 76/08/12 | 76/08/19 | 5039 |
| 196 | DIVOKY | 033 | 3BR776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/13 | 76/07/14 | 5022 |
| 196 | DIVOKY | 033 | 3PI776 | 78/07/12 | 78/01/04 | FOOT/SMALL BOAT | 76/07/31 | 76/08/05 | 5038 |
| 196 | DIVOKY | 033 | 3BB776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/20 | 76/07/26 | 5025 |
| 196 | DIVOKY | 033 | 3PP876 | 78/07/12 | 78/01/04 | ON FOOT | 76/08/30 | 76/09/01 | 5031 |
| 196 | DIVOKY | 033 | 3OK976 | 78/07/12 | 78/01/04 | ON FOOT | 76/09/04 | 76/09/07 | 5032 |
| 196 | DIVOKY | 033 | 2GL876 | 78/07/12 | 78/02/28 | USCG GLACIER | 76/08/06 | 76/09/03 | 5196 |
| 196 | DIVOKY | 033 | 2CL876 | 78/07/12 | 78/01/04 | ON FOOT | 76/08/13 | 76/08/20 | 5030 |
| 196 | DIVOKY | 033 | 2WR776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/30 | 76/08/06 | 5027 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 196 | DIVOKY | 033 | 3C0876 | 78/07/12 | 78/03/16 | ON FOOT | 76/08/01 | 76/08/31 | 5211 |
| 196 | DIVOKY | 033 | 3C0776 | 78/07/12 | 78/03/16 | ON FOOT | 76/07/01 | 76/07/31 | 5209 |
| 196 | DIVOKY | 033 | 30K776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/16 | 76/07/19 | 5023 |
| 196 | DIVOKY | 033 | 3BL676 | 78/07/12 | 78/01/04 | FOOT/CANOE | 76/06/23 | 76/07/03 | 5036 |
| 196 | DIVOKY | 033 | 2PD676 | 78/07/12 | 78/01/04 | ON FOOT | 76/06/17 | 76/06/21 | 5015 |
| 196 | DIVOKY | 033 | 2A7676 | 78/07/12 | 77/11/10 | AERIAL/CESSNA 180 | 76/06/21 | 76/06/21 | 4811 |
| 196 | DIVOKY | 033 | 2A1776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/06 | 76/07/06 | 4807 |
| 196 | DIVOKY | 033 | 2A2776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/08 | 76/07/08 | 4789 |
| 196 | DIVOKY | 033 | 2A3776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/16 | 76/07/16 | 4812 |
| 196 | DIVOKY | 033 | 2A4776 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/07/25 | 76/07/25 | 4813 |
| 196 | DIVOKY | 033 | 2A1876 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/08/06 | 76/08/06 | 4814 |
| 196 | DIVOKY | 033 | 2A2876 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/08/20 | 76/08/20 | 4815 |
| 196 | DIVOKY | 033 | 2A1976 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/09/11 | 76/09/11 | 4816 |
| 196 | DIVOKY | 033 | 2A2976 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/09/20 | 76/09/20 | 4817 |
| 196 | DIVOKY | 033 | 2A1576 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/05/15 | 76/05/15 | 4803 |
| 196 | DIVOKY | 033 | 2A2576 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/05/19 | 76/05/19 | 4804 |
| 196 | DIVOKY | 033 | 2A1676 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/06/21 | 76/06/21 | 4805 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 196 | DIVOKY | 033 | 2A2676 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/06/10 | 76/06/10 | 4806 |
| 196 | DIVOKY | 033 | 2A3676 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/06/11 | 76/06/11 | 4808 |
| 196 | DIVOKY | 033 | 2A5676 | 78/07/12 | 77/11/10 | AERIAL/SINGLE OTTER | 76/06/17 | 76/06/17 | 4809 |
| 196 | DIVOKY | 033 | 2A6676 | 78/07/12 | 77/11/10 | AERIAL/TWIN OTTER | 76/06/19 | 76/06/19 | 4810 |
| 196 | DIVOKY | 033 | 3CR776 | 78/07/12 | 78/01/04 | ON FOOT | 76/07/13 | 76/07/15 | 5021 |
| 196 | DIVOKY | 033 | 2DI976 | 78/07/12 | 78/02/28 | DISCOVERER | 76/09/11 | 76/09/22 | 5195 |
| 196 | DIVOKY | 033 | 2GL875 | 78/07/12 | 78/02/28 | USCG GLACIER | 75/07/30 | 75/08/27 | 5198 |
| 229 | PITCHER | 025 | W75PWS | 77/09/07 | | SHIP | 75/10/01 | 75/12/31 | |
| 229 | PITCHER | 025 | 376KEN | 77/09/07 | | BIG VALLEY | 76/03/17 | 76/03/22 | 1468 & 2176 |
| 229 | PITCHER | 025 | 276KOD | 77/09/07 | | RESOLUTION | 76/02/03 | 76/02/13 | 1467 & 2175 |
| 229 | PITCHER | 025 | 676YAK | 77/09/07 | | SURVEYOR | 76/05/25 | 76/06/03 | 1470 & 3209 |
| 229 | PITCHER | 025 | 576MID | 77/09/07 | | SURVEYOR | 76/05/25 | 76/06/03 | 3034 & 3208 |
| 229 | PITCHER | 025 | 576KAY | 77/09/07 | | SURVEYOR | 76/05/25 | 76/06/03 | 3035 & 3207 |
| 229 | PITCHER | 025 | 576ICY | 77/09/07 | | SURVEYOR | 76/05/25 | 76/06/03 | 3036 & 3212 |
| 229 | PITCHER | 025 | 776TUG | 77/09/07 | | ON FOOT | 76/07/08 | 76/07/12 | 1939 & 2178 |
| 229 | PITCHER | 025 | 476KOD | 77/09/07 | | RESOLUTION | 76/04/12 | 76/04/24 | 3033 & 3215 |
| 229 | PITCHER | 025 | 076KOD | 77/09/07 | | SURVEYOR | 76/10/05 | 76/10/14 | 2588 & 3213 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 229 | PITCHER | 025 | W76KOD | 77/09/07 | | RESOLUTION | 76/11/04 | 76/11/10 | 2589 & 3214 |
| 229 | PITCHER | 025 | 476KEN | 77/09/07 | | RESOLUTION | 76/04/12 | 76/04/12 | 1469 & 2177 |
| 229 | PITCHER | 025 | W77ICY | 78/03/23 | | SURVEYOR | 77/10/25 | 77/11/02 | 4757 |
| 229 | PITCHER | 025 | 377KEN | 78/03/23 | | PANDALUS | 77/03/20 | 77/03/26 | 3816 |
| 229 | PITCHER | 025 | 477KOD | 78/03/23 | | RESOLUTION | 77/04/27 | 77/05/04 | 3891 |
| 229 | PITCHER | 025 | 577KOD | 78/03/23 | | RESOLUTION | 77/05/20 | 77/05/27 | 4013 |
| 230 | BURNS | 025 | 776SHI | 78/04/28 | 77/02/09 | ON FOOT | 76/06/04 | 76/07/12 | 1761 & 2188 |
| 230 | BURNS | 025 | 876GLA | 78/04/28 | 77/02/09 | GLACIER | 76/08/07 | 76/08/25 | 1762 & 3129 |
| 230 | BURNS | 025 | 676NOM | 78/09/06 | 78/09/15 | ON FOOT | 76/06/03 | 76/06/20 | 1759 & 2182 |
| 230 | BURNS | 025 | 676GAM | 78/04/28 | 77/02/09 | ON FOOT | 76/05/11 | 76/06/06 | 1758 & 2181 |
| 230 | BURNS | 025 | 376SAV | 78/04/28 | 77/02/09 | ON FOOT | 76/02/29 | 76/03/27 | 1771 & 2183 |
| 230 | BURNS | 025 | 576PTH | 78/04/28 | 77/02/09 | ON FOOT | 76/03/07 | 76/05/27 | 1760 & 2187 |
| 230 | BURNS | 025 | 476CLI | 78/09/06 | 78/09/15 | ON FOOT | 76/03/10 | 76/04/20 | 1768 & 2186 |
| 230 | BURNS | 025 | 876BAR | 78/09/06 | 78/09/15 | ON FOOT | 76/05/06 | 76/08/07 | 1763 & 2180 |
| 230 | BURNS | 025 | 576SUV | 78/09/06 | 78/09/15 | SURIAIIA | 76/03/19 | 76/05/01 | 1765 & 2189 |
| 230 | BURNS | 025 | 876BTI | 78/09/06 | 78/09/15 | ON FOOT | 76/07/20 | 76/08/03 | 1766 & 2185 |
| 230 | BURNS | 025 | 876WAI | 78/04/28 | 77/02/09 | ON FOOT | 76/06/03 | 76/07/29 | 1764 & 2184 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

616

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE | |
|---|---|---|---|---|---|---|---|---|---|---|
| 230 | BURNS | 025 | 876DIS | 78/09/06 | 78/09/15 | DISCOVERER | 76/08/18 | 76/09/02 | 3130 | |
| 230 | BURNS | 025 | 576DIO | 78/09/06 | 78/09/15 | ON FOOT | 76/05/25 | 76/08/16 | 3132 | |
| 230 | BURNS | 025 | W76NOM | 78/04/28 | | ON FOOT | 76/11/11 | 76/12/21 | | S |
| 230 | BURNS | 025 | W76STE | 78/04/28 | | ON FOOT | 76/11/19 | 76/11/21 | | P |
| 230 | BURNS | 025 | 976MFR | 78/09/06 | | MILLER FREEMAN | 76/09/27 | 76/10/13 | | E |
| 230 | BURNS | 025 | N77PRU | 78/04/28 | | AIRCRAFT | 77/11/06 | 77/11/10 | | P |
| 230 | BURNS | 025 | 877GLA | 78/04/28 | | SHIP | 77/07/31 | 77/09/06 | | P |
| 230 | BURNS | 025 | 477SUV | 78/04/28 | | ON FOOT | 77/03/15 | 77/05/03 | 3893 | R&P&S |
| 230 | BURNS | 025 | 677SAV | 78/04/28 | | ON FOOT | 77/06/19 | 77/06/24 | 4079 | S&P |
| 230 | BURNS | 025 | 677GAM | 78/04/28 | | ON FOOT | 77/05/20 | 77/06/15 | 4080 | S&P |
| 230 | BURNS | 025 | 577DIS | 78/04/28 | | ON FOOT | 77/05/20 | 77/06/11 | 4075 | S&P&R |
| 230 | BURNS | 025 | 677SHI | 78/04/28 | | ON FOOT | 77/06/13 | 77/07/11 | 4082 | S |
| 230 | BURNS | 025 | 677WAL | 78/04/28 | | ON FOOT | 77/05/28 | 77/07/02 | 4340 | S |
| 230 | BURNS | 025 | 177NOM | 78/04/28 | | ON FOOT | 77/01/25 | 77/01/29 | | P |
| 230 | BURNS | 025 | 377NOM | 78/04/28 | | AIRCRAFT | 77/03/07 | 77/03/24 | 3892 | P |
| 230 | BURNS | 025 | 677NOM | 78/04/28 | | ON FOOT | 77/05/29 | 77/06/27 | 4077 | P |
| 230 | BURNS | 025 | 677DIO | 78/04/28 | | ON FOOT | 77/05/20 | 77/06/24 | 4081 | P |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 230 | BURNS | 025 | 577PTH | 78/04/28 | | ON FOOT | 77/04/15 | 77/06/01 | 4076 P |
| 230 | BURNS | 025 | 277BAR | 78/04/28 | | ON FOOT | 77/02/11 | 77/02/16 | P |
| 230 | BURNS | 025 | 477BAR | 78/04/28 | | ON FOOT | 77/04/04 | 77/04/14 | 3894 P |
| 243 | CALKINS | 025 | W75LIO | 77/09/07 | | MONTAGUE | 75/10/28 | 75/11/04 | 1582 & 3216 |
| 243 | CALKINS | 025 | 276LIO | 77/09/07 | | RESOLUTION | 76/02/03 | 76/02/13 | 1583 & 3217 |
| 243 | CALKINS | 025 | 376LIO | 77/09/07 | | BIG VALLEY | 76/03/17 | 76/03/22 | 1584 & 3218 |
| 243 | CALKINS | 025 | 476LIO | 77/09/07 | | RESOLUTION | 76/04/12 | 76/04/24 | 1585 & 3219 |
| 243 | CALKINS | 025 | 576LIO | 77/09/07 | | SURVEYOR IVA | 76/05/25 | 76/06/03 | 1586 & 3220 |
| 243 | CALKINS | 025 | W76LIO | 77/09/07 | | SURVEYOR | 76/10/05 | 76/10/14 | 2591 & 3221 |
| 243 | CALKINS | 025 | 277LIO | 78/03/23 | | YANKEE CLIPPER | 77/02/10 | 77/02/18 | 3817 |
| 243 | CALKINS | 025 | 377LIO | 78/03/23 | | PANDALUS | 77/03/22 | 77/03/26 | 4818 |
| 243 | CALKINS | 025 | 477LIO | 78/03/23 | | RESOLUTION | 77/04/28 | 77/05/21 | 3896 |
| 243 | CALKINS | 025 | 577LIO | 78/03/23 | | RESOLUTION | 77/05/21 | 77/05/27 | 4027 |
| 243 | CALKINS | 025 | W77LIO | 78/03/23 | | SURVEYOR | 77/10/25 | 77/11/02 | 4758 |
| 243 | CALKINS | 025 | N77LIO | 78/03/23 | | RESOLUTION | 77/11/13 | 77/11/19 | |
| 243 | CALKINS | 025 | C77LIO | 78/03/23 | | ON FOOT | 77/03/15 | 77/06/01 | |
| 337 | LENSINK | 033 | FW5038 | 78/09/08 | 78/09/15 | ALEUTIAN TERN | 75/04/16 | 75/09/07 | 4094 J&J |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 337 | LENSINK | 038 | FW6076 | 78/01/13 | 78/01/20 | | | | |
| 337 | LENSINK | 038 | FW6091 | 78/01/13 | 78/01/20 | | | | |
| 337 | LENSINK | 038 | FW6020 | 78/01/13 | 78/01/20 | | | | |
| 337 | LENSINK | 033 | FW7047 | 78/04/14 | | BOAT | 77/10/30 | 77/11/14 | |
| 337 | LENSINK | 033 | FW7029 | 78/07/14 | | | 77/04/20 | 77/04/24 | |
| 337 | LENSINK | 033 | FW8014 | 78/07/14 | | | 78/05/23 | 78/06/05 | |
| 337 | LENSINK | 033 | FW7050 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW7051 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW7052 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW7053 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW7054 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW6096 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW8016 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW8015 | 78/09/08 | 78/09/15 | | | | J&J |
| 337 | LENSINK | 033 | FW6100 | 78/09/08 | 78/09/15 | | | | J&J |
| 417 | LEES | 030 | OKENA1 | 78/09/08 | 77/06/21 | HUMDINGER | 75/07/30 | 75/09/12 | 2571 & 4248 |
| 417 | LEES | 030 | OKENA2 | 78/09/08 | 77/06/21 | HUMDINGER | 76/05/03 | 76/05/08 | 2572 & 4249 |

TABLE 1 (Continued)

TRACKING SYSTEM INPUT REPORT

| RU | NAME | FILE TYPE | FILE IDENT | DATE RECEIVED YY MM DD | DATE CONTROLLED YY MM DD | PLATFORM | SURVEY START YY MM DD | SURVEY END YY MM DD | UNIQUE |
|---|---|---|---|---|---|---|---|---|---|
| 417 | LEES | 030 | OKENA3 | 78/09/08 | 77/06/21 | HUMDINGER | 76/06/30 | 76/07/11 | 3023 & 4250 |
| 417 | LEES | 030 | OKENA4 | 78/09/08 | 77/06/21 | HUMDINGER | 76/08/30 | 76/08/31 | 3024 & 4251 |
| 467 | TRUETT | 038 | MWATCH | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |
| 467 | TRUETT | 033 | AERSV1 | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |
| 467 | TRUETT | 033 | AERSV2 | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |
| 467 | TRUETT | 033 | AERSV3 | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |
| 467 | TRUETT | 033 | AERSV4 | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |
| 467 | TRUETT | 033 | AERSV5 | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |
| 467 | TRUETT | 033 | AERSV6 | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |
| 467 | TRUETT | 023 | FYKE | 78/09/12 | 78/09/15 | ZODIAC | 77/06/01 | 77/09/25 | |

TABLE 2

025 Checking Status

| RU=229 | | | | Program Names | | | |
|---|---|---|---|---|---|---|---|
| File id | ID025 | PRO25 | SQ025 | CD025 | RL025A | TX025 | PFILE |
| W75PWS | X | X | X | X | X | | X |
| 376KEN | X | X | X | X | X | | X |
| 276KOD | X | X | X | X | X | | X |
| 676YAK | X | X | X | X | X | | X |
| 576MID | X | X | X | X | X | | X |
| 576KAY | X | X | X | X | X | | X |
| 576ICY | X | X | X | X | X | | X |
| 776TUG | X | X | X | X | X | | X |
| 476KOD | X | X | X | X | X | | X |
| 076KOD | X | X | X | X | X | | X |
| W76KOD | X | X | X | X | X | | X |
| 476KEN | X | X | X | X | X | | X |
| W77ICY | X | X | X | X | X | | X |
| 377KEN | X | X | X | X | X | | X |
| 477KOD | X | X | X | X | X | | X |
| 577KOD | X | X | X | X | X | | X |
| RU=230 | | | | | | | |
| 776SHI | X | X | X | X | X | | X |
| 876GLA | X | X | X | X | X | | X |
| 676NOM | X | X | X | X | X | | X |
| 676GAM | X | X | X | X | X | | X |
| 376SAV | X | X | X | X | X | | X |
| 576PTH | X | X | X | X | X | | X |
| 476CLI | X | X | X | X | X | | X |
| 876BAR | X | X | X | X | X | | X |
| 576SUV | X | X | X | X | X | | X |
| 876BTI | X | X | X | X | X | | X |
| 876WAI | X | X | X | X | X | | X |
| 876DIS | X | X | X | X | X | | X |
| 576DIO | X | X | X | X | X | | X |
| W76NOM | X | X | X | X | X | | X |
| W76STE | X | X | X | X | X | | X |
| 976MFR | X | X | X | X | X | | X |
| 575MEK | X | X | X | X | X | X | X |
| 675NOM | X | X | X | X | X | X | X |
| 575GAM | X | X | X | X | X | X | X |
| 675SAV | X | X | X | X | X | X | X |
| 675DIO | X | X | X | X | X | X | X |
| 875WAI | x | X | X | X | X | X | X |
| 975BAR | X | X | X | X | X | X | X |
| N77PRU | X | X | X | X | X | | X |
| 877GLA | X | X | X | X | X | | X |
| 477SUV | X | X | X | X | X | | X |

Table 2(Continued)

| | ID025 | PR025 | SQ025 | CD025 | RL025A | TX025 | PFILE |
|---|---|---|---|---|---|---|---|
| 677SAV | X | X | X | X | X | | X |
| 677GAM | X | X | X | X | X | | X |
| 577DIS | X | X | X | X | X | | X |
| 677SHI | X | X | X | X | X | | X |
| 677WAL | X | X | X | X | X | | X |
| 177NOM | X | X | X | X | X | | X |
| 377NOM | X | X | X | X | X | | X |
| 677NOM | X | X | X | X | X | | X |
| 677DIO | X | X | X | X | X | | X |
| 577PTH | X | X | X | X | X | | X |
| 277BAR | X | X | X | X | X | | X |
| 477BAR | X | X | X | X | X | | X |
| RU=243 | | | | | | | |
| W75LIO | X | X | X | X | X | | X |
| 276LIO | X | X | X | X | X | | X |
| 376LIO | X | X | X | X | X | | X |
| 476LIO | X | X | X | X | X | | X |
| 576LIO | X | X | X | X | X | | X |
| W76LIO | X | X | X | X | X | | X |
| 277LIO | X | X | X | X | X | | X |
| 377LIO | X | X | X | X | X | | X |
| 477LIO | X | X | X | X | X | | X |
| 577LIO | X | X | X | X | X | | X |
| W77LIO | X | X | X | X | X | | X |
| N77LIO | X | X | X | X | X | | X |
| C77LIO | X | X | X | X | X | | X |

TABLE 3

Check programs for file type 023

| Program Name | Function | Status |
|---|---|---|
| START | Gathers input for ID023 | Completed |
| ID023 | Checks NODC required fields, taxonomic code executive summary | Completed |
| CD023 | Validates data codes | Completed |
| CD023R | 8 1/2x11 report form of CD023 | Completed |
| EX023 | Executive Summary | Completed |
| TC023 | Validates the taxonomic codes | Completed |
| BL023 | Checks for embedded blanks | Completed |
| PR023 | Predator-Prey display | In design |
| TX023 | Taxonomic code conversion | In design |
| RA023 | Range check | -- |
| RL023 | Relational checks | -- |
| SL023 | Selection of data | -- |
| SQ023 | Sequence number check | -- |

Quarterly Report

Contract Number: 03-7-022-35139
Research Unit Number: 527
Reporting Period: 7/1/78-9/30/78

# OCSEAP Data Processing Services

Harold Petersen Jr.
Data Projects Group
Pastore Laboratory
University of Rhode Island
Kingston, Rhode Island
02881

1 October 1978

## Background and Objectives

The OCSEA Program encompasses a wide variety of investigations dealing with monitoring and assessing environmental parameters. One requirement of this program involves the submission of data collected in this fashion to national archiving centers. Another aspect involves the assimilation of data by individual research units, and the generation of analyses appropriate for Program use.

As part of its overall task, the Juneau Project Office (JPO) seeks assurance that data is submitted in appropriate format and acceptable quality, and that Program products are developed and generated in a timely manner. It is in this framework that data processing services are provided by the Data Projects Group (DPG).

In order to carry out these procedures, use is made of an information management system known as the MARMAP Information System (MIS).

## Past Work

This work was begun in March 1977 with the establishment of procedures necessary for code and data field validations, and subsequent format conversion of File Type 033 data collected in a format internal to the U.S. Fish and Wildlife Service (FWS) into that acceptable to the Program (the "NODC" format). Later, these data were collected in acceptable format, obviating the need for the format conversion. There remained, however, the task of converting the earlier-collected data, and also of validating all data collected in this format by all contributing RU's. A summary of the status of this work plus that of new services is given in this report.

## Current Work

1. New Tapes

Two tapes of 033 data were received during this quarter. The first, received on 18 July 1978, contained data for three field operations carried out by RU 196. Validation products were not sent out until 31 August 1978 because there were some difficulties encountered in using the tape. The tape, reportedly unlabelled, was in fact labelled, and record lengths of 83 were achieved by recording null characters rather than trailing blanks to fill out the records. Null characters, while unprintable and therefore the same as blanks in appearance, correspond to a different bit pattern. The validation products interpreted these characters as data, showing each field thus coded as an error. The null characters were replaced with blanks, the products rerun, and delivered to the RU. They have not yet been returned.

The second tape was received on 5 September 1978, and contained data for two field operations carried out by RU 337. These operations, FW6093 and FW7029, were coded in NODC format. Validation products CODEPULL and LOGLIST were mailed to the RU on 8 September 1978, were returned on 18 September 1978, and presently await editing.

2. Current Processing of RU 337 Data

The validation process for 033 data submitted by this RU is continuing. During this quarter, information was received regarding necessary changes and additions to all data originally entered in FWS format received from this source. These include addition of the transect width field and changes to a portion of the station number field (a portion of this field is used to indicate a transect type code in this case). It is regrettable that these changes were not made before the data were first entered, or when validation products were sent to this RU. Their inclusion at this point will slow processing of the data.

Of the field operations received from this RU in the past, eighteen additional operations have been edited during this quarter to the point where they are ready for conversion to NODC format and editing as referenced above (see also "Field Operation Status Report" below). They are:

FW5015, FW5016, FW5021, FW5025, FW5033, FW6002
FW6007, FW6008, FW6009, FW6021, FW6057, FW6064
FW6070; FW6074, FW6083, FW6086, FW6089, FW6095

Eight others have been converted to NODC format, station numbers and transect width's edited, and sent to NODC. A tape of the same data was also sent to RU 337. These operations include:

FW5008, FW5009, FW5014, FW5027
FW5030, FW5032, FW6001, FW6015

It should be noted that FW5030 and FW5032 were the two operations sent to this RU for a final check on the conversion scheme, and which now serve as a model for subsequent conversions.

Also during this quarter it was decided by Program management that use of species group codes would no longer be supported, and they would be deleted from OCSEAP data. As a result of this decision, species group codes were deleted from the eight operations (above) sent to NODC. Following additional discussions, it was decided not to delete these data on subsequent operations, but rather simply to ignore the presence of these data. Current thinking with regard to this subject is given by Jim Audet (NODC) in a 29 September letter entitled "Species Group Codes."

3. NODC Edits of File Type 033 Data

All OCSEAP data received by NODC is subject to a series of edit checks independent of previous processing. As such, 033 data are edited upon receipt, and results of those edits used to correct any errors found in the data. In the case of 033 data, however, originating RU's would have just finished a heavy involvement with validation products originating from DPG when confronted with any new citations from NODC edit procedures. So that the originating RU deals with only one source of validation products, a scheme has been worked out with NODC as follows: In the past, DPG has delivered copies of an RU's data to both NODC and the RU (plus a final copy of CODEPULL as a listing of the validated data set) following the completion of validation steps and any necessary conversion or other editing. With the initiation of the new procedures, NODC will be sent the data (no copy to the originator), and will send the edit results to DPG, which will in turn seek resolution of cited errors from the originating RU within the context of CODEPULL and LOGLIST validation products. Corrections will be sent to NODC in the form of a report, and the originator's data will be edited and then sent (along with a final CODEPULL) to that site.

Prior to the initiation of these procedures, the NODC edit output for ten field operations already delivered to NODC (and the originating RU) was sent to RU 337. These operations were:

FW7028, FW7031, FW7032, FW7033, FW7034
FW7035, FW7036, FW7042, FW7045, FW7046

That RU resolved error citations and sent them to DPG, which edited the data sets and returned a new copy of the data. A report of these changes is now in preparation for NODC.

Results of NODC edits on data from RU's 239 and 108 have been received by DPG, and are being resolved. These receipts plus those for RU 337 data above comprise all results from the 38 field operations sent by DPG to NODC to date (see also "Field Operation Status Report" below).

4. Program Product Development - RU 083

Data for seven field operations have been received from RU 083. Data for operations UCI501 and UCI601 were received on 7 July 1977, and were coded in FWS format. Data for UCI602 were received in NODC format on 10 April 1978. On 13 June 1978, a resubmission of data for UCI501 was received in NODC format, along with data for UCI701, UCI702, UCI703, and UCI704. All data have now been validated, and field operation UCI601 has been converted to NODC format. However, it has recently been found that linkage data in UCI601 and observation time data in UCI701 and UCI702 require further editing, which will be carried out upon receipt of corrections from the RU.

Data for these field operations are also being converted into MIS data base format for use in the generation of Program-authorized final report products for RU 083. The general description of four such products has been worked out between JPO, the RU, and DPG. Work on the first of these products, a bird density calculation within 10'x10' regions, is projected for completion by 1 November 1978. Data utilized in this product are not affected by the pending edits mentioned above. A description of all four products is contained in a letter to Doug Wolfe (Program Office) from Rod Swope (JPO) entitled "Intended Analyses and Methodology for RU 083 Final Report Products."

5. Field Operation Status Report

Information presented above regarding current processing of 033 data is summarized in the enclosed Field Operation Status Report. As indicated in the report, data for 123 field operations have been received to date. CODEPULL and LOGLIST validation products have been sent to appropriate RU's for all of them, and 119 sets have been returned. Of the four outstanding, three are from RU 196, and the fourth corresponds to the original submission of UCI501 from RU 083 (data for the second submission of this field operation have already been processed). Of the 119 field operations for which edits are available, 39 remain to be edited and 80 have been edited. Of the 80 edited, 38 (these are a combination of 30 originally in NODC format, plus 8 which were converted from FWS format and for which station number and transect width editing was carried out) have been mailed to NODC, 35 are from RU 337 and are ready for conversion plus station number and transect width editing, and 7 are from RU 083, which require some final time and linkage number editing prior to delivery to NODC (one of the 7 was converted from FWS format).

6. Changes to "OCSEAP Data Validation Procedures for File Type 033"

Several changes have been made to the 033 validation procedures during this quarter. They are flagged with an asterisk (*) to the left of each addition in the enclosed copy of the precedures. Some of the changes require additional commentary:

a) A routine has been added to flag all occurrences of an odd number of trailing blanks in the taxonomic code field (all entries should be in doublets).

b) A routine has been added to flag all occurrences of "subspecies" codes when the "species" code has not been filled in ("species" must be known if "subspecies" is known).

c) Time of observation field on ice card ( record type 3) should be in same order as sequence number of the ice card when more than one such observation is made per station (a flag is set if this condition is not met).

d) Ice cards (record type 3) are sorted so as to occur after record type 2 and before other record types. As before, comment cards (record type 4) and data cards (record type 5) appear after earlier record types, and are sorted together by sequence number. In this way, comment cards applying to a particular data card (and indicated as such by use of the same sequence number) will appear as (comment card, data card) pairs, and data card-independent comments will sort to a position which depends on the sequence number(s) used. An example of this sequencing follows:

| RECORD TYPE | SEQUENCE NUMBER |
|---|---|
| 1 | - |
| 2 | - |
| 3 | 001 |
| 3 | 002 |
| 3 | 003 |
| 4 | 001 |
| 5 | 001 |
| 5 | 002 |
| 4 | 003 |
| 4 | 004 |
| 5 | 004 |
| 5 | 005 |
| 4 | 006 |

7. File Type 038 (Migratory Bird Sea Watch) Reformatting

Work begun during the previous quarter aimed at reformatting 038 data in much the same manner as the 033 data was continued during this quarter. This work involves a representative of RU 337 who is in the field much of the time during the field season, hence the setup of the reformatting procedures, which requires input from the RU, has proceeded slowly. To date, one field operation (in FWS 038 format) has been received for use in trying out tentative procedures. A LOGLIST of this field operation has been reviewed by the RU, and this validation product is now ready for use. A CODEPULL has been prepared for this operation, but presently awaits guidance from the RU as to the contents of some of the required code groups. When these code groups are completed, validation procedures will be ready for production use.

8. Distributed Data Entry/Processing

Preliminary steps were taken during this quarter to provide a hardware/software system whereby RU's could enter their data via prompted interactive data entry terminals using standard Program-approved formatting programs. These programs would be developed by DPG, and provided to the appropriate RU's, who would in turn transmit entered data to DPG where it would be recorded on tape and sent to NODC. The data would also be converted to a MIS data base and accessed for product development. Products would be transmitted to the RU's, again using this system.

This procedure is being adopted so that data can be validated at the source, rather than after it has been entered, thus relieving the necessity of generating validation products "after-the-fact." Data which has already been entered can, in turn, be processed by this system and errors cited and corrected at the originating RU. With this approach, RU's should be able to use their validated data for products much earlier than is presently done.

9. Financial Report

The enclosed financial report shows expenses during this quarter as a function of salaries (and overhead), computer expenses, rental of equipment, travel, supplies, and other.

10. Activity/Milestone Chart

(see next page)

RU #: 527 PI: Harold Petersen Jr. -- University of Rhode Island

| | 1978 | | | | | | | | | | 1979 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Major Milestones | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
| Choice of validation criteria for type 038 data | | X | | | | | | | | | | | | | | | | | | | | |
| Procedures for validation of FWS type 038 data operational | | | | | | | | O | | | | | | | | | | | | | | |
| Procedures for validation of 033 data operational | X | | | | | | | | | | | | | | | | | | | | | |
| Procedures for conversion of 033 data operational | | | | | | | X | | | | | | | | | | | | | | | |
| Completion date for editing 033 data | | | | | | | | | | | O | | | | | | | | | | | |
| Completion date for conversion of 033 data | | | | | | | | | | | | O | | | | | | | | | | |
| Feasibility study for distributed data entry and processing completed | | | | | | | X | | | | | | | | | | | | | | | |
| Establishment of distributed data entry and processing node at RU 527 | | | | | | | | | | O | | | | | | | | | | | | |
| Establishment of distributed data entry sites at RU 083 and RU 237 | | | | | | | | | | | | O | | | | | | | | | | |

(continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Establishment of format for four Program-authorized 033 data analysis products for RU 083 | | | X | | | | | | | |
| Delivery of first of four 033 033 analysis products to RU 083 and JPO | | | | | O | | | | | |
| Quarterly Reports | X | X | | X | | O | O | O | O | |
| Annual Report | X | | | | | | O | | | |
| Final Report | | | | | | | | | | O |

Past Contract
<-- Period --><--------- Present Contract Period -------->

O = Planned Completion Date X = Actual Completion Date
FWS = Fish and Wildlife Service NODC = National Oceanic Data Center

11. The Plight of Proposers

An anonymous donor has supplied a copy of a letter dated July 20, 1776, and addressed to Thomas Jefferson of the Continental Congress, Independence Hall, Philadelphia. It reads in part as follows:

"Dear Mr. Jefferson:

"We have read your 'Declaration of Independence' with great interest. ...Unfortunately, the Declaration as a whole fails to meet recently adopted specifications for proposals to the Crown, so we must return the document to you for further refinement. The questions which follow might assist you in your process of revision:

* "In your opening paragraph you use the phrase 'the Laws of Nature and Nature's God.' What are these laws? ...Please document with citations from the recent literature.
* "You state that 'whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute a new Government.' Have you weighed this assertion against all the alternatives?
* "Your strategy for achieving your goal is not developed at all. You state that the colonies ...are 'Absolved from All Allegiance to the British Crown.' Who or what must change to achieve this this objective? ...How long will it take? We have found that a little foresight in these areas helps to prevent careless errors later on.
* "Who among the list of signatories will be responsible for implementing your strategy? ...Who will constitute the advisory committee? Please submit an organizational chart.
* "You must include an evaluation design. We have been requiring these since Queen Anne's War.
* "Please submit a PERT diagram, an activity chart, and an itemized budget.

"We hope that these comments prove useful in revising your 'Declaration of Independence.'

Best Wishes,
Lord North"

OCSEAP DATA VALIDATION PROCEDURES
For File Type 033
(Release 5: Sept 30, 1978)

In order to provide data validation for the File Type 033 data from the OCSEAP Project, four areas need consideration. These include card type validation, data range and relational parameter checking, and format, code, or unit conversion. Since this is a multi-card type file, the card type designation must first be verified (an incorrect value would lead to the improper interpretation of remaining fields on that card), along with the occurrence and sequencing of card types. Second, codes used in each code field (ex. - a two digit weather code) must be compared against all valid codes for that field for verification. Next, range checks must be carried out on all appropriate fields (ex. - sea surface temperature should be between certain upper and lower limits), and relational checks on interrelated fields (ex. - wet bulb temperature readings should be less than or equal to corresponding dry bulb temperature readings). Lastly, if the data are not coded in NODC format, the necessary format changes must be carried out.

Card type designation and sequencing, and valid code field contents are checked in a program called CODEPULL. First the card type is verified. This must be between one and five, and certain other fields are also checked for further verification (ex. - a type five card must have a taxonomic code and a sequence number). Extra cards and missing cards are detected with the sequencing routine. This checks that the cards are in order, that each station has a unique one card followed by a unique two card, and that there are no duplicated or skipped sequence numbers. Then the appropriate code tables are called, and each code of each code field is compared with the appropriate table containing all valid codes for that field.

The output from CODEPULL is a listing of the file in order by station number. Any errors detected are flagged by a brief descriptive message, including a record count for ease in correcting, and, in the case of a bad code, a string of asterisks under the field. Following the file listing is a summary of all the codes used for each code field and their definitions. For a bad code, the record in which it appeared replaces the definition. Figure 1 is a list of the code groups checked and Figure 2 is a portion of a CODEPULL listing.

Data range and relatonal checking are done in a program called LOGLIST. This verifies the data coded as raw numbers, rather than as codes. The contents of the data fields are first checked for numerics, signs, and leading zeros and then compared to upper and lower limits appropriate to each field. In some cases the value of one field is dependent on the value of another field and these relational checks are also made.

LOGLIST prints a columnar listing for each card type. The columns are identified by a three character field code defined prior to the data listing. The record number is listed on the left and any errors detected are flagged in the diagnostics section on the right. A totally blank field is indicated by a row of dots and embedded blanks by an asterisk. Figure 3 is a list of the limit and relational checks made and Figure 4 is a portion of a LOGLIST listing.

These outputs are sent to the Principal Investigator for correcting. He checks the diagnostic messages and the data and marks any necessary corrections directly on the listing. These are returned to us and the updates made to the file with an interactive program called EDITLOG. Then CODEPULL and LOGLIST are rerun for final verification.

Finally the data are converted to NODC format (if they were coded in another format) and submitted to NODC. Format conversion is done with a program called CONVPROG. Many different operations are carried out at this point. For example, data fields are moved from one place to another on a given card, or onto a different card; units are converted and rounded or truncated, or converted to codes; and codes are converted to those equivalent codes acceptable to NODC. Figure 5 is a list of the conversion routines carried out. Data collected in NODC format is also run through the conversion program. This is necessary in order to standardize certain fields since coding varies between investigators, and includes providing leading zeros or blanks, and checking for signs. Figure 6 is a list of transformation routines required.

All of these programs form part of the MARMAP Information System. Their operation is directed by a Master System Table (MST). The MST has an entry for each field of each card type in a file. This contains all the information needed for processing, including field code, data type, position, upper limit, lower limit, relational checking and conversion routines. The programs therefore are data independent and readily adaptable to any file type.

NOTE: An * denotes a change in this entry since the previous report.

FIGURE 1: CODE GROUPS VALIDATED

| Code Field | FWS Columns | NODC Columns |
|---|---|---|
| **CARD TYPE 1** | | |
| Platform Type | 67-68 | 69 |
| Ship Activity | 70 | 71 |
| Sampling Technique | 69 | 70 |
| Collection Code | - | 72 |
| Zone Scheme | - | 73 |
| Angle of View | - | 74 |
| Observation Conditions | - | 75 |
| Speed Type | 60 | - |
| O.B.S. Region | 28-30 | - |
| Observer Location | 74 | - |
| **CARD TYPE 2** | | |
| Wind Direction | - | 45-46 |
| Swell Direction | - | 50-51 |
| Sea State | - | 49 |
| Weather | 16-17 | 55-56 |
| Cloud Type | - | 57 |
| Cloud Amount | - | 58 |
| Water Color | - | 59 |
| Visibility | 18 | 61 |
| Sun Direction | - | 62 |
| Glare Intensity | 61 | 63 |
| Glare Area | 62 | 64 |
| Moon Phase | - | 68 |
| Tide Height | - | 69 |
| Debris | - | 80 |
| Observation Conditions | 19 | - |
| Turbidity | - | 63 |
| **CARD TYPE 3** | | |
| Ice Cover | 16,23,35 | 16,22,51 |
| Ice Pattern/Description | 17,24 | 32 |
| Ice Type | 18,25 | 17,23 |
| Ice Form | 19,26,34 | 18,24,50 |
| Ice Relief | 20,27 | 19,25 |
| Ice Thickness | 21,28 | 20,26 |
| Ice Melting Stage | 22,29 | 21,27 |
| Open Water Type | 30 | 28 |
| Ice Direction | 31,36 | 29,33 |
| Distance | 32,37 | 30,34 |
| Lead/Polyna Width | 33,39,40 | 31,43,44 |
| Ship in Lead/Polyna Location | 38 | 42 |
| Collection Code | 41,42,43 | 35,36,37 |
| Mammal Trace | 44,45 | 38,39 |
| Pond Size | - | 49 |
| Ice Pattern | - | 40,41 |

| Code Field | FWS Columns | NODC Columns |
|---|---|---|
| CARD TYPE 4 | | |
| No Code Groups Appear Here. | | |
| CARD TYPE 5 | | |
| Age Class | 50 | 32 |
| Sex | 51 | 33 |
| Color Phase | 52 | 34 |
| Plumage | 53 | 35 |
| Molt | 54 | 36 |
| Counting Method | - | 42 |
| Reliability | - | 43 |
| Distance Measurement Type | - | 44 |
| Association Type | 55-56 | 50 |
| Behavior | 46-47 | 56-57 |
| Special Marks | 62 | 58 |
| Bird Condition | 63 | 59 |
| Food Source Association | - | 60 |
| Debris | 74 | 71 |
| Oil | - | 72 |
| Habitat | - | 76,77 |
| Substrate Type | - | 81 |
| Cover Code | - | 82 |
| Outside Zone | - | 83 |
| Text Flag | 77 | - |

NOTE: An * denotes a change to this entry since the previous report.

FIGURE 2: SAMPLE CODEPULL LISTING

CODEPULL consists of two major sections.

Figure 2A is a page from the first section showing how the file is listed. It is sorted by Station, Card Type and Sequence Number and has dotted lines dividing the stations. The errors flagged are "Bad Card Type" because the card type 4 has no sequence number; "Bad Sequence Number" because the sequence number field is not numeric; and "Bad Code" because the code entered is invalid.

Figure 2B is a portion of the second section. This first gives a summary of the number of each type of record found in the file, then a list of the codes used and their definitions. For an invalid code the definition is replaced by the record number in which it appeared. This can be seen for the Weather Code on card type 2.

***** CODEPULL *****

Figure 2A

FOR CRUISE FW7032

THE MARMAP INFORMATION SYSTEM          OCSEAP - GULF OF ALASKA PROJECT

*** CODEPULL - CRUISE FW7032

```
---------------------------------------------------------------------------------------------------------------
                              033FW70321 1073595250N1492600W7705232105              10+09 1119  6     4      30
                              033FW70322 1073 260                           2      03
RECORD #     3
TYPE 4 #     1  BAD CARD TYPE -->
                              033FW70324 1073 WAY UP BACK SIDE. SEE FIELD NOTES.

RECORD #     4
TYPE 4 #     2  BAD SEQUENCE# -->
                              033FW70324 1073 KIWH ALL 3 VERY GREY BACKS ONE FEMALE WITH NOTCH IN DORSAL HALF
                              033FW70325 1073   91290106            1                                        001  0
                              033FW70325 1073   9128020301          1                                        002  0
                              033FW70325 1073   9129010502          2                                        003  2
                              033FW70325 1073   9218021601     1    1         001                            004  0
                              033FW70325 1073   9218021601     2    4         001                            005  0
---------------------------------------------------------------------------------------------------------------
                              033FW70321 1173595130N1492615W7705232115              10+09 1120  6     4      30
RECORD #    11
TYPE 2 #     2  BAD CODE -->  033FW70322 1173 256    + 81                   2      03
                                                                                   **
                              033FW70325 1173   9129011302          2      10      20                    001  0
                              033FW70325 1173   9128020301          1              20                    002  0
                              033FW70325 1173   9129010301          4      10      20                    003  0
                              033FW70325 1173   91290106            2      10      20                    004  0
---------------------------------------------------------------------------------------------------------------
                              033FW70321 1273595000N1492730W7705232125              10+09 1118  6     4      30
                              033FW70322 1273 256    + 84               2      03
                              033FW70326 1273   9128020103          1      09      20                    001  0
                              033FW70325 1273   9129010301          8      09      20                    002  0
                              033FW70325 1273   9127070301          3              20                    003  0
                              033FW70325 1273   9109030201          2              61                    004  0
                              033FW70325 1273   91290106            2              20                    005  0
---------------------------------------------------------------------------------------------------------------
                              033FW70321 1373594800N1492715W7705232135              10+09 1118  6     3      30
RECORD #    24
TYPE 2 #     4  BAD CODE -->  033FW70322 1373 265                           3      03
                                                                                   **
                              033FW70325 1373   9128020103          4      09      20                    001  0
                              033FW70325 1373   9129011401          2      09      20                    002  0
                              033FW70325 1373   9129011302          2              03                    003  0
                              033FW70325 1373   91290103            3      10      20                    004  0
                              033FW70325 1373   9129010601          2              03                    005  0
---------------------------------------------------------------------------------------------------------------
                              033FW70321 1473594600N1492715W7705232145              10+09 1118  6     3      30
                              033FW70322 1473 220                           3      03
                              033FW70325 1473   9129011401          1              20                    001  0
                              033FW70325 1473   9128020301          1              20                    002  0
                              033FW70325 1473   912901              5              20                    003  0
                              033FW70325 1473   9128020103          1              20                    004  0
                              033FW70325 1473   91290103            2              20                    005  0
---------------------------------------------------------------------------------------------------------------
                              033FW70321 1573594430N1492715W7705232155              10+09 1118  6     3      30
                              033FW70322 1573   91    + 78                  3      03
                              033FW70325 1573   9129011401          5      09      20                    001  0
                              033FW70325 1573   9129011401          9              01                    002  0
                              033FW70325 1573   9218022001          1                                    003  2
                              033FW70325 1573   9128020103          1              20                    004  0
                              033FW70325 1573   9129011302          2      09      20                    005  0
```

Figure 2B

***** SUMMARY *****

FOR CRUISE FW7032

2219 TOTAL RECORDS

277 TYPE 1 RECORDS
277 TYPE 2 RECORDS
0 TYPE 3 RECORDS
6 TYPE 4 RECORDS
1659 TYPE 5 RECORDS

0 RECORDS WITH AN INVALID TYPE

RECORD TYPE 1

CODE FIELD: PLATFORM TYPE - NODC(1:69)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: SAMPLING TECHNIQUE - NODC(1:70) - FWS(1:69)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: SHIP ACTIVITY - NODC(1:71)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: COLLECTION CODE (PHOTOS TAKEN) - NODC(1:72)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: ZONE SCHEME (TRANSECT WIDTH) - NODC(1:73)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: ANGLE OF VIEW - NODC(1:74)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: OBSERVATION CONDITIONS - NODC(1:75)

| CODES | COMMENT |
|---|---|
| 4 | AVERAGE |
| 3 | POOR |
| 2 | MARGINAL |
| 7 | EXCELLENT |
| 6 | GOOD |
| 5 | FINE |
| BLANK | - |

Figure 2B (cont.)

RECORD TYPE 2

CODE FIELD: WIND & SWELL DIRECTION - NODC(2:45-46)(2:50-51)

| CODES | COMMENT |
|---|---|
| BLANK | - |
| 31 | 305-314 DEG. |
| 14 | 135-144 DEG. |

CODE FIELD: SEA STATE - NODC(2:49)

| CODES | COMMENT |
|---|---|
| 2 | SMOOTH-WAVELET |
| 3 | SLIGHT |
| 4 | MODERATE |
| 1 | CALM-RIPPLED |
| 0 | CALM-GLASSY |
| BLANK | - |

CODE FIELD: WIND & SWELL DIRECTION - NODC(2:45-46)(2:50-51)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: WEATHER - NODC(2:55-56) - FWS(2:16-17)

| CODES | COMMENT |
|---|---|
| 03 | CLOUDS GENERALLY FORMING OR DEVELOPING |
| 0 | *** 000011 000024 000045 000051 000690 000721 |
| 68 | RAIN OR DRIZZLE AND SNOW, SLIGHT |
| 00 | CLOUD DEVELOPMENT NOT OBSERVED OR NOT OBSERVABLE |
| 71 | CONTINUOUS FALL OF SNOW FLAKES, SLIGHT |
| 61 | RAIN, NOT FREEZING, CONTINUOUS, SLIGHT |
| 41 | FOG OR ICE FOG IN PATCHES |
| 43 | FOG OR ICE FOG, SKY INVISIBLE, THINNING DURING LAST HOUR |

CODE FIELD: CLOUD TYPE - NODC(2:57)

| CODES | COMMENT |
|---|---|
| BLANK | - |
| 3 | ALTOCUMULUS |

CODE FIELD: CLOUD AMOUNT - NODC(2:58)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: WATER COLOR - NODC(2:59)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: VISIBILITY - NODC(2:61) - FWS(2:10)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: COMPASS DIRECTION (SUN) - NODC(2:62)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: GLARE INTENSITY - NODC(2:63) - FWS(2:61)

| CODES | COMMENT |
|---|---|
| BLANK | - |

CODE FIELD: GLARE AREA - NODC(2:64) - FWS(2:62)

| CODES | COMMENT |
|---|---|
| BLANK | - |

## FIGURE 3: LIMITS AND RELATIONAL CHECKS

| Field | Format | Ranges | | Relations |
|---|---|---|---|---|
| ALL CARD TYPES | | | | |
| File Type | | | - | Must be 033 |
| File ID | | | - | Must match that of first record on file |
| Unused Columns | | | - | Must be blank |
| CARD TYPE 1 | | | | |
| * Start/End Latitude | F | 33-73 | degrees | - |
| | | 0-599 | minutes/tenths | |
| | N | 33-73 | degrees | - |
| | | 0-59 | minutes | |
| | | 0-59 | seconds | |
| | | N | hemisphere | |
| * Start/End Longitude | F | 118-180 | degrees | - |
| | | 0-599 | minutes/tenths | |
| | | W | hemisphere | |
| | N | 118-180 | degrees | - |
| | | 0-59 | minutes | |
| | | 0-59 | seconds | |
| | | W | hemisphere | |
| Date | | 1-31 | days | - |
| | | 1-12 | months | |
| Time | | 0-23 | hours | - |
| | | 1-59 | minutes | |
| Elapsed time | | 0-30 | minutes | - |
| Ships heading | F | 0-359 | degrees | - |
| | N | 0-35 | degrees/tens | |
| Ships speed | F | 0-15 | knots | When platform is ship |
| | | > 5 | knots | When transect type is 71 |
| CARD TYPE 2 | | | | |
| Wind Direction | F | 0-360 | degrees | (NODC uses a code) |
| Wind Speed | | 0-50 | knots | - |
| Swell Height | | 0-25 | feet | - |

| | Field | Format | Ranges | Relations |
|---|---|---|---|---|
| * | Sea Surface Temp | | -3°C to +10°C | Check signs & numerics |
| * | Wet/Dry Bulb Temperature | | -20°C to +70°C | Wet bulb <= Dry bulb<br>Check signs & numerics |
| * | Barometric Pressure | | .9600-1.0400 bars | - |
| | Barometric Trend | | +, -, 0, or blank | Must be blank when Baro Pressure is blank |
| | Salinity | | 20 o/oo to 34 o/oo | - |
| | Thermocline Depth | | 0-100 meters | - |

CARD TYPE 3

| | Field | Format | Ranges | Relations |
|---|---|---|---|---|
| | Excess Sediment | F | - | Must be blank |
| | Ice Algae | F | - | Must be blank |
| | Other Features | F | - | Must be blank |
| * | Time of Ice Conditions | N | - | Must increase for subsequent ice cards in one station |

CARD TYPE 4

No processing required

CARD TYPE 5

| | Field | Format | Ranges | Relations |
|---|---|---|---|---|
| * | Taxonomic Code | | 88-92 class | Trailing blanks must be paired<br>Species needed if subspecies coded |
| | Direction of Flight | F<br>N | 1-12 o'clock<br>0-35 degrees/tens | - |
| | Begin/End Zone | F | 0-30<br>0-60 | When transect 71 or 78<br>When transect 70 or 77<br>(unless BZN coded 97-99)<br>Begin must be < End zone |
| * | Number of Individuals | | - | Must be numeric<br>Must not be omitted |

NOTES:

In the format field, F=FWS, N=NODC, and Blank=Both formats.
An * denotes a change to this entry since the previous report.

## FIGURE 4: SAMPLE LOGLIST LISTING

LOGLIST lists the data for each card type individually in columnar form. Fields in each record are keyed by acronym codes.

Figure 4A shows the header page and the list of acronym definitions.

Figure 4B is a page from the data listing of card type 1. Blank data fields are depicted by a series of dots as in the LTD and LNG fields, while leading or embedded blanks appear as asterisks as in the SPD and HGT fields. Here the HED field is flagged as "outside" because it should be between 00 and 35 degrees.

Figure 4A

***** LOGLIST *****

FOR CRUISE FW7032

CALL FILE ********

CARD TYPE 1

THE MARMAP INFORMATION SYSTEM        OCSEAP - GULF OF ALASKA PROJECT

Figure 4A (cont.)

*** LOGLIST - CRUISE FW7032 - CALL FILE ******** - CARD TYPE 1

ACRONYM DEFINITIONS

| | |
|---|---|
| STA | STATION |
| LAT | START LATITUDE |
| LON | START LONGITUDE |
| DEG | DEGREES (SUBFIELD OF LON) |
| DAT | DATE - YYMMDD |
| DAY | DAY (SUBFIELD OF DAT) |
| MON | MONTH (SUBFIELD OF DAT) |
| TIM | TIME - HHMM |
| HOR | HOUR (SUBFIELD OF TIM) |
| MIN | MINUTES (SUBFIELD OF TIM) |
| LTD | END LATITUDE |
| LNG | END LONGITUDE |
| ELT | ELAPSED TIME |
| TZS | TIME ZONE SIGN |
| TZN | TIME ZONE NUMBER |
| SPD | SPEED MADE GOOD |
| HED | COURSE MADE GOOD |
| HGT | HEIGHT OF OBS. EYES (ABOVE SEA) |
| PLT | PLATFORM TYPE |
| SMP | SAMPLING TECHNIQUE |
| ACT | SHIP ACTIVITY |
| PHO | PHOTOS TAKEN |
| TRW | TRANSECT WIDTH |
| ANG | ANGLE OF VIEW |
| OBC | OBSERVATION CONDITIONS |
| DIS | DISTANCE MADE GOOD |

ACRONYM DEFINITIONS

| | |
|---|---|
| WTP | WATCH TYPE |
| TRN | TRANSECT WIDTH |

SPECIAL CHARACTERS

| | |
|---|---|
| - | INDICATES A CODE FIELD |
| * | INDICATES A BLANK CHARACTER IN A FIELD |
| . | INDICATES A TOTALLY BLANK FIELD |
| / | FIELD IS LISTED IN THE DIAGNOSTICS IF NON-BLANK (DATA WOULD OTHERWISE NOT FIT ON ONE LINE) |

Figure 4B

*** LOGLIST - CELISE FW7032 - CALI FILE ******** - CARD TYPE 1

| | STA | LAT | LON | DAT | TIM | LTD | LNG | ELT | TZS | TZN | SPD | HED | HGT | PLT | SMP | ACT | PHO | TRW | ANG | DBC | DIS | WTP | TRN | DIAGNOSTICS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | *7279 | 565358N | 1523630W | 770528 | 1950 | ....... | ........ | 10 | + | 09 | **9 | 36 | **8 | . | . | . | . | . | . | 6 | .... | . | *30 | * HED FIELD OUTSIDE * |
| 53 | *7379 | 565408N | 1523518W | 770528 | 2000 | ....... | ........ | 10 | + | 09 | **9 | 36 | **8 | . | . | . | . | . | . | 6 | .... | . | *30 | * HED FIELD OUTSIDE * |
| 54 | *7478 | 565537N | 1523458W | 770528 | 2010 | ....... | ........ | 10 | + | 09 | **9 | 36 | **8 | . | . | . | . | . | . | 7 | .... | . | *30 | * HED FIELD OUTSIDE * |
| 55 | *7578 | 565712N | 1523446W | 770528 | 2020 | ....... | ........ | 10 | + | 09 | **9 | 35 | **8 | . | . | . | . | . | . | 7 | .... | . | *30 | |
| 56 | *7679 | 565850N | 1523508W | 770528 | 2030 | ....... | ........ | 10 | + | 09 | **9 | 35 | **8 | . | . | . | . | . | . | 7 | .... | . | *30 | |
| 57 | *7779 | 570022N | 1523530W | 770528 | 2040 | ....... | ........ | 10 | + | 09 | **9 | 35 | **8 | . | . | . | . | . | . | 7 | .... | . | *30 | |
| 58 | *7878 | 570155N | 1523554W | 770528 | 2050 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 7 | .... | . | *30 | |
| 59 | *7978 | 570308N | 1523712W | 770528 | 2100 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 7 | .... | . | *30 | |
| 60 | *8079 | 570418N | 1523823W | 770528 | 2110 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 4 | .... | . | *30 | |
| 61 | *8178 | 570548N | 1523948W | 770528 | 2120 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 4 | .... | . | *30 | |
| 62 | *8279 | 570706N | 1524106W | 770528 | 2130 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 4 | .... | . | *30 | |
| 63 | *8378 | 570830N | 1524236W | 770528 | 2140 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 4 | .... | . | *30 | |
| 64 | *8479 | 571000N | 1524044W | 770528 | 2150 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 65 | *8578 | 571116N | 1524524W | 770528 | 2200 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 66 | *8678 | 571242N | 1524649W | 770528 | 2210 | ....... | ........ | 10 | + | 09 | **9 | 33 | **8 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 67 | *8777 | 571707N | 1525048W | 770529 | 0400 | ....... | ........ | 20 | + | 09 | **0 | .. | **4 | . | . | . | . | . | . | 7 | .... | . | *60 | |
| 68 | *8873 | 571448N | 1525027W | 770529 | 1737 | ....... | ........ | 10 | + | 09 | *10 | 18 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 69 | *8973 | 571310N | 1525025W | 770529 | 1747 | ....... | ........ | 10 | + | 09 | *10 | 18 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 70 | *9073 | 571124N | 1525028W | 770529 | 1757 | ....... | ........ | 10 | + | 09 | *10 | 18 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 71 | *9179 | 570942N | 1525030W | 770529 | 1807 | ....... | ........ | 10 | + | 09 | *10 | 19 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 72 | *9278 | 570757N | 1525100W | 770529 | 1817 | ....... | ........ | 10 | + | 09 | *10 | 19 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 73 | *9378 | 570612N | 1525200W | 770529 | 1827 | ....... | ........ | 10 | + | 09 | *10 | 19 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 74 | *9479 | 570315N | 1525250W | 770529 | 1837 | ....... | ........ | 10 | + | 09 | *10 | 19 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 75 | *9578 | 570255N | 1525326W | 770529 | 1847 | ....... | ........ | 10 | + | 09 | *10 | 19 | ... | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 76 | *9678 | 570114N | 1525345W | 770529 | 1857 | ....... | ........ | 10 | + | 09 | *10 | 19 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |
| 77 | *9779 | 565925N | 1525345W | 770529 | 1907 | ....... | ........ | 10 | + | 09 | *10 | 18 | **4 | . | . | . | . | . | . | 5 | .... | . | *30 | |

FIGURE 5: FWS - NODC CONVERSION ROUTINES

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| CARD TYPE 1 | | | |
| File type | 1-3 | 1-3 | - |
| File ID | 4-9 | 4-9 | - |
| Station Number | 10-14 | 11-15 | - |
| Record Type | 15 | 10 | - |
| Start Latitude | 16-20 | 16-22 | Degrees, minutes and tenths convert to degrees, minutes, seconds. Add hemisphere "N". |
| Start Longitude | 21-27 | 23-30 | Degrees, minutes, tenths convert to degs, mins, secs. |
| OBS Region | 28-30 | - | No NODC counterpart. |
| Date | 31-34 | 31-36 | Add year and convert from day and month to YYMMDD. |
| Time | 35-38 | 37-40 | - |
| End Latitude | 39-43 | 41-47 | Same as Start Lat above. |
| End Longitude | 44-50 | 48-55 | Same as Start Long above. |
| Elapsed Time | 51-52 | 56-57 | - |
| Time Zone Sign | 53 | 58 | - |
| Time Zone Number | 54-55 | 59-60 | - |
| Ships Speed | 56-59 | 61-65 | Round tenths to whole knots. |
| Speed Type | 60 | - | No NODC counterpart. |
| Course Heading | 61-63 | 64-65 | Round whole degrees to tens of degrees. |
| Height of Eyes | 64-66 | 66-68 | Convert feet to meters (multiply by 0.3048, round). |
| Platform Type | 67-68 | 69 | Convert FWS to NODC code. |
| Sampling Technique | 69 | 70 | - |
| Ship Activity | 70 | 71 | convert FWS to NODC code. |
| Photos Taken | 71 | - | No NODC counterpart. |
| OBS Number | 72-73 | - | No NODC counterpart. |
| OBS Location | 74 | - | No NODC counterpart. |
| Observation Cond | - | 75 | Move from col 19 of FWS card type 2. |
| Distance | - | 76-79 | No FWS counterpart. |
| Watch Type | - | 80 | No FWS counterpart. |
| Transect Width | - | 83 | No FWS counterpart. |
| (Blanks) | 75-80 | - | - |

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| CARD TYPE 2 | | | |
| File type | 1-3 | 1-3 | - |
| File ID | 4-9 | 4-9 | - |
| Station Number | 10-14 | 11-15 | - |
| Record Type | 15 | 10 | - |
| Weather | 16-17 | 55-56 | - |
| Cloud Type | - | 57 | No FWS counterpart. |
| Cloud Amount | - | 58 | No FWS counterpart. |
| Water Color | - | 59-60 | No FWS counterpart. |
| Visibility | 18 | 61 | - |
| Observation Cond | 19 | - | Move to col 75 of NODC card type 1. |
| Wind Direction | 20-22 | 45-46 | Convert FWS degrees to NODC code (divide by 10, truncate, and add 1). |
| Wind Speed | 23-24 | 47-48 | - |
| Wave Ht/Sea State | 25-26 | 49 | Convert feet to NODC code. |
| Swell Direction | - | 50-51 | No FWS counterpart. |
| Swell Height | 27-28 | 52-54 | Convert feet to tenths of meters (multiply by 3.048 then round). |
| Sea Surface Temp | 29-32 | 23-26 | Move sign adjacent to first significant digit (remove embedded zeros or blanks). |
| XBT Temp | 33-36 | - | No NODC counterpart. |
| Wet Bulb Temp | 37-40 | 34-37 | Same as Sea Surf Temp above. |
| Dry Bulb Temp | 41-44 | 30-33 | Same as Sea Surf Temp above. |
| Relative Humidity | - | 38-39 | No FWS counterpart. |
| Barometric Pressure | 45-49 | 40-43 | Truncate left digit. |
| Barometric Trend | 50 | 44 | - |
| Bottom Depth | 51-54 | 16-19 | Convert fathoms to meters (multiply by 1.829, round). |
| Surface Salinity | 55-57 | 27-29 | - |
| Thermocline Depth | 58-60 | 20-22 | - |
| Sun Direction | - | 62 | No FWS counterpart. |
| Glare Intensity | 61 | 63 | - |
| Glare Area | 62 | 64 | - |
| Turbidity Code | 63 | - | No NODC counterpart. |

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| Light Level | - | 65-67 | No FWS counterpart. |
| Moon Phase | - | 68 | No FWS counterpart. |
| Tide Height | - | 69 | No FWS counterpart. |
| Tide Rise/Fall | - | 70 | No FWS counterpart. |
| Distance to Shore | - | 71-74 | No FWS counterpart. |
| Distance to Shelf | - | 75-77 | No FWS counterpart. |
| SECCHI Depth | - | 78-79 | No FWS counterpart. |
| Debris Code | - | 80 | No FWS counterpart. |
| (Blanks) | 64-80 | 81-83 | - |

CARD TYPE 3

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| File type | 1-3 | 1-3 | - |
| File ID | 4-9 | 4-9 | - |
| Station Number | 10-14 | 11-15 | - |
| Record Type | 15 | 10 | - |
| Ice In Transect | | | |
| Cover | 16 | 16 | - |
| Pattern | 17 | 40 | Code groups not convertible. |
| Type | 18 | 17 | - |
| Form | 19 | 18 | - |
| Relief | 20 | 19 | - |
| Thick | 21 | 20 | - |
| Melt | 22 | 21 | - |
| Ice Outside Transect | | | |
| Cover | 23 | 22 | - |
| Pattern | 24 | 41 | Code groups not convertible. |
| Type | 25 | 23 | - |
| Form | 26 | 24 | - |
| Relief | 27 | 25 | - |
| Thick | 28 | 26 | - |
| Melt | 29 | 27 | - |
| Open Water | | | |
| Type | 30 | 28 | - |
| Direction | 31 | 29 | - |
| Distance | 32 | 30 | - |
| Lead/Polyna Wd | 33 | 31 | - |
| Visible Ice | | | |
| Form | 34 | 50 | - |
| Cover | 35 | 51 | - |
| Description | - | 32 | No FWS counterpart. |
| Direction | 36 | 33 | Code groups not convertible. |
| Distance | 37 | 34 | Code groups not convertible. |

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| Ship in Lead/Polyna | | | |
| Location | 38 | 42 | - |
| Width | 39 | 43 | - |
| Distance | 40 | 44 | - |
| Miscellaneous | | | |
| Arctic Cod | 41 | 35 | Convert FWS to NODC code. |
| Excess Sediment | 42 | 36 | Code groups not convertible. |
| Ice Algae | 43 | 37 | Code groups not convertible. |
| Mammal Trace | 44 | 38 | - |
| Other Features | 45 | 39 | Code groups not convertible. |
| Ice Not Coverable | 46 | - | No NODC counterpart. |
| Time of Ice Cond | - | 45-46 | No FWS counterpart. |
| Water/Land Percent | - | 47-48 | No FWS counterpart. |
| Pond Size | - | 49 | No FWS counterpart. |
| (Blanks) | 47-80 | 52-77 | - |
| Sequence Number | - | 78-80 | No FWS counterpart. |
| (Blanks) | - | 81-83 | - |

CARD TYPE 4

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| File type | 1-3 | 1-3 | - |
| File ID | 4-9 | 4-9 | - |
| Station Number | 10-14 | 11-15 | - |
| Record Type | 15 | 10 | - |
| Text | 16-77 | 16-77 | - |
| Sequence Number | 78-80 | 78-80 | - |
| (Blanks) | - | 81-83 | - |

CARD TYPE 5

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| File type | 1-3 | 1-3 | - |
| File ID | 4-9 | 4-9 | - |
| Station Number | 10-14 | 11-15 | - |
| Record Type | 15 | 10 | - |
| Species Name | 16-19 | - | No NODC counterpart. |
| * Taxonomic Code | 20-31 | 18-29 | Blank out trailing zero doublets. |
| * Sub Species | - | - | Now part of Tax Code. |
| Species Group | 32-33 | 30-31 | - |
| No of Individuals | 34-38 | 37-41 | - |

| Field | FWS Cols | NODC Cols | Special Processing |
|---|---|---|---|
| Counting Method | - | 42 | No FWS counterpart. |
| Reliability | - | 43 | No FWS counterpart. |
| Dist Measure Type | - | 44 | No FWS counterpart. |
| Distance to Birds | - | 45-47 | No FWS counterpart. |
| Begin/Outside Zone | 39-40 | 83 | Convert to Outside Zone only when coded 97-99. |
| End Zone | 41-42 | - | No NODC counterpart. |
| Time into Transect | 43-45 | 16-27 | Round minutes and tenths to whole minutes. |
| Behavior | 46-47 | 56-57 | - |
| Flight Direction | 48-49 | 48-49 | Convert from clock position relative to ship to compass direction in tens of degrees (multiply by 30, add rounded heading from card type 1). |
| Age | 50 | 32 | - |
| Sex | 51 | 33 | - |
| Color | 52 | 34 | - |
| Plumage | 53 | 35 | - |
| Molt | 54 | 36 | - |
| Association Type | 55-56 | 50 | Convert FWS to NODC code. |
| Multi-Species Link | 57-59 | 51-53 | - |
| No of Species | 60-61 | 54-55 | - |
| Special Marks | 62 | 58 | - |
| Bird Condition | 63 | 59 | - |
| Food Source | - | 60 | No FWS counterpart. |
| * Tax Code for Food | 64-73 | 61-70 | - |
| Debris | 74 | 71 | - |
| Oil | - | 72 | No FWS counterpart. |
| Dist from Breed Colony | - | 73-75 | No FWS counterpart. |
| Habitat | - | 76-77 | No FWS counterpart. |
| OBS Observer No | 75-76 | - | No NODC counterpart. |
| Text Flag Code | 77 | - | No NODC counterpart. |
| Sequence Number | 78-80 | 78-80 | - |
| Substrata | - | 81 | No FWS counterpart. |
| Cover | - | 82 | No FWS counterpart. |

The following fields will have Leading Zeros
or Leading Blanks inserted as necessary.

| Leading Zeros | Leading Blanks |
|---|---|
| Station Number | Ships Speed |
| Start Latitude | Height of Eyes |
| Start Longitude | Wind Speed |
| End Latitude | Sea Surface Temp |
| End Longitude | Wet Bulb Temp |
| Date and Time | Dry Bulb Temp |
| Course Heading | Bottom Depth |
| Multi-Species Link | No of Individuals |
| Flight Direction | |
| Sequence Number | |

NOTE: An * denotes a change to this entry since the previous report.

FIGURE 6: NODC TRANSFORMATION ROUTINES

| | Field | Card:Cols | Processing |
|---|---|---|---|
| | Sea Surface Temp | 2:23-26 | Move sign adjacent to first significant digit (remove embedded zeros or blanks). |
| | Dry Bulb Temperature | 2:30-33 | Same as Sea Surf Temp above. |
| | Wet Bulb Temperature | 2:34-37 | Same as Sea Surf Temp above. |
| | Flight Direction | 5:48-49 | Compass reading of 36 replaced by 00 degrees. |
| * | Taxonomic Code | 5:18-29 | Blank out trailing zero doublets. |
| * | Tax Code for Food | 5:61-70 | No special routine. |

The following fields will have Leading Zeros or Leading Blanks inserted as necessary.

| Leading Zeros | Leading Blanks |
|---|---|
| Station Number | Ships Speed |
| Start Latitude | Height of Eyes |
| Start Longitude | Wind Speed |
| End Latitude | Sea Surface Temp |
| End Longitude | Wet Bulb Temp |
| Date and Time | Dry Bulb Temp |
| Course Heading | Bottom Depth |
| Multi-Species Link | No of Individuals |
| Flight Direction | Transect Width |
| Sequence Number | |

NOTE: An * denotes a change to this entry since the previous report.

*** FIELD OPERATION STATUS REPORT ***

AS OF 09/30/78

THE MARMAP INFORMATION SYSTEM          OCSEAP - GULF OF ALASKA PROJECT

COLUMN HEADING DEFINITIONS:

| | |
|---|---|
| TAPE NUMBER - | IDENTIFYING NUMBER ASSIGNED TO THE TAPE AS IT IS RECEIVED BY RU 527. |
| RESEARCH UNIT - | RESEARCH UNIT NUMBER OF THE PRINCIPAL INVESTIGATOR. |
| DATE RECEIVED - | DATE THE TAPE WAS RECEIVED BY RU 527. |
| FILE FORMAT - | FORMAT IN WHICH THE DATA ON THE TAPE HAVE BEEN CODED. |
| FIELD OPER. - | NAME ASSIGNED TO THE FIELD OPERATION BY THE PRINCIPAL INVESTIGATOR. "FW" FIELD OPS. FROM DR. CALVIN LENSINK; "UCI" FIELD OPS. FROM DR. GEORGE HUNT; "W" FIELD OPS. FROM DR. JOHN WIENS; "UC" FIELD OPS. FROM DR. JUAN GUZMAN. |
| CODEPULL MAILED - | DATE THE OUTPUT FROM THE QUALITY CONTROL PROGRAM "CODEPULL" WAS MAILED TO THE PRINCIPAL INVESTIGATOR FOR CORRECTIONS. |
| LOGLIST MAILED - | DATE THE OUTPUT FROM THE QUALITY CONTROL PROGRAM "LOGLIST" WAS MAILED TO THE PRINCIPAL INVESTIGATOR FOR CORRECTIONS. |
| CODEPULL RETURNED - | DATE THE CORRECTED OUTPUT FROM "CODEPULL" WAS RECEIVED BY RU 527. |
| LOGLIST RETURNED - | DATE THE CORRECTED OUTPUT FROM "LOGLIST" WAS RECEIVED BY RU 527. |
| EDITLOG COMPLETE - | DATE THE CORRECTIONS WERE MADE TO THE FIELD OP. AT RU 527, THROUGH THE USE OF AN INTERACTIVE PROGRAM "EDITLOG". |
| FINAL CHECK - | DATE THE FIELD OP. WAS READY FOR CONVERSION OR TRANSFORMATION. OCCASIONALLY ADDITIONAL PROBLEMS ARISE WHEN "CODEPULL" AND "LOGLIST" ARE RERUN AFTER EDITING. IF THESE CANNOT BE RESOLVED OVER THE TELEPHONE THE LISTINGS ARE SENT BACK TO THE PI FOR FURTHER CORRECTIONS. THIS FIELD IS NOT FILLED IN UNTIL ALL CORRECTIONS HAVE BEEN MADE. |
| CONVERT TO NODC - | DATE THE FIELD OP. WAS CONVERTED FROM FWS FORMAT TO NODC FORMAT. AN "NA" (NOT APPLICABLE) IS ENTERED HERE FOR FIELD OPS. RECEIVED IN NODC FORMAT. |
| MAIL TO NODC - | DATE THE FIELD OP. IN FINAL FORM WAS SUBMITTED TO NODC. |
| ENDNOTES - | REFERENCE NUMBER TO ADDITIONAL COMMENTS FOLLOWING THE TABLE. |

*** FIELD OPERATION STATUS REPORT ***

AS OF 09/30/78

THE MARMAP INFORMATION SYSTEM          OCSEAP - GULF OF ALASKA PROJECT

| TAPE NUMBER | RESEARCH UNIT | DATE RECEIVED | FILE FORMAT | FIELD OPER. | CODEPULL MAILED | LOGLIST MAILED | CODEPULL RETURNED | LOGLIST RETURNED | EDITLOG COMPLETE | FINAL CHECK | CONVERT TO NODC | MAIL TO NODC | END NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALASKA1 | 337 | 03/12/77 | FWS | FW5004 | 07/12/77 | 08/16/77 | 08/29/77 | 10/06/77 | 02/15/78 | 02/15/78 | | | 1A |
| ALASKA2 | 337 | 03/12/77 | FWS | FW5009 | 07/12/77 | 08/16/77 | 10/06/77 | 10/06/77 | 01/26/78 | 01/30/78 | 09/25/78 | 09/1[illegible]/78 | 1A,8 |
| | | | | FW5013 | 07/12/77 | 08/16/77 | 08/29/77 | 10/06/77 | 01/24/78 | 01/26/78 | | | 1A |
| | | | | FW5018 | 07/12/77 | 08/16/77 | 08/29/77 | 10/06/77 | 01/30/78 | 02/01/78 | | | 1A |
| | | | | FW5023 | 07/12/77 | 08/16/77 | 08/29/77 | 10/06/77 | 02/06/78 | 02/14/78 | | | 1A |
| | | | | FW5024 | 07/12/77 | 08/16/77 | 08/29/77 | 10/06/77 | 02/14/78 | 02/15/78 | | | 1A |
| | | | | FW5030 | 07/12/77 | 08/16/77 | 08/29/77 | 10/06/77 | 12/01/77 | 12/05/77 | 08/30/78 | 09/15/78 | 3,[illegible] |
| | | | | FW5032 | 07/12/77 | 08/16/77 | 08/29/77 | 10/06/77 | 12/01/77 | 12/05/77 | 08/30/78 | 09/13/78 | 6,8 |
| ALASKA3 | 337 | 05/27/77 | FWS | FW5008 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 12/09/77 | 12/09/77 | 09/[illegible]7/78 | 09/13/78 | 3 |
| | | | | FW5016 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 07/25/78 | 07/25/78 | | | 1A |
| | | | | FW5021 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 07/26/78 | 07/2[illegible]/78 | | | 1B |
| | | | | FW5026 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 01/31/78 | 02/01/78 | | | |
| | | | | FW5027 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 02/03/78 | 02/06/78 | 09/08/78 | 09/14/78 | 3 |
| | | | | FW5033 | 07/14/77 | 08/16/77 | 09/06/77 | 09/05/77 | 07/28/78 | 07/31/78 | | | 1B |
| | | | | FW5035 | 07/14/77 | 08/16/77 | 09/06/77 | 09/05/77 | 01/30/78 | 02/01/78 | | | |
| | | | | FW6008 | 12/12/77 | 12/12/77 | 01/10/78 | 01/10/78 | 08/02/78 | 08/08/78 | | | 1B |
| | | | | FW6027 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 03/20/78 | | | | 1C |
| | | | | FW6050 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 03/22/78 | | | | 1C |
| | | | | FW6051 | 07/14/77 | 08/16/77 | 09/06/77 | 09/05/77 | 03/28/78 | | | | 1C |
| | | | | FW6074 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 08/08/78 | 08/08/78 | | | 1B |
| | | | | FW6083 | 07/14/77 | 08/16/77 | 09/06/77 | 09/06/77 | 07/21/78 | 07/24/78 | | | 1B |
| ALASKA4 | 337 | 06/24/77 | FWS | FW5011 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 03/20/78 | | | | 1C |
| | | | | FW5012 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/05/78 | | | | 1C |
| | | | | FW5020 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/05/78 | | | | 1C |
| | | | | FW5031 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/05/78 | | | | 1C |
| | | | | FW5034 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/17/78 | 04/19/78 | | | |
| | | | | FW6015 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/05/78 | 04/18/78 | 09/06/78 | 09/18/78 | 8 |
| | | | | FW6018 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/12/78 | | | | 1C |
| | | | | FW6019 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/18/78 | | | | 1C |
| | | | | FW6067 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/12/78 | | | | 1C |
| | | | | FW6068 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 04/12/78 | | | | 1C |
| | | | | FW6088 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 04/17/78 | | | | 1C |
| | | | | FW6089 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 07/21/78 | 07/24/78 | | | 1B |
| | | | | FW6094 | 08/16/77 | 08/16/77 | 11/01/77 | 11/01/77 | 03/01/78 | | | | 1C |
| ALASKA5 | 337 | 07/01/77 | FWS | FW5015 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 08/08/78 | 08/09/78 | | | 1B |

*** FIELD OPERATION STATUS REPORT ***

AS OF 09/30/78

THE MARMAP INFORMATION SYSTEM          OCSEAP - GULF OF ALASKA PROJECT

| TAPE NUMBER | RESEARCH UNIT | DATE RECEIVED | FILE FORMAT | FIELD OPPR. | CODEPULL MAILED | LOGLIST MAILED | CODEPULL RETURNED | LOGLIST RETURNED | EDITLOG COMPLETE | FINAL CHECK | CONVERT TO NODC | MAIL TO NODC | FLD NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALASKA5 | 337 | 07/01/77 | FWS | FW5025 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 07/24/78 | 07/26/78 | | | 1E |
| | | | | FW6001 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 04/20/78 | 04/25/78 | 09/30/78 | 09/18/78 | 3 |
| | | | | FW6002 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 07/24/78 | 07/26/78 | | | 1E |
| | | | | FW6007 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 07/24/78 | 07/27/78 | | | 1E |
| | | | | FW6009 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 08/03/78 | 08/08/78 | | | 1E |
| | | | | FW6021 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 07/25/78 | 07/26/78 | | | 1E |
| | | | | FW6026 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 04/26/78 | 04/28/78 | | | |
| | | | | FW6029 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 04/26/78 | 05/08/78 | | | |
| | | | | FW6057 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 08/04/78 | 08/07/78 | | | 1E |
| | | | | FW6064 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 07/21/78 | 07/27/78 | | | 1B |
| | | | | FW6066 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 02/22/78 | 02/24/78 | | | |
| | | | | FW6070 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 08/03/78 | 08/07/78 | | | 1E |
| | | | | FW6095 | 09/29/77 | 09/29/77 | 10/20/77 | 10/20/77 | 08/08/78 | 08/09/78 | | | 1E |
| ALASKA6 | 337 | 07/07/77 | FWS | FW5014 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 02/17/78 | 02/22/78 | 09/05/78 | 09/18/78 | 3 |
| | | | | FW5022 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | | | | 1F |
| | | | | FW5029 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | | | | 1F |
| | | | | FW5036 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | 06/07/78 | | | |
| | | | | FW5037 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | 06/07/78 | | | |
| | | | | FW6004 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | | | | 1F |
| | | | | FW6005 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | | | | 1F |
| | | | | FW6010 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | | | | 1F |
| | | | | FW6011 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/05/78 | | | | 1F |
| | | | | FW6012 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW6016 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW6028 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | 06/08/78 | | | |
| | | | | FW6052 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW6077 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW6078 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW6084 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW6085 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW6092 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/07/78 | | | | 1F |
| | | | | FW7026 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/16/78 | | | | 1F |
| | | | | FW7027 | 10/21/77 | 10/21/77 | 11/14/77 | 11/14/77 | 06/26/78 | 06/27/78 | | | |
| ALASKA7 | 083 | 07/07/77 | FWS | UCI501 | 10/07/77 | 10/07/77 | | | | | | | 7 |
| | | | | UCI601 | 10/07/77 | 10/07/77 | 05/26/78 | 05/26/78 | 08/25/78 | 08/25/78 | 08/28/78 | | 1G |
| ALASKA8 | 337 | 07/28/77 | FWS | FW5038 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 06/16/78 | | | | 1F |
| | | | | FW6013 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 06/16/78 | | | | 1F |
| | | | | FW6025 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 06/15/78 | 06/19/78 | | | |

*** FIELD OPERATION STATUS REPORT ***

AS OF 09/30/78

THE MARMAP INFORMATION SYSTEM          OCSEAP - GULF OF ALASKA PROJECT

| TAPE NUMBER | RESEARCH UNIT | DATE RECEIVED | FILE FORMAT | FIELD OPER. | CODEPULL MAILED | LOGLIST MAILED | CODEPULL RETURNED | LOGLIST RETURNED | EDITLOG COMPLETE | FINAL CHECK | CONVERT TO NODC | MAIL TO NODC | END NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALASKA8 | 337 | 07/28/77 | FWS | FW6082 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 05/16/78 | | | | 1F |
| | | | | FW6087 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 05/16/78 | | | | 1F |
| ALASKA9 | 337 | 08/03/77 | FWS | FW5003 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 07/12/78 | | | | 2,1B |
| | | | | FW5006 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 07/12/78 | | | | 2,1B |
| | | | | FW5010 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 07/14/78 | | | | 2,1B |
| | | | | FW6006 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 07/12/78 | | | | 2,1B |
| | | | | FW6014 | 10/28/77 | 10/28/77 | 11/30/77 | 11/30/77 | 07/12/78 | | | | 2,1B |
| ALASKA10 | 337 | 09/06/77 | NODC | FW7032 | 10/07/77 | 10/07/77 | 11/03/77 | 11/03/77 | 11/22/77 | 11/30/77 | /NA/ | 12/12/77 | |
| | | | | FW7033 | 10/07/77 | 10/07/77 | 11/03/77 | 11/03/77 | 11/22/77 | 11/30/77 | /NA/ | 12/12/77 | |
| ALASKA11 | 337 | 11/16/77 | NODC | FW7034 | 11/30/77 | 11/30/77 | 01/04/78 | 01/04/78 | 01/09/78 | 01/10/78 | /NA/ | 02/28/78 | |
| | | | | FW7035 | 11/30/77 | 11/30/77 | 01/04/78 | 01/04/78 | 01/06/78 | 01/17/78 | /NA/ | 02/28/78 | |
| | | | | FW7042 | 11/30/77 | 11/30/77 | 01/04/78 | 01/04/78 | 01/09/78 | 01/16/78 | /NA/ | 02/28/78 | |
| | | | | FW7046 | 11/30/77 | 11/30/77 | 01/04/78 | 01/04/78 | 01/09/78 | 01/16/78 | /NA/ | 02/28/78 | |
| ALASKA12 | 337 | 01/10/78 | NODC | FW7028 | 01/18/78 | 01/18/78 | 01/30/78 | 01/30/78 | 01/31/78 | 02/01/78 | /NA/ | 02/28/78 | |
| | | | | FW7031 | 01/18/78 | 01/18/78 | 01/30/78 | 01/30/78 | 02/01/78 | 02/02/78 | /NA/ | 02/28/78 | |
| | | | | FW7036 | 01/18/78 | 01/18/78 | 01/30/78 | 01/30/78 | 01/31/78 | 02/01/78 | /NA/ | 02/28/78 | |
| | | | | FW7045 | 01/18/78 | 01/18/78 | 01/30/78 | 01/30/78 | 02/01/78 | 02/01/78 | /NA/ | 02/28/78 | |
| ALASKA13 | 337 | 01/10/78 | FWS | FW6086 | 01/18/78 | 01/18/78 | 01/30/78 | 01/30/78 | 07/26/78 | 07/26/78 | | | 1P |
| | | | | FW6186 | 01/18/78 | 01/18/78 | 01/30/78 | 01/30/78 | 02/17/78 | 02/17/78 | | | 5 |
| ALASKA14 | 083 | 04/10/78 | NODC | UCI602 | 04/14/78 | 04/14/78 | 04/25/78 | 04/25/78 | 06/02/78 | 06/06/78 | /NA/ | | |
| ALASKA15 | 083 | 06/13/78 | NODC | UCI501 | 07/07/78 | 07/07/78 | 07/27/78 | 07/27/78 | 08/25/78 | 08/28/78 | /NA/ | | |
| | | | | UCI701 | 07/07/78 | 07/07/78 | 07/27/78 | 07/27/78 | 09/05/78 | 09/05/78 | /NA/ | | |
| | | | | UCI702 | 07/07/78 | 07/07/78 | 07/27/78 | 07/27/78 | 09/05/78 | 09/05/78 | /NA/ | | |
| | | | | UCI703 | 07/07/78 | 07/07/78 | 07/27/78 | 07/27/78 | 08/25/78 | 08/28/78 | /NA/ | | |
| | | | | UCI704 | 07/07/78 | 07/07/78 | 07/27/78 | 07/27/78 | 08/25/78 | 08/28/78 | /NA/ | | |
| ALASKA16 | 337 | 09/05/78 | NODC | FW6093 | 09/08/78 | 09/08/78 | 09/18/78 | 09/18/78 | | | | | |
| | | | | FW7029 | 09/08/78 | 09/08/78 | 09/18/78 | 09/18/78 | | | | | |

*** FIELD OPERATION STATUS REPORT ***

AS OF 09/30/78

THE MARMAP INFORMATION SYSTEM          OCSEAP - GULF OF ALASKA PROJECT

| TAPE NUMBER | RESEARCH UNIT | DATE RECEIVED | FILE FORMAT | FIELD OPER. | CODEPULL MAILED | LOGLIST MAILED | CODEPULL RETURNED | LOGLIST RETURNED | EDITLOG COMPLETE | FINAL CHECK | CONVERT TO NODC | MAIL TO NODC | END NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OREGON1 | 108 | 05/25/77 | NODC | W05220 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/05/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| | | | | W05221 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/05/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| | | | | W05310 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/08/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| | | | | W05311 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/09/78 | 05/17/78 | /NA/ | 05/24/78 | |
| | | | | W05325 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/10/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| | | | | W06211 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/10/78 | 05/17/78 | /NA/ | 05/24/78 | 3A |
| | | | | W06221 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/12/78 | 05/17/78 | /NA/ | 05/24/78 | 3A,3B |
| | | | | W16140 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/12/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| | | | | W16150 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/02/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| | | | | W16161 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/12/78 | 05/17/78 | /NA/ | 05/24/78 | 3A,3D |
| | | | | W26140 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/05/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| | | | | W36070 | 10/26/77 | 10/26/77 | 01/03/78 | 01/03/78 | 05/04/78 | 05/17/78 | /NA/ | 05/24/78 | 3B |
| CANADA1 | 239 | 03/30/78 | NODC | 01UC75 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 05/11/78 | 05/15/78 | /NA/ | 06/12/78 | 4 |
| | | | | 02UC75 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 05/12/78 | 05/15/78 | /NA/ | 06/12/78 | 4 |
| | | | | 03UC75 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 05/15/78 | 05/16/78 | /NA/ | 06/12/78 | 4 |
| | | | | 01UC76 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 06/09/78 | 06/09/78 | /NA/ | 06/12/78 | 4,1D |
| | | | | 02UC76 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 06/09/78 | 06/09/78 | /NA/ | 06/12/78 | 4,1D |
| | | | | 03UC76 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 05/15/78 | 05/16/78 | /NA/ | 06/12/78 | 4 |
| | | | | 04UC76 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 06/09/78 | 06/09/78 | /NA/ | 06/12/78 | 4,1D |
| | | | | 05UC76 | 04/17/78 | 04/17/78 | 05/08/78 | 05/08/78 | 06/09/78 | 06/09/78 | /NA/ | 06/12/78 | 4,1D |
| CALIF 1 | 196 | 07/18/78 | NODC | 1SR377 | 08/31/78 | 08/31/78 | | | | | | | |
| | | | | 1SR477 | 08/31/78 | 08/31/78 | | | | | | | |
| | | | | 1DI577 | 08/31/78 | 08/31/78 | | | | | | | |

### *** FIELD OPERATION STATUS REPORT ***

AS OF 09/30/78

THE MARMAP INFORMATION SYSTEM          OCSEAP - GULF OF ALASKA PROJECT

ENDNOTES:

1. A. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (12/12/77), RETURNED TO RU 527 (01/10/78).
   B. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (03/16/78), RETURNED TO RU 527 (06/26/78).
   C. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (04/26/78), RETURNED TO RU 527 (07/05/78).
   D. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (05/18/78), RETURNED TO RU 527 (06/05/78).
   E. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (06/06/78), RETURNED TO RU 527 (06/26/78).
   F. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (06/27/78), RETURNED TO RU 527 (07/13/78).
   G. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (07/07/78), RETURNED TO RU 527 (07/27/78).
   H. LOGLIST AND CODEPULL SENT BACK TO PI FOR ADDITIONAL CORRECTIONS (07/21/78), RETURNED TO RU 527 (07/28/78).
2. TAPE WAS UNREADABLE, SENT BACK TO PI TO BE RE-GENERATED (03/31/77), RETURNED TO RU 527 (10/21/77).
3. A. UNAUTHORIZED LIGHT LEVEL AND WEATHER CODES USED BY PI, THESE WILL NOT BE INCLUDED IN SUBMISSION TO NODC.
   B. UNAUTHORIZED DISTANCE TO BIRDS ENTRY REPLACED BY OUTSIDE ZONE CODE FOR SUBMISSION TO NODC.
4. TAPE RETURNED TO PI BECAUSE SEVEN OF THE EIGHT EXPECTED FIELD OPS. COULD NOT BE FOUND (01/03/78). NEW TAPE WITH EIGHT FIELD OPS. RECEIVED (03/30/78).
5. FIELD OP. FW6186 IS A CONTINUATION OF FIELD OP. FW6086 BECAUSE FW6086 NEEDED MORE THAN 999 STATIONS.
6. ONE OF FIRST FIELD OPS. CONVERTED (02/28/78). FWS AND NODC FORMATS SENT TO PI FOR REVIEW. RETURNED TO RU527 FOR REVISIONS TO CONVERSION (07/07/78).
7. DATA FOR THIS FIELD OP. RECODED BY ORIGINATOR IN NODC FORMAT AND RECEIVED ON TAPE ALASKA 15.
8. ADDITIONAL PROGRAM WAS REQUIRED TO CORRECT TRANSECT TYPE AND WIDTH FOR RU337.

*** FIELD OPERATION STATUS REPORT ***

AS OF 09/30/78

THE MASMAP INFORMATION SYSTEM OCSEAP - GULF OF ALASKA PROJECT

SUMMARY:

| | |
|---|---|
| TOTAL FIELD OPS. RECEIVED BY RU 527 | 123 |
| CODEPULLS MAILED TO INVESTIGATOR | 123 |
| LOGLISTS MAILED TO INVESTIGATOR | 123 |
| CODEPULLS RETURNED TO RU 527 | 113 |
| LOGLISTS RETURNED TO RU 527 | 119 |
| TOTAL FIELD OPS. BEING EDITED AT RU 527 | 39 |
| FIELD OPS. WHICH PASSED FINAL CHECK | 80 |
| FIELD OPS. CONVERTED TO NODC | 9 |
| FIELD OPS. MAILED TO NODC | 38 |

QUARTERLY REPORT
September 30, 1978

Research Unit no.: 563

Contract no.: 03-78-B01-53

Project no.: RK 0000-R7120815

Archival of Voucher Specimens of Biological Materials Collected under the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Support

Period of Performance: May 1, 1978 - April 30, 1979
Subsequent support subject to availability of funding.

Period Covered by This Report: May 1, 1978 - Sept. 30, 1978.


Insitution: California Academy of Sciences
Golden Gate Park
San Francisco, California 94118

Principal Investigator: William N. Eschmeyer
Director of Research
(415) 221-5100


Authorized Signatures:

William N. Eschmeyer
William N. Eschmeyer
Principal Investigator

George E. Lindsay
George E. Lindsay
Director

## Archival of Voucher Specimens of Biological Materials Collected Under OCSEAP Support

Resume: The extensive biological collections made in conjunction with the Alaskan OCS environmental studies program are presently being maintained by those principal investigators responsible for field collection, identification and analysis of the samples. OCSEAP has established a central repository, the California Academy of Sciences, for preserved specimens from these collections to ensure that materials are permanently available for reference and confirmation of identifications made previously.

The California Academy of Sciences will be responsible for:

1. Specifying preservation techniques for archival voucher specimens;

2. Coordinating the shipment of material from principal investigators;

3. Establishing and maintaining a fully cataloged repository for the collections; and

4. Providing quarterly data summaries on the status and content of the collections.

### Progress Made During the Period May 1, 1978 - Sept. 30, 1978

This contract was issued on May 24, with a starting date of May 1, 1978. The following occurred during the period covered by this report.

### Personnel

William N. Eschmeyer, principal investigator, and Dustin A. Chivers, invertebrate specimen coordinator, began receiving salary on June 1, 1978.

Susan Gray Marelli, Curatorial Assistant, started on 1 August, took a leave of absence from Aug. 7-Aug. 21, and resumed work on Aug. 21.

### Voucher Specimen Policy

The first objective of the project was preparation of the final voucher specimen policy. The first draft was submitted to the Project Office on August 4th and the final revised draft on September 14th, after review by the Project Office. This document appears as Appendix Item 1. It specifies the policy, its application, preservation procedures, labeling instructions, and information on shipment of specimens to the repository.

Pending final approval by the Project Office, the specimen repository will print voucher specimen labels to be completed by field project personnel. These labels are prepared on special paper and serve as the initial label accompanying the voucher specimens to the specimen repository and remain with the specimens permanently (See Appendix Item 2 for sample). The format and instructions for completing the label are discussed on p. 3 of Appendix item 1. These labels will be printed and distributed as soon as final approval is received from the Project Office.

## Shipment of Specimens

The specimen repository has suggested that the easiest way to coordinate shipment of specimens from principal investigators to the specimen repository is for the repository to deal directly with investigators, providing them with shipping containers and instructions for packing and shipment. Final approval for this approach is pending.

## Cataloging Procedures

From labels received with voucher specimens and from textual information (station lists, etc.) supplied by project principal investigators, the repository will prepare a voucher specimen lot record (Appendix Item 3) which will be completed by the repository for each voucher lot. This form will be used as a cross check against EDP data, and from this lot record will be generated the final specimen bottle label for each lot. It was determined that use of this form will serve as a back up for EDP data, will be useful internally for preparation of labels, capture of EDP data, and serve as a method of recording subsequent identifications of the specimens, publications on the specimens, etc. The categories to be used on the form have been established and final printing of these forms will be completed after comments are received from the Project Office.

The specimen repository also has proposed the overprinting of existing bottle labels with the words "OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM."

## Data Management

It was determined that all data management could be electronically processed on a word processor with sorting capabilities. An IMB System 6 unit was ordered in May 1978 for delivery Sept. 29th. The equipment was received on Sept. 20th and operational on Sept. 26th. It is expected that project personnel will complete training on this equipment by October 10th.

Digital data in specified formats will document the holdings of the voucher repository. These data will be submitted to the Project Data Manager on a quarterly basis. The data to be submitted will be part of the entries contained on the voucher specimen lot record, but the exact data to be submitted and the method of formatting awaits consultation with the Project Office.

### Purchase of Supplies

The technical assistant ordered sufficient supplies to begin the project, including curatorial supplies, glassware, lid liners, etc.

### Preparation of Project Workroom

As discussed in the initial application, one room will be set aside for processing OCSEAP materials. Shelving from other funds was erected in July. Addition of a sink and preparation counters is expected to be completed in October.

### Other

The Project Contract Monitor, Francesca Cava, visited the principal investigator and examined the site on July 14, 1978. She and the principal investigator discussed the operation of the contract and other items at that time.

## Objectives for the Next Quarter

1. Print final Voucher Specimen Policy Statement and distribute to principal investigators.

2. Print and distribute voucher specimen labels.

3. Complete purchase of supplies and equipment.

4. Establish with the Project Office and the NOAA Data Center the data management plan, including data products and format.

5. Contact principal investigators and supply them with packing and shipping instructions and provide shipping containers as needed.

6. Begin receiving and processing specimens.

7. Curate specimens, catalog specimens, and capture EDP information.

APPENDIX ITEM 1

REVISED DRAFT
14 Sept. 1978

Outer Continental Shelf Environmental Assessment Program
Voucher Specimen Policy

The voucher specimen system established for OCSEAP projects is intended to develop a reference collection of preserved specimens that can serve as documentation of identifications made by project personnel engaged in OCSEAP projects. The bulk of the material collected and studied has to be discarded, and voucher specimens are to be set aside both to aid in the identification process and to verify as best as possible the identification of material that must be discarded. It is an important phase of the project since data recorded for specimens that can not ever be identified or were misidentified have little or no value. The important point is that the voucher specimen be of the same species as the specimens studied and discarded. The name used for the category is less important; if the species can not be identified during the project it may be subsequently identified by specialists.

The taxonomic literature for many areas being sampled is poor, and it is likely that many identifications will be incomplete (e.g., Sebastes sp.1, Sebastes sp. 2).

Voucher specimens are to be established and preserved as outlined below and are to be deposited in the designated specimen repository where they will be permanently available for reference and for confirmation of prior identifications of materials collected by OCSEAP projects.

Application

Voucher specimens are required for all instances where a named category or taxon (phylum through species) is assigned to biological materials identified by personnel working on OCSEAP-sponsored projects (except for birds and mammals as noted on p. 10).

When in doubt, principal investigators are advised to reserve voucher materials. Large projects with activities that are complex or widely separated in time (e.g. different cruises) may have many sets of voucher specimens. This means that a new series of samples should be reserved whenever there are changes in the identification procedure, such as through changes in personnel making identifications, or separate field trips isolated by 6 months, or separate cruises. For example, as species are identified on a cruise, a representative sample of that category is set aside and hopefully all subsequent identifications of that category will be compared with the voucher specimen(s). The identifier is saying "I have identified other material as this species (or taxon), and I believe them all to be the same, and this is the specimen(s) that represent(s) the species so identified."

Voucher Specimen Repository:

Address: California Academy of Sciences
Golden Gate Park
San Francisco, California 94118

Phone: (415) 221-5100 (415) 221-4214

Contact: William N. Eschmeyer, principal investigator
or
Dustin Chivers or Welton Lee (Invertebrates)
Tomio Iwamoto (Fishes)
Sylvia Earle (Algae)
Dennis Breedlove (Higher Plants)

Procedure:

Voucher specimens should be preserved as outlined in the subsection on preservation.

Voucher specimens should be preserved and labeled under the following conditions:

1. One or more specimens should be preserved for each taxon that is identified by the person assigned to making scientific identifications on the project or particular subproject, such as a specific cruise. For large dominant species only one specimen may be sufficient, but for many species, especially small invertebrates, a series of specimens is necessary.

2. Normally a voucher specimen(s) will represent a species. Only one designated taxonomic category (species, genus, etc.) should be included in the unit of voucher materials covered by one voucher specimen label. More than one stage or sex may be included but only when the sexes or stages are taken in the same collection. If a taxon higher than species is the subject of voucher specimens, more than one species/stage may be included only where all materials are from the same collection. If materials are from separate collections in space/time or made with different types of gear, voucher materials should be separated.

3. Although it is desirable that specimens reserved as vouchers be in good condition, it is also desirable that they represent the general condition of the materials when they are

identified. Furthermore, it is not the intent of OCSEAP voucher policy that voucher materials be used for reference levels of contaminants, although the identification of the biota involved in contamination studies should be documented with voucher specimens.

Contractors are welcome to reserve materials from OCSEAP collections; however, these materials should be separate from voucher materials, and treatment of such reference materials is at the option of the institutions reserving them. Some of the areas, depths, and organisms have been rarely sampled and the e scientific community can benefit through the saving of additional material. Non-voucher specimens that are felt to be important scientific specimens but not part of the voucher series may be deposited in the California Academy of Sciences or the Academy can suggest to the principal investigator other repositories that would be interested in this non-voucher material.

Labeling:

Principal investigators will be supplied voucher specimen labels on special paper that can be written on in pencil or ink (use only India ink) or by typewriter (use only carbon ribbon). The label is as follows:

VOUCHER SPECIMEN LABEL
OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM

| | |
|---|---|
| Ident. | No. spec. |
| NODC No. (ed.) | |
| Ident. by | Date ident. |
| Coll. | Sta. (field) no. |
| Date coll. | Proj. RU no. |
| Host | |
| Locality | |
| | Depth |
| Substrate | Time |
| Method capt. | Fixative |

Ident.: That identification made by the person responsible for scientific identifications.

No. spec.: Number of specimens in the voucher lot.

NODC code: Give the 10-digit number and the code edition. (Copies of the NODC code are available from the project office.)

Ident. by: Person making the identification.

Date ident.: Give day, month, year. Write out the month (e.g., 5 Aug. 1978).

Coll. The collector if a person, name of vessel for cruises.

Date Coll.: Date collected; give day, month, year. Write out month (e.g., 5 Aug. 1978).

Proj. RU no.: RU number of OCSEAP Research Unit.

Host: For stomach contents, parasites, etc., give the scientific name of the prey species or host.

Locality: Location where the material was collected, including latitude and longitude, supplemented where possible by information giving the general location of the site relative to landmarks on standard atlases of the region.

Depth: Depth (or altitude) of capture. Units (m, fm, or ft.) should be specified. For midwater trawls give both the capture depth and bottom depth (e.g., 450 m over 5,000 m).

Substrate: Bottom type, soil, or support or attachment site.

Time: Local time (e.g. 1300-1330 hrs) when collection was made.

Method capt.: The method of capture (e.g., 40-ft. shrimp trawl).

Fixative: The initial field preserving fluid (e.g., 10% formalin).

Note (1): If lists of stations, copies of pertinent station records, or other data can be supplied to the specimen repository that clearly will suffice for the place of capture, and other information below the line on the voucher specimen label, then these categories may be left blank on the voucher specimen label, and they will be completed by the specimen repository.

Note (2): All bottle labels should be placed inside the bottle. Do not record information on lids, etc. Keep all labels that accumulate with a voucher specimen in the bottle and send all to the specimen repository. For example, if a station label and a separate identification label were placed with a specimen, keep these with the specimen as a check when the final voucher label is prepared, and as a check for the specimen repository when they prepare the final bottle label.

Note (3): The voucher specimen labels may be folded or rolled to fit into small containers. If the labels still will not fit in the specimen bottle, as with small vials, then use the following procedure. Place in the bottle or vial at least the project number, station, and identification, as well as a cross-reference number; then complete a voucher specimen label for each bottle or vial and index these with the bottle or vial number. Send the dry voucher labels along with the vials to the specimen repository.

Preservation/Fixation:

By far the most widely used general fixative for biological specimens is formalin. This relatively inexpensive chemical is a saturated solution of gaseous formaldehyde, HCHO, in water. Unfortunately there is often confusion in common usage of the terms formaldehyde, formalin, and formol. The correct usage is formaldehyde for the gaseous state, formalin for aqueous solution; formol is a misnomer, as the ending denotes an alcohol or phenol. Commercial solutions vary from approximately 37% to 40%. Therefore, the normal dilution is nine (9) parts water to one (1) part raw formalin for a 10% formalin solution (= 4% formaldehyde solution), the standard used for fixation in the field. Formalin is slightly acidic and will attack delicate calcareous structures, such as the shells of small bivalves, crustacean exoskeletons, sponge spicules, and even fish bone on long exposure, etc. Hence, formalin should be buffered. Borax may be used as a buffer but a neutral pH is not stable over a long period, but it should be sufficient for most or all OCSEAP projects.

To make a buffered formalin solution, add household borax to raw formalin, mix well, and add more borax if needed until some remains at the bottom of the container. This is a saturated solution. The buffered supernate is ready for use.

Reagent grade formaldehyde should be used. In recent years manufactures have added 10-15% alcohol to reagent grade formaldehyde to prevent the formation of paraformaldehyde at cold temperatures. If the preserving fluids or preserved samples will be exposed to below freezing temperatures, contractors should consult the specimen repository for advice.

To a lesser extent, but in some cases the most appropriate fixatives are alcohols. Ethyl alcohol (ETOH) is the most preferred alcohol but it has minimal advantages as a fixing agent over dilute formalin. The main advantages lie in its neutral pH and its low human toxicity. It is often employed in the fixation of small crustaceans where a tough cuticle slows penetration so that serious distortion of the internal anatomy is seldom incurred. With a few exceptions, it is the preferred fixing agent for Porifera (sponges).

Specialized fixation may be necessary for reliable identification of some taxa, e.g., the flatworms and Nemertinia. When in doubt consult a specialist or the specimen repository.

## Instructions for Preservation

### Phytoplankton (diatoms and thecate flagellates; excluding naked forms)

These require special handling and project investigators may have their preferred way to preserve specimens, including special slide mounting techniques. For general preservation the following can be used:

Utermohl version of Lugol's Stock Solution:

| | |
|---|---|
| $I^2$ | 10 g |
| Kl | 20 g |
| distilled water | 140 ml |
| sodium acetate | 10 g |

Add the stock solution to the water sample until the color is that of light tea (ca. 1%). If samples preserved with iodine are exposed to air or light, the iodine may be degraded and the samples may decompose. If the sample becomes lighter in color under these conditions, add more iodine. Plastic electrician's tape may be used to seal screw-capped sample vials or bottles.

Zooplankton (incl. fish larvae):

Fixative:

Generally use 4-5% buffered formalin for general collections of zooplankton.

When the volume of plankton is small in relation to the volume of the container, then the plankton may be added to prediluted (5%) buffered formalin. When the volume of plankton exceeds about 1/10 of the volume of the container, then the plankton (which is mostly water) will dilute the formalin to a concentration too low for adequate preservation. In this case, add raw formalin (full strength) to the container at the rate of one part raw formalin to 19 parts water and plankton. The easiest way to accomplish this is to measure the volume of the container, then add plankton and some water, then add full strenght formalin equal to 1/20th of the volume of the container, then top off with more water.

To retard evaporation and as an antifreeze if the samples will be subjected to below freezing temperatures, propylene glycohol may be substituted for 10% of the water, but this is not normally necessary.

When removing the voucher zooplankters from previously preserved samples, place the voucher specimens in new 4-5% buffered formalin in vials or suitable containers. Electrician's tape may be used to seal the vials, most of which are very susceptible to evaporation. Until the samples are sent to the designated repository, they should be checked regularly for evaporation and 'topped-off' as needed.

Pigment spots, which are useful in identification of many zooplankters, will remain for much longer periods of time if the samples are kept in the dark.

Preservative:

All zooplankton collections can be kept in 4-5% buffered formalin through shipment to the specimen repository.

Marine Invertebrates:

Relaxant and narcotization:

For proper preservation of some invertebrates, it is often necessary to relax the specimens before preservation. No standard methods are available. Chilling the specimens to a few degrees above the freezing point (do not freeze) often serves as a general relaxant, but is often not useful for cold-temperate invertebrates. Alternate methods which can be tried if time and materials are available, include the slow addition of 95% ethyl alcohol, addition of an isotonic solution of 7.5% magnesium chloride, or flotation of menthol crystals on sea water in a closed container. When the specimens no longer respond to tactile stimulation, they may be transferred to the fixative. Special methods of relaxation for certain groups may require consultation with a specialist, and the principal investigator should consult the specimen repository.

Fixative:

The normal fixative is 10% buffered formalin. Sponges (Porifera) are an exception, and they should be placed directly in 95% ethyl alcohol.

Preservative:

All specimens may be kept in their fixative solution until sent to the specimen repository as long as this will occur within a year or so of initial fixation and if those organisms in formalin are in properly buffered 10% formalin. (The specimen repository will transfer the specimens to their final preserving solution.)

However, some investigators may want to transfer their specimens to the final preserving solution. Formalin even when buffered will cause softening and structural changes in some animals, but usually not over the duration of the projects here undertaken as long as care has been taken to insure that the formalin is buffered.

Specimens should be kept in their initial fixative for at least 3 days, or about a week for large specimens, before being transferred to a preserving solution.

The most satisfactory preservative is ethyl alcohol. For most organisms a concentration of 75% is used. Note that unless labelled absolute, the alcohol comes in a 95% solution and this should be taken into consideration when diluting to 75%. If ethyl alcohol is not available, 50% isopropyl alcohol may be used, although it is less desirable. Do not use denatured ethyl alcohol.

Before placing specimens in the preservative, the fixative may be washed from the specimens by placing them in cool water for about 1/2 hour (running water may be used for nondelicate specimens). Small organisms can be placed directly from formalin into alcohol without washing.

Note that the following should not be placed in alcohol:

Siphonophores, ctenophores, chaetognaths, jellyfish, and salps. Retain in buffered 10% formalin (5% if in zooplankton collection). Do not wash, do not put in alcohol.

Anthozoans (sea anemones). Retain in 10% buffered formalin. It is a good idea to change to fresh formalin solution about two days after initial fixation. Do not put in alcohol. Large specimens should be injected at initial fixation.

Fishes (except larvae):

Fixative:

The normal fixative is 10% buffered formalin.

As with invertebrates, care must be taken to insure that the specimens do not dilute the formalin below a concentration necessary for fixation. Add raw (full strength) formalin equal to 1/10th of the volume of the container, then add some water and the fishes, then top off with water. This will insure that when the water in the specimens is penetrated by formalin, the fixative will be 10% of the total contents.

Specimens greater than 4 or 5 inches total length should have a short slit made in the right side of the abdominal cavity to allow penetration of the formalin into the visceral area. Specimens over a foot or so in length may be injected along the back to insure adequate internal fixation.

Preservative:

Specimens may be retained in buffered formalin through shipment to the specimen repository. However, some investigators may wish to transfer the specimens to alcohol. This should be done only after the specimens have remained in formalin for at least a week and up to several weeks for very large specimens.

Specimens may be rinsed in running cool water or soaked in water for a few hours to remove some of the formalin. Then they should be placed in 75% ethyl alcohol (50% isopropyl alcohol may be substituted). For fishes over about 5 inches in length, or in situations where the specimen(s) accounts for a significant volume of the container, the initial alcohol should be replaced with fresh alcohol after 1 or 2 days because the water/formalin leached from the specimen dilutes the alcohol.

Birds and Mammals:

Voucher specimens are not required. However, where study skins or skeletons have been archived by a project, a list of archived materials and the archiving institutions should be supplied as part of the final report. Because of restrictions on capture of many birds and mammals, an effort should be made to archive important specimens.

Sea Grasses and Macrophytic Algae:

Specimens should either be pressed directly as fresh material or be preserved in 10% formalin.

Terrestrial Plants:

Standard botanical procedures are to be used.

Other:

Contact the specimen repository or specialists for additional advice on fixation and preservation. Follow procedures common to specialty groups as needed (slide mounts, etc.).

## Shipment of Specimens

Upon contact by the principal investigator, the specimen repository will provide shipping containers, supplies, and instructions for packing and shipment.

Most shipments will be made through the mails, using mailing franks. If larger expense is involved, the repository will contact the project office to work out appropriate arrangements.

## Reporting

The specimen repository will provide each principal investigator with a listing of the material he or she deposited. This listing will include the museum catalog number for each lot. Reidentifications by specialists also will be brought to the attention of the principal investigator.

The specimen repository will supply EDP listings of voucher material to NOAA on a regular basis.

APPENDIX ITEM 2

VOUCHER SPECIMEN LABEL
OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM

| | |
|---|---|
| Ident. | No. spec. |
| NODC No. (ed.) | |
| Ident. by | Date ident. |
| Coll. | Sta. (field) no. |
| Date coll. | Proj. RU no. |
| Host | |
| Locality | |
| | Depth |
| Substrate | Time |
| Method capt. | Fixative |

APPENDIX ITEM 3

Draft

# VOUCHER SPECIMEN LOT RECORD

Acc. No. ____________________

NOAA RU No. ______________

## OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM

IDENT. ______________________ CAT. NO. ____________________ GROUP NO. ______

IDENT. BY ______________________ NODC CODE (ed) ________________ NO. SPEC. ______

HOST ______________________ DATE ____________________ STAGE ________

**LOCALITY**

General ________________________________________________

Lat. ______________ Long. ________________ Depth/elev. ______________

Substr. ________________________________ Time ______________

Orig. (field) No. ____________________________ Quadrant no. ______________

COLL. BY ________________________________ Date coll. ______________

METHOD CAPT. ______________________________

FIXATIVE ________________________________ PRESERVATIVE ______________

**PROJECT DATA**

Proj. No. ______________________ Institution ______________________

Prin. Investigators ________________________________________________

**ECOLOGICAL PARAMETERS**

Salinity ______________ Temp. (surface) ______________ Temp. Captur. ______________

Tide ______________ Biol. assoc. ________________________________

Other: ________________________________________________

**REIDENTIFICATIONS**

**PUBLICATIONS**

**REMARKS**



Prepared by ______________ Date __________

ADDENDUM

QUARTERLY REPORT
September 30, 1978

Contract no.: 03-78-B01-53

Project no.: RK 0000-R7120815

Archival of Voucher Specimens of Biological Materials Collected under the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Support

Period of Performance: May 1, 1978 - April 30, 1979
Subsequent support subject to availability of funding.

Period Covered by This Report: May 1, 1978 - Sept. 30, 1978.

Insitution: California Academy of Sciences
Golden Gate Park
San Francisco, California 94118

Principal Investigator: William N. Eschmeyer
Director of Research
(415) 221-5100

Authorized Signatures:

William N. Eschmeyer
Principal Investigator

George E. Lindsay
Director

EXPENDITURES SUMMARY

Expenditures for the period covered by this report were as follows as of September 30, 1978:

| | |
|---|---|
| Salaries: William N. Eschmeyer, Dustin Chivers, and Susan Gray Morelli . . . . . . . . . . . . . . . . . . | $4,033.26 |
| Supplies: Laboratory supplies, etc. . . . . . . . . . . . | 655.47 |
| Phone . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 5.90 |
| Total for period covered by report | $4,694.63 |

☆ U.S. GOVERNMENT PRINTING OFFICE:1979—677-072 / 1244