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RP-6-OC-71 Data Report: Oceanographic Conditions Off the Washington Coast October- November 1971

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NOTICE

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OCEANOGRAPHIC CONDITIONS OFF THE WASHINGTON COAST
OCTOBER - NOVEMBER 1971

T. V. Ryan, N. P. Laird, and G. A. Cannon

1. INTRODUCTION

Wise management of Washington's coastal zone and major estuary requires an understanding of the oceanographic processes which affect the marine environment. In October-November 1971 the Pacific Oceanographic Laboratory (POL), with the support of the NOAA Ship OCEANOGRAPHER, conducted a field investigation for the acquisition of preliminary data basic to a study of the dynamics of Puget Sound and Washington coastal waters.

The common interest in coastal zone processes, shared by POL and the Department of Oceanography of the University of Washington, prompted a cooperative effort which made possible a substantially stronger field program than POL could have conducted alone. The University loaned POL current meters and associated equipment. We in turn, installed and recovered two of their moored instrument systems and launched a large number of their bottom current drogues.

This report of an oceanographic survey off the Washington coast by the Pacific Oceanographic Laboratories, October-November 1971, presents a discussion of the environmental factors which were considered in the planning of the survey, an account of how the cruise actually progressed, and an inventory of the data collected. Selected data on the offshore thermohaline conditions, illustrating changes occurring over a period of a few weeks are presented in graphical form. Data from the moored current meters will be presented in a separate report.

Operational aspects of the field work were supported by NOAA's National Ocean Survey. The NOAA Ship OCEANOGRAPHER OSS-1, provided and operated all data collection facilities, other than the U/W-POL moored instrument systems. The Pacific Marine Center prepared the plotting sheets for the HIFIX positioning and manned the HIFIX shore stations during the two periods that precise positioning was essential. The personnel participating in the field work were:

From the OCEANOGRAPHER - OSS - 1

NAME	FUNCTION
M.J. Tonkel, CAPT NOS	Ship Captain; Operational plans.
J.P. Randall, CDR NOS	Executive Officer; Instrument systems rigging and deployment. Daily operating plans.
J.P. Vandermeullen, LCDR NOS	Field Operations Officer; Daily operational plans, Technical supervision of shipboard personnel.
W. Ulman, LTjg, NOS W. Viertel, ENS, NOS	Ship computer operations and data data plotting.
Ship's Crew	Operation of STD, construction of parachute drogues, salinity analysis, deployment of instrument arrays.

From PACIFIC OCEANOGRAPHIC LABORATORIES:

NAME	FUNCTION
T.V. Ryan	Chief Scientist; Project supervisor.
Dr. G. A. Cannon	Project Scientist; Scientific plans, instrument array design University of Washington project representative.
N.P. Laird	Project Scientist; Plans, Acoustic release systems.
J.P. Stephens	Project Technician; Geodyne current meters, bathykymograph, data processing.

2. PLANS AND OPERATIONS

2.1 Environmental Considerations

A prominent bathymetric feature of Washington's continental shelf is a sinuous, deep (average depth - 300 m) trough or canyon which connects the mouth of the Straits of Juan de Fuca with the Juan de Fuca Canyon. The latter name has been reserved for the sea canyon which starts at the edge of the continental shelf some 55 km southeast of Cape Flattery, and winds its way down the continental slope, almost to the Cascadia Basin (McManus, 1964). Despite its obvious significance in providing a relatively deep passage for waters across the much shallower (100 - 150 m) shelf, this connecting link has no proper name. To facilitate discussion, herein the term "Juan de Fuca Canyon" will be extended to include this connecting "trough" up to its junction with the Straits of Juan de Fuca.

The focal point of the project was on the currents in the Juan de Fuca Canyon and the Canyon's influence on the estuarine and coastal currents. Three major current systems are active in the Canyon and to some extent interact there. The dominent system is the strong current associated with the tidal prism of the great estuary composed of the Straits of Juan de Fuca and Georgia, Puget Sound, and their contiguous waters. A secondary system results from the fresh water added to the estuary from its watershed, and the compensatory current which maintains the salt balance in the estuary. Evidence that this system undergoes large scale fluctuations, probably caused by meteorological factors, had been recently reported by one of the authors (Cannon, 1972). The role of these fluctuations on the flushing characteristics of the estuary are of importance. The third system is the rather vague resultant or weak manifestations of the California (or Japanese) current, the intermittantly present Davidson current, and local wind stresses. Our objective was to obtain data on each of these three systems.

Local regional weather was a prominent factor in the project plans. In summer, the NE Pacific is dominated by a high pressure system centered near 37° N, 150° W; in winter by a low pressure system centered in the Gulf of Alaska. The cruise was thus situated during the transitional period between the two states when frequent frontal passages sweep from west to east through the area with strong winds, shifting from SW to NW. It was anticipated that several of these reversals would occur during the recording period. On a more immediate basis it was anticipated that heavy weather could curtail or jeopardize the successful rigging, implanting and recovery of the instrument arrays, the tracking of parachute drogues, and STD employment. For these reasons the plans were framed with expectations that time and equipment losses were likely, and that rescheduling, cancellations and alternative options were a certain part of the field work.

The more important data resources used in the cruise planning were the report by Ingraham (1967) of geostrophic currents and water properties of the area just seaward of the present study area and the series of data reports on physical, chemical, and biological properties of the Juan de Fuca Straits and the Washington coast from cruises by University of Washington oceanographers. (University of Washington Department of Oceanography Technical Reports Nos. 119, 134, 159, 180).

2.2 Survey Design

For analysis of the primary system, the tidal currents, 30 day current measurements were planned at Sites A and B (fig. 1) with meters at the depths shown in figures 2 and 3. The bathymetry of the study area is indicated in figure 4 (figs. 1-4 are in front material). Concurrent tidal height data was anticipated from the existing standard tide guage maintained by the NOS at Neah Bay, which is on the Washington coast immediately south of Site A. Analysis of the secondary current system, (which determines the fresh-salt water budget of the estuary) was dependent on the data from Site A and B_0 current meters, from which the net flow would be extracted by appropriate data processing. A forty hour time series of STD stations across the mouth of the Strait, (fig. 1) and a twenty-four hour time series at a previously occupied University of Washington reference station off Pillar Point, about 44 km east, were planned to provide details of the water structure to be used with the current data from Site A, and to enable us to relate our findings to the historical data from Pillar Point. River discharge, essential to the water exchange study, is routinely collected by the U.S. Geological Survey.

The coastal current regime was to be studied by analysis of the physical properties of the water (geostrophic field and thermohaline gradients), supplemented by direct current measurements from Site B, and from parachute drogues. The thermohaline properties were to be measured throughout the area by three series of STD stations; at the beginning, middle and end of the 40 day cruise. It was anticipated that each series would require about 6 days. These series are called "regional current system studies," abreviated "RCSS." Plans called for stations on lines oriented normal to the coast, with observations extending from the surface to within four meters of the bottom. Stations were spaced along

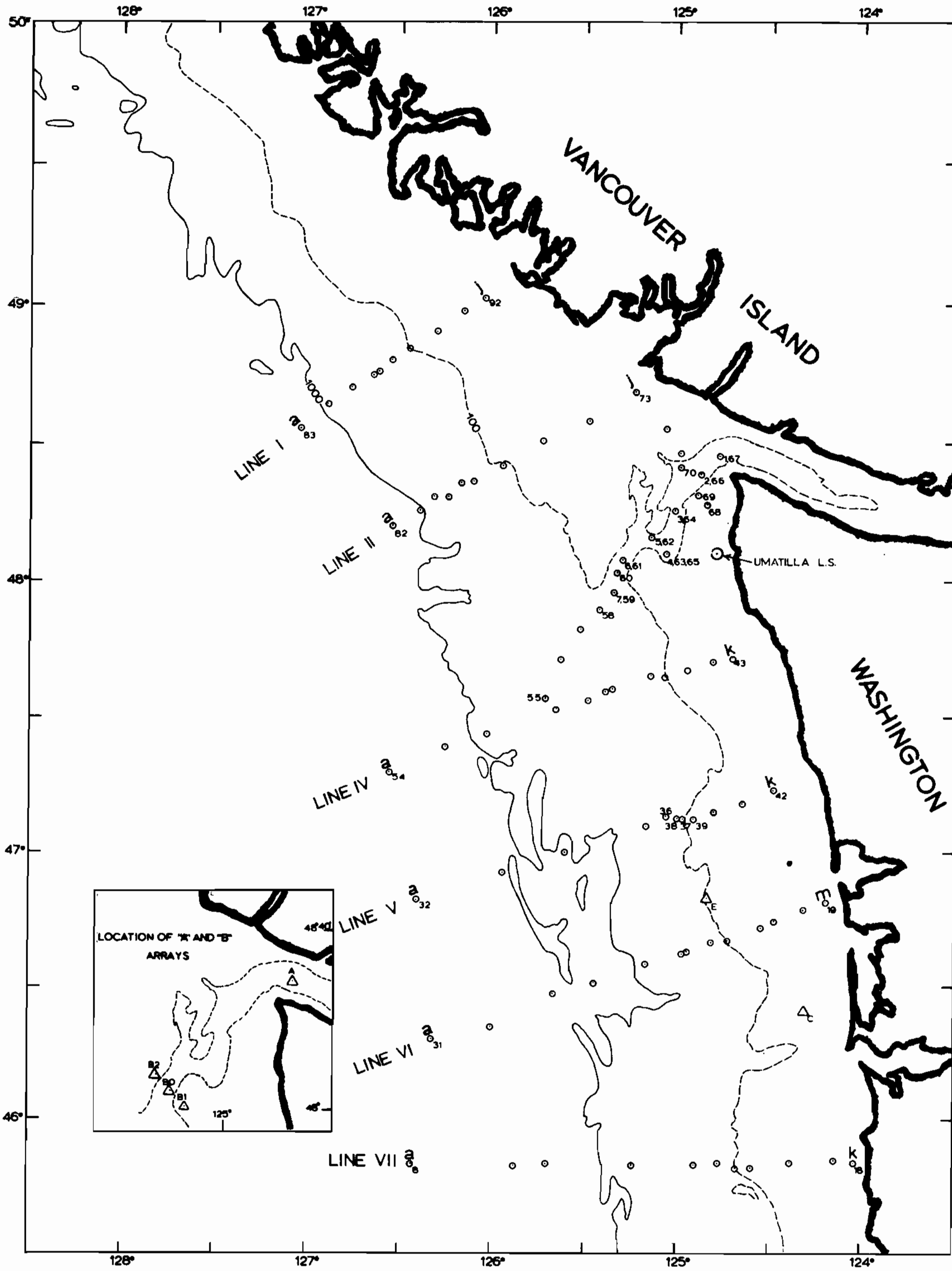

Figure 1a. Station locations for Regional Current System Study 1(RCSS 1) 17-24 October 1971. Stations are identified by serial number and by line and alphabetic designator.

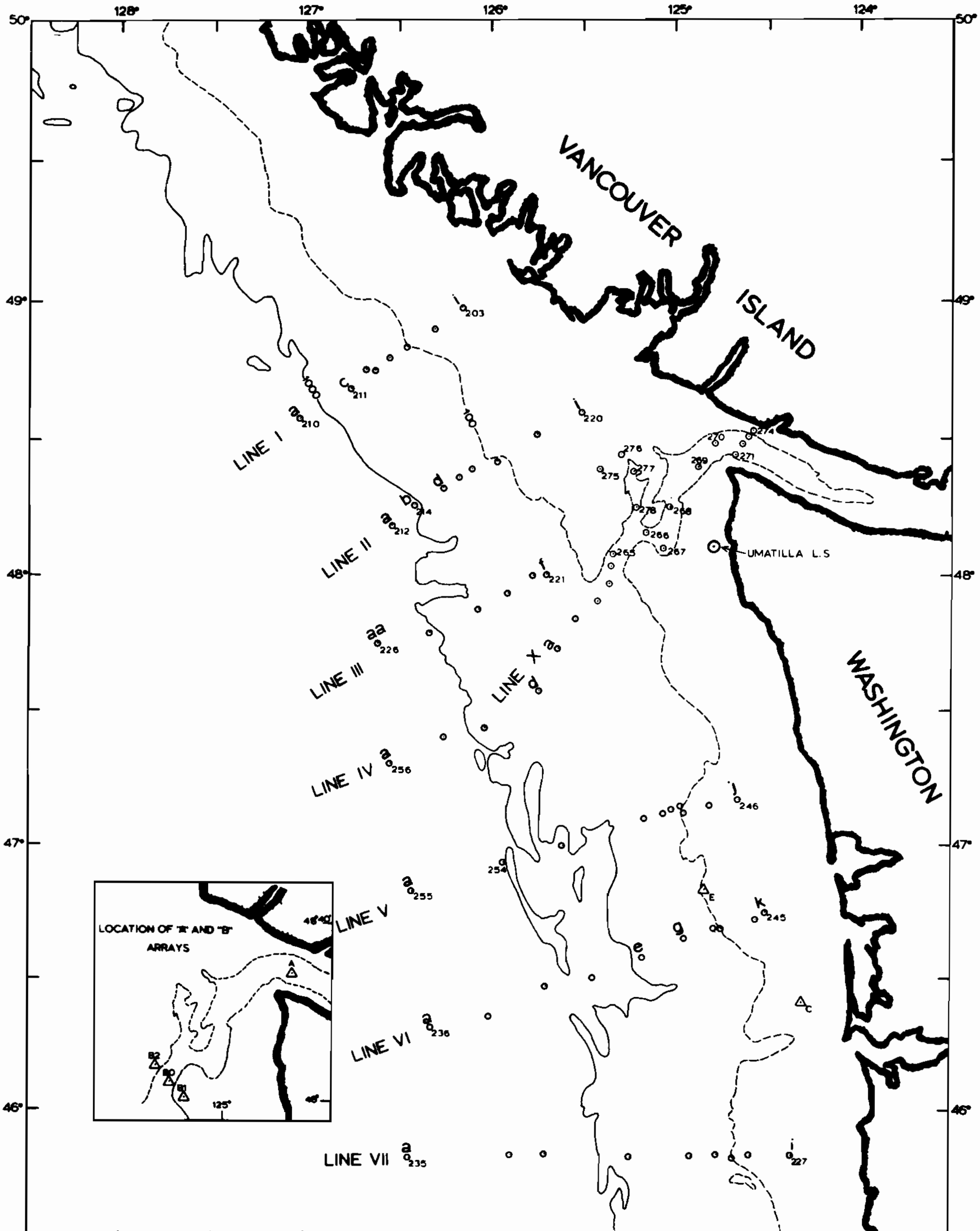

Figure 1b. Station locations for Regional Current System Study 2 (RCSS 2) 12-19 November 1971. Stations are identified by serial number and by line and alphabetic designator.

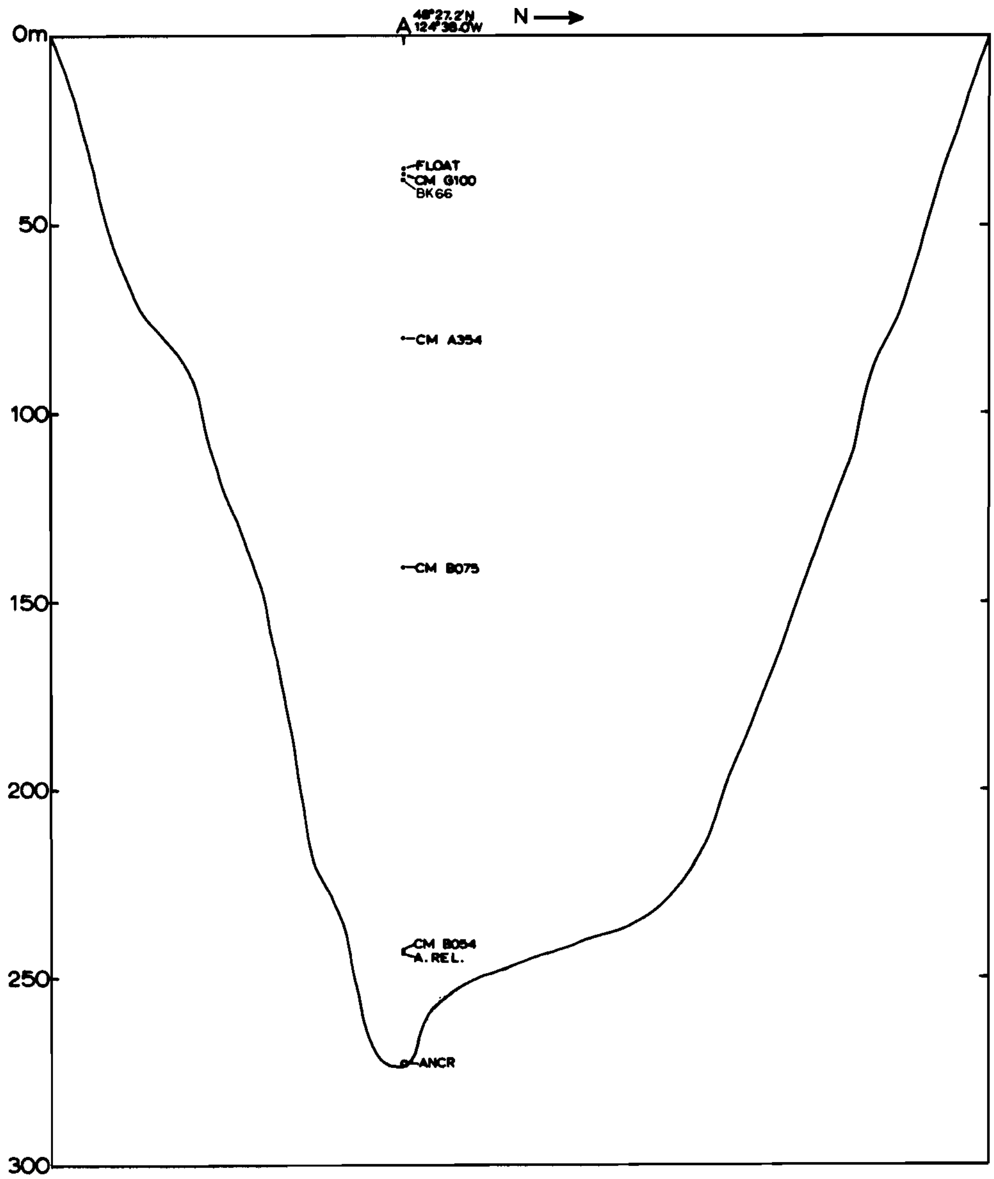

Figure 2. Diagram of Site A instrument array. Symbols: cm = current meter. Letter and numbers following indicate type (G-Geodyne, A-Aanderaa, B-Braincon), and serial number. A. REL = acoustic release. ANCR = anchor. BK = bathykymograph.

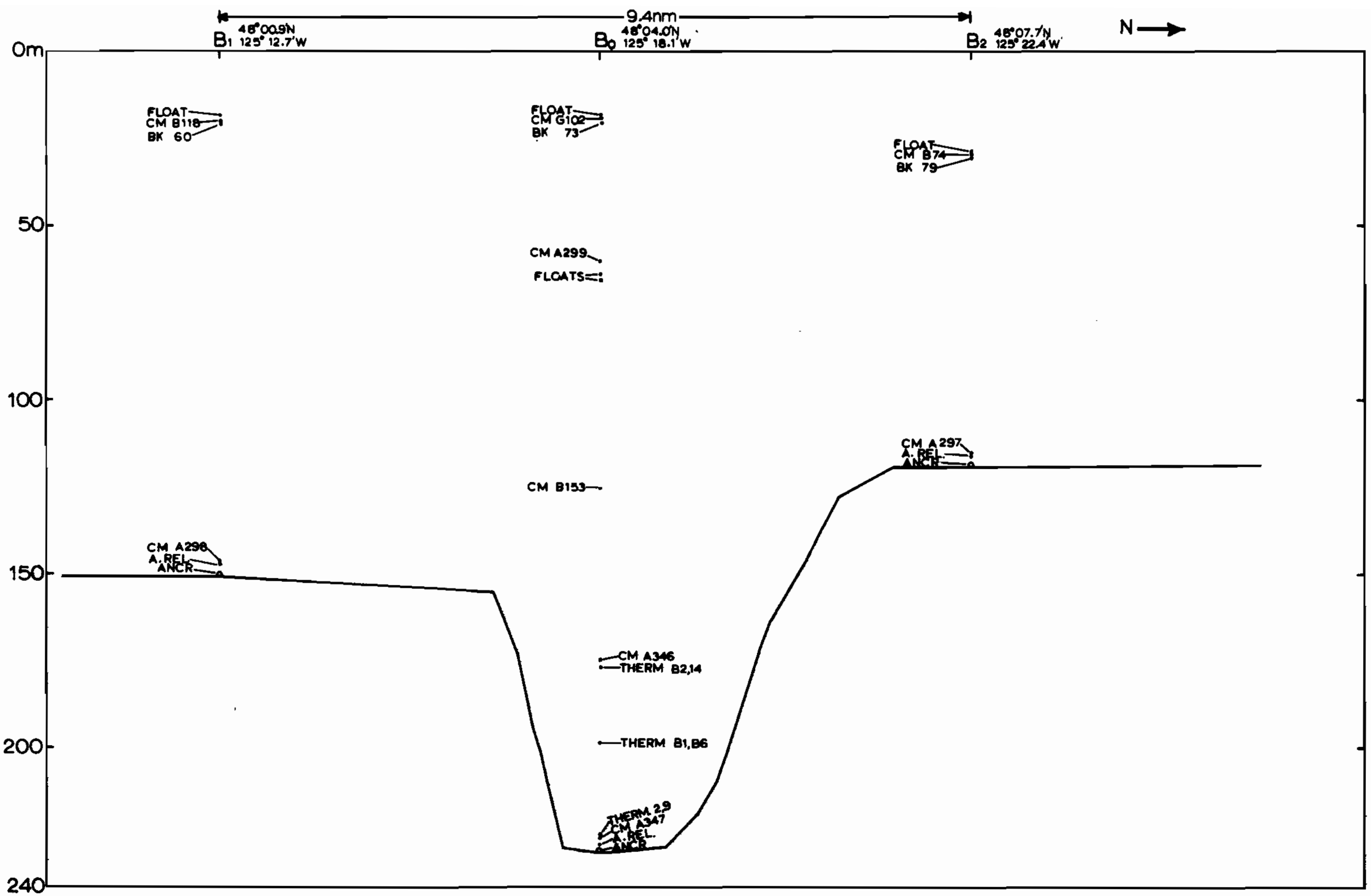

Figure 3. Diagram of Site B instrument arrays. Symbols: cm = current meter. Letter and number following indicate type (G-Geodyne, A-Aanderaa, B-Braincon), and serial number. A.REL = acoustic release. ANCR = anchor. BK = bathykymograph. THERM = thermistors (and serial numbers).

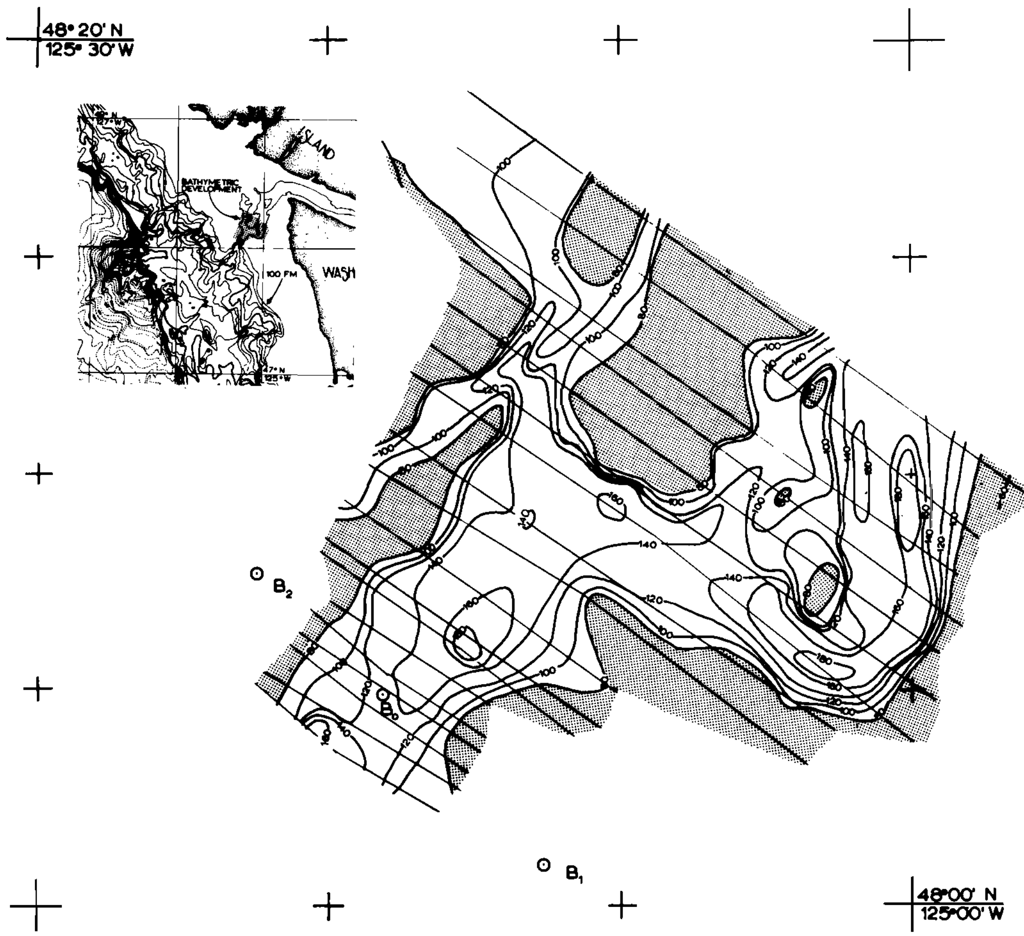

Figure 4. Bathymetry in vicinity of Site B arrays. Contours in fathoms corrected for sound velocity. Shaded areas less than 80 fathoms. Light lines indicate sounding tracks.

the lines so as to reach nominal depth of 20, 30, 50, 70, 100, 200, 400, 600, 800, 1000 and 1300 fathoms. The deeper limit corresponds to the depth of the Cascadia Basin and would require supplemental Nansen bottle casts. Parachute drogue tracking was planned in the vicinity of Site B with drogues set at depths deep in the Canyon, at an intermediate level and in the mixed layer. A second set of drogues was planned as a contingency in the Davidson current, if clear evidence of it were found during the first RCSS, mentioned above. As an alternate option, two lines of Nansen stations extending from the 1000 fm curve to the longitude of Cobb Seamont, were planned for a geostrophic analysis of the offshore currents.

Several auxiliary data collection programs were incorporated in the planning for supportive purposes. Bathymetric reconnaissance surveys were planned at the several moored current meter sites so as to insure placement of the arrays in the axis of the Canyon and to avoid local topographic features which might distort the currents. A closely spaced grid of STD stations was planned at Site B to provide the thermohaline structure in detail for analysis with the current data.

A vertical array of six thermistors with an appropriate recorder, was to be moored at Site B_0 to provide detailed data on the thermal properties of the water concurrent with the 30 day current record. The system was designed to record two independent measurements of temperature at depths of 175, 195, and 235 m at 10 min intervals. The relationship of thermistor depths and current meter depths to the Canyon bathymetry is shown in figures 2 and 3.

To supplement the STD observations for the mapping of surface salinity and temperature distribution, it was planned to operate sea surface temperature and salinity recorders continuously while the ship was streaming on RCSS. Meteorological data (barometric pressure, air temperature, wind speed and direction) are recorded by NOS ships routinely each hour while at sea. The Coast Guard personnel at Neah Bay and Umatilla light ship were alerted that their routinely recorded weather data would be required. The National Weather Service barometric pressure summaries, routinely prepared on a daily basis, 'cover' the study area.

2.3 Field Operations

The project was executed in three phases as planned. During the first phase (13-26 October) the current meter arrays were successfully rigged and implanted, utilizing HIFIX and LORAN A position control. A marker buoy was set near Site B_2 to provide back-up positioning capability. While awaiting daylight for the continuation of the instrument array deployment, a bathymetric development of the Site B area, under HIFIX control, was conducted. The RCSS #1, scheduled during this phase, proceeded slowly owing to very troublesome UNIVAC computer performance and heavy weather. To compensate for the delays, all of Line III and several of the inshore stations on other Lines, were deleted. Sites actually occupied during phase I are illustrated in figure 1a. STD calibration was complicated and degraded by heavy weather because of excessive rolling and the hazardous exposure of the over-the-side sampling facilities. The Site B development, pictured as a STD grid in the project instructions, was executed as a time-series of STD stations at 5 locations in Site B area. Dr. Glenn Cannon suffered a shoulder dislocation during heavy weather on 25 October, and debarked when the ship put in to Port Angeles, Washington, on 26 October. Phase II commenced 29 October with a 24-hour time-series of STD stations at hourly intervals off Pillar Point, Washington. Unfortunately the positioning of these stations varied about 2 miles, thereby complicating the time dependent changes with geographic variations. Immediately following the Pillar Point series, STD stations were occupied sequentially at 1 hour intervals across the mouth of the Straits of Juan de Fuca for a period of 29 hours; an instrumental failure cut short the planned 48 hour sequence. Times and locations of the stations are shown in section 3.2.

RCSS #2, which was planned as a mid-cruise, STD based survey, was deferred in favor of two parachute drogue operations. The first, coded ALPHA, was conducted 1-3 November (local time) near the mid point of LINE II (see fig. 1a). A horizontal current shear had been indicated in this area on 23 October, at depths between 200 and 500 meters by STD stations 77, 78, 79. Existance of the feature was not confirmed by stations 176, 177, 178 occupied on 1 November, immediately prior to the drogue set. Two drogues identified as BLUE and ORANGE were set on either side of the suspected shear, with parachutes hung at 250 m depths. One drogue (BLUE) was tracked for a period of 63 hours. However, the parachute line was found broken on one occasion and at least 6-hours of data was lost. The second drogue (ORANGE) was tracked 53 hours with no failure of parachute line noted. Portions of the trajectories (excluding those portions complicated by weak LORAN positioning data) are shown in section 3.1.2. Flashing Xenon lights (20 flashes/min) attached to the drogue buoy staff were found to be excellent visual aids for night time detection, expecially when used in pairs on each buoy. The slight difference in flash rate provided an especially effective perception aid under marginal conditions.

The buoys were constructed stoutly and survived repeated recovery and resetting.

The second parachute drogue tracking operation, "BETA" was started 4 November (local time) near Site Xi with parachutes initially rigged at depths of 90, 230 and 255 m (depths of 50 and 180 meters were used later in this series). Drogues were reset several times, following grounding (and wire breakage). STD stations (Serial Nos. 189 through 202) were occupied during this period across the Canyon in order to provide data for a study of the relationship between thermohaline structure and current velocities. During this period of the cruise, a special shallow test drogue was observed from the bow observation chamber of the ship. It was found that the sugar-solution release system, used to launch the test parachute, failed to operate, thus restraining the parachute from opening.

Phase II was completed 9 November at the conclusion of the drogue work, and the ship returned to Port Angeles for logistic support.

Phase III commenced 11 November, at Line I, with the initiation of the second regional current system study (RCSS #2). STD sensor and data processing troubles were soon encountered, causing frequent stoppages, repairs, reoccupation of defective stations, etc. Again, special STD calibration tests, necessitated by the replacement of sensors, were delayed due to heavy weather. RCSS #2 was interrupted during occupation of Line III, when good weather provided an opportunity to recover the instrument arrays under favorable sea conditions.

The POL and U/W arrays were recovered successfully on 14-15 November including the recovery of the Site A system at night time. Several of the

U/W instruments were found damaged when brought aboard (see Appendix for details). RCSS #2 was resumed 15 November at the southern extremity of the region (Line VII, inshore station) and proceeded northerly. Two long-delayed Nansen casts were conducted while on Line VI to establish calibration data for the malajusted STD. Owing to an ominous weather map for the Pacific received by radio facsimile on 17 November, the inshore portion of Line IV was deleted to insure completion of higher priority work in the Juan de Fuca Canyon. Figure 1b shows the sites occupied on the second RCSS. Two bathymetric sections across the Canyon were run to test the capability of a special signal processing device for the fathometer. A special set of STDs were occupied during this concluding period of the cruise to determine the relationship of water masses occupying the bottom of several arms of the Canyon. The cruise ended 19 November with the ship returning to Seattle.

3. THE DATA

3.1 Current Data

3.1.1 Current Data from Moored Instruments.

The current data from the moored arrays will be presented in a separate report. An inventory of the available current data follows.

Current data from Site A: (48° 27.2'N; 124° 38.0'W)

The Site A array (see fig. 2) was implanted 0917 hr, 14 October and recovered 2100 hr, November 14. Actual records varied for a variety of reasons, as indicated below:

Meter No.	Depth (m)	Period of Record (+ 8 Time Zone)	Total Hours	Sampling Intrv'l	Remarks
Geodyne G-100	37	0200 OCT 17 to 2100 NOV 14	691.0	10 min	Beginning of film record lost
Aanderaa 354	81	NONE	----	----	Recorder failure
Braincon 075	142	0925 OCT 14 to 1217 NOV 9	629.0	10 min	Recorder capacity exceeded
Braincon 054	245	0925 OCT 14 to 2100 NOV 14	756.7	20 min	Normal

A mechanical depth/time recorder (Marine Advisors Bathykymograph) attached to the array at the float level (nominal depth 37 m) operated from time of launching, 14 October, to about 23 October. As the record is in poor condition (owing to snagging and tearing of the recorder paper) precise interpretation is not possible. A portion of it, redrawn, appears in figure 5. It is clear that the instrument array underwent bend-over or "dips" of at least two classes. The larger, 15 to 20 m, lasted for about 5 hours, the central portion of which is at relatively constant depth. Where the record is readable this class dip reoccurred about 24 hours later. A second class of dip of about 5 meters occurs at about the same time interval. In lieu of better data, an evaluation of the severity of array dip can be surmised from the Geodyne meter-case tilt records. At speeds up to 120 cm/sec, case tilt recorded by Geodyne meter G-100 was always less than 5°. A mean slope of 5° over the entire wire will produce a dip of only 1 m. The current speed-case tilt ratio is variable;

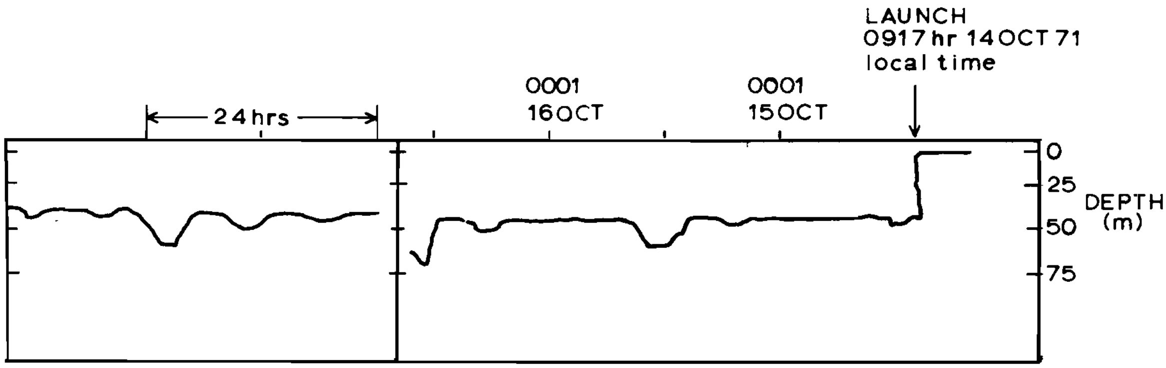

Figure 5. Bathykymograph record from instrument array A. The trace indicates variations in the depth of the top of array A, resulting from horizontal drag forces on the mooring due to currents. (Redrawn from a legible portion of the mutilated original record.)

Current data from Site B_0: (48° 04.0'N; 125° 18.1'W)

Array B_0 (see fig. 3) was implanted 0854 October 15 and released from the mooring at 1601 November 14. Data records are as follows:

Meter No.	Depth (m)	Period of Record (+ 8 Time Zone)	Total Hours	Sampling Intrv'l	Remarks
Geodyne G-102	19	0830 OCT 19 to 1601 NOV 14	629	10 min	Beginning of record lost
Aanderaa 299	60	0920 OCT 15 to 1601 NOV 14	726.6	10 min	Normal
Braincon 153	125	1340 OCT 15 to 1301 NOV 14	723.6	20 min	Beginning of record lost
Aanderaa 346	175	0920 OCT 15 to 1601 NOV 14	726.6	10 min	Normal
Anderaa 347	226	0920 OCT 15 to 1601 NOV 14	726.6	10 min	Normal

however at speeds of 175 cm/sec tilt always exceeded 5° and at 254 cm/sec case tilt reached 40°. A mean slope of 23° over the entire wire would produce a dip of 20 m at the top of the array. Case tilt should be considered in analyses of the higher speed currents as indicative of possible array dip.

The bathykymograph used at Site B_0 did not indicate the dips sensed at Site A. The record shows a smooth variation of about 10 meters over a 3 day period, which we believe is ficticious and due to recorder misalignment. Data on dip from Aanderaa meter 299 will be presented in the separate report listing current meter data.

Current data from Site B_1: (48° 00.9'N; 125° 12.7'W)

Array B_1 (see fig. 3) was implanted 1023 October 15 and recovered 1714 November 14. Data records are as follows:

Meter No.	Depth (m)	Period of Record (+ 8 Time Zone)	Total Hours	Sampling Intrv'l	Remarks
Braincon 118	20	1040 OCT 15 to 1522 NOV 9	604.6	10 min	Exceeded Recorder capacity
Aanderaa 298	148	1040 OCT 15 to 1714 NOV 14	726.5	10 min	Normal

The bathykymograph on array B_1 shows no "dips" of tidal frequency, however a smooth depth increase of about 5 meters, followed by return to initial depth (20 m) occurred between 17 and 20 October.

Array B_2 (see fig. 3) was launched 1725 October 14 and released from moorage 1454 November 14. Meter records are:

Meter No.	Depth (m)	Period of Record (+ 8 Time Zone)	Total Hours	Sampling Intrv'l	Remarks
Braincon 074	22	1740 OCT 14 to 1127 NOV 11	665.8	10 min	Exceeded Recorder capacity
Aanderaa 297	108	1740 OCT 14 to 1454 NOV 14	741.3	10 min	Normal

The bathykymograph at B_2 flooded; no record was obtained. However the bathykymograph at Site B_1, with similar array configuration indicates that "dip" is not a serious problem at this offshore site.

3.1.2 Currents from parachute drogues

Two drogue tracking operations were conducted. The first coded ALPHA, was conducted 1-3 November (local time) near the midpoint of LINE II utilizing two drogues, BLUE and ORANGE, set at 250 m (see section 2.3 for details). Portions of the drogue trajectories are presented in Plate 1. During the middle period of this operation the trajectories show considerable jitter due to poor LORAN signals: this portion has been omitted from the illustrations. BLUE drogue lost its parachute some time after 1144Z 3 November, and was recovered, rerigged and reset at 2248Z 3 November. Prior to resetting

BLUE, STD Stations 179 through 182 were occupied on a line normal to the trajectory of ORANGE to provide thermohaline data for correlation with the observed currents. The drogues exhibited converging trajectories with a net speed of about 20 cm/sec to the ESE. Wind conditions (see section 3.5) varied from calm to over 35 kts during this period.

The second drogue tracking operation, coded BETA was conducted 4-7 November (local time) over the Juan de Fuca Canyon, midway between instrument array Sites A and B (see fig. 1a for general location, section 2.3 for details). Drogue trajectories are illustrated in Plate 1. Drogues BLUE (90 m), YELLOW (230 m) and RED (255 m) were initially set out within a few minutes of each at the same location. As they were lost or grounded they were reset, occasionally with changes in the wire length-to-parachute, and at differing locations. STD Stations 183, (location Xj) and 184 (location Xi) were occupied immediately before the drogue set. During the tracking operations, stations 185 through 202 were conducted to make a section across the Canyon near Xj and a time series in the Canyon. The limiting bathymetric depths relative to drogue depth have been sketched on the figures from a manuscript chart kindly provided by N. McGary of the University of Washington. The location of these contours on the trajectory figures is very approximate and should be used only as a guide.

BLUE drogue (90 m) apparently functioned well but was lost soon after 1602Z 6 November.

RED drogue's (255 m) sustained rapid movement up-Canyon aroused suspicions that the wire to parachute was broken, however a physical check proved it intact. RED was subsequently lost after 1617Z 6 November, and a new drogue, RED_2, set at Site Xj, 0031Z 7 November, where extensive STD observations were in progress. RED_2 was lost after 1513Z 7 November, and reset as RED_3 at 1631Z 7 November with slightly shortened wire, 247 m. RED_3 was tracked until cessation of the operations.

YELLOW drogue (230 meters, initially) was set at the same time (0134Z 5 Nov) and site as BLUE and RED drogue. Soon after 0720Z 6 November, YELLOW grounded and the wire broke. At 0827Z 6 November it was reset at the origin as a 180 m drogue. Again it grounded and broke wire, soon after 0138Z 7 November, and was reset as a 50 m drogue at 1627Z 7 November. Thereafter it was sucessfully tracked until 0210Z 8 November.

3.2 STD Station Data

3.2.1 Data Format

The primary output of the shipboard STD system is an essentially real-time data listing on punched paper tape and write-out by electric typewriter. Details of the signal processing system are described in a manuscript report "Programs for Data Acquisition and Processing aboard the NOAA Ship OCEANOGRAPHER" by LTjg Gregory Holloway, December 1970. The program SUPER 4,2. was used, which averages 4 sets of signals from each sensor, compares each value with the average, rejects the most distant value, and recomputes a new average value. An averaged value for each sensor is computed each second, however the typewriter speed limits write-out to once per 3 seconds. As an off-line process, the punch paper tape can be used to drive the shipboard X-Y plotter, to prepare graphs of temperature, salinity, Vaisala-Brunt frequency and sigma-t versus depth. Figure 6 illustrates data from a typical deeper STD station.

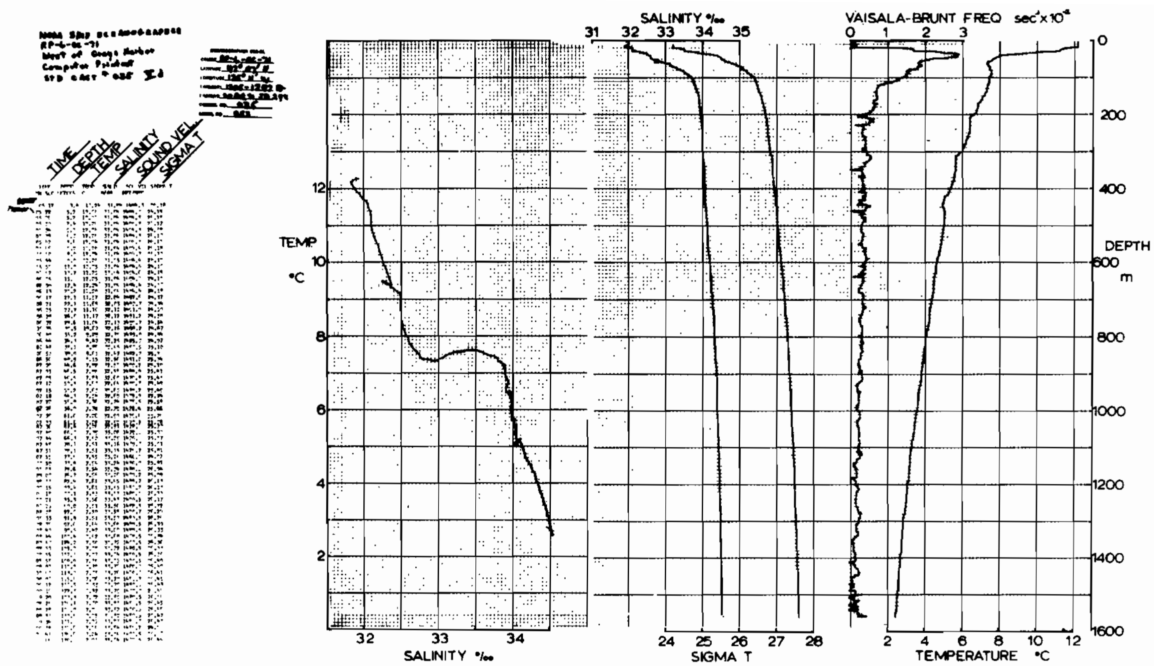

Figure 6. STD Station Data Format.

3.2.2 STD Deployment

As indicated in section 2.2 it was hoped to obtain station data continuously from the surface to within about 4 meters of the bottom. Heavy seas, strong winds and somewhat encumbered maneuvering due to the inoperative condition of the bow thruster, made station keeping (and finding) difficult. As a result, over steeply sloping bottoms in the interest of safety, the sensor was held somewhat higher (8 to 10 m) above the bottom. Despite this, sampling depth as recorded by the STD, exceeded fathomer depth (corrected for sound velocity) about 25% of the time. Some of these inconsistencies could be due to the ship drifting into deeper water during the station, however it is believed that in most cases the fathometer depths are in error, due to the slope effect on the broad beam echo sounder.

3.2.3 STD Calibration

The performance of the STD system was monitored by comparing the STD data with data from Nansen bottles attached to the STD wire immediately above the sensors and with data from conventional Nansen casts. The success of this effort was less than desired due to several factors. Heavy weather prevailing during much of the time, caused considerable ship motion at the stern where the STD was deployed. The resultant vertical surging of the sensor package, largely invalidated calibration attempts for low salinity waters encountered in the Columbia River plume, where vertical thermo-haline gradients are very strong. Further, difficulties with the signal processing system during the early portion of the field work, and sensor failure and replacement at station 213, reduced the number and applicability of the good calibration checks.

For stations 1-213, the calibration data were largely inconclusive except for the determination of a depth correction of 7.5 m for stations 1-17; appropriate adjustment was then made to the data processing system for stations 18-213. Error estimates for stations 1-213 are therefore quoted from the manufacturer's specifications as follows:

Depth	± 5 m
Temperature	± .02 °C
Salinity	± .03 ^{o}/oo

For Stations 214-278, calibration attempts for the replacement sensor package were somewhat more successful. Weather conditions ameliorated enough to allow two Nansen stations to the full depth of the deep STD casts (2000 m), while at the seaward end of the sections. Nansen sta.

No 1 was occuppied in conjunction with STD sta. 236 with 105 minutes between messenger time and end of the STD cast. Nansen sta. No 2 was at the site of STD sta 254, with 88 minutes between the two sets of observations. Data scatter still exceeded previous experience with the system, perhaps more as a result of poor calibration conditions than instrumental instability. Temperature comparisons indicate STD-reversing thermometer differences ranging from +0.08° to -.06 °C, with 60% of comparisons $\pm$ .04 °C. STD salinity was found to require a depth dependent correction, which was calculated to be: $-0.1^{o}/oo - 0.4 \times 10^{-4} Z^{o}/oo$ (Z = depth in meters). This correction has been applied to the data presented graphically in this report.

3.2.4 STD Station Inventory

An inventory of STD stations occupied during this cruise is presented on tables 1 and 2 which list the stations by serial number and location, respectively.

3.2.5 Thermohaline Properties in the Study Area October-November 1971

October and November conditions found in the coastal waters are portrayed by a series of surface views (Plate 2) and cross sections (Plates 3 and 4). The October survey was conducted 17-24 October; the November survey was conducted from 12 November to 19 November. Cross sectional views for Lines I, VII, and X from the November survey are presented to depict the temporal changes in properties which occurred at the north and south extremities of the region and centrally at the Juan de Fuca Canyon. The surface views, for October and November utilize data from all stations plotted on the respective figures.

Table 1. STD Station Inventory by Station Number.

STD STATION INVENTORY BY STATION NUMBER

STA NO.	LOC'N	DATE	CAST DEPTH	STA NO.	LOC'N	DATE	CAST DEPTH	STA NO.	LOC'N	DATE	CAST DEPTH	STA NO.	LOC'N	DATE	CAST DEPTH
1	X k	14 X	297	40	V i	20 X	128	79	II d	23 X	1132	118	X fa	26 X	305
2	X j	14 X	345	41	V j	20 X	86	80	II c	23 X	1600	119	X s	26 X	202
3	X i	14 X	316	42	V k	20 X	49	81	II b	23 X	2006	120	PP*	30 X	190
4	X h	15 X	314	43	IV k	21 X	54	82	II a	24 X	2000	121	PP	30 X	176
5	X g	15 X	287	44	IV j	21 X	92	83	I a	24 X	2006	122	PP	30 X	187
6	X f	15 X	201	45	IV i	21 X	120	84	I b	24 X	1324	123	PP	30 X	192
7	X d	15 X	734	46	IV h	21 X	173	85	I c	24 X	1388	124	PP	30 X	182
8	VII a	17 X	1996	47	IV g	21 X	555	86	I d	24 X	1101	125	PP	30 X	177
9	VII b	17 X	2000	48	IV f	21 X	891	87	I e	24 X	732	126	PP	30 X	182
10	VII c	17 X	2000	49	IVea	21 X	741	88	I f	24 X	330	127	PP	30 X	155
11	VII d	17 X	1288	50	IV e	21 X	997	89	I g	24 X	185	128	PP	30 X	170
12	VII e	17 X	882	51	IV d	21 X	1417	90	I h	24 X	137	129	PP	30 X	176
13	VII f	17 X	549	52	IV c	21 X	1648	91	I i	24 X	80	130	PP	30 X	180
14	VII g	17 X	228	53	IV b	21 X	2003	92	I j	24 X	55	131	PP	30 X	182
15	VII h	17 X	158	54	IV a	22 X	2003	93	X x	24 X	105	132	PP	30 X	179
16	VII i	17 X	136	55	IV d	22 X	1407	94	X f	25 X	232	133	PP	30 X	180
17	VII j	17 X	88	56	X a	22 X	1245	95	X y	25 X	149	134	PP	30 X	178
18	VII k	18 X	56	57	X b	22 X	1068	96	X e	25 X	418	135	PP	30 X	179
19	VI m	18 X	32	58	X c	22 X	849	97	X f	25 X	235	136	PP	30 X	182
20	VI l	18 X	43	59	X d	22 X	647	98	X fa	25 X	280	137	PP	30 X	177
21	VI k	18 X	82	60	X e	22 X	409	99	X s	25 X	198	138	PP	30 X	186
22	VI j	18 X	97	61	X f	22 X	262	100	X h	25 X	314	139	PP	30 X	180
23	VI i	18 X	225	62	X g	22 X	301	101	X e	25 X	420	140	PP	30 X	186
24	VI h	18 X	408	63	X h	22 X	148	102	X f	25 X	213	141	PP	30 X	185
25	VI g	18 X	727	64	X i	23 X	348	103	X fa	25 X	286	142	PP	30 X	186
26	VI f	18 X	1095	65	X h	23 X	344	104	X s	25 X	193	143	PP	30 X	184
27	VI e	18 X	1749	66	X j	23 X	298	105	X h	25 X	319	144	PP	30 X	180
28	VI d	18 X	2002	67	X k	23 X	294	106	X e	25 X	344	145	IX a	30 X	125
29	VI c	19 X	2000	68	VIIIe	23 X	52	107	X f	25 X	229	146	IX b	30 X	228
30	VI b	19 X	1999	69	VIIId	23 X	236	108	X fa	25 X	290	147	IX c	30 X	250
31	VI a	19 X	996	70	VIIIc	23 X	267	109	X s	25 X	212	148	IX d	30 X	126
32	V a	20 X	1500	71	VIIIb	23 X	122	110	X h	25 X	318	149	IX c	30 X	241
33	V b	20 X	1997	72	VIIIa	23 X	102	111	X e	25 X	500	150	IX b	31 X	228
34	V c	20 X	1569	73	II j	23 X	87	112	X fa	25 X	217	151	IX a	31 X	183
35	V d	20 X	1549	74	II i	23 X	135	113	X fa	25 X	302	152	IX b	31 X	226
36	V e	20 X	1141	75	II h	23 X	92	114	X s	26 X	218	153	IX c	31 X	246
37	V g	20 X	293	76	II g	23 X	176	115	X h	26 X	298	154	IX d	31 X	183
38	V f	20 X	626	77	II f	23 X	378	116	X e	26 X	427	155	IX c	31 X	248
39	V h	20 X	164	78	II e	23 X	794	117	X f	26 X	237	156	IX b	31 X	227

* PP Pillar Pt. near 48° 18'N, 124° 04'W.

Table 1. (continued)

STD STATION INVENTORY BY STATION NUMBER
(CONTINUED)

STA NO.	LOC'N	DATE	CAST DEPTH		STA NO.	LOC'N	DATE	CAST DEPTH		STA NO.	LOC'N	DATE	CAST DEPTH		STA NO.	LOC'N	DATE	CAST DEPTH
157	IX a	31 X	183		198	β c	7 XI	318		237	VI b	16 XI	2002		276	X u	19 XI	188
158	IX b	31 X	227		199	β c	7 XI	325		238	VI c	16 XI	2001		277	X v	19 XI	182
159	IX c	31 X	251		200	β c	7 XI	320		239	VI d	16 XI	2001		278	X z	19 XI	225
160	IX d	31 X	224		201	β c	8 XI	301		240	VI e	17 XI	1804					
161	IX c	31 X	243		202	β c	7 XI	321		241	VI g	17 XI	726					
162	IX b	31 X	234		203	I i	12 XI	76		242	VI l	17 XI	363					
165	IX a	31 X	249		204	I h	12 XI	121		243	VI i	17 XI	184					
166	IX d	1 XI	153		205	I g	12 XI	168		244	VI j	17 XI	117					
167	IX c	1 XI	244		206	I f	12 XI	349		245	VI k	17 XI	91					
168	IX b	1 XI	223		207	I e	12 XI	707		246	V j	17 XI	98					
169	IX a	1 XI	171		208	I d	12 XI	1104		247	V i	17 XI	139					
170	IX b	1 XI	228		209	I c	12 XI	1296		248	V h	17 XI	184					
171	IX c	1 XI	244		210	I a	12 XI	1967		249	V g	17 XI	354					
172	IX d	1 XI	203		211	I c	12 XI	1280		250	V f	17 XI	842					
173	IX c	1 XI	243		212	II a	13 XI	2005		251	V e	17 XI	1255					
174	IX b	1 XI	220		213	II b	13 XI			252	V d	17 XI	1579					
175	IX b	1 XI	230		214	II b	13 XI	2008		253	V c	17 XI	1863					
176	II f	1 XI	362		215	II d	13 XI	1255		254	V b	18 XI	1998					
177	II e	1 XI	699		216	II e	13 XI	734		255	V a	18 XI	2001					
178	II d	1 XI	702		217	II f	13 XI	360		256	IV a	18 XI	2002					
179	α* a	3 XI	883		218	II g	13 XI	180		257	IV b	18 XI	1999					
180	α b	3 XI	536		219	II h	13 XI	93		258	IV c	18 XI	1723					
181	α c	3 XI	531		220	II i	13 XI	106		259	IV d	18 XI	1374					
182	α d	3 XI	260		221	III f	13 XI	760		260	X a	18 XI	1226					
183	X j	4 XI	331		222	III e	13 XI	1114		261	X b	18 XI	1007					
184	X i	4 XI	340		223	III d	13 XI	1539		262	X c	18 XI	778					
185	X j	5 XI	319		224	III c	13 XI	1780		263	X d	18 XI	713					
186	X i	5 XI	341		225	III b	14 XI	1770		264	X e	18 XI	534					
187	X h	5 XI	336		226	IIIaa	14 XI	2006		265	X f	18 XI	204					
188	X j	6 XI	321		227	VII i	14 XI	147		266	X g	18 XI	308					
189	β** a	6 XI	121		228	VII h	14 XI	162		267	X h	18 XI	317					
190	β b	6 XI	203		229	VII g	16 XI	271		268	X i	19 XI	287					
191	β c	6 XI	320		230	VII f	16 XI	619		269	X j	19 XI	225					
192	β d	6 XI	247		231	VII e	16 XI	875		270	X k	19 XI	313					
193	β e	6 XI	165		232	VII d	16 XI	1297		271	IX d	19 XI	197					
194	β c	7 XI	318		233	VII c	16 XI	2001		272	IX c	19 XI	251					
195	β c	7 XI	312		234	VII b	16 XI	2002		273	IX b	19 XI	222					
196	β c	7 XI	295		235	VII a	16 XI	2000		274	IX a	19 XI	165					
197	β c	7 XI	314		236	VI a	16 XI	2002		275	X w	19 XI	181					

* For Drogue set α near location II e
** For Drogue set β near location X j

Table 2. STD Station Inventory by Location.

STD STATION INVENTORY BY LOCATION

LINE	LOC'N DESIG	STA NO.	DATE	LINE	LOC'N DESIG	STA NO.	DATE	LINE	LOC'N DESIG	STA NO.	DATE	LINE	LOC'N DESIG	STA NO.	DATE
I	a	83	24 X	II	g	218	13 XI	V	k	42	20 X	VII	d	11	17 X
I	b	84	24 X	II	h	219	13 XI	V	j	246	17 XI	VII	e	12	17 X
I	c	85	24 X	II	i	220	13 XI	V	i	247	17 XI	VII	f	13	17 X
I	d	86	24 X					V	h	248	17 XI	VII	g	14	17 X
I	e	87	24 X	III	f	221	13 XI	V	g	249	17 XI	VII	h	15	17 X
I	f	88	24 X	III	e	222	13 XI	V	f	250	17 XI	VII	i	16	17 X
I	g	89	24 X	III	d	223	13 XI	V	e	251	17 XI	VII	j	17	17 X
I	h	90	24 X	III	c	224	13 XI	V	d	252	17 XI	VII	k	18	18 X
I	i	91	24 X	III	b	225	14 XI	V	c	253	17 XI	VII	l	227	14 XI
I	j	92	24 X	III	aa	226	14 XI	V	b	254	18 XI	VII	h	228	14 XI
I	i	203	12 XI					V	a	255	18 XI	VII	g	229	16 XI
I	h	204	12 XI	IV	k	43	21 X					VII	f	230	16 XI
I	g	205	12 XI	IV	j	44	21 X	VI	m	19	18 X	VII	e	231	16 XI
I	f	206	12 XI	IV	i	45	21 X	VI	l	20	18 X	VII	d	232	16 XI
I	e	207	12 XI	IV	h	46	21 X	VI	k	21	18 X	VII	c	233	16 XI
I	d	208	12 XI	IV	g	47	21 X	VI	j	22	18 X	VII	b	234	16 XI
I	c	209	12 XI	IV	f	48	21 X	VI	i	23	18 X	VII	a	235	16 XI
I	a	210	12 XI	IV	ea	49	21 X	VI	h	24	18 X				
I	c	211	12 XI	IV	e	50	21 X	VI	g	25	18 X	VIII	e	68	23 XI
				IV	d	51	21 X	VI	f	26	18 X	VIII	d	69	23 XI
II	j	73	23 X	IV	c	52	21 X	VI	e	27	18 X	VIII	c	70	23 XI
II	i	74	23 X	IV	b	53	21 X	VI	d	28	18 X	VIII	b	71	23 XI
II	h	75	23 X	IV	a	54	22 X	VI	c	29	19 X	VIII	a	72	23 XI
II	g	75	23 X	IV	d^2	55	22 X	VI	b	30	19 X				
II	f	77	23 X	IV	a	256	18 XI	VI	a	31	19 X	IX	a	145	30 X
II	e	78	23 X	IV	b	257	18 XI	VI	a	236	16 XI	IX	b	146	30 X
II	d	79	23 X	IV	c	258	18 XI	VI	b	237	16 XI	IX	c	147	30 X
II	c	80	23 X	IV	d	259	18 XI	VI	c	238	16 XI	IX	d	148	30 X
II	b	81	23 X					VI	d	239	17 XI	IX	c	149	30 X
II	a	82	24 X	V	a	32	20 X	VI	e	240	17 XI	IX	b	150	31 X
II	f	176	1 XI	V	b	33	20 X	VI	g	241	17 XI	IX	a	151	31 X
II	e	177	1 XI	V	c	34	20 X	VI	l	242	17 XI	IX	b	152	31 X
II	d	178	1 XI	V	d	35	20 X	VI	i	243	17 XI	IX	c	153	31 X
II	a	212	12 XI	V	e	36	20 X	VI	j	244	17 XI	IX	d	154	31 X
II	b	213	13 XI	V	g	37	20 X	VI	k	245	17 XI	IX	c	155	31 X
II	b	214	13 XI	V	f	38	20 X					IX	b	156	31 X
II	d	215	13 XI	V	h	39	20 X	VII	a	8	17 X	IX	a	157	31 X
II	e	216	13 XI	V	i	40	20 X	VII	b	9	17 X	IX	b	158	31 X
II	f	217	13 XI	V	j	41	20 X	VII	c	10	17 X	IX	c	159	31 X

Table 2. (continued)

STD STATION INVENTORY BY LOCATION
(CONTINUED)

LINE	LOC'N DESIG	STA NO.	DATE	LINE	LOC'N DESIG	STA NO.	DATE	LINE	LOC'N DESIG	STA NO.	DATE	LINE	LOC'N DESIG	STA NO.	DATE
IX	b	160	31 X	X	x	93	24 X	X	h	267	18 XI	PP		130	30 X
IX	c	161	31 X	X	f	94	25 X	X	i	268	19 XI	PP		131	30 X
IX	b	162	31 X	X	y	95	25 X	X	j	269	19 XI	PP		132	30 X
IX	a	163	31 X	X	e	96	25 X	X	k	270	19 XI	PP		133	30 X
IX	b	164	31 X	X	f	97	25 X	X	w	275	19 XI	PP		134	30 X
IX	c	165	31 X	X	fa	98	25 X	X	u	276	19 XI	PP		135	30 X
IX	d	166	1 XI	X	z	99	25 X	X	v	277	19 XI	PP		136	30 X
IX	c	167	1 XI	X	h	100	25 X	X	z	278	19 XI	PP		137	30 X
IX	b	168	1 XI	X	e	101	25 X					PP		138	30 X
IX	a	169	1 XI	X	f	102	25 X	α*	a	179	3 XI	PP		139	30 X
IX	b	170	1 XI	X	fa	103	25 X	α	b	180	3 XI	PP		140	30 X
IX	c	171	1 XI	X	h	105	25 X	α	c	181	3 XI	PP		141	30 X
IX	d	172	1 XI	X	e	106	25 X	α	d	182	3 XI	PP		142	30 X
IX	c	173	1 XI	X	f	107	25 X					PP		143	30 X
IX	b	174	1 XI	X	fa	108	25 X	β**	a	189	6 XI	PP		144	30 X
IX	b	175	1 XI	X	z	109	25 X	β	b	190	6 XI				
IX	d	271	19 XI	X	h	110	25 X	β	c	191	6 XI				
IX	c	272	19 XI	X	e	111	25 X	β	d	192	6 XI				
IX	b	273	19 XI	X	fa	112	25 X	β	e	193	6 XI				
IX	a	274	19 XI	X	fa	113	25 X	β	c	194	7 XI				
				X	z	114	26 X	β	c	195	7 XI				
X	k	1	14 X	X	h	115	26 X	β	c	196	7 XI				
X	j	2	14 X	X	e	116	26 X	β	c	197	7 XI				
X	i	3	14 X	X	f	117	26 X	β	c	198	7 XI				
X	h	4	15 X	X	fa	118	26 X	β	c	199	7 XI				
X	g	5	15 X	X	z	119	26 X	β	c	200	7 XI				
X	f	6	15 X	X	j	183	4 XI	β	c	201	8 XI				
X	a	56	22 X	X	i	184	4 XI	β	c	202	8 XI				
X	b	57	22 X	X	j	185	5 XI								
X	c	58	22 X	X	i	186	5 XI	PP***		120	30 X				
X	d	59	22 X	X	h	187	5 XI	PP		121	30 X				
X	e	60	22 X	X	j	188	6 XI	PP		122	30 X				
X	f	61	22 X	X	a	260	18 XI	PP		123	30 X				
X	g	62	22 X	X	b	261	18 XI	PP		124	30 X				
X	h	63	22 X	X	c	262	18 XI	PP		125	30 X				
X	i	64	23 X	X	d	263	18 XI	PP		126	30 X				
X	h	65	23 X	X	e	264	18 XI	PP		127	30 X				
X	j	66	23 X	X	f	265	18 XI	PP		128	30 X				
X	k	67	23 X	X	g	266	18 XI	PP		129	30 X				

* For Drogue set α near location II e.
** For Drogue set β near location X j.
*** PP Pillar Pt. near 48° 18'N, 124° 04'W.

Depth scales and contour intervals were varied in the figures of the plates in order to accomodate the very considerable changes in gradients encountered in these coastal waters; the captions contain the pertinent information. Line X however is presented at a constant depth scale to avoid distortion at the Juan de Fuca Canyon depths. Several comments are offered on the adequacy of these figures. It is customary to consider the contoured data as though they are representative of a synotic look. In fact they are not. The strong horizontal and vertical gradients, (particularly near the mouth of the Columbia [spanned by Lines VI and VII] and the Straits of Juan de Fuca) coupled with the strong currents and severe storm conditions, to some measure vitiate the contour concept. This is particularly evident in the plan views as surface properties are especially subject to time changes. A further complication was the poor STD performance which has been discussed in section 2 of this report. Thus contour interval has been broadened in some areas to avoid the creation of ficticious detail. Despite the above qualifications the cross-sections provide a fairly detailed picture of the properties during a season when strong storm activity is rapidly effecting the fall transition. Truly adequate coverage will require a multiship effort with efficient STD systems.

In this data report it is inappropriate to include other than minimal analysis on the data presented. The common occurance of temperature inversions at depth, particularly in the lamina of 7 to 8 °C water is found in all sections in October, and the three sections presented for November (Lines I, VII, X). The salinity structure associated with these inversions is competent to maintain a stable water column. A common characteristic of the water column as seen in almost all stations of the region, (excluding a few inshore stations on Line I), is a relatively broad range of salinities 32.75 to 33.75 $^{o}/oo$ associated with a very narrow range ($\pm$ 0.25 °C) of temperatures centered at 7.5 °C.

Although barely a month separated the two occupations of Line VII and only 19 days the two series of STDs on Line I, the data reveal substantial cooling of the surface from October values. Heat losses were affected to at least 50 meters (compare figures a, g with h, i of Plate 3, respectively).

3.2.6 STD Time Series

RCSS 1 and RCSS 2 (fig. 1a, 1b) comprise a set of October-November (1971) stations at virtually the same locations. Inspection of table 2 will show other instances of reoccupied sites. The Line IX series (table 2, sta. 145 through 175) are an hourly sequence of 36 stations at four specified locations across the mouth of the Straits of Juan de Fuca. Figure 7 shows the space-time-tide relationship for these stations; the tide data is from the nearby Neah Bay station. For simplicity the spacial relationships are presented in terms of latitude. Longitudinal variations in station locations are relatively small and unimportant in this series. The Pillar Point stations (table 2, sta. 120 through 144) occupied at hourly intervals, varied about $\pm$ 1 mile from the specified location. Inspection of this series shows that the variation in station locations has seriously weakened the significance of the time changes. Several time series were occupied on

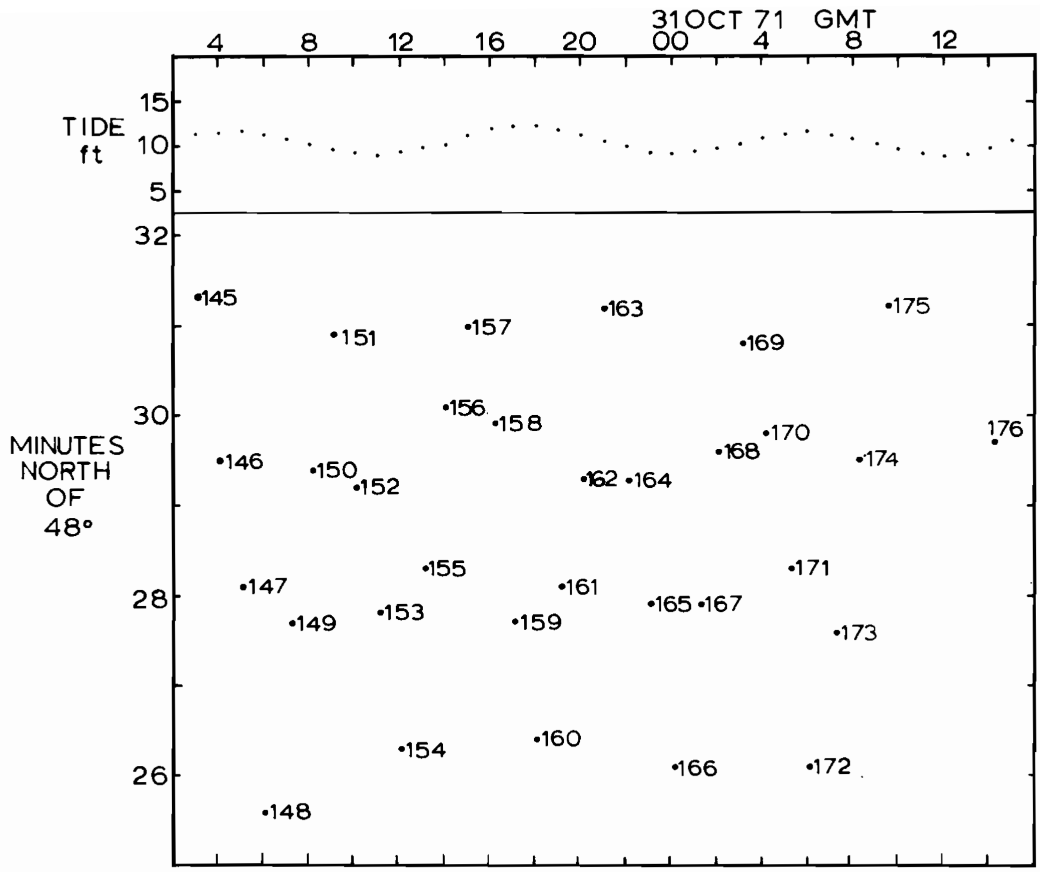

Figure 7. Diagram of STD Station Latitude (vicinity of site A) Time-Tide Relationships. STD stations serial 145 through 176 were occupied at 4 specified latitudes along line normal to axis of Strait of Juan de Fuca near site A. Diagram indicates actual latitude of each station (longitudinal variations were insignificant). The tide data is from nearby Neah Bay.

Line X. Stations 96 through 119 comprise a sequence of 23 observations at 5 locations in the Canyon near Site B_0 over a 29 hour period. Series BETA stations (NOS 189 - 202), were occupied at or near sites Xi and Xj during the BETA drogue series. These sites were also occupied as early as 14 October and as late as 19 November.

3.3 Thermistor Temperature Data from Site B_0

The thermistor based sensing system at Site B_0 operated successfully during the period from launch, 1654 October 15 to recovery 0001 15 November (GMT). Plate 5 illustrates the temperatures recorded at the three sensing levels (175, 195 and 235 m - see fig. 3). The temperature traces for the lower two levels appear to cross each other at several places indicating substantial temperature inversions in some cases (e.g. from 99 to 132 hours, traces for 195 and 235 meter temperatures). In fact the traces rarely cross; inspection of the digital data shows that only at times 317 and 678 hours did actual temperature inversions occur. These inversions were small, ranging up to about 0.05 °C, with durations of 35 and 65 minutes, respectively. The other apparent crossings are in reality only points of tangency, indicating brief periods of isothermal conditions at the two levels.

3.4 Tidal Data from Neah Bay Standard Tide Gage

Hourly tidal height data from the Neah Bay permanent tide gage for the period of the current meter observations are presented in Plate 5. The data were provided by the Tides Branch of NOAA's National Ocean Survey.

3.5 Meteorological Data

Wind data from the Umatilla light ship, recorded in Greenwich Mean Time, (see fig. 1 for location) are reproduced in table 3. The recording interval is uneven but regular, being on a 4, 2, 6 hour cycle throughout the day. Wind data from the Cape Flattery light station are recorded at 3-hour intervals with direction recorded in "points" of the compass. As its location off the Straits may make winds less representative of the open ocean the data are not reproduced here. Meteorological data were recorded hourly on the ship OCEANOGRAPHER. Wind data at 3-hour intervals are reproduced in table 5. Figure 8 illustrates wind vectors recorded at Umatilla light ship and the OCEANOGRAPHER, during a period of storm activity 21, 22 October, when the ship was working on Lines IV and X, relatively close to the light ship. On October 21 the speeds at both stations were about the same; but the direction at the light ship was clearly more easterly than on the survey ship. The limited data available from the light ship suggests that as wind speeds diminished, the wind vectors at both stations became more equal.

3.6 Bathymetry near Site B_o

A limited bathymetric development of the immediate vicinity of Site B was conducted under HIFIX positioning control. The results, corrected for sound velocity but not for slope error, and contoured on a 20 fathom interval, are shown in figure 4. Even at this rather broad contour interval the Canyon floor has numerous irregularities. A heretofore unmapped area of the channel, with depths exceeding 100 fm, trending southwest, is noted in the left central portion of the contoured chartlet.

Table 3. Umatilla Light Ship $48^{\circ}.1$ N $124^{\circ}.8$ W
Wind Speed in Knots.

DATE		HOUR (GMT)											
1971		03		05		11		15		17		23	
		DIR	S	DIR	S	DIR	S	DIR	S	DIR	S	DIR	S
OCTOBER	12	00	00	00	00	09	17	22	07	12	14	17	17
	13	17	20	22	22	30	13	30	22	30	22	29	17
	14	29	16	26	19	26	13	22	06	27	10	26	07
	15	15	05	18	09	02	13	02	08	03	10	33	10
	16	31	07	03	05	05	10	05	10	05	10	33	10
	17	35	10	08	05	18	07	16	08	16	08	16	08
	18	17	04	15	04	21	08	28	05	16	12	11	18
	19	11	20	14	26	18	31	23	25	20	11	26	17
	20	23	31	15	11	17	12	20	15	23	08	21	09
	21	22	18	12	17	17	25	17	18	14	26	11	35
	22	11	35	18	34			12	17	12	15	16	17
	23	16	15	19	17	15	08	15	09	11	03	25	07
	24	30	08	30	04	30	11	25	13	16	17	10	20
	25	16	22	18	32	17	22	19	26	18	30	20	22
	26	28	25	30	27	30	26	32	35	29	27	29	15
	27	30	26	35	26	32	14	02	16	01	16	03	12
	28	07	11	03	09	03	10	04	08	09	06	00	00
	29	00	00	00	00	13	04	15	14	13	15	13	25
	30	15	22	14	26	13	30	14	12	06	08	33	07
	31	35	08	06	04	07	07	15	13	11	23	15	31
NOVEMBER	1	25	25	27	28	29	22	26	19	31	23	28	10
	2	27	17	26	08	24	09	20	15	14	17	15	20
	3	16	26	15	45	14	45	29	04	28	07	28	13
	4	21	13	29	22	24	25	30	35	31	29	31	13
	5	32	05	21	05	09	12	09	11	11	12	29	05
	6	32	07	10	08	08	08	11	10	09	08	04	06
	7	09	13	12	16	17	10	25	20	23	13	20	25
	8	18	20	17	27	15	40	17	35	16	45	17	45
	9	17	40	17	45	17	40	17	40	17	40	17	50
	10	16	37	16	25	16	20	17	24	16	20	14	10
	11	17	15	17	12	00	00	19	05	17	05	31	10
	12	33	08	01	08	01	05	08	08	13	14	15	08
	13	16	14	07	16	17	15	07	15	10	20	18	11
	14	15	20	27	22	16	20	35	22	31	20	29	10
	15	00	00	19	10	14	18	06	05	06	06	00	00
	16	10	08	08	02	00	00	00	00	00	00	00	00
	17	31	03	00	00	18	10	06	06	10	08	35	03
	18	35	13	26	05	00	00	14	05	13	10	15	10
	19	12	20	12	20	16	25	16	22	17	20	17	20

Table 4. NOS Ship OCEANOGRAPHER OSS-1 Wind Speed in Knots.

DATE		HOUR (LOCAL TIME)															
1971		01		04		07		10		13		16		19		22	
		DIR	S	DIR	S	DIR	S	DIR	S	DIR	S	DIR	S	DIR	S	DIR	S
	14	25	16	30	05	28	03	09	02	04	12	30	14	33	05	07	14
	15	08	14	03	14	03	14	04	07	04	06	33	07	01	06	35	05
	16	06	05	02	14	02	07	03	02	02	10	03	12	01	21	02	13
	17	02	12	00	06	00	05	33	04	22	03	20	12	12	11	20	09
O	18	34	20	33	07	32	04	16	05	22	15	18	25	18	32	20	38
C	19	25	30	24	22	27	14	30	22	27	24	28	16	25	16	22	10
T	20	24	17	26	19	26	16	29	12	24	12	20	06	18	12	17	16
O	21	18	22	17	23	14	14	16	28	17	36	16	40	18	38	25	18
B	22	25	10	19	06	15	10	16	14	17	16	17	15	18	14	17	12
E	23	14	10	13	08	09	11	29	08	32	05	29	10	30	12	33	03
R	24	21	06	23	05	20	07	16	12	18	14	16	18	18	18	19	24
	25			18	18	20	17	21	22	22	19	29	18	31	21	32	28
	26	29	28	29	24	25	18										
	27																
	28																
	29											08	12	06	12	08	16
	30	09	16	09	14	11	08	06	03	32	05	15	08	10	06	14	04
	31	10	12	13	08	05	12	12	12	11	14	19	24	28	13	28	24
	1	31	20	29	20	28	22	30	20	31	22	32	14	33	10	31	08
	2	30	06	24	07	20	10	20	15	18	18	19	18	19	31	19	27
	3	24	24	31	08	01	04	07	02	Calm	00	23	08	29	15	30	21
	4	31	22	32	24	32	23	32	19	34	09	31	12	34	11	Calm	00
	5	15	10	12	04	12	08	11	07	22	07	20	09	11	14	09	13
	6	10	18	08	23	08	18	10	20	09	16	10	20	09	18	16	22
N	7	15	24	10	09	26	08	23	13	25	18						
O	8																
V	9																
E	10																
M	11																
B	12	Var.	04			11	12	14	16*	16	18	15	24	14	32	13	25
E	13	14	28	11	29	07	25	10	21	09	16	32	22	32	35	33	36
R	14	33	40	32	33	32	27	31	17	29	17	29	08	20	08	11	08
	15	13	21	31	08	27	09	27	06	30	12	31	08	31	06	34	09
	16	36	14	33	07	01	12	02	08	35	08	33	13	35	08	01	06
	17	09	04	02	06	Calm	00	15	04	25	06	25	06	25	03	22	04
	18	20	04	20	05	16	12	15	16	17	16	15	20	11	10	10	08
	19	20	16	23	04	30	03	16	04	15	11	18	16	14	10		

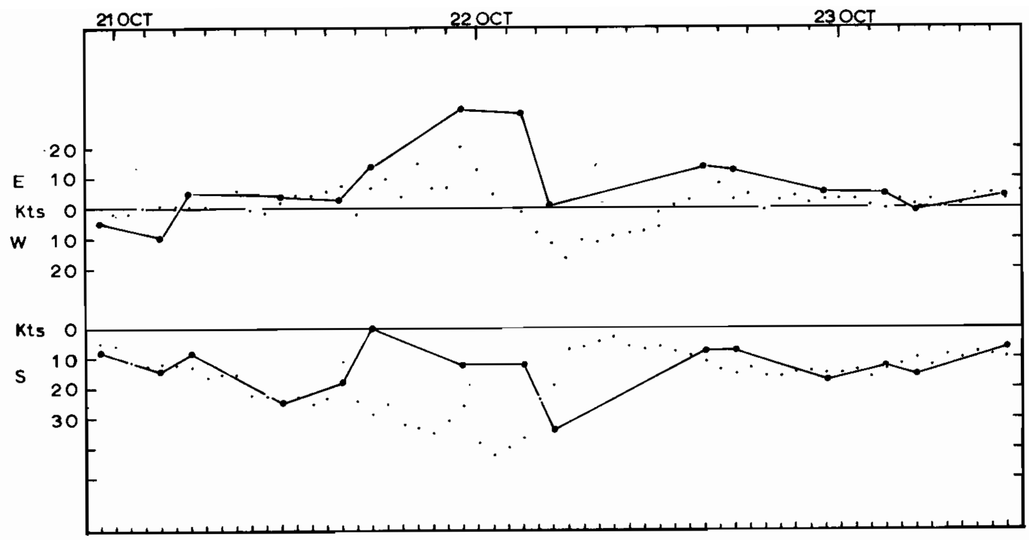

Figure 8. Wind Velocity Vectors Recorded at Umatilla Light Ship (connected data points) and Ship OCEANOGRAPHER (isolated data points) 21-23 October 1971. Ship OCEANOGRAPHER was within 110 km of the Lightship during this period.

As a result of a post-cruise check it has been established that this channel shoals immediately west of the contoured area. The location chartlet for figure 4, was constructed from a bathymetric chart by B. Carson of the University of Washington.

4. ACKNOWLEDGEMENTS

Deployment and retrieval of the moored instrument arrays is a relatively complex operation requiring precise handling of the ground tackle, deck machinery and ship. We wish to call special attention to the services of CDR J.P. Randall, who personally directed all aspects of this difficult work and whose efforts were 100% successful. Checks on the integrity of the parachute drogues, essential in establishing validity

of drogue data, were performed by the rubber boat (ZODIAC) crews under sloppy sea conditions at considerable physical discomfort and risk. ENS K. Schnebele, R. Karlin and Chief Pharmacists Mate J. Scott were unhesitating in performing this difficult work. The Survey technicians on the ship were, to a man, diligent and careful in the most important aspect of the station work that of operating the instrumentation and faithfully recording the data. Their team effort was outstanding. Ensigns D. Black, R.H. Daly and J.H. Wexler assisted in the post-cruise analysis of the data, thereby greatly facilitating the preparation of this report. Finally, it is the Captain of the ship who sets the level of cooperation and effort. We are greatly indebted to CAPT Miller J. Tonkel who communicated his sincere interest in the success of our work to every man on the ship.

5. REFERENCES

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APPENDIX

A.1 Letter report from Chief Scientist to Drs. C. A. Barnes and J. D. Smith of the University of Washington dated December 14, 1971

RF28-20g-571

Report on POL/UW cooperative field work - Washington coast
Fall 1971

Drs. C.A. Barnes and J.D. Smith

Project Instructions for RP-6-OC-71

Current meters and associated instrumentation owned by the University of Washington and POL were deployed during the NOAA POL Research Cruise RP-6-OC-71 (currents in Juan de Fuca Canyon and adjacent waters) to support both the University's and the Pacific Oceanographic Laboratories' research projects. The interests of the two cooperating organizations are complementary in that together the results provide an integrated body of data on the currents off the Washington coast. The general plan for the work is outlined in the attached project instructions dated 10 September 1971.

Six current measuring systems and a marker buoy were deployed and recovered (less marker buoy) essentially in conformance with the project instructions.

Details concerning the two instrument systems deployed for the UW are as follows:

Site Designator: "C"

Site Information: 46°26'N, 124°20'W, water depth 77 m, (near USCG temporary buoy "University of Washington oceanographic lighted Buoy "N").

Deployment: Installed 16 October 1971 2055Z
Recovered 15 November 1971 1845Z

Instrumentation:

Type	Serial No.	Height above bottom (m)	Remarks
Braincon CM	B-129	62	Rotor off bearing when recovered.
Braincon CM	B-128	57	Vane missing (broken off) when recovered.

Braincon CM	B-155	47	Vane missing (broken off) when recovered.
Aanderaa	A-352	28	Tinned copper seizing wire badly eroded.
Aanderaa	A-	11	Same as A-352
Aanderaa	A-348	6	Same as A-352 Swivel rod bent, rotor missing
Acoustic release	ORE-191-3	3	Normal functioning

The 0.2 -m length wire rope connecting A-348 to the ORE-191-3 was severly eroded, only the central strand remaining (see photo #1). This sample was retained and delivered to the Columbia River Effluent Study group at UW.

Comments on site "C" system: Pending processing of the data records, which will establish when the meters were damaged, one can only speculate on the causes of the relatively severe failures of the instruments. The broken fiberglass vanes on Braincon meters B-128, B-155 appeared to be fresh breaks and it is surmised (and hoped) that the breaks occurred upon retrieving the instruments. The Aanderaa meter, A-348, showed oxide discoloration on the bent members, implying the damage was done at installation. As the photo #2 illustrates, the meter was rotated 180° on its vertical axis. It is suspected that this occurred on the free fall to bottom, as a result of 'overshooting' of the falling array. Upon 'overshootin the wire rope would slacken, and attempt to re-lay (having unlayed while in tension). The torque developed in a slack bight could result in winding of the bight and thus fouling of the meter which was momentarily suspended in the slack wire rope. It is speculated that the snagging and resultant damage to the Braincon meters, B-129, B-138, B-155, occurred when a slack bight developed in the wire rope <u>after</u> the array was released from the anchor and the meters were hanging in garlands from the three buoys, now on the surface. Assuming that these slack garlands 'wound up' as a result of torque or set curvature in the wire rope, it seems likely that the vanes were broken during the winching of the system aboard ship.

The above speculation is offered as a probable cause for the regretted damage. Although identical handling was employed on the UW and POL systems, no damage was sustained on the POL systems. The difference I attribute to our use of torgue balanced wire rope. As the manufacturer asserts (see figure 1) the rope does not twist; as it was brought aboard with the capstan and fell free to the deck, it layed twist free. Conversely, I noted that the UW cable had a definite tendency to 'twist' up presumably as a result of a strain induced torque.

Site Designator: "E"

Site Information: 45°50'N, 124°50'W, water depth 167 m (site found to be 9 m shallower than anticipated)

Deployment: Installed 16 October 1971 1745Z
Recovered 15 November 1971 1645Z

Instrumentation:

Type	Serial No.	Height above bottom (m)	Remarks
Braincon	B-117	151	Vane broken off
Braincon	B-132	146	Vane broken off
Braincon	B-156	114	Normal
Aanderaa	A-353	55	Seizing wire eroded
Aanderaa	A-349	10	Same as A-351
Aanderaa	A-351	4	Same as A-351
Acoustic Release	ORE-130-1	1	Normal Functioning

Comments: 11 meters were removed from wire rope separating B-132 and B-156 to compensate for shoaler sounding. It is believed that the damage to B-117 and B-132 was caused by the same cable torgue problem noted at the site "C" installation. The lessened damage at site "E" relative to "C" is probably due to the shorter lengths of cable and proportionately less chance for 'winding up' of the slack cable. Other observations of possible interest are the electrolytic erosion of the seizing wire, the rather uniformly rusty appearance of the wire rope, and the lack of erosion of the galvanizing on the shackles, rings, etc. Conversely, the POL systems showed apparent total removal of the galvanizing from the shackles and rings, etc., but little if any erosion of the torque balanced wire rope.

Bottom drifters

Packets of plastic bottom drifters were identified by Serial No. and released at locations as specified by the UW during the first phase of the cruise. Release information is listed in Table A1.

All instrumentation used on both UW and POL projects has been returned to the University. We are very grateful for the use of the instruments and the splendid pre-use servicing of instruments and support extended by the UW personnel. POL will furnish the University with paper or magnetic tape data translations from the Aanderaa meters used at the UW sites. UW was represented during 13-26 October at sea by Dr. Glenn Cannon of POL who also is an Affiliate Assistant Professor in the Department of Oceanography.

T.V. Ryan
Chief Scientist, RP-6-OC-71

Enclosure

Table A1. Bottom Drifter Release Information

Packet No.	Drifter Nos.	Release Location		Date (Z1971)
20	20601-20625	45° 48.9'	124° 41.0'	17 Oct
19	20626-20650	45° 48.6'	124° 35.5'	17 Oct
13	20651-20675	46° 40.6'	124° 41.5'	18 Oct
14	20676-20700	46° 40.0'	124° 48.5'	18 Oct
12	20701-20725	47° 08.1'	124° 59.1'	20 Oct
11	20726-20750	47° 08.2'	124° 53.9'	20 Oct
9	20751-20776	47° 41.0'	124° 59.5'	21 Oct
10	20776-20800	47° 38.4'	125° 06.4'	21 Oct
8	20801-20825	48° 01.9'	125° 20.5'	22 Oct
7	20826-20850	48° 03.5'	125° 19.3'	22 Oct
6	20851-20875	48° 04.8'	125° 19.0'	22 Oct
16	20876-20900	48° 08.8'	125° 10.5'	22 Oct
15	20901-20925	48° 06.3'	125° 04.1'	22 Oct
3	20926-20950	48° 30.7'	125° 44.1'	23 Oct
4	20951-20975	48° 26.4'	125° 53.0'	23 Oct
5	20976-21000	48° 23.0'	126° 03.0'	23 Oct
2	21001-21025	48° 48.9'	126° 31.0'	24 Oct
1	21026-21050	48° 54.3'	126° 18.7'	24 Oct
18	21051-21075	48° 09.0'	125° 22.2'	25 Oct
17	21076-21100	48° 01.2'	125° 13.7'	25 Oct