NEARSHORE AND COASTAL CIRCULATION IN THE NORTHEASTERN CHUKCHI SEA

by

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I. INTRODUCTION

Nature of Study

Circulation patterns in the Alaska Chukchi Sea and the Beaufort Sea nearshore zones and exchange of water between nearshore and lagoonal environments are major controlling factors with respect to local biological productivity, transport of pollutants, and potential vulnerability to oil and gas development. Previous OCSEAP-sponsored environmental studies of Beaufort Sea systems (i.e. Simpson Lagoon, Prudhoe Bay, and Beaufort Lagoon) have documented this relationship for those regions of potential OCS impact, and the results of these studies are postulated to be applicable to the nearshore system in the Chukchi Sea. This study is designed to test that hypothesis, as well as to describe the Alaskan Chukchi Sea nearshore system in contrast to that along the Beaufort Sea coast.

Objectives

The general program objectives were to describe the coastal hydrography and water circulation patterns in the northeastern Chukchi Sea from Icy Cape to Pt. Barrow during open-water and ice-covered seasons. These objectives were to be accomplished by collecting data on water properties in the nearshore region via CTD and water bottle samples, deploying current meter arrays, and performing both drogued buoy and surface and bottom drifter studies.

Specific objectives of the study were to:

1. Describe the coastal hydrography and water circulation in the northeastern Chukchi Sea during open water and ice-covered conditions.
2. Describe the exchange of observed properties between nearshore and lagoon regions.
3. Describe the circulation patterns, flushing properties, and water residence times in Peard Bay.

II. BACKGROUND

Considerable data has been collected by various investigations in the Chukchi Sea over the past ten to twelve years. However, many of the early programs (Paquette and Bourke, 1974; Mountain et al., 1976; Garrison and Becker, 1976; Wiseman and Rouse, 1980; and Garrison and Paquette, 1982) were conducted to the south of the present study area and few current measurements in the nearshore were available until recently (Wilson, 1982; Aagaard, 1984).

Figure 2.1 illustrates the coastal oceanography of the northeastern Chukchi Sea, dominated by a mean northward Ⓐ flow of Bering Sea shelf water. This water, when combined with local freshwater runoff, is termed Alaskan Coastal Water (Coachman et al., 1975; Mountain et al., 1976) and is of great importance to coastal ecosystems due to its availability for exchange of properties with local lagoon systems extending from Cape Lisburne to Point Barrow. This mutually beneficial exchange includes nutrient influx to the lagoons and outflow of biological materials to the nearshore environment (Schell, 1984). In the spring, heat provided by this mean northerly flow greatly enhances the retreat of the nearshore ice cover (Paquette et al., 1981) and exposes a considerable area of warmer nearshore water Ⓑ for primary biological producers. Measurements by Wiseman (1974, 1980) have shown that, when meteorological conditions confine the nearshore warm waters to the coast, temperatures may be as high as 13 "C with salinities less than 29.0 o/oo in late July. However, as meteorological conditions periodically change and as surface waters are moved offshore, water in the nearshore region is replaced by deeper offshore water and exhibits both reduced temperatures (< 3 "C) and increased salinities (> 31 o/oo). Under certain atmospheric pressure field conditions typically encountered in the fall or winter, the mean northward flow may also exhibit large meteorologically-induced flow reversals (Coachman et al., 1981; Wilson et al., 1982; Wiseman and Rouse, 1980; Garrison and Paquette, 1982). Mountain et al., (1976) has developed a simple analytic model of this interaction and has determined that when a threshold of 12 mb difference in pressure between Barrow and Nome (Barrow greater than Nome) is exceeded, a reversal in the mean northerly to southerly flow is initiated. As this pressure difference decreases, the flow returns to northerly with a time lag on the order of one day. Thus, both inner lagoon and nearshore physical characteristics appear to be closely related to meteorological processes.

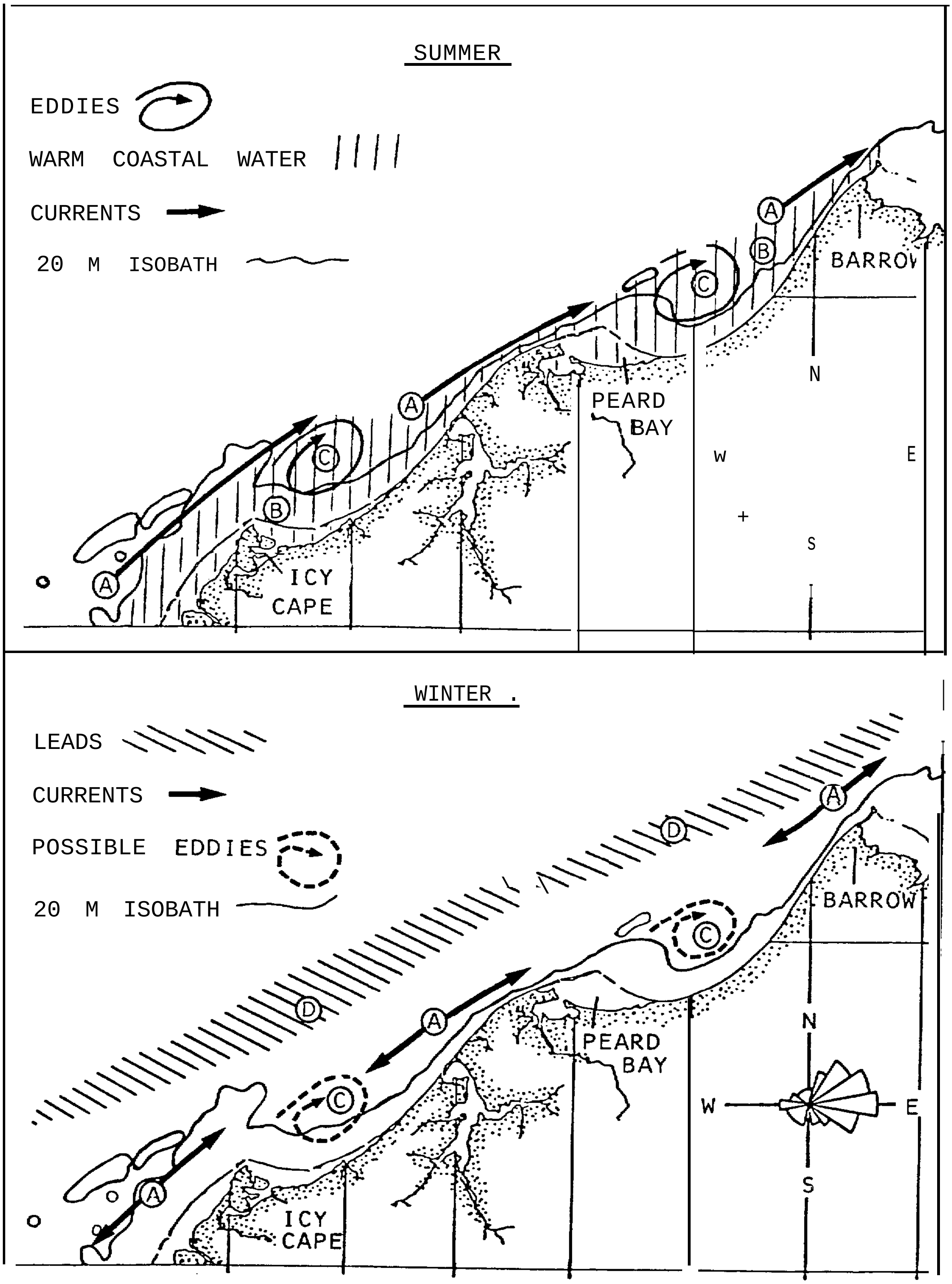


Figure 2.1. Comparison of postulated northeast Chukchi Sea summer and winter conditions.

Other important oceanographic events and features which may be relevant to the impact of oil and gas development in the region include: (1) the formation of eddies C at promontory land forms along the coast which may retard or trap transport of pollutants along the coast; (2) the occurrence of meteorologically driven storm surges and/or large current events (directed with or against the mean flow) along the coast; (3) the location and persistence of a wedge of warm water along the coastline which is extremely important in the spring and summer to ice breakup and biological production and which could rapidly transport pollutants northward along the entire Chukchi coastline; (4) the occurrence of a persistent nearshore lead D in the early spring (Stringer et al., 1980) along the northeast Chukchi Sea coastline which accommodates both shipping and migrating whales in the spring and could act as a trap for spilled oil in the region.

Circulation in the inner shelf of the NE Chukchi, as in the Beaufort Sea, has been shown to be highly influenced by meteorological forcing. The Chukchi differs from the Beaufort, however, in that it exhibits a relatively high velocity (approximately 1.0-1.5 kt) nearshore current which derives its existence independently of the local wind field. Under certain meteorological conditions this current is observed to reverse from its mean northeasterly direction and flow to the southwest. In the summer of 1981 this current was found to reverse for periods of 5-7 days for 35-45 percent of the open water period (Wilson et al., 1982). In winter months, Coachman and Aagaard (1981) found these reversed flow conditions 20-40 percent of the time along the Cape Lisburne inner shelf. The current, whether flowing northeast or southwest, typically follows the bathymetry at depths greater than 20-30 m and possesses a more wind-driven onshore-offshore component at depths less than 20-30 m.

Existence of eddies northeast of Point Franklin and Icy Cape which may occur during nearshore northerly flow periods have tentatively been identified. These eddies, when present at Pt. Franklin, may trap and/or concentrate pollutants in the nearshore region adjacent to the major entrance to Peard Bay where tidal exchange with the Bay would be imminent.

III. PRESENT STUDY

A one-year field measurement and data analysis program was conducted to describe the coastal hydrography and water circulation in the northeastern Chukchi Sea during open water and ice-covered conditions, including those factors and processes responsible for observed circulation patterns and water mass distributions. Field measurements were made during the period August 1983 to February 1984. A description of the exchange of the observed properties between the nearshore and lagoon regions, and the characteristic circulation patterns, flushing properties, and water residence times in Peard Bay, was accomplished in conjunction with a concurrent OCSEAP program studying physical and biological processes in Peard Bay.

The study region selected for this program was a section of the northern Chukchi Sea extending from Icy Cape to Pt. Barrow and from the contiguous terrestrial watershed to about 35 km from the coastline. This region contains landforms characteristic of those found in the northern Chukchi including examples of promontory points of land, limited-exchange lagoons, large rivers, submarine canyons, and seasonal ice cover. In recent years, considerable amounts of new physical oceanographic and meteorological data have been collected in this area (specifically near Pt. Franklin) which will provide an extensive data base for later OCSEAP analysis of multiyear variability.

3.1. Field Methods

A field measurement program was conducted in three phases to include both open-water and ice-covered seasons. This research was integrated with a concurrent physical measurement program studying Peard Bay and a continuing meteorological program studying the northeastern Chukchi Sea region. Coordination of data collection and integration of results from this program with these studies was accomplished in association with OCSEAP investigators D. Wilson and T. Kozo. Specific field activities were designed to collect data on hydrography, currents, tides, and special oceanographic features in the study area. The two phases of the summer program were conducted in

August and September 1983 from the NOAA ship DISCOVERER and in October 1983 from the SURVEYOR. The winter program was conducted in late February 1984 and early March via a NOAA helicopter based in Barrow.

The open-water and winter sampling programs are described below. Sampling stations for both the summer and the winter CTD programs are shown in Figure 3.1.

3.1.1. Basic Measurement Program

Hydrography. Hydrographic surveys of the study area were made twice (August and September 1983) during the open-water season and once (February 1984) during the ice-covered season. CTD casts and water bottle samples were collected to describe the distribution of water properties in the study area. Hydrographic surveys in the nearshore region near Pt. Franklin were coordinated with the Peard Bay ecological study physical measurement program. Four transects in the study area were intended to duplicate data collected by Aagaard in 1981-82 and provide a continuing data base for 1981-84 summer and winter seasons.

Winter hydrographic sections were taken through the ice during February 1984 via daily helicopter flights. CTD stations were occupied in four sections intended to coincide with stations collected during the summer program and with those collected by Aagaard in 1981-82.

Currents. Current meter moorings were deployed along a line extending from Pt. Franklin toward the northwest, and were also intended to extend Aagaard's 1981-82 data series. Placement of the instruments is shown in figure 3.2. Deeper moorings each included three meters: one within 5 m of the bottom in the bottom water layer typically observed below 30-m depths (Mountain, 1974; Garrison and Paquette, 1982), one in shallow water within 20 m of the surface to monitor the upper layer flow, and a third at an intermediate depth to follow the transition zone. The shallower mooring was intended primarily

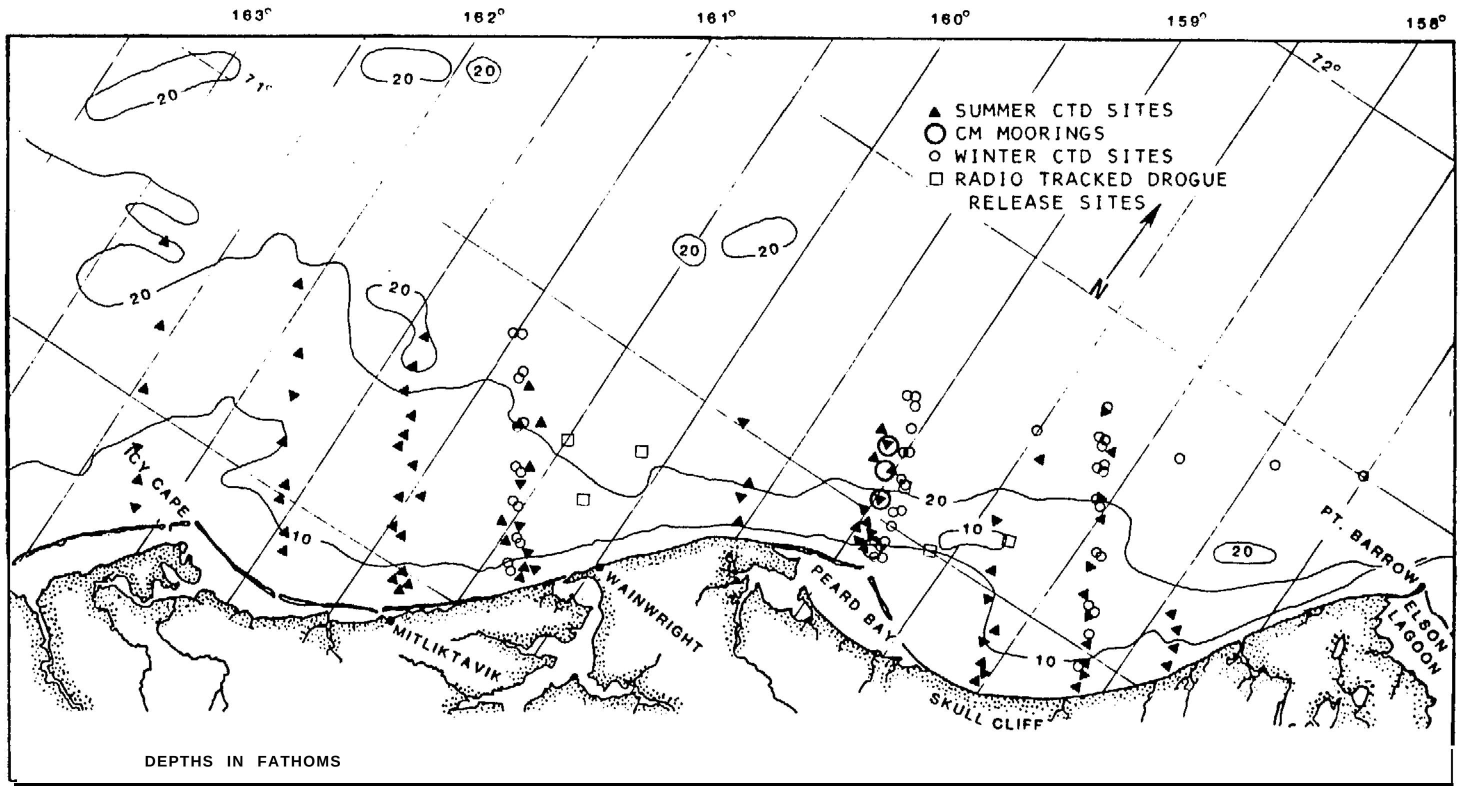


Figure 3,1. CTD sampling stations for summer and winter programs.

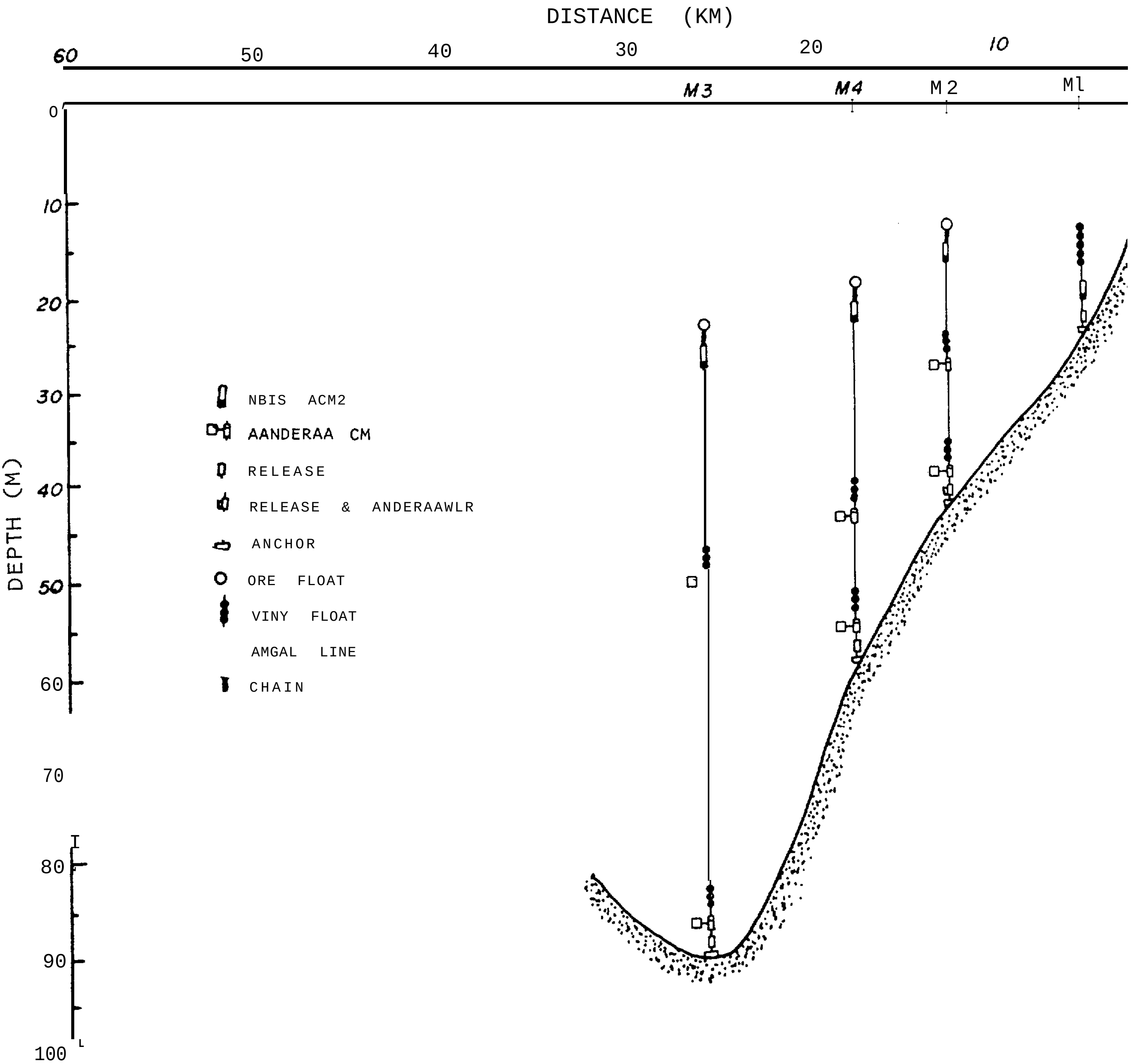


Figure 3.2. Current meter moorings deployed at Pt. Franklin along a line 330 “T.

to measure the currents associated with the vertically mixed warm water coastal wedge when present and therefore included one meter at approximately the 20 m depth.

Two Lagrangian methods for observing currents were employed during the open-water phases of this program. Radio-tracked drogues were deployed by the research vessel 10-15 km offshore to the southwest and northeast of Pt. Franklin and tracked by a helicopter-supported operation from several locations along the coastline. Surface and bottom drifters were also deployed near the coastline to the southwest and northeast of Pt. Franklin to estimate the littoral drift. At each deployment site 50 surface and 25 bottom drifters were deployed for subsequent recovery by helicopter on the two following days.

Tides. The exchange process between lagoonal and nearshore regions was thought to be driven primarily by meteorological and astronomical tides. In addition, it was postulated that the effects of astronomical tides are only a fraction of the effects of meteorological tides. A water-level recorder was deployed off Pt. Franklin on the second current meter mooring to record mean sea-surface variations due to astronomical and meteorological tides.

C

Sea-Surface Measurements. Sea-surface temperature and salinity samples were collected every 5 km during the research vessel's transit through the study area. These data were collected to identify the location and spatial extent of the warm water wedge and surface signatures of eddies which may exist in the area. Sampling stations for these measurements are shown in Figure 3.3.

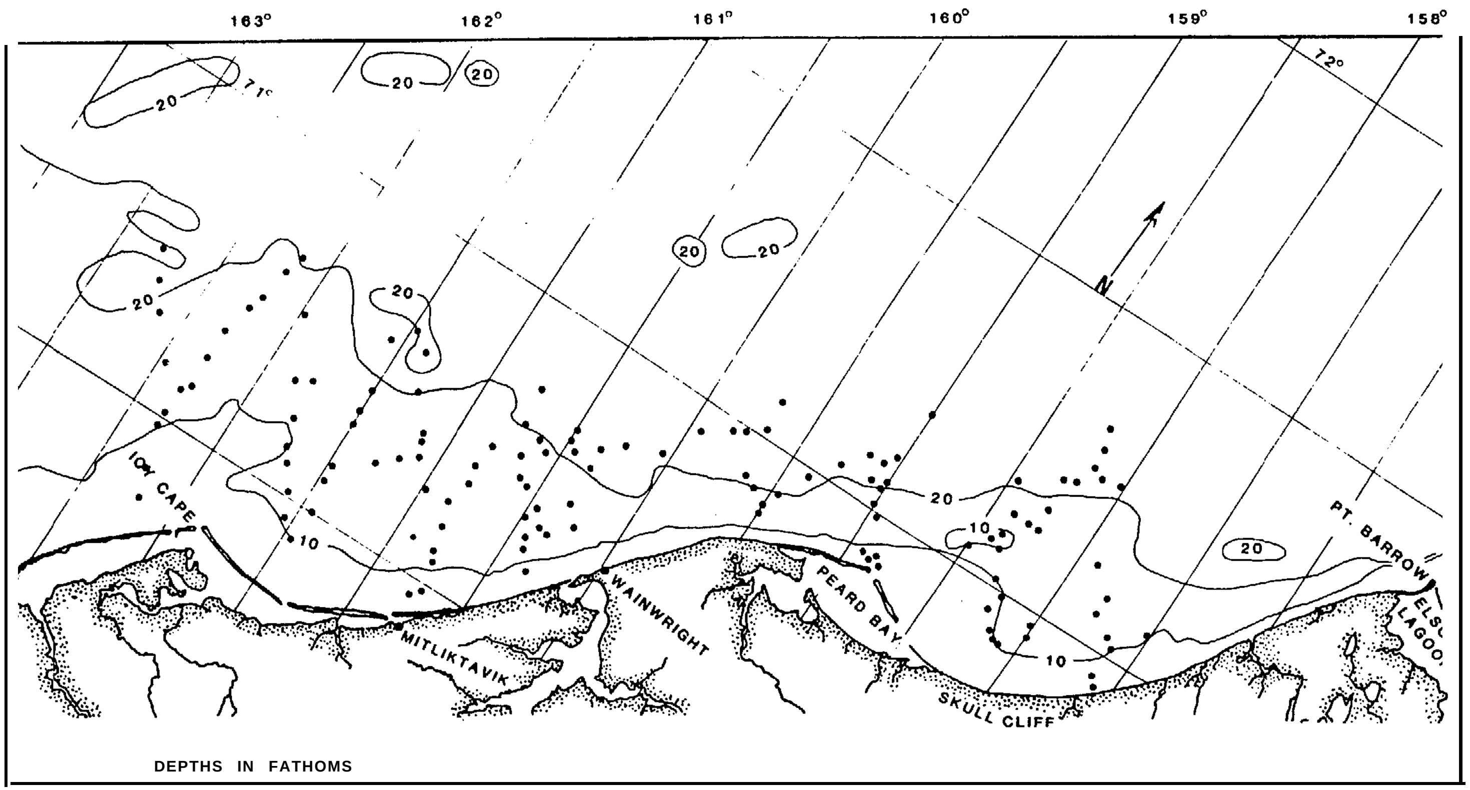


Figure 3.3. Sampling stations for Sea-Surface Bucket samples.

Meteorology. Summer 1983 meteorological data were provided to this program by Dr. T.L. Kozo from a concurrent OCSEAP-sponsored program being conducted in the Northeast Chukchi Sea. Measurements were collected with internally-recording remote meteorological stations located at Pt. Franklin and at Wainwright near the airport meteorological station. Measurements at these two sites included temperature, pressure, and wind speed and direction. Winter meteorological data for Cape Lisburne and Tin City were collected from the USAF llth Weather Squadron courtesy of Major P.B. Mills, and data for Nome, Wainwright, Kotzebue and Barrow were collected from the National Weather Service.

Satellite Imagery. Archived visual and infrared satellite imagery was used prior to the open-water phase to determine the historic existence and location of eddies and warm water coastal wedge in the study area and to modify the proposed hydrographic sampling grid accordingly. These archived data were obtained by the program from the University of Alaska, Geophysical Institute (Fairbanks) with the cooperation of Dr. W. Stringer and university staff. Real-time data on ice conditions in the study area were obtained directly from the NOAA/NESS group in Anchorage.

After the open-water field program, similar satellite imagery was obtained for the summer 1983 period to locate and identify oceanographic features which had been in the study area during the field program.

3.2. Operations and Chronology

3.2.1. Phase I: 10 August - 23 August 1983

Due to ice in the northern parts of the study region, Chief Scientist Lon Hachmeister met DISCOVERER in Nome on 10 August rather than in Barrow on 13 August as planned. The ship left Nome immediately to begin CTD operations in the southern portion of the study area. CTD operations were postponed temporarily to offload gear for the onshore study at the Pt. Franklin base camp. Ice was encountered as far south as Pt. Lay during the transit to Pt. Franklin. While passing Wainwright on the way to Pt. Franklin, the ship's Zodiac was taken into the Wainwright Dewline Station to establish telephone communications with the shore party at the Barrow NARL camp; radio communications had been unsuccessful up to this time. The ship then proceeded to Pt. Franklin. After offloading the equipment and supplies at the Pt. Franklin base camp by use of the ship's Zodiac and Monarc boats, the ship returned to Icy Cape to begin the first of the CTD sections.

CTD/Water Sampling. CTD operations commenced on 13 August off Icy Cape and continued through the remainder of the cruise. The last CTD cast was taken on 21 August near Icy Cape. A total of 87 CTD casts were collected in the study area during the cruise and only one CTD section near Pt. Barrow was eliminated due to heavy concentrations of sea ice. Table 3.1 gives the date, position, and cast depth for each CTD station.

Current Meter Deployments. Four current meter moorings were deployed (ref. Figure 3.1) along a line extending from Pt. Franklin toward 330 'T. Each of the three deeper moorings included a Neil Brown ACM2 vector-averaging current meter at the top and two Aanderaa RCM4 meters below it. The second mooring from shore also contained an Aanderaa water-level recorder attached to the acoustic release. The most inshore mooring consisted of a single ACM2 vector-averaging meter. A CTD cast was taken at the site of each mooring. Table 3.2 gives the time and position of each deployment as well as the water depth and mooring length at the intended deployment location. The fourth mooring was intended for deployment 50 km offshore but was moved to an alternate site between moorings 2 and 3 due to ice at the first position.

Drifter Studies. Surface and bottom drifters were deployed by helicopter within 0.5 km of the shoreline to the northeast and southwest of Peard Bay (ref. Figure 3.1). Wind conditions at the time of deployment were 5-10 kt from the northeast. These drifters were to be recovered via daily helicopter flights along the shoreline for several days following deployment. A total of eight radio-tracked drogued buoys were also deployed in the study area from DISCOVERER in transit between CTD lines. Table 3.3 gives the time and position of each deployment.

Table 3.1

SUMMARY OF CTD OPERATIONS

Cast #	Mater Depth (m)	Date	Latitude (N)	Longitude (W)
01	42	8/12/83	70°41.0′	162°45.5′
02	39	8/13/83	700³4.3″	162°32.6′
03	30	8/14/83	70°28.2′	162°27.2′
04	22	8/14/83	70°23.0′	162°18.5′
05	17	8/14/83	70°20.1′	162°12.7′
06	13	8/14/83	70°16.6′	162°08.1′
07	43	8/14/83	70°45.7′	162°04.5′
08	42	8/14/83	70°40.0′	161°52.3′
09	39	8/14/83	70°36.2′	161°47.6′
10	25	8/14/83	70°31.7′	161°42.0′
11	23	8/14/83	70°27.3′	161°33.8′
12	20	8/14/83	70°25.7′	161°33.4′
13	17	8/14/83	70°23.5′	161°25.8′
14	15	8/14/83	70°21.8′	161°24.1′
15	17	8/14/83	70°23.3′	161°25.6′
16	46	8/15/83	70°47.9′	161°22.6′
17	43	8/15/83	70°41.7′	161°12.0′
18	35	8/15/83	70°36.5′	161°03.3′
19	37	8/15/83	70°39.5′	161°11.3′
20	31	8/15/83	70°33.5′	161°03.0′
21	22	8/15/83	70°29.6′	160°55.1′
22	17	8/15/83	70°27.5′	160°48.5′
23	15	8/15/83	70°26.6′	160°44.1′
24	47	8/15/83	70°48.0′	160°39.0′
25	49	8/1 5/83	70°49.6′	160°47.0′
26	45	8/15/83	70°43.1′	160°34.4′
27	24	8/15/83	70°38.4′	160°26.1′
28	21	8/16/83	70°30.5′	160°20.6′
29	15	8/16/83	70°33.6′	160°17.5′
30	79	8/16/83	70°59.7′	159°46.4′
31	49	8/16/83	70°54.9′	159°36.9′
32	34	8/16/83	70°53.0′	159°33.5′
33	25	8/16/83	70°51.4′	159°27.8′
34	84	8/16/83	71°06.2′	159°12.2′
35	68	8/16/83	71°03.5′	159°09.8′
36	56	8/16/83	71°01.9′	159°05.3′
37	35	8/16/83	70°59.8′	159°01.4′
38	31	8/16/83	70°58.2′	158°59.6′
39	27	8/16/83	70°57.4′	158°57.2′
40	20	8/16/83	70°56.4′	158°56.5′
41	15	8/16/83	70°55.7′	158°55.6′
42	17	8/16/83	70°56.7′	158°57.9′
43	38	8/16/83	71°00.5′	159°01.3′
44	88	8/17/83	71°06.3′	159°08.4′

Table 3.1 (continued)

Cast #	Water Depth (m)	Date	Latitude (N)	Longitude (W)
45	97	8/17/83	71°13.5′	158°26.4′
46	32	8/17/83	71°05.4′	158°30.6′
47	28	8/17/83	71°01.3′	158°20,8′
48	24	8/17/83	70°58.9′	158°17.3′
49	20	8/17/83	70″56.6′	158°08.8′
50	18	8/17/83	70°54.8′	158°10.1′
51	16	8/17/83	70°52.4′	158°06.7′
52	16	8/17/83	70°52.6′	158°05.3′
53	14	8/17/83	70°51.9′	158°05.1′
54	17	8/17/83	71°20.2′	158°19.1′
55	110	8/18/83	71°16.4′	158°12.4′
56	117	8/18/83	71°17.6′	158°09.2′
57	50	8/18/83	71°12.7′	158°04.9′
58	47	8/18/83	71°11.2′	158°01.7′
59	40	8/18/83	71°06.6′	157°56.9′
60	35	8/18/83	71°04.2′	157°50.3′
61	30	8/18/83	71°02.7′	157°49.7′
62	24	8/18/83	71°00.2′	157°44.3′
63	21	8/18/83	70°58.5′	157°41.5′
64	18	8/18/83	70°57.2′	157°39.8′
65	16	8/18/83	70°56.3′	157°38.6′
66	17	8/18/83	71°03.0′	157°20.0′
67	26	8/18/83	71°04.7′	157°21.5′
68	34	8/18/83	71°06.3′	157°23.8′
69	39	8/18/83	71°07.7′	157°27.3′
70	66	8/19/83	71°03.4′	159°07.0′
71	61	8/19/83	71°04.1′	159°04.2′
72	35	8/19/83	70°59.5′	159°01.8′
73	33	8/19/83	70°58.7′	159°00.2′
74	27	8/19/83	70°57.3′	158°58.3′
75	22	8/20/83	70°56.4′	158°56.4′
76	47	8/21/83	70°46.6′	160°44.0′
77	44	8/21/83	70°43.3′	160°34.4′
78	24	8/21/83	70°38.1′	160°25.7′
79	20	8/21/83	70°35.2′	160°21.4′
80	15	8/21/83	70°33.7′	160°18.0′
81	14	8/21/83	70°25.9′	160°46.9′
82	17	8/21/83	70°27.1′	160°49.4′
83	25	8/21/83	70°30.8′	160°58.9′
84	31	8/21/83	70°34.2′	160°58.7′
85	37	8/21/83	70°38.9′	161°11.5′
86	42	8/21/83	70°43.3′	161°18.4′
87	43	8/21/83	70°45.7′	161°20.2′

Table 3.2
CURRENT METER MOORING DEPLOYMENTS

Mooring No.	Time (GMT)	Latitude (N)	Longitude (W)	Water Depth (m)	Mooring Length (m)
1	228 2209Z	70056.7	158053.0	25	7
2	229 0026Z	71"01.5	158056.1	42	29
3	229 0309Z	71006.3	159008.4	90	67
4	231 2012Z	71002.6	159004.5	59	40

Table 3.3
DRIFTER DEPLOYMENTS
a. RADIO TRACKED DRIFTERS

Deployment No.	Drifter 1 D#	Frequency (kHz)	Time (GMT)	Latitude (N)	Longitude (w)
1	520	4118.0	228 0343	70043.5	160015.8
2	515	4157.5	228 0433	70047.9	160031.0
3	516	4233.9	228 0540	70051.2	160010.0
4	513	4197.5	229 0425	70003.8	158057.9
5	512	4184.3	229 0435	70059.4	158040.0
6	514	4222.2	229 0706	71004.2	158022.7
7	518	4262.0	229 0924	71013.5	158026.4
8	510	4194.8	230 1258	71002.8	157032.0

b. SURFACE AND BOTTOM DRIFTERS

Deployment	No. of Seabed Drifter	No. of Yel low Cards	Date	Locataion	Course
1	25	50	8/15/83	0.5 km off Wainwright	330°
2	25	50	8/15/83	1.0 km off Wainwright	330°
3	25	50	8/15/83	0.5 km off Pt. Franklin	330°
4	25	50	8/15/83	1.0 km off Pt. Franklin	330°
5	25	50	8/15/83	0.5 km off Rogers Memorial	330°

Bathymetric Survey. A bathymetric survey of both entrances to Peard Bay was conducted by SAIC investigators from DISCOVERER's motor whaleboat. These measurements were made with a portable fathometer attached to the side of the boat. Position of the boat was determined by attaching a radar transponder to the boat and tracing the boat with the DISCOVERER's radar system. Several southeast-to-northwest sections were run across the main Peard Bay entrance and one east-to-west section was run across the minor entrance. These data were intended to aid in the interpretation of current meter measurements being made in the two entrances and in the determination of lagoon flushing characteristics by the Peard Bay Biological study.

Surface Bucket Samples. Bucket samples of surface water were taken at approximately 5-km intervals throughout the experimental area while the ship was in transit (ref. Figure 3.1). Temperature and salinity data were taken from these samples which were used to locate surface signatures of special oceanographic features in the study region. Table 3.4 gives time and positions for each of the samples.

Table 3.4

WATER-BUCKET SAMPLE SUMMARY

Date Z	Time Z	Latitude (N)	Longitude (W)	Bucket Temp	Analog Temp	Computer Temp	Bottle No.	Salinity
8/13	2041	70041.0	162046.0	4.8	5.6	5.926	49	26.540
	2050	70038.0	162041.8	4.0	4.1		50	25.954
	2110	70035.8	162038.0	3.8	5.4		51	24.501
	2121	70033.8	162034.9	3.4	5.4		52	23.950
	2250	70033.0	162028.7	2.4	2.1		53	24.401
	2310	70031.8	162026.0	3.4	2.8		54	25.220
	2335	70030.1	162030.2	2.4	1.0		55	25.580
8/14	0107	70026.2	162018.0	4.3	3.6		56	26.381
	0150	70023.0	162018.5	5.8	5.4		57	26.475
	0230	70021.6	162014.9	4.4	2.8		58	26.171
	0312	70020.1	162012.7	4.7	4.2		59	26.633
	0532	70018.8	162010.9	4.1	3.6		60	27.127
	0616	70027.4	162019.6	3.5	2.9		61	26.116
	0636	70030.0	162018.0	3.2	2.9		62	25.150
	0656	70030.4	162016.0	2.9	2.6		63	25.202
	0720	70034.2	162°17.7	2.8	2.6		64	25.320
	0745	70037.0	162013.0	2.9	3.1		65	24.624
	0805	70040.7	162013.8	3.7	3.2		66	24.414
	0820	70042.7	162012.4	5.3	4.8		67	27.864
	0845	70046.1	162010.1	5.1	4.6		68	28.569
	0910	70047.5	162015.2	4.1	3.6		69	27.549
	1115	70043.6	161059.9	4.7	4.4		70	26.498
	1145	70041.6	161056.2	4.6	4.0		71	26.454
	1245	70038.6	161045.7	4.7	4.4		72	27.209
	1305	70037.5	161051.5	4.4	3.9		73	27.405
	1348	70033.8	161045.5	4.4	4.0		74	27.954
	1450	70031.9	161041.7	4.8	4.3		75	26.505
	1525	70029.9	161038.0	4.8	4.5		76	25.643
	1630	70027.4	161033.6	5.0	4.6		77	25.674
	1718	70025.7	161033.4	4.1	4.0		78	25.556
	1755	70024.8	161″30.9	3.9	3.7		79	25.981
	1905	70°23.5′	161025.8	2.2	2.5		80	27.273
	1950	70°22.8′	161024.7	2.65	2.4		81	27.405
	2027	missing numbers					82	27.681
	2215	70028.6	161025.0	3.2	3.1		83	26.837
	2235	70029.8	161026.2	3.6	3.4		84	26.570
	2300	70032.1	161027.2	4.2	3.8		85	26.297
	2335	70036.1	161028.3	4.2	4.0		86	27.341
8/15	0005	70039.8	161029.5	4.4	4.0		88	26.832
	0025	70044.0	161035.7	4.6	4.4		89	26.864
	0055	70045.4	161032.8	3.7	3.2		90	27.545
	0115	70047.6	161023.8	3.9	4.4		91	27.925
	0140	70047.9	161023.1	4.9	4.7		92	27.933
	0240	70043.8	161016.9	4.7	4.2		93	26.828

Table 3.4 (continued)

Date Z	Time Z	Latitude (N)	Longitude (W)	Bucket Temp	Analog Temp	Computer Temp	Bottle No.	Salinity
	0320	70041.9	161011.1	4.2	3.8		94	25.916
	0347	70039.8	161008.9	3.6	3.4		95	25.521
	0430	70036.5	161003.3	2.5	2.2		96	26.311
	0629	70039.5	161011.3	3.4	3.0		49	25.406
	0718	70039.1	161008.9	3.8	4.1		no sample	
	0735	70037.1	161006.3	2.5	2.2		50	26.382
	0800	70035.8	161004.7	1.8	1.4		51	26.752
	0825	70034.9	160059.7	2.0	1.7		52	27.730
	0920	70033.5	161003.0	2.6	2.7		54	27.924
	0935	70033.6	160055.0	1.8	1.4		53	28.581
	1040	70029.5	160055.0	1.4	0.6		55	29.343
	1100	70030.0	160046.4	1.4	0.9		56	29.389
	1230	70026.6	160044.1	0.6	0.0		57	30.486
	1256	70030.3	160048.0	().8	0.0		58	29.964
	1315	70032.6	160050.5	1.9	1.4		59	29.183
	1335	70035.4	160052.4	1.9	1.6		60	28.710
	1355	70038.5	160050.0	1.7	1.4		61	27.660
	1415	70041.1	160051.0	2.1	1.6		62	26.782
	1435	70042.8	160049.0	2.2	106		63	25.621
	1500	70044.1	160040.5	2.2	1.8		64	25.396
	1545	70048.0	160039.0	1.8	2.0		65	25.929
	1715	70050.6	160046.4	0.9	0.6		66	24.667
	1750	70046.1	160037.6	1.4	1.6		67	25.868
	2220	70043.1	160034.4	2.4	1.8		68	27.070
	2230	70042.1	160030.4	3.0	2.6		69	28.486
	2255	70038.4	160026.1	2.1	1.9		70	30.040
	2335	70038.1	160026.6	no numbers			71	30.503
8/16	0000	70035.3	160024.1	1.4	0.4		72	30.765
	0210	70035.1	160020.3	0.5	0.4		73	30.992
	0300	70039.3	160021.9	0.0	0.5		74	30.873
	0320	70041.7	160019.5	2.0	1.2		75	30.098
	0340	70040.5	160015.9	2.5	2.4		76	28.192
	0400	70046.7	160020.5	2.1	1.7		77	26.658
	0420	70047.5	160027.5	2.1	1.6		78	25.955
	0440	70048.4	160030.0	1.7	1.0		79	25.860
	0504	70049.0	160022.0	2.2	1.7		80	25.963
	0529	70050.3	160045.0	2.1	1.8		81	26.263
	0545	70°51.2	160010.0	2.8	1.9		82	27.612
	0610	70053.0	160006.1	2.3	no number		83	25.691
	0634	70055.5	159059.1	2.2	1.7		84	25.502
	0705	70057.9	159051.4	2.5	2.5		85	27.718
	0729	70058.9	159047.7	2.7	2.4		86	26.874
	0750	70000.3	159042.7	2.4	2.2		87	26.421
	0820	70055.4	159039.3	2.4	2.05		88	26.086
	1030	70054.8	159035.5	2.1	2.2		89	26.188
	1135	70053.1	159030.0	2.6	2.2		90	25.439

Table 3.4 (continued)

Date Z	Time Z	Latitude (N)	Longitude (W)	Bucket Temp	Analog Temp	Computer Temp	Bottle No.	Salinity
	1215	70050.4	159031.2	0.1	-0.3		91	31.221
	1240	70054.0	159030.0	2.2	1.0		92	27.492
	1255	70055.9	159028.0	1.8	1.6		93	26.334
	1315	71001.4	159017.2	1.4	1.8		95	25.350
	1355	71003.6	159011.0	0.3	0.6		96	24.829
	1705	71003.5	159006.7	1.8	1.5		49	25.777
	1745	71001.7	159003.7	1.2	0.6		50	29.780
	1900	70058.2	159000.2	1.4	0.8		51	29.194
	2015	70055.3	158056.0	no sample drawn				
	no numbers						52 no sample	
8/17	0120	71004.6	159003.6	2.5	1.9		53	26.308
	0425	71003.8	158057.9	1.5	2.4		54	26.162
	0621	71001.8	158032.0	3.0	1.8		55	25.306
	0648	71003.3	158026.7	2.4	1.8		56	26.781
	0705	71″04.2	158022.7	2.4	1.8		57	26.796
	0738	71006.9	150026.0	2.4	1.8		58	26.892
	0808	71010.0	158030.0	1.8	0.7		59	28.500
	0925	71013.5	158026.4	2.0	1.2		60	25.307
	1024	71012.0	158018.8	1.8	1.5		61	25.702
	1110	71008.6	158017.8	2.2	1.1		62	25.630
	1230	71004.7	158031.4	1.8	1.3		63	28.125
	1250	71003.2	158024.0	1.2	1.5		64	26.974
	1342	71000.9	158020.2	1.8	1.3		65	27.176
	1447	70058.8	158015.0	1.9	1.4		66	26.689
	1551	70055.8	158011.8	2.3	2.4		67	26.839
	1645	70054.9	158007.6	2.4	1.6		68	26.879
	1910	70054.3	158010.8	2.5	2.0		69	26.966
	1944	70057.3	158015.3	2.3	1.6		70	27.014
	2011	71000.3	158019.4	2.5	1.4		71	26.734
	2035	71006.7	158019.6	2.4	1.5		72	27.114
	2100	71006.5	158018.1	3.9	1.4		73	27.121
	2120	71011.8	158015.5	3.5	2.0		74	26.377
	2145	71014.5	158013.4	2.8	2.1		75	26.613
	2200	71014.1	158010.7	3.4	2.1		76	25.930
	2220	71016.3	158013.0	2.2	1.6		77	24.702
	2245	71018.6	158015.1	1.9	0.8		no sample	
	2350	71020.2	158019.1	2.5	1.0		79	24.471
8/18	0048	71016.4	158012.4	1.8	1.8		80	24.066
	0300	71015.0	158004.4	1.7	2.1		81	23.551
	0600	71006.6	157056.9	2.2	1.5		82	26.868
	0716	71004.9	157049.4	3.1	1.5		83	26.920
	0845	71002.7	157049.7	2.9	1.9		84	26.601
	0955	71″01.1	157042.6	3*5	2.0		85	26.136
	1122	70057.2	157039.8	3.5	1.8		86	27.393
	1150	70056.3	157038.6	3.5	1.2		no sample	
	1235	71000.8	157039.2	2.8	2.1		87	26.583

Table 3.4 (continued)

Date Z	Time Z	Latitude (N)	Longitude (W)	Bucket Temp	Analog Temp	Computer Temp	Bottle No.	Salinity
	1305	71003.2	157031.0	2.4	1.6		88	25.919
	1848	70″58.1	158001.8	3.9	2.2		89	27.730
	1858	70057.0	158002.5	3.4	2.3		90	27.882
8/19	2125	71000.0	159002.0	4.5	4.1		91	29.117
8/20	0035	70056.0	158055.3	3.6	3.0		92	27.743
	0048	70056.3	158054.0	3.4	3.0		no sample	
	0059	70056.3	158054.4	3.7	3.1		93	28.181
8/21	0219	70047.2	160043.8	2.1	3.3		94	27.658
	0250	70046.0	160036.0	5.3	3.2		95	28.505
	0355	70042.7	160035.6	4.5	4.2		96	28.115
	0418	70039.8	160028.6	4.5	4.4		49	28.299
	0515	70038.5	160024.0	4.0	3.6		50	28.144
	0609	70035.1	160021.2	2.9	2.8		51	28.711
	0935	70025.9	160046.9	3.0	2.1		52	*
	1223	70027.0	160052.0	3.5	2.0		53	*
	1245	70029.8	160055.8	3.6	3.2		54	*
	1333	70032.3	160059.5	4.2	3.8		55	*
	1425	70034.5	160059.3	4.0	3.4		56	*
	1454	70037.1	161009.2	3.8	3.2		57	*
	1523	70038.1	161011.5	5.7	4.3		58	*
	1605	70040.6	161013.6	5.4	4.8		59	*

*Oil from A-frame spill apparent in samples.

3.2.2. Special Cruise: 2-5 September 1983

Heavy ice conditions in the study region indicated a very low probability of recovering the four current meter moorings as planned on the 23 September SURVEYOR cruise. The Principal Investigator and NOAA representatives Mauri Pelto and George Lapiene therefore decided to attempt an early recovery from DISCOVERER which was still operating in the study area and then, if conditions permitted, to conduct the CTD operation from SURVEYOR in late September as planned.

Lon Hachmeister flew to Barrow on 2 September and was transported to the Wainwright Dewline Station by NOAA helicopter. DISCOVERER's launch then provided transportation from the Dewline Station to DISCOVERER which was anchored several kilometers offshore. Operations commenced on 3 September with attempts to recover moorings 3 and 4. Heavy ice in the area, however, prevented the ship from approaching either mooring site. Attempts at locating mooring 2 failed and finally mooring 1 was recovered on 4 September. An opening in the ice was observed on 5 September over the location of mooring 4 and a recovery attempt was successful. A medical evacuation forced the ship to leave the area later that day, and no further attempts to recover moorings 2 and 3 were made.

3.2.3. Phase II: 20 September - 27 September 1983

This phase of the study was originally to be divided into onshore- and offshore-based experiments. The offshore work would use SURVEYOR to recover the current meters and to conduct a hydrographic survey. The onshore work would rely upon a NOAA-supplied helicopter based on SURVEYOR to deploy surface drogues, seabed drifters, and surface drifters, and to monitor their movements through the study region.

Due to reports of an unusually early southern movement of the arctic ice pack, Lon Hachmeister and John Vinelli met SURVEYOR off of Peard Bay on 20 September rather than 23 September. Upon nearing the site of mooring 2 encroaching ice necessitated leaving the area of the mooring to the only area of open water off Pt. Franklin near Peard Bay, where the ship became trapped in the ice. While waiting to leave the area, several bucket samples and CTD casts were taken near Pt. Franklin.

CTD/Water Sampling. CTD operations commenced and ended on 22 September in the area off Pt. Franklin. A total of 7 CTD casts were made within 5 km of Pt. Franklin. All other CTD sections were eliminated due to the presence of sea ice extending from Pt. Barrow to 40 miles southwest of Icy Cape.

Sea Surface Measurements. Surface temperature and salinity measurements were taken from bucket samples collected halfway between each CTD stations (Table 3.5).

Current Meter Recoveries. Neither mooring 2 or 3 were recovered due to sea ice conditions.

Drifter Studies. The drifter study was not done due to sea-ice conditions.

Drogue Studies. No drogue studies of surface currents were made due to sea-ice conditions. One drogue was deployed and recovered from an ice floe in order to measure the signal strength at a distance using a ground plane antenna,

Table 3.5

SEA SURFACE TEMPERATURE AND SALINITY DATA

Bucket Temp.	Bottle #	Salinity	Time (Z)	Date (JD)	Instru. Depth	Sink Temp.	Latitude (N)	Longitude (W)
0.8	001	29.05042	1830	264		3.0	70058.7	158027.8
0.7	002	29.05501	1900	264		2.9	70058.8	158°30
1.0	003	29.43189	1930	264		4.0	71000.3	158°43t
1.1	004	29.57332	2000	264		2.5	71001.2	158°50
1.7	005	29.94154	2030	264		2.3	71001.0	158°53
1.6	006	30.59804	2100	264		3.7	71001.7	158°57
1.6	007	30.49904	2130	264		3.3	71001.7	158°54
1.6	008	29.74574	0000	265		2.1	71002.0	158°45
0.2	009	29.70008	0030	265		1.4	71001.8	158″50
-0.3	010	29.39051	0100	265		0.2	71001.9	158°54
-0.2	012	29.69912	0130	265		2.6	71″02.6	158°59
-0.4	013	29.65443	0200	265		-0.2	71001.0	159°00
<scale	014	29.27294	0230	265		0.2	71001.2	158°54
-0.2	015	29.80082	0300	265		-0.1	71001.5	158°52
-0.1	016	28.98522	1800	265		0.9	70057.0	158°39
0.2	017	29.04621	1830	265		1.0	70057.5	158°40
-0.3	019	28.75403	1847	265		1.0	70057.0	158°40
1.8	020	28.85985	1859	265	13m	Cast1	70″57.0	158°40
1.3	021	28.93819	2000	265		1.0	70056.8	158°40
1.2	022	29.04812	2030	265		1,1	70057.0	158°41
1.2	023	28.90418	2100	265		0.9	70057.6	158°37
1.2	024	29.10378	2137	265		1.0	70058.8	158°37
1.6	025	29.01160	2145	265	15m	Cast2	70058.8	158°37
0.6	026	28.95024	2200	265		0.9	70058.8	158°38
0.0	027	28.98426	2233	265		0.9	70055.9	158°34
x.x	028	28.79299	2233	265	15m	Cast3	70055.9	158°34
-0.8	029	29.65232	2317	265	SFC	Cast4	70054.2	158°35
--	030	28.75403	2325	265	11m	Cast4	70054.2	158°35
-0.3	031	29.17093	2355	265		415trs	70055.2	158°35
-0.8	032	29.37136	0012	266	SFC	Cast5	70055.8	158°37
--	033	28.71183	0018	266	14.6m	Cast5	70055.8	158°37
-0.8	034	29.04353	0043	266		516trs	70056.2	158°38
0.1	035	28.99917	0058	266	SFC	Cast6	70057.0	158041.1
--	036	29.01867	0102	266	15m	Cast6	70057.0	158041.1
0.6	037	29.00242	0132	266		617trs	70057.5	158041.0
-0.1	038	29.00242	0136	266	SFC	Cast7	70057.6	158042.6
--	039	29.00376	0156	266	13m	Cast7	70057.5	158042.6

3.2.4. Phase III: 25 February - 7 March 1984

The third phase of the field program was planned to begin on 20 February 1984; however, extremely low temperatures in Barrow (< -40 'F) prevented the helicopter from transiting from Anchorage. The entire program was delayed as daily updates on Barrow temperatures were monitored. Upon receipt of a favorable weather forecast Lon Hachmeister arrived in Barrow on 25 February and verified the arrival of all required equipment. Upon arrival of the helicopter on 26 February the remainder of the field party was called to Barrow and the study was initiated.

CTD/Water Sampling. CTD operations commenced on 28 February off Pt. Franklin (ref. Figure 3.1). Temperatures continued below -35 'F during most of the program, resulting in considerable difficulty in keeping the ice augers, Nansen bottles, CTD units, and other operational hardware including the helicopter at working temperatures. The last CTD cast was taken on 7 March at the entrance to Peard Bay. A total of 66 CTD and water bottle stations were occupied in the study area during the program. Data from several sections were lost when the primary CTD system's memory malfunctioned after receiving a static electrical discharge during the data recovery operation at NARL. A backup CTD was used to complete the CTD program and no further data loss was experienced. Table 3.6 gives the time, position, and depth of each CTD cast and water bottle station occupied during the program.

Current Meter Mooring Retrieval. Several attempts were made to acoustically contact transponders on current meter moorings 2 and 3 deployed during the open-water phase of the program (i.e. Phase I). The first attempt was made on 28 February after the CTD site data was collected. A total of six different sites were occupied during Phase III in attempting to contact mooring 3, and three sites were occupied for mooring 2. Battery life in the acoustic transponder systems had been estimated at 12 months (more than adequate for an intended 2-month deployment) under optimal conditions; however, under ice-covered conditions over the resulting 7-month deployment the batteries may have been run low by "talking" to ice-induced acoustic signals at 12 kHz.

Table 3.6

CTD STATIONS - PHASE III

Cast No.	CTD Station	Latitude (N)	Longitude (W)	Depth (m)
001	Al	70°55.9′	158°53.8′	12
002	A2	70°57.7′	158°54.4′	27
003	A7	71°11.6′	159°11.9′	85
004	A06	71°06.7′	159°01.7′	85
005	A05	71°03.9′	158°59,6′	60
006	A04	71°01.2′	158°55.8′	34
007	A03	70°59.1′	158°54.8′	25
008	A02	70°57.7′	158°53.0′	19
009	A01	70°56.6′	158°51.6′	8
010	PB01	70°51.4′	158°38.0′	3
011	B07	70°55.0′	161°01.9′	42
012	B06	70°51.8′	160°53.2′	43
013	B05	70°47.7′	160°44.9′	43
014	B04	70°43.6′	160°38.0′	41
015	B03	70°40.4′	160°32.2′	32
016	B02	70°37.3′	160°25.3′	19
017	1301	70°34.6′	160°23.2′	13
018	PB02	70°52.0′	158°40.6′	2
019	PB03	70°52.1′	158°40.6′	6
020	B07	70°54.9′	161°00.4′	42
021	B06 ′	70°51.1′	160°53.6′	47
022	B05′	70°47.5′	160°45.7′	46
023	B04′	70°43.3′	160°36.8′	39
024	B03 ′	70°40.6′	160°32.2′	34
025	B02 ′	70°37.1′	160°24.1′	20
026	B01	70°34.2′	160°21.4′	17
027	A07 ″	71°11.5′	159°09.6′	75
028	A07*	71°08.8′	159°04.9′	>97
029	A06 ″	71°06.3′	159°01.2′	>96
030	A05 ″	71°04.0′	158°58.6′	85
031	A04 ″	71°01.4′	158°54.8′	58
032	A03 ″	70°59.4′	158°53.7′	46
033	A02	70°57.8′	158°53.5′	32
034	C07	70°16.0′	158°08.9′	108
035	C06	71°18.4′	158°14.9′	120
036	C06*	71°16.0′	158°08.9′	88
037	C05	71°13.1′	158°03.3′	47
038	C04	71°08.9′	157°56.4′	44
039	C03	71°03.6′	157°47.7′	30
040	PB04	70°51.8′	158°55.0′	5
041	PB05	70°49.6′	158°54.5′	6
042	PB06	70°49.6′	158°54.5′	6
043	C07	71°21.7′	158°18.3′	108
044	C06	71°18.5′	158°12.4′	113
045	C06*	71°16.0′	158°09.7′	100

Table 3.6 (continued)

Cast No.	CTD Station	Latitude (N)	Longitude (W)	Depth (m)
046	C05	71°13.3′	158°04.5′	59
047	C04	71°08.9′	157°54.5′	46
048	C03	71°03.9′	157°48.2′	32
049	C02	71°01.3′	157°43.5′	27
050	C01	70°58.3′	157°40.5′	18
051	D01	71°29.9′	157°00.7′	136
052	002	71°26.0′	157°26.1′	127
053	D03	71°21.6′	157°52.0′	113
054	D04	71°19.3′	158°14.0′	113
055	D05	71°16.1′	158°32.6′	106
056	D06	71°16.1′	158°32.6′	103
057	D06	71°11.1′	159°07.7′	90
058	PB07	70°52.0′	158°40.7′	2
059	PB08	70°52.0′	158°40.7′	3
060	PB09	70°52.0′	158°40.7′	5
061	PB10	70°52.0′	158°40.7′	7
062	PB11	70°52.0′	158°40.7′	6
063	PB12	70°52.0′	158°40.7′	6
064	PB13	70°52.0′	158°40.7′	6
065	PB14	70°52.0′	158°40.7′	5
066	PB15	70°52.0′	158°40.7′	3

IV. RESULTS

This section contains a discussion of the data obtained in each of the measurement types (currents, hydrography, etc.) during the three phases of the field measurement program and gives examples of data processed as required to meet the program objectives.

4.1. Currents

4.1.1. Current Meter Moorings

Of the four current meter moorings deployed in August 1983 (Figure 3.2) only two have been recovered due to heavy concentrations of ice encountered. Attempts at recovery in September 1984 were also threatened by the presence of ice over the moorings. Table 4.1 summarizes the deployment/recovery history for the instruments on all moorings. All data records on the four recovered meters were intact and have been processed.

Aanderaa and Neil Brown current meter tapes have been processed to produce time series of calibrated data including currents, temperature, pressure and, in the case of the Aanderaa meters, salinity. Time series data for current meters deployed on moorings 1 and 4 are displayed in Figures 4.1-4.2. These figures display the current components in the longshore (positive currents directed toward 60 "T) and in the onshore/offshore (positive currents directed toward 150 "T). Average bathymetric features lie along a line 60 "T throughout the study region and previous measurement programs in the area (Aagaard, 1984; Wilson et al., 1982) have observed that nearshore currents follow the bathymetry. These figures show that at both mooring sites the current was directed along the coast parallel to the local bathymetry and toward the northeast during almost the entire deployment period. A southwest-directed current which was observed at mooring site 1 for the first eight hours of deployment on 17 August (Figure 4.1, middle trace) will be discussed later.

Table 4.1

SUMMARY OF CURRENT METER MOORING DEPLOYMENTS

Mooring	Date Deployed	Date Recovered	Latitude (N)	Longitude (W)	Instrument Type	Instrument Depth	Bottom Depth	Comments
1	8/15/83 Day 228	9/4/83 Day 278	70056.7	158053.0	NBIS ACM	20 m	24 m	All meters recovered; all data records intact.
2	8/16/83 Day 229	--	71001.3	158056.0	NBIS ACM Aanderaa CM Aanderaa CM Aanderaa PG	16 m 27 m 39 m 43 m	43 m	Mooring not recovered due to ice; all meters missing.
3	8/16/83 Day 229	--	‘71006.8	159002.0	NBIS ACM Aanderaa CM Aanderaa CM	28 m 49 m 86 m	90 m	Mooring not recovered due to ice; all meters missing.
4	8/18/83 Day 231	5/5/83 Day 279	71002.6	159004.5	NBIS ACM Aanderaa CM Aanderaa CM	22 m 43 m 54 m	58 m	All meters recovered; all data records intact.

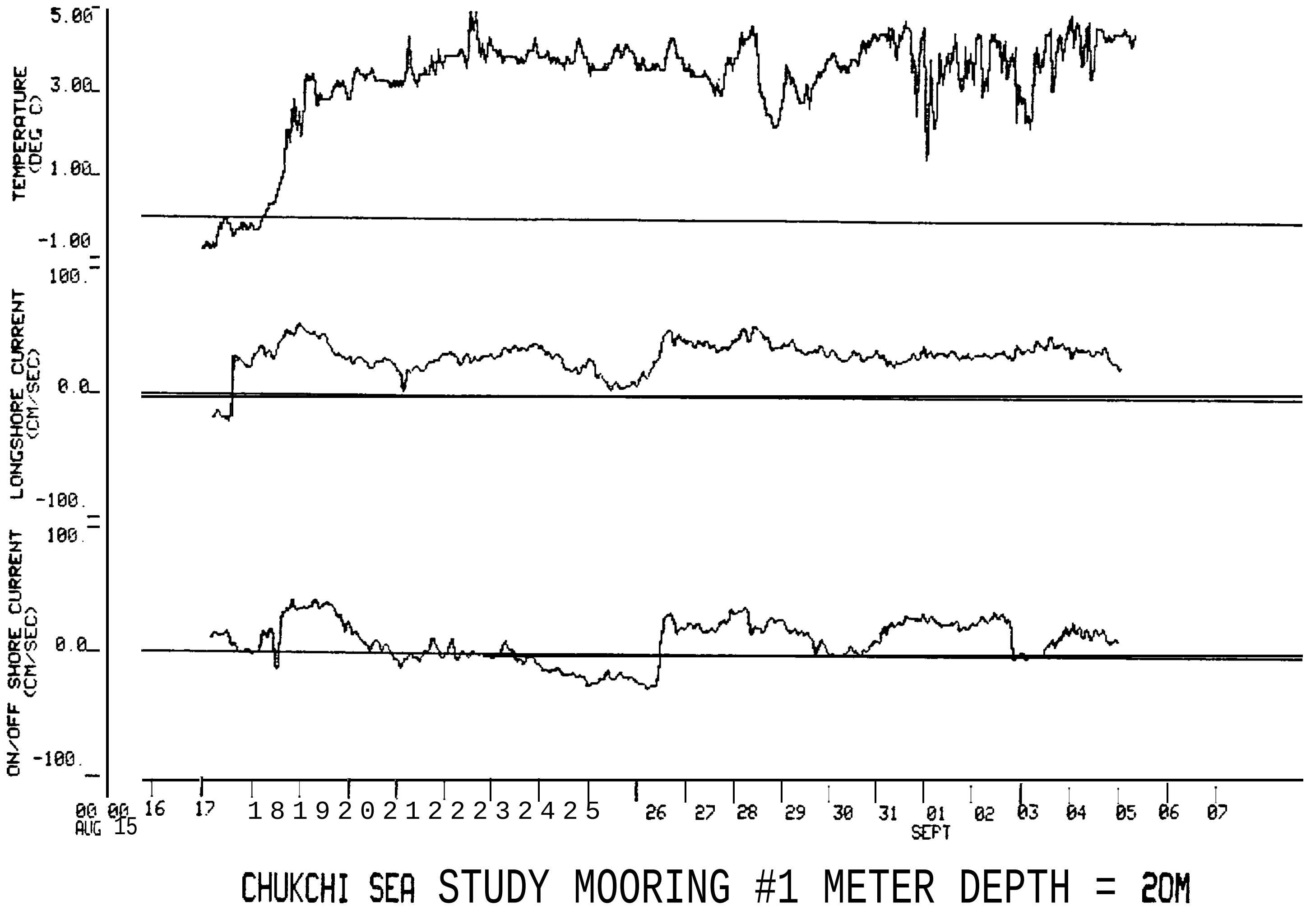
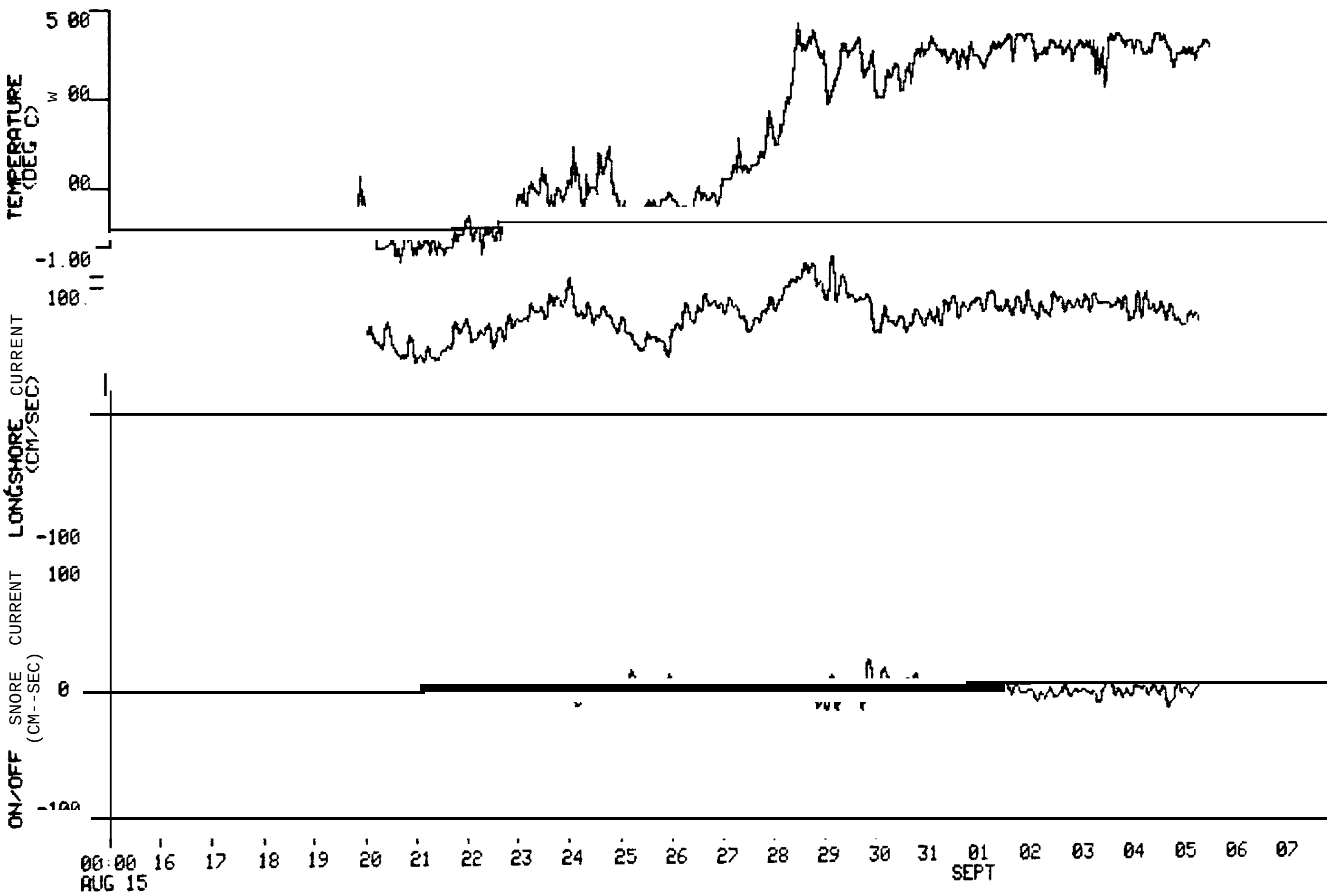
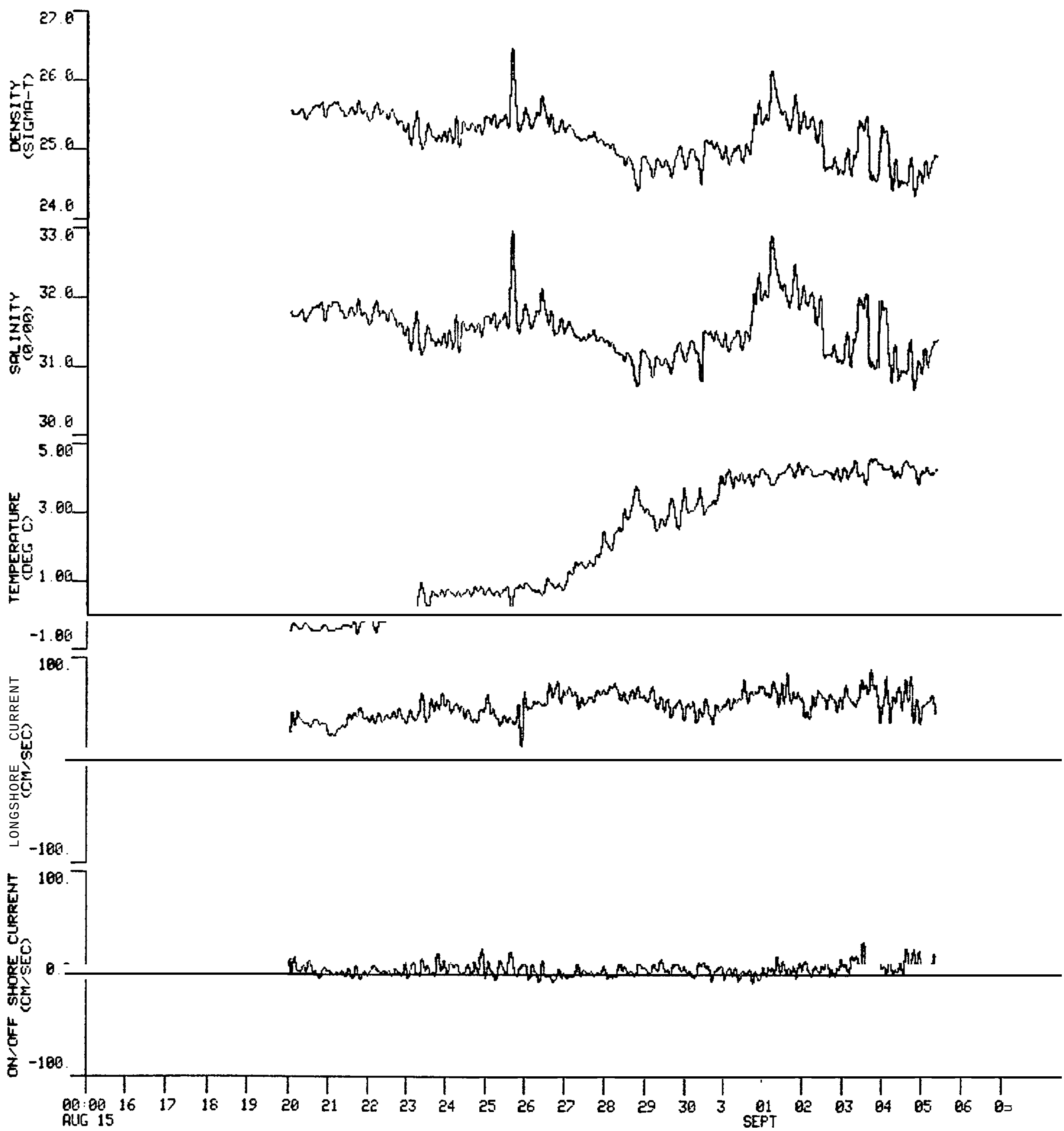


Figure 4.1. Time series data collected at mooring 1. Positive longshore currents are directed toward 60 "T following the average bathymetry and positive on/offshore currents are directed toward 150 "T at right angles to the bathymetry.



CHUKCHI SEA STUDY MOORING #4 METER DEPTH = 22M

Figure 4.2a. Time series data collected at mooring 4 (depth 22 m). Positive longshore currents are directed toward 60 °T following the average bathymetry and positive on/offshore currents are directed toward 150 °T at right angles to the bathymetry.



CHUKCHI SEA STUDY MOORING #4 METER DEPTH = 43M

Figure 4.26. Time series data collected at mooring 4 (depth 43 m). Positive longshore currents are directed toward 60 °T following the average bathymetry and positive on/offshore currents are directed toward 150 °T at right angles to the bathymetry.

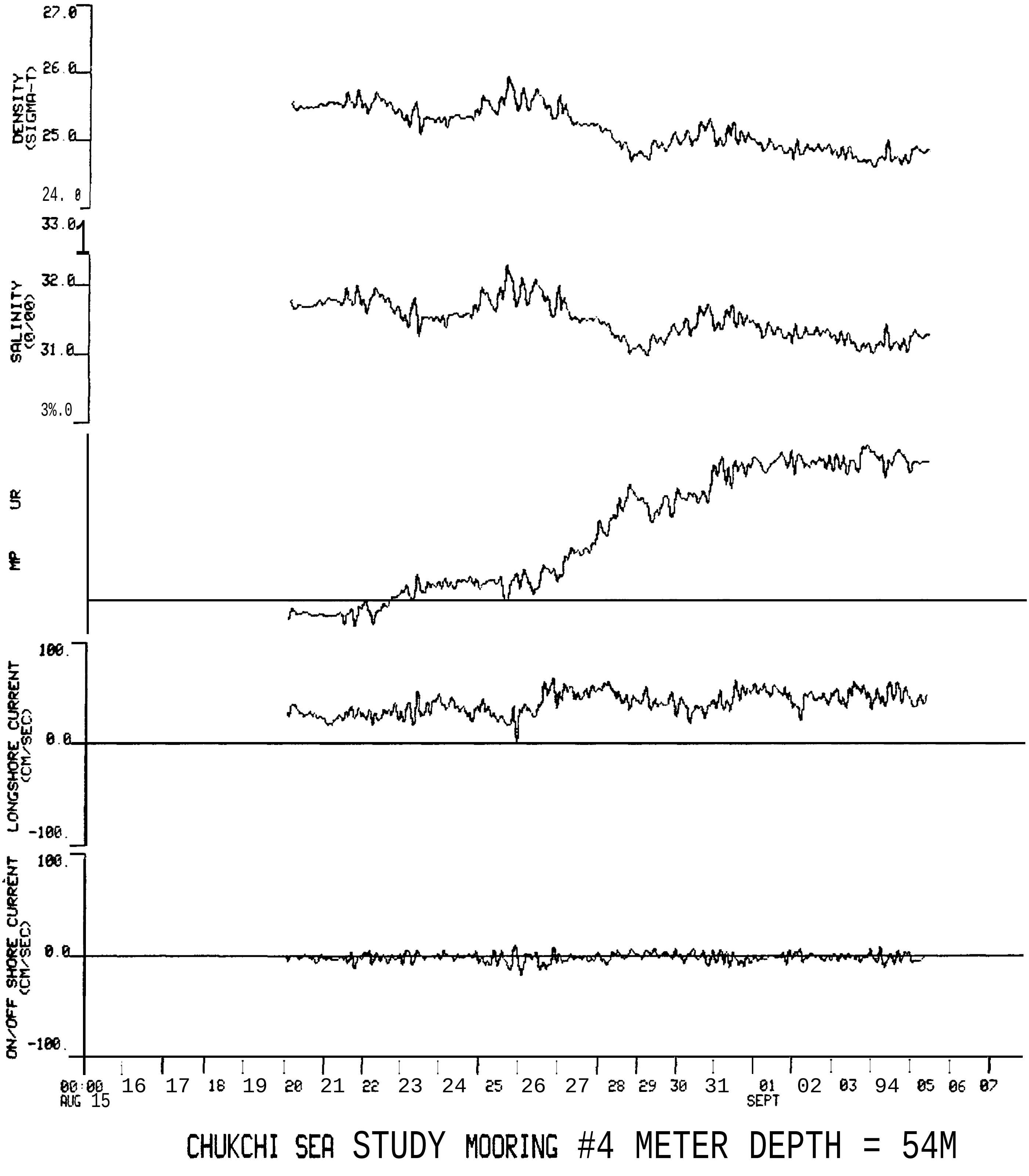


Figure 4.2c. Time series data collected at mooring 4 (depth 54 m). Positive longshore currents are directed toward 60 "T fol 1 owing the average bathymetry and positive on/offshore currents are directed toward 150 "T at right angles to the bathymetry.

There is a high coherence between longshore currents observed at 20 m at mooring 1 and those observed at 22 m at mooring 4. High coherence is also observed between the longshore currents at 22 m and at 43 m on mooring 4, and between the currents at 22 m and 54 m on mooring 4. Onshore/offshore currents observed at mooring 1, however, are considerably different than those observed at mooring 4 at any depth. Whereas the onshore/offshore currents at mooring 4 are quite small (indicating that currents parallel the average bathymetry), the currents at mooring 1 show a considerable onshore/offshore component which is discussed more extensively below.

The difference between the current fields at moorings 1 and 4 are also apparent in Figure 4.3. Note that the movement of water onshore and offshore at mooring site 1 is considerably greater than at mooring 4. Progressive vector diagrams, however, show mean net transport of water toward the northeast at both sites during the 19-day deployment.

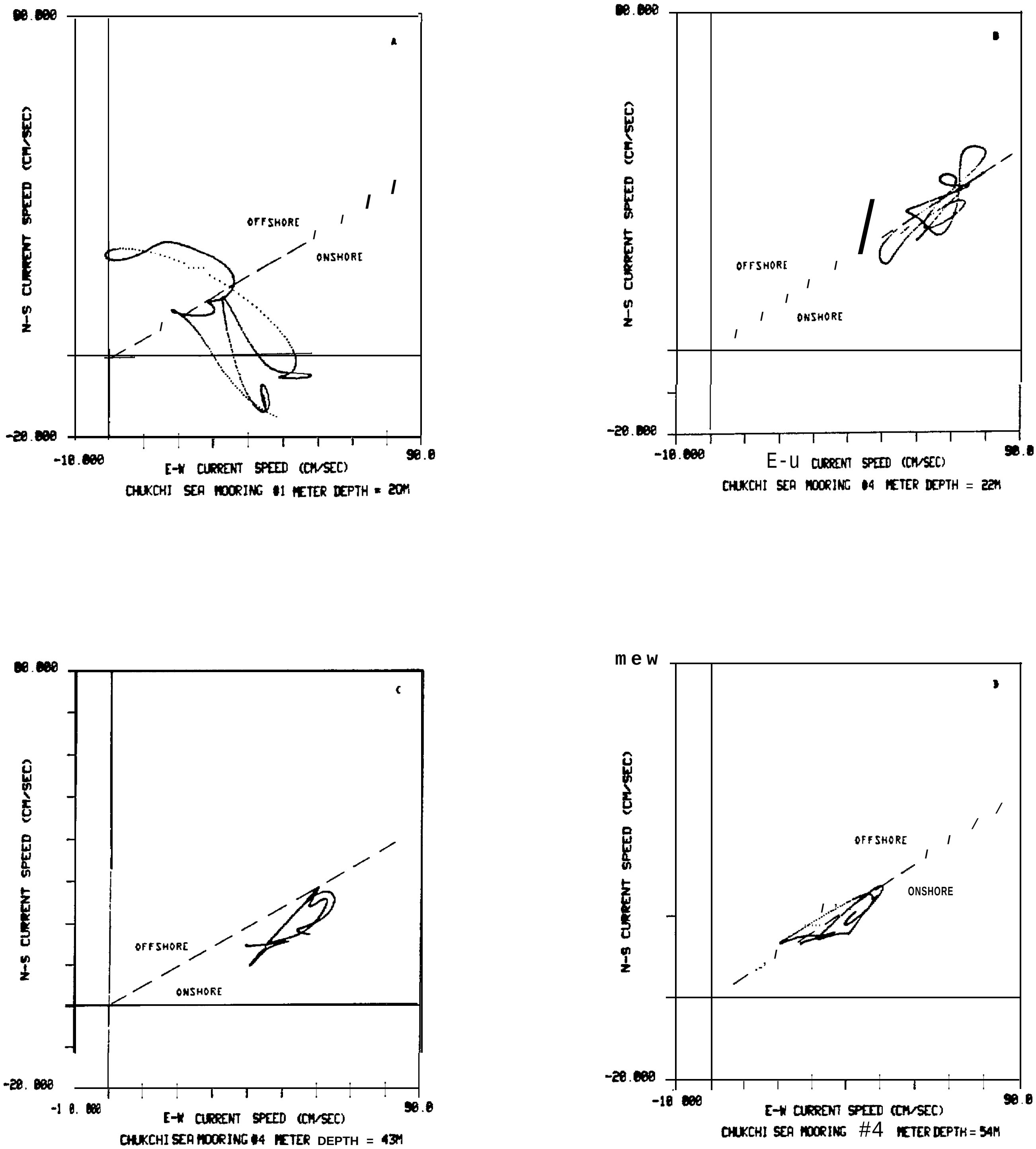


Figure 4.3. North-south currents vs. east-west currents at mooring 1 and 4. Also shown in each figure is a dashed line indicating a 60 "T heading which parallels the average bathymetric features in the study area.

Current roses constructed from the time series data at moorings 1 and 4 are shown in Figures 4.4a-d. The upper portion of each figure shows the current rose constructed from the time series data previously shown in Figures 4.1-4.2. The lower current rose is constructed from highpass-filtered data (corner frequency = 1/35 hr^{-1}) and illustrates the contribution to the total observed current signal by the short-term variability. Shown in each figure are:

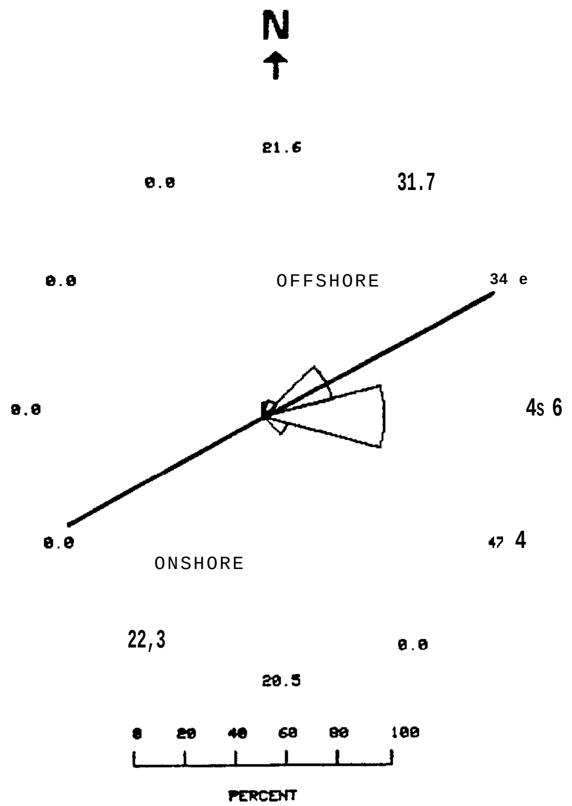
- Tabular data used to construct the current rose including the mean speed (cm/see) in each of the twelve 30-degree bins, the number of points in each bin, and the percent of the total time series occupied in each bin;
- The current rose showing the percent of the time occupied in each bin and around the perimeter of the contours, the mean speed (cm/see) observed in each bin;
- A line indicating the average direction of the bathymetry at the mooring site.

Note that the mean current (Figure 4.4a, upper) is directed onshore and alongshore to the northeast for the greatest portion of the time series (75 percent) and that major current events (Figure 4.4b, lower) are directed in an onshore/offshore direction. In contrast, the mean currents at mooring 4 (Figure 4.4b-d, upper) are directed alongshore to the northeast for almost 94 percent of the time, and current events (Figure 4.4b-d, lower) parallel the local bathymetry. Current rose information for the 43-m depth at mooring 4 (Figure 4.4c) shows some tendency to appear more like the data from mooring 1. This tendency is also observed for some of the temperature and salinity events discussed below.

UNFILTERED DATA

INPUT FILES: C1160.UCF
C1160.VCF
TOTAL POINTS = 905

BIN	DEGREES	MEAN SPEED	# PTS	PERCENT
1	34s- 15	21.6	52	6
2	15- ●	31.7	62	7
3	4s- 75	34.0	256	28
4	7s-105	4S.6	4S5	47
5	1!2s-135	47.4	9S	10
6	13S-165	0.0	0	0
7	165- 19S	20.5	3	0
8	1$S-225	22.3	17	2
9	225-255	0.0	e	e
10	255-285	0.0	e	e
11	285-315	0.0	e	e
12	31S-34S	0.0	e	e



HIGHPASS (35 HR) FILTERED DATA

INPUT FILES : C1160U.TID
C1160V.TID
TOTAL POINTS - 66S

BIN	DEGREES	MEAN SPEED	# PTS	PERCENT
1	345- 15	5.1	64	10
2	15- 45	4.4	33	5
3	45- 75	3.4	44	7
4	75-105	3.2	38	6
5	105-135	6.7	61	9
6	135-165	5.7	78	12
7	165-195	4.5	37	6
8	195-225	4.0	48	7
9	225-255	3.5	57	9
10	255-285	4.3	49	7
11	285-315	4.4	84	13
12	315-345	5.4	72	11

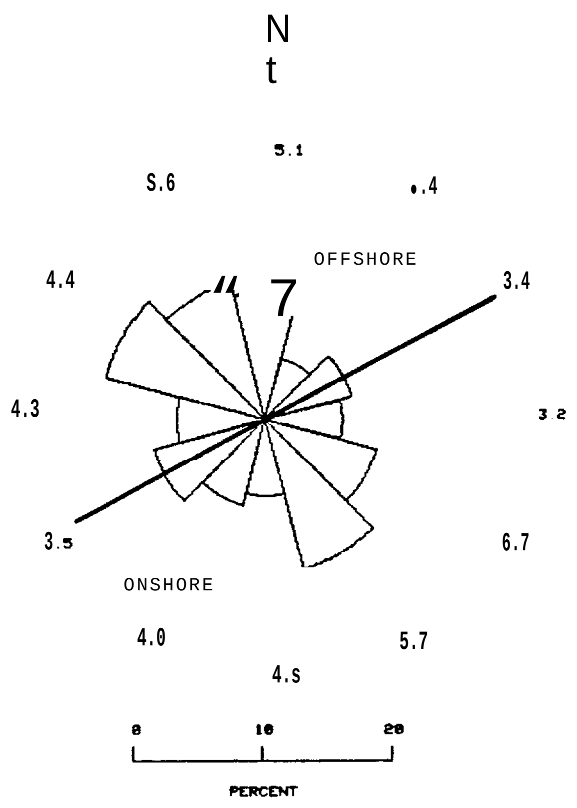
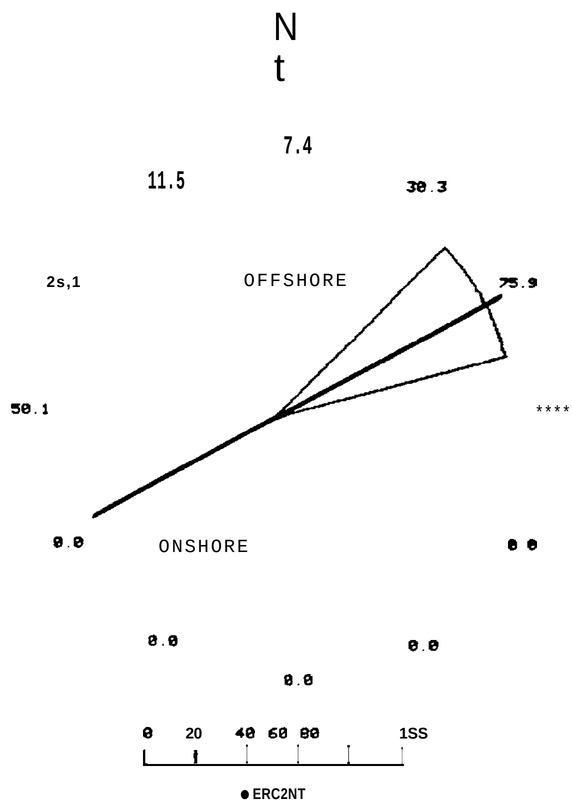


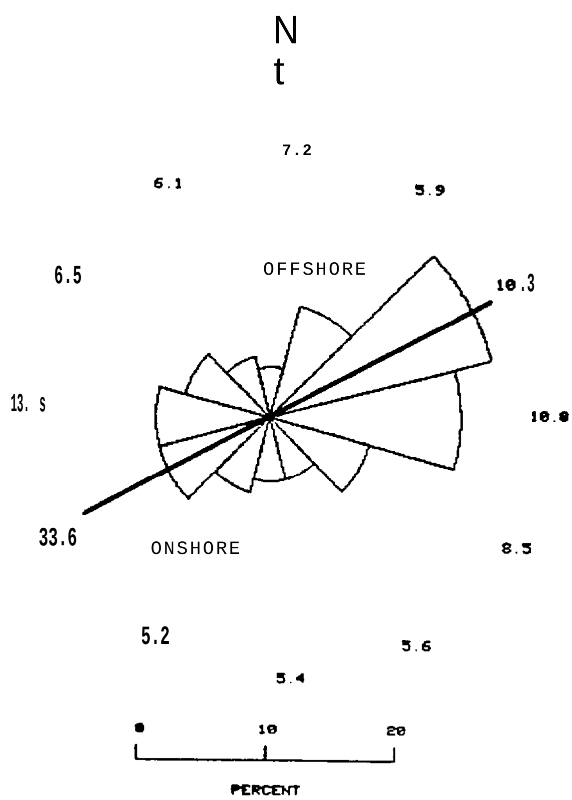
Figure 4.4a. Current roses are displayed for current meter series data at mooring 1 at the 20 m depth. Tabular data includes mean current speeds (cm/s) in each of the twelve 30-degree bins used to construct the current rose, the number of points in each bin, and the percent occurrence of currents in each bin. Graphical data includes the current rose constructed from the percent occurrence data and around the perimeter of the current rose the mean speed (cm/s) for each bin. Also shown is the direction of the average local bathymetry at the



UNFILTERED DATA

INPUT FILES: C1170 UCF
C1170.VCF
TOTAL POINTS - 833

BIN	DEGREES	MEAN SPEED	# PTS	PERCENT
1	345- 15	7.4	1	0
2	15- 45	30.3	6	1
3	45- 75	75.9	785	94
4	75-105	112.3	31	4
5	105-135	0.0	0	0
6	135-165	0.0	0	0
7	165-195	0.0	0	0
8	195-225	0.0	0	0
9	225-255	0.0	0	0
10	255-285	50.1	7	1
11	285-315	20.1	2	0
12	315-345	11.5	1	0



HIGHPASS (35 HR) **FILTERED DATA**

INPUT FILES, C1170U.TID
C1170V.TID
TOTAL POINTS - 545

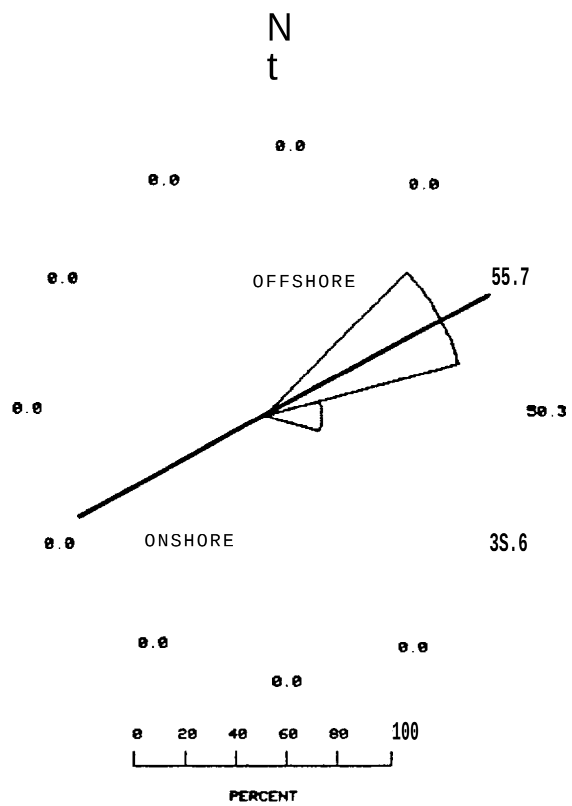
BIN	DEGREES	MEAN SPEED	# PTS	PERCENT
1	345- 15	7.2	23	4
2	15- 45	5.9	48	9
3	45- 75	10.3	98	18
4	75-105	10.8	84	15
5	105-135	8.5	46	8
6	135-165	5.6	28	5
7	165-195	5.4	26	5
8	195-225	5.2	30	6
9	225-255	33.6	48	9
10	255-285	13.5	48	9
11	285-315	6.5	40	7
12	315-345	6.1	26	5

Figure 4.4b. Current roses are displayed for current meter time series data at mooring 4 at the 22 m depth. Tabular and graphic data explained in 4.4a.

UNFILTERED DATA

INPUT FILES, M3448.UF
M3448.VF
TOTAL POINTS - 784

BIN	DEGREES	MEAN SPEED	• PTS	PERCENT
1	345- 15	0.0	0	0
2	15- 45	0.0	0	0
3	45- 75	55.7	612	78
4	75-105	50.3	170	22
5	105-135	30.6	2	B
6	135-165	0.0	0	e
7	165-195	0.0	0	0
8	195-225	0.0	0	0
9	225-255	0.0	0	e
10	255-285	0.0	0	0
11	285-315	0.0	0	0
12	315-345	0.0	0	0



HIGHPASS (35 HR) FILTERED DATA

INPUT FILES: M3448U.TID
M3448V.TID
TOTAL POINTS = 544

BIN	DEGREES	MEAN SPEED	# PTS	PERCENT
1	345- 15	5.3	43	8
2	1s- 45	6.S	71	13
3	4s- 7s	7.6	51	9
4	7s-105	7.9	4S	8
5	105-135	5.3	28	5
6	13s-165	7.1	34	6
7	16s-195	6.6	46	8
8	195-225	7.6	5S	10
9	22S-255	9.0	45	8
10	2s5-2s5	7.7	54	10
11	2S5-31S	6.0	32	6
12	313-34S	5.1	40	7

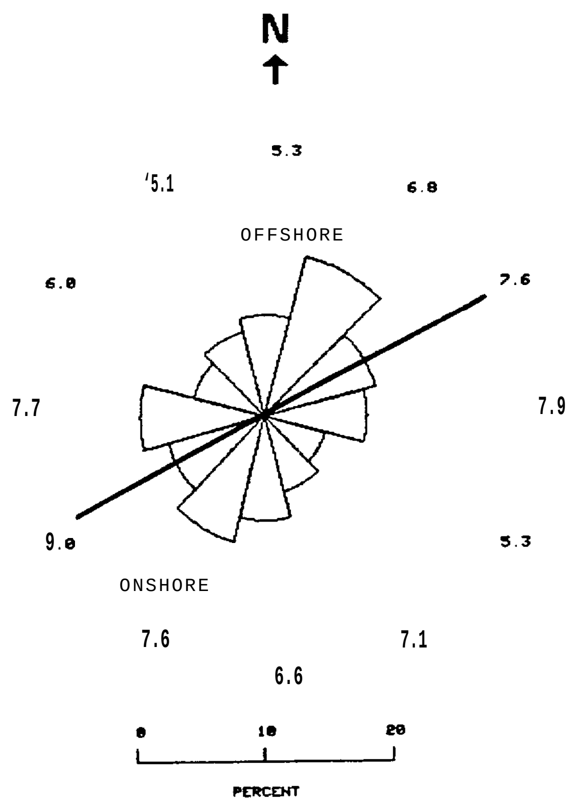
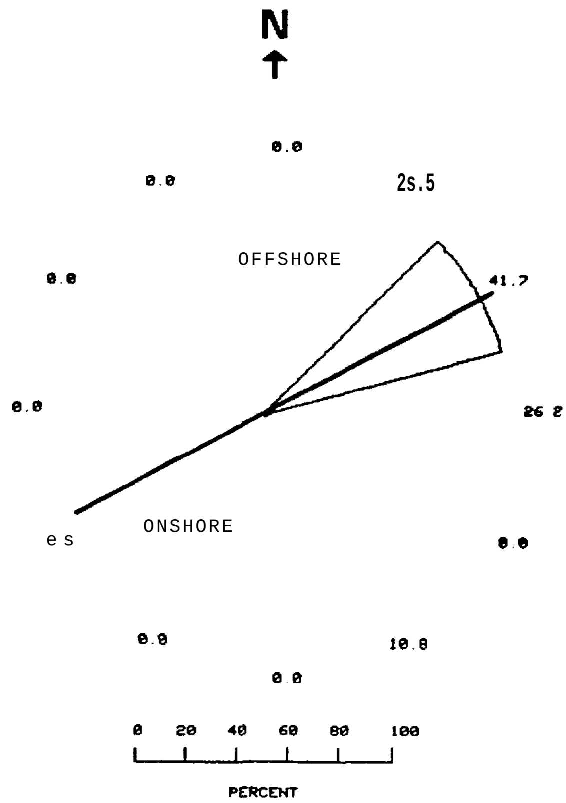


Figure 4.4c. Current roses are displayed for current meter time series data at mooring 4 at the 43 m depth. Tabular and graphic data explained in Figure 4.4a.

UNFILTERED DATA

INPUT FILES: M1821.UF
M1821.VF
TOTAL POINTS = 784

BIN	DEGREES	MEAN SPEED	# PTS	PERCENT
1	345- 15	0.0	0	0
2	15- 45	29.5	13	2
3	45- 75	41.7	756	96
4	75-105	26.?	13	2
5	105-135	0.0	0	0
6	135-165	0.0	2	0
7	165-195	0.0	0	0
8	195-225	0.0	0	0
9	225-255	0.0	0	0
10	255-285	0.0	0	0
11	285-315	0.0	0	0
12	315-345	0.0	0	0



HIGHPASS (35 HR) FILTERED DATA

INPUT FILES: M1 821U.TID
M1821V.TID
TOTAL POINTS = 544

BIN	DEGREES	MEAN SPEED	# PTS	PERCENT
1	345- 15	5.s	35	6
2	15- 45	6.3	59	11
3	45- 75	7.1	76	14
4	75-105	6.7	44	8
5	105-135	4.7	35	6
6	135-165	4.s	34	6
7	165-195	5.s	20	4
8	195-225	9.0	42	8
9	225-255	7.2	88	16
10	255-285	5.5	51	9
11	285-315	5.0	30	6
12	315-345	4.1	30	6

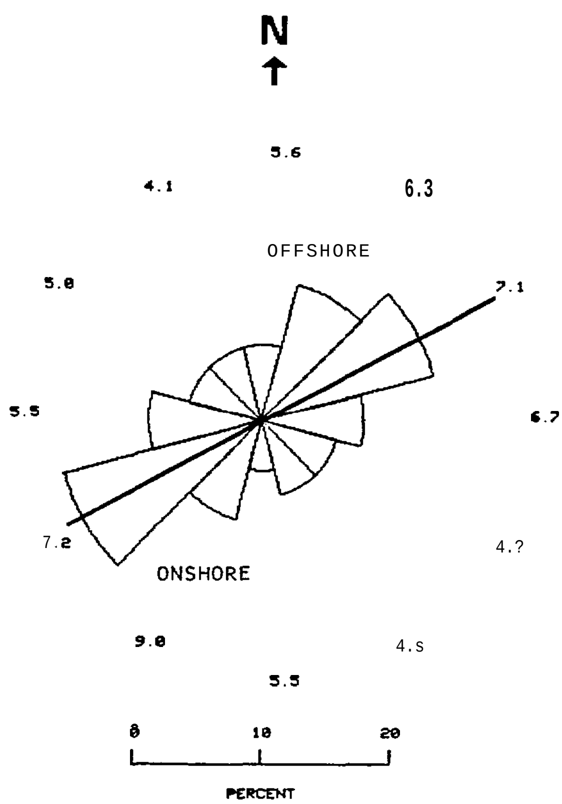
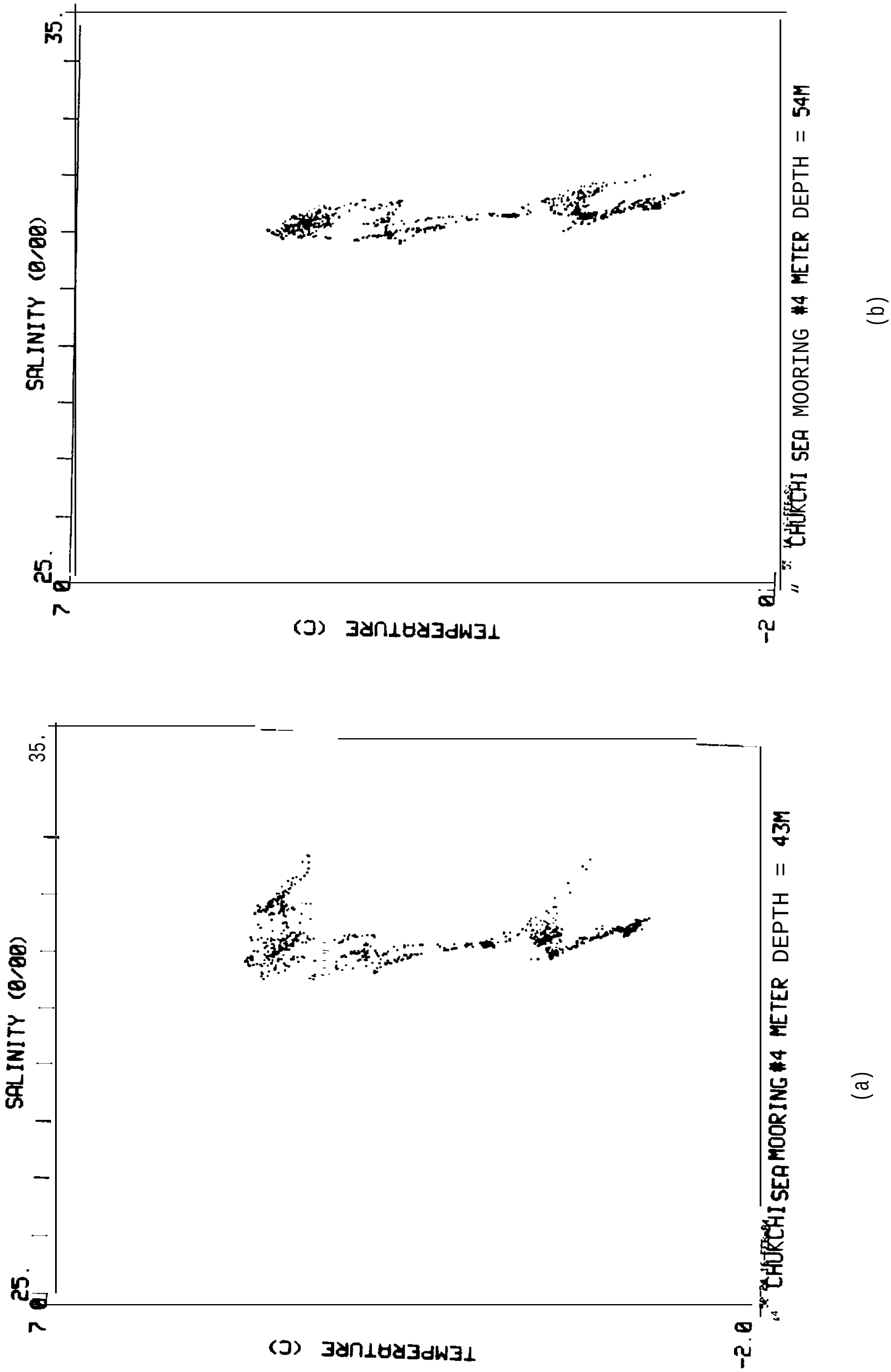


Figure 4.4d. Current roses are displayed for current meter time series data at mooring 4 at the 54 m depth. Tabular and graphic data explained in Figure 4.4a.

Temperature-salinity (T-S) plots for Aanderaa current meters deployed on mooring 4 are shown in Figure 4.5. The T-S signature of the two data records (separated vertically by only 11 meters) is quite similar except for the two water masses seen at the 43-m depth (Figure 4.5a) where the salinity exceeds 32 o/oo at temperatures of O-1 "C and 4-5 "C. These features are not observed at the 54-m depth (Figure 4.5b). These events can be seen in the time series data in Figure 4.2b on 25 August and 1-2 September but are missing on Figure 4.2c for the same period. Two other such events are seen in Figure 4.2b on 3-4 September, although peak salinities only reach 32.0 o/oo on these last two events. Because all of these events have only salinity and no temperature signatures, it cannot be determined if they occur at the 22-m depth where only temperature was recorded. If, however, the temperature time series recorded at mooring 1 is examined for the events beginning on 1 September (ref. Figure 4.1), a change in the character of the temperature signal can be observed in time series data which persists for the period that three events (l-4 September) are observed in the 43-m depth at mooring 4.

4.1.2. Drogue and Drifter Study

Table 3.3 summarized the deployment of eight radio-tracked drogued buoys in the study area. Tracking the drogues was difficult because of heavy concentrations of ice in the nearshore regions. Since the drogue radio signal relies on the propagation of a ground wave signal over a conducting medium (sea water), the presence of ice (fresh water) considerably weakens the signal strength and reliability of signals received at the shore-based tracking stations. In addition, a severe storm arose on 17 August which drove more ice into the nearshore region and prevented helicopter-supported tracking operations for two days. Several drogues were destroyed by the ice. Figure 4.6 shows tracks of several of the drogues deployed near Pt. Franklin.



F gure 4.5. Temperature-salinity plots for mooring 4 at 43-m depth (panel a, and 54-m depth (pane b,.

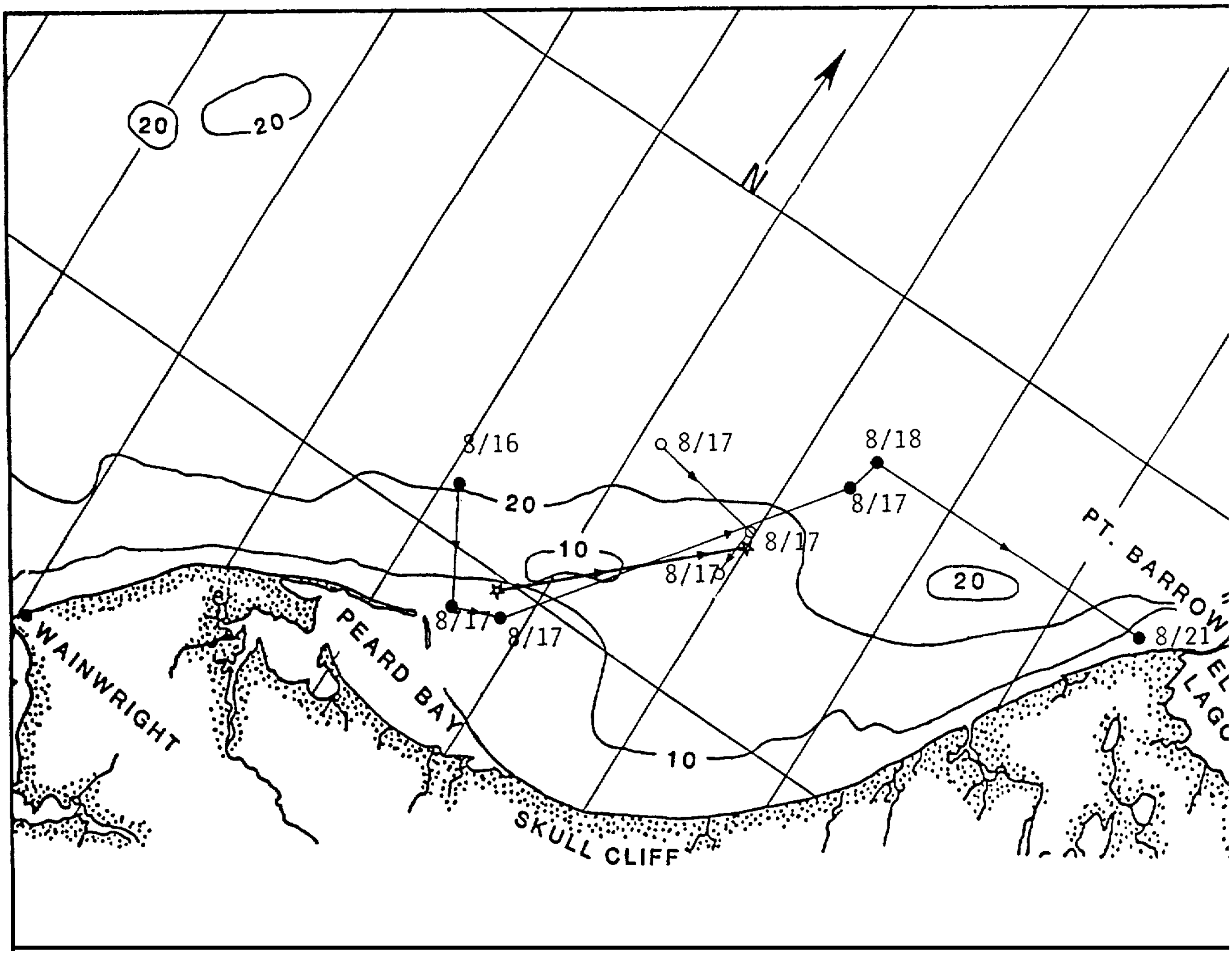


Figure 4.6. Trajectories of three radio-tracked buoy movements in the Pt. Frank area on 8/16-21/85 (●), 8/17/85 (*), and 8/17/85 (0).

Surface and bottom drifter deployments were summarized in Table 3.3. Helicopter searches for beached drifters were conducted on the mornings of 16, 17, 19 and 20 August and no recoveries were made. It must be noted that winds were easterly during all of the drifter deployments and drifters may have moved offshore. When winds changed to southwesterly on 17 August, the ice was moved onshore making drifter recovery almost impossible. However, it is noteworthy that, of the almost 500 drifters which were deployed during this period, none were found anywhere along the beach during any portion of the program.

4.2. Winds

Meteorological measurements obtained at Pt. Franklin (Peard Bay) and Wainwright by Dr. T. Kozo in a concurrent OCSEAP-sponsored program (Kozo, 1984) were made available to this program and are displayed in Figure 4.7. Winds observed at Pt. Franklin/Peard Bay appear to track Wainwright winds quite well, implying that the historic meteorological data which exists for Wainwright airport may be used to characterize winds at Peard Bay. These data and current data previously discussed (Section 4.1.1) have been lowpass-filtered at a corner frequency of 1/35 hr^{-1} and are displayed in Figures 4.8-4.9. These figures show that, while the wind had some effect in directing the currents onshore and offshore at mooring 1, the wind apparently only offset the magnitude of the northeasterly flow at mooring 4. The severe winds from the southwest on 17-18 August (which stranded the shore-based party at Pt. Franklin during a severe storm surge and which trapped DISCOVERER in the ice north of Pt. Franklin for two days) seem to have considerably modified the nearshore temperature field at mooring 1 (Figure 4.8 upper). A similar change in the temperature field was not experienced at mooring 4 until 28 August after a similar southwesterly wind event occured (Figures 4.7 and 4.9).

Other wind data for the winter program for the Peard Bay area have been collected from the US National Weather Service.

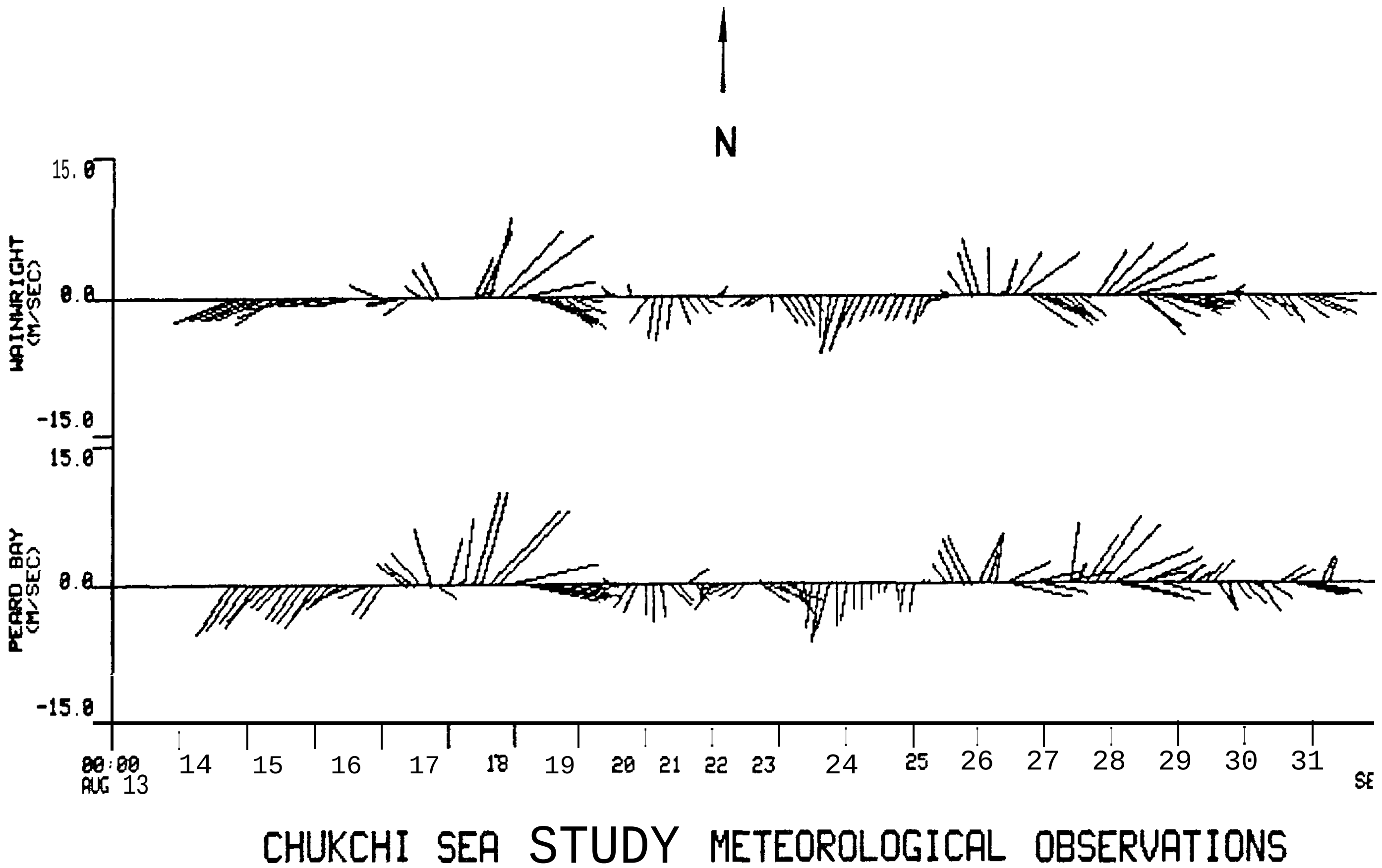


Figure 4.7. Wind measurements at Wainwright Island and Pt. Franklin. Wind vectors indicate direction of wind, i.e. , direction in which air is moving. Vector length denotes wind speed according to scale on vertical axis.

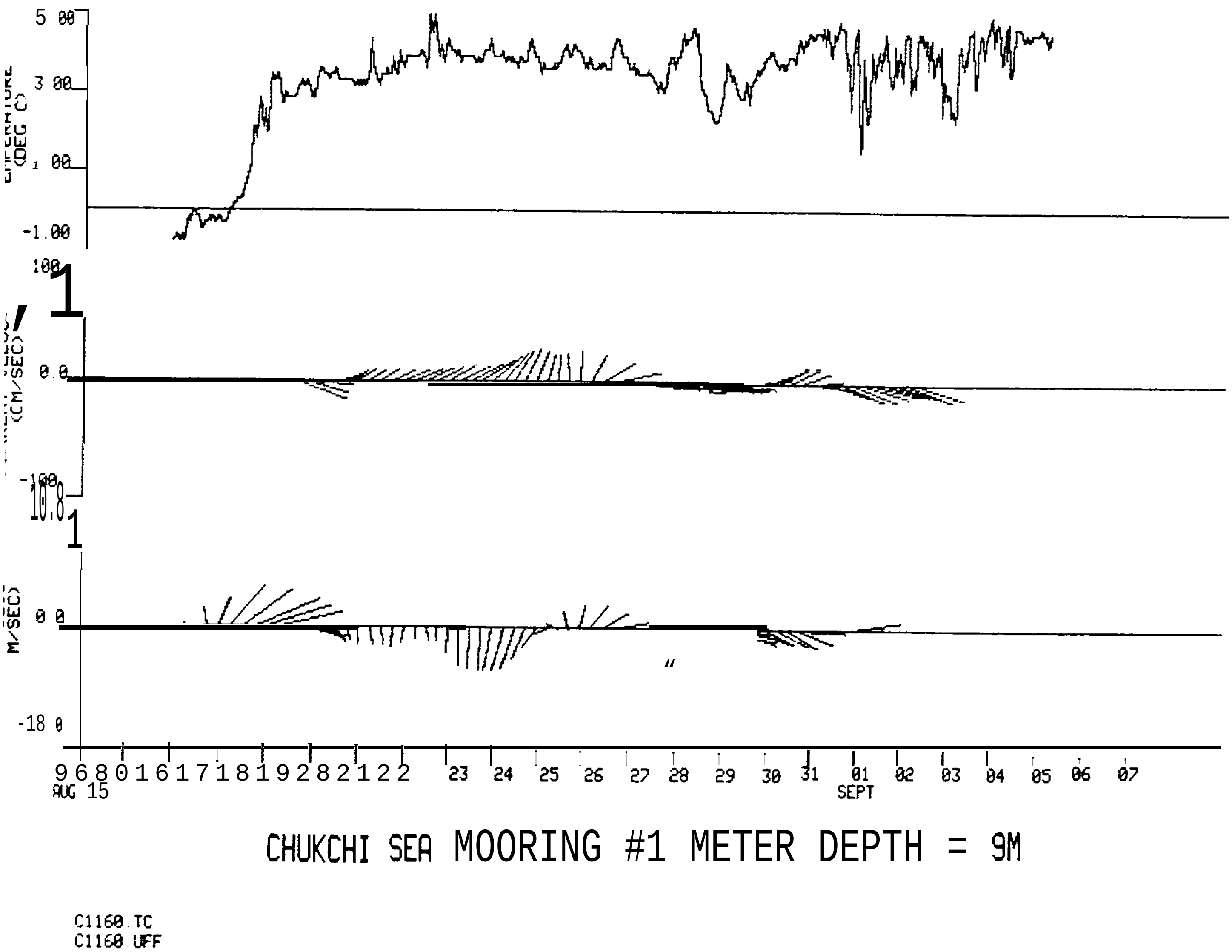


Figure 4.8. Lowpass-filtered wind and current measurements for mooring 1 (depth 20 m).

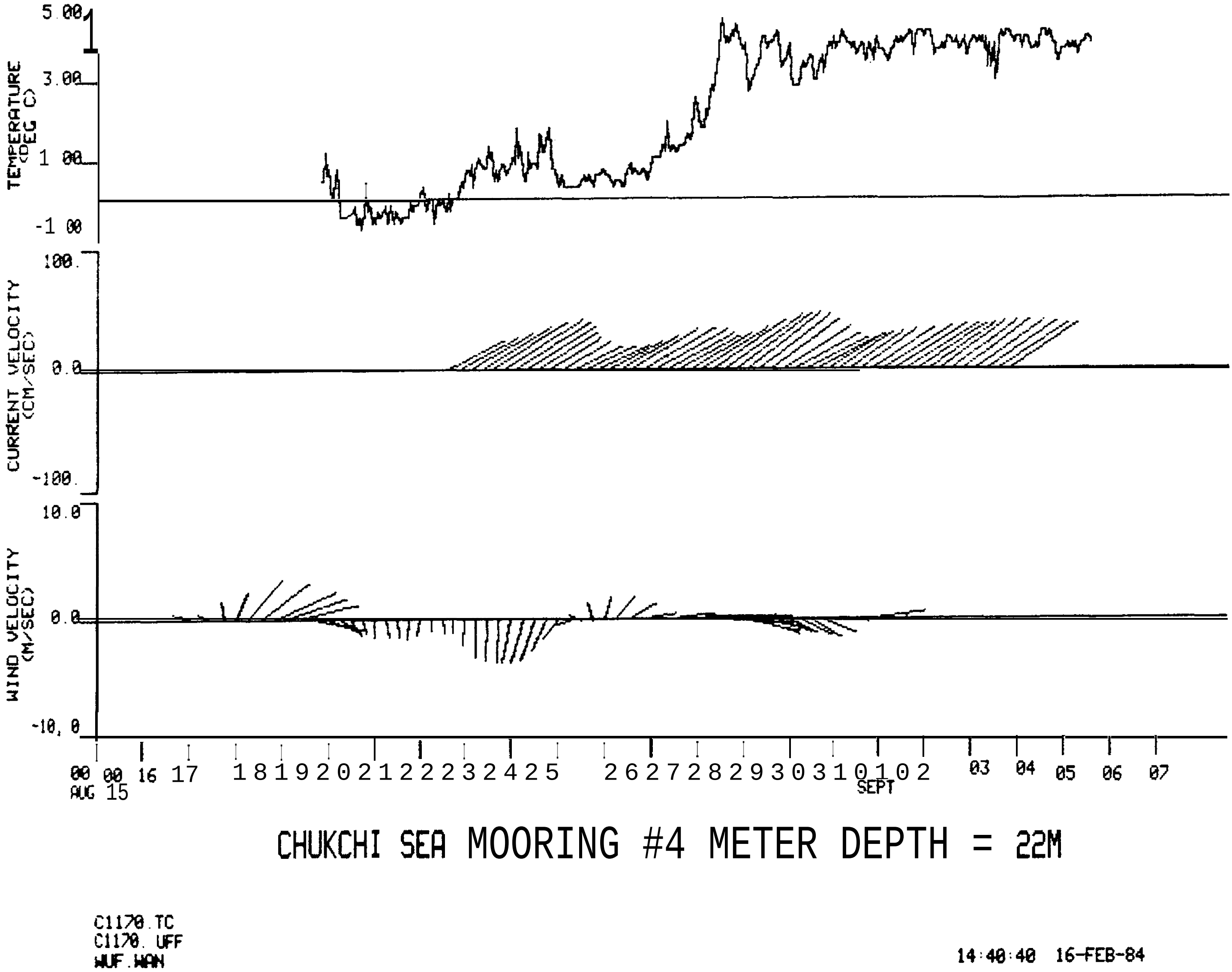


Figure 4.9a. Low-pass-filtered wind and current measurements for mooring 4 (depth 22 m).

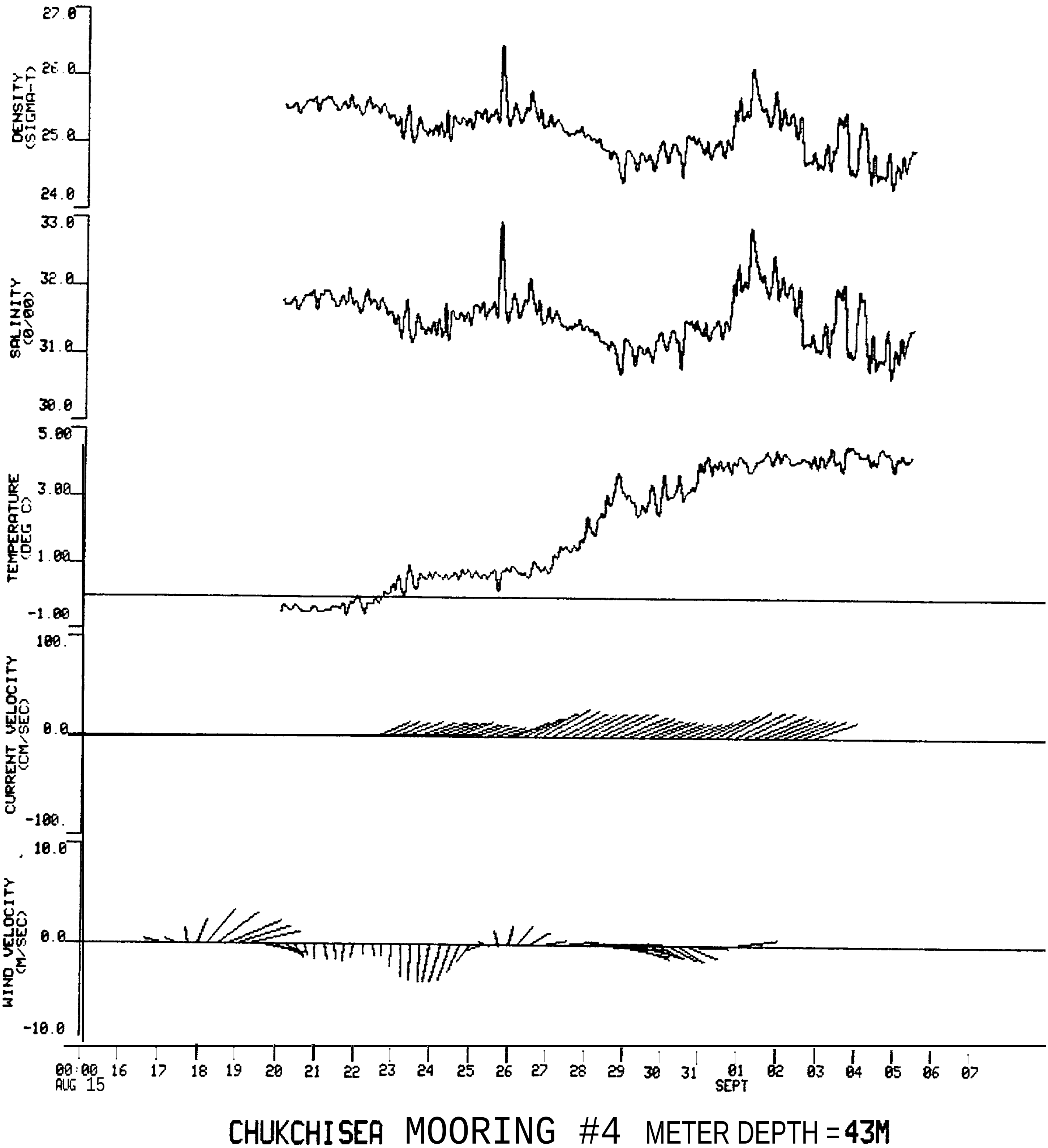


Figure 4.9b. Lowpass-filtered wind and current measurements for mooring 4 (depth 43 m).

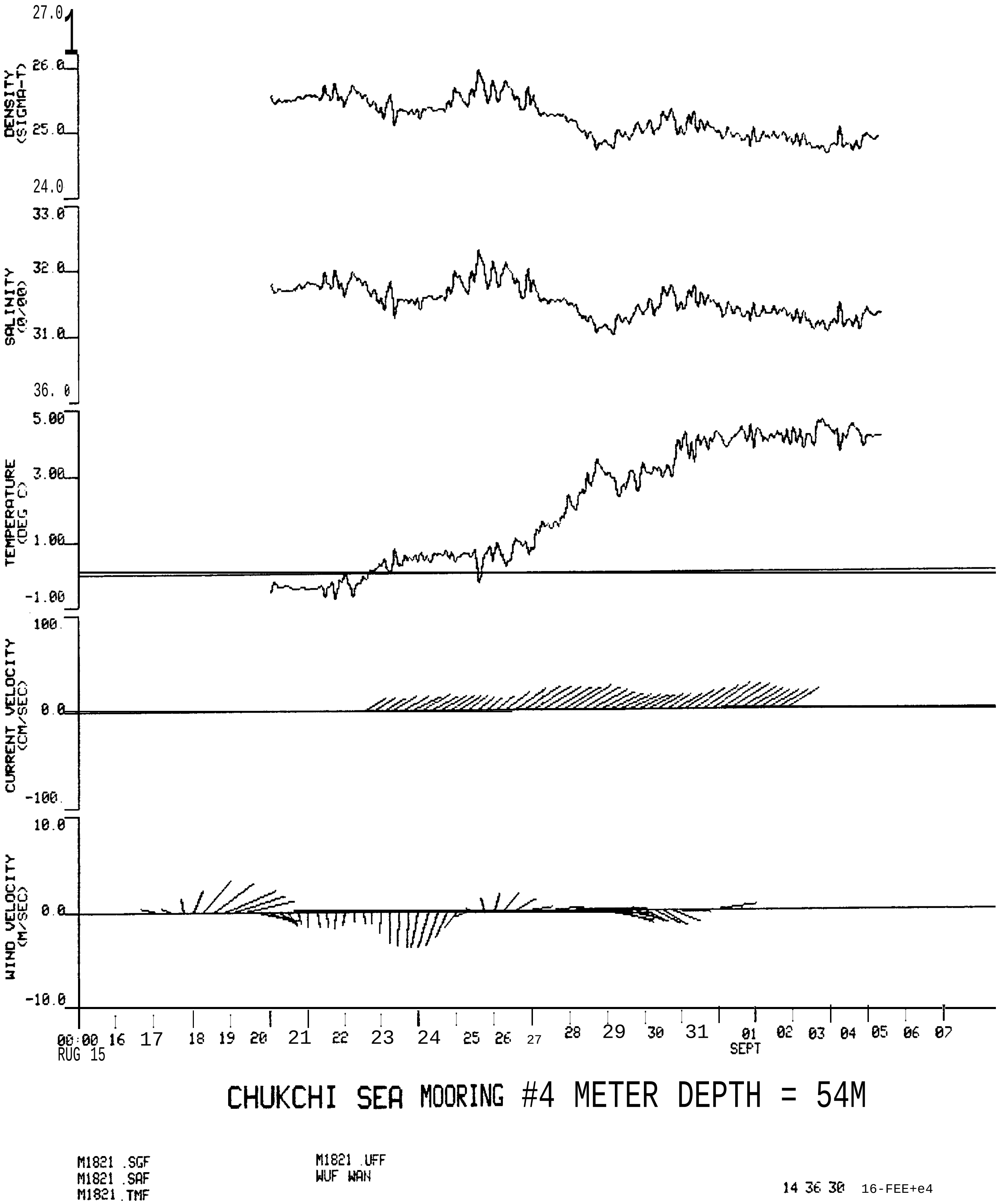


Figure 4.9c. Lowpass-filtered wind and current measurements for mooring 4 (depth 54 m).

4.3. Hydrography

4.3.1. Summer Conditions

A total of 12 CTD sections were taken between Icy Cape and Pt. Barrow during open-water conditions. In addition, sea-surface temperature (SST) and surface bucket samples were collected while the ship transited the study area. These data have been processed and are presented below.

Hydrographic sections have been constructed from the 87 CTD casts made 12-21 August 1983. Data for sections located between Icy Cape and Pt. Barrow are presented in Figures 4.11-4.22. The location of each section is shown in Figure 4.10. These sections show both the varying bathymetry found along the coastline from Icy Cape to Pt. Barrow and the variability of the water mass types which may be observed in the region along with the apparent upwelling (note progress of 0 "C isotherm toward shore in response to wind-driven offshore transport of surface waters) which progressed from 13 to 15 August in response to northeasterly winds. On 17 August the winds rapidly shifted to southerly (Figure 4.7) and eventually southwesterly on 18 August. In response to this changing wind pattern, Sections 5*, 7* and 8* taken on 19 August show that the colder bottom water moved offshore and that a warm northerly-moving (Figure 4.1) coastal wedge was established in the nearshore region out to 20 km (Figure 4.18). This temporal progression of sections taken just south of the Pt. Franklin area is shown more clearly in Figure 4.23. The degree of variability which can be rapidly produced by the changing wind conditions is dramatically illustrated in Figure 4.24. The upper section was taken 16 August under northeasterly wind conditions which promote upwelling in the nearshore region. The lower section was taken 19 August under southwesterly wind conditions which promote the establishment of a warm coastal jet in the nearshore region and remove cooler bottom water from the nearshore. Of particular interest is

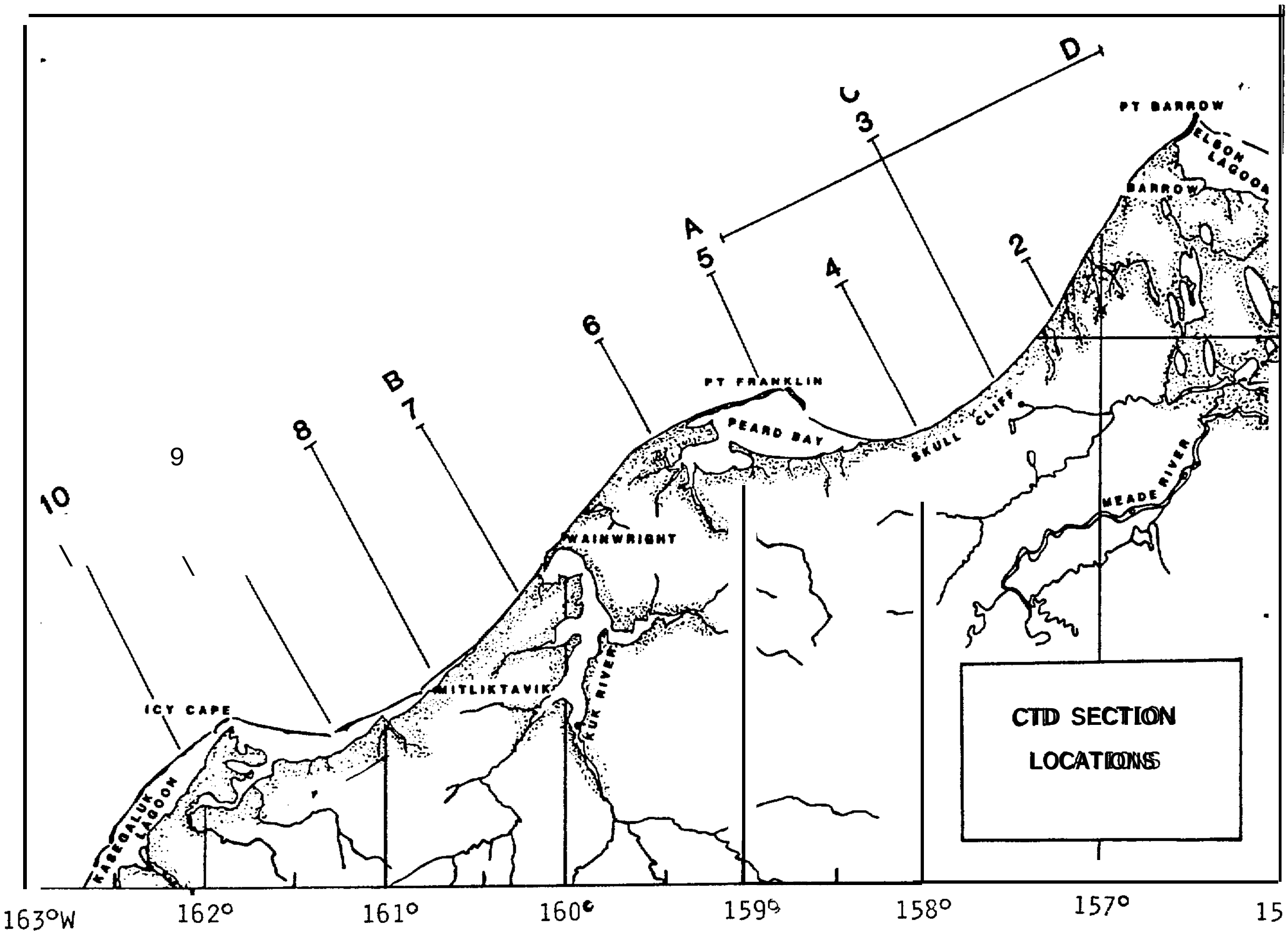


Figure 4.10. CTD sections taken in the August 1983 (locations 2-10) and February/March 1984 (locations A-D) field programs. Note: stations in sections 5, 7, 8 and A were occupied twice.

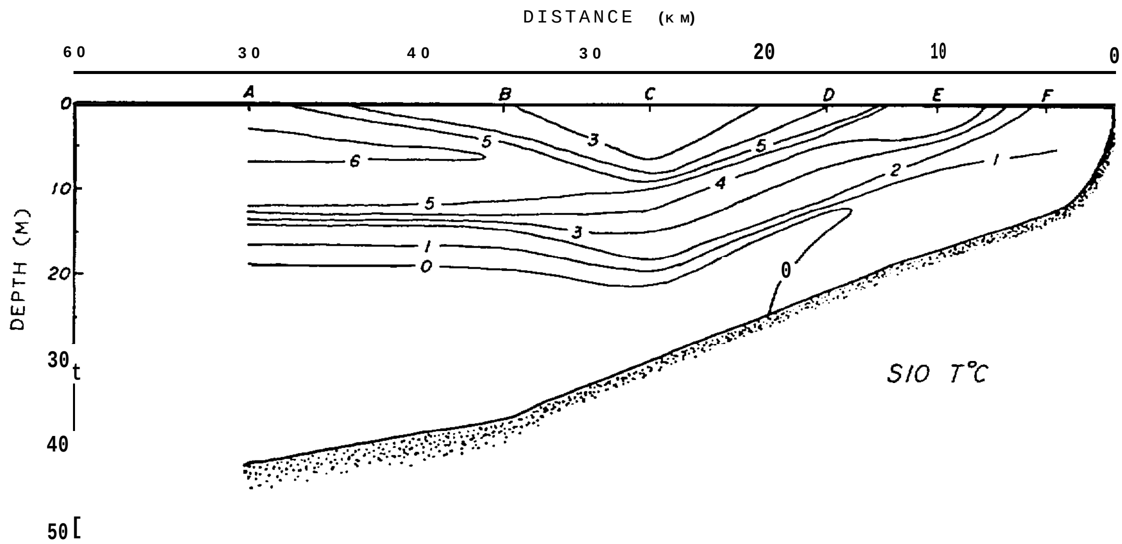


Figure 4.11. Section 10 near Icy Cape occupied 13 August 1983.

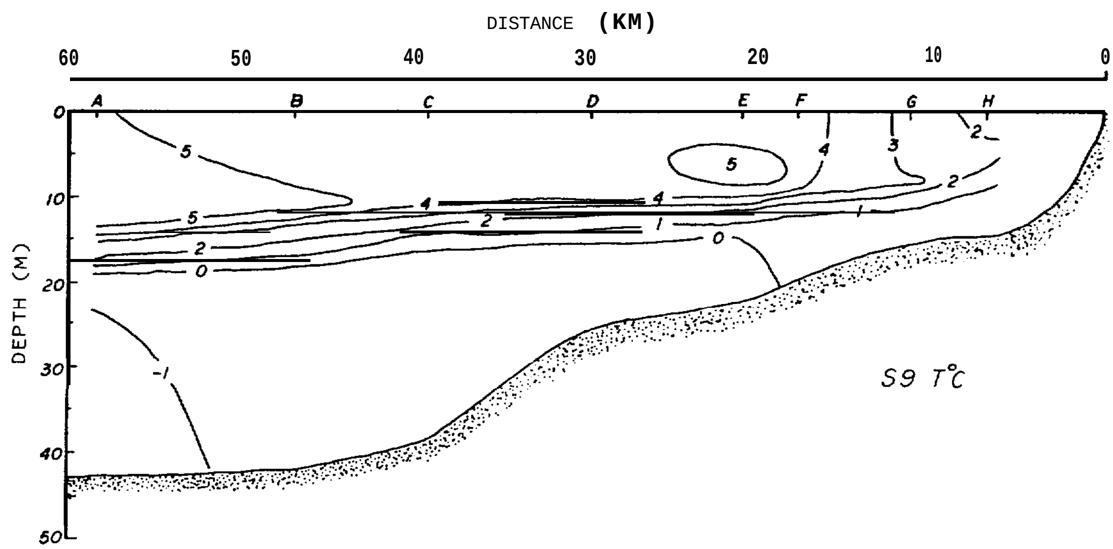


Figure 4.12. Section 9 northeast of Icy Cape occupied 13 August 1983.

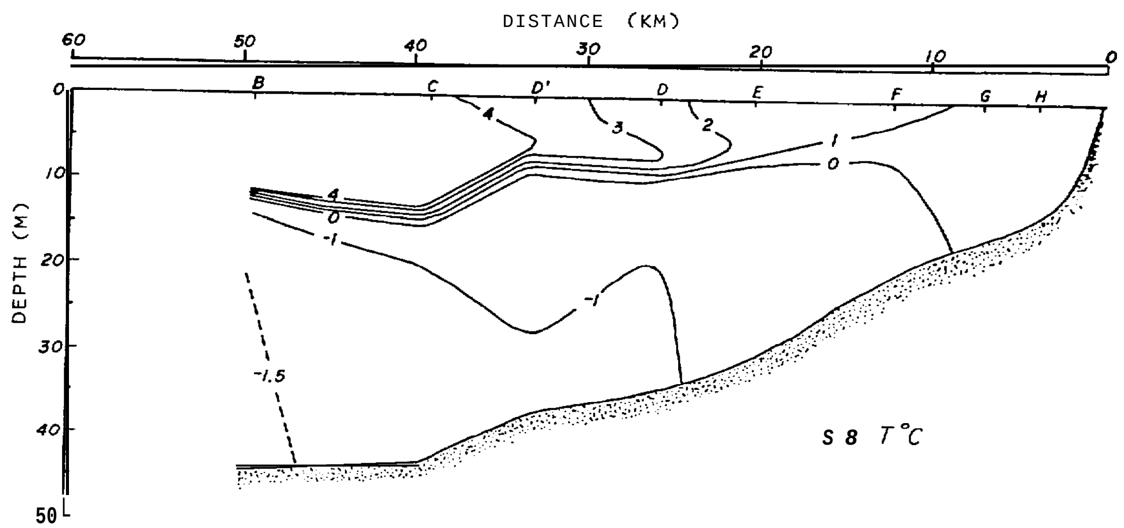


Figure 4.13. Section 8 at Mitliktavik occupied 14 August 1983.

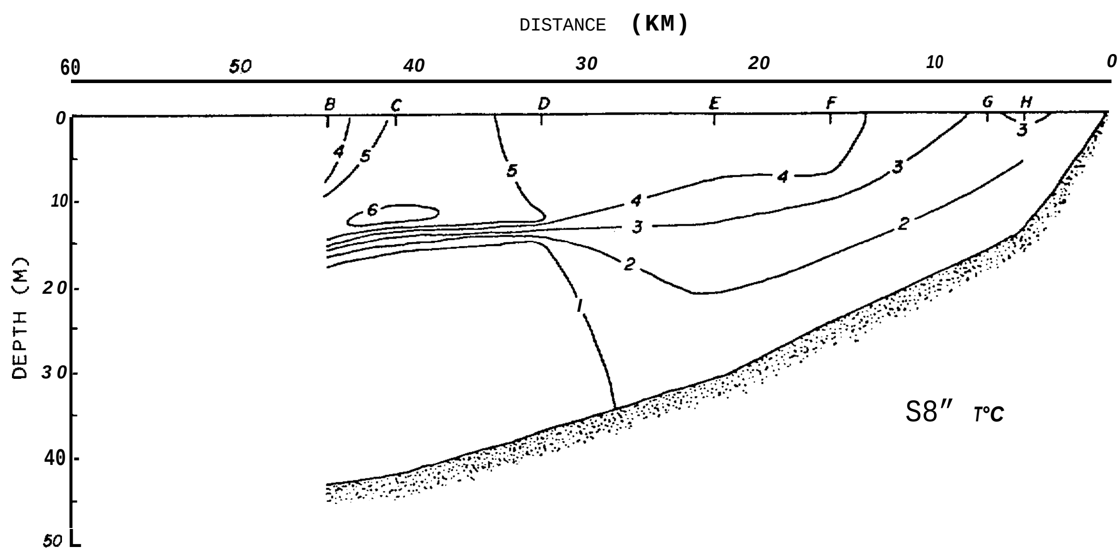


Figure 4.14. Section 8* at Mitliktavik occupied 21 August 1983.

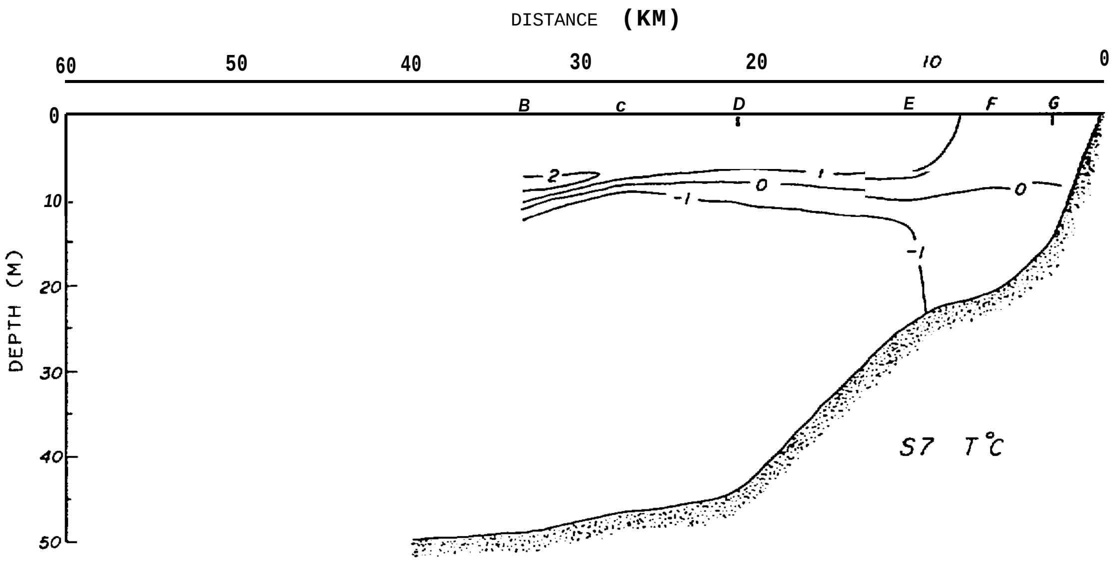


Figure 4.15. Section 7 near Wainwright occupied 14 August 1983.

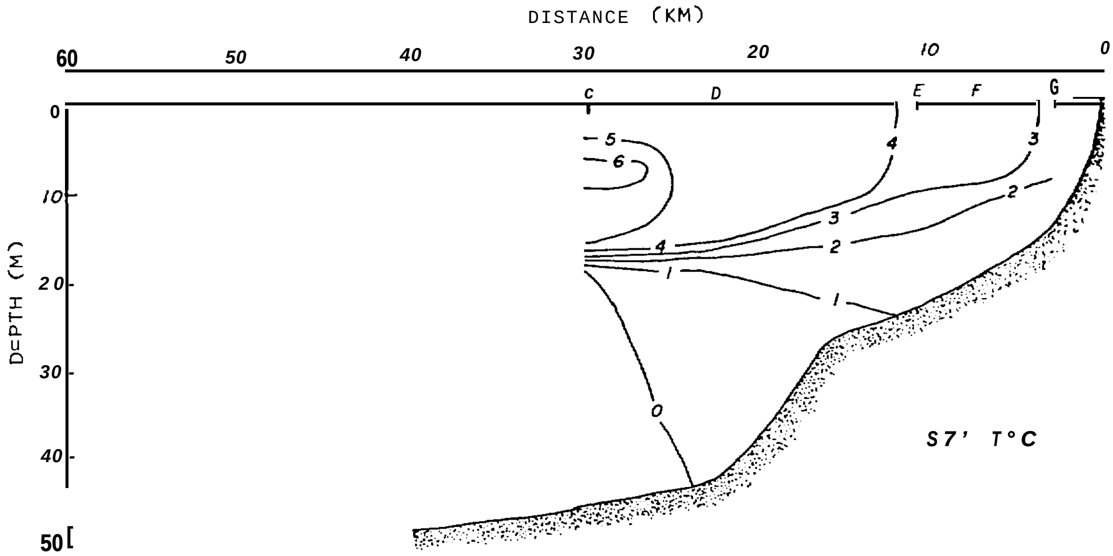


Figure 4.16. Section 7* near Wainwright occupied 21 August 1983.

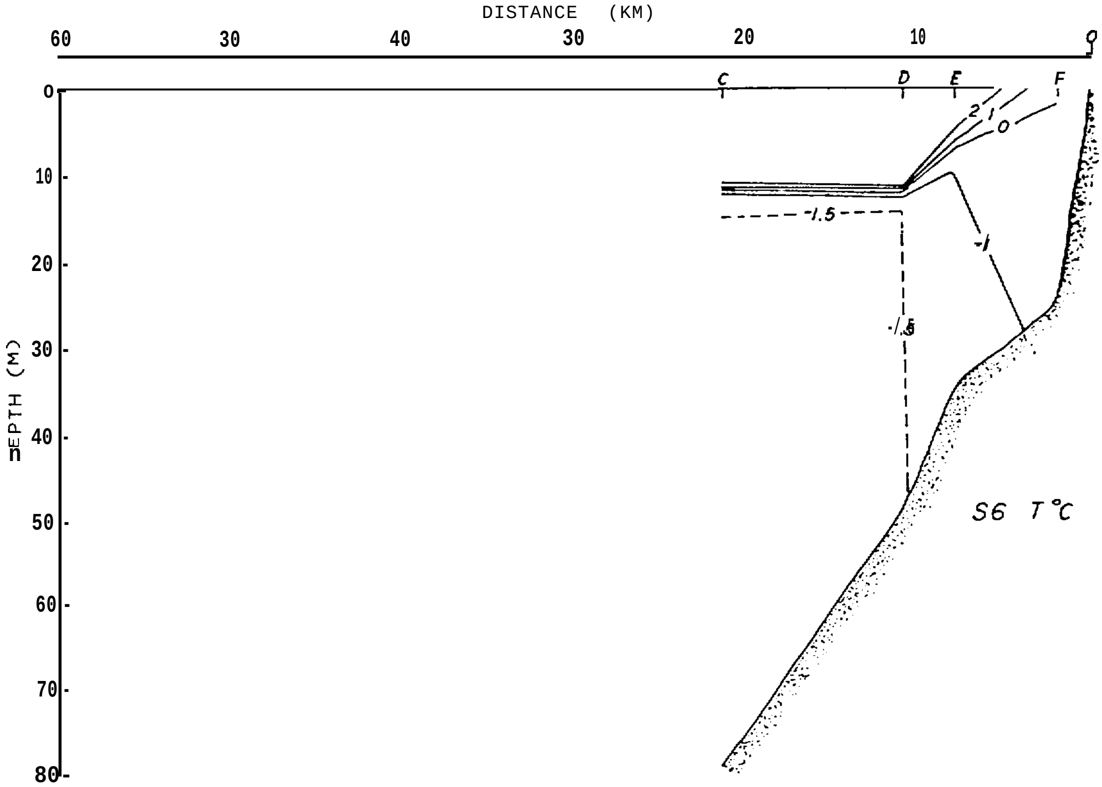


Figure 4.17. Section 6 between Wainwright and Pt. Franklin occupied 15 August 1983.

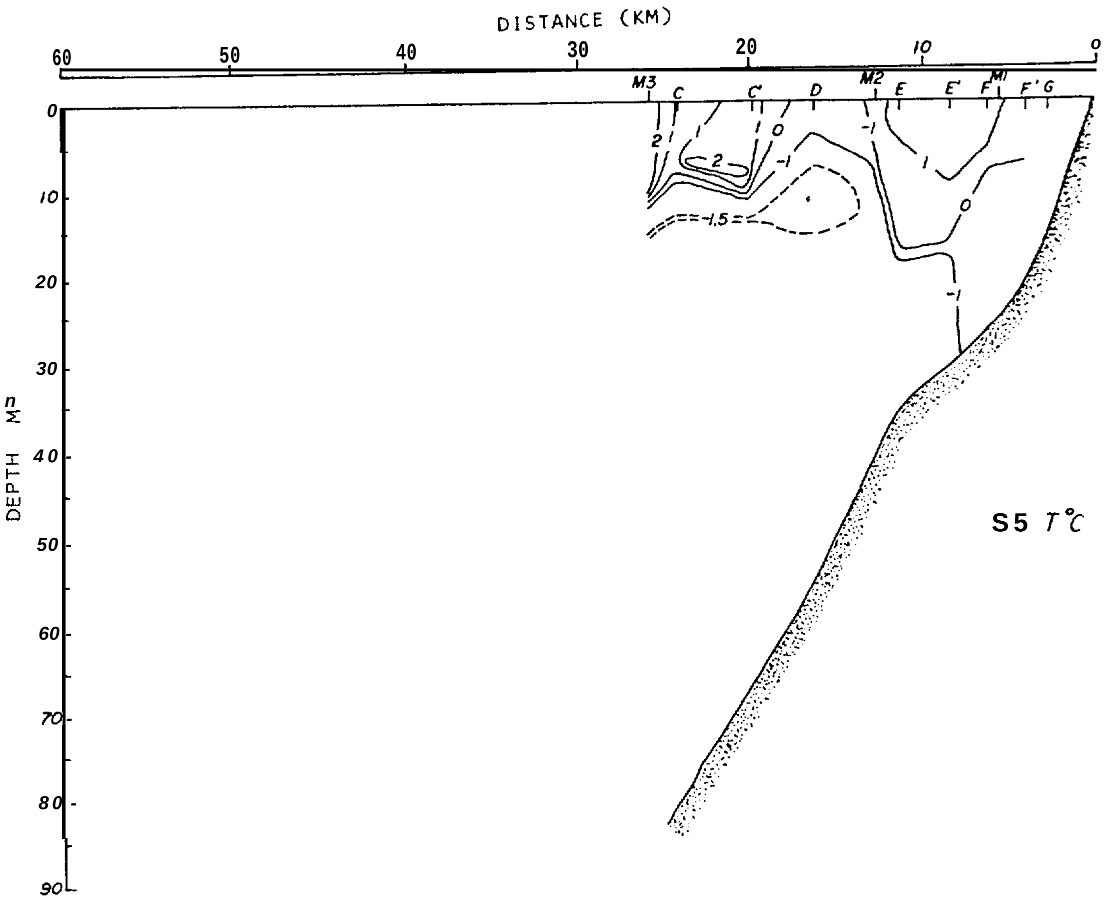


Figure 4.18. Section 5 at Pt. Franklin occupied 15 August 1983.

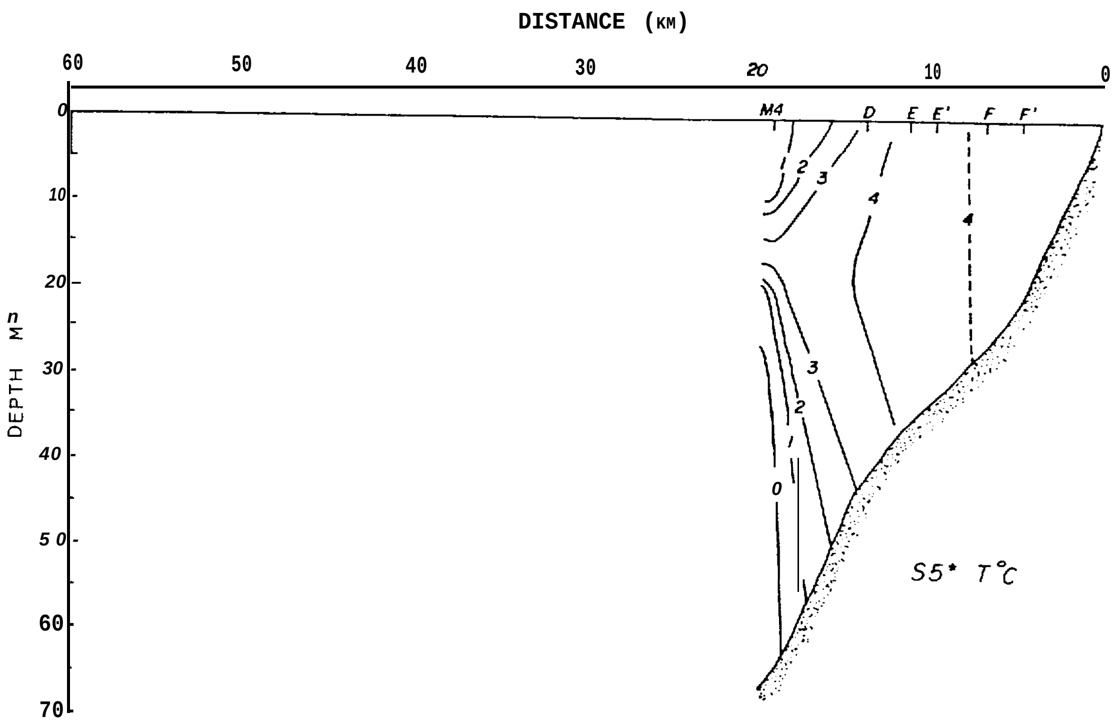


Figure 4.19. Section 5* at Pt. Franklin occupied 19 August 1983.

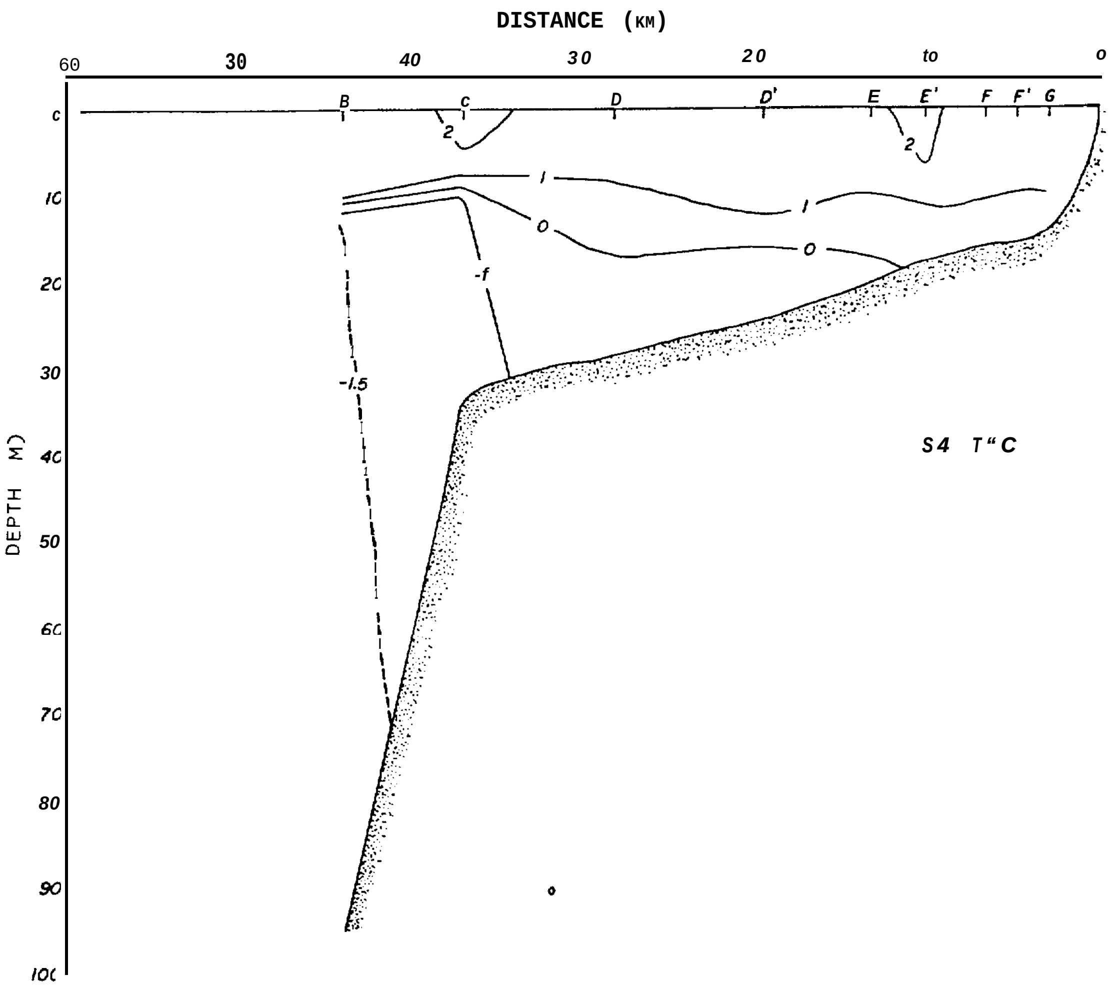


Figure 4.20. Section 4 north of Pt. Franklin occupied 16 August 1983.

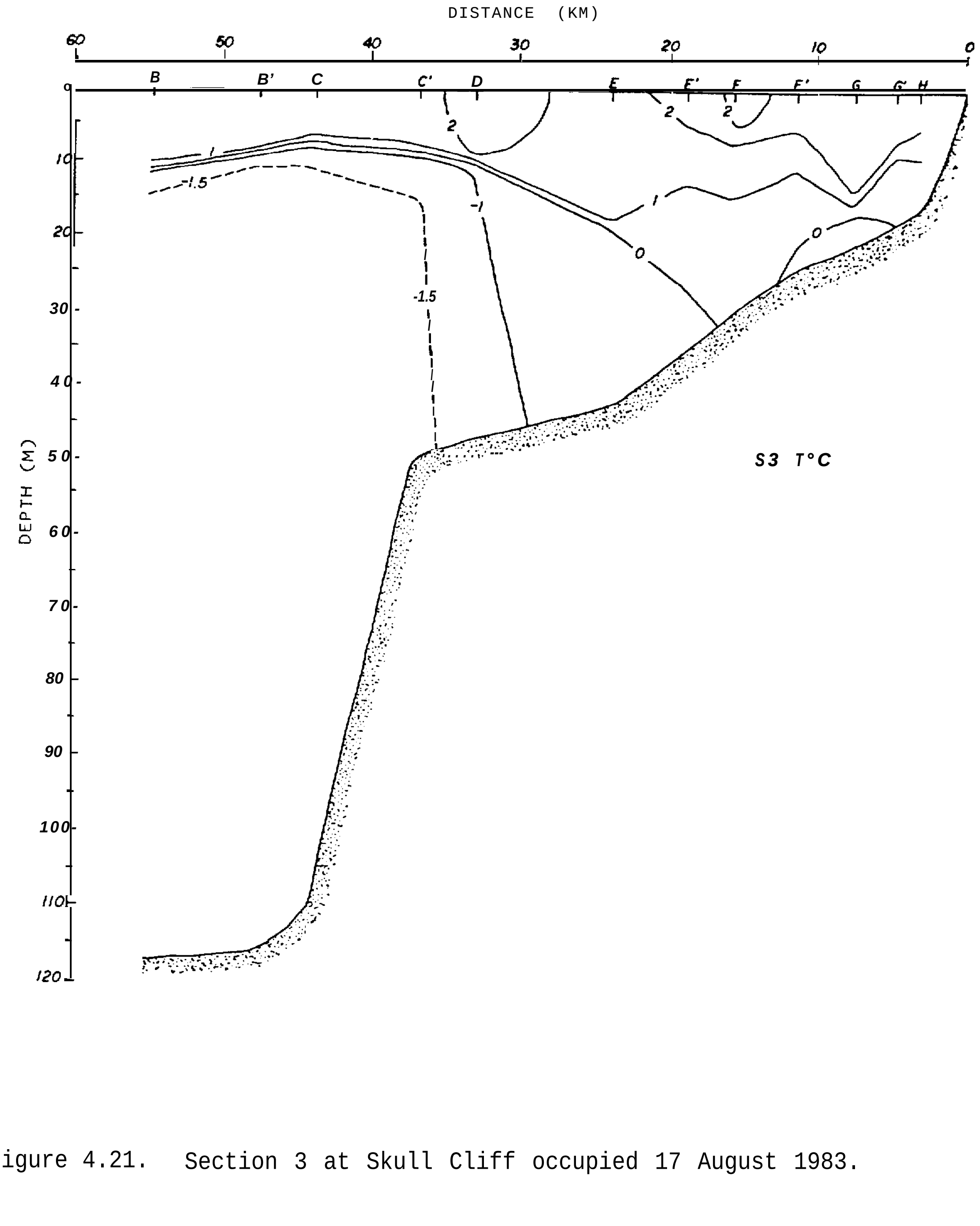


Figure 4.21. Section 3 at Skull Cliff occupied 17 August 1983.

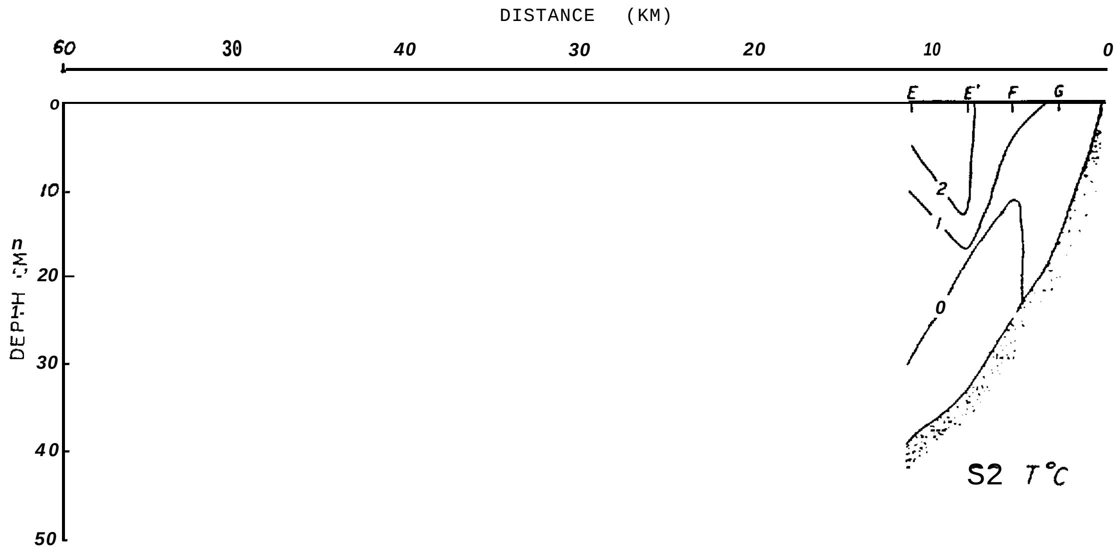
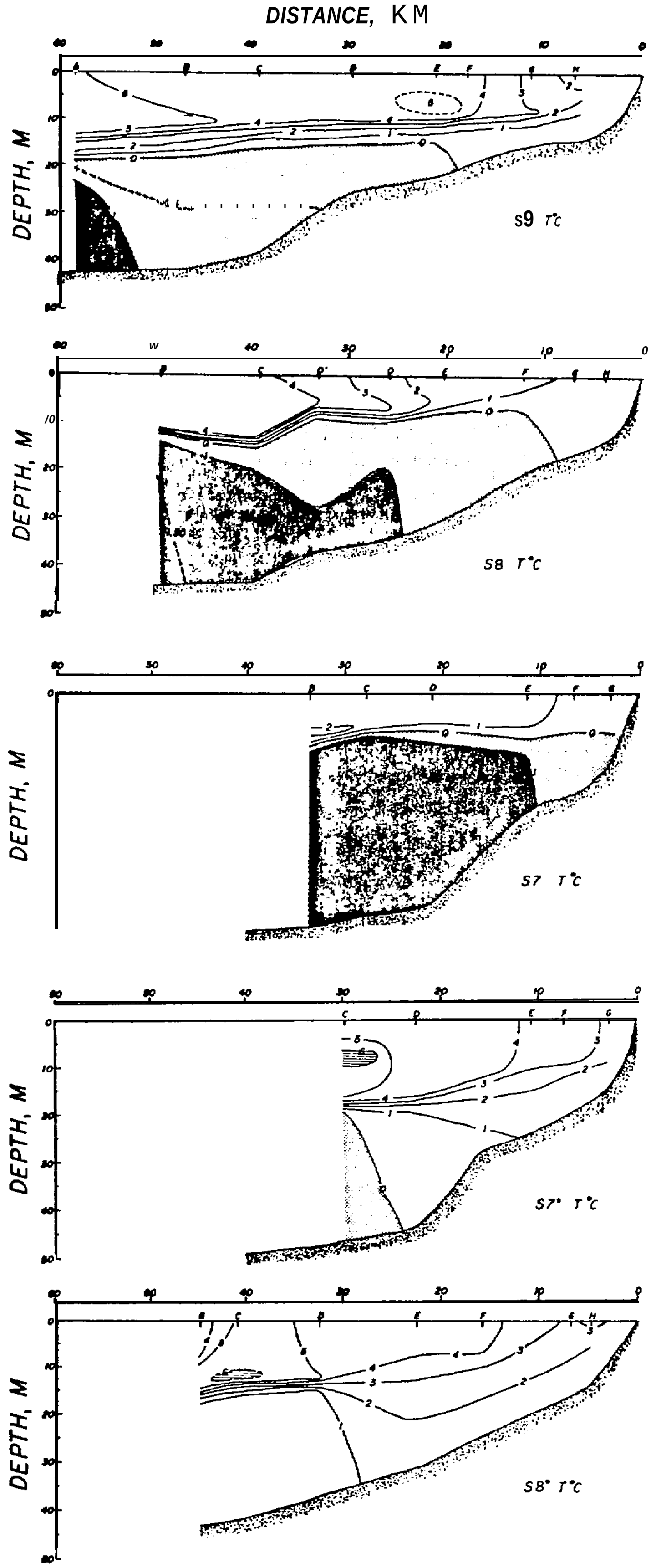


Figure 4.22. Section 2 north of Skull Cliff occupied 17 August 1983.



(A) 14 AUGUST

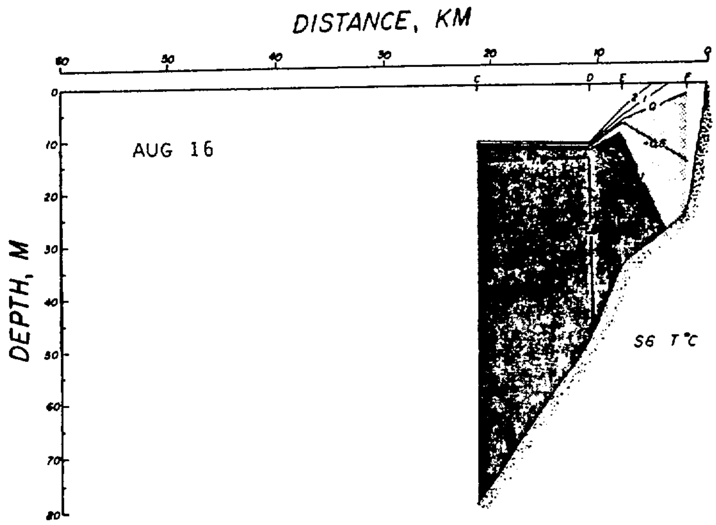
(B) 15 AUGUST

(C) 15 AUGUST

(D) 21 AUGUST

(E) 21 AUGUST

Figure 4.23, Progression of sections taken 14-21 August in the region southwest of Pt. Franklin.



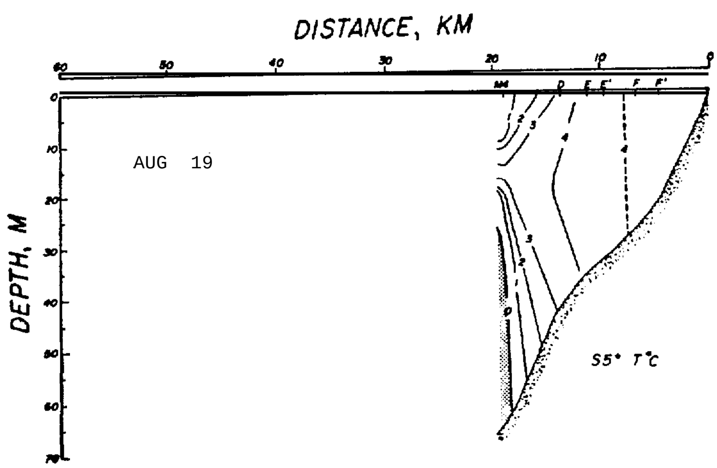


Figure 4.24. Two temperature sections taken offshore Pt. Franklin showing the rapid turnover of nearshore water in response to changing wind conditions.

that, in both cases, current meter moorings show the northeastward movement of water in both the nearshore region and out to 20 km. Figure 4.25 shows composite T-S plots of all CTD data collected during the open water phase of this program (10-22 August 1983) and of all CTD data collected between Bering Strait and Pt. Franklin on the cruise following this program (26 August - 13 September 1983). These casts (Figure 4.25b) are taken from water masses which during the following weeks were transported by the northerly currents to the current meter mooring locations.

4.3.2. Winter Conditions

CTD data were collected along four sections (ref. Figure 4.22) between Wainwright and Pt. Barrow during ice-covered conditions. These sections corresponded to open water sections 5, 7 and 3 and will be referred to as A, B and C, respectively. An additional section (D) was taken from Pt. Barrow toward the southwest following the bottom of Barrow Canyon where it intersected section B. Stations in section A were occupied twice. Wire angle observations were also made at each CTD station to determine current direction relative to the ice.

Hydrographic sections have been produced from these winter CTD data and are displayed in Figures 4.26-4.30. Also displayed in each of these figures is a qualitative indication of the current direction relative to ice and relative current magnitude at each CTD station in the section based on CTD wire angle observations. Although these measurements were taken in the deep winter with 10/10 ice coverage, wire angle measurements must be interpreted cautiously in that no information on possible motion of the ice is known and wire angle only gives an indication of motion relative to the ice not absolute motion. If no current is indicated, wire angle was too small to measure and no current direction is displayed. Comparing the series of Figures 4.26-4.28 it can be seen that a transition occurs from southwesterly flow on 29 February to no flow on 2 March and strong northeasterly flow on 3 March. Although CTD data from 1 March were lost due to a power surge during data retrieval, wire angles indicated strong southwesterly currents along section B at stations 5 and 6 (see Figure 4.27) and weaker currents at

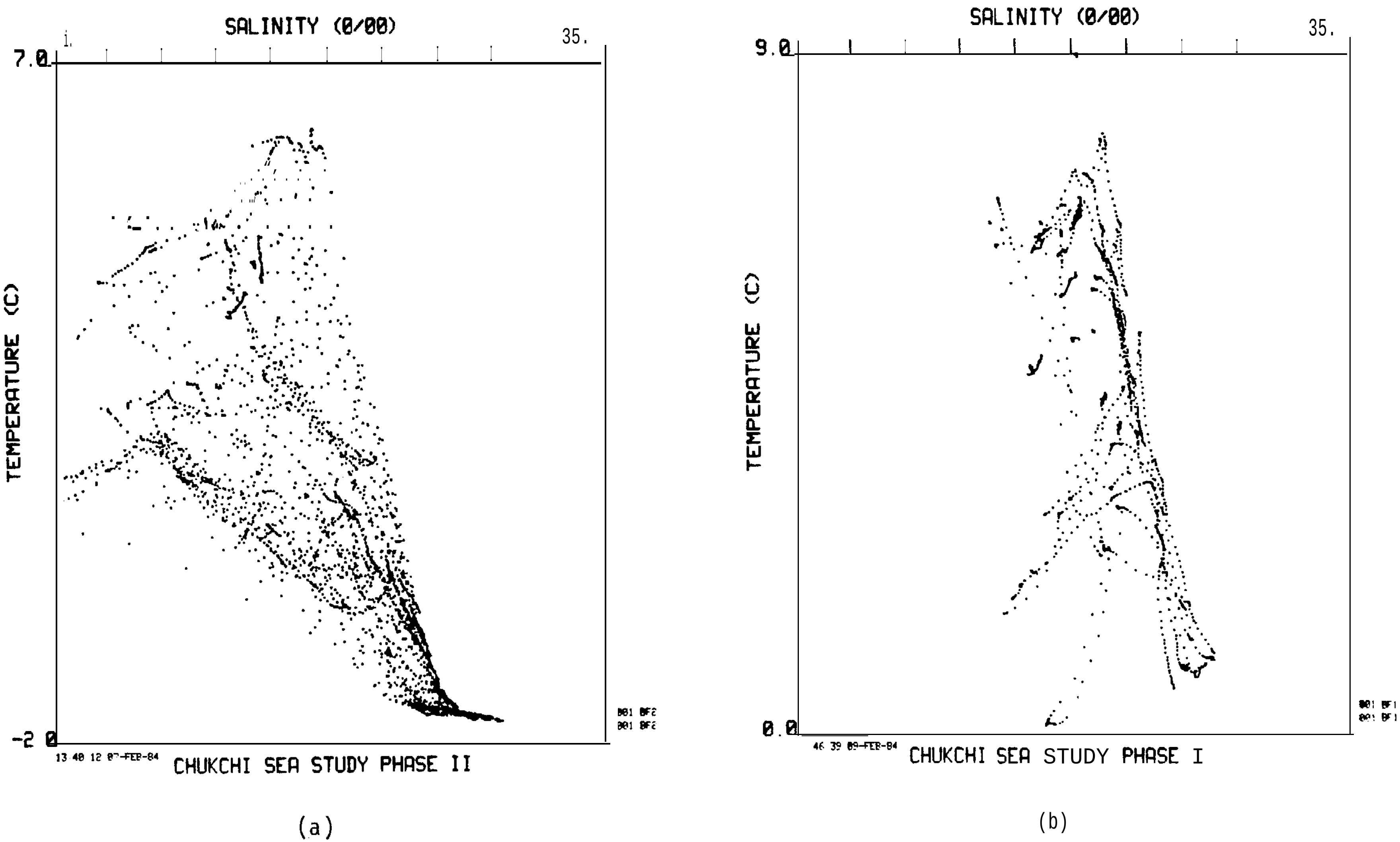


Figure 4.25. Composite TS plot of all CTD data collected during a NOAA/OCSEAP-sponsored measurement program during (a) 10-22 August 1983 and (b) 26 August-13 September 1983 (courtesy of LGL Ecological Research Associates).

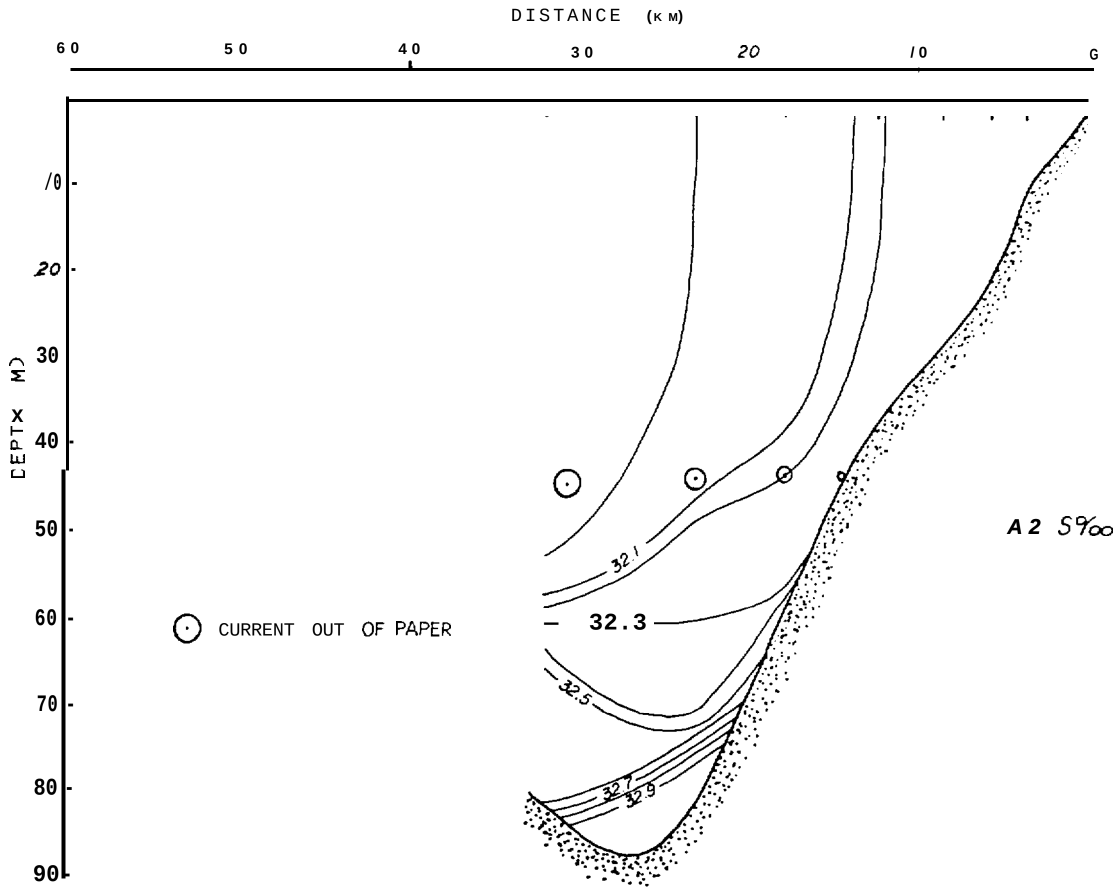


Figure 4.26. Hydrographic section, Day 60.

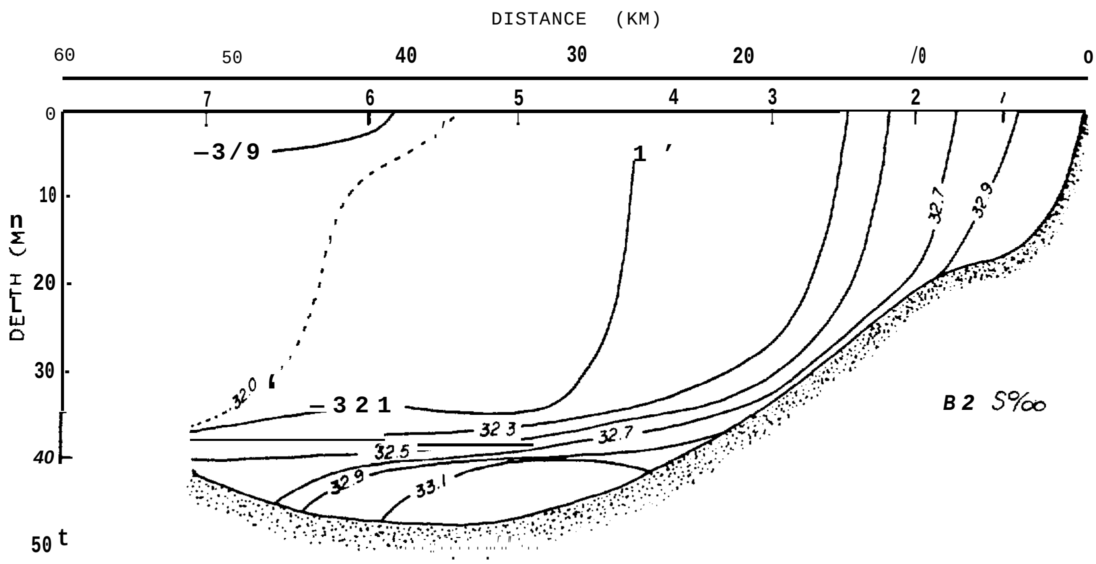


Figure 4.27. Hydrographic section, Day 62 with light winds from ENE.

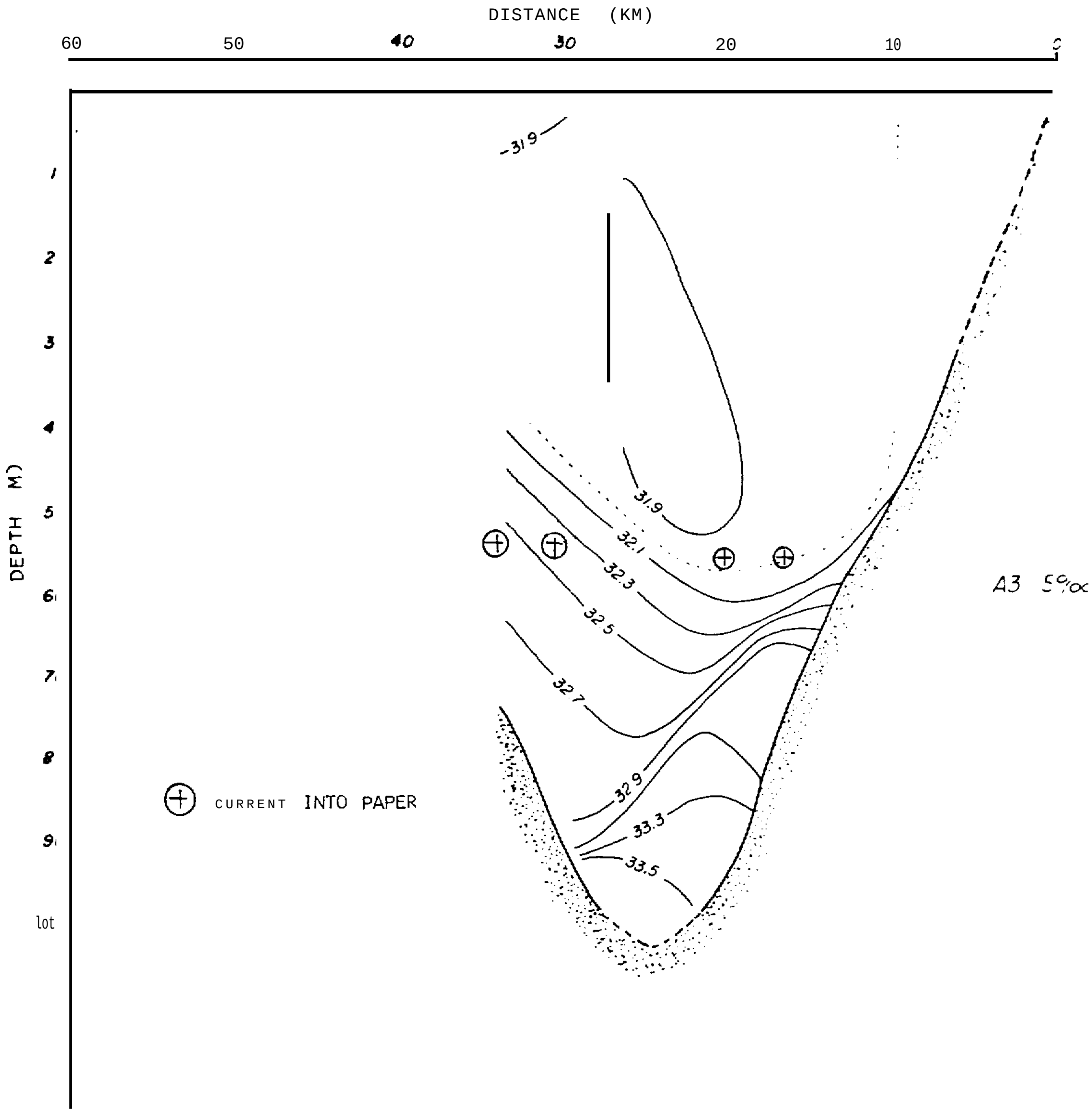


Figure 4.28. Hydrographic section, Day 63 with winds from the NE.

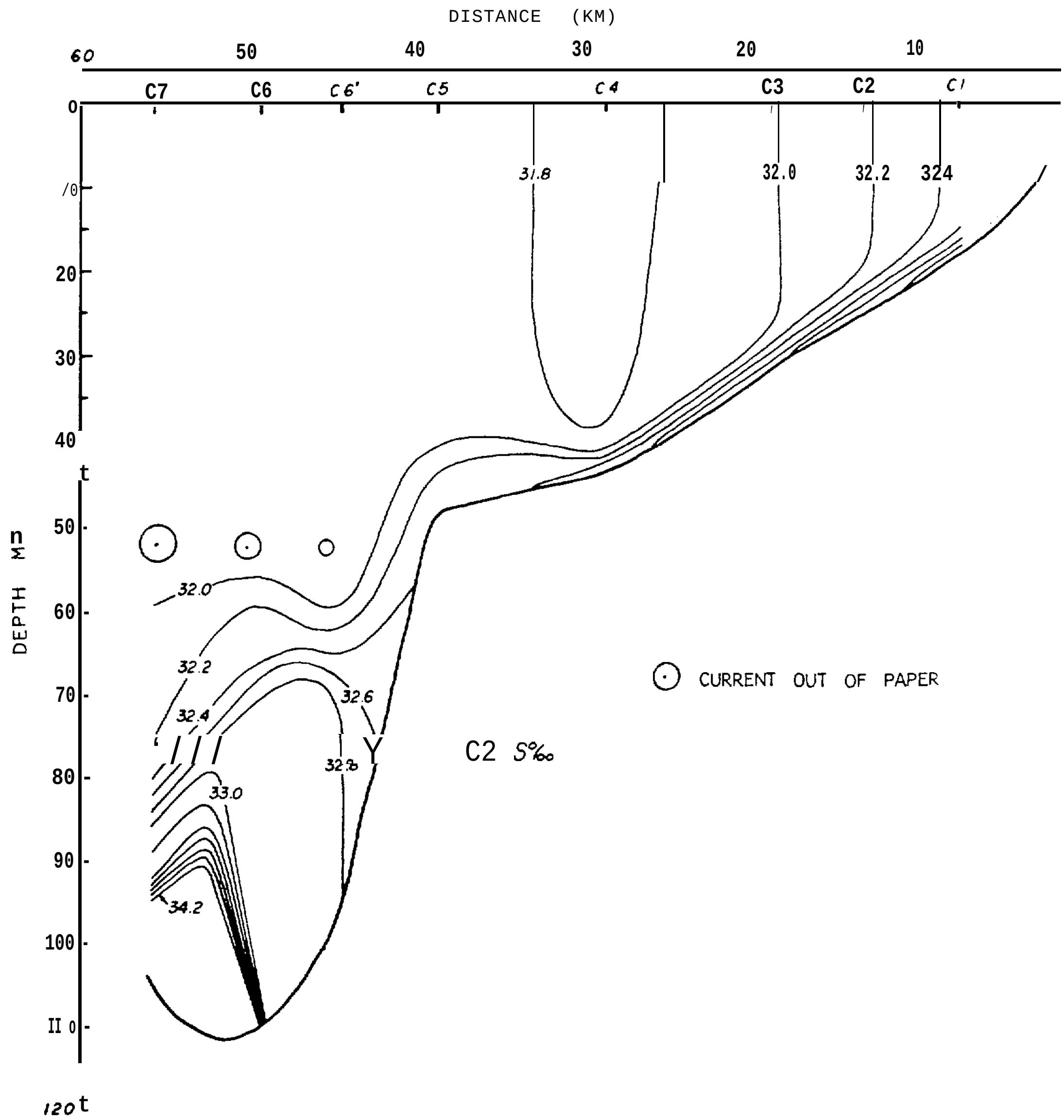
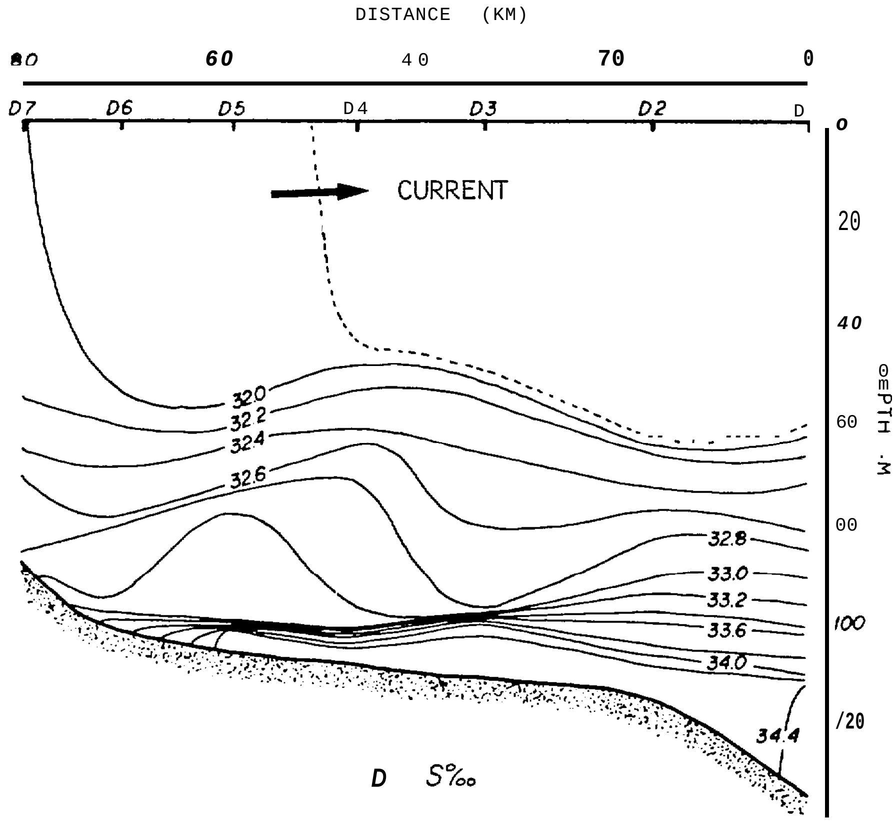


Figure 4.29. Hydrographic section, Day 66 with winds from the NE.

(a)



(b)

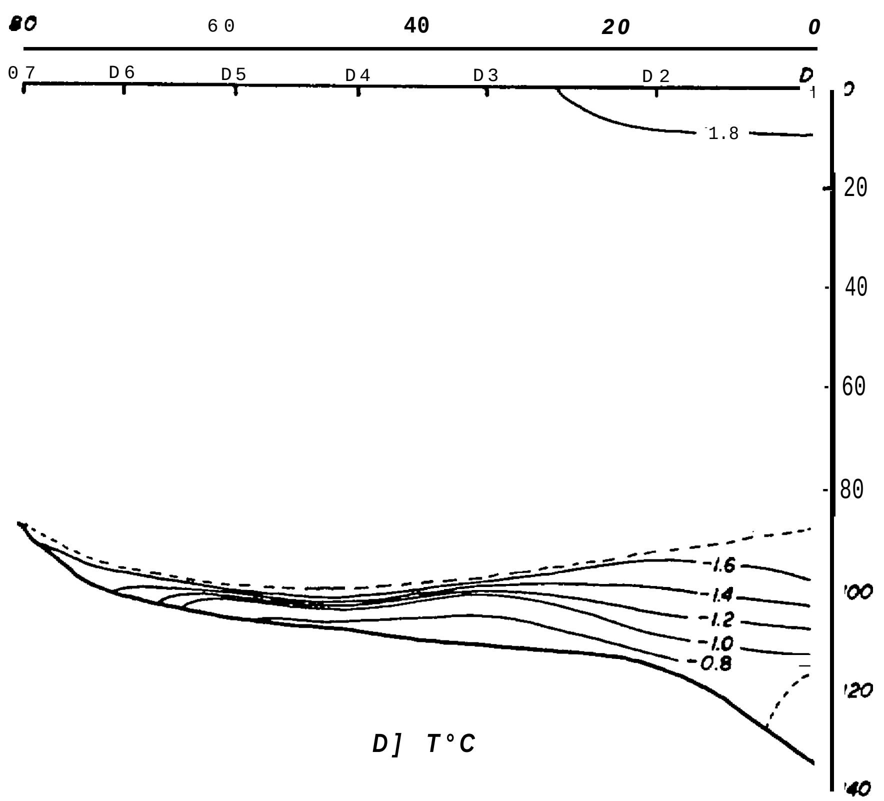


Figure 4.3o. Hydrographic sect, on down Barrow Canyon axis on Day 67 with winds from the NE (a) Salinity. (b) Temperature.

Stations 4 and 7. Currents at station 6 were strong enough to cause strumming of the CTD cable. As discussed above, this current had completely relaxed by 2 March (Figure 4.27). Wainwright winds were light (<8 kt) during the period from 29 February to 4 March and from the north. However, sea level pressure difference between Barrow and Kotzebue dropped from 18.3 mb on 29 February to 3.7 mb on 4 March and attained a peak level of 19.0 mb on 1 March. This high pressure difference over the coastal region between Pt. Barrow and Kotzebue was probably related to the current reversal (current flow to the southwest) observed on 29 February to 1 March. As this high pressure difference began to relax on 2 March, the current reversal stopped and by 4 March the strong northeasterly mean flow characteristic of the region was reestablished. A pressure difference of 18.3 mb (Barrow-Kotzebue) was again present on 6 March and reversed flow was again observed (Figure 4.28) By 7 March the Barrow-Kotzebue pressure difference had relaxed to 8.8 mb, allowing a return to northeasterly flow (Figure 4.29). Although no current or wire angle data are available, a current reversal probably occurred again beginning 8 March where the Barrow-Kotzebue pressure difference again increased to 20.7 mb.

Figure 4.31 shows a composite T-S plot of all CTD data collected during the winter program for comparison with Figure 4.25 from the summer program.

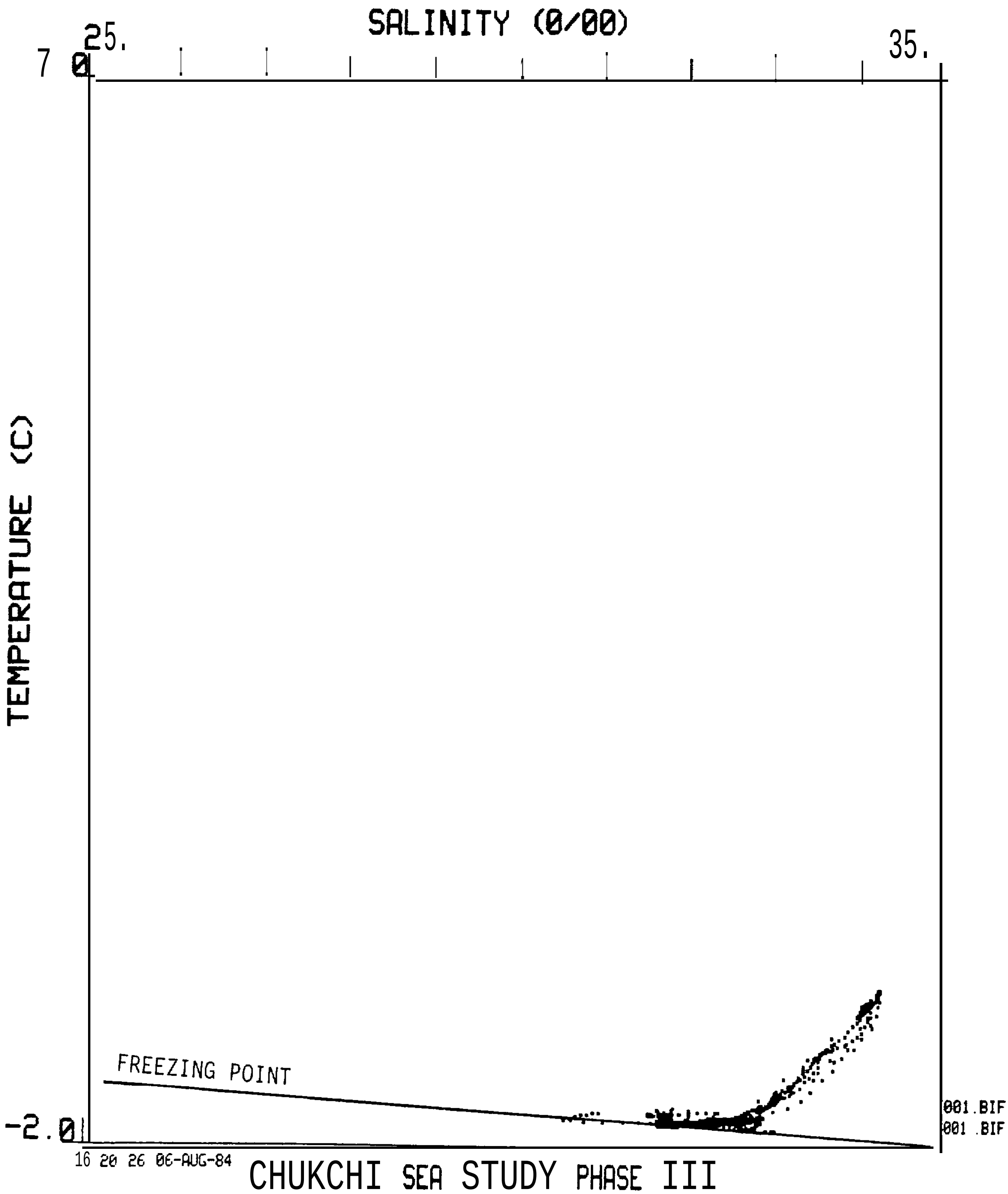


Figure 4,31. T-S plot of all CTD data collected 29 February - 7 March 1984.

4.4. Ice Observations

The presence of heavy sea ice in the study region continued to be a serious problem throughout the "open water" phases of the field program. The bridges on both DISCOVERER and SURVEYOR were requested to record ice observations in the ships Marine Operations Abstract log throughout the program whenever a ship's fix was recorded. This log summarizes the ice conditions in the vicinity of the ship while CTD, SST and bucket samples were being collected. Additional information on ice cover was obtained from ship's radar and from satellite imagery after completion of the field program.

Figure 4.32 shows two examples of these data on ice distribution and movement. The upper map in this figure shows the ice edge in the region just east of Peard Bay on 19 August when a shift in the wind to westerly brought ice into the nearshore, briefly trapping DISCOVERER to the northeast of Pt. Franklin. The ice edge and direction of travel was mapped by ship's radar and ship's motion while in the ice. The lower map (Figure 4.32b) shows the ice motion on two separate occasions while SURVEYOR was trapped in the ice. Ice speeds on these two occasions reached 2 kt. The nearshore region off Skull Cliff was ice-free as this westerly wind event began on 21 September. Although inconclusive, Figure 4.32 presents some evidence for the existence of a possible clockwise eddy to the east of Pt. Franklin at least during open-water conditions.

Figure 4.33 shows a satellite image (LANDSAT-4, Band 6) of the Pt. Franklin region from 30 July 1983 where similar conditions existed. The ice (white areas) and water (black areas) interface indicates ice being drawn onshore to the east of Pt. Franklin and maintained in a recirculation zone. In the spring, warmer Alaskan coastal waters may also pool in this region resulting in early breakup of landfast ice found along the 10-fathom line shown in Figure 4.32.

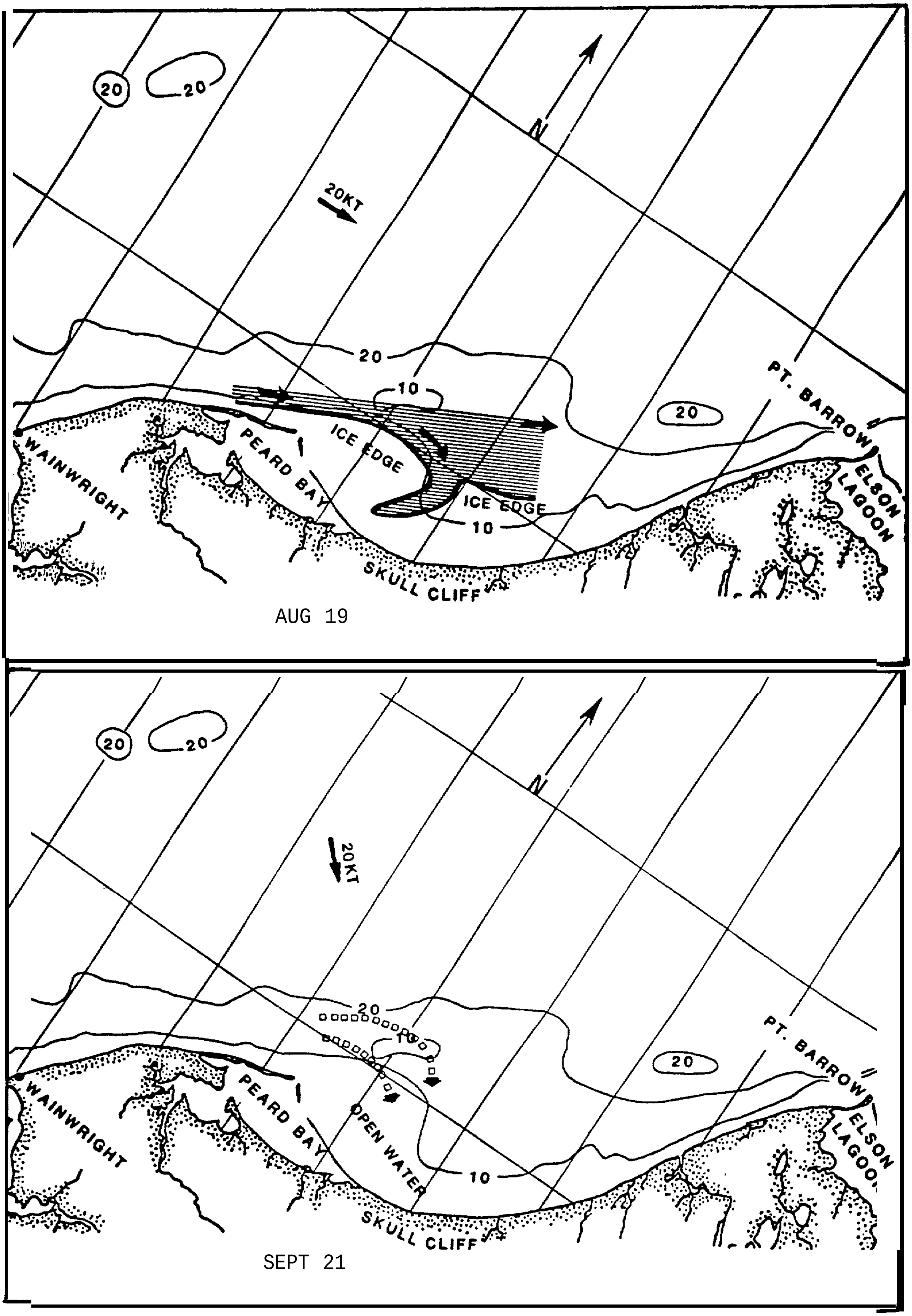


Figure **4.32.** Ice observations in the Pt. Franklin region on 19 August and 21 September 1983 for the R/V DISCOVERER and SURVEYOR.

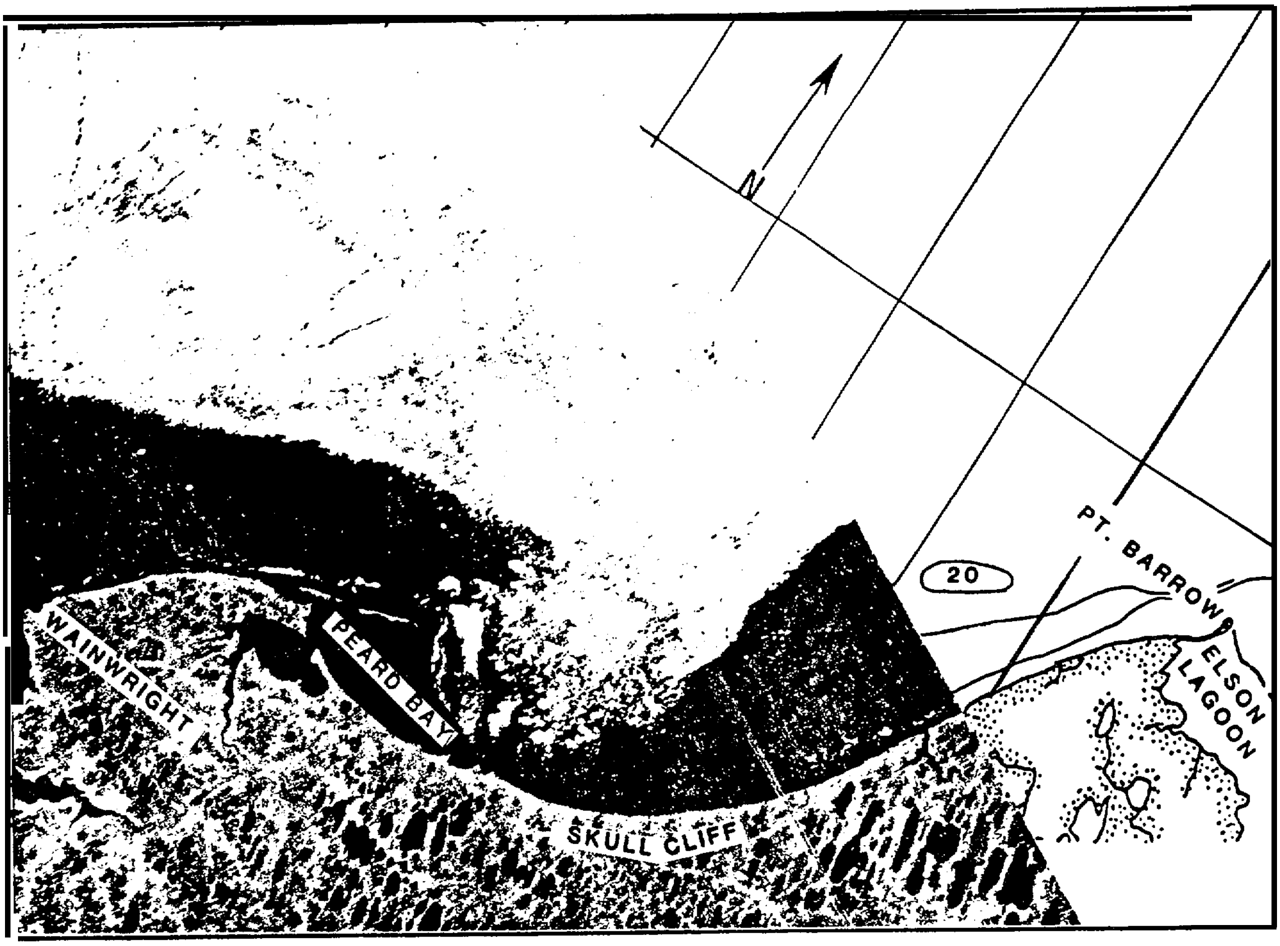


Figure 4.33. Satellite imagery of ice features in the Peard Bay area from 30 July 1983.

Wind conditions continued to move ice onshore from 21 to 26 September while SURVEYOR was trapped in the ice northeast of Peard Bay. Figure 4.34 shows the ice and SURVEYOR's drift-track after the region offshore of Skull Cliff was completely ice-covered. Ice speeds averaged 0.5 kt in 10/10 ice during the period 26-28 September while the ship was driven northeast almost to Pt. Barrow. Ice motion continued to the northeast even after winds shifted to easterly on 28 September; however, the easterly winds began moving some ice offshore, relieving some of the compressive force in the ice and allowing SURVEYOR to escape to the south along the coastline.

4.5. Bathymetry

A bathymetric chart of the study region has been made from bathymetric data collected during this program. These data agree quite well with available bathymetric charts with the exception that Barrow Canyon appears to extend further south than would be assumed based on available charts. Figure 4.35 shows the bathymetry of the region based on measurements from this program.

Bathymetry of the two channels into Peard Bay was also measured using a portable fathometer operated from the motor whaleboat aboard DISCOVERER. The whaleboat position was determined by radar from DISCOVERER which was anchored during the operation just east of Pt. Franklin. The motor whaleboat carries a transmitting radar beam for this purpose. Figure 4.36 shows a section across each of the openings with approximate horizontal scales indicated in the center of the figure. The main entrance to Peard Bay is defined as the entrance to the east of Seahorse Island. The minor entrance is the opening to the west of the island. Note that a deep channel in the minor entrance normally indicated on maps of Peard Bay is not present in August 1983. A deep channel, however, is observed in the main entrance which at its deepest is over 8 m in depth and approximately 100 m in width. A possible remnant of the deep channel in the minor entrance is seen on the southwest of the entrance near the Pt. Franklin spit. This deep channel may be silted over in the summer months when high longshore sediment transport is present and open in the winter when tidal currents through the two entrances are high and along shore sediment transport is at a minimum.

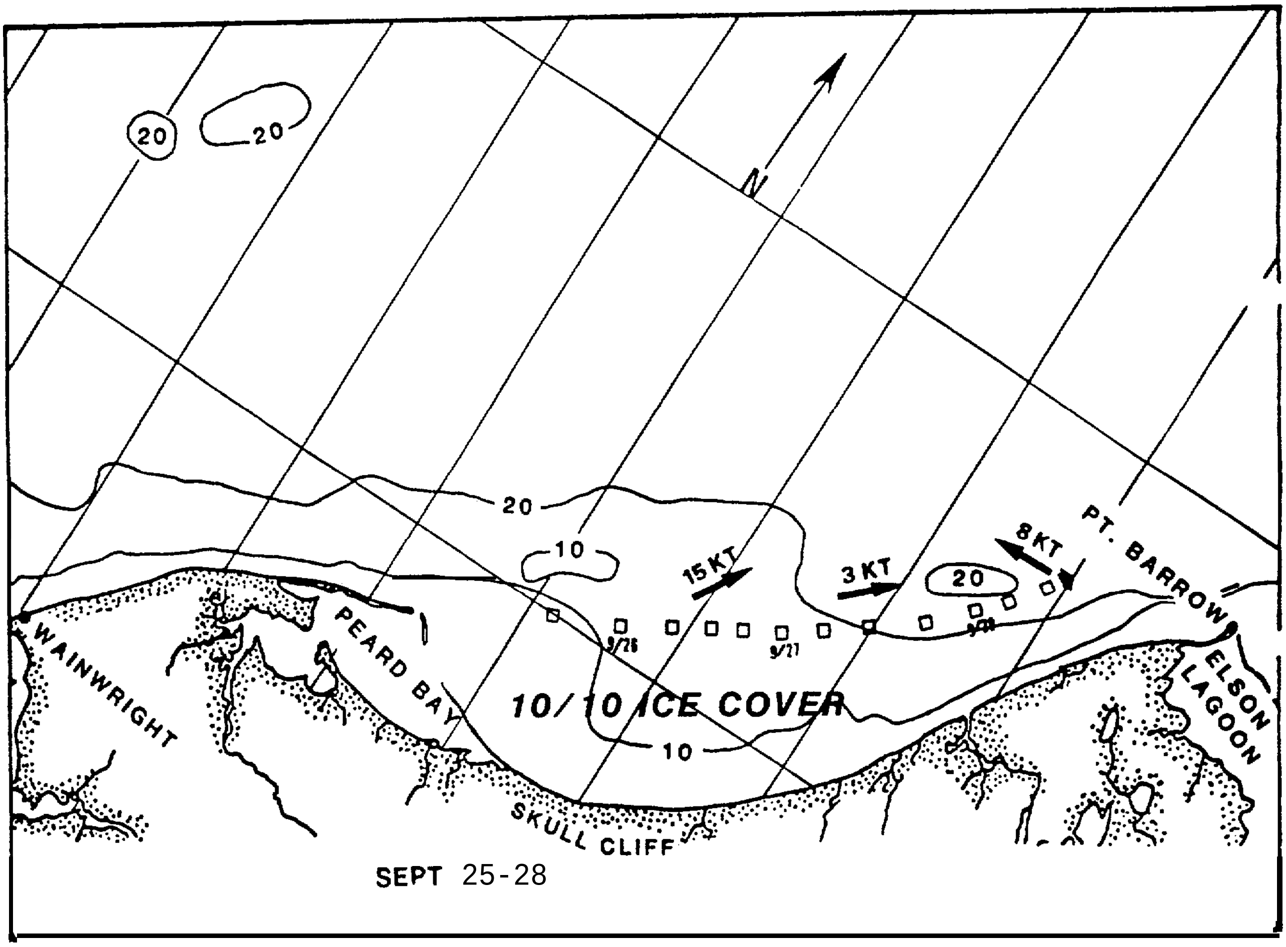


Figure 4.34. Ice drift pattern east of Pt. Franklin under 10/10 ice cover conditions. Wind vectors indicate wind speed and direction at three times during the series of measurements. Measurements were taken from the R/V SURVEYOR.

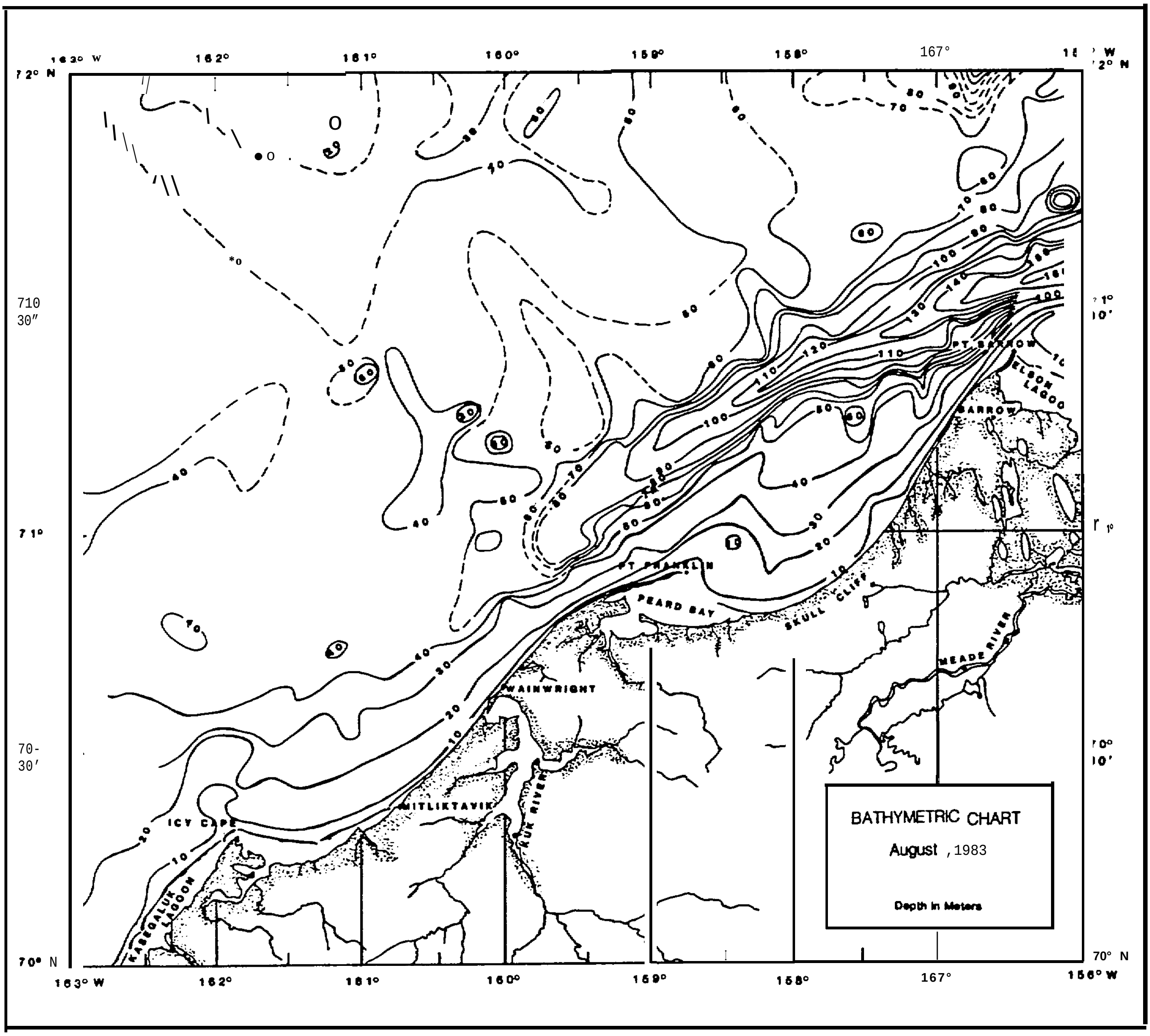


Figure 4.35. Bathymetric chart of study region based on data collected from DISCOVERER during the program in August 1983.

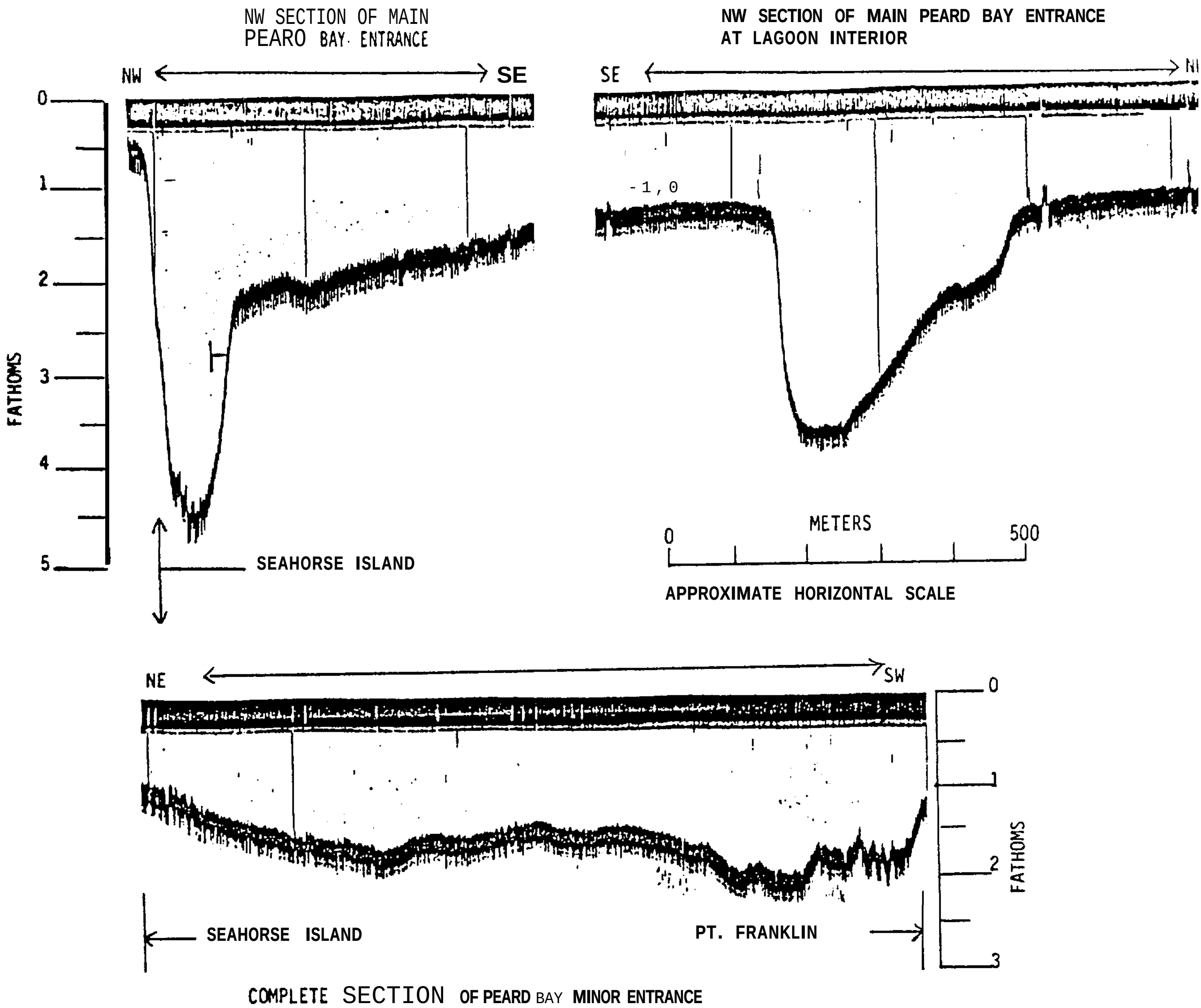


Figure 4.36. Bathymetric sections of the major and minor entrances to Peard Bay.

4.6. Peard Bay

A concurrent physical measurement program was conducted by Kinnetic Laboratories, Inc. in Peard Bay to collect current and tidal data. In this program a current meter was placed on the main entrance to Peard Bay from 22-29 August and three additional moorings were placed in the lagoon center as shown in Figure 4.37 from 30 July-28 August. Figure 4.38 shows the data collected at the main entrance to Peard Bay just southeast of Seahorse Island. The most striking feature of this data record is not the 1.0-1.5 kt currents observed (which have been observed previously in similar arctic lagoon entrances, see Hachmeister et al., 1983) but rather the obvious asymmetry of the record which indicates a large net inflow to the lagoon at this entrance over this period. In comparison to the winds (ref. Figure 4.7) which are highly variable and might be expected to affect the net inflow, the net inflow of water at this mooring is uninterrupted. A more symmetric in/out tidal flow is only observed twice during this data record: 22 August and 24-25 August. Figure 4.7 indicates that these are periods of reduced wind speed. However, on 23 and 25 August higher wind speeds to the south and north, respectively, appear to result in a net inflow of water at the main entrance. It must be concluded that if water is entering the lagoon at this volume through the main entrance then it must be exiting via the minor entrance to the northeast of Seahorse Island. This classifies Peard Bay as a limited exchange lagoon (Hachmeister et al., 1983) with net flowthrough of water and an anticipated higher flushing efficiency than would be expected for a closed lagoon with such an extensive barrier island system under tidal flushing alone.

Time series current data from Peard Bay current meter moorings 1-3 are shown in Figure 4.39. Note that with the exception of a few days early in August (3-6 August) the mean current at mooring 1 is toward the east regardless of wind conditions, indicating a net clockwise circulation in the nearshore or possibly a net mean outflow at the minor entrance to the lagoon as indicated by the net inflow at the main entrance to the lagoon. Current meters at mooring 2, however, show long periods of southwesterly currents indicative of counterclockwise flow.

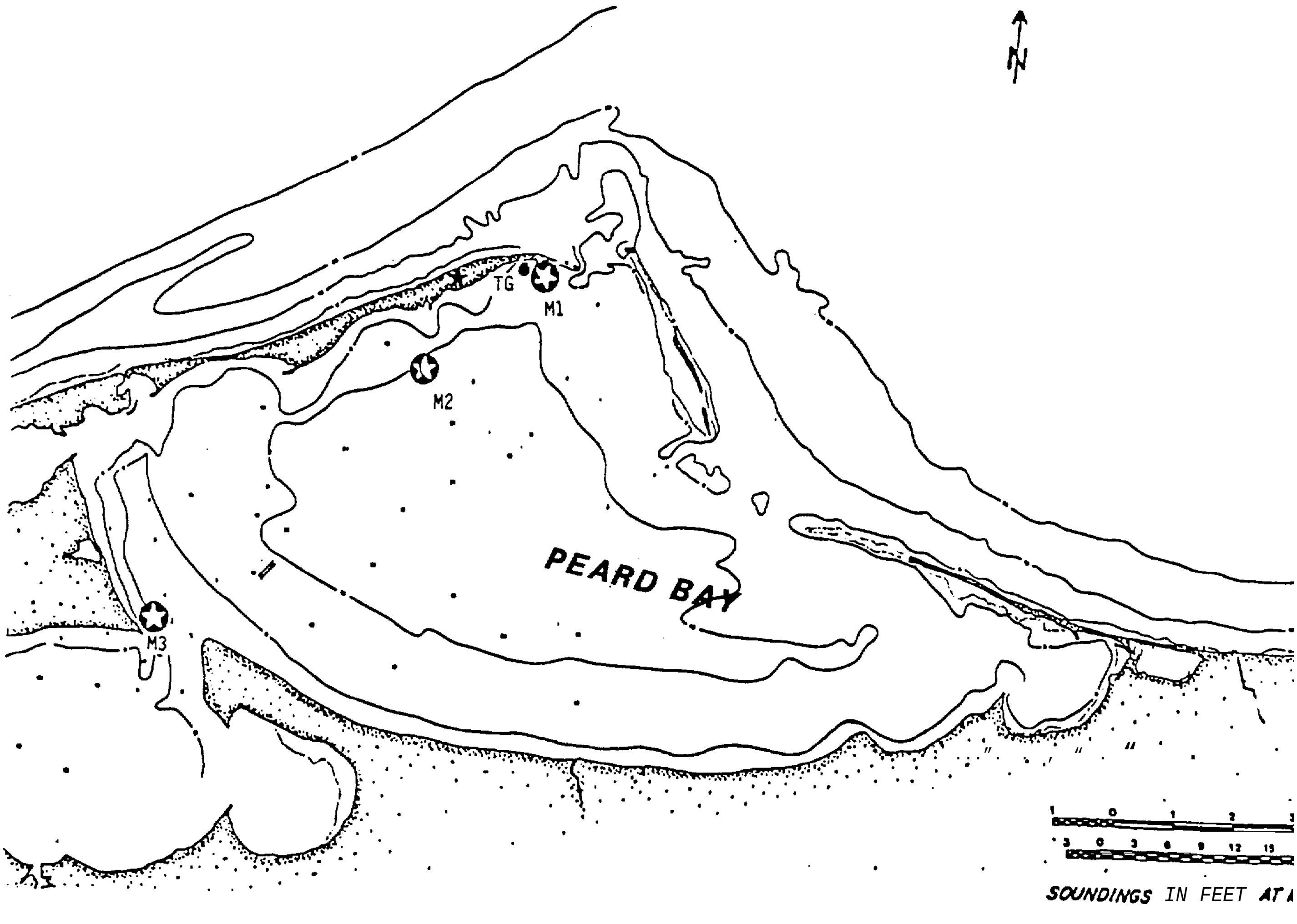


Figure 4.37. Location of Peard Bay mooring deployments (from Wilson et al., 1984).

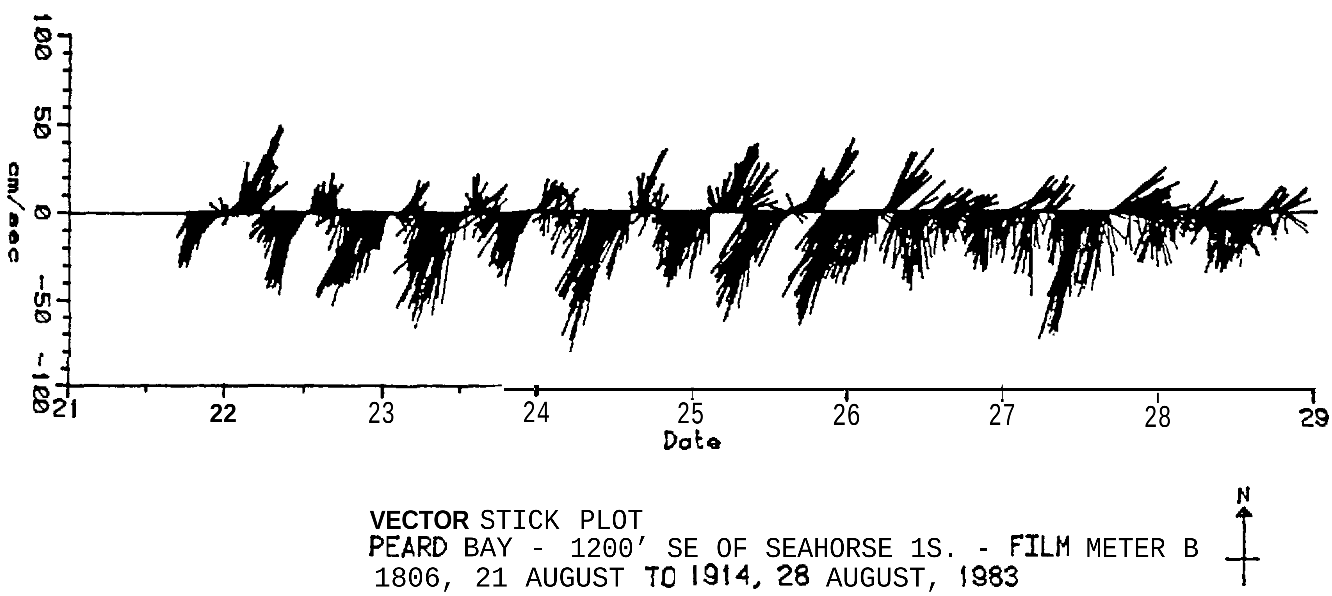
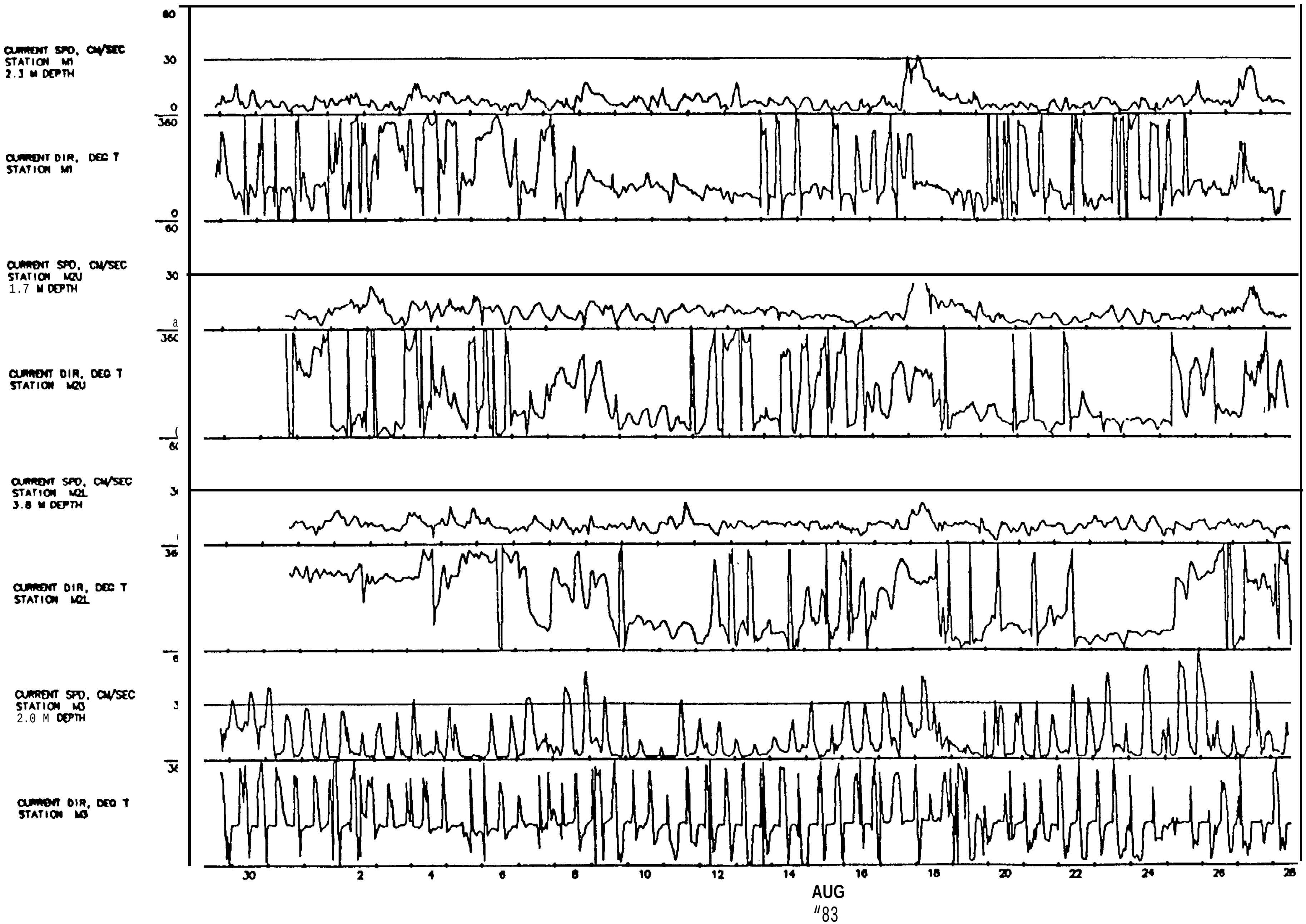


Figure 4.38. Current time series collected in main entrance to Peard Bay (from Wilson et al., 1984.)



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A simple tidal prism model (Hachmeister et al., 1983) beginning on 14 August with nearshore water temperatures set at O “C (Figures 4.16 and 4.17) and Peard Bay temperature set at 6 °C (Figure 4.40 traces b and c) yields a 0.2 °C/day loss in temperature for the lagoon interior assuming 80 percent mixing efficiency, a peak-to-peak tidal amplitude of 0.10 m, and an average lagoon depth of 4.0 m. With this simple model an 18 August predicted lagoon interior temperature of 5.02 °C is determined. This value agrees quite well with the observed value of 5.0 “C recorded by both current meters on mooring 2 (Figure 4.40). The wind event and resulting positive storm surge (Figure 4.41) of +0.50 m on 18 August results, using the same model, in an average lagoon interior temperature of 4.29 ‘C on 19 August and a loss in average temperature of 0.53 “C. The measured data (Figure 4.40 traces b and c) show some vertical layering of temperatures on 19 August with an average of 4.2 ‘C at the 1.7 m depth and 3.9 °C at the 3.8 m depth. Salinities from mooring 1 and the lower meter on mooring 2 (Figure 4.42) show an increase as this wind event occurs and more saline (31.5 o/oo) nearshore waters move into the lagoon. Using the previous model for temperature with the salinity data, the wind event on 18 August should increase the average lagoon salinity from 25.5 o/oo (Figure 4.42) to 26.0 o/oo. The observed salinity at mooring 2 was 25.9 o/oo on 19 August which is at least consistent with the anticipated trend in salinity due to the wind event.

On 19 August the storm surge relaxed and nearshore waters rapidly warmed to over 3 “C (Figure 4.1) as tidal exchange between the nearshore and the lagoon continued. Extending the model run from 19-23 August with these warming nearshore waters predicts that the lagoon temperature would remain relatively constant, dropping only from a value of 4.29 “C on 19 August to 4.13 “C on 23 August. Although input from solar radiation has not been included in this model, a relatively high mixing efficiency of 80 percent appears to apply for Peard Bay. This is probably due at least in part to the net flowthrough observed for the lagoon and the relatively high effective tidal mixing anticipated for a shallow lagoon with the geometry of Peard Bay (Hachmeister et al., 1983).

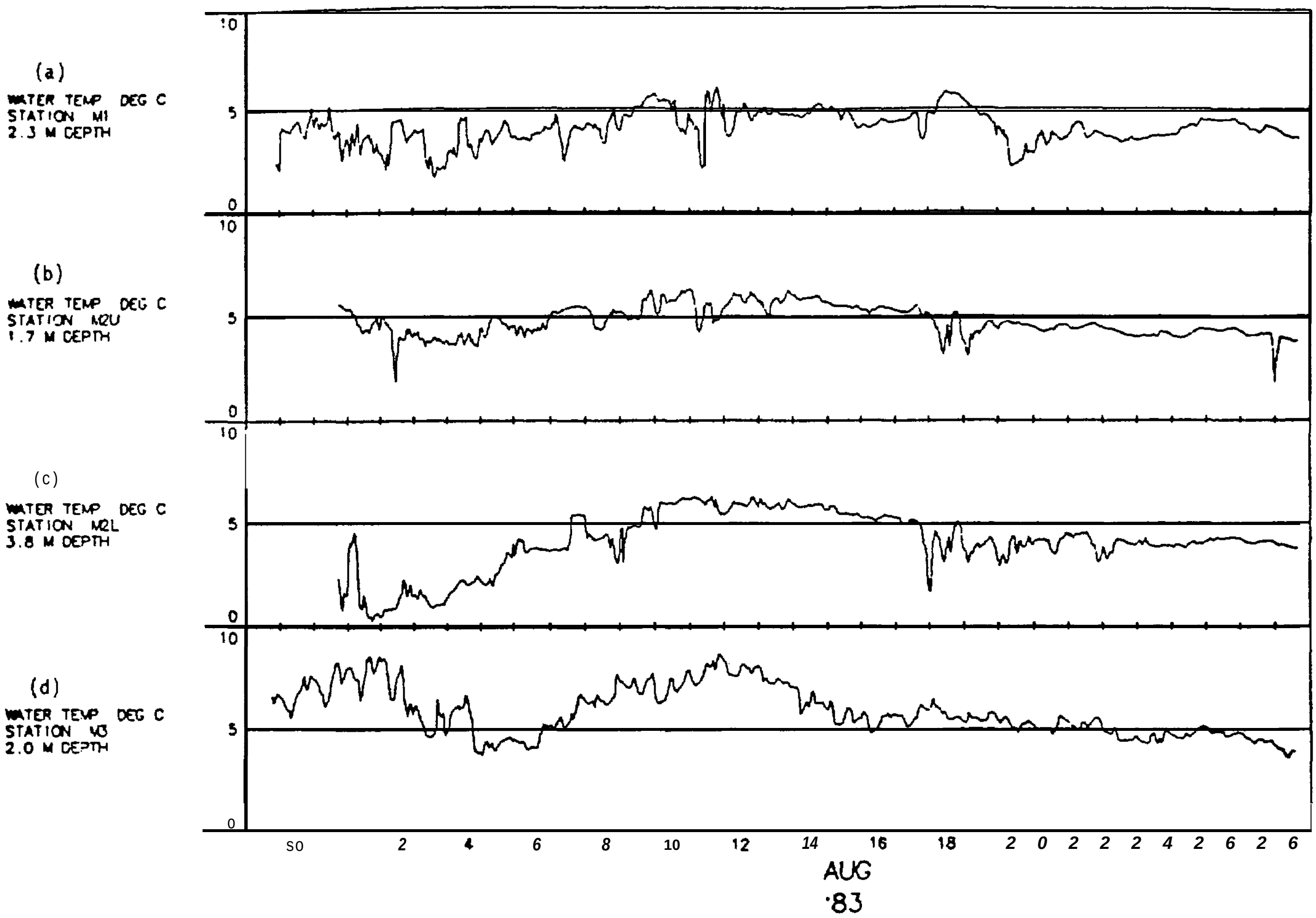

Figure 4.40. Water temperature time series data from moorings 1, 2 and 3 (from Wilson et al., 1984).

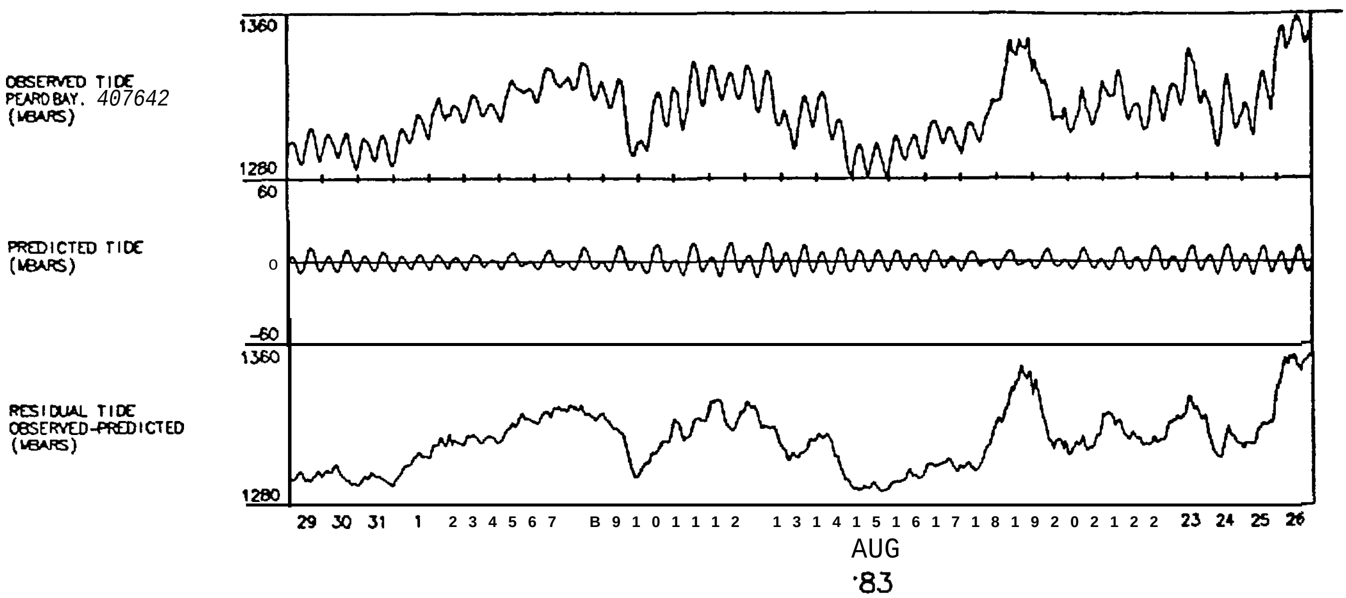

Figure 4.41. Water level time series data from mooring TG (from Wilson et al., 1984).

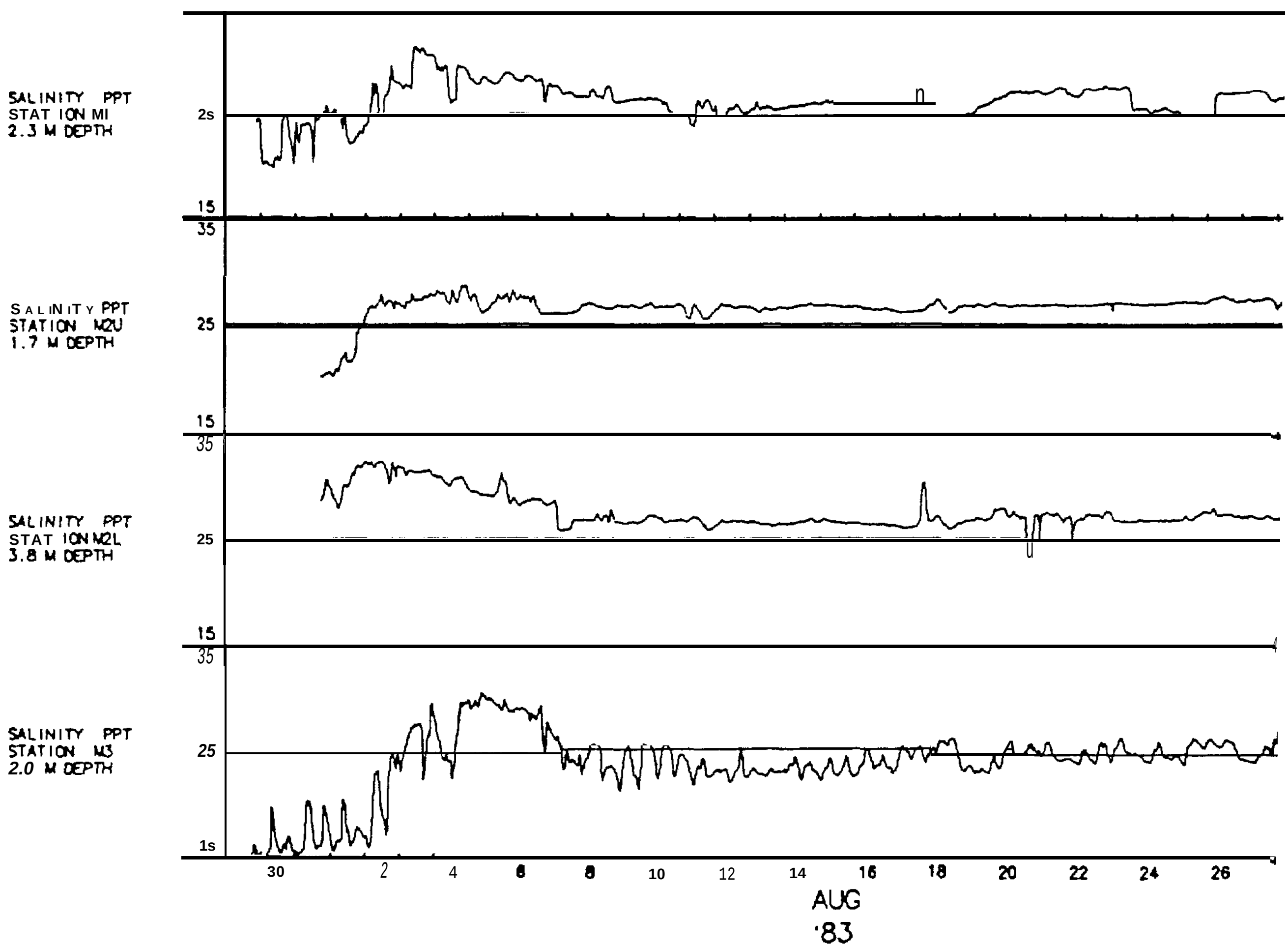

Figure 4.42. Salinity time series data from moorings 1, 2 and 3 (from Wilson et al., 1984)

V. SUMMARY

This program was designed to describe the coastal hydrography and water circulation in the northeastern Chukchi Sea and the exchange of observed properties between nearshore and lagoon regions. Data collected in this and previous programs indicate that there Is a strong relationship between the local meteorology and the physical oceanography of the northeastern Chukchi Sea. These data also show two responses of coastal properties to atmospheric forcing: (1) response of the alongshore current speed and direction to the larger-scale atmospheric pressure field, and (2) response of the on/offshore velocity field to the local wind field. Comparison of atmospheric pressure and current meter data indicate that a threshold pressure difference of >10 mb between Barrow and Nome (Barrow > Nome) is necessary to induce reversal in direction of the mean northeasterly-flowing Alaskan Coastal Current. The limited database also indicates that the reversal in current direction will persist as long as this pressure difference is increasing. If the pressure difference remains stationary or decreases the current field resumes its northeasterly flow. This response to the large-scale atmospheric pressure field has been observed in both open-water and ice-covered seasons and has a response time of approximately one day (see also Mountain et al., 1976).

During the open-water season, the on/offshore flow of surface and bottom waters is controlled by the local wind field and accounts for the presence or absence of a warm coastal wedge and/or the upwelling of bottom water from Barrow Canyon into the nearshore region. Under mean conditions the Alaskan coastal current moves Bering Sea water northward along the eastern coastline of the Chukchi Sea into the Beaufort Sea. While in transit toward the north this water is warmed and freshened by local runoff and solar radiation. The on/offshore location of the warm coastal current is controlled in part by the local wind field and lies either onshore between the coast and 15-20 km offshore, influenced by winds with a westerly component, or offshore centered approximately 20 km from the coastline, influenced by winds with an easterly component.

When the warm waters of the coastal current move offshore at Pt. Franklin under the influences of mean NE winds, water from Barrow Canyon replaces it along the coast and very cold, salty water typical of Chukchi Sea winter bottom water is observed exchanging properties with Peard Bay. Exchange of water properties between the nearshore and Peard Bay occur under the combined influence of meteorological and astronomical forcing with an estimated flushing efficiency of 80 percent.

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APPENDIX A

Other publications and presentations prepared by SAIC based upon the research unit.

Papers Presented

The rapid response of Alaskan coastal waters to strong meteorological forcing in the Chukchi Sea. Presented at the Fall AGU meeting of the American Geophysical Union, San Francisco, December, 1983.

Dynamics of arctic coastal regions. Presented at the American Geophysical Union Ocean Science Meeting, New Orleans, 23-27 January 1984.

The physical environment of Alaskan Arctic Coastal regions. Presented at the 47th Annual Meeting of the American Society of Limnology and Oceanography, Vancouver, British Columbia, Canada, June 1984.

Seminars Given

A characterization of arctic nearshore/lagoon systems. Given at the Minerals Management Service, US Dept. of the Interior, Beaufort Sea Monitoring Workshop, Alyeska Resort, Alaska, 27-29 September 1983.

The northeastern Chukchi Sea: Nearshore circulation, response to winds and exchange with lagoons, Given at the Minerals Management Service, US Dept. of the Interior, Beaufort Sea Monitoring Workshop, Alyeska Resort, 31 October - 2 November 1983.

Physical oceanography of the northeastern Chukchi Sea. Given at the US Dept. of Commerce, NOAA Environmental Research Laboratories, PMEL Seminar, 3 July 1983.

Bottom water generation in the Chukchi Sea. Given at the Minerals Management Service, US Dept. of the Interior, OSCEAP/MMS Information Update Meeting on the Diaper Field Lease Area, MMS offices in Anchorage, Alaska, March 1985.

Published Abstracts

The rapid response of Alaskan coastal waters to strong meteorological forcing in the Chukchi Sea. EOS 64(45), 740.

Dynamics of arctic coastal regions. EOS 64(52), 1049.

The physical environment of Alaskan Arctic coastal regions. Proc. of 47th Annual Meeting of the American Society of Limnology and Oceanography, June 1984.

Manuscripts in Preparation

Hachmeister, L.E. and R.D. Muench, Physical oceanography of the NE Chukchi Sea (to be submitted to J. Geophys. Res.)

Hachmeister, L.E. and J.R. Payne, Dense brine formation in Arctic nearshore region (to be submitted to J. Geophys. Res.)