

**An Oceanographic Survey of the
Canadian Arctic Archipelago
March 1983**

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Institute of Ocean Sciences
Department of Fisheries and Oceans
Sidney, B.C. V8L 4B2

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by

D.B. Fissel, D.D. Lemon and D.N. Knight

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PREFACE

This report was prepared under DSS contract number 035SB.FP941-2-2656 on behalf of the Frozen Sea Research Group, Institute of Ocean Sciences, Sidney, B.C. The Scientific Authority for this contract was Dr. Humfrey Melling.

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ABSTRACT

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Over a fourteen-day period, March 20 to April 2, 1983, 53 profiles of temperature and salinity were determined at 42 locations within the Canadian Arctic Archipelago. Samples for dissolved nutrient analysis were collected at 19 of these sites. As in March 1982, a progressive warming of waters was evident in the main thermocline between the western boundary of the Archipelago and the central sills. A cooling of the underlying Atlantic Water also occurred with the large horizontal gradients found further west, over the continental shelf and western entrances to the Archipelago. In 1983, thermocline waters were cooler than in 1982 in some areas, notably in eastern M'Clure Strait and in Maclean Strait. Atlantic Waters within the Archipelago were apparently warmer in 1983, although in view of observational uncertainties this conclusion cannot be made with confidence. Other interannual variations noted were a reduction in near-surface salinity and mixed layer depth in the western Archipelago and a reduction in the temperature and stability of waters beneath the surface mixed layer in the eastern Archipelago. The near-surface circulation, based on dynamic computations was similar in 1982 and 1983. Baroclinic flows were generally towards Parry Channel within the Archipelago and weak (≤ 2 cm/s), except in Penny Strait (~ 5 cm/s). In western Lancaster Sound, flows of up to 12 cm/s were estimated. Over the continental shelf of the Arctic Ocean currents were weak in 1983. One station pair spanning the continental slope west of M'Clure Strait indicated a 5 cm/s southeastward flow.

Key words: Arctic Archipelago, Arctic Water, Atlantic Water, temperature, salinity.

RESUME

Fissel, D.B., D.D. Lemon and D.N. Knight, 1984. An Oceanographic Survey of the Canadian Arctic Archipelago, March 1983. Can. Contr. Rep. Hydrogr. Ocean Sci. No. 16: 355 p.

Cinquante-trois profils de température et salinité ont été déterminés à 42 endroits de l'archipel arctique canadien au cours d'une période de 14 jours, du 20 mars au 2 avril 1983. Des échantillons ont été prélevés à 19 de ces endroits pour l'analyse des matières nutritives dissoutes. Un réchauffement progressif des eaux de la principale thermocline était évident en mars 1982 entre la limite ouest de l'archipel et les seuils centraux. Il y avait aussi refroidissement de l'eau atlantique sous-jacent, les importants gradients horizontaux se trouvant plus à l'ouest, au-dessus du plateau continental et des entrées ouest de l'archipel. Les eaux de la thermocline de certaines zones, notamment celles de la partie est du détroit de M'Clure et celles du détroit de Maclean, étaient plus froides en 1983 qu'en 1982. Il semble que les eaux atlantiques de l'archipel étaient plus chaudes en 1983, mais des incertitudes quant aux valeurs observées interdisent d'être catégorique. Les autres variations entre les années comprennent une diminution de la salinité près de la surface et de la profondeur de la couche de mélange dans l'ouest de l'archipel et une réduction de la température et de la stabilité des eaux sous-jacents à la couche de mélange de surface dans la partie est. La circulation près de la surface, basée sur des calculs dynamiques, était semblable à celles de 1982 et 1983. Les écoulements baroclines s'effectuaient généralement en direction du passage Parry au sein de l'archipel et étaient faibles ($< 2 \text{ cm.s}^{-1}$) sauf dans le détroit de Penny ($\sim 5 \text{ cm.s}^{-1}$). Des vitesses d'écoulement atteignant 12 cm.s^{-1} ont été estimées dans la partie ouest du détroit de Lancaster. Les courants du plateau continental de l'océan Arctique étaient faibles en 1983. On a déterminé un écoulement vers le sud-est de 5 cm.s^{-1} à deux stations situées au-dessus du talus continental à l'ouest du détroit de M'Clure.

Mots-cles: Archipel arctique, eau arctique, eau atlantique, température, salinité.

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1. INTRODUCTION

In recent years, a number of industrial proposals have been advanced for the year-round transport of natural resources through the channels of the Canadian Arctic Archipelago. Such developments require a thorough understanding of environmental conditions, including the regional oceanography, both to assess and to minimize the effect on the natural environment and to optimize the efficiency and safety of the proposed development.

As one means of improving understanding of the oceanography of the area, three coordinated field studies were begun in the spring of 1982, and continued in the spring of 1983. This report presents the data and preliminary results from the 1983 portion of one of those studies: an oceanographic survey of selected channels of the Archipelago and portions of the adjacent continental shelf, using a twin-engined aircraft. Results of the 1982 survey have been reported separately by Fissel, Knight and Birch (1983). During the 1983 survey, a total of 53 CTD casts were taken at 43 separate stations, including two repeat casts and a 3.5 hour seven-cast time series in Penny Strait. Water samples were collected at 19 stations for subsequent chemical analysis of dissolved nutrients (nitrate, phosphate and silicate).

Other components of the 1983 program included intensive studies of the oceanography of Viscount Melville Sound and Barrow Strait, conducted by two agencies of the Department of Fisheries and Oceans: the Frozen Sea Research Group (FSRG), Institute of Ocean Sciences, Sidney, B.C. and the Bayfield Laboratory for Marine Science and Surveys (BLMSS), Burlington, Ontario. In both of these programs, time series current meter and water level measurements were collected in addition to CTD profiles. To facilitate use of the combined results of these oceanographic studies simultaneous intercomparison casts were made with the CTD instruments from all three groups at the beginning and at the end of the survey.

The objectives of the 1983 survey were:

- 1) to identify water masses by their physical and chemical signatures so as to understand their history;
- 2) to determine interannual variability of water properties by comparing data obtained in 1983 with earlier data available for the same sites and, in particular, with data collected at the same stations in 1982;
- 3) to determine the spatial variability of water properties within the Archipelago; and
- 4) to investigate any progressive modifications in water mass signatures dependent on position and residence time in the Archipelago.

Previous oceanographic research in the Arctic Archipelago has been summarized in Fissel, Knight and Birch (1983). The first significant quantities of oceanographic data were collected during the 1950's in the summer open-water season. By the early 1960's, the large-scale summer surveys had delineated the regional water mass characteristics. The first winter and spring measurements were taken from aircraft and over-ice vehicles during the 1960's. Throughout the 1960's and 1970's, improvements in instrumentation and

techniques for Arctic use resulted in an increased quality and quantity of oceanographic data. During this period, research tended to be concentrated on intensive studies of relatively small geographical areas. In many cases, the data have yet to be fully analyzed and as yet the individual data sets have not been integrated to provide an improved picture of the regional oceanography.

In this report, a review of the physical characteristics of the region is presented in Section 2. Data collection and analysis procedures are described in Section 3, while complete plots and listings of the CTD and nutrient data are contained in the appendices. In Section 4, 1983 data are used to describe the distribution of water properties and geostrophic currents and are compared to 1982 data to establish interannual variability in those quantities. The measurement program is summarized and major findings are presented in Section 5.

2. PHYSICAL SETTING

The Canadian Arctic Archipelago encompasses a vast area extending from latitude 68°N to 82°N, a north-south distance of 1500 km and from longitude 60°W to 130°W, a distance of 2700 km at 70°N. The area consists of many islands separated by a complex pattern of channels (Figure 1). To the north and west, the region is bounded by the Arctic Ocean and the Beaufort Sea. Three of the largest islands within the area (Ellesmere, Devon and Baffin Islands) mark its eastern boundary. Between Ellesmere Island and the North American mainland, the waterways of the Archipelago are connected to the Baffin Bay-Davis Strait-Labrador Sea by Jones and Lancaster Sounds and Fury and Hecla Strait. Northern Baffin Bay and the Arctic Ocean are directly linked by Nares Strait, separating Ellesmere Island and Greenland (Figure 2).

The region has often been subdivided into three subareas, with the central of these, Parry Channel, consisting of M'Clure Strait, Viscount Melville Sound, Barrow Strait and Lancaster Sound. To the north of Parry Channel lie the Queen Elizabeth Islands and to the south is another complex network of water channels.

The total area of the region is about 2.2×10^6 km². Of this total, an area of approximately 0.9×10^6 km² is covered by sea water: 0.3×10^6 km² to the north of Parry Channel, 0.2×10^6 km² in Parry Channel itself, and 0.4×10^6 km² to the south of Parry Channel (Walker, 1977).

2.1 BATHYMETRY

The bathymetry of the area (Figure 2) is complex, with the channels of the Archipelago being shallower than those of the major adjoining oceanic regions, the Arctic Ocean and Baffin Bay. To the north and west, free passage into the Archipelago is limited by the continental shelf, ranging in width from 200 km in the Beaufort Sea to less than 10 km off Ellesmere Island. The continental shelf limits the free passage of water to maximum depths of about 450 m into the Queen Elizabeth Islands (Prince Gustaf Adolf Sea and Peary Channel), to about 380 m into M'Clure Strait and to about 360 m into Amundsen Gulf.

To the east, the study area is bounded by the relatively deep waters of Baffin Bay with depths up to 2300 m. However, exchange between Baffin Bay and the Atlantic Ocean is limited by the presence of the Davis Strait sill at a depth of 700 m. Fury and Hecla Strait provides an alternate connection to Davis Strait by way of Foxe Basin and Hudson Strait. However, Foxe Basin is shallow with maximum depths of less than 200 m while the limiting depth in Fury and Hecla Strait is only 50 m.

Free passage of water through the Archipelago is limited to a maximum depth of about 250 m through Nares Strait. Within the remainder of the region, the next deepest continuous passage occurs at about 125+5 m in Parry Channel with the limiting obstruction occurring in Barrow Strait (based on Natural Resources bathymetric chart no. 26245-A).

Exchanges of water through the Queen Elizabeth Islands are curtailed by the presence of relatively shallow sills in the southern channels connecting this area to: (1) Jones Sound, through Hell Gate (sill depth of 110 m) and

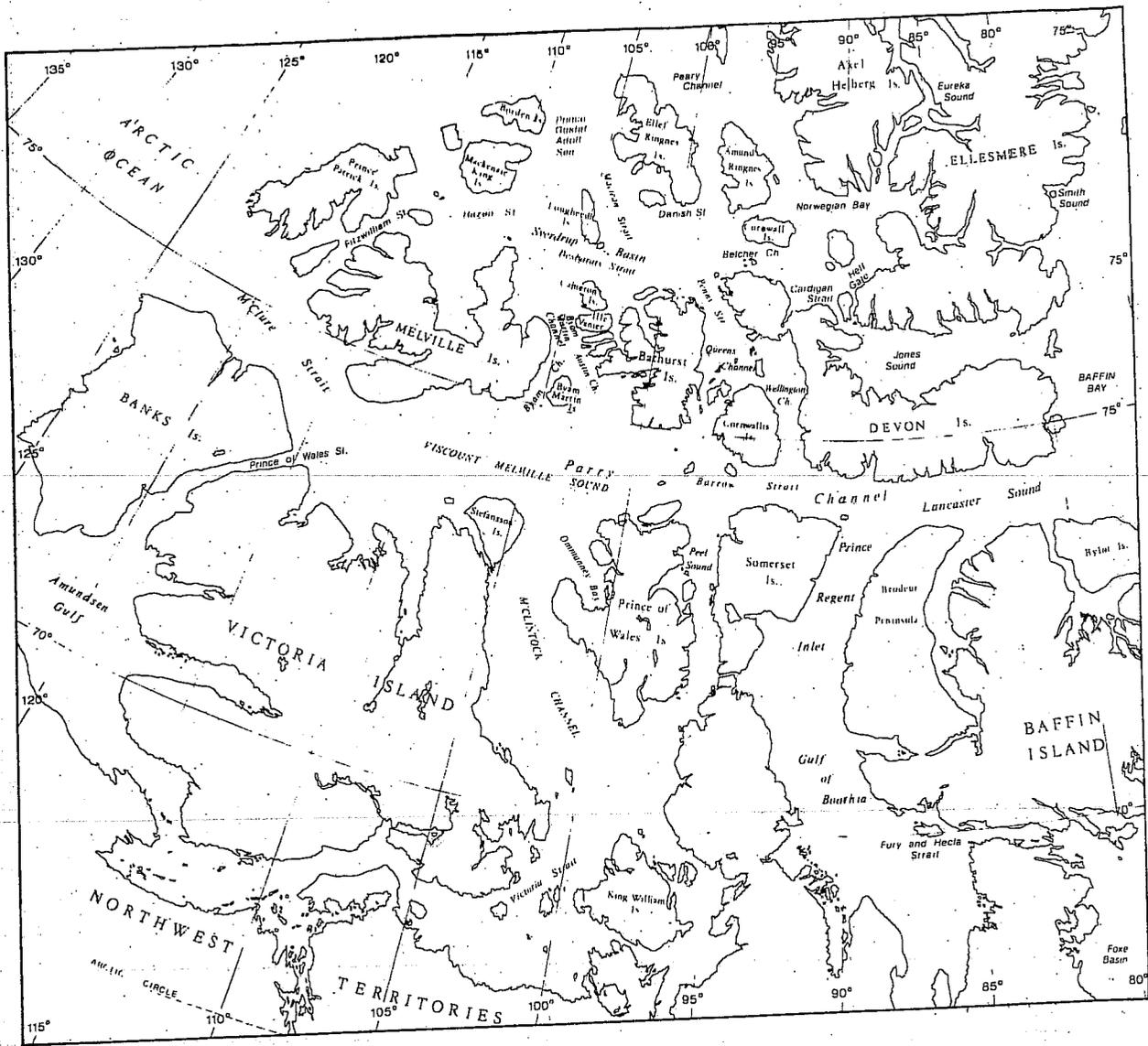


Figure 1: A map of the Canadian Arctic Archipelago.

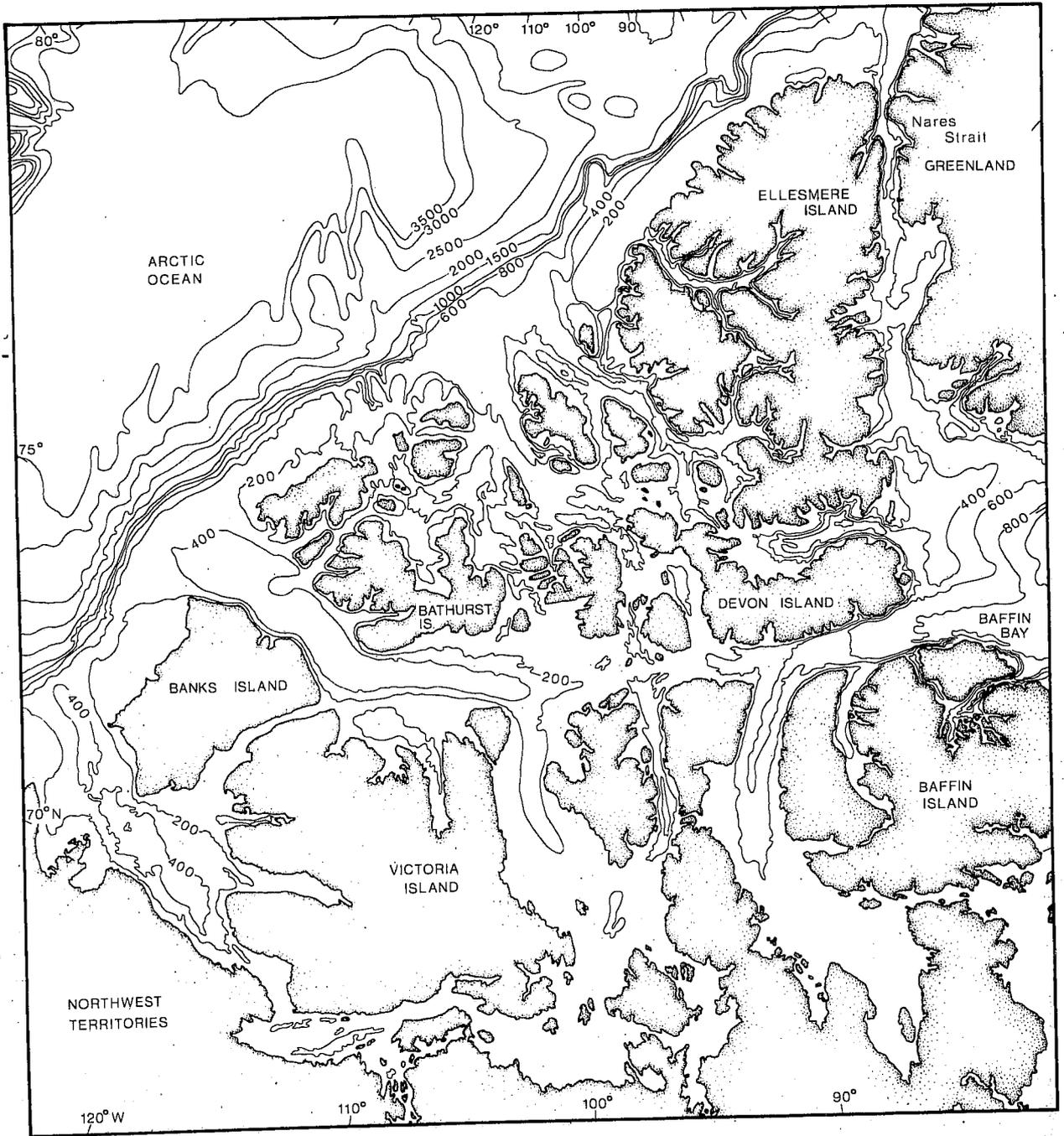


Figure 2: The bathymetry of the Canadian Arctic Archipelago, based on the GEBCO map 5-17, published in 1979. Depth contours are displayed at 200 m intervals up to 1000 m. At greater depths, 500 m intervals are used.

Cardigan Strait (120 m); (2) to Lancaster Sound by way of Penny Strait-Queens Channel (85 m); (3) to Barrow Strait by way of Penny Strait-Wellington Channel (73 m); (4) to Viscount Melville Sound by means of Byam Channel (100 m), Austin Channel (102 m) and (5) to M'Clure Strait by means of Fitzwilliam Strait (250 m).

Within the central waterways of the Queen Elizabeth Islands, often referred to as the Sverdrup Basin, the limiting depth appears to be about 380 m for north-south exchanges although depressions occur to about 600 m in Prince Gustaf Adolf Sea. Even deeper depressions to about 1000 m occur further to the east in the Nansen Sound-Greely Fiord system although free exchange with the Arctic Ocean to the north is limited to depths of about 475 m. In the latter waterway, exchange to the south with the Sverdrup Basin is restricted to depths of 90 m in Eureka Sound.

South of Parry Channel, the depths are characteristically shallow with most of the area being less than 200 m in depth. However, deeper water of over 400 m is found extending into Prince Regent Inlet from Lancaster Sound and Baffin Bay. In addition, water with depths in excess of 200 m protrudes into M'Clintock Channel from Viscount Melville Sound and M'Clure Strait. Throughout the remainder of the area, mostly the southerly portion bordering the continental mainland, water depths are typically 100 m or less with only a few depressions of over 200 m depth.

2.2 SEA ICE

Ice Climatology

From the onset of ice formation in September until clearing in the following summer, virtually all of the study area is covered by sea ice in one form or another. The ice cover is a combination of first-year ice, which has formed since the preceding summer and the harder, thicker second and multi-year ices. The average concentration of multi-year ice is highest in the western and northern portions of the Queen Elizabeth Islands, decreasing to the southeastern area where summer clearing is more extensive. Significant quantities of second and multi-year ice are often found in M'Clure Strait, Viscount Melville Sound and M'Clintock Channel. In the remainder of the study area, the presence of multi-year ice is rare.

In most of the study area, the sea ice consolidates in late autumn or early winter, becoming landfast and immobile. However, in some regions the ice remains mobile throughout the winter and into spring. Areas of such sea-ice mobility are often found in the eastern and western ends of Parry Channel, Prince Regent Inlet, northern Baffin Bay and in western Amundsen Gulf. The location of the ice edges forming the boundary between landfast and mobile sea ice exhibits considerable year-to-year variability in most of the regions. For example, in eastern Parry Channel, Marko (1978) has shown that the ice edge location can vary from western Barrow Strait to eastern Lancaster Sound, over a distance of 500 km.

Even in the winter and early spring, certain areas, referred to as polynyas or flaw leads, are found to have open water or be covered with very thin ice. These polynyas tend to recur from one year to another in the same general locations, shown in Figure 3.

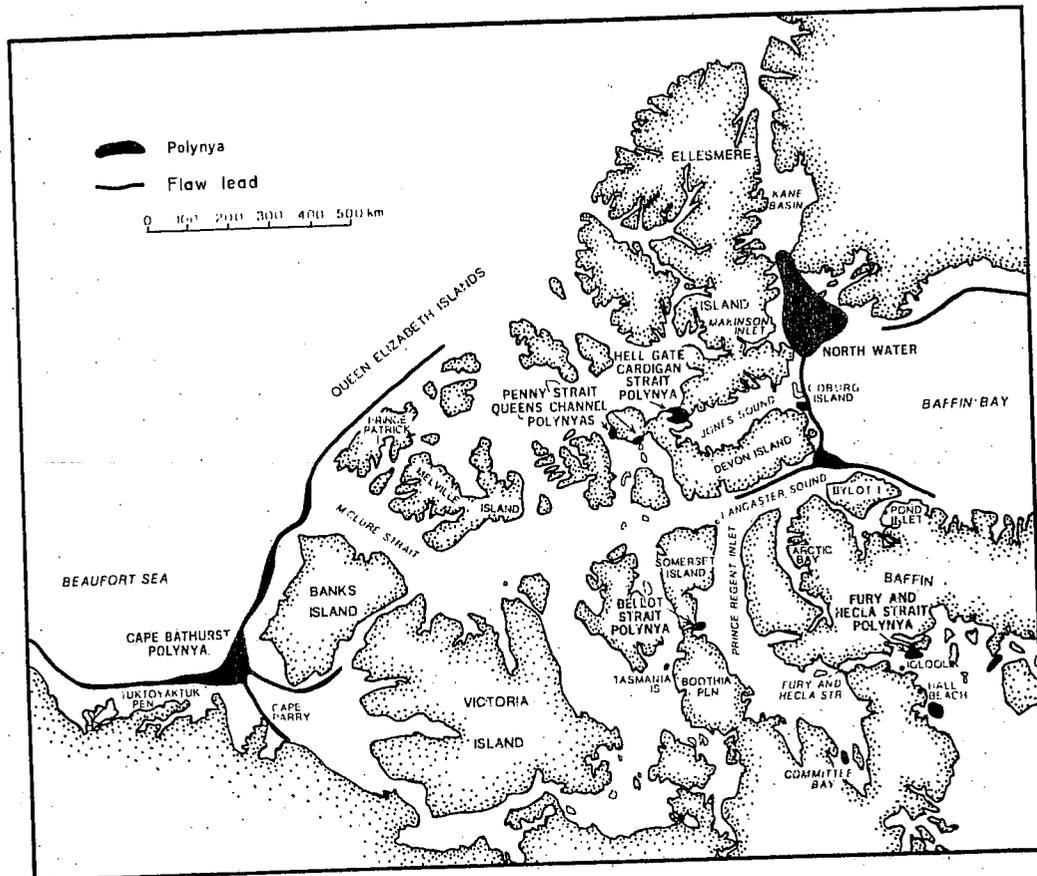


Figure 3: Locations of recurring polynyas and flow leads in the Canadian Arctic Archipelago (from Stirling and Cleator, 1981).

The pattern and extent of sea ice clearing in the study area is quite variable, but some generalizations can be made. Clearing tends to occur to the east through Lancaster Sound into Baffin Bay and to the west through M'Clure Strait and Amundsen Gulf into the Beaufort Sea. The ice from the Queen Elizabeth Islands generally moves southward through the connecting channels into Parry Channel. Sea ice from Parry Channel often collects in M'Clintock Channel, Larsen Sound and Victoria Strait under the influence of prevailing northerly winds, with the result that this area stays congested with sea ice through most of the summer.

In a summer of light ice conditions, complete clearing of sea ice occurs throughout Baffin Bay, Smith, Jones and Lancaster Sounds, Barrow Strait, Prince Regent Inlet, Peel Sound, Wellington and Queens Channels, Norwegian Bay, Eureka Sound, Amundsen Gulf, Prince of Wales Strait and Dolphin and Union Strait, Coronation and Queen Maud Gulfs. The remainder of the study area has varying degrees of ice cover with highest concentrations of more than seven-eighths in the Queen Elizabeth Islands and west of Axel Heiberg Island. In M'Clure Strait, Viscount Melville Sound and M'Clintock Channel, the sea ice is generally limited to two-eighths concentration or less, but some subareas remain with concentrations up to five-eighths.

In a summer of heavy ice conditions, only northern and eastern Baffin Bay, Lancaster Sound, and portions of Barrow Strait, Prince Regent Inlet, Wellington Channel, Peel Sound and Amundsen Gulf are completely free of sea-ice. M'Clure Strait, Viscount Melville Sound and M'Clintock Channel remain covered with unconsolidated ice of greater than seven-eighths concentration. Throughout most of the Queen Elizabeth Islands the sea ice cover is complete and consolidated; only in the southeastern portion around the Norwegian Bay do any openings and appreciable movement of sea ice occur.

Ice Conditions of the Previous Summer (1982)

During the summer preceding the survey, ice conditions in Parry Channel and the Archipelago were moderate. Figures 4 to 6 show the ice conditions at three periods during the summer. The figures were drawn from the weekly AES Ice Central charts for the Arctic. Note that the eastern and western portions of the figures (divided by the dashed line) are separated by two days. The earliest appearance of open water occurred during the week of June 17, when an extensive lead was present at the western end of M'Clure Strait. Open water appeared south of Mould Bay during the week of July 29, and around the Sverdrup Islands during the week of August 3. The maximum simultaneous extent of open water occurred at the beginning of September. By the beginning of October, most of the open water had disappeared.

Ice Observations During Field Studies

Visual observations of ice conditions were made during the period of the survey (March 21 to April 4), and ice thickness was measured at each of the CTD stations. Figure 7 gives a summary of the measured ice thicknesses. Note that the measured thicknesses may not always be representative of the average ice conditions in a particular case, as landings were only made on relatively smooth first-year ice. Rough, multi-year ice and thin areas were not sampled.

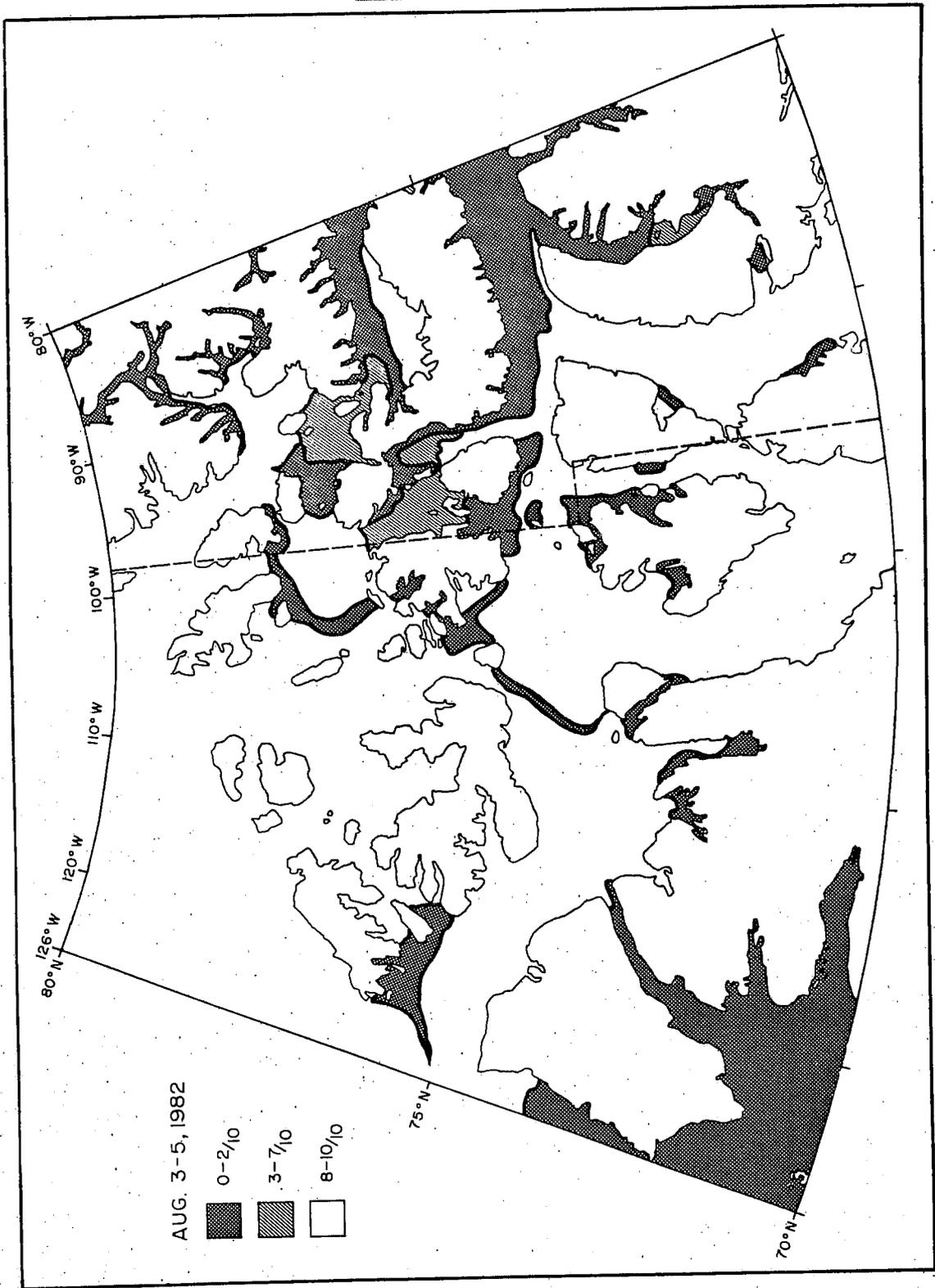


Figure 4: Sea ice conditions on August 3-5, 1982, as reproduced from the weekly Ice Central (Atmospheric Environment Service) charts for the Arctic. The dashed line indicates the boundary between individual charts prepared for the East and Western Arctic, separated by two days.

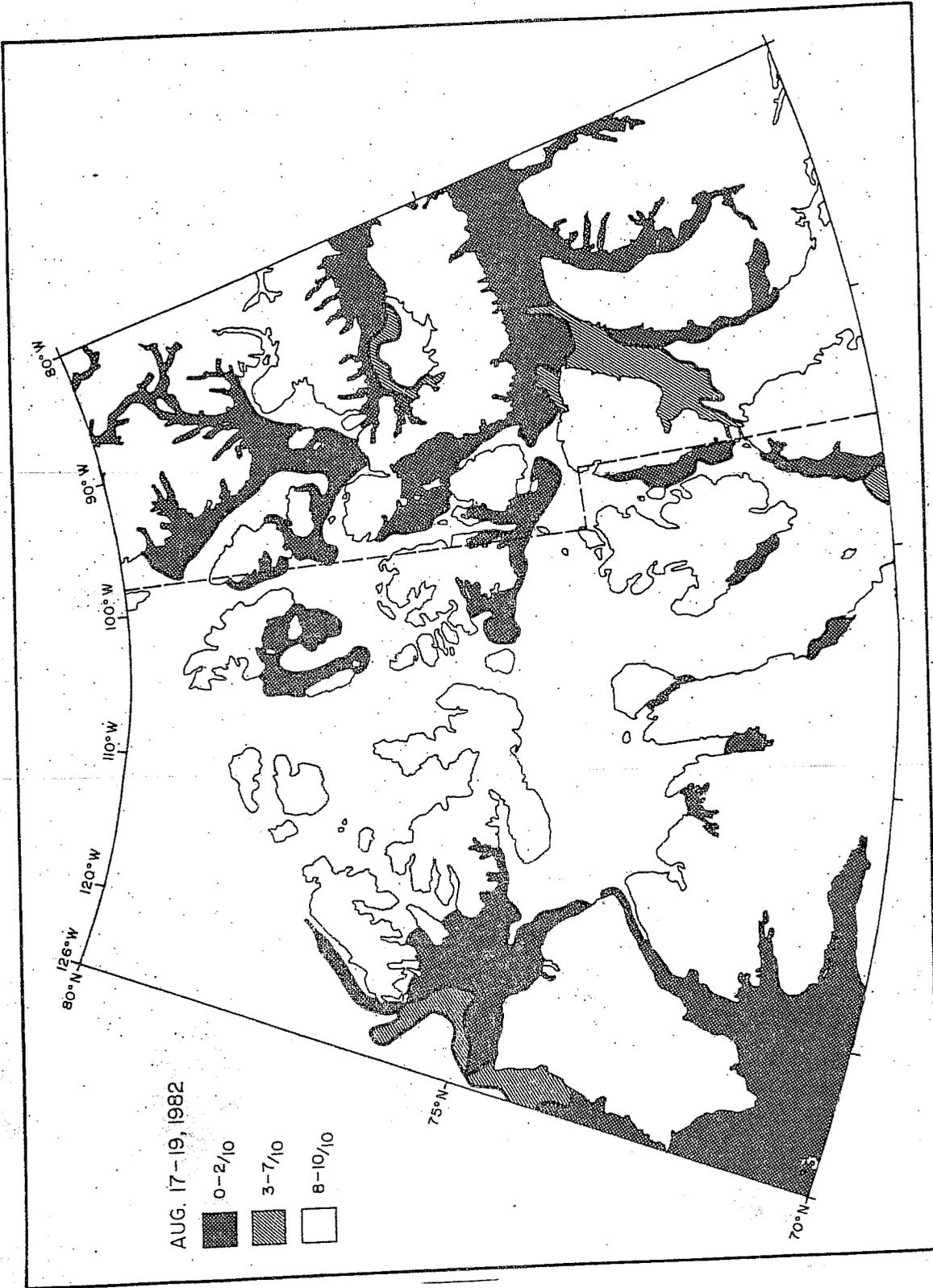


Figure 5: Sea ice conditions on August 17-19, 1982, as reproduced by the weekly Ice Central (Atmospheric Environment Service) charts for the Arctic. The dashed line indicates the boundary between individual charts prepared for the Eastern and Western Arctic, separated by two days.

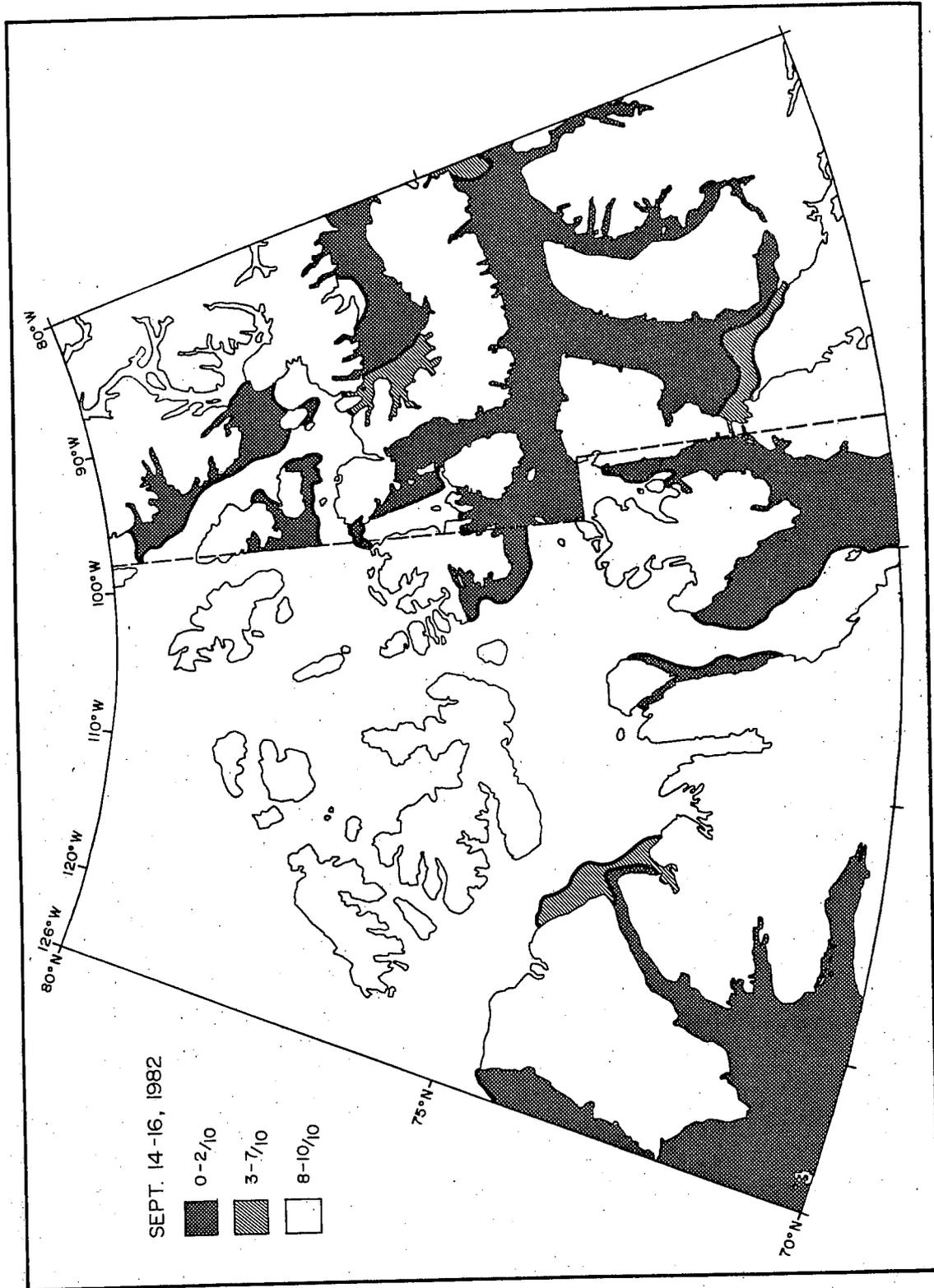


Figure 6: Sea ice conditions on September 14-16, 1982, as reproduced from the weekly Ice Central (Atmospheric Environment Service) charts for the Arctic. The dashed line indicates the boundary between individual charts prepared for the Eastern and Western Arctic, separated by two days.

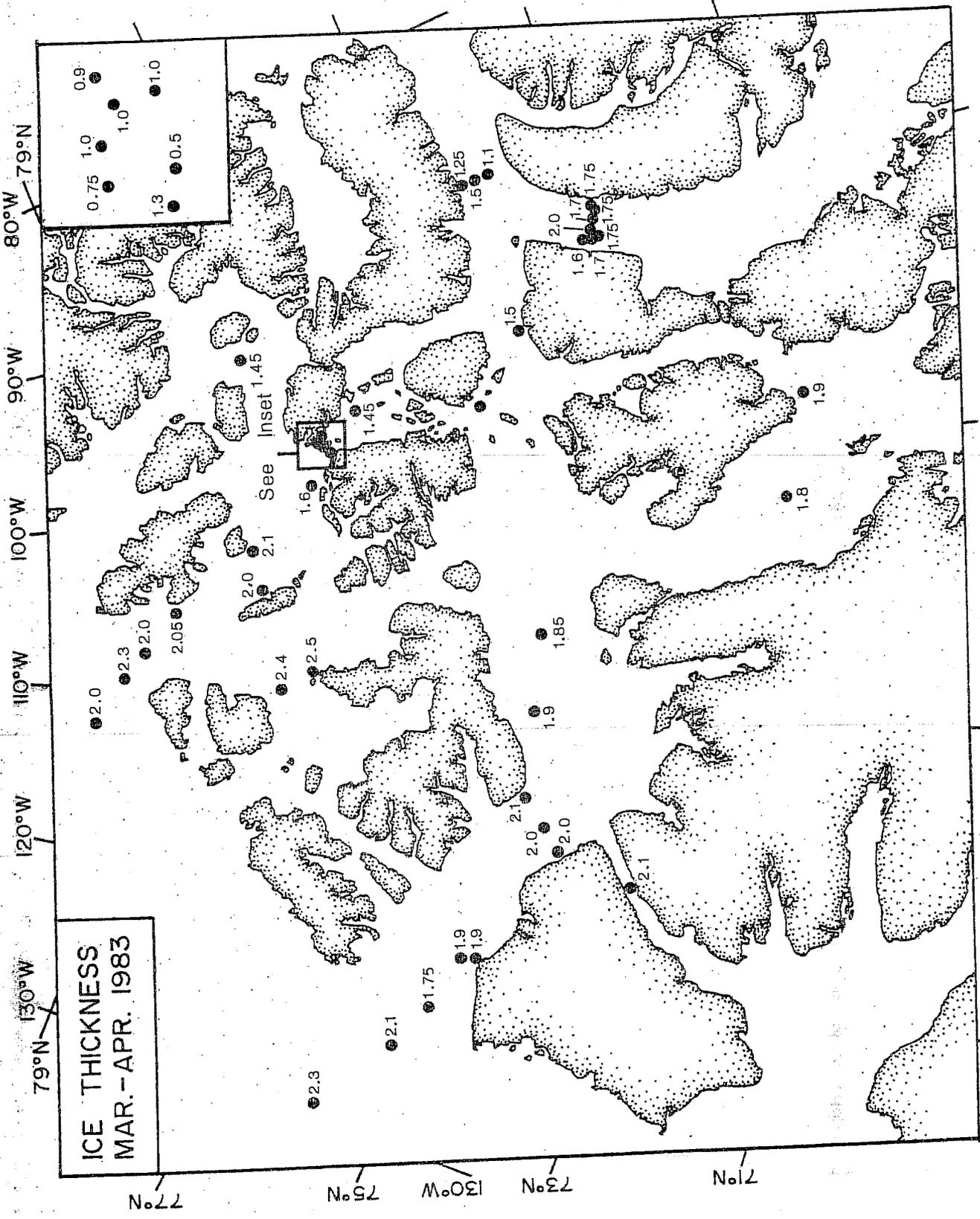


Figure 7: A summary of ice thickness measurements (metres) collected during the field work from March 20 to April 4, 1983.

The thickest ice was found in the northern and western parts of the study area, in the Queen Elizabeth Islands and in M'Clure Strait, where ice thicknesses averaged 2.0 m or greater. In the Queen Elizabeth Islands (line B and the inner part of line P) the ice consisted mostly of large, rough second and multi-year floes unsuitable for landing. Frozen leads suitable for landing were scarce, with the result that only two stations could be occupied in line B across Maclean Strait, and only two in line D, which had to be re-oriented across Hazen Strait.

The outer ends of the continental shelf sections (lines E and P) consisted of a mixture of multi-year floes and very broken first-year ice interspersed with thinly-covered leads. Further in on the shelf, the leads were not as badly broken and more landing sites were available. In the eastern part of M'Clure Strait, in Viscount Melville Sound, Barrow Strait and Prince Regent Inlet, the ice cover consisted mainly of relatively smooth first-year floes, among which no difficulty was experienced in finding landing areas.

The thinnest ice was found in Penny Strait (line A), where measured thicknesses ranged from 0.5 to 1.3 m. The ice consisted of a mixture of first-year floes and thinly-frozen leads. Most of the stations had to be moved from their planned locations, with the result that although all the stations in the section were occupied, they did not lie in a straight line. As Penny Strait is the site of intermittent polynya formation, the presence of thin ice there is not surprising.

The landfast ice edge in Lancaster Sound was located east of Croker Bay, however the ice between the Brodeur Peninsula and the edge was not well consolidated, consisting of broken, ridged first-year floes and thinly-frozen leads. Stations could be occupied only on the northern half of line N, as the southern part of the Sound was too badly broken to find landing sites. Sites were found on leads and first-year floes on the northern half of the sound. Ice thicknesses were less than 1.5 m at all three stations.

3. DATA COLLECTION AND PROCESSING METHODS

3.1 DATA COLLECTION

All data collection was carried out from a DHC-6 de Havilland Twin Otter aircraft, CF-DHB, chartered from Kenn Borek Air Ltd. A total of 53 CTD profiles were obtained at 43 locations shown in Figure 8 to Figure 15, from March 20 to April 4, 1983. Several of the stations had to be relocated from their originally planned positions due to the absence of suitable ice conditions for aircraft landings, as discussed in Section 2.2.

In addition to the CTD data, inorganic micronutrient samples were obtained at two stations on each daily transect. The samples were collected at four depths corresponding to the mixed layer and salinities of 32.75, 33.50 and 34.75. At stations where salinities did not reach 34.75, an intermediate value was chosen. Twice on each daily transect, a salinity sample was collected to check the CTD-derived salinity, and daily measurements with in situ thermistors were made to check the CTD temperature. For every CTD cast, the pressure sensor output was checked against a known length of line out at shallow depths (14.7 m).

Station positions were determined using the GNS-500 VLF/Omega navigation system on the aircraft. Readings of indicated positions at known locations suggested that the positional accuracy was approximately 2 km or better.

The scientific equipment was distributed throughout the aircraft with the CTD winch and a gasoline-powered generator located at the rear opposite the main port-side entry door. The CTD control unit and computer were located forward behind the cockpit. When on station, the arms of the winch were moved forward to protrude through the door opening and the block attached. The CTD probe was then lowered through a hole drilled through the ice immediately below the main doors.

CTD Instrument System

The data were collected using a Guildline Model 8706 digital CTD probe and Model 87102 control unit. The probe carried three sensors: a thermometer, a pressure transducer and a conductivity cell. It transmits data to the surface control unit in digital form along a single-conductor cable. The same cable is used to lower the instrument. The manufacturer's specifications for the sensors and their associated electronics are shown in Table 1.

The instrument samples 25 times per second. The CTD was normally lowered at approximately 1.5 m/s which translates to a spatial sampling interval of about 6 cm.

In addition to the measurement sensors, the CTD probe was equipped with touchdown and bottle-trip reed switches. A lead weight suspended beneath the probe by 5 or 10 m was connected through a nylon line to the touchdown switch. When the lead weight reached the bottom, the touchdown switch would be activated providing a warning for the winch operator. A Knudsen reversing bottle, mounted above the CTD probe, was connected to the bottle-trip switch to indicate when the bottle had tripped during the descent of the probe in response to a dropped messenger. Both of the switch values were recorded on

the digital data tape, along with the pressure, temperature and conductivity ratio data.

Table 1

Specifications for Guildline CTD

Function	Range	Accuracy	Resolution	Stability	Response Time
C*	100 ppm to 40	± 0.005	± 0.001	$\pm 0.002/6$ mos.	<50 ms
T	-2°C to 30°C	$\pm 0.005^{\circ}\text{C}$	$\pm 0.0005^{\circ}\text{C}$	$\pm 0.005^{\circ}\text{C}/6$ mos. $\pm 0.002^{\circ}\text{C}/30$ days	<50 ms
P	to 1500 dbar	$\pm 0.15\%$ F.S.	$\pm 0.01\%$ F.S.		<50 ms

*Specifications for conductivity are given as equivalent salinities.

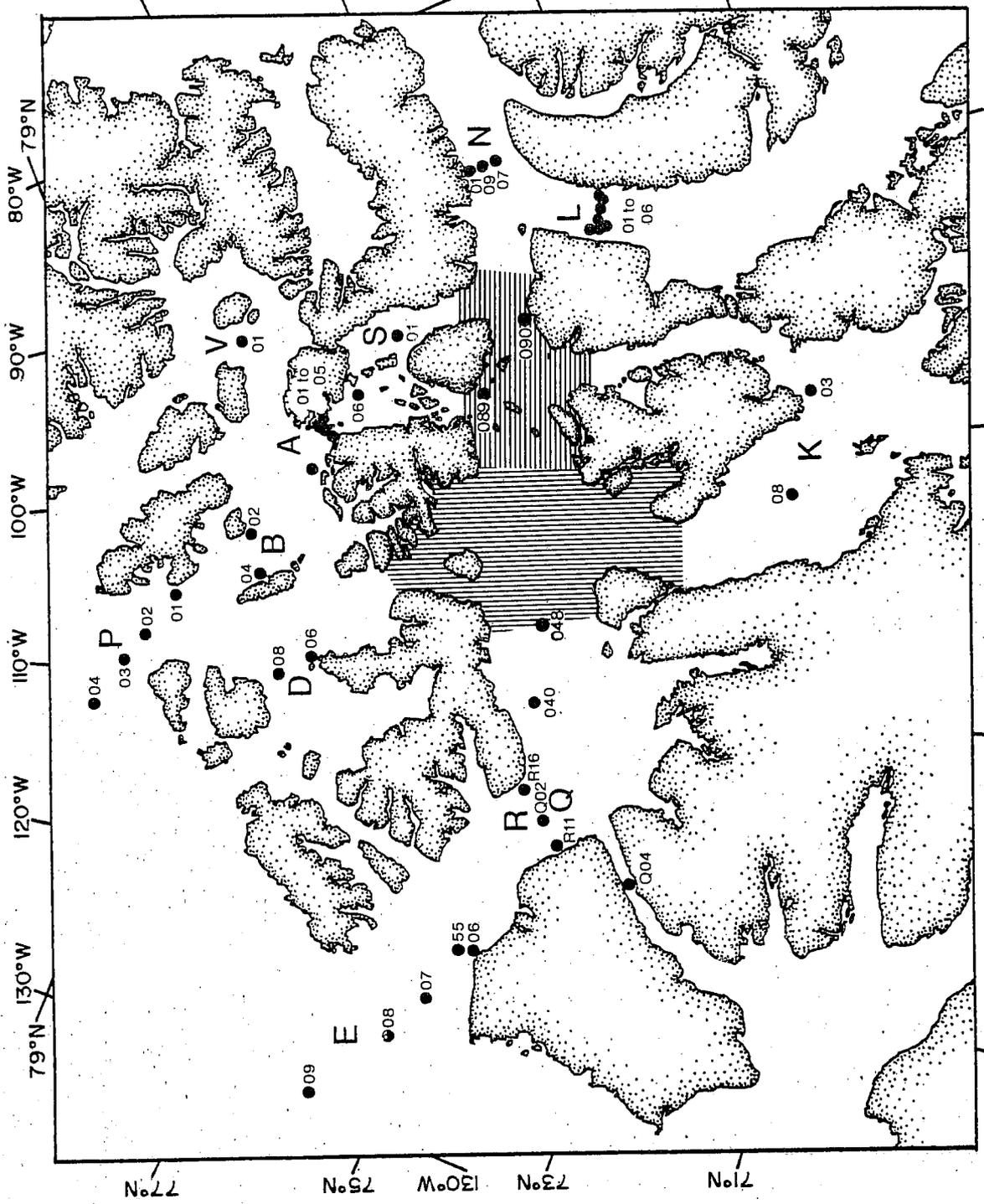
A Hewlett-Packard 9825 computer was used to monitor the CTD data as the probe was lowered. The computer calculated the fall speed as the probe descended so that the fall rate could be kept near 1.5 m/s, in order that the response characteristics of the conductivity and temperature transducers would be matched (Perkin and Lewis, 1982). In addition, the time at which to release the bottle messenger was indicated for a specified bottle depth. The computer also provided a real-time display and vertical profile plot of the temperature and salinity to monitor the quality of the data.

CTD Station Procedures

Once the aircraft had landed, the gasoline-powered generator was started. A nine-inch hole was drilled using an ice auger turned by a one-inch shaft electric drill. After all snow and ice fragments had been cleared from the hole, the ice thickness was measured and a depth sounding taken. The CTD probe was lowered to a depth of 15 m as determined by a previously measured mark on the winch cable. Power was then applied to the probe and the output was monitored through the computer. Successive readings were noted until the instrument stabilized, usually requiring about ten minutes. The probe was then raised to within 4 to 5 m of the surface and the tape recorder was started. The probe was then lowered at a speed of 1.5 m/s until within 30 m of the bottom. At this point, the descent rate of the probe was slowed to about 1.0 m/s, and then stopped when the touchdown switch was activated. The tape recorder was stopped and then the probe was pulled back to the surface. Once the probe was secured within the plane, the conductivity cell was filled with a isopropyl alcohol solution to prevent seawater from freezing within the cell. Isopropyl alcohol was also applied to the temperature sensor coil to keep ice from forming on its surface.

If a salinity sample was required at the station, it was obtained with the Knudsen reversing bottle mounted immediately above the CTD probe. The bottle was tripped by mechanical messenger as the probe descended to provide a simultaneous salinity value for calibration of the CTD probe. From each Knudsen bottle, two samples were drawn into 150 ml glass bottles.

Figure 8: Locations of oceanographic stations occupied between March 20 and April 4, 1983 in the Canadian Arctic Archipelago. The shaded regions indicate the locations of concurrent physical oceanographic studies carried out by the Frozen Sea Research Group (Institute of Ocean Sciences) in eastern Viscount Melville Sound (vertical hatching) and by the Bayfield Marine Laboratory in Barrow Strait (horizontal hatching).



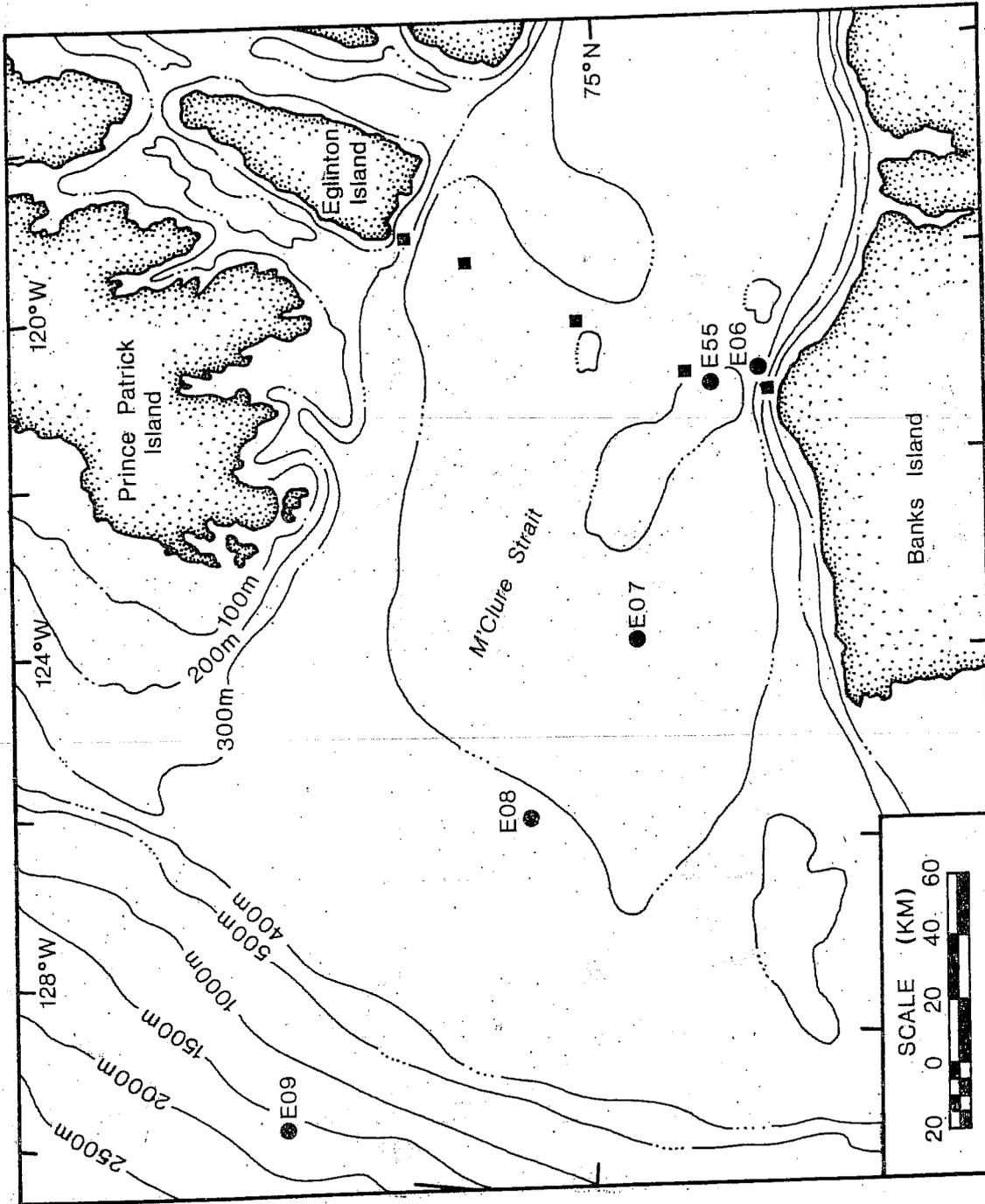


Figure 9: Locations of oceanographic stations, denoted by solid circles, occupied in western M'Clure Strait and the adjoining continental shelf and slope on March 26-27, 1983. The square symbols mark the locations of stations occupied in March 1982.

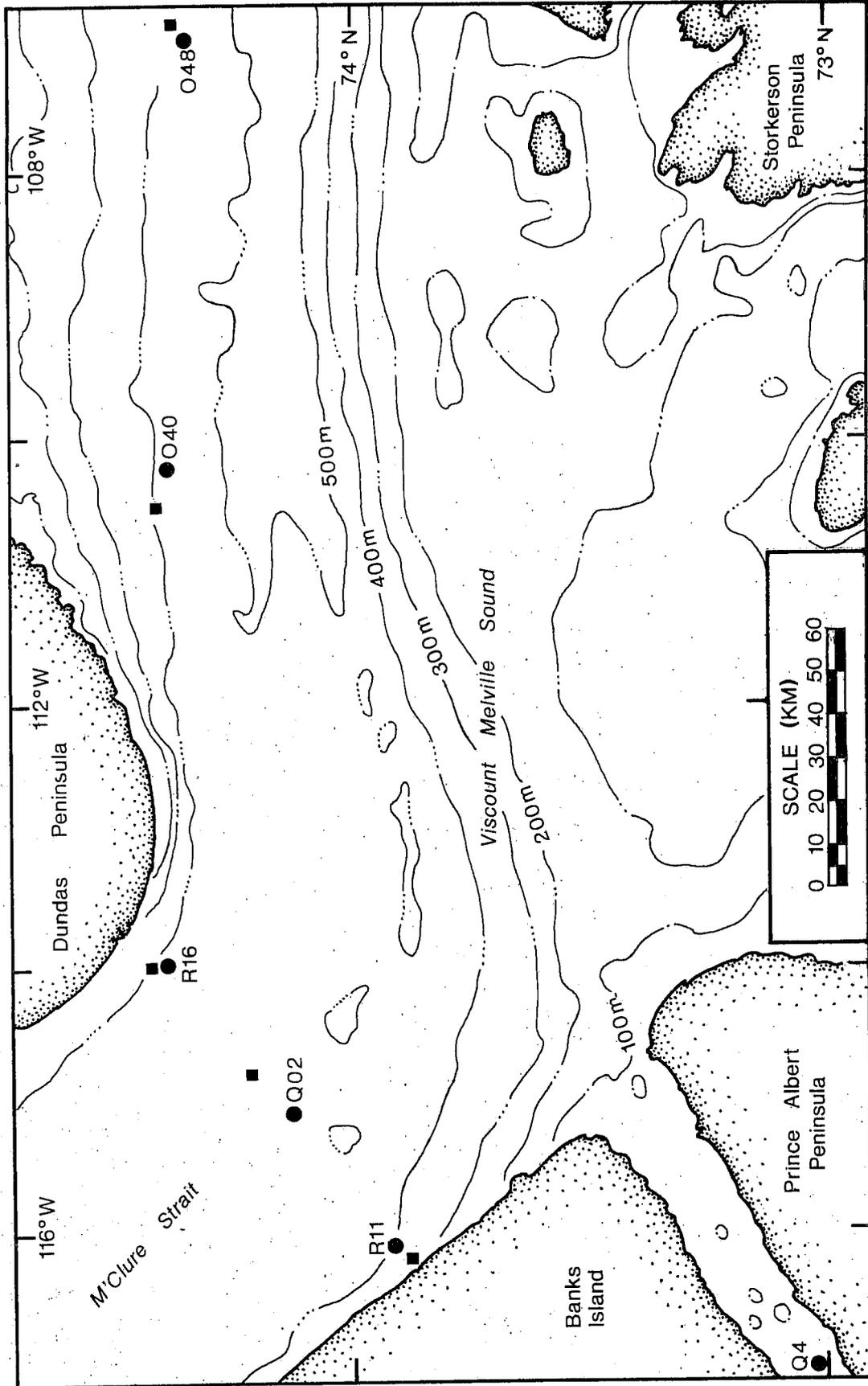


Figure 10: Locations of oceanographic stations, denoted by solid circles, occupied in eastern M'Clure Strait, Viscount Melville Sound and Prince of Wales Strait, March 23 and March 25, 1983. The square symbols mark the locations of stations occupied in March, 1982.

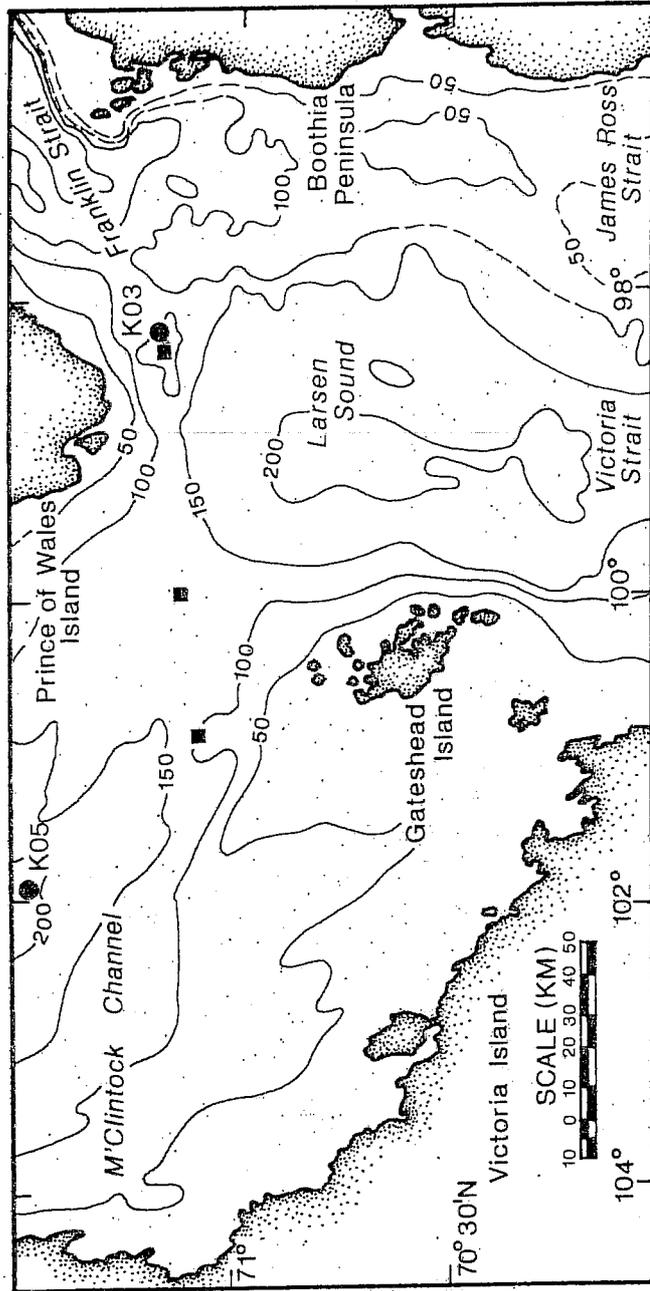


Figure 11: Locations of oceanographic stations, denoted by solid circles, occupied in southern M'Clintock Channel and Larsen Sound, March 22-23, 1983. The square symbols mark the locations of stations occupied in April, 1982.

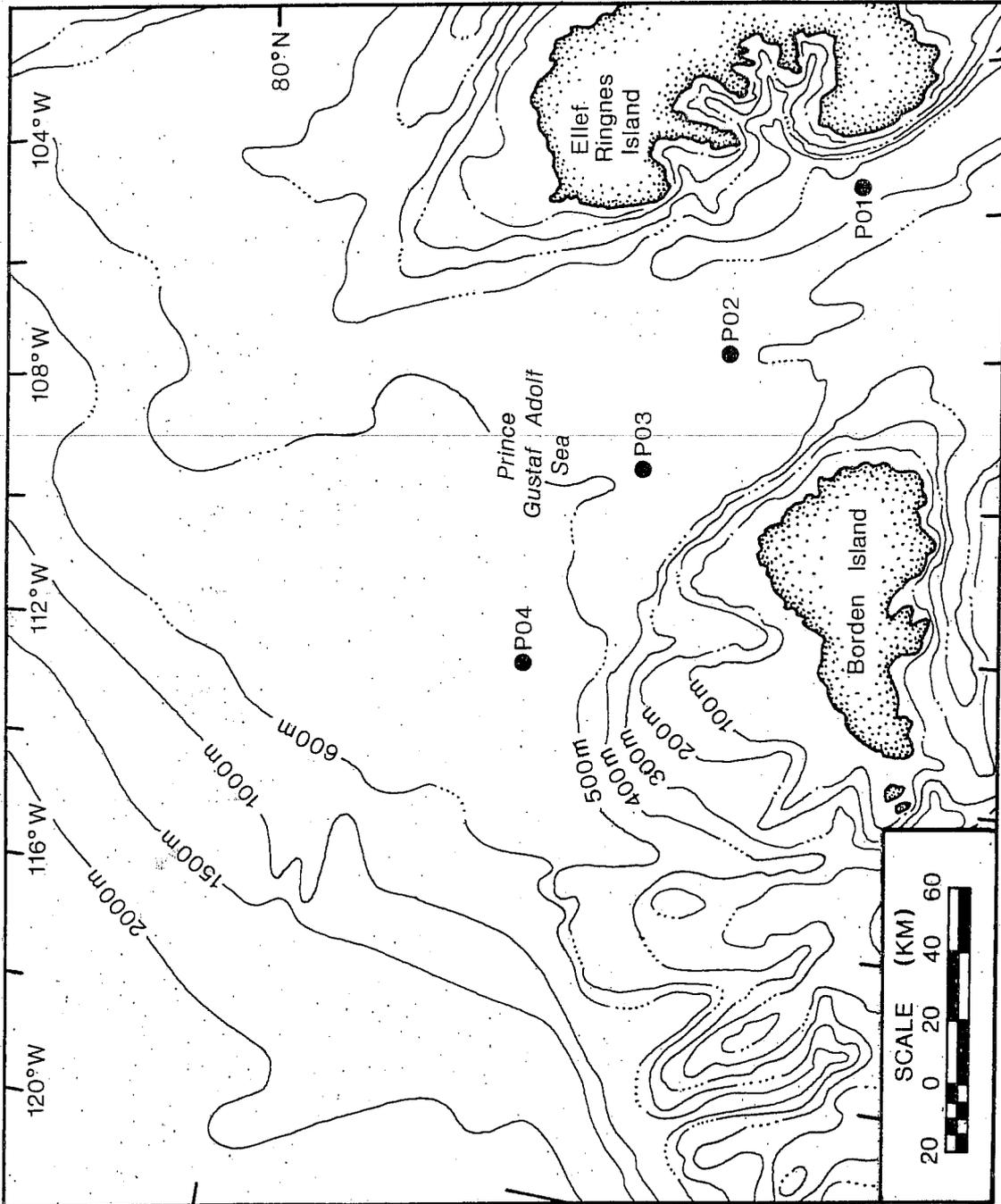


Figure 12: Locations of oceanographic stations, denoted by solid circles, occupied in Prince Gustaf Adolf Sea, March 27, 1983.

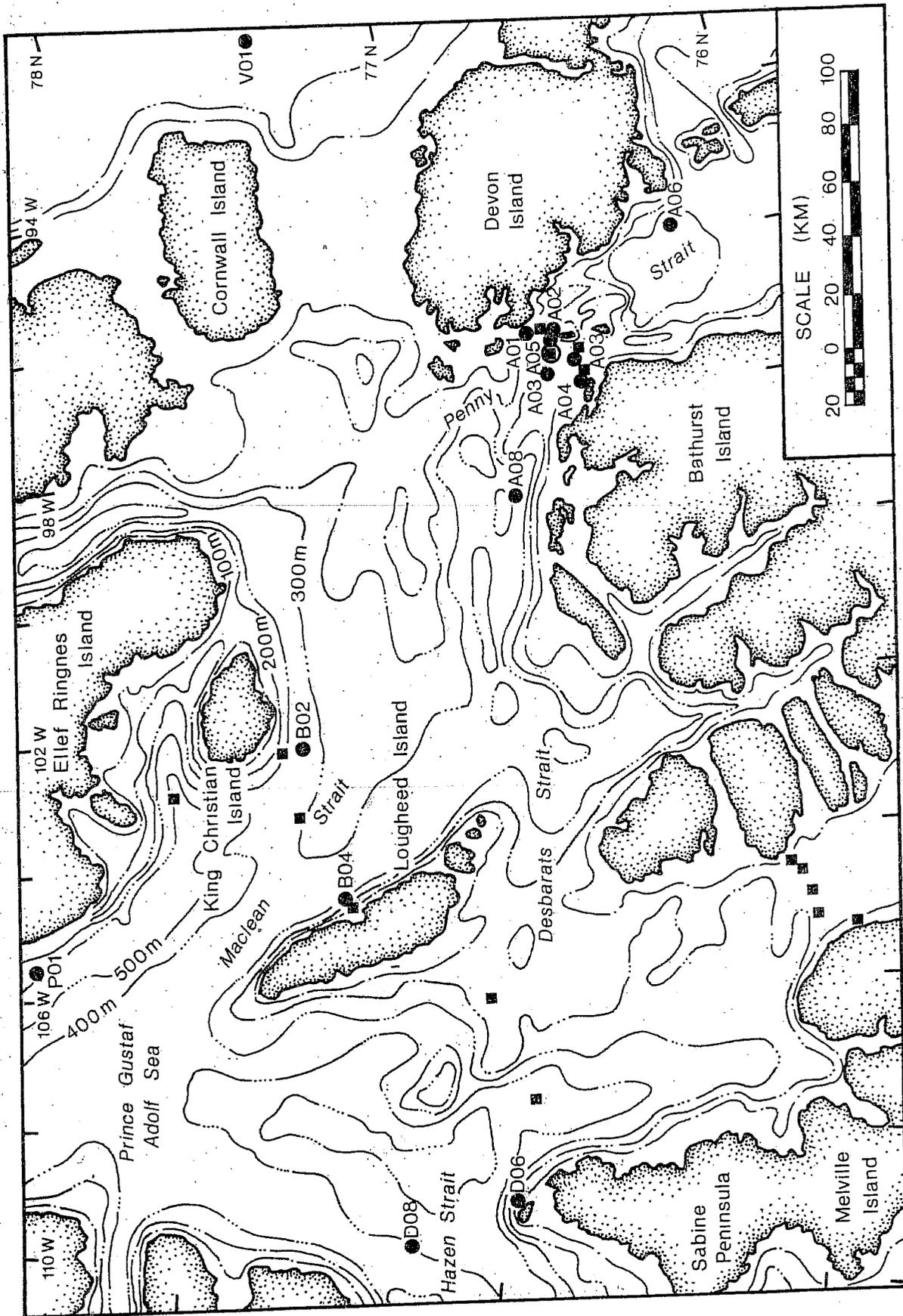


Figure 13: Locations of oceanographic stations, denoted by solid circles, occupied in the Sverdrup Basin (lines B and D) on March 24, 1983; in Penny Strait (line A) on March 29 and April 1-2, 1983; and in Norwegian Bay (station V01) on April 1, 1983. The square symbols mark the locations of stations occupied in March, 1982.

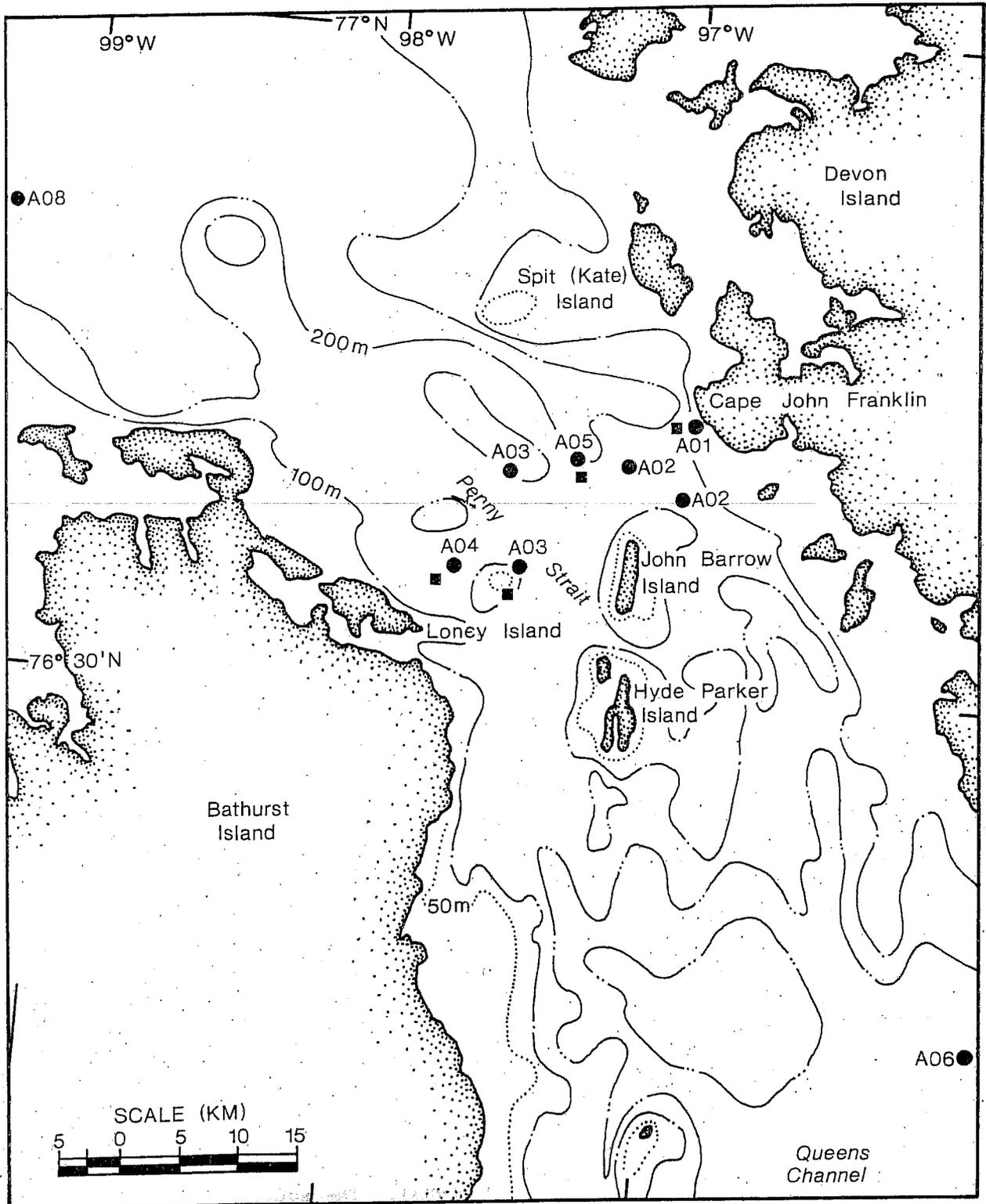


Figure 14: Locations of oceanographic stations, denoted by solid circles, occupied in the vicinity of Penny Strait. Stations A01, A03, A04, A05, A08 and the southern A02 location were occupied on March 29, 1983, while on April 1-2, 1983 seven sequential casts were obtained at the northern A02 location and a single CTD cast was obtained at station A06. The square symbols mark the locations of stations occupied in March, 1982.

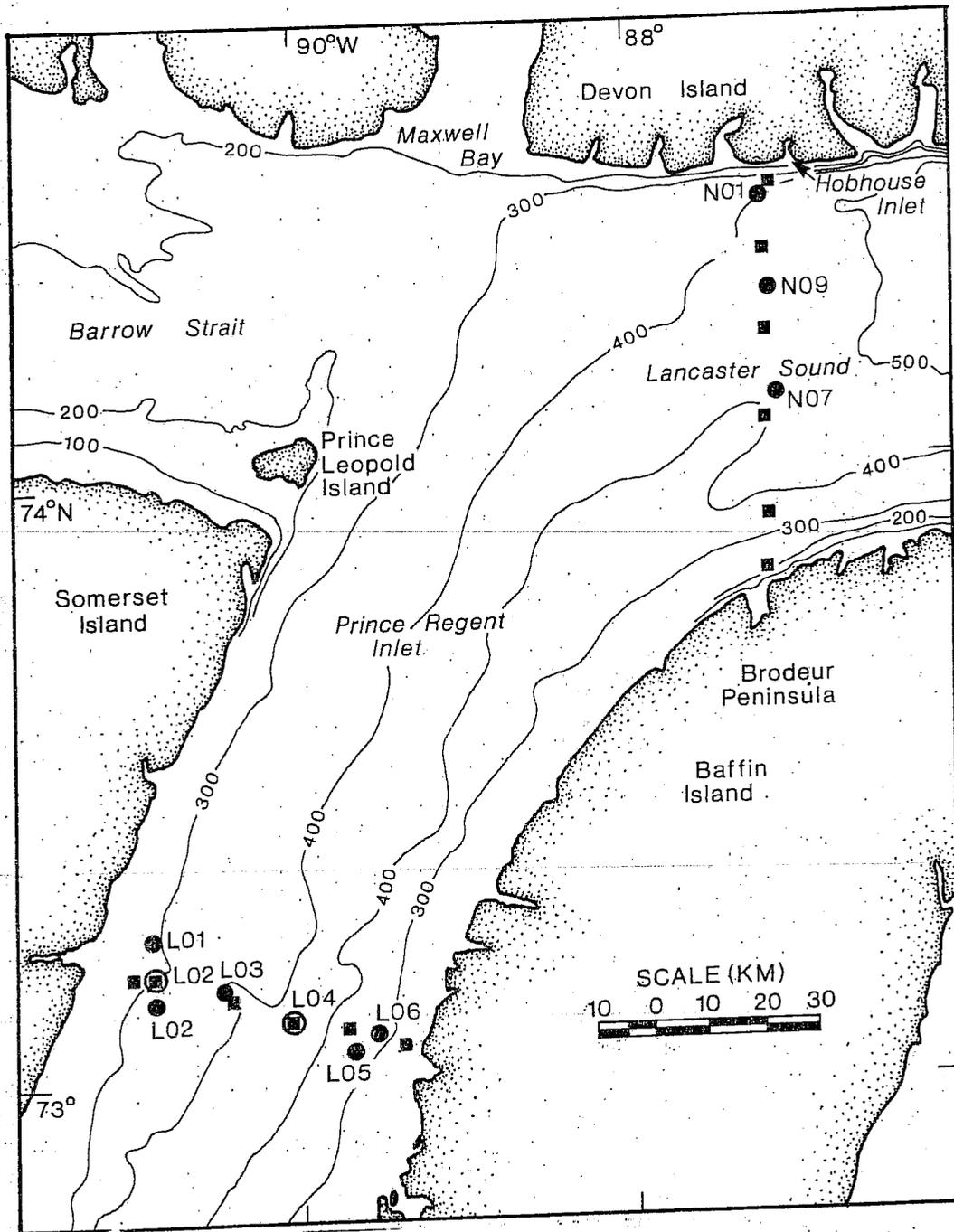


Figure 15: Locations of oceanographic stations, denoted by solid circles occupied in Lancaster Sound (March 28, 1983) (and in Prince Regent Inlet (southern L02 and L05 on March 28, 1983; other locations on March 30, 1983). The square symbols mark the locations of stations occupied in March-April, 1982.

Every effort was made to prevent the salinity samples from freezing. Once the samples were drawn, they were stored in an insulated box and kept in heated surroundings. However, on cold (-35 to -40°C), windy days, some freezing of the seawater did occur in the nozzle of the Knudsen bottle prior to drawing of the samples.

Temperature calibration data were obtained by attaching a pair of bead thermistors adjacent to the temperature sensor of the probe. The probe with attached thermistors was lowered as far as the thermistor cables permitted, about 6.5 m below the surface. The thermistors were connected to an electrical bridge circuit, which was used to determine the temperature from each thermistor by reference to the precision thermistors. This procedure was carried out prior to the CTD profile.

Inorganic Nutrient Sampling

At stations where nutrient samples were collected, the Knudsen bottle was set and then lowered to the depth corresponding to the desired salinity, as chosen from the CTD profile. A display program on the HP9825 was used to monitor the depth. Data were recorded on tape over the 20 m immediately before the depth was reached. The bottle was stripped and returned to the surface. At each sampling depth, six samples were collected: three were drawn into glass tubes and three into plastic tubes. Each tube, having a volume of 20 ml, was rinsed three times prior to drawing the sample. The samples were allowed to freeze immediately and thereafter were stored in a cooler in the aft baggage compartment of the aircraft.

Following the field work, the samples were analyzed on a Technicon II auto-analyzer by Seakem Oceanography Ltd., Victoria, B.C.

3.2 CALIBRATION

Calibration curves for the temperature and conductivity ratio sensors were measured in the laboratory prior to the experiment by the Frozen Sea Research Group. Field calibration checks were made for all three sensors at least daily. The pressure sensor was calibrated against a known length of line out on each cast at shallow depths (14.7 m), and on three occasions at greater depths (49.7 m; 49.7 m and 99.7 m; 49.7 m and 99.7 m) as well, under apparently calm water conditions. The temperature sensor was calibrated daily against two thermistors at approximately 6.5 m depth. Duplicate water samples for conductivity ratio calibration were collected once or twice daily from a sampling bottle mounted above the CTD probe. The water samples were later analyzed on a bench salinometer.

The pressure calibration data are shown in Table 2 (deep values) and Table 3 (daily averages of the shallow values). Depths from measured line out were converted to pressures by integrating the water densities at standard depths provided by the field data logging system from the surface down to the calibration depth. Daily averages of the shallow pressure values were computed to compensate for the effects of atmospheric pressure variations.

Table 2

Comparison of measured pressure and pressures computed from length of line out (deeper casts).

Profile	Date	P Computed from Wire Out (dbar)	P Measured by CTD (dbar)	ΔP (Computed -CTP, dbar)
4807	March 23	50.40	49.20	1.20
4807	March 23	100.82	99.45	1.37
4821	March 27	100.78	99.15	1.63
4825	March 28	50.41	49.20	1.21
4825	March 28	100.82	99.60	1.22

The variation in the pressure error with pressure (Table 2) was opposite in sign to that found when the sensor was last calibrated in the laboratory (July, 1981). The laboratory calibration was therefore not used, and the data of Tables 2 and 3 were used to construct the following corrections for the pressure (at the position of the pressure sensor)

$$P_{cal} = B + 1.00532 P_{CTP} \quad 0 \leq P_{CTP} \leq 100 \text{ dbar}$$

$$P_{cal} = 0.532 + B + P_{CTP} \quad P_{CTP} > 100 \text{ dbar}$$

where B is the daily average offset from Table 3.

Table 3

Mean daily shallow-depth pressure errors.

Date	No. of Casts	ΔP (Computed-CTP, dbar)
March 20	1	0.84
March 22	1	0.77
March 23	2	0.90 \pm 0.06
March 24	4	0.97 \pm 0.03
March 25	4	0.94 \pm 0.05
March 26	5	0.85 \pm 0.11
March 27	4	0.96 \pm 0.11
March 28	5	0.95 \pm 0.03
March 29	4	0.91 \pm 0.11
March 30	5	0.90 \pm 0.09
April 1	9	1.00 \pm 0.09
April 4	1	1.03

Table 4, containing the temperature calibration data, shows the difference between the thermistor and CTP temperature and the thermistor temperature versus time. The asterisks mark days on which only one thermistor was functioning.

The laboratory calibration was used to define the temperature dependence of the calibration relation, while the data of Table 4 were used to define a temperature-independent offset. The data of Table 4 were fitted with a straight-line time variation which had a standard deviation between the measured and fitted values of ΔT of 0.0023°C . The resulting calibration equation for temperature was

$$T_{\text{cal}} = 0.9938 T_{\text{CTP}} + 0.0333^\circ\text{C} - 2.93 \times 10^{-4} N^\circ\text{C}$$

where N is the Julian day number.

Table 4

Temperature calibration data.

Date	Thermistor Temperature ($^\circ\text{C}$)	ΔT (Thermistor-CTP, $^\circ\text{C}$)
March 20	-1.6781	0.0149
March 21	-1.7815	0.0093
	-1.7865	0.0096
March 22	-1.6536	0.0112
March 23	-1.7106	0.0082
March 24*	-1.7530	0.0066
March 25*	-1.7655	0.0041
	-1.7648	0.0030
	-1.7609	0.0091
March 26*	-1.7523	0.0076
March 27*	-1.7295	0.0061
March 28*	-1.7768	0.0089
March 29*	-1.7684	0.0104
March 30	-1.7764	0.0077
April 1	-1.7290	0.0066
April 4	-1.7624	0.0063
	-1.7617	0.0074

The pressure and temperature values corrected as above were combined with the salinity values from the water samples (only samples for which analysis of replicates agreed to within 0.01 were used) to define, via the Practical Salinity Scale 1978, a conductivity ratio for comparison with the ratio measured by the CTP (taken as the average of ten scans before and after the scan corresponding to the point at which the bottle was tripped). The CTP conductivity ratio was corrected for cell-size changes due to pressure and temperature effects. The comparison data are summarized in Table 5 below.

Table 5

Calibration data for conductivity ratio.

Date	Profile No.	C (Water Samples)	C (CTD)	C_{WS}/C_{CTP}
March 20	4800	0.61399	0.61283	1.00189
March 21	4801	0.61361	0.61194	1.00273
March 23	4807	0.67304	0.67154	1.00223
March 24	4808	0.68167	0.67991	1.00259
March 24	4811	0.68063	0.67870	1.00284
March 25	4812	0.68194	0.68015	1.00263
March 25	4815	0.60830	0.60680	1.00247
March 26	4817	0.68384	0.68216	1.00246
March 26	4819	0.68121	0.67941	1.00265
March 27	4821	0.68398	0.68246	1.00223
March 27	4824	0.68312	0.68173	1.00204
March 28	4825	0.64150	0.64039	1.00176
March 28	4827	0.67114	0.66961	1.00231
March 29	4830	0.67822	0.67675	1.00217
March 29	4835	0.63572	0.63421	1.00238
March 29	4837	0.63303	0.63176	1.00201
March 30	4841	0.65127	0.65002	1.00192
March 30	4841	0.65127	0.65002	1.00192
April 1	4842	0.68178	0.68028	1.00220
April 1	4846	0.62464	0.62331	1.00213

The conductivity ratio measured by the probe would normally be corrected by applying a factor equal to the mean of the ratios C_{WS}/C_{CTP} . However, the probe struck bottom on profile 4819 (March-26) and there is a statistically significant (at the 95% confidence level) difference between the mean of the first 9 values (up to and including cast 4819) and the last 10. It is very likely that a change in conductivity ratio calibration could be caused by the bottom impact, and therefore two different calibration factors were applied to the conductivity ratio as follows:

$$C_{cal} = 1.00248 C_{CTP} \quad (\text{casts } 4800-4819)$$

$$C_{cal} = 1.00210 C_{CTP} \quad (\text{casts } 4820-4852)$$

After application of the above calibration constants, the RMS difference in the salinity computed from CTP data, and that measured from the water samples was 0.008. The maximum difference was -0.0214, with the remaining differences being less than 0.0140. The variance associated with differences between duplicate salinity samples is about 0.0025², so that 90% of the error variance must be associated with instability in the CTD.

Intercomparisons with the CTD instruments being used by the Frozen Sea Research Group (FSRG) and the Bayfield Laboratory for Marine Science and Surveys (BLMSS) were carried out at two sites in Barrow Strait on March 21 and April 4. Near-simultaneous casts were taken at sites separated by 200 m or less in each case. Intercomparison data from the probe (#4) used to make the

measurements contained in this report appears in Appendix 1 as casts 4800 (March 21 test) and 4852 (April 4 test). Probe 5 was used by the Frozen Sea Research Group; intercomparison data from that probe is recorded as casts 4700 (March 21) and 4900 (April 4) at FSRG (R. Lake, pers. comm.). Intercomparison data from the BLMSS probe appears as casts 83075-1 (March 21) and 83046-10 (April 4) in Prinsenberg and Sosnoski (1983).

Independent temperature calibration data of the form described above were available for both probes 4 and 5 for measurements taken between March 21 and April 4. Salinity calibration values from water samples were available only for probe 4 during that period, although samples were available for probe 5 from a set of measurements taken after April 4. Laboratory calibration values for pressure, temperature and salinity, measured before the start of field operations, were available for all three instruments.

Temperature data from probes 4 and 5 agreed to within 0.002°C on both March 21 and April 4 when both instruments had been corrected with in situ thermistor measurements. Unlike the March 21 intercomparison, when the two probes were lowered simultaneously, the April 4 casts by probes 4 and 5 were separated by 45 minutes, and significant changes had taken place in the structure of the water column. Temperature comparisons on April 4 were therefore restricted to the lower 30 m of the profiles, where the least amount of change appeared to have taken place. Deep-water salinities from probe 5 were 0.005 below those from probe 4 when probe 4 was calibrated as described above, and probe 5 was calibrated using a cell constant (0.998564) derived from water samples taken after April 4. Comparison of salinity values on March 21, using calibrated measurements from probe 4 and the April 4 cell constant for probe 5 showed the probe 5 to be consistently lower than probe 4 by approximately 0.021. As the salinity calibration for probe 4 had been derived from a series of independent salinity samples, it was decided to correct probe 5 to agree as closely as possible with probe 4 throughout the period March 21-April 4. A cell constant of 0.99934 for probe 5 was required to force agreement in salinity March 21; an average value of $1/2 (0.99934 + 0.998564) = 0.99895$ was therefore applied to all probe 5 data taken between March 21 and April 4. As a result, salinity differences between the two probes ranged from -0.011 (March 21) to $+0.002$ (April 4), which is somewhat greater than the RMS error in the calibration for probe 4. Data from FSRG 1983 included in this report were obtained from preliminary results and were calibrated using a cell constant of 0.99905. Salinity values derived from these data are therefore 0.0035 higher than those in the final set.

Comparison of the BLMSS data (83075-1) with data from probe 4 on March 21 showed the BLMSS temperature to be approximately 0.01°C higher and the BLMSS salinities to be approximately 0.025 higher than the probe 4 values. Comparison of deep-water T-S characteristics from BLMSS cast 83046-10 and probe 4 cast 4852 shows differences in temperature and salinity less than 0.01°C and 0.01, respectively. Since the BLMSS data used in this report were collected after April 4, they have been used without alteration.

Three casts using a third FSRG probe, #6, were also made in conjunction with measurements at station K05 (casts 4803 (probe 6) and 4804) and the April

4 intercalibration (casts 4901 and 4902) and are listed in Appendix 1. Laboratory calibration constants were applied to the probe 6 data as follows:

$$P_{\text{cal}} = P_{\text{CTP}} - 11.02$$

$$T_{\text{cal}} = T_{\text{CTP}} + 0.00318$$

$$C_{\text{cal}} = 0.9955 C_{\text{CTP}}$$

As no other data were collected with probe 6, no attempt has been made to derive improved constants for it.

3.3 DATA PROCESSING

In processing the CTD data, as part of applying the calibration corrections described in Section 3.2, other corrections were applied to the data. The CTD probe temperature and conductivity sensors have different response characteristics to variations within the water column. To compensate for these changes, which vary with the fall speed of the probe, an algorithm was applied to the raw temperature and conductivity ratio data (Perkin and Lewis, 1982). For this purpose, the fall speed was computed as a moving average, over 32 successive scans (approximately 1.3 seconds). Those data acquired at fall speeds of 0.3 m/s or less were discarded. In addition, a correction was applied to the conductivity ratio to compensate for changes in the dimensions of the conductivity cell caused by the varying pressure and temperature during the profiling (Bennett, 1976).

Salinity was computed using the Practical Salinity Scale 1978 (Lewis, 1981) and, in accordance with the convention of the new scale, salinity values are presented as dimensionless numbers. It should be noted that the Practical Salinity values are approximately 1000 times the values of the salinity of the same samples of seawater obtained on the previous scales. For example, a sample of seawater having a salinity of 0.03512 (i.e. 35.12‰) will have a practical salinity of 35.12. (In this report, where comparisons have been made with historical data derived using previous salinity scales, the conversion values of Lewis and Perkin (1981) have been used to determine the magnitude of the changes under the Practical Scale 1978.)

The surface freezing point temperatures were computed according to the new UNESCO definition (Millero, 1978). Density is presented in the form of reduced density:

$$\sigma = (\text{density} - 1) \times 10^3$$

based on UNESCO Equation of State of Seawater (Millero and Poisson, 1981). For this report, the reduced densities, often referred to as sigma-t values, are computed for pressures of one standard atmosphere, not for in situ pressures. The units of reduced density are kg/m³.

Other derived quantities used in this study are dynamic height anomaly and sound speed. The dynamic height anomaly was computed as the pressure integral of specific volume anomaly (Millero et al., 1980) from the surface (Pond and Pickard, 1978). The values are given in units of dynamic metres, where 1 dyn. m = 10 m²/s² = 10 J/kg. Sound speed was calculated by means of the algorithm of Wilson (1960) with units of m/s.

A plot and listing of the CTD data are provided for each station in Appendix 1. The plots display vertical profiles of temperature, salinity and sigma-t. In addition, surface freezing point temperatures are plotted at standard oceanographic pressures (5, 7, 10, 15, 20, 30, 50, 75, 100, 125, 150, 200, 225, 250, 300, 400, 500 dbar). The CTD data are displayed in the plots to a resolution of 0.15 dbar.

3.4 ERROR DETECTION AND REMOVAL

Detection and removal of errors in the CTD data was conducted in two distinct phases. In the first phase, first differences between successive scans of the raw values of the pressure, temperature and conductivity ratio were computed and compared against allowable maximum absolute first differences values of 1.0 dbar (pressure), 0.02C° (temperature) and 0.01 (conductivity ratio). Those data scans which had first differences exceeding these levels were judged to be erroneous. In all cases, erroneous data were replaced with the linearly interpolated value. The number of errors identified by means of this procedure was small (Appendix 4) never exceeding 0.3% for any one channel.

A second phase of error removal was carried out following application of the calibration values, conductivity cell and fall speed corrections, and computation of salinities. The first differences of salinity were computed for each CTD profile, and any scans having an absolute first difference value from the previous reading exceeding 0.01 were listed along with the values of the previous 10 and the following 10 scans. In addition, vertical profile plots of temperature, conductivity ratio and salinity were generated having sufficiently large scales that each individual value could be resolved in the plots. Each salinity difference exceeding 0.01 was investigated.

The data in a scan were considered as erroneous "spikes" if the following criteria applied:

- 1) single point erroneous values - one first difference in salinity (with the preceding or following point) was greater than or equal to 0.010 in absolute value and the other was opposite in sign and greater than or equal to 0.008.
- 2) double point erroneous values - one first difference in salinity (with the preceding or following valid point) was greater than 0.015 in absolute value and the other was opposite in sign and greater than or equal to 0.010.

Furthermore, for the identified spikes to be considered erroneous, the values at the anomalous point had to be less than the preceding 5 values for an anomalously low salinity or greater than the following 5 values for an anomalously high salinity. Salinity spikes which satisfied the above criteria accounted for nearly all of the erroneous values identified in the second phase of error detection (Appendix 4). For such spikes the entire scan was deleted from the record.

Based on a visual examination of the detailed profile plots, other erroneous or suspect data points were noted. In a few cases, these values were deleted from the data record for various reasons as described in

Appendix 4. However, in most cases, we could not be certain that the features in question were erroneous; therefore, these segments of the data were noted in Appendix 4, but not removed from the data.

In 17 of the 53 CTD profiles, the conductivity ratio and salinity profiles contained high wavenumber variations. These small scale variations (Figure 16) occurring as changes of alternating sign between successive scans around the general overall profile, were generally of relatively small amplitude (less than 0.007 in salinity). Occasionally, these would occur with larger amplitude but only over small segments of the total profile (Appendix 4). More commonly, the amplitudes would decrease to very low levels (less than 0.003 in salinity) over large portions of the vertical profiles. In most but not all profiles, these oscillations exhibited an overall tendency to decrease in amplitude with increasing pressure. No attempt was made to remove these high wavenumber variations, unless the amplitudes significantly exceeded 0.010 in salinity. Only one such occurrence of these large amplitudes was detected (from 49.2 to 59.2 dbar in experiment number 4839) and this segment of the record was deleted.

The corrected CTD data, along with the derived quantities σ_t , dynamic height anomaly and sound speed, are provided at the lowest acceptable pressure, then at 1 dbar intervals to 25 dbar, 2.5 dbar intervals to 50 dbar, 5 dbar to 200 dbar, 10 dbar to 400 dbar, 25 dbar to the greatest pressure value. Each listed value is computed as a linear interpolation between the two values at bracketing pressures, where adjacent pressures are separated by about 6 cm.

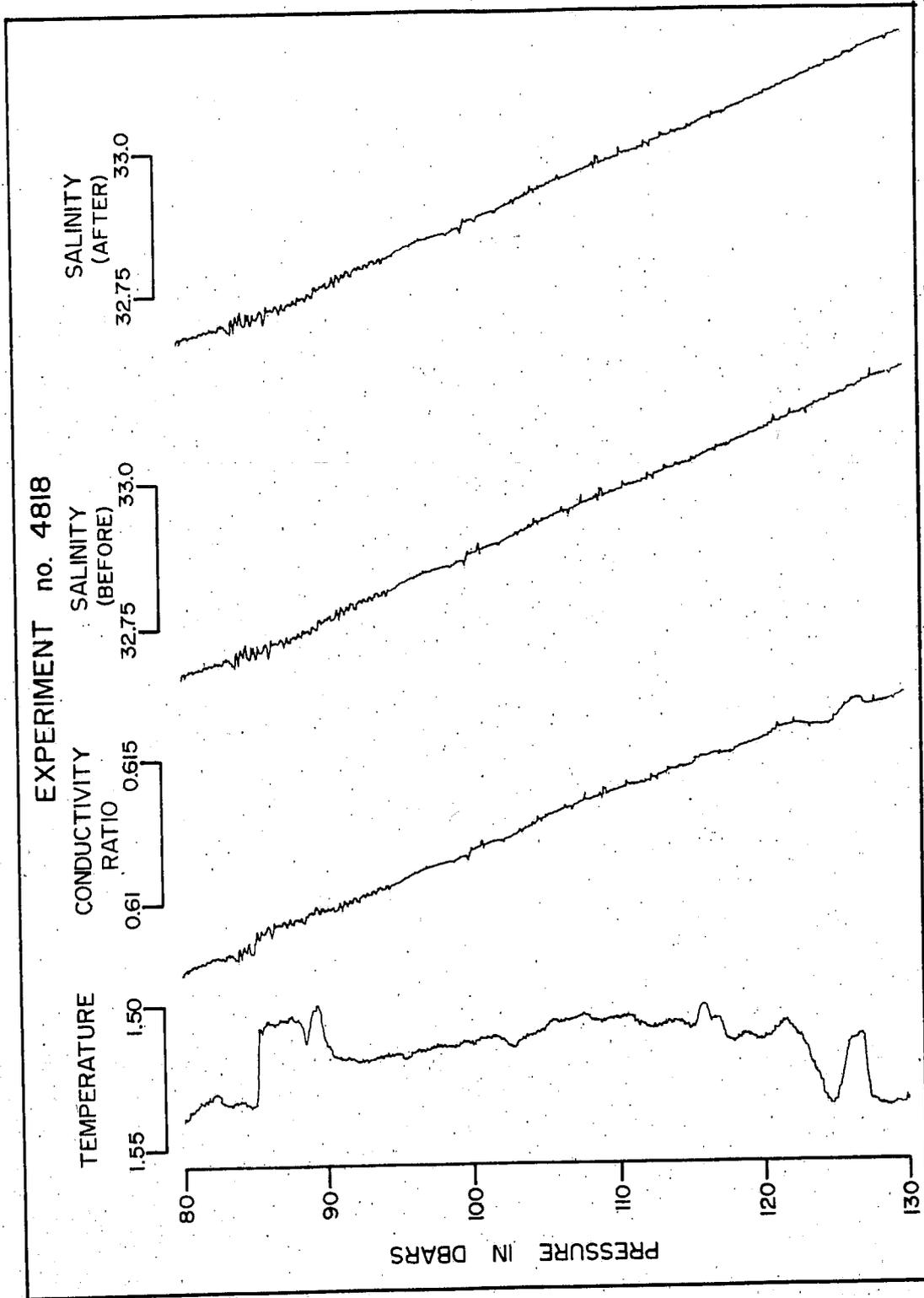


Figure 16; A portion of the CTD data from station E07 (experiment no. 4818) obtained on March 26, 1983. The conductivity and salinity (before) profiles exhibit spike-like features. Those spikes with amplitudes exceeding 0.010 in salinity are removed in the salinity (after) profile.

4. RESULTS

4.1 WATER-MASS DEFINITIONS

Throughout the study area, the water column consists of Arctic Water extending from the surface to depths of 250 to 300 m overlying Atlantic Water at greater depths. Under winter conditions, the Arctic Water can be subdivided into four layers, in order of increasing depth:

- a surface mixed layer, usually characterized by near freezing temperatures
- a subsurface temperature maximum layer within the halocline which occurs intermittently throughout the study area
- a cold layer within the halocline, wherein temperatures are within 0.1° - 0.5° C of the freezing temperature
- the main thermocline layer where a pronounced gradient occurs in both temperature and salinity.

Atlantic Water is customarily defined as having temperatures in excess of 0.0° C, and where the water depth is sufficient, it underlies the colder, less saline Arctic Water. Within the study area, the temperature and salinity ranges of the Atlantic Water are determined in large part by the water-mass characteristics of the adjoining regions. For stations to the west and north of the limiting sills in the vicinity of Cornwallis Island, the Atlantic Water has characteristics similar to those of Canada Basin Atlantic Water (temperatures of up to 0.5° C and salinities of 34.55 to 34.85). In areas to the south and east of the major sills, the water-mass characteristics of Baffin Bay Atlantic Water differ significantly, being warmer (up to 2.0° C) and less saline (34.08 to 34.50 ± 0.05).

4.2 HYDROGRAPHIC SECTIONS THROUGH THE ARCHIPELAGO

Using the CTD data collected in the present study, vertical sections of temperature and salinity were prepared for two longitudinal transects through the Canadian Arctic Archipelago. One transect spans most of the length of Parry Channel beginning in the west at a location (E09) over the continental slope off M'Clure Strait and extending to western Lancaster Sound in the east, a distance of 1300 km (Figure 17). The basis of this transect is formed by 9 stations occupied by Arctic Sciences' personnel from March 23 to April 4. In order to improve the horizontal resolution in the central portion of this transect, some additional CTD data collected by FSRG and BLMSS were also used. The FSRG data consisted of two stations in eastern Viscount Melville Sound collected on March 23 (R.A. Lake, personal communication). The BLMSS data consisted of six stations collected over a longer time span: two stations (BML36 and BML66) on April 6-8, three stations (BML04, BML05 and BML25) on April 14-15, and one station (BML16) on April 25 (Prinsenberg and Sosnoski, 1983).

The second longitudinal transect passes from the continental shelf through the Queen Elizabeth Islands, to Penny Strait, Wellington Channel and Lancaster Sound, a distance of 850 km. Data for the transect consist of ten CTD stations occupied by Arctic Sciences Ltd., collected from March 20 to

April 2 and two BML CTD stations, collected on April 8 (BML64) and April 21 (BML21). To better define oceanographic conditions over the adjoining portion of the Arctic Ocean, a FSRG CTD station (203) obtained over the continental slope off Ellesmere Island on April 13 was also used (R. Perkin, personal communication). This latter station was located further from station P04 than the distance separating P04 from station E09 (380 km compared to 275 km). However, it may be more representative of conditions off the Queen Elizabeth Islands since it is located away from the Beaufort Sea where active modification of temperature and salinity properties are known to occur (Melling et al., 1984). On the vertical section plots and subsequent horizontal maps, the distance separating stations 203 and P04 is based on the offshore component of the actual separation between these two locations.

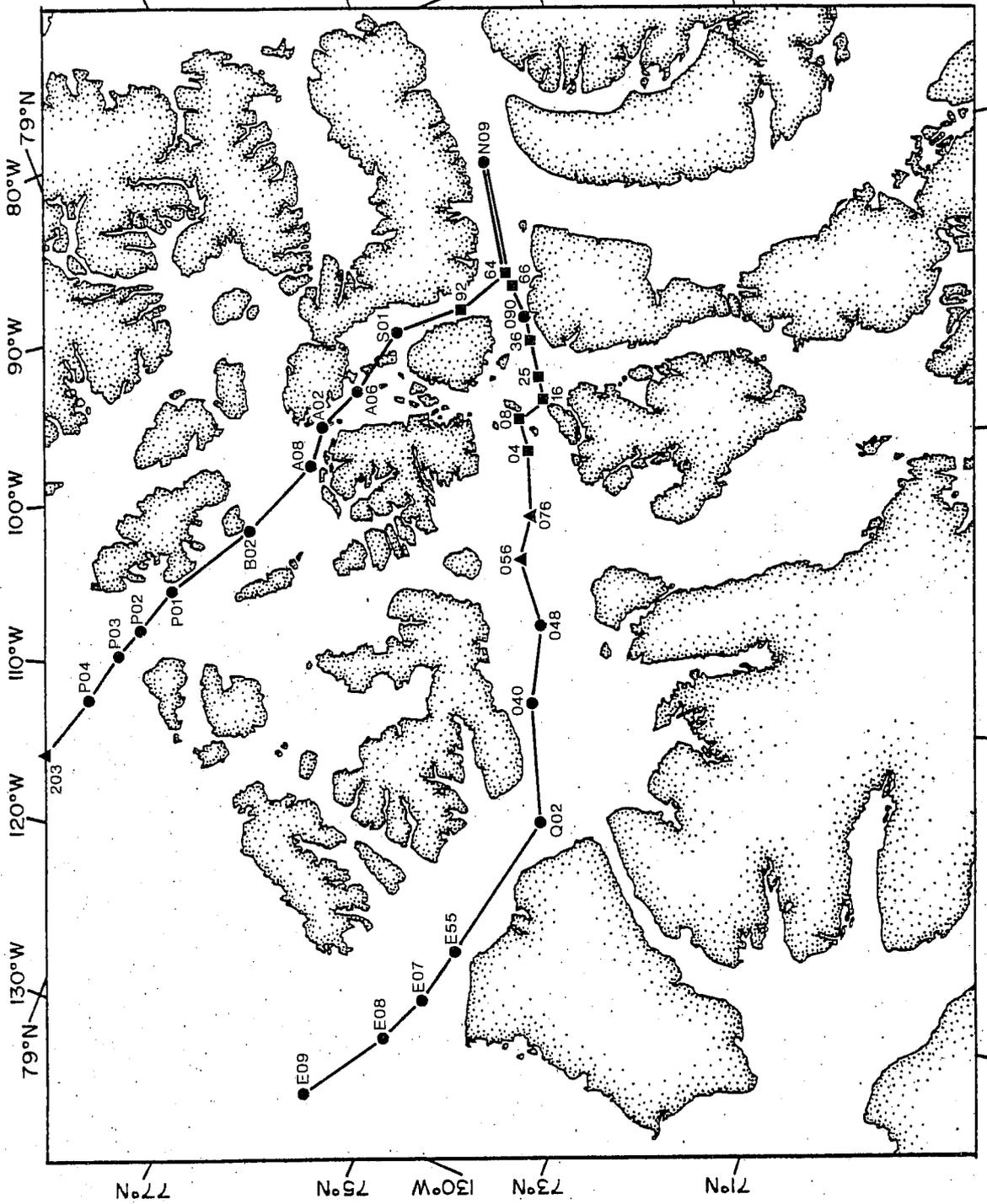
Parry Channel Vertical Section

Major differences in the temperature and salinity distribution (Figure 18) are apparent on either side of the relatively shallow waters of Barrow Strait. Below the sill depth of approximately 125 m, salinities are significantly reduced to the east of the Barrow Strait sill due to the influence of Baffin Bay Atlantic Water in place of Canada Basin Arctic Water. Salinity differences in the horizontal increase from 0.3 at 150 m depth (33.1 compared to 33.4) to nearly constant values of 0.6 at depths of 200 to 450 m (salinity of 34.29 at maximum depth in Lancaster Sound as compared to 34.83 in M'Clure Strait and Viscount Melville Sound). Over the same range of depths, the temperatures are consistently lower within and to the east of Barrow Strait. Temperatures are within a few tenths of a degree of the freezing value (-1.75 to -1.6°) as compared to a range of -1.50 to -1.00° further to the west, at 150 m depth. Temperature differences in the horizontal decrease with increasing depth, with temperatures approaching 0.4° at maximum depths on either side of the sill in Parry Channel.

Throughout the Parry Channel transect, an overall trend of increasing temperatures and salinities towards the east is evident at depths less than 200 m or salinities less than 34.0. The magnitude of the horizontal gradients varies along the length of the transect, being largest over the continental slope and outer area of the shelf, and along the western side of the Barrow Strait sill. From eastern Barrow Strait through western Lancaster Sound, the salinities continue to increase but the temperatures decrease with easterly progression.

Some features with smaller horizontal scales are also evident in the vertical section. Of largest amplitude is the doming of both isotherms and isohalines in eastern Viscount Melville Sound and western Barrow Strait. The largest upward displacement of the contour lines occurs to the west of station BML04, although in the portion of the water column within 40 m of the bottom, the maximum upward displacement appears to be located further to the east, coinciding approximately with the location of the Barrow Strait sill. Further to the east, the isopleths have a very large downward slope, particularly at depths from 125 to the bottom at 220 m. This doming of isotherms and isohalines suggests that an eastward transport may be occurring near the bottom in the vicinity of the Barrow Strait sill. Water having temperatures near -1.3° and salinities near 33.4 is found at a depth of about 150 m, in Viscount Melville Sound. Assuming a net eastward movement, water of this type rises to depths of approximately 120 m over the sill and then abruptly descends to depths near the bottom (200 m or greater) in central and eastern

Figure 17: The locations of CTD stations used in constructing the vertical sections through Parry Channel and the Queen Elizabeth Islands (Figures 18 and 19). Stations are denoted by circles (occupied by ASL, March 20-April 4, 1983); triangles (occupied by FSRG, Viscount Melville Sound, March 24; Arctic Ocean, April 13); and squares (occupied by BLMSS, April 6-25, 1983).



Barrow Strait. Water of the same temperature-salinity (T-S) characteristics was also observed at depths of 190 m at station N09 in western Lancaster Sound. For waters with larger salinities, the isohalines also rise on the western flank of Barrow Strait but do not appear to pass over the sill. Furthermore, at more easterly locations, there is no evidence of similar temperature-salinity characteristics; for a given salinity greater than 33.5, water temperatures are significantly higher in Lancaster Sound.

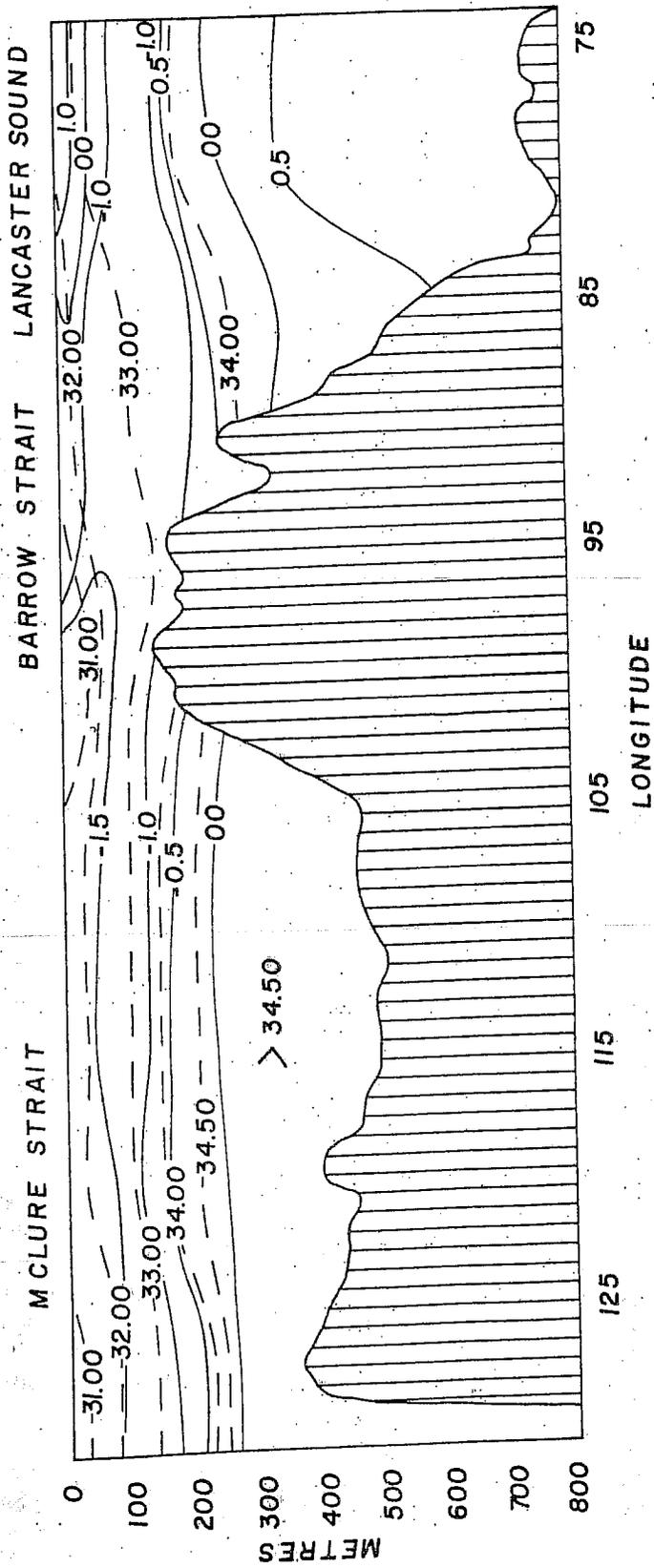
Doming of temperature and salinity contours also occurs near stations E08 off western M'Clure Strait and near 040 in central Viscount Melville Sound. In both areas, this feature is concentrated in the lower half of the water column, below depths of about 150 m and salinities of 33.6. In the former area the feature results from the tilting upward of isopleths of temperature and associated with the Beaufort Gyre flowing southeastward over the continental slope.

For comparison with oceanographic conditions in previous years, vertical cross sections of temperature and salinity through Parry Channel derived in earlier studies are presented in Figures 19 and 20. In both of these studies, measurements were obtained from bottle casts in the summer months. Data from 1956 and 1957 in eastern Parry Channel along with 1958, 1960 and 1961 data for the western channel and Arctic Ocean were used by Collin (1962) to construct Figure 19. Data collected in 1970 from the Hudson '70 expedition were used in Figure 20 (Bellefontaine et al., 1982). At depths greater than 100-150 m the same general patterns observed in 1983 are evident in the earlier cross sections; above 150 m, seasonal differences predominate with warmer less saline water characteristics observed under the summer conditions. The most notable difference observed in 1983 in comparison with the earlier results is found in western Lancaster Sound where temperatures in 1983 are markedly cooler by up to 0.5 approximately 150 to 225 m. This difference results from lateral intrusions of near-freezing waters advected westward from northwestern Baffin Bay, as discussed in Section 4.4-3. The overall eastward trend toward increasing temperature and salinity in western Parry Channel noted in the 1983 results can also be discerned in the earlier cross sections; however the larger horizontal gradients and doming characteristics observed in 1983 within 100 km of the Barrow Strait sill are not as prominent, apparently due to the greater station separation for the earlier cross sections.

Queen Elizabeth Islands - Baffin Bay Vertical Section

Water properties on the vertical transect extending from the Arctic Ocean through the Queen Elizabeth Islands (Figure 21) are similar in many respects to the vertical sections derived for Parry Channel (Figure 18). At depth the waters on either side of the limiting sill in Queens Channel exhibit the characteristics of Arctic Ocean Atlantic Water to the north and west and Baffin Bay Atlantic Water to the south and east. A gradual increase in temperature and salinity from northwest to southeast is also evident, similar to the pattern exhibited through Parry Channel.

Immediately to the west of the Queens Channel sill, the upward tilting of the temperature and salinity contours is pronounced in the uppermost 150 m of the water column. However, unlike the Parry Channel transect, a large gradient of opposite sign exists at depths from 150 m to the bottom (Figure 22). This difference is very striking between stations A08 and A02. At the latter location the water column, from 150 m to the bottom at 250 m, has a



VERTICAL SECTION OF TEMPERATURE AND SALINITY, PARRY CHANNEL

Figure 19: Vertical section of temperature and salinity through Parry Channel derived from summer bottle data in the late 1950's (Collin, 1962).

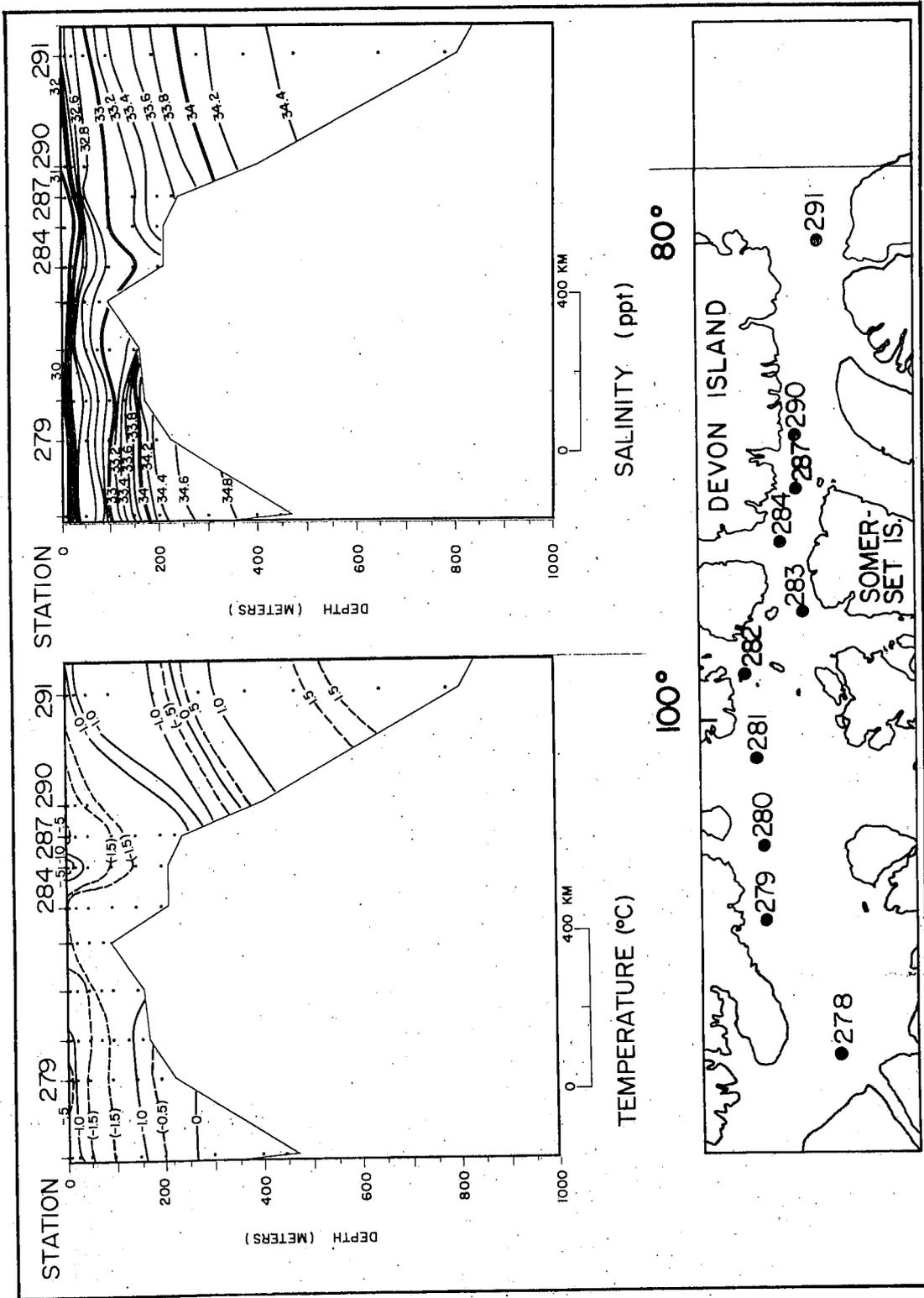


Figure 20: Vertical section of temperature and salinity through Parry Channel derived from bottle data of the Hudson '70 cruise from September 25 to October 1, 1970 (Bellefontaine et al., 1982).

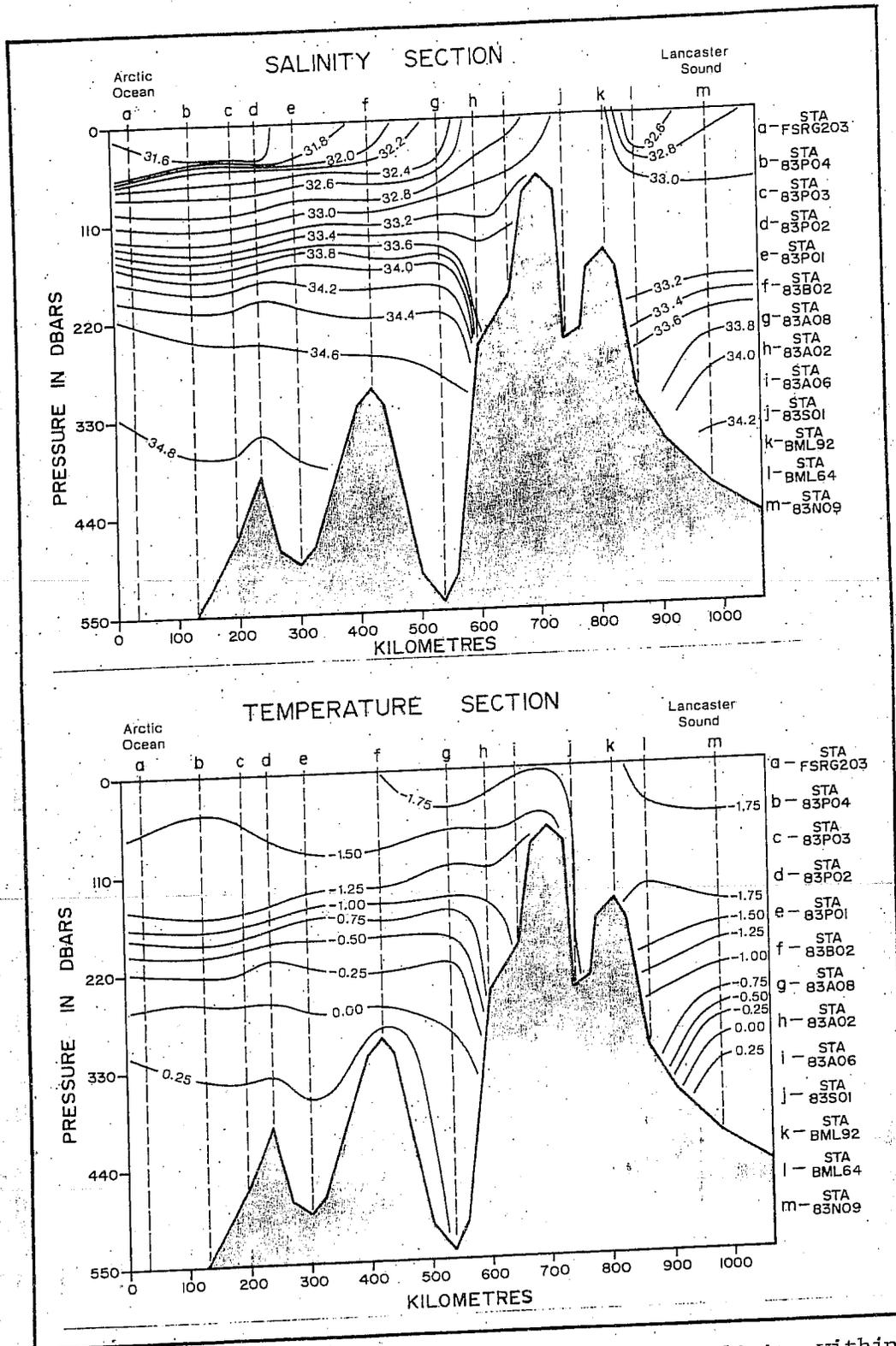


Figure 21: Vertical sections of temperature and salinity within the Archipelago through the Queen Elizabeth Islands and Lancaster Sound. Station locations are shown in Figure 17.

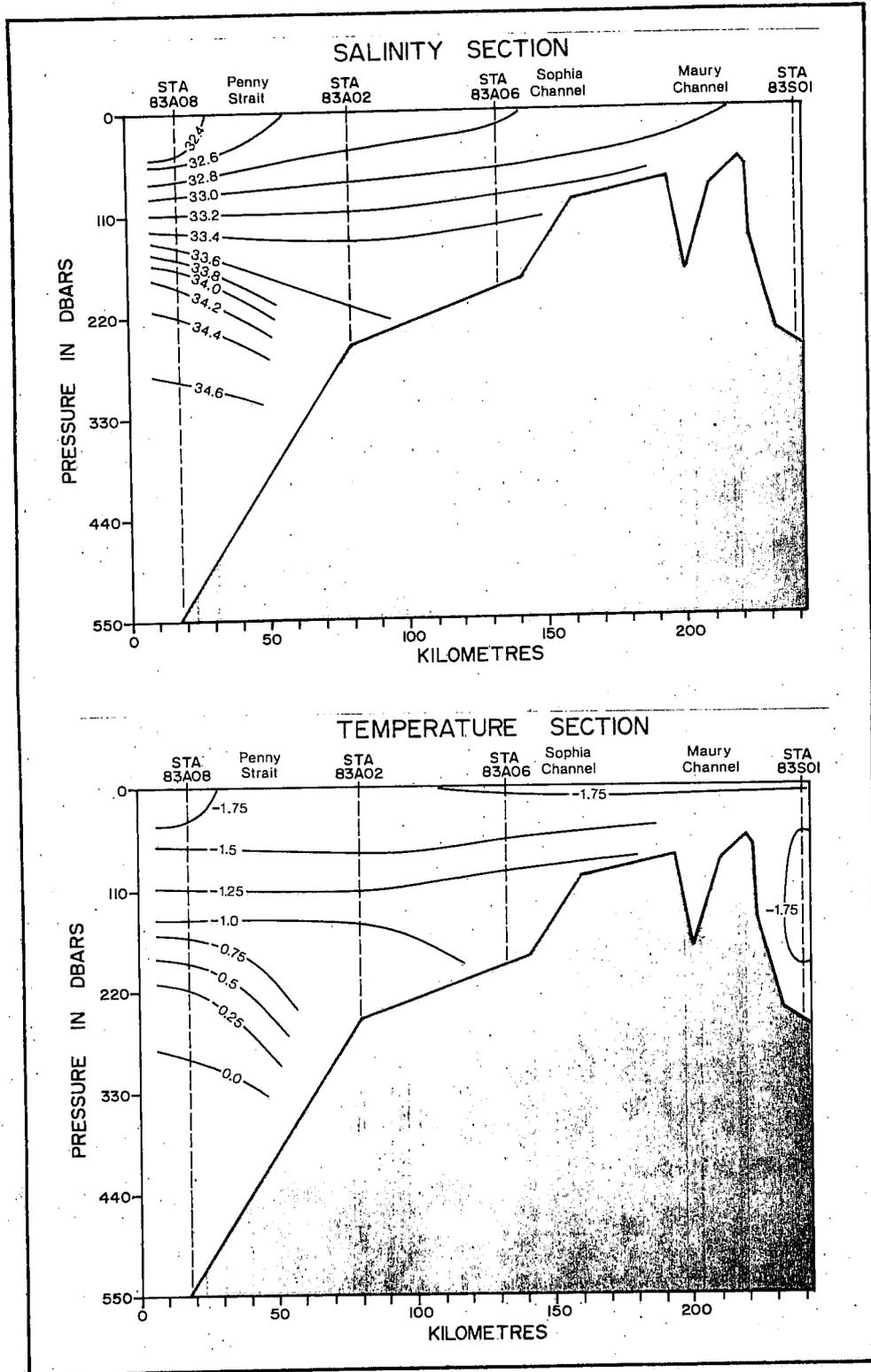


Figure 22: Vertical sections of temperature and salinity from northwest of Penny Strait to northern Wellington Channel. Station locations are shown in Figure 14.

small temperature and salinity range of -1.0°C to -0.8°C and 33.55 to 33.75, respectively, while the water column at station A08, located 60 km to the northwest, is much more stratified, having corresponding ranges of -0.95°C to -0.1°C and 33.7 to 34.5. A sill having a limiting depth of approximately 150 m in the area between stations A08 and A02 could account for this result. Unfortunately, available bottom soundings, including the 1976 survey with a spacing of 1 km, are not adequate to define the sill depth due to the highly irregular bottom in this area.

In Wellington Channel immediately to the southeast of the sill region, the water column exhibits a very low degree of vertical stratification. At stations S01 and BML64, the range of surface to bottom temperatures and salinities are limited to -1.75°C to -1.64°C and 33.03 to 33.15, respectively. The reduction in vertical stratification to the east of the Queens Channel sill is considerably more pronounced than is the case to the east of the Barrow Strait sill, where surface to bottom salinities typically range from 32.4 to 33.1. The reduced level of vertical stratification suggests that a greater amount of vertical mixing occurs in Queens Channel than in Barrow Strait.

4.3 GEOSTROPHIC CURRENTS

Baroclinic currents were computed for each of the cross-channel sections as well as for the sections occupied across the Arctic Ocean continental shelf. The discussion of the currents is organized by area. The reference levels (levels of no motion) used in the sections were generally chosen to be as deep as possible between station pairs, unless other data such as direct current measurements suggested some alternate choice for the reference level. The error in the baroclinic current between two stations is determined largely by the error in σ_t , positional errors usually being negligible in comparison when a system such as GNS is in use. For a given error $\delta\sigma_t$ in density measurement, the error in the baroclinic current at a height, h , above the reference level is approximately given by

$$\delta v \approx \sqrt{2} gh \delta\sigma_t / (\rho f \Delta x)$$

where ρ is the mean water density, Δx is the station separation, g is the acceleration due to gravity and f is the Coriolis parameter. The standard errors of 0.002°C temperature and 0.008 in salinity given in Section 3.2, result in a value for $\delta\sigma_t$ of approximately 0.008 for the range of temperature and salinity covered by the data here. Figure 23 shows the resulting geostrophic current error δv as a function of h and Δx . In most of the discussion that follows, $\delta v \approx 0.5 \text{ cms}^{-1}$.

Queen Elizabeth Islands (Sections A, B, D)

Sections B and D (across Maclean Strait and Hazen Strait, respectively) show little in the way of horizontal gradients in either temperature or salinity (Figure 24), as was the case in 1982. The baroclinic flow is consequently very small, with flows at 10 dbar relative to 200 dbar being less than 2 cm/s in these straits, directed into the Archipelago in both cases.

In contrast, stronger horizontal gradients are evident in the temperature and salinity sections across Penny Strait (Figure 25). Because of the small size of the area and the difficulty of finding landing spots for a fixed-wing

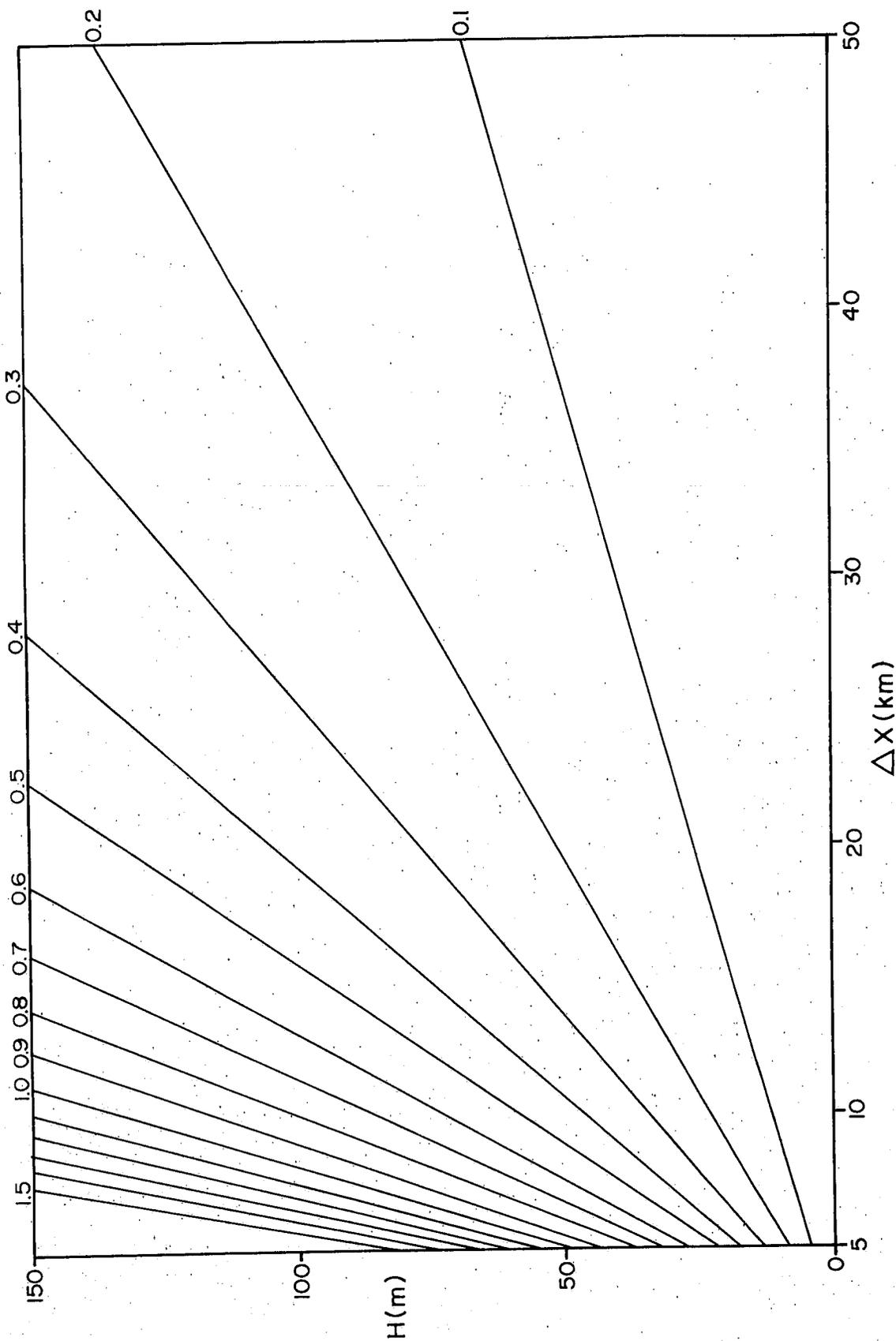


Figure 23: The uncertainty in the baroclinic currents (cm^{-1}) expected on the basis of observed standard errors in the CTD temperature and salinity, as a function of height above reference depth (H) and horizontal separation (ΔX).

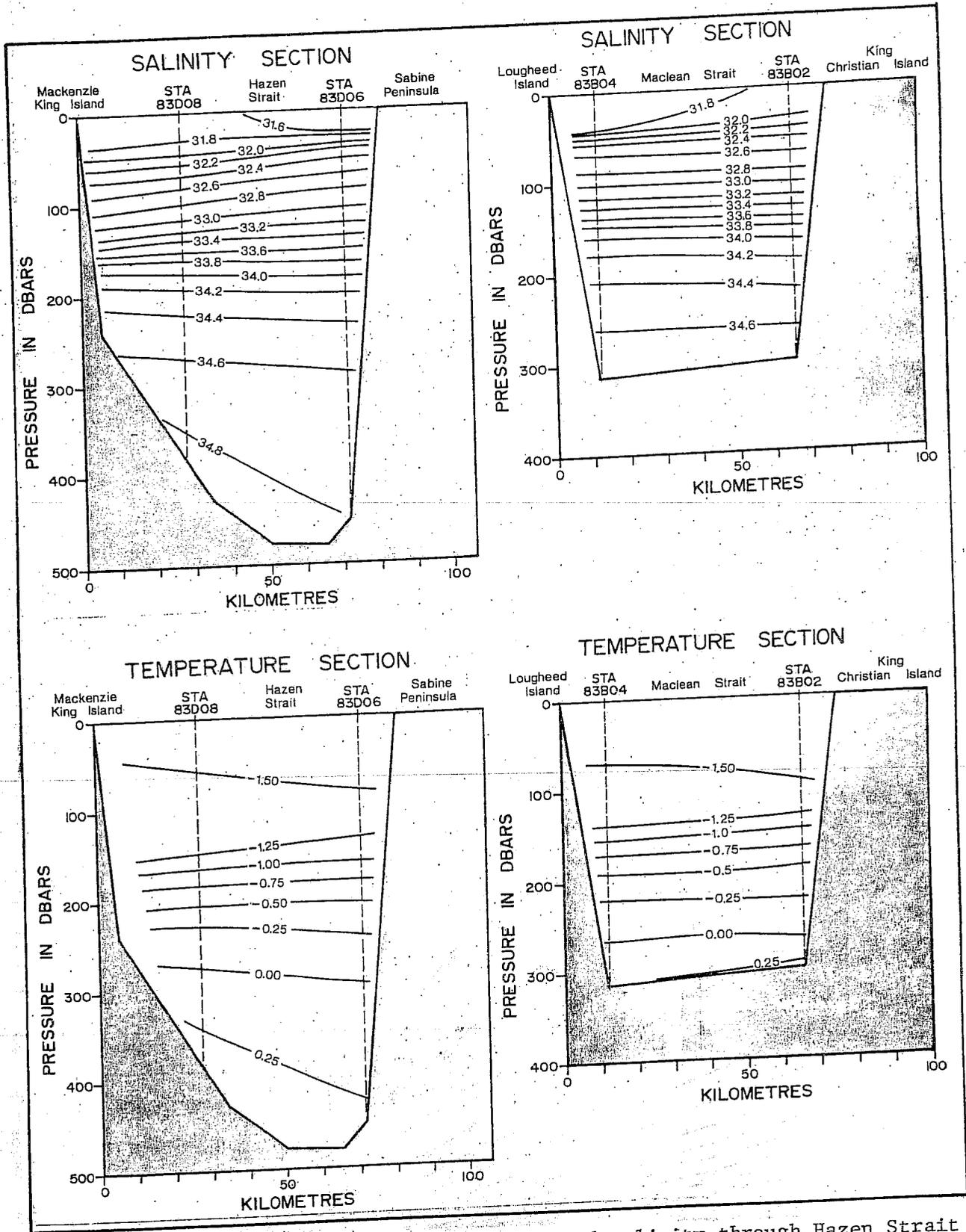


Figure 24: Vertical sections of temperature and salinity through Hazen Strait and Maclean Strait in the Sverdrup Basin. Station locations are shown in Figure 13.

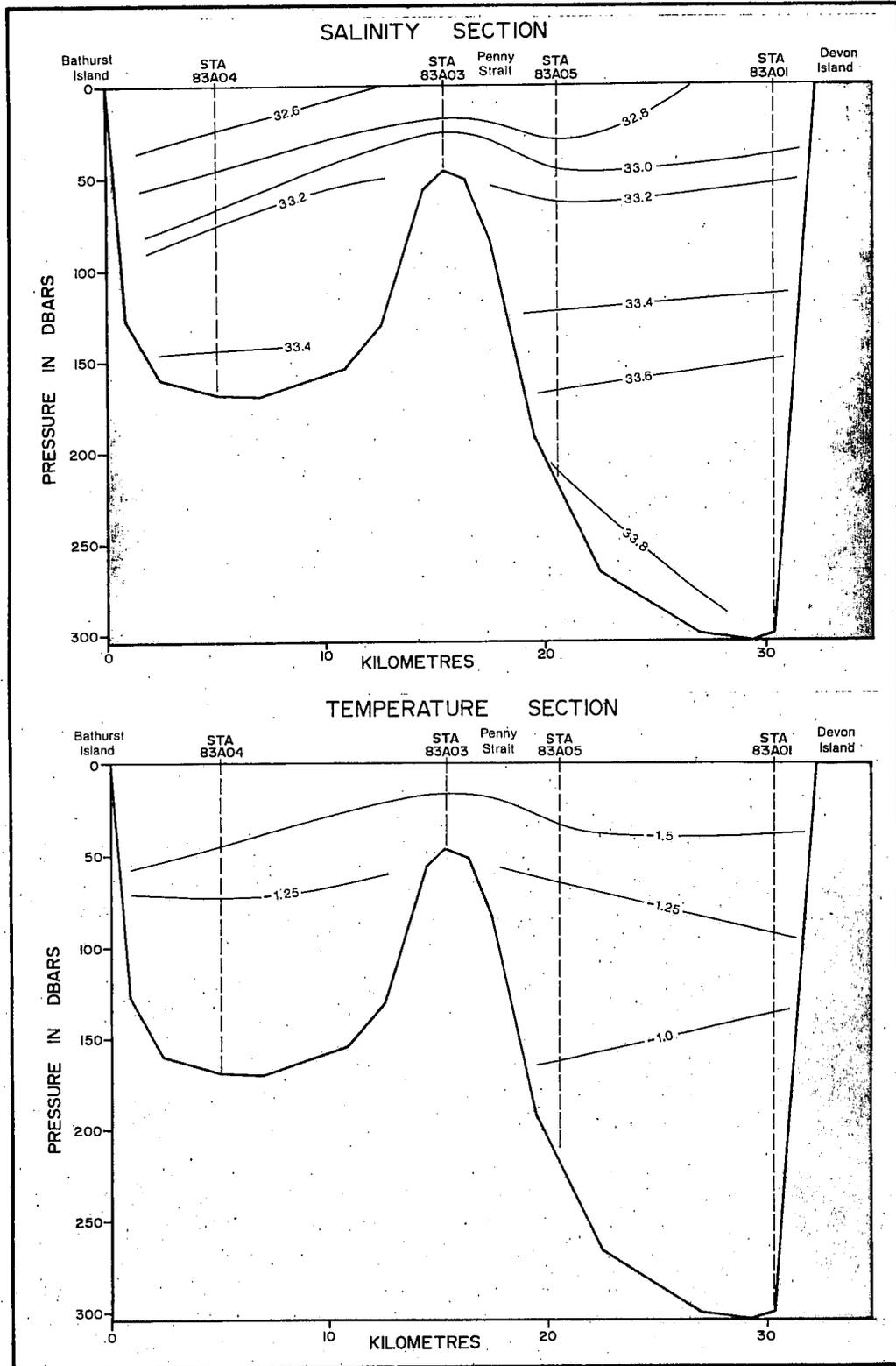


Figure 25: Vertical sections of temperature and salinity through Penny Strait. Station locations are shown in Figure 14.

aircraft, the stations do not form a straight line across the channel. In particular, station A02 has not been included in Figure 25, as it was positioned well to the south of the rest of the stations. Within Penny Strait, considerable internal wave activity exists (Section 4.5) leading to possible uncertainties in baroclinic flow of ± 3 cm/s over distances of 10 km. In 1982, southerly flow was found across the whole channel, with the strongest flows concentrated on the east side. The position of the current is apparently determined by the complex bathymetry of the strait, which has a deep (>350 m), narrow trench entering from the north on the east side which then cuts across to the western side and exits to the south.

In 1983, southerly flow is again apparent across most of the section, with the exception of the centre of the channel, where a counterflow is apparent between stations A03 and A05. Station A03 is, however, situated in a very shallow (<50 m) area north of the deep trench and may not be in the main path of the flow. Because of the positioning of the 1983 stations, only three stations in the section extended to depths greater than 150 m. Computation of the geostrophic flow at 10 dbar relative to 150 dbar showed currents weaker than those observed in 1982, although still stronger on the east side of the channel (6.5 cm/s between stations A05 and A01) than the west side (5 cm/s between stations A04 and A05). Note that flows computed between station pairs A01/A05 and A05/A94, separated by distances of 9 and 16 km, respectively, may not be fully comparable given the internal Rossby Radius of 5 km for this area.

A comparison of currents on opposite sides of the strait using station pairs with more nearly equal spacing may be made using stations A04 and A03 on the west side, and stations A05 and A01 on the east side. Use of station A03 limits the choice of reference level to 30 m depth, however. The surface shear (5 dbar to 30 dbar) is then found to be the same on both sides of the strait, with currents at 5 dbar of 3.5 cm s^{-1} to the southeast, relative to 30 dbar.

Computation of the geostrophic flow between stations A05 and A02 (situated 5 km southeast of the line joining the rest of the stations and not shown in Figure 23) and A01 and A02 showed easterly flows at 10 dbar relative to 150 dbar of 8 cm/s for A05 and A02 and 2.5 cm/s for A01 and A02. The relationship of these results to the southerly flow indicated for the rest of the section is not clear; they may represent a westerly subsurface flow following the deep trench, rather than an easterly surface flow.

M'Clure Strait and Arctic Continental Shelf (Sections Q, E, P)

Figure 26 shows vertical sections of temperature and salinity for line Q across the eastern end of M'Clure Strait. The horizontal gradients are small, corresponding to baroclinic flows of less than 2 cm s^{-1} on both sides of the channel. The current is directed to the east (relative to 400 dbar) over the entire channel; it is concentrated within the upper 20 m on the south side of the strait, but extends to over 200 m depth on the north side.

In view of the very small slopes of the isopycnals on geopotential surfaces (differences of less than 0.082 sigma-t units per 50 km) and the comparatively large absolute measurement uncertainties of 0.008 sigma-t units, the magnitude of the computed geostrophic shears must be regarded as highly uncertain.

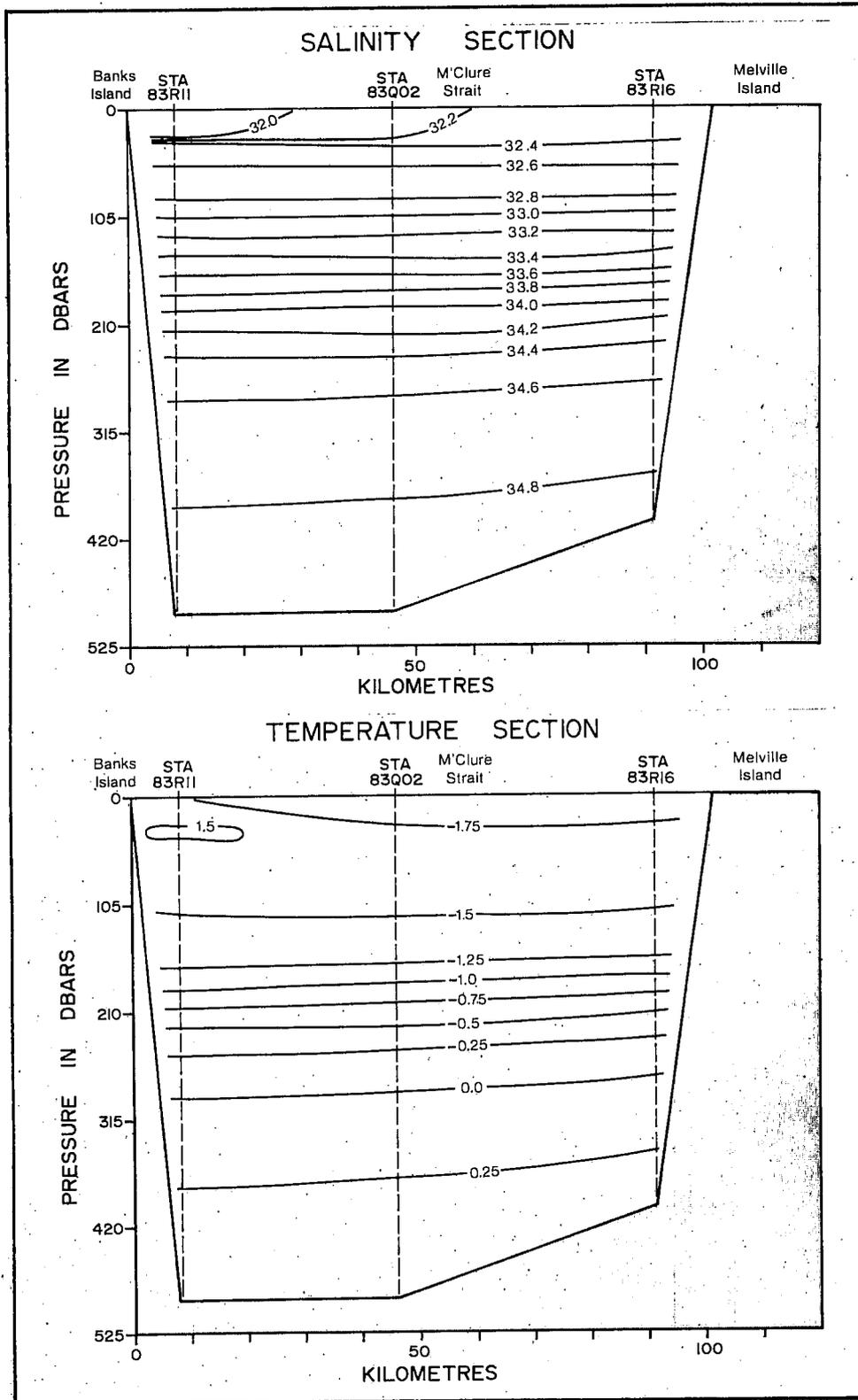


Figure 26: Vertical sections of temperature and salinity through M'Clure Strait. Station locations are shown in Figure 9.

Cross sections of temperature and salinity for line E, running across the continental shelf west of M'Clure Strait are shown in Figure 27. Baroclinic flow is concentrated between stations E08 and E09, with a surface current velocity of 5 cms^{-1} to the southwest, relative to 300 dbar. The true dimensions of the flow are almost certainly not resolved, since the stations are separated by 120 km; the current is likely to be narrower, swifter and concentrated over the continental slope. The baroclinic flows (relative to 300 dbar) on the shelf itself are very weak ($<1.5 \text{ cms}^{-1}$) and vary in direction with both depth and position on the shelf. There may, of course, be stronger cross-shelf flows which would not be detectable given the orientation of the station line, however, the lack of significant flows further east in M'Clure Strait makes it unlikely.

Figure 28 shows the baroclinic current profile computed between stations E06 and E55, north of Cape M'Clure or Banks Island. Relative to 300 dbar, westward flow of approximately 2 cms^{-1} is shown between the surface and 200 m. If, as may be more likely (Melling et al., 1984), the surface flow is zero, then the profile indicates an eastward flow of approximately 2 cms^{-1} between 250 m and the bottom.

Temperature and salinity cross sections from line P, running across the continental shelf into the Prince Gustaf Adolf Sea are shown in Figure 29. The horizontal gradients are small, and indicate southwesterly surface flow of less than 2 cms^{-1} (relative to 300 dbar). Note, however, that the section does not extend to the edge of the shelf and that significant flows which may exist over the continental slope would not be detected. The weak southwesterly currents indicated at the inner end of the section correspond to a flow toward the entrance to Hazen Strait.

Prince Regent Inlet and Lancaster Sound (Sections L and N)

As was the case in 1982, there is significant spatial variation in the baroclinic flow through section L across Prince Regent Inlet (Figure 30). The geostrophic current profiles computed for this area are shown in Figure 31. The reference level for each station pair was taken as the deepest common standard pressure. All the profiles show much stronger flows at depths between 150 and 250 dbar, with northward velocities near 12 cms^{-1} on the west side (between stations L02 and L03) and southward flow in the centre and on the east side (7 cms^{-1} between stations L03 and L04, and 2 cms^{-1} between stations L04 and L06). In all three cases, the near-surface flow is small (approx. 2 cms^{-1}) and to the north. As was the case in 1982, strong velocity shears extend to the reference levels, with the result that the computed currents should be treated with caution, as a change in reference level could result in large changes in the magnitude or direction of computed velocities in the upper 200 m of the water column.

Several prominent features in the current pattern persisted from 1982 to 1983. Among these were the strong southward-flowing subsurface core in the middle of the channel (12 cms^{-1} at 125 m in 1982, 7 cms^{-1} at 200 m in 1983), and the northward flow on the west side of the inlet. In contrast to 1982, however, the flow on the western side of the channel is concentrated in a strong subsurface core (12 cms^{-1} at 175 m between L02 and L03), rather than

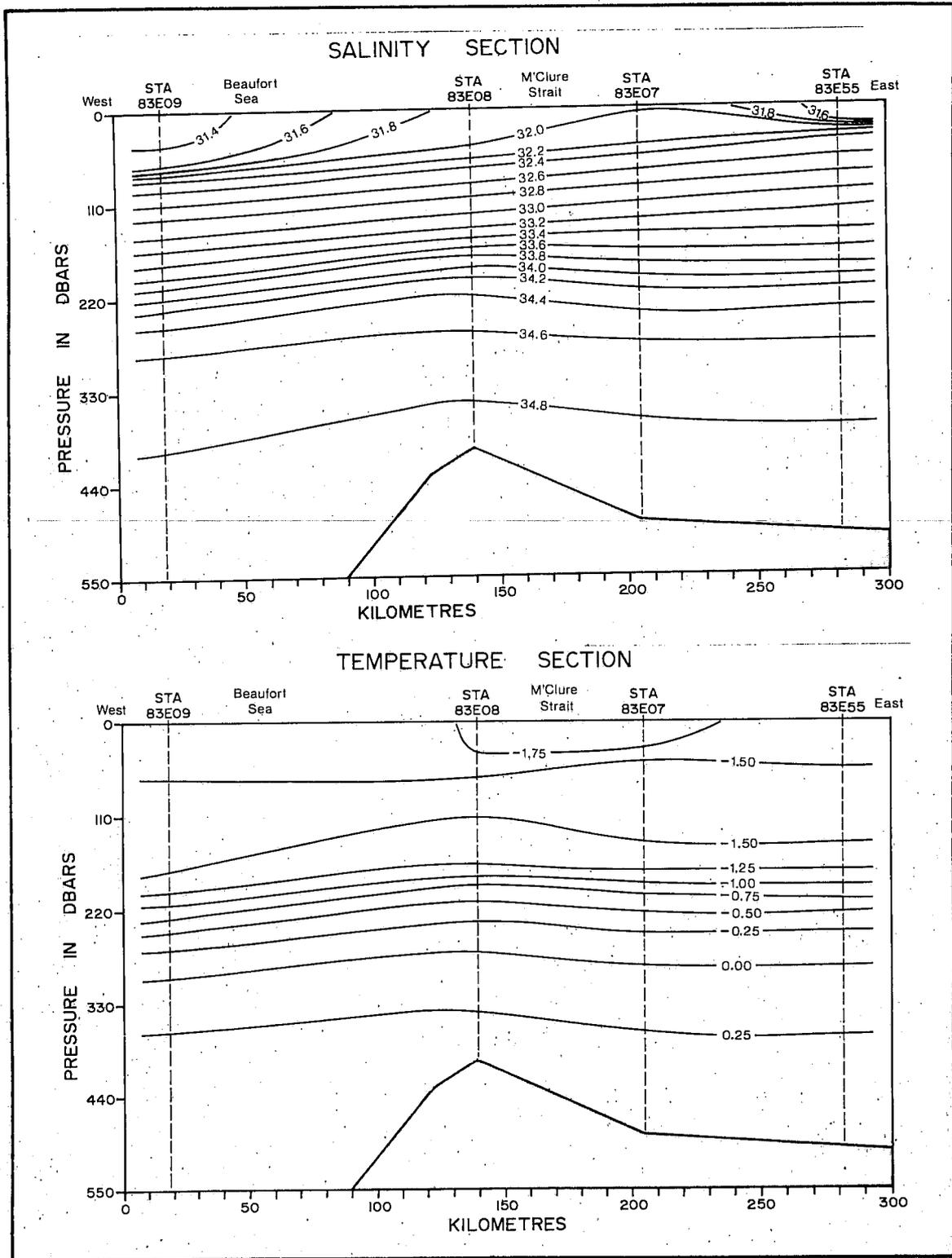


Figure 27: Vertical sections of temperature and salinity from western M'Clure Strait to the adjoining continental shelf and slope. Station locations are shown in Figure 9.

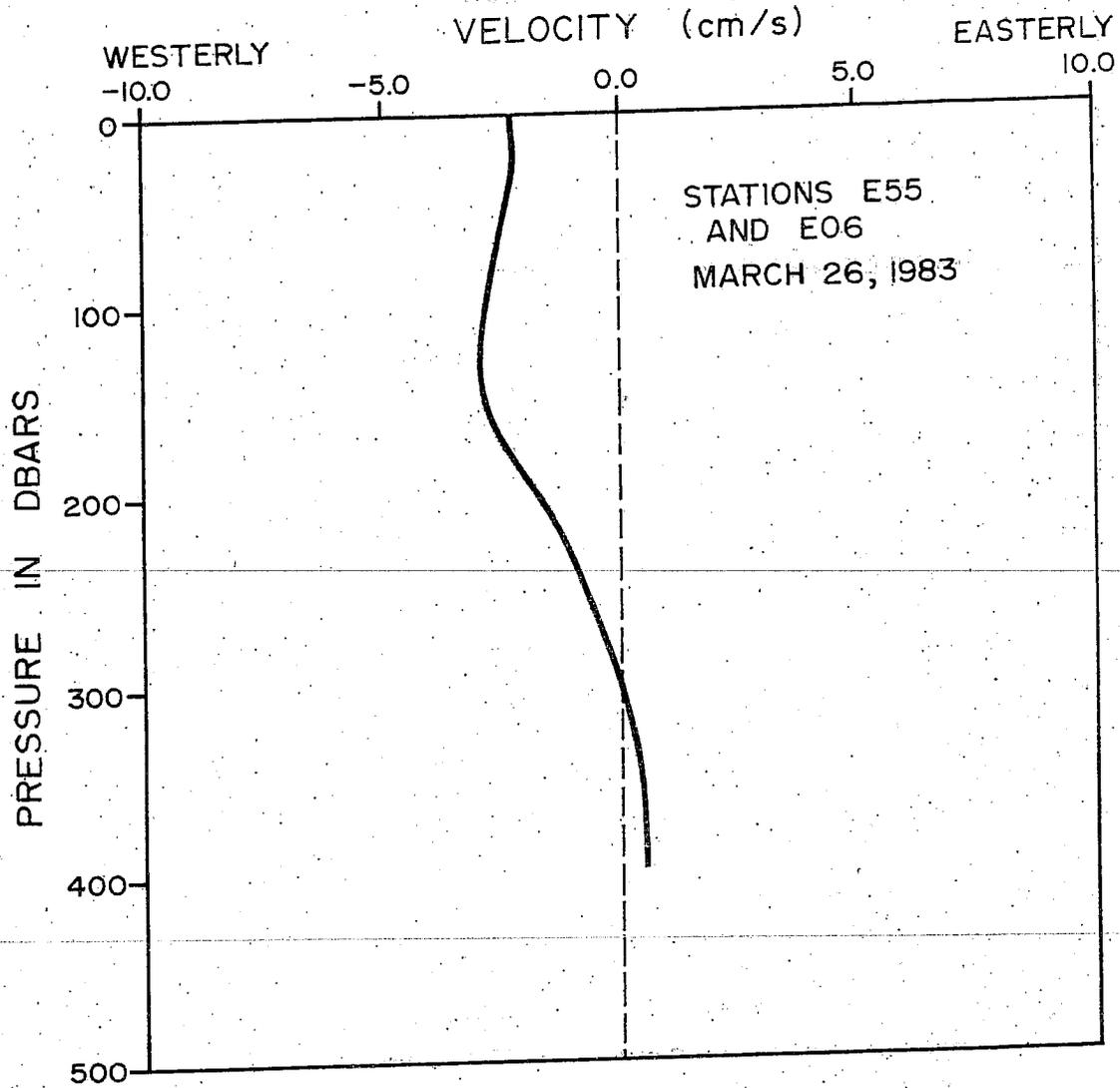


Figure 28: The computed geostrophic shear between stations E06 and E55. Positive values indicate a flow toward 77°T .

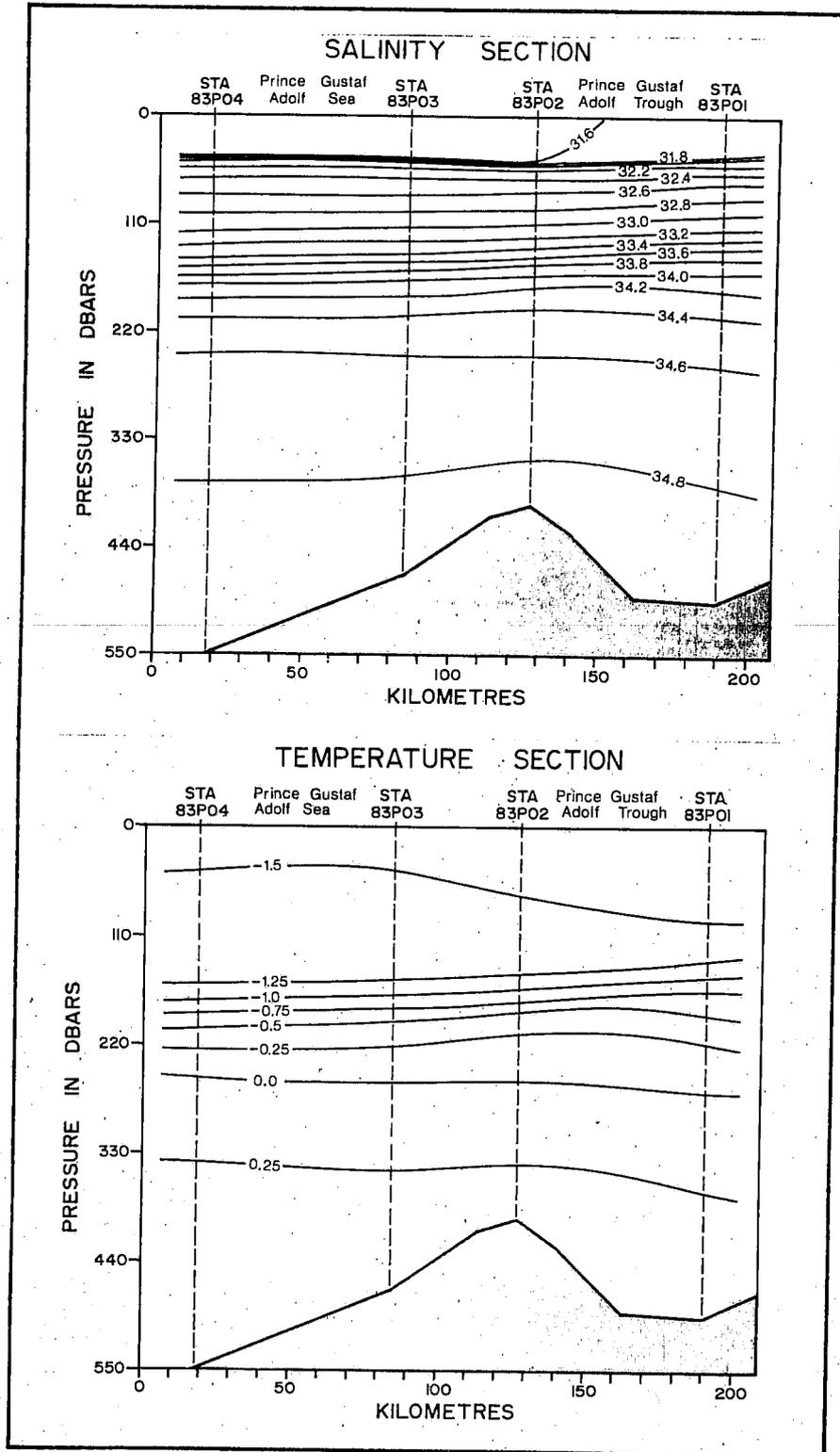


Figure 29: Vertical sections of temperature and salinity through Prince Gustaf Adolf Sea. Station locations are shown in Figure 12.

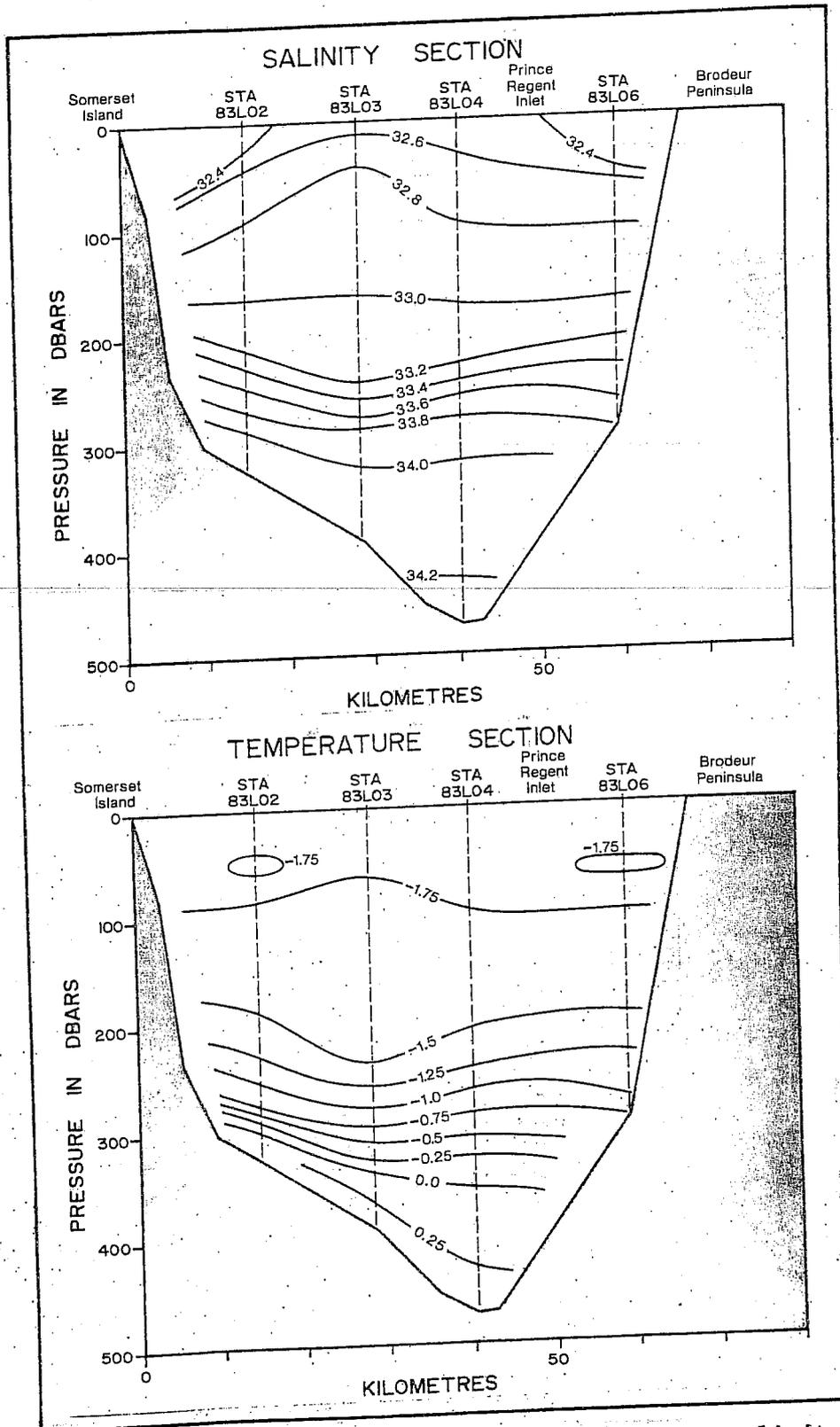
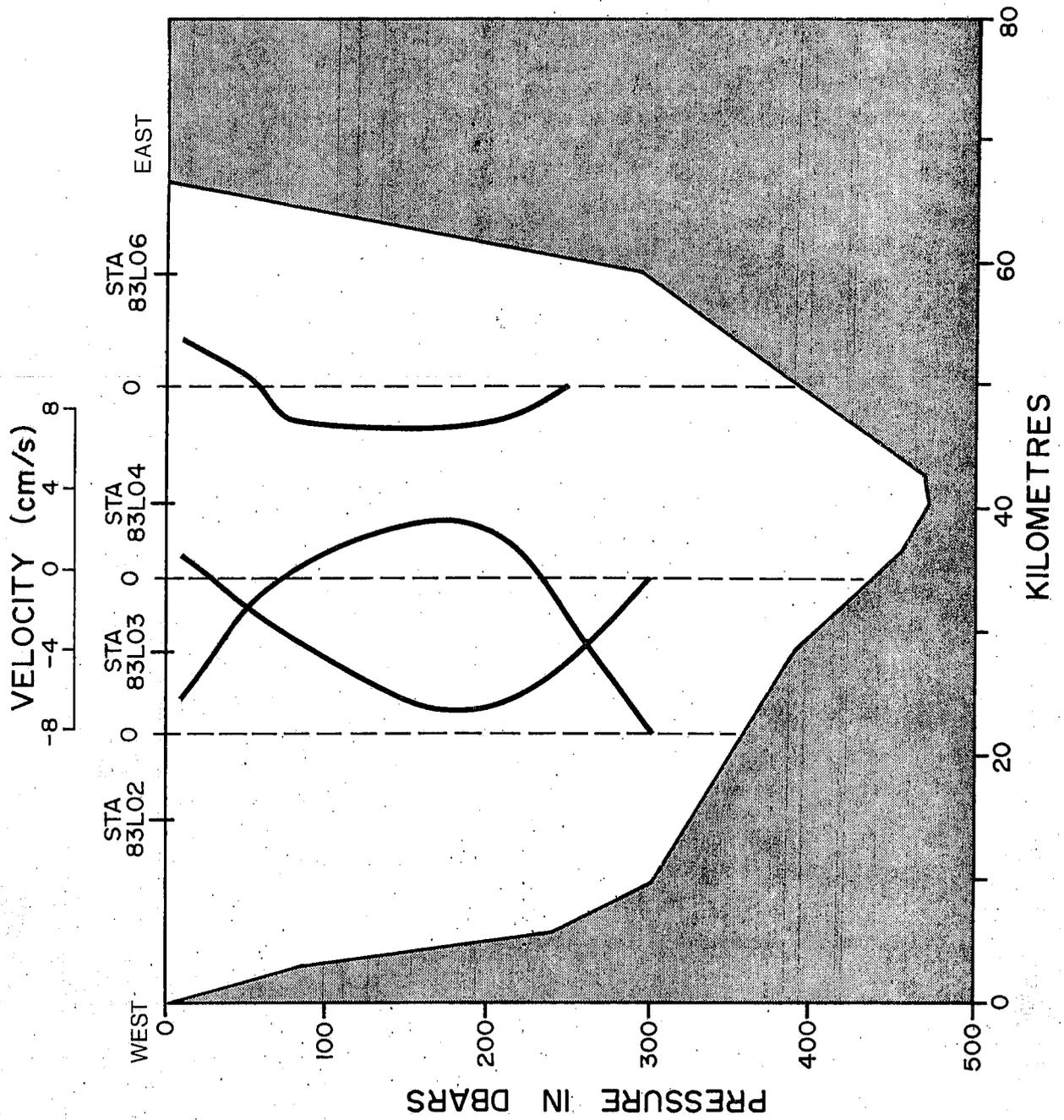


Figure 30: Vertical sections of temperature and salinity through Prince Regent Inlet. Station locations are shown in Figure 15.

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Figure 31: The computed geostrophic shear between stations in Prince Regent Inlet.
Positive values indicate a flow to the north.



being strongest at the surface. With the exception of the near-surface layer there was no northerly flow on the eastern side of the inlet, unlike the situation in 1982.

Lack of suitable ice cover prevented the occupation of the full section N in Lancaster Sound. Figure 32 shows the vertical sections of temperature and salinity, with the derived current profiles in Figure 33. Both profiles show relatively uniform eastward flow in the upper part of the water column (12 cms^{-1} above 150 m between N01 and N09, 2 to 5 cms^{-1} above 150 m between N09 and N07). As was the case in 1982, the current speeds are higher on the north side than in the centre of the Sound; the effect is considerably greater in 1983 however with higher speeds over a greater depth resulting in a significantly greater portion of the apparent transport being found on the north side.

Figure 34 summarizes the near-surface (10 dbar) current velocities computed with respect to the various deep reference levels for the whole data set. The general pattern is similar to that observed in 1982, with weak southeastward flow ($< 2 \text{ cms}^{-1}$) through the channels of the Queen Elizabeth Islands, except in the narrower passage of Penny Strait, where speeds were higher ($> 5 \text{ cms}^{-1}$). Again, near-surface currents in the waterways adjoining Parry Channel were directed into it. Surface currents in eastern M'Clure Strait were weak ($< 2 \text{ cms}^{-1}$ to the east) as was the case in Prince Regent Inlet ($< 2 \text{ cms}^{-1}$ to the north), although stronger subsurface currents were present in Prince Regent Inlet. These inflows apparently result in a net eastward flow through Lancaster Sound, as suggested by the partial section from Devon Island to Baffin Island, where eastward surface speeds up to 12 cms^{-1} were observed.

The near-surface geostrophic flow over the Arctic Ocean continental shelf was uniformly southwestward and weak ($< 2 \text{ cms}^{-1}$) except over the continental slope, where speeds of 5 cms^{-1} were measured west of M'Clure Strait.

4.4 SPATIAL VARIATION OF TEMPERATURE-SALINITY PROPERTIES

Surface Layer

Underlying the sea ice within the Arctic Archipelago is a surface mixed layer, characterized by very uniform density and near-freezing temperature. In this study, an increase in σ_t of 0.040 from the near-surface value at 5 dbar is taken to indicate the base of the surface mixed layer. The water column beneath the mixed layer is characterized by a marked thermocline and halocline at most locations. However, at an appreciable number of stations, temperatures remain uniformly cold (within 0.010°C of the near-surface value) to significantly greater depths while the mixed-layer salinity increases either continuously or in a series of step-like structures. The mixed layer depth, and at those locations where it differs, the depth of uniform temperature, are displayed in Figure 35. Other properties used to characterize the mixed layer are the salinity at 5 dbar pressure (Figure 36) and the deviation from the surface freezing temperature at 5 dbar (Figure 37).

In the areas over and adjacent to the continental shelf (western M'Clure Strait and Prince Gustaf Adolf Sea) along the northwest side of the Archipelago, the surface mixed layer is relatively deep (22 to 50 m) and of low salinity (31.5-32.0). At the only measurement location over the continental slope (E09), the mixed layer was notably shallower (21 m) and less

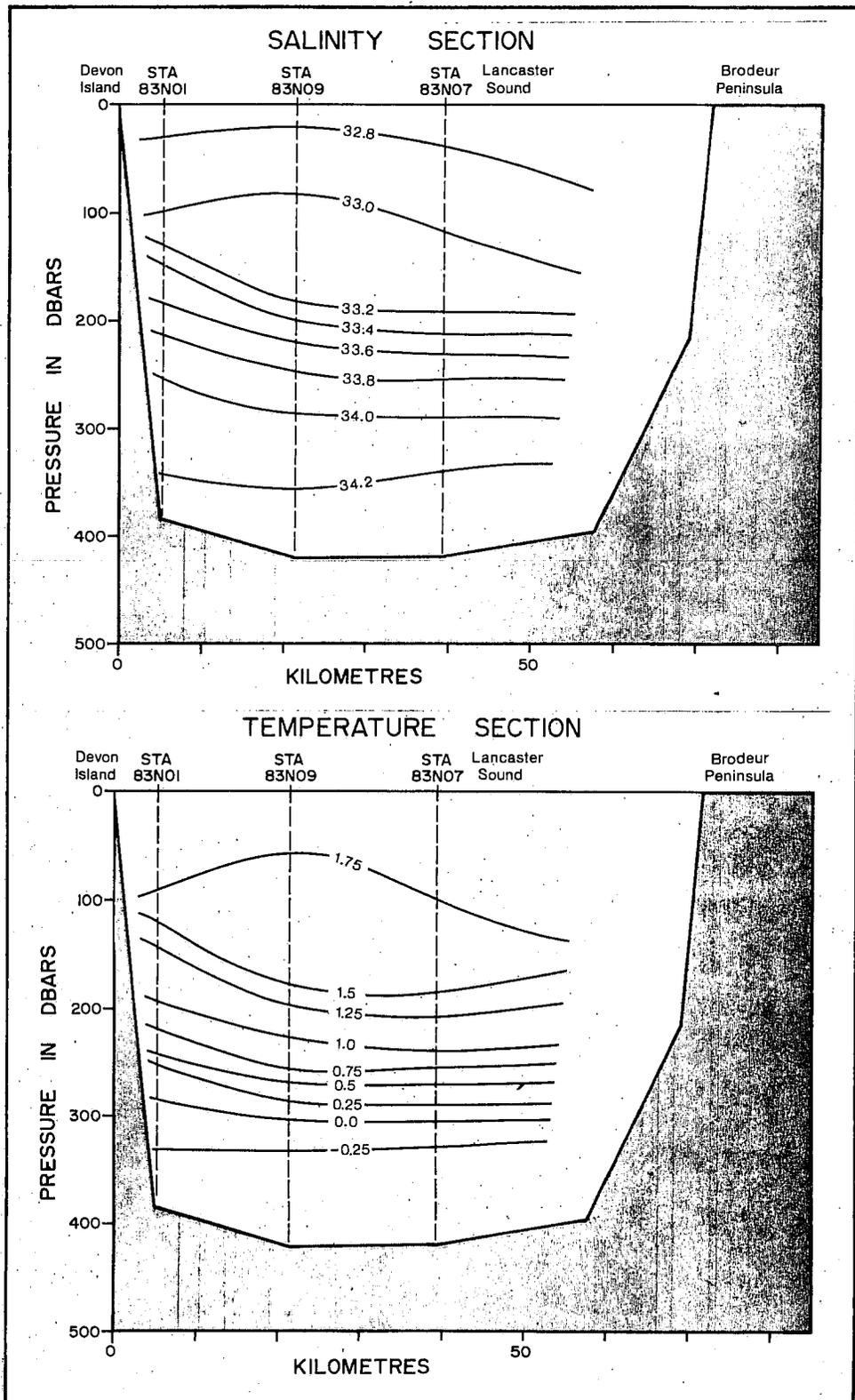


Figure 32: Vertical sections of temperature and salinity through Lancaster Sound. Station locations are shown in Figure 15.

Figure 33: The computed geostrophic shear between adjacent stations in Lancaster Sound.
A positive value indicates easterly flow.

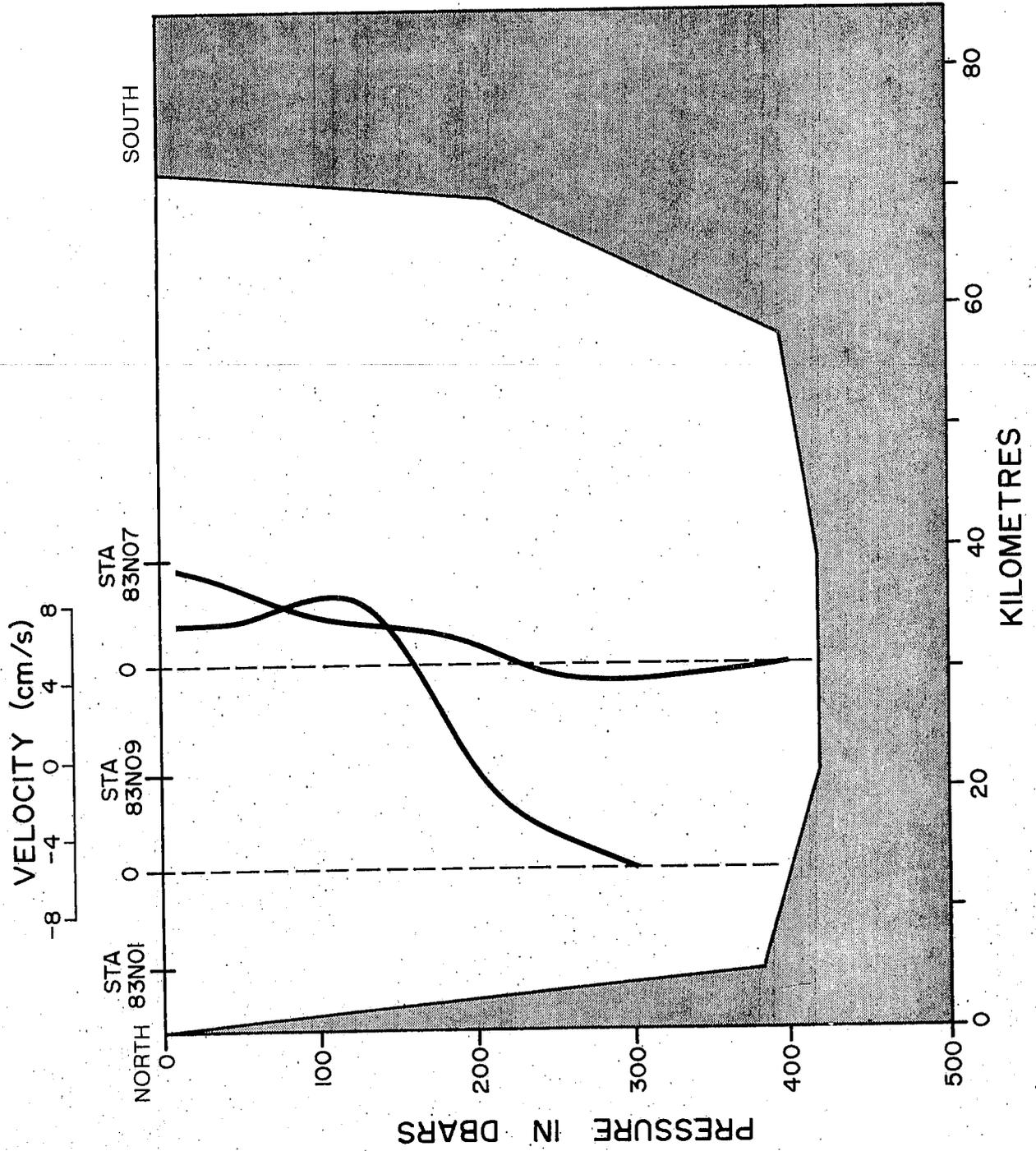


Figure 34: The computed geostrophic shear between station pairs at 10 dbar computed relative to the deepest common standard depth, as indicated in the figure.



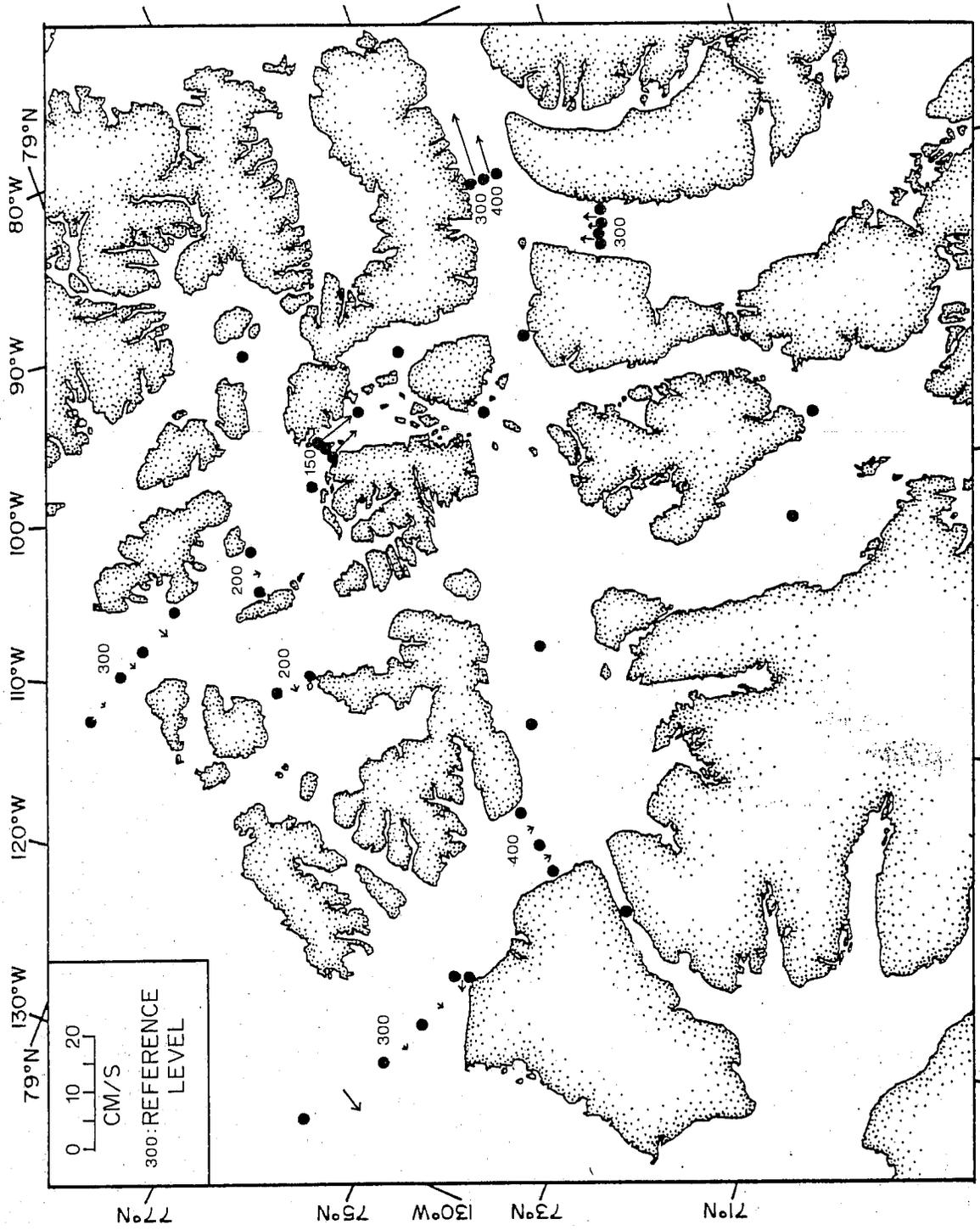


Figure 35: The surface layer depth, computed as the depth at which the $\sigma-t$ value exceeds the value at 5 dbar by 0.040 and as the depth at which the temperature exceeds the 5 dbar value by 0.010C° (bracketed numbers where these differ from the density-based values).

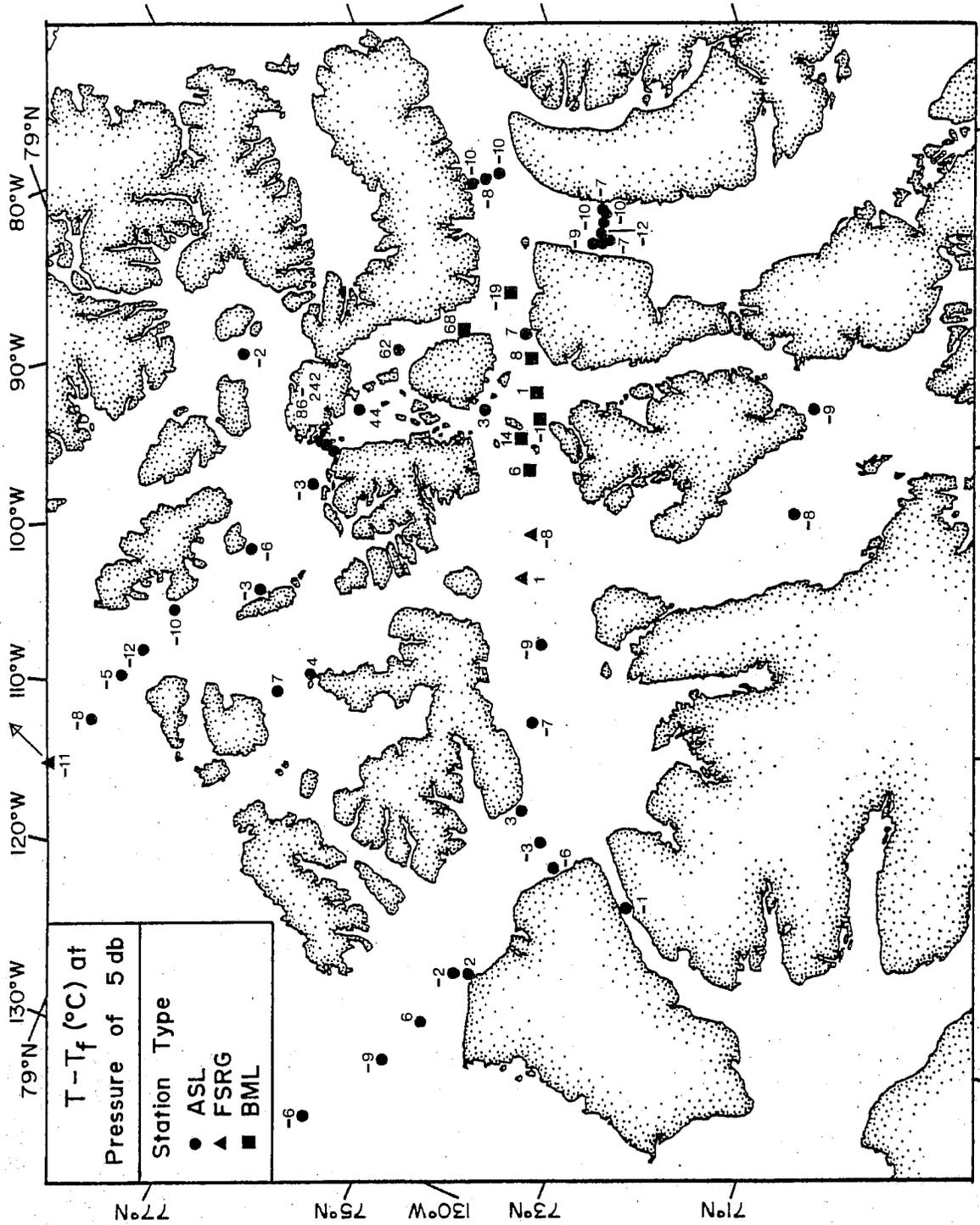


Figure 37: The deviation of temperature (T) from the surface freezing temperature (T_f) at 5 dbar.

saline (31.27). Beneath the shallower mixed layer at this site, the water column was characterized by weak stratification and near-freezing temperatures extending to 57 m coincident with the upper limit of the main halocline.

Within the waterways of the Archipelago proper, to the north and west of the limiting central sills, the surface layer depth is reduced at most measurement locations (5 to 43 m). Near-surface salinities tend to be somewhat larger (31.5 to 32.3) in this area than those measured at the more westerly and northerly locations. However, in southern M'Clintock Channel, the near-surface salinities are low (30.2 to 30.7) reflecting the greater influence of summer river runoff from the continental mainland. Throughout the western Archipelago, surface layer temperatures are within 0.010°C of the freezing point.

Over the relatively shallow areas of the central Archipelago, the near-surface waters become warmer and more saline. In contrast to other regions, a very pronounced increase in the deviation from the freezing point temperature occurs in this area, particularly in Penny Strait (Figure 37) with values ranging from 0.086 to 0.242°C . Increased near-surface temperatures are also found in Queens and Wellington Channels although the deviations from the freezing point temperature are smaller (0.06 to 0.07°C). In northern Barrow Strait, the surface layer temperature also significantly exceeds the local freezing point value but the differences are further reduced from those of Queens and Wellington Channels. In southern Barrow Strait, the surface layer is characterized by lower salinities which Prinsenberg and Sosnoski (1983) explain as a result of an eastward flow of water from Viscount Melville Sound through the southern portion of Barrow Strait. The lower limit of the surface layer depths is poorly defined at many of the stations within this area, due to the greatly reduced stratification throughout the water column.

The higher salinity and the increased temperature of the surface layer, through these relatively shallow passages in the central Archipelago, are indicative of enhanced vertical mixing bringing heat and salt into the surface layer from the warmer, more saline water below. Given the large deviations from freezing temperature in Penny Strait, the degree of vertical mixing appears to be most vigorous in this area. Comparisons of the near-surface temperatures and salinities at stations A01 to A05 inclusive in Penny Strait, with those at station A08 located 55 km to the northwest and station A06 located 55 km to the southeast, indicate that the area of intense mixing is concentrated in Penny Strait itself particularly on the eastern side of the strait, where the strongest baroclinic flows were computed (Section 4.3). Based on these observations, the horizontal scale of the vertical mixing appears to be relatively small, having values of less than a few tens of kilometres.

To the east of the Barrow Strait sill, in Lancaster Sound and Prince Regent Inlet, the surface layer has near-freezing point temperatures with a range of salinities (32.3 to 32.8) falling between those of the central sill region and those of the north and western regions of the Archipelago. Surface layer depths are variable, ranging from 11 to 50 m across Prince Regent Inlet and 20 to 38 m in Lancaster Sound.

Temperature Maximum and Cold Halocline Layers

Subsurface layers (the subsurface temperature maximum and the cold halocline; see Section 4.1) separate the vertically uniform properties of the surface layer from the simultaneously increasing temperatures and salinities of the main thermocline. The subsurface layers significantly vary in character across the Archipelago (Figure 38).

At most locations to the west and south of the central sills, the subsurface layer consists of, in order of increasing depth: a temperature maximum, a temperature minimum, and a zone of low temperatures which gradually warms with depth (Figure 38a). The temperature minimum and the underlying zone of gradually increasing temperatures constitute the cold halocline layer, widely observed within the Arctic Ocean (Aagaard et al., 1981). Within the Queen Elizabeth Islands clear maxima and minima in subsurface layer temperature are generally not evident (Figure 38b).

At the stations to the east of the central limiting sills, the temperature maximum is greatly reduced in both magnitude of temperatures and range of depths (Figure 38d). Typically a series of small amplitude temperature maxima and minima occur beneath the surface layer. Within these, the temperatures remain within 0.20C° of the surface freezing temperature.

In the shallow central region of the Archipelago, maxima and minima in the subsurface layer are very weak (or nonexistent) and highly variable spatially. In Penny Strait and Queens Channel, neither minima nor maxima of temperature are present; rather the water beneath the surface layer has transition zone characteristics as revealed by nearly linear temperature-salinity curves. Within Barrow Strait and Wellington Channel, very minor temperature maxima and/or minima were present at some of the measurement locations.

To characterize the spatial variability of the subsurface layer within the Archipelago, the value of the temperature maximum itself proved to be a rather poor indicator. Instead, the mean freezing temperature deviation was computed (Figure 39) over pressures ranging from the lower limit of the layer of uniform temperature (at which the temperature exceeds the value at 5 dbar by 0.010C°) to the pressure at a salinity of 33.0. The value of this parameter, based on an integral, is not susceptible to differences in the internal structure of the maximum temperature layer (e.g. a maximum of large amplitude over a narrow range of depths would be more comparable to a maximum of lesser amplitude over a larger depth range). The choice of the limiting pressure on the 33.0 isohaline was based on a visual examination of T-S curves which revealed that this pressure was situated near the onset of the main thermocline and below the temperature maximum, if present. At locations in Penny Strait (A01 and A05) or Queens Channel (A06) where the T-S curves are linear to the surface, the mean freezing temperature deviation is not considered appropriate and therefore not presented in the results.

Mean freezing temperature deviations (Figure 39) are markedly reduced in Prince Regent Inlet and Lancaster Sound (0.05 to 0.11C°) located to the east of the central sills in comparison to the western Archipelago (0.17 to 0.33C°). While these former areas experience more open water conditions (Figures 4-6) and hence a greater absorption of radiant energy during the summer months, heat losses due to surface mixing and ice formation in autumn

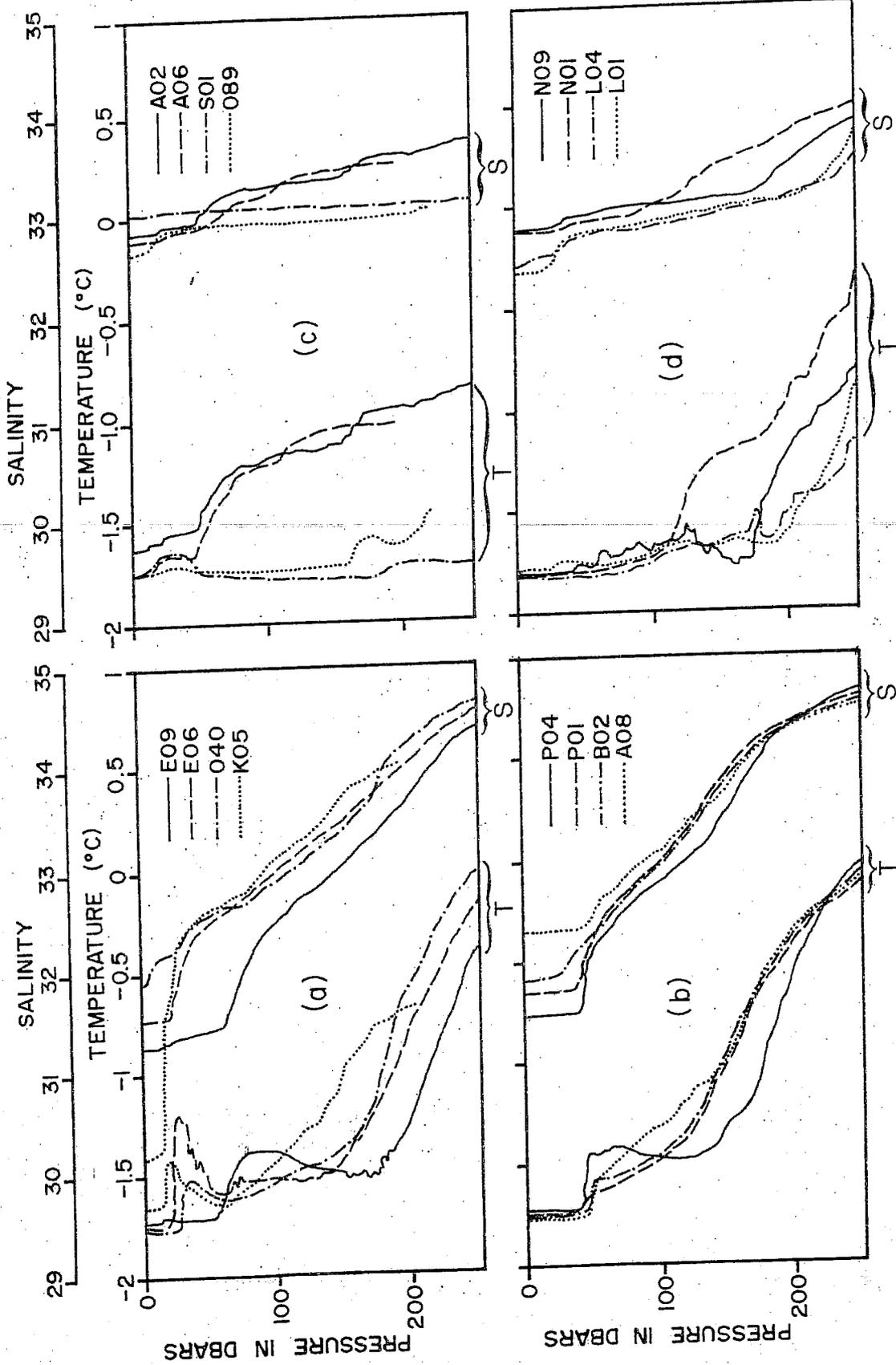


Figure 38: Vertical profiles of temperature and salinity from the surface to 250 dbar. The profiles are grouped by regions of the archipelago: a) west and south, b) north, c) central sills and d) east of sills.

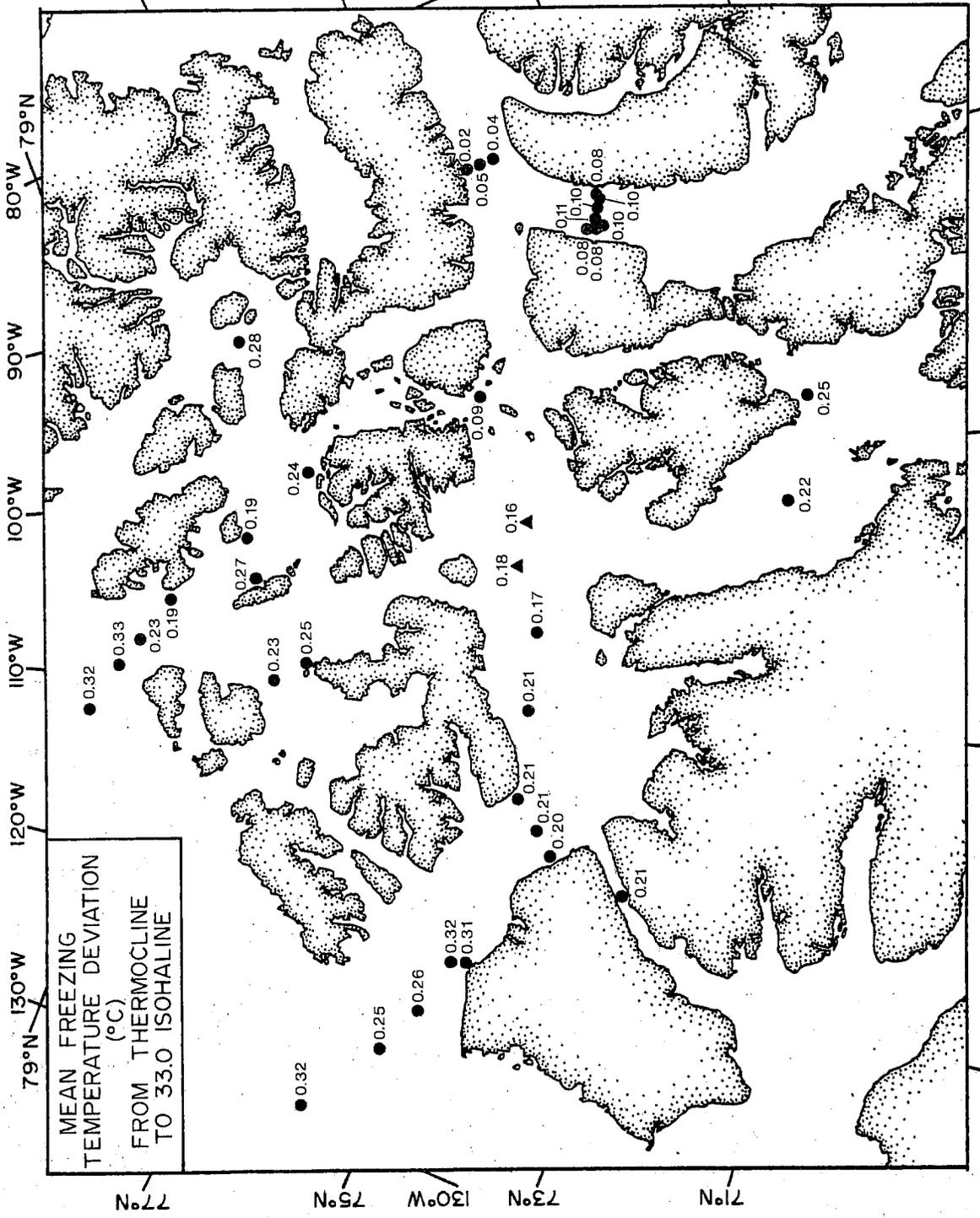


Figure 39: Mean deviation of temperature from the surface freezing temperature between 5 dbar and the pressure at a salinity of 33.0.

and winter are also larger due to the extended time required for ice cover stabilization to occur. In addition, lateral intrusions of cold waters occur at many of these stations (e.g. N09, L02, L04), as indicated by the small-scale (<5 to 25 m) alternating maxima and minima in temperature. These cold water intrusions, most probably originating in areas of northwestern Baffin Bay where (due to thin and unconsolidated sea ice) surface heat losses remain high throughout the winter, could play an important role in accounting for the low mean freezing temperature deviations of the eastern Archipelago.

In the region of the western Archipelago, the largest mean temperature values are found over the continental shelf (0.32, 0.33°C at P04, P03), continental slope (0.32°C at E09) and on the southern side of western M'Clure Strait (0.31, 0.32°C at E06, E55). At the M'Clure Strait locations, the higher values reflect a large amplitude temperature maxima found over a relatively narrow range of depths (20 to 50 m); this feature likely results from a high amount of solar radiation absorbed in the summer off western Banks Island (Figures 4-6). Such radiatively warmed waters are then advected into M'Clure Strait beneath an existing ice cover which limits heat losses in autumn. The origin of the warm water over the continental shelf and slope is less certain. At these locations, the temperature maxima occur at greater depths (in excess of 50 m) and salinities (32.2-32.4), over larger vertical segments of the water column. Possible sources for this subsurface layer include Bering Sea water, summer heating through the leads of the Arctic Ocean pack ice or advection from areas of extended open water during the summer months.

The cold halocline layer occurs on either side of the shallow central region of the Archipelago. The minimum value of the freezing temperature departure occurring within the halocline (and beneath the seasonal thermocline underlying the surface layer) was chosen as a suitable parameter to characterize this layer (Figure 40). At those stations, located away from the shallow central sills of the Archipelago, the minimum freezing temperature departure occurs below the strong halocline underlying the surface mixed layer; where a temperature maximum is present, the minimum freezing temperature departure is found in a distinct temperature minimum between this feature and the main thermocline. At most locations over the central sills of the Archipelago (Penny Strait and Barrow Strait), the minimum freezing temperature departure, is indeterminate because the halocline and thermocline coincide as indicated by the highly linear T-S relation extending to the surface.

Throughout the study area, the minimum freezing temperature departure beneath the surface layer ranges from 0.0°C to 0.325°C. This parameter is generally largest on the Arctic Ocean continental shelf (stations E08, E09, P04, P03), the adjoining waterways of western M'Clure Strait and Prince Gustaf Adolf Sea and in the Sverdrup Basin where it ranges from 0.192 to 0.325°C, with the single exception of station P01 (0.135°C). Minimum temperature values are generally lower in eastern M'Clure Strait (0.114 to 0.171°C), Viscount Melville Sound (0.128 to 0.192°C) and southern M'Clintock Channel (0.137°C to 0.225°C), and further reduced to values of 0.006 to 0.129°C in Wellington Channel, Prince Regent Inlet and Lancaster Sound.

In addition to lower minimum temperatures, near freezing point temperatures occur at significantly greater depths to the east of the central

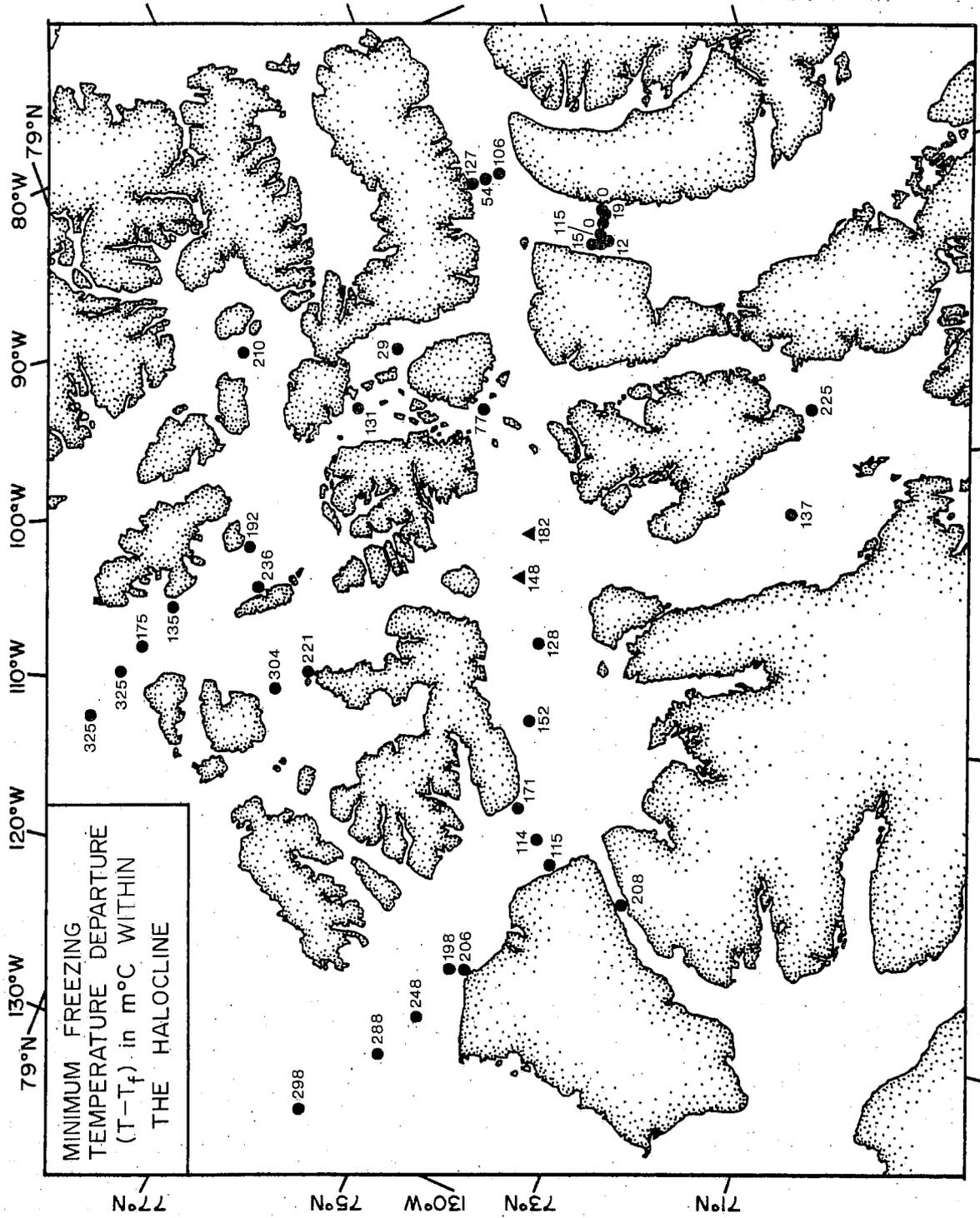


Figure 40: Minimum deviation of temperature from the surface freezing temperature at depths beneath the halocline underlying the surface layer.

Archipelago sills. The point in the temperature profile (marking the lower limit of the cold halocline) at which the slope increases markedly, occurs at depths of 100 to 155 m in the western Archipelago with corresponding temperature and salinity ranges of -1.51 to -1.12°C and 33.1 to 33.6, respectively. To the east of the limiting sills, the lower limit of the cold halocline ranges from 180 to 260 m in depth, -1.70 to -1.33°C , and 33.0 to 33.3 in salinity. Only at the measurement location on the Arctic Ocean continental slope, station E09, are the cold halocline depths comparable at 180 m (with a temperature of -1.44°C and salinity of 33.39) to those measured east of the central sills.

The cold halocline of the western waterways of the Archipelago appears to originate over the continental slope of the Arctic Ocean where waters of very similar T-S properties are observed but at significantly greater depths (approximately 150-180 m vs. approx 100 m; Figure 38). Within the western Archipelago, the properties of the cold halocline are modified only slightly. Near the bottom of the cold halocline (salinity 33.2), temperature increases as one progresses eastward while the opposite trend occurs at lower salinities (32.5-32.8). This trend towards increasing temperatures at depth likely results from an upward diffusion of heat from below. The trend toward decreasing temperatures in the upper part of the cold halocline may result from ice formation in some of the shallower waterways adjoining western Parry Channel (Byam and Austin Channels, the shallow southern side of Viscount Melville Sound) with the cold, more saline water being advected into the halocline at locations of greater depth.

In the eastern portions of the study area, the lower temperature and greater depth (extending to 180-260 m) of the cold halocline is probably a reflection of a much enhanced rate of ice formation further to the east in the North Water polynya of Baffin Bay. The resulting salinization of surface water could enable descent of near-freezing water to greater depths in this area. Lemon and Fissel (1982) have observed increasing salinities and near-freezing temperatures to maximum depths of 200 to 250 m, over the winter period in northwestern Baffin Bay. The presence of many smaller scale temperature maxima and minima within the cold halocline at locations in Lancaster Sound (particularly stations N07 and N09) and Prince Regent Inlet (stations L01, L02 and L04) indicate that a considerable degree of interleaving of distinctly different water masses is actively occurring. Similar features were observed in the CTD profiles obtained in the spring of 1982 in these same areas (Fissel et al., 1984).

The Main Thermocline

Beneath the cold layer of the halocline, the temperature and salinity both exhibit marked increases with depth, thereby delineating a transition zone from Arctic to Atlantic Waters. The greater part of the temperature transition occurs in this zone, thus justifying its designation as the main thermocline. Thermocline water is found at different depths on either side of the central shallow areas of the Archipelago. To the west, this water is typically found over depths ranging from 130 ± 20 to 278 ± 23 m and salinities from 33.35 ± 0.25 to 34.62 ± 0.04 as determined at the upper limit of the main thermocline and at the 0°C isotherm. On the eastern side of the Archipelago, the thermocline occurs at greater depths, ranging from 220 ± 40 to 321 ± 35 m but with reduced salinities, ranging from 33.15 ± 0.15 to 34.09 ± 0.04 .

The temperature-salinity characteristics of the transition zone at selected stations are shown in Figure 41. A progressive warming on isohaline surfaces within the thermocline is evident in the T-S curves with progression from the Arctic Ocean to the vicinity of the shallow central sills of the Archipelago. This warming is most pronounced through the waterways of the Queen Elizabeth Islands (Figure 41b), where the maximum temperature increase of 0.4C° occurs at a salinity near 33.9, with lesser increases at higher and lower salinities (0.29C° at 33.5; 0.15C° at 34.5). Through western Parry Channel, the temperature increases are significantly smaller, particularly at salinities exceeding 33.5. The corresponding temperature increases range from 0.26C° at a salinity of 33.5 to 0.21C° at 33.9 and further decreasing to 0.08C° at 34.5.

To the west of the shallow central sills, the temperature-salinity curves in the transition zone are nearly linear having only a slight degree of positive curvature. A greater degree of curvature is evident in the temperature-salinity curve for station P04 located on the continental shelf north of the Queen Elizabeth Islands, than for the corresponding stations, E09 and E07, located over the continental slope and shelf off M'Clure Strait. The increased curvature of the T-S curves observed over the northwestern continental shelf (Figure 42) is similar in character to that observed in the deeper offshore waters of the Arctic Ocean both to the north of the Archipelago and at offshore locations in the Beaufort Sea. The lower minimum temperatures and enhanced linearity of the T-S curves off M'Clure Strait (and in the southeastern Beaufort Sea) reflect the influence of the penetration of near-freezing surface waters deep into the halocline in these areas (Melling and Lewis, 1982). The contrasting T-S curves obtained over the northwestern shelf (station P04) and further northeast over the Alpha Range (station L03) likely are indicative of the absence of such surface water penetration in these areas.

Figures 43a-b present a more detailed mapping of temperature on two isohaline surfaces, 33.5 and 33.9. Neither surfaces are continuous through the shallow waterways of Barrow Strait and Wellington Channel, where near-bottom salinities are limited to maximum values of 33.4 or less. To the west of the central sills the pressures on these surfaces are smaller (120 to 165 dbar at 33.5; 140 to 195 dbar at 33.9) than is the case to the east of the central sills in Lancaster Sound and Prince Regent Inlet (165 to 270 dbar at 33.5; 230 to 305 at 33.9).

On the 33.5 isohaline surface, the temperature is lower along the southern shore of western M'Clure Strait than either further to the west over the continental shelf or to the east. Melling et al. (1984) found this same pattern in the spring of 1982 (Figure 44). A minimum temperature of -1.40C° , measured at station E06, was attributed to an inflow of cold water from the eastern Beaufort Sea following the southern shore of western Parry Channel. A weaker return flow of warmer waters was deduced for the central and northern half of M'Clure Strait, where the temperature reached -1.25C° near the northern shore. In the spring of 1983, the temperature gradient across eastern M'Clure Strait is smaller by a factor of two, as indicated by the temperature difference of 0.115C° in 1982 and that of 0.052C° in 1983 at stations R11 and R16.

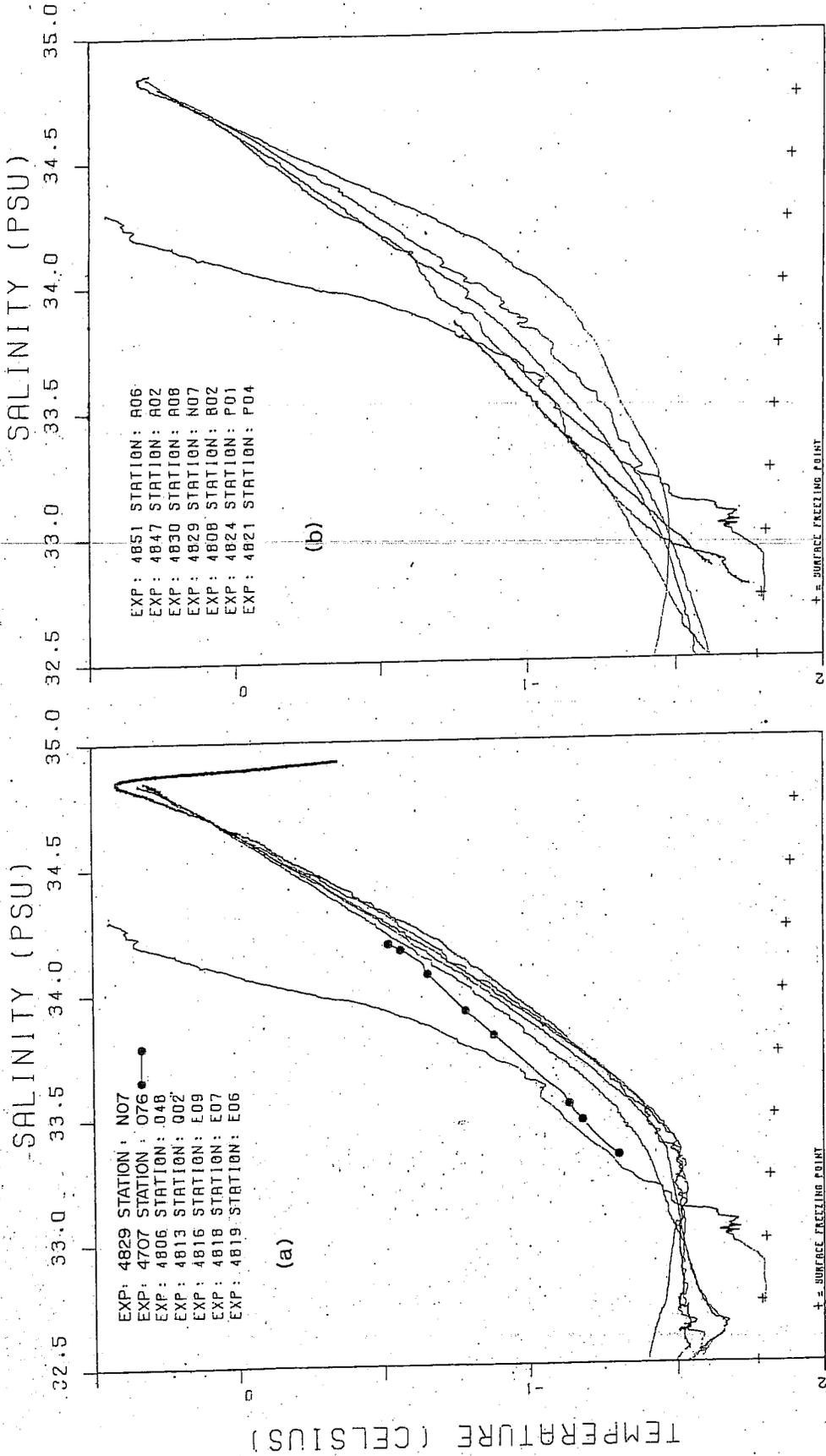


Figure 41: Composite temperature-salinity diagrams for lines of stations extending the Canadian Archipelago: a) through Parry Channel and b) through the Queen Elizabeth Islands to Lancaster Sound. Stations are listed in order of decreasing temperature at a salinity of 33.5.

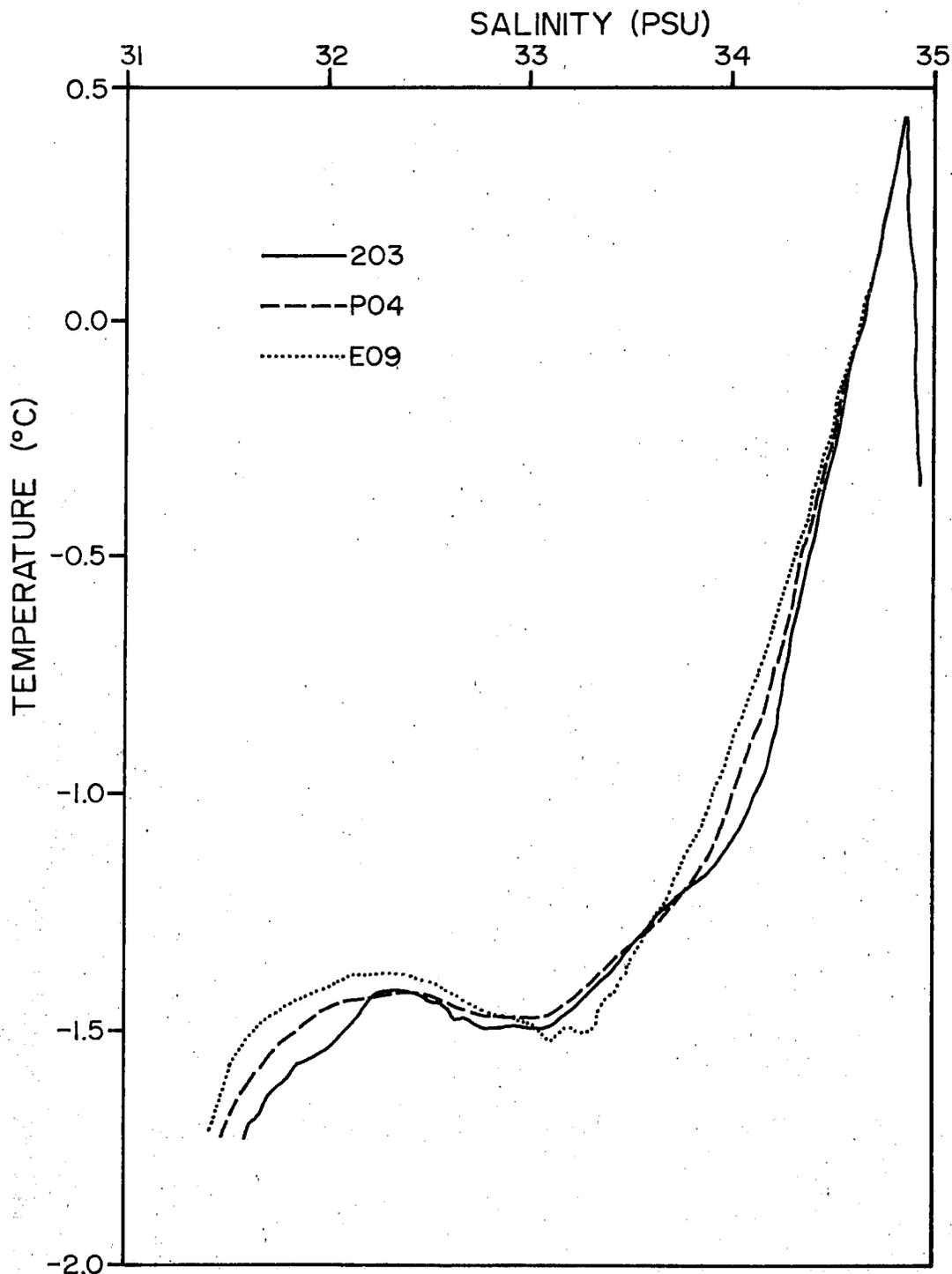


Figure 42: Temperature-salinity diagrams for 1983 stations located over the continental shelf and slope adjoining the northwestern side of the Archipelago. Station 203, located on Alpha Ridge north of Ellesmere Island was occupied on April 13, while stations P04 located off Prince Gustaf Adolf Sea and E09 located off M'Clure Strait, were occupied on March 27 and March 26.

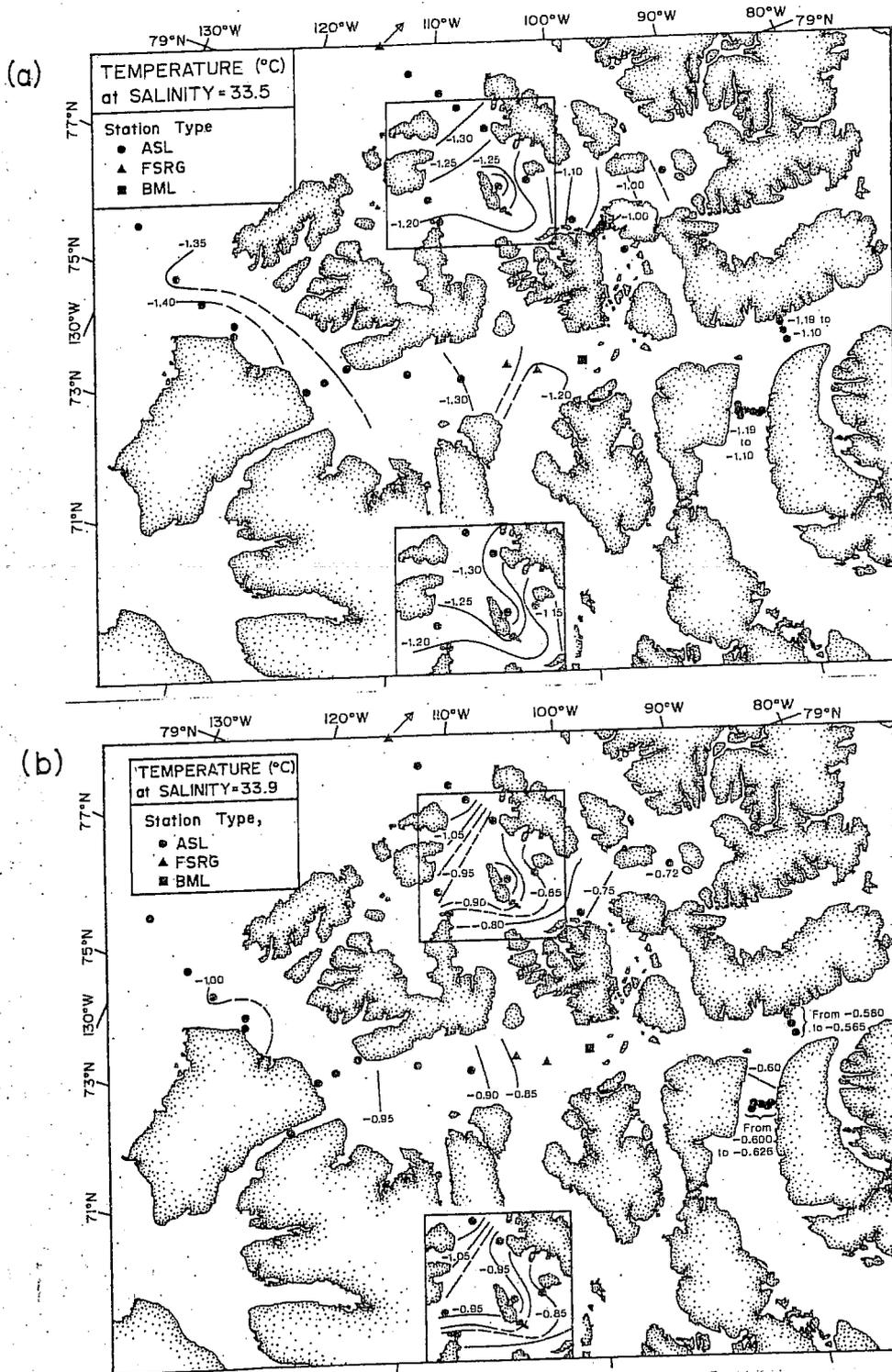


Figure 43: Temperature on two isohaline surfaces in the Canadian Archipelago in March-April 1983: a) 33.5 and b) 33.9 both in the main thermocline. The inset shows an alternative interpretation of the contours in the vicinity of Loughheed Island.

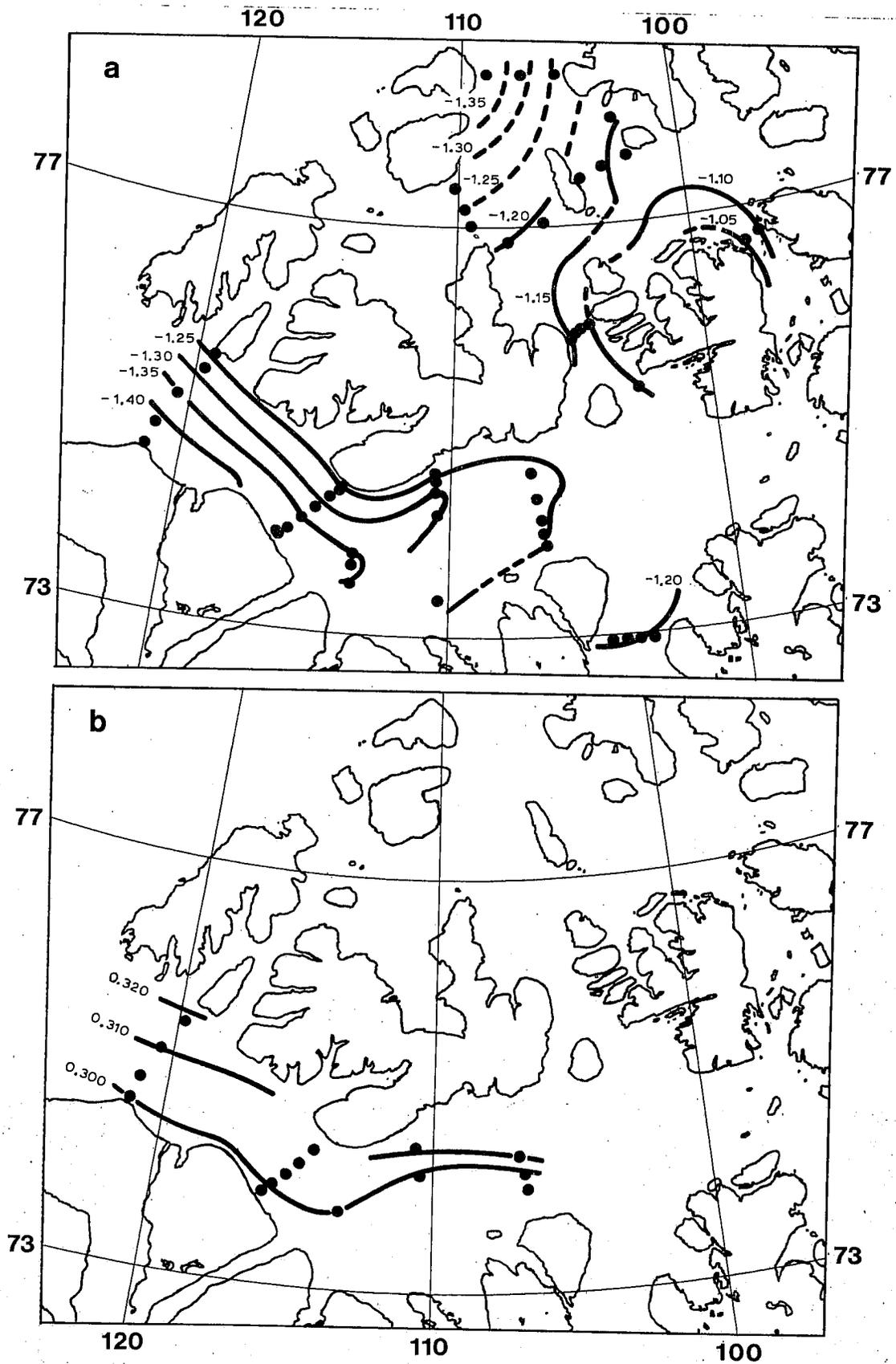


Figure 44: Temperature on two isohaline surfaces in the western Canadian Archipelago in March-April 1982: a) 33.5 in the main thermocline and b) 34.83 in the Atlantic Water.

The influence of the relatively cold water of the eastern Beaufort Sea appears to extend to station E07 located in western M'Clure Strait (temperature of -1.409°C at a salinity of 33.5), but significantly warmer water is present further offshore at station E8 (-1.340°C) near the sill (depth 380 m) across the western end of M'Clure Strait. Further offshore, at station E09 located over the continental slope, temperature at a salinity of 33.5 is again lower, -1.393°C . The higher temperature at station E08 could result from a vertical transfer of heat from the underlying warmer Atlantic Water (see following subsection), and/or from a continuation of the outflow of warmer water from the northern half of M'Clure Strait.

From the 1983 data, the warming of the thermocline water clearly extends into eastern Viscount Melville Sound on both the 33.5 and 33.9 isohaline surface. The highest temperatures were measured at station 076 (-1.160 at 33.5; -0.820 at 33.9).

Within the Queen Elizabeth Islands, temperatures on the 33.5 and 33.9 isohalines are higher by approximately 0.1 to 0.2°C , than in Parry Channel. In terms of the temperature differences within the Archipelago, however, the continental shelf temperatures differ by little: at a salinity of 33.5, the temperature at station P04 is 0.019°C greater than that of station E08, while for a salinity of 33.9, the P04 temperature is 0.013° less than that of station E08. The temperature difference between these two areas appears to be a consequence of the greater east-west gradients within the Queen Elizabeth Islands than those within western Parry Channel. Overall, the along-stream gradient of the former area is larger by a factor of two on the 33.5 isohaline and by nearly a factor of four on the 33.9 isohaline. The horizontal gradients are not uniform along a transect, however. A large increase in temperature occurs between stations P02 and P01 in the entrance to Prince Gustaf Adolf Sea on the 33.9 isohaline and in the northern approaches to Penny Strait on the 33.5 isohaline. Immediately to the east of Loughheed Island the relatively low temperature measured on both could be interpreted as either (1) a local area having anomalously cold water in the main thermocline or (2) a large scale intrusion of cold water on either side of Loughheed Island, originating in western Prince Gustaf Adolf Sea (see inset in Figure 43). Data from the spring 1982 (Fissel et al., 1984) and the spring of 1979 (Peck, 1980) have been combined to illustrate similar temperature ranges and spatial patterns on the 33.5 isohaline surface (Figure 44) and on the 33.9 isohaline surface (not shown) in these areas to the south of the 1983 station P01.

The larger horizontal temperature gradient (from the Arctic Ocean to the central sills of the Archipelago) determined for the waterways of the Queen Elizabeth Islands than for western Parry Channel could be explained in a number of different ways:

- i) the mean advection rate is lower through the Queen Elizabeth Islands (Section 4.3; Fissel et al., 1984) permitting a great uptake of heat from the Atlantic Water;
- ii) more intense vertical mixing occurs in the Queen Elizabeth Islands, most likely in the vicinity of Desbarats Strait and Penny Strait. Tidal currents appear to be enhanced in these areas (Peck, 1977; Peck, 1980b);

- iii) the loss of heat to layers overlying the thermocline, and ultimately to the atmosphere, is reduced in the Queen Elizabeth Islands because of the more extensive ice cover;
- iv) the value of $\partial^2 T / \partial z^2$, a factor in the advective-diffusive heat balance (Melling et al., 1984), is larger in the Queen Elizabeth Islands.

Adoption or rejection of these explanations require additional investigation and, in some cases, more data.

To the east of the central shallow areas of the Archipelago, the T-S characteristics of the upper portion of the thermocline (salinities from 33.2 to 33.7) are similar to those of the waters immediately to the west of the central sills (Figure 41). However, exchanges between these two areas cannot be occurring on a continual basis since the observed bottom salinities in the relatively shallow connecting passages (Figures 18 and 19) too low. In Lancaster Sound, the T-S curves within the thermocline are more strongly curved than those in the western Archipelago. A pronounced positive curvature is apparent for salinities of up to 33.8. At greater salinities, the T-S curve becomes nearly linear.

In Lancaster Sound and Prince Regent Inlet, large differences ($+0.030\text{C}^\circ$) in temperature from station to station occur at salinities from 33.6 to 34.1, with smaller differences on surfaces of lower salinity. These differences in T-S characteristics do not exhibit spatially coherent patterns as in the western Archipelago; instead they have small spatial scales, both in the horizontal and the vertical. In the vertical, small scale features occur over lengths ranging from a few metres to 20 m. In the horizontal, differences on most isohaline surfaces between adjoining stations are as large or larger than those between stations on either side of Prince Regent Inlet, or between stations in Lancaster Sound and Prince Regent Inlet.

Atlantic Water

In the western Archipelago, the T-S characteristics of Atlantic Waters with salinities of 34.70 or less vary spatially in the same manner as those of waters in the main thermocline (a progressive warming occurring on constant salinity surfaces). However, near the temperature maximum of the Atlantic Water, the horizontal gradients change markedly, as indicated by the T-S curves (Figure 45) for salinities of 34.77 to 34.87 and by the temperatures on constant salinity surfaces within this range (Figure 46).

The waters over the continental slope are significantly warmer than those within the Archipelago. At a salinity of 34.83 (depths of 379 to 458 m), the temperature at continental slope stations E09 and 203 were 0.413 and 0.357°C respectively, compared to a range of 0.293 to 0.333 in the Archipelago and over the adjoining continental shelf (Figure 46). As suggested by Melling et al. (1984) the opposite signs of the spatial gradient in temperature between the waters of the continental slope and the Archipelago (within the Atlantic and Arctic Water masses) suggests that an upward transfer of heat occurs from the Atlantic Water to the Arctic Water.

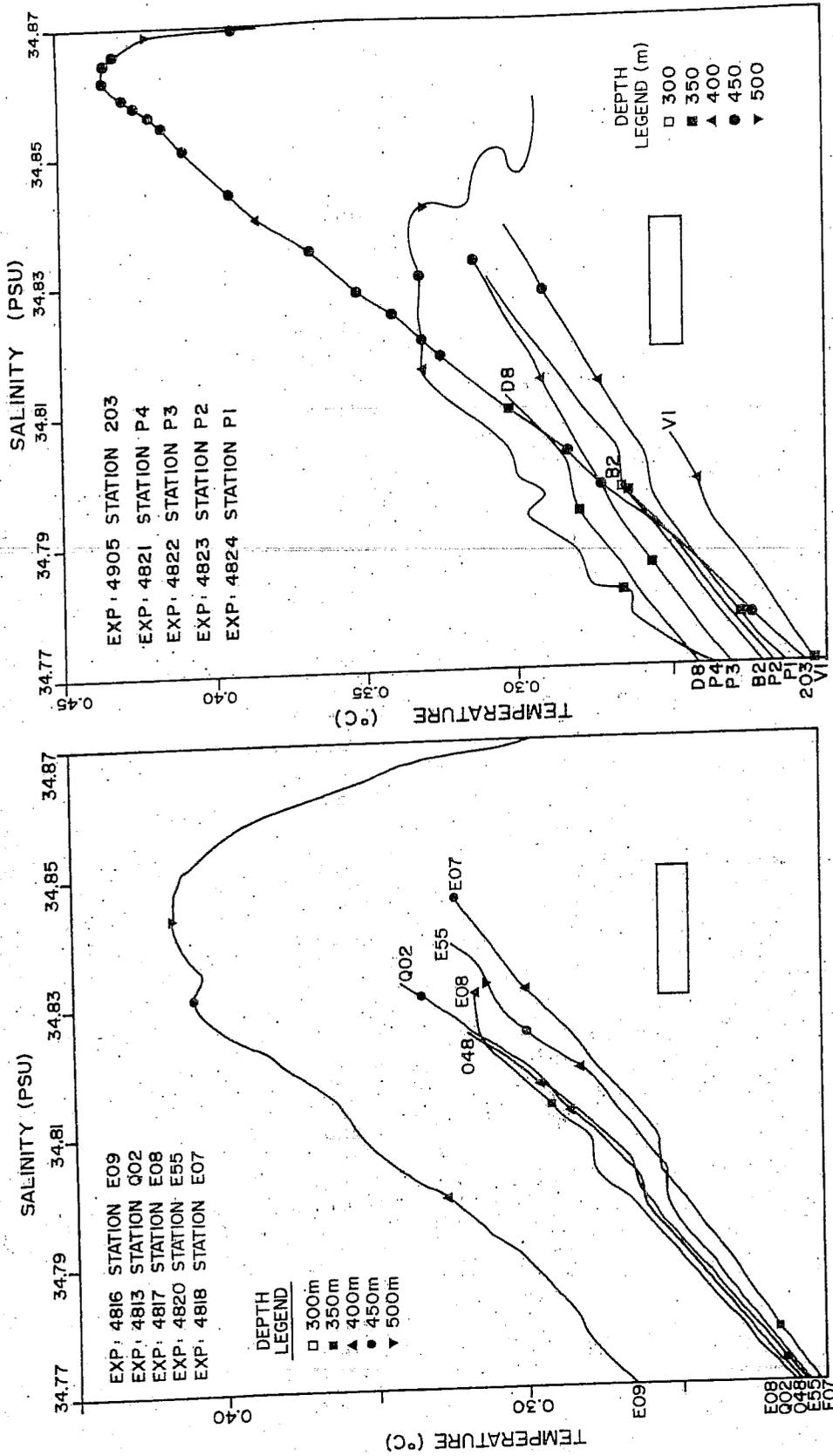


Figure 45: Temperature-salinity characteristics of the deep waters in a) western Parry Channel and the adjoining continental shelf and slope; and b) the Queen Elizabeth Islands and the adjoining continental shelf. The rectangle represents observational accuracy. The occurrence of abrupt horizontal shifts in some of the profiles (e.g. E08 at 34.807 and 34.816) is believed to be a consequence of a change in the suppression word representing conductivity ratio in the CTD probe.

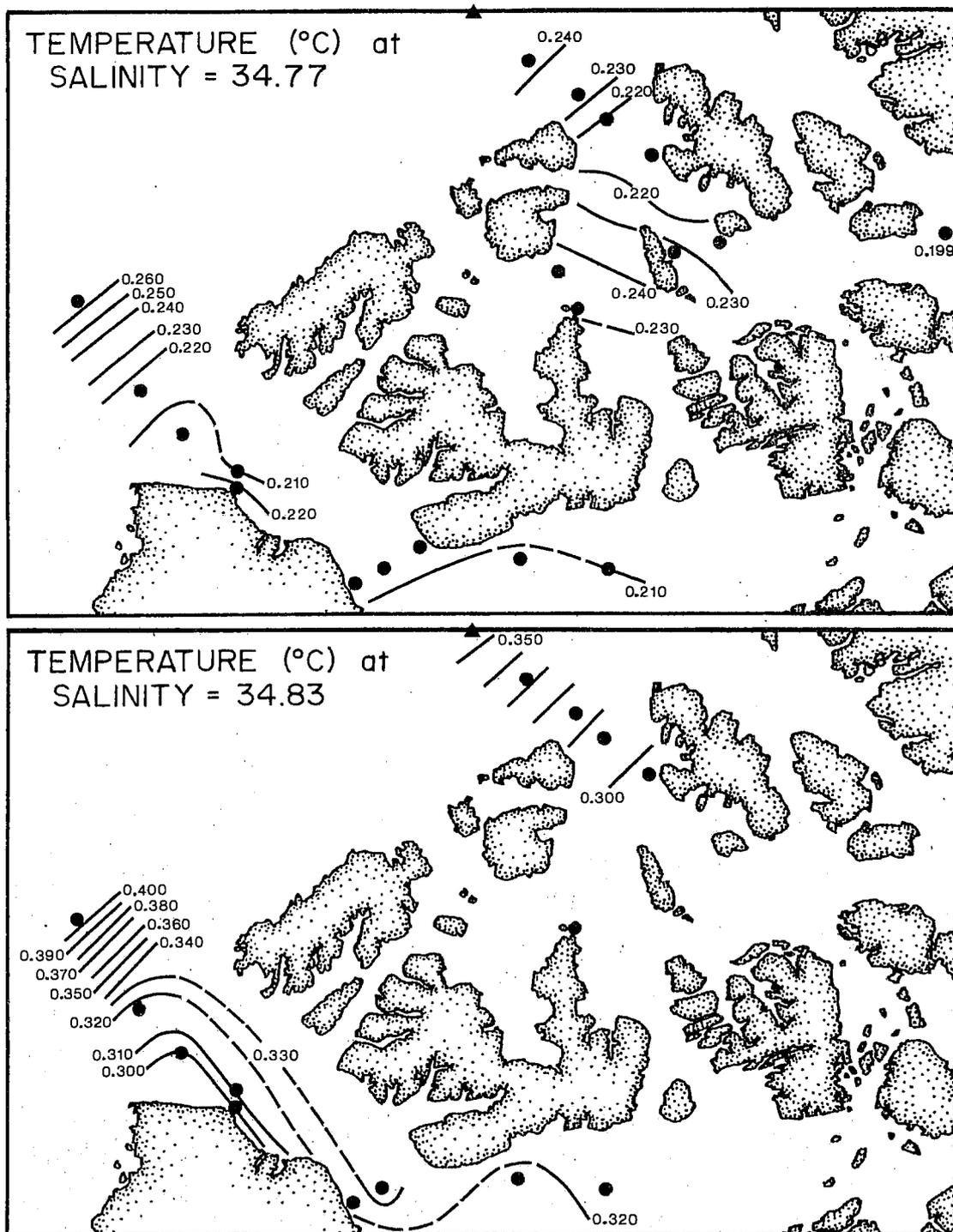


Figure 46: Temperature on two Atlantic layer isohaline surfaces in the western Canadian Archipelago in March-April 1983: a) 34.77 and b) 34.83.

Horizontal gradients in Atlantic Water temperature within the western part of the Archipelago are small in comparison with the gradients found over the continental slope and the outer shelf waters. Within western Parry Channel, the differences are comparable to or less than the measurement uncertainties (Figure 45a). Temperatures increase from west to east within M'Clure Strait. In Viscount Melville Sound, this weak gradient on the 33.83 salinity surface is apparently reversed. Within Prince Gustaf Adolf Sea and the adjoining continental shelf, the horizontal gradient is larger in amplitude, relatively constant and of opposite sign to the gradient in overlying Arctic Water. Due to sills within the waterways of the Queen Elizabeth Islands, penetration of 34.83 salinity water is very limited. Examination of temperatures on the 34.77 isohaline (Figure 46) at pressures between 287 and 403 dbar reveals that the progressive cooling also occurs at this level over the continental shelf and through the Prince Gustaf Adolf Sea. With further penetration into the Archipelago to the vicinity of Loughheed Island, temperatures on the 33.77 isohaline apparently increase slightly. However, the gradients are smaller in amplitude, with measured differences being comparable to the experimental uncertainty.

Of interest on the 34.77 isohaline is the low temperature (0.199°C) at station V01 in Norwegian Bay, which is separated bathymetrically (sill depth less than 100 m) from the Loughheed Island area. The low Atlantic Water temperature at this location reflects the opposite trend of Arctic Water temperatures in this region (Figure 43).

To the east of the central Archipelago, Baffin Bay Atlantic Water occupies the lower portion of western Lancaster Sound and Prince Regent Inlet. Maximum temperatures of 0.45°C are attained at salinities of 34.30 (Figure 47). The range in temperatures amounts to approximately 0.09°C on isohaline surfaces, considerably greater than the range of temperature differences in the western Archipelago. For example, on the 34.20 surface, temperatures range from 0.27 to 0.36°C . Comparisons among the T-S curves (Figure 47) suggest a wide range of temperatures in western Lancaster Sound with lower values on the northern side of the sound. In Prince Regent Inlet temperatures are reduced from those of Lancaster Sound by about 0.05°C .

4.5 SHORT-TERM VARIABILITY OF TEMPERATURE AND SALINITY

Station A02 (first visited on March 29) was revisited April 4, and a time series of seven profiles was collected over 3.5 hours, one profile being taken every 30 minutes. The individual profiles and T-S plots are in Appendix 1 (experiments 4844-4850). Figure 48 shows contour plots of temperature and salinity against time. Vertical isopleth excursions of up to 25 m over half an hour are apparent in both the temperature and salinity. They appear to be most pronounced between 150 and 200 m depths. There is, however, little net displacement of isopleths over the full length of the time series. Inspection of the T-S plots reveals only minor changes in the T-S curves (Appendix 2). The vertical displacements of isopleths are indicative of internal wave activity in Penny Strait. These variations cause appreciable changes in the dynamic height anomaly (DHA). The standard deviation of DHA at 200 m relative to the surface for the seven successive casts was 0.0033 dyn. m. For two stations separated by 10 km experiencing this level of variations of DHA, the

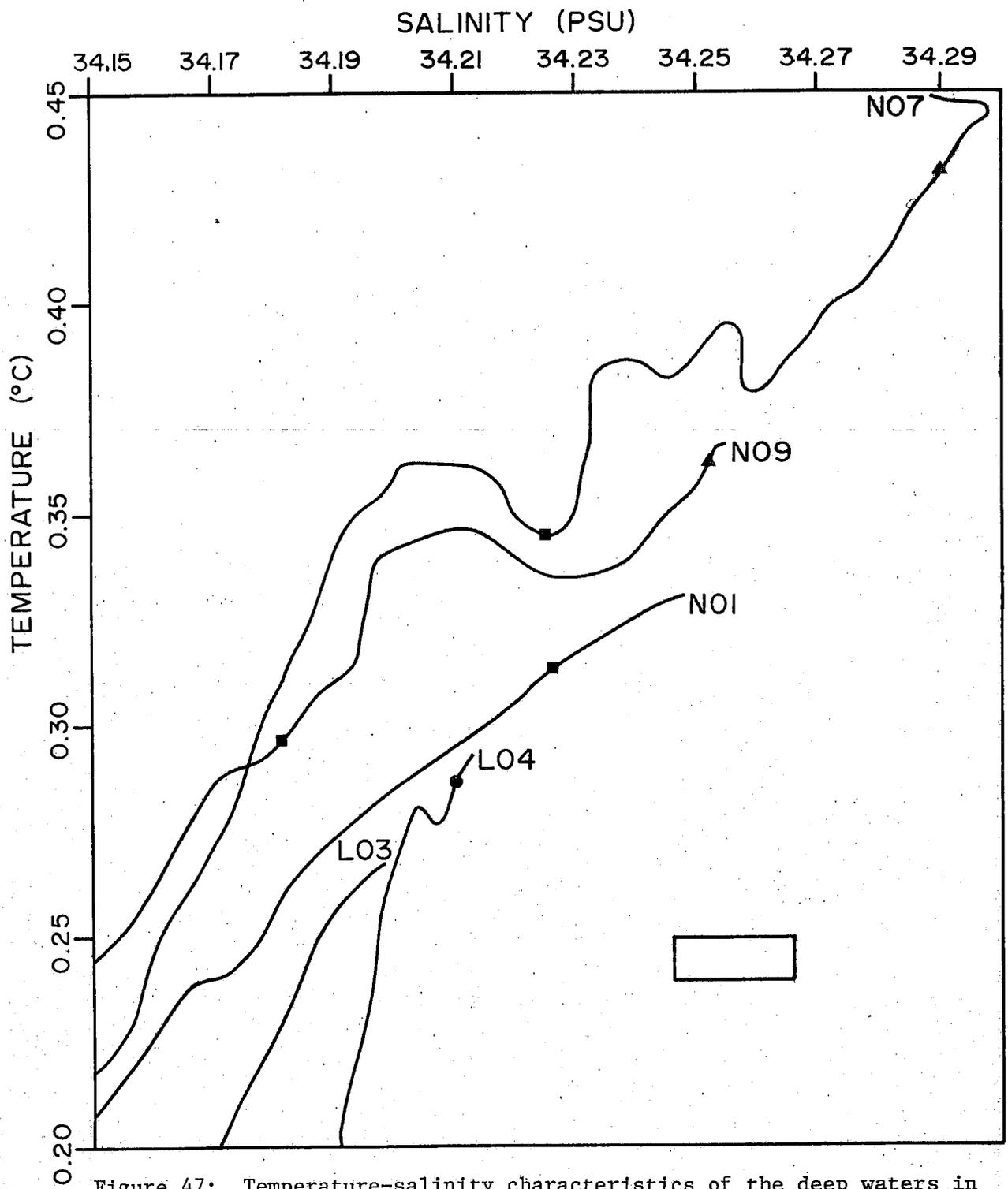


Figure 47: Temperature-salinity characteristics of the deep waters in Lancaster Sound (N01, N07 and N09) and Prince Regent Inlet (L03, L04). The rectangle represents observational uncertainty.

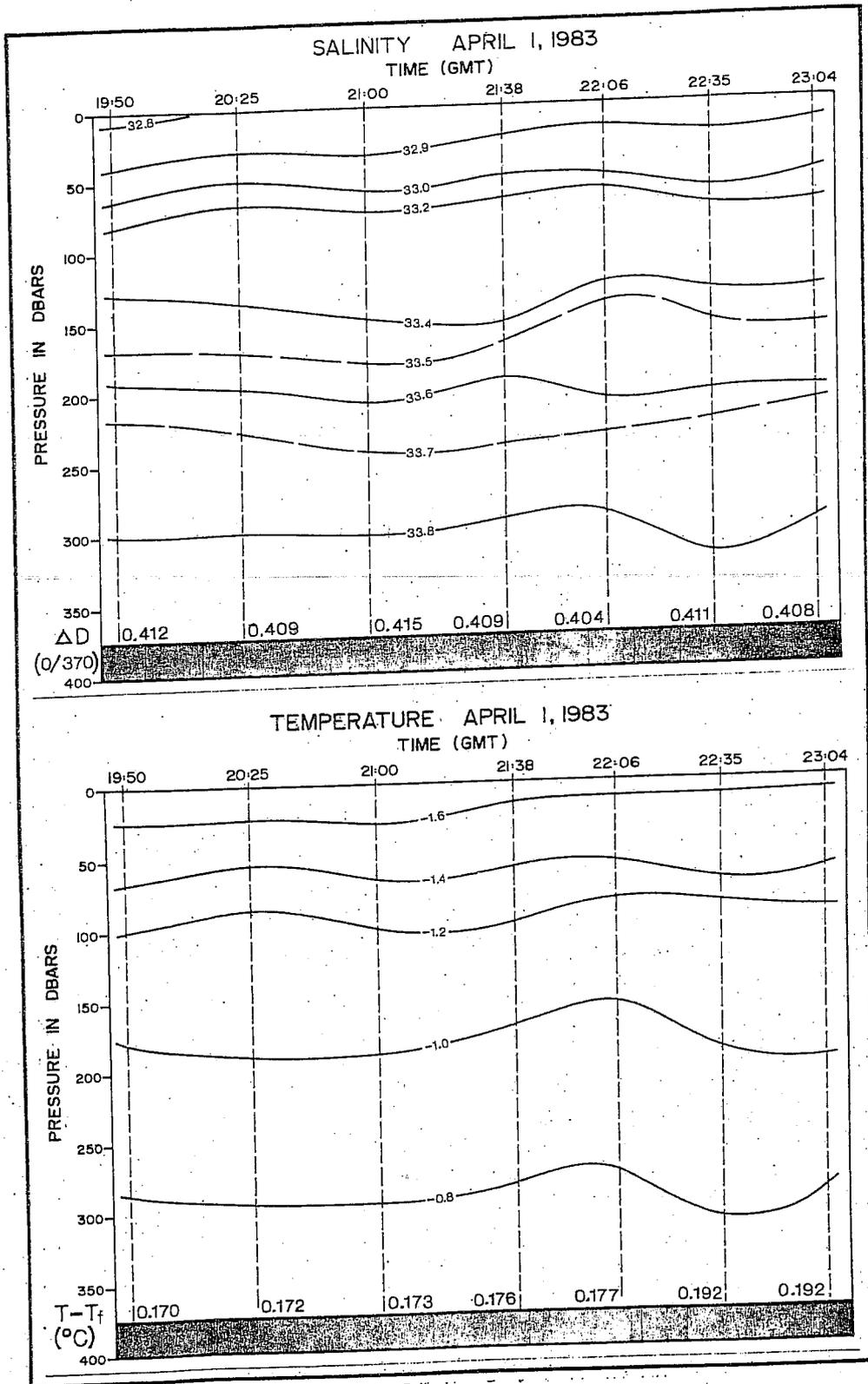


Figure 48: Contours of temperature and salinity from repeated CTD profiles at station A02, 1950 to 2304 GMT April 1, 1983. Also shown are the freezing temperature deviation at 5 dbar and the dynamic height anomaly at 5 dbar relative to 370 dbar for each CTD profile.

standard deviation of the baroclinic shear from 0 to 200 m would be 3.1 cm/s amounting to as much as one-half of the computed baroclinic shears for Penny Strait (Section 4.3).

The detailed structure of the salinity and temperature profiles undergoes changes from one profile to the next. The variations are confined to three sections of the water column where steepened gradients in temperature and salinity exist. An example is shown in Figure 49 where changes occur from step-like to relatively smooth profiles. The steps range in size from 5 to 20 m in thickness and up to 0.15°C and 0.15 in temperature and salinity, respectively. The steep-gradient zones in which the changes are observed are located between 50 and 100 m, 150 to 225 m and 275 to 300 m depth (the location of the middle zone does change by up to 20 m). The variations are greatest in the upper zone and least in the deep zone. Since it is generally not possible to track specific features from one profile to the next, the time scale of the variations is less than 30 minutes. Such small-scale variability is likely indicative of the occurrence of significant mixing in Penny Strait.

Station L02 in Prince Regent Inlet was occupied on March 28 and re-occupied on March 30 and may thus provide an indication of variations over larger periods. Since the two casts are separated by 7.5 km however, differences between them may be caused as much by spatial as temporal variations. The greatest difference occurs below 250 m, where both temperatures and salinities were lower during the first occupation than during the second. At 300 m the temperatures and salinities were -0.430°C and 33.94 on March 28, and 0.032°C and 34.10 on March 30.

4.6 YEAR-TO-YEAR VARIABILITY

Western Parry Channel

The description of year-to-year variability in this region is derived from comparisons between 7 CTD profiles obtained in March and April 1983 during the present study and profiles obtained at nearby locations one year earlier (Fissel et al., 1983). These stations and the distance separating the 1983 locations from those of 1982 are provided in Table 6, along with comparative values for salinity at 5 dbar, mean deviation of temperature from the freezing point from the base of the surface layer of uniform temperature to the 33.0 isohaline, the minimum of deviation from the freezing point temperature below the mixed layer, and temperatures on the 33.5, 33.9 and 34.83 isohalines.

At most locations the surface layer was shallower and less saline in 1983 than in the previous year. In contrast, the temperature maximum layer had larger temperatures and greater thickness. These differences were most prominent at the two stations, E06 and R11, on the southern side of M'Clure Strait. At both stations, the depth of the surface layer was also reduced by nearly a factor of 2 from 48+5 m to 22+1 m. Salinities at 5 dbar were lower by 0.73 at both station E06 (from 32.28) and station R11 (from 32.54), while the value of the maximum temperature increased by 0.42°C from -1.605 and by 0.16°C from -1.727. (At station R11, the mean freezing temperature deviation differs little between 1982 and 1983, due to the much reduced mixed layer depth and reduced minimum temperature deviation of 1983.) At the other two stations in eastern M'Clure Strait (Q02 and R11), similar differences were apparent but with reduced magnitudes. In Prince of Wales Strait, the salinity

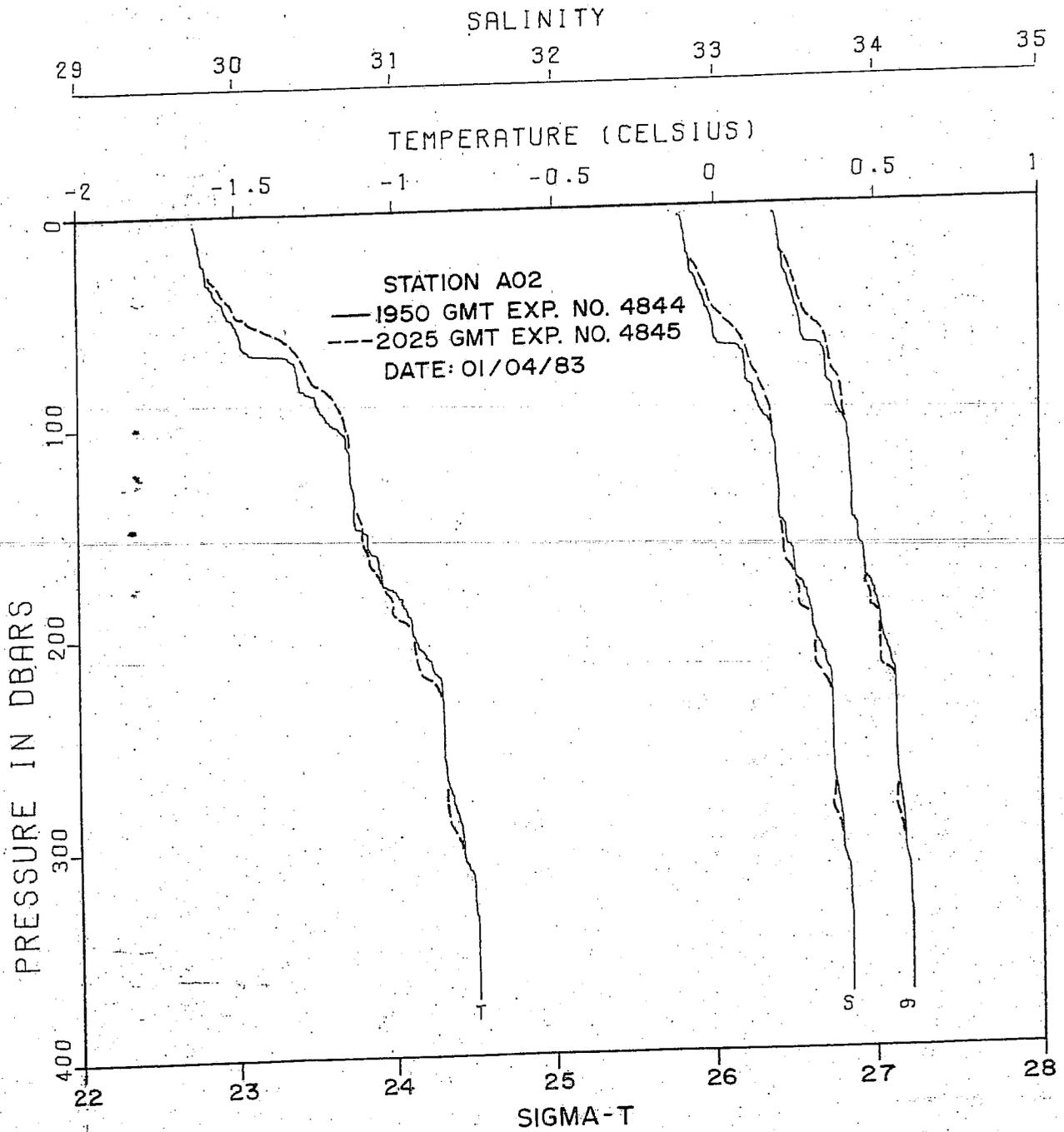


Figure 49: A comparison of two profiles of temperature, salinity and density at station A02, measured at 1950 (solid line) and 2025 (dashed line) on April 1, 1983.

Table 6

A comparison of oceanographic conditions for western Parry Channel stations occupied in the spring for both 1983 and 1982. For each quantity, the order of numerical values is the 1983 value, the 1982 value and the change from 1982 to 1983.

Station	E06	R16	Q02	R11	Q04	040	048	K03
Distance from '82 Stn	6.2 km E	2.4 km S	12.7 km SW	1.9 km NE	10.5 km NE	10.0 km E	2.6 km SW	1.2 km E
M.L. Depth	22 43 <u>-21</u>	25 19 <u>6</u>	28 41 <u>-13</u>	23 52 <u>-29</u>	28 44 <u>-16</u>	<6 19 <u>-13</u>	6 30 <u>-24</u>	8 22 <u>-14</u>
S at 5 dbar	31.55 32.28 <u>-0.73</u>	32.28 32.40 <u>-0.12</u>	32.16 32.35 <u>-0.19</u>	31.81 32.54 <u>-0.73</u>	31.76 32.38 <u>-0.62</u>	31.92 31.50 <u>0.43</u>	31.55 32.16 <u>-0.61</u>	30.72 30.91 <u>-0.19</u>
Mean Temp.	0.309	0.212	0.206	0.196	0.213	0.207	0.172	0.248
Dev.	0.179 <u>0.130</u>	0.111 <u>0.101</u>	0.186 <u>0.020</u>	0.200 <u>-0.004</u>	0.197 <u>0.016</u>	0.185 <u>0.022</u>	0.175 <u>-0.003</u>	0.274 <u>-0.026</u>
Min. Temp.	0.206	0.171	0.114	0.115	0.208	0.152	0.128	0.225
Dev.	0.157 <u>0.049</u>	0.133 <u>0.038</u>	0.147 <u>-0.033</u>	0.139 <u>-0.024</u>	0.186 <u>0.022</u>	0.180 <u>-0.029</u>	0.067 <u>0.061</u>	0.236 <u>-0.016</u>
T at 33.50	-1.421 -1.431 <u>0.010</u>	-1.326 -1.257 <u>-0.069</u>	-1.377 -1.307 <u>-0.070</u>	-1.378 -1.361 <u>-0.017</u>	N/A <u>N/A</u>	-1.311 -1.291 <u>-0.020</u>	-1.300 -1.248 <u>-0.052</u>	N/A
T at 33.90	-1.014 -0.998 <u>-0.016</u>	-0.972 -0.887 <u>-0.085</u>	-0.967 -0.928 <u>-0.039</u>	-0.971 -0.982 <u>0.011</u>	N/A <u>N/A</u>	-0.932 -0.922 <u>-0.010</u>	-0.925 -0.913 <u>-0.012</u>	N/A
T at S =	34.830 0.295 -0.301 <u>-0.006</u>	34.803 0.280 0.263 <u>0.017</u>	34.830 0.332 0.303 <u>0.029</u>	34.830 0.325 0.304 <u>0.021</u>	N/A <u>N/A</u>	34.830 0.312 0.310 <u>0.002</u>	34.825 0.318 0.297 <u>0.021</u>	N/A

of the surface layer was reduced by 0.62 from 32.28, as was the thickness of the surface mixed layer. Further to the east in Viscount Melville Sound and southern M'Clintock Channel, the differences between 1983 and 1982 were generally smaller in absolute magnitude and more variable in sign.

At greater depths, differences between the two consecutive years followed a different spatial pattern. In the lower half of the cold halocline and in the upper part of the main thermocline (depths from 140 to 250 m) temperatures decreased between 1982 and 1983 at most stations in eastern M'Clure Strait and Viscount Melville Sound. This temperature decrease was reflected in a deepening of the cold halocline layer. The decrease is somewhat apparent in the comparison of the temperature on the 33.5 isohaline surface in 1983 (Figure 43) and in 1982 (Figure 44). The largest changes, found at stations R16 and Q02, are reductions of up to 0.15°C (Figure 50). Smaller reductions of up to 0.07°C are found at station 048 in Viscount Melville Sound, while at the locations on the southern side of M'Clure Strait and at station 040 in western Viscount Melville Sound, the temperature changes are less than 0.02°C .

In the Atlantic Water, interannual differences in western M'Clure Strait (station E06) between 1983 and 1982 were small and less than the measurement uncertainty (differences of approximately 0.020°C on isohaline surfaces). For salinities of 34.79 or more, temperature differences on isohalines never exceeded 0.007°C . However, further to the east in western Parry Channel, larger differences occurred as can be deduced from a comparison of temperature on the 34.83 isohaline surface in 1983 (Figure 46) with the corresponding values for 1982 (Figure 44). In eastern M'Clure Strait, temperatures were warmer in 1983 by 0.029°C at Q02 and 0.021°C at R11. At station R16 on the northern side of eastern M'Clure Strait, the temperature on the largest common salinity (34.803) was 0.017°C warmer in 1983 than in 1982. In Viscount Melville Sound, the T-S characteristics at station 040 are nearly identical but at the more easterly station 048, temperatures were higher by 0.021°C on the 34.825 surface.

A comparison of year-to-year differences noted for the T-S characteristics suggest a negative correlation between interannual changes in the main thermocline and the Atlantic Water. Locations (R16, Q02, R11, 048) which exhibit temperature decreases in the Arctic Water from 1982 exhibit temperature increases (of approximately one-fifth the magnitude) in the Atlantic Water. At other locations (040, E06) comparatively small differences occurred at both levels. The reduced degree of warming of the thermocline water from west to east in M'Clure Strait in 1983, may be related to less heat uptake from below and thereby the reduced degree of cooling of the Atlantic Water.

Over the continental slope to the west of M'Clure Strait (station E09), Atlantic Water temperatures were higher, by 0.075 to 0.110°C , than the temperatures within western Parry Channel (Figure 45a). Unfortunately, there are no previous oceanographic data collected near E09. Melling et al. (1984) show that on the continental slope of the S.E. Beaufort Sea, temperatures on the 34.83 isohaline surface decreased from west to east in March-April 1981. Based on this result, a cyclonic circulation of Atlantic Water about the basin was inferred. At the 1981 stations nearest to E09, located some 300 km to the south, the temperatures were in the range of 0.325 to 0.350°C , and their pattern of variation suggested little change towards the northwest. The temperatures measured at station E06 in both 1982 and 1983 (0.300°C) are

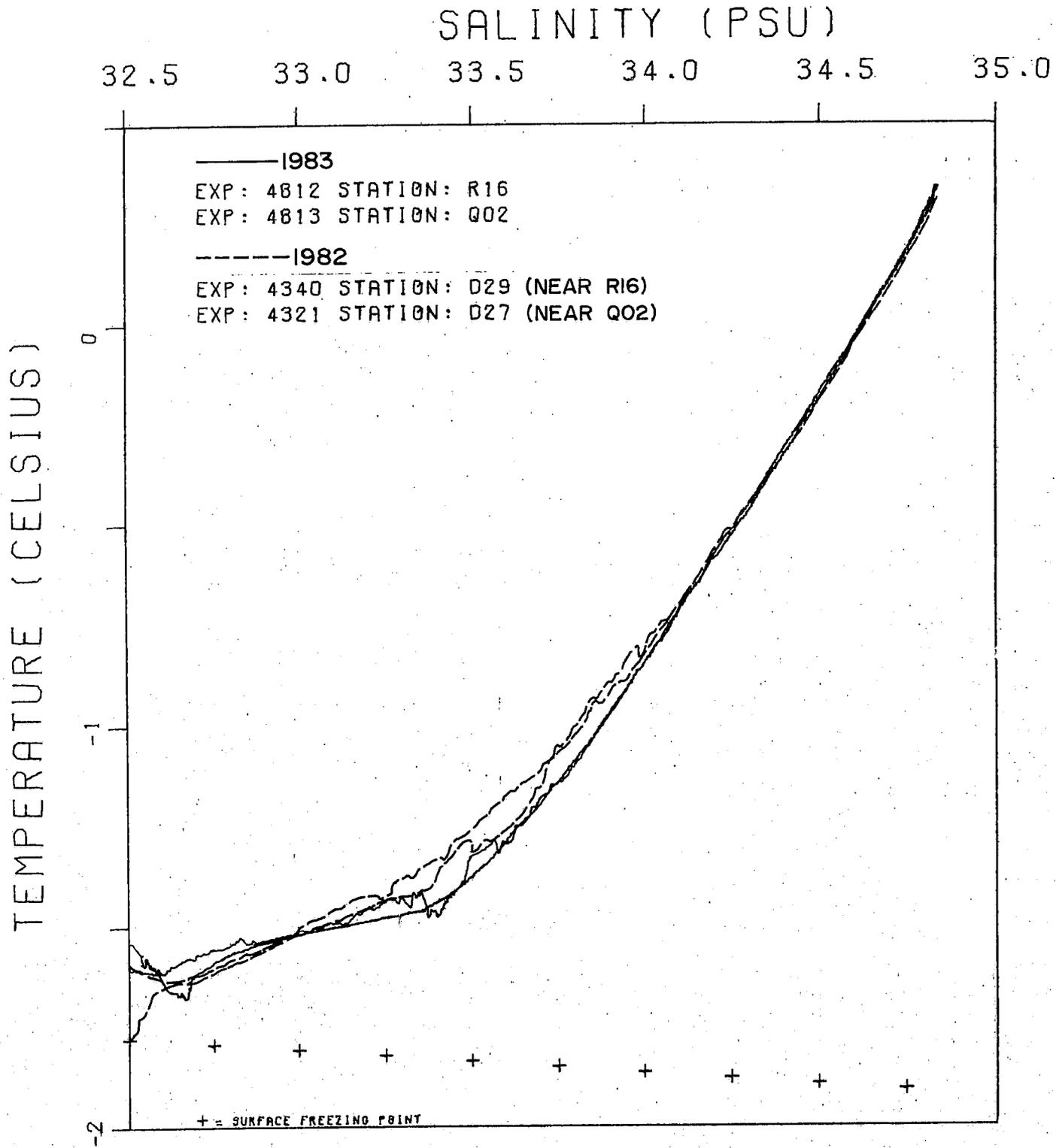


Figure 50: Temperature-salinity diagrams for stations Q02 and R16 in eastern M'Clure Strait obtained in 1982 and 1983. Note the increased temperatures in the main thermocline in 1983 from those of 1982.

consistent with the 1981 data (Melling et al., 1984; Figure 8). However, the much higher temperatures at station E09 (0.408°C at 34.83 salinity), suggest that Atlantic Water reaches this location via a route outside the southern Beaufort Sea. The possibility that large temporal variations occur is considered unlikely in view of earlier bottle cast results obtained over the continental slope off the northern half of Banks Island in 1951 (U.S. Navy Hydrographic Office, 1954) and 1960 (Marine Surveys Division, 1964) as shown in Figure 51, which are consistent with the 1981 results in this same area (although observational uncertainties for these measurements are greater). Thus the observation of notably warmer Atlantic Water at station E09 suggests that the cooler Atlantic Water of the S.E. Beaufort Sea may not be the sole source of Atlantic Waters found on and off the northwestern continental shelf of the Archipelago. Newton and Coachman (1974) infer a direct flow of Atlantic Water to this area from the Chukchi Plateau. Atlantic Water from this source would be expected to have undergone less cooling than Atlantic Water travelling cyclonically along the continental slope in the southern Beaufort Sea.

Queen Elizabeth Islands

For the Queen Elizabeth Islands, comparisons were made with the March-April data obtained in 1982 (Fissel et. al., 1983) and in 1979 (Peck, 1980). For the 1979 data, since information on calibration procedures is not available, there is a greater possibility of systematic differences with the results of the 1982 and 1983 studies. A summary of locations used, and of the comparative values is given in Table 7.

In 1983, the surface layer salinity was reduced at all stations from 1982 (by 0.23 to 0.52) and in 1979 (by 0.24 to 0.75). In 1983, salinities at 5 dbar ranged from 31.41 (D06) to 31.84 (B02). The corresponding ranges were 31.64 to 32.36 in 1982 and were 31.60 to 32.69 in 1979. Along with the decreased salinities, the depth of the surface layer was reduced at most stations (see Table 7).

Over most of the water column from the lower portion of the cold halocline to the Atlantic Water, the marked tendency for warming on isohaline surfaces from northwest to the southeast was evident in all three years (compare Figure 43a and Figure 44a). Differences in T-S characteristics are comparatively small at stations B02 and P01. On the 33.5 isohaline surface, temperatures differed by less than 0.05°C for station B02, and by less than 0.03°C for station P01. The corresponding differences for the 33.9 isohaline are 0.06°C (B02) and 0.05°C (P01).

However, at station B04, located off the east coast of Loughheed Island in Maclean Strait, large reductions occurred in temperatures on isohaline surfaces in 1983 from those of both 1982 and 1979. On the 33.5 surface, temperatures in 1983 were reduced by 0.115°C from 1982 and by 0.067°C from 1979, while on the 33.9 surface, 1983 temperatures were reduced by 0.058°C from 1982 and by 0.010°C in 1979. At station D06, 1983 temperatures were similar to those of 1982, but larger than those of 1979. Warmings of 0.124°C and 0.128°C were computed for the 33.5 and 33.9 isohalines. These changes in T-S characteristics at stations B02 and D06 indicate that hydrographic features of reduced horizontal scale (<50 km) do occur within the Queen Elizabeth Islands.

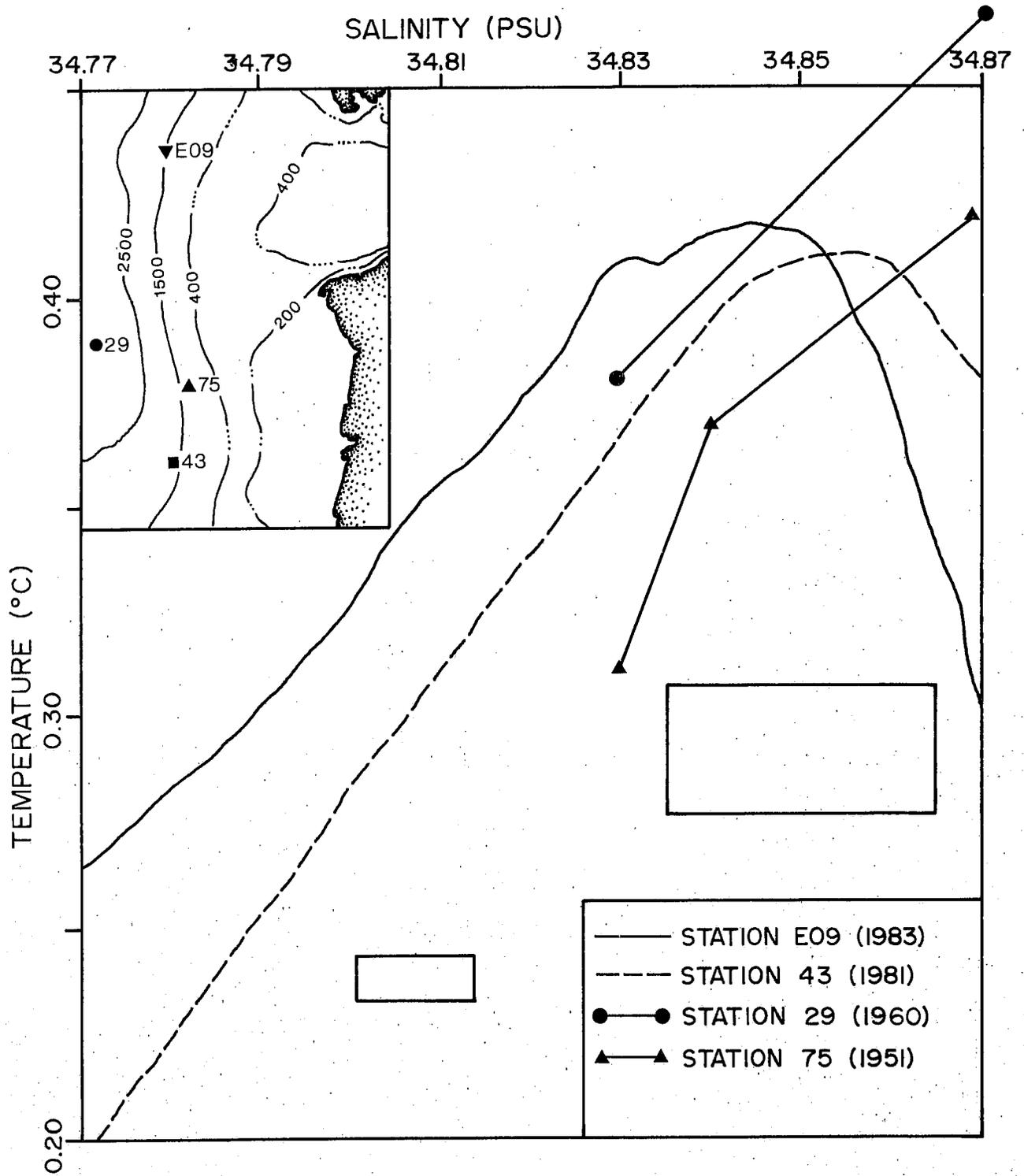


Figure 51: Temperature-salinity characteristics of stations E09 obtained in March 1983 and station 43, obtained in March 1981. Also shown are historical bottle cast data obtained at locations shown in the inset map. The large and small rectangles represent the observational accuracy of the bottle and CTD data, respectively.

Table 7

A comparison of oceanographic conditions for Queen Elizabeth Islands stations occupied in the spring for both 1983 and 1982 or 1979. For each quantity, the order of numerical values is the 1983 value, the 1982 or 1979 value and the change from 1982 or 1979 to 1983. The first three columns are comparisons with 1982 data while the remaining columns represent comparisons with 1979 data. Since station 71 in 1979 was occupied twice, two comparisons are provided.

Station	B02	B04	D06	B02*	B04*	D06*	P01*	P01*
Distance from '82 Stn	4.9 km SE	4.6 km NNE	24.9 km W of D02/82	13.0 km SE of 34/79	5.8 km N of 38/79	16.7 km SE of 63/79	6.6 km NNW of 71/79	1.6 km NNW of 71/79
M.L. Depth	26 25 <u>-1</u>	35 35 <u>0</u>	19 26 <u>-7</u>	26 47 <u>-21</u>	35 27 <u>-8</u>	19 <5 <u>14</u>	37 33 <u>-4</u>	37 39 <u>-2</u>
S at 5 dbar	31.84 32.36 <u>-0.52</u>	31.64 31.93 <u>-0.29</u>	31.41 31.64 <u>-0.23</u>	31.84 32.33 <u>-0.49</u>	31.64 32.25 <u>-0.61</u>	31.41 31.65 <u>-0.24</u>	31.72 32.47 <u>-0.75</u>	31.72 32.47 <u>-0.75</u>
Mean Temp. Dev.	0.194 0.157 <u>0.037</u>	0.267 0.174 <u>0.093</u>	0.230 0.154 <u>0.076</u>	0.194 0.174 <u>0.020</u>	0.267 0.234 <u>0.033</u>	0.230 0.139 <u>0.091</u>	0.192 0.273 <u>-0.081</u>	0.168 0.168 <u>0.024</u>
Min. Temp. Dev.	0.192 0.184 <u>0.008</u>	0.236 0.141 <u>0.095</u>	0.221 0.103 <u>0.188</u>	0.192 N/A	0.236 0.056 <u>0.180</u>	0.221 0.020 <u>0.201</u>	0.135 N/A	0.135 0.308 <u>-0.173</u>
T at 33.50	-1.170 -1.120 <u>-0.050</u>	-1.312 -1.120 <u>-0.115</u>	-1.185 -1.196 <u>0.011</u>	-1.170 -1.169 <u>-0.001</u>	-1.312 -1.245 <u>-0.067</u>	-1.185 -1.309 <u>0.124</u>	-1.260 -1.239 <u>-0.021</u>	-1.260 -1.228 <u>-0.032</u>
T at 33.90	-0.845 -0.787 <u>-0.058</u>	-0.966 -0.865 <u>-0.101</u>	-0.836 -0.863 <u>0.027</u>	-0.845 -0.851 <u>0.006</u>	-0.966 -0.956 <u>-0.010</u>	-0.836 -0.964 <u>0.128</u>	-0.910 -0.968 <u>0.058</u>	-0.910 -0.902 <u>-0.008</u>
T at S =	34.701 0.128 0.113 <u>0.015</u>	34.777 0.246 0.221 <u>0.025</u>	34.799 0.279 0.264 <u>0.015</u>	<34.52 N/A	34.764 0.230 0.122 <u>0.108</u>	34.799 0.279 0.147 <u>0.132</u>	34.830 0.297 0.210 <u>0.087</u>	34.730 0.148 0.170 <u>-0.022</u>

Within the Atlantic Water, a small increase in temperature of approximately 0.015 to 0.025°C is evident for 1983 as compared to 1982 (Figure 52). While these differences are small in terms of the spatial variations within the Queen Elizabeth Islands (changes of up to 0.05°C as shown in Figure 45b), and in comparison to the measurement accuracy of the instrument, the fact that all three locations exhibit approximately the same change in temperature suggests that the result may be meaningful or a systematic error. Larger differences exist between the 1983 and the 1979 results with the temperatures of 1983 being larger by up to 0.132°C for equal near-bottom salinities. Some of these differences could result from systematic calibration errors.

Central Sill Region

Data from the 1982 and 1983 Penny Strait sections may be used to examine year-to-year variability in the central sill region. The Barrow Strait portion of the central sill region has been intensively investigated by the Bayfield Laboratory, and its discussion will be left to them, except for comment on the test casts taken in Barrow Strait as part of the program described in this report. In both 1982 and 1983 one station was occupied on the south side of Barrow Strait (Station BL46 in 1982, Station 090 in 1983). The only significant difference found between the two profiles was the depth of the mixed layer, which was 55 m in 1982 and 35 m in 1983.

In Penny Strait, significant differences in the distribution of water properties across the channel were apparent. T-S curves from the section for both 1982 and 1983 are shown in Figure 53. In both years, the T-S curves are straight lines, the result of strong mixing in the channel. However, in 1983, the properties are more uniform across the channel, and the envelope of the curves is shifted to slightly higher temperatures and lower salinities. At 5 dbar, the decrease in salinity (Table 8) is largest on the eastern side of the strait, with values of 0.25. Temperatures in the surface layer are markedly higher, with deviation from the freezing temperature increasing by amounts ranging from 0.019°C to 0.182°C (A03). The decrease in variation of water properties across the channel is reflected in the reduced cross-channel gradients and weaker geostrophic flow in 1983 compared to 1982 discussed in Section 4.3. The shift of the 1983 T-S envelope for Penny Strait to temperatures higher by approximately 0.020°C and salinities lower by approximately 0.05 does not appear to be due to tidal advection of a property gradient through the Strait such as that discussed by Topham et al. (1983). Because the T-S curves for stations A08 and A06, located north and south of Penny Strait, respectively, bracket the 1983 Penny Strait envelope, but not the 1982 envelope, it is unlikely that this difference in position of the two envelopes could be due to their being measured at different phases of the tide. No excursion in 1983, no matter how great could introduce water to Penny Strait which would coincide with the 1982 envelope.

Prince Regent Inlet and Lancaster Sound

Changes are generally small and lack consistency for near-surface salinity and mixed layer depth between 1983 and 1982 (see Table 9). However, a change in the structure of the cold halocline in both Prince Regent Inlet and Lancaster Sound is apparent when data from 1982 and 1983 are compared. Figure 54 shows vertical profiles at station L04 in Prince Regent Inlet taken in 1982 and 1983. In 1983 the water column between 100 and 250 m is approximately

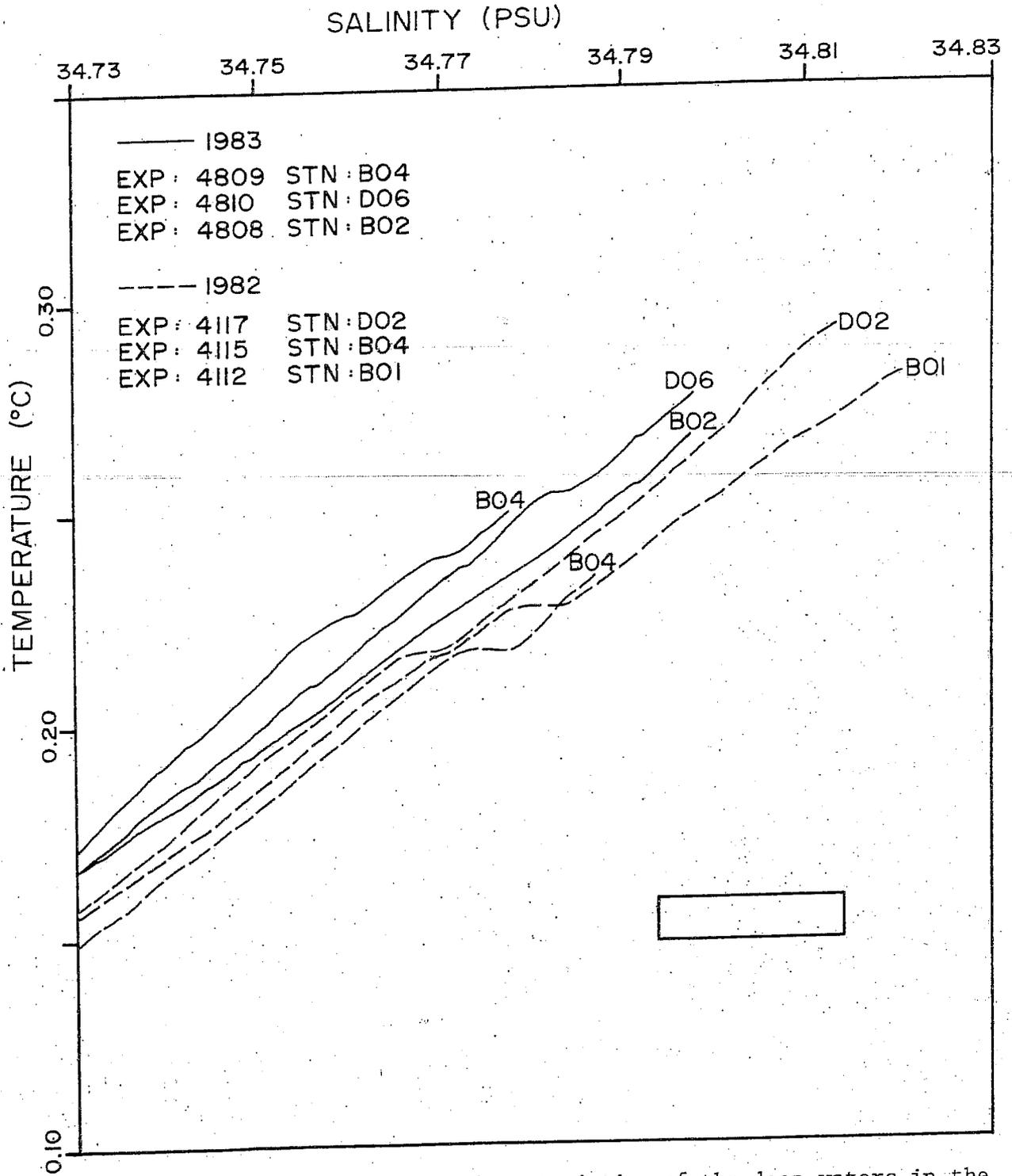


Figure 52: Temperature-salinity characteristics of the deep waters in the Queen Elizabeth Islands for CTD profiles obtained in March 1982 and March 1983. The rectangle represents the observational accuracy of the CTD data.

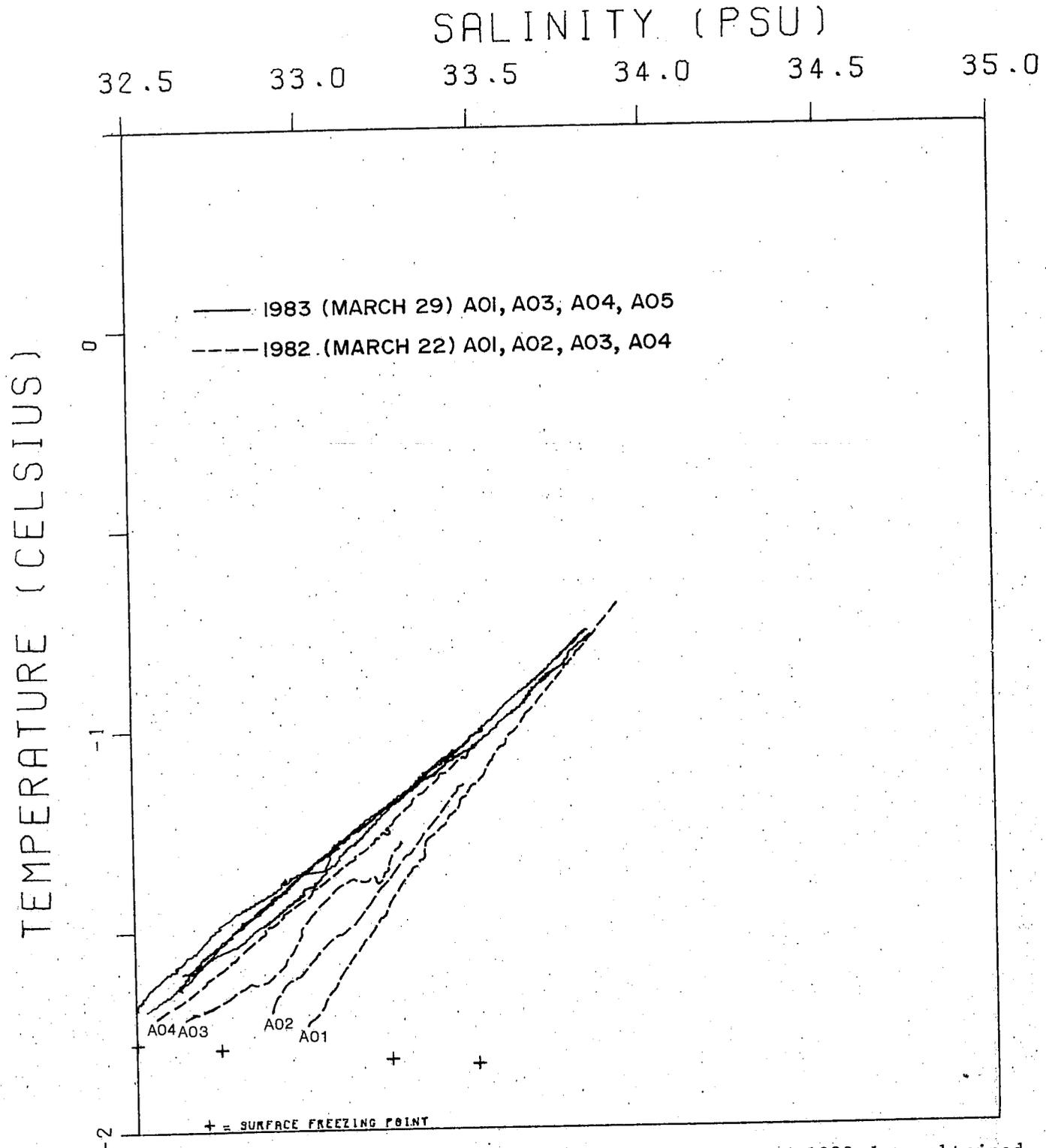


Figure 53: Temperature-salinity diagrams for the 1982 and 1983 data obtained in Penny Strait.

Table 8

A comparison of oceanographic conditions for Penny Strait stations occupied in the spring for both 1983 and 1982. For each quantity, the order of numerical values is the 1983 value, the 1982 value and the change from 1982 to 1983. Of the 1983 stations, the first occupation of A02 (experiment no. 4835) and the second occupation of A03 (experiment no. 4843) were used.

Station	A02	A05	A03	A04
Distance from '82 Stn	6 km N of A01	1.5 km N of A02	2.5 km N	2 km NE
S at 5 dbar	32.76 33.01 <u>-0.25</u>	32.64 32.90 <u>-0.26</u>	32.82 32.62 <u>0.20</u>	32.53 32.55 <u>-0.02</u>
T-T _f at 5 dbar	0.160 0.073 <u>0.087</u>	0.184 0.090 <u>0.094</u>	0.242 0.059 <u>0.183</u>	0.086 0.067 <u>0.019</u>
T at 33.0	-1.445 N/A	-1.406 -1.596 <u>0.190</u>	-1.378 -1.495 <u>0.117</u>	-1.356 -1.418 <u>0.062</u>
T at S =	33.50 -1.035 -1.137 <u>0.102</u>	33.40 -1.088 -1.211 <u>0.123</u>	N/A	33.40 -1.082 -1.120 <u>0.038</u>

Table 9

A comparison of oceanographic conditions for Prince Regent Inlet stations occupied in the spring for both 1983 and 1982. For each quantity, the order of numerical values is the 1983 value, the 1982 value and the change from 1982 to 1983.

Station	090	N01	N07	L01	L02	L03	L04	L05	L06
Distance from '82 Stn	2.2 km W	2.5 km SSW	6.0 km NE of N04	9.8 km WE	1.1 km N	2.6 km N	1.4 km NE	3.3 km S	4.7 km W
M.L. Depth	35 55 -20	38 28 10	20 21 -1	23 19 4	34 15 19	11 15 -4	11 48 -37	51 57 -6	50 34 16
S at 5 dbar	32.40 32.45 -0.05	32.79 32.82 -0.03	32.71 32.35 0.36	32.39 32.70 -0.31	32.28 32.45 -0.07	32.49 32.31 0.18	32.45 32.14 0.31	32.37 32.1 0.21	32.36 32.13 0.23
Mean Temp. Dev.	0.200 0.267 -0.067	0.015 0.112 -0.097	0.043 0.115 -0.072	0.083 0.110 -0.027	0.083 0.171 -0.088	0.113 0.098 0.015	0.096 0.133 -0.037	0.101 0.223 -0.122	0.078 0.155 -0.077
Min. Temp. Dev.	N/A	0.127 0.054 0.073	0.106 0.136 -0.030	0.015 0.116 -0.101	0.012 0.064 -0.052	0.115 0.066 0.049	0.000 0.035 -0.035	0.019 0.136 -0.117	0.000 0.035 -0.035
T at 33.00	-1.454 -1.354 -0.100	-1.743 -1.612 -0.131	-1.691 -1.531 -0.160	-1.649 -1.536 -0.113	-1.545 -1.483 -0.062	-1.678 -1.537 -0.141	-1.550 -1.455 -0.085	-1.511 -1.461 -0.050	-1.670 -1.465 -0.205
T at 33.50	N/A	-1.187 -1.570 0.383	-1.106 -1.665 0.559	-1.105 -1.275 0.170	-1.158 -1.246 0.088	-1.167 -1.247 0.080	-1.104 -1.292 0.188	-1.184 -1.280 0.096	-1.166 -1.256 0.090
T at 33.90	N/A	-0.584 -0.400 -0.180	-0.565 -0.509 -0.056	-0.516 N/A	-0.496 N/A	-0.610 -0.698 0.088	-0.626 -0.748 0.122	-0.615 -0.696 0.081	N/A
T at S =	N/A	34.146 0.186 0.008 0.078	34.191 0.355 0.232 0.123	N/A	N/A	34.165 0.186 0.130 0.056	34.214 0.293 0.255 0.038	N/A	N/A

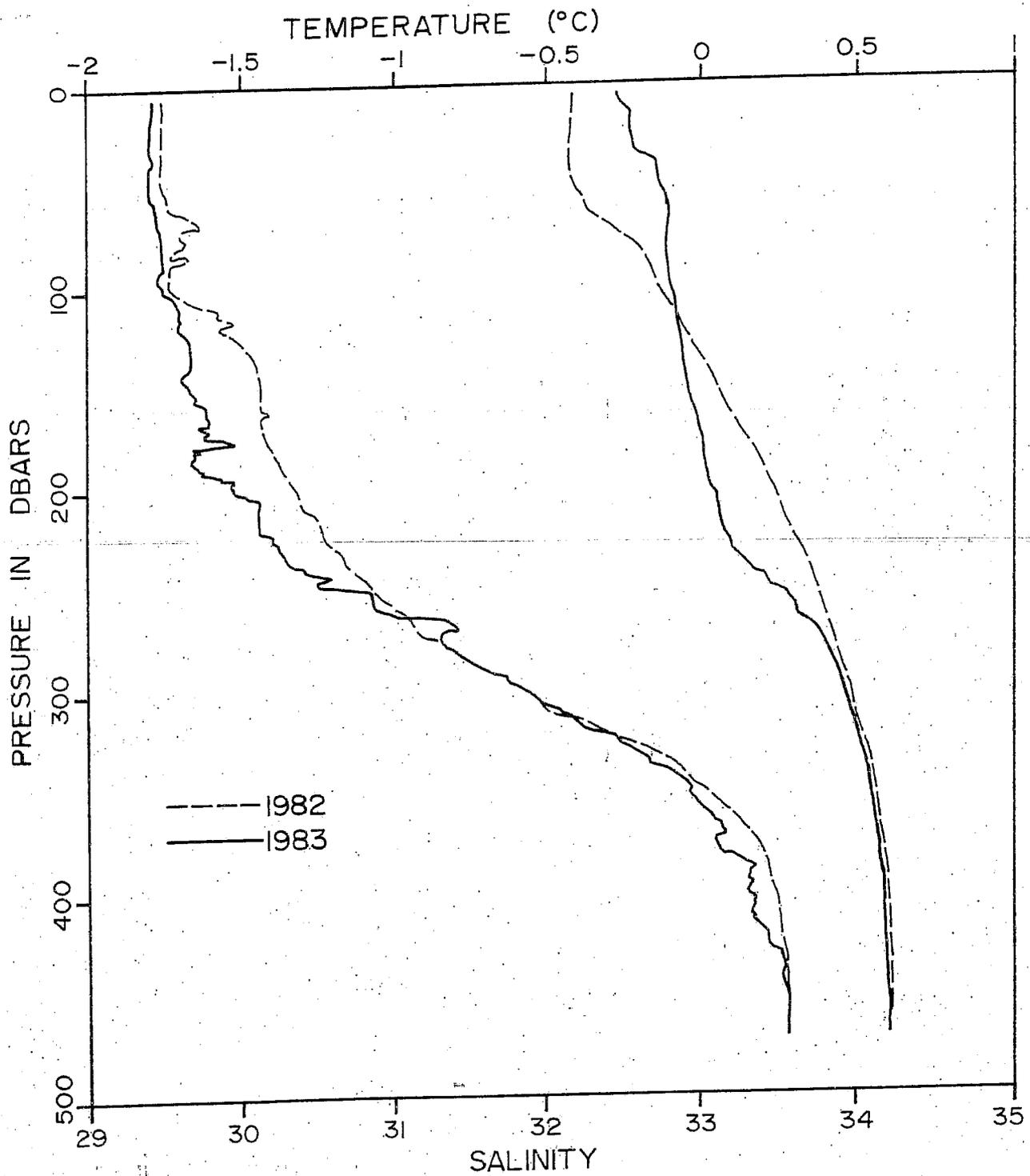


Figure 54: Comparison profiles for temperature and salinity obtained at station L04 on March 30, 1983 (solid line) and April 5, 1982 (dashed line).

0.25°C colder than in 1982, and the salinity gradient is less steep. The difference is not confined to station L04 as evident in the reduction in mean temperature deviations and in temperature at a salinity of 33.0 (cold halocline level) from 1983 to 1982 (Table 9). This temperature reduction is also seen in Figure 55 which shows the family of T-S curves for the Prince Regent Inlet section in 1982 and 1983. The 1983 data show the cold halocline penetrating to salinities between 33.00 and 33.10, whereas in 1982 it was limited to salinities less than 32.94. In the main thermocline, the T-S curves are straighter in 1983, suggesting that more mixing was taking place in 1983 than 1982. Figure 56 demonstrates the same increased linearity in the thermocline in Lancaster Sound, although the curves exhibit too much smaller scale variability in the cold halocline region to reveal whether differences similar to those observed in Prince Regent Inlet are also present.

In Prince Regent Inlet and in Lancaster Sound comparison of the 1983 and 1982 data suggests the occurrence of year-to-year variations in the advection of water into the cold halocline, and in the mixing between the Atlantic and Arctic water masses. The changes in the penetration of the cold halocline between the springs of 1982 and 1983 and the summer of 1979 are shown in Figure 57. The summer data shows the cold halocline penetrating to salinities greater than 33.75, far above the spring values observed in either 1982 or 1983.

Year-to-year changes in the T-S properties of the Atlantic Water in Lancaster Sound and Prince Regent Inlet were also observed (Figure 58). The most striking differences are in Lancaster Sound, where in 1983 the Atlantic Water was warmer by 0.02 to 0.10°C, and included salinities from 0.04 to 0.10 higher than those observed in 1982. In Prince Regent Inlet, the Atlantic Water did not appear to be significantly warmer, but was approximately 0.02 lower in salinity.

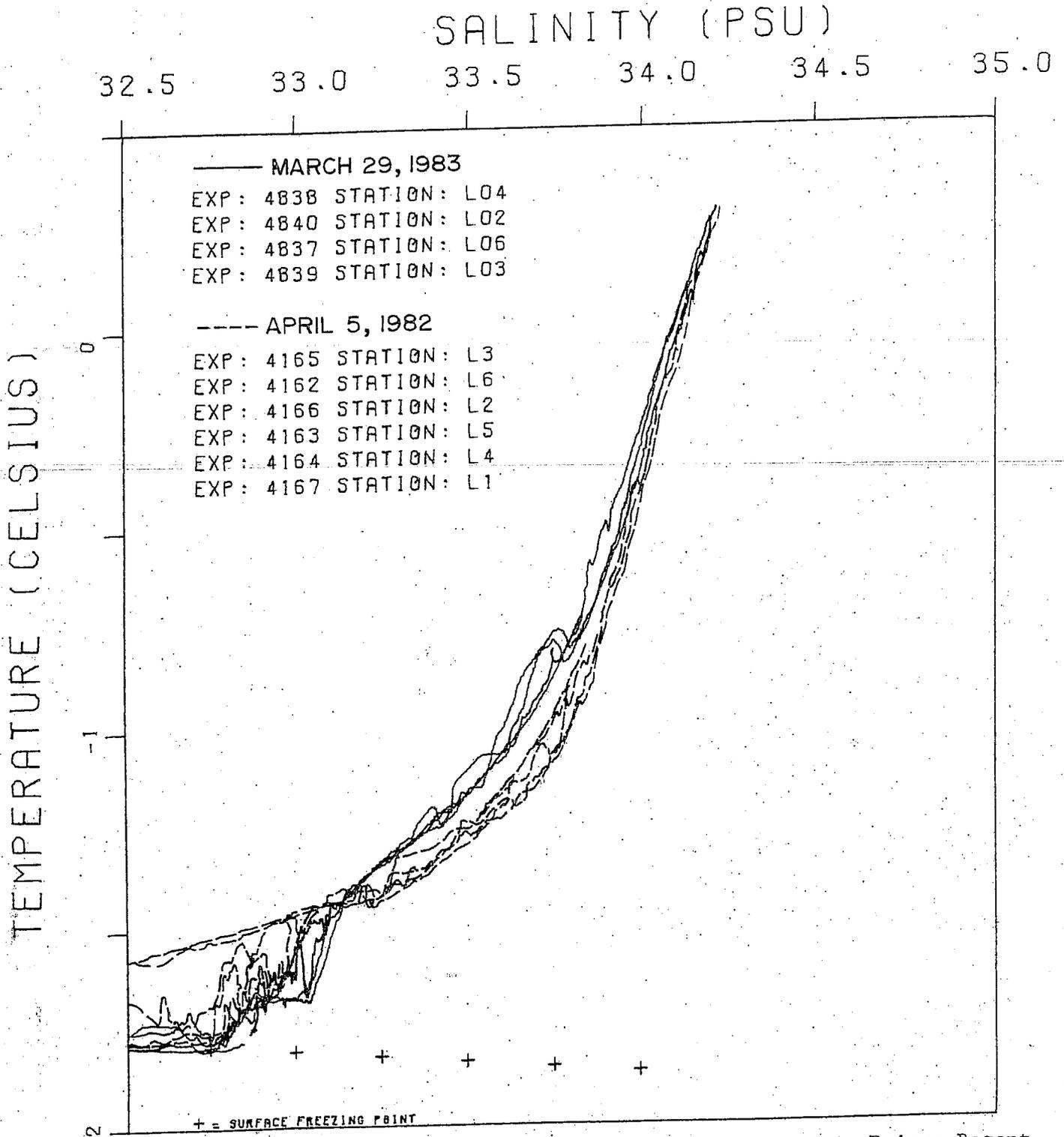


Figure 55: Temperature-salinity diagrams for selected stations in Prince Regent Inlet, obtained on March 30, 1983 and April 5, 1982.

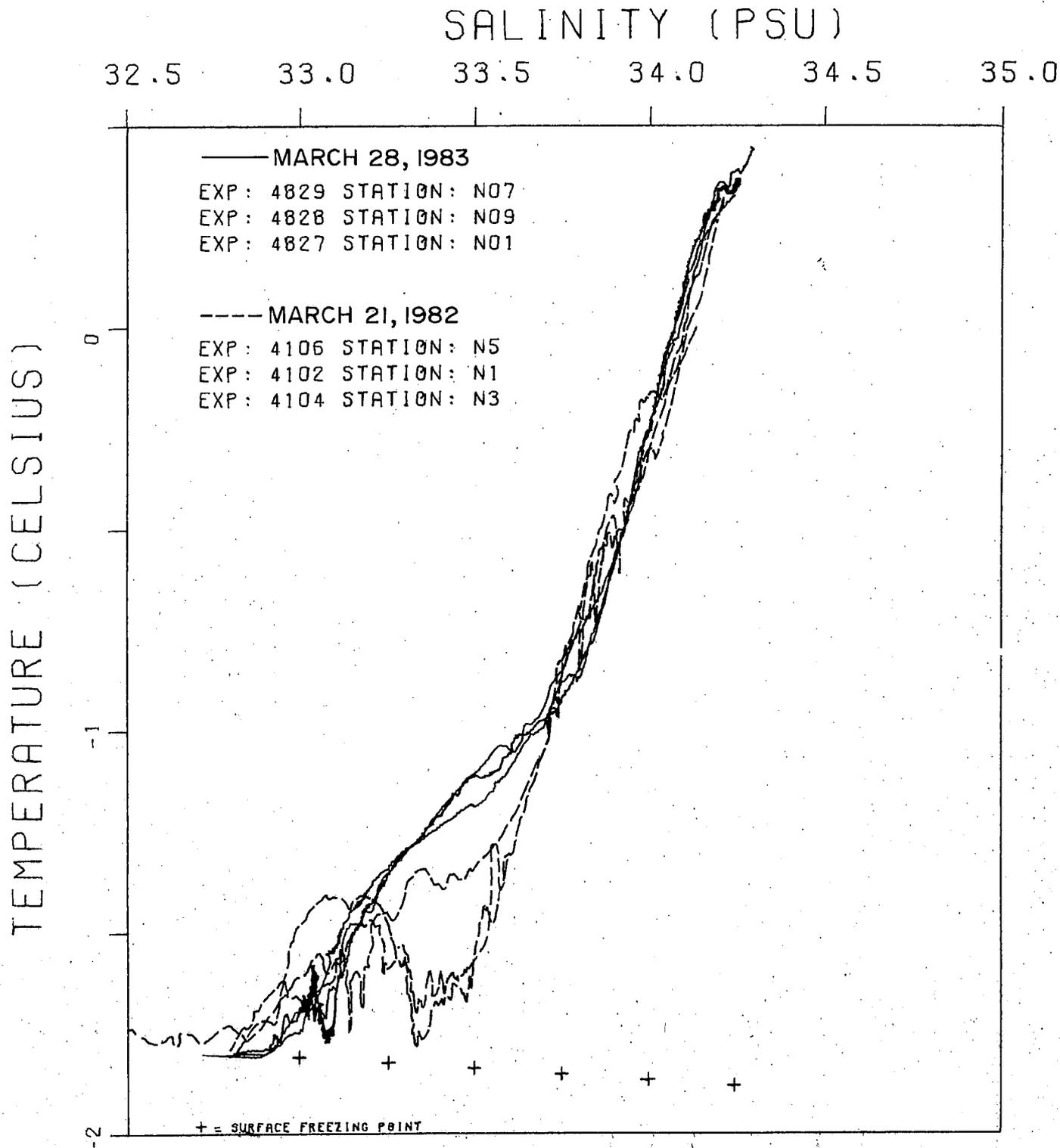


Figure 56: Temperature-salinity diagrams for selected stations in Lancaster Sound, obtained on March 28, 1983 and March 21, 1982.

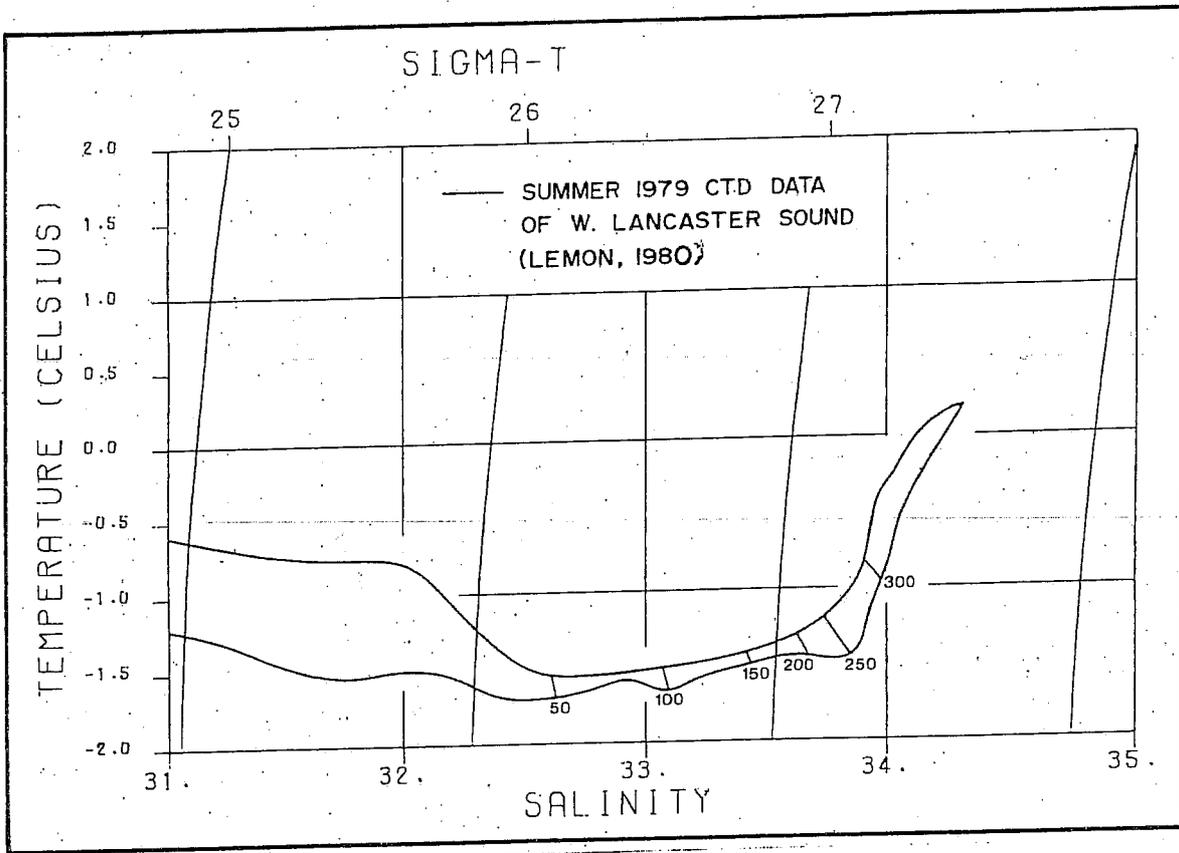


Figure 57: The envelope of T-S curves for CTD stations of western Lancaster Sound and northern Prince Regent Inlet, occupied in the summer of 1979.

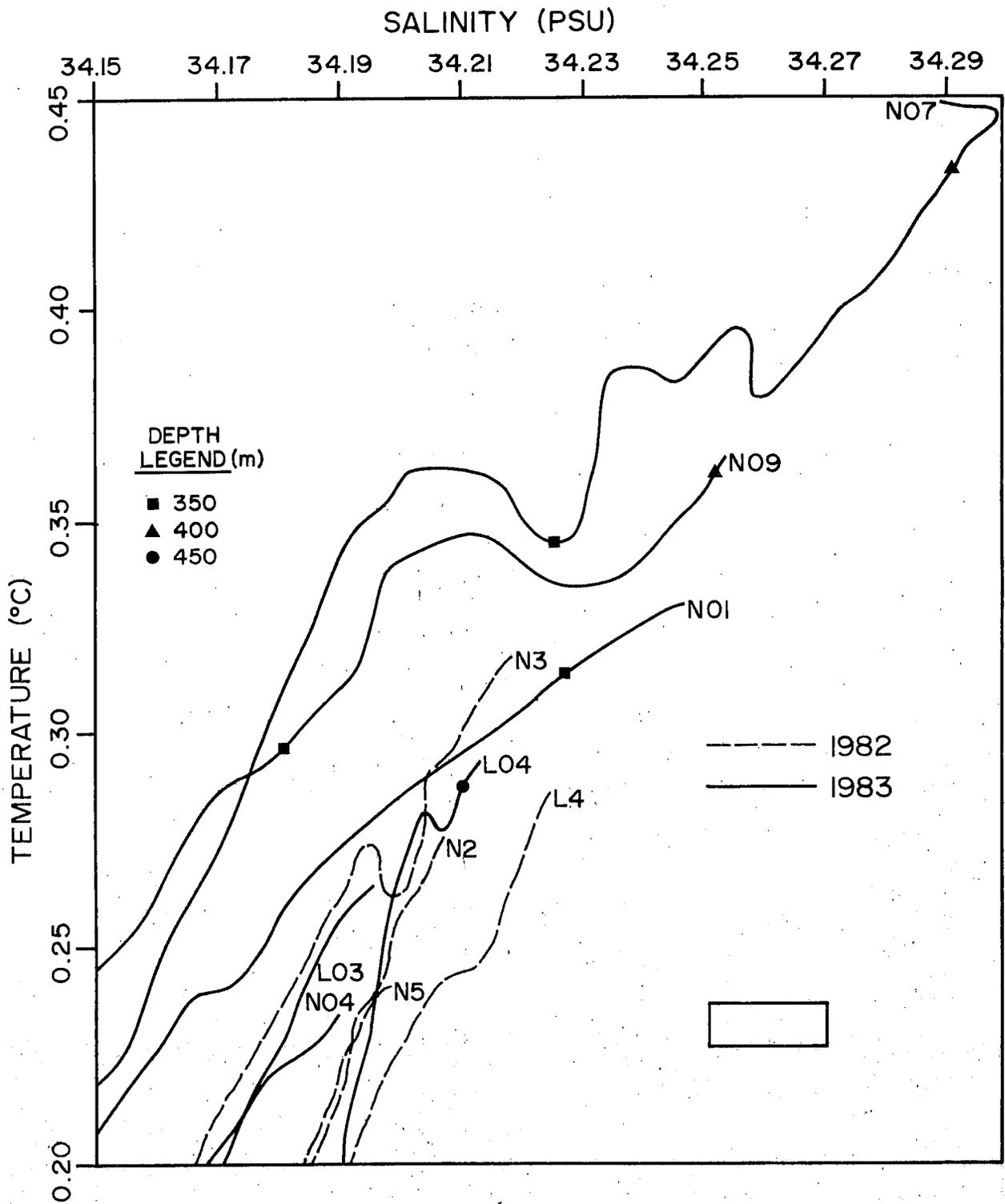


Figure 58: Comparison of detailed T-S curves in the Atlantic Water in Prince Regent and Lancaster Sound, 1982 and 1983.

5. SUMMARY AND CONCLUSIONS

From March 20 to April 2, 1983, a total of 53 CTD casts were obtained through the sea-ice at 43 widely separated locations within the Canadian Arctic Archipelago. Water samples were collected at 19 of these locations for subsequent chemical analysis of dissolved nutrients (nitrate, phosphate and silicate). These data were collected as part of a series of coordinated oceanographic field studies begun in the spring of 1982 (Fissel et al., 1983; Melling et al., 1984).

Vertical sections of temperature and salinity from the Arctic Ocean to Lancaster Sound were constructed over two transects: through the length of Parry Channel and through the Queen Elizabeth Islands-Penny Strait-Wellington Channel-Lancaster Sound region. From the Arctic Ocean to the shallow central sills near Cornwallis Island, an overall trend of increasing temperatures and salinities towards the east is evident in the uppermost 200 m. The horizontal gradients are largest over the continental slope and over the steep rise to the central sills. Over the shallow central area of Barrow Strait and Penny Strait to Wellington Channel, the water column is very well mixed as evident in the relatively small vertical gradients and very linear temperature-salinity curves. To the east of the central shallow area, the water column is marked by very low, near-freezing temperatures appearing to depths of 200 m or more at relatively high salinities.

The near-surface circulation, as inferred from computed baroclinic geostrophic shears, is similar in overall pattern to the results for the spring of 1982. Flows were generally directed towards Parry Channel from adjoining waterways with a net easterly flow through the Channel. Flows are weak ($<2 \text{ cms}^{-1}$) through the channels of the Queen Elizabeth Islands, except in Penny Strait where the flows reached speeds of 5 cms^{-1} . Near-surface currents were also weak and directed towards eastern Parry Channel in both eastern M'Clure Strait ($<1 \text{ cms}^{-1}$) and Prince Regent Inlet ($<2 \text{ cms}^{-1}$ to the north). These inflows apparently result in a net eastward flow through Lancaster Sound, as indicated by computed speeds of up to 12 cms^{-1} across the northern half of the Sound. The near-surface geostrophic flow over the Arctic Ocean continental shelf was uniformly southeastward and weak ($<2 \text{ cms}^{-1}$) except over the continental slope where speeds of 5 cms^{-1} were determined off M'Clure Strait.

The surface mixed layer became more saline from the Arctic Ocean continental slope (31.3) and shelf (31.5) through the western Archipelago (31.5-32.5) to the vicinity of the central shallow sills (32.5-33.0). To the east of the sills, the salinity decreased (32.3-32.8). Over some of the central passages of the Archipelago (Penny Strait, Queens Channel, Wellington Channel), mixed layer temperatures were markedly higher (by 0.044 to 0.242C°) than freezing; elsewhere deviations from freezing temperature in the mixed layer were generally within 0.010C° .

Beneath the mixed layer, temperature maximum and minimum layers were observed over the Arctic Ocean continental slope and shelf and at most locations in the western Archipelago. These features, particularly the temperature maximum, were much less apparent in the eastern Archipelago, and did not exist in most of the central passages. The mean freezing temperature deviations from the mixed layer to the cold halocline are markedly reduced in the eastern Archipelago channels of Lancaster Sound and Prince Regent Inlet

(0.05 to 0.11C°) by comparison to the western Archipelago (0.17 to 0.33C°). Lower values in the east may well result from greater heat losses to the atmosphere in autumn and winter because of later ice cover stabilization in these areas, and from the existence of lateral intrusions of near freezing water from Baffin Bay, where the ice cover remains thinner and unconsolidated throughout the year.

In the central passages, the properties of the surface and subsurface layers (warm, saline water near the surface and linear T-S characteristics) reflect a considerable degree of vertical mixing, resulting in an upward transport of heat. A time series of CTD profiles (every half hour over a 3-hour period) obtained at one site revealed vertical excursions of isopleths of up to 25 m in amplitude, indicative of internal wave activity. The appearance or disappearance of particular step-like features from one profile to another provides further evidence of the occurrence of significant mixing in Penny Strait.

In the main thermocline layer, spatially coherent, large-scale patterns were evident in T-S properties over the Arctic Ocean continental shelf and within the channels of the western Archipelago. Over the continental shelf, T-S curves exhibited an increasing degree of linearity and lower temperatures on isohaline surfaces with progression from the area north of Ellesmere Island southwest to the area adjacent to M'Clure Strait. These changes likely reflect an increasing influence of the penetration of near-freezing surface waters deep into the halocline, associated with the greater amount of ice formation with progression towards the southeast Beaufort Sea (Melling and Lewis, 1982).

Within the western Archipelago, the temperature increases on isohaline surfaces from the continental shelf to the vicinity of the shallow central passages. The increases in temperatures are larger within the Queen Elizabeth Islands (0.29C° at 33.5, 0.40C° at 33.9) than within western Parry Channel (0.26C° at 33.5, 0.21C° at 33.9). The overall horizontal gradients in the Queen Elizabeth Islands are larger by a factor of two on the 33.5 isohaline surface and by a factor of four on the 33.9 isohaline surface, than those in western Parry Channel. While the warming of the waters of main thermocline must be a result of heat uptake from the underlying Atlantic Water, the reasons for the difference in heat uptake between these two regions is not clear. Possible causes include differences in: advective motion (likely lower in the Queen Elizabeth Islands), the intensity of vertical mixing, the loss of heat to the overlying subsurface and surface (likely less in the Queen Elizabeth Islands) and the value of $\frac{\partial T}{\partial z}$. Additional research is required to determine the relative importance of these explanations.

In the Atlantic Water Mass, temperatures decreased markedly between the Arctic Ocean continental slope and the western entrances of M'Clure Strait and Prince Gustaf Adolf Sea. The difference on the 33.83 isohaline surface amounted to as much as 0.100C° in the former area and 0.050C° in the latter. Within the channels of the western Archipelago proper, the horizontal gradients were reduced in magnitude, and differences among stations were generally less than the measurement accuracy. While the cooling of Atlantic Water is reduced with increasing eastward displacement from the continental shelf through the western Archipelago, the warming in the overlying thermocline is increased. This inconsistency in the horizontal gradients provides further evidence supporting the conclusion of Melling et al. (1984)

that while within the Arctic Ocean the upward diffusion of heat from the Atlantic Water is balanced by intrusions of near-freezing water, within the western Archipelago, where the upward diffusion of heat from the Atlantic Water still persists, heat losses within the main thermocline due to intruding near-freezing waters are reduced; the result is a progressive warming.

The temperature of the Atlantic Water at salinities of 34.85 or less measured over the continental slope off M'Clure Strait (station E09) is higher than temperatures observed to the south over the continental slope in the Beaufort Sea in 1981 (Melling et al., 1984). The higher temperatures at station E09 may be evidence of a direct flow of Atlantic water from the Chukchi Plateau to the continental slope off the western Archipelago, as inferred previously by Newton and Coachman (1974).

Detailed comparisons were made of the 1983 CTD data with those obtained one year earlier (Fissel et al., 1984; FSRG, unpublished data). At virtually all of the measurement locations in the western Archipelago, the near-surface salinities of 1983 were reduced by amounts of up to 0.73. Accompanying the reduction in near-surface salinity at most, but not all locations, were decreases in mixed layer depth and an increase in the mean freezing temperature deviation from the base of the mixed layer to the cold halocline. Such differences are consistent with a reduction in heat losses to the surface in the previous autumn and early winter. Such would result in less convective penetration into the upper portion of the water column, and therefore reduced near-surface salinities and mixed layer depths, and a reduced degree of erosion of the underlying temperature maximum layer.

By contrast, a greater degree of cooling may have occurred in the surface and subsurface layers of Lancaster Sound and Prince Regent Inlet. In these areas, the water column is notably cooler, as evident in the penetration of near-freezing temperatures to greater depths and the corresponding reduction in the mean and minimum freezing temperature deviation.

At greater depths, marked reductions of 0.07 to 0.12°C in temperature occurred within the main thermocline at locations in eastern M'Clure Strait and Maclean Strait from 1982 to 1983. An accompanying increase in Atlantic Water temperatures of one-third to one-fifth the magnitude (0.017 to 0.029°C), perhaps largely attributable to observational uncertainty, was observed at these same sites. The combined reduction in warming of thermocline waters and cooling of the Atlantic Water, may reflect less heat uptake from below at these locations in 1983 than for 1982. Interannual variability was also evident in the main thermocline and in Atlantic Waters of Lancaster Sound and Prince Regent Inlet: Atlantic Water temperatures increased for common salinities from 1982 to 1983, while changes in the main thermocline varied substantially, in both amplitude and sign, among locations.

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