NORSK POLARINSTITUTT

RAPPORTSERIE

NR. 73 OSLO 1991

VLADIMIR PAVLOV, ARNE FOLDVIK, BORIS IVANOV and TORGNY VINJE

SOVIET - NORWEGIAN OCEANOGRAPHIC PROGRAMME 1988 - 1992

CRUISE REPORTS 1990

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CRUISE REPORT

R/V LANCE

19 JULY - 16 AUGUST 1990

Cruise report
R/V "LANCE" SNOP - 90

Arne Foldvik[1]

Geophysical Institute, University of Bergen was responsible for the Norwegian contribution to the 1990 field program of the Soviet-Norwegian Oceanographic Programme (SNOP) carried out onboard the R/V LANCE. The expedition started out from Longyearbyen July 19 and was terminated in Longyearbyen August 16. It included participants from the following institutions: AARI (3), NP (6), NTH (2) and UiB (4) (see attached list of participants). Professor A. Foldvik, Geophysical Institute, University of Bergen was the scientific leader and Dr. T. Vinje, Norwegian Polar Research Institute cruise leader.

The first part of the cruise took place in the Barents Sea in collaboration with R/V PROFESSOR MULTANOVSKY and the icebreaker OTTO SCHMIDT. The three vessels met at 35° E during July 21-22. The scientific programme consisted of hydrographic measurements, sea-ice and iceberg investigations and retrieval and deployment of currentmeter rigs. During this phase of the expedition a total of 51 CTD stations were obtained and 7 icestations were carried out on drifting ice and icebergs. Also, two currentmeter rigs with upward looking sonars for ice thickness measurements were deployed.

An attempt to recover two currentmeter moorings deployed in 1989 in the strait between Nordaustlandet and Kvitøya failed. The moorings did not respond to the acoustic releases and a systematic survey using side-looking sonar gave no results. An explanation might be that large icebergs dragged the rigs out of position. Lots of icebergs were observed north of Kvitøya, some of them had an estimated draft of 60-70 m. Due to problems when trying to recover a currentmeter rig near Franz Josef Land, R/V PROFESSOR MULTANOVSKY asked for technical assistance. Hence R/V LANCE sailed into the Soviet economic zone to 50° E. No observations could be made during this part of the cruise.

During the first leg of the cruise CTD measurements were made by helicopter in a lake on Nordaustlandet showing 52 salinity near the bottom (40m). The Norwegian Polar Institute continued this investigation later in the season.

The second part of the expedition took part in the Fram Strait and in the Greenland Sea starting out from Ny Ålesund August 2. An advanced telemetering currentmeter rig belonging to Woods Hole Oceanographic Institution was recovered in the eastern Fram Strait. One currentmeter rig with three currentmeters was deployed in the center of the East Greenland Current. In the Boreas Basin and in the Greenland Sea two rigs were deployed for precise measurements of temperature fluctuations. To investigate the current profile near the critical latitude for the semidiurnal tidal component M_2 two rigs were deployed near 74° N. During the second part of the expediton two 12 hours ice stations were achieved. A total of 51 CTD stations were obtained, 20 of these were deep stations belonging to the Greenland Sea Project station network.

[1]Geophysical Institute, University of Bergen, Norway

During the entire expedition a group from Radiological Dating Laboratory, The Norwegian Institute of Technicology, measured CO_2 and radioactive carbon.

Currentmeter stations deployed by R/V LANCE under SNOP-90

Position	Depth	Date	Name
N 77° 40'358" E 26° 27'048"	166m	24.07.90	SNOP-90-01
N 79° 45'148" E 28° 34'012"	205m	31.07.90	SNOP-90-02
N 79° 12'804" E 03° 16'404"	2203m	07.08.90	NP/GI
N 76° 52'248" E 01° 31'530"	3270m	10.08.90	KLIMATE 1
N 74° 18'352" E 01° 28'829"	3800m	12.08.90	KLIMATE 2
N 74° 13'020" E 11° 27'865"	2258m	12.08.90	TIDE S
N 74° 27'628" E 11° 24'030"	2333m	13.08.90	TIDE N

Scientists onboard R/V LANCE during SNOP-90

A. Foldvik, University of Bergen (UiB)
T. Lossius, "
N. Nordlund, "
K. Nytun, "
V. Denisov, AARI, Murmansk
V.E. Kalyazin, AARI, Leningrad
V. Volkov, "
B. Erlingsson, Norwegian Polar Research Institute (NP)
B. Hansen, "
J. Høkedal, "
Å .S. Johnsen, "
T. Vinje, "
S. Østerhus, "
R. Nydal, Radiological dating Laboratory, Norwegian Inst. of Techn.(NTH)
I. Skjelvan, "
A. Bocconcelli, Woods Hole Oceanographic Institution, USA
S. Aronsen, TV-P, Stavanger

S N O P *CRUISE REPORT 1990*

R/V LANCE

SEA ICE INVESTIGATIONS

T. Vinje[1], V. Kalyazin[3], Å.S. Johnsen[1] and B. Erlingsson[1].

General ice conditions

The southern extension of the sea ice in the Western part of the Barents Sea was close to normal for the season. Heavy multi-year ice was encountered in a tongue extending southwestwards from Kvitøya with big floes (500 - 2000 m) with a concentration of 7/10, while thick winter-ice and second-year ice was encountered in the bight northwest of Kvitøya also with a concentration of 7/10.

To meet with R/V Professor Multanovsky near Zemlya Frantsa Iosifa we sailed to the south of the ice-border. Iceberg countings were made only on this trip.

From the Barents Sea we passed the Hinlopen into the Fram Strait. Here also the ice extension was close to normal for the season. The ice consisted of a mixture of multi-year and second-year ice with big (500-2000 m) - to giant floes (> 10 km) as the predominant ice form. The concentrations varied between 2 and 9/10.

The ice border was generally withdrawing during the cruise period. Most of the winter-ice had melted away and the ice floes were extensively covered with puddles but few holes were observed. The snow depth was 5-10 cm. The ridging in the Barents Sea was moderate. The maximum ridge height was 3 m and the maximum extension of ridge coverage was 2/10. In the Fram Strait some of the extensive ice floes were heavily ridged with maximum heights of 8 m and maximum coverage of 3/10.

The sea ice along the two legs were specified according to the WMO ICEOB-code.

---

1 Norwegian Polar Research Institute, Norway

3 Arctic and Antarctic Research Institute, USSR

tv-snopreport-30.9.91

Icebergs

Altogether 350 icebergs were spotted along the cruise track. The densest population was observed between 38 and 48^{0}E (192 icebergs), with a maximum of 55 at 44,5^{0}E. Most of these icebergs were of a pinacular type. About 7 were

tabular with max dimension of 2-300 m and height about 10 m. On the shelf edge north of Storøya 16 tabular icebergs were grounded or partly grounded (as the tide water mark was partly absent). The size varied between 60 and 250 m with heights varying between 12 and 20 m. The water depth close by was 45 - 60 m. Many of these bergs had been broken into 2 or 3 pieces at the grounding site. The largest, partly afloat, was marked with an Argos positioning and temperature measuring stake-buoy drilled 2 m into the ice. Two other, similar buoys were deployed on icebergs east of Kong Karls Land under a project for the oil companies. The next densest iceberg population was observed outside Bråsvell-breen where 10 major and 30 minor pinacular icebergs were spotted from helicopters.

In the passage between Kvitøya and Storøya two moorings deployed from R/V Akademik Shuleykin in August 1989 could not be relocated in spite of extensive surveying of the area with sidescan sonar, asdic and other detecting equipment. Probably, these moorings have been caught by icebergs keels, and redeployed further south in the current. This suspicion was really supported by the later observation of a large number of icebergs to the north of this passage. To obtain the best basis for a large scale search next year (1991) drift modelling and survey of remote sensing images for the season 1989-90 will be carried out in a joint SNOP project between AARI and NP.

Sea ice topography

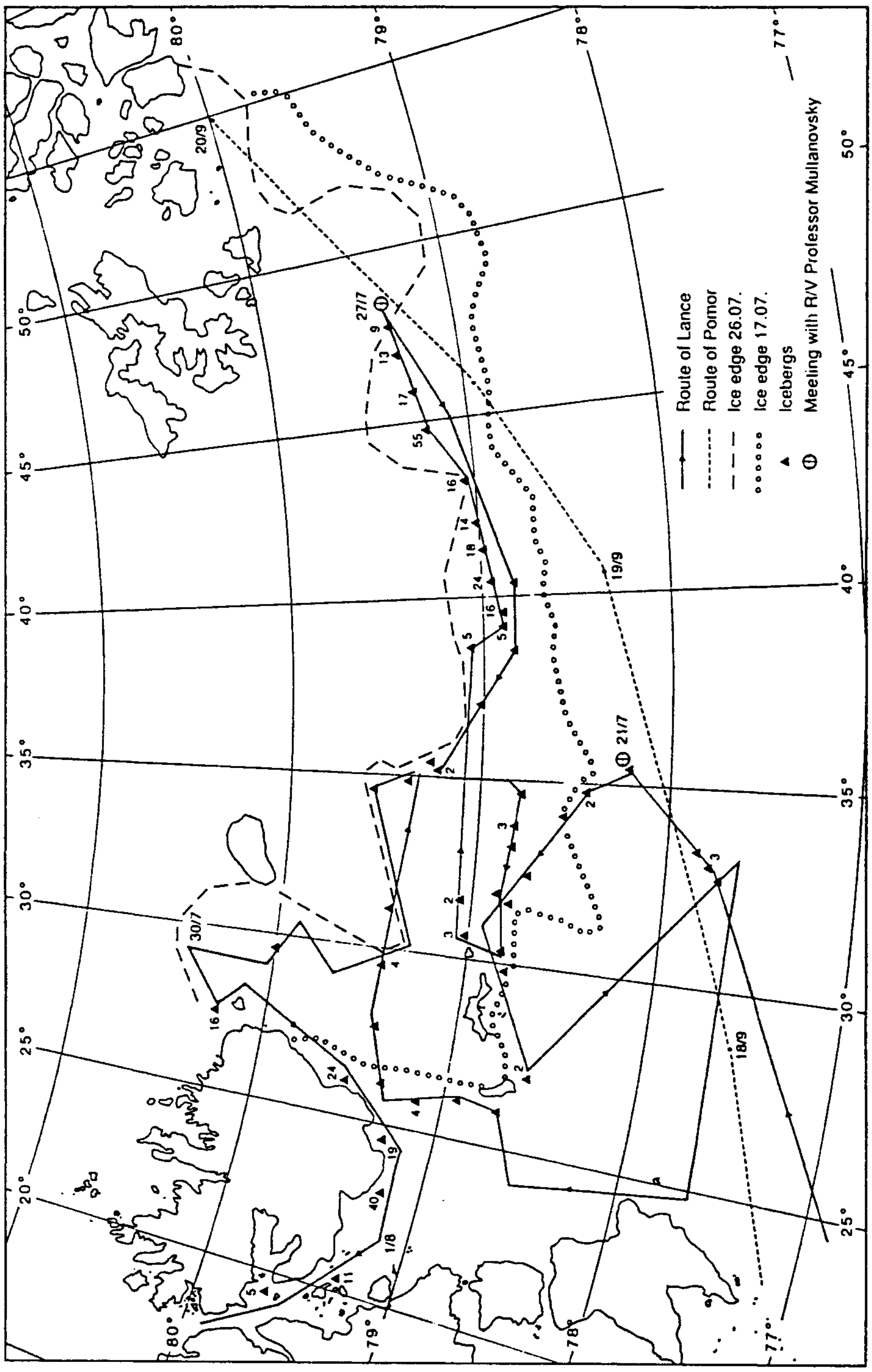
Altogether 45000 m^3 of sea ice was surveyed for study of the relationship between bottom and surface topography. The measurements also give a good estimation of the total ice thickness, ridging included. The bottom and surface topography was surveyed by the use of a Mesotech 971 scanning sonar and sterophoto-graphy. A concordance between the two data sets was secured by the estimation of several common reference points.

Ice drift buoys

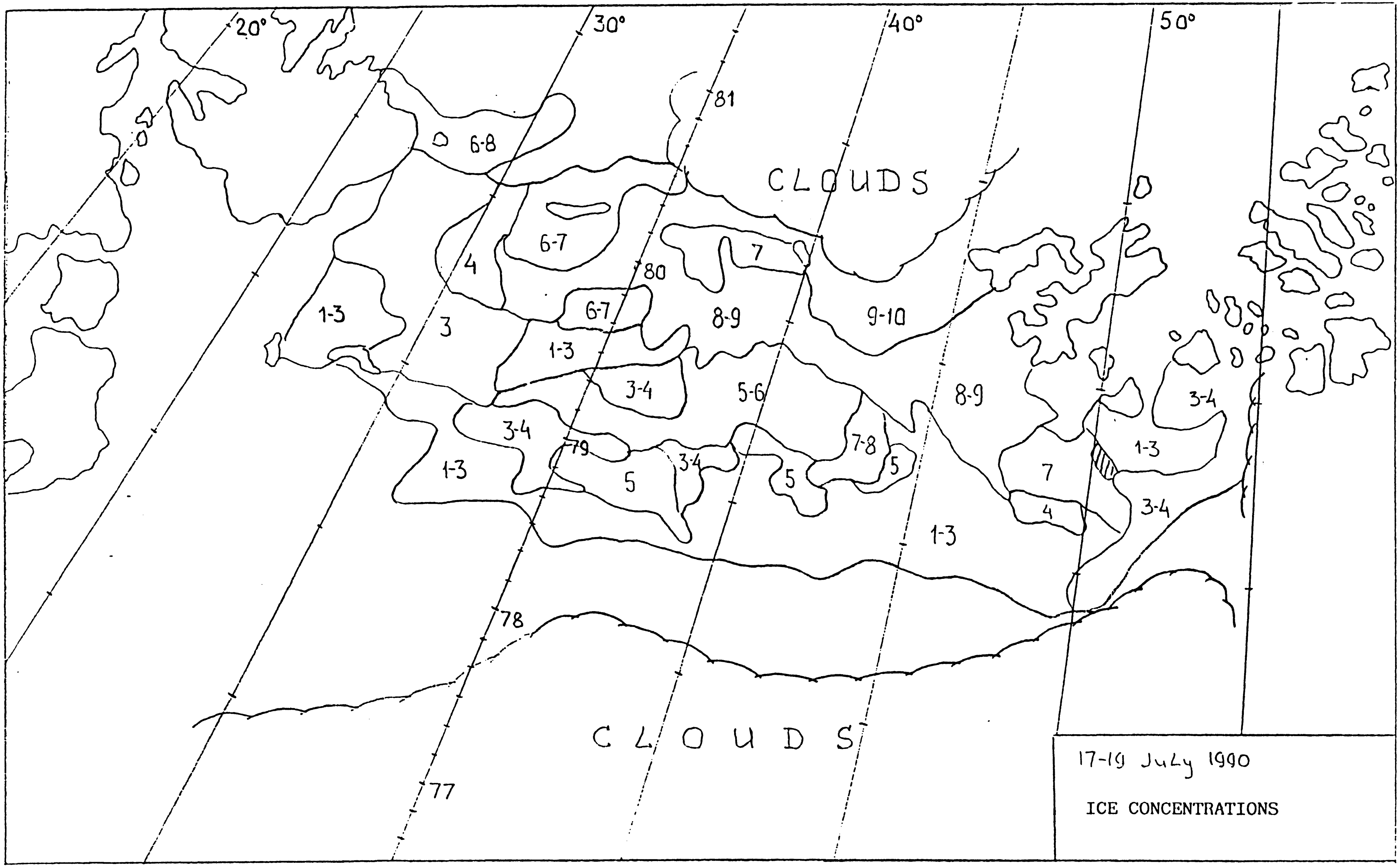
Two Argos positioning buoys were deployed on second-year ice NW of Kvitøya. They will operate for a two year period and give information on the ice exchange rate between the Arctic Ocean and the Barents Sea. The two buoys were deployed fairly close to each other with the intention to study the uniformity in the movement of neighbouring ice floes of different sizes (Ice field entropy).

Automatic ice thickness measurements

Two upward looking sonars (ULS) for ice thickness measure ments were attached to the top of current meter moorings at about 78^{0}N - 27^{0}E and 80^{0}N - 28^{0}E in the Barents Sea and at 79^{0}N - $4^{0}30'$W in the Fram Strait. R/V Polarstern had previously recovered one of our ULS at a position one degree latitude further south and deployed a new one at the same location. The ULS record the ice thickness every 8 minutes and has a battery capacity of 2 years.

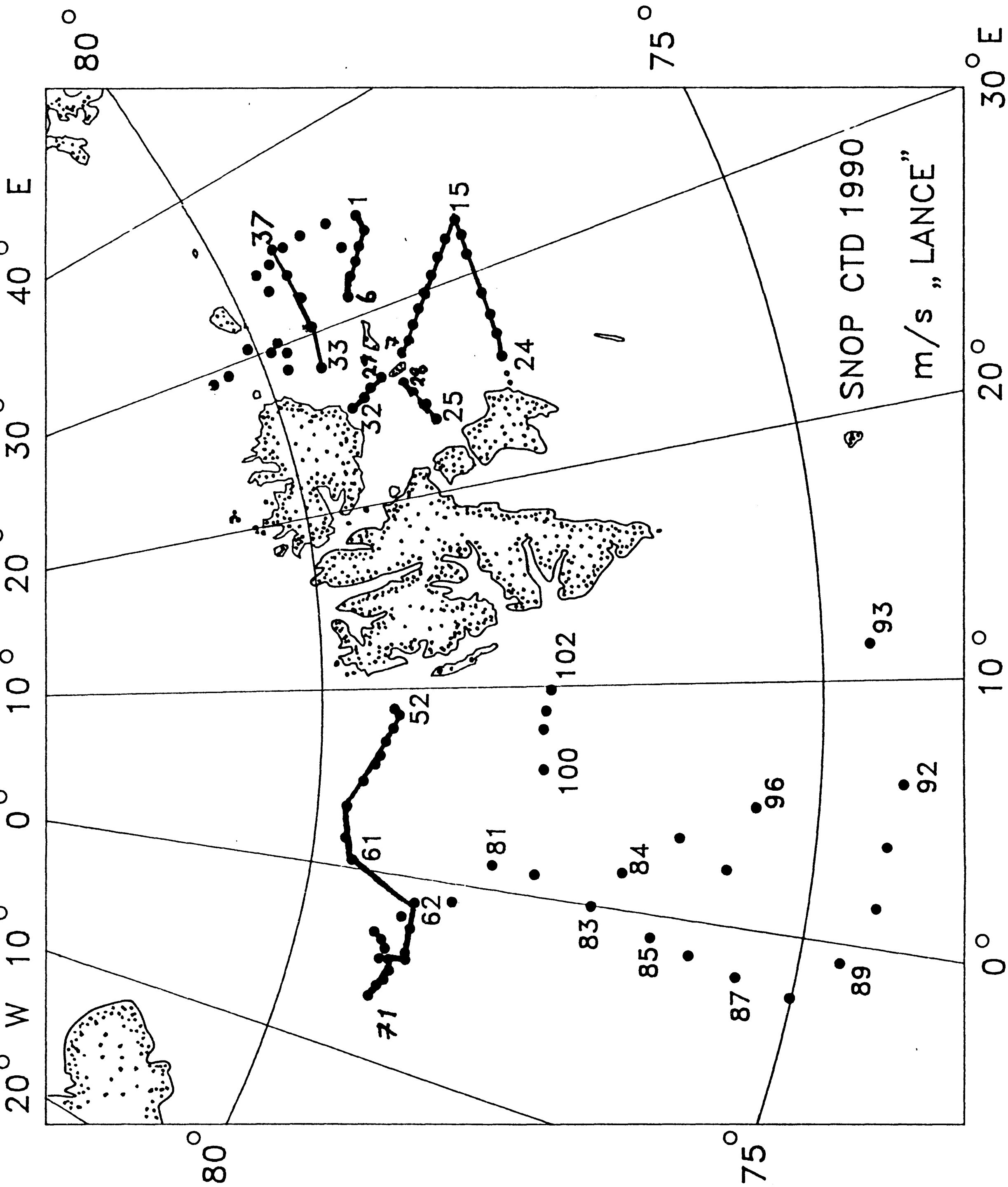


The LANCE cruise track with iceberg observations and sea ice distribution. For a comparison of the iceberg observations the POMOR track is also given (stippled line). Note that no icebergs were observed when crossing the bank SW of ZFI with POMOR about two months after the LANCE crossing of this area.



17-19 July 1990

ICE CONCENTRATIONS


SNOP CTD 1990
m/s „LANCE”
80°
75°
20° W
10°
0°
10°
20°
30°
40° E
30° E
20°
10°
0°
1
6
15
24
25
32
33
37
52
61
62
71
81
83
84
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87
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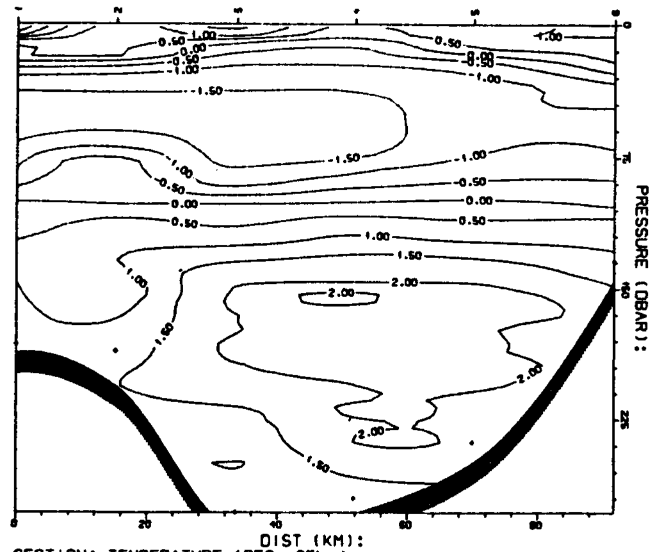
92
93
96
100
102



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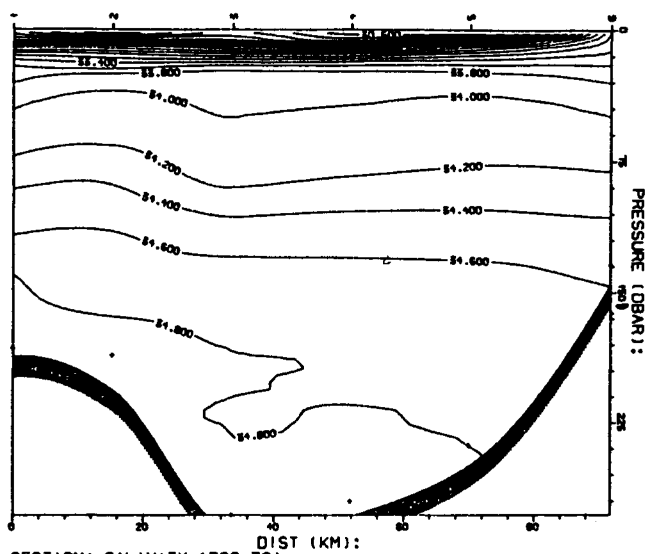
R/V "LANCE"



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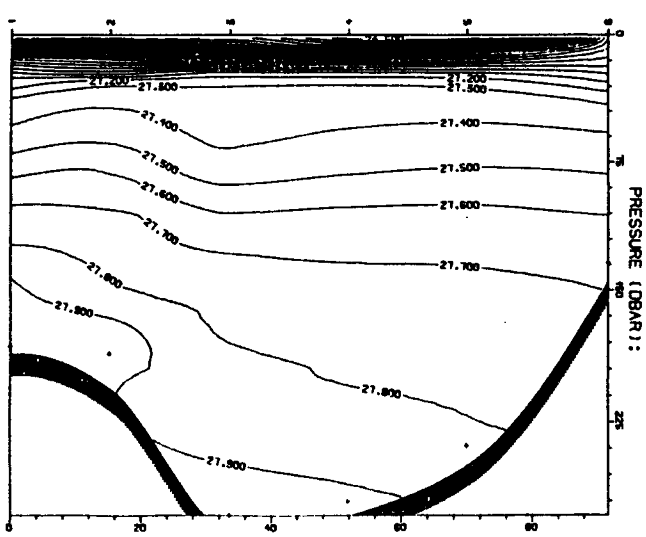

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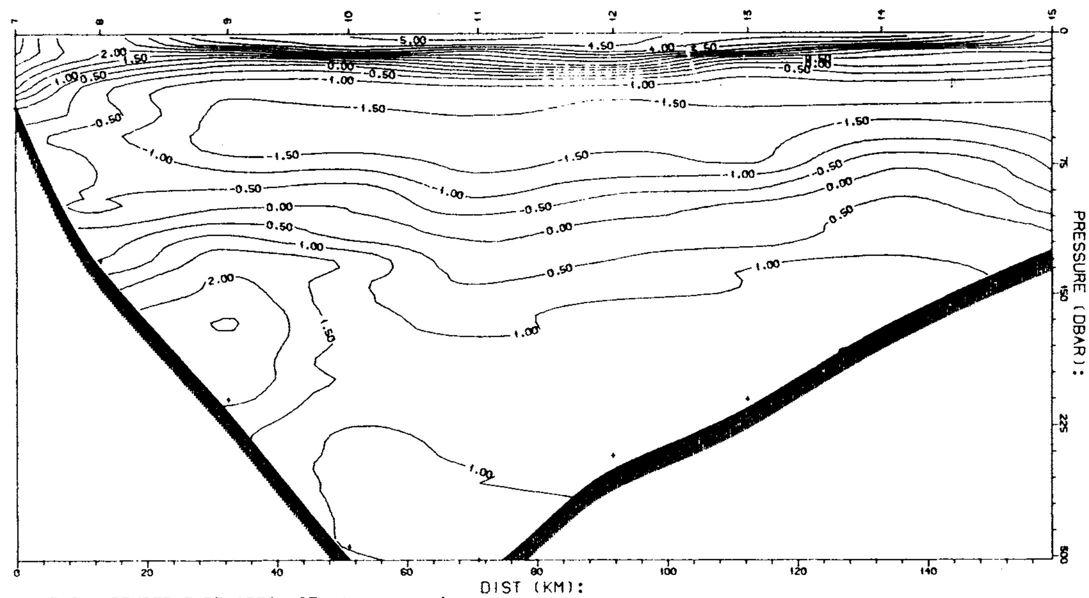

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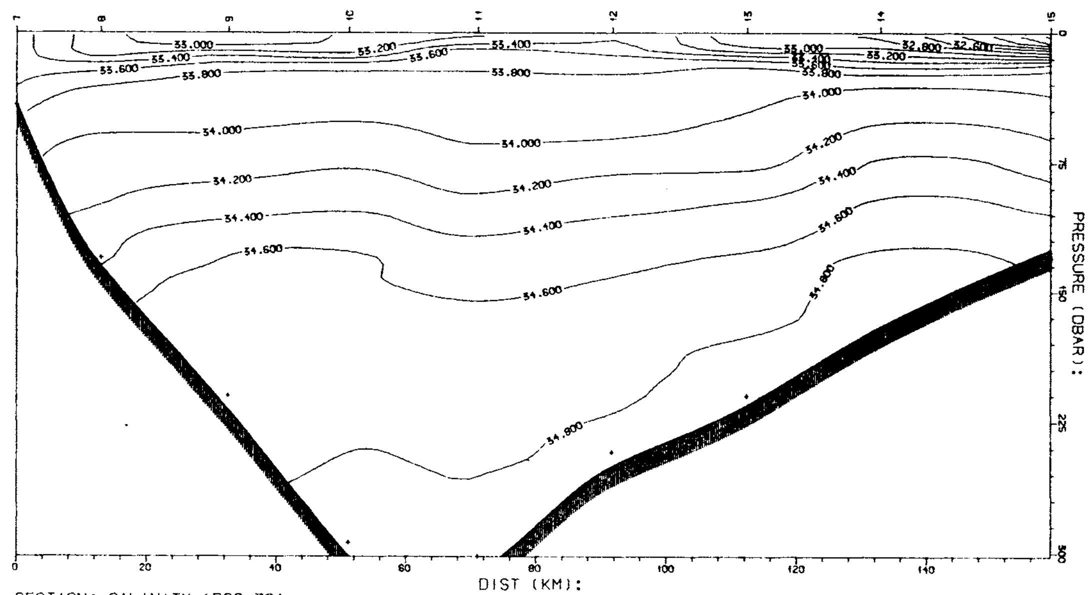

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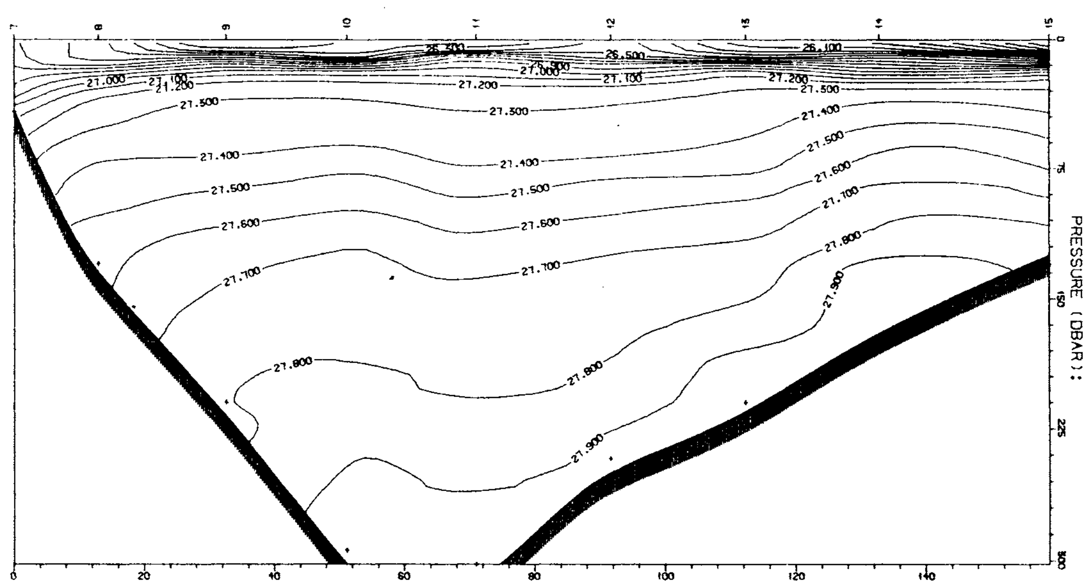

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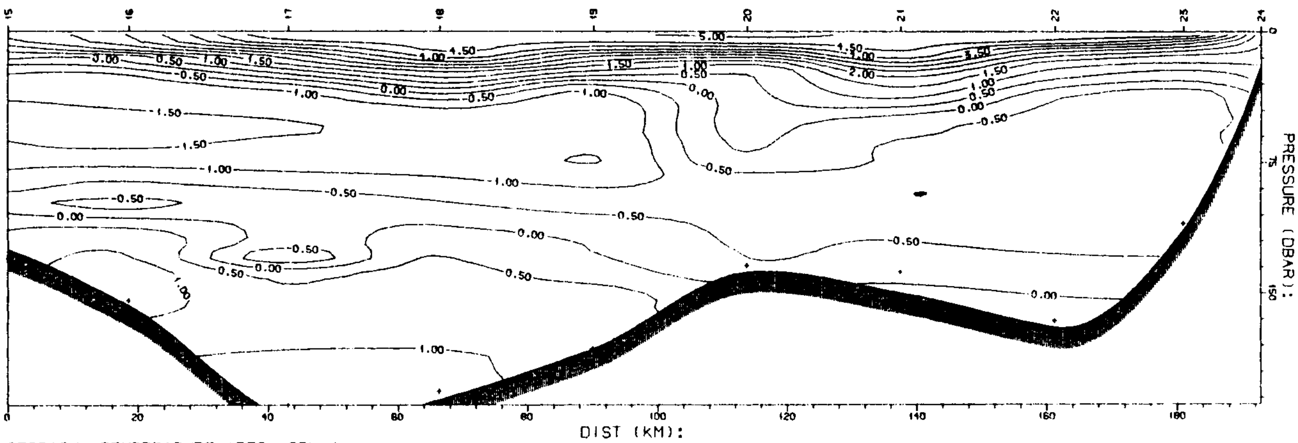

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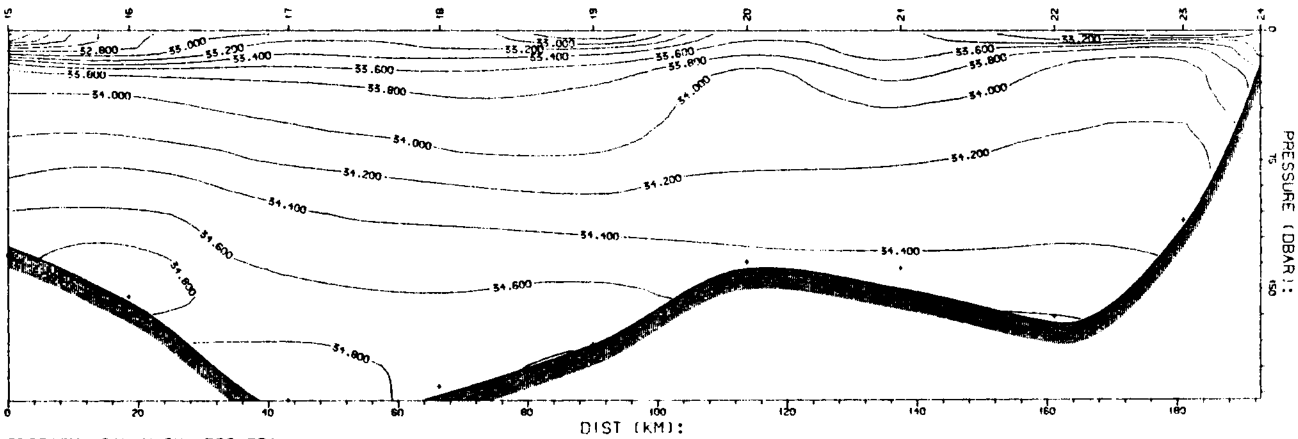

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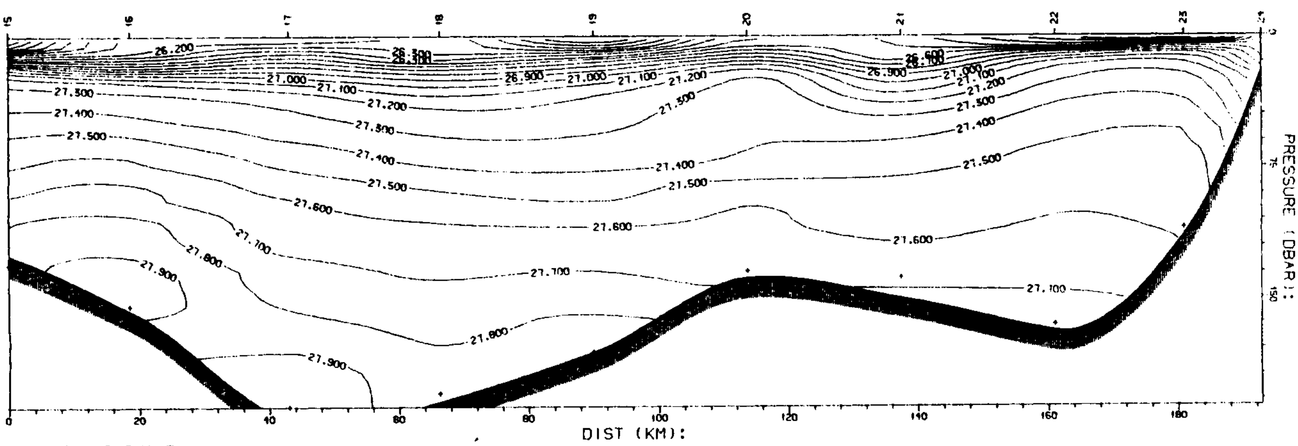

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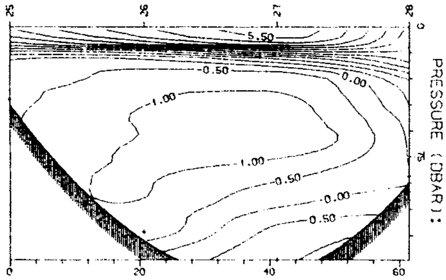

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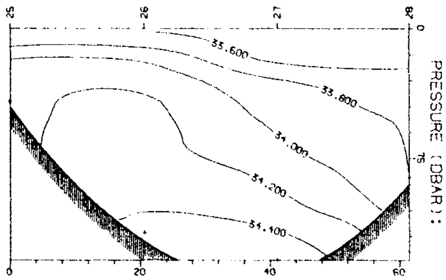
R/V "LANCE"



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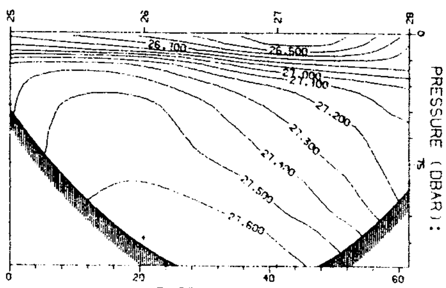

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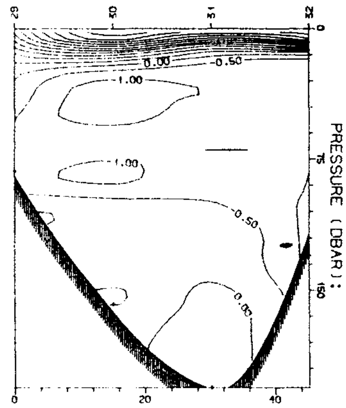

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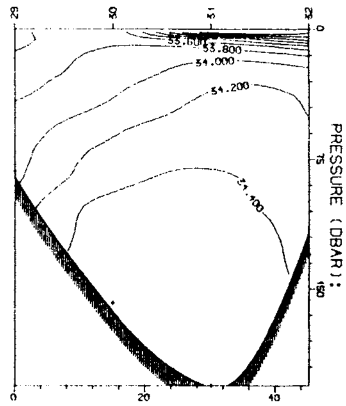

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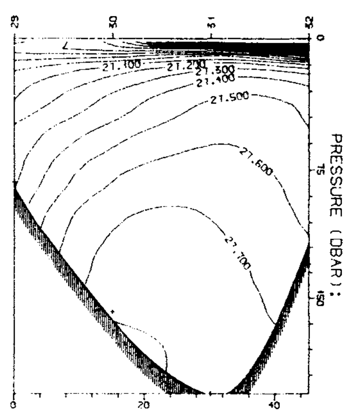

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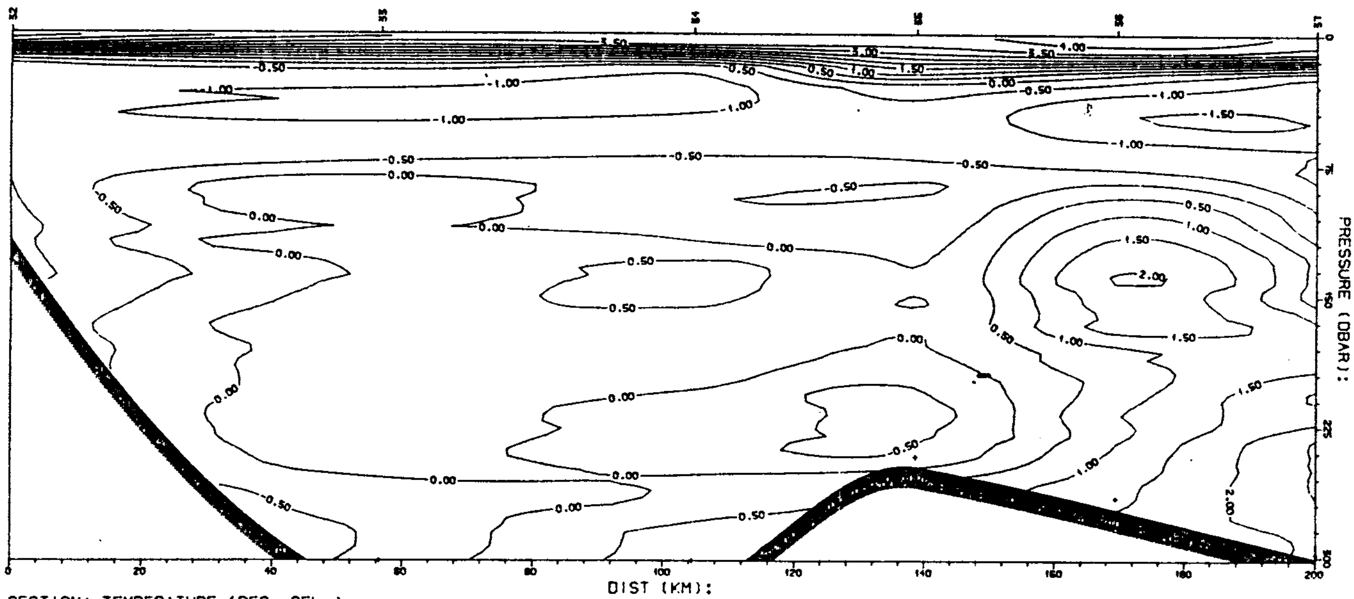

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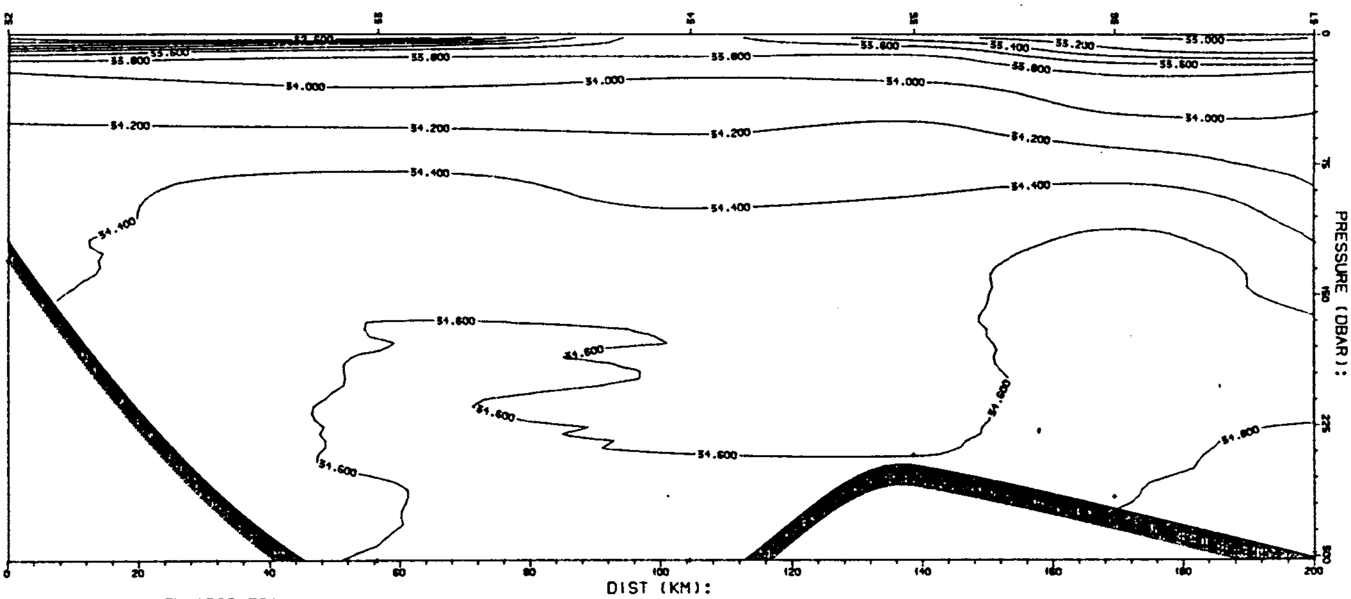

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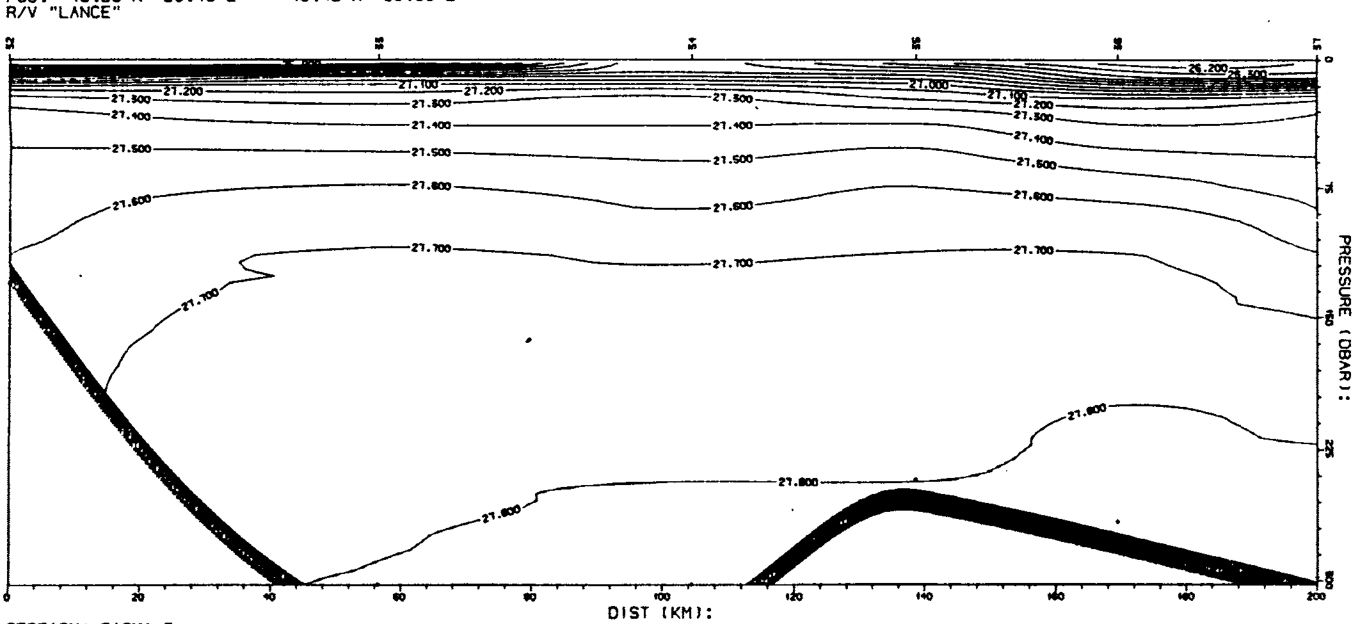

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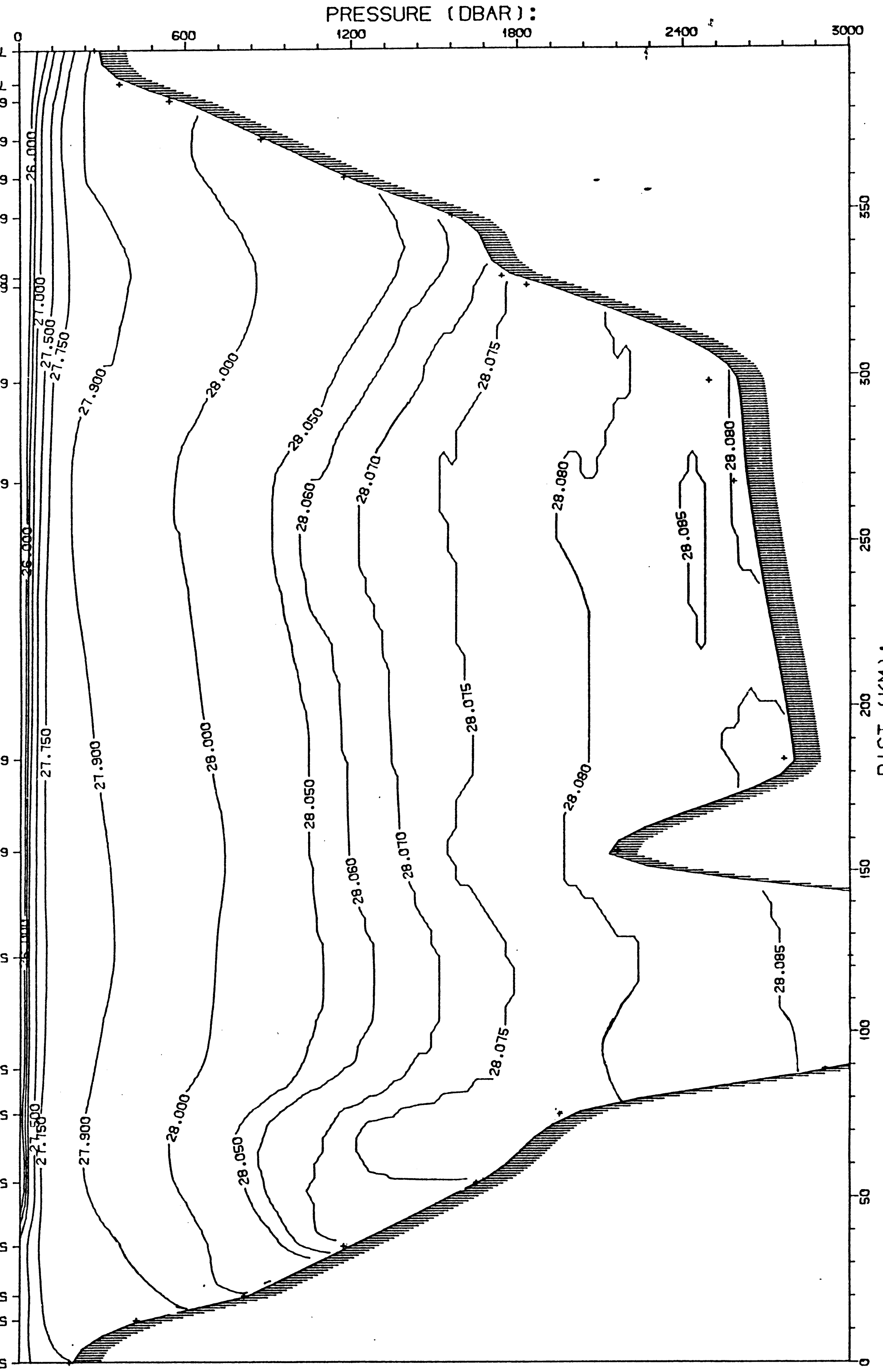

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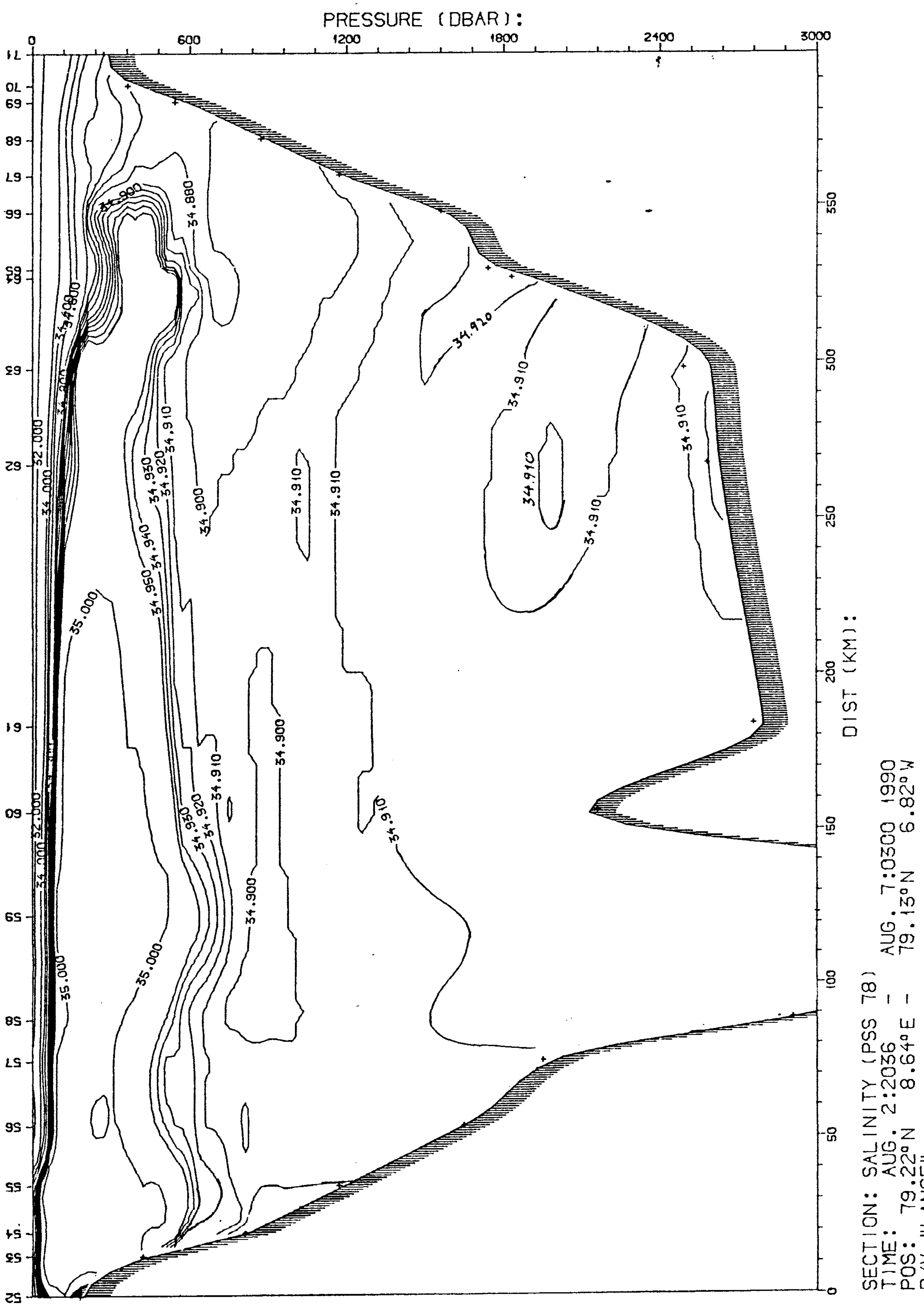
R/V "LANCE"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1800
2400
3000
DIST (KM):
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100
150
200
250
300
350
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34.900
34.910
34.920
34.930
34.940
34.950
34.880
SECTION: SALINITY (PSS 78)
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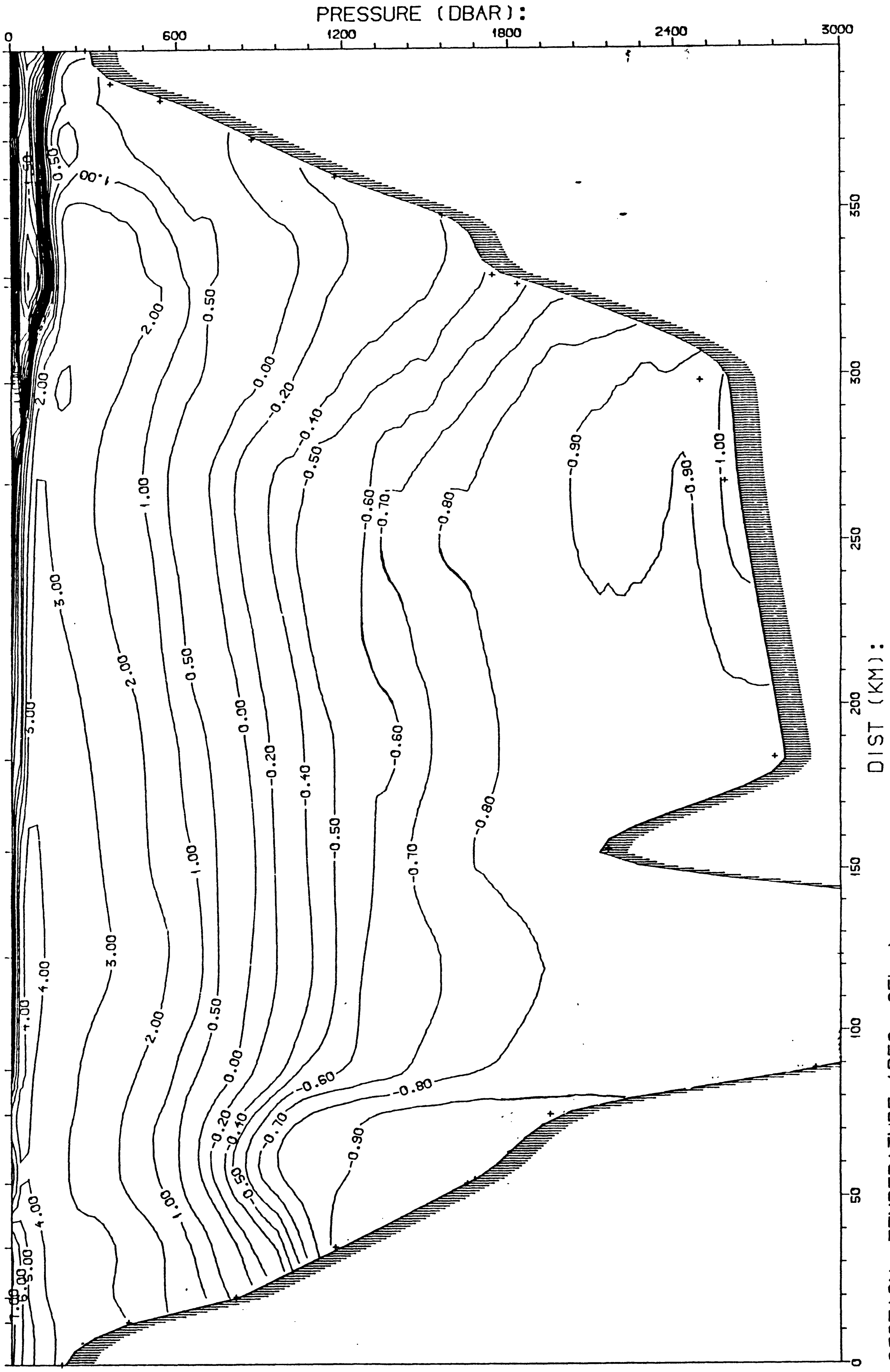
R/V "LANCE"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POS: 79.22°N 8.64°E - 79.13°N 6.82°W
R/V "LANCE"

SOME REMARKS ON OCEANOGRAPHIC DATA FROM R/V "LANCE" CRUISE.

V. Denisov[1], A. Foldvik[2], T. Lossius[2], V. Volkov[3] and S. Østerhus[4].

In the summer of 1990 the ice conditions in the northern part of the Barents Sea were favourable for oceanographic surveys. The year before the ice edge by the end of July was reaching down to the center of the Barents Sea at 76° -77° N. This was due to the abnormal extensive inflow of pack ice from the Artic Basin. R/V "Akademik Shuleykin", then working under the SNOP-program, managed to fulfil the survey program only in a comparativ small zone free of ice between Svalbard, Kvitya and King Karls Land. In July and August 1990 the ice edge was situated near 80° N and even further northwards in the strait between Svalbard and Kvitøya. Hence during the R/V "Lance" cruise we were able to work east of King Karls Land where several cross-sections were carried out, some of them across the deep channels of the area. These channels are regarded to be important for the understanding of the water circulation in the region. Due to bad weather (lots of fog) it was impossible to use a helicopter to complete planned sections across the bottom slope north of the strait between Svalbard and Kvitya.

The survey area is known to be a domain of rather small variations in oceanographic parameters. In particular the distributions of temperature and salinity vary only very little from year to year. Still some main features are not properly investigated due to difficult ice conditions. Especially in the strait between Kvitya and Victoria Island there is a lack of observations.

The heat balance and the biological production in the northern part of the Barents Sea is very dependent on the water and heat exchange with the Artic Basin and in particular the inflow of warm Atlantic water. The main water masses observed are Surface Artic Water (SAW); characterized by temperatures above 0° C in the summer and salinities down to 30-31 , Barents Sea Water (BSW); a cold water underneath the SAW, Atlantic Water (AW); found in the middle deep having temperatures above 0° C and salinities in the range 34.5-34.9 , and Bottom Water (BW) that may be found only in the deep layers underneath the AW. This year we only found patches of BW. The different water masses are easily recognized from vertical profiles of temperature and salinity at stations no. 3, 9 and 17 (see figs. in Foldvik et al. 1991). AW was found north-east and east of King Karls Land (see cross-sections of st.no. 1-7, 8-14, 33-37 and vertical profiles of stations 42-44 (st. no. 42-44 in Foldvik et al. 1991)).

The circulation patterns of AW were traced from the field of maximum temperature in the deep layers. AW seems likely to flow into the Artic Basin through the Fram Strait and then spreads north-eastwards along the slopes off-shore Svalbard, Kvitya and Victoria Island. The main inflow to the Barents Sea is through the deep channels between Victoria Island

[1]Murmansk Hydrometeorological Service, USSR.
[2]Geophysical Institute, University of Bergen, Norway
[3]Artic Antartic Research Institute, Leningrad, USSR.
[4]Norwegian Polar Research Institute, Oslo, Norway.

and Franz Josef Land. In addition there is a inflow between Svalbard and Kvitya, but this is assumed to be much weaker. The inflowing AW spreads out and is found in the shallow areas east of King Karls Land. The suggested circulation seems to be supported by Nikiforov and Shpaiher (1980).

While R/V "Lance" was working in the north-western part of the Barents Sea, the icebreaker "Otto Schmidt" and R/V "Professor Multanovsky", also joining the SNOP-program, were doing surveys east of 35° E and in the ice up to 81° N. By comparing data obtained by all three vessels, the circulation of the Barents Sea might be better understood. Still the inflow of AW through the strait between Kvitya and Victoria Island will be unknown due to lack of observations. When weather conditions allows it will be of great interest to carry out measurments in this region.

During August 2-7 a hydrographic survey consisting of 20 CTD stations across the Fram Strait at approx. 79° N was carried out. Similar surveys have been performed before, e.g. Gammelsrd & Rudels (1983) and Farrelly et. al. (1985). In the surface layer fresh, cold Polar Water dominates, but off-shore Svalbard warm and saline water is found to the surface in the West Spitsbergen Current (S>35.0, T>3° C). Atlantic Water also spreads to the west at depths of 100-500 m, but on the western side temperature and salinity decrease as the Atlantic Water has been modified and recycled and now flows south again. On the continental shelf and slope east of Greenland the East Greenland Current is easily recognized by the very cold and fresh Polar Water (T<-1.5° C in the core at approx. 75 m). On the continental slope west of Svalbard from 800 m to 1800 m a cold dense water mass having the characteristics of Norwegian Sea Deep Water (T<-0.97° C and S=35.905 at the bottom of station 56) seems to be flowing northwards. To the west of this current there is a core of fresher water (salinity less then 34.9) assumed to originate in the Greenland Basin due to winter cooling. On the continental slope east of Greenland at depths of 1600 - 1900 m. a saline and relative warm water is found (S>34.92 in the core). As suggested by Swift & Koltermann (1988) this might be a transport southward of Eurasian Basin Deep Water. Underneath in the very deep layers a temperature and salinity minimum is found on the western side (T=-0.9° C, S=34.91) indicating Norwegian Sea Deep Water.

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CRUISE REPORT

R/V PROFESSOR MULTANOVSKY

18 JULY-24 SEPTEMBER 1990

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H.Sagen	IMR	Scientist, oceanography

Abbreviations:

AARI - Arctic and Antarctic Research Institute, USSR

IMR - Institute of Marine Research, Norway

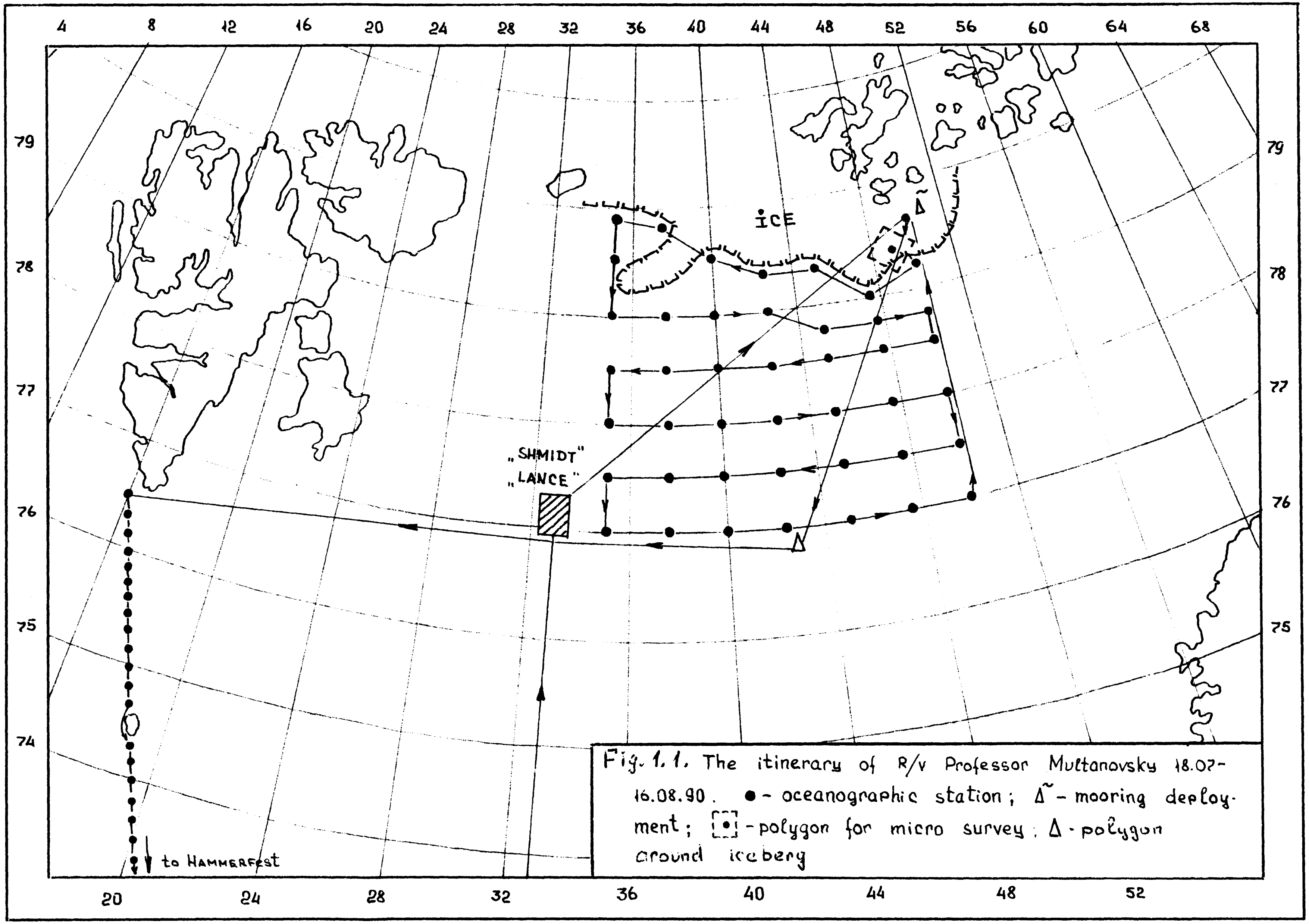

Fig. 1.1. The itinerary of R/v Professor Multanovsky 18.07-16.08.90. ● - oceanographic station; $\tilde{\Delta}$ - mooring deployment; [•] - polygon for micro survey; Δ - polygon around iceberg

1. INTRODUCTION

V.K.Pavlov [1]

The 27th cruise of the R/V"Professor Multanovsky" was one of the stages of SNOP (Fig.1.1.). The work in the strait between Spitsbergen and Franz Josef Land in cooperation with the research icebreaker "Otto Schmidt" and R/V "Lance", carried out at the first stage of the cruise, provided an opportunity to fulfil the most detailed oceanographic survey of this water area during the last years.

Preliminary analysis of the observations allowed one to obtain a number of new interesting conclusions.The formation of thermohaline structure and water dynamics features in the north- eastern part of the Barents Sea together with an analysis of water structure at micropolygon in the vicinity of ice edge are discussed by V.L.Kuznetsov and V.K.Pavlov. In the same paper the analysis of water structure at micropolygon in the vicinity of ice edge is made.

The ice conditions in the northern Barents Sea are reviewed by V.M. Petrov and N.Ye.Dmitriyev deals with the analysis of the thermohaline structure observations around the drifting iceberg.

The data necessary to set boundary conditions for hydro- dynamical modelling of the Barents Sea currents have been obtained by a CTD-section between Nordkapp and Spitsbergen.

In general the results of the 27th cruise of R/V "Professor Multanovsky" significantly contributed to the SNOP studies.

1) Arctic and Antarctic Research Institute, USSR

2. ICE CONDITIONS DURING THE 27TH CRUISE

V.M. Petrov [1)]

2.1 Ice observations from the ship and the general ice conditions in the Barents Sea in July-August 1990

Continous ice observations were carried out during the work of the R/V "Professor Multanovsky" in the ice of the Barents Sea. According to the accepted observation method the following parameters were determined: ice concentration, thickness, age, form, as well as stage of melting, hummock number, and degree of contamination. The observations were conducted visually from the captain's bridge (height 9 m). The ice edge location along the ship's course was determined by the ship's radar. Iceberg observations included positioning and determination of linear dimensions (height, length and their ratio). A sextant was used to measure iceberg angular dimensions and the ship's radar to determine distance and bearing. While navigating in the Barents Sea the ship covered 395 miles in ice. Ice conditions en route are shown in Fig.2.1. As can be seen from Table 2.1 the most part of the ship's navigation was carried out in open ice (330 miles) and while 65 miles in close ice.

Table 2.1

Distance covered by the R/V "Professor Multanovsky" in ice of different concentration in July-August 1990

Concentration (in tenths)	1-3	4-6	7-6	9-10	Total
Miles	222	108	39	26	395
%	56	27	10	7	100

In areas with very open ice covers Ice cakes mostly consisting og hummock remainders predominated. In close pack ice, small and medium floes predominated. The ice cover had a high degree of melting (40-50%) and the ridging amounted to 30-40%. There was practically no snow cover. Level ice thickness varied from 20 to 40 cm. Westwards from the 36th meridian second-year ice inclusions were recorded both in open and in close pack ice. Ship observations revealed small-scale inhomogeneity of ice concentration. It is clearly seen from the example of ice distribution observed at micropolygon (20x20 miles) (Fig.2.2). The ice cover, in general consisted of broken ice, distributed inhomogeneously and with a pronounced zonality, from very open to very close ice. The average concentration was 5/10, in concordance with satellite charts.

1) Arctic and Antarctic Research Institute, USSR

45 icebergs and bergy bits were observed en route in the Barents Sea. The main amount of icebergs was recorded at the near-edge course northwards from 78.5 degree and the distribution was rather uniforme (Fig.2.1). Iceberg density in this zone was equal to 1 iceberg per 20 miles. The southernmost iceberg location was recorded at the 77th parallel. Characteristic iceberg parameters, are presented in Table 2.2. The mean iceberg height was 11 m and the mean length 65 m. Maximum values were 20 and 160 m, respectively.

A detailed hydrological survey in the radius of 7 cable lengths was carried out around an iceberg at 77 07 N and 43 30 E.

2.2 Ice conditions in the Barents Sea, July-August 1990

The ice fields in the Barents Sea, disintegrated from the beginning of summer and continued during the work of the R/V "Professor Multanovsky". The spatial distribution were governed by predominating west winds and intensive melting.

The temporal changes of the ice cover in the Barents Sea in the above mentioned period are shown in Table 2.3.

Table 2.2

Characteristics of icebergs, observed in the Barents Sea in July-August 1990

Date of record	Latitude	Longitude	Height H (m)	Length L (m)	L/H
20.07.	77° 44' N	34° 57' E	10	100	10
22.07.	78 32	35 27	4	30	7
22.07.	78 30	35 26	5	15	3
22.07	78 37	36 43	8	25	3
25.07.	79 15	49 48	10	100	10
25.07.	79 17	47 58	5	30	6
26.07.	79 09	48 33	8	30	4
26.07.	79 30	50 04	10	40	4
27.07.	79 30	49 32	10	50	5
27.07.	79 27	48 33	7	50	7
27.07.	79 27	48 23	20	160	8
28.07.	79 15	48 11	20	120	6
30.07.	78 57	46 42	10	100	10
01.08.	79 00	40 51	6	12	2
01.08.	78 45	47 30	12	80	7
01.08.	78 47	47 30	15	150	10
02.08.	78 30	36 27	20	60	3
02.08.	78 30	36 29	7	50	7
02.08.	78 00	35 04	20	80	4
05.08.	77 00	42 17	10	30	3
08.08.	77 08	43 30	10	30	3

Table 2.3

The ice cover in the Barents Sea regions in July-August 1990 compared with the norm

Region	Ice cover (%)							
	1-10 July		10-20 July		20-30 July		1-10 August	
	actu-ally	norm	actu-ally	norm	actu-ally	norm	actu-ally	norm
Whole sea	24	29	12	23	10	18	8	15
Western part	21	29	8	24	4	20	7	16
NE part	45	43	25	35	28	29	18	25

By the beginning of the cruise the ice area in the Barents Sea was 5% smaller than the norm. A negative anomaly was preserved due to reduced ice area in the western part of the sea, while near to normal conditions was observed in the north-eastern part. The ice area was dramatically reduced in the second decade of July mainly due to the melting in the vast zone of ice with concentration of 1-3 tenths. The ice cover of the whole sea was reduced two-fold and in the north-west a negative anomaly formed. The western edge moved eastwards from Kong Karls Land, which is a rare phenomenon during this period.

The ice edge in the western part of the sea moved up to the 79th parallel in the third decade of July and the ice cover was reduced by 4% The ice transport from the Kara Sea resulted in an increase of ice cover in the NE part of the sea and became near to the norm.

The ice cover was reduced by 2% during the first decade of August, mainly due to reduced ice area in the NE part of the sea. In the western region the ice area increased by 3%, being nevertheless 9% smaller than the norm.

The southern ice edge in the observation area moved 70 miles northwards with mean speed 3 miles per day During the work of the R/V "Professor Multanovsky" in the Barents Sea(Fig.2.3).

Let us compare the ice edge location in the Barents Sea in July and August with its most probable location in these months. Distribution modes of ice edge location in summer months for the meridians 20, 30, 40, 50 degrees E were obtained by V.A,Abramov and are presented together with actual values in Table 2.4.

Table 2.4.

Ice edge location in the Barents Sea in July-August 1990 compared with the most probable location based on long term observations

Meridians	Latitude of ice edge location in degrees			
	July		August	
	act.	mode	act.	mode
20	80.5	77.5	80.5	78.6
30	78.3	76.5	80.2	78.9
40	78.0	77.3	79.2	78.9
50	78.0	78.2	80.0	80.2

At the 20th meridian southwards from Spitsbergen there was no ice in July-August. The ice edge adjoined the northern coast of Spitsbergen, being 3° and 1,9° more nothern than its most probable location.

A substantial difference between mode and actual ice edge location was also observed at 30°E. In July it was equal to 1.8° and in August it was reduced to 1.3°.

At 40°E the edge was also more northern than usual and the differences in July and August were 0.7° and 0.3 °, respectively.

The ice edge location was near to its most probable one at 50°E.

Thus, the analysis of ice cover and changes in location in the Barents Sea allow us to make the following conclusions:

the ice conditions were favourable in July-August,

the ice disintegrating processes was reduced from July to August,

an unusual ice distribution formed in the western part of the sea.

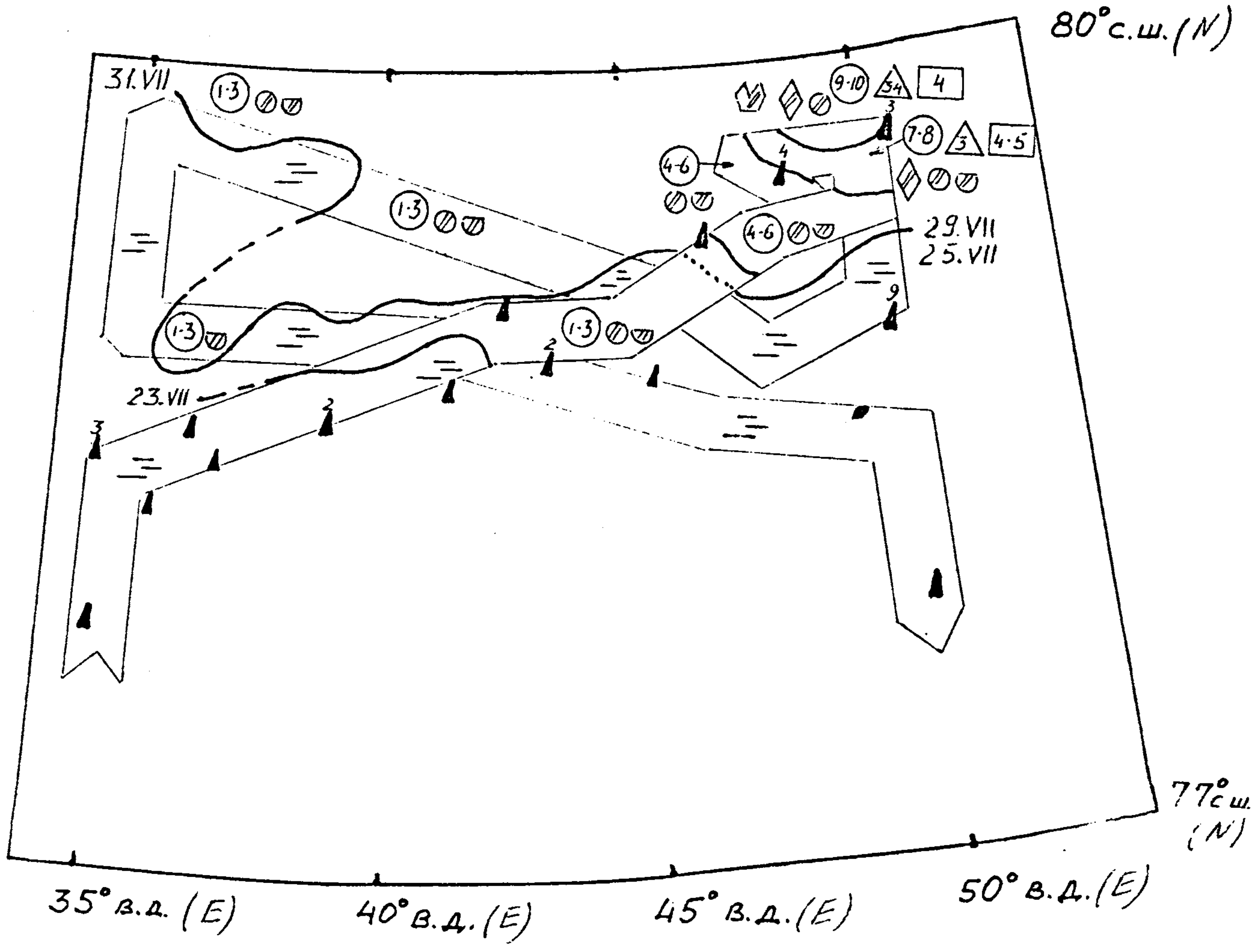

Fig. 2.1. *Distribution of ice and icebergs during cruise of R/V "Professor Multanovcsky" from 22 July to 2 August 1990 (23.07, 25.07, ... - times of crossing ice border).*

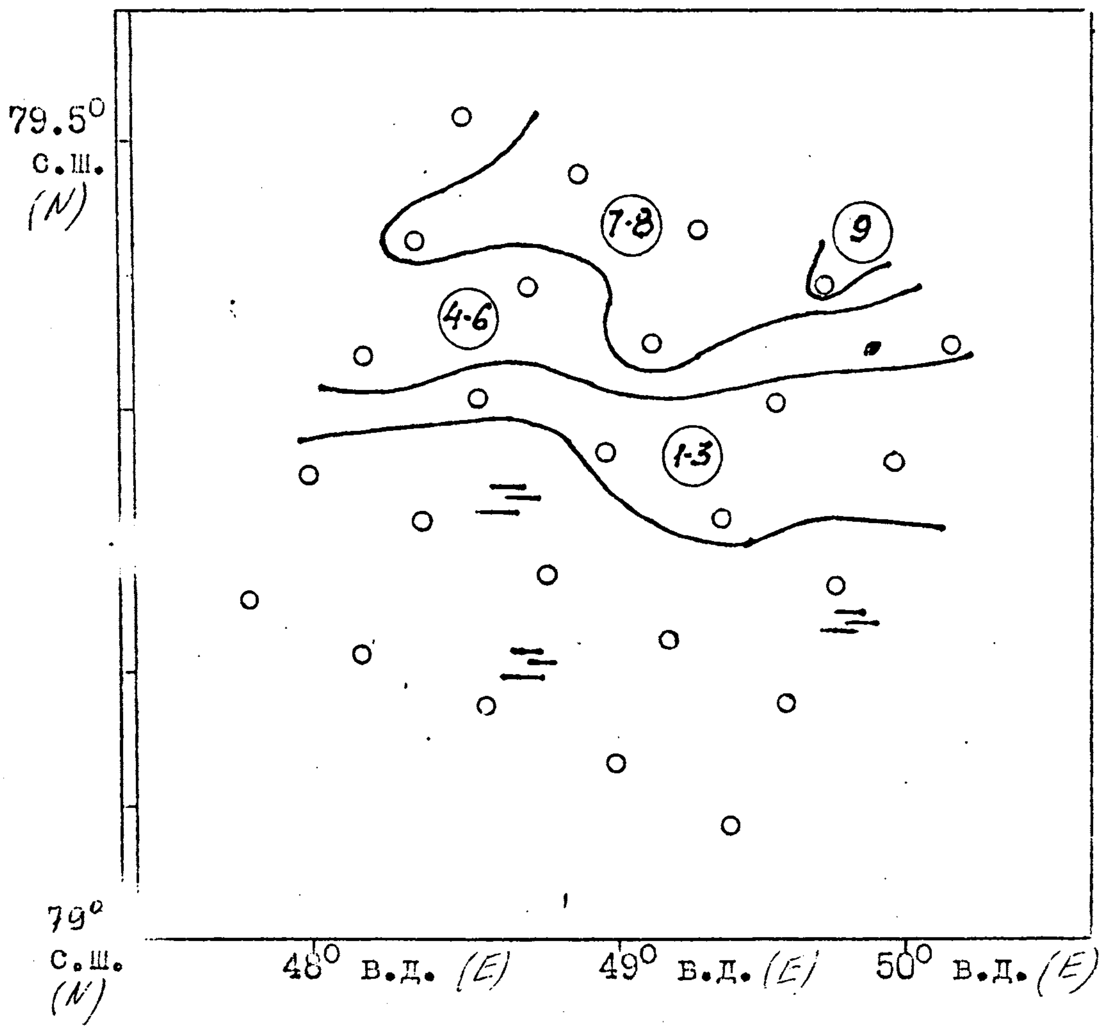

Fig. 2.2. *Distribution of ice concentrations in the polygon micro survey 24-26 July 1990 in the Barents Sea.*
o : oceanographic station

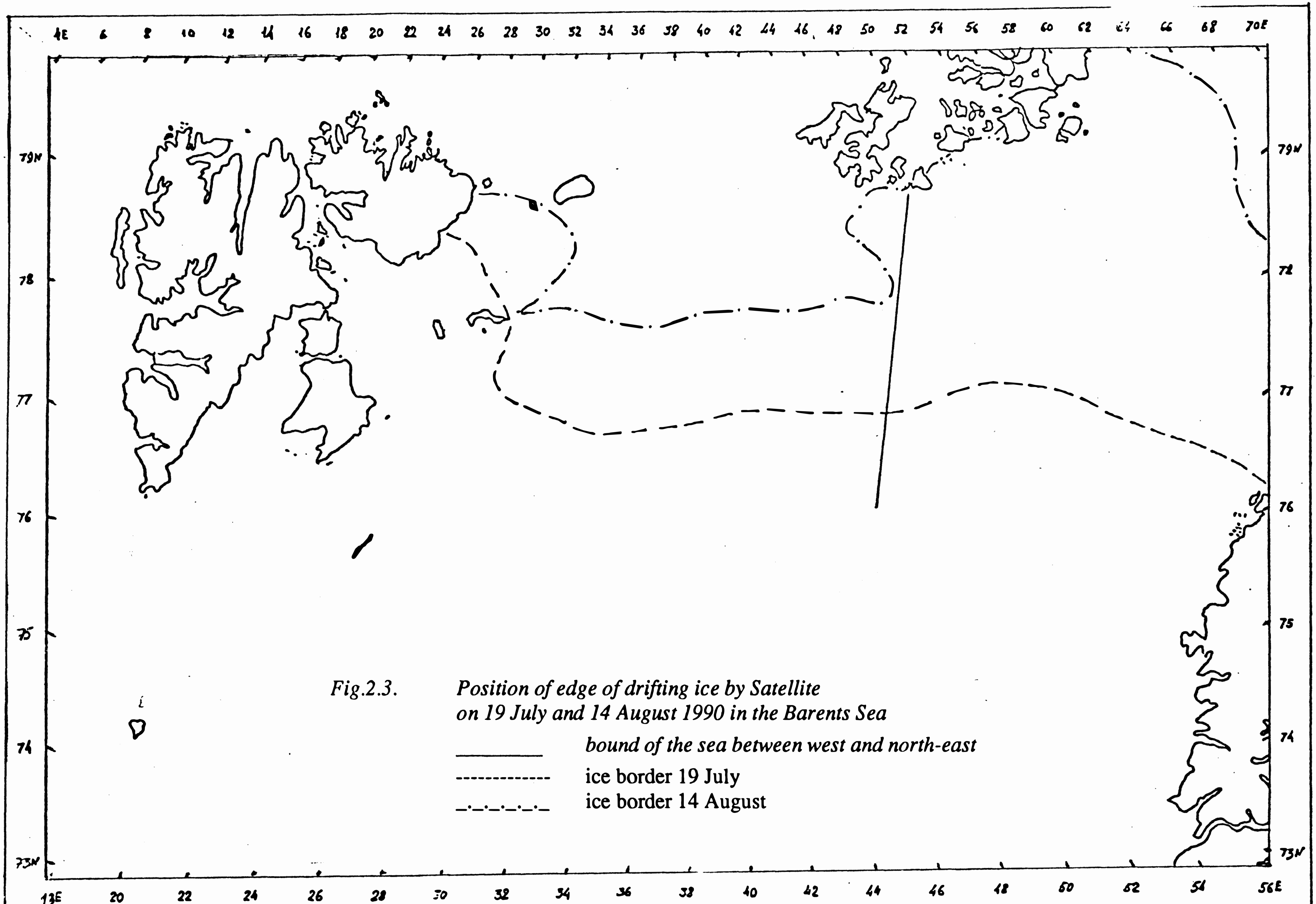

Fig.2.3. *Position of edge of drifting ice by Satellite on 19 July and 14 August 1990 in the Barents Sea*

————	*bound of the sea between west and north-east*
------------	ice border 19 July
_._._._._	ice border 14 August

3. OCEANOGRAPHIC MICROSURVEY AROUND THE ICEBERG

N.Ye.Dmitriyev [1)]

The main task of the hydrological micropolygon survey around the iceberg was the investigation of disturbances, produced by the iceberg in the adjacent field of hydrological characteristics, and determination of scales of this phenomenon. The Micropolygon was located at 77°08'N and 43°40'E. The scheme of stations is shown in the Fig.3.1 and in Table 3.1.

Table 3.1.

The Micropolygon station number, bearing and distances from the centre

Station number	Bearing	Distance (CL=185,2m)
70	270	0.9
71	240	2.8
72	240	4.7
73	205	3.8
74	213	2.0
75	149	1.0
76	60	1.4
77	60	3.1
78	60	5.4
79	105	4.0
80	105	1.5
81	150	2.8
82	150	5.0
83	150	7.0
84	25	3.8
85	25	2.0
86	340	1.0
87	335	2.7
88	330	4.6
89	285	4.0
90	285	1.7

1) Arctic and Antarctic Research Institute, USSR

Meteorological conditions: T= 4.4 [0,254]C, P= 1001.3 mB, humidity - 77%, wind WSW - 3, speed 9-12 m/s. Surface layer temperature is 4.7 - 4.8 [0,254]C. The Micropolygon size is 13x10 CL, 21 CTD soundings were made, mainly to the depth of 100 m.

It should be mentioned that the iceberg was rather small - about 30x30 m and total thickness 30 m. (It was determined when the iceberg tilted during the work at one of the stations). Although the iceberg was relatively small it effected the adjacent fields of temperature and salinity to a considerable extent and the meteorological conditions such as heavy wind, waves, relatively high air and water temperatures, caused an intensive melting. The analysis of synoptic conditions shows that during the preceding 24 hours stable west winds prevailed causing a probable eastward drift. The iceberg trajectory is clearly seen in Fig 3.2, showing T and S fields at the depth of 15 m. Salinity field and vertical profiles of hydrological characteristics at A and B sections (Fig 3.3 and 3.4) also suggest that a drdift has taken place.

At the depth of15 m at stations number 81-83 and 86 a reduced salinity is recorded, the vertical gradient being 0.3 % /m. The spatial distribution of the water temperature at the depth of 15 m seems to be rather unexpected as the iceberg trajectory is marked by higher water temperature. A warm water area is located in the vicinity of the iceberg and stretches along the wind direction. Most probable this temperature field was formed under the influence of convection and dynamical mixing in the surface layer as the stability of the density field was disturbed by inflow of desalinated water, due to iceberg melting. The density field became more homogeneous and due to this, warm surface water moved down to lower horizons.Probably, if meteorological conditions had not been so severe and the mixing not so intensive, fresh water would have been observed in the surface layer above 15 m and at the surface.

The observations indicate that a melting drifting iceberg influences the adjacent fields of hydrological characteristics in a horizontal scale, twice as large as that of the iceberg.

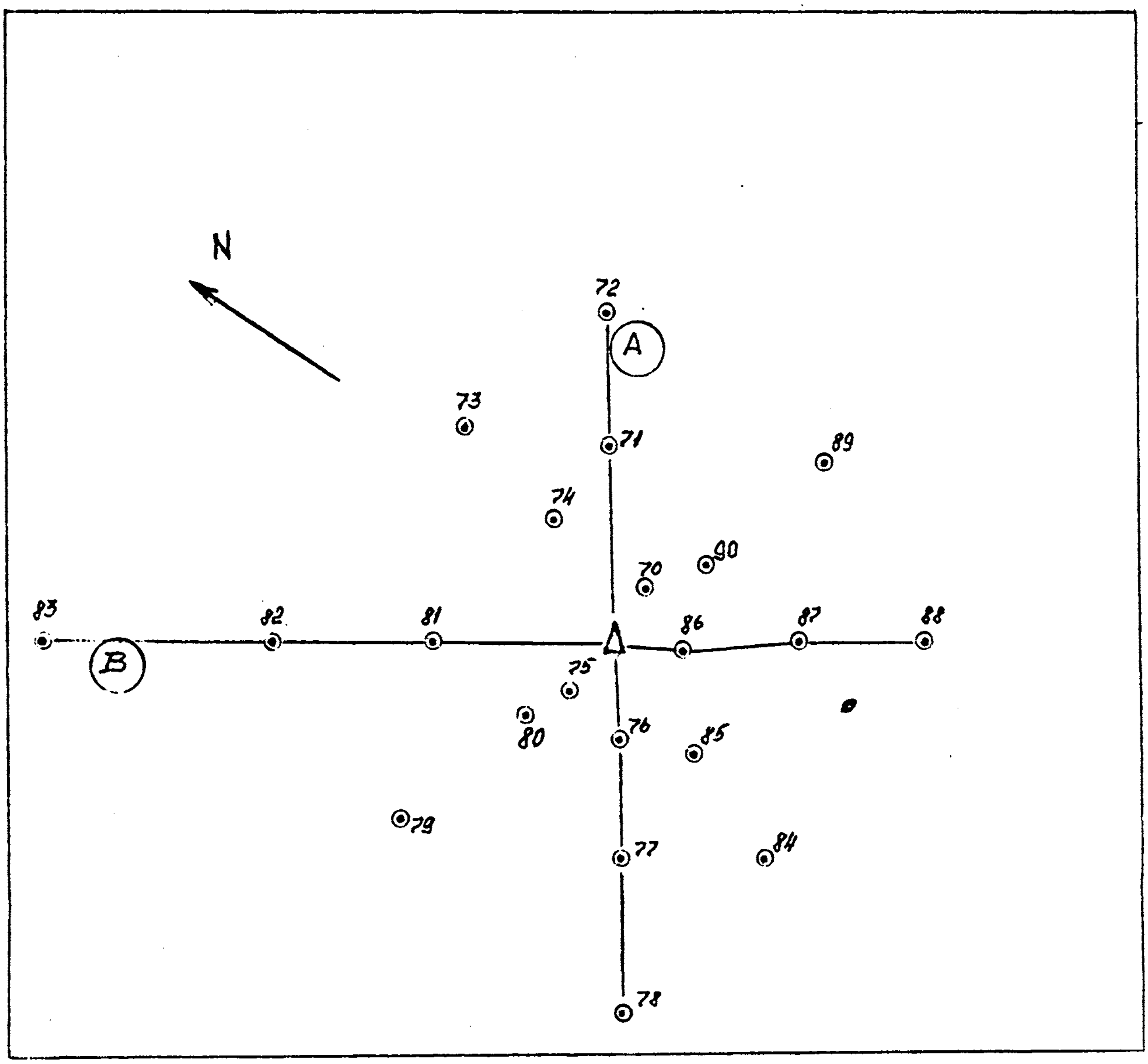

Fig. 3.1. *Positions of the oceanographic stations in the polygon around iceberg*

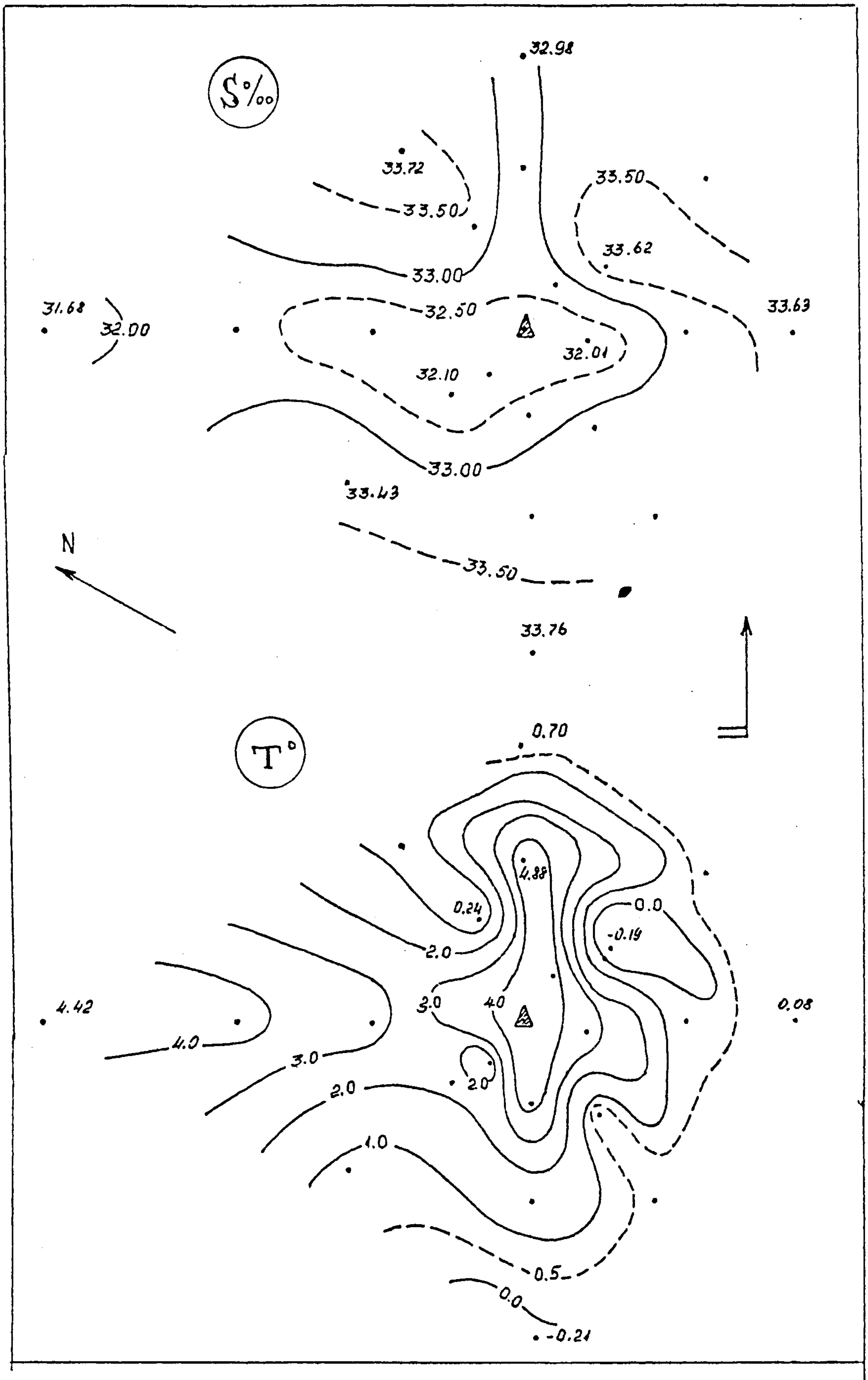

Fig. 3.2. Distribution of salinity (S o/oo) and temperature (T°) on horizon 15 m

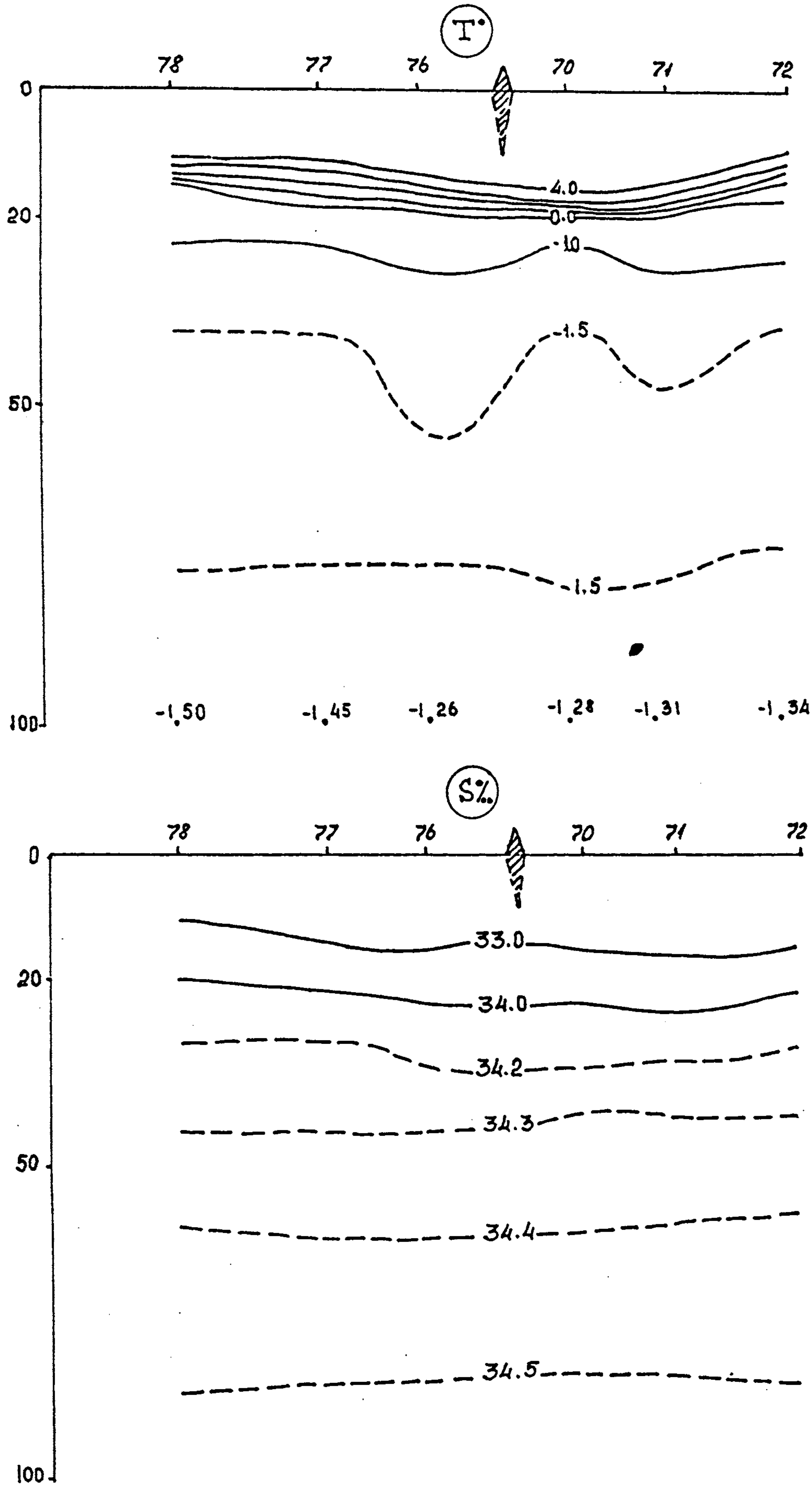

Fig. 3.3. Distribution of salinity (S 0/00) and temperature (T°) in the cross section A

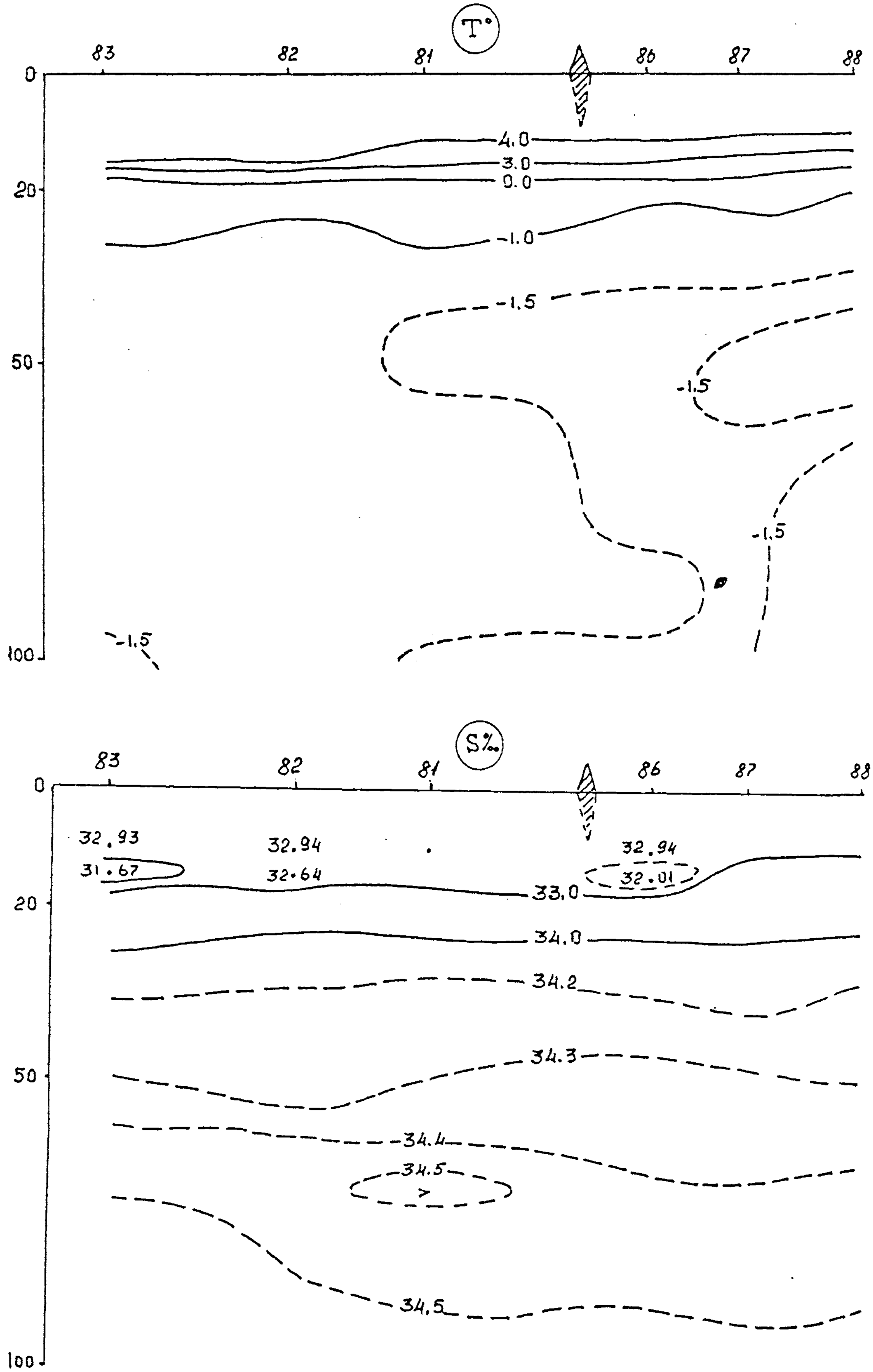

Fig. 3.4. Distribution of salinity (S o/oo) and temperature (T°) in the cross section B

4. THERMOHALINE STRUCTURE AND WATER CIRCULATION IN THE NORTH-EASTERN PART OF THE BARENTS SEA

V.L.Kuznetsov [1)]
V.K.Pavlov [1)]

Observations under SNOP-90 from the R/V "Professor Multanovsky" were conducted in the area between 77 and 79 30 N and 35 and 50 E. In the North it adjoined the deep part of Shelling Strait, separating Spitsbergen and Franz Josef Land.

The main role in water mass formation in this area is played by the processes of water exchange with adjacent oceanic water areas of the North-European and Arctic Basins and thermohaline processes in the sea surface layer, connected with seasonal temperature variations, ice cover formation and decay.

The character of distribution of temperature and salinity fields in the water area under study may be seen in graphs and schemes, presented in Fig. 4.1-4.13. Minimum temperature at the surface (-0.11°C) was recorded in the northern part of the region in the marginal ice zone, with a maximum of +5.27°C in the southern part. The salinity in the surface layer had similar distribution with minimum values about 30 % (29,88%) along the ice edge, and maximum values higher than 33.50 % in the south- eastern part. It is attributed to gradual heating of the desalinated surface layer as soon as the ice edge moves northwards.

A thermocline was observed between 5 and 25 m, gradients growing while moving southwards, amounting to 0,47°C/m 77°N. Vice versa, the salinity gradient at the northern section reached maximum values - 0.26%. The maximum gradients of conventional density were recorded in the northern section at the thermocline boundary and were equal to 0.26 of conventional unit.

TS-curves for most of the oceanographic stations were obtained from the analysis of the water structure and the separation of different water masses in the northern part of the Barents Sea.

The discontinuity of hydrophysical characteristics separates surface Arctic waters /2/, inflowing from the Arctic Basin, from sub-Arctic waters, forming in the surface layer from Arctic ones, during heating and dynamical mixing with lower more saline waters and transformed waters from the Barents Sea. This is characteristic for the northern part of the Barents Sea. Transformed water mass from the Barents Sea is influenced both by surface Arctic waters and underlying Atlantic water bodies. It is situated in the layer from 25 to 100 m, with a temperature ranging from 0 to -1.6°C, and a salinity range from 34 to 34.7%. Characteristics in the core: temperature -1.5°C, salinity -34.6 %.

1) Arctic and Antarctic Research Institute, USSR

The Atlantic water is located lower than the transformed water from the Barents Sea, within 100-300 m. The characteristics are as follows: temperature from 2.8 to 0°C, salinity from 34.6 to 34.9 % . In this case Atlantic water may be considered as transformed recurrent water, inflowing from the Arctic Basin /2/. The distribution of warm and saline Atlantic water south- wards from the northern part of the area under study and thinning of this layer at the meridian 50 E is clearly seen in the graphs of vertical temperature and salinity distribution by sections and in area schemes by depths. Atlantic water inflow to the southern part of the region from the northern branch of North Cape Current is not observed.

Eastwards from the meridian 45°C bottom waters are recorded below 250 m. Bottom water masses in this area are characterized by temperature lower than 0°C and salinity 34.85-34.90%. The bottom water masses, as well as the transfomed water from the Barents Sea are formed within the region in winter during the process of vertical mixing of transformed Atlantic waters with cold ones from the Barents Sea /1/.

It is planned to proceed a detailed water mass classification in the northern Barents Sea including separation of different water structures as soon as the expeditional material under the SNOP program is collected.

A micropoligon survey in the vicinity of the ice edge allowed one to study hygrophysical processes occuring at the ice /open water boundary. The interpretation in diagram form of the obtained data is presented in Fig.4.11-4.13.

A thermocline is not observed in the temperature field under the ice cover. Surface Arctic water with a negative temperature and a reduced salinity are located above the transformed water from the Barents Sea with almost similar temperature. The salinity increases monotonously with depth. A hydrofront appears in the vicinity of the ice edge, being 3 km thick with high horizontal temperature gradients of 0.30°C/km, which is observed up to the depth of 25 m. Moving southward, away from the ice edge the thickness of the layer of less saline Artcic water expands down to 25 m. The ice/water boundary can be clearly seen in the field of dissolved oxygen. The effect of ice and underlying waters with low temperature results in higher content of oxygen ions in water. The amount of dissolved oxygen also identifies the Atlantic water mass.

Isotherm and isohaline courses allows one to study the ice cover influence upon water masses to the depth of 50 m. At the lower horizons water mass stratification is in general determined by advection of transformed Atlantic waters.

Heat content of water column from surface to bottom and within the layer of 0-30 m is calculated at each oceanographic station (Fig. 4.14). The comparison of these schemes of heat content distribution confirms the dominating role of Atlantic waters in the regime formation in NE part of the Barents Sea. In the active layer (0-30 m) the heat content depends upon the heat exchange with the atmosphere, the solar radiation and the water advection, and the heat transfer attributed to ice melting (Fig.4.14B).

The heat deficit zone is located in the ice covered area. The heat content increases while moving from the edge to open water. The Atlantic water, flowing in from the North through the Shelling Strait, mainly contributes to heat content in the whole water column below the active layer (0-30m). As can be seen from Fig.4.14A, the heat deficit occurs only in the shallow water areas in the SE, where there is no Atlantic water.

On the basis of dynamical method the components of geostrophic current vectors, normal to section plane, were determined for each section. Maximum discharge, equal to 1.78 cu. km/hour from the North to the South, was recorded at 78.5° section; geostrophic current vector component at the surface in the middle of the section is equal to 5 cm/s. Minimum discharge of 0.46 cu.km/hour is at the southern section, flow direction being southwards.

Three flows were observed at the micropolygon: one along the western periphery, one in the center with a prodominating southern component and one in between directed towards the North. The maximum discharge at the northern section is 0.22 cu.km/hour and directed southwards. At the section along the ice edge total transfer of 0.04 cu.km/hour is obtained from the northern component with direction towards the edge.

The heat content, calculated for each section, is also quite characteristic. Its value reduces from the North to the South from 2.08×10^8 kcal to 0.15×10^8 kcal, and at section along the ice edge there is an average heat deeficit of -0.69×10^8 kcal with increasing values towards the edge.

The geostrophic transfer processes and Atlantic water advection show that the heat content in the northern part of the Barents Sea is replenished from the adjacent area of the Arctic Basin.

To estimate the contribution of thermohaline flow to the total circulation in the northern Barents Sea the calculations on the basis of modified model of A.S.Sarkisian /3/ were conducted. The oceanographic data obtained during the survey "SNOP-90" were used as an initial material. These data were interpolated to the points of regular net (13x12) with the step between points equal to 25 km, approximating the water area under study. At the boundaries "free flow" condition was assumed.

The vectors, obtained as a result of modelling, are presented in schemes of thermohaline flows (Fig. 4.15-4.17), calculated for each standard horizon (depth).

Two flows can be observed at the surface of the water area under study. The first flow, moving from the northern boundary with a little north-western component to the center and further almost up to the southern boundary, divides here into eastern and western branches.

Similar computations were made using the data obtained at the micropolygon. In this case a regular equilateral 7x7 grid was used.

The vectors, obtained as a result of the thermohaline flow modelling, are presented in Fig.4.18.

In the upper 50 m thick layer the vector directions characterize the field of unsteady flows with eddying structure, originated from spatial inhomogenuity of density field in the zone of hydrofront along the ice edge. The surface velocities are 3-7 cm/s. As the size of the polygon is small, and a large-scale grid with step of 6 km is used, the vector field cannot fully reflect mesoscale dynamical processes, characteristic to open water/ice interfaces /4/. The flows in the open water area, directed to and from the ice edge, show the eddying structure of water dynamics and heat transfer across the edge (Fig.4.18 E). Below the 50 m depth one can observe a south-western transfer across the area under study with velocities amounting to 5 cm/s. This is a steady flow, corresponding to water mass stratification in the region.

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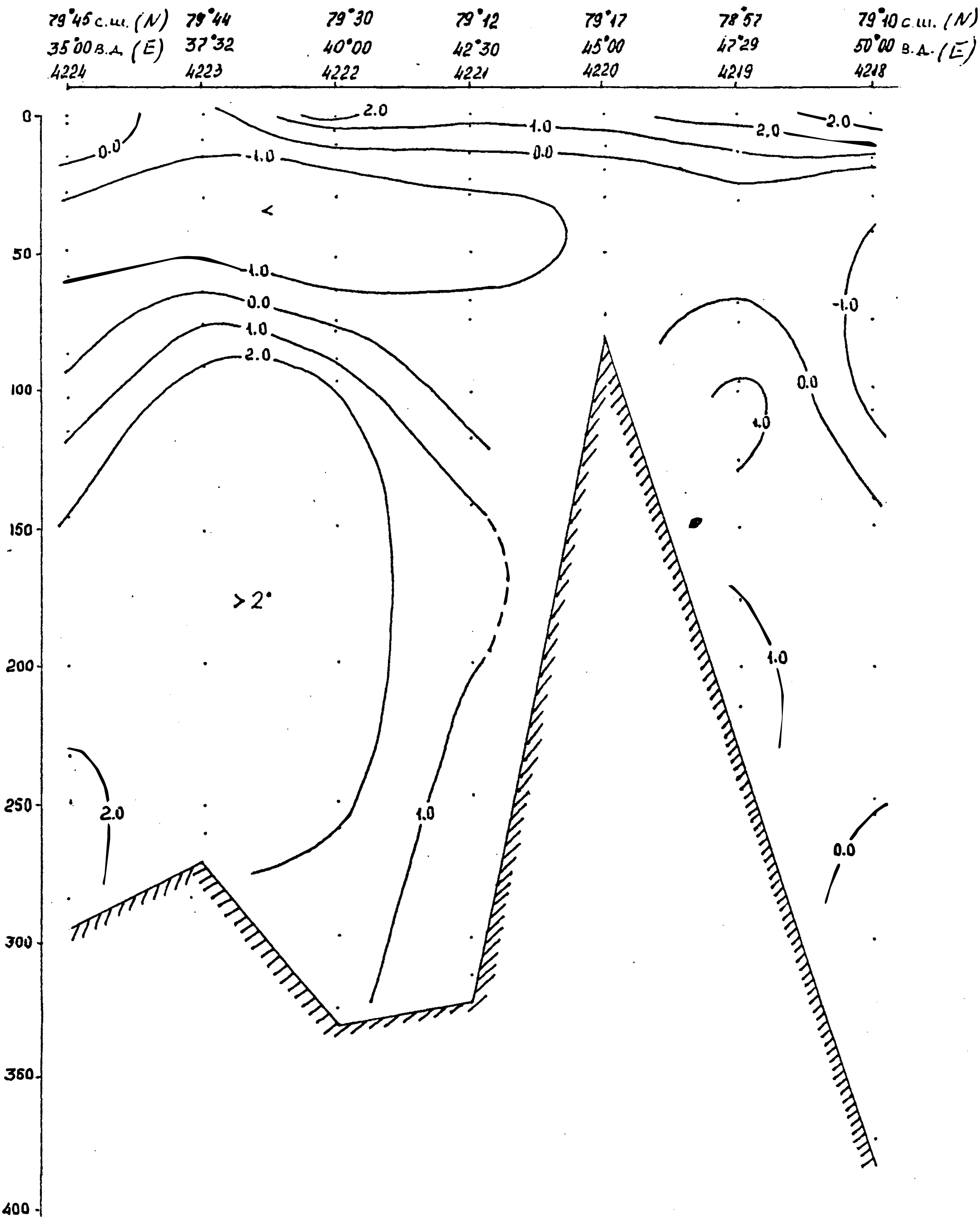

Fig. 4.1. *Distribution of temeprature (T°) of water in the cross section near ice border in the Barents Sea, 27-31.07.90 (27th voyage of RV "Professor Multanovsky")*

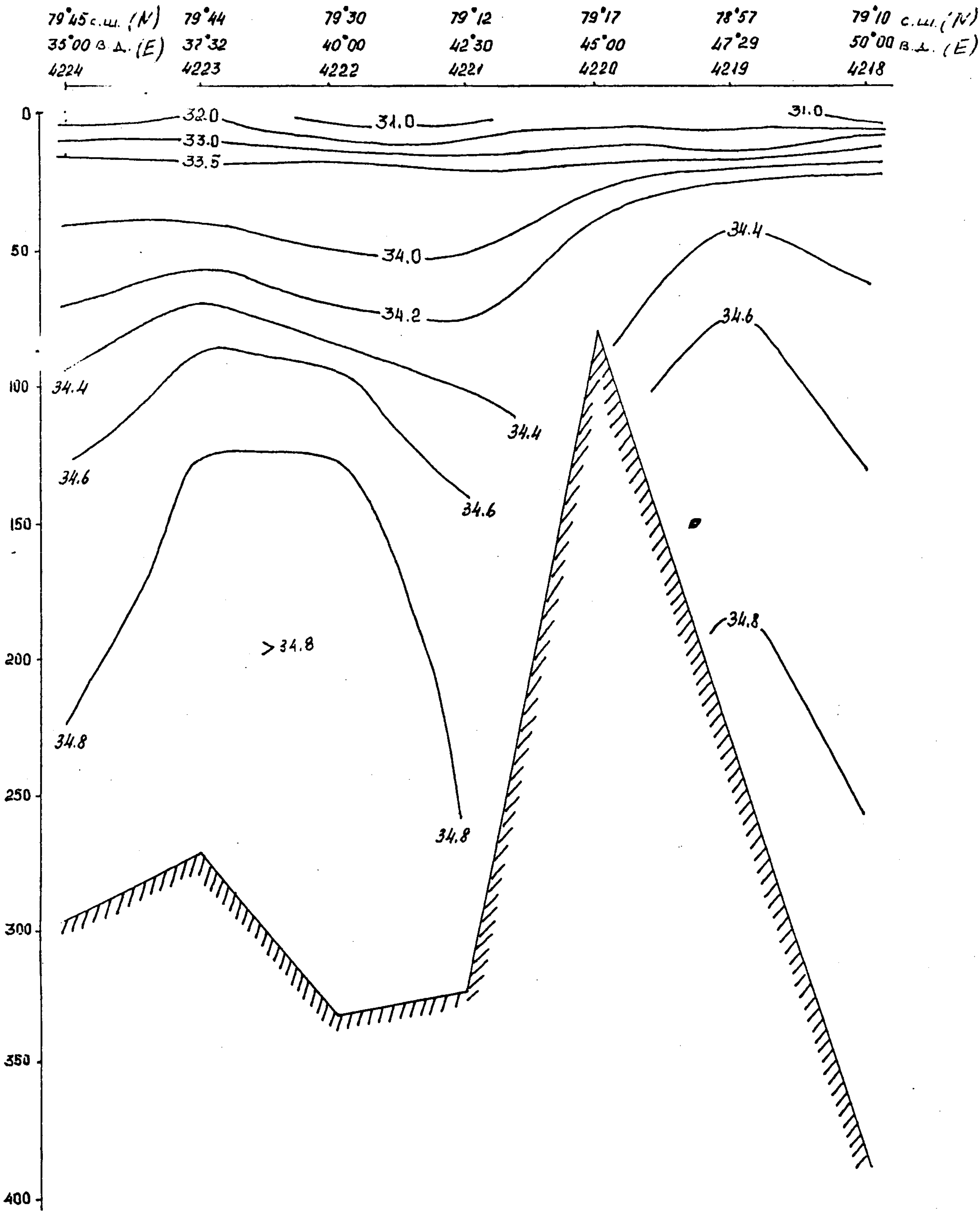

Fig. 4.2. Distribution of salinity (S oloo) of water on the cross section near ice border in the Barents Sea, 27-31.07.90. (27th voyage of RV "Professor Multanovsky")

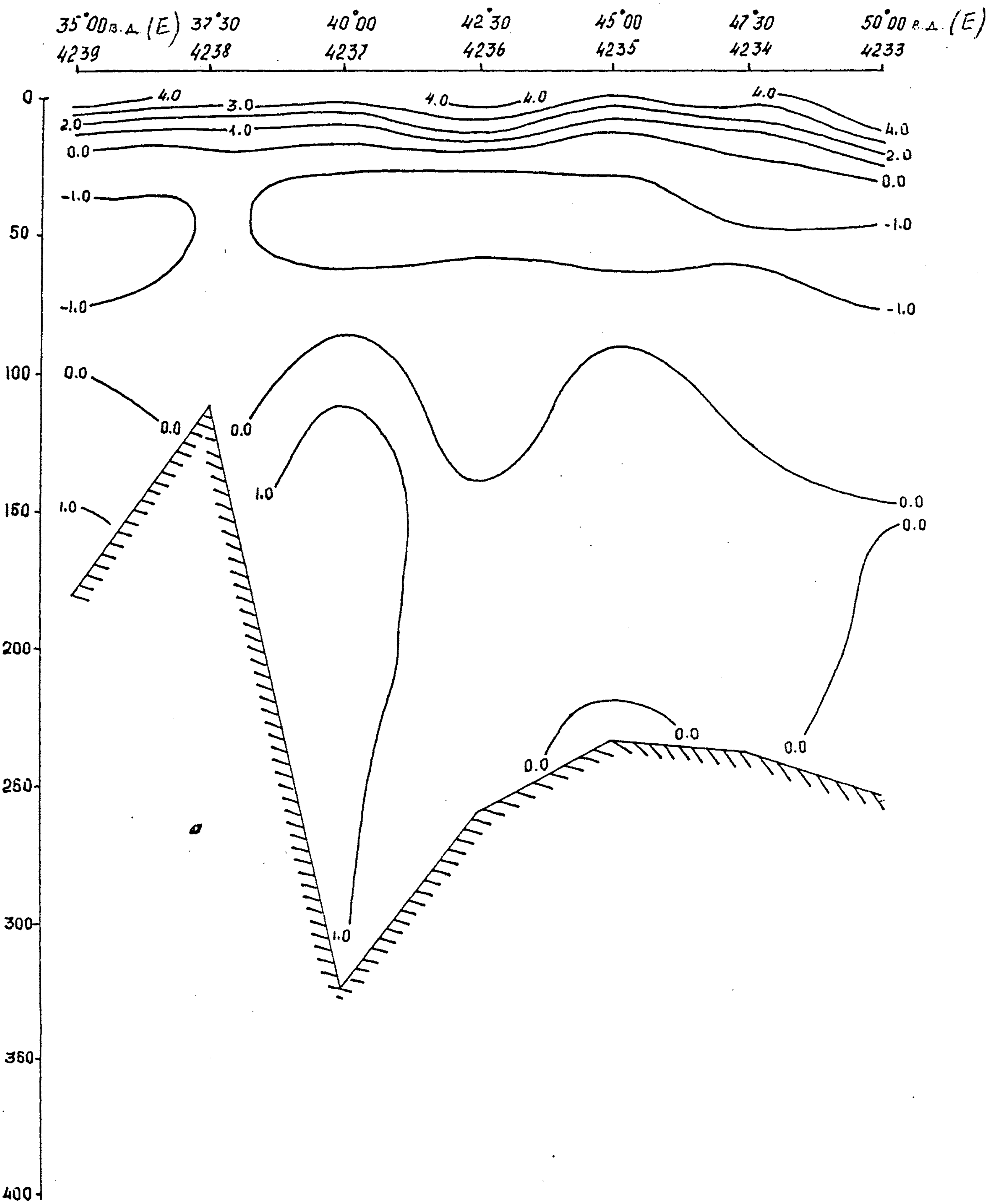

Fig. 4.3. *Distribution of temperature (T°) of water on the cross section on 78°30'N in the Barents Sea, 01-02.08.90 (27th voyage of RV "Professor Multanovsky")*

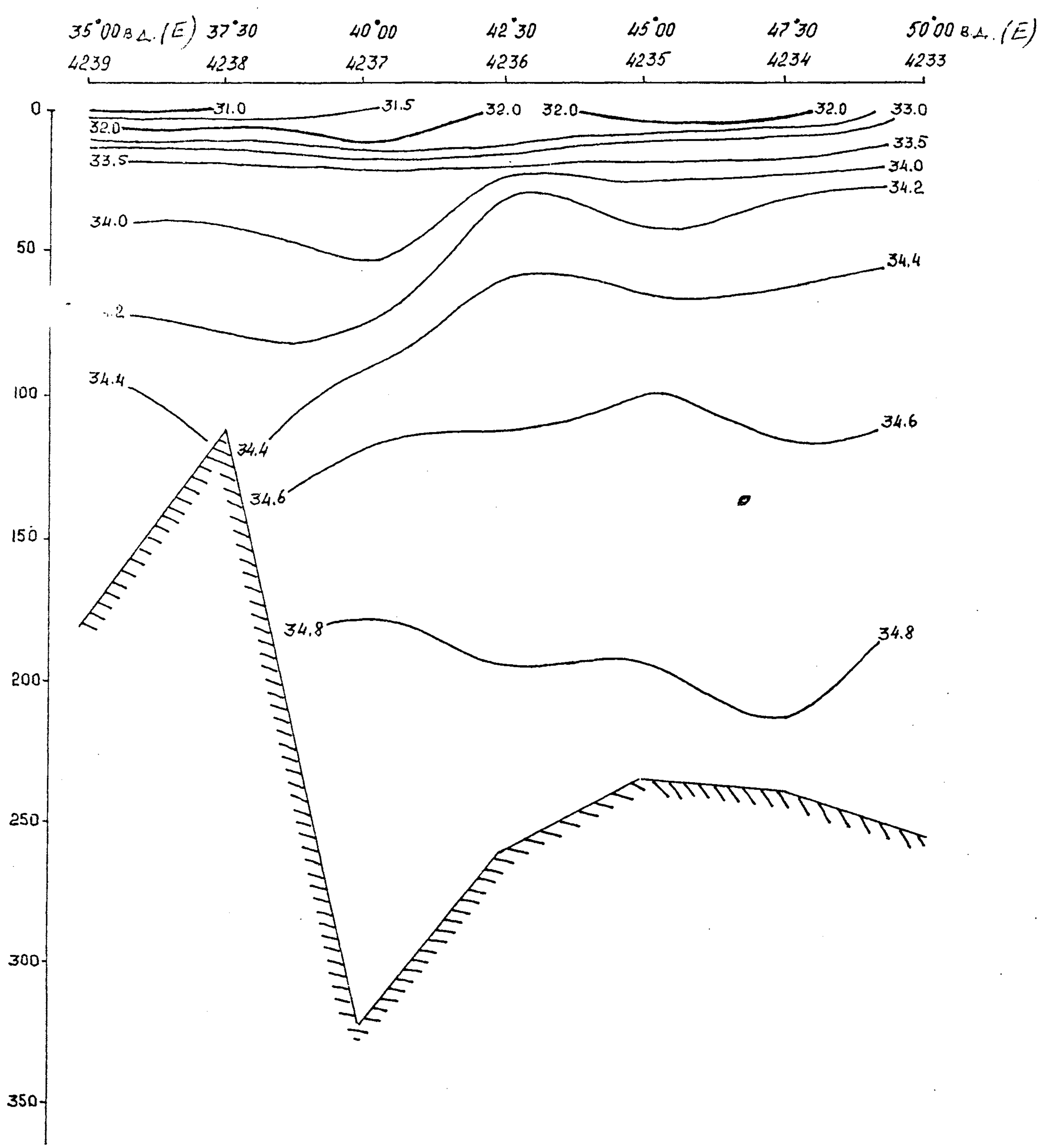

Fig. 4.4. *Distribution of salinity (S o/oo) of water on the cross section on 78°30'N in the Barents Sea, 01-02.08.90 (27th voyage of RV "Professor Multanovsky")*

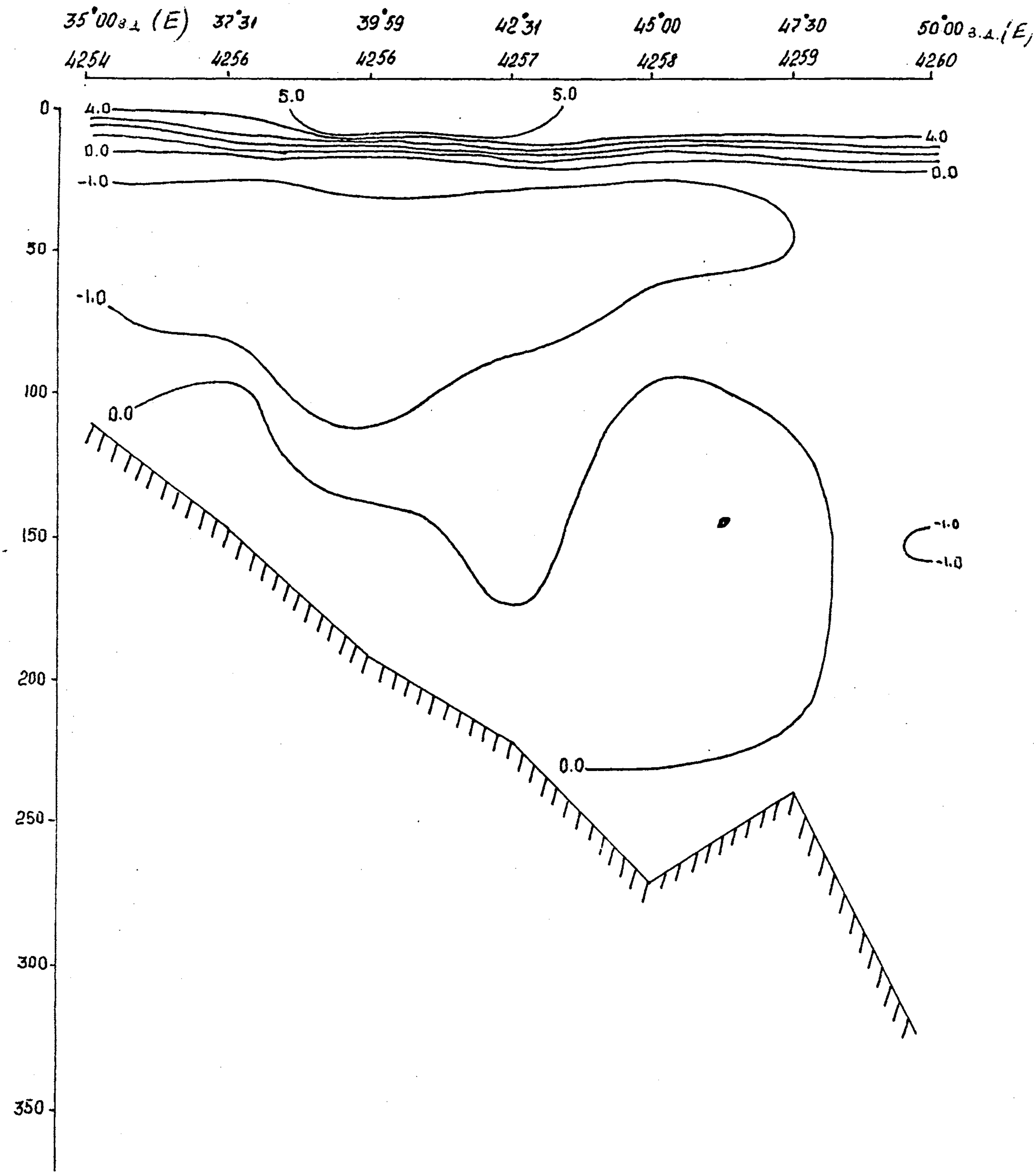

Fig. 4.5. *Distribution of temperature (T°) of water on the cross section on 77°N in theBarents Sea, 04-05.08.90*
(27th voyage of RV "Professor Multanovsky")

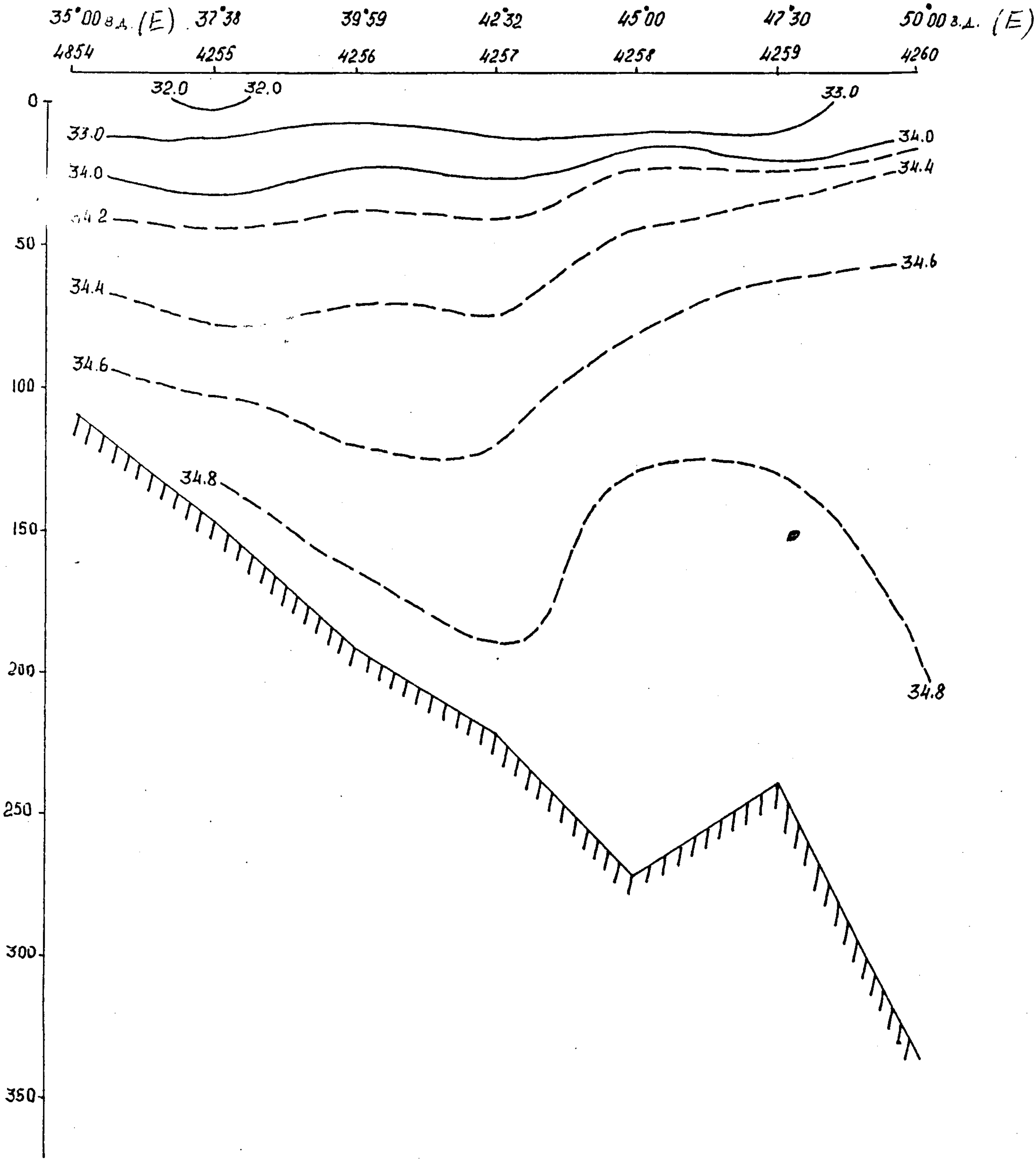

Fig. 4.6. *Distribution of salinity (S o/oo) of water on the cross section on 77°N in the Barents Sea, 04-05-08-90 (27th voyage of RV "Professor Multanovsky")*

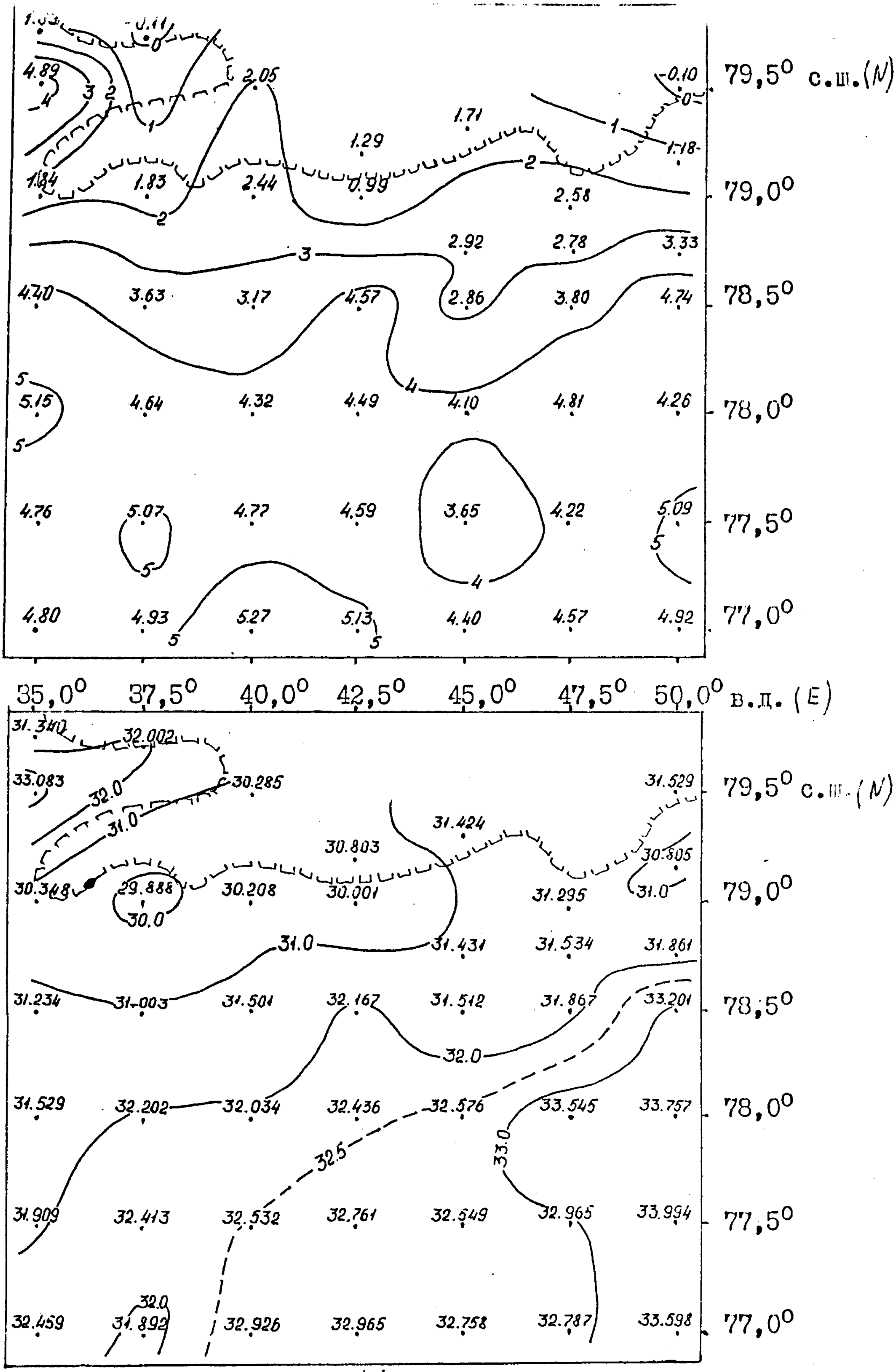

Fig. 4.7. *Distribution of temperature (T°) and salinity (S o/oo) on the horizon 0 m in the Barents Sea,27.07.90-05.08.90 (27th voyage of RV "Professor Multanovsky")*

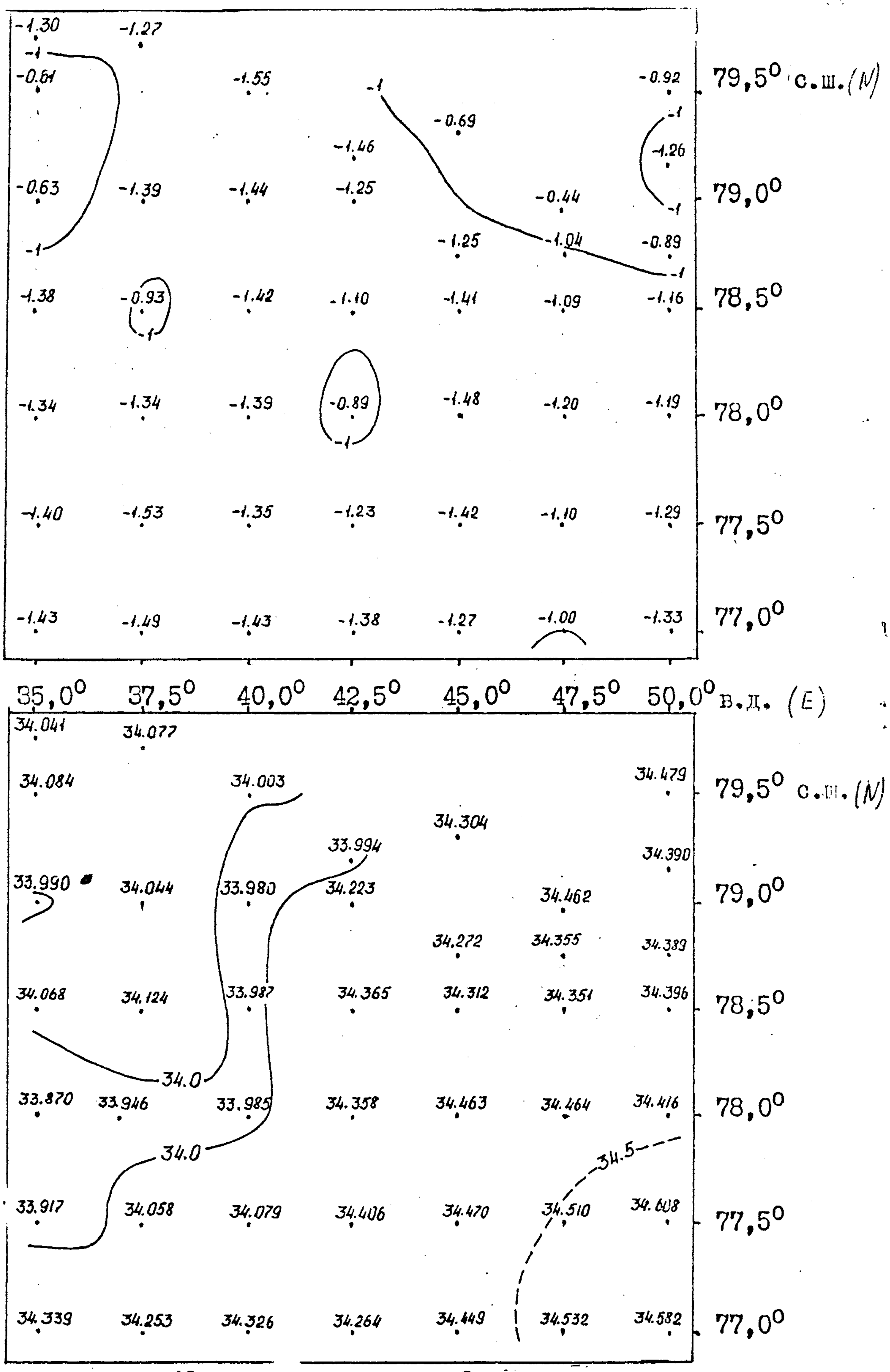

Fig. 4.8. *Distribution of temperature (T°) and salinity (S o/oo) on the horizon 50 m in the Barents Sea, 27.07.90-05.08.90 (27th voyage of RV "Professor Multanovsky")*

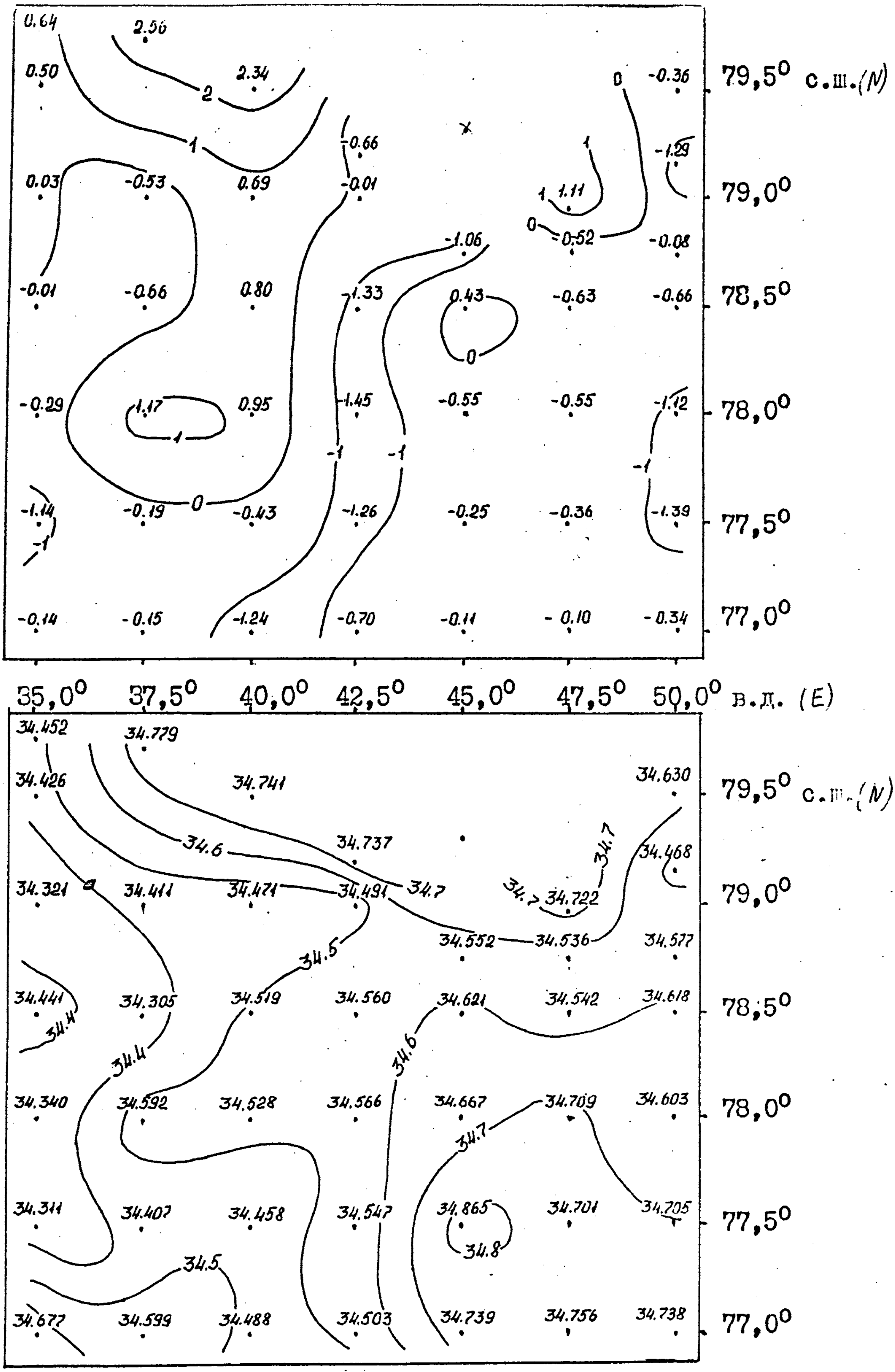

Fig. 4.9. *Distribution of temperature (T°) and salinity (S o/oo) on the horizon 100 m in the Barents Sea, 27.07.90 - 05.08.90 (27th voyage of RV "Professor Multanovsky")*

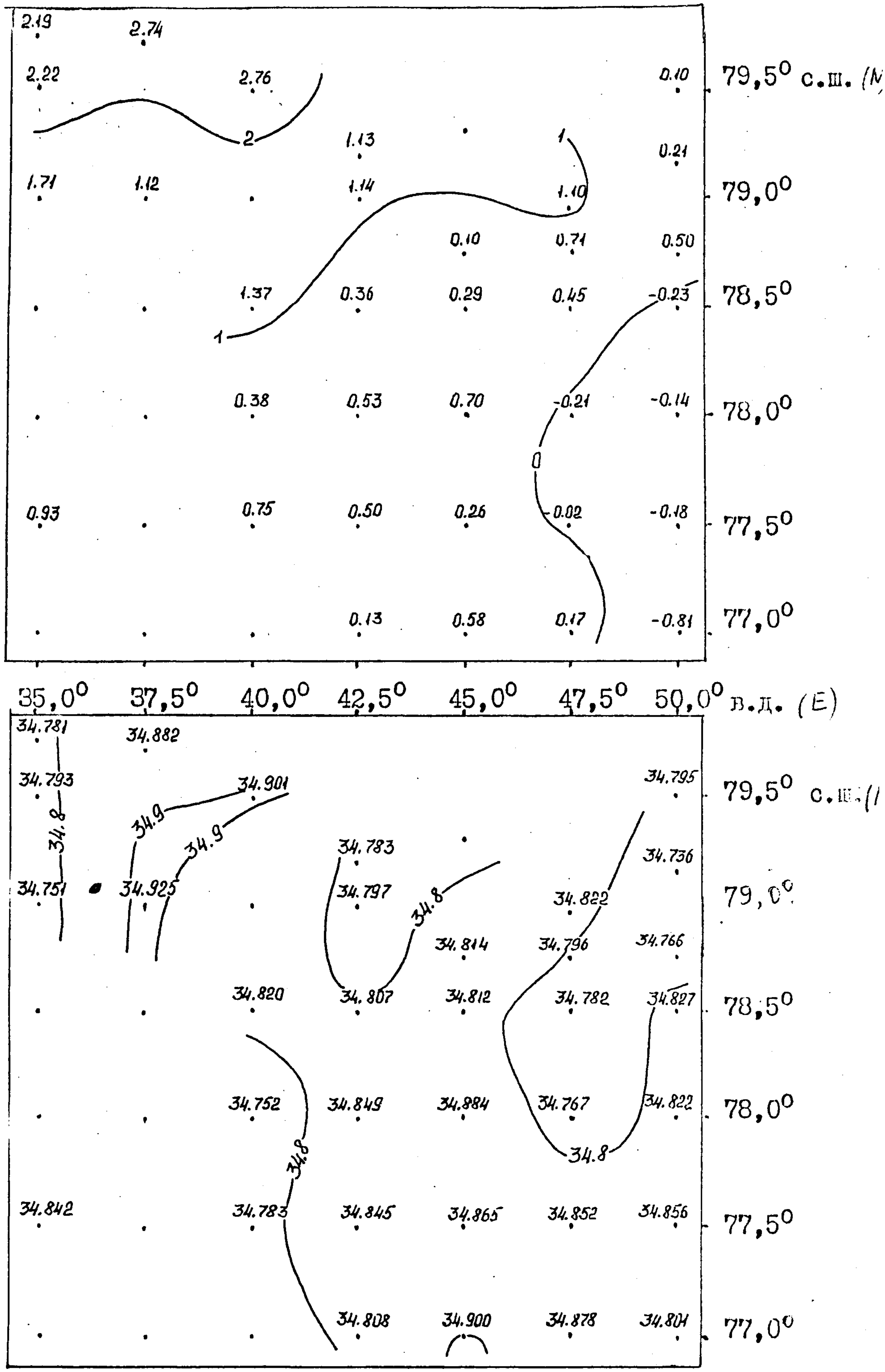

Fig. 4.10. *Distribution of temperature (T°) and salinity (S o/oo) on the horizon 200 m in the Barents Sea, 27.07.90 - 05.08.90 (27th voyage of RV "Professor Multanovsky")*

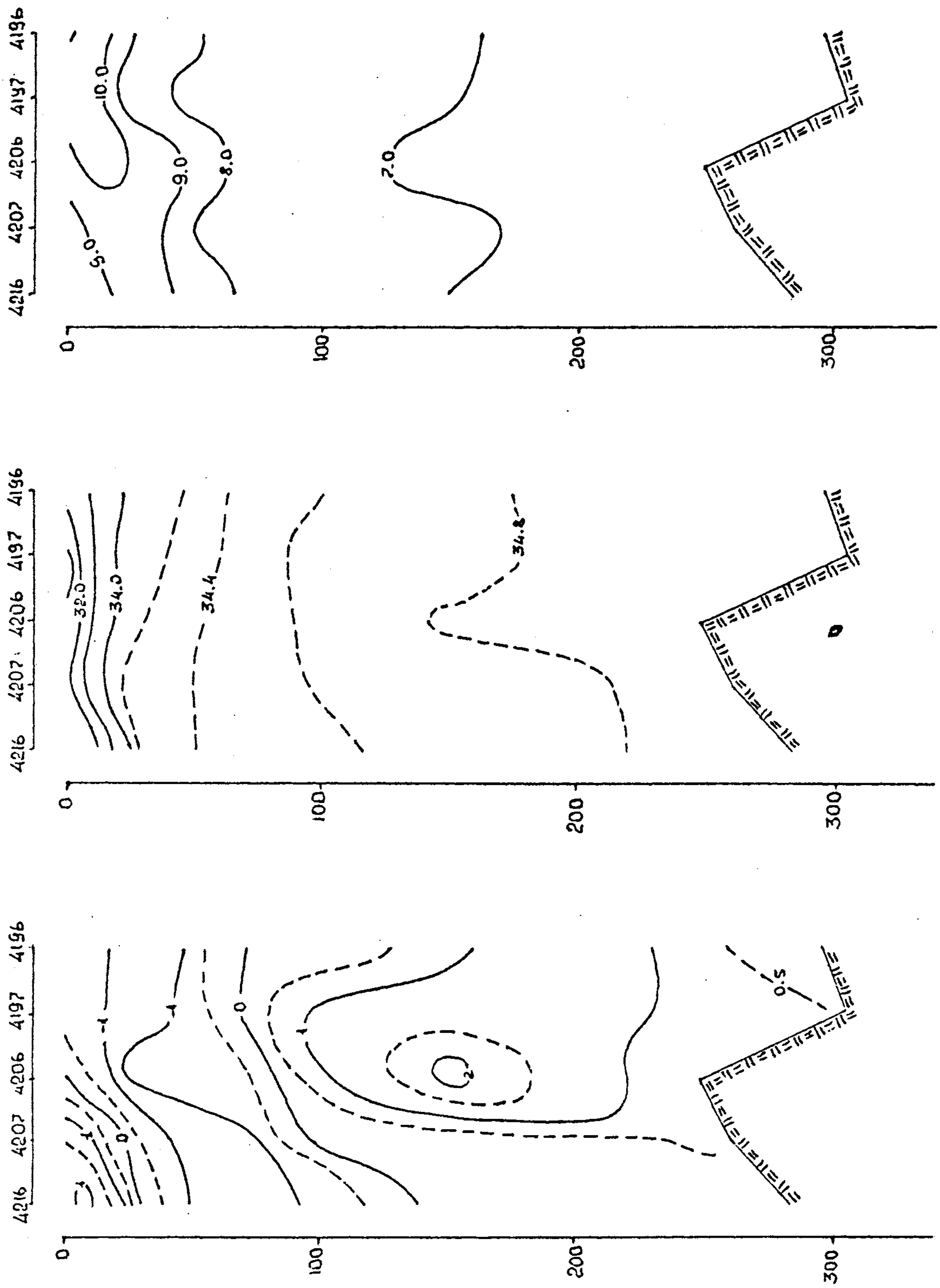

Fig. 4.11. *Distribution of temperature, salinity and oxygen on the west bound of "Micropolygon" in the Barents Sea (27th voyage of RVC "Professor Multanovsky")*

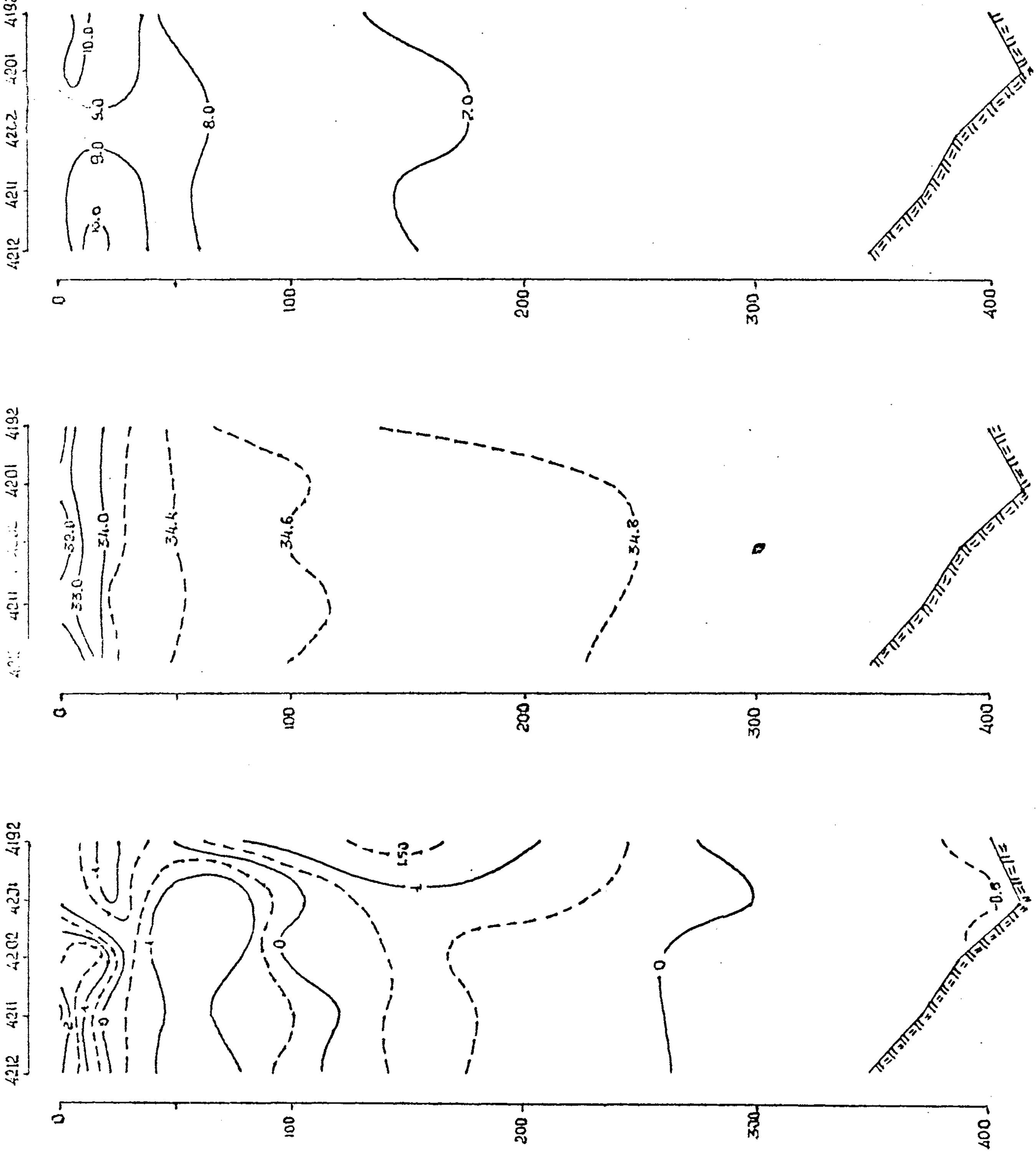

Fig. 4.12. *Distribution of temperature salinity and oxygen on the east bound of "Micropolygon" in the Barents Sea (27th voyage of RV "Professor Multanovsky")*

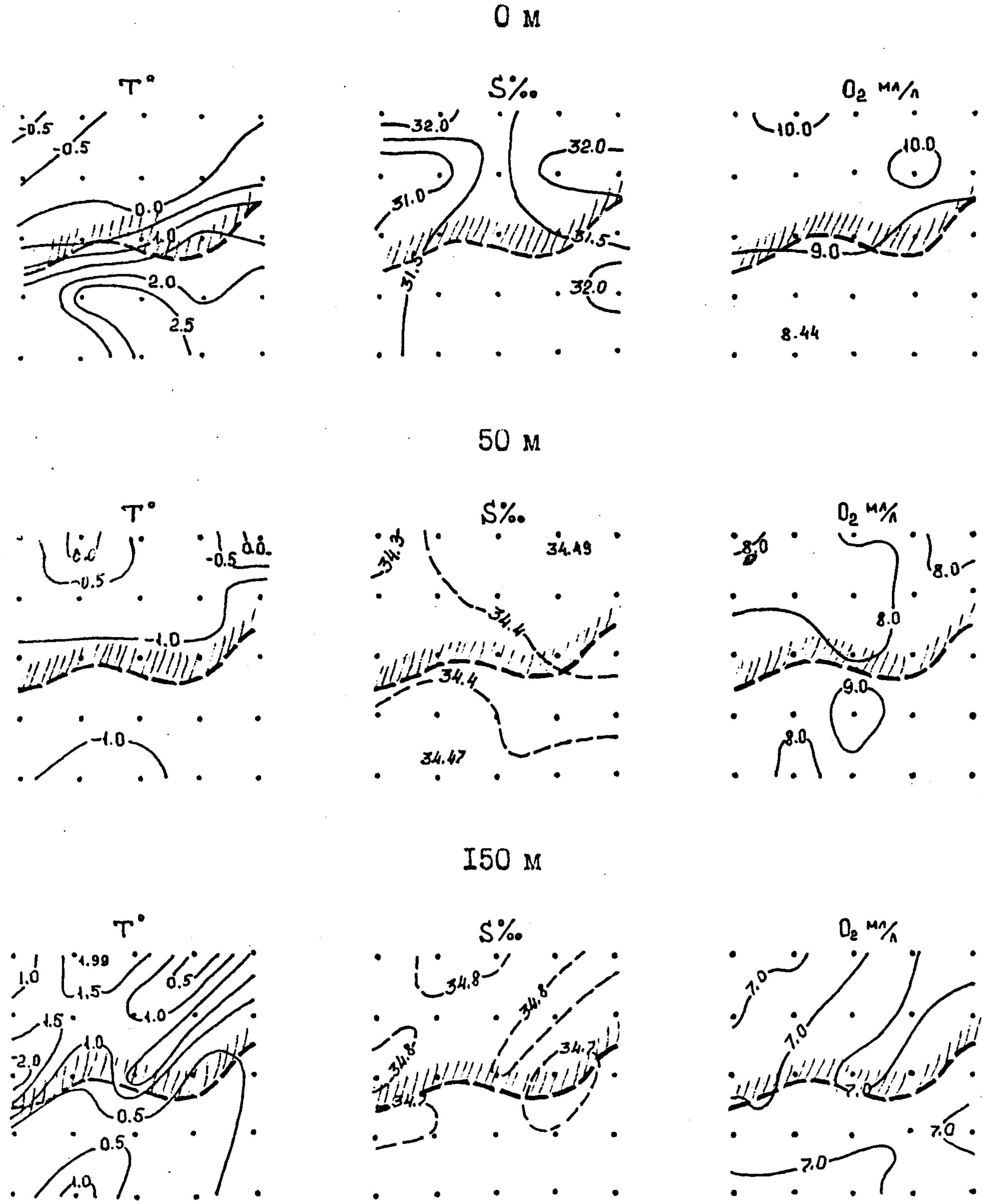

Fig. 4.13. *Distribution of temperature, salinity and oxygen in "Micropolygon" on the horizons 0, 50, 150 m in the Barents Sea, 24-26.07.90 (27th voyage of RV "Professor Multanovsky")*

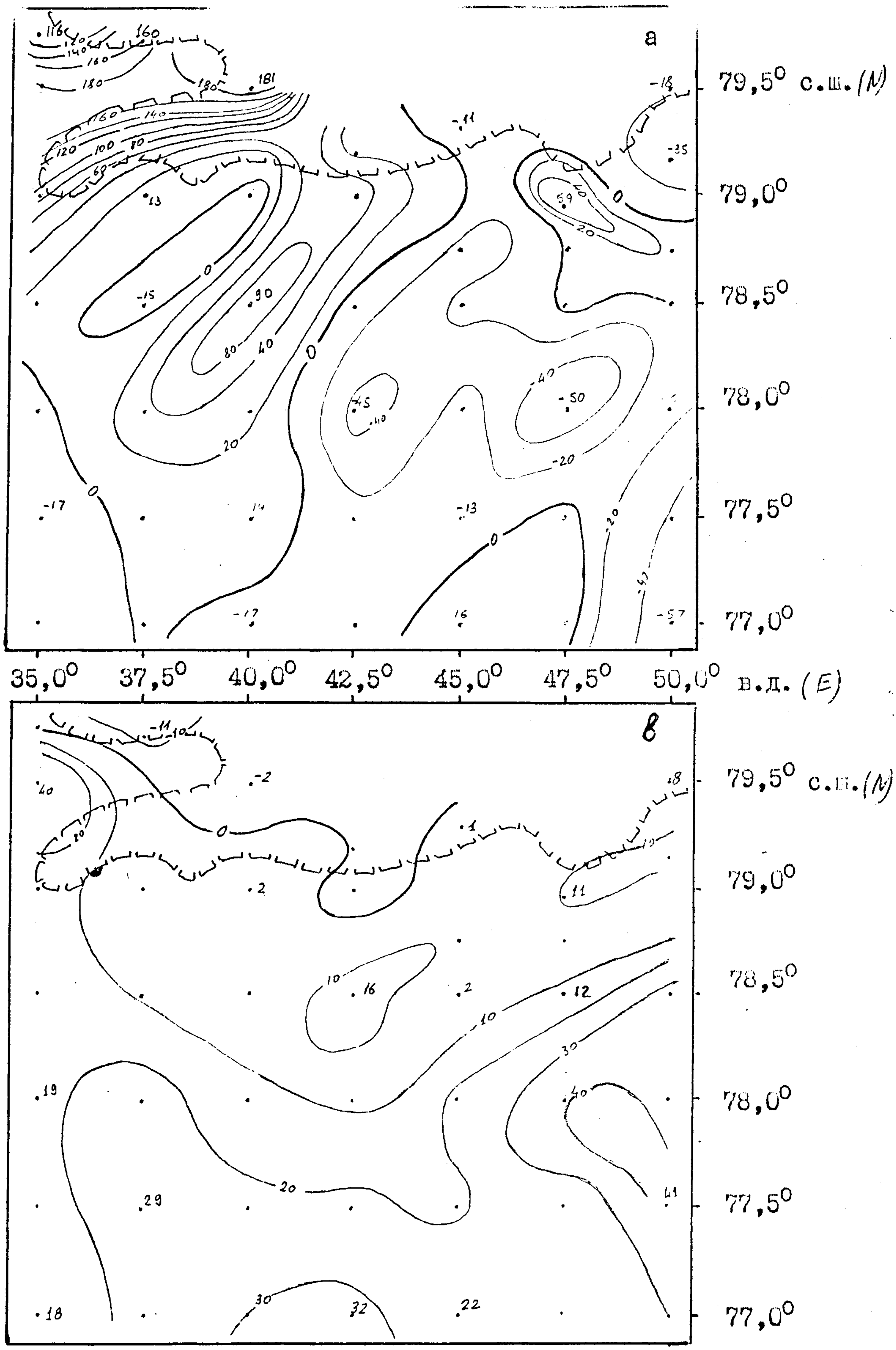

Fig. 4.14. Heat content (kcal) in layers: a: surface - bottom
b: surface - horizon 30 m
(Data of "SNOP-90", 27.07.90-05.08.80)

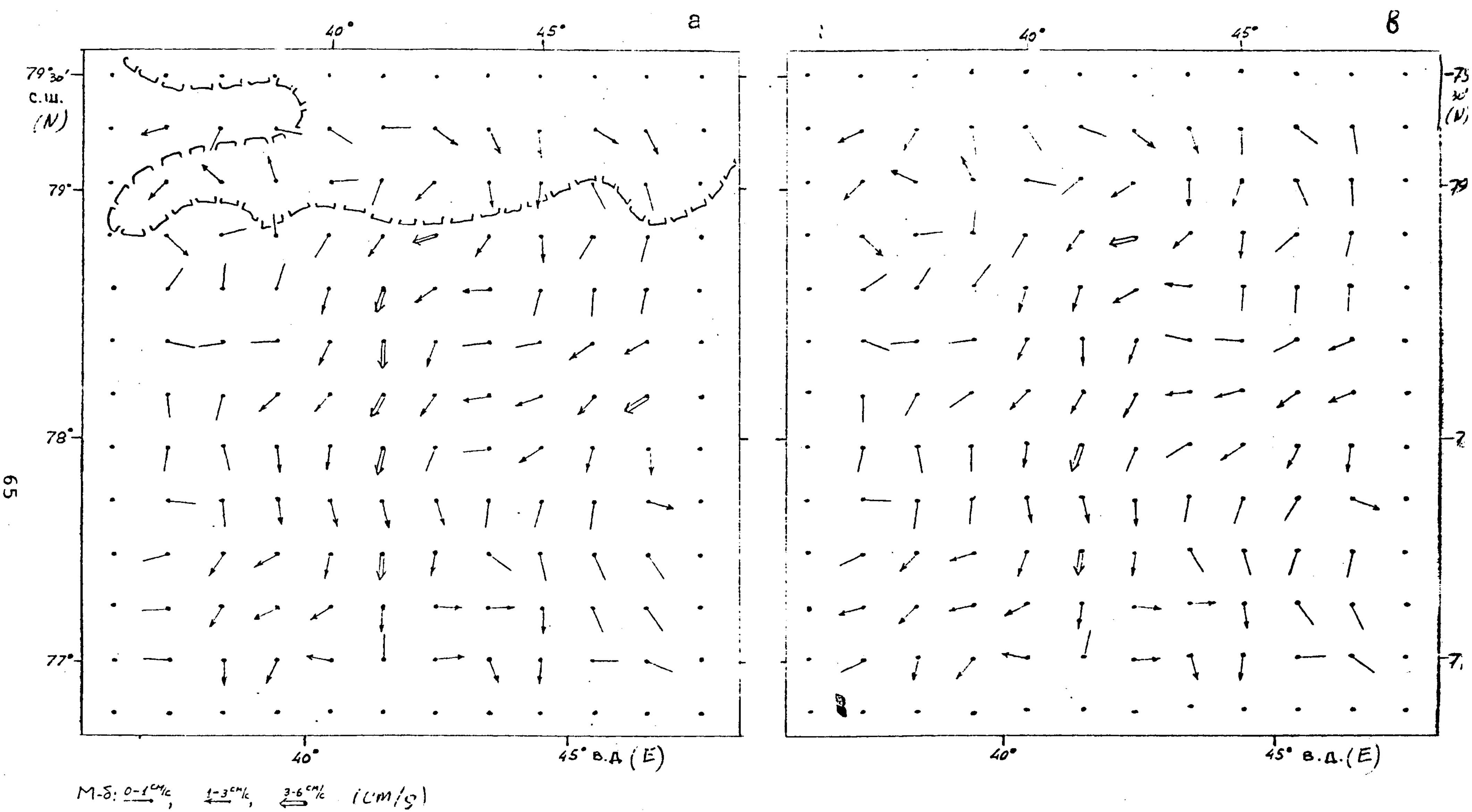

Fig. 4.15 *Termohaline flows on horizons 0 m (a) and 20 m (b). Results of calculation from oceanographic data of "SNOP-90"*

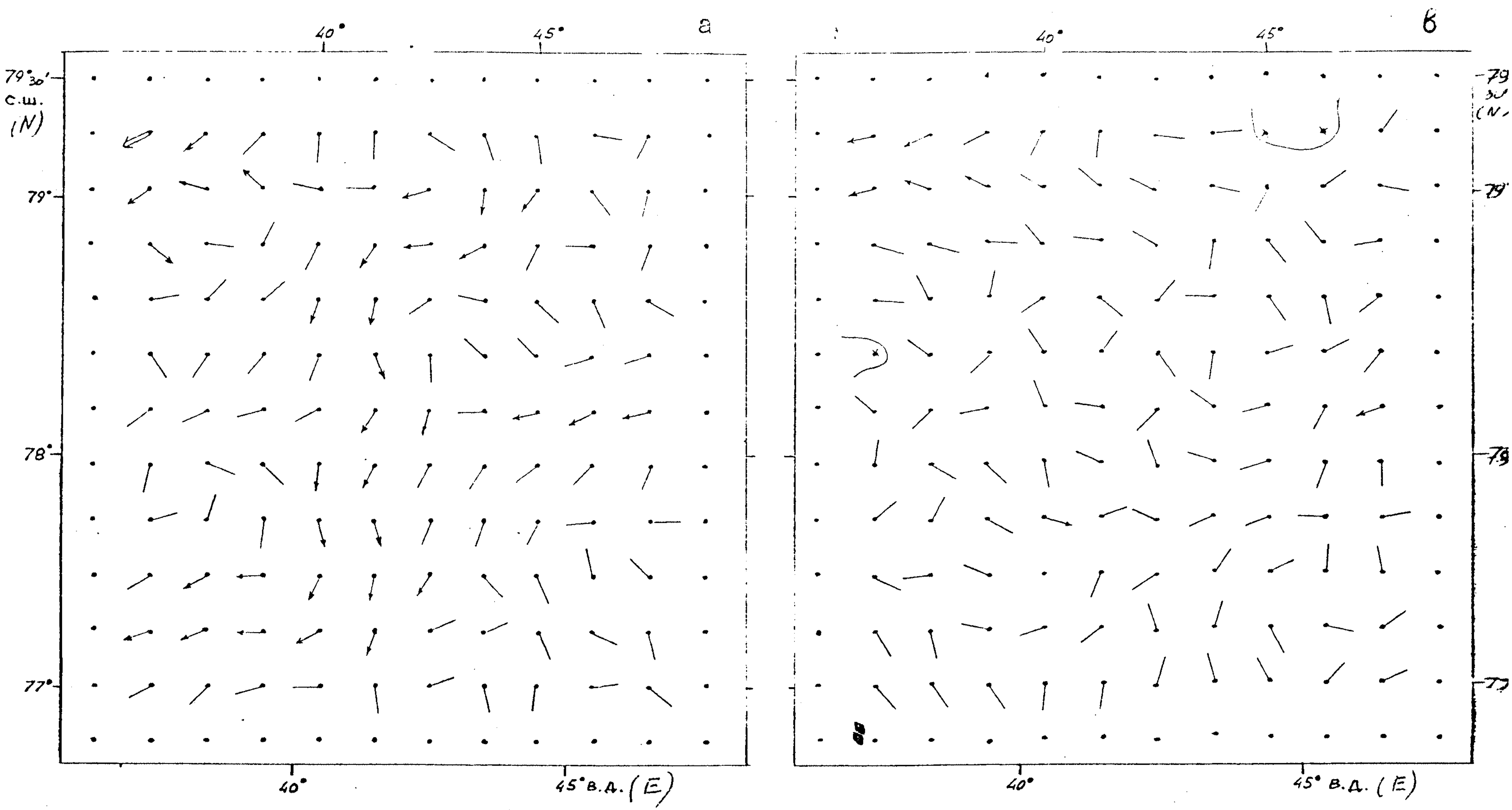

Fig. 4.16. Termohaline flows on horizons 50 m (a) and 100 m (b).
Results of calculation from oceanographic data of "SNOP-90"

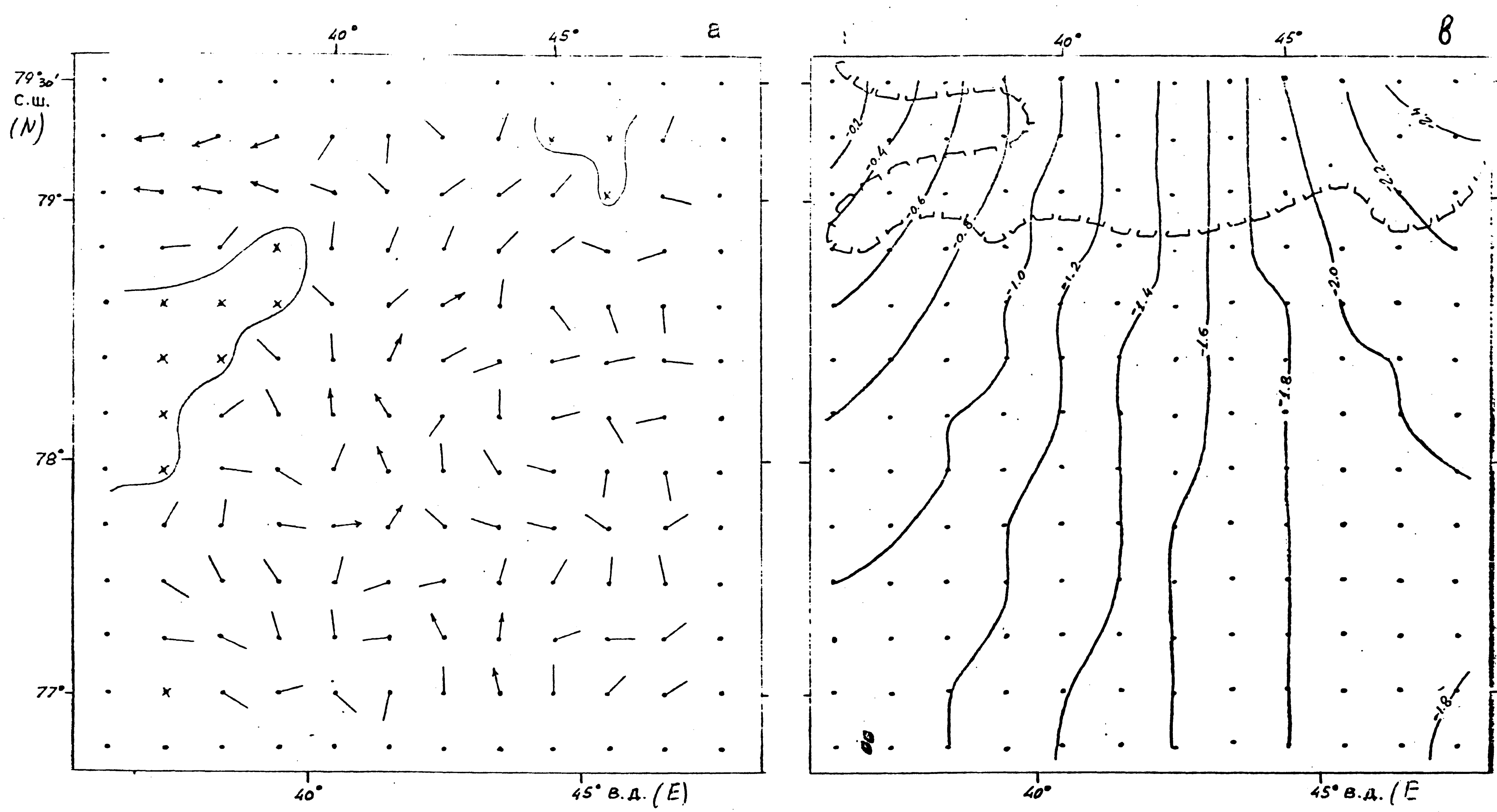

Fig. 4.17. *Termohaline flows on horizons 150 m (a) and sea level surface of the area in sm (b).*
Results of calculation from oceanographic data of "SNOP-90"

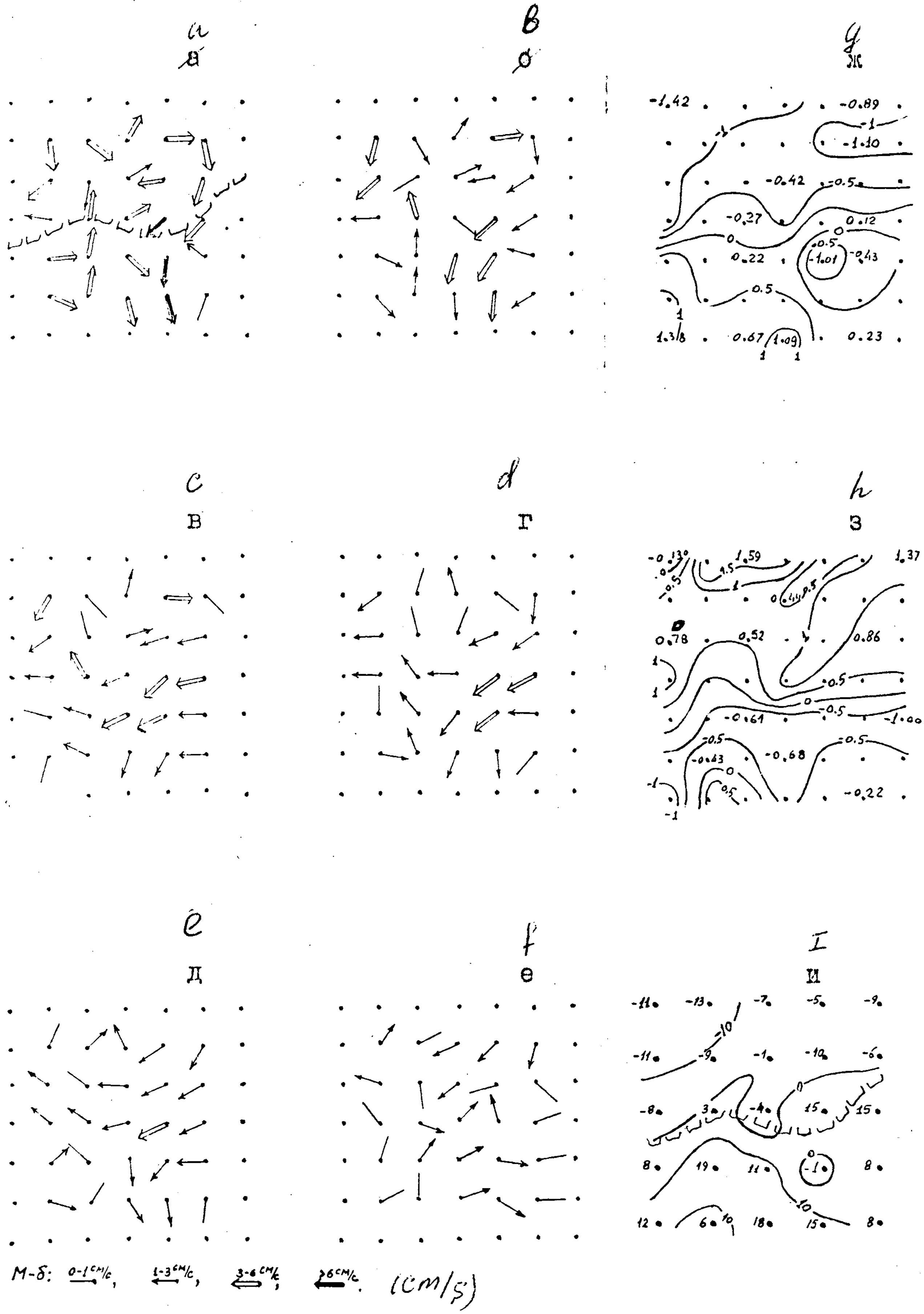

Fig. 4.18. *Distribution of hydrophysical characteristics in "Micropolygon":*

a-f -- - *termohaline flows on horizons; 0, 20, 50, 100, 150 m and near bottom*

g, h - *temperature on horizons: 20, 100 m*

i - *heat content of layer 0-30 m (kcal)*

5. SHORT-TERM TEMPORAL VARIABILITY OF WATER VERTICAL STRUCTURE IN THE STRAIT BETWEEN BEAR ISLAND AND NORWAY

V. K. Pavlov [1)]

To reveal the tidal variability of the vertical thermohaline water structure in the Barents Sea branch of the North-Atlantic current the hydrological work was conducted during the 27th cruise of R/V "Professor Multanovsky" at a two-day station at 71° 14' N and 22° 50'E.

Observations were conducted by means of a "Neil Brown" CTD, provided by the Norwegian Polar Research Institute.

During two days 15 soundings with the interval of 3 hours and vertical resolution of 10 cm were carried out.

The character of salinity and temperature distribution is presented in Fig 5.1.

A quasi-homogeneous layer with characteristic temperatures of 10-12°C and salinity 34.70-34.75 % is located from the surface to the depth of 20-25 m. A developed thermohalocline is observed between 20 and 50 m with vertical gradients of temperature and salinity of 0.164°C/m 0.0112%/m respectively. A homogeneous water mass of Atlantic origin with temperature of 6.5-4.8°C and salinity 35.-2-35.04 % is observed below the lower thermohalocline boundary to the bottom.

Dispersion of temperature and salinity in the two-day observation series by horizons is shown in Table 5.1.

Table 5.1

Dispersion and correlation coefficients between T and S % at observation horizons

Hor	0	25	50	100	150	200	250	300	350	380
DT	0.329	0.489	0.169	0.126	0.088	0.101	0.099	0.024	0.076	0.160
DS	0.054	0.033	0.038	0.011	0.014	0.008	0.010	0.040	0.002	0.002
CC	-0.60	0.60	0.21	0.30	0.43	0.46	0.98	0.61	0.19	-0.03

1) Arctic and Antaractic Research Institute, USSR

DT - dispersion fo temperature (°C)

DS - dispersion of salinity

CC - correlation coefficients (T - S %)

The maximum values of dispersion are recorded in the quasi- homogeneous layer and the thermohalocline, minimum - in the Atlantic water mass at the depth of 300 m, in temperature values, and at 350 m and 380 m in salinity values. The best relationship between temporal course of temperature and salinity is observed in the depth interval 150-300 m (correlation coefficient is 0.43-0.98).

The tidal variability of the water mass thermohaline characteristics is determined by horizontal reverse advection and vertical water mass motion.

The high resolution capacity of "Neil Brown" allowed one to trace the character of water particles displacement in different layers of water mass by means of fixing depth changes in positions of chosen T, S % characteristics.

It is possible to trace temporal course of vertical water particles displacement in different layers by the position of isotherm T = 9.51°C near the upper thermocline boundary (Fig. 5.2A), isotherm 6.10°C in the middle of Atlantic water mass (Fig. 5.2B) and isotherm 5.85 in the bottom layer (Fig. 5.2 C). In general the character of the vertical fluctuations in the water masses have a period near to 1/2 a day. This is particularly seen at depths between 100-150 m (Fig. 5.2B), where the boundary layer disturbances are small and the water movement is near to the geostrophic one. It should be noted that there is no synchronism, and the trend of the isotherm fluctuations in the surface and deep layers (dotted line in Fig. 5.2) has opposite direction.

The fluctuation amplitude equal to 4-5 m at the upper thermocline boundary and 6-70 m in homogeneous Atlantic water mass probably depends on stratification.

Following the law of reverse barometer and using formulae from /1/, which connect the denivelation of free surface level and layer boundaries in water mass in hydrological conditions of observations carried out, we have the following expression for the upper boundary of the thermohalocline:

ζ = 0.2 x 10 x -3 ζ_r (5.1)

ζ - denivelation of free surface level;

ζ_r - denivelation of upper thermohalocline boundary position.

The value of free surface denivelation, calculated according to Formula (5.1) is lower, at least by one order of magnitude, than existing tidal fluctuations in this region. This is an evidence of a more complicated mechanism of transmission of sea surface disturbance signal deep into stratificated liquid than the one considered in /1-3/.

The conclusion made in /1/ suggests that the denivelations of the interface boundaries in the lower layer induced by disturbances in the sea level surface, are an order of magnitude higher than the denivelations of the thermohalocline upper boundary layer.

The temporal variations of dynamic heights , calculated for the 300 m horizon, are shown in Fig. 5.3A. The values of dynamic heights during the whole observation period changed insignificantly. The amplitude of the oscillations was 0.011 dyn.m, and the dispersion values were 0.003. The trend in variations of dynamic heights (Fig.5.3A) is not recorded. The maximum correlation between the changes of dynamic heights and vertical water particle displacement, calculated according to the position of 7°C isotherm (Fig.5.3B), was observed near the lower thermohalocline surface (correlation coefficient R=0.82). There was also no trend in the changes of isotherm position at this horizon (Fig.5.3B).

It should be mentioned, that the results of computations of vertical water displacement, carried out by means of identification of isotherm position, are similar to those, obtained by identification of isohaline positions.

The analysis of the results of vertical water structure variability at the two-day station allows one to make the following preliminary conclusions:

- the short-term variability of water vertical structure is induced by tidal phenomena and has a period near to 1/2 a day;
- the vertical water particle oscillations occur not only in the zones of maximum density gradients at the boundary of different water masses, but also in the whole water column, including layers with small stratification. Probably the vertical motion in the lower layers is induced not only by free surface, but also by each boundary between different water masses;
- the amplitude of the water particle oscillation depends on the startification and its values from several meters to several hundred meters;
- the vertical displacement of the water particles above and under the thermocline occurs in antiphase, which especially characterizes the longer-period oscillations (Fig.5.2);
- there is no trend in the short-term variability of dynamic heights, which is the evidence of compensating adaptation of vertical structure to long-term outer disturbances;
- there is no confirmation for some statements and empiric formulae, resulting from the law of "reverse barometer";
- a special attention should be paid to the fact that there is no considerable water mixing during the whole observation period, even in the zones of minimum vertical thermohaline gradients. This allowed us to conduct the research correctly;
- the maximum velocity values , calculated by water particles displacement, are equal to 0.4 cm/s.

To develop a well-founded phenomenologic model of temporal variability of water mass vertical structure, depending on disturbances at the free sea surface, it is necessary to conduct multi- day stations in the tidal region with duration of 2-3 synoptic periods by means of a sounding equipment with small time lag and high resolution together with simultaneous sea level observations.

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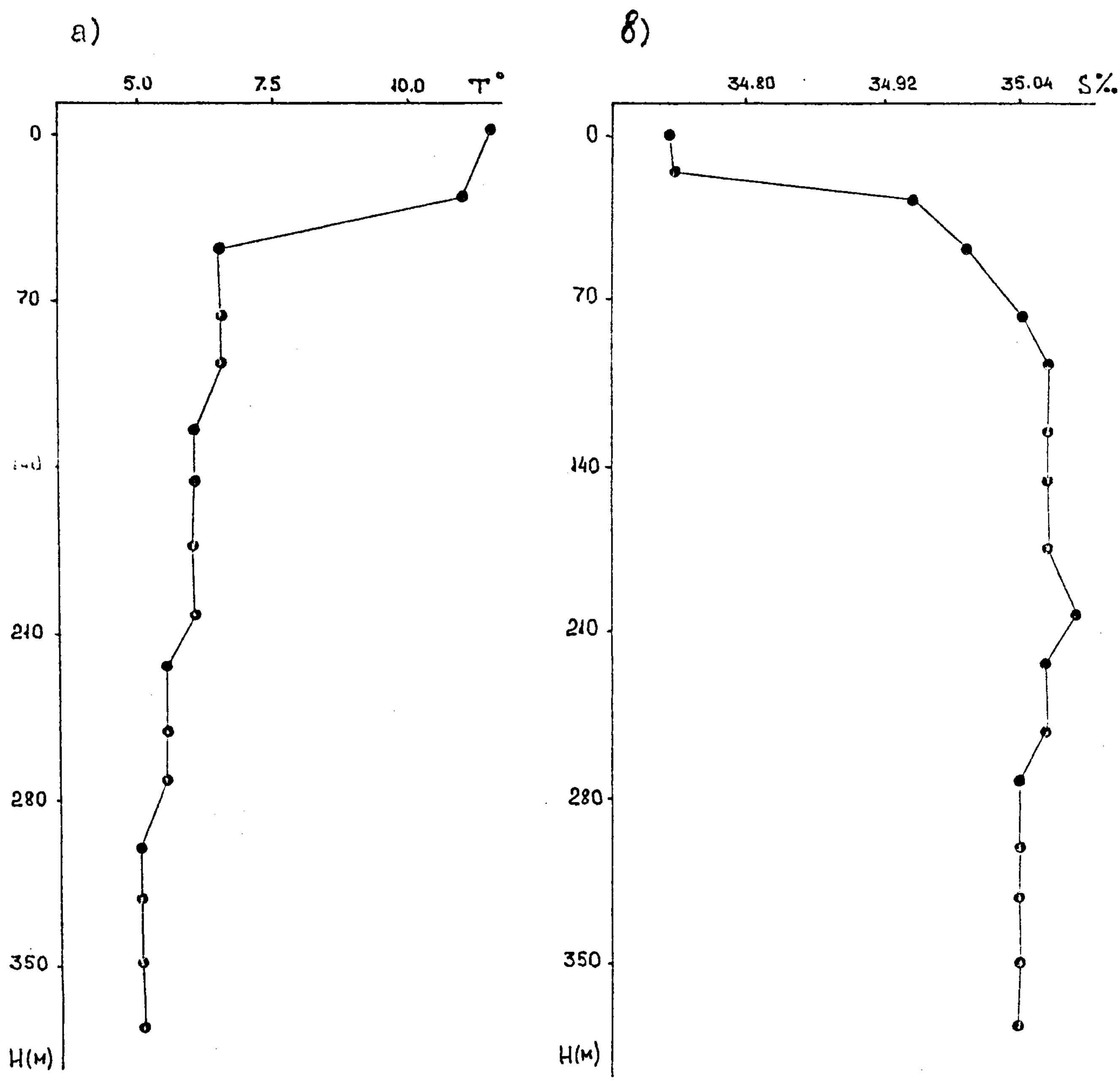

Fig. 5.1. *Characteristic vertical distribution of temperature (a) and salinity (b) at two-day station*

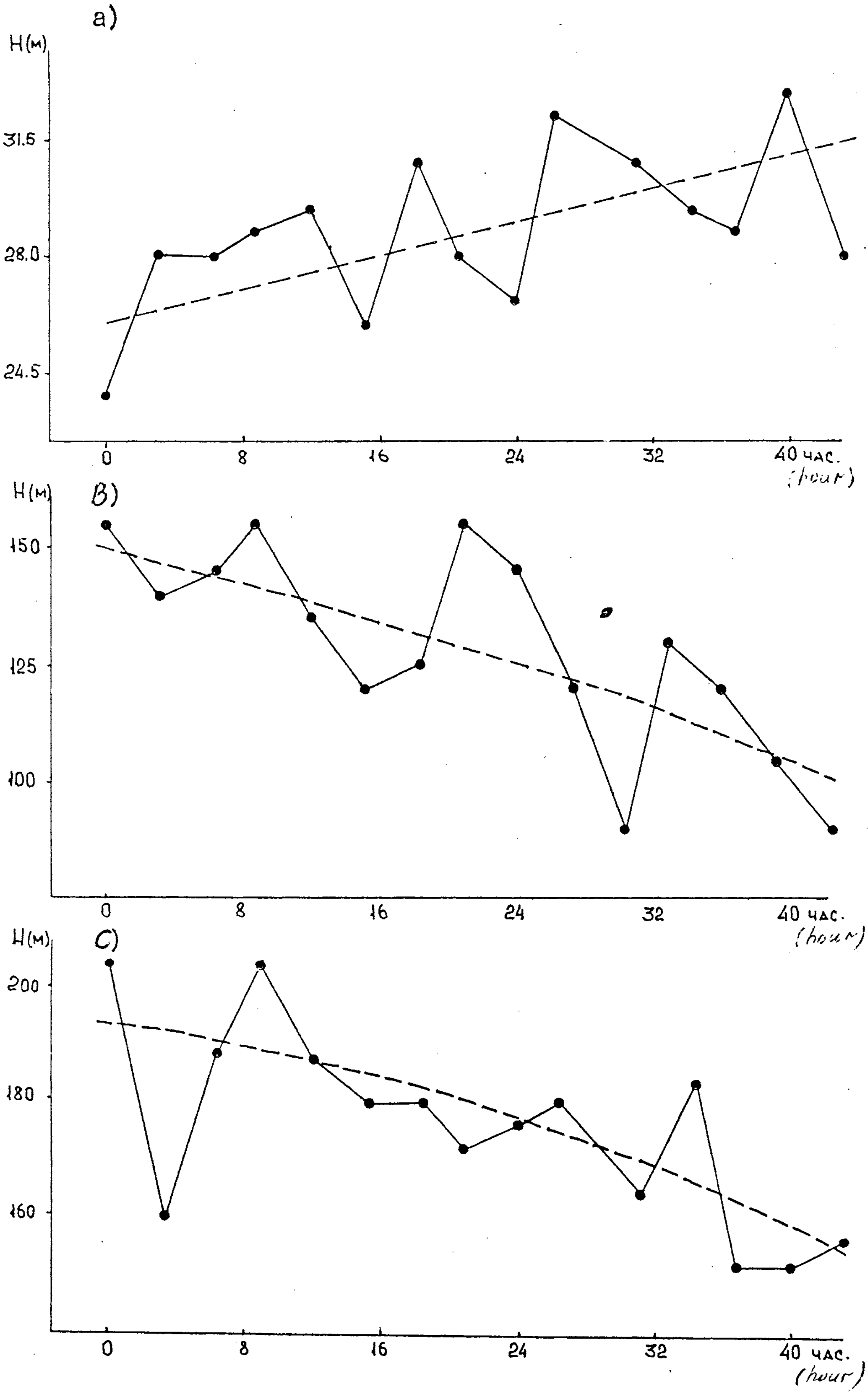

Fig. 5.2. Temporal variations of positions of isotherms 9.50 ℃ (a), 6.10 ℃ (b) and 5.85 ℃ (c)

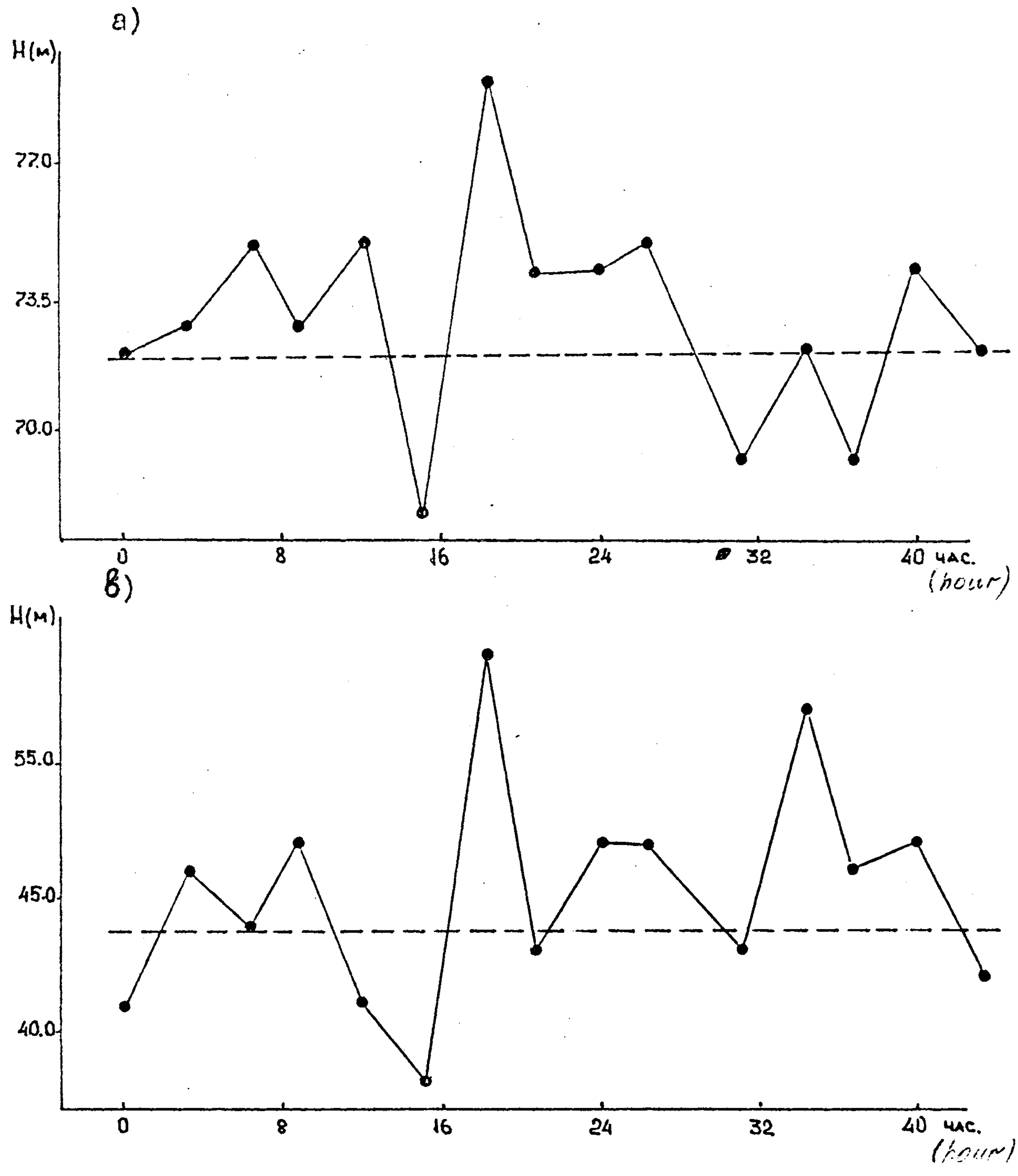

Fig. 5.3. *a- Temporal variations of dynamic height*
(D = (D-291)x100, D - dynamic height, calculated from horizon 300 m)
b - Position of isotherms 7.00 ℃

APPENDIX A

TABLE

List of time and position of the CTD-station during the cruise

STA	Time	Position	
1	24.07.90	79 216°N	50 113'E
2	24.07.90	79 247	49 397
3	24.07.90	79 272	49 184
4	24.07.90	79 286	48 531
5	24.07.90	79 308	48 313
6	24.07.90	79 261	48 179
7	24.07.90	79 243	48 428
8	24.07.90	79 225	49 065
9	25.07.90	79 203	49 323
10	25.07.90	79 176	49 564
11	25.07.90	79 131	49 449
12	25.07.90	79 156	49 198
13	25.07.90	79 176	48 565
14	25.07.90	79 200	48 333
15	25.07.90	79 221	48 085
16	25.07.90	79 175	47 583
17	25.07.90	79 154	48 208
18	25.07.90	79 132	48 445
19	25.07.90	79 112	49 086
20	25.07.90	79 088	49 378
21	25.07.90	79 039	49 234
22	26.07.90	79 066	48 572
23	26.07.90	79 086	48 333
24	26.07.90	79 104	48 094
25	26.07.90	79 126	47 454
26	27.07.90	79 300	50 001
27	29.07.90	79 100	50 000
28	30.07.90	78 569	47 293
29	30.07.90	79 169	45 001
30	30.07.90	79 118	42 302

31	30.07.90	79 300	40 002
32	31.07.90	79 445	37 316
33	31.07.90	79 448	34 596
34	31.07.90	79 299	34 592
35	31.07.90	78 597	34 595
36	31.07.90	79 000	37 298
37	31.07.90	79 000	40 004
38	01.08.90	79 000	42 307
39	01.08.90	78 450	44 599
40	01.08.90	78 451	47 303
41	01.08.90	78 451	49 599
42	01.08.90	78 299	50 007
43	01.08.90	78 300	47 301
44	01.08.90	78 301	44 588
45	01.08.90	78 299	42 301
46	02.08.90	78 300	39 599
47	02.08.90	78 300	37 301
48	02.08.90	78 309	34 593
49	02.08.90	78 000	35 007
50	02.08.90	78 000	37 295
51	02.08.90	77 597	39 597
52	03.08.90	78 001	42 304
53	03.08.90	78 000	44 598
54	03.08.90	78 002	47 301
55	03.08.90	77 598	49 524
56	03.08.90	77 300	50 001
57	03.08.90	77 301	47 303
58	03.08.90	77 301	45 005
59	04.08.90	77 301	42 299
60	04.08.90	77 301	40 002
61	04.08.90	77 300	37 304
62	04.08.90	77 301	35 002
63	04.08.90	77 000	35 004
64	05.08.90	77 000	37 301
65	05.08.90	77 000	39 593
66	05.08.90	76 597	42 322
67	05.08.90	77 000	45 005
68	05.08.90	77 002	47 299
69	05.08.90	77 000	49 598
70	11.08.90	76 141	16 511

71	11.08.90	76 070	17 028
72	11.08.90	75 580	17 133
73	11.08.90	75 490	17 253
74	11.08.90	75 400	17 374
75	11.08.90	75 298	17 495
76	11.08.90	75 211	18 038
77	11.08.90	75 110	18 157
78	11.08.90	75 011	18 265
79	11.08.90	74 492	18 456
80	11.08.90	74 430	18 493
81	12.08.90	74 096	19 279
82	12.08.90	74 011	19 493
83	12.08.90	73 568	20 015
84	12.08.90	73 520	20 092
85	12.08.90	73 439	20 282
86	12.08.90	73 351	20 450
87	12.08.90	73 200	21 152
88	12.08.90	73 010	22 015
89	12.08.90	72 478	22 254
90	12.08.90	72 270	23 120
91	12.08.90	72 020	24 040
92	13.08.90	71 330	25 018
93	13.08.90	71 238	25 249
	13.08.90- -15.08.90	71 140	22 500

CRUISE REPORT

R/V OTTO SCHMIDT

6 JULY - 10 AUGUST 1990

Voyage Report for the Research Icebreaker "Otto Schmidt" July 6 - August 10 1990

B. Ivanov [1], P. Kosterin [2] A. Davydov [2], B. Novikov [2], G. Balyakin [2], G. Gagarin [2] & S. Shutilin [1]

INTRODUCTION

B. Ivanov [1]

In accordance with the expeditional program of the 37th voyage the research icebreaker "Otto Schmidt" left Murmansk on July 4, 1990. During July 8-12 an oceanographic survey was carried out at a mesoscale polygon in the strait between Spitsbergen and Bely Island. The survey consisted of 42 oceanographic stations to the bottom at a grid of 5 x 5 miles.

On July 16 a minisonde SD-200 (Norway) was loaded in Hammerfest, Norway. The three research vessels "Otto Schmidt", "Professor Multanovsky" (USSR) and "Lance" (Norway) then met in the Barents Sea to coordinate the SNOP survey operations.

During July 23-30, 28 soundings were carried out in the area of 78° 30'- 80° 30'N and 37° 60'- 51° 00E. Temperature and salinity were measured by means of Nansen bottle water samples as well as by SD-200. Additional soundings were made by SD-200 while crossing the drifting ice edge every 5 miles.

On July 31 the icebreaker was anchored to a large ice floe. While drifting a large amount of oceanographic observations were achieved. Every 6th hour vertical sounding were performed using Nansen bottles. Every 3rd hour the SD-200 minisonde was lowered to the depth of 60-70 meters (the mean position of the pycnocline) to study internal waves. Current velocities and directions were measured at three levels: imediately under the ice layer, in the pyenocline and in the warm Atlantic water. The drift was completed on August 5.

August 6 the icebreaker and R/V "Professor Multanovsky" met again, this time to transfer the data of observations under SNOP, and to discuss the preliminary results of the joint work.

On August 10 the icebreaker "Otto Schmidt" arrived in Murmansk.

1) Arctic and Antarctic Research Instsitute, Leningrad, USSR
2) Murmansk Hydrometeorological Service, USSR

EQUIPMENT, METHODS, DATA

Oceanography

Oceanographic measurements has been carried out using standard equipment onboard the "Otto Schmidt" icebreaker as well as instruments provided by the Norwegian cooperators:

- Nansen bottles with deep water thermometers;
- EST current meters;
- Minisonde SD-200 (Norway)
- Ship computer CM-4, DS "TOSHIBA" (Norway).

The following work was carried out:

- 94 oceanographic stations by means of Nansen bottles;
- CTD soundings by SD-200;
- CTD soundings by SD-200 during the drift from 31.06 to 5.07.90.

  1 two-hour measurement series by SD-200 in the pycnocline (60-70m) during 31.06-5.07.90
- 240 measurements of current velocities and directions at three levels with 30 min. intervals

Sea ice

Visual observations of drifting ice and iceberg distribution were conducted in accordance with "International Symbols for sea ice charts and WMO Sea Ice Nomenclature" (Gidrometeoizdat, Leningrad, 1984, 65 pp.). To estimate the number of icebergs and the ice edge location, especially under limited visibility, a ship radar was used.

Calculations of drift speed and direction during 31.06 - 5.07.90 were made by means of a ship navigation system FN-200 ("FURUNO"). Satellite charts, ice maps of the Bracknell Meteorological Center and ice reconnaisance data were received.

Hydrochemistry

All hydrochemical measurements were analysed on board the icebreaker. Sea water samples were collected using Nansen bottles and analysed using the following instruments:

- salt gauge GM-65 (in salinity range of 4.993 - 27.013 the measurement error is not more than ± 0.03 , in range of 27.013 - 42.032 ± 0.02). The salt gauge was calibrated using normal water, made at the analytical laboratory of the Shirshow Oceanographic Institute of the USSR Academy of Sciences. Relative conductivity was reduced to salinity units () according to the

International Oceanographic Tables (UNESCO). Prior to calculations the temperature of all samples were controlled;

- the content of dissolved oxygen was estimated by the modified Winkler method;

- silicon concentration in sea water was measured by the method, developed at VNIRO (USSR).

Meteorology

Meteorological and actinometric parameters were measured at normal synoptic hours (00, 03, 06, 09, 12, 15, 18, 21 GMT). Wind speed and direction, atmospheric pressure, air temperature and humidity, sea water temperature and total short-wave radiation were measured.

The state of the sea surface, number and form of clouds, the height of lower cloudiness boundary, atmospheric events, horizontal visibility and ice conditions were defined visually.

Additional meteorological observations were carried out during the work at mesoscale polygon using additional instruments:

- air temperature, (electropsychrometer EPG-70 accuracy ± 0.1°);
- relative air humidity, (soption hydrometer GS-210 accuracy ± 3%);
- water surface temperature (temperature sensor, ± 0.2° C);
- snow, ice surface temperature (infrared radiometer, ± 0.3° C).

ICE CONDITIONS

B. Novikov[1]. *P. Kostezin*[1]

Ice conditions in the Northern Barents sea in summer of 1990

During the studies at a mesoscale polygon (8.7 - 12.7.90) ice of different concentrations from 1-3/10 to 7-8/10 was observed. In the north-eastern part of the polygon close ice prevailed, while the ice over the rest of the water area was more open or very open. The ice cover consisted of first-year ice of all age categories with the inclusions of up to 1/10 of two-years ice. Among the first-year ice, first-year thin ice prevailed, its amount varying from 1 to 5/10. In the northern zone of the polygon ice fields and medium floes were dominating while in the southern area small floes and ice cakes dominated. The thickness of the ice cover (from visual observations) due to melt processes was distinguished by a large non-uniformity, being within 40-250 cm range. The degree of ice decay was 4-5 (in 5 grades scale) (Fig. B1).

During the work in the framework of the general scheme of SNOP (20.07 - 31.07.90) the actual ice edge between the meridians of 36° E and 50° E was located 30 - 60 miles northward of its mean multi-year position. Ice of different concentration was observed varying from very open ice to very close ice. First-year ice of all types was observed, as well as two-year ice, the latter, on average, being 1/10. As to the form, ice fields, medium floes, ice floes and cakes were observed. The decay of the ice cover was 4-5 (in 5 grades scale), hummocking - 2-3 (in 5 grades scale). Ice of land origin in the form of icebouys, bergy bits and growlers were observed in the region under study (Fig. B2).

1) Murmansk Hydrometeoerological Service, USSR

WEATHER CONDITIONS

A. Davydov [1]

Synoptic situation during the period under study

During the period from 8.07 - 12.07.90 (while working in the mesoscale polygon) the following synoptic situation was observed. On 8 and 9 of July and the first part of the 10th the weather in the area was governed by the eastern periphery of the cyclone located over Scandinavia, pressure in the center being 995 mb. The rest of the 10 and 11 July the weather became influenced by a local cyclone, formed to the north of Spitsbergen and mooving eastward. Wind changed from south-south-west, speed 2-5 m/s, to north-east, speed 2-7 m/s, in the afternoon of July 10. During the entire period fog was observed with visibility being 200-500 m and air temperature changing from +1.38 to ÷ 1.6° C.

During the survey of a SNOP station network 23.07 - 30.07.90 the weather formed under the effect of an extensive anticyclone over the entire water area of the Barents Sea. On 23 and 24 of July south-eastern and southern wind of 3-7 m/s was observed and then changed to a north-western, western wind of the same strength. Fog was observed, the visibility being 500-1000m and air temperature changing from +3.1° C to ÷ 0.5° C.

On 31 July the weather in the area under study (drifting station) was governed by the eastern periphery of the anticyclone, the center of which with 1025 mb pressure was located near the northern extremes of the New Land. South-western wind of 1-5 m/s was observed, with the visibility in the fog decreasing to 200-500 m and air temperature varying from ÷ 0.9° C to ÷ 0.2° C.

For the rest of the period of the drift the weather in the north of the Barents Sea formed under the effect of the back part of the cyclone now moving eastward from the Franz-Josef Land. The northern and north-eastern wind of 5-10 m/s prevailed, snow was falling and fog occured reducing visibility to 500-100 m. Air temperature varied from ÷ 2.3° C to +0.2° C.

1) Murmansk Hydrometeorological Service, USSR

OCEANOGRAPHY

B. Novikov[2] , *B. Ivanov* [1], *G. Balyakin* [2]

Preliminary results of oceanographic surveys

The survey of the mesoscale polygon was conducted in a period of intensive ice melting. Due to this there were a lot of fresh water. Minimum values of salinity and maximum values of temperature were recorded in the central part of the polygon (S = 32.0 , T = 0.5° C). The analysis of vertical temperature and salinity distribution revealed four types of water bodies: Arctic surface water (1), the Barents Sea winter water (2), Atlantic water (3) and bottom water (4) - Fig. B3.

Bottom water temperature distribution (200 m) showed that the Atlantic water exchange between the Arctic Basin and Barents Sea was weak (compared with the same period of the previous year).

Oceanographic stations under the general SNOP scheme revealed a higher fresh water content with salinities down to 30 in the eastern part of the observation area (Fig. B4).

In general the vertical structures of water bodies are similar to that of the mesoscale polygon. At depths lower than 100 m water with temperature above 2° C and salinity of 34.8 - 34.9 was recorded (Fig. B5). This seems to be water of Atlantic origin, flowing into the Barents Sea through the submarine canyon Franz-Victorio.

Observations were carried out for several days at the drifting station from 1 August 1990. Starting point coordinates are 80° 15'N, 43° 13'E, final point coordinates are 79° 50'N, 41° 39'E.

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2) Murmansk Hydrometeorological Service, USSR

HYDROCHEMISTRY

V. Gagarin [1]

Preliminary results of the analyses

It is known that there is a certain relationship between the oxygen content in sea water and its temperature and ice concentration. Thus in the most compact ice (9-10/10) and colder surface water maximum values of absolute and relative oxygen content were recorded (area in the vicinity of Franz-Josef Land). Maximum horizontal gradients of oxygen content were measured when moving from compact to open ice (4-6/10) between 80° and 79° N. This is an additional characteristic of marginal frontal zone in this area (Fig. B6).

1 Murmansk Hydrometeorological Service, USSR

OCEAN-ICE-ATMOSPHERE INTERACTION

B. Ivanov[1], S. Shutilin[1]

Features of energy exchange in the marginal zone of the Barents Sea in the summertime

Denominations:

- T_a - air temperature,
- T_w - water temperature,
- V - wind speed,
- P - atmospheric pressure,
- n - total cloudiness,
- N - total concentration of ice cover,
- H - turbulent flux of sensible heat,
- E - turbulent flux of latent heat,
- Q - total short-wave radiation,
- Q - reflected short-wave radiation,
- B_g - long-wave radiation balance.

Data of major and supplementary meteorological observations, collected during the survey and characterizing the state of the surface atmospheric layer, were used to calculate the components of the thermal (heat) balance of sea surface covered with drifting ice. The algorithm used [B. Ivanov, A. Makstas, 1988] have been employed in previous similar field studies with success.

The analysis of the synoptic situation allowed one to identify two similar synoptic periods. The first one, from 8.07 to 10.07.90, was characterized by winds of south-western direction, the second one, from the midday of 10.07. and to the end of the cruise, by north-eastern winds. This was well-pronounced in temporal variations of major meteorological parameters such as T_a, P, V, n, given in Fig. B7. At the same time it should be noted that the T_w and N values, averaged over the intervals mentioned above, remained unchanged. The latter indicates that temperature of the underlying surface during the period of observations remained constant. This allowed us to investigate the features of energy exchange in more detail and its dependence on the synoptic situation.

Fig. B8 shows main components of the surface heat balance. During the period from 8.07 to 10.07.90 (south-western transport) a stable stratification was observed in the surface layer ($T = T_a - T_w > 0$). Mean value of turbulent fluxes of sensible and latent heat was equal to 3 Wm^{-2} and -0.8 Wm^{-2}, respectively (negative sign signifies that the flux is directed from the atmosphere to the ocean). From 10.07 to 12.07.90 (north-eastern transport) the stratificaton was neutral or weakly-nonstable (T=0, T< 0), mean values H

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and E were equal to 4 Wm^{-2} and 5 Wm^{-2}, respectively. Within both periods there were no distinct daily variations of flux values or any initial meteorological parameters, for example T_a. Maximum values of H and E are equal to 15 Wm^{-2} and were observed during the night from 10.07 to 11.07.90. They are mainly related to the wind speed maximum of that period. On the whole the character (flux direction) of turbulent heat exchange was completely governed by the type of incoming air mass (remembering that the temperature of the underlying surface was constant). In the first case the income was a relative warm (relative T_w) and in the second case a cold air mass.

The transfer direction in the surface ice layer was clearly defined in the values of the radiation balance components. Also in this case the cloudiness appears to be the governing parameter along with the fog, most often occurring with relatively warm mass flowing over the cold surface (the latter in this case being water and drifting ice). During the first period of work the amount of cloudiness was equal mainly to 10/10, which was well-pronounced not only in the B_g value, closely connected with cloudiness, (the amount of cloudiness directly included into the Angstrem formula, used to calculate B_g), but also in the Q value, which for the experiment conditions during this period did not exceed -300 Wm^{-2}. On the other hand during the period from 10.07. to 11.07.90 when cloudiness was actually absent or was insignificant, the Q value reached -500 Wm^{-2}. During the same period maximum values not only of Q , but B_g as well, were observed, reaching respectively 125 Wm^{-2} and 100 Wm^{-2}.

The temporal variability of the residual term of the heat balance equation is completely governed by the Q value, or to be exact, by the value of full radiation balance (Q + Q + B_g). The transport in the ice surface layer is effected by the amount of cloudiness, or more precisely, regulated by the latter. Air temperature in this case is not dominant, regulating only the character of turbulent exchange. However, it is negligible when considering radiation terms. Thus, during the first stage of the experiment the heat flux to the water was equal to -98 Wm^{-2}, while during the second stage it was equal to 124 Wm^{-2}, which is an order of magnitude larger then the values of H and E mentioned above. Apart from the comparison of the orders of magnitudes of the balance components considered, one can mention that air temperature and cloudiness produce an opposite effect on the character of heat exchange with different types of transfer. For example, in the case of the north-eastern transfer the air temperature decrease contributes to surface heat loss increase due to turbulent heat fluxes. However, cloudiness decreases and the possibility for fog occurrence contributes to additional heat flux to the surface due to the radiation factor, namely, total short-wave radiation. In the case of the south-western transfer the situation is just the opposite.

Finally, to conclude the description of energy exchange features at the meso-polygon the estimates of the Bowen Number (B_o = H/E) for the observed experiment conditions are regarded. For the period of stable stratification B_o = 1.6, for neutral and for weak-unstable B_o = 0.9.

Appendix A:

VOYAGE PARTICIPANTS

Name	Institution	Speciality
B. Ivanov	AARI	Research scientist, oceanography, Voyage leader.
B. Novikov	Murmansk	Chief scientist, Gidromet, oceanography.
A. Davydov	- " -	Head of meteorological group, meteorology.
V. Gagarin	- " -	Head of hydrochemical group, hydrochemistry.
P. Kosterin	- " -	Engineer, ice observation.
S. Shutilin	AARI	Scientist, oceanography

Annex B:

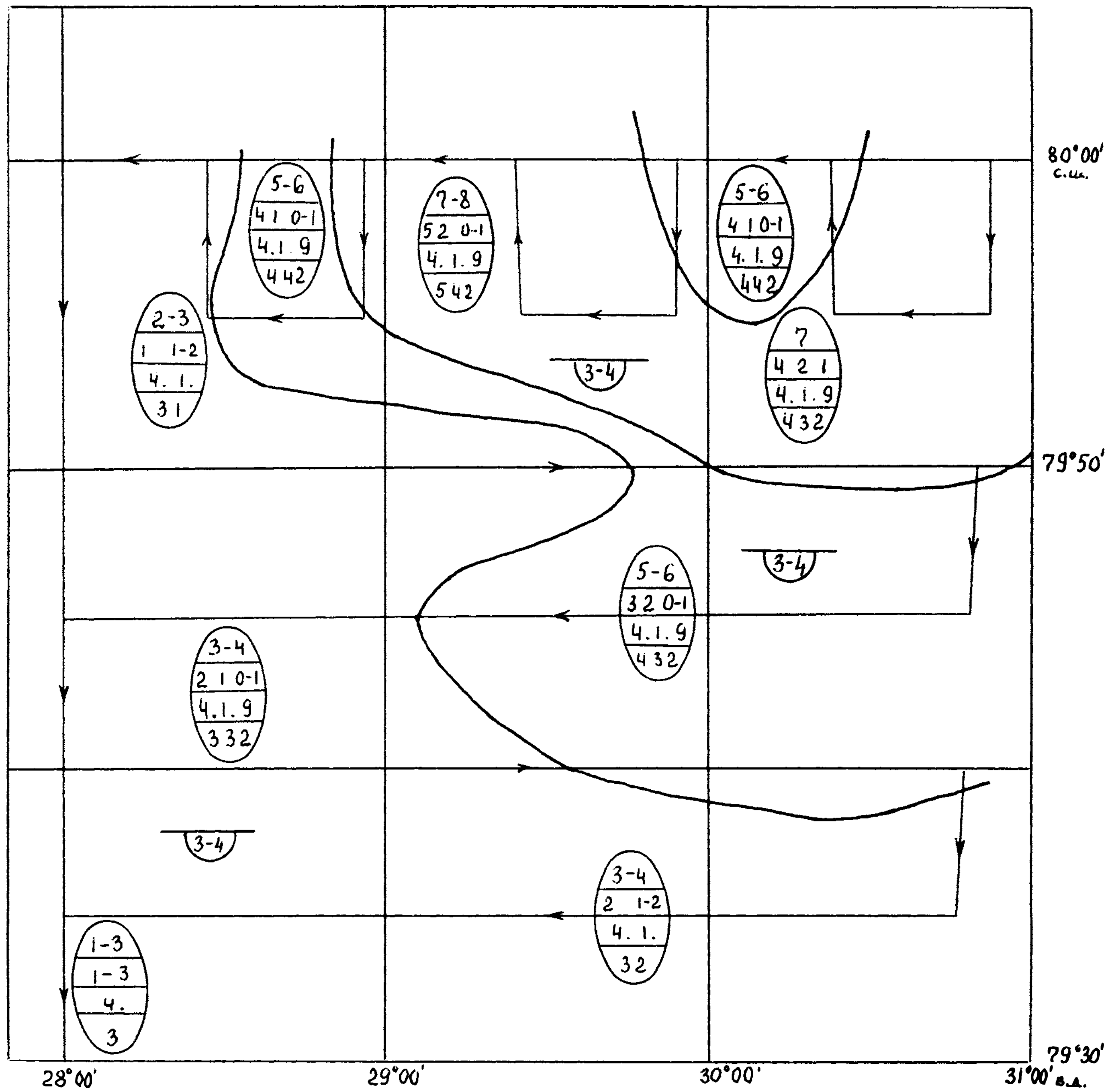


Fig. B1

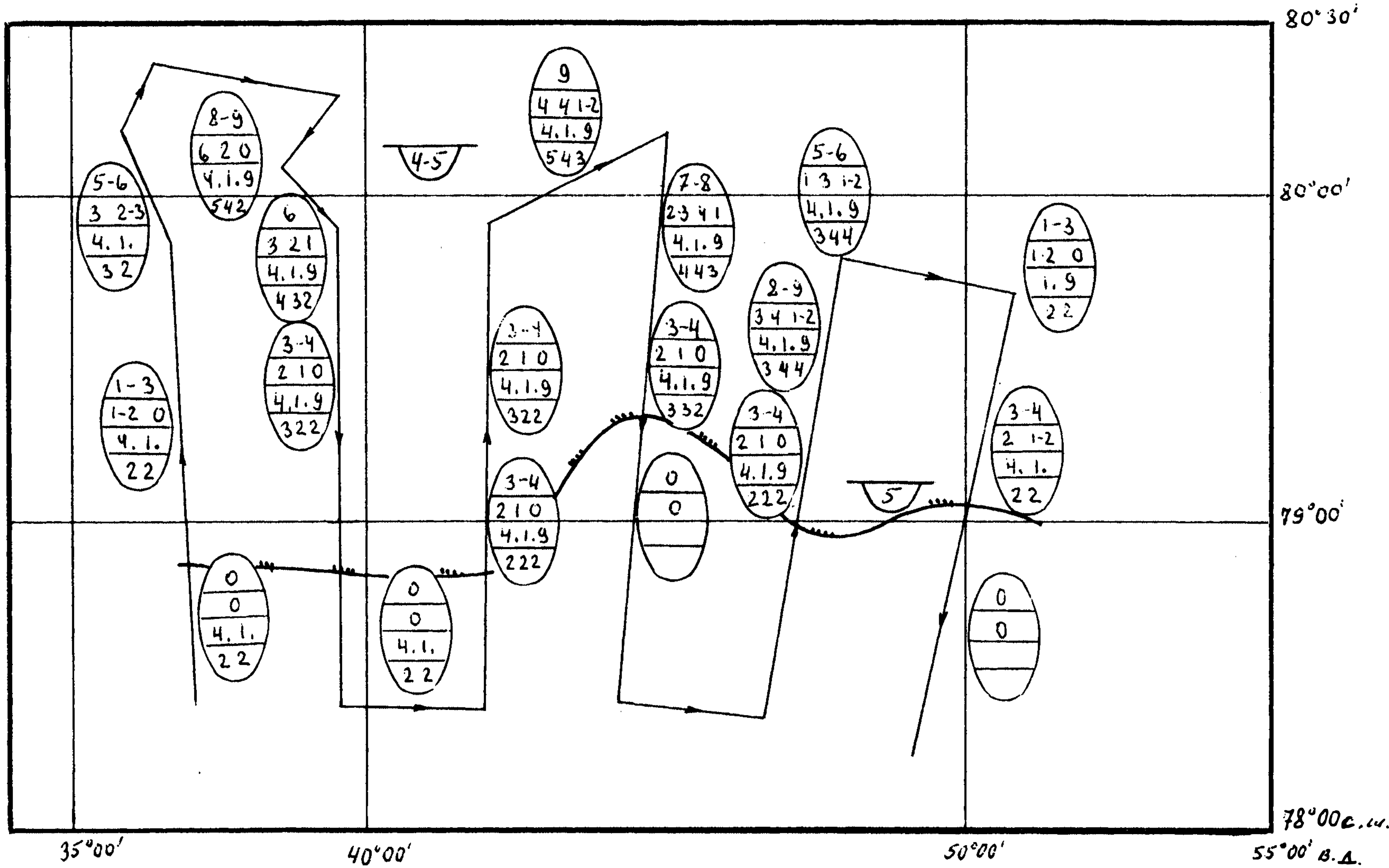


Fig. B2

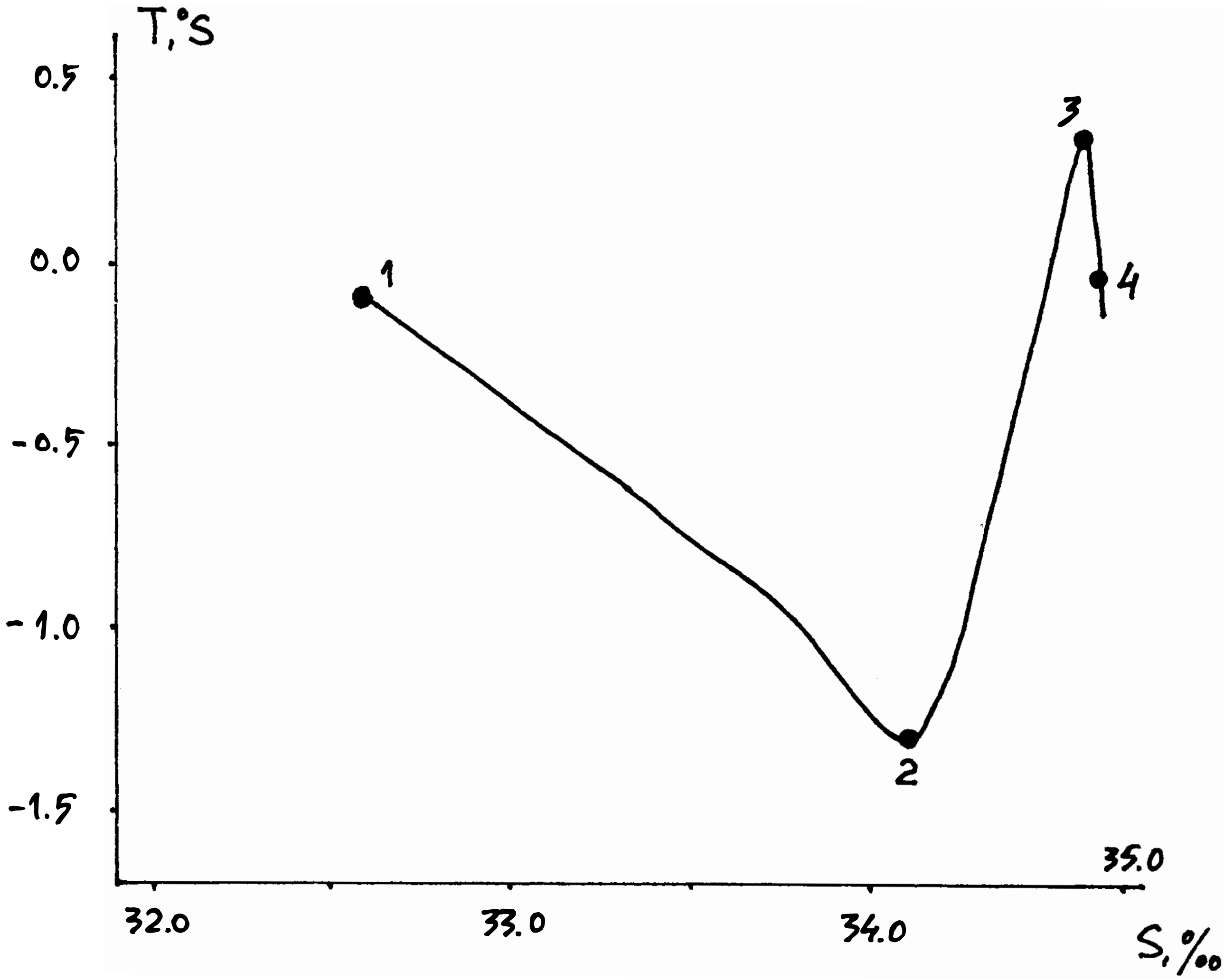
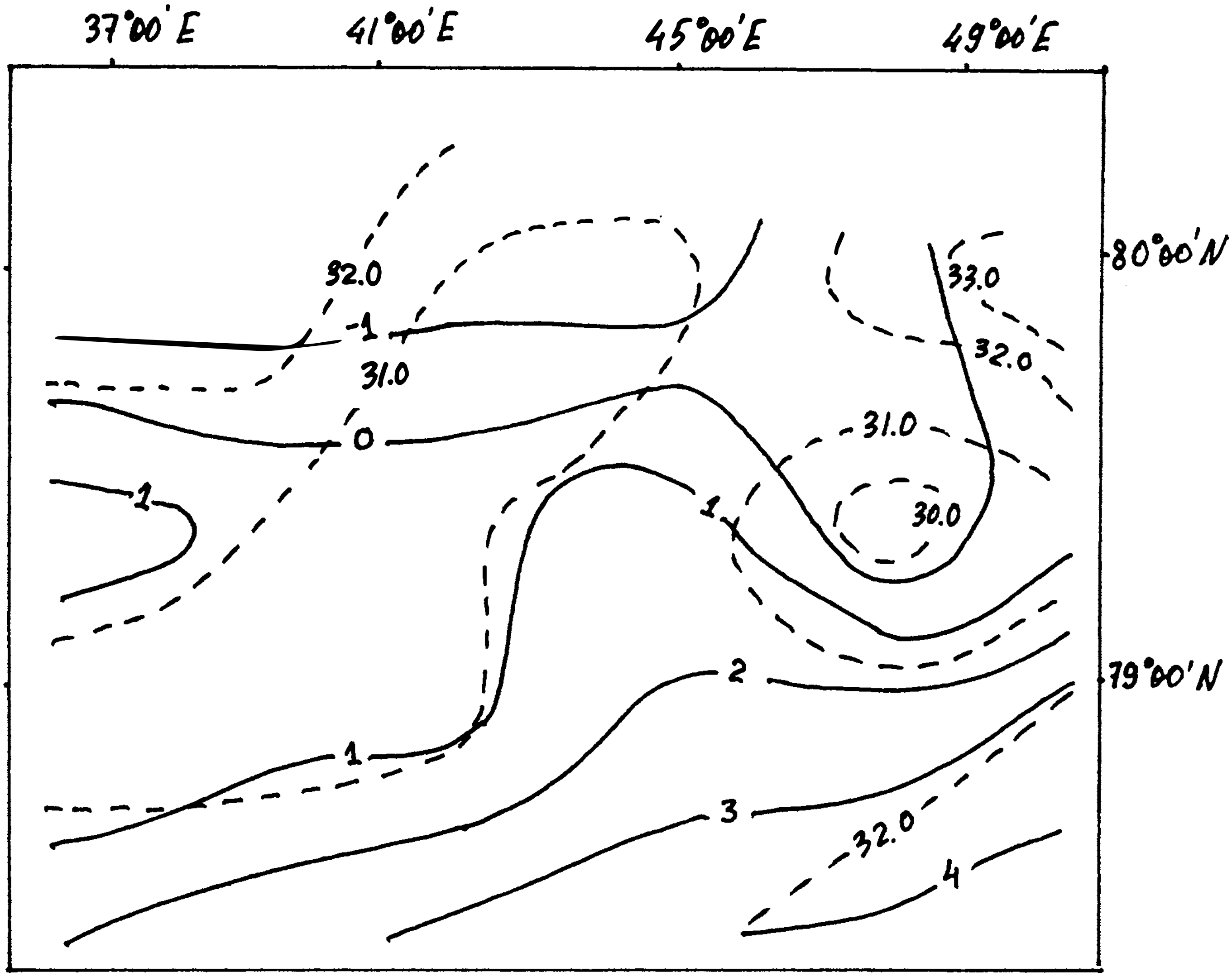


Fig. B3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80°00'N
79°00'N
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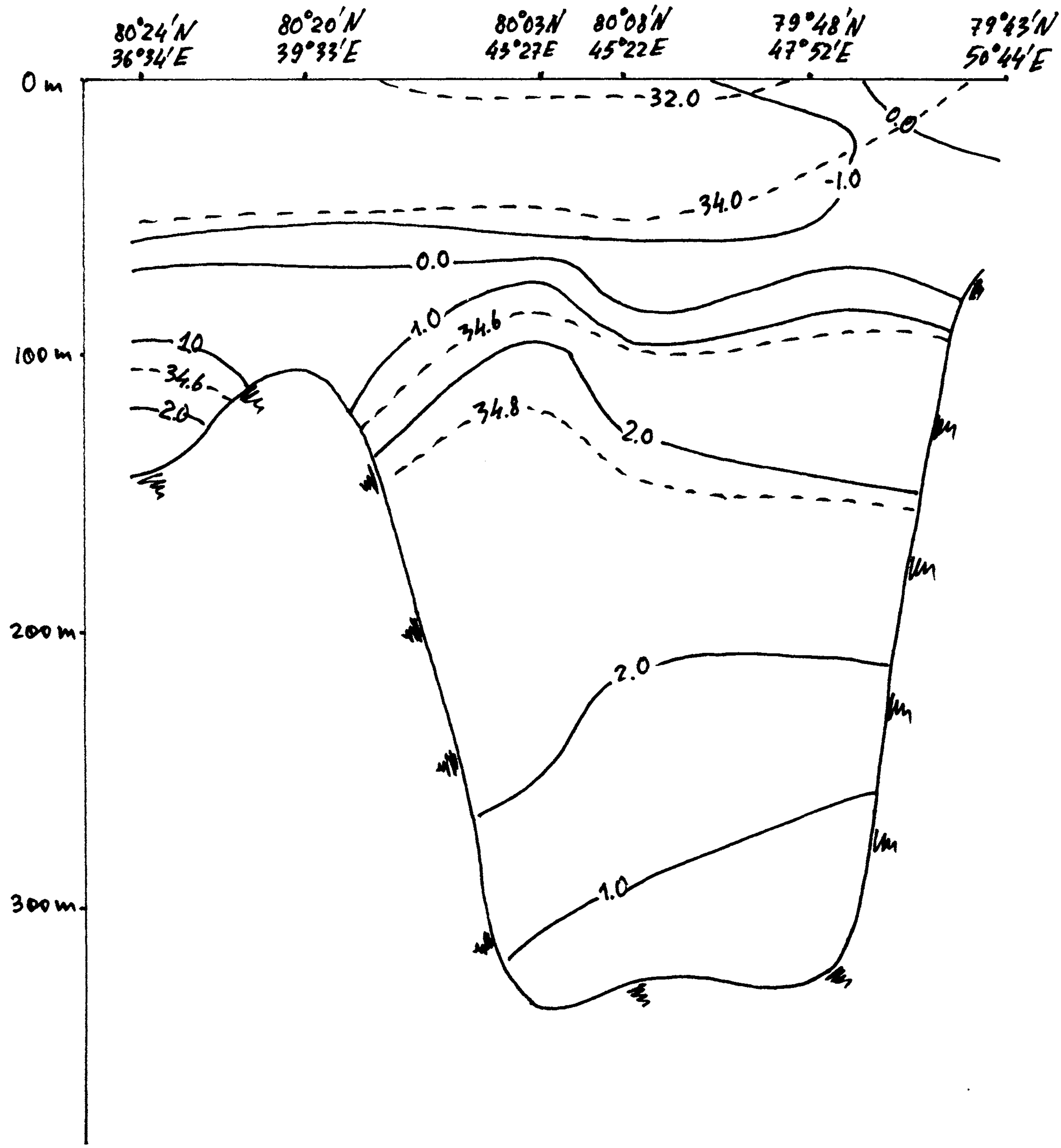
31.0
0
-1
33.0
32.0
31.0
30.0
-1
1
2
3
32.0
4

Fig. B 4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80°20'N
39°33'E
80°03'N
43°27E
80°08'N
45°22E
79°48'N
47°52'E
79°43'N
50°44'E
0 m
100 m
200 m
300 m
32.0
0.0
-1.0
34.0
0.0
1.0
34.6
1.0
34.6
2.0
34.8
2.0
2.0
1.0

Fig. B 5

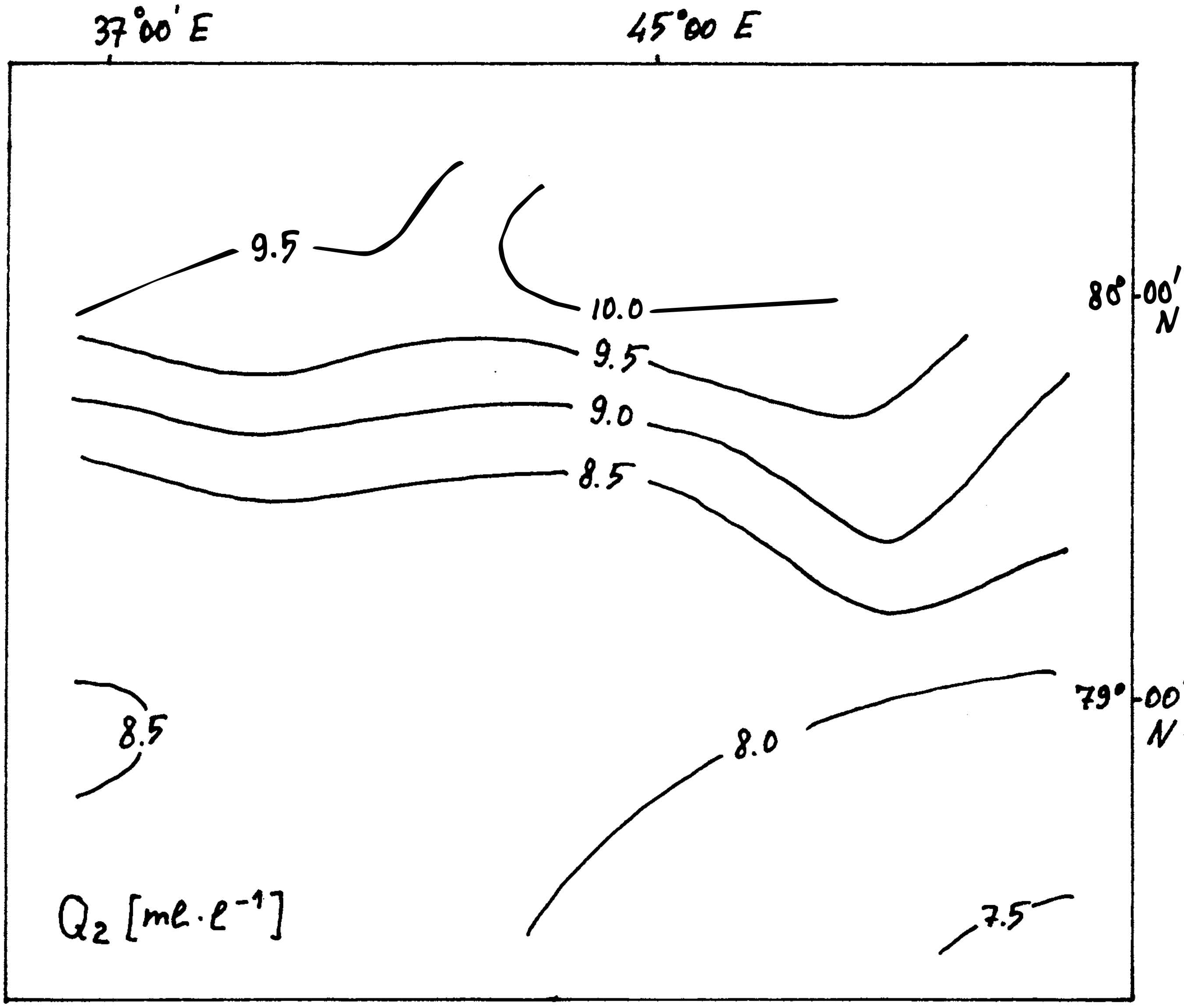


Fig. B6

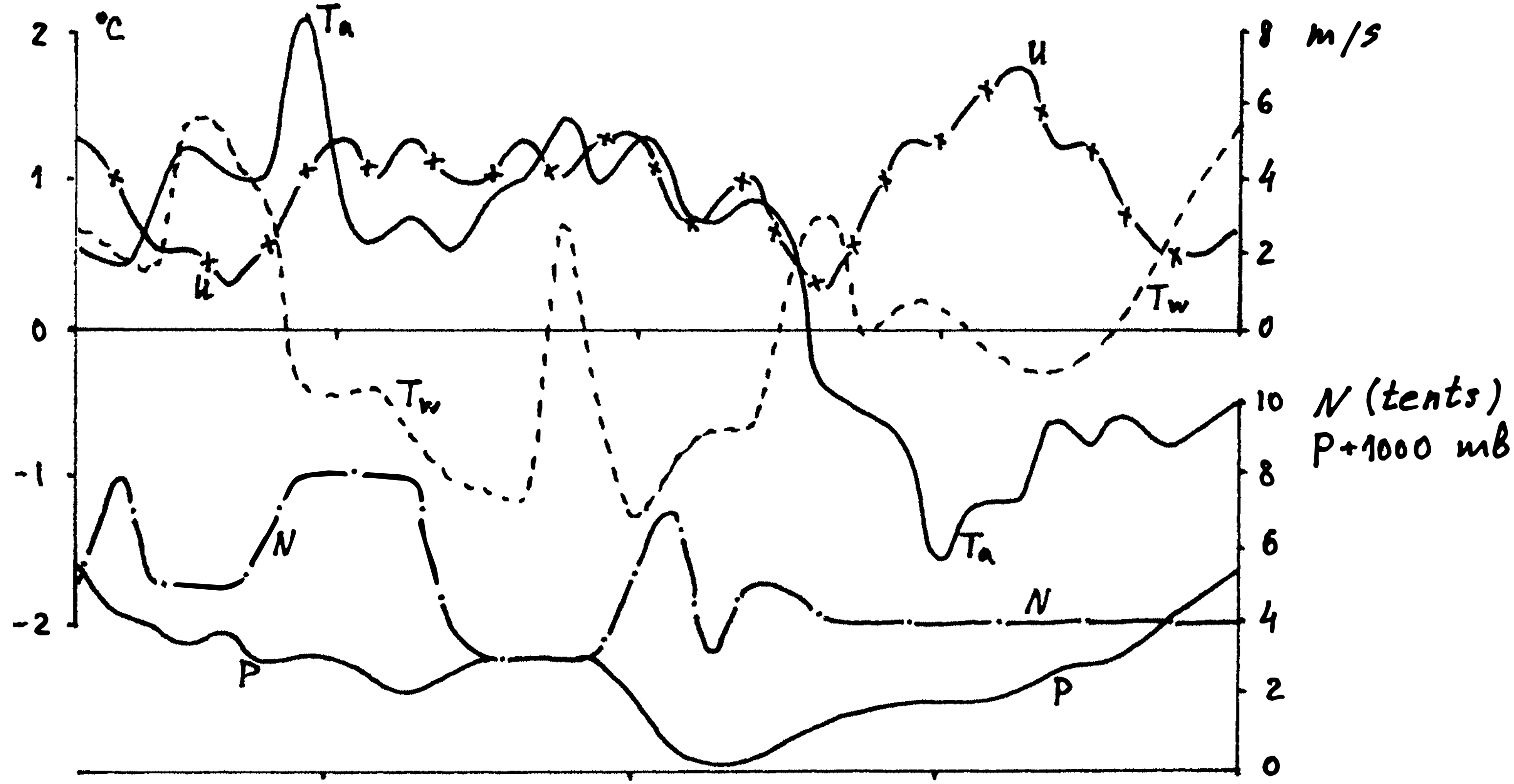
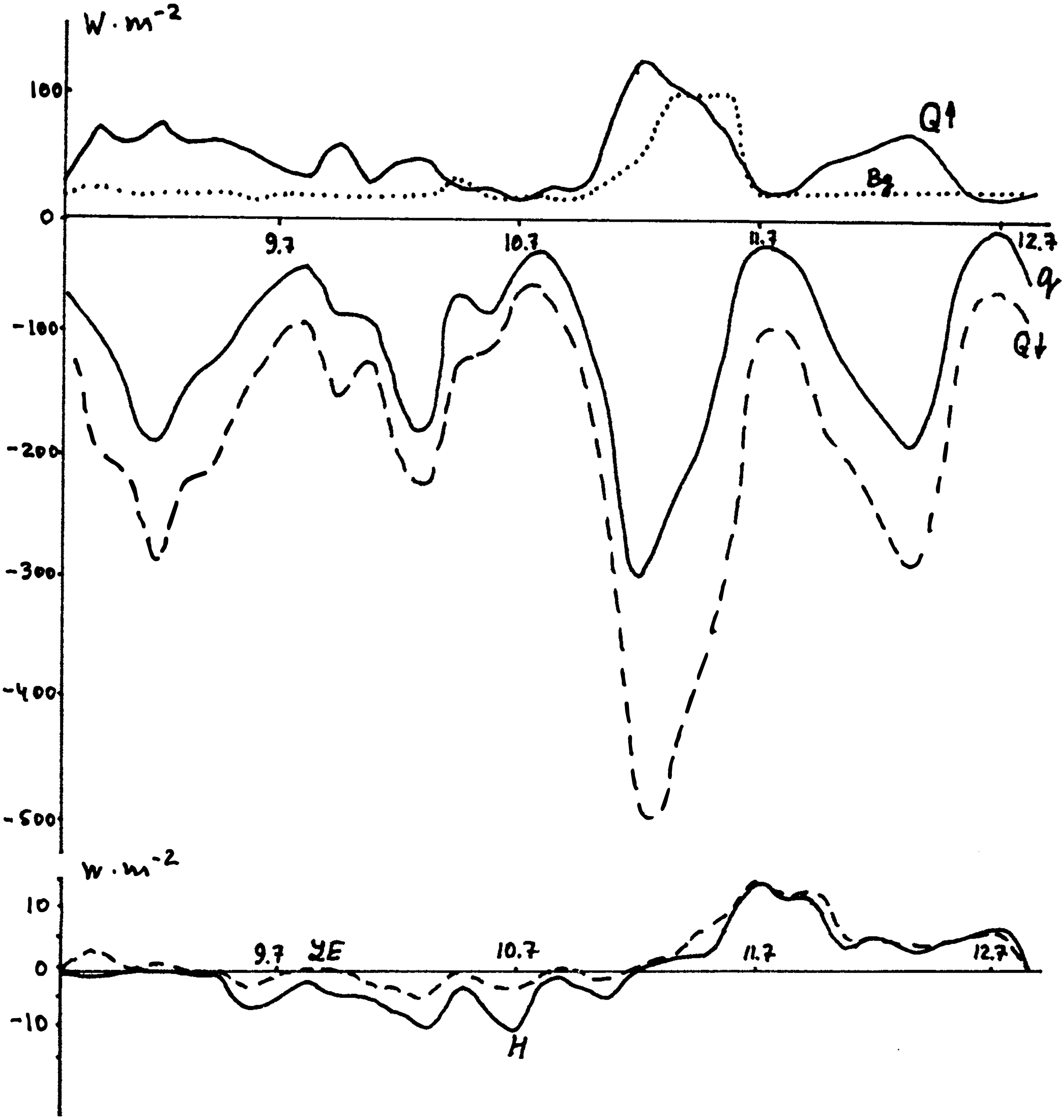


Fig. B7


W · m-2
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-100
-200
-300
-400
-500
9.7
10.7
11.7
12.7
Q↑
Bq
q
Q↓
W · m-2
10
0
-10
9.7
LE
10.7
11.7
12.7
H

Fig. B 8

Produsert av GCS A/S, OSLO