ICES Annual Science Conference 2000
Theme Session L: North Atlantic Processes

ICES CM. 2000/L: 14

The Eastern Basin Water and currents in the Barents Sea

by

V.K.Ozhigin, A.G.Trofimov, and V.A.Ivshin

Knipovich Polar Research Institute of Marine Fisheries and Oceanography
(PINRO)
6 Knipovich Str., Murmansk, 183763, Russia

ABSTRACT

The objective of the paper is to show that cold, high salinity waters of the Eastern Basin are of local origin, being formed by a significant transformation of Atlantic waters rather than carried by the Central current from the northeast, as shown on the generally accepted map of the Barents Sea currents (Tantsyura 1959).

Data on depth of isopycnic surface 28.0 is indicative of a dome-shaped structure of waters in the Eastern Basin, and, consequently, a cyclonic water motion in this area. There is a close asynchronous relationship between variations of temperature and salinity in the Eastern Basin and in the Kola section (r=0.70-0.80, lag=12 months). This testifies to the Atlantic origin of the Eastern Basin Water. The distribution of salinities shows that haline frontal zones impede the water flow from the northeast Barents Sea to the Eastern Basin. Winter position of ice edge and distribution of O-group fish in August-September also confirm the absence of strong Central Current.

The results of numerical modelling suggest the existence of a well-pronounced cyclonic circulation in the Eastern Basin with its northern limit at 76°N. Model results have shown no water transport from the northeast Barents Sea into the study area.

An updated map of currents is made on the basis of a critical review of information available on water circulation in the Barents Sea.

Key words: The Barents Sea, the Eastern Basin, water mass, temperature, salinity, currents.

INTRODUCTION

The Eastern Basin is a region in the eastern Barents Sea extending from the south-southwest to the north-northeast and characterized by the depth from 300 m and more (Fig. 1).

The Eastern Basin is a unique area. It is the region where the waters with negative temperatures extend southward to 72°N and contact with much warmer waters in the west, south and east (Fig.2). Negative temperatures are usually registered there nearly in the whole water column the whole year round. Having low temperature this water mass is characterized by a fairly high salinity close to that of the Atlantic waters flowing into the Barents Sea from the west.

The mechanisms behind formation of the water mass with such unusual properties have been attracting attention of researchers for a long time. Knipovich (1906) made an assumption that these waters were a mixture of the Atlantic and Arctic Waters. According to Nansen (1906) these waters were of local origin, i.e. they formed in the Eastern Basin area; besides, he described the underlying physical processes. Adrov (1958) showed that the water mass in this area formed under the influence of cold bottom waters flowing from the eastern flank of the Central Bank. In the mid-80s, Midttun (1985) developed further the theory suggested by Nansen; he reconfirmed a local origin of dense bottom waters and showed that they could flow out of the Barents Sea along the southern slope of the channel between the Novaya Zemlya and Frantz Josef Land. Ozhigin and Ivshin (1999) showed that the Eastern Basin Water, by its physical nature was of Atlantic origin, but significantly transformed.

The generally accepted map of currents developed by Tantsyura (1959) (Fig.3) has over the past 40 years served as a basic idea of water circulation in the Barents Sea. In our opinion, this map contains a number of contradictions and raises some questions. According to this map the Eastern Basin Water is transported to this area from the north by the strong Central Current. In connection with this, the question of what force deflects to the left the water, flowing from the strait between the Novaya Zemlya and Frantz Josef Land arises. The deflecting force of the earth's rotation, or Coriolis force, is known to deflect the currents in the Northern hemisphere to the right. Water circulation in the shelf seas is much affected by bottom topography, however, there are no any large elevations impeding the water flow in the area where the Central and Makarov Currents split. Besides, the waters transported to the Eastern Basin from the north must be getting warmer owing to milder local conditions and also due to an interaction with warmer Atlantic waters. As a result of warming their density must also decrease. However, this does not occur - the Eastern Basin is occupied by waters which are much denser than in the surrounding areas ($\sigma_t > 28.0$).

Specific feature of Tantsyura's map is a convergence of warm waters from the southwest and cold waters from the northeast at the Polar front. Inflow through the sea boundaries clearly prevails over outflow. Therefore, another question arises of whether a balance is maintained. It is known that the sea level in the Polar front zone and over the sea on the whole does not increase. Logically, one can make an assumption of a descent of waters in the zone of currents convergence and of their spreading over the bottom in opposite directions. However, no such phenomenon is presently noted. The likely reason for the contradictions mentioned is that the map basically addressed the temperature non-uniformity (warm and cold "streams"). Actual physical mechanisms behind the patterns of circulation, have not apparently been taken due account of. A leftward "bend" of the Central Current was probably required to explain the origin of very cold waters in the Eastern Basin and over the Central Bank.

The contradictions mentioned and questions put forward have called for a need to address this problem again in order to review it on the basis of more comprehensive data on temperature, salinity and currents available now. The objective of the paper was to get a more advanced understanding of the physical nature of the Eastern Basin Water and to update the map of currents.

MATERIALS AND METHODS

Data on water temperature and salinity available in PINRO oceanographic database, as well as published information about the Barents Sea currents, have been used.

With quite a large number of standard oceanographic sections in the southern Barents Sea, only section 18 crosses the Eastern Basin in the north (Fig.4). However, this section is mainly occupied in summer and autumn but not on a regular basis. No long-term data series are available for this section.

Most data are available from the Kola, Kharlov and Kanin sections, however, only two latter go as far north as the Eastern Basin. Therefore, to study the interannual variability of oceanographic conditions in this area data from only selected stations (9 - in Kharlov section, 20 - in Kanin section and 8- 10 – in section 18) were used. In addition, data for autumn months from a site (73°00' -73°40'N, 41°00' -44°00'E) in the central part of the Eastern Basin were used.

To study variability of temperature and salinity in waters, flowing from the Norwegian into the Barents Sea, average values in O-200 m layer at stations 3-7 in the Kola section (70°30' - 72°30'N, 33°30'E) are usually used. However, a haline frontal zone, separating the coastal and Atlantic waters, runs across the middle part of this section (between stations 4 and 6) (Ozhigin, Ivshin 1999). Most frequently higher salinities are registered in the deeper layers at station 7. For this reason we believe that temperature and salinity data from this station more accurately reflect the Atlantic water properties than those from stations 3-7.

To analyse interannual fluctuations, the time series of monthly means of temperature and salinity for a 100-meter layer at the bottom of the water column were established, i.e. 200-300 m - at station 9 (Kharlov section) and in a rectangular site in the center of the area; 150-250m - at stations 20 (Kanin section) and 8-10 (section 18). In the 50-60s, observations at these sections were seldom. The time series were therefore established only for the period 1970-1994. The time series of monthly mean temperature and salinity for a 150-250-meter layer at station 7 of the Kola section were developed to analyse the variability in the Atlantic waters.

In addition to the time series mentioned, data from the 0-200-meter layer in the Kola section (Tereshchenko 1997) were used.

To study the circulation pattern in the Eastern Basin and in adjacent areas, the numerical model (Trofimov 2000), was used. The model includes density field, atmospheric circulation and bottom topography, with nonlinear effects and lateral mixing taken into account. To run the model, the long-term mean temperature and salinity fields for the autumn months, as well as climatic fields of atmospheric pressure, were used as input data.

RESULTS AND DISCUSSION

Water structure in the Eastern Basin

Nansen (1906) noted that the cold bottom waters mount up in the Eastern Basin. In addition, he indicated a cyclonic water motion there. However, he did not associate the water structure with the circulation. But an ascent of waters is likely to be caused by a cyclonic water motion. An ascent is always observed in the central part of cyclones, irrespective of whether they are atmospheric or oceanic.

Midttun and Loeng (1987), using the data from the 1977 autumn survey, showed that isopycnic surface 28.0 lays at the depth of about 50m or slightly deeper in the Eastern Basin, while in the Atlantic waters to the west, south and east it was found at 150-200m depth. To the north of 76°N this surface gradually descends to the depth of 100-l 50m. This survey showed a well pronounced dome of dense waters, however, this could be a particular case.

We decided to test the long-term mean data to confirm it. September data on temperature and salinity from latitudinal and longitudinal zones of 10- 15 mile width over the Eastern Basin were extracted from the database. Sigma-t was further calculated and mean depth of isopycnic surface 28.0 estimated. The examples are given in Fig.5. The results revealed that the dome of dense bottom waters was also well pronounced. It had an irregular shape extending from the south-southwest to the north-northeast along the Eastern Basin. In its northern limit between 75" and 77°N the isopycnic surface 28.0 was notably deeper. This indicated that the Eastern Basin Water did not flow from the north.

The pattern of water circulation in this area could be as follows. Under cyclonic rotation there is a component at the bottom directed to the centre. In our opinion, this component promotes sinking along the slopes of cold and dense waters, which formed in the adjacent shallows during autumn-winter period. The eastern flank of the Central Bank is a major source of the dense bottom waters and we agree entirely with Adrov (1958) in this. Some amount of winter waters can sink from the slopes of the Novaya Zemlya shallows and Novaya Zemlya Bank (Midttun 1985). In the central part of cyclone cold bottom waters ascend to the surface where they diverge. Even in summer negative temperatures can be occasionally found as deep as 30m. Ascent of bottom waters is a very slow process. The amounts of cold dense bottom waters formed in winter are so large that they fill the whole Eastern Basin under the influence of cyclonic rotation.

During formation of dense bottom waters one water type is transformed into another. A new portion of bottom waters forms each winter. The Atlantic waters flowing from the west are in our opinion the source material. They are transformed on the northern and eastern flanks of the Central Bank to where they flow as a continuation of the North Cape Current northern branch, as well as on the western flank of the Novaya Zemlya shallows to where they flow as the Novaya Zemlya Current. Dense bottom waters from the northeastern limit of cyclonic gyre flow along the Novaya Zemlya Bank western slope into the strait between the Novaya Zemlya and Frantz Josef Land where they exit the Barents Sea area.

Interannual variations of temperature and salinity

Interannual fluctuations in oceanographic conditions in the southern Eastern Basin can be seen in Fig.6. Shown there are temperature and salinity anomalies at station 9 of the Kharlov section compared to those for the Kola section. As seen from this figure the variations of temperature and salinity are rather similar. Besides, the variations of temperature at station 9 in the Kharlov section are seen to be approximately one year delayed compared to the fluctuations of temperature in the Kola section. Cross-correlation analysis has shown the relationship between these time series is the strongest for the time lag of minus 12-13 months (r = 0.74). The relationship between temperature variations at station 9 (Kharlov section) and in 150-250-m layer at station 7 of the Kola section (the Atlantic waters) is the strongest for the time lag of minus 11-12 months (r=0.70).

Significant similarities are also typical of the variations of salinity, however the relationship is not so strong. Coefficient of correlation for salinity time series at station 9 (Kharlov section) and at stations 3-7 (Kola section) is maximal (0.59) for the time lag of minus 13 months. The strongest correlation is found for the variations of salinity at station 9 (Kharlov section) and station 7 (Kola section); correlation coefficient for the time lag of minus 13 months is 0.78.

The variations of temperature and salinity at station 20 (Kanin section) are given in Fig.7. The fluctuations of these parameters in the eastern Eastern Basin and in the Kola section (stations 3-7) are similar. Maximum correlation (r = 0.73) for temperature is found for the time lag of minus 6 months. The correlation for salinity is weaker. The comparison of the data from station 20 and station 7 (Kola section) shows that the maximum correlation (0.72) for temperature is for the lag of minus 5 months. For salinity, the strongest correlation is for the lag of minus 12 months (r=0.81).

Similar patterns and delay in variations of temperature relative to the Kola section are also found for the central Eastern Basin and section 18.

Thus, variations of temperature and salinity in the Eastern Basin are closely related to those in the Kola section, especially in its part where the Atlantic waters flow. This provides one more proof that the waters in the Eastern Basin are transported from the west rather than from the north. A nature of delay in variations of temperature and salinity of the Eastern Basin Water relative to Atlantic Water yet remains unclear. It can only be assumed that it may be related to the “time of transportation” or to the time required for the properties to be transformed.

Other evidence

A number of arguments supporting a lack of Arctic water transport from high latitudes of the Barents Sea (to the north of 77°N) have already been given. However, there could be some other.

The long-term mean positions of ice edge in winter (Fig.8) suggest no evidence of ice transport to the south by the strong Central Current. Typical bends of the ice edge show the existence of the cold Bear Island Current, as well as warming effect of the Novaya Zemlya Current and the North Cape northern branch. The ice edge climatic position has a very smoothed shape, however if we look at the ice maps for specific months of specific years, no evidence of ice transport by the Central Current can be found and, hence, no confirmation of its existence.

The data on distribution of O-group fish show that in August-September the Eastern Basin (its surface layer) is very often the area where juveniles dwell which at this stage are still passive migrants. The juveniles can be transported to this area only by the currents from spawning grounds situated far in the west. This in the first place refers to the warm years and to the years of appearance of abundant year classes. Usually there is no "tongue" of waters, flowing from the north and free of young fish. This circumstance can be considered as an indirect evidence of the absence of a strong current flowing from the north.

Results from nearly l-year (1 February 1993 – 4 January 1994) measurements of surface currents with an "OCEANOR" (Norway) mooring (73°10'N, 43°45'E) are shown in Fig. 9. The vector-diagram shows stable transport of waters northeastward. Mean velocity is about 15 cm/s. The mooring position should probably be considered as the eastern periphery of cyclonic gyre.

The distribution of the long-term mean data on salinity at 0 and 50m depths in September is shown in Fig. 10. Salinity maps for other months show that haline frontal zones are rather stable. The figure clearly shows that the Eastern Basin area is located in the region with a rather homogeneous salinity field extending from the western boundary of the sea eastward to the Novaya Zemlya. The Eastern Basin area is separated from fresher waters in the northern part of the sea by a frontal zone between 76" and 77°N. The maps of salinity give no evidence of water transport southward into the central part of the sea. Salt Atlantic waters flow through the Barents Sea from the southwest to the northeast and transform gradually. Waters with lower salinity enter the sea from the northeast and north and flow to the west and southwest.

Considering the cyclonic motion of waters over the Eastern Basin, we naturally mean a southward transport along its western slope. It starts to the south of 76°N at eastern flank of the Central Bank. Currents measurements with two moorings (Loeng 1990) showed a southward and southwestward transport along the western slope of the Eastern Basin, however the velocity of residual currents was fairly slow (1 .O-2.0 cm/s). Here, it would be appropriate to refer to Nansen (1906) who noted the southward currents with slow velocities in this area.

Results from numerical modelling

Long-term mean data for October were used as input data. Velocity fields, surface level and vertical movements were calculated.

The results (Fig.1 1) correspond fairly well to a contemporary view of the Barents Sea currents and results from current measurements. Surface current velocities are in the range of 5-15 cm/s. Maximum values (50-70 cm/s) are calculated for the continental slope area where Atlantic waters flow northward. A direction of currents does not change with depth, while velocity decreases slightly.

In general, the circulation has a cyclonic pattern. Waters flow eastward in the southern Barents Sea and northeastward at the Kanin and Goose Banks. They flow westward in the northern part of the sea and change their direction to southwestward at 30-35°E.

As shown by Fig.1 1 the North Cape Current can be easily idenfied. Its northern branch partly recirculates and mixes with the Bear Island Current. The same branch reaches 76°N, turns to the east and gets into anticyclonic motion over the Central Bank; some amount of cooled waters from the eastern flank of the Bank flows southward along the western slope of the Eastern Basin. Current velocity there is rather slow. It is much higher on the southern and eastern slopes of the Basin. The northern limit of the cyclonic gyre is at about 76°N. The model results have not shown any significant flow of Arctic waters into the Eastern Basin. But they show a well-pronounced northeastward transport along the western slope of the Novaya Zemlya Bank. Current velocity there is fairly high. In our opinion, this current carries dense waters out from the Eastern Basin into the strait between the Novaya Zemlya and Frants Josef Land.

Thus, the results from numerical modelling confirm the validity of the arguments referred to earlier regarding the circulation in the Eastern Basin.

Updated map of currents

All results, in our opinion, rather convincingly confirm that the so-called Central Current, carrying cold Arctic waters far south, does not exist. This calls for a development of a more accurate map of currents in the Barents Sea. Preliminary version of such a map is given in Fig.12.

A "belt" version was chosen rather than an "arrow" one. This was done because the long-ten-n current measurements in the Barents Sea in the 80s-90s (Loeng, 1979; Loeng et al. 1993; Loeng et al. 1994; Ingvaldsenet al. 1999) showed a very high variability of both speed and direction of currents. Such long-term measurements allow to get reliable estimates of mean current parameters. Since such measurements are few, we consider that presently there are no reasons for using numerous arrows indicating the direction, speed and stability of currents in the maps. With "belts" only the position of main streams and general direction of water transport are shown.

The proposed map is based on critically revised maps of currents developed by researchers before (Mohn 1887; Knipovich 1906; Nansen 1929; Sokolov 1936; Agenorov 1946; Tantsura 1959, 1973; Novitsky 1961; Anon. 1961; Anon. 1985; Asplin et al. 1998). Data from current measurements, the long-term in particular (Blindheim 1989; Blindheim and Loeng 1978; Loeng 1979, 1990; Loeng et al. 1989; Loeng et al. 1993; Loeng et al. 1994; Orvik et al. 1995; Ingvaldsen et al. 1999), were used. Basic elements of the Barents Sea water structure, i.e. water masses and frontal zones (Ozhigin, Ivshin 1999) were taken into account. The flow of Atlantic waters through the Barents Sea, now proven (Loeng et al. 1997), was also given due regard. Some attention was also given to numerous, however, contradictory results of numerical modelling in the past 10-15 years (Slagstad 1987; Slagstad et al. 1989; Aadlandsvik 1989a,b; Bulushev, Sidorova 1994; Arkhipov, Popov 1996; Semenov, Chvilev 1996; Asplin et al. 1998; Ingvalsen et al. 1999; Yakovlev 1998, 1999; Trofimov 2000).

The Barents Sea is a shelf sea. Its mean depth (230m) is comparable with depth difference between elevation tops and the bottom of depressions (it is more than 400 m on the Spitsbergen Bank southern slope, and within 100-200m at most large forms of bottom topography). Therefore, the bottom topography plays the most important role in water circulation in this sea. Influenced by Coriolis force the main streams keep to the slopes, leaving them on the right side. In view of this, we relate the position of main streams with the largest forms of bottom topography.

A basic principle underlying the map is a balance of fluxes, i.e. inflow should be equal to outflow. The fluxes should be balanced both for the whole sea and for its parts. The map should therefore be further updated as new data on currents become available.

REFERENCES

Aadlandsvik, B. 1989a. A wind-driven model of the Barents Sea. Bergen Scientific Centre Report Series, No. 89/14: 20 pp.

Aadlandsvik, B. 1989b. Wind-driven variations in the Atlantic inflow to the Barents Sea. ICES C.M. 1989/ C:18. -13 p.

Anon. 1961. Map of prevailing surface currents in the Barents Sea. -Murmansk: PINRO. 1 p. (in Russian).

Anon. 1985. Life and conditions of its existence in the Barents Sea pelagial. Ed. Z.N.Yakovlev. Apatity: Izdatelstvo KF AN SSSR. 218 pp. (in Russian).

Anon. 1990. Barents Sea. Hydrometeorology and hydrochemistry of USSR seas. Vol. 1, vyp. 1 Leningrad, Hydrometeoizdat; 280 pp.

Anon. 1997. Scientific and technical approaches to estimation of impact of oil and gas production upon the ecosystems of the Arctic seas. Apatity, Izdatelstvo KNTS RAN: 393 pp. (in Russian).

Anon. 1998. Climatic atlas of the Barents Sea, 1998: temperature, salinity, oxygen. NOAA Atlas NESDIS 26. Silver Spring - Murmansk, 24 pp.+ appendices.

Adrov, M.M. 1958. How the cold deep Water of the Eastern Basin in the Barents Sea form, Nauchno-tekhnicheskiy bulleten PINRO. No.2(6): 32-40 (in Russian).

Agenorov, V.K. 1946. On dynamics of the Barents Sea waters. Moscow-Leningrad: Gidrometeoizdat, 132 pp. (in Russian).

Arkhipov, B.V. and SK. Popov. 1996. Modelling of geostrophic and wind-induced currents in The southeastern Barents Sea. Okeanologiya. Vo1.36, No.6: 805-8 13 (in Russian).

Asplin L., R. Ingvaldsen, H. Loeng, B. Aadlandsvik. 1998. Description and validation of a three-dimensional numerical model of the Nordic and Barents Seas. Fisken og havet, Nr. 10: 35 pp.

Blindheim J. 1989. Cascading of the Barents Sea bottom water into the Norwegian Sea. Rapp. P.-v. Reun. Cons. int. Explor. Mer. 188: 49-58.

Blindheim J., H. Loeng. 1978. Strommoliger i omradet Troms-Bjornoya i 1970, 1971 og

1975. Fisken og havet, Nr. 2: 46 s.

Bulushev, M.G. and A.N. Sidorova. 1994. Calculations of monthly mean circulation in the Barents Sea. Meteorologiya i gidrologiya. No.4: 78-86 (in Russian).

Ingvaldsen R., L. Asplin, H. Loeng. 1999. Short time variability in the Atlantic inflow to the Barents Sea. ICES C.M. 1999/L:05: 12 pp.

Knipovich, N.M. 1906. Fundamentals of hydrography of the European Arctic Ocean. St.-Petersburg, 15 10 pp. (in Russian).

Loeng H. 1979. Stommolinger i omradet Fugloya-Bjoroya i perioden juni 1978 - mars 1979. Fisken og havet, Nr. 9: 84 s.

Loeng H. 1990. Current measurements southeast of Centralbanken in the Barents Sea. Rep, 9002. Dept. of Mar. Environment. Inst. of Mar. Res. Bergen, Norway. 18 pp. +3 appendices.

Loeng H., L. Midttun, H. Sagen. 1994. Current measurements between the Central and Great Banks in the Barents Sea. Fisken og have, Nr. 3: 21 pp. + 3 appendices.

Loeng H., V. Ozhigin, B. Aadlandsvik. 1997. Water fluxes through the Barents Sea. ICES J. Mar. Sci. 54: 3 10-3 17.

Loeng H., S. Sundby, 0. Ostensen. 1989. Drifting Argos buoys in the Barents Sea. ICES C.M. 1989/ C:19: 10 pp.

Loeng H., H. Sagen, B. Aadlandsvik, V. Ozhigin. 1993. Current measurements between Novaya Zemlya and Frans Josef Land. September 1991 - September 1992: Data report No. 2. Dept. of Mar. Environment. Institute of Marine Research. Bergen. Norway. 23 pp. + 4 appendices.

Midttun L. 1985. Formation of dense bottom water in the Barent Sea. Deep-Sea Research, Vol. 32, No. 10: 1233-1241.

Midttun L., H. Loeng. 1987. Climatic variations in the Barents Sea. The effect of oceanographic conditions on distribution and population dynamics of commercial fish stocks in the Barents Sea: Proc. of the third Sov.-Norw. Symp. Institute of Marine Research. Bergen, Norway. 13-27.

Mohn H. 1887. The North Ocean, its Depth, Temperature and Circulation: The Norwegian North-Atlantic Expedition, 1876-I 878. Christiania, 2 12 pp.

Nansen F. 1906. Northern waters: Captain Roald Amundsen's oceanographic observations in the Arctic Seas in 190 1. Christiania, 145 pp.

Nansen F. Die Erforschung der unnbekannten Innerarktis. Iustus Pertes. -1929.

Novitsky, V.P. 1961. Persistent currents in the northern Barents Sea. Trudy GOIN, Vyp. 64: 3-32 (in Russian).

Ozhigin, V.K., V.A. Ivshin. 1999. Water masses of the Barents Sea. Murmansk, Izdatelstvo PlNRO: 48 pp. (in Russian).

Orvik K.A., L. Lundberg, M. Mork. 1995. Topographic influence on the flow field off Lofoten-Vesterolen. Ecology of Fjords and Coastal Waters. Elsevier Science, 165-175.

Semenov, G.A., Chvilev, S.V. 1996. Numerical modelling of interannual variability of the Barents Sea circulation in summer. Okeanologiya, Vol. 36, No. 4: 498-5 11 (in Russian),

Slagstad D. 1987. A 4-Dimensional Physical Model of the Barents Sea. SINTEF Report No. STF48 F87013. Trondheim, Norway, 34 pp.

Slagstad D., S. Stokke. 1994. Simulering av strmmfelt, hydrografi, isdekke og primarproduksjon i det Nordlige Barentshav. Fisken og havet, Nr. 9: 47 s.

Slagstad D., K. Stole-Hansen, H. Loeng. 1989. Density-driven currents in the Barents Sea calculated by numerical model. ICES C.M. 1989/ C:20: 14 pp.

Sokolov, A.V. 1936. Present-day views of the Barents Sea hydrography (dynamics of the Barents Sea waters). Priroda, No.7: 38-49 (in Russian).

Tantsyura, A.I. 1959. On currents in the Barents Sea. Trudy PINRO, Vyp. 1 35-53 (in Russian).

Tantsyura, A.I. 1973. 'On seasonal variations of the Barents Sea currents. Trudy PINRO, Vyp.34: 108-l 12 (in Russian).

Tereshchenko, V.V. 1997. Seasonal and interannual variations in temperature and salinity of main currents in the Kola section in the Barents Sea. Murmansk, Izdatelstvo PINRO: 71 pp. (in Russian).

Trofimov, A.G. 2000. Numerical modelling of water circulation in the Barents Sea: Preprint. Murmansk, Izdatelstvo PINRO: (in press, in Russian).

Yakovlev, N.G. 1998. Modelling of spreading of Atlantic waters in the Arctic Ocean, Meteorologiya i gidrologiya, No.2: 73-84 (in Russian).

Yakovlev, N.G. 1999. Calculation of monthly mean circulation in the Barents Sea and analysis of its sensitivity to water exchange through the open boundaries. Izvestiya AN. Phizika atmosphery i okeana, Vol.35, No.6: 846-857 (in Russian).

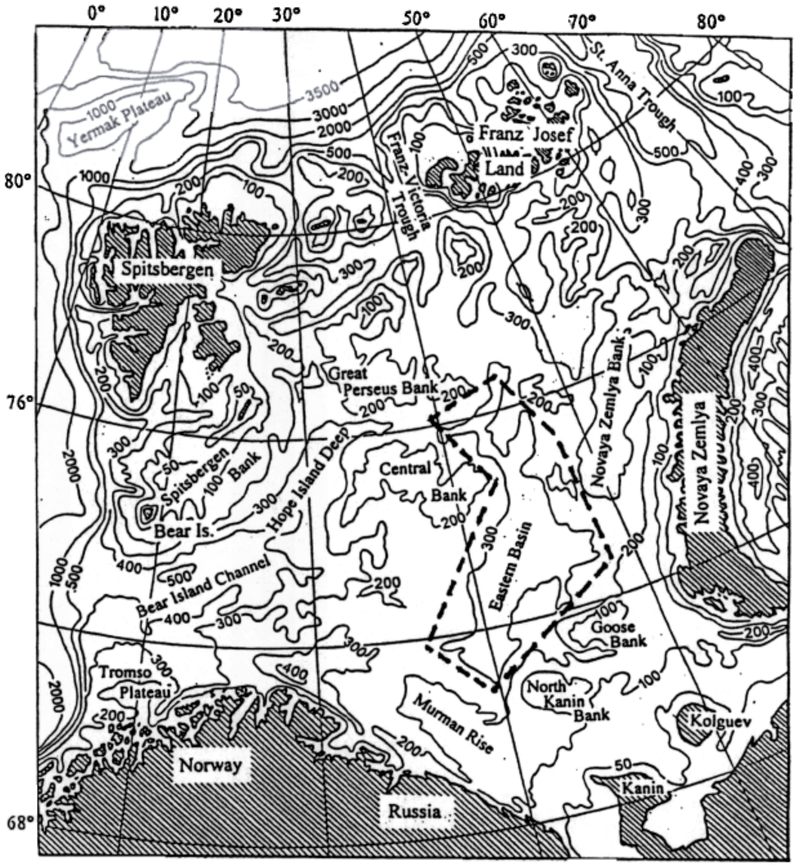


Fig. 1. Bottom topography of the Barents Sea.
The Eastern Basin is shown with the broken line

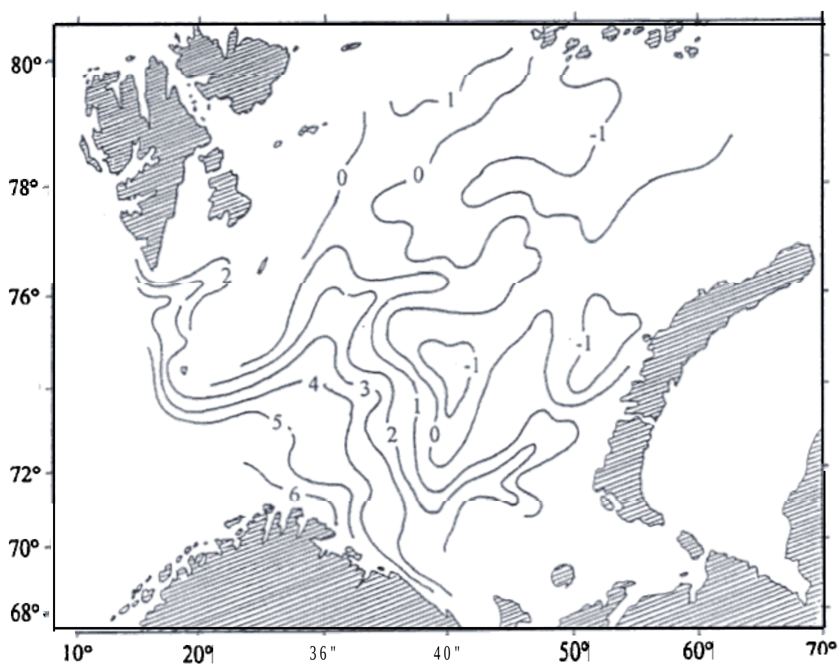


Fig. 2. Temperature at 150 m in September

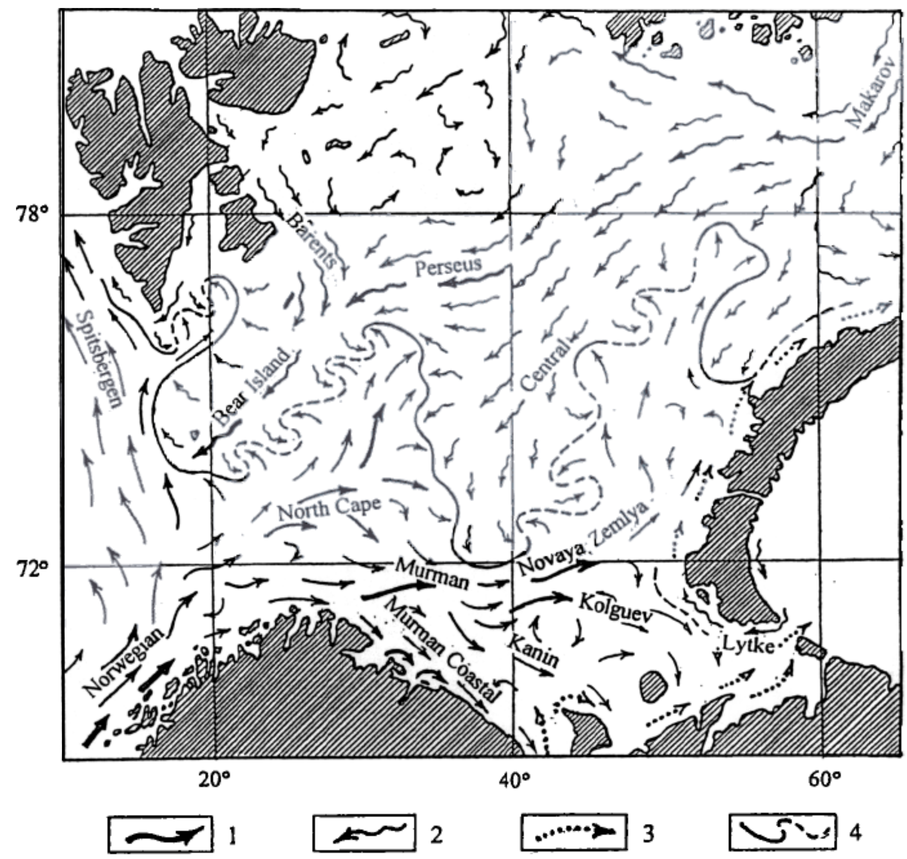


Fig. 3. Main surface currents in the Barents Sea (Tantsyura 1959): 1 – warm; 2 – cold; 3 – coastal with decreased salinity; 4 – frontal zones

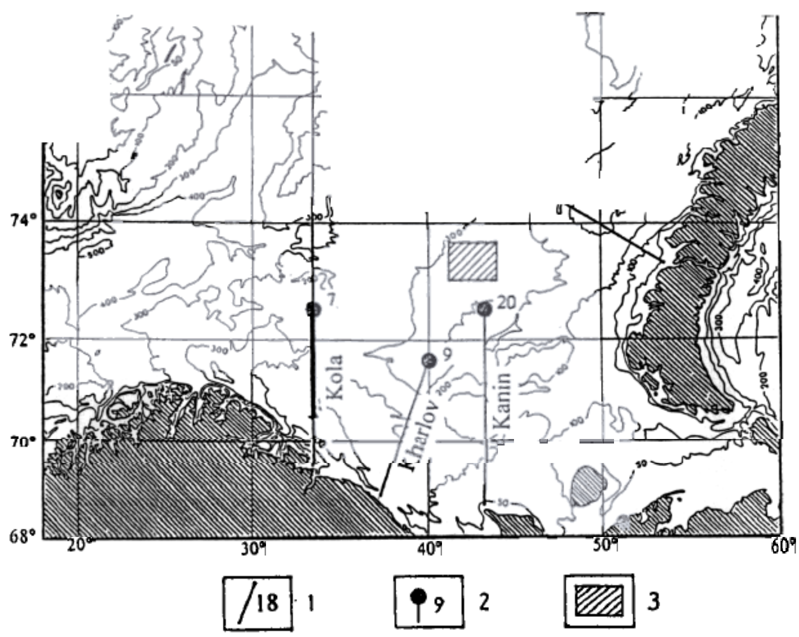


Fig. 4. Standard sections (1), oceanographic stations (2) and site in the Eastern Basin (3), the data from which are used in the paper

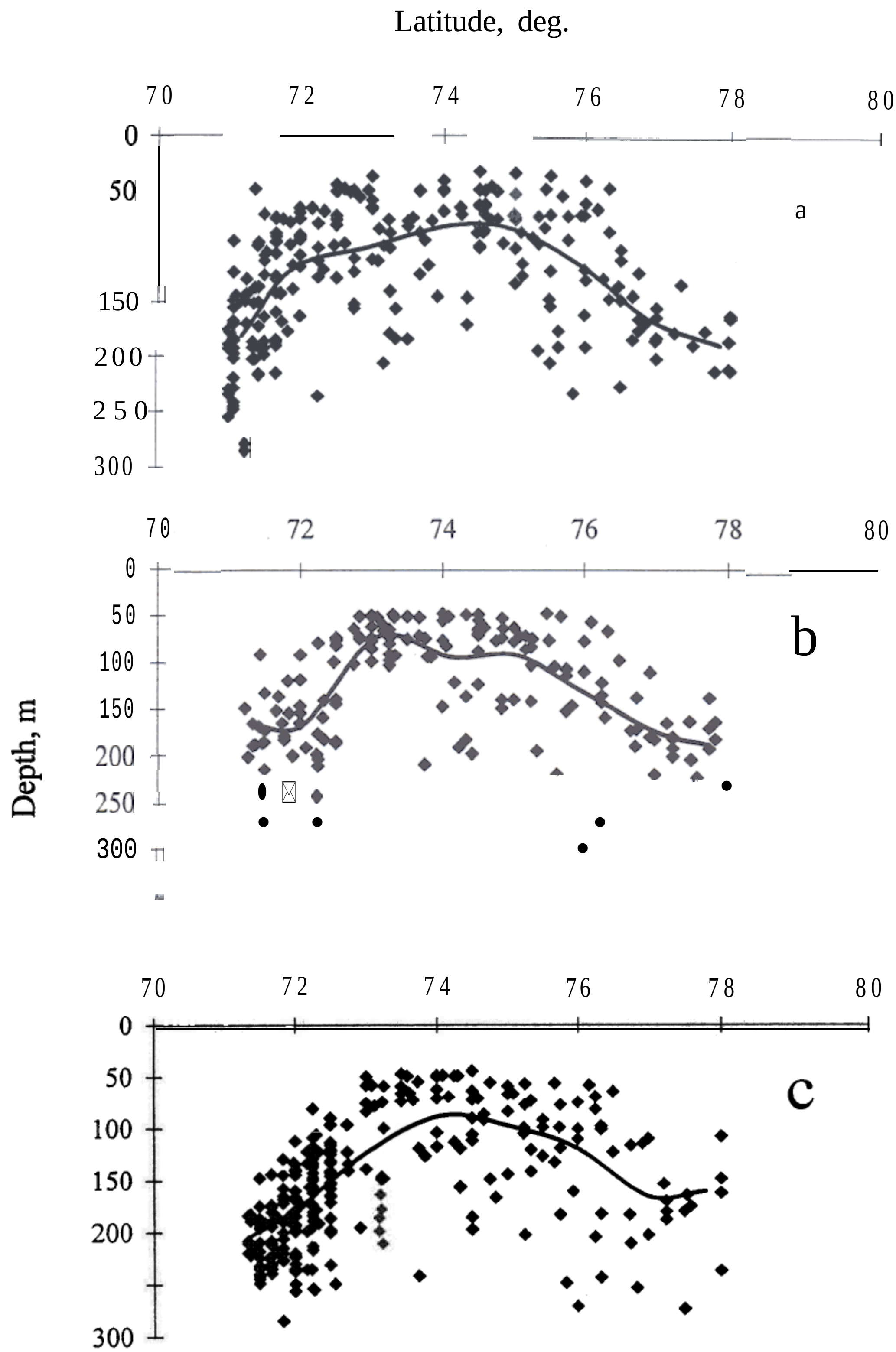


Fig. 5. The depth of the sigma-t surface 28.0 in September of different years (squares) and long-term average (line) in the longitudional zones a) 39-40° E; b) 41-42° E; c) 43-44° E

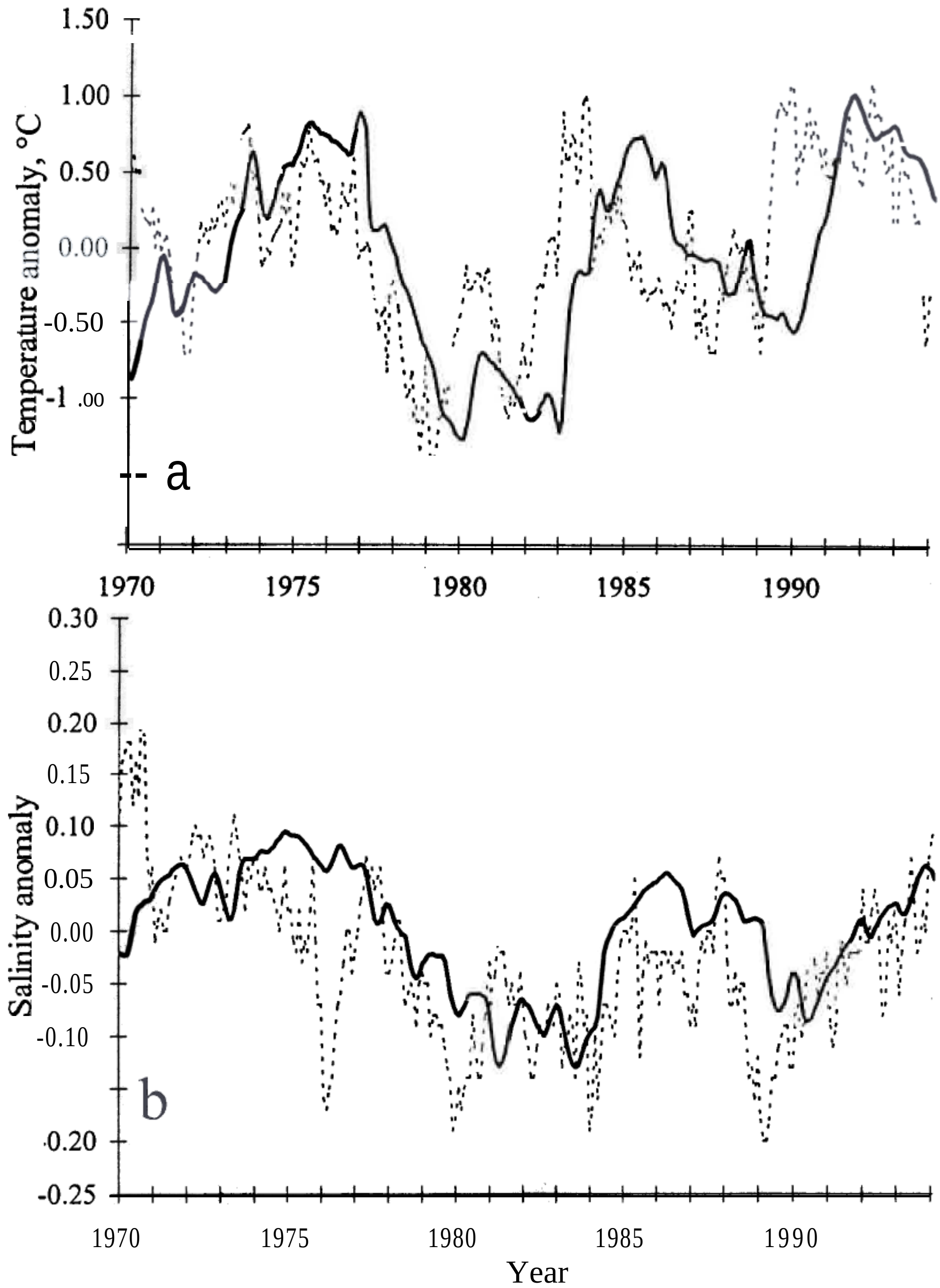


Fig. 6. Interannual variations of temperature (a) and salinity (b) in the layer 200-300 m at station 9 of the Kharlov section (solid line) and in the layer O-200 m at stations 3-7 of the Kola section (broken line)

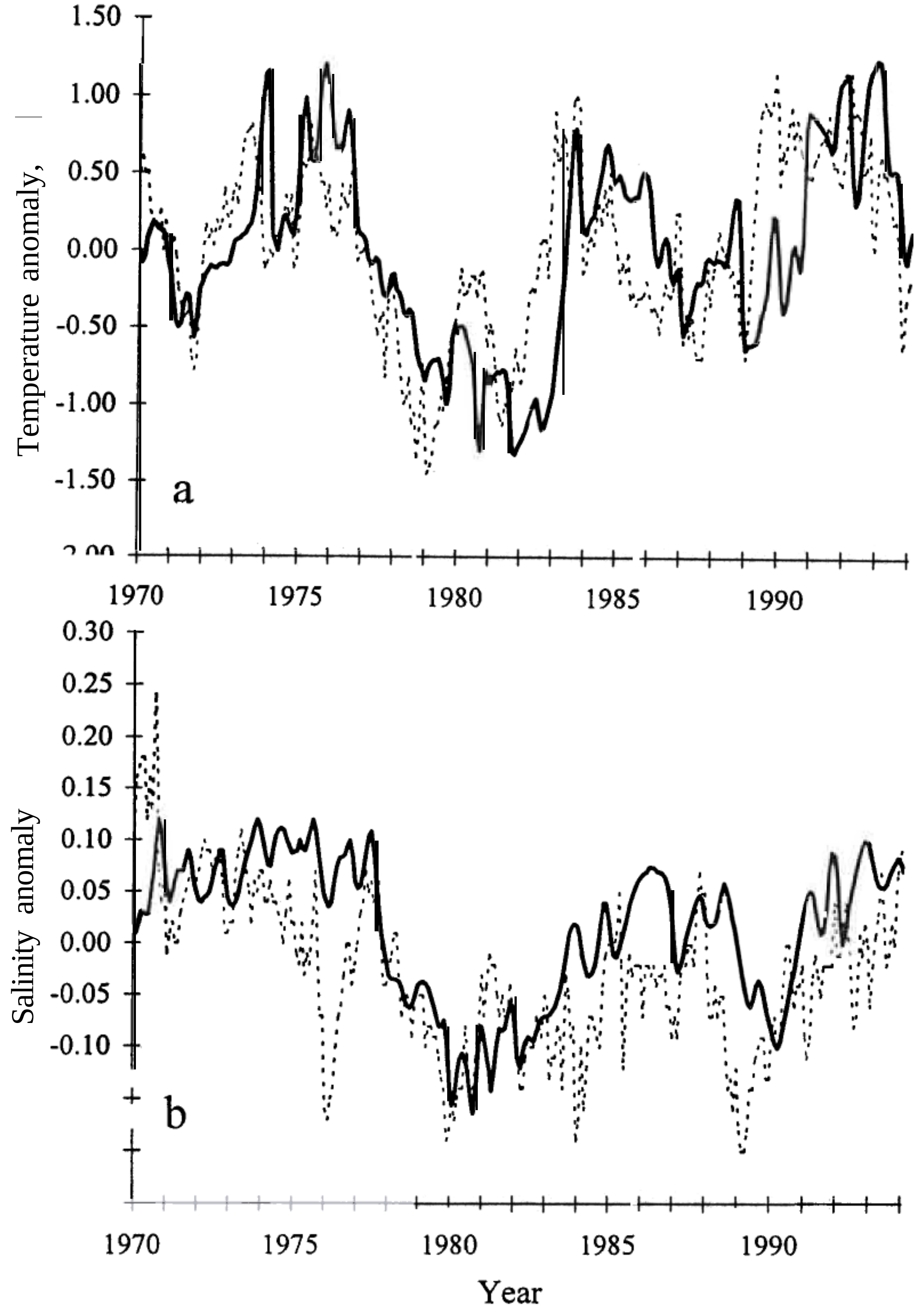


Fig. 7. Interannual variations of temperature (a) and salinity (b) in the layer 150-250 m at station 20 of the Kanin section (solid line) and in the layer 0-200 m at stations 3-7 of the Kola section (broken line)

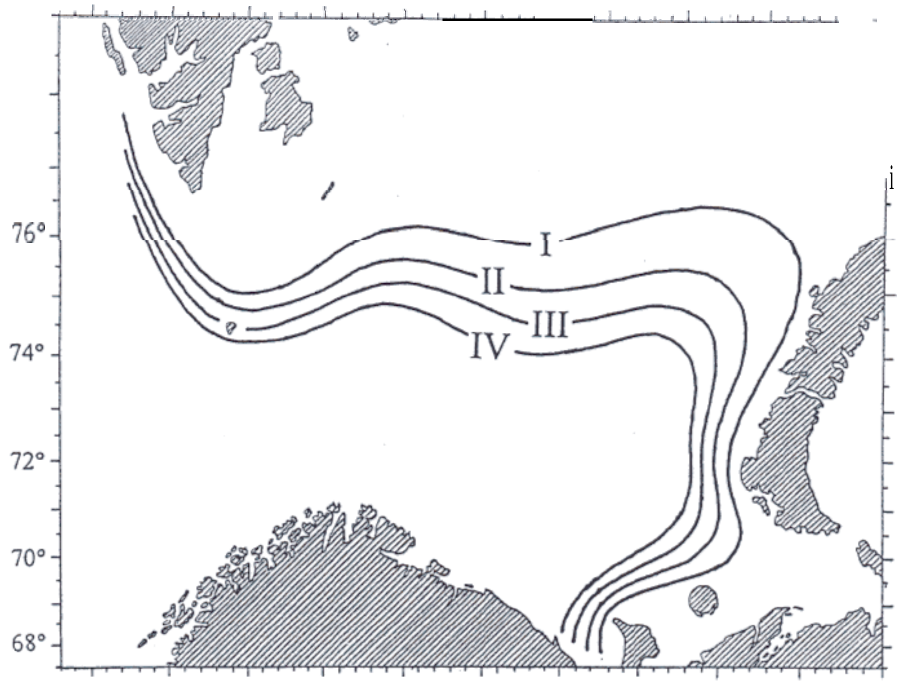
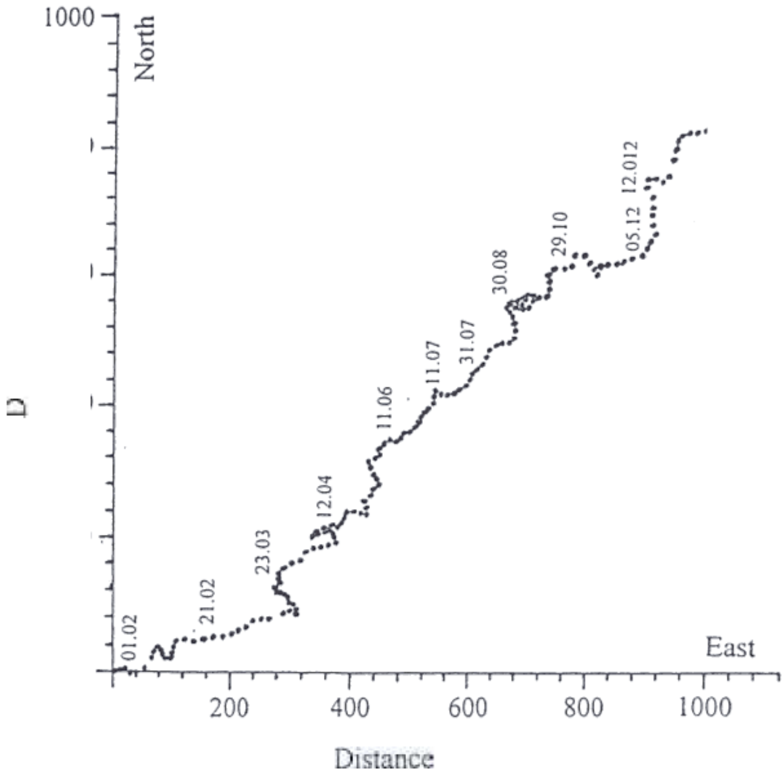


Fig Long average ice edge the Barents Sea January April (Anon 1990)



Vector diagram the surface the central part the Eastern Basin 73°10′ 43°45′ 1993 according to the data from OCEANOR mooring (Anon 1997)

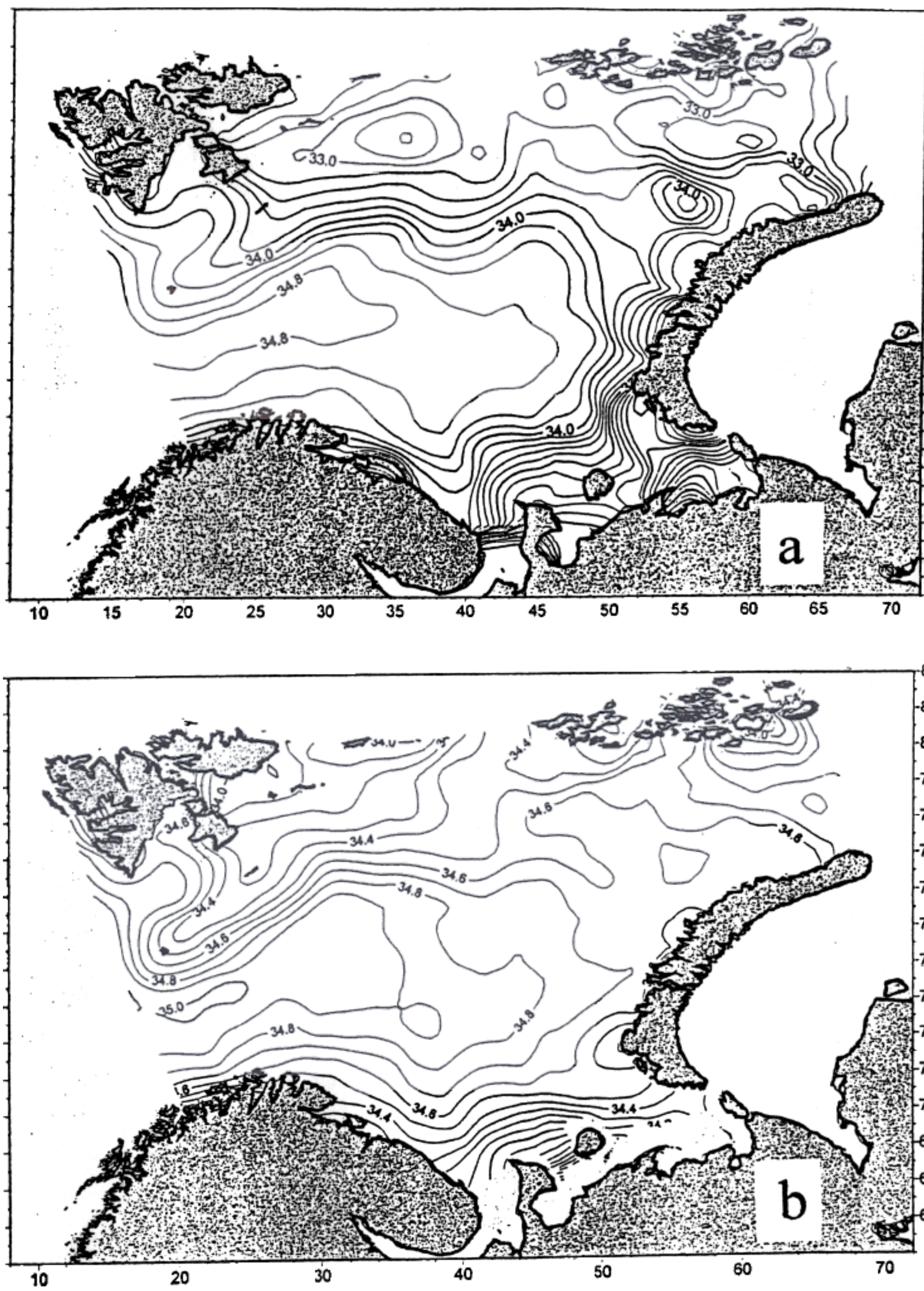


Fig. 10. Long-term average salinity in the Barents Sea
at the surface (a) and 50 m (b) in September (Anon 1998)

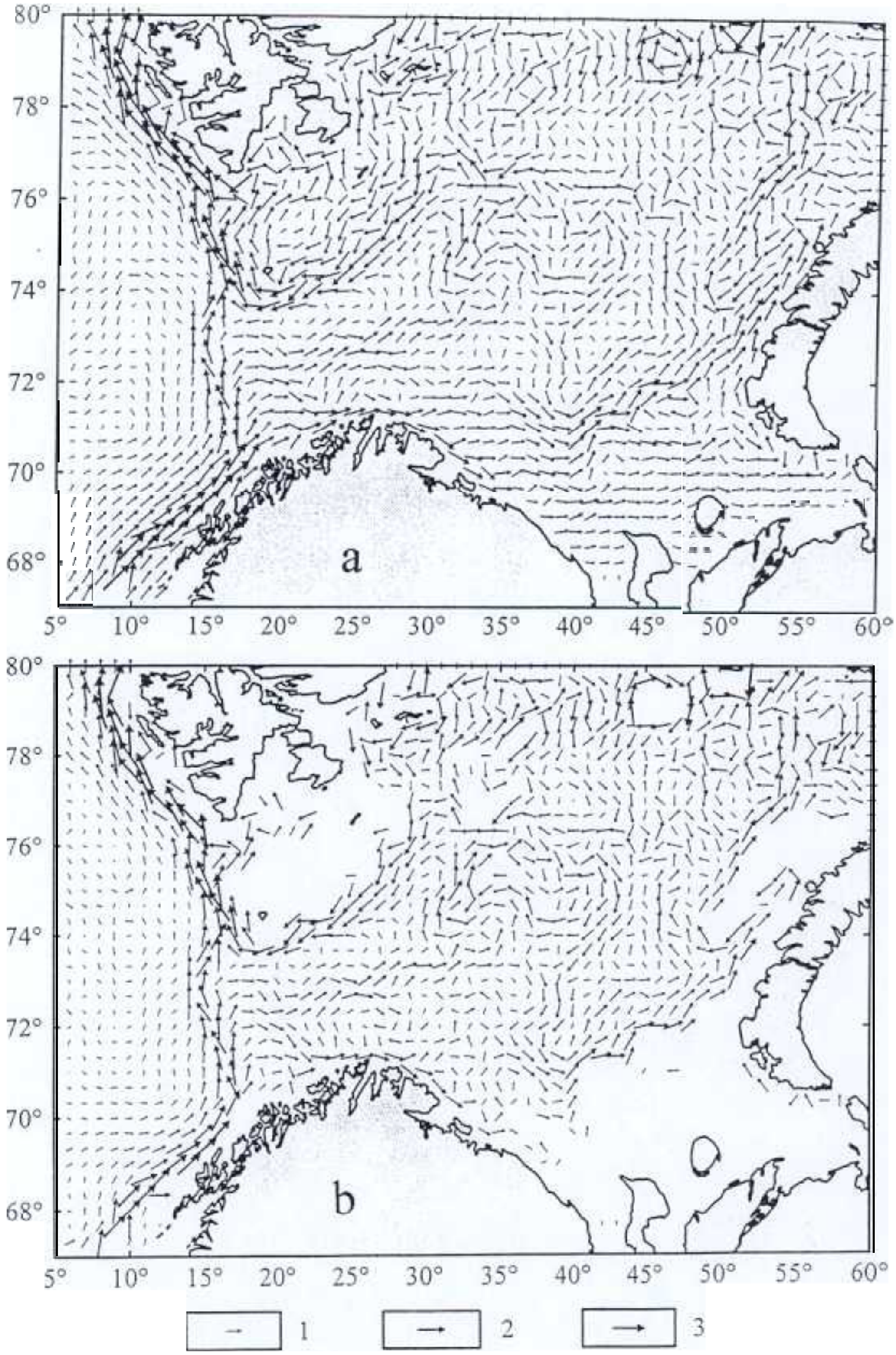


Fig. 11. Calculated currents at the surface (a) and 150 m (b) in October (Trofimov 2000)
1 – 10 cm/s; 2 – 30 cm/s; 3 – 50 cm/s

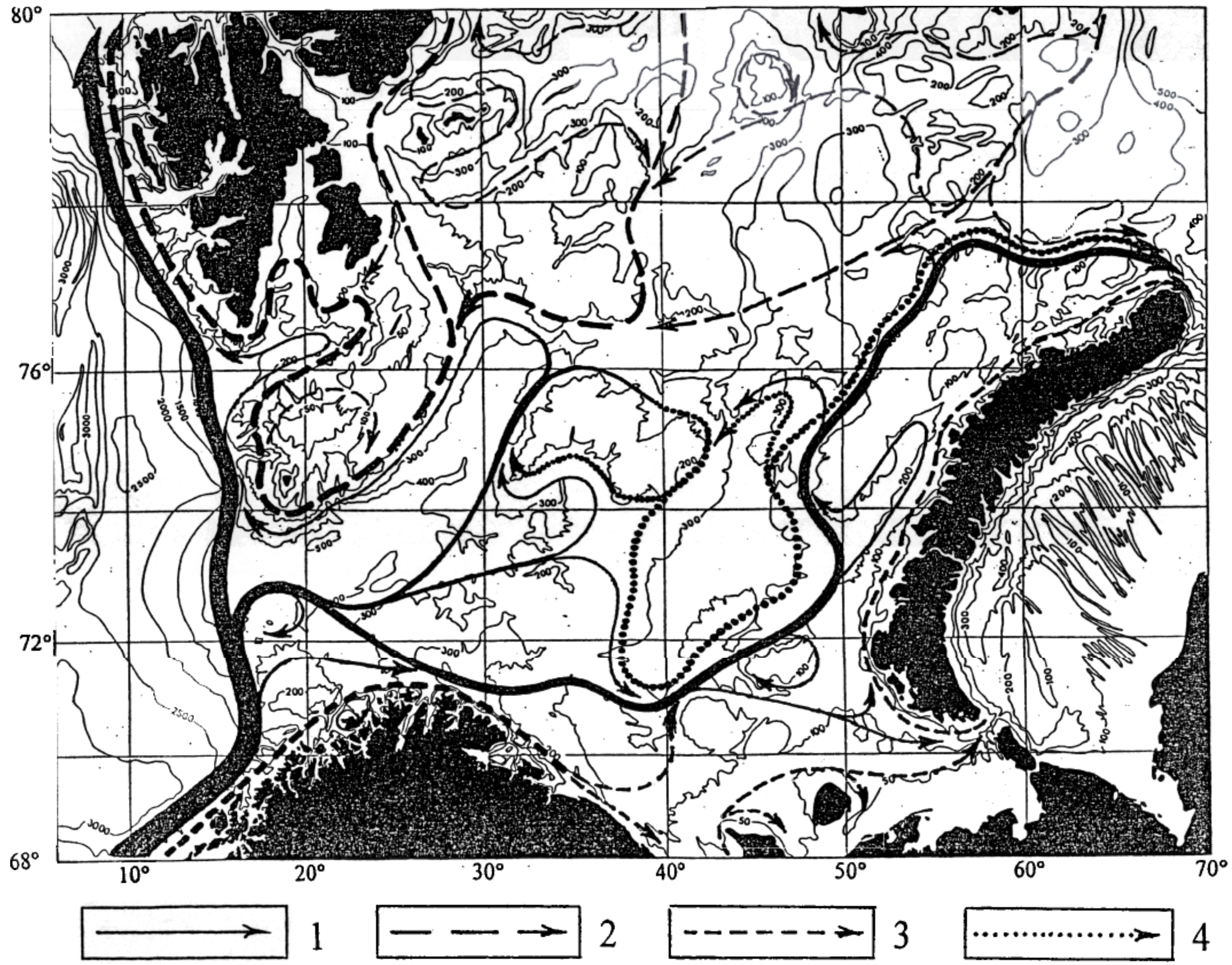


Fig. 12. Map of the circulation in the Barents Sea: 1 – Atlantic currents; 2 – Arctic currents; 3 – coastal currents; 4 – transport of the dense bottom water