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Spatial structure and variability of fields of currents, attenuation factor of light, and temperature in the surface layer of the northwest part of the Black Sea*

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Abstract — On the basis of the results of simultaneous observations of parameters of currents, attenuation factor of light, and temperature performed aboard a moving vessel, we established the main characteristics and features of the circulation of waters and the structure of transparency and temperature fields in the surface layer of the northwest part of the Black Sea. We investigate the correlation between the variability of fluid dynamics and redistribution of transparency and temperature fields. The measured currents are compared with those calculated using the actual field of atmospheric pressure during the time of observation. It is shown that the results obtained in the areas of steady currents in the west and central regions are in good agreement.

INTRODUCTION

A knowledge of the character and variability of the circulation of waters in the northwest part of the Black Sea is of special importance due to the great influence of currents on the formation and variability of hydrophysical, hydrochemical, and hydrobiological fields and due to the necessity of solving numerous ecological problems in this region of the sea. The specific features of the northwest part of the sea are discharge of rivers, mixing of fresh and sea waters, and their drift to the south with an alongshore current. Along with the development of methods for remote investigation of physical processes in seas and oceans, full-scale observations of hydrooptical characteristics of water in the surface layer of sea are also important.

At present, we have little experimental data on the fields of currents and transparency of waters in the northwest part of the Black Sea, especially in its shallow shelf zone, which does not enable one to plot a map of the spatial structure of these fields for different seasons [1–3]. Also note that we have no information on simultaneous and continuous observations of currents and transparency of waters in the Black Sea.

Geostrophic calculations of currents performed on the basis of the density field, as a rule, give a rather general picture of circulation with scales of at least 50–100 km; moreover, these calculations can be performed only for deeper regions of the sea. For the shallow regions of shelf, one can perform model calculations of the circulation of waters, which also describe only general features [4, 5].

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According to the results presented in the mentioned works, the circulation of waters in the northwest (shelf) part of the sea has significant variability caused, mainly, by variations in the wind field. Depending on the force, direction, and duration of wind in the northeast and west regions of the shelf, one observes the phenomena of downwelling and upwelling, which determine the distance from the shore, size, and form of the frontal zone, which is the zone of mixing of fresh and sea waters and which is sometimes called the hydrofront.

The cyclonic circulation of waters is observed for north winds, including light northwest winds. It is characterized by downwelling and the presence of a narrow coastal zone of brackish water near the west shore and by upwelling near the west shore of the Crimea. The anticyclonic character of currents is formed under the influence of south winds and northwest winds with velocity of 8 m sec^{-1} and duration of more than two days. The latter winds are characterized by upwelling near the west shore accompanied by the formation of one or two anticyclonic gyres in coastal waters, which are the largest zones of convergence in this region. The location and size of these anticyclonic gyres, which depend on the strength and duration of a wind, are, in turn, determined by the level of freshening and pollution of the entire northwest region of the sea due to the river discharge. In bays, depending on the direction of wind, cyclonic and anticyclonic gyres appear. In the southeast part of the region, one usually observes a quasistationary anticyclonic gyre.

We can assume that the circulation of waters is the main factor that determines the transparency field in the northwest part of the sea, which is mainly formed due to mixing of river waters, which are rich with dissolved and suspended substance of chemicobiological and terrigenous nature, with more transparent waters of a deeper part of the sea. In the spring–summer period, the development of phyto- and isoplankton also affects the transparency of waters. In shallow bays with silty and sandy bottom and regions of shelf adjacent to them, the transparency is determined by the dynamics of waters and waving, which stirs up bottom sediments, and also by the pollution of waters due to the precipitation and washout of the upper layer of soil saturated with chemical fertilizers and pesticides. Thus, the northwest region differs from the other regions of the sea by a more contrast distribution of transparency, which is formed both by large-scale and local dynamic formations. In turn, the data on transparency can be useful for the analysis of currents. For this reason, simultaneous measurements of parameters of currents and the attenuation factor of light are especially important for the determination and explanation of the structure of circulation and transparency of waters.

In this work, we analyze the results of synchronous and continuous full-scale observations of the fields of currents, attenuation factor of light, and temperature in the surface layer of the northwest region of the Black Sea obtained in the course of expeditions of the E/V *Muksun* in autumn (Cruise 97, November 14–23, 1983), winter (Cruise 45, March 17–23, 1978, and Cruise 99, February 25–March 15, March 29–30, 1984), and spring (Cruise 76, April 24–25, 1981) and in the course of a summer expedition of the R/V *Ai-Todor* (Cruise 3, June 1979). In spring and summer, only the attenuation factor of light and temperature were measured. We also present results for fields of winds and surface currents calculated on the basis of the data on the actual field of atmospheric pressure.

Autumn–winter seasons are characterized by the absence of a seasonal thermocline in shallow waters of the northwest shelf, steady homothermy, and almost complete homogeneity of waters in depth due to the strong convection and intermixing. The only exception is the region of hydrofronts, where stratification in a narrow coastal zone is maintained by river discharge.

METHODS AND EQUIPMENT

Measurements were performed with towed equipment: a BITIP gauge for measuring the attenuation factor of light and temperature [6] and an ÉMIT electromagnetic gauge for measuring the velocity of current [7]. In winter, in addition, samples of water were taken from the sea surface to determine the concentration of pigments of chlorophyll.

In the process of measurement, under conditions of prevailingly stormy weather, we used only a longitudinal ÉMIT with measurement base of 100 m, which continuously recorded the difference of potentials caused by the component of the velocity of a current perpendicular to the course of the vessel. The total vector of the current was determined every 5–15 miles, depending on the variability of the current, if the weather conditions allowed us to do this.

It is known that the accuracy of determination of parameters of currents on the basis of data obtained with an ÉMIT gauge depends on many factors [7], including the depth of sea in the region of measurement. For example, in the shallow regions of the sea, the accuracy of measurements with an ÉMIT gauge is low. At the same time, in ref. 8, it is shown that, in shallow regions, in the presence of a sufficiently powerful conducting sedimentary layer, one can successfully use an ÉMIT gauge and its efficiency improves with an increase in the following ratios: the thickness of the sedimentary layer to the depth of the sea, the conductance of sediments to the conductance of the sea water, and the width of the current to its depth. The error of measurement of parameters of currents with an ÉMIT gauge according to the method proposed in ref. 8 with regard for the actual data on the parameters of the sedimentary layer and sea water for the northwest part of the sea [9] is about 5–15%. The measurement error can reach 15–20% near the west shore in the zone of intense mixing of fresh and sea waters owing to the resulting electrochemical potentials recorded with an ÉMIT gauge. The indicated estimates of measurement errors enable one to regard the results of measurements of currents as reliable, provided that other procedural errors [7] (first of all, the sea telluric currents caused by perturbations of Earth's magnetic field) are eliminated. The measurement errors caused by the sea telluric currents can be significant (50% and more), especially in view of the fact that the prevailing longitudinal direction of currents in the northwest part of the sea [10] coincides with the directions of the majority of measuring tacks. Fortunately, according to the geomagnetic data, there were no noticeable perturbations of Earth's magnetic field during the investigations. Also note that the disturbances caused by telluric currents are mainly short-term ones and, moreover, they can easily be detected by the character of a record and discarded.

For the calculation of the fields of wind and currents on the basis of the actual field of atmospheric pressure, we used synoptic conditions with a steady direction of wind for a time sufficient for the surface current to be regarded as steady. Using synoptic maps, we calculated the direction and velocity of wind at ten nodes of the coordinate grid with a step of 30′ in latitude and 1° in longitude (from 45°N, 30°E to 46°N, 32°30′E). For the calculation of currents, we used the method presented in ref. 11, which is successfully used for a sea of small and middle depth. For the determination of boundary conditions, we took into account the water exchange between the northwest part and open sea through the boundary along 44°N [12]. It is necessary to take into account the fact that, in this region of the sea, to a greater extent than in the other regions, there exists the constant pressure gradient directed along the normal from the shore and caused by an increase in salinity near the shore due to discharge of continental waters. This, together with the action of the stream of the Basic Black-Sea Current that enters this region, results in the presence of a slight cyclonic system of currents here even in the absence of wind. For this reason, for the calculation of surface currents in the northwest part of the sea, it is recommended in ref. 12 to take this component into account by adding it to the calculated vector.

RESULTS OF CALCULATIONS AND OBSERVATIONS

Autumn hydrologic season. Since the direction of circulation of waters in the northwest region substantially depends on the wind field, we made an attempt to determine the character of circulation in this region in a period of time preceding the measurements. According to the data of weather observations on November 5–11, 1983, there were northwest and north winds with velocities of 8–12 m sec^{-1} caused by a cyclone over the north part of the Ukraine which moved in the southeast direction. This type of wind field induces a cyclonic circulation of waters in the northwest region of the sea, which is also confirmed by the results of hydrologic investigations carried out in this region during Cruise 7 of the R/V *Professor Kolesnikov* on November 6–11, 1983.

Synoptic conditions during Cruise 97 of the E/V *Muksun* were characterized by a passage of cyclones through Belarus and the north of the Ukraine. In particular, from November 14 to November 17, the region under investigation was subject to the action of the southwest periphery of a cyclone with center near Poltava, which caused the prevalence of northwest winds with velocities of 8–12 m sec^{-1}. According to the data of ship observations, northwest and west winds with velocities of 7–14 m sec^{-1} also prevailed; only for measurements on tacks 17–21, northeast winds prevailed. The map of the mean atmospheric pressure on November 14–17, 1983 is displayed in Fig. 1a. The directions and velocities of winds at selected points are denoted by feathered arrows as accepted in the synoptic practice. The long feather corresponds to 4 m sec^{-1} and the short one stands for 2 m sec^{-1}. It is known that, in view of the small value of friction of an air flow against the underlying surface of the sea, as in free atmosphere, the direction of wind over the sea coincides, in fact, with the geostrophic direction, and isobars over the sea surface can be regarded as current lines. Bold arrows correspond to the scaled vectors of surface currents calculated for selected points. It follows from the calculation of currents that the cyclonic circulation of waters sets up in the surface layer, which agrees with the mean weather data presented in refs. 12 and 13.

Analysis of parameters of currents on the basis of the data obtained with an ÉMIT gauge (thin arrows in Fig. 1a) shows that the motion of waters has a cyclonic direction in the central and west regions and anticyclonic direction in the east and northeast regions. The velocities of currents in the central part of the region are equal to 0.15–0.25 m sec^{-1} and, in certain coastal regions, they reach 0.5–0.6 m sec^{-1} (Cape Tarkhankut, to the south of the Tendrovskaya Spit).

Against the background of the general circulation, smaller anticyclonic formations in the Kalamitsky and Karkinitsky Bays with velocities of currents of 0.3–0.4 m sec^{-1} are observed. In the southeast part of the region investigated, there is an anticyclonic gyre (sometimes called the *Sevastopol* anticyclone) with horizontal dimensions of about 70–80 km and velocities of currents at periphery of 0.3–0.35 m sec^{-1}.

The direction of measured currents between the Odessa Bay and the west part of the Tendrovskaya Spit shows the existence of a cyclonic gyre elongated along the latitudinal direction for a distance of at least 60 km in this region. The mean velocities of currents at periphery of this gyre are equal to 0.2–0.25 m sec^{-1}.

Near the west shore of the investigated region, the dynamics of waters is quite complicated. For example, near the Dnestrovsky Estuary, the current forms an anticyclonic meander (in view of a small amount of measurement data, we cannot state that an anticyclonic gyre exists here). It is known from ref. 1 that an anticyclonic gyre is formed in this region for south and west winds.

Opposite the Kiliiskoe Branch of the Danube, an anticyclonic gyre with cross-sectional dimensions of about 35–40 km and the center at 45°30′ N, 30°E is clearly seen. The velocities of the currents in this gyre are equal to 0.2–0.25 m sec^{-1}. Slightly to the south, opposite the Sulinskoe and Georgievskoe Branches of the Danube, we recorded a fairly large meander that extends from the shore to the open sea up to 100 km. The center of this meander has the coordinates 45°N, 30°25′ E. The typical velocities of currents at its periphery are equal to 0.35–0.4 m sec^{-1}. These anticyclonic formations are dynamically connected with one another.

At the south boundary of the northwest part of the sea, there is a conspicuous meandering current, which is the north periphery of the Basic Black-Sea Current.

The described dynamic formations can be analyzed using the maps for the transparency and temperature fields in Figs. 2a and 3a.

In the Kalamitsky Bay, there is a spot of more transparent (ε = 0.2 m^{-1}) and warm (T = 12.5°C) water as compared with surrounding waters.

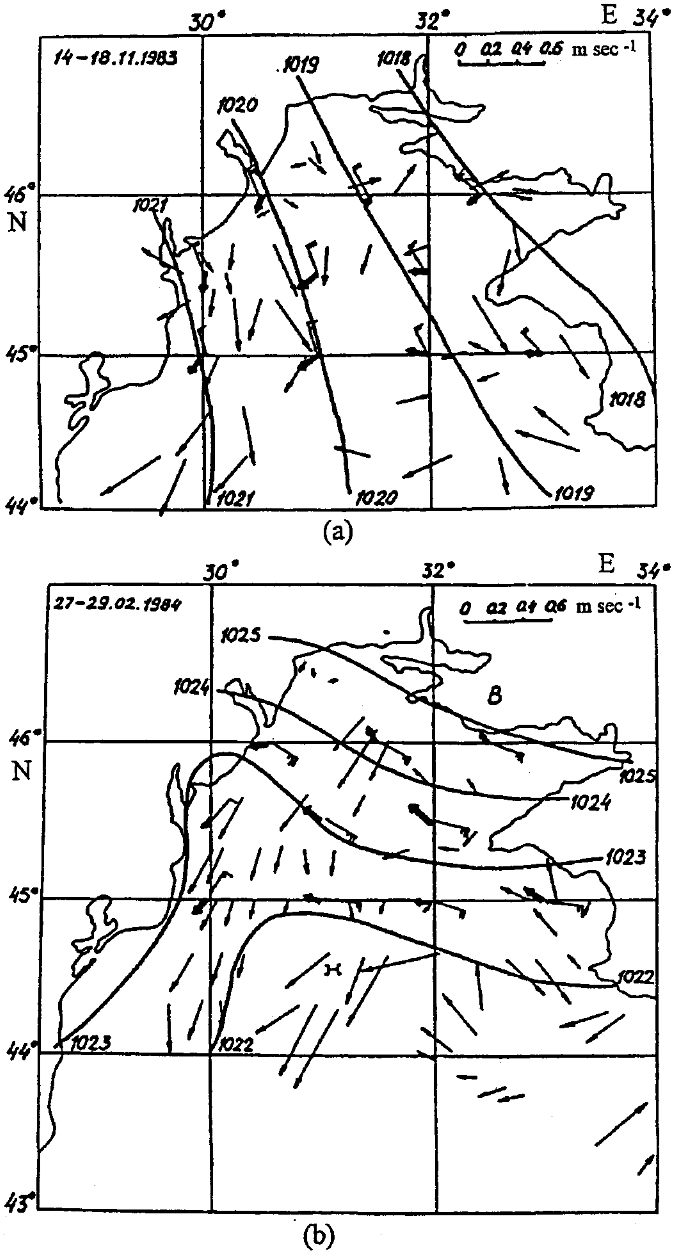

Figure 1. The map of surface currents in the northwest part of the Black Sea in autumn (a) and winter (b) hydrologic seasons.

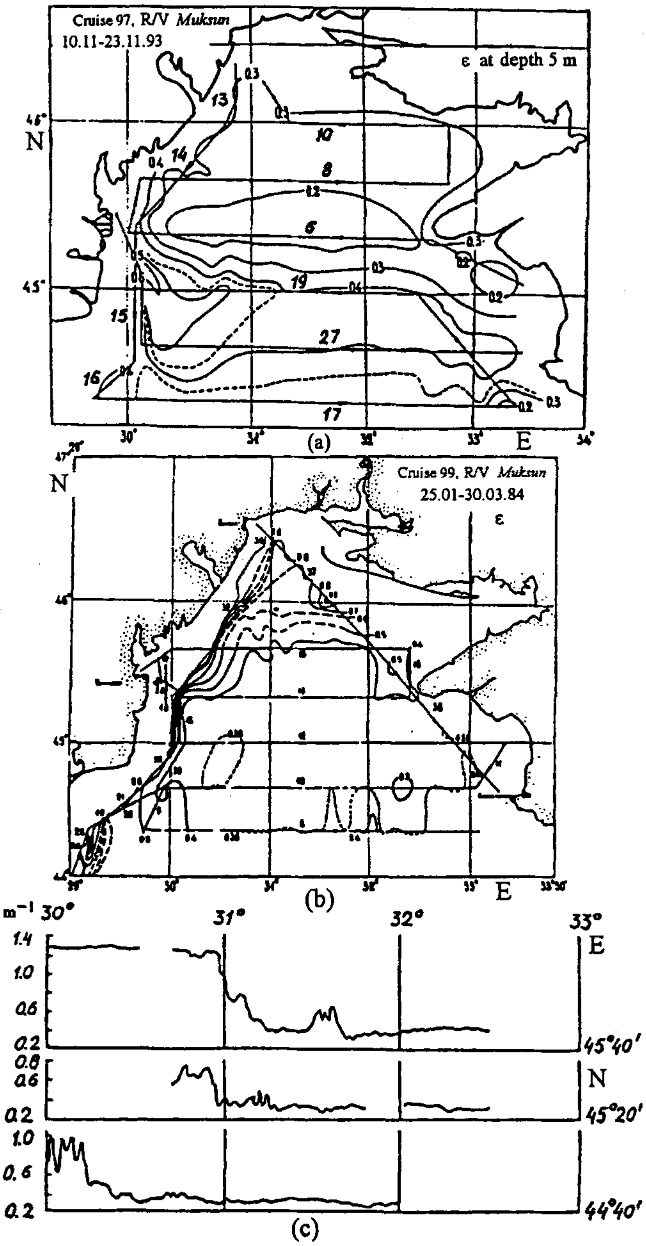

Figure 2. Distribution of the attenuation factor of light in the northwest part of the Black Sea in autumn (a), winter (b), and summer (c) hydrologic seasons (digits stand for the tack numbers).

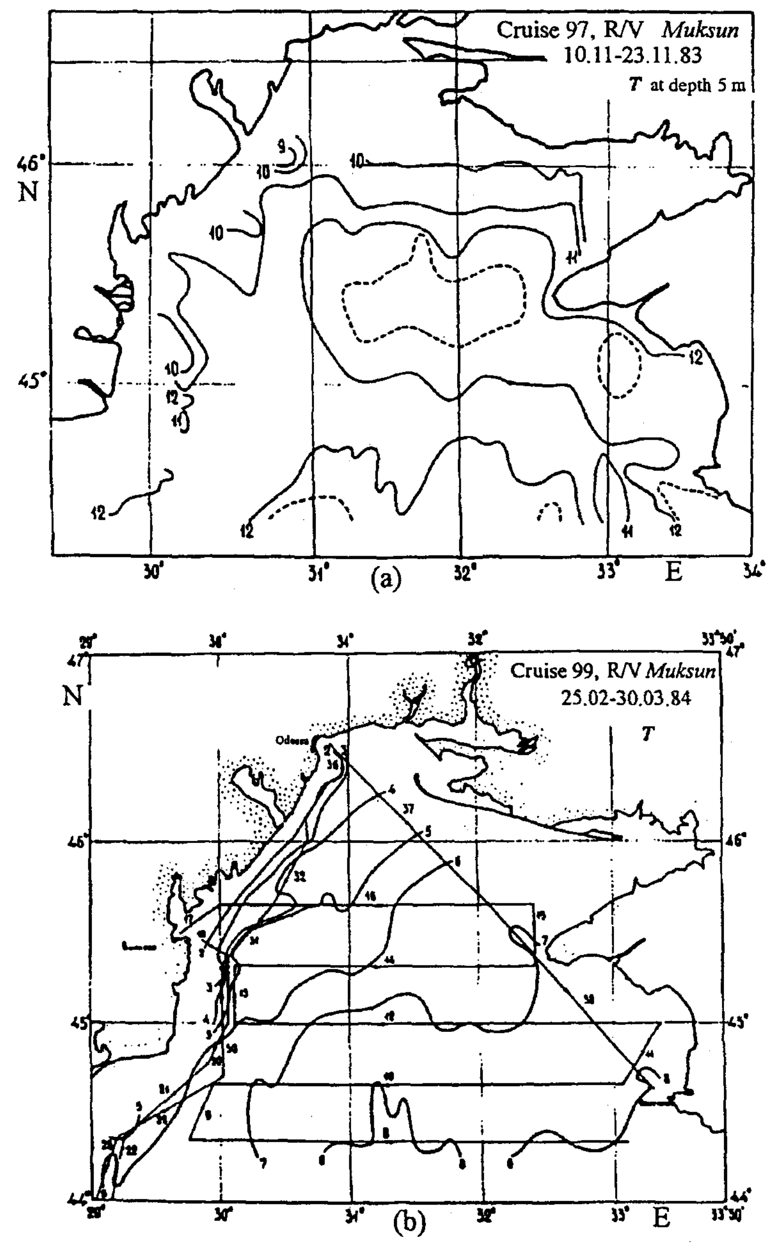

Figure 3. The map of distribution of temperature in the northwest part of the Black Sea in autumn (a) and winter (b) hydrologic seasons.

In the central part of the region, there is a fairly large water region elongated along a latitude of 45°20′ for at least 140 km and having at least 35 km in the meridional direction. This region is characterized by low values of the attenuation factor ($\varepsilon = 0.2\ m^{-1}$) and increased temperature as compared with those for surrounding waters.

At the south boundary of the region, the horizontal distributions of transparency and temperature also confirm the meandering character of the Basic Black-Sea Current, which joins the west alongshore current in the region of 30°E.

In the west part of the region, there is an alongshore strip of turbid and colder waters (a hydrofront), which is the zone of mixing of river waters with waters of the central part of the region. An isotherm of 11°C and isoextinction of 0.3 m^{-1} can be regarded as a conditional boundary of the hydrofront.

As follows from the distribution of transparency, mostly Dnieper waters propagate along the west shore up to 45°40′N. Dniester waters manifest themselves by a cold tongue of waters ($T \leq 9$°C) near the Dniester Estuary.

Beginning with the branches of the Danube, there is an extended region of waters of increased turbidity elongated to the east. The anticyclonic meander determined on the basis of dynamic characteristics, which causes the drift of these waters toward the east almost to the shores of the Crimea, coincides with this region. There is a certain increase in the temperature field in the zone of propagation of these turbid waters to the east.

Winter hydrological season. During the entire period of observations in Cruise 99 of the E/V *Muksun*, using the ship data we recorded northeast winds with velocities of 5–9 m sec^{-1}. The wind field and the actual field of atmospheric pressure averaged over the period of February 27–29, 1984, which was determined by the influence of the southwest periphery of anticyclone with the center to the north of Voronezh, is shown in Fig. 1b. During this period, east and east-southeast winds with velocities of 8–10 m sec^{-1} prevailed, which agrees with the seasonal characteristics of these parameters presented in ref. 12. On the whole, the calculated fields of currents in Fig. 1b have a cyclonic character as in autumn.

Analysis of the data obtained with an ÉMIT gauge, mainly, for the period of February 27–29 also corroborates the existence of the general cyclonic direction of the circulation of waters (Fig. 1b). In the central part of the region, the velocities of currents are 0.15–0.2 m sec^{-1}, which is somewhat lower than in autumn. In the west part, a jet alongshore current with velocity of 0.3–0.4 m sec^{-1} and width of at least 20 km stands out along the entire west shore.

Note several features of circulation of water masses. For example, in a region of 46°N, we recorded a jet flow directed to the southeast with the velocity of current in deep stream of 0.5 m sec^{-1} and width of 15–20 km, which expanded and joined the west alongshore current in a region of 45°20′–45°40′ N, 30°25′ E. In the Odessa Bay, we observed indications of a cyclonic vortex with the velocity of current of 0.1–0.16 m sec–1 and horizontal dimensions of about 20 km. It is possible that the relatively high velocity of the north current measured in the Kalamitsky Bay (0.25–0.35 m sec^{-1}) is caused by the penetration of a branch of the Basic Black-Sea Current into the southwest shelf or by the existence of a small anticyclonic gyre in this bay. To the north of 45°N, the Basic Black-Sea Current in the form of a jet current was not observed in winter. On the whole, we can note a slight decrease in the value of velocity of currents in winter in the majority of regions of the northwest part of the sea as compared with autumn.

The measurements performed on February 28 and March 29–30, 1984 to the southwest and west of Cape Sarych confirmed the presence of a quasistationary anticyclonic gyre whose center shifted approximately by 40 km to the southeast against its position in autumn. The velocities of currents at periphery somewhat increased (up to 0.35–0.4 m sec^{-1}) and the cross-sectional dimensions were at least 100 km.

To the west of this anticyclonic gyre, at tacks 10 (up to 44°20′ N) and 8 (up to 44°40′ N), a southwest current was recorded. This dynamic picture can possibly be explained by a meandering behaviour of the Basic Black-Sea Current accompanied with the formation of the mentioned anticyclonic gyre and the adjoined cyclonic meander at the northwest periphery of the cyclonic meander in the region of a "topographic trench" along 31°30′ E, and, maybe, a cyclonic gyre, as well. However, the absence of data of measurements to the south of 44°N in a region of 30–32°E does not enable us to state the latter. Similar dynamic formations are called vortex dipoles and were observed in this region according to the data of sheep measurements and satellites surveys [14]. The maximum velocities of currents in this flow, which is, apparently, a periphery of a cyclonic meander, reach 0.6–0.7 m sec^{-1}, which can partially be explained by an increase in the northeast wind at the moment of measurements up to 10–15 m sec^{-1}. The deep stream of this flow was located above a continental slope (500–700 m). The horizontal size of the cyclonic meander was about 60 km.

The structure of transparency and temperature fields of the surface waters of the northwest part of the sea (Figs. 2b and 3b) significantly differs from that in the autumn season. A major part (about 90%) of the water area is occupied by waters with $\varepsilon \geq 0.4$ m^{-1}. In autumn, such a high value of the attenuation factor (0.4 m^{-1}) was caused by the tongue of turbid waters extended from the Danube mouth to the east.

The west frontal zone (hydrofront), which most clearly manifests itself by the transparency of waters located to the south of 45°20′ N, shifts approximately by 35 km to the west and becomes significantly more narrow (Figs. 2b and 3b). This is explained by the fact that, for the existing orientation of shores, the northwest wind increases the water level, which leads to a natural increase in the gradients of transparency and temperature in the frontal zone as compared with autumn. As mentioned above, this factor also manifests itself in the existence of a jet longitudinal current in the frontal zone. At the same time, in the north part of the region, we observed a significant extension of the frontal zone bounded by isolines of (1–0.4) m^{-1}. Isotherms of 2–7°C have a similar behaviour (Fig. 3b).

A restructuring of the transparency fields evidently manifests itself by changes in the region of transparent water ($\varepsilon \leq 0.2$ m^{-1}) that was located in the central part of the region in autumn. In winter, the transparency of water in this region decreased to $\varepsilon \leq 0.35$ m^{-1} and its center shifted northwestward to the point 44°50′ N, 30°30′E. The dimensions in the latitudinal and meridional directions were about 28 and 40 km, respectively.

Waters of the Basic Black-Sea Current are discernible on the distributions of ε and T in the southeast part of the region in the form of a tongue of warmer and more transparent waters. In tacks 8 and 10, we see wave-like distributions of transparency and temperature in a region of 31–32°E, which confirms the meandering behaviour of the Basic Black-Sea Current in the velocity field indicated above. A small tongue of turbid waters ($\varepsilon \leq 0.9$ m^{-1}) coinciding with the southwest flow in a region of 46°N is apparently explained by the removal of turbid waters from the Karkinitsky Bay and from the south shore of Tendrovskaya Spit due to the development of upwelling in the case of the northwest wind, which does not manifest itself in the temperature field in winter.

It is interesting to compare the results of measurements for ε and T performed in March, 1978 and March, 1984. In 1978, the measurements were carried out on the Yalta–Cape Khersones–a turning point at 46°10′N, 30°07′E–Vilkovo–Sevastopol course (the returning point lied slightly to the southwest). Thus, the route passed through main characteristic hydrologic regions of the northwest shelf.

As a whole, the behaviour of the distribution of ε in both cruises coincides. In east regions, waters are much more transparent than in the north and west regions, where the values of transparency vary from 0.7 to $\varepsilon > 1.0$ m^{-1}. Note a sharp increase in the turbidity from 0.2 to 0.7–0.9 m^{-1} in March, 1978 in a strip 20–25 km wide in a region of 46°N, 31°20′E, where a southwest flow of turbid waters ($\varepsilon \leq 0.9$ m^{-1}) of nearly the same width was recorded in 1984. The values of temperature of waters between Cape Khersones to Cape Tarkhankut are also close. However, there are also certain differences. For example, in the east part of the region, waters were more transparent by a factor of 1.5–2 in 1978. The temperature of waters in the north (to the north of 45°30′N) and west regions measured that year is lower by 2–3°C in the mean.

Spring hydrological season is the period of spring flood, when the influence of brackish waters on the northwest part of the sea can be significant. For this reason, even isolated measurements of ε and T in the surface layer of the sea performed during Cruise 76 of the R/V *Muksun* on April 24–25, 1981 in two oppositely directed meridional tacks along 31°35′E between the south part of the sea and a latitude of 46°N are of interest and can give a certain representation of the structure of ε and T in this region. In the course of measurements, east and southeast winds with velocities of 4–7 m sec^{-1} were observed.

In an open deep-sea region, the transparency varied within the range 0.25–0.35 m^{-1} and the temperature decreased from 12.5 to 11.2°C in the course of motion from the south to north (up to 44°N). In the vicinity of a latitude of 44°10′, the transparency decreased jumpwise from 0.32 to 0.4 m^{-1} and preserved this value up to 45°N with variations of $\pm$ 0.2 m^{-1}. Further to the north, we recorded a jumpwise decrease in ε to 0.2–0.3 m^{-1} and a decrease in temperature T by 1.3°C (from 11.0

to 9.7°C). These values of ε and T were preserved to a latitude of 45°50′ N, after which a jumpwise increase in ε to values greater than 0.6–0.7 m^{-1} took place. Note that, in fact, the mean temperature of water at a depth of 0.5 m in the region of 44–46°N did not change. A similar distribution of transparency in the region between 44°N and 45°50′ N was observed in the autumn season, in which a strip of turbid waters from Danube's mouth to the east was observed; to the north of this strip, there was a region of transparent waters with $\varepsilon = 0.2\ m^{-1}$. One could assume that the indicated strip of turbid waters belongs to the north periphery of the Basic Black-Sea Current. However, the measurements carried out on the indicated sections and on the meridional section from Cape Aiya show that, for waters of the Basic Black-Sea Current, ε did not drop below 0.3–0.32 m^{-1}. For this reason, the existence of a strip of turbid waters with cross-sectional dimensions of 90–100 km and $\varepsilon = 0.38 - 0.42\ m^{-1}$ can be apparently explained by the influence of brackish waters brought here with an anticyclonic gyre formed during flood in Danube's mouth, the zone of influence of which reached as high as 100 km [15]. The data of observations obtained in the course of our measurements in April, 1981 and presented in ref. 16 confirm the existence of the east periphery of an anticyclonic gyre exactly in this region.

Summer hydrological season. Measurements carried out in three latitudinal sections (Fig. 2c) do not enable us to plot a map of distribution of the attenuation factor of light in the entire northwest part of the sea. Nevertheless, we can note several features of the horizontal structure of ε.

The central part of the region is occupied by waters with values $\varepsilon = 0.3$–$0.4\ m^{-1}$, which are close to those obtained in autumn and winter. As in winter, in summer the hydrofront was also well pronounced in the field of transparent waters; as compared with its winter location, it moved to the east in north tacks by 45–60 km. Such a situation arises in the case of south and west winds, which is typical of the spring–autumn period [13], when the region of mixing of fresh and sea waters moves to the east and, in addition, anticyclonic gyres can be formed in the regions of mouths of the Danube and Dniester, which has already been indicated above. The simulation of the freshening effect of river discharge during flood also shows that even in the absence of south wind, the transformation of stratification of waters caused by freshening leads to the appearance of an anticyclonic gyre in the vicinity of Danube's mouth, where this effect is most significant [15]. In this case, the east flow of salt sea waters through the south open boundary of the basin caused by peculiarities of the relief of bottom becomes more intense. This manifests itself in a considerably smaller distance of the frontal zone from the shore in the south as compared with its location in the north. This situation is similar to that in autumn, when anticyclonic vortex formations were also formed opposite Danube's mouth. An increase in the turbidity of waters up to 0.5–0.65 m^{-1} in a tack along 46°40′ N in the region of 31°30′–31°40′ E can be explained by the influence of a flow of turbid waters observed in this region in the winter and spring seasons.

CONCLUSIONS

The obtained synchronous continuous data of field measurement of parameters of currents, attenuation factor of light, and temperature enabled us to determine the main properties and features of the circulation of waters and the structure of transparency and temperature fields in the surface layer of the northwest part of the Black Sea with high spatial resolution in different hydrological seasons.

We investigated the influence of the dynamics of waters on the redistribution of the transparency and temperature fields and established that instantaneous variations in the parameters of currents were not accompanied by the immediate redistribution of the transparency and temperature fields. The variability can be observed in certain space–time scales.

The comparison of the measured and calculated parameters of currents shows a good agreement between them in the regions of steady currents (central and west regions) and significant differences between them in the east and north regions, in which the variation of currents is considerable. We note a good agreement between the results of theoretical calculations of currents and the transparency and temperature fields.

The obtained experimental data can serve as a reference for comparison with the results of subsequent measurements in the case of monitoring of aqueous medium and can be used for the determination of the effect of natural and anthropogenic factors on the ecosystem of the northwest part of the sea.

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