Komorin, V., Dykhanov, Y., Bolshakov, V., Popov, Y., Melnik, E., Savinykh-Paltseva, L.: Hydrological structure of the waters in the Drake Passage based on the survey of December, 2018, Ukrainian Antarctic Journal, 1, 29—40, 2020.
doi:10.33275/1727-7485.1.2020.377

V. Komorin [1,2,*], **Y. Dykhanov** [1,2], **V. Bolshakov** [1,2], **Y. Popov** [1,2,3], **E. Melnik** [1,2], **L. Savinykh-Paltseva** [1,2]

[1] Scientific Institution Ukrainian Scientific Center of Ecology of the Sea, Odessa, 65000, Ukraine
[2] State Institution National Antarctic Scientific Center of the Ministry of Education and Science of Ukraine, Kyiv, 01016, Ukraine
[3] Odessa Area Branch of State Hydrographic Service of Ukraine, Odessa, 65038, Ukraine

*** Corresponding author:** vkomorin@gmail.com

Hydrological structure of the waters in the Drake Passage based on the survey of December, 2018

Abstract. The results of the analysis of hydrological observations made on the Ukrainian fish-krill trawler "More Sodruzhestva" in the south-eastern part of the Drake Passage in December, 2018 are presented in article. The aim of the investigation is to study the thermohaline structure of the 200 m surface water layer in the research area and comparison of the actual state of the water masses in the summer of 2018 with those identified during previous studies. The expedition was carried out at the hydrological polygon from eight stations. Measurements were conducted by the sensing complex CTD SBE 37SM. Traditional methods for graphic and statistical analysis have been used to process the obtained data. Water structures were allocated based on the analysis of the T,S and O_2,σ-diagrams. In addition, satellite data of the Marine Environment Monitoring Service from the Copernicus website as well as information from one of the drifting buoys of the Project ARGO which took place through the research area during this time were involved in the analysis. The results are the spatial hydrological structure of the upper 200 m water layer in the research area. The main water masses formed this structure, as well as the actual position of the Polar Front in the north and the Scotia Sea Front in the south. Characteristics of the spatial variability of the cold intermediate layer are highlighted. The largest volume of water was occupied by the Southern Front of the Southern branch of the ACC that moves the relatively desalinated surface waters of the Bellingshausen Sea in this layer; there is a significant role of the influence of dynamic factor on the distribution of hydrological characteristics. It is noted that the on-site surveillance data are well consistent with the information obtained from Copernicus and the Project ARGO.

Keywords: Drake Passage, water mass, cold intermediate layer

1 Introduction

The circulation of the waters of the Southern Ocean is among the most significant components of the World Ocean circulation. It is here, near the Antarctic shore, that the upwelling raises the deep (higher and lower) circumpolar water masses rich in nutrients to the upper layer where they interact with the colder surface waters of the Antarctic area. Part of the waters slides down the slope making up the regional bottom waters, and the other part in the Ekman transport layer moves northwards where it is overlaid by lighter polar waters forming Antarctic Intermediate Water (AIW). Thus operates the meridional overturning circulation of the Southern Ocean.

As a result, the Southern Ocean has a powerful impact not only on the planetary climate but also on the global carbon (and nutrients in general) cycle. Most of the World Ocean including the bottom waters gains its physical and biochemical characteristics in the surface layer of the Southern Ocean in contact with the atmosphere, and so any change in the Southern Ocean can have fundamental impact on the World Ocean and climate in general (Sallée, 2018; Talley et al., 2011).

Nowadays, a powerful tool for climate research and prognosis is mathematical modelling of the climate system. A special place in this research occupies the water exchange through the Drake Passage as the Antarctic Circumpolar Current (ACC) narrows down there from the 2–2.5 thousand km wide in the Atlantic, Indian and Pacific Oceans to merely 800 km which has a large influence on the positions of the main hydrophysical fronts.

Also, the Drake Passage area lies within the Fishing Area 48 according to the Southern Ocean zoning by CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) Convention, according to its importance for the tasks of both food production and environmental protection.

In accordance to the growing body and improving quality of satellite data as well as the oceanography bases becoming progressively more exact, novel possibilities open to enable more thorough and detailed analysis of processes shaping the oceans and seas.

Thus the study of the fine-jet structure of the ACC (Tarakanov, Gritsenko, 2018) based on data from satellite altimetry on two hydrophysical profiles done in the Drake Passage and on the analysis of the θ,S-curves of the upper 800 m layer identified 11 individual jets of the ACC in 2010 and 9 in 2011. The article also specifies the seasonal position of hydrological and dynamic fronts. Firing et al. (2016) showed the position of three main fronts of the Southern Ocean at the exit of the ACC from the Drake Passage into the Scotia Sea: the Subantarctic Front (SAF) which lies here between 54° and 57° S, Polar Front (PF) between 56° and 59° S and Southern Front of the ACC (SACCF) between 59° and 62° S. There was found an anticyclonic, possibly quasi-stationary meander both on the surface and at the depth of more than 2000 m.

Interesting facets of biology and trawling of krill and their connections with hydrological and meteorological conditions are provided, for instance, in (Zhuk, 2011–2012).

The currents bring not only the biogenic substances but the young krill, too. For example, specialists in its biology and size parameters discern the Bellingshausen population. The larger krill is more often found in areas with warmer upper water layer (Zhuk, Korzun, 2016).

In the light of the above it is understandable how important it is to correctly estimate the water volumes carried by the ACC. This attracts much attention and effort to the Drake Passage. The interest to the processes caused by climate change in the Drake Passage grows with each passing year. Results of a study of the frontal structure of the surface waters of the Southern Atlantic Ocean by a survey in November–December 2018 are reported in Komorin et al., 2019. Until recently the climatic models were advised to use the volume transport value of 134 Sv (1 Sv = $= 10^6$ km$^3 \cdot$ s^{-1}). The number was taken for canonical; it was obtained in late 1970-s–early 80-s in the framework of the International Southern Ocean Study program (ISOS) (Whitworth III, Peterson, 1985).

Later estimates vary: (Sukhovey, Ruban, 2009) put it at 112 Sv, and (Antipov et al., 2014) at 105–125 Sv, which makes it 10–20% less than the canonical one, while others, for example (Koshlyakov et al., 2007) evaluate it as 148–158 Sv which is larger by approximately the same amount.

Yet the number which should be given preference due to the sheer scale and sound organization of research that went into it was obtained by the cDrake experiment (www.cdrake.org) aimed at quantitative estimate of transport and dynamic balances of the ACC in the eponymous passage. The experiment lasted four years (November 2007–November 2011). The observations were done at 17 points across the passage; an array of 18 more was set up to measure the eddy activity. At these points there were installed over 40 CPIES (Current and Pressure recording Inverted Echo Sounder). Besides that, there were widely used shipboard and lowered Acoustic Doppler Current Profilers (ADCP) mounted on the CTD rosette. The re-

ISSN 1727-7485. Ukrainian Antarctic Journal, 1, 2020, doi:10.33275/1727-7485.1.2020.377

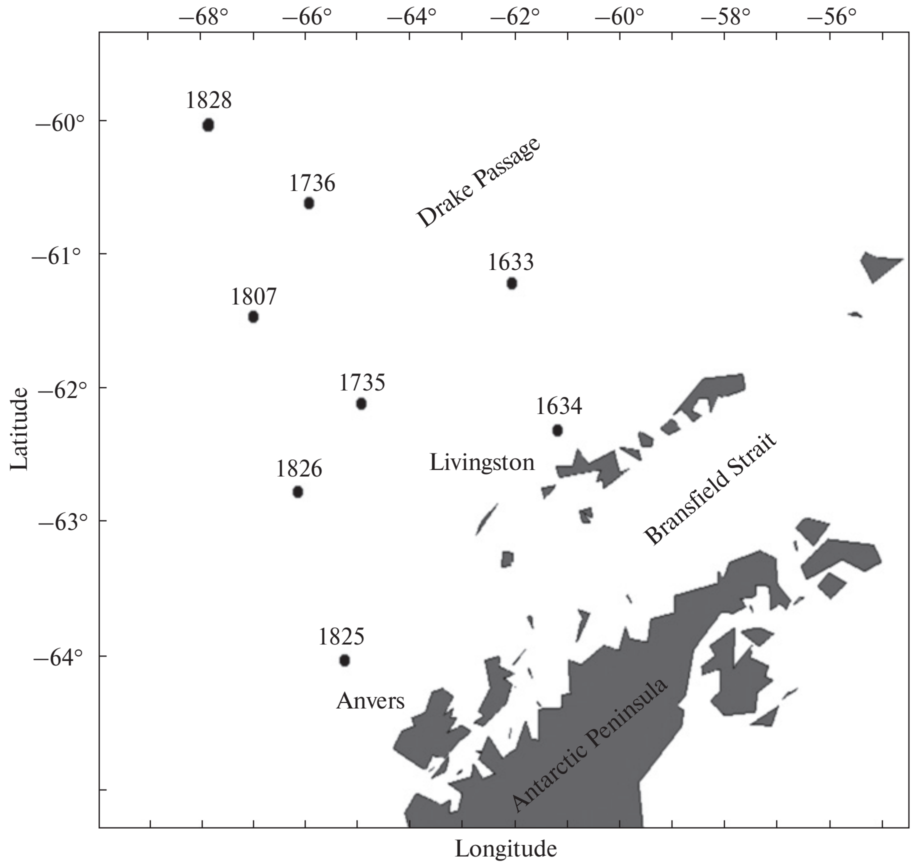


Figure 1. Scheme of CTD station location

sults (Donohue et al., 2016) showed that the mean baroclinic component of the ACC in the Drake Passage was 127.7 ± 5.9 Sv, the barotropic one (independent of depth) was 45.6 ± 8.9 Sv, and their sum was 173.3 ± 10.7 which is 30% more than the canonical value.

The research of the hydrological structure of the Drake Passage waters in three regions at 2883 stations selected from the archive base WOD-2009 (Artamonov et al., 2011–2012), showed seasonal variability of the areas of two main water masses of the upper layer — the Antarctic Winter Water Mass (AWW) and Antarctic Intermediate Water Mass (AIW) which reach maximal areas in September–October and March–April, respectively. The AIW is rich in biogenic substances, and so its volume has an impact on the region's fisheries productivity.

A typical sign of the AWI is an intermediate temperature minimum as a result of the autumn-winter convection and further spring-summer warming. Thus, on summer maps of vertical distribution of temperature AWW is identified by the Cold Intermediate Layer (CIL) which under certain meteorological conditions can practically disappear. In this article we shall use both definitions.

In the Drake Passage there were identified (Ukrainsky et al., 2000) five modifications of the Antarctic Surface Water Mass (ASW): the main water, the northern water, the Bellingshausen Sea water, the Bellingshausen Sea–Scotia Sea convergence water, and the shelf water of the Bellingshausen Sea.

The urgency of the research is recognized by the State Special-Purpose Research Program in Antarctica for 2011–2020 on the trends in climatic variability of the oceanographic fields of the Southern Ocean and prognosis of areas of increased biological productivity and fisheries significance, section Oceano-

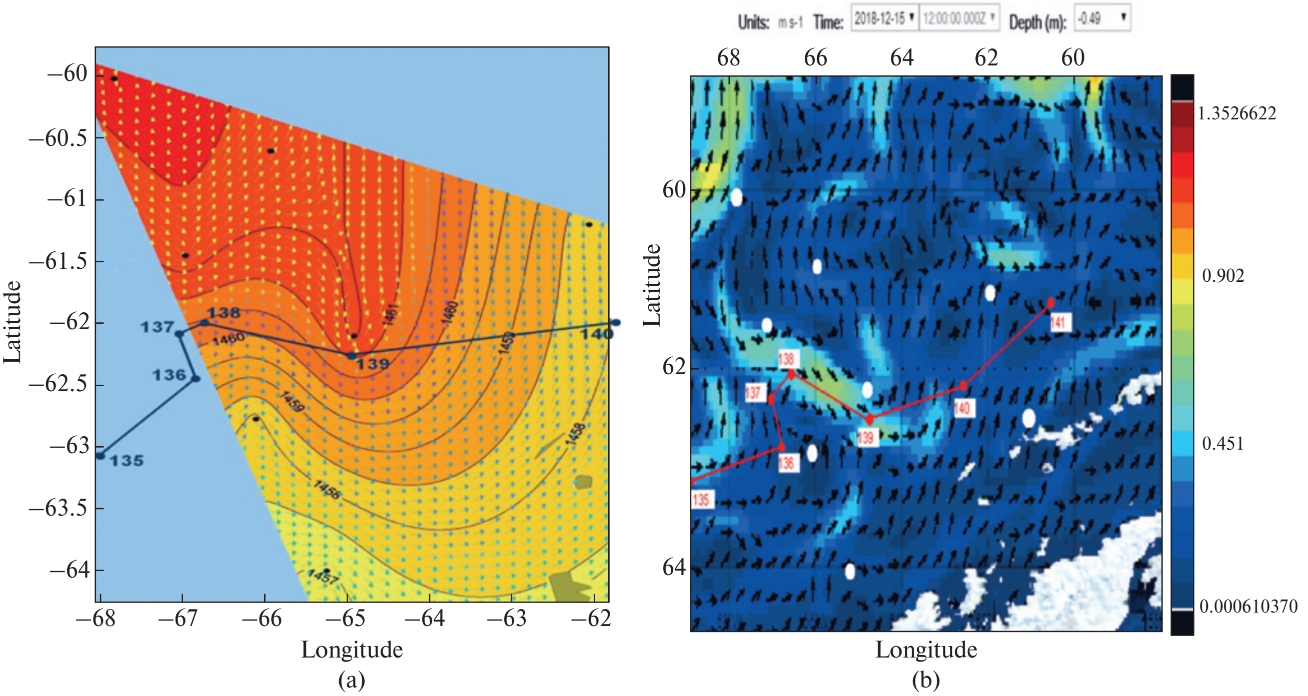


Figure 2. (a) Map of the dynamic topography of the area, (b) surface currents are obtained from the Copernicus website; white circles — "More Sodruzhestva" in December 2018; red circles — Argo 7900296 float locations from 21 December 2018 (sounding 135) to 19 February 2019 (sounding 141)

graphic research. The article tackles the hydrological aspect of the tasks set by the program. The aim of the work was to reveal the hydrological structure of the Drake Passage waters during the research period.

2 Materials and methods

The oceanographic observations in the south-eastern part of the Drake Passage were carried out aboard the Ukrainian fish-krill trawler "More Sodruzhestva" during December 13–18, 2018. The water mass sounding was done at eight stations to the depth of 200 m, using measuring equipment CTD SBE 37SM.

The number codes and coordinates of the stations were identified according to CCAMLR requirements. All stations were within Fisheries Area 48.1 (Fig. 1).

The data were processed using traditional methods of graphic and statistical analysis; the water masses were identified based on the analysis of the T,S and O_2, σ_t-diagram. For comprehensive analysis of the obtained materials we used satellite data: from the drifting buoys of the ARGO program and from the Copernicus Marine Environment Monitoring Service.

3 Results and discussion

Circulation. Currently, there are three ACC currents generally recognized in the Drake Passage; the southernmost one carrying waters from the Bellingshausen Sea practically never ceases, and the northern and central periodically merge together (Sukhovey, Ruban, 2009).

By the general consensus, the movement of waters in the Drake Passage from surface to at least 2000 m deep should be directed to East-North-East. According to the literature the maximum velocities of geostrophic currents in the surface layer are 40–45 cm · s^{-1} in the middle part of the passage and 10–15 cm · s^{-1} at the southern edge. The real surface velocities, strengthened by drift transfer in the summer, can be 1.5 times larger (Bulgakov et al., 2000).

The map of dynamic topography of the surface (Fig. 2a) based on the sounding data shows a more complicated movement of water in the surface layer compared to the aforementioned model. A typical feature of the upper 200 m layer kinematics is a meander which was revealed on maps of dynamic topography distribution and the map of surface currents from the Copernicus website, incorporating the altimetry data, Ocean Surface Temperature (OST) and vertical profiles of temperature and salinity *in situ* (Fig. 2b) (http://marine.copernicus.eu/).The meander naturally had an effect on the dynamics of the region's streams and the distribution of main parameters of seawater. From then on, until the end of December, the structure turned into a "warm" anticyclonic eddy which according to satellite data was well-identifiable in the OST field and lasted until January, 7, 2019.

As a bonus, in the period of the study the territory was crossed by Argo buoy 7900296 (December, 12, 2018 – February, 19, 2019). The float's trajectory throughout the Drake Passage plotted by its ascension coordinates was mapped onto the map of the dynamic topography and the map of currents (Fig. 2a, b).

Argo floats's standard settings pace their work as ten-day cycles; 9.5 days they passively drift at the depth of 2000 m, and the remaining half a day is spent measuring water parameters while ascending, information transfer to the satellite and re-sounding at the buoy's return to the erstwhile depth.

The float's trajectory is an integrated over time and space characteristic of the current's movement. It mostly reflects the movement of water at 2000 m

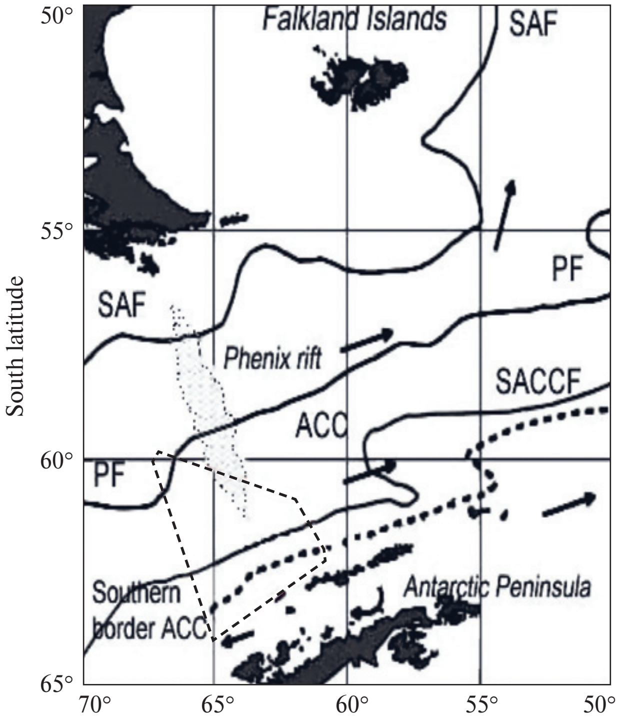
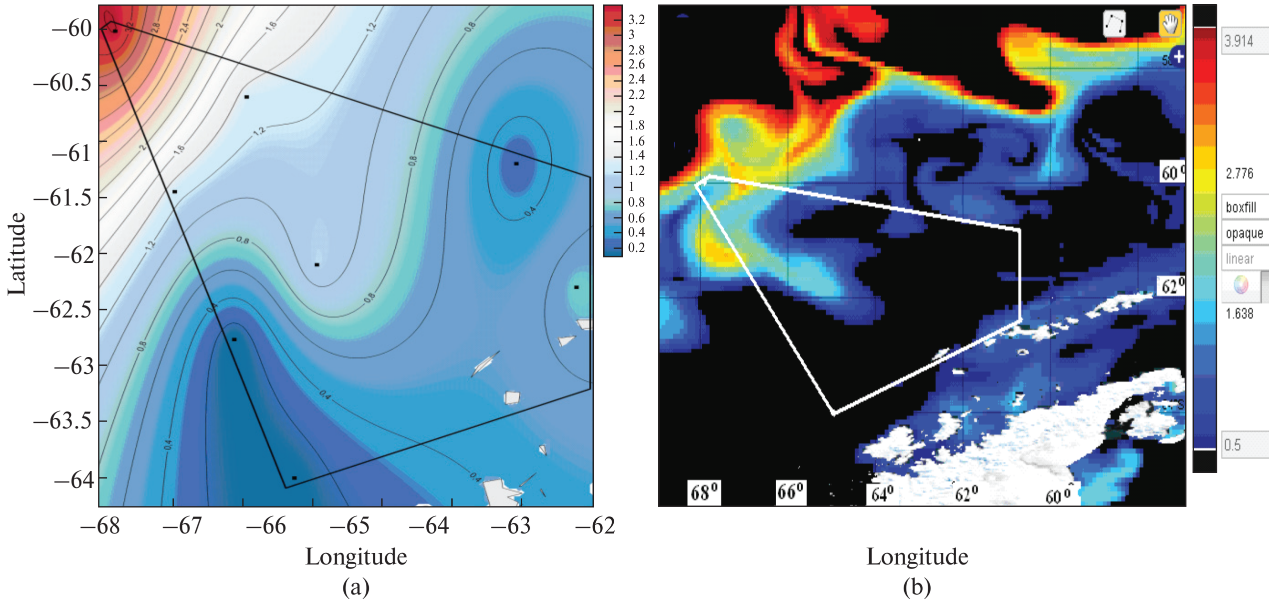


Figure 3. The location of the main hydrophysical fronts in the Drake Passage according to Shulgovsky (Shulgovsky, 2005), augmented from Tarakanov (Tarakanov, 2012): the dashed line marks the area of the study area

and the fact that the device took two months to cross the field of the study. The course is also well-aligned with the map of surface currents on the Copernicus

Table. Assessment of speed and direction of the Argo drift buoy (code 7900296)

Cycle	Date and time of floating	Latitude	Longitude	Distance, km	Cycle time, s	Drift velocity, $m \cdot s^{-1}$	Azymuth, °
134	Ascending profile11/12/2018 03:58:35	63°06.0′ S	069°52.5′ W	60.54	868769	7	99
135	Ascending profile21/12/2018 05:18:04	63°11.0′ S	068°41.0′ W	153.45	861891	18	73
136	Ascending profile31/12/2018 04:53:54	62°45.5′ S	066°47.5′ W	52.07	860891	6	344
137	Ascending profile10/01/2019 04:18:43	62°18.5′ S	067°04.5′ W	36.74	860951	4	28
138	Ascending profile20/01/2019 03:26:54	62°01.0′ S	066°44.30′ W	112.30	862589	13	125
139	Ascending profile30/01/2019 03:03:13	62°35.0′ S	064°56.5′ W	135.60	862842	16	71
140	Ascending profile09/02/2019 02:44:55	62°09.5′ S	062°28.5′ W	104.20	862254	12	52
141	Ascending profile19/02/2019 02:15:49	61°34.0′ S	060°56.0′ W	60.54	868769		



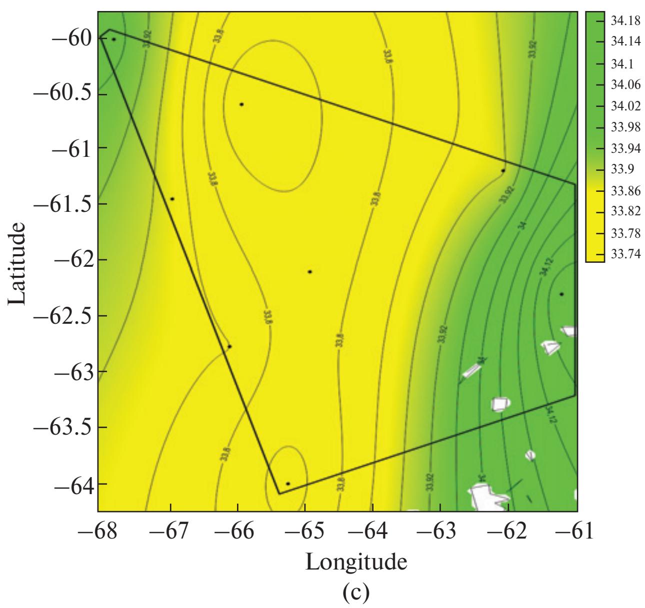


Figure 4. Distribution of temperature (a), salinity (c) in the surface layer of water in the area (13–18 December 2018) and ocean surface temperature according to "Copernicus" (b) (15 December 2018)

website (Fig. 2b), where there are quite a few mesoscale eddies of various orientations (http://marine.copernicus.eu/).

The calculated velocities of the float's drift between floating points (Table) were of an order of magnitude with geostrophic currents from the Bellingshausen Sea reported by Bulgakov et al. (2000). Azymuths of the float's drifts between cycles 136 and 139 suggest strong deviation from the overall east-north-eastern direction of the current, up to a western vector between cycles 136 and 137. It may be hypothesized that the change in the buoy's direction occurred due to local bottom relief features, like the Hero Ridge and Phoenix Ridge with depth differences up to 2000 m, Fig. 3 (Tarakanov, 2012).

Hydrological structure. The hydrological structure of the upper 200 m layer in the southern-eastern part of the Drake Passage depended on the season and the

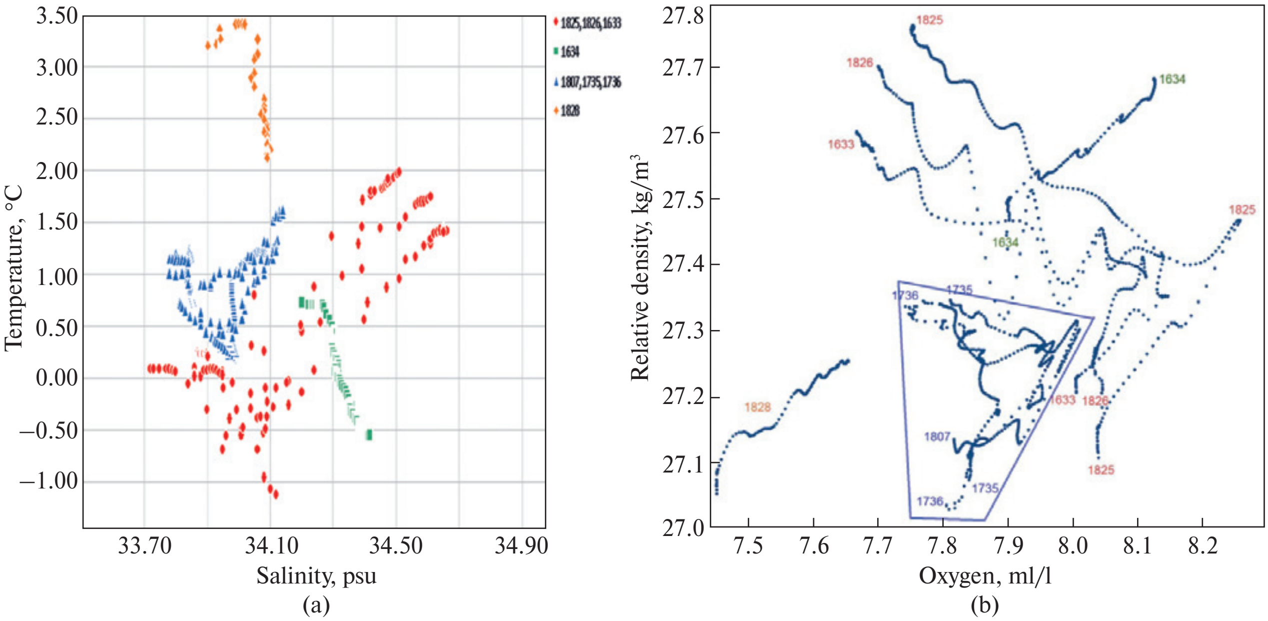


Figure 5. T,S-diagram (a) and O_2,σ_t-diagram (b) of all study stations

seasonal dynamics during the observation period. It is mostly determined by the intensity of the southern branch of the ACC which brings in the less saline waters of the Bellingshausen Sea, the position of PF, the state of CIL, the upwelling processes in the Antarctic Circumpolar Deep Water Mass (ACDWM), intensity of convergence, alongshore advection of the Scotia Sea and the Bransfield Strait waters, and the meteorological conditions.

The main part of the field of study lied within the Antarctic area between the Polar Front on the north and the Southern Edge which separates slope waters from waters carried by the Southern Branch of the ACC (Fig. 3).

At the time, the vertical hydrological structure of the waters on most of the stations was the following: in the uppermost layer (2 to 10 m deep) the temperature and salinity decreased, evidently due to iceberg melting. Beneath this layer, except for stations in the meander area, there was a uniform layer to the depth of approximately 40 m which was followed by CIL with the core at 70–100 m. Below the core both the temperature and salinity increased.

On the maps of the horizontal distribution of the temperature and salinity (Fig. 4a, c) and on a map from the Copernicus website (http://marine.copernicus.eu/) (Fig. 4b), in the middle there appeared the meander. On the Fig. 4b the color range of the distribution of temperature is in the interval of 0.5–3.9 °C which in our opinion paints a more detailed image of the complexity of the Antarctic and polar waters' mixing processes. The differences in details of the figures can be explained by the fairly large distances between observation stations (120 to 200 km) and the time required to perform the experiment (six days, December, 13–18), while the Copernicus image refers to a single day, December, 15, and is shown with horizontal resolution of 1/12 degree as a uniform rectangular projection on latitude and longitude.

The central part of the region is occupied by weakly freshened and relatively cold waters of the Southern Front of the southern branch of ACC coming in from the Bellingshausen Sea.

Analysis of vertical and horizontal distribution of temperature, salinity and oxygen, as well as the T,S and O_2,σ_t-analysis (Fig. 5) of the obtained data for all stations allows to identify four typical plots; in Fig. 5 they are assigned different colors.

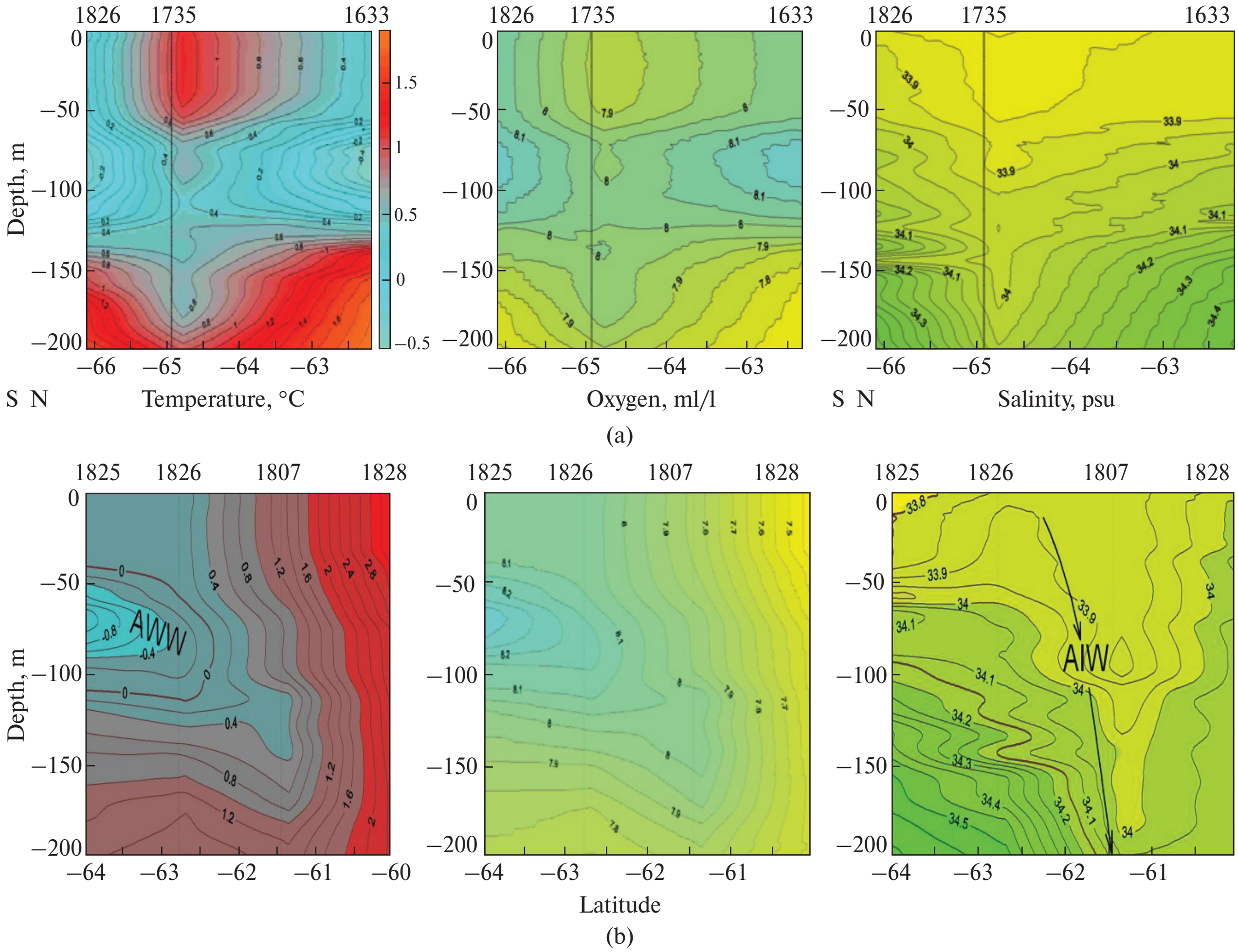


Figure 6. Distribution of the temperature (°C) of water and oxygen concentration (ml/l) and salinity (psu) in the longitudinal (a) and transverse (b) transects of the study area

Oceanologic stations were set up in such a way that only the northernmost of them (Station 1828) lied at the southern edge of the PF with minimal, relative to the rest of the study area's waters, oxygenation, salinity of 33.9 psu and temperature of 2 to 3.3 °C on the surface. Meridional gradient of temperature was approximately 1 °C per 0.5 degree longitude, which corresponds with PF gradients (Ukrainsky et al., 2000). T,S-parameters of the station are characterized by processes of mixing in the frontal area of warmer polar waters with waters of the Antarctic area.

The parameters of stations in the meander zone are grouped fairly closely together on the T,S- and O_2,σ_t-diagrams. They are plotted in blue on the T,S-diagram (Fig. 5a), and on the O_2,σ_t-diagram (Fig. 5b) lie within the quadrilateral. These are relatively warm and light waters with above-zero temperature values — from 1.7 °C on the surface to 0.3 °C at 200 m which corresponds to the transformed ASW of the Bellingshausen Sea (T — 1.5–2 °C; S — 33.7–33.92 psu). Notably, a typical feature of the area was a significantly weakened CIL and stable thermohaline characteristics possibly as a result of more intense mixing processes.

A specific feature of the next area (Stations 1825, 1826, 1833) was the presence of CIL on all stations. The subsurface minimum of temperature is a mark of the AWW. This layer of water is well-identifiable by lower values in the temperature distribution and higher oxygen content on the profiles along and across the passage (Fig. 6a, b).

Isohalines curving southwards of the PF suggest sinking of the less saline waters. AIW is formed (33.8–34.3 psu). Taking the latitudinal position of the zero isotherm for the southern edge of the AIW, one can note that it is situated to the south of its mean multiyear value after (Artamonov et al., 2011–2012). The situation is explained by mesoscale dynamics of the frontal zone.

From the graphs one can see that the upper edge of the CIL lied at the 40 m horizon (Station 1825) and gradually deepened northwards. The structure can be traced to the middle of the Passage at the depth of 155 m and distance 400 km from the northern shore of the Antarctic Peninsula.

The minimal temperature of the CIL core was recorded at the Station 1825, 240 km from the shore at the depth of 71 m (–1.14 °C). This coincided with the maximal oxygen content of 8.34 ml/l.

In the center of the profile there was a discontinuity in the CIL (Station 1735) as a result of waters sinking due to the anticyclonic structure (Fig. 6a).

On temperature profiles obtained from the Argo buoy 7900296, the minimal temperature values were –1.09 °C found at 60 to 90 m (Fig. 7).

Below that there was seen the layer of the AWW mixing with ADWM where the temperature and salinity increased monotonically with depth. It was here that the maximal salinity value was recorded (34.65 psu at 228 m, Station 1825).

Station 1834 was at the depth of 300 m near the shelf 30 km away from the shore of the Livingston Island in the eastern part of the field of study. Hydrodynamical processes in the region of the shelf are fairly complex and during summer depend, in significant ways, on the direction and velocity of the wind and the topography of the region and the peculiarities of the shoreline (Maderich et al., 2018). By the T,S-characteristics and satellite observations the waters of the upper layer are formed under the influence of the spring-summer advection of more saline waters from the Bransfield Strait and Scotia Sea creating a hydrological frontal break in the salinity field between them

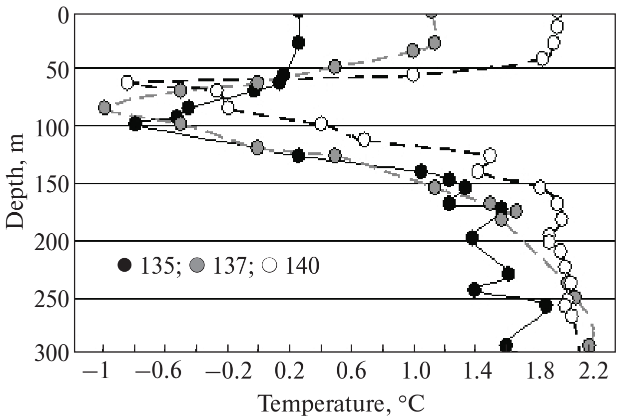


Figure 7. The vertical distribution of water temperature in the upper 300-meter layer according to the Argobuoy 79000296 in the Drake Passage from 21 December 2018 (profile 135) to 09 February 2019 (profile 140) (http://www.argodatamgt.org/)

and the Bellingshausen Sea waters (Fig. 4c). Also of note is that starting at 84 m the temperature became negative and continued to decrease with depth until minus 0.56 °C.

4 Conclusions

In total, the hydrology of the Drake Passage in the period of the study was in line with the current oceanological consensus. First of all, it had two frontal areas, AWW and the convergence area where AIW were formed.

On the northern edge of the study area there could be seen the border of the Polar Front with the maximum temperature of 3.42 °C on the surface and a meridional gradient of the OST of approximately 1 °C per 0.5 degree.

At the southern edge of the study area in the shelf area there was seen a hydrological front caused by advection of more saline waters of the Scotia Sea and Bransfield Strait.

The most volume (up to 30%) was occupied by water with temperature of 0° to 1 °C and salinity of 33.9 to 34.1 psu. Orci et al. (1995) separate the waters of the Southern Front of the southern branch of the ACC which in this layer carries relatively cold freshened surface waters of the Bellingshausen Sea based on such Orci indices.

AWW is identifiable by its intermediate temperature minimum and maximum oxygenation. In the central part of the region AWW was found at 50 to 110 m depth. Its volume grew towards the shore of the Antarctic Peninsula. In the southern-western part its upper edge sank to 70 m and its lower edge was below the sounding depth of 168 m. In the AWW core minimal temperature was recorded 240 km away from the shore at 71 m (−1.14 °C).

The spatial distribution of the hydrological characteristics of the region was shaped to a notable extent by local hydrodynamic features; first and foremost, by the meander which appeared at the southern edge of the Polar Front and moved aside the edge of the convergence zone for a while.

The field observations were well-aligned with data from the Copernicus website and the Argo float which significantly enlarged our knowledge of the regional hydrology and in particular compensated information scarcity due to sparsely placed stations.

The direction of the Argo float drift mostly coincided with the general eastwards direction of the ACC although some of its way went across the general transport highlighting its heterogeneity.

The research presented in this article should be continued; the next step could possibly be the development of regular environmental monitoring revealing trends in oceanographic fields of the Southern Ocean, bringing us another step closer to being able to predict the areas of increased biological productivity.

Author contributions. VK: general supervision, task setting and methods selection, scientific edition of the article. VK, YuD, VB, YuP, YeM: treatment and analysis data. YuD, VB: preparation of the introduction. VK, YuD: conclusions. YuP: abstract. YeM: collection and laboratory treatment of field data. LSP: reference review, map preparation, illustration edition, general edition and translation. All authors have read and agreed to the published version of the manuscript.

Competing interests. The authors declare that they have no conflict of interest.

Acknowledgements. The study was funded by the State Institution National Antarctic Scientific Center in the framework of the State Special-Purpose Research Program in Antarctica for 2011–2020.

References

About c Drake: http://www.cdrake.org/, last access: 11 October 2019.

Antipov, N.N., Danilov, A.I., Klepikov, A.V.: Issledovaniya Yuzhnogo okeana po nauchnyim programmam AANII: ot programmyi "POLEKS-Yug" do FTsP "Mirovoy okean" [Studies of the Southern Ocean within the AARI scientific programmes: from POLEX-South programme to FTP "The World Ocean"], Problemy Arctiki i Antarctiki [Problems of Arctic and Antarctic], 1 (99), 65–85, http://www.aari.ru/misc/publicat/paa_statia.php?arh=1&ns=347&jur=341, 2014, last access: 11 October 2019.

Artamonov, Ju.V., Skripaleva, E.A., Fedirko, A.V.: Seasonal and interannual variability of water masses in Drake passage, Ukrainian Antarctic Journal, 10–11, 161–171, 2011–2012.

Bulgakov, N.P., Bibik, V.A., Dzhiganshin, G.F.: Tsirkulyatsiya vod v prolive Dreyka i zapadnoy chasti Atlanticheskogo sektora Antarktiki v letneye vremya [Water circulation in the Drake Channel and the western part of the Atlantic sector of the Antarctic in the summer], Bulletin of the Ukrainian Antarctic Centre, 3, 110–118, 2000.

Copernicus Marine Service: http://marine.copernicus.eu/, last access: 11 October 2019.

Donohue, K.A., Tracey, K.L., Watts, D.R., Chidichimo, M.P., Chereskin, T.K.: Mean Antarctic Circumpolar Current transport measured in Drake Passage, Geophysical Research Letters, 43 (22), 11760–11767, doi:10.1002/2016GL070319, 2016.

Firing, Y.L., McDonagh, E.L., King, B.A., Desbruyères, D.G.: Deep temperature variability in Drake Passage, Journal of Geophysical Research: Oceans, 122 (1), 713–725, doi:10.1002/2016JC012452, 2016.

Komorin, V.M., Bolshakov, V.M., Dikhanov, Yu.M., Melnik, E.A.: Research of frontal structure of the surface layer of the South Atlantic based on the passing observations in November — December 2018, Ukrainian Antarctic Journal, 1 (18), 84–92, 2019.

Koshlyakov, M.N., Lisina, I.I., Morozov, E.G., Tarakanov, R.Yu.: Absolute geostrophic currents in the Drake Passage based on observations in 2003 and 2005, Oceanology, 47, 451–463, doi:10.1134/S0001437007040029, 2007.

Maderich, V., Terletskaya, K., Brovchenko, I., Bezhenar, A.: Modeling Summer Circulation and Distribution of Temperature and Salinity in the Bellingshausen Sea and on the Antarctic Peninsula Shelf, Ukrainian Antarctic Journal, 1 (17), 48–57, doi:10.33275/1727-7485.1(17).2018.31, 2018.

Orci, A.H., Whitworth III, T., Nowlin, Jr. W.D.: On the meridional extent and fronts of the Antarctic Circumpolar Current, Deep Sea Research Part I: Oceanographic Research

Papers, 42 (5), 641–673, doi:10.1016/0967-0637(95)00021-W, 1995.

Sallée, J.-B.: Southern Ocean warming, Oceanography, 31 (2), 52–62, doi:10.5670/oceanog.2018.215, 2018, last access: 11 October 2019..

Shulgovsky, K.E.: Large-scale variability of oceanological conditions in the western Atlantic sector of the Antarctic and its impact on krill distribution, Publishing house Atlant NIRO, Kaliningrad, 148 pp., 2005 (in Russian).

Sukhovey, V.F., Ruban, I.G.: The structure of Antarctic Circumpolar Current at Drake Passage and interannual variability of its transport, Bulletin of Odessa State Environmental University, 7, 203–209, 2009.

Tarakanov, R.Y.: The Scotia Sea and the Drake Passage as an orographic barrier for the Antarctic Circumpolar Current, Oceanology, 52 (2), 157–170, doi:10.1134/S0001437012010195, 2012.

Tarakanov, R.Yu., Gritsenko, A.M.: Jets of the Antarctic Circumpolar Current in the Drake Passage Based on Hydrographic Section Data, Oceanology, 58 (4), 503–516, doi:10.1134/S0001437018040100, 2018.

Talley, L.D., Pickard, G.L., Emery, W.J., Swift, J.H.: Descriptive Physical Oceanography, 6th ed., Academic Press, Elsevier, Boston, 560 pp., doi:10.1016/C2009-0-24322-4, 2011.

The Argo Data Management site: http://www.argodatamgt.org/, last access:11 October 2019.

Ukrainsky, V.V., Popov, Yu.I., Artamonov, Yu.V., Lomakin, P.D.: Frontalnyye zony i vodnyye massy na poverkhnosti yugo-zapadnoy Atlantiki i prilegayushchego sektora Yuzhnogo okeana [Frontal zones and water masses on the surface of the south western Atlantic and the adjacent sector of the Southern Ocean], Bulletin Ukrainian Antarctic Centre, 3, 68–77, 2000.

Whitworth III, T., Peterson, R.G.: Volume Transport of the Antarctic Circumpolar Current from Bottom Pressure Measurements, Journal of Physical Oceanography, 15, 810–816, doi: 10.1175/1520-0485(1985)015<0810: VTOTAC>2.0.CO;2, 1985.

Zhuk, N.N.: Fishery and biological aspects of *Euphausia superba* on its fishery grounds at the South Shetland Islands and in the Bransfield Strait in March—May, Ukrainian Antarctic Journal, 10–11, 201–211, 2011–2012.

Zhuk, N.N., Korzun, Yu.V.: Fishery report of the krill catching trawler "Cooperation Sea" on the Antarctic krill (*Euphausia superba*) biology and hydrometeorological conditions in the fishing area of the Atlantic Antarctic during the summer-winter fishing season of 2015, Ukrainian Antarctic Journal, 15, 131–152, 2016.

Received: 17 March 2020
Accepted: 6 June 2020

В. Коморін[1, 2, *], Ю. Диханов[1, 2], В. Большаков[1, 2], Ю. Попов[1, 2, 3], Є. Мельник[1, 2], Л. Савіних-Пальцева[1, 2]

[1] Науково-дослідна установа «Український науковий центр екології моря», м. Одеса, 65000, Україна

[2] Державна установа Національний антарктичний науковий центр МОН України, м. Київ, 01016, Україна

[3] Філія державної установи «Одеський район Держгідрографії», м. Одеса, 65038, Україна

***Автор для кореспонденції:** vkomorin@gmail.com

Гідрологічна структура вод протоки Дрейка за експедиційними даними в грудні 2018 року

Реферат. У статті наведені результати аналізу гідрологічних спостережень, виконаних з борту українського рибно-крилевого траулера супер (ТРК-С) «Море Содружества» в південно-західній частині протоки Дрейка у грудні 2018 р. Метою роботи є вивчення термохалинної структури вод поверхневого двохсотметрового шару у районі досліджень. Проведено порівняння фактичного стану водного середовища влітку 2018 р. з існуючими уявленнями про гідрологію протоки, які сформувалися в ході попередніх досліджень. В експедиції були виконані роботи на гідрологічному полігоні, що складався з восьми станцій. Виміри проводилися зондуючим вимірювальним комплексом CTD SBE 37SM. Для обробки отриманих даних застосовувалися традиційні методи графічного та статистичного аналізу, також водні структури виділялися на основі аналізу T,S та O_2,σ–діаграм. Додатково залучалися супутникові дані Служби моніторингу морського середовища веб-сайту «Copernicus» та інформація з дрейфуючих буїв проєкту «Argo», які проходили на той час район досліджень. В результаті проведених досліджень отримане уявлення про просторову гідрологічну структуру верхнього двохсотметрового шару району досліджень, показані основні водні маси, які формують цю структуру; а також фактичне, на час проведення робіт, розташування Полярного фронту на півночі та фронту море Скоша — на півдні. Виділено характеристики просторової мінливості холодного проміжного шару. Зроблений висновок, що найбільший обсяг займала вода Південного фронту південної гілки Антарктичної циркумполярної течії (АЦТ), яка в цьому шарі переносить відносно розпріснені поверхневі води моря Беллінсгаузена, та про суттєву роль впливу динамічного чинника на розподіл гідрологічних характеристик. Відзначено, що натурні спостереження добре відповідають інформації веб-сайту «Copernicus» та проєкту «Argo».

Ключові слова: протока Дрейка, водні маси, холодний проміжний шар