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SPATIAL VARIABILITY OF THERMOHALINE PARAMETERS AND PHYTOPLANKTON COMPOSITION OF WEST ANTARCTICA IN SUMMER SEASON

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Spatial variability of thermohaline characteristics (temperature, salinity, and dissolved oxygen) and phytoplankton structure (composition, abundance, and biomass) of the Southern Ocean during austral summer were investigated. New data were obtained for a little-studied area of Antarctica: on transects along the eastern border of the Ross Sea along W156° (T1, length of 35 km, 6 stations), near the Russkaya station (T2, 87 km, 13 stations), at the single station (Roosevelt Island area, Bay of Whales, Ross Sea), and in the Bransfield Strait (T3, 118 km, 11 stations). The relevance of the analysis of this area is due to its location on the border of the shelf and continental slope with different parameters of temperature and water structure. Low salinity and different temperature characteristics were revealed in surface waters of T1 and T2: lower values for T2 (−1.5 °C) and higher for T1 (0 °C). For the Bransfield Strait waters (T3), typical data on salinity and oxygen content were obtained against the backdrop of slightly increased temperature (up to +2 °C). For the single station, relatively fresh, cold, and oxygenated water of the upper 100-meter layer was recorded, and low temperature values of the bottom area, with high mineralization, were registered. In the phytoplankton composition of the study area, 48 taxa of microalgae from 5 divisions were identified (Bacillariophyta, 38; Dinophyta, Cyanoprokaryota, and Chrysophyta, 3 taxa each; and Haptophyta, 1) and 1 macrophyte taxon (Rhodophyta). The maximum similarity in the species composition of phytoplankton (on average, 43%) was typical for shelf stations in different areas. The total abundance of phytoplankton in the study area of the Southern Ocean ranged within 4.3–264.0 thousand cells·L^{-1}, and biomass, 0.07–1.18 mg·L^{-1}. The main contributors to quantitative characteristics of phytoplankton throughout the study water area were diatoms, mainly representatives of the genus *Fragilariopsis* Hustedt, confined to the shelf and coastal areas. At a distance and in the open sea of transects T1 and T2 deeper than 50 m and in surface waters of transect T3, *Phaeocystis antarctica* Karsten (Haptophyta) developed in mass. For T2, the dependence of phytoplankton abundance on water temperature and salinity was revealed.

Keywords: West Antarctica, Bransfield Strait, shelf, spatial variability, thermohaline parameters, phytoplankton

The Southern Ocean (hereinafter SO) is one of the most highly productive in the world and plays a key role in global cycling of matter [Iida, Odate, 2014; Petrou et al., 2016; Varela et al., 2002]. In this area, temperatures have increased by more than 1 °C in recent decades [Mangoni et al., 2017]. In waters off the Antarctic Peninsula, this temperature trend is most pronounced, and it contributes to the destruction of ice shelves, receding of the ice barrier, exposure of new coastal habitats, alterations in physicochemical properties of the water column, and transformation of marine food webs [Mendes et al., 2012; Rozema et al., 2017].

Approximately 60% of the SO surface is free from ice throughout the year. In these waters, the factors limiting primary production are irradiance and availability of iron and phosphorus. The productivity of water masses of the remaining 40% of the SO surface (~ 19 million km^2) is highly dependent on seasonal ice cover and regulated by the timing of its receding, providing 5–30% of annual primary production [Biggs et al., 2019; Moreau et al., 2020; Petrou et al., 2016]. In its turn, the zonal latitudinal distribution of ice affects habitats of phytoplankton and zooplankton [Iida, Odate, 2014]. In nutrient-rich coastal waters of Antarctica, 350 algal species have been identified in phytoplankton, and cell density during blooms reaches 10^8 *per* 1 L [Deppeler, Davidson, 2017].

A significant amount of data has been accumulated on phytoplankton spatial structure, seasonal distribution, and biodiversity in the SO waters to the west of the Antarctic Peninsula (the South Shetland Islands, Bransfield Strait, and Bellingshausen Sea). The fairly complete investigation of the western Ross Sea and episodic one of the Amundsen Sea are due to the occurrence of stable polynyas in summer and nearby location of year-round Antarctic research stations. Phytoplankton of the water area from Cape Colbeck (Edward VII Peninsula, W158°) to Cape Dart (western Amundsen Sea, W126°) between the Ross and Amundsen seas, in the Russkaya station area, remains poorly studied. There, our research on transects T1 and T2 was carried out. This site is of certain interest from an oceanographic point of view: it is located in the area delimiting parts of Antarctica which differ in temperature and water structure (on the shelf and continental slope). Also, it is affected by oceanic and atmospheric circulations [Antipov et al., 2020].

The work is devoted to studying the spatial variability of thermohaline parameters, composition, and distribution of West Antarctica phytoplankton during the summer season in the Pacific sector of the Southern Ocean from Bay of Whales (Roosevelt Island area) to Cape Burks (Russkaya station area) and in the Bransfield Strait.

MATERIAL AND METHODS

Oceanographic and algological observations were carried out during the 65th Russian Antarctic Expedition on the RV “Akademik Tryoshnikov” on 06.02.2020–10.03.2020. Along the RV route, we investigated little-studied waters of West Antarctica:

- station 3 in the southeastern Ross Sea (Bay of Whales), 12 km north of Roosevelt Island (78°41.13′S, 163°42.58′W, 06.02.2020);
- transect 1 (T1), 35 km long, covering 6 stations, along the eastern border of the Ross Sea at Cape Colbeck of Edward VII Peninsula (along W156°, 07.02.2020);
- transect 2 (T2), 87 km long, covering 13 stations, 450 km to the east of T1 (Russkaya station area), 36 km from the front of the Hull Glacier shelf, crossing almost the entire shelf which is relatively narrow there (24.02.2020).

In the Bransfield Strait (area of the Antarctic Bellingshausen station, 09.03.2020–10.03.2020), transect 3 (T3), 118 km long, covering 11 stations, was analyzed. A scheme of the study area is shown in Fig. 1.

Deep-sea oceanographic observations were carried out at 34 stations with a SBE 19plus profiler (Sea-Bird Scientific) equipped with a frame for installing bathometers. It allows obtaining continuous data on temperature, salinity, and pressure profiles down to a depth of 6,000 m. Based on fluctuations in temperature and salinity, for all stations (from 5–8 horizons), right after bathometer raising, dissolved oxygen was determined iodometrically, by the Winkler titration [Shishkina, 1974].

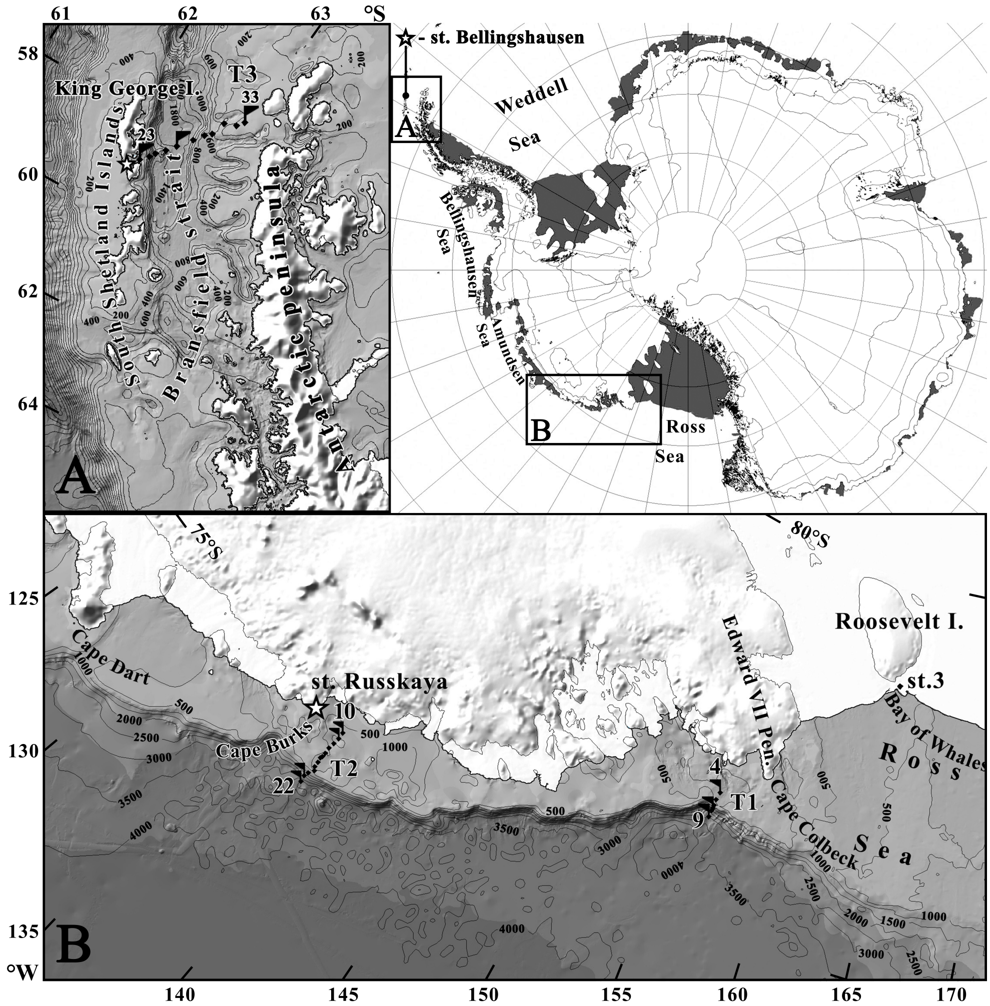

Fig. 1. Map of the study area in the Southern Ocean. A, transect 3; B, transects 1 and 2 and station 3

Water samples of 1–1.5 L in volume were concentrated using a reverse filtration funnel with Vladipor membrane filters (pore diameter of 3.0 μm) and fixed with formaldehyde to a final concentration of 1–2%. At each station, phytoplankton was sampled by the bathometric method (subsurface layer, 10 m, 50 m, and 100 m; for sta. 10, 11, and 22, 200 m as well). Data on phytoplankton from depths exceeding 100 m were not considered in the work due to their fragmentation and insignificant occurrence of algal cells. Samples were processed in a 0.01-mL Nageotte chamber. Biomass was determined by the counting–volumetric method. Permanent preparations of diatoms were made by cold combustion with a mixture of sulfuric acid and potassium chromate, followed by filling with Naphrax – highly refractive resin [Metodika izucheniya biogeotsenozov, 1975]. Samples were analyzed under an Axiostar Plus light microscope (Carl Zeiss, Germany) at a magnification of ×400 and ×1,000 (oil immersion). Species with the abundance of ≥ 10% were considered dominant ones. The taxonomic affiliation of algae of various groups was established using keys and papers on the SO planktonic flora [Carmelo, 1997; Cefarelli et al., 2010; Gerasimiuk, 2008; Gogorev, 2010, 2013; Gogorev, Samsonov, 2016; Hoppenrath et al., 2009]. The similarity in the species composition of phytoplankton was assessed by the Sørensen–Czekanowski coefficient [Magurran, 1992]. The obtained data were processed in the programs SBE Data Processing [Sea-Bird Scientific, 2023] and Surfer 11 [2023]. The statistical package R for MS Office Excel was applied as well [Novakovskiy, 2016].

RESULTS

Hydrological features. At the single station 3, the layer down to a depth of 100 m was characterized by occurrence of the warmest (−1.19 °C), least saline (32.8 PSU), and most oxygen-saturated (7.7 mL·L^{-1}) water masses. In deeper horizons, salinity rose (up to 34.24 PSU), while temperature and oxygen content dropped (to −1.93 °C and 6.39 mL·L^{-1}, respectively) (Fig. 2).

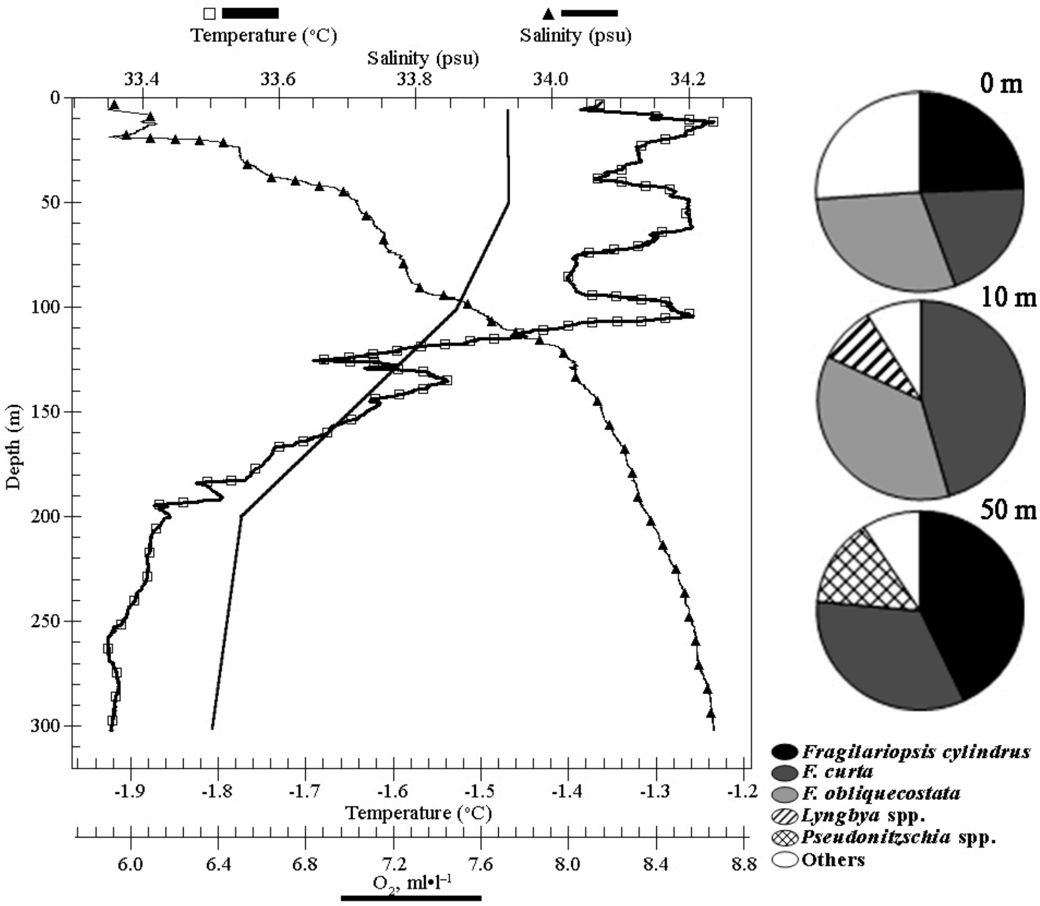

Fig. 2. Vertical profile of temperature, salinity, and oxygen concentration at station 3 and phytoplankton taxonomic composition (in the upper 50-m layer), Roosevelt Island area

Water masses of the upper 500-m layer on transect T1 had the minimum temperature down to −1.8 °C and salinity of 34 PSU and lower. At the same time, this layer was more oxygenated (> 6 mL·L^{-1}) than the layer of Circumpolar Deep Water (4 mL·L^{-1}). At a depth of down to 50 m, water temperature was about 0 °C, and oxygen content was high, 7.4–7.7 mL·L^{-1}. Significant depth of mixing and, at the same time, low salinity of the upper horizon allow explaining the greater thickness of the layer by the effect of continuous strong winds characteristic of the area (Fig. 3).

On transect T2, bottom topography was more complex than on transect T1 (see Fig. 3). There, both local depressions (with a depth of > 1,000 m) at the beginning of the transect and relatively shallow spots (a depth of < 400 m) at mid-transect were recorded. This area, from Cape Colbeck at the eastern edge of the Ross Sea to Cape Burks, has a relatively narrow shelf and the steepest continental slope in the western sector of Antarctica [Antipov et al., 2020].

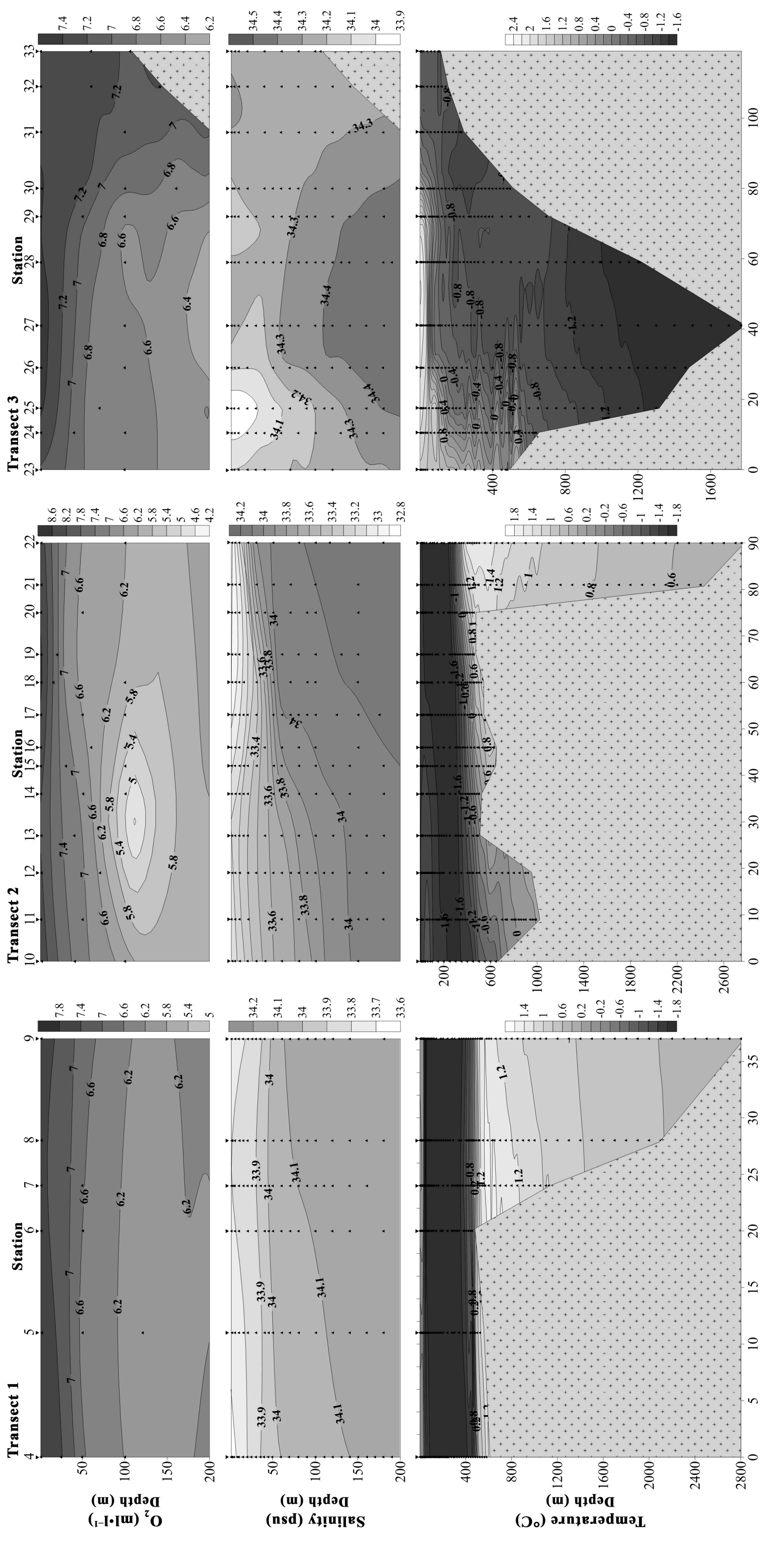

Fig. 3. Salinity (PSU), temperature (°C), and oxygen content ($mL \cdot L^{-1}$) along transects 1, 2, and 3. Oxygen content and salinity are given down to depth of 200 m

On transect T2, a cold (down to −1.79 °C) layer with oxygen content of 5–7 mL·L^{-1} reached a depth of 400–500 m. The layer of water mass down to 50 m was warmer, especially in the transect gate, with high content of dissolved oxygen (8.0–8.7 mL·L^{-1}) and the lowest mineralization (32.8 PSU). The maximum temperature (+1.56 °C) and salinity (34.7 PSU) on the transect were observed at a distance of about 20 km from the shelf edge, at a depth of 450 m, and against the backdrop of a relatively low oxygen content, about 4.4 mL·L^{-1}.

The SO waters at the northern tip of the Antarctic Peninsula (T3, Bransfield Strait) were characterized by an uneven distribution of thermohaline parameters. Importantly, this area has a large number of islands and complex bottom topography (Figs 1, 3).

At a depth of down to 100 m, water masses with temperature above 0 °C were distributed almost up to the southern coast of the strait. On the northern transect, warm (0…+2 °C), less saline, and less oxygen-saturated waters prevailed; these waters originated from the southwest – from the Bellingshausen Sea. Above-zero temperatures persisted in the water column down to 500 m over a distance of 15 km from the transect gate. Within the range of 300–500 m, oxygen saturation was of 4.8–5.5 mL·L^{-1}, and salinity was of 34.6 PSU. Cold waters of the Weddell Sea dominated the area adjacent to the Antarctic Peninsula. In general, salinity in the surface layer was of 34.0–34.5 PSU, and oxygen content was of 7.2–7.5 mL·L^{-1}; interestingly, this layer extended to a greater depth in the southern Bransfield Strait (Fig. 3). The maximum depth on the transect reached 1,770 m; waters were saline (34.55 PSU) and relatively oxygenated (6.5–6.7 mL·L^{-1}); and the temperature was of −1.5 °C.

Spatial distribution of phytoplankton. Phytoplankton of the study SO areas covered 49 algal species and intraspecific taxa. Bacillariophyta division included 38 representatives; out of them, the most diverse genus was *Fragilariopsis* Hustedt: *Fragilariopsis curta* (Van Heurck) Hustedt, *F. cylindrus* (Grunow ex Cleve) Helmcke et Krieger, *F. ritscheri* Hustedt, *F. obliquecostata* (Van Heurck) Heiden, *F. rhombica* (O'Meara) Hustedt, *F. pseudonana* (Hasle) Hasle, *F. separanda* Hustedt, and *F. kerguelensis* (O'Meara) Hustedt. Plankton included Dinophyta, Cyanoprokaryota, and Chrysophyta – 3 representatives each, as well as Haptophyta and, presumably, Rhodophyta – 1 taxon each. At stations of transects T1 and T2 and at the single station 3, the structure was generally typical for coastal areas of Antarctica: we recorded species of the genera *Fragilariopsis*, *Pseudo-nitzschia* H. Peragallo, *Azpeitia* M. Peragallo, *Actinocyclus* Ehrenberg, *Thalassiosira* Cleve, *Chaetoceros* Ehrenberg, *Corethron* Castracane, *Porosira* Jørgensen, and *Eucampia* Ehrenberg. The maximum species richness was typical for surface horizons against the backdrop of the predominance of diatoms (Table 1). On T1, the diversity of phytoplankton communities decreased from the shelf (sta. 4) to the edge (sta. 7) and the deep-sea area (sta. 9). On T2, species richness increased from a southern station in 35 km from the front of the Hull Glacier shelf (sta. 10) to a deep-sea one (sta. 22). There, the most even phytoplankton composition was recorded (similarity of 58% according to the Sørensen–Czekanowski coefficient). On T3, 17 algal taxa were identified; out of them, 12 were diatoms. The minimum diversity of diatoms (3 species each) was observed at sta. 23 and 27. At all stations of this transect, fragments of macrophyte thalli were noted in the water column, presumably of the genus *Helminthora* J. Agardh (Rhodophyta). Similarity of phytoplankton across transect stations was very low, 17%.

For similar stations in terms of location relative to the shelf, on different transects, similarity in the species composition of phytoplankton was maximum on the shelf, (43 ± 7) %, with a range of 23–64%. Between stations of the edge area, similarity was lower, (33 ± 5) %, with a range of 30–50%. At deep-sea stations, it was minimum, (20 ± 1) %, with a range of 19–22 % (Fig. 4). A comparison of phytoplankton composition within transects showed its similarity at deep-sea stations and in the edge area at the level of 30%; at shelf and deep-sea stations, 31% (up to 56%); and at shelf stations and in the edge area, 38% (up to 72%).

Table 1. Phytoplankton composition at different stations of transects 1–3 and at the single station

Area	Station number	Species number				
		Bacillariophyta	Haptophyta	Rhodophyta	Other	In total
Transect 1	4	18	1	–	2	21
	7	7	1	–	3	11
	9	6	–	–	3	9
	4–9	29	1	–	5	35
Transect 2	10	16	–	–	–	16
	11	14	–	–	1	15
	21	20	–	–	2	22
	22	19	1	–	–	20
	10–22	30	1	–	3	34
Transect 3	23	3	1	1	3	8
	27	3	1	1	–	5
	33	7	–	1	2	10
	23–33	12	1	1	3	17
Single station	3	11	–	–	1	12
Total		38	1	1	9	49

Phytoplankton abundance in the study SO areas ranged within 4.3–264.0 thousand cells·L^{-1}, and biomass varied within 0.07–1.18 mg·L^{-1}. The main contributors were diatoms. Particularly high abundance and biomass values were revealed at sta. 21 (T2) in less saline surface layers (Fig. 5). An increase in cell abundance at a depth of 50 m was registered at sta. 7 (T1) at the edge of layers with different temperatures and at sta. 11 (T2).

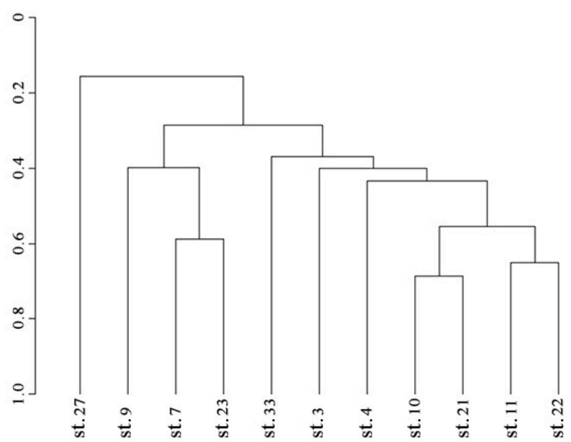

Fig. 4. Similarity tree of algal species composition at the stations of the study area

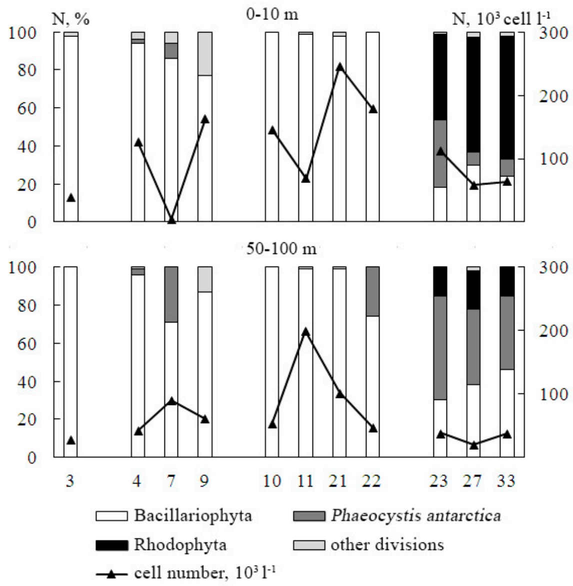

Fig. 5. Bacillariophyta, Rhodophyta, and Haptophyta contribution (in %) in total abundance of phytoplankton at the stations of the study area in 0–10-m and 50–100-m layers

At sta. 3, the main contributors to phytoplankton abundance (39 thousand cells·L^{-1}) and biomass (0.10 mg·L^{-1}) were diatoms of the genus *Fragilariopsis* (74% of the total abundance). In the surface layer, the maximum values were noted; to the horizon of 50 m, those decreased by 1.5 times.

On T1, mean values of phytoplankton abundance were of (107.4 ± 27.7) thousand cells·L^{-1}, and biomass was of (0.55 ± 0.26) mg·L^{-1}. In addition to *Fragilariopsis* representatives, abundant development was characteristic of *Corethron pennatum* (Grunow) Ostenfeld, *Thalassiosira lentiginosa* (Janisch) Fryxell, and *Thalassiosira antarctica* Comber. In the surface water layer, the distribution of the phytoplankton community formed by diatoms and *Phaeocystis antarctica* Karsten (Haptophyta) had a sharp drop in the total abundance of algae at mid-transect above the slope at sta. 7 and an increase at sta. 9. At mid-transect (sta. 7), at 50-m depth, there was a peak in the development of microalgae (Fig. 5). There, 29% of the abundance were formed by *Ph. antarctica*.

In T2 water area, phytoplankton abundance varied 100 to 250 thousand cells·L^{-1}, and biomass varied 0.44 to 1.18 mg·L^{-1}. The maximum values were recorded above the slope (sta. 21), in the surface layer. The entire transect was characterized by the massive development of *Fragilariopsis* and *Thalassiosira* representatives, *Pseudo-nitzschia seriata* (Cleve) H. Peragallo, and *Thalassionema synedriforme* (Greville) Hasle. *Ph. antarctica* was registered only at the final station of the transect (sta. 22) at a depth of > 50 m; it formed 25% of phytoplankton abundance there.

On T3, the mean phytoplankton abundance was (73.1 ± 16.4) thousand cells·L^{-1}, and biomass was (0.09 ± 0.01) mg·L^{-1}. The highest values of quantitative development of microalgae were noted on the shelf on the northern transect (sta. 23), where the main contributors for the surface layer were Rhodophyta representatives (45%) and *Ph. antarctica* (36%). At a depth of 50 m, the latter one formed 55% of the abundance, while diatoms (*Fragilariopsis*, *Thalassiosira*, and *Azpeitia* representatives) formed about 30%. Interestingly, the proportion of red algae at this depth rapidly dropped (see Fig. 5).

Analysis of the relationship between the degree of phytoplankton development and hydrological and hydrochemical parameters of the SO water masses made it possible to identify negative correlations of algae cell density on water temperature and salinity (Table 2). The correlation coefficients are significant for the relationship between phytoplankton abundance and water temperature on T2 for surface horizons and on T1 and T3 for the water column down to 50 m.

Table 2. Correlation coefficients of thermohaline characteristics and phytoplankton abundance in the study area

Phytoplankton abundance	Temperature, °C	O_2, mg·dm^{-3}	Salinity, mg·dm^{-3}
Transect 1, surface	−0.34	0.12	−0.98*
Transect 1, mean over horizons	−0.97*	0.37	−0.92*
Transect 2, surface	−0.90*	0.25	−0.89*
Transect 2, mean over horizons	−0.43	0.81	−0.71*
Transect 3, surface	0.42	−0.65	−0.91*
Transect 3, mean over horizons	−0.89*	0.41	−0.87*

Note: * denotes results significant at $p \leq 0.05$.

For all transects, both for the surface layer and the entire water column, a noticeable correlation of phytoplankton abundance and salinity was revealed, with the coefficient for different stations varying from −0.63 to −0.98. Correlation coefficients between algae abundance and concentration of dissolved oxygen were not significant. Also, correlation analysis showed a natural rise in species richness at stations of T2 with lower salinity (0.79; $p \leq 0.05$).

DISCUSSION

In recent years, there is a noticeable increase in volume of data on hydrological parameters and phytoplankton structure in the Amundsen Sea [Bett et al., 2020; Jenkins et al., 2018; Mattson et al., 2012; Schofield et al., 2015; The Amundsen Sea Expedition, 2018] and in the Ross Sea, especially in its western area [Andreoli et al., 1995; Fonda et al., 2005; Guo et al., 2021; Kaufman et al., 2017; Mangoni et al., 2017; Mosby, 2013; Porter et al., 2019; Shields, 2007].

Desalinated water with a lower temperature and higher oxygen content, compared to those according to literature data (in summer, salinity usually varies between 34.0 and 34.8 PSU, and temperature varies between −1 and +1 °C), was recorded at sta. 3, in the immediate vicinity to the ice shelf [Mattson et al., 2012; Porter et al., 2019; Shields, 2007]. For the bottom area of the Ross Sea shelf (sta. 3), remote both from trenches and inflows of Circumpolar Deep Water, low temperatures are quite typical, in contrast to low mineralization [Porter et al., 2019].

The formation of supercooled dense Antarctic shelf water between the Ross and Amundsen seas (T1 and T2) was not registered according to the data of the 59th (2014) and 65th Russian Antarctic Expeditions [Antipov et al., 2020]. In T1 area, the shelf receives salty but relatively warm Circumpolar Deep Water carried out by the Antarctic Circumpolar Current. The low salinity of T1 and T2 areas recorded during the 65th expedition most likely indicates long-term wind mixing and seems to be associated with intense ice melting under the effect of modified Circumpolar Deep Water [Antipov et al., 2020; Schofield et al., 2015]. Also, the supply of these water masses can serve as an additional source of nutrients and contribute to massive bloom observed in polynyas of the Amundsen Sea [Schofield et al., 2015]. We identified the highest values of abundance and biomass for phytoplankton precisely on transects T1 and T2.

For T1 and T2, a distinctive feature is the temperature of the 50-m layer – a relatively high one on T1 (up to 0 °C) and lower one on T2 (about −1.5 °C). Notably, T2 is located closer to the Amundsen Sea, and works were carried out much later on this transect. Apparently, the above-mentioned differences in thermohaline indicators for T1 and T2 are driven by the cyclicity of hydrological parameters, as shown in a number of works on the western sector of Antarctica [Guo et al., 2021; Jenkins et al., 2018; The Amundsen Sea Expedition, 2018].

The obtained values of hydrological parameters for the most studied spot in the vicinity of the Antarctic Peninsula and the South Shetland Islands (T3) are consistent with the data of other researchers [Cefarelli et al., 2011; Dotto et al., 2021; García et al., 2002; Garibotti et al., 2003; Hofmann et al., 1996; Mendes et al., 2012; Rozema et al., 2017; Varela et al., 2002]. The effect of the Antarctic Circumpolar Current and influx of the Bellingshausen Sea water ensured above-zero temperatures down to a 400-m depth over a distance of 30 km from the transect gate. A layer up to 200 m thick, with the temperature of 0…+2 °C, covered almost the entire Bransfield Strait. Data analysis for a wide area from Elephant Island to Palmer Archipelago, with the Bransfield Strait included, also showed that the warmest waters are traditionally concentrated off the South Shetland Islands. The most saline water masses are located both along the South Shetland Islands and off the Antarctic Peninsula, probably, depending on seasonal changes [García et al., 2002; Garibotti et al., 2003]. On T3, the temperature maximum was observed at a depth of down to 200 m; this fact was described earlier as well [Hofmann et al., 1996]. The Weddell Sea coastal waters (east of the Antarctic Peninsula) are saltier and denser than warmer waters around the South Shetland Islands. In the southern area of T3, we registered maximum oxygen content near the northern Antarctic Peninsula and Gerlache Strait, and it was determined by the effect of the Weddell Sea water masses [Dotto et al., 2021].

In high latitudes, the phytoplankton community was formed chiefly by Bacillariophyta and Haptophyta representatives which is typical for the SO [Gogorev, 2010, 2013; Gogorev, Samsonov, 2016; Kuzmenko, 2004; Nissen, Vogt, 2021]. Shifts in phytoplankton species composition and quantitative characteristics we recorded can be associated with different sampling time (summer for T1 and T2; early autumn for T3) and features of transect location, as well as with the penetration of waters of various origin into the study areas, *e. g.*, Circumpolar Deep Water or glacier meltwater.

The values of phytoplankton abundance and biomass in the study SO areas do not exceed those provided in literature, 1×10^3 to 1×10^6 cells·L^{-1} [Andreoli et al., 1995; Cefarelli et al., 2011; Fonda et al., 2005; Kang, Fryxell, 1993]. However, the summer research season is characterized by a narrower range of values, with phytoplankton abundance usually higher in the southern summer, 1×10^6 to 1×10^8 cells·L^{-1} [Cefarelli et al., 2011; Deppeler, Davidson, 2017]. Diatoms had the highest abundance in phytoplankton throughout the study SO areas. *Fragilariopsis* representatives are generally typical for the SO waters [Carmelo, 1997; Cefarelli et al., 2010; Kennedy et al., 2019] and develop in mass both in the water column and in ice, near the ice edge or off the coast. Their widespread distribution and development were noted in our survey as well. At some stations of transects at a depth of > 50 m, high abundance of *Ph. antarctica* was recorded (15–39% of the total). According to previous investigations, the intensive vegetation of this species results from its development in mixed and iron-poor open waters of the SO [Mendes et al., 2012; Petrou et al., 2016; Varela et al., 2002], with high irradiance and low salinity mostly in surface layers [Goffart et al., 2000; Schofield et al., 2015]. Information on development of diatoms and haptophytes, both spatial and temporal, is widely presented in literature [Kang, Fryxell, 1993; Kaufman et al., 2017; Mangoni et al., 2017; Mosby, 2013; Nissen, Vogt, 2021]. In particular, there are extensive data on the central Ross Sea [Andreoli et al., 1995; Goffart et al., 2000; Mosby, 2013].

To date, the limited information on the algal flora on transects T1 and T2 does not allow us to identify the key factors affecting phytoplankton species composition and quantitative characteristics. Apparently, the most significant ones are seasonal successions associated with the availability of sunlight, ice melting, and nutrient balance. A relationship was revealed between the abundance of algae and water temperature on T2 in the surface layer (0–10 m) and with the salinity which may be a consequence of alterations in ice conditions and insolation.

The unevenness of hydrological parameters of the water column on T3 results from the water influx from the Bellingshausen and Weddell seas, effect of the Antarctic Circumpolar Current and Circumpolar Deep Water, and occurrence of seasonal changes. Obviously, this unevenness determines the minimum similarity in phytoplankton composition between stations. Specifically, with distance from islands and relatively warm water masses with high salinity, phytoplankton abundance decreased on T3 by more than 2 times. Similar changes in phytoplankton development on this transect and its low species richness were noted in other works [Garibotti et al., 2003; Kuzmenko, 2004; Mendes et al., 2012; Varela et al., 2002]. Our results differ from those available in literature: we registered fragments of red algae thalli occurring in mass in the surface layer on T3. This fact requires further study.

Conclusion. Oceanographic data, including results of hydrophysical research and analysis of the structure of phytoplankton communities, were obtained during the 65th Russian Antarctic Expedition on the RV "Akademik Tryoshnikov" in the Pacific sector of Southern Ocean. These data supplemented the material of the program of regular observations of the little-studied region from Cape Colbeck to Russkaya station and in the Bransfield Strait.

At the single station in the southeastern Ross Sea, relatively fresh, cold, and oxygenated waters were recorded in the upper 100-m layer. Low temperature values, along with higher salinity, were registered in the bottom area.

In surface waters of transects T1 and T2, low salinity and different temperature characteristics were revealed: lower values on T2 (−1.5 °C) and higher on T1 (0 °C). For the Bransfield Strait water (transect T3), typical data on salinity and oxygen content were obtained, against the backdrop of slightly increased temperature values (up to +2 °C).

In the phytoplankton community of the study areas, 48 taxa of microalgae from 5 divisions were identified (Bacillariophyta, 38; Dinophyta, Cyanoprokaryota, and Chrysophyta, 3 taxa each; and Haptophyta, 1), as well as 1 macrophyte taxon, Rhodophyta. The spatial distribution of phytoplankton was characterized by significant patchiness; the Southern Ocean areas differed in species composition and contribution of certain species and groups to the total abundance and biomass of plankton. The similarity of phytoplankton species composition was maximum for shelf stations, on average 43%. The main contributors to the quantitative characteristics of phytoplankton throughout the study water area were diatoms, chiefly *Fragilariopsis* representatives confined to the shelf and coastal areas. At a distance or in the open sea, the proportion of diatoms decreased, and the species *Phaeocystis antarctica* developed in mass. A correlation was revealed between the abundance of algae, water temperature on transect T2, and salinity in the 0–50-m layer of water masses.

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ПРОСТРАНСТВЕННАЯ ИЗМЕНЧИВОСТЬ ТЕРМОХАЛИННЫХ ПАРАМЕТРОВ И СОСТАВА ФИТОПЛАНКТОНА ЗАПАДНОЙ АНТАРКТИКИ В ЛЕТНИЙ ПЕРИОД

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В результате исследования пространственной изменчивости термохалинных характеристик (температура, солёность и растворённый кислород) и структуры фитопланктона (состав, численность и биомасса) Южного океана в летний период получены новые данные для малоизученного региона Антарктики — разрезов вдоль восточной границы моря Росса по меридиану 156° з. д. (Р1, протяжённость 35 км, 6 станций) и вблизи станции Русская (Р2, 87 км, 13 станций), а также одиночной станции (район острова Рузвельт) и пролива Брансфилд (Р3, 118 км, 11 станций). Актуальность анализа этого региона обусловлена его расположением на границе шельфа и материкового склона с разными параметрами температуры и структуры вод. В поверхностных водах Р1 и Р2 выявлены низкая солёность и различные температурные характеристики — более низкие значения на Р2 (−1,5 °C) и более высокие на Р1 (0 °C). Для вод пролива Брансфилд (Р3) получены типичные данные по солёности и содержанию кислорода, но несколько повышенные значения температуры (до +2 °C). На одиночной станции зарегистрирована относительно пресная, холодная и насыщенная кислородом вода верхнего 100-метрового слоя и отмечены низкие значения температуры придонной части, а также высокая минерализация. В составе фитопланктона исследованных районов определены 48 таксонов микроводорослей из 5 отделов (Bacillariophyta — 38, Dinophyta, Cyanoprokaryota и Chrysophyta — по 3, Haptophyta — 1) и 1 таксон макрофитов (Rhodophyta). Максимальное сходство видового состава фитопланктона (в среднем 43 %) характерно для шельфовых станций разных районов. Общая численность фитопланктона изученной акватории Южного океана колебалась в пределах 4,3–264,0 тыс. кл.·л$^{-1}$, биомасса — 0,07–1,18 мг·л$^{-1}$. Основной вклад в количественные характеристики фитопланктона во всей исследованной акватории вносили диатомовые водоросли, преимущественно представители рода *Fragilariopsis* Hustedt, приуроченные к шельфу и прибрежным районам. При удалении от берега и в открытом море на разрезах P1 и P2 глубже 50 м и в поверхностных водах на разрезе P3 отмечено массовое развитие вида *Phaeocystis antarctica* Karsten (Haptophyta). Для P2 выявлена зависимость численности фитопланктона от температуры и солёности воды.

Ключевые слова: Западная Антарктика, пролив Брансфилд, шельф, пространственная изменчивость, термохалинные параметры, фитопланктон