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HYDROCHEMICAL OBSERVATIONS AT AN ANCHORED STATION IN EZCURRA INLET *

1. INTRODUCTION

It was planned that the research ship would be anchored in Ezcurra Inlet for almost three months during the Polish Academy of Sciences' Second Antarctic Expedition to the Henryk Arctowski Station on King George Island (South Shetland Islands). During this time the ship was to serve as a supply base for the expansion of the Polish polar station. This enabled the ship to be used as an oceanographic station for preliminary, complex surveys of hydrological, hydrochemical and hydrobiological regimes of waters in the region, to find relationships between various parameters determining the state of the marine environment and their fluctuations in time. Systematic meteorological observations were also carried out on board. The purpose of the investigations was to obtain preliminary information about this unexplored region and provide a base for further, more accurate exploration of the marine foreground of the Polish Antarctic Station.

The research programme on board the anchored ship included measurements of water movements (waves, currents, tides), hydro-optical phenomena (attenuation and scattering of light), energetics of photosynthetic processes, primary production (photosynthetic pigments and assimilation of carbon), suspended matter, qualitative and quantitative

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analyses of phyto- and zoo-plankton as well as physiological functions of some marine organisms. The results of these investigations can be found in individual papers, some of which are published in this volume. Some of the results are now being prepared for publication. This paper includes the results of measurements of basic hydrochemical parameters which, apart from the temperature and salinity, include the levels of oxygen, silicates, phosphates, nitrites and nitrates. The results of investigations of the chemical composition of suspended matter and fresh water flowing into Ezcurra Inlet are only mentioned in brief, as they will be published in full elsewhere.

2. SURVEY SITE

Ezcurra Inlet constitutes part of Admiralty Bay, situated in the southern region of King George Island. The fiord cuts into the land in a southeasterly direction over a distance of about 8 km. It is surrounded with mountains, the steep slopes of which attain 200—450 m above sea level, the submerged part forming a trough more than 400 m deep at the entrance to Admiralty Bay. The rocks, mainly lava and andesite tuffs, as well as breccia are of volcanic origin and, as the result of intensive weathering, deteriorate and drop into the fiord. In the less steep places they are deposited in the form of scree and heaps of debris along the coast line.

The southern sides of the fiord have no permanent ice sheet. During the Antarctic summer, when temperatures slightly above 0°C predominate, snow melts and flows down in many streams to intensify erosion of the bedrock. Fronts of the glacier, which covers about 90% of the surface area of the island, are exposed on its northern side. When in November — December the fiord looses its solid ice cover, the glacier produces ice-blocks of various size, which feed the area with variable intensity and are always present.

The anchorage chosen was about 1 km off the cone-shaped rocky islet of Dufayel situated in the middle of the fiord in the direction of the entrance. Here, the fiord is about 2.1 km wide, 60 m deep and there is an underwater sill. The ship had freedom of movement over an area with a radius of approx. 200 m, with the wind astern. The depth of the points at which measurements were carried out varied accordingly between 60 and 90 m. The location of the measuring area is shown in Fig. 1.

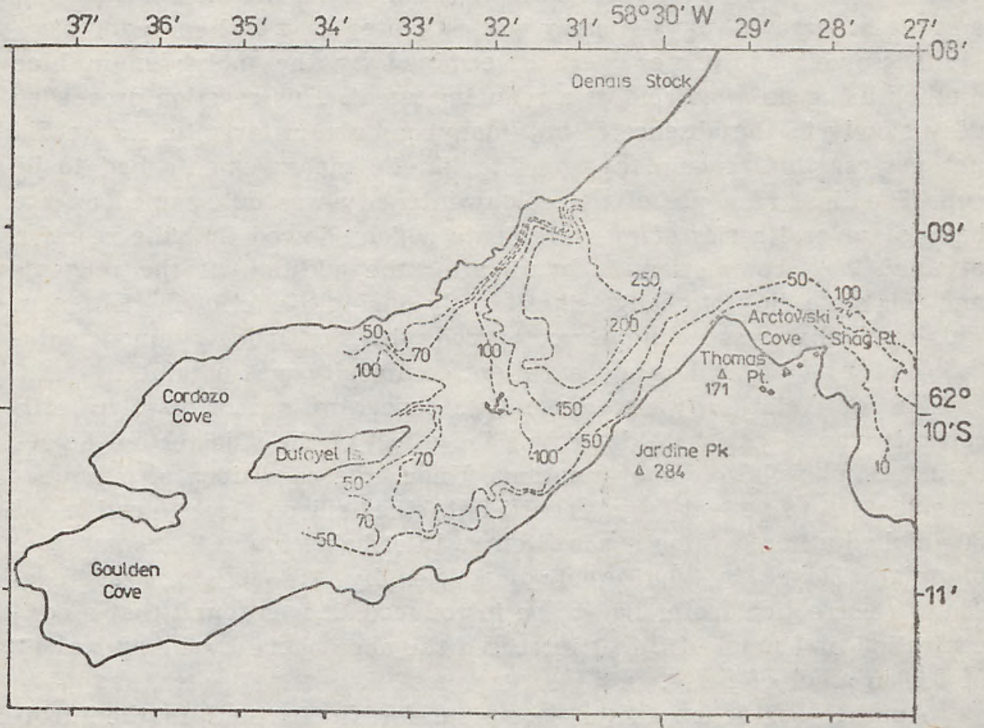

Fig. 1. Survey site and anchorage of the ship
Rys. 1. Obszar badań i miejsce zakotwiczenia statku

3. MATERIAL AND METHODS

The research was carried out on board the Merchant Marine Academy's training ship „Antoni Garnuszewski", 5500 GRT. For the period of the Antarctic Expedition the ship was equipped with measuring and sampling posts astern. Laboratory investigations were carried out in a laboratory and workshop made available in the engine-room. Water was sampled with a 12-dm^3 non-transparent plastic bottle from depths of 1, 5, 10, 15, 20 and further every 10 m down to the bottom. This water was used for all chemical analyses. Measurements of salinity, quantity and particle size distribution of suspended matter, primary production and composition of phytoplankton were carried out on the same volume of water. Analyses were run immediately after sampling.

Dissolved oxygen was determined by the standard Winkler method using a starch solution as indicator. Thiosulphate was standardised using a standard KIO_3 solution. Calibrated oxygen bottles with a nominal volume of 100 cm^3 were used. The precision of the titration was ±0.25% and the accuracy of oxygen assay was estimated as $\pm 0.02\ cm^3 \cdot dm^{-3}$.

Dissolved phosphates were determined by the molybdenum blue method using ascorbic acid as a reducing agent. This reaction proceeded very slowly in the absence of antymonyl potassium tartrate. As we did not possess this reagent, appropriate kinetic measurements had to be run. The time response of the colour intensity was determined on the basis of several series of measurements which showed that the reaction attained 96% completion 24 hours after the addition of the reagents and this state did not change significantly during the following 24 hours. This method was subsequently compared with that using stannous chloride as a reducing agent and excellent conformity was obtained.

As the Antarctic waters have high concentrations of dissolved silicates, it was necessary to determine the effect of the silicates on the accuracy of phosphorus determinations. Under the conditions of our measurements this effect was significant, the silicon concentration of 80 $\mu mol \cdot dm^{-3}$ predominating in Ezcurra Inlet being found to increase the phosphate level by 0.37 $\mu mol \cdot dm^{-3}$, i.e. by 15—20% on average. Thus, a correction factor had to be introduced. It was found that a concentration of 1 μmol of SiO_3^{2-} increased the absorbance by an equivalent of 0.0046 μmol of PO_4^{3-}.

Another correction factor accounted for fluctuations in the turbidity of the water. This correction factor for measurements in 10-cm absorption cells at $\lambda = 800$ nm amounted to 0.005—0.070 absorbance unit and was determined for each sample. The final result was calculated from the expression:

$$C = \left[F \frac{(A - A_r)}{0.96} - 0.0046\, C_{Si} - C_B \right] \mu mol\, PO_4^{3-}\ dm^{-3}$$

where C_B is the phosphate concentration in the blank, C_{si} is the concentration of silicates in the sample, A is the sample absorbance, A_r is the absorbance due to turbidity; F is the calibration coefficient ($\mu mol\ PO_4^{3-}/1\ A$) determined by using phosphate-free and silicate-free sea water. Dissolved silicates were determined by the molybdenum blue method using ascorbic acid as a reducing reagent. The measurements were carried out in 1-cm cuvettes at $\lambda = 780$ nm. Calibration was carried out using a standard silicate solution diluted with silicate-free sea water.

Dissolved nitrates were determined with N-1-naphthylethylenediamine and sulphamic acid after previous reduction to nitrites in a column packed with coppered cadmium. Calibration was performed using a nitrate-free sea water enriched with known quantities of nitrate ions.

The measurements were carried out in 1-cm cuvettes at $\lambda = 542$ nm.

Dissolved nitrites were determined by the same method as nitrates with omission of the reduction step.

The absorbance was measured in 10-cm absorption cells and the absorbance due to water turbidity was subtracted. Owing to the substantial turbidity of the Ezcurra Inlet waters the correction factor was quite high, exceeding in some cases the net absorbance of samples. Preliminary tests showed the absorbance of samples stored in the laboratory in open vessels to increase with time. Analogous samples kept in closed vessels were stable for several days. Hence, it was assumed as a rule to keep the samples off the laboratory air which probably contained enhanced levels of nitrogen oxides. Calibration was carried out by means of a standard nitrite solution in distilled water.

Total phosphorus and total nitrogen were determined in the same manner as phosphates and nitrates after oxidation of the samples with potassium persulphate in a borate buffer of pH 8 in Teflon autoclaves.

The measurements were run on a SPECOL (Carl Zeiss, Jena, G.D.R.) spectrophotometer. Their precision, estimated on the basis of pairs of parallel assays, was 2, 3, 5 and 14% for silicon, nitrates, phosphates and nitrites, respectively. In several cases, however, it was worse owing to voltage fluctuations caused by the occasional switching on of heavy electrical gear on the ship.

Particulars concerning the analytical procedure can be found in the literature [2] on which all the methods were based.

4. RESULTS AND DISCUSSION

Observations were made from the day the ship arrived (20th December, 1977) to 10th March 1978, i.e. during almost the whole Antarctic summer. During this period, 660 water samples were taken from the vertical cross-section at more or less regular time intervals. The salinity in all samples was determined by means of a laboratory inductive salinometer. Temperature profiles were taken by means of a bathothermograph with an accuracy of ±0.1°C. Not all samples were analyzed chemically. All results of the measurements are listed in Table 1.

Experimental evidence shows that during the fairly long observation period (almost 3 months), the fluctuations in the hydrochemical conditions were relatively small. The fluctuations of salinity amounted to ±0.2 per mille with respect to the weighted average of 33.913 per mille. The temperature varied by ±1°C with respect to the mean value of +0.2°C.

Table 1. Results of hydrochemical measurements at the anchored station in Ezcurra Inlet during the period of 20 Dec. 1977—10 March 1978

Tab. 1. Wyniki pomiarów hydrochemicznych na zakotwiczonej stacji we fiordzie Ezcurra od 20 grudnia 1977 do 10 marca 1978 r.

Date and hour (GMT) Data i godz. (GMT) Air pressure (mbar) Ciśn. powietrza (mbar) Air temperature (°C) Temp. powietrza (°C) Wind direction and velocity (m · s^{-1}) Kierunek i prędkość wiatru (m · s^{-1})	Depth Głębokość m	Temperature Temperatura °C	Salinity Zasolenie ‰	Oxygen Tlen cm · dm^{-3}	Dissolved nutrients Rozpuszczone sole biogenne µmol · dm^{-3}			
					SiO$_3^{2-}$	PO$_4^{3-}$	NO$_2^-$	NO$_3^-$
1	2	3	4	5	6	7	8	9
20 Dec. 15.00	1	0.2	33.881	8.36	80	2.07		
1001.8 mb	5	0.1	33.871	8.32	80	2.00		
3.5°C	10	—0.1	33.905	8.30	81	1.94		
260° 2 m · s^{-1}	15	—0.15	33.915	8.31	81	1.91		
	20	—0.2	33.927	8.31	80	2.01		
	30	—0.2	33.949	8.28	81	2.03		
	40	—0.15	33.963	8.26	80	1.84		
	50	—0.05	33.975	8.23	80	1.81		
	60	—0.1	33.986	8.08	81	1.98		
	70	—0.15	34.004	7.97	82	1.96		
20 Dec. 18.00	1	0.35	33.796					
998.7 mb	5	0.1	33.818					
3.9°C	10	—0.1	33.886					
290° 5 m · s^{-1}	15	—0.1	33.911					
	20	—0.01	33.933					
	30	—0.05	33.956					
	40	—0.15	33.964					
	50	—0.2	33.982					
	60	—0.25	33.992					
	70	—0.3	34.009					

1	2	3	4	5	6	7	8	9
20 Dec. 21.00	1	0.35	33.727	8.42	89	1.72	0.19	
995.8 mb	5	0.2	33.718	8.38	90	1.59	0.20	
5.9°C	10	0.0	33.943	8.34	77	1.91	0.19	
250° 7 m · s^{-1}	15	—0.1	33.949	8.31	85	1.82	0.19	
	20	—0.1	33.941	8.27	86	1.62	0.21	
	30	—0.15	33.962	8.26	76	1.90	0.21	
	40	—0.25	34.000	7.99	80	1.78	0.17	
	50	—0.3	34.017	7.86	80	1.84	0.16	
	60	—0.25	34.032	7.83	83	2.01	0.16	
	70	—0.25	34.040	7.82	81	1.85	0.17	
21 Dec. 0.00	1	0.25	33.706					
994.8 mb	5	0.15	33.827					
2.6°C	10	—0.05	33.943					
260° 12 m · s^{-1}	15	—0.05	33.951					
	20	—0.05	33.944					
	30	—0.2	33.970					
	40	—0.2	33.994					
	50	—0.3	34.009					
	60	—0.3	34.031					
	70	—0.45	34.098					
21 Dec. 3.00	1	0.1	33.795	8.24	74	1.73	0.17	
994.2 mb	5	0.0	33.829	8.32	76	1.71	0.17	
1.5°C	10	—0.1	33.871	8.32	74	1.64	0.18	
260° 11 m · s^{-1}	15	—0.1	33.928	8.31	74	1.65	0.17	
	20	—0.15	33.974	8.30	76	1.82	0.18	
	30	—0.2	33.977	8.23	76	1.84	0.17	
	40	—0.3	33.998	7.99	76	1.84	0.16	
	50	—0.3	34.011	7.90	83	1.92	0.16	
	60	—0.3	34.036	7.79	80	1.84	0.15	
	70	—0.3	34.051	7.71	80	1.90	0.15	
21 Dec. 6.00	1	—0.05	33.804					
993.5 mb	5	—0.05	33.794					
1.3°C	10	—0.05	33.758					
260° 12 m · s^{-1}	15	—0.05	33.847					
	20	—0.05	33.937					

1	2	3	4	5	6	7	8	9
	30	—0.15	33.966					
	40	—0.2	33.965					
	50	—0.3	33.973					
	60	—0.3	33.982					
	70	—0.35	34.007					
21 Dec. 9.00	1	—0.05	33.855	8.29	77	1.74	0.20	
993.6 mb	5	—0.1	33.853	8.26	77	1.74	0.19	
1.9°C	10	—0.1	33.882	8.24	78	1.97	0.19	
250° $8\ \mathrm{m \cdot s^{-1}}$	15	—0.1	33.911	8.25	73	1.84	0.19	
	20	—0.1	33.949	8.25	74	1.82	0.20	
	30	—0.15	33.953	8.20	76	1.89	0.20	
	40	—0.15	33.957	8.23	75	1.89	0.19	
	50	—0.15	33.978	8.12	74	1.89	0.18	
	60	—0.2	33.989	8.04	74	1.87	0.16	
	70	—0.25	33.998	7.98	80	1.87	0.17	
21 Dec. 12.00	1	—0.05	33.865					
994 mb	5	—0.1	33.904					
2.3°C	10	—0.1	33.910					
250° $9\ \mathrm{m \cdot m^{-1}}$	15	—0.1	33.931					
	20	—0.1	33.934					
	30	—0.15	33.948					
	40	—0.2	33.955					
	50	—0.2	33.957					
	60	—0.2	33.963					
	70	—0.2	33.981					
21 Dec. 15.00	1	0.1	33.771	8.29	82	2.09	0.20	
995.1 mb	5	0.0	33.898	8.25	84	2.07	0.19	
5.0°C	10	—0.05	33.918	8.30	83	2.05	0.19	
250° $9\ \mathrm{m \cdot s^{-1}}$	15	—0.1	33.942	8.21	85	2.03	0.19	
	20	—0.15	33.870	8.24	83	2.07	0.20	
	30	—0.2	33.959	8.15	80	2.09	0.18	
	40	—0.2	33.957	8.12	88	2.05	0.18	
	50	—0.2	33.982	8.03	79	2.01	0.17	
	60	—0.2	33.992	8.07	86	1.89	0.17	
	70	—0.2	33.993	8.10	79	1.97	0.17	

1	2	3	4	5	6	7	8	9
26 Dec. 15.00	10	0.1	33.813	8.18	80.4			
976.1 mb	50	—0.2	33.976	7.91	81.3			
1.4°C								
200° 6 m · s^{-1}								
26 Dec. 20.00	10	—0.2	33.914	8.09	80.0			
977.9 mb	50	—0.6	34.123	7.32	85.9			
3.8°C								
200° 4 m · s^{-1}								
27 Dec. 19.00	10	0.1	33.702	8.08	78.5			
986.7 mb	50	—0.3	33.986	7.89	79.1			
2.6°C								
140° 2 m · s^{-1}								
27 Dec. 20.00	10	—0.2	33.848	8.15	77.8			
992.6 mb	50	—0.5	34.035	7.68	80.7			
3.1°C								
0 m · s$^{-\circ}$								
28 Dec. 11.00	10	0.2	33.872	8.13	78.4			
1000.3 mb	50	—0.2	33.971	7.89	79.2			
1.0°C								
0 m · s^{-1}								
28 Dec. 16.00	10	0.1	33.789	8.17	78.5			
1000.7 mb	50	—0.1	33.916	7.87	80.0			
4.8°C								
0 m · s^{-1}								
29 Dec. 11.00	1	0.0	33.853	8.04	79.0	1.93	0.21	
1000.3 mb	5	—0.1	33.868	8.02	78.8	1.89	0.19	
0.2°C	10	—0.1	33.865	8.03	79.1	1.88	0.20	
220° 8 m · s^{-1}	15	—0.1	33.882	7.96	79.2	1.88	0.20	
	20	—0.1	33.916	7.90	79.5	1.97	0.19	
	30	—0.2	34.004	7.74	81.4	1.92	0.17	
	40	—0.3	34.052	7.58	82.5	2.00	0.15	
	50	—0.3	34.054	7.57	82.5	2.02	0.15	

1	2	3	4	5	6	7	8	9
	60	—0.3	34.051	7.56	82.5	2.02	0.14	
	70	—0.4	34.060	7.50	84.1	2.01	0.14	
29 Dec. 19.00	1	0.1	33.853	8.00	78.6	2.07	0.24	
998.3 mb	5	0.1	33.855	7.99	78.6	2.09	0.24	
1.5°C	10	0.1	33.849	7.99	78.6	2.07	0.24	
240° 10 $m \cdot s^{-1}$	15	0.1	33.865	7.98	79.0	2.07	0.23	
	20	0.1	33.908	7.95	79.0	2.07	0.23	
	30	0.1	33.927	7.91	79.5	2.07	0.23	
	40	0.1	33.927	7.86	79.8	2.07	0.22	
	50	—0.1	33.969	7.77	80.3	2.06	0.21	
	60	—0.1	33.998	7.69	81.3	2.09	0.20	
	70	—0.1	34.006	7.66	81.3	2.09	0.20	
30 Dec. 12.00	1	0.1	33.916					
998.9 mb	5	0.1	33.916					
3.8°C	10	0.1	33.914	7.96	79.5	2.05	0.20	
230° 14 $m \cdot s^{-1}$	15	0.1	33.916					
	20	0.1	33.923					
	30	0.1	33.919					
	40	0.1	33.923					
	50	—0.1	33.943	7.77	80.5	2.02	0.18	
	60	—0.1	33.971					
	70	—0.1	33.981					
30 Dec. 19.00	1	0.3	33.864					
999.3 mb	5	0.3	33.880					
6.2°C	10	0.2	33.881	7.99	79.0	2.06	0.19	
250° 11 $m \cdot s^{-1}$	15	0.2	33.878					
	20	0.2	33.876					
	30	0.2	33.936					
	40	0.2	33.931					
	50	0.1	33.949	7.90	79.9	2.05	0.18	
	60	0.1	33.969					
	70	0.1	33.978					
1 Jan. 1978 23.00	1	0.2	33.950					
994.2 mb	5	0.2	33.951					

1	2	3	4	5	6	7	8	9
4.7°C	10	0.2	33.945	7.76	82.3	1.84	0.18	23.2
250° 17 m · s^{-1}	15	0.2	33.953					
	20	0.1	33.957					
	30	0.1	33.962					
	40	0.1	33.953					
	50	0.1	33.965	7.68	82.9	1.96	0.19	22.8
	60	0.0	33.967					
	70	—0.1	34.004					
2 Jan. 15.00	1	0.4	33.882					
994.2 mb	5	0.4	33.888	7.77	80.9	1.92	0.21	24.7
4.7°C	10	0.3	33.890	7.74	80.7	1.89	0.21	25.0
250° 17 m · s^{-1}	15	0.2	33.892					
	20	0.1	33.925					
	30	0.1	33.957					
	40	0.0	33.960					
	50	0.0	33.963	7.61	82.4	2.02	0.21	24.7
	60	0.0	33.964	7.61	82.5	2.02	0.21	24.8
	70	0.0	33.996	7.54				
2 Jan. 20.00	1	0.5	33.577					
986.4 mb	5	0.3	33.781	7.66	81.3	1.97	0.24	25.0
5.0°C	10	0.2	33.776	7.68	81.1	1.90	0.21	24.4
280° 7 m · s^{-1}	15	0.2	33.908					
	20	0.2	33.916					
	30	0.2	33.925					
	40	0.2	33.946					
	50	0.2	33.941	7.60	82.0	1.92	0.19	25.0
	60	0.1	33.965	7.60	82.4	1.91	0.17	24.8
	70	0.0	34.017					
3 Jan. 0.00	5	0.5	33.757	7.72	81.9	2.02	0.21	24.8
981.9 mb	10	0.3	33.748	7.70	82.0	1.94	0.22	24.8
5.0°C	50	0.0	33.959	7.59	82.7	1.99	0.17	25.1
310° 18 m · s^{-1}	60	—0.1	34.012	7.54	81.6	1.81	0.15	24.3
3 Jan. 18.00	0	0.8	33.794	7.62	81.9	2.00	0.14	25.4
980.7 mb	1	0.3	33.894	7.62				

1	2	3	4	5	6	7	8	9
3.5°C	5	0.2	33.890	7.63	82.3	2.05	0.14	25.4
290° 4 m · s^{-1}	10	0.1	33.891	7.63	82.5	2.00	0.14	25.2
	15	0.1	33.903	7.64				
	20	0.0	33.923	7.64				
	30	—0.1	33.933	7.61				
	40	—0.1	33.954	7.65				
	50	—0.1	33.961	7.67	81.6	1.89		24.4
	60	—0.1	33.975	7.64	81.3	1.89		24.1
	70	—0.2	34.007	7.60				
4 Jan. 0.00	1	0.2	33.784					
981.5 mb	5	0.2	33.734	7.66	82.7	1.93	0.13	25.1
1.8°C	10	0.2	33.795	7.66	82.3	1.93	0.14	25.0
230° 10 m · s^{-1}	15	0.2	33.904					
	20	0.2	33.906					
	30	0.1	33.916					
	40	0.0	33.947					
	50	0.0	33.950	7.64	82.3	1.72		24.7
	60	0.0	33.966	7.64	81.9	1.74		24.4
	70	0.0	33.973					
4 Jan. 14.00	5	0.3	33.744	7.67	83.4	1.91	0.13	25.3
984.5 mb	10	0.3	33.855	7.69	82.7	1.91	0.16	25.0
0.8°C	15	0.3	33.853					
110° 4 m · s^{-1}	20	0.3	33.887					
	30	0.2	33.933					
	40	0.2	33.930					
	50	0.1	33.933	7.64	82.7	1.94	0.18	24.8
	60	0.1	33.946	7.63	82.7	1.94	0.19	24.8
4 Jan. 20.00	1	0.5	33.439					
985.5 mb	5	0.3	33.796	7.72	82.7	2.02	0.16	25.1
1.1°C	10	0.3	33.853	7.68	82.7	1.94	0.18	25.1
30° 2 m · s^{-1}	15	0.3	33.865					
	20	0.3	33.872					
	30	0.2	33.883					
	40	0.2	33.908					
	50	0.1	33.914	7.65	82.7	1.91	0.18	24.9
	60	0.0	33.934	7.63	82.7	1.90	0.19	25.1

1	2	3	4	5	6	7	8	9
5 Jan. 15.00	1	0.6	33.489					
987.5 mb	5	0.5	33.780	7.91	81.3	1.95	0.17	23.8
0.3°C	10	0.3	33.838	7.69	83.8	2.10	0.16	25.0
60° 1 m · s^{-1}	15	0.3	33.863					
	20	0.2	33.879					
	30	0.1	33.912					
	40	0.0	33.963					
	50	—0.1	33.990	7.47	82.4	2.11	0.16	25.0
	60	—0.1	34.072	7.26	83.8	2.15	0.17	26.2
5 Jan. 21.00	1	0.6	33.419					
988.0 mb	5	0.3	33.777	7.96	79.4	2.21	0.19	23.5
0.8°C	10	0.3	33.822	7.71	81.1	2.15	0.16	24.9
240° 4 m · s^{-1}	30	0.1	33.904					
	50	—0.3	34.043	7.36	82.7	2.29	0.16	25.7
	60	—0.4	34.166	7.00	86.2	2.40	0.15	27.1
6 Jan. 16.00	1	0.4	33,908					
986.6 mb	5	0.3	33.891	7.66	82.8	1.93	0.19	24.9
1.0°C	10	0.3	33.920	7.62	82.8	1.94	0.19	24.9
250° 17 m · s^{-1}	15	0.2	33.950					
	30	0.0	34.031					
	50	—0.2	34.106	7.28	85.8	2.00	0.18	26.1
	60	—0.2	34.139	7.17	86.5	1.98	0.15	26.5
14 Jan. 21.00	1	0.1	33.998	7.43	84.8	2.03	0.18	25.7
976.2 mb	5	0.1	33.991	7.38	84.5	2.01	0.18	25.4
3.1°C	10	0.0	34.008	7.36	84.8	2.01	0.20	25.3
40° 5 m · s^{-1}	15	0.0	34.007	7.38	83.1	2.02	0.19	25.5
	20	0.0	34.001	7.37	84.2	2.01	0.20	25.4
	30	0.0	34.006	7.35	84.2	2.05	0.19	25.7
	40	—0.1	34.020	7.28	84,8	2.12	0.21	25.7
	50	—0.1	34.033	7.28	85.4	2.13	0.20	25.7
	60	—0.2	34.084	7.12	86.0	2.15	0.19	26.1
	70	—0.3	34.158	6.92	86.4	2.17	0.19	26.9
15 Jan. 16.00	1	0.1	33.942	7.42	83.2	1.97	0.15	25.7
974.0 mb	5	0.1	33.950	7.40	83.2	1.99	0.21	25.7

1	2	3	4	5	6	7	8	9
0.5°C	10	0.1	33.939	7.40	83.6	1.96	0.16	25.7
260° 8 m • s^{-1}	15	0.0	33.976	7.37	82.8	1.98	0.16	
	20	0.0	34.020	7.33	82.8	1.98	0.16	
	30	—0.1	34.020	7.34	82.8	2.00	0.17	
	40	—0.1	34.032	7.31	82.8	1.99	0.17	
	50	—0.1	34.042	7.35	82.8	2.00	0.16	25.7
	60	—0.1	34.051	7.27	82.6	1.98	0.16	25.4
	70	—0.2	34.072	7.23	82.8	1.98	0.16	25.8
17 Jan. 15.00	0	2.7	33.738					
972.3 mb	1	0.8	33.810					
1.6°C	5	0.6	33.836					
0 m • s^{-1}	10	0.5	33.863					
	15	0.2	33.869					
	20	0.2	33.886					
	30	0.2	33.900					
	40	0.2	33.923					
	70	0.1	34.005					
18 Jan. 19.00	1	0.6	33.803	7.75	81.6	1.84	0.19	23.7
981.2 mb	5	0.4	33.802	7.78	80.8	1.82	0.16	23.3
0.2°C	10	0.3	33.905	7.70	82.0	1.84	0.17	23.8
230° 5 m • s^{-1}	15	0.2	33.922					
	20	0.2	33.933					
	30	0.1	33.938					
	40	0.1	33.974					
	50	—0.1	34.053	7.15	86.0	2.01	0.16	25.8
	60	—0.2	34.133	6.90	88.3	2.04	0.16	26.8
	70	—0.3	34.157	6.81	88.3	2.04	0.14	27.4
	80		34.203	6.72	89.5	2.06	0.14	27.4
19 Jan. 13.00	1	0.6	33.807	7.78				
990.0 mb	5	0.5	33.826	7.76	79.1	1.98	0.16	23.5
0.4°C	10	0.5	33.826	7.83	78.5	1.96	0.17	23.5
210° 4 m • s^{-1}	15	0.5	33.839					
	20	0.4	33.846					
	30	0.3	33.867					
	40	0.3	33.889					

1	2	3	4	5	6	7	8	9
	50	0.3	33.902	7.63	79.0	2.02	0.18	24.0
	60	0.2	33.907	7.63	78.9	2.12	0.18	24.3
	70	0.2	33.904	7.65	78.5	2.18	0.17	24.3
21 Jan. 14.00	1	0.6	33.785	7.81	79.2	1.73	0.19	23.4
1000.8 mb	5	0.6	33.790	7.82	79.1	1.72	0.18	24.5
0.2°C	10	0.6	33.796	7.87	79.1	1.75	0.19	23.6
240° 10 m • s^{-1}	15	0.6	33.811					
	20	0.6	33.820					
	30	0.5	33.874					
	40	0.4	33.882					
	50	0.4	33.890	7.65	79.1	1.66	0.17	24.1
	60	0.3	33.919	7.54	81.0	1.73	0.17	23.3
	70	0.2	33.972					
	80		33.970	7.40	82.3	1.84	0.15	25.5
21 Jan. 21.00	1	0.6	33.738	7.73	82.4	1.67	0.18	23.6
998.2 mb	5	0.5	33.743	7.79	80.8	1.81	0.18	23.7
3.6°C	10	0.4	33.749	7.74	80.1	1.74	0.17	23.6
240° 11 m • s^{-1}	15	0.3	33.768	7.70				
	20	0.2	33.886	7.64				
	30	0.1	33.992	7.29	82.6	1.79	0.17	25.4
	40	—0.2	34.026	7.19				
	50	—0.4	34.180	6.75	85.7	1.97	0.14	27.4
	60	—0.4	34.203	6.66	87.0	1.96	0.16	27.9
	70	—0.4	34.215	6.62				
	80		34.228	6.54	86.7	2.07	0.14	28.3
24 Jan. 16.00	1	0.5	33.800	7.72	79.9	1.98	0.20	23.9
991.6 mb	5	0.5	33.806	7.75	79.2	1.90	0.19	23.7
3.7°C	10	0.5	33.798	7.78	79.6	1.92	0.19	23.7
240° 10 m • s^{-1}	15	0.5	33.835					
	20	0.5	33.850					
	30	0.4	33.850					
	40	0.3	33.869					
	50	0.3	33.891	7.54	80.2	2.00	0.18	24.6
	60	0.3	33.947	7.55	80.5	1.98	0.17	24.7
	70	0.3	33.944	7.50				
	80	0.0	34.051	7.08	82.6	2.01	0.15	26.3

1	2	3	4	5	6	7	8	9
24 Jan. 22.00	1	0.5	33.838	7.69	80.0	1.99	0.22	24.1
991.9 mb	5	0.5	33.838	7.69	79.3	1.99	0.20	24.0
3.9°C	10	0.4	33.861	7.72	79.1	1.97	0.18	24.0
250° 12 m • s^{-1}	15	0.3	33.902					
	20	0.2	33.941					
	30	0.1	34.007					
	40	—0.1	34.115					
	50	—0.2	34.168	6.77	85.2	2.26	0.17	27.9
	60	—0.3	34.194	6.70	85.2	2.29	0.15	28.3
	70	—0.3	34.201	6.67				
	80	—0.3	34.205	6.66	85.2	2.26	0.15	28.4
26 Jan. 3.00	1	0.5	33.650	7.66	80.4	1.83	0.17	24.2
996.7 mb	5	0.5	33.845	7.68	80.7	1.83	0.17	24.4
1.0°C	10	0.4	33.845	7.62	80.4	1.88	0.16	24.4
270° 3 m • s^{-1}	15	0.3	33.855	7.57				
	20	0.1	33.851	7.59				
	30	0.0	33.892	7.57				
	40	—0.1	34.127	6.93				
	50	—0.2	34.133	6.85	84.4	1.96	0.15	27.1
	60	—0.2	34.143	6.74	86.0	2.01	0.15	27.8
	70	—0.2	34.229	6.64				
	80	—0.2	34.236	6.52	87.5	1.97	0.14	28.8
27 Jan. 11.00	1	0.9	33.821	7.68	79.5	1.71	0.18	23.6
991.4 mb	5	0.7	33.824	7.74	80.2	1.74	0.18	23.7
3.4°C	10	0.6	33.825	7.69	79.1	1.72	0.17	23.5
60° 7 m • s^{-1}	15	0.5	33.867	7.57				
	20	0.5	33.882	7.58				
	30	0.4	33.911	7.49				
	40	0.4	33.921	7.43				
	50	0.2	34.030	7.18	82.5	1.83	0.15	25.6
	60	0.0	34.111	6.95	84.2	1.93	0.14	27.1
	70	—0.1	34.170	6.79				
	80	—0.2	34.191	6.74	84.9	1.98	0.14	27.9
27 Jan. 17.00	1	0.6	33.842	7.71	81.0	1.64	0.18	23.5
990.4 mb	5	0.6	33.840	7.76	80.4	1.68	0.18	23.5

1	2	3	4	5	6	7	8	9
3.8°C	10	0.6	33.853	7.71	80.2	1.69	0.18	23.6
30° 3 m • s^{-1}	15	0.5	33.847	7.69				
	20	0.4	33.886	7.61				
	30	0.4	33.955	7.36				
	40	0.3	33.904	7.41				
	50	0.2	34.048	7.21	82.6	1.82	0.17	25.6
	60	0.1	34.074	7.13	82.8	1.86	0.17	26.2
	70	0.0	34.173	6.78				
	76	—0.1	34.163	6.82	85.4	1.98	0.15	27.5
29 Jan. 3.00	1	1.2	33.895	7.45	81.0	1.64	0.17	25.5
995.2 mb	5	0.7	33.962	7.33	81.5	1.66	0.18	26.3
4.5°C	10	0.65	34.046	7.26	82.3	1.70	0.16	26.7
60° 3 m • s^{-1}	15	0.55	34.057	7.13	82.6	1.72	0.17	27.1
	20	0.45	34.079	7.04				
	30	0.4	34.134	6.92				
	40	0.4	34.124	6.96				
	50	0.4	34.156	6.86	84.5	1.81	0.16	28.2
	60	0.4	34.160	6.84	84.9	1.87	0.13	28.5
30 Jan. 12.00	1	1.4	33.805	7.64	81.5	1.58	0.16	25.4
994.9 mb	5	1.1	33.908	7.51	81.2	1.62	0.16	25.6
1.1°C	10	1.0	33.964	7.44	81.4	1.63	0.16	25.5
130° 4 m • s^{-1}	15	1.0	33.986	7.45	81.1	1.62	0.17	26.0
	20	0.9	33.998	7.42				
	30	0.7	34.074	7.19				
	40	0.6	34.111	7.09				
	50	0.5	34.139	6.94				
	60	0.5	34.134	6.90	83.4	1.78	0.17	27.6
	64	.	34.203	6.67	83.7	1.78	0.16	27.8
30 Jan. 19.00	1	1.0	33.863	7.52	81.5	1.65	0.18	25.9
993.2 mb	5	1.0	33.863	7.49	81.9	1.67	0.18	25.9
0.8°C	10	1.0	33.878	7.48	82.2	1.66	0.17	26.0
140° 10 m • s^{-1}	15	1.0	33.962	7.48	81.6	1.66	0.17	26.3
	20	1.0	33.949	7.46				
	30	1.0	33.985	7.43				
	40	0.9	34.023	7.34				

1	2	3	4	5	6	7	8	9
	50	0.7	34.032	7.22	82.8	1.71	0.16	27.2
	60	0.5	34.172	6.96	85.2	1.90	0.15	27.9
6 Feb. 20.00	5		33.823		78.4	1.99	0.16	24.6
976.2 mb	10		33.924		79.5	1.99	0.15	25.9
3.8°C	30		33.948		80.8	1.98	0.15	26.0
60° 3 m • s^{-1}	50		34.076		82.8	2.13	0.15	28.0
7 Feb. 17.00	1	0.9	33.806	7.62	79.9	1.96	0.16	25.4
979.9 mb	5	0.9	33.821	7.67	79.8	1.87	0.16	25.4
4.8°C	10	0.9	33.791	7.63	79.1	1.85	0.17	25.4
360° 7 m • s^{-1}	15	0.9	33.853	7.58				
	20	0.9	33.869	7.60				
	30	0.7	33.961	7.40				
	40	0.6	34.014	7.24				
	50	0.5	34.031	7.19	82.8	2.01	0.16	27.2
	60	0.5	34.147	7.03	83.0	2.06	0.15	27.6
	70		34.106	6.94				
	80		34.129	7.11	83.0	2.10	0.16	27.5
8 Feb. 22.00	1	0.8	33.982	7.32	85.0	1.96		26.2
986.8 mb	5	0.8	33.985	7.31	84.1	1.95		26.3
2.6°C	10	0.7	33.976	7.34	84.6	1.97		26.4
260° 14 m • s^{-1}	15	0.7	34.016	7.30				
	20	0.7	33.996	7.26				
	30	0.6	34.058	7.16	84.8	1.89		26.7
	40	0.6	34.171	6.87				
	50	0.6	34.165	6.83	85.4	2.04		28.5
	60	0.6	34.213	6.72	89.5	2.02		28.8
	70		34.285	6.37	89.9	2.05		29.7
	80		34.290	6.28	90.7	2.06		30.0
	90		34.313	6.26	93.4	2.09		30.0
10 Feb. 12.00	1	0.6	33.868	7.42	82.4	2.06	0.17	26.1
986.1 mb	5	0.5	33.882	7.38	82.0	1.97	0.16	26.1
—1.1°C	10	0.5	33.902	7.43	81.4	1.99	0.16	26.0
130° 5 m • s^{-1}	15	0.4	33.898	7.44				
	20	0.4	33.907	7.41				

1	2	3	4	5	6	7	8	9
	30	0.4	33.944	7.45				
	40	0.4	33.919	7.45				
	50	0.4	33.956	7.36	80.3	1.94	0.17	26.4
	60	0.4	34.080	7.07	82.8	2.04	0.16	27.6
	65		34.207	6.62	86.2	2.08	0.16	28.6
14 Feb. 12.00	1	0.9	33.853	7.50	80.4	1.97		25.8
981.4 mb	5	0.8	33.861	7.45	80.8	1.95		24.3
3.2°C	10	0.8	33.913	7.38	80.8	1.89		25.9
0 $\mathrm{m \cdot s^{-1}}$	15	0.8	33.882	7.43				
	20	0.8	33.908	7.39				
	30	0.8	33.923	7.40				
	40	0.8	33.933	7.39				
	50	0.7	33.991	7.16	82.5	1.93		25.6
	60	0.6	34.030	6.97	83.0	1.97		26.9
14 Feb. 19.00	1	1.2	33.785	7.47	80.6	1.83		25.5
989.6 mb	5	1.2	33.713	7.42	80.8	1.82		26.2
2.8°C	10	1.0	33.830	7.47	80.1	1.76		25.9
250° 6 $\mathrm{m \cdot s^{-1}}$	15	1.0	33.755	7.46				
	20	1.0	33.892	7.47				
	30	1.0	33.920	7.46	80.7	1.75		26.1
	40	0.9	33.932	7.41				
	50	0.8	33.954	7.37	81.0	1.79		26.6
	60	0.7	33.951	7.35	81.5	1.85		26.9
16 Feb. 20.00	5	0.9	33.790			2.14		23.6
1011.2 mb	10	0.9	33.776			2.08		23.3
3.2°C	30	0.8	33.873			2.14		23.6
260° 6 $\mathrm{m \cdot s^{-1}}$	50	0.5	34.073			2.14		24.4
	60					2.20		25.0
18 Feb. 17.00	1	1.0	33.830	7.53	80.8	2.01		24.2
999.8 mb	5	1.0	33.819	7.51	80.8	2.05		24.1
3.6°C	10	1.0	33.825	7.47	80.8	2.00		24.0
280° 12 $\mathrm{m \cdot s^{-1}}$	15	1.0	33.833	7.46				
	20	1.0	33.822	7.49				
	30	1.0	33.841	7.44				

1	2	3	4	5	6	7	8	9
	40	0.9	33.914	7.36				
	50	0.8	34.044	7.00	82.8	2.02		25.2
	60	0.6	34.133	6.74	83.9	2.05		25.8
	70		34.156	6.60	84.1	2.05		25.9
21 Feb. 15.00	1	1.1	33.815	7.56	78.9	1.98		23.9
995.1 mb	5	1.0	33.808	7.55	78.5	1.92		23.8
1.9°C	10	1.0	33.827	7.53	78.5	1.94		23.8
260° 5 m · s^{-1}	15	1.0	33.822	7.54				
	20	1.0	33.829	7.54				
	30	1.0	33.849	7.46				
	40	0.9	33.873	7.47				
	50	0.9	33.913	7.37	78.6	1.93		23.6
	60	0.8	33.949	7.25	79.1	1.98		24.2
	70		33.961	7.21	79.4	1.97		24.3
21 Feb. 21.00	1	1.2	33.809	7.62	79.0	1.89		24.9
992.1 mb	5	1.1	33.810	7.57	79.0	1.90		24.8
2.2°C	10	1.1	33.821	7.55	78.9	1.88		25.0
270° 5 m · s^{-1}	15	1.1	33.815	7.57				
	20	1.0	33.815	7.56				
	30	0.9	33.915	7.36				
	40	0.9	33.966	7.22				
	50	0.8	34.009	7.06	81.2	2.02		26.1
	60	0.6	34.170	6.71	84.4	2.11		27.4
	70		34.195	6.54	85.7	2.18		27.6
24 Feb. 11.00	1	1.0	33.759	7.55	78.5			24.2
972.4 mb	5	1.0	33.767	7.56	78.5			24.1
2.2°C	10	1.0	33.779	7.61	78.4			24.4
280°C 3 m · s^{-1}	15	1.0	33.795	7.56	79.0			24.4
	20	1.0	33.809	7.52	78.7			24.4
	30	0.9	33.847	7.49	79.2			24.5
	40	0.8	33.870	7.41	78.9			24.7
	50	0.8	33.905	7.30	79.0			25.0
	60	0.8	33.990	7.14	80.2			25.5
	70		34.017	7.01	80.7			26.1

1	2	3	4	5	6	7	8	9
24 Feb. 14.00	1	1.2	33.437	7.63				
971.8 mb	5	1.1	33.475	7.63				
2.6°C	10	1.1	33.767	7.57				
290° 4 m · s^{-1}	15	1.0	33.812	7.56				
	20	1.0	33.831	7.49				
	30	0.9	33.834	7.45				
	40	0.9	33.882	7.32				
	50	0.8	33.926	7.23				
	60	0.8	33.953	7.19				
	69		34.088	6.83				
24 Feb. 17.00	1	1.0	33.363	7.66	77.6			24.2
971.2 mb	5	1.0	33.658	7.67	77.6			24.1
2.8°C	10	0.9	33.806	7.63	77.9			24.4
180° 2 m · s^{-1}	15	0.9	33.821	7.56	77.6			24.2
	20	0.9	33.848	7.51	77.9			24.4
	30	0.8	33.898	7.36	78.9			24.5
	40	0.8	33.909	7.31	79.1			25.0
	50	0.7	33.941	7.23	79.1			25.0
	60	0.7	33.955	7.20	79.3			25.3
	70		33.992	7.09	80.0			25.4
24 Feb. 20.00	1	1.1	33.603	7.65				
971.5 mb	5	1.0	33.790	7.62				
2.6°C	10	1.0	33.800	7.57				
30° 1 m · s^{-1}	15	1.0	33.878	7.40				
	20	0.9	33.890	7.40				
	30	0.9	33.972	7.20				
	40	0.8	33.987	7.14				
	50	0.8	34.002	7.06				
	60	0.7	34.017	7.03				
	70		34.054	6.96				
24 Feb. 23.00	1	1,1	33.445	7.65	78.5			24.2
974.4 mb	5	1.1	33.463	7.62	78.9			24.2
—0.6°C	10	1.0	33.691	7.65	78.9			24.4
140° 4 m · s^{-1}	15	1.0	33.798	7.60	78.9			24.4
	20	1.0	33.945	7.23	79.6			25.4

1	2	3	4	5	6	7	8	9
	30	0.8	33.997	7.13	81.4			25.7
	40	0.8	34.072	6.87	82.3			26.5
	50	0.7	34.123	6.75	83.0			26.8
	60	0.6	34.120	6.76	83.0			27.1
	70		34.134	6.71	83.2			27.1
25 Feb. 2.00	1		33.543	7.62				
978.3 mb	5		33.584	7.60				
—0.8°C	10		33.811	7.56				
190° 3 m • s^{-1}	15		33.921	7.31				
	20		33.882	7.34				
	30		34.007	7.07				
	40		34.086	6.82				
	50		34.120	6.74				
	60		34.166	6.62				
	70		34.179	6.59				
25 Feb. 5.00	1	0.9	33.358	7.66	78.5			24.6
980.6 mb	5	0.9	33.622	7.59	78.9			24.7
—0.2°C	10	0.9	33.805	7.57	79.0			24.7
270° 6 m • s^{-1}	15	0.9	33.820	7.51	78.7			24.6
	20	0.8	33.841	7.39	78.9			25.1
	30	0.7	33.933	7.24	79.0			25.3
	40	0.6	33.976	7.15	80.3			25.4
	50	0.6	34.047	6.94	82.0			26.1
	60	0.5	34.187	6.53	84.4			27.2
	70		34.229	6.41	84.8			27.6
25 Feb. 8.00	1	0.9	33.550	7.62				
983.8 mb	5	0.8	33.615	7.58				
0.6°C	10	0.8	33.696	7.56				
270° 9 m • s^{-1}	15	0.8	33.771	7.54				
	20	0.8	33.865	7.35				
	30	0.7	33.966	7.19				
	40	0.7	33.978	7.15				
	50	0.6	34.034	7.00				
	60	0.5	34.019	7.02				
	70		34.098	6.80				

1	2	3	4	5	6	7	8	9
25 Feb. 11.00	1	0.9	33.714	7.54	79.4	2.00		25.0
985.2 mb	5	0.9	33.763	7.53	79.5	2.00		25.0
1.0°C	10	0.9	33.754	7.56	79.5	2.00		25.0
250° 15 m • s^{-1}	15	0.9	33.706	7.56	80.7	1.99		25.0
	20	0.9	33.862	7.41	80.7	1.99		25.0
	30	0.9	33.922	7.33	81.0	2.06		25.2
	40	0.9	33.971	7.24	82.2	2.08		25.5
	50	0.8	33.999	7.15	82.8	2.15		25.6
	60	0.8	34.024	7.05	83.0	2.16		26.4
	70		34.021	7.05	84.0	2.21		26.3
28 Feb. 12.00	1	0.9	33.808	7.56	81.2	1.83		23.7
	5	0.9	33.801	7.55	80.8	1.85		23.9
	10	0.9	33.805	7.59	80.8	1.85		23.7
	15	0.9	33.809	7.54	80.4	1.84		23.9
	20	0.9	33.811	7.43	80.4	1.90		23.9
	30	0.9	33.840	7.45	81.1	1.91		23.9
	40	0.9	33.861	7.42	81.1	1.95		24.3
	50	0.9	33.857	7.40	81.6	1.94		24.3
	60	0.8	33.855	7.41	81.6	1.98		24.5
	70		33.878	7.36	81.4	2.04		25.0
28. Feb. 19.00	1	1.0	33.697	7.82	79.6	1.76		22.2
	5	1.0	33.696	7.80	78.5	1.75		22.0
	10	1.0	33.695	7.83	79.5	1.77		22.1
	15	1.0	33.703	7.80	79.1	1.76		22.2
	20	1.0	33.720	7.79	79.1	1.76		22.3
	30	1.0	33.772	7.66	79.9	1.83		22.8
	40	0.9	33.791	7.61	81.2	1.94		23.4
	50	0.8	33.793	7.59	80.4	1.96		23.6
	60	0.8	33.793	7.58	80.8	1.98		23.7
	70		33.797	7.55	80.4	2.05		23.8
4 March 11.00	1	1.1	33.643	7.83	78.5	1.82		22.4
1013.2 mb	5	1.1	33.655	7.80				
0.0°C	10	1.1	33.700	7.71	78.2	1.85		22.9
260° 11 m • s^{-1}	15	1.1	33.700	7.72				
	20	1.1	33.785	7.52	78.5	1.91		23.5

1	2	3	4	5	6	7	8	9
	30	1.0	33.879	7.10	81.2	2.04		24.4
	40	0.9	33.974	7.04	82.8	2.10		25.5
	50	0.6	34.091	6.73	85.6	2.18		26.6
	60	0.5	34.113	6.66	84.6	2.18		27.3
	70		34.172	6.48	85.3	2.21		28.3
4 March 16.00 1013.2 mb 0.2°C 260° 11 m • s^{-1}	1	1.1	33.652	7.81	79.3	1.83		22.1
	5	1.1	33.654	7.81				
	10	1.1	33.662	7.80	80.8	1.87		22.2
	15	1.1	33.675	7.78				
	20	1.1	33.697	7.67	80.4	1.91		22.7
	30	1.1	33.818	7.46	81.6	1.96		23.5
	40	0.9	34.002	6.97	84.0	2.13		25.5
	50	0.5	34.187	6.40	87.5	2.35		27.6
	60	0.4	34.197	6.27	89.9	2.36		28.2
	70		34.227	6.23	90.3	2.39		28.3
7 March 11.00 998.7 mb 0.2°C 240° 13 m • s^{-1}	1	0.8	33.829	7.24	85.5	2.10		25.8
	5	0.8	33.830	7.22				
	10	0.8	33.837	7.21	85.5	2.12		25.8
	15	0.8	33.875	7.20				
	20	0.8	33.876	7.20	84.9	2.12		25.6
	30	0.8	33.883	7.23	84.8	2.11		25.6
	40	0.8	33.884	7.22	84.5	2.22		25.5
	50	0.8	33.874	7.27	84.0	2.16		25.6
	60	0.7	33.900	7.25	83.6	2.17		25.7
	70		33.927	7.18	84.1	2.17		25.8
7 March 16.00 999.8 mb 0.8°C 250° 9 m • s^{-1}	1	1.0	33.775	7.28	85.2	2.18		25.4
	5	0.9	33.769	7.28				
	10	0.8	33.878	7.27	84.9	2.12		25.2
	15	0.8	33.885	7.27				
	20	0.8	33.889	7.28	84.6	2.11		25.3
	30	0.8	33.891	7.27	84.2	2.13		25.0
	40	0.8	33.893	7.24	84.4	2.19		25.0
	50	0.8	33.930	7.17	84.4	2.19		25.3
	60	0.8	33.966	7.12	84.8	2.22		25.1
	70		33.962	7.10	84.4	2.23		25.0

1	2	3	4	5	6	7	8	9
10 March 11.00	1	0.9	33.733	7.42	82.5	1.93	0.22	25.8
982.0 mb	5	0.9	33.736	7.42				
—0.6°C	10	0.9	33.740	7.41	84.4	1.94	0.21	25.7
260° 15 m • s⁻¹	15	0.9	33.729	7.41				
	20	0.9	33.759	7.40	82.8	1.94	0.21	25.8
	30	0.9	33.806	7.35	81.6	1.95	0.20	25.5
	40	0.9	33.857	7.30	82.8	1.98	0.19	26.0
	50	0.9	33.867	7.28	82.5	2.01	0.21	26.0
	60	0.8	33.873	7.27	82.3	2.02	0.23	25.9
	70		33.939	7.11	83.4	2.02	0.22	26.4
10 March 16.00	1	1.0	33.776	7.39	82.8	1.99		25.6
983.2°C	5	0.9	33.770	7.39				
0.3°C	10	0.9	33.771	7.38	82.6	1.98		25.6
260° 18 m • s⁻¹	15	0.9	33.773	7.37				
	20	0.9	33.771	7.38	82.6	1.94		25.8
	30	0.9	33.792	7.38	82.3	1.96		
	40	0.9	33.808	7.37	82.4	2.01		25.4
	50	0.9	33.837	7.33	81.8	2.01		25.5
	60	0.8	33.865	7.28	82.3	2.02		25.6
	70		33.880	7.24	81.6	2.02		25.6

The hydrological and hydrochemical situation in Ezcurra Inlet depends on anemobaric conditions and periodic, predominantly 12-hr cycle tides. The geographical situation of the fiord and its topography (in particular the steep inclination of the floor towards Admiralty Bay and further to Bransfield Strait) ensure free exchange of water with the open ocean. Slight differences in water density from surface to bottom mean that vertical mixing takes place with particular ease.

The surface waters of the fiord are under the influence of those flowing down the glacier and thawing ice floes. During strong solar radiation, an epidermal stratum of low-salinity water is produced on the surface. This has only a slight effect on the vertical density structure. This effect appears in the form of a transient salinity gradient down to a depth of 5 m. It must, however, be emphasized that throughout the whole water column a small, permanent salinity gradient continues down to the bottom, as an outcome of large-scale seasonal climatic variations. The mean vertical salinity distribution for the measuring period is shown in Fig. 2 where also the dispersion of single values is marked as $\pm 1\sigma$ standard deviation.

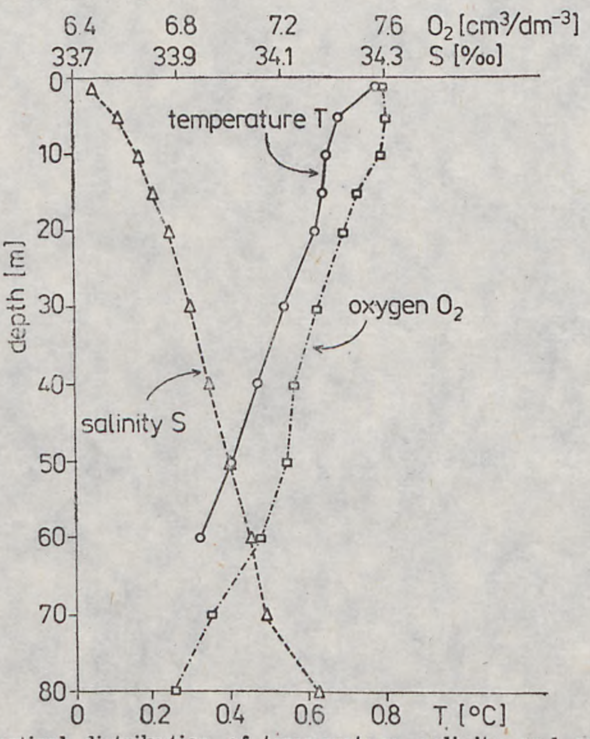

Fig. 2. Vertical distribution of temperature, salinity and oxygen concentration in Ezcurra Inlet waters at the anchored station during the period of 1 January — 10 March 1978 (mean values)

Rys. 2. Pionowy rozkład temperatury, zasolenia i stężenia tlenu w wodach fiordu Ezcurra od 1 I do 10 III 1978r. (wartości średnie)

The concentrations of inorganic nutrients are high, their relative variations in time and vertical cross-sections being, however, small. In the majority of cases they fall within the range of experimental errors. More differentiated concentrations of the inorganic nutrients can be related to particular hydrological situations where intrusion of waters from the deeper strata of the open ocean occurred. Variations, which could be unequivocally attributed to life activity of plankton in these waters do not appear, however, particularly as regards a decrease in concentrations at depths corresponding to the maximum photosynthesis or seasonal drop accompanying the spring-summer phytoplankton blooming.

Oxygen. The fluctuations of oxygen concentration are greatest and readily observable both within vertical cross-sections and in time. Fig. 3 illustrates fluctuations of mean oxygen concentrations at various depths during particular decades from December to March. In the surface layer, at a depth of 1 m, the mean concentration (in $cm^3 \cdot dm^{-3}$) was 7.69 ± 0.27 (1σ). During the following decades it varied only slightly from 7.46 to 7.66 $cm^3 \cdot dm^{-3}$, with the exception of the first decade of December with its exceptionally high mean concentration of 8.23 $cm^3 \cdot dm^{-3}$. This high value was caused by the first five measurements run during the first 24 hrs after the ship's arrival. Such high values were never observed again.

At the next two depths the fluctuations of oxygen concentrations were similar and the mean values identical, thus indicating equalization of concentrations within the whole layer down to a depth of 10 m. Beginning from the 15-m level, the oxygen concentration decreases at a rate of about 0.01 $cm^3 \cdot dm^{-3} \cdot m^{-1}$. If in further considerations one omits the high values recorded during the last decade of December, it can be observed that the deviation of single measurements from the mean, expressed as $\pm 1\sigma$ standard deviation, decreases with depth, to attain the lowest values at 20—40 m, then increases once more to reach the highest value at the bottom. An identical pattern can also be noted in salinity distribution which also shows that the most stable layer is that lying mid-way between the surface and the bottom (Table 2).

The fluctuations of oxygen concentrations in time have different causes at the surface and at the bottom. Assuming that the surface water layer should be close to equilibrium with atmospheric oxygen, the fairly large differences in surface concentrations, even after averaging in particular decades of the months, were striking. Calculation of the percentage oxygen saturation based on the UNESCO solubility tables

(1973) data for waters of given salinity and temperature revealed that almost all of them were less than 100%, falling mostly within the 92—98% range. The equilibrium of oxygen concentration in sea water depends, however, not only on the temperature and salinity, but also on its partial pressure at the air — sea interface. This, in turn, depends

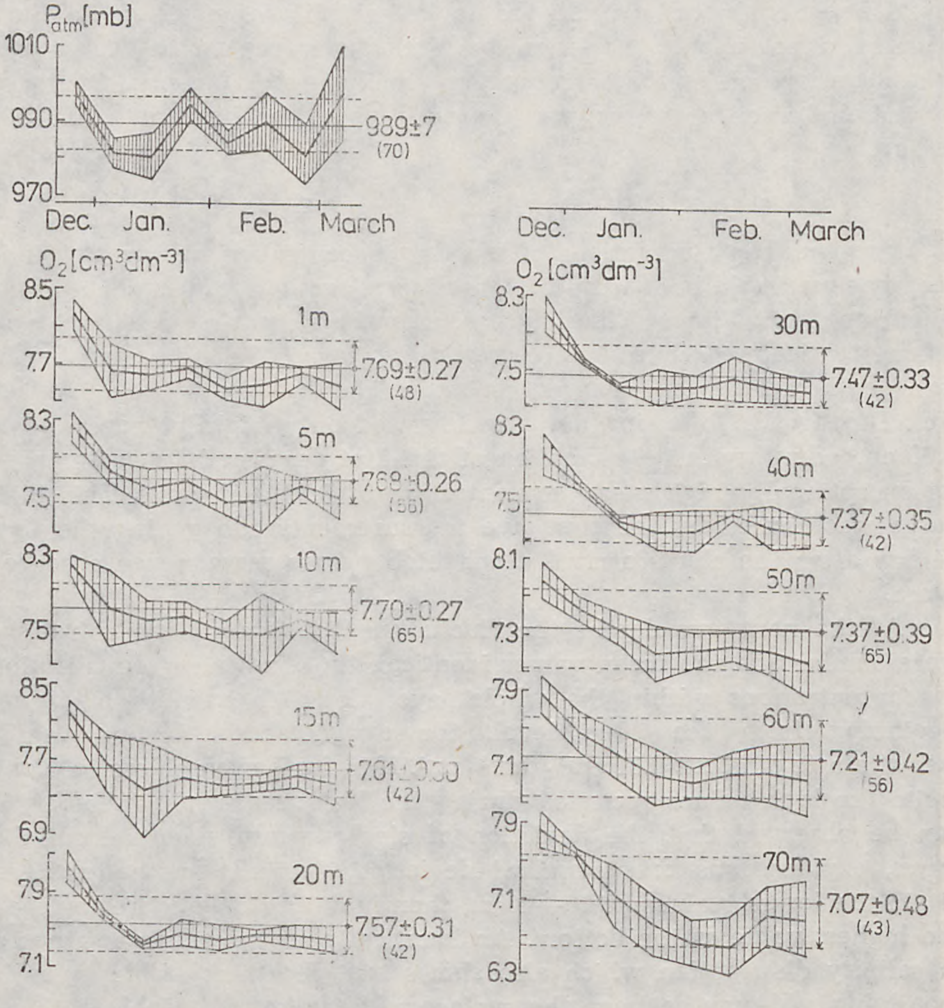

Fig. 3. Temporal variations in oxygen concentrations at different depths. The concentrations are averaged over decades of months

The shaded area indicates spread of the data within ±1 S.D. limits. On the right, mean oxygen levels for the whole observation period are given. In parentheses the numbers of measurements is given.

Rys. 3. Wahania stężenia tlenu w czasie na różnych głębokościach. Stężenia są uśrednione dla poszczególnych dekad miesięcy.

Obszary zacienione ukazują rozrzut wyników w granicach jednego standardowego odchylenia. Liczby po prawej stronie rysunków oznaczają średnie stężenia tlenu dla całego okresu obserwacyjnego. W nawiasach podano liczbę pomiarów.

Table 2. Summary of hydrochemical data for the Ezcurra Inlet water during the period of 1 Jan. — 10 March 1978

Tab. 2 Podsumowanie danych hydrochemicznych dla wód fiordu Ezcurra od 1 stycznia do 10 marca 1978

Depth Głębokość m	Temperature Temperatura °C	Salinity Zasolenie ‰	Oxygen Tlen $cm^3 \cdot dm^{-3}$	Silicates Krzemiany	Phosphates Fosforany	Nitrites Azotyny	Nitrates Azotany
				$\mu mol \cdot dm^{-3}$			
1	0.78±0.32 (49)	33.738±0.164 (49)	7.59±0.15 (40)	80.89±2.07 (34)	1.879±0.15 (30)	0.181±0.02 (16)	24.57±1.1 (34)
5	0.70±0.31 (52)	33.788±0.109 (53)	7.61±0.17 (49)	80.69±1.68 (40)	1.900±0.14 (37)	0.176±0.02 (27)	24.52±0.9 (41)
10	0.65±0.33 (51)	33.832±0.081 (53)	7.59±0.16 (50)	81.07±2.0 (47)	1.905±0.12 (44)	0.170±0.2 (29)	24.60±1.0 (48)
15	0.64±0.35 (49)	33.856±0.084 (49)	7.50±0.15 (35)	80.47±1.7 (12)	1.824±0.15 (8)	0.170±0.01 (5)	24.97±1.3 (10)
20	0.62±0.36 (48)	33.879±0.073 (48)	7.44±0.15 (34)	81.07±2.3 (15)	1.961±0.10 (11)	0.190±0.02 (3)	24.61±1.1 (14)
30	0.54±0.37 (51)	33.924±0.072 (52)	7.34±0.16 (35)	81.69±1.8 (19)	1.972±0.11 (16)	0.176±0.02 (5)	24.97±1.0 (18)
40	0.47±0.38 (52)	33.961±0.084 (48)	7.25±0.20 (35)	82.24±1.8 (15)	2.064±0.09 (11)	0.190±0.02 (3)	25.24±0.7 (14)
50	0.40±0.38 (52)	34.003±0.096 (52)	7.23±0.31 (50)	82.65±2.02 (46)	1.996±0.15 (43)	0.170±0.02 (26)	85.67±1.28 (47)
60	0.32±0.37 (50)	34.040±0.109 (50)	7.12±0.34 (49)	83.43±2.47 (45)	2.014±015 (42)	0.167±0.02 (25)	26.12±1.42 (46)
70		34.071±0.120 (41)	6.93±0.37 (36)	83.85±3.06 (23)	2.096±0.13 (19)	0.171±0.02 (7)	26.48±1.50 (23)
80		34.167±0.090 (10)	6.79±0.31 (10)	85.78±2.70 (10)	2.033±0.10 (10)	0.146±0.01 (9)	27.76±1.20 (10)
90			6.26 (1)	93.4 (1)	2.09 (1)		30.0 (1)

Average values ± 1 S.D.

Średnie wartości ± 1 S.D.

In parentheses — numbers of measurements

W nawiasach — liczby pomiarów

on its molar fraction in the gas and its total pressure. The oxygen solubility tables were drawn up under the assumption that the molar fraction of oxygen in dry air was 0.2095, the relative humidity 100% and the atmospheric pressure equal to 1013 mb (760 mm Hg). Meteorological observations carried out on board the ship showed that the Ezcurra Inlet zone was frequently in a low pressure area. Averaged values of atmospheric pressure shown in Fig. 3 resemble those of the oxygen concentrations in the surface layer of water down to a depth of 5 m, i.e. increase in atmospheric pressure goes hand-in-hand with an increase in oxygen concentration in the water and vice versa.

A correction factor accounting for the variations in oxygen solubility under the effect of pressure and humidity fluctuations can be calculated from the following equation:

$$\delta_p = \left(\frac{P_{atm} - \left(\frac{h}{100}\right) p_o}{760 - p_o} - 1 \right) 100\%$$

where:

P_{atm} — the atmospheric pressure [mm Hg],
h — the relative humidity of air [%],
p_o — the pressure of saturated water vapour at water temperature.

Whilst at temperatures close to 0°C, fluctuations of humidity had only a slight effect (of the order of 0.1—0.2%), fluctuations of atmospheric pressure could not be ignored, as can be seen from the following data:

P_{atm} [mm Hg]	770	760	750	740	720	710
δ_p [%]	+1,3	0,0	−1,3	−4,0	−5,3	−6,6

Barometric records showed that the lowest atmospheric pressure in this region during the whole research period was 969.6 mb (727 mm Hg) (on Feb. 6th, 1978, 09.00 hrs GMT). The corresponding correction factor for this pressure, δ_p, is —4.3%.

The low pressure accounts, however, only for part of the low results for oxygen in the surface waters. During the observation period there were frequently cases of low oxygen concentrations at relatively high pressures. The most striking case is afforded by the situation on 7th March, 1978, 11.00 hrs GMT, when the oxygen concentration in the surface water was one of the lowest measured (7.24 $cm^3 \cdot dm^{-3}$), and the saturation was 91%. The atmospheric pressure recorded on this day at 09.00 hrs GMT was 1018 mb (764 mm Hg) and was the highest measured in this region during the whole observation period. Vertical distribution of all hydrological and hydrochemical parameters was very even from the surface down to the bottom, thus indicating that the water body was well mixed (Fig. 4). That the water came from the deep is indicated not only by the low oxygen concentration, but also by high levels of silica, phosphates and nitrates characteristic for this type of waters.

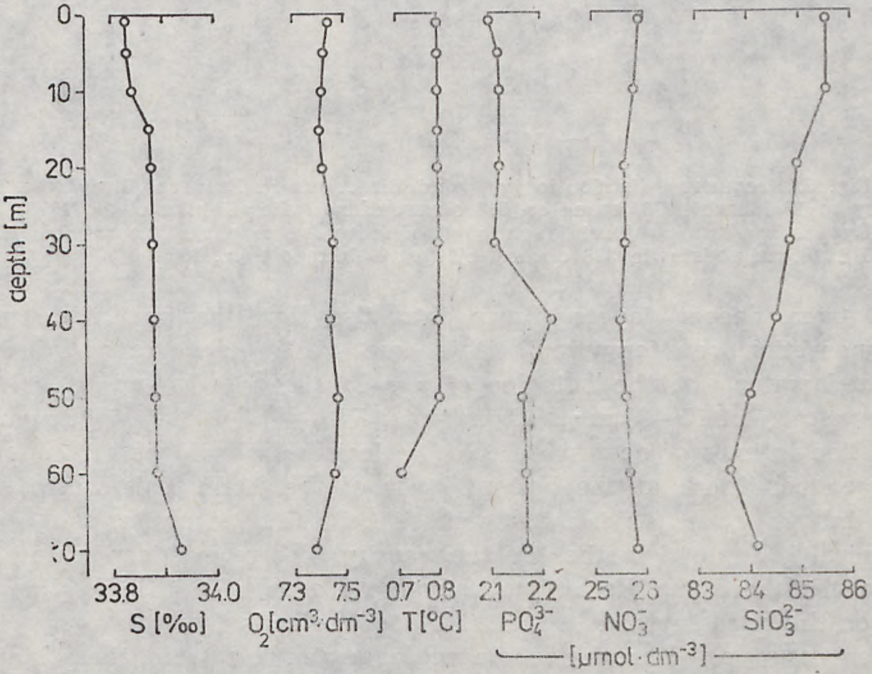

Fig. 4. Vertical distribution of hydrochemical parameters on 7 March 1978, 11.00 GMT

Rys. 4. Pionowy rozkład parametrów hydrochemicznych w dniu 7 marca 1978, 11.00 GMT

The development of this situation should be ascribed to the action of wind. The situation of Ezcurra Inlet along the WSW — ENE axis and the considerable height of the glacier-coated slopes makes the distribution of wind directions highly unsymmetrical, with distinct preponderance of westerly winds (42% of all cases, Fig. 5). The mean wind velocity, calculated from eight periods during 24 hrs for the period of summer investigations, was 7.4 and 6.3 $m \cdot s^{-1}$ for Ezcurra Inlet and the nearby Arctowski Polish Polar Station, respectively. The west winds were the strongest, reaching velocities of 30 $m \cdot s^{-1}$ and more. They push the surface water out of the fiord into Admiralty Bay, from where wa-

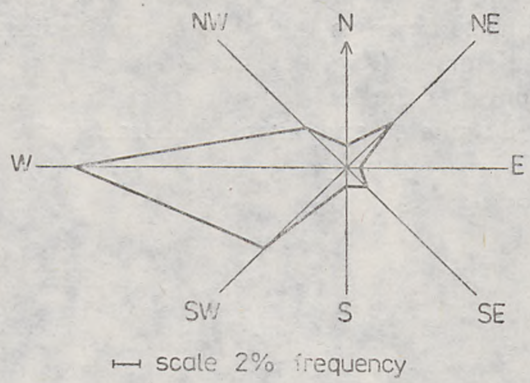

Fig. 5. Frequency distribution of wind directions in Ezcurra fiord from 1 January to 16 March 1978, based on 536 observations (after Pahlke et al., 1978)

Rys. 5. Rozkład częstości kierunków wiatrów we fiordzie Ezcurra od 1 I do 16 III 1978, na podstawie 536 obserwacji (wg Pahlkego i in., 1978)

ter from deeper layers flows into the fiord as an undersurface compensation countercurrent. This case of the appearance of well-mixed water was the outcome of a 3-day storm with winds blowing at a velocity of 10—30 m · s^{-1} from sector W.

The inflows of deep water play a decisive role in the formation of oxygen conditions at the bottom layer of the fiord. This water, with a salinity of over 34 per mille, comes from the open ocean, penetrating Admiralty Bay and further its arms easily. The term „deep water" has been used here to differentiate it from the warmed and less saline water on the fiord surface. In fact, this deep water is the Antarctic surface water occurring over the whole region extending from the Antarctic continent to the north of Antarctic convergence (to approx. 52°S) where it plunges abruptly to a deeper layer, wedging between subtropical surface water and the warm deep south-flowing current. The water appearing at the inlet to Admiralty Bay from Bransfield Strait constitutes a mixture of fresh water from melting ice and snow with highly saline water from the warm deep current coming from the North Atlantic, and its properties are modified by alternating climatic conditions [1]. It is colder (+1°C to —1°C) and less saline (34.0—34.4 per mille) as compared with the warm, deep current. Due to the mixing, the oxygen concentration increases from those typical for the warm deep current (4—4.5 cm^3 of O_2 per dm^3) to 6—6.5 cm^3 of O_2 per dm^3 at a depth of 200 m and to 7—7.5 cm^3 of O_2 per dm^3 on the surface. Freshly upwelled deeper Antarctic waters are thus oxygen-deficient and absorb it from the atmosphere tending to equilibrium. The departure from saturation state may provide an indication as to the time when the upwelling occurred. Finding of quantitative relationships is complicated, as, among other things, the structure of oxygen profiles in a particular water body, turbulent diffusion processes and the dynamics of the invasion of oxygen from the atmosphere to water under fluctuating meteorological conditions should be accounted for.

It can be seen from Fig. 6 that the relationship between the oxy-

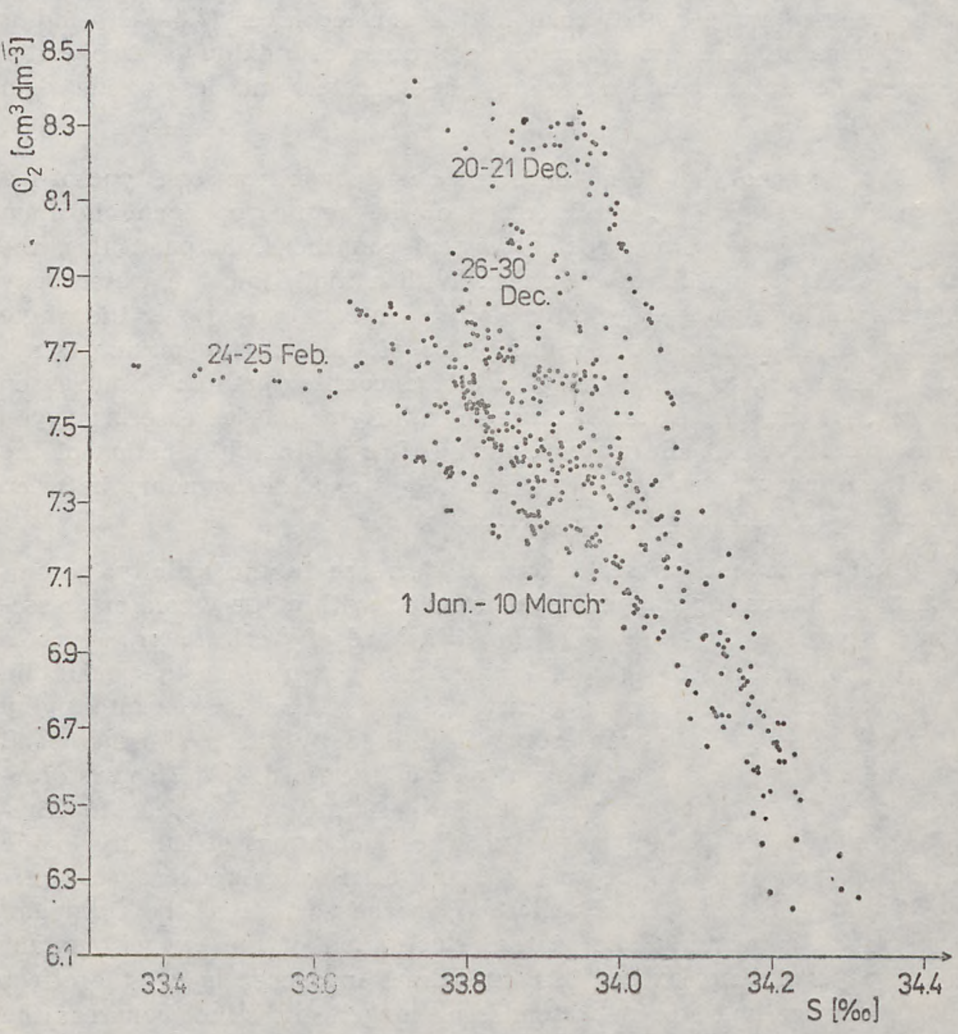

Fig. 6. Relationship between salinity and oxygen concentration in Ezcurra Inlet waters

Rys. 6. Zależność między zasoleniem a stężeniem tlenu w wodach fiordu Ezcurra
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gen content in water and salinity cannot be represented by one straight line. At a salinity of less than 33.9 per mille the oxygen concentration is close to saturation and varies only slightly as the salinity varies (ΔO_2 [$cm^3 \cdot dm^{-3}$]/ΔS[‰] = 0.2—0.5). This situation is observed in the surface layer of water (down to a depth of 15 m) where the equilibration with the atmosphere is facilitated by the action of waves, wind and movements of ice sheets. At depths where the salinity exceeds 34 per mille, the decrease of the oxygen content with increasing salinity is an order of magnitude higher than in the surface layer (2.8—4.4) and is linear. This relationship reflects the process of mixing of two water masses, the upper being more oxygen-saturated and less saline than the lower.

At a depth of 15—40 m there is a changeover from one type of relationship to the other, the situation of the boundary depending upon existing hydrological and meteorological conditions. In particular, the strong effect of tides was observed. With a high tide, the water body moves from Admiralty Bay to the fiord at an equal speed over the whole vertical cross-section. During this phase of the tide the mixing is not very significant, as the water does not encounter greater obstacles on its way. At the bottom, an increase in salinity and a decrease in oxygen level is observed as the water flows in. During the culmination of the tide these magnitudes reach extreme values and the boundary between the two layers shifts up to the surface.

During the ebb phase, a gradual decrease in the salinity, accompanied by increasing oxygen level is noted within the whole cross-section. There is a large outflow from the fiord of fresh water, which is produced from thawing glaciers and flows down over the mountain sides. As the water recedes during the ebb tide, it mixes intensively with sea water, the process being facilitated by the shallowness and roughness of the floor in the distal part of the fiord. Fig. 7 shows diurnal fluctuations in vertical distribution of salinity and oxygen together with relative variations of sea level. The fluctuations of salinity in the surface layer down to a depth of 15 m are irregular and probably reflect the patchiness of its distribution on the surface of the fiord and Admiralty Bay waters. The diurnal fluctuation of the oxygen contant in this layer did not exceed 0.11 $cm^3 \cdot dm^{-3}$. In deeper layers the effect of thawing ice and stream waters is no longer so distinct, whereas the observed fluctuations in salinity, with simultaneous change in oxygen content, are due to the tides (Fig. 8). The relationship between oxygen content and salinity is linear (Fig. 9). The extrapolation of this relationship, as well as others shown in Fig. 6, to a salinity of 35 per mille gives the

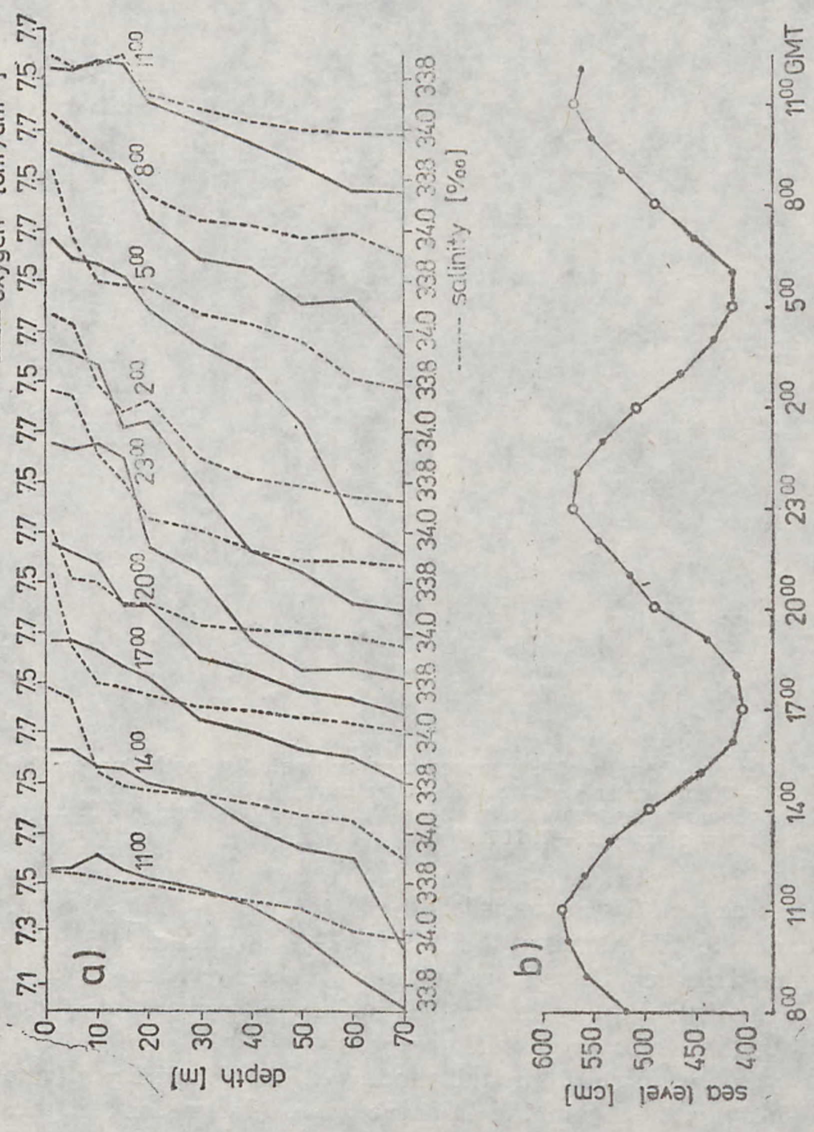

Fig. 7. Diurnal course of the oxygen concentration (solid lines) and salinity (dashed lines) changes with depth in Ezcurra Inlet waters on 24—25 February 1978
A record of tide phases is shown in the lower part of the Figure

Rys. 7. Dobowy przebieg zmian stężenia tlenu (linia ciągła) i zasolenia (linia przerywana) z głębokością w wodach fiordu Ezcurra 24—25 II 1978 r.
W dolnej części rysunku pokazano zapis faz pływu

oxygen content to be in the range of 4.0—4.6 cm³ • dm⁻³. These values are typical for deep waters coming from outside the convergence zone as the preceding warm deep current and remain unaffected by mixing.

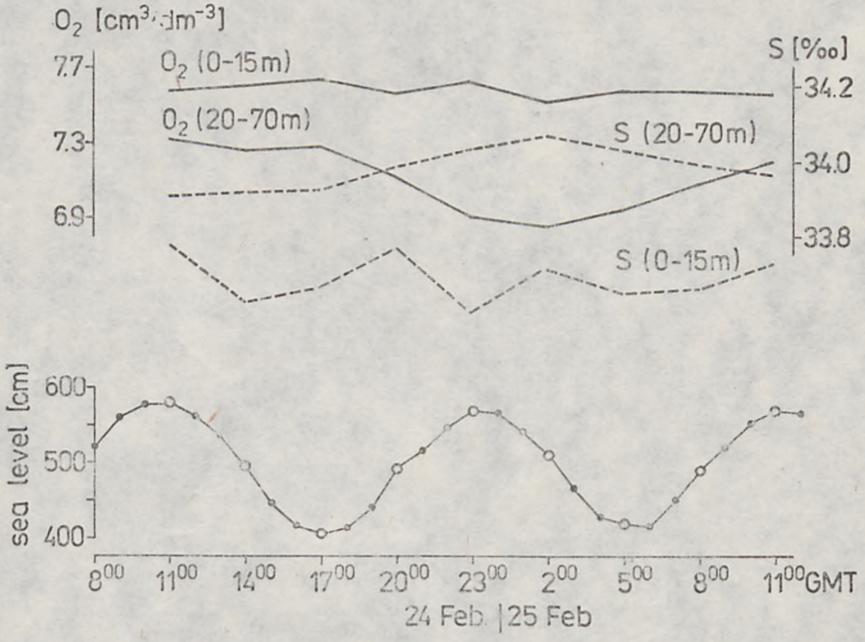

Fig. 8. Diurnal changes of oxygen content and salinity in the upper (0—15 m) and lower (20—70 m) water strata on 24—25 February 1978

Rys. 8. Dobowe zmiany zawartości tlenu i zasolenia w górnej (0—15 m) i dolnej (20—70 m) warstwie wody 24—25 II 1978 r.

The lowest oxygen levels recorded by us were 6.2—6.3 $cm^3 \cdot dm^{-3}$ and corresponded to the highest salinities (34.2—34.3 per mille). The linear relationship between these parameters and their vertical distributions indicate that both the oxygen content and salinity over the whole area explored in the water layer below approx. 20—30 m change fairly monotonously owing to the thorough mixing of deep waters with those of lower salinity produced in the in-shore zone. Fluctuations of the oxygen content in water is mostly affected by physical factors. The role played by phytoplankton as an oxygen producer in the photic zone is likely to be negligible as indicated by the absence of maxima on oxygen distribution curves ($\Delta O_2 < 0.1$ $cm^3 \cdot dm^{-3}$). Occasionally, negative oxygen anomalies were observed (not exceeding 0.2 $cm^3 \cdot dm^{-3}$) which could be unequivocally ascribed to larger populations of krill in this water layer (single specimens were found in water bottles). These facts indicate that over the ocean area explored, continuous absorption of oxygen from the atmosphere takes place.

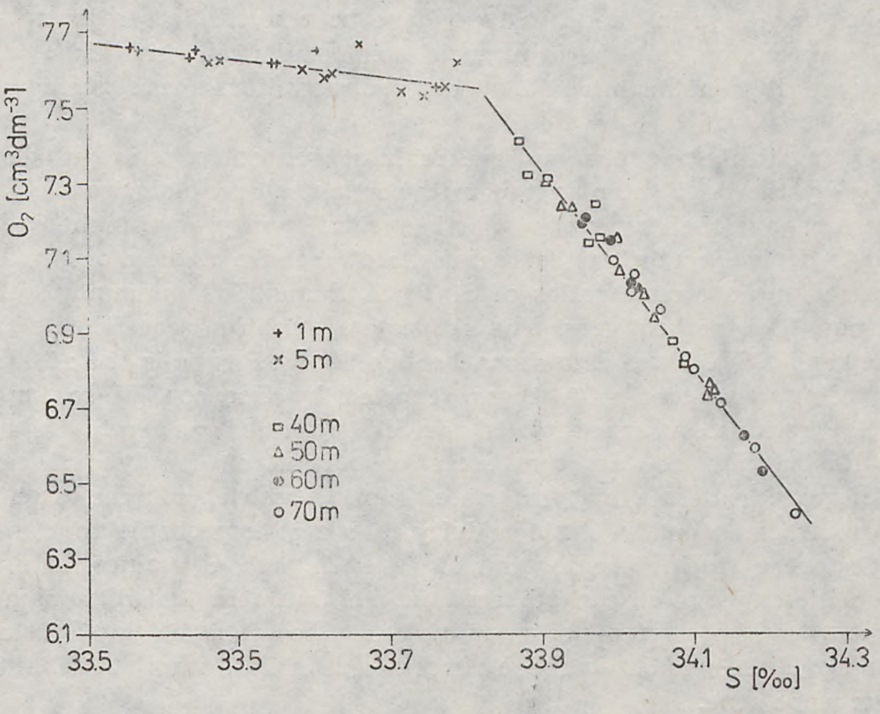

Fig. 9. Oxygen — salinity relationship based on the measurements carried out during 24—25 February 1978

Rys. 9. Zależność między stężeniem tlenu a zasoleniem na podstawie pomiarów w dniach 24—25 II 1978 r.

Nutrient salts. Waters around the Antarctic, south of the convergence zone, are known to be abundant in inorganic phosphorus, nitrogen and silicon compounds, the origin of which should be ascribed mostly to the Atlantic deep. This refers also to the South Shetland Islands, thus including Ezcurra Inlet. A statistical characteristic of the results of measurements of the levels of dissolved silicate silicon, phosphate phosphorus and nitrate and nitrite nitrogen is shown in Table 2. The weighted averages within the whole water column for the period from January 1st to March 10th, 1978, were 82.2, 1.96, 25.4 and 0.17 μmol $\cdot$ dm^{-3}, respectively. The fluctuations in time were small as shown by the low variation coefficient values, $\delta_n/\bar{x}$, amounting to 2.2, 6.4, 3.8 and 4.1%, respectively. There are no temporal fluctuations of the values in vertical distribution attributable to the life activity of plankton.

The slight decrease in the phosphate phosphorus level noted during the last few days in January could have been attributed to its uptake by phytoplankton, but the difference is not statistically significant and, moreover, it is not confirmed by other observations made during this period.

Owing to the fact that in Ezcurra Inlet nutrient salts are produced mostly by the decay of plankton in the Atlantic, and biological activity did not change their mutual proportions significantly, one might expect them to depict proportions characteristic of the site of their origin. The measured mean atomic ratios of Si/P, Si/N and N/P amount to 42.3, 3.17 and 13.5, respectively. The respective variation coefficients are 6.4, 3.0 and 7.7%. These data show that the Si : N : P ratio is 42.3 : 13.5 : 1, thus being consistent with those reported by Spencer [5] so far as the N/P ratio is concerned, whilst the Si/P ratio is considerably higher. Notwithstanding the fact that some proportion of dissolved silicates in Antarctic waters might originate from terrestrial sources, such as rock weathering and volcanic activity, it seems improbable that these sources were responsible for the observed high Si/P values. A more reasonable explanation can be based on the argument that diatoms predominate in the phytoplankton in the area between 50 and 40°S and they provide the main source of excess silicon in waters south of the convergence zone.

Occasionally, surface and bottom concentrations of nutrients differ markedly from each other, as in the case of salinity and oxygen content. Most often, however, the water is so well mixed that the concentrations of all nutrient salts in the whole water body (from surface to bottom) are practically equal. In some cases, however, the differences can be determined with satisfactory accuracy. They amount, on average to ±2.4, 4.4 and 4.9% for $SiO^{2}{}_{3}{}^{-}$, $PO^{3}{}_{4}{}^{-}$ and NO_3^-, respectively. The greatest differentiation, noted on March 4th, 1978, amounted to ±5.6, ±11.8 and ±11.3%. Where the concentrations vary with depth, there is distinct linear relationship between the concentrations of particular nutrients as well as between these nutrients and the salinity and oxygen levels (Figs 10 and 11).

The mean atomic ratios of the $\Delta Si/\Delta P$, $\Delta Si/\Delta N$ and $\Delta N/\Delta P$ were determined by the best fit of the linear relationship to the results of measurements of individual components within vertical cross-sections of the water body. The respective values are 23.1, 1.51 and 14.8 and differ markedly from the simple Si/P, Si/N and N/P values determined in these waters. Thus, in the transformation processes of waters, changes in the concentrations of the components due to mixing are accompanied by a change in their proportion. This process is reflected by the

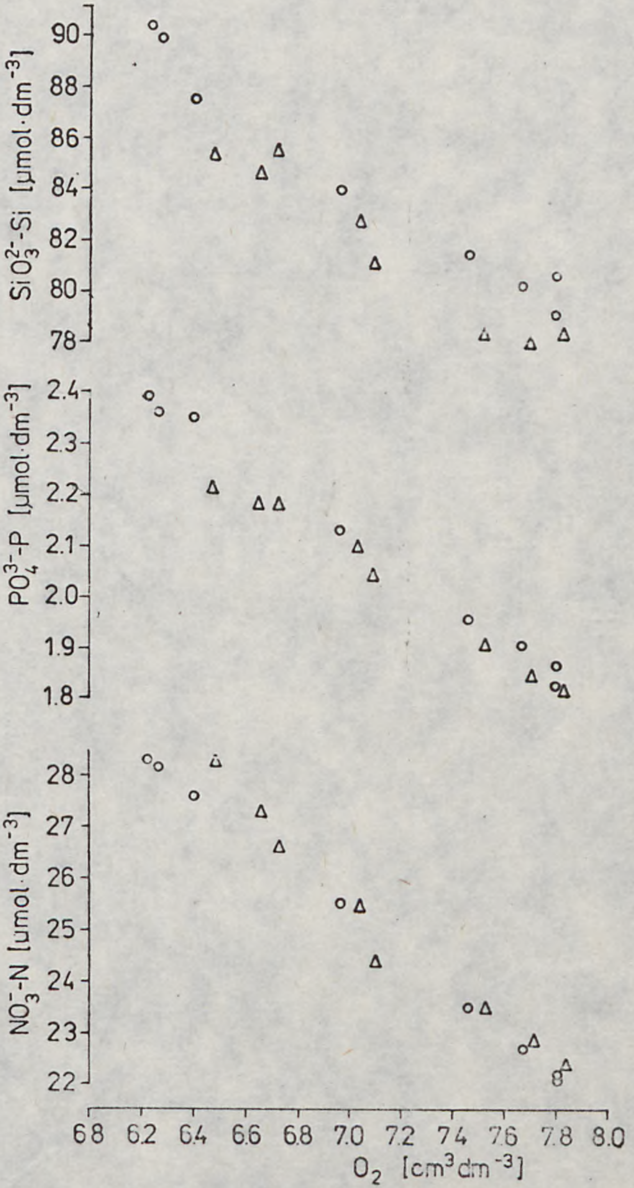

Fig. 10. Nutrient-oxygen relationships in Ezcurra Inlet waters (4 March 1978)
O — flow tide, Δ — ebb tide

Rys. 10. Współzależności między substancjami biogennymi a tlenem w wodach fiordu Ezcurra (4 III 1978 r.)
O — faza przypływu, Δ — faza odpływu

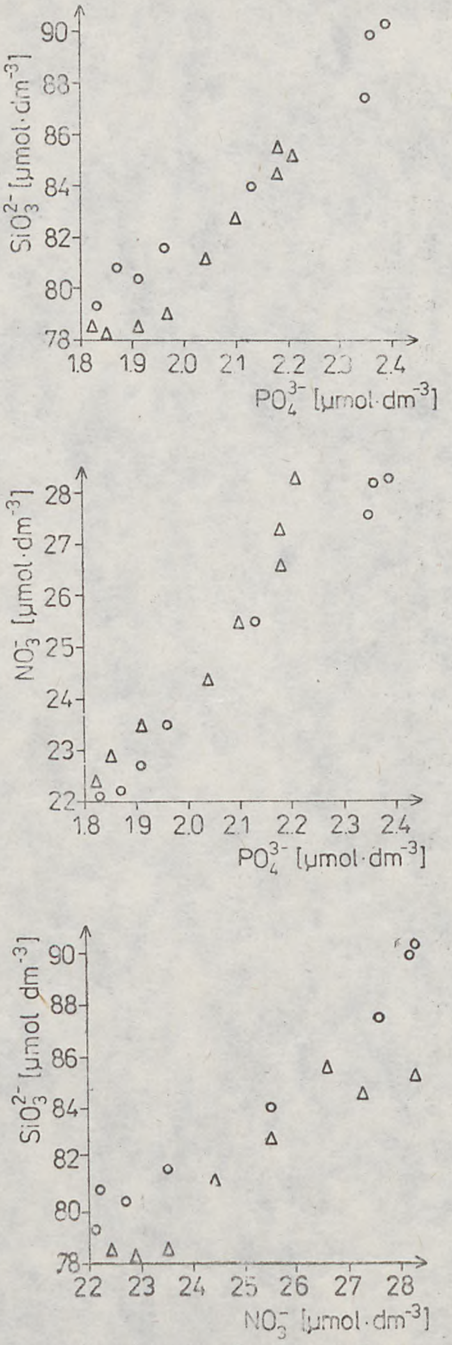

Fig. 11. Inter-nutrient relationship in Ezcurra Inlet waters (4 March 1978). O — flow tide, Δ — ebb tide

Rys. 11. Współzależności między poszczególnymi substancjami biogennymi w wodach fiordu Ezcurra (4 III 1978 r.)
O — faza przypływu, Δ — faza odpływu

differentiation of the levels of nutrient salts in the surface and bottom waters. The highest levels of silicates, phosphates and nitrates at the bottom are 93.4, 2.39 and 30.0 μmol • dm^{-3}, respectively. They usually occur simultaneously and are accompanied by the highest salinity and lowest oxygen levels. The opposite situation is observed on the surface.

A change in the proportion of the components is possible only in the case when ionic relations in water diluting the bottom water are different. During the expedition, water samples were taken from six melt-water streams flowing down the mountain sides from the ice cap to the fiord. The samples were taken on two or three occasions at various time intervals. The results of the analyses of these samples, shown in Table 3, indicate that the inflow of fresh water can affect ionic relations in the fiord waters.

Simple calculations of the budget of nutrient salts in the upper and lower layers of fiord waters and mean concentrations of the salts in inflowing waters enable the evaluation of the conditions under which the mixing of these two types of water can produce such proportions of salts as those measured. The closest agreement with the data given in Table 3 can be obtained by substituting in the calculations various ratios of volumes of fresh waters flowing to the fiord to those of sea water flowing in from Admiralty Bay so as to obtain a ratio close to 1:9.35. The corresponding nutrient salt concentrations in fresh waters, satisfying the budget equations, amount to 43, 0.3 and 0.9 μmol · dm^{-3} of SiO_3^{2-}, PO_4^{3-} and NO_3^-, respectively.

There were always some quantities of nitrite nitrogen in the Ezcurra Inlet waters. The mean level of this form of nitrogen was 0.17 μmol · dm^{-3} and fluctuated over a relatively narrow range of 0.13—0.24 μmol · dm^{-3}. There was no regularity in these fluctuations, the levels remaining constant over the whole observation period from December to March. There was also no significant differentiation in vertical distribution, with the exception of a slight tendency for the concentration to decline with depth. On the other hand, considerable nitrite levels (up to 200 μmol • dm^{-3}) were observed in shallow basins formed in rocky depressions on land around the fiord, which were visited by water flow. It is likely that at least a part of the nitrites occurring in fiord waters originates from thawing ice and excrement from the birds. This form of nitrogen is likely to be unimportant, yet it can be indicative of biological activity in near-shore waters.

During February and March attempts were made to estimate the quantity of organic phosphorus and nitrogen in the fiord waters (i.e. the difference between total P and N and the concentrations of PO_4^{3-}-P and NO_3^--N). The total P and N were determined by wet oxidation with

Table 3. Mean concentration of nutrient elements in streams discharging into Ezcurra Inlet
Tab. 3. Średnie stężenie pierwiastków biogennych w strumykach spływających do fiordu Ezcurra

Stream (number of samples) Strumyk (liczba prób)	Concentration Stężenie (µmol · dm^{-3})				Atomic ratios Stosunki atomowe		
	SiO_3^{-2}-Si	PO_4^{3}-P	NO^-_3-N	NO^-_2-N	Si/P	Si/N	N/P
1 (3)	35.8	0.81	1.36	0.03	44.2	26.3	1.68
2 (3)	35.3	1.22	0.77	0.05	28.9	45.8	0.63
3 (3)	16.6	0.96	0.71	0.19	17.3	23.4	0.74
4 (3)	25.0	0.80	0.74	0.19	31.3	33.8	0.93
5 (2)	20.7	0.18	0.51	0.06	115	40.6	2.83
Average Średnia (14)±1 S.D	25.2±9.1	0.73±0.49	0.86±0.46	0.10±0.07	34.5	29.4	1.18
Ezcurra Inlet water Woda z fiordu Ezcurra	82.2±1.8	1.96±0.13	25.4±1.0	0.17±0.01	42.3	3.17	13.5

ammonium persulphate in Teflon autoclaves [2]. In the total number of five series of measurements the organic forms of P and N occurred in concentrations of less than 10% of the total quantities of these elements, i.e. lower than the accuracy of the analytical procedure employed. On this basis the preliminary conclusion can be drawn that phosphates and nitrates provide the predominating forms of phosphorus and nitrogen, respectively, and that the contribution of organic forms of the elements does not exceed 2 — 3 μmol · dm^{-3} of N and 0.2 μmol · dm^{-3} of P.

All water samples taken for analyses were unfiltered. The fiord waters contained appraciable amounts of suspended matter, mostly of mineral origin (0.5 — 2.7 mg · dm^{-3}, mean 1.3 mg · dm^{-3}). Its role as a carrier of certain forms of nutrient salts is unquestionable. The results of chemical investigations of suspensions in this region will be published separately. It is worth noting here that the concentration of phosphorus in the suspended matter, determined after complete decomposition of the material with $HF+HClO_4$, was 0.3 μmol · dm^{-3} on average, ranging between 0.06 and 0.70 μmol · dm^{-3}. The mean content of total phosphorus in the suspended matter was 0.12%, being higher than that in the suspension washed off the land (0.070%). The difference can be considered as phosphorus bound with plankton and organic detritus. Rough calculations showed that approx. 30% of the suspended phosphorus was of organic origin. Phosphorus in the suspension displayed stronger dynamics of changes than the dissolved phosphorus. Its peak concentrations appeared in December (0.5 μmol · dm^{-3} on average). The phosphorus concentration then declined in time, reaching a mean value of 0.1 μmol · dm^{-3} in March. Similar variations were noted in the contribution of the phosphorus mass in the suspension. These variations are undoubtedly due to those of the biological activity of waters, peak intensity of which occurred during the initial period of our investigations.

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HYDROCHEMICZNE OBSERWACJE WE FIORDZIE EZCURRA NA ZAKOTWICZONEJ STACJI

Streszczenie

W pracy przedstawiono wyniki pomiarów rozpuszczonego tlenu, fosforanów, krzemianów, azotynów i azotanów w wodach fiordu Ezcurra, wykonywanych od 19 XII 1977 do 10 III 1978 w ramach II Wyprawy Antarktycznej Polskiej Akademii Nauk. Średnie wartości w okresie obserwacyjnym wynosiły (w μmol · dm$^{-3}\pm1\sigma$): Si 82.2±1.8, P 1.96±0.12, NO_2' — N 0.17±0.02 i NO_3' — N 25.4±1.0, a średnie zasolenie wynosiło w tym czasie 33.913‰. Udział rozpuszczonych organicznych form fosforu i azotu nie jest większy niż 10% ogólnej ich ilości. Zmiany stężeń rozpuszczonych składników biogennych i stężenia tlenu kształtują się pod wpływem czynników fizycznych, głównie wiatru i pływów. Rytmy biologiczne nie wpływają zauważalnie na zmiany zawartości tlenu i rozpuszczonych substancji biogennych, natomiast uwidaczniają się w sezonowej zmienności fosforu zawieszonego. Wody fiordu Ezcurra nie wytwarzają stabilnej struktury grawitacyjnej, co sprzyja wyrównywaniu stężeń w całej kolumnie wodnej pod wpływem czynników powodujących mieszanie. Permanentne niedosycenie tlenem sprawia, że wody w tym rejonie pochłaniają tlen z atmosfery.

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