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Distribution of dissolved amino acids, dissolved saccharides and urea in the southern Drake Passage and the Bransfield Strait during BIOMASS-FIBEX, 1981 *)

ABSTRACT: Following compounds were determined in samples from Bransfield Strait and southern part of Drake Passage (area "A"): dissolved free- and combined amino acids. dissolved mono- and polisaccharides and urea.

Concentration of urea in most samples ranges from traces to 1.5 μgat $N_{urea} \cdot l^{-1}$ and total urea content in water column from 10 to 150 m lies between 19.23 and 197.4 mgat N_{urea}. Dissolved free amino acids concentration ranges from 0 to 0.60 $\mu g \cdot l^{-1}$ and total free amino acid content are found to be between 20 and 60 mmol. Concentrations of combined amino acids lay below 7 $\mu mol \cdot l^{-1}$ and integrated value for combined amino acids fluctuates between traces and 450 mmol.

Monosaccharides concentrations in most samples do not exceed 2.5 $\mu mol \cdot l^{-1}$ and their content in water column lies below 180 mmol. Polysaccharides content in water column ranges from 1.8 to 3.94 mol and concentrations vary between 8 and 32 $\mu mol \cdot l^{-1}$.

Evident differences in the content of dissolved organic compounds between Bransfield Strait and southern part of Drake Passage were found.

Key words: Antarctica, FIBEX, dissolved amino acids. dissolved saccharides, urea

1. Introduction

Dissolved organic matter (DOM) in the sea includes true dissolved matter together with colloidal material passing by a 0.45 μm membrane filter. DOM is usually predominant form of organics in the sea. The amount of DOM exceeds the particulate organic fraction by a factor of 10-20 and particulates include not only detritus and phytoplankton but also bacterioplankton, zooplankton and fish (Riley and Chester 1971).

The sources of DOM are generally grouped into three categories:

1) excretion and/or secretion from plankton, nekton and benthos,
2) bacterial and autolytic decomposition of organic debris and
3) allochthonous drainage i.e. from land, rivers, air, wastes.

Allochthonous sources are of special importance in coastal waters and estuaries where DOM may accumulate in quantities high enough to generate anoxic conditions (Bent and Goulder 1981).

Ecological significance of DOM is undoubtedly very high. It functions as the source of organic substrates for heterotrophic metabolism (Dawson and Gocke 1978, Steward 1979, Burney, Johnson and Sieburth 1981); phytoplankton may use some dissolved compounds as a readily assimilable form of carbon or nitrogen (Carpenter, Remsen and Watson 1972, Crawford, Hobbie and Webb 1974). Some DOM sonstituents may act as growth-promoting or inhibiting factors, antibiotics, vitamines (Riley and Chester 1971). Special value for marine organisms has chelating action of DOM; on one hand it improves the availability of trace metals and on the other it decreases "activity" of toxic metals (Sunda and Lewis 1978, Fisher and Food 1980).

The constituents of dissolved organic matter with high biological significance are: amino acids, free- and combined, used as a source of carbon and nitrogen and with high chelating action, mono- and polysaccharides, a valuable substrate for heterotrophic metabolism and urea (source of nitrogen). Concentrations of all those compounds are usually very low mainly because of their very short turn-over time (Williams et al. 1976, Lee and Bada 1977, Dawson and Gocke 1978). Accumulation of such compounds may suggest some disturbances in the ecosystem.

There are only few data on quantity and quality of dissolved organic matter in polar regions. In the Antarctic such investigations have been carried out by Zlobin et al. (1975), Naletova and Vladymirskaja (1977), Naletova (1979). In Arctic waters DOM was analysed by Loder and Hood (1972). The aim of this work was to determine the concentrations of dissolved free amino acids (DFAA), dissolved combined amino acids (DCAA), dissolved monosaccharides (DMCHO), dissolved polysaccharides (DPCHO) and urea in water samples collected from some oceanographic stations located in FIBEX area "A".

2. Material and methods

Water samples were collected from six levels: 10, 30, 50, 75, 100 and 150 m. For technical reasons it was not possible to process more samples from one station. Fig. 1 presents stations investigated in FIBEX Area "A". Detailed data on stations location are given by Rakusa-Suszczewski (1982).

Surface water was not investigated because there was no possibility to cut off technological and sanitary sewage. Samples of seawater were collected with a precleaned, sterile organic-glass bathometer (6 l volume) and immediately transferred to precombusted at 450°C glass bottle. Samples were
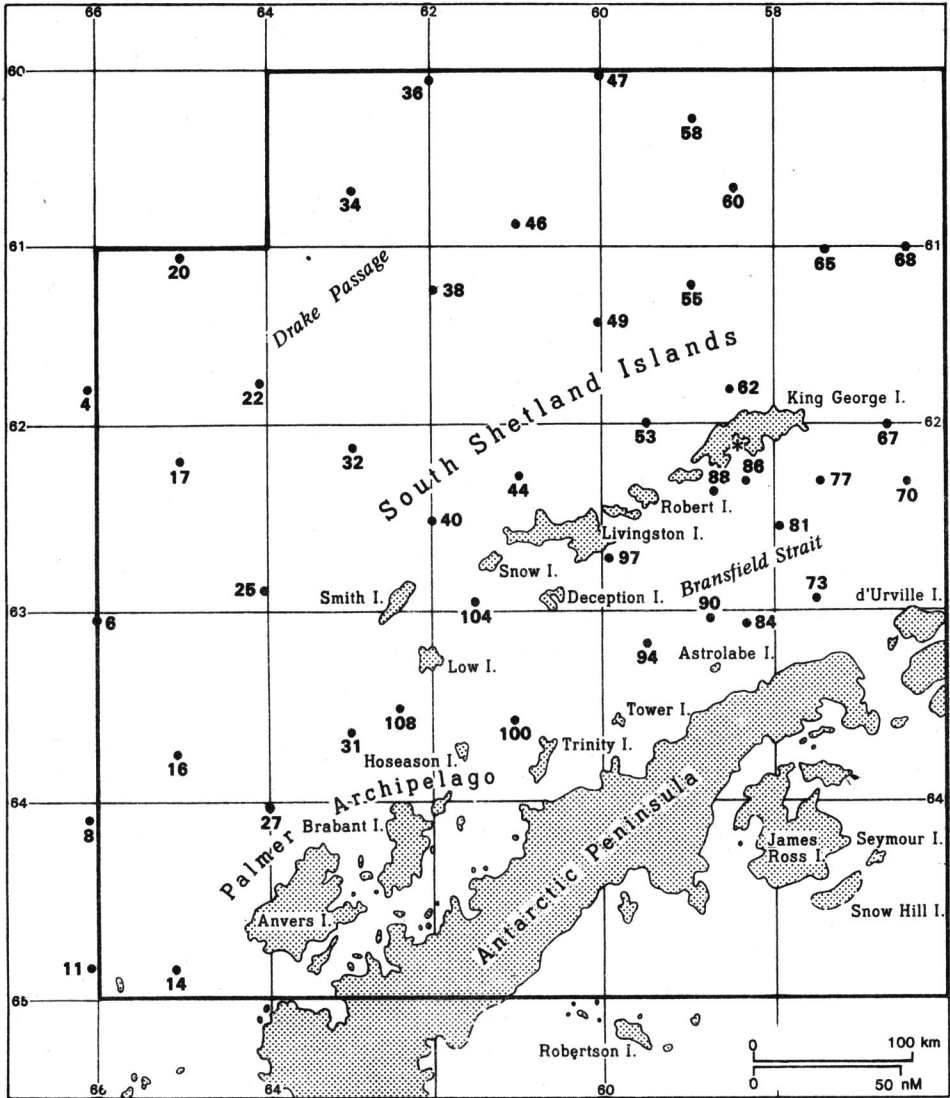
Fig. 1. Stations locations in the southern Drake Passage and in the Bransfield Strait
* — stations 136, 137 and 138 are located in Admiralty Bay (King George Island).

stored at 4 C whilst awaiting analyses. In most cases samples were analysed within 2–3 hours.

Determinations of urea and free amino acids were carried out in non-filtered water. Sugars and combined amino acids were determined in water filtered through $0.40\,\mu m$ membranes filter (Synpor, Czechoslovakia) under slight underpressure. Too high pressure causes cells rupture and overestimation of DOM.

All reagents were of analytical grade. Water used was doubledistilled from a glass distillation unit. All glassware used for the sampling and

work-up of the samples was cleaned by rinsing with detergent (RBS, Pierce, USA) followed by copious rinses with bidistilled water. The glassware was than dried in a cabinet at 450°C to reduce the level of organic contaminations.

Membrane filters were boiled in three successive portions of doubly distilled water.

Determination of urea. K o r e l e f f (1976) method was used. Volume of a sample was 35 ml. 2 g NaCl was added to each sample instead of 4 g proposed by K.oroleff. All analysis were made in duplicates. Analytical determinations were made with a Specord spectrophotometer (Carl Zeiss, GDR).

Determination of amino acids. Free amino acids were determined in non-filtered water with the o-phthalaldehyde fluorimetric method according to D a w s o n and L i e b e z e i t (1980 a). Fluorescence was measured after exactly 2-minutes incubation with a Spectro/glo Filter Fluorimeter (Gilson Medical, USA). Combined amino acids were determined as the difference between total amount of amino acids (after hydrolysis) and free amino acids. Hydrolysis conditions were as follows: 4 N HCl, 20 hours, 105°C, under N_2. After the hydrolysis period samples were neutralized to pH 6—8 (NaOH) and the neutralized hydrolizates were analyzed by methods described above for free amino acids. All determinations were made in duplicates.

Determination of sugars. MBHT method was used (D a w s o n and L i e b e z e i t 1980 b). Samples were filtered. Polysaccharides were determined as a difference between total sugar concentration (aftei• hydrolysis) and monosaccharides concentration. Hydrolysis: 0.1 N HCl, 20 hours, 105°C. After cooling samples were neutralized with NaOH. Spectrophotometer Specord (Carl Zeiss, GDR) was used for analytical determinations.

3. Results

Urea. Concentration of urea in all samples analyzed ranges from traces to 3.603 $\mu gatN_{urea} \cdot 1^{-1}$. Most of results are contained in narrower limit; in almost 75% of data urea concentrations lay between 0 and 1 $\mu gatN_{urea} \cdot 1^{-1}$ and in 93% of cases — between 0 and 1.5 $\mu gatN_{urea} \cdot 1^{-1}$. Total urea content under 1 m^2 in water column from 10 to 150 m (integrated value) ranges from 19.23 (station 32) to 197.4 mgatN $_{urea}$ (station 88). Detailed data are presented in Table I.

The highest urea content were found in the region of Bransfield Strait and over the shelf north of South Shetland Islands (stations 40, 44, 62). Also stations 34, 46, 42, northern most of area "A" are rich in urea. The rest of the stations lay in region poor in urea.

Vertical gradients of urea concentrations are very heterogenous. In stations 32, 38, 53, 77, 97 full vertical homogeneity of urea concentration is found. Stations 14, 20, 22, 27, 34, 36, 55, 60, 62, 68, 70, 73, 100, 137, 138 and — in a lesser degree — stations 11, 25, 84, 86 reveal the presence of a single peak, chemocline, located on different depths. In only six stations chemocline occurs in line with pycnocline (11, 14, 27, 36 and 25, 86).

Table I.

Concentration of urea in seawater samples in different stations (μgat$-N_{urea}\cdot l^{-1}$)

Depth (m)	4	6	8	11	14	16	17	20	22	25	27	31	32	34	36	38	40	44	46	47	49	53	55	58	60	62	65	67	68	70	73	77	81	84	86	88	90	94	97	100	104	108	136	137	138
10	n.d.	n.d.	1.074	0.313	0.174	0.043	0.237	0.305	0.254	0.183	0.575	0.460	0.381	0.135	0.485	0.485	2.108	0.540	1.250	1.375	2.965	0.662	0.255	0.340	0.732	1.115	1.227	2.301	0.400	0.567	0.109	0.364	1.013	1.120	1.229	1.257	3.603	0.653	1.014	0.658	1.144	0.518	1.125	0.656	0.594
30	n.d.	n.d.	0.850	1.186	0.152	0.218	0.564	0.316	0.223	0.974	0.690	0.621	0.157	0.247	0.297	0.054	0.622	0.729	0.750	1.725	0.315	0.568	0.510	0.850	0.488	0.662	0.399	1.104	0.200	0.400	0.436	0.509	1.147	0.693	0.754	0.179	0.810	0.862	1.288	0.521	0.954	0.872	1.781	0.844	0.615
50	n.d.	n.d.	0.835	0.917	0.708	0.588	0.586	0.192	0.588	0.304	0.897	0.391	0.247	0.583	1.351	0.216	1.270	1.216	1.850	0.700	0.379	0.599	0.368	0.397	1.394	0.801	0.521	1.740	1.233	1.267	0.109	0.364	0.987	1.147	1.257	1.089	0.783	0.914	1.014	0.685	0.926	0.573	0.593	1.656	0.625
75	n.d.	n.d.	0.380	1.253	traces	0.545	0.474	0.508	0.994	0.142	1.655	0.115	0.224	1.233	0.352	0.351	1.270	1.189	0.925	0.200	0.473	0.536	0.850	0.850	1.045	2.091	0.276	0.982	0.433	0.567	0.436	0.218	0.720	1.440	1.536	1.732	0.836	0.601	1.014	1.397	0.926	0.790	0.750	1.250	0.906
100	n.d.	n.d.	0.380	1.208	traces	0.240	0.271	0.135	0.365	traces	0.529	0.299	traces	2.489	0.595	0.297	1.622	1.000	0.050	1.400	0.473	0.662	0.312	0.227	0.314	1.254	0.890	1.043	traces	0.400	3.381	0.436	0.853	1.627	1.201	2.430	0.783	0.627	1.068	0.630	1.117	0.354	1.625	0.687	0.500
150	n.d.	n.d.	0.660	0.875	traces	1.242	1.113	0.158	0.385	0.669	0.253	0.161	0.045	0.493	0.486	0.486	0.757	1.432	0.800	1.175	0.252	0.145	0.397	0.425	0.139	1.220	0.215	0.859	0.467	0.433	0.872	0.400	0.453	0.667	0.754	0.894	1.044	1.358	0.630	0.740	1.717	0.872	0.937	0.687	0.344
Urea in water column *)	n.d.	n.d.	86.87	145.9	20.71	71.70	76.67	35.40	68.39	48.43	107.3	43.93	19.23	155.9	84.45	42.85	173.6	150.4	114.1	150.9	80.34	71.81	63.91	69.72	89.82	172.2	77.62	170.3	58.35	82.18	171.8	53.80	116.6	164.6	157.9	197.4	146.2	116.8	139.9	109.5	159.3	90.32	163.3	134.9	82.51

n. d. not determined

*) μgat$-N_{urea}$ under 1 m² from 10 to 150 m

Table II.

Concentration of dissolved free amino acids (DFAA) in seawater samples in different stations (μm$\cdot l^{-1}$)

Depth (m)	4	6	8	11	14	16	17	20	22	25	27	31	32	34	36	38	40	44	46	47	49	53	55	58	60	62	65	67	68	70	73	77	81	84	86	88	90	94	97	100	104	108	136	137	138
10	0.338	0.171	2.270	0.670	0.507	traces	0.531	0.243	0.265	0.309	0.628	0.674	0.490	0.377	0.178	0.251	0.540	1.277	0.437	0.317	0.309	0.435	0.259	0.128	0.218	0.344	0.507	0.681	0.630	0.478	0.272	0.561	0.522	0.428	0.328	0.332	0.251	0.398	0.402	0.459	0.350	0.445	0.400	0.296	0.321
30	0.350	0.138	1.635	0.338	0.408	traces	0.396	0.166	0.254	0.356	0.579	0.800	0.585	0.383	0.168	0.254	0.356	0.611	0.548	0.399	0.323	0.271	0.416	0.218	0.134	0.230	0.321	0.385	0.693	0.566	0.415	0.306	0.490	0.481	0.386	0.353	0.321	0.295	0.398	0.414	0.395	0.376	0.419	0.352	0.290
50	0.345	0.017	0.680	0.571	0.641	traces	0.379	0.201	0.466	0.315	0.563	0.756	0.457	0.240	0.189	0.169	0.653	0.530	0.377	0.420	0.171	0.448	0.171	0.192	0.177	0.344	0.204	0.594	0.466	0.392	0.289	0.418	0.493	0.307	0.413	0.350	0.251	0.386	0.414	0.414	0.385	0.351	0.387	0.352	0.284
75	0.402	traces	0.708	0.536	0.548	traces	0.414	0.183	0.236	0.099	0.273	0.718	0.150	0.154	0.054	0.157	0.552	0.566	0.216	0.384	0.116	0.568	0.158	0.239	0.153	0.309	0.111	0.582	0.496	0.329	0.278	0.334	0.386	0.271	0.298	0.274	0.343	0.369	0.414	0.369	0.321	0.257	0.381	0.302	0.302
100	0.426	0.457	0.528	0.641	0.542	traces	0.286	0.083	0.165	0.082	0.197	0.433	0.106	0.069	0.184	0.210	0.493	0.443	0.061	0.152	0.304	0.370	0.076	0.058	0.065	0.286	0.082	0.422	0.193	0.299	0.278	0.328	0.368	0.265	0.298	0.315	0.202	0.300	0.385	0.395	0.332	0.163	0.287	0.327	0.260
150	0.350	0.248	0.466	0.565	0.175	traces	0.356	0.160	0.129	0.075	0.197	0.235	0.170	0.154	0.411	0.210	0.047	0.356	0.361	0.055	0.152	0.133	0.303	0.135	0.023	0.094	0.321	0.082	0.146	0.334	0.064	0.202	0.266	0.253	0.085	0.140	0.207	0.184	0.314	0.299	0.315	0.094	0.212	0.240	0.210
DFAA in water column *)	52.87	28.21	119.8	77.86	66.05	traces	51.73	21.96	33.53	24.72	50.61	78.19	38.23	27.12	27.92	24.07	73.50	75.44	29.89	36.50	29.98	58.40	20.97	17.00	24.18	44.07	26.86	72.76	49.31	46.39	39.37	50.69	54.73	41.95	40.38	39.78	32.86	45.70	55.00	53.32	47.51	34.75	46.67	43.73	37.95

*) mmol DFAA under 1 m² from 10 to 150 m

Table III

Concentration of dissolved combined amino acids (DCAA) in water samples in different stations ($\mu m \cdot l^{-1}$)

Depth (m)	4	6	8	11	14	16	17	20	22	25	27	31	32	34	36	38	40	44	46	47	49	53	55	58	60	62	65	67	68	70	73	77	81	84	86	88	90	94	97	100	104	108	136	137	138
10	0.229	1.775	7.918	13.59	5.885	5.328	4.652	traces	0.086	1.671	0.928	0.010	0.303	0.010	1.236	1.371	traces	0.010	0.399	0.010	1.348	0.011	0.151	0.727	traces	traces	0.010	1.465	0.074	0.495	0.313	4.717	1.697	1.701	0.086	0.965	4.712	0.010	1.067	2.310	0.591	2.680	0.010	0.010	0.010
30	0.010	1.072	3.765	6.970	2.996	5.818	2.128	0.336	0.708	1.624	0.339	1.229	5.148	traces	1.190	1.523	traces	0.010	0.533	0.010	0.011	0.201	0.071	0.808	traces	traces	0.047	0.010	0.010	0.708	0.010	2.601	0.693	5.454	1.467	7.250	1.152	6.983	1.743	2.481	1.149	1.370	0.010	3.174	1.165
50	0.061	2.958	5.556	6.911	3.191	5.371	3.099	0.915	0.392	2.840	1.206	0.704	0.206	5.047	0.511	4.371	traces	0.926	0.010	traces	1.149	0.140	0.832	0.272	traces	traces	0.372	0.748	0.362	0.403	0.107	1.494	3.196	0.891	8.467	2.146	0.847	2.105	6.119	2.049	1.276	1.311	1.568	3.782	0.010
75	0.691	6.430	0.744	4.437	2.963	9.581	1.673	0.010	0.011	8.531	0.419	0.825	7.247	0.010	0.037	2.894	traces	0.010	0.010	traces	0.012	6.635	0.010	0.239	traces	traces	0.295	0.010	0.705	0.356	0.010	6.637	1.472	0.660	1.034	1.517	1.811	1.126	5.140	1.773	0.590	3.857	8.733	0.108	0.010
100	0.843	4.605	0.840	8.451	1.200	6.322	5.213	1.589	0.010	1.806	3.620	0.596	6.199	0.594	0.010	0.833	traces	0.174	0.010	0.010	0.010	0.027	0.010	0.391	traces	traces	0.062	1.916	0.277	1.783	0.010	0.575	1.425	0.680	2.751	1.772	1.077	2.992	6.317	5.465	2.079	1.051	3.212	0.010	0.010
150	1.459	3.559	4.342	13.09	5.399	9.931	3.098	1.831	0.313	2.165	1.307	7.475	7.330	traces	2.529	1.941	traces	0.830	0.010	0.472	traces	4.401	0.807	0.977	traces	traces	1.059	2.833	0.060	1.154	0.011	1.596	5.604	2.976	9.957	8.410	3.059	1.688	9.424	3.113	1.023	1.164	0.010	0.010	0.010
DCAA in water column *)	89.23	526.2	439.1	1185.3	444.6	1015.4	427.6	133.0	32.34	448.2	222.1	270.36	707.5	116.6	111.5	343.0	traces	49.34	87.85	12.95	40.41	284.2	42.44	74.62	traces	traces	45.58	174.6	38.59	132.8	6.460	360.2	331.1	262.7	593.6	517.6	251.4	369.7	784.4	445.9	175.9	248.9	374.6	152.0	24.50

*) — mmol DCAA under 1 m² from 10 to 150 m

Table IV

Concentration of dissolved monosaccharides in seawater samples in different stations ($\mu m \cdot l^{-1}$)

Depth (m)	4	6	8	11	14	16	17	20	22	25	27	31	32	34	36	38	40	44	46	47	49	53	55	58	60	62	65	67	68	70	73	77	81	84	86	88	90	94	97	100	104	108	136	137	138
10	1.442	2.853	4.509	traces	traces	0.909	0.966	0.347	0.636	0.210	0.524	0.380	0.570	0.526	0.409	0.294	0.853	1.553	1.304	0.371	0.743	0.279	0.754	0.583	0.583	0.644	0.954	6.568	0.028	0.201	0.575	0.270	1.667	0.638	0.638	0.510	0.091	0.937	1.875	2.243	traces	0.190	0.722	0.462	0.925
30	1.202	4.601	1.994	0.114	traces	1.562	0.455	0.607	0.636	0.420	0.804	0.380	0.949	0.760	0.877	0.500	0.735	0.994	1.460	traces	0.314	1.117	0.559	0.583	0.667	0.361	0.954	1.006	0.199	0.690	0.172	0.392	1.102	0.372	0.319	0.842	0.122	0.750	1.469	0.208	0.174	0.316	0.202	0.520	1.272
50	1.971	4.018	2.025	0.428	traces	0.710	0.455	0.376	1.590	0.385	0.280	0.506	1.266	0.731	0.702	0.206	0.559	1.149	1.863	0.201	0.571	0.419	1.173	0.556	0.694	0.412	0.412	2.101	0.199	traces	0.431	0.417	1.716	0.532	0.452	0.561	0.335	0.531	0.844	0.243	0.174	0.411	0.636	0.347	0.607
75	2.308	3.190	2.239	0.371	traces	0.824	1.420	0.462	0.665	0.280	0.734	0.348	1.139	0.731	0.789	0.382	0.648	1.149	1.429	0.400	0.257	0.391	0.670	0.667	0.722	0.412	0.696	5.769	0.227	0.201	0.287	0.343	0.417	0.559	0.452	0.561	0.457	0.656	1.375	0.121	0.174	0.411	0.636	0.347	0.578
100	1.202	5.031	2.147	1.000	traces	1.080	0.767	0.578	0.434	0.734	2.028	0.443	3.354	0.643	1.053	0.765	0.559	1.118	1.429	0.714	0.429	0.335	0.754	0.667	0.556	0.412	0.464	3.580	0.369	0.029	0.201	0.417	0.417	0.505	0.319	0.689	0.183	0.625	0.719	0.764	traces	0.570	0.347	0.520	0.318
150	2.212	3.589	1.994	2.400	1.057	0.881	2.131	3.584	0.751	1.294	0.559	0.538	1.171	1.140	4.327	0.912	1.618	1.242	2.019	0.314	0.657	0.866	0.099	1.333	0.583	0.335	0.515	1.711	0.341	0.460	0.172	0.221	0.441	0.186	0.319	0.587	0.457	0.469	1.062	0.347	traces	0.222	0.318	0.520	0.780
MCHO in water column *)	240.9	569.1	316.9	118.7	32.17	139.4	146.5	146.9	106.5	86.04	136.0	61.45	246.7	107.8	204.8	78.61	113.4	163.0	223.9	52.83	65.49	78.54	107.6	105.0	88.26	57.05	85.56	454.0	36.77	33.42	37.90	49.66	114.4	63.35	54.17	89.10	40.60	87.88	155.1	172.41	11.74	53.25	62.43	64.00	94.22

*) mmol MCHO under 1 m² from 10 to 150 m

In stations 8, 16, 40, 49, 65, 67, 90 and 31, 81 urea concentrations decrease and in stations 17, 44, 94, 104 and 25 increase with depth. In stations 136, 137, 138 composing a hydrographic profile of Admiralty Bay urea content gradually decrease from the entrance to the bay (163.3→ 134.9→82.51 μgatN$_{urea}$) and there is a marked rise in vertical homogeneity of urea concentrations. Stepwise sinking of the chemocline is also observed in the profile.

Dissolved free amino acids. DFAA concentrations in the area "A" range from traces to 2.270 μmol·l^{-1}. Nearly 80% of data obtained lay in the range 0.15—0.60 μmol·l^{-1} and 93% of the data are found between 0 and 0.60 μmol·l^{-1}.

Total DFAA under 1m^2 in the water column from 10 to 150 m ranges from traces (station 16) to 119.8 mmol (station 8) but for 80% of stations DFAA content lays between 20 and 60 mmol (see Table II).

The highest DFAA concentrations were observed in Bransfield Strait, over the shelf north of South Shetland Islands and on the south-west of the area "A". In the region of open ocean only stations 4 and 17 are DFAA-rich. Other stations are poor in DFAA.

In the profile in Admiralty Bay (stations 136, 137 and 138) DFAA content decreases from the entrance to the bay (46.27→43.73→37.95 mmol).

Vertical gradients of DFAA in the area investigated are diverse but decreasing forms prevail. In some stations (e.g. 22, 25, 27, 31, 47, 53, 58) a distinct chemocline may be found. In most cases it is located near pycnocline. Stations 4, 20, 62, 74, 90, 97, 104 reveal more-or-less homogeneous pattern of DFAA vertical distribution. No relation was found between type of vertical gradient and location of the station. In the Admiralty Bay profile homogeneity of vertical distribution of DFAA increases from station 136 through 137 to station 138.

Dissolved combined amino acids. Concentrations of DCAA in the area investigated lay between traces and 13.59 μmol·l^{-1}. Over 82% of data obtained range from 0 to 4 μmol·l^{-1} and nearly 95% of the results are below 7 μmol·l^{-1}.

DCAA content in water column 10–150 m under 1 m^2 fluctuates between trace amounts and 1185.3 mmol. For about 83% of stations DCAA content in water column do not exceed 450 mmol. Detailed data are presented in Table III.

The richest region in DCAA is Bransfield Strait and in particular stations near South Shetland Islands, the shelf on south-west of the area "A" (stations 11, 16 and 8, 14) and some stations in the open ocean (6, 32 and 17, 25). Remaining open ocean samples and the samples of the shelf waters north of South Shetland Islands are poor or even very poor in DCAA.

Combined amino acids content in stations in Admiralty Bay decreases rapidly from the entrance to the bay (374.6 mmol in station 136, 152.0 mmol in station 137 and 24.50 mmol in station 138).

The nature of DCAA vertical gradient is so variable that it is difficult to find any regularities among all stations. In most cases single or multiple chemoclines are found. The chemoclines often appear near the pycnocline

(stations: 6, 8, 32, 34, 38, 46, 49, 55, 81, 86, 108). Stations 22, 40, 47, 62, 68, 73 have homogenous vertical distribution of DCAA. In many stations a decrease of DCAA concentrations from 10 m level to various depths is observed.

In the profile in Admiralty Bay (stations 136, 137, 138) there is an increase in vertical homogeneity. Chemocline in these three stations reveal a tendency to shallow.

' Monosaccharides. MCHO concentrations in samples from area "A" range from traces to 6.568 μmol·l^{-1}. More than 80% of data do not exceed 1.25 μmol·l^{-1} and 95% of the results lay below 2.5 μmol·l^{-1}.

MCHO content under 1 m^2 in water column from 10 to 150 m ranges from 11.74 mmol (station 104) to 569.10 mmol (station 6) but nearly 85% of stations contain less than 180 mmol of MCHO (see Table IV).

The highest MCHO content is found in the region of open ocean, in particular in the western part of area "A". In the eastern part stations 68, 47 and 49 are poor in MCHO. Stations in Bransfield Strait have in general low MCHO content with the exception of stations 67, 97, 81. On the shelf on south-west of the area investigate MCHO contents (except of station 14) are high.

Over the shelf north of South Shetland Islands stations 40 and 44 are rich in MCHO while stations 53, 62 have lower MCHO content. Vertical gradients of MCHO are very different in all stations. In some stations (31, 60, 62, 68, 74, 77, 84, 86, 88, 90, 94, 104, 108) vertical distribution of MCHO is quite homogeneous. In stations 11, 14, 20, 25, 34, 36, 40, 58 MCHO concentrations increase with depth. In some stations (4, 6, 16, 17, 22, 27, 32, 46, 49, 53, 55, 70, 81, 97) chemocline is formed but only in stations 6, 16, 22, 32, 34, 36, 38, 46, 55, 65, 81 chemocline locates near the pycnocline. Stations from Admiralty Bay profile are characterized by a very irregular vertical gradients of MCHO concentrations. MCHO content in water column in these stations (136, 137, 138) slightly increases from the entrance to the bay (62.43→64.00→94.22 mmol).

Polysaccharides. From technical reasons complete set of data on PCHO concentrations is not available for stations 1–43. For the remaining stations PCHO concentration range from 2.001 μmol·l^{-1} to 40.712 μmol·l^{-1}. 75% of all results lay between 13 and 28 μmol·l^{-1} and about 90% of all data range from 8 to 32 μmol·l^{-1} (Table V).

The lowest PCHO content in the water column (10–150 m, under 1 m^2) was found in station 108 (1.210 mol) and the highest — in station 53 (3.940 mol). About 80% of stations contain more than 1.8 mol.

The highest PCHO content are specific for open ocean stations and shelf stations north of South Shetland Islands. In Bransfield Strait the values are lower (except of station 84).

Vertical gradients of PCHO concentrations are very complicated in shape. In many cases multiple maxima occur. Only stations 44, 46, 47, 86 reveal homogeneous vertical distribution of PCHO. Stations 53 and 84 are nearly homogeneous. In general there is no correlation between the location of the chemo- and pycnocline.

In the profile in Admiralty Bay there is also an increase of homogeneity

Table V.

Concentration of dissolved polysaccharides in seawater samples in different stations (μm·l^{-1})

Depth (m)		No. of station																											
	4–40	44	46	47	49	53	55	58	60	62	65	67	68	70	73	77	81	84	86	88	90	94	97	100	104	108	136	137	138
10	n.d.	23.544	24.959	25.371	24.162	27.121	26.979	20.757	15.345	26.338	23.721	25.385	27.420	13.123	15.984	5.092	13.110	24.189	22.658	12.441	13.109	19.521	20.458	22.744	22.899	9.732	18.786	21.058	19.757
30	n.d.	24.857	28.574	25.743	20.233	26.616	26.341	17.664	24.230	18.811	13.957	2.544	20.008	21.898	23.887	18.853	14.471	24.455	19.763	13.390	14.391	22.833	21.698	15.476	17.218	6.272	21.485	19.826	19.242
50	n.d.	24.428	25.360	26.716	25.507	28.148	19.394	24.032	23.854	19.292	5.979	14.230	26.215	20.676	23.334	8.615	14.816	23.529	22.691	14.037	15.302	10.761	28.156	3.289	20.446	7.613	17.867	15.139	20.075
75	n.d.	24.702	24.559	28.527	22.469	28.009	26.563	21.292	23.401	19.470	19.896	26.184	17.556	15.475	14.213	11.721	3.828	21.665	22.997	11.476	18.743	19.802	22.208	2.842	20.067	9.118	19.039	13.463	17.757
100	n.d.	23.979	24.491	28.213	24.644	27.065	29.313	24.539	23.104	25.860	5.927	2.001	20.699	24.765	20.328	4.626	7.977	27.689	21.446	19.213	17.517	30.667	20.573	20.426	20.430	9.744	27.541	24.016	11.146
150	n.d.	23.855	24.861	26.937	26.092	31.534	29.534	16.451	21.530	31.953	6.586	12.826	20.038	5.658	15.357	9.450	10.027	40.712	22.059	6.145	16.681	12.906	8.146	17.425	20.241	8.915	16.844	19.156	17.052
PCHO in water column *)	n.d.	3.395	3.546	3.814	3.358	3.940	3.735	2.965	3.165	3.329	1.535	1.676	2.981	2.491	2.666	1.325	1.399	3.858	3.063	1.869	2.305	2.862	2.802	1.884	2.807	1.210	2.949	2.664	2.422

n.d. — not determined

*) mol PCHO under 1 m² from 10 to 150 m

in vertical distribution of PCHO and the content of PCHO in the water column decreases slightly from 2.94 mol at the entry to the bay (station 136) to 2.32 mol in the bay (station 138).

4. Discussion

Quantitative determination of organic compounds dissolved in the sea is connected with many methodical troubles. The main difficulty lies in the fact that individual organic compounds occur in seawater in very low or even extremely low concentrations that are exceeded by several orders of magnitude by the concentrations of inorganic salts. Desalting of seawater samples or their concentration procedures result in losses or alterations of compounds under investigation (Dawson and Mopper 1978, Dawson and Pritchard 1978, Mopper et al. 1980). To perform analyses of these compounds with a minimum amounts of pretreatment is the ultimate aim of the analyst. This in turn suggests sensitive and specific techniques employing small quantities of seawater.

Dissolved amino acids were determined with very sensitive fluorimetric method (Dawson and Liebezeit 1980 a) specific for primary amines thus including some contribution from aminosugars, oligopeptides and ammonia to varying extent. The class of compounds detected should better be described as o-phthalaldehyde reactive substances (ORS) expressed as an amino acid equivalent. Concentrations of combined amino acids were calculated as a difference between the two independent determinations (dissolved total amino acids — DFAA) and as such they may be encumbered with a higher error than concentrations of DFAA alone.

Sugars were determined with a spectrophotometric method described by Johnson and Sieburth (1977) and modified by Dawson and Liebezeit (1980 b). The method is sensitive and various sugars give fairly uniform responses towards the reagent employed, so the results are not dependent on qualitative composition of a sample. The procedure determines all glycol-containing compounds such as alditols, aminosugars and uronic acids in addition to monosaccharides.

DPCHO concentrations were — as in the case of DCAA — calculated from the difference.

In the method used for urea determination (Koroleff 1976) the only interfering compounds are cytruline, allantoine and biurea. In normal condition however they occur in seawater in too low concentration to disturbe urea analysis.

Dissolved amino acids are found in the sea in the "free" and "combined" state. As "free" amino acids are understood those determined without the necessity of previous hydrolysis. They are chemically free what does not necessarily mean their biological availability. Through adsorbtion on some macromolecular structures or complexation with metals amino acids determined as "free" may not be utilised by marine organisms (Daumas 1976, Dawson and Gocke 1978).

Combined amino acids occur mainly as polipeptides or proteins. Most of DAA come from decay of organic matter and from excretion by living organisms. Being a valuable substrate for heterotrophs amino acids are ingested by numerous microorganisms with a high rate therefore their concentrations are very low (Crawford, Hobbie and Webb 1974, Dawson and Gocke 1978, Liebezeit et al. 1980). All significant variations in the utilisation of dissolved amino acids or their production should always result in changes of concentrations.

DAA play an important role as chelators of various metals, mainly copper (Sunda and Lewis 1978, Fisher and Food 1980).

Results presented here suggest that DAA concentrations in the area investigated are slightly higher than in other regions. In various parts of the Baltic Sea DFAA concentration ranges from 21.2 $\mu g \cdot 1^{-1}$ in Gotland Deep to 38.6 $\mu g \cdot 1^{-1}$ in Gdańsk Deep (Dawson and Gocke 1978). Similar results obtained Mężykowski (in press) for Polish fishery sector in the Baltic Sea, namely 20–40 $\mu g \cdot 1^{-1}$. In North Atlantic waters DFAA occur in concentration 6–47 $\mu g \cdot 1^{-1}$ (Pocklington 1971). Sargasso Sea contain DFAA from 26 to 100 $\mu g \cdot 1^{-1}$ (Liebezeit et al. 1980). Naletova (1979) in her studies in the Scotia Sea found DFAA concentrations varying in the range 44–276 $\mu g \cdot 1^{-1}$. The results are in general higher than FIBEX data but it is to be noted that Naletova determined DFAA during austral spring and early in the summer whereas our determinations were made in late austral summer.

The range in which most of DCAA concentrations occur in FIBEX area "A" was estimated at 0–700 $\mu g \cdot 1^{-1}$. Again, as in the case of DFAA, this is somewhat higher than in other works. In the Baltic Sea DCAA concentrations were determined by Mężykowski (in press) at 200– – 500 $\mu g \cdot 1^{-1}$. In Irish Sea DCAA range is from 90 to 120 $\mu g \cdot 1^{-1}$ (Daumas 1976). According to Naletova (1979) in the Scotia Sea combined amino acids concentrations are between 12 and 585 $\mu g \cdot 1^{-1}$.

The most abundant region in DAA is first of all Bransfield Strait and south-westernmost sector of the area "A" that strongly suggests intensification of organic matter decomposition in this region. Most of open ocean samples are rather poor in DAA. Detailed analyses and interpretation of vertical and horizontal distribution of DAA in area "A" will be possible only on the basis of other oceanographic and biological data from FIBEX. It should be noted that all determinations were carried out in each station for single water samples. The samples were collected partly during the day and partly during the night. Both these facts should be kept in mind when analyzing the reliability of results obtained. It seems that various sub-regions are better described with integrated values (content of a given compound in water column) than with a detailed gradient description.

The main source of sugars in sea water are marine plants. Between 15 and 90% of assimilated carbon is excreted by algae in the form of carbohydrates, mainly sugars (Otsuki and Hanya 1972, Mopper et al. 1980). Even at low concentration sugars are significant source of carbon for heterotropic bacteria (Burney et al. 1979, Moshiri, Crumplon and Aumen 1979, Burney, Johnson and Sieburth 1981).

In the area investigated MCHO concentrations are in the range 0–450 $\mu g \cdot l^{-1}$ being higher than values described in literature. PCHO concentrations are between 1440- and 5940 $\mu g \cdot l^{-1}$ and these values are well over the data for other regions. Mopper et al. (1980) in their studies of dissolved organic matter in various waters found that e.g. in the Baltic Sea near GFR coasts MCHO are in the range 23–52 $\mu g \cdot l^{-1}$. In North Sea — 61.2 $\mu g \cdot l^{-1}$ in open sea and 255.6 $\mu g \cdot l^{-1}$ in the estuary of Weser. Mężykowski (in press) determined MCHO concentrations in Polish fishery sector in the Baltic Sea at 126–270 $\mu g \cdot l^{-1}$. In Sargasso Sea MCHO varied between 50 and 250 $\mu g \cdot l^{-1}$, depending on the depth (Liebezeit et al. 1980). In estuaries glucose level reaches 200 $\mu g \cdot l^{-1}$ (Moshiri, Crumplon and Aumen 1979). PCHO in coastal waters is found in everage concentration equal to 364 $\mu g \cdot l^{-1}$ (Wheeler 1976). According to Maurer[1]) in Mexico Bay polisaccharides concentrations range from 115 to 250 $\mu g \cdot l^{-1}$. In North Sea PCHO reach 645 $\mu g \cdot l^{-1}$ (Mopper 1977) and in North Atlantic are between 0 and 379 $\mu g \cdot l^{-1}$ (Burney et al. 1979).

In general PCHO concentrations correlate well with the amount of phytoplankton and bacterioplankton (Burney, Johnson and Sieburth 1981) and therefore complete interpretation of data obtained is not possible without full set of oceanographic and biological results from FIBEX.

The highest sugar concentrations are found in open ocean samples and over the shelf north of South Shetland Islands and in the south-western part of the area "A". Bransfield Strait is relatively poorer in DCHO.

Urea is a component of urine of various animals, mostly mamals but also numerous invertebrates (Hochachka and Somero 1973). Sources of urea in the sea are mainly autochthonous but to some extent, especially in coastal waters, urea comes with rivers and wastes. Urea is also generated by the extracellular reaction: arginine→ornitine+urea (Crawford, Hobbie and Webb 1974). Urea is a valuable form of nitrogen for fito- and bacterioplankton (Remsen 1971, Carpenter, Remsen and Watson 1972). Concentrations of urea in seawater are variable and no clear correlation between urea and other parameters was observed (Koroleff 1976). Urea content in samples of sewater varies from 0 to 11.2 $\mu gatN_{urea} \cdot l^{-1}$ (Remsen 1971).

In the area "A" urea concentration lays in the range 0–1.50 $\mu gatN_{urea} \cdot l^{-1}$. Higher values are found in Bransfield Strait and over the shelf north of South Shetland Islands. Also northern most stations in the investigated region are relatively more abundant in urea. The picture of urea distribution is quite similar to that of DFAA. The data should be compared with zooplankton distribution and species composition of zooplankton samples.

5. Резюме   .

В рамах программы БИОМАСС-ФИБЭКС в период январь—февраль 1981 было определено содердание следующих органических соединений растворенных в воде: свободных

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[1]) Maurer L. 1971 — Ph. D. dissertation, University of Texas at Austin.

аминокислот (ДФАА), соединенных аминокислот (ДСАА), моносахаридов (ДМСХО), полисахаридов (ДРСХО) и мочевины.

Пробы морской воды отбирались с шести уровней: 10, 30, 50, 75, 100 и 150 м. Поверхностная вода не была исследована по техническим причинам.

Аминокислоты определялись флуориметрическим методом с применением о-фтальальдегида, сахариды — спектрофотометрическим методом с применением МВХТ, мочевина — методом Королеффа.

Концентрации мочевины в большинстве проб колебались в пределах от следовых величин до 1,5 µгат $N_{urea} \cdot л^{-1}$, а содержание мочевины в столбе воды под 1 м² — от 19,23 до 197,4 µгат $N_{urea} \cdot л^{-1}$. Концентрация ДФАА колебалась в пределах 0—0,60 µмоли·л⁻¹. а общее содержание ДФАА в столбе воды под 1 м² изменялось в градиенте 20—60 ммоли. Концентрация ДСАА в большинстве проб составляло менее чем 7 µмоли·л⁻¹, а интегрированные величины для ДСАА были в пределах от следовых до 450 ммоли. Концентрация ДМСХО в большинстве проб не превышала 2,5 моля·л⁻¹, а их содержание в столбе воды составляло меньше чем 180 ммоли. Содержание полисахаридов в столбе воды колебалось от 1,8 до 3,94 °моля, а содержание — от 8 до 32 моля·л⁻¹.

Вертикальные градиенты концентраций исследуемых соединений были очень разнородны. Трудно выделить какие-либо региональные закономерности в формах градиентов. Кажется, что отдельные подрегионы исследуемой территории лучше характеризовать с помощью интегрированных величин, чем с помощью подробного описания градиента.

Концентрации ДФАА, ДСАА, ДМСХО, ДПСХО были как правило выше, чем в пробах морской воды, представленных в литературе.

6. Streszczenie

W trakcie realizacji programu FIBEX-BIOMASS w okresie styczeń-luty 1981 r. przeprowadzono oznaczenia zawartości następujących związków organicznych rozpuszczonych w wodzie: wolnych aminokwasów (DFAA), związanych aminokwasów (DCAA), monosacharydów (DMCHO). polisacharydów (DPCHO) oraz mocznika.

Próbki wody morskiej pobierano z sześciu głębokości: 10. 30. 50. 75. 100. i 150 m. Wody powierzchniowej nie badano z przyczyn technicznych.

Aminokwasy oznaczano metodą fluorymetryczną z użyciem o-ftalaldehydu. cukry — metodą spektrofotometryczną z zastosowaniem MBHT. Mocznik oznaczano metodą Koroleffa.

Stężenie mocznika w większości próbek wahało się w zakresie od wartości śladowych do 1,5 µgat $N_{urea} \cdot l^{-1}$. a zawartość mocznika w słupie wody pod 1 m² wahała się między 19,23 a 197,4 µgat $N_{urea} \cdot l^{-1}$. Stężenie DFAA wahało się w zakresie 0–0,60 µmoli·l⁻¹, a całkowita zawartość DFAA w słupie wody pod 1 m² zmieniała się w zakresie 20-60 mmoli. Stężenie DCAA dla większości próbek wynosiła poniżej 7 µmoli·l⁻¹, a wartości zintegrowane dla DCAA mieściły się w przedziale od wartości śladowych do 450 mmoli. Stężenie DMCHO w większości próbek nie przekraczało 2,5 µmola·l⁻¹, a ich zawartość w słupie wody wynosiła poniżej 180 µmoli. Zawartość polisacharydów w słupie wody wahała się od 1.8 do 3.94 mola, a stężenie — od 8 do 32 µmola·l⁻¹.

Gradienty pionowe stężeń badanych związków były bardzo różnorodne. Trudno jest znaleźć jakiekolwiek prawidłowości regionalne w formach gradientów. Wydaje się. że poszczególne podregiony badanego obszaru lepiej jest charakteryzować przy pomocy wartości integrowanych niż za pomocą szczegółowego opisu gradientu.

Stężenia DFAA. DCAA. DMCHO. DPCHO były zazwyczaj wyższe niż w innych próbkach wody morskiej opisywanych w literaturze.

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