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Particulate organic matter composition in a semi-enclosed Periantarctic system: the Straits of Magellan*

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SUMMARY: The elemental and biochemical composition of particulate organic matter (POM) was investigated in the Straits of Magellan during February-March 1991. Twenty-two stations were selected in order to identify different areas of the Magellan ecosystem from a trophic point of view. The Strait of Magellan can be divided into three subsystems characterized by different hydrological and geomorphological conditions. Seston concentrations were mostly constrained by physical events, particularly the influence of oceanic and land run-off water inputs and the strong vertical mixing and resuspension events. POM composition displayed quali-quantitative differences between the three areas. In the first subsystem, influenced by Pacific waters, the low seston and POM concentrations and the high POC/Chl-a ratio values indicated the general predominance of the detrital and heterotrophic fractions. In the second subsystem, characterized by superficial stratification, higher seston and organic matter concentrations and lower values of POC/Chl-a ratio were found, indicating that this subsystem was influenced by an active autotrophic component. Shallow waters with intense tidal regime and strong vertical mixing characterized the third subsystem, connected to the Atlantic Ocean, which displayed an increasing importance of the inorganic fraction (values of the POC/TSM ratio lower than in the other systems). Moreover, the third subsystem showed higher values of the RNA/DNA ratio, possibly indicating that resuspension events may enhance the metabolic state of the organic particles mainly dominated by heterotrophic components.

Key words: Particulate organic matter, biochemical composition, Straits of Magellan .

RESUMEN: COMPOSICIÓN DE LA MATERIA ORGÁNICA PARTICULADA EN UN SISTEMA PERIANTÁRTICO SEMI-CERRADO: EL ESTRECHO DE MAGALLANES. – Se estudió la composición elemental y bioquímica de la POM (materia orgánica particulada) en el Estrecho de Magallanes durante el periodo febrero-marzo de 1991. Se eligieron 22 estaciones a fin de identificar diferentes áreas del ecosistema magallánico desde un punto de vista trófico. De acuerdo con las características hidrológicas y geomorfológicas dicho Estrecho se puede dividir en 3 subsistemas. Las concentraciones de seston estuvieron condicionadas, principalmente, por los fenómenos físicos y, en particular, por los aportes oceánicos y terrestres, por la mezcla vertical y por los fenómenos de resuspensión. La composición de la materia orgánica particulada (POM) mostró diferencias cualitativas y cuantitativas en las tres áreas. En el primer subsistema, influenciado por las aguas del Océano Pacífico, las bajas concentraciones de seston y POM y los altos valores de la relación POC/clorofila *a* indicaron una predominancia general de las fracciones detrítica y heterótrofa. En el segundo subsistema, caracterizado por una estratificación superficial, se encontraron altas concentraciones de seston y de materia orgánica y bajos valores de la relación POC/clorofila *a*, señalando una influencia de la componente autótrofa activa. El tercer subsistema, conectado con el Océano Atlántico y caracterizado por aguas poco profundas y por un régimen mareal intenso y una fuerte mezcla vertical, mostró un importante aumento de la fracción inorgánica (valores de la relación POC/TSM más bajos que en los otros dos subsistemas). Por otra parte, el tercer subsistema mostró altos valores de la relación RNA/DNA, indicando que posiblemente el estado metabólico de las partículas orgánicas (dominadas principalmente por componentes heterótrofas) estaría influenciado por fenómenos de resuspensión.

Palabras clave: Materia orgánica particulada, composición bioquímica, Estrecho de Magallanes.

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INTRODUCTION

Particulate organic matter (POM) represents a complex system (composed of living and detrital - i.e. non-living - particles) reflecting the trophic state of aquatic ecosystems (Dortch and Packard, 1989) and providing indicators of distinctive hydrographical and biological features (Berdalet *et al.*, 1997). An initial approach to the quantitative study of this component, based on its elemental determination (Ichicawa, 1982, Copin-Montegut and Copin-Montegut, 1983), has been implemented with the analysis of the main biochemical classes of organic compounds (e.g. proteins, carbohydrates, lipids, nucleic acids) that might provide a better understanding of the biological processes associated to the particle dynamics (Handa *et al.*, 1992; Nelson *et al.*, 1996; De Master *et al.*, 1996; Socal *et al.*, 1997). POM viewed in terms of C and N is different from the biochemical approach, because although different compounds may contain similar amounts of each element, they are not equivalent as food sources for consumers. Recent studies in different marine systems (e.g. Antarctic, Mediterranean; Fabiano *et al.*, 1992, 1993, 1995, 1996; Berdalet *et al.*, 1997; Handa *et al.*, 1992; Misic and Fabiano, 1996) have demonstrated that the biochemical composition of POM can provide information on origin, functional state and food availability of suspended particles. Thus, a study based on both elemental and biochemical approaches may give a nearly complete picture of the POM system.

Studies on periantarctic ecosystems are scarce. In particular, information on Straits of Magellan waters is limited to studies on phytoplankton and pigment composition (Lembeye *et al.*, 1978; Lembeye, 1981; Uribe 1988, 1991; Cabrini and Fonda Umani, 1991; Panella *et al.*, 1991; Iriarte *et al.*, 1993; Carrada *et al.*, 1994; Saggiomo *et al.*, 1994) and zooplankton composition and distribution (Fonda Umani and Monti, 1991; Guglielmo *et al.*, 1991; Mazzocchi and Ianora, 1991). Quantitative data on POM origin and composition are practically non-existent (Panella *et al.*, 1991; Povero *et al.*, 1991).

The geomorphological and hydrological features of the Straits of Magellan , which appear to be particularly complex (Pickard, 1971, 1973; Chuecas, 1980; Medeiros and Kjerfve, 1988; Michelato *et al.*, 1991; Panella *et al.*, 1991), recommend the division of the area into different sub-basins (Carrada *et al.*, 1994; Saggiomo *et al.*, 1994). The sub-basin from the Pacific entrance to Cabo Froward is quite deep (reaching 1100 m), characterized by steep bottom profiles and, moving towards the east, by a depth decrease to about 60 m. After this sill the bottom depth increases again, reaching 250 m depth in the easternmost zone. The sub-basin is characterized by numerous fjords, secondary channels and, along the southern coast, by a complex web of waterways ending up in the Pacific. The second sub-basin, which includes the widest part of the channel (Punta Arenas), is located east of Cabo Froward. This area covers the largest portion of the Straits, with a width of 32 Km, a length of 119 km and a maximum depth of about 500 m. The third sub-basin, connected to the Atlantic Ocean, consists of a series of narrows and embayments, showing a depth range from 30 to 80 m, and is highly influenced by macrotidal cycles. On the basis of the available information (Carrada *et al.*, 1994), these areas are characterized by strong differences in productivity and influence of allochthonous inputs, which may determine particular trophic structures.

The aim of this investigation was to describe the distribution and biochemical composition of suspended POM in the different subsystems in the Straits of Magellan, a semi-enclosed, periantarctic ecosystem. Different biochemical descriptors were utilized in order to identify the trophic characteristics of the subsystems.

MATERIAL AND METHODS

Study site and sampling

Water samples were collected from the 20th of February to the 5th of March 1991 at 22 stations (Fig. 1) using R/V "Cariboo". In the first subsystem, between the Pacific entrance and Cabo Froward, 12 stations were sampled. This area was further divided into four sectors: the first, in the Pacific area, included stations 1 and 4, the second stations 5, 6, 7, 8 and 9 near Cabo Pilar, the third stations 10 and 11 in Isla Carlos III area, while the fourth included stations 12 and 13, located from the island to Cabo Froward. In the second subsystem, from Cabo Froward to Isla Isabel (Paso Ancho area) 6 stations were sampled (from St. 14 to St. 20). In the third subsystem, close to the Atlantic Ocean (Primera and Segunda Angostura), 4 stations were sampled (from St. 21 to St. 26).

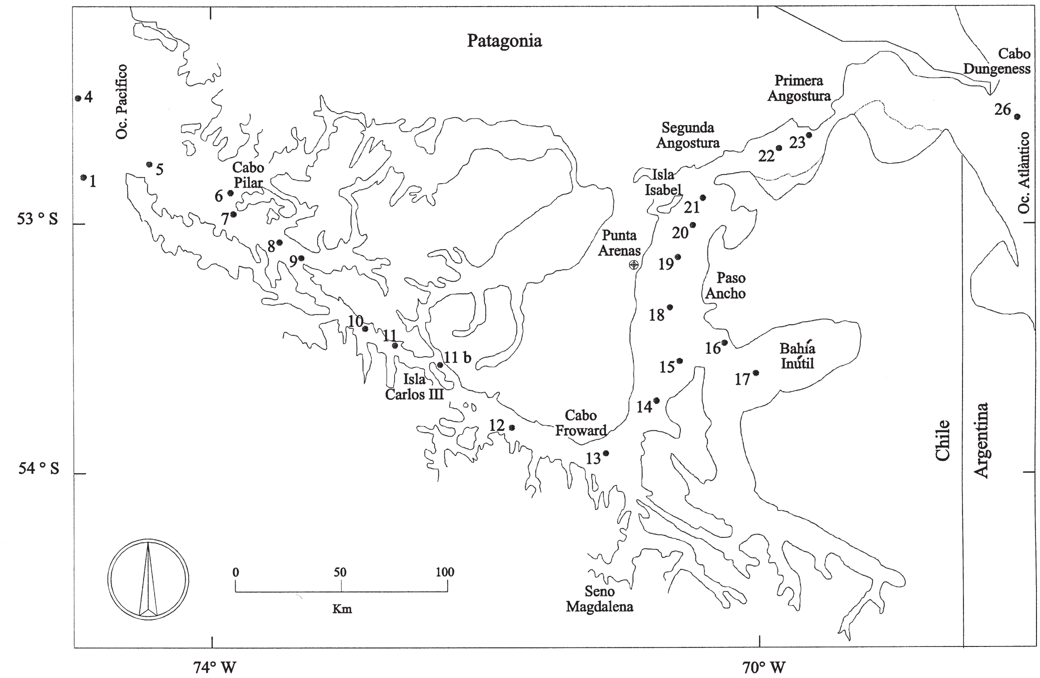

FIG. 1. – Sampling area and station location.

Samples were collected with a Rosette sampler equipped with 10 l Niskin bottles previously washed with a solution of 0.1 N HCl, according to Burney *et al.* (1979). Sampling depths were selected according to light extinction profiles from the surface down to a maximum of 200 m depth. Hydrological data were collected with a Neil Brown MK III CTD system (Artegiani *et al.*, 1991). Water samples (0.5-2.0 l) were prefiltered through a 200 μm mesh net to avoid the larger zooplankton, and then filtered onto Nuclepore filters (0.4 μm pore size) for the analysis of total suspended matter (TSM), proteins (PRT), carbohydrates (CHO), lipids (LIP) and nucleic acids (DNA and RNA). Whatman GF/C filters, previously treated in muffle furnace (450°C, 4h), were used for particulate organic carbon (POC) and nitrogen (PON) determinations. Before analysis, filters for the determination of PRT, CHO, LIP were subjected to ultrasonic treatment for 2 h in 1.0 ml of distilled water in order to detach organic particles from the membranes.

Particulate matter analysis

Total suspended matter was assessed gravimetrically using a Mettler M3 balance (accuracy ±1.0 μg) according to Strickland and Parsons (1972). After removal of carbonates by HCl fumes (Hedges and Stern, 1984), particulate organic carbon and nitrogen were determined using a CHNS-O EA1108 Elemental Analyzer (Carlo Erba). Cyclohexanone-2,4-dinitro-phenylhydrazone was used as standard. Particulate carbohydrates were measured according to Dubois *et al.* (1956). Absorbance was measured at 490 nm using a Varian 635 spectrophotometer. Solutions of D(+)-glucose were used as standards. Particulate proteins were determined according to Hartree (1972). Absorbance was measured at 650 nm with a Varian 635 spectrophotometer. Bovine albumin solutions were used as standards. Particulate lipids were extracted according to Bligh and Dyer (1959) and determined by carbonization according to Marsh and Weinstein (1966). Absorbance was measured at 375 nm with a Varian 635 spectrophotometer. Tripalmitine solutions were used as standard. Nucleic acids extraction and measurement were performed according to Lukavsky *et al.* (1973), modified following Zachleder (1984). The carbon content of the main biochemical classes (C-POM) was expressed as the sum of the C content of proteins, carbohydrates and lipids, according to Fabiano *et al.* (1993).

Statistical analyses were carried out using the STATISTICA package. Identification of the characteristics of Magellan subsystems on the basis of discontinuities in the data series was obtained by means of hierarchic clustering algorithm (complete linkage, Euclidean distance) (see Legendre, 1987).

RESULTS AND DISCUSSION

The elemental and biochemical composition of suspended matter in the three subsystems of the Straits of Magellan displayed remarkable differences, related to distinct hydrological and biological processes. In order to define the trophic characteristics of the three areas, quali-quantitative indices have been employed. POC:TSM ratio was utilised to estimate the organic fraction of the seston and the C-POM:POC ratio was applied to estimate the contribution of the labile fraction to the total particulate organic carbon pool (Fabiano *et al.*, 1993). Due to the different analytical approaches and to the use of conversion factors, this ratio may overestimate the actual concentration of labile organic carbon (expressed as C-POM). The relevance of the autotrophic component to the particulate matter pool was defined by POC:Chl-a ratio (Treguer *et al.*, 1990). The C:N and PRT:CHO ratios provide indication of the importance of the nitrogen fraction in the organic matter pool (Cawet, 1978; Martin *et al.*, 1987), while the RNA:DNA ratio was used as an index of metabolic activity associated to the organic particles (Dortch *et al.*, 1983).

The concentrations of the different parameter investigated are shown in Table 1, while the main ratios are illustrated in Table 2**.** Data on chlorophyll-a (Chl-a) and on the hydrological features were obtained during the same sampling campaign and reported, respectively, by Magazzù *et al.* (1991) and Artegiani *et al.* (1991).

TABLE 1. – Concentrations of particulate matter parameters in the surface (average value 0-50 m) and deep layers (average value 50-200 m) of the different subsystems: Total Suspended Matter (TSM, mg l^{-1}), Particulate Organic Carbon (POC, μg C l^{-1}), Particulate Organic Nitrogen (PON, μg N l^{-1}), particulate proteins (PRT, μg l^{-1}), particulate carbohydrates (CHO, μg l^{-1}), particulate lipids (LIP, μg l^{-1}), particulate organic matter (C-POM, μg C l^{-1}), DNA (μg l^{-1}), RNA (μg l^{-1}).

Sampling area	Stations	Depth	TSM	POC	PON	PRT	CHO	LIP	C-POM	DNA	RNA
Pacific Ocean area	1-4	Surface	0.42	78.90	10.74	50.09	27.86	26.05	55.22	16.47	4.28
		Deep	0.60	91.19	10.84	58.01	31.84	41.24	72.08	9.90	6.97
Cabo Pilar area	5-9	Surface	0.38	103.77	17.89	52.00	21.18	19.90	48.88	5.89	15.09
		Deep	0.37	60.17	8.05	8.80	15.81	20.72	26.18	4.89	5.25
Isla Carlos III area	10-11	Surface	0.51	103.03	21.25	101.58	31.87	29.83	84.90	21.49	3.53
		Deep	0.29	41.50	5.57	21.20	12.68	30.19	38.10	17.56	1.50
Cabo Froward area	12-13	Surface	0.38	60.18	10.34	39.29	22.88	24.01	46.41	30.48	1.50
		Deep	0.45	30.64	5.11	21.58	24.62	18.89	34.59	9.33	4.09
Pacific subsystem	1-13	Surface	0.42	88.53	15.03	57.29	26.00	24.15	56.59	17.30	6.99
		Deep	0.41	53.97	7.60	23.31	20.05	26.34	39.20	9.54	4.27
Paso Ancho subsystem	14-20	Surface	0.61	124.97	20.99	81.38	33.62	30.26	76.02	20.17	13.25
		Deep	0.42	38.23	5.75	26.32	18.13	23.30	37.62	18.85	3.70
Atlantic subsystem	21-26	Water column	4.16	131.02	17.92	147.44	71.87	41.11	127.86	24.30	62.40

TABLE 2. – Values of ratios between the particulate matter fractions in surface and deep layers of the different subsystems. Chlorophyll *a* data from Magazzù *et al.* (1991)

Sampling area	Stations	Depth	POC:TSM	C-POM:POC	C:N	PRT:CHO	POC:Chl-a	RNA:DNA
Pacific entrance	1-4	Surface	0.19	0.70	7.3	1.8	176.9	0.26
		Deep	0.15	0.79	8.4	1.8	259.9	0.70
Cabo Pilar area	5-9	Surface	0.28	0.47	5.8	2.5	186.8	2.56
		Deep	0.16	0.44	7.5	0.6	665.3	1.07
Isla Carlos III area	10-11	Surface	0.20	0.82	4.8	3.2	126.0	0.16
		Deep	0.15	> 0.90	7.4	1.7	528.2	0.09
Cabo Froward area	12-13	Surface	0.16	0.77	5.8	1.7	129.9	0.05
		Deep	0.07	> 0.90	6.0	0.9	399.0	0.44
Pacific subsystem	1-13	Surface	0.21	0.64	5.9	2.2	161.2	0.40
		Deep	0.13	0.73	7.1	1.2	498.3	0.45
Paso Ancho subsystem	14-20	Surface	0.20	0.61	6.0	2.4	111.4	0.66
		Deep	0.09	> 0.90	6.6	1.5	351.6	0.20
Atlantic subsystem	21-26	Water column	0.03	> 0.90	7.3	2.1	253.0	2.92

First subsystem

This subsystem, influenced by Pacific waters, was characterized by different physical features (oceanic influence, run-off inputs, deep-water upwelling). The Pacific entrance (St. 1 and St. 4) showed a well-mixed vertical structure (salinity values ranging between 32.044 and 33.520 PSU and temperature from 10.4 to 11.5 °C in the whole water column, Artegiani *et al.*, 1991). The sector from Cabo Pilar to Isla Carlos III (St. 5 to St. 11) showed a sharp pycnocline (Artegiani *et al.*, 1991), due to the high run-off of the complex system of fjords and channels, mainly in the easternmost stations (St. 10 and St. 11), which displayed the lowest surface salinity values (27.703-27.734 PSU respectively against 30.092 PSU of St. 5; Artegiani *et al.*, 1991). The sector from Isla Carlos III to Cabo Froward (St 12 and St. 13) was characterized by the presence of a divergence, inducing nutrient upwelling (Catalano and Goffart, 1991; Saggiomo *et al.*, 1994).

POM distribution and composition were strongly influenced by the physical features of the system. Stations at the Pacific entrance (stations 1-4), characterized by shallow depths, showed a quite uniform vertical distribution of seston and organic matter concentrations (Figs. 2a, 2b and 2c). A water mass characterized by higher salinity (32.847-33.520 PSU) and lower temperature (10.4-11.2 °C) was observed in the deep layer (Artegiani *et al.*, 1991), leading to a local particulate matter increase, maybe related to sediment resuspension events. The relatively high POC:Chl-a ratios (from 176.9 to 259.9 in the surface and bottom layer respectively, Tab. 2) indicate the relevance of the heterotrophic and detrital component with increasing depth. POM biochemical composition showed a predominance of the PRT fraction (46.2 %) on CHO and LIP (25.5 and 28.2 % respectively) all along the water column.

The area comprised between station 5 and 11 was characterized by variable land run-off influence. Moving eastwards the superficial layer, POC concentrations (Fig. 2b), declined from about 150 μg C/l at St. 5 to less than 100 μg C/l at St. 11b.

Between station 5 and 9 the surface water layer displayed a large organic contribution to the seston pool (Fig. 2b and Table 2, POC:TSM ratio = 0.28). Moreover, the decrease of the autotrophic component, indicated by the high POC:Chl-a ratio (on average up to 186.8), and the reduced labile organic fraction (C-POM:POC ratio less than 0.5), suggest a mature phase of the system, characterized by a large presence of heterotrophic and detrital material, mainly of allochthonous origin.

In the area comprised between station 10 and 11, instead, fresh water inputs influenced vertical stratification of the water masses, thus enhancing the autotrophic fraction (POC:Chl-a ratio 126.0). Such physical and biological conditions determined an increase of the labile POM fraction (Fig. 2c and Table 2, C-POM:POC ratio up to 0.82), as indicated by the low C:N ratios (C:N=4.8) and the high PRT:CHO ratios (PRT:CHO up to 3.2).

Particulate proteins represented the main biochemical class of organic compounds accounting for 55.9 % of POM at stations 5-9 and up to 62.2% at station 10 and 11. In the area between station 5 and 9, the RNA:DNA ratio displayed high values (RNA:DNA = 2.56) indicating an increased metabolic activity associated to a large heterotrophic component.

The deep layer of the water column showed a strong decrease in POM concentration (Fig. 2c), mainly related to a large protein depletion with increasing depth, only partially balanced by the increase of the lipid fraction (which accounted for 45.7 % of POM concentration). In this regard, the presence of large zooplankton biomass (Guglielmo *et al.*, 1991), due to the generally high lipid content of these organisms, may have influenced POM composition. Although no differences were observed between surface and deep water layers in terms of inorganic fraction, the increase of POC:Chl-a ratio (> 500) in deeper waters suggested the occurrence of intense grazing activities, which strongly depleted the bulk of phytoplankton-derived organic matter, increasing the detrital fraction of POM.

In the Cabo Froward sector (stations 12 and 13) the marked instability of the water column did not allow a large POM production, which at the surface reached values similar to the oceanic sector (Fig. 2c). When compared to the other considered areas, the low POC:Chl-a ratios of the surface water layers (on average 129.9), pointed out the limited influence of the autotrophic component on the organic matter pool, which further decreased in deeper water layers (POC:Chl-a = 399.0). POC and PON concentrations showed a decrease with water depth, mainly due to protein depletion (from 39.29 to 21.58 μg l^{-1}), as observed for the second sector. The increase of the metabolic activity of the particulate matter from the surface layer (RNA:DNA ratio 0.05) to the deep layer (0.44) seemed to be related to the presence of

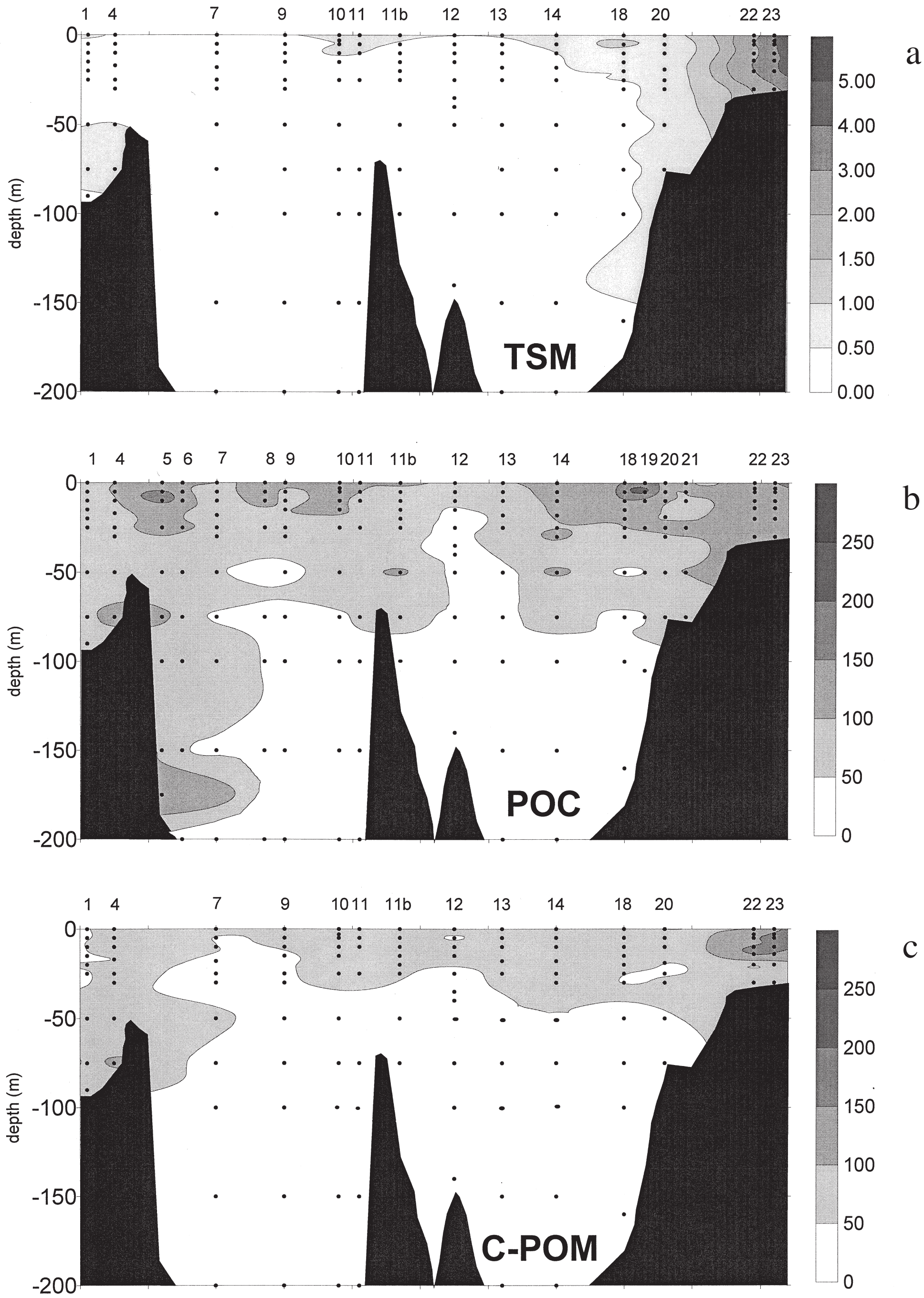

FIG. 2. – Distribution and composition of suspended matter in the Straits of Magellan: a) Total suspended matter (TSM, mgl^{-1}); b) Particulate organic carbon (POC, μgC l^{-1}); c) Particulate organic matter (C-POM, μgC l^{-1}).

zooplankton (Guglielmo *et al.*, 1991) and the production of fast sinking particles (faecal pellets, fragments of dead organisms) largely colonized by active microbial assemblages.

The overall picture of this subsystem, mainly influenced by the Pacific waters through the numerous waterways connecting the sub-basins to the ocean, shows during the study period a general predominance of the heterotrophic and detrital components over the autotrophic one. The concentrations of proteins, carbohydrates and lipids were generally low, both in the surface and in the deep-water layers. Their local increase depended mainly on the development of conditions which favoured autotrophic production, and on the occurrence of zooplankton-derived particles.

Second subsystem

The available information on the hydrological features of the area comprised between station 14 and 20 (Medeiros and Kjerfve, 1988; Michelato *et al.*, 1991; Panella *et al.*, 1991) pointed out a sharp decrease of the tidal range and related east currents. These conditions favoured vertical stratification (Artegiani *et al.*, 1991) that reached its maximum at the centre of the basin. The decreasing importance of oceanic water influence and of run-off inputs from land led to quite homogeneous salinity values (ranging from 30.211 to 31.194 PSU) in the whole water column (Artegiani *et al.*, 1991). When compared to the previous sector, surface seston concentrations (Figs. 2a, 2b and 2c) appeared to be high (0.61 mg l^{-1}), and characterized by higher POC and PON content, which resulted in POC:TSM ratios of about 0.20. POM biochemical composition was characterized by the dominance of proteins (56.0 %) followed by carbohydrates (23.2 %) and lipids (20.8 %). A shallow mixing depth may favour primary production and facilitate phytoplankton growth and accumulation (Berdalet *et al.*, 1997). Thus, the higher chlorophyll-a concentrations (1.12 μg l^{-1}) and the low values of the POC:Chl-a ratio (111.4) suggested a phytoplanktonic origin of the suspended matter in this area. Moreover, data collected during the same cruise on inorganic nutrients indicated a sharp decrease in nitrate concentrations both in surface and subsurface layers (Catalano *et al.*, 1991) corresponding to high levels of primary production (Saggiomo *et al.*, 1994).

Protein concentrations clearly decreased with depth (Fig. 2c), while the relative significance of lipids increased (from 20.8 to 34.4 % in surface and deep layer respectively). The presence of zooplankton assemblages (Guglielmo *et al.*, 1991) may again have influenced POM biochemical composition.

Third subsystem

Shallow waters influenced by an intense tidal regime and strong currents (Michelato *et al.*, 1991; Panella *et al.*, 1991) characterized the area comprised between Isla Isabel and the Atlantic Ocean (stations 21-23). Due to the quite uniform vertical profiles and the shallow depths (average depth of about 50 m), data presented here were not divided into surface and deep-water layers.

This area displayed the highest TSM concentrations (> 3 mg l^{-1}, Tab. 2 and Fig. 2a) that clearly indicate the presence of sediment resuspension processes. Despite their high concentrations POC and PON accounted only for a negligible fraction of seston (POC:TSM ratio of about 0.03), significantly lower than in other subsystems (on average about 0.16). The increase of the inorganic fraction was coupled with the increase of the C:N ratio (7.3), probably enhanced by the resuspension of sedimentary organic carbon, generally characterized by higher C:N ratios. The biochemical composition of particulate organic matter was characterized by the dominance of proteins (56.6 %), followed by carbohydrates. Both components displayed concentrations significantly higher than in the two other subsystems. The high values of the RNA:DNA ratio (on average 2.92) indicated the presence of high metabolic activities, probably due to bacteria, associated to the organic particles. In this respect, Wainright (1990) demonstrated that sediment resuspension might provide a significant contribution of benthic bacterial biomass to the plankton. This feature, characteristic of shallow-water areas such as coastal lagoons, appeared to be similar to the characteristics reported in this subsystem.

Despite the important phytoplankton assemblages reported by Marino *et al.* (1991), POC:Chl-a ratios (on average 253.0) suggested a limited role of the autotrophic component. This value coupled with the large micro- and mesozooplankton (Fonda Umani and Monti, 1991; Guglielmo *et al.*, 1991), biomasses and the high PRT:CHO ratio (2.1) suggests the relevance of the heterotrophic fraction in this system.

CONCLUSIONS

The Straits of Magellan appear to be a complex and heterogeneous periantarctic ecosystem characterized by different subsystems. The quali-quantitative composition of particulate organic matter provided a trophic characterisation of the Straits of Magellan, complementary and in concordance with the indications obtained utilising different biological (Antezana *et al.*, 1991; Carrada *et al.*, 1994; Crisafi *et al.*, 1991; Guglielmo *et al.*, 1991; Saggiomo *et al.*, 1994), chemical (Catalano *et al.*, 1991) and hydrological (Artegiani *et al.*, 1991) approaches. Geomorphological and oceanographic features appear to be the main forcing functions of the three subsystems, able to affect and drive trophic conditions. Moving from the Pacific to the Atlantic sector the seston concentration increased

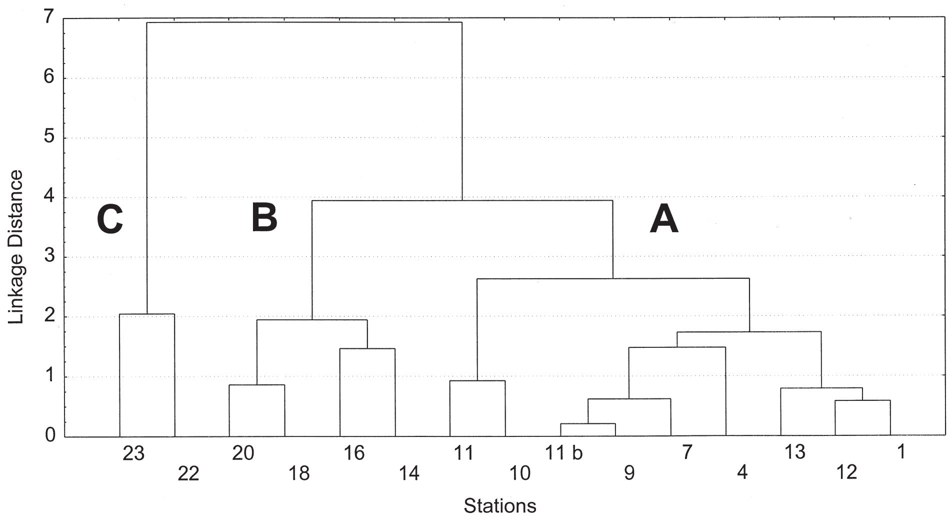

FIG. 3. – Results of the cluster analysis for the Straits of Magellan. The analysis was carried out on particulate matter parameters (TSM, POC, PON, PRT, CHO, LIP) and chlorophyll-a values (data from Magazzù *et al.,* 1991).

and its qualitative changes were related to the balance of autochthonous/ allochthonous inputs and to resuspension processes. The statistical analysis (Fig. 3), performed by means of hierarchic clustering algorithm (complete linkage, Euclidean distance), focused on the actual grouping of the stations, which were divided by the quantitative features of seston. Thus, the characteristics of the three subsystems identified can be summarised as follow (Fig. 4):

A) the sector between Cabo Pilar and Cabo Froward, characterized by non homogeneous hydrological features, influenced by land run-off, that probably did not create the optimal conditions for phytoplankton development. This area was dominated by the detrital-heterotrophic component.

B) the sector from Cabo Froward to Isla Isabel, presenting a clear stratification of the water masses and a reduced hydrological regime, that favoured phytoplankton growth. The area displayed the highest contribution of primary organic matter.

C) the sector close to the Atlantic Ocean, strongly influenced by macro-tidal cycles resuspension processes and continuous water column mixing. This physically-controlled area showed a strong dominance of the inorganic fraction and an active heterotrophic component.

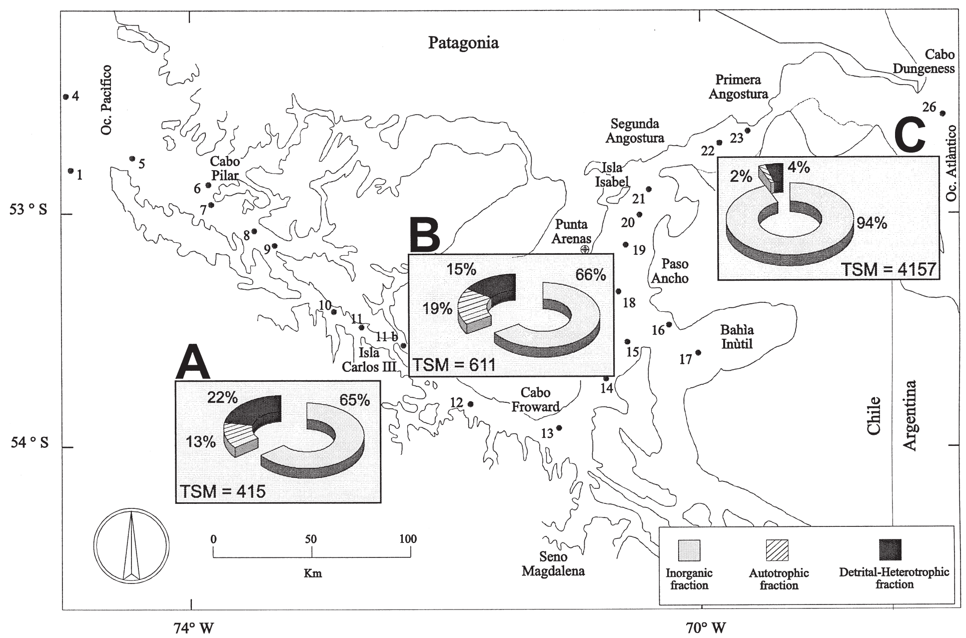

FIG. 4. – The three subsystems (A, B - surface layer- and C - whole water column) characterized on the basis on their trophic features. Total Suspended Matter (TSM) is expressed in μgl^{-1}.

Except for some stations located in the Paso Ancho area, particulate organic matter concentrations in the Magellan Straits are quite low if compared to Antarctic values (Fabiano *et al*., in press). The whole Magellan Straits system seems to be more similar to mid latitude environments than to an actual peri-antarctic system. POM concentration and composition appear to be primarily affected by the hydrological conditions (El Sayed and Fryxell, 1993; Von Bodungen *et al*., 1986; Berdalet *et al*., 1997; Povero *et al*., 1998; Talbot *et al*., 1997). The starting point of organic matter production generally appears to be the stratification of the water masses, induced by seasonal warming and/or local fresh water inputs.

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