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Polychaetes from a southwestern shallow shelf Atlantic area (Argentina, 38° S) affected by sewage discharge

Poliquetos de una plataforma somera del Atlántico sudoccidental (Argentina, 38° S) afectada por efluentes cloacales

RODOLFO ELÍAS[1], CLAUDIA S BREMEC[2] & EDUARDO A. VALLARINO[1]

[1]Departamento de Ciencias Marinas, Universidad Nacional de Mar del Plata, Deán Funes 3350 (7600), Mar del Plata, Argentina, e-mail: roelias@mdp.edu.ar
[2]Consejo Nacional de Investigaciones Científicas y Tecnológicas & Instituto Nacional de Investigación y Desarrollo Pesquero, Casilla de Correos 175 (7600) Mar del Plata, Argentina

ABSTRACT

A benthos-sampling program was carried out in the coastal area of Mar del Plata city in order to know the composition and distribution of infaunal polychaetes living on a subtidal soft-bottom substrate affected by the sewage discharge. Sandy bottoms showed heterogeneous sediment composition and very low organic matter content. Thirty three polychaete species were identified in a range depth between 6.5 to 12.5 m. A comparison with data from 30 years ago from adjacent areas deeper than 12 m is herein presented. Polychaete distribution was related both to the type of sediment and to the content of organic matter. *Owenia fusiformis* Delle Chiaje was dominant and peaked at stations near the sewage effluent. Small-sized polychaetes were abundant in the sampling area. A possible explanation to the faunal composition of sites near sewage effluents is that hydrodynamic forces frequently disturb the area, and benthic fauna is permanently in an early stage of development. The effect of sewage appeared to be restricted to the shallower subtidal area around the outfall.

Key words: polychaetes, domestic outfall, sandy subtidal bottoms, South Atlantic.

RESUMEN

Un programa de muestreo bentónico fue llevado a cabo en la ciudad de Mar del Plata con el fin de examinar la composición y distribución de los poliquetos infaunales de los sustratos submareales afectados por el vertido cloacal. Los fondos arenosos muestran heterogeneidad en su composición de sedimentos y un bajo contenido de materia orgánica. Se identificó un total de 33 especies de poliquetos en el rango de profundidades comprendido entre 6,5 y 12,5 m. En este trabajo se presenta una comparación de estos datos con datos de 30 años atrás provenientes de fondos de más de 12 m de profundidad. El patrón de distribución de los poliquetos se relaciona tanto con el tipo sedimentario como con el contenido de materia orgánica. *Owenia fusiformis* Delle Chiaje fue la especie dominante en las estaciones más cercanas al efluente. Dicha área estuvo caracterizada por la presencia de poliquetos de tamaño pequeño. Una explicación probable para la composición faunística en estos ambientes bentónicos cercanos a descargas es que los procesos hidrodinámicos perturban frecuentemente el área, y la fauna bentónica se encontraría permanentemente en un estado de desarrollo inicial. El efecto del efluente cloacal parece estar limitado al área submareal somera alrededor de la descarga.

Palabras clave: poliquetos, efluente cloacal, fondos submareales arenosos, Atlántico sur.

INTRODUCTION

Organic enrichment of sediments is perhaps the best-documented disturbance on marine environments (Pearson & Rosenberg 1978). To assess the impact of man-made changes, it is useful the use of benthic fauna, at the level of species, population or community.

One of the most neglected, major group of marine invertebrates may be the polychaetous Annelids that could be useful as indicators of varying degrees of marine pollution (Reish 1980). Polychaetes are used as monitors for toxic materials, as bioassay organisms, and as pollution indicators at the various levels for marine environmental quality (Pocklington & Wells 1992). Reish (1955) has early mentioned the relationship between Polychaetous Annelids and harbor pollution. After this, many papers have used these organisms in qualitative and/or quantitative studies about pollution (e.g., Reish 1957, 1963), including an Annelid Index of Pollution (Bellan

1980) to assess pollution at a site affected by municipal sewage (Bellan et al. 1988). Some species of the families Capitellidae, in particular *Capitella capitata* (Fabricius 1780), and Spionidae have become widely accepted as organic pollution indicators (Tsutsumi 1990, Pocklington & Wells 1992).

In Argentina, studies on the relationship between polychaetes and pollution are scarce, and are related to the community level. In Blanca bay (39° S), a mixohaline shallow environment, the presence of an infaunal community dominated by Polychaetes was found in relation to organic enrichment (Elías 1992, Elías & Bremec 1995).

The Mar del Plata city has only a pre-treatment plant for sewage of 800,000 inhabitants, and the effluent discharges directly on an intertidal northern beach, with a continuous rate flow between 2.5 to 8.0 $m^3 seg^{-1}$ (in rainy days). However, the city is the greatest recreational place of Argentina, and receives more than 2,000,000 people during summer. The city also has a port that concentrates the catches and commercialization of coastal fisheries. Municipal government has the intention to construct a submarine pipe 3 km seaward, where sand bottoms are at 11 m depth. Previous benthic studies in the area of Mar del Plata were carried out in bottoms deeper than 12 m, almost 30 years ago (Olivier et al. 1968). Very scarce information was obtained till present about benthic communities of the shallow soft-bottoms.

A monitoring program was carried out in this area to know the composition and distribution of macrozoobenthos, to have reference data for comparing the present condition with the resulting changes during and after the pipe construction. In this contribution we describe the polychaete composition and distribution in subtidal bottoms between 6.5 to 12.5 m depth, in front of the domestic sewage discharge. The aim of this study is to detect a polychaete distribution pattern useful for assessing organic enrichment in the area.

MATERIAL AND METHODS

Study area

The sampling area is an open coast subjected to the littoral current (south to north) and to autumn-winter storms (predominantly south-southeast). Sand ridges dominate the northern areas, while sand ribbons characterize the southern part. Ridges are composed by fine sand with coarse material (mainly shells) in the swales, while sand ribbons are fine-sand bodies (Isla & Schnack 1986[1]). The sewage flume is mostly directed to north, but with strong north winds it falls to the south (Isla & Ferrante 1997). Organic matter values in sediment range between 0.21 to 0.76 % (Isla et al. 1997).

Sampling procedures and analysis

During 1996 we collected 12 samples from subtidal bottoms (between 6.5 to 12.5 m depth) using a benthic dredge (600 x 250 x 200 mm) during 10 min each (Fig. 1). The sediment was sieved (1 mm) and the retained polychaetes were identified and counted. Sediment analysis (by dry sieving) was performed for subsamples of sedi-

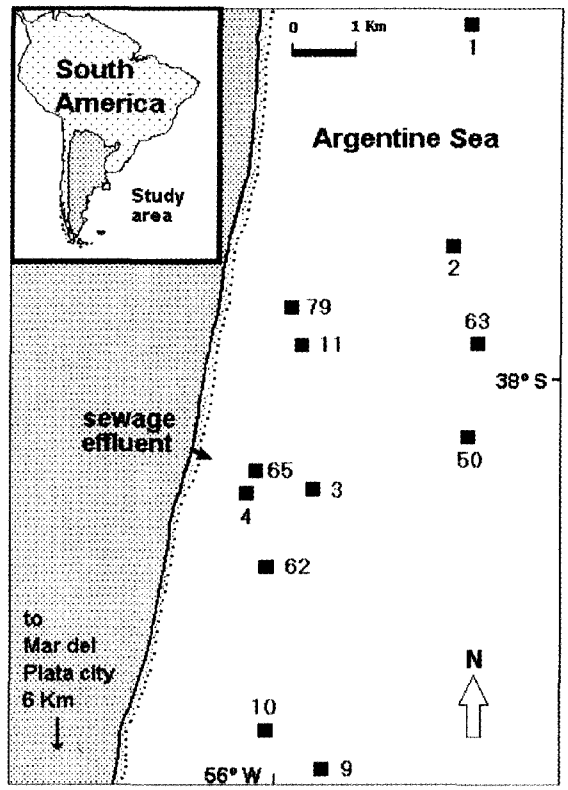

Fig. 1: Location of sampling area and sampling stations around sewage outfall in the shallow shelf area in front of the Mar del Plata city (38° S, Argentina).

Ubicación geográfica del área y de las estaciones de muestreo alrededor del efluente cloacal en la plataforma somera frente a la ciudad de Mar del Plata (38° S, Argentina).

[1] ISLA FI & EJ SCHNACK (1986) Gradación "ribbons"/dorsales de arena en la plataforma costera entre Mar Chiquita y Mar del Plata. Extended Abstracts from Primera Reunión Argentina de Sedimentología, La Plata, Argentina: 45-48.

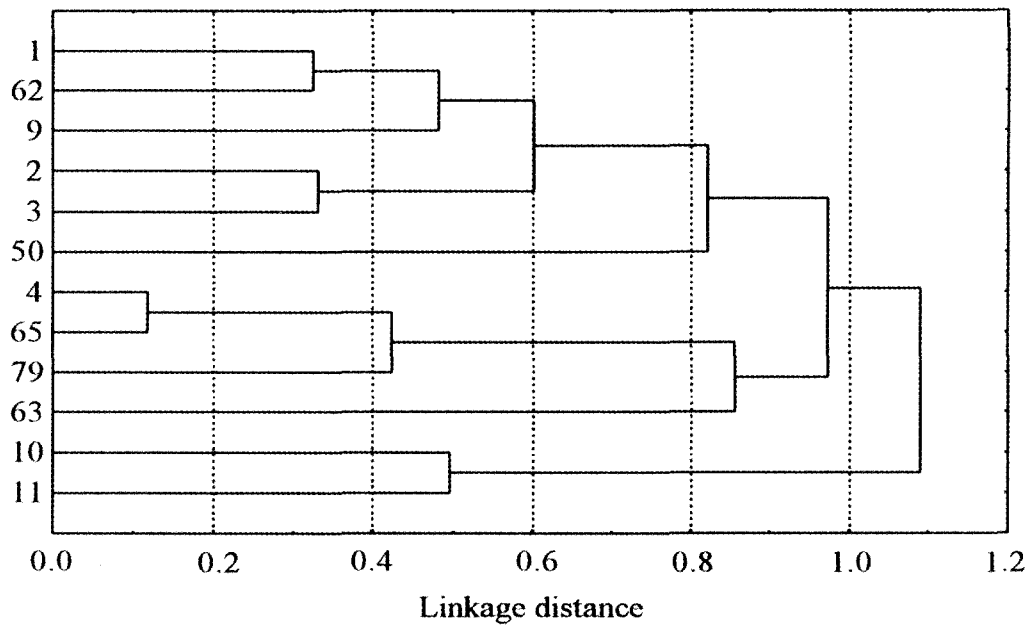

Fig. 2: Cluster analysis (1-Pearson r Index, UPGMA) performed on the abundance of 22 polychaete species having a frequency of 20 % or more (data transformed to $\log_{10} X + 1$), which were found at 12 subtidal stations in front of the Mar del Plata's sewage effluent.

Análisis de agrupamiento (índice 1-Pearson r, UPGMA) sobre la abundancias de 22 especies cuya frecuencia es de 20 % o superior (datos transformados a $\log_{10} X + 1$), halladas en 12 estaciones submareales frente a la descarga cloacal de la ciudad de Mar del Plata.

ments, including the determination of grain-size parameters in phi units ($-\log_2$ of particle diameter) and organic matter content (Isla et al. 1997). Polychaete species were ranked according to their dominance (number of individuals/total number 100). The frequency (%) was also calculated for each species, and the Shannon index of diversity (Shannon & Weaver 1963) was calculated for each sampling unit. Feeding guilds followed Fauchald & Jumars (1979). Classification and ordination were performed with abundance ($\log_{10} X + 1$) in the polychaete species (22) with frequency up to 20 % by using Cluster (1-Pearson r index, UPGMA), and Multi-dimensional Scaling (MDS) analyses (Clarke & Warwick 1993[2]).

RESULTS

Polychaetes comprised 33 species and 1,356 individuals, being the dominant group in the community (37.93 % of species) and second in total abundance (30.55 %). The most abundant polychaete species in the area were *Owenia fusiformis* Delle Chiaje 1844 (3rd in the general rank order), followed by *Armandia* sp., *Ampharete* sp., *Glycera americana* Leidy 1855 and *Prionospio* sp. The most frequent species were *Prionospio* sp. and *Lumbrineris tetraura* (Schmarda 1861), followed by *G. americana* and *Ampharete* sp., but *O. fusiformis*, *Armandia* sp., *Aglaophamus uruguayi* Hartman 1953, *Diopatra viridis* Kinberg 1865 and *Phyllodoce* sp. also reached high frequency (Table 1). All specimens were juveniles or small-sized polychaetes.

Owenia fusiformis reached higher dominance in three stations, two of them closest to the sewage effluent (4 and 65) with abundances up to 400 ind sample^{-1} and also associated to low values of both species number and diversity (Table 2). In Cluster and MDS (Fig. 2 and 3), these stations were grouped around a mean phi of 3.0 ± 0.41 and they had the highest organic matter content of sediments (between 0.48 and 0.76 %). Diversity, especially near the effluent, was low. The highest dominance at these stations was achieved by *Owenia fusiformis*, and, secondarily, by *Ampharete* sp. The Station 63, the richest and most diverse, was dominated by *Aglaophamus uruguayi*, *Glycera Americana*, and *Prionospio* sp. (with moderate dominances between 19 to 14 %), exhibited a phi of 3.17, an

[2] CLARKE B & R WARWICK (1993) Environmental Effects on Benthic Communities. Lecture Notes for SEAS/EPOS II Workshop, Plymouth Marine Laboratory. 144 pp.

organic matter content of 0.48 %, and it was associated in cluster analysis with the *Owenia*-dominated stations.

Stations 1, 2, 3, 9 and 62 on the one hand, and stations 10 and 11 on the other, were grouped (in opposite sides) along Dimension 1. Former stations were characterized by the dominance of *Armandia* sp. and *Ampharete* sp., or by *Prionospio* sp. with *Armandia* sp. (or *Magelona riojai* Jones 1963, in Station 50) around a mean phi of 1.98 ± 0.78, and low organic content (0.21 %). The hard-bottom species of Syllidae or *Dodecaceria concharum* Saint-Joseph, 1898, respectively, characterized stations 11 and 10.

Graphically, the two major groups were distributed in fringes parallel to coastal line (Fig. 4). Dimension 1 seemed influenced by grain-size parameters.

TABLE 1

Dominance (%) and frequency (%), and feeding guilds of polychaete species found in the shallow shelf area in front of Mar del Plata city affected by domestic sewage. Feeding guilds follow Fauchald & Jumars (1979); the three-letter code denotes feeding type (F for filter-feeders, C for carnivores, S for superficial deposit-feeders, and B for subsuperficial deposit-feeders), motility (M for motile, D for discretely motile, and S for sessile), and feeding structures (J for jawed, P for pumping, T for tentacled, and X for other)

Dominancia (%), frecuencia (%) y gremios tróficos de poliquetos hallados frente a la plataforma somera de la ciudad de Mar del Plata afectada por efluentes cloacales. La asignación de gremios sigue el criterio de Fauchald & Jumars (1979); el código de tres letras indica tipo de alimentación (F para filtradores, C para carnívoros, S para alimentadores de depósito superficial y B para alimentadores de depósito subsuperficial), movilidad (M para móviles, D para discretamente móviles y S para sésiles) y presencia de estructuras alimentarias (J para mandibulados, P por bombeo, T para tentaculados y X para otras estructuras)

Polychaete species	Dominance	Frequency	Feeding guild
Owenia fusiformis	34.2	58.3	F-ST-SDT
Armandia sp.	10.0	58.3	BMX
Ampharete sp.	8.1	66.7	SST
Glycera americana	6.4	75.0	CDJ-BMJ
Prionospio sp.	6.0	83.3	F-ST-SDT
Aglaophamus uruguayi	4.8	58.3	CMJ-BMJ
Lumbrineris tetraura	4.4	83.3	HMJ-CMJ-CDJ-BMS
Syllidae unidentified	3.8	41.7	CMJ
Magelona riojai	3.2	50.0	SDT
Maldanidae sp.1	2.3	25.0	BSX
Phyllodoce sp.	2.0	58.3	CMX
Chone cf. dunneri	2.0	33.3	F-SD-SDT
Diopatra viridis	1.5	58.3	HDJ-CMJ-CDJ-SDJ
Thelepus plagiostoma	1.5	50.0	SST
Onuphis setosa	1.5	25.0	HDJ-CMJ-CDJ-SDJ
Dodecaceria cf. concharum	1.4	25.0	SST
Maldanidae sp. 2	1.0	41.7	BSX
Halosydnella australis	0.8	41.7	CMJ-CDJ
Piromis sp.	0.7	25.0	SDT
Haploscoloplos sp.	0.7	25.0	FDT-SDT
Scoloplos (S.) sp.	0.4	16.7	FDT-SDT
Serpulidae unidentified	0.4	16.7	FST
Paraprionospio pinnata	0.4	8.3	FDT-SDT
Pectinariidae unidentified	0.4	8.3	BMX
Capitella capitata	0.4	8.3	BMX
Euphrosinidae unidentified	0.3	33.3	CMX
Lumbrineriopsis mucronata	0.3	16.7	HMJ-CMJ-CDJ-BMS
Neanthes succinea	0.2	25.0	HMJ-CMJ-CDJ-FDP-SDJ
Onuphis eremita	0.2	16.7	HDJ-CMJ-CDJ-SDJ
Polydora sp.	0.2	8.3	FDT-SDT
Pista corrientis	0.1	8.3	SST
Paleanotus intermedius	0.1	8.3	CMX
Syllis sp.	0.1	8.3	CMJ

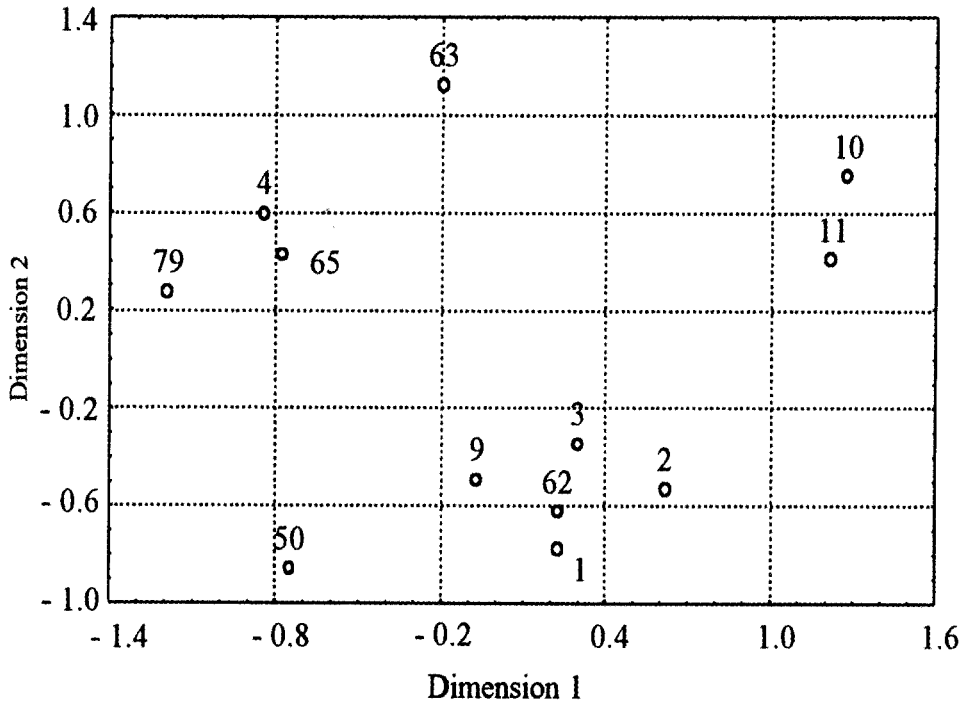

Fig. 3: Multi-dimensional scaling analysis of 12 subtidal stations located in front of Mar del Plata sewage, which included 22 polychaete species whose frequency was 20 % or more.

Análisis de escalamiento multidimensional de 12 estaciones submareales frente a la descarga cloacal de Mar del Plata con la inclusión de 22 especies de poliquetos cuya frecuencia fue de 20 % o superior.

TABLE 2

Biotic parameters of polychaete benthic assemblages of sampling stations in the Mar del Plata shallow shelf affected by sewage outfall. Parameters include maximum polychaete dominance, total abundance (A, ind·sample^{-1}), species richness (S), species diversity as measured by the Shannon index (H'), sediment grain size (Phi = -$\log_2$ of sediment particle diameter), and the content of organic matter of sediments in each station

Parámetros bióticos de los ensambles de poliquetos en estaciones de muestreo ubicadas en la plataforma somera de Mar del Plata afectada por vertidos cloacales. Los parámetros incluyen dominancia máxima de poliquetos, abundancia total (A, ind muestra^{-1}), riqueza de especies (S), diversidad de especies de acuerdo al índice de Shannon (H'), tamaño de partícula del sedimento (Phi = -$\log_2$ del diámetro de las partículas), y contenido de materia orgánica del sedimento en cada estación

Station	Dominant species	Maximum dominance (%)	A	S	H'	Phi	Organic matter (%)
1	*Armandia* sp.	54.1	98	16	1.66	1.03	0.21
2	*Prionospio* sp.	29.1	79	20	2.40	2.62	-
3	*Prionospio* sp.	25.0	40	13	2.12	2.62	-
4	Owenia fusiformis	70.6	34	4	0.84	2.53	-
9	*Armandia* sp.	60.5	38	6	1.18	-	-
10	Dodecaceria concharum	51.7	29	6	1.40	-	-
11	Syllidae	39.1	110	12	1.73	1.22	-
50	Magelona riojai	25.3	75	17	2.36	1.73	0.21
62	*Ampharete* sp.	39.0	82	10	1.62	1.67	0.55
63	Aglaophamus uruguayi	18.9	259	18	2.42	3.17	0.48
65	Owenia fusiformis	84.8	481	8	0.61	3.17	0.76
79	Owenia fusiformis	38.7	31	10	1.90	3.3	0.48

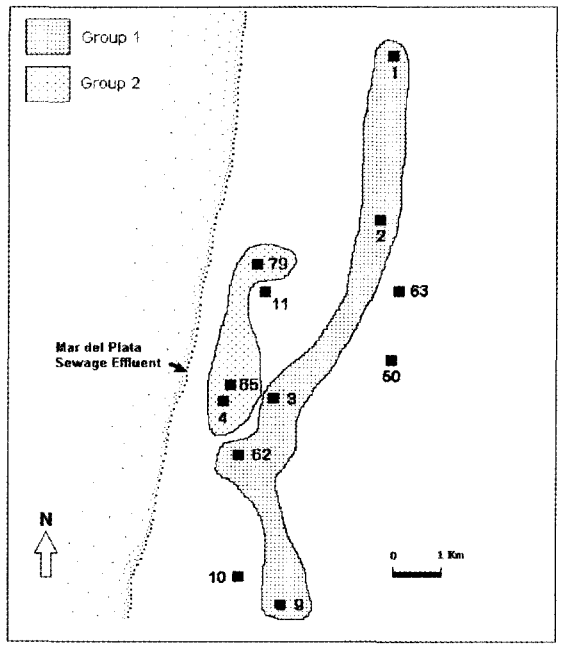

Fig. 4: Polychaete assemblages defined by cluster and multi-dimensional scaling analyses. *Armandia* sp. or *Prionospio* sp. dominance defines group 1, while *Owenia fusiformis* dominates in shallow stations of group 2.

Asociaciones de poliquetos definidas por análisis de conglomerados y de escalamiento multidimensional. El grupo 1 está definido principalmente por la dominancia de *Armandia* sp. o de *Prionospio* sp., mientras que *Owenia fisiformis* domina en las estaciones someras del grupo 2.

DISCUSSION

The only available information about polychaetes in the area of Mar del Plata is referred to bottoms deeper than 12 m and is represented by records cited in Olivier et al. (1968), and taxonomic reports by Orensanz (1973, 1974).

The onuphids *Onuphis eremita* Audouin & Milne Eduards 1833 and *O. setosa* Kinberg 1865 were found in waters shallower than previous records, more than 40 m in the former, and 13 to 25 m the latter, while *Diopatra viridis* was frequent in the subtidal sandy bottoms of the area (Orensanz 1974). In Talcahuano bay (Chile), an environment subjected to sewage outfall, *Diopatra chilensis* Quatrefages 1865 is the third species in terms of biomass (Oyarzún et al. 1987). Two lumbrinerids were recorded, but only *Lumbrineris tetraura* was the most frequent. This species has been cited for sandy bottoms of the area, being a common predatory polychaete (Orensanz 1973, Carrasco & Oyarzún 1988). Oyarzún et al. (1987) found a very important biomass of *L. tetraura* in the nearest station in front of the Talcahuano port affected by sludge from factories and municipal sewage. However, it has been suggested that if the genus *Lumbrineris* is absent, and the diversity is low, the chance that the site is impacted is great (Rygg 1985). Other frequent predatory polychaete species were *Glycera americana*, common in the area at all depths, *Aglaophamus uruguayi*, Syllidae, and *Phyllodoce* sp.

The pattern of polychaete distribution reported herein agrees with previous analyses carried out at a community level in the study area (Elías et al. 1997[3]), and in which sampling stations formed three groups after conducting principal component and cluster analyses. One of them contains the "rich" stations (mean species number S = 34, mean abundance A = 544 ind·sample^{-1}) in fine and very fine sand (phi = 3). An association characterized by juveniles of the bivalve *Amiantis purpuratus* (Lamarck 1835), tanaidaceans and amphipods inhabits these stations. Other group cluster of "poor" stations (mean S = 19, mean A = 128), located in coarse sand and gravel with shell debris (phi between 1 and 2), was dominated by the crustacean *Corophium* sp., the polychaetes *Armandia* sp. and *Ampharete* sp., and amphipods. A third group, with the high loading stations 4 and 65 (the closest to the effluent), is dominated by the polychaete *Owenia fusiformis*. The similarity of these results reveals the important role of polychaetes in structuring the subtidal community.

On the other hand, other benthic associations occupied bottoms deeper than 12 m. The shallowest one is characterized by the anthozoan *Renilla* sp., the echinoderm *Encope emarginata* (Leske 1778), and the amphioxus *Branchiostoma platae* Hubbs 1922 (Olivier et al. 1968). *Owenia fusiformis* was widely distributed in the stations deeper than 12 m, but rare (Olivier et al. 1968). The occurrence of a relatively high and stable population abundance of *O. fusiformis* (45 % of the total biomass of the assemblage) was also reported in relation to domestic sewage in the Mediterranean Sea, which is supported by the increased possibilities of flow changes at the mouth of the harbor (Pinedo et al. 1997). In the Talcahuano bay, in the vicinity of a sewage discharge, *O. collaris* (= *O. fusiformis*) is also frequent (Oyarzún et al. 1987). *Owenia fusiformis* is a surface-deposit feeder (Fauchald & Jumars 1979,

[3] ELÍAS R, EA VALLARINO, RO BASTIDA, JP MARTIN & EN IENO (1997) Mar del Plata's sewage impact on coastal soft-bottom benthic communities, Argentina. Extended Abstract of the VII Congreso Latinoamericano de Ciencias del Mar, Santos, Brasil, volume I: 276-278.

Gambi 1989) that alternates its feeding mechanisms in relation with the environmental conditions. When high planktonic inputs are produced and flow conditions change, *O. fusiformis* can behave as a filter feeder (Gambi 1989). Desroy et al. (1997) show that filter feeding predominates at the adult population level, while juveniles alternate between deposit and filter feeding activities under still water conditions at similar frequencies. In the Mar del Plata area, the great south to north current with the high suspended matter due to the domestic sewage allows this species to be enhanced at intermediate distances from the effluent.

Capitella capitata, a classical indicator of organically enriched sediments, appeared once and at low abundance. However, it is frequent and abundant in the interstitial sediments of intertidal mussel beds developed around the effluent (Elías et al. 1999[4]).

It is remarkable that the shallower shelf was never studied faunistically, and several species were new records for Argentine waters, like *Magelona riojai* (Elías & Bremec 1997), and the genus *Armandia* (Elías & Bremec unpublished results). Besides, at least two species (*Aricidea* and *Prionospio*) seem to be either new for the area or new species. The fringe between 6.5 to 12.5 m depths seems characterized by small-sized polychaetes, like *Owenia fusiformis*, *Prionospio* sp., *Magelona riojai*, *Scoloplos (S.)* sp., *Paraprionospio pinnata* (Elhers 1901), *Armandia* sp., and *Glycera americana*. Most of these polychaete species are deposit feeders or carnivores, preying upon other polychaetes or small invertebrates, while suspensivores are scarce (Table 1).

A similar association of small polychaetes was observed in the northern shallow shelf of Chile and Perú, characterized by species of the genus *Aricidea*, *Tharyx*, *Prionospio*, *Owenia*, *Magelona* and *Leitoscoloplos*, and also by the medium-sized *Paraprionospio pinnata* (Carrasco 1997). The frequent dominance of the macrobenthos by small-sized forms has been already reported (Beukema 1988). A model proposed by Rumohr et al. (1996) for benthic communities at the Baltic sea predicted a intermediate successional stage (III) dominated by small polychaete worms (or their ecological equivalents, like amphipods) in relation to a gradient of bottom organic enrichment.

Other possible explanation for the presence of small-sized polychaetes is that hydrodynamics forces frequently disturb the area, and benthic fauna is permanently in an early stage of development. Recolonization following complete defaunation due to disturbances caused by winds and storms is frequently reported on benthic environments (see Probert 1984). Small, opportunistic, tube-dwelling polychaetes are the first faunal components to colonize new or newly disturbed bottoms (Rhoads & Boyer 1982). In the shallow shelf of southern Brazil, it is suggested that after the winter defaunation a recolonization period by opportunistic species (like spionid Polychaetes) takes place (Paiva 1993). In Talcahuano bay (Chile), the small opportunistic spionid *Cossura chilensis* Hartmann-Schröeder, 1965 dominated bottoms affected by domestic sewage (Oyarzún et al. 1987).

Physical disturbances could be responsible for the low diversity, the small size of dominant fauna, and for the great variability in species number and relative abundance of these assemblages. Sedimentary pattern found in this study agrees with a high-energy environment (Isla et al. 1997). Other studies carried out on macrobenthos of the Argentine shelf also revealed a great bottom heterogeneity, even in relatively small areas, and probably due to hydrodynamic forces (Olivier et al. 1968, Roux et al. 1993). These facts suggest that the main structuring factor in the shallow shelf is the physical disturbance due to strong hydrodynamic forces. However, it is suspected that between 0-6 m depth sewage discharge will be also an important structuring factor of both polychaete populations and macrobenthic communities.

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[4] ELÍAS R, EA VALLARINO, CS BREMEC & C GRAVINA (1999) Los poliquetos de la comunidad intermareal como bioindicadores de enriquecimiento orgánico en el Atlántico Sudoccidental. Extended Abstracts of the VIII Congreso Latinoamericano de Ciencias del Mar, Trujillo, Perú, volume II: 904-905.

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