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Distribution of Polychaeta in soft-bottoms of a Galician Ria (NW Spain)

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SUMMARY: Macrobenthic polychaete distributions were studied along the soft-bottoms of the Ensenada de San Simón (Galicia, NW Spain). Results suggest that the distribution and abundance of polychaetes in the inlet were highly dependent on depth, sediment characteristics (grain size, organic matter and calcium carbonate content) and bottom water temperature. In the inner area of the inlet, intertidal bottoms colonised by the seagrasses *Zostera marina* and *Z. noltii* were dominated by spionids and capitellids, and showed low species number and diversity. Shallow muddy bottoms of central areas were mostly dominated by ampharetids, terebellids and cirratullids. These families along with paraonids, maldanids and syllids were the most abundant families in the deeper subtidal muddy bottoms at the mouth of the inlet. These sediments also showed the highest number of species, diversity and density of individuals.

Keywords: Polychaeta, macrofauna, soft-bottoms, Ensenada de San Simón, Atlantic Ocean, Spain.

RESUMEN: DISTRIBUCIÓN DE LOS POLIQUETOS DE FONDOS BLANDOS EN UNA RÍA GALLEGA (NO ESPAÑA). – La distribución de los poliquetos macrobentónicos ha sido estudiada en los fondos blandos de la Ensenada de San Simón (Galicia, NO España). La profundidad, las características del sedimento (granulometría, contenido en materia orgánica y carbonatos) y la temperatura del agua del fondo fueron los principales factores que determinaron la distribución y abundancia de los poliquetos en la ensenada. En la zona más interna, los fondos intermareales colonizados por las fanerógamas *Zostera marina* y *Z. noltii* estuvieron dominados numéricamente por espiónidos y capitélidos, y mostraron bajos valores de diversidad y número de especies. Los fondos fangosos someros del área central presentaron una fauna de poliquetos dominada principalmente por anfarétidos, terebélidos y cirratúlidos. Asimismo, estas familias estuvieron presentes en los fondos más profundos de la boca de la ensenada, donde paraónidos, maldánidos y sílidos mostraron una dominancia numérica importante. Los máximos valores de diversidad, número de especies y densidad de individuos se registraron en estos fondos submareales fangosos.

Palabras clave: Polychaeta, macrofauna, fondos blandos, Ensenada de San Simón, Océano Atlántico, España.

INTRODUCTION

The Galician rias (NW Spain) are a particular kind of estuarine system and have been extensively studied due to their great socio-economic importance, especially with regard to fisheries, mussel culture on rafts and shellfish resources. This has led to numerous faunistic and ecological works on the macrobenthic communities of the Galician coasts in recent years (e.g. López-Jamar, 1982; Garmendia *et al.*, 1998; Olabarria *et al.*, 1998). Studying benthic faunas is particularly important because they are considered to be good indicators of marine bottom conditions (Grall and Glémarec, 1997).

Benthic communities in the Ría de Vigo have been studied since 1886, when Hidalgo published a list of marine species of the NW Spanish coast. Later works focused on the distribution and composition of macrofaunal assemblages (e.g. Anadón, 1980; López-Jamar and Cal, 1990; Abella *et al.*, 1996).

Despite a number of scientific studies devoted to the Ensenada de San Simón (Nombela *et al.*, 1995; Fernández-Rodríguez *et al.*, 1997), few studies have actually analysed patterns of spatial distribution of benthic fauna, and none have yet determined the structure of polychaete populations. Polychaete faunas have been extensively studied in other rias and in other areas of the Ría de Vigo, from either descriptive (Viéitez, 1976; Moreira *et al.*, 2006) or taxonomic points of views (Moreira *et al.*, 2000a; Moreira *et al.*, 2000b; Parapar *et al.*, 2000). Consequently, improving our knowledge of benthic macrofauna in general, and of polychaetes in particular, is essential for ensuring correct resource management in the area, especially since it has been included in the Nature 2000 Network as a Special Conservation Zone. Therefore, the aim of the present study is to describe the composition and distribution of polychaete assemblages and their relationships with a number of environmental variables.

MATERIAL AND METHODS

Study area

The Ensenada de San Simón is located in the inner part of the Ría de Vigo, between 42º17' and 42º21'N and between 8º37' and 8º39'W (Fig. 1). Soft-bottoms of this inlet are mainly muddy with high organic matter content (Vilas *et al.*, 1995). Intertidal and shallow subtidal areas have meadows of the seagrasses *Zostera noltii* Hornem. 1832 and *Zostera marina* L. Culture of mussels on rafts is a common practice in large areas at the mouth of the inlet. There is a large freshwater input into the innermost part of the inlet which results in salinity fluctuations on a tidal and seasonal basis (Nombela and Vilas, 1991).

Sampling and sedimentary analysis

Samples were collected during November and December 1999 from 29 sites (Fig. 1). Five replicate samples were taken at each site by means of a Van Veen grab (0.056 m^2). Samples were sieved through 0.5 mm mesh and the retained material was fixed in 10% buffered formalin. Fauna was sorted from the sediment and preserved in 70% ethanol for identification. Temperature and pH were measured in situ for water and sediment. An additional sedimentary sample was taken at each site for later grain-size

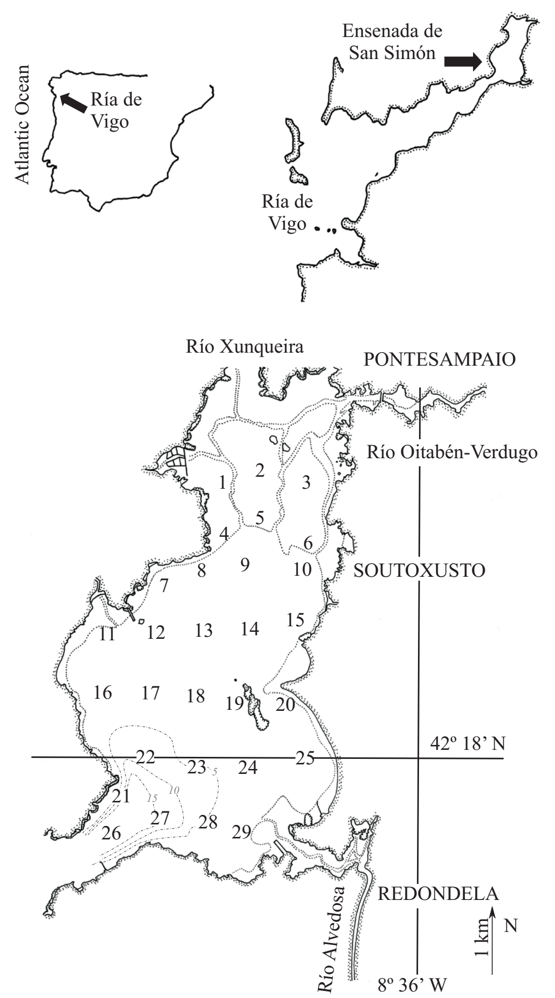

FIG. 1. – Location of the Ensenada de San Simón (Ría de Vigo) and position of the 29 sampling sites.

analyses and to determine calcium carbonate and total organic matter contents. Sedimentary types were determined according to Junoy (1996). Median grain size (Q_{50}) and sort coefficient (S_o) were also determined for each sample. Calcium carbonate content (%) was estimated by treating samples with hydrochloric acid, and total organic matter content (%) was estimated from the weight lost (Parada *et al.*, 1993) after samples were placed in a furnace for 4 hours at 450ºC.

Data analysis

Total abundance (N), number of species (S), Shannon-Wiener's diversity index (H', as $\log_2$) and Pielou's evenness index (J) were determined for each site. Polychaete assemblages were determined through non-parametric multivariate techniques using the Plymouth Routines of the Multivariate

TABLE 1. – Depth (those under 2 m are intertidal sites sampled during high tide) and physical characteristics of sediments at each site: Q_{50}, median particle size; Bt, Bottom type (M, mud; SM, sandy mud; MS, muddy sand; VCS, very coarse sand; CS, coarse sand); TOM, total organic matter and CO_3, calcium carbonate content. Seagrass presence is cited in the last column.

Site	Depth (m)	Q_{50} (mm)	Gravel (%)	Sand (%)	Silt/Clay (%)	Bt	TOM (%)	CO_3 (%)	Seagrass
1	1.6	0.01	0.08	16.83	83.08	M	26.52	5.52	*Z. marina*
2	1.6	0.01	2.21	32.93	64.86	M	23.30	5.60	*Z. marina, Z. noltii*
3	1.6	0.08	0.00	56.74	43.26	SM	19.05	6.12	*Z. marina, Z. noltii*
4	1.6	0.32	17.79	73.99	8.22	MS	2.16	6.00	-
5	1.8	1.25	29.96	64.36	5.68	MS	4.90	7.33	-
6	1.6	1.15	21.13	76.83	2.05	VCS	0.95	11.98	-
7	3.4	0.15	0.32	74.30	25.38	SM	3.95	6.31	-
8	3.2	0.04	0.63	35.89	63.48	M	10.88	5.80	-
9	2.9	0.01	0.87	27.67	71.46	M	18.12	4.28	-
10	2.9	0.01	0.00	2.33	97.67	M	36.93	4.28	*Z. marina*
11	3.6	0.01	0.00	8.86	91.14	M	26.50	4.81	*Z. marina*
12	3.8	0.01	1.10	19.18	79.71	M	19.93	2.12	-
13	3.5	0.01	3.01	23.00	73.99	M	23.00	2.36	-
14	4.6	0.01	7.07	24.37	68.56	M	19.78	2.28	-
15	1.8	0.74	3.49	94.39	2.12	CS	1.00	8.35	-
16	4.2	0.01	0.95	15.48	83.57	M	21.47	4.53	-
17	3.7	0.02	4.72	31.11	64.17	M	18.93	5.90	-
18	4.5	0.01	1.98	19.97	78.05	M	15.20	4.52	-
19	4.7	0.01	0.00	13.94	86.06	M	21.05	4.53	-
20	2.6	0.21	11.83	77.69	10.48	MS	1.80	4.85	*Z. marina*
21	18	0.01	0.59	26.35	73.06	M	19.50	4.61	*Z. noltii*
22	10.4	0.01	1.03	37.38	61.59	M	12.98	5.51	-
23	5.9	0.01	1.25	25.15	73.60	M	22.17	5.40	-
24	4.1	0.01	0.00	12.59	87.41	M	21.42	4.07	-
25	1.6	0.01	6.85	31.79	61.36	M	23.72	5.47	-
26	28.2	1.50	40.17	48.34	11.49	MS	7.22	40.46	-
27	11.5	0.01	9.30	28.21	62.49	M	10.60	8.61	-
28	4.7	0.01	2.37	19.03	78.60	M	22.32	4.61	-
29	2	0.01	0.09	31.71	68.20	M	14.33	4.45	-

Ecological Research software package (PRIMER; Clarke and Warwick, 1994). A similarity matrix was carried out using the Bray-Curtis coefficient after applying the fourth-root transformation to species abundance. Classification and ordination of sites and species were carried out with cluster analysis using the UPGMA algorithm and non-metrical multidimensional scaling (MDS) respectively. The SIMPER analysis was used to identify species that contributed to dissimilarity among groups of sites determined by classification and ordination analyses.

Species were classified according to the constancy index (Dajoz, 1971) into five categories, according to the number of sites in which any given species was found in relation to the total number of sites: constant (>76%), very common (51-75%), common (26-50%), uncommon (13-25%) and rare (<12%). Species were further classified according to the fidelity index (Cabioch, 1968) into accidental (<10%), occasional (11-33%), accessory (34-50%), preferent (51-66%), elective (67-90%) and exclusive (>91%). Species were also classified according to the Frequency-Dominance product.

Relationships between polychaete abundance and environmental variables were studied by means of the BIOENV procedure (PRIMER package). Environmental variables expressed in percentages were previously transformed by log (x+1) and all of them were normalised.

RESULTS

The soft bottoms of the Ensenada de San Simón were characterised by a predominance of muddy sediments with high total organic matter content and low calcium carbonate content (Table 1). Sandy sediments were present in tidal channels in the inner inlet where total organic matter values were low. Sediments became increasingly muddy towards the deeper bottoms at the centre and mouth of the inlet. The areas around the outer part had muddy sands with a large gravel fraction composed of mussel shells.

Sampling yielded 24581 polychaetes belonging to 123 species in 38 families (Appendix 1). Spionidae was the family best represented in terms of number of individuals (32.13% total abundance), with *Pseudopolydora paucibranchiata* accounting for 22.33% of all polychaetes. In general, spionid species were more abundant in outer areas, except for *Streblospio shrubsolii*, which reached the highest densities in internal sandy areas. Other dominant families were

TABLE 2. – Faunistic parameters at each sampling site: S, number of species; N, total abundance per 0.28 m^2 and per m^2; J, Pielou's evenness; H'(log_2), Shannon Wiener diversity index.

Site	S	N (0.28 m^2)	N(m^2)	J'	H'(log_2)
1	7	74	264.3	0.54	1.52
2	7	1266	4521.4	0.76	2.13
3	12	1026	3664.3	0.49	1.74
4	9	84	300.0	0.70	2.22
5	13	1102	3935.7	0.40	1.48
6	11	381	1360.7	0.56	1.93
7	18	161	575.0	0.61	2.56
8	18	128	457.1	0.79	3.29
9	21	267	953.6	0.71	3.10
10	14	154	550.0	0.66	2.53
11	11	31	110.7	0.90	3.11
12	16	137	489.3	0.66	2.63
13	18	68	242.9	0.82	3.41
14	50	2001	7146.4	0.66	3.73
15	15	704	2514.3	0.56	2.18
16	41	1148	4100.0	0.63	3.37
17	39	1442	5150.0	0.58	3.04
18	29	346	1235.7	0.76	3.69
19	46	1097	3917.9	0.69	3.82
20	21	1261	4503.6	0.27	1.17
21	59	1318	4707.1	0.68	3.99
22	66	3025	10803.6	0.66	3.96
23	42	1251	4467.9	0.66	3.57
24	17	92	328.6	0.77	3.13
25	26	126	450.0	0.83	3.90
26	69	2762	9864.3	0.65	3.99
27	60	2683	9582.1	0.66	3.89
28	25	358	1278.6	0.70	3.24
29	7	88	314.3	0.50	1.39

Ampharetidae (18.51%, due to high densities of *Ampharete finmarchica* and *Melinna palmata*), Cirratulidae (12.72%, due mainly to *Aphelochaeta marioni* and *Chaetozone gibber*) and Capitellidae (8.18%). These species, along with *Paradoneis lyra* and *Microphthalmus pseudoaberrans*, accounted for more than 65% of the total abundance of polychaetes. The families best represented in terms of number of species were Spionidae and Syllidae (14 species each), Phyllodocidae (11 species) and Dorvilleidae and Cirratulidae (8 species each).

Three species were found to be constant (*P. paucibranchiata*, *Capitella* cf. *capitata* and *Heteromastus filiformis*), 11 very common, 25 common, 29 uncommon and 55 rare.

The lowest densities were recorded at sites 11, 1, 4, 29 and 24 (31 to 92 individuals per 0.28 m^2) (Table 2). The greatest polychaete numbers were recorded at sites 22, 26 and 27 (2683-3025 ind. per 0.28 m^2) due to the high abundance of *P. paucibranchiata*, *A. finmarchica*, *P. lyra* and *A. marioni*. These sites also showed the largest number of species (60-69). Only 7 species were found at sites 1, 2 and 29, which were located at the mouth of the Oitabén-Verdugo and Alvedosa rivers. The Shannon-Wiener's diversity index fluctuated between 1.17 (site 20) and 3.99 (sites 21 and 26), (2.89 ± 0.89; mean ± standard deviation) and evenness ranged from 0.27 (site 20) to 0.83 (site 25). The greatest diversity values (H') were recorded at sites along the mouth of the inlet while the lowest values were found in intertidal sites near the mouth of the rivers.

The dendrogram obtained through cluster analysis based on abundance data showed three main groups (Fig. 2I): Group A (sites 1, 2, 3, 4, 5, 6, 10, 15, 20 and 29), Group B (sites 7, 8, 9, 11, 12, 13, 18, 24, 25 and 28) and Group C (sites 14, 16, 17, 19, 21, 22, 23, 26 and 27). Ordination of sites through MDS analysis agreed with the results of the dendrogram (Fig. 2II).

Cluster analysis and MDS based on abundance data of the dominant species (dominance>1%) showed four main groups (Fig. 3). Group 1 was composed of the species *S. shrubsolii* and *M. pseudoaberrans*, which were numerically dominant in the coarser sediments of the intertidal bottoms (Group A of the dendrogram). *Pseudopolydora paucibranchiata* and *C.* cf. *capitata* (Group 2) were distributed along the entire inlet, and appeared in high densities in a variety of bottoms which differ in stability and

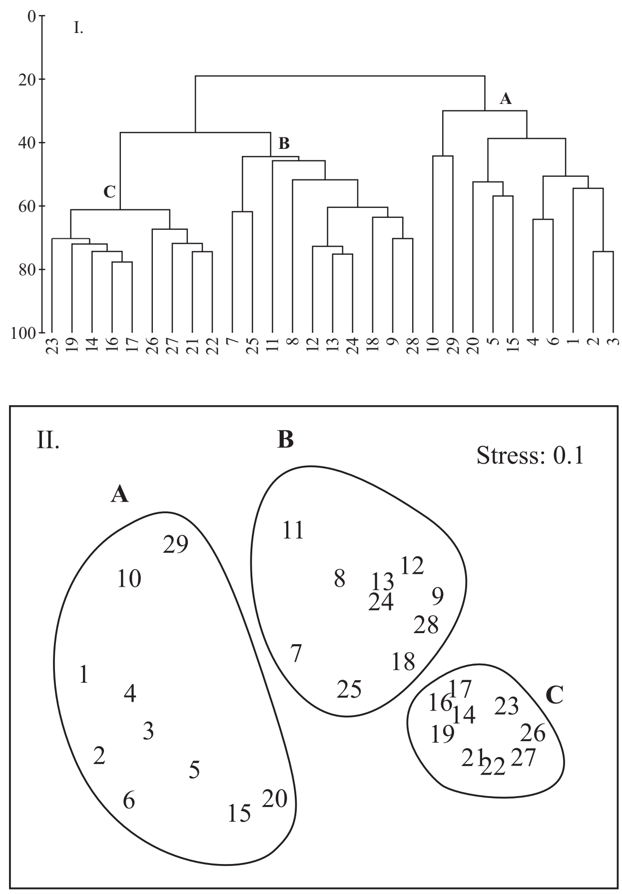

FIG. 2. – Dendrogram (I) and MDS (II) using Bray-Curtis similarity coefficient showing the classification and ordination of sites.

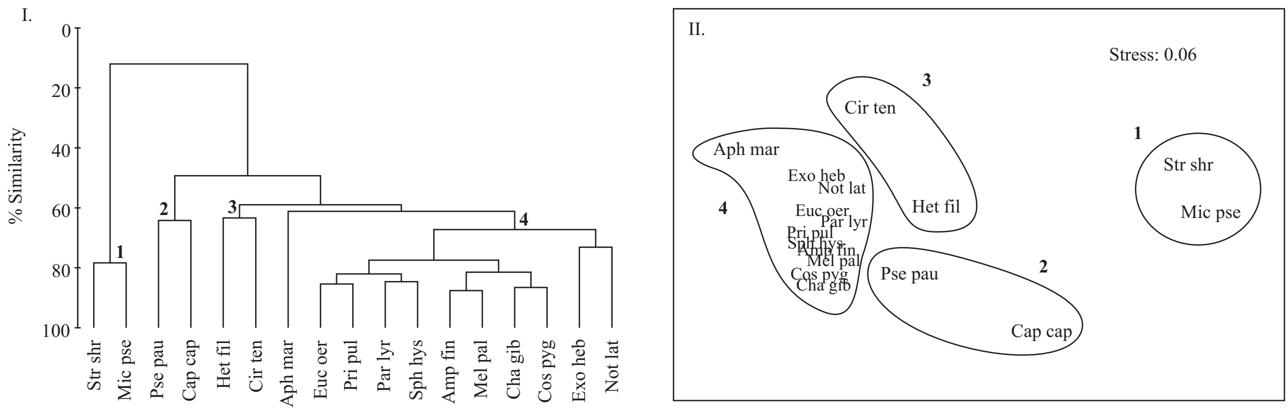

FIG. 3. – Dendrogram (I) and MDS (II) using Bray-Curtis similarity coefficient showing the classification and ordination of species with a numerical dominance ≥1%. Species codes: Amp fin, *A. finmarchica*; Aph mar, *A. marioni*; Cap cap, *C.* cf. *capitata*; Cha gib, *C. gibber*; Cir ten, *C. tentaculata*; Cos pyg, *C. pygodactylata*; Euc oer, *E. oerstedii*; Exo heb, *E. hebes*; Het fil, *H. filiformis*; Mel pal, *M. palmata*; Mic pse, *M. pseudoaberrans*; Not lat, *N. latericeus*; Par lyr, *P. lyra*; Pri pul, *P. pulchra*; Pse pau, *P. paucibranchiata*; Sph hys, *S. hystrix*; Str shr, *S. shrubsolii*.

granulometric composition. Group 3 was formed by *H. filiformis* and *Cirriformia tentaculata*; the former was present in the coarse sands of the inner part of the inlet and both species were present in deeper muddy sediments. Group 4 comprised the largest group of species, which were mostly found in muddy bottoms with high total organic matter content located at the middle and outer part of the inlet (Groups B and C of the dendrogram).

The combination of bottom water temperature and medium sand, very fine sand, total organic matter and calcium carbonate contents showed the highest correlation with polychaete abundance data (BIOENV: Spearman's rank correlation p_w: 0.318).

Description of assemblages

Three different assemblages were determined according to the dendrogram and MDS (Groups A, B, C; Table 3). Group A was located in the innermost part of the inlet, in intertidal sediments subjected to strong salinity variations close to the mouth of the rivers Oitabén-Verdugo, Xunqueira and Alvedosa. Sampling sites differed greatly in granulometric composition, with sedimentary types ranging from mud to very coarse sand. Diversity values were low due to the low number of species and also due to the high dominance in numbers of *P. paucibranchiata*, *S. shrubsolii* and *C.* cf. *capitata*, where average dominance was 23.48%, 20.04% and 24.13% respectively. The seagrasses *Zostera marina* and *Z. noltii* were spread across most of these intertidal and shallow subtidal bottoms, at depths of 1.6 to 2.9 m. Other species with high abundance were *M. pseudoaberrans* and *H. filiformis*, with densities higher than 450 ind m^{-2} at some sites. The aforementioned species were the most characteristic according to frequency-dominance product values (FxD, Table 4). SIMPER analysis showed that *C.* cf. *capitata*, *P. paucibranchiata* and *S. shrubsolii* were the species that made the greatest contribution to similarity (56.78%) within Group A. The average similarity for this group was 42.21%.

TABLE 3. – Summary of characteristics for each association. - I. Ecological features of the polychaete assemblages determined in the Ensenada de San Simón, indicating average and standard deviation of biotic and physical characteristics. Q_{50}, median grain size; Bt, Bottom type (M, mud; CS, Coarse sand; SM, sandy mud, MS, muddy sand); TOM, total organic matter content; CO_3, calcium carbonate content; H', Shannon Wiener diversity index; J, Pielou's evenness; S, number of species; D, density (ind per 0.28 m^2).

Group	A	B	C
Q_{50} (mm)	0.379 ± 0.489	0.026 ± 0.043	0.177 ± 0.496
Bt	M-CS	M-SM	M-MS
Depth (m)	1.91 ± 0.47	3.53 ± 0.88	10.13 ± 8.25
TOM (%)	13.09 ± 12.90	18.50 ± 6.81	17.08 ± 5.40
CO_3 (%)	6.45 ± 2.31	4.44 ± 1.35	9.09 ± 11.88
H'	1.83 ± 0.44	3.21 ± 0.41	3.71 ± 0.33
J	0.54 ± 0.14	0.76 ± 0.09	0.65 ± 0.03
S	11.60 ± 4.45	19.90 ± 5.38	52.44 ± 11.33
D	614.00 ± 513.68	171.40 ± 113.72	1858.56 ± 774.31

Group B was present along muddy bottoms in shallow sediments at the centre of the inlet, from intertidal areas to 4.7 m depth (site 28). Sediments were mainly composed of silt and clay (>50%), and ranged from mud to sandy mud. Species numbers generally increased from sites in inner areas towards those located at the mouth. Average individual density was the lowest in comparison to Groups A and C. Evenness in this group showed the highest values for the inlet. FxD and dominance values indicated that the most characteristic species were *M. palmata*,

TABLE 4. – Summary of characteristics for each association. – II. Species with highest FxD values (Frequency*Average Dominance in decreasing order: 1, 2, 3...); *, dominant species for each group up to 90% accumulated dominance; $\overline{S}$, Average similarity for the group; species that contribute most to similarity (S) for each group; Constancy (Ct, constant; VC, Very common) and Fidelity (Ex, Exclusive; El, Elective; Pr, Preferential; Ac, Accesory, Oc, Ocasional).

	A ($\overline{S}$: 42.21%)		B ($\overline{S}$: 54.59%)		C ($\overline{S}$: 66.75%)	
	F * D	S	F * D	S	F * D	S
C. cf. *capitata*	1*	10.73 (Ct/Ac)	4*	4.78 (Ct/Ac)	18*	0.64 (VC/Oc)
P. paucibranchiata	2*	7.16 (Ct/Oc)	2*	5.9 (Ct/Ac)	1*	3.81 (Ct/Pr)
S. shrubsolii	3*	6.07 (VC/El)				
M. pseudoaberrans	4*	3.85 (VC/El)				
H. filiformis	5*	4.25 (Ct/Oc)	16	1.02 (VC/Oc)	10*	2.23 (Ct/Ac)
Polydora ciliata	6*	3.1 (VC/El)				
M. vulgaris	*					
Fabricia sabella		1.61 (VC/El)				
Glycera tridactyla		1.46 (C/Ac)				
Chaetozone gibber			1*	5.75 (Ct/Ac)	6*	2.74 (Ct/Ac)
C. pygodactylata			3*	5.54 (Ct/Ac)	9*	2.45 (Ct/Ac)
Melinna palmata			5*	4.03 (Ct/Ac)	3*	3.58 (Ct/Pr)
A. finmarchica			6*	5.46 (Ct/Ac)	2*	4.26 (Ct/Pr)
Nephtys hombergi			7*	5.14 (Ct/Pr)		
Paradoneis lyra			8*	2.67 (Ct/Ac)	4*	3.36 (Ct/Pr)
Prionospio pulchra			9*	1.37 (VC/Ac)	8*	2.37 (Ct/Pr)
Sphaerosyllis hystrix			10*	1.85 (VC/Ac)	11*	2.39 (Ct/Pr)
Lagis koreni			11*	1.31 (VC/Ac)		0.81 (Ct/Pr)
Exogone naidina			12*	2.08 (Ct/Ac)		0.65 (VC/Ac)
Ophryotrocha sp.			13*		*	1.4 (Ct/Pr)
E. oerstedii			14*	1.57 (VC/Ac)	7*	2.87 (Ct/Pr)
Phyllodoce mucosa			15	1.28 (VC/Oc)		0.89 (Ct/Ac)
Spio decoratus			17*		*	1.06 (Ct/El)
S. caeca			18*		*	1.6 (Ct/Pr)
Exogone hebes			19*		14*	2.13 (Ct/El)
Sabella pavonina			*			
Nephthys cirrosa			*			
A. marioni					5*	1.24 (Ct/El)
C. tentaculata					12*	1.45 (Ct/El)
N. latericeus					13*	2.14 (Ct/El)
Polydora flava					15*	0.89 (Ct/Ex)
Praxillella sp.					16*	0.65 (VC/El)
Prionospio fallax					17*	1.35 (Ct/El)
Eumida sanguinea					19*	1.53 (Ct/El)
P. synophthalmica					*	1.56 (Ct/Ex)
T. stroemi					*	1.43 (Ct/El)
Chaetozone setosa						1.16 (Ct/El)
O. flexuosus						1.15 (Ct/El)
G. oculata						1.08 (Ct/El)
S. costarum						1.06 (Ct/El)
A. hibernica						0.97 (Ct/Ex)
Polydora sp.						0.81 (Ct/El)
Polydora caeca						0.69 (Ct/Ex)
L. latreilli						0.6 (VC/Ex)
Harmothoe sp.3						0.55 (VC/Ex)
P. cf. *longipes*						0.53 (VC/Ex)

Chaetozone gibber, *Cossura pygodactylata*, *A. finmarchica* and again *P. paucibranchiata*. Exclusive species for this group were *Ancistrosyllis groenlandica* (rare) and *Protodorvillea* sp. (rare). The polychaetes *P. paucibranchiata*, *C. gibber*, *C. pygodactylata*, *A. finmarchica*, *Nephtys hombergi* and *C.* cf. *capitata* defined this group according to the SIMPER analysis (average similarity within the group was 54.59%), with 59.67% similarity.

Group C was distributed along the mouth of the inlet at a maximal depth of 28.2 m. Sediments were predominantly composed of silt and clay that showed high total organic matter content. This group showed the highest number of species, densities and diversity. The species with the highest values of FxD were *P. paucibranchiata*, *A. finmarchica* and *M. palmata*. A total of 52 species were exclusive to this assemblage and 31 were constant. These species contributed 64% of the similarity within the group (average similarity of the group was 66.75%); most of these species (Table 4) were also responsible for dissimilarities among dendrogram groups.

DISCUSSION

Polychaete fauna distribution was primarily determined through sediment characteristics and bottom water temperature in the Ensenada de San Simón. The spatial distribution of polychaetes has generally been related to these and other factors, such as depth, sediment characteristics, temperature, salinity and hydrodynamism (Hutchings, 1998; Simboura *et al*., 2000).

A predominance of muddy sediments in the Ensenada de San Simón is a consequence of the hydrodynamic regime in the area: lack of strong currents in most of the inlet (maximum of 18 cm s^{-1} in the bottom layers; Vilas *et al*., 1995), and the presence of seagrass meadows in the inner parts. These features result in the deposition of finer fractions brought in by rivers; bivalve raft culture also contributes to this deposition by means of the mussel faecal pellets. In the Galician rias, coarser sediments are generally located at the mouth while the finer fractions are deposited in greater amounts in the inner areas. However, the opposite effect is seen in the Ensenada de San Simón, where the inner and marginal areas are regularly subjected to river currents and therefore mean grain-size is greater in these areas than in deeper bottoms, where finer particles are deposited.

Total organic matter content found in San Simón fluctuated between 0.95 and 36.93%. Maximum values are higher than in other muddy sediments of the Galician rias (e.g. Rodríguez-Castelo and Mora, 1984; López-Jamar and Mejuto, 1986; Mora *et al*., 1989; López-Jamar and Cal, 1990; Parra *et al*., 2002). Organic matter content in the rias of Arousa, Muros, the harbour area of Ferrol, Vigo and Pontevedra, ranged from 2.32 to 21.31%. In San Simón, the high organic matter content might be due to the contribution of detritus from the dense seagrass meadows located in the intertidal and shallow subtidal areas and also from detritus produced by mussels cultured on rafts. A lack of strong currents also results in gradual ongoing organic enrichment in the area. Thus, Vilas *et al*. (1995) found maximal organic matter content of 10% while four years later maximal contents were found to be about three times higher (this work). The anoxic conditions present in the inner areas of the southern Galician rias (Rías Baixas) may affect benthic populations through a decrease in macrofaunal diversity and by favouring colonisation of opportunistic species such as *Spiochaetopterus costarum* (Rodríguez-Castelo and Mora, 1984). Surprisingly, this species, which is characteristic of organically enriched muddy sediments in the Rías Baixas, appears in low densities in San Simón.

Intertidal sediments in the San Simón area are subject to salinity changes due to freshwater input from several rivers (Vilas *et al*., 1995). Such salinity fluctuations may greatly influence the number and types of species that can survive there and/or numerically dominate the community (Planas and Mora, 1987). Thus, the dominant species in these sediments were the deposit-feeder *Streblospio shrubsolii* and the carnivorous *Microphthalmus pseudoaberrans*. Moreover, coarser sediments provide a greater diversity of interstitial spaces to organisms than finer sediments (Olabarria *et al.*, 1998), and thereby facilitate habitats for small-sized species such as *M. pseudoaberrans*. On the other hand, intertidal sediments colonised by *Z. noltii* and *Z. marina* showed low diversities. Seagrass meadows are known to provide a complex habitat that may be colonised by many species (Somerfield *et al.*, 2002). In the Ensenada de San Simón, however, these meadows are located in areas subjected to wide salinity changes which are a major limiting factor for many species (Planas and Mora, 1987; Junoy, 1996).

The greatest values of species diversity and numbers were found in muddy sediments at the mouth of the inlet, where there is a greater stability of salinity values and hydrodynamic conditions (Nombela *et al.*, 1987). In fact, the highest diversity value was recorded at site 26, which was characterised by a greater grain-size heterogeneity and was the deepest site. Heterogeneous sediments with biogenic fragments which allow high diversity of microhabitats are mostly associated with greater faunal diversity (Nicolaidou and Papadopolou, 1989; Lastra *et al*., 1990; Villora-Moreno, 1997; Simboura *et al*., 2000; Moreira *et al*., 2006).

Three major polychaete assemblages were determined in the Ensenada de San Simón through multivariate analyses. Intertidal bottoms colonised by the seagrasses *Z. marina* and *Z. noltii* (Group A) showed a greater numerical dominance by spionids and capitellids and low species number and diversity values. The species composition of this group, i.e. *Pseudopolydora paucibranchiata*, *Streblospio shrubsolii*, *Capitella* cf. *capitata*, *M. pseudoaberrans*, *Heteromastus filiformis,* has also been reported for other intertidal and shallow subtidal sediments in the Galician rias (A Foz (Anadón, 1980); Ría de Ares-Betanzos (Garmendia *et al*., 1998); Miño estuary (Mazé *et al*., 1993); harbour of Baiona (Moreira *et al*., 2003)).

The muddy bottoms of Group B had polychaete fauna which was mostly dominated by ampharetids, terebellids, cirratulids and spionids. These families were also present in Group C. Group C was located in the deepest muddy bottoms at the mouth of the inlet and showed the highest number of species and densities. Other deposit feeders, such as paraonids and maldanids, were numerically dominant in these bottoms. According to the polychaete fauna present in Groups B and C (*Melinna palmata*, *Chaetozone gibber*, *Cossura pygodactylata*, *Ampharete finmarchica*, *P. paucibranchiata*, *Nephtys hombergi*, *C.* cf. *capitata*), these groups can be considered as two different facies of the *Abra alba* community defined by Petersen (1918). This community, also determined by other invertebrates such as the molluscs *Hydrobia ulvae* (Pennant, 1777) and *Cerastoderma edule* (Linnaeus, 1758), has been reported along European and Galician coasts in a number of muddy sediments (Lastra *et al.*, 1988; López-Jamar and Cal, 1990; Carpentier *et al.*, 1997; Thiébaut *et al.*, 1997; Olabarria *et al.*, 1998; Sánchez Mata and Mora, 1999; Moreira *et al.*, 2005; Lourido *et al.*, 2008). Several species, such as *C. pygodactylata*, have been linked to muddy bottoms with *Zostera* leaves showing decomposition (Bachelet and Laubier, 1994; Moreira *et al.*, 1999). In fact, *C. pygodactylata* is known to be an opportunistic species which appears in anoxic habitats such as those present in San Simón.

Species numbers, diversity and evenness values were lower in the intertidal bottoms than in the subtidal areas of the inlet. Salinity fluctuations coupled with effects from a number of human activities may be responsible for the scarce polychaete fauna. Thus, the sites with the lowest number of species and densities were found along bottoms close to the mouth of freshwater channels and in the main harbour area at the inlet (site 29). For instance, the deposit-feeder *C.* cf. *capitata*, usually recorded in organically enriched environments (Méndez *et al.*, 1997), was the dominant species at site 29. Deposit feeders are, in general, numerically dominant in fine grain-size sediments (Sanders, 1968; Levinton, 1977). This was also true for muddy bottoms of the Ensenada de San Simón, where surface and subsurface deposit-feeder polychaetes (spionids, cirratulids and capitellids) were the most abundant polychaetes. Dominance by spionids has been considered to be an indicator of polluted environments; nevertheless, their reproductive and feeding plasticity make them good colonisers of different kinds of environments (Herrando-Pérez *et al.*, 2000), and therefore they should not always be considered to be a symptom of anthropogenic perturbation (Moreira *et al.*, 2006).

Average diversity and number of species is generally greater in ocean-exposed rias with sandy and more heterogeneous sediments, such as the Ensenada de Baiona (total number of species: 132; Moreira *et al.*, 2006) and the Ría de Aldán (total number of species: 145; Lourido *et al.* 2008). In fact, high organic matter content is related to low diversity and species richness (López-Jamar and Cal, 1990). Nevertheless, polychaete diversity values (2.89 ± 0.89) and number of species (27.1 ± 19.1, 123 species in total) in the Ensenada de San Simón were higher than in other Galician rias with similar sedimentary conditions. For example, the *Spiochaetopterus costarum* community described by López-Jamar and Mejuto (1986) in the rias of Arousa and Muros was only composed of 12 polychaete species. López-Jamar (1978) found a total of 52 species in the Ría de Pontevedra, while Rodríguez Castelo and Mora (1984) cited 12 to 27 species per site for the same area. Organic enrichment of sediments in the San Simón area is mostly due to mussel culture and detritus originating from seagrass meadows. This organic richness, promoted by high hydrodynamical and substrate stability, benefits depositivore polychaetes, which reach maximum densities in the subtidal bottoms where there is no tidal stress or influence from rivers.

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Appendix 1. – Number of individuals of the polychaeta species found at each site (0.28 m^2).

Site	1	2	3	4	5	6	7	8	9	10
Aricia foetida (Claparède, 1870)										
Paradoneis lyra (Southern, 1914)								2	3	
Cirrophorus cf. *furcatus* Hartmann, 1957										
Cossura pygodactylata Jones, 1956							4	15	109	
Aonides oxycephala (Sars, 1862)					1					
Malacoceros vulgaris (Johnston, 1827)							1			37
Polydora caeca (Oersted, 1843)										
Polydora ciliata (Johnston, 1838)	7	84	9		5					3
Polydora flava Claparède, 1870										
Polydora sp.										
Prionospio fallax Söderström, 1920										
Prionospio pulchra Imajima, 1990									1	
Pseudopolydora pulchra (Carazzi, 1895)										
Pseudopolydora paucibranchiata (Okuda, 1937)		8	3	12	801	16	69	17	17	5
Pygospio elegans Claparède, 1863										
Spio decoratus Bobretzky, 1871								1	2	
Streblospio shrubsolii (Buchanan, 1890)	5	452	318	39	18	200				
Spionidae sp.										
Magelona filiformis Wilson, 1959										
Poecilochaetus serpens Okuda, 1937										
Chaetopterus variopedatus (Renier, 1804)										
Spiochaetopterus costarum (Claparède, 1870)										
Aphelochaeta marioni (Saint-Joseph, 1894)									8	
Caulleriella alata (Southern, 1914)										
Caulleriella bioculata (Keferstein, 1862)										
Caulleriella sp.										
Monticellina dorsobranchialis (Kirkegaard, 1959)										
Cirriformia tentaculata (Montagu, 1808)					5		1			
Chaetozone gibber Woodham and Chambers, 1994			1				2	15	26	
Chaetozone cf. *setosa* Malmgren, 1867										
Capitella cf. *capitata* (Fabricius, 1780)	53	113	126	17	22	5	46	37	1	61
Heteromastus filiformis (Claparède, 1864)	1	168	7	4	148	32	1			
Notomastus latericeus Sars, 1851										
Euclymene lombricoides (Quatrefages, 1865)										
Euclymene oerstedii (Claparède, 1863)							4		1	
Clymenura clypeata (Saint-Joseph, 1894)							4			
Praxillella sp.									2	
Armandia cirrhosa Filippi, 1861								2		
Eteone foliosa Quatrefages, 1866										
Eteone cf. *longa* (Fabricius, 1780)			2							
Eteone picta Quatrefages, 1866										1
Eumida cf. *bahusiensis* Bergström, 1914										
Eumida sanguinea (Oersted, 1843)							2			
Paranaitis kosteriensis (Malmgren, 1867)										
Phyllodoce lineata (Claparède, 1870)										
Phyllodoce cf. *longipes* Kinberg, 1866										
Phyllodoce mucosa Oersted, 1843					10		3			1
Phyllodoce rosea (McIntosh, 1877)										
Pseudomystides limbata (Saint-Joseph, 1888)										
Harmothoe sp.1										
Harmothoe sp.2										
Harmothoe sp.3										
Pholoe synophthalmica Claparède, 1868										
Microphthalmus pseudoaberrans Campoy and Viéitez, 1982	4	428	531	8	11	107		1		
Ophiodromus flexuosus (Chiaje, 1825)										
Ophiodromus cf. *pelagica* Rioja, 1923										
Podarkeopsis capensis (Day, 1963)										
Syllidia armata Quatrefages, 1865										
Ancistrosyllis groenlandica McIntosh, 1879										
Pilargis verrucosa Saint-Joseph, 1899										
Autolytus cf. *edwardsi* Saint-Joseph, 1887				1						1
Autolytus sp.										
Exogone hebes (Webster and Benedict, 1884)										
Exogone naidina Oersted, 1845					1		1		3	1
Parapionosyllis brevicirra Day, 1954										
Parapionosyllis minuta (Pierantoni, 1903)				1	11	1				
Proceraea sp.										
Sphaerosyllis belizensis Rusell, 1989								1		1
Sphaerosyllis campoyi San Martín *et al.*, 1982								3	1	
Sphaerosyllis hystrix Claparède, 1863									24	
Sphaerosyllis websteri Southern, 1914										

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
			1		1			2			3	1						
	4	2	62		111	79	9	108	1	86	88	78	1	5	391	369	12	
																2		
5	4	10	78		88	61	25	16		23	90	22	1	2	14	29	86	
										15	29				5	10		
																		8
			6		1					4	3	8			3	1		
				4					35	12	1				3			
			19			1				1	9	55			54	33		
			2		1			3		6	14	5			5		1	
			11			8	1	10		11	31	36			3	8	3	1
	6	2	51		4	32	13	47		43	90	101	11		21	32	3	
				1			1									2		
2	1	2	406	331	301	650	26	170	1022	46	759	320	24	29	14	395	34	10
									1									
			23		9	18	5	9		2	1	1	1		1		15	
			3	186			1											
											1							
					1	1					3							
						1												
					1			1		1		5						
	2	1	1		5	2		4		4	4	11	2			2	3	
			304		5		2	1		348	38				544	62	1	
										2	27				94	11		
										1								
			1															
										5	14	4		2	24	96	1	
			4		1	3		1	1	39	210	1		4	7	196		
8	27	19	97		178	28	50	127		17	56	20	17		162	79	98	
	2		4		2	2		7		5	5	3				6		
5	2	1	8	20	8	2	12	49	123	2	6		1	16			13	64
		1	10	3	8	17	1	11	1	91	115	9	1	4	177	92	1	
			13	59	17	21	5	63	2	33	25	23	2		8	25		
											1							
	2		44		27	66	9	48		51	225	70	1	1	28	220	1	
			8		1		2	5			2			1		1		
			3					2		23	74				10	67		
			2		2	20						1			1	2	6	
			1															
					1											1	1	
			1			1				1	1							
						1												
			15	1	1	5		3	4	5	34	1		8	55	17		
			1					1			1				3			
							1			1	3				1	2		
			4		2						7	1			2	13		
	1	1	7	3	3	7	3	15	17	4	2		1	2	10			3
																1		
			1															
								1										
										1								
								1		5	12	2			32	5		
			3		1	3		4		6	23	16			34	14		
		1	2		4	5	1	6		6	4	6				2		
															1			
											1							
										1	4				24	1		
							1											
												1						
															1			
												1						
		1	57		13	5	49	11		16	88	11			17	84		1
1	1	1	14	1	7	7	1					1		1	10	4	1	
				55											1			
					3													
										1					2			
		1	2				1				1				11			
	1	2	59		23	19	9	15	1	27	47	9	2	1	242	38	6	
											1							

APPENDIX 1 (cont.). – Number of individuals of the polychaeta species found at each site (0.28 m^2).

Site	1	2	3	4	5	6	7	8	9	10
Syllides cf. *edentatus* (Westheide, 1974)										
Syllis columbretensis (Campoy, 1982)										1
Syllis gracilis Grube, 1840										
Eunereis longissima (Johnston, 1840)										
Neanthes caudata (Chiaje, 1828)										3
Platynereis dumerilii (Audouin and Milne-Edwards, 1834)			9			5			2	24
Glycera tridactyla Schmarda, 1861				1	67	2	2			
Glycera unicornis Savigny, 1818										
Goniadella galaica Rioja, 1923						4				
Goniada sp.										
Nephtys cirrosa Ehlers, 1868							2	10		
Nephtys hombergi Savigny, 1818	2			1			13	7	22	
Sphaerodopsis garciaalvarezi Moreira *et al*., 2004										
Sphaerodorum gracile (Rathke, 1843)										
Diopatra neapolitana Chiaje, 1841								1	4	
Hyalinoecia bilineata Baird, 1870										
Eunice vittata Chiaje, 1828										
Abyssoninoe hibernica (McIntosh, 1903)										
Lumbrineris impatiens (Claparède, 1868)										
Lumbrineris latreilli Audouin and Milne-Edwards, 1834										
Dorvilleidae sp.										
Ophryotrocha sp.									7	
Protodorvillea kefersteini (McIntosh, 1869)										
Protodorvillea sp.										
Schistomeringos caeca (Webster and Benedict, 1884)							1	5		
Schistomeringos neglecta (Fauvel, 1923)						8				
Schistomeringos rudolphi (Chiaje, 1928)										
Schistomeringos sp.						1				
Sternaspis scutata (Renier, 1807)										
Galathowenia oculata (Zaks, 1922)										
Flabelligera affinis Sars, 1829										
Pherusa monilifera (Chiaje, 1841)										
Sabellaria spinulosa Leuckart, 1849										
Lagis koreni Malmgren, 1866								2	2	
Ampharete finmarchica (Sars, 1866)			4				1	7	17	
Melinna palmata Grube, 1870								1	12	
Amphitritides gracilis (Grube, 1860)										
Lanice conchilega (Pallas, 1766)								1	3	
Paramphitrite tetrabranchia Holthe, 1976										
Pista cristata (Müller, 1776)										
Polycirrus sp.										
Terebellides stroemi Sars, 1835										
Branchiomma linaresi Rioja, 1917										
Branchiomma vesiculosum (Montagu, 1815)										
Fabricia sabella (Ehrenberg, 1837)	2	13	2		2					8
Fabricia sp.										
Jasmineira elegans Saint-Joseph, 1894										
Sabella pavonina Savigny,1822							4			
Pomatoceros lamarcki (Quatrefages, 1865)										
Pomatoceros triqueter (Linneo, 1767)										
Janua pagenstecheri (Quatrefages, 1865)										7
Protodrilidae sp.			14							

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
						1		1			2	6				1		
								2		1	1				3			
						1												
2									2	2								
			1		1		3	2	2	8	1	4		5				
			4	34				1	27	6	3			1				
								1				1			1	1		
															1			
											1							
											1							
2	6	6	14		5	1	12						1	2	7		6	1
															3	1		
															1			
			3							1	4						1	
														1	2			
															4	1		
					1	1		1		2	6	8			9	2		
										1	1				1			
								3		3	14	2			19	9		
								1		1					1			
2			10		1	5	1	2		6	39	1		1	4	6	11	
										1					10	1		
														1				
			6	4	5	8		3	1	6	14	1		11	11	11		
											2					1		
															2			
															7			
								1										
			8		1	2				8	6	2		1	4	12	1	
															7	1		
										2					1			
															9	4		
		3	7		3	9		4			2		2	4	7	2	3	
1	12	9	367		122	163	26	126		222	481	231	14	3	460	592	42	
1	64	5	237		172	174	75	199		90	278	163	10	2	73	91	8	
																2		
			12					2		1				6	3	8		
											1				1	2		
								2		2	3				79	1		
			1			1			1	1	3				8	1		
	2		3		7	11	1	5		1	7	8			3	3		
												1				4		
				1					7									
2									1									
				1														
											1				3			
									9					12	2			
									1	2						2		
										6	1				1	2		
									2									