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SCIENTIA MARINA 74(3)
September 2010, 455-464, Barcelona (Spain)
ISSN: 0214-8358
doi: 10.3989/scimar.2010.74n3455

Composition and distribution of subtidal and intertidal crustacean assemblages in soft-bottoms of the Ria de Vigo (NW Spain)

EVA CACABELOS, ANTÍA LOURIDO and JESÚS S. TRONCOSO

Dpto. Ecoloxía e Bioloxía Animal, Facultade de Ciencias do Mar, Universidade de Vigo, Campus Lagoas-Marcosende, 36310, Vigo (Pontevedra), Spain. E-mail: cacabelos@uvigo.es

SUMMARY: The intertidal and subtidal soft-bottoms of the inner area of the Ria de Vigo (NW Spain) were sampled in November and December 1999, and spatial distribution of crustacean species was examined. Environmental variables from water and sediment were measured at each sampling site. Amphipods and myocopids were the numerically dominant orders (49.9 and 26.9% dominance), amphipods accounting for more than 54% of identified taxa. The highest crustacean densities occurred with 55-41 species and 5953.6-4346.4 ind. m^{-2} in external areas, where the diversity index reached the maximum values. Multivariate techniques revealed that distribution of crustaceans in the inlet was highly dependent on depth. Ordination analysis determined three major assemblages: Intertidal bottoms colonized by seagrasses and subjected to strong variations of salinity were dominated by the amphipod *Melita palmata*, harpacticoids and the isopod *Idotea baltica* (Group A). The amphipod *Corophium* cf. *runcicorne* and the cumacean *Iphinoe tenella* predominated in the muddy bottoms of central areas (Group B). These species were also present in the deep muddy bottoms of the mouth of the inlet, with high carbonate and gravel contents, and with the myocopids and the amphipod *Microdeutopus* cf. *armatus* displaying maximum dominances (Group C).

Keywords: marine crustaceans, macrofaunal composition, soft bottoms, Ensenada de San Simón, Ria de Vigo, Atlantic Ocean.

RESUMEN: COMPOSICIÓN Y DISTRIBUCIÓN DE LAS ASOCIACIONES DE CRUSTÁCEOS SUBMAREALES E INTERMAREALES EN FONDOS BLANDOS DE LA RÍA DE VIGO (NO ESPAÑA). – Los fondos blandos intermareales y submareales de la parte interna de la Ría de Vigo (NO España) fueron estudiados en relación a la distribución de los crustáceos y a las variables ambientales asociadas a sus aguas y sedimentos. Los anfípodos y miocópidos fueron los órdenes más abundantes (49.9 y 26.9%), presentando los anfípodos más del 54% de los taxa identificados. Las mayores densidades de crustáceos aparecieron en las áreas externas, con 55-41 especies y 5953.6-4346.4 individuos por m^2, alcanzándose aquí los máximos valores de diversidad. Se emplearon técnicas multivariantes para analizar los datos, demostrando que la distribución de los crustáceos en la ensenada dependía principalmente de la profundidad. Se observaron tres principales asociaciones de crustáceos: Los fondos intermareales, colonizados por las fanerógamas marinas *Zostera marina* y *Z. noltii* y sometidos a drásticos cambios de salinidad, estuvieron dominados por el anfípodo *Melita palmata*, los harpacticoideos y el isópodo *Idotea baltica* (Grupo A). El anfípodo *Corophium* cf. *runcicorne* y el cumáceo *Iphinoe tenella* predominaron en los fondos fangosos de la zona central (Grupo B). Estas especies también estuvieron presentes en los fondos profundos de la boca de la ensenada, donde los miocópidos y el anfípodo *Microdeutopus* cf. *armatus* presentaron sus máximas dominancias (Grupo C).

Palabras clave: crustáceos marinos, composición macrofaunística, fondos blandos, Ensenada de San Simón, Ría de Vigo, Océano Atlántico.

INTRODUCTION

The study of the composition and distribution of benthic communities is of great interest, because they are considered as good indicators of the conditions of marine sediments (Grall and Glémarec, 1997; Conradi and López-González, 2001). Crustaceans are an important component of soft-bottom benthic communities in temperate latitudes. Amphipods in particular play an important role in structuring benthic assemblages (Duffy and Hay, 2000) as secondary and tertiary producers in marine communities (Guerra *et al.*, 2002). Dauvin (1988) and Beare and Moore (1996) showed amphipods to be an important source of food for benthic fauna of commercial interest. Amphipods are also very ecologically sensitive organisms and good indicators of natural or disturbed environmental conditions (Conradi *et al.*, 1997). Moreover, benthic databases are essential for comparisons which can be used in impact studies or monitoring programmes, in order to preserve the environments and the species of commercial importance that they support (Desroy *et al.*, 2002).

The highly macrobenthic diversity characteristic of the Galician rias (NW Spain) is due to their great variety of habitats and sediments (Troncoso and Urgorri, 1993; Moreira *et al.*, 2009). They are characterized by a regular incoming of nutrients due to upwelling (Nombela *et al.*, 1995), which is translated into a high primary productivity. However, the ria seashores are also highly populated and therefore subject to many anthropogenic perturbations (e.g. culture of bivalves and construction of harbours). This is translated into organic enrichments and changes in sedimentary composition (López-Jamar and Mejuto, 1985; Moreira *et al.*, 2009).

The Ria de Vigo is one of the largest and most complex estuarine systems on the Galician coasts, and the first in terms of economic importance and human population. During the last forty years it has been extensively studied, especially with regard to its oceanography, fisheries, mussel culture on rafts and shellfish resources (Abella *et al.*, 1996; Pérez-Arlucea *et al.*, 2000). Previous studies on the benthic fauna of the Ria de Vigo only referred to specific areas and/or faunistic groups (López-Jamar and Cal, 1990; Moreira *et al.*, 2004, 2009; Cacabelos *et al.*, 2008a, b). Except for the studies of Cacabelos *et al.* (2008c) about the macrofaunal assemblages found in the Ensenada de San Simón as a whole, in which some of the most relevant arthropods are mentioned, the crustacean fauna of the inlet has not been properly studied.

Since grain size is one of the most often reported factors affecting the distribution of crustaceans elsewhere, we hypothesized that in this particular inlet this factor could influence the pattern of crustacean zonation. Therefore, the objectives of the present study are (i) to describe the structure of the crustacean communities in intertidal and shallow subtidal areas of the Ensenada de San Simón, (ii) to analyse the interactions between the different assemblages and (iii) to relate any observed faunal pattern to sediment characteristics and other environmental variables. This knowledge will be essential to ensure the correct management of resources in the area, especially since it has been included in the Nature 2000 Network as a Special Conservation Zone.

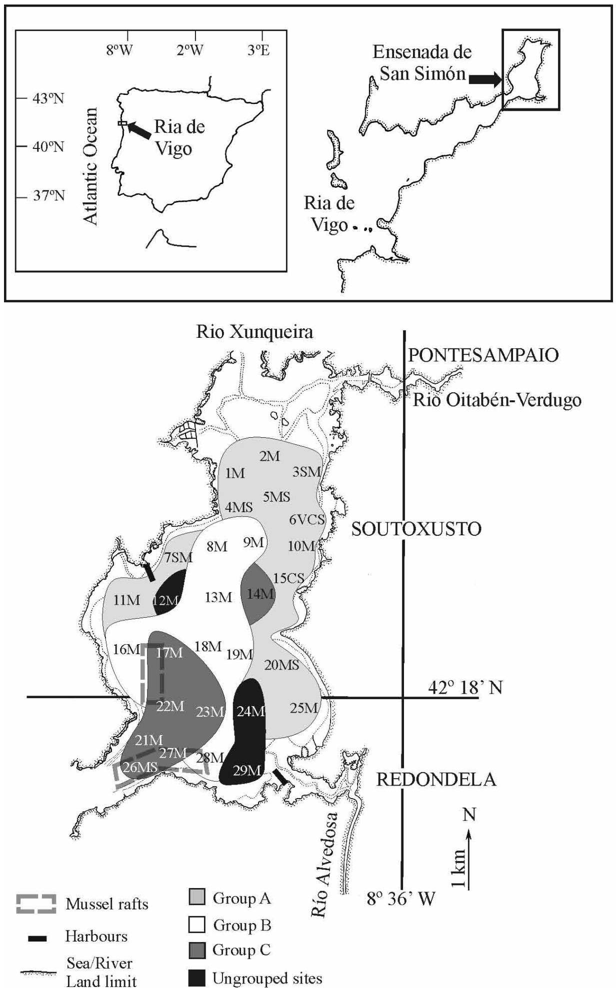

FIG. 1. – Location of the Ensenada de San Simón (Ria de Vigo) with position of the 29 sampling sites and spatial distribution of crustacean assemblages related to sediment grain size (M, mud, SM, sandy mud, MS, muddy sand, CS, coarse sand, VCS, very coarse sand).

METHODS

Study area

The Ensenada de San Simón is located in the innermost part of the Ria 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 (0.69-10%) (Vilas *et al.*, 1995). Intertidal and shallow subtidal areas have meadows of the seagrasses *Zostera noltii* Hornem. 1832 and *Zostera marina* L. The culture of mussels on rafts is a common practice in large areas of the mouth of the inlet, where 75 rafts are exploited. Two small harbours are located in the inlet sides. The major hydrological features of the inlet are the large freshwater inputs occurring in the innermost part of the inlet, resulting in drastic temperature and salinity fluctuations on a tidal and seasonal basis (6-35.3 psu; Saiz *et al.*, 1961; Nombela and Vilas, 1991). Previous studies (Cacabelos *et al*., 2008a, b, c) have included detailed information about this study area.

Sampling and sedimentary analysis

Quantitative samples were collected from 29 sites using a van Veen grab in November and December 1999 (Fig. 1). Five replicate samples were taken at each site (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 from water and sediment. An additional sedimentary sample was taken at each site for later grain-size analysis and to determine calcium carbonate and total organic matter contents. Sedimentary types were determined according to Junoy (1996). Median grain size (Q_{50}) and sorting coefficient (S_o) were also determined for each sample. Kurtosis (Kg) and skewness (Sk) coefficients were calculated according to Folk and Ward (1957). Calcium carbonate content (%) was estimated by sample treatment with hydrochloric acid, and total organic matter content (%) was estimated from the weight loss after placing samples in a furnace for 4 hours at 450ºC.

Data analysis

Abundance data of each crustacean species were organized in matrices, and the five samples taken at each site were pooled (0.28 m^2). Total abundance of crustaceans (N), number of species (S), Shannon-Wiener diversity index (H', log_2) and Pielou's evenness index (J) were determined for each site. Correlations between these diversity measures, the abundance of dominant species and environmental variables were determined using Spearman's non-parametric correlation coefficient. Crustacean assemblages were determined through non-parametric multivariate techniques using the Plymouth Routines of the Multivariate Ecological Research software package (PRIMER; Clarke and Warwick, 1994). A similarity matrix was performed using the Bray-Curtis coefficient after applying the fourth-root transformation to species abundance. Classification and ordination of sites and species were performed by cluster analysis through the algorithm UPGMA and non-metrical multidimensional scaling (MDS), respectively.

With regard to the abundance of the species recorded in the Ensenada de San Simón, five categories of constancy index were considered according to the number of times the species was found in the total of samples: constant (>76%), very common (51-75%), common (26-50%), uncommon (13-25%) and rare (<12%). According to the ratio between this index and the total constancy in the considered area, the fidelity index classify the species as accidental (<10%), occasional (11-33%), accessory (34-50%), preferential (51-66%), elective (67-90%) and exclusive (>91%) (Cabioch, 1968; Dajoz, 1971).

Relationships between abundance of crustaceans and environmental variables were studied by means of the BIOENV procedure (PRIMER package) and canonical correspondence analysis (CANOCO package; ter Braak and Prentice, 1988). Environmental variables expressed in percentages were previously transformed by log (x+1) and all of them were normalized.

RESULTS

The soft bottoms of the Ensenada de San Simón were characterized by a predominance of muddy sediments with a high organic matter and low calcium carbonate contents. Sandy sediments were present in tidal channels in the inner inlet where low total organic matter content was found. The shallow sediments became increasingly muddy towards the deeper bottoms

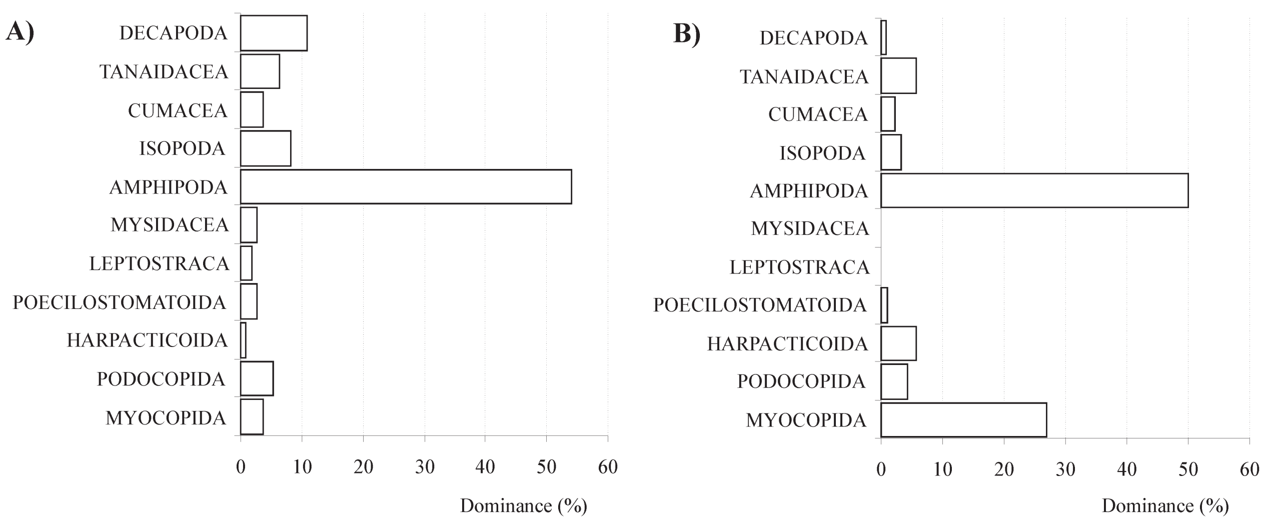

FIG. 2. – Dominances (%) of different orders calculated in function of number of taxa (A) and individuals (B).

TABLE 1. – Significant Spearman's rank correlation coefficients between biotic and environmental parameters. Tªb, bottom water temperature, S_o, sort coefficient, CO_3, carbonate content, S, number of species, N, total abundance and H'(log_2), Shannon Wiener diversity index. (N=29, * p<0.05, ** p<0.01).

	S	N	H'(log_2)
Tªb	0.399*	0.277	0.121
S_o	0.402*	0.259	0.016
Depth	0.556**	0.3	0.554**
CO_3	0.29	0.446*	0.115

in the centre and at the mouth of the inlet. The areas around the outer part had muddy sands with a large gravel fraction composed by mussel shells.

Sampling yielded 10916 crustaceans belonging to 11 orders and 111 species or taxa, of which 60 were amphipods, 11 decapods, 9 isopods, 7 tanaidaceans, 6 podocopids, 4 myocopids and 4 cumaceans, 3 poecilostomatoids and 3 mysidaceans, 2 leptostraceans and 2 harpacticoids (Supplementary material Appendix 1 and 2; Fig. 2A).

The Amphipoda fauna was the dominant order in the inlet (Fig. 2B). The numerically most important species of this group were *Microdeutopus* cf. *armatus* (11.43% of total fauna), *Melita palmata* (7.30%), *Metaphoxus simplex* (2.91%), *Harpinia dellavallei* (2.80%) and *H. crenulata* (2.78%). The Order Myocopida accounted for 26.88% of all specimens. The rest of the orders were less dominant in terms of abundance.

The highest numbers of species and densities were recorded at sampling sites 27, 22 and 26, with 55-41 species and 5953.6-4346.4 ind. m^{-2}. The lowest densities and number of species were recorded at sites 12, 29 and 24, with 0-35.7 ind. m^{-2} and 0-7 species. The Shannon-Wiener diversity index ranged between 4.20 (site 26) and 0.00 (sites 12 and 29). Evenness showed low values on bottoms with high dominances of myocopids and the amphipods *Harpinia* spp. (site 17) or the harpacticoids (site 10).

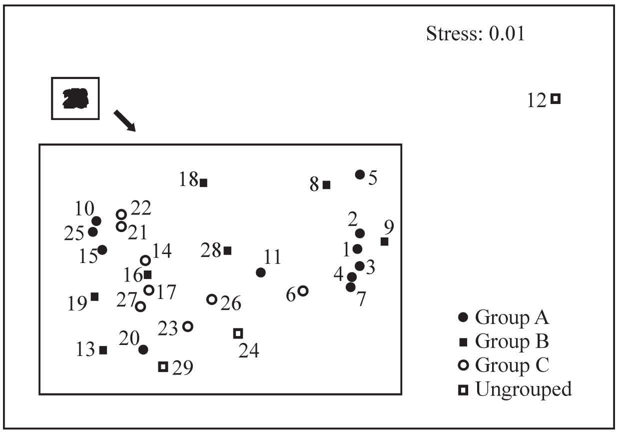

FIG. 4. – Non-metric multidimensional scaling ordination of crustacean assemblages.

Spearman's correlation coefficient showed that depth was positively correlated with number of species and Shannon-Wiener diversity index (p<0.01). Temperature of bottom water and sorting coefficient showed positive correlations with number of species (p<0.05), while carbonate content was positively correlated (p<0.05) with abundance of individuals (Table 1).

Crustacean assemblages and species affinities

The dendrogram obtained through cluster analysis based on abundance data showed the presence of three major groups (Fig. 3; assemblages illustrated in Fig. 1): Group A, composed of intertidal sites; Group B, located in the shallow muddy bottoms of the centre of the inlet and Group C, composed of the deeper muddy bottoms of the mouth of the inlet. These same groups appeared in the MDS ordination (Fig. 4), in which site 12 was eliminated due to its absence of individuals. The abiotic and faunistic characteristics of these assemblages

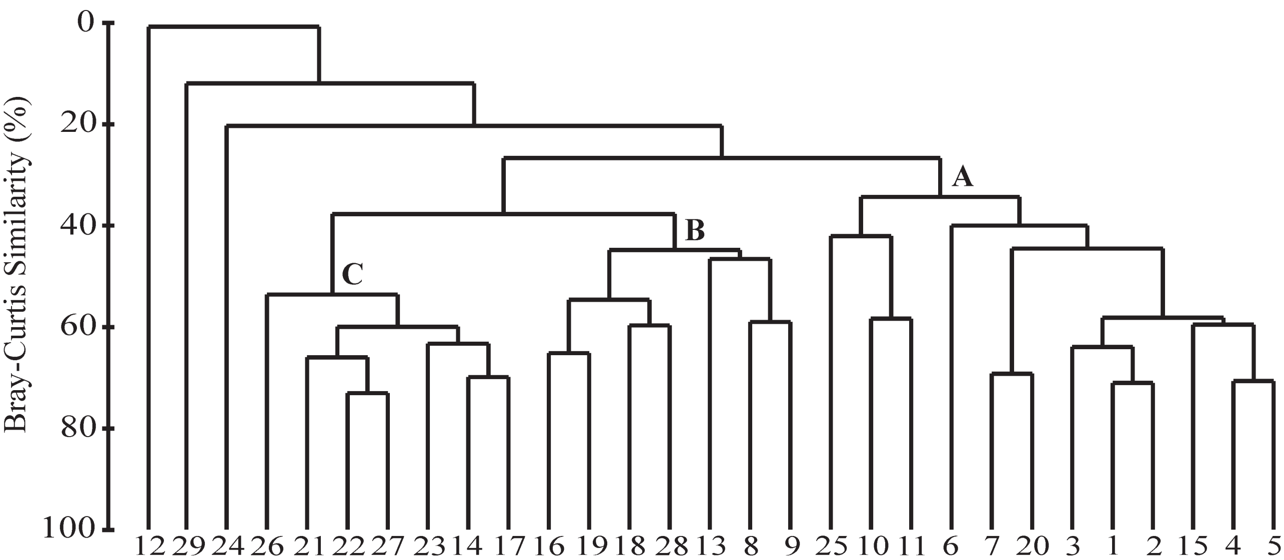

FIG. 3. – Dendrogram using Bray-Curtis similarity coefficient showing the classification of sites.

TABLE 2. – Ecological features of the crustacean assemblages determined in the Ensenada de San Simón, indicating ranges and average ± standard deviation of biotic (values per 0.28 m^2) and physical characteristics. S, number of species; N, number of individuals; J', Pielou's evenness; H', Shannon Wiener diversity index; Q_{50}, median grain size; Bt, bottom type (M, mud; CS, coarse sand; SM, sandy mud, MS, muddy sand); OM, organic matter content; CO_3, carbonate content. Species that add up to 75% of the total abundance in each assemblage are listed in order of dominance (%), and constancy (Ct, constant; VC, very common; C, common) and fidelity (Ex, exclusive; El, elective; Pr, preferential; Ac, accessory; Oc, occasional) are indicated.

		Group A	Group B	Group C
Sites		1, 2, 3, 4, 5, 6, 7, 10, 11, 15, 20, 25	8, 9, 13, 16, 18, 19, 28	14, 17, 21, 22, 23, 26, 27
S	Mean ± SD	14.83 ± 5.20	16.57 ± 6.35	38.00 ± 9.1
	Range	25-7	25-7	55-29
N	Mean ± SD	214.58 ± 130.69	95.57 ± 71.39	1094.43 ± 458.1
	Range	405-28	242-28	1667-326
J'	Mean ± SD	0.68 ± 0.10	0.77 ± 0.12	0.64 ± 0.1
	Range	0.92-0.56	0.93-0.63	0.78-0.47
H'(log_2)	Mean ± SD	2.71 ± 0.55	3.08 ± 0.70	3.40 ± 0.7
	Range	3.53-1.65	4.12-2.26	4.20-2.32
Depth (m)	Mean ± SD	2.14 ± 0.77	3.96 ± 0.75	11.76 ± 8.8
	Range	3.6-Intertidal	4.7-2.9	28.2-3.7
Q_{50} (mm)	Mean ± SD	0.33 ± 0.46	0.01 ± 0.01	0.22 ± 0.6
	Range	1.25-0.01	0.04-0.01	1.5-0.01
Gravel (%)	Mean ± SD	7.81 ± 10.15	1.40 ± 1.07	9.16 ± 14.1
	Range	29.96-0	3.01-0.00	40.17-0.59
Sand (%)	Mean ± SD	50.92 ± 30.97	22.14 ± 7.60	31.56 ± 8.6
	Range	94.39-2.33	35.89-13.94	48.34-24.37
Silt/Clay (%)	Mean ± SD	41.28 ± 36.94	76.46 ± 7.63	59.28 ± 21.6
	Range	97.67-2.05	86.06-63.48	73.60-11.49
OM (%)	Mean ± SD	14.23 ± 12.99	18.86 ± 4.44	15.88 ± 5.6
	Range	36.93-0.95	23.00-10.88	22.17-7.22
CO_3 (%)	Mean ± SD	6.39 ± 2.08	4.38 ± 1.02	10.40 ± 13.4
	Range	11.98-4.28	5.8-2.36	40.46-2.28
Bt	Range	M-VCS	M	M-MS
Dominant taxa		*Melita palmata* (30.37/Pr/VC)	*Corophium* cf. *runcicorne* (18.24/Ac/VC)	Myocopida sp. 4 (34.19/Pr/Ct)
		Harpacticoida spp. (15.53/Oc/Ct)	*Iphinoe tenella* (9.72/Ac/Ct)	*Microdeutopus* cf. *armatus* (15.65/Ac/Ct)
		Idotea baltica (9.32/Ex/VC)	Harpacticoida spp. (9.27/Oc/Ct)	*Metaphoxus simplex* (4.15/Ex/VC)
		Microdeutopus gryllotalpa (7.38/Ex/VC)	*Propontocypris* sp. (7.03/Oc/VC)	*Harpinia crenulata* (3.97/Ex/Ct)
		Propontocypris sp. (6.49/Oc/VC)	Poecilostomatoida sp. 1 (6.28/Ac/Ct)	*Harpinia dellavallei* (3.93/El/VC)
		Zeuxo normani (4.19/Oc/VC)	*Lembos* sp. (6.28/Ac/VC)	*Tanaopsis graciloides* (3.43/Ex/Ct)
		Cytheracea sp. (3.81/Pr/VC)	*Corophium* spp. (4.93/Ac/Ct)	Myocopida sp. 1 (3.41/El/Ct)
			Zeuxo normani (4.33/Ac/Ct)	*Harpinia antennaria* (3.41/El/VC)
			Leucothoe incisa (4.19/Oc/C)	*Ampelisca tenuicornis* (2.99/Pr/Ct)
			Ampelisca tenuicornis (3.89/Ac/VC)	
			Myocopida sp. 4 (3.59/Ac/VC)	

are summarized in Table 2. Dominant species and their constancy and fidelity indices are also shown in this table. Cluster analysis based on abundance data of the species with dominances higher than 1% (inverse analysis) showed 4 main groups (Fig. 5).

Group A was located in the innermost part of the inlet (Fig. 1), in intertidal sediments subject to strong variations of salinity close to the mouth of the rivers Oitabén-Verdugo and Xunqueira. Sites showed high granulometric differences, with sedimentary types ranging from mud to very coarse sand. These bottoms were poor in total number of species and Shannon-Wiener diversity index (Table 2). The seagrasses *Zostera marina* and *Z. noltii* were spread across most of these intertidal and shallow bottoms, with depths from 3.6 m to intertidal levels. Species with the highest abundance were, cited in decreasing order, the amphipod *Melita palmata*, the harpacticoids, the isopod *Idotea baltica,* the amphipod *Microdeutopus gryllotalpa*, the podocopid *Propontocypris* sp., the tanaidacean *Zeuxo normani* and the podocopid Cytheracea sp. The harpacticoids, the amphipods *M. palmata, M. gryllotalpa* and *Corophium* spp., the podocopid *Propontocypris* sp. and the isopod *I. baltica* were the species with the greatest similarity contribution for the group. A total of 22 species were exclusive to this assemblage, while only the harpacticoids were constant. This assemblage was linked to Group 1 of inverse analysis (Fig. 5), since it included *M. palmata*, *I. balthica* and *M. gryllotalpa*.

Group B was present in the shallow muddy bottoms of the centre of the inlet. Sediments were mainly composed of silt and clay with a high organic matter content. The average individual density was the lowest of the inlet, and the sites showed the greatest mean evenness

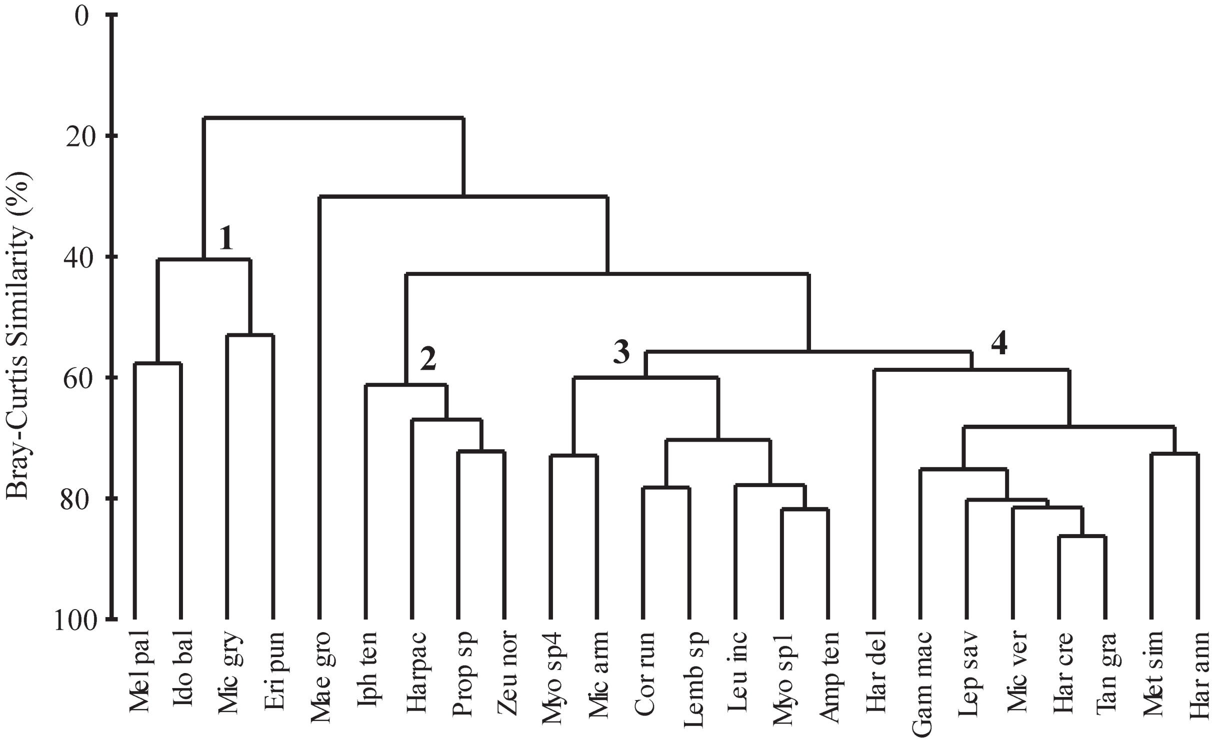

FIG. 5. – Dendrogram using Bray-Curtis similarity coefficient showing the classification of species with a numerical dominance ≥1%. Species codes: Myo sp4, Myocopida sp. 4; Mic arm, *Microdeutopus* cf. *armatus*; Mel pal, *Melita palmata*; Harpac, Harpacticoida spp.; Met sim, *Metaphoxus simplex*; Har del, *Harpinia dellavallei*; Har cre, *Harpinia crenulata*; Myo sp1, Myocopida sp. 1; Har ann, *Harpinia antennaria*; Tan gra, *Tanaopsis graciloides*; Amp ten, *Ampelisca tenuicornis*; Prop sp, *Propontocypris* sp.; Ido bal, *Idotea baltica*; Mic gry, *Microdeutopus gryllotalpa*; Zeu nor, *Zeuxo normani*; Iph ten, *Iphinoe tenella*; Cor run, *Corophium* cf. *runcicorne*; Lep sav, *Leptochelia savignyi*; Mic ver, *Microdeutopus versiculatus*; Eri pun, *Ericthonius punctatus*; Leu inc, *Leucothoe incise*; Lemb sp, *Lembos* sp.; Mae gro, *Maera grossimana*; Gam mac, *Gammaropsis maculata*.

index (Table 2). The amphipod *Corophium* cf. *runcicorne*, the cumacean *Iphinoe tenella*, harpacticoids, *Propontocypris* sp., Poecilostomatoida sp. 1, the amphipods *Lembos* sp. *Leucothoe incisa*, *Ampelisca tenuicornis* and *Corophium* spp., *Zeuxo normani*, and Myocopida sp. 4 were the most dominant taxa. *Corophium* spp., harpacticoids, poecilostomatoids, *I. tenella*, *Z. normani*, *Propontocypris* sp. and *C.* cf. *runcicorne* defined this group. The harpacticoid *Porcellidium* sp., the mysid *Paramysis* sp., *Microdeutopus* sp., the isopod Arcturidae sp. and the decapod Callianassidae sp. were exclusive to the assemblage, and the amphipods *Ampelisca brevicornis* and *Colomastix pusilla* were elective. Among dominant species, harpacticoids, *Corophium* spp., Poecilostomatoida sp. 1, *I. tenella* and *Z. normani* were constant. Groups 2 of inverse analysis, composed of *I. tenella*, harpacticoids, *Propontocypris* sp. and *Z. normani* were connected with this assemblage.

Group C was situated in the mouth of the inlet, reaching up to 28.2 m depth. Sediments were predominantly composed of silt and clay, but showed the highest carbonate and gravel contents. The number of species, the density of individuals and the Shannon-Wiener diversity index were the highest found in the inlet (Table 2). Species with the highest abundance in these bottoms were myocopids sp. 4 and sp. 1, the amphipods *M.* cf. *armatus*, *M. simplex*, *H. crenulata*, *H. dellavallei*, *H. antennaria* and *A. tenuicornis* and the tanaid *Tanaopsis graciloides*. A total of 38 species were exclusive to this assemblage, and 17 were constant. Among the dominant species, *H. crenulata*, *Microdeutopus versiculatus*, Myocopida sp.1, *L. incisa*, *H. dellavallei* and the tanaids *T. graciloides* and *Leptochelia savignyi* were exclusive to this group. Groups 3 and 4 of figure 5 were linked to this assemblage.

Relationships between crustacean fauna and environmental variables

According to the BIOENV analysis, the crustacean assemblages correlated best with bottom temperature-depth-kurtosis coefficient and bottom temperature-depth-sediment temperature-kurtosis coefficient combinations (Spearman's rank correlation ρ_w: 0.250 and 0.243 respectively). Temperature of bottom water and depth were the variables with the best values when each variable was considered alone (ρ_w: 0.221 and 0.215 respectively).

Canonical correspondence analysis showed that the first two axes accounted for 37.24% of the total variance of species-environment relation, and 30.7% of the species variance (Fig. 6). Forward selection in this analysis selected bottom temperature, depth, coarse silt, fine sand and very fine sand as the variables explaining most of the variance in the species data ($p<0.01$). The graphic representation showed an ordination of sites

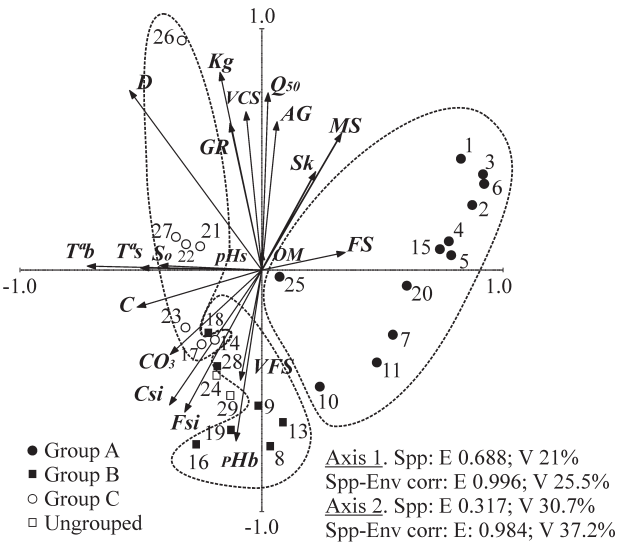

FIG. 6. – Canonical correspondence analysis ordination of environmental variables and sampled sites relative to the axes I and II for the Ensenada de San Simón. Eigenvalues (E) and variance (V) for species data and species-environment correlations are indicated. Ts, sediment temperature, Tb, temperature of bottom water, So, sorting coefficient, Kg, kurtosis, Sk, skewness, GR, gravel, VCS, very coarse sand, CS, coarse sand, MS, medium sand, FS, fine sand, VFS, Vvery fine sand, CSi, coarse silt, FSi, fine silt, C, clay, CO_3, carbonate content, OM, organic matter content, Q_{50}, median grain size.

following a gradient in depth, bottom temperature and grain size (Fig. 6). Sampling sites from group A were distributed along positive quadrants of axis I, in shallow bottoms following an increase in content of coarse silt and very fine sand. Groups B and C followed an increase in depth appearing distributed along the negative part of axes I.

According to the results obtained through these analyses (BIOENV, CCA), the distribution of the crustacean fauna in the Ensenada de San Simón was mainly related to depth, temperature of bottom water and sediment grain size.

DISCUSSION

Results showed that distribution of the crustacean fauna in the Ensenada de San Simón was primarily linked to temperature of bottom water and depth. Quantitative sampling showed that the number of species observed in the Ensenada de San Simón (111 taxa) was similar to that found in other Galician rias. Garmendia *et al.* (1998) found 66 amphipod species in the Ria de Ares-Betanzos, while Lourido *et al.*, 2008, found 125 peracarid species in the Ria de Aldán. Our number of species was high in comparison with those reported from other European estuaries (e.g. 20 crustacean species were found in the Ria de Huelva (Cano and García, 1987), 51 in the Arcachon Bay (Bachelet *et al.*, 1996), 23 in the Rance Basin (Desroy and Retière, 2001), 14 in the Bidasoa Estuary (Garmendia *et al.*, 2003) and 50 malacostracean species in the Santander Bay (Lastra *et al.*, 1990)). However, as can be observed in Table 3, some authors sieved organisms with 1 mm mesh, which could involve the loss of small organisms (e.g. Podocopida or Harpacticoida).

Both crustacean diversity and number of species were greater on subtidal bottoms and impoverished towards the brackish intertidal areas, as was also reported from other estuarine suprabenthic communities (Mees *et al.*, 1995; Cunha *et al.*, 1999). Aquatic fauna are submitted to stressful conditions in intertidal zones (e.g. desiccation, fluctuations in salinity; Kikuchi, 1987), derived from changes in freshwater inputs. Intertidal and subtidal soft bottoms of the Ensenada de San Simón were sampled in autumn 1999, the rainy season in these temperate latitudes. In the inlet, changes in salinity are drastic during the year (Saiz *et al.*, 1961; Vilas *et al.*, 1995). Similar areas with more stable salinities and temperatures during the year showed higher biodiversities (e.g. Lourido *et al.*, 2008). Euryhaline species such as *Melita palmata* or *Corophium acherusicum* benefit from salinity fluctuations. However, our study referred specifically to the autumn, and the conclusions should be interpreted carefully. Different structures of the crustacean community were found during the year. For most species from temperate latitudes the larval settlement takes place during the summer period (Pfister, 1997; Pallas *et al.*, 2006) or during two annual recruitment cycles (Upchurch and Wenner, 2008), especially in the nursery habitats of seagrass meadows (Heck *et al.*, 2003). The existence of these vegetated bottoms could be relevant in the temporal evolution of the crustacean community. To present a complete study of the assemblage structure, an analysis of the seasonal pattern should be the next step (as in García Muñoz *et al.*, 2008), integrating the life cycle of the fauna and looking for the strongest factors influencing its distribution. Distribution of the crustacean fauna in the inlet was linked to temperature of bottom water and depth, which directly influence the hydrodynamic conditions. The importance of the temperature should be interpreted carefully, since Ysebaert and Herman (2002) pointed out that long-terms averages of environmental variables are more important than values obtained during samplings. The gradual increase in water depth is accompanied by other environmental gradients such as stability of the substrate, which are usually determinant for the macrofauna distribution (Corbera and Cardell, 1995; Cunha *et al.*, 1999). Accordingly with our results, the grain size is one of the most often reported factors in determining the distribution and composition of crustaceans (Robertson *et al.*, 1989). Higher sediment diversity increases the benthic faunas due to a higher diversity of microhabitats (e.g. Simboura *et al.*, 2000; Lourido *et al.*, 2008). The Ensenada de San Simón has a predominance of muddy bottoms, thus limiting the crustacean biodiversity along the inlet.

Intertidal sediments colonized by *Zostera noltii* and *Z. marina* in San Simón showed low crustacean species numbers. Usually, seagrass meadows provide a complex habitat that can be colonized by many spe-

Table 3. – Species of crustacean determined in different areas of the Atlantic Iberian Peninsula. Amp, Amphipoda, Iso, Isopoda, Mys, Mysidacea, Cum, Cumacea, Tan, Tanaidacea, Dec, Decapoda, Others include Podocopida, Myocopida, Poecilostomatoida, Leptostraca and Harpacticoida. Dredge and sampling area are detailed, and ranges of sediment characteristic are provided: median grain size (Q_{50}, mm) and organic matter content (OM,%). * Organisms sieved trough mesh ≥ 1 mm.

	Amp	Iso	Mys	Cum	Tan	Dec	Others	Total	Sampling	Depth	OM	Q_{50}
Ensenada de San Simón (present study)	60	9	3	4	7	12	16	111	Van Veen 0.28 m²	Intertidal-28.2 m	0.95-36.93	0.009-1.500
Galician coasts (NW Spain)												
Ria de Foz (Junoy and Viéitez, 1988)	9	9	4	2	0	5	0	29*	0.16 m²	Intertidal	0.08-3.11	0.06-0.31
Ria de Ares-Betanzos (Garmendia *et al*., 1998)	73	9	7	13	2	18	1	123	Rallier du Baty Box-corer de Reineck	2.5-44 m	-	Gravel-Sandy mud
Ria de Arousa (López-Jamar, 1982)	7	2	0	1	1	0	0	17	Van Veen 0.25 m²	-	4.22-14.68	0.010-0.287
Estuario de La Foz (Anadón, 1980)	5	3	1	1	0	3	0	13*	0.12 m²	Intertidal	0.47-1.91	0.109-1.168
Estuario del Miño (Mazé *et al*., 1993)	8	5	1	0	0	3	0	17*	Shipek 0.04 m² (4 times)	-	0-0.624	Sand
Atlantic Iberian coasts												
Basque continental shelf (Martínez and Adarraga, 2001)	40	5	3	18	1	0	0	67	Van Veen 0.1 m²	5-225 m	1.16-5.60	0.06-0.65
Hendaya beach (San Vicente and Sorbe, 2001)	19	3	12	5	0	10	0	49	Suprabenthic sled (50 x 20 cm²)	Intertidal	-	0.195
Western Portuguese coast (Sousa Reis *et al*., 1982)	20	8	5	5	0	6	0	44*	7-50 litres	Intertidal-30 m	-	Muddy sand -Coarse sand
Albufeira and Obidos lagoons (Rodrigues and Dauvin, 1985)	36	-	5	4	-	-	-	45	Rallier du Baty 0.5-40 m	-	-	
Ria de Alvor (Rodrigues and Dauvin, 1987)	19	6	4	1	1	-	-	31	0.5 m²	Intertidal-Subtidal	-	Mud-Sand
Mondego Estuary (Marques *et al*., 1993)	18	10	1	0	0	4	0	33*	3 litres	Intertidal	-	
Tage Estuary (Calvário, 1984)	13	11	0	0	2	2	0	28	-	Intertidal	-	-
Algarve coast (Alves *et al*., 2003)	10	3	3	1	2	12	2	33*	0.0625 m²	7-9 m	-	-
Punta Umbría (Rodríguez and Viéitez, 1992)	6	1	0	1	1	9	0	18 *	Aprox. 20 litres	5.4-12.6 m	0.76-2.28	0.099-0.670
Cádiz Bay (Drake *et al*., 1997)	30	22	10	2	1	21	1	87	Suprabenthic net	-	-	-

cies (Somerfield *et al*., 2002), stabilizing the sediment and providing protection for potential preys. Many ecological studies have shown salinity to be the main factor controlling zonation in the structure of the benthic communities. However, some other authors have emphasized that this is not the main factor in brackish environments (Bazaïri *et al*., 2003). In our inlet the seagrasses were located in intertidal and/ or shallow subtidal areas subject to abrupt salinity changes. The salinity or other factors related to depth are the major limiting factors for the non-euryhaline species, as suggested by Junoy (1996). Nevertheless, as in Marques and Bellan-Santini (1987), high densities of *Melita palmata* and *Microdeutopus gryllotalpa* were recorded within the *Zostera* meadows. These species can be acting here as detritus feeders (Cunha *et al*., 1999). *M. gryllotalpa* has been recorded in other organic enriched environments (Drake *et al*., 1997). However, *M. palmata* showed a restricted distribution in San Simón, since it has been classically cited in bottoms down to 50 m depth (Lincoln, 1979; Ruffo, 1982; Hayward and Ryland, 1990).

The highest values of diversity and number of species were found in the stable subtidal sediments situated on the mouth of the inlet, while the lowest values were found in the mouth of the rivers Oitabén-Verdugo and Alvedosa and in the proximities of the harbours (sites 12, 24 and 29). These results confirmed observations made by Conradi *et al*. (1997), who found a clear differentiation between the amphipods populations living in outer sites of a bay and those living in the inner area. In fact, these authors showed that the amphipod communities reflect the physico-chemical conditions in the area (e.g. *Melita palmata* or *Idotea baltica* showing a high tolerance to large physico-chemical fluctuations in San Simón).

Multivariate analysis showed three major crustacean assemblages in the Ensenada de San Simón. The group A assemblage, characterized by *Melita palmata*, *Mycrodeutopus gryllotalpa* and *Idotea baltica*, was settled in the intertidal area. Similar fauna was found in intertidal areas along European coasts, e.g. in tidal channels of the Arcachon Bay (Bachelet *et al*., 1996), the Ria de Foz (Junoy and Viéitez, 1990) and the Mira Estuary (Marques and Bellan-Santini, 1987), and in a coastal lagoon of the NW African coast (Bazaïri *et al*., 2003). In our case, *Melita palmata* was the dominant species, as in the communities described by Bachelet *et al*. (1996) and Bazaïri *et al*. (2003). Group B, characterized by *Corophium* cf. *runcicorne* and *Iphinoe tenella*, represented a facies of transition. Finally, on the subtidal bottoms a facies of *Harpinia crenulata*, *H. dellavallei* and *Tanaopsis graciloides* (Group C) was found. This kind of continuous transition between assemblages is characteristic of estuaries and semi-enclosed coastal ecosystems (Bazaïri *et al*., 2003), and has been cited as evidence of the importance of quantitative studies in differentiating assemblages (García Muñoz *et al*., 2008). Similar fauna was found in the community described by Desroy and Retière (2001) in the subtidal bottoms of the Rance Basin (western English Channel), although *Ampelisca tenuicornis* and *Microdeutopus versiculatus* showed high dominances in that estuary.

The intertidal assemblage displayed some features in common with the *Cardium edule-Scrobicularia* community described by Thorson (1957). In subtidal areas, the assemblages displayed common features with the *Abra alba* community described by Petersen (1914). Therefore, the patterns of crustacean distribution are similar to those previously reported for other benthic taxa in the same area (Cacabelos *et al*., 2008a, b). In conclusion, the most important factor in determining distribution patterns of crustacean communities in the Ensenada de San Simón was the water depth, directly influencing the hydrodynamic conditions and sediment composition of the inlet.

ACKNOWLEDGEMENTS

We gratefully thank the team at the Adaptations of Marine Animals laboratory for their invaluable help with the sample collection, the identification of the species and the understanding of the statistical methods. This paper is a contribution to the research project PGIDT 00PXI30119 PR.

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Scient. ed.: P. Abelló.
Received May 25, 2009. Accepted November 2, 2009.
Published online May 10, 2010.

SUPPLEMENTARY MATERIAL

The following appendices are available through the web page http://www.icm.csic.es/scimar/supplm/sm74n3455sm.pdf

Appendix 1. – Faunistic list of crustacean species found in the Ensenada de San Simón during the study.

Appendix 2. – Abundance of species in each sampling site expressed as ind. m^{-2}.

Composition and distribution of subtidal and intertidal crustacean assemblages in soft-bottoms of the Ria de Vigo (NW Spain)

EVA CACABELOS, ANTÍA LOURIDO and JESÚS S. TRONCOSO

Supplementary material

APPENDIX 1. – Faunistic list of crustacean species found in the Ensenada de San Simón during the study.

CLASS OSTRACODA
ORDER MYOCOPIDA
Myocopida sp.1
Myocopida sp.2
Myocopida sp.3
Myocopida sp.4
ORDER PODOCOPIDA
Cytheracea sp.
Family Pontocyprididae G.W. Müller, 1894
Pontocypris sp.
Propontocypris sp.
Family Trachyleberididae Sylvester-Bradley, 1948
Carinocythereis sp.
Family Hemicytheridae Sylvester-Bradley, 1948
Aurila sp.
Family Cytheruridae G.W. Müller, 1894
Semicytherura sp.
CLASS COPEPODA
ORDER HARPACTICOIDA
Harpacticoida spp.
Family Porcellidiidae Boeck, 1865
Porcellidium sp.
ORDER POECILOSTOMATOIDA
Poecilostomatoida sp.1
Poecilostomatoida sp.2
Poecilostomatoida sp.3
CLASS MALACOSTRACA
ORDER LEPTOSTRACA
Family Nebaliidae Samouelle, 1819
Nebalia kocatasi Moreira, Koçak and Katagan, 2007
Nebalia strausi Risso, 1826
ORDER CUMACEA
Family Bodotriidae T. Scott, 1901
Iphinoe tenella Sars, 1878
Family Leuconidae G.O. Sars, 1878
Eudorella truncatula (Bate, 1856)
Family Diastylidae Bate, 1856
Diastylis laevis Norman, 1869
Diastylis sp.
ORDER TANAIDACEA
Family Apseudidae Leach, 1814
Apseudes latreilli (Milne-Edwards, 1828)
Apseudes talpa (Montagu, 1808)
Family Tanaidae Dana, 1849
Zeuxo normani (Richardson, 1905)
Family Paratanaidae Lang, 1949
Heterotanais oerstedi (Krøyer, 1842)
Leptochelia savignyi (Krøyer, 1842)
Family Leptognathiidae Sieg, 1976
Pseudoparatanais batei (G.O. Sars, 1882)
Tanaopsis graciloides (Liljeborg, 1864)
ORDER MYSIDACEA
Family Mysidae Dana, 1850
Praunus neglectus (G.O.Sars, 1869)
Paramysis sp.
Erythrops sp.
ORDER ISOPODA
Family Gnathiidae Harger, 1880
Gnathia oxyurea (Lilljeborg, 1855)
Family Anthuridae Leach, 1814
Cyathura carinata (Kroyer, 1847)
Family Cirolanidae Dana, 1853
Cirolana sp.
Family Sphaeromatidae (Dahl, 1916)
Lekanesphera levii (Argano and Ponticelli, 1981)
Family Janiridae Sars, 1897
Janiropsis breviremis Sars, 1899
Family Munnidae Sars, 1899
Munna sp.
Family Arcturidae Sars, 1899
Arcturidae sp.
Arcturella sp.
Family Idoteidae Samouelle, 1819
Idotea baltica (Pallas, 1772)
ORDER AMPHIPODA
Family Lysianassidae Dana, 1849
Lepidepecreum longicorne (Bate and Westwood, 1861)
Orchomene humilis (A.Costa, 1853)
Perrierella audouiniana (Bate, 1857)
Family Ampeliscidae Bate, 1861
Ampelisca brevicornis (A. Costa, 1853)
Ampelisca remora Bellan-Santini and Dauvin, 1986
Ampelisca tenuicornis Liljeborg, 1855
Ampelisca typica (Bate, 1856)
Family Colomastigidae Stebbing, 1899
Colomastix pusilla Grube, 1861
Family Amphilochidae Boeck, 1872
Amphilochus spencebatei (Stebbing, 1876)
Amphilochus neapolitanus Della Valle, 1893
Gitana sarsi Boeck, 1871
Family Leucothoidae Dana, 1852
Leucothoe incisa Robertson, 1892
Leucothoe richiardii Lessona, 1865
Family Stenothoidae Boeck, 1871
Stenothoe monoculoides (Montagu, 1813)
Family Hyalidae Bulycheva, 1957
Hyale perieri (Lucas, 1849)
Family Gammaridae Leach, 1814
Gammaridae sp.
Echinogammarus sp.1
Echinogammarus sp.2
Gammarus insensibilis Stock, 1966
Family Melitidae Bousfield, 1973
Cheirocratus cf. *intermedius* Sars, 1894
Gammarella fucicola (Leach, 1814)
Maera grossimana (Montagu, 1808)
Maera othonis (Milne-Edwards, 1830)
Melita palmata (Montagu, 1804)
Family Argissidae Walker, 1904
Argissa hamatipes (Norman, 1869)
Family Oedicerotidae Liljeborg, 1865
Perioculodes longimanus (Bate and Westwood, 1868)

Pontocrates altamarinus (Bate and Westwood, 1862)
Westwoodilla rectirostris (Della Valle, 1893)
Family Phoxocephalidae Sars, 1893
Harpinia antennaria Meinert, 1890
Harpinia crenulata (Boeck, 1871)
Harpinia dellavallei Chevreux, 1910
Metaphoxus simplex (Bate, 1857)
Family Dexaminidae Leach, 1814
Atylus vedlomensis (Bate and Westwood, 1862)
Family Aoridae Stebbing, 1899
Aoridae spp.
Lembos sp.
Leptocheirus pilosus Zaddach, 1844
Microdeutopus anomalus (Rathke, 1843)
Microdeutopus cf. *armatus* Chevreux, 1887
Microdeutopus gryllotalpa A. Costa, 1853
Microdeutopus versiculatus (Bate, 1856)
Microdeutopus sp.
Family Isaeidae Dana, 1853
Isaeidae spp.
Gammaropsis maculata (Johnston, 1827)
Gammaropsis palmata (Stebbing and Robertson, 1891)
Gammaropsis sophiae (Boeck, 1861)
Megamphopus cf. *longicornis* Chevreux, 1911
Photis longicaudata (Bate and Westwood, 1862)
Photis longipes (Della Valle, 1893)
Photis sp.
Family Corophiidae Dana, 1849
Corophium acherusicum (A. Costa, 1851)
Corophium acutum Chevreux, 1908
Corophium insidiosum Crawford, 1937
Corophium multisetosum Stock, 1952
Corophium cf. *runcicorne* Della Valle, 1893
Corophium sextonae Crawford, 1937
Corophium spp.
Family Ischyroceridae Stebbing, 1899
Ericthonius punctatus (Bate, 1857)
Family Caprellidae White, 1847
Caprella sp.
Family Pariambidae Laubitz, 1993
Pariambus typicus (Kroyer, 1844)
Family Phtisicidae Vassilenko, 1968
Phtisica marina Slabber, 1769
ORDER DECAPODA
Family Palaemonidae Rafinesque, 1815
Palaemon elegans Rathke, 1837
Palaemon serratus (Pennant, 1777)
Family Alpheidae Rafinesque, 1815
Athanas nitescens (Leach, 1814)
Family Cangronidae Haworth, 1825
Crangon crangon (Linneo, 1758)
Family Callianassidae Dana, 1852
Callianassidae sp.
Family Paguridae Latreille, 1803
Anapagurus hyndmanni (Bell, 1846)
Family Porcellanidae Haworth, 1825
Pisidia longicornis (Linneo, 1767)
Family Majidae Samouelle, 1819
Inachus leptochirus Leach, 1817
Macropodia rostrata (Linneo, 1761)
Family Portunidae Rafinesque, 1815
Liocarcinus arcuatus (Leach, 1814)
Carcinus maenas (Linneo, 1758)

Appendix 2. – Abundance of species in

Site	1	2	3	4	5	6	7	8	9	10	11	12	13
Myocopida sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	0
Myocopida sp. 2	0	0	0	0	0	0	0	0	0	0	0	0	0
Myocopida sp. 3	0	0	0	0	0	0	0	0	0	0	0	0	0
Myocopida sp. 4	0	3.6	0	0	0	0	0	0	3.6	0	0	0	0
Cytheracea sp.	0	0	257.1	7.1	7.1	10.7	10.7	0	0	0	0	0	0
Pontocypris sp.	0	0	0	0	0	0	10.7	10.7	3.6	0	0	0	0
Propontocypris sp.	0	7.1	0	0	7.1	3.6	75.0	78.6	71.4	250.0	0	0	7.1
Cariocythereis sp.	0	0	0	0	0	0	0	3.6	0	0	0	0	0
Aurila sp.	0	0	0	0	14.3	0	0	3.6	7.1	0	3.6	0	0
Semicytherura sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Harpacticoida spp.	78.6	32.1	60.7	35.7	207.1	125.0	85.7	14.3	3.6	592.9	14.3	0	42.9
Porcellidium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Poecilostomatoida sp.1	7.1	17.9	0	0	0	0	32.1	0	14.3	0	0	0	25.0
Poecilostomatoida sp.2	0	0	0	0	0	0	0	0	0	0	0	0	0
Poecilostomatoida sp.3	0	0	3.6	10.7	21.4	0	0	0	0	0	0	0	0
Nebalia kocatasi	0	0	0	0	0	0	7.1	0	0	0	0	0	0
Nebalia strausi	0	0	0	0	0	0	0	0	0	0	0	0	0
Iphinoe tenella	0	0	0	57.1	14.3	0	67.9	153.6	60.7	0	0	0	3.6
Eudorella truncatula	0	0	0	0	0	0	0	0	0	0	0	0	0
Diastylis laevis	0	0	0	0	0	0	0	0	0	0	0	0	0
Diastylis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Apseudes latreilli	0	0	0	0	0	0	0	0	0	0	0	0	0
Apseudes talpa	0	0	0	0	0	0	0	0	0	0	0	0	0
Zeuxo normani	0	0	0	0	0	0	39.3	7.1	39.3	239.3	3.6	0	7.1
Heterotanais oerstedi	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptochelia savignyi	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudoparatanais batei	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanaopsis graciloides	0	0	0	0	0	0	0	0	0	0	0	0	0
Praunus neglectus	0	0	0	0	0	0	7.1	0	0	0	0	0	0
Paramysis sp.	0	0	0	0	0	0	0	3.6	0	0	0	0	0
Erythrops sp.	0	0	0	0	0	0	3.6	0	0	0	0	0	0
Gnathia oxyurea	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyathura carinata	0	0	7.1	10.7	46.4	0	0	0	0	0	0	0	0
Cirolana sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Lekanesphera levii	3.6	7.1	10.7	3.6	85.7	82.1	0	0	0	0	0	0	0
Janiropsis breviremis	0	0	0	0	0	0	0	0	0	0	0	0	0
Munna sp.	0	0	0	0	0	0	28.6	0	0	0	3.6	0	0
Arcturidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Arcturella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Idotea baltica	64.3	575.0	189.3	10.7	7.1	3.6	0	0	0	0	0	0	0
Lepidepecreum longicorne	0	0	0	0	0	0	0	0	0	0	0	0	0
Orchomene humilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Perrierella audouiniana	0	0	0	0	0	0	0	0	0	0	0	0	0
Ampelisca brevicornis	0	0	0	0	0	0	0	7.1	7.1	0	10.7	0	0
Ampelisca remora	0	0	0	0	0	0	0	0	0	0	0	0	0
Ampelisca tenuicornis	0	0	0	0	0	0	0	0	7.1	0	0	0	0
Ampelisca typica	0	0	0	0	0	0	0	0	0	0	0	0	0
Colomastix pusilla	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphilochus spencebatei	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphilochus neapolitanus	0	0	0	0	0	0	0	0	0	0	0	0	0
Gitana sarsi	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucothoe incisa	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucothoe richiardii	0	0	0	0	0	0	0	0	0	0	0	0	0
Stenothoe monoculoides	0	3.6	0	0	0	0	0	0	0	0	0	0	0
Hyale perieri	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammaridae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinogammarus sp. 1	0	0	0	0	0	0	0	0	0	0	0	0	3.6
Echinogammarus sp. 2	7.1	0	75.0	0	0	0	60.7	0	0	0	0	0	0
Gammarus insensibilis	0	0	0	0	17.9	0	0	0	0	0	0	0	0
Cheriocratus cf. *intermedius*	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammarella fucicola	0	0	0	0	0	0	0	0	0	0	0	0	0
Maera grossimana	0	0	0	0	0	0	0	0	0	0	0	0	0
Maera othonis	257.1	557.1	478.6	435.7	239.3	7.1	271.4	0	0	0	0	0	0
Melita palmata	0	0	0	0	0	0	0	0	0	0	0	0	0
Argissa hamatipes	0	0	0	0	0	0	0	0	0	0	0	0	0
Perioculodes longimanus	0	0	0	0	0	0	0	0	0	0	0	0	0
Pontocrates altamarinus	0	0	0	0	0	0	0	0	0	0	0	0	0
Westwoodilla rectirostris	0	0	0	0	0	0	0	0	0	0	0	0	0
Harpinia antennaria	0	0	0	0	0	0	0	0	0	0	0	0	0
Harpinia crenulata	0	0	0	0	0	0	0	0	0	0	0	0	0
Harpinia dellavallei	0	0	0	0	0	0	0	0	0	0	0	0	0
Metaphoxus simplex	0	0	0	0	0	0	0	0	0	0	0	0	0

each sampling site expressed as ind. m^{-2}.

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
100.0	0	28.6	178.6	10.7	17.9	0	100.0	0	60.7	0	0	214.3	278.6	0	0
0	0	0	0	0	0	0	0	0	0	0	0	10.7	0	0	0
0	0	0	0	0	0	0	0	7.1	0	0	0	17.9	0	0	0
1425.0	0	32.1	2278.6	14.3	32.1	0	78.6	1950.0	1339.3	7.1	3.6	1003.6	1278.6	3.6	0
0	28.6	0	7.1	0	0	28.6	3.6	3.6	0	3.6	0	0	0	0	0
10.7	0	7.1	0	3.6	0	3.6	10.7	125.0	0	0	0	64.3	32.1	3.6	0
53.6	25.0	0	3.6	3.6	7.1	196.4	25.0	10.7	3.6	7.1	32.1	0	14.3	0	0
17.9	0	3.6	17.9	0	0	0	10.7	3.6	0	0	0	0	0	0	0
0	0	0	17.9	3.6	0	0	0	0	0	0	0	0	0	0	0
0	7.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
207.1	78.6	7.1	14.3	10.7	25.0	14.3	7.1	221.4	10.7	0	103.6	46.4	42.9	117.9	0
0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0
78.6	0	10.7	0	21.4	75.0	7.1	0	28.6	3.6	0	7.1	25.0	25.0	3.6	0
0	0	0	0	0	0	3.6	0	0	0	0	3.6	7.1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	60.7	3.6	0	0	0	7.1	10.7	0	0
64.3	0	3.6	21.4	7.1	0	82.1	7.1	50.0	0	0	0	7.1	3.6	3.6	0
0	0	3.6	39.3	0	0	0	7.1	50.0	32.1	0	0	17.9	85.7	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
21.4	0	0	0	0	0	0	3.6	3.6	0	0	0	0	10.7	0	0
14.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46.4	3.6	17.9	3.6	0	28.6	28.6	17.9	21.4	42.9	0	71.4	25.0	25.0	3.6	3.6
0	0	0	0	0	0	0	0	0	0	0	3.6	3.6	92.9	0	0
3.6	3.6	0	3.6	0	0	0	28.6	217.9	10.7	0	3.6	103.6	96.4	0	0
0	0	0	0	0	0	0	0	0	0	0	0	10.7	0	0	0
21.4	0	0	3.6	0	0	0	285.7	285.7	7.1	0	0	57.1	278.6	0	0
0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	7.1	0	0	0	7.1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	7.1	0	0	0
0	10.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	7.1	0	0	3.6	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0
0	7.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
0	0	0	0	0	0	0	7.1	7.1	46.4	0	0	0	7.1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
17.9	0	14.3	0	0	7.1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	50.0	0	0	0
203.6	0	42.9	46.4	14.3	25.0	0	100.0	160.7	92.9	0	0	50.0	164.3	3.6	0
0	0	0	0	0	0	0	3.6	89.3	0	0	0	35.7	42.9	0	0
0	0	42.9	0	0	0	0	0	0	7.1	0	0	0	0	3.6	0
0	0	0	0	0	0	0	0	10.7	0	0	0	14.3	10.7	0	0
0	0	0	0	0	0	0	0	0	3.6	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0
50.0	0	82.1	78.6	0	17.9	0	3.6	78.6	67.9	0	0	21.4	39.3	0	0
0	0	7.1	0	0	3.6	0	3.6	0	39.3	0	0	0	0	0	0
0	0	0	0	0	7.1	0	0	0	0	0	0	7.1	3.6	0	0
0	0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0
3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
0	10.7	0	0	0	0	121.4	0	0	0	0	3.6	0	0	0	0
0	7.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	7.1	0	0	0	0	0	0	0	0
7.1	0	0	0	0	0	0	0	0	0	0	0	385.7	3.6	0	0
0	0	0	0	0	21.4	0	3.6	67.9	3.6	0	0	0	14.3	0	0
14.3	139.3	0	3.6	0	0	407.1	28.6	3.6	0	0	0	0	3.6	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
0	0	0	0	0	0	0	0	7.1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	14.3	0	0	0
0	0	0	0	0	0	0	7.1	92.9	485.7	3.6	3.6	14.3	332.1	0	0
139.3	0	0	82.1	0	0	0	67.9	360.7	71.4	0	0	92.9	271.4	0	0
0	0	10.7	507.1	0	3.6	0	82.1	64.3	250.0	3.6	0	0	171.4	0	0
0	0	0	0	0	0	0	17.9	392.9	14.3	0	0	346.4	364.3	0	0
0	0	0	0	0	0	0	0	0	0	0	0	89.3	0	0	0

Appendix 2 (cont.). – Abundance of species in

Site	1	2	3	4	5	6	7	8	9	10	11	12	13
Atylus vedlomensis	0	0	0	0	0	0	3.6	0	0	0	0	0	0
Aoridae spp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Lembos sp.	0	0	0	0	0	0	0	0	0	14.3	14.3	0	0
Leptocheirus pilosus	0	0	0	0	0	0	53.6	7.1	7.1	0	7.1	0	0
Microdeutopus anomalus	21.4	3.6	3.6	14.3	0	0	435.7	0	0	32.1	25.0	0	0
Microdeutopus cf. *armatus*	0	0	0	0	0	0	0	0	0	0	0	0	0
Microdeutopus gryllotalpa	0	0	0	0	0	0	0	0	7.1	0	0	0	0
Microdeutopus versiculatus	3.6	0	0	7.1	0	0	32.1	0	3.6	3.6	7.1	0	0
Microdeutopus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Isaeidae spp.	0	3.6	0	0	0	0	42.9	0	0	0	0	0	0
Gammaropsis maculata	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammaropsis palmata	0	0	0	0	0	0	0	0	0	0	0	0	0
Gammaropsis sophiae	0	0	0	0	0	0	0	0	0	0	0	0	0
Megamphopus cf. *longicornis*	0	0	0	0	0	0	0	0	0	0	0	0	0
Photis longicaudata	0	0	0	0	0	0	0	0	0	0	0	0	0
Photis longipes	3.6	46.4	0	46.4	42.9	0	60.7	0	0	0	0	0	0
Photis sp.	0	0	0	0	0	0	42.9	3.6	0	17.9	0	0	0
Corophium acherusicum	0	0	25.0	0	0	0	0	0	0	0	0	0	0
Corophium acutum	0	0	0	0	0	0	3.6	3.6	0	0	0	0	0
Corophium insidiosum	3.6	3.6	3.6	0	0	0	0	0	17.9	3.6	0	0	0
Corophium multisetosum	0	17.9	7.1	7.1	7.1	0	46.4	46.4	25.0	3.6	7.1	0	10.7
Corophium cf. *runcicorne*	21.4	14.3	0	75.0	0	0	21.4	0	0	10.7	3.6	0	0
Corophium sextonae	0	0	0	0	0	0	0	0	3.6	0	0	0	0
Corophium spp.	0	0	0	0	0	0	0	0	17.9	0	0	0	0
Ericthonius punctatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Caprella sp.	0	0	0	0	0	0	0	0	3.6	0	0	0	0
Pariambus typicus	0	0	0	0	0	0	0	0	17.9	0	0	0	0
Phtisica marina	0	0	0	0	0	0	0	0	0	0	0	0	0
Palaemon elegans	0	0	0	0	0	0	0	0	0	0	0	0	0
Palaemon serratus	0	0	0	0	0	0	3.6	0	0	0	0	0	0
Athanas nitescens	0	0	0	0	0	0	0	0	0	0	0	0	0
Crangon crangon	0	0	3.6	0	0	0	0	0	0	0	0	0	0
Callianassidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Anapagurus hyndmanni	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisidia longicornis	0	0	0	0	0	0	0	0	3.6	0	0	0	0
Inachus leptochus	0	0	0	0	0	0	0	0	0	0	0	0	0
Macropodia rostrata	0	0	0	0	0	0	0	0	0	0	0	0	0
Liocarcinus arcuatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Carcinus maenas	7.1	42.9	10.7	17.9	14.3	0	0	0	0	0	0	0	0

each sampling site expressed as ind. / m^2.

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
142.9	0	85.7	103.6	14.3	39.3	0	3.6	0	17.9	0	3.6	3.6	0	10.7	0
0	0	0	0	0	7.1	0	0	7.1	0	0	0	3.6	28.6	0	0
0	0	0	0	0	0	7.1	0	0	0	0	3.6	0	0	0	0
692.9	0	21.4	3.6	0	21.4	10.7	64.3	950	42.9	0	42.9	575.0	1953.6	3.6	0
0	10.7	0	0	0	0	132.1	0	0	0	0	0	0	0	0	0
153.6	0	0	17.9	0	0	0	42.9	64.3	85.7	0	3.6	42.9	50.0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.1	0	10.7	3.6	0	0	0	0	0	3.6	0	3.6	0	7.1	3.6	0
25.0	0	0	3.6	0	10.7	0	28.6	57.1	0	0	0	157.1	110.7	0	0
0	0	0	0	0	0	25.0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	75.0	17.9	0	0
39.3	0	14.3	39.3	0	17.9	0	0	0	7.1	3.6	0	21.4	28.6	17.9	0
0	0	0	0	0	0	0	0	0	0	0	0	3.6	0	0	0
0	0	3.6	0	0	0	0	0	0	10.7	0	0	0	0	0	0
0	0	0	0	0	0	7.1	3.6	0	0	0	3.6	17.9	0	0	0
0	0	0	0	0	0	10.7	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	10.7	3.6	0	0	0	3.6	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64.3	0	396.4	42.9	10.7	14.3	0	7.1	17.9	7.1	0	0	21.4	3.6	10.7	0
0	0	0	0	0	0	0	0	0	3.6	0	0	0	3.6	0	0
7.1	3.6	3.6	46.4	7.1	10.7	3.6	10.7	17.9	14.3	0	0	32.1	0	14.3	0
0	0	0	0	0	0	0	7.1	3.6	0	0	0	303.6	0	0	0
0	0	0	0	0	0	0	0	96.4	0	0	0	0	0	0	0
110.7	0	0	128.6	28.6	7.1	0	0	39.3	7.1	7.1	0	0	7.1	0	0
0	0	0	0	3.6	3.6	0	7.1	3.6	7.1	0	0	39.3	17.9	0	0
0	0	0	0	0	0	0	0	96.4	0	0	0	0	0	0	0
110.7	0	0	128.6	28.6	7.1	0	0	39.3	7.1	7.1	0	0	7.1	0	0
0	0	0	0	3.6	3.6	0	7.1	3.6	7.1	0	0	39.3	17.9	0	0
0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3.6	0	0	0	0	0	0	0	0	0
0	0	0	3.6	0	0	0	0	0	0	0	0	0	7.1	0	0
0	0	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	78.6	3.6	0	0
0	0	0	3.6	0	0	0	0	28.6	7.1	0	0	0	0	0	0
0	0	0	0	7.1	0	0	0	3.6	0	0	0	3.6	0	0	0
0	0	0	0	0	0	0	0	3.6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	7.1	0	0
0	14.3	0	0	0	0	10.7	0	0	0	0	0	0	0	0	0