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Subtidal Benthic Macroinfauna in an Estuary of South Chile: Distribution Pattern in Relation to Sediment Types

E. JARAMILLO[1,*], S. MULSOW[1], M. PINO[2] & H. FIGUEROA[3]

[1] Instituto de Zoologia, Universidad Austral de Chile, Valdivia, Chile.
[2] Instituto de Geociencias, Universidad Austral de Chile, Valdivia, Chile
[3] Instituto de Estadística, Universidad Austral de Chile, Valdivia, Chile

With 8 figures and 7 tables

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Abstract. A quantitative survey (18 stations) of the subtidal soft bottom macroinfauna in an estuary of the south Chilean coast was conducted during January, 1980. The map of sedimentological facies elaborated for the Queule River Estuary shows sandy bottoms in the outlet and upper part of the area studied, while the middle part is occupied by muddy sand. The ordination of stations by Principal Component Analysis is fundamentally defined by mud and gravel percentage and is, in general, concordant with the distribution of sediments in the facies map. A total of 17,405 animals was collected (16 taxa), *Polychaeta* being the dominant group in density (77.47 %) and biomass (73.4 %). The maximum number of species was obtained outside the mouth of the estuary, while maximum densities and biomass were obtained in the middle of the estuary.

The Factor Analysis performed with the abundances data of the most abundant species rendered the ordination of two groups of stations (concordant with a Cluster Analysis) in the Q-mode and two groups of species in the R-mode. One group of stations is restricted to sandy habitats of the outlet area and is dominated by suspension feeders. The other, in the middle and upper part of the estuary (muddy sand or sandy bottoms with a higher percentage of organic matter), is dominated by deposit feeders. Between these two groups, significant differences in sedimentological variables (sand, mud, and organic matter percentage) were detected. Each of the two delineated groups of species corresponds to the groups of stations, showing that most of the taxa can be combined in faunal assemblages with preference for different types of substrate.

Problem

The Chilean littoral, with a coastline of about 4,000 km, is characterized in its central and southern area by numerous estuaries which, from an ecological point of view, are scarcely known. Although some physicochemical studies

* Temporary address: Department of Zoology, Spaulding Life Science Building, University of New Hampshire, Durham, N. H. 03824 USA.

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(CAMPOS *et al.*, 1974) and some works on the distribution of organisms such as polychaetes (BERTRÁN, 1980), bivalves (STOTZ, 1981), barnacles (ARENAS, 1971), crabs (RETAMAL, 1969), and fishes (FISHER, 1963; CAMPOS, 1973; PEQUEÑO, 1979) have been carried out in some of these estuaries, there is a lack of integrative studies to establish a conceptual unity of the bionomic characteristics of the whole estuarine community. There are, however, a number of papers dealing with interactions between a bivalve and a barnacle in subtidal hard bottoms (STOTZ, 1979; 1981) and with the zonation pattern of the intertidal macroinfauna inhabiting semiexposed and sheltered beaches (BERTRÁN, in press). Such studies are necessary if we wish to establish the degree of similarity between the estuaries of the south of Chile and the more thoroughly studied ones in the northern hemisphere, considering the biogeographic isolation and low density that seems to be characteristic of the Chilean coast (*e.g.*, MARINCOVICH, 1973; SANTELICES, 1980).

The purpose of the present study is to determine the composition and distribution pattern of the subtidal macroinfauna in the soft bottoms of the Queule River Estuary using quantitative methods and to analyse the characteristics of the organism-sediment relationship observed for soft bottoms (see reviews by GRAY, 1974, 1981).

Material and Methods

1. Area of study

The Queule River Estuary is located in the southern part of Queule Bay (39°24'S, 73°13'W). The zone studied was restricted to a length of approximately 3600 metres (Fig. 1). In this area the estuary has a maximum width of 440 metres and a minimum width of 80 metres. The maximum depth of the basin is 7 metres with a mean of about 3 metres.

Records maintained monthly for three stations in the estuary (from October, 1980 to April, 1981 for station A, Fig. 1; and from May, 1980 to April, 1981 for stations B and C, Fig. 1) showed that the widest variation of values of bottom water temperature and salinity were found at the middle and upper part of the estuary (stations B and C) (Table 1), which are under the influence of limnetic water.

Table 1. Ranges of bottom water temperature and salinity at each water sampling station in the area of study.

		A	B	C
high tide	°C	10.0–13.0	10.0–15.8	10.0–16.8
	S‰	27.6–34.3	19.9–34.0	16.3–31.6
low tide	°C	10.0–14.5	9.0–18.2	9.4–21.0
	S‰	25.4–35.2	0.5–28.0	0.5–18.0

2. Sampling methods and treatment

Five samples (0.025 m^2) were collected by EMERY grab at each of the 18 stations in the Queule River Estuary (Fig. 1). All of the stations were sampled in January, 1980. A subsample of sediment was taken from each grab with a cylindrical 40 mm corer for grain size analysis and organic matter

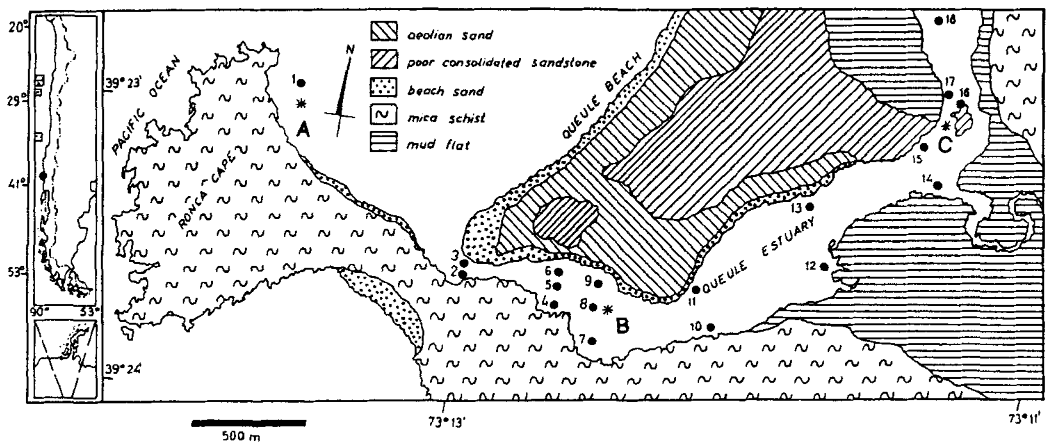


Fig. 1. Queule River Estuary. Macroinfauna sampling stations (1 to 18) and water sampling (A, B, C) in the area of study.

measurements. Gravel, sand, and mud mean percentages were used to make a map of grain size spatial distribution. For this purpose, the grain size triangle for gravel-sand-mud mixture was used (FOLK, 1974). The organic matter content was estimated as the loss in weight of dried sediment (60 °C, 96 h) after combustion (550 °C, 6 h).

The values of sedimentological variables (gravel, sand, mud, and organic matter mean percentages) at each station were used for Principal Component Analysis. This was done to group stations with similar bottom characteristics. This analysis reduces the number of variables to components which are linear combinations of these same variables. Individuals (stations) give scores which can be plotted on axes representing the components which explain the major percentage of variance in the data.

Samples for macroinfauna were sieved (0.5 mm), preserved with 10 % formaldehyde, identified, counted, and weighed. Dry weight biomass was determined by using a drying oven at 100 °C (4 days).

The abundance data (total of five replicates) of the 10 species occurring in more than four samples (Table 3) were subjected to Factor Analysis. In Factor Analysis, one assumes that many variables chosen to be measured are aspects or realizations of other, more basic underlying processes (termed "factors") (SHULENBERGER, 1980). Thus, many of the variables measured are correlated with one another due either to cause and effect or because both are responses to some common underlying process (SHULENBERGER, 1980). This analysis was carried out to group and analyse trends in the distribution of stations (Q-mode) or of species (R-mode).

In the Q-mode, the individuals are species and the variables are stations. This mode delineates groups of stations which are similar in their quantitative composition of species. This means that the members of a group should have similar numerical variations across individuals. In the R-mode the data matrix is transposed, and the individuals are now stations and the variables are species. This mode renders grouping of species which may be regarded as more or less associated due to their quantitative distribution over the stations (*i. e.* members of a group should have similar numerical variation across the stations). This analysis was done with the program contained in the Statistical Package for the Social Sciences (NIE *et al.*, 1975). Orthogonal (varimax) rotation was performed using raw data of abundance following a log (n + 1) transformation.

The biocenotic similarity between pairs of stations was calculated with WINER's Index:

$$S_w = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \, \Sigma y^2}}$$

in which the abundance values of each species in the samples is compared (SAIZ, 1980). A dendrogram was obtained after the Weighed Pair Group Method (SOKAL & SNEATH, 1973). The multivariate analyses were performed on a DECSYSTEM-2020 computer at the Centro de Informática y Computación, Universidad Austral de Chile.

Results

1. The bottom

The sediments of the studied area were classified (after FOLK, 1974) as sand [S], slightly gravelly sand [(g)S], muddy sand [mS], and slightly gravelly muddy sand [(g)mS] (Fig. 2 A). Both types of muddy sands are found in the middle of the estuary; sand was found in the northern side of the outlet area. Slightly gravelly sand was found in the south of the outlet and in the upper part of the estuary (Fig. 2 A).

Highest values of organic matter were found in the middle of the area (3.5–7.6 %), while the lowest values were in the outlet area (0.8–1.5 %) (Fig. 2 B). Sediments high in mud content were high in organic matter. The correlation coefficient between these two bottom variables was 0.95 ($p < 0.05$, $n = 18$).

In the Principal Component Analysis, the first two components accounted for 98.39 % of the total variance in the correlation matrix obtained: I: 72.93 %, II: 25.46 %. In component I, mud has the major load (0.99) among the variables used for this analysis (gravel, sand, mud, and organic matter) while in component II, gravel has the major load (1.00).

In general, ordination of the stations as projections on the first two components (Fig. 3) followed the sediment type distribution, outlining four groups of stations. Groups A and B include stations where the bottom is sand or slightly gravelly sand, Group C represents stations with muddy sand or slightly gravelly

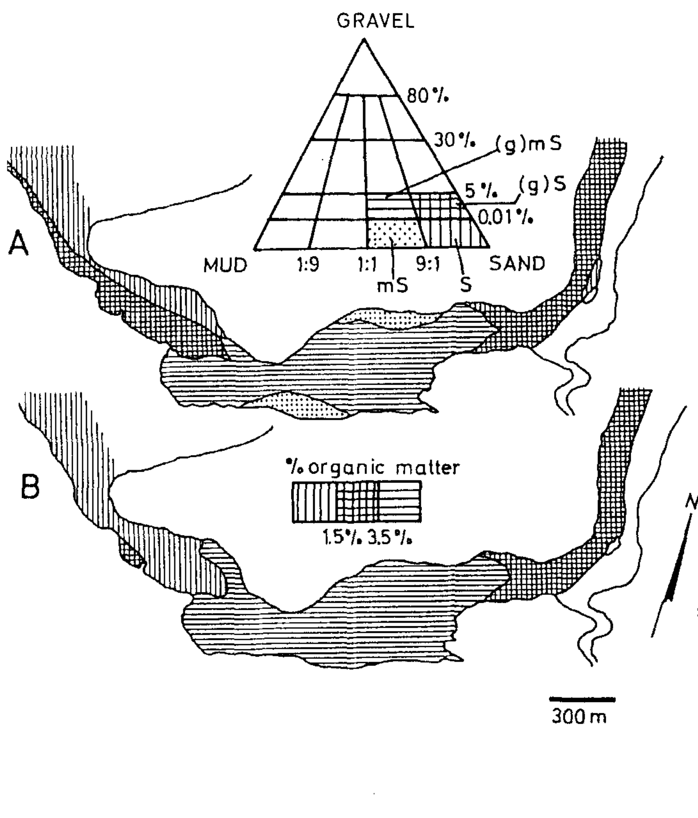


Fig. 2. Spatial distribution of subtidal sediment types (A) according to triangular major textural classes (FOLK, 1974) and organic matter content (B) in the Queule River Estuary.

muddy sand, and Group D includes three stations which are separated from Groups A, B, and C by component II because of their high percentage of gravel (Table 2).

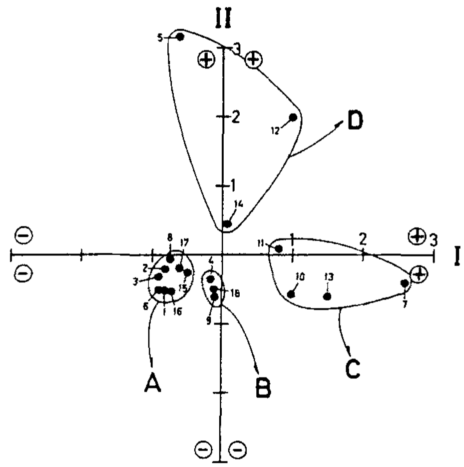


Fig. 3. Principal component ordination for sedimentological samples taken at each station. I: first principal component. II: second principal component. A, B, C and D outline stations with similar bottom characteristics.

Table 2. Bottom variables with standard deviations (S. d.) of means ($\bar{x}$) at each station group outlined by Principal Component Analysis.

		A $\bar{x}$ (S. d.)	B $\bar{x}$ (S. d.)	C $\bar{x}$ (S. d.)	D $\bar{x}$ (S. d.)
gravel	(%)	0.19 (0.2)	0.10 (0.1)	0.28 (0.5)	3.10 (1.7)
sand	(%)	99.20 (0.9)	96.10 (0.8)	81.88 (5.8)	91.99 (5.8)
mud	(%)	0.60 (0.8)	3.80 (0.8)	17.96 (5.8)	5.94 (5.7)
o. matter	(%)	1.42 (0.4)	1.86 (0.3)	2.28 (0.4)	3.03 (1.9)

2. The macroinfauna

Sixteen species were obtained from the 18 stations sampled. *Peracarida (Amphipoda, Isopoda,* and *Cumacea)* were the most diverse group with 9 species (56.3 %), followed by *Polychaeta* with 4 (25 %) and *Bivalvia* with 3 (18.8 %) (Table 3). In all, 17,405 specimens (77.5 % polychaetes, 12.9 % peracarids, and 9.6 % bivalves) were collected from a sample area of 2.25 m^2 (90 grabs). Two species, *Minuspio chilensis (Polychaeta, Spionidae)* and *Perinereis gualpensis (Polychaeta, Nereidae)* contributed 77.4 % to the abundance, while all the others were represented individually with less than 10 %. These worms were also the main contributors to biomass, with 73.4 % of the entire dry weight (4.040 g) (Table 3).

Frequency of occurrence at the stations and in the grabs is shown in Table 3. Five of the 16 collected species have a wide distribution, being present in more

Table 3. Number, biomass (dry weight in g) and frequency (F_1: at the stations (18), F_2: in the grabs (90)) of occurring species of *Polychaeta* (P), *Bivalvia* (B), *Amphipoda* (A), *Isopoda* (I), and *Cumacea* (C) in the Queule River Estuary. + = values under 0.1 %.

Species	Taxon	Number	%	Biomass	%	F_1	%	F_2	%
1. *Minuspio chilensis* FOSTER	P	11,364	65.3	1.215	30.1	13	72.2	58	64.4
2. *Perinereis gualpensis* JELDES	P	2,111	12.1	1.751	43.3	14	77.8	66	73.3
3. *Mesodesma donacium* LAMARCK	B	1,591	9.1	0.169	4.2	4	22.2	11	12.2
4. *Cheus* sp. THURSTON	A	1,141	6.6	0.149	3.7	13	72.2	43	47.8
5. *Paracorophium chilensis* VARELA	A	1,020	5.9	0.277	6.9	14	77.8	58	64.4
6. *Kingiella chilenica* SOOT RYEN	B	73	0.4	0.155	3.8	12	66.7	25	27.8
7. *Diastylis* sp. SAY	C	47	0.3	0.015	0.4	1	5.6	5	5.6
8. *Edotea dahli* MENZIES	I	18	0.1	0.012	0.3	1	5.6	5	5.6
9. *Glycera* sp. SAVIGNI	P	15	0.1	0.052	1.3	2	11.1	6	6.7
10. *Mulinia edulis* (KING)	B	10	0.1	0.009	0.2	3	16.7	5	5.6
11. *Excirolana hirsuticauda* MENZIES	I	6	+	0.011	0.3	4	22.2	4	4.4
12. *Macrochiridothea mehuinensis* JARAMILLO	I	3	+	0.002	0.0	1	5.6	2	2.2
13. *Phoxocephalopsis mehuinensis* VARELA	A	2	+	0.003	0.1	1	5.6	1	1.1
14. *Serolis gaudichaudii* AUDOIN & MILNE EDWARDS	I	2	+	0.210	5.2	1	5.6	2	2.2
15. *Excirolana monodi* CARVACHO	I	1	+	0.003	0.1	1	5.6	1	1.1
16. *Nephtys impressa* BAIRD	P	1	+	0.007	0.2	1	5.6	1	1.1
		17,405		4.040 g					

Table 4. Number of species, mean and range of density and biomass (dry weight in g) · m^{-2} at each station sampled in the Queule River Estuary.

Station	Species	density · m^{-2}		biomass · m^{-2}	
		mean	range	mean	range
1	10	13,672	520–28,960	4.443	0.498–10.108
2	2	136	80– 280	0.228	0.061– 0.572
3	4	64	40– 120	0.197	0.061– 0.592
4	4	1,576	560– 2,360	0.403	0.154– 0.639
5	4	696	520– 1,120	0.240	0.160– 0.590
6	5	2,712	1,040– 5,640	0.490	0.275– 0.908
7	4	16,352	9,440–24,600	5.358	4.283– 6.457
8	5	4,672	2,000– 6,640	0.651	0.486– 0.862
9	4	2,696	880– 4,040	0.782	0.309– 1.098
10	5	6,024	3,520–11,880	2.242	1.100– 2.986
11	5	2,488	800– 3,960	1.017	0.623– 1.636
12	5	23,480	17,880–28,280	5.668	2.592– 7.879
13	4	14,088	3,440–45,000	4.711	1.692–11.640
14	6	23,152	15,680–30,880	2.636	1.782– 4.550
15	5	2,904	1,360– 4,920	0.703	0.506– 0.924
16	5	14,520	2,000–27,000	2.390	1.462– 3.938
17	5	4,096	2,240– 9,360	0.751	0.256– 1.390
18	5	5,744	3,280– 8,400	0.820	0.028– 1.628

than 12 stations. These are the polychaetes *Minuspio chilensis* and *Perinereis gualpensis,* the amphipods *Paracorophium chilensis* and *Cheus* sp., and the bivalve *Kingiella chilenica.* The same species also have the highest frequency of occurrence, taking into account the number of grab samples (Table 3). The highest number of species (10) were obtained in the most external station sampled (station 1) (see Table 4), while mean density and biomass were higher in the middle of the estuary up to 23,480 individuals · m^{-2} and 5.668 g · m^{-2} (station 12, Fig. 1) (Table 4). The high density at station 1, fundamentally, represents a recruitment of the bivalve *Mesodesma donacium.*

3. Distribution and composition of the macroinfauna: multivariate analysis

In the Q-mode of Factor Analysis, the first two factors have eigenvalues representing 90.7 % of the total variance (I: 64.7 %, II: 26.0 %). Using a score higher than 0.80 as a basis for grouping (obtained from the varimax rotated factor matrix), Group 1 and Group 2 stations were established (Table 5, Fig. 4). In Group 1 there are 5 stations with scores higher than 0.80 to Factor II, while in Group 2 there are 12 stations with scores higher than 0.80 to Factor I (Table 5). Station 1 remains ungrouped because it lacks scores higher than 0.80 to both factors.

The stations with scores over 0.80 to one of the two factors showed a distinct distribution in the Queule River Estuary (Fig. 5), which indicates that the two factors represent different environmental conditions. Of the 12 stations represented by Factor I (Fig. 5), six were located in the middle of the estuary (7, 9, 10, 11, 12, 13) where the bottom is sand (station 9), muddy sand or slightly gravelly muddy sand with an organic matter percentage higher than 3.5 % (Fig. 2 A, 2 B). Six stations (4, 14, 15, 16, 17, 18) were located in areas where the bottom is slightly gravelly sand with organic matter ranging from 1.5 to 3.5 % (Fig. 2 A, 2 B). Station 4 is located near the mouth of the estuary and the other stations in the upper part of the estuary.

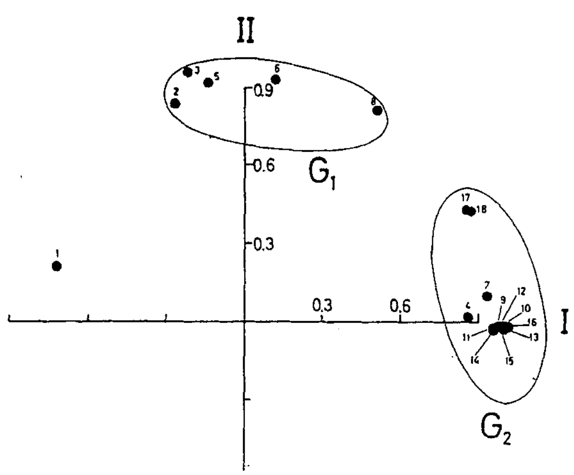


Fig. 4. Position of stations on factors I and II in the Q-mode of Factor Analysis. G_1 and G_2: macroinfauna stations group 1 (outlet area) and 2 (middle and upper part of the estuary).

The stations with scores over 0.80 to Factor II were located in the outlet area (Fig. 5) where the bottom is sand or slightly gravelly sand with organic matter below 1.5% (Fig. 2A, 2B). Station 4, located in the outlet area and not included in the group with scores higher than 0.80 to Factor II, was similar in granulometric characteristics to the sandy stations of this area. However, its higher percentage of organic matter (above 1.5 %) in relation to these stations is similar to those located in the sandy habitats of the upper part of the estuary (Fig. 2B).

Table 5. Coordinates on the first two factors obtained by the Q-mode Factor Analysis. Macroinfauna stations arranged in groups in accordance to high scores (over 0.80) to F-I (factor I) or to F-II (factor II).

Station	F-I	F-II
G_1		
2	−0.27	0.84
3	−0.22	0.96
5	−0.14	0.92
6	0.12	0.93
8	0.51	0.81
G_2		
4	0.86	0.02
7	0.93	0.10
9	0.97	−0.12
10	0.97	−0.13
11	0.95	−0.15
12	0.97	−0.07
13	0.97	−0.15
14	0.95	−0.13
15	0.99	0.12
16	0.97	−0.07
17	0.85	0.43
18	0.86	0.42
Ungrouped		
1	−0.72	0.21

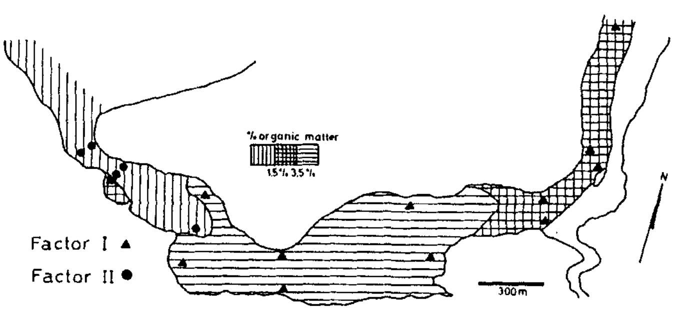
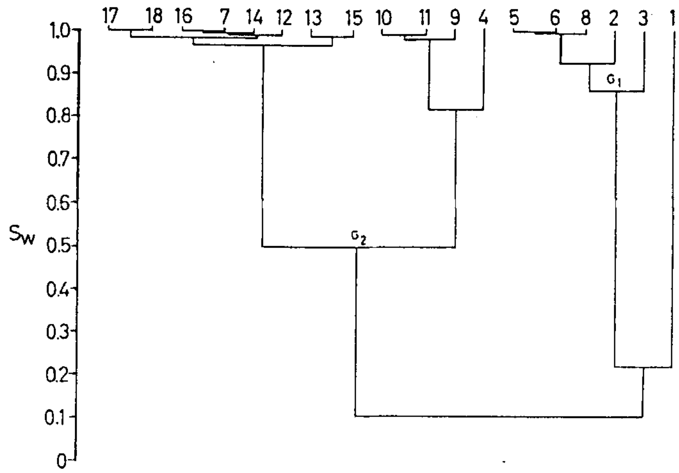


Fig. 5. Distribution of stations with factor values higher than 0.80 to factors I and II in the Q-mode of Factor Analysis. The percentage distribution of the organic matter content in the area studied is represented.

Fig. 6. Dendrogram produced by weighted pair group method with WINER's similarity index. Two groups, G_1 (outlet area) and G_2 (middle and upper part of the estuary) are distinguishable. Numbers refer to station numbers in Fig. 1.



The dendrogram from the classification of stations using values of the WINER Index is presented in Fig. 6. The arrangement of stations reveals a trend similar to the one obtained by the Q-mode of Factor Analysis (Fig. 4). When this dendrogram is arbitrarily truncated at the 0.4 level, a well defined distribution pattern with two groups and one isolated station appears. Stations in Group 1 (Fig. 6) correspond to stations of Group 1 in Factor Analysis (Fig. 4) and they include the samples obtained in the outlet area. Station 1 is linked to this group at a value of 0.22. In addition, Group 2 stations correspond to stations of Group 2 in Factor Analysis (Fig. 4) (stations located in the middle and upper part of the estuary).

In the R-mode of Factor Analysis, the first two factors have eigenvalues representing 83 % of the total variance (I: 58.2 %, II: 24.8 %). Using scores of Factor I and II for each species, Group 1 and 2 were established (Table 6,

Table 6. Coordinates on the first two factors obtained by the R-mode Factor Analysis. Species arranged in groups in accordance to high scores to F-I (factor I) or to F-II (factor II). *Polychaeta* (P), *Amphipoda* (A), *Bivalvia* (B), *Cumacea* (C), and *Isopoda* (I).

Species		F-I	F-II
G_1			
Mesodesma donacium	(B)	0.92	−0.30
Diastylis sp.	(C)	0.98	−0.17
Edotea dahli	(I)	0.98	−0.17
Glycera sp.	(P)	0.92	−0.27
G_2			
Minuspio chilensis	(P)	−0.17	0.90
Perinereis gualpensis	(P)	−0.26	0.90
Paracorophium chilensis	(A)	−0.22	0.88
Kingiella chilenica	(B)	−0.14	0.64
Ungrouped			
Mulinia edulis	(B)	0.85	−0.03
Cheus sp.	(A)	0.02	−0.57

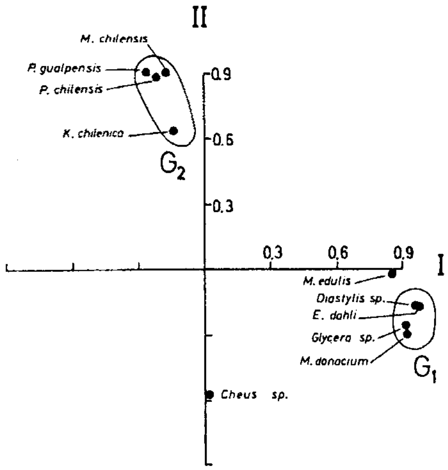


Fig. 7. Position of species on factors I and II in the R-mode of Factor Analysis. G_1 and G_2: macroinfauna species group.

Fig. 7). In Group 1 there are 4 species (the bivalve *Mesodesma donacium,* the isopod *Edotea dahli,* the polychaete *Glycera* sp., and the cumacean *Diastylis* sp.) with scores higher than 0.90 to Factor I and with scores ranging from − 0.17 to − 0.30 to Factor II. Group 2 includes species with scores higher than 0.60 to Factor II and with values going from − 0.14 to − 0.26 to Factor I. In this group the polychaetes *Minuspio chilensis* and *Perinereis gualpensis,* the amphipod *Paracorophium chilensis,* and the bivalve *Kingiella chilenica* are found. Two species, *Mulinia edulis* and the amphipod *Cheus* sp. are not included in the former groups since the first one, although it has a similar score to Factor I with Group 1, has a very different score to Factor II. The second species has very different scores to Factor I and II for both groups. This situation can be

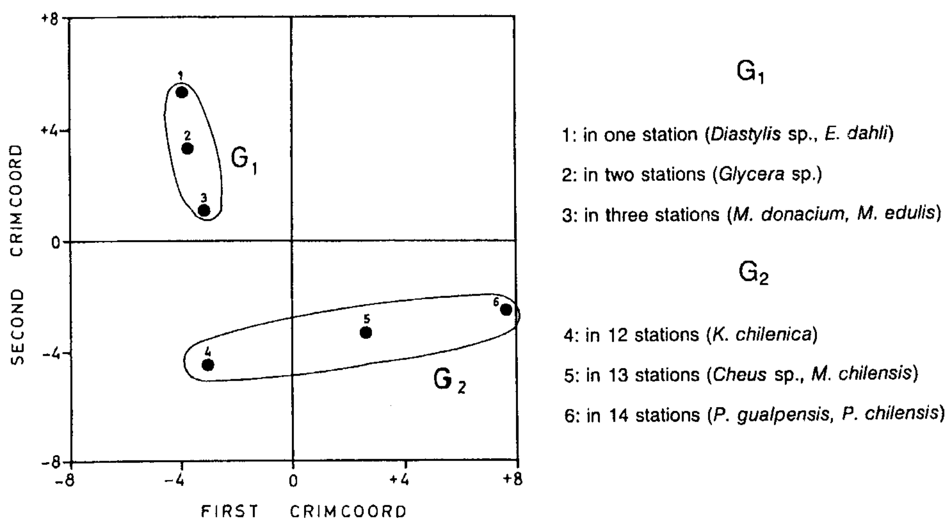


Fig. 8. Position of species on the first two canonical discriminant functions. G_1 and G_2: macroinfauna species groups.

explained by the discontinuous distribution of these 2 species in the Queule River Estuary (*Mulinia edulis* in station 1, 11, 14; *Cheus* sp. in both extremes of the estuary, absent in some stations of the middle part).

As a further test of the species groups outlined above, we have submitted the abundance species table to a Canonical Discriminant Analysis included in the Statistical Package for the Social Sciences (NIE *et al.*, 1975) using the number of stations where each species was collected as the discriminating variable. In our analysis, the first two Canonical Discriminant Functions have eigenvalues representing 98.76% of the total variance (I: 85.38%, II: 13.38%). The analysis grouped the species as shown in Fig. 8. In Group 1 the same species (with the exception of *Mulinia edulis*) included in Group 1 of R-mode (Fig. 7) are present, and they have a distribution restricted fundamentally to the stations of Group 1 (outlet area) in the Q-mode of Factor Analysis (Fig. 4). In Group 2 the same species (with the exception of *Cheus* sp.) included in Group 2 of R-mode (Fig. 7) whose distribution correspond to Group 2 of Q-mode (Fig. 4) are present. This group has the broadest distribution in the estuary and is restricted basically to the middle and upper parts of the area studied.

Discussion

In this study, the use of Factor Analysis has provided a clear picture of the species distribution and station affinities in the Queule River Estuary. Two groups of stations (Q-mode) and two of species (R-mode) were obtained that are associated with different sediment types and dominated by different feeding types. Station 1 (Fig. 1) remains isolated (Fig. 4), while in the Cluster Analysis it is linked to the stations located in the outlet area (Fig. 6). It represents the marine component of the estuary (mixoeuhaline waters) with 2 species, *Edotea dahli* and *Diastylis* sp., restricted to it. On the other hand, other species, not used in Factor Analysis because of their low densities, were only collected at this station: the amphipod *Phoxocephalopsis mehuinensis* and the isopods *Macrochiridothea mehuinensis* and *Serolis gaudichaudii.*

Group 1 stations (outlet area) were dominated (density and biomass) by suspension feeders (*Bivalvia* and *Amphipoda*), while in the Group 2 stations (middle and upper part of the estuary) deposit feeding polychaetes were dominant. Both station groups differ significantly in bottom variables (Table 7). Group 2 has mean mud and organic matter contents which are, respectively, eight and four times higher than those in Group 1. In relation to density and biomass, the mean values of Group 2 are about six times higher. The suspension feeding bivalve *Mesodesma donacium* was the dominant species in the faunal assemblage of the sandy outlet area (Group 1) reaching densities up to 13,000 individuals · m^{-2} (mean value in station 1). In the faunal assemblage located in the middle and upper part of the estuary (Group 2), the deposit feeder *Minuspio chilensis* was the most abundant species, reaching densities up to 22,000 individuals · m^{-2} (mean value in station 14).

It is evident that a classification or characterization of a faunal assemblage, based upon the numerical abundance, could underestimate the importance of other members of the community having a lower density. The holothuroid

Table 7. Bottom variables with standard deviations (S. d.) of means ($\bar{x}$) at macroinfauna station groups. t: STUDENT's t test.

Bottom	G_1 $\bar{x}$ (S. d.)	G_2 $\bar{x}$ (S. d.)
gravel (%)	1.2 (1.9)	0.6 (0.9)
sand (%)	98.7 (1.9)	90.7 (8.1)
mud (%)	0.1 (0.1)	8.7 (7.9)
o. matter (%)	1.1 (0.2)	3.7 (1.7)

t 1,2 (gravel) = 0.68 $P > 0.05$
t 1,2 (sand) = 3.22 $P < 0.005$
t 1,2 (mud) = 3.77 $P < 0.005$
t 1,2 (o. matter) = 5.20 $P < 0.005$

Molpadia oolitica, which occurs in soft bottoms of Cape Cod Bay (Massachusetts), is a good example. This species is low in density in relation to polychaetes and bivalves but its activity, consisting in the deposition of uncompacted feces on the sediment surface, produces microhabitats used by other members of the community. It therefore has an important function in the organization of the community (RHOADS & YOUNG, 1971). Furthermore, a specific assemblage might better be characterized by species of the epifauna (such as crabs) or fishes whose action (predation, removal of the substrate) could be an important factor in the organization of a soft bottom community (NAQVI, 1968; VIRNSTEIN, 1977; WOODIN, 1981). It should be further considered that species which tend to fluctuate widely in abundance are often characteristic of such unpredictable environments (BOESCH *et al.*, 1976) as estuaries. In this sense, species other than those mentioned as dominant for the Group 1 stations *(Mesodesma donacium)* and Group 2 stations *(Minuspio chilensis)* could be dominant at another time of the year.

The mean overall density of the macroinfauna throughout the Queule River Estuary (7,726 individuals · m^{-2}) was higher than that compiled by MAURER *et al.* (1978) for some temperate estuaries in other parts of the world (with some caution because of the difference in mesh sizes used [1 mm] and sampling time). For Delaware Bay, for example these authors give a mean of 722 individuals · m^{-2}, while LARSEN (1979) gives a mean value of 771 for the Sheepscot River, New England.

The number of species obtained in this study (16) is low in relation to other temperate estuaries. LOI & WILSON (1979) reported 55 taxa for a mesohaline habitat in Cheasapeake Bay. MAURER *et al.* (1978) found 109 and 125 species during 1972 and 1973 respectively, in Delaware Bay. LARSEN (1979) mentioned the presence of 78 species in the Sheepscot River Estuary, and LÓPEZ-JAMAR (1981) found 109 species in the Ría de Muros, Spain.

As has been pointed out above, the soft bottom macroinfauna of the Queule River Estuary can be divided into two faunal assemblages. It is obvious, however, that boundaries between them are not clear cut and that species present a continuum distribution such as has been shown in soft bottoms of the northern hemisphere (JOHNSON, 1971; LIE, 1978; MAURER *et al.*, 1978; LOI & WILSON, 1979) and southern hemisphere (CASSIE, 1972). While most of the species were found in one of the station groups and in a particular type of substrate, individuals of some species were also found in other substrates. Species with their highest densities in the middle and upper part of the estuary such as *Perinereis gualpensis, Minuspio chilensis,* and *Paracorophium chilensis* were also present along the border of sandy habitats which characterize the outlet area. *Cheus* sp. was characteristically present in sandy bottoms of the outlet and in the upper part of the estuary, but it was also found in low number in some stations of muddy sand in the middle of the estuary. In contrast, the species characteristics of the faunal assemblage located in the outlet area (*Edotea dahli, Diastylis* sp., *Mesodesma donacium,* and *Glycera* sp.) were not collected in muddy sand habitats. This situation could be interpreted in the sense of RHOADS & YOUNG (1970), who demonstrated that reworking by deposit feeders in bottoms with high amounts of mud results in the exclusion of many suspension feeders. Alternatively we can regard the distribution of the above-mentioned species as responding not only to sediment types, but also to tidal currents and abiotic factors of the bottom water, like salinity. The last two factors can be limiting for the distribution of the species living in the middle and upper part of the estuary towards the outlet area, where salinity and tidal currents are higher. On the other hand, the increasing fluctuations of bottom salinity towards the interior of the estuary (see Area of Study) can affect the dispersion of sandy bottom species living in the outlet area to the middle and upper parts of the estuary.

Summary

The composition and distribution of the macroinfauna in relation to the soft bottoms of the Queule River Estuary agree with the generalized organism-sediment relationships observed in other soft bottom areas of the world; suspension feeders dominate sandy habitats, while as the sediment becomes finer (muddy habitats), deposit feeders increase until they dominate (see reviews by GRAY, 1974, 1981). Representatives of estuarine cosmopolitan genera and species, cited by HEDGPETH (1957), have not been found in this estuary. This situation, together with the paucity of species are the main differences detected in this study compared to the more thoroughly studied estuarine areas of the northern hemisphere.

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