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Annual fluctuations of the subtidal macroinfauna in an Estuary of South of Chile

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Annual Fluctuations of the Subtidal Macrofauna in an Estuary of South of Chile

E. JARAMILLO, C. BERTRÁN, G. AGUILAR, A. TURNER
and M. PINO

ABSTRACT

JAMARILLO E., C. BERTRÁN, G. AGUILAR, A. TURNER & M. PINO (1984): **Annual fluctuations of the subtidal macrofauna in an estuary of south of Chile.**

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Monthly samples taken at two separate stations in the Queule River Estuary, between May 1980 and April 1981, were used to study annual fluctuations of the subtidal macrofauna. In both stations, the macrofauna showed a seasonal trend towards maximum densities and biomass in summer or autumn, with minimum densities during winter sampling, when salinities of bottom waters were the lowest. Annual variations of sedimentological characteristics did not show a direct relation with the seasonal trends presented by density and biomass.

In station A (muddy sand substrate), the overall mean density of macrofauna was 294.7 individuals per 0.025 m², while in station B (sandy bottom) it was 33.4 animals per 0.025 m². In the first station the overall mean biomass was 103.27 mg per 0.025 m², while in the second it was 7.71 mg per 0.025 m². Two polychaetes, *Minuspio chilensis* Foster (Spionidae) and *Perinereis gualpensis* Jeldes (Nereidae) and two amphipods, *Paracorophium chilensis* Varela (Corophidae) and *Cheus* sp. Thurston (Cheidae) were the species represented throughout all the year. The first three taxa presented higher density and biomass values in the muddy sand habitat, while *Cheus* sp. had higher values in the sandy bottom of station B.

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INTRODUCTION

In the south of Chile, knowledge concerning the dynamics of the estuarine communities is limited to studies of phytoplankton (Durr Schmidt, 1978), fishes (Campos, 1973; Pequeño, 1979) and interactions in hard bottom communities (Stotz, 1979). Knowledge about the fluctuations of estuarine populations and community structure must be expanded with several aims in mind. First; in relation to seasonal variations of the community, in order to evaluate relations among such fluctuations and abiotic factors whose oscillations represent the most general characteristics of an estuary. Second; macrofauna species of these estuaries are known to serve as food for demersal fishes as *Eleginops*



maclovinus (Valencienne) (Pequeño, 1979; Navarro, unpublished data). Therefore, the basic knowledge concerning the macroinfauna fluctuations becomes basic in evaluating the amount of biomass stored in the bottom. It has become clear that soft bottom macrobenthos is the most important link between primary production and secondary and tertiary production which only can be utilized by man (Arntz, 1978). Third; estuaries in the south of Chile are known as reservoirs of natural banks of mussels (*Mytilus chilensis* Hupé and *Choromytilus chorus* (Molina)) and populations of *Eleginops maclovinus*. Therefore, biological studies must develop the basic knowledge needed to provide fishery managers with the best possible information for an intelligent and rational management of resources.

In May 1980, a study of the seasonal dynamics of subtidal soft bottom macroinfauna was begun at the Queule River Estuary (39° 24' S) (Fig. 1), to provide data concerning fluctuations of density and biomass. Periodic sampling for a year at two stations enabled a comparison of species dynamics between areas with different types of substrate. Soft bottom macroinfauna living in this estuary is largely dominated by polychaetes in muddy-sand and peracaridans (fundamentally amphipods) in sandy bottoms (Jaramillo et al., in press). Their local distribution has been widely analyzed by Jaramillo et al. (in press) and Mulsow (1982).

MATERIALS AND METHODS

Study Area

Queule River Estuary is located in the south end of Queule Bay (39° 24' S, 73° 13' W), in southern Chile. The estuary has a maximum width of 440 m and a minimum of 80 m. The maximum depth of the basin is 7 m, with an average of about 3 m.

In the south east section of the estuary there is an extensive mud flat system, originated in part by descent and compactness of the soil caused by the earthquake of 1960. The south boundary of the estuary corresponds to metamorphic clasts (Fig. 1). The north side is limited by deposits of poorly consolidated sandstone from the pleistocenic age. These deposits have contributed with large amounts of sand which constitute dunes, beaches and subtidal bottom sediments.

The two stations chosen for the study were in the middle of the estuary (Fig. 1). Station A (depth 3 m) was on muddy sand sediments (with black reduction layer), while station B (depth 5 m, about 100 m apart) was on sandy bottom. Records maintained periodically in the surrounding waters of this area (monthly from May, 1980 to April, 1981) show that bottom water temperature varied from 9.2°C in fall to 17.2°C in summer (Fig. 2). During high tide the bottom water is polyhaline in fall and winter, according to the Venecia System (1958) and ranging from 19.9‰ to 29.8‰. In spring and summer salinity ranges between 31.6 and 34‰, corresponding to a mixoeuhaline condition. At low tide it is mesohaline in fall (10.3 to 12.6‰), oligohaline in winter (ranging from 0.5 to 1.3‰) and polyhaline in spring and summer (16.5 to 27.8‰) (Fig. 2).

Sampling and analytic procedures

Six samples were taken with a 0.025 m² Emery grab, at monthly intervals between May 1980 and April 1981, so that thirteen sets of samples were processed for each station. One sample was used for sedimentological analysis, and the other five for macroinfauna studies.

Sand-mud proportion analyses were performed by wet sieving through a 4 Ø sieve (62.5 µ). Sand was dried (105°C, 24 hrs), weighed, burned (550°C, 4 hrs) and reweighed. Percentage of interstitial organic matter content was obtained by weight difference. The amount of mud was

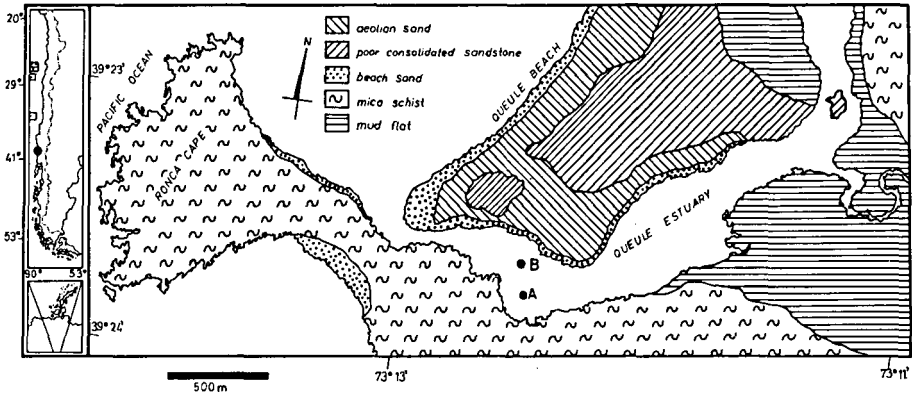


Fig. 1. Location of study sites (A, B) in the Queule Estuary.

determined by using the pipette method (Folk, 1974). Percentage of interstitial organic matter contents of this fraction was also calculated by weight difference. Sediment size class analyses were performed by sieving and by using the pipette method (only for station A) (Folk, 1974). A mechanical shaker with a set of $\phi/2$ interval sieves (from -1ϕ to 4ϕ) was used for 15 min. on each sample. The cumulative curve was drawn for each of them. The statistical parameters of graphic mean (M_2) and inclusive graphic standard deviation (σ_1) were calculated with this curve (Folk, 1974).

Bottom samples of macrofauna were sieved on the field through a 0.5 mm screen. The residue was preserved in neutral formaline (10%) and brought back to the laboratory for sorting under a stereomicroscope. Dry weight biomass was determined by using a drying oven at 60° for four days.

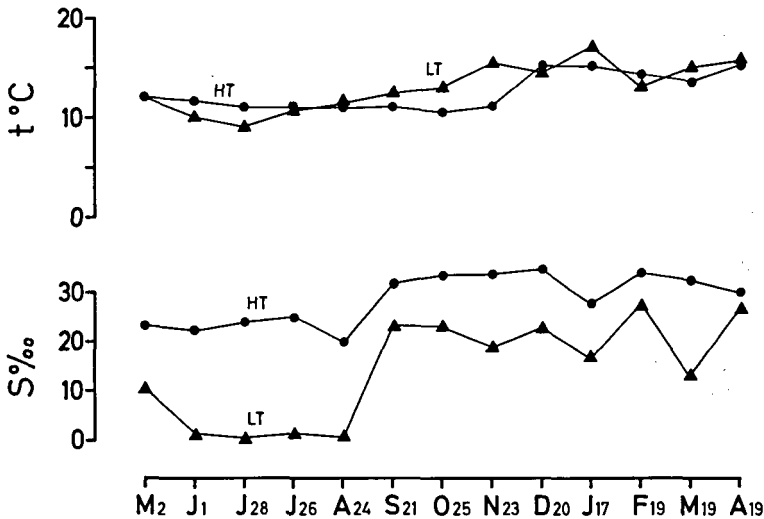


Fig. 2. Seasonal fluctuation of bottom water temperature and salinity at the study area.

RESULTS AND DISCUSSION

The bottom

Results of sedimentological analysis are given in Table 1. Granulometrically, the sediment of station A corresponds to muddy sand. The graphic mean (M_z) ranges from 3.12 ϕ (August 1980) to 5.03 (May 1980) (Fig. 2), being the average 4.04 ϕ (Table 1). The average graphic mean for station B is 2.24 ϕ (fine sand, Table 1), ranging from 1.32 ϕ (September 1980) to 2.58 ϕ (April 1981) (Fig. 2).

Inclusive graphic standard deviation (σ_1) values are above 1.5 ϕ in station A and below 1 ϕ in station B (Fig. 2). The average value for the first station is 2.04 ϕ (very poorly sorted; after Folk, 1974) and 0.51 ϕ (moderately well sorted; after Folk, 1974) for station B (Table 1). These differences could be interpreted as the result of disparity in the kinetic energy at the deposition moment, so that station A (sheltered position) represents a low energy in relation to station B, placed in the drain channel of the estuary. Station B is subject to the washing of finer sediments during tidal currents and storm periods. Such an idea is reinforced by the presence of mica in station A, which needs by his flake shape small energy for deposition (Folk, 1974). Then, the bad selection of station A is due to the absence of currents able to wash the silt and clay fraction of the bottom.

Sand and mud percentage average values are different in the two stations studied (Table 1). Station A has a high content of mud fraction in relation to

Table 1. Bottom variables with standard deviations (S.d.) of means (\bar{x}) at station A and B. t: Student's t test.

	A		B			
	\bar{x}	S.d.	\bar{x}	S.d.		
Graphic Mean (M_z)	4.04	0.54	2.24	0.40		
Inclusive Graphic Standard Deviation (σ_1)	2.04	0.24	0.51	0.19		
63-2000 fraction (sand)						
Organic matter	4.03	1.69	1.58	1.35		
Inorganic matter	53.94	13.92	96.37	2.24		
< 63 fraction (mud)						
Organic matter	4.99	1.60	0.40	0.34		
Inorganic matter	37.04	11.28	1.67	1.81		
	M_z	σ_1	sand		mud	
			org. matter	in. matter	org. matter	in. matter
t A, B	P < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

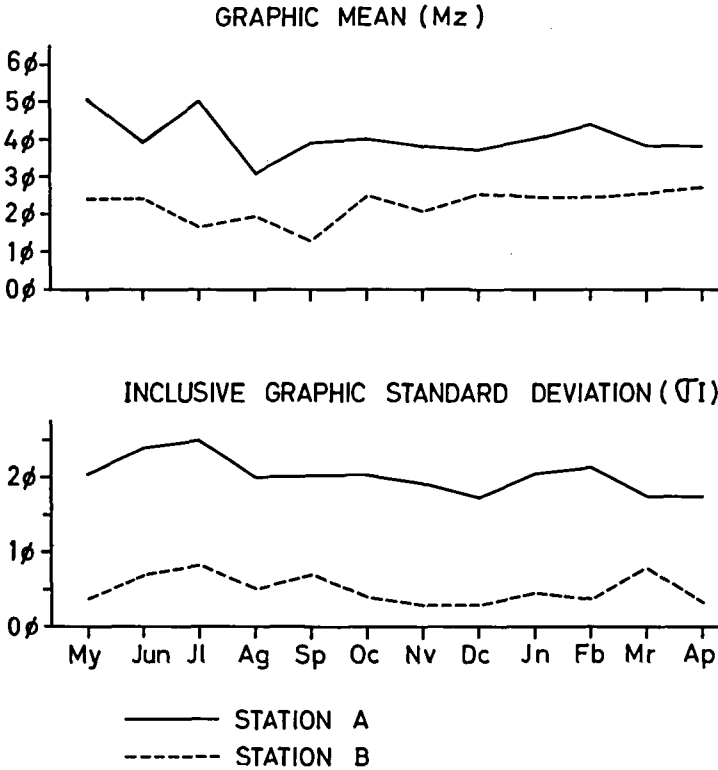


Fig. 3. Stations A and B. Seasonal fluctuations of graphic mean and inclusive graphic standard deviation.

the low values calculated for station B (Table 1). The high amount of mud in station A can be explained by its sheltered position. Since the strength of tidal currents at this location is low, this might result in low turbulence and more favorable depositing conditions. This, added to the fact that a landing place for fishing boats is located nearby (where wastes from hauls are dumped into the water) could also explain the higher amount of interstitial organic matter in relation to station B (Table 1). Student t Test was used to probe the bottom differences mentioned above. For this purpose, the average values of all sedimentological variables were used. All of those are different at a significance level of 95% (Table 1).

The whole macroinfauna

While eleven species have been mentioned for this section of the estuary (Mulsow, 1982), only four taxa were collected throughout all the year: *Minuspio chilensis* (Polychaeta, Spionidae), *Perinereis gualpensis* (Polychaeta, Ne-

reidae), *Paracorophium chilensis* (Amphipoda, Corophidae) and *Cheus* sp. (Amphipoda, Cheidae). Other taxa collected on some occasions were the bivalves *Mulinia edulis* (King) and *Kingiella chilena* Soot Ryen (in station A and B) and the isopod *Idotea dahli* Menzies (only in station B). This could be due to the fact that in this work only two stations have been studied, while in Mulsow's work (1982) the macroinfauna was analyzed over a transection enclosing several depth ranges (from intertidal to subtidal zone).

Within the area studied in the Queule River Estuary, the two stations sampled differed in density and biomass of the macroinfauna. The overall mean total density of macroinfauna in station A was 294.7 individuals per 0.025 m². This number is approximately 9 times greater than station B (overall mean of 33.4 animals per 0.025 m²) (Table 2). The first station presented a overall mean total biomass approximately 13 times greater in relation to station B (Table 2). Low stability of the substrate in station B can represent a strong impediment to the establishing of more dense infaunal population in a place subject to the direct effect of strong tidal currents.

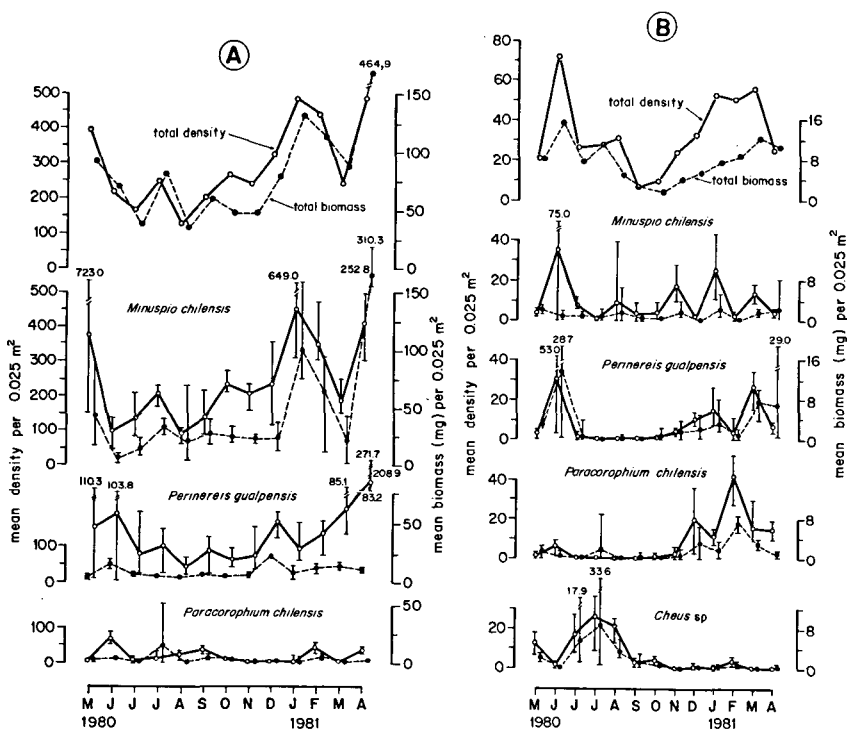
In station A, the mean seasonal density ranged from a low of 125.4 organisms in August 1980 to a high of 488 and 489.6 in January and April 1981 (Table 2). In station B, the mean seasonal density ranged from a low of 6.4 animals in September 1980 to a high of 72.2 in June 1980 (Table 2). In general, the macroinfauna of both stations showed a seasonal trend towards maximum densities in summer (January, February, March) or autumn (months of May and June) with minimum densities during winter sampling (August, September) (Fig. 4 and 5). In station A, the mean seasonal biomass ranged from a low of 34.41 mg in August 1980 to a high of 464.86 in April 1981 (Table 2). In the station B, the range goes from 1.58 mg in October 1980 to 12.26 mg in March 1981 (Table 2). In general, trends of mean biomass were similar to those of seasonal variations of mean total density (Fig. 4 and 5).

Authors like Boesch et al. (1976), Romaine et al. (1977), Arntz (1978), Loi and Wilson (1979) and Siegfried et al. (1980) had discussed variations in soft bottom benthic populations in relation to seasonal variations in abiotic factors of water and bottom. On the other hand, biological interactions between species in relation to competition for space (Peterson, 1977; Woodin, 1974), predation (Virnstein, 1977) and trophic group amensalism (Rhoads and Young, 1970) have been mentioned as playing a significant role in explaining many of the population fluctuations in soft bottom benthos. Among the complex of abiotic factors salinity is particularly important in estuaries since it affects the physiological process of any of the life stages of an organism (Boesch et al., 1976). In the Queule River Estuary, the minimum values of density and biomass were observed when the lowest values of salinity occurred (Fig. 2). For many of the winter months, the bottom water was below 2‰ in low tide and below 25‰ in high tide. Notwithstanding, without experimental data (i.e. tolerance to wide ranges of salinity) it is fruitless to hypothesise about cause-effect relations among these abiotic factors and density or biomass.

Variations of sedimentological characteristic throughout the period studied

Table 2. Mean density and biomass of macroinfauna sampled monthly.

	May 80	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr. 81	grand mean	
density A)	393.2	216.6	162.4	242.8	125.4	196.6	265.0	239.0	325.2	488.0	443.2	242.0	489.6	294.7
B)	20.8	72.2	26.2	27.4	31.2	6.4	9.4	24.2	32.8	52.6	50.0	56.0	24.6	33.4
biomass A)	91.77	68.17	37.39	80.27	34.41	59.58	47.82	47.48	78.70	131.50	113.38	87.16	464.86	103.27
B)	8.31	15.49	7.49	11.28	5.12	2.44	1.58	4.01	5.61	7.48	8.74	12.26	10.48	7.71



Figs. 4 and 5. Station A and B. Seasonal fluctuations in mean density and biomass of macroinfauna and specific taxon. For each sampling month is indicated the mean value and range values.

(Fig. 3 and 6) do not show direct relationship with seasonal fluctuations of density and biomass. Fig. 6 shows a continuous shifting of sediments probably due to local currents and not directly related to polychaete-amphipod proportion. In this sense, each type of substrate maintains its own sedimentological characteristic throughout the time and its variation does not seem to be wide enough to influence in the seasonal trends shown by density and biomass in the macroinfauna.

The species

As Table 3 and 4 illustrate, *Minuspio chilensis* and *Perinereis gualpensis* present the highest values of density and biomass. Both deposit feeder worms showed higher values to these two population parameters in station A, where bottom is muddy sand with a high amount of interstitial organic matter (Table 1). *Minuspio chilensis* population mean density peaked at this station in

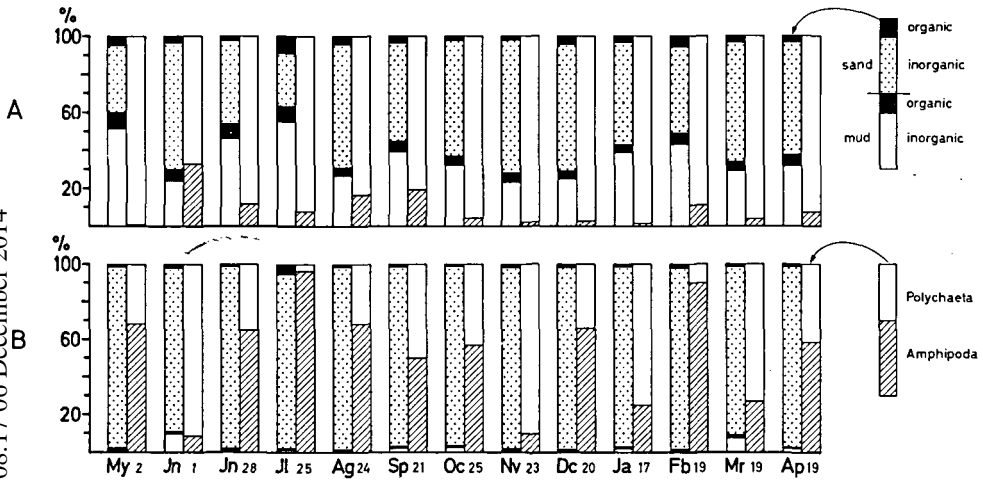


Fig. 6. Stations A and B. Seasonal fluctuations of the sedimentological characteristics and the Polychaeta - Amphipoda relation.

January 1981 (453.8), but was also high in May 1980 and April 1981 (Fig. 4; Table 3). The seasonal mean biomass peaked in April 1981 with 252.84 mg, also having high values in January and February 1981 (Fig. 4; Table 4). At station B, the mean density peaked in June 1980 and January 1981 (Table 4) while mean biomass presented higher values in January and April 1981 (Table 4). The annual cycle of *Perinereis gualpensis* at station A (Fig. 4) showed higher values for mean density in June 1980 (49.8) and December 1980 (76.6) (Table 4). These two peaks were concordant with those of June and December's biomass (Fig. 4). However, the highest values of mean biomass were obtained in March and April 1981 (Fig. 4; Table 4). At station B, the mean density peaked in June 1980, January and March 1981 (Table 3), while mean biomass presented higher values in June 1980, March and April 1981 (Table 4).

Paracorophium chilensis also presented the highest values of density and biomass in the station A (Table 3 and 4). High values of mean density were obtained in June 1980 (71), February and April 1981 (49.2 and 38, respectively) (Table 3). The seasonal mean biomass peaked in July 1980 and February 1981 (Fig. 4; Table 5). At station B, the highest values for the mean density and biomass were in December 1980 and February 1981 (Fig. 5; Table 3 and 4). *Cheus* sp. had higher values to mean density and biomass in the station B (almost absent in the station A; Table 3) where the bottom is sandy with a low amount of interstitial organic matter (Table 1). This taxon occurs principally in areas near the outlet and upper parts of the estuary (sandy bottom), being almost absent in the muddy sand bottoms of the middle of the Queule River Estuary (Jaramillo et al., 1984).

Table 3. Mean density of the species sampled monthly. Mean values per 0.025 m².

Taxon		May 80	Jun.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr. 81	grand mean
<i>Minuspio chilensis</i>	A)	375.6	95.6	134.0	207.6	91.2	136.2	236.8	211.4	239.6	453.8	353.0	185.8	414.6	241.2
	B)	3.8	35.8	8.2	1.0	9.4	3.0	3.4	17.6	1.0	25.8	1.8	13.8	4.4	9.9
<i>Perinereis gualpensis</i>	A)	12.8	49.8	19.0	15.6	13.4	22.2	16.0	22.2	76.6	28.2	41.0	47.2	37.0	30.9
	B)	2.8	30.0	1.0	0.0	0.4	0.2	0.6	4.2	10.2	15.0	3.2	27.0	5.8	7.7
<i>Paracorophium chilensis</i>	A)	4.8	71.0	9.4	18.8	20.4	38.2	12.2	4.2	9.0	6.0	49.2	7.8	38.0	22.2
	B)	1.2	5.6	0.2	0.2	0.0	0.4	1.2	2.4	20.4	11.4	41.4	15.2	14.2	8.8
<i>Cheus</i> sp	A)	0.0	0.2	0.0	0.8	0.4	0.0	0.0	1.2	0.0	0.0	0.0	1.2	0.0	0.3
	B)	13.0	0.8	16.8	26.2	21.4	2.8	4.2	0.0	1.2	0.4	3.6	0.0	0.2	7.0

Table 4. Mean biomass of the species sampled monthly. Mean values (mg) per 0.025 m².

Taxon		May 80	Jun.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr. 81	grand mean
<i>Minuspio chilensis</i>	A)	42.57	5.55	14.29	33.50	19.98	27.11	24.52	23.16	23.92	101.58	64.96	21.70	252.84	509.44
	B)	2.21	0.86	0.93	0.69	1.60	0.55	0.45	1.78	0.06	2.38	0.12	1.62	2.26	1.19
<i>Perinereis gualpensis</i>	A)	46.69	58.26	22.68	31.25	12.70	27.59	19.75	22.96	52.80	28.52	42.22	62.66	208.94	49.00
	B)	2.59	14.11	0.84	0.00	0.24	0.10	0.47	1.58	2.04	3.40	0.52	7.88	7.12	3.15
<i>Paracorophium chilensis</i>	A)	2.51	4.34	0.42	15.41	1.56	4.88	3.55	1.27	1.98	1.40	6.20	1.78	3.08	3.72
	B)	1.17	0.44	0.07	1.78	0.00	0.51	0.12	0.65	3.20	1.54	7.36	2.76	0.92	1.58
<i>Cheus</i> sp	A)	0.00	0.02	0.00	0.11	0.17	0.00	0.00	0.09	0.00	0.00	0.00	1.02	0.00	0.11
	B)	2.34	0.08	5.65	8.81	3.28	1.28	0.54	0.00	0.31	0.16	0.74	0.00	0.18	1.80

In contrast, the species *Paracorophium chilensis* occurs in muddy sand and sandy bottom of the middle and upper parts of this estuary (Jaramillo et al., in press). In this sense, quality of sediments seems to be more important for *Cheus* sp. than for *Paracorophium chilensis*. This situation could be related to the nourishment type of each species. The seasonal cycle of *Cheus* sp. at station B, showed high values of mean density and biomass in winter months, while in spring and summer these values were very low (Fig. 5; Table 3 and 4).

Analysis of seasonal fluctuations of the species mentioned above has provided basic information about the annual productivity of two kinds of bottom in the Queule River Estuary. Although the two stations studied were characterized by a low number of species, when compared with the results reported by Jaramillo et al. (in press) and Mulsow (1982) for other areas of this estuary, the muddy sand bottoms of station A could be classified as high producers of macroinfauna. The minimum mean biomass for the same station was obtained in winter time (August, Table 2). This value is above the values obtained from all the sandy bottom of Queule River Estuary and also from other muddy sand sediments of this area (Jaramillo et al., in press).

The importance of the macroinfauna as food for demersal fishes in estuaries of the south of Chile has been evidenced by Pequeño (1979) and Navarro (unpublished data). The first author mentions that *Eleginops maclovinus* feeds on polychaetes and amphipods in the Lingue River Estuary (39°26'S), while Navarro gives some numerical antecedents taking into account a sample of 12 animals from an area approximately 200 m from the section studied here. *Paracorophium chilensis* and *Perinereis gualpensis* represented in such a sample (May 1981) a percentage of 44 and 27.7 of the food items analysed in those samples. Other species represented were *Minuspio chilensis*, *Mulinia edulis*, *Kingiella chilena*, *Cheus* sp. (Navarro, unpublished data). This situation shows that all taxa found in this study are known to be utilized as food by demersal fishes. The same antecedents suggests an important role of fishes in the organization and the dynamics of the soft bottom macroinfauna in the estuaries of south of Chile, as has been demonstrated for other estuarine areas (i.e. Virnstein, 1977; Holland et al., 1980).

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