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Research Article

Composition and vertical distribution of metazoan meiofauna assemblages on the continental shelf off central Chile

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ABSTRACT. A quantitative study of metazoan meiofauna was carried out in Valparaiso Bay (33°S 71°W) which is affected by seasonal hypoxia in central Chile. The contents of bottom water, dissolved oxygen (BWDO), organic carbon, chloroplast pigments and composition of stable carbon isotope (δ^{13}C) in the sediment were used as a measure of the contribution of primary production in the water column, which accumulates in the sediment. Meiofauna abundances in the three sampling stations (80-140 m depth) ranged from 2.218 ± 643 to 1.592 ± 148 ind 10 cm^{-2}. Nine upper metazoan meiofauna groups were recorded, with nematodes as the dominant group, contributing with more than 95% of total abundances. The abundance vertical distribution was concentrated in the first layers of sediment in most groups except Acari and nauplii larvae. Canonical correspondence analysis revealed significant correlations (P < 0.05) between the meiofauna abundance and organic content, depth and redox potential from sediments. These results represent a first approach to understanding the ecology of meiofaunal assemblages in the Valparaiso Bay and may be useful as a baseline for future comparisons and descriptions of the ENSO (El Niño Southern Oscillation) and seasonal variations of these unknown benthic communities.

Keywords: meiofauna**,** nematodes, abundance, sediment, Valparaiso Bay, southeastern Pacific.

Composición y distribución vertical de los ensambles de meiofauna metazoaria en la plataforma continental frente a Chile central

RESUMEN. Se realizó un estudio cuantitativo de la meiofauna metazoaria en la Bahía de Valparaíso (33°S, 71°W), afectada por hipoxia estacional en Chile central. Los contenidos de oxígeno disuelto en el agua de fondo, carbono orgánico, pigmentos cloroplásticos y composición de isotopos estables de carbono en el sedimento (δ^{13}C) se usaron como una medida del aporte de producción primaria en la columna de agua, que se acumula en el sedimento. La abundancia de la meiofauna en las tres estaciones de muestreo (80-140 m de profundidad) varió de 2.218 ± 643 a 1.592 ± 148 ind 10 cm^{-2}. Se registraron nueve grupos superiores de la meiofauna metazoaria, siendo los nemátodos el grupo dominante, contribuyendo con más de 95% de la abundancia total. La distribución vertical de la abundancia se concentró en las primeras capas del sedimento en la mayoría de los grupos a excepción de Acari y larvas nauplii. El análisis de correspondencia canónico reveló correlaciones significativas (P < 0,05) entre la abundancia de la meiofauna y el contenido orgánico, profundidad y potencial redox de los sedimentos. Estos resultados representan una primera aproximación al conocimiento de la ecología de ensambles de meiofauna de fondos blandos en la Bahía de Valparaíso y pueden ser útiles como línea de base para futuras comparaciones y descripciones de las condiciones ENSO (El Niño Oscilación del Sur) y las variaciones estacionales de estas desconocidas comunidades bentónicas.

Palabras clave: meiofauna, nematodos, abundancia, sedimentos, Bahía de Valparaíso, Pacífico suroriental.

INTRODUCTION

The seafloor benthic assemblages inhabiting the continental shelf off north and central Chile are influenced by several oceanographic features such as oxygen minimum zones (OMZs) (Gallardo *et al*., 2004; Sellanes *et al*., 2007, 2010; Fuenzalida *et al*., 2009, Ulloa & Pantoja, 2009), coastal upwelling (Fossing *et*

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al., 1995; Gutiérrez *et al*., 2006) and the ENSO events (Arntz *et al*., 1991; Neira *et al*., 2001a, 2001b; Sellanes *et al*., 2007; Moreno *et al*., 2008). In this region, a large fraction of the organic matter derived from primary production is accumulated on the sediment, which is characterized by having high remineralization rates (Gutiérrez *et al*., 2000). These factors may change the biochemical properties of the sediments (Cowie, 2005; Neira *et al*., 2013) and bottom water column with observable effects on the composition, abundance, diversity and distribution of benthic fauna as has been observed in another regions (Levin, 2003; Gooday *et al*., 2009, 2010).

The meiofauna represents the most abundant metazoan group in the marine benthic system, distributed from the intertidal to abyssal depths, and with productivity rates similar to or higher than those of macrofauna (Gerlach, 1971; Giere, 2009). The meiofauna enhance organic matter biomineralization enhancing the recycling of nutrients and organic carbon making them available for assimilation into new biomass (*e.g.*, Gerlach, 1971; Fenchel, 1978; Giere, 2009; Neira, *et al*., 2013). In addition, these communities are also food supply for a large number of larger organisms and show sensitivity to anthropogenic impacts, serving as environmental indicators (Boyd *et al*., 2000). Meiobenthic studies from Chilean waters have been carried out from intertidal (Asencio *et al*., 1995; Rodríguez *et al*., 2001; Lee & Riveros, 2012; Valderrama-Aravena *et al*., 2014), continental shelf (Neira *et al*., 2001a, 2001b; Sellanes *et al*., 2003; Sellanes & Neira, 2006; Veit- Köhler *et al*., 2009; Neira *et al*., 2013) and hadal trenches environments (Danovaro *et al*., 2002; Gambi *et al*., 2003). There are also studies on the use of these organisms as anthropogenic bioindicators (Lee *et al*., 2006; Lee & Correa, 2007) and their relationships with abiotic parameters from sediments in fjords ecosystems (Chen *et al*., 1999; George & Schminke, 1999; Stead *et al*., 2011).

Investigations made on the continental shelf have been mostly developed off Concepción, south central Chile (36°40’S). They have focused on describing the composition, structure and function of meiofaunal assemblages in response to ENSO and OMZs conditions as well as their function in the energetic flux of benthic systems (Sellanes *et al*., 2003; Sellanes & Neira, 2006; Neira *et al*., 2013). In Valparaíso Bay (33°S), there are limited studies on continental shelf mega- and macrobenthic communities (Andrade, 1986, 1987) and virtually there are no studies about the meiobenthos. Therefore, the current research is the first to investigate the composition and community structure of soft bottom meiofauna assemblages in Valparaíso Bay. The aims were a) to describe the taxonomic composition, density and vertical distribution of the metazoan meiofauna, and b) to characterize environmental factors influencing the meiofauna distribution.

MATERIALS AND METHODS

Study area

Valparaíso Bay (32°9´S, 71°6´W) is located on the continental shelf off central Chile. In this area, oceanographic process such as upwelling, OMZs, ENSO and local organic enrichment associated with sewage outfalls influence sediment conditions and benthic communities (Brandhorst, 1971; Andrade *et al*., 1986; Sievers & Vega, 2000; Silva & Valdenegro, 2003; Rutllant *et al*., 2004; Bello & Maturana, 2004). In addition, terrestrial inputs from Aconcagua River contribute to organic enrichment and habitat heterogeneity in coastal zones, and are distributed by complex local hydrographic conditions thus enhancing the species sensitivity levels, which may lead to changes in their geographical distribution limits as has been already documented for other locations (Teixeira *et al*., 2012). An oceanographic campaign was undertaken in March 2013, considering three stations along a depth transect. The two shallowest stations (3 and 4) are situated on the inner continental shelf at 80 and 100 m depth respectively (Fig. 1). The deepest station (5) is situated on the outer continental shelf at 140 m depth, where hypoxic conditions have been recorded (Fig. 1). Records of the location and depth of each sampling station were made using a GPS Echo-sounder Garmin.

Sampling and processing

Water column temperature, salinity and dissolved oxygen (DO) were measured using a CTDO Seabird 19 Plus. In addition, discrete water samples at different depths were collected with Niskin bottles for DO. Samples for meiofauna and sediment parameters were collected using a gravity corer with a 50 mm internal diameter. Five sediment samples were collected in each station for organic matter content (OM), grain size, redox potential (Eh_{NHE}), chlorophyll-*a* (Chl-*a*), phaeopigment (Phaeop), carbon stable isotope ratio (δ^{13}C), total organic carbon (TOC) and carbon-nitrogen ratio (C:N) analyses. From each station two replicates for meiofauna were sub-sampled with Plexiglas tubes 30 mm internal diameter. To study the vertical distribution the first six centimeters of sediment column were examined. In order to achieve these the tubes were processed and subdivided into three horizontal layers (0-2, 2-4 and 4-6 cm). All samples were fixed in 4% formalin buffered with sodium borate. A 63 µm mesh sieve was used and meiofauna were extracted using the

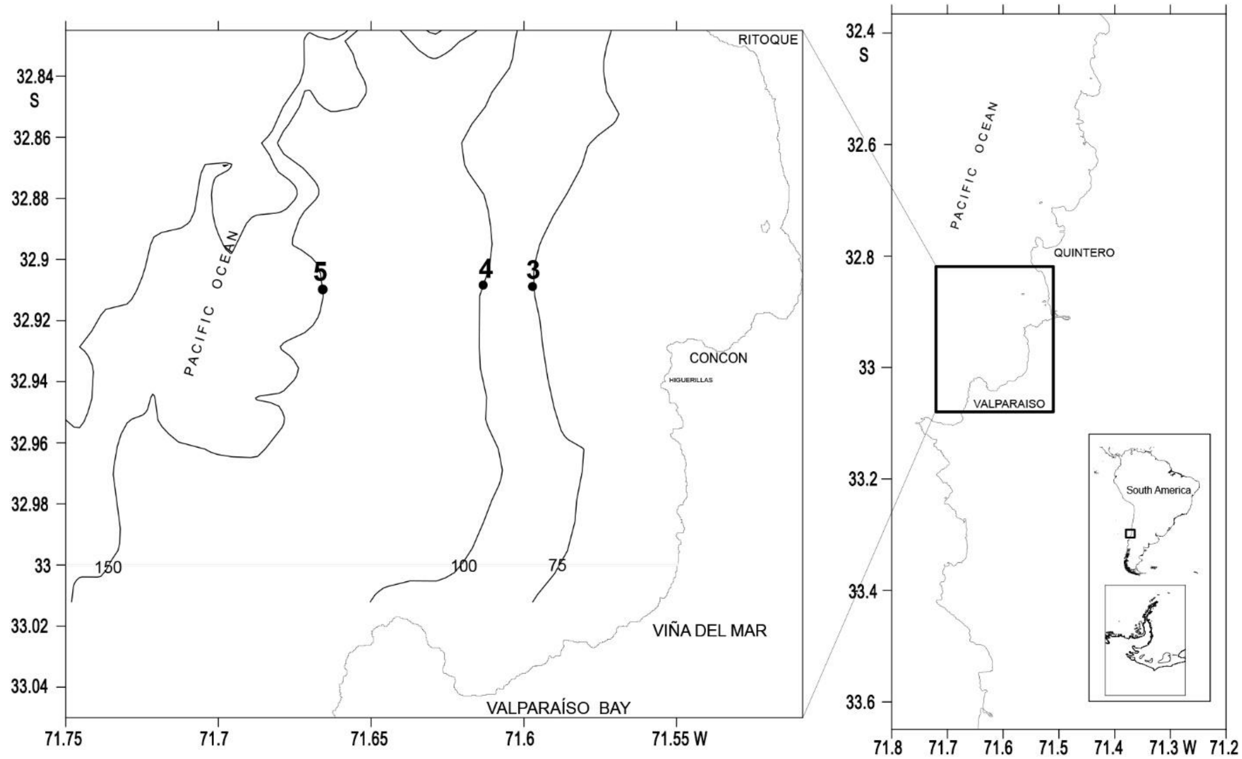

Figure 1. Study site showing the oceanographic sampling stations.

methodology of resuspension-decantation (Wieser, 1960) after sonicating the sediment for 10 s (Thiel *et al*., 1975). The efficiency of this method has been reported by Murrell & Fleeger (1989). All meiofaunal individuals were sorted, identified into major taxa and counted under a stereo microscope Nikon Eclipse E 200. Abundance was expressed as individuals per 10 cm^2.

Laboratory analyses

The samples for DO were analyzed by the Winkler method as modified from Carpenter's technique (Knap *et al*., 1993), and microtitrated with a DOSIMAT. Total organic matter (TOM) in marine sediments was determined at 2 cm intervals by loss of weight on ignition at 475-500ºC for 4 h (Byers *et al*., 1978). Carbon stable isotope content ($\delta^{13}C$) was analyzed by mass spectrometry (VG Micromass 602C equipment) at the Environment Isotopes Laboratory of the CCHEN (Chile). The $\delta^{13}C$ (‰) values are relative to the Pee Dee Belemnite (PDB) Standard (Silva *et al*., 2011). In order to estimate the contribution of allochthonous organic matter (Alloch) in the study area, we used -26.9‰ as terrestrial reference value, and we used for marine sediment an average value obtained from samples in the study area (-21.7‰), which were consistent with those reported by Silva *et al*. (2011).

The total organic carbon (TOC) and total nitrogen (TN) content of the surface sediments were analyzed on freeze-dried and homogenized sample material. Measurements were made in a CHN elemental analyzer (Flash EA 2000) after acidification treatment with 1 N HCl. Redox potential (Eh_{NHE}) was measured at 2 cm intervals in the laboratory using a platinum standard combination electrode with a calomel internal reference (SG™, Mettler Toledo). The total sulfides content in was determined colorimetrically according to method of Cline (1969). Chl-*a* and phytopigment degradation products (*i.e*., phaeopigments) were extracted from duplicate subsamples of wet sediment (*ca*. 1 g) using 90% acetone. After 24 h of darkness at 4°C, the samples were sonicated for 5 min, centrifuged at 3,000 rpm (1,000 g) for 10 min, and extracts were fluorometrically analyzed for Chl-*a* and Phaeop content. Chl-*a* and Phaeop values were obtained before and after acidification with 1 N HCl, respectively, according to Lorenzen's method, as described in Parsons *et al*. (1984), where the volume of water is substituted by the dry weight (DW) of the sediment expressed in gram. Values were thus expressed, corrected for porosity as measured by the water content, as µg Chl-*a* g^{-1} DW. This was obtained after drying duplicate sediment subsamples (*ca*. 1 g) at 105°C for 20 h. Chloroplast pigment equivalents (CPE) is the sum of Chl-*a* and Phaeop, which is an indicator of fresh organic matter

(Pfannkuche & Soltwedel, 1998). Particle grain size data were analyzed following Folk and Ward scale (Folk, 1980; Blott & Pye, 2001).

Data analyses

Kruskal-Wallis test were used to detect differences in meiofauna mean abundance between sites. The correlations between biological and sediment variables were calculated using Spearman correlation analyses. All tests were performed using the Statistica software package version 7.0. In addition, Canonical correspondence analysis (CCA) was performed with the software PAST 3.01 (Hammer *et al.*, 2001). CCA was applied to relate the set of environmental parameters and meiofaunal groups among sampling stations, as suggested by Jongman *et al.* (1987).

RESULTS

Sediment properties

Details of environmental parameters are shown in Table 1. Bottom water DO concentrations showed a decreasing pattern with depth with a mean of 2.42 ± 0.29 mL L^{-1}. Similar spatial trends were observed for Chl-*a*, Alloch and $\delta^{13}C$ variables with mean values of 10.9 ± 1.35 µg g^{-1}, 41.03 ± 22.95 (%) and -23.83 ± 1.19 ‰, respectively. The opposite pattern was observed for organic matter content (%) with a higher proportion at station 5 in the 0-2 and 2-4 cm sediment layers. The same situation was recorded for Eh_{NHE} (mV) with the highest values recorded in the 2-4 and 4-6 cm sediment layers. The values observed for these parameters indicate the low oxidation of sediments at the study site. The rest of sediment variables showed spatial variability without a clear pattern with mean values of 15.23 ± 4.44 mg g^{-1} for TOC, 12.21 ± 1.11 molar for C:N, 22.97 ± 8.28 µg g^{-1} for Phaeop, and 33.88 ± 9.41 µg g^{-1} for CPE. The sediment composition (*e.g.*, grain size) was characterized by a higher proportion of mud (>70%) and lower content of sand (<28%) in all stations. However, the sediment parameters did not exhibit significant differences among stations in the study area (Kruskal-Wallis test $P > 0.05$).

Taxonomic composition and abundance

A total of 40 taxa (different morphotypes) were recognized in the study site belonging to nine upper metazoan meiofaunal groups. Nematodes were the dominant group contributing with more than 95% of relative abundance at all sites (Table 2). In this group 22 taxa were distinguished belonging to 14 familias. Copepoda and Acari with 6 and 9 taxa respectively were the next most important groups, but they did not exceed 3 and 6% of total relative abundance, respectively. The rest of taxa: nauplii larvae, gastrotrichs, kinorhynchs, polychaetes, oligochaetes and cumaceans exhibited low relative abundances (below 1%) and scarce taxonomic representation. The main taxonomic groups are show in Fig. 2. Details of taxonomic composition and hits relative abundance are show in Annex 1.

Meiofaunal abundance decreased with the depth ranging from 2,218 ± 643 ind 10 cm^{-2} at stn. 3 to 1,592 ± 148 ind 10 cm^{-2} at stn. 4. No significant differences were observed between stations (Kruskal-Wallis test, $H_2 = 1.21$, $P > 0.05$). Nematode abundances reached maximum values at station 3 with 2,136 ± 634 ind 10 cm^{-2}, while the lowest abundances were recorded at stn. 4 with 1,528 ± 138 ind 10 cm^{-2} (Fig. 3a). Acari abundances were two to three orders of magnitude lower than nematodes, and were the second most abundant meiofaunal group, which ranged from 56 ± 9 ind 10 cm^{-2} at stn. 3 to 7 ± 2 ind 10 cm^{-2} at station 5 (Fig. 3b). Copepod abundances varied from 10 ind 10 cm^{-2} at stn. 4 and 5, to 5 ± 0.98 ind 10 cm^{-2} at stn. 3. The rest of taxa recorded abundances lower than 2 ind 10 cm^{-2}. Nematodes, nauplii larvae, copepods, acari and gastrotrichs were recorded at all stations. Contrasting, kinorhynchs were recorded at stn. 4 and 5, with higher abundances at the stn. 5 (27 ± 6 ind 10 cm^{-2}). Cumaceans and oligochaetes were also recorded at station 4, while polychaetes only at stn. 5. These taxa always were recorded with very low abundances (<1 ind 10 cm^{-2}).

Vertical distribution

Vertical distribution profiles of the major meiofaunal taxa are shown in Figure 4. The meiofauna vertical distribution varied in the three stations. Meiofaunal abundances decreased with the sediment depth and nematodes were the dominant group at each depth (>90% of abundance) dictating the overall vertical distribution pattern for the whole community. The single exception to this trend was Acari. This group increased with sediment depth recording the highest density in the 4-6 cm layer with a mean of 19.3 ± 14,9 ind 10 cm^{-2}. On the other hand, nauplii larvae recorded a density slightly lower at 4-6 cm layer (3.79 ± 4.13 ind 10 cm^{-2}) in comparison to 0-2 cm layer (3.83 ± 4.37 ind 10 cm^{-2}). The great majority of the taxa were concentrated in the 0-2 cm sediment layer. Even some groups such as kinorhynchs, cumaceans and polychaetes were not recorded in the lower layers, while copepods and gastrotrichs had a wider vertical distribution. Including all sites and sediment layers, the median proportion of specimens (relative abundance) recorded in the 0-2, 2-4 and 4-6 cm layers was 75.2%,

Table 1. Abiotic properties of three sampling stations off central Chile. Sedimentary parameters are given for the top 0-1 cm layer (means of 3 samples). TOC: total organic carbon; C:N: carbon-nitrogen ratio; Chl-*a*: chlorophyll-*a*; Phaeop: phaeopigments; Eh: redox potential; TOM: total organic matter; δ^{13}C: ratio of stable isotopes; CPE: chloroplast pigment equivalents; Alloch: allochthonous organic matter.

	Station 3	Station 4	Station 5
Depth (m)	80	100	140
Latitude	32°54'31	32°54'31	32°54'31
Longitude	71°35'44	71°36'48	71°38'57
Bottom water temperature (°C)	11.31	11.26	11.2
Bottom water oxygen (mL L^{-1})	2.73	2.37	2.16
TOC (mg g^{-1})	12.41	20.35	12.95
C:N ratio (molar)	12.79	12.91	10.93
Chl*a* (µg g^{-1})	12.28	10.84	9.59
Phaeop (µg g^{-1})	32.44	17.06	19.42
CPE (µg g^{-1})	44.73	27.91	29.01
Eh_{NHE} (mV)			
0-2 cm	56	27	33
2-4 cm	-26	-32	-44
4-6 cm	-68	-76	-107
Sulfides (mg kg^{-1})	15	17.2	1.15
Mud (%)	84.4	72	93.6
Sand (%)	15.6	28	6.3
TOM (%)			
0-2 cm	6.1	7.6	7.7
2-4 cm	6.5	7.7	8.4
4-6 cm	6.4	6.8	6.5
δ^{13}C (‰)	-24.8	-24.2	-22.5
Alloch (%)	59.62	48.08	15.38

Table 2. Relative abundance (%) of meiofaunal groups in the study area in different sediment layers (0-2, 2-4 and 4-6 cm). Nem: Nematoda, Cop: Copepoda, Nau: Nauplii, Pol: Polychaeta, Aca: Acari, Cum: Cumacea, Gas: Gastrotricha, Olig: Oligochaeta, Kin: Kinorhyncha

Station	Nem	Cop	Nau	Pol	Aca	Cum	Gas	Olig	Kin
3									
0-2 cm	98.3	0.25	0.20	-	0.65	-	0.55	-	-
2-4 cm	97.2	-	0.13	-	2.70	-	-	-	-
4-6 cm	82.4	0.60	3.57	-	13.40	-	-	-	-
Total	96.3	0.23	0.55	-	2.54	-	0.35	-	-
4									
0-2 cm	97.6	0.78	0.66	-	0.11	0.06	0.17	-	0.61
2-4 cm	95.9	-	-	-	4.10	-	-	-	-
4-6 cm	72.4	-	1.60	-	25.20	-	-	0.79	-
Total	95.9	0.63	0.63	-	2.10	0.04	0.13	0.04	0.49
5									
0-2 cm	97.1	0.64	-	0.05	-	-	0.29	-	1.90
2-4 cm	97.2	0.31	0.31	-	1.80	-	0.31	-	-
4-6 cm	90.5	-	3.17	-	6.40	-	-	-	-
Total	97	0.57	0.12	0.04	0.41	-	0.29	-	1.60

18% and 6.8% respectively for the total meiofauna. Nevertheless, without considering the nematode abundances this proportion changed between stations. At stn. 3 the higher proportion of specimens, 51.8%, was concentrated at 4-6 cm sediment layer. At stn. 4 specimens were slightly more abundant at 0-2 cm

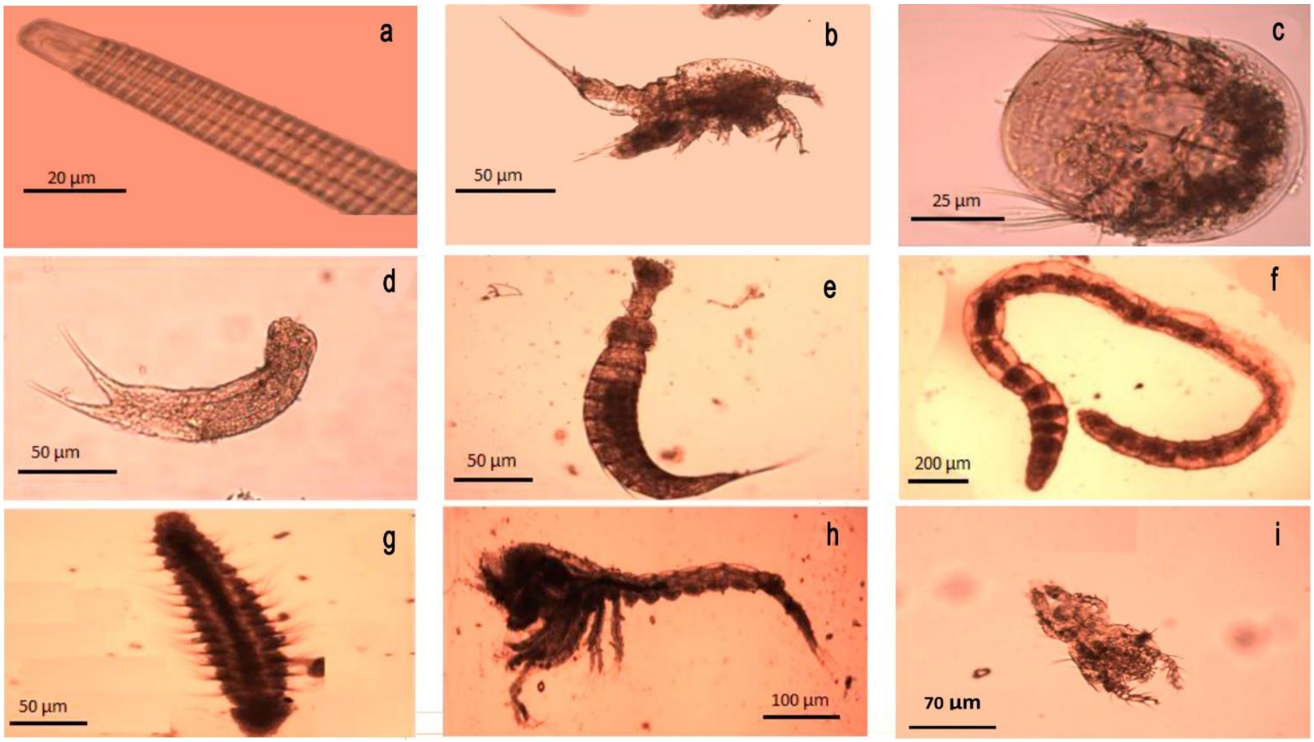

Figure 2. Light microscope photographs of meiofaunal taxa found at Valparaiso Bay. a) Nematoda, b) Copepoda, c) Nauplii, d) Gastrotricha, e) Kinorhyncha, f) Oligochaeta, g) Polychaeta, h) Cumacea, i) Acari.

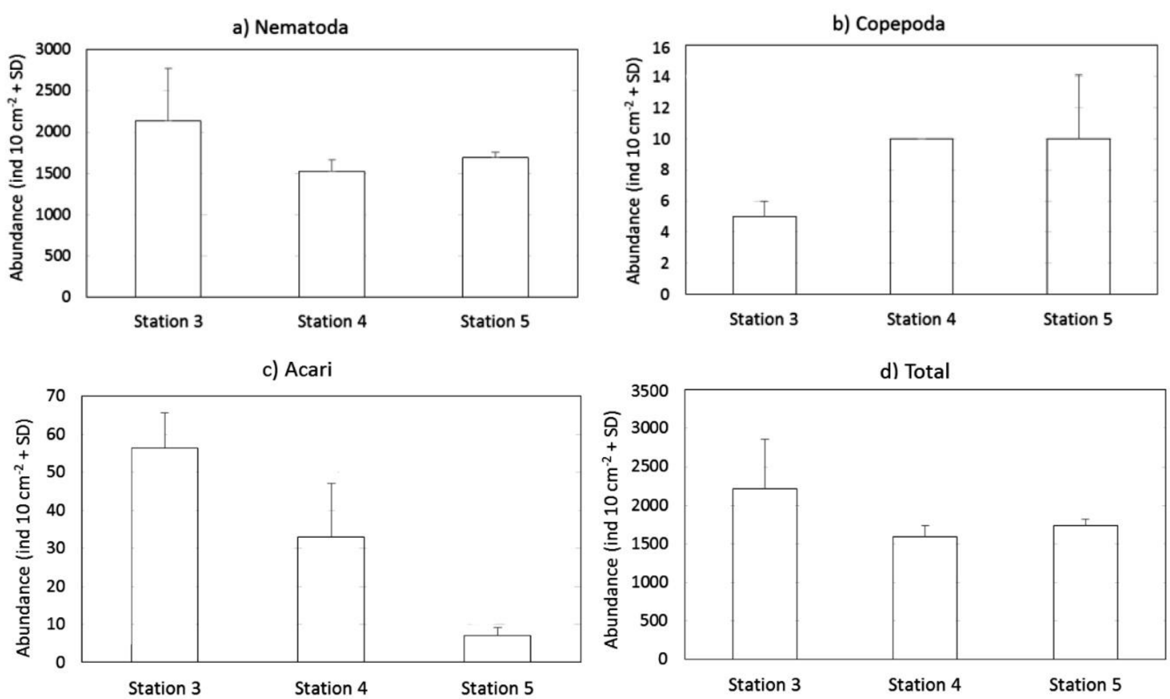

Figure 3. Meiofauna mean abundance in each sampling station. a) Nematoda, b) Copepoda, c) Acari, and d) Total meiofauna. Error bars indicate the standard deviation**.**

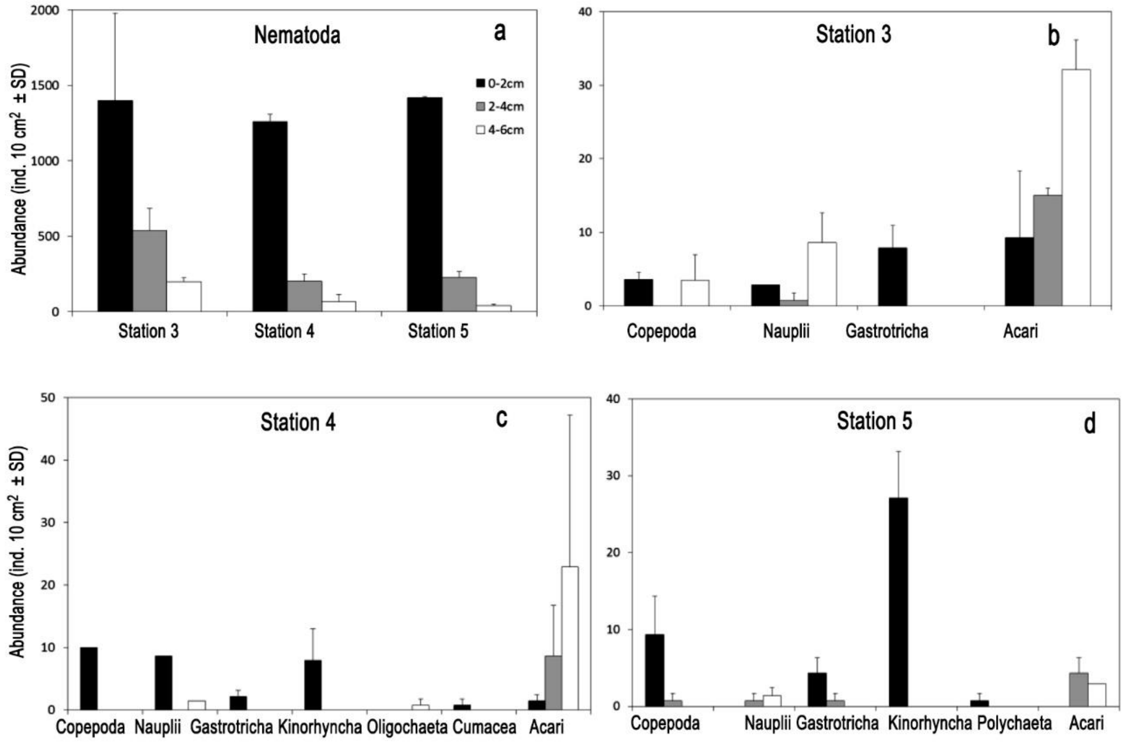

Figure 4. Mean abundance vertical distribution at 0-2, 2-4 and 4-6 cm sediment layers. a) Nematoda (all stations), b) Station 3, c) Station 4, and d) Station 5. Graphs b, c and d: nematodes excluded.

(47.7%), while that at stn. 5 the distribution was closer to the overall pattern (nematodes included) with 79.4% at 0-2 cm sediment layer.

Relationships between environmental parameters and meiofauna

The results of the CCA are shown in Fig. 5. Only the five environmental variables that explained most of the variance were included in the analysis (*i.e.*, Depth, C/N, Allochthonous OM, TOC and Redox potential). When the abundance of the dominant meiofaunal groups is related to the environmental variables the first CCA axis eigenvalues accounted for 89.8% of the total variance and the second CCA axis eigenvalues accounted for 10.3% of the explained variance. This suggests a relatively good dispersal of the biological data along the different axis in both analyses. For the meiofauna composition, the first axis reveals gradients influenced by allochthonous content of organic matter (r = 0.99), C/N ratio (r = 0.96) and depth (r = -0.85), while the second axis reflects a gradient influenced by TOC (r = 0.97) and redox potential (r = -0.84). In terms of meiofauna composition, Nematoda was the dominant group in all stations, but Cumacea and Oligochaeta were more representatives in stn. 4, while Polychaeta and Kinorhyncha in stn. 5.

DISCUSSION

Environmental parameters

Meiofaunal assemblages at central Chile are influenced by the Equatorial Subsurface Water (ESSW), which flows poleward over the shelf and upper slope (Sellanes & Neira, 2006). This water mass has low oxygen concentrations and is the source of coastal upwelling that drives high primary production (Fossing *et al*., 1995; Daneri *et al*., 2000) and generates the food supply to the seabed (Gutiérrez e*t al*., 2000). The C/N ratio value recorded in this study was 10.93 on the outer continental shelf. This value indicates that accumulated organic matter has been decomposed from nitrogen compounds (Scheffer & Schachtschabel, 1984). C/N ratio values in the first few centimeters of sediment were similar to values found off Peru with 9.8 (Levin *et al*., 2002) and higher in comparison to values recorded in Concepción Bay by Veit-Köhler *et al*. (2009) and Neira *et al*. (2013) with 7.8 and 7.06, respectively. TOC contents in the study area were similar to those recorded by Neira *et al*. (2013) off Concepción at 122 m depth with 46.91 mg g^{-1}. In comparison with other upwelling areas, TOC values were also similar to those reported at the Arabian Sea (14.3-54.3 mg g^{-1}) (Smallwood & Wolff, 2000), but lower that those recorded off Peru

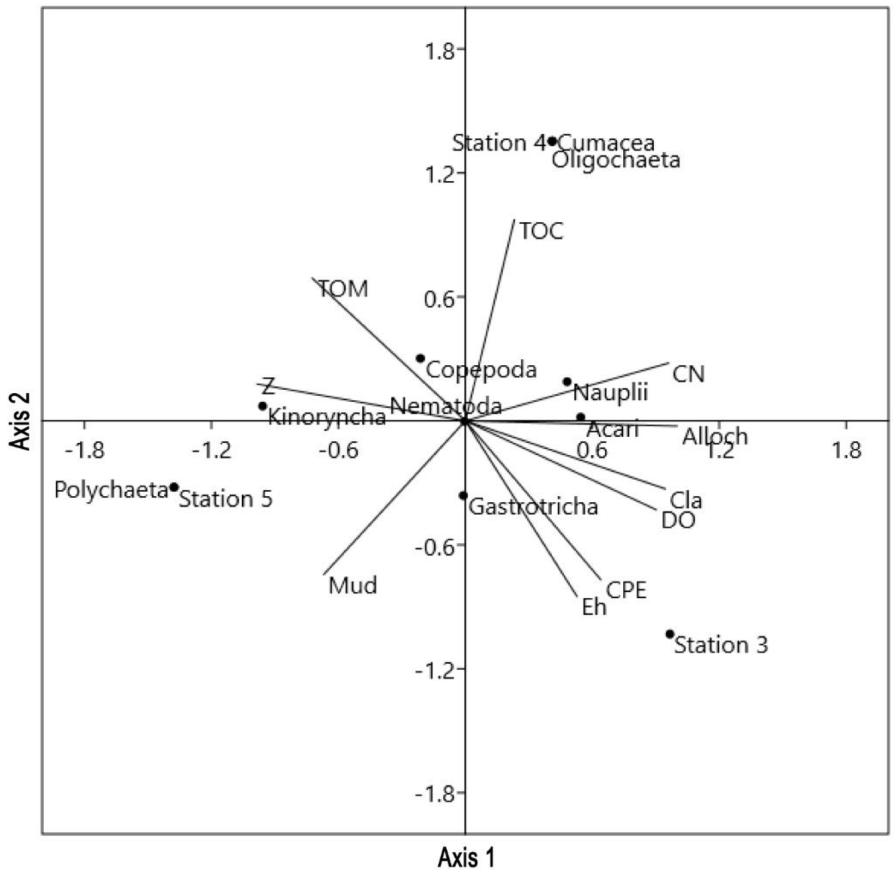

Figure 5. Canonical correspondence analysis displaying the meiofaunal groups in relation to environmental variables that best explain the abundance distribution among stations. Relationships were significant ($P < 0.05$).

(>205 mg g^{-1}) (Neira *et al*., 2001b). The concentrations of Chl-*a* and Phaeop in the current research were lower than found in studies made by Neira *et al*. (2013) (124.62 and 196.76 µg g^{-1}, respectively). However, they were higher than those recorded by Neira *et al*. (2001b) (4.30 µg g^{-1}) on the continental slope off Peru.

Meiofauna

It is known that habitat heterogeneity due to physical or chemical properties of the sediment would be an important factor controlling the meiobenthos community structure (Gooday *et al*., 2010). In physical terms the grain size variations recorded were not important as correlations with meiofaunal groups were not found. However in chemical terms in addition to the DO, content of organic matter, Chl-*a* and CPE decreased with depth and significant correlations were found between meiofauna abundance and organic content (C/N, Allochthonous organic matter and TOC), depth and redox potential sediment parameters. For instances, the organic matter content, Chl-*a* and DO were positively correlated with meiofauna abundance in Concepción Bay (Neira *et al*., 2013; Sellanes *et al*., 2003; Sellanes & Neira, 2006; Veit-Köhler *et al*., 2009). In our study area, nematodes constitute more than 95% of total meiofauna abundances, being considered the taxon that can best cope with low oxygen conditions and high organic matter content on the sediments. In fact, only meiofauna is well adaptated to low oxygen in the suboxic to anoxic layers (Braeckman *et al*., 2013). In this sense the deeper vertical distribution of Acari and nauplii larvae in some sedimentos layers, where negative values of redox potential were recorded, would demonstrate this kind adaptation in the current study.

Table 3 shows the meiofaunal abundance from different locations with similar characteristics to Valparaíso Bay. The total abundances of nematodes at the three stations were slightly higher than those reported by Sellanes *et al*. (2003) and Veit-Köhler *et al*. (2009) for the continental shelf off central Chile. Mean abundances recorded on the inner and outer continental shelf in the current study (Fig. 3d) were similar to those described by De Bovée *et al*. (1996), where meiofaunal

Table 3. Comparison of meiofaunal abundances among areas sharing similar characteristics with Valparaíso Bay and/or adjacent continental shelf. Abundances reported as ind 10 cm^{-2}.

Zone	Depth (m)	Environment	Nematode abundance	Total meiofauna	Reference
Arabian Sea	400	Upwelling	1.700	-	Cook *et al*. (2000)
Southeast continental shelf of India	75-100	Upwelling	-	700	Ansari *et al.* (2012)
	100-150			800	
Continental shelf Perú (12°S)	305	OMZ	1.502 ± 430	1.517 ± 431	Neira *et al*. (2001b)
Atacama Trench	1.050	Bathyal depths	498 ± 157	550 ± 186	Danovaro *et al*. (2002)
	7.800	Hadal depths	5.072 ± 2.344	6.378 ± 3,061	
Continental shelf central Chile	88	OMZ	1.193 - 2.417	1.202 - 2.433	Sellanes *et al*. (2003)
	120	OMZ	738 - 1.268	895 - 1.318	
Continental shelf central Chile	126	OMZ	1.555 - 3.077	1.577 - 3.229	Veit-Köhler *et al*. (2009)
Continental shelf, Valparaiso Bay	80	Seasonal hypoxia	2.136 ± 633	2.218 ± 643	This study
	100	Seasonal hypoxia	1.528 ±138	1.592 ± 148	
	140	Seasonal hypoxia	1.687 ± 69	1.739 ± 82	

densities ranged between 1.000 and 2.000 ind 10 cm^{-2} from subtidal muddy environments. It is important to note that the study area is influenced by a seasonal hypoxia with DO concentrations about 2.34 mL L^{-1}, while low oxygen levels (<0.5 mL L^{-1}) have been documented at Concepción bay. Indeed, low oxygen levels have been registered on the continental shelf off Peru (Neira *et al*., 2001b) and in the Arabian Sea (Cook *et al*., 2000), where nematodes abundance appear to be similar to our study. On the other hand, the number of taxonomic groups found in this study (9 taxa) was lower than observed for Concepción Bay by Sellanes *et al*. (2003) with 13 taxa and for Chiloé, southern Chile by Veit-Köhler *et al*. (2009) where 16 taxa were recorded. This minor presence of taxonomic groups could be explained by nematode dominance (total abundance >95%) (Table 2) or due to minor number of samples considered. Levin *et al*. (1991) and Neira *et al*. (2001b) argue that these organisms are highly successful in sediments rich on organic matter and with low dissolved oxygen concentrations. In this respect the organic matter content averaged 7.13% in surficial sediments (0-2 cm) while hypoxic conditions were recorded (Table 2). These authors affirm that the oxygen could control the meiofauna composition at level of major taxonomic groups within the OMZ zones.

Meiofauna vertical distribution is mainly controlled by food deficiency and oxygen availability with around 90% of total meiofauna being concentrated between 0-5 cm sediment layers (Giere, 2009). In our study, 93% of total meiofauna was concentrated in the 0-4 cm sediment layer (Fig. 4a) which could be an adaptive response related to their trophic strategies. However our results suggest that this vertical distribution pattern would be mainly determined by higher concentrations of fresh organic content in the surficial sediment layers. It is well know that nematodes have a wide variety of trophic strategies from carnivore predators to bacterivorous guilds (Wieser, 1960; Neira *et al.*, 2013) and they are dominants in all type of sediments inhabiting in both oxidized and reduced conditions. However a trophic guild classification was not made for this study, although some similar trophic strategies to those reported by Neira *et al.* (2013) for Concepción could be found. In addition, nematodes dominance is thought to be the result of the capacity to tolerate low oxygen conditions and the reduced predation pressure/competition as a result of the higher sensitivity of other benthic organisms to hypoxia/anoxia (Neira *et al*., 2001a, 2001b; Levin *et al*., 2002). The results recorded in the current study showed that the vertical distribution of nematode abundances changed mainly between 2-4 and 4-6 cm sediment layers (Table 2). This minor relative abundance that was clearly observed at station 4, where a higher proportion of sand was recorded, could be explained by the higher relative abundance of Acari and nauplii at 4-6 cm layer. This could be suggesting a nematode response to competition with other taxa or sensitivity to redox potential conditions of the sediments as revealed by CCA.

Gastrotrichs, kinorhynchs and copepods concentrated their abundances in the first centimeters of the sediment. The vertical distribution in these groups could be explained by their sensitivity to low levels of DO, their morphology and body size (Giere, 2009). In the case of copepods they could be unable to easily adapt to interstitial environments. A different vertical distribution pattern was observed for nauplii and Acari. Nauplii did not show a higher abundance in surficial sediment layers, with wide vertical variation between stations. Contrastingly, Acari were mainly distributed in sub-surficial sediment layers (2-4 and 4-6 cm) at all stations. Vertical distribution pattern for nauplii and Acari could be associated to predation pressure and bioturbation in surficial sediment where the competition for habitat and fresh food supply is very high. For instances, a similar vertical distribution pattern also have been recorded for Acari (Acarina) in seamounts (Zeppilli *et al*., 2013).

It is known that oceanographic characteristics along the continental margin off central Chile are influencing the spatial distribution of mega-, macro- and meiobenthic communities (*e.g.*, Palma *et al*., 2005; Quiroga *et al*., 2009; Sellanes & Neira, 2006). In fact, the effects of upwelling under normal, ENSO and OMZs conditions have been well documented off central Chile (Neira *et al*., 2013; Sellanes *et al*., 2003; Sellanes & Neira, 2006), the continental shelf off Peru (Neira *et al*., 2001b; Levin *et al*., 2002) and in the Arabian sea (Cook *et al*., 2000; Gooday *et al*., 2000). From these studies, the organic matter quality and oxygen availability have been the main variables explaining the meiofauna community structure. In the current study the organic content of the sediments comes from primary production together to redox potential and depth were the only environmental variables explaining the distribution of meiofauna groups, while oxygen levels were not correlated. The composition, abundance and distribution of the meiobenthic community provided in this study represents a non-ENSO condition and can be useful as a baseline for future descriptions of this relevant oceanographic phenomena, which has already been confirmed for the South Pacific Ocean by 2015 (National Wheather Service, 2014). Time series studies are suggested to assess the ecological response of these assemblages to conditions before mentioned and to another such as OMZ and upwelling seasonal changes.

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Annex 1. Meiofaunal community composition and its relative abundance (%) in the study site.

	Station 3	Station 4	Station 5
Nematoda			
Axonolaimidae sp.1	12	7	3
Odontophora sp.	14	13	6
Cyatholaimidae sp.1			1
Cyatholaimidae sp.2	3		
Enoplidae	5		
Ironidae	17	15	6
Oncholaimidae	8	4	
Selachinematidae	13		
Ceramonematidae			
Ceramonema sp.			13
Pselionema sp.	6	13	13
Desmoscolecidae sp.1	4		8
Desmoscolecidae sp.2	2	11	
Desmoscolex sp.	11	24	7
Oxystominidae			
cf *Halalaimus* sp.	5	13	
Diplopeltidae sp.1			4
Campylaimus sp.			9
Comesomatidae sp.1			3
Sabatieria sp.			2
Chromadoridae sp.1			7
Neochromadora sp.			8
Microlaimidae			5
Thoracostromopsidae			5
Acari (Halacarids)			
Acari sp.1	32	34	12
Acari sp.2	23	14	7
Acari sp.3	21	18	29
Acari sp.4	16	5	
Acari sp.5	8		7
Acari sp.6		12	20
Acari sp.7		7	6

Continuation

	Station 3	Station 4	Station 5
Acari sp.8			14
Acari sp.9		10	5
Copepoda (Harpacticoidea)			
Copepoda sp.1	54	46	12
Copepoda sp.2	39	17	38
Copepoda sp.3	7	25	
Copepoda sp.4		12	
Copepoda sp.5			34
Copepoda sp.6			16
Nauplii larvae			
Nauplii sp.1	47	40	29
Nauplii sp.2	36	29	23
Nauplii sp.3	17	12	8
Nauplii sp.4		19	24
Nauplii sp.5			16
Cumacea			
Dyastilidae sp.1		100	
Polychaeta			
Paraonidae sp.1			100
Gastrotricha			
Gastrotricha sp.1	75	60	
Gastrotricha sp.2	25	20	100
Gastrotricha sp.3		10	
Kinorhyncha			
Kinorhyncha sp.1		100	60
Kinorhyncha sp.2			40
Oligochaeta			
Oligochaeta sp.1		100	