DISTRIBUTION OF BENTHIC INVERTEBRATES IN THE BEAGLE CHANNEL, ARGENTINA

DISTRIBUCIÓN DE INVERTEBRADOS BENTÓNICOS EN EL CANAL BEAGLE, ARGENTINA

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ABSTRACT

Bathymetric and spatio-temporal distributions of both abundance and biomass as well as secondary production of benthic invertebrates in the Beagle Channel were determined. The sampling stations were seasonally placed in three different areas in the Beagle Channel at two depth ranges, 15-40 m and 70-259 m. A total of 32,686 specimens distributed in 30 taxonomic groups were identified. In addition, 4 taxa were quantified only in terms of biomass. The invertebrate abundance and biomass were different with depth. Secondary production at this range was 0.59 ±0.51 kJ·m^{-2}year^{-1} whereas it decreased to 0.09 ±0.08 kJ·m^{-2}year^{-1} at 70-259 m. In contrast to secondary production, P/B ratio showed a positive increment with depth. Furthermore, seasonal variations were not observed in secondary production of the macrozoobenthos. Parameters directly associated with depth could be involved in structuring the macrobenthic assemblages in the Beagle Channel.

Key words: Zoobenthos, Subantarctic waters, abundance, biomass, P/B ratio

RESUMEN

Se determinó la distribución batimétrica, espacial y temporal de la abundancia y biomasa de invertebratrados bentónicos del Canal Beagle, como también su producción secundaria. Las muestras se tomaron estacionalmente en tres lugares diferentes del Canal Beagle y en dos estratos de profundidad, 15-40 m y 70-259 m. Se identificó un total de 32.686 individuos distribuidos en 30 grupos taxonómicos. Además, 4 taxones se cuantificaron sólo en términos de biomasa. La abundancia y biomasa de invertebrados fue diferente con la profundidad. La producción secundaria en este estrato fue 0,59 ±0,51 kJ·m^{-2}año^{-1} mientras que a 70-259 m disminuyó a 0,09 ±0,08 kJ·m^{-2}año^{-1}. Por el contrario, la tasa P/B

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mostró un incremento positivo con la profundidad. A su vez, no se observaron variaciones estacionales en la producción secundaria del macrozoobentos. Parámetros asociados directamente con la profundidad podrían estructurar los ensambles macrobentónicos en el Canal Beagle.

Palabras clave: Zoobentos, subantártica, abundancia, biomasa, tasa P/B

INTRODUCTION

Recently, the Magellan sub-Antarctic region has been the object of several studies focused on distribution patterns, composition, abundance, biomass and production of marine benthic communities (Brey & Gerdes 1999, Gerdes & Montiel 1999, Gutt *et al.* 1999, Thatje & Mutschke 1999, Montiel *et al.* 2001, Ríos *et al.* 2003). This increasing interest on the Magellan region among other sub-Antarctic regions, has been motivated by its nearest biogeographic relationship with the Antarctic region (Hedpgeth 1969, Arntz *et al.* 1994). Both regions remain geographically connected by islands and shallow waters through the Scotia Arc (Arntz *et al.* 2005), and certain marine invertebrate groups are differentially represented in both regions. In the Antarctic, reptant decapods and bivalves that are commonly in the Magellan region have declined through time, whereas others like poriferans, cnidarians, polychaetes, peracaridans, pycnogonids, bryozoans and echinoderms appear to be more important (Arntz *et al.* 1994, Crame 1999).

The Beagle Channel, at the southernmost limit of the Magellan region, is situated at the southern tip of South America. This channel is a paleo-fjord that links the Pacific and Atlantic waters and, because of its glacial origin, it has kept relatively isolated from the open oceanic waters and constitutes a partially closed system (Isla *et al.* 1999). Although the Beagle Channel may represent an interesting area of study because of its geographical location, little is known about the benthic assemblages (Pérez-Barros *et al.* 2004, Arntz *et al.* 2005). Information on the structure of benthic marine assemblages is of importance in understanding the ecosystem and the species involved. This information becomes more important when some species of the benthos are of economic importance. Ecologically, the abundance and distribution patterns of the benthic invertebrates in the Beagle Channel are important due to the key role that they play in benthic-pelagic coupling, where several benthic species are of economic interest. Then, understanding the structure and distribution of benthic assemblages in the Beagle Channel will provide the basis for future studies, both ecological and economic.

The present work provides information about small-scale benthic assemblages of a thermally sub-Antarctic area (Barnes *et al.* 2006). Thus, the aims of this work were (1) to characterize the invertebrate epibenthic community and (2) to assess the spatial-temporal and bathymetric distribution of epibenthic invertebrate abundance, biomass and secondary production in the Beagle Channel.

MATERIAL AND METHODS

Study site

This study was carried out in a area of ~45 km along the Beagle Channel (*ca.* 55 ºS, 68 ºW), Tierra del Fuego, Argentina (Fig. 1). The sea bottom at the site was mainly thick sand and fragments of shells in shallow waters, whereas deeper waters were predominantly mud (Brambati *et al.* 1991). Average surface water temperature ranges between 4.2 and 9.8 ºC in winter and summer, respectively, and salinity varies from 26.7 psu in November to 31.3 psu during July[1].

Sampling

During 1999 and 2000, epibenthic samples were taken seasonally at three areas: Bahía Lapatia, Bahía Ushuaia and Punta Segunda (Fig. 1). These three areas are rather different and they were categorized by their oceanographic characteristics. Bahía Lapataia has estuarine characteristics since it is a paleo-fjord with an important inflow of freshwater and limited

[1] Balestrini, C., G. Manzella & G.A. Lovrich 1998. Simulación de corrientes en el canal Beagle y Bahía Ushuaia, mediante un modelo bidimensional, Inf. Téc. Nº 98 Servicio de Hidrografía Naval 1-58.

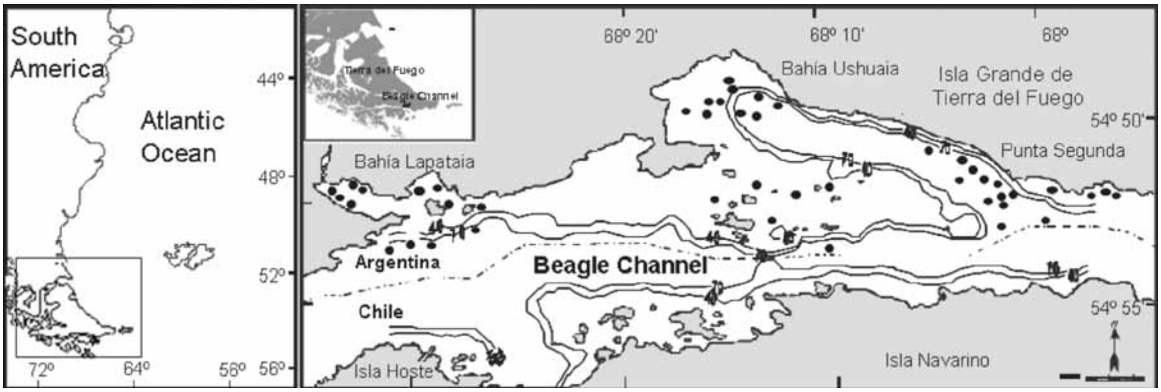

Fig. 1: Position of sampling sites for study of the macrozoobenthos in the Beagle Channel, Argentina. Both 40m and 70m isobaths are indicated.

water exchange with the rest of the Beagle Channel due to the presence of a submerged frontal moraine (Isla *et al.* 1999). In contrast, Punta Segunda is an area where the channel narrows and is characterized by strong water currents[2], whereas Bahía Ushuaia is dominated by shallow waters of *ca.* 30 m depth[2] and islands surrounded by kelp forests of *Macrocystis pyrifera* Linnaeus, 1781. At the three areas, samples were taken at two depth ranges (15–40 m and 70–259 m). These two strata were selected on the basis of the presence and absence of the kelp forest *M. pyrifera* since ~40 m isobath represents its deepest bathymetric distribution (Kühneman 1970). The portion of bottom between 40 and 70 m depth represents ~10% of the Beagle Channel[2], hence, samples in this depth strata were not taken.

A total of 45 epibenthic samples, 23 at 15–40 m (12 and 11 in 1999 and 2000, respectively) and 22 at 70–259 m (12 in 1999 and 10 in 2000) were obtained in the sampling areas with a “Rauschert” dredge of 0.5 m mouth width, with a mesh size of 1 mm. To avoid large objects damaging the small macrobenthic fauna, two other inner nets (5 and 10 mm mesh size) were used. Tows were carried out during daylight at a speed of 0.4–0.7 $m \bullet s^{-1}$ for 5–15 min. Initial and final geographic positions of each tow were recorded with a GPS. Depth of each tow was recorded with a portable echo-sounder. In the laboratory, all samples were sifted with a 0.75 mm sieve, fixed in 4% buffered formaline seawater for 48 h and preserved in 70% ethanol. Samples were identified and sorted to Phylum, Class and Order under stereoscopic microscope.

Abundance and biomass

Tow distance (TD) over the bottom was estimated as the difference between the initial and end boat positions of each tow once the net was on the sea bottom, using the following equation:

$$TD\,(m) = \sqrt{\left[\left(lat_i - lat_f\right)^2 + \left(\left(long_i - long_f\right)\cos\left(\frac{lat_i - lat_f}{2}\right)\right)^2\right]}$$

Sampled sea bottom surfaces were calculated using the tow distance and the trawl width. Abundance and biomass of invertebrates were estimated as number and wet mass of individuals per 10,000 m^2, respectively. In addition, relative abundance (RA) and relative biomass (RB) were calculated as:

$$RA or\ RB = (Wi / Wt) \bullet 100$$

where *Wi* is the number or wet mass of the *i* taxon and *Wt* is the total number or wet mass in each sample. Colonial specimens were considered as being present for the calculation of the abundance values. In order to obtain production estimates, biomass values were converted to g C_{org} and kJoules using taxon-specific conversion factors[3].

2 Servicio de Hidrografía Naval, Archipiélago Fueguino, Islas Malvinas, Derrotero Argentino, Suppl. 1, Parte III, third edition, Buenos Aires, 1981

3 Brey, T. 2001. Population Dynamics in Benthic Invertebrates – A virtual handbook- http://www.thomasbrey.de/science/virtualhandbook/ Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

Secondary production and annual production / biomass (P/B ratio)

The P/B ratio for each taxonomic group was estimated using Artificial Neural Networks (ANN) (Brey *et al.* 1996). ANN is a specific multivariate non-linear approach which estimates annual population P/B ratio from both abiotic and biotic parameters (Brey *et al.* 1996). Annual production was calculated as the ratio P/B values multiplied by the population biomass[3]. Taxonomic groups were used as population units and the community production at each depth strata was estimated as the sum of these values (Brey & Gerdes 1998).

Statistical analysis

Multivariate analysis using PRIMER software was performed (Clarke 1993, Clarke & Warwick 2001). Similarities and differences in epibenthic macrofaunal communities based on taxa abundance (excluding sessile and colonial) and taxa biomass were explored using Non-metric Multidimensional Scaling (MDS) and Analyses of Similarity (ANOSIM), using

TABLE 1. Benthic invertebrate taxa sampled in the Beagle Channel. The relative proportions are percentages of each taxa in relation to the total number or grams of invertebrates collected. A: abundance. B: biomass. The frequency of occurrence is the proportion of samples where each taxa occurred. Taxa quantified only in terms of biomass were denoted by asterisks.

Taxa	Relative proportion (%)		Frequency of occurrence	Abundance ± SD (ind.• 10,000 m-2)		Biomass ± SD (g • 10,000 m-2)	
	A	B		<40 m	>70 m	<40 m	>70 m
Porifera *		14	40	-	-	630.2 ± 1360.3	1.4 ± 4.7
Hydrozoa *		<1	15	-	-	5.4 ± 15.6	1.5 ± 7.3
Anthozoa	<<1	<1	2	2.8 ± 13.7	0	14.2 ± 68.1	0
Nemertea	2.3	<1	55	1883.1 ± 4336.3	483.4 ± 885.4	0.2 ± 0.7	4.9 ± 20.5
Nematoda	17.3	<<1	44	11364 ± 25989.7	4462.8 ± 10014.1	1.8 ± 5.4	0.4 ± 0.7
Kinorhyncha	<<1	<<1	2	0	2.1 ± 6.2	0	<<1
Sipuncula	<1	<<1	42	182 ± 319.4	315.2 ± 1134.2	0.4 ± 0.5	0.6 ± 2.3
Priapulida	<<1	<<1	2	5 ± 24.2	0	<<1	0
Echiura	<<1	<<1	4	17.5 ± 67.2	14.8 ± 46.1	<<1	<<1
Polyplacophora	1.4	1.2	69	1173.5 ± 2099	42.4 ± 88.5	53.5 ± 201	0.9 ± 2.4
Aplacophora	<1	<1	15	90.3 ± 220.2	213.4 ± 654.5	10 ± 47.5	0.6 ± 1.7
Gastropoda	10.5	4.8	78	9154.2 ± 16334.2	194.4 ± 231.6	215.5 ± 663.2	1.6 ± 2.8
Bivalvia	25.4	6.6	98	18808.6 ± 22668.5	5138.4 ± 8856.5	142.2 ± 286.3	180.5 ± 249.4
Scaphopoda	<1	<1	20	40.9 ± 196.1	482.2 ± 705	<<1	6.2 ± 20.2
Polychaeta	21	5	100	13501.2 ± 17703.8	7112.8 ± 12820.7	219 ± 455.6	19.3 ± 31.2
Oligochaeta	<1	<<1	11	667.2 ± 1689.6	39 ± 138.6	0.5 ± 2.4	0.1 ± 0.5
Pycnogonida	<1	<<1	29	257 ± 389.2	13.7 ± 49.7	0.3 ± 0.5	<<1
Acari	<1	<<1	18	139.5 ± 329.2	1.3 ± 6.2	<<1	<<1
Ostracoda	1.6	<<1	40	1487.7 ± 2504.2	44 ± 80.6	0.7 ± 2.7	0.3 ± 0.8
Harpacticoidea	2.5	<<1	38	2316.1 ± 7000	92 ± 189.8	0.1 ± 0.3	0.2 ± 0.4
Cirripedia	<1	6.8	33	497 ± 816.2	4.1 ± 19.5	297.3 ± 1134	<<1
Euphausiacea	<1	<<1	13	15 ± 72	80.3 ± 221.8	0.1 ± 0.7	1.2 ± 3.4
Decapoda	1.8	17.6	89	941.5 ± 601.2	748.8 ± 908.3	809.8 ± 1370.3	41.7 ± 81.2
Amphipoda	4.9	1	100	3476 ± 3015.6	1186 ± 941.4	32.3 ± 47.7	12 ± 21.3
Isopoda	3.2	<<1	62	2761.3 ± 4569.6	206.2 ± 275.5	3.1 ± 7.2	0.5 ± 1
Cumacea	1	<1	53	321 ± 765	644 .3 ± 699	2.6 ± 12.3	5.8 ± 20.1
Tanaidacea	<1	<<1	37	268.1 ± 385.5	71.2 ± 141.4	0.1 ± 0.3	0.1 ± 0.2
Brachiopoda	1	2	37	765.8 ± 1351.7	64.7 ± 303.7	70.1 ± 178.1	1.2 ± 5.9
Bryozoa *		6.3	55	-	-	186.5 ± 538.7	105.8 ± 342.2
Asteroidea	<1	31.3	42	136.3 ± 303.7	88.7 ± 216	1416.2 ± 3264.4	67 ± 238.1
Ophiuroidea	2	1	71	1646.8 ± 2620.7	152.6 ± 325.7	44.5 ± 64.5	2.7 ± 8
Echinoidea	<1	1	51	503.7 ± 913.8	12.4 ± 22.4	25.5 ± 53.7	15.6 ± 73
Holothuroidea	<<1	<1	24	28.1 ± 83.2	30.3 ± 76.8	2.7 ± 11	33 ± 134.7
Tunicata *		<<1	11	-	-	1.8 ± 5	<<1

Bray–Curtis similarity index (values were transformed to square root when necessary) (Clarke 1993). Similarity percentages tests (SIMPER) were developed to determine similarities between sampling areas, depth ranges and benthic assemblages. According to SIMPER results, taxonomic groups with values >5% were used to test for difference in abundance and biomass with depth and sampling areas.

Correlations between number of taxa and abundance/biomass were done. The null hypothesis of no difference in both taxa abundance and biomass between depth strata in each area (per year) was assessed using a one-way ANOVAs test (Sokal & Rohlf 1995). Assumptions of normality and homoscedasticity were previously tested with a Kolmogorov-Smirnov and Bartlett´s test, respectively (Sokal & Rohlf 1995). A one-way ANOVA was used to identify seasonal fluctuations in secondary production. When significant differences were found, post hoc comparisons were made (Sokal & Rohlf 1995). Abundance, biomass and secondary production values were transformed to $\log_{10}$ (x + 1), to fulfil the assumptions of the model (Sokal & Rohlf 1995).

RESULTS

A total of 32686 specimens of macrobenthic invertebrates distributed in 30 taxonomic groups were collected in the Beagle Channel. In addition, 4 taxa were only quantified in terms of biomass (Table 1). Number of taxa in each sample varied between 6 and 22, and was positively correlated with abundance and biomass of invertebrates in each sample (r= 0.58, p= 0.003; and r= 0.4, p= 0.04, respectively).

The macrobenthic community structure differed among sampling areas, years and depth ranges. ANOSIM for sampling areas showed significant differences for taxa abundance (global R= 0.354, P= 0.03; global R= 0.57, P= 0.01; 1999 and 2000 respectively) but not in biomass (global R= 0.024, P= 0.3; global R= 0.083 P= 0.2; 1999 and 2000 respectively) at 15–40 m depth.

Taking into account the abundance of taxonomic groups found (excluding sessile and colonial taxa) Bahía Lapataia differed significantly from Punta Segunda in both years ($R_{statistic}$= 0.844 and 0.907 for 1999 and 2000, respectively). MDS in both years showed that samples of Bahía Lapataia and Punta Segunda represent different groups whereas samples of Bahía Ushuaia suggested a mixed area (Fig. 2). Taxa responsible for differences in 1999 were mainly Bivalvia and Polychaeta, which contributed to 50% of the samples, whereas Gastropoda, Nemertea, Nematoda and Copepoda were about 25% altogether. In 2000, the dissimilarity was due to Polychaeta and Nematoda, which contributed to 50% of the samples, followed by Bivalvia, Gastropoda and Isopoda.

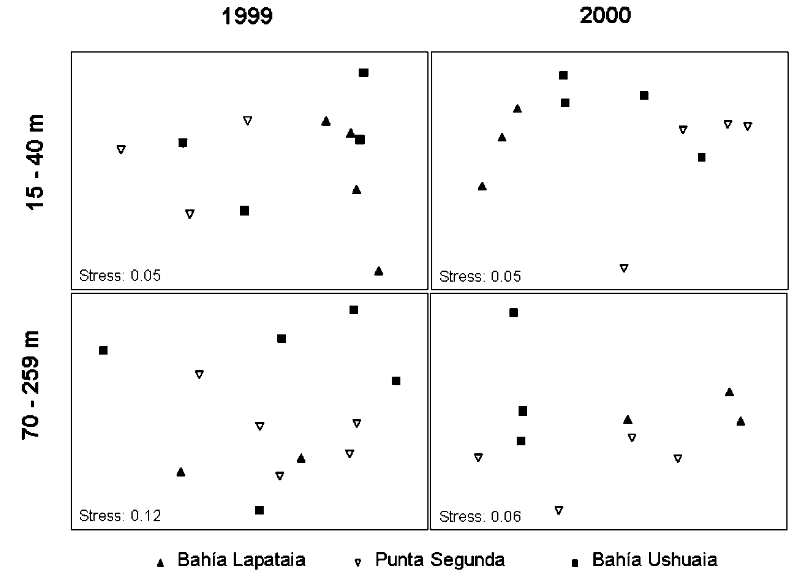

Fig. 2: MDS ordination plots of the two study years and two depth strata using data of abundance. Squares correspond to Bahía Ushuaia stations black and white triangles correspond to Bahía Lapataia and Punta Segunda stations.

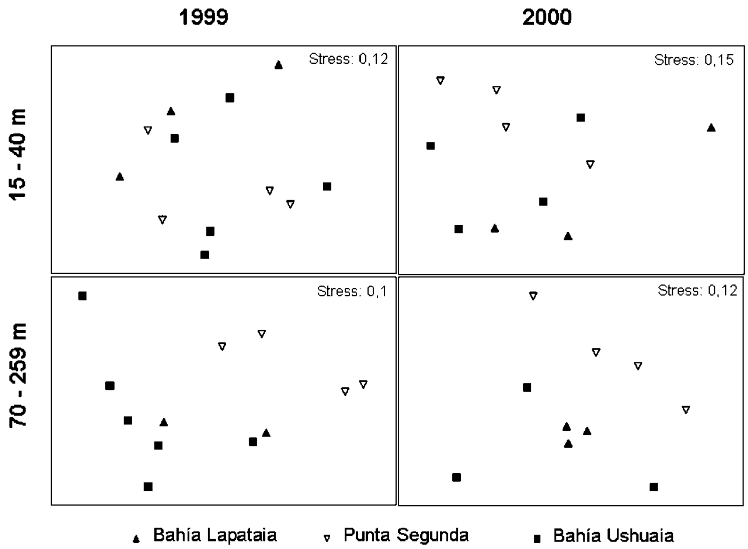

Fig. 3: MDS ordination plots of the two study years and two depth strata using data of biomass. Squares correspond to Bahía Ushuaia stations black and white triangles correspond to Bahía Lapataia and Punta Segunda stations.

In terms of biomass, Bahía Lapataia was significantly different from Punta Segunda and Bahía Ushuaia in 1999 ($R_{statistic}$= 0.333 and 0.087, respectively), whereas, during 2000, Bahía Lapataia differed significantly only with Punta Segunda ($R_{statistic}$= 0.278). Results from MDS in both years showed that samples of Bahía Lapataia were separated, but those of Punta Segunda and Bahía Ushuaia were mixed (Fig. 3). In both years at 15–40 m depth, Bahía Lapataia differed significantly from Punta Segunda ($R_{statistics}$= 0.844 and 0.907, for 1999 and 2000, respectively).

TABLE 2. SIMPER analysis of invertebrates contributions (>5 %) at each area and depth range according to taxa abundance and biomass during the study period.

	Abundance												Biomass											
	Bahia Lapataia				Bahia Ushuaia				Punta Segunda				Bahia Lapataia				Bahia Ushuaia				Punta Segunda			
	15-40 m		70-259 m		15-40 m		70-259 m		15-40 m		70-259 m		15-40 m		70-259 m		15-40 m		70-259 m		15-40 m		70-259 m	
Taxa	99	00	99	00	99	00	99	00	99	00	99	00	99	00	99	00	99	00	99	00	99	00	99	00
Porifera													64.3											
Nematoda				43.4		12.6	12.3			17.0														
Polychaeta	18.4	16.6	9.7	23.2	31.5	22.5	25.8	24.8	13.4	38.8	28.1	31.3			61.6	8.9	5.0			20.2		8.9	14.4	7.0
Bivalvia	16.1	26.0	22.2	21.4	22.9	8.5	20.2	38.4	50.1	22.1		13.4		5.5		75.0	27.6		89.0	29.9	13.2	5.5		33.4
Gastropoda	11.9	19.4			6.9	17.2			8.4	7.1				7.2				9.4						
Polyplacophora																							5.9	
Cirripedia	6.2																	12.1						32.9
Decapoda	14.4	9.4	8.8		7.7		5.1	8.7			9.2	16.8	28.8	6.1	9.7		33.6	57.2		8.29	10.3	19.8	45.6	
Amphipoda	19.9	14.9	21.3	5.2	14.0	15.1	20.7	16.7	7.9		25.1	16.6			16.3				5.3	13.2			15.6	
Isopoda							5.8			5.7														
Cumacea			7.9								21.1	16.3											10.5	
Asteroidea																6.9					52.9	56.9		17.7
Ophiuroidea						11.2											25.2	7.3						
Sipuncula			18.6												5.5									
Bryozoa																				25.7				
Nemertea			5.3		8.7						8.3													
Oligochaeta		7.5																						

In regard to depth ranges along the sampling areas, differences were significant for abundance of taxa (global R= 0.334, P= 0.002; global R= 0.25, P= 0.009; for 1999 and 2000, respectively) and biomass (global R= 0.35, P= 0.001; global R= 0.621, P= 0.001; for 1999 and 2000, respectively). SIMPER procedure showed that Bivalvia and Polychaeta contributed most to abundance differences with depth in 1999; and Polychaeta, Nematoda, Bivalvia and Gastropoda in 2000 (Table 2). SIMPER also revealed that differences in biomass with depth were due to Asteroidea, Decapoda, Porifera and Bivalvia in 1999 and Asteroidea, Decapoda and Porifera in 2000.

In Punta Segunda, average abundance of Bivalvia, Polychaeta and Amphipoda represented significant differences between both depth ranges during 1999 (ANOVA, F= 30.82, p< 0.001; F= 7.761, p= 0.03 and F= 7.783, p= 0.03 respectively). In 2000, Bivalvia and Polychaeta were more abundant in 15–40 m depth strata (ANOVA, F= 11.177, p= 0.01 and F= 7.290, p= 0.03; respectively). In Bahía Ushuaia, only Amphipoda showed significant differences for the same year (ANOVA, F= 8.172, p< 0.05). In Bahía Lapataia, no differences were detected in abundance in 1999; however, Nematoda mean abundance was different between depth ranges in 2000 (ANOVA, F= 15.440, p= 0.01) (Fig. 4). In Punta Segunda, Polychaeta was the only taxa that showed significant differences in biomass between depths, and was more abundant at 15–40 m in 1999 (F= 7.47, p= 0.03). However, in Bahía Ushuaia and Bahía Lapataia, significant differences in biomass of dominant taxa were not observed in either year (Fig. 5).

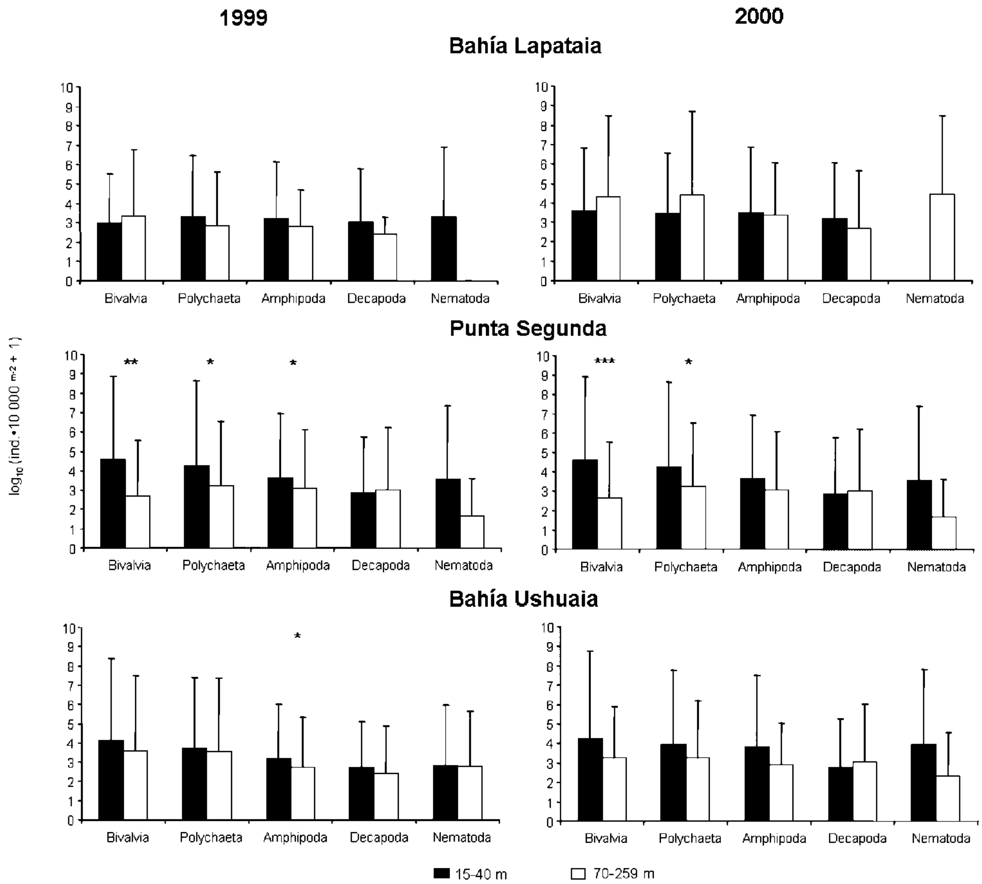

Fig. 4: Mean abundance ± standard deviation of dominant benthic invertebrate taxa at two depths, in two years and three sampling locations in the Beagle Channel. Asteriks above bars indicate indicate significant differences. * p< 0.05, ** p< 0.01, *** p< 0.001.

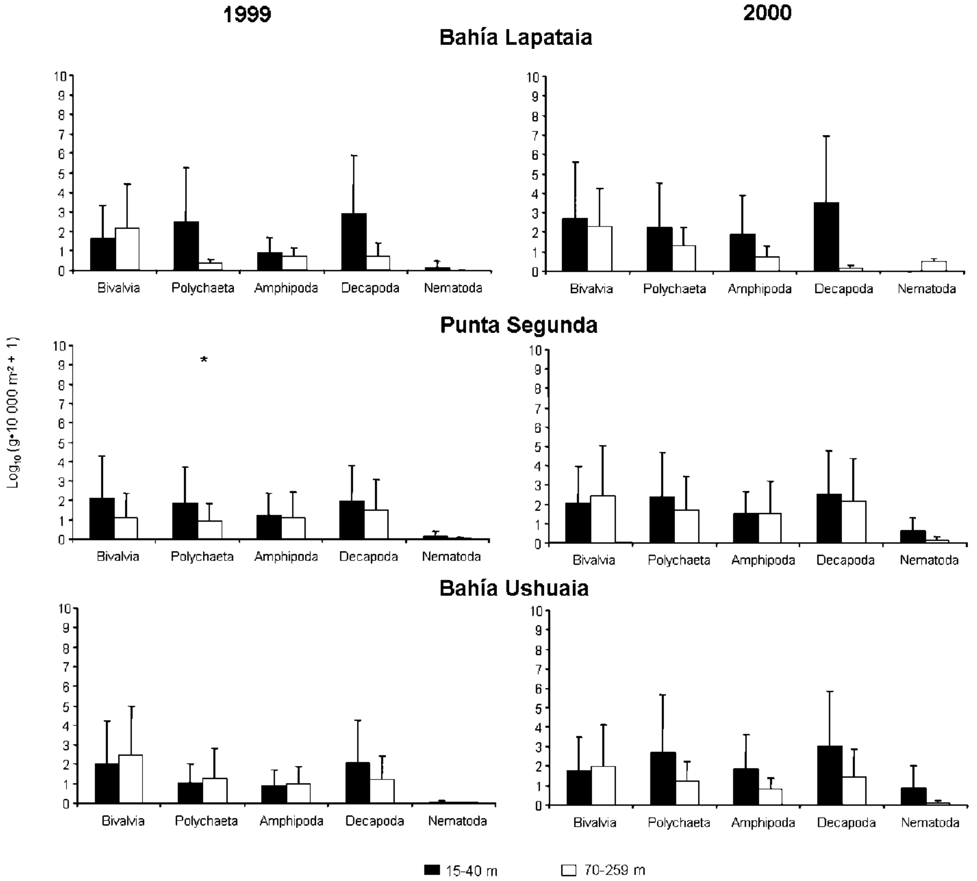

Fig. 5: Mean biomass ± standard deviation of dominant benthic invertebrate taxa at two depths, in two years and three sampling locations in the Beagle Channel. Asteriks above bars indicate indicate significant differences. * $p< 0.05$.

Seven taxa were responsible for 86% of community production: Decapoda, Polychaeta, Asteroidea, Gastropoda, Bivalvia, Porifera and Amphipoda. The secondary production varied between 0.004 and 1.76 $kJ{\cdot}m^{-2}{\cdot}$ $year^{-1}$, and was negatively correlated with depth ($r= -0.31$, $p< 0.001$). Particularly, the mean production at 15–40 m was 0.59 ±0.51 $kJ{\cdot}m^{-2}year^{-1}$, whereas at 70–259 m this value decreased to 0.09 ±0.08 $kJ{\cdot}m^{-2}year^{-1}$. In contrast to secondary production, P/B ratio showed a positive correlation with depth ($r= 0.33$, $p< 0.05$) with mean values of 0.51 $year^{-1}$ and 0.76 $year^{-1}$ at 15–40 m and 70–259 m, respectively. The energy flow at 15–40 m was dominated by Decapoda (20% of biomass, 38% of production), whereas in deeper waters the most productive groups were Bivalvia (35% biomass, 24% production) and Decapoda (10% biomass, 23% production) (Fig. 6). The secondary production of macrobenthic invertebrates from the Beagle Channel was similar among seasons in 1999 and 2000 at 15–40 m (ANOVA; $F= 1.26$; $p> 0.05$ and $F= 0.06$; $p> 0.05$; respectively) (Fig. 6) and at 70–259 m (ANOVA; $F= 0.75$; $p> 0.05$ and $F= 0.07$; $p> 0.05$; respectively) (Fig. 7).

DISCUSSION

Results presented in this article constitute the first data that describe temporally and bathymetric variations on the macrozoobenthos of the Beagle Channel at the community level. In consequence, this study gives information about composition, abundance, biomass and secondary production of dominat taxa of macrobenthic invertebrates and their spatio-temporal variations.

The higher abundance and biomass of the invertebrate species in shallow waters observed in

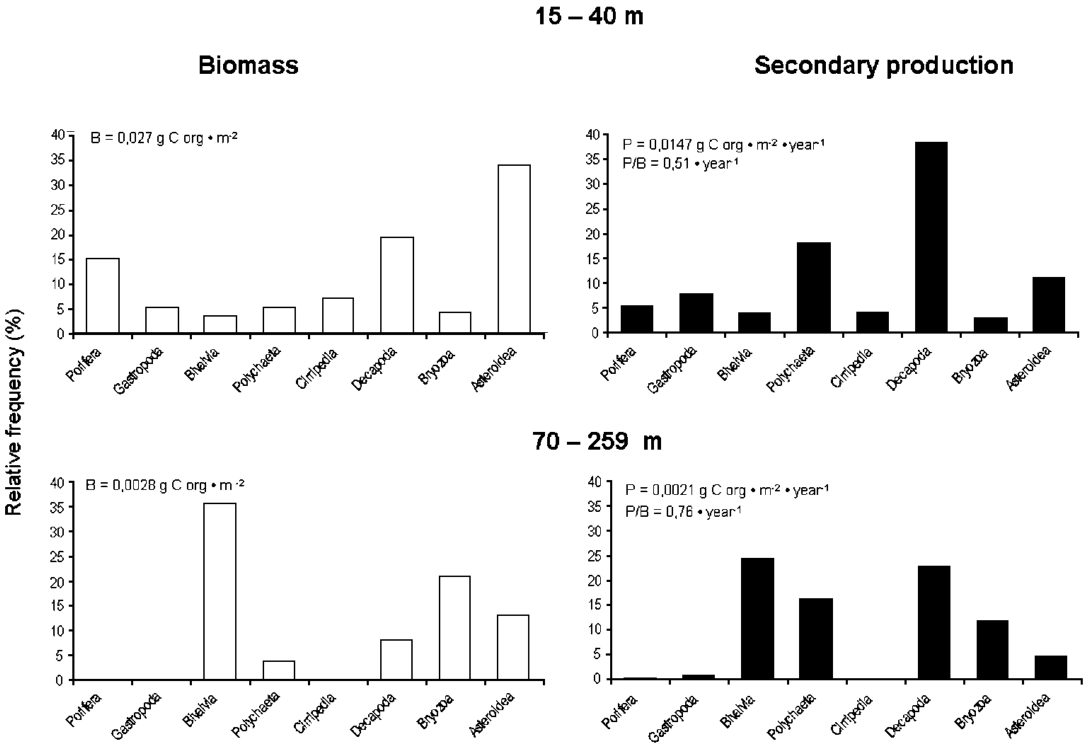

Fig. 6: Biomass and secondary production of macrozoobenthos at two depth strata of the Beagle Channel. Histograms indicate distribution of biomass and production between taxonomic groups.

this study is associated with the complex and tri-dimensional structure of the Beagle Channel bottom until ~40 m depth. Shallow waters of the Beagle Channel are dominated by the kelp *Macrocystis pyrifera* and polychaete-tubes *Chaetopterus varipedatus* Renier 1804. Both species occur in higher densities at 15–40 m depth and their morphological characteristics confer a tri-dimensional structure to the bottom providing diverse habitats and shelters for benthic invertebrates. This distribution pattern seems to be a feature in the Magellanic region since it also has been observed in the Magellan Strait located northern of the Beagle Channel (Gutt *et al.* 1995, Ríos *et al.* 2007). In addition, sediment type varies with depth in this area; thick with shell fragments in shallow waters transitioning to mud at deeper waters (Brambati *et al.* 1991). Thus, substrate type may be a very important variable associated with depth and could play a key role in benthic invertebrate assemblage structure in the Beagle Channel.

In our study area, Punta Segunda and Bahía Lapataia constitute two extremes of benthic

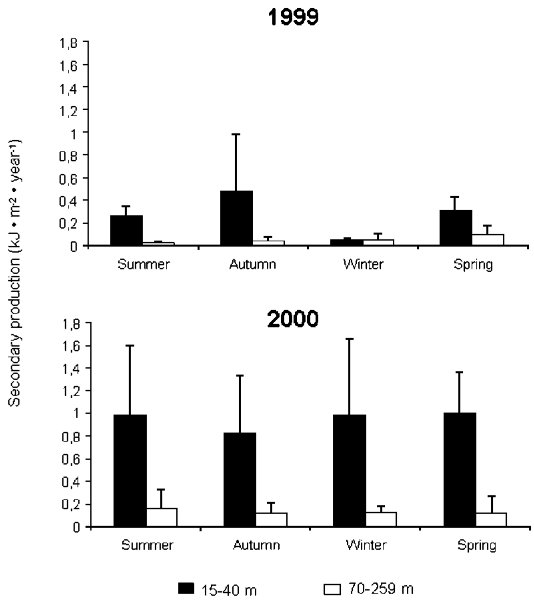

Fig. 7: Seasonal fluctuations of secondary production of the macrozoobenthos in the Beagle Channel at two depths in two consecutive years.

macroinvertebrates abundance, whereas Bahía Ushuaia presents intermediate conditions between these extremes. This pattern corresponds with the geographic location of these areas; Bahía Ushuaia is located between Punta Segunda and Bahía Lapataia. Thus, composition, abundance and biomass of macrobenthic assemblages in each area could be related with their own environmental and geomorphological features (see Material and Methods).

There are many theories that explain how environmental factors determine the structure of macroinvertebrate assemblages in the Southern Ocean. In waters of the South Shetland Islands, depth or its related factors, play an important role in structuring community biomass (Sáiz-Salinas *et al.* 1997). In the South Greenwich Islands changes in small-scale habitat heterogeneity were associated with both depth and benthic assemblages (Gallardo *et al.* 1977). In waters of the Scotia Arc, environmental variables such as temperature, salinity, macroalgae detritus and disturbance levels change together with depth (Barnes 2005).

The available information at the specific level of fauna in the macrobenthic communities in the Magellan region is poor. Nevertheless, the use of several taxonomic levels allowed us to compare our results with data obtained in both sub-Antarctic (Ramos 1999, Gerdes & Montiel 1999, Thatje & Mutschke 1999) and Antarctic studies (Jazdzewski *et al.* 1986, Sáiz-Salinas *et al.* 1997, Gerdes y Montiel 1999, Piepenburg *et al.* 2002). In terms of abundance, Polychaeta and Bivalvia occur as dominant groups in both regions. Particularly, Polychaeta present the highest abundance in Antarctic and sub-Antarctic waters (Jazdzewski *et al.* 1986, Gerdes & Montiel 1999, Thatje & Mutschke 1999, Piepenburg *et al.* 2002), except for the South Orkney and South Sandwich islands (Ramos 1999). In terms of biomass, Decapoda was one of the dominant taxa. However, in the present study the abundance and biomass of Decapoda could have been underestimated, *e.g. Munida* gregaria Fabricius 1793 (=*M. subrugosa*) are decapod species that have been estimated to constitute 50% of benthic biomass in the Beagle Channel[4] but were poorly represented in our study. Other abundant groups in the area such as lithodids (Lovrich 1997) were captured in low proportions. Observations with submarine video cameras showed that these organisms could detect the dredge and actively escape (Tapella pers. obs.).

Indeed, the abundance and biomass values found at the study area were lower than those reported for other sites of the Magellan region (Gerdes & Montiel 1999, Thatje & Mutschke 1999). These lower values could be related to the sort of dredge used in sampling. The Rauschert dredge is equipped to exclude large items (Rhem *et al.* 2006, Rhem *et al.* 2007). Thus, the selectivity and the epibenthic nature of the dredge could explain differences with other studies that used different dredges such as Agassiz trawls. Nevertheless, the Rauschert dredge collects samples from a vast surface compared with others sample devices, which is necessary in primary studies to give insight into the community structure.

The secondary production for the Beagle Channel was lower than in other areas of the Magellan region (Brey & Gerdes 1999, Thatje & Mutschke 1999). However, this finding may be the result of different sampling techniques. P/B ratio increases with depth as much in Antarctic (Brey & Gerdes 1998) as in the Beagle Channel, but the latter is more productive in terms of P/B (0.54 $year^{-1}$) than the Weddell Sea (0.18 $year^{-1}$) (Brey & Gerdes 1998). In this context, significant seasonal variation in secondary production of the macrozoobentos was not found. This finding is not related to the seasonality of primary production in the region[5]. An alternative explanation for this data could be that the organic matter deposited during the summer may provide a food source for benthic organisms during winter months when primary production is low (Thomas *et al.* 2008) thus keeping secondary production levels relatively constant.

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