Quantitative analysis of soft-bottom molluscs in the Bellingshausen Sea and around Peter I Island

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Keywords
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Abstract

Macrobenthic soft-bottom molluscs were sampled in 30 stations located in the Bellingshausen Sea at depths ranging from 90 to 3304 m. The samples were collected using a quantitative grab box-corer during the cruises BENTART 03, from 24 January to 3 March 2003, and BENTART 06, from 2 January to 16 February 2006. Molluscs represent 1074 specimens belonging to 62 species of Polyplacophora, Gastropoda, Bivalvia and Scaphopoda. The bivalve *Cyamiocardium denticulatum* was the most abundant species (448 specimens). The abundance per station varied between 1 and 446 specimens. The Shannon–Wiener diversity index ranged between one specimen and 2.36, the Pielou evenness index ranged between 0.00 and 1 and species richness ranged from 1 to 14 species. Diversity showed great variations at different stations. After multivariate analysis (cluster analysis and nonmetrical multidimensional scaling) based on Bray–Curtis similarities, we were able to separate two principal clusters. The first cluster groups together species from shallower bottoms near Peter I Island and the Antarctic Peninsula, and the second cluster groups together species from deeper bottoms in the Bellingshausen Sea. The combination of environmental variables with the highest correlations with faunistic data was that of depth and coarse sand at the surface.

Information about the benthic macrofauna of the Bellingshausen Sea and Peter I Øy (Peter I Island) was scarce. To date, approximately 895 species of gastropods and 379 species of bivalves are known from the Southern Ocean and adjacent regions (Linse et al. 2006); Clarke et al. (2004) mentioned approximately 530 species of gastropods and 110 of bivalves found exclusively in the Southern Ocean. Only three families and 11 species were recorded in the Bellingshausen Sea, and two families and three species were recorded at Peter I Øy. This apparently low number of species is the result of poor sampling of this area: two samples on the continental shelf (1–1000 m), none on the continental slope (1000–3000 m) and six deeper (>3000 m) have been obtained in the Bellingshausen and Amundsen seas out of 1490, 98 and 36 respective samples performed in these three zones in the whole Southern Ocean (Clarke et al. 2004).

The BENTART 03 (from 24 January to 3 March 2003) and BENTART 06 (from 2 January to 17 February 2006) research programs were carried out on board the RV *Hesperides* in the Bellingshausen Sea and off Peter I Øy. Benthic molluscs have a particularly wide ecological and ethological spectrum. So the assessment and analysis of their assemblages is likely to contribute to a better understanding of the structure and interactions inside the more complex benthic assemblages in which they live and interact.

As an integrated study of the benthic ecosystem, the BENTART programme is a good opportunity for analysing malacological assemblages. On the basis of the data obtained during this survey, we try to answer the following questions. Is the molluscan fauna really poor in the Bellingshausen Sea and nearby areas? How many molluscan assemblages are living there? What are their species diversity and dominant species? What are their ecological characteristics or requirements?

Material and methods

Study area

During the research cruises BENTART 03 (January–February 2003) and BENTART 06 (January–February 2006) molluscs were collected, together with other benthic invertebrates, at 40 stations in the Bellingshausen Sea, from the Antarctic Peninsula to Thurston Island on the border of the Amundsen Sea (Fig. 1), at depths ranging from 90 to 3304 m (Table 1). Because of the weather conditions (big waves, heavy winds) the box-corer cannot work in all sampling stations, and for this reason only 30 stations were sampled and used in the present quantitative studies.

Sample collection

In each station, the samples were collected using a quantitative grab box-corer (BC) with a maximum break-through of 60 cm and an effective surface of sampling of 25 × 25 cm. Four samples were taken in each station. The first BC was used immediately after sampling to measure temperature, pH and redox (Eh) at 6 and 25 cm below the surface of the sediment, and was subsampled later in the laboratory to analyse the sediment grain size, level of carbonates and content of organic matter. The three replica BC remaining were used to obtain the fauna. The content of each replica was sieved using three mesh sizes (5, 1 and 0.5 mm). The molluscan groups retained in the two largest sieves were counted to estimate their relative abundance in the total macrobenthic fauna. Afterwards, the material was fixed in formalin and preserved in 70% ethanol for further taxonomic study.

Using the superficial layer of sediment, the following percentages of granulometric fractions were recorded: coarse sand, medium sand, fine sand and mud. Carbonate content (%) was measured by treatment of the sample with hydrochloric acid, and the total organic matter content (OM%) was estimated from the weight loss of the samples after 4 h at 450°C in an oven.

Data analysis

Data were organized into station by species matrices. Univariate measures were calculated for each sampling

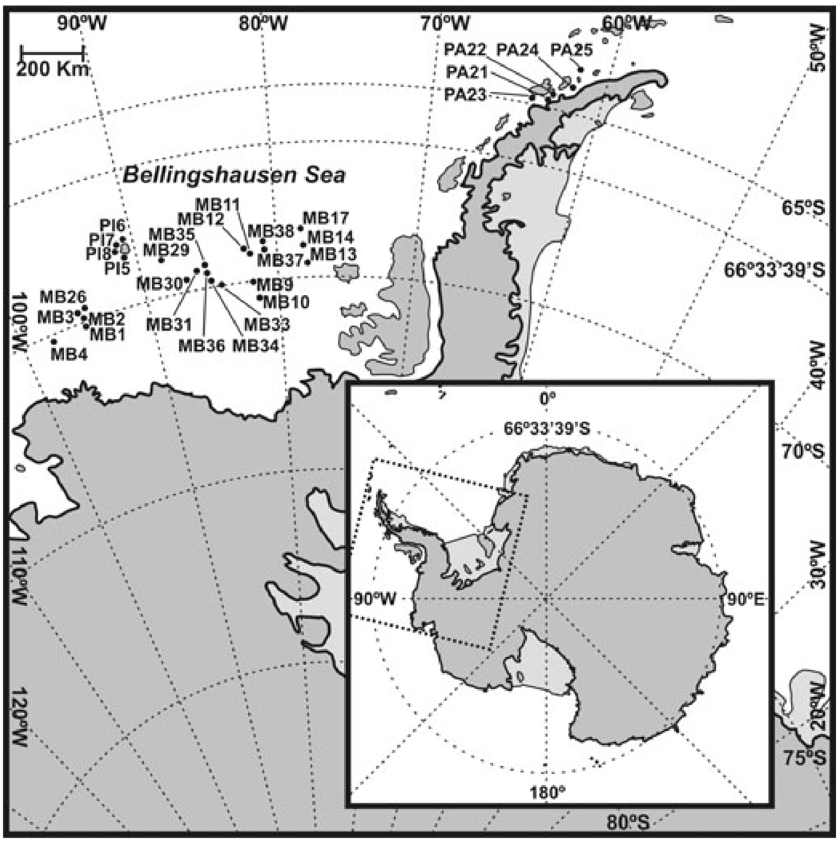

Fig. 1 Study area and benthic sampling stations during the BENTART cruises in 2003 and 2006.

Table 1 Location, depth and environmental parameters at the surface of sediments of survey stations: redox potential (mV), organic matter (OM%), carbonates (%), gravel (% > 2 mm), coarse sand (% > 0.5 mm), medium sand (% > 0.25 mm), fine sand (% > 0.0625 mm) and mud (% < 0.0625 mm).

Station	Latitude S	Longitude W	Depth (m)	Redox	OM	Carbonates	Gravel	Coarse sand	Medium sand	Fine sand	Mud
MB1 (2003)	70°38.22′	95°15.36′	534	252.2	4.81	n.d.	14.30	7.90	7.50	19.10	51.20
MB2 (2003)	70°29.25′	95°14.83′	780	289.3	5.02	n.d.	81.40	1.80	1.10	4.20	11.50
MB3 (2003)	70°17.58′	95°11.86′	1431	259.8	5.42	n.d.	29.00	4.30	3.40	30.50	32.80
MB4 (2003)	70°52.86′	98°26.12′	425	271.3	4.56	n.d.	31.00	9.60	5.40	16.40	37.60
PI 5 (2003)	68°56.70′	90°35.70′	126	199.3	1.43	n.d.	0.14	0.14	0.32	19.50	79.90
PI 6 (2003)	68°49.61′	90°48.78′	210	122.5	1.35	n.d.	0.00	0.10	0.10	21.00	78.80
PI 7 (2003)	68°42.20′	90°40.80′	410	174.8	1.85	n.d.	0.00	0.20	0.20	6.10	93.50
PI 8 (2003)	68°50.18′	90°51.08′	90	155.8	1.23	n.d.	0.10	0.80	4.90	58.90	35.30
MB9 (2003)	70°14.40′	81°47.03′	532	261.8	5.96	n.d.	3.90	6.10	4.40	12.40	73.20
MB10 (2003)	70°44.31′	81°27.85′	497	260	4.05	n.d.	15.80	5.20	7.90	16.40	54.70
MB11 (2003)	69°27.07′	82°06.76′	1289	266	3.81	n.d.	22.40	8.50	3.70	10.60	54.80
MB12 (2003)	69°24.27′	82°11.88′	2032	261.5	5.29	n.d.	23.00	11.10	5.80	18.06	42.04
MB13 (2003)	69°49.56′	77°43.68′	605	240.5	4.64	n.d.	10.20	3.60	4.10	17.50	64.60
MB14 (2003)	69°21.12′	78°04.91′	498	n.d.	3.68	n.d.	34.70	5.10	3.80	11.70	44.70
MB17 (2003)	68°54.88′	78°14.16′	2044	224.7	1.98	n.d.	64.50	18.60	3.90	2.90	10.10
PA21 (2003)	64°54.01′	63°01.11′	107	133.5	2.49	n.d.	4.40	14.80	17.90	34.80	28.10
PA22 (2003)	64°50.58′	62°57.91′	294	137	6.40	n.d.	0.00	0.00	0.30	3.20	96.50
PA23 (2003)	64°55.95′	63°38.40′	655	272.5	6.75	n.d.	0.00	0.50	0.50	7.10	91.90
PA24 (2003)	64°20.11′	61°58.82′	1056	170.5	8.32	n.d.	0.00	0.24	0.23	1.53	98.00
PA25 (2003)	63°52.85′	61°48.52′	110	n.d.	1.16	n.d.	23.80	22.90	13.50	36.30	3.50
MB26 (2006)	70°14.62′	95°02.20′	1920	178.9	1.99	5.87	1.33	11.22	29.09	49.43	8.94
MB29 (2006)	69°26.08′	88°26.17′	3304	262.1	8.92	1.14	1.54	5.56	2.47	5.25	85.19
MB30 (2006)	69°58.98′	87°31.08′	1814	187.7	7.01	2.97	58.38	1.78	1.02	8.88	29.95
MB31 (2006)	69°56.98′	86°19.27′	1426	207.8	5.31	2.54	0.00	2.22	4.81	20.74	72.22
MB33 (2006)	70°15.90′	84°11.45′	438	290.2	4.02	1.38	20.11	12.99	8.86	26.32	31.72
MB34 (2006)	70°08.20′	84°51.68′	603	326	1.80	1.27	0.00	12.91	14.98	59.89	12.21
MB35 (2006)	69°56.03′	85°11.30′	1117	260.7	7.36	2.40	47.65	3.78	1.73	9.13	37.72
MB36 (2006)	69°56.28′	80°24.55′	560	289	8.51	0.47	33.15	1.08	1.08	3.96	60.72
MB37 (2006)	69°26.38′	80°51.62′	495	244	5.70	0.64	35.37	17.04	10.27	16.15	21.17
MB38 (2006)	69°14.08′	80°61.20′	1324	298.2	5.98	0.83	65.69	3.14	1.26	2.72	27.20

MB, Bellingshausen Sea; n.d., not determined; PA, Antarctic Peninsula; PI, Peter I Øy. BENTART 2003, January–February 2003; BENTART 2006, January–February 2006.

station: total abundance (N), number of species (S), the Shannon–Wiener diversity index (H', $\log_e$) and Pielou's evenness (J'). Molluscan assemblages were determined through non-parametric multivariate techniques as described by Field et al. (1982) using the PRIMER v5.0 (Plymouth Routines in Multivariate Ecological Research) software package (Clarke & Warwick 1994). A similarity matrix between sampling stations was constructed by means of the Bray–Curtis similarity coefficient by first applying fourth-root transformation on species abundance to downweight the contribution of the most abundant species. From this matrix, a classification of the stations was performed by cluster analysis based on the group-average sorting algorithm, as well as an ordination by means of nonmetrical multidimensional scaling (MDS). Possible differences in faunistic composition between the two major groups of stations were tested using a one-way ANOSIM test. The SIMPER program was then used to identify species that greatly contributed to the differentiation of station groups.

The BIO-ENV procedure was used to research the possible relationship between molluscan distributions in the Bellingshausen Sea and the measured environmental variables. The following variables were considered in this analysis: depth (m), redox (Eh), OM (%) and all granulometric fractions (%). Carbonates were discarded from the analysis because of the lack of such data from BENTART 03. All variables were previously transformed by $\log(x + 1)$.

Results

Abundance, number of species and diversity

A total of 1074 molluscan specimens were collected belonging to 62 species in four classes. The best-represented class, in terms of number of species, was Gastropoda (14 families and 33 species), followed by Bivalvia (15 families and 25 species), Scaphopoda (three families and three species) and Polyplacophora (one family and one species) (Table 2, Fig. 2). The bivalves *Thyasira bongraini* and *Cyamiocardium denticulatum* accounted for 60% of all molluscs.

The number of molluscs species per sampling site ranged from 1 to 14 (Table 3). Maximal abundances were found at sites PI5 (446) and PI8 (244), and the lowest were found at sites MB1, MB10, MB12 and MB17, with only one specimen in each. In MB26, MB29 and MB34, no molluscs species were obtained. The highest diversity was recorded at site PA21 ($H' = 2.36$) in contrast to that found at MB9 ($H' = 0.27$). J' is usually high in sampling sites, except in stations near Peter I Øy.

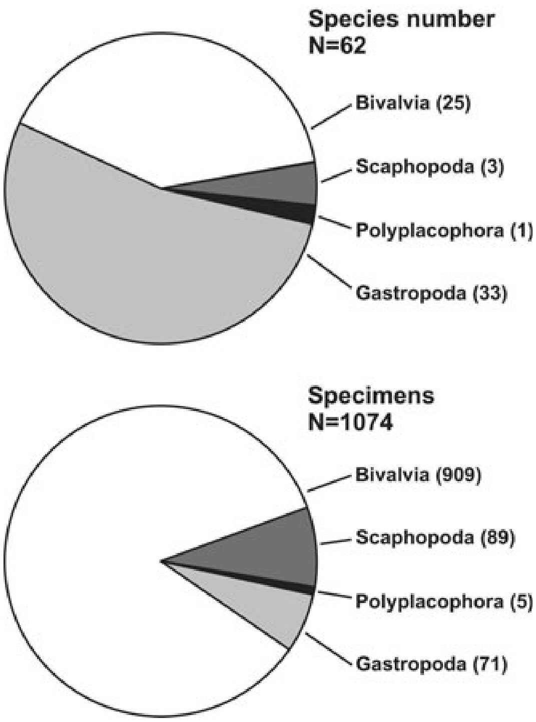

Fig. 2 Number of species and specimens of each molluscan class.

Molluscan assemblages

The cluster analysis (Fig. 3) showed the presence of major groups of sites at a similarity level of 20%: group A (six shallow-water stations, 90–410 m in depth, high % of mud and low values of OM) and group B (16 deep-water stations, 438–2044 m in depth, medium values of mud % and high OM). MDS ordination (Fig. 4) showed similar results to those of the dendrogram, with an acceptable stress value (0.05). Two major groups (A and B) are segregated from right to left, which can be identified as the depth gradient from shallow stations off Peter I Øy and the Antarctic Peninsula to deeper stations in the Bellingshausen Sea. The ANOSIM test showed significant differences on the faunistic composition between groups A and B according to the depth factor: shallow (group A) vs. deep (group B) stations (global $R = 0.571$, $p = 0.001$).

Results of the SIMPER analysis for the dissimilarity between groups are shown in Table 4. The bivalves *Thyasira bongraini*, *Cyamiocardium denticulatum*, *Cuspidaria infelix*, *Adacnarca nitens*, *Cyclocardia astartoides*, *Limopsis lilliei* and the scaphopod *Siphonodentalium dalli* f. *antarcticus* contributed greatly to the similarity (up to a cumulative 92%) in populations found for shallow-water stations of group A. The deeper-water of group B is mainly determined by *Dentalium majorinum*. The species that contribute most to the dissimilarity between the two groups according to ratio values were *T. bongraini*, *D. majorinum*, *C. infelix* and *C. denticulatum*.

Relationship between biotic and environmental variables

Sediments were predominantly mud, with relatively high contents of organic matter (Table 1). The superficial sediments appeared to be oxidized, as shown by redox (Eh) values of greater than 122.5 mV. Carbonate content was low in stations of BENTART 06 (MB26, 29, 30, 31, 33, 34,

Table 2 Systematic list of species found, indicating stations where these were collected.

Class/Family	Species	Station
POLYPLACOPHORA		
Leptochitonidae	*Leptochiton kerguelenensis* Haddon, 1886	MB11, MB14, MB17, PA23
GASTROPODA		
Anatomidae	*Anatoma euglypta* (Pelseneer, 1903)	MB31
Trochidae	*Antimargarita* sp.	MB37
	Calliotropis pelseneeri Cernohorsky, 1977	MB4
	Calliotropis sp.	MB30
	Margarella antarctica (Lamy, 1905)	PI8
	Solariella antarctica Powell, 1958	MB11
	Submargarita notalis (Strebel, 1908)	PA21

Table 2 *Continued*

Class/Family	Species	Station
Zerotulidae	*Dickdellia labioflecta* (Dell, 1990)	PA22
Eatoniellidae	*Eatoniella glacialis* (Smith, 1907)	PA21
Rissoidae	*Onoba gelida* (Smith, 1907)	PI8, PA21
	Onoba kergueleni (Smith, 1875)	PI8
Capulidae	*Torellia planispira* (Smith, 1915)	PA21
Naticidae	*Amauropsis anderssoni* (Strebel, 1906)	PA25
	Amauropsis aureolutea (Strebel, 1908)	MB11
	Falsilunatia delicatula (Smith, 1902)	PI5, PI8
Eulimidae	*Balcis antarctica* (Strebel, 1908)	MB13
Muricidae	*Trophon cuspidarioides* Powell, 1951	PI7
	Trophon drygalskii Thiele, 1912	MB31
	Trophon longstaffi Smith, 1907	PI5
Buccinidae	*Chlanidota signeyana* Powell, 1951	PI5, PI7, PA24
	Neobuccinum eatoni (Smith, 1875)	PI5
	Pareuthria regulus (Watson, 1882)	PI5
	Probuccinum costatum Thiele, 1912	PI7
	Prosipho chordatus (Strebel, 1908)	PI8
	Prosipho hedleyi Powell, 1958	PI8
Volutidae	*Harpovoluta charcoti* (Lamy, 1910)	PA23
Conidae	*Belaturricula gaini* (Lamy, 1910)	PA23
Turridae	*Leucosyrinx paratenoceras* Powell, 1951	MB36
	Lorabela sp.	PI5, PI8
	Pleurotomella simillina Thiele, 1912	PI7
	Typhlodaphne innocentia Dell, 1990	PI5, PI8
Acteonidae	*Acteon antarcticus* Thiele, 1912	MB3
	Neactaeonina cf. *edentula* (Watson, 1883)	PI5
BIVALVIA		
Nuculanidae	*Propeleda longicaudata* (Thiele, 1912)	PA21, MB33
Yoldiidae	*Yoldia eightsi* (Couthouy, 1839)	PA22
	Yoldiella antarctica (Thiele, 1912)	PI7
	Yoldiella ecaudata (Pelseneer, 1903)	MB3, MB36
	Yoldiella oblonga (Pelseneer, 1903)	MB9, MB14
	Yoldiella profundorum (Melvill & Standen, 1912)	PA22
Malletiidae	*Malletia pellucida* Thiele, 1912	MB31, MB35
Arcidae	*Bathyarca sinuata* Pelseneer, 1903	MB3, MB13, MB30, MB35, MB38
Limopsidae	*Limopsis lilliei* Smith, 1915	PA21, PA25
	Limopsis longipilosa Pelseneer, 1903	MB33, MB37
Philobryidae	*Philobrya sublaevis* (Pelseneer, 1903)	PI8
	Adacnarca nitens Pelseneer, 1903	PI5, PI8, PA21
Mytilidae	*Dacrydium albidum* Pelseneer, 1903	MB38
Limidae	*Limatula simillina* Thiele, 1912	MB37
Pectinidae	*Adamussium colbecki* (Smith, 1902)	MB2, MB3, PI5, PI7, MB30, MB31, MB35
Thyasiridae	*Thyasira bongraini* (Lamy, 1910)	PI5, PI6, PI7, PI8, PA21, PA22, PA25
	Thyasira dearborni Nicol, 1965	PA22
Lasaeidae	*Mysella antarctica* (Smith, 1907)	PA22
	Pseudokellya cardiformis (Smith, 1885)	PA21
Cyamiidae	*Cyamiocardium denticulatum* (Smith, 1907)	MB4, PI5, PI7, PI8, PA21
	Cyamiomactra laminifera (Lamy, 1906)	PI8
Carditidae	*Cyclocardia astartoides* (Martens, 1878)	PA21, PA25
	Cyclocardia cf. *intermedia* Thiele, 1912	MB4
Thraciidae	*Thracia meridionalis* Smith, 1885	PA21
Cuspidariidae	*Cuspidaria infelix* Thiele, 1912	PI5, PI7, PI8, PA21
SCAPHOPODA		
Dentaliidae	*Dentalium majorinum* Mabille & Rochebrune, 1891	MB1, MB2, PI7, MB9, MB10, MB13, MB14, MB31, MB33, MB35, MB36, MB38
Rhabdidae	*Rhabdus* cf. *perceptus* (Mabille & Rochebrune, 1891)	PI7, MB12
Gadilidae	*Siphonodentalium dalli* f. *antarcticus* (Odhner, 1931)	PI5, PI6, PI7, PA24

35, 36, 37, 38 and 39). The depths in the sampling sites of the Bellingshausen Sea varied from 90 to 3304 metres. The ANOSIM test also showed differences in faunistic composition among stations following a gradient of depth.

Table 3 Faunistic parameters at each station: species richness (*R*), total abundante (*N*), Pielou even ness index (*J'*) and Shannon–Wiener diversity index calculated with the natural logarithm (*H'*), MO data (***).

Station	Richness (*S*)	Abundance (*N*)	Evenness (*J'*)	Diversity(*H'*)
MB1	1	1	***	0
MB2	2	2	1	0.69
MB3	4	5	0.96	1.33
MB4	3	3	1	1.10
PI5	14	446	0.40	1.06
PI6	2	145	0.72	0.50
PI7	12	67	0.58	1.45
PI8	14	244	0.49	1.29
MB9	2	13	0.39	0.27
MB10	1	1	***	0
MB11	3	3	1	1.10
MB12	1	2	***	0
MB13	3	3	1	1.10
MB14	3	7	0.87	0.96
MB17	1	1	***	0
PA21	13	22	0.92	2.36
PA22	6	55	0.91	1.63
PA23	3	3	1	1.10
PA24	2	2	1	0.69
PA25	4	7	0.92	1.28
MB30	3	8	0.82	0.90
MB31	5	7	0.96	1.55
MB33	3	3	1	1.10
MB35	4	4	1	1.39
MB36	3	7	0.72	0.80
MB37	3	7	0.72	0.80
MB38	3	6	0.92	1.01

The BIO-ENV procedure (Table 5) showed that the combination of environmental variables with the highest correlations with faunistic data was depth and coarse sand at the surface. Redox (Eh) and fine sand at the surface were not involved in the best combinations. Depth was the variable with the best value when each variable was considered alone ($p_w = 0.390$).

Discussion

Linse et al. (2006) divided the Southern Ocean into seven subregions based on richness hotspots of gastropods and bivalves: Antarctic Peninsula, Weddell Sea, three East Antarctic subregions (Dronning Maud Land, Enderby Land and Wilkes Land), Ross Sea, and the independent Scotia Arc and sub-Antarctic islands, and excluded the West Antarctic Region (Eights Coast and the Bellingshausen and Amundsen seas), previously defined by Clarke et al. (2004) from this classification because it is insufficiently studied. So, the present study, together with future more comprehensive faunistic studies (Aldea & Troncoso, unpubl. data), represents notable progress in the knowledge of the Bellingshausen Sea.

For neighbouring areas, several surveys of semiquantitative (e.g. Arnaud et al. 1998) and quantitative analyses of molluscan or macrobenthic fauna of the soft bottom have appeared in recent literature (e.g. Sáiz-Salinas et al. 1997; Sahade et al. 1998; Arnaud et al. 2001) showing distribution patterns and assemblages of several species, mainly from north-west of the Antarctic Peninsula. Likewise, similar studies about the Ross Sea have previously been published (e.g. Russo & Gambi 1994; Gambi et al. 1997). Only one survey of the benthic marine fauna of

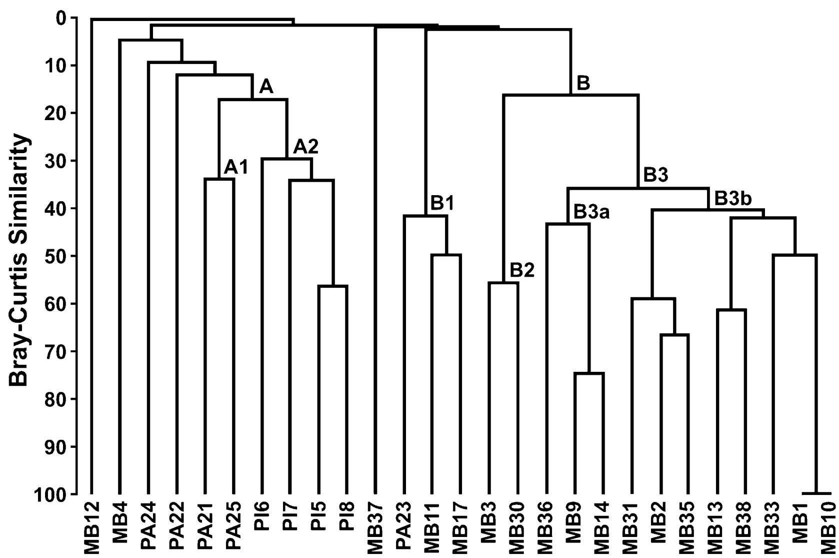

Fig. 3 Faunistic assemblages in the study are determined by cluster analysis based on Bray-Curtis Similarity.

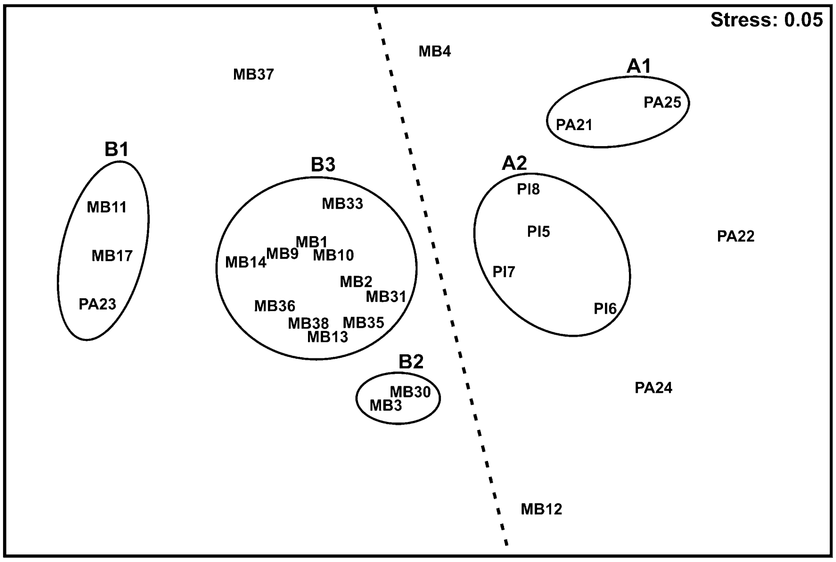

Fig. 4 MDS ordination of faunistic assemblages. The dotted line represents the separation of two main groups (A, B). The subgroups delimited with solid lines are derivates of cluster analysis.

Table 4 Results of SIMPER analysis. Species were ranked according to their average contribution to dissimilarity (Contrib. %) between groups of stations. Average abundance for each group (Av. abund.), average dissimilarity (Av. diss.), ratio value (dissimilarity/standard deviation, Diss./SD) and percentage of cumulative dissimilarity (Cum. %).

Groups B & A (Average dissimilarity = 96.79)	Group B	Group A				
Species	Av. abund.	Av. abund.	Av. diss.	Diss./SD	Contrib. %	Cum. %
Thyasira bongraini	0	2.36	16.46	1.54	17.01	17.01
Dentalium majorinum	1.21	0.31	8.47	1.54	8.75	25.76
Cyamiocardium denticulatum	0	1.64	7.17	1.12	7.41	33.17
Siphonodentalium dalli f. antarcticus	0	0.86	6.72	0.67	6.94	40.11
Cuspidaria infelix	0	1.03	4.74	1.36	4.9	45.01
Cyclocardia astartoides	0	0.4	3.87	0.62	4	49.01
Limopsis lilliei	0	0.33	3.26	0.62	3.37	52.38
Amauropsis anderssoni	0	0.22	3.01	0.44	3.11	55.49
Adacnarca nitens	0	0.65	2.9	0.98	2.99	58.48
Adamussium colbecki	0.29	0.33	2.76	0.72	2.85	61.33
Bathyarca sinuata	0.29	0	2.04	0.53	2.11	63.44
Onoba gelida	0	0.39	1.86	0.7	1.92	65.37
Chlanidota signeyana	0	0.36	1.75	0.67	1.81	67.18
Falsilunatia delicatula	0	0.4	1.62	0.68	1.67	68.85
Lorabela sp.	0	0.39	1.55	0.69	1.6	70.45
Typhlodaphne innocentia	0	0.36	1.47	0.7	1.51	71.97
Propeleda longicaudata	0.09	0.17	1.46	0.49	1.51	73.48
Yoldiella oblonga	0.18	0	1.31	0.41	1.36	74.83
Torellia planispira	0	0.22	1.27	0.44	1.32	76.15
Thracia meridionalis	0	0.22	1.27	0.44	1.32	77.47
Pleurotomella simillina	0	0.22	1.21	0.44	1.25	78.71
Malletia pellucida	0.18	0	1.17	0.42	1.2	79.92
Neactaeonina cf. edentula	0	0.26	1.03	0.44	1.07	80.99
Submargarita notalis	0	0.17	0.97	0.44	1	81.99
Eatoniella glacialis	0	0.17	0.97	0.44	1	82.99
Pseudokellya cardiformis	0	0.17	0.97	0.44	1	83.99
Philobrya sublaevis	0	0.24	0.96	0.44	0.99	84.98
Trophon cuspidarioides	0	0.17	0.92	0.44	0.95	85.92
Probuccinum costatum	0	0.17	0.92	0.44	0.95	86.87
Yoldiella antarctica	0	0.17	0.92	0.44	0.95	87.82
Rhabdus cf. perceptus	0	0.17	0.92	0.44	0.95	88.77
Margarella antarctica	0	0.2	0.81	0.44	0.83	89.6
Prosipho hedleyi	0	0.2	0.81	0.44	0.83	90.44

Table 5 Best combinations of variables obtained through BIO-ENV analysis according to the values of the Spearman's rank correlation (p_w) for survey stations: depth (m), organic matter (OM %), gravel (% > 2mm), coarses and (% > 0.5mm), mediums and (% > 0.25 mm) and mud (% < 0.0625 mm).

Number of variables	Correlation (p_w)	Best variable combination
2	0.454	depth; coarse sand
3	0.410	depth; OM; coarse sand
1	0.390	Depth
3	0.385	depth; gravel; coarse sand
3	0.382	depth; coarse sand; mud
4	0.378	depth; OM; coarse sand
3	0.378	depth; coarse sand; medium sand
4	0.368	depth; OM; coarse sand; medium sand
4	0.362	depth; OM; coarse sand; mud
3	0.359	depth; OM; gravel

the Bellingshausen Sea has been published previously (Richardson & Hedgpeth 1977).

The main species recorded in the present survey are the same as those recorded during a similar survey in the South Shetland Islands and Bransfield Strait (Arnaud et al. 2001): the tiny *Cyamiocardium denticulatum* and *Thyasira bongraini*, and the large *Dentalium majorinum*, *Siphonodentalium dalli* f. *antarcticus*, *Cuspidaria infelix* and *Yoldia eightsi*. Mühlenhardt-Siegel (1989) also found a high presence of *T. bongraini*. The same situation occurs in the Ross Sea, where Cattaneo-Vietti et al. (2000) found mainly the bivalves *Adamussium colbecki*, Galeommatidae undet., *Y. eightsi* and *T. dearborni* (named as *Genaxinus debilis*).

Molluscan assemblages exhibit a bathymetric pattern from deep-water stations (depth > 438 m) to shallow-water ones (depth < 410 m). Deep-water stations with very low abundances (<13 specimens) mainly belong to group B, which is widely dominated by the large *D. majorinum*, followed by the bivalves *A. colbeki*, *Bathyarca sinuata* and the tiny species *Limopsis longipilosa* and the chiton *Leptochiton kerguelenensis*. On the contrary, shallow-water stations with high abundances (22–446 specimens), belonging mainly to group A, and mostly located near the Antarctic Peninsula or Peter I Øy, are dominated by the tiny *C. denticulatum* and *T. bongraini*, followed by the larger scaphopod *S. dalli* f. *antarcticus*, *C. infelix* and *Y. eightsi*. This result agrees with those of studies carried out in adjacent areas at depths generally shallower than 500 m, where Arnaud et al. (2001) have reported the high presence and abundances of the bivalves *C. denticulatum* and *T. bongraini*. However, this result disagrees with the survey of Cattaneo-Vietti et al. (2000), who found mainly large bivalves (*A. colbecki*, *Y. eightsi*) in depths of less than 380 m, and the tiny infaunal bivalve *T. dearborni* (under the name *G. debilis*) at depths of 222–1000 m. This is an inverse pattern, with tiny infaunal molluscs dominating at greater depths.

In conclusion, the main molluscan species of the Ross Sea (Schiaparelli et al. 2006), Weddell Sea (Hain 1990) and the South Shetland Islands (Arnaud et al. 2001) are also present in the Bellingshausen Sea, but in lesser abundance. Peter I Øy presents the highest values of abundances and number of species. *T. bongraini* and *C. denticulatum* contribute 60% of the total number of the specimens. Depth and percentage of coarse sand could be the environmental variables that explain the distribution of molluscan assemblages in the Bellingshausen Sea.

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