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Diversity and distribution of mollusc assemblages on the Victoria Land coast and the Balleny Islands, Ross Sea, Antarctica

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Abstract: In 2004 as part of the joint Latitudinal Gradient Project in the Ross Sea, cruises of RV *Tangaroa* and RV *Italica* along the Victoria Land coast and the Balleny Islands collected 142 species of mollusc (four Polyplacophora, 99 Gastropoda, 37 Bivalvia and two Scaphopoda). About 20% of these species represent new records for the Ross Sea quadrant. The species richness was found to be higher at 71–72°S (Cape Hallett–Cape Adare) and lower at 74–75°S (Terra Nova Bay–Cape Russell) using Shannon-Wiener's H', Pielou's J' and Simpson's λ indices, as well as by using species richness estimators (e.g. ICE, Chao 2, Jack 2). The Balleny Islands (65–67°S), though not exhaustively sampled, show diversity values comparable to those of Terra Nova Bay–Cape Russell. These islands, located in the main Antarctic Coastal Current, appear to represent a crossroads in the Southern Ocean, with mollusc and other invertebrate species present, that have previously been recorded only from the Weddell Sea. The higher diversity in the Cape Hallett–Cape Adare area is not easy to interpret, but could be a result of the intense iceberg scouring off the two capes, observed from seafloor mapping, a factor that is known to enhance species diversity at the regional scale. The existence of a decreasing trend in diversity towards higher latitudes along the Victoria Land coast cannot yet be shown, due to the large gaps in sampling coverage.

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Key words: diversity, Latitudinal Gradient Project, mollusca, Southern Ocean

Introduction

The benthic fauna of the Antarctic continental shelf has been shaped by a series of peculiar climatic, physical and biotic factors since the Eocene (Dayton *et al*. 1970, Arntz *et al*. 1994). The progressive decrease of water temperature in Antarctica is believed to have led to the extinction of entire clades of benthic organisms including, for example, the decapod crustaceans, whose predation pressure can reshape assemblage structure of shelled organisms (Aronson & Blake 2001, Thatje *et al*. 2005a, Vermeij 1976, 1977). In particular, the increase of shelf ice during glacial cycles has provoked extinction of most shelf taxa, favouring the selection of species that were able to take refuge in the deeper waters of the continental slope (Brey *et al*. 1996, Thatje *et al.* 2005b).

The present composition of actual shelf Antarctic assemblages, with species highly adapted to low temperatures and to a marked seasonality in food supply is, therefore, the result of faunal shifts between deep-sea and coastal habitats, which occurred when shelves became available again after glacial retreat, as indirectly shown by the general eurybathy of many Antarctic benthic invertebrates (Brey *et al*. 1996) and by the phenomena of polar emergence, as shown by the *Adamussium* fauna (Berkman *et al*. 2004, Schiaparelli & Linse 2006).

But our knowledge of the driving forces that structure sublittoral Antarctic macrobenthos still remains at a basic level (Gutt 2000).

Today, one of the major challenge of diversity studies in Antarctica is the assessment of possible latitudinal clines, such as those known to occur in the Northern Hemisphere (Clarke & Johnston 2003). However, in Antarctica, this is a not easy task for several reasons. Firstly the geomorphology of the continent does not offer, *per se*, many suitable coastal sites, to test for the existence of latitudinal gradients. In practice, this is feasible only along the Antarctic Peninsula in the Weddell Sea, and in the western Ross Sea.

Secondly, Antarctic benthic assemblages are very patchy and show a wide range of scale-dependent spatial patterns (Gutt & Piepenburg 2003). This spatial variability is still poorly quantified (Teixidó *et al*. 2002) and, obviously, this aspect need to be taken into particular account when extrapolations to a large scale are attempted.

Another potential bias is the well known "proximity effect" (Clarke & Johnston 2003), as most of the available data for benthic communities comes from studies undertaken near research stations. For example, in the Ross Sea, although benthic assemblages have been widely studied since the 1950s (Bradford-Grieve & Fenwick 2001 and references therein), the principal data available is only for areas near established scientific stations such as those at McMurdo, Scott Base and Mario Zucchelli Station.

In addition there are major gaps in sampling coverage of inaccessible areas, more or less permanently covered by ice.

Table I. List of sampling stations with latitude, longitude, gear, depth and date of sampling. Abbreviations for gears: AGT = Agassiz trawl, BEAM = beam trawl, DREDGE = naturalist dredge, GRAB = Van Veen grab (60 l of volume), GVVL = large Van Veen grab (90 l of volume), ORH = bottom trawl ("orange roughy"), SEL = epibenthic dredge. Abbreviation for locations: 'Ross 1' to 'Ross 5' = *Tangaroa* 2004 stations along transects done in the Ross Sea (Cape Adare and Cape Hallett area), 'Sturge' and 'Young' = *Tangaroa* 2004 stations around islands of the Balleny Archipelago, 'Balleny' and 'S-100' = *Tangaroa* 2004 stations located on seamounts of the Balleny Archipelago, TNB = Terra Nova Bay historical stations, CH = Cape Hallett and CR = Cape Russell = stations sampled during the 2004 *Italica* cruise.

Station	Transect/ location	Lat S	Long E	Gear	Depth (m)	Date
RV *Tangaroa* 2004 stations						
3	Ross3	71°41.5	172°03.5	GVVL	634	04 Feb. 2004
8	Ross3	71°42.8	171°49.6	SEL	537	04 Feb. 2004
13	Ross3	71°42.6	171°49.6	SEL	535	05 Feb. 2004
14	Ross3	71°43.9	171°45.0	GVVL	451	05 Feb. 2004
15	Ross3	71°43.7	171°44.1	SEL	466	05 Feb. 2004
16	Ross3	71°44.4	171°39.5	GVVL	411	05 Feb. 2004
17	Ross3	71°44.4	171°39.3	SEL	420	05 Feb. 2004
18	Ross3	71°43.6	171°46.9	ORH	522	05 Feb. 2004
19	Ross3	71°44.1	171°44.0	ORH	429	05 Feb. 2004
21	Ross3	71°48.0	170°56.9	GVVL	168	09 Feb. 2004
22	Ross3	71°48.1	170°56.5	SEL	151	09 Feb. 2004
24	Ross3	71°47.9	170°56.5	GVVL	119	09 Feb. 2004
25	Ross3	71°47.9	170°56.0	SEL	127	09 Feb. 2004
27	Ross3	71°43.6	171°34.0	ORH	337	09 Feb. 2004
28	Ross3	71°43.1	171°30.2	ORH	305	09 Feb. 2004
30	Ross3	71°44.8	171°17.5	GVVL	277	09 Feb. 2004
32	Ross3	71°44.5	171°33.9	GVVL	340	10 Feb. 2004
33	Ross3	71°45.3	171°25.0	SEL	282	10 Feb. 2004
35	Ross3	71°46.1	171°06.6	SEL	241	10 Feb. 2004
38	Ross3	71°45.3	171°08.6	GVVL	226	10 Feb. 2004
39	Ross3	71°45.3	171°08.9	SEL	250	10 Feb. 2004
47	Ross5	72°18.9	170°21.7	GVVL	130	12 Feb. 2004
48	Ross5	72°19.0	170°21.7	SEL	132	12 Feb. 2004
51	Ross5	72°20.0	170°23.3	GVVL	152	12 Feb. 2004
52	Ross5	72°20.2	170°23.7	SEL	154	12 Feb. 2004
53	Ross5	72°19.9	170°25.7	GVVL	197	13 Feb. 2004
54	Ross5	72°19.5	170°25.7	SEL	206	13 Feb. 2004
55	Ross5	72°18.5	170°21.5	ORH	130	13 Feb. 2004
56	Ross5	72°18.6	170°22.7	ORH	150	13 Feb. 2004
57	Ross5	72°20.5	170°26.6	ORH	203	13 Feb. 2004
59	Ross5	72°19.6	170°27.5	SEL	236	13 Feb. 2004
63	Ross5	72°19.3	170°28.7	SEL	303	13 Feb. 2004
64	Ross5	72°19.8	170°29.5	GVVL	314	13 Feb. 2004
65	Ross5	72°20.1	170°30.0	SEL	328	13 Feb. 2004
67	Ross5	72°19.3	170°28.5	ORH	272	13 Feb. 2004
72	Ross5	72°03.7	173°14.7	SEL	620	13 Feb. 2004
77	Ross5	72°07.8	172°42.8	GVVL	499	14 Feb. 2004
78	Ross5	72°07.0	172°41.9	SEL	495	14 Feb. 2004
82	Ross5	72°03.6	172°54.2	SEL	526	14 Feb. 2004
88	Ross5	72°05.9	172°55.8	GVVL	515	14 Feb. 2004
89	Ross5	72°16.7	171°24.8	ORH	415	14 Feb. 2004
90	Ross5	72°16.5	171°27.8	GVVL	423	14 Feb. 2004
94	Adare	71°31.8	170°06.7	BEAM	220	17 Feb. 2004
96	Ross1	71°11.3	170°58.6	SEL	719	18 Feb. 2004
97	Ross1	71°11.8	170°57.9	GVVL	630	18 Feb. 2004
102	Ross1	71°15.2	170°44.2	GVVL	536	18 Feb. 2004
105	Ross1	71°15.5	170°38.1	SEL	470	18 Feb. 2004
107	Ross1	71°16.6	170°36.1	GVVL	400	18 Feb. 2004
108	Ross1	71°16.3	170°36.0	SEL	400	18 Feb. 2004
116	Ross1	71°17.9	170°32.4	SEL	312	18 Feb. 2004
117	Ross1	71°18.6	170°34.3	GVVL	314	18 Feb. 2004
120	Ross1	71°11.3	170°58.8	ORH	713	18 Feb. 2004
123	Ross1	71°18.8	170°30.1	GVVL	243	19 Feb. 2004
124	Ross1	71°18.6	170°28.6	SEL	212	19 Feb. 2004
125	Ross1	71°19.0	170°27.9	GVVL	163	19 Feb. 2004
126	Ross1	71°18.6	170°27.0	SEL	161	19 Feb. 2004
127	Ross1	71°19.4	170°24.5	GVVL	85	19 Feb. 2004
128	Ross1	71°19.6	170°24.8	SEL	85	19 Feb. 2004
129	Ross1	71°19.6	170°27.1	GVVL	120	19 Feb. 2004
130	Ross1	71°19.8	170°27.6	SEL	120	19 Feb. 2004
132	Adare	71°38.9	170°10.8	SEL	162	23 Feb. 2004
133	Adare	71°38.7	170°13.1	SEL	249	23 Feb. 2004
134	Adare	71°38.5	170°09.2	SEL	65	23 Feb. 2004
139	Ross4	72°00.8	170°46.6	GVVL	236	26 Feb. 2004
140	Ross4	72°00.8	170°46.5	SEL	231	26 Feb. 2004
142	Ross4	72°01.1	170°48.5	GVVL	302	26 Feb. 2004
143	Ross4	72°01.4	170°48.2	SEL	317	26 Feb. 2004
149	Ross4	71°58.9	171°58.0	GVVL	456	26 Feb. 2004
150	Ross4	71°58.8	171°58.1	SEL	480	26 Feb. 2004
152	Ross4	71°59.7	172°08.1	SEL	515	26 Feb. 2004
154	Ross4	72°00.1	172°13.3	SEL	536	26 Feb. 2004
157	Ross4	71°59.1	172°10.7	SEL	737	26 Feb. 2004
162	Ross2	71°28.5	171°59.8	GVVL	738	26 Feb. 2004
173	Ross2	71°28.9	171°57.9	ORH	644	27 Feb. 2004
174	Ross2	71°29.6	171°36.3	ORH	485	27 Feb. 2004
175	Ross2	71°31.8	171°18.0	ORH	348	27 Feb. 2004
177	Ross2	71°31.8	171°18.1	GVVL	350	27 Feb. 2004
178	Ross2	71°31.9	171°18.3	SEL	348	27 Feb. 2004
182	Ross2	71°31.6	171°24.6	SEL	385	27 Feb. 2004
184	Ross2	71°30.0	171°36.4	SEL	480	27 Feb. 2004
185	Ross2	71°29.3	171°56.6	BEAM	600	27 Feb. 2004
186	Ross2	71°30.7	171°25.5	BEAM	390	27 Feb. 2004
188	Ross2	71°32.9	171°06.7	SEL	286	27 Feb. 2004
193	Ross2	71°36.1	170°52.8	SEL	228	28 Feb. 2004
194	Ross2	71°37.3	170°55.6	GVVL	246	28 Feb. 2004
195	Ross2	71°37.3	170°55.4	SEL	244	28 Feb. 2004
197	Ross2	71°37.2	170°52.0	SEL	198	28 Feb. 2004
198	Ross2	71°37.0	170°53.6	GVVL	222	28 Feb. 2004
202	Ross1	71°09.3	171°05.5	ORH	930	29 Feb. 2004
209	Sturge	67°34.3	165°02.6	SEL	640	02 Mar. 2004
210	Sturge	67°35.1	165°01.7	GVVL	732	02 Mar. 2004
213	Sturge	67°26.2	165°16.5	SEL	1382	03 Mar. 2004
214	Sturge	67°25.4	165°15.8	ORH	1389	03 Mar. 2004
217	Sturge	67°14.2	164°50.8	GVVL	356	03 Mar. 2004
218	Sturge	67°15.2	164°52.5	ORH	348	03 Mar. 2004
222	Sturge	67°16.0	164°31.3	SEL	212	03 Mar. 2004
231	S-100	67°25.2	163°56.4	GVVL	111	04 Mar. 2004
232	S-100	67°25.2	163°56.6	SEL	117	04 Mar. 2004
233	S-100	67°25.1	163°54.9	SEL	230	04 Mar. 2004
237	S-100	67°25.0	163°57.0	ORH	129	04 Mar. 2004
239	Young	66°54.8	163°13.5	GVVL	85	04 Mar. 2004
240	Young	66°55.5	163°14.4	ORH	75	04 Mar. 2004
241	Young	66°54.8	163°13.7	SEL	70	04 Mar. 2004
245	Young	66°40.5	162°45.4	SEL	380	05 Mar. 2004
250	Young	66°33.1	163°00.2	GVVL	557	05 Mar. 2004
251	Young	66°33.1	163°00.2	SEL	584	05 Mar. 2004
257	Young	66°13.0	162°26.5	ORH	1261	05 Mar. 2004
260	Young	66°10.5	162°15.9	GVVL	396	05 Mar. 2004
266	Balleny	65°26.9	160°55.5	SEL	118	07 Mar. 2004
267	Balleny	65°29.4	161°03.1	GVVL	759	07 Mar. 2004
268	Balleny	65°29.5	161°03.0	SEL	764	07 Mar. 2004
274	Balleny	65°29.8	160°56.7	SEL	371	07 Mar. 2004
276	Balleny	65°24.8	160°52.9	GVVL	125	07 Mar. 2004
277	Balleny	65°24.5	160°53.3	SEL	103	07 Mar. 2004
278	Balleny	65°24.8	160°53.2	BEAM	114	07 Mar. 2004
Terra Nova Bay historical stations						
AC5	TNB	74°46.5	163°59.2	GRAB	61	1997/98
ADAB 1	TNB	74°41.9	164°07.8	GRAB	66	1995/96
ADAB 1bis	TNB	74°41.9	164°07.8	GRAB	84	1993/94
ADAB 2	TNB	74°41.9	164°07.7	GRAB	64	1995/96

Table I. List of sampling stations with latitude, longitude, gear, depth and date of sampling. Abbreviations for gears - see previous page.

Station	Transect/ location	Lat S	Long E	Gear	Depth (m)	Date
ADAB 3	TNB	74°41.9	164°07.6	GRAB	44	1995/96
ADAB 3bis	TNB	74°41.9	164°07.7	GRAB	55	1993/94
ADAB 6	TNB	74°42.1	164°07.8	GRAB	84	1993/94
ADAB 4	TNB	74°42.0	164°07.6	GRAB	41	1995/96
ALB 2	TNB	74°43.0	164°07.5	GRAB	50	1993/94
ALB 4	TNB	74°43.0	164°07.5	GRAB	50	1993/94
ALB 5	TNB	74°42.9	164°07.4	GRAB	43	1993/94
B14	TNB	74°42.2	164°10.9	GRAB	286	1987/88
B26	TNB	74°43.0	164°26.6	GRAB	652	1987/88
B30	TNB	74°46.9	164°03.1	GRAB	163	1987/88
B47	TNB	74°45.1	164°30.1	GRAB	640	1987/88
C25	TNB	74°46.4	164°01.6	GRAB	25	1989/90
C4	TNB	74°46.7	164°02.3	GRAB	123	1989/90
C5	TNB	74°46.8	164°02.7	GRAB	153	1989/90
D126	TNB	74°44.7	164°08.1	GRAB	126	1989/90
D136	TNB	74°43.9	164°08.4	GRAB	136	1989/90
D18	TNB	74°43.4	164°19.4	DREDGE	552	1987/88
D23	TNB	74°44.5	164°24.0	DREDGE	450	1987/88
D31	TNB	74°47.3	164°09.8	DREDGE	283	1987/88
D33	TNB	74°45.1	164°12.1	DREDGE	222	1987/88
D35	TNB	74°46.1	164°11.7	DREDGE	215	1987/88
D3D	TNB	74°44.1	164°08.5	DREDGE	127	1989/90
D48	TNB	74°46.7	164°33.4	DREDGE	810	1987/88
E135	TNB	74°43.2	164°08.7	GRAB	135	1989/90
E157	TNB	74°43.2	164°09.0	GRAB	157	1989/90
EOLO	TNB	74°40.4	164°04.9	GRAB	177	1995/96
F1	TNB	74°41.8	164°07.8	GRAB	38	1989/90
F4	TNB	74°41.6	164°08.2	GRAB	146	1989/90
F4bis	TNB	74°41.6	164°08.1	GRAB	143	1989/90
FAR 50 A	TNB	74°43.0	164°07.4	GRAB	44	1993/94
FAR 50 B 3	TNB	74°43.0	164°07.4	GRAB	48	1993/94
FAR 50 B1	TNB	74°43.0	164°07.5	GRAB	50	1993/94
FAR 50 C	TNB	74°43.1	164°07.4	GRAB	50	1993/94
FARB 1	TNB	74°43.5	164°09.2	GRAB	205	1993/94
FARPOR 2	TNB	74°43.2	164°08.4	DREDGE	43-126	1993/94
G1	TNB	74°45.1	164°04.6	GRAB	30	1989/90
G2	TNB	74°45.1	164°04.3	GRAB	56	1989/90
G2 bis	TNB	74°38.4	164°11.2	GRAB	181	1997/98
G3	TNB	74°46.4	164°03.8	GRAB	120	1989/90
GERLA B 2	TNB	74°40.2	164°06.9	GRAB	256	1995/96
H2D	TNB	74°45.1	164°05.4	GRAB	96	1989/90
H50	TNB	74°45.1	164°05.4	GRAB	50	1989/90
I48	TNB	74°41.4	164°06.9	GRAB	48	1989/90
I82	TNB	74°41.2	164°06.1	GRAB	82	1989/90
IB12	TNB	74°47.9	164°49.8	GRAB	820	1987/88
IB13	TNB	74°45.8	165°30.9	GRAB	670	1987/88
IB25	TNB	74°57.2	166°17.2	GRAB	>1000	1987/88
IB31	TNB	75°06.4	165°29.1	GRAB	1000	1987/88
IB37	TNB	75°16.7	164°51.8	GRAB	770	1987/88
IB38	TNB	75°17.8	165°26.6	GRAB	716	1987/88
IB39	TNB	75°17.8	166°08.8	GRAB	850	1987/88
IB46	TNB	75°29.0	165°31.8	GRAB	849	1987/88
IB47	TNB	75°30.0	166°13.2	GRAB	680	1987/88
IB48	TNB	74°57.2	164°37.2	GRAB	953	1987/88
IB5	TNB	74°42.0	166°04.5	GRAB	710	1987/88
IB7	TNB	74°44.5	164°48.0	GRAB	578	1987/88
ID16	TNB	74°48.2	167°17.3	DREDGE	681	1987/88
ID24	TNB	74°58.0	165°38.0	DREDGE	1100	1987/88
ID30	TNB	75°09.0	165°00.3	DREDGE	850	1987/88
MM106	TNB	74°47.0	164°01.7	GRAB	106	1989/90
MM31	TNB	74°43.5	164°08.9	GRAB	197	1989/90
MM50	TNB	74°54.0	164°08.4	GRAB	240	1989/90
MM56	TNB	74°52.3	164°15.2	GRAB	246	1989/90
MM59	TNB	74°51.9	164°08.6	GRAB	275	1989/90
MM64	TNB	74°49.1	164°07.2	GRAB	168	1989/90
MM67	TNB	74°49.2	164°10.2	GRAB	292	1989/90
MM68	TNB	74°49.2	164°11.8	GRAB	332	1989/90
MM70	TNB	74°49.6	164°19.0	GRAB	339	1989/90
MM73	TNB	74°48.5	164°13.7	GRAB	373	1989/90
MM79	TNB	74°41.4	164°04.9	GRAB	183	1989/90
MM81	TNB	74°38.6	164°04.1	GRAB	145	1989/90
MM86	TNB	74°38.4	164°15.2	GRAB	104	1989/90
MM88	TNB	74°38.6	164°14.1	GRAB	96	1989/90
MM91	TNB	74°38.1	164°10.7	GRAB	106	1989/90
PEN 1 A	TNB	74°46.4	163°59.0	GRAB	36	1993/94
PEN 1 B	TNB	74°46.4	163°59.2	GRAB	41	1993/94
PEN 1 C	TNB	74°46.2	163°57.9	GRAB	40	1993/94
PEN 1 C bis	TNB	74°46.4	163°59.3	GRAB	47	1993/94
PEN 1 D	TNB	74°46.4	163°59.1	GRAB	37	1993/94
PEN 1 E	TNB	74°46.4	163°59.1	GRAB	40	1993/94
PEN 2 A	TNB	74°46.3	163°57.8	GRAB	68	1993/94
PEN 2 B	TNB	74°46.3	163°57.9	GRAB	67	1993/94
PEN 2 C	TNB	74°46.3	163°58.0	GRAB	67	1993/94
PEN 4 B	TNB	74°47.1	164°02.7	GRAB	146	1993/94
Policheti 1	TNB	74°45.7	164°07.9	GRAB	142	1997/98
Q1	TNB	74°41.5	164°07.2	GRAB	43	1989/90
Q2	TNB	74°41.5	164°07.2	GRAB	40	1989/90
Q3	TNB	74°41.5	164°07.2	GRAB	46	1989/90
SCOB 1	TNB	74°42.3	164°07.8	GRAB	52	1993/94
SP B 1	TNB	74°43.0	164°08.1	GRAB	135	1993/94
ST 11	TNB	74°40.1	164°17.5	GRAB	230	1995/96
ST 20	TNB	74°41.2	164°24.7	GRAB	270	1995/96
ST 21 B 2	TNB	74°42.3	164°20.0	GRAB	390	1995/96
St 411	TNB	74°44.8	164°50.4	GRAB	626	1995/96
St 414	TNB	74°47.9	165°18.4	GRAB	692	1995/96
St 426	TNB	74°54.7	163°58.5	GRAB	233	1995/96
St 426 bis	TNB	74°54.6	163°58.3	GRAB	237	1995/96
St 505	TNB	74°51.2	164°26.6	GRAB	544	1995/96
St 506	TNB	74°52.8	164°29.9	GRAB	544	1995/96
TOR 1	TNB	74°41.9	164°28.6	GRAB	406	1993/94
TOR 4	TNB	74°41.0	164°25.0	GRAB	248	1993/94
TOR 5	TNB	74°41.3	164°08.0	GRAB	153	1993/94
RV *Italica* 2004 stations						
Hin2	CH	72°17.1	170°11.7	GRAB	400	11 Feb. 2004
Hin3	CH	72°17.4	170°12.3	GRAB	312	16 Feb. 2004
Hin4	CH	72°17.5	170°12.5	GRAB	266	17 Feb. 2004
Hin3	CH	72°17.0	170°13.1	AGT	316	16 Feb. 2004
Hin4	CH	72°17.1	170°14.0	AGT	196	16 Feb. 2004
Hin5	CH	72°17.2	170°17.9	AGT	84	16 Feb. 2004
Hout1	CH	72°15.9	170°27.8	GRAB	494	05 Feb. 2004
Hout1	CH	72°15.5	170°28.3	AGT	537	05 Feb. 2004
Hout2	CH	72°16.1	170°27.6	GRAB	475	05 Feb. 2004
Hout2	CH	72°16.3	170°24.9	AGT	337	05 Feb. 2004
Hout2	CH	72°17.5	170°29.4	AGT	353	11 Feb. 2004
Hout2 bis	CH	72°17.1	170°29.9	AGT	388	17 Feb. 2004
Hout3	CH	72°17.0	170°25.8	GRAB	273	04 Feb. 2004
Hout3	CH	72°17.5	170°26.1	AGT	246	04 Feb. 2004
Hout3 bis	CH	72°17.4	170°26.4	AGT	258	17 Feb. 2004
Hout4	CH	72°17.2	170°23.4	GRAB	195	04 Feb. 2004
Hout4	CH	72°17.2	170°23.9	AGT	208	04 Feb. 2004
Hout4 bis	CH	72°18.5	170°26.8	AGT	235	12 Feb. 2004
Hout4 ter	CH	72°18.2	170°26.0	AGT	218	12 Feb. 2004
Hout5	CH	72°16.9	170°17.0	AGT	105	09 Feb. 2004
Hout5	CH	72°17.9	170°19.7	GRAB	103	09 Feb. 2004
R2	CR	74°49.0	164°18.1	AGT	364	21 Feb. 2004
R2	CR	74°49.5	164°23.8	GRAB	457	21 Feb. 2004
R3	CR	74°49.9	164°13.0	GRAB	307	21 Feb. 2004
R4	CR	74°50.0	164°05.2	GRAB	174	21 Feb. 2004
R4 bis	CR	74°50.2	164°05.5	AGT	216	22 Feb. 2004
R3	CR	74°49.3	164°11.5	AGT	330	20 Feb. 2004
R4	CR	74°50.0	164°05.7	AGT	208	20 Feb. 2004

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In 2004, Italian, New Zealand, and US researchers undertook two parallel cruises, using the New Zealand RV *Tangaroa* and the Italian RV *Italica*, under the joint Latitudinal Gradient Project (LGP) (http://www.lgp.aq/; Berkman *et al*. 2005), along the Victoria Land coast. One of the major tasks of the two expeditions was to survey the biodiversity of selected marine assemblages in the Ross Sea. In this paper we present the data for Mollusca (Cephalopoda and Solenogastra excluded), one of the fairly well-known Antarctic phyla (Clarke & Johnston 2003) and one of the most useful taxa in revealing latitudinal and longitudinal gradients in taxonomic diversity (Griffiths *et al*. 2003). The Ross Sea mollusc fauna is now taxonomically well known (e.g. Dell 1990, Clarke & Johnston 2003 for a review), but the structure of its assemblages has seldom been taken into account, the only quantitative data available being that for the Terra Nova Bay area (Cattaneo-Vietti *et al*. 2000).

Our specific aim was to test if there are differences in mollusc diversity, at the large geographic scale, along the Victoria Land stretch of coast (Howard-Williams *et al.* 2006). In particular, we compared mollusc assemblages from the north Ross Sea (Cape Adare–Cape Hallett area), the middle Ross Sea (Terra Nova Bay–Cape Russell area) and the edge of the Ross Sea (Balleny Islands). For this we combined the large datasets obtained from the *Tangaroa* and *Italica* cruises and, to endorse our latitudinal coverage, we also took into account the historical stations from Terra Nova Bay (Cattaneo-Vietti *et al*. 2000), an area not exhaustively covered during the 2004 sampling.

Material and methods

Sampling

The RV *Tangaroa* BioRoss Expedition sampled around the Balleny Islands (65–67°S) and in the area between Cape Adare (71°S) and Cape Hallett (72°S) in a depth range between 38 and 1750 m (Mitchell & Clark 2004; www.rosssea2004.govt.nz); 200 stations were investigated; mollusc specimens were obtained from 89 stations from the Cape Adare–Cape Hallett area and 26 stations at the Balleny Islands.

At Balleny Islands, stations were randomly chosen around islands (‘Sturge’ and ‘Young’ stations in Table I) or seamounts (‘Balleny’ and ‘S-100’ stations in Table I) and not organized in transects; along the Victoria Land coast, these were randomly chosen along five transects (namely Ross 1, Ross 2, Ross 3, Ross 4 and Ross 5 in Table I). Onboard *Tangaroa*, a different array of sampling gears was deployed: a large Van Veen grab (90 l volume, GVVL), an epibenthic dredge (SEL), a bottom trawl ("orange roughy", ORH) and beam trawl (BEAM).

The RV *Italica* explored the area between Cape Adare (71°S) and Cape Russell (75°S), using an Agassiz trawl (AGT) and Van Veen grab (60 l volume) in a depth range between 84 and 537 m (Ramoino 2004). Here, data from the Cape Hallett (19 stations) and Cape Russell (seven stations) transects are included.

During both cruises, grab samples were sieved on a series of sieves with decreasing mesh size, down to a minimum of 1 mm. Dredge and trawl samples (or sub-samples) were sorted by eye on a sorting desk. Biological material was then divided in the main groups, labelled and preserved in alcohol or formalin. In the laboratory, samples from individual stations were further sorted to morphospecies or operational taxonomic units, OTUs (New 1999). Few juvenile specimens (*Amauropsis* sp. juv., Chitonidae ind. juv.) could not be classified and were excluded from the analysis. The classes Solenogastra and Cephalopoda were not taken into account in the present study.

To this large dataset, 106 historical stations from Terra Nova Bay (Balduzzi & Cattaneo-Vietti 1991) were added to the analysis in order to have a broader idea of the mollusc assemblages between 74° and 75°S, bringing to 247 the number of the stations studied (Table I).

Multivariate analysis

To determine the existence of any trend along the latitudinal transect 65°–75°S, we used Primer 6 multivariate analysis (Plymouth Marine Laboratory; Clarke & Warwick 2001).

Because of the variety of sampling gears used, abundances were transformed into presence/absence data and a Bray-Curtis (1957) similarity index was used to generate a similarity matrix. When grab samples were analysed alone, their abundances were first standardized by the total and then transformed to their square root. To standardize the different datasets, abundances from different grab replicates of the same stations were averaged and their mean used for the calculations.

Non-metric multidimensional scaling (nm-MDS; Kruskal & Wish 1978) was used to generate 2D plots. Analyses of similarities (ANOSIM; Clarke 1993) were performed to test four different factors:

1. depth (with the levels: 1 = 0–100 m, 2 = 101–200 m, 3 = 201–300 m, 4 =301–400 m, 5 = 401–500 m, 6 = 501–600 m, 7 > 601 m),
2. gear (levels: GVVL = Van Veen grab, SEL = epibenthic dredge, DREDGE = naturalist dredge, ORH = “orange roughy” trawl, BEAM = beam trawl, AGT = Agassiz trawl),
3. latitude extended (levels: 65°S, 66°S, 67°S, 71°S, 72°S, 74°S, 75°S) that considered each single degree of latitude sampled,
4. latitude synthetic with broader latitude intervals (levels: B = 65–67°S, R = 71–72°S, T = 74–75°S) to specifically test whether there were differences between the northern Ross Sea (Cape Adare–Cape

Hallett area), the middle Ross Sea (Terra Nova Bay and Cape Russell area) and the outer Ross Sea (Balleny Islands).

The similarity breakdown procedure (SIMPER; Clarke 1993) was used to identify the species responsible for separating the groups highlighted by the ANOSIM.

Diversity indices and species richness estimators

The alpha diversity H' Shannon-Wiener index (ln base) (Shannon & Weaver 1949) and Pielou's J' eveness index (Pielou 1969, 1975) were calculated using Primer 6 (Plymouth Marine Laboratory; Clarke & Warwick 2001). As H' is notoriously sample-size dependent (Clarke & Warwick 2001) and we are comparing no equivalent set of data, we also used the λ Simpson index (Simpson 1949), as a more "robust" diversity measure (Magurran 2004). Their values were calculated for each sampling stations and data were averaged within each group of latitudes, according to the "latitude synthetic" levels; means were then statistically tested with one-way ANOVA. Post-hoc comparisons for unequal number of samples were performed with Tukey HSD, Spjtvoll-Stoline test (Spjotvoll & Stoline 1973) using the software Statistica 5.1.

Cumulative curves were produced with the software EstimateS 7.5 (Colwell 2005), after a 100 computer-generated random sequences (Holme 1953, Karakassis 1995), allowing the calculation of the means of the following estimators of species richness: ACE, ICE, Chao 1, Chao 2, Jack 1, Jack 2 (Burnham & Overton 1978, 1979, Chao 1984, 1987, Smith & van Belle 1984, Chao *et al*. 2000, Chazdon *et al.* 1998).

Results

In total, 247 stations were taken into account, with 2277 specimens corresponding to 142 mollusc species comprising four Polyplacophora, 99 Gastropoda, 37 Bivalvia and two Scaphopoda (Table II). Ten species were exclusively found at the Balleny Islands, 80 at Cape Adare–Cape Hallett, and 14 in Terra Nova Bay–Cape Russell. The new records for the Ross Sea account for about the 20% of the total number of recorded species.

The species richness of the samples was highly variable, with 49 species (34% of the total) found as singletons. The 39% of the stations (92 on the whole), gave single mollusc specimens, leading to very low mean H' values (see below), as already recorded for other Antarctic mollusc assemblages (e.g. Arnaud *et al*. 2001).

Multivariate analysis

The first MDS, performed on the whole dataset with presence-absence data (not shown) (stress 0.01), revealed a heavily clustered group of stations, surrounded by five stations (historical station TNB C25 and *Tangaroa* 2004 stations 19, 78, 178 and 268) characterized by the presence of single species, found only in those stations (*Cuspidaria infelix*, *Doto* sp. nov., *Leucosyrinx badenpowelli*, *Asperiscala eltaninii*, and *Calliotropis antarctica*, respectively).

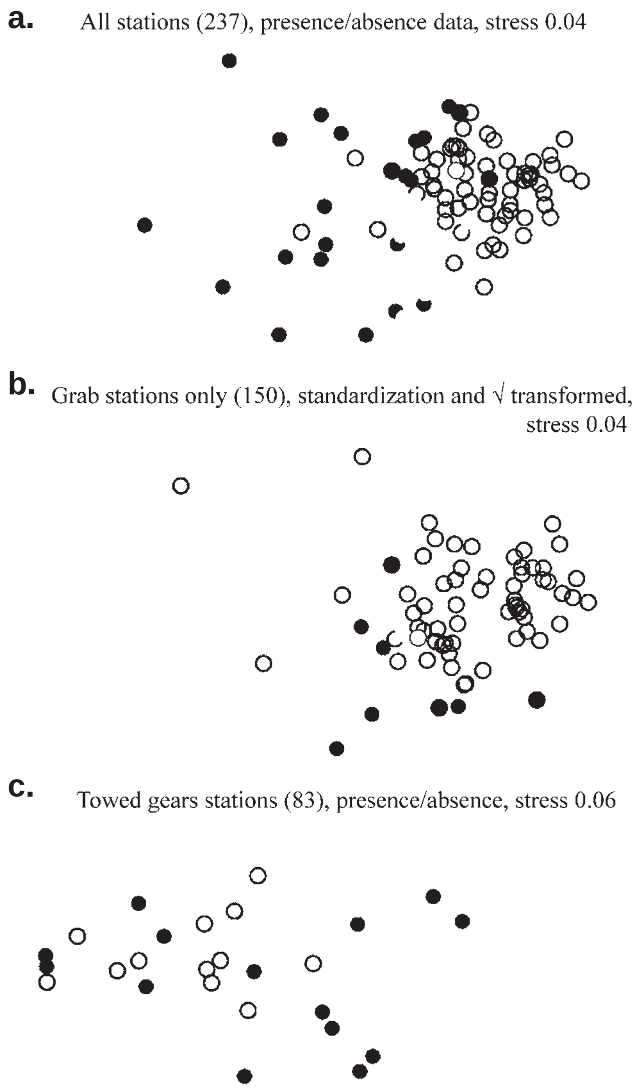

Fig. 1. MDS plots relative to the different mollusc assemblages obtained considering all the stations together, or different subsets sampled with different gears; labels are according to "latitude synthetic" factor levels: open circles = 74–75°S (middle Ross Sea, Terra Nova Bay–Cape Russell area), filled circles = 71–72°S (north Ross Sea, Cape Adare and Cape Hallett area), black circles = 65–67°S (outer Ross Sea, Balleny Islands). **a**. MDS representing all stations sampled with different gears (presence/absence data, stress 0.04). **b**. MDS representing grab stations only (150 stations) (standardized and √ transformed data, stress 0.04). **c**. MDS representing stations investigated with towed gears (grab excluded) (83 stations) (presence/absence data, stress 0.06).

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Table II. Distribution of the species: B = outer Ross Sea (Balleny Islands at 65–67°S), R = north Ross Sea (71–72°S), T = middle Ross Sea (74–75°S), in bracket is reported the number of stations considered at each latitude. Depth: 1 = 0–100 m, 2 = 101–200 m, 3 = 201–300 m, 4 =301–400 m, 5 = 401–500 m, 6 = 501–600 m, 7 > 601 m, in brackets is reported the number of stations considered for each bathymetric interval. The species here reported, refer only to those collected in the framework of this study and do not represent a complete checklist, 'old' Ross Sea records have been excluded. * new record for the Ross Sea.

Distribution			Taxon	Author	Depth						
B (26)	R (108)	T (113)			1 (45)	2 (52)	3 (43)	4 (27)	5 (22)	6 (12)	7 (34)
			Class POLYPLACOPHORA								
			Fam CALLOCHITONIDAE								
	X		**Callochiton bouveti*	Thiele, 1906					X		
	X	X	**Callochiton steinenii*	Pfeffer, 1886		X	X	X	X		X
			Fam LEPIDOPLEURIDAE								
X	X		**Leptochiton kerguelensis*	Haddon, 1886	X				X		X
			Fam CALLISTOPLACIDAE								
	X	X	*Nuttalochiton mirandus*	(Thiele, 1906)		X	X	X	X	X	X
			Class GASTROPODA								
			Fam SCISSURELLIDAE								
	X		*Anatoma euglypta*	(Pelseneer, 1903)		X			X		
			Fam FISSURELLIDAE								
	X		*Puncturella spirigera*	Thiele, 1912					X		X
	X		*Parmophorella mawsoni*	(Powell, 1958)					X	X	X
			Fam TROCHIDAE								
X			**Calliotropis eltanini*	Dell, 1990				X			
X			**Calliotropis antarctica*	Dell, 1990							X
	X		*Falsimargarita gemma*	(Smith, 1915)			X	X			X
	X		*Falsimargarita thielei*	(Hedley, 1916)	X	X					
	X	X	*Antimargarita dulcis*	(Smith, 1907)	X	X	X	X	X		
	X		*Margarites crebrilirulata*	(Smith, 1907)		X					
	X		*Margarites refulgens*	(Smith, 1907)		X	X	X			
			Fam TURBINIDAE								
	X		*Leptocollonia innocens*	(Thiele, 1912)		X	X				
			Fam CYCLOSTREMATIDAE								
	X		**Brookula delli*	Numanami, 1996			X				
			Fam LEPETIDAE								
	X		*Iothia coppingeri*	(Smith, 1881)		X		X			
			Fam LITTORINIDAE								
X	X		*Laevilitorina antarctica*	(Smith, 1912)	X	X					
X			*Pellilitorina setosa*	Smith, 1875	X						
			Fam EATONIELLIDAE								
	X		*Eatoniella* cf. *kerguelensis*	(Smith, 1875)		X					
X		X	*Eatoniella glacialis*	(Smith, 1907)	X						
			Fam RISSOIDAE								
X		X	*Onoba gelida*	(Smith, 1907)	X	X					
X	X		*Onoba kergueleni*	(Smith, 1875)	X	X					
X			*Onoba subantarctica wilkesiana*	(Hedley, 1916)	X						
			Fam CINGULOPSIDAE								
	X		*Skenella paludinoides*	(Smith, 1902)		X					
			Fam CERITHIOPSIDAE								
	X		**Cerithiella "erecta"*	Thiele, 1912					X		
	X		*Krachia antarctica*	(Smith, 1907)		X	X				
	X		**Eumetula strebeli*	(Thiele, 1912)							
			Fam CAPULIDAE								
		X	*Capulus subcompressus*	Pelseneer, 1903		X					
	X		*Torellia antarctica*	(Thiele, 1912)		X					
	X		*Torellia cf. planispira*	(Smith, 1915)		X					
	X		*Torellia exilis*	(Powell, 1958)	X		X				
	X		**Torellia lanata*	Waren, Arnaud & Cantera, 1986	X						
	X		*Torellia smithi*	Waren, Arnaud & Cantera, 1986			X	X			
		X	*Torellia mirabilis*	(Smith, 1907)				X	X		
			Fam EPITONIIDAE								
	X		*Asperiscala eltanini*	Dell, 1990				X			
			Fam EULIMIDAE								
	X		**Melanella antarctica*	(Strebel, 1908)		X					
	X		*Melanella convexa*	(Smith, 1907)			X				

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Table II. (continued) Distribution of the species: B = outer Ross Sea (Balleny Islands at 65–67°S), R = north Ross Sea (71–72°S), T = middle Ross Sea (74–75°S), in bracket is reported the number of stations considered at each latitude. Depth: 1 = 0–100 m, 2 = 101–200 m, 3 = 201–300 m, 4 =301–400 m, 5 = 401–500 m, 6 = 501–600 m, 7 > 601 m, in brackets is reported the number of stations considered for each bathymetric interval. The species here reported, refer only to those collected in the framework of this study and do not represent a complete checklist, 'old' Ross Sea records have been excluded. * new record for the Ross Sea.

Distribution			Taxon	Author	Depth						
B (26)	R (108)	T (113)			1 (45)	2 (52)	3 (43)	4 (27)	5 (22)	6 (12)	7 (34)
	X		_Melanella_ sp.				X				
	X		_Hemiaclis_ cf. _incolorata_	(Thiele, 1912)			X				
			Fam NATICIDAE								
	X		*_Amauropsis anderssoni_	(Strebel, 1906)		X					
	X		_Amauropsis rossiana_	Smith, 1907			X	X	X		
	X		*_Falsilunatia falklandica_	(Preston, 1913)						X	
X	X	X	_Kerguelenatica bioperculata_	Martens, 1878	X	X		X	X		
	X		_Sinuber microstriatum_	Dell, 1990			X	X	X		
			Fam LAMELLARIIDAE								
	X		_Marseniopsis mollis_	(Smith, 1902)			X	X	X		
X	X		_Marseniopsis conica_	(Smith, 1912)	X	X					
X	X		*_Marseniopsis_ cf. _spherica_	Numanami, 1996	X	X					
X	X		*_Marseniopsis_ cf. _syowaensis_	Numanami & Okutani, 1991			X	X			
	X		_Marseniopsis_ sp				X				
			Fam BUCCINIDAE								
	X		BUCCINIDAE ind			X	X	X	X	X	
	X		_Antarctoneptunea aurora_	(Hedley, 1916)	X	X	X	X	X		
	X		*_Probuccinum costatum_	Thiele, 1912			X	X			
X			_Probuccinum tenerum_	(Smith, 1907)		X					
	X	X	_Probuccinum tenuistriatum_	Hedley, 1916	X		X	X	X	X	
	X		_Prosipho cancellatus_	Smith, 1915			X				
	X		_Prosipho cf mundus_	Smith, 1915		X	X				
	X		_Prosipho contrarius_	Thiele, 1912		X					
	X		*_Prosipho crassicostatus_	Melvill & Standen, 1907							X
	X		*_Prosipho glacialis_	Thiele, 1912		X					
	X		_Prosipho hunteri_	Hedley, 1916					X		
	X		_Prosipho pusillus_	Thiele, 1912			X				
	X		_Prosipho spiralis_	Thiele, 1912							X
	X		_Chlanidota cf vestita_	Martens, 1878	X						
X	X		*_Chlanidota lamyi_	Dell, 1990		X	X	X		X	X
X	X		_Neobuccinum eatoni_	(Smith, 1875)	X	X	X				
	X		_Pareuthria innocens_	(Smith, 1907)			X				
	X		_Pareuthria plicatula_	Thiele, 1912		X	X	X			
	X		_Meteuthria multituberculata rossiana_	Dell, 1990			X				
			Fam MURICIDAE								
	X		_Trophon coulmanensis_	Smith, 1907				X			
	X		_Trophon minutus_	Strebel, 1907		X	X				
	X		_Trophon scotianus_	Powell, 1951			X				
	X		_Trophon shackletoni shackletoni_	Hedley, 1911		X	X		X		
			Fam CANCELLARIIDAE								
	X		*_Admete haini_	Numanami, 1996	X						
X			_Nothoadmete antarctica_	(Strebel, 1908)			X				
			Fam VOLUTIDAE								
	X		*_Harpovoluta charcoti_	(Lamy, 1910)		X		X	X	X	X
			Fam. VOLUTOMITRIDAE								
X	X		_Paradmete cf fragillima_	(Watson, 1882)		X	X	X	X	X	
			Fam MARGINELLIDAE								
	X		*_Marginella ealesae_	Powell, 1958			X		X		
	X		_Marginella hyalina_	Thiele, 1912		X	X		X	X	
			Fam TURRIDAE								
	X		TURRIDAE sp. A	Powell, 1942			X				
		X	_Belalora striatula_	(Thiele, 1912)	X						
	X		*_Belaturricula turrita turrita_	Dell, 1990					X		
	X		_Leucosyrinx badenpowelli_	Dell, 1990					X		
	X		_Typhlodaphne innocentia_	Dell, 1990			X	X			
	X		*_Lorabela pelseneri_	(Strebel, 1908)			X				

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Distribution					Depth						
B (26)	R (108)	T (113)	Taxon	Author	1 (45)	2 (52)	3 (43)	4 (27)	5 (22)	6 (12)	7 (34)
	X		**Belaturricula ergata*	Hedley, 1916					X	X	
			Fam MATHILDIDAE								
	X		*Turritellopsis latior*	Thiele, 1912		X					
			Fam DIAPHANIDAE								
	X		*Toledonia* sp. A				X				
	X		*Toledonia* sp. B				X				
	X		*Toledonia major*	(Hedley, 1911)	X	X		X			
	X		**Toledonia* aff. *perplexa*	Dall, 1902			X				
	X		*Toledonia striata*	Thiele, 1912		X					
	X		*Newnesia antarctica*	Smith, 1902			X				
			Fam CYLICHNIDAE								
X	X		*Cylichna gelida*	(Smith, 1907)							X
			Fam PLEUROBRANCHIDAE								
	X		*Bathyberthella* sp 1								X
	X		**Bathyberthella antarctica*	Willan & Bertsch, 1987				X	X		
	X		*Bathyberthella* sp 2						X		
			Fam BATHYDORIDIDAE								
	X		*Bathydoris clavigera*	Thiele, 1912				X	X		
			Fam DOTIDAE								
	X		**Doto antarctica*	Eliot, 1907		X			X		
	X		*Doto* sp. nov.						X		
			Fam TRITONIIDAE								
X	X		*Tritonia challengeriana*	Eliot, 1907	X	X	X			X	
			Fam AEGIRETIDAE								
	X		*Aegires albus*	Thiele, 1912	X	X	X				
			Fam DORIDAE								
X	X		*Austrodoris kerguelenensis*	Bergh, 1884		X	X	X	X	X	X
			Class BIVALVIA								
			Fam SAREPTIDAE								
		X	*Yoldia eightsi*	(Couthouy, in Jay, 1839)	X	X					
X	X	X	*Yoldiella antarctica*	Thiele, 1912	X	X			X		X
		X	*Yoldiella ecaudata*	(Pelseneer, 1903)	X	X	X		X	X	X
		X	*Yoldiella oblonga*	Pelseneer, 1903		X					
			Fam SILICULIDAE								
		X	*Propeleda longicaudata*	Thiele, 1912							X
		X	*Silicula rouchi*	Lamy, 1911			X				
			Fam NUCULANIDAE								
		X	*Nuculana inaequisculpta*	Lamy, 1906							X
			Fam ARCIDAE								
X			*Bathyarca sinuata*	Pelseneer, 1903							X
			Fam LIMOPSIDAE								
	X		*Limopsis lilliei*	Smith, 1915			X	X		X	
X	X		*Limopsis marionensis*	Smith, 1885		X	X	X	X	X	
			Fam PHILOBRYIDAE								
	X	X	*Philobrya sublaevis*	Pelseneer, 1903		X	X		X		
	X	X	*Philobrya wandelensis*	Lamy, 1906		X	X	X	X	X	
X	X		*Lissarca notorcardensis*	Melvill & Standen, 1907	X	X	X	X			X
	X		*Adacnarca limopsoides*	(Thiele, 1912)					X		
X	X	X	*Adacnarca nitens*	Pelseneer, 1903		X	X	X	X		X
			Fam MYTILIDAE								
	X		*Dacrydium albidum*	Pelseneer, 1903		X					
			Fam PECTINIDAE								
	X	X	*Adamussium colbecki*	Smith, 1902	X	X					
			Fam LIMIDAE								
	X	X	*Limatula hodgsoni*	(Smith, 1907)		X	X	X	X		
	X		*Limatula simillima*	Thiele, 1912		X		X			

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Distribution					Depth						
B (26)	R (108)	T (113)	Taxon	Author	1 (45)	2 (52)	3 (43)	4 (27)	5 (22)	6 (12)	7 (34)
			Fam KELLIIDAE								
X	X		*Pseudokellia gradata*	Thiele, 1912	X		X				
		X	*Pseudokellia cardiformis*	(Smith, 1885)		X	X	X	X		
			Fam MONTACUTIDAE								
		X	*Montacuta nimrodiana*	Hedley, 1911	X	X	X				
X	X	X	*Mysella* cf. *charcoti*	(Lamy, 1906)	X	X	X				X
	X	X	*Mysella gibbosa*	(Thiele, 1912)	X	X					X
			Superfam GALEOMMATOIDEA								
		X	*Waldo parasiticus*	(Dall, 1876)	X	X					
			Fam CYAMIIDAE								
	X		*Cyamiomactra laminifera*	(Lamy, 1906)		X	X	X			
			Fam THYASIRIDAE								
X		X	*Thyasira dearboni*	Nicol, 1965	X		X	X		X	X
X	X	X	*Genaxinus debilis*	(Thiele, 1912)	X	X	X	X	X	X	X
	X		**Genaxinus cf. bongraini*	Lamy, 1910					X		
			Fam ASTARTIDAE								
X	X		*Astarte longirostris*	Orbigny, 1846		X	X		X		X
			Fam CARDITIDAE								
X	X	X	*Cyclocardia astartoides*	(Martens, 1878)	X	X	X	X			X
			Fam LATERNULIDAE								
	X	X	*Laternula elliptica*	(King & Broderip, 1831)	X	X	X				
			Fam LYONSIIDAE								
	X	X	*Lyonsia arcaeformis*	Martens, 1885		X			X		
			Fam THRACIIDAE								
X	X	X	*Thracia meridionalis*	Smith, 1885	X	X	X	X			
			Fam CUSPIDARIIDAE								
		X	*Cuspidaria infelix*	Thiele, 1912	X						
		X	*Cuspidaria tenella*	Smith, 1907						X	X
X		X	*Subcuspidaria kerguelensis*	Smith, 1885	X						
			Class SCAPHOPODA								
			Fam DENTALIIDAE								
X			*Dentalium majorinum*	Mabille & Rochebrune, 1889			X	X		X	X
			Fam GADILIDAE								
X			*Siphonodentalium dalli antarcticus*	(Odhner, 1931)				X			X

After the removal of these stations from the dataset, the MDS plot gave a clearer representation (Fig. 1a, stress 0.04), clearly dividing those stations along the Victoria Land coast into two groups, corresponding to 71–71°S (filled circles) and 74–75°S (open circles). Only stations around the Balleny Islands appear to be dispersed within the two groups (black circles).

ANOSIM values for "extended" and "synthetic latitude" factors (Table III) indicate that there are differences between latitudes. Pair-wise comparisons indicate significant differences between 74°S (T) and the Balleny Islands (B), and between 71–72°S (Cape Adare–Cape Hallett, R) and all the other latitudes, except 65°S (Balleny Seamount stations).

The factor "depth" has been tested with two-way crossed ANOSIM, on the same dataset, to evaluate differences existing between levels of the factor "latitude synthetic" averaged across all depth groups and for differences between levels of the factor "depth" averaged across all "latitude synthetic" groups.

In the first test, latitudinal groups are still well separated, although B and R only with a 0.2% of significance (Table IV). The analysis for factor "depth" showed a general dissimilarity between groups (Table V) with shallower depths (level 1 = 0–100 m) clearly different from the other depths; stations below 400 m cannot be distinguished.

Table VI shows the species most responsible for similarities at each latitude group, as output of the 2-way SIMPER analysis for factor "latitude synthetic" groups averaged across all depth groups, are reported.

Table VII shows the species most responsible for similarities within each depth group as output of the 1-way SIMPER analysis for factor "depth".

Table III. One-way ANOSIM values (global R and pairwise tests) relative to the MDS with all species (presence/absence data) for differences between levels of the factors latitude, "extended" and "synthetic". Codes: B = outer Ross Sea (Balleny Islands: 65–67°S), R = north Ross Sea (Cape Adare and Cape Hallett: 71–72°S), T = middle Ross Sea (Terra Nova Bay and Cape Russell: 74–75°S).

	R	Sign. (%)
Factor Latitude Synthetic		
Global R	0.18	0.1
Pairwise test		
R, B	0.09	0.1
R, T	0.193	0.1
B, T	0.203	0.1
Factor Latitude Extended		
Global R	0.179	0.1
Pairwise test		
65, 74	0.221	0.1
66, 74	0.221	0.1
67, 74	0.247	0.1
71, 67	0.096	0.1
71, 74	0.223	0.1
71, 75	0.162	0.1
72, 66	0.176	0.1
72, 67	0.199	0.1
72, 74	0.227	0.1
72, 75	0.223	0.1
71, 66	0.104	0.2
67, 65	0.187	0.3
67, 75	0.28	0.3
65, 75	0.362	0.3
66, 75	0.269	0.7
66, 65	0.149	1.5
74, 75	0.061	3.1
71, 72	0.027	3.4
71, 65	0.07	4.4
72, 65	-0.001	47
67, 66	-0.026	62.3

The ANOSIM analysis, carried out on the whole dataset testing the factor "gear", showed differences between the gears used (global R = 0.059, significance 0.1%), mainly between grab vs dredge (R = 0.061, 0.1%) and grab vs ORH trawl (R = 0.084, 0.1%). Considering these differences, we analysed the grab samples separately from the other gears.

Table IV. Two-way crossed ANOSIM values (global R and pairwise tests) relative to the MDS with all species (PRES/ABS data) for differences between levels of the factor "latitude synthetic" averaged across all "depth" groups. Codes: B = outer Ross Sea (Balleny Islands: 65–67°S), R = north Ross Sea (Cape Adare and Cape Hallett: 71–72°S), T = middle Ross Sea (Terra Nova Bay–Cape Russell: 74–75°S).

	R	Sign. (%)
(Global R)	0.419	0.1%
Pairwise tests		
R, B	0.143	0.2
R, T	0.386	0.1
B, T	0.493	0.1

Table V. Two-way crossed ANOSIM values (global R and pairwise tests) relative to the MDS with all species (PRES/ABS data) for differences between levels of the factor "depth" averaged across all "latitude synthetic" groups.

	R	Sign. (%)
(Global R)	0.273	0.1
Pairwise tests		
7, 2	0.213	0.1
7, 1	0.654	0.1
6, 1	0.699	0.1
5, 1	0.586	0.1
2, 1	0.305	0.1
4, 1	0.626	0.1
3, 1	0.465	0.1
7, 3	0.111	0.4
2, 3	0.073	0.7
5, 3	0.066	2.8
7, 5	0.158	4.2
7, 4	0.109	4.7
6, 3	0.093	5.7
4, 3	0.048	7
2, 4	0.066	9.3
5, 2	0.073	14.4
6, 2	0.068	14.9
7, 6	0.103	15.6
6, 4	-0.033	76.8
6, 5	-0.032	79
5, 4	-0.031	88.4

The MDS performed on grab samples only (not shows) (stress 0.01) gave a heavily clustered group of stations, surrounded by two stations (*Tangaroa* 2004 Station 3 and the historical station C25) whose peculiarity was the presence of single specimens (*Falsimargarita gemma* and *Cuspidaria infelix* respectively). After the removal of these two anomalous stations, we obtained a clearer MDS (stress 0.04) (Fig. 1b). The ANOSIM performed for the factor "latitude synthetic" provided evidence that the more southern stations 74–75°S (T) are different from the Cape Adare–Cape Hallett area (R) and the Balleny Islands (B). Conversely, the last do not differ much from Cape Adare–Cape Hallett area (Table VIII).

We also performed an analysis of samples obtained with towed gears, excluding grab ones, on presence/absence data. The first MDS relative to this dataset (not reported) (stress 0.01) gave a heavily clustered group of stations, surrounded by seven stations (*Tangaroa* 2004 stations 19, 78, 178, 214, 257, 268 and historical station H2D), whose peculiarity was the presence of single species (*Doto* sp., *Leucosyrinx badenpowelli*, *Asperiscala eltaninii*, *Bathyberthella* sp. 1 and sp. 2, *Leptochiton kerguelensis*, *Calliotropis antarctica* and *Yoldia eightsi*, respectively). After the removal of these stations, the MDS plot (Fig. 1c, stress 0.06) gave a clearer representation of the mollusc assemblies sampled with gears different from the grab. The ANOSIM showed, for the factor "latitude synthetic", differences between the different latitudinal groups (Table IX).

Table VI. Two-ways SIMPER analysis for factor "latitude synthetic" groups averaged across all "depth" groups (cumulative percentages cut off at 90%).

Species	Av. abund.	Av. sim.	Sim/ SD	Contrib. %	Cum. %
Group B (Average similarity: 7)					
Thracia meridionalis	0.13	2.52	0.25	36.03	36.03
Leptochiton kerguelensis	0.08	0.85	0.15	12.16	48.19
Limopsis marionensis	0.13	0.85	0.15	12.16	60.35
Neobuccinum eatoni	0.17	0.85	0.15	12.16	72.50
Tritonia challengeriana	0.08	0.71	0.15	10.13	82.63
Siphonodentalium dalli antarcticus	0.13	0.61	0.15	8.68	91.32
Group R (Average similarity: 6.49)					
Nuttalochiton mirandus	0.18	1.07	0.18	16.58	16.58
Cyclocardia astartoides	0.19	1.06	0.20	16.40	32.98
Antarctoneptunea aurora	0.13	0.74	0.14	11.41	44.39
Trophon shackletoni shackletoni	0.07	0.48	0.10	7.42	51.81
Antimargarita dulcis	0.11	0.48	0.13	7.35	59.16
Limopsis marionensis	0.12	0.34	0.11	5.20	64.36
Harpovoluta charcoti	0.09	0.31	0.07	4.84	69.20
Callochiton steinenii	0.07	0.25	0.06	3.82	73.02
Lissarca notorcardensis	0.10	0.25	0.11	3.78	76.80
Astarte longirostris	0.07	0.24	0.08	3.70	80.50
Margarites refulgens	0.08	0.14	0.09	2.20	82.71
Bathydoris clavigera	0.04	0.14	0.06	2.17	84.87
Marseniopsis sp	0.03	0.12	0.06	1.93	86.80
Philobrya wandelensis	0.05	0.11	0.06	1.73	88.53
Paradmete cf *fragillima*	0.08	0.09	0.08	1.40	89.93
Chlanidota lamyi	0.08	0.08	0.06	1.28	91.20
Group T (Average similarity: 31.48)					
Adamussium colbecki	0.29	14.21	0.53	45.14	45.14
Waldo parasiticus	0.16	3.17	0.33	10.06	55.20
Genaxinus debilis	0.29	3.16	0.27	10.03	65.23
Montacuta nimrodiana	0.16	2.87	0.31	9.12	74.35
Yoldia eightsi	0.15	2.06	0.21	6.56	80.91
Pseudokellia cardiformis	0.15	1.78	0.20	5.67	86.58
Thyasira dearboni	0.14	1.31	0.16	4.16	90.74

The SIMPER cumulative percentage similarities of species contributing to the similarity of grab samples and of towed gear, are reported in Tables X & XI. The species that most contribute to the SIMPER overall similarity within the different latitudinal groups are reported in Tables XII & XIII.

Species richness and its estimators

The mean values of the diversity indices as the "H" Shannon-Wiener diversity index (ln base) and the λ Simpson index, tested with the ANOVA (Table XIV), indicate that there are differences, with Cape Adare–Cape Hallett area, clearly showing a higher diversity (an higher H' and a lower λ value; Fig. 2a & c respectively) than the two other areas. Post-hoc comparisons (not shown) indicate that, both for H' and λ values, differences ($P < 0.001$) exist between Cape Adare–Cape Hallett vs Terra Nova Bay–Cape Russell, but the Balleny Islands do not differ statistically from the previous two. The equitability, expressed by the Pielou's J' index, did not show significant differences

Table VII. 1-way SIMPER analysis for factor "depth": species contributing to similarities between "depth" groups. (cumulative percentages cut off at 90%).

Species	Av.abund	Av.sim	Contrib%	Cum.%
Depth 0–100 (Average similarity: 31.13)				
Adamussium colbecki	0.64	19.86	63.79	63.79
Waldo parasiticus	0.39	4.34	13.95	77.75
Montacuta nimrodiana	0.36	3.94	12.64	90.39
Depth 101–200 (Average similarity: 5.53)				
Pseudokellia cardiformis	0.21	1.68	30.34	30.34
Cyclocardia astartoides	0.19	0.85	15.34	45.67
Yoldia eightsi	0.12	0.75	13.49	59.17
Genaxinus debilis	0.13	0.51	9.24	68.41
Adamussium colbecki	0.1	0.3	5.5	73.9
Antimargarita dulcis	0.1	0.21	3.78	77.68
Limopsis marionensis	0.1	0.2	3.68	81.36
Philobrya sublaevis	0.06	0.14	2.5	83.87
Astarte longirostris	0.08	0.14	2.45	86.31
Philobrya wandelensis	0.06	0.13	2.27	88.59
Chlanidota lamyi	0.06	0.09	1.62	90.21
Depth 201–300 (Average similarity: 6.02)				
Genaxinus debilis	0.19	1.23	20.41	20.41
Thyasira dearboni	0.14	0.87	14.41	34.82
Adacnarca nitens	0.14	0.68	11.3	46.12
Nuttalochiton mirandus	0.19	0.66	10.98	57.1
Antarctoneptunea aurora	0.16	0.59	9.78	66.88
Cyclocardia astartoides	0.16	0.43	7.19	74.07
Trophon shackletoni shackletoni	0.12	0.43	7.14	81.21
Limopsis marionensis	0.09	0.16	2.7	83.91
Lissarca notorcardensis	0.12	0.16	2.7	86.61
Laternula elliptica	0.09	0.16	2.61	89.22
Marseniopsis sp	0.07	0.11	1.85	91.07
Depth 301–400 (Average similarity: 4.34)				
Genaxinus debilis	0.19	1.55	35.8	35.8
Callochiton steinenii	0.11	0.41	9.49	45.28
Nuttalochiton mirandus	0.15	0.4	9.31	54.59
Thracia meridionalis	0.11	0.34	7.79	62.38
Harpovoluta charcoti	0.11	0.32	7.44	69.83
Limopsis marionensis	0.11	0.29	6.69	76.52
Thyasira dearboni	0.11	0.26	5.94	82.46
Philobrya wandelensis	0.11	0.26	5.94	88.4
Antarctoneptunea aurora	0.07	0.11	2.63	91.03
Depth 401–500 (Average similarity: 3.91)				
Callochiton steinenii	0.2	1.38	35.39	35.39
Nuttalochiton mirandus	0.2	1.14	29.25	64.64
Bathydoris clavigera	0.15	0.6	15.27	79.91
Limopsis marionensis	0.1	0.21	5.39	85.3
Genaxinus cf. bongraini	0.1	0.15	3.85	89.15
Marginella ealesae	0.1	0.13	3.37	92.51
Depth 501–600 (Average similarity: 2.71)				
Falsilunatia falklandica	0.15	0.51	18.9	18.9
Harpovoluta charcoti	0.15	0.51	18.9	37.8
Thyasira dearboni	0.15	0.51	18.9	56.69
Genaxinus debilis	0.15	0.43	15.75	72.44
Yoldiella ecaudata	0.15	0.43	15.75	88.19
Nuttalochiton mirandus	0.15	0.32	11.81	100
Depth > 600 (Average similarity: 11.33)				
Genaxinus debilis	0.36	4.79	42.31	42.31
Thyasira dearboni	0.27	3.09	27.26	69.57
Yoldiella ecaudata	0.24	1.65	14.57	84.14
Adacnarca nitens	0.15	0.73	6.43	90.56

Table VIII. SIMPER for factor "gear" (grab only) on presence/absence data of the complete dataset (cumulative percentage values cut off at 80%).

Group GVVL (Average similarity: 7.37)					
Species	Av.abund	Av.sim	Sim/SD	Contrib%	Cum.%
Adamussium colbecki	0.21	2.20	0.19	29.90	29.90
Genaxinus debilis	0.20	1.52	0.18	20.60	50.50
Yoldia eightsi	0.11	0.52	0.10	7.00	57.50
Thyasira dearboni	0.11	0.47	0.10	6.43	63.93
Waldo parasiticus	0.12	0.46	0.11	6.20	70.13
Montacuta nimrodiana	0.12	0.45	0.11	6.05	76.17

Table IX. SIMPER for factor "gear" (towed gears only) on presence/absence data of the complete dataset (cumulative percentage values cut off at 80%).

Group DREDGE (Average similarity: 3.06)					
Species	Av.abund	Av.sim	Sim/SD	Contrib%	Cum.%
Cyclocardia astartoides	0.16	0.54	0.14	17.60	17.60
Genaxinus debilis	0.11	0.36	0.10	11.92	29.52
Adacnarca nitens	0.08	0.31	0.07	10.26	39.79
Antarctoneptunea aurora	0.08	0.30	0.07	9.76	49.55
Harpovoluta charcoti	0.08	0.28	0.07	9.20	58.74
Nuttalochiton mirandus	0.07	0.11	0.05	3.51	62.26
Antimargarita dulcis	0.08	0.10	0.07	3.30	65.56
Marseniopsis cf. *syowaensis*	0.05	0.09	0.04	2.98	68.53

Table X. One-way ANOSIM values (global R and pairwise tests) relative to the MDS of grab stations only (standardization and square root transformation) for the factor "latitude synthetic". Codes: B = outer Ross Sea (Balleny Islands: 65–67°S), R = north Ross Sea (Cape Adare and Cape Hallett: 71–72°S), T = middle Ross Sea (Terra Nova Bay–Cape Russell: 74–75°S).

	R	Sign. (%)
Factor Latitude Synthetic		
Global R	0.201	0.1
Pairwise test		
R, B	0.096	2.9
R, T	0.217	0.1
B, T	0.15	0.1

Table XI. One-way ANOSIM values (global R and pairwise tests) relative to the MDS of all stations (grab samples excluded) (presence/absence data) for the factor "latitude synthetic". Codes: B = outer Ross Sea (Balleny Islands: 65–67°S), R = north Ross Sea (Cape Adare and Cape Hallett: 71–72°S), T = middle Ross Sea (Terra Nova Bay–Cape Russell: 74–75°S).

	R	Sign. (%)
Factor Latitude Synthetic		
Global R	0.156	0.1
Pairwise test		
R, B	0.133	0.1
R, T	0.178	0.1
B, T	0.207	0.1

Table XII. SIMPER analysis for grab stations only on standardized and √transformed data (cumulative percentage values cut off at 80%). Bold indicates species also collected at the same latitudes with towed gears (Table XIII). Codes: B = outer Ross Sea (Balleny Islands: 65–67°S), R = north Ross Sea (Cape Adare and Cape Hallett: 71–72°S), T =middle Ross Sea (Terra Nova Bay and Cape Russell: 74–75°S).

Species	Av.abund	Av.sim	Sim/SD	Contrib%	Cum.%
Group B (65–67°S) (Average similarity: 5.37)					
Thyasira dearboni	2.52	3.01	0.23	56.12	56.12
Thracia meridionalis	1.67	0.93	0.19	17.39	73.51
Group R (71–72°S) (Average similarity: 4.91)					
Limopsis marionensis	1.24	0.94	0.15	19.22	19.22
Cyclocardia astartoides	1.17	0.89	0.18	18.16	37.38
Callochiton steinenii	1.04	0.68	0.12	13.76	51.14
Astarte longirostris	0.91	0.48	0.12	9.69	60.83
Philobrya wandelensis	0.81	0.41	0.09	8.29	69.12
Genaxinus debilis	0.80	0.32	0.07	6.59	75.71
Group T (74–75°S) (Average similarity: 12.64)					
Adamussium colbecki	2.12	3.83	0.24	30.30	30.30
Genaxinus debilis	2.09	3.34	0.26	26.44	56.73
Pseudokellia cardiformis	1.26	1.21	0.14	9.61	66.34
Yoldia eightsi	1.25	1.11	0.15	8.81	75.15

Table XIII. SIMPER analysis for towed gears stations (grab samples excluded, towed gears only) on presence/absence data (cut off for low contributions: 90%). Bold indicates species also collected at the same latitudes in the grab samples (Table XII).

Species	Av. abund.	Av. sim.	Sim/SD	Contrib. %	Cum. %
Group B (65–67°S) (Average similarity: 6.09)					
Thyasira dearboni	0.21	1.54	0.18	25.25	25.25
Limopsis marionensis	0.21	1.43	0.18	23.45	48.70
Dentalium majorinum	0.21	1.05	0.18	17.24	65.94
Neobuccinum eatoni	0.21	1.03	0.18	16.88	82.82
Marseniopsis cf. *syowaensis*	0.14	0.37	0.10	6.01	88.83
Tritonia challengeriana	0.14	0.37	0.10	6.01	94.85
Group R (71–72°S) (Average similarity: 7.54)					
Nuttalochiton mirandus	0.28	2.26	0.24	30.01	30.01
Antarctoneptunea aurora	0.22	1.34	0.19	17.72	47.73
Harpovoluta charcoti	0.13	0.92	0.12	12.21	59.94
Cyclocardia astartoides	0.15	0.46	0.13	6.16	66.11
Lissarca notorcardensis	0.15	0.44	0.13	5.85	71.96
Antimargarita dulcis	0.15	0.43	0.13	5.69	77.64
Trophon shackletoni shackletoni	0.10	0.27	0.09	3.61	81.25
Chlanidota lamyi	0.10	0.24	0.09	3.21	84.46
Limopsis marionensis	0.10	0.20	0.09	2.60	87.06
Austrodoris kerguelensis	0.07	0.13	0.05	1.74	88.81
Bathydoris clavigera	0.07	0.12	0.06	1.65	90.45
Group T (74–75°S) (Average similarity: 15.26)					
Adacnarca nitens	0.42	4.11	0.39	26.96	26.96
Genaxinus debilis	0.42	3.52	0.41	23.03	49.99
Thyasira dearboni	0.33	2.83	0.30	18.53	68.52
Yoldiella ecaudata	0.33	1.93	0.31	12.67	81.19
Limatula hodgsoni	0.25	0.89	0.21	5.81	87.01
Philobrya sublaevis	0.17	0.51	0.12	3.31	90.32

Table XIV. Analysis of variance testing for differences in the means of the values of the diversity indices H', J' and λ.

Index	df	MS	F	p-level	Prob	Cochran's test
H'	2	0.68342	5.42	0.005	$P < 0.01$	ln (x+1)
J'	2	3104.447	1.27	0.281	n.s.	n.s.
λ	2	0.502741	5.94	0.003	$P < 0.01$	n.s.

between Cape Adare–Cape Hallett, Terra Nova Bay–Cape Russell and the Balleny Islands (Table XIV) and the means are between 0.77 and 0.89 (Fig. 2b).

The values of selected estimators of species richness are reported in Table XV. In the graphs with the accumulation curves divided per latitudinal groups (Fig. 3), only ICE, Chao 2 and Jack 2 were plotted, since they are known (at least the first two) to give a better performance at moderate levels of patchiness (Magurran 2004). In fact, all these estimators are sensitive to patchiness and could be biased toward overestimation when used to compare assemblages along wide ecological gradients (Magurran 2004).

The area of Terra Nova Bay–Cape Russell (74–75°S) appears to have been exhaustively sampled (Fig. 3a), having an observed value of 37 and an expected one of 43 species. However, considering also the more shallow stations, sampled by SCUBA diving or by other means, (excluded by the present count), the number of known species from this area is up to 56 (see Cattaneo-Vietti *et al*. 2000).

At the Cape Adare–Cape Hallett area the collector's accumulation curve has still to reach the asymptote (Fig. 3b): here 'only' 116 species have been found, but up to 177 can be expected as more samples are collected. The Balleny Islands (65–67°S), although not satisfactorily sampled (only 25 stations have been investigated), already show values of diversity comparable with Terra Nova ones: here, 106 species can be expected against an observed number of 38 species (Fig. 3c).

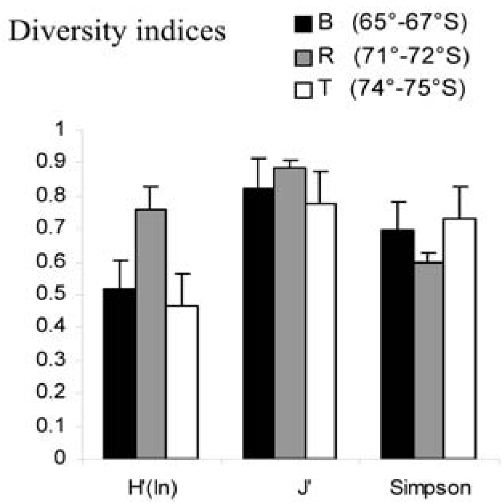

Fig. 2. Histograms (means ± SE) relative to diversity and equitability indices for the different latitudinal groups - H' Shannon-Wiener index (ln base), Pielou's J' index, and Simpson's λ index.

Discussion

The 142 living species used in the multivariate analysis, represent the 74% of the species cited by Dell (1990) for the Ross Sea area, or the 52% of a more recent estimate for the same area (Bradford-Grieve & Fenwick 2001). However,

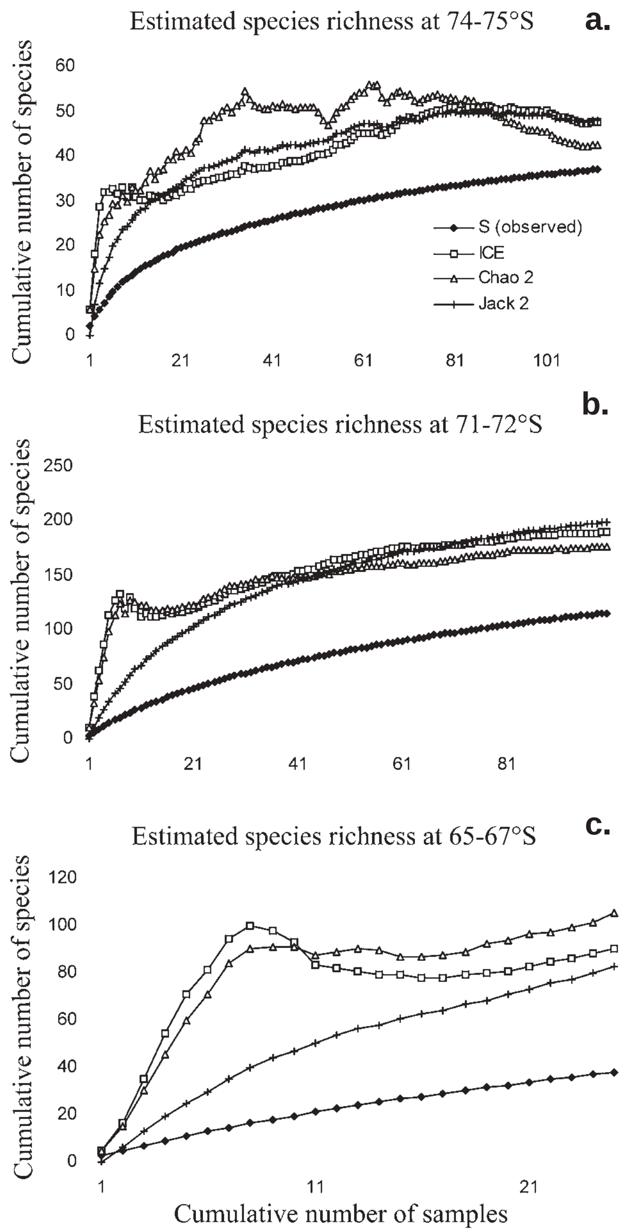

Fig. 3. Cumulative curves for S (observed) and ICE, Chao 2, Jack 2 estimators of species richness for the different latitudinal groups. **a**. For 74–75°S (Terra Nova Bay and Cape Russell area). **b**. For 71–72°S (Cape Adare and Cape Hallett area). **c**. For 65–67°S (Balleny Islands).

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Table XV. Estimated species richness at different latitudes according to the different estimators: ACE, ICE, Chao 1, Chao 2, Jack 1, Jack 2 (Burnham & Overton 1978, 1979, Chao 1984, 1987, Smith & van Belle 1984, Chazdon *et al.* 1998, Chao *et al.* 2000).

Lat. S	Stations	Individuals	S (obs.)	ACE	ICE	Chao 1	Chao 2	Jack 1	Jack 2
65–67°	25	286	38	65.02	90.55	92	105.6	62.96	82.47
71–72°	100	651	116	176.51	189.71	181.79	176.75	169.46	199.1
74–75°	112	1372	37	45.72	47.48	47	42.56	46.91	47.97

the total of species given by Dell (1990) and Bradford-Grieve & Fenwick (2001), also take into account rare species, some which were not found alive but only in thanatocoenoses (dead assemblages). There is some uncertainty for the classification of a few species from our dataset, whose taxonomic status needs further study, but it is possible to estimate in about 20% the number of new records of molluscs found in the Ross Sea.

Given the above, it appears clear that the present knowledge of the Ross Sea mollusc fauna is still not sufficient to permit a direct comparison with the better studied areas of the Weddell Sea and the Antarctic Peninsula. It is also not easy to assess the real number of living species in the Ross Sea, as many of the old records need to be carefully checked and their status, living vs not living, assessed.

Multivariate analyses reveal that the mollusc assemblages from the Balleny Islands, Cape Adare–Cape Hallett area and Terra Nova Bay–Cape Russell can be clearly distinguished on a statistical basis. These differences appear to be robust, as the outcomes of the ANOSIM analysis are almost the same, either considering the whole dataset (qualitative approach: presence/absence data; Table IV), or distinguishing the sampling techniques and considering grab samples alone (quantitative approach: standardization and √ transformed data; Table VIII), or samples collected with towed gears (dredge, trawl and beam trawl) (qualitative approach: presence/absence data; Table IX).

Most new records were provided by the dredge. Some of these are remarkable, since they are macroscopic species (2–5 cm), such as *Falsilunatia falklandica* or *Amauropsis anderssoni*, that could not have been overlooked during previous expeditions. This implies that the Victoria Land stretch of coast is still to be more carefully sampled and it appears that the differentiation of sampling techniques is a key factor in the success of sampling. Other new records belong to small (~1 cm) epibenthic species (as *Calliotropis antarctica* and *C. eltaninii*, *Doto antarctica* and *Doto* sp., *Marseniopsis* cf. *sphaerica* and *M.* cf. *syowaensis*, *Pellilittorina setosa* and *Callochiton bouveti*) that are very difficult to obtain by using the grab. Only a few, almost ubiquitous and eurybathic species, *Thyasira dearborni*, *Limopsis marionensis*, *Cyclocardia astartoides* and *Genaxinus debilis* (reported in bold in Tables XII & XIII) were always present in the biological material obtained employing the different gears. It is worth noting that small sized, mud-loving infaunal molluscs do not differ much in grab samples between the Balleny Islands and Terra Nova Bay–Cape Russell (Table VIII).

Considering the Victoria Land latitudinal gradient, we found that mollusc richness is higher at 71–72°S (Cape Hallett–Cape Adare) and lower at 74–75°S (Terra Nova Bay–Cape Russell). This has been shown by Shannon-Wiener's H' and Simpson's λ indices (Table XIV). The Balleny Islands (65–67°S), although not exhaustively sampled, already show diversity values comparable to Terra Nova Bay–Cape Russell. Nonparametric species richness estimators (e.g. Chao 2, Table XV and Fig. 3) indicate that a higher number of species should be expected both at Cape Adare–Cape Hallett and at the Balleny Islands.

Indeed, it is evident that mollusc diversity in the Ross Sea is not homogeneous. Whether these differences represent a real trend in mollusc diversity is still not possible to say, as complete check lists (e.g. from McMurdo at 78°S) are lacking and there are also large gaps between Cape Adare–Cape Hallett and Terra Nova Bay–Cape Russell.

In Antarctica, a clear latitudinal cline in diversity, oriented north to south along the western Antarctic Peninsula, has been reported for macroalgae (Moe & deLaca 1976), while the lower diversity of isopods at greater latitudes in the Weddell Sea was mostly interpreted as a depth effect rather than a latitudinal one (Brandt *et al.* 2005). The existence of a cline also in mollusc diversity, has to be considered as an appealing hypothesis, but further work is needed to cover the geographical gaps.

The causes of a higher diversity at the Cape Hallett–Cape Adare area are not easy to explain and are probably due to multiple factors, possibly acting in a synergistic way. Environmental data were collected during both cruises but, unfortunately, they are still not available, preventing a test of the existence of a direct link between the structure of benthic assemblages as a whole (not only molluscs) and, for example, some environmental determinants such as sediment features, organic matter availability, etc., which have already been proved to affect distribution patterns of Antarctic molluscs (e.g. Arnaud *et al*. 2001).

However, during both the *Italica* and the *Tangaroa* cruises, 3D seafloor mapping revealed an intense iceberg scouring off Cape Hallett and Cape Adare (Thrush *et al*. in press, Berkman *et al*. 2005). This kind of disturbance is know to play a great role in shaping continental shelf Antarctic benthic assemblages (Gutt *et al*. 1996, Barnes 1999, Peck *et al.* 1999, Gutt 2001, Gutt & Starmans 2001, Thatje *et al*. 2005). At a regional scale (1 to 100 km), it also increases habitat heterogeneity enhancing species diversity (Gutt & Pipenburg 2003).

It is therefore plausible that an increased habitat heterogeneity caused by iceberg-scouring in the Cape Adare–Cape Hallett could be the reason for an higher number of species in this area (present data) and of a dominance of Polychaeta and Gastropoda instead Arthropoda, as observed in 'Rauschert dredge' samples from the *Italica* cruise (Rehm *et al*. 2006). The high intensity of this kind of disturbance was also considered the reason for the almost complete absence of the thin shelled pectinid *Adamussium colbecki* at 71–72°S, while this species forms dense populations at 74–75°S (Schiaparelli & Linse 2006).

While the low diversity at Terra Nova Bay was known from previous studies (Cattaneo-Vietti *et al*. 2000 and references therein), with almost no new faunal addition after the 2004 cruises, the overall species composition that characterizes the Balleny Islands deserve further attention. These islands, located four latitudinal degrees north of the Ross Sea, in the main Antarctic Coastal Current (or East Wind Drift), seem to represent a kind of crossroad in the Southern Ocean, mirroring the situation described for Bouvet Island, situated in the South Atlantic Ocean at about 54°S (Linse 2006).

At the Balleny Islands, in addition to the species shared with the 'true' Ross Sea stations, a certain number of invertebrates previously known only for the Weddell Sea have been found; for example, the holothuroid *Laetmogone* cf. *wyvillethompsoni* (Sieg & Wägele 1990), the anthozoan *Anthomastus bathyproctus* (Bayer 1993) and the deep water trochids, *Calliotropis antarctica* and *Calliotropis eltaninii* (Dell 1990). Moreover the Balleny Islands host species typical of New Zealand waters, such as the king crab *Neolithodes brodiei* (Thatje & Lörz 2005).

It appears clear that the Balleny Islands, located far from the mainland, seem to be greatly favoured in intercepting planktonic larvae and may play, at least in the deep, the well-known role of 'stepping stone' in the dispersal of benthic invertebrates (Hubbs 1959, De Forges *et al*. 2000). Whether this process is true also for shallow, coastal species is still not possible to ascertain. However, the presence of *Pellilittorina setosa* at the Balleny Islands (*Tangaroa* 2004 station 241), a sub-Antarctic shallow water species, found in the Ross Sea only once before (Dell 1990), seems to support this hypothesis.

Further studies that take into account larval strategies of the species collected by these cruises (and in the past) could help towards a better understanding of the observed spatial patterns of diversity and species distribution in the Ross Sea.

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