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Macrobenthic communities on the continental shelf of the Prydz Bay, East Antarctica

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Abstract

To explore the spatial pattern of macrobenthic communities and their response to environmental factors in the Prydz Bay, samples were collected using a 0.25-m^2 box corer at 10 stations from November 2012 to April 2013. A total of 50 species of macrobenthos belonging to 8 phyla and 33 families were identified, of which polychaetes (e.g., *Maldane sarsi*) and sponges (e.g., *Halichondria* sp. and *Leucosolenia* sp.) were the most prominent groups. The macrobenthos in study area were categorized into five functional groups based on the feeding type, and the detritivorous group represented by polychaetes showed the highest average abundance, while the planktophagous group represented by sponges showed the highest average biomass. Macrobenthos abundance (0–592 ind./m^2) and biomass (0–1 155.5 g/m^2) in the Prydz Bay were relatively lower than those of other Antarctic shelf soft-bottom waters, although the compositions of the dominant species and functional feeding groups were similar. The results of the Spearman rank correlation analysis indicated that the average biomass of the macrobenthos and the biomass of the planktophagous group in the study area were negatively correlated with the water depth, sediment grain size and silt percentage. However, these variables were clearly not strong determinants of macrobenthos assemblage structure. Many factors not measured in the study, e.g., sediment organic matter and iceberg interference, have probably influenced the spatial distribution of macrobenthic community structure in the Prydz Bay.

Key words: macrobenthic communities, functional feeding groups, environmental factors, Antarctica, Prydz Bay

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1 Introduction

Climate change in Antarctica has been rather volatile recently, leading to the collapse of a large number of ice shelves, melting of glaciers, major changes in surface water temperature and salinity, and instability in marine ecosystems (Moline et al., 2004; Meredith and King, 2005). Due to continuous climate warming, the coverage and duration of the sea ice around Antarctic have undergone major changes, and the composition of algal communities has gradually changed from macroalgae to microalgae. Changes in phytoplankton biomass and particle size have directly affected *Euphausia superba*, a key species of the Southern Ocean ecosystem, and this alteration has greatly impacted organisms of higher trophic levels (e.g., benthos, fishes, seals and penguins), threatening the stability of the entire ecosystem (Fraser and Hofmann, 2003; Siegel, 2005).

The Prydz Bay, located in the east Antarctica sea area, is the largest bay in the Indian Ocean sector of the Antarctic continent. Due to its unique geographical and natural environment, this bay is an ideal place for predicting changes in the Antarctic marine ecosystem within the context of climate change. The Prydz Bay has a wide continental shelf and a complex terrain with large variations in water depth and bottom sediment types, with the deepest point in the bay being more than 1 100 m in depth (Hodgkinson et al., 1991). Strong katabatic winds in the bay blow away newly formed sea ice, creating the only polynya in the eastern Antarctic, which results in high primary productivity (chlorophyll concentration greater than 1 mg/m^3) and provides abundant food for marine organisms (Arrigo and Van Dijken, 2003; Hosie and Cochran, 1994). The range, area, and formation time of the polynya as well as the melting sea ice are important factors that affect the coastal ecosystems of the Prydz Bay (Pakhomov and Perissinotto, 1996). However, the response of ecosystems in this sea area to environmental alterations remains unknown within the context of climate change.

Macrobenthos are an important component of marine ecosystems and mainly exhibit a rather slow growth rate and long life cycle, rendering them less vulnerable to interannual changes and small fluctuations in water column productivity (Carey, 1991; Barnes and Conlan, 2007). Therefore, macrobenthos can serve as a good indicator of potential changes in ecosystems. Indeed, changes in macrobenthic communities at a timescale of years to decades can predict long-term changes in ecosystems caused by

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climate change (Dunton et al., 2005; Sahade et al., 2015; Liu et al., 2015). For example, the disintegration of the Larsen A ice shelf of the Antarctic Peninsula has, after only two favorable growth periods in four years, resulted in 2- and 3-fold increases in the abundance and biomass, respectively, of a glass sponge that formerly maintained stable growth, leading to a significant change in the characteristics of the macrobenthic community structure in the area (Fillinger et al., 2013).

Previous studies of the macrobenthos in the Prydz Bay have mainly focused on species description and taxonomy (O'Loughlin et al., 1994; O'Loughlin and Vanden Spiegel, 2010; Moles et al., 2015), whereas the spatial and temporal distributions of community structure and diversity have rarely been addressed (Stark, 2000). Biological Investigations of Marine Antarctic Systems and Stocks (1977–1986) involve a large-scale survey of major living organism resources in the Prydz Bay, such as plankton, krill, fishes, birds, and mammals, but neglected macrobenthos (El-Sayed, 1994). Investigating the effect of bottom trawling on the macrobenthos of the Prydz Bay, Constable (1991) found sponges and ascidians to be the dominant groups. To evaluate and predict the impact of bottom fisheries and climate change on vulnerable macrobenthic communities and habitats, Hibberd (2016) studied the composition of macrobenthic biomass by trawling at 19 stations in the Prydz Bay.

Studies to date have shown that the response of a single isolated species to environmental changes is affected by its competitors (Davis et al., 1998), resulting in reduced confidence in bioclimate envelope models. Thus, the impact of environmental change should be examined from the point of view of the entire community (Pearson and Dawson, 2003). As we currently know very little about the composition and distribution characteristics of the macrobenthic community in the Prydz Bay, this study aims to answer the following questions using data acquired in the Prydz Bay during the 29th Chinese National Antarctica Research Expeditions (CHINAREs) combined with previous survey data and the literature: (1) what is the composition and spatial variability in macrobenthic communities in the Prydz Bay; and (2) is there a quantifiable relationship between spatial differences in macrobenthic communities and environmental factors? The quantitative data on benthic macrofauna we obtained enhances our knowledge about macrobenthic community dynamics within the context of rapid climate change. The results reported in this paper represent some of the first quantitative analyzed datasets from the study area.

2 Methods

2.1 *Survey area*

The Prydz Bay is the largest embayment in the Indian sector of the Southern Ocean, and located at the end of the Lambert Glacier/Amery Ice Shelf system, between approximately 67°45′–69°30′S and 70°–80°E (Fricker et al., 2001; Borchers et al., 2011). The southernmost part of the bay is in contact with the Amery Ice Shelf, and the northernmost part extends to the continental shelf edge (Fig. 1). The water depth gradually increases from north to south. The Four Ladies Bank and the Fram Bank reside at the east and west sides of the continental shelf, respectively, where their shallowest water depths are less than 200 m. The Prydz Channel runs southeast to northwest between the two shoals, mostly with a depth of more than 500 m, and is the main channel for material exchange between the bay and the adjacent sea areas (Barbara et al., 2010). At the site of the shelf break, the terrain is rather steep, and the water depth dramatically increases from 600 m to more

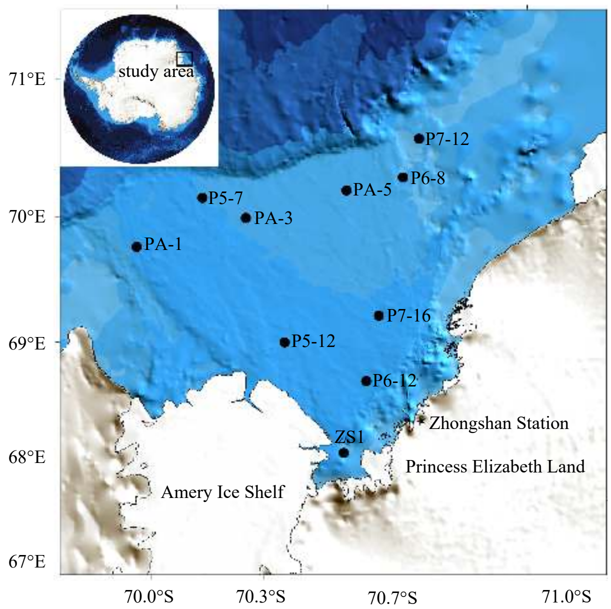

Fig. 1. Diagram of macrobenthos sampling sites in the Prydz Bay.

than 3 000 m, which is the typical deep ocean region depth.

Unlike other sea areas in the world, relatively little of the sea bed of the Southern Ocean is continental shelf. Much of this shelf is unusually deep due to scouring from ice shelves and depression by the enormous mass of continental ice. Our research was based on the definition by Clarke that the edge of the Prydz Bay continental shelf is 1 000 m (Clarke and Johnston, 2003)

Sea ice in the Prydz Bay is predominantly seasonal. In winter, the entire bay is frozen, with an ice thickness of up to 2 m; drift ice extends northward and can even reach the area near 60°S. In summer, the sea ice is partially melted, although there is still high coverage of drift ice, with varying covered areas (Taylor et al., 1997).

2.2 *Sampling methodology*

Macrobenthic samples were collected at 10 stations in the Prydz Bay (Fig. 1) while aboard the R/V *Xuelong* during the 29th CHINARE (Chinese National Antarctic Research Expedition) from November 2012 to April 2013. The sampling stations were all within the continental shelf area: P5-7, PA-3 and PA-1 are in the Prydz Channel; P7-16 and P5-12 are in the Amery Basin; P7-12, PA-5 and P6-8 are on the Four Ladies Bank; ZS1 is on the front edge of the Amery Ice Shelf; and P6-12 is in the Svenner Channel (Fig. 1, Table 1).

One sediment sample per station was collected using a 0.25-m^2 box corer (50 cm×50 cm×60 cm). Each sample was sifted through a mesh with a pore size of 0.5 mm to collect macrobenthos, which were fixed in 7% formaldehyde solution and transported to the laboratory for species identification, counting, and weighing. For colonial animals, such as sponges, counts were calculated according to one individual (Griffiths et al., 2008). Taxon names were cross-checked against the World Register of Marine Species (http://marinespecies.org/).

The environmental factors of the water bodies mainly included depth and bottom water temperature, which were simultaneously measured on site using a Sea-Bird Electronics (SBE911 Plus) CTD system. Grain analysis (the percentage of sand, silt,

Table 1. Parameters of environmental factors and sediment types at various stations

Region	Station	Depth /m	Median particle size (Φ)	Bottom temperature/°C	Sand /%	Silt /%	Clay /%	Gravel /%	Sediment type
Front edge of Amery Ice Shelf	ZS1	664	126.9	–1.91	64.0	26.0	7.8	2.2	silty sand
Amery Basin	P5-12	667	17	–1.90	7.0	78.9	14.1	0.0	silt
Amery Basin	P7-16	558	26.6	–1.89	27.9	59.9	11.3	0.9	sandy silt
Svenner Channel	P6-12	699	16.4	–1.91	7.6	77.7	14.7	0.0	silt
Prydz Channel	P5-7	510	16.9	–1.38	6.4	78.8	14.8	0.0	silt
Prydz Channel	PA-3	487	18.1	–1.80	20.4	66.0	13.6	0.0	sandy silt
Prydz Channel	PA-1	545	48.7	–1.89	42.9	48.6	8.5	0.0	sandy silt
Four Ladies Bank	PA-5	353	13.7	–1.85	10.1	76.3	13.6	0.0	silt
Four Ladies Bank	P7-12	225	42.4	–1.71	41.1	49.0	7.4	2.5	sandy silt
Four Ladies Bank	P6-8	386	25.2	–1.85	23.7	66.5	8.5	1.3	sandy silt

clay and gravel) of the filtered sub-samples was performed at each station using a Malvern Mastersizer laser particle sizer according to Yao et al. (2014); median particle diameter (Md) and sorting values were also calculated. Water body and sediment characteristic parameter data were obtained from the National Earth System Science Data Sharing Platform of the Polar Science Data Center (http://www.chinare.org.cn).

2.3 *Data treatment and analysis*

The PRIMER 6.0 software package was used to calculate the Bray-Curtis similarity coefficient and to establish a similarity matrix. Based on the similarity matrix, hierarchical aggregation clustering (CLUSTER) was conducted using the group average method. To identify characteristic species for each macrobenthic group, we used a similarity profile (SIMPROF) to assess different groups based on a similarity percentage (SIMPER) to sort inter-group percentages of the average similarity contribution.

Macrobenthos were categorized into five functional groups according to their feeding habits (Boaventura et al., 1999; Yuan et al., 2002):

(1) Planktophagous group (Pl), which feeds on minuscule plankton through various feeding filters, e.g., bivalves, crustaceans;

(2) Phytophagous group (Ph), which mainly feeds on vascular plants and algae, e.g., gastropods, bivalves, crabs;

(3) Carnivorous group (C), which preys on small or young animals, e.g., annelids and decapods;

(4) Omnivorous group (O), which directly absorbs organic matter dissolved in water through skin or epidermal tendon cells and also feeds on rotting plant leaves, small bivalves and crustaceans, e.g., gastropods, bivalves, crabs;

(5) Detritivorous group (D), which feeds on organic detritus and sediments, ingests organic substances in the digestive tract, e.g., nematodes, bivalves.

The relationship between the macrobenthic community and environmental factors was analyzed using the non-parametric Spearman rank correlation analysis. Statistical analysis results were carried out in the SPSS 21.0 software, and graphs were plotted using ArcGIS 10.3 software.

3 Results

3.1 *Oceanographic conditions*

The parameters of each type of environmental factor, i.e., water body or sediment, at each station in the Prydz Bay are shown in Table 1. The average water depth for all stations was 509 m, with a range of 225–699 m; the shallowest point was at Sta. P7-12 of the Four Ladies Bank and the deepest at Sta. P6-12 of the Svenner Channel. The bottom temperature at each station was rather uniform, ranging from 1.91°C to –1.38°C; the highest temperature was found at Sta. P5-7 in the Prydz Channel and the lowest temperature at Sta. ZS1 on the front of the Amery Ice Shelf and at Sta. P6-12 in the Svenner Channel.

Silt is the main form of sediment in the study area, and gravels were present at some sites. The median particle size at each station varied in the range of 16.4Φ to 126.9Φ. The greatest median size was found at Sta. ZS1 on the front edge of the Amery Ice Shelf, and the lowest was found at Sta. P6-12 in the Svenner Channel; sediment types were silty sand and silt, respectively.

3.2 *Species composition and distribution*

A total of 50 species of macrobenthos from 33 families and 8 phyla were identified in the study area. Polychaetes (26 species) and crustaceans (10 species) were dominant, accounting for 72% of the total species. The remainder included echinoderms (4 species), nemerteans (4 species), sponges (3 species), sipunculan (1 species), and cnidarian (1 species). The number of species at each station was between 0 and 18. The greatest number was found at Sta. P6-12, but none were found at Sta. P7-16. Stations P6-12, ZS1, P7-12, and PA-01 were dominated by polychaetes, which accounted for more than 50% of the total species at each station (Fig. 2).

3.3 *Distribution of abundance and biomass*

The average abundance of macrobenthos in the sea area was 195.2 ind./m^2, with a range of 0 to 592 ind./m^2. Polychaetes (121.6 ind./m^2) and crustaceans (30.4 ind./m^2) accounted for the highest proportions (62.3% and 15.6%, respectively). Abundance higher than 300 ind./m^2 were found at three stations (P6-12, P7-12 and ZS1) of the Svenner Channel, Four Ladies Bank, and front edge of the Amery Ice Shelf, respectively, with polychaetes being dominant (Fig. 3).

The average biomass was 220.4 g/m^2, varying in the range of 0–1 155.5 g/m^2. Sponge biomass accounted for the highest proportion (193.1 g/m^2), at 87.6% of the total biomass. Among the stations, Sta. PA-05 at the Four Ladies Bank had the highest biomass (1 155.5 g/m^2) due to the presence of a large quantity of sponges such as *Halichondria* sp. and *Leucosolenia* sp., with biomass of 907.7 and 245.4 g/m^2, respectively (Fig. 4).

3.4 *Community structure*

The macrobenthos abundance data for the Prydz Bay was quadratic root-transformed, and cluster analysis was conducted based on the Bray-Curtis similarity matrix. The macrobenthic communities were divided into six groups based on a 25% similarity threshold (Fig. 5), and significant differences in species

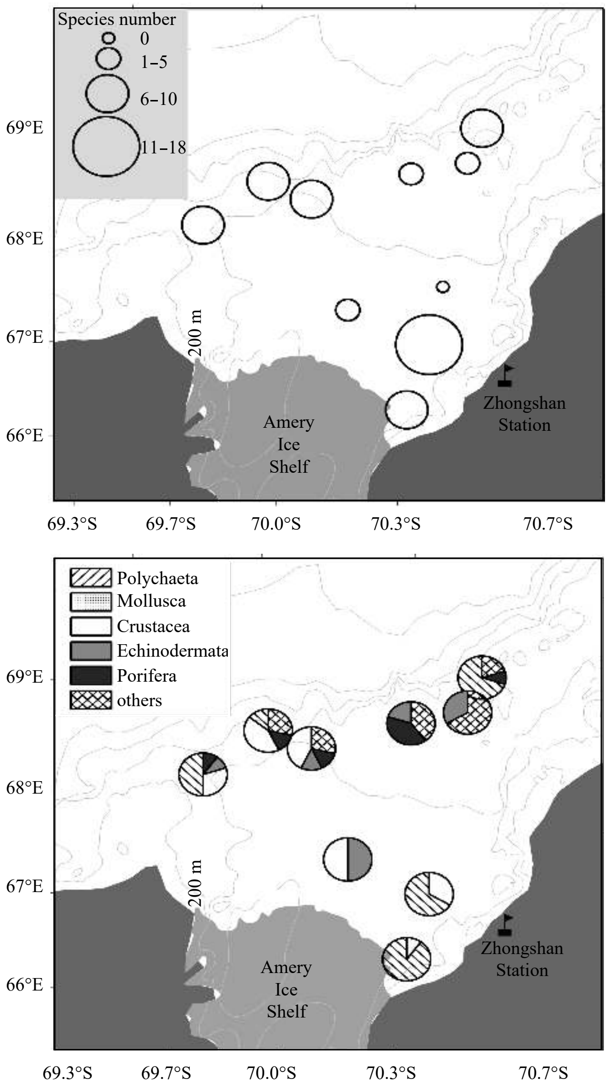

Fig. 2. Species number and composition of macrobenthos in the Prydz Bay.

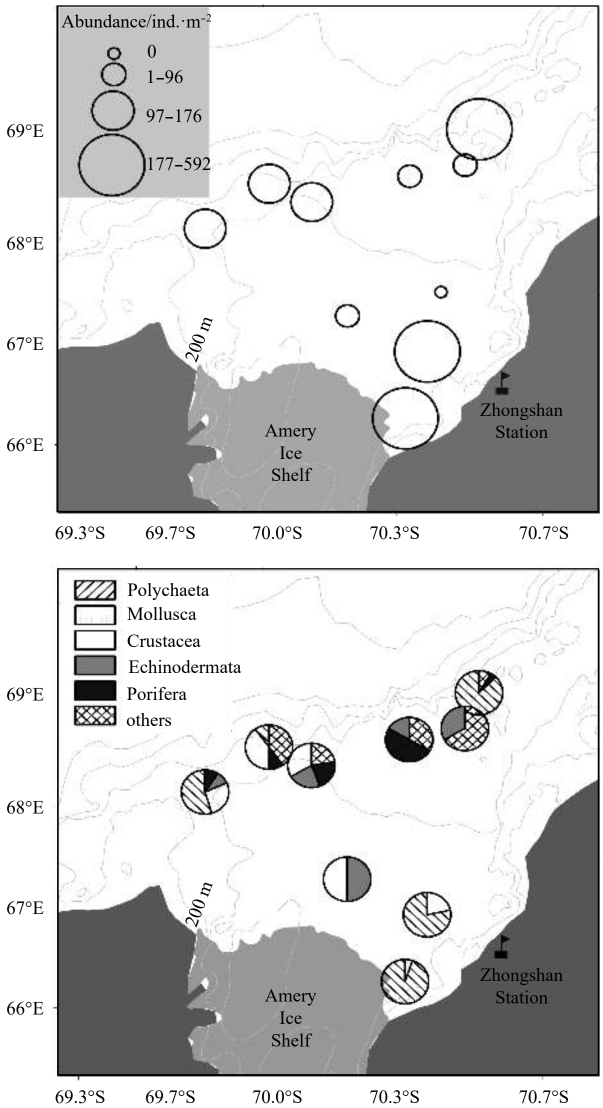

Fig. 3. Spatial distribution of macrobenthos abundance in the Prydz Bay.

composition were found among the groups (global R=0.96, p=0.1%). The SIMPER method was employed to identify species in each group with a cumulative contribution rate of 90% (Table 2), excluding groups present at only one station, e.g., Groups 1, 5 and 6. Through similarity analysis of the macrobenthos, the community can be described based on characteristic species with the highest contribution rate in groups. The geographical distribution of each group is shown in Fig. 6.

3.5 *Composition and distribution of functional feeding groups*

Based on feeding type, the macrobenthos in the Prydz Bay were divided into five functional groups (Fig. 7). Among them, the detritivorous group (21 species) contained the most species, accounting for 42% of the total species, followed by the carnivorous group (18 species), which accounted for 36%. Fewer species of planktophagous (7 species) and omnivorous (4 species) groups were found, with no species at all in the phytophagous group. The average abundance of the five functional groups was as follows: detritivorous group (90 ind./m^2) > carnivorous group (75 ind./m^2) > planktophagous group (19 ind./m^2) > omnivorous group (11 ind./m^2). The average biomass was as follows: planktophagous group (193.7 g/m^2) > detritivorous group (21.3 g/m^2) > carnivorous group (4.9 g/m^2) > omnivorous group (0.5 g/m^2). The detritivorous group exhibited a large number of species and average abundance and was mainly dominated by polychaetes that feed on benthic detritus. The planktophagous group showed the highest biomass and accounted for 87.9% of the total, which was mainly due to the presence of a large quantity of sponges that feed on tiny organisms suspended in the water body.

In terms of the spatial distribution of the abundance of these above macrobenthic functional groups, Stas PA-05 and PA-03 were mainly dominated by planktophagous and carnivorous groups, whereas other stations were mainly dominated by detritivorous and carnivorous groups. Significant variations in the spatial distribution of biomass was observed, with Stas P7-12, PA-05, PA-03 and PA-01 mainly being dominated by the planktophagous group, Stas P6-12, P6-08 and P5-07 by the detritivorous group, and Sta. ZS1 by the carnivorous group (Fig. 8).

3.6 *Relationship between macrobenthos and environmental factors*

Spearman rank correlation analysis revealed no significant

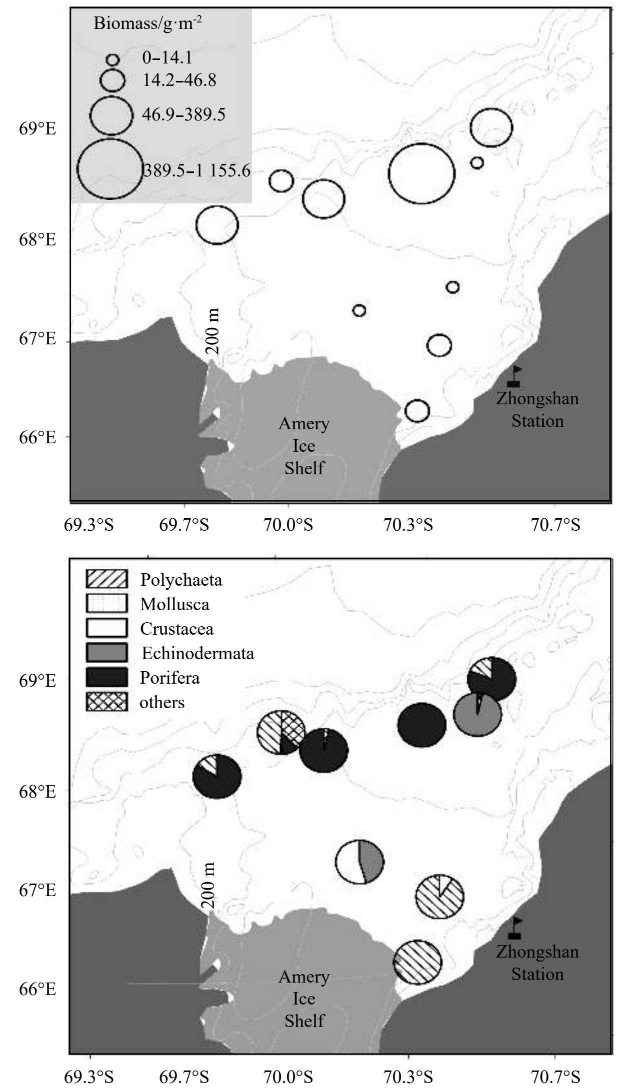

Fig. 4. Spatial distribution of macrobenthos biomass in the Prydz Bay.

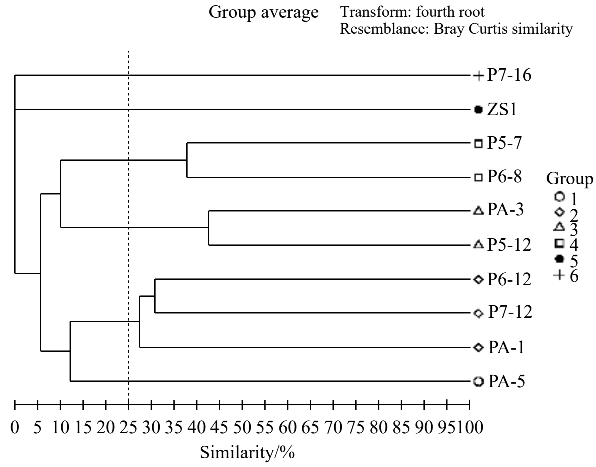

Fig. 5. Bray-Curtis similarity cluster analysis of macrobenthic communities in the Prydz Bay.

correlation between the spatial distribution of the macrobenthic community and environmental factors (characteristics of the sediment and water environments) in the Prydz Bay. Water depth displayed a weakly negative correlation with total biomass (r_s=–0.624) and the average biomass of the planktophagous group (r_s=–0.597). Conversely, the other biological variables showed little correlation with environmental factors (Table 3).

4 Discussion

The results of this study indicate that the macrobenthic communities in the Prydz Bay exhibit a dispersed and patchy distribution pattern. The maximum values of average abundance and average biomass were found at the Svenner Channel and the Four Ladies Bank, respectively, where polychaetes and sponges dominated. The macrobenthos in the Prydz Bay can be divided into four functional feeding groups: the planktophagous and detritivorous groups dominated, with the former having the highest biomass and the latter the highest number of species as well as the highest abundance.

Compared with other sea areas of the Antarctic continental shelf with soft-sediment bottoms (Table 4), the macrobenthos species number, abundance and biomass in the Prydz Bay were low. The average abundance of macrobenthos in the study area was equivalent to that of Site A (southwestern Ross Sea) and Site C (the northern bank of the Mawson bank) in the Ross Sea (Gambi and Bussotti, 1999). Additionally, our average abundance values were also lower than those reported for "oligotroph-

Table 2. SIMPER similarity analysis based on the macrobenthic communities composition of the Prydz Bay

Group	Species	Average abundance/ind.·m^{-2}	Average similarity/%	Contribution rate/%	Cumulative percentage/%
2	*Ophelina* sp.	2	7.19	25.33	25.33
(Average similarity: 28.39%)	*Isocirrus yungi*	1.67	3.59	12.64	37.97
	Halichondria sp.	1.33	3.02	10.62	48.59
	Tharyx sp.1	1.89	2.87	10.12	58.71
	Maldane sarsi	1.94	2.87	10.12	68.83
	Notomastus sp.	1.67	2.42	8.51	77.34
	Glycera sp.	1.54	2.14	7.55	84.9
	Aricidea sp.	1.46	2.14	7.55	92.45
3	*Pseudharpinia antarctica*	2	21.33	50	50
(Average similarity: 42.65%)	*Amphiophiura metabula*	2.19	21.33	50	100
4	*Cephalothrix* sp.	2.19	18.93	50	50
(Average similarity: 37.85%)	*Golfingia* sp.	2.19	18.93	50	100

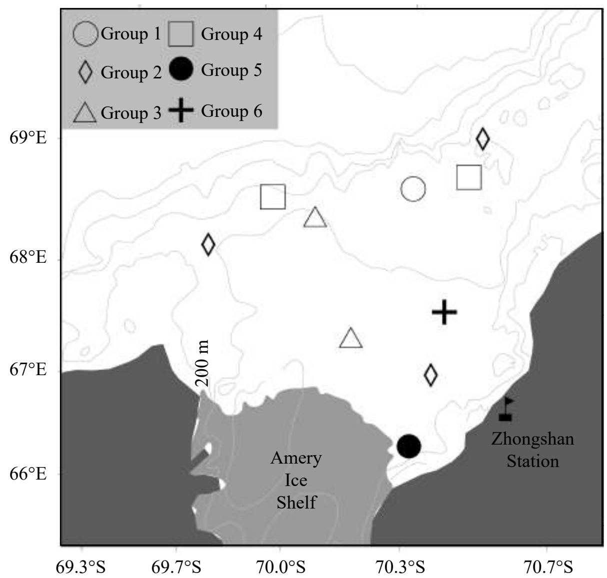

Fig. 6. Spatial distribution patterns of macrobenthic communities in the Prydz Bay.

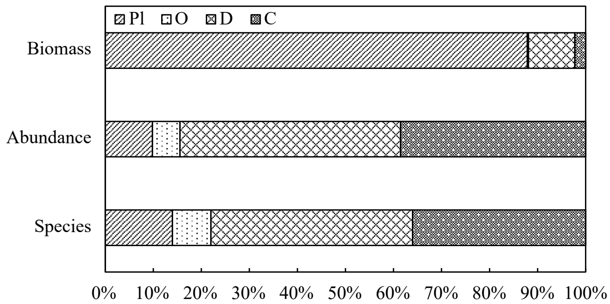

Fig. 7. Species number, abundance and biomass of functional feeding groups.

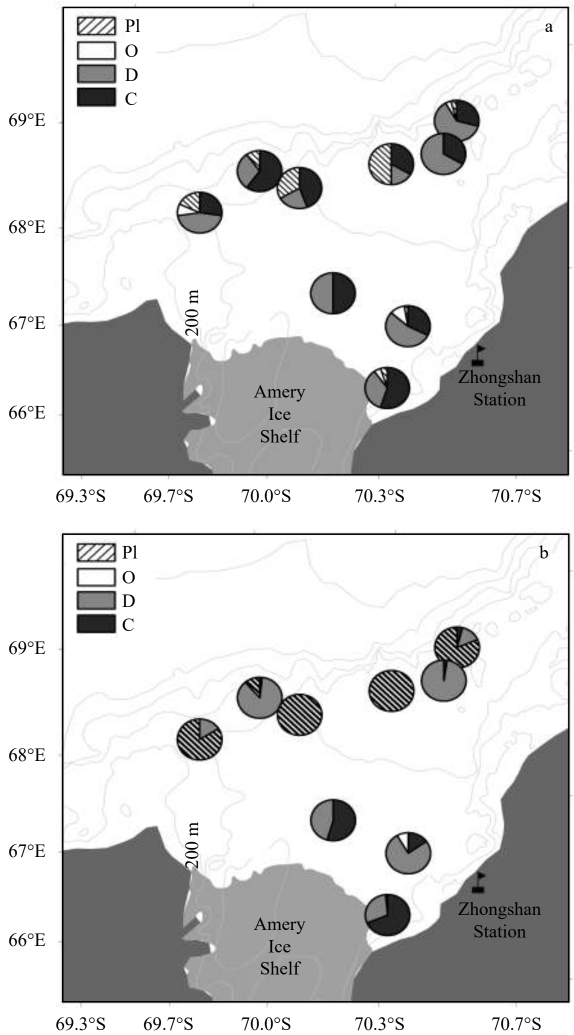

Fig. 8. Spatial distribution of the abundance and biomass of functional feeding groups. a. Abundance and b. biomass.

ic" benthic communities in west McMurdo Sound (Dayton and Oliver, 1977), which are nourished by the advection of nutrient-poor water from below the Ross Ice shelf (Barry and Dayton, 1988). Furthermore, the average biomass we detected was lower than that collected at South Shetland Island by Arnaud and Sáiz-Salinas (Arnaud et al., 1986; Sáiz-Salinas et al., 1997) but similar to that of the Weddell Sea (Gerdes et al., 1992).

Similar to other sea areas of the Antarctic continental shelf with soft-sediment bottoms, polychaetes and sponges were the dominant groups (Table 4) and crustaceans accounted for a certain proportion in some regions (Rehm et al., 2006). According to Constable and Hibberd, sponges were the dominant groups of macrobenthos collected by trawling in the Prydz Bay (Constable, 1991; Hibberd, 2016), which was similar to the Weddell Sea, the Ross Sea, and the George V Shelf. However, the dominant group in the Amundsen Sea was mainly echinoderms (Linse et al., 2013) and that in the near-shore shallow-water area of Terre Adélie (20 to 100 m in depth) was mainly sea cucumbers, polychaetes, and ascidians, whereas sponges were rare (Gutt et al., 2007). Such differences in macrobenthos dominant species in Antarctic continental shelf may be associated with the emergence of colder Antarctic bottom water, which is absent in the Amundsen Sea and the shallow-water areas of Terre Adélie (Gutt et al., 2007; Olbers et al., 1992).

Currently, the two major macrobenthic communities found in the Prydz Bay are characterized by suspension feeders, such as Porifera or detritus feeders, such as Polychaeta, and the spatial distribution of macrobenthic functional feeding groups is closely related to their habitat types and biological characteristics (Costanza et al., 1997; Liu et al., 2016). Sedimentation of the Four Ladies Bank and Prydz Channel is mainly affected by currents that have a high flow velocity (Hodgkinson et al., 1991), leading to the overall fineness and high silt content of the sediment. An appropriate habitat and abundant food brought by currents enable the planktophagous group to dominate in these two regions (including Stas PA-05, P7-12, PA-01 and PA-03). Station ZS1 at the front edge of the Amery Ice Shelf had sediment with a high sand content and large particle size. This front edge area is also the main source of the Prydz Bay iceberg, and with the disintegration of ice shelves and melting of icebergs, coarser terrestrial debris is deposited on the front edge of the ice shelf, and this input of rich organic matter favors the survival of carnivorous and detritivorous groups (mainly polychaetes). Gambi and Bussotti (1999) found that infaunal sub-surface and surface-deposit feeders such as polychaetes, mollusks, and crustaceans dominate in areas with biogenic fine sediments at Site A (southwest of the Ross Sea) and Site B (center of the northern part of the Joides

Table 3. Correlation between biological variables and environmental factors

	Depth	Median particle	Bottom temperature	Sand%	Silt%	Clay%	Gravel%
Abundance	0.055	0.152	–0.067	0.224	–0.297	–0.127	0.130
Biomass	**–0.624**	–0.152	0.467	0.079	–0.176	–0.115	–0.171
Species	0.111	0.178	–0.129	0.265	–0.339	–0.111	0.042
APl	–0.350	–0.165	0.248	0.076	–0.216	0.076	–0.401
AO	0.312	0.340	–0.437	0.430	–0.430	–0.277	0.219
AD	0.104	0.238	–0.079	0.244	–0.287	–0.177	0.223
AC	0.140	0.043	–0.079	0.079	–0.176	0.024	0.086
BPl	**–0.597**	–0.092	0.443	0.135	–0.246	–0.135	–0.149
BO	0.288	0.336	–0.425	0.425	–0.425	–0.308	0.309
BD	–0.219	0.195	0.274	0.158	–0.170	–0.207	0.134
BC	0.207	0.249	–0.195	0.201	–0.243	–0.152	0.219

Note: APl, AO, AD and AC: the abundance of planktophagous group, omnivorous group, detritivorous group and carnivorous group, respectively; BPl, BO, BD and BC: the biomass of planktophagous group, omnivorous group, detritivorous group and carnivorous group, respectively.

Table 4. Summary of data from some quantitative macrobenthic studies in various regions of the Antarctic

Region	Depth/m	Abundance /ind.·m^{-2}	Biomass /g·m^{-2}	Dominant groups	Reference
Southeastern Weddell Sea	170–2 037	131–12 846	0.12–16 446	sponges, holothurians, asteroids, polychaetes	Gerdes et al. (1992)
Admiralty Bay	60–250	889–2 834	153 –2 464	polychaetes, bivalves, tunicates, echinoderms	Jażdżeski et al. (1986)
King George Island	130–2 000	730–14 000	50–950	polychaetes, bivalves, crustaceans, ophiuroids	Piepenburg et al. (2002)
South Shetland Island	60–850	1 960–54 450	14–825	polychaetes, mollusks, echinoderms, crustaceans	Mühlenhardt-Siegel (1988)
South Shetland waters	42–671	160–4 380	23.3–6 673	ascidians, sponges, polychaetes	Sáiz-Salinas et al. (1997)
Elephant Island	100–400	140–47 620	1–197	polychaetes, mollusks, echinoderms, crustaceans	Mühlenhardt-Siegel (1988)
Anvers Island, Arthur Harbour	5–75	2 891–86 514		polychaetes, oligochaetes, amphipods	Richardson and Hedgpeth (1977)
West Antarctic Peninsula continental shelf	550–625	11 000–21 000		polychaeta	Glover et al. (2008)
Antarctic waters	100–800	170–20 000			Glover et al. (2008)
Ross Sea shelf					Gambi and Bussotti (1999)
Site A (southwest Ross Sea)	810	250–600		polychaetes, bivalves	
Site B (the northern part of the Joides basin)	580	1 040		polychaetes	
Site C (the northern flank of the Mawson bank)	450	516		crustaceans, polychaetes, echinoderms	
Prydz Bay	225–699	0–592	0–1 155.5	polychaetes, sponges	this study

basin), which are closely related to the input of organic matter such as organic carbon and biogenic silica.

Due to specific geographical and environmental conditions, polar benthic communities present a highly discrete patchy distribution pattern (Thrush et al., 2006; Lin et al., 2016; Liu et al., 2019). Compared to strong species exchanges between the Arctic and adjacent sea areas (Grebmeier et al., 2006), the degree of geographical isolation in Antarctic waters is higher, and the benthic organisms exhibit a unique faunal structure. Clarke divided the Antarctic benthos into six faunas, with the Prydz Bay categorized with the Wilkes Land fauna, the largest of the six, and due to the spatial heterogeneity of Wilkes Land, the fauna exhibits diverse community structures (Clarke et al., 2007; Clarke, 2008). In the present study, the macrobenthic communities in the Prydz Bay were roughly divided into three groups. The *Ophelina* sp.-*Isocirrus yungi* fauna (Group 2) had a species similarity of 28.39% and were mainly distributed in the Four Ladies Bank, Svenner Channel, and Prydz Channel, which dominated by polychaetes and sponges. *Ophelina* sp., the characteristic species with the highest contribution rate in the community (25.33%), showed an average abundance of 16 ind./m^2 and an average biomass of 0.56 g/m^2. The *Pseudharpinia antarctica*-*Amphiophiura metabula* fauna (Group 3) had a species similarity of 42.65% and was mainly distributed in the Amery Basin and Prydz Channel, where the water depth varies in the range of 487–667 m; this group was dominated by crustaceans and echinoderms. The *Cephalothrix* sp.-*Golfingia* sp. fauna (Group 3) showed a species similarity of 37.85% and was mainly distributed in the Four Ladies Bank and Prydz Channel, where the water depth varies in the range of 386–510 m. The group was dominated by nemerteans.

The key environmental factors affecting high-latitude Antarctic coastal marine ecosystems are persistent low temperatures, sea ice coverage, seasonal changes in primary productivity and unique current systems (Thrush et al., 2006). These unique environmental factors lead to the distinct environmental isolation of the Southern Ocean from other sea areas, giving rise to unique community structures and species diversity, with endemics being enriched in benthic organisms.

The results of non-parameter statistical analysis (Spearman analysis) showed that these environmental variables are not strong determinants of macrobenthic community structure. The relationship between the macrobenthic community structure and environmental variables in the Ross Sea remains unclear (Gambi and Bussotti, 1999; Choudhury and Brandt, 2007; Kröger and Rowden, 2008). Cummings performed canonical correspondence analysis (CCA) and concluded that fine sand and silt, the ratio of sediment chlorophyll *a* to pheophytin, and depth are the main factors affecting the macrobenthic community in the continental shelf area of the Northwest Ross Sea, nevertheless environmental variables only explained 17.3% of the macrobenthic distributions in different regions (Cummings et al., 2010).

Due to limitations caused by the study conditions, many environmental factors that may affect the macrobenthic distribution, e.g., sediment organic matter content and pigment concentration (e.g., chlorophyll *a* and pheophytin), submarine topography, and iceberg interference, were not assessed in this study. Iceberg interference may be a factor that leads to differences in macrobenthic communities among different stations in the Prydz Bay. During the processes of iceberg collapse and breakage as well as current flow, local disturbance from ice and subsequent recolonization create a patchy distribution pattern on the seafloor, with macrobenthos that exhibit different life forms dominating different stages of succession (Gutt, 2001; Teixidó et al., 2004). Gerdes et al. (2003) argued that iceberg clipping exerts a great impact on the macrobenthic community in the southeastern part of the Weddell Sea. The number of species, the abundance, and the diversity of functional groups of polychaetes significantly decreased in areas with newly clipped icebergs, but that a diverse pattern of different succession stages of recolonization in disturbed areas may occur over the time. Station ZS1 at the front edge of the Amery Ice Shelf is in the major area of clustering icebergs in the Prydz Bay, but there are few sampling stations in this area and thus limited data on iceberg distribution and movement trajectories. Therefore, little is known about the relationship between the macrobenthic community distribution and iceberg disturbance. With the continuous changes in global climate and the accelerated melting of ice shelves, the influence of iceberg interference on Antarctic marine benthic ecosystems is increasing. Accordingly, an understanding of the relationship between the two needs to be continuously strengthened in future investigations.

5 Conclusions

Based on macrobenthos sampling data from China's 29th Antarctic scientific expedition, this study is the first to quantitative analyze the composition and spatial distribution of the macrobenthic community structure in the Prydz Bay continental shelf and their relationships with environmental factors. We found that the macrobenthic fauna in the study area assumed a discrete patchy distribution pattern and were dominated by sessile suspension feeders and mobile detritus feeders represented by sponges and polychaetes, respectively. The average abundance and the average biomass of the macrobenthos in the Prydz Bay were low in the sea areas of the Antarctic continental shelf with soft-sediment bottoms. The environmental factors that we measured, such as the depth and sediment characteristics, are not good predictors of community composition of the macrobenthic communities of the Prydz Bay, and these findings emphasize the complexity of these marine systems and the role of other environmental and biotic factors in governing distribution patterns.

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Appendix:

Table A1. Species catalogue of the macrobenthos in the Prydz Bay

Phylum	Family	Species	Functional feeding groups
Cnidaria	Clavulariidae	*Telesto* sp.	D
Annelida	Ampharetidae	Ampharetidae und.	D
	Capitellidae	*Notomastus* sp.	D
	Cirratulidae	*Tharyx* sp.1	D
	Cirratulidae	*Tharyx* sp.2	C
	Glyceridae	*Glycera* sp.	C
	Lumbrineridae	*Paraninoe antarctica* (Monro, 1930)	C
	Lumbrineridae	*Lumbrineris* sp.	D
	Maldanidae	*Isocirrus yungi* Gravier, 1911	D
	Maldanidae	*Maldane sarsi* Malmgren, 1865	D
	Maldanidae	Maldanidae und.1	D
	Maldanidae	Maldanidae und.2	D
	Maldanidae	Maldanidae und.3	D
	Maldanidae	*Notoproctus* sp.	C
	Nephtyidae	*Aglaophamus* sp.	C
	Nephtyidae	*Aglaophamus virginis* (Kinberg, 1865)	C
	Nephtyidae	*Nephtys* sp.1	C
	Nephtyidae	*Nephtys* sp.2	O
	Opheliidae	*Ophelina* sp.	D
	Orbiniidae	*Leodamas marginatus* (Ehlers, 1897)	D
	Paraonidae	*Aricidea* sp.	D
	Paraonidae	*Paraonis* (*Paraonides*) *gracilis* Monro, 1930	C
	Polynoidae	Polynoidae und.1	C
	Polynoidae	Polynoidae und.2	D
	Scalibregmatidae	*Scalibregma inflatum* Rathke, 1843	O
	Spionidae	*Laonice* sp.	D
	Terebellidae	*Neoleprea* sp.	Pl
Mollusca	Kelliidae	*Kellia* sp.	O
Arthropoda	Ampeliscidae	*Ampelisca bouvieri* Chevreux, 1912	C
	Gnathiidae	*Gnathia dentata* (Sars G.O., 1872)	D
	Liljeborgiidae	*Liljeborgia macrodon* Schellenberg, 1931	C
	Lysianassidae	*Cheirimedon crenatipalmatus* Stebbing, 1888	C
	Lysianassidae	*Tryphosella longiseta* Ren, 1991	O
	Nymphonidae	*Nymphon stroemi* Krøyer, 1844	C
	Oedicerotidae	*Oediceroides* sp.	Pl
	Photidae	*Gammaropsis* sp.	Pl
	Photidae	*Megamphopus* sp.	C
	Phoxocephalidae	*Pseudharpinia antarctica* Ren, 1991	D
Echinodermata	Amphiuridae	*Amphioplus* sp.	D
	Amphiuridae	*Amphiura* sp.	D
	Ophiuridae	*Amphiophiura metabula* H.L. Clark, 1915	D
	Stichopodidae	Stichopodidae und.	Pl
Porifera	Clathrinidae	*Clathrina* sp.	Pl
	Halichondriidae	*Halichondria* sp.	Pl
	Leucosoleniidae	*Leucosolenia* sp.	C
Nemertea	Cephalothricidae	*Cephalothrix* sp.	C
	Emplectonematidae	*Nemertopsis* sp.	C
	Lineidae	*Cerebratulus* sp.	C
	Lineidae	Lineidae und.	D
Sipuncula	Golfingiidae	*Golfingia* sp.	Pl

Note: Pl represents planktophagous group, O omnivorous group, C carnivorous group, and D detritivorous group.