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Baseline

Quantitative distribution and functional groups of intertidal macrofaunal assemblages in Fildes Peninsula, King George Island, South Shetland Islands, Southern Ocean

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ABSTRACT

To evaluate spatial distribution pattern of intertidal macrofauna, quantitative investigation was performed in January to February, 2013 around Fildes Peninsula, King George Island, South Shetland Islands. A total of 34 species were identified, which were dominated by Mollusca, Annelida and Arthropoda. CLUSTER analysis showed that macrofaunal assemblages at sand-bottom sites belonged to one group, which was dominated by *Lumbricillus* sp. and *Kidderia subquadrata*. Macrofaunal assemblages at gravel-bottom sites were divided into three groups while *Nacella concinna* was the dominant species at most sites. The highest values of biomass and Shannon–Wiener diversity index were found in gravel sediment and the highest value of abundance was in sand sediment of eastern coast. In terms of functional group, detritivorous and planktophagous groups had the highest values of abundance and biomass, respectively. Correlation analysis showed that macrofaunal abundance and biomass had significant positive correlations with contents of sediment chlorophyll a, phaeophorbide and organic matter.

With unstable environment due to ice melting, studies of Antarctic shallow benthic fauna especially in intertidal areas received a lot of attention (Knox, 1960; Arntz et al., 1994; Peck et al., 2006; Barnes and Conlan, 2007). Arnaud (1992) summarized that scarce fauna in Antarctic intertidal and upper subtidal zones. Most studies about intertidal macrofauna in the Southern Ocean were carried out in Adelaide Islands (Antarctic Peninsula), South George Island, Signy Island (Scotia Arc) and South Shetlands Islands. Several investigations focused on the correlation between macrofaunal distribution and depth, latitude, season, food web in intertidal and subtidal areas (Arntz et al., 1994; Corbisier et al., 2004; Filgueiras et al., 2007; Aldea et al., 2008; Choy et al., 2011; Siciński et al., 2011; Gillies et al., 2012).

The highest species richness and diversity of Scotia Arc were found at high latitude areas, which were under the highest physical disturbance due to ice scour (Waller, 2008). The investigation about subtidal benthic communities showed that the community simplicity and dominance of unitary (compared to colonial) fauna increased with latitude (Barnes and Arnold, 1999). Jazdzewski et al. (2001) found that the order of macrofaunal biomass of the stony beach in King George Island was as follows: autumn > summer > spring > winter.

Until now, studies of intertidal benthos were much less than those from the deep sea. While many marine organisms are reported from the Southern Ocean, most of these species were found from trawls and grab samples from early expeditions and fishery bycatch (Strebel, 1908; Thiele, 1912; Roux et al., 2002). Coastal and subtidal biota are still relatively obscure (Barnes et al., 2006).

King George Island is the largest island in the South Shetland Islands in Antarctica. The island is about 80 km in length while it has different sizes in width from south to north with 30 km width at its broadest point. The whole island is covered with ice and snow all year round except some places along the coast in austral summer. The island is about 960 km away from Cape Horn which is at the southern tip of South America and 129.5 km away from Antarctic Peninsula. There are several scientific research stations on this island: Great Wall (China), Bellingshausen (Russia), Frei (Chile), Arctowski (Poland), Jubany (Argentina), Ferraz (Brazil), Artigas (Uruguay), King Sejong (R.O. Korea), Machu Picchu (Peru), and the summer stations of Chile and Argentina on Ardley Island. Situated on the southwest part of the King George Island, Fildes Peninsula is the largest ice-free zone in King George Island. This Peninsula, which is about 10 km in width, has an area of about

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30 square kilometers. There is a multi-level marine deposit bench mostly consisting of gravel and sandiness beach in Fildes Peninsula (Fig. 1, E, 2010).

Most of the investigations of intertidal macrofauna in Fildes Peninsula focused on the qualitative analysis and food chain of macrofauna (Yang et al., 1992a,b; Shen et al., 1999), while quantitative investigations are restricted to areas in Maxwell Bay and Admiralty Bay (Filcek, 1993; Siciński et al., 2011; Bick and Arlt, 2013). In order to reveal the quantitative distribution of intertidal macrofaunal assemblages in Fildes Peninsula and to provide a baseline for evaluation of the effect of climate changes and human activities on intertidal ecosystems in the Southern Ocean, we report here about comprehensive survey results of intertidal macrofaunal assemblages.

In the austral summer (January to February 2013), macrofauna and environmental variables at 20 intertidal sites in Fildes Peninsula (Fig. 1; Table 1) were sampled during the Chinese 29th exploration on the Antarctic Ocean. Samples were collected at low tide during flood tide of every month, without dividing them into different tidal zones because of the narrow intertidal zones. Two samples were collected by a metal square-shaped frame (0.5 m × 0.5 m) at each sites of the gravel beach and four samples were collected by a square-shaped frame (0.25 m × 0.25 m) at each sandy site for macrofaunal analysis. The samples were sieved with a 0.5 mm mesh sieve. All animals were fixed by 5% buffered formalin solution and identified in the laboratory. Samples for sediment characteristics were collected from surface sediments and stored at −20 °C until analysis. Sediment organic matter content was measured by the ($K_2Cr_2O_7$–H_2SO_4) oxidization method. Sediment chlorophyll a (Chl-a) and phaeophorbide (Pha) contents were measured by spectrophotometer (Liu et al., 2007). Sediment grain size was measured by sieving method. Seawater characteristics (temperature, salinity, pH) were measured by YSI 600XLM sonde *in situ*.

Shannon–Wiener diversity index (H'), species richness index (d), species evenness index (J') were used to evaluate the macrofaunal biodiversity, which were calculated according to the following formulas:

$$H' = -\sum_{i=1}^{s} P_i \ln P_i;\ d = (S-1)/\log_2 N;\ J' = H'/\log_2 N;$$

where P_i is the percentage of the abundance of species i; N is the abundance of all species; S is the number of macrofaunal species of each sample.

Principal component analysis (PCA) was performed to identify the dominant environmental factors. Hierarchical clustering (CLUSTER) analysis was used to delineate macrofaunal assemblages of the sampling stations. BIOENV analysis was used to reveal the most important environmental factors to determine the macrofaunal distribution patterns. All of the abovementioned data analyses were performed using the PRIMER 6.0 software package. In order to assess relationships among the dominant species abundance and environmental variables, Spearman Correlation analysis was performed by SPSS software package.

Index of relative importance (IRI) was calculated to find the dominant species according to the following formula:

$$\mathrm{IRI} = (N + W) * F$$

where N and W are the percentages of abundance and biomass of each species; F is the frequency of each species in all the sampling sites (Pinkas et al., 1971).

The classification of functional groups of macrofauna is based on Li et al. (2013), including: (1) Planktophagous group (Pl): animals feeding on small microzooplankton by filter organs; (2) Phytophagous group (Ph): animals feeding on vascular plants and seaweeds; (3) Carnivorous group (C): animals feeding on meiofauna and larva; (4) Omnivorous group (O): animals feeding on other organisms, rotted leaf, small bivalves and crustaceans; (5) Detritivorous group (D): animals feeding on organic detritus and sediment.

Seawater temperature of the intertidal zones ranged from 0.69 °C to 4.22 °C with a mean of 2.09 °C. The highest and lowest temperature values of the eastern coast occurred at E4 (4.22 °C), E5 (0.69 °C) while the highest and lowest temperature values of the western coast occurred at W5 (3.12 °C), W6 (1.33 °C). Seawater salinity ranged from 28.95 to 36.26 with a mean of 34.63. The highest and lowest salinity values of eastern coast occurred at E11 (36.26), E2 (28.95) while the highest and lowest salinity values of the western coast occurred at W4 (36.24), W1 (33.82). Seawater pH ranged from 7.33 to 8.61 with a mean of 8.13. The highest and lowest pH of the eastern coast occurred at E2 (8.53), E5 (7.33) while the highest and lowest pH values of the western coast occurred at W1 (8.61), W6 (8.05).

Sediment median grain size (Md) in the intertidal zone ranged from 0.45 to 1.60 mm with a mean of 1.04 mm. The highest and lowest overall Md occurred at W4 (1.60 mm), E6 (0.45 mm). At the sandy sites, Md ranged from 0.59 to 1.60 mm with a mean of 1.09 mm. The highest and lowest of sandy sediment Md occurred

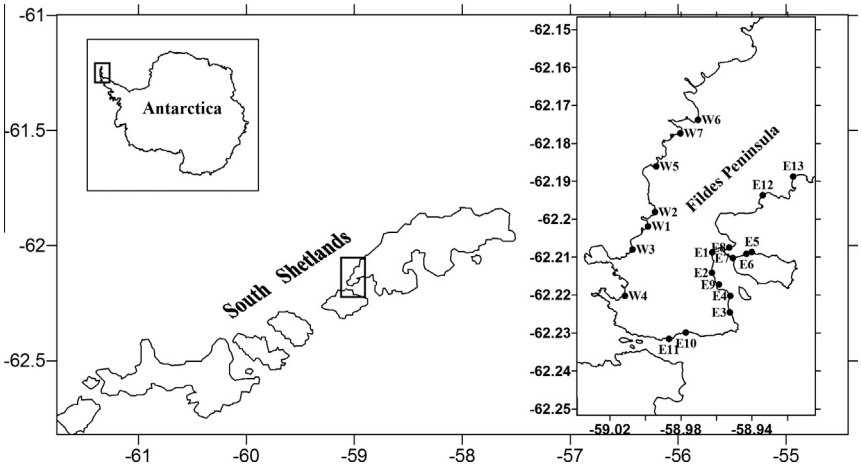

Fig. 1. Map of the sampling sites of intertidal zones in Fildes Peninsula, King George Island.