



Community structure and species diversity of intertidal benthic macroalgae in Fengming Island, Dalian[☆]



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ABSTRACT

We investigated the community structure, seasonal variation, species diversity, and ecological niche of the intertidal benthic macroalgae community in Fengming Island, Dalian, China. Five sampling sites were established in the study area, and investigations were conducted in July 2010, April and October 2011, and January 2012. Species diversity index, cluster analysis, Levin's index, and Pianka's index were applied to determine species diversity and ecological niche. A total of 74 species were identified, of which, 15 belonged to *Chlorophyta*, 15 belonged to *Phaeophyta*, one belonged to *Cyanophyta*, and 43 belonged to *Rhodophyta*. The transverse distribution of the macroalgae species varied among the different sampling sites and seasons. In the longitudinal distribution, the low-tide zone had the highest abundance of species, which were predominately *Rhodophyta*; the mid-tide zone ranked second in the abundance of species, which were predominately *Phaeophyta*; and the high-tide zone had the lowest abundance of species, which were predominately *Chlorophyta*. Seasonal species number followed the pattern spring > summer > winter > autumn. *Rhodophyta* species were the most abundant in all four seasons, followed by *Chlorophyta* and *Phaeophyta* species, with *Cyanophyta* species being the least abundant. The benthic macroalgae in the study area were primarily temperate species, with the warm temperate composition greater than the cold temperate composition. Biomass distribution in each study site showed seasonal variation, and followed the pattern summer > spring > autumn > winter. Species diversity and cluster analysis demonstrated obvious seasonal variations, with the species diversity, evenness, and species richness indices higher in spring and summer than those in autumn and winter. Species diversity also varied among sampling sites. The function and status of different algae in the ecosystem were defined by the niche breadth and overlap results.

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1. Introduction

Intertidal zone is an ecotone between terrestrial and marine ecosystems and is an important habitat for marine life. As an important part of the intertidal ecosystem, benthic macroalgae are primarily composed of *Rhodophyta*, *Phaeophyta*, and *Chlorophyta* living on the rocks or gravel. They play an extremely important role in energy flow, circulation of materials, and information transfer in the intertidal zone, and are the most potential community for development of algae resources [1]. Studies of intertidal benthic algae focus on flora, species composition, distribution characteristics, and other basic characteristics [2–6]. In recent years, the scope of research has extended to changes in community structure and diversity [7,8], and shifted to a more microscopic level, such as physiological ecology, symbiosis mechanism, and trophic relationship [9,10].

Several ecological studies have been conducted in coastal intertidal zone in Dalian, China. Li et al. investigated benthic algae and analyzed seasonal variation in community in Heishijiao and Xiaoping Island [11], and also reported the distribution and abundance of benthic algae in Changshan Archipelago [12]. Xiong et al. reported seasonal variation in species composition, coverage, and biomass of intertidal benthic algae, and changes in dominant species in Shimiao area [13]. Wang et al. reported seasonal variation of benthic algae in Xinghai Bay [14]. Tian et al. reported seasonal variation of benthic algae in Zhangzi Island [15]. Xu et al. reported seasonal variation of intertidal commercial benthic macroalgae community in Xizhong Island [16]. However, these studies do not relate to community structure and diversity of benthic algae in Fengming Island.

This study intended to clarify the species composition, community structure characteristics, seasonal variation, species diversity characteristics, and ecological niche of intertidal benthic macroalgae in Fengming Island in Dalian, China based on field investigation. The results presented may lay a foundation for algae germplasm conservation and sustainable exploitation of marine resources, and provide a scientific basis for marine ecological environment remediation and ecological civilization in coastal waters.

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2. Research methods

2.1. Study area overview

Fengming Island is located in the Bohai Sea, 44 km southwest of Wafangdian City, Dalian, China, with an area of 49 km². The geographical location is 121°26'25"–121°19'05"E, 39°21'40"–39°26'25"N. It is under the jurisdiction of Changxing Island Economic and Technological Development Zone of Wafangdian City. Due to a continental monsoon climate, annual water temperature in Fengming Island waters varies greatly from an average of 23 °C in August to an average of 2 °C in January, representing a difference of 21 °C [17]. Intertidal sediment is primarily rock and gravel beaches, with rich benthic algae resources.

2.2. Sampling method

Five sampling sites were established (Fig. 1) based on the differences in geographic conditions and algal growth substrate. The sediment of S1 (Xibei Hai) and S4 (Nanhaitou) is gravel beaches, and that of S2 (Taipingding), S3 (Qianchang) and S5 (Qianshaocun Dongxiaoquan) is rocks. The sites were positioned using GPS. Three stations (low-tide, mid-tide, and high-tide) were set at each site. Quantitative and qualitative sample collection of benthic macroalgae in the study area was conducted on a spring tide day in July 2011, April 2012, October 2012, and January 2013, respectively. Species composition, seasonal dynamics, and active growth and reproduction period of benthic macroalgae were observed and recorded.

2.2.1. Quantitative sample collection

Quadrats were established for quantitative collection based on beach area. More quadrats were established in a large beach, for example, two quadrats in high-tide zone, three in mid-tide zone, and one or two in low-tide zone; while less quadrats were established in a small beach,

for example, one quadrat in high-tide zone, two in mid-tide zone, and one in low-tide zone. The size of biomass collection box was 25 cm × 25 cm for bio-sparse areas and 10 cm × 10 cm for bio-intensive areas. Benthic macroalgae in the quadrats were removed from substrate using a small blade, transferred into plastic bags, and numbered. Indoor samples were analyzed on dry biomass basis. Weighing, calculation, and data compilation followed the methods specified in Specifications for Oceanographic Survey [18].

2.2.2. Qualitative sample collection

Extensive qualitative samples were collected on the basis of quantitative sample collection.

Nonperishable algae (such as *Ulva lactuca*, *Laminaria japonica*, and *Corallina officinalis*) were directly placed in ziplock bags. Perishable, thin, or easily damaged algae (such as *Antithamnion densum*, *Hyalosiphonia caespitosa*, and *Dasya villosa*) were placed in bottles with seawater. Some algae, such as *Desmarestia viridis*, would release sulfate ions after death, which could cause the death of other algae, and thus were placed in separate ziplock bags and numbered after collection.

2.3. Data processing

2.3.1. Diversity index

Shannon–Wiener diversity index, Pielou evenness index, and Margalef richness index were used for characterization [19,20]:

$$\text{Shannon-Wiener diversity index: } H' = -\sum_{i=1}^s P_i \cdot \log_2 P_i \quad (1)$$

$$\text{Pielou evenness index: } J = \frac{H'}{H_{\max}} \quad (2)$$

$$H_{\max} = \log_2 S \quad (3)$$

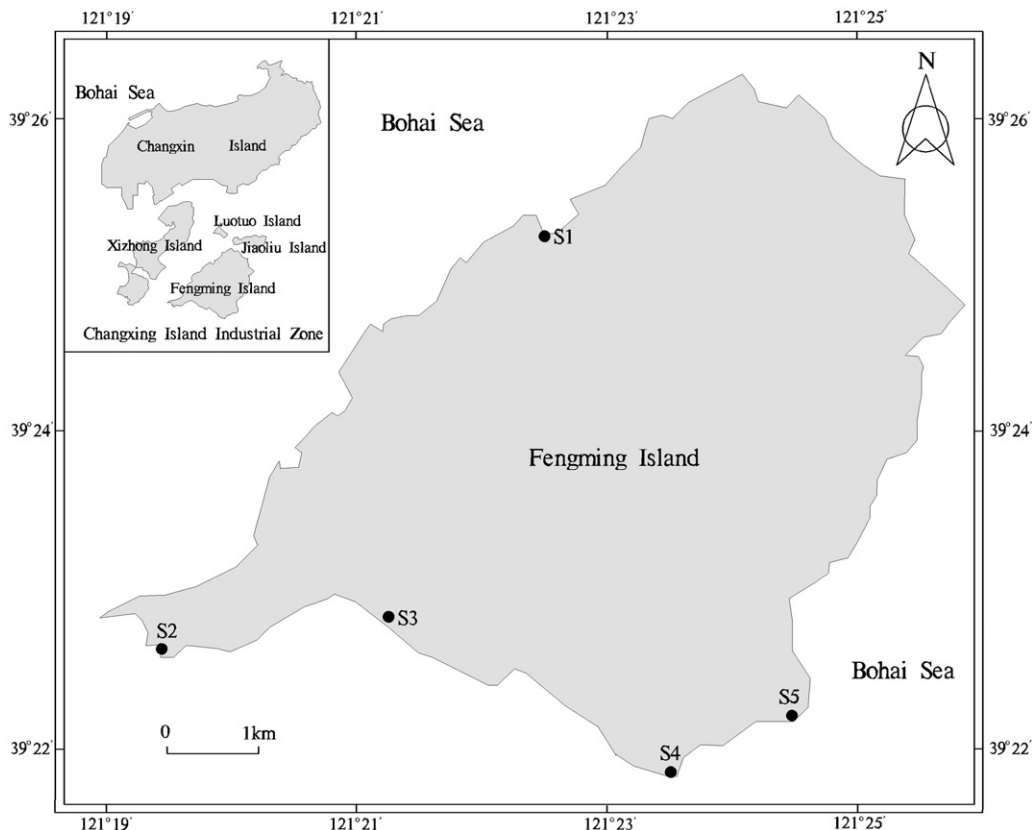


Fig. 1. Sampling sites of intertidal benthic macroalgae in Fengming Island, Dalian.

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