



Temporal and spatial distributions of intertidal macrobenthos in the sand flats of the Shuangtaizi Estuary, Bohai Sea in China



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ABSTRACT

The intertidal macrobenthos in the sand flats of the Shuangtaizi Estuary, Bohai Sea in China, were investigated in the spring, summer, and autumn in 2013 to identify the macrobenthic community of species components, abundance, and biomass. Twenty-nine species were identified, and classified primarily as mollusks (45%), polychaetes (31%), and crustaceans (21%). The abundance and biomass of the macrobenthos in the intertidal zone of the Shuangtaizi Estuary exhibited distinct seasonal patterns; both factors were higher in summer (16,762 ind/m² and 782.5 g/m², respectively) than in spring or autumn. The intertidal macrobenthos displayed a remarkable vertical distribution, and exhibited typical characteristics of estuaries: polychaetes such as *Perinereis aibuhitensis* distributed in the high tidal zone. Mollusks, such as *Bullacta exarata*, *Potamocorbula laevis*, and *Umbonium thomasi* mainly inhabited the mid-tidal zone. The buried clams *Macraa veneriformis* and *Meretrix meretrix* were dominant in the mid-tidal and low tidal regions, where the two clams shared overlapping habitats to some extent. Moreover, these benthic species were also highly abundant in the sections near the Shuangtaizi River mouth (23,661 ind/m²), but were detected as a high biomass in the sections far from the mouth (1492.9 g/m²). The bivalve *P. laevis* and *M. veneriformis* primarily contributed to the abundance and biomass of mollusks. The average Shannon–Wiener, evenness, and species richness indices of the intertidal macrobenthos in the estuary were 0.83, 0.37, and 0.45, respectively. The surface sediments in the intertidal zone consisted mainly of clay, silt sand, fine-grained sand, and sand types, which were closely related to the distributions of macrobenthos. Our study suggests that the Shuangtaizi Estuary is an important shellfish fishery, and the high abundance and biomass of *P. laevis* and *U. thomasi* can be exploited further. However, effective measures should be implemented to protect and restore the population of the clam *M. meretrix*.

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1. Introduction

The estuary is a transitional zone between land and sea, and this zone is one of the most productive ecosystems worldwide [8]. Terrigenous freshwater that carries large amount of particulate matters such as mud and sand, flows into the sea and forms large areas of sand flats, and this region is the most distinct habitat in estuarine ecosystems. Terrigenous freshwater that contains high levels of nutrients and organic materials provides abundant food sources for estuarine organisms [10]. As such, the intertidal sand flats in estuaries are highly productive, and serve as habitats and breeding grounds for diverse macrobenthic invertebrates [14]. These sand flats also function as important migration stopover sites for migratory waders [22]. Macrobenthos play an important role in the nutrient cycling and energy flow of estuarine ecosystems [12,25,28]. Therefore, the knowledge of estuarine macrobenthic community and distribution relative to their habitat is fundamental to understand estuarine

ecological characteristics, such as biodiversity, conservation biology and environmental protection [24].

The ecological characteristics of macrobenthos in estuaries have been extensively investigated worldwide, for instance, these characteristics have been obtained from Hawkesbury- and Tasmanian Estuaries, Australia [3,14], Basque Estuary, Spain [7], Schelde Estuary, Belgium [24], Lima Estuary and the Mondego River Estuary, Portugal [15,17], Humber Estuary, UK [5], Richibucto Estuary, Canada [12], Natori River Estuary, Japan [18], Zuari Estuary, India [16], and Han River Estuary, Korea [25]. However, the community characteristics of macrobenthos in estuaries in China have been rarely investigated: studies regarding these parameters have been conducted in Pearl River Estuary [29], Yellow River Estuary [11,19–21] and Xiaoqing Estuary [13].

The Shuangtaizi Estuary, which is located at the top of Liaodong Bay, Bohai Sea in China, is one of the few remaining intertidal sand flats and an important clam fishery area. Around the estuary, three main rivers, namely Shuangtaizi River, Daliao River and Daling River, continuously flow into the sea and form sand flats, which cover the intertidal flats of approximately 6.7×10^4 hm² and account for 56% of the total mudflat area in Liaodong Bay [23,26]. The estuary is an important fishing ground

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and preferred place of feeding, spawning and perching for many economic macrobenthic species [2]. However, macrobenthic communities in the Shuangtaizi Estuary have yet to be described. Therefore, this study involved a quantitative survey of macrobenthic communities in spring, summer, and autumn to identify the temporal and spatial characteristics of these communities. This study also provided suggestions related to protection and proper utilization of fishery resources. Moreover, this study can present useful background data to help develop an ecologically sustainable estuarine management program and restore the fishery resources.

2. Materials and methods

2.1. Sampling areas

The Shuangtaizi Estuary is the highest-latitude estuary in China, with a long-term ice cover during winter from early November to the end of March. Our sampling area, which covers approximately 6500 hm², is

located in the western part of Shuangtaizi Estuary (Panshan shore). This area is composed of one of the few remaining intertidal sand flats (Fig. 1) and is a significant habitat of different marine organisms, especially clams [28].

2.2. Sampling process and data analysis

The intertidal macrofauna were sampled at 46 sites in 7 sections (A–G, perpendicular to the Shuangtaizi River current), in the spring, summer, and autumn of 2013 (Fig. 1). We could not sample during winter because the investigation area had long-term ice cover. The distances between the adjacent sections and sampling sites were approximately 2.2 km and 500 m, respectively. Eight subsamples were randomly collected at each sampling site by a Van Veen Grab sampler (25 cm × 25 cm) to a depth of 20 cm, and sieved through a 1-mm iron mesh screen with seawater. All benthos of the eight subsamples were pooled and preserved in 5% formalin solution (v/v) until counting and identification were performed. The treatment, preservation, counting and weighing protocols were

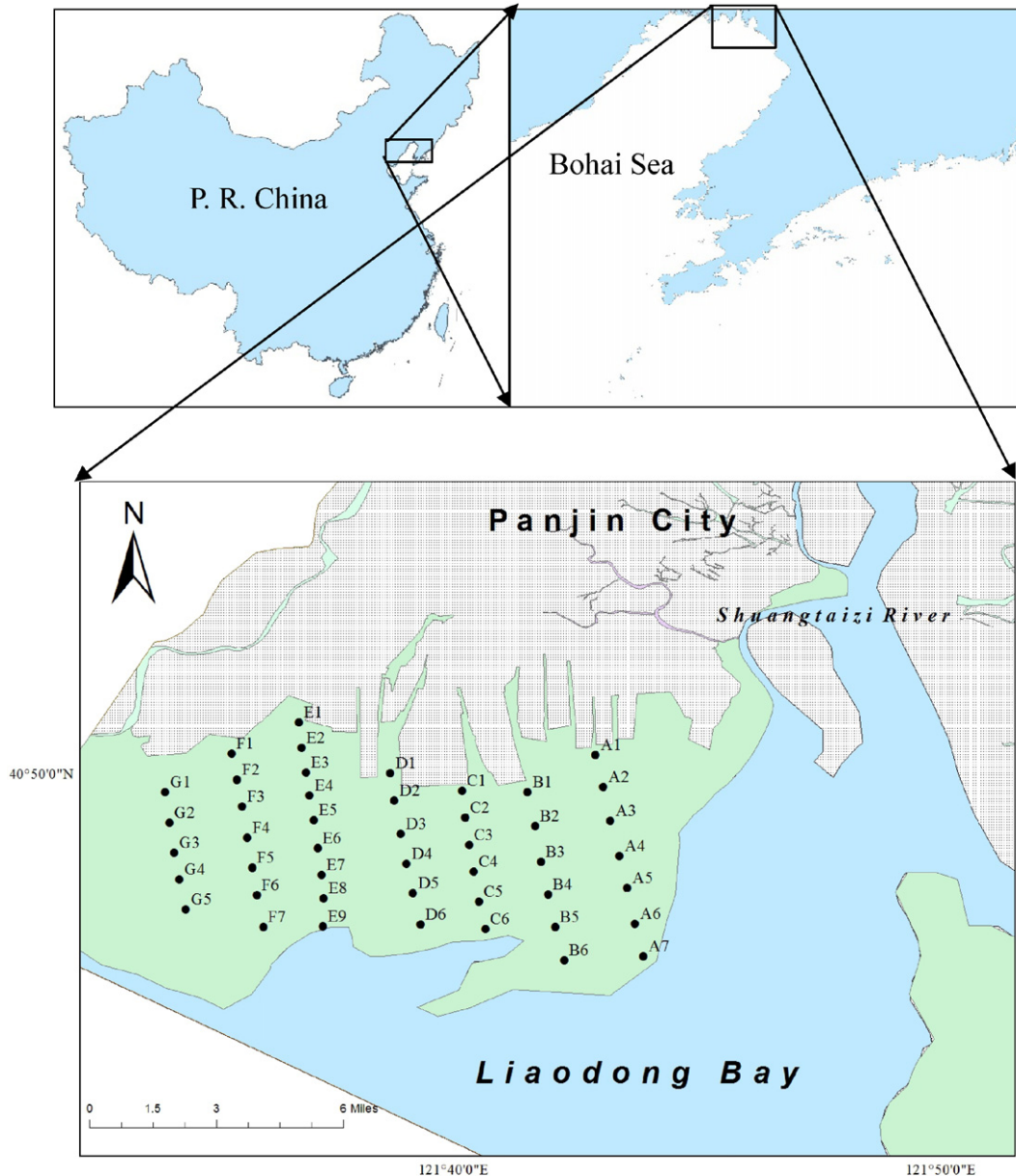


Fig. 1. Sampling sites for macrobenthos in the intertidal zone of Shuangtaizi Estuary.

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