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SCIENCE DIRECT
Estuarine, Coastal and Shelf Science 64 (2005) 316–322
ESTUARINE COASTAL AND SHELF SCIENCE
www.elsevier.com/locate/ECSS

Spatial shifts in food sources for macrozoobenthos in an estuarine ecosystem: Carbon and nitrogen stable isotope analyses

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Received 1 November 2004; accepted 25 February 2005
Available online 19 April 2005

Abstract

Carbon and nitrogen stable isotope ($\delta^{13}C$ and $\delta^{15}N$, respectively) analyses were made on estuarine macrozoobenthos in order to examine the relationships between their feeding habits (feeding mode and food selectivity) and the spatial shifts in food sources from upstream to downstream in an estuary. The $\delta^{13}C$ values of two ocypodid crabs were similar to those of benthic diatoms, indicating that they use their specialized mouth parts to selectively feed on benthic diatoms. The $\delta^{13}C$ values of a gastropod and another ocypodid crab at the site furthest downstream were higher than values at an upstream site, suggesting that these unselective deposit feeders shift from feeding mainly on benthic diatoms downstream to feeding on sediment organic matter (SOM) upstream. The $\delta^{13}C$ values of deposit feeding polychaetes were not significantly different among sampling sites, indicating that they feed mainly on SOM at all sites. These results show that species- and site-specific feeding habits must be considered when evaluating the roles of macrozoobenthos in regulating estuarine material flows.

Keywords: feeding habits; deposit feeders; ocypodid crabs; gastropod; polychaetes; benthic microalgae; sediment organic matter

1. Introduction

Organic matter in an estuary is a mixture of allochthonous (i.e. imported) material from the river and sea, and autochthonous material that is produced within the estuary. The contribution of each component to the total organic budget changes spatially from the mouth to the head of an estuary (Little, 2000; Wetzel, 2001). Recently, stable isotope analyses have revealed that the macrozoobenthos, which are important primary consumers in most estuaries, shift their main food source from one component to another as the composition of organic matter changes (e.g., Coach, 1989; Cifuentes et al., 1996). Thus, the roles of some macrozoobenthos in an estuarine food web are likely to change spatially, although few studies have examined this (but Wainright et al., 2000). Such a study requires clarifying the relationship between macrozoobenthos' feeding habits and food sources, because the role of benthic species depends on both their feeding mode (e.g., suspension, deposit or predatory feeding), and food selectivity (selective and unselective feeding that

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doi:10.1016/j.ecss.2005.02.028

correspond with specialists and generalists, respectively). Other ecological variables, such as co-occurring macrozoobenthos and food source density and distribution, are also important. In addition, the contribution of allochthonous and autochthonous organic material differs between watersheds, depending on the geology, freshwater input, and tidal range of each estuary (Little, 2000; Mann, 2000). Therefore, empirical studies on various estuary types are needed.

The majority of macrozoobenthos in estuaries are suspension and deposit feeders. Their feeding activity forms an important link between the sediment and suspended material, and this affects nutrient cycling in estuarine ecosystems (see Little, 2000; Mann, 2000 for reviews). However, it is often difficult to evaluate macrozoobenthos' food sources. For example, the sediment organic matter (SOM) that benthic deposit feeders eat is a composite of microalgae, bacteria, and aquatic and terrestrial plants. Some deposit feeders selectively use only one part of the SOM (e.g., only the microalgae), while others feed unselectively on all SOM. Therefore, carbon and nitrogen stable isotope analyses, which are now widely used as a means of tracing material flow through food webs (e.g., Kurata et al., 2001), are recommended for estimating actual food sources for the benthic animals of the same feeding mode but having the different food selectivity.

The present study conducted carbon and nitrogen stable isotope analyses for macrozoobenthos at three sites from the mouth to the head of the Kitakami estuary, in northeastern Japan. The macrozoobenthos species were compared among different feeding modes and/or food selectivity to determine if these feeding habits conferred different stable isotope ratios. The macrozoobenthos were categorized according to their feeding habits and potential food sources, and the stable isotope data were used to identify spatial shifts in the use of organic material as its composition varies in the estuary.

2. Materials and methods

2.1. Study area

The Kitakami River estuary is located in the northeast of Honshu Island, Japan (38°30–34′N, 141°18–28′E). Three sampling stations, Sts. 1, 2, and 3 were set at approximately 2, 8, and 16.5 km, respectively, upstream from the river mouth (Fig. 1). All the stations were on intertidal flats with salt marshes that consisted mainly of *Phragmites australis*. The salt marsh at St. 1 was smaller and had developed relatively large, bare sand flat, as compared with the larger marshes at Sts. 2 and 3, where bare areas were restricted to the marsh edges. At St. 1, the benthic microalgae were only readily available to collect samples in the sparse marsh, while at Sts. 2 and 3, the benthic microalgae were not available, probably due to light limitation by salt marsh. Water salinity varied considerably with tidal movements and the mass of river flow (e.g., during 1999, the range of salinity in the surface water at St. 1 was ca. 0–30, Matsumasa, personal communication). The macrozoobenthic species composition changes with the salinity gradient and the spatial arrangement of habitable substrate (see below Table 1; Matsumasa and Kikuchi, 1993; Matsumasa, 1994).

2.2. Sample collection and preparation for isotopic analyses

On 10 August 2001 the following dominant adult macrozoobenthos were collected with three individuals for the replicate sample at Sts. 1, 2, and 3: a bivalve

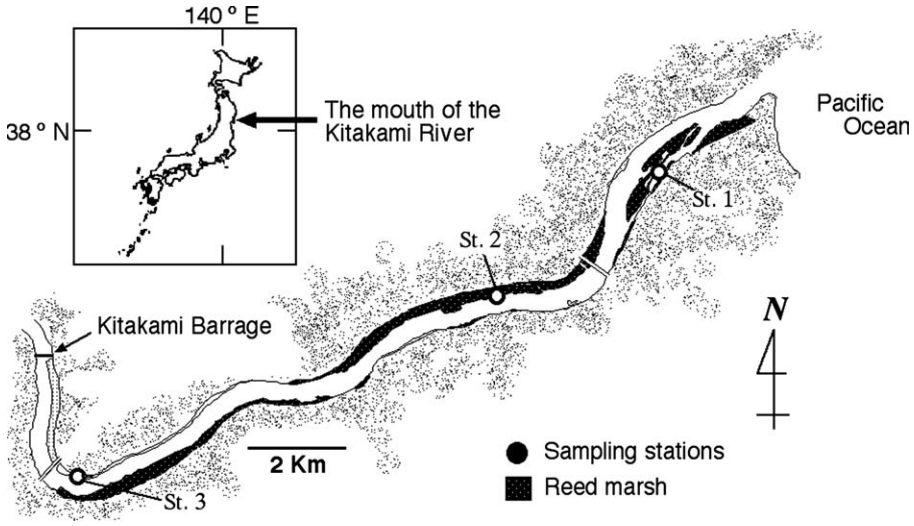

Fig. 1. Map of the Kitakami River estuary.