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Recent Research Topics in Biological Production Processes of Marine Bio-resources in the Coastal Waters and Estuaries

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Summary

Characteristics on estuarine ecosystems and biological production processes in the coastal waters were investigated. Food supply for suspension-feeding bivalves were investigated by means of stomach contents analyses and analyses of stable isotopes of carbon and nitrogen. The surf clam may scarcely intake pelagic microalgae produced in the upper layers of the water column, showing that the layer connected with food supply is confined to the narrow space close to the bottom interface. Food supply for bivalves distributing in the estuaries such as *Colobicula japonica* and *Ruditapes philippinarum* also is investigated. We assumed that the ecological role of microphytobenthos may be more important than that of phytoplankton as primary producer in estuarine systems. We investigated the feeding habits and growth of juvenile flatfish, *Platichthys bicoloratus* in estuarine nurseries. Polychaete palps and bivalve siphons (mostly *Nuttaria olivacea*) were selected and consumed by juveniles in estuarine nurseries. Regeneration process of *N. olivacea* siphons should be determined to evaluate the food productivity for juvenile flatfishes.

Food Supply for Suspension-Feeding Bivalves

The food supply for each species is a dominant factor determining carrying capacity in an area. Suspension-feeding bivalves ingest various suspended organic particles, including planktonic and benthic microalgae, bacteria and resuspended detritus. Food sources of the surf clam *Spisula sachalinensis* were investigated by comparing the microalgal composition in the stomach to those in the overlying water and in the bottom sediment. Microalgal composition in the stomach contents resembled that of the sediment, in which four microalgal species groups constituted a large proportion in total through the period. By contrast, dominant microalgae in the water column changed seasonally and differed from those in the stomach contents and the sediment. Because the surf clam is an obligate suspension feeder, these indicate that the surf clam may rely on the overlying water proximal to the bottom surface as a food source layer. It might probably be several cm or less thick. Microalgae dominant even in the layer 0.1 m above the bottom were rarely input into the food source layer.

We also used analysis of stable isotopes of carbon and nitrogen. Carbon isotopic compositions of the adductor muscle of the surf clam ranged from -15 to $-16‰$, which were near to the value of $-16‰$ for benthic microalgae. Compared with this, the values of particle organic matter in the sea water ranged from -21 to $-25‰$, and those in the sediment -19 to $-21‰$. The wide differences between the value of the adductor muscle and that of organic particles in the seawater negated the direct consumption of the planktonic microalgae by the surf clam.

Consequently, the surf clam may scarcely intake pelagic microalgae that are produced in the upper layers of the water column, showing that the layer connected with food supply is confined to the narrow space close to the bottom interface. It doesn't fit the case of infaunal suspension-feeding bivalves in open shallow sandy bottoms that pelagic microalgae produced in the upper layers are transported to the bottom layer by vertical mixing and are supplied as food to benthos.

Characteristics on estuarine ecosystems

(1) Two major pathways on trophic structure and the importance of microphytobenthos

We discussed the characteristics of the estuarine ecosystems based on a case study at the Natori River in Miyagi prefecture, where is an important fishery ground of the bivalves such as *Corbicula japonica* and *Ruditapes philippinarum*, and are nursery grounds for juveniles of fishes. Our studies based on the analysis of stable isotopes and stomach content analysis of organisms in the estuary suggested that the trophic structure is consisted of two major pathways. One is the pelagic food chain derived from phytoplankton, and the other is the benthic food chain derived from microphytobenthos. Many fishes collected in the estuary were demersal fishes such as *Acanthogobius lactipes*. Therefore, we assumed that the ecological role of microphytobenthos may be more important than that of phytoplankton as primary producer in estuarine systems. There were many kinds of species and the variety in the life style of microphytobenthos even in the same habitat. They had higher diversity in size and growth form. These ecological characteristics on microphytobenthos would link to the importance on food supply for primary consumers, especially a lot of benthos, in estuarine systems.

(2) A key species, bivalve Nuttallia olivacea, in estuarine ecosystems

Tellinacean bivalve *Nuttallia olivacea* is a key species in Natori River flat. They were dominant species and their inhalant siphons were one of the most important prey items in the diet for juvenile stone flounder *Platichthys bicoloratus*. Feeding habits and growth of juvenile *P. bocoloratus* were investigated in several estuarine nurseries in Sendai Bay. Polychaete palps and bivalve siphons (mostly *N. olivacea*) were positively selected and consumed by juveniles, indicating the generality of sublethal feeding of juvenile flounder in estuarine nurseries. Therefore estimating the growth rate of *Nuttallia olivacea* and their siphon productivity is important to understand the estuarine ecosystems.

The growth rate of the bivalve *Nuttallia olivacea* in the field was estimated by the marking-recapture and caging methods in a Natori River flat. Individuals with a shell length of 9-20 mm were marked, returned to the tidal flat, and recaptured monthly for measurement of their size and weight. Daily increments in shell length and weight were largest in summer (August to September), and smallest in winter (February to April). The annual growth in terms of shell length and weight was 13.49 ($\pm$2.44) mm and 3.14($\pm$0.89) g.

Regeneration process of *N. olivacea* siphons should be determined to evaluate the food productivity for juvenile stone flounder. We carried out rearing experiments of siphon-removed bivalves in their natural habitat. In a 3-mo caging experiment in the field, the siphon weight of siphon-removed bivalves, adding the removed weight, was significantly larger than that of non-amputated bivalves, indicating the occurrence of quantitative regeneration. In a 1-mo caging experiment, bivalves that had approximately 15% of their siphons amputated were selected at some intervals to illustrate the quantitative regeneration process. Estimated daily siphon production was remarkably high only a few days after amputation. It decreased greatly thereafter, but regeneration was not completed within 30 d. These results indicate that bivalves regenerate siphons rapidly just after losing siphon tissues and then siphon regeneration is slowed down before it is completed.

References

Ito, K., Kaga, T., Sasaki, K., and Omori, M. Biological production process and food environment for bivalves in tidal flat. *Bull. Fisheries Research Agency, Supplement*, No. **3** : 1-15, 2005. (in Japanese with English summary)

Ito K, Sasaki K, Omori M, Okata A. Growth rate of the bivalve *Nuttallia olivacea* measured by marking-recapture and caging. *Jpn J Benthol*, **56** : 9-17, 2001. (in Japanese, with English summary)

Ito, K. and Kakegawa, T. Food resources of fishes in estuaries, Discoveries in aquatic animal ecology presented by stable isotopes—Bivalve to Whale—, Ed. Tominaga, O., and Takai, N., Koseisha Koseikaku Co. Ltd., Tokyo, pp. 70–84, 2008. (in Japanese)

Sasaki K, Kudo M, Tomiyama T, Ito K, Omori M. Predation pressure on the siphons of the bivalve *Nuttallia olivacea* by the juvenile stone flounder *Platichthys bicoloratus* in the Natori River estuary, north-eastern Japan. *Fish Sci.*, **68** : 104–116, 2002.

Sasaki, K., Sanematsu, A., Kato, A. and Ito, K., Dependence of the surf clam *Pseudocardium sachalinensis* (Bivalvia : Mactridae) on the near-bottom layer for food supply. *J. Moll. Stud.*, **70** : 207–212, 2005.

Tomiyama, T., Komizunai, N., Shirase, T., Ito, K., and Omori, M. Spatial intertidal distribution of bivalves and polychates in relation to environmental conditions in Natori River estuary, Japan. *Estuarine, Coastal and Shelf Science* **80** : 243–250, 2008.

Tomiyama, T., Omori M. and Minami,T. Feeding and growth of juvenile stone flounder in estuaries : generality and the importance of sublethal tissue cropping of benthic invertebrates. *Mar. Biol.*, **151** : 365–376, 2007.

Tomiyama T, Sasaki K, Omori M Predator-prey size relationship in siphon cropping between the juvenile stone flounder *Platichthys bicoloratus* and the bivalve *Nuttallia olivacea.* *Fish Sci.,* **70** : 531–536, 2004.