Proper management of fishery resources using a bivalve growth model which included fishery catch and feeding damage

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Ariake Bay, which is one of the most prominent fishing grounds, is located in southwest Japan. The area is about 1700 km^2 with a tidal flat of about 190 km^2. Since the 1980's, fishery catch has decreased year by year. Among the suspected causes of the decrease, there are outbreaks of red tide, rise of water temperature, excessive fishery pressure and feeding damage by predators. Especially, as a cause of the feeding damage, it is reported that longheaded eagle rays (*Aetobatus flagellum*) have been seen in Ariake Bay since the 1990's, and prey on large amounts of bivalves. The eagle ray is more than 1 m in body width and 10 kg in weight. In Ariake Bay, a large number of rays appear in April and disappear in December. In this study, a simple numerical simulation model based on the bivalve growth considering fishery catch and feeding by the rays is developed and applied to assist with the proper management of fishery and extermination of predators.
The growth of bivalves is simulated as a function of water temperature. The quantity of natural resources of the bivalves is calculated by multipling recent population density by habitation area. The fishery catch is estimated by summing up values of monthly catch from statistical reports. Monthly catch amount is more than 500,000 tons in the big catch years and equal to or less than 10,000 tons in the poor catch years. The biomass of the ray is estimated to be more than 3,000 tons based on the amount of capture for extermination. The daily amount of predation on bivalves by the rays is calculated to be 1% of the biomass during the appearance period.
As a result of this simulation, the bivalve resources varied according to the biomass of the rays. It was indicated that the predation pressure by the rays could be a serious factor affecting bivalve resources. With the big catch amount of the past years, the bivalve biomass of recent years was entirely consumed causing the exhaustion of the bivalve. It clearly explains that the current bivalve resources cannot support the same amount of fishing as in the past. Under the conditions of both predations of the ray and past fishery catch, bivalve resources were diminished. To maintain the resources with this predation and catch, a biomass 4 times larger than recent bivalve populations is required. Our simulation model has revealed that it is important to decrease the feeding damage and to manage the fishery catch properly to maintain the bivalve resources.

Monitoring of macrobenthos and bivalve for biologically productive artificial tidal flats, Ago Bay, Japan

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Ago Bay in Japan is a typical enclosed coastal sea, which is connected to the Pacific Ocean through a very narrow and shallow entrance. The bay has been extremely contaminated by the practice of culturing pearls, which has been ongoing for the past 110 years. Because sediment eutrophication, oxygen deficient water and harmful algal blooms have occurred in recent years, the pearl culture industries were damaged. To address this problem, many attempts are being tried in order to improve the natural self-cleaning capability in the bay region by forming artificial tidal flat, shallow water area and sea algae and/or sea-grass bed inside the bay. To clean up the dredged sediments accumulated at the bottom of the sea, where the contamination is progressive, we are exploring the technologies to decompose the organic materials. This new technology-the Hi-Biah-System (HBS)-was developed in 2005. This system could dewater muddy dredged sediments and coagulate them to the solidified sea bottom

sediments for constructing an artificial tidal flat. The purpose of this study was to evaluate the environmental conditions of the constructed tidal flat over two years after it was built. We monitored the biological characteristics (restoration of macrobenthos and growth of bivalve) and physico-chemical parameters (oxidation-reduction potential, acid volatile sulphide, loss on ignition, water content, total organic carbon, total nitrogen, chlorophyll a, and particle size) for five types of constructed tidal flats and a natural tidal flat. At the same tidal situation, the physico-chemical parameters were almost similar among the five constructed and natural tidal flats. However, the biomass and macrobenthic population in the constructed flats was higher compared to the natural one. Moreover, it was observed that the results for the young short-necked clam indicated remarkably larger growth in the artificial tidal flat relative to that obtained in the natural one. From this result, it was supported that the muddy solidified sea bottom sediments were very effective for the excellent growth of the young clams. These observations may be considered to be attributable to the minerals which were supplied from the solidified sea bottom sediments. These solidified materials would give the good ecological conditions to benthic animals. The muddy dredged sediments generated by the HBS could provide useful materials for enhancing the productivity of the tidal coast in order to create new environment.

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Isotopic evidence of seasonal variation in feeding niche of river and brackish gastropods

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Dynamics of organism's feeding niche in response to environmental changes is of fundamental importance for understanding determinants of community structures and diversity. Feeding niche can be examined by stable isotope analysis. At a downstream bank of Yura River, Kyoto, Japan, feeding habit of three common gastropods and their possible food were studied using ^{13}Carbon and ^{15}Nitrogen stable isotopes. Anadromous gastropod *Clithon retropictus* depended mostly on benthic microalgae and marine POM as source of nutrition. It utilized about 65% benthic microalgae in spring and slightly decreased to 62% in summer while marine POM in its diet increased from 25% in spring to 30% in summer. Marine water enters Yura estuary and intrudes midstream from spring to summer, making oceanic phytoplankton available as part of the diet of *C. retropictus*. *Cipangopaludina japonica* and *Semisulcospira libertina* which are both freshwater gastropods change diet from spring to summer. In spring, *C. japonica* consumed about 67% from organic matter of the sediment but shifts its diet to river POM (68%) in summer. A wider food spectrum is consumed by *S. libertina* in spring; about 27% river POM, 25% sediment POM, 24% estuary POM and 16% microalgae. In summer, it shifts its diet to mostly river POM (71%).

To understand the dynamics of feeding niches of the three river gastropods, we measured and analyzed stable Carbon isotope trends of the five possible food items in the study site. Stable isotope ^{13}C of microalgae had enriched greatly from spring to summer, from -25% to -17% which indicated the presence of marine-origin epiphyton. The same trend was observed in sediment POM which increased from -26% to -22%. River POM showed the opposite trend, ^{13}C decreased from -24% to -27% from spring to summer which indicated more influence of terrestrial-origin materials in the river freshwater during summer. Marine and estuarine POM showed relatively constant ^{13}C values in the two seasons (-22% and -24% respectively).

C. retropictus utilized marine POM aside from benthic microalgae. Although marine-origin materials are more available in summer due to marine water intrusion, *C. japonica* and *S. libertina* still selected terrestrial-origin materials either from river POM or sediment POM. Shift, expansion and overlapping of feeding niches were thought to be responses to food availability, competition and water dynamics in the estuary. River discharge and movement of marine water into the river may play an important role in the temporal change of feeding niches of the gastropod populations. This has implication on the diversity and management of river and estuary systems.

Evaluation of restoration effect in the coastal unused reclaimed area by promoting sea water exchange in Ago Bay, Mie Prefecture, Japan