Succession of Benthic Assemblages in Wild Bird Park, a Sanctuary Established on Reclaimed Land in Osaka Port

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In order to obtain data relevant to increasing the numbers of prey organisms for shorebirds, the population of benthic animals and the environment were surveyed from 1982 to 1989 in three areas (Marsh A, Marsh B and Lagoon) of Wild Bird Park, which was laid out on reclaimed land in Osaka Port. In Marsh A, formed by standing rainwater, marine benthic organisms intruded as seawater was introduced. In Marsh B, created by the pumping in of seawater, intertidal gammarids disappeared and chironomid larvae dominated as freshwater gradually replaced the seawater. In the Lagoon, connected to the sea by ducts, a large biomass and high species diversity were found but large, intertidal animals were scarce. A comparison with the results of surveys made on the tidal flat at the mouth of Onosato River suggests that natural features should be introduced into Wild Bird Park for the future development of an intertidal assemblage.

Wild Bird Park in Osaka Port (Fig. 1) has been open to bird-watchers since September 1983. The park, which was reclaimed from the sea by the deposition of sludgy sediments dredged from the harbor area, has a sandy area of 12.8 ha, a planted area of 6.5 ha, and three cottages for observations. In the sandy area there are two marshes and a lagoon, each of which was formed by a different process: Marsh A was formed in a depression in which rainwater has collected since August 1981; Marsh B was created by the pumping in of seawater from December 1981 through February 1982, then the seawater was gradually replaced by freshwater as time passed; the Lagoon was made via a connection with the sea formed by ducts in October 1982.

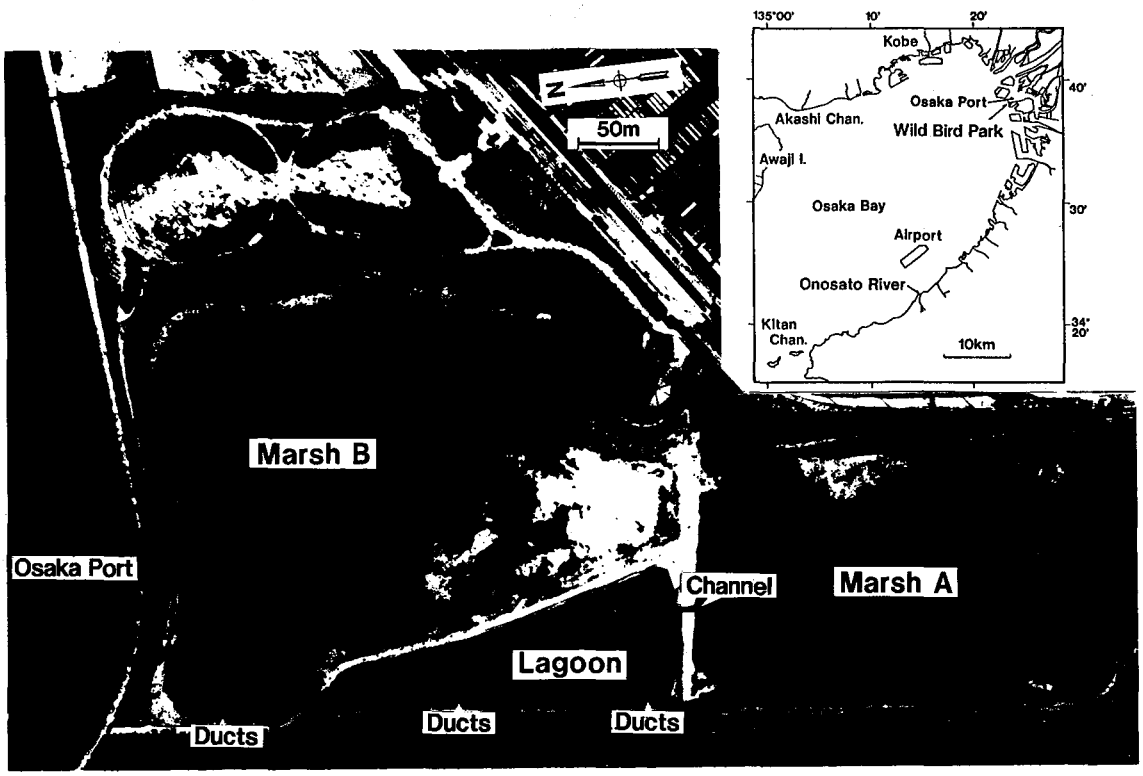

Fig. 1 Wild Bird Park in Osaka Port.

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Results of the first six surveys of benthic organisms in the bird sanctuary were reported by Yokoyama *et al.* (1984). In this report, we describe the succession of benthic organisms and their habitats in Wild Bird Park, and we suggest environmental factors that are essential for the improvement of the park from results of a comparison with the environment on a natural tidal flat.

Methods

Twenty three surveys were conducted during the period between November 1982 and November 1990 in Wild Bird Park. Benthic animals were collected with a 0.0225-m^2 Ekman-Birge grab and a 1-mm-mesh sieve from 2 to 5 stations in each area. Numbers of individuals and wet weights were determined for each species. Samples of water and sediment were collected and analyzed in the laboratory. To obtain data applicable to the improvement of the park, benthic fauna, configuration of the ground, and the nature of the sediment such as grain size, ignition loss, COD and quantity of debris of terrestrial plants contained in it were surveyed seasonally on the natural tidal flat at the mouth of Onosato River (Fig. 1) from May 1986 to January 1987.

Results and Discussion

Marsh A

In this area, the water quality has been getting worse, as indicated by the increasing values of COD (Fig. 2). This tendency seems to depend on the enrichment by organic matter that originates in the debris from aquatic plants, such as the green alga *Oedogonium inversum* and the angiosperm *Ruppia maritima*, and in exudates from the bottom sediments. To improve the water quality, the water was pumped out of the marsh at the beginning of August 1986, and then seawater was pumped into the marsh at 17–22 September 1986. As a result, increased chlorinity and decreased COD were recorded in November 1986. Marsh A was dominated by chironomid larvae that included *Polypedilum* sp., *Pentaneura* sp. and *Chironomus* sp. before the seawater was pumped into this marsh. The seawater brought the chironomid *Chironomus salinarius*, which occurs in saline waters at the seashore, as well as marine animals, such as the gammarid *Corophium insidiosum* and the polychaetes *Capitella capitata* and *Polydora* sp., into Marsh A. As a result, the biomass increased markedly. However, the numbers of these animals decreased as the seawater was exchanged for freshwater. The value of COD increased again and reached 30mg ℓ^{-1} in August 1987. Therefore, in order to introduce seawater into Marsh A through the Lagoon at high tide, a channel (Fig. 1) was made in March 1988. Then COD decreased, and the density and biomass increased again as a result of the intrusion of marine animals.

Marsh B

Marsh B was dominated by the gammarids *Corophium volutator* and *Grandidierella japonica* at the time of the first two surveys, when the chlorinity was 3‰ (Fig. 2). It is estimated that these marine species were carried into the marsh with the seawater pumped up into it when the marsh was made. However, these species disappeared and chironomid larvae, including *Chironomus* sp. and *Polypedilum* sp., predominated as the water was replaced by accumulating rainwater.

Lagoon

The Lagoon was characterized by the high density and occurrence of a rich variety of species, which included the polychaetes *Capitella capitata, Polydora* sp. and *Pseudopolydora* sp., the chironomid *Chironomus salinarius*, and the gammarids *Corophium insidiosum* and *Grandidierella japonica* (Fig. 2). Large biomasses of >100g m^{-2} or high densities of >30000 individuals m^{-2} were often found in summer. However, large benthic organisms (*e.g.*, the polychaete *Neanthes japonica*, the gastropod *Batillaria multiformis*, and the brachyurans *Scopimera globosa, Ilyoplax pusilla* and *Macrophthalmus japonicus*), which are common on Japanese tidal flats, were scarcely found in this area. Their absence may be caused by the fact that water remains present at low tide because of the higher position of the ducts as compared with the bottom of the lagoon.

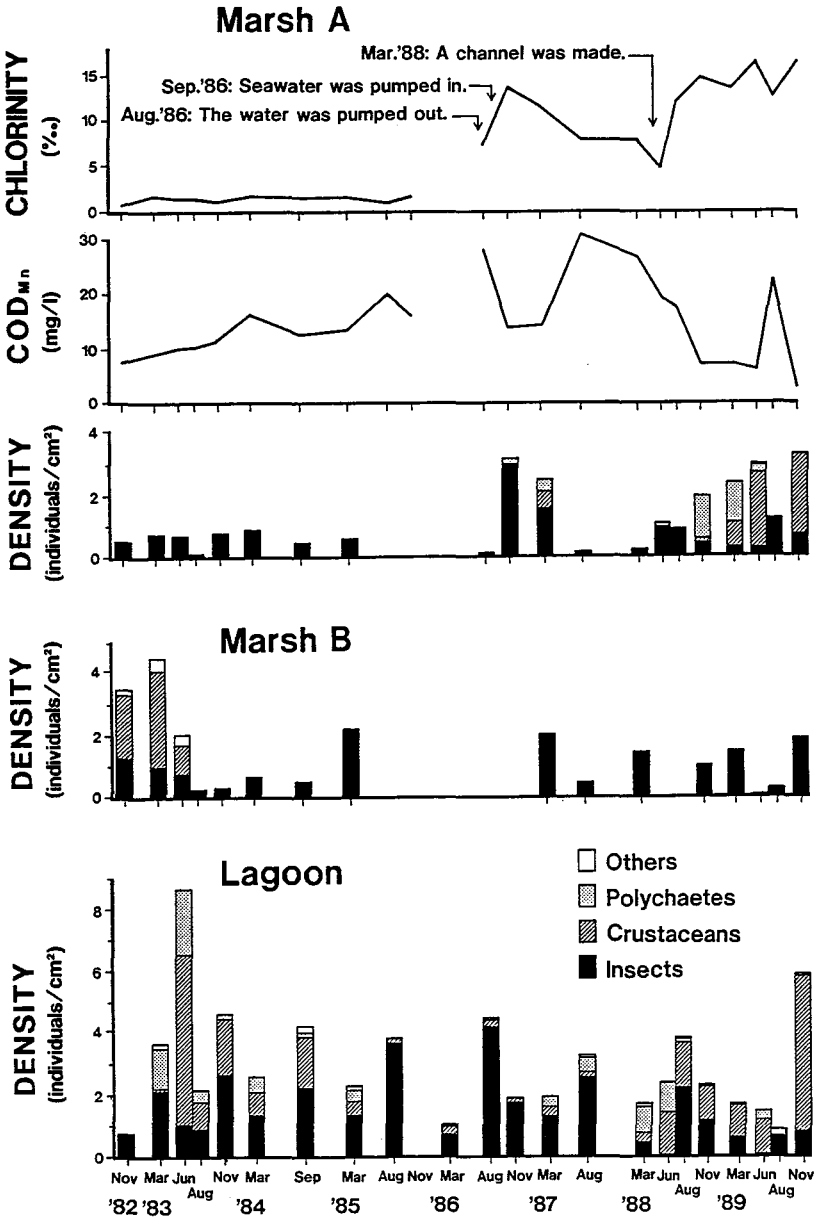

Fig. 2 Long-term trends with respect to chlorinity, COD and macrobenthic organisms in Marsh A and with respect to macrobenthic organisms in Marsh B and in the Lagoon at Wild Bird Park.

Tidal flat at the mouth of Onosato River

The mouth of Onosato River is sheltered from the sea by a sandbank, and a small tidal flat with an area of 1 ha, which has a tidal creek and a tide pool, is formed in this area. The tidal flat is characterized by the presence of three brachyurans, namely, *Macrophthalmus japonicus*, *Helice tridens tridens*, and *Uca lactea lactea*, which most likely fall prey to shorebirds. *H. tridens tridens* was unevenly distributed on the tidal flat. The other two species had their own specific patterns of distribution. *M. japonicus* occurred as the dominant species in wettish, muddy sediments, while *U. lactea lactea* was distributed only in a sandy area. Heights of the four sampling stations ranged from CDL (chart datum level) +100cm to CDL +116cm (*cf.*, mean sea level ≒ CDL +94cm). The lowest station had fine (median diameter = Mdϕ, 2.8−3.1), wettish sediments that contained a large quantity of organic matter (ignition loss, 3.4−3.9%; COD, 5.4−6.0mg g^{-1} dry mud; dry weight of debris of terrestrial plants, 306g m^{-2}), while the highest station had coarse (Mdϕ, 1.4−1.7), drier sediments that contained a small quantity of organic matter (ignition loss, 1.9−2.5%; COD, 2.2−3.0mg g^{-1} dry mud; dry weight of debris of terrestrial plants, 62g m^{-2}). Such a variety of habitat may be responsible for the segregation of the constituent species. Details of results of the surveys have already been described by Yokoyama & Yamanishi (1987a, b).

Tidal flats, where emersion and submersion alternate with the tidal cycle, are valuable feeding areas for migrating shorebirds. Expansion of the area of the tidal flat is necessary for recruitment of large intertidal animals in Wild Bird Park. Data obtained from the tidal flat at the mouth of Onosato River such as details of the natural features, changes in the height of the ground above sea level and variations in the grain size of the sediment should assist in plans for the improvement of Wild Bird Park.

Conclusions

The introduction of seawater into the marsh of the artificial bird-sanctuary was very useful for the improvement of the water quality and the increase in population of the benthic animals. For the further development of the benthic assemblage in the sanctuary, it is necessary to expand the intertidal area with reference to the data obtained from the natural tidal flat.

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