Mitigation and habitat creation on reclaimed land in Osaka port

Yosihiro Natuhara, Masaaki Kitano, Kaoru Goto, Tsuneya Tsuchinaga, Chobei Imai, Koichi Yamada and Kenshiro Tsuruho

Abstract

The authors examined the efficacy of habitat creation for shorebirds on reclaimed land in Osaka Port. The Wild Bird Park was laid out on reclaimed land at Sakishima, in Osaka Port in 1983. A modern history of the area as a habitat for shorebirds can be classified in 4 stages. First, many shorebirds visited the tidal flat of 30 ha that emerged on the south part of the Sakishima. These lands were reclaimed from the sea in 1941, but were abandoned between 1950 and 1958 (Kobayashi 1959). Second, the tidal flat disappeared by the start of the reclamation of the north part of Sakishima in 1958, and a salt marsh of 85 ha emerged in the north part between 1974 and 1982. Third, the salt marsh disappeared due to construction and the Wild Bird Park was opened on a part of the salt marsh in 1983. The park had a planted area of 6.5 ha and a sandy area of 12.8 ha, which included 2 ponds and a lagoon. Fourth, one of the ponds was remade to a tidal flat in 1995. This resulted in increasing the area of tidal flat from 0.2 ha to 2.6 ha, and the number of shorebirds increased from 205 (the average of 1991-1995) to 1042 (1996). The abundance and species richness of shorebirds is equivalent to those at the first stage (1950's). The species composition of benthic animals has also changed; the dominant species was Chironomid larvae at the second and third stages and Polychaetes at the fourth stage, and the species richness was greatest at the fourth stage. However, the tidal flat of the park had fewer brachyurans and molluscus than natural tidal flats in Japan. This might cause a decrease in the abundance of large sandpipers in the fourth stage compared with that at the first and second stages.

INTRODUCTION

Lagoons and salt marshes are important habitats for many species. In Japan, however, many of these areas have been drained or filled over the past 1500 years. In particular, those of Osaka Bay were damaged, because the Osaka Plain has been a Japanese economic and political center. The first attempt at drainage was started in the 5th century. Only a small area with remnants of the tidal flat remains in this area. Thus, it is urgent to protect these small remnants and create new marshes in this area. Wild Bird Park in Osaka Port was established on reclaimed land in 1983 as a mitigation for landfill. This functions as a sanctuary for ducks and shore birds. The authors and co-workers have surveyed the populations of prey organisms for shorebirds and collected other environment data for the park since 1982. In the present paper, the results of the survey and history of habitats for shorebirds in this area are reported and the efficacy of habitat creation is discussed. We acknowledge Osaka Port Development and Technology Association for its support of our study and Dr. Takada for his suggestions and help.

Wild Bird Park

The Wild Bird Park was opened on part of the salt marsh in a landfill of Osaka Port in 1983 (Figure 1). The park has a planted area of 6.5 ha and a sandy area of 12.8 ha, which includes 2 pools (4.6 ha comprise the north pool and 3.8 ha comprise the south pool) of fresh water and a lagoon (1.4 ha). The lagoon is connected with the sea through ducts. A tidal flat of only 0.2 ha

Authors' address: Osaka City Institute of Public Health and Environmental Sciences, 8-34 Tojo-cho, Tennoji, Osaka 543-0026, Japan

has emerged at the east side of the lagoon.

The north pool was remade into a tidal flat in 1995 by connecting with the sea through ducts in order to enlarge an area of tidal flat which provides a habitat for plovers and sandpipers (Figure 2). By this improvement, the north pool is filled with sea water at high tide and dry at ebb tide. Thus the area of tidal flat was increased to 2.6 ha.

METHODS

Benthos and Water Quality

Benthos and water quality were surveyed at least twice a year from 1982 to 1998. Benthic animals were collected with a 0.0225-m^2 Ekman-Birge grab and a 1-mm-mesh sieve from 2 to 6 plots 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. Benthos and water quality between 1982 and 1991 were cited in Yokoyama et al. (1991).

Bird Census Data

Bird data were obtained from the following sources; Kobayashi (1959), Bird Society of Japan Osaka Branch (1989) and unpublished data collected by volunteers.

RESULTS

Benthos and Water Quality

Salinity and chemical oxygen demand (COD) in the lagoon were nearly equivalent to that of Osaka (Figure 2). However, salinity in the northern pond has increased since 1992, though this pool did not connect with the sea and its water was supplied by rain. This increase was caused by sea water introduced to the pond by big waves and an increase of permeating sea water through the bottom of the pool by subsidence of the Park. COD has increased gradually in the north pool since 1984, but decreased in 1996 after the introduction of tide.

There were prominent differences in benthic faunae between the lagoon and the north and south pools. Both abundance and species richness of benthic animals was higher in the lagoon than in the pools (Fig. 3). In particular, mollusks, polychaetes such as *Capitella capitata* and *Cirriformia* sp., and gammarids such as *Corophium insidiosum*, *Grandidierella japonica* and *Tanais* sp. characterized the fauna of the lagoon. In north pool, chironomids were predominant before the introduction of tide even after the salinity increased nearly sea level, but polychaetes and gammarids replaced chironomids after the introduction of tides in the north pool. Initially, *C. capitata* was dominant in March 1996, 4 months after the introduction, then *Cirriformia* sp. became dominant in May. *C. capitata* is resistant against polluted water and distributed around the world. In addition, its high growth rate (1 or 2 month to maturity) made this species predominant soon after the introduction of tide. Although we did not quantify the population, a brachuran, *Hemigrapsus penicillatus*, increased in the rocky shores of the north pool. However, brachyurans living in the marsh were not distributed, and large polychaetes were scarce in the Wild Bird Park.

Bird Populations

Bird population changed drastically by the introduction of the tide in the north pool (Figure 4). Bay ducks such as *Aythya ferina* were predominant before the introduction, but were replaced by plovers and sandpipers after the introduction of tide; the number of shorebirds increased from 205 (the average of 1991-1995) to 1042 (1996). The dominant species were small sandpipers, *Calidris ruficollis* and *C. alpina*. Some of the large sandpipers, *Tringa brevipes* and *Numenius phaeopus* that prey on *H. penicillatus* also increased.

DISCUSSION

Evaluation of Benthic Fauna

The wet weight of benthic animals in the north pool was 60.3 g/m^2 in March 1996 and 39.9 g/m^2 in August 1996. These values were smaller than the median of that of natural tide flats in Japan (Akiyama and Matuda 1974). However, the wet weight of benthic animals in Tokyo bay was between 47.4 and 53.75 in Kasai (artificial beach), between 10.25 and 67.4 in Inage-Kemigawa (artificial beach), between 35.3 and 80.25 in Bansu (natural beach) (Akazawa et al. 1991). These values are equivalent to that of the north pool.

The dominant brachuran in the wild bird park was *H. penicillatus* which lives on the rocky shore. There were not any branchurans living in sandy or muddy shores. Thus, brachuran fauna in the wild bird park is poor compared to that of natural tidal flats. In the Onosato River mouth, the only natural tidal flat in Osaka, there are sandy brachyurans, *Macrophthalmus japonicus*, *Helice tridens tridens*, and *Uca lactea lactea* (Yokoyama and Yamanishi 1987) and these most likely fall prey to shorebirds (Yokoyama et al. 1991).

Landfill and Mitigation

Ancient Osaka City developed on the mouth of the Yodo River. The climate was warm 6000 years ago and most part of Osaka Plain was still below the sea level (Figure 5). Gradually the temperature decreased and Osaka Plain became a lagoon surrounded by the marsh. Salt marshes had been drained in the Edo era (1600-1868 AD) to make

paddy fields and the natural coasts disappeared. Unfortunately no records of avifauna in those days exist, though place names having wetland bird names such as crane remain.

A modern history of the area as a habitat for shorebirds can be classified in four stages. First, many shorebirds have visited the tidal flat of 30 ha that emerged on the south part of the Sakishima. This area was reclaimed from the sea in 1941, but was abandoned between 1950 and 1958 (Figure 1; Kobayashi 1959). Second, the tidal flat disappeared by the start of the reclamation of the north part of Sakishima in 1958, and a salt marsh of 85 ha emerged in the north part between 1974 and 1982.

Third, the salt marsh disappeared due to the construction of buildings and the Wild Bird Park was opened on a part of the salt marsh in 1983. Fourth, one of the pools, the north pool was remade into a tidal flat in 1995 creating a connection with the sea through ducts. By this improvement, the north pool is filled with sea water at high tide and dry at ebb tide. The area of tidal flat was increased to 2.6 ha.

Our experience in Osaka Port shows that artificial wetland provides a habitat for many animals including birds. The numbers of shorebirds in 1996 and 1997 were equivalent to those in the first and second stages. Levels of benthic fauna are similar to that between the second stage (Aso 1985).

Unfortunately the population of large sandpipers and snipe was decreased by landfill even after the enlargement of the tidal flat in 1995. These species may require a larger area than the present situation and/or other prey animals.

REFERENCES

Akazawa, Y., Miyoshi, Y., Shimazu, T., Kimura, K. and Oshima, N. 1991. The purification ability of artificial tidal flat 4. Annual Report of Tokyo Institute of Environmental Science 1991-2: 124-134. (in Japanese)

Akiyama, A. and Matsuda, M. 1974. Higata no Seibutsu Handobukku. Toyokan Shuppansha, Tokyo. (in Japanese)

Aso, I. 1985. Benthic animals. Osaka Nanko no Yacho o Mamoru Kai (ed.) Osaka wan ni Shigi, Chidori no Rakuen o. pp30-32. Osaka Nanko no Yacho o Mamoru Kai, Osaka. (in Japanese)

Kajiyama, H. and Ichihara, M. 1986. Osaka Heiya no Oitachi. Aoki shoten, Tokyo.

Kobayashi, K. 1959. Notes on Osaka Bay Waders. Private publishing. (in Japanese with English abstract)

Wild Bird Society of Japan Osaka Branch 1989. Shigi, Chidori Chosa 1974-1987. Chukan Hokoku. Wild Bird Society of Japan Osaka Branch, Osaka. (in Japanese)

Yokoyama, H., Umehara, T. and Oda, K. 1991. Succession of benthic assemblages in Wild Bird Park, a sanctuary established on reclaimed land in Osaka Port. Marine Pollution Bulletin 23: 739-742.

Yokoyama, H. and Yamanishi, R. 1987. Macrobenthic animals and their habitats on the tidal flat at the mouth of Onosato River (2). Nature Study 33: 111-115. (in Japanese)

Table 1 Comparison of count of shore birds.

Year	Spring	Autumn
51-'56[a]	784.0	993.9
74-82[b]	635.9	467.3
83-'87[b]	399.2	137.4
'90-95[c]	226.0	370.0
96-'97[c]	1051.0	711.5

The average of maximum counts was shown, in which the yearly maximum count of each species was summed for every species.a: Kobayashi (1959): Wild Bird Society of Japan, Osaka Branch (1989) Nanko Group 96 (unpublished)

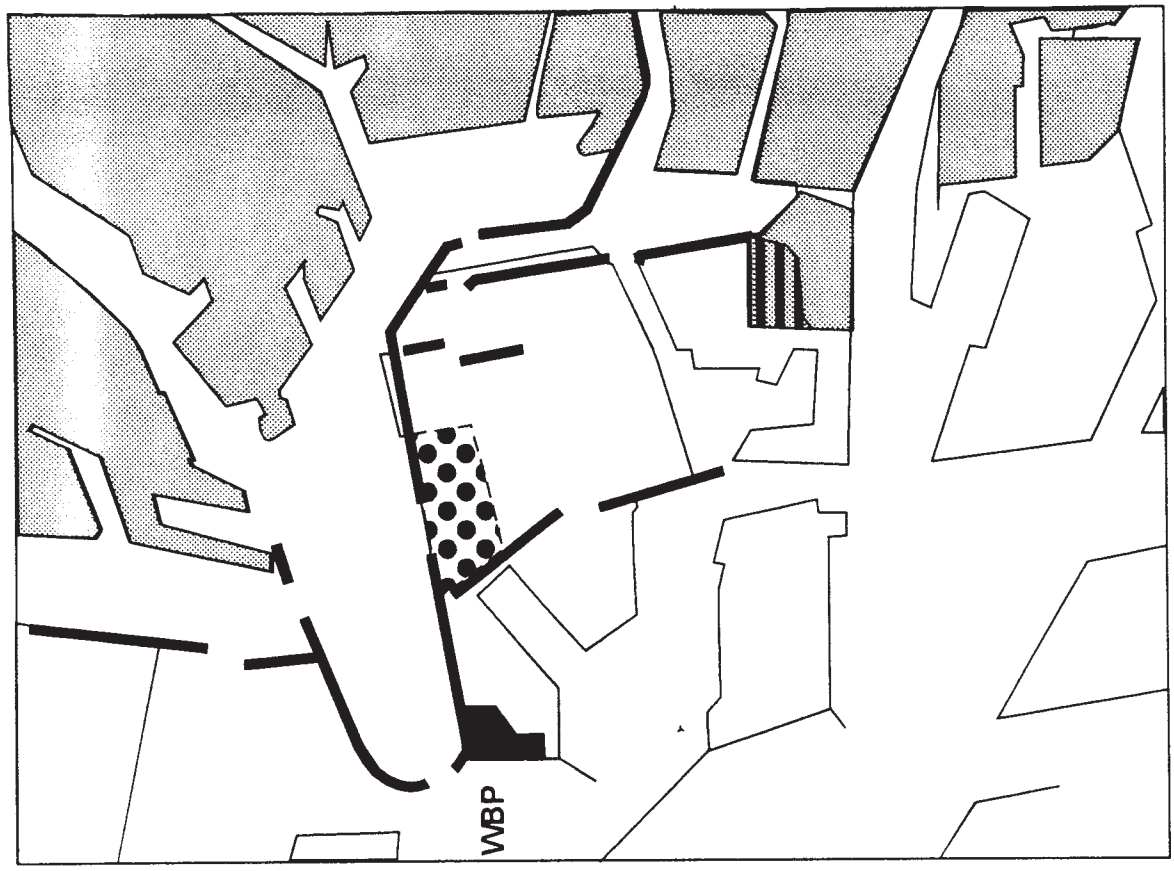

Figure 1 Landfill and marsh in Osaka Port. Shadows and thick lines were land and breakwaters, respectively in 1957. Stripes were tidal flat in 1957. Filled and dotted areas were salt marsh in 1977. The filled area is the Wild Bird Park.

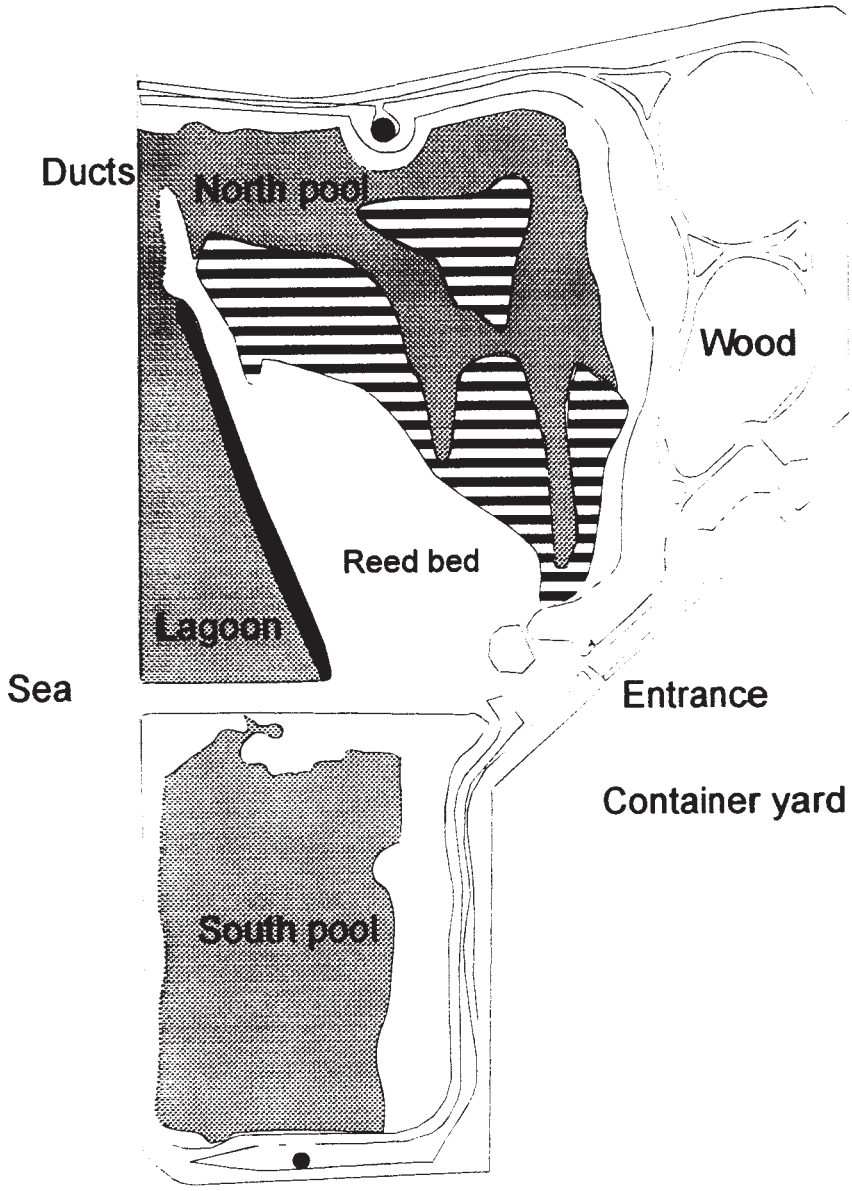

Figure 2. Wild Bird Park. Dotted areas are water surface, filled area became tidal flat in 1983, and striped area is the tidal flat created after November 1995.

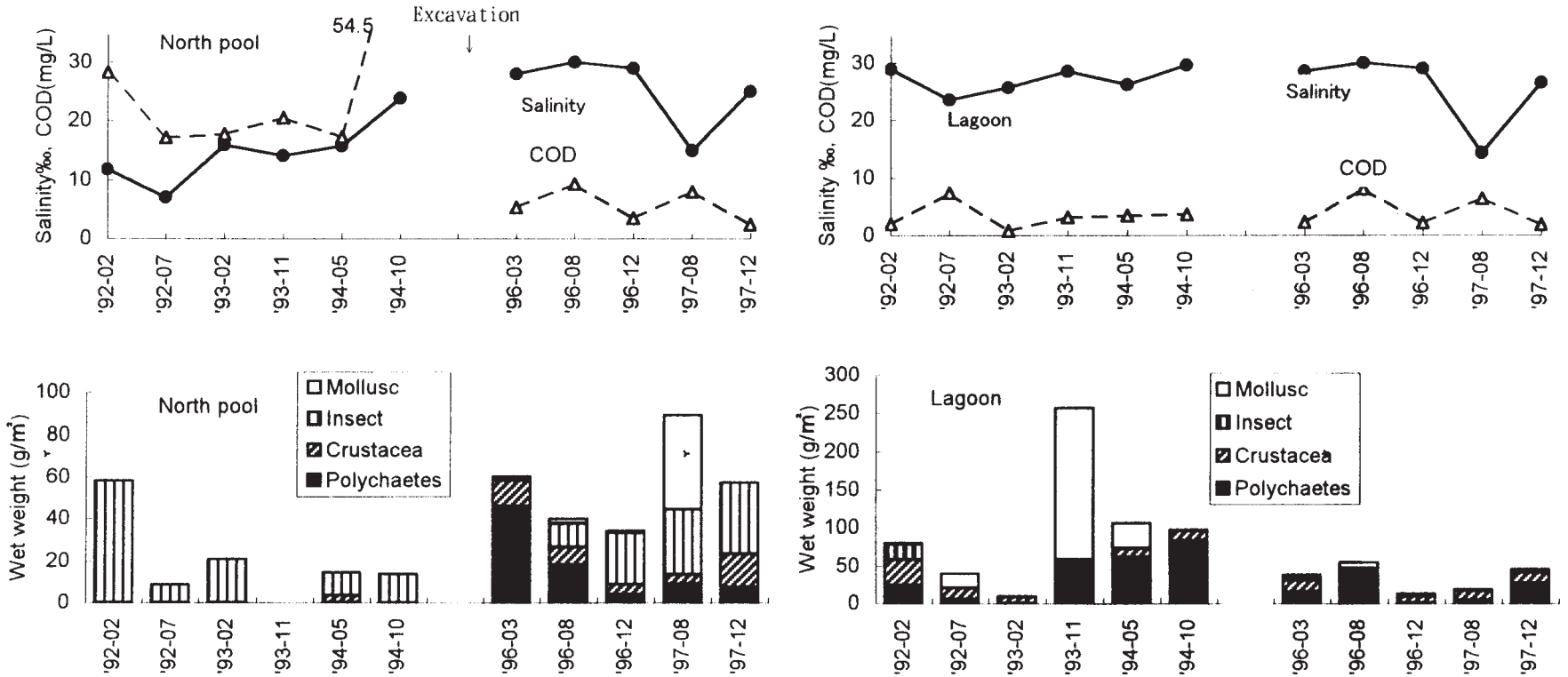

Figure 3. Water qualities of the north pool and the lagoon.

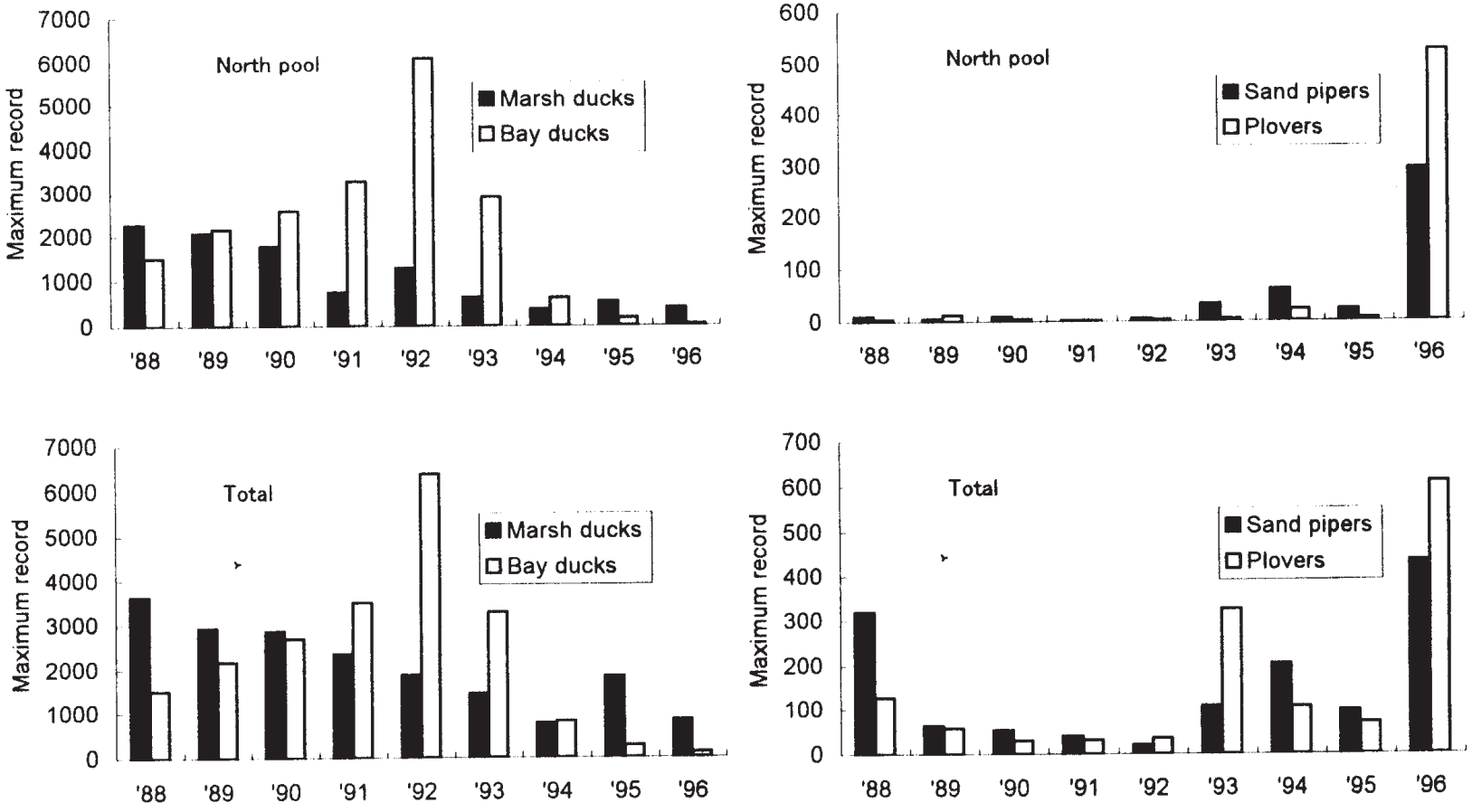

Figure 4. Changes in count of ducks and shore birds.

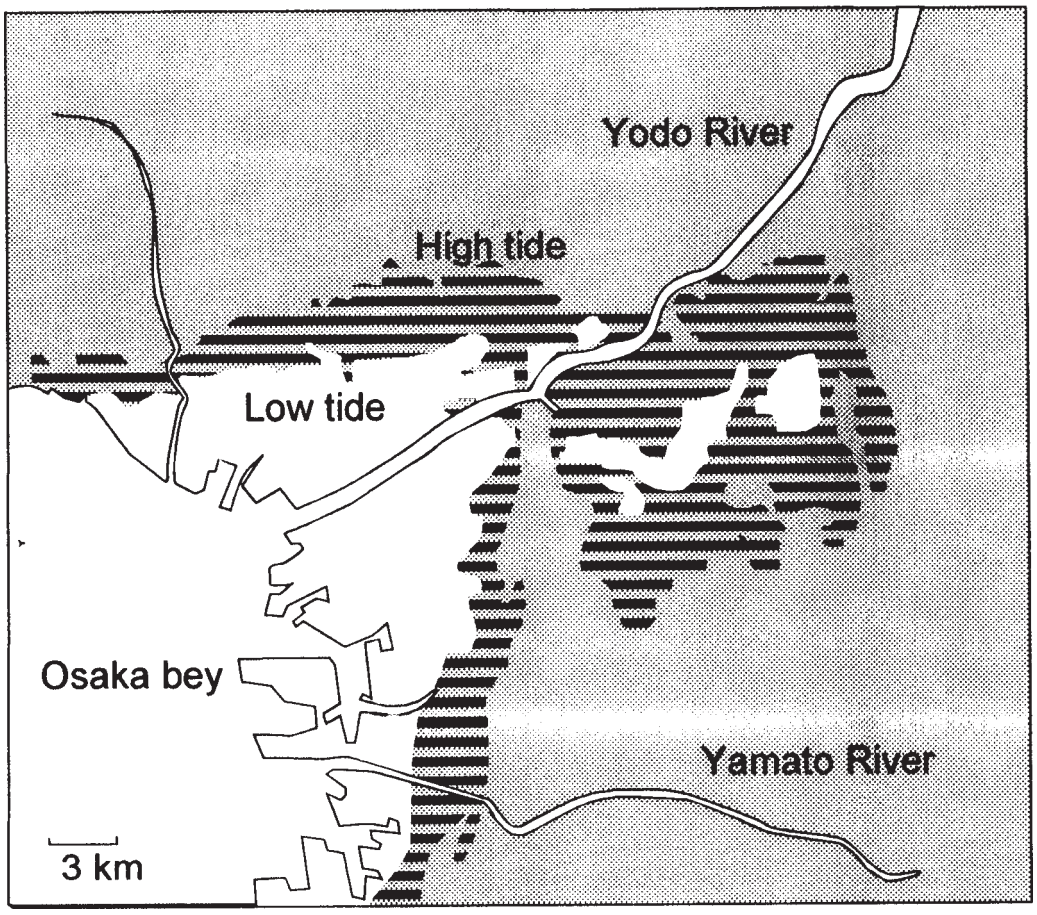

Figure 5. An estimation of ancient lagoon and salt march of Osaka (after Kajiyama and Ichihara 1986).