Chapter 1

Introduction

The term *coastal engineering* had been used for port construction design and then extended to disaster prevention in the late 1950's, and to environmental protection in the 1970's. Its purpose is to solve engineering problems in construction works under coastal and ocean environments. Figure 1.1 shows the general view of areas that coastal, ocean engineers and oceanographers deal with. Initially, the area of discipline of coastal engineers was limited to the shallow-water region, however, with the advancement and development of new construction techniques, their area of activity has extended to the continental shelf and to the open ocean.

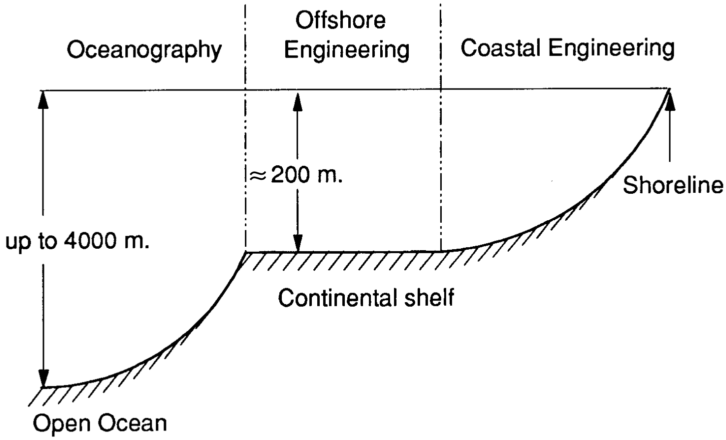

Figure 1.1 General view of engineering territory.

In order to get a picture of the activities of this field, I selected examples of current research topics in the field of coastal engineering, as shown below.

(1) Design of Coastal and Ocean Structures

a) Wave Mechanics: Wave is the major driving force that governs the design of structures. Also it is important for port and harbor construction.
b) Directional Irregular Wave
c) Wave Force on Structures
   Near-shore Current, in particular Wave Induced Current
d) Design Standard for Coastal Structures
e) New Design Technique including Landscape Planning

(2) Influence of Structures to Environment

a) Sediment Transport, Siltation (Dredging) Problem
b) Mud Transport Model
c) Local Scour, Beach Topography Change
d) Three Dimensional Modeling of Topography Change
e) Surf Zone Hydrodynamics
f) Role of Long Waves to Environment

(3) Disaster Prevention

a) Numerical Simulation of Storm Surge and Tsunami
b) Mechanism of Disaster under Storm Surge and Tsunami
c) Floods in Coastal Urban Area

(4) Environmental Problem

a) Water Quality in Bay
b) Model for Diffusion and Dispersion
c) Global Sea Level Rise and Its Effect to Local Beach Erosion

A number of books have been written in this area. For practical examples involving coastal protection, the following book is useful: U.S. Army Corps of Engineers, Coastal Engineering Manual, Part I to VI, 2006.

However, for the most updated information on the field, the reader should refer to the following journals or proceedings.

Coastal Engineering Journal (CEJ, World Scientific and JSCE),
Coastal Engineering (Elsevier),
Journal of Waterway, Port, Coastal and Ocean Engineering (ASCE),
Proceeding of Coastal Engineering Conference (ASCE),
Proceedings of Asia and Pacific Coast (APAC), and
Proceedings of Coastal and Port Engineering in Developing Countries (COPEDEC).

1.1 Three Examples of Japanese Experiences of Coastal Environment Change Due to Construction Works

The possible change in the environmental system due to coastal area developments is an important factor in planning new projects in the coastal and near-shore regions. This environmental change is very complicated and consists of individually complex processes. The response time of the coastal environment to the development project ranges from an immediate change to the scale of decades. Among these responses, the long term response is more important than the short term one, because the long term response affects a wider area and the mechanism of change is less easily understood and therefore more difficult to predict before the project starts. Three typical examples of Japanese experiences regarding coastal protection works or coastal environment works in the 150 years after the modernization process started in Japan are presented in the next sections.

1.1.1 *Ookozu channel for flood control of the Shinano River*

The Shinano River is 367 km long and it is the longest river in Japan. Before the 19th century, the main flow of the Shinano River crossed the Niigata plain. River flooding occurred frequently and seriously disrupted rice production in the Niigata plain. In the late 19th century, the Japanese Government started a project to stop flooding in the Shinano River. However, it was very hard to control the flooding, and in 1909 the government started the construction of a new channel for flood control. Figure 1.2 shows the geometry of the Shinano River and the location of the Ookozu Channel. During flood times, it is possible to divert water into the Ookozu channel and thus decrease the flow along the Shinano River.

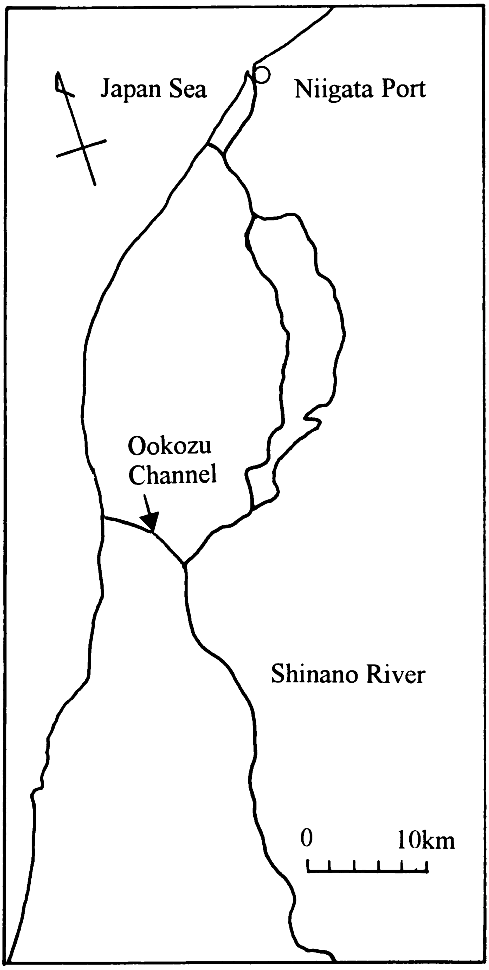

Figure 1.2 Geometry of the Shinano river and Ookozu flood channel.

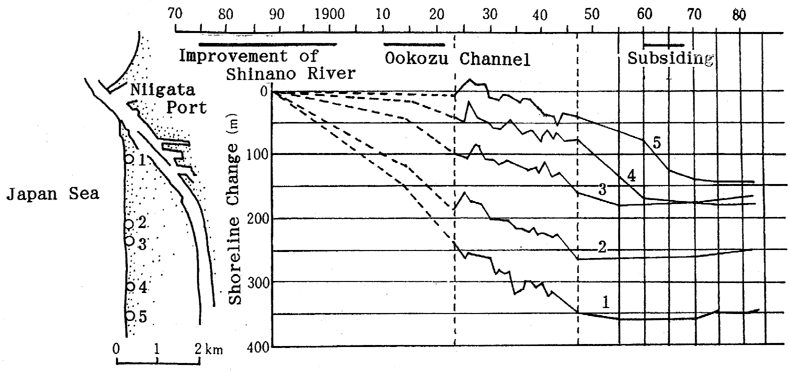

Figure 1.3 Time history of shoreline change in the vicinity of Shinano river mouth. (Data from Ministry of Land, Infrastructure and Transport.)

This channel was also good for the maintenance of Niigata port, located in the river-mouth of the Shinano River. Previously, it was difficult to maintain the waterway between the open ocean and Niigata port due to the large amount of sand discharge from the Shinano River. After the completion of Ookkozu channel, the amount of sediment discharge to original river mouth was diminished.

At the same time, erosion of Niigata coast started and continues till present. Wave attack to Niigata coast in winter season is severe, with significant wave heights of up to 5m and wave periods of up to 10s. Figure 1.3 shows the time history of shoreline change from 1890 to 1980. After the completion of Ookozu channel in 1922, the rates of erosion become quite severe, and the graph shows the erosion recorded at Mitonori beach close to the river mouth is more than 350m. In order to make the beach stable, it is necessary to continue constructing new protection works which require large sums of money and effort.

1.1.2 *Reclamation work in Tokyo Bay*

In 1960's, Japan experienced rapid growth in its economy. This development required areas to be reclaimed from the sea in Tokyo, Osaka and Ise Bay areas because most of the population, infrastructure and capital was concentrated in these areas. From 1960 to 1972, a total of

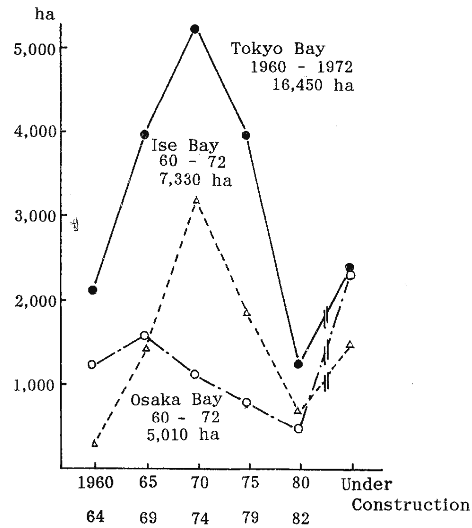

Figure 1.4 Time history of reclamation area in three major bays in Japan. (Data from Ministry of Land, Infrastructure and Transport, 1983.)

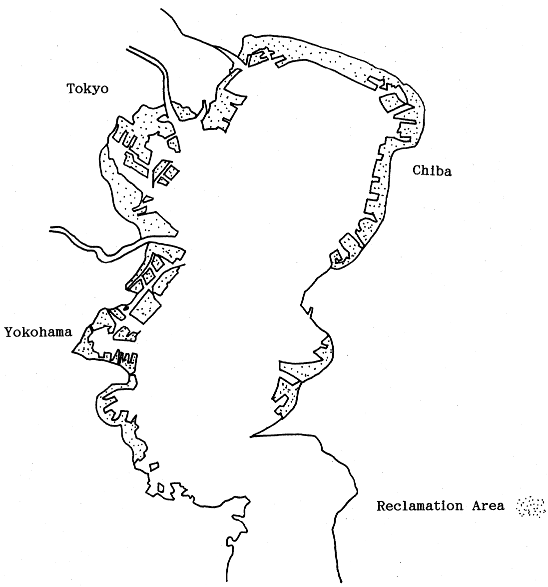

Figure 1.5 Reclamation area in Tokyo bay. (Data from Ministry of Land, Infrastructure and Transport.)

16,450 ha were reclaimed in Tokyo bay. Figure 1.4 shows the time history of reclamation in the three major bay areas in Japan. Reclamation still continues at present, with Fig. 1.5 showing the original coastline in Tokyo bay and the area that has already been reclaimed. In the reclamation of the northeast side of the bay (an area called Chiba), during the 1960's the reclamation material was taken from the sea bottom close to the reclamation area.

When the reclamation material was taken from the sea bottom, big holes were left after taking the materials. Figure 1.6 shows the topography of the area with holes. Nowadays it is not allowed to take materials from the bottom, but the holes still exist.

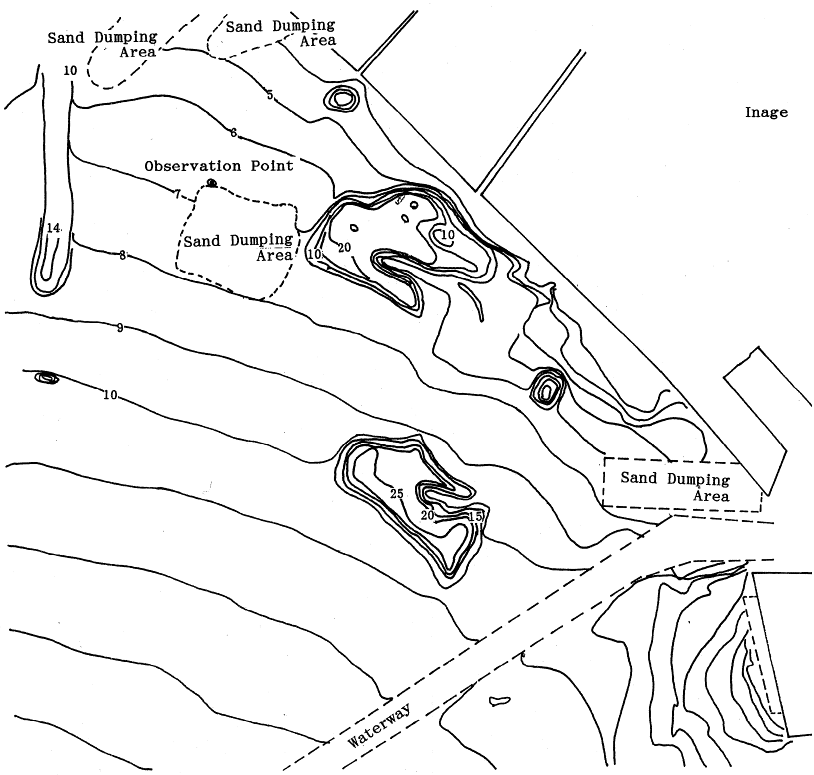

Figure 1.6 Bottom topography in Chiba area. (Data from marine chart, Marine Safety Agency.)

In these thirty years a ‘blue tide’, which is a water body with low or no oxygen solved, frequently appears in the Chiba area. The mechanism of the generation of blue tide was studied and it appears that a mass of water with a small concentration of oxygen forms at the bottom of the hole and then it moves under the effect of stratified flow in the summer season. Currently efforts are being made to cover the hole and make the bottom flat, but it will take a long time to recover the whole area.

1.1.3 *Coastal protection works in Suruga Bay*

The Suruga coast is located in the middle part of Japan on the Pacific Ocean side. The Abe River is a major source of beach sand for the Suruga coast. Previously, the widths of the beaches in this area were more than 70 m. Before 1968, a large amount of sand was taken from the river area for use as material for major construction works. The decade of the 1960’s corresponds to the first stage of rapid growth in the Japanese economy and there was a big demand for river sand as to make concrete. Beach erosion started and coastal protection measures such as coastal revetments, detached breakwaters or jetties were constructed from 1959. In 1977, rapid beach erosion started and coastal revetments were destroyed due to major typhoons. Figure 1.7 shows the time history of the shoreline locations from 1969 to 1981 (data from Toyoshima *et al*., 1981). From the figure, it can be concluded that beach width decreased after 1969.

In 1968, sand collection from river and coastal area was prohibited and sand deposition in the river mouth area gradually recovered in the 1970’s. From 1983 to 1993, sand deposition of over $10 \times 10^4 m^3$/year was observed (Uda *et al*., 1994). At this stage it was suggested that the existing detached breakwaters decreased the longshore transport of supplied sand from the river mouth. This means that the detached breakwaters interrupt sand movement and diminish the supply of sand in the downstream direction of longshore transport. This intersects the sand flow and is the major reason for beach erosion in the downstream area. Uda *et al*. (1994) estimated that the reduction rate of sand velocity due to detached breakwaters in this area is between 71 to 53%.

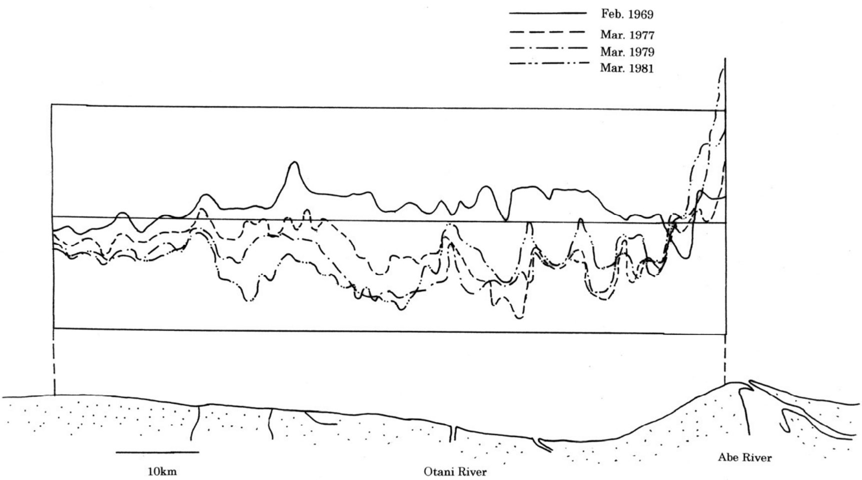

Figure 1.7 Shoreline changes in Shizuoka Coast from 1969 to 1981. (Modified from Toyoshima *et al*., 1981.)

Three typical examples of the impact of a development project to the coastal environment in Japan were explained in the previous sections. From these three examples we can say that the long-term impact of new construction is sometimes not easily predicted. Coastal engineers should be very careful to monitor the change in the vicinity of their projects and be flexible to cope with environmental changes. Nowadays we can find the same type of mechanisms of environment change in the coastlines of many developing countries in Asia and Africa.

1.2 General View of River Sediment Supply to Coastal Area over the World (Tuan and Shibayama, 2003)

During last few decades, a number of numerical models have been developed to simulate the sediment transport process. A common aspect of these models is that they need sediment boundary conditions to accurately simulate the process. Since the major source of the sediments that are transported to the coastal zone are the rivers that drain through the land (Milliman and Meade, 1983), the boundary conditions of these models are often calculated by using observed river sediment discharge at or near the river mouths. Figure 1.8 shows major river basins over the

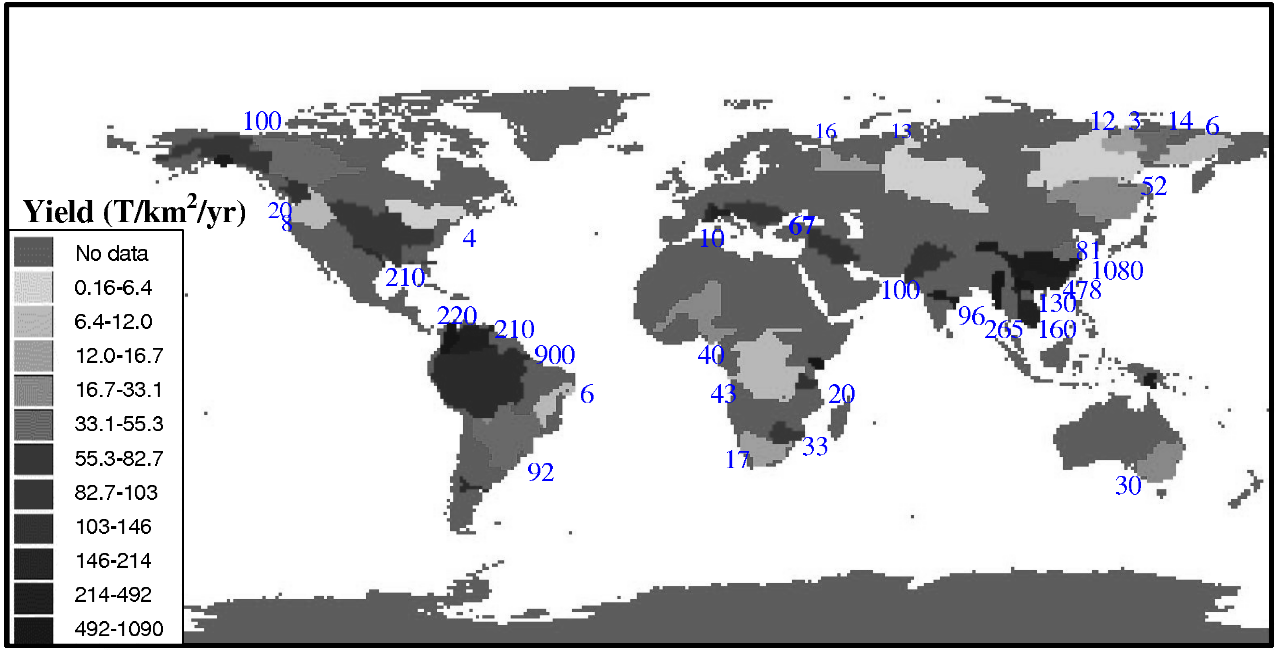

Figure 1.8 Sediment yields (ton/km^2/year) and measured total sediment discharge (10^{6}ton/year) of major rivers in the world. (Data from Milliman *et al.*, 1983.)

world and their total sediment dischage to the coastal environment. Big amounts of sediments are produced and are transported to the coast in major Asian rivers, such as the Mekong, Chao Phraya, Irrawadhy, Ganzes, Indus and Yangtze rivers. Also a big amount of sediment discharge is found in Indonesia. The Amazon, Mississippi and Danube are also big sources of sediment supply.

In the Asian coast, big sediment discharge from inland and coastal erosion due to high waves were balanced in previous times. But in recent years, sediment supplies from river mouths have been changing due to the rapid change of land use in their river basins. When it decreases, coastal erosion occurs and when it increases, coastal deposition appears. Rapid changes of coastal line in Asia is strongly controlled by supply of sand from the river basins.

References

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Milliman, J.D. *et al*. (1983): World-wide delivery of river sediment to Oceans, *Jour. of Geology*, 91, 1-21.

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