Chapter 1
WHAT IS BEACH EROSION?

Beach erosion is a phenomenon in which land is worn away and disappears due to wave action. Generally, coasts exposed to open ocean are separated into sandy beaches and rocky coasts. The eroding velocity of the rocky coast with its large compressive strength is extremely small compared with that of the sandy beach. From an engineering point of view, erosion of the rocky coast may be neglected, except when unconsolidated strata of the sea cliffs are eroded. On the other hand, one of the characteristics of the sandy beach is that rapid response can take place in reaction to changes in wave field and sand supply, because the sandy beach is composed of a collection of grains of sand, the positions of which can be freely changed depending on wave action.

Regarding the transport of sand, various studies have been carried out over many years, and still the study on the movement of sand is one of the main themes in coastal engineering currently. In this document, beach changes with these characteristics and resultant beach erosion are described.

When visiting sandy beaches, which once had a wide foreshore, at various places in Japan after a long absence, we often find the situation that the beach has been rapidly eroded and the beach we remember has been totally lost without a trace. In addition, when visiting some coasts for which we have fond memories, we often hear that the coastline had been covered with a high seawall and concrete armor units. In this case, as for the reason beach was severely eroded, it is impassively explained that it is only due to the attack of high storm waves, but this reasoning is often difficult for us to understand.

For example, as in the reason for the formation of a high scarp, as shown in Fig. 1.1, the explanation that "it is due to high storm waves and the eroded sand was transported offshore" has been offered. Many specialists and researchers provide the same explanation. Undoubtedly, high waves could have attacked the coast when the scarp was formed, but in many

Fig. 1.1. High scarp formed north of Misawa fishing port (12 June 1998).

cases, the disappearance of a sandy beach also depends heavily on other factors.

If this line of reasoning was correct, then the sandy beaches throughout Japan and the world would be destined to rapidly disappear, and there would be no way that we could build up impregnable defenses against waves so that waves could no longer reach the land. However, there are no beaches that have disappeared for this reason in all the examples of eroded coasts that were studied.

The sea reached its present level around 8,000 years ago in Japan. Since then, high waves would have repeatedly occurred, whereas severe beach erosion took place in the last 20–30 years at most in Japan. Comparing the wave actions during this period and the geologically long period of several thousand years, the disappearance of the sandy beach is too abrupt.

One researcher suggests that this is due to the rise in sea level. However, if beach erosion is triggered by the rise in sea level, such an event must

happen uniformly all over the country and the world, but there are a number of beaches with the same wide foreshore as in the past.

Taking these points into consideration, the man-made effects must inevitably be studied in considering beach erosion in Japan. A number of construction works have been carried out in the last several decades nationwide during the period when beach erosion has become severe. In rivers carrying sediment to the coast, riverbed excavation for sand mining or dam construction has been carried out, resulting in the obstruction of the continuous movement of sand in the river course. At present, the number of large dams with a height over 15 m is 2,532 in Japan (http://wwwsoc.nii.ac.jp/jdf/Dambinran/binran/Top). Sediment flowing into the sea at the mouth of a river is transported alongshore, but such continuous movement may also be obstructed by the breakwaters of ports and fishing ports, or river-mouth jetties. The construction and maintenance of these structures have been carried out independently by the Fishery Agency of the Ministry of Agriculture and Forestry, the Port Bureau of the Ministry of Land, Infrastructure and Transport, and the River Bureau of the same Ministry, on the basis of the Fishing Port Act, Port Act and River Law, respectively. The number of fishing and other ports are 2,931 (http://www.pref.hokkaido.jp/srinmu/sr-ggson/contents/gyoko/sub2.htm) and 1,079 (http://www.mlit.go.jp/kowan/), respectively, at present. This means that they are distributed with one port per 8.5 km nationwide, since the total length of the coastline in Japan is 34,000 km. In each case, various problems have resulted.

Similarly, countermeasures against cliff erosion have been taken along the sea cliffs, which are one of the supply sources of sediment to coasts, resulting in a decrease in sand supply. Furthermore, a long offshore breakwater was extended to form the wave-shelter zone. A large amount of sand accumulated on the lee side of the wave-sheltering structure associated with the elongation of the breakwater, and the beach was eroded in the neighboring area.

Of course, these public works have been carried out to produce good results on the basis of various laws, and it is a fact that such works supported the rapid economic growth of Japan in the past. Every construction work was carried out most efficiently, and it is obvious that they were not carried

out to cause beach erosion. However, there must be no other nation that conducted such rapid and large-scale land alteration of its national land with both limited space and many steep rivers.

All these works have been carried out as public works. In that case, the work itself was implemented by the sector-by-sector system under the thinking that it was vitally important to enhance the efficiency of the work, even if the influence on the surrounding coastline was overlooked. Their results were not deliberate, but consideration of the environment of the surrounding coasts was significantly lacking at that time, compared with the present era, when the importance of the coastal environment must be adequately considered. Since the information was not available to the public at that time, discussion of the negative points was taboo among the people concerned, and significant time passed before many people realized the facts.

When such influences accumulated and appeared at many coasts, the coasts of Japan came to a situation in which fundamental improvements were no longer possible in every respect because of the astronomical budget required. The most feared situation is that since the number of extensively artificial coastal areas have increased, young people, who carry the future of Japan on their shoulders, seem to pay no attention and have no interest in the nature of the coast or the coastal environment.

The author still has memories of natural coasts in the decades before development. However, with the decrease in the number of people in this generation with such memories of natural coasts, it becomes difficult to convey the facts to young people. Remembering the original, past scenery of the coast will become totally impossible, even if people want to recover it.

In considering the future perspective on the coasts of Japan, first we must clearly realize why Japan's coasts arrived in their current condition. In this document, the real situation of the coasts in Japan is described from this point of view. Next, to prevent the recurrence of beach erosion, predicting the topographic changes of the coast, where many kinds of artificial alterations are carried out, is required. Therefore, some practical

models for predicting beach changes are introduced, which have been developed to simulate real topographic changes occurring on coasts.

In the process of investigating the reality of beach erosion deeply, it has been noted that the barrier for solving the erosion problem does not exist primarily as a scientific problem that cannot be solved, but rather in the present land management system that includes the coastal zone. Although this is a considerably difficult problem to tackle, it is unavoidable, if a true solution is to be achieved. Therefore, we discuss these fundamental problems related to the land management system.

In Chap. 2, beach erosion is classified into several categories depending on its characteristics, and the current reality of erosion is discussed. In this case, we avoid a detailed analysis of the bathymetric survey data and show instead the effectiveness of the simple method by combining the comparison of aerial photographs and field observations at the eroded coasts, collected while walking along the coastline with a measuring stick.

The past aerial photographs of all coasts of Japan taken between 1947 and 2000 are available from the Geographical Survey Institute (http://www.gsi.go.jp) for free, or at a cost of about $10 each for the recent aerial photographs. The long-term and large-scale shoreline changes can be investigated quantitatively using these aerial photographs, and in addition to this, if field observations are carried out, the causes of beach erosion on almost all coasts can be clearly identified. Anyone can use this method, and comparatively reasonable results can be obtained. In what follows, examples of many coasts are described from this point of view.

In Chap. 3, some practical models for predicting beach changes, which are needed to suggest countermeasures against beach erosion, are introduced for several types of beach erosion as mentioned in Chap. 2.

In Chap. 4, we show for the beach erosion problems, many examples of which were given in Chap. 2, that structural problems related to the social system in Japan must be considered in order to really address the situation, apart from which a perspective on the future cannot be obtained. Finally, a way to avoid the occurrence of the same kind of beach erosion problems in other countries is discussed on the basis of the Japanese experience as an

example of behavior that should be avoided in conducting shore protection projects.

Finally, for the convenience of the readers, English and Japanese references are shown separately at the end of each section, and Japanese articles are denoted by an asterisk next to the reference in the text.