Toward Integrated Coastal Zone Management in Japan

Masahiko ISOBE
Professor
Department of Civil Engineering
University of Tokyo

presented at the
ESENA Workshop:
Energy-Related Marine Issues in the Sea of Japan
Tokyo, Japan
11-12 July 1998

ABSTRACT

There are three functional aspects of coastal zones—provision of ecological services, disaster prevention, and human utilization. In this paper the current status of the Japanese coastal environment relative to each of these functions is first examined and problem areas identified. Following this, a basic theoretical framework for an integrated coastal zone management (ICZM) scheme in Japan is introduced. Such a scheme will seek to integrate the ecological, disaster prevention, and human utilization functions of coastal zones. Examples of practical experiments in ICZM in Japan are then discussed. The paper arrives at the conclusion that an ICZM scheme is absolutely essential to solve Japan's development-related coastal zone problems.

TABLE OF CONTENTS

1. Introduction

Coastal regions can be narrowly thought of as the “dividing boundary” between sea and land—the coastline—or broadly thought of as the zone in which the three spheres of air (atmosphere), water (hydrosphere), and land (lithosphere) converge—the coastal zone. Coastal regions are intensely dynamic areas, and are of critical important to humans.

Coastal zones contain unique, irreplaceable ecosystems. At the same time, coastal zones are subject to intense use by humans—for transportation activities, resources and energy extraction, industrial uses, and recreation. Furthermore, coastal zones are the first line of defense against inland disasters. They are buffer zones against the ravages of tsunamis, rough waves, flooding, and erosion. In short, there are three functional aspects—provision of ecological services, disaster prevention, and human utilization—which are part of the human relationship to coastal zones. Each of these aspects are intricately linked. Consequently, humans must monitor and manage each facet in an integrated manner to ensure that the human relationship to coastal zones remains harmonious.

In the first section of the paper, the current status of the coastal environment in Japan is examined and problem areas identified. Following this, a basic theoretical framework for an integrated coastal zone management (ICZM) scheme in Japan is introduced. Examples of practical experiments in ICZM in Japan are then discussed. Finally, conclusions are drawn about the present state of ICZM in Japan.

2. Current Status of the Coastal Environment in Japan

Japan is part of the Asian temperate monsoon climatic region, and it is bathed by the warm Japan Current on the Pacific side and Tsushima Current on the Sea of Japan side of the country. Thus, Japan experiences relatively high sea temperatures and a warm climate given its high northern latitude. The difference in tides at flood stage on the Pacific coast is approximately 1.5 meters, and approximately 0.2 meters on the Sea of Japan coast. It is more than four meters on the Ariake Sea coast due to its unique topography.

The total land area of Japan is approximately 378,000 square kilometers (see Table 1). Coastal areas which are 20 meters or less below sea level account for about 31,000 square kilometers, which is approximately 10% of the total land area of Japan. The 200-mile economic exclusion zone encompasses an area of about 4.47 million square kilometers. The total length of Japan's coastline is roughly 35,000 kilometers. Japan has 91 meters of coastline per square kilometer of total land area. If small island states are excluded, Japan comes in second in the world behind Denmark (150 meters of coastline per square kilometer of total land area) in coastline length per unit total land area. This fact helps demonstrate the importance of the coastal zone to Japan.

Table 1: Coastal Zone Facts of Japan

Variable		
Total Land Area of Japan		377,720 km^2
Water Depth Area	0 - 20 m	30,880 km^2
	20 - 50 m	49,850 km^2
	50 - 100 m	79,740 km^2
200-mile Economic Zone Area		4,470,000 km^2
Length of Coastline		34,536 km

In the following sections we will examine the current status of Japan's coastal zone relative to the three functional aspects of coastal zones important to humans mentioned above—disaster prevention, human utilization, and provision of ecological services.

2.1. Disaster Prevention

Japan is prone to seaborne natural disasters, including typhoon-induced flooding and high waves, and tsunamis or tidal waves. In addition, Japan's coastline is prone to erosion. Thus, prevention of disasters related to typhoons, tsunamis, and erosion is one important functional aspect of coastal zones that must taken into account in any ICZM schemes developed in Japan.

Most of Japan is threatened by flooding and high waves during the typhoon season around September. In addition, the Sea of Japan side of Japan is buffeted by strong winds and rough seas in the winter. Storm conditions combined with high tides can cause especially severe damage. High tides in the three major bays of Tokyo, Ise, and Osaka, as well as in the Ariake Straits, can be amplified by storm winds. A particularly damaging typhoon hit the Tokyo area in 1953. Maximum tide deflection was 3.9 meters in Tokyo Bay. The worst recorded typhoon-induced damaged was experienced in the Ise Bay Typhoon of 1959 which caused a high tide deflection of 3.4 meters and resulted in more than 5000 deaths and damage to almost one million buildings. Damage caused by flooding has diminished in recent years, but it is unclear whether this is a result of efforts to protect the coastline, or the lack of severe typhoons in recent years.

Tsunamis are also a source of severe damage and loss of life in Japan. They can hit anywhere in Japan, but they are most common on the Pacific coast. In particular, high energy tsunamis are frequently experienced in the Sanriku region in the northeast part of the main island of Honshu. Two tsunamis, however, hit the Sea of Japan coast in 1983 and 1993, which underscores the need for vigilance in this area as well.

While typhoon-induced floods and tsunamis cause enormous damage in a short period of time, the most serious damage to coastal areas has been wrought by slow coastal erosion over a long period of time. In contrast to typhoons and tsunamis, this damage is not the result of natural forces but human forces. Coastal erosion has been particularly severe since the end of World War II and coincides with Japan's rapid industrialization after the war. Industrial development combined with the severity of sea conditions during typhoons and the fact that Japan has an inadequate natural supply of soil and sand, has resulted in a serious coastal zone erosion problem in Japan.

Analysis of erosion speeds of sand-pebble coasts as determined by comparing of past and present topographic maps shows that coastal erosion has accelerated in the post-war era (Tanaka et al., 1993). Given that the average erosion speed for sand-pebble beaches is 0.168 m (approximately one-sixth of a meter), and that the average width of these beaches is 30 meters (Ministry of Agriculture, Forest and Fisheries et al., 1990), a simple calculation reveals that at this speed all such beaches will be lost in 180 years.

Coastal erosion is a problem of utmost importance in Japan because coastal erosion compromises the ability of coastal zones to act as front-line defenses against floods, tsunamis, and rough seas, to provide adequate utilization functions, and to maintain the integrity of shallow water ecosystems. Coastal erosion also, in essence, means that the land of Japan itself is lost.

A wide variety of structures have been built in Japan with the express purpose of preserving coastal areas against the above-discussed problems of typhoon-flooding, tsunamis, and slow coastal erosion. The total length of the coastline in Japan as of 1992 was 34,536 km. Approximately one-half of this total, or 15,932 km, requires protection against coastal erosion. Structures have been built along about two-thirds, or 9382 km, of this portion. In the 30-year period from 1962 to 1992 protective structures were built on about 4,248 km of coast. While it can be said that the coastline has been protected, it can also be said that the coastline is no longer natural. It is an artificial coastline.

Of the protective structures, banks and seawalls were built primarily in the first 10 years of this 30-year period. In the next 10 years, construction of seawalls together with off-shore barriers dominated. In the last 10 years, the focus was primarily on off-shore barriers. This shift in emphasis was due to the fact that banks and seawalls were limited in their ability to stop the effects of rough seas. Off-shore barriers were found to be more effective in controlling rough seas and coastal beach currents.

2.2. Human Utilization

Coastal zones have been used for various human activities from time immemorial. In ancient times they were used by hunters and gatherers as a place to harvest marine resources, today they are used as sites for airports, petroleum exploration, fuel storage and energy generation, industrial and commercial development, waste dumps, and recreation areas.

Comparison of those cities, towns, and villages which border coast lines with those which are landlocked in terms of their area, population, value of industrial shipments, and value of commercial sales shows that despite the fact that waterfront municipalities do not exceed 32% of the total area, they account for 45% of the population, 47% of the value of industrial shipments, and 77% of the value of commercial sales. These figures clearly underscore just how central coastal zones are to human activity in Japan. The reason for this concentration of activity on coasts is not difficult to determine for Japan. Japan is covered with mountainous regions unsuitable for intense human utilization. Thus, its population and accompanying activities tend to be located in flat areas, especially along the coast. Table 2 shows a comparison of the Tokyo Bay and San Francisco Bay areas. The land area is just about the same, but the ratio of the population

density in the drainage basin is 60:1 in Tokyo Bay's favor. This highlights the inescapable need in Japan to make efficient use of its coastal zones.

Table 2: A Comparison of Tokyo Bay and San Francisco Bay

	Tokyo Bay	**San Francisco Bay**
water area (km^2)	1380	1240
drainage area (km^2)	7549	153,000
average water depth (m)	45 (15 within the bay area)	6
water flowing in from rivers (m^3/s)	300	500
drainage basin population	24,920,000	8,000,000
drainage basin population density (individuals/km^2)	3301	52
area reclaimed (km^2)	249	240

2.3. Ecology

Healthy coastal ecosystems are vital to healthy coastal zones. In particular, dry beaches, seaweed beds, and coral reefs are important elements of coastal ecosystems. However, coastal erosion and construction of coastal preservation structures are adversely affecting these ecosystems. Analysis of the changes in the spatial area of dry beaches, seaweed beds, and coral reefs in Japan in the post-war period shows that the drop in dry beach area in the 1970s is particularly striking. This coincides with increased landfill in bays. This underscores the fact that human activity in Japan has reached a level where its impact on coastal zones can not be ignored.

Landfills and coastal preservation structures are causing coastal zones to become increasingly artificial or semi-artificial. An artificial coastal area is an area where structures have been erected in shallow waters. Semi-artificial coastal areas are those in which structures are erected but are either on the land side of the high tide beachline or the sea side of the low tide beachline. Analysis of changes in the coastline reveal that as artificial coastline has increased, and that natural coastline has correspondingly decreased. Despite a slowdown in the speed of construction of landfill coastline and preservation structures, the trend toward increased artificiality of the coastline remains unchanged.

3. A Theoretical Framework for ICZM in Japan

ICZM schemes must address both the human and natural elements of the total coastal environment. Specifically, it must address the ecological, human utilization, and disaster prevention aspects discussed above. Thus, one objective of ICZM is to preserve the ecological integrity of coastal zone ecosystems. Such ecosystems exist in generally harsh conditions—conditions of strong winds, high salt concentrations, and wide conditions such as fluctuations in air and water temperature. However, at the same time, nutrient salts supplied from rivers and abundant light in the shallow waters support high primary productivity. Coastal zone management must be sensitive to the nuances of the ecological variables of coastal ecosystems. A second objective is to aid in appropriate human utilization of coastal areas. Utilization refers to harvesting

of fish, shellfish and seaweed, construction of ports, establishment of sites for industry, building of residential homes, and setting aside of recreation areas. A third objective is to prevent excess material damage and loss of life from natural disasters such as high tides, high waves, strong winds, flooding, earthquakes, tsunamis, and coastal erosion. A final objective is to comprehensively integrate the separate efforts undertaken to achieve the first three objectives.

Mimura et al. (1996) set down specific items for evaluation in each of the three objectives, and proposed an integrated evaluation method for judging management schemes relative to them. One of the purposes of Mimura et al.'s method is to overcome the trade-offs between the objectives.

The basis of ICZM is that it must strive to maintain a healthy "environmental foundation." The environmental foundation is defined to be the coast type (craggy, pebble, muddy), and the combined characteristics of the atmo-sphere (climate, air quality, light, sound, odor, etc.), the hydro-sphere (sea climate, sea bottom topography, water quality and bottom quality, etc.), and the litho-sphere (topography, soil quality, groundwater, surface water, etc.) It is upon this foundation that the ecological, human utilization, and disaster prevention functions of the coastal zone rest. If the environmental foundation is not maintained over long time scales (say, decades), the ecological, disaster prevention, and human utilization functions of coastal zones will suffer. In other words, the status of the environmental foundation determines the health and viability of coastal zones.

4. Japan's Present Coastal Zone Management System

Japan's first formal coastal zone management scheme was embodied in the Coastal Act of 1953. Its objective was the prevention of disasters. It was not drafted from the viewpoint of integrated management of the coastal zone. Until recently prevention of disasters was the primary focus of Japanese coastal zone management. Laws such as the Harbor Act, Fishing Port Act, and the Public Waterfront Landfill Act were set down separately and cover the development and utilization of Japan's coastal zone. The National Parks Act and the Seto Inland Sea Preservation Special Measures Act cover the protection of nature.

There is, however, no law that serves to coordinate all the relevant aspects of each of these separate laws. The different laws result in differing responsibilities by different government agencies. The coastal zone is classified into, for instance, harbors, fishing ports, and reclaimed agricultural lands. Each classified area is overseen by a different ministry such as the Ministry of Transportation, Ministry of Agriculture, Forest and Fisheries, or Ministry of Construction. To achieve true ICZM, establishment of new laws and administrative bodies is desirable.

5. Examples of ICZM in Japan

Japan has established no ICZM system for maintaining the integrity of the coastal zone. Although no codified system exists in Japan, restoration of the environment, creation of new environments, and concern for the environment are present. These practices can be incorporated in the developing concept of ICZM in Japan.

The Dashihira Dam on the Kurobe River in Fujiyama Prefecture was constructed so that sand which accumulated on the upstream side of the dam is expelled through a sand flushgate. This ensures a supply of soil and sand downstream. In addition, a sand control dam was constructed with a sand flushport so that soil is expelled during normal hours. Ensuring a steady supply of soil to the mouth of the river by minimizing the extraction of soil from mid- and downstream can be termed environment restoration. The maintenance of coastal sand drifts provides another example of ICZM. A sand bypass was employed to maintain what is perhaps Japan's most famous coastal sand drifts—a formation known as Ama-no-Hashidate (Bridge of Heaven) in Kyoto Prefecture.

One specific project which aims to both restore and create habitat is a project to create an artificial dry beach in Itsukai City in Hiroshima Prefecture. A 24-hectare dry beach has been created along a breakwater to replace the dry beach at the mouth of a river which was been lost to harbor development. This dry beach provides a feeding and resting area for birds such as sea gulls, snipes and plovers. The number of birds on the artificial beach rivals the number that were present before its construction. However, there are problems with the dry beach, including sinking of the site.

Methods for creating a base for seaweed to adhere using blocks placed at the bottom of the sea and methods for transplanting seaweed have been employed to create sites for new seaweed beds. A 60,000 square meter seaweed mound was created to replace a seaweed site that was destroyed by the construction of the Ikata power plant in Ehime Prefecture. Another example is found in Hiaijima in Kumamoto Prefecture where a 19,000 square meter transplant site was created to replace an eelgrass site that was lost with the creation of an artificial recreational beach. Two years after the transplant, the density of the eelgrass was observed to have doubled.

Efforts have been made to shape seawalls and sunken piers to make them into appropriate habitats. It was found that aquatic plants and animals were able to attach themselves easier to a slanted stacked stone seawall which was built for the Kansai International Airport in Osaka Bay. Monitoring confirmed the adherence of seaweed to the structures and a return of reef fish which were not present prior to construction. As another example, a block shaped, gently slanted seawall on the Sumiyoshi coast in Miyazaki Prefecture was constructed so that sea turtles could lay their eggs on the beach. Compared to conventional gently slanted seawalls, the block shaped seawall resulted in an increase numbers of eggs laid.

There are numerous other examples of restoration of the environment and creation of new environments in Japan's coastal zones. Significant progress has been in the technology required to put ICZM into practice. Japan has very little marshland in comparison to the United States, thus, compared to the U.S., Japan is focusing on creating sand beaches, dry beaches, and seaweed sites.

6. Conclusion

ICZM is absolutely essential to solve Japan's development-related coastal zone problems. Development in the post-war era has resulted in Japan's coastline becoming an artificial coastline. ICZM seeks to integrate the ecological, disaster prevention, and human utilization functions of coastal zones. ICZM seeks a long-term and broad-based perspective in coastal management. Creation of a healthy and stable environmental foundation is the goal of ICZM. To this end,

Japan's prowess in technological development can be harness to integrate separate technologies into a coherent mitigation-oriented system of technologies that can enhance the coastal zone environmental foundation.

7. References

Agricultural Structure Improvement Bureau of the Ministry of Agriculture, Forestry and Fisheries, Fisheries Agency of the Ministry of Agriculture, Forestry and Fisheries, Harbor Bureau of the Ministry of Transportation, and the River Bureau of the Ministry of Construction. (1990). Survey Report on the Nationwide Coastal Zone Preservation and Utilization Plan, p. 336

Coastal Long-Term Vision Research Bulletin. (1995) *Creation of a Bountiful Seaside*, Daiichi Houki Shuppan, p. 91.

Environment Agency of Japan. (1980, 1984, and 1992). Basic Survey on the Preservation of the Natural Environment, Sea Region Survey Report, p. 339, p. 203, and p. 20, respectively.

Habara, Yukifumi, Takahama, Shigemori and Imamura, Hitoshi. (1996) Functional Evaluation of Artificial Dry Beaches Created for Mitigation, *Papers on Coastal Engineering*, Vol. 43, pp. 1161-1165.

Ishizaki, Yukihito. On the Creation of Substitute Seaweed Sites and the Adherence Conditions of Seaweeds in the Number 3 Reactor at the Ikata Atomic Energy Plant, *Inland Sea Science*, Vol. 3, No. 3, pp. 33-37.

Isobe, Masahiko. *Creation of Coastal Environments*, Asakura Shoten, p. 208.

Mimura, Nobou et al. (1996) Reinvestigation of Coastal Zone Characteristics Evaluation Methods based on an Awareness Survey, *Papers on Coastal Engineering*, Vol. 43, pp. 1286-1290.

River Bureau of the Construction Agency. (1963, 1973, 1983 and 1993) *Coastal Statistics*.

Tamizu, Tatsuyuki. Coastal Erosion Countermeasures Taking into Consideration Laying of Eggs by the Red Sea Turtle. Techno-Ocean '92.

Tanaka, Shigenobu, Koarai, Mamoru and Fukazawa, Mitsuru. Changes in the National Coastline Based on a Comparison of Topographic Maps. *Papers on Coastal Engineering*, Vol. 40, pp. 416-417.