SAND SPIT DECLINE AT THE SAGAMI RIVER MOUTH

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ABSTRACT

River mouth morphology is much influenced by nearby coastal structures. At the Sagami River mouth, the sand spit is declining in recent years after having been stable until the 1970s. In this study, this decline is quantified by the use of aerial photographs taken from the 1960s. The measurement results show that the sand spit retreated into the river more than 200 meters from 1983 to 2001. From the analysis on the extensions of the close-by coastal structures in function of time, it can be supposed that these structures have a long-time effect to the recession of the sand spit.

1. INTRODUCTION

The history of a river mouth demonstrates a continuous change in its geometry, its configuration and its cross-sectional area. Compared to carrying out continuous field observation, aerial photograph analysis is an alternative and more economical means for achieving information on river mouth morphology change (Srivihok and Tananka, 2006).

The Sagami River mouth, bounded by two jetties, has experienced sand spit recession in recent years (Furuike et al., 2009; Uda et al., 2004), as well as several other Japanese rivers like the Naruse River and the Ohyodo River. In addition to the decrease of sediment supply from the river and the dredging of the river bed, constructions of coastal structures are also supposed to be one cause of the sand spit recession. It is supposed that the response speed of river mouth morphology depends on the distance between the river mouth and the coastal structure (Kawamura and Tanaka, 2005).

Aerial photographs are the most commonly used data source in shoreline mapping (Moore, 2000). In the present study, traditional aerial photograph analysis methods, which consists of tracing shoreline positions on digitized photographs, is used to quantify the morphological change of the Sagami River mouth from 1961 to 2001. Special focus is taken on the decline of the sand spit at the left bank.

2. STUDY AREA

The Sagami River is in Kanagawa and Yamanashi Prefectures on the island of Honshu, Japan as shown in Figure 1. The catchment area is 1,680 km^2 and the mainstream is 109 km in length (Unno et al., 2004). The peak discharge is about 7,300m^3/s (Uda, 1989). The construction of Sagami Dam and a large scale dredge, in the 1940s and 1950s respectively, are the main events on the river basin. In coastal area, the construction of Chigasaki Port, headlands and Hiratsuka Port are the main events (Kawamura and Tanaka, 2005). In this study, we focus on the river mouth which has a sand spit extending from the left bank to the right bank with an opening near the right bank (Figure 1).

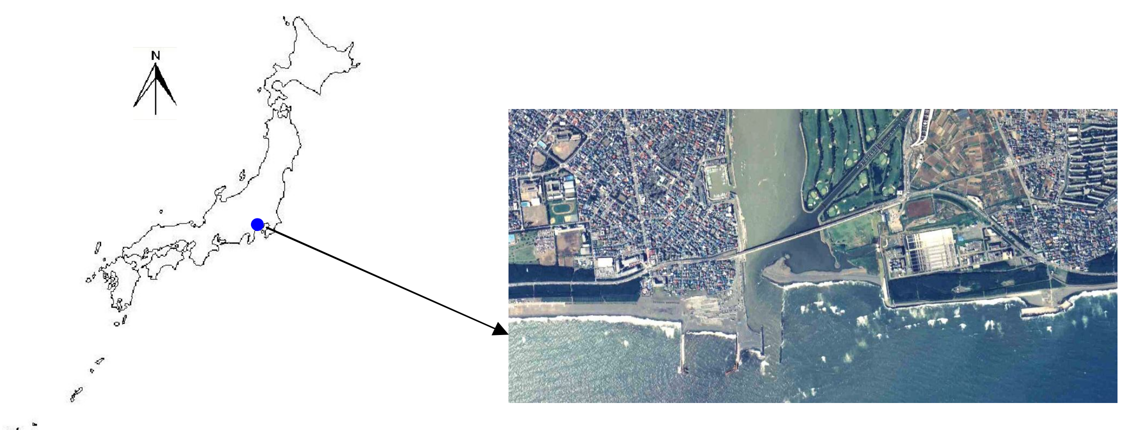

Figure 1: *The Sagami river mouth*

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3. METHODOLOGY

Data sources

Fourteen aerial photographs were collected from 1961 to 2001. The shooting date, time and the tidal stage are tabulated in Table 1. The resolution of the photos is 200 dpi. The tidal levels are obtained from the website “Homepage of Real-time Tide” that shows the tidal data for 20 tide stations managed by the Japan Coast Guard and for 65 tide stations by the Japan Meteorological Agency.

Table 1: *Shooting date, time of the aerial photographs and the tidal level of the time*

No	Acquired date	Acquired time (hh:mm:ss)	Tidal level from MSL (cm)
1	Aug. 26, 1961	11:07:07	-72
2	Jul. 24, 1964	10:14:36	-82
3	Nov. 4, 1965	11:02:53	0
4	Jun. 1, 1967	11:07:59	3
5	May. 21, 1972	09:44:15	3
6	Dec. 22, 1972	10:24:07	18
7	Nov. 10, 1977	10:39:30	-24
8	Nov. 30, 1977	12:35:10	-8
9	Oct. 29, 1983	13:10:32	38
10	Aug. 28, 1993	08:28:09	-46
11	Jul. 24, 1999	12:27:19	-2
12	Dec. 3, 1999	13:25:55	43
13	2000	Unknown	/
14	2001	Unknown	/

Rectification of the aerial photographs

For the utilizing of aerial photographs, the discrepancy among the photos is to be considered. The discrepancy can occur form various causes. For example, the elevation difference of the air plans during photo shooting contributes to the inconsistency in scale and the inclination of the air plan results in the image tilt. This is the reason for which it is necessary to rectify all set of the photographs in order to produce the comparability.

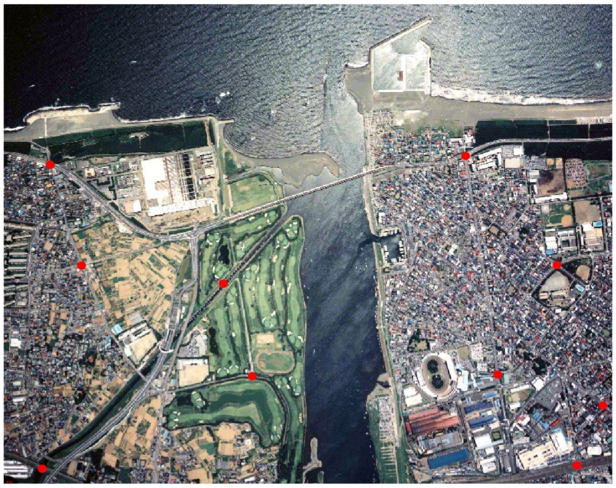

Figure 2: *Ground Control Points on the photo of 2001*

Ten Ground Control Points (GCPs) are chosen with Japan Map in Geodetic system which has an interval of 0.05 second or 2.0 meter approximately. The coordinates of the GCPs are converted to JGD2000/Japan Plane Rectangular CS-X system which expresses in meter. The selected GCPs are discernable on every photo and are well spread as much as possible. They are unmovable with the passing of time, for example a corner of a building, a section of roads or any other permanent structures with known coordinate in the map (Figure 2).

Because of the small scale in the present study, the 1st order transformation or linear transformation was applied to rectify the whole set of aerial photographs. However, the perfect fit for all GCPs is not possible for linear transformation. The rectification results show an average Root Mean Square (RMS) error about 4.7 m, which means the results are distanced in average 4.7m approximately with their real coordinates on earth.

Indicator of the shoreline position

Many papers have been published dealing with the measurement of beach recession and almost exclusively these papers have dealt with trend measurement using indicators such as shoreline (Hanslow, 2007). Chen and Chang (2009) pointed out that a shoreline is idealistically defined as the interface of land and sea. Actually, the shoreline position changes continually with time because of beach variation that results from on-offshore and alongshore sediment transport. The dynamic nature of water levels, such as waves and tides, causes also shoreline position variation.

Because of this dynamic nature of the idealized shoreline boundary, for practical purposes coastal investigators have typically adopted the use of shoreline indicators. A shoreline indicator is a feature that is used as a proxy to represent the "true" shoreline position. Individual shoreline indicators generally fall into one of two categories i.e. a feature that can be physically seen in coastal imagery, for example, a previous high-tide line or the wet/dry boundary; or a tidal datum-based indicator which is determined by the intersection of the coastal profile with a specific vertical elevation, for example, mean high water (MHW) or mean sea level (Boak and Turner, 2005). In the present study, the mean sea level is expected to be the shoreline indicator which will serve to the comparison of shoreline position on each photo. However, since it is not a feature that can be directly seen from the photographs, the wet/dry boundary is therefore chosen as a alternative indicator as shown in Figure 3. This line, present on every aerial photo, is easy to be discerned by color contrast. The shoreline position measured based on this line will need to be corrected to the mean sea level by using tidal stage and wave run up.

Figure 3: *The wet/dry boundary is chosen as an alternative shoreline indicator which is corrected later to mean sea level (MSL)*

Extraction of the shoreline position

A baseline is defined parallel to the shoreline with a distance not too far neither too near to the shoreline (Figure 4). In the present study, the shoreline "position" will be, in fact, the distance between the shoreline (the wet/dry boundary) and the baseline.

The portion of shoreline being studied is 2360m in length, which is divided into 118 sections by transects. Each section is 20m in length (Figure 4). Thus the shoreline position is recorded every 20 meters. The alongshore distance from the left is noted L. The portion between L= 1920m and L = 2360m is considered as the sand spit (Figure 4).

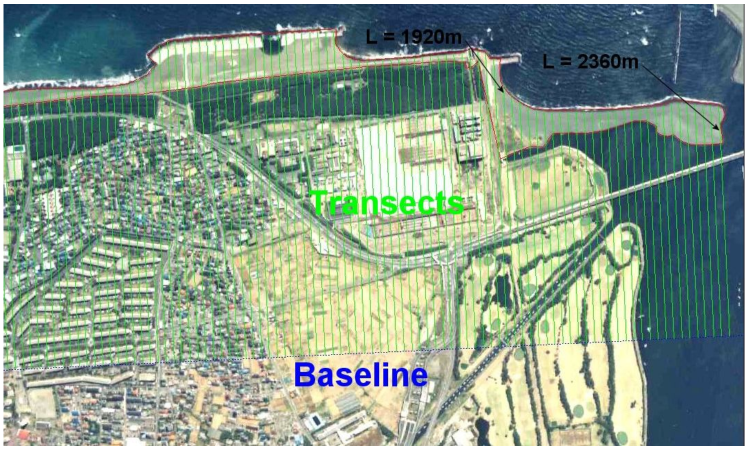

Figure 4: *Baseline and transect for the measurement of shoreline position*

Tidal correction

The local slope, noted α_b, is assumed equal to 0.04 based on the general relationship between beach slope and grain diameter in Reeve (2004) as shown in Figure 5. Owing to the lack of detailed wave data, corrections are made without taking account wave run up. Thus, the corrected shoreline position is given by:

$$Y = Ym + h_{TD} / \alpha_b \quad (1)$$

where Ym is the measured shoreline distance in meter, h_{TD} is the height of tidal stage in meter (Table 1) and Y is the corrected shoreline distance in meter.

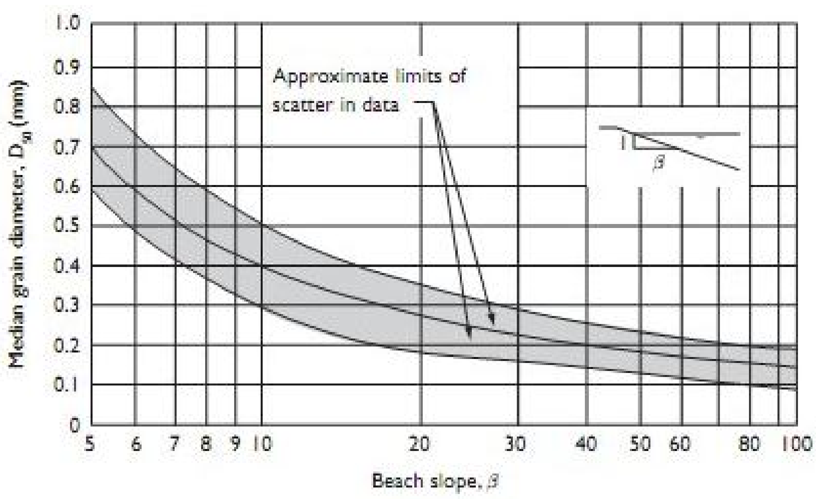

Figure 5*: Relationship between beach slope and grain diameter (Reeve, 2004)*

4. RESULTS AND DISCUSSIONS

For each of the 14 aerial photographs, the shoreline position around the Sagami River mouth is measured and corrected by the method mentioned above. The results are plotted in Figure 6. The length of six typical transects crossing the sand spit, including the left border (L=1920m) and the right border (L=2360m), are presented in the graphic with different forms and colors. Except the two borders, the transects have distance 100 meters one another.

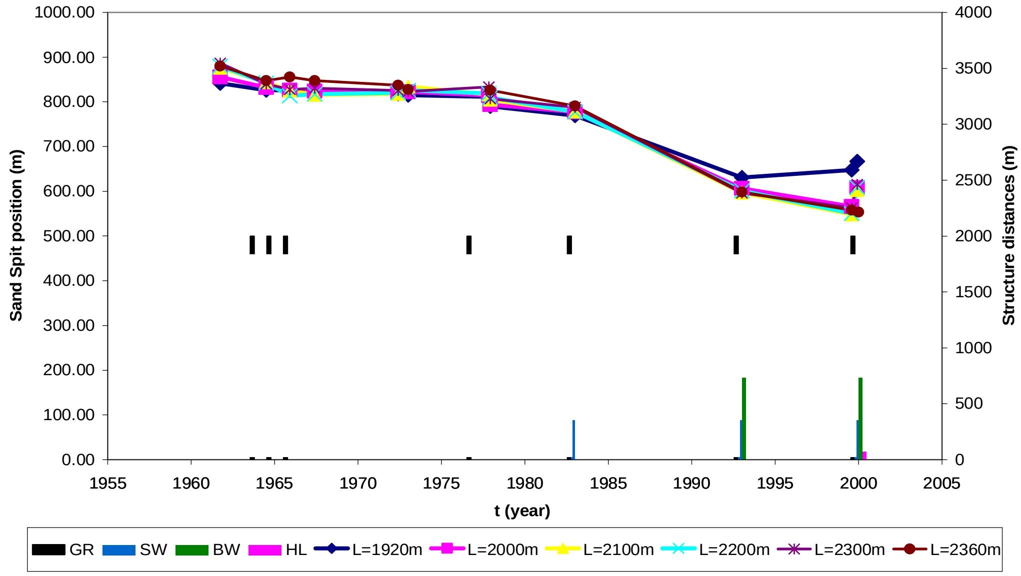

Figure 6: *Results of shoreline distance measurement and positions of nearby coastal structures.*

All the six typical transects have the same evolution, thus are representative for the sand spit position change with the passing of time. It can be seen that the sand spit had been stable until the 1970s. However, from 1983 to 2001, it declined into the river more than 200 meters. Especially during the first ten years from 1983, the migration extent was as much as 175m.

The evolutions of nearby costal structures are plotted below the sand spit position lines by columns, taking account to their distances with the river mouth. At the very near place, a sea wall (SW), a breakwater (BW) and a headland (HL) were constructed in the 1980s and extended later. Two kilometers further, a groin (GR) was constructed in the 1960s. In the 1970s a supplementary groin was accomplished in parallel with the initial one. The both were later developed to be a harbor.

The sea wall, the breakwater and the headland are supposed not to have huge impact to sediment transport in considering the fact that they are constructed in alongshore direction. However, the groins that is perpendicular to the shoreline may had influenced the alongshore sediment transport in long time scale, despite of its long distance with the river mouth. Figure 7 shows the extension of the groin. After being constructed in the 1960s, it has been lengthened around 150 meters by 1983 and another groin was also constructed in parallel nearby. In the other hand, it was from this year that the sand spit began to retreat into the river. Thus, it can be concluded that the construction of the groin is related directly to the sand spit recession.

5. CONCLUSION

In the present study, available aerial photographs have been used for measurement of long-term morphology change of the Sagami River mouth. The dry/wet division line on the photographs has been defined as the indicator of the shoreline position. The results of measurement, corrected with the tidal level, showed that the sand spit at the left bank of the river mouth declined more than 200m from 1960 to 2001. From 1983 to 1993, the migration was as much as 175m. The nearby coastal structures, especially the groin that is distanced 2000 meters with the river mouth, is supposed to have influenced alongshore sediment transport and thus contributed the decline of the sand spit from the 1980s.

Supplemented studies are to be carried out on other Japanese rivers, with objective of obtaining empirical laws of the river mouth response to coastal structures. Particularly, the dependence of this response to the river mouth/structure distance is to be analyzed.

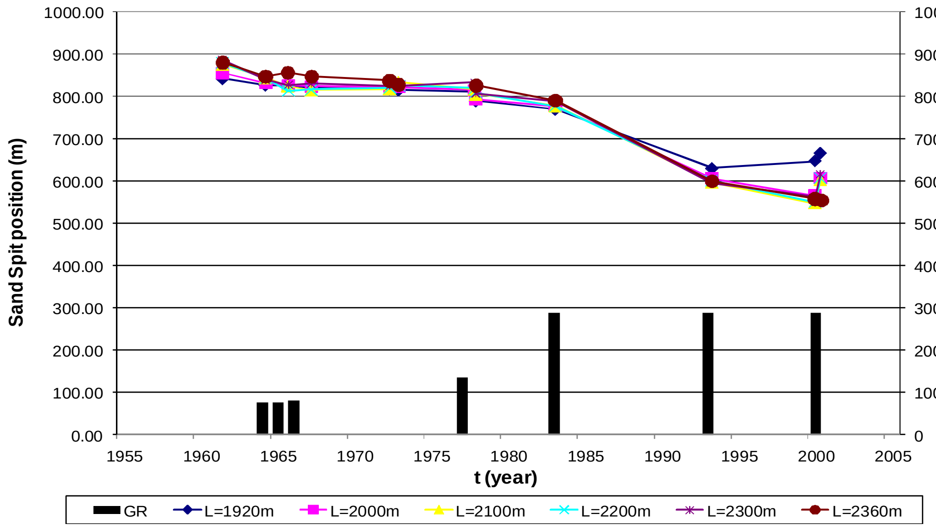

Figure 7: *Extension of the groin*

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