SEDIMENT DYNAMICS AND DEPOSITIONAL PATTERNS OF SANDY BEACH SPIT, GASPÉ BAY, QUEBEC

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INTRODUCTION AND SITE DESCRIPTION

The sediment dynamics of a modern coastal spit are important to analyze for several reasons. Knowledge of the processes involved in a modern beach environment is essential both for understanding preserved sedimentary records and predicting the changes which occur along a modern coastal area. These modern day changes are often of great interest for development issues as well as for coastal management plans. It is the purpose of this study to examine the present day spit dynamics and the morphological changes of the spit throughout the last fifty years. The rapid rate of change of Sandy Beach Spit is of particular interest in the area due to the importance of the spit as a breakwater for the west side of Gaspé Bay and for the harbor of Gaspé. Field research for this study was conducted during the month of June, 1991.

Sandy Beach Spit is a north-south orientated spit, roughly 4 km in length, which at high tide is divided into a northern and southern section. Sandstone cliffs lie to either side of the southern base of the spit, and a steep unconsolidated slope lies directly to the south. The southern section of the spit is triangular in shape, 1 km wide at the base, and contains a saltwater marsh enclosed within two thin strips of eolian dunes. The northern section is more linear, about 100 m wide, and contains a strip of dunes extending down the center. The surface of the spit is located on a shallow submerged sediment platform, just over 4 km in length and 1.5 km wide, which extends into Gaspé Bay from the south. The spit is somewhat sheltered from storms due to its location almost halfway into the Bay, but northeast storms do occasionally cause high wave energy upon the spit.

FIELD AND LABORATORY METHODS

A variety of field methods were used in the investigation of the spit. A baseline was laid out along the eastern length of the the spit and along the west side of the southern section using a laser theodolite. This baseline was marked by stakes every 160 m (500 ft.), with the exception of the tidal breach section, where stakes were placed every 192 m (600 ft.). Beach profile surveys were conducted at each stake from dunes to below mean low tide using the stake and horizon method. A topographic map of the spit was constructed using this profile data adjusted to mean low tide level using local tidal charts (figure 1). An 8:1 offshore exaggeration is used on figures 1 and 2 in order to show detailed changes along profiles.

One hundred and nine sediment samples were collected in the field along the beach profiles. Five samples were taken along each profile on the east side of the spit; one in the dune area, three equally spaced along the shoreface, and one below the water level at the end of the profile. In the tidal breach in the middle of the spit, five samples were taken at each profile even though there was no dune vegetation and the shoreface was not well defined. Due to time constraints, sampling along the west side of the northern section of the spit was incomplete and only three foreshore samples were taken at each profile.

The beach samples were sieved in the laboratory and the cumulative phi sizes were treated mathematically for grain size parameters (Folk and Ward 1957). The parameters of mean phi size, standard deviation, skewness, and kurtosis were calculated for each sample and plotted on contour maps, although only mean and standard deviation will be discussed here. Figure 2 illustrates sediment distribution according to mean grain size, again with an 8:1 offshore exaggeration.

Air photo analysis was conducted to examine rates of erosion and deposition on the spit over recent history. Canadian Geologic Survey air photos dating back until 1943 were used, creating a record showing the changes in the shape of the spit over time. Figure 3 shows the difference between the 1991 spit shape and the shape of the spit in 1961. One beach trench was also dug on both the east and west side of the spit to determine the spit history through analysis of the sedimentary structures present below the current beach level.

SEDIMENT ANALYSIS

The topographic map constructed from the profile data (figure 1) shows the general characteristics of the spit. The entire length of the spit is revealed at mean low tide, with dunes to the north and dunes and marsh to the south. During higher tides a tidal breach exists in the center of the spit between the dune sections. This breach is of great interest in that it has greatly influenced the current patterns and sediment characteristics along the spit. The tidal breach is also important in analyzing trends in sediment distribution and spit morphology over time, as sand deficits such as this constitute good evidence that the spit is attenuated due to overextension and a subsequent sediment deficit. (Carter, 1988).

All four of the mathematical parameters of the sediment samples; mean, standard deviation, skewness, and kurtosis, showed trends along and across the spit. The mean grain size of the samples, contoured in figure 2, showed that the majority of the spit consisted of sediment 1 to 2 phi units, classified in the Wentworth size scheme as medium sand. Coarse samples including mean sizes of granule (-2 to -1 phi) were found at the west side of the southernmost section of the spit and appeared to have originated from the nearby sandstone cliffs. Mean grain size generally became finer towards the northern tip, with the exception of the tidal breach. Due to higher current and wave energies during high tide, the breach was comprised of coarse sand (0 to 1 phi) and very coarse sand (-1 to 0 phi). The finest sediments were found on the east side of the northern section of the spit, where fine sand (2 to 3 phi) was predominant.

The sorting of the sediment samples, as defined by standard deviation, was highly variable, yet definite patterns are found. As is to be expected, the dune samples in general were the most well sorted due to eolian transport of fine sediment. The poorest sorting of the samples occurred at the southern end of the spit near the shoreline and in the tidal breach. The poor sorting in the tidal breach is most likely due to the variable nature of the currents with high velocity at high tide slowing as the section emerges during low tide.

EROSION AND DEPOSITION

Figure 3 shows the coastlines of the spit in both 1991 and 1961, with the erosional and depositional patterns throughout that time. The northern two thirds of the spit has shown the greatest amount of reworking and sediment redistribution. In 1961, the spit was 500 meters shorter than in 1991, with no permanent vegetation beyond the level of the marsh channel at the tip of the southern section. This elongation suggests strong northward longshore currents, although sediment deposition at the north tip was surely facilitated by the presence of a stone jetty running for several hundred meters from the spit to the lighthouse. This jetty has since been covered with sediment and only a pile of rubble on the foreshore exists where the lighthouse once stood. The southern base of the spit has shown minimal changes with slight deposition on both sides of the spit.

CONCLUSIONS

The data described above can be used to draw various conclusions about this study. 1) The topographical information and grain size analysis suggest transport of sediment away from the sandstone cliffs to the northern section of the spit. This along-beach transport, most likely caused by longshore current (Dyer, 1986), has resulted in a sediment deficiency in the center of the spit to cause attenuation and breaching of the spit. 2) The base of the spit and the marsh section have changed very little over the course of the last sixty years, but the northern two thirds of the spit has migrated considerably within the confines of an offshore sediment platform. The source of this sediment wedge and more ancient spit migrations will be further examined with forthcoming data.

REFERENCES

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Folk, R.L. and Ward, W.C., 1957, Brazos River bar: A study on the significance of grain size parameters, Jour. Sed. Petrol., v. 27, No. 1, pp. 3-26.

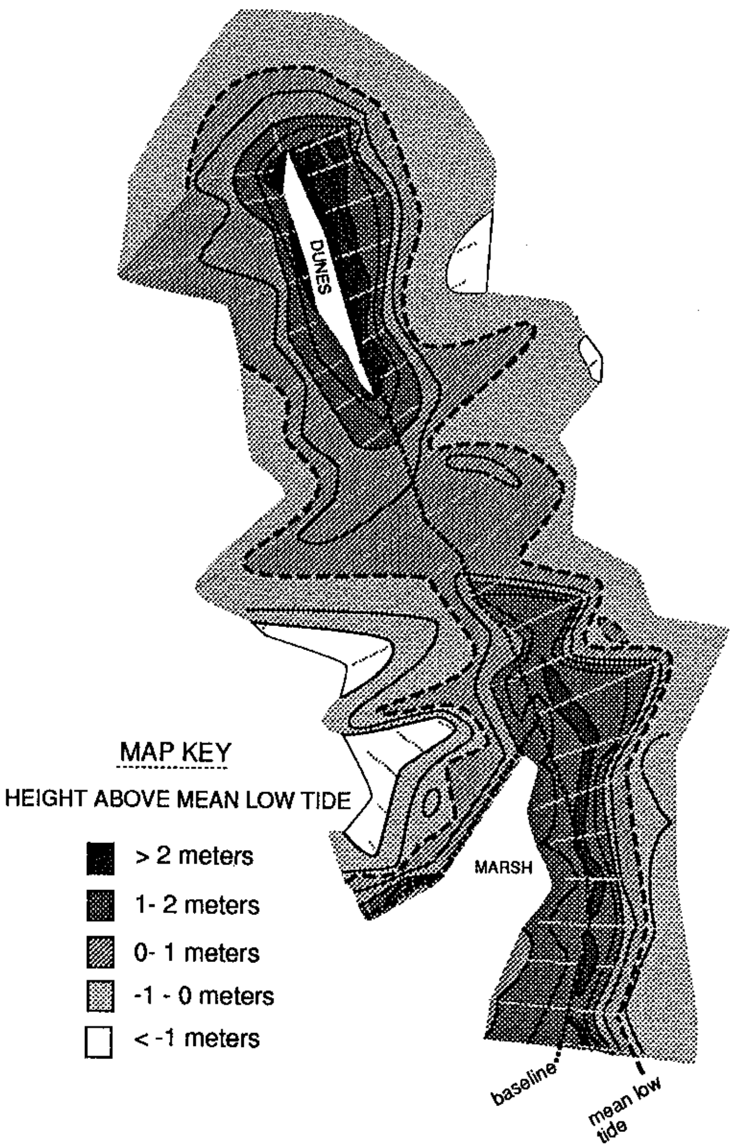

FIGURE 1: TOPOGRAPHY OF SANDY BEACH SPIT

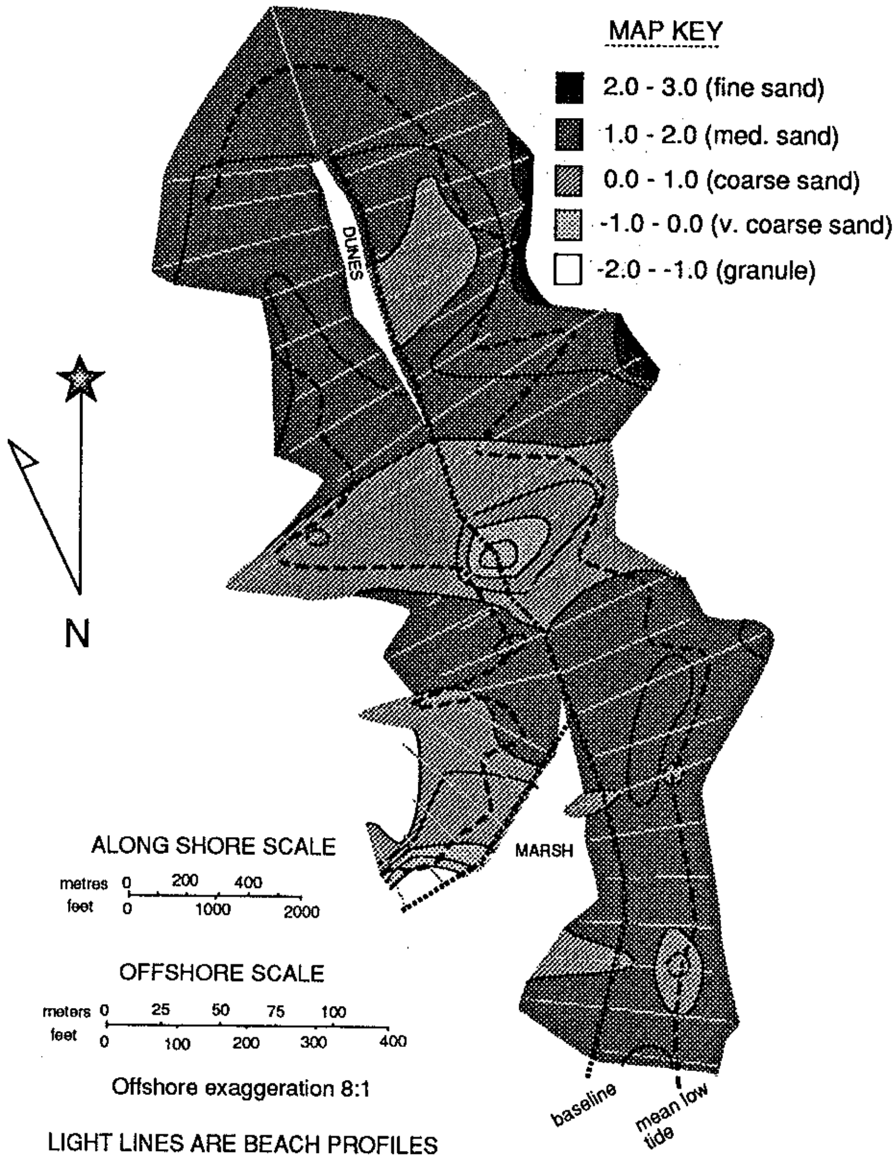

FIGURE 2: MEAN GRAIN SIZE IN PHI UNITS

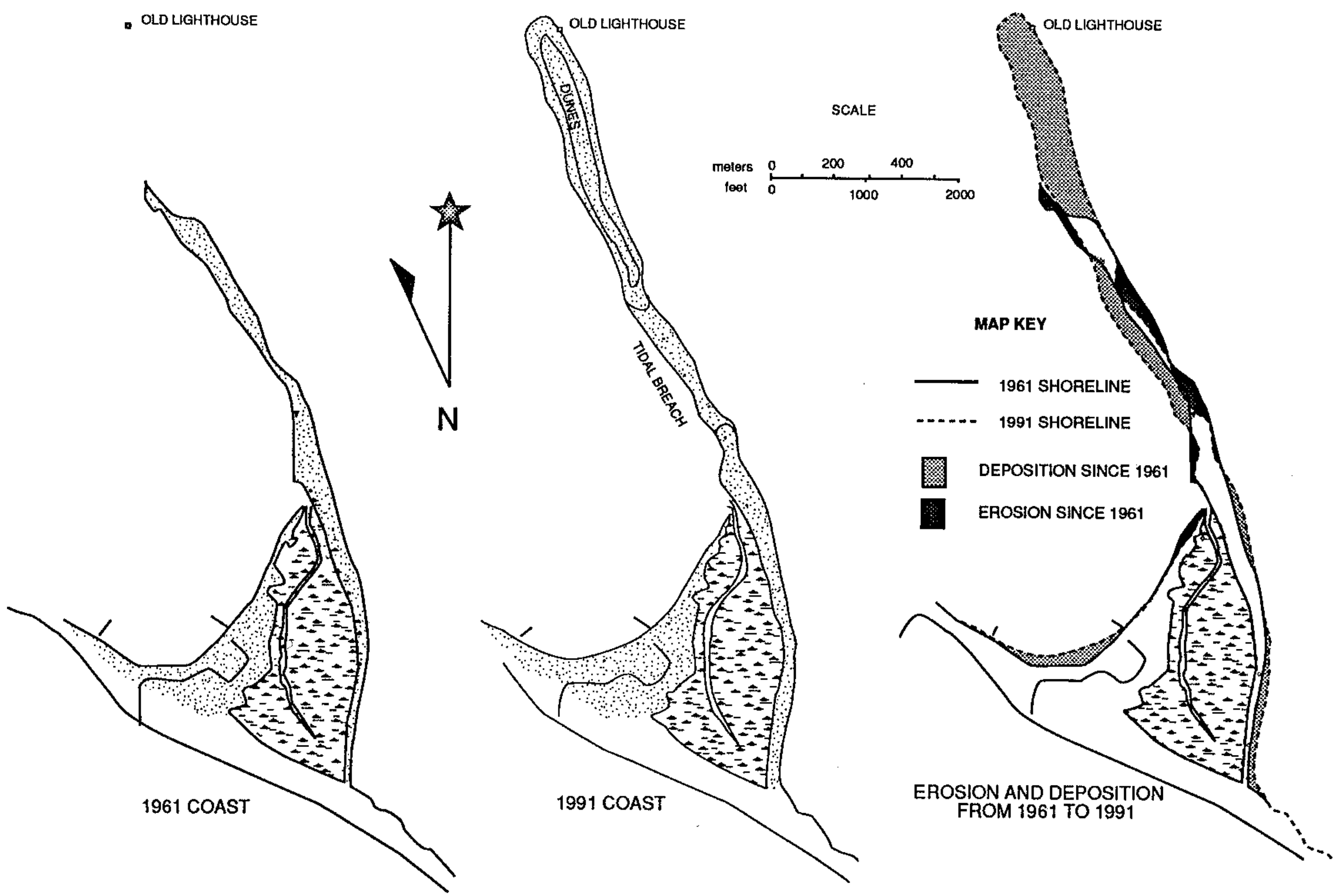

FIGURE 3: EROSIONAL AND DEPOSITIONAL CHANGES OF SANDY BEACH SPIT SINCE 1961