SATELLITE APPLICATIONS ON A COASTAL INLET STABILITY STUDY

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INTRODUCTION

It is known that longshore drift of alluvial material occurs along sandy barrier islands. Inlets between these barrier islands intercept the normal littoral drift, resulting in a net loss of sand from the beaches. During a flood tide, sand is brought into the inlet and part of it is retained to form the inner bar; during ebb cycle, part of the sand is jetted out into the ocean to form an outer bar. The reversing flows of flood and ebb cycles may also cause deposition or scouring on the bottom of inlet channels.

There are two sets of parameters pertinent to the behavior of inlets. The first set deals with the changes in the dynamic bottom configuration (i.e. the movement of inner and outer bars, the choking or scouring of the inlet channel). The second set of parameters regards the driving forces of the coastal system (i.e. wave climate, tide, wind and currents). Understanding the interrelationship of these two sets of parameters lead to the solution of stabilizing the inlet. The time sequential dynamic interrelationships and natural tendencies of inlets are well-portrayed on available Landsat imageries.

The techniques of mapping the sand bars and their movements are traditionally done by a sounding boat and survey team. The derived point and line information are then used to produce the contour map of the bottom. Extensive interpolations are needed because many details between the points and lines are missing. The operation is expensive and the procedures are time consuming. Techniques using remote sensing can be used to monitor the changes that take place, reducing costs and increasing efficiency.

Eventhough standard procedures have not yet been established, the satellite sensing of bottom features has progressed considerably in recent years. Sherman (1975), Middleton and Barber (1976), Hubbard (1977), and Lyzenga and Thomson (1978) all demonstrated that it is possible to correlate the radiance values of multi-spectral images, such as Landsat imagery, with the depth related information in shallow water. The present study is one more example of such an effort.

IMAGE ANALYSIS AND INTERPRETATION

Two Landsat magnetic tapes (1974 and 1976) covering Pinellas County shoreline was obtained and displayed on the screen of an IMAGE 100 computer. Spectral radiance values were derived from the magnetic tape for various key locations in the Clearwater Beach area as it is shown by the dark squares in Figure 1. These radiance values were later used to compare with ground truth observation and measurement. Typical scene of the image manipulations are given in Figures 2 through 7. Figure 2 shows a cluster rendition of the study area in general. The land water boundary is nicely shown in Figure 7. These two figures are used as reference figures for the comparison with the specific signatures, their extent and location in Figures 3, 4, 5 and 6. In Figure 3, the large shaded dark area in the left one third (approximately) of the picture represented the area of water depth greater than 10 feet. The dark shaded area in Figure 4 was identified as the grass bed. Figure 5 showing the intermediate water depth region of 4 to 10 feet was found to surround the barrier island chain. The extremely shallow water areas were found in Figure 6.

The natural navigation channel at Clearwater Pass can be clearly observed in the enlargement picture on the north-east corner of Figures 8 and 9. Figure 9 is a binary computer printout showing the results of Golay Cluster techniques. The enlargement picture in Figure 10 (also a binary printout) gave the location of shoals.

GROUND TRUTH

A team equipped with survey instruments and sounding gear were sent to determine shallow water bottom conditions. The inlets cross sectional area and the shoaling region were measured by sounding and survey. These ground truth observations were used for the comparison with radiance values of the Landsat imagery.

The difficulty encountered during ground truth operations was the identification of the bottom condition by boat. An analogy to this would be best described by an old saying: "When you are in the forest, you don't see the trees." To improve the situation, two flights were flown to collect low altitude photographs. The first set of photos covered a shoreline of approximately ten miles in length, and the flight line was along the beach. The second flight emphasized on the Clearwater Pass and on the bay area.

The hydrographic measurements together with the aerial photos constitute the basis of ground truth for interpretation and calibration of the Landsat imageries. The reader is directed to the two reports by Wang, et al (1977) for ground truth details.

FIGURE 1. TRAINING SITES IN CLEARWATER BEACH REGION

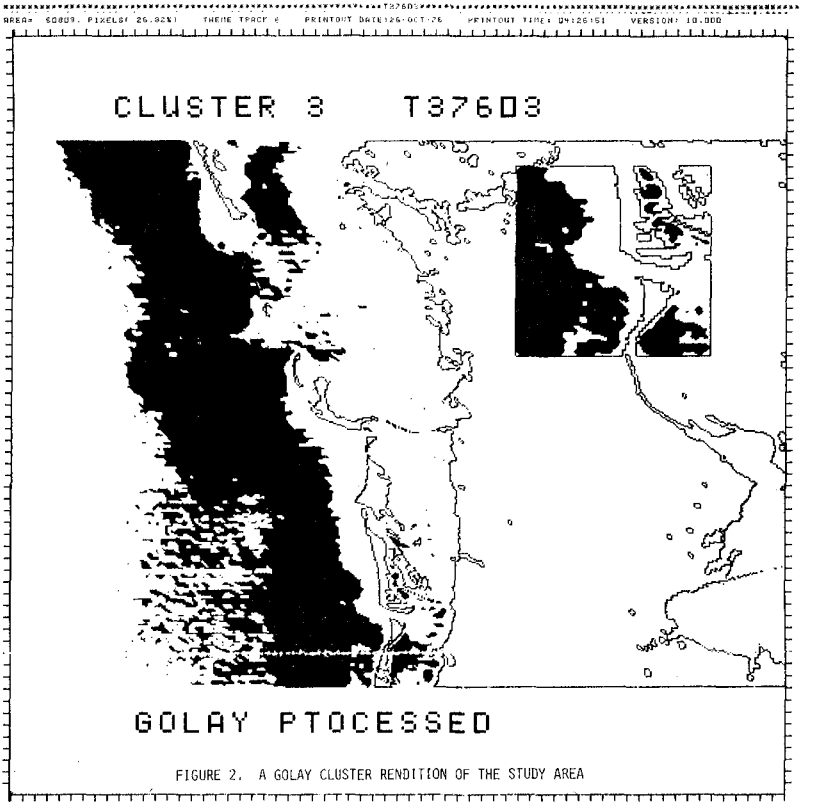

FIGURE 2. A GOLAY CLUSTER RENDITION OF THE STUDY AREA

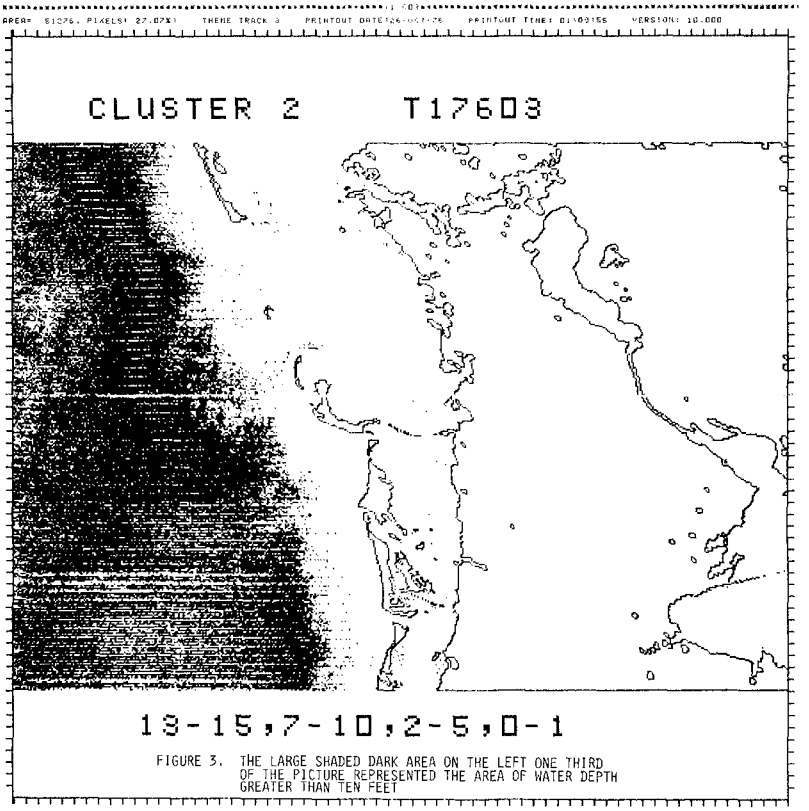

FIGURE 3. THE LARGE SHADED DARK AREA ON THE LEFT ONE THIRD OF THE PICTURE REPRESENTED THE AREA OF WATER DEPTH GREATER THAN TEN FEET

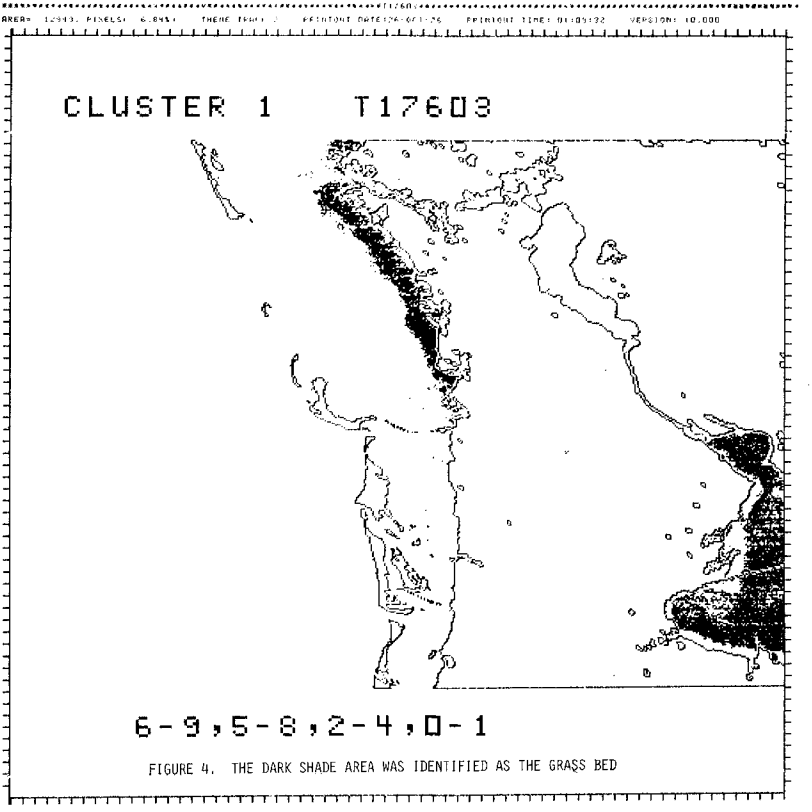

FIGURE 4. THE DARK SHADE AREA WAS IDENTIFIED AS THE GRASS BED

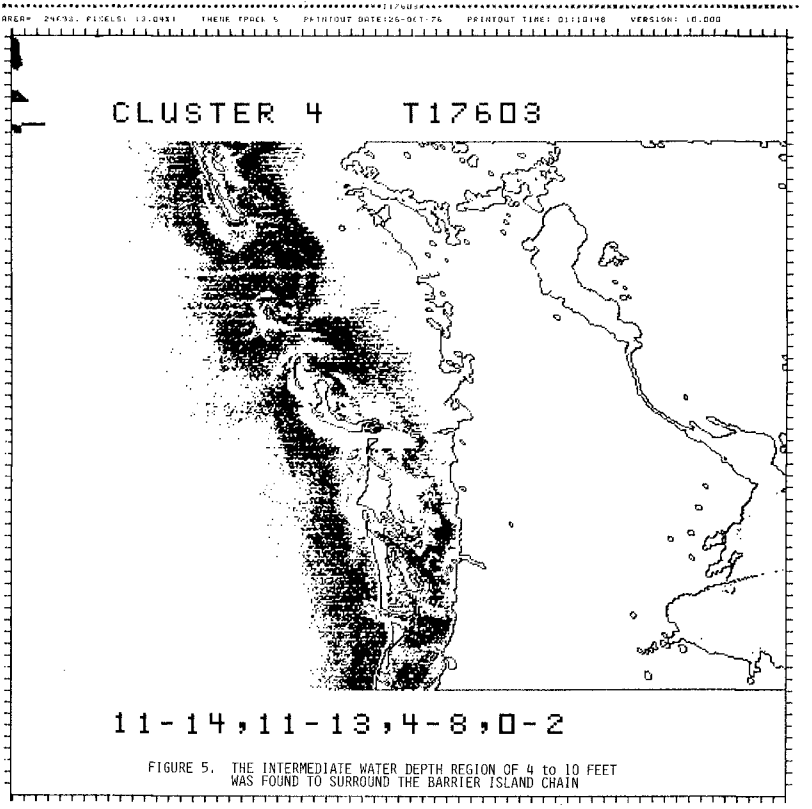

FIGURE 5. THE INTERMEDIATE WATER DEPTH REGION OF 4 to 10 FEET WAS FOUND TO SURROUND THE BARRIER ISLAND CHAIN

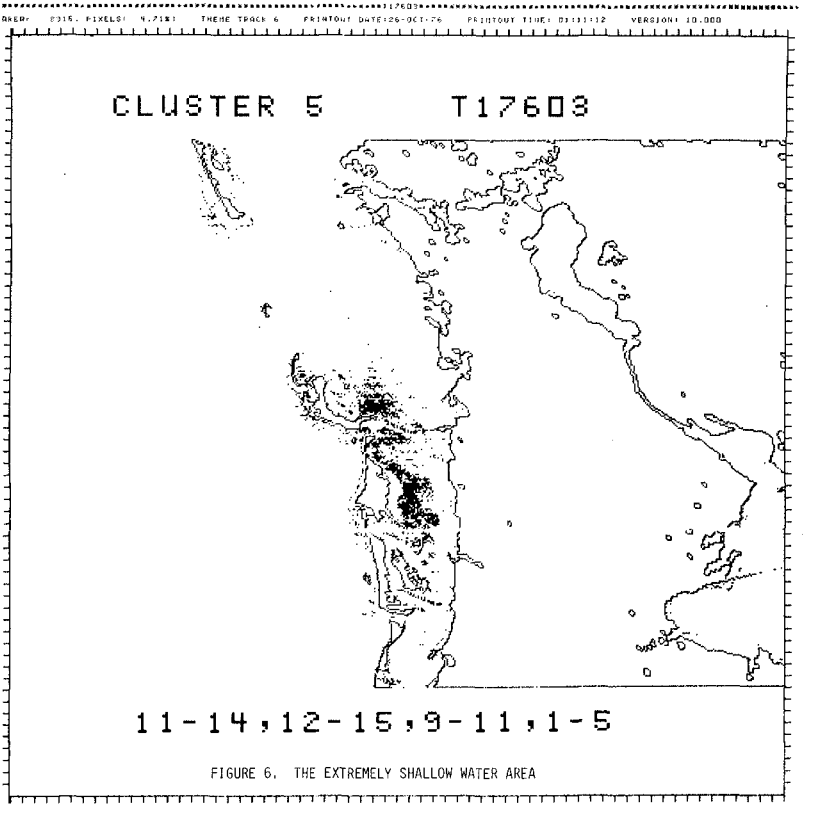

FIGURE 6. THE EXTREMELY SHALLOW WATER AREA

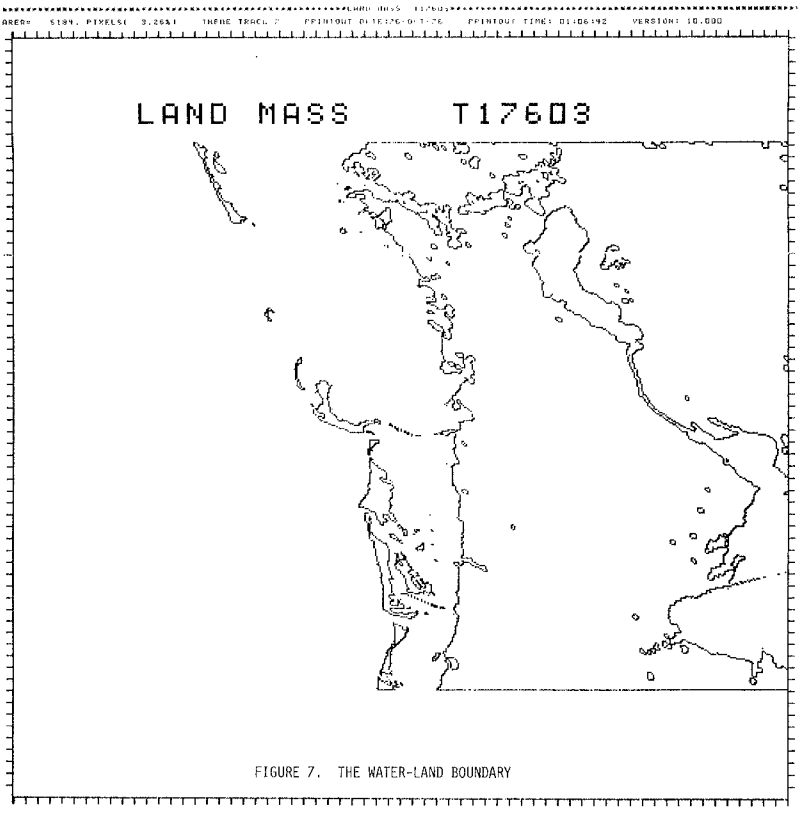

FIGURE 7. THE WATER-LAND BOUNDARY

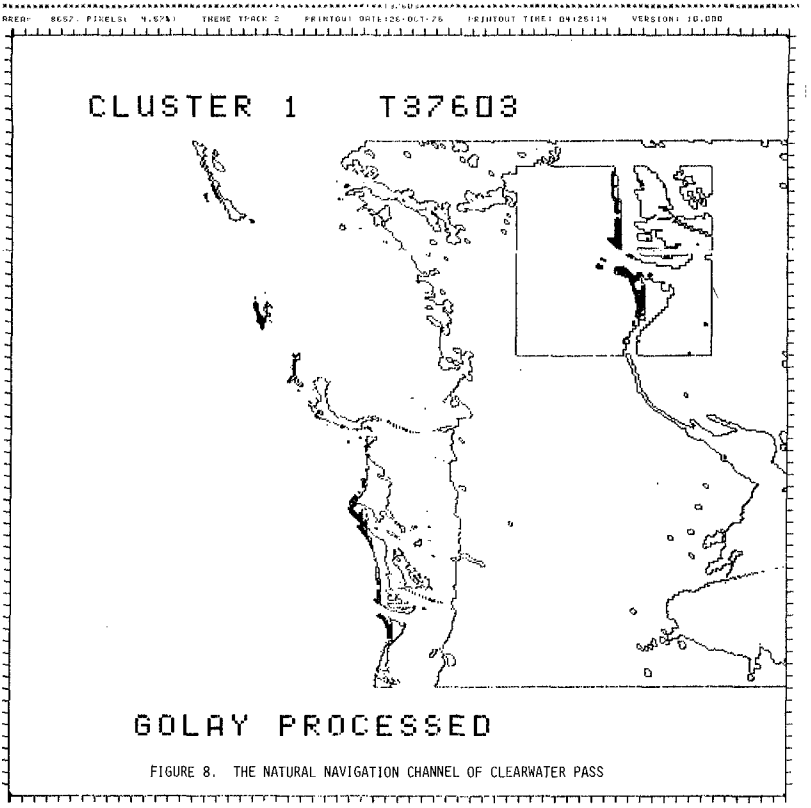

FIGURE 8. THE NATURAL NAVIGATION CHANNEL OF CLEARWATER PASS

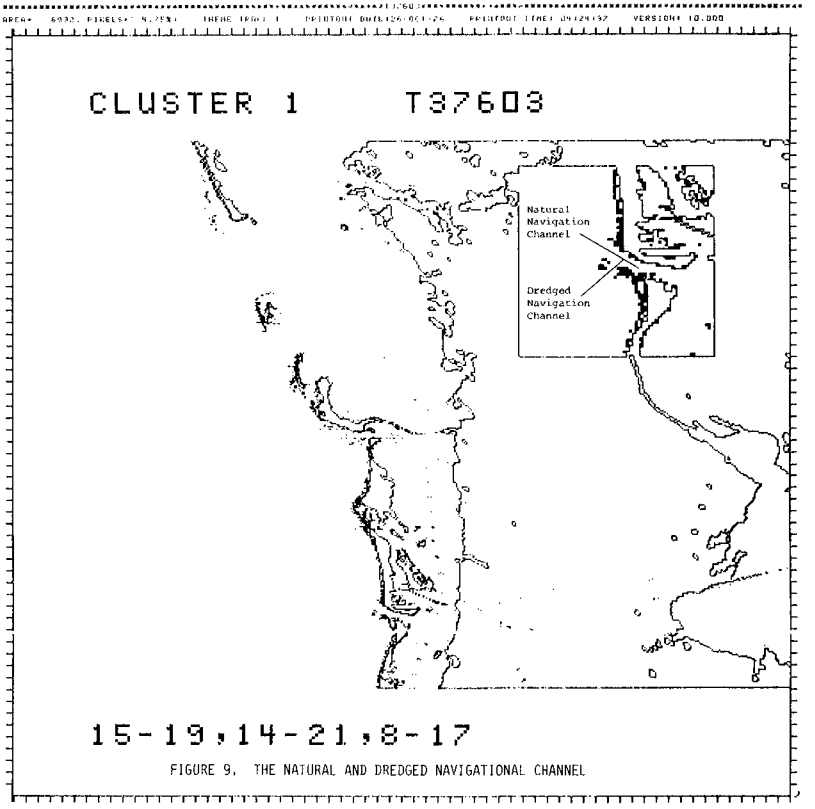

FIGURE 9. THE NATURAL AND DREDGED NAVIGATIONAL CHANNEL

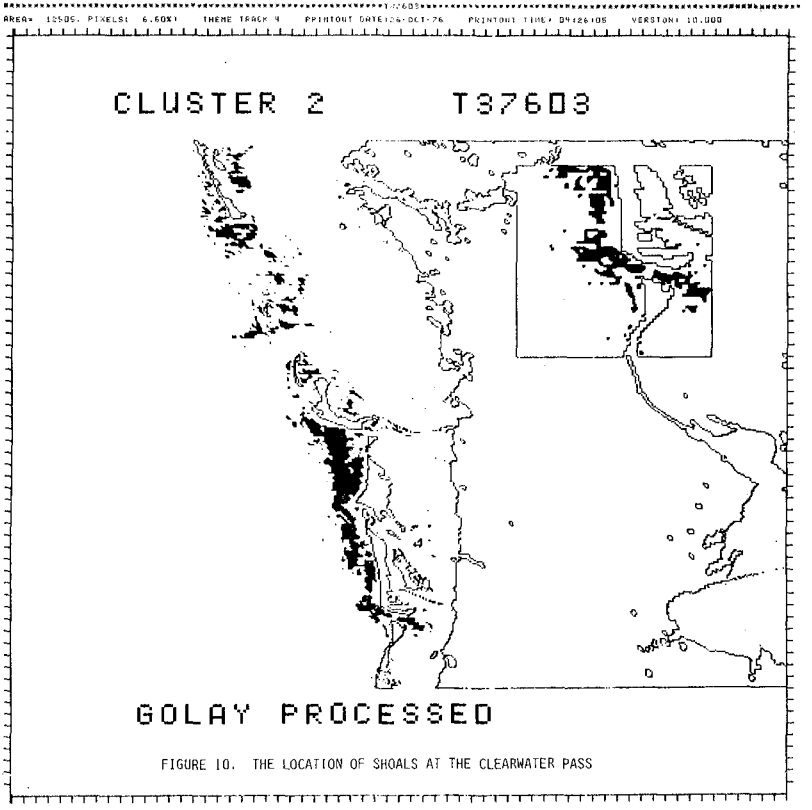

FIGURE 10. THE LOCATION OF SHOALS AT THE CLEARWATER PASS

ENGINEERING ASSESSMENT FROM LANDSAT DATA

1. Identification of the pass's natural channel: Spectral analysis of the Landsat imagery (see Figures 8 and 9) has revealed the direction of the natural course of the inlet channel. The main stream (deep part) along the inlet has been eccentric and parallel to the north bank of the inlet. As a result, the beach erosion is likely to occur at south end of the Clearwater beach. It is also clear that the dredged navigation channel at the inlet mouth deviates from the inlet's natural channel course (see Figure 9).

2. Location of shoals:

A. Outer bars: The extremely shallow region and outer bars, such as the bathing zone and the second bar parallel to shoreline, are identifiable by the shaded regions in Figure 6. These regions correspond well with the area identified on the aerial photos. The identification of the bar location at the inlet mouth (Figure 9) has helped to reveal the need for realignment of the navigational channel for the following reasons: (i) the existing dredged navigation channel turned towards the outer bar and cut through the middle of the outer bar; this means the dredged channel may be filled with sand more rapidly and therefore will require more frequent dredging; (ii) the 35^{o} turn that the channel made at the inlet mouth would create navigational hazards, since the current at the inlet mouth is strong and the wave field is variable there, particularly in bad weather; (iii) since the bar location is known the realignment of the navigational channel should be chosen in such a way that a straighter course cutting through the trough between two shoaling areas is possible.

B. Inner bars: The identification of the inner bar location in the bay area (see Figure 10) is important with regard to the future dredging practice in connection with the inlet stability problem. The inner bars slowed down the flow by increased bottom friction. As a result, the bay flow pattern was concentrated in two streams at the inlet throat. One was along the east bayshore where the navigation channel is maintained, the other was parallel to the west bayshore between the bridge and the toll booth. This flow concentration pattern focused its momentum on one part and was weakened in other regions of the inlet channel. Therefore, it was responsible for the scouring at the bridge pier and silting along the south jetty.

CONCLUDING REMARKS

This study has demonstrated the following:

1. The multi-spectral imagery, such as the Landsat imagery, can

be used to study many coastal phenomena and monitoring changes that take place. Navigation channel alignment, shoal locations and water depths are among the good examples.

2. Remote sensing by satellite should and can reduce cost and increase efficiency. It only needs a few training sites and ground truth measurements.

3. Formulation of engineering judgement and opinion from Landsat data are illustrated.

REFERENCES:

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2. Lyzenga, D. and F. Thomson (1978), "Basic Remote Sensing Investigation for Beach Reconnaissance," Final Technique Report No. 108900-11-F, ERIM

3. Middleton, E. M. and J. L. Barber (1976), "Hydrographic Charting From Landsat Satellite: A Comparison with Aircraft Imagery," Ocean '76

4. Sherman, J. W. III (1975), "Working Paper on a Possible Change In The Landsat-C Green Band for Improved Bathymetry Application," National Environmental Satellite Service, NOAA, Washington, D.C.

5. Wang, Y. H., M. Smutz, B. E. Ruth and H. K. Brooks (1977), "Satellite Applications To A Coastal Inlet Study, Clearwater Beach, Florida," Technique Report UFL/COEL-77/025, Coastal and Oceanographic Engineering Laboratory, University of Florida

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