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VARIATIONS IN SEDIMENT BUDGET AND MORPHOLOGY AT OREGON INLET, NORTH CAROLINA

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Many scientists as well as the National Park Service are on record as being opposed to the Oregon Inlet jetty project as proposed by the Corps of Engineers. The project would disrupt the ecology of the area. Land in the Cape Hatteras National Seashore has recently been approved for construction purposes by Congress. Because this project is extremely controversial, it seems appropriate to study the ramifications surrounding the project as much as possible, before funding becomes available.

The research here attempts to define the nature and magnitude of geomorphic change in the vicinity of Oregon Inlet. Rates of morphometric change and sediment budgets are presented as base line data as they are related to the dynamic stability of the inlet and the adjacent coastline.

Historical Changes

Oregon inlet is part of the barrier island system separating Bodie Island to the north and Pea Island to the south. The inlet is important for navigation since it is the only inlet at the present time between Cape Henry and Hatteras Inlet. State and local officials view the stabilization of the inlet essential to the economy of the area, especially for the local fishing industry at Wanchese Harbor on Roanoke Island.

Early charts of the study area show several inlets in the vicinity of Oregon Inlet (Figure 1). Because of the inaccuracies of these early charts it is difficult to determine which might be the predecessor of the present inlet. The existing inlet opened during the hurricane of September sixth and seventh in 1846. An 1843 chart shows an inlet in the area, but some distance south of the present location. The closing of Roanoke Inlet, the one Sir Walter Raleigh supposedly used in 1584, prompted politicians of the period to promise to reopen the inlet it elected.

The inlet was relatively undisturbed except for occassional dredging until 1964 when Bonner Bridge was completed. While it has been hypothesized that the bridging has contributed to inlet migration, narrowing, and shoaling, it has not been substantiated. More than likely, it has been the decrease in storm fequency and magnitude since the hurricanes of the 1950's and the Ash Wednesday storm of 1962.

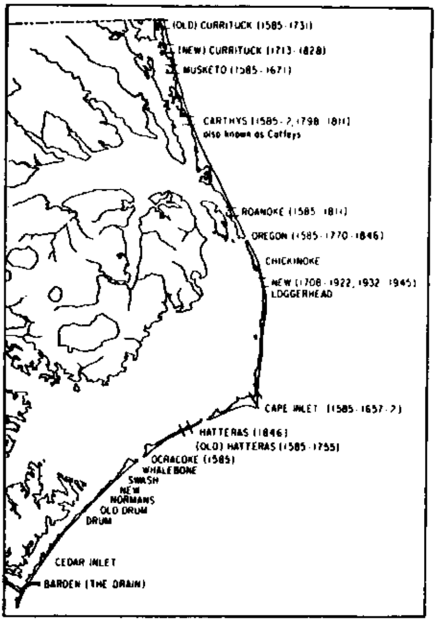

Figure 1. Inlet locations of the Outer Banks of North Carolina. Source: Birkemeier, 1981.

Data Sources and Analyses

For this investigation, the shoreline in the vicinity of Oregon Inlet is divided into three sections, which are: (1) the updrift ocean beach on southern Bodie Island, (2) the downdrift ocean beach on northern Pea Island, and (3) Oregon Inlet. The Oregon Inlet section can be further subdivided into three components, which are: (1) the sea shoals or ebb tidal delta, (2) the sound shoals or flood tidal delta, and (3) the inlet gorge or channel. An inspection of historic maps and charts between 1848 and 1982 shows that the inlet has been migrating southward at a rate of ninety feet per year (Figure 2). Concomitant with this southerly migration, is the change in inlet throat width (Figure 3). The width of the inlet throat in 1848, 1915, and 1949 ranged between four tenths and one half of a mile (Figure 4). The occurance of the Ash Wednesday storm resulted in a widening of the inlet to 1.6 miles (Figure 5). In 1982, calculations showed that the inlet throat had been narrowing since 1974 at a rate of three hundred and fifty-six feet per year in order to attain its present width of about three tenths of a mile. Since the opening of the inlet in 1846, considerable change has occurred with respect to the approximate location of the existing inlet and the proposed jetties (Figure 6).

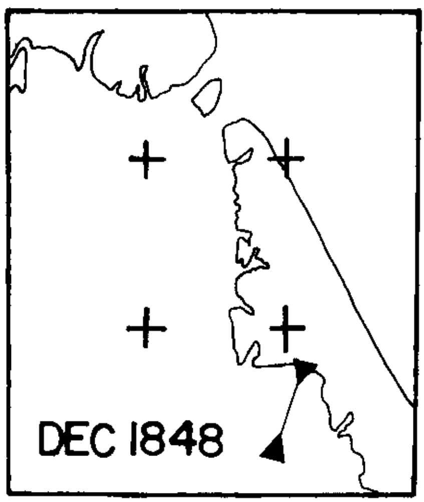

Figure 2. Inlet in 1848 with present gorge shown between triangles. (After Duke University Geol. Lab.).

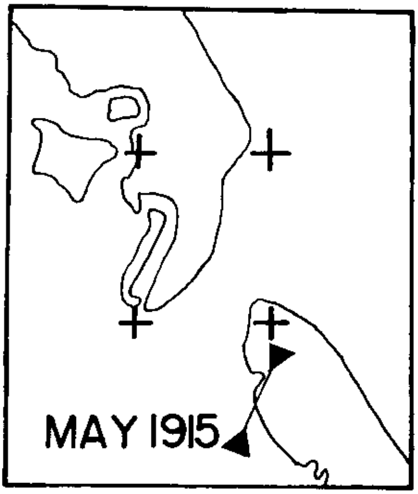

Figure 3. Inlet in 1915 with present gorge shown between triangles. (After Duke University Geol. Lab.).

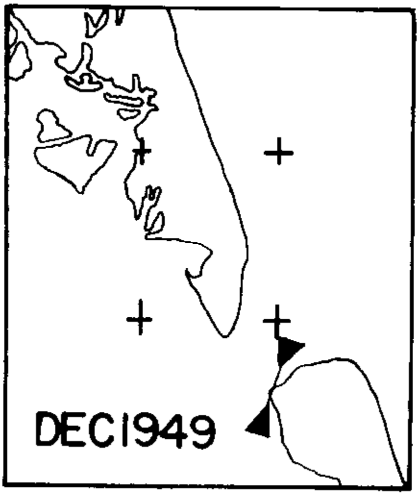

Figure 4. Inlet in 1949 with present gorge shown between triangles. (After Duke University Geol. Lab.).

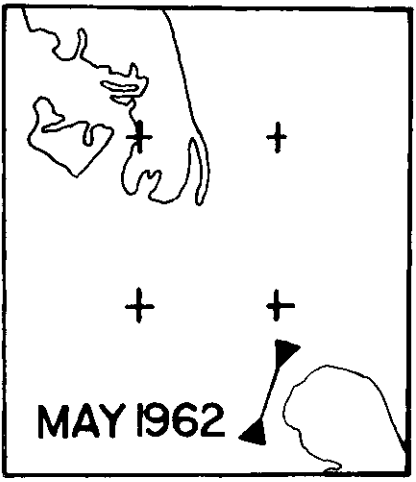

Figure 5. Inlet in 1962 with present gorge shown between triangles. (After Duke University Geol. Lab.).

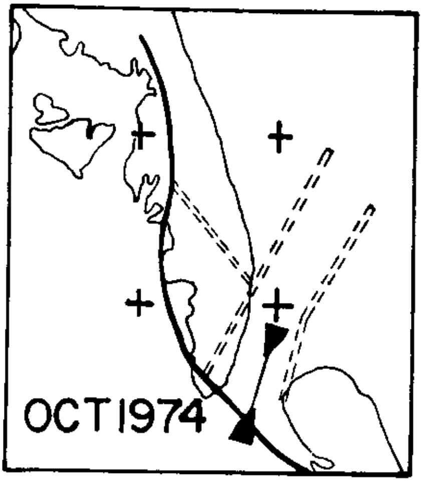

Figure 6. Inlet in 1974 with the location of the present gorge, the proposed jetty system and the Bonner Bridge. (After Duke University Geol. Lab.).

The main channel of the inlet has also been migrating southward through time and it has also tended to become shallower since the mid 1960's (Figure 7). Between 1937 and 1957, the depth of the main channel changed from twenty feet to thirty-two feet respectively. And

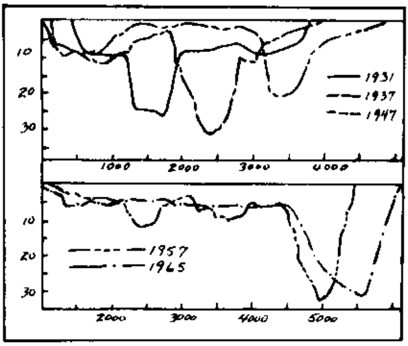

Figure 7. Inlet crossections. Source: Dolan and Classen, 1973.

when the inlet attained its greatest cross-sectional area in 1965, the main channel of the inlet was thirty-one feet deep. The seemingly greater depth and cross-sectional area recorded in 1957 and in 1965 are thought to be related to the large number of hurricanes that occurred in the area from 1954 through 1959, and the impact of the Ash Wednesday storm of 1962. In the late 1970's, the bridge pilings near Pea Island were being undermined by the main channel and forced the bridge to be closed temporarily. The channel now must be dredged almost continually to maintain a depth and location required for navigation purposes.

The period between the Ash Wednesday storm and the present has seen relatively little storm activity. There has been a marked decrease in the frequency and magnitude of severe northeasters and a major hurricane has not made landfall within the locality of the inlet during this period. This quiescent period has been marked by a high accretion rate in both the ebb tidal and flood tidal deltas. Changes in the morphometry of the sound and the sea shoals were made by recording depth measurements along a series of transects. It was found that the mean depth of the ebb delta decreased from 17.6 feet in 1961 to 13.7 feet in 1972 (Figure 8).

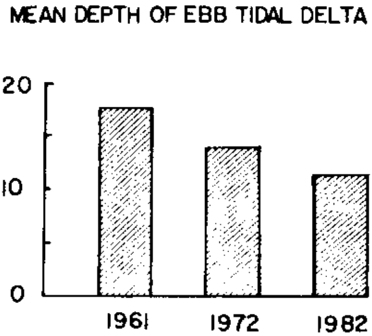

Figure 8. Mean depth of ebb tidal delta, in feet, for 1961, 1972 and 1982.

While between 1972 and 1982 the mean depth of the ebb delta decreased an additional two feet, to 11.7 feet. This rate of sediment accumulation represents an annual increase of 0.85 cubic yards of sediment per square yard of area or 805,513 total cubic yards per year over the area of the ebb tidal delta (Figure 9). The flood delta has

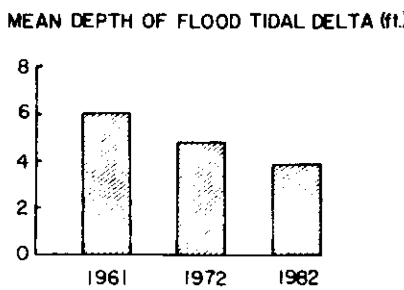

Figure 9. Mean depth of flood tidal delta, in feet, for 1961, 1972 and 1982.

also been decreasing in depth. Between 1961 and 1972, the mean depth of the flood delta decreased from six feet to 4.8 feet. While between 1972 and 1982, the mean depth decreased an additonal foot to a depth of 3.8 feet. This rate of sediment accumulation marks an annual increase of 0.31 cubic yards of sediment per square yard of area or 613,098 total cubic yards per year over the flood tidal delta. The total accretion for both the ebb and flood tidal deltas is calculated to be 1,418,611 cubic yards per year.

This accumulation of sediment in the inlet can be observed in the total area of the shoals exposed at low water in both the ebb and flood tidal deltas (Figure 10). Between 1961 and 1972, exposed shoals were not observed in the ebb delta. While in 1982, ten acres of shoals were exposed. Twenty-four acres of shoals were exposed at low water on the flood delta in 1961. This increased to fifty-five acres in 1972, and to seventy-nine acres in 1982. However, it must be realized that some of this accumulation could be spoil from dredging activity.

SHOALS EXPOSED
AT LOW WATER (acres)

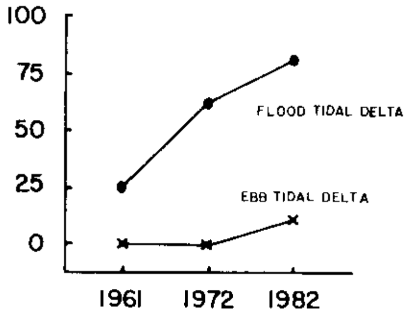

Figure 10. Acres of shoals exposed at low water for 1961, 1972 and 1982.

An examination was made of the updrift and downdrift ocean beaches at Bodie Island and Pea Island respectively in order to determine if any significant differences exist in the beach/dune complexes (Figure 11). Data for the analyses were derived from two engineering surveys dating from 1937 and 1976. A four mile reach of beach was examined on either side of the inlet. Within each section, twenty profiles were used. The profiles are located approximately one thousand feet apart and originate behind a foredune ridge baseline and extend to mean high water. Both the updrift and downdrift beaches were found to be receding with a rising sea level. The maximum amount of recession was found to be twenty-five feet per year, and occurred on the updrift section near Coquina Beach. The maximum rate of recession on the downdrift beach was twenty feet per year and occurred in the proximity of the National Wildlife Service Headquarters building on Pea Island. Additionally, an increase in dune height in excess of ten feet has been observed since 1937. This is the result of the construction and maintenance of a barrier dune line by the National Park Service.

Volumetric changes were calculated for the updrift and downdrift beaches (Figure 12). It was found that the updrift beaches were eroding at a rate of 114,000 cubic yards annually, while the downdrift beaches were accreting at a rate of 124,000 cubic yards annually. These figures represent a net loss of 5.39 cubic yards of sediment per linear foot of beach per year for the updrift beaches and a net gain of 5.87 cubic yards per linear foot per year for the downdrift beaches. These changes in the storage characteristics of the beach/dune complex represents a variety of coastal processes which relate to changes in beaches, capes and inlets.

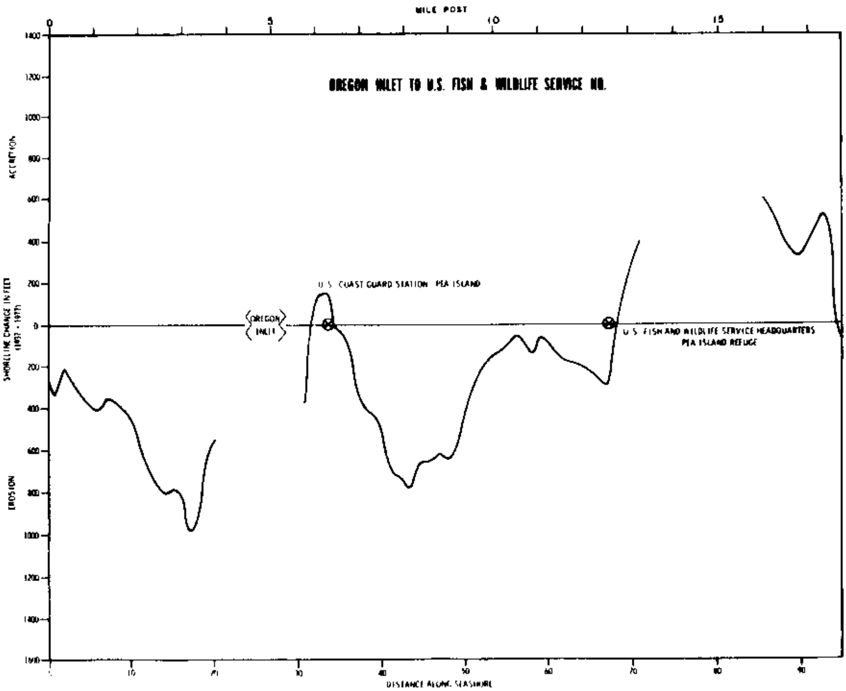

Figure 11. Shoreline change in the vicinity of Oregon Inlet. Source: Sharica, 1978.

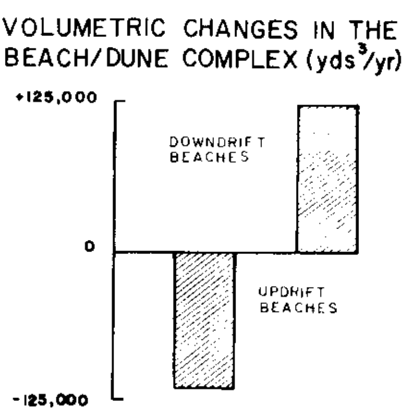

Figure 12. Volumetric changes in the beach/dune complex, in cubic yards per year.

Using data between 1972 and 1978 from the Corps pier at Duck, North Carolina (Figure 13), the average monthly and annual predicted rates of longshore transport can be determined based on the method recommended in the Shore Protection Manual (CERC, 1973). Along the northern portion of the Outer Banks the net longshore transport is to the south at a rate of 1,068,004 cubic yards per year. The sediment that is transported onshore is a significant factor in the present infilling at Oregon Inlet. But a total of 114,000 cubic yards of the longshore transport is derived from the updrift beaches within four miles of the inlet. Of the total 1,418,611 cubic yards that is deposited annually in the ebb and flood tidal deltas, 1,182,004 cubic yards or about 83.3 percent is derived from longshore transport. The remaining 236,607 cubic yards of sediment is derived from either sound or offshore sources. An exact determination cannot be made on the amount of sediment that escapes the inlet's sink annually because the downdrift longshore transport rate is not known. However, it is estimented that 124,000 cubic yards are being deposited annually on the four mile section of the downdrift beach on Pea Island. This amount is essentially equivalent to the amount being removed from the updrift beaches on Bodie Island.

Conclusions

Most barrier island inlets are in a state of dynamic stability and tend to close with time. An inlet's demise can be related to the movement of sediment and all that this implies, including the closing of other inlets that are less favorably located. At Oregon Inlet with its migration shoaling and narrowing, wave action is decreasing as is the tidal prism which tends to lessen the integrated flux of energy. This situation does not allow a significant amount of sand to move. For an inlet to remain open for a long period of time it requires the maximization of the tidal prism as compared to the littoral drift. The larger and more irregular the drift and the smaller the tidal flow the greater the possibility of the inlet shoaling and closing. Also, inlet efficiency is equal to the inverse relationship between the inlet's cross-sectional area and the sound area. In the case of Oregon Inlet the cross-sectional area has decreased since 1962 while we assume the sound area has remained the same. In 1965, while the cross-sectional area was larger than in 1937, the 1977 cross-sectional area was considerably less than in 1937 or 1965. It is suggested here that the 1962 Ash Wednesday storm scoured the inlet, but since that time, decreasing storm magnitude and frequency has allowed the inlet to become smaller.

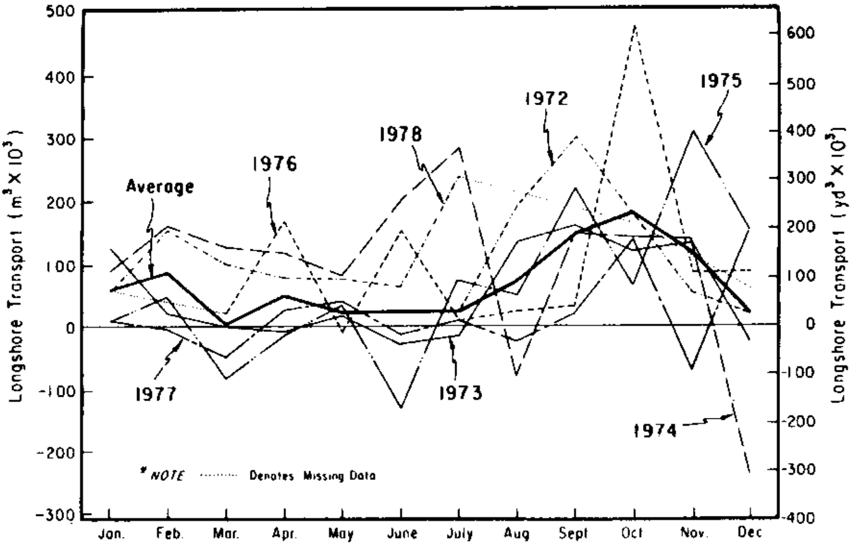

Figure 13. Longshore Transport at Duck, N.C. by month from 1972 to 1978. Source: Birkemeier, 1981.

The inlet's morphology, which consists of the sea and sound shoals and the inlet gorge, seemingly has changed with the cyclic nature of storms. The inlet's morphology also responds to changes in the longshore drift and the tidal prism. When drift is minimized and the prism is maximized there is commonly more than a single dominant channel through the inlet. Oregon Inlet, now has a single channel through the sea shoal which is dredged to maintain its location and a navigatable depth.

Any attempt to simplify the complexity of the inlet processes by jettying or even dredging, is tantamount to altering the tilt of the earth's axis, and expecting nothing to happen. It is strongly suggested here that more research is needed to decide on a long term management policy such as jettying; and that the short term dredging should be continued until jettying or hopefully other management alternatives are more intensively studied.

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