CHAPTER 86

PERFORMANCE OF A JETTY-WEIR INLET IMPROVEMENT PLAN

by

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ABSTRACT

Comprehensive monitoring has been carried out since 1970 to determine the performance and effects of a navigation and inlet stabilization project at Ponce de Leon Inlet, Florida. The improvement plan at the tidal inlet included construction of two jetties, a weir sand by-pass system, and dredging of a navigable channel (Figure 1). An evaluation was made of the general current patterns, the relative refracted wave energy distribution, and the volumetric beach and hydrographic fluctuations associated with the inlet. An analysis of this data was used to interpret the dramatic and unexpected changes which have resulted along the adjacent coastline and within the inlet after the completion of the inlet improvements.

BACKGROUND AND DESCRIPTION OF INLET SYSTEM

Ponce de Leon Inlet is located in Volusia County on the east coast of Florida, about 65 miles south of St. Augustine Harbor and about 57 miles north of Canaveral Harbor. The inlet connects the Atlantic Ocean with the Halifax River and the Indian River North which are used extensively by commercial and recreational vessels (Figure 1). The mean tidal range is 4.1 ft. in the ocean and 2.3 ft. inside the inlet channel, with an estimated mean tidal prism of about 12,000 acre-feet.

Past records (1, 2)* indicate an average annual recession of the mean low water line in the 2-mile reach immediately north of the inlet of

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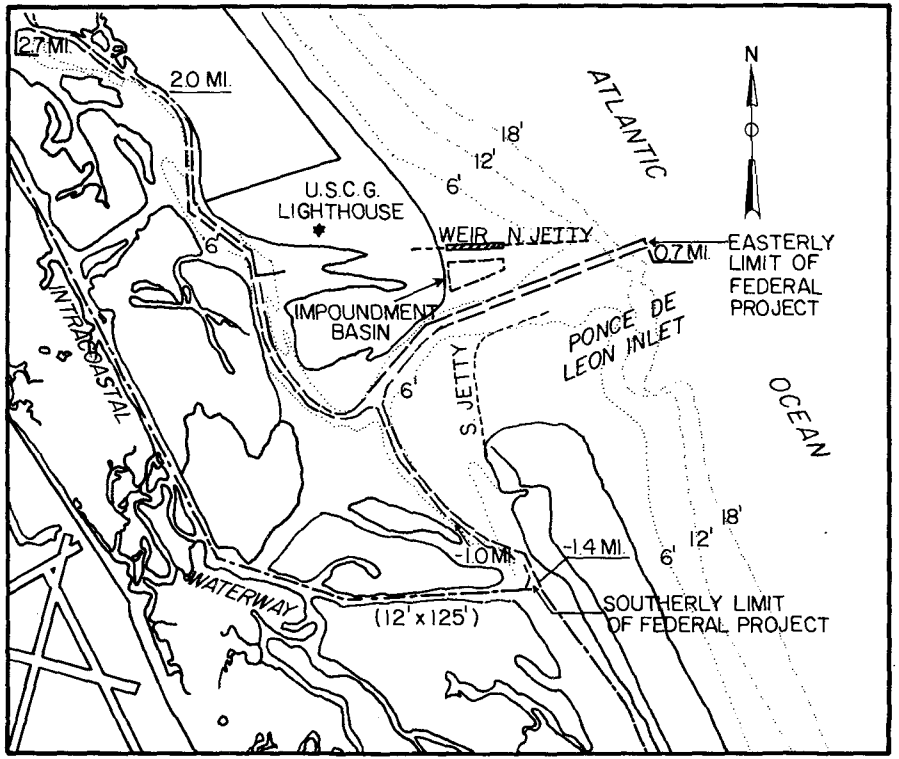
*Numbers in parentheses indicate references at the end of the paper.



GENERAL PLAN OF IMPROVEMENT

FIGURE 1

PROJECT: An entronce channel 15 feet deep ond 200 feet wide ocross the oceon bor and thence 12 by 200 feet and 12 by 100 feet to Indion River North, thence 12 by 100 feet southword to the Inter-coastol Waterway; 7 by 100 feet in Halifax River northward to the IWW; ocean jetties obout 4,200 feet long and obout 2,700 feet long on the north ond south sides of the inlet, respectively; a weir in the north jetty and on impound-ment bosin inside the weir for tronsfer of littoral drift ocross the inlet by use of a pipeline dredge. Length of the project is about 5 miles.

MEAN TIDAL RANGE: 4.0 feet at entronce, 2.3 feet ot the Coast Guard Station inside the inlet ond 4.1 feet in the ocean at Daytona Beach.

PONCE DE LEON INLET
FLORIDA

SCALE IN FEET
1000 0 1000 2000 3000

about 7 ft. per year. For the 4-mile reach immediately below the inlet, shoreline recession is accompanied by accretion of the offshore portion of the profile. The net average annual littoral transport rate in the vicinity of Ponce de Leon Inlet has been estimated to be in the neighborhood of 500,000 cubic yards southerly and 100,000 cubic yards northerly.

Navigation through the original natural inlet had always been difficult and hazardous. A typical fan-shaped sandbar characterized the ocean entrance over which intense wave breaking took place. Inadequate depths across the bar and continuous shifting of the channel crossing that bar caused the principal difficulties and hazards to navigation.

In July 1968, the Jacksonville District, U. S. Army Corps of Engineers undertook the construction of an inlet stabilization system consisting of an entrance channel, a pair of jetties and an impoundment basin south of the north jetty. The north jetty contained a submerged weir section to allow the southward moving sand to pass over it and deposit in the impoundment basin. This basin would then be dredged periodically with the material being placed on the beach south of the inlet. This design was based on (a) the previously mentioned mean annual rate of southerly littoral drift, (b) an expected rapid accretion north of the north jetty, (c) negligible accretion immediately south of the South jetty, and (d) beach erosion further south of the inlet.

PLAN OF IMPROVEMENT

The north jetty called for in the improvement plan (3) is composed of 500 ft. of prestressed concrete sheet piling, 1800 ft. of king pile weir panels, and 1750 ft. of rubble mound section. The first 300 ft. of the weir crest are at an elevation of +4.00 ft. while the crest elevation of the remaining 1500 ft. of the weir is 0.00, which is taken at mean low water level. The crest elevation of the 1750 ft. of the rubble mound offshore section of the jetty is +7.00 ft.

The south jetty has a total length of about 3800 ft. It is entirely rubble mound construction of variable composition (3). The impoundment basin, (Figure 2), has a horizontal area of about 600,000 ft.^{2} and it is to be dredged to a depth of -20.00 ft. Initial dredging of the basin corresponded to about 400,000 cu. yds. of dredged material. The outlined design was based on an amount of littoral drift of 310,000 cu. yds. expected to pass over the weir annually.

A 7200 ft. long entrance channel leads from the ocean to the Halifax and Indian River north, where it divides into two inner channels following these two rivers (Figure 1). The entrance channel has been designed with a width of 200 ft., a depth of 12 and 15 ft., an over-depth of 2 ft. and a side slope (vertical over horizontal) 1 on 5.

Of interest to the present work is that material excavated from the entrance channel and the impoundment basin was to be disposed immediately south of the south jetty in order to assure a strong land connection between the west end of the south jetty and the existing barrier beach.

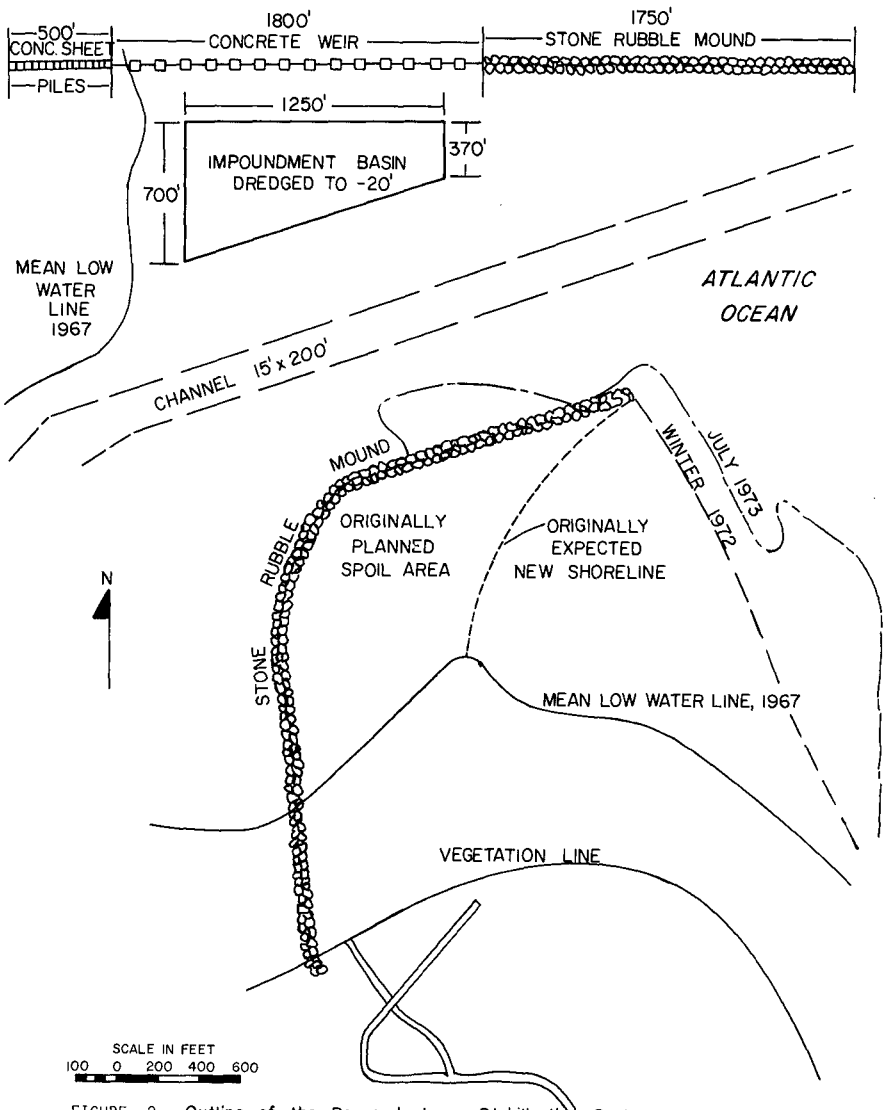


FIGURE 2 Outline of the Ponce de Leon Stabilization System

Figure 2 shows an outline of the July 1973 shoreline and M.L.W. and of the originally expected new shoreline after the dredge disposal.

STUDIES AND INVESTIGATION OF IMPROVEMENT SYSTEM

Extensive historical records of the Ponce de Leon Inlet area (4) have been utilized to produce a quantitative study of sand movement as influenced by the jetty-weir-impoundment basin system. In general, relative volumetric fluctuations for each beach, offshore and basin section influenced by the inlet improvement project were determined. The entire study area was analyzed according to location: Beach South of South Jetty (extending approximately 5000 feet south of the inlet); Offshore South of South Jetty (same); Beach North of North Jetty (extending approximately 4000 feet north of the inlet); Offshore North of North Jetty (same); Outer Basin (area between jetties including the impoundment basin and channel); and Impoundment Basin. Detailed inquiries as to the movement of sand within the study area must be referred to Reference (6).

South of South Jetty

Construction of the south jetty was begun in July 1968 and was completed in October 1969. Rapid accretion in the area immediately south of the south jetty became evident soon after completion. This area was to be used as the primary spoil area for material dredged from the impoundment basin and navigation channels. Immediately preceeding any spoil deposition (August 1971), it is estimated that about 2,000,000 cu. yds. of sand had accreted in this area since construction was completed. This amount surpasses the littoral drift estimates for this area, hence the theory was put forward that the offshore, by-pass bar was migrating westward due to the influence of construction (5). The effect of this migration was to deposit vast amounts of sand in this area.

The beach section of the area immediately south of the south jetty has continued to accrete gaining 1,260,000 cu. yds. between August 1971 and July 1973, including deposition of dredge spoil.

Between August 1971 and July 1973 the offshore volumes have shown a loss of some 80,000 cu. yds. The total volume (beach and offshore) for this same period therefore has increased 1,180,000 cu. yds.

The latest trend between May 1973 and July 1973 shows that the beach has lost almost 300,000 cu. yds. of sand. However, the offshore volume during this same period gained some 240,000 cu. yds.

It therefore appears that the beach-offshore areas south of the south jetty seem to be approaching a quasi-steady state.

Accretion reached the eastern tip of the south jetty in the summer of 1971. Since that time a prominent bulge has formed on the beach and continually grown seaward. This promontory appears to be the remnants of the offshore by-pass bar, and in fact has taken on the orientation of

a northerly growing by-pass bar. Examination of recent records (4) indicated growing trend of a bar encroaching towards the channel to the north. Continued growth would of course have a direct influence on navigation.

It is pointed out that beach areas from the south jetty extending approximately 2400 ft. southerly have generally been accreting since September 1967, however, beach areas, an additional 1600 ft. southerly, from this point, have decreased in volume from August 1971 to September 1972 but have generally accreted from September 1972 to July 1973. Part of this accretion may be due to the seasonal variation. Looking at the offshore volumes it can be seen that from the south jetty to a point approximately 1600 feet south there has been a very slight decrease and from the offshore area of the southernmost reaches of the study area there has been a slight increase in volume. The very small fluctuations in these areas surely support the theory of an approaching quasi-steady state in the southern reaches of the study area.

North of North Jetty

The north jetty was constructed in several stages beginning in September, 1968 and ending with the final placing of the horizontal weir sections in July 1971. Coastline changes north of the north jetty have been most severe.

Prior to and during construction of the north jetty, the general area presently occupied by that rubble mound structure was characterized by extensive shoals. After the completion of the north jetty and weir in July 1971, the area just north of the north jetty experienced dramatic accretion of sand as was expected. The sections of beach farther north, for the most part have experienced continuing erosion ever since the final placing of the weir sections. The beach section 4000 to 2000 ft. north of the jetty-weir lost almost 390,000 cu. yds. of sand between August 1971 (just after construction), and July 1973. During this same time period the offshore section of the same area gained over 265,000 cu. yds. This creates a total deficit of some 125,000 cu. yds., some of which deposited in the fillet north of the north jetty.

Between February 1973 and July 1973 the beach, extending 4000 ft. north of the jetty, lost some 248,000 cu. yds. and the offshore volumes gaines 428,000 cu. yds. creating a total gain of approximately 180,000 cu. yds.

It is evident from these volumetric fluctuations that the beach areas north of the north jetty, continue to lose material, while, the latest trend seems to be a stabilization pattern, perhaps attributable to seasonal fluctuations. Although the loss of material from the beach area is quite significant, it is even more dramatic because of the loss of dunes and beachline recession of up to 200 ft. On the other hand, there has been a continual gain of material in the offshore areas during the same time periods. The net effect when comparing the beach and offshore volumes has been a gain of sand in the area north of the north jetty. Moreover, the trend is a continual buildup of material on the

offshore areas. Hence the sand is apparently not being lost to the system but is moving offshore.

It is felt that the jetties per se were not the cause of the upland (beach area) erosion to the north, but rather a combination of factors. Historically the area north of the inlet has suffered from accumulation-erosion cycles (1, 3). More recently the general area has suffered from some rather severe storms and erosion to the dunes has been apparent for long stretches of the coastline north of the inlet. It is also felt that the construction sequence also contributed in part to the upland erosion north of the north jetty.

The north jetty seems to be "anchoring" the offshore material as evidenced by the volumetric comparisons. This action will undoubtedly in time progressively improve the beach areas. There is, however, evidence that a by-passing bar around the inlet is once more being established. Unfortunately quantitative measurements of this bar were beyond the limits of this study.

Outer Basin

The area defined in this study as the outer basin was characterized by extensive shoals before construction was begun. During construction, this area continued to accrete, gaining approximately 19,000 cu. yds. of sand between September 1967 and August 1971, which was deposited on the shoal just inside and adjacent to the north jetty. During construction, (July 1968 - July 1971), not only did the outer basin accrete, but an extensive shoal developed in the south interior portion of the inlet, indicating much greater deposition than appears in the outer basin volumetric estimates. The spit on the well-developed north interior shoal continued to grow inward.

The land mass immediately south of the inlet has a seaward offset with respect to the north side. This seemingly does not support the theory of a predominant southerly drift of littoral material. Historical information however, shows that accumulated material to the north periodically "detached" and moved to the south beach (1, 3).

Upon completion of the rubble mound jetties, a fairly well defined channel was formed due to constriction of the inlet's outer cross-section and resulting increased velocities. Evident throughout the construction sequence was the typical offshore by-pass bar around the mouth of the inlet. This appears to have been partly dissipated due perhaps to the improved flushing characteristics of the inlet.

The volume of sand in the outer basin has fluctuated somewhat since construction of the jetties was completed. These fluctuations are attributable to dredging operations and to several storms which hit the area.

In August 1972, the impoundment basin was dredged, removing slightly more than 400,000 cu. yds. During this time natural flushing had removed

what remained of the outer shoal just inside the north jetty.

Intense erosion of the beach section just south of the north jetty on the north shoal became evident just after completion of the north jetty. This phenomenon continues to the present, resulting in the growth of a spit westerly along the north side of the channel. In Febuary 1973, under the influence of a strong northeast storm, dramatic erosion took place causing the complete deterioration of this beach section and the breaching of an old channel on the north side of the north shoal. Intense shoaling of the interior portions of this channel is taking place, with inner shoals reportedly hampering navigation to marinas located at its extreme interior portion. The closure of this channel now seems to be taking place, however this process should be expedited with the use of dredge spoil or by other means.

In June 1972, it became apparent that sand began blowing over, washing through, or circumventing the south jetty and depositing just inside the basin on the north side of the south jetty. Around December 1972, a shoal began forming at the inner seaward extremity of the south jetty. The shoal continued to grow in size and migrate westward on into the inlet. It is felt that the growth of this shoal has influenced, and is continuing to influence, the channel orientation. This shoal will be continually nourished by sand passing through or around the south jetty.

Between February 1973 and July 1973 the amount of material in the outer basin appears to have remained fairly constant. However, due to local complaints, maintenance dredging in the entrance channel was completed during March-April 1973. Approximately 95,000 cu. yds. was dredged by a hopper dredge and 27,000 cu. yds. by a side caster.

Since completion of the dredging, the channel has been affected by shoaling. As mentioned above, the growth of the shoal on the north side of the south jetty has, and is presently, influencing a northerly migration of the channel. In addition, the growth of an offshore bar around the tip of the north jetty is also influencing the navigation channel. The combined effect of this offshore bar and inner shoal is to force the outer portion of the channel southward and the mid-section of the channel northward toward the impoundment basin, resulting in a clockwise shifting of the outer portions of the channel. In connection with the navigation channel, it should be noted that the throat section of the inlet between the extensive inner north and south shoals appear to be reaching an apparent equilibrium. It must be noted that this equilibrium cross-sectional area has shown a tendency to move southward, due to the influence of the growing spit on the inner north shoal.

It is felt that the immediate future tendencies for the outer basin are: (a) the continued deflection of the navigation channel as explained above; (b) continued growth and westward migration of the outer south shoal; (c) eventual filling of the breached north channel with slight replenishment of that beach section; and (d) continued equilibrium trends in the throat section.

Impoundment Basin

The impoundment basin is situated immediately inside and parallel to the weir section in the north jetty (Figures 1, 2). The basin itself is approximately 700 ft. x 1250 ft. x 370 ft., and dredged to a depth of -20 ft. below M.L.W. The original dredging of this basin called for the removal of slightly more than 400,000 cu. yds. of material. As mentioned previously, it was anticipated that the littoral drift passing over the weir annually would amount to about 310,000 cu. yds., or 620,000 cu. yds. every two years. These figures were founded on gross annual drift rates estimated to be about 600,000 cu. yds., southerly and 100,000 cu. yds. northerly, resulting in a net southerly drift of 500,000 cu. yds. The validity of these estimates has since been questioned. Walton (6) has recently estimated the drift to be about 386,000 cu. yds. southerly and 309,000 cu. yds. northerly leading to a net southerly drift of 77,000 cu. yds.

Dredging of the impoundment basin was completed in August 1972. Though slightly more than 400,000 cu. yds. was removed in constructing the basin, the capacity of the basin was estimated at 620,000 cu. yds. allowing the overflow into adjacent areas. As previously noted, estimates called for dredging of the impoundment basin every two years.

As of February 1973 there had been a deposition of approximately 200,000 cu. yds. of drift material in the impoundment basin since July 1972. Further examination shows the deposition of an additional 100,000 cu. yds. as of July 1973. This has taken place over a one year span, and seemingly corroborates the rate of deposition in the basin as estimated in the design.

The above estimates of deposition do not validate the littoral drift estimates, however. The southerly growth of an offshore bar around the tip of the north jetty (4), indicates the deposition of littoral material at this point. The growth of this bar as mentioned previously influencing the outer section of the navigation channel, and may have an effect on the operation of the weir-impoundment basin system. Further monitoring of this bar growth is desirable.

R. R. Clark (7) estimates the flow of sand moving across the throat section of the inlet over one flood cycle to be around 21,000 cu. yds., while the growth of the shoal on the north side of the south jetty indicates the input of northerly drift into the inner basin. In addition, intense erosion has taken place just south of the north jetty resulting in a breakthrough of the old channel. Regardless of the source, it is evident that vast amounts of sand are within the inner basin itself. Vast amounts of sand which could have helped fill the impoundment basin, while the southerly drift contributes to the growth of the aforementioned bar sand around the north jetty tip.

Dye tests carried out on June 29, 1973 indicate strong tidal flows over the weir on both ebb and flood flow. Scuba observations in the impoundment basin area, noted relatively strong bottom currents and sand motion attributable to the interaction of tidal currents and wave activity.

An examination of contour maps (4) shows a flattening of the basin adjacent to the weir, probably a result of the current activity.

It must be concluded that the sand deposition in the impoundment basin can not be totally attributed to the flow over the weir. It is evident, from above, that other sources of sand within the system are most likely contributing to the impoundment basin. Rate of filling of various areas of the impoundment basin may offer some clues as to source. Future sand tracing experiments may also be a help as well as comprehensive sand sampling and analysis. Growth of the offshore bar around the north jetty must also be observed and evaluated.

CURRENT PATTERNS

In order to help evaluate the mechanisms associated with the physical shoreline and hydrographic changes being experienced in the vicinity of Ponce de Leon Inlet, an understanding of the flow patterns through the inlet was attempted. A dye tracer test was conducted to determine flow patterns in the inlet during the peak discharges of ebb and flood flow.

Water-tight dye packets were floated at predetermined locations within and immediately outside of the inlet. At the estimated peak discharge of ebb and flood flow, respectively, the dye packets were opened, and distinct, continuous streamlines of green dye resulted. Aerial observation of the streamlines depicted the relative magnitude, strength, and direction of the current flows at various locations within the inlet. Figures 3 and 4 indicate the predominant flow direction and relative magnitude observed during each cycle.

The relative length of the tracer streamlines in these figures indicate the location of higher current. In the throat section, the dye pattern reveals a stronger flood current against the north edge of the channel. The friction loss over the shallower south bank explains the lower current on the south half of the channel. Seawater overtopping the north jetty weir section at flood tends to hug the north boundary of the channel and enter the Halifax River, whereas flow entering between the heads of the north and south jetty seem to be diverted into both Rockhouse Creek and the Indian River North. During ebb flow, through the throat section, the dye streak on the south bank is longer than that on the north side, indicating stronger velocities. The ebbing current was measured across the channel on a different occasion and the results showed a slightly stronger current on the south half of the channel. This is probably due to the strong ebb flow from the Halifax River which cannot make the abrupt bend into the inlet, and thus is thrust against the south bank. Also, the flow is concentrated into a smaller cross-section during ebb and is not allowed to flow across the extensive shoals to the south.

Figure 3 denotes a strong current overtopping the weir section during flood flow. There is also a very strong southerly flow evident along and parallel to the beach just north of the weir. It should be noted that this strong current is independent of any visible wave induced current

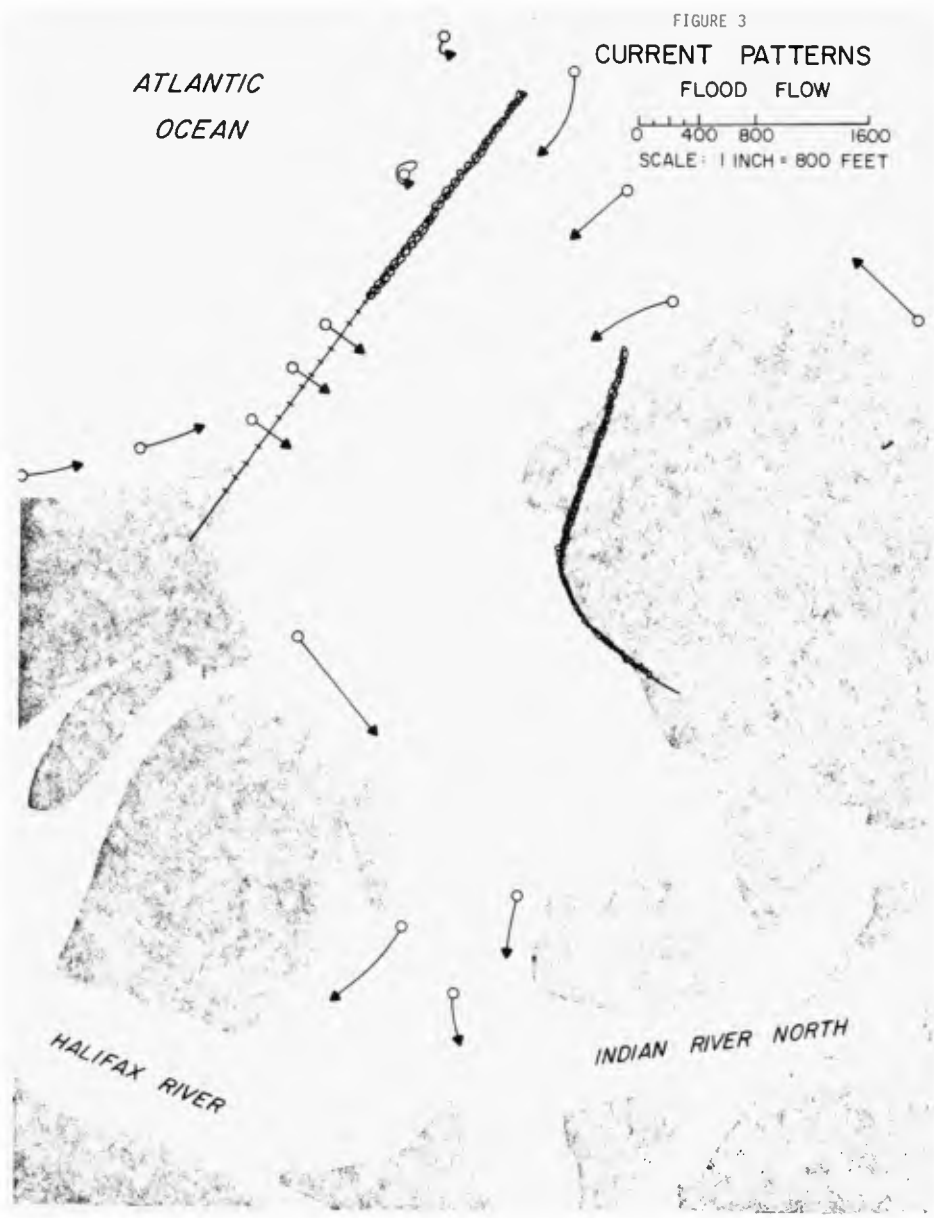


FIGURE 3
CURRENT PATTERNS
FLOOD FLOW
0 400 800 1600
SCALE: 1 INCH = 800 FEET
ATLANTIC
OCEAN
HALIFAX RIVER
INDIAN RIVER NORTH

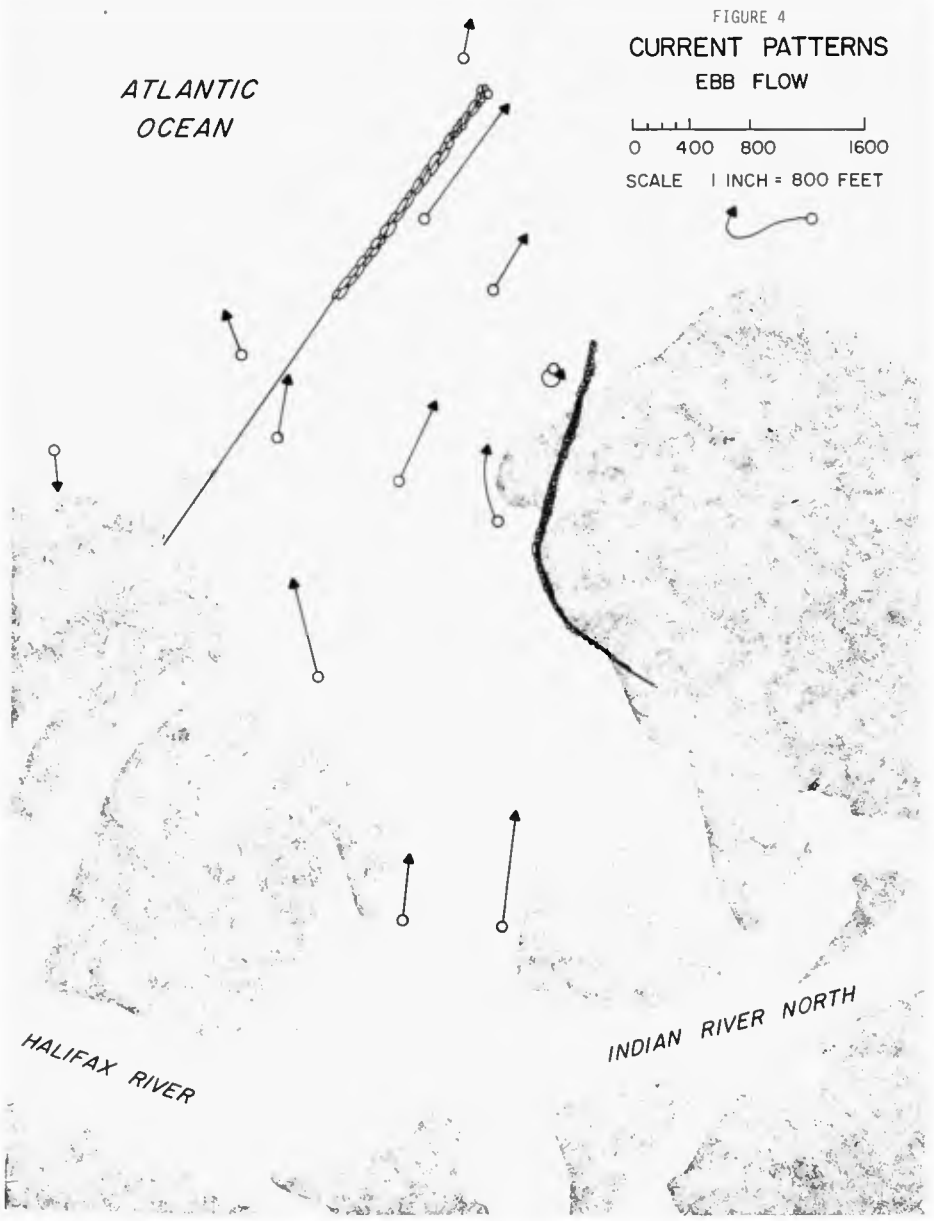


FIGURE 4
CURRENT PATTERNS
EBB FLOW
0 400 800 1600
SCALE 1 INCH = 800 FEET
ATLANTIC OCEAN
HALIFAX RIVER
INDIAN RIVER NORTH

since the dye tests were made on a day with very minimal wave activity while later, at slack water, there was a negligible longshore current. On ebb flow, at a time when the tide level is approaching the level of the weir section, a strong flow is observed both across the weir and along the north jetty. Divers have observed that the current across the weir section to the northeast is quite strong during the ebb cycle. The weir section effects the inlet hydraulics by increasing the flow area during the flood cycle, while somewhat constricting the flow to within the two jetties during the extreme ebb flows. Another interesting phenomena may be observed in Figure 4 where the dye released to the north of the weir and just seaward of the breakers progresses shoreward during the ebb cycle.

Current patterns at the seaward end of the channel indicate a stronger current during ebb than at flood due to the above mentioned constriction. Due to the configuration of the jetty system whereby the project channel is constructed closer to the north jetty than to the south jetty, the currents tend to be greater and more concentrated on the north side of the entrance during both the ebb and flood cycles. Dye released along the north side of the north jetty indicate negligible flow outside of the channel.

In Figure 4 a large eddy is observed during ebb current which tends to circulate clockwise moving water and sediment back into the inlet. This is a classical example of an inlet performing as a sediment sink on ebb flow as well as during flood. Sediment is rounding the south jetty and contributing to the large shoal extending from the south jetty. As this shoal progrades further into the channel, a more constricted channel flow results. Hydrographic surveys reveal this shoal to be migrating westward toward the large inner shoal area south of the throat. It is interesting that this shoal has aligned itself directly opposite the north jetty.

The dye study reveals many things not readily apparent to casual observation. Although certain limitations are evident, a general pattern of the surface currents may be reasonably described. In that channel depths are very small in comparison with the channel width and length, the circulation shown by the surface currents is a good indication of the general circulation of the bottom currents. From these current patterns a better understanding of the sediment movement and shoal formation and migration is accomplished.

WAVE REFRACTION ANALYSIS

In order to evaluate the significance of the physical changes taking place at Ponce de Leon Inlet, and to obtain a broad overview of the effects of wave forces on the erosion patterns and littoral drift characteristics, a refraction analysis of deepwater waves approaching the shore in the vicinity of the inlet was conducted. It is not intended to infer that refraction of wave energy is the primary cause for these changes, but rather a contributing process which should be investigated and evaluated.

Computation and construction of the refracted wave rays was achieved through the use of a computer program developed by the Coastal Engineering Research Center (8), a digital computer, and an incremental plotter. Deepwater waves with periods of 4, 7 and 12 seconds were directed toward the inlet from directions both perpendicular and at 45° angles to the shoreline. Wave refraction diagrams (4) were plotted for each of the above conditions, two of which are shown on Figures 5 and 6. These diagrams illustratively portrayed the effect of the irregular bathymetry in the vicinity of Ponce de Leon Inlet on the refraction of wave energy. Locations of concentrated wave energy could be observed for the particular conditions assumed.

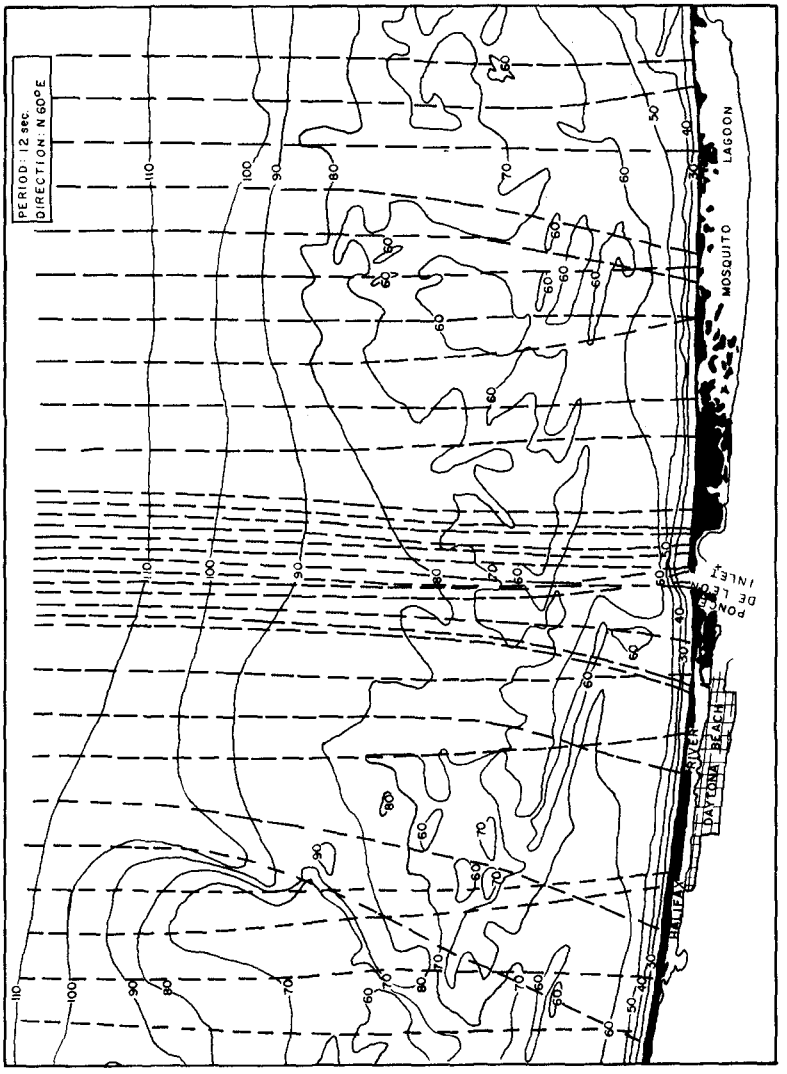
Wave energy distributions were also obtained from the refraction diagrams and plotted on a relative basis (Figure 7 and 8) from which could be determined the areas displaying a general tendency for energy concentration or reduction. It was noted that the larger storm waves caused greater concentrations of energy at certain points along the shoreline than the more normal waves. Also, by observing the resultant angle of wave approach at the shoreline, it was concluded that for an equal distribution of waves originating from different directions, a net southerly drift predominance would result to the north of the inlet and a varying drift predominance to the south.

The wave rays generated in deepwater and converging on the inlet were then superimposed on a smaller grid encompassing the immediate inlet area, and refracted shoreward. Figure 6 shows a typical nearshore wave refraction pattern which was developed. From these diagrams, distinct locations of energy concentration and tendencies toward physical shoreline changes were determined. It appears that the existence and growth of the large promontory located just to the south of the south jetty is a result of a localized reversal of drift to the north associated with the refraction wave energy. Also, waves entering the entrance of the inlet tend to be refracted toward the north jetty and shoreline to which it is attached, thence enhancing the significant erosion which is being experienced in this area. Lastly, it was noted that, with respect to the region just north of the inlet, regardless of the wave characteristics, the rays are everywhere bent toward the inlet. It was therefore concluded that along the shoreline to the north side of the inlet there exist a predominant tendency for drift toward the inlet.

CONCLUSIONS

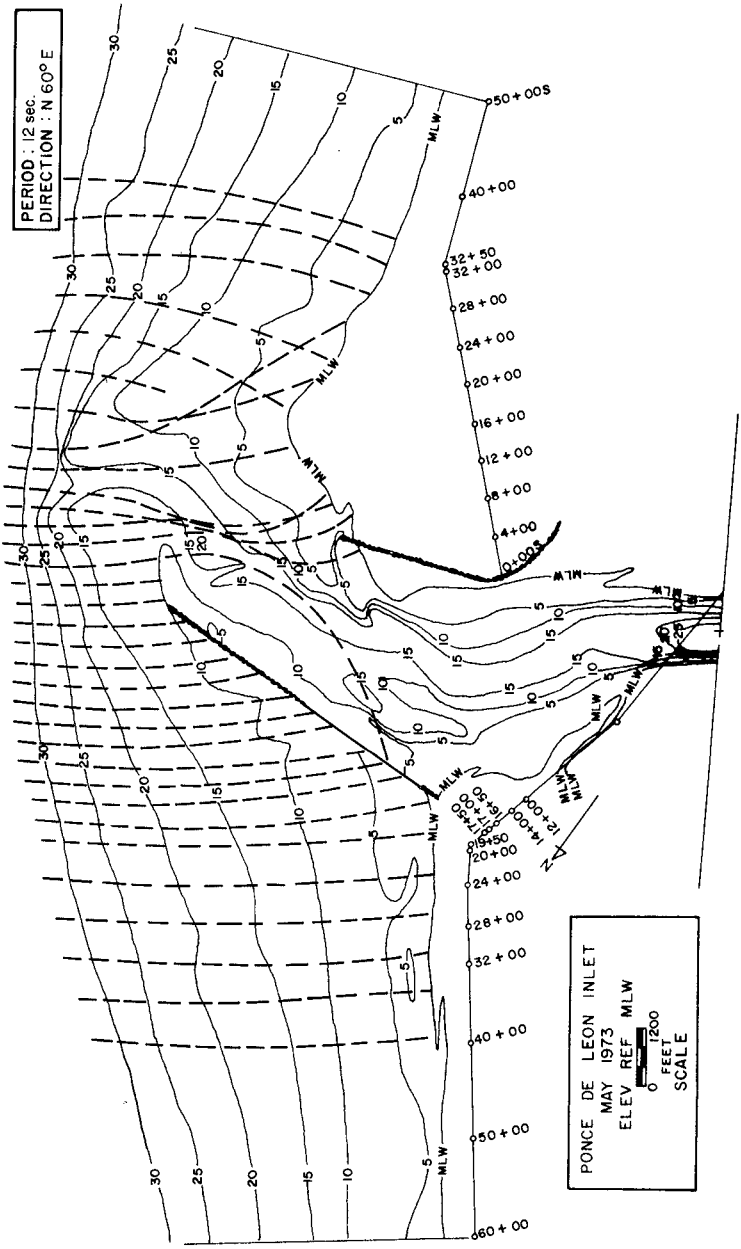
It was the objective of this study to determine the performance and effects of the Ponce de Leon Inlet Improvement Plan. In doing so, an evaluation was made of the general current patterns, the relative refracted wave energy distribution, and the volumetric beach and hydrographic fluctuations associated with the inlet. These analyses resulted in the following conclusions:

1. Since construction of the inlet stabilization system and navigation project at Ponce de Leon Inlet, dramatic changes have resulted along the adjacent coastline and within the inlet.



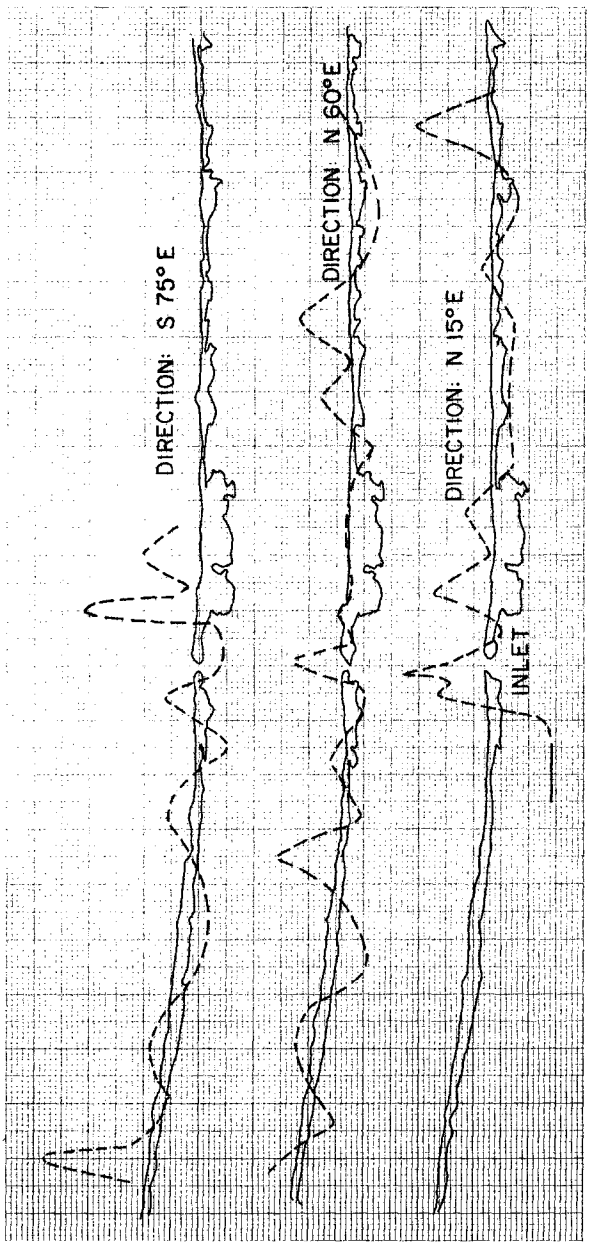
DEEPWATER REFRACTION OF 12 SEC. WAVES FROM N 60° E DIRECTION

FIGURE 5



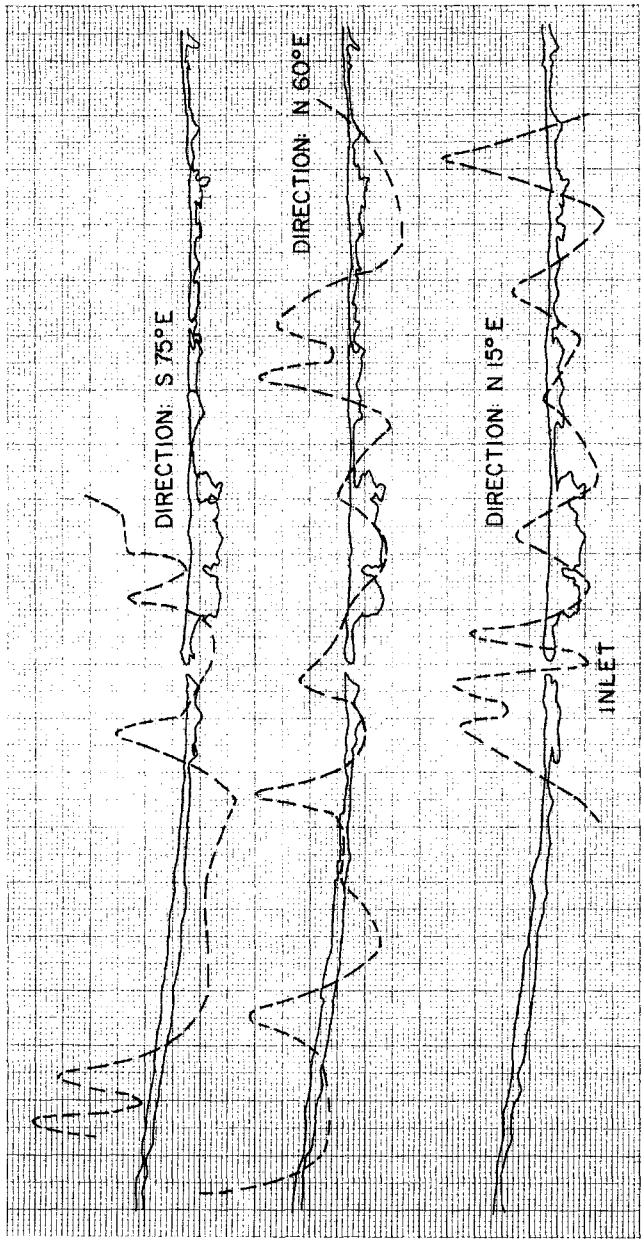
NEARSHORE REFRACTION OF 12 SEC. WAVES FROM 60° E DIRECTION

FIGURE 6



WAVE ENERGY DISTRIBUTIONS ON SHORELINE FOR 7 SEC. WAVES

FIGURE 7



WAVE ENERGY DISTRIBUTIONS ON SHORELINE FOR 12 SEC. WAVES

FIGURE 8

2. Rapid sand accretion has been experienced south of the south jetty. This growth began during construction and has persisted to date. The rate of this rapid growth has led some to conclude that the large net annual littoral drift rate assumed in the design of the stabilization system was in error, and a more balanced drift condition may exist. This theory was seemingly substantiated by the simultaneous erosion being experienced on the beaches north of the inlet. However, results of this study indicate the former estimate is more logical and that other factors related to the construction of the jetties and weir system to be the major cause. It was noted that, since construction, the significant offshore bypass bar across the entrance to the inlet has tended to move shoreward, bringing with it a large volume of sand. Also during this construction period, relatively few northeast storms were experienced affording favorable conditions for net northward littoral drift transport, which was in turn trapped by the south jetty. Recent hydrographic data indicate this area just south of the south jetty is reaching a relative quasi-steady state equilibrium condition, with the only major changes being the continued growth of the offshore bypass bar system, and the passage of sand around and over the south jetty forming a significant shoal in the heart of the inlet.

3. Associated with this rapid accretion to the south of the inlet was a significant dune erosion to the north of the inlet. This is believed to be due in part to the sequence of construction. With the south and north rubble mound jetties being constructed first, a free, unobstructed flow of longshore drift was diverted through the opening where the weir was to be. This change was noted by the progression of the beach profile toward shore immediately north of the inlet during this construction period. Likewise, the erosion condition was worsened with the elimination of northward moving drift by the south jetty. However, since construction of the weir section, the offshore profile north of the inlet began to grow seaward again, indicating an entrapment of material. Volumetric comparisons show that beach plus offshore areas have shown a net, albeit, small gain in material since inlet improvement. Nonetheless, erosion still persists along the shoreline well north of the inlet. This erosion is felt to be due more to the storms experienced during the recent past rather than to the effects of the inlet improvements. The stretch of beach north to Daytona has a history of erosion prior to any inlet improvements.

4. The erosion of the shore immediately inside the north jetty can be expected to continue until an equilibrium condition is reached. Unfortunately, the limits of this eventual erosion cannot easily be determined, but it is not believed that the entire north shoal will dissipate.

5. Monitoring of the weir-impoundment basin, indicates that approximately 75 percent of the material dredged from the basin in August 1972 has been replaced. It was determined that the impoundment basin presently contains approximately 50 percent of its maximum expected volume. This would indicate that the estimated net southerly drift rate, designed basin dimensions, and scheduled maintenance intervals set forth in the design memorandum are of the proper magnitude. However, it is also noted that significant longshore drift material appears to be moving sufficiently offshore so as to miss the weir section and to enhance the development of

an entrance bar growing around the tip of the north jetty.

6. Appreciable littoral transport, by-passing the weir section and impoundment basin and contributing to the growth of a spit on the south side of the inner north shoal is gradually pushing the inner channel cross-section to the south. This is a slow process and is showing some signs of abatement. However, the portion of the channel between the impoundment basin and south jetty is still in a condition of flux. Tendencies have been for the channel to move northward toward the basin and north jetty in this region, due to the naturally deep water of the basin and the expanding shoal adjacent to the south jetty. It should be noted that once the deposition basin is dredged again, the northward tendency for movement will be enhanced, with a possible adverse affect to the north jetty. As the channel approaches the ocean entrance, the shoal bar circumventing the north jetty is pushing the channel to the southeast. Again, this condition may be expected to continue as the by-passing bar grows. In summary, the channel is seemingly following a closkwise alignment, succumbing to the pressure of littoral transport and deposition.

ACKNOWLEDGEMENT

This study was supported by the Coastal Engineering Research Center through the Department of the Army, Jacksonville District, U. S. Army Corps of Engineers.

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