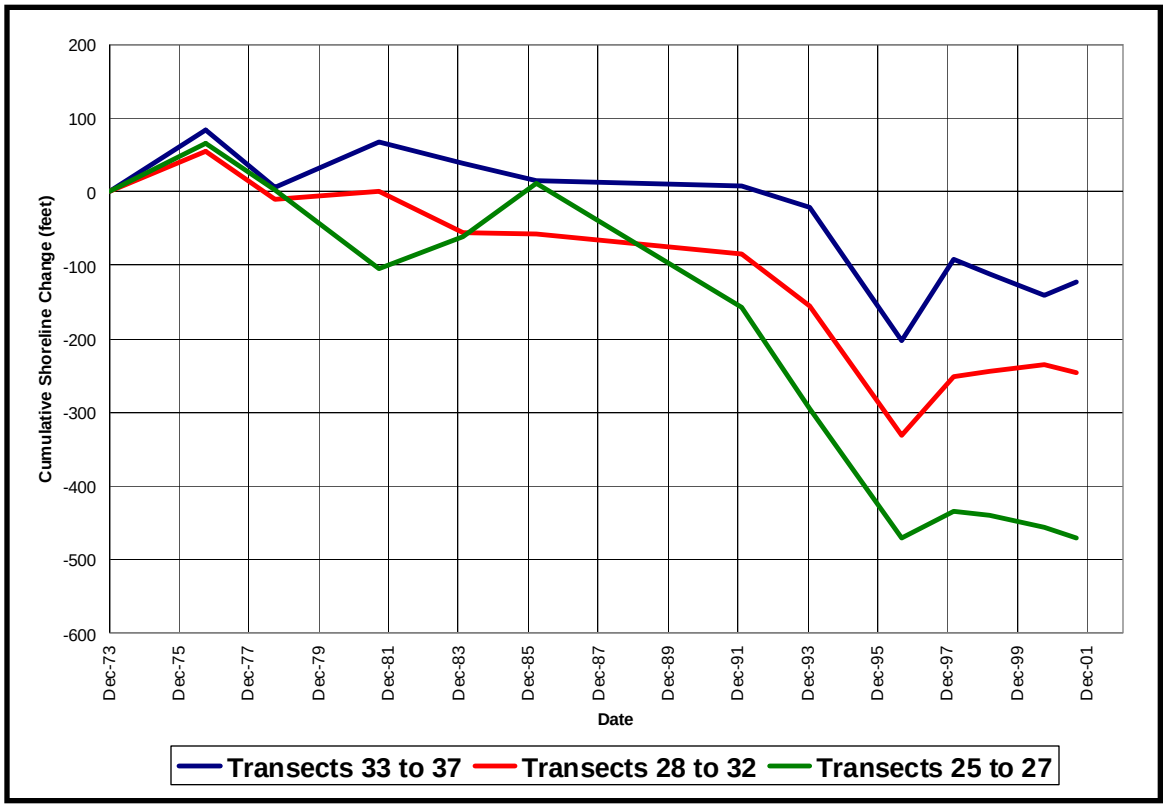

Figure 3.20 Average Cumulative Shoreline Change – 1973 to 2001
For: Transects 25 to 27; 28 to 33; and 33 to 37
Hammocks Beach State Park

end of the island with the erosion zone migrating in a westerly direction. For the period from 1978 to 2001, again a time when the channel moved from its central location toward Bogue Banks, the average amount of erosion for transects 25 to 27 was 472 feet. The other two sections of Hammocks Beach represented by transects 28 to 32 and 33 to 37 lost an average of 235 feet and 173 feet respectively.

3.13. Impact of Ebb Tide Delta on Ocean Shoreline Changes. The surface area and shape of the ebb tidal delta have changed considerably since 1973 with the surface area of the delta ranging from a maximum of approximately 29 million square feet in 1973 to a minimum of 18 million square feet in 1991. This wide range of values may reflect errors involved in the methodology used to define the surface area of the delta, however the data do provide a means of assessing the relationship between ebb delta shape changes and the various shoreline changes. The apparent surface area changes can be correlated with the three basic phases of the evolution of the inlet morphology that were identified from the inspection of the historic aerial photographs. The initial phase (1973 to 1981) was one of general instability characterized by a period of channel reorientation related to shoal breaching, an initial period of westward channel migration and the

formation of a single ebb channel. The surface area of the ebb shoals during this phase was initially high and steadily declined until the early 1980s.

3.14. The second phase inlet evolution in the 1980s was characterized by an eastward migration of the ebb channel, development of a wide marginal flood channel on the western margin of the inlet (Bear Island) and growth of the mid inlet shoal. The surface area of the ebb delta during this interim stage of morphologic development was generally low. Since the late 1980s until 2001, the apparent surface area of the ebb delta has generally increased as the ebb channel continued to migrate toward Bogue Banks. The morphology of the platform and the mid inlet shoal have changed little during this interval.

3.15. The eastward trek of the ebb channel over the past two decades coupled with the alignment of the channel along the Bogue Banks margin have resulted in the development of a highly skewed ebb delta whose seaward most protrusion has shifted approximately 2,500 feet in an eastward direction since 1978. Figure 3.21 illustrates that since the mid 1980s, the percentage of the surface area of the ebb tide delta located east of the ebb channel (% Ebb Tidal Delta in Shoal Segment B) has fluctuated between 19-30% of the total area of the entire offshore shoal.

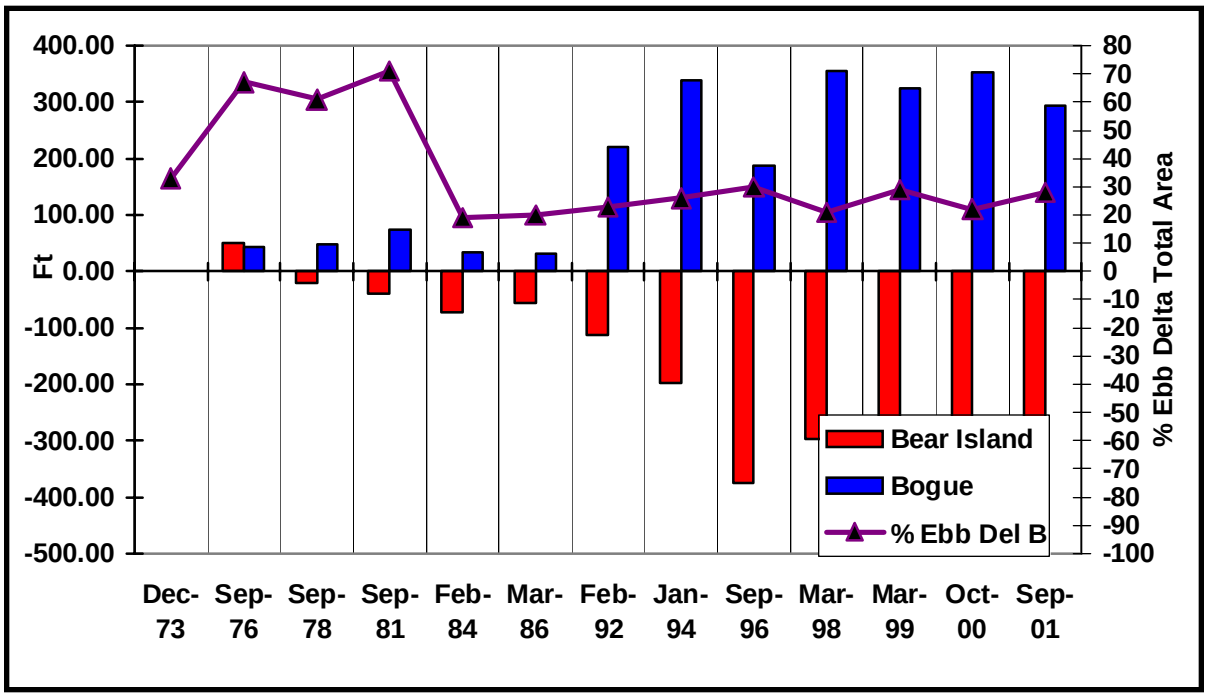

Figure 3.21 Bogue Banks and Bear Island (Hammocks Beach)
Cumulative Oceanfront Shoreline Change
vs % Ebb Tidal Delta in Shoal Segment B

3.16. A slight shift in the orientation of the axis of the outer bar channel (ebb channel) generally causes a minor shift in the position of the apex of the ebb tidal delta. The slight shift in an east or west direction controls the erosion or accretion along the extreme

western oceanfront reach of Bogue Banks. The short-term shoreline change pattern is a function of the development of a secondary marginal flood channel on eastern margin of the main ebb channel. An eastward shift in the axis of the ebb channel resulted in the encroachment of the marginal flood channel on the Bogue Banks margin and the eventual erosion of the oceanfront. The continued eastward migration of the ebb channel and the associated development of the asymmetrically shaped ebb tidal delta since the mid 1980s had a long-term positive influence on the net progradation along west end of Bogue Banks. In contrast to the chronic erosion along the inlet shoreline, the Bogue Banks oceanfront continued to build seaward as the ebb channel migrated to the east. The consequences of the easterly channel movement for the Bogue Banks oceanfront were twofold: first and foremost, large swash bar complexes that formed on the eastern shoal segment migrated landward, attached to, and nourished the immediate shoreline; secondly the highly asymmetric ebb-tidal delta afforded protection for the western end of the island from wave attack and simultaneously aided in the buildup of the western end of Bogue Banks. Wave refraction around the ebb delta, coupled with the presence of the linear margin bar/swash bar complex that developed off the western end of the island, produced a wedge shaped zone of accretion on the west end of Bogue Banks.

3.17. The eastward migration of the ebb channel and the attendant morphologic changes in the inlet system has not only controlled the shoreline change patterns along Bogue Banks, but concurrently they have played a significant role in the Bear Island oceanfront erosion. The consequences of the complex morphological changes related to the easterly channel movement for the Bear Island oceanfront are the reverse of those for the Bogue Banks oceanfront. The data show there has been a net shoreline loss along the majority of Bear Island. The greatest losses have occurred since the late 1980s when the ebb delta and the inlet throat began to assume their current morphologic identities. The apex (seaward protuberance) of the ebb delta in 2001 was approximately 5,550 feet east of its 1976/78 position. The eastward shift of the bulge is a by-product of the eastward migration of the ebb channel. The significant net morphologic changes that resulted from the channel's eastward migration were the widening of the inlet throat accompanied by the buildup of the mid inlet shoal as the western portion of the terminal lobe (zone of breaking waves) migrated landward. The complex interaction of the above variables combined to produce a reconfigured barrier that was increasingly exposed to increased wave activity and hence continued shoreline recession.

3.18. Dudley Island Shoreline Changes. The marsh and sandy shoreline segments that comprise the seaward portion of the Dudley Island (Figure 3.22) have also been significantly impacted by configuration changes in the channel/shoal system of Bogue Inlet. Segments of Dudley Island have experienced significant and rapid erosion primarily due to the eastward migration of the ebb channel; the attendant spit growth along the Bogue Banks shoulder, and the consequent migration of the Eastern Channel toward Dudley Island. Elongation of the Bogue Banks spit and the extension of its sub aqueous platform had caused the thalweg of Eastern Channel to shift toward Dudley Island, resulting in erosion and overtopping of the landward bank.

3.19. Changes in the marsh shoreline of Dudley Island between September 1976 and September 2001 were measured along 11 transects shown on Figure 3.22. Cumulative changes in the Dudley Island shoreline position for transects 2 to 9 are shown on Figures 3.23 to 3.24 (Note: transects 1, 10, and 11 not shown due to incomplete data). The encroachment of Eastern Channel on the eastern portion of the marsh complex has generally resulted in recession of the marsh shoreline between transects 1 and 6 (Figures 3.23 & 3.24). The shoreline located immediately to the northwest of the Bogue Banks

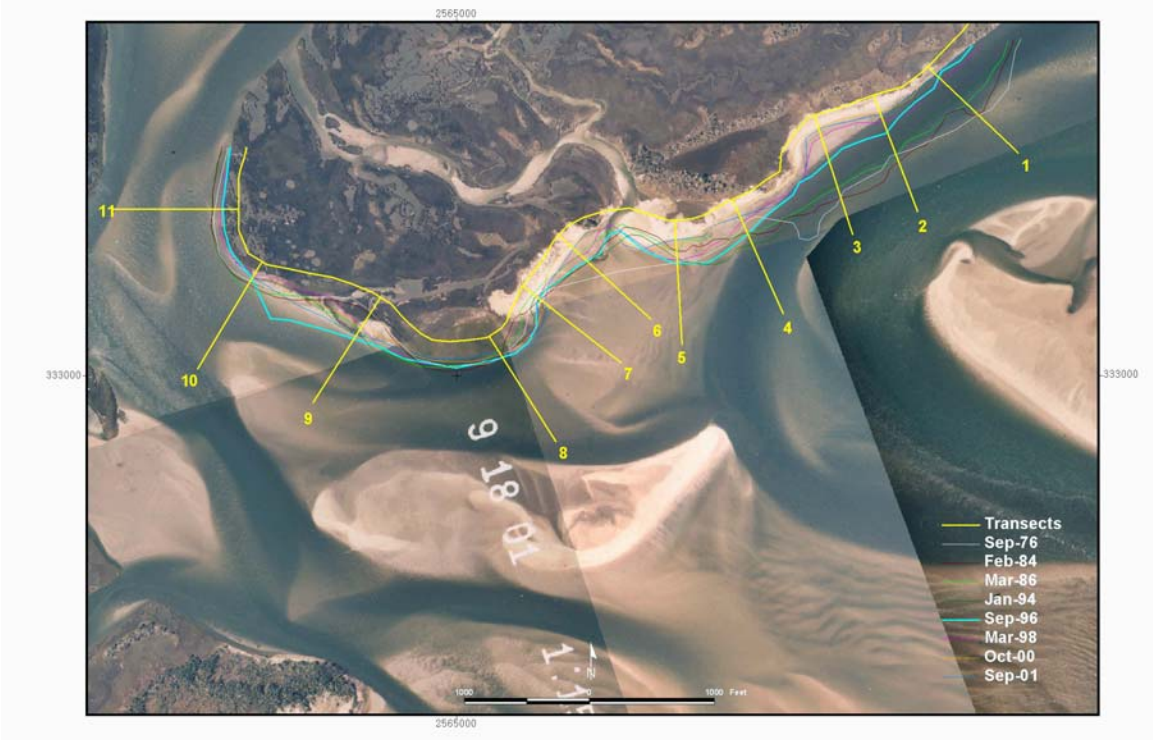

Figure 3.22. Enlarged aerial photograph of a portion of Dudley Island showing marsh shoreline transects and various shoreline positions between September 1976 and September 2001.

spit (transects 2 and 3) has eroded the greatest amount (343 and 567 feet) since 1976 with transects 4 to 6 also experienced significant erosion ranging from 78 feet at transect 4 to 320 feet at transect 6. Erosion of this section of Dudley Island stemmed from the migration of Eastern Channel as the spit platform extended into the channel resulting in deflection of the flow toward the Dudley Island shoreline. The majority of the marsh and sandy shoreline along the western portion of Dudley Island (transects 9 to 11) has also receded due to encroachment of various feeder channel segments. Generally the least amount of erosion and the greatest buildup occurred in the lee of the Island 2 (transects 7 and 8) near the tip of the flood ramp.

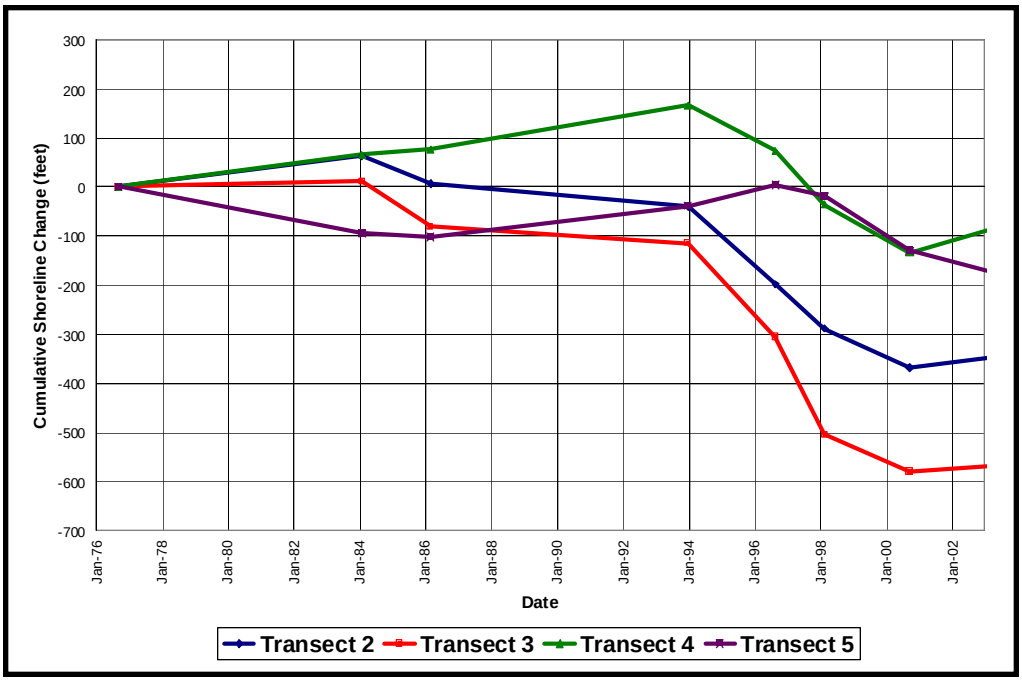

Figure 3.23 Cumulative Changes – Dudley Island – Transects 2 to 5

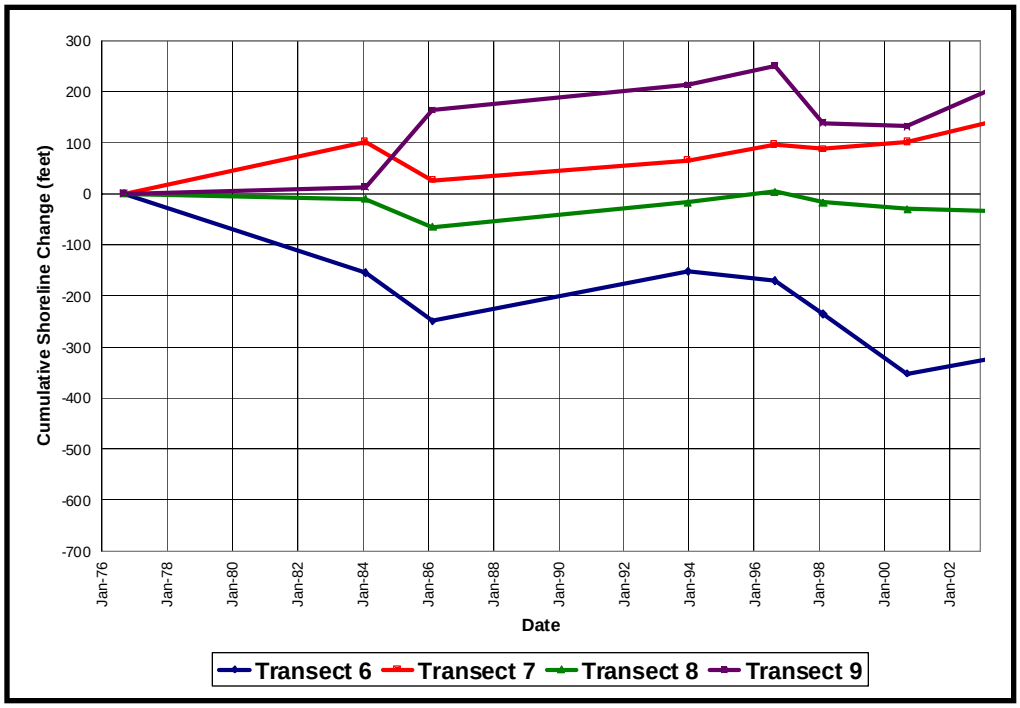

Figure 3.24 Cumulative Changes – Dudley Island – Transects 6 to 9

3.20. Islands 1 and 2. Islands 1 and 2 represent extremely small sand accumulations located within the mid inlet shoal complex. These islands are ephemeral in nature and of low relief (elevations generally less than 2 feet NGVD). Island 1 began to develop in 1995/96 along the western margin of the ebb channel. The feature increased in size and

Figure 3.25 September 2002 Aerial Photograph of Bogue Inlet

extent up until 2001 but appears to have recently diminished in size as evidence by a September 2002 aerial photograph of the inlet shown on Figure 3.25. Theextremely shallow depths across the landward portion of the mid inlet shoal favored the development of Island 2 through a combination of processes associated with breaking waves and the associated swash that partially or completely overtops the low relief island. Extreme wave action during elevated water levels will likely erode a portion or the entire feature. Although no measurements were made, the eastern margin of Island 2 appears to be eroding in response to the westward movement of Eastern Channel that is occurring as a result of the growth of the Bogue Banks spit. Also, a cursory comparison between the September 2001 aerial photograph and the September 2002 photograph showed Island 2 had migrated approximately 1,000 feet to the west.

3.21. Optimum Channel Location. The overall goal of the geomorphic analysis was to develop an understanding of the relationship between the inlet's temporal and spatial morphologic changes and the changes that occurred along the adjacent oceanfront

segments since 1973. A secondary goal was to utilize this understanding to select an optimum channel location and to evaluate the impacts of the relocated channel on the various components of the system. The detailed analysis of the historic changes that have taken place since 1973 clearly show that the movement of the ebb channel and the attendant ebb-tidal delta symmetry changes are the forcing variables that dictate the erosion and accretion trends along the inlet and oceanfront shorelines of both Bogue Banks and Bear Island. The erosion of the eastern inlet shoreline in the vicinity of the Pointe (Bogue Banks) and the concurrent progradation of the adjacent oceanfront shoreline on the west end of Bogue Banks are directly related to the eastward migration of the ebb channel. The data also indicate that the inlet and oceanfront erosion along adjacent Bear Island stem directly from the complex morphologic changes related to the eastward migration of the ebb channel and the associated shoal shape changes. Based on the results of this analysis, the optimal channel location is one situated within a corridor midway between the two islands with the channel oriented essentially perpendicular to the general alignment of the two islands. This optimum channel corridor corresponds to an area bounded by the 1976 and 1978 ebb channels. The proposed channel shown on Figure 1.2 falls within this optimal channel corridor.

3.22. Impacts of Relocated Channel. The information developed from the geomorphic analysis was used to predict changes in the inlet and adjacent shorelines that would be associated with the proposed channel relocation project. In this regard, two channel relocation scenarios were considered, one that relies on natural sediment transport processes to infill the existing ebb channel (Scenario No. 1) and the second in which the existing channel would be closed with dredged material (Scenario No. 2).

3.23. Scenario No. 1 – Sediment Transport Fills the Existing Channel. Relocation of the ebb channel to a mid inlet location will alter the sediment transport patterns dramatically on both shoulders and ultimately result in the significant reconfiguration of the ebb tidal delta. After an initial period of adjustment, the apex of the ebb delta will eventually shift between 2,500 and 3,000 feet in a westward direction. During this initial period of equilibration, which may last several years, a significant volume of the ebb-tidal flow will be redirected from the erosion hot spot along the eastern shoulder of the inlet to the new channel. However, a sufficient volume of flow may still persist in the existing channel to cause additional erosion of the Pointe shoreline.

3.24. The gradual collapse of the ebb shoal segment fronting the Bogue Banks oceanfront will lead eventually to infilling and abandonment of the existing ebb channel along the eastern inlet margin. Concurrent with the reorganization of the eastern ebb delta segment; bar bypassing events will eventually promote spit growth on the eastern shoulder. Elongation of the estuarine portion of the existing Bogue Banks spit may continue and as a result, further erosion of the Dudley Island shoreline will occur as the spit builds into Eastern Channel. The eventual infilling of the seaward segment of the former ebb channel will lead to westward growth of the Bogue Banks oceanfront.

3.25. Shoreline Adjustments on Bogue Banks. Given sufficient time, the oceanfront shoreline along Bogue Banks will erode and recede to a position that is approximated by

the location of the 1978 shoreline depicted on Figure 3.4. Based on the amount of accretion that occurred on Bogue Banks between 1978 and 2001 (see paragraph 3.11), the shoreline recessions that could occur as a result of the channel relocation project along various segments on the west end of Bogue Banks are as follows:

For Transects 1 to 5: Average erosion [(a)] = -10 feet; Maximum erosion = -80 feet
For Transects 6 to 10: Average erosion [(a)] = -150 feet; Maximum erosion = -300 feet
For Transects 11 to 13: Average erosion [(a)] = -350 feet; Maximum erosion = -400 feet
[(a)] Note: Average erosion rates rounded from those presented in paragraph 3.11.

Figure 3.26 provides a plot of the average shoreline recession and the maximum recession that could be expected following the relocation of the Bogue Inlet ebb channel. As shown on this figure, the predicted shoreline recessions would position the adjusted shoreline slightly seaward of the primary dune system. These predicted shoreline changes would be the same for both Scenario 1 and Scenario 2 (discussed below). However, the time period for these adjustments to occur would differ for each scenario, which is also discussed later.