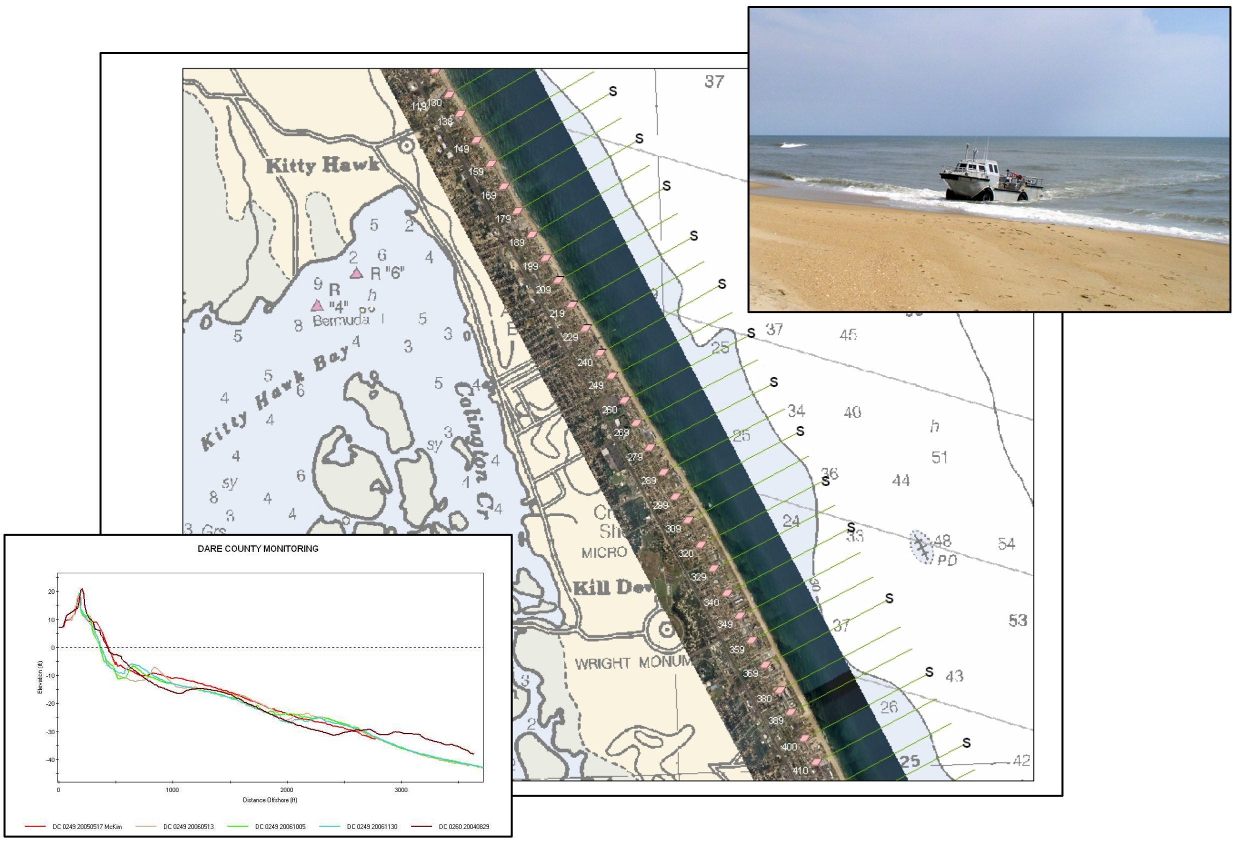
PHYSICAL MONITORING
DARE COUNTY BEACHES (BODIE ISLAND PORTION)
SHORE PROTECTION PROJECT

REPORT NO. 1



PREPARED BY:

U.S. ARMY CORPS OF ENGINEERS
WILMINGTON DISTRICT

August 2008

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Part 1 INTRODUCTION

Purpose. This report is the first in a series to document the physical monitoring results of data collected as a part of the beach nourishment project along the Bodie Island beaches of Dare County, NC (Figure 1). The monitoring is expected to cover the pre-, during- and post-construction phases of the project as discussed in the approved Physical Monitoring Plan, May 2004 (USACE 2004).

The data collected under this monitoring program will be used to assess the beach response to the fill placement and will serve as the basis for operating and maintaining the project through the most effective use of future periodic beach re-nourishments. The monitoring will also address the dispersion of the fill from the project limits to adjacent non-project areas such as along the southern terminus of the project area which adjoins the Cape Hatteras National Seashore and Oregon Inlet.

The physical monitoring plan is also designed to provide data in support of a companion biological monitoring effort. The companion program is being undertaken to assess potential environmental impacts associated with the shore protection project. The final report summarizing the pre-condition ecological conditions is available on the Wilmington District web site at: http://www.saw.usace.army.mil/Dare%20County/main.htm.

This initial report presents the findings to date covering a portion of the pre-construction phase of the project. These findings serve to help establish the base conditions of the project areas against which future project performance and impacts will be measured.

Project Description. The shore protection project on Bodie Island consists of a berm and dune section as shown in Figure 2 (USACE 2000). The 25 foot wide dune has a crest elevation of approximately 12 feet above the North American Vertical Datum (NAVD88), fronted by a 50 foot wide berm at an elevation of around 6 feet NAVD88. During placement the berm will be widened an additional 100 to 200 feet so that an adequate amount of material is placed to establish the offshore portion of the beach profile.

The project limits are given in Figure 1 and consist of a 3.0 mile reach of the Kitty Hawk-Kill Devil Hills Area (hereafter referred to as the North Project Area) and a 9.0 mile reach of the Nags Head Area (hereafter referred to as the South Project Area). An additional 3,000 foot transition is included at each end of both fill areas (except reduced to 2,850 on the south end of the South Project Area). This results in an overall total placement length of 14.2 miles with 4.1 miles along the North Project and 10.1 mile coverage along the South Project.

The transition for the North Project Area starts at Station 108+30 near Sanderlin Street in Kitty Hawk (note: project stationing 0+00 begins near the Kitty Hawk northern town limit). The main fill starts at Station 138+30 at Kitty Hawk Road. The main fill ends at Station 297+30, 500 feet south of 1st Street in Kill Devil Hills. The transition ends at Station 327+30 in Kill Devil Hills (Prospect Avenue).

The transition for the South Project Area starts at Station 491+60 in Nags Head near Blackman Street. The main fill starts at Station 521+60, 200 feet north of Nags Head Pier. The main fill ends at Station 996+50, 800 feet south of Altoona Street in Nags Head. The southern transition, 2,850 feet long, ends at Station 1025+00 at the Nags Head southern town limit at the border with the Cape Hatteras National Seashore property.

Borrow Areas. The sources of the beach fill for the project are two borrow sites located 1-2 miles offshore of the project area as indicated on Figure 1 as N1 and S1.

Borrow site N1 will be used for the initial construction of the North Project Area and S1 will be used for initial construction of the South Project. Initial construction will require approximately 8,040,000 cubic yards (in place volume on the beach) for the South Project Area, and 4,300,000 cubic yards for the North Project Area, for a total volume of 12,340,000 cubic yards.

All future renourishment is planned to utilize borrow site S1 as the source for sand for both the South and the North Project Areas. Periodic renourishment will be accomplished in phases such that some portion of the project will be renourished each year, with total renourishment requiring three years to complete. Each 3 year cycle will require approximately 2,835,000 cubic yards (in place volume on the beach) for the South Project Area, and 1,055,000 cubic yards for the North Project Area for a total of 3,890,000 cubic yards per cycle.

Extrapolating the renourishment requirement over a 50 year project life plus adding the initial construction quantity results in a total estimated volume of 21,180,000 cy for the North Project and 53,400,000 cy for the South Project. This gives a grand total of 74,580,000 cy for the entire project life. Nearly 110,000,000 cy of sand have been identified within the two borrow sites to adequately cover this estimated project demand.

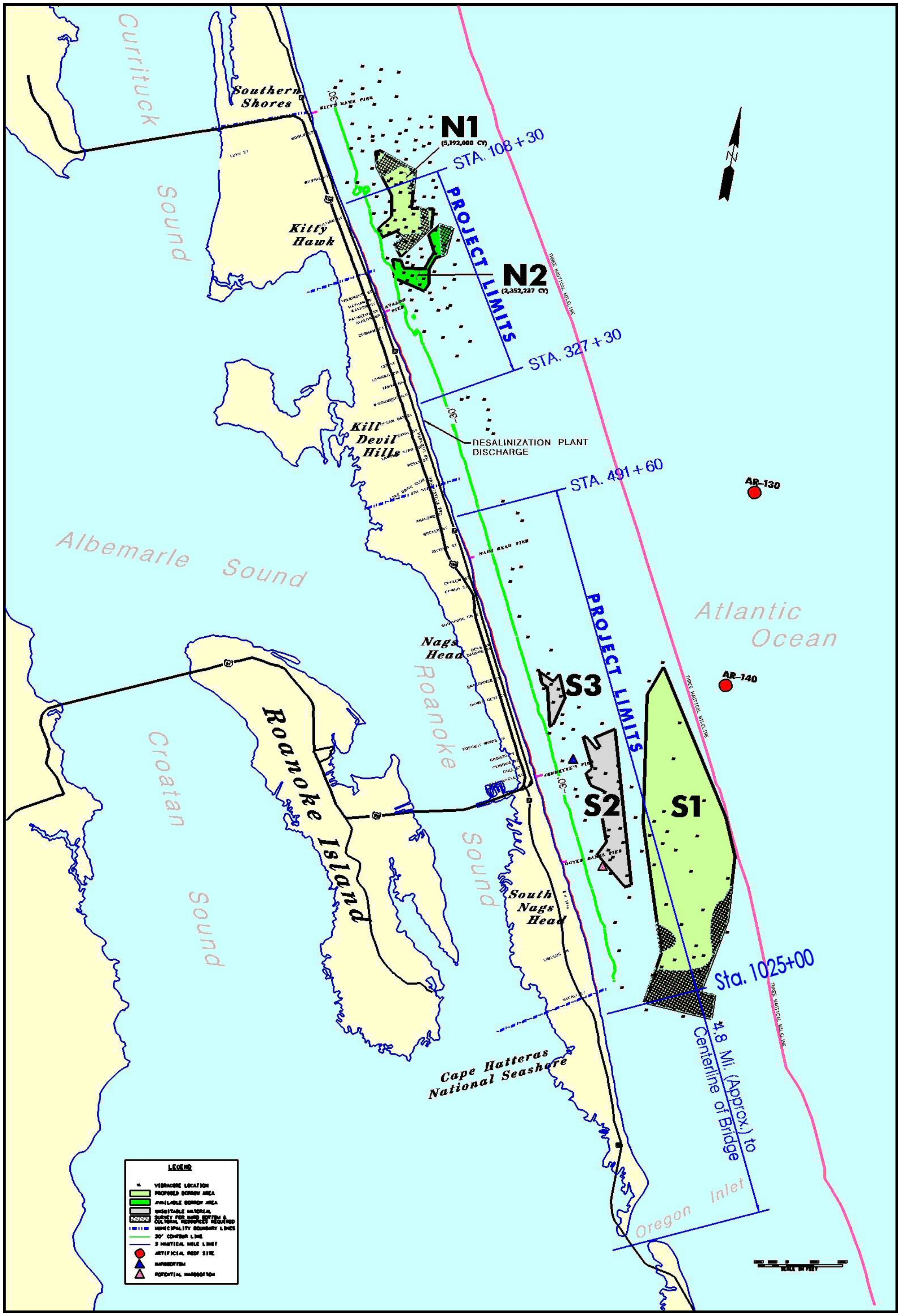

Figure 1. Project Location Map

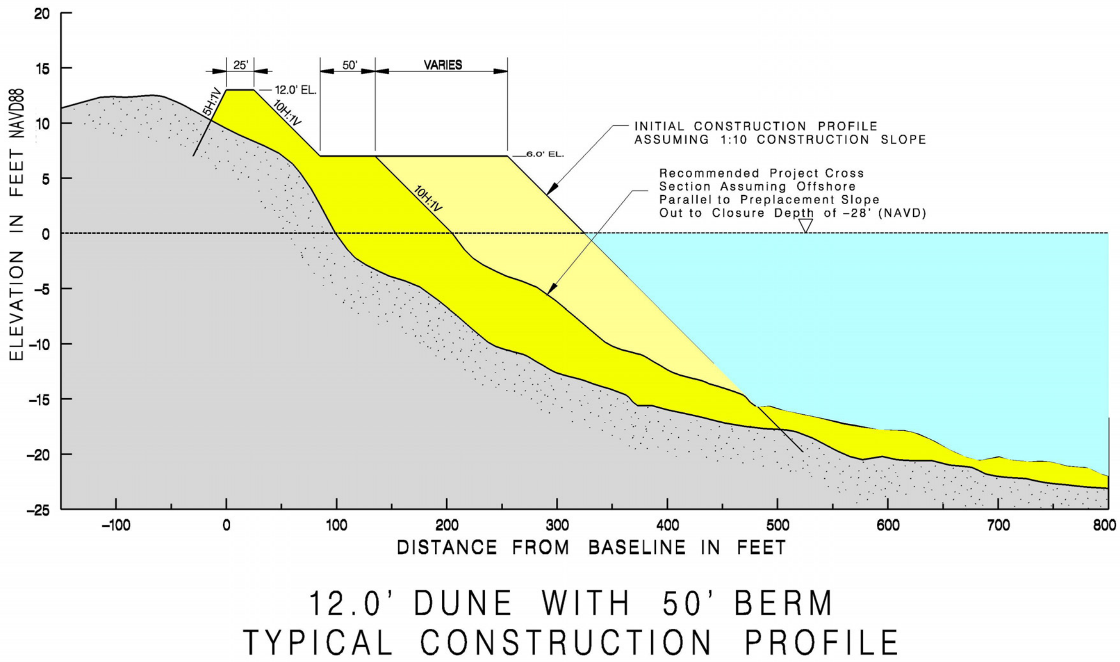

Figure 2. Typical Berm & Dune Profile

Construction Plan. Initial construction is scheduled to take three years to complete. The South Project Area is to be constructed in three equal stages spread across three fiscal years with the middle segment constructed first followed by the southern segment and finally the northern segment. The middle segment of the South Project Area extends from Station 705+00 to Station 845+00, with transitions extending the limits to Station 675+00 and to Station 875+00. The North Project Area is to be constructed simultaneously with the middle segment of the South Project.

The project schedule is dependent on funding and a date for the initial construction is not available at this time. In addition to the Federal project, a local permit project is being pursued for beach nourishment in the Nags Head area. Timing of the local project or possible implications from it on the Federal project are unknown at the time of publication for this report.

The time sequence for constructing the South Project Area was based on erosion patterns and longshore transport results. Also, an attempt was made to break up the nourishment so that adjacent segments would not be nourished at the same time, to allow benthic and other beach organisms to more readily recover.

The North Project Area is expected to take about 12 months to construct. For the South Project Area, each phase is expected to take 6 to 8 months to complete.

Maintenance Cycles. Each segment of the South Project Area will be renourished on a three-year cycle, with each phase receiving the initial renourishment the third year following construction. Due to the staggered construction phasing, a periodic renourishment operation will occur every year along some segment of the South Project Area, with the sequencing following the same order as construction, i.e. mid-segment (1^{st}), southern segment (2^{nd}) and northern segment (3^{rd}). Periodic renourishment of each phase of the South Project Area is scheduled to begin mid-November and proceed until completion in January or February, i.e. 2 to 3 months of dredging. All renourishment of the South Project Area is expected to utilize the southern borrow area and be accomplished with an ocean certified pipeline dredge.

Periodic renourishment of the North Project Area will also be accomplished using the southern borrow site. However, due to the great distance from the borrow site to the North Project Area, a hopper dredge will the most practical means of accomplishing this work. In order to reduce the chance of sea turtle takes by the hopper dredging, a shorter dredging window will be adhered to with the renourishment being done in two separate four month phases occurring in year one and year two of the renourishment cycle. Each phase will begin in January and proceed through April. This work will start at the beginning of the third year after completion of construction of the North Project Area. Under this plan no dredging will be undertaken during the third maintenance year. In the event that a stricter hopper-dredging window is enforced, ending in March instead of April, then renourishment will have to be accomplished in three phases, with dredging and fill placement occurring annually.

Part 2 PHYSICAL MONITORING PROGRAM

The physical monitoring program consists of four major components: beach profile surveys, beach sediment sampling, aerial shoreline photography, and wave/water level measurements. These four components provide information necessary to document the physical response and condition of the beach both within and outside of the fill limits. In addition, physical measurements will also be taken within a non-project control area to support biological sampling. The control area is located north of the North Project, within the community of Southern Shores, NC.

Beach Profile Surveys. The beach profiles provide shoreline monitoring coverage of approximately 27 miles of Dare County beaches. The coverage extends from Southern Shores southward to Oregon Inlet as shown in Figures 3 through 5. As such, the profiles extend beyond and between the Northern and Southern Project areas. Profiles are scheduled to be surveyed semi-annually, typically occurring in the fall and spring of the year. Profiles are collected in the same manner and frequency outside the fill limits as they are within the fill limits. These data provide a baseline of the pre-project conditions for future monitoring of the effects of fill on the placement and non-placement zones.

Beach profiles along the Dare County beaches are generally spaced about 1000 feet apart and are typically perpendicular to the shoreline. There are a total of 144 profiles overall. Each profile represents a surveyed transect of the beach and typically includes elevation measurements at least every 25 feet or at significant breaks in grade. Each profile begins behind the dune and extends seaward to -30 feet NAVD88 and 1 mile offshore. Bathymetric surveys of these profiles from offshore through the surf zone are collected with the Engineering Research and Development Center's LARC (Lighter Amphibious Re-supply Cargo) survey system. The LARC vehicle transits through water, across shoals, through the surf zone up to the base of the beach dunes. Topographic collection of survey data is made with a backpack mounted RTK GPS system. Data is typically collected from the baseline seaward at 2 foot intervals and overlaps the bathymetric data collected using the LARC.

There are essentially three separate baselines covered in the monitoring program, which are shown in Figures 3, 4, and 5. The main baseline extends from the northern end of Kitty Hawk, station 0+00, to the southern end of Nags Head at station 1020+79. This baseline covers the Dare County beaches study area. The northern baseline shown in Figure 3, covering Southern Shores from station -10+00 to -150+00, was established to serve as a control area outside of the main project area. The southern baseline, referred to as Bodie Island and shown in Figure 5, was established previously under the Oregon Inlet monitoring program and falls within the Cape Hatteras National Seashore. This shoreline extends from station 264+00 at the northern end to station 19+00 at the southern end near Oregon Inlet.

<u>Beach Sediment Sampling.</u> Sediment samples were collected along 67 selected beach profile locations. In general, sediment samples were collected along every other line throughout the project and control areas. Outside of these areas, samples were collected on every third monitoring line. These locations are identified by the letter "S" at the end of the respective profile lines in Figures 3, 4, and 5. The samples were tested to determine grain size and grain size distribution in an effort to document pre-construction sediment characteristics along the project. Also, the analysis of these data will assist in identifying any changes on the beach that may occur associated with fill placement and future maintenance. The sediment characteristics can be used to ensure that compatibility between the native beaches and fill material is achieved over the project life. Sand grain size and textural properties also play a significant role beach ecology issues which are being monitored as part of the companion environmental monitoring program.

The sediment sampling consists of surface grab samples taken along both the subaerial and subaqueous portions of the profile lines. A total of 10 samples are collected along each line with five samples from the onshore portion and five samples offshore. Specific profile sampling locations include: 1) dune (elevation +12.04 feet), 2) Berm (elevation +6.04 feet), 3) mean high water (elevation +1.18 feet), 4) mean sea level (elevation -0.46 feet), 5) mean low water (-2.05 feet), 6) –6 foot contour, 7) –12 foot contour, 8) –18 foot contour, 9) –24 foot contour and 10) –30 foot contour. Note that all elevations are with respect to NAVD88.

Sediment samples were gathered at the described locations on two occasions. The first data were gathered during the months of August to October 2004. These data are representative of a typical summer season profile. The second set of sediment data were gathered between the months of April and May 2006 and represent conditions observed following a typical winter season profile. On both occasions 670 samples were obtained with a total of 1,340 samples available for the sediment characterization study discussed later in this report.

Waves and Water Levels. Waves and water levels are the principal hydrodynamic forcing parameters that control the beachfill response over time. This response is in terms of cross-shore changes induced by storm waves and surges as well as longshore changes that reshape the planform of the fill. Due to the importance of the wave and water levels on the performance of any beach fill project, a monitoring gage was placed in service in March 2004 and has been maintained by the Engineering Research and Development Center's Field Research Facility (FRF). The bottom mounted gage consists of a combination of an Acoustic Doppler Current Profiler (ADCP) meter and pressure sensor. This combination is capable of producing measurements of water level, wave height, wave period, wave direction, as well as currents over the water column. The gage was positioned just landward of borrow area N1 at a water depth of 48 feet as shown in Figure 3. Operation of the gage is planned to cover the pre-, during- and post-construction phases of the project through one complete re-nourishment cycle. Given the large project area it is intended to move the gauge to various strategic locations over the monitoring cycle.

Based on the approved monitoring plan the wave gauging will be integrated into an overall wave and shoreline model of the project area. This model was established during the planning phase of the project and consists of the Generalized Model for Simulating Shoreline Change (GENESIS) and the Steady State Spectral Wave (STWAVE) wave transformation model. The modeling will be used in two basic ways; 1) to help assess project impacts and 2) as an operational tool for project maintenance. Project impacts include the response of the beach plan-form to the fill placement, alongshore dispersion of the fill, and effects of the borrow area deepening on the beaches. These impacts were addressed during the planning and design phases of the project and would be documented and verified by the physical measurements and modeling of the actual response of the beach. With respect to the operation and maintenance of the project, the models will be utilized to assist in the sand management decisions so the most effective use is made of each beach re-nourishment. In this mode, the model will serve as a predictive tool to determine the optimum location of the maintenance material along both the northern and southern project areas, and the likely longevity of the re-nourishment for given wave scenarios.

Aerial Photography. Vertical color aerial photographs on a nominal scale of 1 inch equals 1000 feet were planned to be taken to coincide with spring and fall beach surveys. Due to funding restrictions only one set of photography has been acquired to date. Aerial photography is planned to be taken again just prior to construction of the Dare County beaches project as well as on each subsequent survey after the project is constructed. Extent of the photography will include the entire monitoring area from the Duck pier at the U.S. Army Field Research Facility to Oregon Inlet.

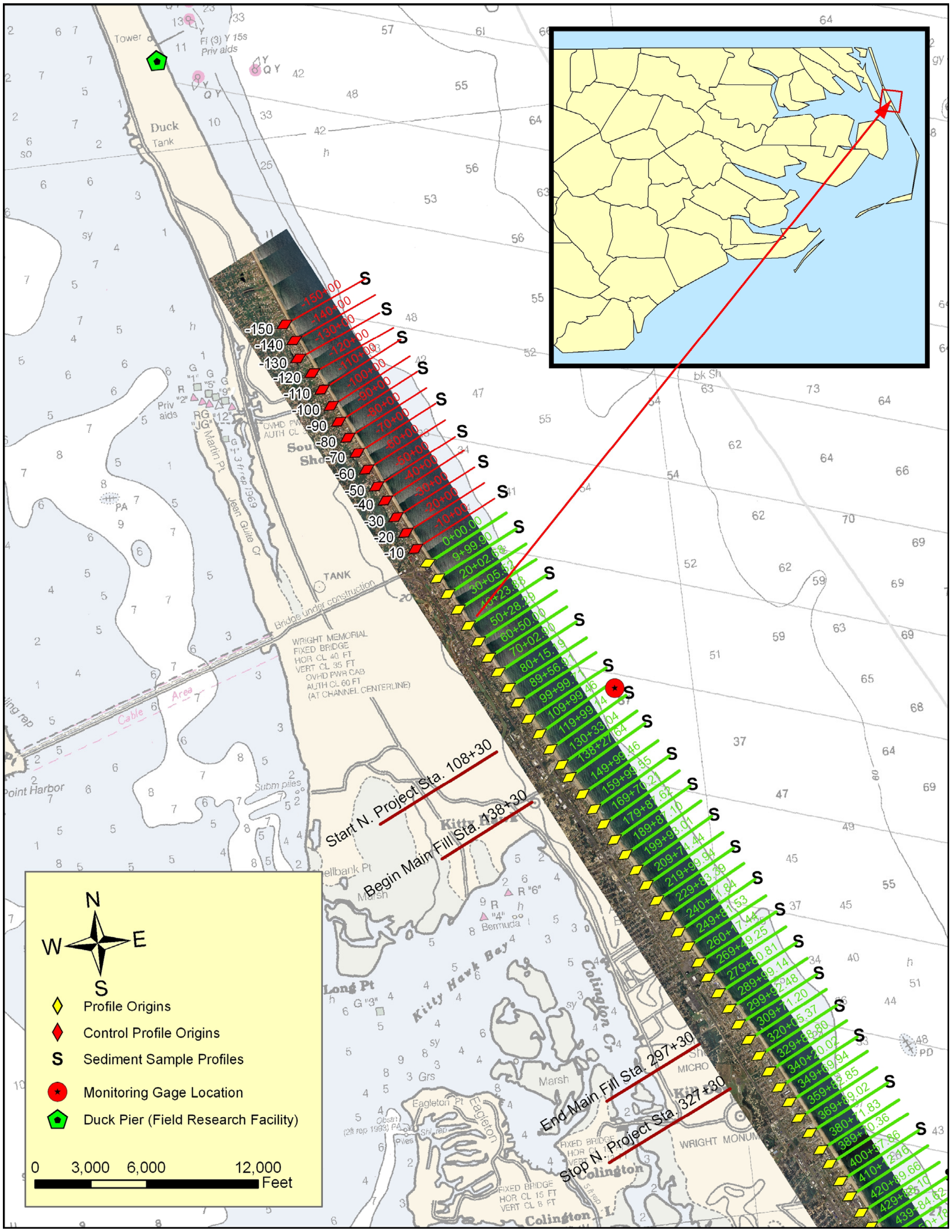

Figure 3. Beach Profile Locations for the Northern Project and Control Site

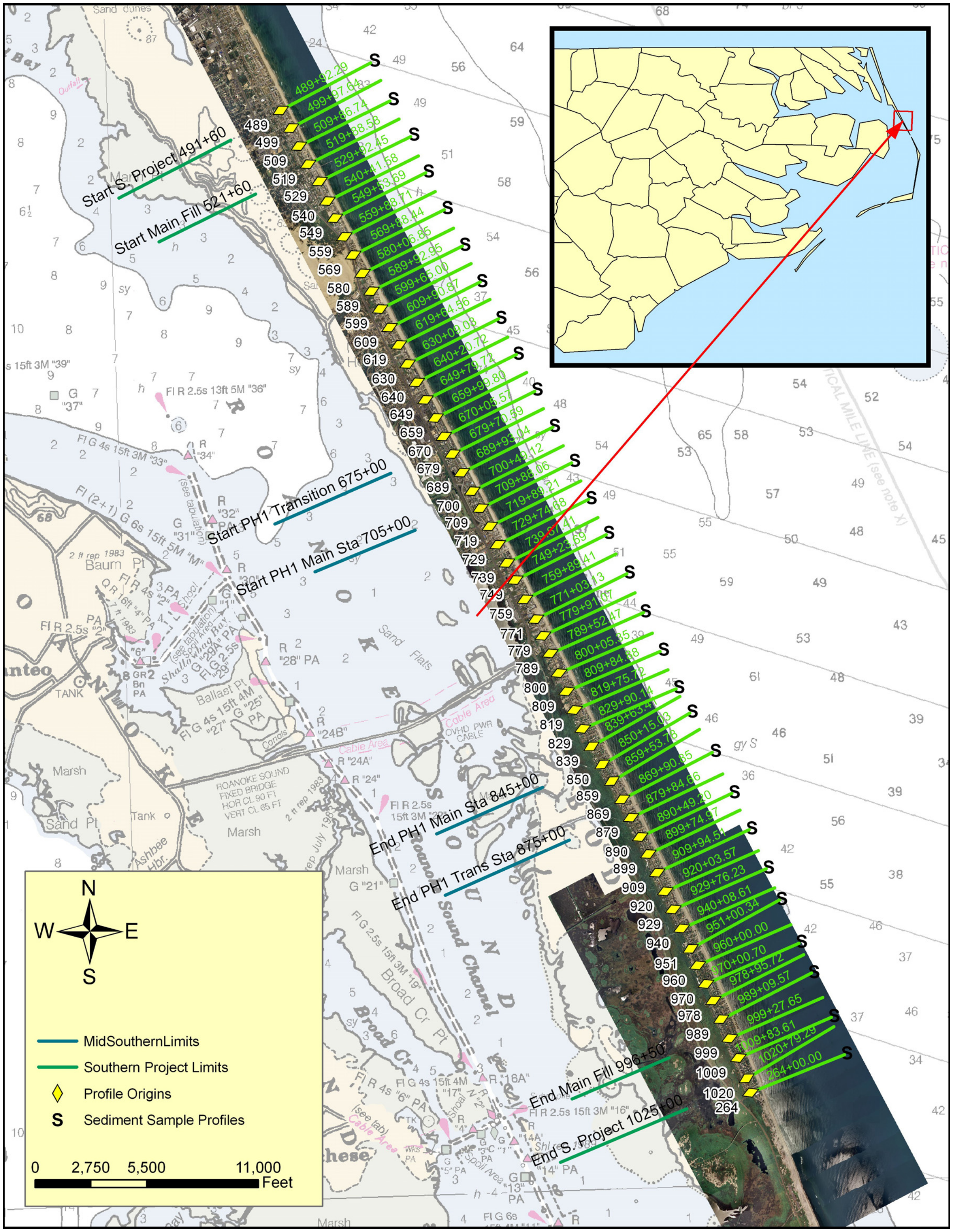

Figure 4. Beach Profile Locations for the Southern Project Area

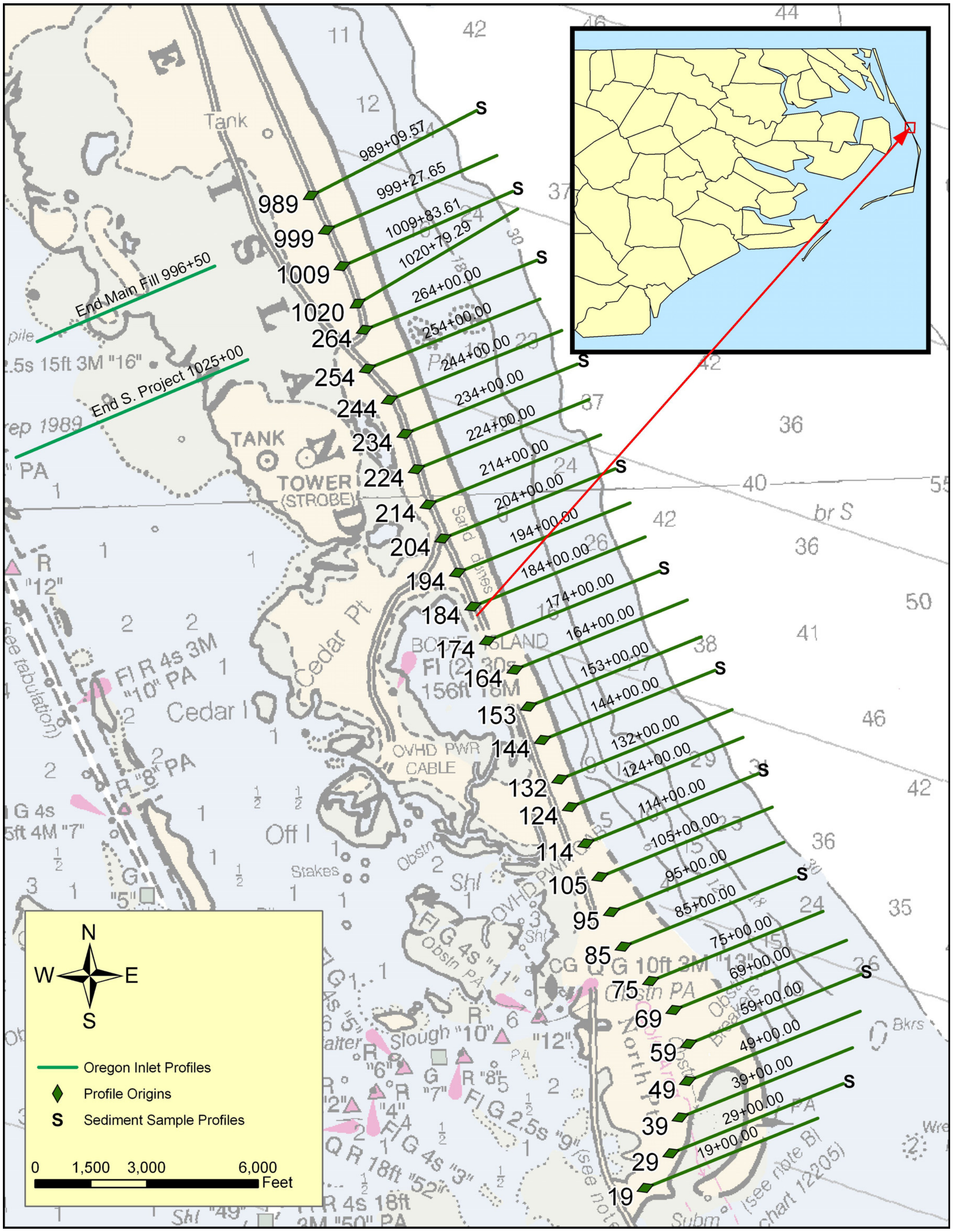

Figure 5. Oregon Inlet Profiles South of Dare Project Limits

Activities to Date. A time line activity chart of all monitoring tasks is given in Figure 6. These activities through the end of this monitoring cycle are summarized below:

- Four scheduled surveys have been completed to date. They were done in August 2004, May 2005, May 2006, and October 2006. All four surveys were complete coverage of all profiles out to the depth of closure.
- One additional survey was completed following the largest storm to impact the beach since the start of the monitoring program, in November 2006. This irregularly timed survey was used to specifically measure the response of the beach to the storm.
- Two complete sets of sediment grab samples were collected containing 670 samples each. The first set was gathered in August to October 2004 and the other in April to May 2006.
- A sediment characterization study for our subject area was completed by the ERDC in Vicksburg, MS.
- A single wave gage was deployed in March 2004 and has been in virtually continuous operation since, gathering data on wave height, period, and direction for our project location.
- The spring aerial photography was flown in May 2006, which is the only pre-construction aerial photography taken to date.

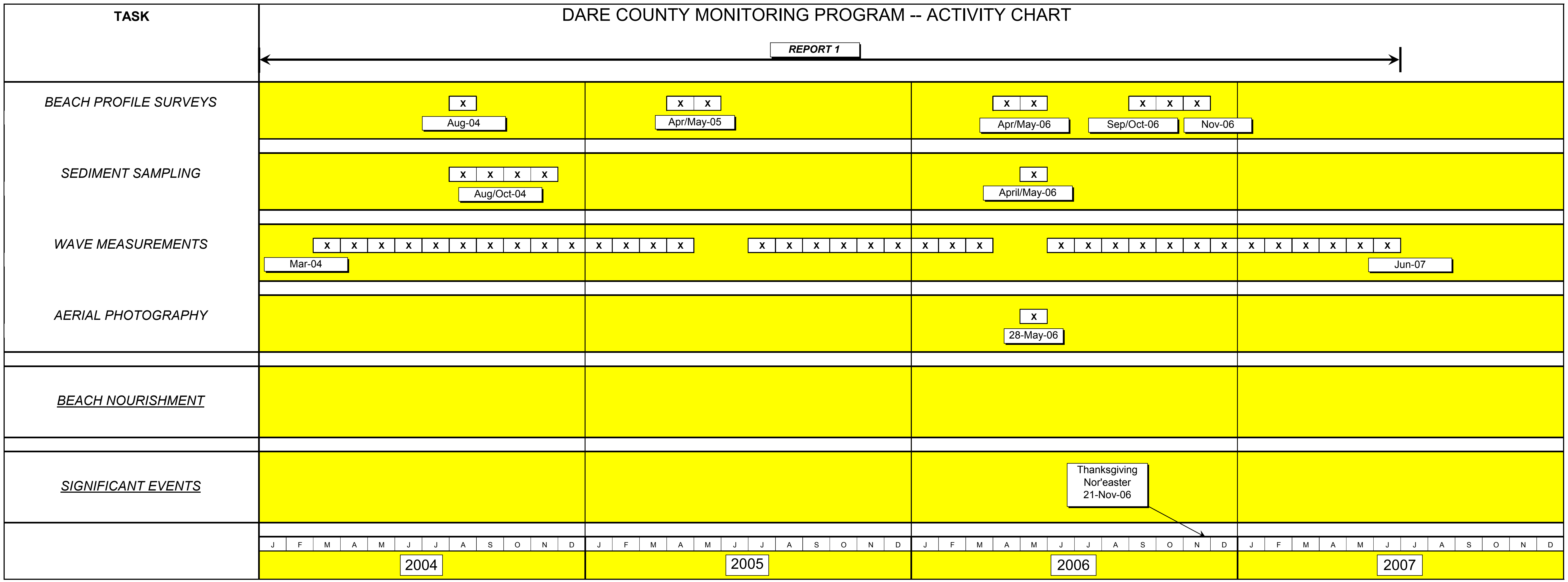

Figure 6. Dare County Monitoring Program – Activity Chart

Part 3 DATA ANALYSIS AND RESULTS FROM FIRST MONITORING CYCLE

Data collection for the monitoring program was initiated in August 2004 to document existing conditions on Dare County beaches prior to construction of the upcoming federal shore protection project. This section of the report describes the data collected to date and results through October 2006, the most recent regularly scheduled monitoring survey. An analysis of the changes due to the Thanksgiving storm documented by the November 2006 survey is provided in a separate section of this report.

Beach Profile Analysis-Shoreline and Profile Change. The beach profile surveys were analyzed using BMAP (Beach Morphology Analysis Program) (Sommerfield, 1994) to determine both shoreline and unit volume changes over time for each profile of interest. The beach profile locations for the project as well as the control profiles in Southern Shores and monitoring profiles in Bodie Island are given in Figures 3, 4, and 5. It is noted that the beach profile numbers are reflective of their location on the baseline. For example, the origin of beach profile 20 is located near station 20+00 on the project baseline. The shoreline used in the analysis is represented by the mean high water line which is 1.18 feet NAVD88.

The current monitoring period includes four regular monitoring surveys, namely August 2004, May 2005, May 2006, October 2006, and one additional post-storm survey taken just after the November 2006 Thanksgiving storm. Shoreline changes for the current monitoring period are given in Figures 7 through 11, which show the shoreline changes relative to the start of the monitoring program in August 2004. These figures were separated based on township boundaries within the monitoring area

As shown in these graphs, the shoreline fluctuates from profile to profile and from region to region. The average shoreline change measured from August 2004 through October 2006 was -1.2 feet for the entire monitoring area. Breaking this number down further reveals that when the Bodie Island portion of the monitoring area is excluded, the average shoreline change is a net increase in shoreline position of 6.4 feet. The average shoreline change for the Bodie Island portion of the beach was -35.3 feet, and as shown in Figure 11 the shoreline erosion increases as distance from Oregon inlet decreases. Maximum shoreline increase for the entire monitoring area was 71 feet at profile 279 in Kill Devil Hills, with the maximum shoreline decrease of 192.4 feet located at profile 29 in Bodie Island. The results indicate that the majority of the beach is accreting, when in fact they may be showing the effect of the natural recovery of the beach after a major storm. As previously stated, the monitoring program started in August 2004, which is less than a year after Hurricane Isabel made landfall in September 2003 within 70 miles of the project location. Hurricane Isabel was the most significant event ever recorded at the U.S. Army Corps of Engineers FRF waverider gauge (August 1978 to present), with wave heights as high as 39.7 feet recorded.

Within the monitoring area there are four significant areas that have increased erosion when compared with neighboring profiles. The first is an area approximately 6000 feet long located in Kitty Hawk from profile 99 to 149 (Figure 8). This area experienced a shoreline erosion of 17.3 feet while the town as a whole experienced an average shoreline loss of only 0.9 feet. The second area is located in Kill Devil Hills from profile 349 to profile 389 which represents approximately 5,000 feet of shoreline (Figure 9). This area experienced an average shoreline loss of 26.6 feet, compared to the average increase of 3.1 feet for the town of Kill Devil Hills. The last two areas are located in Nags Head from profile 779 to 800 and profile 879 to 899 and each represent approximately 3,000 feet of shoreline (Figure 10). These two areas experienced shoreline losses of 48.4 feet and 15.5 feet, respectively. These numbers are magnified even more when compared to the average shoreline increase for the Nags Head area which was 9.4 feet. Further monitoring of these areas should determine their long term stability as well as to monitor how they respond to the nourishment project.

Figures 12 through 15 display a representative profile cross section from each of these erosional “hot spots”, respectively. These Figures represent profiles 138, 369, 789, and 879 respectively, and display the profiles lines for the four surveys taken to date. The retreat in the mean high water line (1.18 feet NAVD88) is clearly visible in each of these figures. Also, all four of these areas show the formation of a nearshore bar. This may indicate that the material is moving from the onshore portion of the profile into the nearshore rather than being moved north or south of the “hot spot”.

Outside the limits of the nourishment project, which includes Southern Shores and Bodie Island, the only potential hot spot observed since the start of the monitoring period was located in Southern Shores from profile -40 to -50. The shoreline in this area has receded by 20 feet since the start of the monitoring, while the control area as a whole has accreted an average 9.5 feet. The Bodie Island shoreline, with the exception of an area approximately 3,000 feet long near the northern end, is eroding at a rapid pace. This area should be closely monitored in the future in order to quantify any changes and determine how they relate to the nourishment project. However, large scale shoreline changes in the vicinity of Oregon Inlet over similar time intervals are not uncommon.

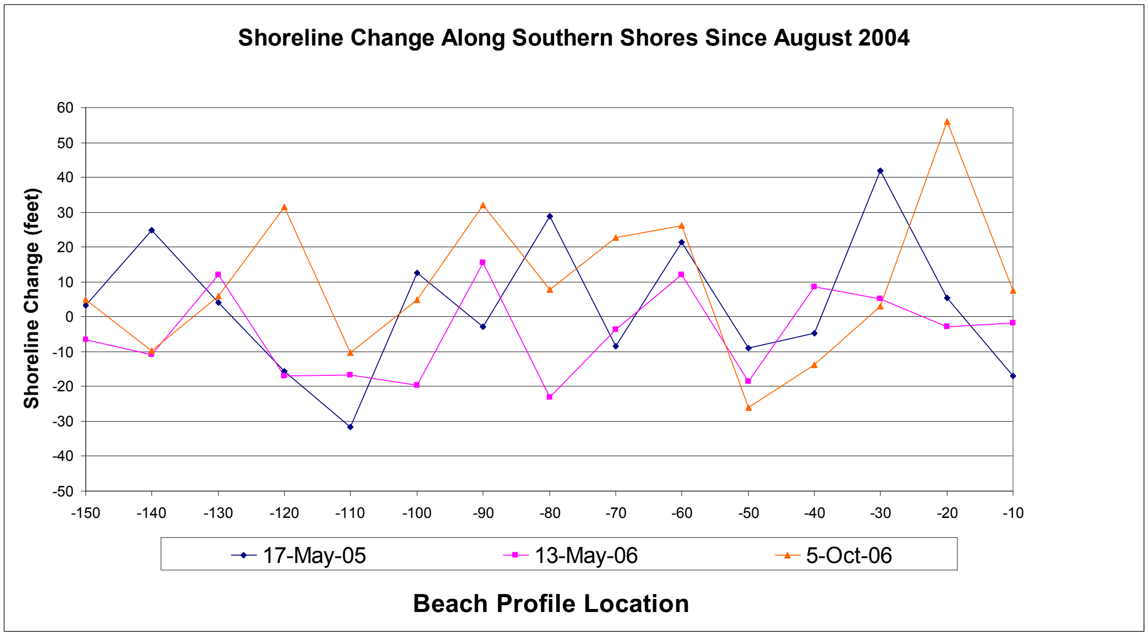

Figure 7. Shoreline Change Since Start of Monitoring (Aug 2004), Southern Shores

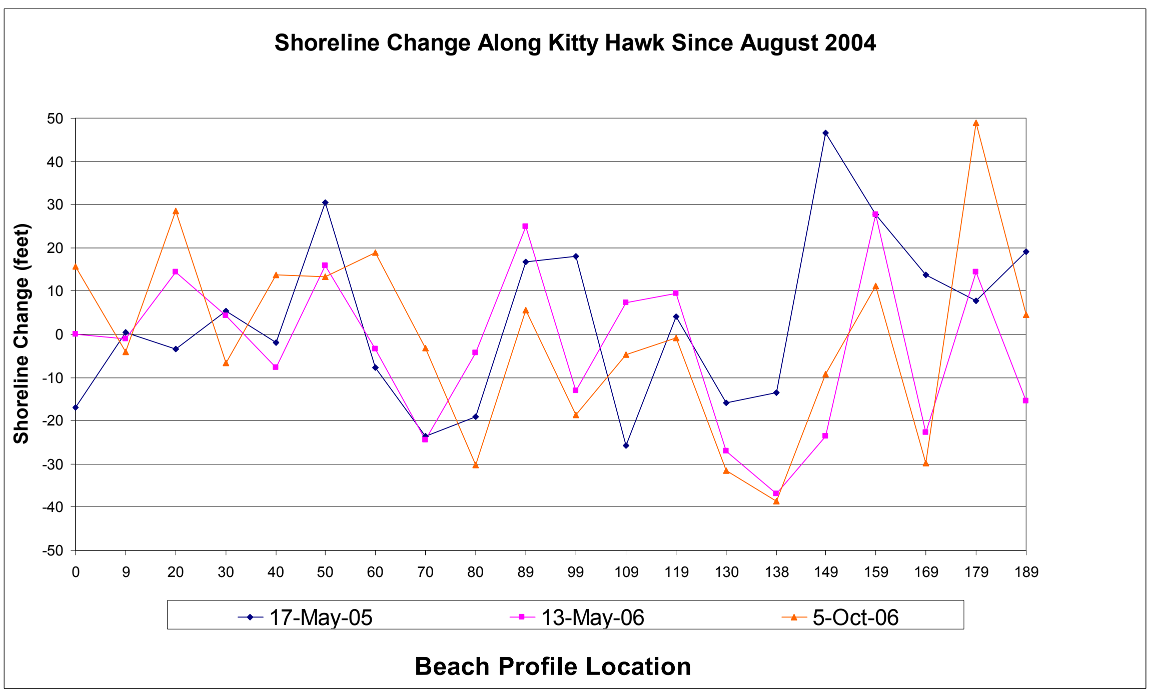

Figure 8. Shoreline Change Since Start of Monitoring (Aug 2004), Kitty Hawk

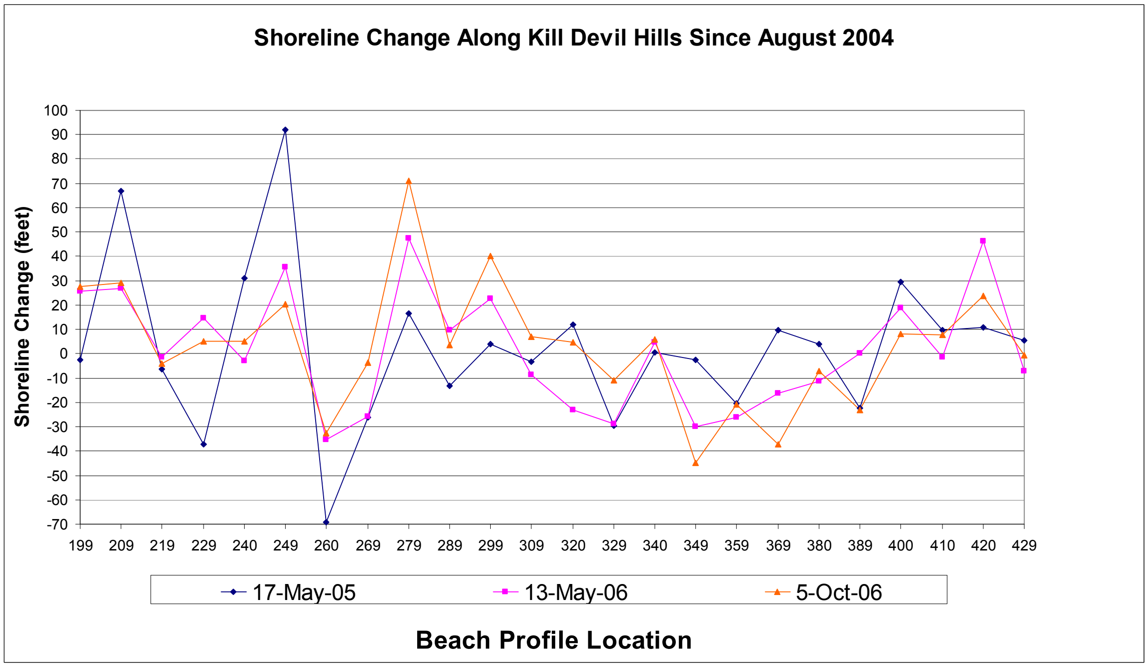

Figure 9. Shoreline Change Since Start of Monitoring (Aug 2004), Kill Devil Hills

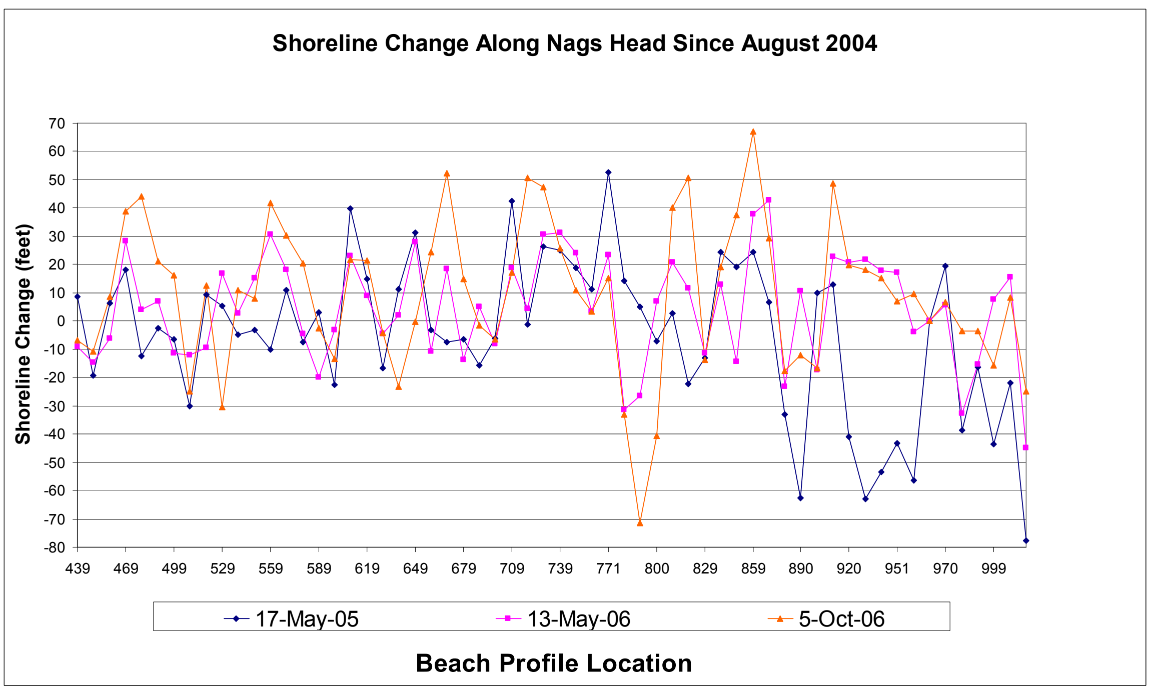

Figure 10. Shoreline Change Since Start of Monitoring (Aug 2004), Nags Head

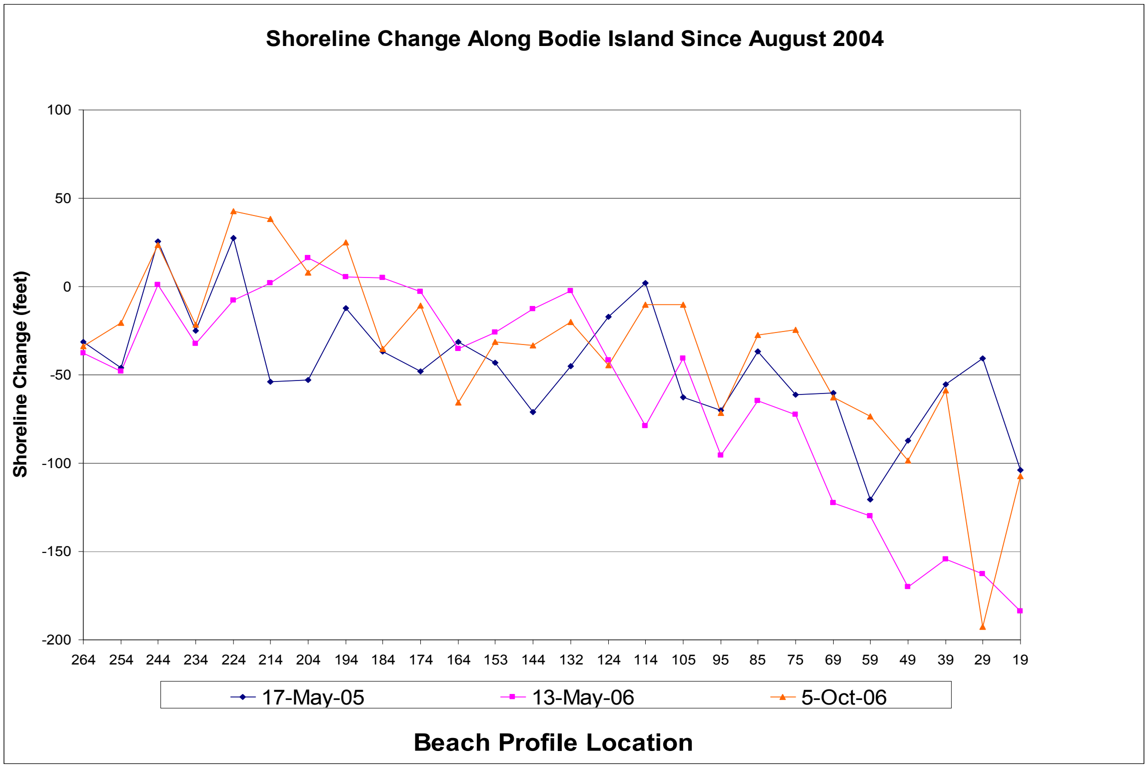

Figure 11. Shoreline Change Since Start of Monitoring (Aug 2004), Bodie Island

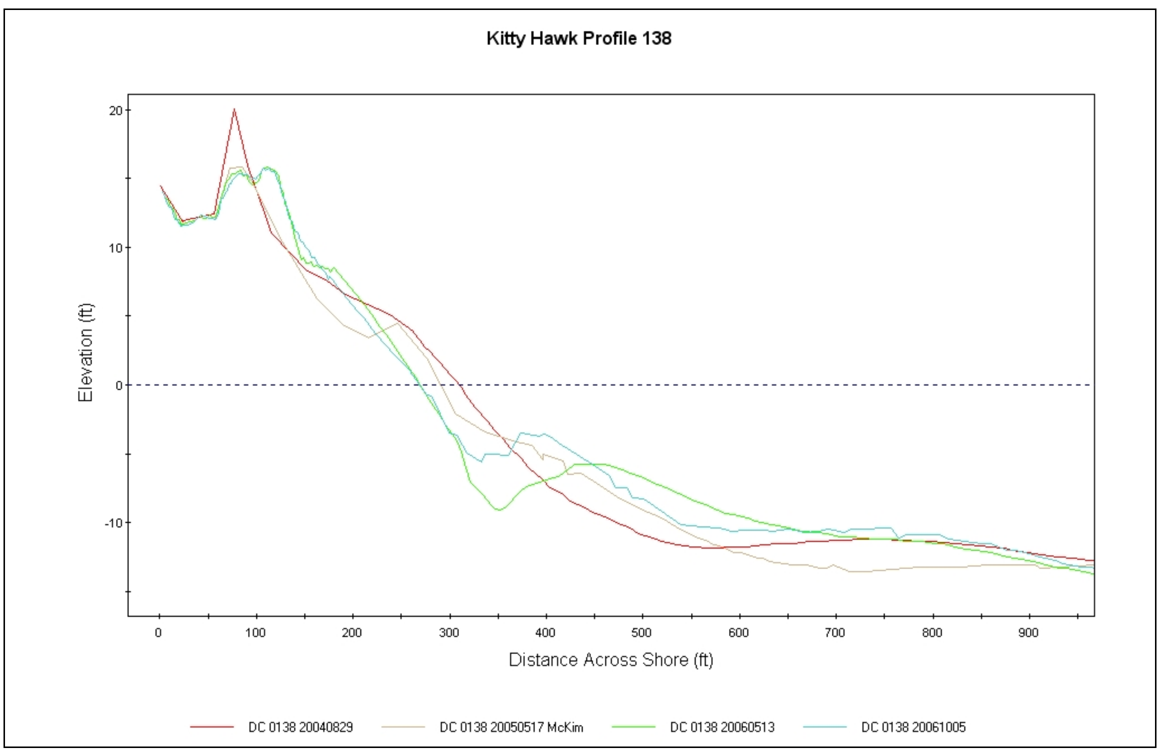

Figure 12. Kitty Hawk Profile 138

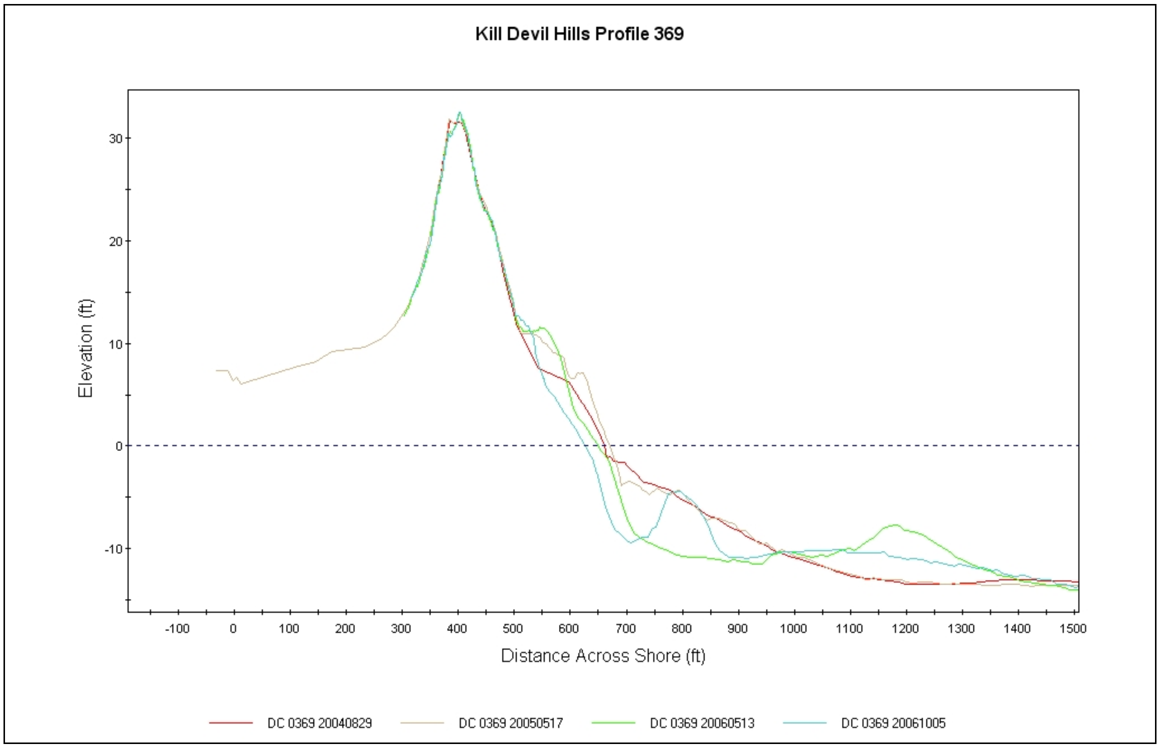

Figure 13. Kill Devil Hills Profile 369

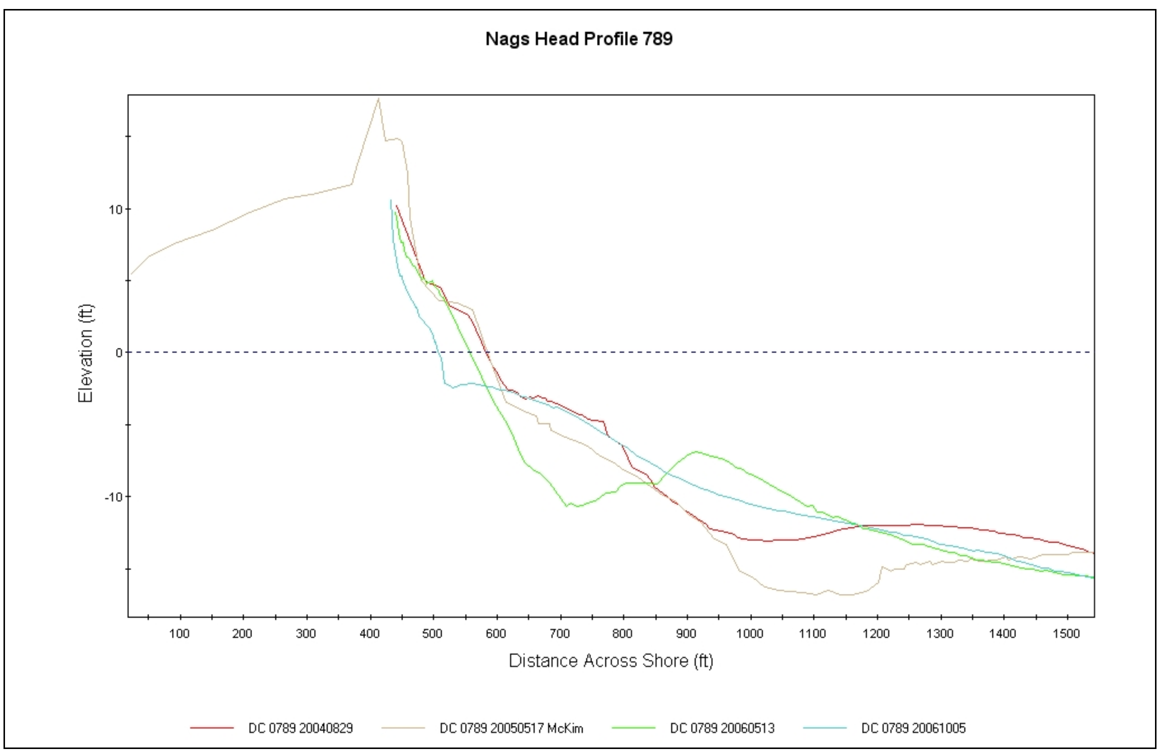

Figure 14. Nags Head Profile 789

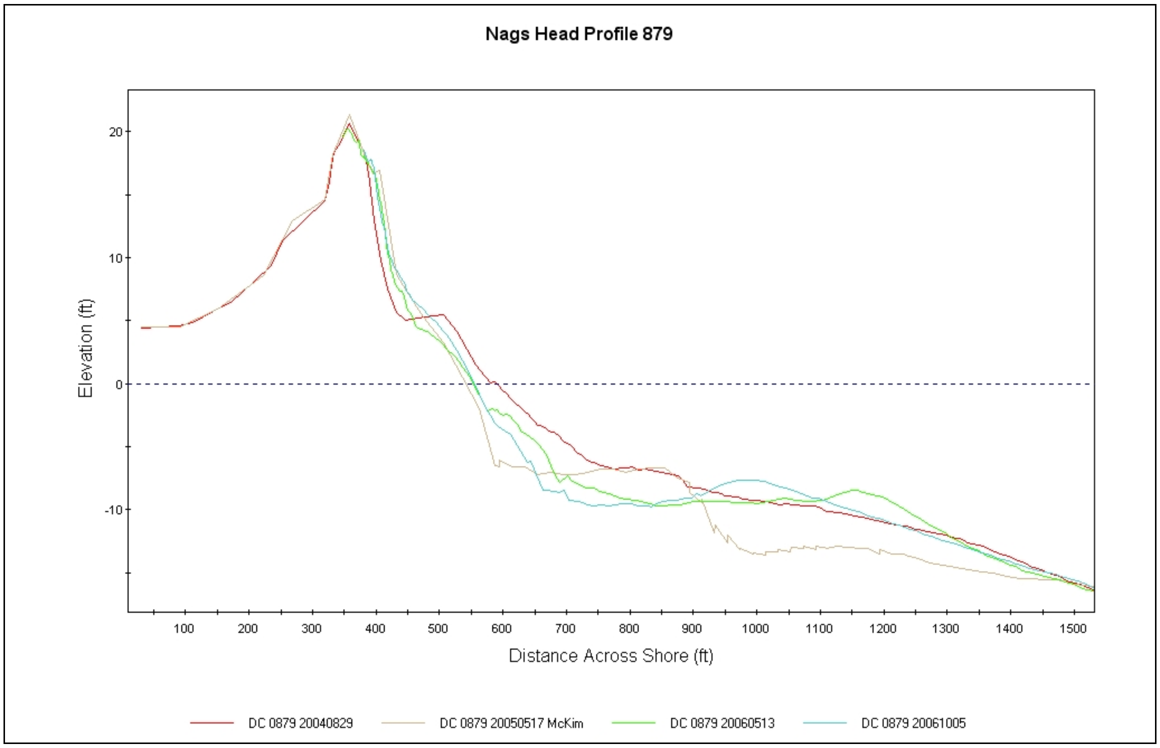

Figure 15. Nags Head Profile 879

Beach Profile Analysis – Volumetric Change. The analysis of each beach profile also included volumetric changes over time. As with the shoreline change data, the volumetric changes are made relative to the start of the monitoring cycle. Volumes are computed for both the onshore beach (i.e. to wading depth) and for the total survey covering both the onshore and offshore areas. The onshore volumes are calculated from a common stable landward point to an elevation down to -2 feet NAVD88. The offshore volumes are computed to an observed closure depth for each profile line. The volumes are calculated using the BMAP program where unit volume changes are computed for each profile. The average area end method is then used between profile locations in computing the volume over the length of the project and monitoring areas. Table 1 summarizes the landward and seaward extents as well as the observed closure depths for each profile compared in this section.

The onshore volumetric changes measured along the Dare County beaches are given in Figures 16 through 20 and are separated by township limits. These figures show the volumetric changes along the island since the beginning of the monitoring program in August 2004.

In general, the volumetric changes observed in the onshore portion of the profile are similar to the changes measured in the mean high water position. The volume changes show that most of the island has accreted since the beginning of the monitoring effort with the exception of south Nags Head and Bodie Island. These volume changes have been broken into township limits and are given in Table 2. Overall, the onshore portion of the beach gained nearly 353,000 cubic yards of material since August 2004. However, the Bodie Island region combined with the southern end of Nags Head from station 951+00 through 1020+79 lost nearly 192,000 cubic yards. There are two other areas that show noticeable volumetric change when compared with adjacent profiles. The first, an area approximately 7,000 feet long, is from profile 309 through profile 369 in Kill Devil Hills (Figure 18) that lost nearly 36,000 cubic yards of material. The second area is from profile 779 through profile 800 in Nags Head (Figure 19), which is approximately 3,000 feet in length. This area lost nearly 41,000 cubic yards since the start of the monitoring program. Both of these areas overlap segments of the beach identified earlier in this report as possible hot spots within the future project limits.

To illustrate the overall trends in volume change, Figure 21 through 25 show plots of total volume changes over time with respect to the initial monitoring survey in August 2004. For each profile comparison, volumes were computed from a common stable landward point to an observed closure depth offshore.

Measurements over the entire profile show that each township area within the monitoring project lost material since August 2004, with the exception of Kill Devil Hills which has a measured gain of approximately 16,800 cubic yards. Total volume loss for the entire project area was approximately 1,472,000 cubic yards with the Nags Head and Bodie Island areas having the greatest losses of nearly 506,900 and 779,000 cubic yards, respectively. As with the shoreline change and onshore volume losses, the diminution of sand on Bodie Island was greatest at the southern end near Oregon Inlet.

Survey profiles for two profile locations are shown in Figures 26 and 27. Figure 26 displays profile surveys that exhibit extreme change in the total volume while Figure 27 is a profile within the project that remained relatively stable. In Figure 26, a significant change was noticed in the offshore with the depletion of the offshore bar between August 2004 and May 2005. During this same time period, the volume of material in the nearshore area showed significant changes with the profile eroding between the 0 feet and -7 feet NAVD88 contours and accreting between the -7 feet and -15 feet NAVD88 contours. While the profile exhibits unusual offshore changes which dominate the total volume calculations for this area, it has been checked for accuracy to the fullest extent possible and appears to be valid. The profiles in Figure 27 show little change in the offshore portion of the profile and are relatively stable in the nearshore portion. For this profile set only the May 2005 and May 2006 profiles showed significant changes in the nearshore zone. Both of these areas of deepening recovered quickly and were back to the typical profile shape by the time of the next survey.

Township	Station	Station ID	Landward Boundary (feet from baseline)	Seaward Boundary (feet from baseline)	Observed Closure Depth (feet, NAVD88)
Southern Shores	-150+00	-150	290	2282	-25
Southern Shores	-140+00	-140	239	2328	-26
Southern Shores	-130+00	-130	551	2520	-25
Southern Shores	-120+00	-120	287	2269	-25
Southern Shores	-110+00	-110	264	2276	-25
Southern Shores	-100+00	-100	296	2332	-25.5
Southern Shores	-90+00	-90	368	2700	-26.5
Southern Shores	-80+00	-80	367	2484	-26
Southern Shores	-70+00	-70	384	2512	-26.5
Southern Shores	-60+00	-60	390	2458	-25.5
Southern Shores	-50+00	-50	361	2592	-27
Southern Shores	-40+00	-40	349	2530	-26.5
Southern Shores	-30+00	-30	314	2683	-27
Southern Shores	-20+00	-20	289	2493	-26.5
Southern Shores	-10+00	-10	266	2393	-26
Kitty Hawk	0+00.00	0	132	2467	-28
Kitty Hawk	9+99.90	9	125	2458	-28
Kitty Hawk	20+02.68	20	8	2454	-28
Kitty Hawk	30+05.52	30	5	2284	-27
Kitty Hawk	40+23.88	40	112	2251	-27
Kitty Hawk	50+28.29	50	15	2796	-30.5
Kitty Hawk	60+50.00	60	87	2700	-30
Kitty Hawk	70+02.90	70	4	2833	-31
Kitty Hawk	80+15.19	80	119	2702	-30
Kitty Hawk	89+56.91	89	57	2938	-32.5
Kitty Hawk	99+99.71	99	4	2088	-27.6
Kitty Hawk	109+99.46	109	148	1613	-26
Kitty Hawk	119+99.14	119	29	1425	-22
Kitty Hawk	130+33.04	130	28	2730	-29.5
Kitty Hawk	138+27.64	138	56	2924	-33
Kitty Hawk	149+99.46	149	29	2030	-24.8
Kitty Hawk	159+99.55	159	61	1490	-22
Kitty Hawk	169+70.21	169	30	3063	-32.3
Kitty Hawk	179+87.62	179	31	2233	-28
Kitty Hawk	189+87.10	189	45	2269	-30.2
Kill Devil Hills	199+93.01	199	32	1984	-28.5
Kill Devil Hills	209+74.44	209	61	1792	-25
Kill Devil Hills	219+99.94	219	132	2094	-27.5
Kill Devil Hills	229+83.39	229	147	2279	-33.5
Kill Devil Hills	240+41.84	240	187	2915	-36
Kill Devil Hills	249+81.53	249	179	2761	-34
Kill Devil Hills	260+17.44	260	198	1762	-22
Kill Devil Hills	269+49.25	269	232	2640	-35
Kill Devil Hills	279+80.81	279	280	3609	-35
Kill Devil Hills	289+99.14	289	349	3561	-32.5
Kill Devil Hills	299+92.48	299	449	3630	-32.5
Kill Devil Hills	309+71.20	309	505	3607	-32
Kill Devil Hills	320+05.37	320	493	3684	-32
Kill Devil Hills	329+88.80	329	529	2760	-26.5
Kill Devil Hills	340+20.02	340	498	2897	-27.5
Kill Devil Hills	349+69.94	349	311	2876	-27.5
Kill Devil Hills	359+82.85	359	486	2815	-27
Kill Devil Hills	369+89.02	369	365	2968	-28
Kill Devil Hills	380+71.83	380	211	3036	-28.5
Kill Devil Hills	389+70.36	389	435	2908	-27.5
Kill Devil Hills	400+57.86	400	358	3100	-29
Kill Devil Hills	410+12.16	410	370	2655	-26
Kill Devil Hills	420+89.66	420	356	2471	-25
Kill Devil Hills	429+88.10	429	282	2950	-28.5
Nags Head	439+84.62	439	361	2960	-28.5
Nags Head	450+18.31	450	400	2916	-28.5
Nags Head	460+03.41	460	345	2864	-28.5
Nags Head	469+90.51	469	482	2984	-28.5
Nags Head	482+61.53	482	329	2806	-28.5
Nags Head	489+92.29	489	319	2785	-28.5
Nags Head	499+97.64	499	239	2692	-28.5
Nags Head	509+86.74	509	266	3118	-30
Nags Head	519+88.58	519	313	3037	-30.5
Nags Head	529+92.45	529	195	2964	-28.5
Nags Head	540+41.58	540	284	2924	-30
Nags Head	549+53.69	549	317	2944	-30
Nags Head	559+88.71	559	305	2949	-30

Table 1. Boundary Limits for Profile Volume Calculation

Township	Station	Station ID	Landward Boundary (feet from baseline)	Seaward Boundary (feet from baseline)	Observed Closure Depth (feet, NAVD88)
Nags Head	569+88.44	569	279	2922	-30
Nags Head	580+06.85	580	313	2910	-30
Nags Head	589+92.95	589	205	2903	-30
Nags Head	599+65.00	599	203	2897	-30
Nags Head	609+90.87	609	271	2855	-30
Nags Head	619+64.56	619	192	2500	-27.8
Nags Head	630+09.03	630	264	3681	-36.8
Nags Head	640+20.72	640	275	3670	-37
Nags Head	649+79.72	649	275	3622	-37
Nags Head	659+99.80	659	246	3354	-35
Nags Head	670+05.57	670	322	3093	-32.7
Nags Head	679+70.59	679	310	2175	-23
Nags Head	689+93.04	689	331	2653	-28
Nags Head	700+49.12	700	272	2895	-30.5
Nags Head	709+88.06	709	300	2738	-29.5
Nags Head	719+89.21	719	281	2671	-29
Nags Head	729+74.68	729	353	2805	-29.5
Nags Head	739+87.41	739	353	3318	-34.5
Nags Head	749+23.69	749	343	3358	-35.3
Nags Head	759+89.41	759	317	3257	-34.6
Nags Head	771+03.13	771	257	2097	-24
Nags Head	779+91.07	779	329	2308	-25.5
Nags Head	789+52.47	789	441	2943	-30.5
Nags Head	800+05.35	800	455	3350	-34.5
Nags Head	809+84.88	809	470	2953	-30
Nags Head	819+75.72	819	406	2895	-30
Nags Head	829+90.14	829	566	3505	-34
Nags Head	839+63.41	839	548	2981	-29.5
Nags Head	850+15.03	850	485	2600	-27
Nags Head	859+53.78	859	405	2478	-26.3
Nags Head	869+90.85	869	360	3048	-34.5
Nags Head	879+84.66	879	382	3054	-33.5
Nags Head	890+49.20	890	353	3102	-34.5
Nags Head	899+74.97	899	364	2464	-25.5
Nags Head	909+94.51	909	364	3019	-33
Nags Head	920+03.57	920	422	2883	-31
Nags Head	929+76.23	929	393	2493	-26.5
Nags Head	940+08.61	940	435	2805	-30
Nags Head	951+00.34	951	497	2801	-29.5
Nags Head	953+00.00	953	482	2798	-30
Nags Head	970+00.70	970	499	2773	-30
Nags Head	978+95.72	978	461	3209	-33.5
Nags Head	989+09.57	989	507	3164	-35.5
Nags Head	999+27.65	999	343	4265	-40
Nags Head	1009+83.61	1009	389	4077	-39
Nags Head	1020+79.29	1020	356	3833	-38
Bodie Island	264+00(ZN)	264	504	3892	-36.5
Bodie Island	254+00(YN)	254	685	4140	-35
Bodie Island	244+00(XN)	244	457	3116	-29
Bodie Island	234+00(WN)	234	406	3878	-37.5
Bodie Island	224+00(VN)	224	397	4535	-37
Bodie Island	214+00(UN)	214	290	4384	-36.5
Bodie Island	204+00(TN)	204	455	2970	-26.5
Bodie Island	194+00(SN)	194	434	3358	-30
Bodie Island	184+00(RN)	184	494	3619	-31.5
Bodie Island	174+00(QN)	174	489	3030	-27
Bodie Island	164+00(PN)	164	128	2603	-33.5
Bodie Island	153+00(ON)	153	160	2483	-31.6
Bodie Island	144+00(NNII)	144	165	3457	-31.5
Bodie Island	132+00(MN85)	132	151	3059	-26.7
Bodie Island	124+00(MNI)	124	267	3872	-30.7
Bodie Island	114+00(MNII)	114	382	4153	-32
Bodie Island	105+00(LN)	105	294	4190	-31.5
Bodie Island	95+00(KN85)	95	157	4172	-30
Bodie Island	85+00(JN90)	85	262	3999	-28.5
Bodie Island	75+00(IN)	75	207	4380	-31
Bodie Island	69+00(HN)	69	-25	5269	-36
Bodie Island	59+00(GN)	59	1	5389	-34.5
Bodie Island	49+00(FN)	49	150	5049	-27.6
Bodie Island	39+00(EN)	39	1051	5233	-22.5
Bodie Island	29+00(DN)	29	1583	7587	-28
Bodie Island	19+00(CN-350)	19	2501	9729	-33.5

Table 1 (Continued). Boundary Limits for Profile Volume Calculation

Volume Change August 2004 to October 2006				
Township	Onshore (Above -2' NAVD)	Onshore (cy/ft)	Total Volume (To Closure Depth)	Total Volume (cy/ft)
Southern Shores	*55,745*	*3.82*	*-106,391*	*-7.30*
Kitty Hawk	*60,624*	*3.03*	*-96,112*	*-4.81*
Kill Devil Hills	*84,907*	*3.54*	*16,797*	*0.70*
Nags Head	*296,291*	*5.02*	*-506,884*	*-8.59*
Bodie Island	*-143,695*	*-5.55*	*-779,053*	*-30.10*
Total	*353,872*	*2.47*	*-1,471,643*	*-10.26*

Table 2. Onshore/Total Volume change by Township

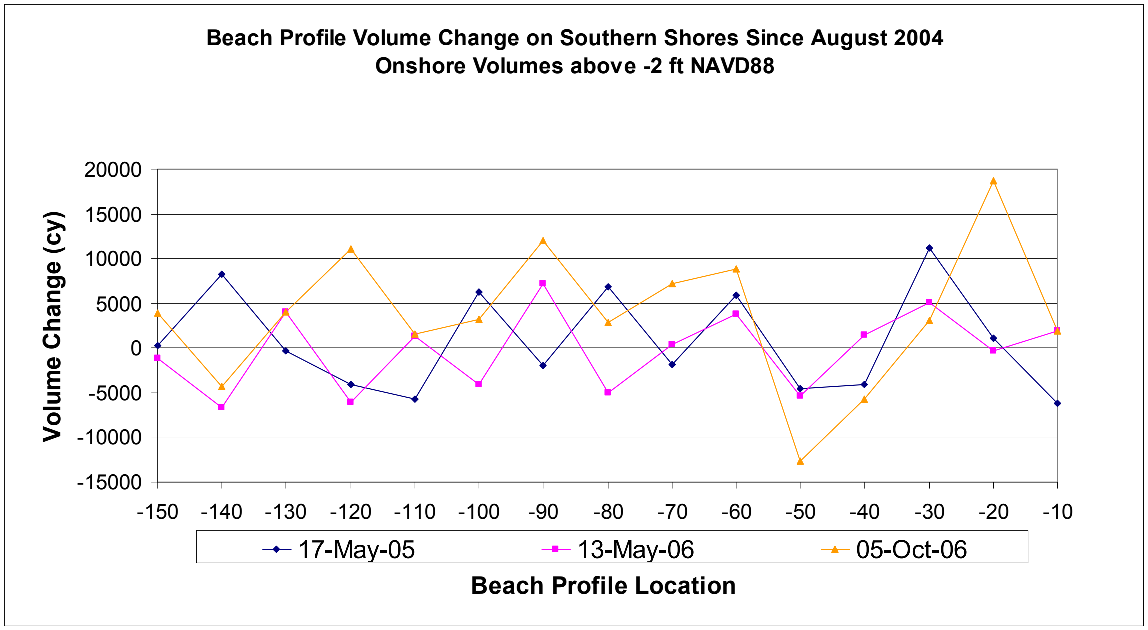

Figure 16. Beach Profile Volume Changes at Southern Shores Since the Start of Monitoring (August 2004)

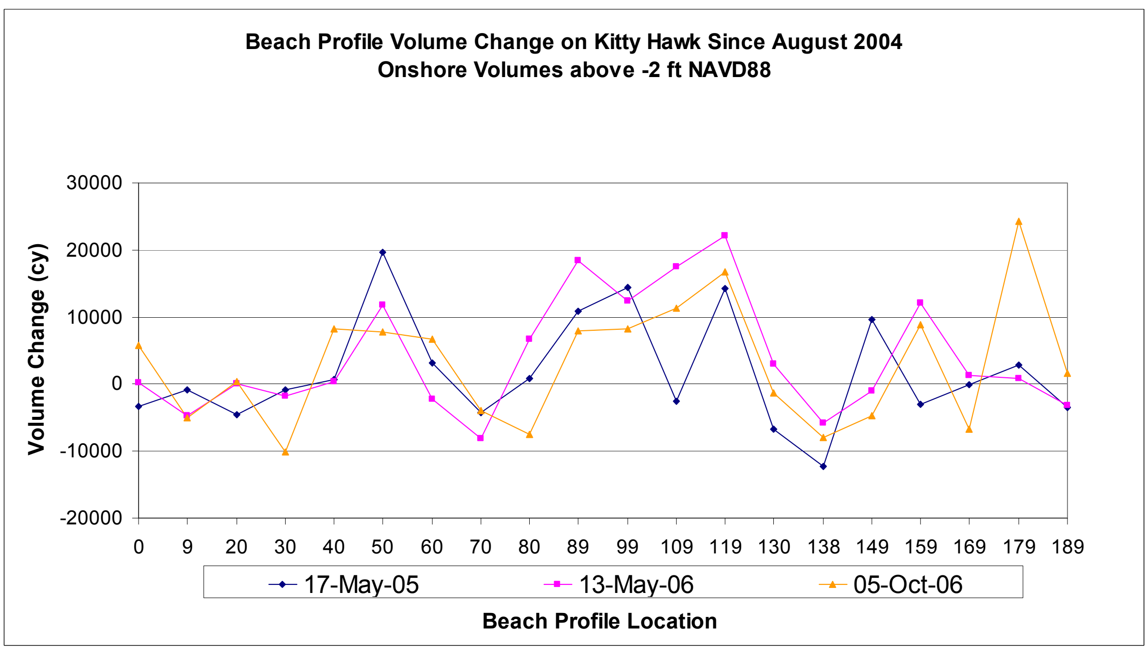

Figure 17. Beach Profile Volume Changes at Kitty Hawk Since the Start of Monitoring (August 2004)

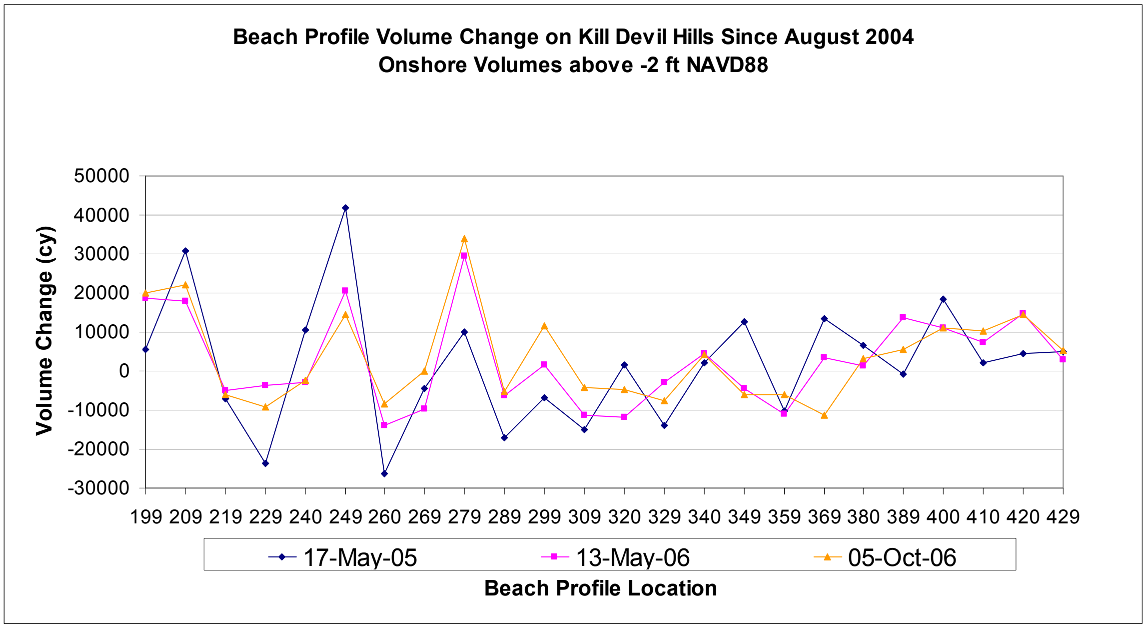

Figure 18. Beach Profile Volume Changes at Kill Devil Hills Since the Start of Monitoring (August 2004)

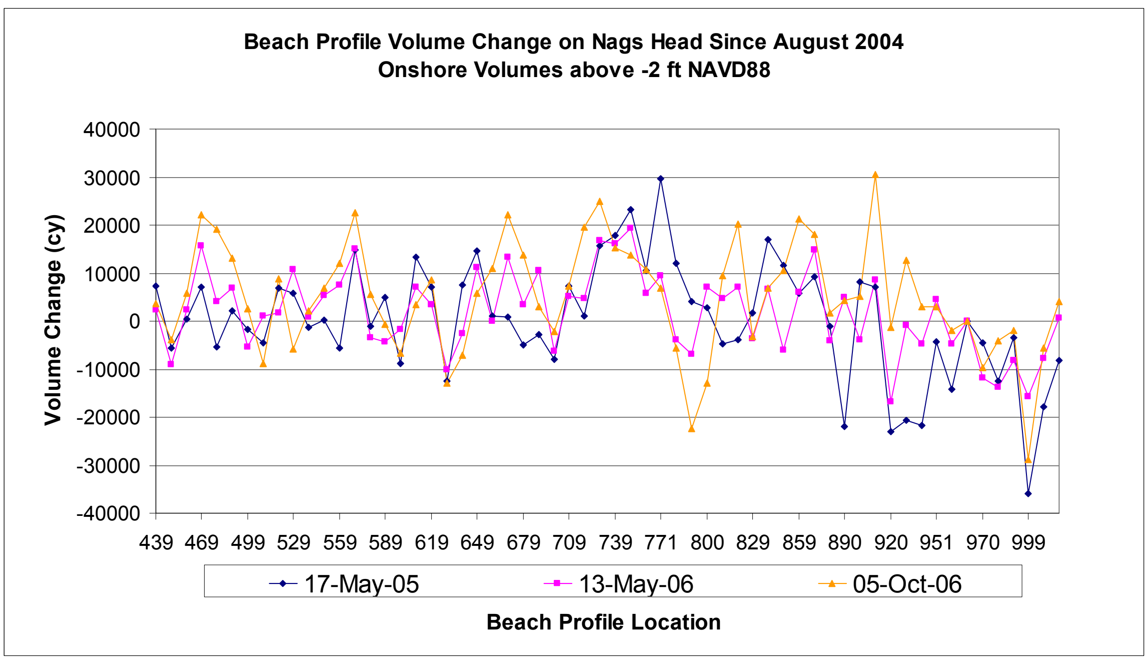

Figure 19. Beach Profile Volume Changes at Nags Head Since the Start of Monitoring (August 2004)

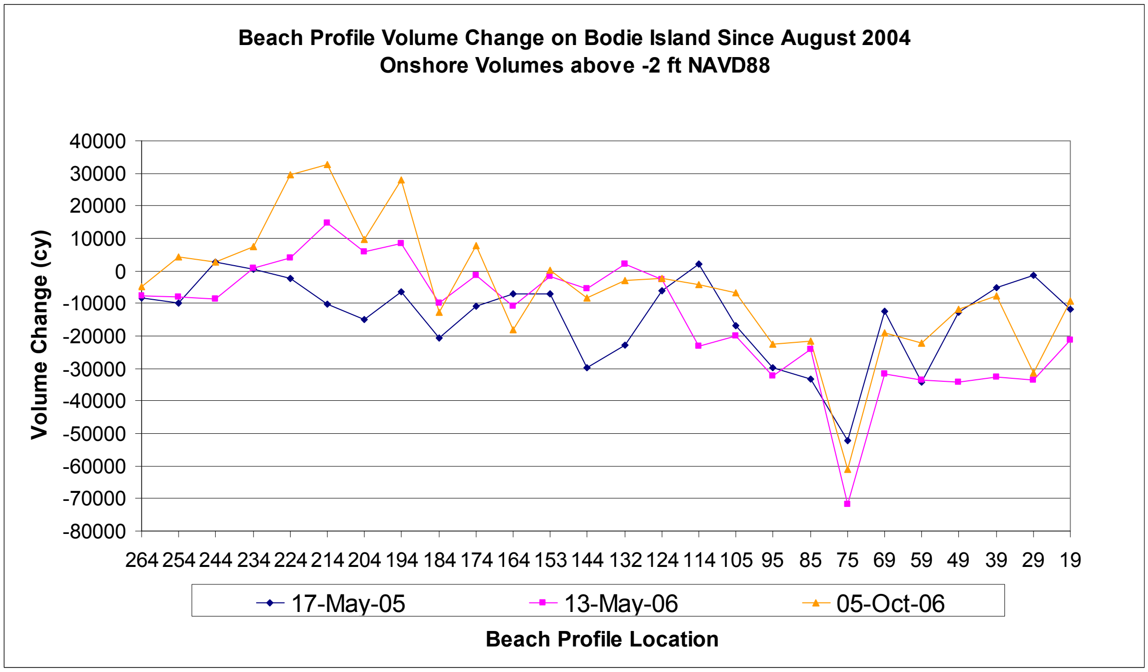

Figure 20. Beach Profile Volume Changes at Bodie Island Since the Start of Monitoring (August 2004)

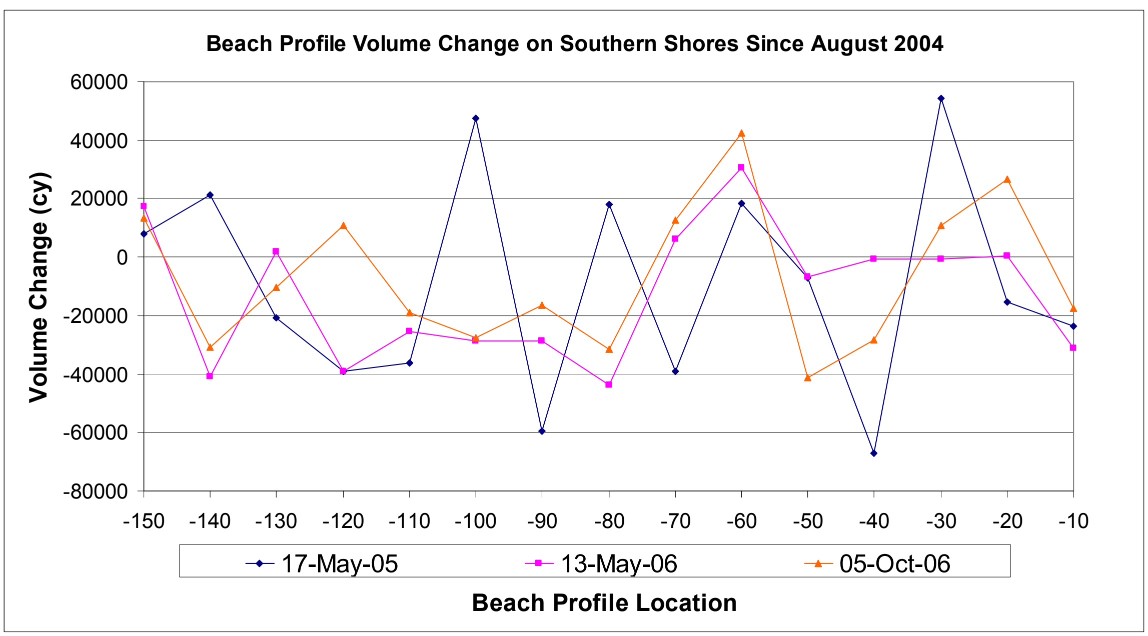

Figure 21. Beach Profile Total Volume Changes at Southern Shores Since the Start of Monitoring (August 2004)

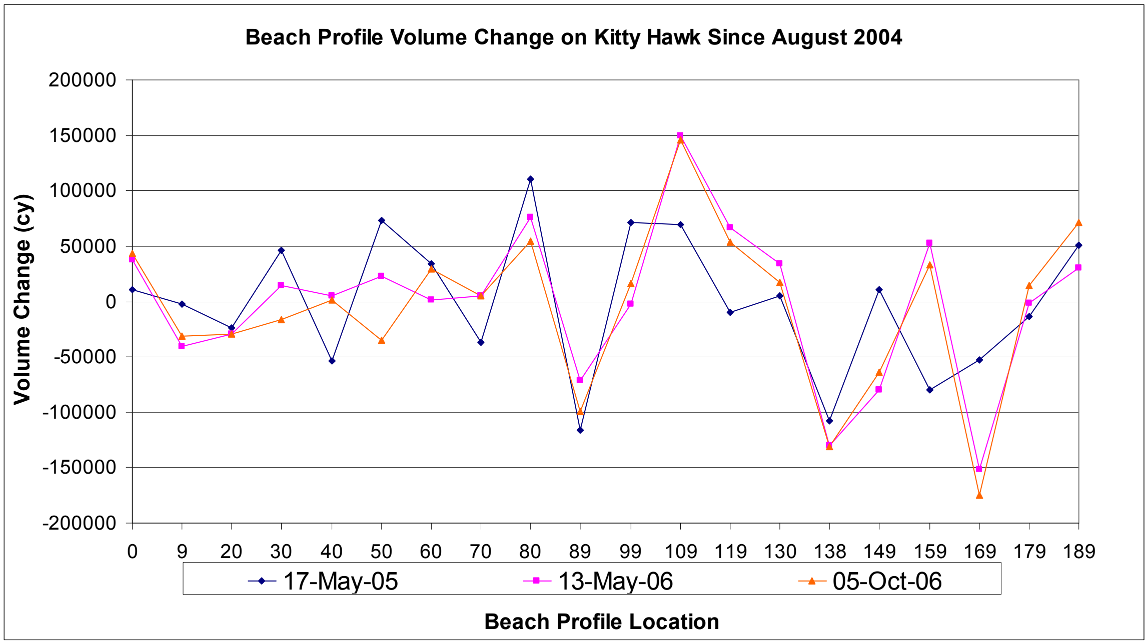

Figure 22. Beach Profile Total Volume Changes at Kitty Hawk Since the Start of Monitoring (August 2004)

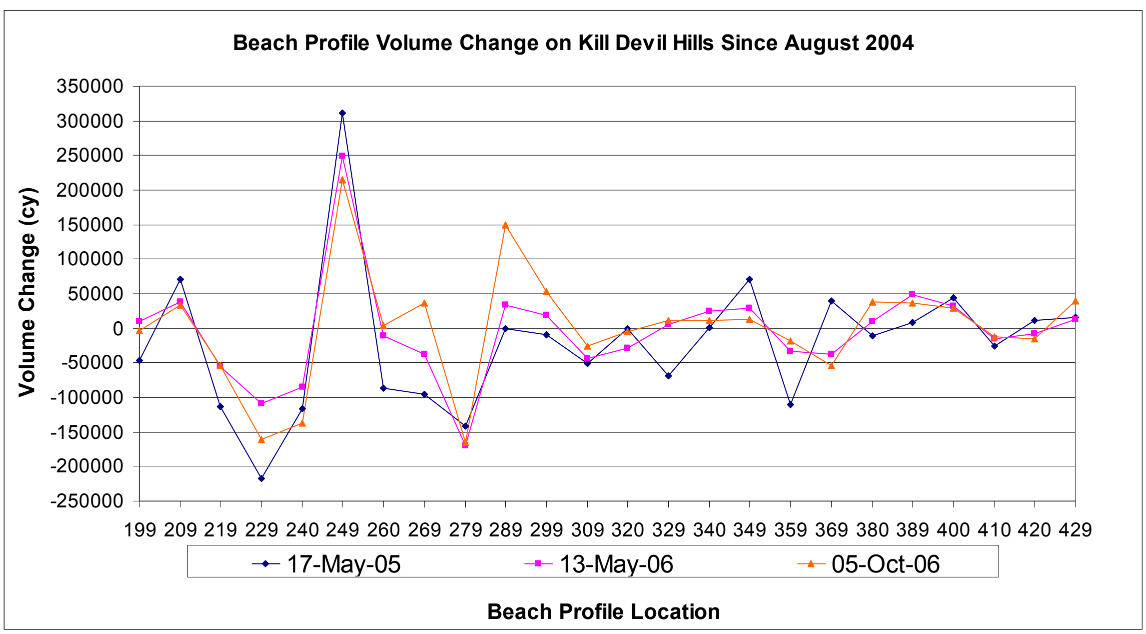

Figure 23. Beach Profile Total Volume Changes at Kill Devil Hills Since the Start of Monitoring (August 2004)

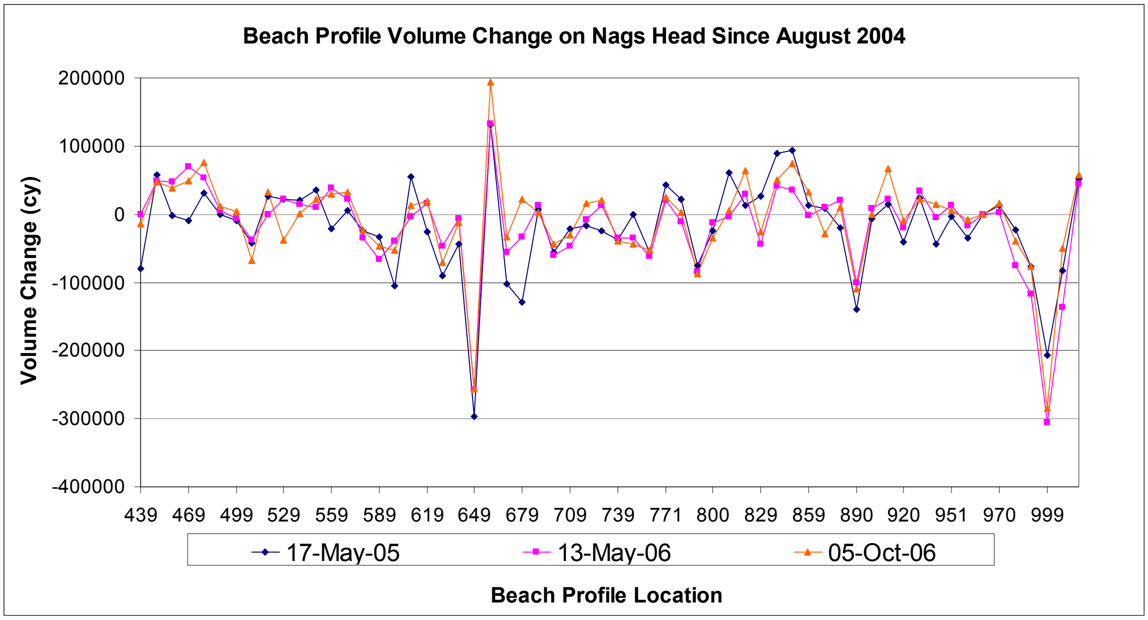

Figure 24. Beach Profile Total Volume Changes at Nags Head Since the Start of Monitoring (August 2004)

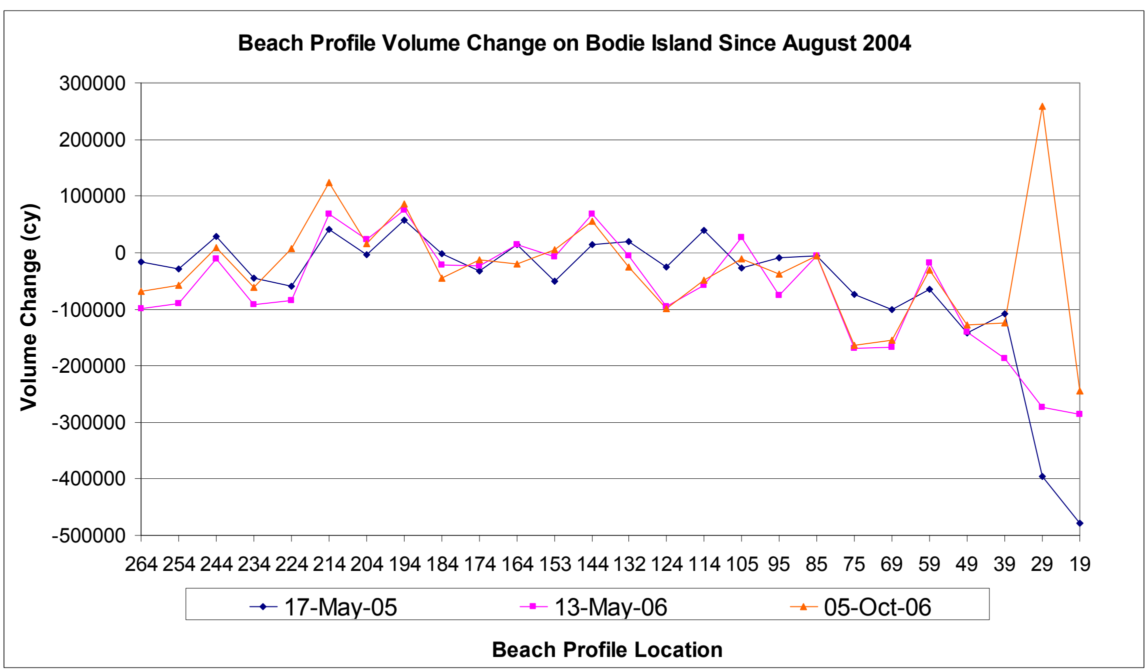

Figure 25. Beach Profile Total Volume Changes at Bodie Island Since the Start of Monitoring (August 2004)

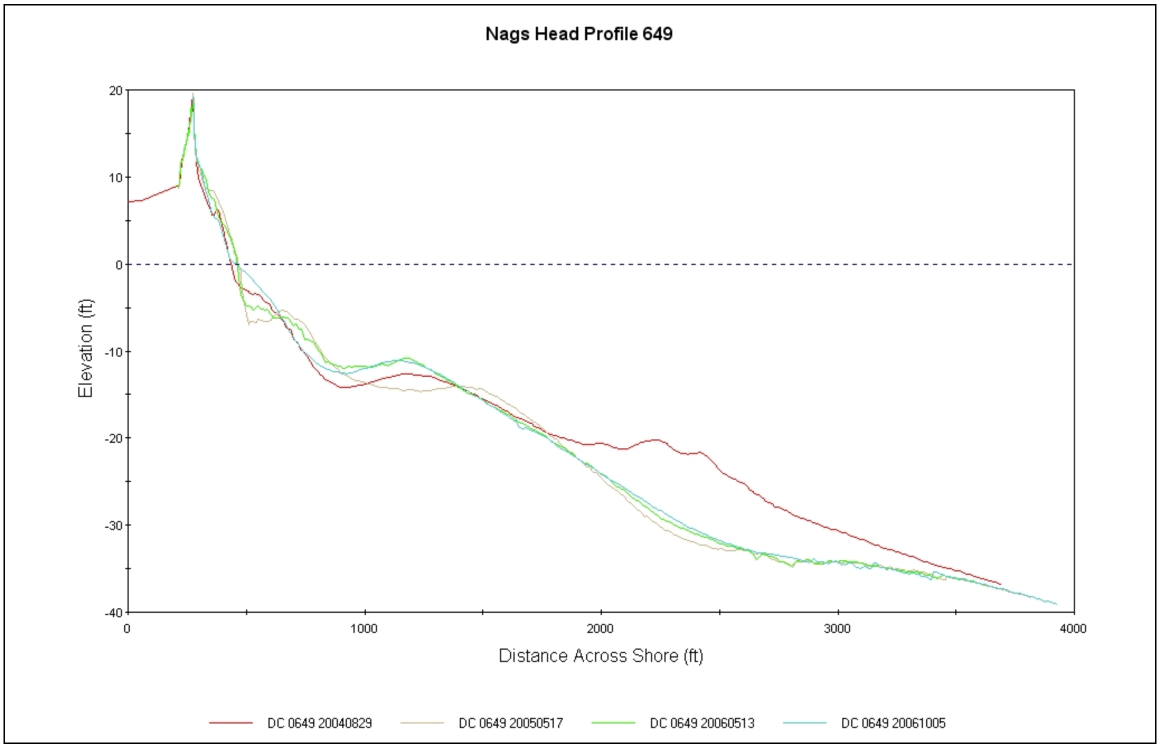

Figure 26. Extreme Total Volume Change at Profile 649

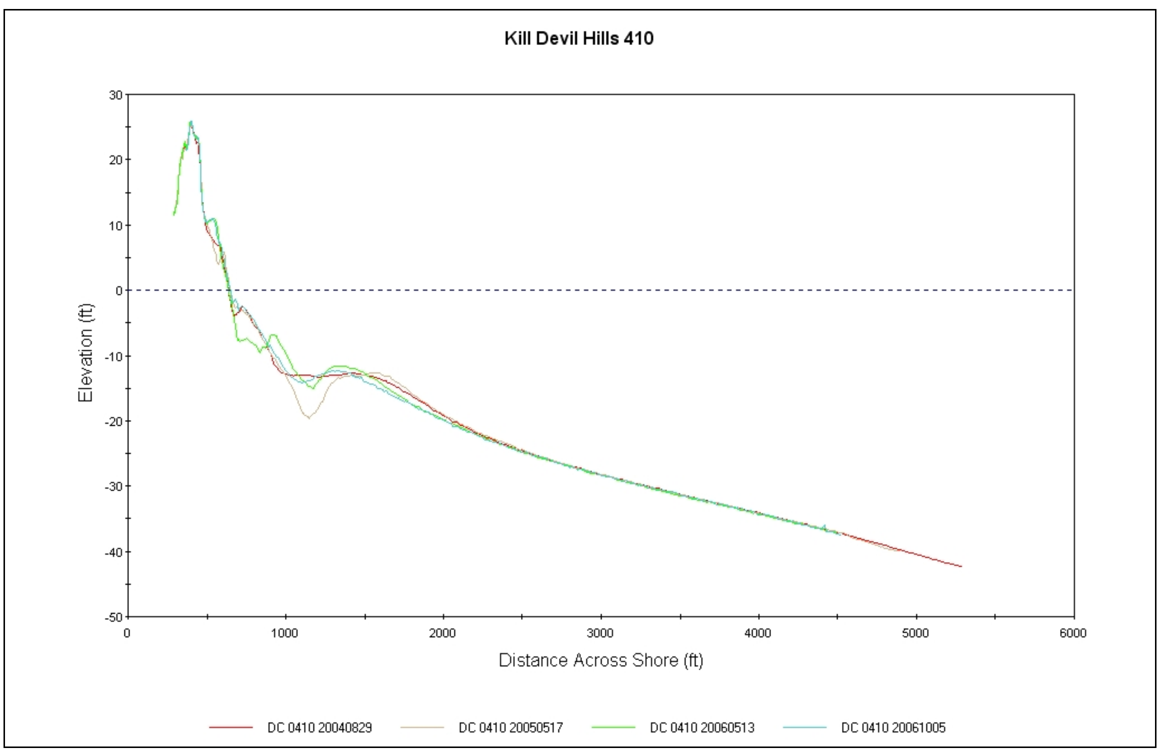

Figure 27. Extreme Total Volume Change at Profile 410

Thanksgiving 2006 Storm Analysis. The largest storm since the beginning of the physical monitoring occurred November 21st 2006, lasting approximately sixteen hours. Wave heights during the storm were as high as 17 feet with storm surge of 3.5 feet recorded at the USACE Field Research Facility in Duck, North Carolina. Just prior to the arrival of the November storm a regularly scheduled monitoring survey was taken in early October 2006. In response to the storm occurring so close to the normal monitoring survey, an additional survey was ordered in an attempt to quantify the impact of the storm on the project area. The results of the comparison are discussed below in terms of shoreline and volumetric change.

Shoreline Analysis. Shoreline change was measured by extracting the cross-shore position of the mean high water contour (1.18 feet NAVD88) for each profile from both the pre-storm and post-storm surveys. Subtracting these cross-shore position values provides a measure of the impact the storm had on the dry beach portion of the profile.

Figure 28 displays the measured change at each profile location within the monitoring area. The average shoreline change for the entire monitoring area including the control profiles located in Southern Shores was -11.4 feet. The maximum shoreline recession of 130.4 feet occurred at profile 39 in Bodie Island with the maximum shoreline advance of 78.3 feet occurring at profile 184, also in Bodie Island. The pre- and post-storm profiles for both of these locations are shown in Figures 29 and 30, respectively.

All regions located within our monitoring limits experienced an average shoreline loss. The town of Kill Devil Hills had the lowest average shoreline loss at only 1.5 feet. The Bodie Island and Nags Head portions of the island experienced the highest average shoreline loss, at 21.4 and 12.4 feet respectively. The Bodie Island portion of the monitoring area displayed two distinct ranges. The northern portion of Bodie Island, stations 164+00 through 264+00, had shoreline growth averaging 31.3 feet. In contrast, the southern portion of the town, profiles 19 through 153 experienced erosion with an average loss of 60.3 feet. For Nags Head a peak erosion of approximately 82.6 feet occurred near profile 920 in the southern portion of the town. Figures 31 and 32 show the dune overwash during the storm which resulted in shoreline erosion of approximately 24.3 feet at profile 999.

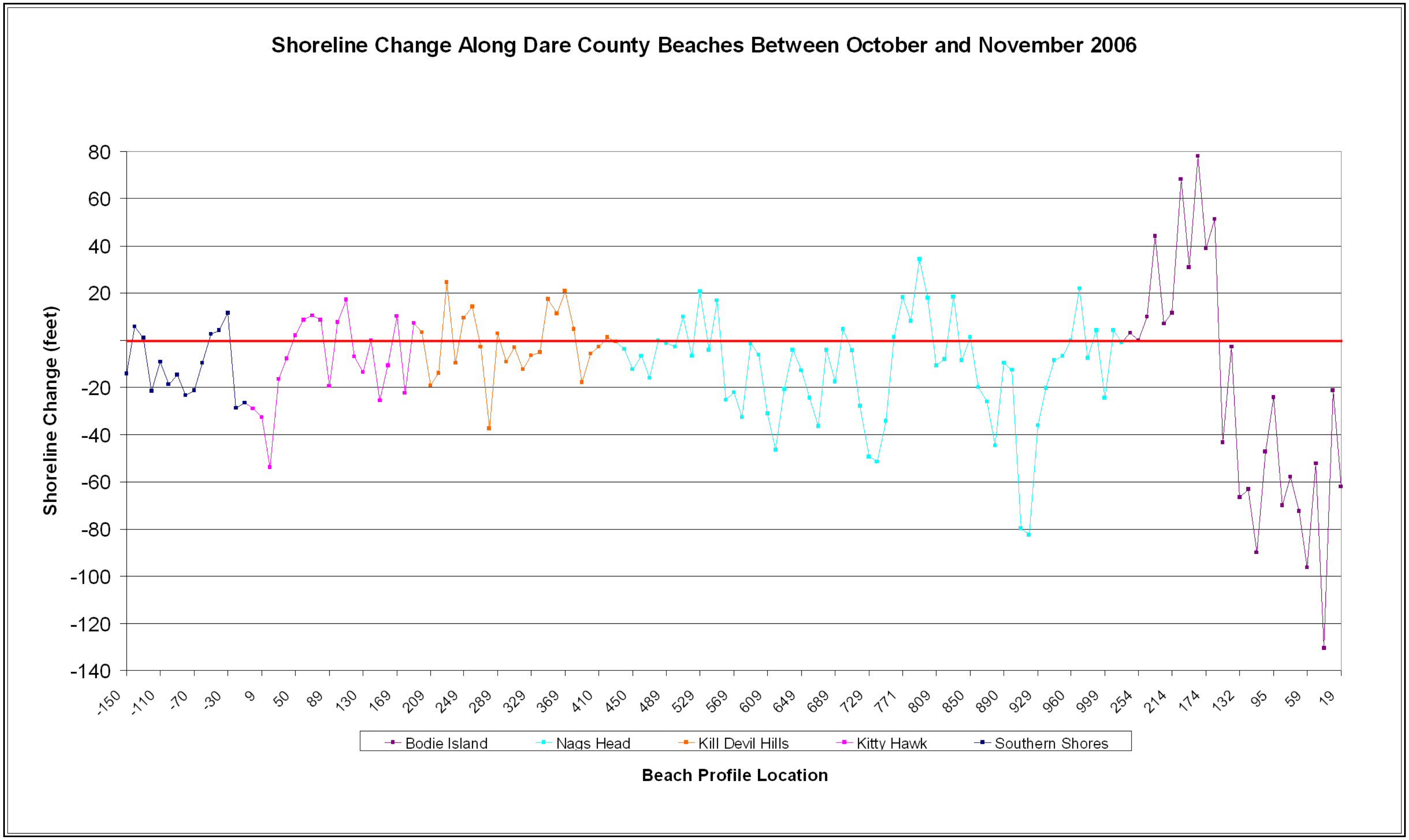

Figure 28. Shoreline Change by Profile Before and After the Thanksgiving 2006 Storm

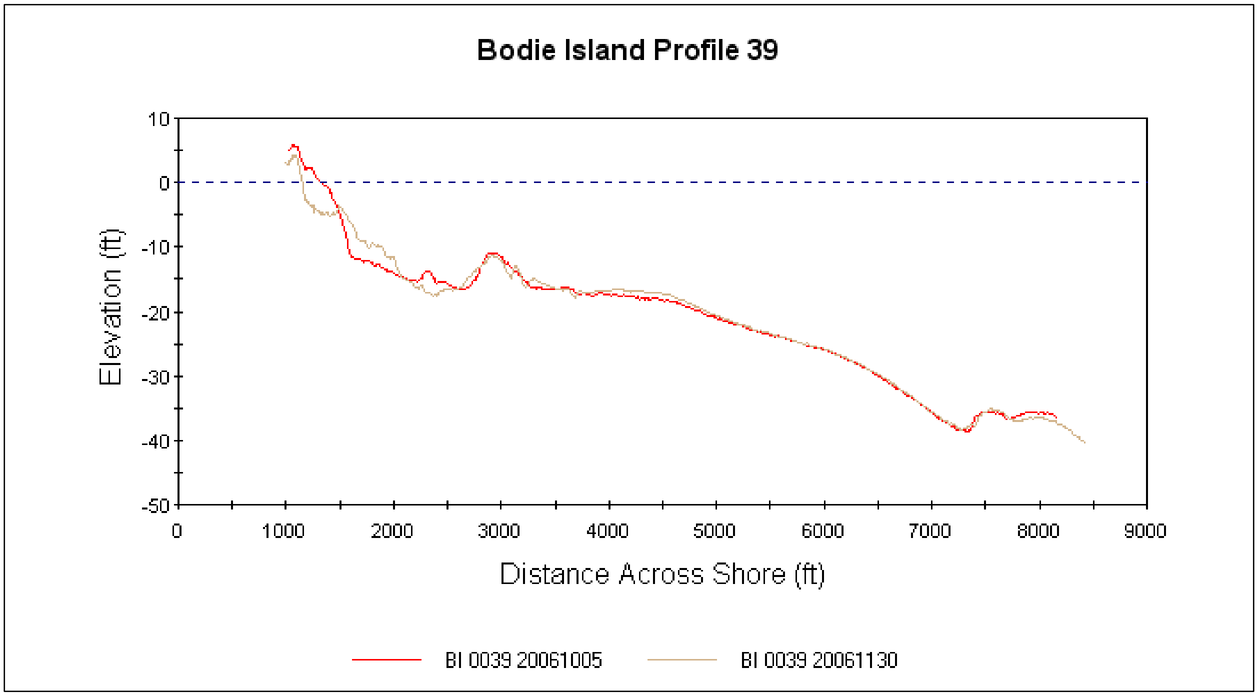

Figure 29. Bodie Island Profile 39 Before and After Storm Comparison

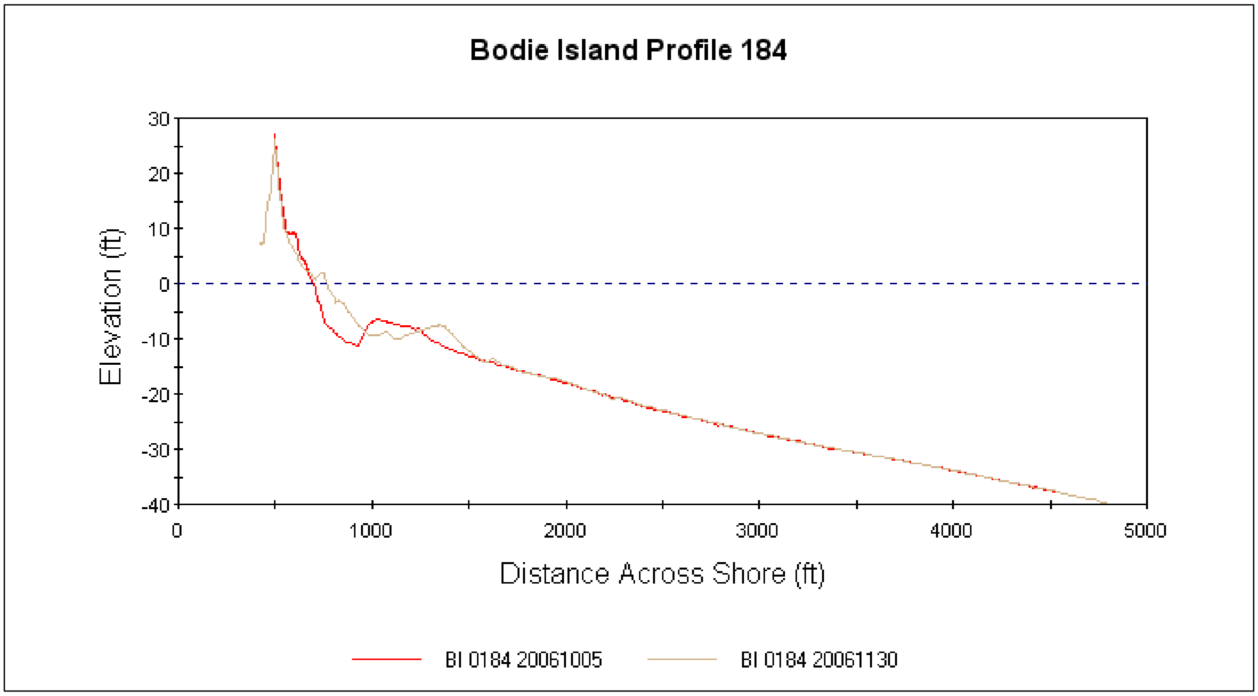

Figure 30. Bodie Island Profile 184 Before and After Storm Comparison

Figure 31. Thanksgiving 2006 Storm Inundation Near Profile 999
(Photo courtesy of Charles Rocknak)

Figure 32. Thanksgiving 2006 Storm Inundation and Overwash Near Profile 999
(Photo courtesy of Charles Rocknak)

Volumetric Analysis. The analysis of each beach profile also included volumetric changes before and after the storm. The onshore volumes are calculated from a common stable landward point to an elevation down to –2 feet NAVD88. The offshore volumes are computed to an observed closure depth for each profile line. The volumes are calculated using the BMAP program where unit volume changes are computed for each profile. The average area end method is then used between profile locations in computing the volume over the length of the monitoring area.

The onshore volumetric changes measured between the pre- and post-storm surveys are presented in Figure 33. The onshore volumetric change calculated for the entire monitoring area was -1,058,037 cubic yards. While all five regions located within the monitoring area lost material in the onshore portion of the profile, the vast majority, 899,630 cubic yards, was lost in Nags Head and Bodie Island. This onshore volume loss corresponds well to the measured shoreline change for this area. As discussed earlier in this section, these same areas had the highest measured shoreline loss.

An alternate way to describe the onshore volume loss between the pre- and post-storm surveys is a comparison of the volume lost per linear foot of beach. The Nags Head through Bodie Island portion of the beach lost an average of 10.6 cubic yards per foot of beach while the remainder of the beach, Southern Shores through Kill Devil Hills, lost only 2.7 cubic yards per foot of beach. Nags Head alone lost 8.2 cubic yards per foot while the Bodie Island region of the island lost approximately 16 cubic yards per foot.

Computing the total volume loss for the entire monitoring area shows a net loss of 1,179,477 cubic yards of material due to the November storm. A closer look at the individual profile volume changes show that the losses were spread throughout the monitoring area, however, the major losses were concentrated in the Nags Head area between stations 559+88 and 859+53. The losses in this area accounted for nearly 50% of the total losses while only representing 22% of the monitoring area. Figure 34 shows the total volumetric loss for each profile contained in the monitoring area.

Comparing the calculated total volume losses with the onshore volume losses helps illustrate the sand movement associated with the storm response. A comparison of these values, broken into town reaches and summarized in Table 3, shows that every township other than Nags Head lost less material in the total profile than it lost in the onshore portion of the profile. This would indicate that in many places the losses are less significant than the shoreline change would imply with respect to the amount of beach material lost. The material lost in the onshore for many of these profiles is simply pushed into the offshore portion of the reach. Over time the natural processes of the wave action should push this material landward and naturally rebuild a portion of the beach.

The extensive loss of material in Nags Head is not easily explained with the limited survey information available. However, it is worth noting that the average long-term shoreline change rate for the Nags Head area is the highest of all of the areas within the monitoring program. Several possibilities exist that may in part explain the movement such as: (1) Offshore bathymetric differences causing wave conditions to focus more intensely on this portion of the island, (2) Geologic differences in the makeup of the profile between the onshore and offshore portions, (3) Geologic differences between the profiles within the Nags Head hot spot and the neighboring profiles, (4) The hot spots proximity to Oregon Inlet to the south. Considering the proximity to Oregon Inlet, it is possible that material lost from within the Nags Head hot spot moved south replacing material lost from the Bodie Island region into Oregon Inlet. This would explain how the Bodie Island portion of the beach only experienced a net loss of approximately 225,000 cubic yards while the onshore portion lost approximately 415,000 cubic yards.

Location	Total Volume Change		Volume Change Above -2' NAVD88	
	(CY)	(CY/FT)	(CY)	(CY/FT)
Southern Shores	4,672	0.3	-39,232	-2.8
Kitty Hawk	-41,381	-2.1	-93,662	-4.7
Kill Devil Hills	-17,657	-0.7	-25,514	-1.1
Nags Head	-899,363	-15.2	-484,208	-8.2
Bodie Island	-225,269	-8.6	-415,421	-15.8
Entire Area	-1,178,997	-8.2	-1,058,037	-7.4

Table 3. Volume Change Summary Before and After the 2006 Thanksgiving Storm

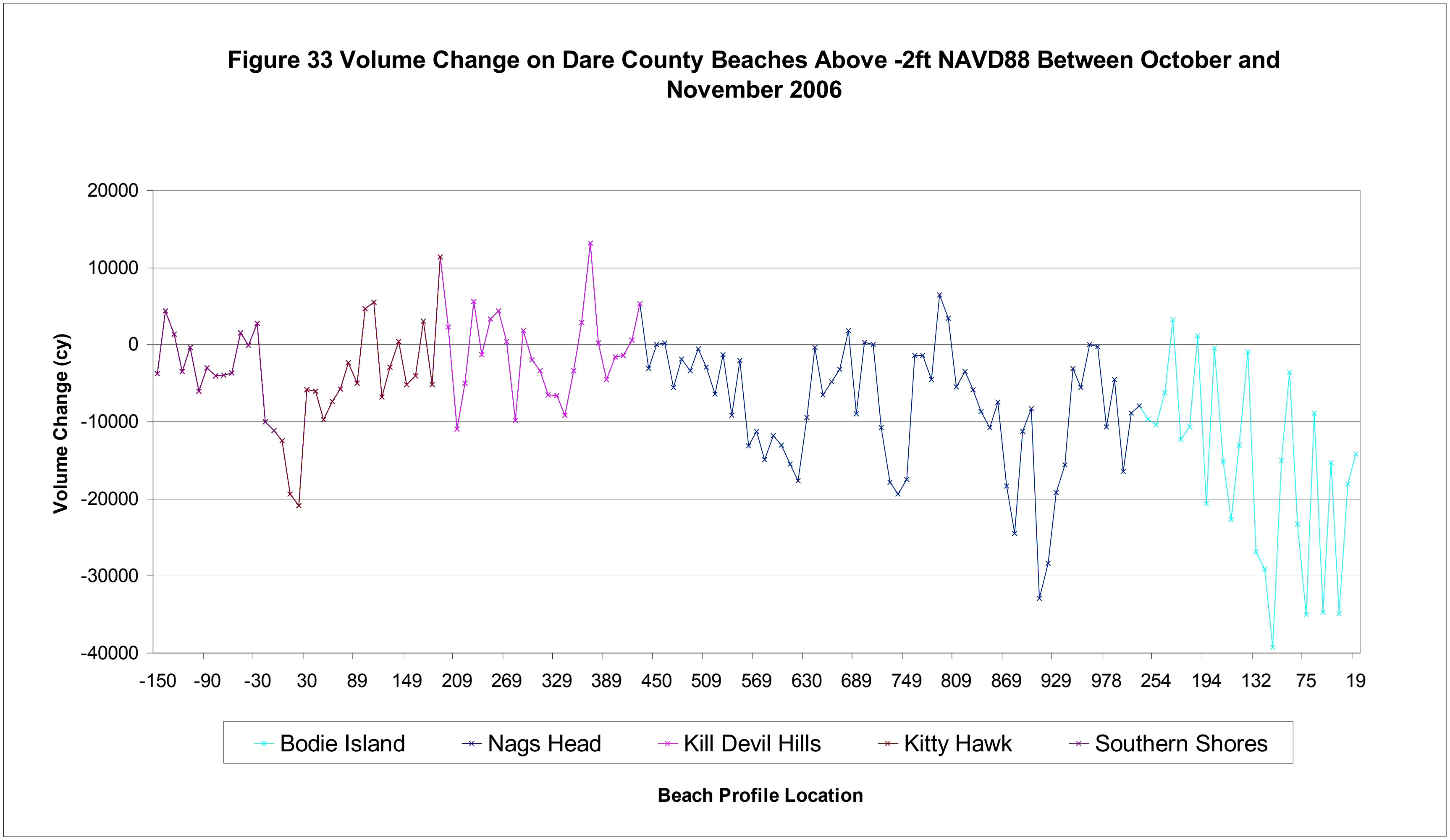

Figure 33. Onshore Volume Change by Profile Before and After the Thanksgiving 2006 Storm

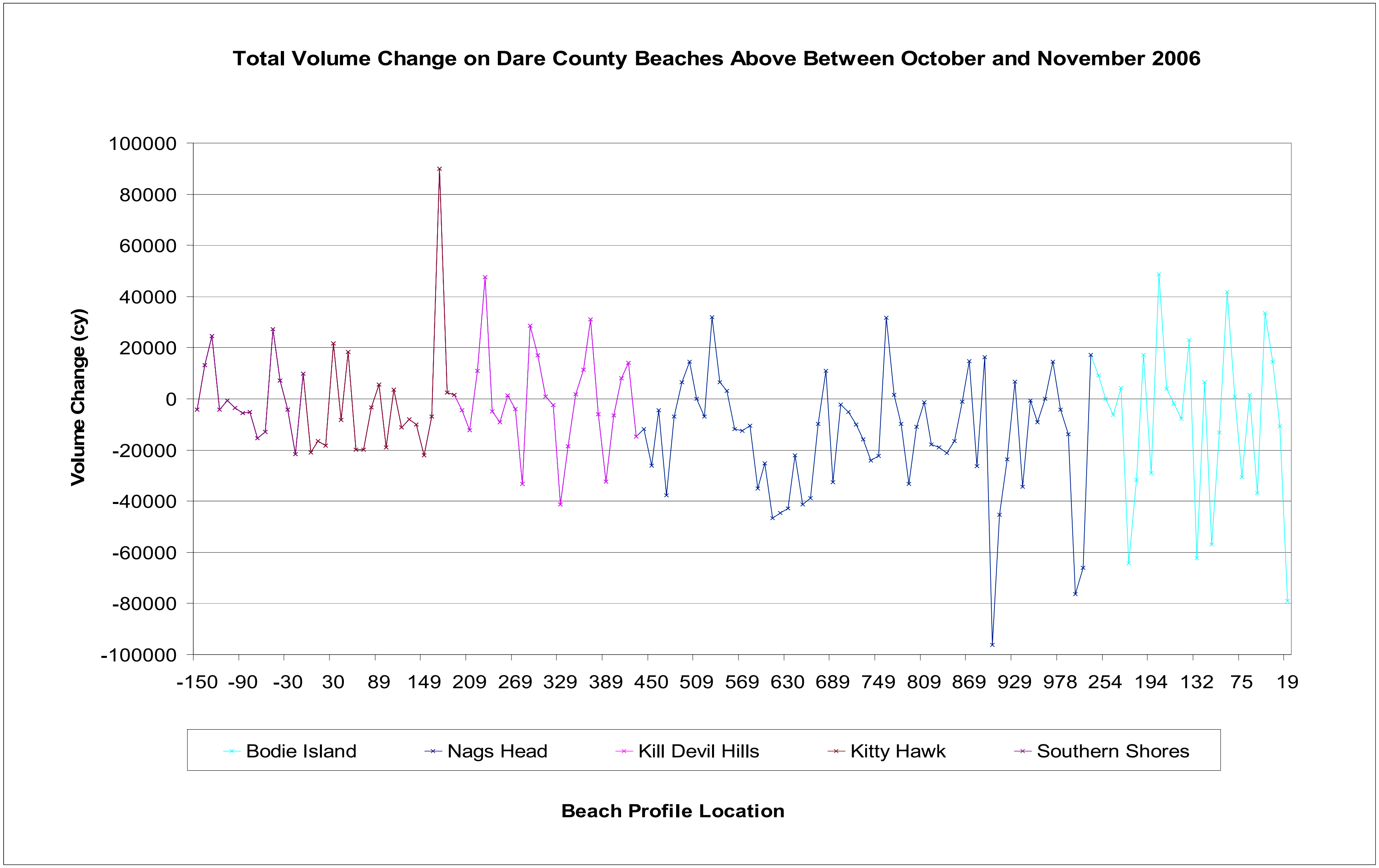

Figure 34. Total Volume Change by Profile Before and After the Thanksgiving 2006 Storm

<u>Beach Sediment Sampling and Characterization</u>. In an effort to optimize the beach fill placed as part of the Dare County Beaches Shore Protection Project and to establish the pre-project base sediment conditions, a sediment data collection and analysis was conducted as part of the monitoring program. This work was conducted by the U.S. Army Engineer Research and Development Center. This section of the monitoring report summarizes the findings in their report titled "Native Beach Characterization of a Complex Coastal Area" (Stauble, 2007) which was completed in December 2007. The report provides the techniques used to characterize the grain size of the native beach and provides an explanation behind the complicated shoreline morphology.

The grain size analysis was conducted on two data sets collected in 2004 and 2006. The first data set was collected between August and October 2004 and represents a "summer" beach cycle, while the second set was collected from April to May 2006 representing the "winter" time period. Both sediment collection efforts consisted of collecting 10 samples on 67 profile lines (see Figures 3, 4, and 5 for sediment sample locations) for a total of 1,340 samples. On each occasion samples were collected along specified elevations corresponding to typical areas of the beach such as the toe of the dune, berm crest, and mean high water location. The use of two data sets from different time periods in the seasonal cycle of the beach will help form a composite grain size and help document the natural range over the course of a season

The analysis of all 1,340 data samples show that there is high variability in the cross shore profile with the greatest inconsistency and coarsest material located between the MHW and -6 feet NAVD contours. The sand closer to the dune toe as well as the nearshore material was found to be finer sands. Further seaward of the nearshore bar the material continues to be fine grained and has become more uniform in its distribution. This cross shore distribution of the sand sizes is typical of other ocean beaches and has been documented in several previous studies (Bascom, 1959; Zarillo, et al, 1985; Stauble, 1992; Stauble and Bass, 1999).

There is considerable variability in the alongshore distribution of sand sizes as well. While the nearshore grain size distribution indicated a fine grained, well sorted sand from the control area south to Oregon Inlet, the upper beach and intertidal samples indicated more variability. The material in these areas was coarser and poorly sorted in the northern part of the study and finer more-well sorted to the south.

Due to the high variability in the berm crest and -6 feet samples along the Dare County beaches, the analysis included the creation of a beach composite for each profile that included samples of the berm crest, MHW, MSL, MLW and -6 feet location. This curve was chosen over the typical composite sample, which would include all ten samples taken in the cross shore, because of the abundance of fine well sorted sands in the typical nearshore. The typical curve for Dare County beaches would have been so influenced by the abundance of fine well sorted sands that it would not adequately identify the grain size distribution along the project.

The Dare County beaches project was divided into five zones to help identify spatial and temporal patterns on the native beach. The zones were identified as: North of Project, station -150 to -10; North Fill area, approximate stations 109 to 329; Between Fills, approximate stations 340 to 460; South Fill area, stations 489 to 1020; and South of Project, stations 265 to 29 (stationing scheme is reversed in this area of the Cape Hatteras National Seashore).

The North of Project area included sampling on 10 lines and is characterized by coarse grained poorly sorted sand with narrow beach widths and steep beach slopes. Comparing the composite grain size distribution curves within this zone does not reveal a discernable pattern in the distribution due to the high degree of variability. Peaks in the composite profiles are found in the very coarse, coarse to medium and fine sand ranges.

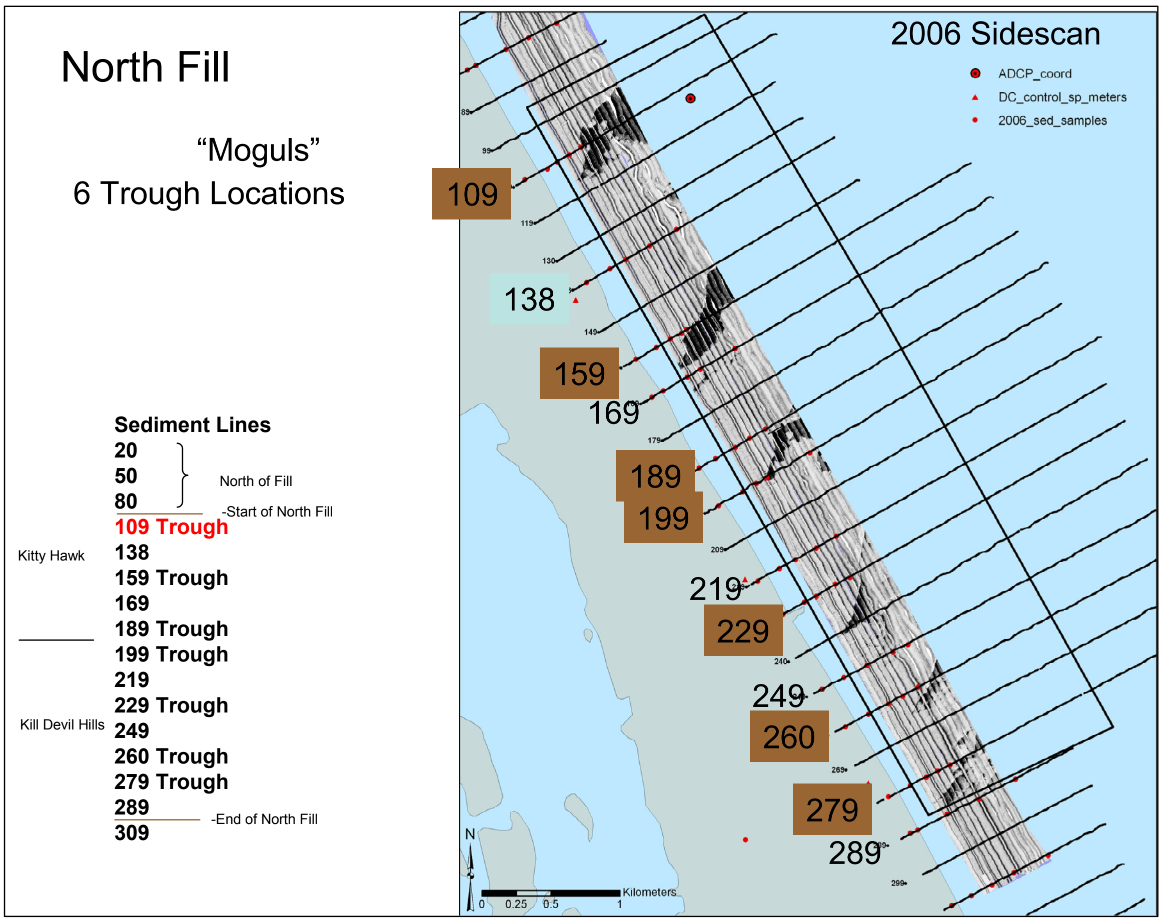

Figure 35. Map of the Nearshore Troughs in the North Fill Area

Within the North Fill area sediment samples were collected along 16 profile lines, 8 in Kitty Hawk and 8 in Kill Devil Hills. The bathymetry within this area is unique with an irregular series of six troughs that propagate from the shore in a northeast direction as shown in Figure 35. Within these troughs are coarser harder sediments than are found on the surrounding beach, of which 7 of the 16 sediment collection profile lines travel through. The North Fill area is characterized by relatively narrow steep beach slopes and indentations that correspond with these troughs. The variability of the composite profiles is dependent on the location of the sediment sample. It is influenced by the coarse material within the troughs as well as the local fills that occurred in some of these areas between 2004 and 2006. Sand sizes over this time period ranged from coarse to fine with no linear relationship to the long shore position on the beach. Material in Kill Devil Hills did become slightly finer than those samples taken in Kitty Hawk; however a high degree of variability in grain size distribution remained. Generally, the coarser beach composites are along the profile lines that transect the troughs and the finer beach composites area along the lines that transect the flat shelf.

The area extending between profiles 340 and 460 in the town of Nags Head is a stable portion of the coast line and is not included in the planned beach fill project. There are five profiles within this area of no fill where sediment samples were obtained. This will enable future comparisons and help measure the influence of the fill placed to the north and south of this area. In general this area has a more uniform offshore slope with none of the trough like areas located within this region. The 2004 and 2006 profiles show the typical differences between the surveys with the 2004 profiles containing a low tide terrace configuration and the 2006 profiles showing the characteristic trough and bar. The beach within the area is a relatively wide steep beach that is fairly straight. The profile composites are made up of two modes in grain size, very coarse and medium to fine sand. Data collected in both sample years show the distribution is very consistent with only minor changes that may be related to the differences in the sieve sets used in the two analyses or to the different profile configurations due to the times of the year that the samples were taken.

The South Fill area is the largest fill stretching between stations 489 and 1020, approximately. Sediment data were gathered on 27 profiles within this area and showed that the sediments in the South Fill area are generally finer than to the north, which leads to the flatter and wider foreshore slope. The South Fill was broken into three areas of analysis due to the size of the area. The north section of this area is from station 489 to 649 in the vicinity of Jockey's Ridge. Similar differences were observed between the 2004 and 2006 data sets with the 2004 having the low tide terrace and the 2006 having the trough and bar formations. The 2004 profiles were relatively consistent while the 2006 profiles varied in the alongshore direction. The composites in this area show a fining of material toward the south in both data sets. The majority of composite profiles were composed of medium to fine material with 4 of the 18 data sets peaking in the coarse size range.

The center section extended from profile 670 to 829 and covered the central part of Nags Head. The 2004 profiles within this section are typical of others from that data set. Although the 2006 profiles still had the trough and bar typical of this data set, the trough was typically lower than to the north. The composite set for this section was similar to the north end of the South Fill. These composite profiles were found to skew toward fine sands with only 3 of the 18 composite samples peaking in the coarse fraction range.

The southern section, profiles 850 to 1009, is located behind an offshore shoal. The 2004 profiles in this area showed more variability in the low tide terrace, while the 2006 data contained a more pronounced trough/nearshore bar relief in the nearshore. The composites in this area are all composed of fine grained material and show better sorting of grain sizes. The composites from this area are distinctly different from the North Fill and North of Project Fill which have a high percentage of coarse material.

South of the proposed project, in the Cape Hatteras National Seashore, nine profiles were monitored using sediment sampling techniques. The typical profiles in this area from the 2004 and 2006 data sets show the low tide terrace/bar trough formations which were common to these data. The sediments in the South of Project area are generally finer and similar to that of the South Fill area with less variability between the grain size distributions of the nearshore and beach samples. The composites for this area show a progressive fining toward the south in both data sets. All 18 composite profiles from both data sets indicated medium to fine sands with only 3 profiles from the 2006 showing small percentages in the coarse size range.

The use of the composite sample profiles can be used to attempt to explain anomalous shoreline behavior at some sections of the beach. Figure 36 shows a plot of the mean for the beach composite relative to the alongshore position of the profile in the study area. Patterns seen in this figure are similar between 2004 and 2006, where the composite means are coarser in the north and become finer to the south. Variations between the two graphs could be attributable to the different sieve sets used for the analysis or to seasonal variations in the data sets. As seen in Figure 36 the coarsest material is located in the North Fill area in an area that contains the ancestral Albemarle River channel (Browder and McNinch, 2006; McNinch, 2004). This river channel was filled in due to barrier island migration as the result of sea level rise. The complex morphology of the troughs in this area combined with the existing geology could be influencing the erosion rates within this zone of the beach.

This core sampling analysis effort has established a pre-fill baseline that can be used to evaluate project performance once constructed. The fill behavior can be compared to the native beach to identify re-nourishment requirements and possibly assist in improving current designs to maximize the efficacy of the project. Analysis of the sediment samples showed that, as expected, the grain size distribution in the cross shore was highly variable. Sediment analysis also showed that the long shore distribution of sand was highly variable as well. Material was typically finer in the northern areas and became progressively coarser in the south towards Oregon Inlet. However, there was considerable variability from profile to profile especially in the trough areas which typically contained very coarse material, as seen in Figure 36.

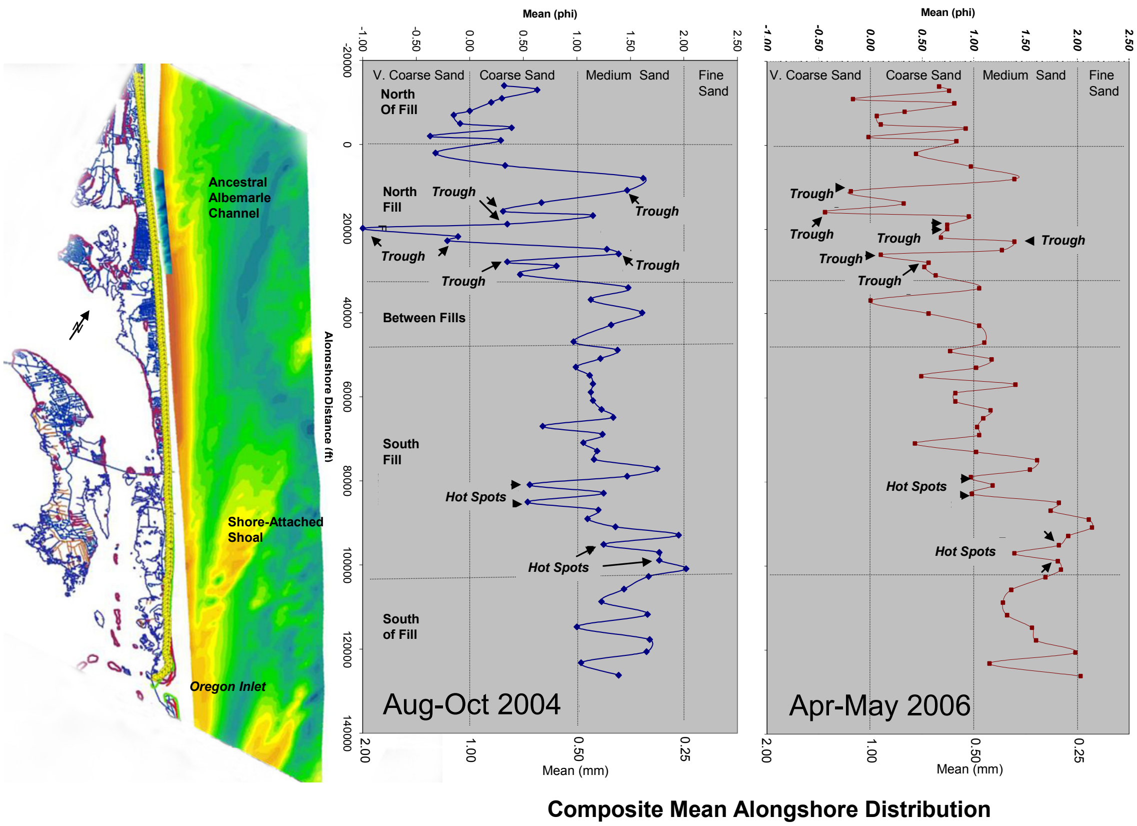

Figure 36. Alongshore Distribution of the Beach Composites for 2004 and 2006 Relative to the Project Areas.

Wave Data Analysis. An investigation of wave conditions at the project site is being conducted as part of the Dare County physical monitoring program through the use of a wave gauge presently located at the north end of the project offshore of Kitty Hawk. In this section, the wave data collected to date are presented through relative comparisons over time and with the most recent data from the Wave Information Studies (WIS) epoch (1980-1999) for the nearest WIS location (219). Significant wave events are also identified for the initial 3-year monitoring period.

Wave Gauge Analysis. Directional wave, water level, and current data are collected at one nearshore location as shown in Figure 37 near profile 109. Water depth at this location is approximately 48 feet. The gauge location was chosen to be just landward of one of the proposed offshore borrow areas, N1, to provide a representative wave climate prior to dredging. Future reports will use this pre-project wave climate to compare with the post-project wave climate to help determine any impacts including wave height and wave direction changes. The deployed gauge is a bottom mounted Acoustic Doppler Current Profiler (ADCP) accompanied by a pressure transducer. Directional wave spectra are calculated from time series of velocity at various depths obtained by the ADCP. Corresponding significant wave height Hm0, peak period Tp, and peak direction Dp parameters are determined from the directional spectrum. Peak frequency represents the highest energy density in the frequency spectrum integrated over all directions. Peak direction is determined as the vector mean at the peak frequency and is referenced to meteorological convention where due north is set at 0 degrees. Wave direction represents the direction from which the wave is coming, i.e. a direction of 90 degrees indicates a wave approaching from due east. Water level is determined from the pressure transducer record. Time series of current velocity at the surface, mid-depth, and bottom are also provided from the ADCP gauges. The Kitty Hawk gauge currently collects 20-min time series at 3-hr intervals.

Since the gauges initial deployment in March 2004, it has operated consistently with only two significant outages. The gauge experienced a two month data gap between May 2005 and July 2005 as well as a two month data gap between March 2006 and May 2006. In addition to these major data gaps, there were several minor gaps ranging from hours to several days.

Wave Climate. The wave data were analyzed using the Coastal Engineering Design and Analysis System (CESAS), Nearshore Evolution Modeling System (NEMOS) software (NEMOS 2000). Table 4 summarizes the mean monthly conditions for the nearshore gauge from March 2004 to June 2007. The table includes the mean monthly wave height, period and direction (Hsmean, Tpmean & Dpmean). The average annual wave height (Hsmean) observed for the Kitty Hawk gauge over the entire deployment period was 3.0 feet. In addition to determining average wave conditions, the monthly time series for all gauges were analyzed to determine the maximum wave height (Hsmax). The associated peak period (Tpmax) and wave direction (Dpmax) with each event were also computed. The Kitty Hawk gauge had maximum monthly wave heights on the order of 8.5 feet, with waves typically arriving from the northeast to east southeast directions.

The seasonality of the wave climate is illustrated in Figure 38. This graph shows the mean monthly wave heights for all the data collected to date (2004-2007) for the Kitty Hawk gauge. The largest waves are found to occur between September and April averaging 3.4 feet, reflecting the influence of the winter northeasters and fall tropical storms. Wave heights during the remainder of the year averaged 2.2 feet. The seasonality of the waves can also be seen in Figure 39 which is a plot of mean monthly wave direction for each gauge. When comparing these two figures it is clear that there is a direct relationship between the wave direction and the average wave height. The fall and winter months where the higher wave heights are recorded have an average wave direction of 77.2 degrees, whereas in the late spring and summer months where the lower wave heights are recorded the wave direction is coming from almost due east at an average angle of 93.5 degrees.

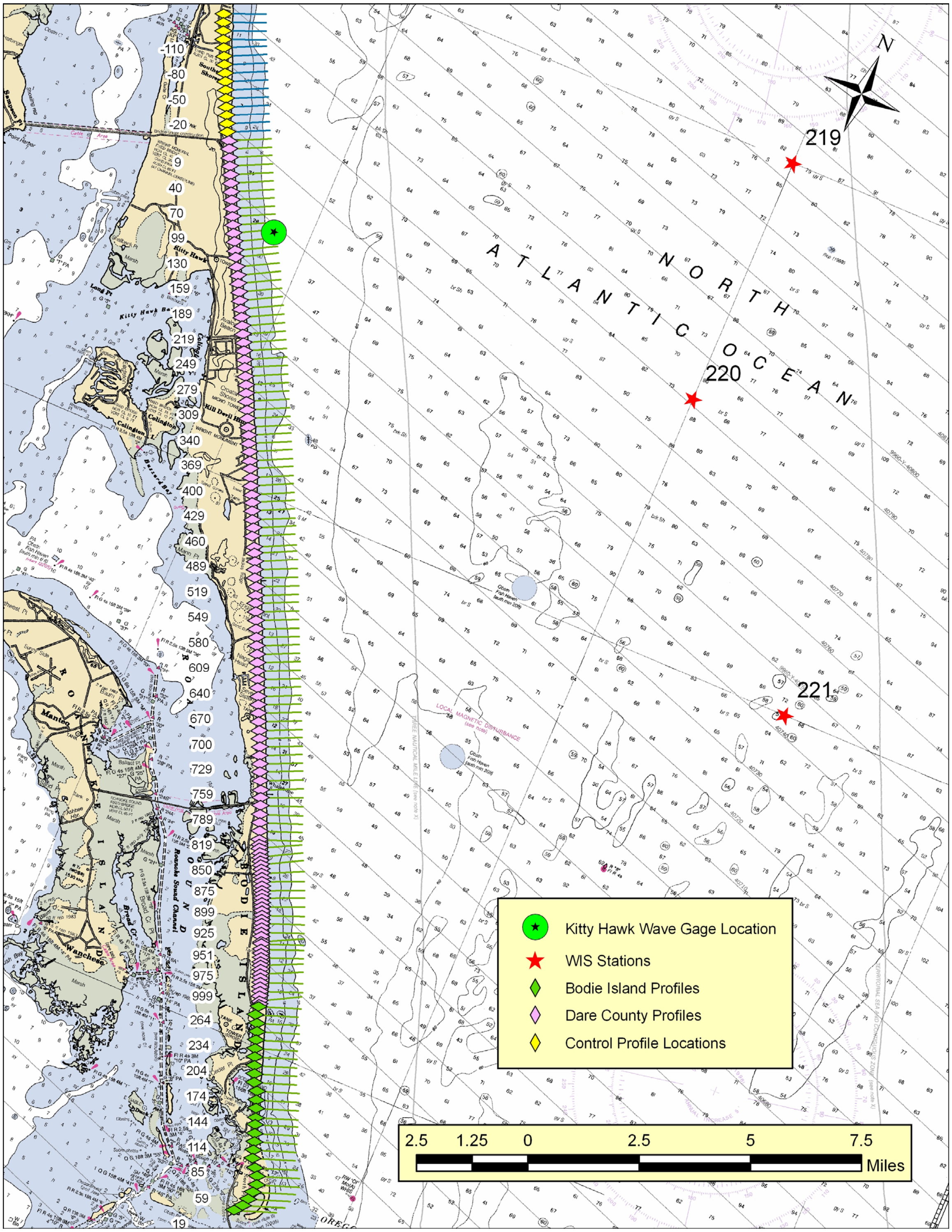

Figure 37. FRF and WIS Wave Gauge Locations

Table 4. Kitty Hawk Gauge Monthly Summaries

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Kitty Hawk	HsMax	2004			9.6	4.9	5.7	7.1	4.2	11.3	11.4	10.2	10.0	10.8	**8.5**
Kitty Hawk	HsMax	2005	9.7	13.4	7.5	13.9	2.9		3.8	4.4	9.1	12.0	7.5	7.6	**8.3**
Kitty Hawk	HsMax	2006	9.2	10.8	7.4		2.6	5.7	5.1	9.2	9.2	8.5	21.2	7.8	**8.8**
Kitty Hawk	HsMax	2007	7.6	9.3	8.5	6.4	16.7	7.5							**9.3**
	AVERAGE		**8.8**	**11.2**	**8.3**	**8.4**	**7.0**	**6.8**	**4.4**	**8.3**	**9.9**	**10.2**	**12.9**	**8.7**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Kitty Hawk	DpMax	2004			60.0	359.0	66.0	28.0	103.0	71.0	30.0	79.0	27.0	63.0	**88.6**
Kitty Hawk	DpMax	2005	79.0	68.0	31.0	84.0	19.0		59.0	108.0	106.0	88.0	35.0	63.0	**67.3**
Kitty Hawk	DpMax	2006	56.0	69.0	42.0		28.0	101.0	80.0	58.0	70.0	26.0	111.0	24.0	**60.5**
Kitty Hawk	DpMax	2007	52.0	35.0	71.0	80.0	99.0	112.0							**74.8**
	AVERAGE		**62.3**	**57.3**	**51.0**	**174.3**	**53.0**	**80.3**	**80.7**	**79.0**	**68.7**	**64.3**	**57.7**	**50.0**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Kitty Hawk	HsMean	2004			5.1	2.3	1.9	2.1	1.9	2.5	4.0	3.6	3.2	2.9	**3.0**
Kitty Hawk	HsMean	2005	4.0	4.4	3.0	3.6	1.9		1.8	2.3	4.4	4.3	3.1	3.1	**3.3**
Kitty Hawk	HsMean	2006	3.3	2.6	2.7		1.4	2.2	2.0	2.0	3.4	3.2	4.8	2.5	**2.7**
Kitty Hawk	HsMean	2007	2.8	2.8	3.1	2.7	3.5	2.6							**2.9**
	AVERAGE		**3.4**	**3.3**	**3.5**	**2.9**	**2.2**	**2.3**	**1.9**	**2.3**	**3.9**	**3.7**	**3.7**	**2.8**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Kitty Hawk	TpMax	2004			12.8	12.8	25.6	25.6	25.6	25.6	16.0	14.2	16.0	25.6	**20.0**
Kitty Hawk	TpMax	2005	25.6	14.2	16.0	14.2	10.6		25.6	12.8	11.6	12.8	25.6	25.6	**17.7**
Kitty Hawk	TpMax	2006	25.6	25.6	14.2		14.2	16.0	10.6	25.6	14.2	16.0	12.8	10.6	**16.9**
Kitty Hawk	TpMax	2007	25.6	25.6	25.6	25.6	16.0	25.6							**24.0**
	AVERAGE		**25.6**	**21.8**	**17.2**	**17.5**	**16.6**	**22.4**	**20.6**	**21.3**	**13.9**	**14.3**	**18.1**	**20.6**	

(Continued)

Table 4. Kitty Hawk Gauge Monthly Summaries (Continued)

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Kitty Hawk	TpMean	2004			10.0	8.0	8.4	7.7	8.0	8.2	9.0	10.0	8.8	8.8	**8.7**
Kitty Hawk	TpMean	2005	8.9	9.0	9.0	9.2	7.1		8.8	8.8	8.1	8.2	8.6	7.8	**8.5**
Kitty Hawk	TpMean	2006	8.9	8.5	7.3		7.1	8.3	8.1	8.9	9.8	8.9	8.8	7.6	**8.4**
Kitty Hawk	TpMean	2007	7.7	7.7	8.4	8.2	8.3	9.3							**8.3**
	AVERAGE		**8.5**	**8.4**	**8.7**	**8.5**	**7.7**	**8.4**	**8.3**	**8.6**	**9.0**	**9.0**	**8.7**	**8.1**	

GAGE	STAT	YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVERAGE
Kitty Hawk	Dpmean	2004			74.2	82.7	92.9	78.9	94.0	81.3	77.8	68.9	70.3	72.6	**79.4**
Kitty Hawk	Dpmean	2005	66.5	68	67.7	77.9	83.4		101.6	100	91.5	64.3	91.7	77.2	**80.9**
Kitty Hawk	Dpmean	2006	85.8	70.3	61.6		99	97.4	102.6	91.1	80.4	74.1	83.4	86.5	**84.7**
Kitty Hawk	Dpmean	2007	79.5	79.9	87.7	86.2	101.2	92.5							**87.8**
	AVERAGE		**77.3**	**72.7**	**72.8**	**82.3**	**94.1**	**89.6**	**99.4**	**90.8**	**83.2**	**69.1**	**81.8**	**78.8**	

NOTE: Wave Height (HsMax, HsMean) Units are feet, Wave Period (TpMax, TpMean) Units are seconds, Wave Direction (DpMax, DpMean) are meteorological (deg North, from).
-- denotes no data or missing data. ** denotes suspect wave period measurements.

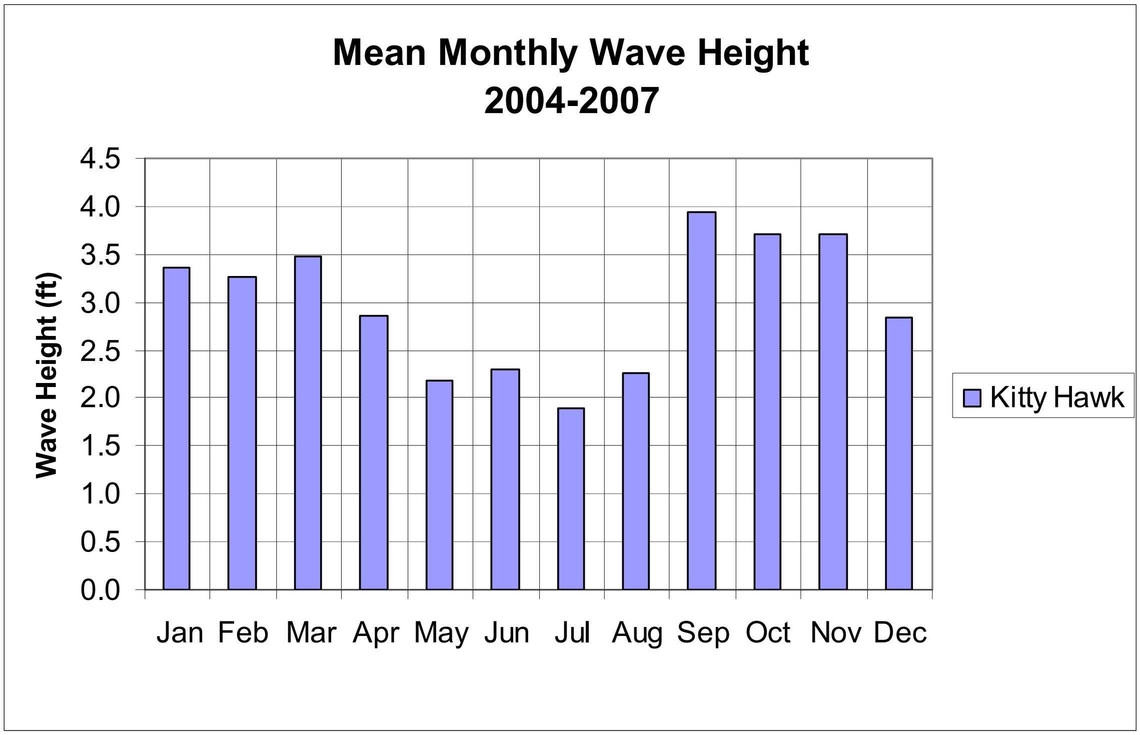

Figure 38. Mean Monthly Wave Height 2004-2007 for the Kitty Hawk Gauge

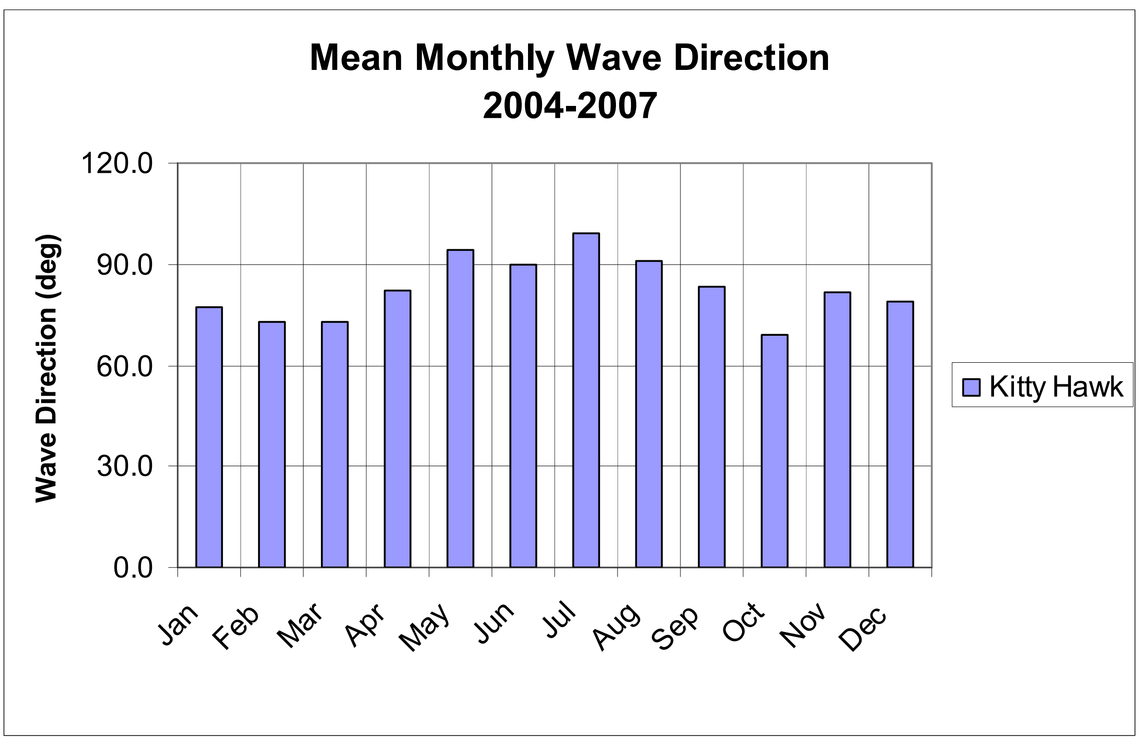

Figure 39. Mean Monthly Wave Direction 2004-2007 for the Kitty Hawk Gauge

Further insight into the wave climate at the Kitty Hawk gauge location is given in Figures 40 and 41. Figure 38 shows the wave histogram that was created using all available data between March 2004 and June 2007. Figure 41 shows the wave rose that was generated for this same time period. Dominate wave direction is coming from the east and east southeast directions with a smaller but significant percentage coming from the northeast.

Time series for the Kitty Hawk gauge were separated into yearly components and analyzed to assess the statistical variation in wave climate. Annual wave height roses for 2004, 2005, 2006, and 2007 were generated and are given in Appendix A. The year to year comparison of the roses shows very similar patterns in the distribution of wave height and direction. The only significant changes noted are the year to year fluctuation of wave percentages coming from the northeast direction, however, waves coming from an easterly direction dominate through all years.

Figures 42 and 43 give the yearly mean wave height and direction for the Kitty Hawk gauge during the current monitoring period. Yearly mean wave height varies from a low of 2.7 feet in 2006 to a high of 3.3 feet in 2005. Both of these extremes are within 10 percent of the average annual wave height for the entire monitoring period which is 3.0 feet. With regard to the yearly variation in terms of mean wave direction there is little variation from the average of 83.2 degrees.

Significant Events. Several large storm events occurred during the monitoring period that may have significantly altered beach shorelines and profiles. An analysis was conducted to identify storm event parameters that exceeded a 6-foot significant wave height threshold with a minimum duration of 12 hours. Events were selected through screening of the Kitty Hawk gauge time series and are summarized in Table 5. In total there were 38 events that exceeded the set criteria over the entire monitoring period. Events were spread throughout the year, however, the months of May through August contained the fewest number of significant events. Waves originated from between the north-northeast to the east-southeast, with an average angle of 66.1 degrees. Offshore wave heights for these significant events ranged from 6.4 to 21.2 feet with wave periods from 5.5 to 14.2 seconds. The peak wave height of 21.2 feet occurred during what is known as the “Thanksgiving Storm” of November 2006. Surveys were taken just prior to and just after this storm and further analysis of its impact on the beach is contained in the Shoreline Analysis section of this report.

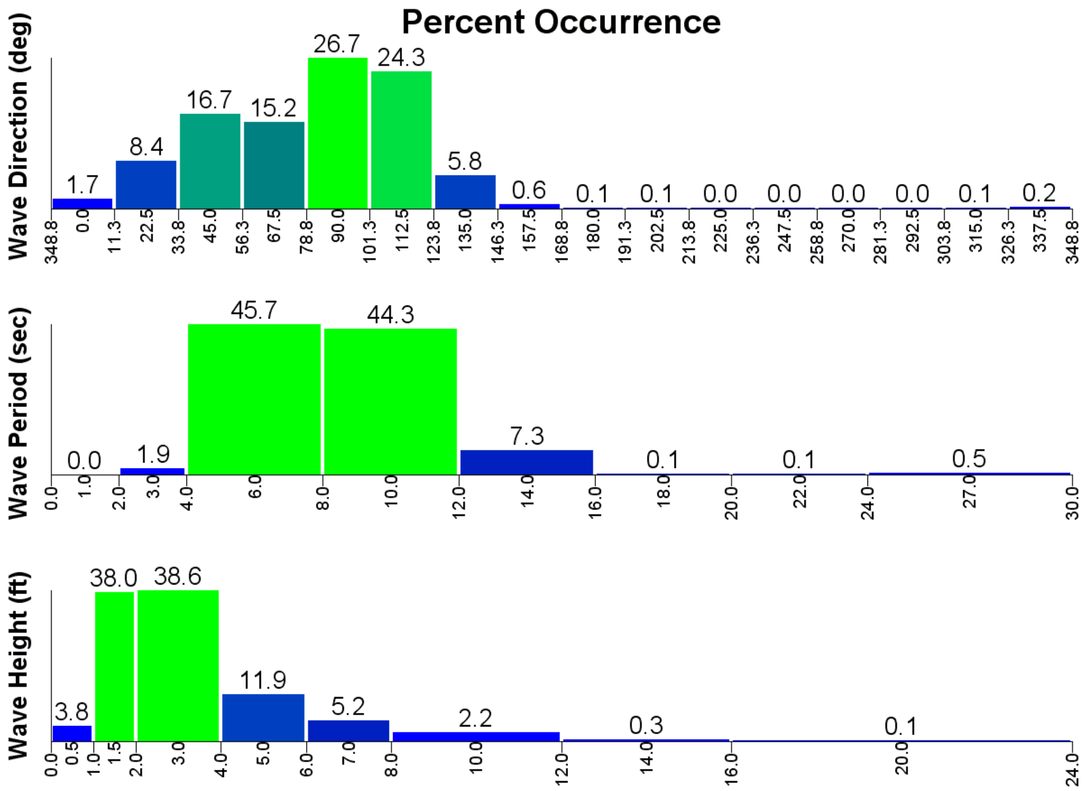

Figure 40. Kitty Hawk Gauge Histogram Throughout Deployment

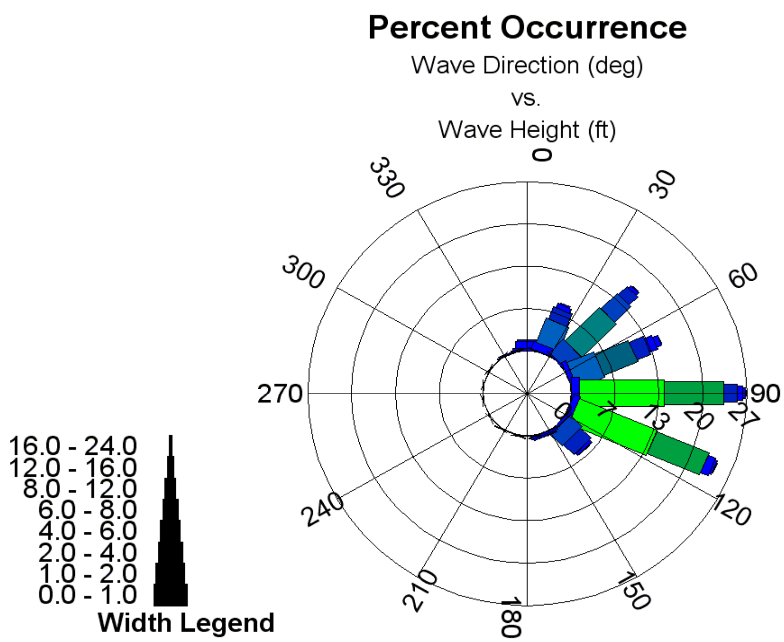

Figure 41. Kitty Hawk Gauge Wave Height Rose Throughout Deployment

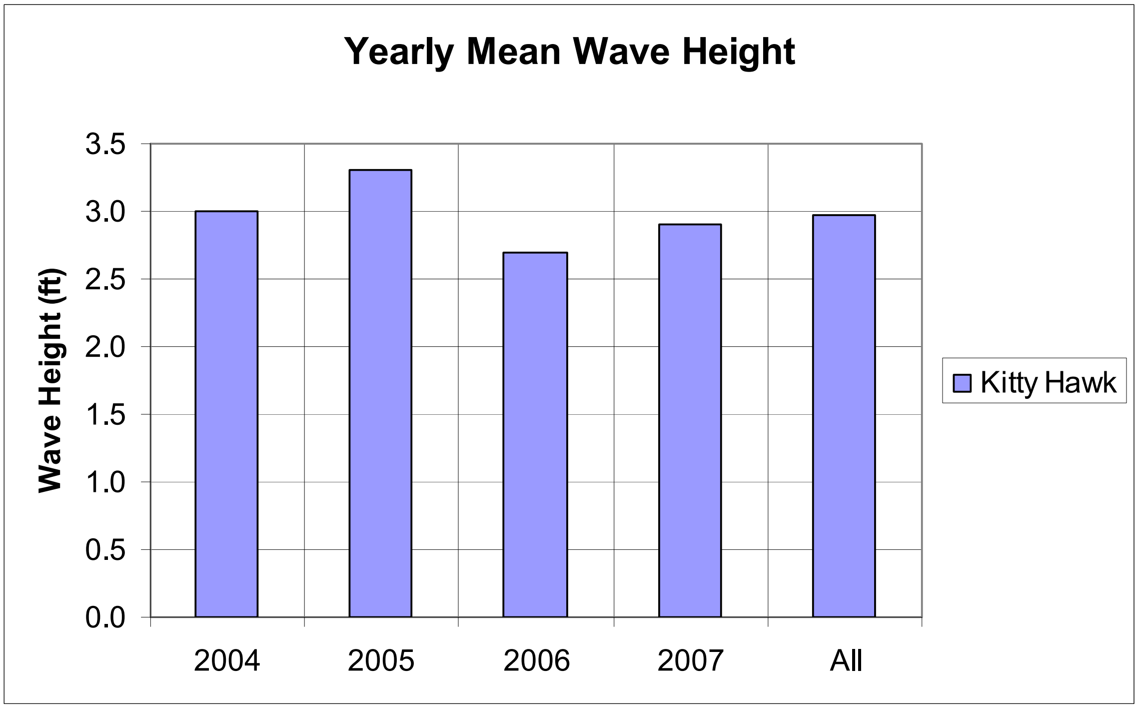

Figure 42. Yearly mean Wave Heights for Years 2004 through 2007

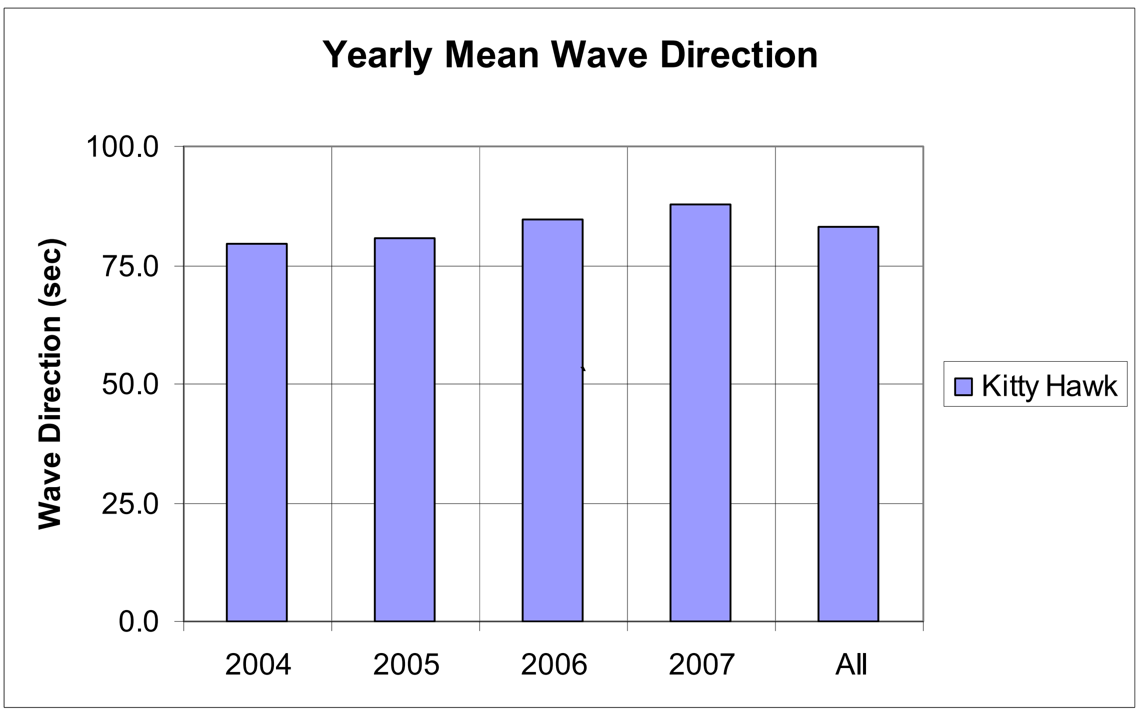

Figure 43. Yearly Mean Wave Directions for Years 2004 through 2007

EVENT	START DATE	TIME	STOP DATE	TIME	Dur (hrs)	Kitty Hawk				
						Hs (feet)	Tp (sec)	Dp (deg)	DATE PEAK	TIME
1	28-Mar-04	16:00:00	30-Mar-04	16:00:00	48	9.6	10.6	60	29-Mar-04	1:00:00
2	3-Aug-04	16:00:00	6-Aug-04	13:00:00	69	11.3	6.4	71	3-Aug-04	16:00:00
3	2-Sep-04	19:00:00	6-Sep-04	4:00:00	81	7.1	12.8	93	3-Sep-04	4:00:00
4	18-Sep-04	22:00:00	20-Sep-04	22:00:00	48	11.4	8.5	30	19-Sep-04	7:00:00
5	20-Oct-04	19:00:00	26-Oct-04	19:00:00	144	10.2	14.2	79	24-Oct-04	10:00:00
6	13-Nov-04	7:00:00	14-Nov-04	19:00:00	36	9.8	9.8	51	13-Nov-04	13:00:00
7	27-Nov-04	22:00:00	29-Nov-04	10:00:00	36	8.1	8.5	108	28-Nov-04	1:00:00
8	24-Dec-04	1:00:00	28-Dec-04	13:00:00	108	10.8	12.8	63	27-Dec-04	13:00:00
9	14-Jan-05	16:00:00	18-Jan-05	13:00:00	93	9.7	9.1	79	16-Jan-05	16:00:00
10	23-Jan-05	16:00:00	24-Jan-05	16:00:00	24	8.7	7.5	47	24-Jan-05	1:00:00
11	27-Jan-05	7:00:00	8-Feb-05	10:00:00	291	10.3	14.2	79	4-Feb-05	19:00:00
12	24-Feb-05	10:00:00	25-Feb-05	10:00:00	24	9.4	8	88	24-Feb-05	16:00:00
13	28-Feb-05	7:00:00	28-Feb-05	22:00:00	15	13.4	10.6	68	28-Feb-05	13:00:00
14	17-Mar-05	4:00:00	18-Mar-05	1:00:00	21	7.5	7.5	31	17-Mar-05	16:00:00
15	9-Apr-05	13:00:00	10-Apr-05	13:00:00	24	8.3	9.1	73	10-Apr-05	7:00:00
16	13-Apr-05	16:00:00	17-Apr-05	19:00:00	99	13.9	10.6	80	15-Apr-05	16:00:00
17	5-Sep-05	13:00:04	7-Sep-05	19:00:04	54	8.7	8.0	66	6-Sep-05	4:00:00
18	10-Sep-05	10:00:04	12-Sep-05	1:00:04	39	8.3	8.5	94	11-Sep-05	10:00:00
19	15-Sep-05	4:00:04	16-Sep-05	16:00:04	36	9.1	9.8	106	16-Sep-05	4:00:00
20	24-Oct-05	10:00:04	25-Oct-05	19:00:04	33	12.0	9.1	88	24-Oct-05	22:00:00
21	10-Nov-05	16:00:04	11-Nov-05	7:00:04	15	6.9	6.7	57	10-Nov-05	16:00:04
22	17-Nov-05	4:00:04	18-Nov-05	7:00:04	27	7.5	6.7	35	17-Nov-05	7:00:00
23	5-Dec-05	1:00:04	6-Dec-05	13:00:04	36	7.6	6.4	63	5-Dec-05	4:00:00
24	3-Jan-06	22:00:04	6-Jan-06	13:00:04	63	7.7	7.1	33	4-Jan-06	1:00:00
25	15-Jan-06	1:00:04	15-Jan-06	19:00:04	18	9.2	8.0	56	15-Jan-06	7:00:00
26	22-Jan-06	4:00:04	22-Jan-06	16:00:04	12	7.7	6.7	41	22-Jan-06	7:00:00
27	26-Jan-06	10:00:04	27-Jan-06	10:00:04	24	6.5	6.7	41	26-Jan-06	13:00:00
28	26-Feb-06	4:00:04	26-Feb-06	22:00:04	18	10.8	8.0	69	26-Feb-06	10:00:00
29	31-Aug-06	16:00:04	1-Sep-06	13:00:04	22	9.2	7.1	58	31-Aug-06	22:00:00
30	11-Sep-06	4:00:04	14-Sep-06	1:00:04	69	8.9	14.2	77	13-Sep-06	7:00:00
31	6-Oct-06	16:00:04	9-Oct-06	7:00:04	63	8.5	8.5	26	6-Oct-06	22:00:00
32	21-Nov-06	7:00:03	24-Nov-06	22:00:03	87	21.2	9.8	111	22-Nov-06	7:00:00
33	8-Dec-06	1:00:04	8-Dec-06	13:00:04	12	7.8	7.1	24	8-Dec-06	4:00:00
34	16-Jan-07	22:00:04	17-Jan-07	13:00:04	15	7.6	7.1	52	17-Jan-07	7:00:00
35	18-Apr-07	7:00:05	19-Apr-07	19:00:05	12	6.4	11.6	80	19-Apr-07	16:00:00
36	6-May-07	10:00:06	8-May-07	22:00:06	60	16.7	12.8	99	7-May-07	13:00:00
37	18-May-07	7:00:06	19-May-07	4:00:06	21	7.6	8.0	96	18-May-07	19:00:00
38	14-Jun-07	1:00:06	15-Jun-07	1:00:06	24	7.0	5.5	41	14-Jun-07	7:00:00

Table 5. Significant Events at Kitty Hawk Gauge Exceeding Significant Wave Height of 6 feet for 12 Hours

WIS Hindcasts. To determine changes in the wave climate between offshore areas and the local Kitty Hawk gauge an analysis of an offshore WIS station was made. This analysis illustrates the sheltering and wave transformation that occurs between the offshore and nearshore locations.

The Wave Information Studies (WIS) project has developed wave information along U.S. coasts by computer simulation of past wind and wave conditions. This type of simulation is termed hindcasting. The hindcast data provide a valuable source of decades-long wave data needed in coastal engineering design, at dense spatial resolution and at a level of temporal continuity not available from field measurements. The most recent hindcast information consists of a 20-yr continuous time series from 1980-1999. Time series of bulk wave parameters, significant wave height, period, direction, as well as wind speed and direction, are available at 1-hour intervals for a densely-spaced series of nearshore points along the U.S. coastline (in water depths of 50-60 feet) and a less dense series of points in deep water (water depths of 300 feet or more). WIS stations of interest to this area are displayed in Figure 37.

The WIS Level 3 output station used in this monitoring report for comparison to the nearshore ADCP gauge is station 219. Station 219 is located in 75.5 feet of water approximately 12 miles northeast of the Kitty Hawk gauge. The WIS station is located in open water and should serve as a good representation of offshore wave conditions.

In order to compare the WIS Level 3 output station to our nearshore ADCP gauge, wave rose and wave histograms were created similar to those prepared for the Kitty Hawk gauge. The wave rose shown in Figure 44 shows the wave direction vs. wave height. The majority of waves at this location approach from the north through the southeast direction, with the dominant direction being east-northeast. Comparing this plot with the nearshore wave rose plot shows that significant wave transformation occurs between the two. The dominant wave direction shifts from east-northeast to east-southeast. Also noted is the difference in the number of waves on the landward side of the gauge (between 150 and 330 degrees azimuth). While the offshore gauge shows a considerable number of waves approaching from these directions, the nearshore gauge indicates virtually all waves between these angles have been filtered out.

Table 6 contains the mean monthly wave heights for WIS station 219 for 1980 through 1999. As indicated in the table, the average annual wave height for the WIS record is 3.65 feet, with the larger waves occurring in the months of September through May. While, as expected, the average annual wave height for the local gauge is smaller at 3.0 feet, there is good correlation between the two gauges in showing similar seasonal variation in wave height.

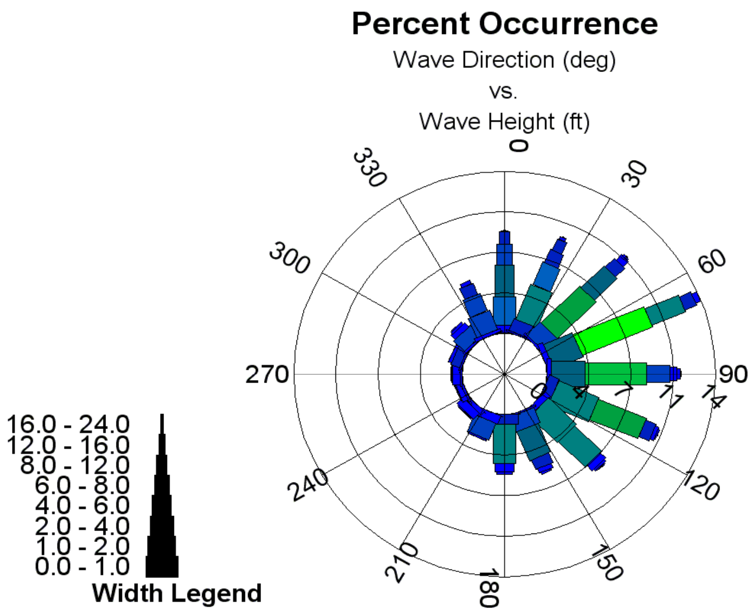

Figure 44. Wave Height Rose for WIS Level 3 Station 219.

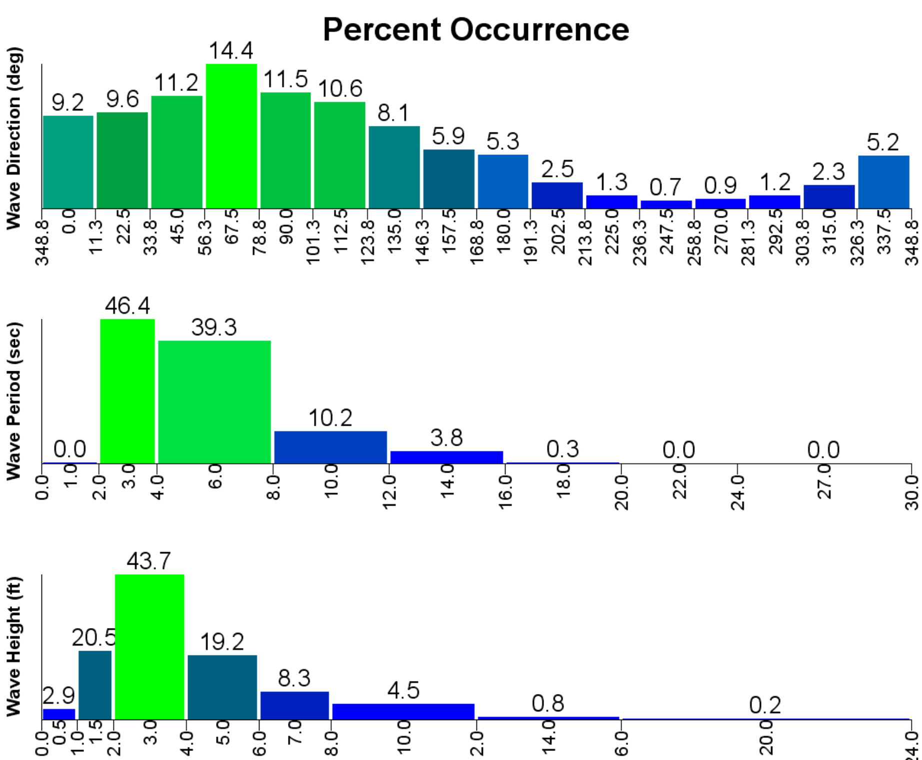

Figure 45. Wave Histogram for WIS Level 3 Station 219.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1980	5.31	4.33	4.99	3.22	2.46	2.43	2.17	2.53	2.92	4.00	4.53	5.48	3.71
1981	4.04	4.82	4.23	3.18	3.67	2.03	2.46	3.54	4.17	4.82	4.89	4.53	3.87
1982	4.30	5.09	3.87	3.84	2.23	2.53	2.10	2.17	3.08	4.76	4.66	4.33	3.58
1983	5.15	5.61	5.22	3.48	2.72	2.59	1.94	2.33	3.81	4.92	3.58	4.82	3.84
1984	5.28	3.90	4.53	3.18	3.22	2.49	2.13	1.97	4.69	4.63	4.99	3.67	3.74
1985	4.46	3.81	4.04	2.99	3.18	2.17	2.33	2.82	4.10	4.43	4.69	3.97	3.58
1986	4.43	3.90	4.40	3.81	3.35	2.89	1.51	3.02	3.08	4.13	4.20	4.76	3.61
1987	4.89	4.86	4.89	4.79	3.58	2.07	2.03	3.02	3.18	4.17	3.71	3.54	3.71
1988	4.23	3.51	3.25	3.81	3.02	2.59	2.10	2.39	3.18	3.87	3.81	4.10	3.31
1989	4.30	4.30	4.95	3.94	2.92	2.17	2.17	2.62	4.89	3.51	3.90	5.54	3.77
1990	2.53	3.77	3.35	3.22	2.76	2.36	2.33	2.33	3.31	4.13	3.18	4.40	3.12
1991	4.23	3.44	3.61	3.18	2.43	2.62	1.84	2.33	3.58	4.79	3.87	3.67	3.28
1992	4.23	4.66	4.07	3.54	4.30	2.33	1.74	2.30	4.43	3.71	4.30	5.77	3.77
1993	5.25	5.35	4.59	4.17	2.85	2.33	2.10	3.08	3.05	4.27	4.89	4.69	3.87
1994	4.79	4.04	4.00	3.05	3.61	2.72	2.00	2.76	3.31	4.59	5.15	5.97	3.84
1995	4.66	3.90	4.27	3.05	3.38	2.85	2.30	5.48	4.99	4.10	4.56	4.79	4.04
1996	5.35	4.79	5.18	3.48	3.31	2.66	2.69	2.46	4.10	4.86	4.33	4.43	3.97
1997	3.28	3.51	4.10	3.08	2.69	3.28	2.20	2.00	2.49	3.02	3.84	3.15	3.05
1998	4.46	5.87	3.58	3.41	2.99	1.97	2.10	4.36	2.89	3.38	3.15	3.77	3.48
1999	4.00	4.13	4.53	3.44	4.20	3.74	2.23	3.35	5.28	4.04	4.69	4.04	3.97
Mean	4.46	4.36	4.30	3.48	3.15	2.53	2.13	2.85	3.74	4.20	4.23	4.46	3.65

Table 6. Mean Yearly and Monthly Wave Heights (feet) for WIS Level 3 Sta. 219

Part 4 BEACH RESPONSE/COMPARISON WITH HISTORIC TRENDS

Beach Response- Shoreline Change Rates. One of the measures used to evaluate project impacts on existing shoreline conditions is the comparison of pre-project shoreline change rates with post-project shoreline change rates. This section of the report will detail the development of the shoreline change rates selected for the pre-project base condition. The rates were developed by combining three historic survey inventories: 1) North Carolina Division of Coastal Management (NCDCM) shorelines, 2) United States Geologic Survey (USGS) mean high water shorelines, and 3) U.S. Army Corps of Engineers (USACE) beach profile surveys. The rates developed for this report will be updated in the second monitoring report to include the final pre-project survey of the island, which will be taken just prior to actual construction.

The NCDCM database consists of shorelines derived by mapping the wet/dry shoreline visible on historic photographs. For our project area there were six survey dates available including January of 1940, 1949, 1980, and 1997, August of 1998, and September of 2004. Of these, the 1940 and 1949 shorelines were partial coverage of the project area with the 1940 shoreline covering basically the Southern Shores and Kitty Hawk area and the 1949 shoreline covering Nags Head through Bodie Island. The shorelines provided by USGS were collected using their SWASH (http://woodshole.er.usgs.gov/operations/swash/) system data collection vehicle, where SWASH stands for "Surveying Wide-Area Shorelines". Data were collected multiple times and 16 of these sets were selected from a period covering January 1997 through August 2005 for use in this analysis based on coverage and time intervals between surveys. These data were collected and extrapolated to mean high water, the defined shoreline position, with all sixteen sets covering the entire project area. The third source of data used in the development of the pre-project shoreline change rates were the current USACE beach profile monitoring surveys. As noted previously, these surveys were initiated in March 2004 and to date a total of five surveys have been collected with the most recent being in November 2006. The mean high water position, 1.18 feet NAVD88, was extracted from these surveys using the BMAP (Beach Morphology Analysis Program) (Sommerfield, 1994) and incorporated into the shoreline change rate database.

Once the data set was compiled, a least squares fit regression analysis was computed on the data for each profile location. This regression analysis produced the slope of the best fit line through the data which is used as the shoreline change rate. Individual plots of these regression calculations for each profile line are included in Appendix B. The rates were then averaged in a longshore sense to remove drastic changes between adjacent profiles, especially in the immediate area of Oregon inlet. The smoothing of the shoreline change rate was computed by averaging five adjacent profiles. The five profiles averaged include the profile of interest, two north of the profile, and two south of the profile, which represent approximately 5,000 feet of shoreline. At the extreme north and south ends of the project, averaging only included the profiles available, which would be the profile of interest and the two adjacent profiles. Figures 46 through 50 show the shoreline change rates by region. These Figures include the shoreline change rate computed by the entire data set, which will be used to establish the pre-construction shoreline change rate, as well as the shoreline change rate computed from the USACE physical monitoring program surveys only. Figures 51 and 52 graphically display the long-term change rates over the entire monitoring and control area. Appendix C contains shoreline change plots for each USACE monitoring profile for a graphical representation of these calculations.

As shown in Figures 46 through 50 there is a great amount of variability between the historic shoreline change rate and the rate computed using the USACE monitoring surveys only. Table 7 contains the summary descriptive statistics for the shoreline change rates for both long term rates and the current monitoring period. While the variability between the two data sets does exist, a close look at the standard deviations in Table 7 shows that the trends are similar from north to south in both data sets. Variability is least in the control area to the north of the project and increases as one nears Oregon Inlet. This is consistent over both data sets indicating the strong influence of the Oregon Inlet complex on the adjacent shorelines.

The average shoreline change rate for the long term shoreline data set is -1.48 ft/yr with the maximum erosion being 8.18 ft/yr at profile 194 in Bodie Island. The maximum accretion rate was 21.52 ft/yr at profile 19 which is the last monitoring station and is adjacent to Oregon Inlet. The average shoreline change rate for the Corps monitoring program surveys was -3.94 ft/yr with the maximum erosion rate of 78.59 ft/yr occurring at station 19 adjacent to Oregon Inlet and the maximum accretion rate of 11.57 ft/yr occurring at profile 839 in Nags Head.

A large divergence in shoreline change rates between the long term and Corps monitoring survey rates is apparent when looking at the maximum and minimum rates at profile 19 as well as examining Figure 50. This divergence of rates is due primarily to the re-orientation of the entrance channel into Oregon Inlet between 1987 and 1989. Figure 53 shows the before and after photographs for the inlet, in which the change in inlet orientation is clear. The inlet changed from a north northeast direction to an almost due east alignment. The result of this change was a massive amount of sand to the north of the new channel orientation which welded onto the beach on the Bodie Island side of the inlet. The beach width at profile 19 increased by nearly 3,600 feet between 1987 and 1989 due to the channel re-orientation. As a result of this massive increase in shoreline position, the long-term shoreline change rates do not indicate a large erosion rate over time in the vicinity of Oregon Inlet. Having been collected after the channel re-orientation, the current monitoring surveys do not include the change and as a result a large erosion rate has been observed since the start of the monitoring program. Future comparisons of this area with post construction surveys will be problematic due to these discrepancies and adjustments may be needed in the calculation of the long term change rate.

As discussed earlier in the Shoreline and Profile Change section of this report, there were four areas identified as possible "hot spot" erosion zones using the USACE monitoring survey data only (August 2004 - October 2006). In comparing the shoreline change rates in these areas with the averages for the township computed using the long term data set, there does not appear to be any major differences. The area in Kitty Hawk from profile 99 to 149 has a change rate of -2.09 ft/yr which compares well to the town average of -1.64 ft/yr. In Kill Devil Hills from profile 349 to 389 the change rate is accreting at 1.19 ft/yr, while the average for Kill Devil Hills is eroding at 0.39 ft/yr. The two areas in Nags Head, profile 779 to 800 and 879 to 899, have rates of -1.44 ft/yr and -2.21 ft/yr, both of which compare well with the -2.21 ft/yr average for Nags Head. One possible explanation for this is that because of the amount of data points within the long term data set, the short term changes recently observed in the monitoring surveys are averaged out.

When comparing the shorter data set containing only the Corps monitoring profiles, the “hot spot” zones have increased erosion rates when compared to their relative township averages. Profile 99 to 149 in Kitty Hawk has an erosion rate of 6.82 ft/yr where the average change rate for Kitty Hawk is only -1.65 ft/yr. In Kill Devil Hills, profile 349 to 389 is eroding at 7.18 ft/yr where the town on average is accreting at 0.7 ft/yr. The two areas in Nags Head, profile 779 to 800 and 879 to 899, are eroding at 3.82 ft/yr and 3.63 ft/yr. Both of these rates exceed the average accretion rate for Nags Head which is 1.35 ft/yr. In addition to these “hot spot” rates exceeding the averages for the Corps data set, they also exceed the averages for the long term historic data set. As with the measurements recorded for shoreline and volumetric change, further comparisons will need to be made post-construction to confirm the existence of these hot spots.

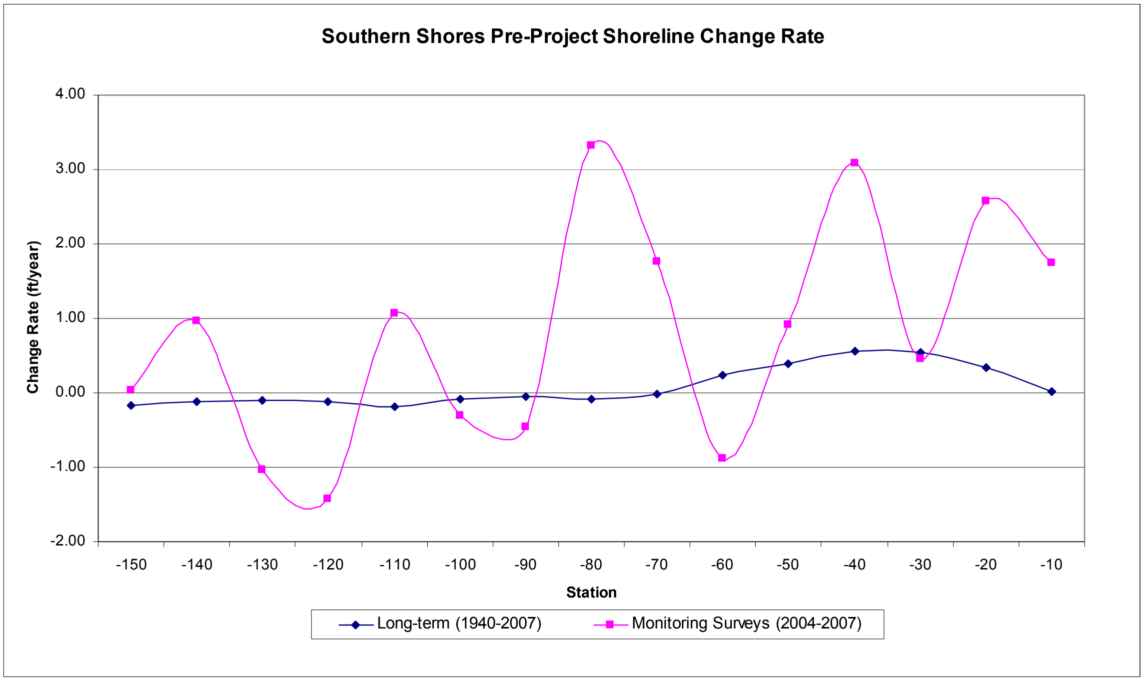

Figure 46. Southern Shores Pre-project Change Rate

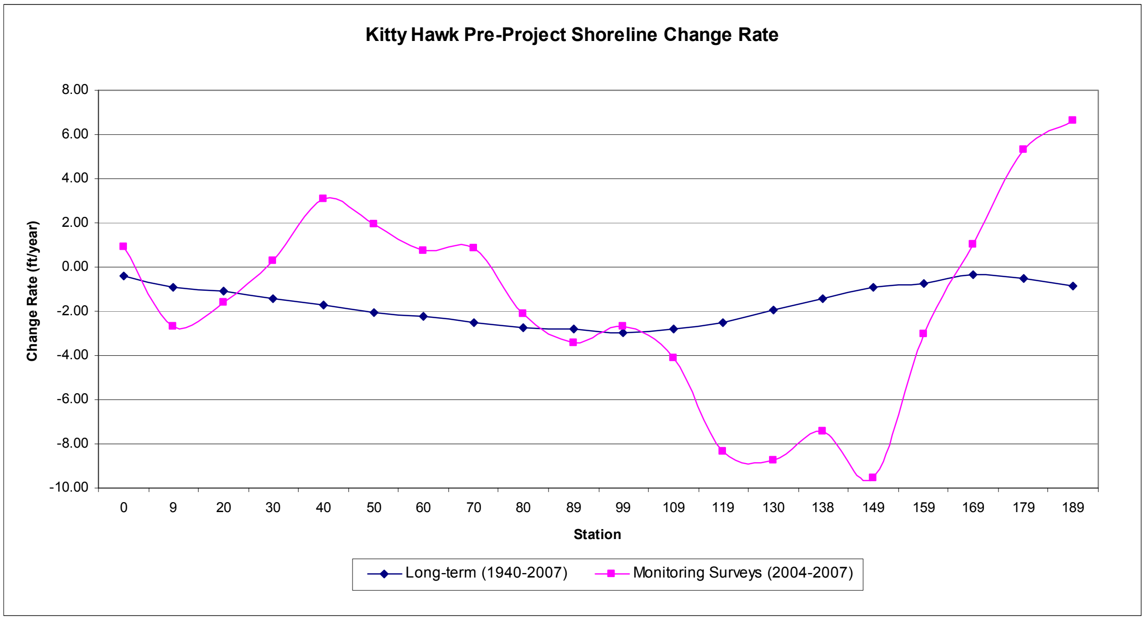

Figure 47. Kitty Hawk Pre-project Change Rate

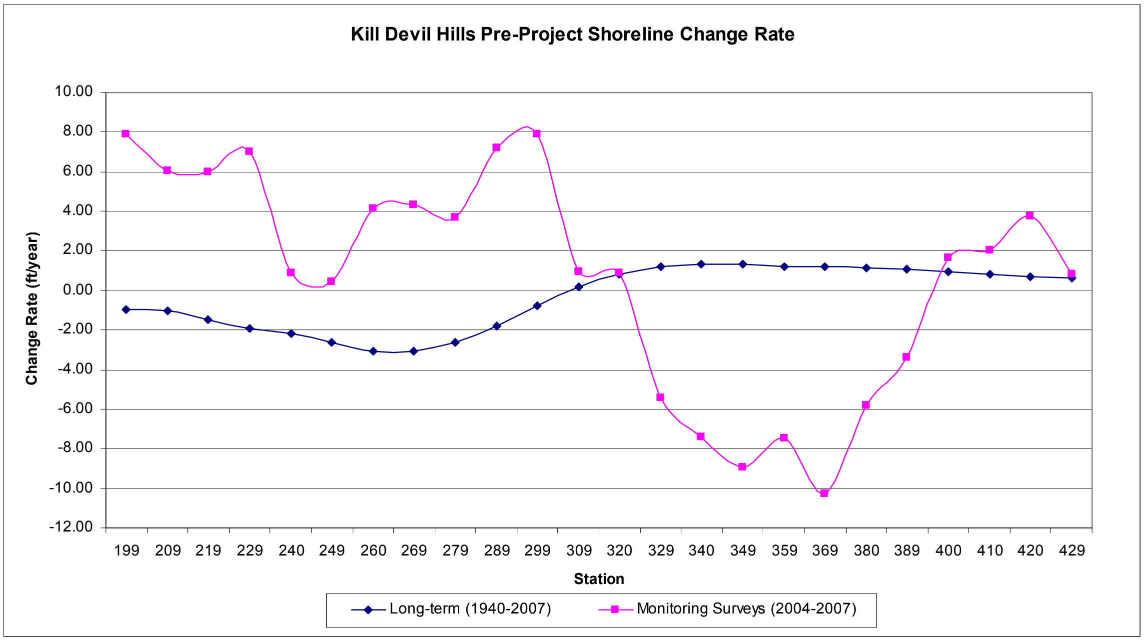

Figure 48. Kill Devil Hills Pre-project Change Rate

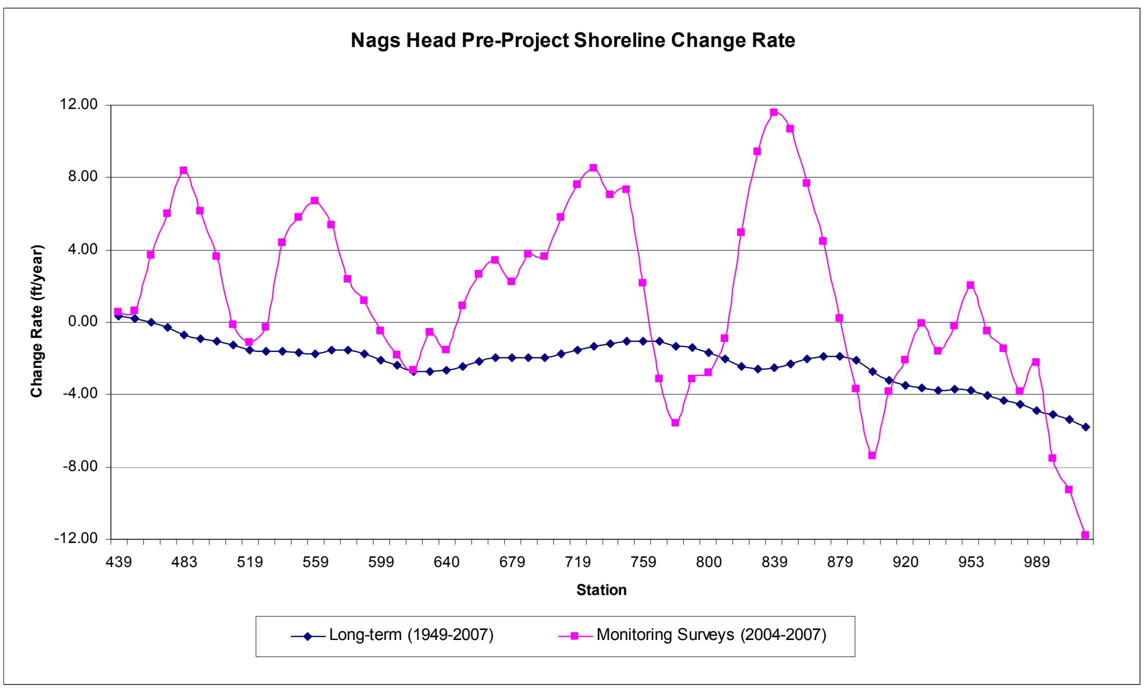

Figure 49. Nags Head Pre-project Change Rate

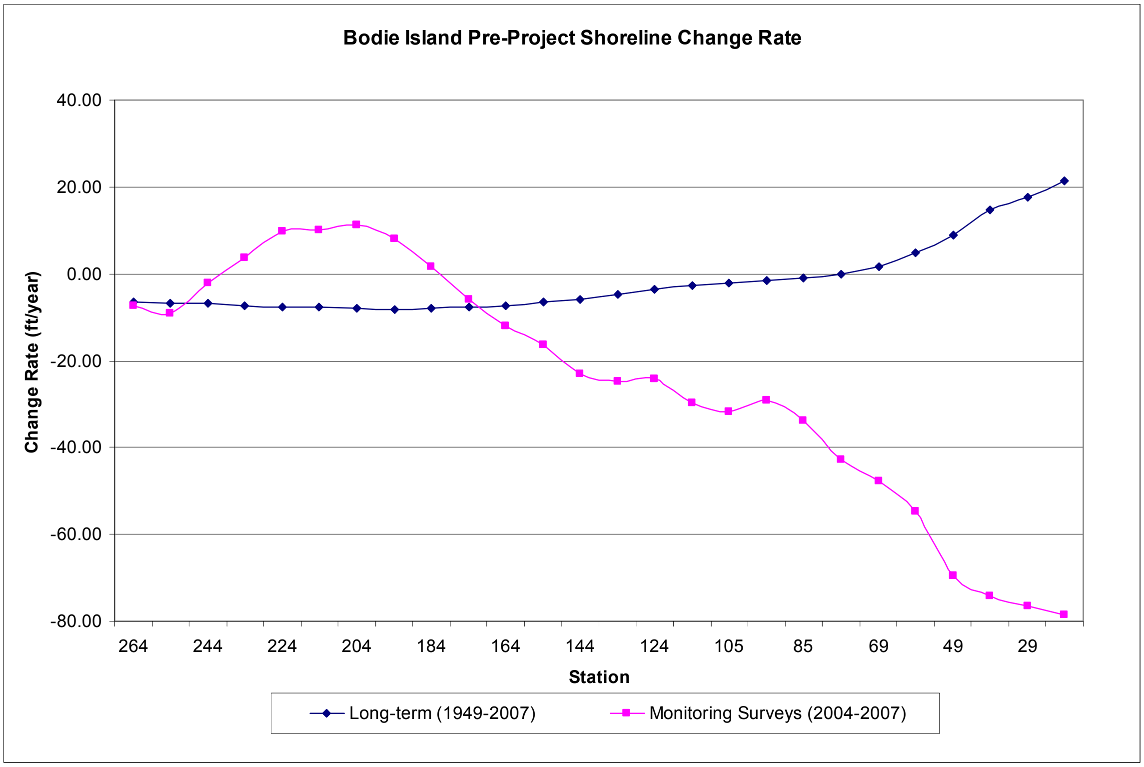

Figure 50. Bodie Island Pre-project Change Rate

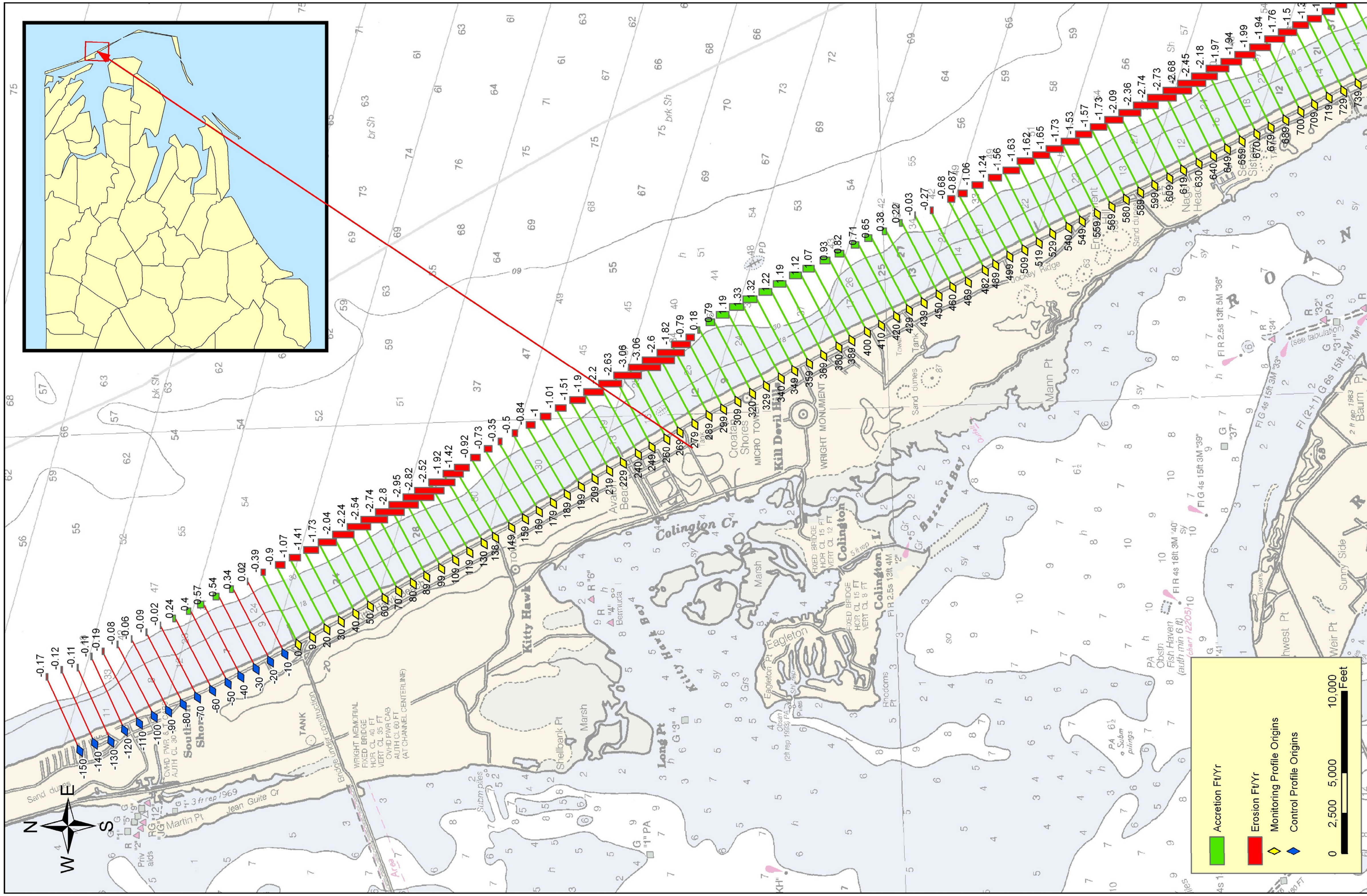

Figure 51. Pre-project Profile Change Rates (Profile -150 through 719)

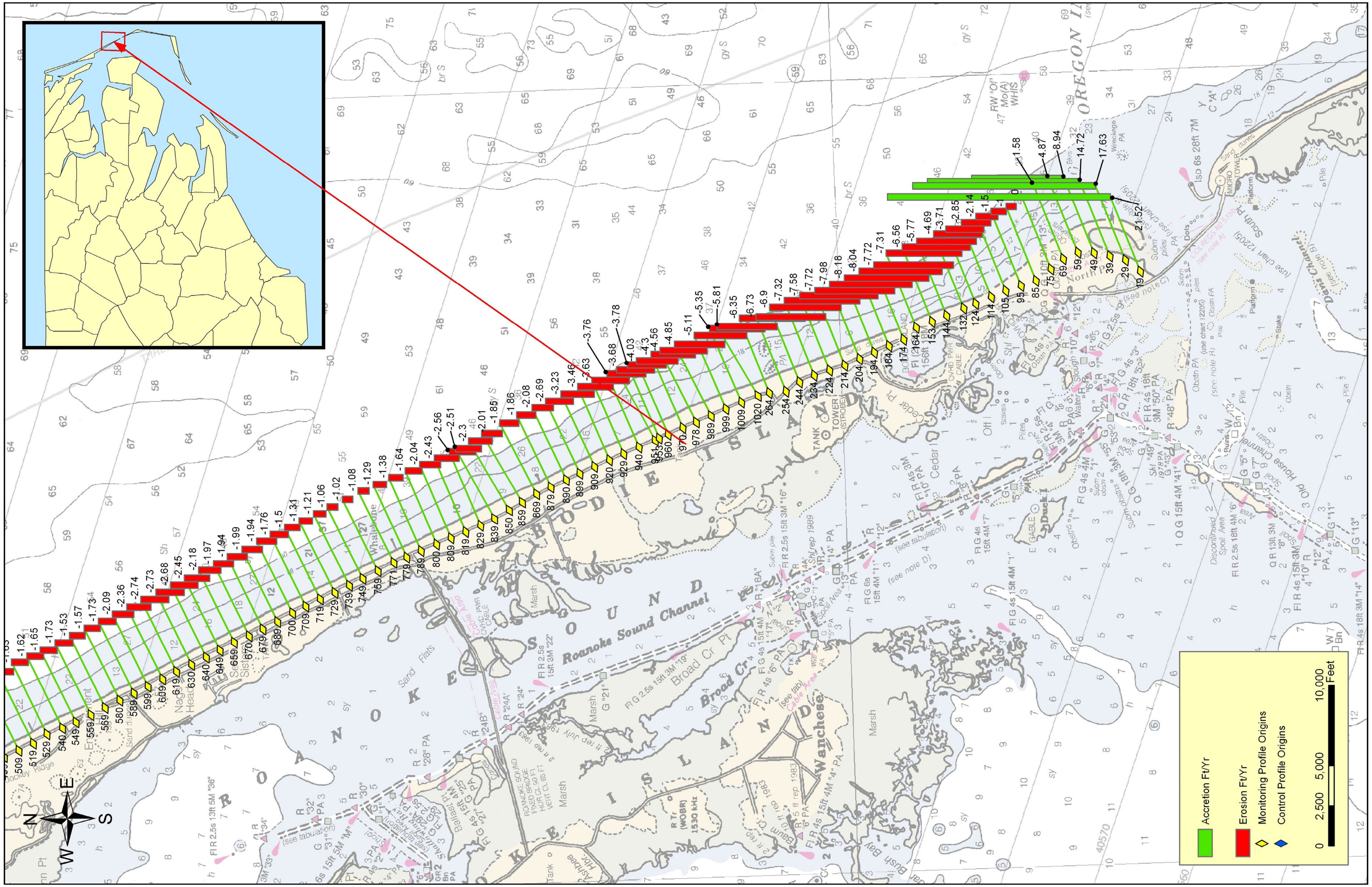

Figure 52. Pre-project Profile Change Rates (Profile 540 through 19)

		Number of Profiles	Mean Erosion Rate (ft/yr)	Std. Deviation	Std. Error	95% Confidence Interval for Mean (ft/yr)		Maximum Erosion Rate (ft/yr)	Minimum Erosion/Maximum Accretion Rate (ft/yr)
						Lower Bound	Upper Bound		
All Historic Surveys (1940-2007)	Southern Shores	15	0.08	0.26	0.07	-0.07	0.22	-0.19	0.57
	Kitty Hawk	20	-1.64	0.90	0.20	-2.06	-1.22	-2.95	-0.35
	Kill Devil Hills	24	-0.38	1.60	0.33	-1.05	0.30	-3.06	1.33
	Nags Head	60	-2.21	1.33	0.17	-2.56	-1.87	-5.81	0.38
	Bodie Island	26	-1.57	8.42	1.65	-4.97	1.83	-8.18	21.52
	Total	145	-1.48	3.77	0.31	-2.10	-0.86	-8.18	21.52
Corps Monitoring Profiles Only (2004-2007)	Southern Shores	15	0.79	1.49	0.39	-0.04	1.62	-1.42	3.33
	Kitty Hawk	20	-1.65	4.51	1.01	-3.76	0.46	-9.53	6.61
	Kill Devil Hills	24	0.70	5.64	1.15	-1.68	3.09	-10.25	7.93
	Nags Head	60	1.36	4.92	0.64	0.08	2.63	-11.77	11.57
	Bodie Island	26	-24.96	28.18	5.53	-36.35	-13.58	-78.59	11.28
	Total	145	-3.94	15.93	1.32	-6.56	-1.33	-78.59	11.57

Table 7. Descriptive Statistics of Historic Shoreline and Corps Monitoring Profile Shoreline Change Rate

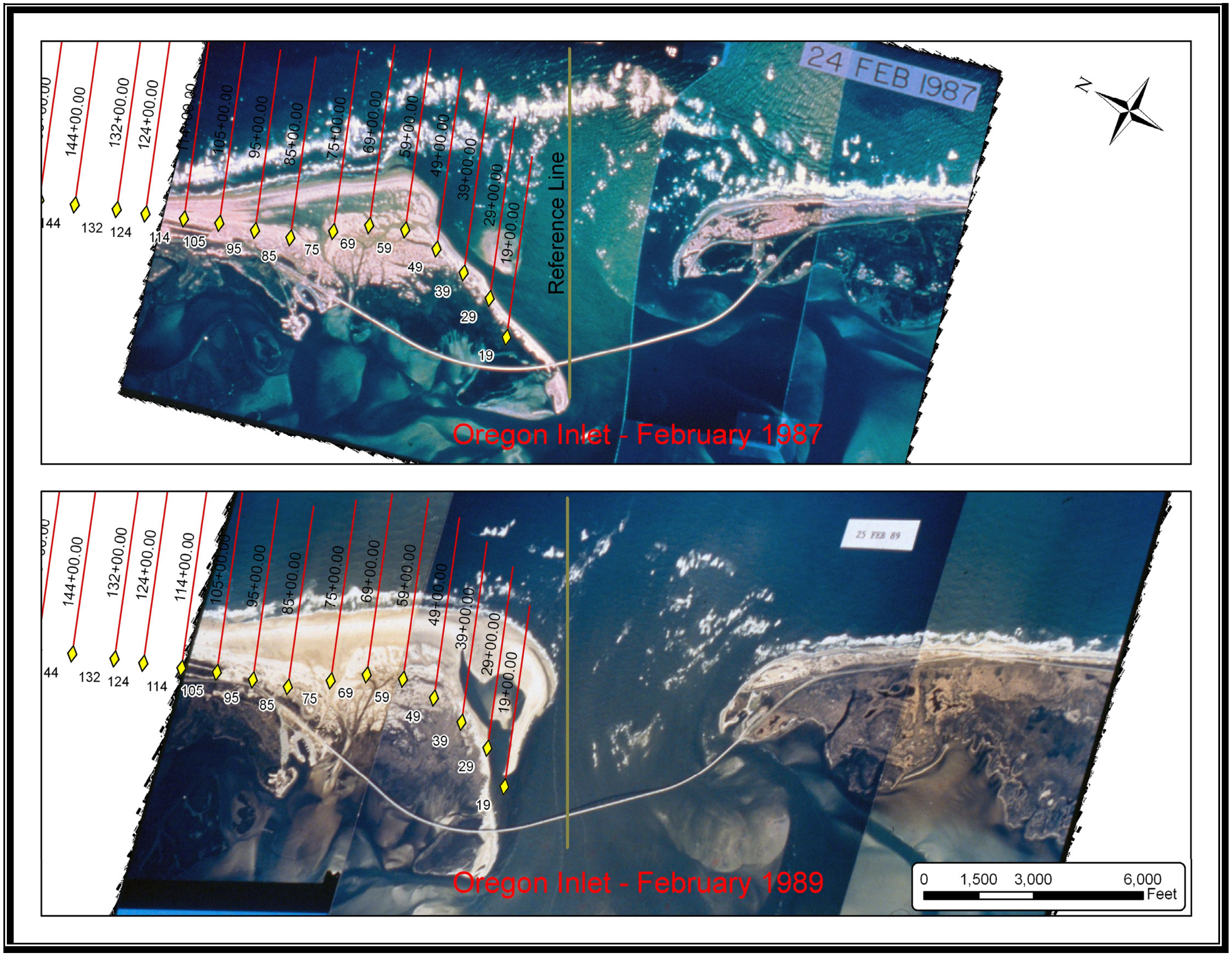

Figure 53. Oregon Inlet Orientation Comparisons (1987-1989)

Part 5 FINDINGS/CONCLUSIONS

The first monitoring cycle to establish the baseline pre-construction conditions along the Bodie Island beaches of Dare County is complete covering the period of August 2004 to November 2006. Activities to date have included: 1) The collection of five complete surveys for both the project and control areas 2) Two sediment sampling efforts collecting 1,340 total grab samples used in characterizing the existing beach 3) Deployment and operation of a project wave gauge near Kitty Hawk to establish the pre-project wave climate and 4) Collection of one aerial photography set in May 2006 covering the project area.

Shoreline and volumetric changes were measured over the period from August 2004 to October 2006 which includes four beach profile data sets. The fifth data set was a post-storm survey which is compared separately to highlight the impacts of a significant event on the beach. The results of the regularly scheduled surveys show that the project area as a whole experienced a shoreline loss of 1.2 feet. The most severe shoreline losses were in the Cape Hatteras National Seashore portion of the monitoring area which lost an average of 35.3 feet of shoreline over the period of August 2004 to October 2006. It is unclear at this time if these values represent the true shoreline trends or if the values are showing the effects of a recovering beach profile following the passage of Hurricane Isabel which occurred just prior to the first monitoring survey. Four potential erosion "hot spot" areas were identified in the shoreline and volumetric change calculations, which need to be confirmed with future surveys/reports. One "hot spot" was located in both Kitty Hawk and Kill Devil Hills and two were located within the Nags Head region. These "hot spots" are areas along the shoreline where shoreline change greatly exceeds the shoreline change average for the surrounding area or township.

Volume changes were computed at each profile along the beach to determine changes in the onshore and over the total profile. The onshore changes were computed by calculating volume above -2 feet NAVD88, while the total profile volume changes were computed above the depth of closure for the particular transect. The onshore volume changes show the monitoring area volumes increased as a whole by nearly 353,000 cubic yards. The southern areas, including Cape Hatteras National Seashore and southern Nags Head, had the largest changes in the onshore with a loss of nearly 192,000 cubic yards. Volumes computed over the entire profile, out to the depth of closure, were very different from the volume changes in the onshore portion of the beach. The project as a whole lost approximately 1,472,000 cubic yards of material with the greatest losses in the National Seashore and southern Nags Head areas.

A comparison was made of pre- and post-storm surveys for the November 2006 "Thanksgiving Storm", which was the largest event recorded over the monitoring cycle. The shoreline as a whole eroded due to the storm with the most severe erosion occurring in the National Seashore and southern Nags Head areas. Peak shoreline changes in this area ranged from an increase in shoreline position of approximately 78 feet to a maximum shoreline loss of nearly 130 feet. The volumetric changes were more complex.

The onshore portion of the beach lost nearly 1,060,000 million cubic yards of material, with the losses occurring in each region and the heaviest losses occurring in Nags Head and the National Seashore. Total volume changes were not much higher than the total onshore losses, with the total lost being nearly 1,200,000 million cubic yards. The major difference between the onshore and total volume losses was where they occurred. Four of the five regions within the monitoring area lost less material in the total volume measurement than they did in the nearshore (above -2 feet NAVD88) measurements. The exception was the Nags Head area which lost approximately 899,000 cubic yards of material or 76% of the 1,200,000 million cubic yards lost in the total volume calculation for the entire monitoring area. This indicates that during the storm, a significant portion of the material being lost in the onshore is not lost to the system; rather it is moved into the offshore portion of the beach and should partially recover through natural processes over time. The extreme loss in Nags Head is not easily explained, however, several possibilities are given within the body of the report.

Wave height and direction data were gathered for this project beginning in March 2004 with the deployment of an ADCP gauge referred to as the "Kitty Hawk" gauge. The gauge was placed at a water depth of 48 feet just landward of the proposed project borrow source, N1. Operation has been continuous with only few outages through June 2007. Analysis of the gauge records determined the peak wave conditions as well as seasonality of these conditions. These records will also be used once the project is constructed to make comparisons between the pre- and post-construction wave climate. This will help quantify the changes in wave direction and intensity as well as any impacts resulting on the nearshore from the removal of sand from borrow areas. Comparisons of the local gauge were made to the long term wave climate data available for WIS station 219, which is further offshore in approximately 75.5 feet of water. These comparisons showed that significant transformation occurs to the wave field between this offshore location and our local gauge. Dominant wave directions shift from east-northeast to east-southeast between the gauges. In addition to the directional changes, significant sheltering occurs at the local gauge as expected, with almost no waves approaching from the landward side of the gauge (between angles 150 and 330).

Shoreline change rates were developed during this initial monitoring period using historic data sets from the N.C. Division of Coastal Management, U.S. Geologic Survey, and U.S. Army Corps of Engineers. These shoreline change rates will be updated just prior to construction to include the pre-construction survey and will then serve as the baseline change rate used in comparing post-project rates. These rates show that the control area located in Southern Shores was very stable with an average shoreline change rate of only 0.08 ft/yr. The Kitty Hawk area has an average shoreline change rate of -1.64 ft/yr. Erosion in this region was most severe in the middle with a maximum erosion rate computed at profile 99 of 2.95 ft/yr. The northern and southern ends of the area had much lower shoreline change rates, however, all are eroding. The Kill Devil Hills section of the monitoring area had a very mild erosion rate of only 0.38 ft/yr, on average. This region of the beach was divided into two areas with the northern half, profile 199 to 299, eroding at an average rate of 1.96 ft/yr. The southern half, profile 309 to 429, is accreting at an average rate of 0.96 ft/yr. The change rate computed for the Nags Head region shows that, on average, it is eroding at a rate of 2.21 ft/yr. While these rates fluctuate within the region, they trend from slight accretion in the north to very erosive in the south. The maximum change rate within the region is -5.81 ft/yr and occurs at profile 1020. The southern most region of the monitoring area, the Cape Hatteras National Seashore, has an average change rate of -1.57 ft/yr. This region is divided into two sections as well. The northern half, profile 264 to 85, is eroding at an average rate of 5.79 ft/yr while the southern half, profile 75 to 19, is accreting at an average rate of 9.90 ft/yr.

The computed long-term rates were also compared to shoreline change rates calculated from the surveys over the present monitoring period. The change rates produced from the monitoring surveys alone were higher with an average rate of -3.94 ft/yr compared to -1.48 ft/yr computed by the total historic database. The largest divergence between the change rates calculated from the monitoring surveys and the rates calculated from all the historic data occurs at the southern limits of the study area. This divergence is due to a significant realignment of Oregon Inlet between 1987 and 1989 which caused the southern end of the island to accrete nearly 3,600 feet. This increase in shoreline is included in the long term data set resulting in an accreting rate for this area, however, the shorter monitoring survey database does not include this and the rate produced in this area is one of erosion.

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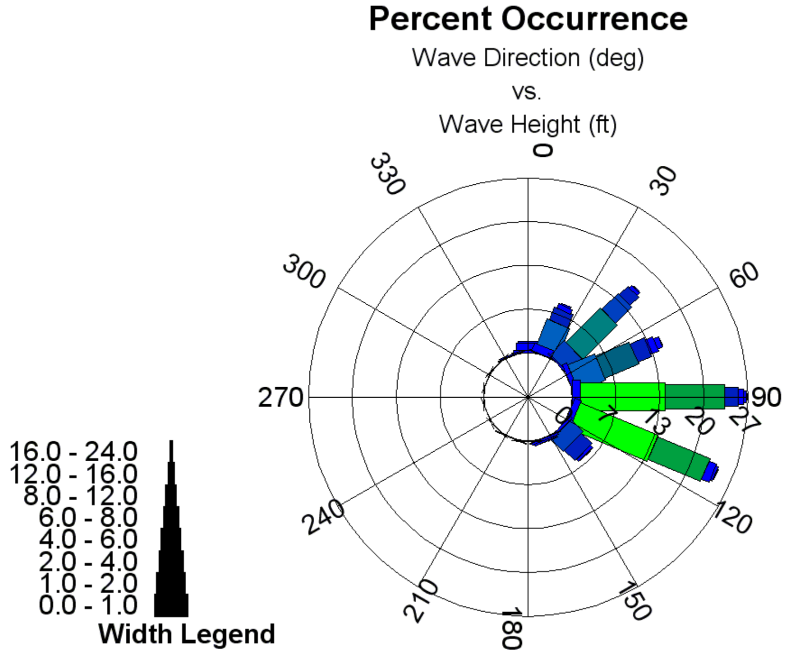
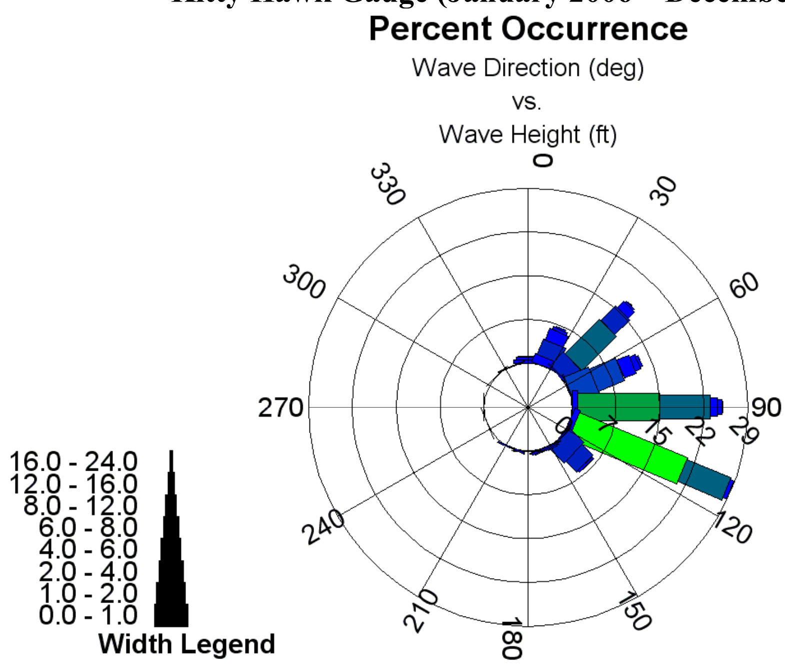
Appendix A

Wave Gauge Data
Wave Roses (2004-2007)

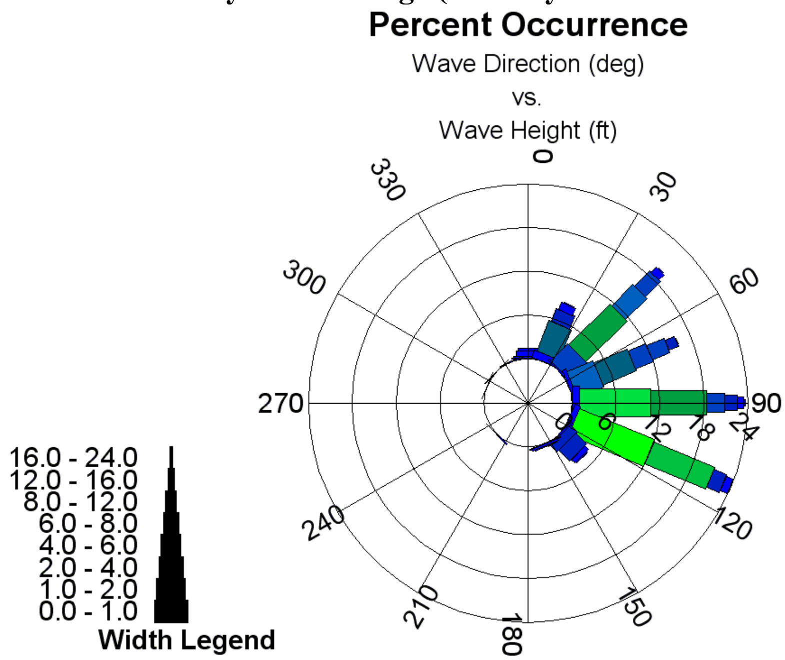
Kitty Hawk Gauge (March 2004 – June 2007)



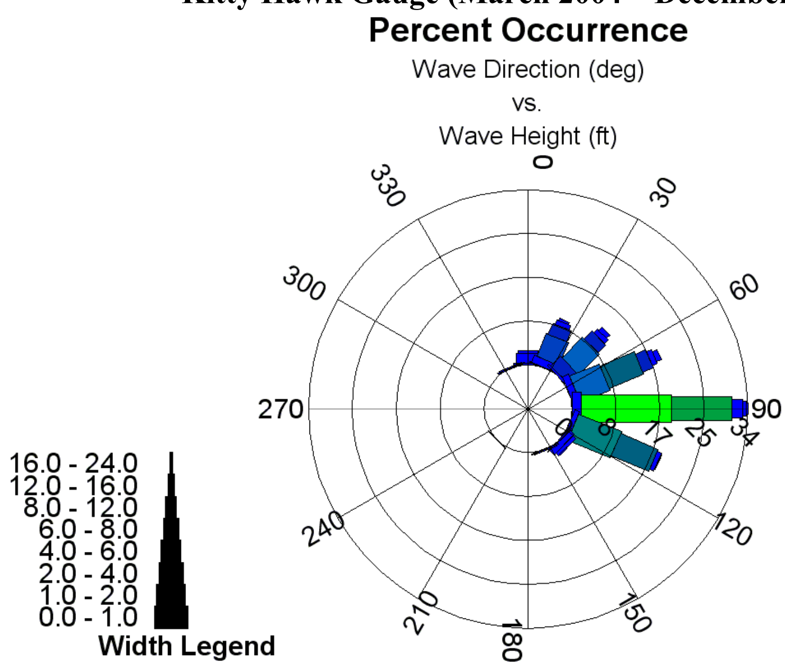
Kitty Hawk Gauge (January 2006 – December 2006)



Kitty Hawk Gauge (January 2005 – December 2005)

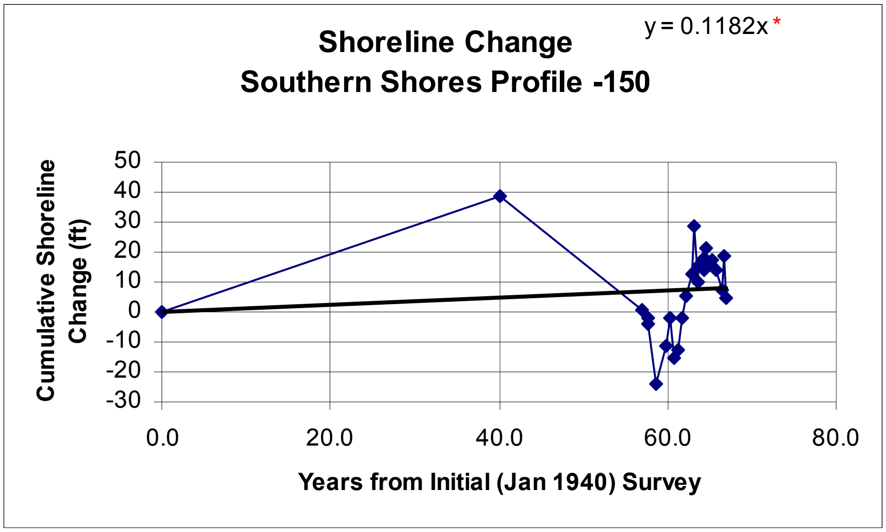


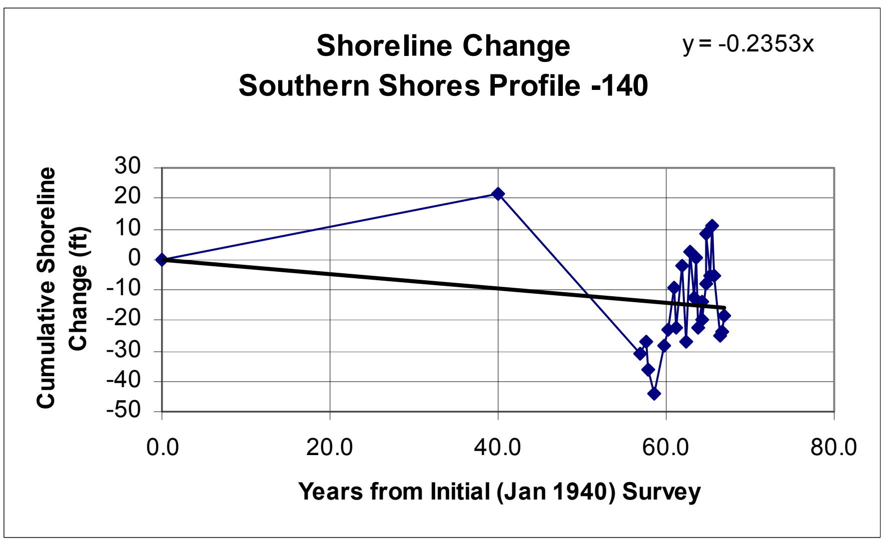
Kitty Hawk Gauge (March 2004 – December 2004)

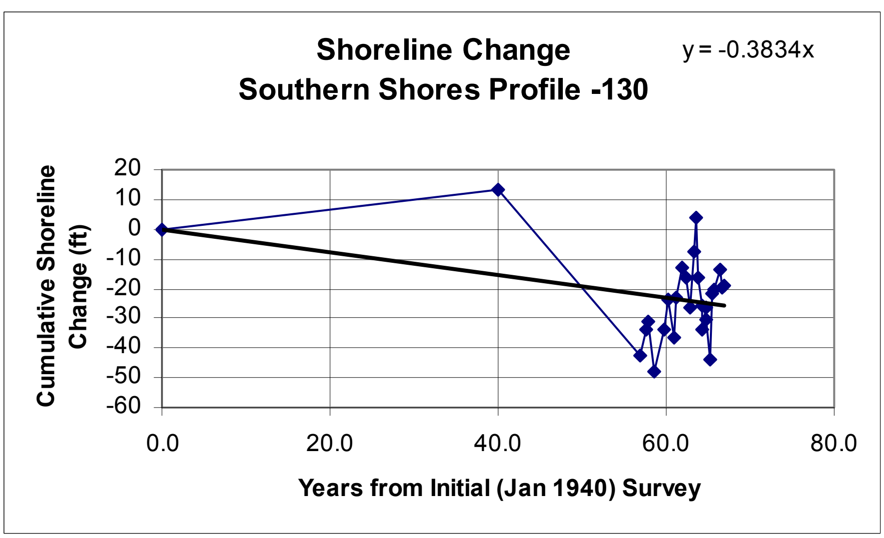


<u>Appendix B</u>

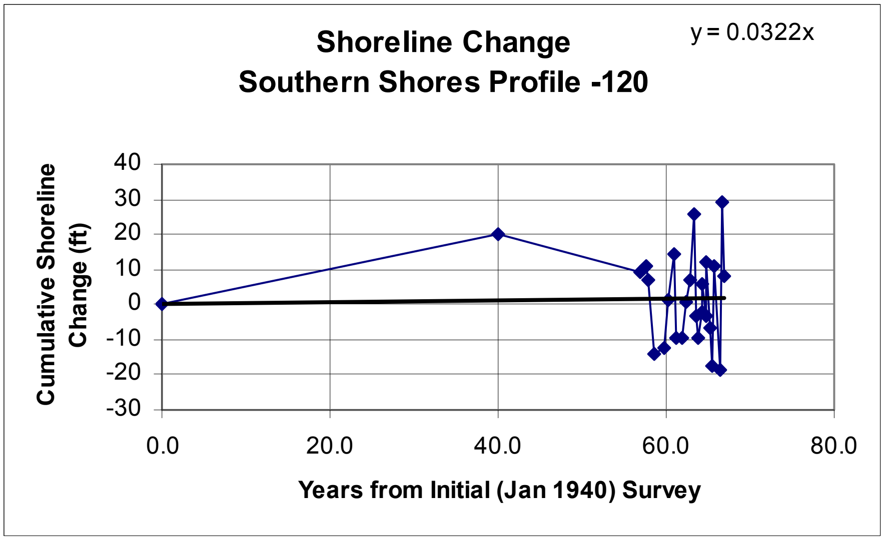
Shoreline Change Rates
Historic Survey Database
(NCDCM, USGS, and USACE Monitoring Surveys)

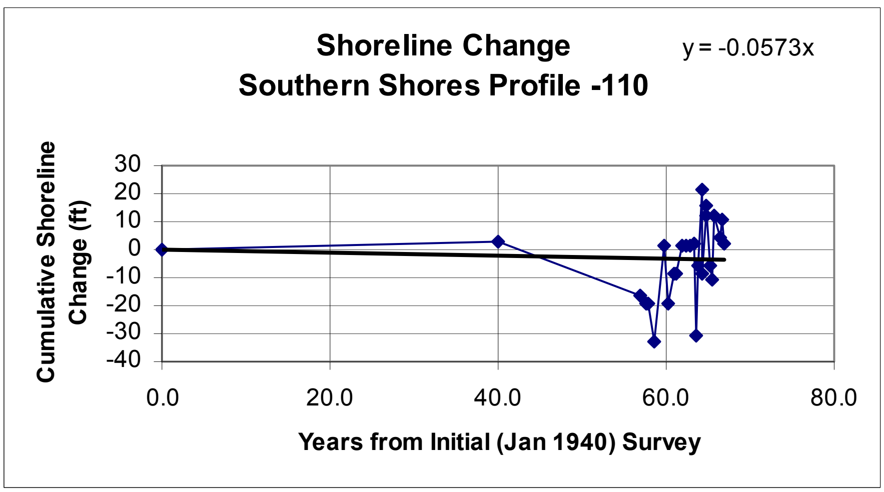


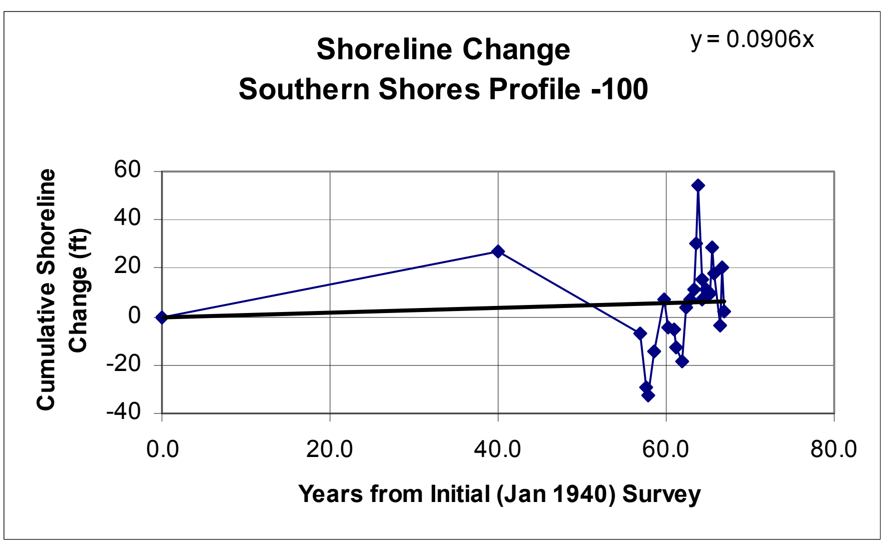


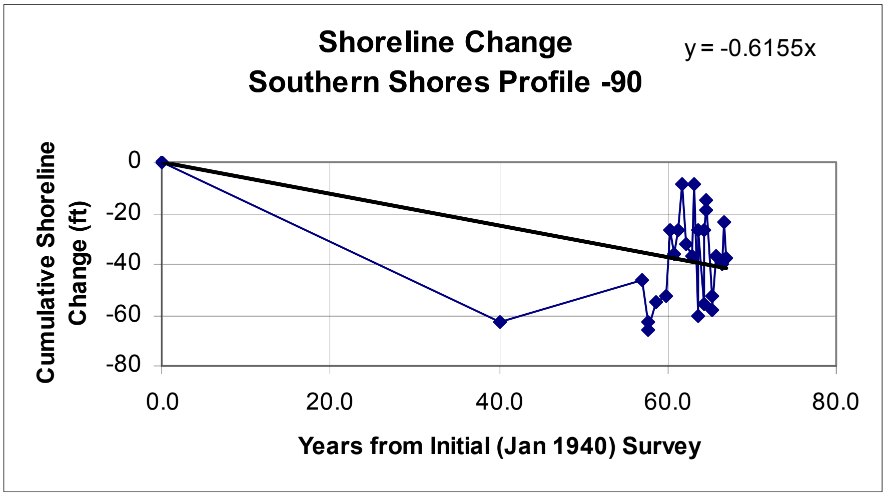


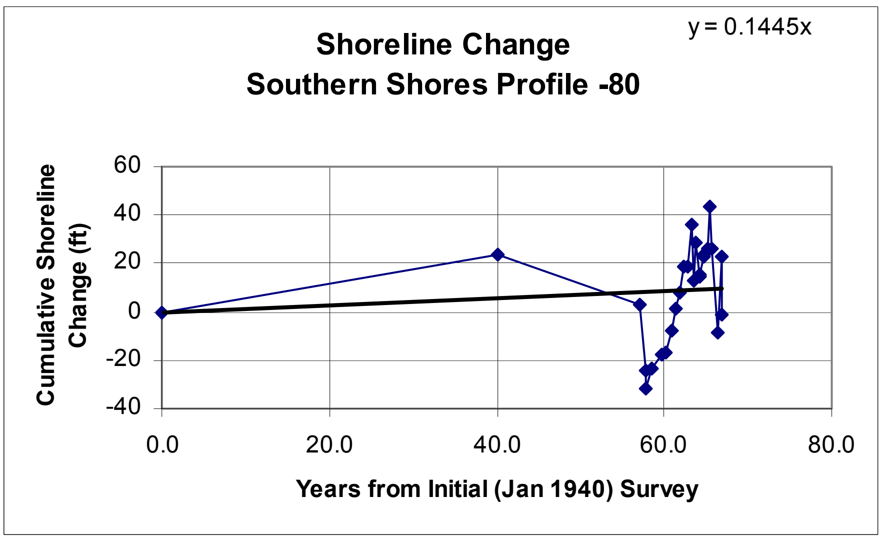
* The regression line is represented by the equation y=mx where m is the slope of the line, indicating the rate of shoreline change in feet per year

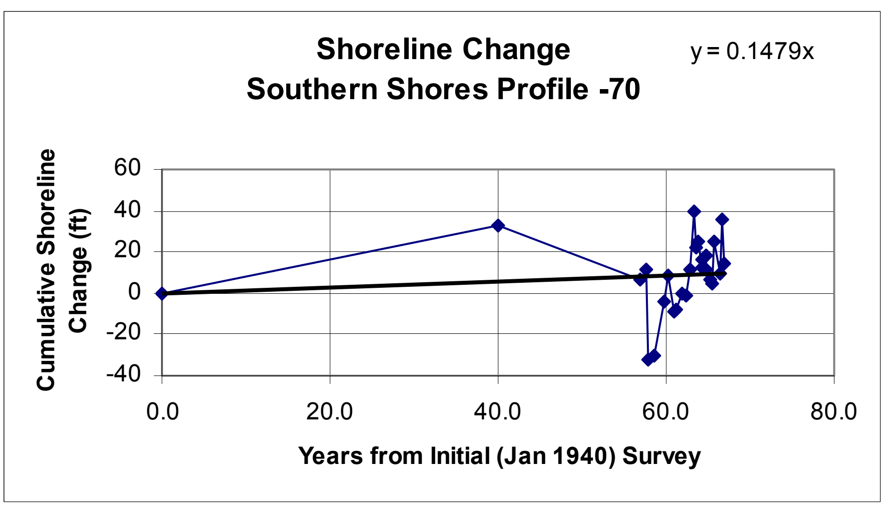

Shoreline Change
Southern Shores Profile -120
y = 0.0322x
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

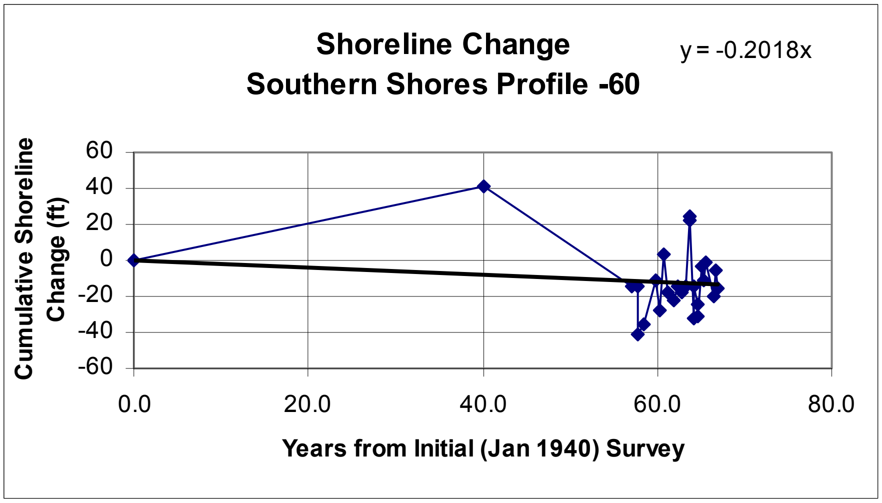

Shoreline Change
Southern Shores Profile -110
y = -0.0573x
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
-30
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

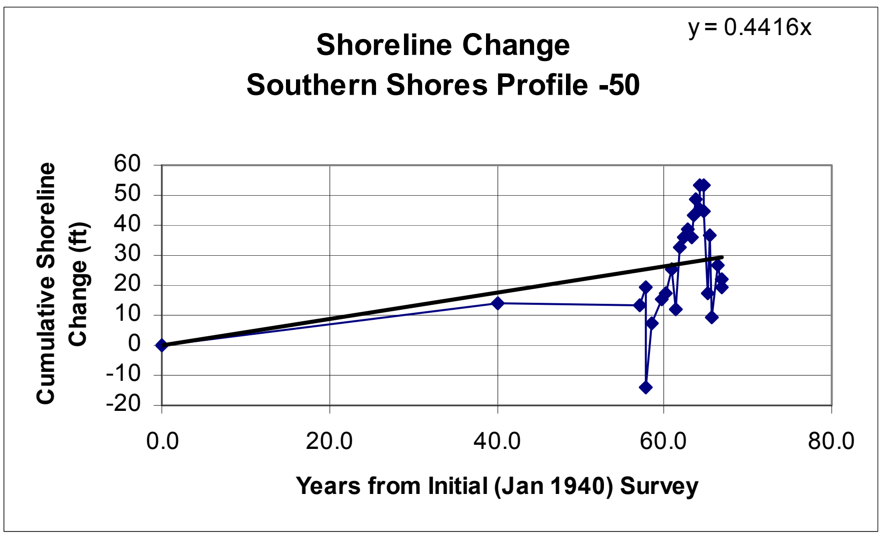

Shoreline Change
Southern Shores Profile -100
y = 0.0906x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

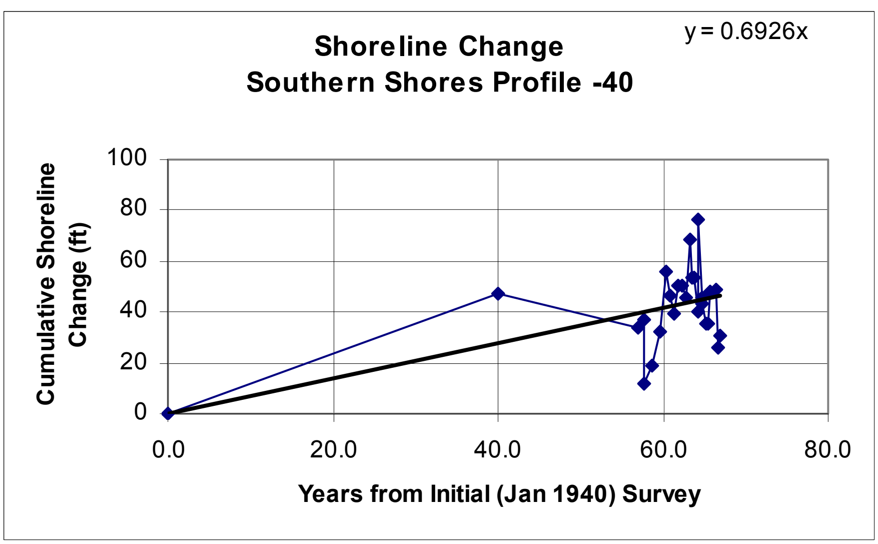

Shoreline Change
Southern Shores Profile -90
y = -0.6155x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

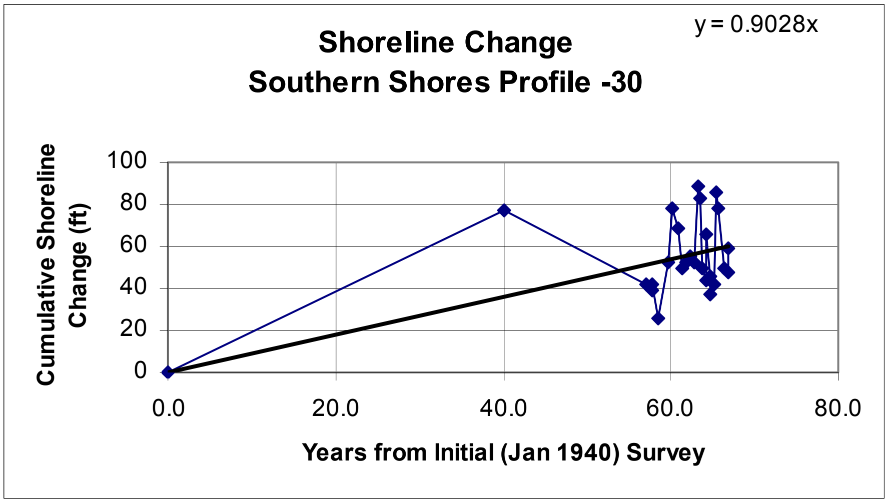

Shoreline Change
Southern Shores Profile -80
y = 0.1445x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

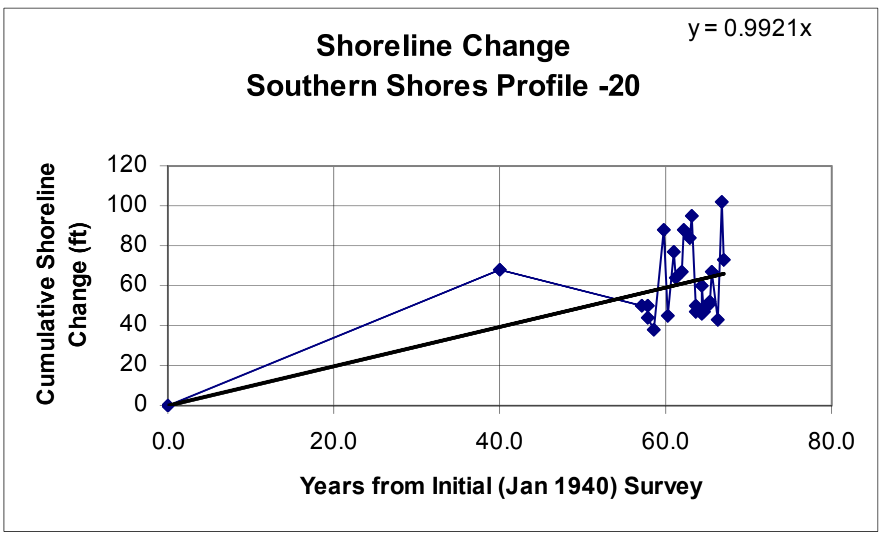

Shoreline Change
Southern Shores Profile -70
y = 0.1479x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

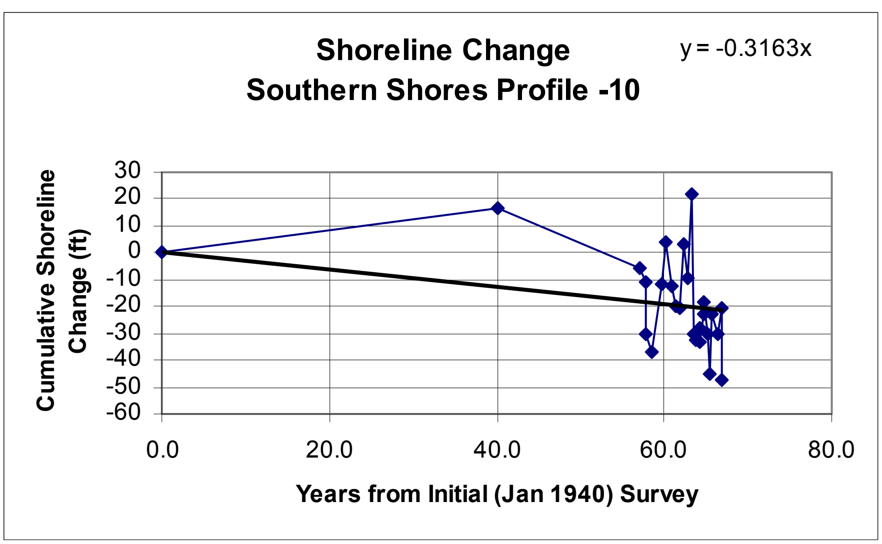

Shoreline Change
Southern Shores Profile -60
y = -0.2018x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
-60
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

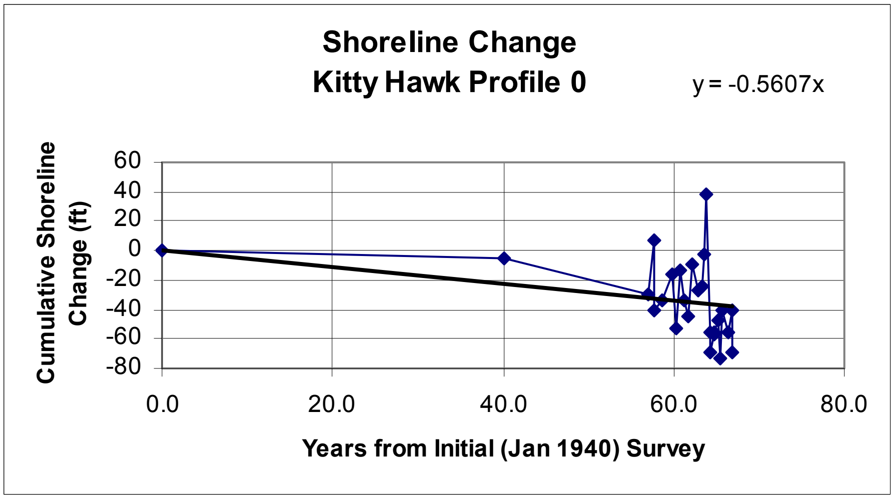

Shoreline Change
Southern Shores Profile -50
y = 0.4416x
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
-10
-20
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

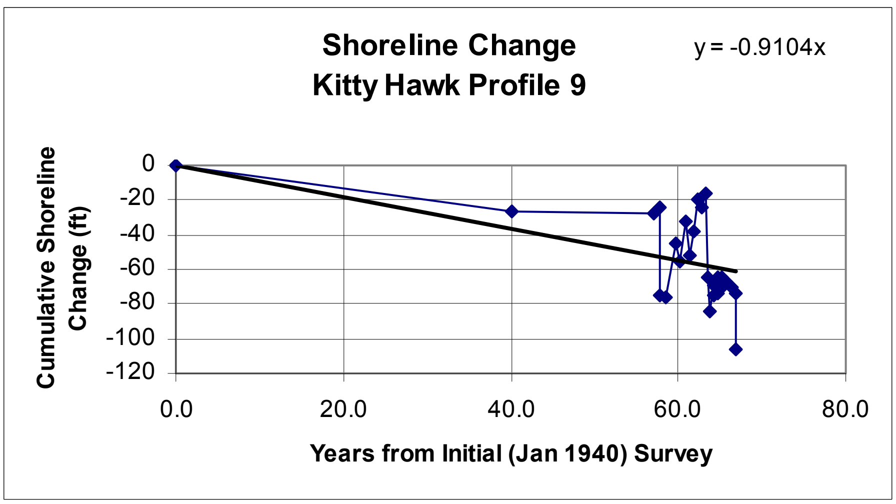

Shoreline Change
Southern Shores Profile -40
y = 0.6926x
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

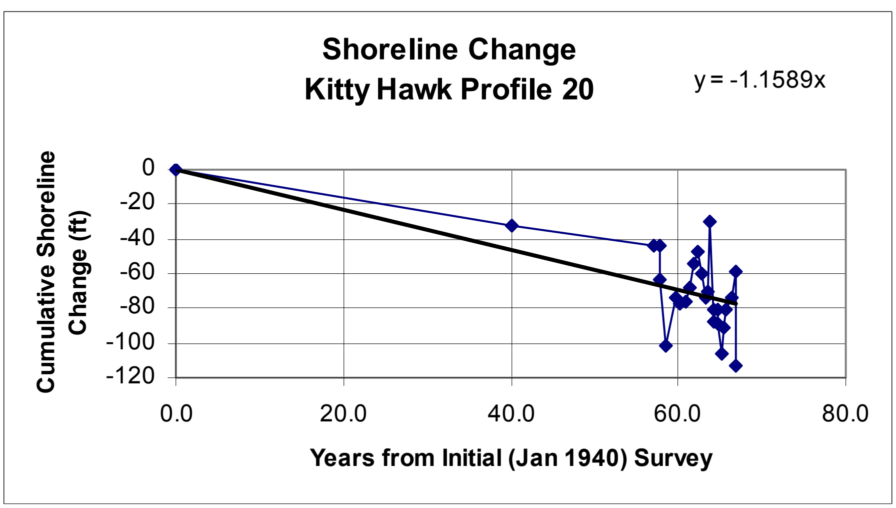

y = 0.9028x
Shoreline Change
Southern Shores Profile -30
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

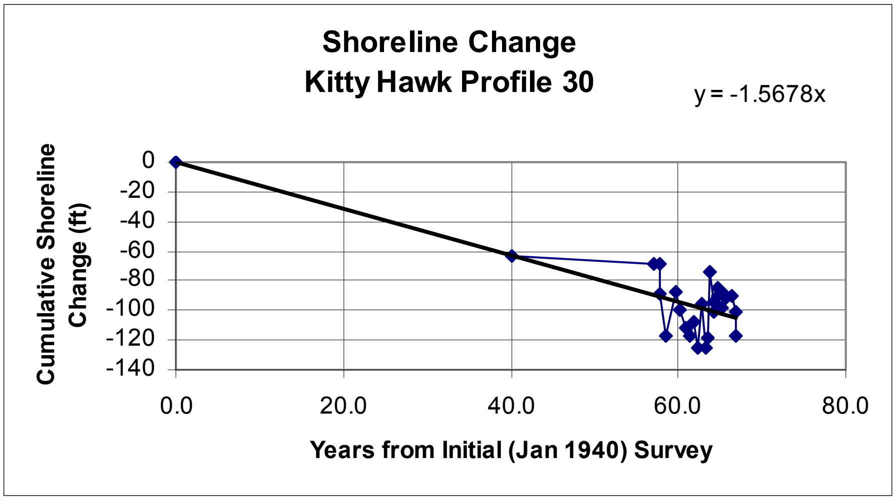

y = 0.9921x
Shoreline Change
Southern Shores Profile -20
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

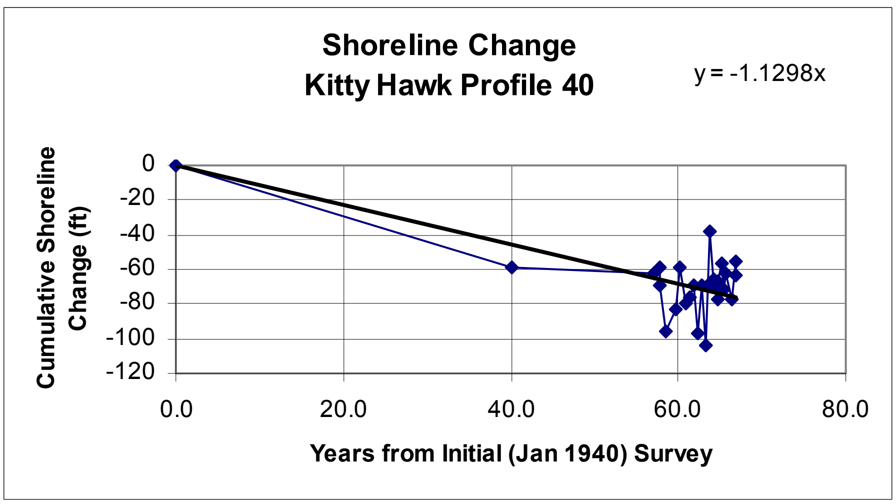

y = -0.3163x
Shoreline Change
Southern Shores Profile -10
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
-30
-40
-50
-60
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

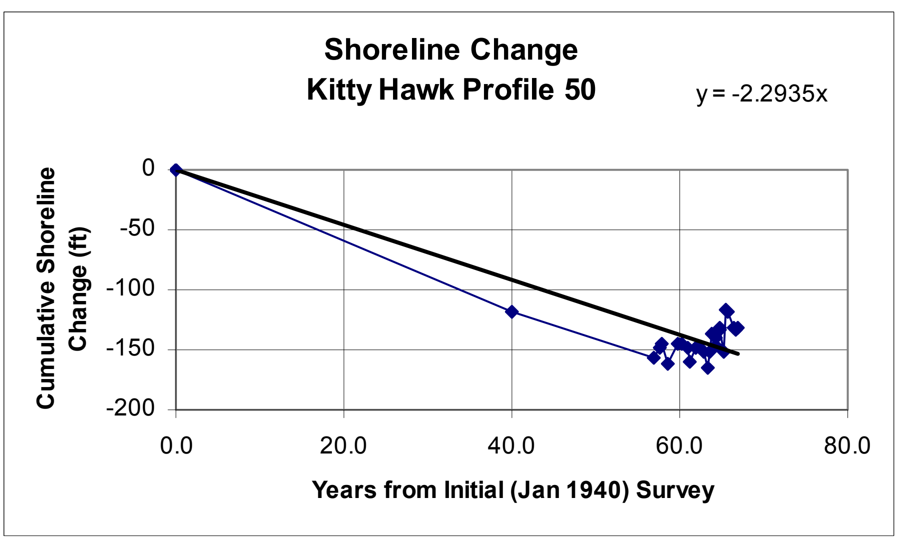

Shoreline Change
Kitty Hawk Profile 0
y = -0.5607x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
-60
-80
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

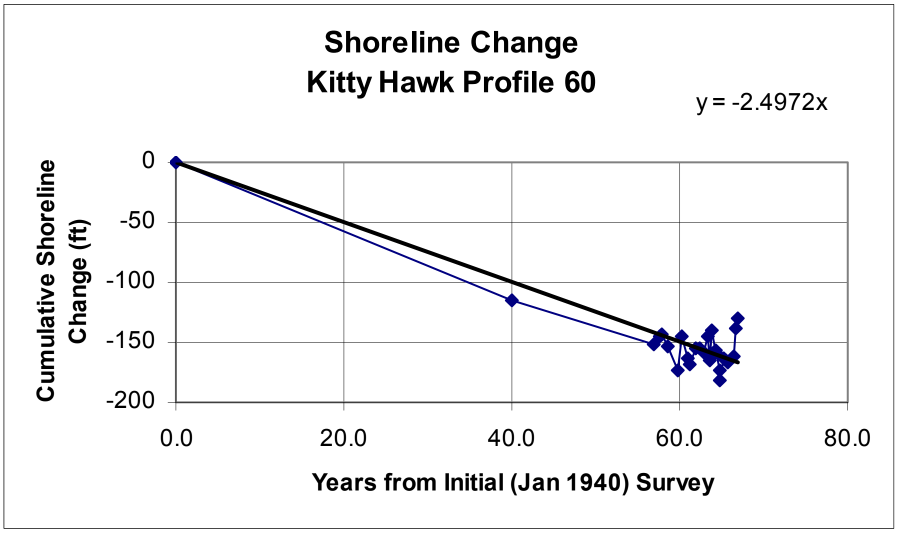

Shoreline Change
Kitty Hawk Profile 9
y = -0.9104x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

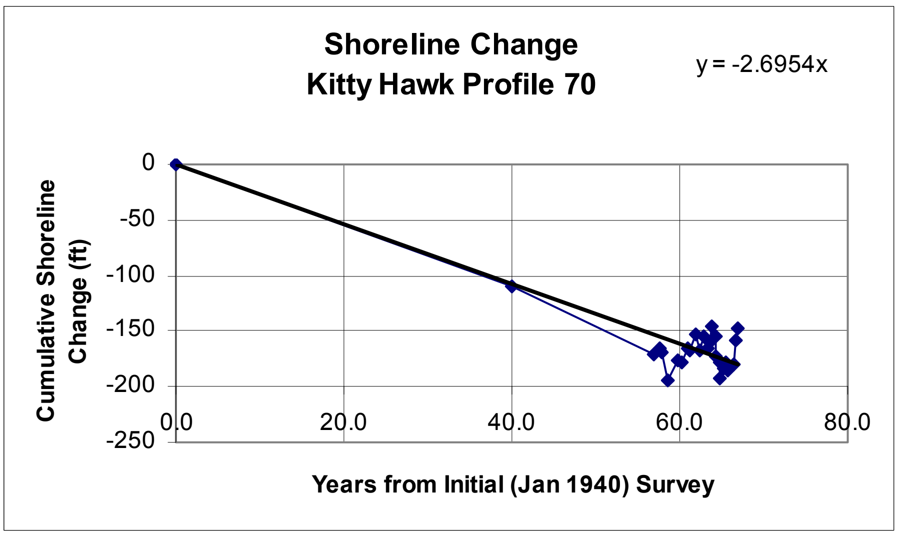

Shoreline Change
Kitty Hawk Profile 20
y = -1.1589x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

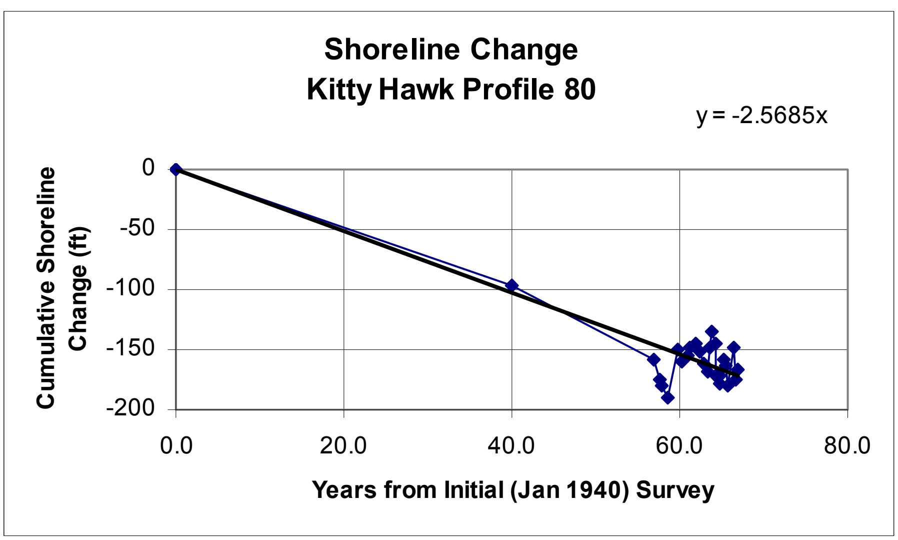

Shoreline Change
Kitty Hawk Profile 30
y = -1.5678x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
-140
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

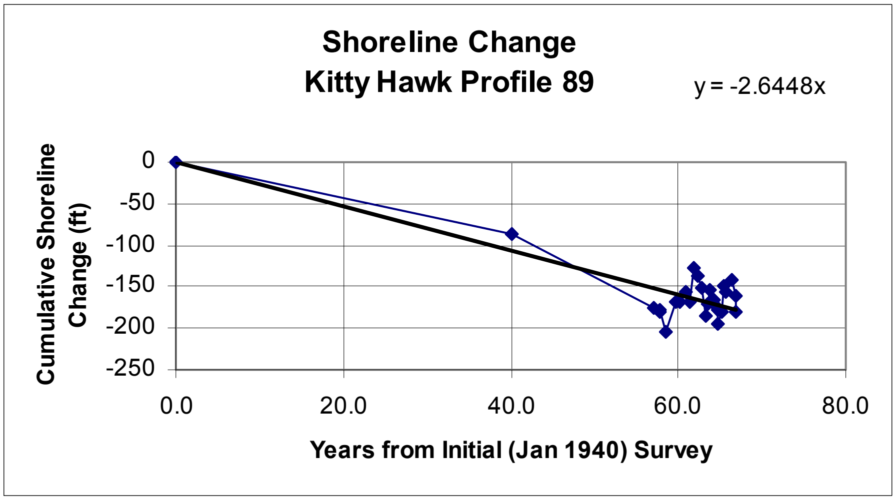

Shoreline Change
Kitty Hawk Profile 40
y = -1.1298x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

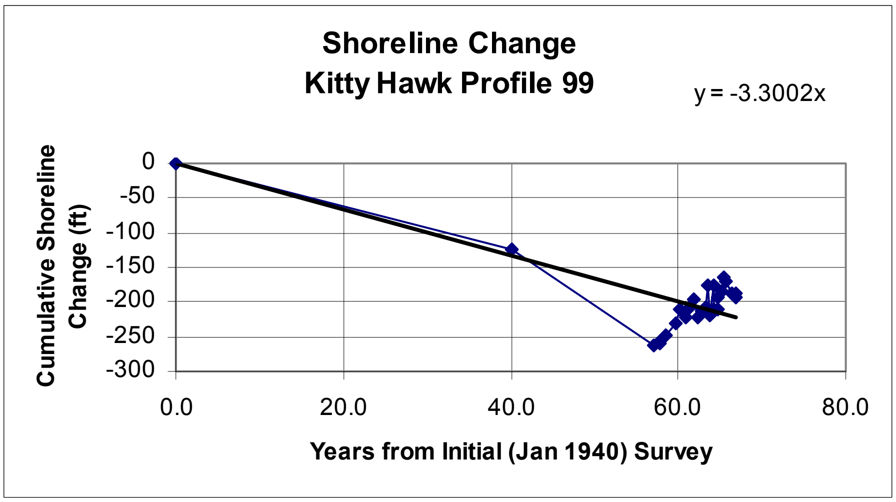

Shoreline Change
Kitty Hawk Profile 50
y = -2.2935x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

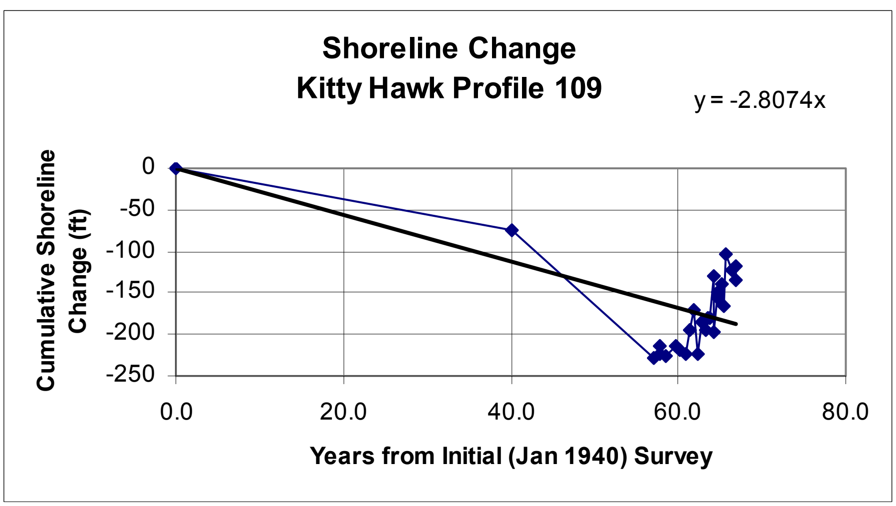

Shoreline Change
Kitty Hawk Profile 60
y = -2.4972x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

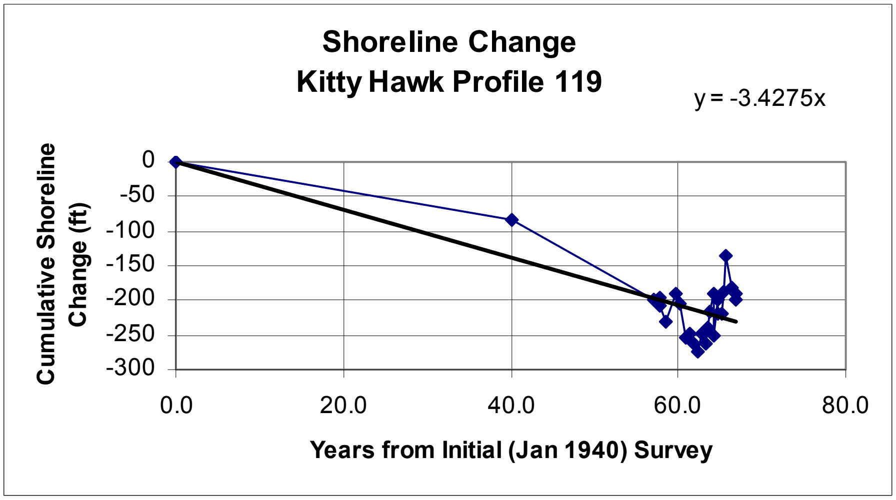

Shoreline Change
Kitty Hawk Profile 70
y = -2.6954x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

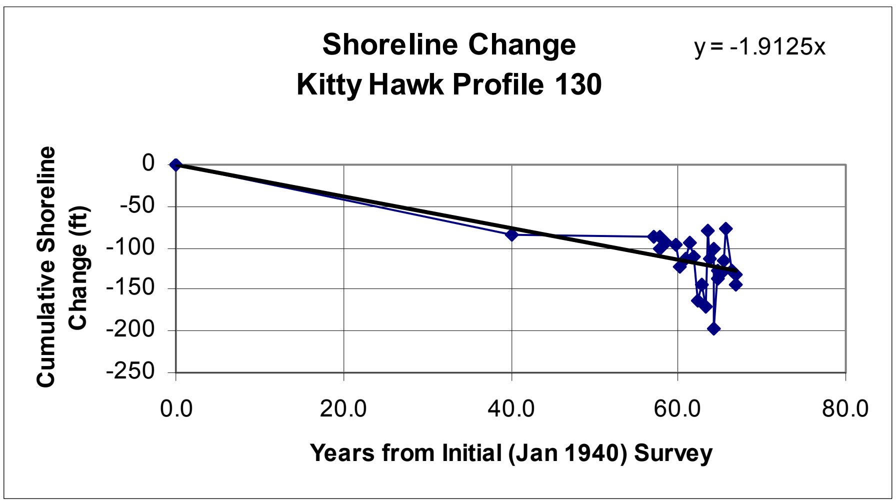

Shoreline Change
Kitty Hawk Profile 80
y = -2.5685x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

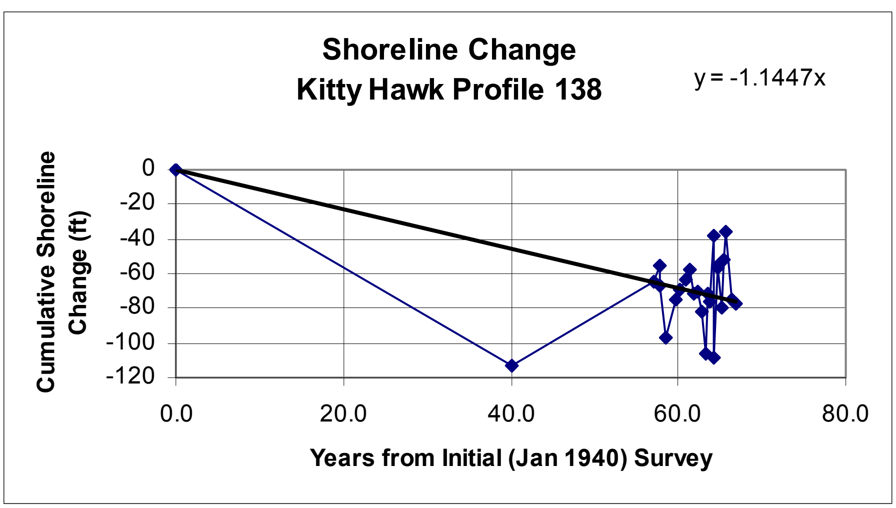

Shoreline Change
Kitty Hawk Profile 89
y = -2.6448x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

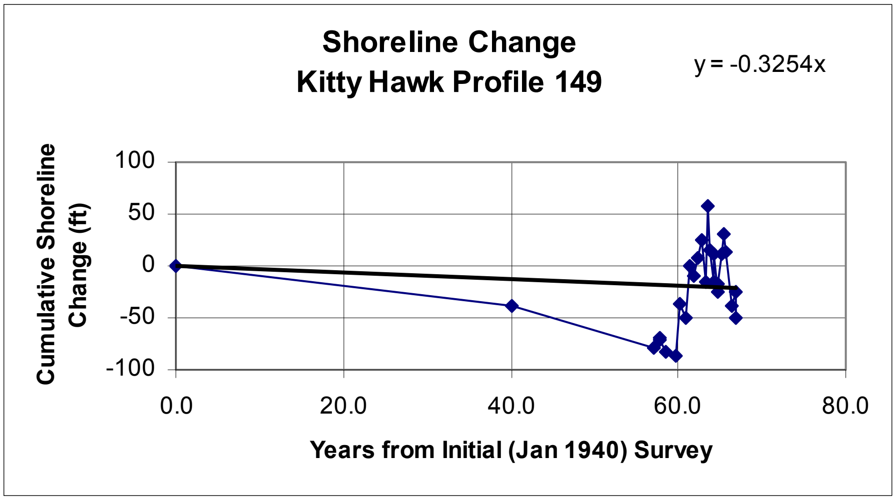

Shoreline Change
Kitty Hawk Profile 99
y = -3.3002x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

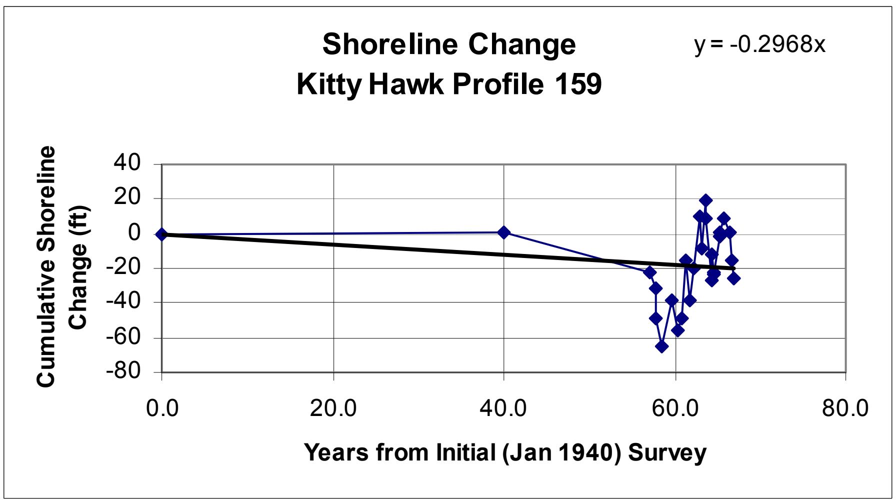

Shoreline Change
Kitty Hawk Profile 109
y = -2.8074x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

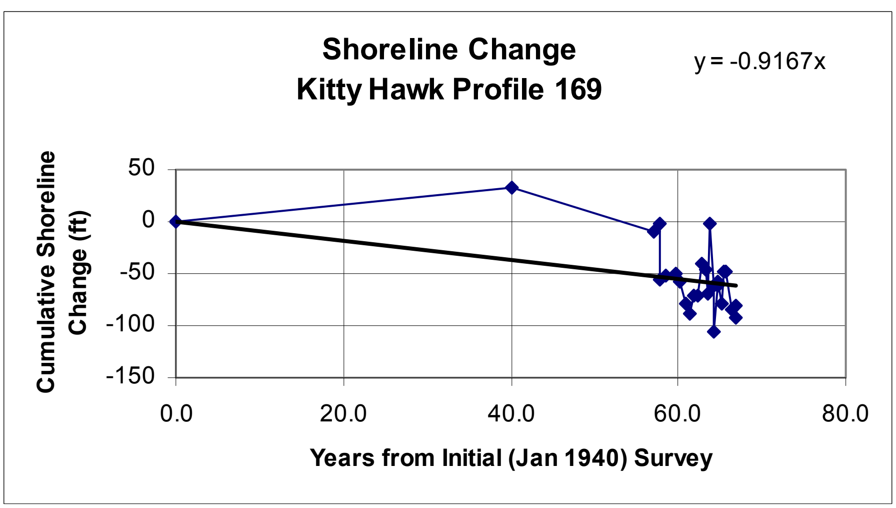

Shoreline Change
Kitty Hawk Profile 119
y = -3.4275x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

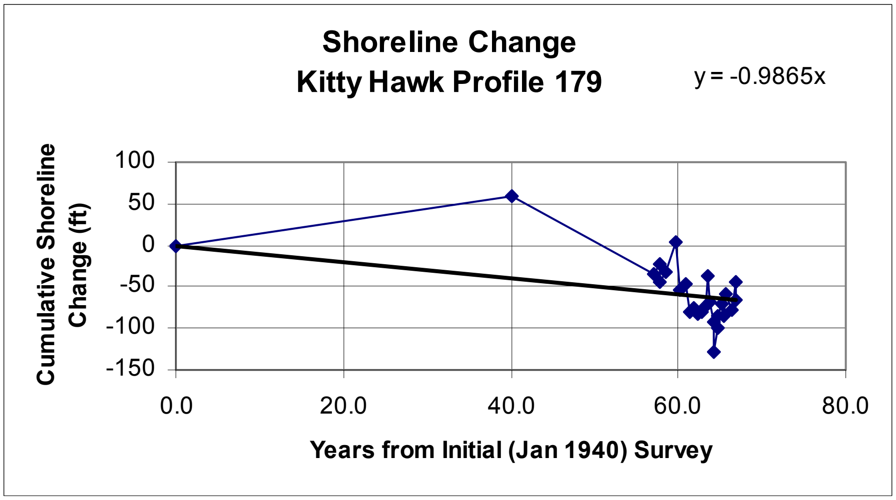

Shoreline Change
Kitty Hawk Profile 130
y = -1.9125x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

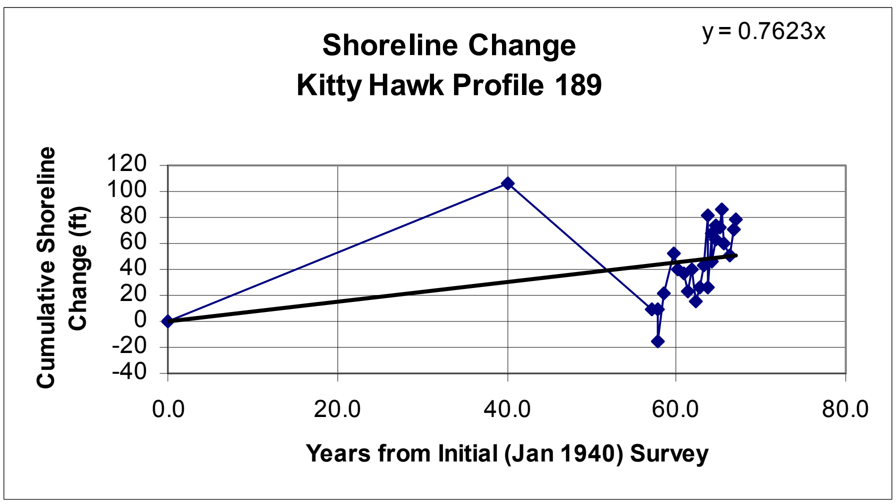

Shoreline Change
Kitty Hawk Profile 138
y = -1.1447x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

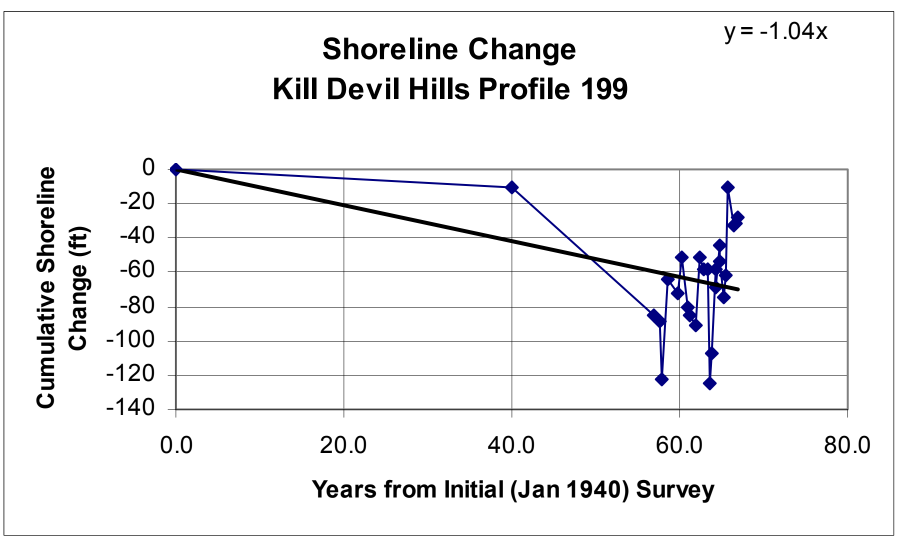

Shoreline Change
Kitty Hawk Profile 149
y = -0.3254x
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

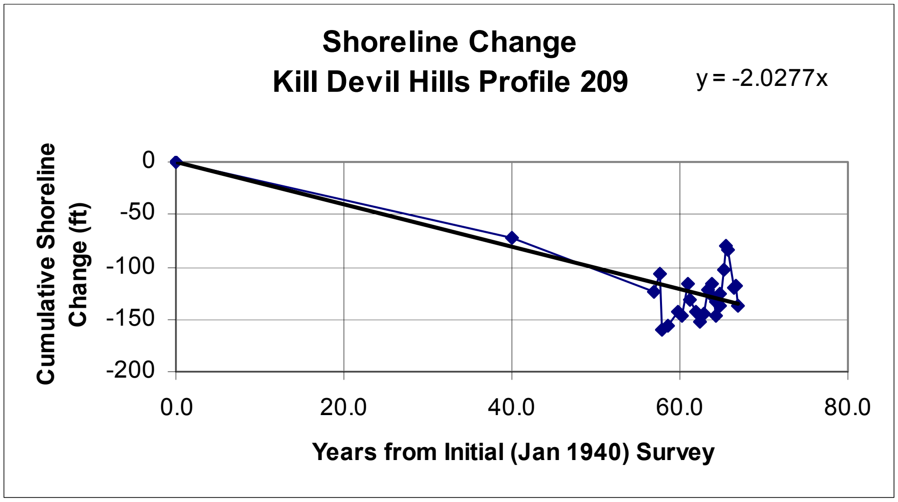

Shoreline Change
Kitty Hawk Profile 159
y = -0.2968x
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
-80
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey


Shoreline Change
Kitty Hawk Profile 169
y = -0.9167x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

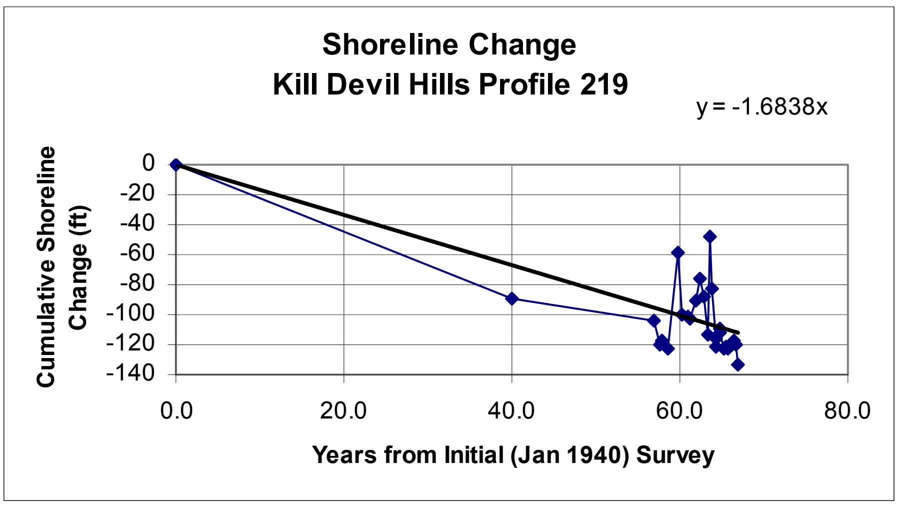

Shoreline Change
Kitty Hawk Profile 179
y = -0.9865x
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey


Shoreline Change
Kitty Hawk Profile 189
y = 0.7623x
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

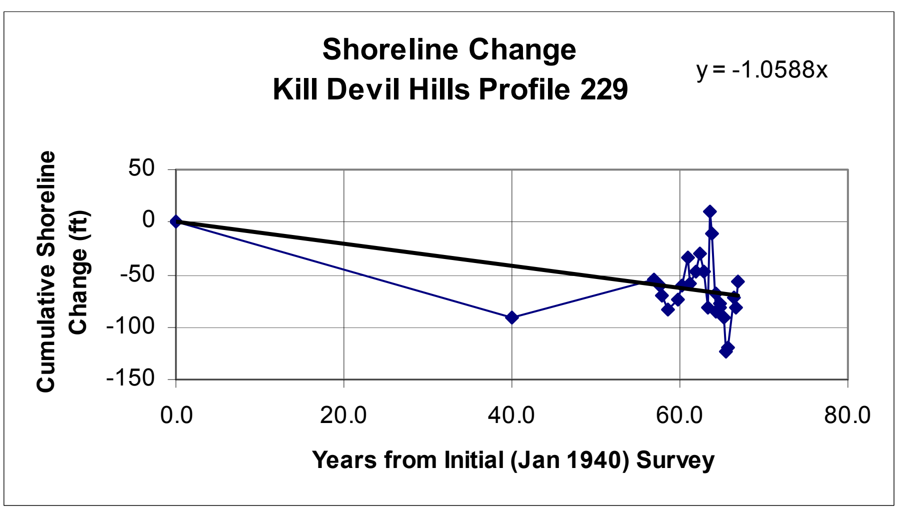

Shoreline Change
Kill Devil Hills Profile 199
y = -1.04x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
-140
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey



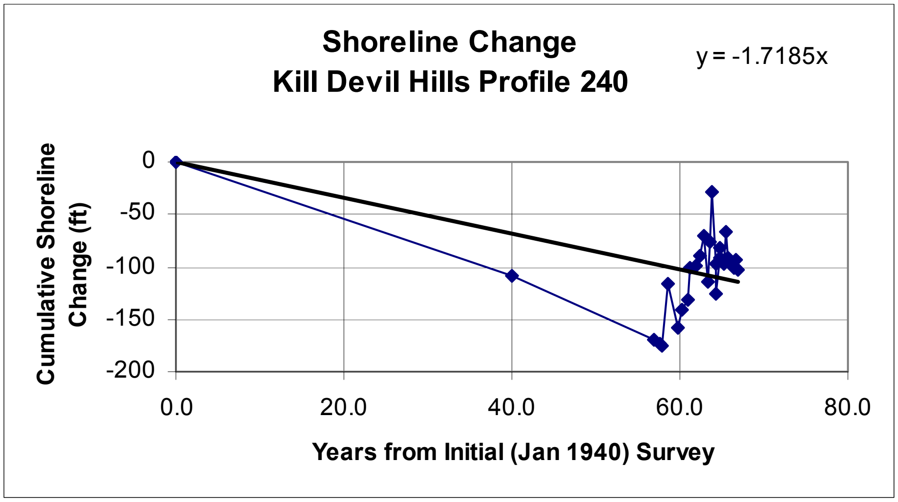
Shoreline Change
Kill Devil Hills Profile 209
y = -2.0277x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

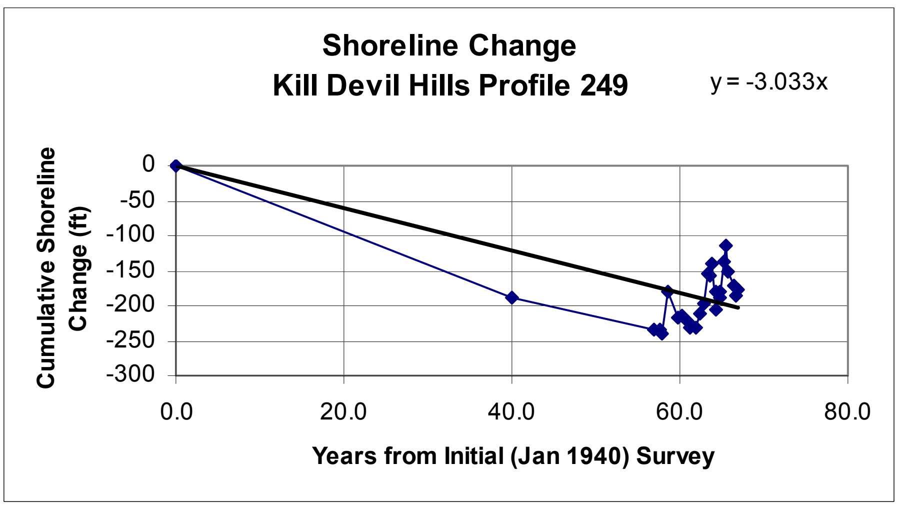


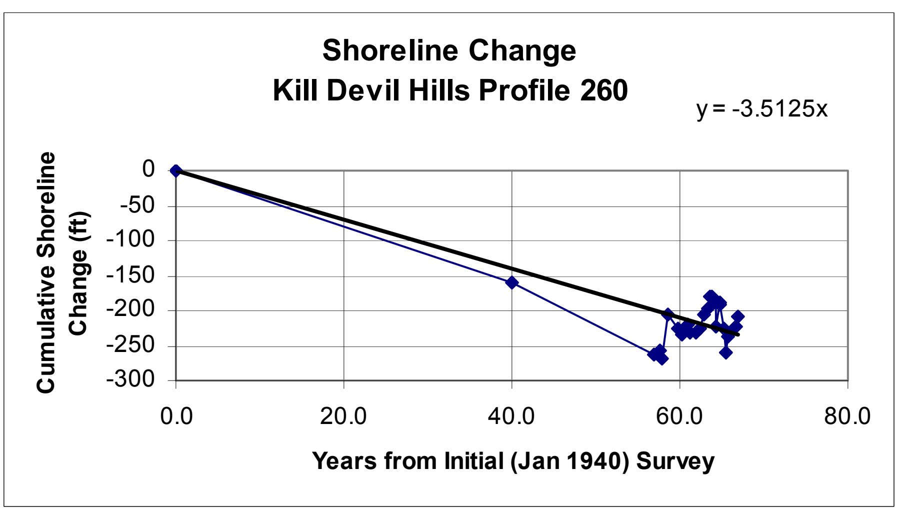
Shoreline Change
Kill Devil Hills Profile 219
y = -1.6838x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
-140
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

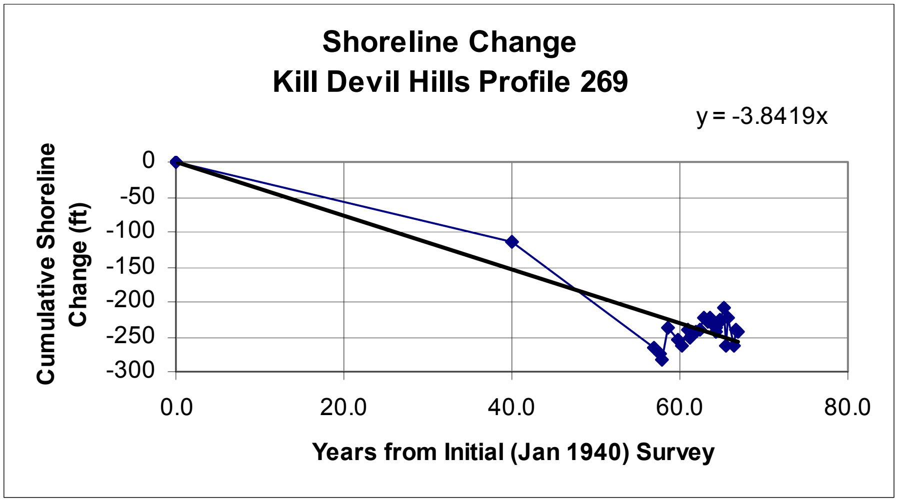


Shoreline Change
Kill Devil Hills Profile 229
y = -1.0588x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

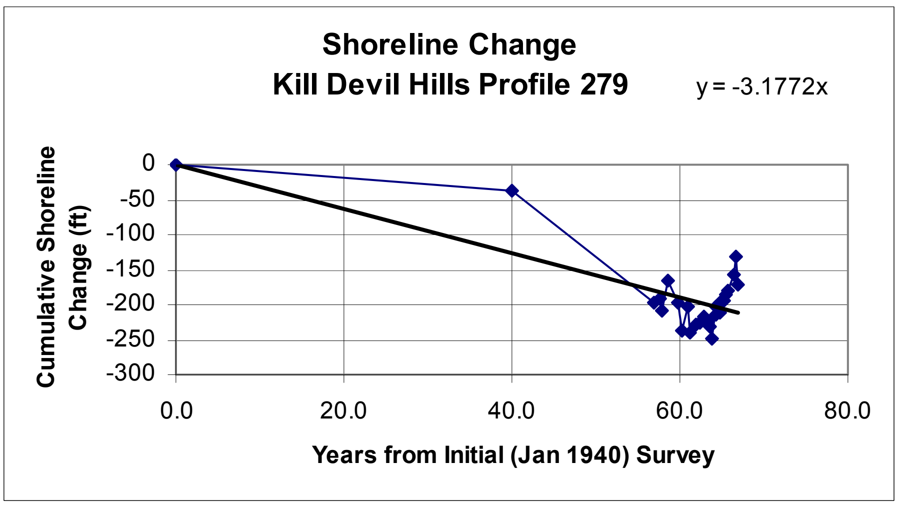

Shoreline Change
Kill Devil Hills Profile 240
y = -1.7185x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey


Shoreline Change
Kill Devil Hills Profile 249
y = -3.033x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

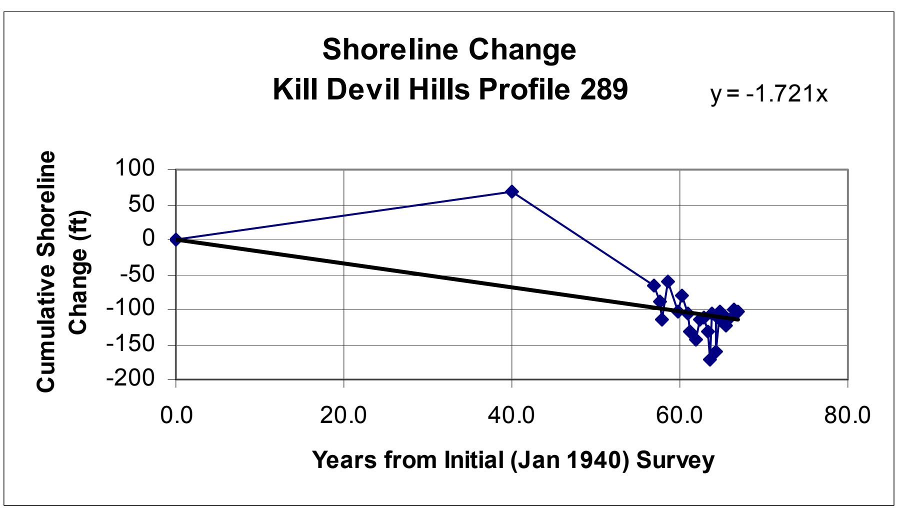

Shoreline Change
Kill Devil Hills Profile 260
y = -3.5125x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey



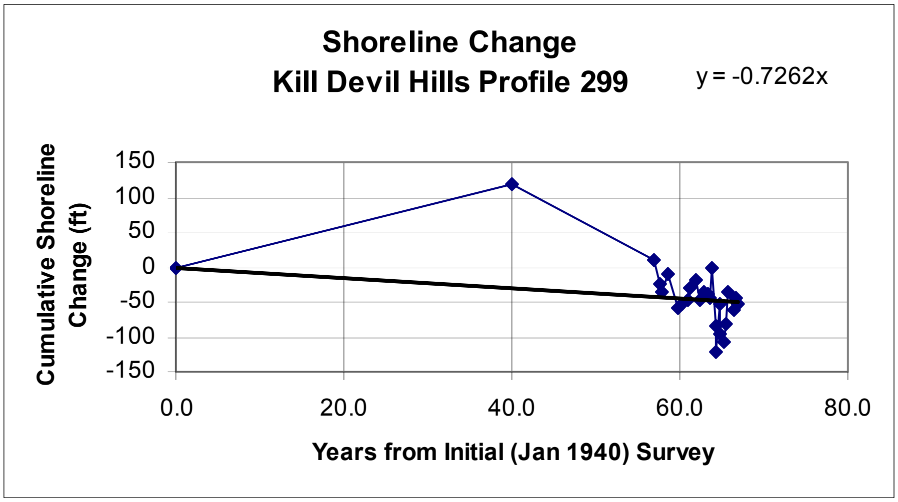
Shoreline Change
Kill Devil Hills Profile 269
y = -3.8419x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

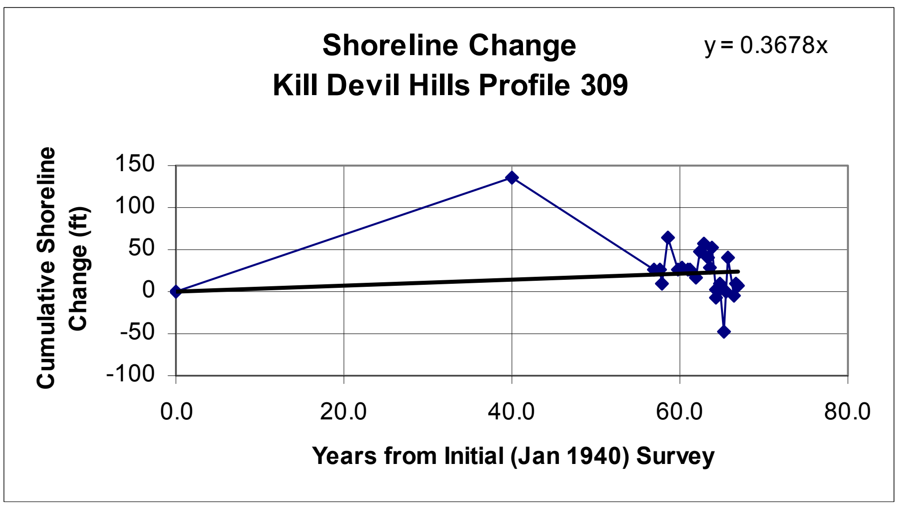


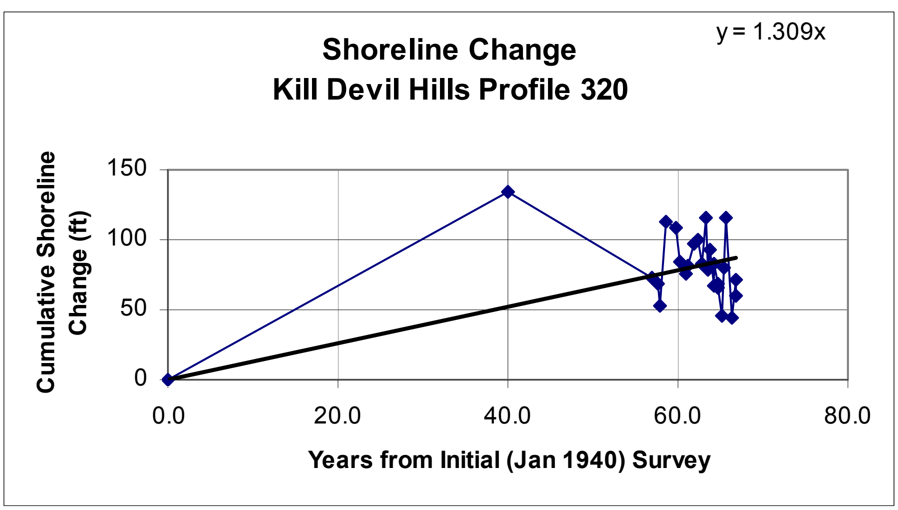
Shoreline Change
Kill Devil Hills Profile 279
y = -3.1772x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

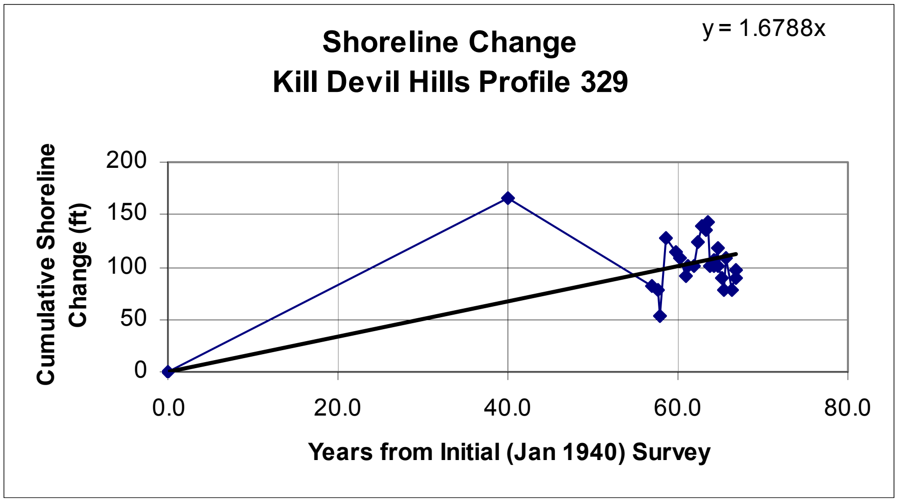


Shoreline Change
Kill Devil Hills Profile 289
y = -1.721x
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

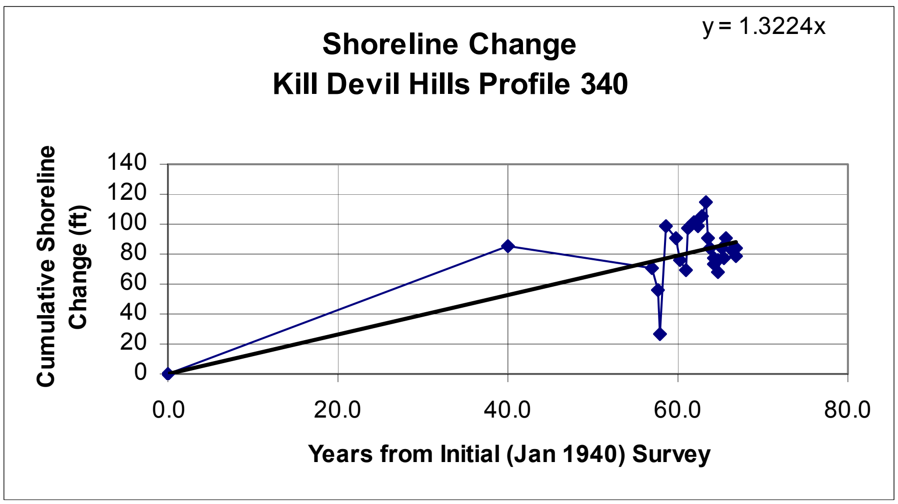

Shoreline Change
Kill Devil Hills Profile 299
y = -0.7262x
Cumulative Shoreline Change (ft)
150
100
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey


Shoreline Change
Kill Devil Hills Profile 309
y = 0.3678x
Cumulative Shoreline Change (ft)
150
100
50
0
-50
-100
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

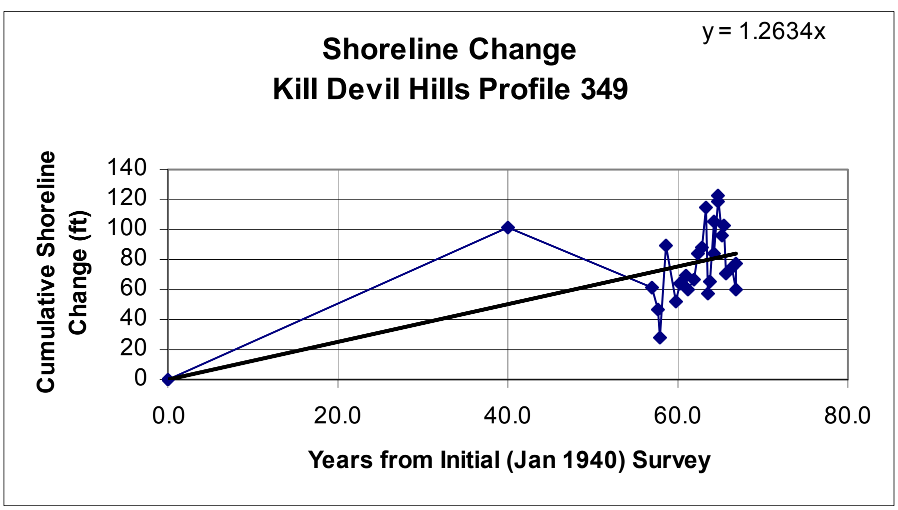

Shoreline Change
Kill Devil Hills Profile 320
y = 1.309x
Cumulative Shoreline Change (ft)
150
100
50
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey



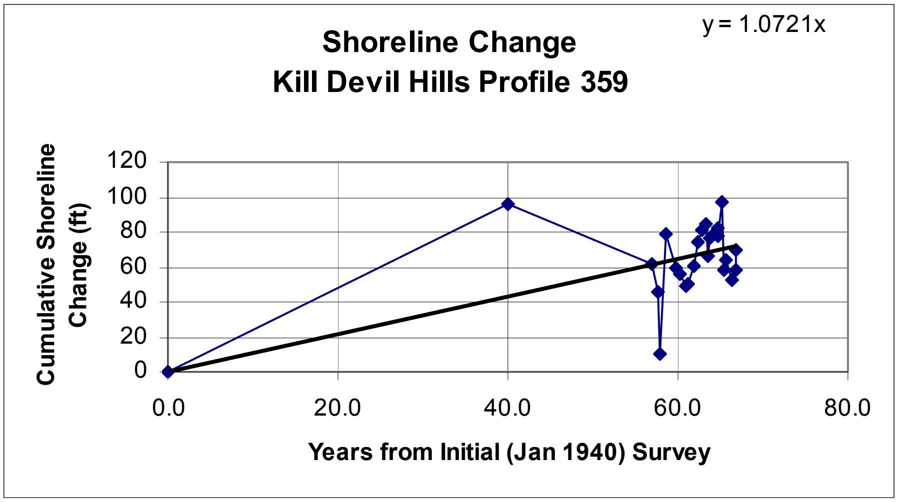
y = 1.6788x
Shoreline Change
Kill Devil Hills Profile 329
Cumulative Shoreline Change (ft)
200
150
100
50
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

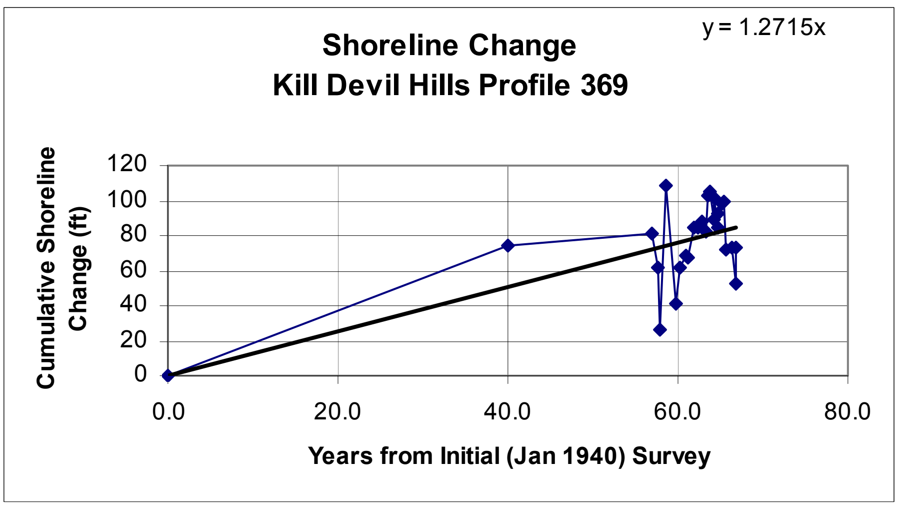


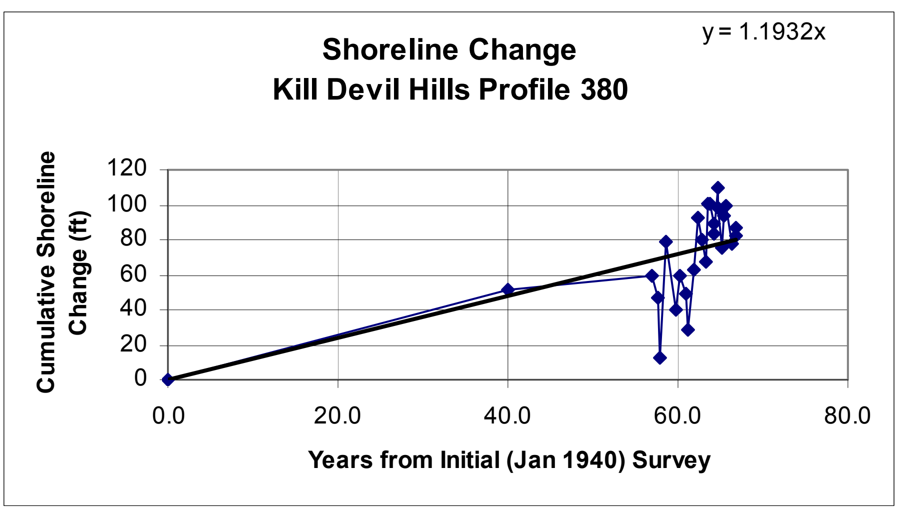
y = 1.3224x
Shoreline Change
Kill Devil Hills Profile 340
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

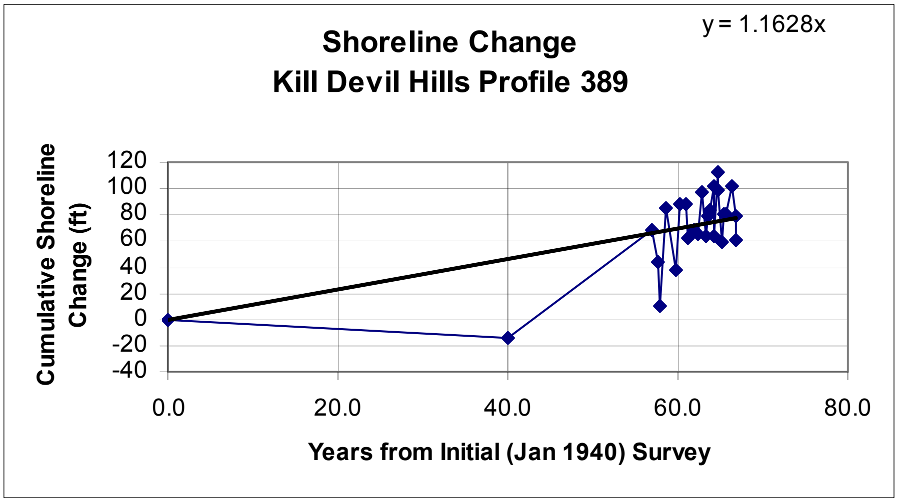


y = 1.2634x
Shoreline Change
Kill Devil Hills Profile 349
Cumulative Shoreline Change (ft)
140
120
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

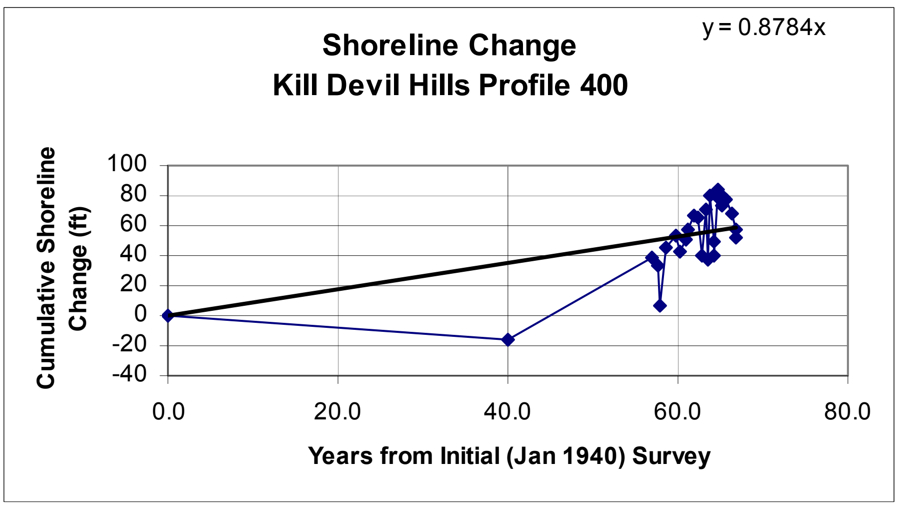

y = 1.0721x
Shoreline Change
Kill Devil Hills Profile 359
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey


y = 1.2715x
Shoreline Change
Kill Devil Hills Profile 369
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

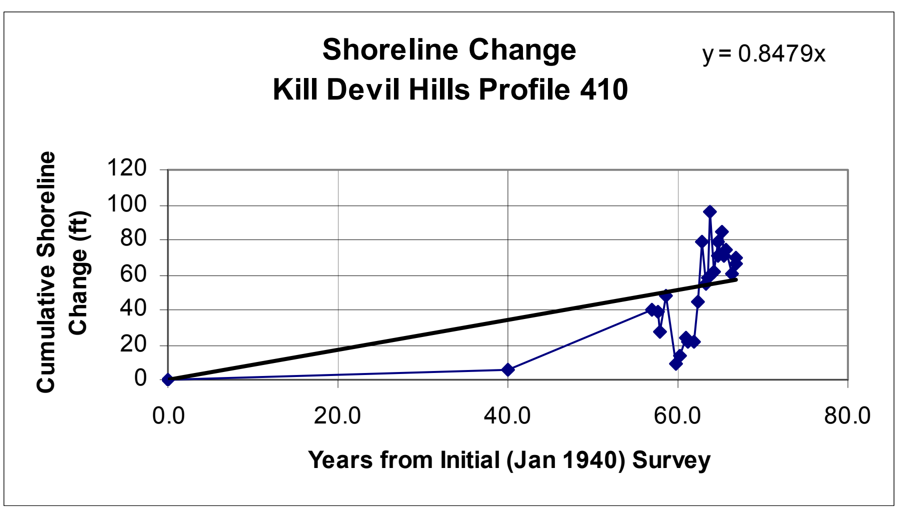

y = 1.1932x
Shoreline Change
Kill Devil Hills Profile 380
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey



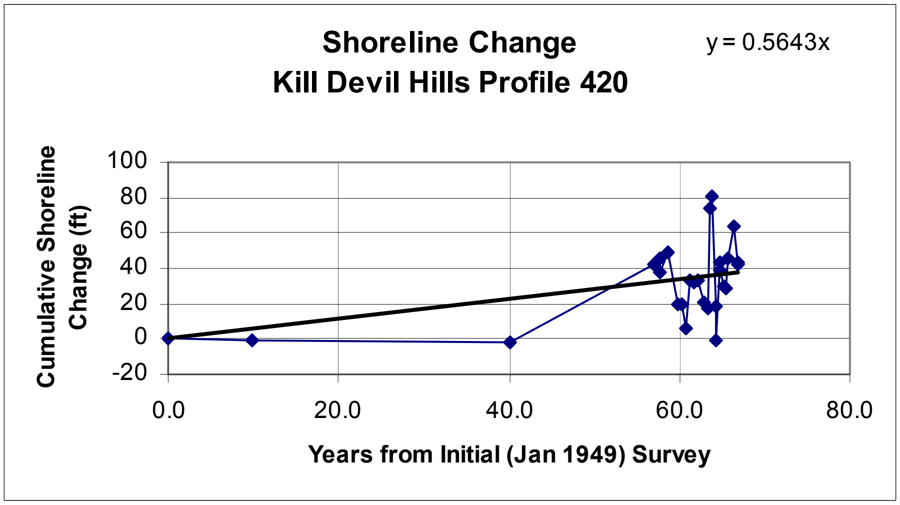
Shoreline Change
Kill Devil Hills Profile 389
y = 1.1628x
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

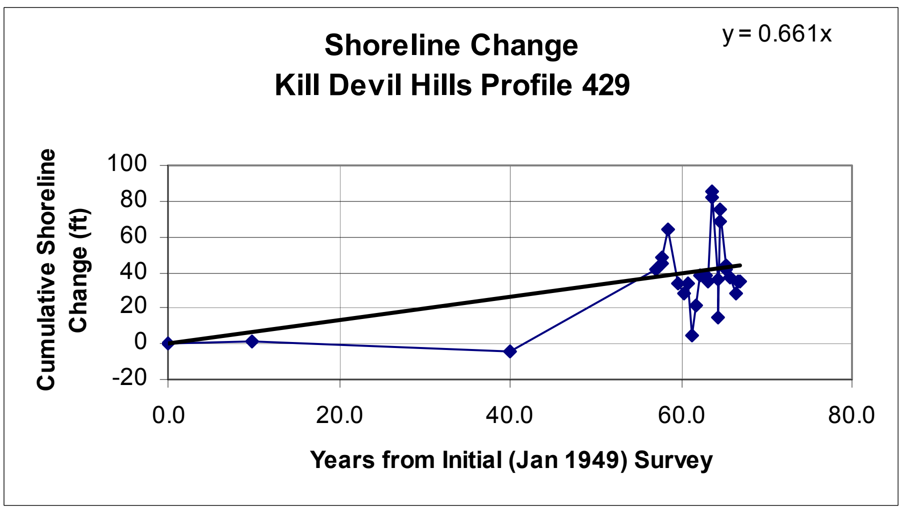


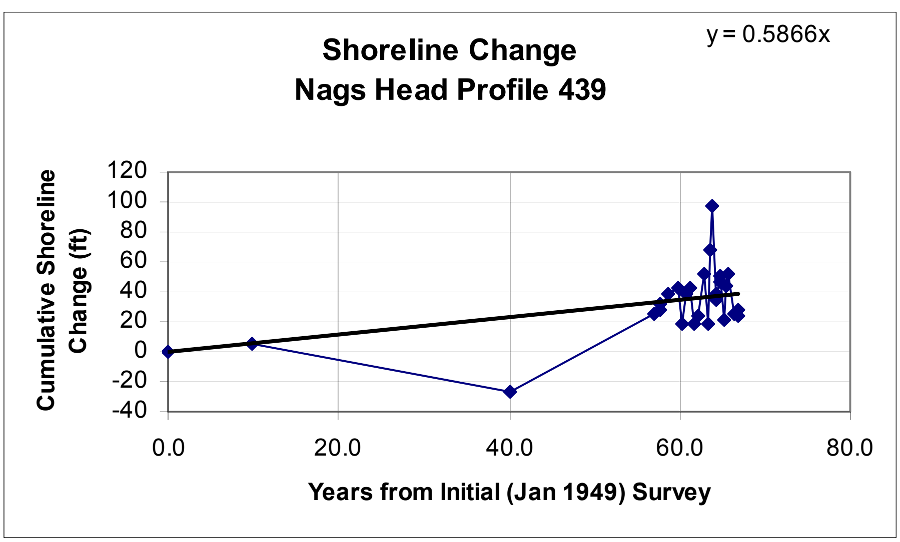
Shoreline Change
Kill Devil Hills Profile 400
y = 0.8784x
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

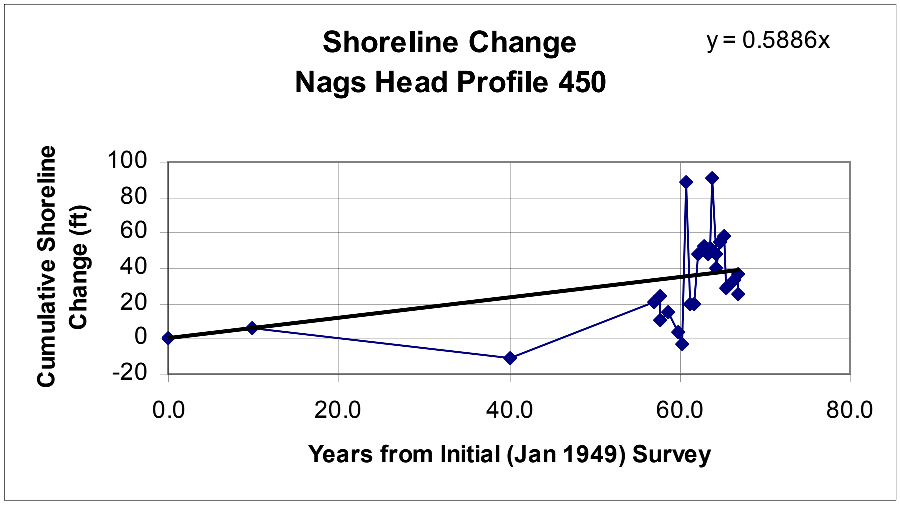


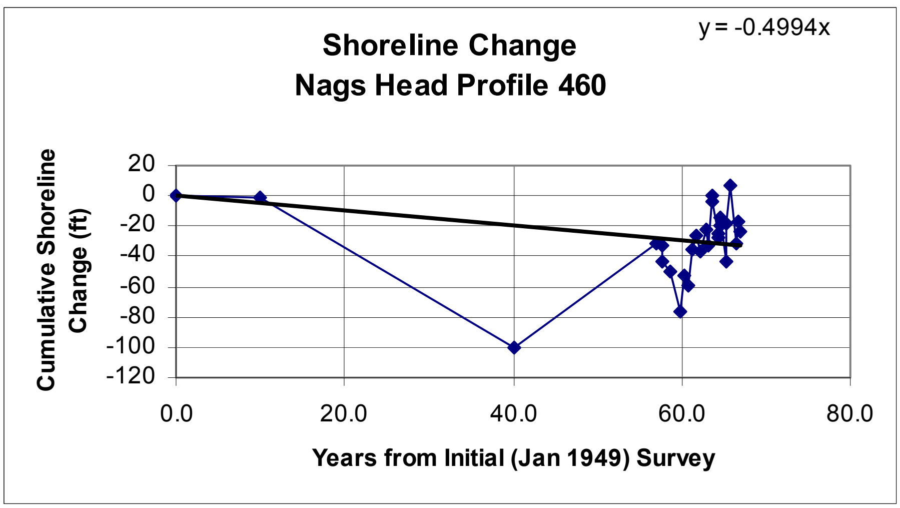
Shoreline Change
Kill Devil Hills Profile 410
y = 0.8479x
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1940) Survey

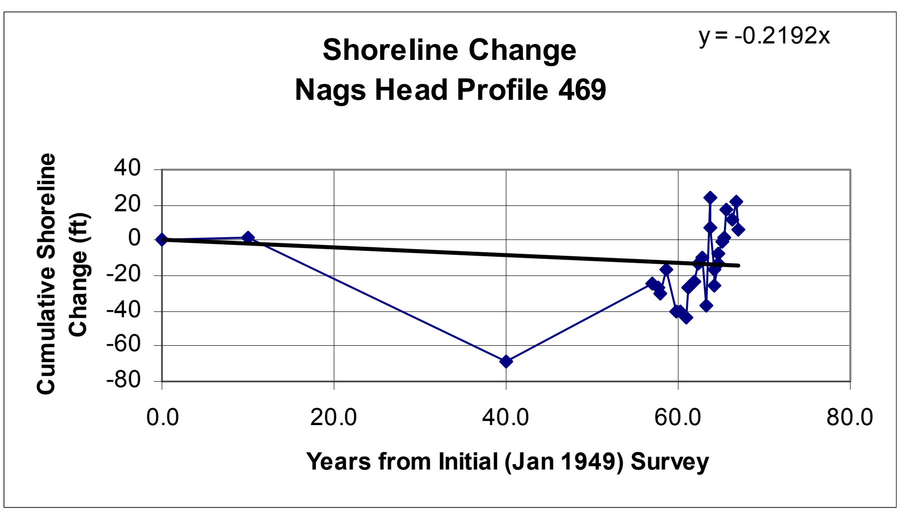

Shoreline Change
Kill Devil Hills Profile 420
y = 0.5643x
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

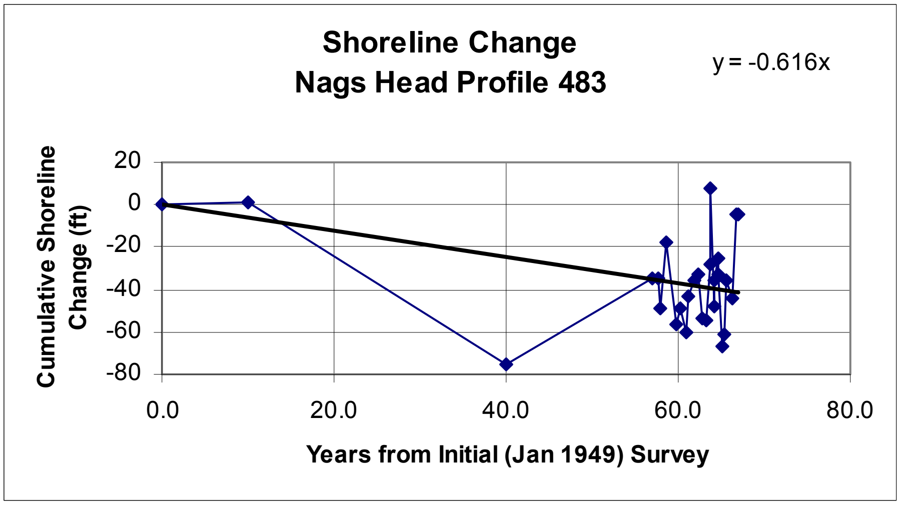

Shoreline Change
Kill Devil Hills Profile 429
y = 0.661x
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 439
y = 0.5866x
Cumulative Shoreline Change (ft)
120
100
80
60
40
20
0
-20
-40
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

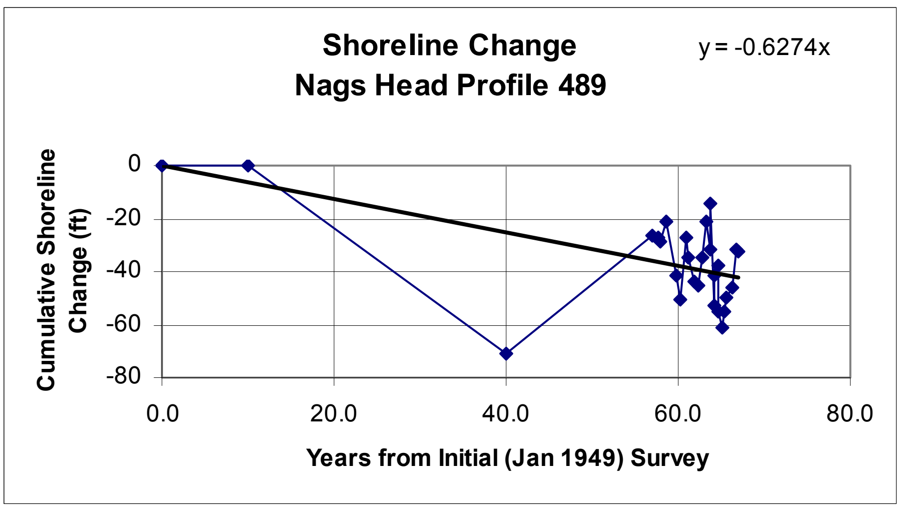

Shoreline Change
Nags Head Profile 450
y = 0.5886x
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
-20
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 460
y = -0.4994x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

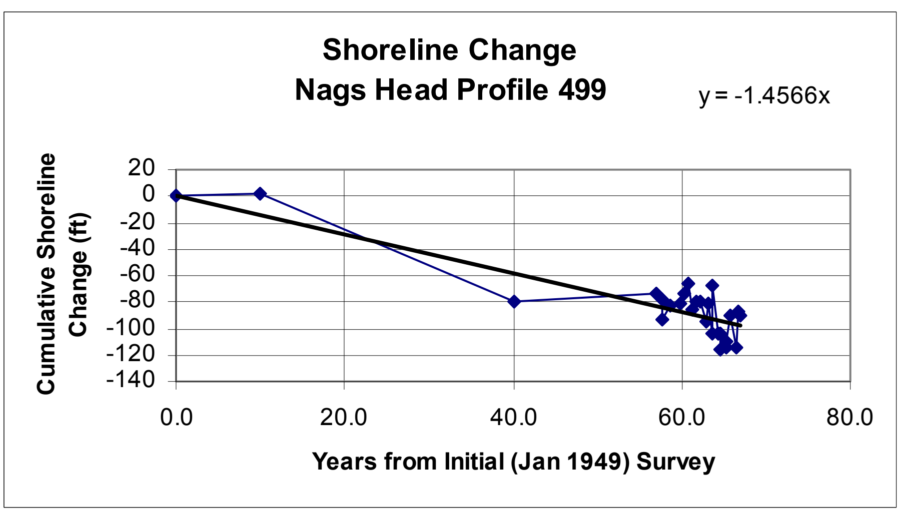

Shoreline Change
Nags Head Profile 469
y = -0.2192x
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
-80
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey



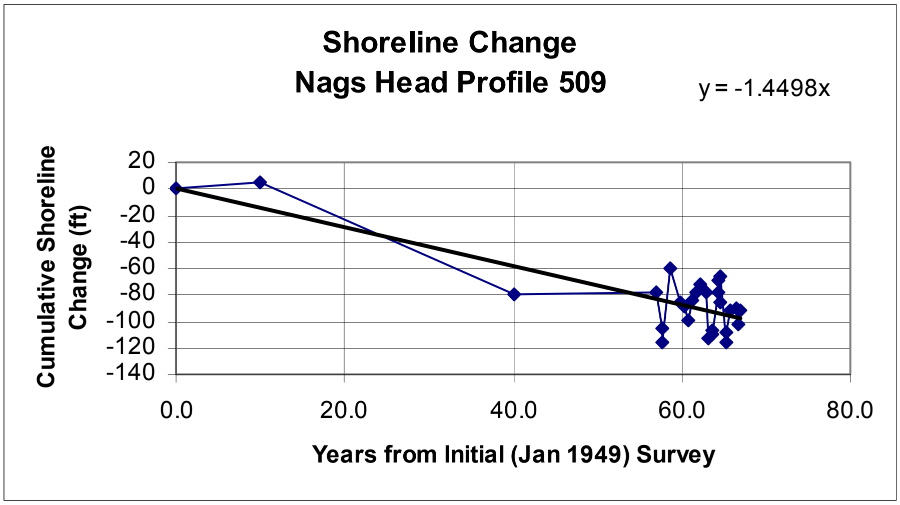
Shoreline Change
Nags Head Profile 483
y = -0.616x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

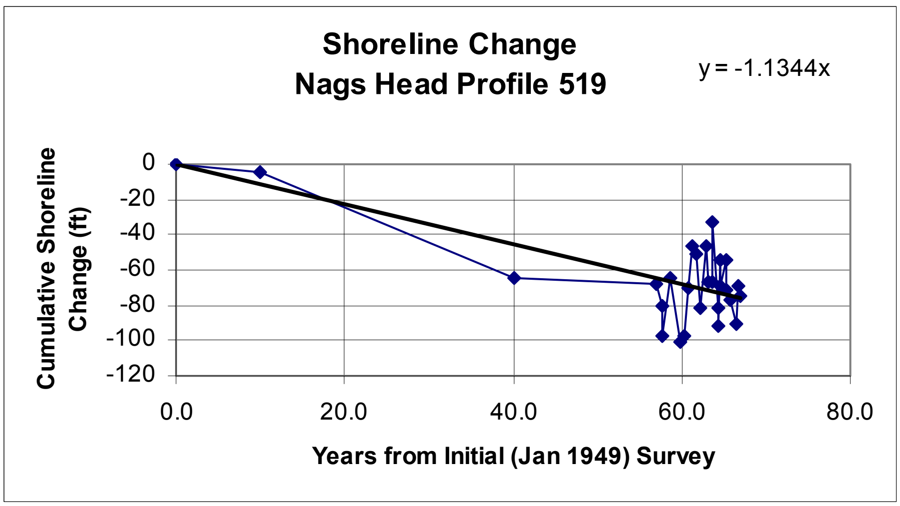


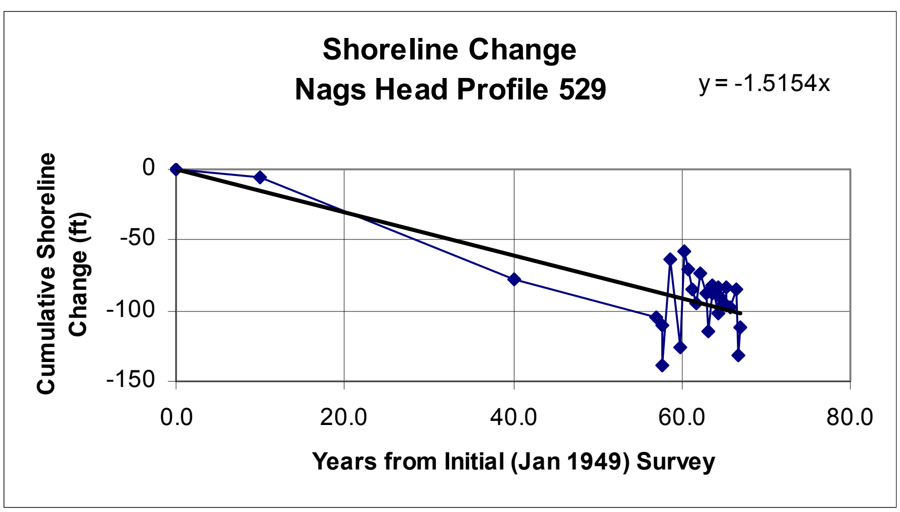
Shoreline Change
Nags Head Profile 489
y = -0.6274x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

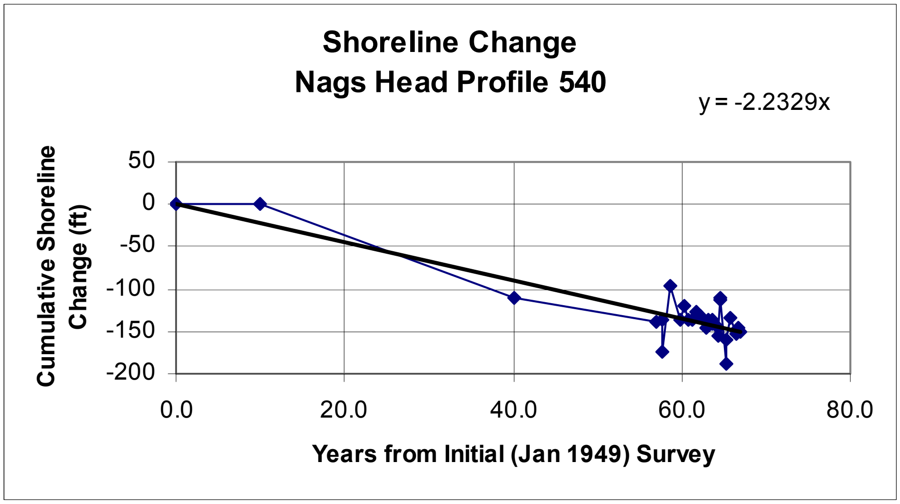


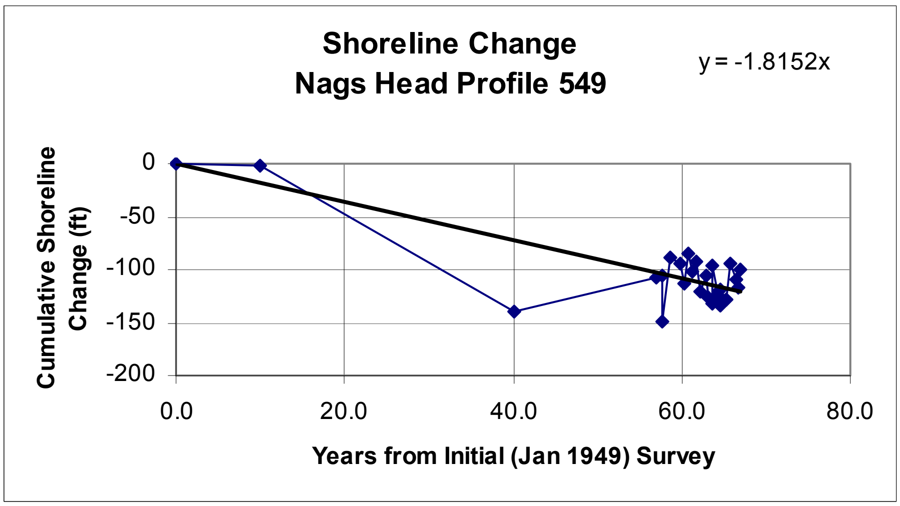
Shoreline Change
Nags Head Profile 499
y = -1.4566x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
-140
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

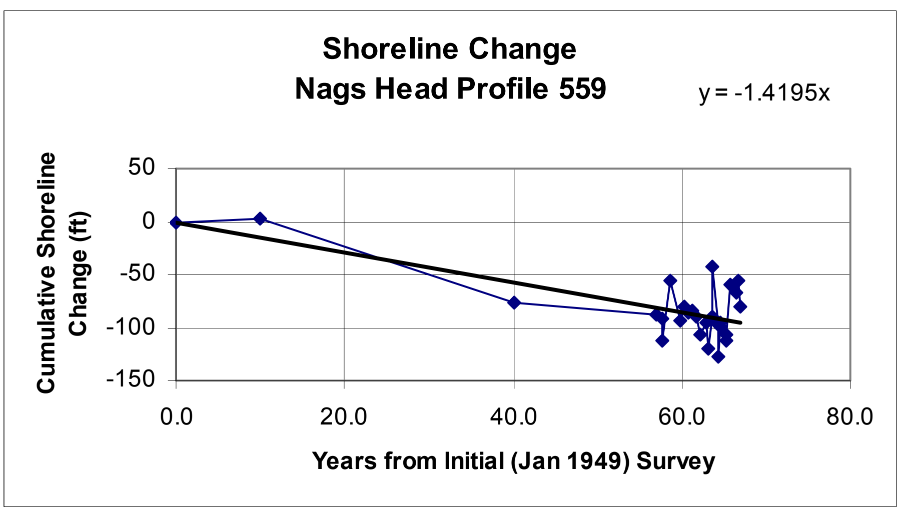

Shoreline Change
Nags Head Profile 509
y = -1.4498x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
-140
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

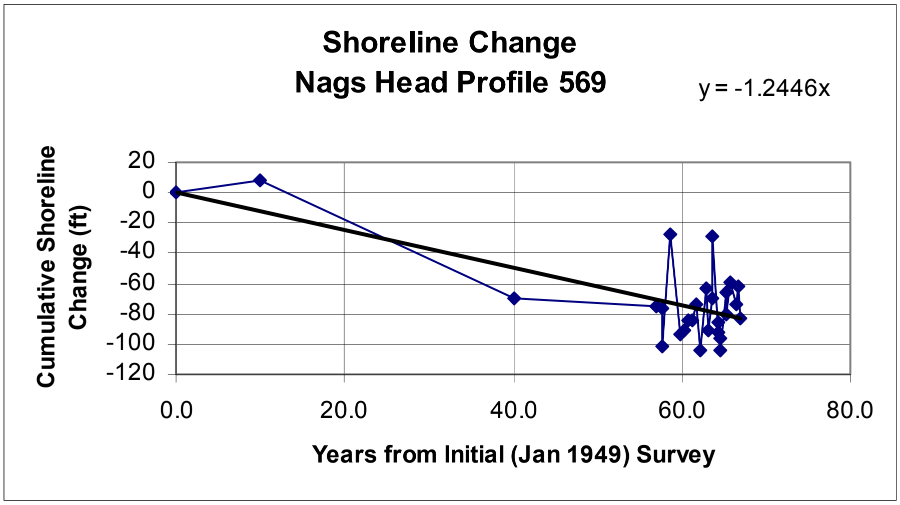

Shoreline Change
Nags Head Profile 519
y = -1.1344x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

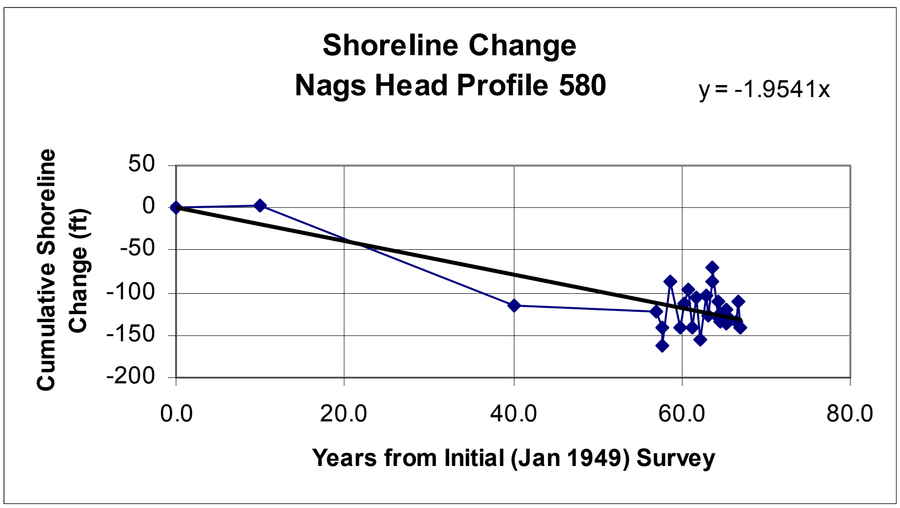

Shoreline Change
Nags Head Profile 529
y = -1.5154x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

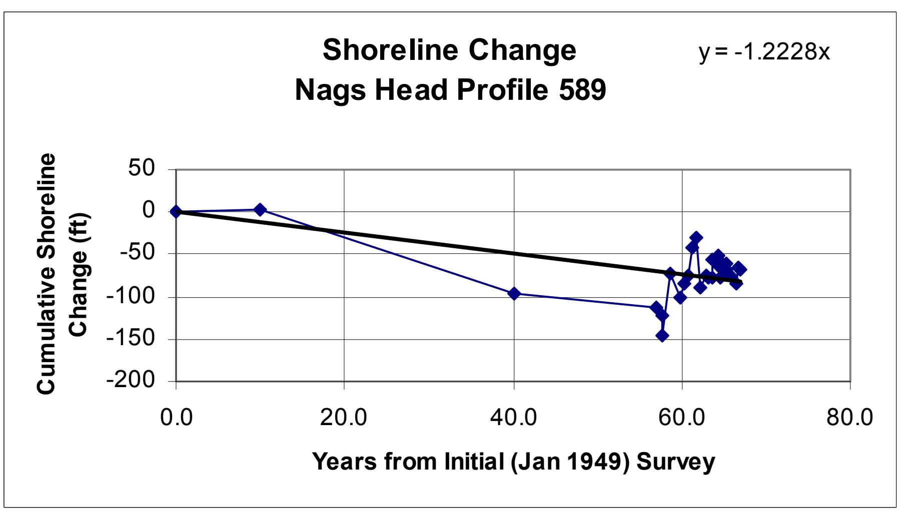

Shoreline Change
Nags Head Profile 540
y = -2.2329x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

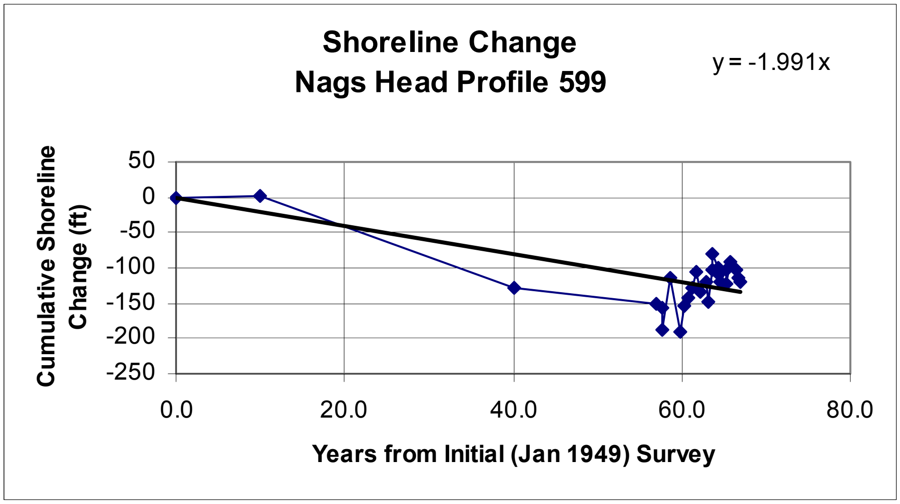

Shoreline Change
Nags Head Profile 549
y = -1.8152x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

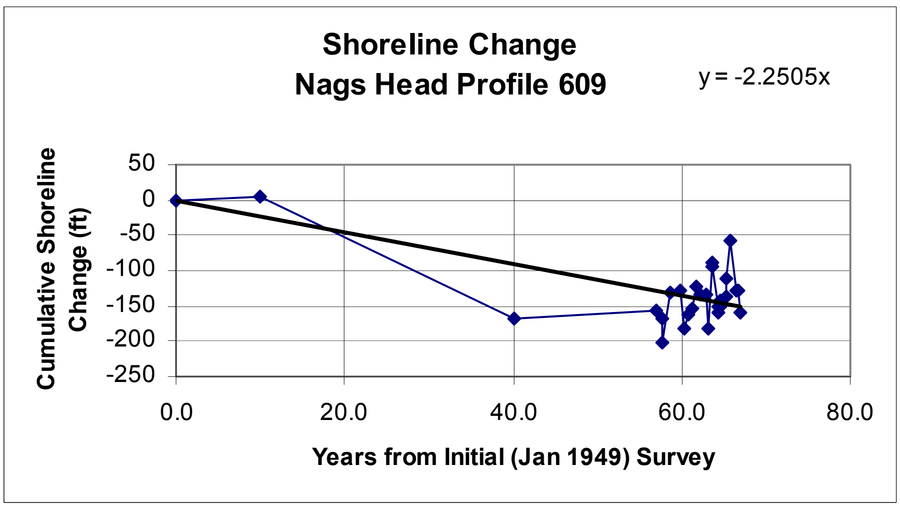

Shoreline Change
Nags Head Profile 559
y = -1.4195x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

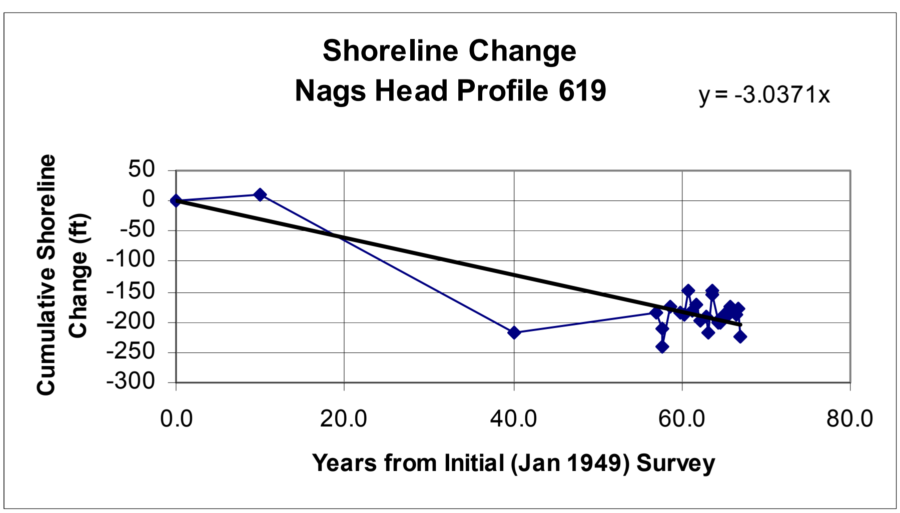

Shoreline Change
Nags Head Profile 569
y = -1.2446x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

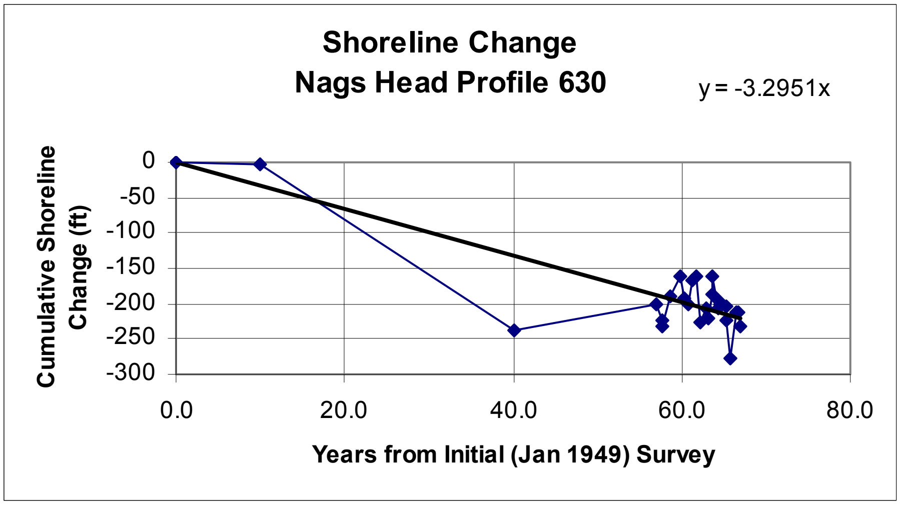

Shoreline Change
Nags Head Profile 580
y = -1.9541x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

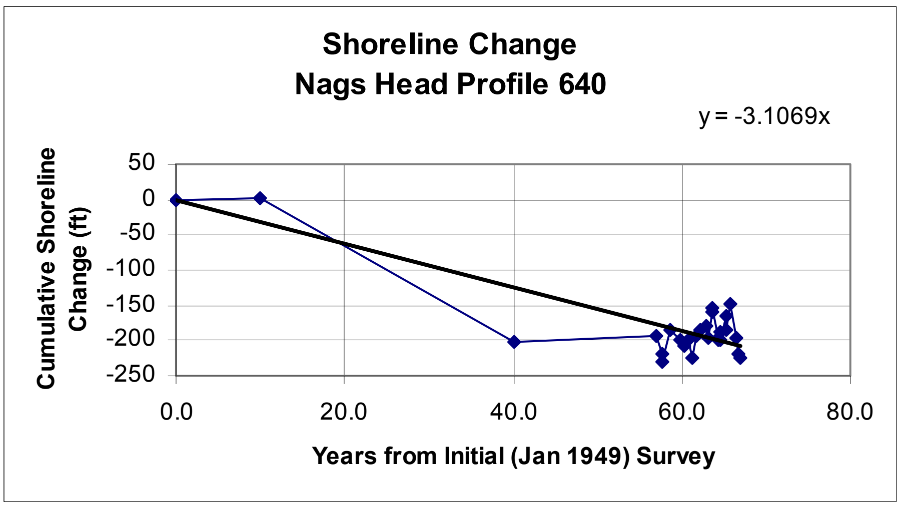

Shoreline Change
Nags Head Profile 589
y = -1.2228x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

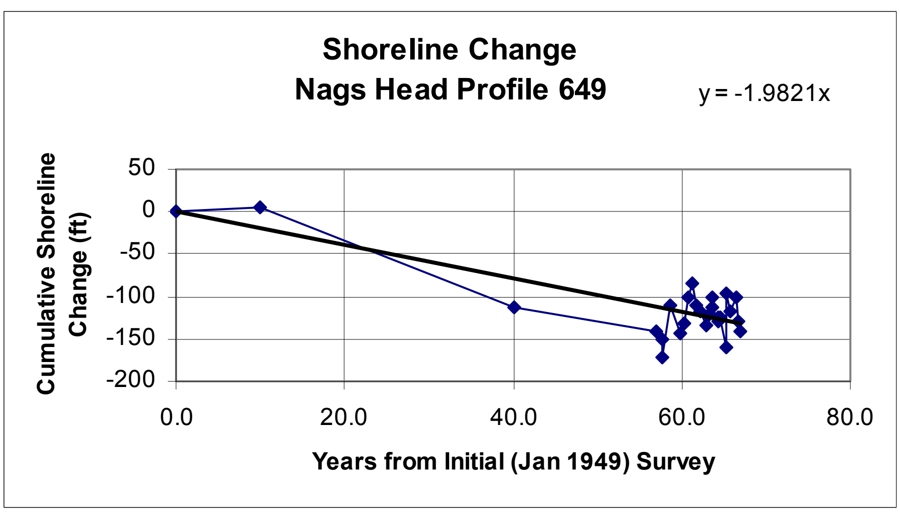

Shoreline Change
Nags Head Profile 599
y = -1.991x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

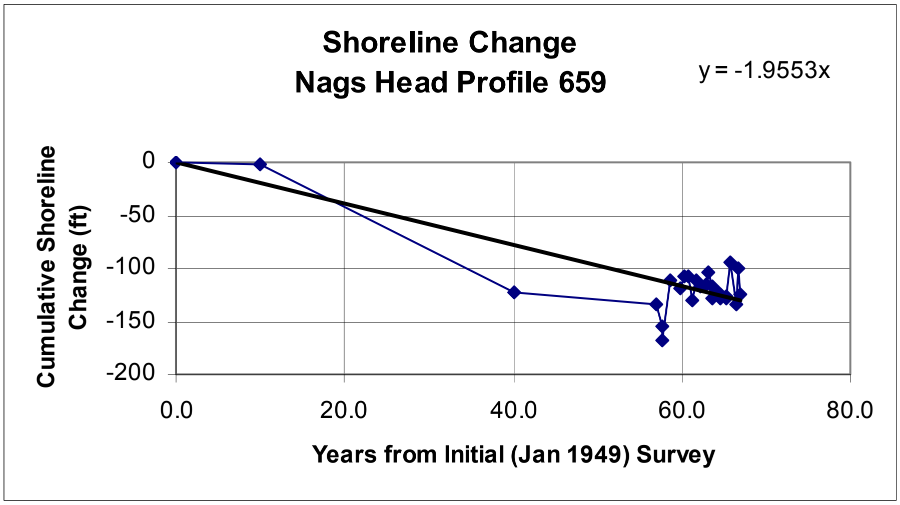

Shoreline Change
Nags Head Profile 609
y = -2.2505x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 619
y = -3.0371x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

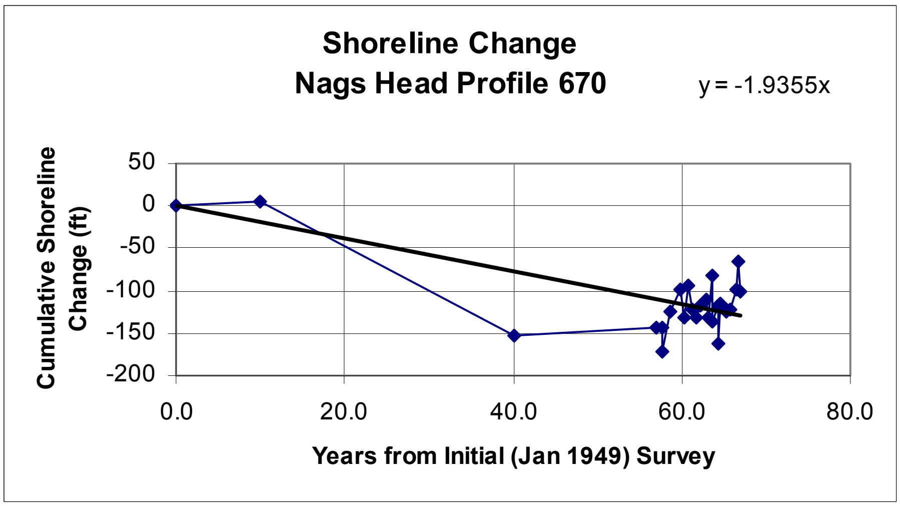

Shoreline Change
Nags Head Profile 630
y = -3.2951x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 640
y = -3.1069x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

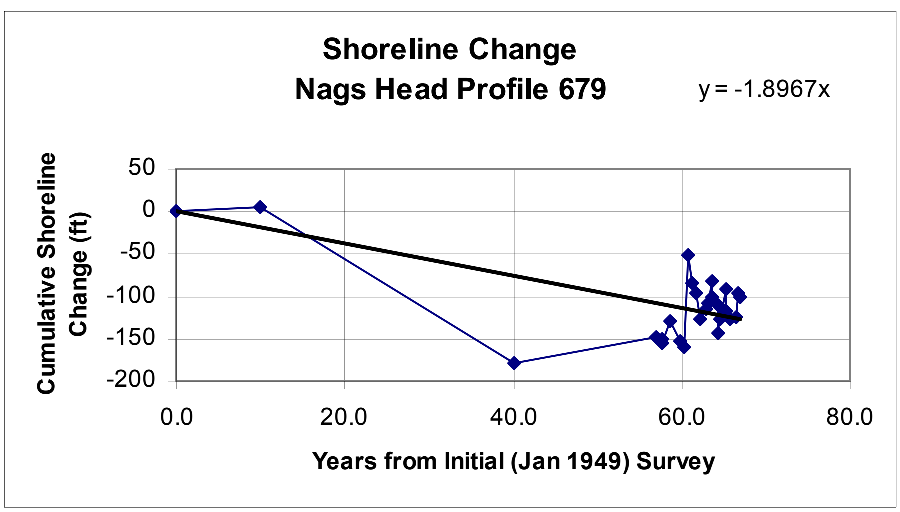

Shoreline Change
Nags Head Profile 649
y = -1.9821x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey



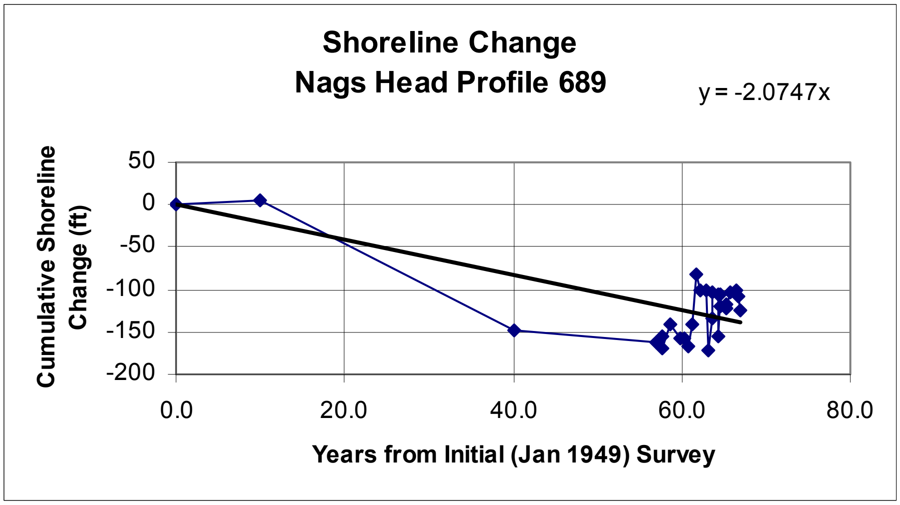
Shoreline Change
Nags Head Profile 659
y = -1.9553x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

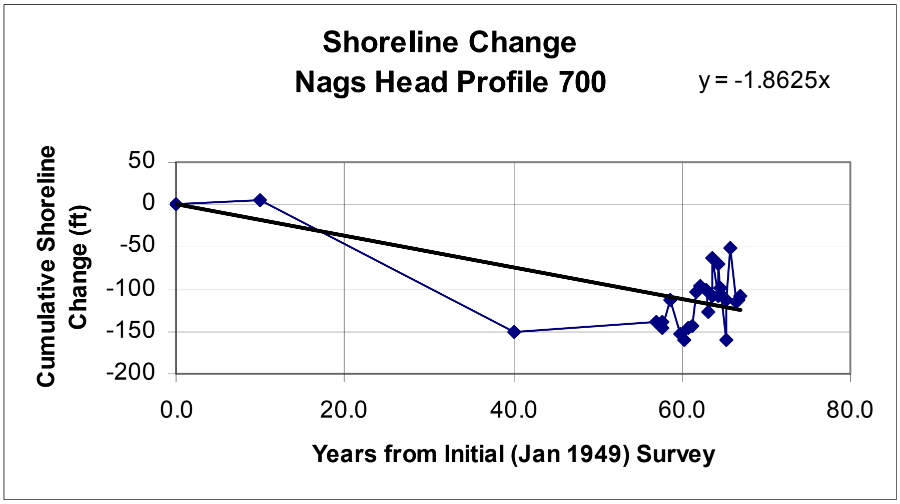


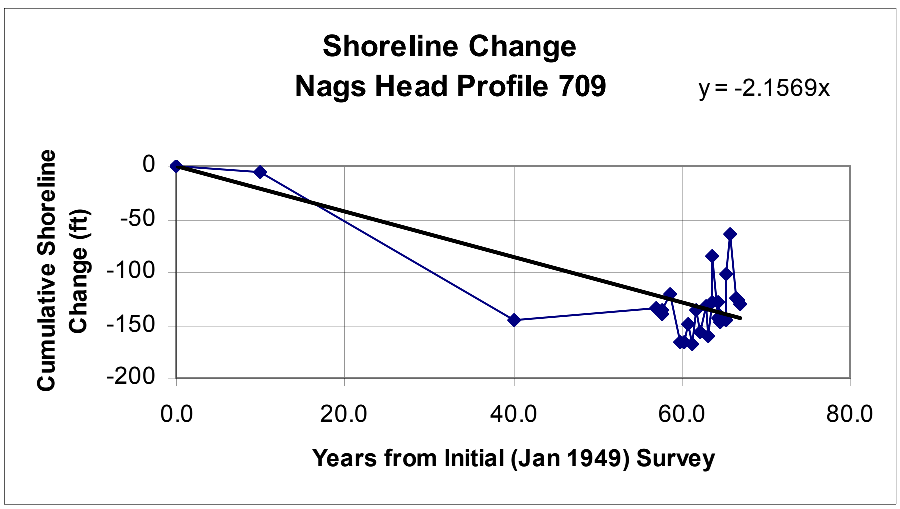
Shoreline Change
Nags Head Profile 670
y = -1.9355x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

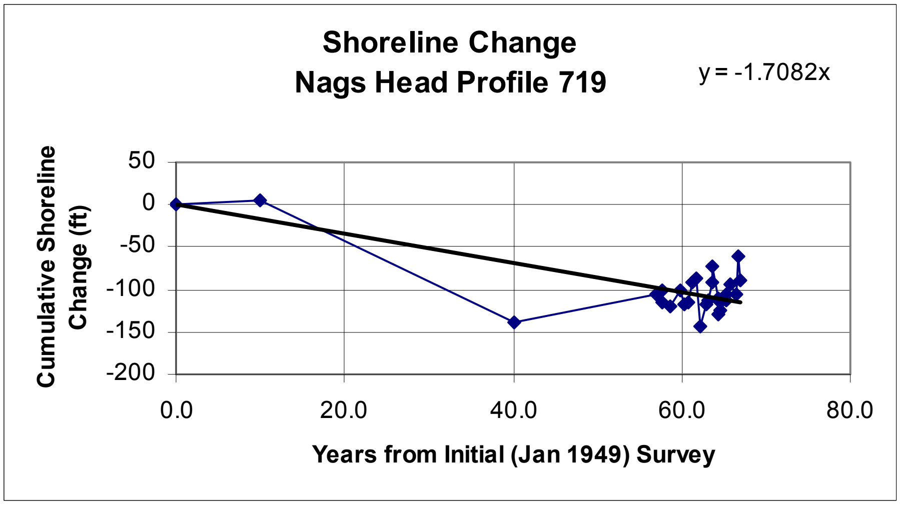


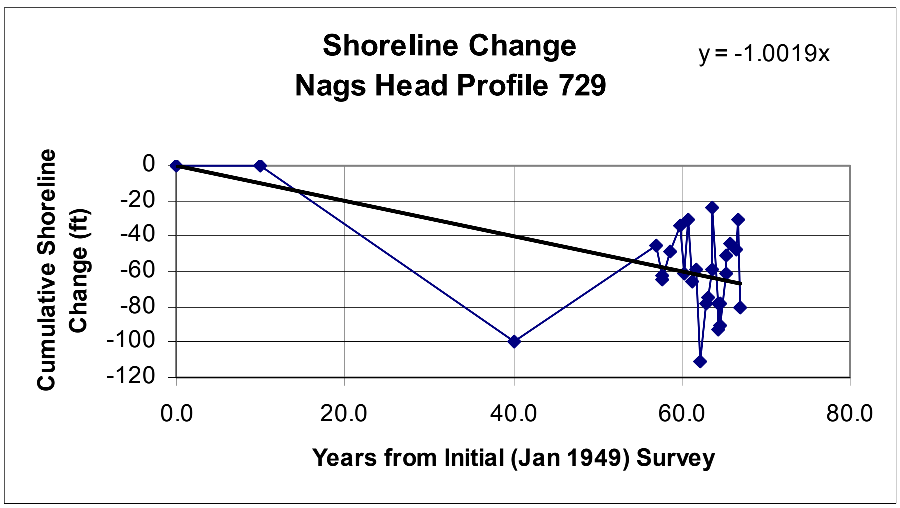
Shoreline Change
Nags Head Profile 679
y = -1.8967x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

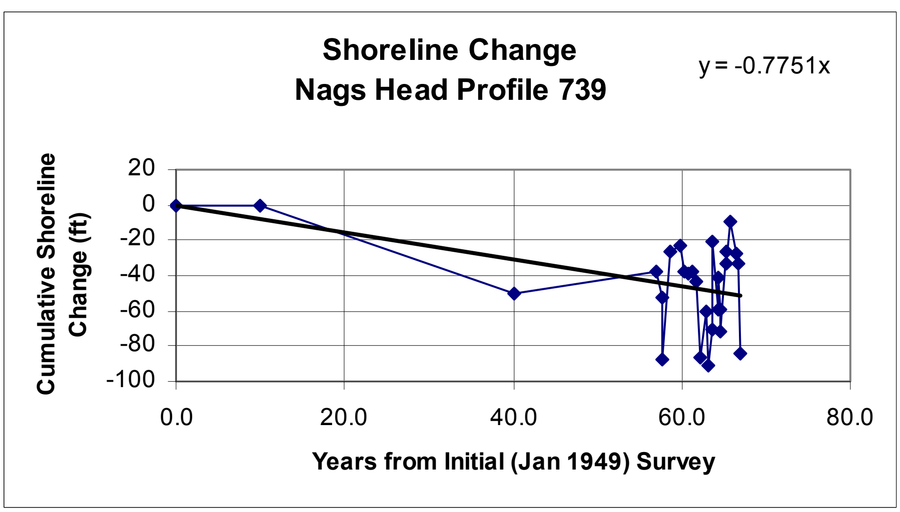

Shoreline Change
Nags Head Profile 689
y = -2.0747x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

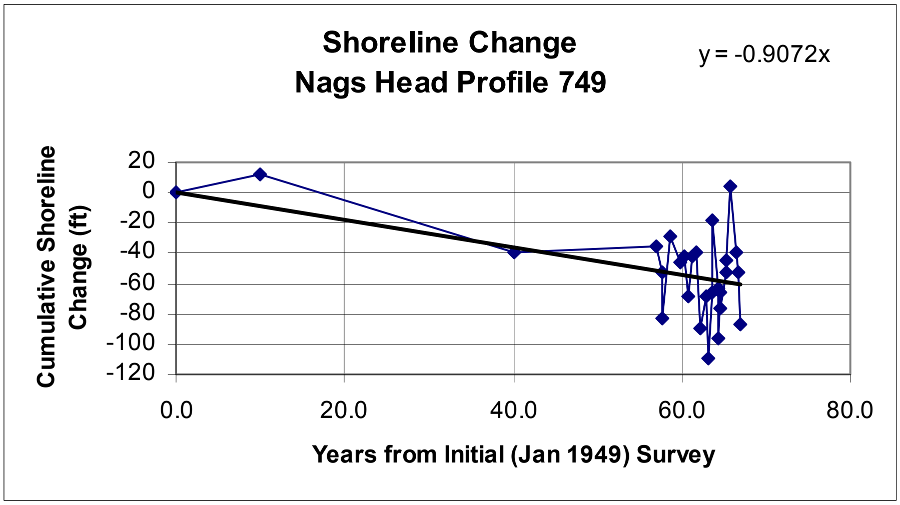

Shoreline Change
Nags Head Profile 700
y = -1.8625x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

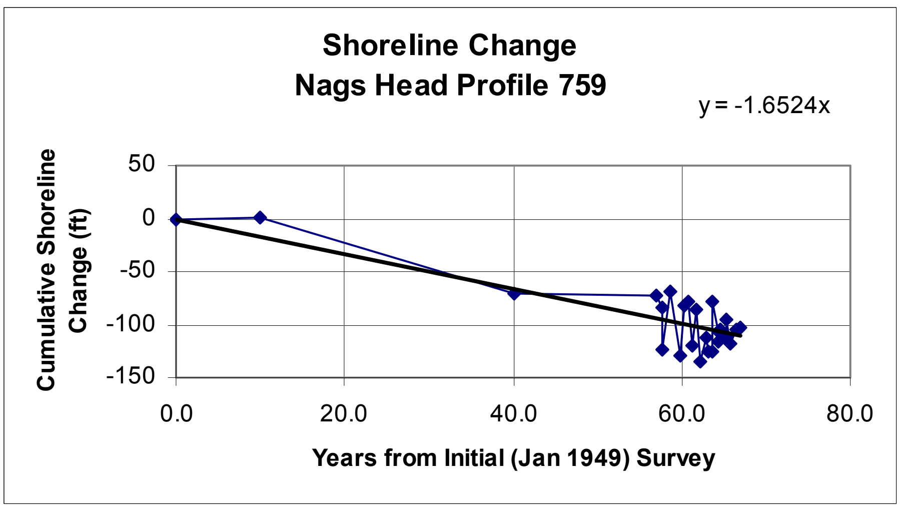

Shoreline Change
Nags Head Profile 709
y = -2.1569x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

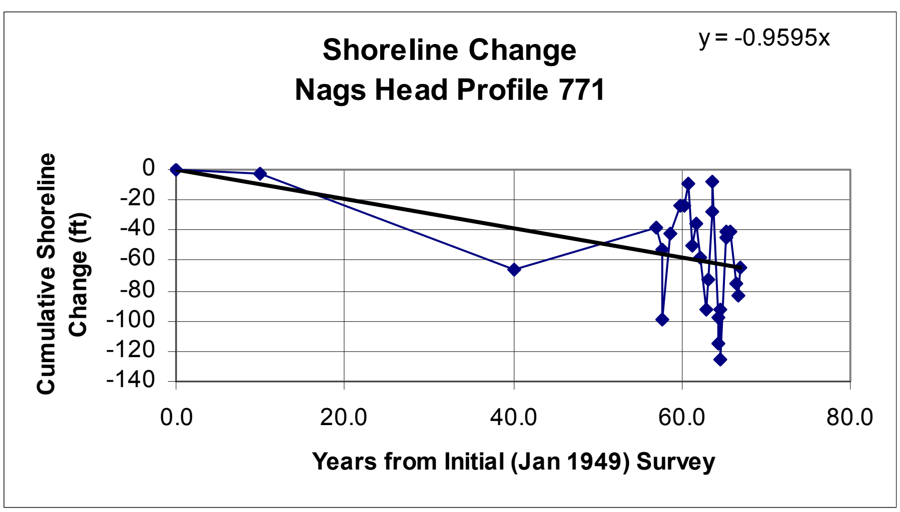

Shoreline Change
Nags Head Profile 719
y = -1.7082x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

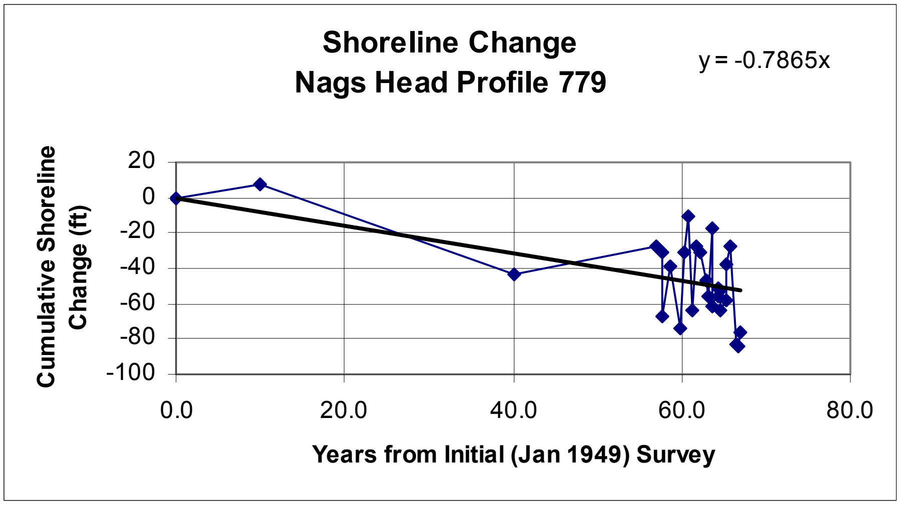

Shoreline Change
Nags Head Profile 729
y = -1.0019x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 739
y = -0.7751x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

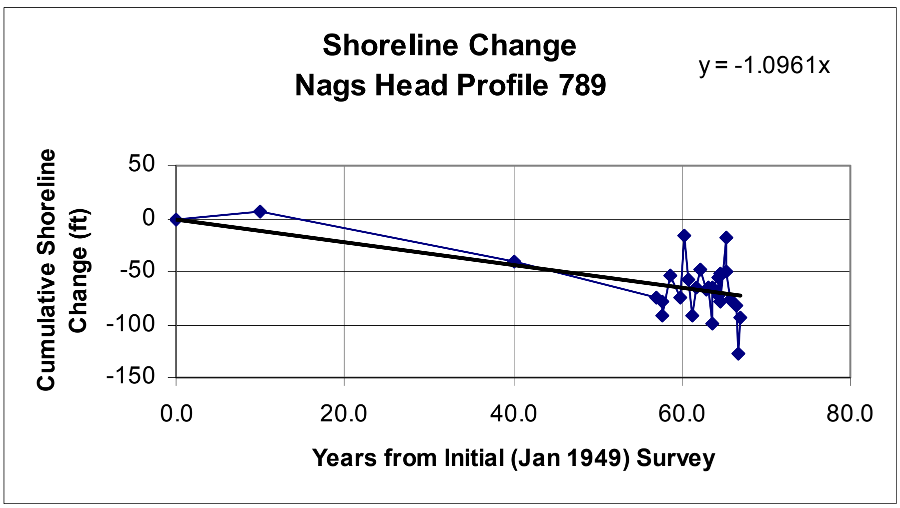

Shoreline Change
Nags Head Profile 749
y = -0.9072x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 759
y = -1.6524x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

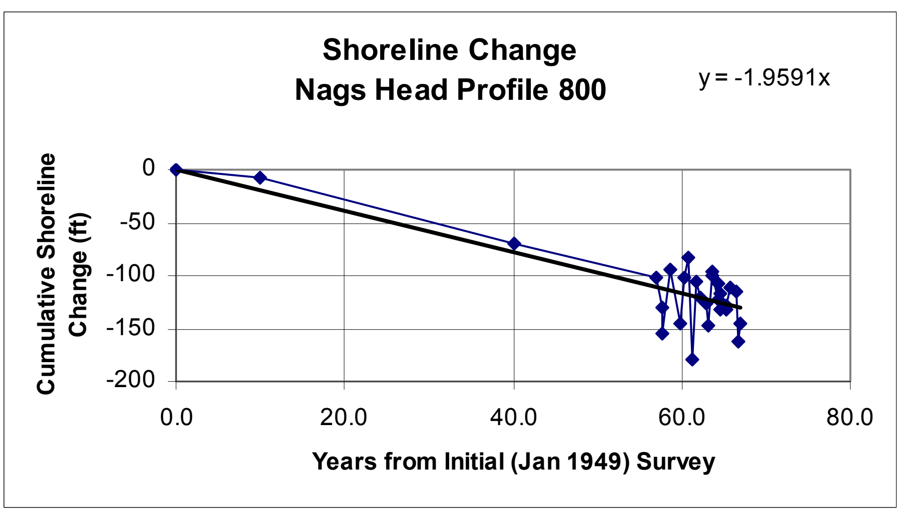

Shoreline Change
Nags Head Profile 771
y = -0.9595x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
-140
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey



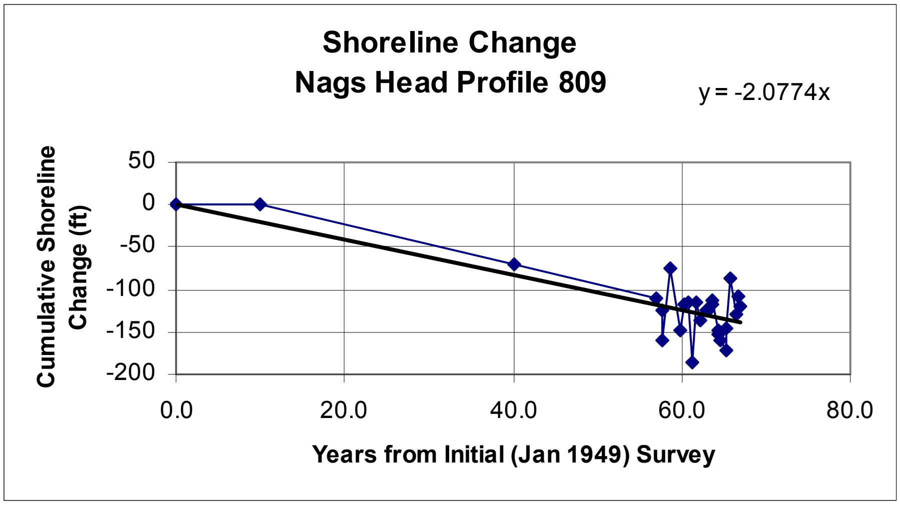
Shoreline Change
Nags Head Profile 779
y = -0.7865x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey



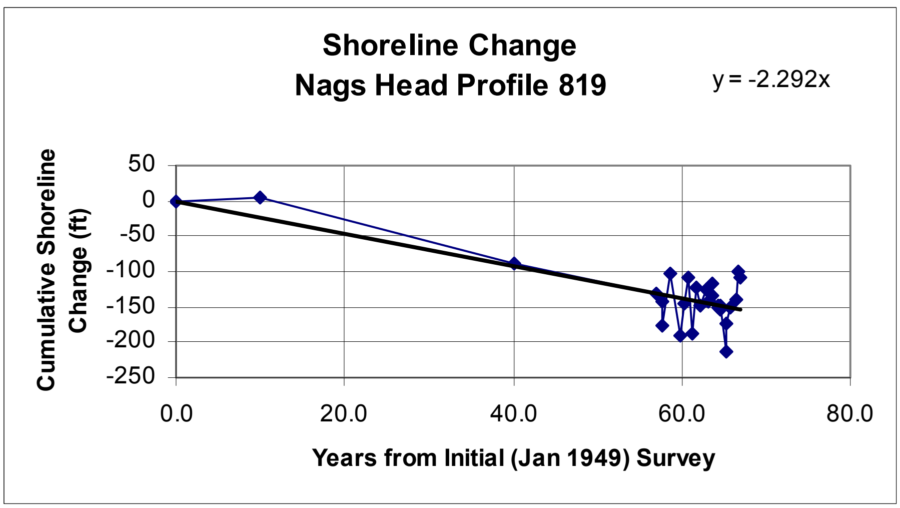
Shoreline Change
Nags Head Profile 789
y = -1.0961x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey



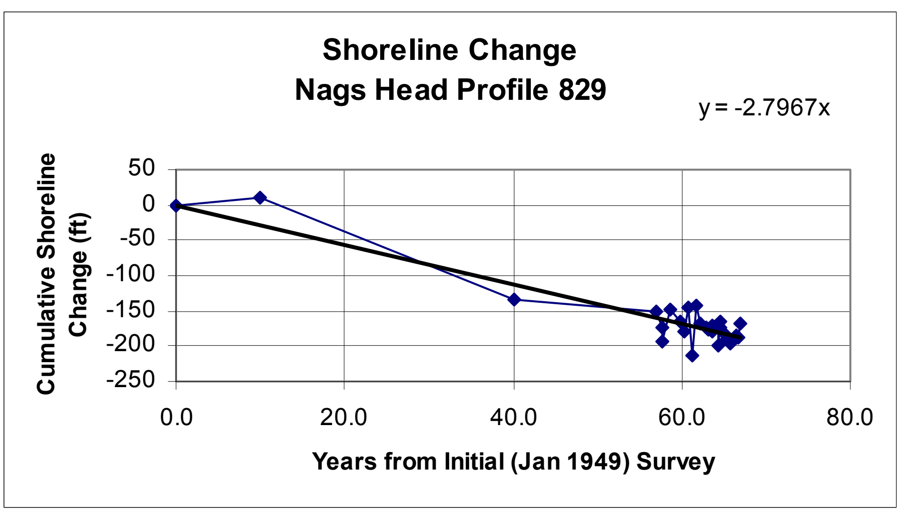
Shoreline Change
Nags Head Profile 800
y = -1.9591x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey



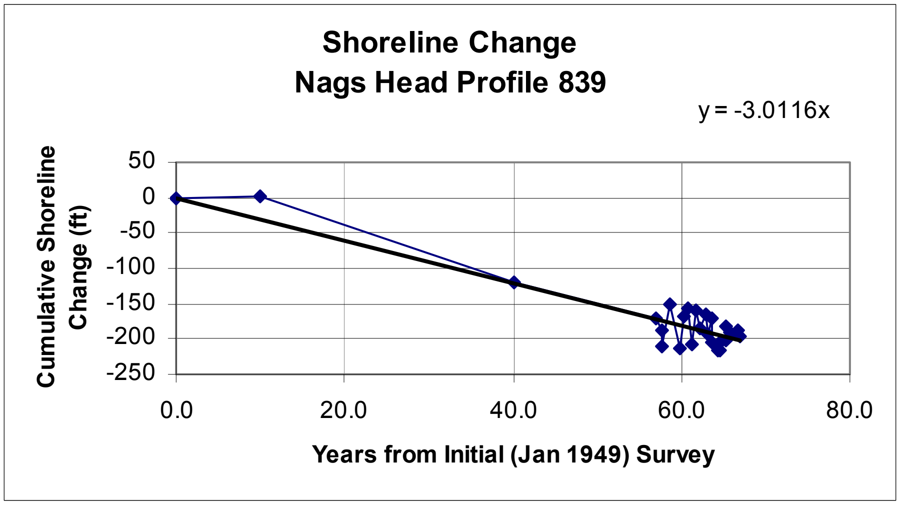
Shoreline Change
Nags Head Profile 809
y = -2.0774x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

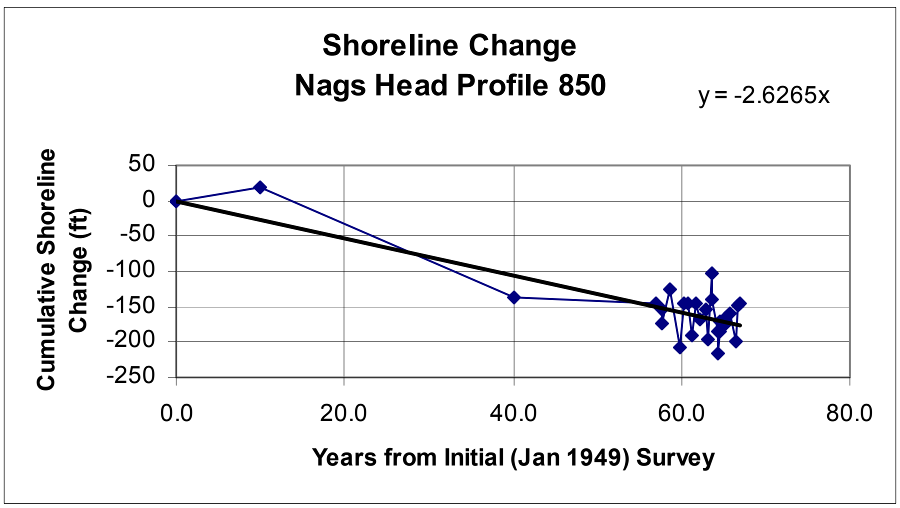


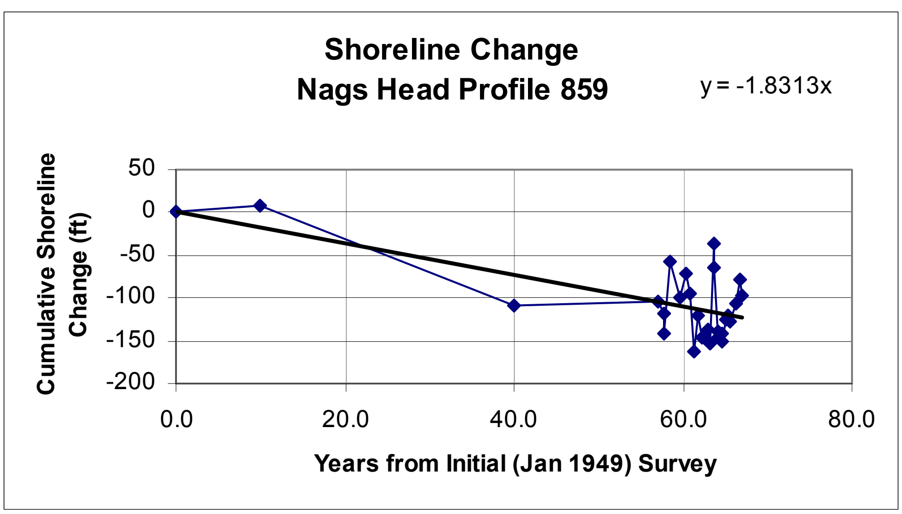
Shoreline Change
Nags Head Profile 819
y = -2.292x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

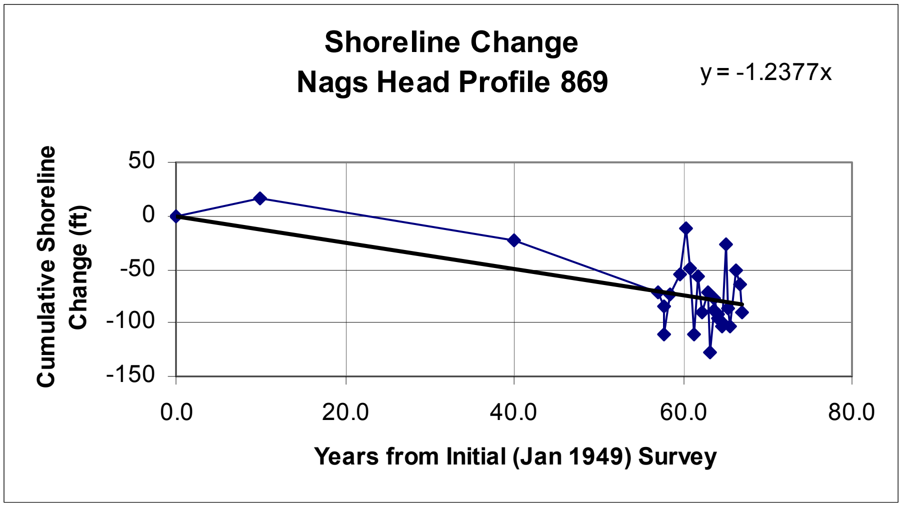


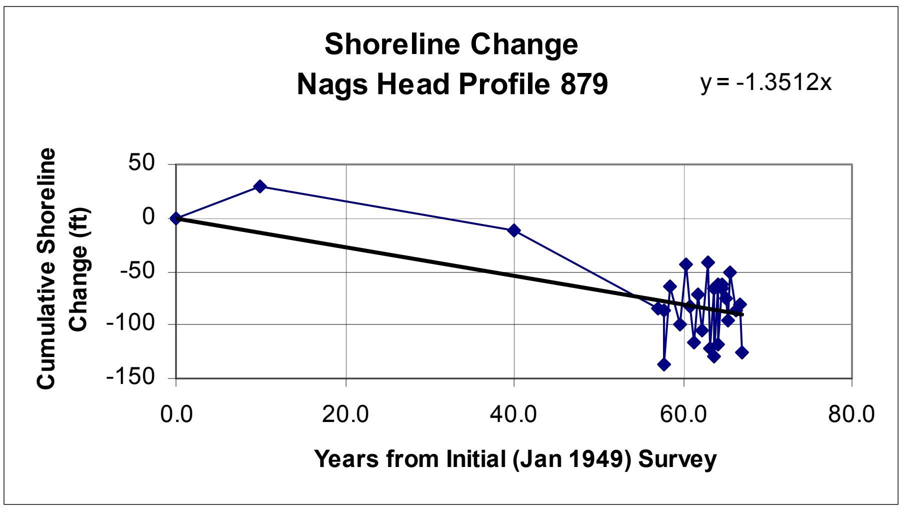
Shoreline Change
Nags Head Profile 829
y = -2.7967x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

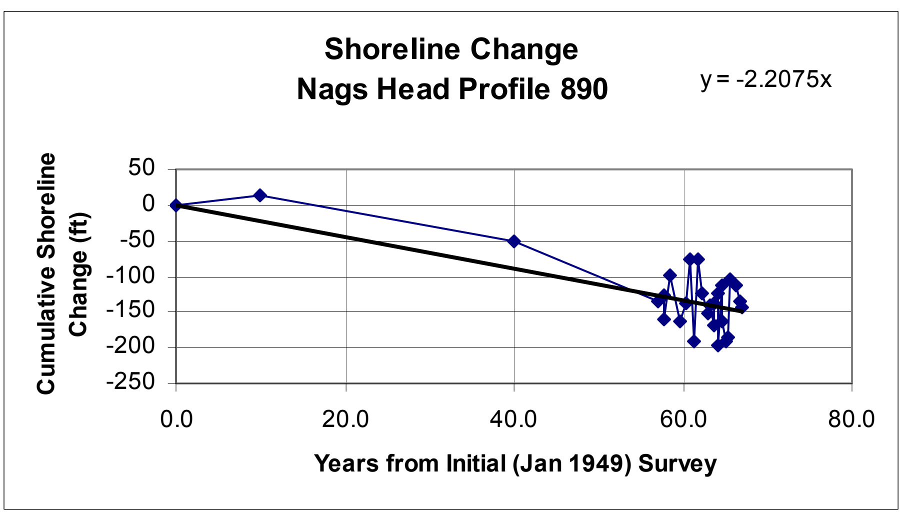

Shoreline Change
Nags Head Profile 839
y = -3.0116x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

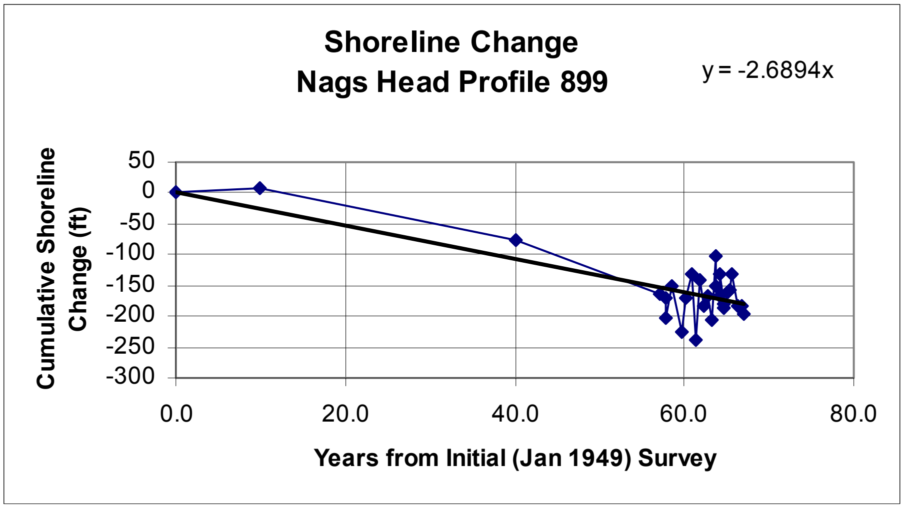

Shoreline Change
Nags Head Profile 850
y = -2.6265x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

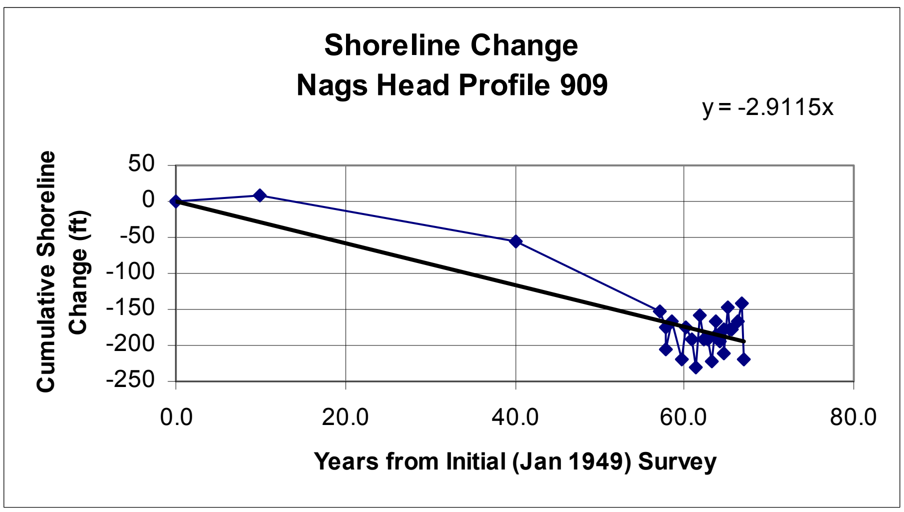

Shoreline Change
Nags Head Profile 859
y = -1.8313x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

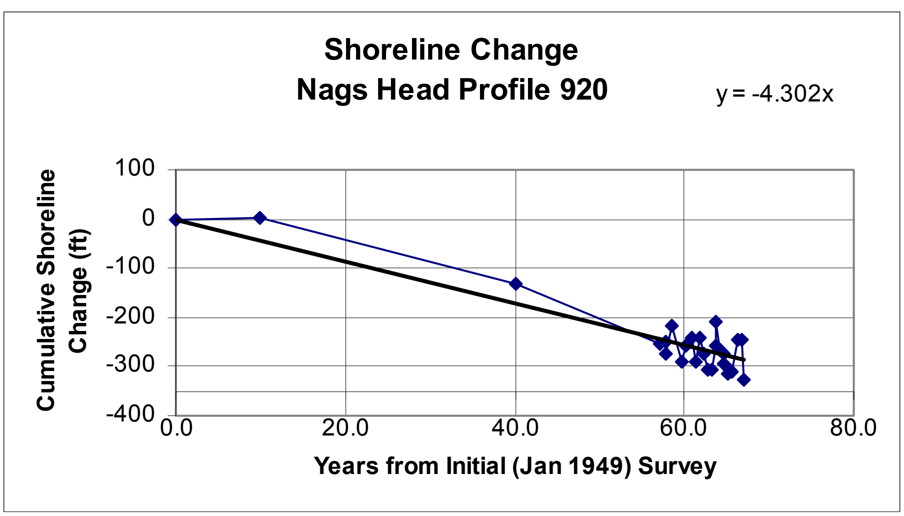

Shoreline Change
Nags Head Profile 869
y = -1.2377x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

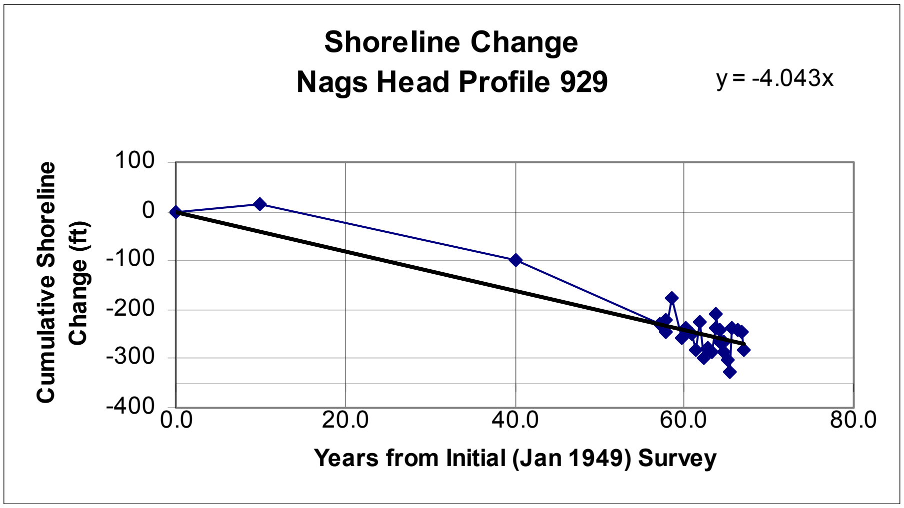

Shoreline Change
Nags Head Profile 879
y = -1.3512x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

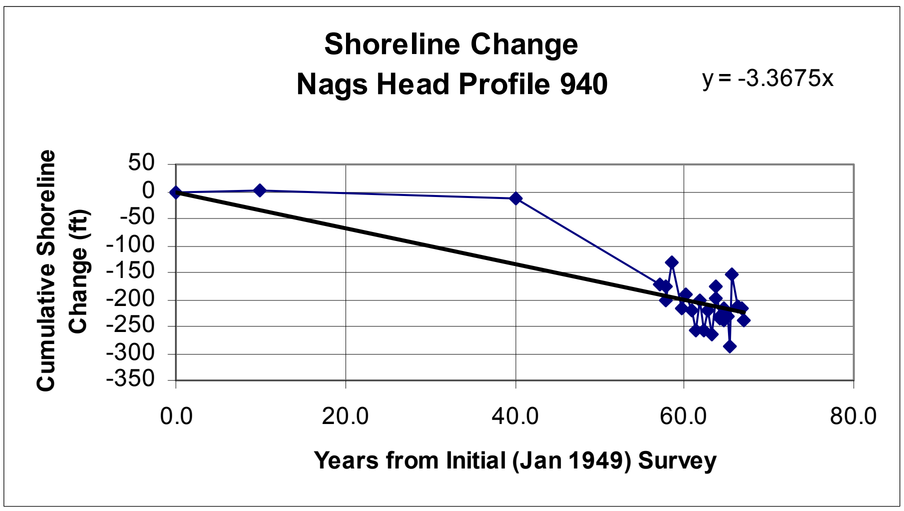

Shoreline Change
Nags Head Profile 890
y = -2.2075x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

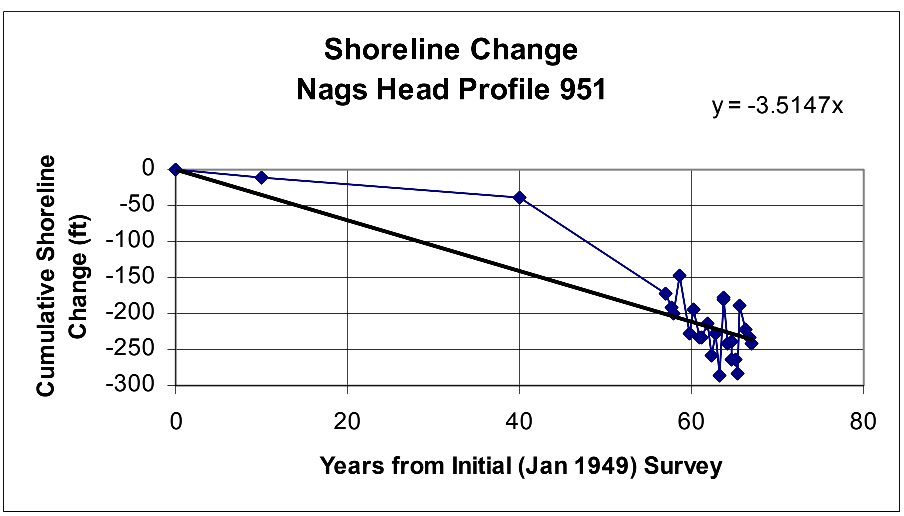

Shoreline Change
Nags Head Profile 899
y = -2.6894x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

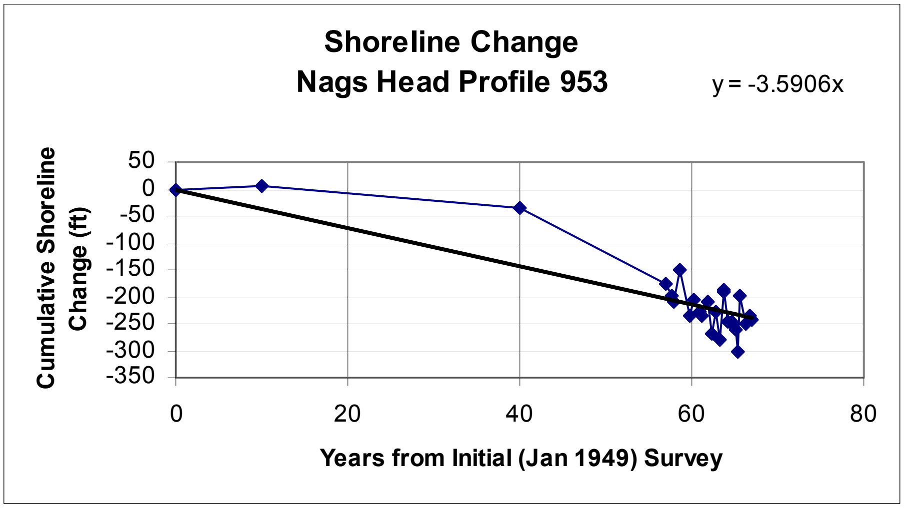

Shoreline Change
Nags Head Profile 909
y = -2.9115x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

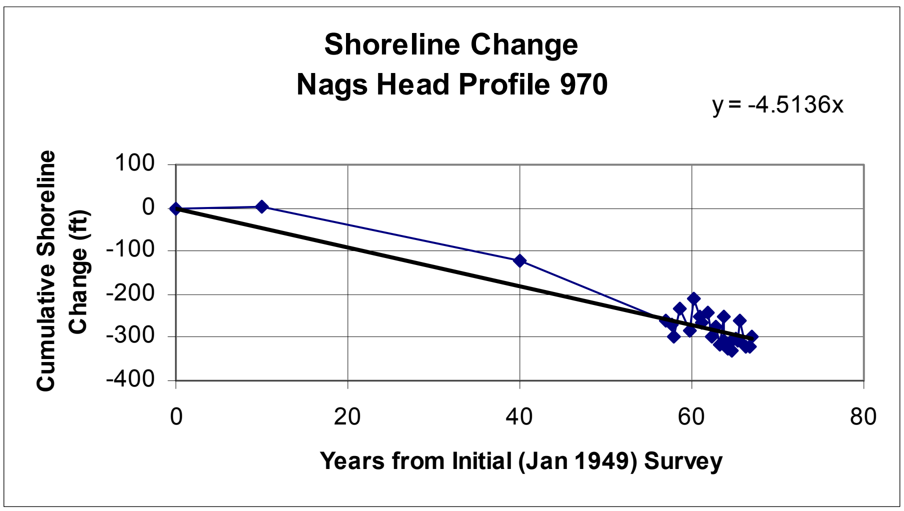

Shoreline Change
Nags Head Profile 920
y = -4.302x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

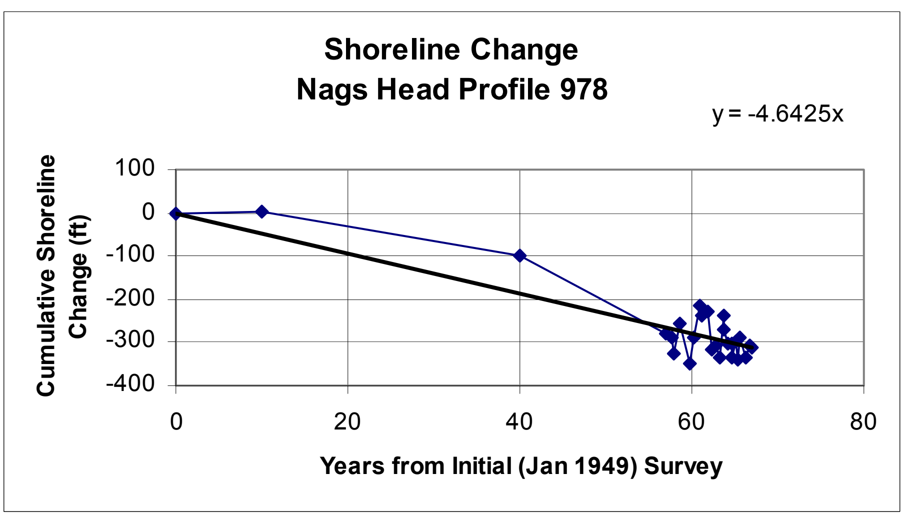

Shoreline Change
Nags Head Profile 929
y = -4.043x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

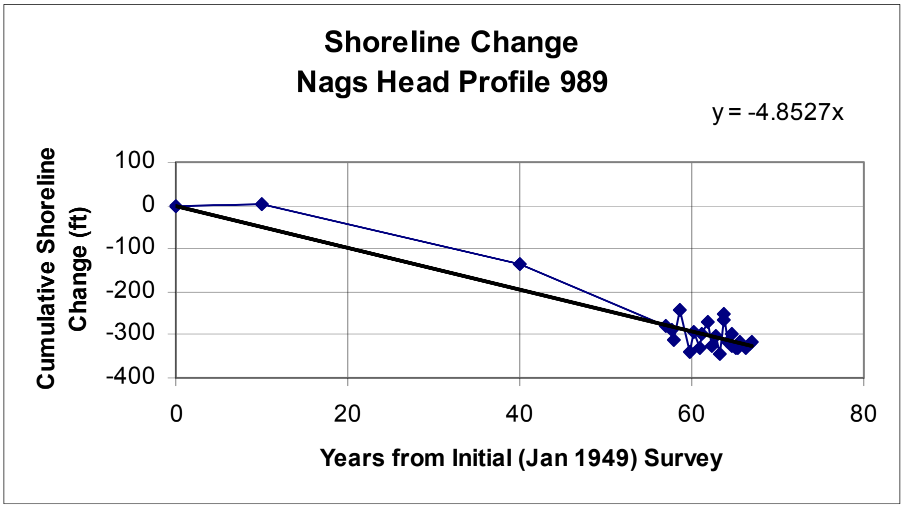

Shoreline Change
Nags Head Profile 940
y = -3.3675x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
-300
-350
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

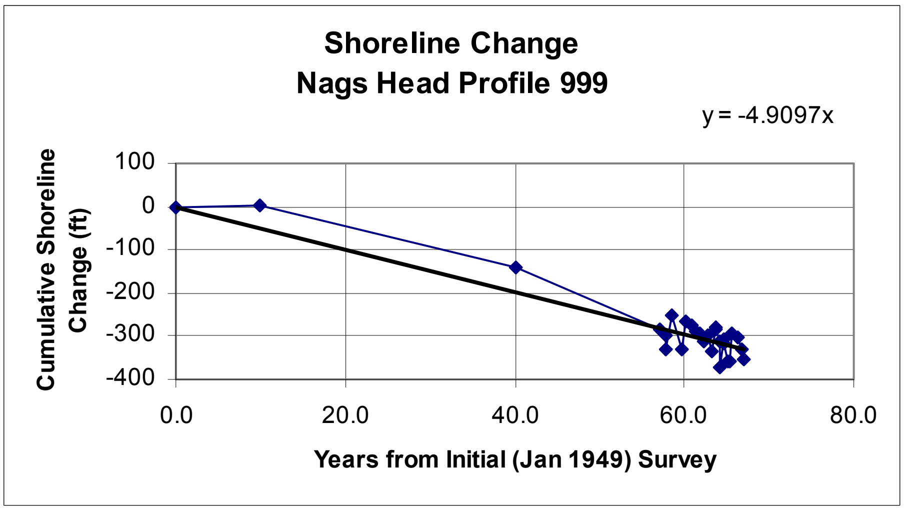

Shoreline Change
Nags Head Profile 951
y = -3.5147x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
-300
0
20
40
60
80
Years from Initial (Jan 1949) Survey

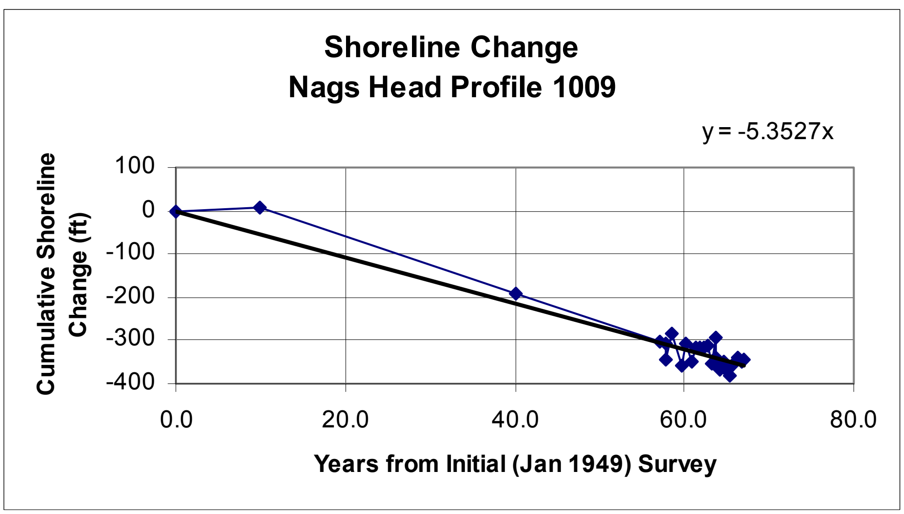

Shoreline Change
Nags Head Profile 953
y = -3.5906x
Cumulative Shoreline Change (ft)
50
0
-50
-100
-150
-200
-250
-300
-350
0
20
40
60
80
Years from Initial (Jan 1949) Survey

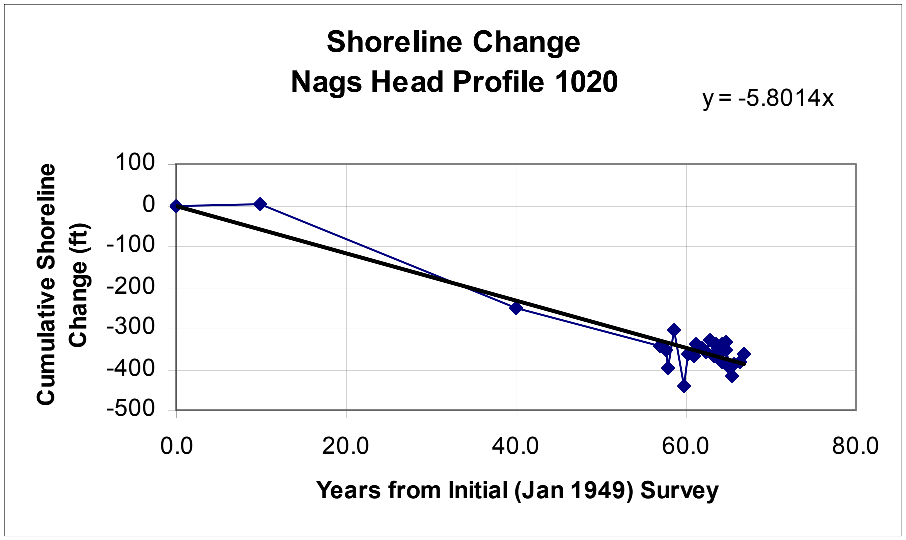

Shoreline Change
Nags Head Profile 970
y = -4.5136x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
0
20
40
60
80
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 978
y = -4.6425x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
0
20
40
60
80
Years from Initial (Jan 1949) Survey

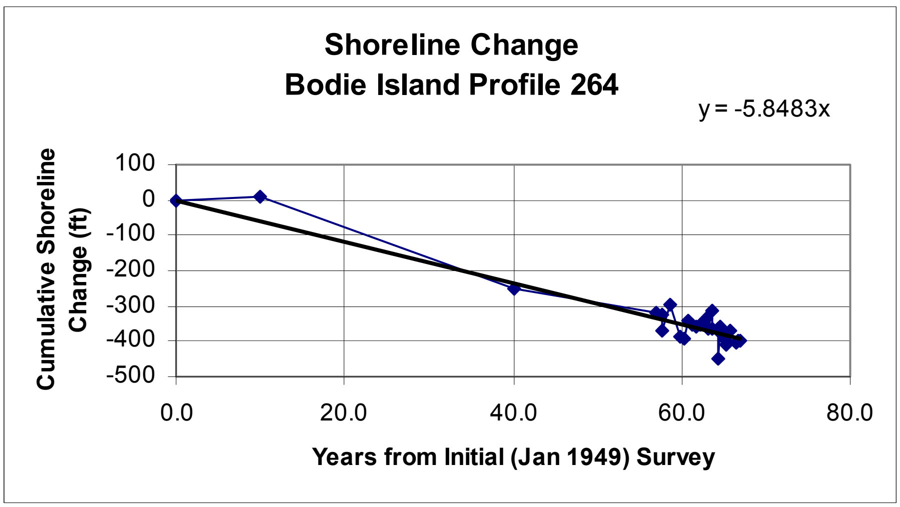

Shoreline Change
Nags Head Profile 989
y = -4.8527x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
0
20
40
60
80
Years from Initial (Jan 1949) Survey


Shoreline Change
Nags Head Profile 999
y = -4.9097x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

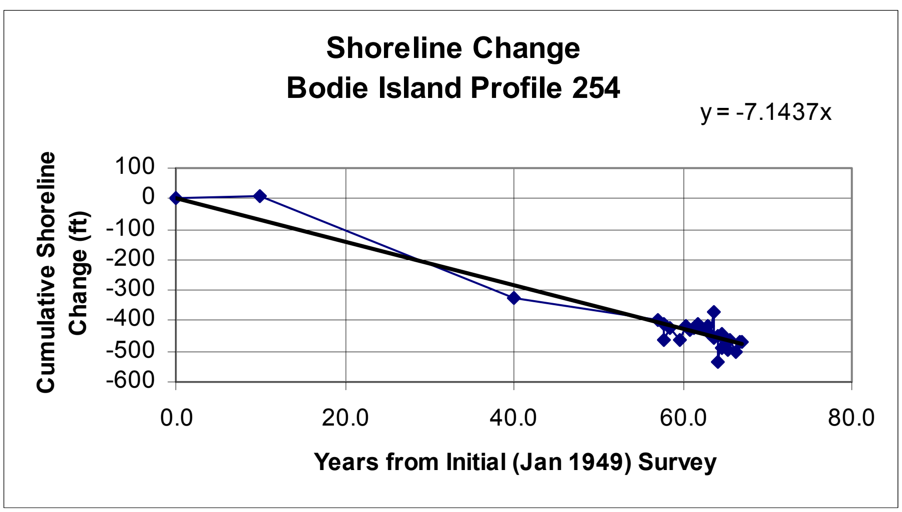

Shoreline Change
Nags Head Profile 1009
y = -5.3527x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey



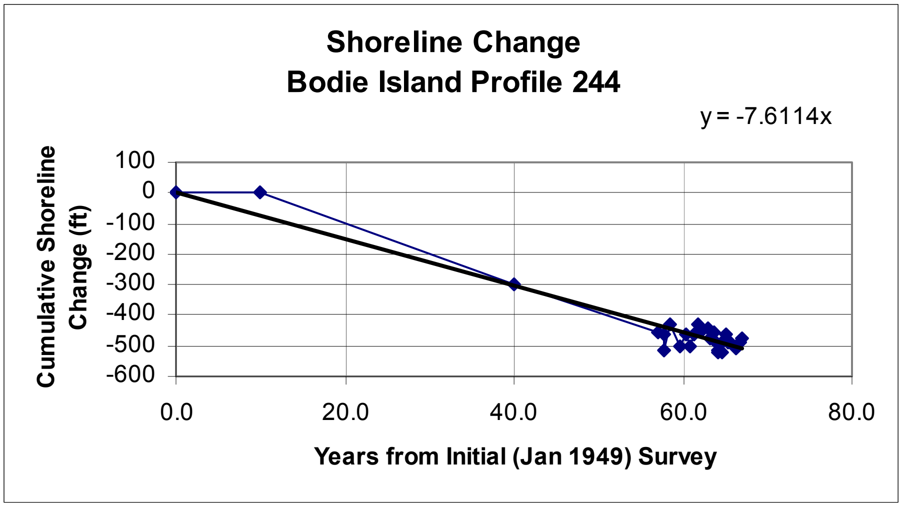
Shoreline Change
Nags Head Profile 1020
y = -5.8014x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

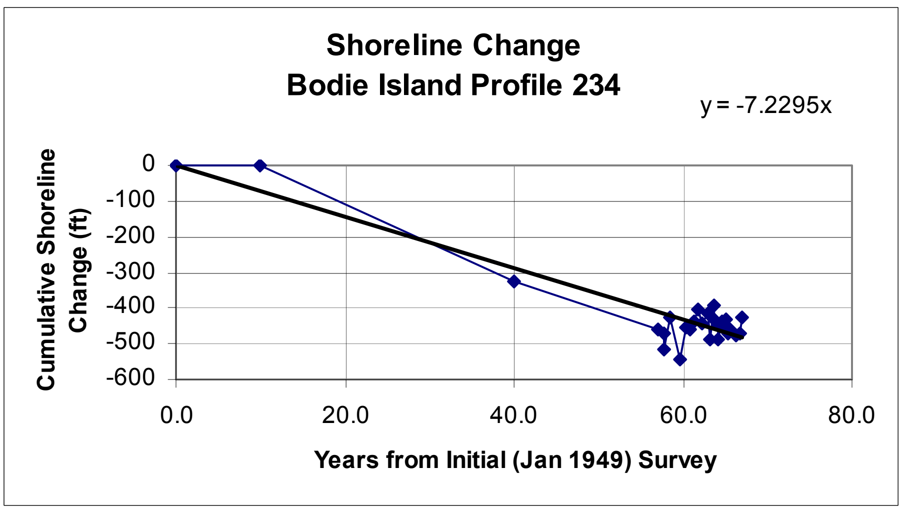


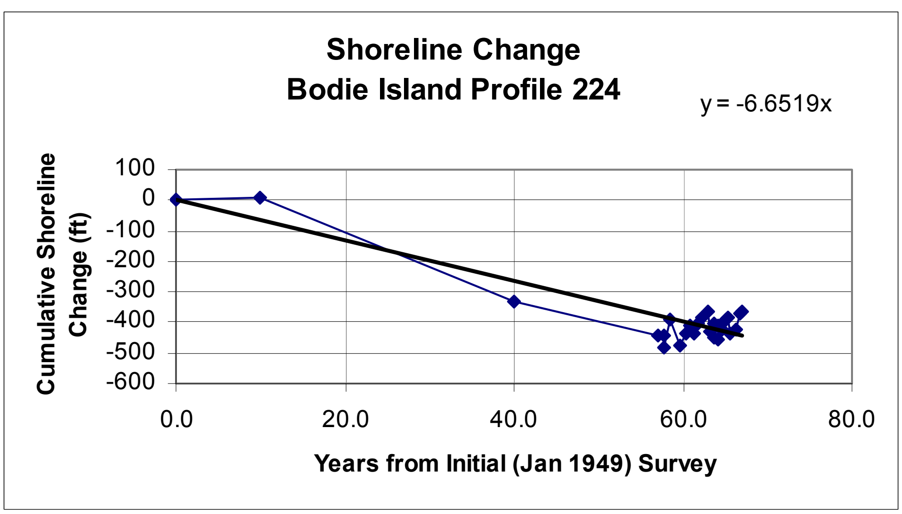
Shoreline Change
Bodie Island Profile 264
y = -5.8483x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

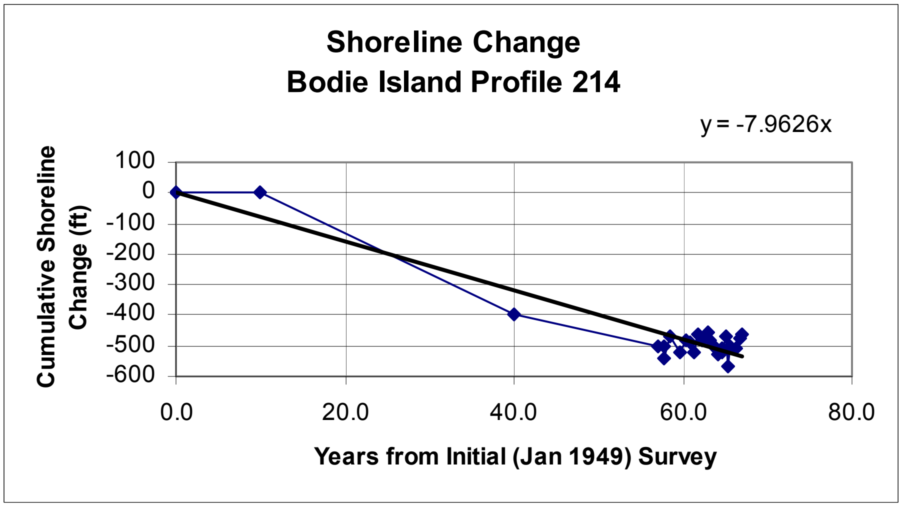


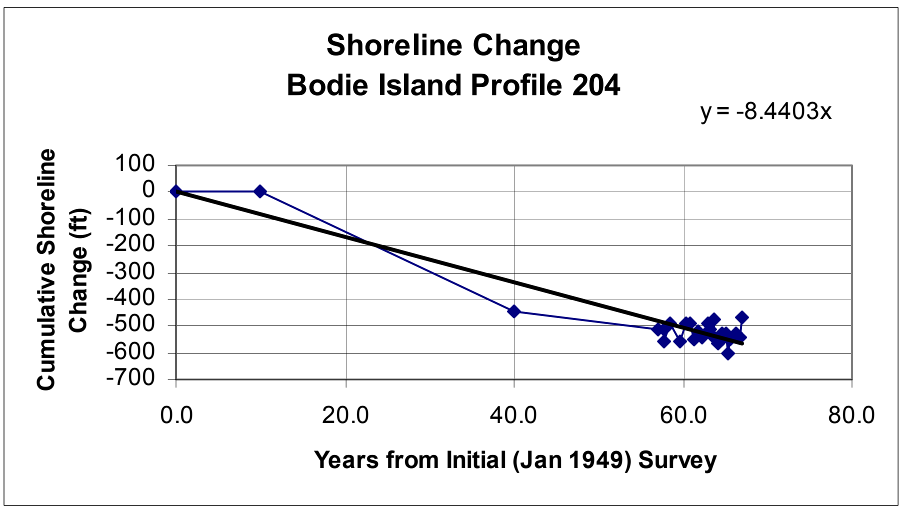
Shoreline Change
Bodie Island Profile 254
y = -7.1437x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

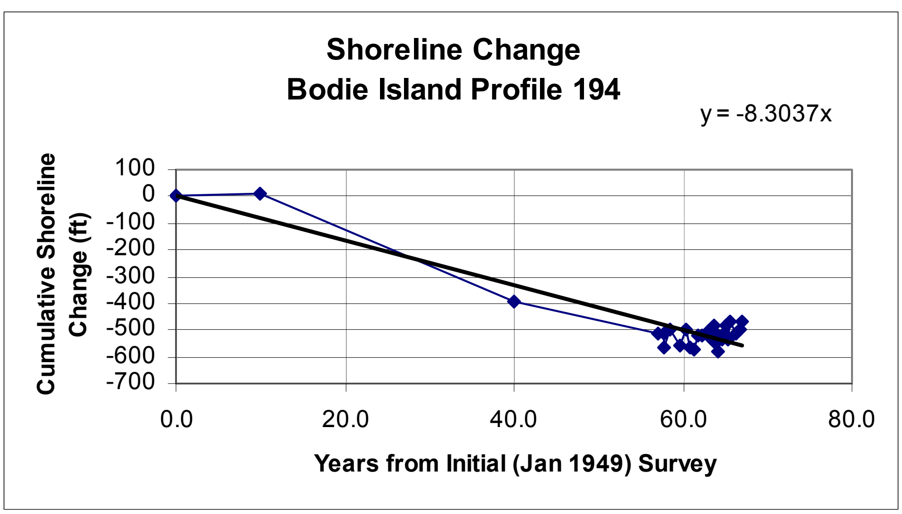

Shoreline Change
Bodie Island Profile 244
y = -7.6114x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

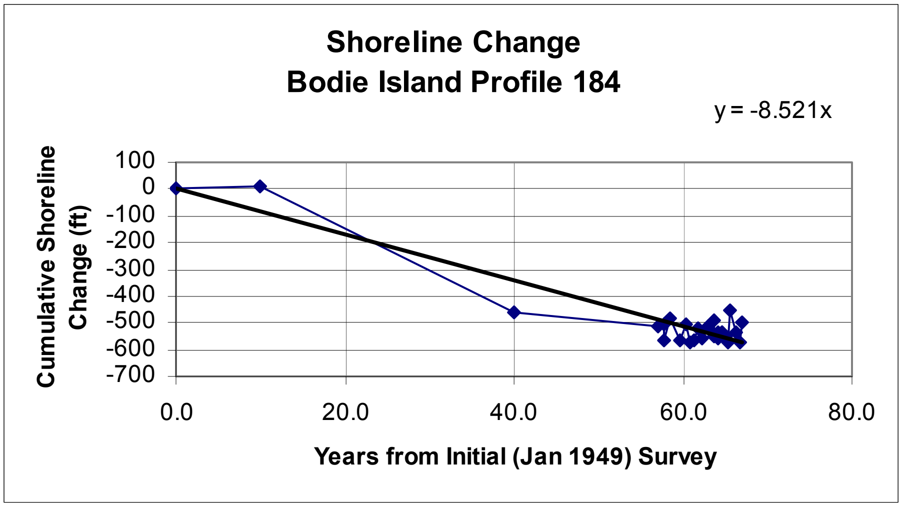

Shoreline Change
Bodie Island Profile 234
y = -7.2295x
Cumulative Shoreline Change (ft)
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

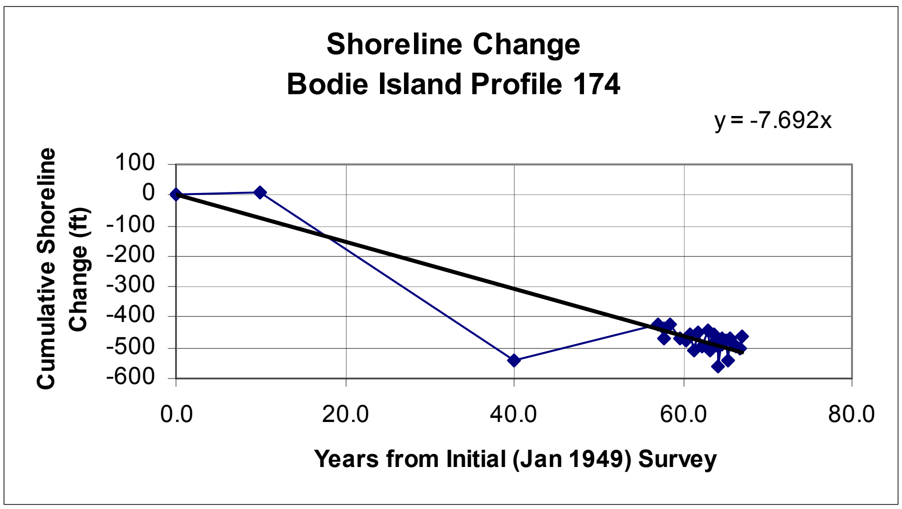

Shoreline Change
Bodie Island Profile 224
y = -6.6519x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

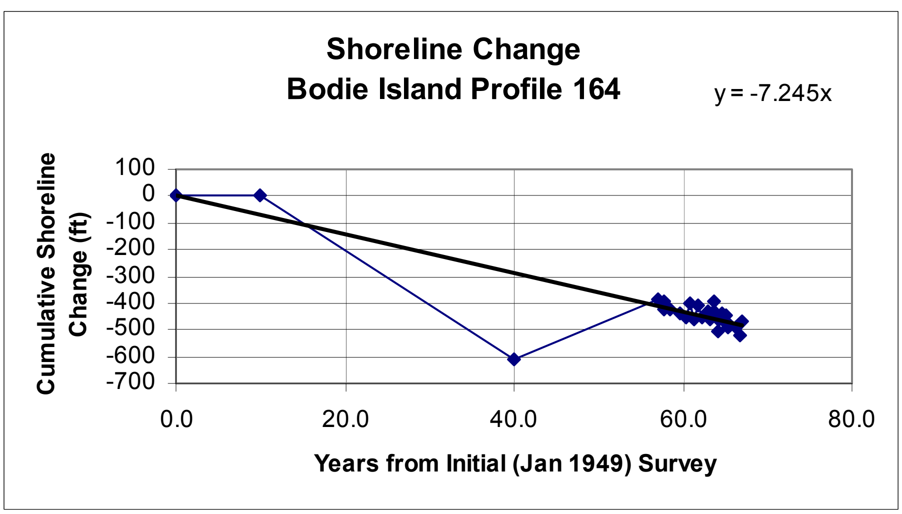

Shoreline Change
Bodie Island Profile 214
y = -7.9626x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

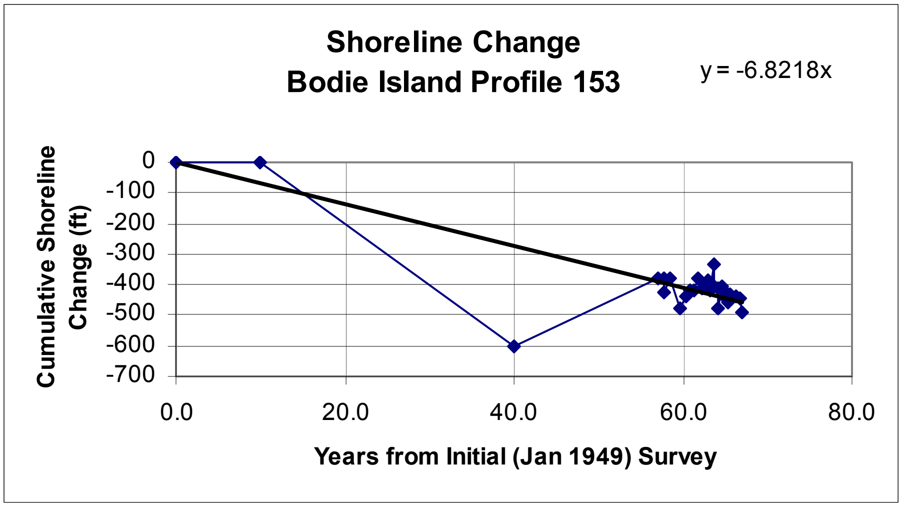

Shoreline Change
Bodie Island Profile 204
y = -8.4403x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
-700
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

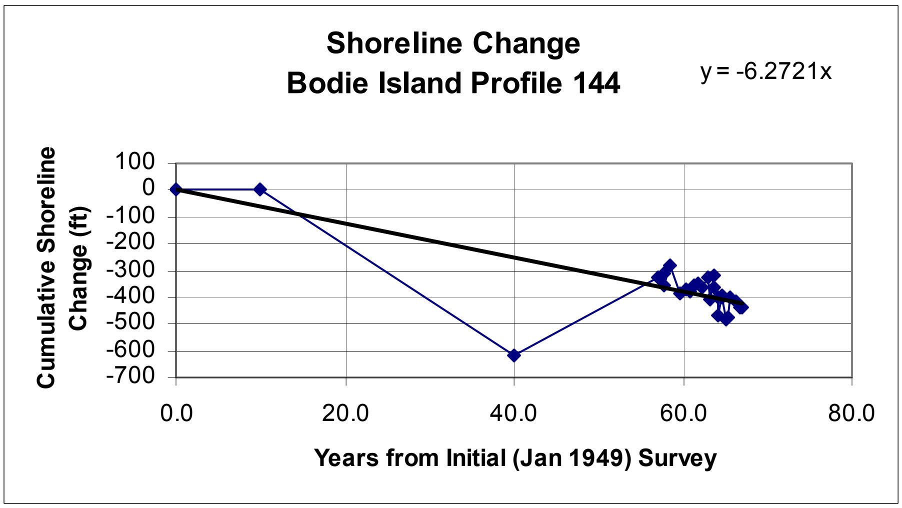

Shoreline Change
Bodie Island Profile 194
y = -8.3037x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
-700
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

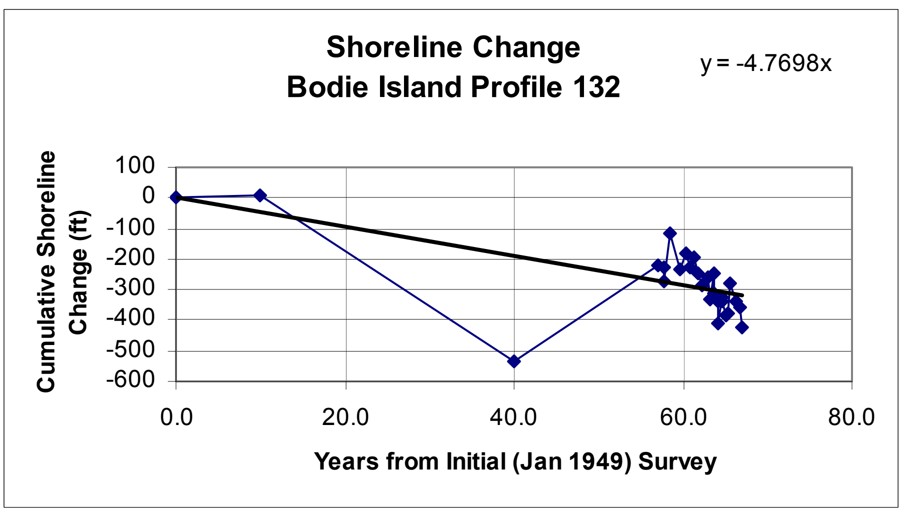

Shoreline Change
Bodie Island Profile 184
y = -8.521x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
-700
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

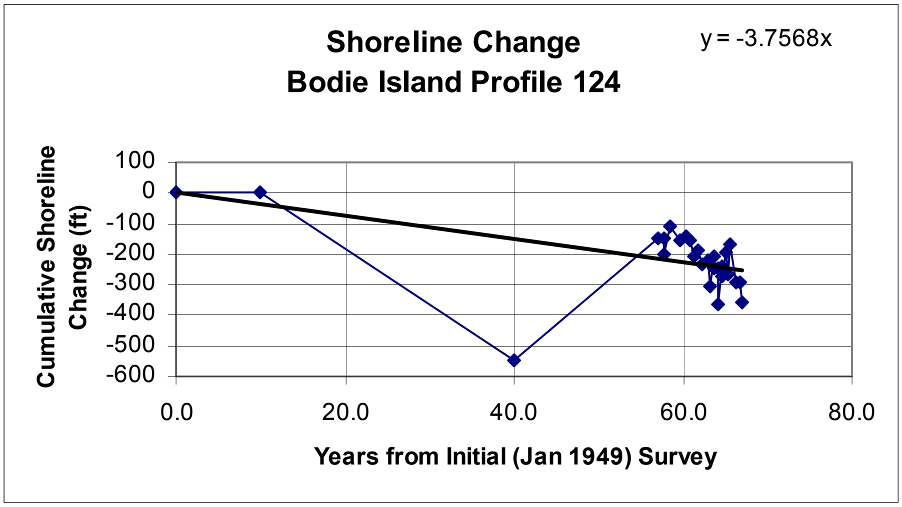

Shoreline Change
Bodie Island Profile 174
y = -7.692x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

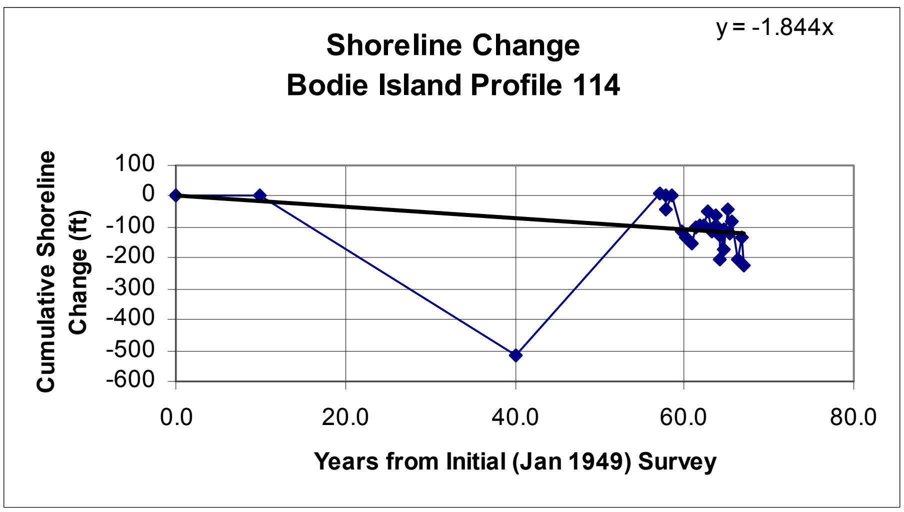

Shoreline Change
Bodie Island Profile 164
y = -7.245x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
-700
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

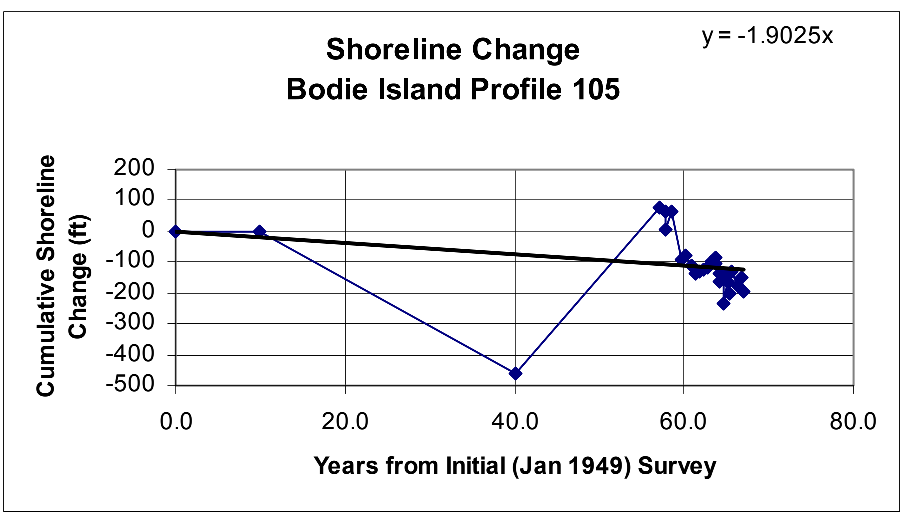

Shoreline Change
Bodie Island Profile 153
y = -6.8218x
Cumulative Shoreline Change (ft)
0
-100
-200
-300
-400
-500
-600
-700
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

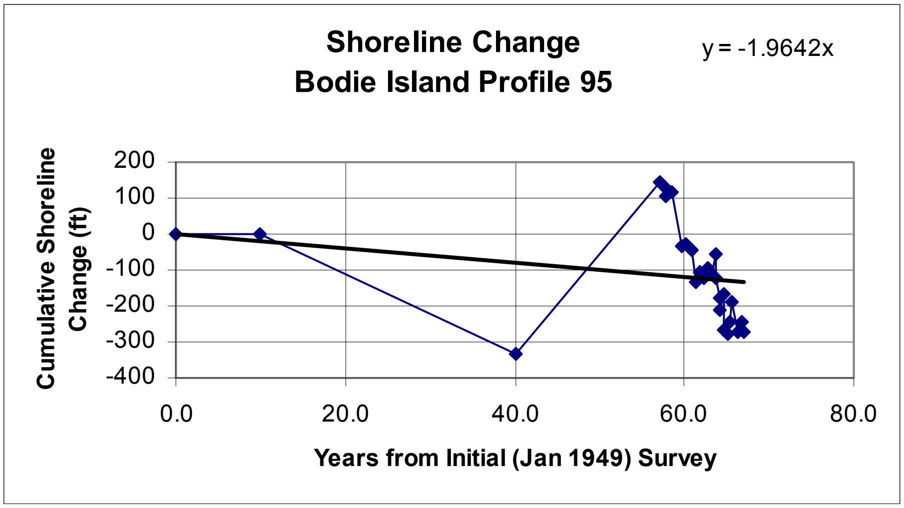

Shoreline Change
Bodie Island Profile 144
y = -6.2721x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
-700
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

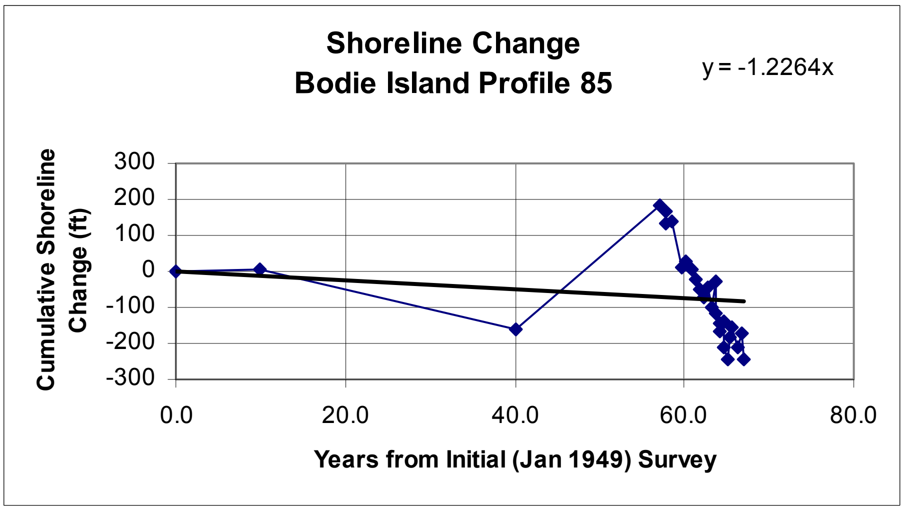

Shoreline Change
Bodie Island Profile 132
y = -4.7698x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

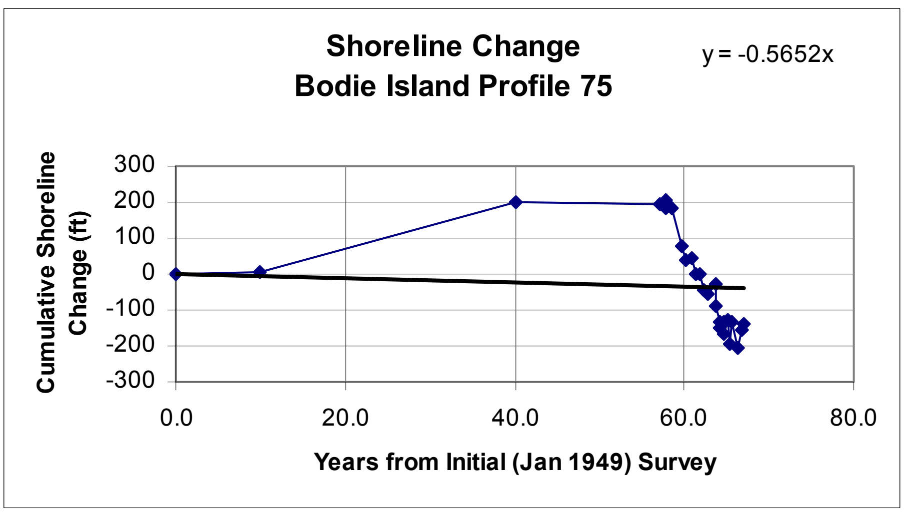

Shoreline Change
Bodie Island Profile 124
y = -3.7568x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

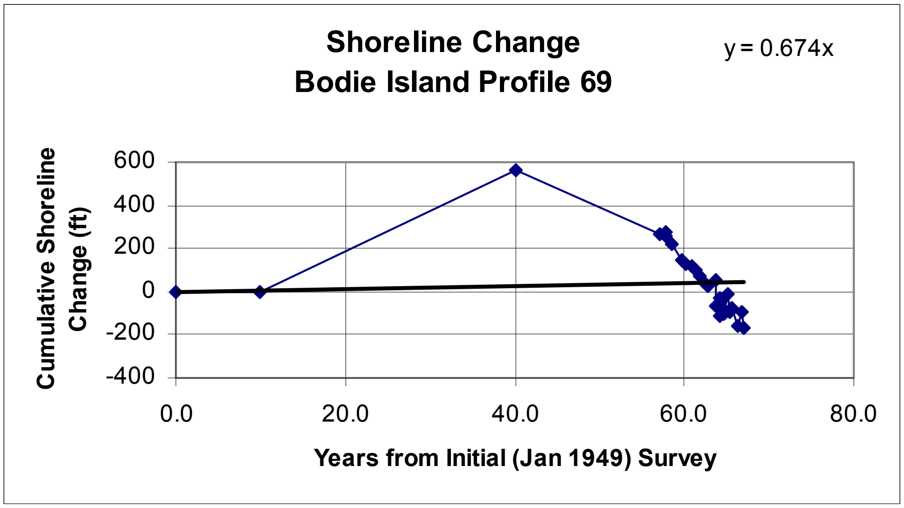

Shoreline Change
Bodie Island Profile 114
y = -1.844x
Cumulative Shoreline Change (ft)
100
0
-100
-200
-300
-400
-500
-600
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

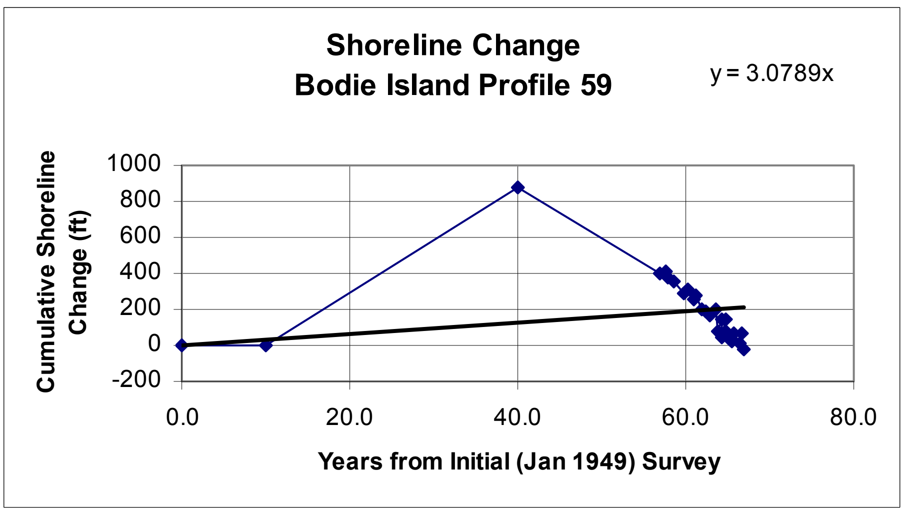

Shoreline Change
Bodie Island Profile 105
y = -1.9025x
Cumulative Shoreline Change (ft)
200
100
0
-100
-200
-300
-400
-500
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

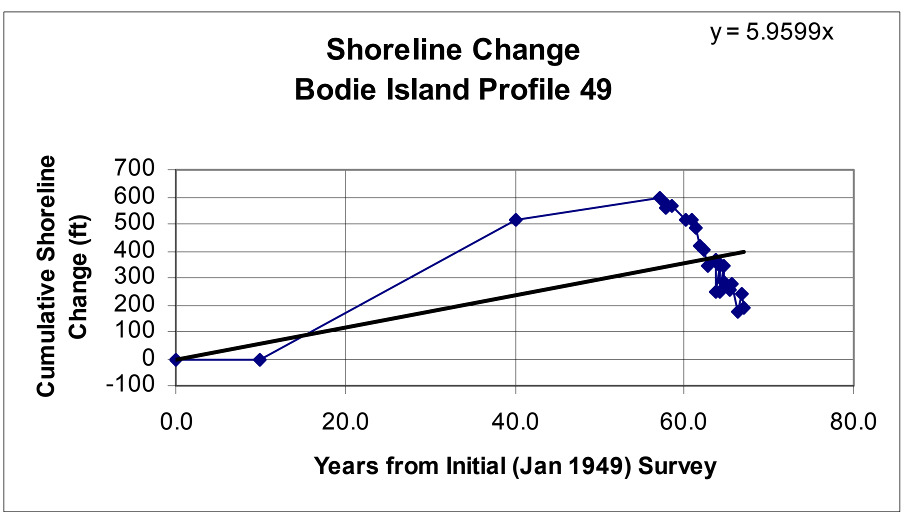

Shoreline Change
Bodie Island Profile 95
y = -1.9642x
Cumulative Shoreline Change (ft)
200
100
0
-100
-200
-300
-400
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

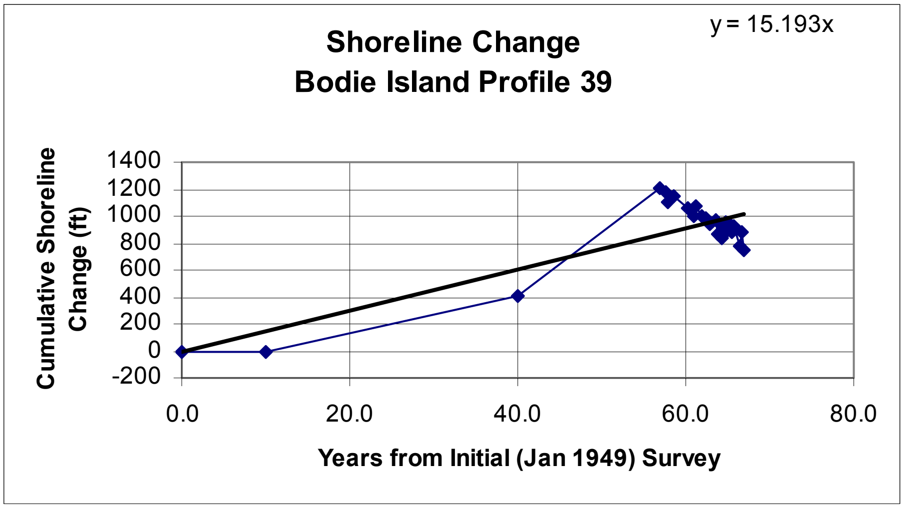

Shoreline Change
Bodie Island Profile 85
y = -1.2264x
Cumulative Shoreline Change (ft)
300
200
100
0
-100
-200
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

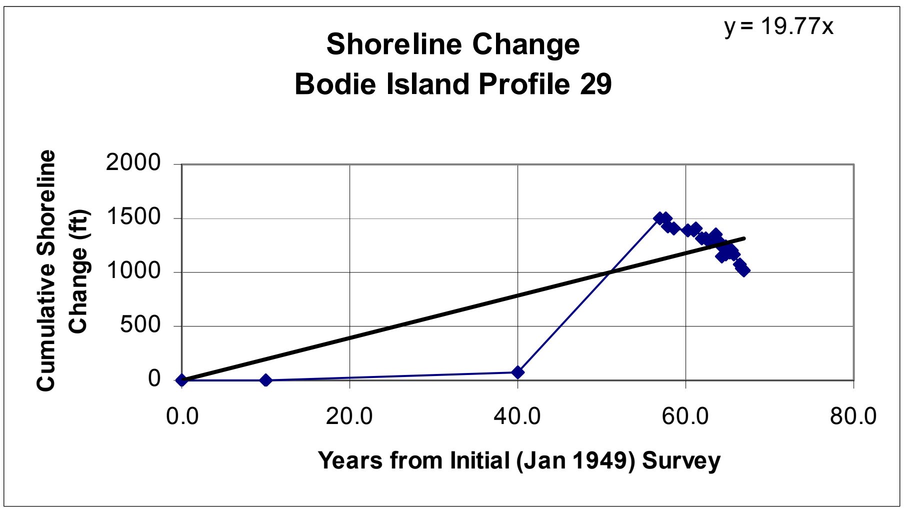

Shoreline Change
Bodie Island Profile 75
y = -0.5652x
Cumulative Shoreline Change (ft)
300
200
100
0
-100
-200
-300
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

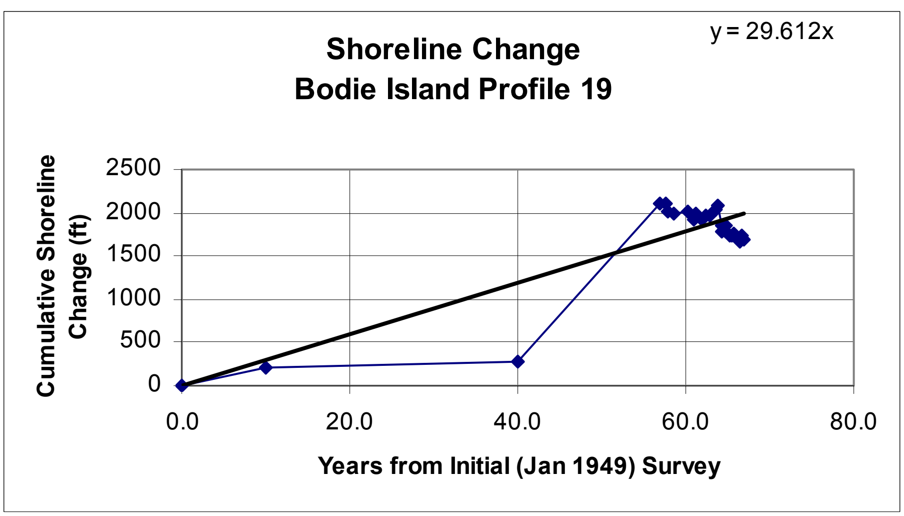

Shoreline Change
Bodie Island Profile 69
y = 0.674x
Cumulative Shoreline Change (ft)
600
400
200
0
-200
-400
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


Shoreline Change
Bodie Island Profile 59
y = 3.0789x
Cumulative Shoreline Change (ft)
1000
800
600
400
200
0
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey


y = 5.9599x
Shoreline Change
Bodie Island Profile 49
Cumulative Shoreline Change (ft)
700
600
500
400
300
200
100
0
-100
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

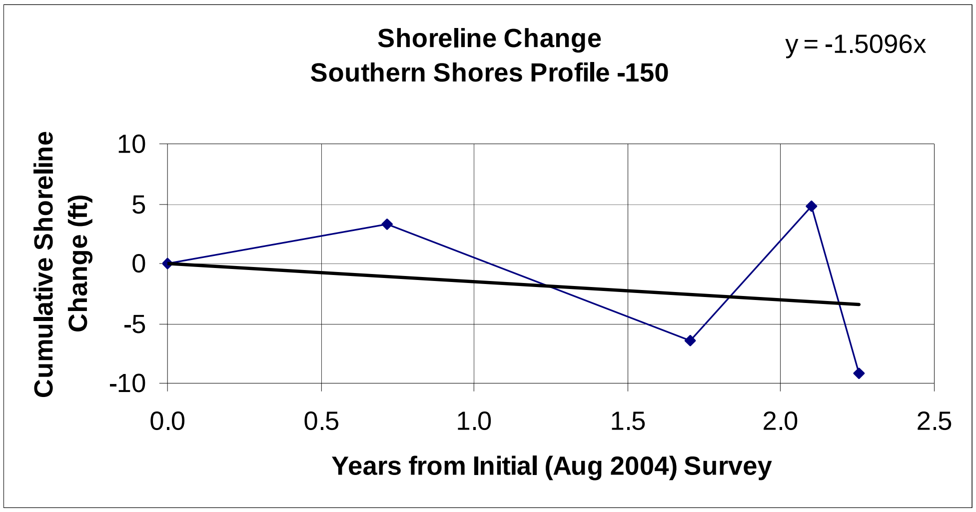

y = 15.193x
Shoreline Change
Bodie Island Profile 39
Cumulative Shoreline Change (ft)
1400
1200
1000
800
600
400
200
0
-200
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

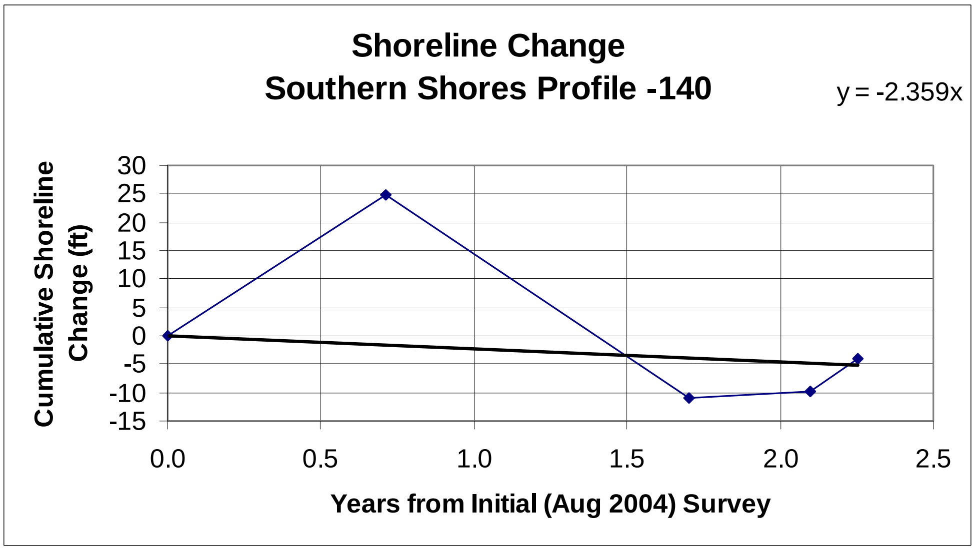

y = 19.77x
Shoreline Change
Bodie Island Profile 29
Cumulative Shoreline Change (ft)
2000
1500
1000
500
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

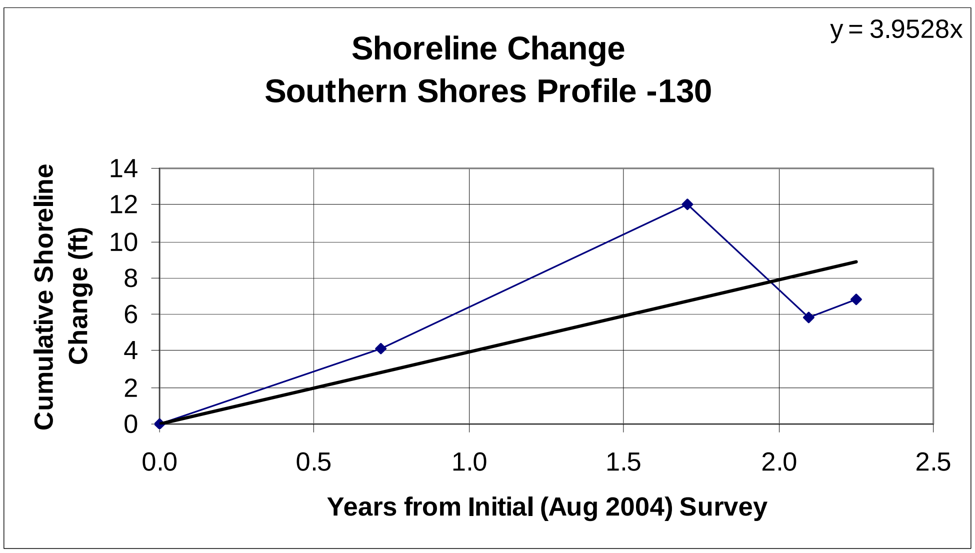

y = 29.612x
Shoreline Change
Bodie Island Profile 19
Cumulative Shoreline Change (ft)
2500
2000
1500
1000
500
0
0.0
20.0
40.0
60.0
80.0
Years from Initial (Jan 1949) Survey

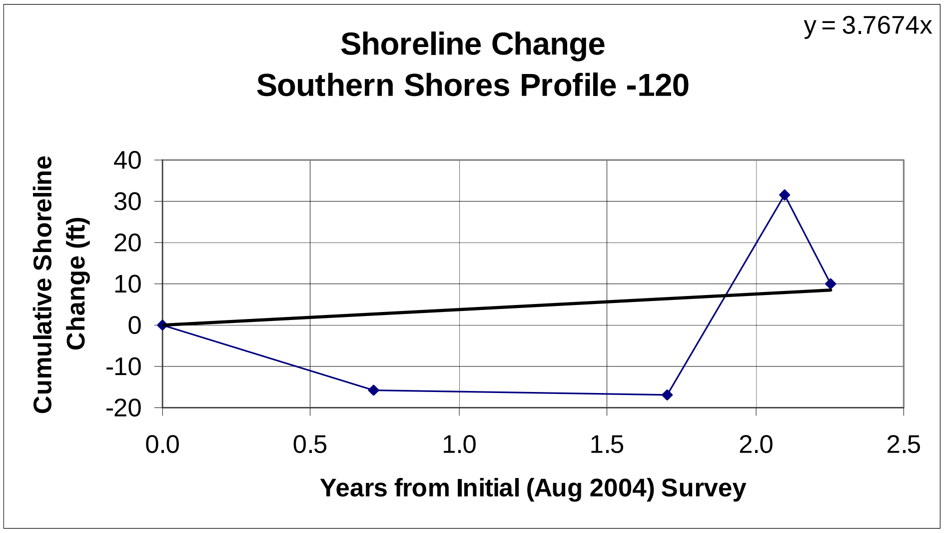
Appendix C

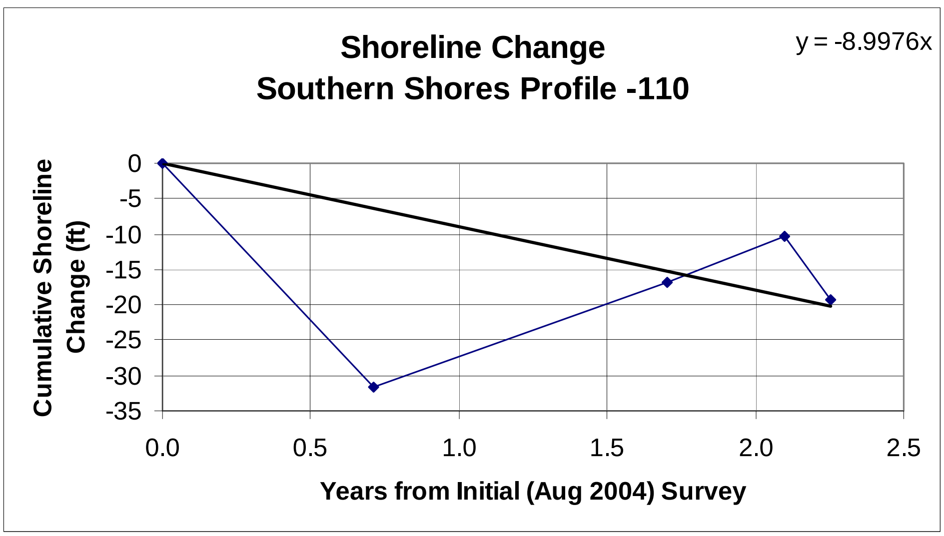
Shoreline Change Rates
USACE Monitoring Survey Database Only

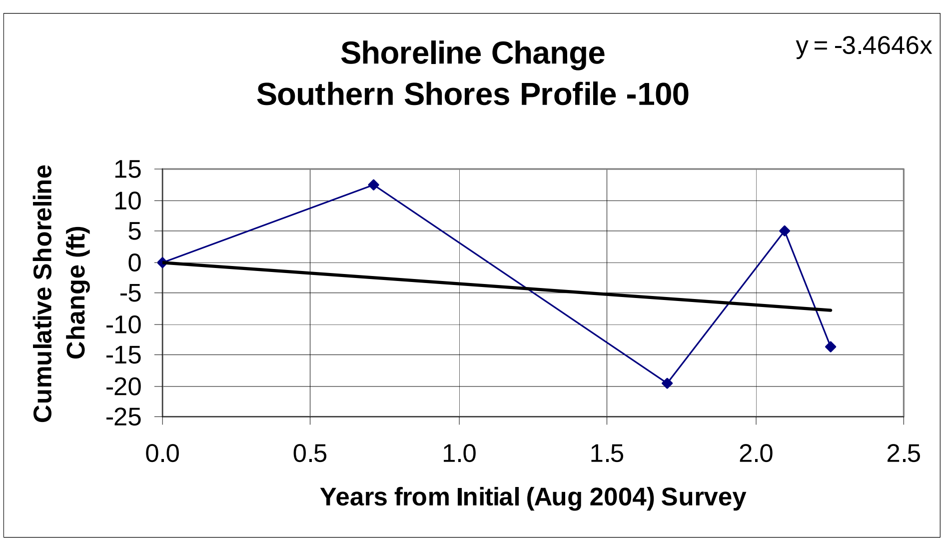

Shoreline Change
Southern Shores Profile -150
y = -1.5096x
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

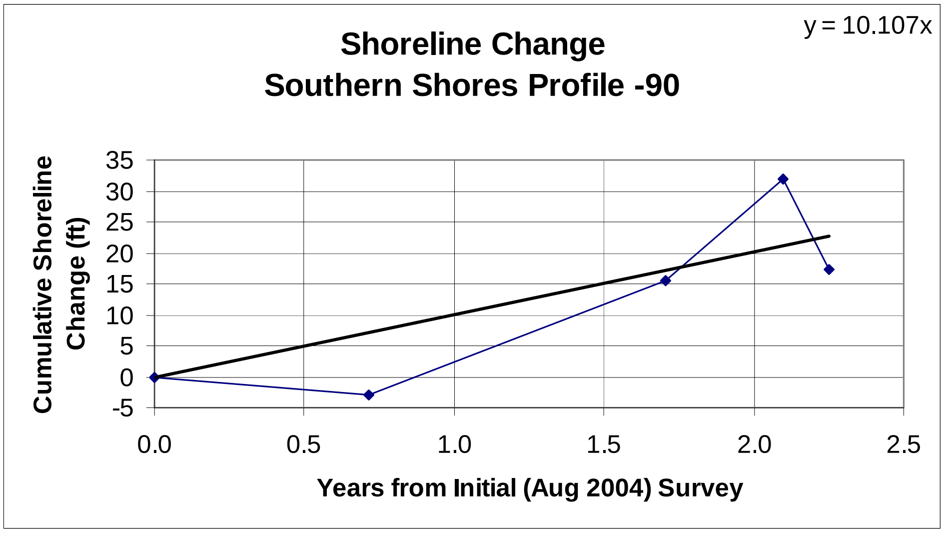

Shoreline Change
Southern Shores Profile -140
y = -2.359x
Cumulative Shoreline Change (ft)
30
25
20
15
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

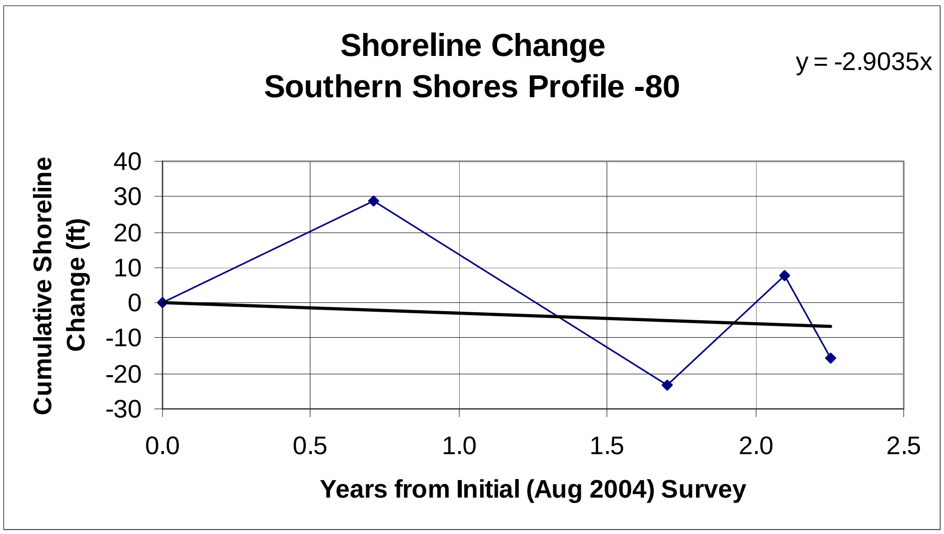

y = 3.9528x
Shoreline Change
Southern Shores Profile -130
Cumulative Shoreline Change (ft)
14
12
10
8
6
4
2
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

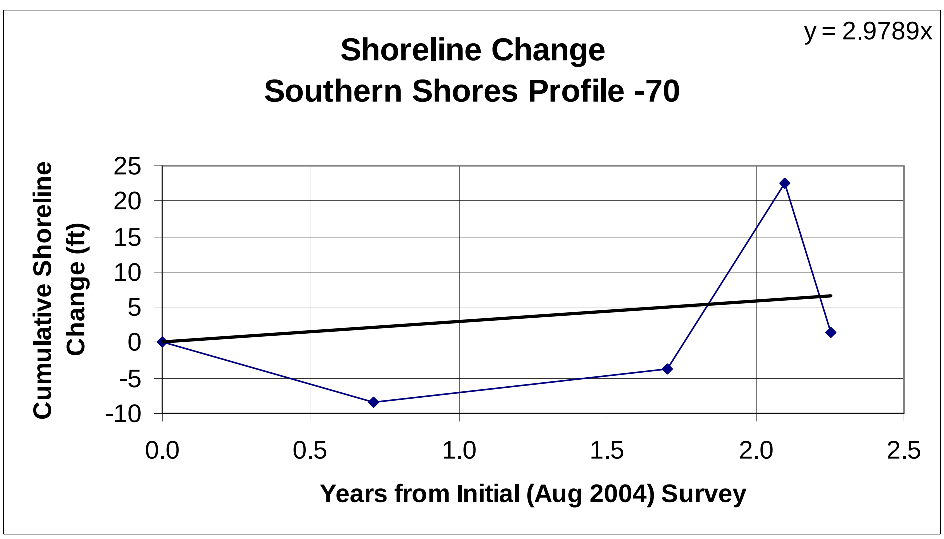

y = 3.7674x
Shoreline Change
Southern Shores Profile -120
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

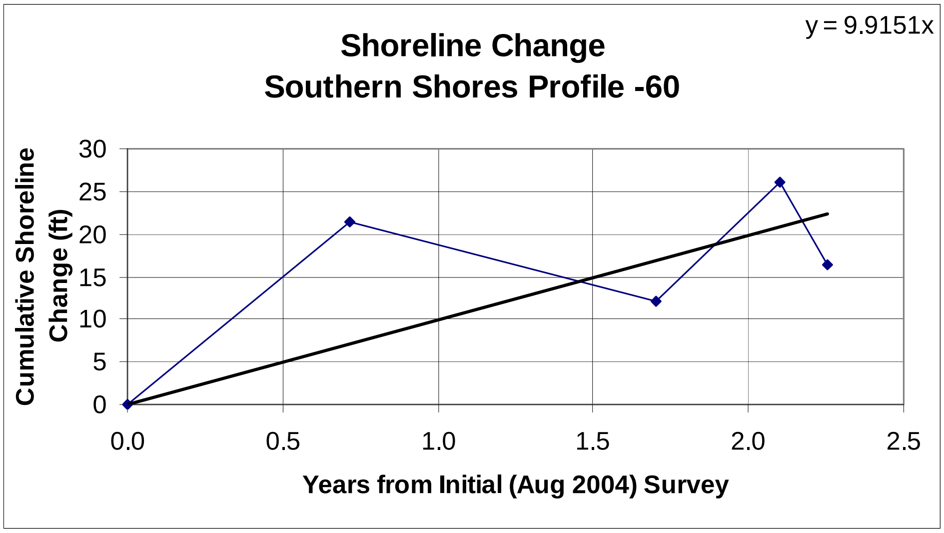

y = -8.9976x
Shoreline Change
Southern Shores Profile -110
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
-35
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

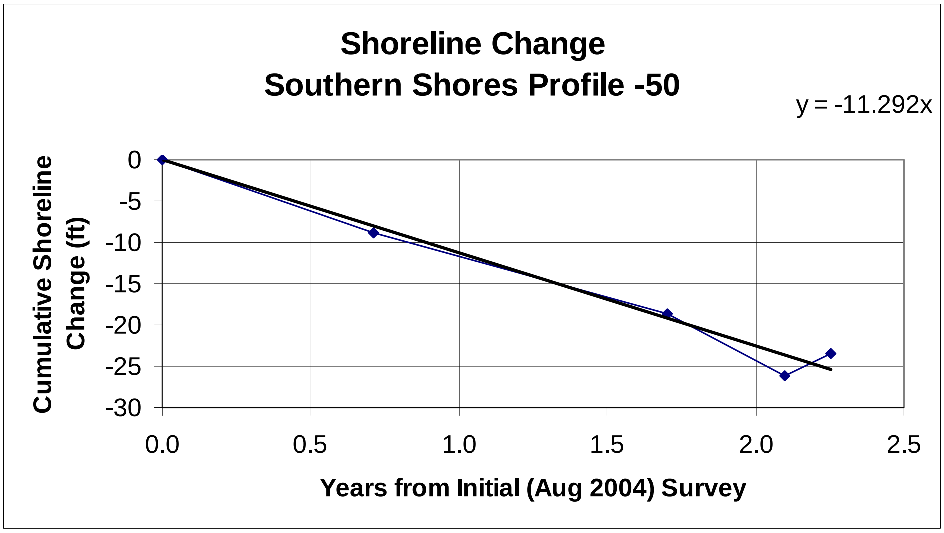

y = -3.4646x
Shoreline Change
Southern Shores Profile -100
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

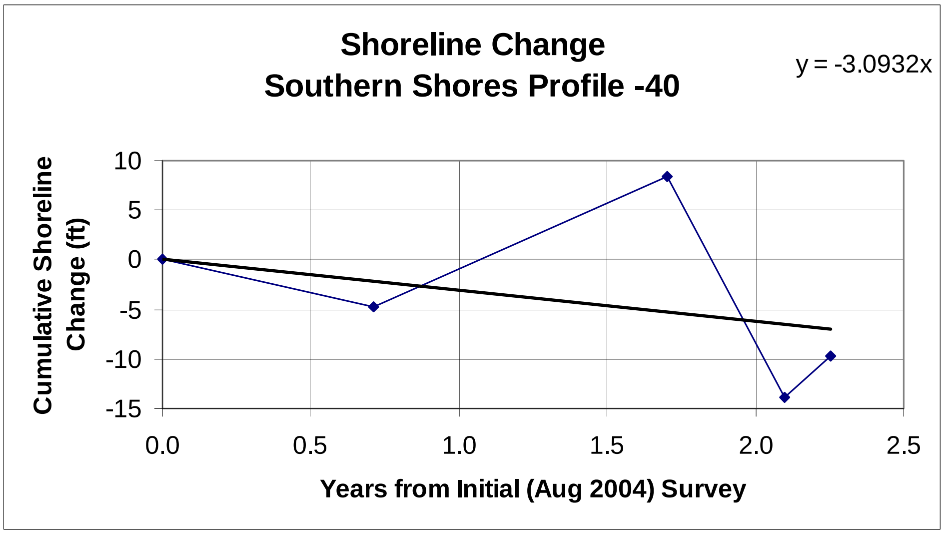

y = 10.107x
Shoreline Change
Southern Shores Profile -90
Cumulative Shoreline Change (ft)
35
30
25
20
15
10
5
0
-5
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

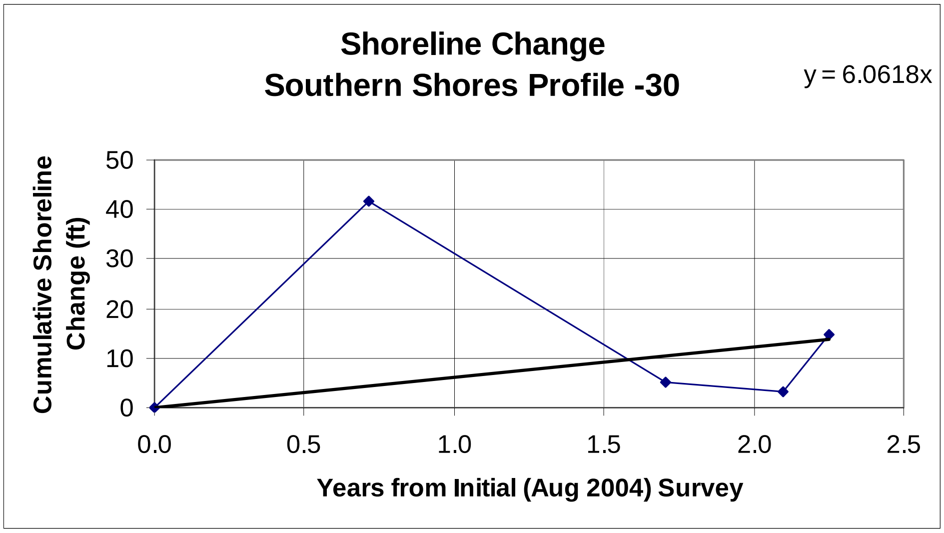

Shoreline Change
Southern Shores Profile -80
y = -2.9035x
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

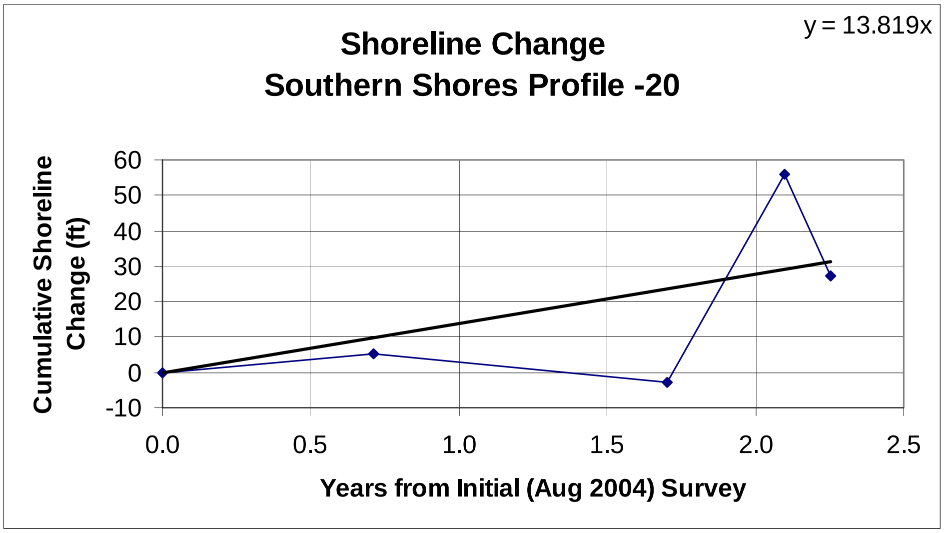

y = 2.9789x
Shoreline Change
Southern Shores Profile -70
Cumulative Shoreline Change (ft)
25
20
15
10
5
0
-5
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

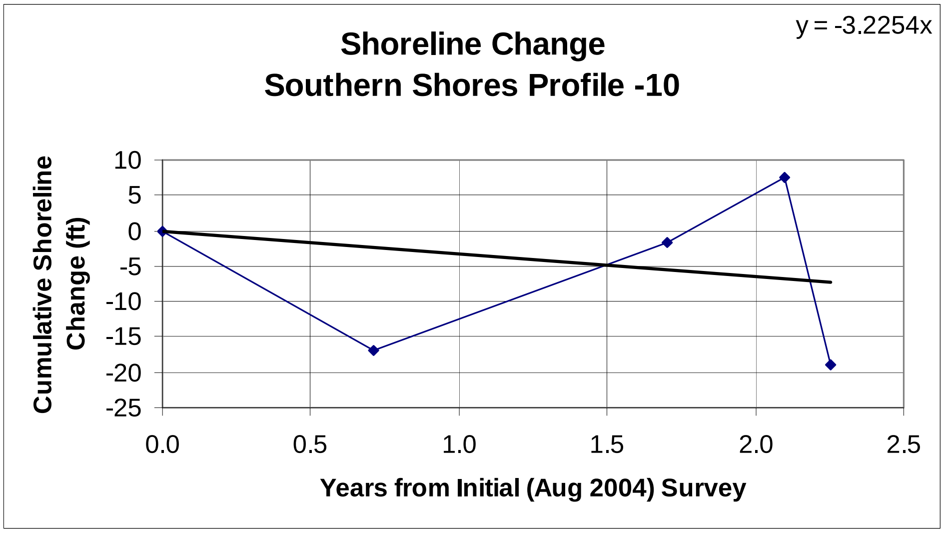

y = 9.9151x
Shoreline Change
Southern Shores Profile -60
Cumulative Shoreline Change (ft)
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

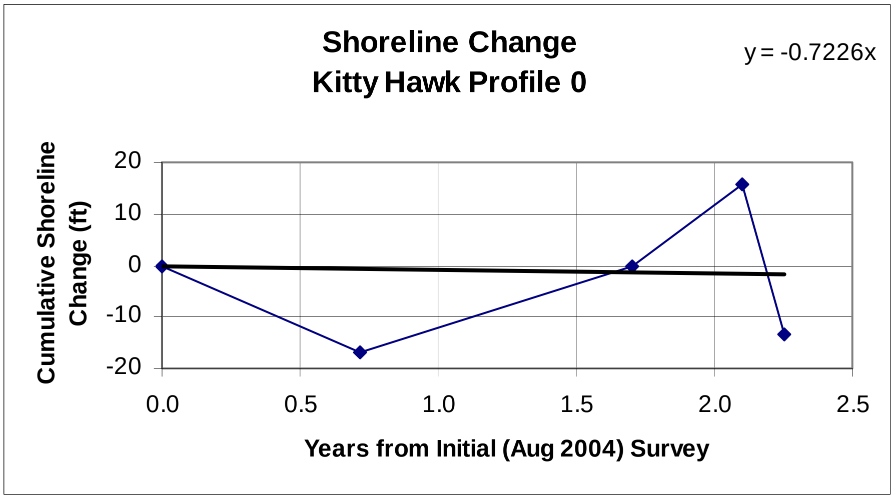

Shoreline Change
Southern Shores Profile -50
y = -11.292x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

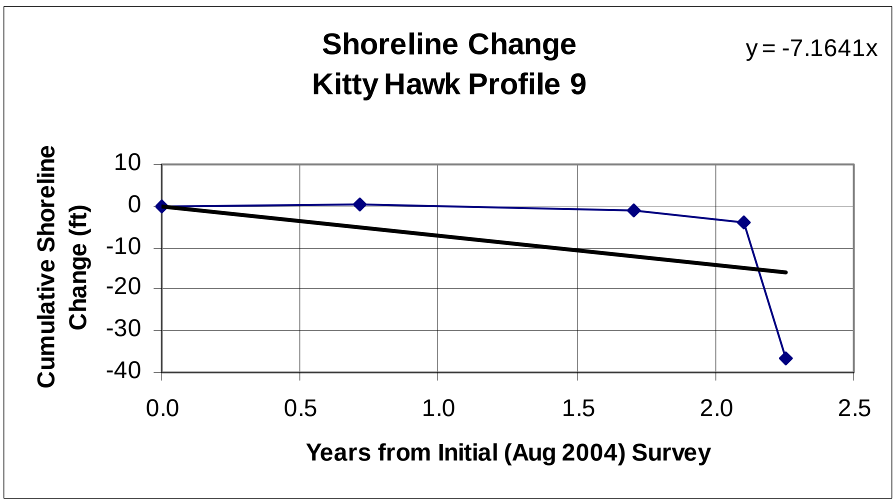

Shoreline Change
Southern Shores Profile -40
y = -3.0932x
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

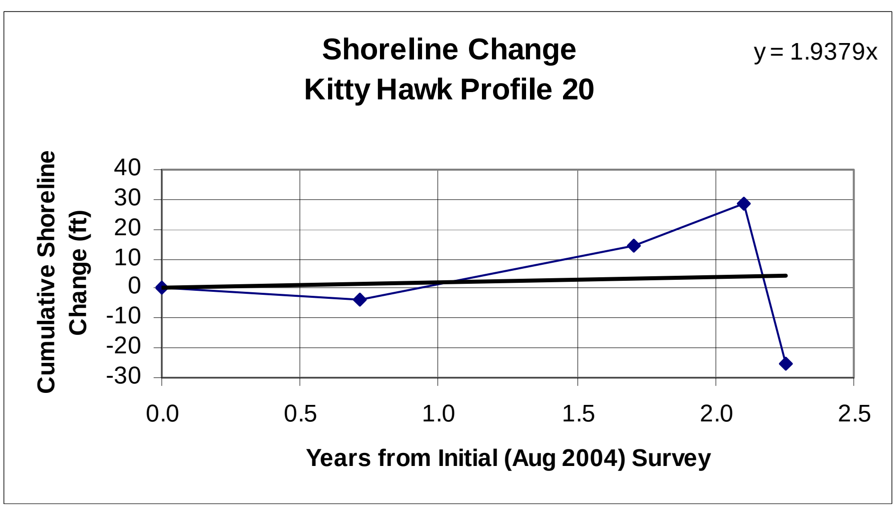

Shoreline Change
Southern Shores Profile -30
y = 6.0618x
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

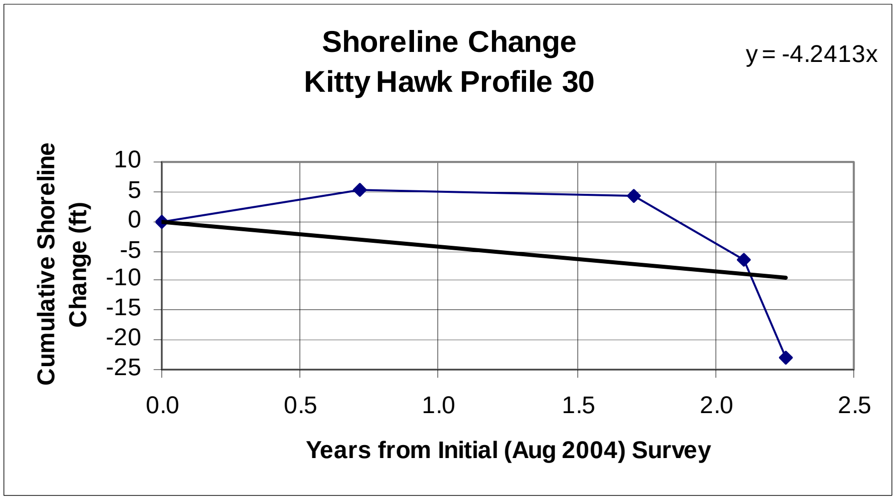

y = 13.819x
Shoreline Change
Southern Shores Profile -20
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

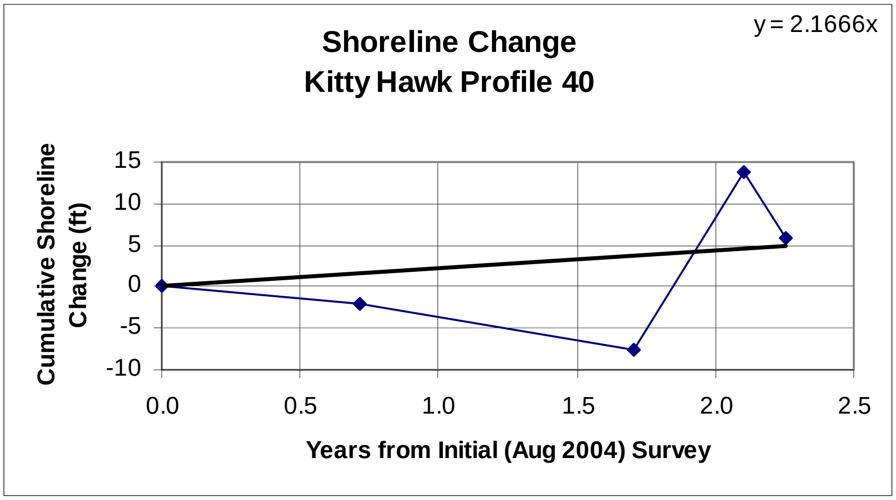

y = -3.2254x
Shoreline Change
Southern Shores Profile -10
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

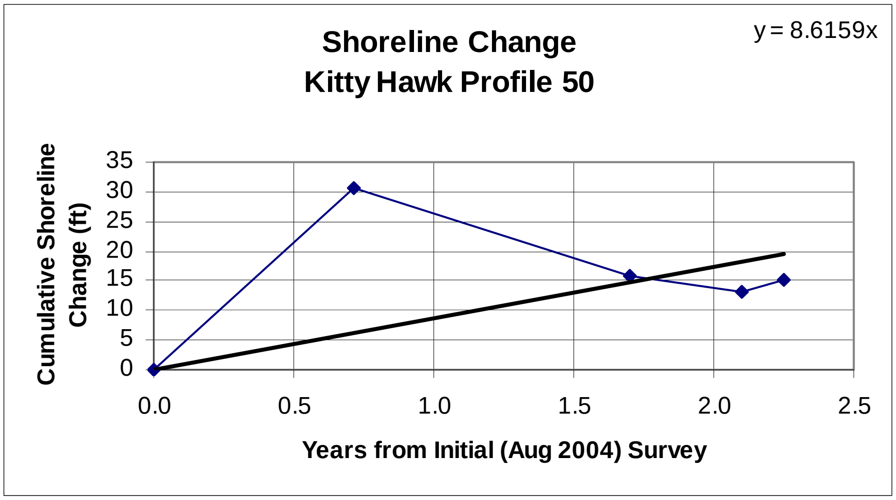

Shoreline Change
Kitty Hawk Profile 0
y = -0.7226x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

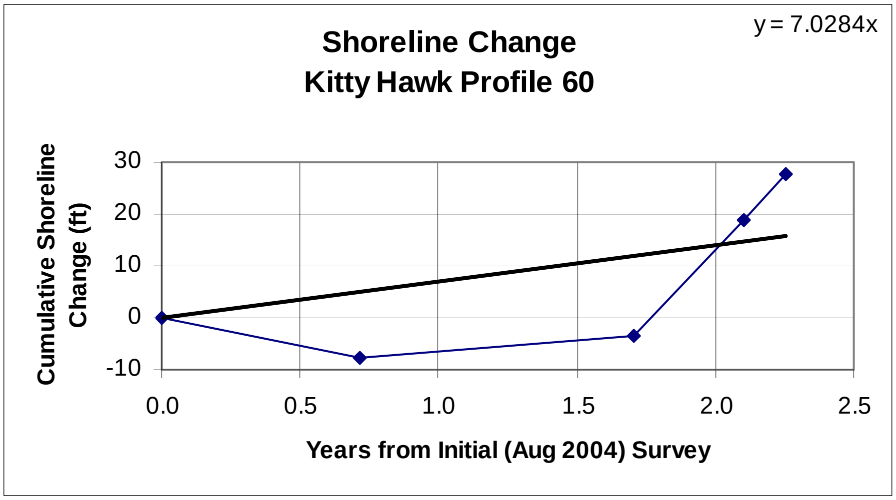

Shoreline Change
Kitty Hawk Profile 9
y = -7.1641x
Cumulative Shoreline Change (ft)
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

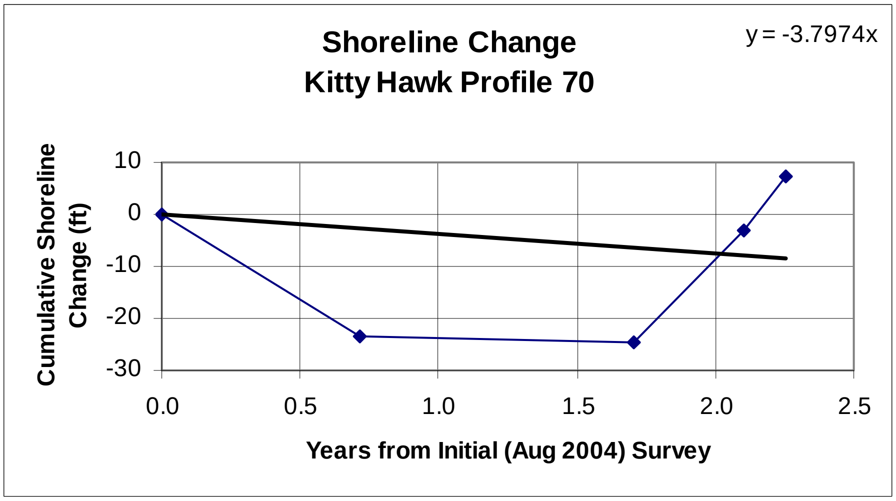

Shoreline Change
Kitty Hawk Profile 20
y = 1.9379x
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

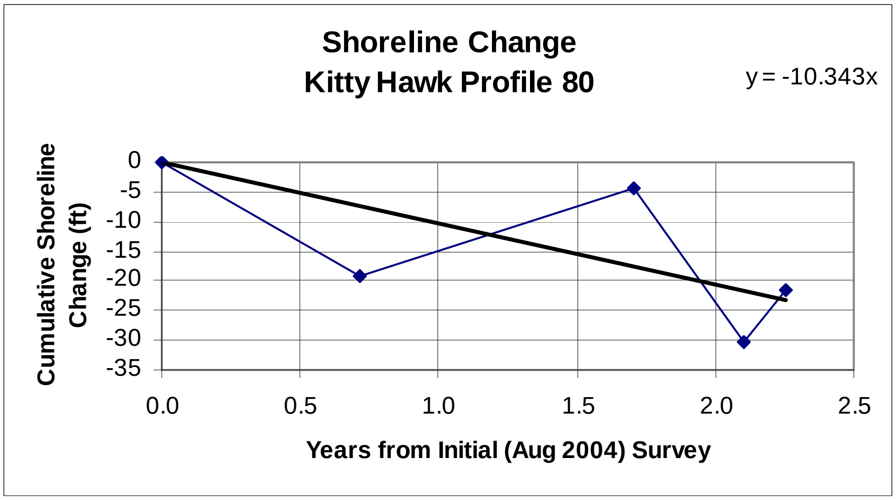

Shoreline Change
Kitty Hawk Profile 30
y = -4.2413x
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

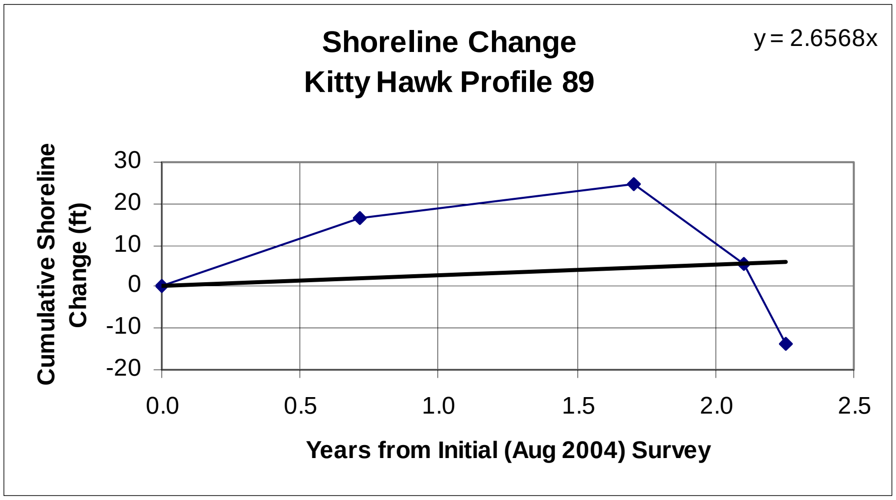

Shoreline Change
Kitty Hawk Profile 40
y = 2.1666x
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

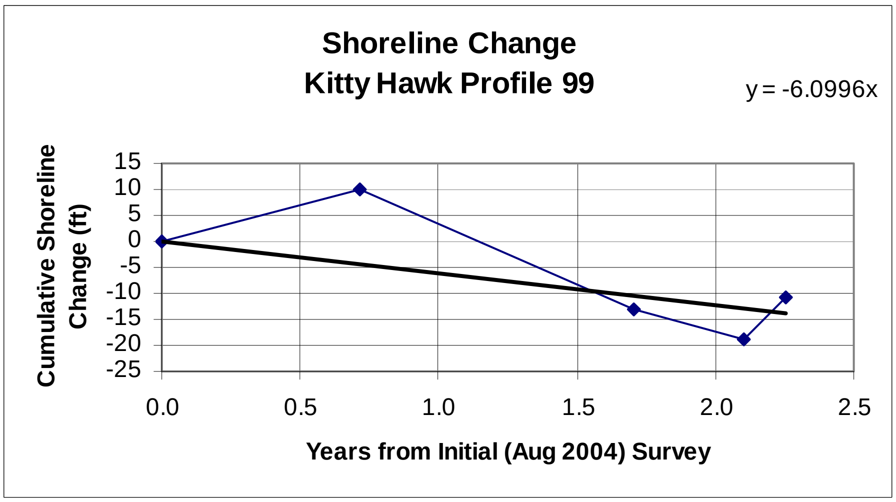

Shoreline Change
Kitty Hawk Profile 50
y = 8.6159x
Cumulative Shoreline Change (ft)
35
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

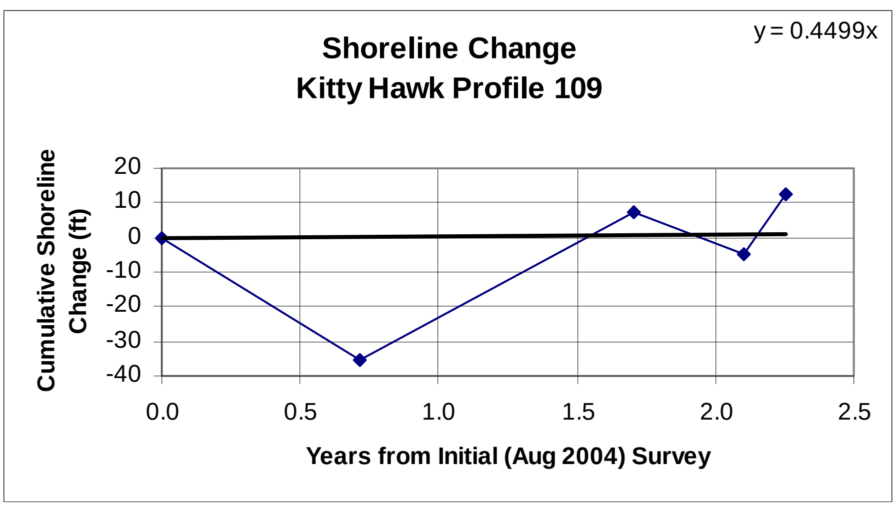

y = 7.0284x
Shoreline Change
Kitty Hawk Profile 60
Cumulative Shoreline Change (ft)
30
20
10
0
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

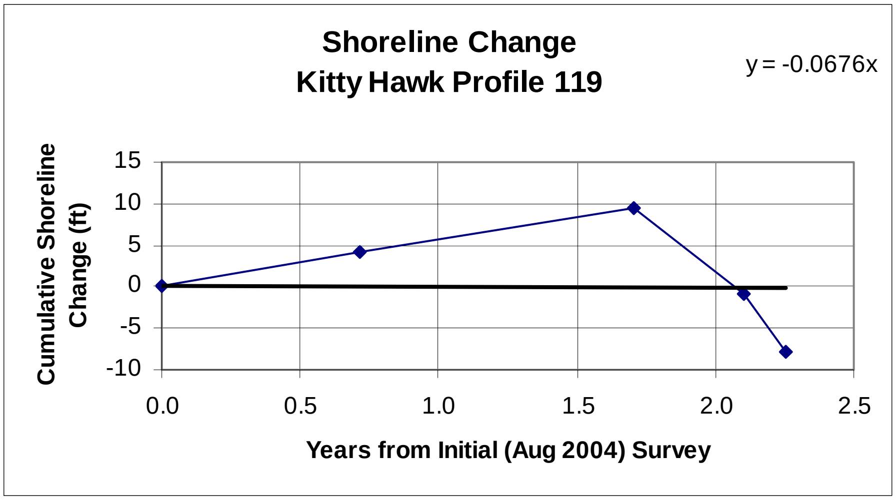

y = -3.7974x
Shoreline Change
Kitty Hawk Profile 70
Cumulative Shoreline Change (ft)
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

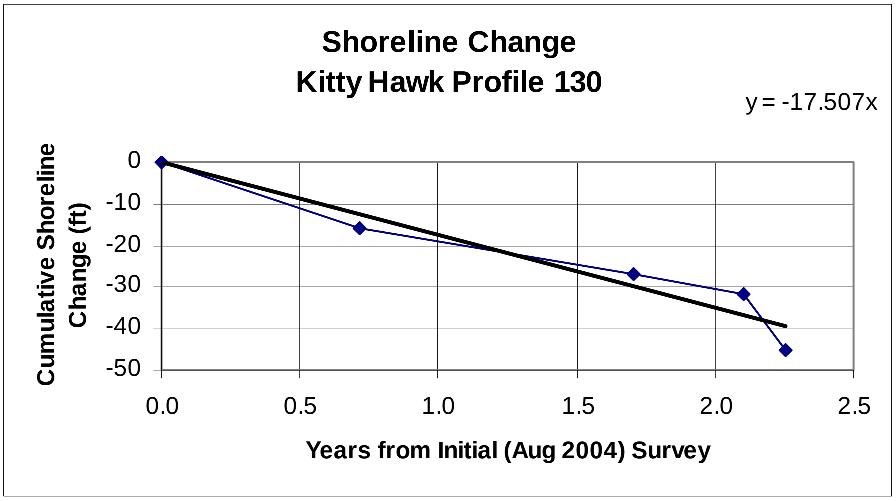

Shoreline Change
Kitty Hawk Profile 80
y = -10.343x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
-35
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

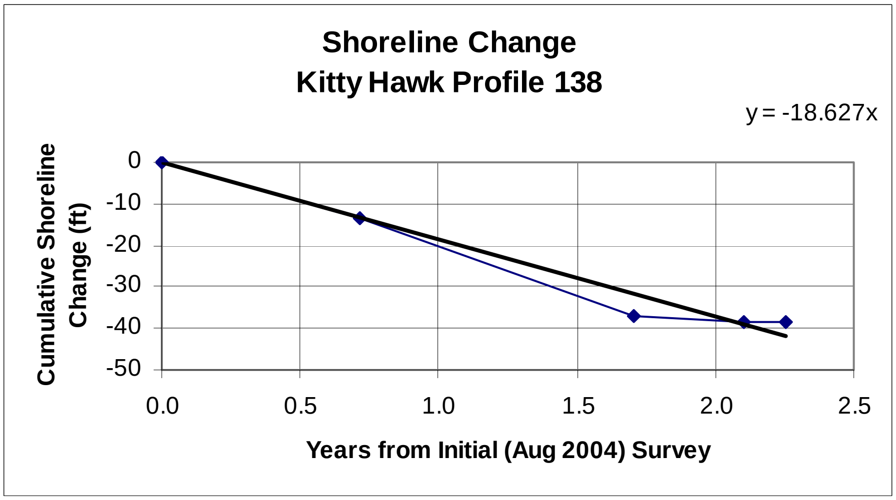

Shoreline Change
Kitty Hawk Profile 89
y = 2.6568x
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

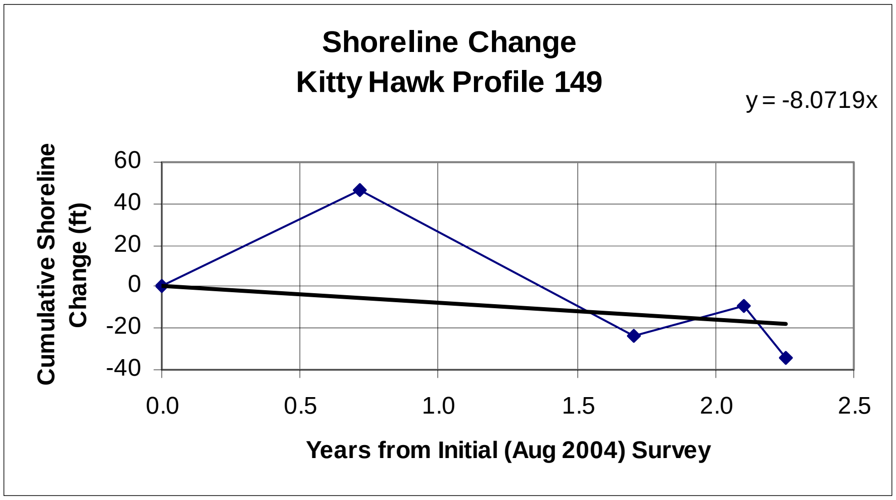

Shoreline Change
Kitty Hawk Profile 99
y = -6.0996x
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

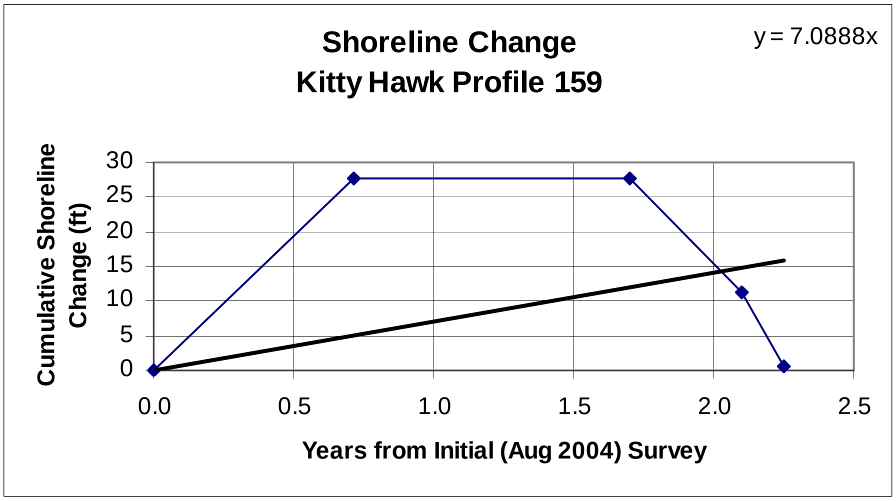

Shoreline Change
Kitty Hawk Profile 109
y = 0.4499x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

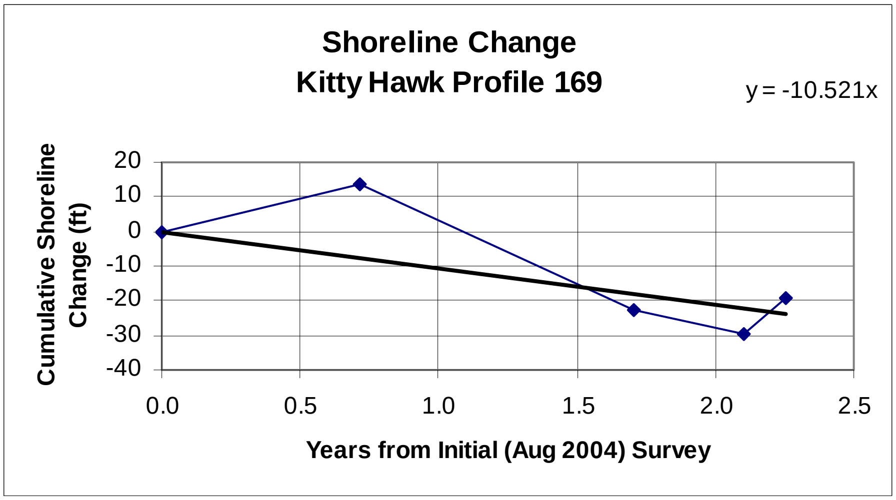

Shoreline Change
Kitty Hawk Profile 119
y = -0.0676x
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

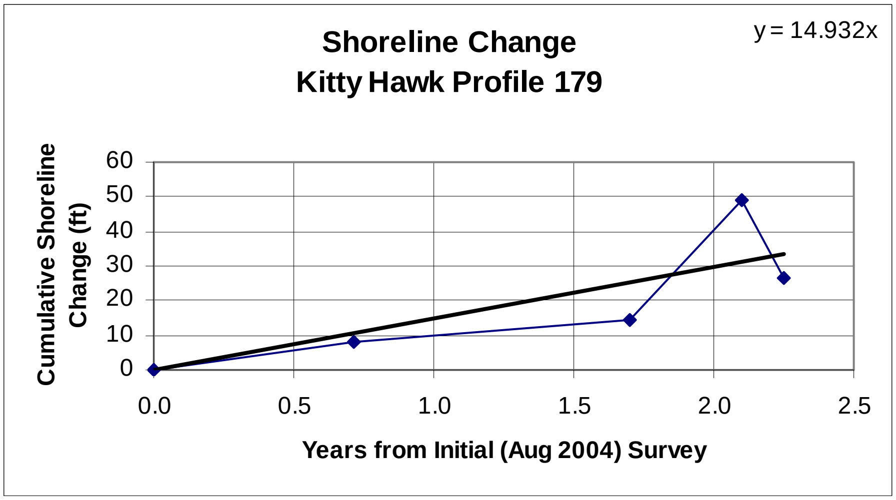

Shoreline Change
Kitty Hawk Profile 130
y = -17.507x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

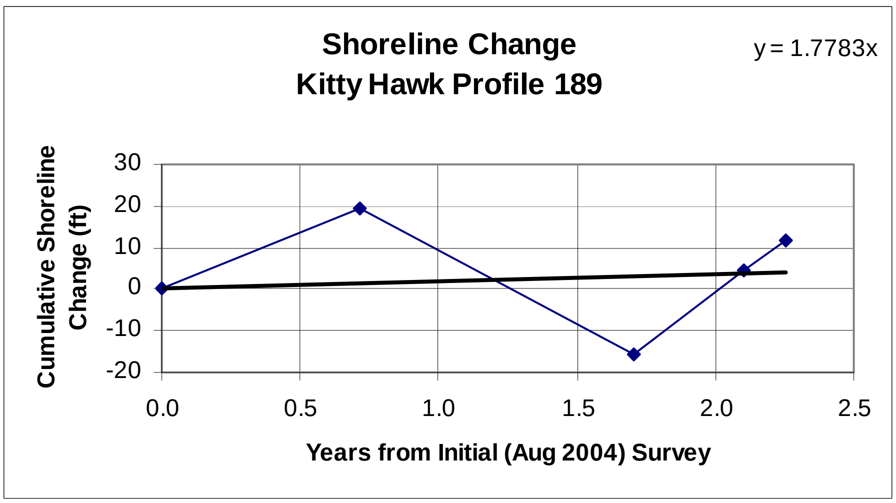

Shoreline Change
Kitty Hawk Profile 138
y = -18.627x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

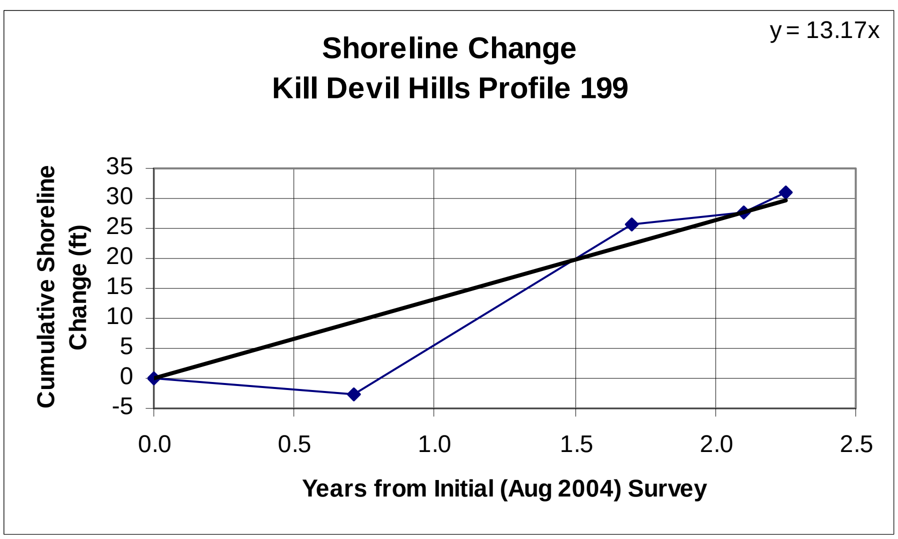

Shoreline Change
Kitty Hawk Profile 149
y = -8.0719x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

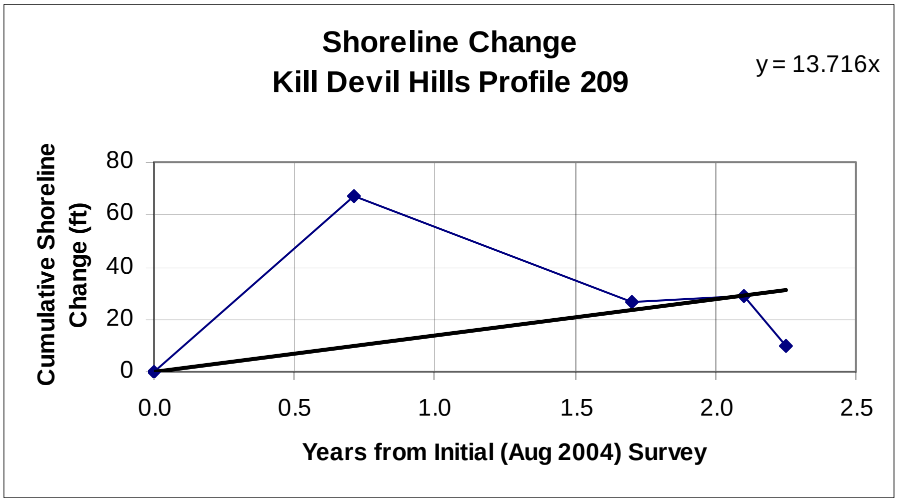

Shoreline Change
Kitty Hawk Profile 159
y = 7.0888x
Cumulative Shoreline Change (ft)
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

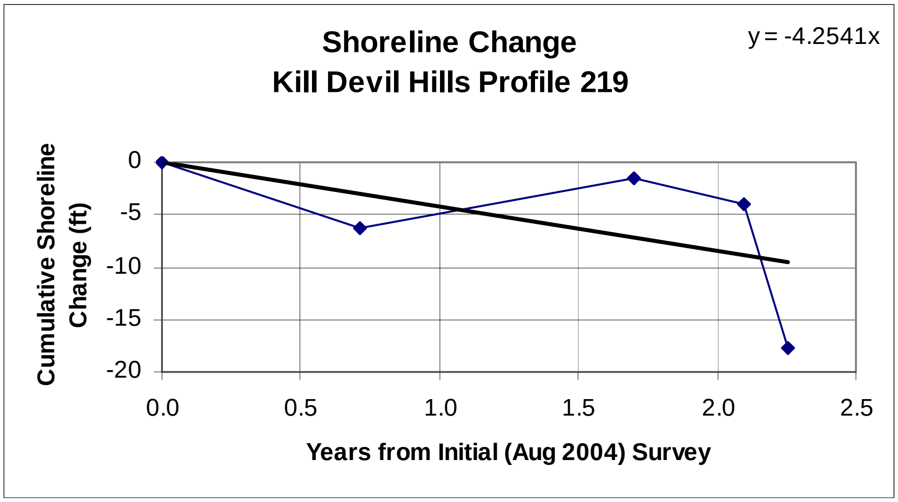

Shoreline Change
Kitty Hawk Profile 169
y = -10.521x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

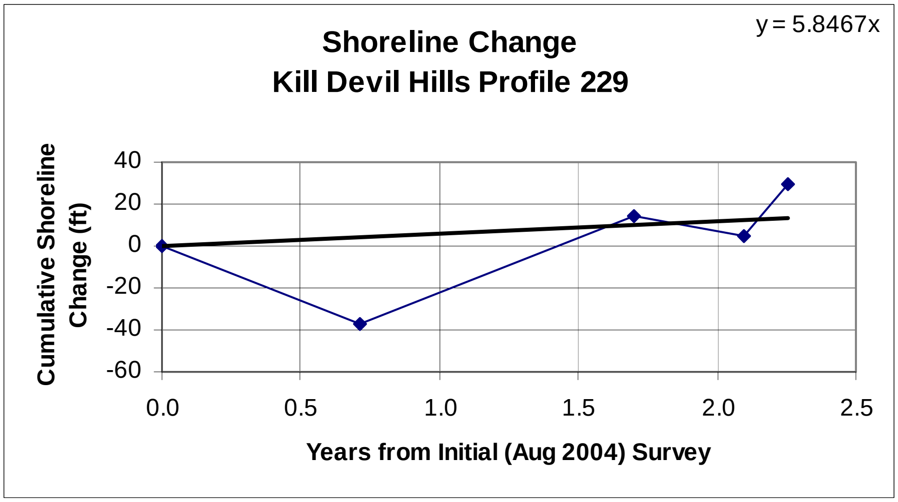

Shoreline Change
Kitty Hawk Profile 179
y = 14.932x
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

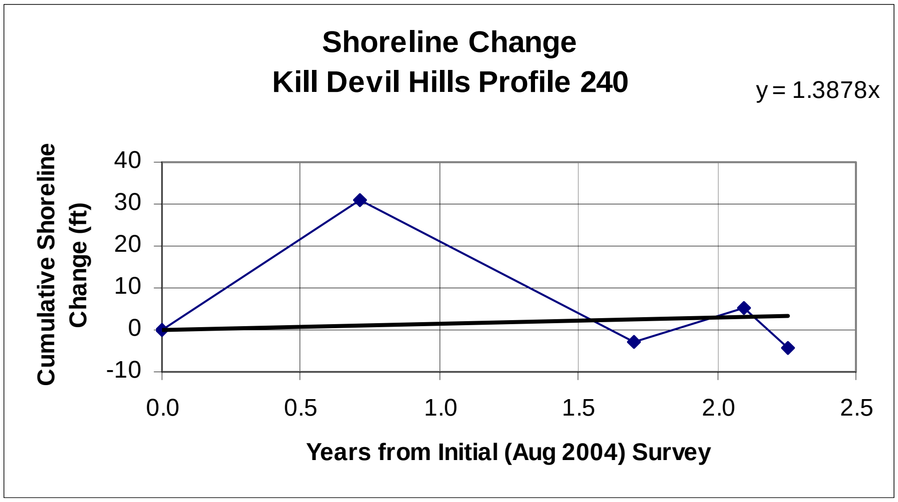

Shoreline Change
Kitty Hawk Profile 189
y = 1.7783x
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

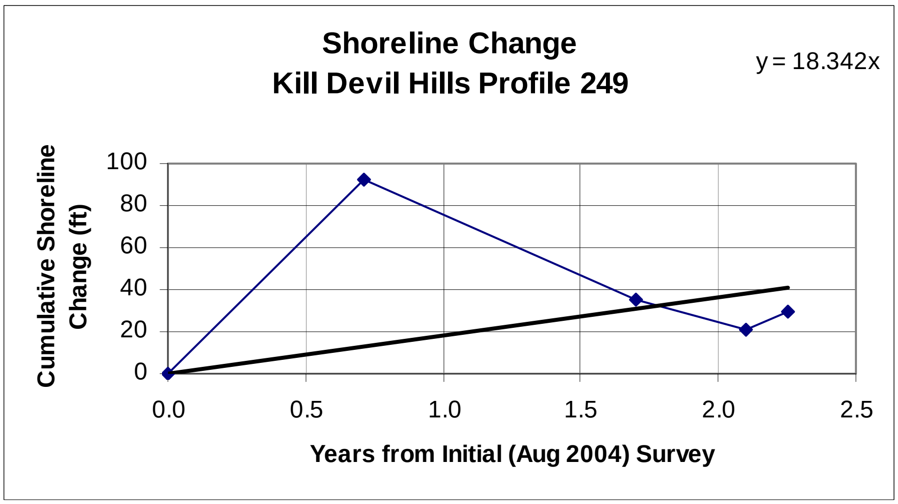

Shoreline Change
Kill Devil Hills Profile 199
y = 13.17x
Cumulative Shoreline Change (ft)
35
30
25
20
15
10
5
0
-5
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

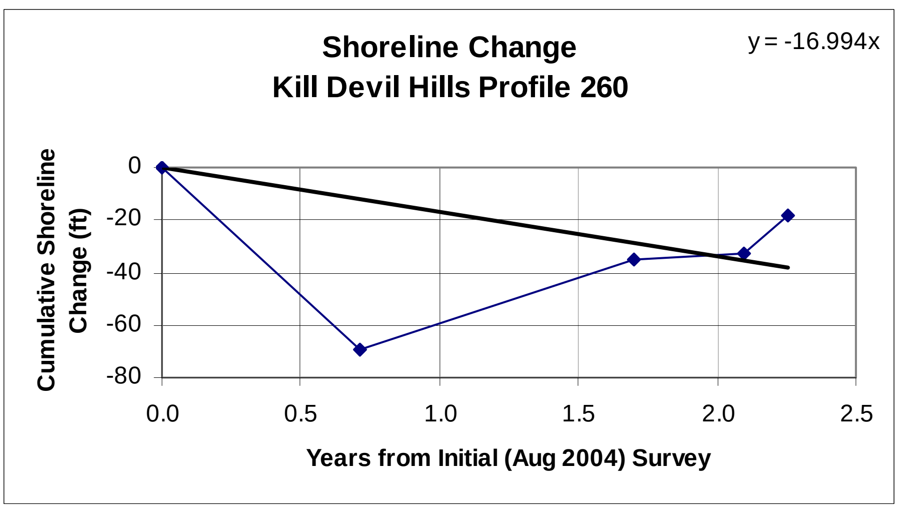

Shoreline Change
Kill Devil Hills Profile 209
y = 13.716x
Cumulative Shoreline Change (ft)
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

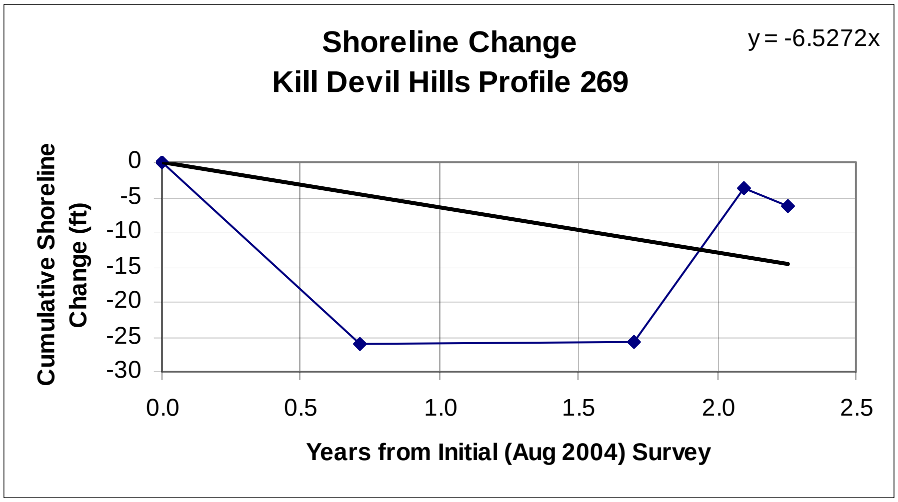

Shoreline Change
Kill Devil Hills Profile 219
y = -4.2541x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

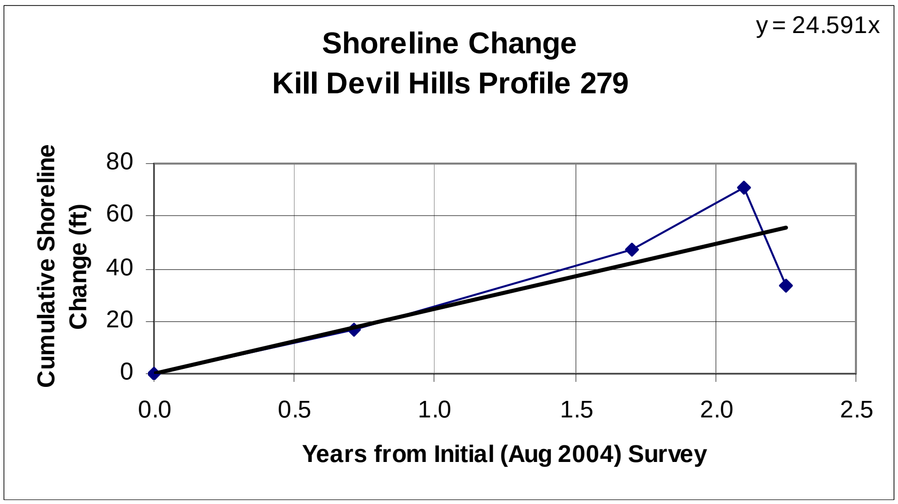

Shoreline Change
Kill Devil Hills Profile 229
y = 5.8467x
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

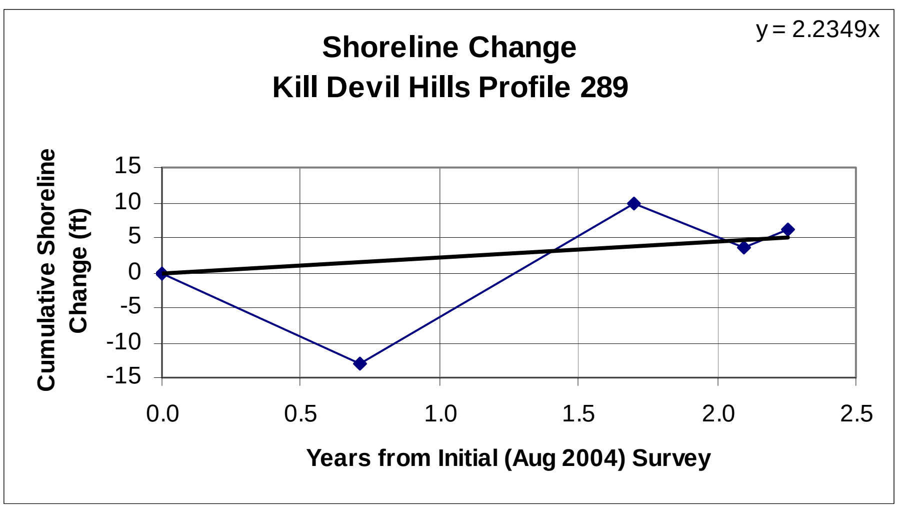

Shoreline Change
Kill Devil Hills Profile 240
y = 1.3878x
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

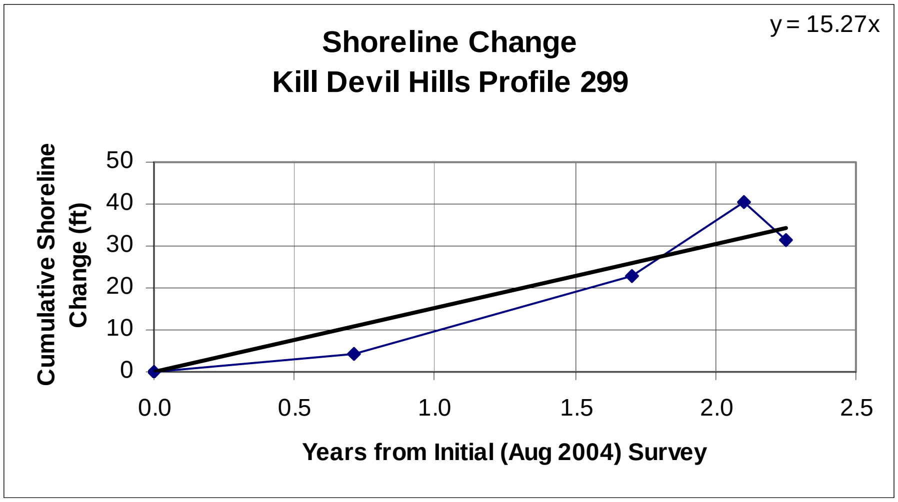

Shoreline Change
Kill Devil Hills Profile 249
y = 18.342x
Cumulative Shoreline Change (ft)
100
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

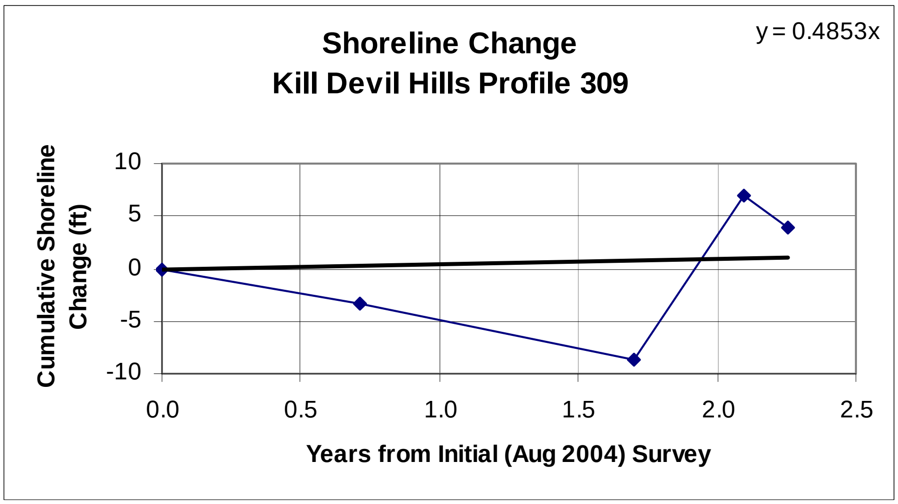

Shoreline Change
Kill Devil Hills Profile 260
y = -16.994x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

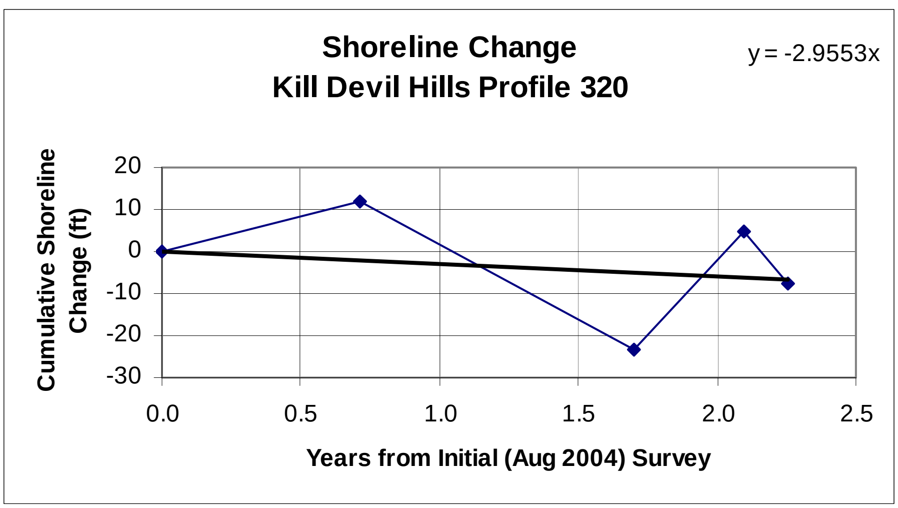

Shoreline Change
Kill Devil Hills Profile 269
y = -6.5272x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

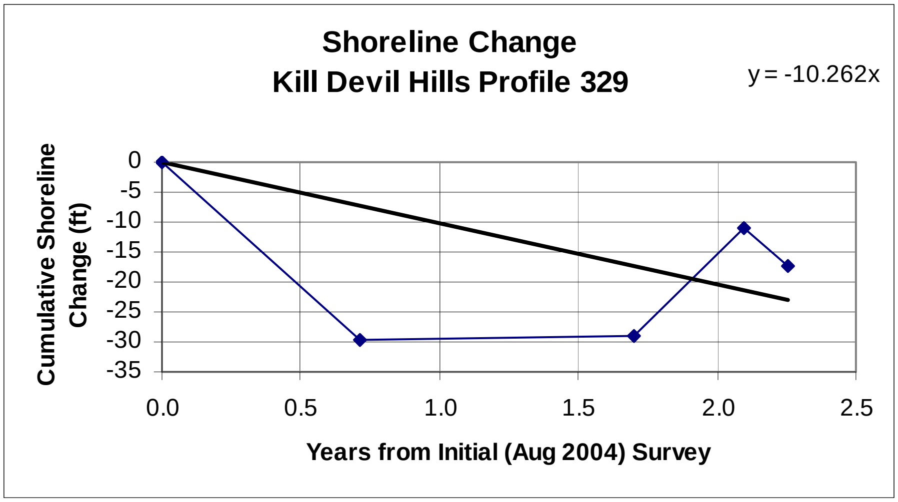

Shoreline Change
Kill Devil Hills Profile 279
y = 24.591x
Cumulative Shoreline Change (ft)
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

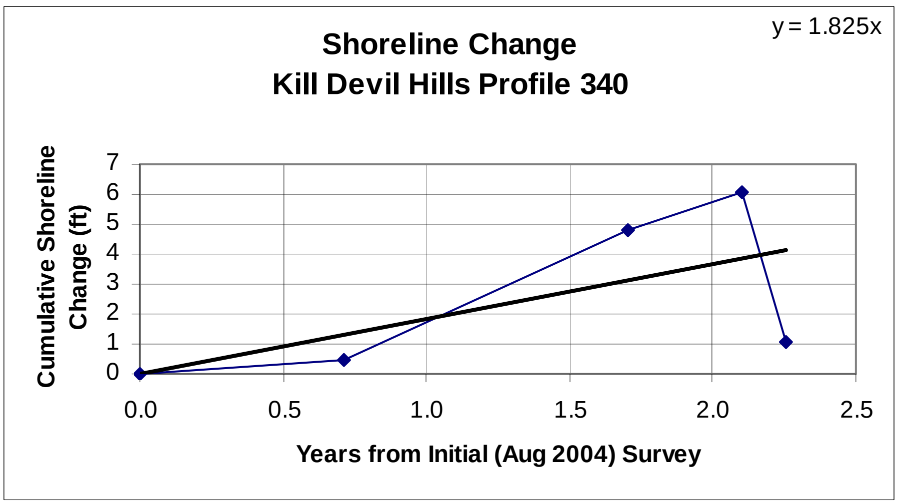

Shoreline Change
Kill Devil Hills Profile 289
y = 2.2349x
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

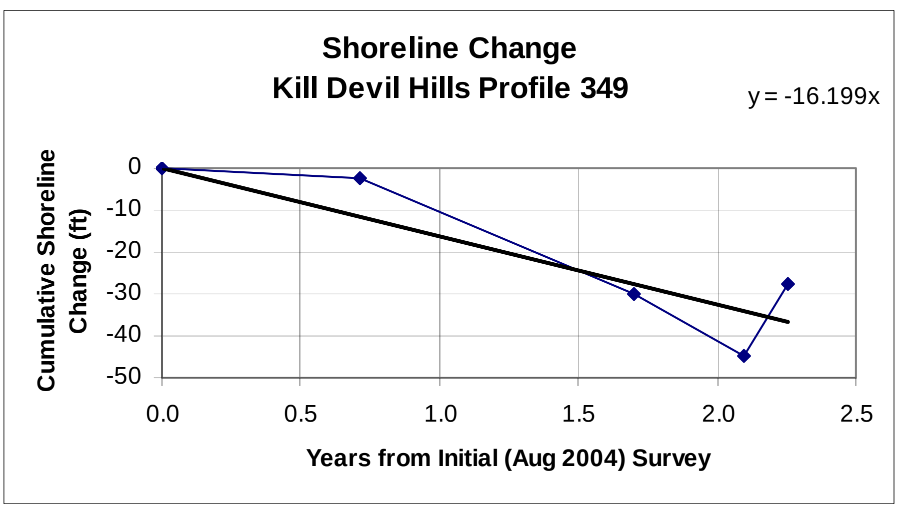

y = 15.27x
Shoreline Change
Kill Devil Hills Profile 299
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

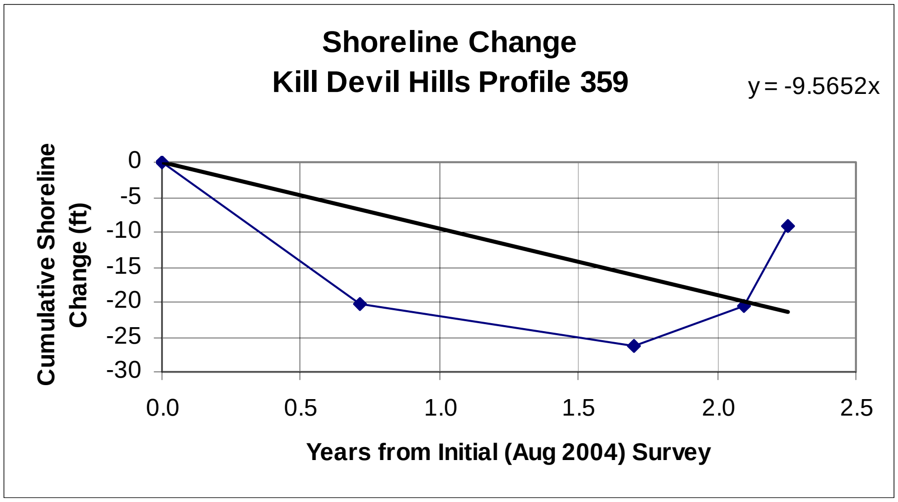

y = 0.4853x
Shoreline Change
Kill Devil Hills Profile 309
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

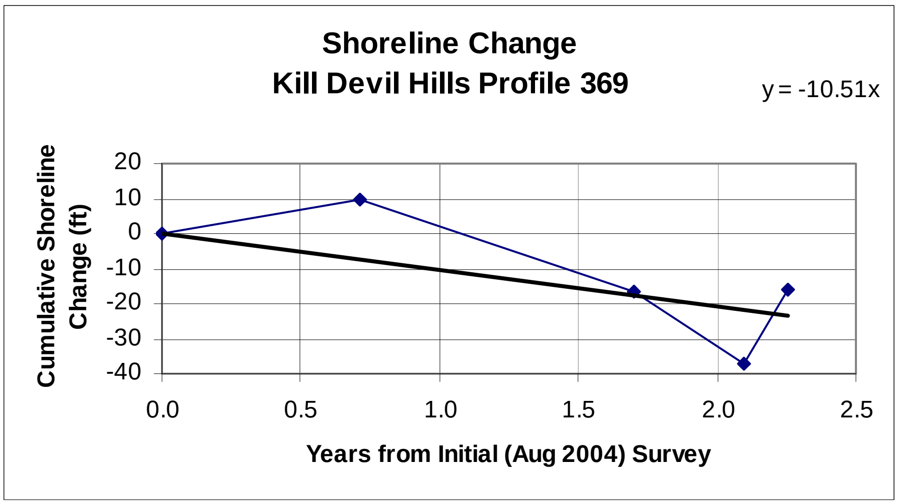

Shoreline Change
Kill Devil Hills Profile 320
y = -2.9553x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

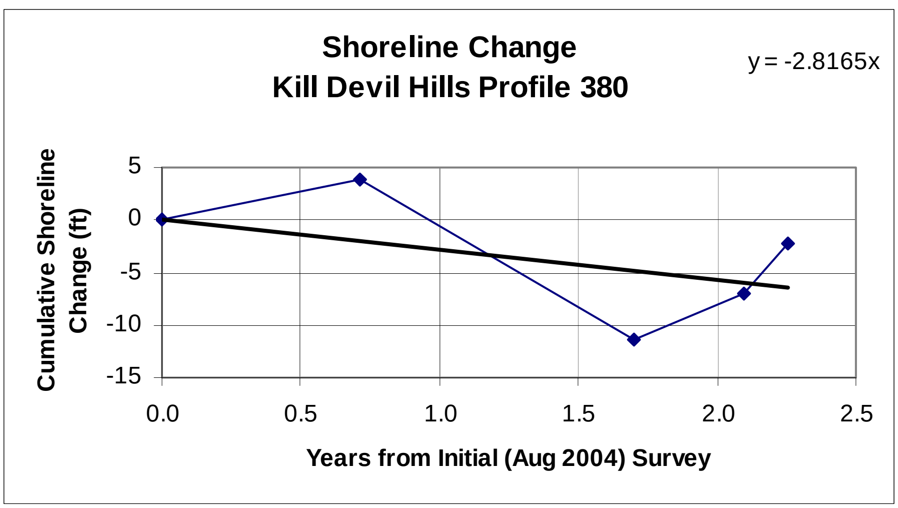

Shoreline Change
Kill Devil Hills Profile 329
y = -10.262x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
-35
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

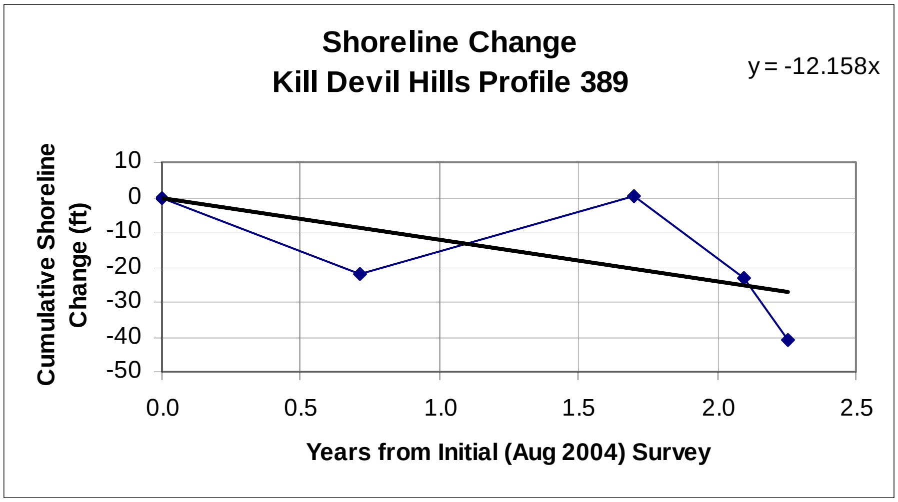

Shoreline Change
Kill Devil Hills Profile 340
y = 1.825x
Cumulative Shoreline Change (ft)
7
6
5
4
3
2
1
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

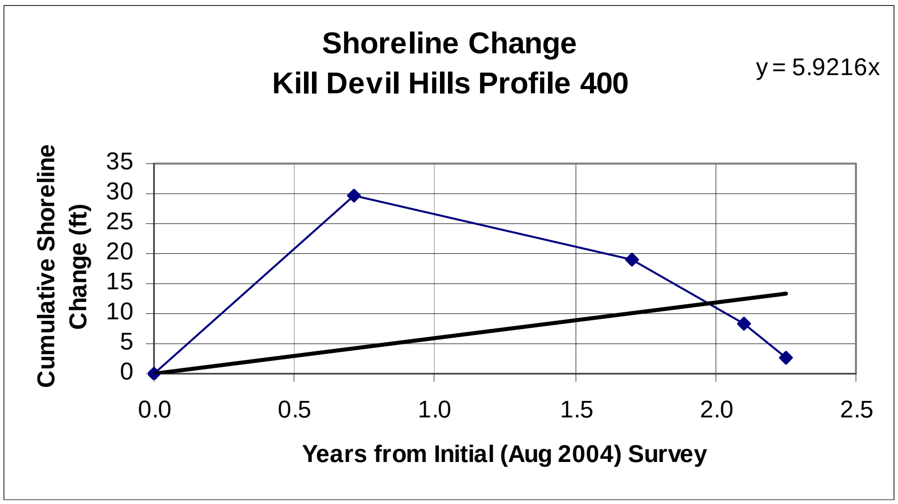

Shoreline Change
Kill Devil Hills Profile 349
y = -16.199x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

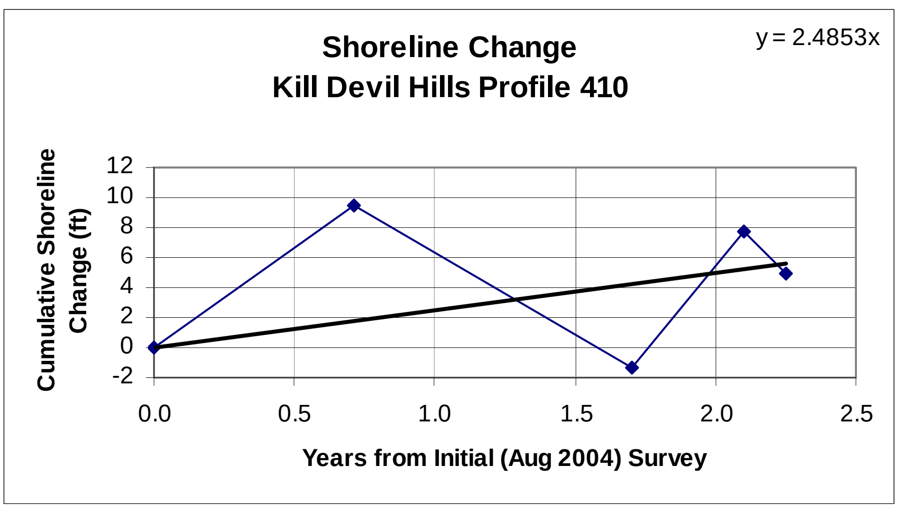

Shoreline Change
Kill Devil Hills Profile 359
y = -9.5652x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

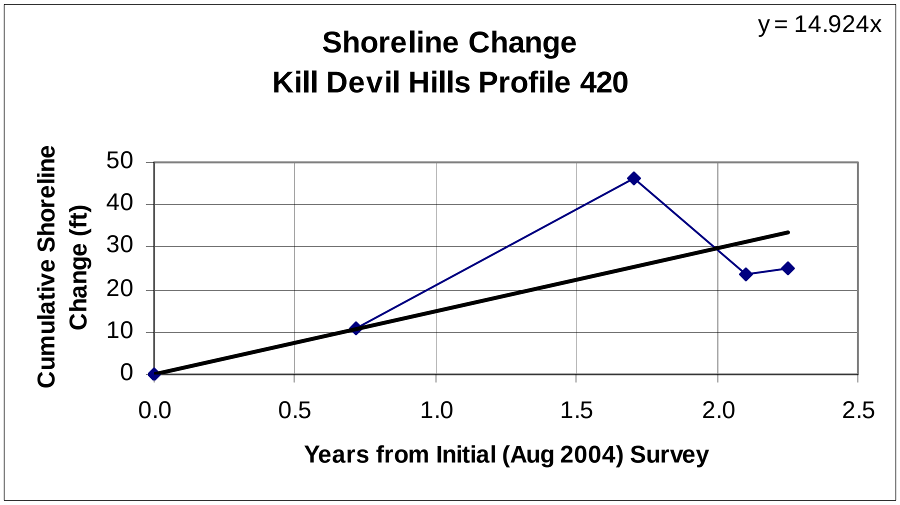

Shoreline Change
Kill Devil Hills Profile 369
y = -10.51x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

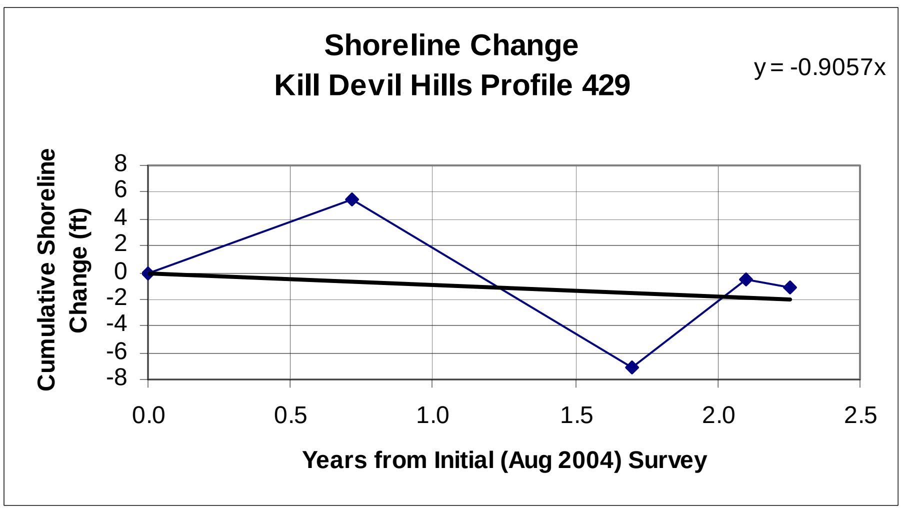

Shoreline Change
Kill Devil Hills Profile 380
y = -2.8165x
Cumulative Shoreline Change (ft)
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

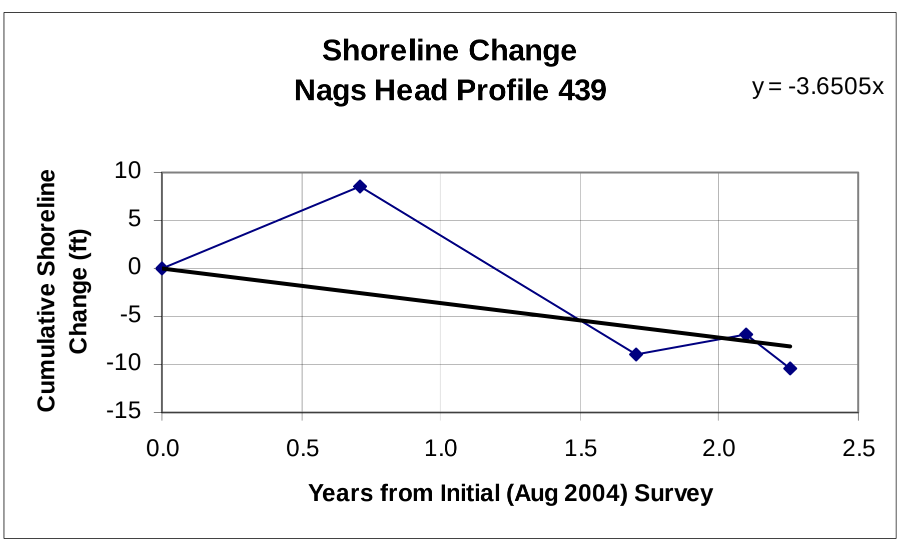

Shoreline Change
Kill Devil Hills Profile 389
y = -12.158x
Cumulative Shoreline Change (ft)
10
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

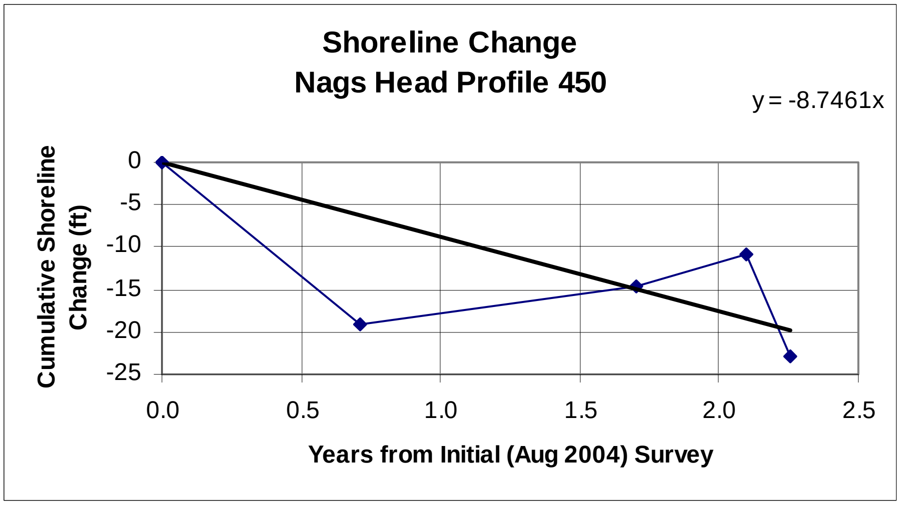

Shoreline Change
Kill Devil Hills Profile 400
y = 5.9216x
Cumulative Shoreline Change (ft)
35
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

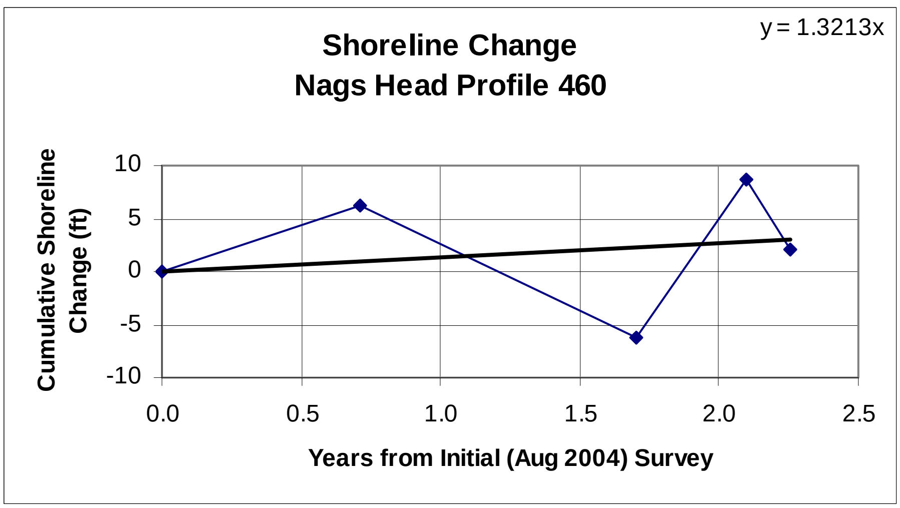

Shoreline Change
Kill Devil Hills Profile 410
y = 2.4853x
Cumulative Shoreline Change (ft)
12
10
8
6
4
2
0
-2
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

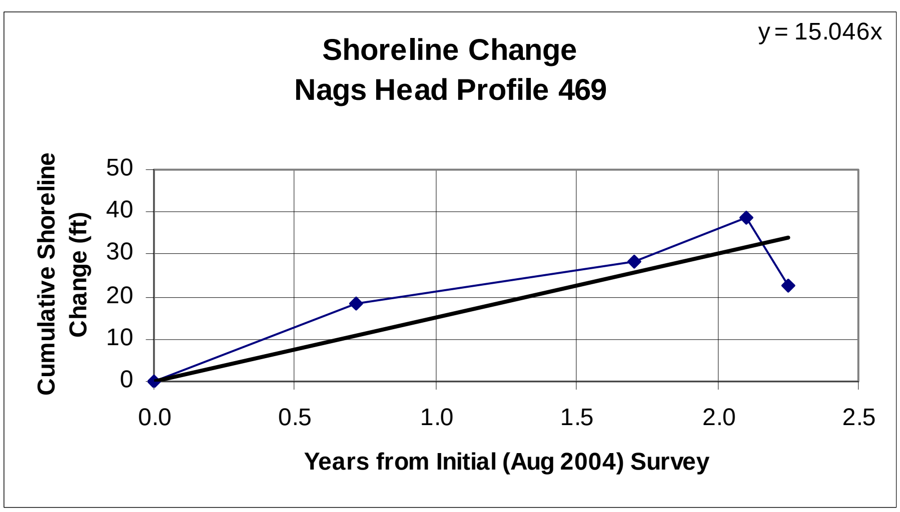

y = 14.924x
Shoreline Change
Kill Devil Hills Profile 420
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

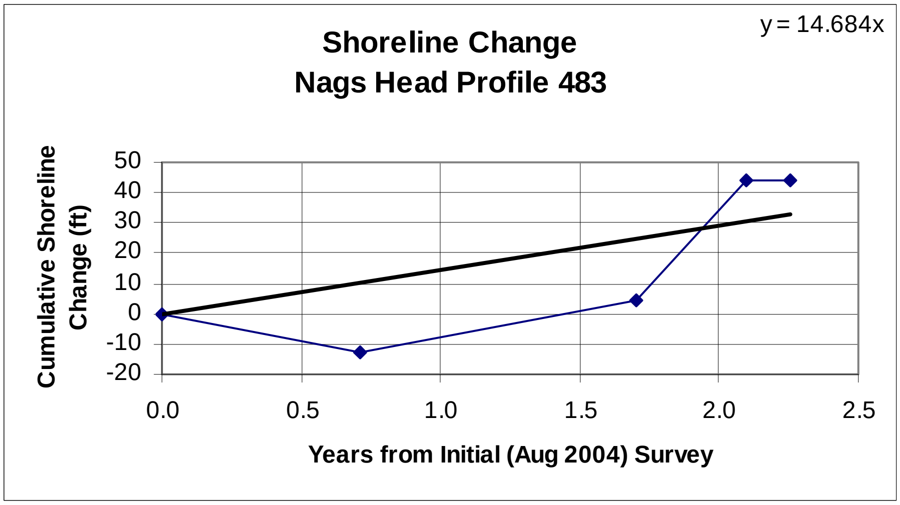

Shoreline Change
Kill Devil Hills Profile 429
y = -0.9057x
Cumulative Shoreline Change (ft)
8
6
4
2
0
-2
-4
-6
-8
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

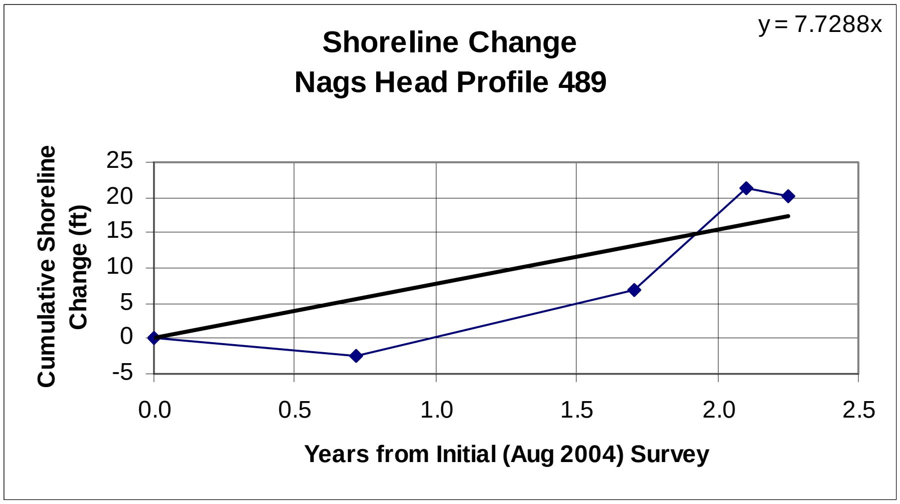

Shoreline Change
Nags Head Profile 439
y = -3.6505x
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

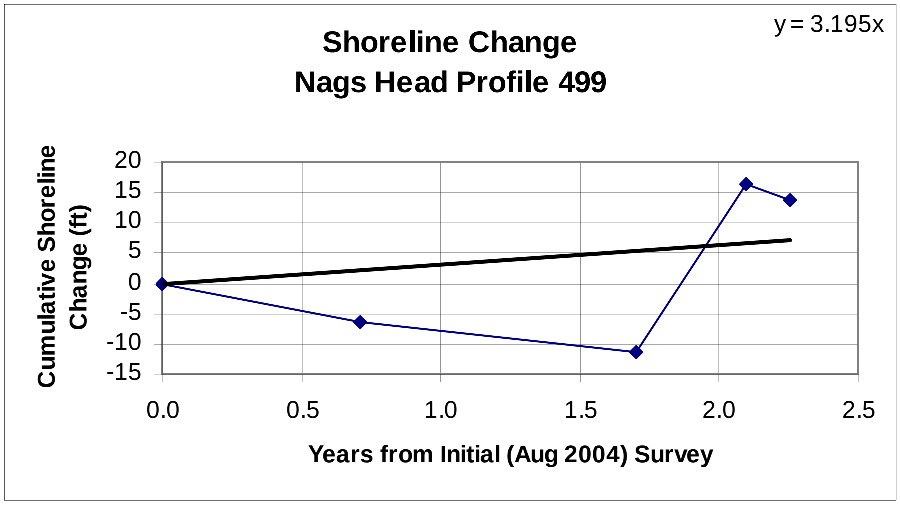

Shoreline Change
Nags Head Profile 450
y = -8.7461x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

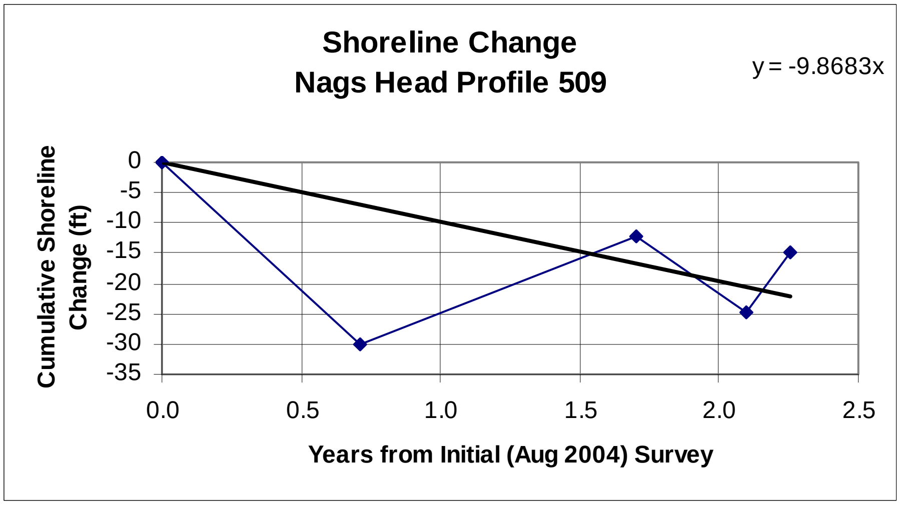

y = 1.3213x
Shoreline Change
Nags Head Profile 460
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

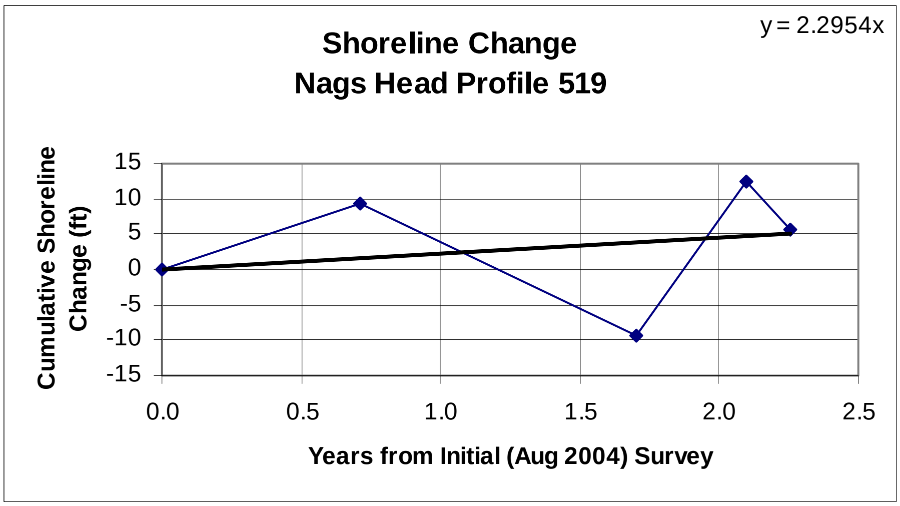

y = 15.046x
Shoreline Change
Nags Head Profile 469
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

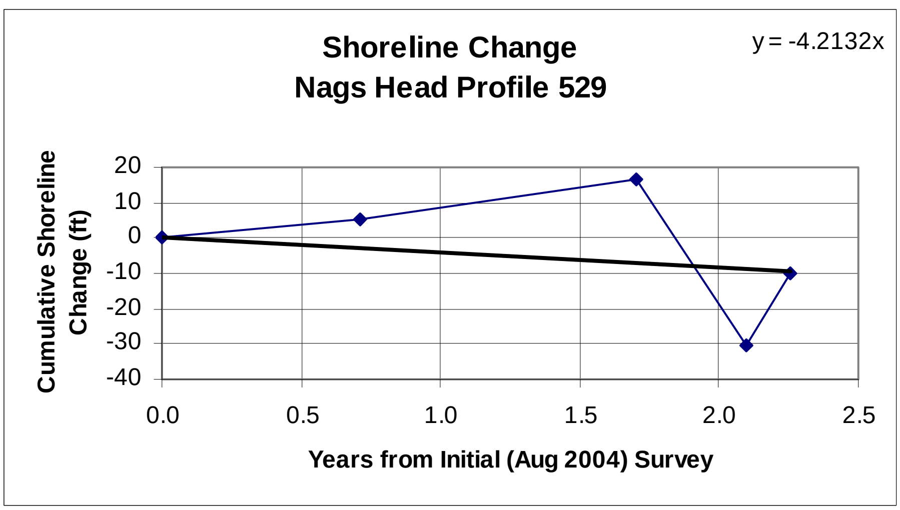

y = 14.684x
Shoreline Change
Nags Head Profile 483
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

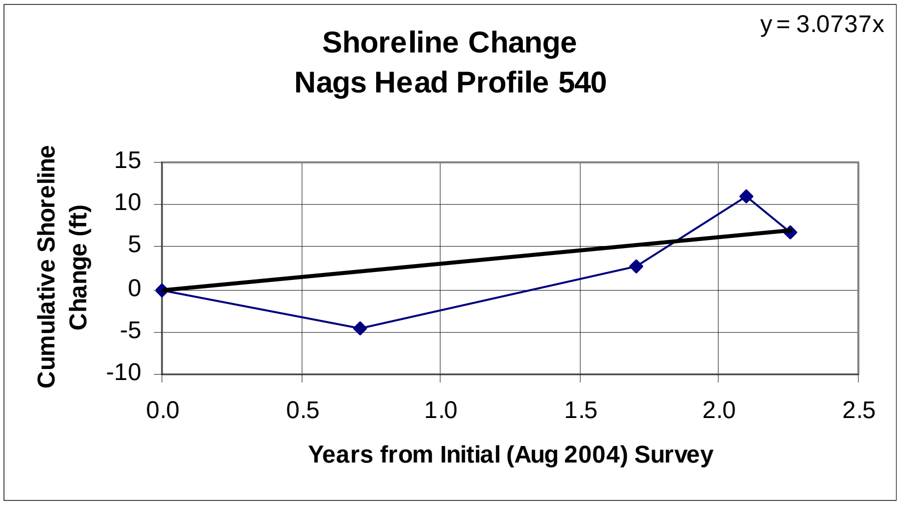

y = 7.7288x
Shoreline Change
Nags Head Profile 489
Cumulative Shoreline Change (ft)
25
20
15
10
5
0
-5
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

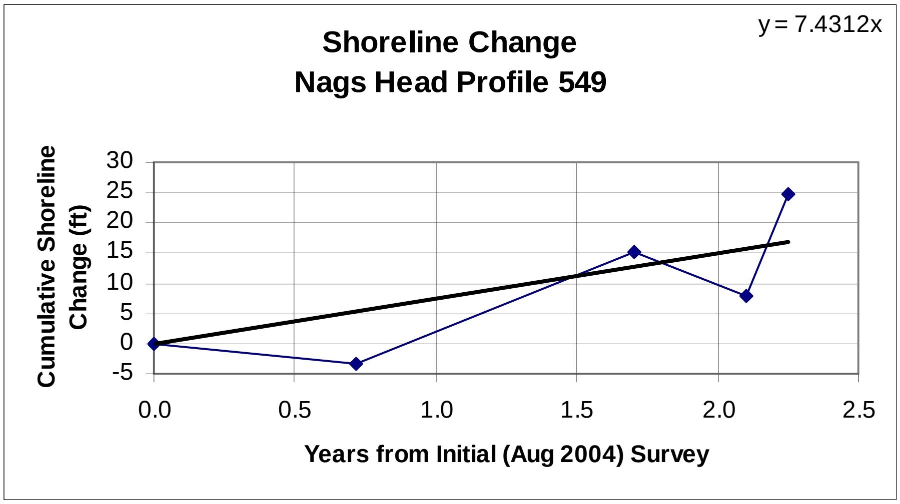

y = 3.195x
Shoreline Change
Nags Head Profile 499
Cumulative Shoreline Change (ft)
20
15
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

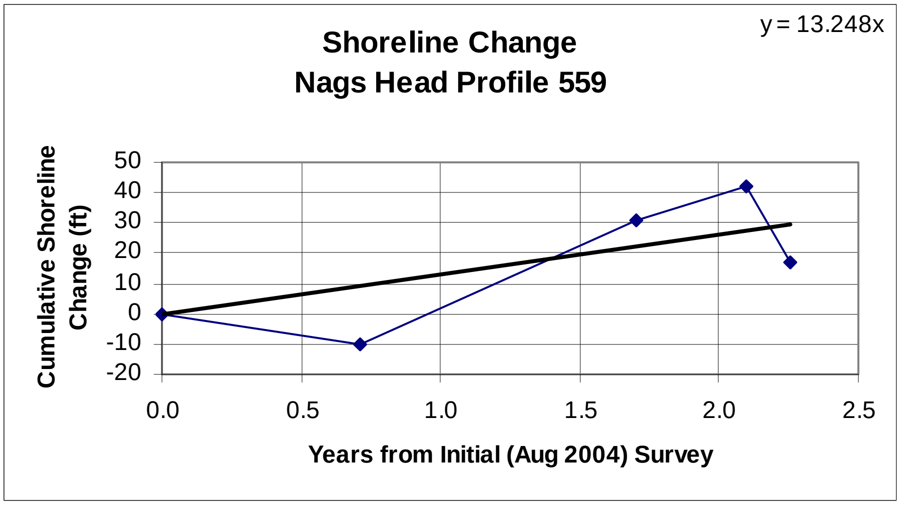

Shoreline Change
Nags Head Profile 509
y = -9.8683x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
-35
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

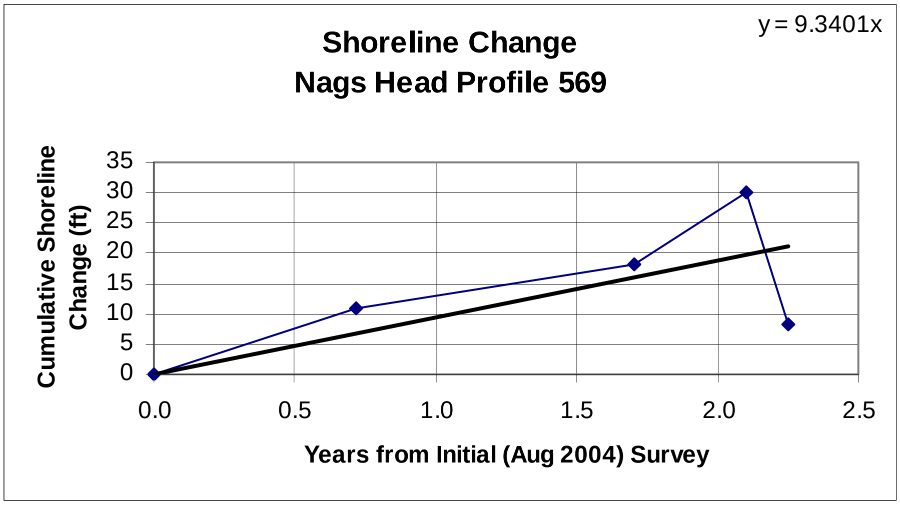

Shoreline Change
Nags Head Profile 519
y = 2.2954x
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Nags Head Profile 529
y = -4.2132x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

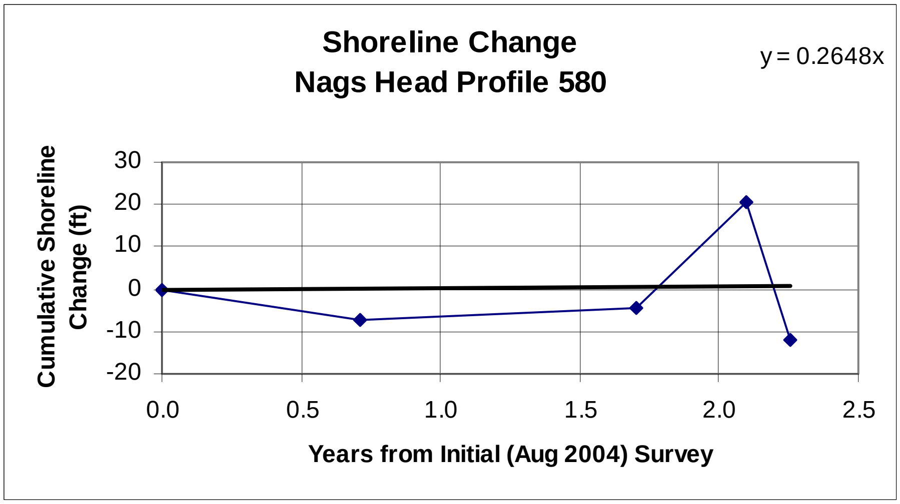

y = 3.0737x
Shoreline Change
Nags Head Profile 540
Cumulative Shoreline Change (ft)
15
10
5
0
-5
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


y = 7.4312x
Shoreline Change
Nags Head Profile 549
Cumulative Shoreline Change (ft)
30
25
20
15
10
5
0
-5
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

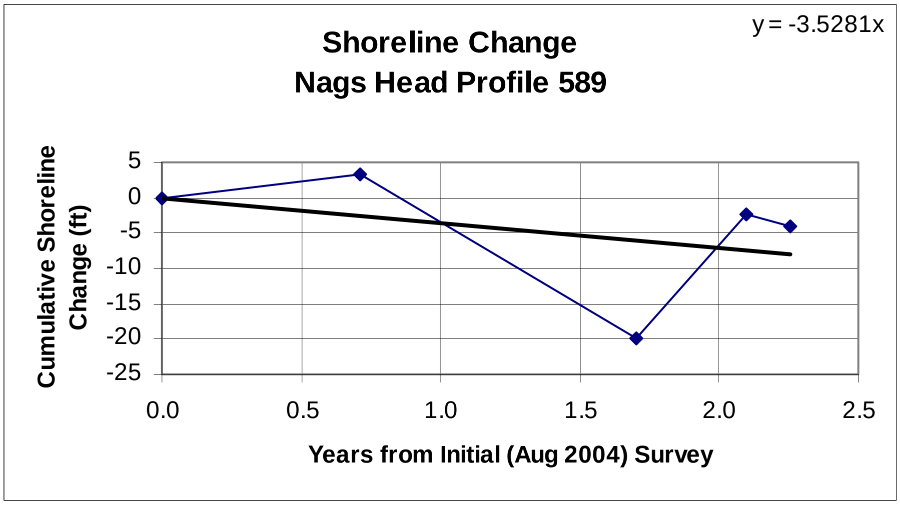

y = 13.248x
Shoreline Change
Nags Head Profile 559
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey



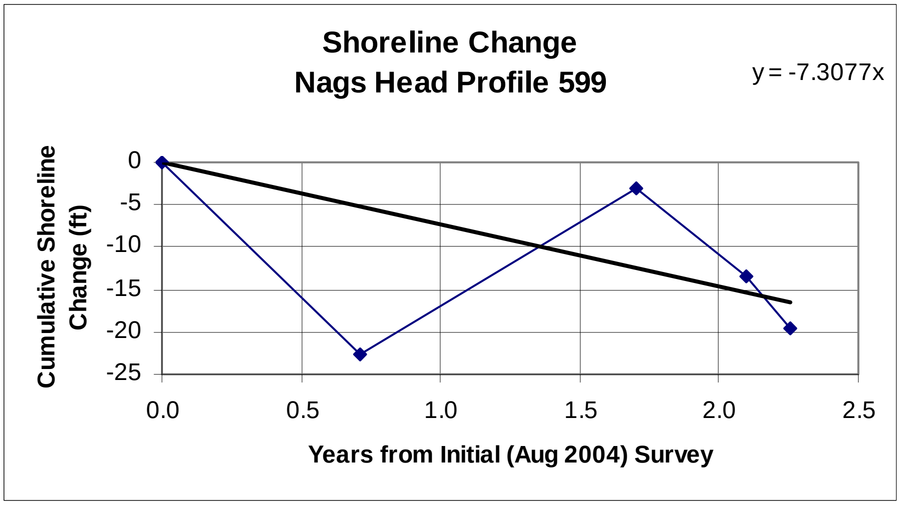
y = 9.3401x
Shoreline Change
Nags Head Profile 569
Cumulative Shoreline Change (ft)
35
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

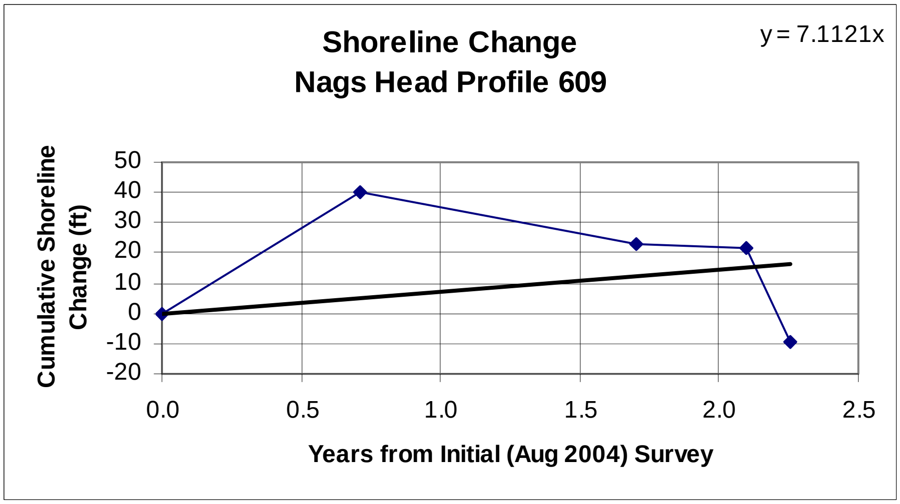


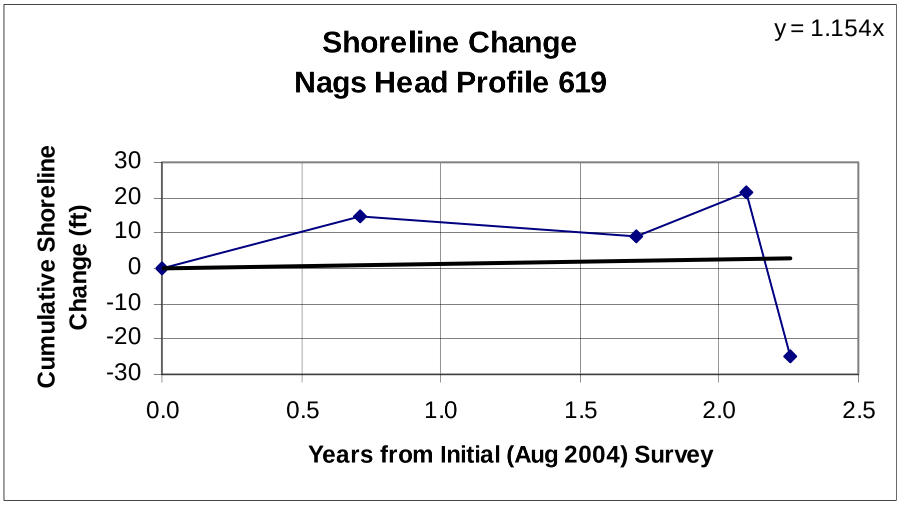
Shoreline Change
Nags Head Profile 580
y = 0.2648x
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

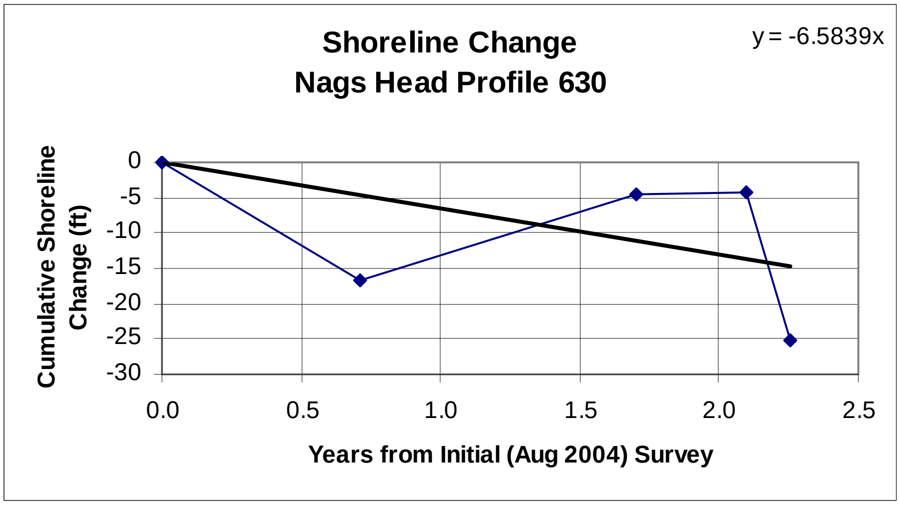


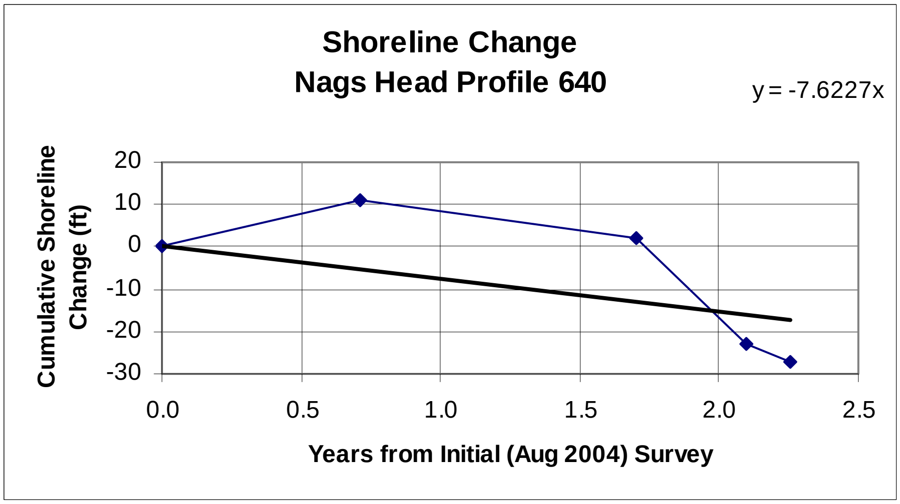
y = -3.5281x
Shoreline Change
Nags Head Profile 589
Cumulative Shoreline Change (ft)
5
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

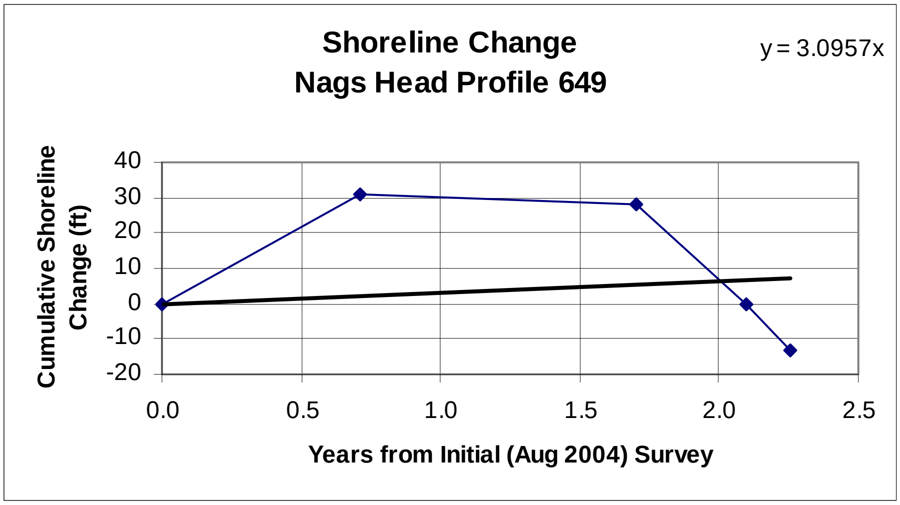

Shoreline Change
Nags Head Profile 599
y = -7.3077x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

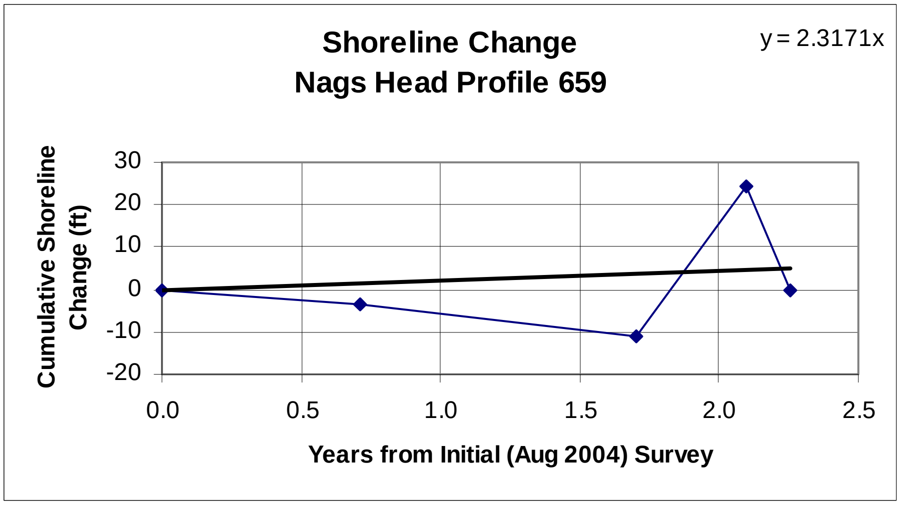

Shoreline Change
Nags Head Profile 609
y = 7.1121x
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

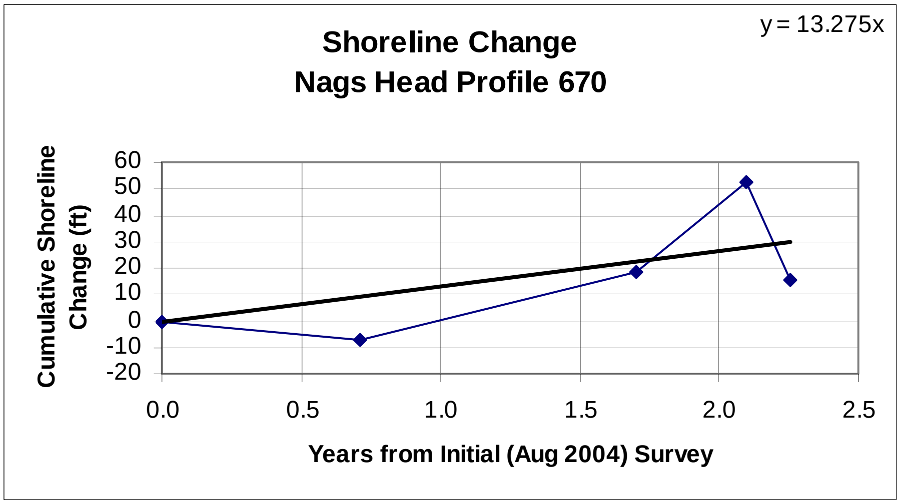

Shoreline Change
Nags Head Profile 619
y = 1.154x
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

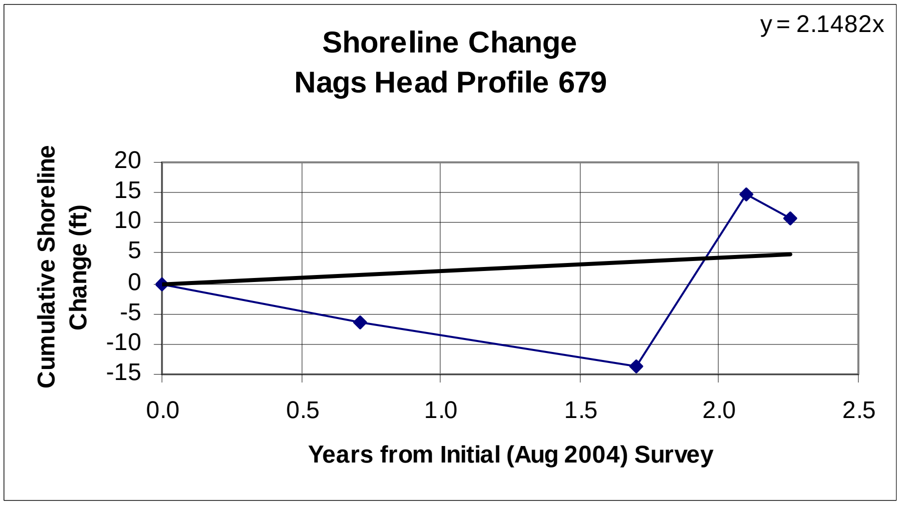

Shoreline Change
Nags Head Profile 630
y = -6.5839x
Cumulative Shoreline Change (ft)
0
-5
-10
-15
-20
-25
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

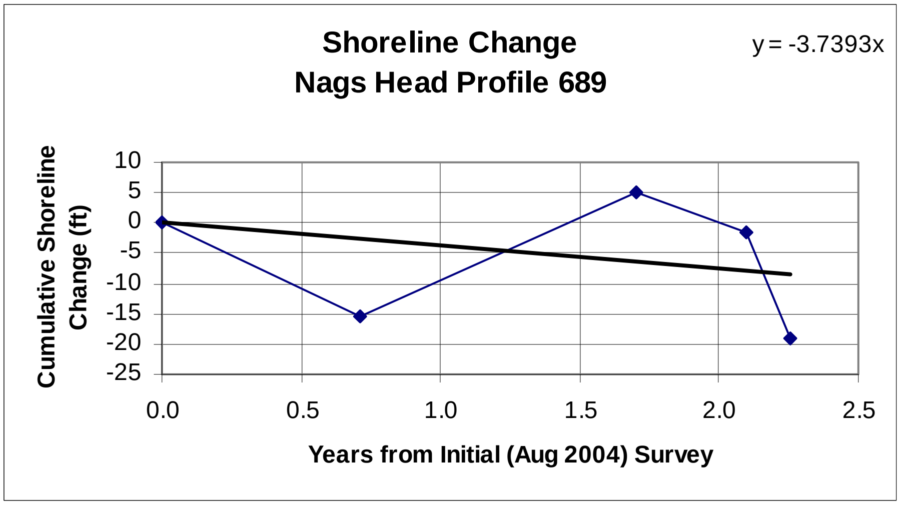

Shoreline Change
Nags Head Profile 640
y = -7.6227x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

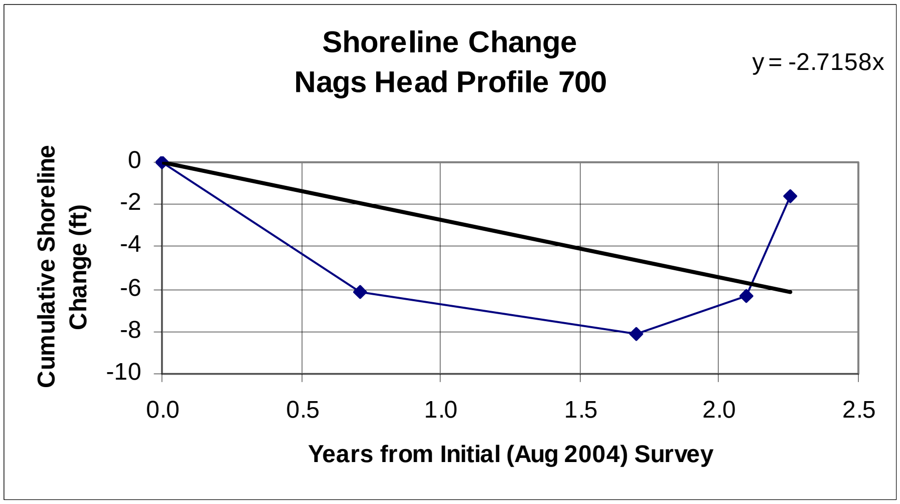

Shoreline Change
Nags Head Profile 649
y = 3.0957x
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

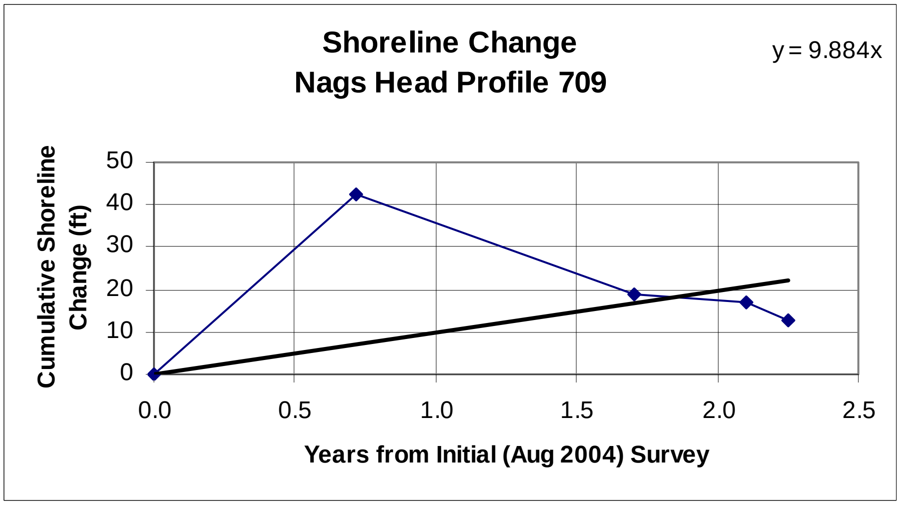

Shoreline Change
Nags Head Profile 659
y = 2.3171x
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

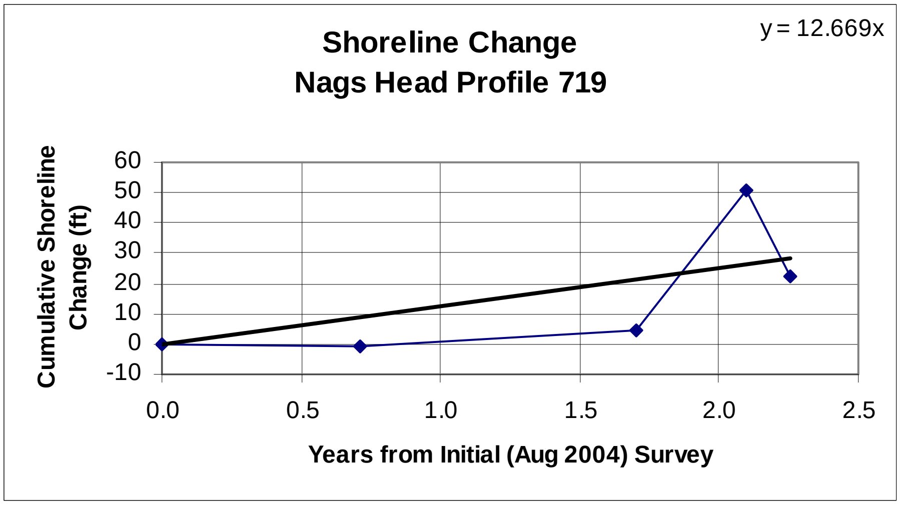

Shoreline Change
Nags Head Profile 670
y = 13.275x
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

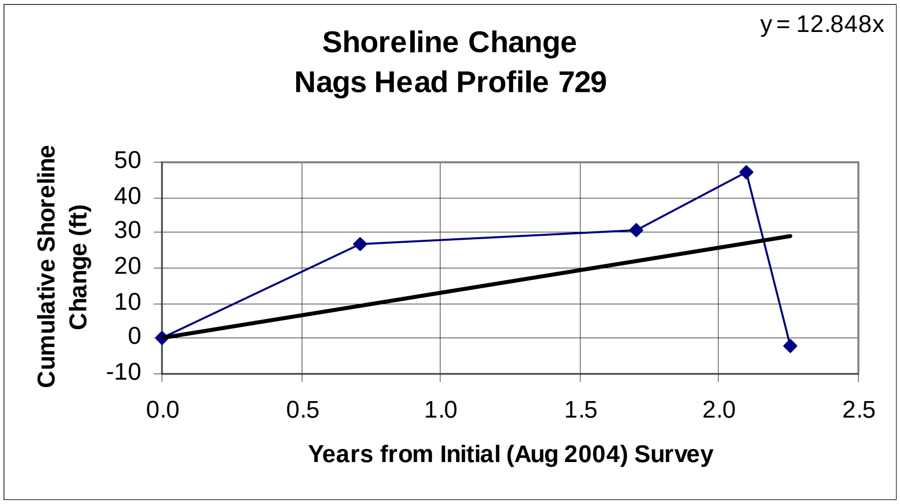

Shoreline Change
Nags Head Profile 679
y = 2.1482x
Cumulative Shoreline Change (ft)
20
15
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

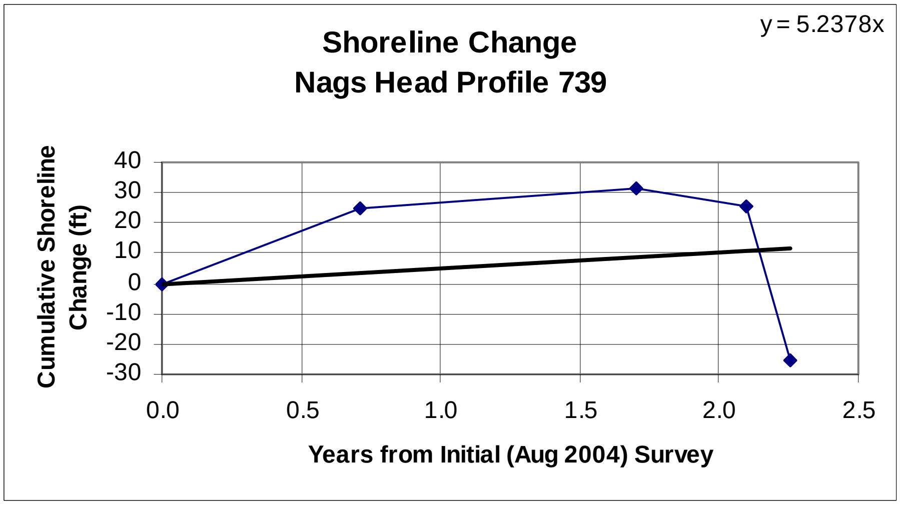

Shoreline Change
Nags Head Profile 689
y = -3.7393x
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
-20
-25
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

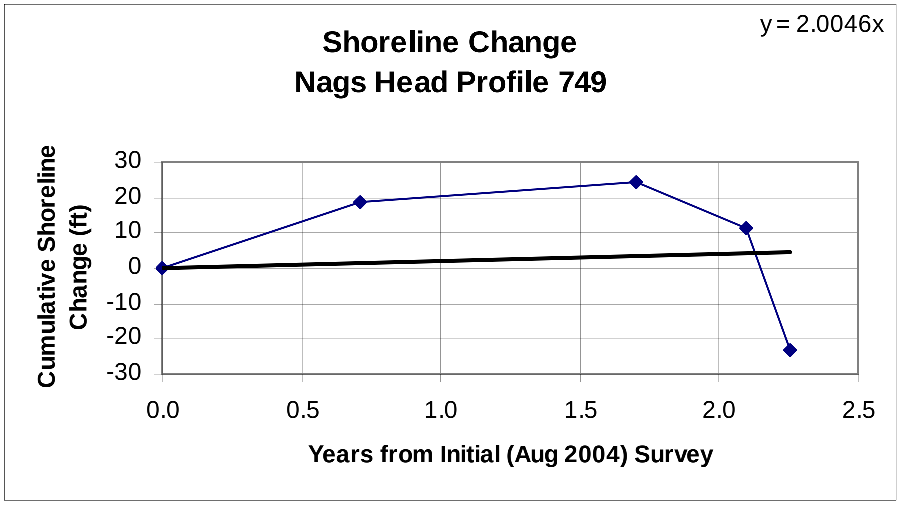

Shoreline Change
Nags Head Profile 700
y = -2.7158x
Cumulative Shoreline Change (ft)
0
-2
-4
-6
-8
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

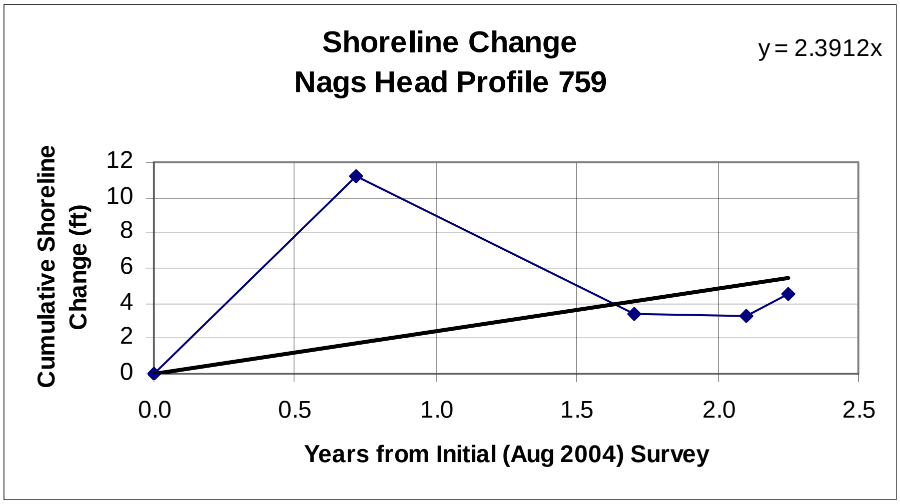

Shoreline Change
Nags Head Profile 709
y = 9.884x
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

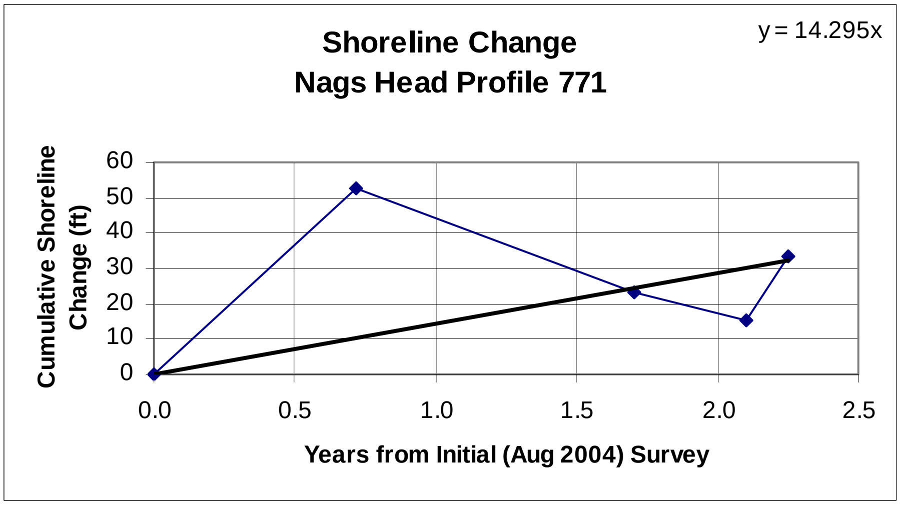

Shoreline Change
Nags Head Profile 719
y = 12.669x
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

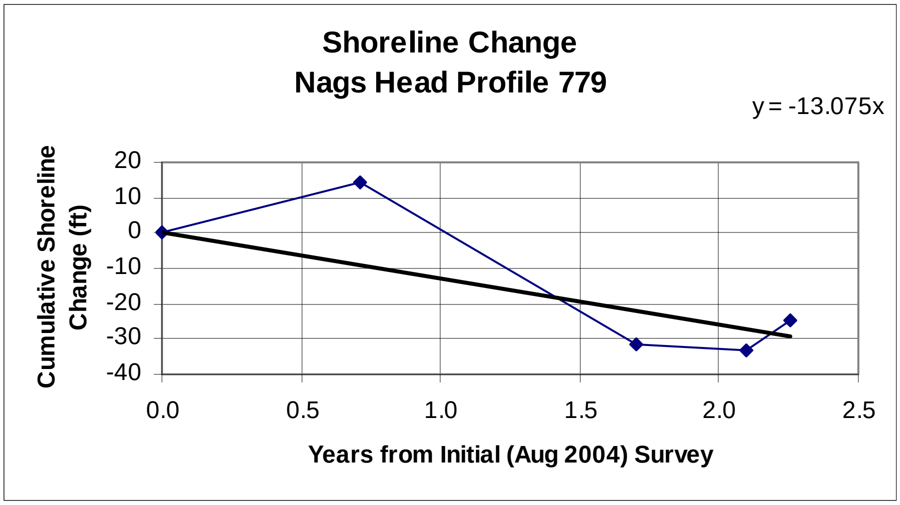

Shoreline Change
Nags Head Profile 729
y = 12.848x
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
-10
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

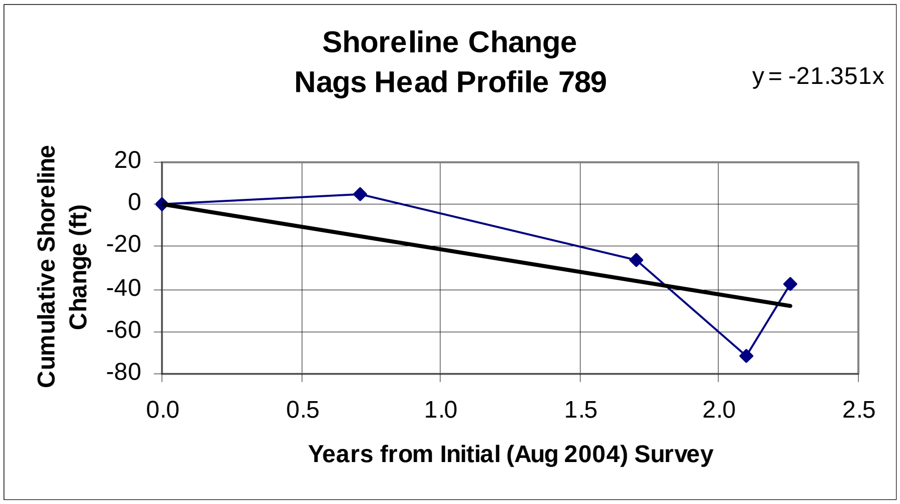

Shoreline Change
Nags Head Profile 739
y = 5.2378x
Cumulative Shoreline Change (ft)
40
30
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

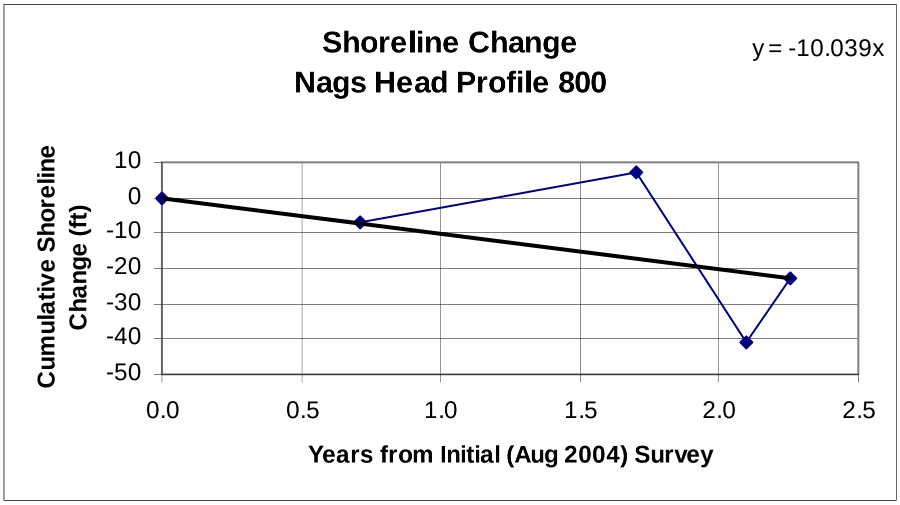

y = 2.0046x
Shoreline Change
Nags Head Profile 749
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

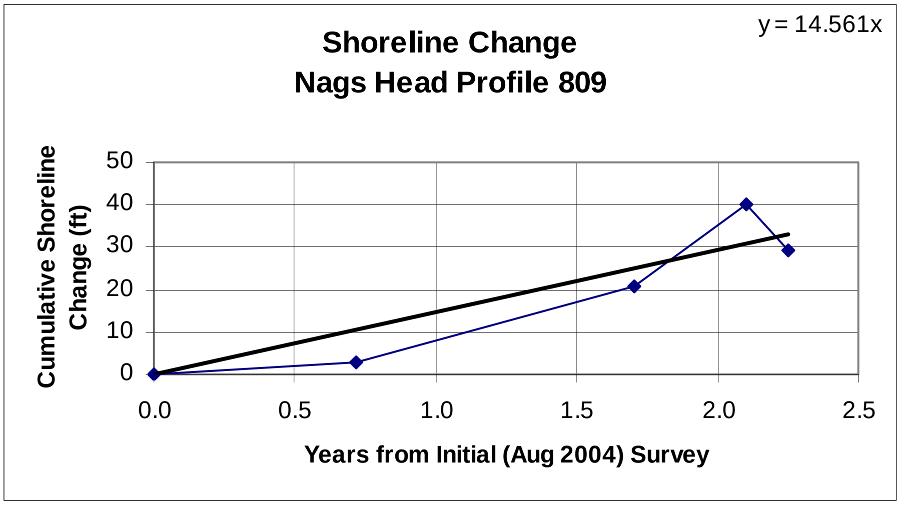

Shoreline Change
Nags Head Profile 759
y = 2.3912x
Cumulative Shoreline Change (ft)
12
10
8
6
4
2
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

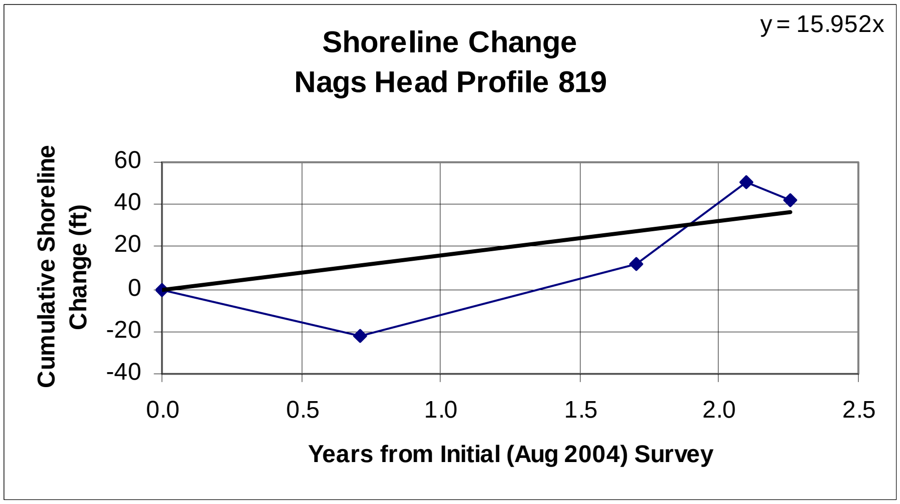

y = 14.295x
Shoreline Change
Nags Head Profile 771
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

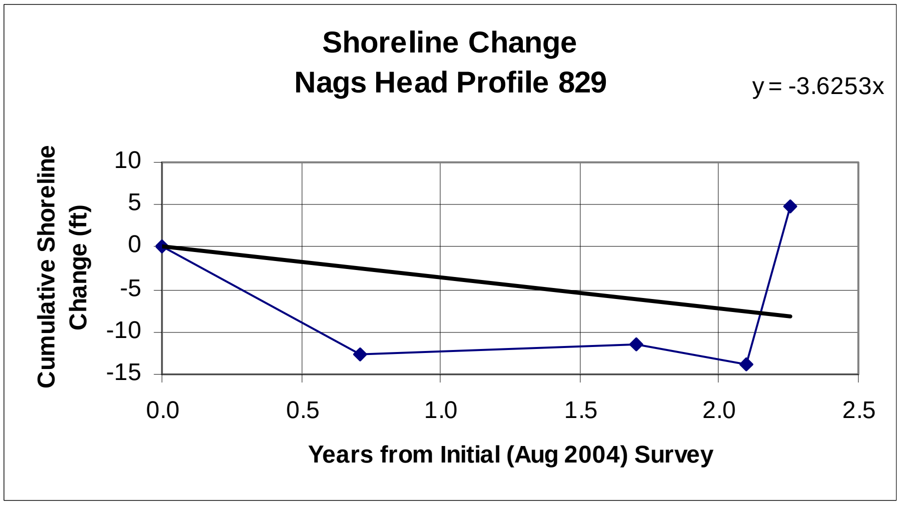

Shoreline Change
Nags Head Profile 779
y = -13.075x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

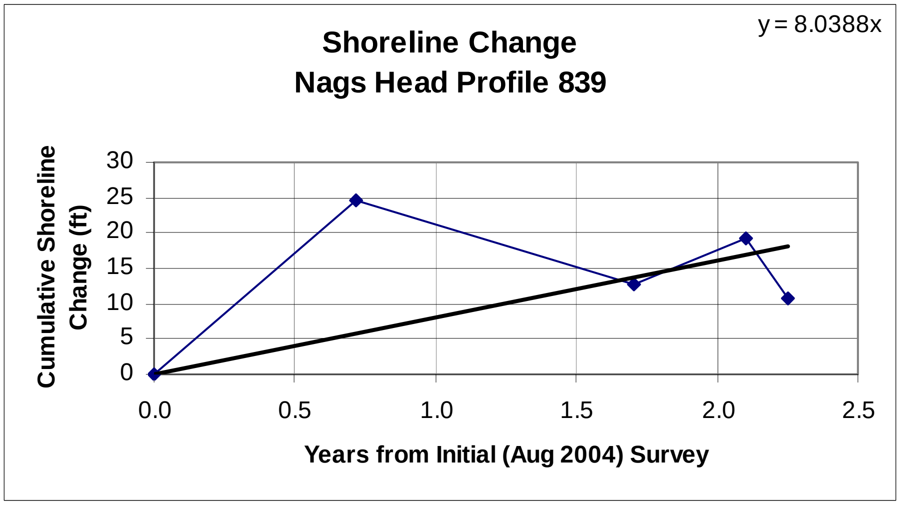

Shoreline Change
Nags Head Profile 789
y = -21.351x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

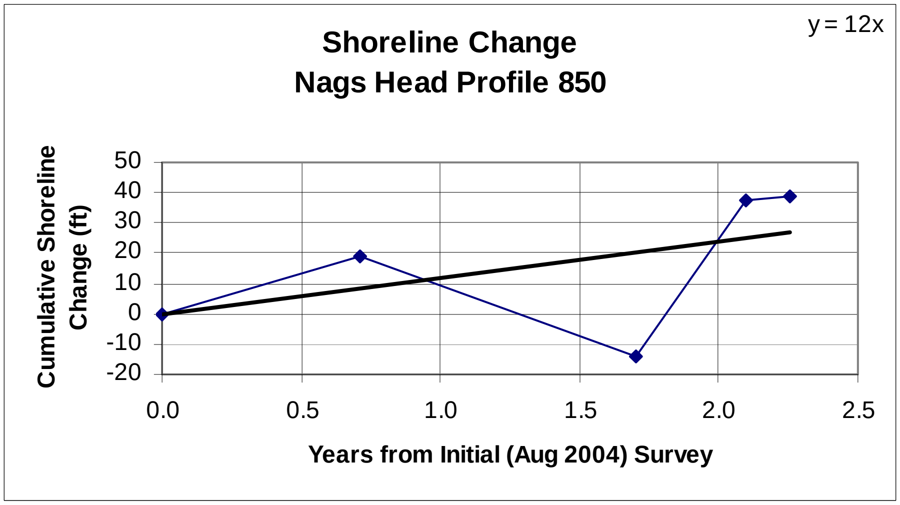

Shoreline Change
Nags Head Profile 800
y = -10.039x
Cumulative Shoreline Change (ft)
10
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

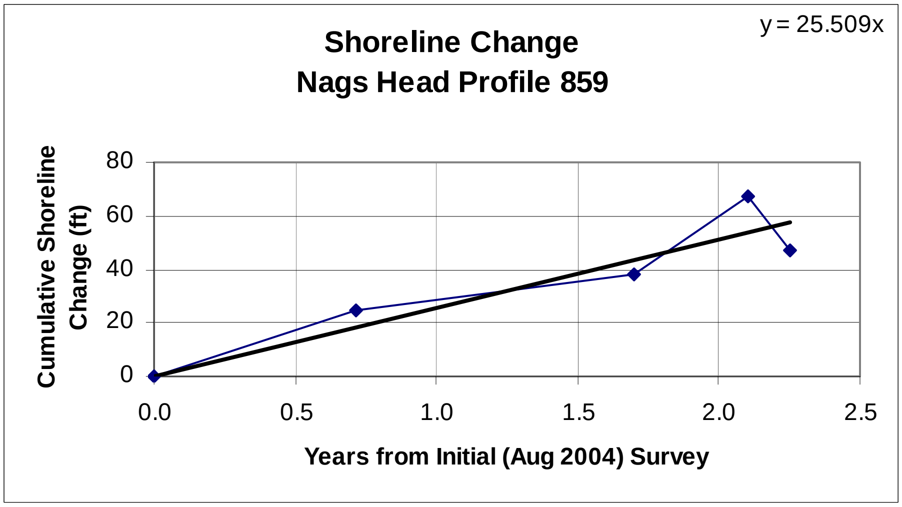

y = 14.561x
Shoreline Change
Nags Head Profile 809
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

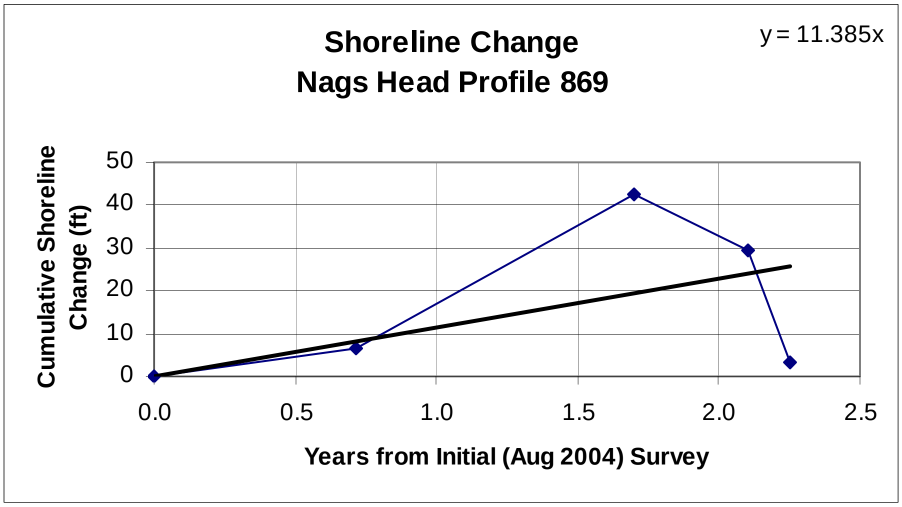

y = 15.952x
Shoreline Change
Nags Head Profile 819
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

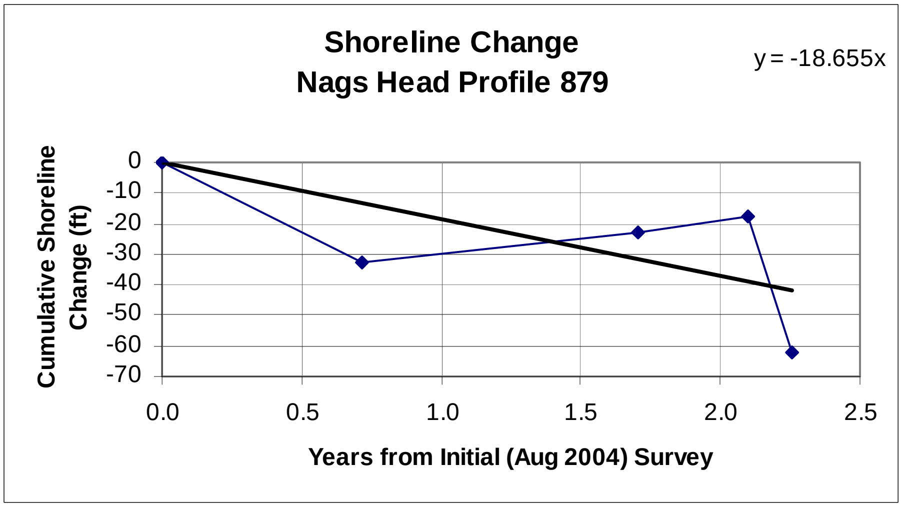

Shoreline Change
Nags Head Profile 829
y = -3.6253x
Cumulative Shoreline Change (ft)
10
5
0
-5
-10
-15
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

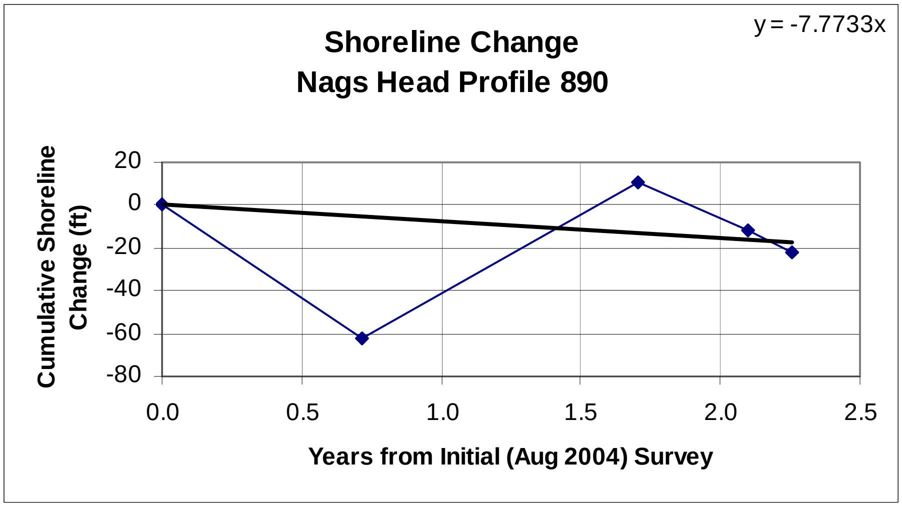

y = 8.0388x
Shoreline Change
Nags Head Profile 839
Cumulative Shoreline Change (ft)
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

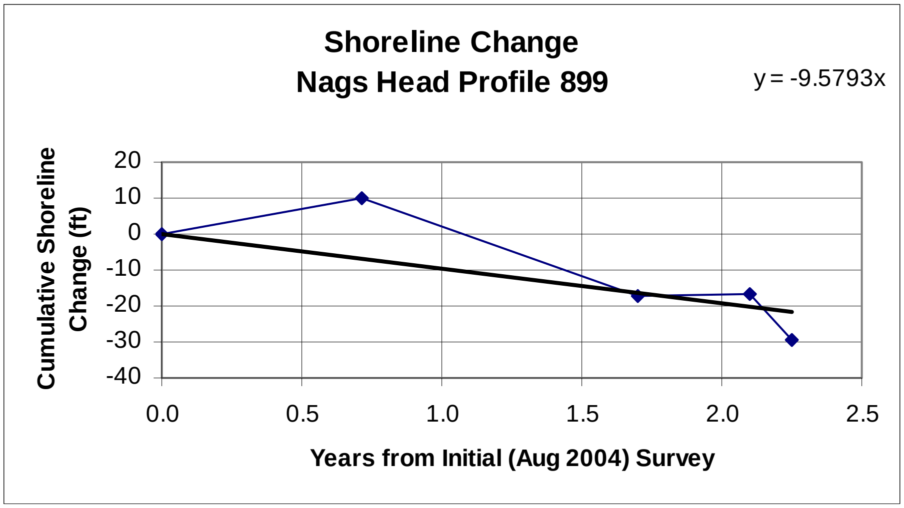

y = 12x
Shoreline Change
Nags Head Profile 850
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

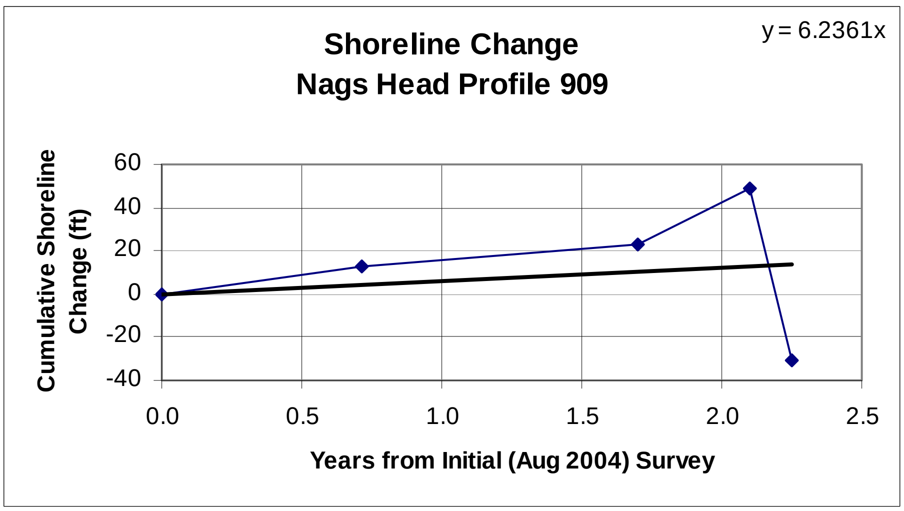

y = 25.509x
Shoreline Change
Nags Head Profile 859
Cumulative Shoreline Change (ft)
80
60
40
20
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

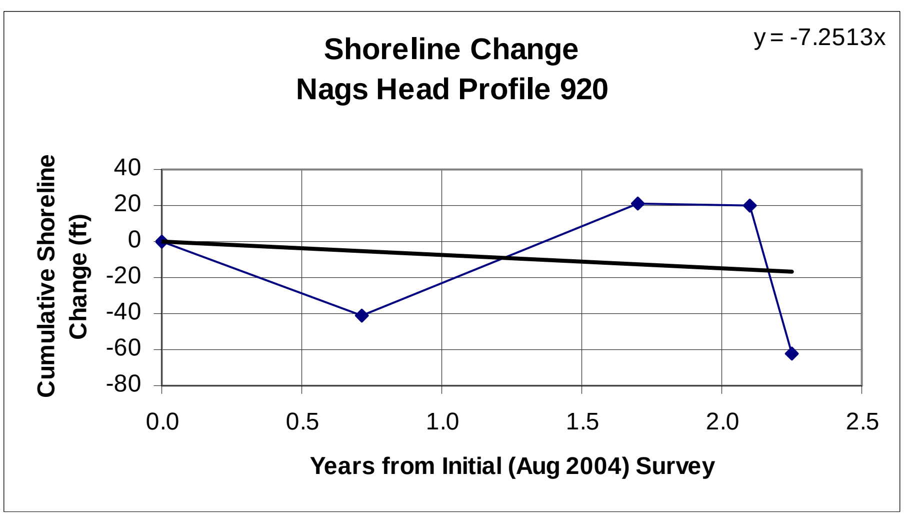

Shoreline Change
Nags Head Profile 869
y = 11.385x
Cumulative Shoreline Change (ft)
50
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

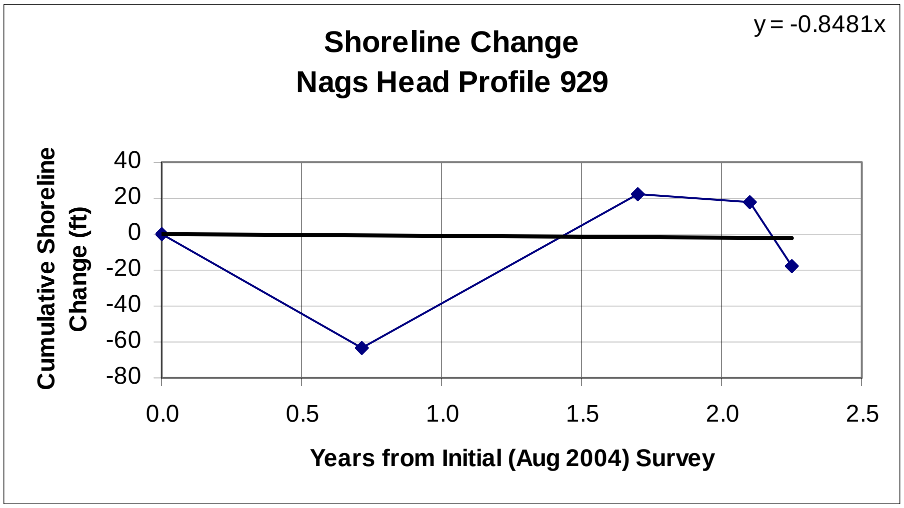

Shoreline Change
Nags Head Profile 879
y = -18.655x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
-60
-70
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

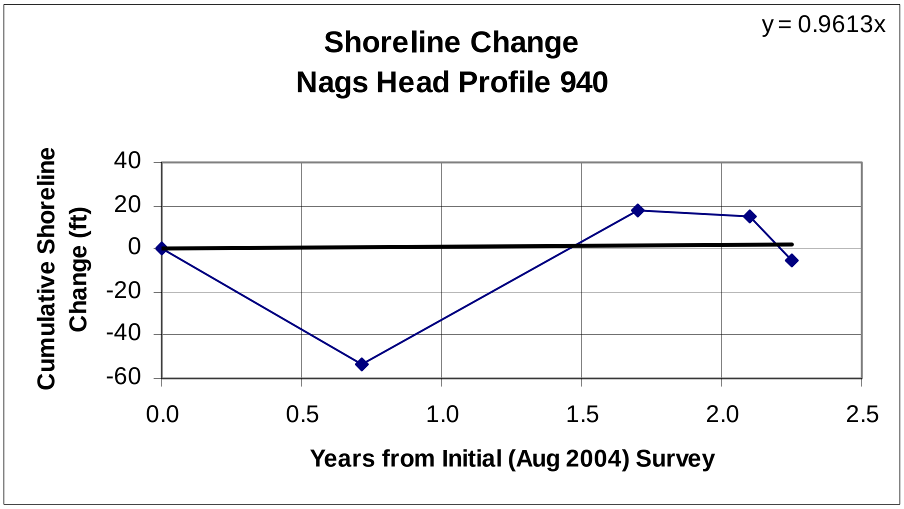

Shoreline Change
Nags Head Profile 890
y = -7.7733x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

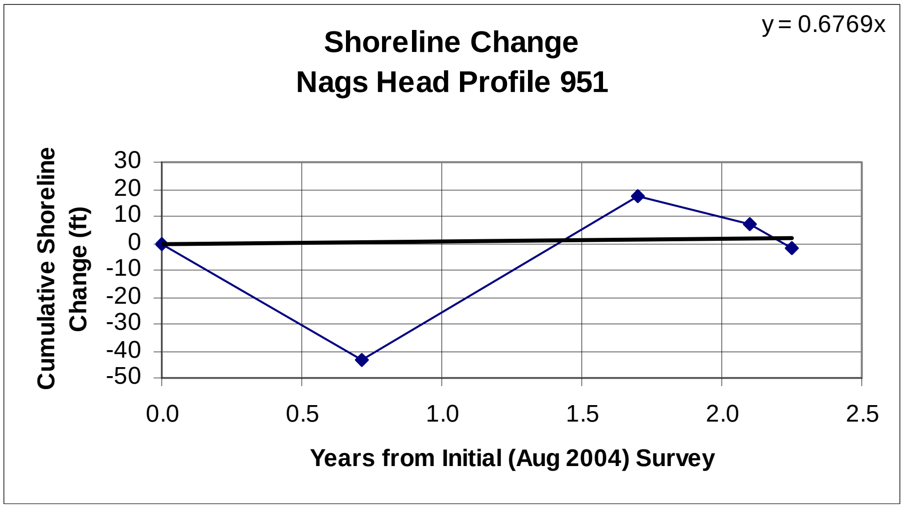

Shoreline Change
Nags Head Profile 899
y = -9.5793x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

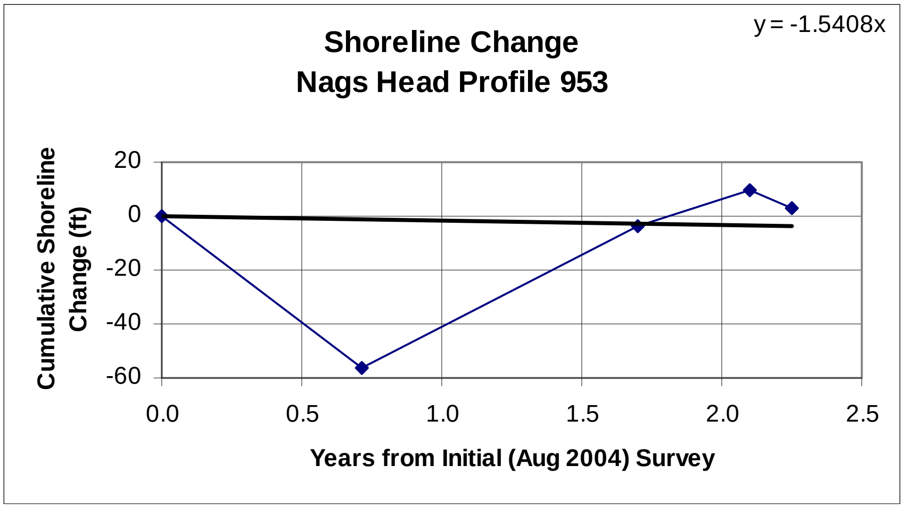

Shoreline Change
Nags Head Profile 909
y = 6.2361x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Nags Head Profile 920
y = -7.2513x
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

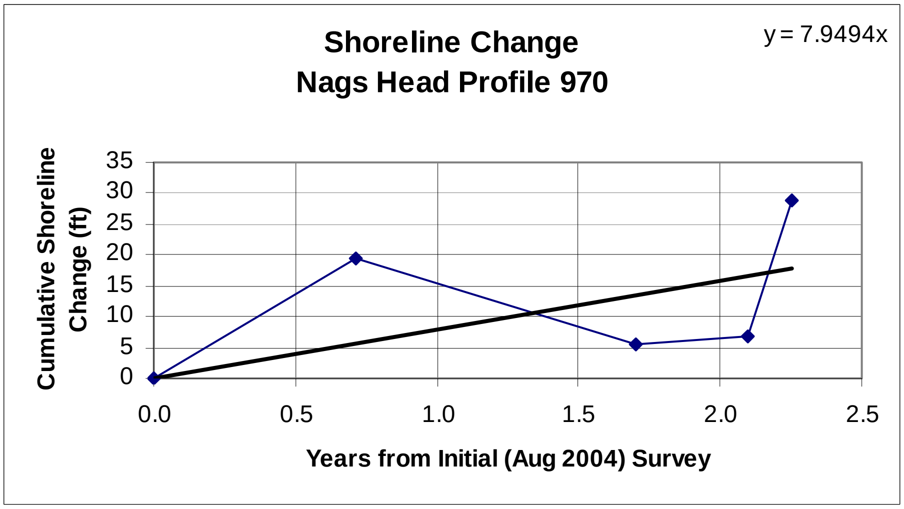

y = -0.8481x
Shoreline Change
Nags Head Profile 929
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


y = 0.9613x
Shoreline Change
Nags Head Profile 940
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

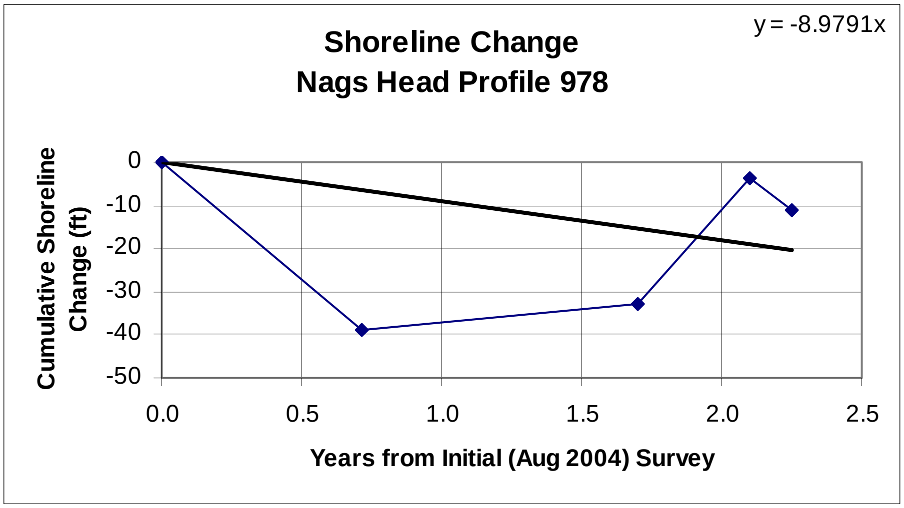

y = 0.6769x
Shoreline Change
Nags Head Profile 951
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey



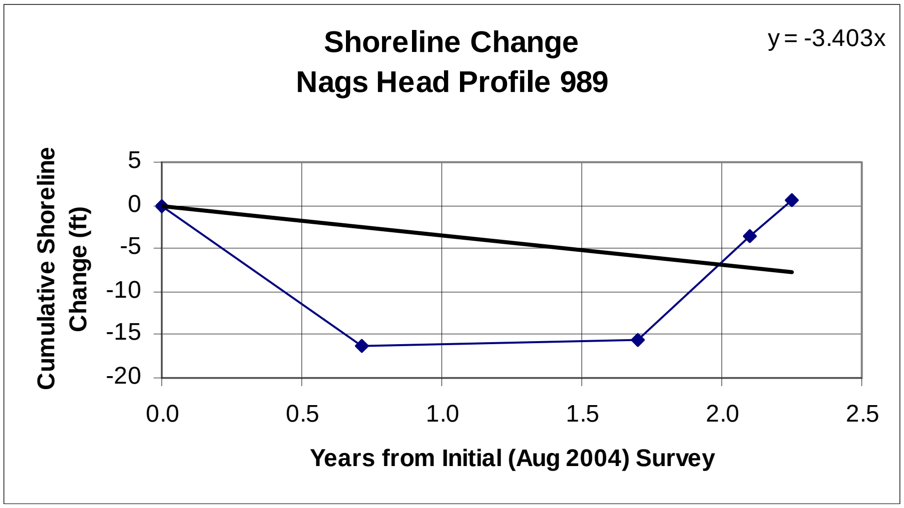
Shoreline Change
Nags Head Profile 953
y = -1.5408x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

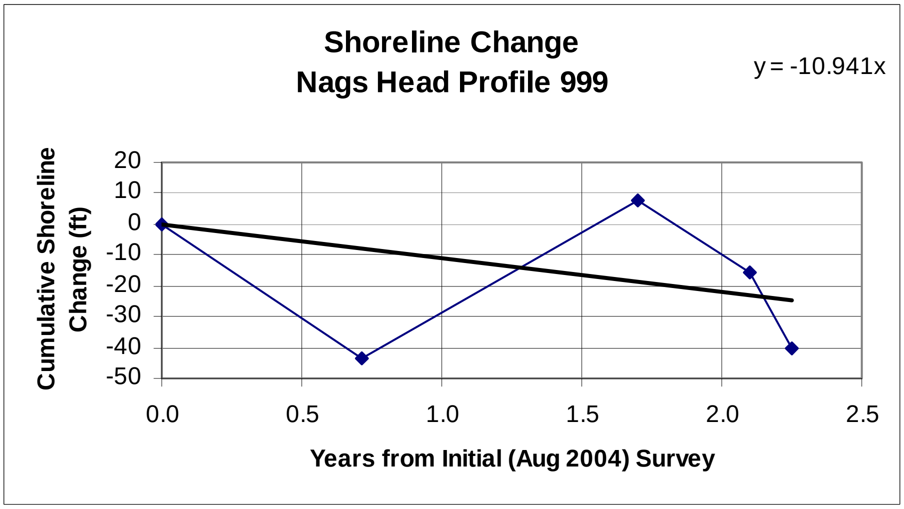


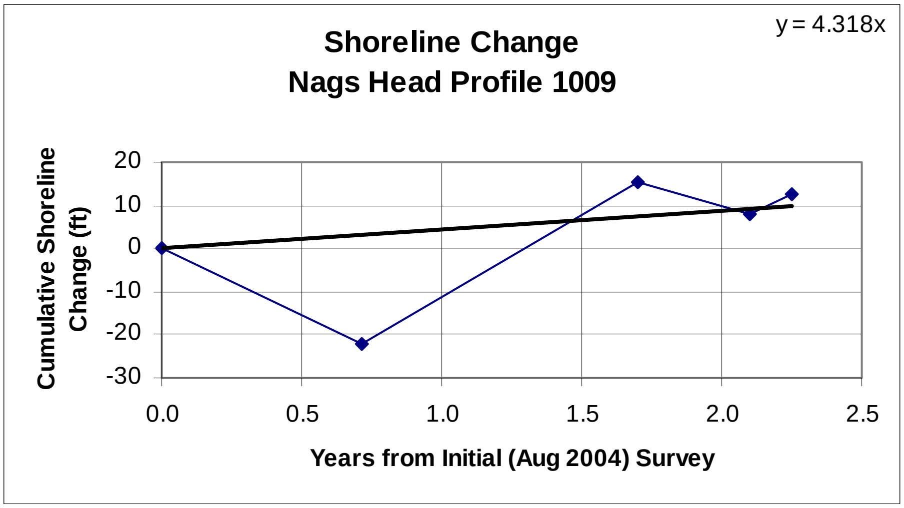
Shoreline Change
Nags Head Profile 970
y = 7.9494x
Cumulative Shoreline Change (ft)
35
30
25
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

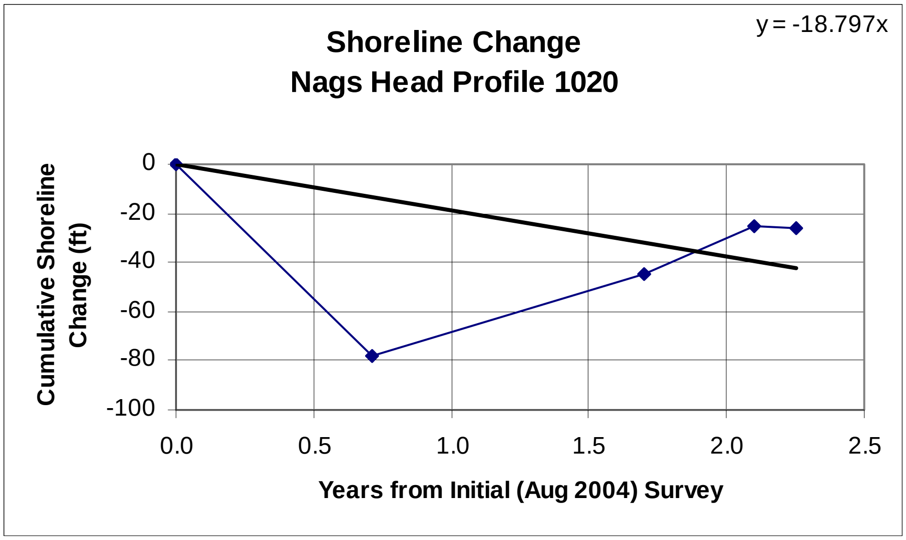


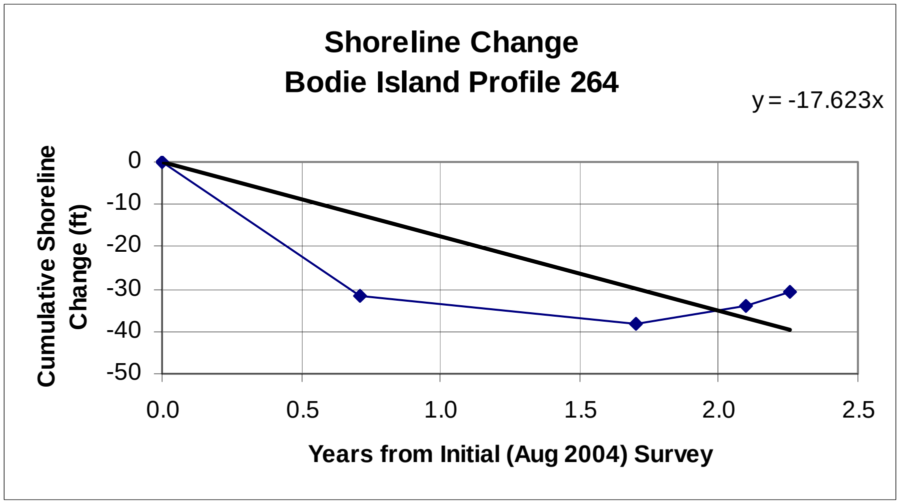
Shoreline Change
Nags Head Profile 978
y = -8.9791x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

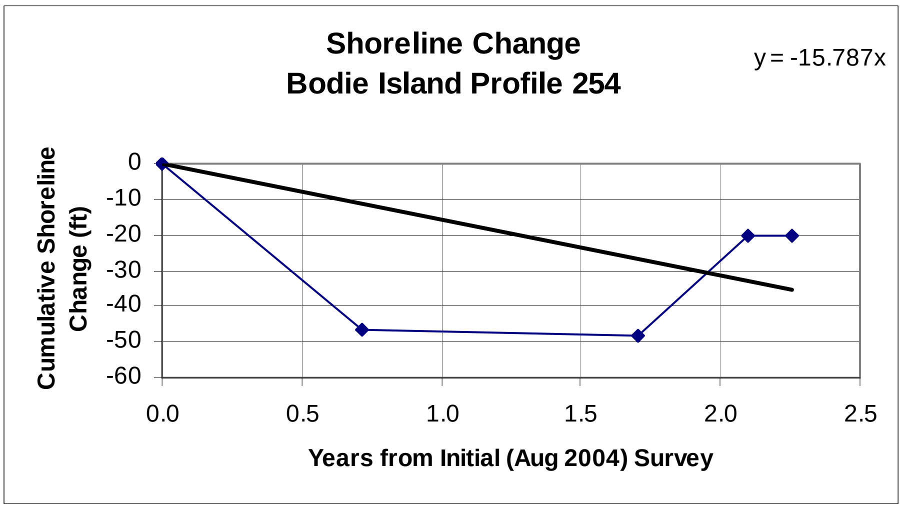

Shoreline Change
Nags Head Profile 989
y = -3.403x
Cumulative Shoreline Change (ft)
5
0
-5
-10
-15
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

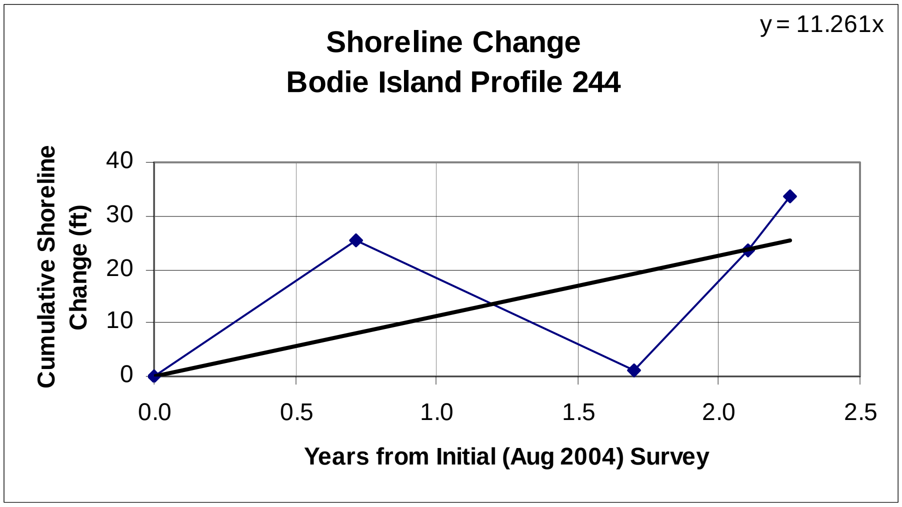

Shoreline Change
Nags Head Profile 999
y = -10.941x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

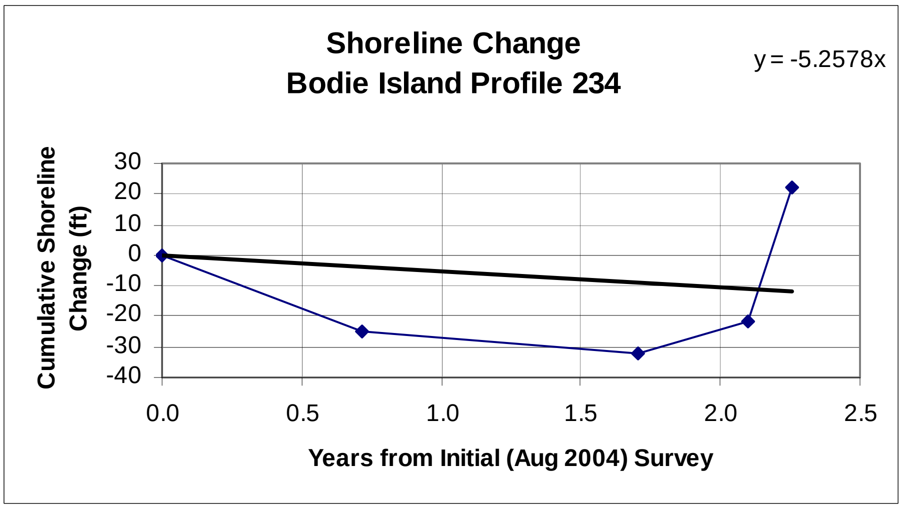

Shoreline Change
Nags Head Profile 1009
y = 4.318x
Cumulative Shoreline Change (ft)
20
10
0
-10
-20
-30
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

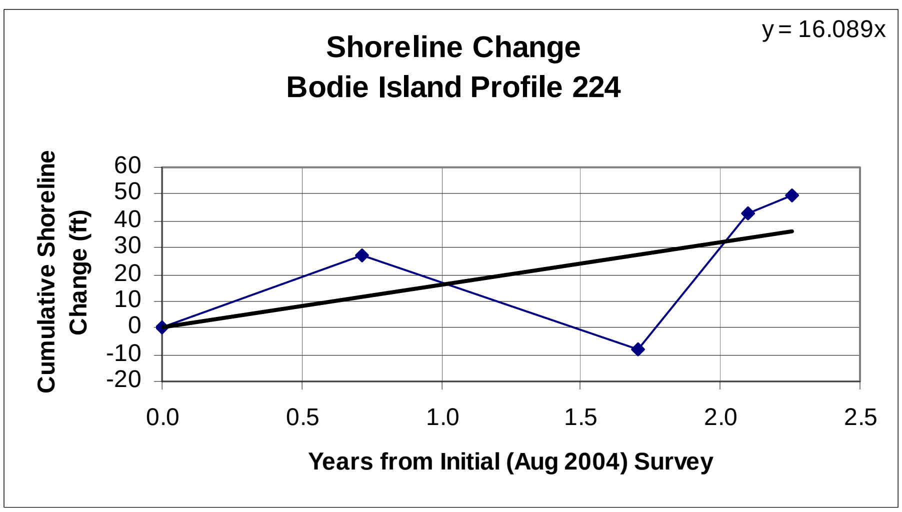

Shoreline Change
Nags Head Profile 1020
y = -18.797x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

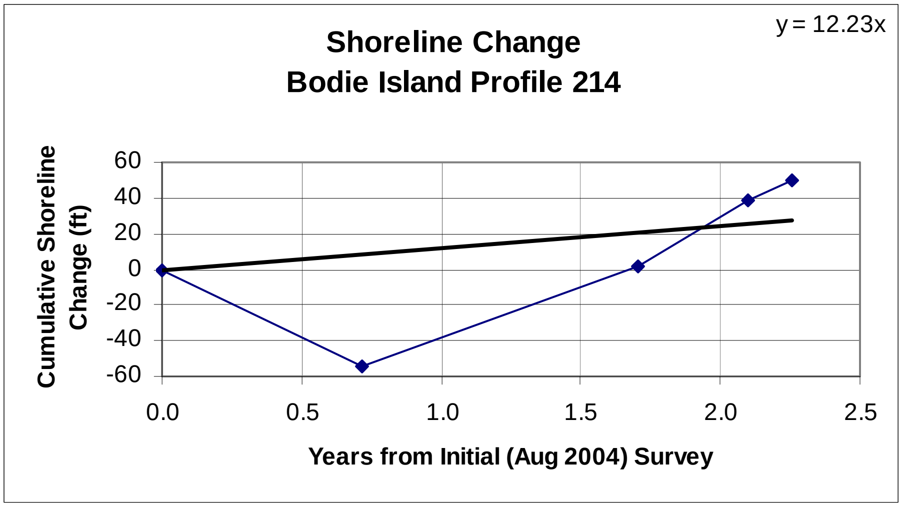

Shoreline Change
Bodie Island Profile 264
y = -17.623x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

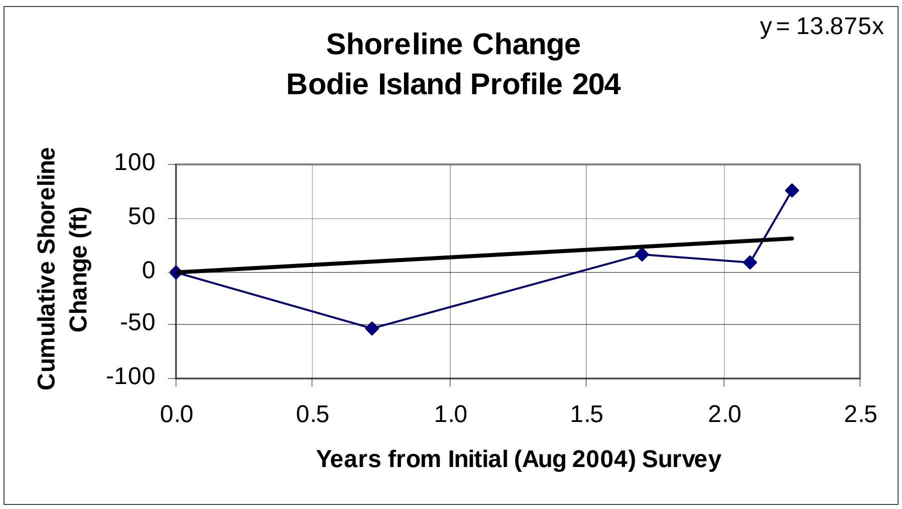

Shoreline Change
Bodie Island Profile 254
y = -15.787x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
-60
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

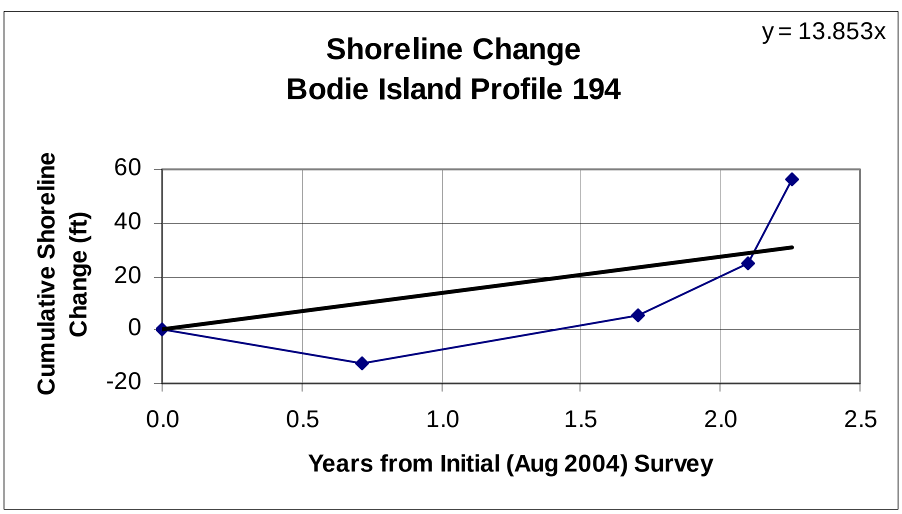

y = 11.261x
Shoreline Change
Bodie Island Profile 244
Cumulative Shoreline Change (ft)
40
30
20
10
0
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

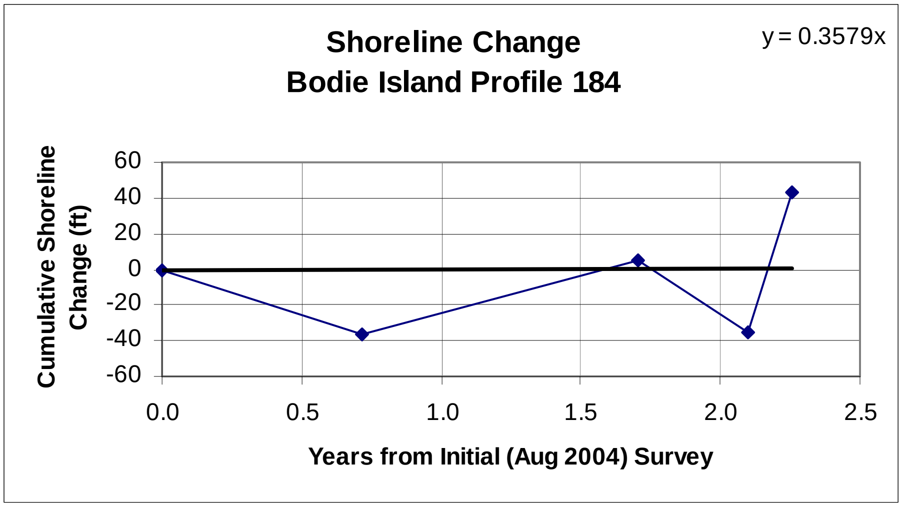

Shoreline Change
Bodie Island Profile 234
y = -5.2578x
Cumulative Shoreline Change (ft)
30
20
10
0
-10
-20
-30
-40
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

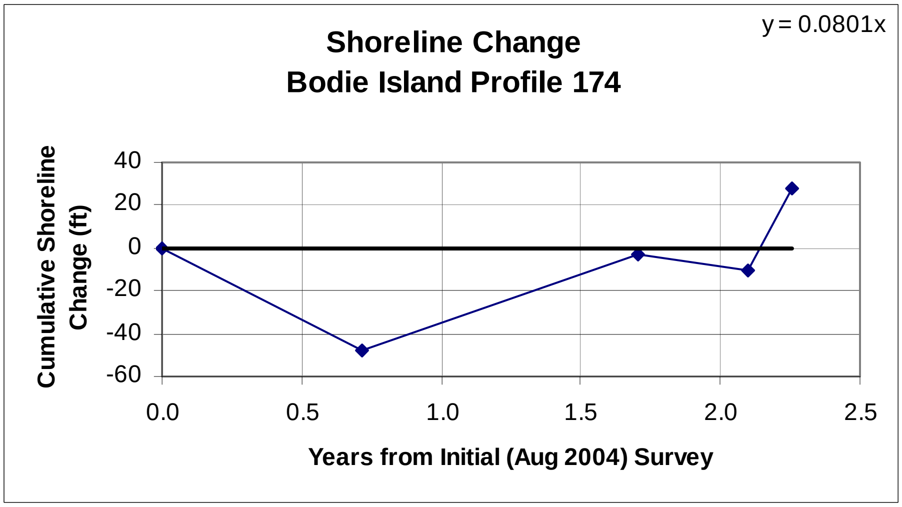

y = 16.089x
Shoreline Change
Bodie Island Profile 224
Cumulative Shoreline Change (ft)
60
50
40
30
20
10
0
-10
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

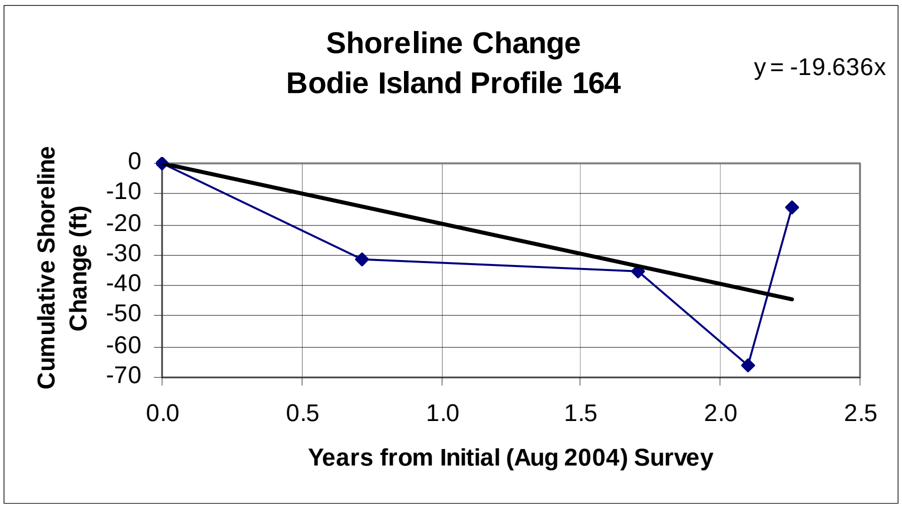

y = 12.23x
Shoreline Change
Bodie Island Profile 214
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
-60
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

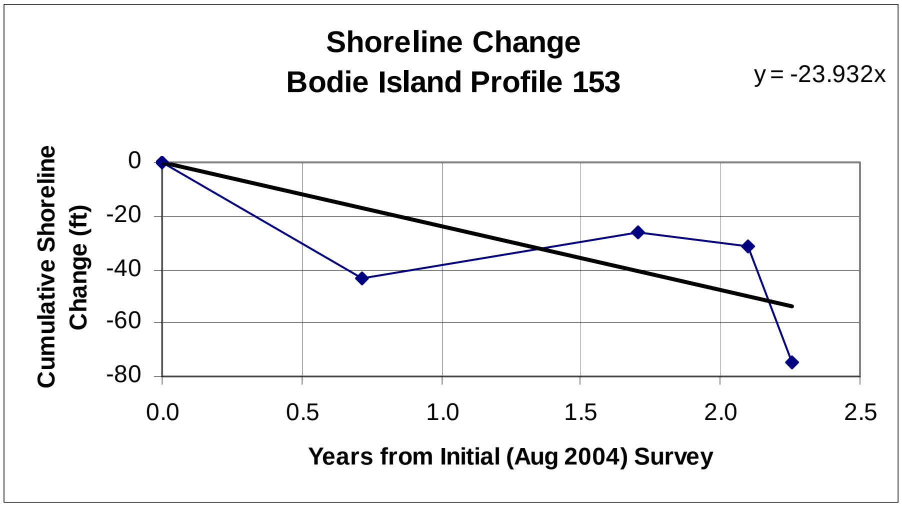

y = 13.875x
Shoreline Change
Bodie Island Profile 204
Cumulative Shoreline Change (ft)
100
50
0
-50
-100
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

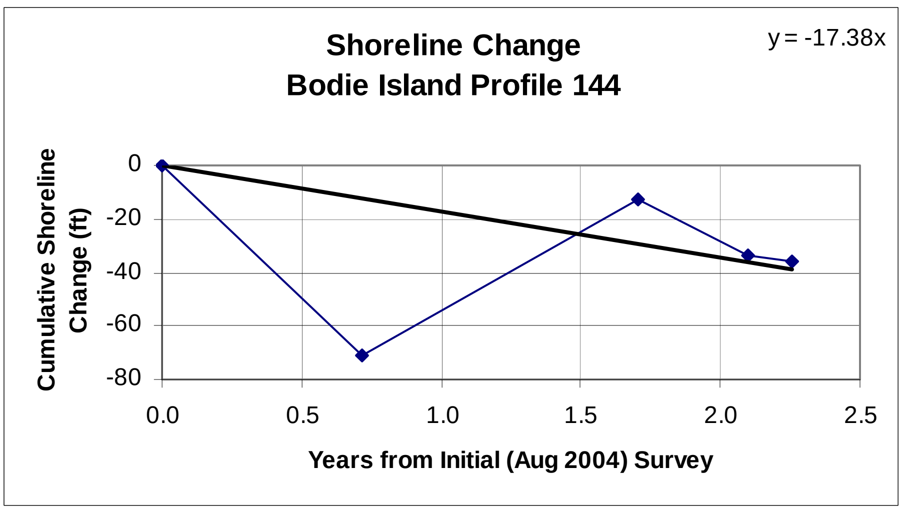

y = 13.853x
Shoreline Change
Bodie Island Profile 194
Cumulative Shoreline Change (ft)
60
40
20
0
-20
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

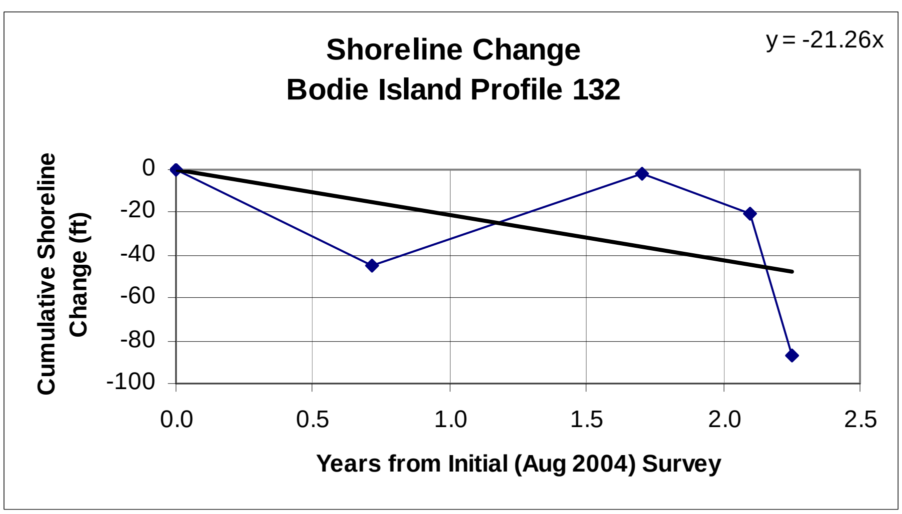

Shoreline Change
Bodie Island Profile 184
y = 0.3579x
Cumulative Shoreline Change (ft)
60
40
20
0
-20
-40
-60
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

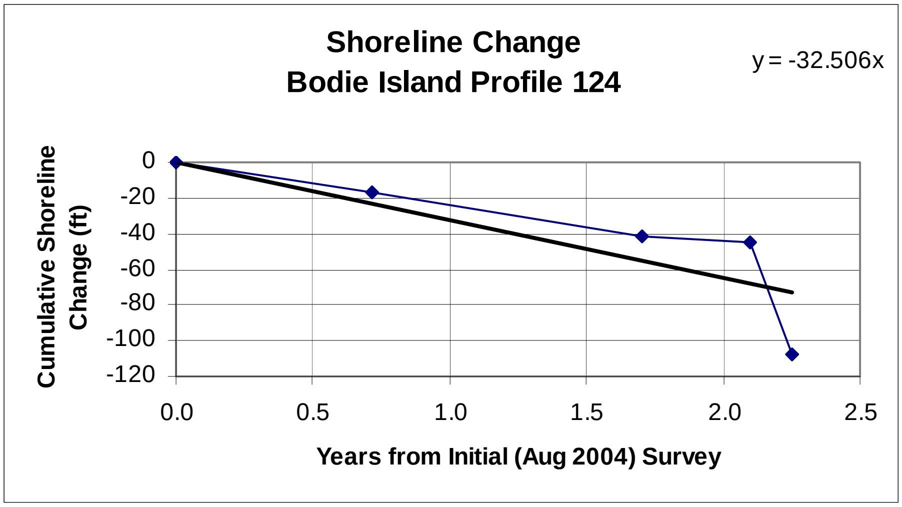

Shoreline Change
Bodie Island Profile 174
y = 0.0801x
Cumulative Shoreline Change (ft)
40
20
0
-20
-40
-60
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Bodie Island Profile 164
y = -19.636x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
-60
-70
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

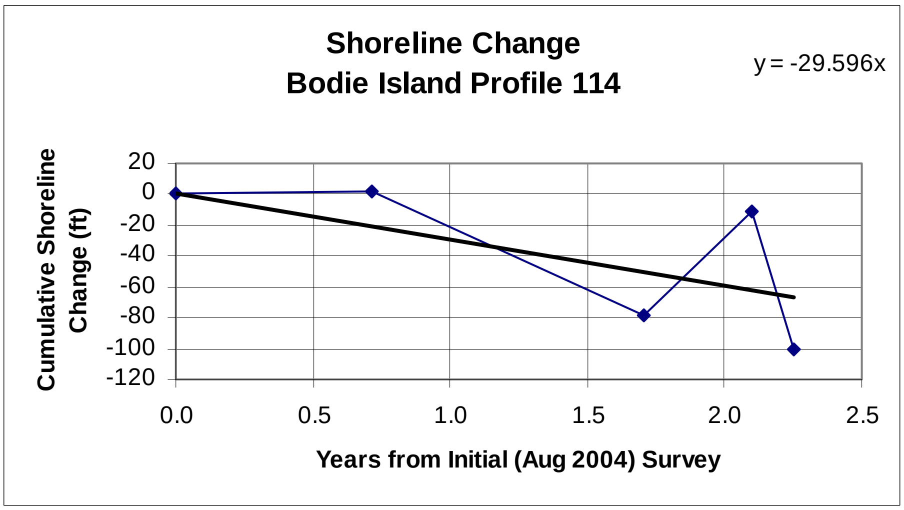

Shoreline Change
Bodie Island Profile 153
y = -23.932x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Bodie Island Profile 144
y = -17.38x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

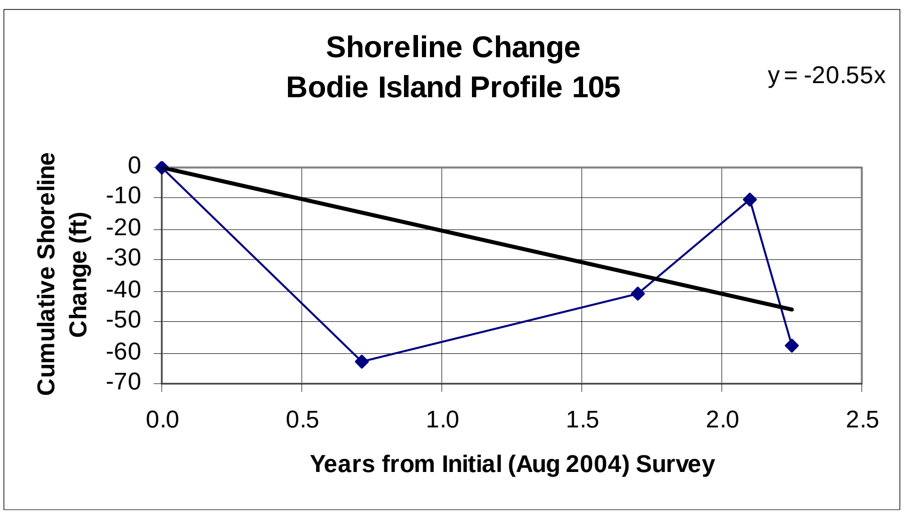

Shoreline Change
Bodie Island Profile 132
y = -21.26x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey



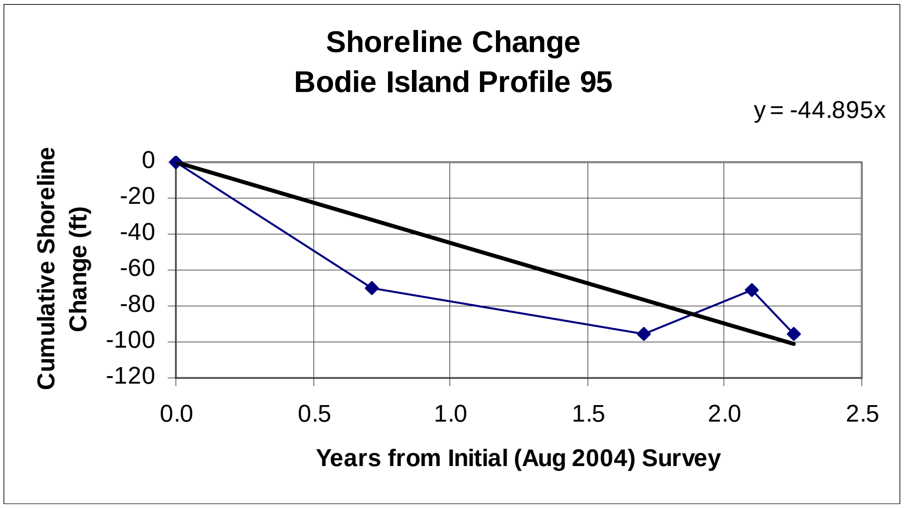
Shoreline Change
Bodie Island Profile 124
y = -32.506x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

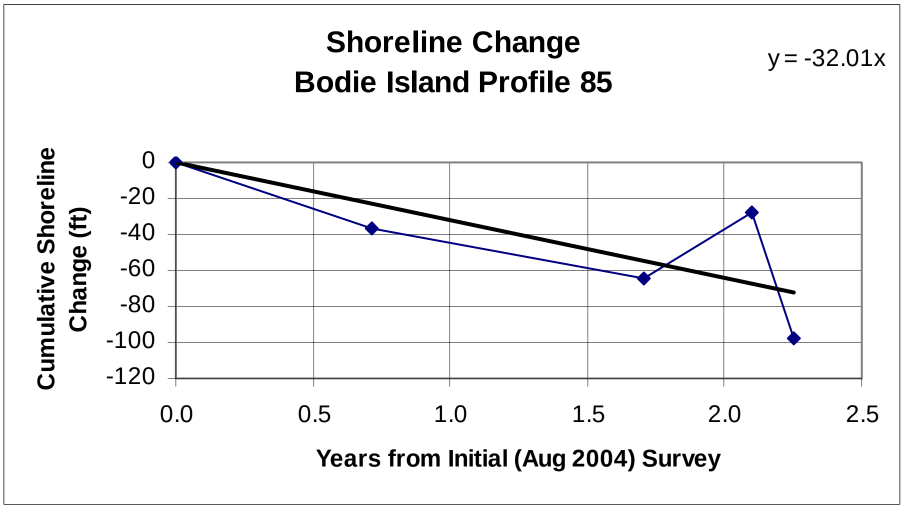


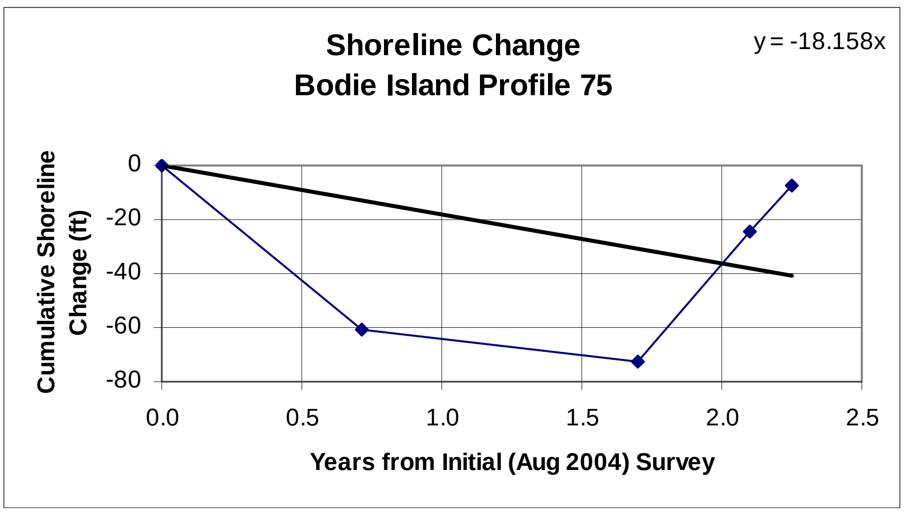
Shoreline Change
Bodie Island Profile 114
y = -29.596x
Cumulative Shoreline Change (ft)
20
0
-20
-40
-60
-80
-100
-120
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

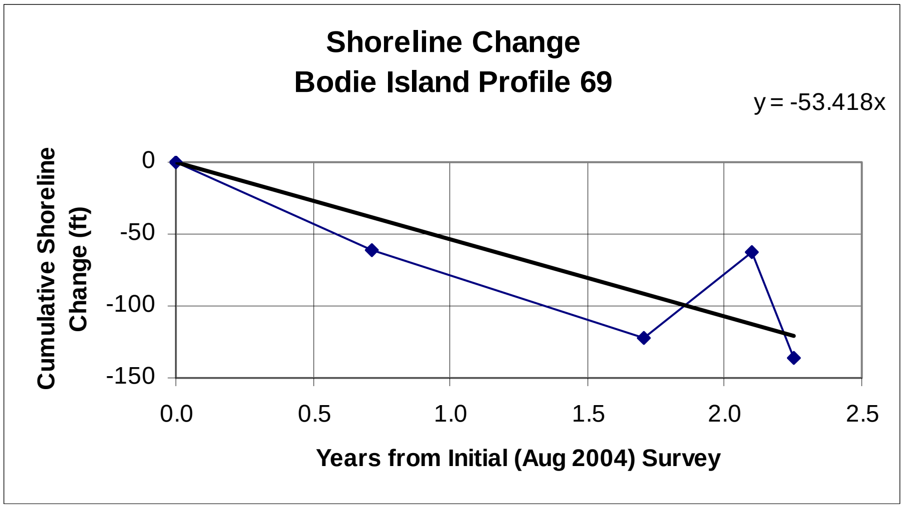


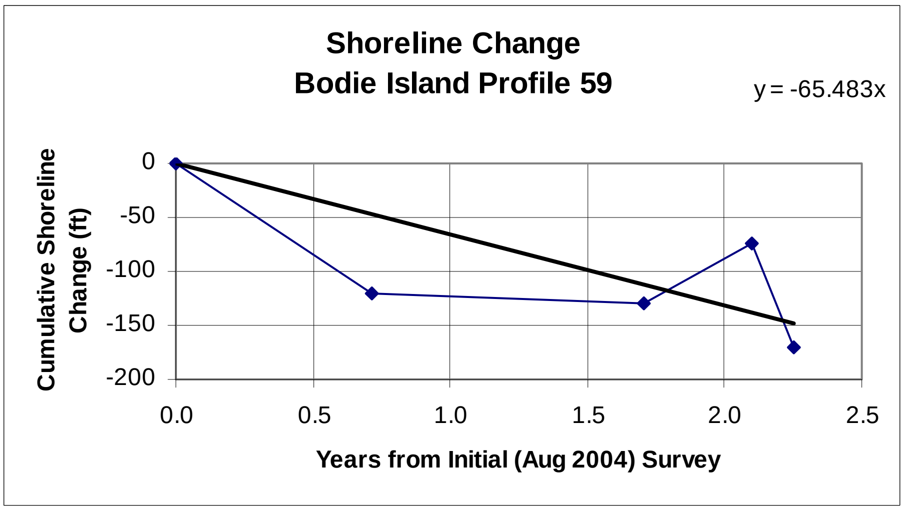
Shoreline Change
Bodie Island Profile 105
y = -20.55x
Cumulative Shoreline Change (ft)
0
-10
-20
-30
-40
-50
-60
-70
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

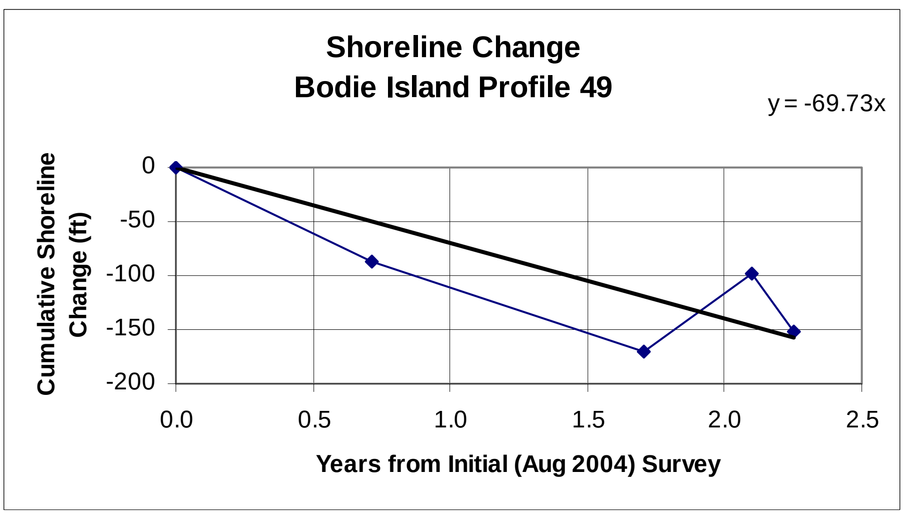

Shoreline Change
Bodie Island Profile 95
y = -44.895x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

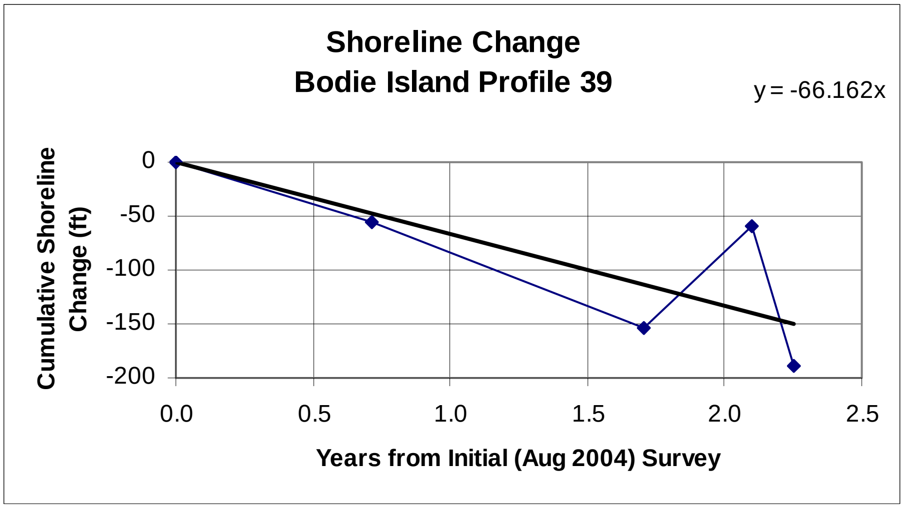

Shoreline Change
Bodie Island Profile 85
y = -32.01x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
-100
-120
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

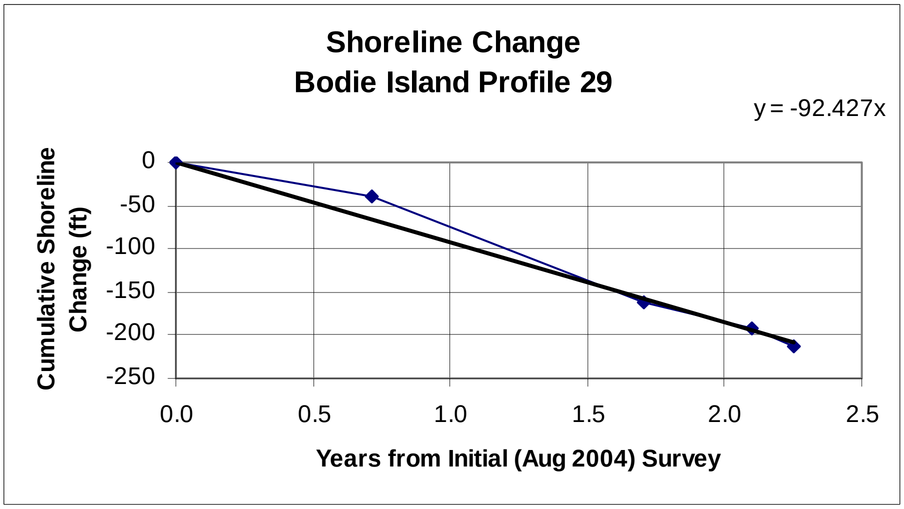

Shoreline Change
Bodie Island Profile 75
y = -18.158x
Cumulative Shoreline Change (ft)
0
-20
-40
-60
-80
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey

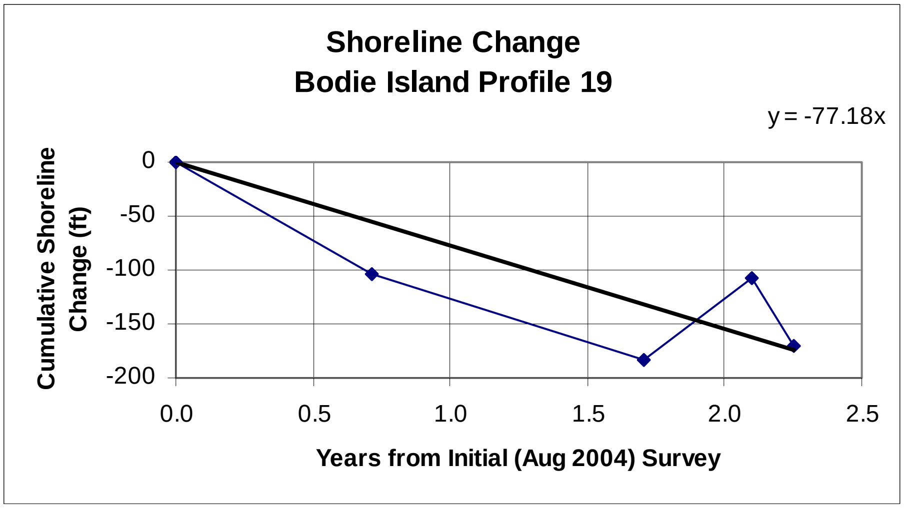

Shoreline Change
Bodie Island Profile 69
y = -53.418x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Bodie Island Profile 59
y = -65.483x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Bodie Island Profile 49
y = -69.73x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Bodie Island Profile 39
y = -66.162x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Bodie Island Profile 29
y = -92.427x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
-250
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey


Shoreline Change
Bodie Island Profile 19
y = -77.18x
Cumulative Shoreline Change (ft)
0
-50
-100
-150
-200
0.0
0.5
1.0
1.5
2.0
2.5
Years from Initial (Aug 2004) Survey