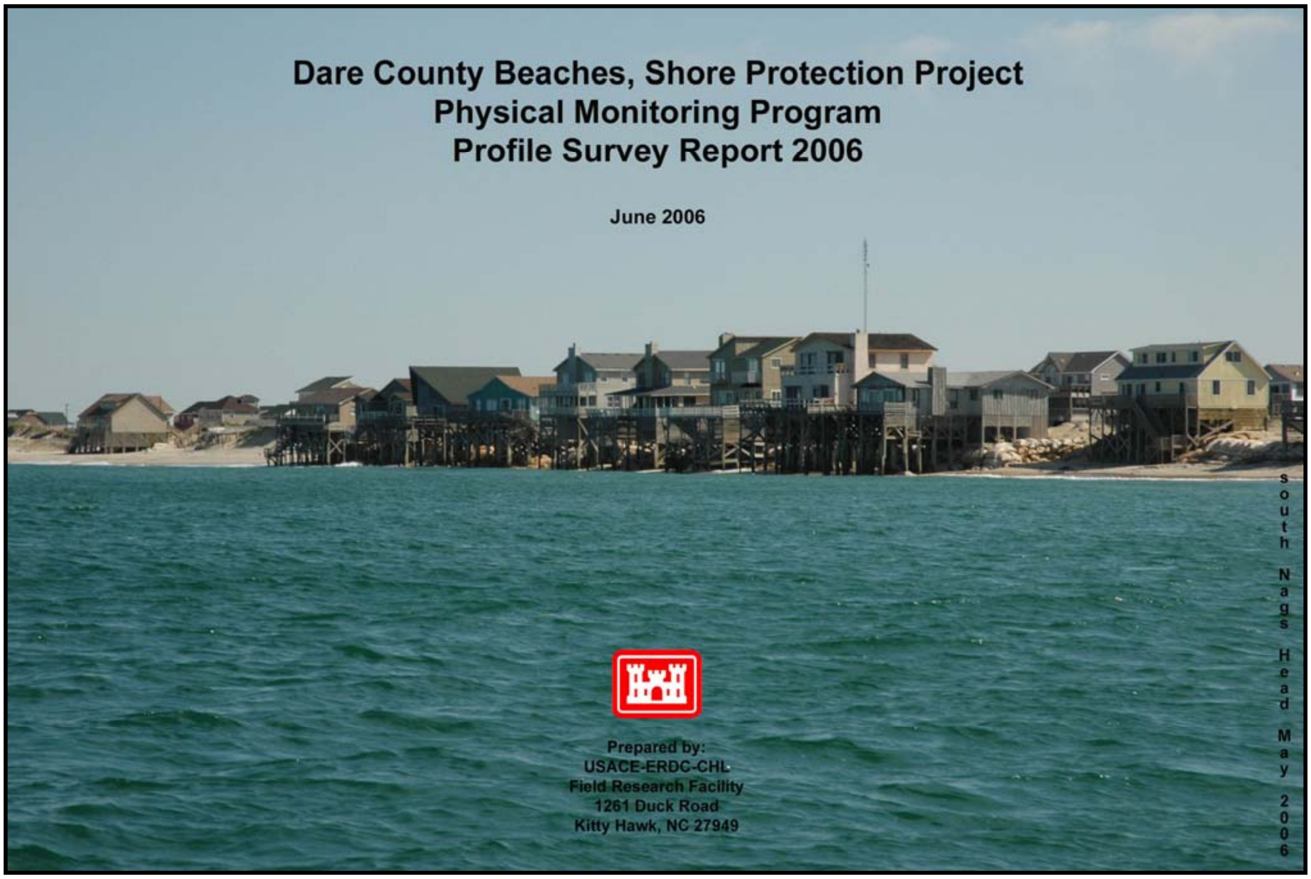

Dare County Beaches, Shore Protection Project
Physical Monitoring Program
Profile Survey Report 2006

June 2006

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1. Purpose

This report presents the results from the profile survey conducted in April 2006. The intent of this report is to provide a written reference for interpretation of the data. In addition to the profiles, 671 sediment samples were collected along with swath bathymetry to supplement the profiles in areas of 3d morphology. This report begins with a brief overview and list of previous surveys. Next, survey methods and datums are discussed, followed by the last sections which present the data and dissemination.

2. Overview

The Dare County Beaches (Bodie Island) Shore Protection Project includes the towns of Kitty Hawk, Kill Devil Hills, and Nags Head along the Outer Banks of North Carolina. The design is to construct a 25-ft wide, 13-ft (ref. National Geodetic Vertical Datum of 1929-NGVD) high dune fronted by a 50-ft wide berm at an elevation of 7 ft (NGVD). In 2004, the South Atlantic Division, Wilmington District (SAW) initiated physical and biological monitoring to assess the performance of the project. SAW partnered with the United States Army Corps of Engineer (USACE) Engineer Research and Development Center, Coastal and Hydraulics Laboratory's Field Research Facility (FRF) located in Duck, NC for the physical monitoring. Data collected under the physical monitoring plan will be used to assess the beach response to the fill placement and will serve as the basis for maintaining the project. The physical monitoring will be used to address the movement of fill from the project limits to adjacent non-project areas. This monitoring will also provide data in support of the biological monitoring effort. For this reason, the physical monitoring includes control areas outside the project limits.

The physical monitoring will cover the pre-, during- and post-construction phases of the project. The plan includes continuous operation of a single directional wave gauge and current meter (ADCP). Summaries of the wave and current measurements can be found on the FRF's web site, http://frf.usace.army.mil/. This gauge will be used to provide a general wave climate and will be re-located approximately annually to address a number of specific issues. The initial location is in the lee of a northern borrow site. The next location will likely be close to where sand is initially placed on the beach. At some point in the future, the gauge will be returned to the initial location to determine if excavation has caused a change in the wave characteristics.

The monitoring plan calls for beach and nearshore profile surveys to be taken every 1000 ft starting 3-miles north of the Kitty Hawk town limit in Southern Shores and continuing south to Oregon Inlet, **Figures 1 and 2.** See **Appendix 1** for a listing of the profile numbers, origin points, and line azimuths. Each of the 144 profile lines extends from a stable point landward of the dune to the -30 ft depth contour. These profile lines will be surveyed twice per year, scheduled for the spring (Mar-Apr) and fall (Oct-Nov).

The survey plan also calls for sediment samples to be taken from 67 profile lines. On each sampled profile, 5 sediment samples will be taken along the onshore portion and 5 along the offshore portion. Sediment sample analysis, the responsibility of SAW, will be used to determine grain size and distribution before the project and any changes during the project. The sediment characteristics can be used to ensure compatibility between the native-beach and fill material over the project life. Grain size and textural properties play a significant role in beach ecology. The last major component of the monitoring will be semi-annual aerial photography.

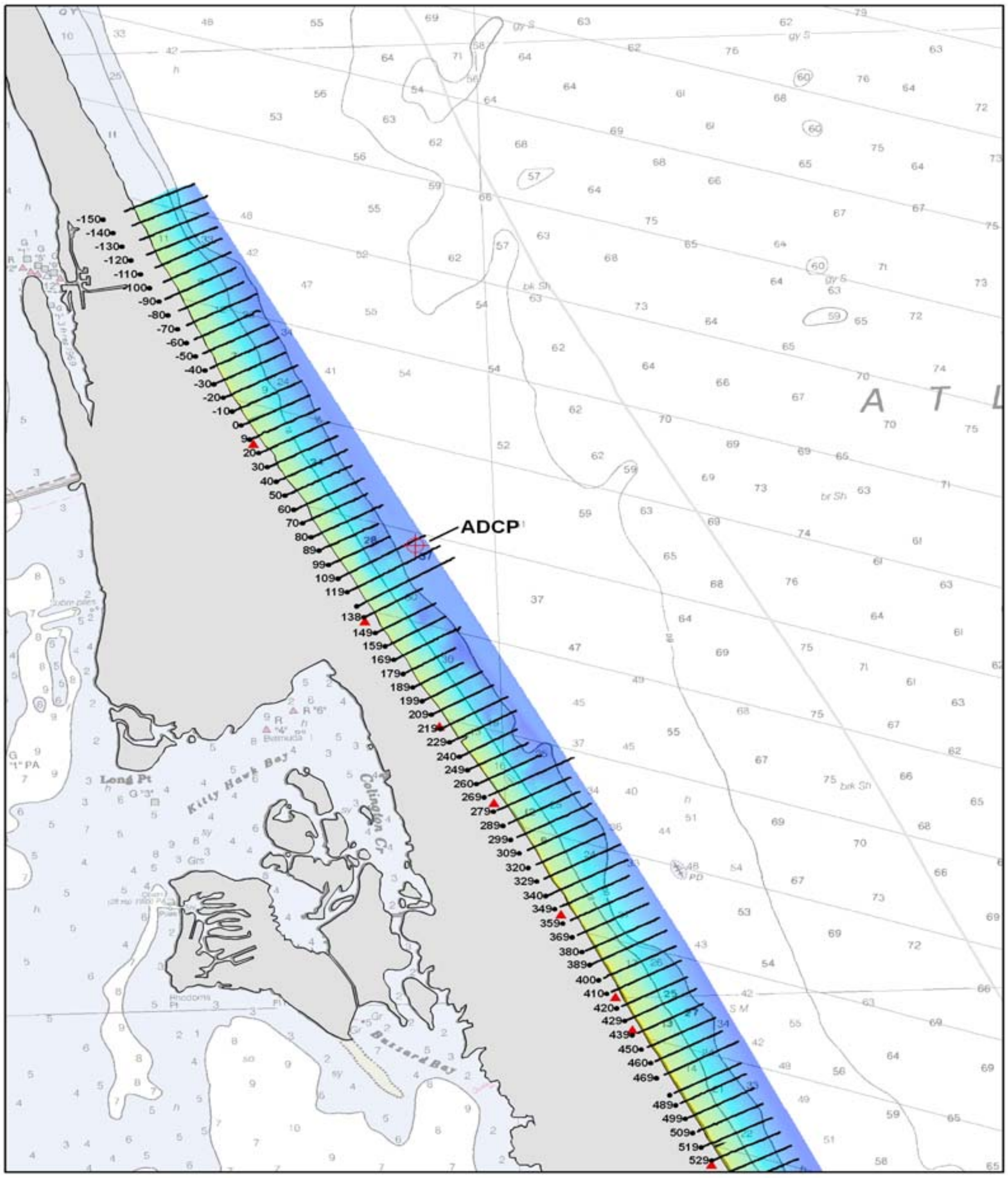

Figure 1. Profile lines, control stations (red triangles), and ADCP locations in Southern Shores and Kitty Hawk. Colored bathymetry contours represent areas surveyed in 2006.

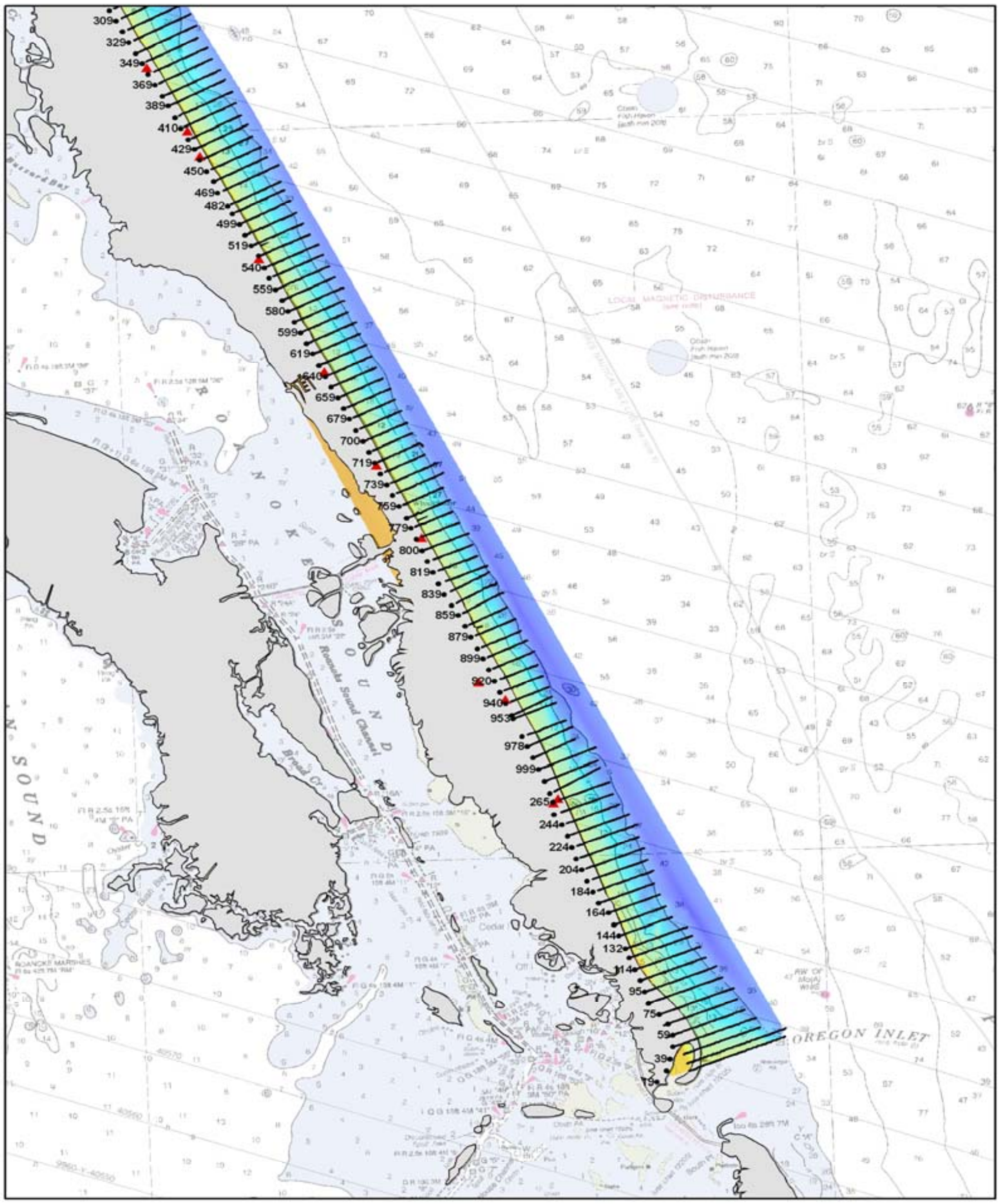

Figure 2. Profile lines and control locations (red triangles) in Nags Head and Cape Hatteras Seashore (Bodie Island). Colored bathymetry contours represent areas surveyed in 2006.

3. Previous Surveys

The 2004 survey was the first of this monitoring program. The other surveys that exist are listed in **Table 1**. On sixty-two profile lines from Duck to Oregon Inlet, the beach was surveyed monthly from 1974-1977 as part of the USACE Beach Evaluation Program (BEP). In the mid 1990s, SAW established new lines in anticipation of the Dare Co. project. These lines will be referred to as the "DARE" profiles. In 1994, SAW surveyed both the beach and nearshore portion of the DARE profiles. The BEP lines within the project area were then resurveyed by SAW in 1995. In 2001, a subset of the DARE lines, where the anticipated first phase of the project would be located, was surveyed by SAW. The 2001 survey did not include the most northern lines, southern lines, and the middle lines in between the two fill areas. In 2003, the FRF in partnership with the U.S. Geological Society (USGS) surveyed the DARE lines from Southern Shores to Jeannette's pier in Nags Head. In August 2004, all 144 DARE profiles were surveyed by the FRF.

Table 1. Previous Dare County Surveys

Data Set	Lines	By	Dissemination
1974-1977	BEP	USACE BEP	FRF
1994	DARE	SAW	SAW
1995	BEP	SAW	SAW
2001	DARE	SAW	SAW
2003	DARE	FRF/USGS	FRF/USGS
2004	DARE	FRF	SAW
2005	DARE	FRF	SAW

4. 2006 Bathymetric and Topographic Surveys

Bathymetric and topographic surveys began on 2 April and were completed by 14 May 2006. The survey schedule **(Appendix 2),** shows that 23 of the 32 days were lost to inclement weather (wind and waves).

4.1. LARC Profiles.

The bathymetric data were collected with the FRF's LARC 191, a Korean War era Army *Lighter Amphibious Resupply Cargo* amphibious vessel. The survey system consisted of a Real Time Kinematic (RTK) Global Positioning Satellite (GPS) system, single beam echo sounder, and a motion sensor measuring heave, pitch and roll, **Figure 3**. Using input from a base station at a known location, published accuracies for RTK GPS systems are between 1 to 3 inches depending on satellite configurations and distance from the base station. Trimble 4000 dual frequency receivers were used both on the LARC and at the base station. Equipment specifications are given in **Table 2**. Control, datums, and other considerations are provided below.

The echo sounder was a Knudsen 320BP dual frequency fathometer. This unit has been widely used by the USACE. Although equipped with 50 and 200 kHz frequency transducers, in this application, only the 200 kHz was used to provide better resolution at shallow depths, (0-66 ft.) The Knudsen was also equipped with a close proximity option allowing accurate depths as shallow as 0.5 ft. to be obtained. This was valuable since when the LARC wheels stop touching the sand, in depths over 1.5 ft below the transducer, the fathometer signal was required. The VT TSS Ltd DMS Series 3-25 heave, roll, and pitch sensor was used to track the vessel's motion.

Coastal Oceanographic's Hypack Max v.4.3 was used to guide the vessel along the profiles and to collect the position, depth, and motion information. The RTK-GPS signal was sampled at 1 Hz, the sounder at 9 Hz, and the motion sensor at 20 Hz. Custom software developed at the FRF used the RTK GPS information to remove the wave and water level variation. This was accomplished by careful adjustment of the timing between sounder and GPS data streams such that a precise measure of the depth was obtained at the exact moment that the GPS position was acquired. With this sampling rate, data points were acquired, on average, every 10 ft. The sounder depth value was also adjusted for the roll and pitch of the boat and for the variation in the speed of sound through the water column. The speed of sound was determined by measuring the conductivity, temperature, and depth (CTD), with an Ocean Sensors CTD OS200. These CTD casts were performed approximately every 2 hours at the offshore ends of the survey line in approx 11m depth. From the CTD information, the speed of sound was computed. Speed of sound can be important, for example an 80 ft/s error in the speed of sound (nominally 4,950 ft/s) will result in a 5 inch depth error in 30 ft of water.

Figure 3. Equipment on LARC

Table 2. Survey Equipment List

Model	LARC-V	US Army
Length	10.7 meters / 35 feet	
Drive System	Four Wheel plus marine drive	see Figure 1
	Echosounder	
Model/Manufacturer	320B/P Portable	Knudsen Engineering
Frequency	50/200 kHz	Only 200 kHz during Survey
Resolution	1cm	0-99.99 meters range
Sound Velocity	1300-1700 m/s	Resolution 1 m/s
Transmit Blanking	0-5 meters	User Selectable
	Motion Reference Unit	
Model/Manufacturer	DMS Series 3-25	VT TSS Limited
Heave Accuracy	The greater of 5cm or 5%	Resolution 1 cm
Pitch/Roll Accuracy	+/-0.25 degree	
	GPS Receivers	
Model/Manufacturer	4000 SSE, 4700, & 5700	Trimble
Frequency	Dual high precision L1 and L2	
RTK-GPS Accuracy	Dependant on conditions such as multipath, obstructions, satellite geometry, atmospheric parameters and base station control quality.	
Published Horizontal Accuracy	10mm + 1ppm RMS	
Published Vertical Accuracy	20mm + 1ppm RMS	
Solution Precision	2 to 5 cm	
	Speed of Sound Instrument (CTD)	
Model/Manufacturer	OS-200	Ocean Sensors
Maximum Scan Rate	145 per second	
Pressure Accuracy	dBar = 0.50%	
Temperature	deg C = 0.01	
Conductivity	mS/cm = 0.02	
Salinity	PSU = 0.03	
	Computers & Software	
Model/Manufacturer	Inspiron Laptop 730 Mhz	Dell
Collection Software	Hypack Max version 4.3	Coastal Oceanographics
Echosounder	Sounder Suite	Knudsen Engineering
Tablet PC	Stylus ltp-600	Fujitsu
Processing Software	Fathomax	Custom FORTRAN routine
CTD Processing	CTD2SSP	Custom PERL routine

4.2. Topographic Profiles.

Topographic (Topo), or beach, profiles were obtained with backpack mounted Trimble 5700 RTK GPS systems. **Figure 4**. The GPS antennas were mounted on the backpacks at a fixed height, and data points were collected every second (approx. every 2ft) as the surveyor continuously walked along the profile. The beach profiles began at a baseline (such as a road) or a stable point behind the primary dune and continued to the waters edge. The surveyor used a Fujitsu Tablet PC with Hypack v. 4.3 for data logging and navigation along the pre-programmed line. All terrain vehicles (ATV) were used to transport the surveyors to each profile location.

Figure 4. Backpack survey system

The same control was used for both the beach and offshore surveys. For each profile the Topo overlapped the LARC data to ensure homogeneity. The LARC was used to cover the wet portion of the Topo lines extending up onto the beach to the toe of the dune providing much more than required overlap with the walking backpack data collection.

4.3 Control, Datums, and QA/QC.

Horizontal/vertical control and datums are basic ingredients for accurate surveys. Geodesy controls for this survey were the North American Datum of 1983 (NAD83), as adjusted in 2001, North Carolina State Plane for horizontal and the North American Vertical Datum of 1988 (NAVD88), using the 2003 Geoid for the vertical. The survey data was collected using metric units and post processed to English (feet) units.

The 30 miles of coast was broken up into 6 approximately 5-mile-long sections. In each section a base station and separate calibration station locations were established. First order control for the base and calibration stations listed in **Table 3** was provided by SAW. Prior to the 2006 survey, the NPS Pipe 2005 base station became unstable because of dune erosion. The FRF re-established NPS Pipe using the control network SAW provided in 2003, along with cross checks against National Geodetic Survey monuments in the area. This control station has been renamed NPS South and was established in a more stable location behind the primary dune.

Fig. 5. Topographic Cal check on Juncos MP 19.7

Both Topo and LARC survey teams occupied calibration stations at least daily to document horizontal and vertical accuracies (**Figure 5**). **Appendix 3** contains tables for the 7 calibration stations that summarize the daily evaluations. For all of the calibration stations, both the Topo and LARC systems operated well within the expected vertical RTK-GPS accuracy of 1 to 3 inches.

Table 3. Dare County Control 2005

Station Name	Monument Type	Northing, Ft.NAD 83	Easting,Ft. NAD 83	Elevation,Ft. NAVD 88
FRF	Base	2958653.75	900893.72	44.380
X254 (NGS)	Calibration	2968919.11	876471.20	9.928
B PELICAN 2005	Base	2977875.63	859508.57	37.120
KITTY (NGS)	Base	2977203.87	859360.76	9.173
BYRD MP1.8	Calibration	2971880.53	870749.39	9.385
HAYMAN MP5.4	Calibration	2981902.87	852867.83	10.530
KILL RESET (NGS)	Calibration	2986925.95	841415.54	7.405
CLARION MP9.6	Base	2991377.76	835737.95	61.604
T 168 (NGS)	Calibration	2993940.71	827215.78	10.574
CURLEW MP12.4	Calibration	2996550.02	825134.69	7.020
FORREST MP15.5	Calibration	3005064.66	808172.86	9.143
COMFORT MP17.2	Base	3008336.95	802172.61	78.202
Y 168 (NGS)	Calibration	3012445.99	790256.26	3.234
JUNCOS MP19.7	Calibration	3014416.70	788825.18	4.684
NPS South	Base	3018480.73	779825.26	9.539
NPS PK MP22	Calibration	3017900.65	780292.49	4.538

4.4 Field Notes

The Topo and LARC survey notebooks are included as **Appendices 4 and 5**, respectively. These field notes describe the status of the GPS equipment as each line is surveyed and any notes the survey technician added to better define the field conditions. Topo line notes are particularly valuable during processing to explain variations in point densities due to inaccessibility along the line or loss of GPS signal due to sky-view obstructions. LARC line notes also include the number of satellites and the GPS Position Dilution Of Precision (PDOP) number, which is a measure of the accuracy of the position information, recorded at the start and end of each survey line, locations of where CTD measurements were collected, and any notes to provide insight when post processing the data. Federal Geographic Data Committee approved metadata files have been created for each survey day and are included in the appendices. These metadata files are named with year, month, and day in the following format 20060413.met.

5. Sediment Sampling

Sediment sampling began on 8 May and was completed on 24 May. Of the 17 days 8 were lost due to inclement weather conditions.

The FRF's second LARC 935 was used to collect the sediment samples **Figure 6**. The LARC facilitated sediment sampling in shallow water where sampling proved to be very difficult. SAW provided two Corps employees for assistance in the collection of sediment samples.

Surface samples were collected at 10 positions on 67 selected profiles including the toe of the dune, on the berm, at mean high water, (+2.5 ft) mean sea level (0.5 ft), mean low water (-1 ft), -6 ft, -12 ft, -18 ft, -24 ft, and -30 ft relative to NGVD. Approximately 1 pint of sediment was obtained at each location. A Ponar sampler, **Figure 7** was used for the sub-aqueous samples.

Figure 6. LARC 935 collecting sediment samples

Depths were determined with the LARC's fathometer based on the stage of the tide. Horizontal position was determined with a differential GPS. The location of each subaqueous sample was recorded, see **Appendix 6**. Sub-aerial samples were taken by hand along the designated lines at the selected locations mentioned above. All of the sediment samples were shipped to the Coastal Hydraulics Laboratory in Vicksburg, MS for analysis.

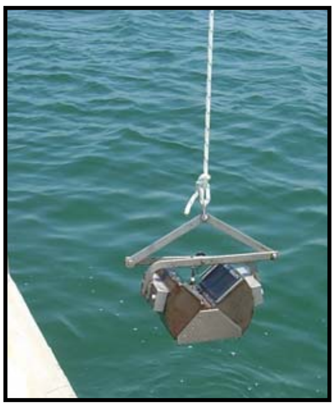

Figure 7 Ponar Sediment Sampler

6. Data

Comparison of the 2006 profiles to prior surveys is useful for quality control and, for determining how the profiles have varied over time. The example "stacked" cross-section plot is shown in **Figure 8**, and the complete set of plots comparing the 2006 profiles to 2005, 2004, and 2003 are in **Appendix 6**. The 2006 survey compares well with prior surveys. Though there are, some differences.

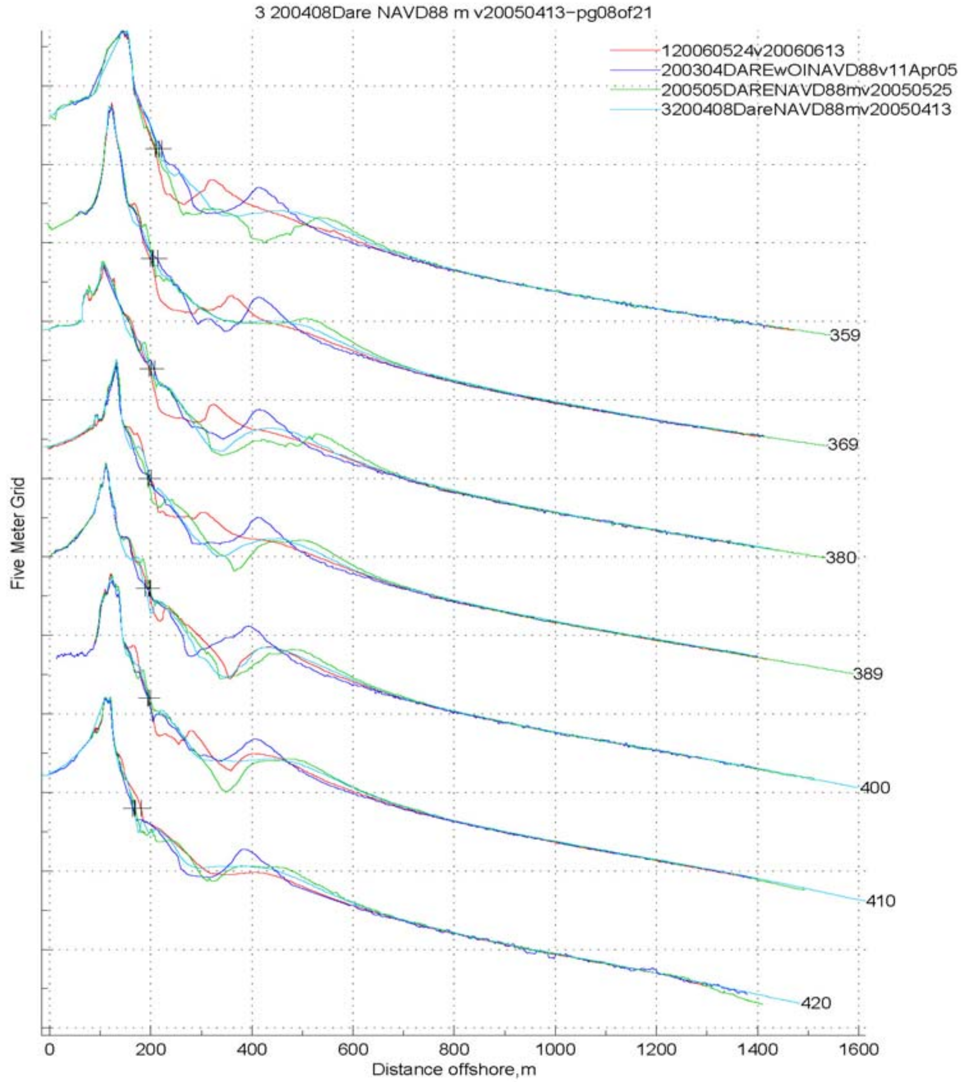

Figure 8. Example stack plot comparing select profiles in 2006 (red) with 2005 (green), 2004 (light blue), and 2003 (dark blue).

One measure of data consistency and, to some extent, quality is to examine changes at the seaward end of the profile; particularly for parallel offsets between successive surveys and between adjacent lines. For the most part, the offshore ends of all the surveys are tight and consistent alongshore, however there are a few areas which display more variable behavior.

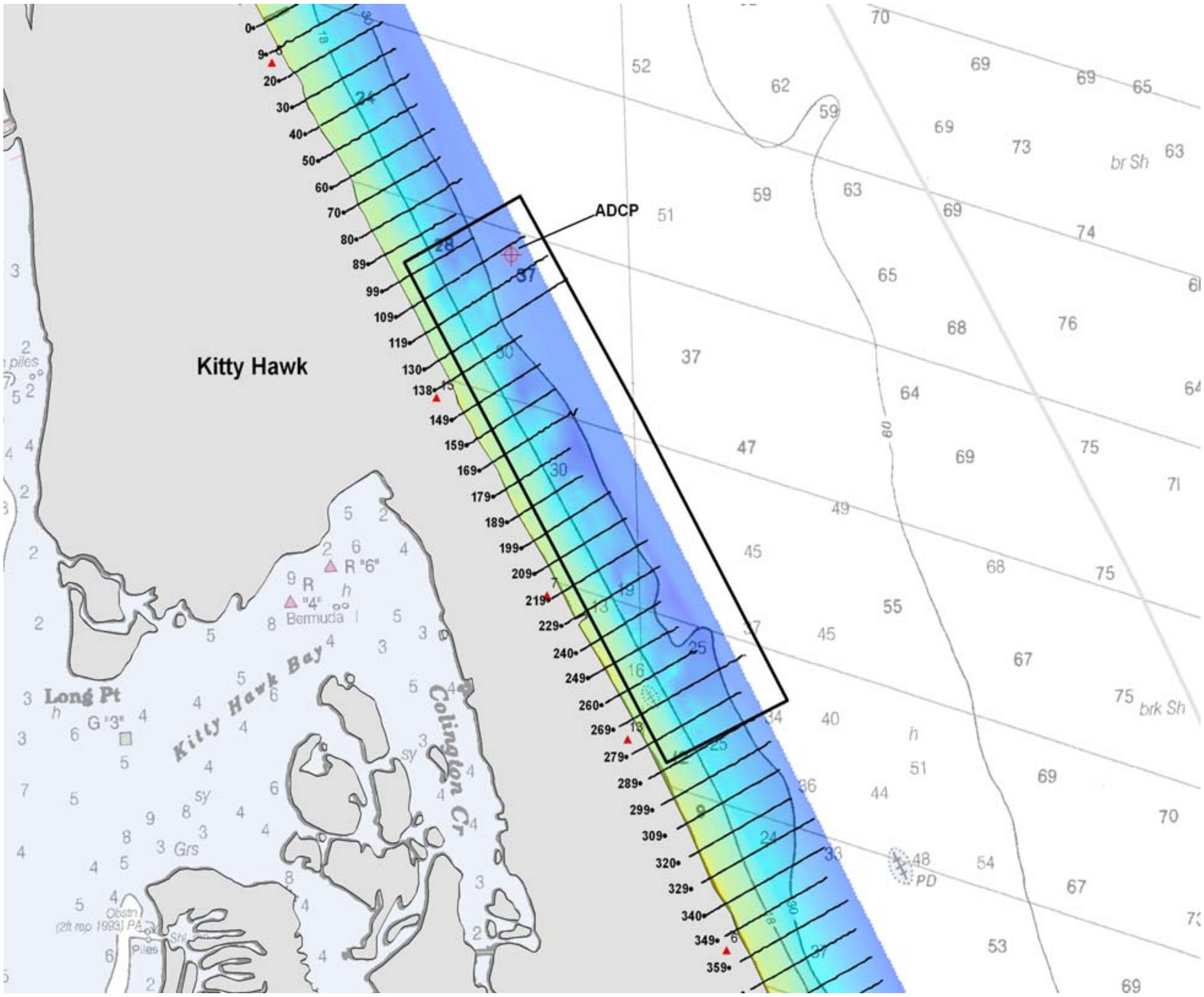

Figure 9a. Shore oblique bars in Kitty Hawk.

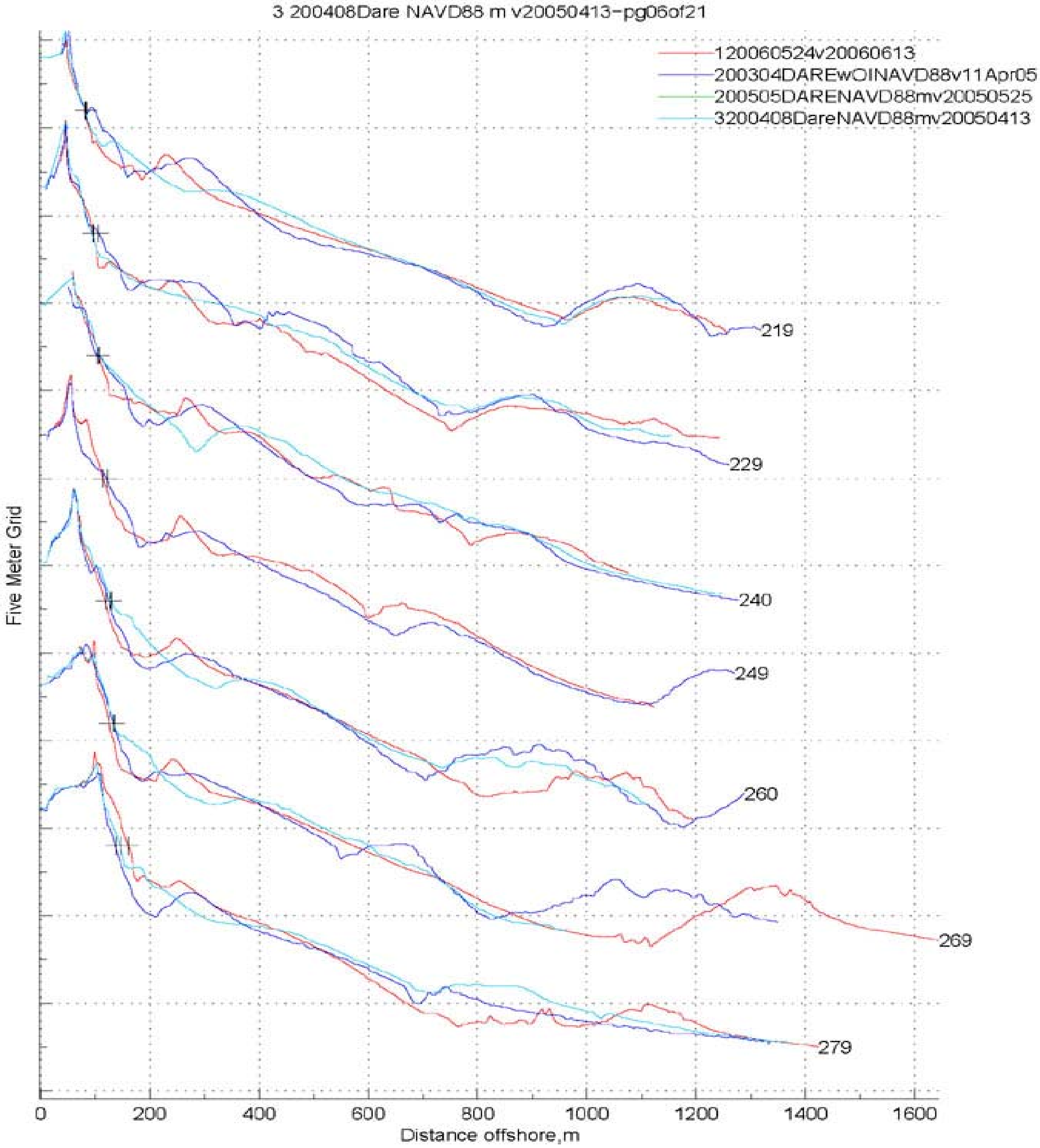

Figure 9b. Select Profiles corresponding with black box in figure 9a

Profile lines between 99 and 279 in Kitty Hawk continue to exhibit complex shape between survey years. The 2006 and prior surveys, along with other recent studies including those of Virginia Institute of Marine Science (VIMS) and Unites States Geological Survey (USGS), have revealed the importance of sand supply and geologic controls which have created complicated morphology within this region. This region is dominated by 3D morphology which these widely spaced profiles do not adequately document. In these regions, slight differences in the position of the LARC when data was collected can result in profiles that are different (**Figures 9a and 9b**).

The consequence of using profiles in this region is that cross-section change computations along these lines will not be as accurate as on the other lines. Longshore averaging of the changes between these lines may also be less accurate. Another area of known 3D morphology is to the south along profile lines 19 through 174 near Oregon Inlet. Not only are the geologic controls a factor in this region, but so is the proximity to Oregon Inlet where the profiles are much more complex. A high resolution swath survey was collected by the FRF at both these areas in May 2006 to supplement the profile dataset. These data and report will be provided under separate cover.

In March 2006 a small beach nourishment project was completed in the town of Kitty Hawk. Contractors hauled 6,818 truckloads of sediment with placement on average of 6 cubic yards per foot. This was a FEMA sponsored project. The 2006 TOPO surveys will indicate sand gains between lines 9 through 189 when compared to the 2005 survey (**example photo to right**).

6.1. Data Transfer.

The data products are a 3D file and a BMAP file. The .3D file contains space delimited xyz values. For all of the profiles, each data point is described by 24 columns of information which include: the project location, profile number, survey number, latitude, longitude, northing, easting, distance from baseline, offline distance, depth, date, time and time from midnight. The .bmap file is much simpler and facilitates profile comparisons, see format **example** below. These data along with daily metadata files, the appendices, and other documentation will be transferred via the CHL Guest FTP site at the following link: ftp://134.164.34.99/frf/DareCounty/2006/ This link will need to be copied into a WEB browser and the **username**: *chlguest* and **password**: *7map4qik* entered into the appropriate dialog boxes.

```
BMAP File Example

DC -150 20041013 COMBINED
386
  1256.4000     20.2760
  1262.1700     18.2810
  1268.8000     15.4400
  1278.3400     13.4580
  1289.2400     11.4800
```

where the lines are:
location, line number, date
number of data points
distance along line & depth pairs

An EXCEL spreadsheet has also been provided that contains a summary of the data processing. This includes: the date processed, profile ID, survey number, date the LARC data was collected, time the LARC data collection started, date the Topo data collection started, number of Topo data points, easting, northing, azimuth, total number of data points, start distance, average spacing between points, maximum spacing between points, distance to maximum spaced point, depth max, latency, tide level, tide standard, heave offset average, pitch average, and roll average. On the FTP site see: 20060524_v20060605.csv.

Additional diagnostic information is available in the form of a "processing summary text" file; see 20060524_v20060605.txt. This file captures the processing from the Fathomax program. It includes: the processing program version, date processed, number of CTD casts, smoothing technique, minimum distance between points, control point used, original number of GPS points, original number of fathometer points, vertical jumps found, sound speed correction, number of points after corrections, latency, GPS points dropped, spikes dropped, duplicate points dropped, number of beach and LARC points that overlapped, etc.

Routine QA/QC began with a review of plots generated by Fathomax. They show the data collection track, raw GPS signal, raw echo sounder signal, combined GPS and echo signals, and the final profile in comparison to a prior survey; see DARE2006_v20060605.pdf. That review facilitated rapid recognition of problems, such as: data gaps, off line errors, and problems with the equipment. More than one person, (typically 3), inspected these plots for each profile. If additional information was required, the processing summary text file was consulted. Spikes in the data were then manually edited out. Note, since surveys and processing were accomplished in metric units, diagnostics information are metric.

This is the third in what is expected to be a series of FRF Dare County Beaches, Shore Protection Project Physical Monitoring Program Profile Survey and Sediment Sampling Reports. Future reports will have approximately the same format and content. Suggestions for improving the reports, questions about the contents of this report, and/or about the data should be directed to Mr. Mike Forte, Survey Specialist, at Michael.f.forte@erdc.usace.army.mil or by phone 1-252-261-6840 ext 228.