Dare County Beaches, Shore Protection Project
Physical Monitoring Program
Profile Survey and Sediment Sampling Report 2004

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The picture that's worth a thousand words, Kill Devil Hills near line 380

Table of Contents

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1. Purpose

This report presents the results of the first survey in August 2004. The survey included bathymetric and topographic profiles and sediment sampling. To supplement the profile surveys, swath surveys were also conducted; however, those survey results will be summarized in an accompanying report. The intent of this report is to provide a written reference for interpretation of the data. The report begins with a brief overview and list of previous surveys. The survey methods and datums are described next. Following is a description of the sediment sampling procedures. The last section discusses data 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. 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 USACE Engineering Research and Development Center, Coastal and Hydraulics Laboratory's Field Research Facility (FRF) located in Duck, NC for the physical monitoring. The FRF is well known for conducting a long-term, uninterrupted, comprehensive, coastal monitoring program. 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 also be used to address the dispersion of the fill from the project limits to adjacent non-project areas. This monitoring will also provide data in support of the biological monitoring effort being undertaken by another contractor. For this reason, the physical monitoring extends outside the project limits to include control areas to assess potential environmental impacts.

The physical monitoring, which began in 2004, 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. 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 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. Bathymetric and topographic surveys will be used to determine how the sand fill adjusts to the wave and current processes.

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 1-3.** See **Appendix 1** for listing of profile location, origin, and azimuth. 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). Sediment samples will be collected along selected beach profiles.

Five sediment samples along the onshore portion and 5 along the offshore portion of the 67 profiles identified in **Appendix 1** will be used to document pre-construction sediment characteristics and any changes that may occur associated with fill placement and future project maintenance. The last major component of the monitoring will be semi-annual aerial photography.

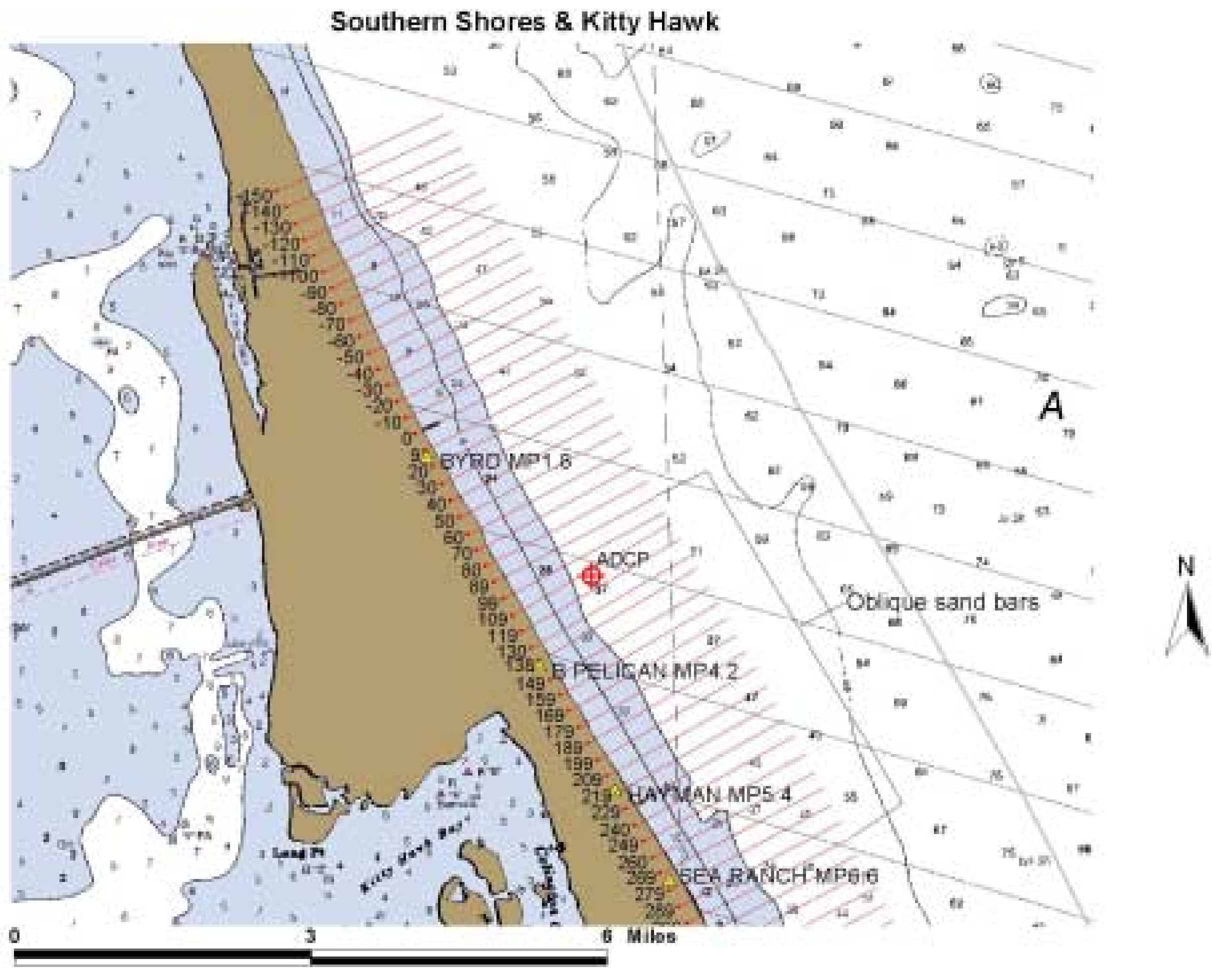

Figure 1. Profile lines, control, and ADCP locations in Southern Shores and Kitty Hawk

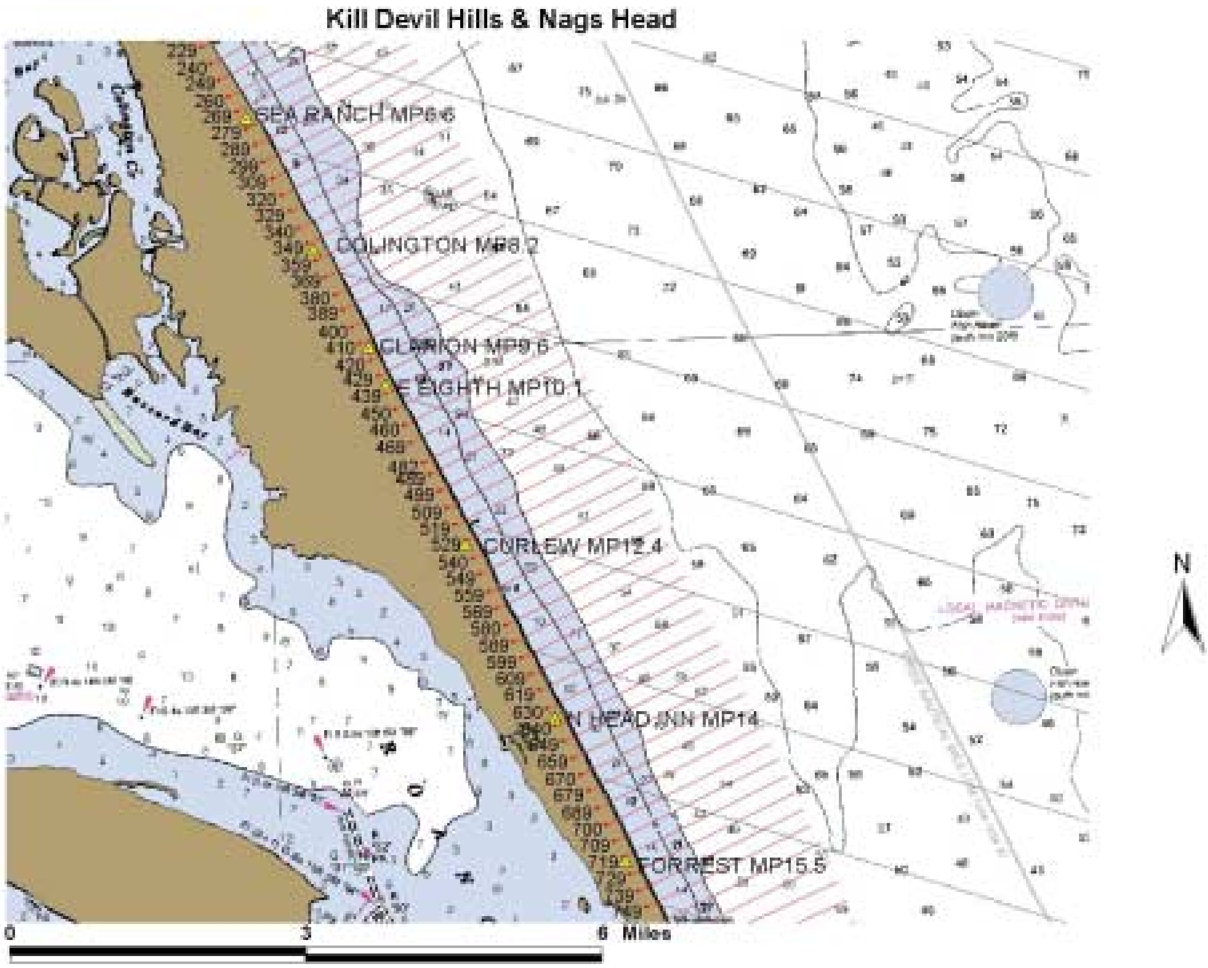

Figure 2. Profile lines and control locations in Kill Devil Hills and Nags Head

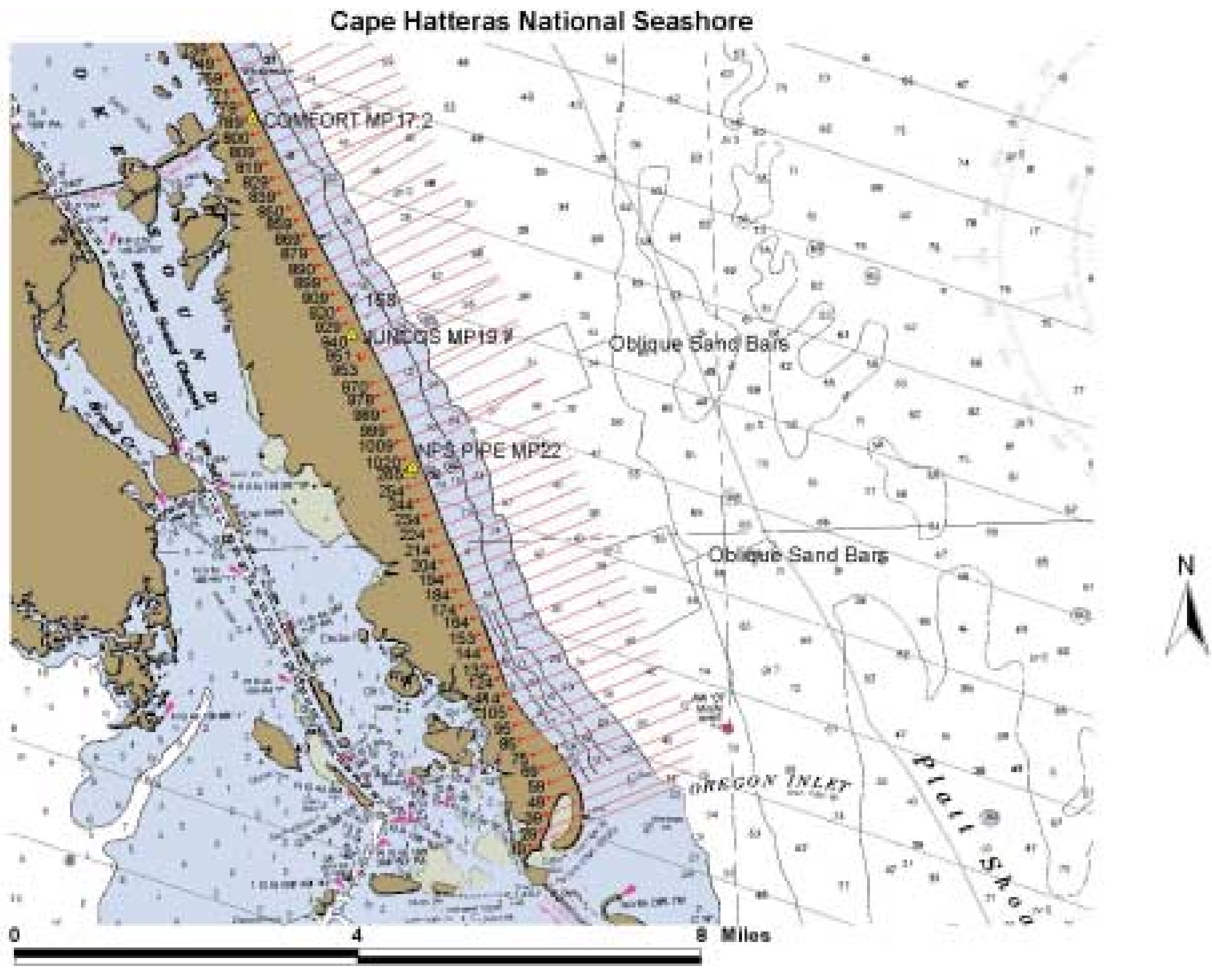

Figure 3. Profile lines and control in Cape Hatteras National Seashore

3. Previous Surveys

Although the 2004 survey was the first of this monitoring program, it was not the initial survey of profile lines along the project, **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. Missing in 2001 were the most northern and southern lines, along with 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. A brief discussion of how 2004 compares to 2003 and 2001 is included below in Part 6.

Table 1. Previous Dare County Surveys

	Data Set	Lines	By	Dissemation
1	1974-1977	BEP	USACE BEP	FRF
2	1994	DARE	SAW	SAW
3	1995	BEP	SAW	SAW
4	2001	DARE	SAW	SAW
5	2003	DARE	FRF/USGS	USGS
6	2004	DARE	FRF	SAW

4. 2004 Bathymetric and Topographic Survey

Bathymetric and topographic surveys of the 144 profiles began on 20 August and were completed 14 October 2004. A complete survey schedule is included as **Appendix 2**. Of the 56 total days, 15 were working and 41 were lost primarily due to weather.

The profile surveys were supplemented with swath surveys that provide more complete coverage from the bar out to the 30-ft isobath. The Virginia Institute of Marine Science's (VIMS's) Submetrix Interferometric swath sonar was run along shore-parallel transects along the entire region. With a swath width of 10 times the depth, almost complete coverage was obtained. The swath surveying was conducted simultaneously with the profiling, beginning on 27 August and ending on 29 August. Summary of the swath survey system and combined profile and swath data processing, gridding and presentation are to be provided in a follow-on report.

4.1. LARC Profiles.

The LARC is a Korean War era Army *Lighter Amphibious Resupply Cargo* vessel. The surveying system consists of a Real Time Kinematic (RTK) GPS system, single beam echo sounder, and a motion sensor measuring heave, pitch and roll, **Figure 4**. RTK GPS permits the position and elevation of the LARC to be determined to an accuracy of ± 2 cm using input from a base station at a known location onshore. 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 is a Knudsen 320BP dual frequency fathometer. This unit has been widely used by the USACE. Although equipped with 50 and 200 kHz frequency transceivers, in general, only the 200 kHz is used because it provides better resolution at shallow depths, 0-66 feet. The Knudsen is also equipped with a close proximity option. Accurate depths are obtainable in as shallow as 0.5 ft. This is valuable since when the LARC wheels stop touching the sand, in depths over 1.5 ft, the fathometer signal is required. The VT TSS Ltd DMS Series 3-25 heave, roll, and pitch sensor is used to track the vessel's motion.

Figure 4. Survey LARC Showing Equipment

Coastal Oceanographic's Hypack Max v.4.3 was used to guide the vessel along the profiles and collect the position, depth, and motion information. The RTK-GPS signal is sampled at 1 Hz, the sounder at 9 Hz, and the motion sensor at 20 Hz. Custom software developed at the FRF uses the RTK-GPS information to remove the wave and water level variation. This is accomplished by careful adjustment of the timing between sounder and GPS data streams such that a precise measure of the depth is obtained at the exact moment that the GPS position is acquired. With this sampling rate, data points were acquired on average every 10 ft. The sounder depth value is also adjusted for the roll and pitch of the boat and for 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 through the water column approximately every 2 to 3 hours at both inshore and offshore sites while surveying. From the CTD information the speed of sound can be computed. Speed of sound can be important, an 80 ft/s error in the speed of sound (nominally 4,950 ft/s) amounts to a 5 inch difference in depth in 30 ft of water.

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	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
Datalogger	TSC-1 Datalogger	Trimble
Processing Software	Fathomax	Custom FORTRAN routine
CTD Processing	CTD2SSP	Custom PERL routine

4.2. Topographic Profiles.

The topographic, or beach, portion of the profiles were obtained with a backpack mounted Trimble 4700 RTK GPS system with the antenna on a range pole, **Figure 5**. A Trimble TSC-1 data collector was used to document position and elevation approximately every 10 ft or at every major change in slope. As with the LARC data collection, the profiles were preprogrammed into the unit to minimize data being obtained off of the line. The topo portion of the survey took just 18 days to complete. Each data point was recorded for at least 3 minutes to produce very accurate results.

Figure 5. Backpack mounted GPS

The same control was used for both the beach and offshore surveys. For each profile the topo overlapped the LARC data to ensure homogeneity. In the next section, control, datums, and methods/procedures used to ensure accurate results are described. The method was to use the LARC 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. Great effort was taken each day to ensure the data collected were correct and directly related to known control and datums. Geodesy controls for this survey were NAD83, as adjusted in 2001, North Carolina State Plane for horizontal and NAVD88, Geoid 99, for vertical. The survey data was collected using metric units and post processed to English feet units.

The approximately 30 miles of coast was broken up into 6 approximately 5-mile-long sections. In each section base station and separate calibration station locations were established. The “cal stations” were used daily to verify the proper equipment setup and operation. First order control for the base and cal stations listed in **Table 3** was provided by SAW. Because it was determined that Station NPS Pipe MP22 had been disturbed prior to first use, it was re-established by the FRF using the first order network that SAW provided.

Both LARC and topo survey teams occupied cal stations at least daily to document the equipment’s horizontal and vertical accuracies. **Appendix 3** contains tables for the 6 cal stations that summarize the daily evaluations. At Hayman and NPS, both the topo and LARC were within 0.4 inches. At the other sites, the topo and LARC tended to differ from the control values by the same amount, less than 3 inches. There was one site, at Curlew, where the topo RMS difference was 3.2 inches and the LARC was 0.3 inches. Evidently, there are 2 PK nails at that site;

discovered later when it was clear of wind-blown sand. For all of the cal stations, both the topo and LARC systems operated well within the expected vertical RTK-GPS accuracy of 3 to 4 inches.

Table 3.

DARE COUNTY CONTROL 2004				
North to South Sort		feet		
Type Point	Description	Northing NAD 83	Easting NAD 83	Geoid 99 NAVD88
PK	Byrd MP 1.8	870749.39	2971880.53	9.39
Base	B. Pelican MP 4.2	859508.57	2977875.63	37.12
PK	Hayman MP 5.4	852867.83	2981902.87	10.53
Base	Sea Ranch MP 6.6	848034.70	2984836.23	61.83
PK	Colington MP8.2	840955.71	2988442.80	9.93
Base	Clarion MP9.6	835737.95	2991377.76	61.60
PK	E. Eigth MP10.1	833666.58	2992286.15	9.32
PK	Curlew MP12.4	825134.69	2996550.02	7.02
Base	Nags Head Inn MP14.8	815834.46	3001311.45	66.44
PK	Forrest MP15.5	808172.86	3005064.67	9.14
Base	Comfort Inn MP17.2	802172.61	3008336.95	78.20
PK	Juncos MP19.7	788825.18	3014416.70	4.68
Base (A)	NPS PIPE MP22 (A)	780653.50	3018203.80	31.87
	Original ^			
Base (B)	NPS PIPE MP22 (B)	780653.50	3018203.80	30.00
Pipe was resurveyed in, because it got moved				
PK	NPS Nail MP22	780292.49	3017900.65	4.54

4.4 Field Notes

The LARC and topo survey logs are included as **Appendices 4 and 5**, respectively. These logs describe the status of the GPS equipment as each line is surveyed and any notes the survey technician may add 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 GPS PDOP settings, a measure of the accuracy of the position information, at the start and end of each survey line.

5 Sediment Sampling

Sediment sampling also commenced on 20 August, but was not completed until 2 November. No sediment sampling was possible during 2-16 September or 18 September through 18 October, resulting in 2/3 of the total 75 days lost due to weather.

The FRF's LARC was also used to obtain the sediment samples. The LARC facilitated sediment sampling in shallow water where sampling proved to be very difficult. Initially, the procedure was to combine surveying and sediment sampling using a single LARC. This turned out to be time consuming and inefficient. After the first weather delay, a second LARC, captain, and crew was employed and dedicated exclusively to sediment sampling, **Figure 6**. This improved the efficiency of both the sediment sampling and surveying.

Figure 6 FRF LARCs: Survey on right, sediment on left

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.

Figures 7. **Ponar sediment sampler and test grab sample**

Surface samples were collected at the toe of the dune, on the berm, at mean high water, mean sea level, mean low water (-1 ft), -6ft, -12ft, -18ft, -24ft, and -30 ft relative to mean tide level. Approximately 1 pint of sediment at each of the 10 positions was obtained along the select profiles. A Ponar sampler, **Figure 7**, was used for the sub-aqueous samples. To make the sampling less strenuous, the LARC was outfitted with a crab pot puller to retrieve the Ponar, **Figure 8**. With a little practice, the combined team of SAW and FRF personnel became quite proficient, obtaining samples on the first cast almost every time.

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 sample was recorded, see **Appendix 6**. Sub-aerial samples were taken by hand and the position documented with the backpack GPS unit.

Figure 8. LARC mounted crab pot puller and Ponar

6. Data

Comparison of the 2004 profiles to prior surveys is useful for quality control and, of course, for determining how the profiles have varied over time. "Stacked" cross-section plots, see example **Figure 9**, comparing the 2004 to 2003 and 2004 to 2001 are given in **Appendices7 and 8,** respectively. As can be seen, the 2004 survey compares well with prior surveys. There are, however, some differences, such as those discussed below for 2004 versus 2003.

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 the 2004 and 2003 surveys are tight and consistent alongshore. A curious difference is between line 580, which shows no offshore change, and the adjacent line 589 where the profiles are different from year to year. This difference extends south to line 759, but does not appear on line 771. This might be real as Hurricane Isabel affected the area between these surveys, but it remains a curiosity. We expect to revisit these data again after the 2005 survey, which should shed additional light on the nature of these profiles.

Another exception is between lines 89 and 289. The 2004 and prior surveys, along with other recent studies including those of VIMS and 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. Clearly, slight differences in profile location can result in profiles that are different. Another region of known 3D morphology is to the south along the profile lines 19 through 174 near Oregon Inlet.

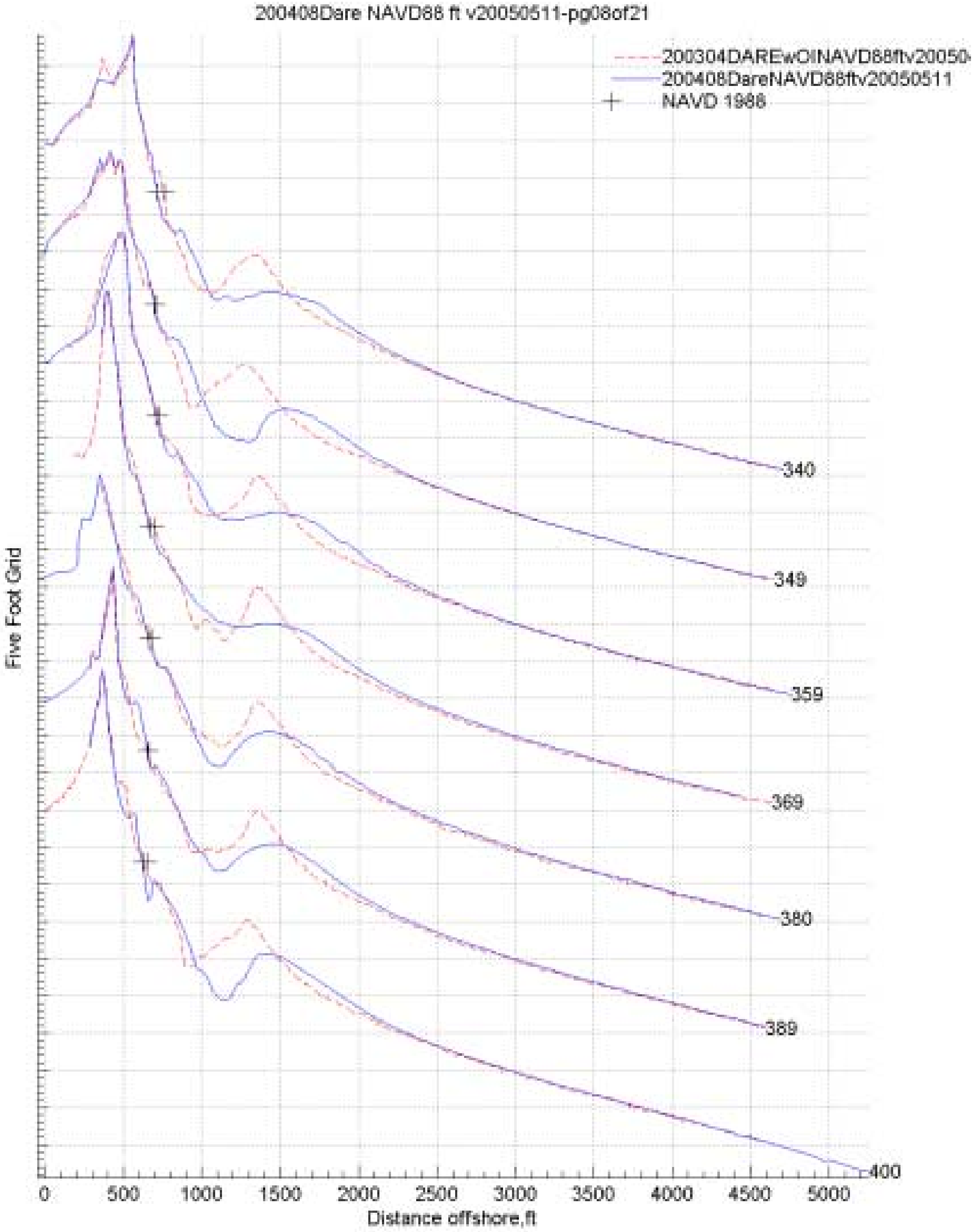

Figure 9. Example stack plot comparing select profiles in 2004 with 2003.

Please note, the 2003 survey was conducted by merging the beach/nearshore segment of the profile done by the FRF's LARC hydrosurvey system with the USGS waverunner-based similar hydrosurvey system. This optimized the survey, using the LARC near the beach where it's most appropriate with the quicker waverunner for the longer offshore segments. Unfortunately the two systems didn't always agree in the zone where they overlapped, with the waverunner data at times being 10 to 15 cm shallower than the LARC data. The difference is not constant on every line and after much reanalysis it became unclear as to which part of the survey was correct. As a result, the data presented in these plots were created by keeping the LARC data and removing any overlapping waverunner points.

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 for each data point. The .bmap file is much simpler and facilitates profile comparisons, see format **example** below. These data along with a metadata file, the appendices, and other documentation will be transferred via the CHL Guest FTP site at the following link: ftp://chlguest:7map4qik@134.164.34.99/FRF/2004_DareCounty_Survey_Report/

```
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 is provided that contains a summary of the data collection and processing. This includes: the date processed, profile ID, survey number, date the LARC data was collected, time the LARC data was collected, date the TOPO data was collected, 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: 2004DARE_NAVD88_v20050511.csv.

Additional diagnostic information is available in the form of a "processing summary text" file; see 2004DARE_NAVD88_v20050511.txt. This file 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, sound speed correction, number of points after corrections, which specific points were adjusted, latency, GPS points dropped, spikes dropped, duplicate points dropped, number of beach and LARC points that overlapped, etc, etc. This text file is only of use as part of the whole data processing package.

Routine QA/QC begins with a review of many plots, including plots of the track, raw GPS signal, raw echo sounder signal, combined GPS and echo signals, and the final profile in comparison to a prior survey; see 200408DARE_NAVD88_m_v11MAY05.pdf. This facilitates rapid recognition of problems, such as: data gaps, off line errors, and problems with the equipment. More that one person, (typically 3), inspect these plots for each profile. If additional information is required, the processing summary text file is consulted. Last, spikes in the data are manually edited. Note, the surveys and processing are accomplished in metric units and results are converted to English units. The "_m" in the plot file name above indicates that the graphs are in metric units.

Questions regarding the contents of this report and about the data should be directed to Mr. Carl Miller, Research Oceanographer, at herman.miller@erdc.usace.army.mil or 1-252-261-6840 ext 240.