

Jet probe locations were recorded using the Trimble DGPS interfaced with Coastal Oceanographic “HYPACK Max” navigation system. Water depths for each site were determined using Innerspace precision echo sounder in water depth greater than two (2) feet and with a survey rod for water depths less than two (2) feet. These jet probes were used to determine the thickness of the unconsolidated sediment to a maximum of twenty (20) feet, and to acquire the characteristics of the different sediment types.

Jet probing involves the jetting of a 20-foot long PVC pipe into the seafloor using a water pump mounded on CPE’s 24 foot boat. As the probe penetrates into the sediment a CPE geologist/diver observes the depth of the probe and the characteristics of the sub-surface sediment. The geologist/diver estimated the sub-surface sediment characteristics based on probe resistance, the feel of the probe as it penetrates the sub-surface and from the sediment being flushed out of the jet probed hole. A second diver records the turbidity level which indicates the presence of silts/clays by observing the plume created during jet probing process.

A small deposit mound is formed around the jet probe site as the jetted water flushes sediment to the surface. Three samples were obtained from each jet probe site. The three samples taken are: 1) an undisturbed bottom surface sample, 2) a sample from the jet probe mound that penetrated the seafloor to 20 feet or until the probe hits refusal and 3) a sample from a second jet probe mound that penetrates the seafloor half the depth of the first probe. One of the three sediment samples collected for each jet probe site was analyzed by standard sieve analysis and the remaining two samples characteristics were estimated visually.

Vibracore Survey

Vibracoring operations were conducted using the M/V Artemis, a thirty (30) foot aluminum platoon vessel with a ~2.5 foot draft. The vessel was equipped with a DGPS navigational system, fathometer, anchors, deck winches and A-frame. From July 17th to July 20th five (5) vibracores were obtained by Athena Technologies of Columbia, South Carolina under the direction of Coastal Planning & Engineering, Inc. geologist.

The majority of the five vibracores were taken in two or three phases. In the first phase a 3-inch galvanized steel tubing or a 5-inch diameter aluminum tubing was vibrated into the sediment to a depth of eight (8) to twelve (12) feet. This was followed by jetting a 3-inch galvanized steel tubing to the depth of recovery and then vibrating the 3-inch galvanized steel tubing into the sediment to a depth of twenty (20) feet or until the vibracore hits refusal. If this first 3-inch galvanized steel tubing attempt did not recover a core of suffice length, a second 3-inch galvanized steel tubing was jetted to the depth of recovery of the first jetted galvanized steel tubing and then vibrated into the sediment to a depth of twenty (20) feet or until the vibracore hits refusal. Each core was measured and labeled onboard the vessel. At the end of each day the cores were transported to shore, where they were cut lengthwise, visually inspected and sealed in plastic. At the end of the vibracoring operations the archived half of the cores were transported to the University of North Carolina at Wilmington and the sampled half was transported to the CPE Boca Raton office for sampling and logging.

ADDITIONAL STUDIES

The existing ebb channel through the inlet follows a circuitous route (Figure 1) from Dudley Island past the western end of the Town of Emerald Isle and across the ebb tide delta. The latest bathymetric survey of the inlet and shoal was conducted in October 2001 by Coastal Science and Engineering (CSE).

The USACE, as part of an island wide Federal storm damage reduction feasibility study, has collected samples of the native beach for the entire length of the island. These samples start at the base of the dune and ends at the 30-foot depth contour with samples being collected at 2-foot depth intervals across the profile. The grain size analysis for these samples will be used as a basis of comparing the compatibility of the inlet material with the native material (Appendix I).

Coastal Science and Engineering (CSE) collected samples of the native beach material from Bogue Banks in 1999 and 2001. All of the samples collected by CSE were obtained from the dune seaward to the low tide terrace (LTT). Since some of the dune material was deposited via mechanical means (bulldozing of the foreshore), all of the dune samples were excluded from the composite analysis. Also, samples collected from Station 90 on Atlantic Beach and Station 110 near the U.S. Coast Guard Station at Fort Macon, were from areas previously nourished by navigation maintenance material obtained from the Morehead City Harbor navigation project and were also excluded from the composite analysis (Appendix I).

SURVEY RESULTS

In general, the jet probe logs and the vibracores logs indicate a fairly uniform sand deposit throughout the proposed channel with minor layers of shell fragments or shell hash and minimal amounts of silt/clay.

Sieve analyses were carried out for vibracore and jet probe samples in accordance with the American Society for Testing and Materials Standard Materials Designation D422-63 for analysis of soils (ASTM, 1987). This method covers the quantitative determination of the distribution of sand size particles.

The results from sieve analyses were entered into CPE's sieve analysis program, which computes the moment method for mean and median grain size, sorting and silt/clay percentages for each sample and plots a distribution curve for each sample.

Jet Probe

Jet probe logs were created for each probe site that detailed the sediment characteristics, penetration results and location (Appendix II). A total of ninety-one (91) samples were collected during the jet probe survey (Table 1).

**Table 1
Bogue Inlet Jet Probe Visual Grain Size Estimates**

	Surface Sample	Middle Sample	Bottom Sample
BIJP-02-01	0.21 mm	0.20 mm - 0.25 mm	0.20 mm - 0.25 mm
BIJP-02-02	0.30 mm - 0.35 mm	0.31 mm	0.30 mm - 0.35 mm
BIJP-02-03	0.25 mm - 0.35mm	0.20 mm - 0.30 mm	0.25 mm
BIJP-02-04	0.21 mm	0.20 mm - 0.25 mm	0.20 mm - 0.25 mm
BIJP-02-05	0.20 mm - 0.30 mm	0.24 mm	0.20 mm - 0.30 mm
BIJP-02-06	0.20 mm - 0.25 mm	0.20 mm - 0.25 mm	0.22 mm
BIJP-02-07	0.20 mm	0.15 mm - 0.25 mm	0.20 mm - 0.25 mm
BIJP-02-08	0.29 mm	0.30 mm - 0.40 mm	0.30 mm - 0.35 mm
BIJP-02-09	0.15 mm - 0.25 mm	0.26 mm	0.20 mm - 0.25 mm
BIJP-02-10	0.30 mm - 0.40 mm	0.35 mm - 0.40 mm	0.40 mm
BIJP-02-11	0.30 mm	0.25 mm - 0.30mm	0.30 mm - 0.35 mm
BIJP-02-12	0.35 mm - 0.40 mm	0.34 mm	0.35 mm - 0.40 mm
BIJP-02-13	0.35 mm - 0.40 mm	0.35 mm	0.35 mm - 0.40 mm
BIJP-02-14	0.25 mm - 0.30mm	0.20 mm - 0.25 mm	0.30 mm
BIJP-02-15	0.36 mm	0.30 mm - 0.35 mm	0.30 mm - 0.40 mm
BIJP-02-16	0.17 mm	0.15 mm - 0.25 mm	0.15 mm - 0.25 mm
BIJP-02-17	0.20 mm - 0.30mm	0.25 mm - 0.35mm	0.33 mm
BIJP-02-18	0.16 mm	0.15 mm - 0.25 mm	0.15 mm - 0.25 mm
BIJP-02-19	0.36 mm	0.40 mm - 0.45 mm	0.30 mm - 0.40 mm
BIJP-02-20	0.25 mm - 0.30 mm	0.22 mm	0.25 mm - 0.30mm
BIJP-02-21	0.20 mm - 0.25 mm	0.23 mm	0.20 mm - 0.30mm
BIJP-02-22	0.20 mm	0.20 mm - 0.30 mm	0.15 mm - 0.25 mm
BIJP-02-23	0.15 mm - 0.20 mm	0.20 mm - 0.30 mm	0.21 mm
BIJP-02-24	0.20 mm - 0.25 mm	0.19 mm	0.15 mm - 0.20 mm
BIJP-02-25	0.16 mm	0.15 mm - 0.20 mm	0.15 mm - 0.20 mm
BIJP-02-26	0.20 mm - 0.25 mm	0.20 mm - 0.25 mm	0.19 mm
BIJP-02-27	0.20 mm - 0.25 mm	0.23 mm	0.20 mm - 0.25 mm

 Sieve Analyses Sample

Sixty-four (64) were visually estimated for grain size estimate and twenty-seven (27), one from each jet probe site, were analyzed by mechanical sieving in accordance with the American Society for Testing and Materials Standard Materials Designation D422-63 for analysis of soils (ASTM, 1987). The resulting gradation analysis reports and distribution curves are in Appendix III and Appendix IV, respectively. The jet probe samples indicate that the proposed channel sediment is mostly gray fine to medium grained sand with occasional shell fragment or shell hash layers.

For this report the shoal has been sub-divided into five (5) regions (Figure 5). Region 1 is along the proposed channel corridor on the deeper portion of the shoal and outside of the breakers. Region 2 is along the proposed channel corridor on the shallow portion of shoal. Region 3 is along the proposed channel corridor within the backwater portion of the ebb shoal. Region 4 is near a small sand island that has formed as part of the backwater portion of the shoal. Region 5 is along the western edge of present day channel near two sand islands that has formed along the edge of the channel.

Ten (10) jet probes were obtained within Region 1. Overall the ten probes consisted of gray fine to medium grained quartz sand to a depth of -16.0 feet MLLW. In two of the probes a half foot (0.5) layer of sand with shell fragment layers was defined at an elevation ranging from -15 feet to -21 feet MLLW. In six of the probes a four foot (4.0) layer of sand with some shell fragment layers was defined at an elevation ranging from -17 feet to -27 feet MLLW. In one probe, on the outside of the shoal, a one foot (1.0) layer of clay was defined at an elevation of -35.9 feet, significantly below the depth of the proposed channel. The depths of penetration for the ten probes were all greater than -16.0 feet MLLW.

Ten (10) jet probes were obtained within Region 2. Overall the ten probes consisted of gray fine to medium grained quartz sand to a depth of -16.0 feet MLLW. Three (3) probes in Region 3 contain a 0.5 to 2.0 feet layer of sand with shell fragment between -3.0 to 10.0 feet MLLW. Two of the probes contain a 0.5 to 1.0 foot layer of silt sand. In five of the probes a two (2.0) to six foot (6.0) layer of sand with some shell fragment layers was defined at an elevation ranging from -8.0 feet to -12.7 feet MLLW. The depths of penetration for eight of the probes were greater than -16.0 feet MLLW. Two of the probes hit a resistant substrate at a depth of -13.0 feet MLLW and -15.6 feet MLLW.

Three (3) jet probes were obtained within Region 3. Overall the three probes consisted of gray fine to medium grained quartz sand. The depth of penetration for two of the probes was greater than -16.0 feet MLLW. The third probe hit a resistant substrate at a depth of -14.7 feet MLLW.

One jet probe was obtained within Region 4. The probe consisted of gray fine to medium grained quartz sand with a one (1.0) foot layer of silty sand at -5.0 feet MLLW and a one (1.0) foot layer of shell fragments with some fine grained sand at -8.0 feet MLLW. The probe hit a resistant substrate at a depth of -16.5 feet MLLW.

Three (3) jet probes were obtained within Region 5. Overall the three probes consisted of gray fine to medium grained quartz sand. The depths of penetration for the three probes were greater than -16.0 feet MLLW.

Vibracore

A total of five (5) vibracores were collected along the proposed channel relocation corridor. These cores were visually described and logged using USACE logging format (Appendix V), photographed at two foot intervals (Appendix VI) and archived at the University of North Carolina. Visual descriptions included sediment color, grain size, shell content, silt percent and thickness of each distinct unit. Samples from each distinct unit were taken and then analyzed by mechanical sieving in accordance with the American Society for Testing and Materials Standard Materials Designation D422-63 for analysis of soils (ASTM, 1987). A total of 21 samples were

analyzed and the resulting gradation analysis reports and the distribution curves are displayed in Appendix VII and Appendix VIII, respectively.

The channel cut analysis for the proposed channel used cut depths of 12, 14, 16 feet and total length of core. Vibracores BIVC-02-01 was taken on the shallow portion of the shoal along the proposed channel corridor. BIVC-02-01 was obtained in three stages with a total penetration of 19.3 feet and a total length of recovery at 18.0 feet at -19.0 feet MLLW. BIVC-02-01 is comprised of gray to light gray, fine to medium grained sand with a one (1.0) foot layer of shelly sand at -9.0 feet MLLW and a half foot (0.5) layer of shelly sand at -18.4 feet MLLW. The weighted mean grain size for BIVC-02-01 with a 12, 14 and 16 foot channel cut is 2.02F or 0.25mm, a weighted sorting of 0.81F and the weighted silt percent ranges from 1.43% to 1.46% (Tables 2 through 4).

Table 2 COMPUTED COMPOSITE DISTRIBUTION FOR 2002 BOGUE INLET VIBRACORES (12FT CUT)				
SAMPLE	PHI MEAN	MEAN (mm)	PHI SORTING	% SILT
BIVC-02-01	2.02	0.25	0.81	1.43
BIVC-02-02	1.86	0.28	0.79	1.23
BIVC-02-03	1.28	0.41	1.40	1.09
BIVC-02-04	1.94	0.26	0.84	1.21
TOTAL COMPOSITE	1.72	0.30	1.05	1.25
Note: Composite numbers obtained from gradation curves. Note: Cut Volume = ~700,000 cy				

Table 3 COMPUTED COMPOSITE DISTRIBUTION FOR 2002 BOGUE INLET VIBRACORES (14FT CUT)				
SAMPLE	PHI MEAN	MEAN (mm)	PHI SORTING	% SILT
BIVC-02-01	2.02	0.25	0.81	1.43
BIVC-02-02	1.89	0.27	0.75	1.23
BIVC-02-03	1.32	0.40	1.37	1.09
BIVC-02-04	1.91	0.27	0.88	1.22
TOTAL COMPOSITE	1.76	0.30	0.98	1.25
Note: Composite numbers obtained from gradation curves. Note: Raw Cut Volume = ~900,000 cy				

Table 4
COMPUTED COMPOSITE DISTRIBUTION FOR
2002 BOGUE INLET VIBRACORES (16FT CUT)

SAMPLE	PHI MEAN	MEAN (mm)	PHI SORTING	% SILT
BIVC-02-01	2.02	0.25	0.81	1.46
BIVC-02-02	1.91	0.27	0.72	1.23
BIVC-02-03	1.04	0.49	1.70	1.05
BIVC-02-04	1.78	0.29	1.14	1.22
TOTAL COMPOSITE	1.67	0.31	1.14	1.24

Note: Composite numbers obtained from gradation curves.

Note: Raw Cut Volume = ~1,000,000 cy

Vibracores BIVC-02-02 was taken on the shallow portion of the shoal along the proposed channel corridor. BIVC-02-02 was obtained in two stages with a total penetration of 18.0 feet and a total length of recovery at 16.7 feet at -17.9 feet MLLW. BIVC-02-02 is comprised of gray, fine to medium grained sand with a trace of shell fragments and shell hash. The weighted mean grain size for BIVC-02-02 with a 12, 14 and 16 foot channel cut ranges from 1.91F or 0.27mm to 1.86F or 0.28mm, a weighted sorting ranging from 0.72F to 0.79F and the weighted silt percent is 1.23% (Tables 2 through 4).

Vibracores BIVC-02-03 was taken on the shallow portion of the shoal along the proposed channel corridor. BIVC-02-03 was obtained in two stages with a total penetration of 19.5 feet and a total length of recovery at 17.1 feet at -18.1 feet MLLW. BIVC-02-03 is comprised of gray to light gray, fine to medium grained sand with a one and half (1.5) foot layer shelly sand at -8.3 feet MLLW and a four (4.0) foot layer of shelly sand at -14.0 feet MLLW. The weighted mean grain size for BIVC-02-03 with a 12, 14 and 16 foot channel cut ranges from 1.32F or 0.40mm to 1.04F or 0.49mm, a weighted sorting ranging from 1.37F to 1.70F and the weighted silt percent ranging from 1.05% to 1.09% (Tables 2 through 4).

Vibracores BIVC-02-04 was taken on the deeper portion of the shoal along the proposed channel corridor and outside of the breakers. BIVC-02-04 was obtained in three stages with a total penetration of 11.4 feet and a total length of recovery at 9.0 feet at -22.4 feet MLLW. BIVC-02-04 is comprised of gray, fine to medium grained sand with a one and half (1.5) foot layer of shelly sand at 16.6 feet MLLW and a one and half (1.5) foot layer of shelly sand at 18.5 feet MLLW. The weighted mean grain size for BIVC-02-04 with a 12, 14 and 16 foot channel cut ranges from 1.94F or 0.26 mm to 1.78F or 0.29mm, a weighted sorting ranging from 0.84F to 1.14F and the weighted silt percent ranging from 1.21% to 1.22% (Tables 2 through 4).

Vibracores BIVC-02-05 was taken on the deeper portion of the shoal along the proposed channel corridor in eighteen (18.0) feet water depth. BIVC-02-05 was taken in one stage with a

penetration of 11.0 feet and with a recovery length of 8.8 feet at -26.8 feet MLLW. BIVC-02-05 is comprised of gray, fine to medium grained sand with little shell fragments and shell hash. BIVC-02-05 was taken offshore of the proposed channel in eighteen (18.0) feet water depth and therefore will not be dredged. The mean grain size average is 2.43F or 0.19 mm with a sorting of 0.71F and silt percent average is 1.78% (Table 5).

Table 5 COMPUTED COMPOSITE DISTRIBUTION FOR 2002 BOGUE INLET VIBRACORES TOTAL CORE LENGTH				
SAMPLE	MEAN	(mm)	PHI SORTING	% SILT
BIVC-02-01	1.97	0.25	0.84	1.45
BIVC-02-02	1.90	0.27	0.72	1.23
BIVC-02-03	0.93	0.52	1.32	1.01
BIVC-02-04	1.39	0.38	1.37	1.13
BIVC-02-05	2.43	0.19	0.71	1.78
TOTAL COMPOSITE	1.68	0.31	0.98	1.29
Note: Composite numbers obtained from gradation curves.				

CONCLUSIONS

From July 16th to July 20th, 2002, twenty-seven (27) jet probes and five (5) vibracores were obtained within or adjacent to the proposed channel location and along the margins of Bogue Inlet. In general, the jet probe and the vibracores indicate a fairly uniform sand deposit throughout the proposed channel corridor with minor layers of shell fragments or shell hash and a weighted average of less than two (2.0%) percent of silt. No clay layers were found in any of the five cores taken. The mean grain sizes for a 12-foot cut channel ranges from 0.41 mm to 0.25 mm with a weighted average mean of 0.30 mm. The volume of sand within the 12-foot cut is approximately 700,000 cubic yards (Table 2).

The mean grain sizes for a 14-foot cut channel ranges from 0.40 mm to 0.25 mm with a weighted average of 0.30 mm. The volume of sand within the 14-foot cut is approximately 900,000 cubic yards (Table 3).

The mean grain sizes for a 16-foot cut channel ranges from 0.49 mm to 0.25 mm with a weighted average of 0.31 mm. The volume of sand within the 14-foot cut is approximately 1,000,000 cubic yards (Table 4).

Overall the sand consisted of gray fine to medium grained quartz sand with occasional layers with some shell fragment. No clay layers were found within proposed channel depth of cut. The

material with the proposed channel cut is coarser than the native sand and is low in silt content. The sand is suitable as beach fill.

REFERENCES

American Society for Testing and Materials. 1987. "Annual Book of ASTM Standards." Section 4 – Construction Volume 04.08 Designation D 422-63. 115-121 pp.