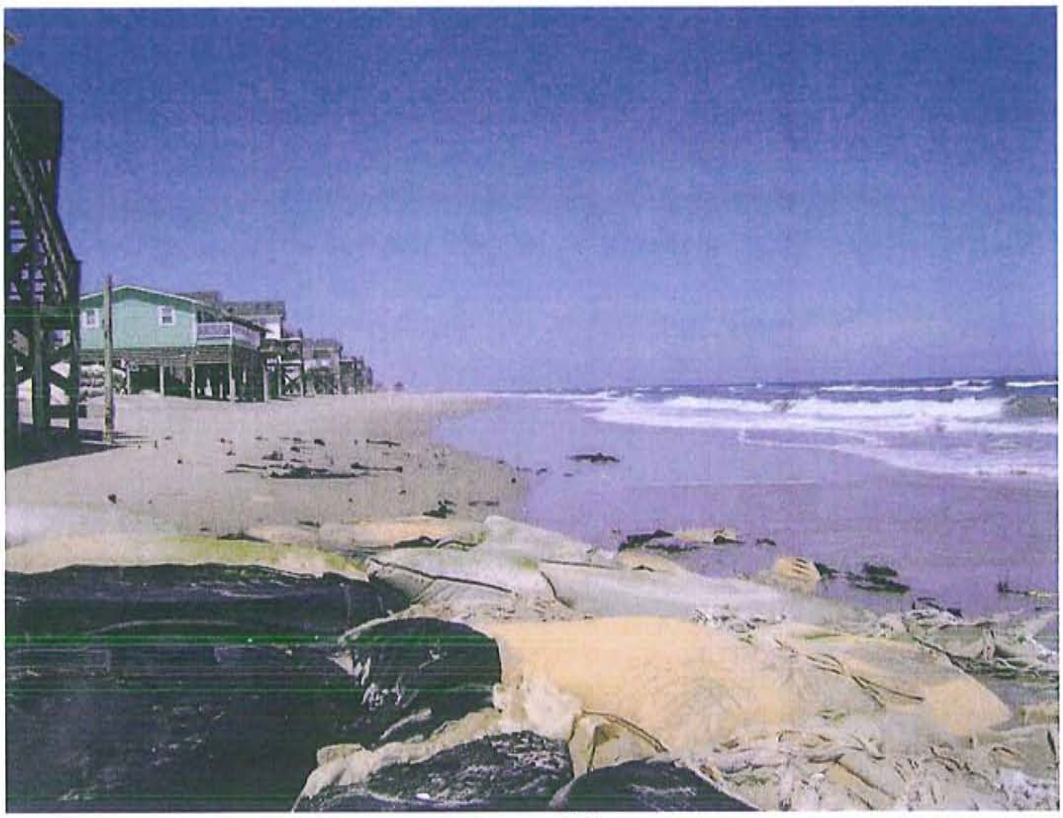
Nags Head Beach Nourishment Project
Pre-impact Report on Benthic Sampling
Spring, Summer, Fall 2010, and Winter 2011



Prepared for:

Town of Nags Head, Dare County, NC

Prepared by:

CZR Incorporated
Wilmington, NC
and
Coastal Science & Engineering, Inc.
Columbia, SC

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Nags Head Beach Nourishment Project
Pre-impact Report on Benthic Sampling
Spring, Summer, Fall 2010, and Winter 2011

EXECUTIVE SUMMARY

As required by North Carolina Department of Environment and Natural Resources (NCDENR)/North Carolina Department of Coastal Management (NCDCM) Permit 45-10 Beach Nourishment Town of Nags Head, four pre-dredge benthic sampling events occurred in the following areas:

- 10 Nags Head impact beach stations
- five Kitty Hawk control beach stations
- five Cape Hatteras National Seashore control beach stations, and
- 10 each offshore borrow and control stations in the S1 high quality beach nourishment material polygon identified by the Army Corps of Engineers.

The Nags Head impact beach (NHB) spans approximately 10 miles. The Kitty Hawk control beach (KH) is located between Kill Devil Hills to the south and Southern Shores to the north and spans approximately 2 miles. The National Seashore control beach (NSS) is located on Bodie Island directly adjacent to the ramp at the Coquina Beach recreation area. The middle NSS sample station is directly adjacent to the Coquina Beach ramp.

Each seasonal sampling event occurred over a two-day period, during a two-hour window either side of low tide, for a maximum of four hours of possible sample collection. Each beach sample station consisted of an upper-beach swash Zone A and a lower-beach subtidal Zone B. Offshore sample collection took one day with two divers deployed from a boat usually on the first day of sampling. Sediment samples were also collected at each beach and offshore station and analyzed for various parameters. The spring event occurred on 8-9 June 2010, the summer event occurred on 19-20 August 2010, the fall event occurred on 17-18 November 2010, and the winter event occurred on 14-15 April 2011. Even scheduling was highly weather-dependent and, therefore, could not be accomplished on an even quarterly basis.

OFFSHORE

During pre-impact sampling of the 20 offshore sample stations 71 taxa were identified from the 10 control stations and 75 taxa were identified from the 10 impact stations; 99 total taxa were identified from the four pre-impact sample events. The most abundant offshore taxon collected was *Ensis directus*, a razor clam, with 1,670 individuals identified from offshore impact and control stations (1,547 in the impact/borrow area). This taxon appeared in large numbers during the spring sampling event but this species was not found to be abundant in any other sampling events. Other taxa common across

offshore sampling events include sea squirts belonging to the class Ascidiacea, *Polygordius jouinae*, a polychaete worm, and juvenile bivalves. When all pre-impact sampling events are combined the average number of species per station for all offshore sites was 18.6 species; the combined control stations contained 17.3 species per station and combined impact/borrow stations contained 19.8. The number of species found per station during any sampling event averaged 5.6 taxa (borrow and control stations combined) with averages of 5.3 species per station in the impact stations and 5.9 in the control stations.

Grain size ranged from 0.311 mm to 0.761 mm with an average of 0.513 mm (coarse sand). Offshore grain sizes were similar to the subtidal Zone B of the Nags Head impact beach and the National Seashore control beach.

Offshore Comparison Summary:

- Seasonal variation exists between taxa richness, abundance, and dominant groups.
- Taxa richness was significantly different between impact/borrow and control stations during the summer sampling ($p=0.029$).
- Taxa richness was not significantly different between impact/borrow and control groups
- Average grain size per station was not significantly different between the impact/borrow and control stations.
- Using the Shannon index of diversity the impact/borrow stations were more diverse when all events are combined ($H'=2.44$) compared to the control stations ($H'=1.69$).
- When evaluating seasonal diversity the summer sampling was most diverse for both the impact/borrow ($H'=2.69$) and control stations ($H'=2.79$).

BEACH

A total of 34 taxa were recorded from all beach stations during the four pre-impact sample events with 28 taxa identified on the Nags Head impact beach and 26 taxa identified on the control beaches. The most common taxon collected from beach stations was *Scolelepis squamata*; a polychaete worm, with an abundance of 150 individuals from the impact beach and 507 individuals from the control beach. Other abundant taxa from the beach samples during pre-impact events include, *Amphiporeia virginiana*, an amphipod with 416 individuals, and *Donax variabilis*, a bivalve with 280 individuals. When all pre-impact sampling events are combined the average number of species per station for all beach sites was 5.8 species; the impact beach averaged 6.1 and the control beaches averaged 5.6 per station. When sampling events are not combined the average number of species found per station during any sampling event averaged 2.2 species; 2.6 species for the impact beach, and 2.1 species for the control beach.

Generally the grain sizes were largest on the Kitty Hawk control beach (1.62 mm) and smallest on the National Seashore control beach (0.51 mm) with the grain sizes on the Nags Head impact beach in between (0.79 mm).

Beach Comparison Summary:

- No significant difference was found between taxa richness at control and impact stations.
- No significant seasonal difference was found between taxa richness of control and impact stations.
- No significant Zone A or B differences were found between taxa richness of impact and control beach stations
- Abundance was higher at the control beaches than impact beaches.
- The impact beach is slightly more diverse (H'=2.058) than control beaches (H'=1.92)
- Grain sizes were smallest on the National Seashore control beach, largest on the Kitty Hawk control beach, with Nags Head impact beach grain sizes in between.
- Kitty Hawk beach zone grain sizes were significantly different from National Seashore's beach zone grain sizes.
- The swash Zone A of the Nags Head impact beach was significantly different from the swash Zone A of both the Kitty Hawk and National Seashore control beaches.
- The subtidal Zone B of the Nags Head impact beach was significantly different from the Kitty Hawk subtidal Zone B, but not from the National Seashore subtidal Zone B.
- Grain sizes from the swash Zone A of the Nags Head impact beach were significantly different from both the control and impact/borrow offshore stations; however, the grain sizes from the Nags Head impact beach subtidal Zone B was not significantly different than either offshore set of stations.

1.0 INTRODUCTION

This report was prepared in connection with requirements of NCDENR/NCDCM Permit 45-10 Beach Nourishment Town of Nags Head and in accordance with the benthic monitoring plan proposed and submitted to the Town of Nags Head and regulatory agencies in April 2010. The report presents methodology and results of the four seasonal pre-impact benthic sampling events (spring 2010 – winter 2011). The report was prepared under the direction of the Town of Nags Head and Coastal Science & Engineering, Inc. (project engineer).

2.0 METHODOLOGY

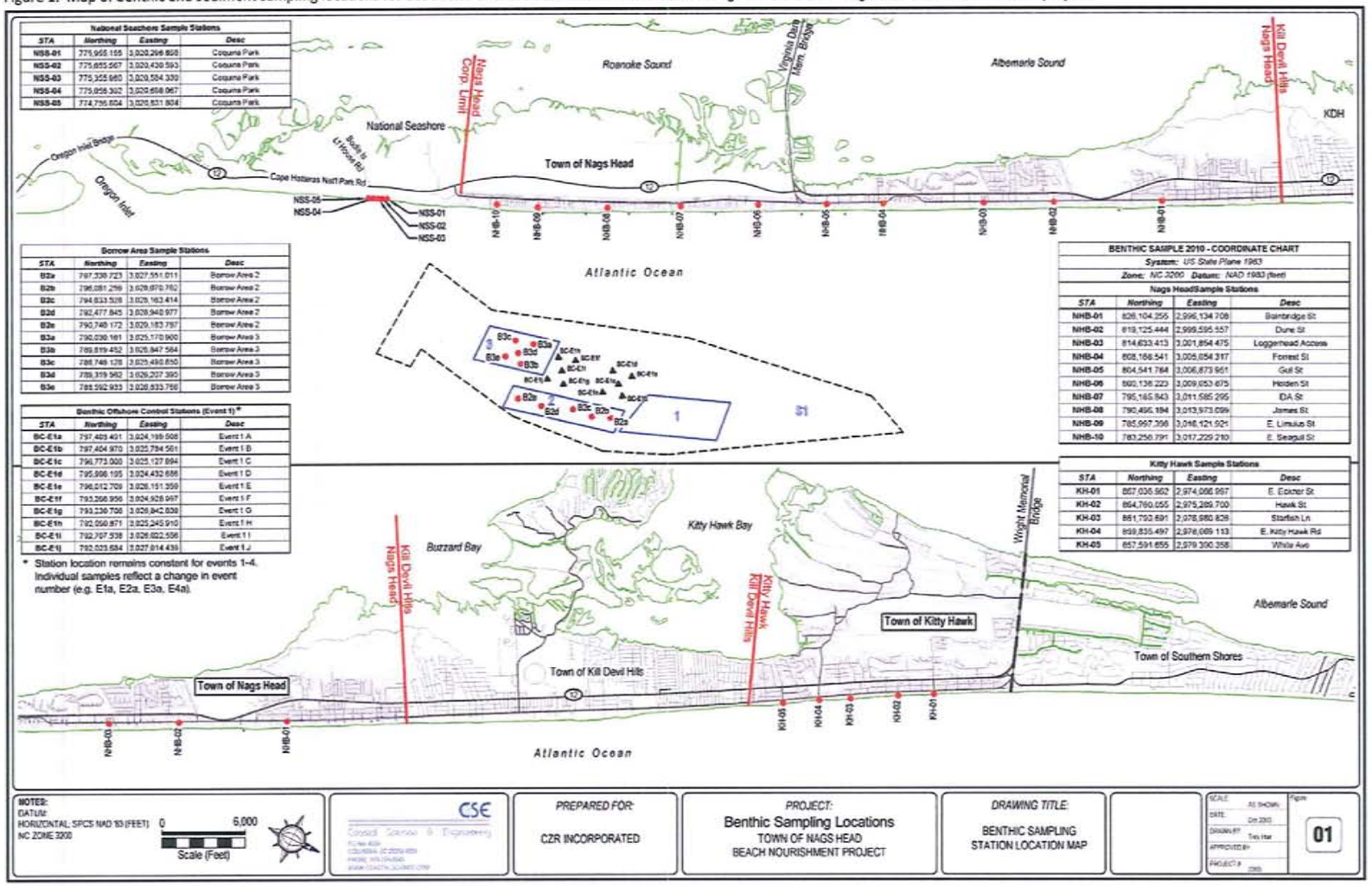
2.1 Borrow Stations Sampling

Ten (10) impact borrow stations and 10 control borrow stations were randomly selected within the S1 polygon identified previously by the Corps of Engineers (Corps) as an offshore borrow area for Outer Banks beach nourishment projects. The S1 area was further subdivided by the Corps of Engineers into 3 polygons designated as potential borrow areas for the Nags Head Beach nourishment project (1, 2, and 3) as shown on Figure 1. These areas are in approximately 40 feet of water. Five random GPS points (within the areas designated and at least 100 feet away from the edge) were generated in the S1-2 polygon (B2a- B2e) and five random GPS points were generated in the S1-3 polygon (B3a-B3e); these 10 points were the borrow impact stations. Ten (10) randomly generated GPS points were selected in the area outside of and between the three subarea polygons but still within the S1 polygon. Extensive coring and sediment analysis by the Corps and/or Coastal Science & Engineering (CSE) indicated points within this area would serve as the 10 borrow control stations (BCE1a-BCE1j). Tables within Figure 1 contain the GPS coordinates for all sample stations.

Coordinates for borrow stations were entered into the GPS system on the sampling boat and used to navigate and anchor the boat. Once anchored, a diver used two corers and four caps to collect the required sediment for benthic and grain size analysis (one core each). Sediment was collected with a clear 1.2 cm (0.25 in) thick acrylic tube/core with an approximately 10 cm (4-in) inside diameter and marked with tape at 15 cm (approximately 6 in) from the bottom. A full core up to the 15 cm mark contains approximately 1,180 ml. Samples were collected via a hand-driven corer and secured with sealed caps to create a vacuum and contain sediment.

The samples were then gently sieved with a 0.5-mm mesh bucket on the transom of the boat, preserved in 10 percent formalin with added Rose Bengal, and labeled during navigation between sample stations, boat anchoring, and diver preparation for the next sample collection.

Figure 1. Map of benthic and sediment sampling locations for beach and offshore stations with north and easting coordinates for Nags Head beach nourishment project.



National Seashore Sample Stations			
STA	Northing	Easting	Desc
NSS-01	775,955.155	3,028,266.808	Coquina Park
NSS-02	775,655.567	3,029,429.593	Coquina Park
NSS-03	775,355.680	3,029,584.330	Coquina Park
NSS-04	775,056.392	3,029,658.067	Coquina Park
NSS-05	774,756.804	3,029,831.804	Coquina Park

Borrow Area Sample Stations			
STA	Northing	Easting	Desc
B2a	797,338.723	3,027,551.011	Borrow Area 2
B2b	796,081.256	3,029,870.762	Borrow Area 2
B2c	794,833.528	3,029,163.414	Borrow Area 2
B2d	792,477.845	3,028,940.977	Borrow Area 2
B2e	790,748.172	3,029,183.757	Borrow Area 2
B3a	790,030.161	3,025,170.900	Borrow Area 3
B3b	789,819.452	3,026,847.564	Borrow Area 3
B3c	788,749.128	3,025,490.650	Borrow Area 3
B3d	789,319.562	3,026,207.395	Borrow Area 3
B3e	788,592.933	3,026,833.766	Borrow Area 3

Benthic Offshore Control Stations (Event 1)*			
STA	Northing	Easting	Desc
BC-E1a	797,483.491	3,024,199.508	Event 1 A
BC-E1b	797,404.970	3,025,784.561	Event 1 B
BC-E1c	796,773.000	3,025,127.694	Event 1 C
BC-E1d	795,996.195	3,024,432.686	Event 1 D
BC-E1e	796,012.709	3,026,151.359	Event 1 E
BC-E1f	793,266.956	3,024,928.997	Event 1 F
BC-E1g	793,236.706	3,026,842.838	Event 1 G
BC-E1h	792,056.871	3,025,245.910	Event 1 H
BC-E1i	792,707.538	3,026,822.506	Event 1 I
BC-E1j	792,023.684	3,027,814.439	Event 1 J

* Station location remains constant for events 1–4. Individual samples reflect a change in event number (e.g. E1a, E2a, E3a, E4a).

BENTHIC SAMPLE 2010 - COORDINATE CHART			
System: US State Plane 1983			
Zone: NC 3200 Datum: NAD 1983 (feet)			
Nags HeadSample Stations			
STA	Northing	Easting	Desc
NHB-01	826,104.355	2,996,134.708	Bainbridge St
NHB-02	819,125.444	2,999,595.557	Dune St
NHB-03	814,633.413	3,001,854.475	Loggerhead Access
NHB-04	808,186.541	3,005,054.317	Forrest St
NHB-05	804,541.764	3,006,873.951	Gull St
NHB-06	800,136.223	3,009,053.675	Holden St
NHB-07	795,165.843	3,011,585.295	IDA St
NHB-08	790,466.194	3,013,973.099	James St
NHB-09	785,997.398	3,016,121.921	E. Limulus St
NHB-10	783,256.791	3,017,229.210	E. Seagull St

Kitty Hawk Sample Stations			
STA	Northing	Easting	Desc
KH-01	857,036.562	2,974,066.997	E. Eckner St
KH-02	864,760.055	2,975,289.700	Hawk St
KH-03	861,792.691	2,978,980.828	Starfish Ln
KH-04	859,835.497	2,978,089.113	E. Kitty Hawk Rd
KH-05	857,591.655	2,979,390.358	White Ave

NOTES:
DATUM:
HORIZONTAL: SPCS NAD 83 (FEET)
NC ZONE 3200

0 6,000
Scale (Feet)

CSE
Coastal Science & Engineering

PREPARED FOR:
CZR INCORPORATED

PROJECT:
Benthic Sampling Locations
TOWN OF NAGS HEAD
BEACH NOURISHMENT PROJECT

DRAWING TITLE:
BENTHIC SAMPLING
STATION LOCATION MAP

SCALE: AS SHOWN
DATE: Oct 2010
DRAWN BY: Trey Hair
APPROVED BY:
PROJECT #: 2365

Figure 01

2.2 Beach Stations Sampling

Ten (10) impact beach stations and 10 control beach stations were selected based on proximity to existing beach profile stations, proximity to the beach sampling stations previously used during the CSA South benthic collections for the Town of Nags Head (CSA South 2008), and proximity to public beach access. With the exception of the five south control beach stations (see Section2.2.1 below), all other beach stations (impact and north control) are as shown in the draft monitoring plan submitted to state resource agencies in April 2010.

Each beach station (control and impact) was comprised of two sampling zones, the low-tide swash Zone A and the low-tide subtidal Zone B. The sampling window for all beach stations was presumed to be no more than two hours either side of the predicted low tide. The low-tide swash Zone A was the area of active wave run-up and the low-tide subtidal Zone B was assumed to be knee deep water. The sediment collector was the same as the corer used for the offshore sample collection. Three cores were collected at random locations in each zone and deposited in a tray. Sediments from these three cores were gently mixed in the tray and then a 1,000 ml Nalgene sample jar was filled, labeled inside and out, and transported to iced coolers.

Upon completion of beach sampling, all benthic beach samples were gently sieved through a 0.5-mm mesh bucket, placed in labeled sample jars, and preserved in 10 percent formalin with added Rose Bengal, and stored in coolers for transport.

While care was taken to carefully turn and upend the jars after the formalin was added in an effort to distribute the fixative throughout the sample, at the laboratory, some organisms from the spring event did not appear to have been as exposed to the fixative or to the Rose Bengal as others. This seemed to have been a random occurrence, but may be related to poorly-sorted sediment preventing thorough mixing of the formalin and/or too much sediment in the jar. To avoid the latter and guard against the former, the three subsequent sampling events followed the 2009 EPA field protocols dated 23 April 2010 which require use of more than one jar per sample if the sampled sediment fills the jar more than halfway (USEPA 2009).

2.2.1 Relocation of Cape Hatteras National Seashore South Control Beach Stations (NSS01-NSS05)

After submittal of the draft benthic monitoring plan in April 2010, further consultation among CSE, CZR, and NC Division of Marine Fisheries determined that the NSS control stations could be moved due to the potential during the course of the study for some, or all, of the NSS beach sampling stations identified in the draft plan to be within restricted access areas as designated by the National Park Service. The stations were moved to the vicinity of Coquina Beach Access Ramp 2 and the spacing between sites was reduced. The revised station locations were set up 100 meters apart with the center station, NSS03, located perpendicular from the Ramp 2 signpost as shown in Figure 1. This change was necessary in order to preserve a high likelihood that the same south beach control stations can be used for the duration of the monitoring.

2.3 QA/QC Benthic Sorting and Identification

Benthic samples were sorted and identification of taxa was completed by CZR; however, ten percent of samples were sent to an outside laboratory for re-sorting and re-identification (two control beach samples, two impact beach samples, and two borrow samples). These samples were selected upon completion of the majority of the sorting and identification effort to make best use of the QA/QC process. The selection methodology of which samples to send to the lab for QA/QC ensured that the benthic ecologist had no pre-knowledge of which samples would be selected.

Taxa identified only to genus were not counted when another taxon identified to species shared that genus. Similarly, a taxon identified to a family level or higher was not counted when taxa in that family or group were identified to a lower taxonomic level. Appendix A contains a complete list of taxa identified seasonally from control and impact stations on the beach and offshore.

2.4 Sediment Sampling

Following the same methodology as described above for benthic samples, a fourth core sample was taken at each beach station zone (40 cores) and a second core sample was taken at each offshore location (20 cores) for sediment analysis. These samples were labeled and sealed in plastic bags and analyzed for grain size and calcium carbonate content.

Sediments collected were analyzed in the CSE lab via standard dry-sieving at 0.5 phi intervals and the results provided to CZR Incorporated in a digital format. Appendix B contains graphic depictions of grain size distribution and other data from each sampling event

2.4.1 Percent Calcium Carbonate Substituted for Percent Organic

Subsequent to the April 2010 monitoring plan submittal and after the June 2010 sampling event, additional correspondence among CZR, CSE, and NCDCM representatives (Anne Deaton of the Wilmington office and Jeff Warren of the Raleigh office) resulted in a decision to analyze the sediment for percent calcium carbonate by acid digestion for all events as opposed to percent organic content by combustion as specified in the draft plan. Analysis followed ASTM Method D2487 for classification of soils where sieve sizes range from 4.75 mm (US Standard sieve No. 4) to 63 µm (US Standard sieve No. 230) and sediments were categorized by Wentworth's classification (Wentworth 1922).

3.0 RESULTS

For ease of future comparison some graphic depictions of benthic data were modeled after previous sampling efforts performed by Versar for the U.S. Army Corps of Engineers (Versar 2006). The "groups" classification used in the Versar reports is not a formal taxonomic classification; class, orders, subphyla, and other formal classifications are retained under the umbrella of "group" for this report as well as for Appendix A. Taxa richness, abundance, number of groups, and diversity indices were calculated. To evaluate the diversity and evenness of all species found, the Shannon Index of diversity was utilized. Values for this index typically range from 1.5 (low diversity) to 3.5 (high diversity).