FINAL
MONITORING PLAN

ASSESS POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH THE DARE COUNTY BEACHES (BODIE ISLAND) SHORELINE PROTECTION PROJECT DARE COUNTY, NORTH CAROLINA

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SHORELINE PROTECTION PROJECT
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1.0 Introduction

The purpose of this study plan is to describe the environmental monitoring that will be performed in order to assess the biological impacts of the Dare County beach replenishment project at both the sand borrow sites and at the beaches being restored. Initial construction will entail placement of approximately 8,000,000 cubic yards of sand in the South Project Area, and 4,300,000 cubic yards in the North Project Area, for a total volume of 12,300,000 cubic yards. Initial construction is scheduled to begin in late calendar year (CY) 2005 for both the North Project Area, and the middle segment of the South Project Area. The remaining two phases for initial construction of the South Project Area will begin in late CY 2006 for the southern segment and in late CY 2007 for the northern segment. Beach fill material for the North and South Project Areas will be excavated from the N1/N2 and S1 borrows site located about a mile offshore of Kill Devil Hills and Nags Head, NC, respectively (Figure 1).

Versar Inc. was awarded a contract from the Wilmington District of the U.S. Army Corps of Engineers to develop a monitoring plan based on their overall experience in rigorous statistical design of natural resources surveys and ecological monitoring programs, and, in particular, their recent experience in monitoring a very similar beach replenishment project in Brunswick County study (conducted as part of the Cape Fear River Deepening). After the July 17, 2003 award of the contract, an initial meeting with agency personnel, community planners, environmental groups, and concerned citizens was convened in Kill Devil Hills on August 12, 2003. Approximately 15 people attended the meeting and participated in a site visit to the project area. The attendees were encouraged to voice any particular concerns they may have about the project and to comment on what issues should be addressed in the monitoring plan. Because the plan was in the initial stages of development at the time, only a broad outline of potential monitoring program elements and a sampling schedule were discussed at that meeting. The draft monitoring plan was sent to all attendees at the meeting and other interested parties who were invited to submit format comments by December 19, 2003. Responses to comments are summarized in Appendix A. This monitoring plan has been revised based on comments received.

The USACE made it clear that they would conduct two years of pre-construction monitoring (to establish a baseline), one year of direct impact monitoring, and at least two years of post-construction monitoring (to assess recovery). Because the construction schedule calls for beach replenishment to commence in late CY 2005 at the North Project

Area (Figure 1), this beach and associated borrow sites was selected for monitoring. The South Project area will not be monitored because

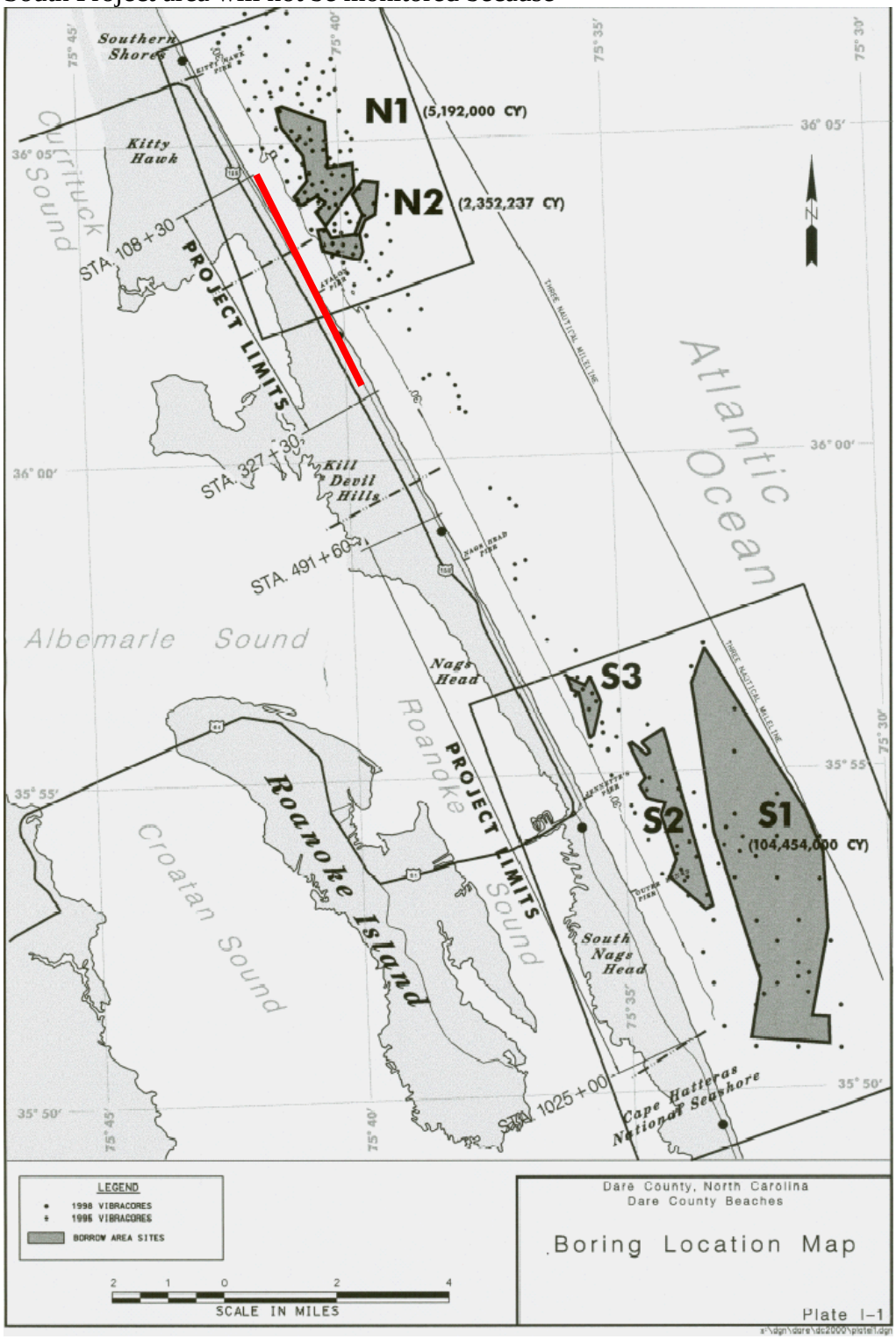

Figure 1. Locations of the North and South Project area and their respective borrow sites for the Dare County beach replenishment project. Red line indicates the approximate location of subject beach study area in the North Project Area. The reference site for the beach sampling is depicted in Figure 2.

there are few physical differences among the beach project area. Thus, the monitoring results at the Northern Project Area will be adequately representative of responses that would occur throughout the entire project area.

This draft monitoring plan consists of four major elements including:

- Pre-construction, during construction, and post-construction monitoring of the project's effects on surf-zone benthic and fish communities (beach studies)
- Pre-excavation, during excavation, and post excavation monitoring of the project's effects on borrow site benthic and fish communities (off-shore studies)
- Weekly shorebird monitoring on the subject and reference beach
- Weekly recreational fishing surveys on the subject and reference beach

2.0 Study Plan

2.1 Beach Effects and Recovery

2.1.1 Pre- and Post-construction Beach Monitoring

Seasonal sampling (i.e., winter, spring, summer, fall) based on a stringent experimental design will be conducted at a series of ten (10) dune to surf zone transects systematically located along the length of the North Project Area (Figure 1) and at ten (10) transects along a reference beach (Figure 2) two years prior to construction and two years after construction (Table 1). The beach will be divided into ten longitudinal segments, with transects randomly positioned at within each segment. The transects will coincide with the physical monitoring transects (conducted by another contractor) and will remained fixed for the duration of the program. The locations of the transects will be fixed for the length of the study to strengthen the ability to detect temporal changes in abundance, biomass and population characteristics resulting from the beach replenishment. Fixed transects over time will reduce the effects of spatial variability, thus enhancing the power for detecting temporal changes. Seasonal sampling will be conducted within a two-week window and confined to similar temporal periods, water temperatures, and weather conditions to the extent that project logistics allow.

The reference beach will be located in a similar surf-zone beach habitat north of the replenishment project near the USACE Coastal and Hydraulic Laboratory facility in Duck, NC. All benthic and fish parameters measured at the subject beaches will also be measured at ten systematically allocated transects established at the reference for each seasonal sampling event. The reference beach will be similar in length to the subject beach (3 miles) with transects spaced randomly within ten segments.

Table 1. Generalized monitoring schedule for the North Project Area for the Dare County beach replenishment project.				
2004	2005	2006	2007	2008
Pre-construction	Pre-construction	During Construction	Post-construction	Post-construction

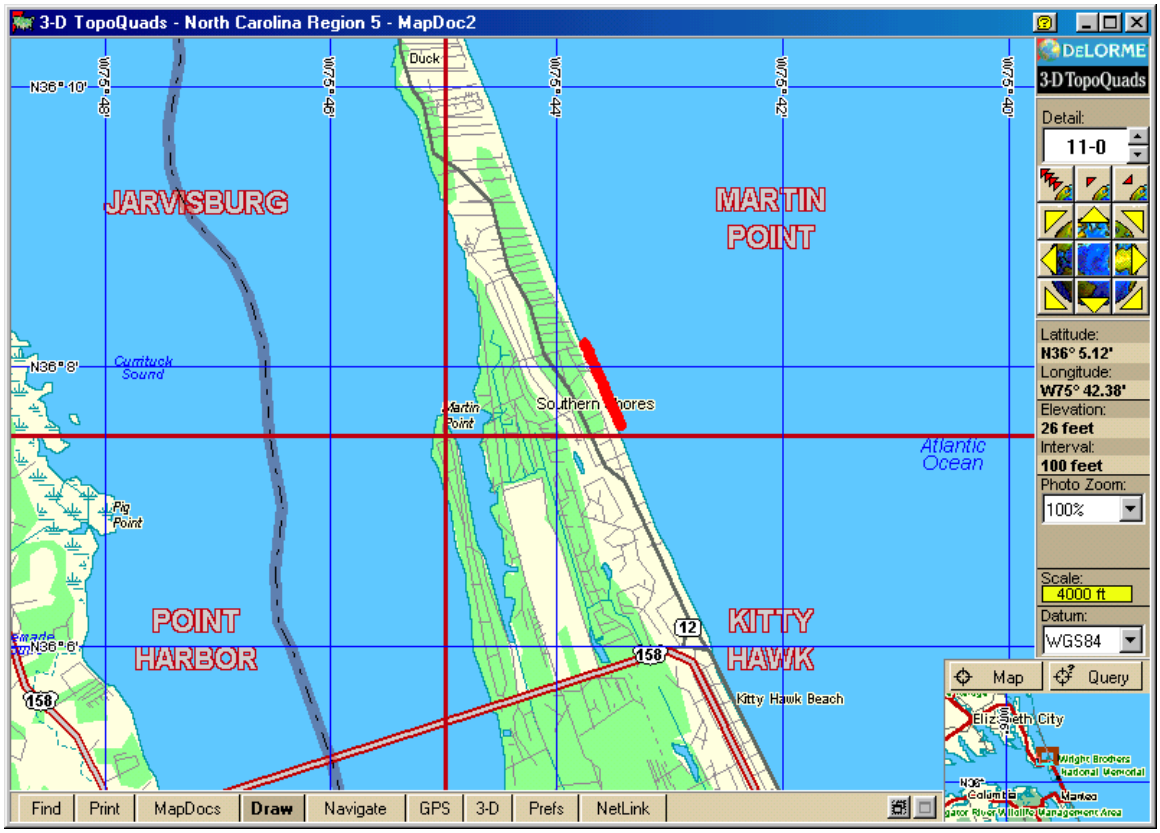

Figure 2. Location of reference beach north of Kitty Hawk, NC (site near the USACE Field Research Facility)

Benthic Sampling

Benthic invertebrate species composition, abundance, and biomass will be quantified by collecting bottom grab samples in swash zone and shallow sub-tidal habitats. The shallow sub-tidal habitat is defined at that area below the low tide line in about 2 feet of water. No sampling in the deep habitat (the zone just outside the breaking waves in about 12 feet of water) is proposed. Studies conducted on the Brunswick County beaches indicated that this habitat was marginally affected by beach replenishment activities (Versar 2002 and 2003) making the additional effort for monitoring this habitat unjustified. One sample will be collected in each habitat at each of the ten transects on the subject beach. Similarly, one sample per habitat will be collected at each of the ten transects at the reference beach for each seasonal event. Replicate samples at each sampling point along the ten transects is not recommended as we are interested in characterizing the conditions along the entire length of the subject beach, not at one particular spot. For the Brunswick study we collected two replicate samples in each habitat along eight transects. Analysis of the replicate samples indicated that the observations from the samples taken in one small area were more similar than observations from different transects. For this study we used an intra-cluster correlation coefficient (Snedechor and Cochran 1980) to measure the homogeneity of samples taken near each other relative to samples among transects. The results indicated that we would have been much better off if we had spread our sampling points out along the beach rather than taking multiple samples at one point.

To determine the appropriate number of samples we used a proportional odds model (Agresti 1990) to compute the power of detecting shifts in the distribution of abundance or biomass data collected before and after impact using the Brunswick County data. In principle, data on abundance or biomass collected before impact can be grouped into four ordered categories, from low to high abundance levels, based on the quartiles. Using this approach, the null hypothesis for a test then can be that the distributions of samples by abundance category are the same before and after impact (25% in each). The alternative hypothesis could specify that the samples collected after impact has a distribution of values that is shifted towards lower abundance categories. We used a proportional odds ratio of two for the alternative hypothesis (i.e., the impacted samples would be twice as likely as the before samples to be in a lower category), corresponding to 71% of samples being in the low abundance category and only 4% being in the highest abundance category. Using Proc-StatXact we estimated that ten samples per habitat will provide a power of over 80% to detect a shift in abundance or biomass for benthic communities (Table 2) of at least this magnitude for an alpha level of 10%. This is a reasonable balance of type I and type II errors.

Table 2. Power for detecting a shift in distribution of abundance and biomass data, with before impact samples having equal distributions, and the after impact samples showing a shift towards lower values with proportional odds ratio of 2.0.

	Alpha-level	
Sample size per habitat (n)	**5%**	**10%**
5	31	50
6	42	62
7	50	67
8	58	73
9	65	78
10	70	82

Swash zone and shallow subtidal samples will be collected at or near low tide from the beach by wading out into the surf-zone approximately 30-feet from the low tide line with a handheld ponar grab. The ponar grab will be worked into the sediment by stepping on the top of the grab in shallow water so that the depth of sample will be 10-cm. All samples will be sieved through a 0.5mm screen and all retained organisms will be identified to species (or lowest practical taxon) and counted for both the swash and shallow subtidal samples. After identification and enumeration, organisms will be grouped into predetermined taxonomic levels for ash-free dry weight (AFDW) biomass determinations. AFDW biomass will be determined by (1) drying and weighing each taxonomic group to a constant weight at 60 °C, (2) ashing in a muffle furnace at 500 °C for 5 hours, and (3) weighing the remains. For each seasonal event at the subject beach and the reference beach, a combined total of 40 benthic samples will be collected, yielding 160 benthic samples per year (Table 3).

Area counts of ghost crab holes shoreward of each sampling transect will be conducted during each sampling event. While the ghost crab hole data collected in the Brunswick county study were of limited value, the minimal time it takes to collect this information warrants its inclusion in the program. Two 30-foot long transects parallel to shore will be marked on wrack line of the beach and all ghost crabs holes behind each transect extending to the toe of the dune will be recorded. To provide replicate counts within each 30-foot section each swash zone to dune toe ghost crab borrow count sequestered into five six-foot wide “counting” lanes. The distance from the wrack line to the dune toe will be noted to provide a ghost crab density estimate for each sampling area. One ghost grab will be assumed to occupy each active hole.

Sediment samples for grain size analysis will be taken at the ten swash and ten shallow samples for both the subject beach and reference beach. Grain size will be measured using ASTM Method D2487. Sieve sizes will range from 4.75 mm (U.S. Standard Sieve No. 4) to 63 micron (U.S. Standard Sieve No. 230). The primary purpose of the grain size analysis is to provide ancillary qualitative information on sediment conditions to help interpret the benthic invertebrate results. To provide information on changes in shell distribution that may affect foraging shore birds large shells will be

counted as well. The grain size samples will be collected directly adjacent to the benthic sample grabs using the same gear. The ten samples for each habitat will be composited for both the subject beach and reference beach for a total of 4 grain size samples per season (Table 3). Based on the Brunswick County work grain size distribution within the swash and shallow habitats were very similar so composite samples between the subject beach and reference beach should be adequate to help discern benthic community parameter differences that are related to grain size. Because sediment characteristics can influence benthic community composition, these data can be used partition project impacts from natural variation due to sediment effects.

Haul Seine Sampling

Commercial haul seine collections will be conducted in the proximity of each of the ten subject beach transects and the ten reference beach transects using a 250 yard haul seine (half the length typically deployed in this local fishery). Use of half the length of the commercial seine is advantageous because it can be deployed and retrieved more rapidly, thereby increasing the number of hauls that can be taken for a fixed survey cost. Also, deploying the entire length of haul seine (500 yards) would sample too large an area (i.e., bottom habitats not impacted by the beach replenishment). The haul seine will be deployed in a semi circle so that an approximate sampling radius of 125 yards will be swept for each sample. Seine mesh size will be 3-inch stretch and will target larger recreationally and commercially important species. This effort is expected to take about four field days per season as the local commercial fishermen that will be contracted to conduct the hauls estimate that each sample will take about two hours to deploy, retrieve, and work up the catch. Beach seining will be restricted to relatively calm conditions (wave height of 2-feet or less). Each seasonal haul seine sample will be collected in conjunction with one sample at the ten reference site transects near Duck, NC. Versar fisheries biologists will accompany the commercial haul seiners to direct and assist with the sampling effort and record the catch data. Sampling at or near low tide is recommended to control for possible differences if fish abundance among various tidal stages and to provide an area to work on the eroded beaches. Fishes and macroinvertebrates (e.g., crabs and shrimps) will be identified to species and enumerated. A random sample of 25 specimens for each species will be measured for total length for each seine haul.

Three target species of demersal feeding adults fish taken from the haul seine samples will be retained for gut content analysis. Fish species with demersal feeding habitats that are closely linked to the benthic invertebrates that will be directly impacted by the beach re-nourishment will be selected. Anticipate target species include gulf kingfish, spot, spotted hake, Florida pompano, black drum, or Atlantic croaker. Seasonal changes in fish composition may require that we use more than three target species over the course of a year. These data will be used to estimate prey selectivity by fishes and evaluate feeding responses of fishes to changes in densities of invertebrate prey species caused by the beach construction. The stomach of fish from specimens selected for gut content analysis will be dissected upon collection and immediately frozen on dry ice or in a portable freezer to prevent the digestion of soft-bodied organisms. Gut content analysis

will include identification to the lowest practical taxon, and frequency of occurrence of each taxa. For the entire gut contents the percent full, total dry-weight biomass of prey items found in the stomachs will be measured. The sampling of stomachs for each species will be stratified by size class, with two stomachs collected from each length class. The analysis of stomachs collected for each target species will be spread out across stations, and over time. Initially a minimum of 5 stomachs will be analyzed for each target species from any individual catch. Because intra-haul correlation is expected for prey items, little loss in precision is expected to result from this subsampling as compared to sampling all stomachs (Pennington and Vølstad 1994a, 1994b; Bogstad et al. 1995).

Table 3 presents a summary of the proposed sampling effort for each year of the pre- and post-construction monitoring effort on the subject and reference beach.

Table 3. Summary of proposed sampling effort each year of the pre- and post construction monitoring for the subject and reference beaches.

	Winter	**Spring**	**Summer**	**Fall**
Subject Beach				
Ghost Crab Transects	**20**	**20**	**20**	**20**
Benthic - Swash	**10**	**10**	**10**	**10**
Benthic - Shallow	**10**	**10**	**10**	**10**
Grain Size (swash and shallow)	**2**	**2**	**2**	**2**
Haul Seine - Fish	**10**	**10**	**10**	**10**
Reference Beach				
Ghost Crab Transects	**20**	**20**	**20**	**20**
Benthic - Swash	**10**	**10**	**10**	**10**
Benthic - Shallow	**10**	**10**	**10**	**10**
Grain Size (swash and shallow)	**2**	**2**	**2**	**2**
Haul Seine - Fish	**10**	**10**	**10**	**10**

2.1.2 During Construction Beach Monitoring

As the beach construction moves through the North Project area, seasonal sampling will be conducted behind and in front of the pipeline using an experimental design that is effective for assessing short-term recovery. Four transects will be positioned near the beach replenishment operations. Three transects will be positioned behind the end of the pipeline to correspond to sections of the beach that were replenished at fixed time intervals representing 2, 4, and 8 weeks of recovery prior to the sampling event (Figure 3). To assess conditions prior to construction during each seasonal event, one transect will be placed in front of the pipeline, in close proximity to the pipeline but with sufficient distance to avoid any down drift effects from the beach re-nourishment. Short-term recovery for each season will be assessed from data collected on one sampling event per season. The exact location of each transect will be repositioned each season according to the progression of the beach replenishment, which will be carefully monitored throughout the construction period. The primary advantage of this design is that samples are collected simultaneously in sections of the beach that are in various recovery states, thus removing the influence of natural temporal variation in the abundance, biomass, and composition of benthic communities that could mask effects of the replenishment. The proposed design will provide estimates of average abundance (biomass) at 2, 4, and 8 week recovery periods and for sites in front of the pipe (control) across seasons and space. Thus, there is a spatial/temporal replication incorporated into the design. Although, spatial and temporal patterns cannot be separated, the study should provide estimates of average abundance (biomass) for each recovery period. If the pre-construction sampling indicates strong spatial patterns along the alternative designs for estimating short-term impacts will be considered. One possible approach is to sample one or more small areas in front of the pipe, and then re-sample these areas after 2,4, and 8 weeks of recovery time has passed.

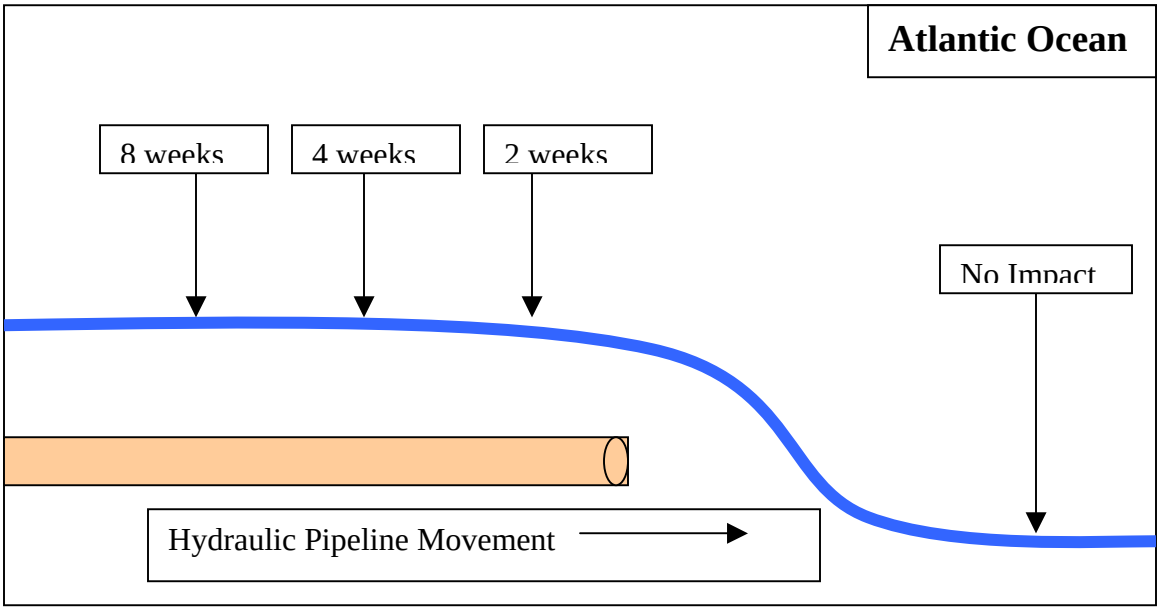

Figure 3. Schematic of during construction seasonal sampling at three recovering and one non-impacted transect on the subject beach.

Benthic Sampling

For each seasonal during-construction event, five replicate samples will be taken within each habitat (swash and shallow) at the four transects, for a total of twenty (20) samples per habitat (Table 4). Because we are interested in short-term differences related to recovery from the beach replenishment, replicate sampling at each specific site is needed to differentiate between small scale spatial variation and parameter differences related to various recovery time periods. Along with the subject beach sampling, one sample per habitat will be taken at each of the ten reference site transects. One composite sediment sample will be collected at each habitat along the four subject beach transects for grain size analysis, for a total of eight (8) samples (Table 4). Two composite grain size samples will be collected among the ten transects at the reference beach (swash and shallow) for a total of 10 samples for each construction season collection event. Ghost crab hole counts behind each transect will also be conducted following the protocols established for the pre- and post-construction monitoring.

Haul Seine Sampling

For each seasonal event, replicate hauls seine will be conducted behind and in front of the pipeline in proximity to the areas established for the benthic sampling. The four stations will be sampled on two consecutive days to provide two replicate samples for each transect (due to the large size, anticipated large catches and the complicated nature of haul seining, only about 4 to 5 haul seines can be accomplished in a day). Sampling at or near low tide is recommended to control for possible differences if fish abundance among various tidal stages and to provide an area to work on the eroded beaches.

Three target species of demersal feeding adults fish taken from the haul seine samples will be retained for gut content analysis. Gut content analysis will include identification to the lowest practical taxon, and frequency of occurrence of each taxa. For the entire gut contents the percent full, total dry-weight biomass of prey items found in the stomachs will be measured. The sampling of stomachs for each species will be stratified by size class, with two stomachs collected from each length class. The analysis of stomachs collected for each target species will be spread out across stations, and over

time. Initially a minimum of 5 stomachs will be analyzed for each target species from any individual catch.

Table 4 presents a summary of the proposed sampling effort for the construction year monitoring effort on the subject and reference beach.

Table 4. Summary of proposed sampling effort during the construction year monitoring for the subject and reference beaches.

	Winter	**Spring**	**Summer**	**Fall**
Subject Beach				
Ghost Crab Transects	**8**	**8**	**8**	**8**
Benthic - Swash	**20**	**20**	**20**	**20**
Benthic - Shallow	**20**	**20**	**20**	**20**
Grain Size (swash and shallow)	**8**	**8**	**8**	**8**
Haul Seine - Fish	**8**	**8**	**8**	**8**
Reference Beach				
Ghost Crab Transects	**20**	**20**	**20**	**20**
Benthic - Swash	**10**	**10**	**10**	**10**
Benthic - Shallow	**10**	**10**	**10**	**10**
Grain Size (swash and shallow)	**2**	**2**	**2**	**2**
Haul Seine - Fish	**10**	**10**	**10**	**10**

2.2 Borrow Area Effects and Recovery (Borrow Area N1/N2)

2.2.1 Pre- and Post-construction Borrow Area Monitoring

To assess the long-term ecological effects and recovery from the sand excavation at the offshore borrow site, seasonal sampling of benthic invertebrates and fish communities

and remote bottom imaging is proposed. The area within borrow site N1/N2 that will be used as a source of sand for the North Project Area will be delineated based on consultant with the USACE and the dredging contractor. The borrow area reference will be selected based on the result of a bottom imaging survey to be conducted prior to initiating the program. To verify that the selected off-shore reference site posses similar physical and biological characteristics to the borrow site a two-day bottom imaging survey (see below) will be conducted at the beginning of the program at Borrow Site N1/N2, Borrow Site S1 (to verify similar surface conditions exist relative to N1/N2), and potential areas around North Project Area and South Project Area borrow sites in state waters. Based on these data the reference site will be selected such that the physical and biological features are similar to those observed at Borrow Area N1/N2. To avoid any disturbance of the study area during the seasonal sampling the benthic collections will be done first, followed by the bottom imaging, and finally the trawl survey to the extent that is logistically feasible.

Benthic Sampling

Seasonal benthic surveys of invertebrate abundance, species composition, and biomass will be conducted at the borrow site and its respective reference site. For each seasonal sampling event ten (10) borrow area and ten (10) reference site samples will be collected (Table 5). Based on our power analysis of the Brunswick County sampling we anticipate a power of 0.80 to detect differences. Grabs will be taken using a Young grab deployed from Versar's sampling vessel. Any grabs that penetrate less than 7-cm of sediment will be rejected and re-sampled. Each benthic invertebrate sample will be accompanied by a grain size sample (i.e., not composited) because sediment characteristics can influence benthic community composition, particularly in this deeper habitat that is expected to have a higher variation in sand and slit content relative to surf-zone habitats. These data will help partition project impacts from natural variation due to sediment effects.

Bottom Imaging

To characterize large epi-benthic fauna and macro-scale physical features within the borrow site and reference site a late summer bottom imaging survey will be conducted in the two pre-construction and the two post-construction years of the project. The bottom imaging will be accomplished using an epi-benthic sled equipped with an underwater camera and light strobe, with tracks allocated to provide representative samples from the study area. The bottom imaging will be done along established tow lanes that will be consistently re-sampled in subsequent years. Thousands of geo-referenced images will be recorded over the subject borrow site and reference site. Images will be post-processed in the laboratory where both physical and biological bottom features will be examined and categorized. The physical and biological categories will provide information on relative complexity of the bottom habitat and will help evaluate changes in the habitat caused by dredging operations. Bottom imaging will be conducted over a two-day sampling effort before the seasonal trawl sampling to avoid altering the habitat by the trawl gear (one day each for the Borrow Site and reference site).

The towed sled (Figure 4) will have three video cameras mounted in three different configurations to provide a broad overview of: 1) the bottom water column and cables leading to the surface, 2) near bottom horizontal view to see fish over the bottom and bed form types, and 3) a vertical high resolution view for sediment type and biogenic features. The broad overview camera will be mounted about 1.5 feet off the bottom and angled to view the bottom out in front of the sled from 6 to 30 feet. The near bottom horizontal camera will be mounted 1.2 feet off the bottom at an oblique angle of 20^{o} to provide a close-up view of bottom morphology and the presence of juvenile fish and other mobile fauna from 1.2 to 3 feet in front of the sled. The vertical camera will be mounted perpendicular to the bottom of the sediment surface. Illumination for the vertical and horizontal cameras will be provided by electronic video strobes. The video sled will be linked to the surface via two cables that provided power to the cameras and strobes. The video signals will be transmitted to the surface where sled performance and bottom features can be viewed in real-time. The video signal from each camera will be multiplexed and recorded on to a single master tape that will be used for aligning the video from the horizontal and vertical cameras. Video signals from the horizontal and vertical cameras will also recorded on higher resolution digital recorders for later analysis. Video data files for each region of interest and reference site will be combined with the DGPS positions by aligning timing mark placed in the DGPS files, the time code recorded with the multiplex video, and the time code generated by the digital video recorders used with the horizontal and vertical cameras.

Benthic habitats will be classified by analyzing videotapes recorded from the horizontal and vertical cameras. Physical and biological features will be sampled from the recorded videotape at 2.5-minute intervals. All fish visible from the forward or downward cameras will be identified to the lowest possible taxon and physical and biological features of the benthic habitats at the instance the fish was will be recorded. Data on bed roughness, sediment type, shell hash, biogenic structures, epifaunal organisms, and fishes and rays will be collected and entered into an excel spreadsheet

Bottom habitats will be classified based on both physical and biological characteristics. Physical characteristics will include variables for bedforms type and size, which are primarily wavelength and form, and sediment grain size. Biological characteristics included variables for shell fragment cover, mobile fauna, sedentary fauna, and other biogenic structures (Figure 5). Maps of the various biological and physical bottom features will be made using GIS software for each seasonal survey similar to the map presented in Figure 6.

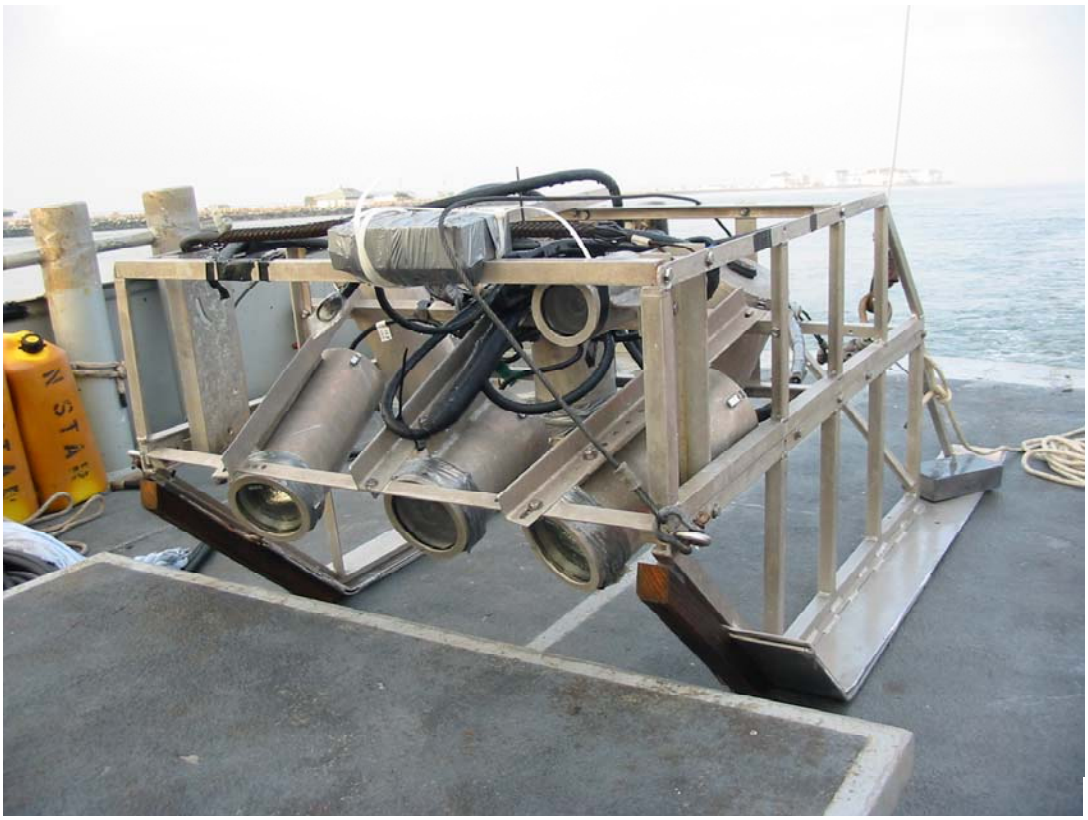

Figure 4. Video sled to be used to conduct bottom imaging surveys within Borrow Site N1/N2 and the selected reference site. The overview camera is at the top right corner of the sled, horizontal camera is in the front center and flanked by two electronic video strobes, close-up vertical camera is in the center of the sled, behind the horizontal camera.

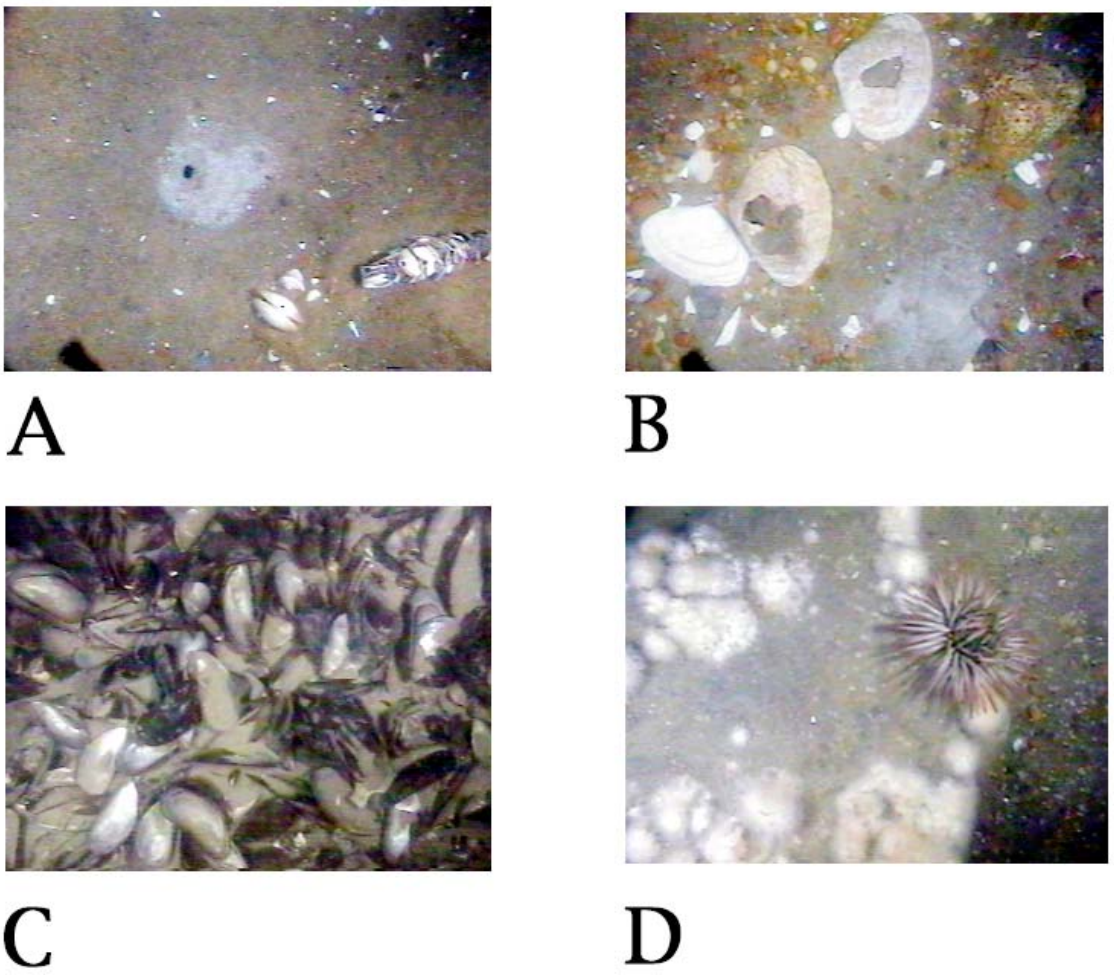

Figure 5. Examples Biological Habitat types observed in video sled survey studies: A - Biogenic feeding mound produced by subsurface feeding organisms; B – Surf clam shell bed; C – Blue mussel shell bed; D – Encrusting bryozoans on cobble. Each image is 28 cm wide.

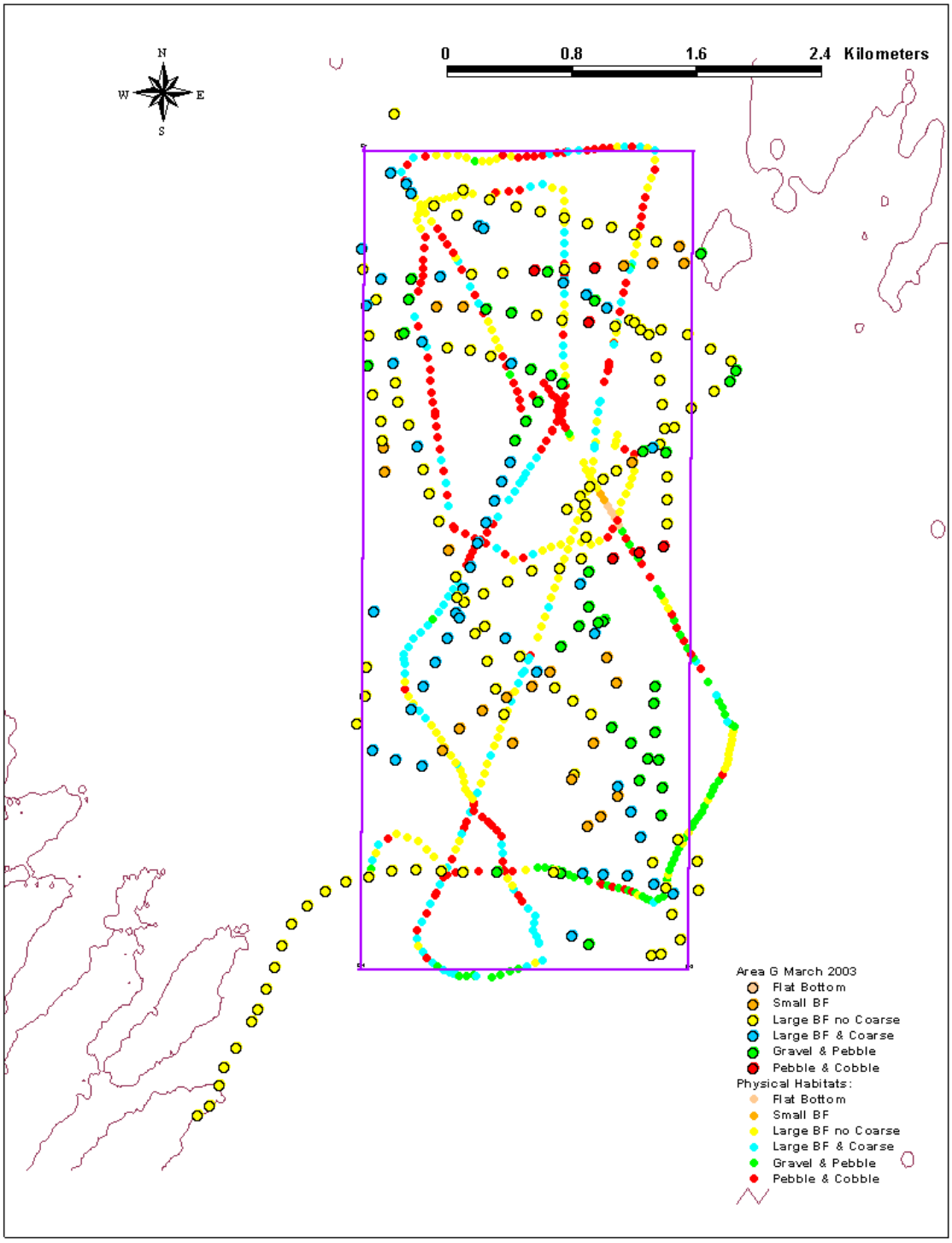

Figure 5. Example of video mapping data display showing various physical bottom features observed within the sled track lines.

Commercial Trawl Sampling

Seasonal collections of fish and shellfish abundance and species composition will be conducted in the borrow site and reference site. Fish collections will be conducted using a local commercial trawler (hired out of Oregon Inlet or other nearby port) equipped with 80-foot otter trawls outfitted with a small (removable) mesh liner in the cod-end to retain juveniles as well as adults. Versar fisheries biologists will be onboard the vessel to direct the sampling activities, assist with the gear, and work up the data on the trawl catches. The experience of the captain and his crew will be employed to maximize the effectiveness of the gear. Trawling will be restricted to relatively clam seas (i.e., wave heights greater that 4-feet). One standardized trawl haul will be conducted at each of twelve representatively selected locations within the borrow site and the reference site, for a total of 24 swept-area samples per season (Table 5). Sampling sites will initially be selected based on a stratified random approach, and then fixed for all subsequent surveys to reduce spatial variability and enhance the ability to detect trends. To avoid trawling over the same area twice in one year subsequent transects will be offset by a few hundred feet for each of the four seasons. Trawls will be towed at constant speed for 5 to 10 minutes depending on the season fish densities and the advise of the vessel's captain who will be contracted to conduct the trawls. Distance covered will be estimated from Differential Global Positioning System (DGPS) coordinates recorded at the beginning and end of each trawl. Collected fishes and macroinvertebrates (crabs and shrimps) will be identified to species, enumerated, and a random sample of 25 specimens for each species will be measured for total length for each trawl.

Three target species of demersal feeding adults fish taken from borrow and reference site trawl samples will be retained for gut content analysis. These data will be used to estimate prey selectivity by fishes and evaluate feeding responses of fishes to changes in densities of invertebrate prey species caused by the sand excavation. Gut content analysis will include identification to the lowest practical taxon, and frequency of occurrence of each taxa. For each stomach, the percent fullness and total dry-weight biomass of prey items for the entire gut content will be measured. The sampling of stomachs for each species will be stratified by size class, with two stomachs collected from each length class chosen to represent year classes. The analysis of stomachs collected for each target species will be spread out across stations, and over time. Initially a minimum of 5 stomachs will be analyzed for each target species from any individual catch.

Table 5 presents a summary of the proposed sampling effort for the pre- and post-construction year monitoring effort at Borrow Site N1/N2 and offshore reference site.

Table 5. Summary of proposed sampling effort during the pre- and post construction year monitoring for Borrow Sites N1/N2 and offshore reference site.				
	Winter	**Spring**	**Summer**	**Fall**
Borrow Site N1/N2				
Benthic – Young grab	**10**	**10**	**10**	**10**
Grain Size	**10**	**10**	**10**	**10**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**
Borrow Site Reference				
Benthic – Young grab	**10**	**10**	**10**	**10**
Grain Size	**10**	**10**	**10**	**10**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**

2.2.2 During Construction Borrow area Monitoring

Borrow Area N1/N2 will be partitioned into four equally spaced sections for seasonal sampling. Since it is anticipated that the excavation will take the better part of a year and will be done primarily by a pipeline dredge, seasonal effects will be limited to specific areas within the borrow site. Sampling four separate strata can partition the data partitioned into various recovery time frames. The construction contractor will supply the environmental contractor with a tentative schedule of where and when they plan to dredge. This information will be updated and mapped as they progress in case deviations in the dredging schedule occur that may require adjustments in the biological sample locations. For each seasonal sampling event during the sand excavation operation benthic and fish sampling will be conducted in the strata being impacted and the three strata not being impacted by the excavation operation. Data analysis will include comparing the benthic and fish communities in the reference borrow area to the various stages of impact and recovery strata sampled within the active borrow site sampled throughout the construction season.

Benthic Sampling

Ten benthic samples will be collected in each of the four borrow site strata during each seasonal event. Ten benthic samples will also be collected in the borrow site reference site for a total of 50 benthic samples per season (Table 6 and 7). Each benthic invertebrate sample will be accompanied by a grain size sample. Subsequent season sampling during the construction year will sample the borrow site strata in various stages of recovery as the dredging equipment moves through the area (Table 6).

Table 6. During construction borrow site sampling plan for benthic invertebrates. The number of replicate samples is indicated within the cells of the table.

Season 1	Season 2	Season 3	Season 4
Borrow Area			
10	**10**	**10**	**10**
10	**10**	**10**	**10**
10	**10**	**10**	**10**
10	**10**	**10**	**10**

Key:

IMPACTED	NOT IMPACTED	RECOVERY

Reference Site			
10	**10**	**10**	**10**

Bottom Imaging

To characterize potential changes to large epi-benthic fauna and macro-scale physical features within the borrow site a late summer bottom imaging survey will be conducted during the construction year. This survey will be used to assess the effects of the excavation in the segments recently mined and to the areas not disturbed by the dredge. The bottom imaging will provide data on how the dredging altered the bottom features and will include reference site bottom imaging.

Commercial Trawl Sampling

Three trawls each of the four strata will be collected each season within the construction year (total of 12 tows per season; Table 7). In conjunction with the borrow site collections twelve (12) samples will be conducted in each survey season at the reference borrow site area established for the benthic sampling. Stomach content analysis will be conducted on the target species as per the pre- and post-construction monitoring. The data analysis for the during construction trawl collections will be similar to the analyses conducted for the pre- and post construction monitoring periods.

Table 7 presents a summary of the proposed sampling effort for the construction year monitoring at Borrow Site N1/N2 and offshore reference site.

Table 7. Summary of proposed sampling effort during the construction year monitoring for Borrow Site N1/N2 and offshore reference site.

	Winter	**Spring**	**Summer**	**Fall**
Borrow Site N1/N2				
Benthic – Young grab	**40**	**40**	**40**	**40**
Grain Size	**40**	**40**	**40**	**40**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**
Borrow Site Reference				
Benthic – Young grab	**10**	**10**	**10**	**10**
Grain Size	**10**	**10**	**10**	**10**
Commercial Trawl - Fish	**12**	**12**	**12**	**12**
Bottom Imaging (days)	**0**	**0**	**1**	**0**

2.3 Bird Counts

Shorebird counts (including piping plovers) will be conducted during the pre-, during, and post-construction periods along the entire 3-mile length of subject beach and

reference beach in Duck, NC. Counts will be conducted weekly from February 15 through November, and every other week in December and January following the field methods used for the Brunswick County study (CZR 2003). This effort will be coordinated with local environmental groups and will involve a local hire to conduct this work under Versar's supervision. While conducting this survey the field technician will take field notes estimating the number and species of the shorebirds feeding, nesting, or loafing along the length of beach. The observer will take bird observations while walking in a linear or zigzag fashion (depending on the width of the beach). The field data will be stratified by 1000-foot beach sections to provide spatial information on bird populations on the subject beach. The field technician will also record the number people using the beach area, whether any local beach construction activities are occurring (e.g., dune building) and other pertinent information such as tide state, wind speed and direction, air temperature. All observations will be taken in the morning hours (during first feeding) and the start day of the week will be randomized to the extent feasible. No surveys will be conducted under high wind conditions (e.g.> 25 mph).

2.4 Recreational Fishing Survey

Recreational fishing surveys will be conducted weekly along the entire 3-mile length of beach (and fishing piers) located on the subject beach and the Duck, NC reference during the pre-, during-, and post-construction periods. This effort will also be coordinated with local environmental groups and will involve a local hire to conduct this work under Versar's supervision. Survey questionnaire forms will include data field similar to those used by local and state natural resources agencies.

Because recreational fishing is likely to occur along the entire stretch of beach it would be costly to conduct an exit survey, with data collection (by interviews) from completed fishing trips. Hence we propose to conduct a roving creel survey (Pollock et al. 1994, Chapter 11), with a progressive count of anglers to estimate effort along the beach. In the roving survey, effort cannot be obtained directly from angler interviews as in the exit survey design because the field technician intercepts the anglers before they complete their fishing trips. We propose to alternate the weekly sampling between weekend days and weekdays. All fishermen interviews will be made during daylight hours and day of the week and time interval will be randomized to the extent possible.

The direction of the count will also be randomized to eliminate bias. The field technician will walk the length of the subject beach and count the number of people (and poles per person) actively fishing along the beach. For the subject and reference beach, the counts will be conducted separately for fishing piers and the remaining stretch of beach within the study area (these represent three strata). This stratification is likely to improve the precision in overall estimates of fishing effort for the subject beach by reducing the variation on angler counts within the designated strata.

Before or after completing the initial count the field technician will interview actively fishing recreational fishermen using pre-printed survey forms. If feasible, the angler counts will also be grouped into categories depending on the number of fishing rods (i.e.,

number of anglers with one rod, number of anglers with two rods, and so on). The combined count and interview survey on the subject and reference beach is expected to take about two days for each weekly event. Because it will not be possible to interview fishermen at the end of their trip they will be primarily asked what the caught in their last hour of fishing to provide a relative measure potential changes in relative catch. The mean catch per hour for each season can then be combined with the independent effort estimate to obtain an estimate of total catch, following methods described in Pollock et al. (1994). This survey will provide estimates of total angler hours and catch by species. Because the mean trip length can only be crudely estimated from incomplete trips, the number of angler trips cannot be precisely estimated form this survey alone. Anglers can be asked when they started, and when they plan to stop fishing, but such estimates are likely to be unreliable because fishing success and weather can influence trip duration. Number of trips can be estimated if mean trip length can be obtained from other sources.

Fishing pier operators will be contacted and asked to participate in the survey by providing estimates of fishing activity based on their tickets sales.

To insure that the recreational fishing survey is conducted in a consistent manner, creel clerk training and a survey manual will be developed to provide the field technicians specific instructions on how to conduct the survey.

Table 8 presents a summary of the proposed sampling effort for the yearly sampling effort (field days) for the shorebird survey and the recreational fishing survey.

Table 8. Summary of the proposed effort for the yearly sampling (in field days) for the shorebird survey and the recreational fishing survey.

	Winter	**Spring**	**Summer**	**Fall**
Subject Beach				
Shorebird Survey Days	**7**	**12**	**12**	**12**
Creel Survey Days	**12**	**12**	**12**	**12**
Reference Beach				
Shorebird Survey Days	**7**	**12**	**12**	**12**
Creel Survey Days	**12**	**12**	**12**	**12**

3.0 Data Analysis

The monitoring will be used to assess area wide effects and to detect and estimate any longitudinal trends (gradients) in benthic and fish population parameters, using standard statistical methods (e.g., Gilbert 1987). The proposed Before-After sampling design will provide simultaneous impact-control data (Schmitt and Osenberg 1996) for assessing short-term impacts, and will control for recovery time length. Project effects on ecological and environmental elements not specifically monitored by the program (e.g., ichthyoplankton populations, large pelagic fish species, marine mammals, turbidity plumes created by the dredges) will be address by conducting literature reviews and drawing inferences from former studies on beach replenishment impacts.

Long-term beach replenishment and borrow site effects will be assessed using a Before-After-Control-Impact (BACI) approach where the addition of a control beach will allow us to separate effects of the beach replenishment from other natural sources of spatial and temporal variability through analysis of variance. The BACI is a survey design commonly used to determine the impacts of alterations of the environment on biological communities (Greene 1979; Underwood 1991, 1994; Osenberg et al. 1994). The simplest BACI design involves sampling before and after impact in treatment and control areas with measurements in all combinations of time and area. As an example of this approach, assume that two beaches are sampled. One beach is subject to disposal, and a neighboring beach with similar characteristics and the reference beach samples will serve as a control. If both beaches are sampled at the same points in time before and after disposal, impact can be assessed by comparing the before and after samples of the control beach with the before and after samples for the disposal beach. A portion of the fixed sites sampled in the short-term effects survey will provide data that can be analyzed within the BACI framework.

Stewart-Oaten et al. (1986) extended the simple BACI design by pairing surveys at several selected time points before and after impact. In the BACI with paired sampling (BACI P) the control and impacted sites are measured at the same time points, and an analysis of how the difference between the control and impact sites changes over time would reveal if an impact has occurred. In the short-term during-construction effects survey, we use an approach similar to the BACI-P to target sampling in the neighborhood of the hydraulic pipeline at regular time intervals. The short-term effects survey follows the progression of the pipeline, and will provide local estimates of the short-term recovery rates and the acute effects of the dredging operation. The BACI-P survey will be conducted once per sampling period for fish and benthos. At each sampling event a nearby site in front of the pipeline (no replenishment yet) and the ten transects on the reference beach will serve as a control to characterize the local benthic and fish communities before impact. This nearby site beyond the altered beach is expected to provide a good reference condition for measuring impact on the biota because it is subject to the same broad-scale natural physical variation at the time of sampling. The area adjacent to the end of the pipeline represents the acutely impacted beach habitat, and sites after pipeline has passed represent impacted habitats at various recovery times. Accurate

data on the progression of the pipeline will be recorded to determine specific recovery times.

The benthic results from the swash, shallow subtidal, and borrow site sampling zone will be analyzed using several measures of biological condition including diversity, abundance, and biomass. Diversity will be measured in several ways including but not limited to number of taxa (i.e., taxa richness), Shannon-Wiener Diversity Index, and the Simpson's Dominance Index. Additional data analysis will include, if appropriate, log transformed plots of mean abundance, non-parametric statistics using species rank or total densities, regression analysis, and analysis of variance techniques. Abundance and biomass will be examined in total and in groupings appropriate to the study objectives.

Software for the Statistical Analysis of Correlated Data (SUDAAN) or another statistical package will be used to obtain descriptive statistics (e.g., mean number of species, biomass, CPUE) for undisturbed and impacted beach sections, and for hypothesis testing. Using SUDAAN standard errors of ratio estimates, means, totals, regression coefficients and other statistics in accordance with the complex sample design will be computed (Shah et al. 1997). The samples for benthos and fish will be used to test the acute and short-term effects of disposal. By comparing biomass, abundance, and diversity of fish and benthos at disturbed and undisturbed (control) sites changes in the recolonization rates will be tested using parametric and non-parametric methods.

The broad-scale sampling at regular intervals provides baseline data that reflects natural spatial and temporal variability in fish and benthic communities. Pre-construction and post-construction seasonal sampling at the ten subject beach and ten reference beach transects two years before and after the disposal is will provide data for evaluating long-term impact. The statistical analysis for this pre- and post-construction sampling will focuses on the detection of long-term impact for the study beach, based on samples collected two years before the impact and after the impact. The analyses of long-term effects will consist of tests of differences among means of various attributes (abundance, biomass, and species richness) of each biological community sampled (e.g., benthic macro-invertebrates in the shallow zone) at disturbed and reference sites before impact and after impact. We will use a two-way analysis of variance (ANOVA) model to evaluate long-term effects of beach replenishment on the benthic and fish communities:

$$y_{ijk} = \mu + B_j + T_k + B_j T_k + \varepsilon_{ijk}$$

where B_j represent the main effect of beach location (disturbed beach versus control beach), T_k represents the main effect of time (before disturbance and after disturbance), and $B_j T_k$ represent the interaction of location and time. The ε_{ijk} represents random error terms assumed to be normally distributed with mean zero and constant variance σ^2. The analysis of benthic abundance and biomass will be based on log-transformed mean counts for each station, with a constant of 1 being added to all observations in cases where zero-observations occurred. The main interest in this analysis will be to test if the interaction

terms are significant, and if so, to test weather the mean values were depressed in the years after beach replenishment, as compared to sample before disturbance. The main effects are introduced to account for overall differences among years, and for differences between the control beach and study beach.

The spatial sampling coverage of the benthic study along the subject beach will support resource estimates that will be linked with the bird survey. Depending on the feeding habits of bird species, estimates will be provided for different spatial scales from single or combined blocks in the neighborhood of the bird sites on the subject beach.

4.0 Monthly and Annual Reports

Monthly Status Reports: By the fifth working day of each month, a written letter report will be submitted. This report will summarize the previous month's sampling activities, preliminary results, and important observations. These status reports will also be used to discuss potential problems and solutions related to contract performance or conditions that might affect performance. Monthly status reports must accompany requests for partial payment.

Annual Project Reports: Within 120 days of completion of all work tasks under each contract year, the Contractor shall submit a draft report for review. The report and findings shall be objective and fully substantiated by documentation. The report shall follow the format required by reputable scientific periodicals, including abstract, summary, introduction, methods, results, discussion, conclusions and recommendations, references, and appendices. The appendices will contain tabulations of all physical, biological, and statistical data and a list of all participating technical staff and their respective responsibilities on the project. The report shall contain appropriate summary tables and figures. In addition, the report must include:

(1) Equipment maintenance and data collection procedures, equipment replacement and malfunctions, and problems with lost or questionable data;
(2) Description of monitoring methodology, results and any problems;
(3) Discussion of the results, including apparent difference among sites especially as compared to the control.
(4) Comparison of data and existing literature from the first and subsequent years of monitoring especially related to recovery rates and issues related to benthic resources, and affect on feeding habitats and occurrence of fishes along the beaches.

A final annual report must be submitted to the Corps within 30 working days after the date that the Corps provides comments on the draft to the Contractor.

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CZR 2003. Waterbird and shorebird use of beaches in Brunswick County, year 2. Prepared for the USACE, Wilmington District by CZR, Inc., Wilmington, North Carolina.

APPENDIX A

RESPONSE TO COMMENTS ON DRAFT STUDY PLAN

Response to comments on the Dare County Beach Replenishment Monitoring Plan

Written Comments received from:

David McHenry, North Carolina Wildlife Commission

Sara Winslow, North Carolina Division of Marine Fisheries

Andy Coburn, Duke University, Durham, North Carolina

Michelle Duval, Environmental Defense, Raleigh, North Carolina

Jan DeBlieu, North Carolina Coastal Federation, Manteo, North Carolina

Charles Peterson, University of North Carolina, Marine Sciences Program, Morehead City, NC

Mike Wicker, U.S. Fish and Wildlife Service

Some underlying general themes among the reviewer comments:

General Comment 1: Sampling should also be conducted within the northern project area even though there is not enough time to monitor for two years prior to beach construction (initial construction is scheduled for 2005 in this area). By not monitoring beach replenishment effects at these sites impacts could occur that will go undetected until it is too late to do anything about it.

Versar Response: In the interim between drafting the original plan and receipt of comments on the plan the beach replenishment schedule has been delayed by one year. Now that that there is sufficient time to obtain nearly two years of pre-construction data we have shifted our study site to the northern project area including the N1/N2 borrow site.

General Comment 2: Several reviewers faulted the study design for not presenting a mitigation plan if project effects were determined to be severe enough to warrant this action.

Versar Response: Our experience with the Brunswick County two-year study and the results from the growing body of information on the effects of beach nourishment generated from other recent studies along the eastern seaboard indicate that marine organisms inhabiting surf zone habitats recover very quickly. Many of these studies cannot even detect an impact despite having an ample sampling intensity. While there clearly has to be some level of impact on surf zone communities during beach

construction, significant, long lasting, population level effects are not likely based on past monitoring efforts as long as the sediments are similar to existing conditions. If effects are detected, it is more likely that they will be subtle and subject to some level of uncertainty. Although the need for future mitigation cannot be totally ruled out, it will probably not be necessary based on the ecological responses observed in other similar beach replenishment projects. While we do not anticipate that the effects of the beach nourishment will be great enough to justify a large-scale mitigation effort, any future mitigation would need to be negotiated between the USACE and the various stakeholders.

Our objective for this task is to design and implement a cost effective, logistically feasible monitoring plan with sufficient replication, robustness, and intensity to detect biologically meaningful impacts (e.g., those impacts that will alter benthic productivity) - not to develop a mitigation plan for the action. If future mitigation is needed it could include, the creation of artificial reefs, relocating mole crabs before impact, and restricting construction to certain seasonal windows (particularly for re-nourishment events) to name a few. However, determining what level of impact should trigger mitigation and then establishing the level of mitigation required for the detected impact is difficult and will undoubtedly be subject to much debate and controversy. Establishing these guidelines is important for this and any other project but it is not within our scope to design a monitoring program.

General Comment 3: The monitoring plan only covers five years, yet the USACE's projected life of the project is 50 years when periodic re-nourishment is taken into account. The current plan does not address the accumulative effects of re-nourishment over the life of the project.

Versar Response: Re-nourishment will be conducted periodically based on predicted erosion rates. The current USACE plan calls for a 3-year re-nourishment cycle. While the current monitoring plan only focuses on detecting effects of the initial construction, there are plans to alter the program in future years to evaluate accumulative effects of periodic re-nourishment of the beaches. The level of effort needed beyond the initial construction assessment can be evaluated based on the degree of impact observed in the first five years of study. It would be more prudent to plan a long-term study after reviewing the results of the five-year study.

General Comment 4: The three target fish species to be used in the gut content analysis has not been identified.

Versar Response: Our plan is to select fish species with demersal feeding habitats that are closely linked to the benthic invertebrates that will be directly impacted by the beach re-nourishment. We anticipate target species could be gulf kingfish, spot, spotted hake, Florida pompano, black drum, or Atlantic croaker. Because we can't control what will be in fish collections we purposely left this vague in the monitoring plan to provide the needed flexibility so we could adjust our selection of target species among the above pool of potential species based on the dominant organisms taken by the gear. Also, seasonal

changes in fish composition may require that we use more than three target species over the course of a year. We have added the list of potential target fish species for gut content analysis to the study plan.

Responses to specific comments by individual reviewers:

David McHenry, North Carolina Wildlife Commission (NCWC)

NCWC Comment 1: Earlier (at meeting in August) there was some discussion about need/desire for invertebrate monitoring over multiple cycles (e.g., after construction and also after first maintenance cycles) to determine what effect, if any, will repeated nourishment activity in relatively short time frames have on near complete recovery. We believe this is an important question given the increasing spatial extent and frequency of nourishment projects on NC beaches and corresponding implications to forage availability for shorebirds if such repeat activities do have cumulative/additive effects. I sent an email to you in October with this point and I believe you followed up with me at the mole crab relocation meeting in Morehead that this would be looked for the Dare project, but possibly separate from the targeted construction impact monitoring as is currently proposed. Please let me know if I am wrong or right on that and, if correct, please remind me what the approach will be to doing the monitoring. I was thinking about this at the December 2 meeting, but didn't bring it up because I couldn't recall what you had indicated to me previously. Please advise.

Versar Response: See response to general comment 3 above. Also, Frank Yelverton from the USACE provided the following comment in an email response:

"Regarding comment 1, toward the end of the two years of post construction monitoring my intent is to design a plan (with input from all interested parties) to look at the issue of what impacts repeat activities have. I think that it is best to wait until then to design a study because we will have more information on recovery issues."

NCWC Comment 2: Regarding the potential variation of invertebrates on cusps versus other beach features, I raised that issue as consideration in the statistical comparisons. Since a relatively straight beach will be created and compared to a reference beach, presumably with natural shoreline variation, we may need to consider how sample sites are selected on the reference beach. For example, should we include a mix of both cusp and other "non cusp" (?) sampling in the n=9 sites or restrict it to only consistent habitats. As a reference, the former may be advisable to get an overall representation of "natural" conditions. From a statistical comparison stand point, this can throw much extraneous variation in, but this may not matter much because of the rank based (quartiles) comparisons to be used.

Versar Response: This comment appears to be based on a University of Virginia PhD dissertation by Cynthia Donoghue, entitled "The Influence of Swash Processes on *Donax*

variabilis and *Emerita talpoida*". Her research showed that higher numbers of *Donax* exists in the downflow cusp side relative to the horn, embayment, or upflow side of side of the cusp. While it maybe tempting to fine tune the location of the transects to target the downflow side (where Donax may concentrate) this would violate the principals of random sampling. Because we want to characterize conditions along the entire subject beach every point along the beach must have an equal probability of being sampled. Our approach to randomizing the transect locations within the ten subsections of the beach should capture the variance associated with these micro-scale differences in mole crab and coquina distribution. Including a mix of sampling within cusps could not be done consistently because some beach areas won't have cusps and cusps will migrate overtime in response to storms and seasonal erosion and accretion rates. The shallow sub-tidal sampling will be less affected by cusps, as the sampling will be conducted in about two feet of water on or about low tide. Based on typical beach profiles that exist within surf zones, this will put the sampling point some distance away (30-feet or greater) from the potential small-scale effects of the cusps.

NCWC Comment 3: This is relatively minor, but please take a look (if you haven't since the meeting) how the statistical model is described in the plan. I believe it indicates a 2 factor design based on time (pre and post construction) and beach (nourished versus reference), plus the interaction. I guess the season factor, which should have large influence on invertebrate populations, would be accounted for by doing individual pre and post comparisons by season? How will the quartile comparisons, which also weren't described in the section on data analysis, influence the analyses of variance proposed? I think you indicated after the meeting that this was how the comparisons would be done and that this is how the power analyses were calculated. However, do these quartile comparisons lend themselves to parametric comparisons or would some other rank based statistics be needed? It just seems that some minor revising and clarity is needed in the data analysis section.

Versar Response: We plan to use both parametric (Generalized or Mixed-models) and non-parametric analysis (Wilcoxon Rank Sum test) to estimate effects of beach nourishment. In the GLM or Mixed models (which are forms of ANOVA), factors will include "status" (pre and post construction), beach (subject beach versus reference beach), and possibly season. If season cannot be included in the overall model, we will apply a two-factor model (with "status" and "beach" as factors) separately for each season as suggested in comment 3. Interaction between factors will also be included if this improves the model fit. The ANOVA analysis will be complemented by exact non-parametric analysis, using StatXact 5. The multinomial comparisons mentioned in the study plan were conducted primarily to estimate the minimum number of replicate samples per habitat required to detect a specified change with 80% power and 10% alpha level. We applied the non-parametric Wilcoxon Rank Sum test to determine a minimum sample size based on exact power calculated for a specified hypothesis about the distribution of the response variable. The frequency distribution of abundance (or biomass) data for four classes was the basis for comparing before and after nourishment results. The abundance (or biomass) data for population 1 (before nourishment) were classified into four classes based on their quartiles. The data for population 2 (after

nourishment) was grouped into the same four classes. The alternative hypothesis for the power analysis specified a shift (or increase in the proportional odds) of 2.0 in the cumulative response probability. The power analysis we conduced for the draft study plan showed that a sample size of 9 before construction, and 9 after construction would yield an asymptotic power of 82%, and an exact power of 78% for the above hypothesis. We have revised the plan to include 10 samples before and 10 samples after construction to ensure a power of at least 80% at the 10% alpha level. The exact power for 10 replicates was estimated at 82%.

Power analysis based on the ANOVA models is problematic because the variance of abundance and biomass typically increases as a function of the means, which will not be known in advance. However, the factorial design with a two-year pre-construction data collection period is expected to yield sufficient power for detecting changes also for the parametric tests.

Sara Winslow, North Carolina Division of Marine Fisheries (NCDMF)

NCDMF Comment 1: Since Hurricane Isabel, will the beach area south of Duck be appropriate as a reference beach?

Versar Response: Both the proposed reference beach and the subject beach was impacted by last fall's Hurricane Isabel so any storm related changes on the marine communities inhabiting the surf zone would have affected a broad area. Since we will be comparing changes in the subject beach relative to the reference beach this should not diminish our ability to detect construction related impacts.

NCDMF Comment 2: What are the three demersal finfish species that will be utilized for the gut content analysis?

Versar Response: See response to general comment 4 above.

NCDMF Comment 3: The beach seine crews and trawlers that are contracted is it the intention to allow them to sell the "catch"? This would probably be an issue with the SCP.

Versar Response: Our intention is to use commercial haul seiners and trawler and to direct the sampling based on systematic sampling that is routinely employed in scientific surveys. They will be paid a per day rate which will be equivalent to what they normally make when they are commercial fishing on their own. Since we will be conducting unbiased sampling we will not allow them to target schools so the incentive to "sell" the catch will not be strong. We have used commercial fishing vessels successfully in studies we have conducted for USACE, Philadelphia District, and the Mineral Management Service. In those studies we have allowed them to keep the catch after we have processed the samples as long as they within their commercial license requirements. While this added to their willing to work with us, catches were never large enough to represent typical trip. If this is an issue with Dare County resource managers, we will not

allow the fishermen to keep the catch. We are also very sensitive to the public perception of monitoring programs (particularly the beach seine activities). As a Versar policy we make every effort to release the catch alive after processing to the extent possible based on sampling logistics and catch size.

Jan DeBlieu, North Carolina Coastal Federation (NCCF)

NCCF Comment 1: NCCF has serious concerns about the plan, especially about the timing of the monitoring and any mitigation that would occur should such monitoring show that the re-nourishment project negatively affected the biological abundance of the Dare beaches. Because of this, NCCF considers the plan unacceptable in its current form.

The contractor is in an untenable position. To achieve the Corps' laudable goal of providing two years of baseline monitoring while still meeting the dredging schedule, the contractor is forced to conduct monitoring on a small section of southern beach while the northern beaches in the project area are re-nourished. According to the schedule in the plan, results will not be known until 2008 after two years of post-construction monitoring. By then, the entire project will have been completed. This approach will not protect our beaches since there will be no opportunity to correct problems uncovered by the monitoring. Moreover, under the current plan the North Project Area is not to be monitored at all. This is not acceptable, since geologists have previously raised questions about the sand compatibility of the N1/N2 borrow areas and the effects of using that sand on the beach. Nor do we find it acceptable that the middle section of the South Project Area is exempted from monitoring. The statement is made that there are few differences between the project areas, but no data is provided to support this.

An arbitrary schedule is at the root this problem. NCCF strongly urges the Corps to delay the re-nourishment project for two years to allow the contractor to perform pre-project monitoring on the first sections of beach to be filled. Monitoring could then proceed as outlined—during construction and for two years after the initial phase is completed. Such an approach will at least allow you to alter the project on most of the remaining beach if the post-construction monitoring detects problems. It is highly unlikely that federal funding will be available to allow the project to move forward in 2005. It makes no sense to omit these portions of the project from monitoring because of a schedule that will almost certainly be broken.

Versar Response: We now moved our study site up to the Northern Project area because the construction schedule has been delayed by one year. (see response to general comment 1 above). Borrow site sampling will therefore be conducted in N1/N2. No monitoring of S1 is now proposed which may be an issue with this reviewer. In the process of selecting potential borrow sites for beach replenishment projects the USACE geotechnical scientists go through great lengths to find sites with sufficient quantities of sand that matches the grain size distribution on the subject beach to ensure the material will stay in place and not change the natural conditions in the surf zone. Several hundred vibracore borings were taken offshore of the subject beaches in the planning stages of the project to help select the borrow sites. Because the compatibility of the grain size is

typically very close to what exists in the beach face, sediment type differences between the Northern and Southern borrow sites are similar which would not warrant a separate sampling effort based on sediment differences as this reviewer has suggested.

NCCF Comment 2: NCCF is extremely concerned that there is no mention in the monitoring plan of providing mitigation in the event that biological abundance is shown to be significantly diminished by the placement of fill. Because the results of the monitoring will not be known until the project is completed, it is incumbent on the Corps to explain what it will do if our beaches are negatively affected. Neither are there any thresholds in the plan beyond which mitigation would be required. For the plan to be at all meaningful, abundance threshold levels should be set by the appropriate resource agencies, and the Corps should spell out precisely what steps will be taken should the number of organisms collected fall below the designated thresholds.

Versar Response: See response to general comment 2 above.

NCCF Comment 3: NCCF also echoes several of the comments made by participants at the December 2 meeting in Kill Devil Hills. The sampling window should be narrowed from three months. Rather than confining it to one month, we believe scheduling should be determined by similarities in water temperatures, sea conditions and, as an added factor, weather conditions.

Versar Response: We plan to conduct the season sampling within a two-week window that we will confine to similar temporal periods, water temperatures, and weather conditions to the extent that project logistics and budget allow. As with any large-scale project of this nature involving many different program elements, sampling vessels, subcontractors, and field crews, scheduling the sampling activities will be a logistical challenge. Given the physical limitations of ocean sampling offshore of North Carolina's outer banks (particularly in winter and early spring) weather may force us to change our planned sampling schedule. We will make every effort to conduct the study under consistent physical conditions among seasons and years but some deviations in the sampling plan are inevitable.

NCCF Comment 4: Consideration needs to be given to other activities that alter the beach, such as bulldozing, when assessing cumulative impacts. We have a special concern here. The town of Nags Head has applied for permits to construct a five-year emergency berm along roughly half the town's oceanfront beaches. According to town planner Bruce Bortz, the amount of sediment to be placed on the beach would equal 10.1 cubic yards per linear foot. I have heard that this would allow the town to build a line of dunes up to nine-and-a-half feet tall, with an 85-foot width. Bruce indicates that none of the sand would come from dredging; instead, it would be placed on the beach from a stockpile of sediment pushed across Bodie Island by Hurricane Isabel. This project is designed to be confined to the upper beach. However, because of the severity of the recent erosion within Nags Head, some of the sediment would almost certainly be placed below mean high tide. As a result, it would affect organisms in the swash zone.

Versar Response: All three beach communities are planning emergency dune/berm work above mean high water related to damage from Hurricane Isabel. Therefore impacts should be similar regardless of which beach is chosen for monitoring. We will coordinate with the township planners and monitor the construction of dunes and the use of bulldozers on the beach. This would primarily affect the ghost crab counts on the dry beach, which is not a major parameter for the program. We will also monitor whether the dune building extends below mean tide to help explain patterns in the data if the activity impacts the swash and shallow habitats we are monitoring. If the activities were confined to the upper beach then we would expect that effects on the tidal and sub-tidal areas to be minimal.

NCCF Comment 5: We question whether a federal re-nourishment project should begin only a year after so much sediment has been placed on the beach. Significant damage may occur, especially if the berm building extends into the spring months, when organisms become plentiful in the surf. If the start of the federal re-nourishment project is delayed because of a lack of funding, as expected, our concerns would be somewhat allayed. However, scheduling the placement of a major amount of sediment on the beaches two years in a row is unwise policy and could have major cumulative impacts on the organisms on the lower beach and within the swash zone. If funding indeed becomes available for 2005, we ask that nourishment be deferred until at least 2006 for the portions of Nags Head protected by the new, five-year berm.

Versar Response: The construction schedule has now been delayed by about one year so there should be sufficient recovery time after the locally sponsored berm building project. Also see response to NCCF comment 4 above.

NCCF Comment 6: It should be noted as well that the berm-building project will seriously compromise the results of biological monitoring along the Nags Head beaches.

Versar Response: See response to NCCF comment 4 above.

NCCF Comment 7: We have questions about the suitability of the beach at Duck as a reference beach, especially since the beach profile may have changed since the passage of Hurricane Isabel. Care needs to be taken to use a reference beach with a similar profile and erosion rate as the portions to be nourished. A new survey of the area will likely be needed. In fact the beaches in Dare County differ so markedly from north to south that there may not be a good candidate for a reference beach. This increases the importance of careful biological monitoring on the beaches that are to be nourished.

Versar Response: Although Nags Head took the brunt of landfall of last fall's hurricane, the beach at Duck, NC (as well as most of the mid-Atlantic seaboard) took a pounding as well. We believe it is safe to assume that the proposed reference beach and the subject beach was similarly impacted by the storm so any changes on the marine communities inhabiting the surf zone would have affected both areas equally. Since we will be comparing changes in the subject beach relative to the reference beach this should not diminish our ability to detect construction related impacts.

NCCF Comment 8: Beyond the comments made by the participants at the December 2 meeting, we are concerned to see that the plan does not contain a provision for measuring possible sediment flow increases into Oregon Inlet caused by the project. Nor does it contain provisions for monitoring possible changes in the transport of larval fish through the inlet. The placement of such a large amount of fill upstream may significantly alter the physical and biological dynamics of the inlet. We understand that Corps models show that the additional influx of sand through the inlet channel will not be substantial. However, models are not always perfect. This would be a good opportunity to test the accuracy of the model—while making sure that the ability of local fishermen to pass through the inlet is not being compromised.

Versar Response: The comment is correct in that the Corps sediment transport modeling showed that influx of sediment from the Dare Project to Oregon Inlet would not be substantial. This result has been independently supported by a recently completed study prepared for the U.S. Fish and Wildlife by Drs. Robert Dean and Robert Dolan (Jan 2004). This study found that only a 20,000 cy/yr average increase in sediment transport to the inlet could be expected over the 50-year project life. This value is very small when compared to the gross sediment transport estimated at Oregon Inlet that is on the order of 2 million cubic yards per year. Not withstanding the finding of the two studies, the physical monitoring program is designed to track the dispersion of the fill using beach profiles that extend from the southern limit of the project to the northern shoulder of Oregon Inlet. Further, condition surveys of the Oregon Inlet navigation channel will continue on a regular basis to detect unusual increases in shoaling which may be linked with the placement of the Dare County beach fill. With respect to transport of larval fish, the Corps does not believe that tidal flows through the inlet will be affected with the implementation of the Dare County project. Therefore, monitoring of larval transport is not proposed.

NCCF Comment 9: We are concerned that the results from two years of sampling will be interpreted as measuring the "long-term" impacts of beach re-nourishment (page 25). This is a 50-year project. It is not reasonable to suggest that the negative impacts from five decades of fill can be estimated from the data collected during the first two years.

Versar Response: See response to general comment 3 above.

NCCF Comment 10: We urge you to include turbidity monitoring for the near shore zone and the surf zone. Increased turbidity can affect the survival of visually-feeding fish species, such as bluefish.

Versar Response: Extensive monitoring and mapping of turbidity plumes generated from sand pumping and dewatering activities was conducted during the recent two-year study along the Brunswick County beaches as part of USACE's Cape Fear River Deepening project (http://www.saw.usace.army.mil/wilmington-harbor/main.htm). Continuous water quality monitoring at the two Oak Island fishing piers conducted before, immediately after, and one-year after beach reconstruction revealed that beach

replenishment operations did not create large increases in turbidity over background conditions. While turbidity spikes where observed when the pipeline was near both piers, similarly high turbidity values were recorded during periods when the beach replenishment operations were miles from the monitoring sites or when dredging operations where temporarily shut down. Observed increases in turbidity detected during the second year of sampling were attributed to storm events and high surf conditions. Turbidity plume mapping based on the first year's data revealed that the turbidity created by the pipeline discharge hugged the shoreline following the long-shore currents. On-shore wind events contributed to keeping turbidity plume close to shore and in most cases the plumes were not discernable from turbidity created by the breaking waves in the surf zone a few 100 meters away from the end of the pipeline. Elevated suspended sediment loads outside of the surf zone were rarely observed. These data suggest that turbidity plumes caused by the de-watering operations on the beach face were small and short-lived. Since similar dredging and disposal techniques will be used for the Dare County beach re-nourishment and the borrow material will be comprised of mostly sand and few fines (like the Brunswick study) there is little reason to believe that turbidity plumes will be much different along the Dare County beaches. Therefore, additional turbidity monitoring is not proposed.

NCCF Comment 11: We would like to see Versar identify the demersal fish species that are to be used for gut content analysis in the haul seine and trawling surveys. The survey results will vary markedly depending on the species used in the sampling. The consultants should conduct gut content analysis on at least one species that feeds along the bottom, such as flounder. Biologists from the state Division of Marine Fisheries should be consulted on this point.

Versar Response: See response to general comment 4 above. We question the suggestion to include flounder as a target species for gut content analysis (particularly summer flounder) as they lay in wait on the bottom to feed on small baitfish and not directly on benthic invertebrates.

Michelle Duval, Environmental Defense (ED)

ED Comment 1: Currently, there is nothing in the monitoring plan which addresses mitigation requirements should the project have significant adverse impacts on the ecosystem. Given the temporal, spatial and fiscal magnitude of this project, the need for mitigation should be anticipated and specified. Thresholds of impact should be established for each of the parameters (fish, benthic invertebrates, sediment composition) being monitored at both the deposition and mine sites; once the threshold is reached, mitigative measures are triggered. Clearly, these would need to be determined in coordination with both federal and state resource agencies. Utilized properly, the BACI design for the pre- and post-construction monitoring should detect a shift in abundance or biomass of one of the monitored parameters. Given natural variability, it might be prudent to establish a threshold such that depressed abundance for two consecutive seasonal sampling periods would trigger such measures.

Versar Response: See response to general comment 2 above.

ED Comment 2: Page 25, paragraph two states: "Pre-construction and post-construction seasonal sampling at the ten subject beach and ten reference beach transects two years before and after the disposal will provide data for evaluating long-term impact." Two years of post-construction monitoring is not "long term" for a 50-year project, certainly not with respect to detecting long term impacts. The during-construction monitoring will be useful in detecting "immediate" impacts, while the two years post-construction is "short term". Given the total taxpayer monies being allocated for this project and the public resources affected, a long term monitoring plan to detect cumulative impacts of repeated sand deposition is necessary. The Corps has an opportunity – and the obligation – to make a useful contribution to the state of the science with regard to this issue. I have made similar, repeated statements of this nature in reviewing the multiple projects proposed for Bogue Banks. Project applicants need to accept that this analysis is the long-term cost of modifying public trust resources.

Versar Response: See response to general comment 3 above.

ED Comment 3: The sampling design needs to be independently reviewed by a professional biostatistician; Duke, UNC-Chapel Hill and NC State Universities all have statistics departments with qualified individuals. I have several sampling concerns: (1) for the pre- and post-construction monitoring at the subject and reference beaches, only one benthic sample for both "habitats" (swash and shallow subtidal) is proposed for each of the 9 replicate transects. I would strongly suggest that 5 samples be taken in both habitats at each of the 9 replicate transects, in order to address microspatial variation, and provide a mean for each of the 9 replicates. (2) I would argue that the setup for the seasonal during-construction benthic sampling is guilty of pseudoreplication. The proposed 5 samples to be collected in both the swash and subtidal areas for each of the 4 replicate transects does not result in 20 **independent** samples as outlined in Table 4; the 5 samples per habitat would provide 4 independent means per habitat, one for each replicate transect. (3) How does "compositing" the sediment samples for the pre- and post-construction monitoring impact the analysis with regard to statistical power?

Versar Response: Our study design and sampling plan was developed with the support and input form of our PhD level staff biostatistician, Dr. Jon Volstad. Dr. Volstad directed much of the statistical analysis for the Brunswick County beach nourishment project Versar recently completed for the USACE and is therefore intimately familiar with the type of data that will be generated from the Dare County project. His area of expertise includes statistical survey methods; quantitative fisheries dynamics; fisheries stock assessment & management; quantification of uncertainty & risk; spatial statistics; Monte-Carlo simulations & resampling methods. Dr. Vølstad has 18 years of international research and consulting experience in quantitative fisheries biology and statistics. Dr. Vølstad is also an adjunct faculty (biometrics) at the Department of Animal and Avian sciences, University of Maryland. He was on a review team selected by the American Fisheries Society's Marine Fisheries Section, assessing three potential programs for sampling for-hire fisheries (i.e., charter and party/head boats) on the

Atlantic Coast. While we always welcome peer review comments we are confident that the program has sufficient statistical robustness to address impacts and recovery.

The suggestion to have five replicates taken at each of the ten transects in each habitat for the pre- and post construction monitoring phase would a wasted effort, as we are interested in characterizing the conditions along the entire length of the subject beach, not micro-scale differences at one particular spot. For the Brunswick study we collected two replicate samples in each habitat along eight transects. Analysis of the replicate samples indicated that the observations from the samples taken in one small area were more similar than observations from different transects. For this study we used an intra-cluster correlation coefficient (Snedechor and Cochran 1980) to measure the homogeneity of samples taken near each other relative to samples among transects. The results indicated that our power to detect project related impacts would have been much higher if we had spread our sampling points out along the beach rather than taking multiple samples at one point. On the other hand, we do need to quantify the variance at a particular spot during the construction phase of the project because the premise of the sampling is that selected points along the beach will represent a certain period of short-term recovery. Quantifying the variances in abundance and biomass at each sampling point is necessary to allow us to evaluate differences among the various 2, 4, and 8 week recovery periods which will be sampled in one event per season during the beach construction operations using five replicate samples for each treatment category.

The sediment samples are only intended to provide ancillary data on the grain size composition in the swash and the shallow sampling zone to help qualitatively interpret benthic results. No statistical analyses are planned for these data. Compositing the samples are designed to maximize the use of limited financial resources.

ED Comment 4: The sampling protocol should be reviewed by scientists engaged in active research on mobile fishing gear and its impacts on soft bottom habitats. The effort is made to avoid impacts within the seasonal sampling protocol by conducting benthic sampling first (followed by bottom imaging and finally trawling); however, by using the same transects for each sampling event, there is potential for minimal recovery between each seasonal sampling event. There is a balance between reducing spatial variability and being able to detect impacts of dredging vs. impacts of the trawl.

Versar Response: We will offset subsequent transects by a few hundred feet for each of the four seasons to avoid trawling over the same area twice in one year.

ED Comment 5: It was my understanding when reviewing the EIS for this project, that there were differences between the two mine sites (S1 and N1/2) that would warrant mine site monitoring for the northern section as well. The results of the bottom imaging survey should be independently reviewed before a final decision to monitor only the southern area is made.

Versar Response: The N1/N2 borrow site will be monitored now that the construction schedule has been moved back about one year (see response to NCCF Comment 1

above). In addition to imaging the bottom on potential nearby reference areas we will incorporate a tow through the S1 borrow area and provide the information to USACE and stakeholders for their review.

ED Comment 6: Both the haul seine and trawl protocols indicate that "three target species of demersal feeding adult fish" will be taken from subject and reference sites for gut content analysis to determine if there are impacts from project construction on feeding and prey densities. What are the "target" species? The Division of Marine Fisheries needs to be consulted on this issue.

Versar Response: See response to general comment 4 above.

ED Comment 7: The draft plan states that only the southern portion of the south project area is being monitored as a subject beach because there are few physical differences throughout the project area. Where are the data to support this?

Versar Response: This is a general statement based on the fact that we are discussing a twenty-mile long contiguous nearly linear length of outer banks ocean shoreline with no nearby inlets that has a homogeneous sand bottom. For the Brunswick beach monitoring study (which was centered around several inlets including the Cape Fear River inlet) we investigated whether a gradient in benthic community structure existed up and down the beach at undisturbed sampling sites. From a biological perspective, there was no gradient. The Dare County subject beaches are far from Oregon inlet and generally have a more uniform coastline.

ED Comment 8: I would strongly suggest that turbidity sampling be conducted; elevated nearshore and surf zone turbidity levels can impact the foraging ability of recreationally important visual fish predators. To that end, I am glad to see that a recreational creel survey is being included as a component of the monitoring plan, and would again recommend that the protocol be reviewed by state/federal resource agency personnel with experience in such surveys.

Versar Response: Regarding turbidity monitoring, see response to NCCF comment 10 above. Again, while we always welcome peer review, Dr. Jon Volstad designed and will implement the creel survey work for our program. Dr. Volstad has extensive experience in this area and has recently completed (in the last year) a large-scale recreational fishing survey for the Pennsylvania Fish and Boat Commission for the Delaware River and Estuary. The Delaware River project entailed training and directing the efforts of over a dozen creel clerks covering over 150 miles of river, conducting weekly aerial surveys of fishing effort in addition to the statistical analyses and report preparation. We will obtain copies of creel survey forms used by existing state and local programs to ensure that our creel survey measures similar parameters.

Andy Coburn, Duke University (DU)

DU Comment 1: Monitoring should take place during the entire life of the project, and should extend beyond the termination of project construction. The two-year post-

construction monitoring discussed in the draft report is misleading because, as proposed, it will only evaluate changes that occur within a two-year period after the initial nourishment of a relatively small area of the project. Since the segment of beach being proposed for post-construction monitoring could theoretically be renourished every three years for a period of fifty years, the two years of "post-construction monitoring" as discussed is woefully inadequate and cannot possibly detect any long-term cumulative impacts in the project area. The Corps should monitor the project for its entire duration, or until some point in time at which all stakeholders reasonably agree that the project has not caused, and will not cause, any long-term cumulative impacts. Considering the massive expenditure of public funds that may be expended on this project, and the geographic extent of public trust resources that may be impacted, it is not unreasonable for the Corps to assume the additional costs associated with additional monitoring efforts.

Versar Response: See response to general comment 3 above.

DU Comment 2: The document lacks a mitigation plan in the event a monitoring effort does identify significant adverse impacts resulting from the proposed project. Given the temporal, spatial and fiscal extent of the project, it is imperative that an effective mitigation plan be developed in conjunction with all pertinent state and federal resource management agencies and other stakeholders. The mitigation plan should establish impact thresholds for each parameter being monitored - at both the deposition and mining sites - that would trigger mitigation action.

Versar Response: See response to general comment 2 above.

DU Comment 3: The monitoring/sampling design and protocol presented in the document is complex, highly technical, contains excessive jargon and requires an advanced understanding of statistics. As written, the document is most certainly incomprehensible to the lay reader and we have serious reservations about the ability of local and state elected/appointed officials, upon which the ultimate responsibility of the project rests, to understand it. We request that an objective, professional biostatistician from Duke, UNC-Chapel Hill or NC State University review any draft monitoring plan before it is finalized.

Versar Response: See response to ED comment 3 above. Also, we believe that local and state officials who have been actively involved in the early stages of the program have more technical knowledge of the issues and the scientific method than this reviewer suggests.

DU Comment 4: Mine site monitoring: We agree with comments submitted by Environmental Defense (dated and submitted on December 19, 2003) regarding monitoring of the mining site. These comments are being reproduced in their entirety here: "The sampling protocol should be reviewed by scientists engaged in active research on mobile fishing gear and its impacts on soft bottom habitats. The effort is made to avoid impacts within the seasonal sampling protocol by conducting benthic sampling first (followed by bottom imaging and finally trawling); however, by using the same transects

for each sampling event, there is potential for minimal recovery between each seasonal sampling event. There is a balance between reducing spatial variability and being able to detect impacts of dredging vs. impacts of the trawl. Finally, it was my understanding when reviewing the EIS for this project, that there were differences between the two mine sites (S1 and N1/2) that would warrant mine site monitoring for the northern section as well. The results of the bottom imaging survey should be independently reviewed before a final decision to monitor only the southern area is made."

Versar Response: See response to ED comments 4 and 5 above.

DU Comment 5: The potential reference site for borrow site monitoring is immediately adjacent to an actual borrow site – might the proximity of these locations impact monitoring results?

Versar Response: Now that we have moved the monitoring to the Northern Project area we will have to rely more heavily on the benthic bottom imaging that will be conducted before initiating the program to select the most appropriate reference site for N1/N2.

DU Comment 6: Pre-construction monitoring will commence only months after Hurricane Isabel impacted the project area - what effect will this have on pre-construction monitoring results?

Versar Response: See response to NCDMF Comment 1 and NCCF Comment 7.

DU Comment 7: On page 2, the document states that this project is very similar to a replenishment project in Brunswick County (conducted as part of the Cape Fear River Deepening). How often will the beaches in the Brunswick County project be replenished, and what is the duration of monitoring for that project?

Versar Response: The Brunswick County beach replenishment was a one time beneficial use of material dredged to deepen the Cape Fear River not solely a project to repair storm-damaged beaches as in the Dare County example. One year of during construction and one year of post construction monitoring was conducted for this project.

DU Comment 8: Page 7 of the document states that ghost crab hole counts are of little value. Why is this? If the benefits of this effort are negligible, it should not be included in the monitoring plan for this project (even if only requires "minimal time").

Versar Response: The dry portion of the beach is heavily impacted by human activity particularly in the peak of the tourist season which will likely trample the ghost crab borrows we plan to count. However, the data may be more useful in the cooler months when fewer people visit the area (we counted ghost crab borrows for the Brunswick study). Because it adds very little extra field time to conduct the counts, we retained the parameter for the Dare County study.

Charles Peterson, University of North Carolina, (UNC)

UNC Comment 1: The potential to collect only 1 year of pre-construction data at the North Project Area and at the middle section of the South Project Area does not justify the exclusion of these phases from monitoring. That justification would require a showing that the sediments to be used for each phase are identical (which is unlikely given the use of different borrow areas) and the beach habitats (native sedimentary composition by size and also beach morphology) are identical. In addition, one would need to show that there are no other confounding perturbations (such as presence of buried seawalls or proximity to groins, etc) that may affect some areas of the beach but not others.

Versar Response: See response to general comment 1 above. Also, USACE selects borrow sites so that the sediments are a close match to the subject beach grain size, therefore the sediment conditions between the Northern and Southern borrow site should be very similar.

UNC Comment 2: The assessment design fails to replicate control beaches. The problem of lack of replication and interspersion of nourished and control beaches in impact studies and monitoring of beach nourishment projects is effectively articulated in W Nelson's reviews. Spatially unreplicated designs have been used effectively in the BACI mode but only where replication consists of several "before" sampling periods. Here, for any given season, there will be only 2 before sampling dates. Seasons must be treated differently and cannot readily be incorporated into the BACI analyses as replicates because even the control beaches show cold-season declines in beach invertebrate densities and biomass to near zero, thereby violating an assumption of BACI. This monitoring design should be modified to include multiple (3-5) control beaches, as advocated extensively in literature on "On beyond BAI" by AJ Underwood. Nevertheless, the specific methods proposed by Underwood use an improper error term and need to be modified by reference to the recent (2001) review by A Stewart-Oaten.

Versar Response: We believe that the current study design balances the allocation of effort between the control beach and the beach subject to nourishment. For a given survey cost, it is not necessarily true that the inclusion of another control beach would be the optimum use of resources. Based on this and other review responses we have increased the sampling effort to include 10 replicate transects.

UNC Comment 3: The proposal argues the merits of a systematic arrangement of transects (equal spacing) but fails to address the potential flaws in such a design. Specifically, if there exists any repeating pattern on the beach that occurs on the same frequency as the sampling then the transects will not be independent and, worse yet, the estimates of biota will be biased. There is one such structural periodicity known to exist on these beaches that may or may not reflect the transect distribution periodicity. That is the alternation of cusps on the beach. Whether this (or any other structural periodicity) occurs on these beaches and matches the transect spacing needs to be included to defend the systematic design.

Versar Response: We proposed to systematically allocate transects (after a random start) to increase the precision in estimated parameters in the presence of spatial auto-correlation (for example resulting from a gradient). Periodicity with equal wavelength is extremely rare in natural populations, and is not likely to occur at the study site. To eliminate the potential impact of periodicity in the population parameters, we propose to modify the study design as follows (see Gilbert 1987, p. 22):

1. Divide the beach into even sized segments (longitudinally), and
2. Allocate one transect randomly within each segment.

This restricted random sampling ensures that transects are well spaced along the beach, while eliminating concerns related to periodicity in the study population.

UNC Comment 4: The nourished beaches will apparently have another contractor sample them for physical data. However, it is not clear whether that same information will be collected using the exact same design for the control beach locations. This is a potentially serious oversight.

Versar Response: The same physical information will be collected at the nourished and control beaches. The physical monitoring will include many more transects than the biological monitoring transects. The nearest physical transect (conducted by another contractor) to the biological transect will be moved so it is in the same location, or new physical transects will be created at the biological transects.

UNC Comment 5: The sampling device for collecting supposedly quantitative samples of benthic infauna is not a rigorously accurate sampler. A grab does not sample equally from all depth levels in the sediments. What is needed is a proper core sample with either cylindrical or rectangular solid geometry. That is the standard of the discipline and easy to collect in an intertidal habitat or shallow subtidal habitat where sampling is done by hand. The reason that core samples that sample equally from all subsurface depths is critical is that absent such sampling one cannot relate the quantitative results accurately to surface area. That is the standard basis for quantification (numbers per unit surface area as projected through all the occupied depths). Perhaps even more importantly, a grab sample limits the depths into the sediments that can be sampled. A core tube sample can extend to 20 or more cm in depth and thus guarantee inclusion of deeply buried animals. There is real potential for these benthic invertebrates of the intertidal beach to be buried deeply after storms and during cold months. Overlooking deeper animals will bias the sampling. Burial depth could even vary between control beaches with more easily penetrated sediments and nourished beaches with greater compaction and perhaps also more coarse fractions difficult to excavate. In that instance, the entire estimate of abundance and biomass differences between nourished and control beaches will be seriously biased, as sampling grossly underestimates densities on control beaches where burial of invertebrates goes deeper than the sampler reaches.

Versar Response: The ponar grab will collect organism to a depth of 10-cm as the field sampler will press the grab into the sediments to its maximum depth of penetration. The

organisms we are primarily interested in within the swash zone are Donax and Emerita both of which feed at the sediment surface and are important forage food for shorebirds that also feed along the sediment surface. According to our PhD level staff benthic ecologist few organisms inhibiting the inter-tidal areas along the east coast are deeper than 10-cm. A similar depth of penetration will be achieved in the sub-tidal shallow habitat. While we may miss some deeper dwelling bivalves we will adequately quantify the benthic communities that provide forage food to demersal fish. Either way ponar grabs will provide a consistent quantitative measure of benthic invertebrate community abundance and composition for organisms inhabiting the top 10-cm of sediment representing most of the available biomass to higher trophic levels.

UNC Comment 6: The criterion on which the power analyses were conducted and on which the adequacy of sampling design and effort is justified in the document is not the proper criterion that should be measured and upon which design and sampling adequacy needs to be based. Specifically, the criterion used is whether movement of abundance (biomass) between the lowest and highest quartiles of distribution can be detected. The parameter that needs instead to be analyzed is not this esoteric distributional switch but rather the simple estimate of mean density (biomass) in the beach habitats. Power estimation based upon this distributional analysis do not guarantee that power will be adequate to answer the fundamental questions that such monitoring must address: do mean abundance (biomass) differ between nourished and control beaches and by how much and for how long. In the absence of a power analysis done on the fundamental variables of interest and of most importance to the public trust, the adequacy of the sampling design and effort is not justified in this study.

Versar Response: We used a non-parametric model to obtain an estimate of the required minimum sample size to detect broad shifts in the parameter distributions based on exact non-parametric inference. The estimation of sample sizes to detect a specified difference in mean abundance (biomass) with a certain power is problematic for the parametric mixed models because the variance of such parameters tends to increase with the mean (e.g., Pennington, M. and J.H. Vølstad. 1991, Biometrics 47: 717-723). Because the mean abundance (biomass) and the variance is not know in advance, it is not possible to estimate the exact power to detect a specified difference for a given sample size. However, the balanced factorial design with sampling before and after nourishment at the subject beach and the control beach should ensure that we detect substantial changes in mean abundance (or biomass). For example the Brunswick study had a similar factorial study design with one control beach and one subject beach with eight replicate transects for each event. For this study the ANOVA analysis (GLM model) had sufficient power to detect a decline in mean biomass in the shallow habitat from 0.5 to 0.3 g/sq m carbon at the 5% alpha level. This corresponded to a 40% reduction that could be attributed to the beach nourishment.

UNC Comment 7: The sampling plan of taking a single sample in each of two "habitats", the swash zone and the shallow subtidal at 2-ft deep is inadequate and fails to meet the accepted scientific standards established for sampling of the intertidal benthic invertebrates. The most applicable literature on how to sample these beach invertebrates

can be found in papers by O Defeo. Sampling must be done at intervals along a vertical transect with transect totals pooled to form an estimate of density per linear distance of beach. These invertebrates are distributed to elevations higher on shore than the swash zone during low tide as many become stranded in the intertidal. Sampling only elevations covered by water at low tide will miss a fraction of the population. What is worse is that that fraction missed will not remain constant but can vary with wave conditions, beach slope, and sedimentary habitat. The disturbance of nourishment has great potential to influence the degree of occupation of intertidal beach by *Donax* and *Emerita*, such that this inadequate and incomplete sampling will lead to biased estimates of the effects of nourishment by excluding a fraction of the population that varies with the treatment. Furthermore, no indication is given of how the single sample per depth "habitat" is to be located. Will this sample be placed at random? Centered in the depth zone? Haphazardly? Within what boundaries? With the methods proposed, even the sampling within depth zones ("habitats") is inadequate to estimate density within the specific zones because of lack of randomization and full coverage across the incompletely defined depth zone.

Versar Response: Versar Response: While we recognize that there could be nuances in the distribution of organism along a swash zone to shallow zone transect, the costs of processing samples at multiple positions along the transect will be prohibitively high. We selected the swash inter-tidal and shallow sub-tidal habitats because these areas are representative of most of what exists within the surf zone. Detected impacts and recovery within these sampling strata would provide an index of what is occurring at other slightly shallower or deeper bottom profiles that were not sampled by the program. The shallow sampling will be consistently taken in two feet of water on or about low tide. Based on typical beach profiles that exist within surf zones, this will put the sampling point 30-feet offshore of the swash zone sampling.

UNC Comment 8: The sampling for ghost crabs should use more but smaller replicates to achieve higher power to detect differences. Two 30-ft transects should be replaced by several 6-ft transects (which on Bogue Banks include sufficiently high densities of active ghost crab burrows to provide a large enough sample for analysis.

Versar Response: This suggestion can be easily accommodated by keeping each swash zone to dune toe ghost crab borrow count sequestered into five six-foot wide "counting" lanes.

UNC Comment 9: No methodology is presented to explain how sampling for grain size will be conducted. Specifically, will core surface areas be large enough to include large shells? These can be very important to beach animals in that they prevent shorebirds from foraging beneath them, for example, but traditional sediment sampling has used such small cores that large shells, cobbles, etc are excluded. Furthermore, will the specific locations of these sediment samples by placed at random? If not, they may be biased by even inadvertent observer choices.

Versar Response: We will use ASTM Method D2487 for the grain size. Sieve sizes will range from 4.75 mm (U.S. Standard Sieve No. 4) to 63 micron (U.S. Standard Sieve No. 230). The primary purpose of the grain size analysis is to provide ancillary qualitative information on sediment conditions to help interpret the benthic invertebrate results. To provide information on changes in shell distribution that may affect foraging shore birds we will count large shells as well. The grain size samples will be collected directly adjacent to the benthic sample grabs using the same gear.

UNC Comment 10: To preserve items that are digested rapidly in fish guts (such as polychaetes), formalin must be introduced immediately after capture in the field, typically by injection into the guts. Absent this procedure gut contents are biased towards types of prey that have hard parts. Five stomachs represent far too small a sample for powerful statistical analysis. No power estimation is done to justify sample sizes for fish guts. Many fish will even show empty guts. The mass of gut contents needs to be adjusted by a covariate for fish size, perhaps remaining body weight, to reduce error variance in analysis of whether mass of gut contents varies with nourishment treatment.

Versar Response: The stomach of fish from specimens selected for gut content analysis will be dissected upon collection and immediately frozen on dry ice or in a portable freezer to prevent the digestion of soft-bodied organisms. Dr. Volstad, our PhD level fisheries scientist and biostatistician conducted many studies involving gut content analysis in his professional career. His research, mostly conducted in the North Sea, Norway, indicated that is was better to sample a few stomachs from many different sites than taking a large number of specimens from one site. He theorizes that aggregates of fish in one area tend to eat the same thing or all have empty stomachs. Spreading this effort out over a larger area provides a better picture of what constitutes their diet. We also conducted a power analysis using variance estimates for mean weight of prey between and within stations from (Bogstad et al. 1995; Fisheries research 23: 37-46) to estimate expected level of precision as a function of number of stations and number of stomachs sampled from each station. The variance in mean stomach content is primarily driven by differences between stations because the diet within a station tends to be homogenous (i.e. fish at a location tends to have similar stomach content because prey generally are patchy). Our analysis showed that the sampling of more than 5 stomachs resulted in minimal reduction in the standard errors (< 3%) of the mean stomach weights. The increase in number of stations from 5 to 10 resulted in a 5% reduction in standard errors. These results showed that sampling more than five stomachs at nine to ten sites did little to tighten up the variance. A substantial improvement in the precision could only be obtained by increasing the number of stations, and not by sampling more stomachs within each station.

UNC Comment 11: Surely fish and crabs can be identified to species without even much taxonomic expertise. It is unclear why the study design cannot commit to that level of identification for these taxa.

Versar Response: Of course they can and will be. This is just standard Scope-of-Work language in the event that rare or unusual hard to identify species are encountered.

UNC Comment 12: Because of the extensive transport of during the active phase of a nourishment project, particularly in a region with such tremendous long-shore transport rates, it is impossible to insure that an area sampled a fixed distance ahead of where the pipe is located will not have been impacted already by that turbidity.

Versar Response: During the beach construction monitoring phase of the study extensive transport of sediment down current from the end the pipeline is not anticipated. We conducted extensive monitoring and mapping of turbidity plumes generated from sand pumping and dewatering activities during our recent two-year study along the Brunswick County beaches as part of USACE's Cape Fear River Deepening project. The results demonstrated that turbidity plumes did not travel far down drift from the end of the pipeline nor did the plumes extent much beyond the breakers. Since similar dredging and disposal techniques will be used for the Dare County beach re-nourishment and the borrow material will be comprised of mostly sand and few fines (like the Brunswick study) there is little reason to believe that turbidity plumes will be much different along the Dare County beaches.

UNC Comment 13: I question whether identifying areas completed 2, 4, and 8 weeks previously is even possible. Even after pumping is complete, there is often bulldozer work that trails behind a project and redistributes and redisturbs sediments pumped to the beach at different times. I suspect that time since disturbance cannot be resolved at this fine a scale.

Versar Response: We did this accurately and without much difficulty during the Brunswick County study. Time is money to dredging contractors and as a result they build up the beach very rapidly and quickly move on. Based on the Brunswick County experience we anticipate that each 200-foot section of beach will be built and left to recover within a 24-hours. However, unanticipated changes in the direction and speed of beach building will happen which will require flexibility in the sampling plan according to conditions encountered each seasonal sampling event.

UNC Comment 14: This sampling design proposed to test differences between 2,4 and 8 weeks of recovery is quite definitely not a BACI design, despite the incorrect contentions that it is. A BACI design separates spatial from temporal effects so that the impacts can be estimated without need to make assumption about either lack of spatial or lack of temporal pattern in the absence of the disturbance. The design proposed here fundamentally confounds spatial and temporal patterns, requiring the assumption that in the absence of the nourishment there would be no spatial pattern. Thus, it is not a BACI design. It is spatial sampling intended to assess temporal dynamics by making assumptions of no pre-existing spatial pattern because there is no before sampling at those same locations to test that assumption and to allow the interaction term to be used to assess potential impacts.

Versar Response: We will evaluate if spatial patterns (e.g., gradients) exists for the population parameters of interest based on 2 years pre-construction sampling. Previous sampling in Brunswick suggests that this will not be an issue. The proposed design for

estimating short-term recovery is constrained by logistics. Previous experience suggests that the nourishment operations do not progress at a constant speed. The proposed design will provide estimates of average abundance (biomass) at 2, 4, and 8 weeks recovery periods and for sites in front of the pipe (control) across seasons and space. Thus, there is a spatial/temporal replication incorporated into the design. It is true that the spatial and temporal patterns cannot be separated, but the study should provide estimates of average abundance (biomass) for each recovery period.

If the pre-construction sampling indicates strong spatial patterns along the beach we will consider alternative designs for estimating short-term impacts. One possible approach is to sample one or more small areas in front of the pipe, and then re-sample these areas after 2, 4, and 8 weeks of recovery time has passed. However, based on our Brunswick County study we do not anticipate that strong longitudinal spatial patterns exist along the Dare County beaches.

UNC Comment 15: Sampling of benthos proposed for the beach during the project fails to meet established rigorous protocols for beach invertebrate sampling, as I explained earlier for the before and after monitoring. Specifically, sampling is not done at fixed intervals along vertical transects, thereby missing variable fractions of the populations. Cores are not used to produce quantitative samples that can be related to surface area and cannot insure sufficiently deep penetration to sample to all depths in the sediments that may be occupied. And replication of 5 is almost certainly inadequate to conduct powerful tests of effects on mean abundance (biomass). No proper power estimation is done for these two fundamental response variables of greatest significance to managers.

Versar Response: See response to ED Comment 3 and UNC Comment 5 and 7 above.

UNC Comment 16: It is not clear whether surf conditions will be adequately controlled during haul seining. This concern is a particularly important one when the researchers are not local and thus cannot efficiently be on site for a long enough period to guarantee choosing similarly calm conditions for all sampling. Without that assurance, the data will have a large unexplained error variance induced by variable sampling conditions.

Versar Response: We have already discussed this issue with the potential commercial haul seiners we may hire and have determined that we will need to limit the sampling to relatively calm conditions (wave height of 2-feet or less). Since we are using commercial fishermen we will have a good handle on local conditions, furthermore the restrictive conditions necessary for using beach seines in ocean surf zones alone will insure that the sampling will be conducted within similar sea states. Versar's field crews did all the seining for the Brunswick County study so we are very familiar with the limitations to deploying the gear.

UNC Comment 17: "Biologically meaningful differences" is an undefined platitude with no data given to support the contention and show that replication of 9 samples provides sufficient power to detect effects. I doubt it. Furthermore, no methods for sampling are provided. This sampling should be done by diver coring for the same

reasons articulated earlier. Grabs are especially inadequate when deployed from a boat because depth of penetration cannot be controlled and varies with bottom type and wave conditions.

Versar Response: In our statement about biologically meaningful differences we were eluding to short-term shifts in benthic abundance or biomass that does not affect higher trophic levels such as fish or shorebirds. We removed this statement from the monitoring plan. Our staff biostatistician conducted a power analysis using recent data from the Brunswick County study and determined that ten samples were adequate. We are confident that the proposed number of samples is sufficient to address the impacts and recovery from the beach re-nourishment project. Sampling the borrow site with cores using SUBA will be un-necessarily expensive, logistically constraining, and dangerous. The Young grab (a larger ponar like system housed in a heavy triangular frame) has become the standard sampler for most benthic surveys conducted in North America. The U.S. EPA EMAP program initiated in the early 1990's was among the first large-scale benthic monitoring programs to use the device. It consistently samples full grab regardless of bottom type (weights can be added) or wave conditions. We have successfully used the Young grab extensively in sediment ranging from mud to hard oceanic sands. Also as part of our standard operation procedures grabs with less than 7-cm of penetration are rejected and re-sampled.

UNC Comment 18: The bottom imaging is casually done and not designed using a systematically developed plan of sampling that would allow quantitative estimations and contrasts.

Versar Response: The bottom imaging will be done along established tow lanes that will be consistently re-sampled in subsequent years. The initial survey conducted to help select the best reference area for the borrow site sampling will be more exploratory in nature.

UNC Comment 19: It is impossible to detect infaunal organisms from photos or videos of the sediment surface, even for species that leave surface evidence like burrow openings (which most do not).

Versar Response: The purpose of the bottom imaging is to monitor changes and recovery of large epi-benthic organisms such as starfish, sand dollars, anemones, mussels, and bivalve feeding tubes. Infaunal communities will be monitored with the Young grab sampler. We removed the reference to infaunal benthos for this section.

UNC Comment 20: It is unclear whether wind, wave, and weather conditions are to be controlled for the commercial trawl sampling. Absent such controls, there will be large uncontrolled error variance.

Versar Response: As with the beach haul seines, the offshore trawling cannot be done during adverse weather conditions (i.e., wave heights greater that 4-feet).

UNC Comment 21: It is unclear whether the three target species to be used for gut contents will be the same three at all treatments and dates or will vary. To be able to compare the disturbed to the control treatments, the same species of fish must be examined. However, the important fish can change from summer to winter so target species should vary seasonally. For example, striped bass are important cold-season species in this area.

Versar Response: See response to general comment 4 above. Also we question the suggestion to include striped bass in the gut content analysis, as species is not a benthic feeder.

UNC Comment 22: The proposal to sample by section (or area or stratum) to assess impacts on borrow-site benthos during the project is vague, unclear, and conceptually unjustified in its design. The logic of what will be compared is unclear. It is also unclear how intensity of disturbance by the dredge will be known for any given sampling area. The proposal to assess impacts on the borrow site fails to replicate and disperse control areas generally and thus fails to meet the basic criterion of independence required to evaluate potential impacts.

Versar Response: Dredging contractors are routinely required to maintain an accurate log of their mining activities to document the quantities and location of the sediment removal (this if often used as the basis for their billing). For the Dare County project the USACE will include a clause in the dredging construction contract requiring their close coordination with the environmental contractors. The construction contractor will supply the environmental contractor with a tentative schedule of where and when they plan to dredge. This information will be updated and mapped as they progress in case deviations in the dredging schedule occur that may require adjustments in the biological sampling locations. The handling of the resulting data will be very straightforward as we plan to compare and contrast the benthic and fish communities in the reference borrow area to the various stages of impact and recovery strata sampled within the active borrow site sampled throughout the construction season relative to the reference borrow site.

UNC Comment 23: Humans present on beaches during shorebird surveys can be readily and accurately counted – there is no need for qualitative categorization as low-medium-high in human use assessments. Also, because conditions change so dramatically with day and even time of day, this sampling should be done using two observers counting at the same times, one of nourished and the other on control beaches.

Versar Response: While that may be true during the off-season it may be an overwhelming task for the bird survey technician during peak seasons. We will count the number of people on the beach when the numbers are reasonably small but may have to revert to estimating the crowd size during the summer surveys. Our plan was to hire a local person on a part time basis (e.g., a retiree) to conduct the weekly shorebird surveys in the morning hours during first feeding and limiting the survey work to low wind conditions. If we split one part time job into two smaller part time jobs we may have difficulties in finding local staff to do the work. We will take it under consideration.

UNC Comment 24: Similarly, the recreational fish survey needs to employ 2 people simultaneously, one working the nourished and the other working the control beaches so as to control for temporal variation not only in fish catches but also in time of day that interviews about fish catches are conducted.

Versar Response: See response to UNC comment 23above.

UNC Comment 25: Species diversity indices computed for single small grab samples are meaningless because of strong biases of sample size and spatial confounding of all the individuals collected in the same sample. In addition, because nourishment changes the slope of the beach, effects on diversity may be predicted from the extensive work done by McLachlan on benthic invertebrate diversity on intertidal beaches. That work should be cited and conceptually integrated into the design, perhaps even controlling for changes in beach slope by using a covariate. Frankly, the cost of identifying all benthos to species just to be able to conduct a species diversity analysis is unjustified in a system with such low diversity (perhaps 20 macrofaunal species). If there is concern about species diversity, then the meiofaunal diversity should be sampled, not the macrofauna. There are over 100 species of flatworms alone on the NC beaches. For macrofauna, the overwhelmingly important question of importance to public trust is whether their abundance and biomass are affected because they dictate the ability of the benthos to provide the most important ecosystem service of the sand beach – feeding shorebirds, surf fishes, and crabs.

Versar Response: We will be developing species composition information from a series of ten replicate samples taken in the beach habitats and off shore borrow sites not single grab samples. While we do expect only about 20 species in the shallow beach habitat samples, many more will occur in the borrow site samples. Our recently completed Brunswick study included sampling in deeper habitats well beyond the surf zone in waters greater than 15 feet deep. Although we are not proposing to sample this habitat for the Dare County study (few affects were observed) we found more on the order of 60 infaunal species in deeper water. It is likely that a higher number of species will be found in the borrow sites. We have found species diversity indices extremely helpful in assessing impacts and recovery and believe it will be particularly important for the borrow site monitoring. Identifying the infaunal organisms to species will also help determine the succession of organisms that will re-colonize the borrow site after initial mining.

Mike Wicker, U.S. Fish and Wildlife Service, (FWS)

FWS Comment 1: Try to pick a sampling period that makes biological sense. For example if sampling birds try to hit the key abundance periods during each event or at least the same biological event. It is probably easier for me to explain with a fish example. It may be desirable for a particular project to sample the peak spawning period for an American shad fish on a spawning site. On a warm year this may be an earlier calendar date than on a cold year.

Versar Response: See response to NCCF Comment 3 above.

FWS Comment 2: It is desirable to have the same biologically relevant period sampled each year. In your notes Wilson thought you were suggesting a shorter period. What he meant was maintaining as tight a consistency from one year to the next as possible. There was no interest in having less sampling but there is an interest in having a tight sampling window to reduce seasonal bias in between year comparisons.

Versar Response: See response to NCCF Comment 3 above.