Appendix 5.3-A

Benthic Macroinvertebrate Community Assessment 2001

Benthic Macroinvertebrate Community Assessment

CAPE WIND ENERGY PROJECT

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TABLE OF CONTENTS

SECTION **PAGE**

1.0 INTRODUCTION 1

2.0 METHODS 1
- 2.1 Field Collection 1
- 2.2 Laboratory Analysis 2

3.0 RESULTS 3
- 3.1 Taxonomic Richness 3
- 3.2 Faunal Density 4
- 3.3 Percent Dominant Taxa 5

4.0 SUMMARY AND CONCLUSIONS 7

5.0 REFERENCE LITERATURE 7

TABLES

Table 1 Macroinvertebrate sampling data for selected sites along the preferred and alternative submarine cable routes and the wind farm grid, August 2001
Table 2 Summary statistics for invertebrate data collected from the preferred and alternative submarine cable routes and the wind farm grid, August 2001
Table 3 Abundance and distribution of benthic taxa present in sediment samples taken in Nantucket Sound

FIGURES

Figure 1 Benthic Grab Sample Locations
Figure 2 The Van Veen Grab Sampler

1.0 INTRODUCTION

ESS Group, Inc. (ESS) conducted an assessment of the benthic organisms along the preferred and alternative submarine cable routes and wind farm grid in Lewis Bay, Popponesset Bay, and Horseshoe Shoal respectively during August 2001. Benthic organisms (or benthos) include those organisms that either live on or beneath the seabed floor such as worms, insects, small clams, and other macroinvertebrates. The information presented in this section has been compiled from comprehensive field investigations conducted in support of this Project and from previous studies of benthic conditions within Nantucket Sound.

2.0 METHODS

2.1 Field Collection

One surface grab benthic sample was obtained from locations consistent with each of the 46 sediment core sampling locations sampled as part of this Project (Figure 1). Benthic macroinvertebrates in each sample were identified down to the lowest practicable taxonomic level and enumerated. Sample locations were chosen in order to reflect the range of benthic habitats along the preferred and alternative cable routes originating from Lewis and Popponesset Bay as well as the wind farm grid on Horseshoe Shoal. The survey vessel was anchored at each sample location, and sample positions were recorded using a Differential Global Positioning System (DGPS) unit.

The benthic samples were taken with a portable gravity dredge (or grab) sampler deployed over the side of the survey vessel. A Van Veen grab sampler was used throughout the study (Figure 2) and was found to provide adequate sample recovery in various sediment types and water depths encountered throughout the study area.

The Van Veen grab sampler (measuring 12" x 12.5") was lowered through the water column with the jaws open and locked (as shown in Figure 2). The grab sampler cover had a grated opening to minimize any disturbance of the benthic community caused by shockwaves generated by lowering the sampler. Lowering the sampler quickly and decisively into the sediment resulted in the least disturbance to the sample. Once the jaws of the sampler were released, the lines were given a sharp tug to completely set the jaws around the sample. The sampler was then brought back on deck for field logging and sampling.

Figure 2. The Van Veen Grab Sampler

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Once the grab sampler had been retrieved, field descriptions of the sample were made including: sample identification, the date the sample was taken, nature of substrate material, depth of water at the sample site, and the depth and area of sediment removed from the dredge. The depth and area of sediment removed from the grab sampler was measured since the volume of bottom material collected often exceeded the volume of the sample container or, in some instances, would be less than the full size of the grab when the sampler was deployed in areas of harder substrates or on sloping bottoms. Knowing the effective bottom area sampled allowed benthic data to be presented in numbers of organisms per square meter of bottom area, which enabled comparisons among the samples.

In all instances when less than the full grab was placed into the sample jars, a gloved hand was used to remove at least the top 1.5 - 2 inches of sediment from the grab. Samples (bottom material and benthos) were then placed in a pre-labeled one-quart sample jar. Immediately thereafter, each sample was preserved by adding sufficient Formalin solution to yield a concentration of approximately 10% Formalin and 90% sample/seawater. The Formalin solution was gently mixed throughout the sample so that benthic organisms were adequately preserved but not damaged. The preserved samples were returned to ESS for subsequent laboratory analysis.

2.2 Laboratory Analysis

As described in the field collection methods section, one (1) benthic sample was collected at each of the 46 sites located along the preferred and alternative cable routes and on Horseshoe Shoal (Figure 1). The liquid portion of each sample (formalin and seawater) was decanted through a 500µm sieve and stored in a sealed container. The sieve retained any animals or sediment present in the sample. The solid portion of each sample (sand, stones, shells, plant matter, etc.) was then emptied into the same 500µm sieve and gently washed with tap water to eliminate all final traces of formalin. The material in the sieve was gently washed to one side, minimizing the opportunity for organisms to become damaged from the direct flow of water. The rinsed material retained in the sieve was then washed into a grid-lined tray and the sieve was checked carefully to ensure no organisms remained; any found were picked off carefully with tweezers and added to the tray. The sample material was then spread evenly throughout the tray and sorted through with fine tweezers. This process was facilitated by the use of a lighted magnification lamp (3X magnification) and dissecting microscope (7X – 45X magnification). Each section of the grid marked on the tray was sorted through until 100 organisms had been picked out, or until the entire sample had been sorted if less than 100 organisms were present. The organisms found were removed with the tweezers, placed in a separate jar of 70% ethanol and labeled with the date, sample identification and the corresponding fraction of the sample that had been sorted.

All sorted organisms were subsequently identified to the lowest taxonomic level possible using a dissecting microscope and readily available taxonomic keys. The taxonomic keys used for this task included:

- Smith. R.I. 1964. Keys to the Marine Invertebrates of the Woods Hole Region. Marine Biological Laboratory.
- Martinez, A.J. 1999. Marine Life of the North Atlantic, Canada to New England. Down East Books.
- Gosner, K.L. 1978. The Peterson Field Guide Series. A Field Guide to the Atlantic Seashore From the Bay of Fundy to Cape Hatteras. Houghton Mifflin Company.
- Weiss. H.M. 1995. Marine Animals of Southern New England and New York. Identification Keys to Common Nearshore and Shallow Water Macrofauna. Bulletin 115 of the State Geological and Natural History Survey of Connecticut. Department of Environmental Protection.

A reference collection was compiled including a representative of each organism identified from within the study area. This reference collection has been retained.

For quality assurance and quality control (QA/QC) purposes, a second appropriately trained staff member periodically performed a quality check on approximately 10% of the samples analyzed. The quality check

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included both the sorting and identification phases of the analysis to ensure that no organisms or groups of organisms were being inadvertently excluded in the sorting process and to ensure that all organisms were being properly identified.

In the sorting phase, the QA/QC reviewer checked the sample material for any remaining organisms. If the QA/QC reviewer found that more than 10% of the total number of organisms found by the sorter still remained, then four (4) additional samples were to undergo quality assurance checks. If the percent error in these additional samples was also found to be more than 10% then all samples sorted by the original processor were to be reprocessed. In this study, the QA/QC reviewer never found that more than 10% of the organisms were missed.

In the identification phase, a second ESS staff member trained in benthic macroinvertebrate identification reviewed organisms that presented difficulty in identification as well as the entire macroinvertebrate reference collection that was compiled.

3.0 RESULTS

The sampled benthic community of Nantucket Sound was found to be composed of a variety of organisms including worms, snails, clams and crustaceans. A total of 95 benthic macroinvertebrate taxa from 11 Classes were recorded in the samples analyzed from the 46 sampled sites in the project area (Figure 1). A complete list of benthic organisms identified throughout is presented in Table 1. A summary of the macroinvertebrate community statistics for the preferred and alternative submarine cable routes and the area of the wind farm grid are presented in Table 2. It was found that 8 taxa, of the 95 total taxa found, comprised over 80% of the organisms collected and that 47 taxa (or less than half) accounted for nearly 98% of the organisms collected (Table 3).

3.1 Taxonomic Richness

Taxonomic richness is defined as the number of different taxa that exist within a given area or community. A taxon is defined as a group or category, at any level, (e.g. Order, Genus, Species), in a system for classifying plants or animals. Taxonomic richness is believed to be an important measure of the quality of a benthic site, because in general, taxonomic richness decreases with decreasing water and/or habitat quality (Resh and Grodhaus, 1983).

The average taxonomic richness for the 46 sites sampled in this study was 10 taxa per sample, with a total taxonomic richness for the proposed Project area of 95 taxa (Table 2). Site BG-C4 located in nearly 50 feet of water midway between Horseshoe Shoal and the Popponesset Bay landfall, had the highest taxonomic richness, with 22 taxa recorded, while sites BG-G3 and BG-MT1 (Figure 1) had the lowest taxonomic richness, with only 3 taxa recorded at each site.

Although not specific to the Project area, data collected by Wigley (1968) and Pratt (1973) described the dominant sand fauna of Nantucket Shoals and Georges Bank. In general, the data from these previous researchers is consistent with the data collected in this study. Organisms that were found to be dominant by these researchers were also the dominant inhabitants in the 46 benthic grab samples collected and analyzed from within the Project area. This would be expected since the areas being compared are generally characterized by sandy substrate, and as would be expected for a sandy sediment habitat, suspension feeders (filter feeders) are the dominant feeding type in terms of both diversity and total biomass.

The sandy sediments of Buzzards Bay, Vineyard Sound, and Nantucket Sound were previously reported to support mixed populations of three species of *Ampelisca* and the closely related amphipod *Byblis serrata* (Sanders, 1958). Amphipods were reported to often represent more than 35 percent of the individuals in the benthic community, which is also consistent with the current investigation.

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Crustaceans were found to make up nearly 50 percent of the benthic fauna, followed by annelids, and then mollusks. However, the benthic crustaceans are small compared to bivalve mollusks and represented only about 12 percent of the wet weight biomass of the sandy sediments.

3.2 Faunal Density

Faunal density is the number of individuals found per unit area. In this and most other benthic studies faunal density is the measure of the abundance of invertebrates within a square meter of bottom area. Faunal density is an important indication of external impacts on a site because, under certain stresses, the density of standing crops (numbers or biomass) of benthic organisms may increase or decrease according to the type of stress and the tolerance of the study species (Resh and Grodhaus, 1983).

The average faunal density for the 46 sites sampled in this study was 4,180 individuals per m^2 (Table 2) . Site BG-G7 located approximately 1.5 miles north of Halfmoon Shoal, which is essentially the southern end of Horseshoe Shoal, had the highest faunal density, with 38,400 individuals per m^2, while Site BG-G3, located approximately 1.0 mile west of Broken Ground at the northeast end of Horseshoe Shoal, had the lowest faunal density, with 125 individuals per m^2.

The data from this study (Tables 2 and 3) indicate that faunal density does not appear to be related to taxonomic richness i.e., although the site of lowest faunal density did have one of the lowest levels of taxonomic richness, other sites with much higher faunal density also had very low levels of taxonomic richness. Similarly, the highest levels of taxonomic richness found did not match the sites of highest faunal density. This seems to indicate that there is some factor at work within the studied environment that selects for a small number of taxa, which then dominate the benthic community of that area in terms of density. These findings are supported by earlier studies of Nantucket Sound, Georges Bank and Southern New England Shelf (Sanders, 1956, Wigley, 1968; Pratt, 1973; Avery et al., 1996; Theroux and Wigley, 1998), which found the benthic community of Nantucket Sound to have a lower than average invertebrate diversity as compared to the rest of the Southern New England Shelf, but the density and biomass was found to be relatively high. This is not surprising, as it is understood that only a limited number of taxa are capable of withstanding the shifting, sandy substrates characteristic of these shallower waters. Consequently, these habitats are able to support greater densities of each successfully adapted organism.

Table 3 shows the abundance /faunal density of individual benthic taxa present in Nantucket Sound during this study in descending order, with a register of how common each individual is. It is clear from Table 3 that in terms of abundance/faunal density throughout the study area overall, the Families Ampeliscidae and Ischyroceridae almost completely dominate. Together the two Crustaceans, both from the Order Amphipoda, compose nearly 50% of the total number of invertebrates enumerated in the study. Ampeliscid amphipods, which are important prey items for demersal fish, are often found to be highly productive on a localized basis (patchy distribution). In all instances in which amphipods were found in these high densities, the samples were collected from areas on or in the immediate vicinity of Horseshoe Shoal rather than along either of the proposed submarine cable routes. This is consistent with data collected from previous researchers, whom reported very high densities of amphipods from sandy bottom substrates sampled in shallow waters throughout Nantucket Sound (Pratt, 1973; Theroux and Wigley, 1998). Although these two amphipods were the two most abundant, they were only present (and therefore only dominant) at a few sites (Table 3).

The average faunal density observed by the ESS study throughout the entire project area was 4,180 individuals per m^2 (Table 2). This value exceeds the numbers reported by previous studies conducted in the region. The benthic macroinvertebrate fauna of the Southern New England Shelf, including Nantucket Sound, was reported to be quite abundant with a mean of more than 2,000 individuals/m^2 of sea floor (Theroux and Wigley, 1998). However, it should be noted that a natural annual and seasonal variability in most benthic communities is typical as these communities are constantly subjected to a combination of physical and biological factors which results in

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a high degree of environmental variability (Zajac, 1998). It also follows that this environmental variability on a localized basis typically translates into a high sample-to-sample variability in total macroinvertebrate abundance. These same conclusions were also drawn by more recent researchers that documented the benthic community of Nantucket Sound to be highly variable from season to season and location to location (Avery et al.,1996). It is believed that the patchy nature of "microhabitats" (defined as, the specific combination of habitat elements in the place occupied by an organism for a specific purpose) in terms of such parameters as depth, substrate type, temperature, light penetration, food availability, shelter, disturbance, currents, and predation, could be the reason for such variability (DeLeuw et al., 1991). However, no obvious relationship between the variations in invertebrate abundance and the depth or substrate type data collected or other patterns were identified in the results of this study.

3.3 Percent Dominant Taxa

Percent dominant taxa is defined as the ratio of individuals in numerically dominant taxa to the total number of individuals. In this study, dominant taxa are defined as those taxa that make up more than 50% of the total number of individuals in a sample. Percent dominant taxa is an important indication of external impacts on a site, as a community dominated by relatively few species could indicate environmental stress (Plafkin et al., 1989) and a high percent contribution by a single taxon generally indicates community imbalance (Bode, 1988).

Polychaeta

Of the eleven taxonomic Classes found in this study, Polychaeta (bristle worms) were dominant at more sites than any other Class. Fifteen of the 46 sites were dominated by Polychaete individuals with a maximum of 84% at site number BG-MT1. The three most abundant Polychaete taxa per square meter throughout the study area were *Glycera dibranchiata* (blood worm), *Lumbrineris sp* (Lumbrinerid thread worm) and *Syllides spp.* (Syllid worm).

Of the 45 sites at which Polychaeta were present, the blood worms were more abundant throughout the study area than all of the other Polychaete worms and comprised greater than 50% of the Polychaete taxa at 7 out of these 45 sites, contributing a maximum of 100% at sites BG-G3 and BG-MT1. Blood worms were also quite common compared to other Polychaete worms across the study area, being present at 17 out of the 46 sites sampled and ranking eighth in average faunal density overall (Table 3). In general, blood worms tend to be found in abundance on tidal flats, especially where there is some mud and organic debris mixed with sand. They are known to be fast burrowers but poor swimmers (Gosner, 1978).

The Lumbrinerid thread worms comprised greater than 50% of the Polychaete taxa at only 3 of these 45 sites contributing a maximum of 67% at site BG-Y1. However they were quite common compared to other Polychaete worms throughout the study area, being present at 12 out of the 46 sites and ranked ninth in average faunal density overall (Table 3). In general Lumbrinerid thread worms are found from lower intertidal to subtidal and into deep water, burrowing in mud or mixed-bottom debris (Gosner, 1978).

The Syllid worms comprised greater than 50% of the Polychaete taxa at only 2 of these 45 sites, contributing a maximum of 75% at site BG-C6. However they were the most common of the Polychaete worms across the study area, being present at 24 out of the 46 sites and ranked tenth in average faunal density overall (Table 3). In general Syllid worms are found among bottom debris, seaweeds and benthic animals from lower intertidal to subtidal at great depths. They are presumed to be predators that use a piercing-sucking technique (Gosner, 1978).

It should also be noted that *Nepthys picta* (red lined worms), although only ranking fourth in abundance per square meter among the Polychaete worms, comprised more than 50% of the Polychaete taxa at 5 of the 45 sites, contributing a maximum of 64% at site BG-P4. They were also the second most common of the Polychaete worms, being present at 18 out of the 46 sites and ranked fifteenth in average faunal density overall (Table 3).

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In general red lined worms are common intertidal worms, they are active predators on other invertebrates and burrow in sand or mud (Gosner, 1978).

Crustacea

The Crustacea were the second most dominant Class found, with 11 of the 46 sites being dominated by Crustacean individuals (Table 2), contributing a maximum of 99% at site BG-C6. The two most abundant Crustacean taxa were the Families Ampeliscidae (four eyed amphipods) and Ischyroceridae (fouling amphipods) from the Order Amphipoda. The high density of Amphipods found during the course of this study is consistent with data collected from previous researchers, which reported very high densities of amphipods from sandy bottom substrates sampled in shallow waters throughout Nantucket Sound (Pratt, 1973; Theroux and Wigley, 1998).

Of the 44 sites at which Crustacea taxa were present, the four-eyed amphipod comprised greater than 50% of the Crusteacea taxa at 6 of these 44 sites, contributing a maximum of 100% at site BG-MT1. Although they were not relatively common across the study area, being present at only 10 of the 46 sites, they ranked as the most abundant organism overall (Table 3). In general, four eyed amphipods are very abundant offshore and in the lower intertidal zone on muddy and sandy bottoms, especially in eelgrass beds (Weiss 1995).

The fouling amphipods, also known as tubicolous amphipods, comprised greater than 50% of the Crustacea taxa at only 2 of the 44 sites found to have Crustaceans, contributing 100% at site BG-C6. They were relatively uncommon, being present at only five sites, however they ranked as second most abundant overall (Table 3). As well as being known for building open-ended mud tubes on pilings wharves and buoys in which to live, fouling amphipods are commonly found on eelgrass and soft sediments in channels (Weiss 1995).

Another amphipod of the family Aoridae was also relatively dominant comprising greater than 50% of the Crustacea taxa at 3 of the 44 sites found to have Crustaceans, contributing a maximum of 85% at site BG-C1. They were quite common across the study area, being present at 16 of the 46 sites and ranked as sixth most abundant overall (Table 3). In general these are common in muddy and sandy bottoms in the lower intertidal and offshore (Weiss 1995).

The family Phoxocephalidae (amphipods) were dominant at more sites and more common than any of the other Crusteacea taxa. They comprised greater than 50% of the Crustacea taxa at 12 of the 44 sites found to have Crustaceans, contributing a maximum of 100% at sites BG-C8 and BG-Y4 and were present at 25 of the 46 study sites (Table 2). However, this amphipod family only ranked as seventh most abundant overall (Table 3) and thus was below those amphipods mentioned above in terms of overall abundance across the study area. In general, this family of amphipods is known to burrow in fine or sandy mud bottoms, often being found in the lower intertidal zone in protected bays and estuaries (Weiss 1995).

Gastropoda

The Gastropoda (snails), were the third most dominant Class found, with 6 of the 46 sites being dominated by Gastropod individuals (Table 2), contributing a maximum of 86% at site BG-G11. The two most abundant gastropod taxa (by an enormous amount) were the species *Crepidula convexa* (convex slippersnail) and *Crepidula fornicata* (common Atlantic slippersnail). A wide variety of gastropods were found in relatively high densities throughout the study area, particularly along the alternative submarine cable route to Popponesset Bay where numbers often exceeded 10,000 snails per square meter (Table 2). These results are consistent with previous research in Nantucket Sound (Pratt, 1973; Theroux and Wigley, 1998), where a wide variety of Gastropods (snails) were also documented to occur within the Project area.

Of the sites where Gastropods were present, the convex slippersnail comprised greater than 50% of the gastropod taxa at 6 of these 17 sites, contributing a maximum of 100% at sites BG-Y4, BG-C6 and BG-C5. They were not common across the study area, being present at only 12 of the 46 sites, although they ranked as third

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most abundant overall (Table 3). In general these snails are found attached to almost any available hard object, often arranged in small to large sacks, common especially along protected bays and sounds (Gosner, 1978).

The common atlantic slippersnail comprised greater than 50% of the gastropod taxa at 8 of these 17 sites, contributing a maximum of 94% at site BG-G11. They were not common across the study area, being present at only 11 of the 46 sites, although they ranked as fourth most abundant overall (Table 3). As with the convex slippersnail they are found attached to almost any available hard object, often arranged in small to large sacks, common especially along protected bays and sounds (Gosner, 1978).

Nematoda

It should also be noted that the Class Nematoda, although dominant at only one site BG-C8, were still the fifth most abundant taxa overall throughout the study (Table 3). They were also the most common taxa, being found at 39 out of the 46 sites sampled. Nematoda are generally known to be the most numerous marine invertebrates and are adapted to live literally everywhere (Gosner, 1978).

4.0 SUMMARY AND CONCLUSIONS

Overall, most of the benthic macroinvertebrate taxa documented during this study were also reported in earlier studies of Nantucket Sound with similar patterns of community composition and abundance. The variability between the current study and previously cited studies is most likely due to natural variance in physical and biological factors (Zajac, 1998). These factors can include such variables as depth, substrate type, temperature, light penetration, food availability, shelter, disturbance, currents, and predation, the combination of which constitute a "microhabitat" (DeLeuw et al., 1991). However, no obvious patterns among macroinvertebrate abundance and sample depth or substrate type were identified as part of this study.

An important consideration when evaluating potential impacts to the benthic community is the ability of the community to re-colonize areas following disturbance. Recovery of the benthos following disturbance is an ongoing process over much of the seafloor. Typical disturbances cover a range of natural and man induced events including the natural shifting of sediment resulting from storms and currents and impacts associated with the use of fishing equipment and anchors.

It is widely recognized that benthic invertebrates are able to opportunistically invade unoccupied areas following disturbance (Hynes, 1970; Rosenberg and Resh, 1993; Rhoads et al., 1978; Howes et al., 1997). Due to the limited width of direct impact anticipated during the Project's installation activities, mobile invertebrates (such as amphipods, polychaetes, oligochaetes, etc.) living in adjacent undisturbed areas will not have far to migrate to re-colonize the disturbed area. These organisms are considered "pioneer" species, and are expected to be the earliest colonizers of the disturbed areas. In addition, many benthic invertebrates with relatively short life cycles disperse through reproduction; e.g., bivalves such as mussels and clams. These organisms will re-colonize during the first spawning season as their veligers float into the area from existing stocks. For these reasons, the limited area of direct disturbance is unlikely to result in anything more than a temporary impact to the benthic community. Equilibrium of benthic communities after similar disturbances is generally achieved within less than one year. Therefore, no specific mitigation actions are recommended.

5.0 REFERENCE LITERATURE

Avery, D.E., J. Green and E.G. Durbin. 1996. The distribution and abundance of pelagic Gammarid amphipods on Georges Bank and Nantucket Shoals. Deep Sea Research II. Vol. 43, Nos.7-8, 1521-1532.

Bode, R.W. 1988. Quality Assurance Work Plan for Biological Stream Monitoring in New York State. Stream biomonitoring Unit, Bureau of Monitoring and Assessment, Division of Water, New York State Department of Environmental Conservation, Albany, NY.

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DeLeuw, Cather, & Company. 1991. Technical Memorandum #8, An inventory of Selected Aquatic and Biological Resources in the vicinity of the Quinnipiac River Bridge.

Gosner, K.L. 1978. The Peterson Field Guide Series. A Field Guide to the Atlantic Seashore From the Bay of Fundy to Cape Hatteras. Houghton Mifflin Company.

Howes, B.L., D.R. Schlezinger, J.A. Blake, and D.C. Rhoads. 1997. Infaunal "recovery" as a control of sediment organic matter remineralization and the fate of regenerated nutrients in Boston Harbor: 14th Biennial Estuarine Research Federation (ERF) International Conference - The State of Our Estuaries. Oct. 12-16, Providence, R.I. Abstracts; p. 84.

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Toronto. 555 pp.

Martinez, A.J. 1999. Marine Life of the North Atlantic, Canada to New England. Down East Books.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M. Hughes. 1989. Rapid Bioassessment protocols for use in Streams and Rivers. Benthic Macroinvertebrates and Fish. EPA/444/4-89/001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, DC.

Pratt, S.D. 1973. Benthic fauna. Pages 5-1 to 5-55 In: Coastal and Offshore Environmental Inventory. Cape Hatteras to Nantucket Shoals. Marine Publication Series No. 2. University of Rhode Island, Kingston, RI.

Resh V.H. and G. Grodhaus. 1983. Aquatic insects in urban environments. In Urban Entomology: Interdisciplinary Perspectives, eds. G.W. Frankie and C.S. Koehler, pp. 247-76. Praeger Pubs., New York.

Rhoads, D.C., P.L. McCall, and J.Y. Yingst. 1978. The ecology of seafloor disturbance. *Am. Sci.* **66**: 577-586.

Rosenberg, D.M. and V.H. Resh (eds). 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall, New York, N.Y. 488 pp.

Sanders, H. L. 1958. Benthic studies in Buzzards Bay. I. Animal-sediment relationships. Limnol Oceanogr 5:138-153.

Sanders, H.L. 1956. Oceanography of Long Island Sound. X. The Biology of marine bottom communities. Bulletin Bingham Oceanography collection 15: 245-258.

Smith. R.I. 1964. Keys to the Marine Invertebrates of the Woods Hole Region. Marine Biological Laboratory.

Theroux, R.B., and Wigley, R.L., 1998, Quantitative composition and distribution of the microbenthic invertebrate fauna of the continental shelf ecosystems of the northeastern United States, National Oceanographic and Atmospheric Administration Technical Report NMFS 140, 240 p.

Weiss. H.M. 1995. Marine Animals of Southern New England and New York. Identification Keys to Common Nearshore and Shallow Water Macrofauna. Bulletin 115 of the State Geological and Natural History Survey of Connecticut. Department of Environmental Protection.

Wigley, R. 1968. Benthic Invertebrates of the New England Fishing Banks, in "Underwater Naturalist", American Littoral Society, Vol. 5, No. 1.

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Zajac, R.N. 1998. A review of research on benthic communities conducted in Long Island Sound and an assessment of structure and dynamics. Chapter 4 in Long Island Sound Environmental Studies, U.S. Geological Survey Open-File Report 98-502.

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Tables

Table 1. Macroinvertebrate sampling data for selected sites along the preferred and alternative submarine cable routes and the wind farm grid, August, 2001.

	Number of Individuals m^2- Alternative submarine cable route (Popponesset Bay)															
Taxa	**BG-PB4**	**BG-PB3**	**BG-PB2**	**BG-PB1**	**BG-C1**	**BG-P1**	**BG-P2**	**BG-C2**	**BG-P3**	**BG-P8**	**BG-P4**	**BG-C8**	**BG-C3**	**BG-P9**	**BG-C4**	**BG-C5**
Anopla																
Procephalothrix spiralis	124											124				31
Carinoma tremaphoros																
Cerebratulus sp.																
Tetrastemma sp.												62				
Zygeupolia rubens																279
Anthozoa																
Haloclava producta																
Arachnida																
Halacaridae	31															
Bivalvia																
Anadara transversa									100						25	62
Ensis directus																
Gemma Gemma	93								100							
Nucula proxima							25		100							
Pandora gouldiana																
Periploma leanum																
Tagelus sp.																93
Tellina agilis										25	75			25		
Crustacea																
Amphipoda																
Ampeliscidae			868		100											
Ampithoidae						50										
Aoridae	124		31		3900	200	25		400		50				350	
Calliopius laeviusculus									500						25	
Caprella penantis					250	1825										
Corophiidae					50										50	
Dexamine thea					100											
Gammaridae					50											
Haustoriidae								25		75	25		75	25		
Ischyroceridae																
Lysianassidae					100											
Melitidae	31															
Phoxocephalidae	155						225	425	100	150	50	217	75	225		62
Unicola Spp.																
Cirripedia																
Balanus sp.															2375	
Cumacea																
Lamprops quadriplicata								25								31
Cyclaspis varians			31					25								
Decapoda																
Dyspanopeus sayi				31	50	25			400						225	
Gilvossius setimanus																
Libinia dubia																
Ovalipes ocellatus																
Pagurus sp.																
Pinnixa spp.																
Thalassinoidea							25								50	31
Isopoda																
Cyathura polita																
Mysidacea																
Heteromysis formosa									300						50	
Tanaidacea																
Leptochelia savignyi																31
Leptognathia caeca	279												25			
Valvifera																
Chiridotea sp.		31														
Insecta																
Diptera																
Chironomidae								125								
Gastropoda																
Crepidula convexa									8800						4175	31
Crepidula fornicata					350				500						7400	
Crepidula plana									1000						125	
Ilyanassa trivittata																
Littorina obtusata									100							
Mitrella lunata					50				400						125	
Seila adamsi															25	
Pyramidellidacea																
Urosalpinx cinerea															75	
unidentified marsh snail				31												
Nematoda	62	744	62	186	1500	100	250	75	200	50	25	1829	100	25	25	372
Oligochaeta		93			100	200		25		25						93
Polychaeta																
Ampharete acutifrons																
Aricidea sp.					150				400		25		50	25		
Capitellidae	31						200									62
Cirratulus grandis																
Clymenella sp.		31														
Diopatra cuprea					50											
Dispio uncinata		93														
Eteone sp.							25	25							25	
Eulalia sp.															25	
Glycera dibranchiata		31			200	25		150								62
Harmothoe sp.															325	
Lepidonotus squamatus									400						75	
Lumbrineris sp.	310	93	62	682		25	400	150	100							
Magelona rosea		124										31				
Maldane sarsi														50		
Nephtys picta	62						125	150		50	175	31	175	150		
Nereis arenaceodonta	124				750	75			200							186
Nereis pelagica				31												
Nereis virens				155												
Nereis sp.																
Odontosyllis fulgurans					250										25	
Onuphis sp.												31				
Orbinia ornata							25									62
Paranaitis speciosa																
Paraonis sp.													50			
Paraonis fulgens																31
Pherusa sp.																
Phyllodocidae	93	62		62										100		
Pista cristata					100											
Polyphysia crassa							25				50					
Prionospio sp.					250											
Scoloplos sp.		31				25										93
Scoloplos fragilis	62		31		200	100	75	125		25	25	155	25			
Streblospio benedicti			155	341												
Syllides spp.	372	279			400	125	150	25	100	75		62			25	62
Terebellidae																
Tharyx spp.									200						50	
Polyplacophora																
Chaetopleura apiculata																
Total	**1953**	**1612**	**1240**	**1519**	**8950**	**2775**	**1575**	**1350**	**14400**	**475**	**500**	**2542**	**575**	**625**	**15650**	**1674**
Number of Taxa	**15**	**11**	**7**	**8**	**21**	**12**	**13**	**13**	**20**	**8**	**9**	**9**	**8**	**8**	**22**	**18**

	Number of Individuals per m^2- Preferred submarine cable route (Lewis Bay)								
Taxa	**BG-L1**	**BG-Y1**	**BG-L2**	**BG-L3**	**BG-Y2**	**BG-L4**	**BG-Y3**	**BG-Y8**	**BG-Y4**
Anopla									
Procephalothrix spiralis						31			
Carinoma tremaphoros					25				
Cerebratulus sp.									
Tetrastemma sp.			62	31					
Zygeupolia rubens				31					
Anthozoa									
Haloclava producta									
Arachnida									
Halacaridae									
Bivalvia									
Anadara transversa							25		
Ensis directus						31			
Gemma Gemma		175							
Nucula proxima									
Pandora gouldiana							25		
Periploma leanum									
Tagelus sp.									
Tellina agilis	31	50							
Crustacea									
Amphipoda									
Ampeliscidae					50				
Ampithoidae									
Aoridae			155				100	150	
Calliopius laeviusculus									
Caprella penantis									
Corophiidae								125	
Dexamine thea			93						
Gammaridae		25							
Haustoriidae									
Ischyroceridae				31					
Lysianassidae									
Melitidae									
Phoxocephalidae		725	155	186	25	403	25		100
Unicola Spp.							25		
Cirripedia									
Balanus sp.									
Cumacea									
Lamprops quadriplicata						186			
Cyclaspis varians					25				
Decapoda									
Dyspanopeus sayi			31					250	
Gilvossius setimanus									
Libinia dubia									
Ovalipes ocellatus									
Pagurus sp.									
Pinnixa spp.									
Thalassinoidea									
Isopoda									
Cyathura polita		25							
Mysidacea									
Heteromysis formosa								375	
Tanaidacea									
Leptochelia savignyi									
Leptognathia caeca									
Valvifera									
Chiridotea sp.									
Insecta									
Diptera									
Chironomidae									
Gastropoda									
Crepidula convexa	93						3650	1200	25
Crepidula fornicata		25					50	2125	
Crepidula plana					25			200	
Ilyanassa trivittata									
Littorina obtusata									
Mitrella lunata	62							25	
Seila adamsi								50	
Pyramidellidacea									
Urosalpinx cinerea									
unidentified marsh snail		25							
Nematoda	31	275	248	31	250	620	75	50	25
Oligochaeta		450			225	31	50	25	25
Polychaeta									
Ampharete acutifrons					25		150		
Aricidea sp.					50	31	25		
Capitellidae					50				
Cirratulus grandis								25	
Clymenella sp.						62			
Diopatra cuprea									
Dispio uncinata									
Eteone sp.		50							
Eulalia sp.									
Glycera dibranchiata					25		25	25	
Harmothoe sp.									
Lepidonotus squamatus	62						25	175	
Lumbrineris sp.		150			775	217			100
Magelona rosea						558			
Maldane sarsi									
Nephtys picta					75	124			75
Nereis arenaceodonta	31		62	217					
Nereis pelagica									
Nereis virens									
Nereis sp.									
Odontosyllis fulgurans									
Onuphis sp.									
Orbinia ornata									
Paranaitis speciosa							25		
Paraonis sp.			31						
Paraonis fulgens			31						
Pherusa sp.									
Phyllodocidae	31			93					25
Pista cristata									
Polyphysia crassa						31	50		25
Prionospio sp.									
Scoloplos sp.									
Scoloplos fragilis	31	25	93			155			
Streblospio benedicti	31								
Syllides spp.					275	217	50		
Terebellidae									
Tharyx spp.									
Polyplacophora									
Chaetopleura apiculata									
Total	**403**	**2000**	**961**	**620**	**1900**	**2697**	**4375**	**4800**	**400**
Number of Taxa	**9**	**12**	**10**	**7**	**14**	**14**	**16**	**14**	**8**

	Number of Individuals per m^2 - Wind farm grid (Horseshoe Shoal)																				
Taxa	**BG-C6**	**BG-G2**	**BG-G3**	**BG-Y5**	**BG-G1**	**BG-Y6**	**BG-Y7**	**BG-14**	**BG-G13**	**BG-C7**	**BG-G4**	**BG-G12**	**BG-SP1**	**BG-G5**	**BG-G11**	**BG-G10**	**BG-G6**	**BG-G7**	**BG-G9**	**BG-MT1**	**BG-G8**
Anopla																					
Procephalothrix spiralis													50								25
Carinoma tremaphoros																	25				50
Cerebratulus sp.																					25
Tetrastemma sp.																					
Zygeupolia rubens												31									25
Anthozoa																					
Haloclava producta												62									
Arachnida																					
Halacaridae				31																	
Bivalvia																					
Anadara transversa																					
Ensis directus											100										
Gemma Gemma																					
Nucula proxima																					
Pandora gouldiana																					
Periploma leanum																50	75				
Tagelus sp.																					
Tellina agilis						31	25				100			31		25					25
Crustacea																					
Amphipoda																					
Ampeliscidae							50				13900			279				36400	93	100	50
Ampithoidae																					
Aoridae							50		50	124								600			75
Calliopius laeviusculus					300										84						
Caprella penantis												31									
Corophiidae																					
Dexamine thea						31			25												
Gammaridae					100			31													
Haustoriidae			25	62		93	25														25
Ischyroceridae	22250	18476				31			25												
Lysianassidae																					
Melitidae																					
Phoxocephalidae				93	1000	341		31	50					62			25		868		
Unicola Spp.																		200			25
Cirripedia																					
Balanus sp.																					
Cumacea																					
Lamprops quadriplicata																	25				
Cyclaspis varians																					
Decapoda																					
Dyspanopeus sayi										62									217		
Gilvossius setimanus				31							100		25								
Libinia dubia																			31		
Ovalipes ocellatus																					25
Pagurus sp.										31											
Pinnixa spp.																					25
Thalassinoidea														31							
Isopoda																					
Cyathura polita																					
Mysidacea																					
Heteromysis formosa															84						
Tanaidacea																					
Leptochelia savignyi					500			31											31		
Leptognathia caeca		248		186																	
Valvifera																					
Chiridotea sp.																					
Insecta																					
Diptera																					
Chironomidae																					
Gastropoda																					
Crepidula convexa	50				100				25	248					42						
Crepidula fornicata					1800				125	1519					2646				310		
Crepidula plana					100					279					84				155		
Ilyanassa trivittata										93									62		
Littorina obtusata																					
Mitrella lunata																			31		
Seila adamsi										93					42				31		
Pyramidellidacea									25												
Urosalpinx cinerea																			62		
unidentified marsh snail																					
Nematoda	100	62	50	155	1000			62	150		300	62		217	84	25			31		125
Oligochaeta		62		155					100		100					25		400		200	
Polychaeta																					
Ampharete acutifrons																			31		
Aricidea sp.		62																			
Capitellidae	50																				
Cirratulus grandis													50								
Clymenella sp.																					
Diopatra cuprea																					
Dispio uncinata																					
Eteone sp.																					
Eulalia sp.																					
Glycera dibranchiata			50		100			124	125			31				250	125	400		1600	
Harmothoe sp.																			31		
Lepidonotus squamatus										62					126				31		
Lumbrineris sp.																					
Magelona rosea		62																			
Maldane sarsi																					
Nephtys picta					400	62	25		25			31		93							25
Nereis arenaceodonta																					
Nereis pelagica																					
Nereis virens																					
Nereis sp.							25														
Odontosyllis fulgurans																					
Onuphis sp.																					
Orbinia ornata														31							
Paranaitis speciosa																					
Paraonis sp.																					
Paraonis fulgens																					
Pherusa sp.											200										
Phyllodocidae														31					62		
Pista cristata																					
Polyphysia crassa						31					200		75					400	62		
Prionospio sp.																					
Scoloplos sp.						31															
Scoloplos fragilis		62			300							31									50
Streblospio benedicti																					
Syllides spp.	150				200			62	25	31			75	31		100	25		62		
Terebellidae													25								
Tharyx spp.					100														31		
Polyplacophora																					
Chaetopleura apiculata					100					124					84						
Total	**22600**	**19034**	**125**	**713**	**6100**	**651**	**200**	**341**	**750**	**2666**	**15000**	**279**	**300**	**806**	**3276**	**475**	**300**	**38400**	**2232**	**1900**	**575**
Number of Taxa	**5**	**7**	**3**	**7**	**14**	**8**	**6**	**6**	**12**	**11**	**8**	**7**	**6**	**9**	**9**	**6**	**6**	**6**	**19**	**3**	**14**

Table 2. Summary statistics for invertebrate data collected from the preferred and alternative submarine cable routes and the wind farm grid, August, 2001.

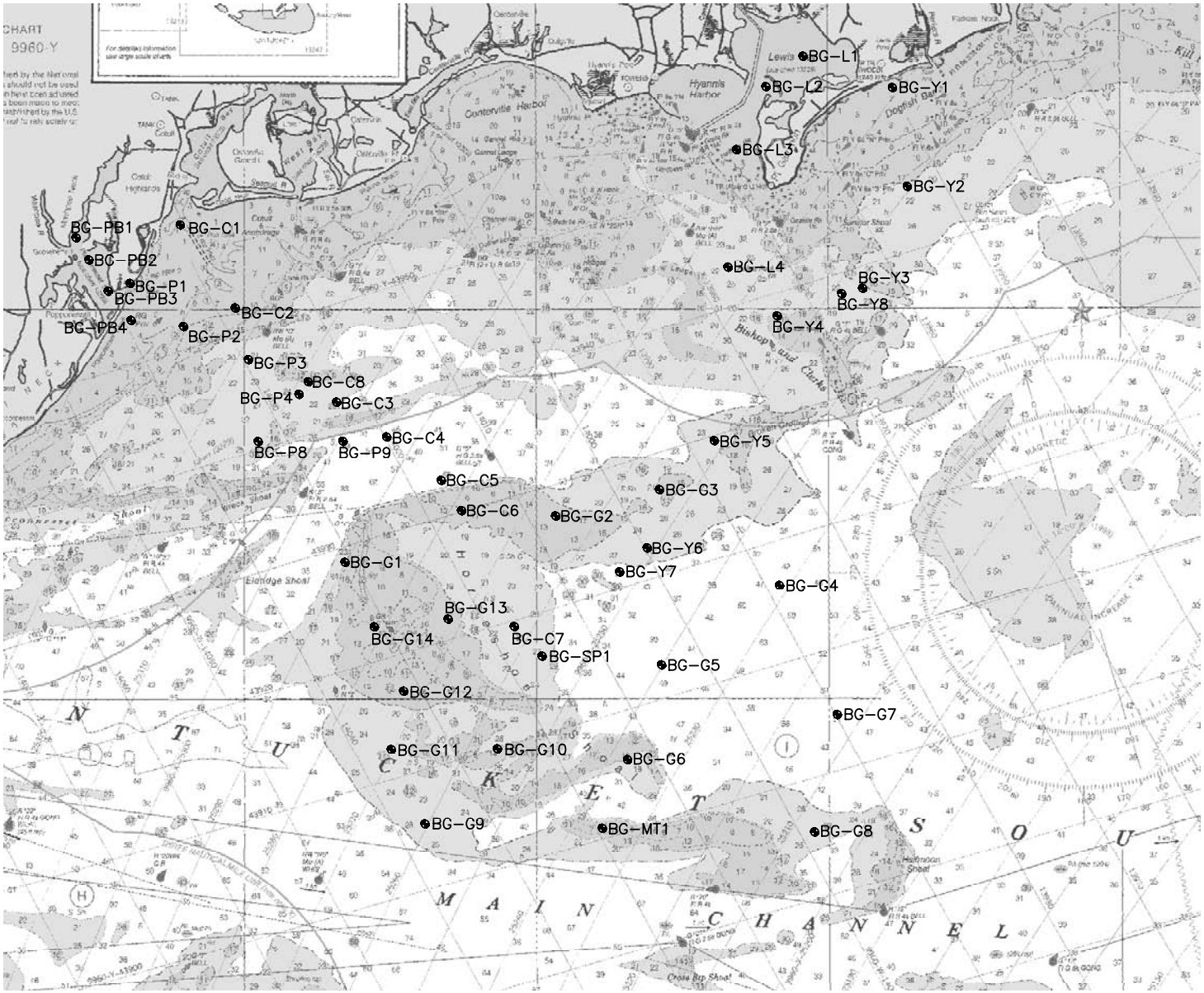
Areas Under Investigation	Total Taxa Present	Average Number of Taxa per Sample	Average Number of Individuals per m^2
Alternative Submarine Cable Route (P. Bay)	72	12.6	3,588
Preferred Submarine Cable Route (Lewis Bay	49	11.6	2,017
Wind Farm Grid (Horseshoe Shoal)	58	8.2	5,558
Entire Project Area	95	10.4	4,180

Table 3. Abundance and distribution of benthic taxa present in sediment samples taken in Nantucket Sound.

Taxon	Average No. Individuals/m^2	% Total	Cumulative %	No. of Sites	% of Sites
Ampeliscidae	1128.0	26.99	26.99	10	22
Ischyroceridae	887.2	21.23	48.22	5	11
Crepidula convexa	400.8	9.59	57.81	12	26
Crepidula fornicata	366.3	8.76	66.57	11	24
Nematoda	209.4	5.01	71.58	39	85
Aoridae	138.8	3.32	74.90	16	35
Phoxocephalidae	125.5	3.00	77.90	25	54
Glycera dibranchiata	72.8	1.74	79.64	17	37
Lumbrineris sp.	66.6	1.59	81.24	12	26
Syllides spp.	64.7	1.55	82.78	24	52
Oligochaeta	51.8	1.24	84.02	19	41
Balanus sp.	51.6	1.24	85.26	1	2
Caprella penantis	45.8	1.10	86.35	3	7
Crepidula plana	42.8	1.02	87.38	8	17
Nephtys picta	40.3	0.96	88.34	18	39
Nereis arenaceodonta	35.8	0.86	89.20	8	17
Scoloplos fragilis	30.8	0.74	89.96	17	37
Dyspanopeus sayi	28.1	0.67	90.63	9	20
Lepidonotus squamatus	20.8	0.50	91.13	8	17
Polyphysia crassa	20.6	0.49	91.62	10	22
Calliopius laeviusculus	19.8	0.47	92.09	4	9
Aricidea sp.	17.8	0.43	92.52	9	20
Heteromysis formosa	17.6	0.42	92.94	4	9
Magelona rosea	16.8	0.40	93.34	4	9
Leptognathia caeca	16.0	0.38	93.73	4	9
Mitrella lunata	15.1	0.36	94.09	6	13
Leptochelia savignyi	12.9	0.31	94.40	4	9
Phyllodocidae	12.2	0.29	94.69	9	20
Streblospio benedicti	11.5	0.27	94.96	3	7
Haustoriidae	9.9	0.24	95.20	10	22
Tellina agilis	9.6	0.23	95.43	11	24
Capitellidae	8.5	0.20	95.63	5	11
Procephalothrix spiralis	8.4	0.20	95.83	6	13
Tharyx spp.	8.3	0.20	96.03	4	9
Gemma Gemma	8.0	0.19	96.22	3	7
Zygeupolia rubens	8.0	0.19	96.41	4	9
Harmothoe sp.	7.7	0.19	96.60	2	4
Scoloplos sp.	7.3	0.17	96.77	5	11
Chaetopleura apiculata	6.7	0.16	96.93	3	7
Odontosyllis fulgurans	6.0	0.14	97.08	2	4
Lamprops quadriplicata	5.8	0.14	97.21	4	9
Unicola Spp.	5.4	0.13	97.34	3	7
Prionospio sp.	5.4	0.13	97.47	1	2
Dexamine thea	5.4	0.13	97.60	4	9
Seila adamsi	5.2	0.13	97.73	5	11
Corophiidae	4.9	0.12	97.85	3	7

Taxon	Average No. Individuals/m^2	% Total	Cumulative %	No. of Sites	% of Sites
Anadara transversa	4.6	0.11	97.96	4	9
Gammaridae	4.5	0.11	98.06	4	9
Ampharete acutifrons	4.5	0.11	98.17	3	7
Pherusa sp.	4.3	0.10	98.27	1	2
Gilvossius setimanus	3.4	0.08	98.36	3	7
Tetrastemma sp.	3.4	0.08	98.44	3	7
Ilyanassa trivittata	3.4	0.08	98.52	2	4
Nereis virens	3.4	0.08	98.60	1	2
Thalassinoidea	3.0	0.07	98.67	4	9
Urosalpinx cinerea	3.0	0.07	98.74	2	4
Ensis directus	2.8	0.07	98.81	2	4
Nucula proxima	2.7	0.07	98.87	2	4
Periploma leanum	2.7	0.07	98.94	2	4
Chironomidae	2.7	0.07	99.00	1	2
Eteone sp.	2.7	0.07	99.07	4	9
Orbinia ornata	2.6	0.06	99.13	3	7
Carinoma tremaphoros	2.2	0.05	99.18	3	7
Lysianassidae	2.2	0.05	99.23	1	2
Littorina obtusata	2.2	0.05	99.29	1	2
Pista cristata	2.2	0.05	99.34	1	2
Tagelus sp.	2.0	0.05	99.39	1	2
Clymenella sp.	2.0	0.05	99.43	2	4
Dispio uncinata	2.0	0.05	99.48	1	2
Cyclaspis varians	1.8	0.04	99.52	3	7
Paraonis sp.	1.8	0.04	99.57	2	4
Cirratulus grandis	1.6	0.04	99.61	2	4
Haloclava producta	1.3	0.03	99.64	1	2
Halacaridae	1.3	0.03	99.67	2	4
Paraonis fulgens	1.3	0.03	99.70	2	4
unidentified marsh snail	1.2	0.03	99.73	2	4
Diopatra cuprea	1.1	0.03	99.76	1	2
Maldane sarsi	1.1	0.03	99.78	1	2
Melitidae	0.7	0.02	99.80	1	2
Libinia dubia	0.7	0.02	99.81	1	2
Pagurus sp.	0.7	0.02	99.83	1	2
Chiridotea sp.	0.7	0.02	99.85	1	2
Nereis pelagica	0.7	0.02	99.86	1	2
Onuphis sp.	0.7	0.02	99.88	1	2
Cerebratulus sp.	0.5	0.01	99.89	1	2
Pandora gouldiana	0.5	0.01	99.91	1	2
Ovalipes ocellatus	0.5	0.01	99.92	1	2
Pinnixa spp.	0.5	0.01	99.93	1	2
Cyathura polita	0.5	0.01	99.94	1	2
Pyramidellidacea	0.5	0.01	99.96	1	2
Eulalia sp.	0.5	0.01	99.97	1	2
Nereis sp.	0.5	0.01	99.98	1	2
Paranaitis speciosa	0.5	0.01	100.00	1	2
Terebellidae	0.5	0.01	100.01	1	2

Figures



-N-

BG-C7 LEGEND:

BENTHIC GRAB LOCATION

NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ISLAND ZONE (2002), NAD 83.

2. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 25 JUNE–15 JULY, 2001 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

3. NO DISTINCTIVE FEATURES PRESENT ON THE SEAFLOOR. PREDOMINANT SEDIMENT TYPE IS FINE–COARSE SAND, WHICH MAY CONTAIN LOCALIZED FRACTIONS OF CLAY, SILT, GRAVEL, SHELL FRAGMENTS AND OR COBBLES.

4. THIS MAP WAS DERIVED FROM A COPY OF OCEAN SURVEY INC.'S MAP ENTITLED "PLAN VIEW" DATED 15 SEPTEMBER 2001.

0 8,000 16,000

SCALE IN FEET

FIGURE NO.
1

PROJECT NO.
B159-002.7

BENTHIC GRAB SAMPLE LOCATIONS

NOAA Chart #13237, Nantucket Sound & Approaches
Cape Wind Project

Cape Wind™
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