New York and New Jersey Harbor Deepening Project

HARBORWIDE BENTHIC MONITORING PROGRAM

Final Report

U.S. Army Corps of Engineers – New York District
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1 Introduction

The United States Army Corps of Engineers New York District (USACE-NYD) has played a major role in the navigation, development and maintenance of water resource activities in the New York / New Jersey Harbor (The Harbor) for more than two centuries and is committed to maintaining the Harbor as a viable port into the future while preserving the natural resources of the estuary. To keep pace with changes in the shipping industry, USACE-NYD has been conducting the NY/NJ Harbor Navigation Study (HNS) since 1999 in order to identify navigation channels that need improvements (i.e. dredging). The Recommended Plan in the FEIS for the HNS included a fourth Federal channel deepening project consisting primarily of deepening the main shipping channels within the Harbor to 50 feet (52 feet in rock or otherwise hard material). The Harbor Deepening Project is the consolidation of all projects to deepen the Port to 50 feet.

The HDP provides for improvements to selected navigation channels to allow access by larger, deeper draft vessels to five main container terminals: Port Newark/Elizabeth Marine Terminal, Howland Hook Marine Terminal, Global Marine Terminal on the Port Jersey Peninsula, the former Military Ocean Terminal at Bayonne (MOTBY), and the South Brooklyn Marine Terminal. The Program encompasses the deepening of these navigational channels from 45 to 50 feet. Previous documents including a Final Environmental Impact Statement (FEIS; USACE 1999) and a subsequent Environmental Assessment (EA) were completed by the Corps to evaluate the environmental impacts of the HSN and HDP.

The Kill Van Kull (KVK) and Newark Bay (NB) Channels were deepened from 35 feet to 40 feet in the late 1980’s through the early 1990’s (i.e. KVK/NB-40 Deepening). Most of these same channels (i.e. KVK/NB-45) were further deepened to 45 feet beginning in 1999 and ending in 2004. Deepening the Arthur Kill (AK) Channel to 41 and 40 feet (AK-41/40), and the Port Jersey Channel to 41 feet (PJ-41), began in 2002. South Elizabeth Channel was dredged in 2002 to 45’. These navigation channel deepening projects were authorized before the HDP and are referred to collectively as predecessor projects. The predecessor projects were authorized as §101, §102, and §202a of WRDA 1986, Pub.L. No. 99-662, as amended. Anchorage Channel was last dredged during operation and maintenance work in the 1970s and the portions of Ambrose Channel to be deepened under the HDP were last dredged during operation and maintenance work in 1984.

As the HNS and HDP are multi-year dredging projects, USACE-NYD developed biological monitoring programs to collect data on existing fish and benthic communities during these dredging programs. This report presents benthic community data from navigation channels prior to HDP dredging.

1.1 Background

Invertebrate communities are an important part of marine foodwebs in the Harbor. The benthic community consists of a wide variety of small aquatic invertebrates which live burrowed into or in contact with the bottom, such as worms and snails. Through suspension and deposit feeding, benthic organisms cycle nutrients from the sediment and water column to higher trophic levels. Additionally, the sediment is modified by the benthos through bioturbation and the formation of fecal pellets (Wildish and Kristmanson, 1997).

The benthos life strategies and sediment characteristics are tightly coupled. The distribution and abundance of benthic invertebrates is influenced by a wide variety of physical parameters, such as substrate, water temperature, dissolved oxygen, pH, salinity, and hydrodynamics. Benthic organisms can provide information about local environmental conditions because they live and feed on the sediment and have limited mobility and cannot avoid exposure to contaminants in the sediments.

Benthic organisms living in the sediment in the dredge contract areas will be directly impacted by dredging. When an area is disturbed, the benthic community is often the first to reestablish, especially if sediment conditions are improved over previous conditions. Thus, it is important to understand how dredging in the contract areas may change the benthic community and to also understand the timing of reestablishment.

1.2 Study Objectives

The objectives of the Benthic Monitoring Program are:

- Collect existing information on species composition, distribution and abundance of the benthic invertebrate community prior to dredging activities associated with the Harbor Deepening Program and;
- Determine the potential impacts of Harbor dredging activities on the benthic community after dredging.

2 Methods

2.1 Sample Collection

Benthic samples were collected throughout the Harbor in the summer of 2005 except for the Kill Van Kull Channel, which were collected in April due to the HDP dredging schedule. Samples were collected at five sites in the Kill van Kull and at three sites at each of Ambrose Channel, Anchorage Channel, Bay Ridge Channel, Elizabeth Channel, Newark Bay Channel, Port Jersey Channel, and South Elizabeth Channel during July (Figure 1). Because benthos distribution is not uniform and the dredge contract areas were large, sample locations were chosen by sediment types (data provided by USACE from geological surveys). Two samples were collected at each site.

Benthic samples were collected using a 0.1 m2 Smith-McIntyre Grab. At each sampling location, one benthic sample was collected and washed onboard the sampling vessel using a 500-µm mesh sieve. Material retained within the sieve was placed into a labeled sample bottle and preserved with 10% buffered Formalin containing Rose Bengal stain for laboratory analysis. For each grab sample, the date, time, location, weather/oceanographic conditions, water depth, and sediment characteristics were recorded.

In the laboratory, organisms were sorted from the remaining debris, identified by experienced taxonomists and enumerated. Identifications were made to the lowest practical identification level when not to the species level. Strict quality control procedures consisting of a Continuous Sampling Plan (CSP) to assure an Average Outgoing Quality Limit (AOQL) of 90% was followed during sample sorting, enumeration and identification. When the number of organisms in a sample was large (>500) subsampling was conducted using a sampling tray with 30 grids, each 6 cm x 6 cm. For all samples, organisms in randomly selected grids were counted until the total number of organisms reached 100 or the entire sample was sorted, whichever occurred first.

2.2 Data Analysis

Benthic community biodiversity was assessed through calculation of taxa richness, Shannon-Wiener's Index, and evenness (or equitability) from the benthic grab data. Each biodiversity index was calculated for the average catch from each of the two samples collected at each station (e.g. "Ambrose Station 1") as well as for all stations combined within each area (e.g., "Ambrose").

Species richness is a measure of the total number of taxa (or species) collected at a site. In counting the number of taxa present, general taxonomic designations at the generic, familial, and higher taxonomic levels were dropped if there was one valid lower-level designation for that group. For example, if *Leitoscoloplos sp.*, *Leitoscoloplos fragilis*, and *Leitoscoloplos robustus* were all identified in one sample, then *Leitoscoloplos* sp. was skipped when counting the number of taxa. The number of taxa recorded in this example would be two.

The Shannon-Wiener Diversity Index (*H'*) is a widely used species diversity index. It provides more information about the benthic community structure than taxa richness because it takes into account the relative abundance of each taxa as well as taxa richness. The diversity index *H'* can range between values of 0 and 4. Low values of *H'* indicate low taxa richness and an uneven distribution of abundance among species while high values indicate high taxa richness and an even distribution of abundance among taxa. Typically, a healthy benthic macroinvertebrate community would have a high *H'* value. The index is computed as follows:

$$H' = -\sum_{i=1}^{s} (p_i)(Log_2 p_i)$$

where S is the total number of species per sample (i.e., taxa richness) and p_i is the proportion of total individuals in the i^{th} species. Mathematically, p_i is defined as n_i/N where n_i is the number of individuals of a taxa in a sample and *N* is the total number of individuals of all taxa in the sample.

The Evenness (E; or equitability) measures the distribution among species within the community by scaling one of the diversity measures relative to its maximal possible value. The evenness can range from 0 (low diversity) to 1 (high diversity). It is computed as follows:

$$E = \frac{H'}{H'_{\max}}$$

where H' is the observed diversity (as cited above) and H'_{max} is the logarithm of the total number of taxa (S) in the sample ($H'_{max} = \text{Log}_2 S$).

The proportions of benthic organisms characterized as pollution-tolerant and pollution-sensitive in grab samples were also calculated. Pollution-tolerant taxa include: Oligochaeta, *Leitoscoloplos* sp., Capitellidae, *Eteone* sp., *Streblospio benedicti*, and *Mulinia lateralis*. Pollution-sensitive taxa include: *Glycera* sp., *Nephtys* sp., *Ampelisca abdita*, *Cyathura polita*, *Ensis directus*, *Tellina agilis*, and *Mercenaria mercenaria*.

3 Results

Benthic community data collected during the summer of 2005 is summarized by sampling area below. Sampling areas are discussed in alphabetical order.

3.1 Ambrose Channel

A total of 33 taxa were collected in Ambrose grab samples (Table 1). These taxa were distributed among annelids (52%), arthropods (21%), mollusks (21%) and other (6%) (Table 2 and Figure 2). Overall, the benthic community living in the sediments of Ambrose exhibited moderate levels of organism abundance (775 organisms/m^2), high community diversity (H'= 3.3), and high evenness (E=0.63) relative to the other areas sampled (Table 3). Blue mussel (*Mytilus edulis*) dominated the catches, accounting for 41% of the total catch. Amphipods (Gammaridae), Polychaetes (*Nephtys* sp. and *Magelona* sp.) and northern dwarf tellin (*Tellina Agilis*) also contributed significantly to the catches in this area. Pollution-sensitive taxa were generally collected in a higher proportion than pollution-tolerant taxa (Table 3).

Sediment at the three Ambrose sampling stations was composed primarily of sand with some fine sand evident at Station 1 (Table 4). Despite the relative consistency in sediment type across the three sampling stations, catches at Station 3 (1,820 organisms/m^2) were considerably higher than at Station 1 (345 organisms/m^2) and Station 2 (160 organisms/m^2) primarily due to large catches of blue mussel (940 organisms/m^2) and Gammaridae (215 organisms/m^2).

Overall, the benthic community in Ambrose can be characterized as having relatively high diversity and evenness, and a high proportion of pollution-sensitive taxa relative to the other areas sampled.

3.2 Anchorage Channel

Benthic samples collected in Anchorage Channel displayed the highest taxa richness (42 taxa) of all eight areas sampled (Table 1). These taxa were distributed among annelids (55%), arthropods (19%), mollusks (21%) and other (5%) (Table 2 and Figure 2). Overall, the benthic community living in the sediments of the Anchorage Channel exhibited a relatively high mean density (5,013 organisms/m^2), moderate community diversity (H'= 1.6), and low evenness (E=0.30) (Table 3). Blue mussel (*Mytilus edulis*) dominated the catches, accounting for 79% of the total catch. Amphipods (Ampeliscidae), northern dwarf tellin (*Tellina agilis*), and the annelid species (*Spio setosa*) also contributed significantly to catches in this area. Some pollution-sensitive and few pollution tolerant taxa were collected at all sampling locations(Table 3).

Sediment at Anchorage Channel Station 1 was composed of sand and rock while stations 2 and 3 were composed of silt (Table 4). Catches at Station 1 were also considerably different than those at stations 2 and 3. Organism density at Station 1 was 12,460 organisms/m^2 primarily due to large catches of blue mussel (*Mytilus edulis*). Catches at stations 2 and 3 were considerably lower at 1,360 and 1,220 organisms/m^2, respectively. Taxa richness was highest at Station 2 (28) and lowest at Station 3 (12).

Overall, the benthic community in Anchorage Channel can be characterized as having relatively high organism abundance, moderate community diversity, and a very low proportion of pollution-tolerant taxa relative to the other areas sampled.

3.3 Bay Ridge Channel

A total of 20 taxa were collected in Bay Ridge grab samples (Table 1). These taxa were distributed among annelids (50%), arthropods (20%), mollusks (30%) and other (0%) (Table 2 and Figure 2). Overall, the benthic community living in the sediments of Bay Ridge exhibited the lowest levels of organism abundance (217 organisms/m^2) but the highest community diversity (H'= 3.7) and evenness (E=0.84) of the eight areas sampled (Table 3). The high community diversity and evenness is the result of a relatively even distribution of abundance among the 20 taxa that were collected. Dwarf surf clam (*Mulinia lateralis*) were collected in the highest densities (35 organisms/m^2), accounting for 16% of the total catch. The northern dwarf tellin (*Tellina agilis*) and a polychaete (*Nephtys* sp.) also contributed significantly to the catches in this area. Pollution-sensitive taxa were collected in higher proportion in this area (31%) than any other area sampled. Nonetheless, pollution-tolerant taxa were collected in a higher proportion than pollution-sensitive taxa overall (Table 3).

Sediment at stations 1 and 2 were similar and consisted of mud, clay and silt, while Station 3 was composed primarily of shell (Table 4). Despite this difference in sediment type, organism densities and taxa richness were relatively similar across stations, ranging from 100 to 290 organisms/m^2 and 7 to 11 taxa per station.

Overall, the benthic community in Bay Ridge can be characterized as having relatively low organism abundance, high community diversity, and a very high proportion of pollution-sensitive taxa relative to the other areas sampled.

3.4 Elizabeth Channel

Elizabeth grab samples collected the lowest number of taxa (11) of the eight sample areas (Table 1). These taxa were distributed among annelids (64%), arthropods (18%), mollusks (18%) and other (0%) (Table 2 and Figure 3). Overall, the benthic community living in the sediments of Elizabeth also exhibited relatively low levels of organism abundance (490 organisms/m^2), low community diversity (H'= 1.4), and low evenness (E=0.37) (Table 3). The polychaetes, *Leitoscoloplos* sp. and *Pectinaria gouldii*, accounted for 67% and 26% of the organisms collected in this area. Pollution-tolerant organisms were collected in much higher proportion (41% to 78%) than pollution-sensitive organisms (2% to 6%) at all three stations (Table 3).

Sediment at the three Elizabeth sampling stations was composed of silt with clay also present at stations 2 and 3 (Table 4). Despite these differences in sediment type, catches at all three stations were quite similar except for the large catch of *Leitoscoloplos* sp (740 organisms/m^2) at Station 3.

Overall, the benthic community in Elizabeth can be characterized as having relatively low organism abundance, low community diversity, and a high proportion of pollution-tolerant taxa relative to the other areas sampled.

3.5 Kill Van Kull Channel

A total of 32 taxa were collected in the five Kill Van Kull grab samples (Table 1). These taxa were distributed among annelids (44%), arthropods (22%), mollusks (28%) and other (6%) (Table 2 and Figure 3). Overall, the benthic community living in the sediments of the Kill Van Kull exhibited a relatively high community diversity (H'=3.2) and evenness (E=0.62) as well as the highest mean density (21,972 organisms/m^2) of all the sample areas (Table 3). Nematodes, blue mussel (*Mytilus edulis*), and polychaetes (predominately of the Paraonidae, Sabellaridae and Spionidae families) were the dominant organisms. Pollution-tolerant taxa were collected in low proportions relative to the other areas sampled. However, pollution-tolerant taxa were found in higher proportions than pollution-sensitive taxa at all stations (Table 3).

The benthic community living in sandier sediments (stations 1, 2 and 3) exhibited a more complex and stable benthic community with high diversity and abundance of organisms as compared to stations 4 and 5 (Table 3). The dominant annelids were Paraonidae, *Sabellaria vulgaris* and *Streblospio benedicti* with densities up to 13,063 organisms/m^2 while the dominant arthropod was amphipods from the Aoridae family with densities up to 6,006 organisms/m^2. Blue mussel (*Mytilus edulis*) was the most abundant mollusk with densities up to 13,814 organisms/m^2 and large numbers of Nematoda were also collected with densities up to 12,312 organisms/m^2.

At Stations 4 and 5, where the sediment was composed of clay and mud, the benthic community was less complex with lower species diversity and low abundance (particularly at Station 5) when compared to the sandy sites. Annelids dominated this community, in particular, the family Paraonidae (1,463 organisms/m^2) and *Pectinaria gouldii* (2,388 organisms/m^2). Moreover, there were relatively few arthropods and mollusks identified in these samples (Table 1).

Overall, the benthic community in Kill Van Kull can be characterized as having relatively high organism abundance, high community diversity, and a low proportion of pollution-tolerant taxa relative to the other areas sampled. Station 5 was the exception with low organism abundance, low taxa richness, and lower diversity.

3.6 Newark Bay Channel

A total of 20 taxa were collected in Newark Bay Channel grab samples (Table 1). These taxa were distributed among annelids (45%), arthropods (25%), mollusks (20%) and other (10%) (Table 2 and Figure 4). Overall, the benthic community living in the sediments of Newark Bay Channel exhibited relatively moderate to high levels of organism abundance (1,909 organisms/m^2) and moderate levels of community diversity (H'= 2.2) and evenness (E=0.49) relative to the other areas sampled (Table 3). The polychaetes, *Pectinaria gouldii* and *Leitoscoloplos* sp., as well as sea grapes (*Molgula* sp.) dominated catches in the combined Newark Bay Channel samples accounting for 38%, 21%, and 32% of the total catch, respectively. Pollution-tolerant taxa were collected in a higher proportion than pollution-sensitive taxa at all three stations, particularly at Station 2 where 88% of the organisms collected can be characterized as pollution tolerant (Table 3).

Sediment at Newark Bay Channel stations 1 and 2 was composed of silt with some clay at Station 1, while Station 3 was composed of mud and clay (Table 4). Despite these differences in sediment composition taxa richness ranges a narrow 11 to 12 taxa across the stations. Organism abundance at Stations 1 and 3 were similar 2,240 and 2,278 organisms/m^2, respectively, while catches at Station 2 were the lowest in this area with 1,210 organisms/m^2.

Overall, the benthic community in Newark Bay Channel can be characterized as having moderate to high organism abundance, moderate community diversity, and a low proportion of pollution-sensitive taxa relative to the other areas sampled.

3.7 Port Jersey Channel

A total of 14 taxa were collected in Port Jersey Channel grab samples (Table 1). These taxa were distributed among annelids (64%), arthropods (14%), mollusks (21%) and other (0%) (Table 2 and Figure 4). Overall, the benthic community living in the sediments of Port Jersey Channel exhibited low organism abundance (401 organisms/m^2), low community diversity (H'= 1.5), and low evenness (E=0.39) relative to the other areas sampled (Table 3). The Polychaete *Leitoscoloplos* sp. dominated the catches in this area, accounting for 76% of the total catch. Unidentified Oligochaetes were the second most abundant taxa accounting for 10% of the total catch. Pollution-tolerant taxa were collected in higher proportions (78% to 92%) in Port Jersey

Channel than at any other area sampled (Table 3). Additionally, pollution-tolerant taxa were collected more often than pollution-sensitive taxa (3% to 5%) at all three stations (Table 3).

Sediment in the Port Jersey Channel sampling area was generally composed of a mixture of clay, silt, and sand, except that no sand was found at Station 2 and no silt at Station 3 (Table 4). The number of taxa collected at stations 1 and 2 were similar at 11 and 10 taxa, respectively, while the density of organisms was more similar at stations 2 and 3 at 205 and 255 organisms/m^2, respectively. Taxa richness at Station 3 was a low 6 taxa while abundance at Station 1 was a relatively high 743 organisms/m^2.

Overall, the benthic community in Port Jersey Channel can be characterized as having low organism abundance, low community diversity, and a high proportion of pollution-tolerant taxa relative to the other areas sampled.

3.8 South Elizabeth Channel

A total of 13 taxa were collected in South Elizabeth grab samples (Table 1). These taxa were distributed among annelids (46%), arthropods (15%), mollusks (31%) and other (8%) (Table 2 and Figure 4). Overall, the benthic community living in the sediments of South Elizabeth exhibited moderate levels of organism abundance (943 organisms/m^2) and the lowest levels of community diversity (H'= 1.0) and evenness (E=0.26) relative to the other areas sampled (Table 3). The Polychaetes *Leitoscoloplos* sp. and *Pectinaria gouldii* dominated the catches in this area, accounting for 84% and 9% of the total catch. Pollution-tolerant taxa were collected in a higher proportion (82% to 89%) than pollution-sensitive taxa (0% to 2%) at all three stations (Table 3).

Sediments at the South Elizabeth sampling stations 1 and 2 were composed of silt and sand while sediments at Station 3 consisted of silt, sand, clay and rock (Table 4). Collections at Station 1 produced the lowest taxa richness (2 taxa) of any station sampled within the eight areas sampled during 2005 and abundance was relatively low at this station as well at 465 organisms/m^2. Collections at stations 2 and 3 had more typical taxa richness (10 and 7 taxa) and abundance values of 1,280 and 1,085 organisms/m^2, respectively.

Overall, the benthic community in South Elizabeth can be characterized as having moderate organism abundance, very low community diversity, and a high proportion of pollution-tolerant taxa relative to the other areas sampled.

4 Discussion

Physical modifications associated with urbanization often result in the loss of habitats within estuaries. Impacted areas are generally characterized by lower species diversity, altered community composition and reduced habitat diversity (Dauer et al 2000). The Harbor is an example of an estuarine system that is impacted by urbanization. However, despite extensive changes and urbanization, the Harbor is a productive estuary supporting diverse communities of benthic invertebrates (Woodhead et al. 1999).

The benthic community in the Harbor serves several important roles in ecosystem function, such as increasing habitat structural complexity (e.g., mussel beds, worm and amphipod tube mats), restructuring sediments (deep-burrowing deposit-feeders), facilitating decomposition of organic matter and providing food for higher trophic level organisms. Benthic assemblages throughout the Harbor are linked to a number of environmental factors such as temperature, dissolved oxygen, water flow, sediment type and pollution (Watson and Barnes 2004). There have been several studies on the benthic communities found in the Lower Bay and New York Bight Apex. Generally, more species have been found in Lower Bay than in other areas of the Harbor (USACE 1998). This is due to the type of sediment, water flow and water chemistry (dissolved oxygen and temperature) found there.

Previous studies indicate that density and diversity of benthic organisms are negatively correlated with pollution and silt-clay content throughout the Harbor (Stainken 1984, Cerrato 1986). Sediment contamination, including synthetic compounds used in herbicide and pesticide production (Bopp et al. 1991), metals, and petroleum hydrocarbons (Conner et al. 1979), has resulted from combined sewer discharges, urban runoff, stormwater runoff, industrial discharges, and maritime and industrial accidents (Long et al. 1995, HEP 1996). The spatial distribution of these contaminants varies, but their presence and concentrations could influence benthic community composition, species distributions, and species abundance (Stainken 1984, Cristini 1991, Long et al. 1995). The percentage of pollution tolerant species is one parameter amongst others, such as sediment and water quality, that describes the overall habitat quality of the benthic community. Typically, pollution tolerant species are found in heavily disturbed areas and are opportunistic species. Pollution tolerant taxa include: Oligochaeta, *Leitoscoloplos sp*., Capitellidae, *Streblospio benedicti*, and *Mulina lateris*. Pollution sensitive taxa include: *Diopatra cuprea*, *Spiophanes bombyx*, *Cyathura polita*, *Acteocina canaliculata*, *Ensis directus*, *Mercenaria mercenaria*, *Spisula solidissima*, and *Tellina agilis*.

The majority of species identified in grab samples collected during the 2005 Benthic Monitoring Program were nematodes, annelids (oligochaetes and polychaetes), arthropods (amphipods and cumaceans), and mollusks (bivalves and gastropods). These species are typically found in the Harbor, and vary considerably in occurrence and abundance both seasonally and spatially (Iocco et al. 2000; Gandarillas and Brinkhuis 1981; Cerrato et al. 1989; Dean 1975; BVA 1998).

The eight areas sampled during the summer of 2005 range from what appear to be largely impacted benthic communities, to fully-functioning benthic communities with an abundance of pollution-sensitive species. For example, Elizabeth, South Elizabeth and Port Jersey Channel were found to share low taxa richness, low biodiversity and evenness, high proportions of pollution-tolerant organisms, and low proportions of pollution-sensitive organisms. Each of these areas can be characterized with more fine-grained sediments, such as silt and clay, and as having impacted benthic communities, likely a result of poor sediment and water quality (Stainken 1984, Cristini 1991, Long et al. 1995, Cerrato 1986).

Other areas, including Ambrose, Bay Ridge, Anchorage Channel, and most of Kill Van Kull tended to have relatively high taxa richness, high biodiversity and evenness, high proportions of pollution-sensitive organisms, and low proportions of pollution-tolerant organisms. These areas can be characterized as having more diverse sediment types, including both fine and coarse materials such as mud, clay, sand, shells, and rocks, which can support diverse and stable benthic communities. The remaining area, Newark Bay Channel, had a more moderate level of taxa richness, diversity and evenness as compared to the other areas.

The physical habitat following dredging operations is anticipated to be similar to the present conditions depending on contact area. The fine grained sediments that are generally associated with degraded benthic habitats are likely to be removed during the dredging activities to reveal coarser grained sediments. However, in some areas the coarser grain sediments may be rapidly covered by new fine grain sediments. The dredged area is expected to be re-colonized by similar benthic organisms to those that are currently present. Due to the anticipated rapid recovery to pre-dredge conditions after disturbance, the short term loss of the benthic community as a result of deepening activities is unlikely to be significant (Gray and Elliot 2009, Santos and Simon 1980, Tsutsumi 1987, Pearson and Rosenberg 1978).

The navigational channels in NY/NJ Harbor are dredged on a regular basis for maintenance dredging. The Harbor Deepening Project (HDP) will have similar impacts to the benthic community as the maintenance dredging. Characterization of the benthic conditions obtained from this investigation will allow for comparison with HDP post-dredging surveys. Upon completion of the post-dredging surveys, the timescale for benthic communities to recolonize and become stable (abundant and diverse) should be determined and additional information regarding the change in substrate type and the consequential increase or decrease in benthic abundance will be documented.

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Table 1: Average organism density (No./m^2) at 2005 benthic invertebrate sampling stations

					Ambrose Stations				Anchorage Channel Stations				Bay Ridge Stations				Elizabeth Stations			
Phylum	Class	Order	Family	Genus/Species	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
Annelida	NA	Echiura	Sipunculoidea/Echiuroidea	---	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	Oligochaeta	---	---	---	5	5	60	**23**	0	20	50	**23**	20	55	15	**30**	0	0	0	**0**
	Polychaeta	---	---	---	10	0	0	**3**	0	0	0	**0**	0	0	5	**2**	0	10	0	**3**
		Aciculata	Dorvilleidae	*Schistomeringos sp.*	15	0	0	**5**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Pilargidae	---	5	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Arenicolidae		---	5	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Arenicola	*Arenicola sp.*	0	0	0	**0**	0	0	0	**0**	5	0	0	**2**	0	0	0	**0**
		Ariciida	Opheliidae	*Ophelia sp.*	0	0	5	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Orbiniidae	---	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Leitoscoloplos Fragilis	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Leitoscoloplos sp.	0	0	10	**3**	7	150	0	**52**	60	0	0	**20**	140	105	740	**328**
		Canalipalpata	Ampharetidae	*Amage auricula*	0	0	0	**0**	0	15	0	**5**	0	0	0	**0**	0	0	0	**0**
			Sabellidae	*Potamilla neglecta*	0	0	0	**0**	15	0	0	**5**	0	0	0	**0**	0	0	0	**0**
		Capitellida	Capitellidae	---	10	0	0	**3**	7	100	75	**61**	15	0	0	**5**	0	0	0	**0**
			Maldanidae	---	0	0	0	**0**	0	35	0	**12**	0	0	0	**0**	0	0	0	**0**
			Cirratulidae	---	10	0	45	**18**	0	0	10	**3**	0	0	0	**0**	0	0	0	**0**
		Eucinida	Lumbrinereidae	*Lumbrineris sp.*	5	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Onuphidae	*Diopatra cuprea*	0	0	0	**0**	7	0	0	**2**	0	0	0	**0**	0	0	0	**0**
		Magelonida	Magelonidae	*Magelona sp.*	5	5	135	**48**	0	0	5	**2**	0	0	0	**0**	0	0	0	**0**
		Phyllodocida	Glyceridae	*Glycera sp.*	0	0	0	**0**	130	35	30	**65**	5	0	35	**13**	0	15	20	**12**
			Nephtyidae	*Nephtys sp.*	80	5	120	**68**	67	10	30	**36**	10	10	60	**27**	5	0	0	**2**
			Nereidae	*Nereis sp.*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Nereis succinea	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	5	0	0	**2**
			Phyllodocidae	---	0	0	5	**2**	0	0	0	**0**	0	0	5	**2**	0	0	5	**2**
				Eteone sp.	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**
				Phyllodoce sp.	10	0	0	**3**	0	0	0	**0**	0	0	0	**0**	0	0	5	**2**
			Polynoidae	---	0	0	5	**2**	7	0	0	**2**	0	0	0	**0**	0	0	0	**0**
				Lepidonotus sp.	0	5	0	**2**	0	0	0	**0**	0	0	15	**5**	0	0	0	**0**
			Syllidae	---	0	0	20	**7**	7	0	0	**2**	0	0	0	**0**	0	0	0	**0**
		Spionida	Chaetopteriadae	---	0	0	0	**0**	0	10	0	**3**	0	0	0	**0**	0	0	0	**0**
			Paraonidae	---	5	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Paraonidae	*Paraonis sp.*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	10	0	**3**
			Sabellariidae	*Sabellaria vulgaris*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Spionidae	---	5	10	140	**52**	22	5	15	**14**	0	0	0	**0**	0	0	0	**0**
				Polydora ligni	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Polydora sp.	0	5	5	**3**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Scolecolepides viridis	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Spio setosa	0	0	0	**0**	0	0	405	**135**	0	0	0	**0**	0	0	0	**0**
				Spio sp.	0	0	0	**0**	30	20	90	**47**	0	0	30	**10**	0	0	0	**0**
				Spiophanes sp.	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**
				Streblospio benedicti	0	0	0	**0**	0	10	0	**3**	0	0	0	**0**	0	0	0	**0**
		Terebellida	Ampharetidae	---	0	0	0	**0**	0	10	0	**3**	0	0	0	**0**	0	0	0	**0**
			Pectinariidae	*Pectinaria gouldii*	0	0	0	**0**	0	85	0	**28**	0	15	0	**5**	110	110	160	**127**
Arthropoda	Crustacea	Amphipoda	Ampeliscidae	---	0	0	0	**0**	0	590	0	**197**	0	5	0	**2**	0	0	0	**0**
				Ampelisca abdita	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Ampelisca sp.	0	0	0	**0**	0	0	0	**0**	0	0	5	**2**	0	0	0	**0**
			Aoridae	---	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Gammaridae	---	0	10	215	**75**	7	0	0	**2**	0	0	5	**2**	0	0	0	**0**
				Gammarus sp.	30	0	0	**10**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Melitidae	*Melita sp.*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Phoxocephalidae	---	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Cumacea	Diastylidae	*Diastylis sp.*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Decapoda	Cancridae	*Cancer irroratus*	0	0	0	**0**	250	0	0	**83**	0	0	0	**0**	0	0	0	**0**
				Cancer sp.	0	0	5	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Crangonidae	*Crangon septemspinosa*	0	0	15	**5**	0	0	0	**0**	10	5	0	**5**	5	0	10	**5**
			Paguridae	*Pagurus longicarps*	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**
				Pagurus sp.	0	0	0	**0**	0	0	0	**0**	0	0	5	**2**	0	0	0	**0**
			Portunidae	---	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Ovalipes ocellatus	0	0	0	**0**	0	0	5	**2**	0	0	0	**0**	0	0	0	**0**
			Xanthidae	---	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Panopeus herbstii	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**
		Isopoda	Anthuridae	*Cyathura polita*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Idoteidae	*Idotea sp.*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Mysidacea	---	---	5	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	5	0	**2**
			Mysidae	*Neomysis americana*	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**
	Malacostraca	Decapoda	Portunidae	*Carcinus maenas*	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**
		Isopoda	Cirolanidae	*Politolana sp.*	0	15	0	**5**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Chordata	Ascidacea	Pleurogona	Molgulidae	*Molgula manhattensis*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Molgula sp.	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Echinodermata	Echinoidea	---	---	---	0	10	0	**3**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Clypeasteroida	Echinarachnidae	*Echinarachnius parma*	5	0	0	**2**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Mollusca	Bivalvia	---	---	---	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Eudesmodontida	Pandoridae	*Pandora Gouldiana*	0	0	0	**0**	0	10	0	**3**	10	0	0	**3**	0	0	0	**0**
		Myoida	Myidae	*Mya arenaria*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	5	**2**
		Mytioida	Mytilidae	*Mytilus edulis*	5	0	940	**315**	11,777	0	50	**3,942**	0	0	0	**0**	0	0	0	**0**
		Nuculoida	Nuculanidae	*Yoldia Limatula*	0	0	0	**0**	0	5	0	**2**	0	0	0	**0**	0	0	0	**0**
				Yoldia sp.	0	0	0	**0**	0	0	0	**0**	40	0	0	**13**	0	0	0	**0**
		Veneroida	Mactridae	---	0	10	0	**3**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Mulinia lateralis	0	0	0	**0**	0	45	0	**15**	105	0	0	**35**	0	0	5	**2**
				Spisula Solidissima	0	0	0	**0**	0	30	35	**22**	0	5	0	**2**	0	0	0	**0**
			Solenidae	*Ensis directus*	0	0	5	**2**	0	5	5	**3**	0	0	0	**0**	0	0	0	**0**
				Siliqua costata	25	10	40	**25**	0	0	0	**0**	10	5	0	**5**	0	0	0	**0**
			Tellinidae	*Tellina agilis*	75	55	25	**52**	72	25	410	**169**	0	0	80	**27**	0	0	0	**0**
				Tellina sp.	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Veneridae	*Mercenaria mercenaria*	0	0	0	**0**	0	15	0	**5**	0	0	0	**0**	0	0	0	**0**
	Gastropoda	---	---	---	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Archaeogastropoda	Naticidae	---	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Neverita Duplicata	10	0	0	**3**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Cephalaspidea	Acteonidae	*Rictaxis puntcostriatus*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Scaphandridae	*Acteocina canaliculata*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Mesogastropoda	Calyptraeidae	*Crepidula fornicata*	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Neogastropoda	Nassariidae	*Ilyanassa trivittata*	0	0	5	**2**	0	0	5	**2**	0	0	0	**0**	0	0	0	**0**
Nematoda	---	---	---	---	0	0	0	**0**	50	0	0	**17**	0	0	0	**0**	0	0	0	**0**
Nemertea	---	---	---	---	20	0	20	**13**	0	95	0	**32**	0	0	0	**0**	0	0	0	**0**
			TRUE Species Richness (total number of taxa)		21	14	18	**33**	14	28	12	**42**	11	7	9	**20**	5	5	7	**11**
			Mean Density (total number of individuals/m2)		345	160	1820	**775**	12460	1360	1220	**5013**	290	100	260	**217**	265	255	950	**490**

Table 1: Average organism density (No./m^2) at 2005 benthic invertebrate sampling stations

					Kill Van Kull Stations						Newark Bay Channel Stations				Port Jervis Channel Stations				South Elizabeth Stations			
Phylum	Class	Order	Family	Genus/Species	1	2	3	4	5	Avg.	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
Annelida	NA	Echiura	Sipunculoidea/Echiuroidea	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	Oligochaeta	---	---	---	0	1,502	0	0	0	**300**	0	35	0	**12**	22	90	5	**39**	0	0	0	**0**
	Polychaeta	---	---	---	0	0	0	0	0	**0**	0	15	45	**20**	0	5	0	**2**	0	15	0	**5**
		Aciculata	Dorvilleidae	*Schistomeringos sp.*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Pilargidae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Arenicolidae		---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Arenicola	*Arenicola sp.*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Ariciida	Opheliidae	*Ophelia sp.*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Orbiniidae	---	0	300	0	0	0	**60**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Leitoscoloplos Fragilis	0	0	0	250	25	**55**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Leitoscoloplos sp.	0	0	0	0	0	**0**	55	990	168	**404**	620	65	230	**305**	415	1,045	910	**790**
		Canalipalpata	Ampharetidae	*Amage auricula*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Sabellidae	*Potamilla neglecta*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Capitellida	Capitellidae	---	0	0	0	0	0	**0**	5	35	0	**13**	0	5	0	**2**	0	0	0	**0**
			Maldanidae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Cirratulidae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Eucinida	Lumbrinereidae	*Lumbrineris sp.*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Onuphidae	*Diopatra cuprea*	0	0	0	0	0	**0**	5	0	0	**2**	0	0	0	**0**	0	0	0	**0**
		Magelonida	Magelonidae	*Magelona sp.*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Phyllodocida	Glyceridae	*Glycera sp.*	38	0	225	0	5	**54**	10	25	25	**20**	12	5	5	**7**	0	20	10	**10**
			Nephtyidae	*Nephtys sp.*	0	0	0	0	0	**0**	0	0	0	**0**	10	5	5	**7**	0	0	0	**0**
			Nereidae	*Nereis sp.*	100	300	75	50	0	**105**	25	15	0	**13**	0	5	0	**2**	0	0	0	**0**
				Nereis succinea	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	50	0	0	**17**
			Phyllodocidae	---	63	1,502	450	88	5	**421**	0	0	50	**17**	0	0	0	**0**	0	0	10	**3**
				Eteone sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	5	0	**2**
				Phyllodoce sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	5	**2**
			Polynoidae	---	0	150	0	0	0	**30**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Lepidonotus sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Syllidae	---	0	150	225	0	10	**77**	0	0	0	**0**	6	5	0	**4**	0	0	0	**0**
		Spionida	Chaetopteriadae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Paraonidae	---	2,326	9,159	3,003	1,463	135	**3,217**	0	5	8	**4**	0	0	0	**0**	0	0	0	**0**
			Paraonidae	*Paraonis sp.*	0	0	0	0	0	**0**	0	0	0	**0**	5	0	0	**2**	0	0	0	**0**
			Sabellariidae	*Sabellaria vulgaris*	1,300	13,063	9,459	888	5	**4,943**	0	0	8	**3**	0	0	0	**0**	0	0	0	**0**
			Spionidae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Polydora ligni	125	150	150	75	0	**100**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Polydora sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Scolecolepides viridis	0	0	75	0	0	**15**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Spio setosa	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Spio sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Spiophanes sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Streblospio benedicti	125	601	6,231	300	5	**1,452**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Terebellida	Ampharetidae	---	38	0	450	0	0	**98**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Pectinariidae	*Pectinaria gouldii*	138	300	225	2,388	85	**627**	2,100	40	18	**719**	17	10	5	**11**	0	150	115	**88**
Arthropoda	Crustacea	Amphipoda	Ampeliscidae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Ampelisca abdita	0	0	0	25	0	**5**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Ampelisca sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Aoridae	---	25	6,006	3,679	0	0	**1,942**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Gammaridae	---	325	450	0	0	0	**155**	0	0	8	**3**	0	0	0	**0**	0	5	10	**5**
				Gammarus sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Melitidae	*Melita sp.*	0	0	150	0	0	**30**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Phoxocephalidae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Cumacea	Diastylidae	*Diastylis sp.*	0	0	150	0	0	**30**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Decapoda	Cancridae	*Cancer irroratus*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Cancer sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Crangonidae	*Crangon septemspinosa*	0	0	0	0	0	**0**	5	15	10	**10**	20	5	0	**8**	0	5	15	**7**
			Paguridae	*Pagurus longicarps*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Pagurus sp.	0	0	0	0	0	**0**	0	0	8	**3**	0	0	0	**0**	0	0	0	**0**
			Portunidae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Ovalipes ocellatus	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Xanthidae	---	0	300	0	0	0	**60**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Panopeus herbstii	0	0	0	0	0	**0**	0	0	10	**3**	0	0	0	**0**	0	0	0	**0**
		Isopoda	Anthuridae	*Cyathura polita*	25	0	0	0	0	**5**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Idoteidae	*Idotea sp.*	0	0	0	0	0	**0**	20	0	0	**7**	0	0	0	**0**	0	0	0	**0**
		Mysidacea	---	---	0	0	0	0	0	**0**	0	0	0	**0**	11	0	0	**4**	0	0	0	**0**
			Mysidae	*Neomysis americana*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	Malacostraca	Decapoda	Portunidae	*Carcinus maenas*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Isopoda	Cirolanidae	*Politolana sp.*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Chordata	Ascidacea	Pleurogona	Molgulidae	*Molgula manhattensis*	0	0	150	25	0	**35**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Molgula sp.	0	0	0	0	0	**0**	0	0	1,833	**611**	0	0	0	**0**	0	0	0	**0**
Echinodermata	Echinoidea	---	---	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Clypeasteroida	Echinarachnidae	*Echinarachnius parma*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
Mollusca	Bivalvia	---	---	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	15	0	**5**
		Eudesmodontida	Pandoridae	*Pandora Gouldiana*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Myoida	Myidae	*Mya arenaria*	0	601	0	0	0	**120**	0	5	0	**2**	0	0	0	**0**	0	5	0	**2**
		Mytioida	Mytilidae	*Mytilus edulis*	3,613	13,814	3,829	75	0	**4,266**	5	10	35	**17**	0	0	0	**0**	0	0	0	**0**
		Nuculoida	Nuculanidae	*Yoldia Limatula*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Yoldia sp.	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Veneroida	Mactridae	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Mulinia lateralis	225	0	0	75	0	**60**	5	0	0	**2**	0	0	0	**0**	0	5	0	**2**
				Spisula Solidissima	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Solenidae	*Ensis directus*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
				Siliqua costata	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Tellinidae	*Tellina agilis*	0	0	0	0	0	**0**	0	10	50	**20**	0	0	0	**0**	0	0	10	**3**
				Tellina sp.	38	0	0	0	0	**8**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Veneridae	*Mercenaria mercenaria*	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
	Gastropoda	---	---	---	0	300	0	125	0	**85**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Archaeogastropoda	Naticidae	---	0	150	0	0	0	**30**	0	0	0	**0**	5	0	0	**2**	0	5	0	**2**
				Neverita Duplicata	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Cephalaspidea	Acteonidae	*Rictaxis puntcostriatus*	0	150	0	0	0	**30**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
			Scaphandridae	*Acteocina canaliculata*	0	0	0	25	15	**8**	0	0	0	**0**	17	0	0	**6**	0	0	0	**0**
		Mesogastropoda	Calyptraeidae	*Crepidula fornicata*	0	150	0	0	0	**30**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**
		Neogastropoda	Nassariidae	*Ilyanassa trivittata*	0	0	0	25	0	**5**	0	0	0	**0**	0	5	5	**3**	0	0	0	**0**
Nematoda	---	---	---	---	1,550	12,312	3,679	19	5	**3,513**	5	10	0	**5**	0	0	0	**0**	0	0	0	**0**
Nemertea	---	---	---	---	0	0	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	5	0	**2**
			TRUE Species Richness (total number of taxa)		16	20	17	15	10	**32**	11	12	11	**20**	11	10	6	**14**	2	10	7	**13**
			Mean Density (total number of individuals/m2)		10052	61411	32207	5,894	295	**21,972**	2,240	1,210	2,278	**1,909**	743	205	255	**401**	465	1,280	1,085	**943**

Table 2: Taxa richness and abundance of organisms collected at 2005 benthic invertebrate sampling stations

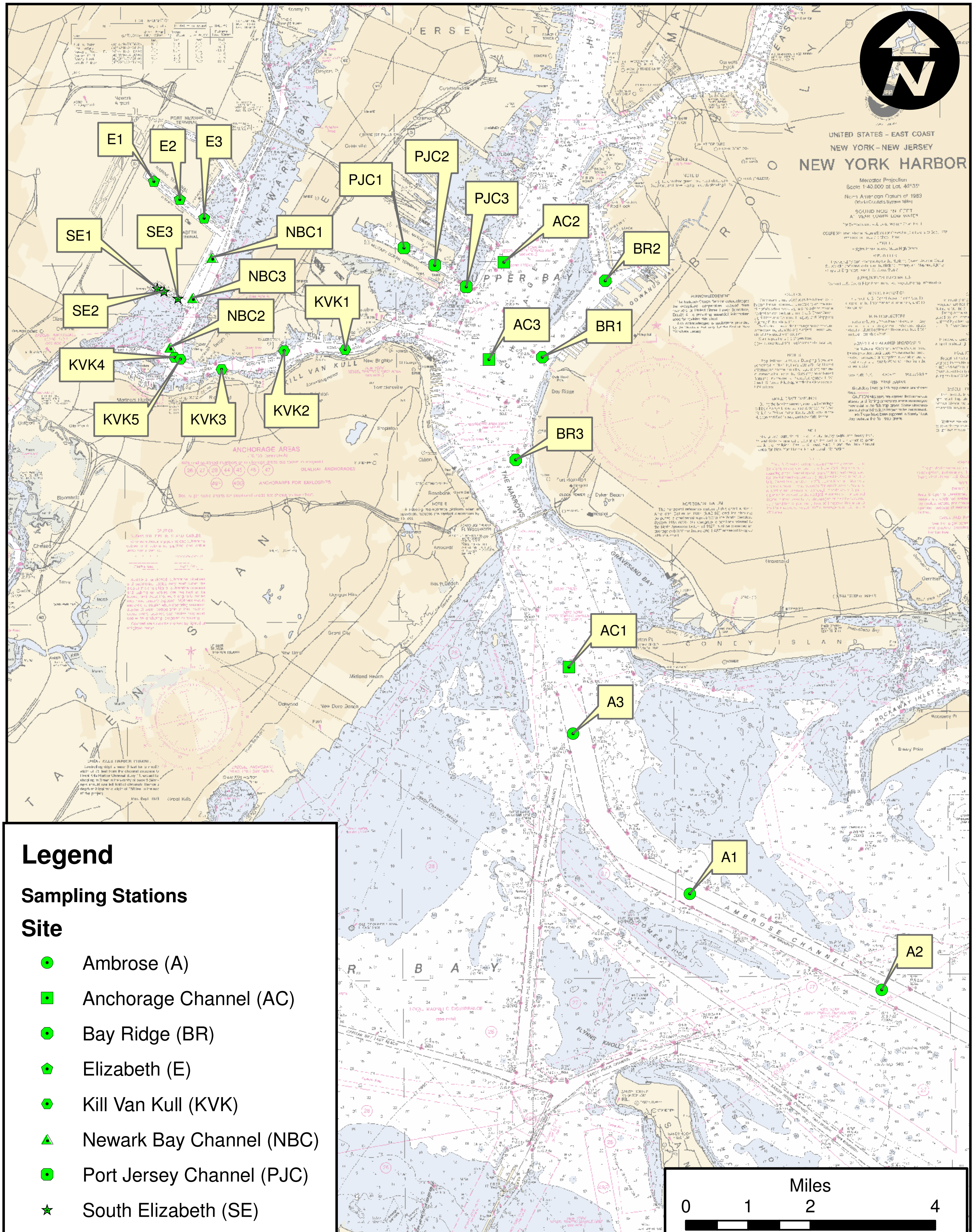
Site	Sampling Station	Number of Taxa								Number of Individuals							
		Annelida		Arthropoda		Mollusca		Other		Annelida		Arthropoda		Mollusca		Other	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ambrose Stations	**1**	13	62%	2	10%	4	19%	2	10%	170	49%	35	10%	115	33%	25	7%
	2	6	43%	4	29%	3	21%	1	7%	40	25%	35	22%	75	47%	10	6%
	3	9	50%	3	17%	5	28%	1	6%	550	30%	235	13%	1,015	56%	20	1%
	Overall	17	52%	7	21%	7	21%	2	6%	253	33%	102	13%	402	52%	18	2%
Anchorage Channel Stations	**1**	9	64%	2	14%	2	14%	1	7%	302	2%	257	2%	11,850	95%	50	0%
	2	15	54%	5	18%	7	25%	1	4%	520	38%	610	45%	135	10%	95	7%
	3	7	58%	1	8%	4	33%	0	0%	710	58%	5	0%	505	41%	0	0%
	Overall	23	55%	8	19%	9	21%	2	5%	511	10%	291	6%	4,163	83%	48	1%
Bay Ridge Stations	**1**	6	55%	1	9%	4	36%	0	0%	115	40%	10	3%	165	57%	0	0%
	2	3	43%	2	29%	2	29%	0	0%	80	80%	10	10%	10	10%	0	0%
	3	5	56%	3	33%	1	11%	0	0%	165	63%	15	6%	80	31%	0	0%
	Overall	10	50%	4	20%	6	30%	0	0%	120	55%	12	5%	85	39%	0	0%
Elizabeth Stations	**1**	4	80%	1	20%	0	0%	0	0%	260	98%	5	2%	0	0%	0	0%
	2	4	80%	1	20%	0	0%	0	0%	250	98%	5	2%	0	0%	0	0%
	3	4	57%	1	14%	2	29%	0	0%	930	98%	10	1%	10	1%	0	0%
	Overall	7	64%	2	18%	2	18%	0	0%	480	98%	7	1%	3	1%	0	0%
Kill Van Kull Stations	**1**	9	56%	3	19%	3	19%	1	6%	4,251	42%	375	4%	3,876	39%	1,550	15%
	2	11	55%	3	15%	5	25%	1	5%	27,177	44%	6,757	11%	15,165	25%	12,312	20%
	3	11	65%	3	18%	1	6%	2	12%	20,571	64%	3,979	12%	3,829	12%	3,829	12%
	4	8	53%	1	7%	4	27%	2	13%	5,501	93%	25	0%	325	6%	44	1%
	5	8	80%	0	0%	1	10%	1	10%	275	93%	0	0%	15	5%	5	2%
	Overall	14	44%	7	22%	9	28%	2	6%	11,555	53%	2,227	10%	4,642	21%	3,548	16%
Newark Bay Channel Stations	**1**	6	55%	2	18%	2	18%	1	9%	2,200	98%	25	1%	10	0%	5	0%
	2	7	58%	1	8%	3	25%	1	8%	1,160	96%	15	1%	25	2%	10	1%
	3	6	55%	2	18%	2	18%	1	9%	323	14%	37	2%	85	4%	1,833	80%
	Overall	9	45%	5	25%	4	20%	2	10%	1,228	64%	26	1%	40	2%	616	32%
Port Jersey Channel Stations	**1**	7	64%	2	18%	2	18%	0	0%	691	93%	31	4%	22	3%	0	0%
	2	8	80%	1	10%	1	10%	0	0%	195	95%	5	2%	5	2%	0	0%
	3	5	83%	0	0%	1	17%	0	0%	250	98%	0	0%	5	2%	0	0%
	Overall	9	64%	2	14%	3	21%	0	0%	379	94%	12	3%	11	3%	0	0%
South Elizabeth Stations	**1**	2	100%	0	0%	0	0%	0	0%	465	100%	0	0%	0	0%	0	0%
	2	4	40%	2	20%	3	30%	1	10%	1,235	96%	10	1%	30	2%	5	0%
	3	4	57%	2	29%	1	14%	0	0%	1,050	97%	25	2%	10	1%	0	0%
	Overall	6	46%	2	15%	4	31%	1	8%	917	97%	12	1%	13	1%	2	0%

Table 3. Benthic community taxa richness, density (organisms/m^2), Diversity (H'), Eveness (E), and proportion of pollution-tolerant and pollution-sensitive taxa at 2005 benthic invertebrate sampling stations

Site	Sampling Station	Species Richness (No. of taxa)	Mean Density (individuals/m^2)	Diversity H'	Evenness E	Proportion of Pollution-Tolerant Taxa (%)	Proportion of Pollution-Sensitive Taxa (%)
Ambrose Stations	**1**	21	345	3.6	0.82	4%	45%
	2	14	160	3.3	0.86	3%	38%
	3	18	1,820	2.6	0.60	4%	8%
	Overall	33	775	3.3	0.63	4%	16%
Anchorage Channel Stations	**1**	14	12,460	0.5	0.12	0%	2%
	2	28	1,360	3.2	0.66	24%	7%
	3	12	1,220	2.6	0.67	10%	39%
	Overall	42	5,013	1.6	0.30	3%	6%
Bay Ridge Stations	**1**	11	290	2.8	0.80	69%	5%
	2	7	100	2.1	0.74	55%	10%
	3	9	260	2.8	0.80	6%	67%
	Overall	20	217	3.7	0.84	42%	31%
Elizabeth Stations	**1**	5	265	1.3	0.58	53%	2%
	2	5	255	1.8	0.68	41%	6%
	3	7	950	1.1	0.35	78%	2%
	Overall	11	490	1.4	0.37	67%	3%
Kill Van Kull Stations	**1**	16	10,052	2.6	0.65	3%	1%
	2	20	61,411	2.9	0.66	3%	0%
	3	17	32,207	2.9	0.71	19%	1%
	4	15	5,894	2.5	0.63	11%	0%
	5	10	295	2.2	0.67	10%	2%
	Overall	32	21,972	3.2	0.62	9%	0%
Newark Bay Channel Stations	**1**	11	2,240	0.5	0.15	3%	0%
	2	12	1,210	1.3	0.35	88%	3%
	3	11	2,278	1.3	0.34	7%	3%
	Overall	20	1,909	2.2	0.49	23%	2%
Port Jersey Channel Stations	**1**	11	743	1.2	0.34	86%	3%
	2	10	205	2.3	0.67	78%	5%
	3	6	255	0.7	0.27	92%	4%
	Overall	14	401	1.5	0.39	86%	3%
South Elizabeth Stations	**1**	2	465	0.5	0.49	89%	0%
	2	10	1,280	1.1	0.30	82%	2%
	3	7	1,085	0.9	0.31	84%	2%
	Overall	13	943	1.0	0.26	84%	1%

Table 4. 2005 benthic invertebrate sampling station sediment characteristics

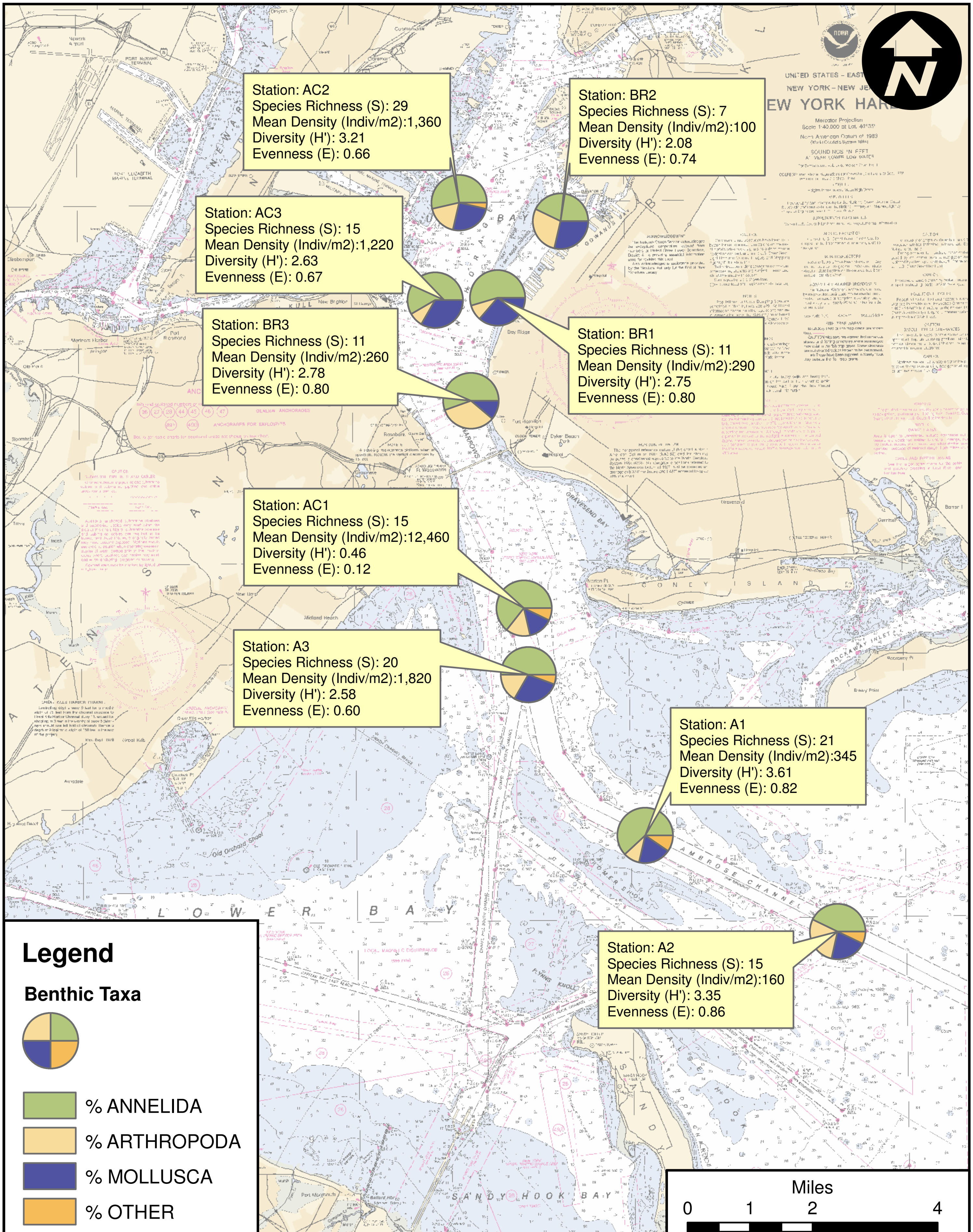
Sampling Station	Sediment Texture
Ambrose 1 - Sample 1	fine sand
Ambrose 1 - Sample 2	sand
Ambrose 2 - Sample 1	sand
Ambrose 2 - Sample 2	sand
Ambrose 3 - Sample 1	sand
Ambrose 3 - Sample 2	sand
Anchorage Channel 1 - Sample 1	sand/rock
Anchorage Channel 1 - Sample 2	sand
Anchorage Channel 2 - Sample 1	silt
Anchorage Channel 2 - Sample 2	silt
Anchorage Channel 3 - Sample 1	silt
Anchorage Channel 3 - Sample 2	silt
Bay Ridge 1 - Sample 1	mud/clay
Bay Ridge 1 - Sample 2	mud/clay
Bay Ridge 2 - Sample 1	clay
Bay Ridge 2 - Sample 2	clay/silt
Bay Ridge 3 - Sample 1	shell
Bay Ridge 3 - Sample 2	shell
Elizabeth 1 - Sample 1	silt
Elizabeth 1 - Sample 2	silt
Elizabeth 2 - Sample 1	silt/clay
Elizabeth 2 - Sample 2	silt/clay
Elizabeth 3 - Sample 1	silt/clay
Elizabeth 3 - Sample 2	silt/clay
Kill Van Kull 1 - Sample 1	sand/rocks
Kill Van Kull 1 - Sample 2	clay
Kill Van Kull 2 - Sample 1	sand
Kill Van Kull 2 - Sample 2	sand
Kill Van Kull 3 - Sample 1	Mussel shells, sand, mud
Kill Van Kull 3 - Sample 2	Mussel shells, sand, mud
Kill Van Kull 4 - Sample 1	mud/clay
Kill Van Kull 4 - Sample 2	mud/clay
Kill Van Kull 5 - Sample 1	mud/clay
Kill Van Kull 5 - Sample 2	mud/clay
Newark Bay Channel 1 - Sample 1	silt
Newark Bay Channel 1 - Sample 2	silt/clay
Newark Bay Channel 2 - Sample 1	silt
Newark Bay Channel 2 - Sample 2	silt
Newark Bay Channel 3 - Sample 1	clay/rock
Newark Bay Channel 3 - Sample 2	clay/rock
Port Jersey Channel 1 - Sample 1	clay/silt
Port Jersey Channel 1 - Sample 2	clay/sand/silt
Port Jersey Channel 2 - Sample 1	silt
Port Jersey Channel 2 - Sample 2	clay/silt
Port Jersey Channel 3 - Sample 1	clay/sand
Port Jersey Channel 3 - Sample 2	clay/sand
South Elizabeth 1 - Sample 1	silt
South Elizabeth 1 - Sample 2	silt/sand
South Elizabeth 2 - Sample 1	silt/sand
South Elizabeth 2 - Sample 2	silt/sand
South Elizabeth 3 - Sample 1	clay/sand/rock
South Elizabeth 3 - Sample 2	silt/clay/sand



HDR | LMS

Sampling Stations

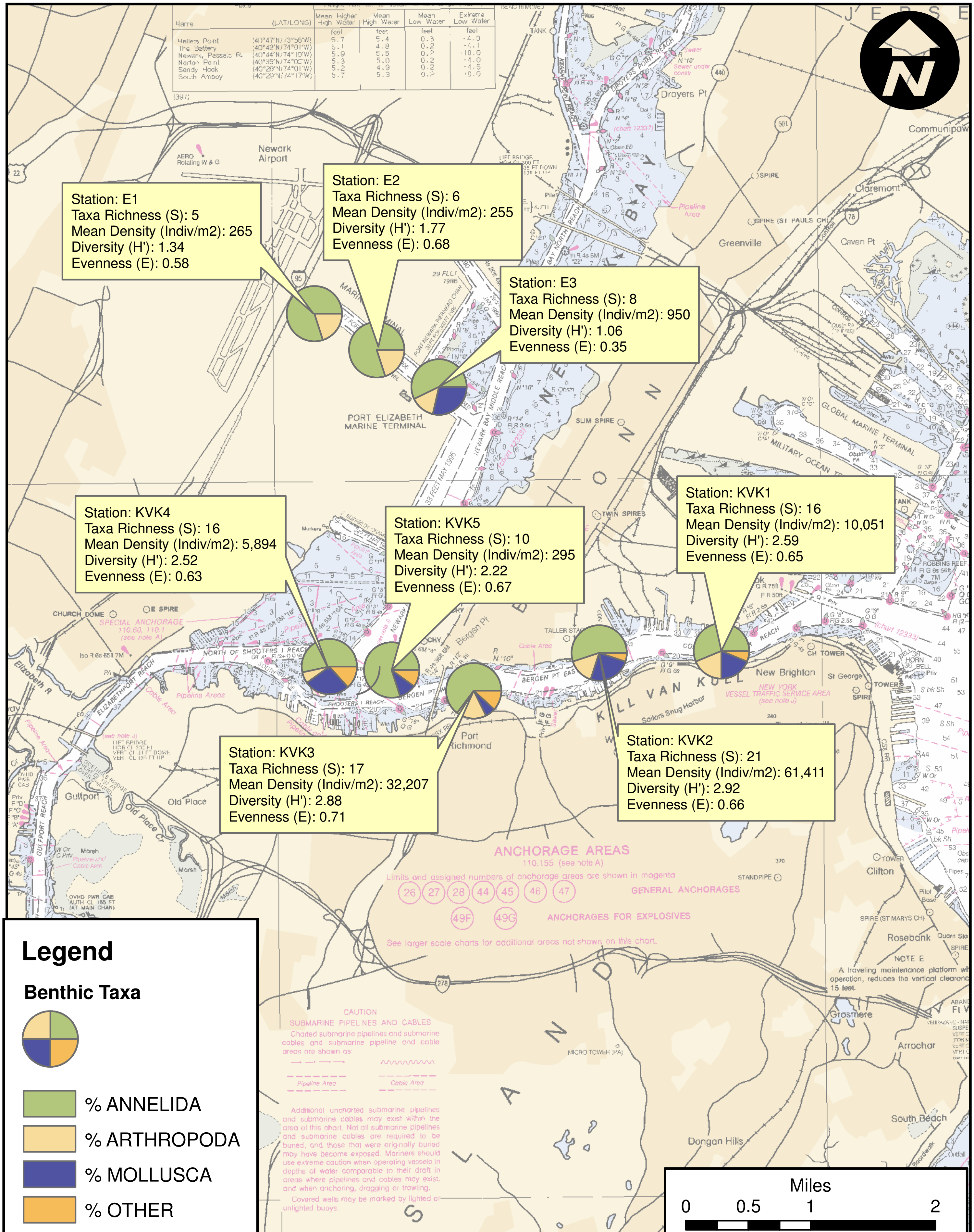
Job No.	Date	Figure No.
29505	04/27/06	1



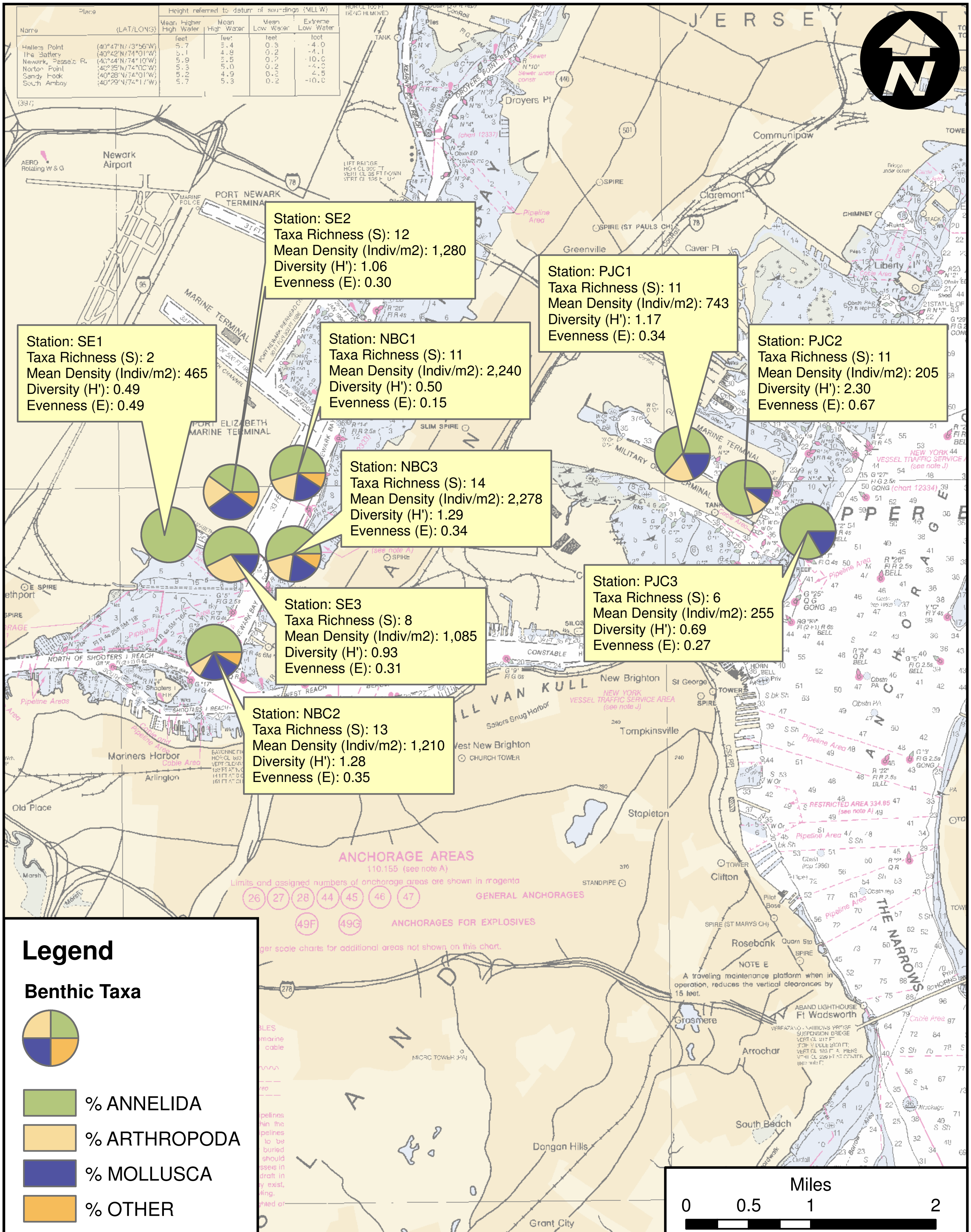
HDR | LMS

Ambrose (A), Anchorage Channel (AC), and Bay Ridge (BR) 2005 Benthic Invertebrate Sampling Locations

Job No.	Date	Figure No.
29505	04/27/06	2



	Elizabeth (E), and Kill Van Kull (KVK) 2005 Benthic Invertebrate Sampling Locations	Job No.	Date	Figure No.
		29505	04/27/06	3



Newark Bay Channel (NBC), Port Jersey Channel (PJC), and South Elizabeth (SE)
2005 Benthic Invertebrate Sampling Locations

Job No.	Date	Figure No.
29505	04/27/06	4