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The distribution of surficial sediments in New Haven Harbor, Connecticut, and the New Haven Dumping Grounds, north-central Long Island Sound

by

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ABSTRACT

Grain-size analyses were performed on 61 samples from New Haven Harbor, Connecticut, and on 25 samples from the New Haven Dumping Grounds (Central Long Island Sound Disposal Site) in north-central Long Island Sound. The relative grain-size frequency distributions and related statistics are reported herein. Descriptions of the benthic character from video tapes and still camera photographs of the bottom at these stations, and 5 others from New Haven Harbor, are also presented.

In the New Haven Harbor study area, silts and clayey silts dominate the main shipping channel north of Lighthouse Point, within the abandoned borrow pit in Morris Cove, northwest of the middle breakwater, and in smaller patches just north and south of the eastern breakwater. Slightly coarser sandy silts occur in the shallower areas within Morris Cove and around the western breakwater. Sands are prevalent off Oyster River Point and in a broad band that extends south-southwest from West Haven across the central part of the study area. Gravelly sediments are present around Lighthouse and Morgan Points.

Muddy sediments dominate the lower energy environment in the vicinity of the New Haven Dumping Grounds. Coarser sediments, where present, consist of medium-to-fine grained sands associated with dredge spoils or the materials used to cap these spoils.

INTRODUCTION

This study builds upon cooperative research with the State of Connecticut that was initiated in 1982. During the initial phase of this cooperative program, geologic framework studies in Long Island Sound were completed (Lewis and Needell, 1987; Needell and others, 1987; Lewis and Stone, 1991). The second and current phase of the program emphasizes studies of sea floor sediment distributions, processes that control these distributions, near-shore environmental concerns, and the relationship of benthic community structures to the sea floor geology.

Anthropogenic wastes, toxic chemicals, and changes in land use patterns from residential, commercial, and recreational development have stressed the environment of the Sound causing degradation and potential loss of benthic habitats (Long Island Sound Study, 1994). Data on surficial sediment attributes are needed to help evaluate the extent of adverse impacts and manage resources in the future. The purpose of this study was: 1) to measure the grain size distributions of surficial sediment samples from New Haven Harbor, Connecticut's major port, and from the New Haven Dumping Ground, the most active disposal site in Long Island Sound 2) to determine the frequency distributions of the grain-size data, and 3) to calculate statistical descriptions that adequately characterize these samples. These grain-size data will eventually be used to help describe the sedimentary processes active in this portion of Long Island Sound, and to evaluate near-shore sand and gravel resources. Other potential uses for these textural data

include benthic biologic studies that evaluate faunal distributions and relate them to habitats, and geochemical studies involving the transport and deposition of pollutants.

STUDY AREA

Long Island Sound is about 182 km long by a maximum of 32 km wide. It is bordered on the north by the rocky shoreline of Connecticut, on the east by the Race and Block Island Sound, on the south by the eroding sandy bluffs of Long Island, and on the west by the East River and the New York metropolitan area. Long Island Sound is an estuary; a place where saltwater from the ocean is mixed with fresh water drained from the land. Because of their unique physical and chemical oceanography, estuaries are among the most highly productive environments in the world (Long Island Sound Study, 1994).

The New Haven Harbor study area (Figs. 1, 2), which covers about 27.4 km^2 along the central Connecticut shoreline, falls largely within the harbor, but extends offshore covering most of the area between Morgan and Oyster River Points. New Haven Harbor is not only Connecticut's major commercial port facility, but is also part of a thriving shellfish aquaculture industry. The farmed shellfish, primarily eastern oysters (*Crassostrea virginica*) and hard clams or quahogs (*Mercenaria mercenaria*), thrive under conditions that include: a stable shallow-water habitat, appropriate nutrient availability, suitable salinities, and favorable tidal current patterns (John Volk, 1997, Connecticut Department of Agriculture).

Much of the northern part of the study area lies within a seaward extension of the Central Lowland of Connecticut and, therefore, is presumably underlain by Mesozoic rocks. The principle onshore equivalent of these rocks, the New Haven Arkose (Upper Triassic, possibly Lower Jurassic at the top), is composed of red, pink, and gray, coarse-grained, locally conglomeratic, poorly sorted sandstone interbedded with layers of reddish micaceous siltstone (Flint, 1965; Rodgers, 1985). The Light House Gneiss, a pink or gray to red, medium grained, generally well foliated granitic gneiss(Proterozoic ?), underlies most of the land south of Morris Cove and crops out near Lighthouse and Morgan Points. The Eastern Boundary Fault, which separates the New haven Arkose from the Light House Gneiss, continues west-southwestward under the study area across the southern part of Morris Cove. The gray to silver, medium to fine grained, well layered to laminated rocks of the Oronoque Schist (Lower Ordovician?) underlie the southwestern part of the study area. These rocks crop out at Bradley and Oyster River Points (Rodgers, 1985). Three valleys incised in the bedrock, which are seaward extensions of the West, Quinnipiac, and Farm River Valleys, coalesce under the inner harbor to form a single linear valley that extends toward the west-southwest (Sanders, 1965).

The bedrock across much of southeastern Connecticut is unconformably overlain by two tills, one of pre-Wisconsinan age and

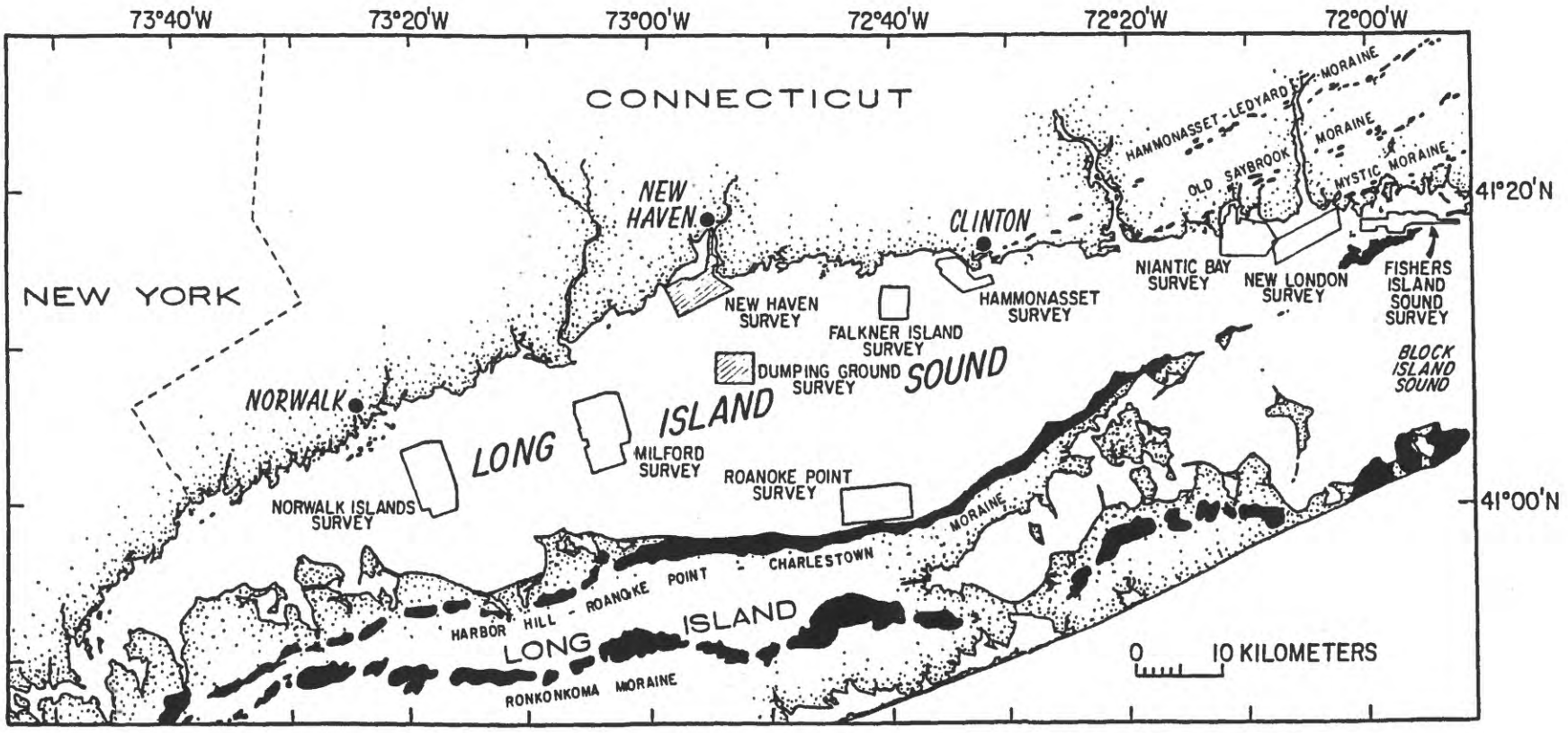

Figure 1. Index map showing the location of the New Haven Harbor and New Haven Dumping Grounds (Central Long Island Sound Disposal Site) study areas (hatched polygons). Map also shows the locations of other sidescan sonar and sampling surveys (open polygons) conducted as part of this series (Norwalk: Poppe and others, 1996a; Twichell and others, 1997; Milford: Poppe and others, 1996b; Twichell and others, 1998; Falkner Island: Poppe and others, 1997c; Poppe and others, 1997d; Hammonasset Beach: Poppe and others, 1995; Poppe and others, 1997a; Roanoke Point: Poppe and others, 1997e; Poppe and others, 1998a; Niantic Bay: Poppe and others, 1996c; Poppe and others, 1998b ; New London: Poppe and others, 1992; Moffett and others, 1994; Fishers Island Sound: Poppe and others, 1994; Poppe and others, 1997b).

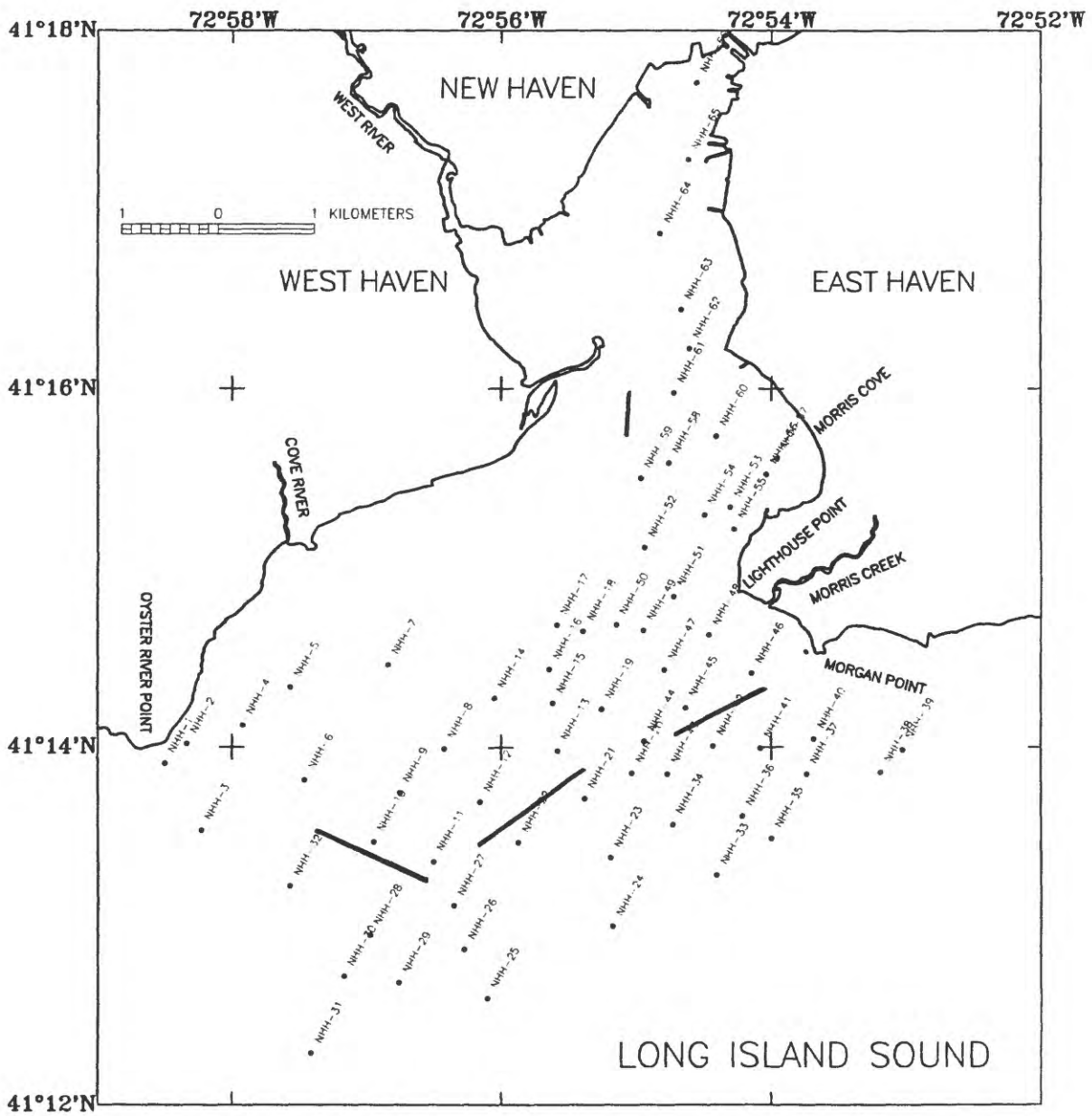

Figure 2. Map of the New Haven Harbor, Connecticut, showing the sampling and bottom photography station locations. Stations where surficial sediment samples and/or bottom photographs were collected are shown as solid circles. Heavy offshore lines represent breakwaters.

one of late Wisconsinan age (Lewis and Needell, 1987; Needell and others, 1987; Stone and Schafer, 1994). The younger till forms a thin (2-5 m), discontinuous mantle over nearly all of the higher land around New Haven Harbor. This till is exposed onshore near the southwestern part of the study area around Oyster River and Bradley Points, near the southeastern part of the study area around Lighthouse and Morgan Points, and along the northeast shore of Morris Cove (Stone and others, 1992). The till, which is typically loose to compact and sandy and stony with large subrounded boulders, resembles the bedrock that immediately underlies it and possesses a distinct southwest fabric. Although both till sheets have been identified in the adjacent Branford and Mount Carmel Quadrangles (Flint, 1965), the older till has not been found around New Haven Harbor. Although the northward retreat of the late Wisconsinan ice sheet is marked in southeastern Connecticut by a northward succession of minor recessional moraines (i.e. the Hammonasset-Ledyard, Old Saybrook, and Mystic Moraines) no end moraines have been identified along the shores of New Haven Harbor (Flint, 1965; Goldsmith, 1980).

Stratified drift, deposited by glacial streams as outwash facies, blankets the tills and bedrock over most of West Haven and New Haven, as part of the New Haven valley train, and around Morris Creek east of Morris Cove, as part of the Farm River valley train (Flint, 1965; Stone and others, 1992). Offshore from New haven Harbor, deltaic and varved lake deposits of glacial Lake Connecticut variously overlie the bedrock and glacial drift(Lewis and Stone, 1991; Stone and others, 1992). This lake, which occupied most of the Long Island Sound basin, was formed when the last ice front began to recede from the Harbor Hill-Roanoke Point Moraine position and meltwater was impounded in the expanding, long, narrow basin between the moraine and the retreating ice to the north (Stone and Borns, 1986).

The glacial drift and glaciolacustrine deposits are truncated by an unconformity. This unconformity is a composite product of the subaerial exposure, which occurred after glacial Lake Connecticut drained, and of the marine transgression that occurred after 15 ka (Lewis and Stone, 1991). A marine facies, which occurs in quiet-water areas throughout the Long Island Sound basin, overlies these earlier deposits and records deposition during the postglacial Holocene eustatic rise of sea level.

Salt marsh deposits, which consist of seaward thickening wedges of peaty mud and muddy peat, occur along Morris Creek, and Cove, West, and Quinnipiac Rivers. Although previously larger, some of the marshes have been filled during city redevelopment activity. Much of the present shoreline within New Haven Harbor, especially in New Haven and East Haven north of Morris Cove, is composed of sediment and man-made materials that have been artificially emplaced (Flint, 1965). Freshwater contributions from rivers discharging into New Haven Harbor are minor relative to the total tidal flux of water in and out of the harbor (Richards, 1988).

The New Haven Dumping Grounds study area, which is located

about 10.4 km south-southeast of Morgan Point and encompasses the Central Long Island Sound Disposal Site, covers about 15.9 km^2 in north-central Long Island Sound (Figs. 1, 3). Water depths (Mean Low Water) range between 16 and 26 m, and average about 21 m.

This area and three other open-water sites within Long Island Sound (Eatons Neck, Brigeport, and New London) have historically received the vast majority of the spoils dredged from the borders of the Sound. During 1954 and 1956 more than 4 million m^3 were disposed of at the New Haven site (Schubel and others, 1979). The New Haven Dumping Grounds continues to be one of the most active containment sites in New England because the area is thought to be located within an area of Long Island Sound that is characterized by long-term deposition, relatively weak bottom current regimes, and subject to only shallow, wind-driven waves (Morris and others, 1996; Signell and others, 1998; Knebel and others, in press). The proximal location of the New Haven Dumping Grounds to major commercial and recreational port facilities also minimizes disposal costs (Boyd and others, 1972). For example, during the period October 1993 through January 1994 the U.S. Army Corps of Engineers dredged approximately 642,000 m^3 of sediments from the navigational channel in New Haven Harbor which were then disposed at the New Haven Dumping Grounds (Bohlen and others, 1996).

Tidal and wind-driven currents have extensively reworked both the glacial and post-glacial deposits around the outer harbor and continue to influence the sedimentary processes and surficial sediment distributions in both study areas (Lewis and Stone, 1991). Tidal currents alone exceed 25 cm/s across the outer harbor (Caruso and others, 1995) and 20 cm/s at 1 m above the bottom over the dumping grounds (Signell and others, 1998; Knebel and others, in press).

METHODS

Surficial sediment samples and bottom photographs were attempted at 66 locations in New Haven harbor and 25 locations near the New Haven Dumping Grounds during March, 1998 aboard the State of Connecticut Department of Environmental Protection vessel the RV John Dempsey using a Van Veen grab sampler (Figs. 2 and 3). This grab sampler was equipped with Osprey video and still camera systems; the video system was attached to an 8 mm video cassette recorder. These photographic systems were used to appraise intra-station bottom variability and to observe boulder fields and bedrock outcrops where sediment samples could not be collected (Appendices A and B). The 0-2 cm interval in the surficial sediments was subsampled from the grab sampler; these samples were frozen and stored for later analysis. Navigation was performed using a differential Global Satellite Positioning system.

A total of 86 surficial sediment samples (61 from New Haven Harbor and 25 from the New Haven Dumping Grounds) were collected for grain size analysis. The samples were thawed and visually inspected in the laboratory. If the sample contained gravel, the entire sample was analyzed. If the sample was composed of only sand, silt,

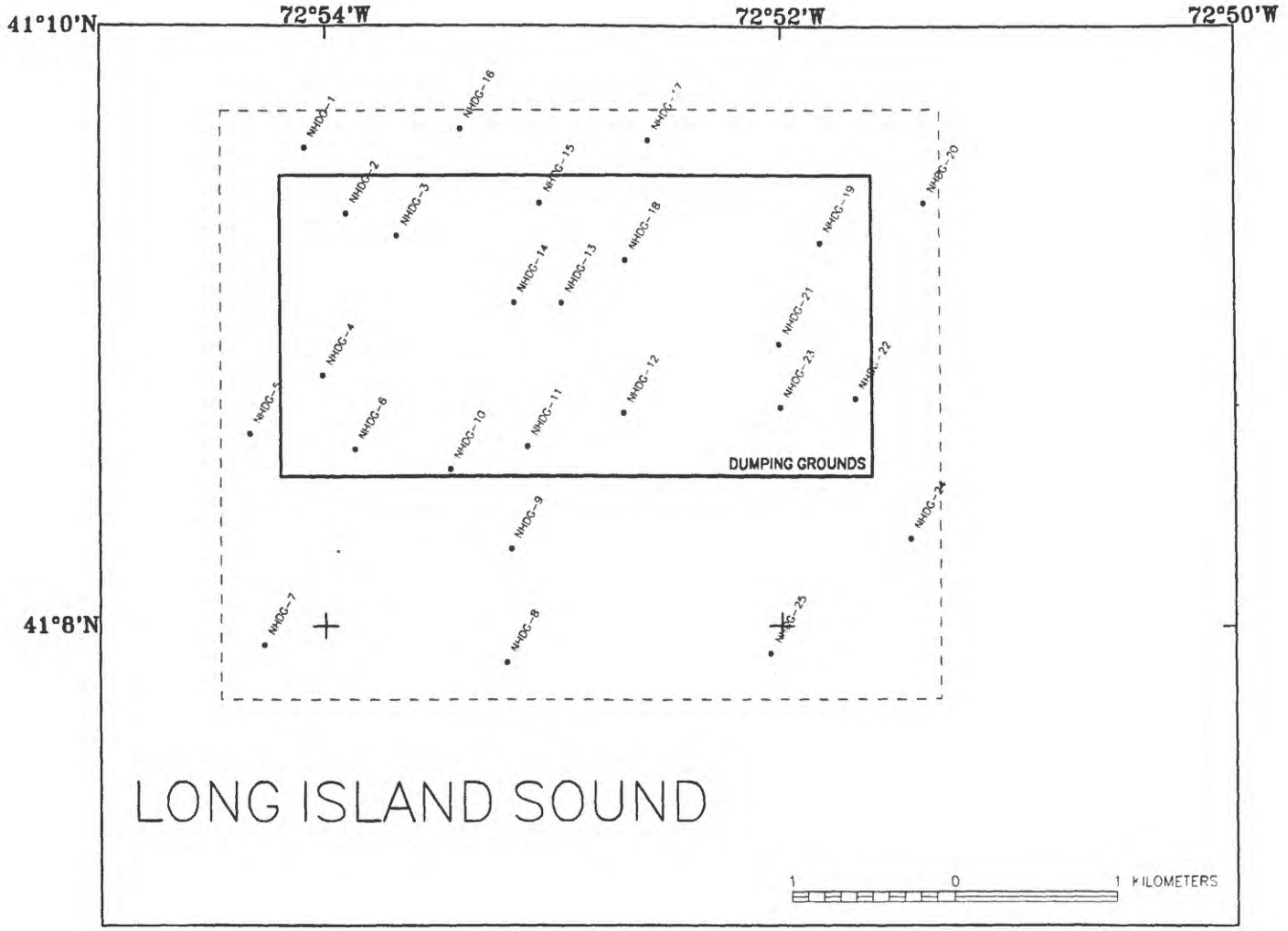

Figure 3. Map of the New Haven Dumping Grounds study area in north-central Long Island Sound showing the sediment sampling and bottom photography station locations (solid circles), the outline of the Central Long Island Sound Disposal Site (solid line), and the boundary of the study area (dashed line).

and clay, an approximately 50-gram, representative split was analyzed. The sample to be analyzed was placed in pre-weighed 100 ml beaker, weighed, and dried in a convection oven set at 75 °C. When dried, the samples were placed in a desiccator to cool and then weighed. The decrease in weight due to water loss was used to correct for salt; salinity measurements averaged 26 °/oo. The weight of the sample and beaker less the weight of the beaker and the salt correction gave the sample weight.

The samples were disaggregated and then wet sieved through a number 230, 62 μm (4ϕ) sieve using distilled water to separate the coarse- and fine-fractions. The fine fraction was sealed in a Mason jar and reserved for analysis by Coulter Counter (Shideler, 1976). The coarse fraction was washed in tap water and reintroduced into the pre-weighed beaker. The coarse fraction was dried in the convection oven at 75 °C and weighed. The weight of the coarse (greater than 62 μm) fraction is equal to the weight of the sand plus gravel. The weight fines (silt and clay) can also be calculated by subtracting the coarse weight from the sample weight. The coarse fraction was dry sieved through a number 10, 2.0 mm (-1ϕ) sieve to separate the sand and gravel. The size distribution within the gravel fraction was determined by sieving. Because biogenic carbonates commonly form in situ, they are not representative of the depositional environment from a textural standpoint. Therefore, bivalve shells and other biogenic debris greater than 0ϕ (1.0 mm) were manually removed from the samples and the weights corrected to mitigate this source of error.

If the sand fraction contained more than 16 grams of material (enough to run the analysis twice), a rapid sediment analyzer (Schlee, 1966) was used to determine the sand distribution. If less than 16 grams of sand were available, the sand fraction was dry sieved using a Ro-Tap shaker.

The fine fraction was analyzed by Coulter Counter. To mitigate biologic or chemical changes, storage in the Mason jars prior to analysis never exceeded five days. The gravel, sand, and fine fraction data were processed by computer to generate the distributions, statistics, and data base (Poppe and others, 1985). One limitation of using a Coulter Counter to perform fine fraction analyses is that it has only the ability to "see" those particles for which it has been calibrated. Calibration for this study allowed us to determine the distribution down to 0.7 μm or about two-thirds of the 11ϕ fraction. Because clay particles finer than this diameter and all of the colloidal fraction were not determined, a slight decrease in the 11ϕ (and finer) fraction is present in the size distributions (Appendix B).

RESULTS AND COMMENTS

Sample locations, water depths, and brief comments on the benthic processes and biota from the bottom photography for New Haven Harbor and the New haven Dumping Grounds are presented in Appendices A and B, respectively. New Haven Harbor sample locations with low numerical designations (e.g. NHH-1) tend to be located in

the western portion of the study area; sample locations with higher numerical designations tend to be located in the eastern and northern portions of the study area (e.g. NHH-55, NHH-66; Fig. 2). Similarly, New Haven Dumping Ground sample locations with lower numerical designations (e.g. NHDG-5) tend to be located in the western part of that study area; sample locations with higher numeric designations tend to be in the eastern part of that study area (e.g. NHDG-24; Fig. 3). The relative frequency distributions of the grain-size analyses for New Haven Harbor and the New Haven Dumping Grounds are presented in Appendices C and D, respectively; the related statistics and verbal equivalents are presented in Appendices E and F. Size classifications are based on the method proposed by Wentworth (1929); the statistics were calculated using the method of moments (Folk, 1974). The verbal equivalents were calculated using the inclusive graphics statistical method (Folk, 1974) and are based on the nomenclature proposed by Shepard (1954). Because of the constant reworking, contacts between the various lithologies are gradational and lateral changes in lithology are seldom abrupt.

New Haven Harbor Survey

The finest grained sediments in the New Haven Harbor study area are restricted to environments protected from the strong tidal and storm conditions. Poorly sorted, finely skewed silts and clayey silts dominate in and adjacent to the main shipping channel north of Lighthouse Point (e.g. NHH-66), within the abandoned borrow pit in Morris Cove (NHH-57), northwest of the middle breakwater (e.g. NHH-8), and in smaller patches just north (e.g. NHH-45) and south (e.g. NHH-42) of the eastern breakwater. Slightly coarser very poorly sorted, coarsely skewed, leptokurtic sandy silts occur in the shallower areas within Morris Cove (e.g. NHH-54) and west (e.g. NHH-32) and north (e.g. NHH-9) of the western breakwater. These muddy areas are extensively bioturbated; most bottom features originate from biologic activity. Amphipod communities, worm tubes, shrimp burrows, snails, and mud crabs are common.

The muddy sediments progressively grade into bands of silty sand and coarser grained sediments as the water depth decreases and the exposure to storm and tidal currents increases. The silty sands are typically very poorly sorted (standard deviations greater than 2.0), nearly symmetrical to finely skewed, and platykurtic. Although faint current ripples are present, the effects of bioturbation are still more evident. Scattered shells and shell debris are present; crabs, worm tubes, hydrozoans, bivalves, and gastropods are common components in the faunal assemblage.

Sands occur off Oyster River Point and are the dominate lithology in a broad band across the central part of the study area. This band extends south-southwest from West Haven along a seaward-trending bathymetric high, in and adjacent to the main shipping channel south of Lighthouse Point, in the vicinity of the gap between the middle and eastern breakwaters, and across much of the study area outside the breakwaters. The sands shoreward of the

breakwaters are typically fine to medium grained, poorly sorted, and strongly finely skewed to nearly symmetrical (e.g. NHH-7, NHH-14). The sands near the gap between the middle and eastern breakwaters are typically medium grained, moderately well sorted, nearly symmetrical to coarsely skewed, and leptokurtic (e.g. NHH-19, NHH-20). Sorting decreases and the distributions become finely skewed and very leptokurtic in the sand outside the breakwaters (e.g. NHH-22, NHH-35). Current ripples are ubiquitously present in the sandy areas and reflect the constant reworking by tidal and storm currents. Although sands are present north of Lighthouse Point, these sediments are restricted to small patches and shallow water Turekian and others, 1972). Decreased visibility due to resuspension during a passing storm was observed in the bottom video. Locally, shells (oyster, razor, and quahog) and shell debris liter the bottom and concentrate in the ripple troughs. Starfish, hermit crabs, welk, clam burrows, and hydrozoans are common.

Gravelly sediments, which tend to be very poorly sorted and bimodal, are concentrated in shallow, higher energy environments around Lighthouse (NHH-48) and Morgan (e.g. NHH-38) Points. Starfish and oyster, razor clam, and quahog shell and shell debris are common; hydrozoans grow on the shell material.

Sampling was not attempted at station NHH-39 off Morgan Point, where bottom photography revealed the presence of boulders or bedrock. Sponges, algae, and seaweed are attached to the rocks; patches of rippled sand with scattered shells occur between the boulders. A thin (<2 cm), possibly seasonal, layer of fine-grained, presumably hemipelagic, detritus covers the rocks. The limited thickness of this layer suggests that it is episodically removed by storm-generated currents.

New Haven Dumping Grounds Survey

Muddy sediments dominate the lower-energy environment in the vicinity of the New Haven Dumping Grounds. These sediments are generally poorly sorted siliciclastic silts and clayey silts with unimodal, finely skewed to nearly symmetrical, mesokurtic distributions (e.g. NHDG-22, NHDG-25). Although the central Long Island Sound basin floor is characterized by long-term deposition, faint longitudinal ripples, which trend east-northeast, and a current-swept appearance reflect some remobilization of the sediments by periodic tidal and episodic storm currents. Nut clam (nucula) shells, burrows (shrimp, clam (e.g. *Pitar*), mud crab, and lobster), burrowing anemones (e.g. *Ceriantheopsis americana*), worm tubes, hydrozoans, and amphipod communities are common in the heavily bioturbated bottom.

Very poorly sorted sands, silty sands, and sandy silts are common within the New Haven Dumping Grounds portion of the study area (e.g. NHDG-18). These coarser grained sediments reflect the presence of dredge spoils, or the materials used to cap the spoils (Morris and others, 1996). Identifiable anthropogenic debris (i.e. wires, cables, pipe) are occasionally present in the bottom video at these stations. Amphipod communities, worm tubes, and shrimp and

crab burrows are common in the areas characterized by spoils.

DATA DISSEMINATION

Interested parties can obtain copies of the grain-size analysis data, the associated statistics, and an explanation of the variable headings in ASCII format and on 3.5" diskettes for this and other bottom sampling and photographic studies completed as part of this series (Poppe and others, 1992; Poppe and others, 1995; Poppe and others, 1996a; Poppe and others, 1996b; Poppe and others, 1996c; Poppe and others, 1997c; Poppe and others, 1997e) at the Woods Hole Field Center of the Coastal and Marine Geology Program of the U.S. Geological Survey, Woods Hole, Massachusetts, or by contacting any of the authors. Videotapes showing the bottom character of the station locations can also be viewed at the Woods Hole offices of the U.S. Geological Survey or at the Long Island Sound Resource Center at Avery Point, Groton, Connecticut.

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APPENDIX A

This table contains a list of the sample numbers, navigation (latitudes and longitudes) in degrees decimal minutes, water depths in meters (not corrected for tides), and comments on the bottom character for samples collected in New Haven Harbor.

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	COMMENTS
NHH-1	41d13.9099'	-72d58.4986'	5.8	CURRENT RIPPLES, ORGANICS ON RIPPLES, SOME GRAVEL, SCATTERED SHELL HASH, FLOUNDER
NHH-2	41d14.0188'	-72d58.3362'	7.0	ABUNDANT OYSTER SHELLS, SOME SHELL HASH, VENEER OF SILT, SNAILS, HERMIT AND MUD CRABS
NHH-3	41d13.5378'	-72d58.2290'	9.3	SOFT, UNDULATING BIOTURBATED BOTTOM, SCATTERED SHELLS, WORM TUBES, SHRIMP BURROWS, CRAB TRACKS
NHH-4	41d14.1232'	-72d57.9221'	7.8	SOFT, UNDULATING BIOTURBATED BOTTOM, WORM TUBES, SCATTERED SHELLS, TRACKS
NHH-5	41d14.3330'	-72d57.5635'	7.3	SOFT, BIOTURBATED, SCATTERED SHELLS, WORM TRACKS, CRAB TRACKS, SHRIMP AND CLAM BURROWS, AMPHIPODS
NHH-6	41d13.8199'	-72d57.4607'	8.3	SOFT, UNDULATING BIOTURBATED BOTTOM, CRABS (MUD) AND TRACKS, WORM TUBES
NHH-7	41d14.4595'	-72d56.8376'	4.2	SHELLS, VENEER OF SILT, SNAILS
NHH-8	41d13.9903'	-72d56.4225'	5.3	SOFT, FLAT BIOTURBATED BOTTOM, HEAVILY TRACKED, SHELLS AND SHELL HASH (NUCULA), AMPHIPODS
NHH-9	41d13.7460'	-72d56.7558'	5.7	BIOTURBATED, SCATTERED SHELLS (NUCULA), SHRIMP AND CLAM BURROWS, WORM TUBES
NHH-10	41d13.4754'	-72d56.9494'	9.6	SHELLS AND SHELL HASH, CRABS (MUD), SNAILS
NHH-11	41.13.3630'	-72d56.5053'	9.1	ABUNDANT SHELL HASH, SCATTERED SHELLS
NHH-12	41d13.6950'	-72d56.1571'	5.5	SOFT, FLAT, HEAVILY CRAB TRACKED, SHRIMP AND CLAM BURROWS, TRACE OF SHELL HASH, WORM TUBES, THIN LAYER OF RUST-BROWN ORGANICS
NHH-13	41d13.9806'	-72d55.5795'	6.0	CURRENT RIPPLES, SPONGES, RAZOR CLAM SHELL HASH IN THE TROUGHS, HERMIT CRABS, SEAWEED
NHH-14	41d14.2691'	-72d56.0510'	5.1	RIPPLES, SHELLS AND SHELL DEBRIS, SNAILS, HERMIT CRABS
NHH-15	41d14.2424'	-72d55.6158'	4.3	CURRENT RIPPLES, SHELL HASH IN RIPPLE TROUGHS, SNAILS
NHH-16	41d14.4343'	-72d55.6403'	5.4	ABUNDANT OYSTERS, SEAWEED, HYDROZOANS
NHH-17	41d14.6832'	-72d55.5852'	2.5	CURRENT SWEPT ORGANICS, SCATTERED SHELLS, SEAWEED CURRENT RAFTING ON SHELLS AND ROCKS, HYDROZOANS
NHH-18	41d14.6495'	-72d55.3916'	6.4	SOFT, FLAT, BIOTURBATED, ABUNDANT CRAB TRACKS, TRACE OF SHELL DEBRIS, SHRIMP AND CLAM BURROWS, AMPHIPODS
NHH-19	41d14.2097'	-72d55.2556'	6.2	CURRENT RIPPLES, SCATTERED SHELL DEBRIS
NHH-20	41d13.8556'	-72d55.0346'	7.0	CURRENT RIPPLES, SCATTERED SHELLS
NHH-21	41d13.7157'	-72d55.3853'	6.6	CURRENT RIPPLES, TRACKS, SHELL HASH
NHH-22	41d13.4698'	-72d55.8742'	8.2	CURRENT RIPPLES, SHELLS AND SHELL HASH, CRABS (MUD)

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	COMMENTS
NHH-23	41d13.3846'	-72d55.1937'	6.7	CURRENT RIPPLES, SHELL HASH, CRABS (MUD), GRAVEL BELOW SURFICIAL SAND
NHH-24	41d13.0008'	-72d55.1771'	8.4	CURRENT RIPPLES, SHELLS (OYSTER AND RAZOR), SHELL HASH IN RIPPLE TROUGHS, STARFISH
NHH-25	41d12.5930'	-72d56.1035'	9.4	CURRENT RIPPLES, ABUNDANT OYSTER SHELL HASH
NHH-26	41d12.8693'	-72d56.2743'	9.0	CURRENT RIPPLES, SHELL HASH (OYSTER AND RAZOR) IN TROUGHS, WELK
NHH-27	41d13.1163'	-72d56.3503'	8.7	CURRENT RIPPLES, SHELL HASH (OYSTER AND RAZOR) IN RIPPLE TROUGHS, FLOUNDER, CRABS (MUD), SNAILS
NHH-28	41d12.9516'	-72d56.9761'	10.1	ABUNDANT SHELL (OYSTER, MERCENARIA, AND RAZOR), SNAILS
NHH-29	41d12.6832'	-72d56.7605'	10.3	FLAT BOTTOM, ABUNDANT SHELL (OYSTER, MERCENARIA, AND RAZOR), WELK
NHH-30	41d12.7185'	-72d57.1691'	10.9	SOFT, BIOTURBATED, CRAB TRACKS, SCATTERED SHELL (OYSTER, MERCENARIA, AND RAZOR) HASH, BURROWS
NHH-31	41d12.2886'	-72d57.4107'	11.8	SOFT, BIOTURBATED, ABUNDANT CRAB TRACKS, WORM TUBES, SCATTERED SHELLS (NUCULA) AND SHELL HASH, SHRIMP BURROWS
NHH-32	41d13.2258'	-72d57.5703'	9.9	SOFT, BIOTURBATED, FAINTLY RIPPLED, SCATTERED SHELLS AND SHELL HASH, SHRIMP BURROWS, CRAB (MUD) AND CRAB TRACKS, SCALLOP, LEAF
NHH-33	41d13.2888'	-72d54.4061'	10.8	SOFT, SCATTERED SHELLS AND SHELL HASH, CURRENT SWEPT APPEARANCE, SHRIMP BURROWS, HYDROZOANS, TRACKS, LEAVES
NHH-34	41d13.5707'	-72d54.7354'	12.5	ABUNDANT SHELLS, SOME GRAVEL, SNAILS CRABS (MUD), STARFISH
NHH-35	41d13.4930'	-72d53.9991'	8.3	UNDULATING BOTTOM, ABUNDANT SHELLS AND SHELL HASH (RAZOR AND MERCENARIA),HORSESHOE AND SPIDER CRABS, STARFISH
NHH-36	41d13.6175'	-72d54.2122'	8.5	ABUNDANT SHELLS AND SHELL HASH (OYSTER, RAZOR, AND CLAM, SOME PEA GRAVEL, HERMIT AND MUD CRABS, SEAWEED
NHH-37	41d13.8499'	-72d53.7364'	7.0	MUDDY, SOFT, FAINTLY RIPPLED, ABUNDANT SHELLS AND SHELL HASH, HYDROZOANS, SNAILS, WELK
NHH-38	41d13.8602'	-72d53.1856'	3.0	GRAVELLY PATCHES, CURRENT RIPPLES, SHELLS AND SHELL HASH, STARFISH
NHH-39	41d13.9869'	-72d53.0241'	4.8	BOULDERS, PATCHES OF RIPPLED SAND, SPONGES, SEAWEED, SCATTERED SHELLS
NHH-40	41d14.0444'	-72d53.6820'	5.9	FAINTLY RIPPLED, SHELLS AND SHELL HASH, SEAWEED
NHH-41	41d13.9942'	-72d54.0774'	7.0	SOFT, SCATTERED SHELLS (NUCULA), HERMIT CRABS, THIN OXIDIZED LAYER
NHH-42	41d14.0060'	-72d54.4309'	7.3	SOFT, SCATTERED SHELLS AND SHELL HASH (NUCULA), SNAILS AND SNAIL TRACKS, SULFIDE ODOR
NHH-43	41d13.8516'	-72d54.7736'	8.7	CURRENT RIPPLES ON SAND WAVES, SHELLS AND SHELL HASH
NHH-44	41d14.0318'	-72d54.9432'	11.7	PATCHES OF BOULDERS, RIPPLED SAND, SHELL HASH IN THE TROUGHS
NHH-45	41d14.2210'	-72d54.6370'	4.3	SOFT, FLAT, BIOTURBATED, SNAIL TRACKED, LOBSTER AND SHRIMP BURROWS, AMPHIPODS
NHH-46	41d14.4112'	-72d54.1431'	4.7	GRAVEL, OYSTER SHELLS, HYDROZOANS
NHH-47	41d14.4313'	-72d54.7929'	5.2	SOFT, FLAT, BIOTURBATED, SNAIL TRACKS, WORM TUBES, AMPHIPODS, LEAVES
NHH-48	41d14.6276'	-72d54.4624'	5.6	OYSTER SHELLS, GRAVEL
NHH-49	41d14.6522'	-72d54.9493'	10.5	SOFT, SCATTERED SHELL DEBRIS, CRABS (MUD), SHRIMP AND CLAM BURROWS, SNAILS, SEAWEED, LEAVES

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	COMMENTS
NHH-50	41d14.6868'	-72d55.1508'	4.1	SOFT, BIOTURBATED, TRACE OF SHELL DEBRIS, SHRIMP BURROWS, REDDISH-BROWN ORGANIC VENEER
NHH-51	41d14.8439'	-72d54.7272'	5.5	SOFT, FAINTLY RIPPLED, ABUNDANT AMPHIPODS, TRACE OF SHELL HASH
NHH-52	41d15.1176'	-72d54.9432'	5.5	SOFT, BIOTURBATED, TRACKED, CRABS (MUD), SHRIMP BURROWS, PATCHY AMPHIPOD COMMUNITIES
NHH-53	41d15.3410'	-72d54.3042'	3.9	SOFT, UNDULATING BIOTURBATED BOTTOM, PATCHES OF SHELLS AND SHELL DEBRIS, CRABS (MUD), SNAILS AND SNAIL TRACKS
NHH-54	41d15.2974'	-72d54.4971'	3.8	SOUPY, BIOTURBATED, SULFIDE ODOR
NHH-55	41d15.2194'	-72d54.2749'	3.5	OYSTER SHELLS, VENEER OF SILT, SNAILS, GRAVEL
NHH-56	41d15.5251'	-72d54.0373'	3.5	SOFT, SNAIL TRACKS, REDDISH-BROWN ORGANIC VENEER
NHH-57	41d15.6105'	-72d53.9597'	8.2	SOFT, FLAT BIOTURBATED, SHRIMP, CRABS (MUD) AND CRAB TRACKS,
NHH-58	41d15.5843'	-72d54.7636'	11.5	SOFT, FLAT BIOTURBATED, TRACKS, TRACE OF SHELL DEBRIS, CRABS, SHRIMP BURROWS, AMPHIPODS, WORM TUBES
NHH-59	41d15.5025'	-72d54.9703'	4.6	SOFT, UNDULATING BIOTURBATED BOTTOM, SHRIMP BURROWS, ABUNDANT AMPHIPOD TUBES, TRACE OF SHELL DEBRIS, CRABS (MUD)
NHH-60	41d15.7362'	-72d54.4094'	3.4	SOFT, SHELL HASH
NHH-61	41d15.9761'	-72d54.7236'	11.9	SOFT, UNDULATING BIOTURBATED BOTTOM, PATCHY AMPHIPOD COMMUNITIES, SNAIL TRACKS, OYSTER AND SCALLOP SHELLS
NHH-62	41d16.2242'	-72d54.6079'	4.9	SOFT, UNDULATING BIOTURBATED BOTTOM, SCATTERED SHELL DEBRIS
NHH-63	41d16.4393'	-72d54.6687'	12.0	SOFT, BIOTURBATED, AMPHIPOD COMMUNITIES, SNAIL AND CRAB TRACKS, SHRIMP BURROWS
NHH-64	41d16.8681'	-72d54.8248'	5.1	SOFT, FLAT BIOTURBATED BOTTOM, ABUNDANT SNAILS AND TRACKS, SHRIMP BURROWS, SCATTERED AMPHIPODS
NHH-65	41d17.2769'	-72d54.6157'	12.5	SOFT, BIOTURBATED, SNAIL TRACKS, SHRIMP BURROWS, TRACE OF SHELLS, SEAWEED, FISH
NHH-66	41d17.7084'	-72d54.5519'	11.1	SOFT, ABUNDANT SNAILS AND TRACKS, FLAT, AMPHIPODS

APPENDIX B

This table contains a list of the sample numbers, navigation (latitudes and longitudes) in degrees decimal minutes, water depths in meters, and comments on the bottom character for samples collected at the New haven Dumping Grounds (Central Long Island Sound Disposal Site.)

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	COMMENTS
NHDG-1	41d09.5924'	-72d54.0919'	18.0	SOFT, UNDULATING BIOTURBATED BOTTOM, CRABS (MUD) AND TRACKS, ANEMONES, BURROWS (SHRIMP, CLAM), SNAIL TRACKS
NHDG-2	41d09.3723'	-72d53.9073'	18.2	UNDULATING BIOTURBATED BOTTOM, CRABS (MUD) AND TRACKS, TRACE OF SHELLS, SHRIMP AND CLAM BURROWS, WORM TUBES
NHDG-3	41d09.2978'	-72d53.6863'	19.5	UNDULATING BIOTURBATED BOTTOM, SHELLS, LOBSTER AND BURROWS, SNAIL TRACKS, HYDROZOANS, SEAWEED
NHDG-4	41d08.8353'	-72d54.0116'	20.1	SOFT, FLAT, CRABS (MUD), TRACE OF SHELLS, SHRIMP BURROWS, ANEMONES
NHDG-5	41d08.6399'	-72d54.3347'	20.2	SOFT, UNDULATING BIOTURBATED BOTTOM, PATCHES OF SHELLS, CRAB TRACKS, BURROWS, WORM TUBES
NHDG-6	41d08.5891'	-72d53.8729'	18.1	FLAT, TRACE OF SHELLS, CRAB TRACKS, HYDROZOANS, FLOUNDER, SEAWEED, SULFIDE ODOR
NHDG-7	41d07.9353'	-72d54.2721'	22.4	SOFT, UNDULATING BIOTURBATED BOTTOM, CRABS (MUD) AND CRAB TRACKS, BURROWS, FISH, ANEMONES
NHDG-8	41d07.8789'	-72d53.2057'	24.4	SOFT, UNDULATING BOTTOM, FAINT LONGITUDINAL RIPPLES (CRESTS PARALLEL TO DIRECTION OF CURRENT),SCATTERED SHELLS, BURROWS(SHRIMP, CLAM, LOBSTER AND CRAB),CRABS AND TRACKS, ANEMONES, SKATE, HYDROZOANS
NHDG-9	41d08.2587'	-72d53.1878'	22.2	UNDULATING BIOTURBATED BOTTOM, CRAB AND SHRIMP BURROWS
NHDG-10	41d08.5228'	-72d53.4577'	21.2	UNDULATING BIOTURBATED BOTTOM, CURRENT-SWEPT APPEARANCE, SCATTERED PATCHES OF SHELLS, CRABS (MUD) AND TRACKS, HYDROZOANS, ANEMONES, BURROWS (SHRIMP, LOBSTER, CRAB, AND CLAM) WORM TUBES
NHDG-11	41d08.5984'	-72d53.1151'	20.8	SOFT, ABUNDANT CRABS (MUD) AND TRACKS, SPOILS (WIRE), LOBSTER BURROWS
NHDG-12	41d08.7093'	-72d52.6897'	21.5	FAINT LONGITUDINAL RIPPLES, SCATTERED PATCHES OF SHELLS, CRABS (MUD) AND TRACKS, ANEMONES
NHDG-13	41d09.0757'	-72d52.9618'	19.8	SOFT, BIOTURBATED, FAINT LONGITUDINAL RIPPLES, ANEMONES, BURROWS (SHRIMP, CLAM, LOBSTER, CRAB),SCATTERED PATCHES OF NUCULA SHELLS
NHDG-14	41d09.0765'	-72d53.1718'	19.0	SOFT, FAINT LONGITUDINAL RIPPLES, PATCHY SHELLS, HYDRZOANS, CRABS (MUD
NHDG-15	41d09.4079'	-72d53.0560'	18.5	SOFT, BURROWS (SHRIMP, CLAM, LOBSTER, CRAB), ANEMONES, CRABS (MUD) AND TRACKS, HYDROZOANS
NHDG-16	41d09.6556'	-72d53.4103'	17.2	FAINT LONGITUDINAL RIPPLES (CRESTS PARALLEL TO THE CURRENT), BURROWED, ANEMONES, SPOIL (RUBBLE, WIRE) AMPHIPODS, CRABS, HYDROZOANS

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	COMMENTS
NHDG-17	41d09.6155'	-72d52.5776'	20.8	SOFT, SCATTERED SHELLS, FAINT LONGITUDINAL RIPPLES, ANEMONES, HYDROZOANS, BURROWS
NHDG-18	41d09.2178'	-72d52.6781'	20.1	BIOTURBATED BOTTOM, ABUNDANT BURROWS (WORM, CLAM), CRABS (MUD), TRACE OF SHELL FRAGMENTS
NHDG-19	41d09.2741'	-72d51.8246'	20.8	SOFT, FAINT LONGITUDINAL RIPPLES, PATCHY SHELLS (NUCULA), BURROWS, HYDROZOANS, ANEMONES
NHDG-20	41d09.4072'	-72d51.3684'	20.7	SOFT, UNDULATING BIOTURBATED BOTTOM, FAINT RIPPLES, CRABS (MUD) AND TRACKS, ANEMONES, WELK, BURROWS
NHDG-21	41d08.9371'	-72d52.0080'	21.7	SOFT, UNDULATING BIOTURBATED BOTTOM, FAINT LONGITUDINAL RIPPLES, CURRENT-SWEPT APPEARANCE, PATCHY SHELLS, CRABS (MUD) AND TRACKS, BURROWS (SHRIMP, CLAM, LOBSTER, CRAB) AMPHIPOD TUBES, SEAWEED
NHDG-22	41d08.7558'	-72d51.6721'	22.8	SOFT, BIOTURBATED, FAINT LONGITUDINAL RIPPLES, SCATTERED SHELLS (NUCULA), ANEMONES, FLOUNDER, AMPHIPODS, WORM TUBES, BURROWS, HYDROZOANS
NHDG-23	41d08.7272'	-72d52.0044'	22.7	UNDULATING BIOTURBATED BOTTOM, FAINT LONGITUDINAL RIPPLES, ANEMONES, PATCHY SCATTERED SHELLS, BURROWS
NHDG-24	41d08.2909'	-72d51.4309'	24.5	SOFT UNDULATING BIOTURBATED BOTTOM, FAINT LONGITUDINAL RIPPLES, ANEMONES, CRABS (MUD), BURROWS (SHRIMP, CLAM, LOBSTER, AND CRAB), JUVENILE FLOUNDER, HYDROZOANS, SHELLS (NUCULA)
NHDG-25	41d07.9083'	-72d52.0479'	25.2	SOFT, UNDULATING BIOTURBATED BOTTOM, FAINT LONGITUDINAL RIPPLES (CRESTS PARALLEL TO CURRENT), SHELLS (NUCULA), SOME SHELLS MOVING IN THE CURRENT, ANEMONES, CRABS (MUD) AND TRACKS, BURROWS (SHRIMP, CLAM, LOBSTER, AND CRAB), JUVENILE FLOUNDER AND OTHER FISH, HYDROZOANS

APPENDIX C

This table contains the relative grain-size frequency distributions by weight in whole phi units for samples collected in new Haven Harbor. The -5ϕ fraction contains all sediment coarser than 32 mm; the 11ϕ fraction contains sediment with diameters between .001 and 0.00055 mm.

	CLAY			SILT				SAND				GRAVEL				
SAMPLE NUMBER	11ϕ	10ϕ	9ϕ	8ϕ	7ϕ	6ϕ	5ϕ	4ϕ	3ϕ	2ϕ	1ϕ	0ϕ	-1ϕ	-2ϕ	-3ϕ	-4ϕ	-5ϕ
NHH-1	0.14	0.29	0.49	0.63	0.83	0.91	0.37	0.27	6.34	68.62	19.15	1.96	0.0	0.0	0.0	0.0	0.0
NHH-2	0.20	0.42	0.73	1.15	1.76	2.69	2.62	9.49	12.00	38.39	25.48	3.68	1.38	0.0	0.0	0.0	0.0
NHH-3	0.89	1.98	3.94	6.83	12.29	23.01	28.70	5.38	6.76	5.66	2.76	1.73	0.07	0.0	0.0	0.0	0.0
NHH-4	1.25	2.48	4.59	7.00	10.32	15.22	14.95	8.40	16.86	13.74	3.84	1.36	0.0	0.0	0.0	0.0	0.0
NHH-5	1.47	3.03	5.85	9.24	12.88	14.23	8.21	6.69	16.71	19.27	2.28	0.14	0.0	0.0	0.0	0.0	0.0
NHH-6	1.33	3.48	6.28	9.25	13.67	19.17	17.66	6.43	8.25	7.57	4.11	2.80	0.0	0.0	0.0	0.0	0.0
NHH-7	0.53	1.23	1.99	2.55	2.96	4.15	2.87	2.83	18.00	40.56	18.05	3.28	0.99	0.0	0.0	0.0	0.0
NHH-8	4.29	7.51	12.92	17.28	20.78	23.09	9.62	1.98	0.74	0.89	0.79	0.11	0.0	0.0	0.0	0.0	0.0
NHH-9	2.15	4.53	7.68	11.28	15.75	23.18	18.00	4.55	4.07	4.52	2.68	1.60	0.0	0.0	0.0	0.0	0.0
NHH-10	0.16	0.32	0.48	0.60	0.85	1.51	2.37	3.42	36.73	38.41	12.38	2.55	0.23	0.0	0.0	0.0	0.0
NHH-11	0.32	0.65	1.04	1.40	1.83	2.87	3.83	1.41	18.54	36.09	23.52	7.80	0.71	0.0	0.0	0.0	0.0
NHH-12	2.54	5.45	9.43	13.67	19.40	26.51	14.03	2.88	1.74	2.05	1.62	0.68	0.0	0.0	0.0	0.0	0.0
NHH-13	0.07	0.14	0.19	0.21	0.25	0.25	0.16	0.56	28.11	52.06	15.31	2.69	0.0	0.0	0.0	0.0	0.0
NHH-14	0.39	0.68	1.06	1.28	1.50	2.18	2.20	3.43	33.41	33.79	12.95	3.77	0.56	2.79	0.0	0.0	0.0
NHH-15	0.03	0.05	0.06	0.08	0.12	0.18	0.18	0.27	23.76	58.07	15.50	1.70	0.0	0.0	0.0	0.0	0.0
NHH-17	0.05	0.12	0.17	0.21	0.26	0.32	0.33	0.11	5.78	74.95	16.68	1.01	0.0	0.0	0.0	0.0	0.0
NHH-18	2.79	5.37	8.14	11.25	16.20	27.10	18.12	6.01	2.53	1.74	1.07	0.18	0.0	0.0	0.0	0.0	0.0
NHH-19	0.01	0.02	0.03	0.04	0.06	0.07	0.03	0.06	9.88	62.42	23.40	3.65	0.14	0.19	0.0	0.0	0.0
NHH-20	0.01	0.03	0.05	0.06	0.10	0.17	0.18	0.13	14.40	62.13	19.58	3.09	0.07	0.0	0.0	0.0	0.0
NHH-21	0.06	0.14	0.22	0.29	0.37	0.52	0.41	0.73	28.31	49.64	15.07	3.70	0.55	0.0	0.0	0.0	0.0
NHH-22	0.19	0.51	0.87	1.21	1.72	2.96	3.55	2.74	16.74	41.79	20.00	5.22	1.37	1.14	0.0	0.0	0.0
NHH-23	0.14	0.09	0.14	0.19	0.23	0.31	0.27	0.15	20.24	58.40	16.74	2.91	0.29	0.0	0.0	0.0	0.0
NHH-24	0.05	0.13	0.21	0.28	0.36	0.46	0.33	0.15	10.25	46.31	26.27	9.68	2.76	2.76	0.0	0.0	0.0
NHH-25	0.14	0.36	0.59	0.77	0.85	1.08	0.85	0.78	36.67	41.73	10.94	2.35	0.43	2.47	0.0	0.0	0.0

SAMPLE NUMBER	CLAY			SILT				SAND					GRAVEL				
	11φ	10φ	9φ	8φ	7φ	6φ	5φ	4φ	3φ	2φ	1φ	0φ	-1φ	-2φ	-3φ	-4φ	-5φ
NHH-26	0.11	0.26	0.44	0.61	0.70	0.99	0.81	0.36	12.02	39.53	32.54	8.93	1.57	1.12	0.0	0.0	0.0
NHH-27	0.09	0.24	0.36	0.46	0.53	0.57	0.38	0.35	16.15	49.50	25.05	5.62	0.71	0.0	0.0	0.0	0.0
NHH-28	0.19	0.45	0.72	1.00	1.44	2.25	3.09	2.07	18.41	38.80	24.59	4.91	0.94	1.16	0.0	0.0	0.0
NHH-29	0.19	0.49	0.83	1.17	1.56	2.26	2.43	1.72	24.94	37.43	19.36	5.51	1.21	0.90	0.0	0.0	0.0
NHH-30	0.66	1.67	2.90	4.50	7.41	13.70	12.82	7.16	20.59	17.94	7.66	2.84	0.15	0.0	0.0	0.0	0.0
NHH-31	1.44	3.44	6.20	9.11	14.12	18.99	15.22	7.72	12.66	5.46	3.22	2.33	0.19	0.0	0.0	0.0	0.0
NHH-32	1.23	3.08	5.33	7.62	11.14	18.97	27.98	10.37	5.86	3.51	2.40	2.47	0.05	0.0	0.0	0.0	0.0
NHH-33	1.45	3.45	5.46	7.11	10.37	14.28	10.29	12.32	20.15	10.55	2.55	1.95	0.06	0.0	0.0	0.0	0.0
NHH-34	0.19	0.35	0.49	0.54	0.70	1.09	1.37	1.67	27.27	54.51	10.16	1.37	0.29	0.0	0.0	0.0	0.0
NHH-35	0.40	0.74	0.98	1.16	1.56	3.03	3.93	2.43	21.09	30.64	25.60	5.82	1.26	1.37	0.0	0.0	0.0
NHH-36	0.13	0.25	0.42	0.62	0.95	1.68	2.29	1.95	20.00	12.77	33.92	16.74	4.74	2.52	1.01	0.0	0.0
NHH-37	1.61	3.05	4.82	6.38	7.79	10.81	8.86	7.79	30.61	9.90	5.58	2.32	0.48	0.0	0.0	0.0	0.0
NHH-38	0.07	0.12	0.20	0.27	0.36	0.47	0.40	0.18	7.19	45.15	27.53	7.51	2.50	2.86	5.18	0.0	0.0
NHH-40	0.13	0.37	0.70	1.18	2.10	4.30	4.13	1.97	12.32	22.98	25.04	16.76	5.51	0.95	1.56	0.0	0.0
NHH-41	2.76	5.07	8.95	12.73	17.46	26.72	20.78	2.04	1.06	0.74	0.89	0.82	0.0	0.0	0.0	0.0	0.0
NHH-42	3.61	6.58	10.85	13.35	19.03	24.26	14.98	2.18	1.60	1.70	1.31	0.54	0.0	0.0	0.0	0.0	0.0
NHH-45	1.90	4.47	8.37	12.73	20.05	28.63	16.68	1.78	1.04	1.37	1.50	1.25	0.22	0.0	0.0	0.0	0.0
NHH-46	0.13	0.27	0.51	0.83	1.25	1.92	1.52	1.33	6.37	24.10	28.20	13.26	3.76	5.24	8.54	2.77	0.0
NHH-47	2.36	4.31	7.22	10.60	17.09	28.10	21.68	3.64	1.47	1.521	1.05	0.94	0.03	0.0	0.0	0.0	0.0
NHH-48	2.01	3.36	5.83	7.44	9.49	10.92	3.29	2.82	5.62	18.87	8.58	8.65	0.99	4.72	7.41	0.0	0.0
NHH-49	3.34	5.64	9.60	14.02	21.42	25.87	12.62	3.52	1.52	1.14	0.76	0.56	0.0	0.0	0.0	0.0	0.0
NHH-50	3.50	4.79	7.89	11.80	18.51	28.91	13.28	5.67	1.90	1.75	1.11	0.59	0.30	0.0	0.0	0.0	0.0
NHH-51	3.26	5.87	10.07	12.72	20.55	25.60	13.14	3.47	1.70	1.44	0.94	1.23	0.0	0.0	0.0	0.0	0.0
NHH-52	1.37	3.22	5.44	8.07	13.61	26.56	34.36	2.34	1.15	1.38	1.14	1.33	0.55	0.0	0.0	0.0	0.0
NHH-53	2.67	6.18	11.21	15.31	24.33	23.24	7.47	3.25	1.96	2.32	1.23	0.82	0.0	0.0	0.0	0.0	0.0
NHH-54	1.82	4.68	8.28	12.36	16.99	18.34	12.75	6.48	4.66	6.57	3.98	3.10	0.0	0.0	0.0	0.0	0.0
NHH-56	1.68	4.15	8.17	12.46	19.60	23.61	10.99	3.88	4.03	6.89	2.62	1.94	0.0	0.0	0.0	0.0	0.0
NHH-57	2.91	6.67	11.68	17.67	25.77	26.08	7.27	0.50	0.53	0.54	0.28	0.11	0.0	0.0	0.0	0.0	0.0
NHH-58	2.71	6.81	11.72	17.42	23.90	24.78	9.06	1.35	0.80	0.67	0.42	0.35	0.0	0.0	0.0	0.0	0.0
NHH-59	2.72	6.15	10.72	16.05	20.94	25.62	11.92	2.91	0.79	0.88	1.28	0.03	0.0	0.0	0.0	0.0	0.0
NHH-60	1.12	2.75	5.22	8.69	14.19	21.05	15.23	8.15	5.43	7.97	6.20	4.00	0.0	0.0	0.0	0.0	0.0
NHH-61	2.65	6.06	10.92	15.52	22.04	23.87	9.78	2.72	2.17	1.95	1.48	0.83	0.0	0.0	0.0	0.0	0.0

	CLAY			SILT				SAND						GRAVEL			
SAMPLE NUMBER	11φ	10φ	9φ	8φ	7φ	6φ	5φ	4φ	3φ	2φ	1φ	0φ	-1φ	-2φ	-3φ	-4φ	-5φ
NHH-62	2.11	4.95	8.53	14.07	20.76	26.35	20.93	0.63	0.48	0.55	0.64	0.0	0.0	0.0	0.0	0.0	0.0
NHH-63	2.04	5.50	10.13	14.89	23.10	29.71	12.93	0.74	0.43	0.31	0.16	0.06	0.0	0.0	0.0	0.0	0.0
NHH-64	3.20	6.73	11.81	18.60	24.52	26.07	8.29	0.48	0.15	0.09	0.07	0.0	0.0	0.0	0.0	0.0	0.0
NHH-65	3.46	8.93	15.28	20.49	24.78	20.93	4.75	0.50	0.19	0.36	0.26	0.07	0.0	0.0	0.0	0.0	0.0
NHH-66	3.59	8.46	14.73	21.39	26.24	20.18	4.73	0.53	0.10	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX D

This table contains the relative grain-size frequency distributions by weight in whole phi units for sample from the New Haven Dumping Grounds. The -5ϕ fraction contains all sediment coarser than 32 mm; the 11ϕ fraction contains sediment with diameters between .001 and 0.00055 mm.

	CLAY			SILT				SAND					GRAVEL			
SAMPLE NUMBER	11ϕ	10ϕ	9ϕ	8ϕ	7ϕ	6ϕ	5ϕ	4ϕ	3ϕ	2ϕ	1ϕ	0ϕ	-1ϕ	-2ϕ	-3ϕ	-4ϕ	-5ϕ
NHDG-1	2.36	4.87	8.36	12.19	17.69	25.78	19.68	4.71	2.32	1.19	0.57	0.29	0.0	0.0	0.0	0.0	0.0
NHDG-2	1.32	3.06	5.54	8.23	12.09	18.01	15.40	7.10	12.77	11.54	3.27	1.24	0.42	0.0	0.0	0.0	0.0
NHDG-3	1.23	2.73	4.93	7.31	10.20	15.86	12.02	11.94	18.94	10.32	2.61	1.26	0.31	0.34	0.0	0.0	0.0
NHDG-4	2.48	5.49	9.38	13.38	18.28	28.17	16.79	3.25	0.96	1.12	0.47	0.22	0.0	0.0	0.0	0.0	0.0
NHDG-5	2.42	5.46	8.83	12.77	17.81	26.76	22.76	2.24	0.28	0.23	0.20	0.23	0.0	0.0	0.0	0.0	0.0
NHDG-6	0.45	0.97	1.84	3.03	4.40	6.51	6.74	8.62	34.05	24.97	5.24	1.62	0.76	0.80	0.0	0.0	0.0
NHDG-7	1.88	4.40	7.67	12.29	18.01	28.77	25.07	1.35	0.16	0.11	0.10	0.18	0.0	0.0	0.0	0.0	0.0
NHDG-8	2.63	4.51	7.47	11.77	16.31	27.93	26.90	1.48	0.24	0.25	0.17	0.34	0.0	0.0	0.0	0.0	0.0
NHDG-9	2.12	4.20	7.58	11.67	15.53	23.95	22.96	3.58	2.20	2.63	1.54	0.57	0.39	1.09	0.0	0.0	0.0
NHDG-10	2.16	4.27	7.82	12.38	17.30	22.88	16.37	8.25	4.60	2.59	1.34	0.01	0.0	0.0	0.0	0.0	0.0
NHDG-11	1.76	3.59	6.45	9.84	16.24	26.81	23.63	8.17	1.93	1.13	0.43	0.01	0.0	0.0	0.0	0.0	0.0
NHDG-12	1.73	3.40	6.01	8.89	13.55	19.07	15.92	9.95	7.92	9.23	3.28	0.75	0.30	0.0	0.0	0.0	0.0
NHDG-13	2.57	4.65	8.17	11.60	16.11	22.58	16.28	9.36	4.86	2.66	1.13	0.04	0.0	0.0	0.0	0.0	0.0
NHDG-14	2.58	5.96	9.94	12.89	17.74	24.61	17.42	5.60	1.73	1.06	0.34	0.13	0.0	0.0	0.0	0.0	0.0
NHDG-15	0.93	2.39	4.37	7.49	13.99	25.97	31.64	8.71	2.64	1.29	0.42	0.17	0.0	0.0	0.0	0.0	0.0
NHDG-16	0.53	1.33	2.63	4.65	7.89	15.69	18.23	12.04	12.05	12.09	7.14	2.93	1.46	1.38	0.0	0.0	0.0
NHDG-17	2.74	6.47	10.94	15.86	17.96	23.45	11.48	5.82	2.36	1.83	0.71	0.38	0.0	0.0	0.0	0.0	0.0
NHDG-18	0.35	0.92	1.77	2.78	4.23	6.36	5.06	5.47	21.80	36.88	11.29	2.77	0.33	0.0	0.0	0.0	0.0
NHDG-19	1.89	4.93	9.06	13.53	19.52	25.26	17.42	4.48	1.77	1.38	0.71	0.04	0.0	0.0	0.0	0.0	0.0
NHDG-20	2.56	6.64	11.59	16.96	21.74	22.37	10.52	4.58	1.39	1.11	0.54	0.0	0.0	0.0	0.0	0.0	0.0
NHDG-21	2.27	5.52	10.16	15.46	21.17	23.78	12.63	5.22	1.69	1.41	0.67	0.02	0.0	0.0	0.0	0.0	0.0
NHDG-22	2.32	6.09	11.13	16.38	22.79	24.01	11.36	3.87	1.04	0.66	0.34	0.01	0.0	0.0	0.0	0.0	0.0
NHDG-23	1.33	3.57	6.70	10.54	16.87	29.39	24.50	4.05	1.21	1.02	0.66	0.16	0.0	0.0	0.0	0.0	0.0
NHDG-24	2.20	5.82	10.44	15.26	18.31	27.55	15.86	3.30	0.63	0.40	0.24	0.0	0.0	0.0	0.0	0.0	0.0
NHDG-25	2.27	5.69	10.15	14.72	21.36	26.73	14.83	3.04	0.61	0.41	0.20	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX E

This table contains the sample weight analyzed, percent gravel (>2.0 mm), percent sand (2.0 mm>x>0.062 mm), percent silt (0.063 mm>x>0.004 mm), percent clay (<0.004 mm), the verbal-equivalent sediment classification (Shepard, 1954), and the related method of moments statistics for samples from New Haven Harbor. Modes are given in the middle of whole phi intervals.

SAMPLE NUMBER	WEIGHT (GRAMS)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT	PERCENT CLAY	SEDIMENT CLASS	MEDIAN (ϕ)	MEAN (ϕ)	STANDARD DEVIATION	SKEWNESS	KURTOSIS	MODE 1 (ϕ)	MODE 2 (ϕ)	MODE 3 (ϕ)
NHH-1	46.2494	0.0	96.34	2.74	0.92	SAND	1.42	1.53	1.19	2.04	21.01	1.5		
NHH-2	45.0458	1.38	89.05	8.22	1.36	SAND	1.51	1.89	1.76	0.86	4.01	1.5		
NHH-3	26.0907	0.07	22.29	70.83	6.81	SANDY SILT	4.96	4.93	2.06	-0.11	0.47	4.5	2.5	
NHH-4	30.8486	0.0	44.19	47.49	8.32	SANDY SILT	4.39	4.40	2.42	0.15	-0.62	2.5	5.5	
NHH-5	29.8975	0.0	45.09	44.56	10.35	SILTY SAND	4.60	4.57	2.55	0.14	-1.03	1.5	5.5	
NHH-6	25.8932	0.0	29.15	59.76	11.09	SANDY SILT	5.17	4.99	2.46	-0.10	-0.41	5.5	2.5	
NHH-7	38.3637	0.99	82.73	12.53	3.75	SAND	1.68	2.30	2.18	0.83	2.48	1.5		
NHH-8	21.2416	0.0	4.50	70.77	24.73	CLAYEY SILT	6.62	6.72	1.84	-0.12	0.61	5.5		
NHH-9	23.1265	0.0	17.42	68.21	14.27	SANDY SILT	5.63	5.60	2.27	-0.18	0.19	5.5		
NHH-10	44.6933	0.23	93.49	5.33	0.95	SAND	1.91	2.04	1.35	1.09	8.80	1.5		
NHH-11	41.1537	0.71	87.35	9.93	2.01	SAND	1.50	1.86	1.89	0.93	4.16	1.5		
NHH-12	21.3698	0.0	8.97	73.61	17.42	CLAYEY SILT	6.02	6.14	2.00	-0.20	0.90	5.5		
NHH-13	43.7701	0.0	98.73	0.87	0.40	SAND	1.61	1.66	0.94	1.40	20.79	1.5		
NHH-14	44.1859	3.36	87.35	7.16	2.13	SAND	1.89	2.04	1.88	0.67	4.57	1.5		
NHH-15	43.2202	0.0	99.30	0.55	0.14	SAND	1.56	1.59	0.75	1.12	21.23	1.5		
NHH-17	43.2217	0.0	98.54	1.12	0.34	SAND	1.43	1.45	0.78	2.72	47.15	1.5		
NHH-18	22.9974	0.0	11.52	72.67	15.80	CLAYEY SILT	5.75	5.95	1.94	0.01	0.30	5.5		
NHH-19	45.2569	0.33	99.42	0.20	0.05	SAND	1.36	1.29	0.69	0.36	16.58	1.5		
NHH-20	46.5367	0.07	99.32	0.52	0.10	SAND	1.44	1.42	0.73	0.92	19.45	1.5		
NHH-21	46.9408	0.55	97.45	1.59	0.42	SAND	1.62	1.66	1.06	1.11	14.59	1.5		
NHH-22	43.1164	2.51	86.49	9.43	1.57	SAND	1.53	1.83	1.83	0.79	4.06	1.5		
NHH-23	45.5235	0.29	98.44	1.00	0.28	SAND	1.51	1.54	0.89	1.32	21.10	1.5		
NHH-24	44.7372	5.52	92.65	1.43	0.40	SAND	1.18	1.05	1.30	0.52	8.84	1.5		
NHH-25	43.7135	2.90	92.47	3.54	1.09	SAND	1.81	1.85	1.48	0.69	8.47	1.5		
NHH-26	44.6672	2.69	93.38	3.12	0.81	SAND	1.15	1.23	1.44	1.07	9.69	1.5		
NHH-27	46.3590	0.71	96.67	1.93	0.70	SAND	1.38	1.43	1.21	1.40	15.13	1.5		
NHH-28	46.6977	2.10	88.76	7.77	1.37	SAND	1.47	1.72	1.73	0.87	5.15	1.5		
NHH-29	44.6489	2.11	88.96	7.41	1.51	SAND	1.62	1.83	1.75	0.84	4.97	1.5		

SAMPLE NUMBER	WEIGHT (GRAMS)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT	PERCENT CLAY	SEDIMENT CLASS	MEDIAN (ϕ)	MEAN (ϕ)	STANDARD DEVIATION	SKEWNESS	KURTOSIS	MODE 1 (ϕ)	MODE 2 (ϕ)	MODE 3 (ϕ)
NHH-30	32.0150	0.15	56.18	38.43	5.23	SILTY SAND	3.11	3.68	2.39	0.25	-0.41	2.5	5.5	
NHH-31	27.1874	0.19	31.29	57.44	11.08	SANDY SILT	5.17	5.01	2.41	-0.06	-0.39	5.5	2.5	
NHH-32	25.5045	0.05	24.61	65.70	9.64	SANDY SILT	4.91	5.03	2.17	-0.05	0.39	4.5		
NHH-33	33.2958	0.06	47.52	42.05	10.37	SILTY SAND	4.24	4.50	2.48	0.17	-0.63	2.5	5.5	
NHH-34	44.0847	0.29	94.98	3.70	1.03	SAND	1.70	1.90	1.25	1.54	14.52	1.5		
NHH-35	46.0263	2.63	85.58	9.69	2.12	SAND	1.52	1.84	1.96	0.79	3.81	1.5		
NHH-36	180.5100	8.27	85.39	5.56	0.79	SAND	0.74	1.05	1.87	0.56	3.22	0.5	2.5	
NHH-37	30.3294	0.48	56.20	33.84	9.48	SILTY SAND	3.14	4.04	2.58	0.28	-0.46	2.5	5.5	
NHH-38	186.1900	10.54	87.57	1.50	0.39	GRAVELLY SEDIMENT	1.10	0.80	1.61	-0.06	5.07	1.5	-3.5	
NHH-40	185.3900	8.02	79.07	11.72	1.20	SAND	1.01	1.36	2.18	0.53	1.72	0.5		
NHH-41	19.0069	0.0	5.54	77.69	16.77	SILT	5.89	6.13	1.88	-0.06	1.08	5.5		
NHH-42	18.7809	0.0	7.33	71.63	21.05	CLAYEY SILT	6.18	6.32	2.02	-0.15	0.66	5.5		
NHH-45	19.0769	0.22	6.94	78.10	14.74	SILT	5.91	6.03	1.94	-0.30	1.82	5.5		
NHH-46	255.8600	20.31	73.26	5.52	0.91	GRAVELLY SEDIMENT	0.58	0.43	2.37	0.24	1.75	0.5	-3.5	
NHH-47	21.4855	0.03	8.60	77.47	13.89	SILT	5.70	5.88	1.91	-0.07	1.16	5.5		
NHH-48	96.4746	13.12	44.54	31.14	11.20	GRAVELLY SEDIMENT	2.14	3.08	3.80	0.02	-1.01	1.5	-0.5	-3.5
NHH-49	20.4104	0.0	7.50	73.92	18.58	CLAYEY SILT	6.19	6.32	1.90	-0.11	0.89	5.5		
NHH-50	23.1992	0.30	11.02	72.51	16.17	CLAYEY SILT	5.88	6.04	2.02	-0.13	1.00	5.5		
NHH-51	21.7907	0.0	8.78	72.02	19.20	CLAYEY SILT	6.12	6.23	2.02	-0.20	1.03	5.5		
NHH-52	21.0597	0.05	7.34	82.59	10.02	SILT	5.31	5.54	1.81	-0.05	1.84	4.5		
NHH-53	23.4792	0.0	9.59	70.35	20.06	CLAYEY SILT	6.40	6.36	2.01	-0.32	1.14	6.5		
NHH-54	25.0151	0.0	24.78	60.44	14.78	SANDY SILT	5.68	5.40	2.55	-0.22	-0.33	5.5	1.5	
NHH-56	21.9003	0.0	19.36	66.65	13.99	SANDY SILT	5.83	5.61	2.35	-0.27	0.07	5.5	1.5	
NHH-57	17.9614	0.0	1.95	76.79	21.26	CLAYEY SILT	6.57	6.73	1.59	0.00	0.96	5.5		
NHH-58	20.8767	0.0	3.60	75.16	21.24	CLAYEY SILT	6.53	6.64	1.71	-0.13	1.20	5.5		
NHH-59	18.5039	0.0	5.88	74.53	19.59	CLAYEY SILT	6.31	6.43	1.82	-0.11	0.75	5.5		
NHH-60	25.6861	0.0	31.75	59.16	9.09	SANDY SILT	5.14	4.79	2.52	-0.14	-0.46	5.5	1.5	
NHH-61	20.5950	0.0	9.16	71.22	19.63	CLAYEY SILT	6.33	6.31	2.02	-0.30	1.05	5.5		
NHH-62	16.9727	0.0	2.30	82.11	15.59	SILT	6.02	6.26	1.65	0.12	0.59	5.5		
NHH-63	19.8420	0.0	1.69	80.63	17.68	SILT	6.25	6.47	1.55	0.16	0.44	5.5		
NHH-64	17.9262	0.0	0.79	77.47	21.74	SILT	6.61	6.80	1.52	0.20	-0.12	5.5		
NHH-65	17.4734	0.0	1.38	70.95	27.67	CLAYEY SILT	6.93	7.05	1.57	-0.06	0.72	6.5		
NHH-66	51.0885	0.0	0.68	72.54	26.78	CLAYEY SILT	6.92	7.07	1.48	0.15	-0.37	6.5		

APPENDIX F

This table contains the sample weight analyzed, percent gravel (>2.0 mm), percent sand (2.0 mm>x>0.062 mm), percent silt (0.063 mm>x>0.004 mm), percent clay (<0.004 mm), the verbal-equivalent sediment classification (Shepard, 1954), and the related method of moments statistics for samples from the New Haven Dumping Grounds. Modes are given in the middle of whole phi intervals.

SAMPLE NUMBER	WEIGHT (GRAMS)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT	PERCENT CLAY	SEDIMENT CLASS	MEDIAN (ϕ)	MEAN (ϕ)	STANDARD DEVIATION	SKEWNESS	KURTOSIS	MODE 1 (ϕ)	MODE 2 (ϕ)	MODE 3 (ϕ)
NHDG-1	24.2258	0.0	9.08	75.34	15.58	SILT	5.82	6.03	1.86	0.03	0.41	5.5		
NHDG-2	31.0246	0.42	35.93	53.73	9.92	SANDY SILT	4.89	4.73	2.45	0.02	-0.59	5.5	2.5	
NHDG-3	33.5825	0.66	45.07	45.39	8.89	SANDY SILT	4.36	4.47	2.42	0.11	-0.42	2.5	5.5	
NHDG-4	22.2617	0.0	6.02	76.62	17.36	SILT	5.97	6.23	1.79	0.03	0.53	5.5		
NHDG-5	21.6701	0.0	3.18	80.11	16.71	SILT	5.90	6.22	1.69	0.20	0.34	5.5		
NHDG-6	42.8990	1.56	74.50	20.68	3.26	SILTY SAND	2.49	2.98	2.11	0.50	1.31	2.5		
NHDG-7	22.5400	0.0	1.90	84.15	13.95	SILT	5.80	6.12	1.58	0.30	0.53	5.5		
NHDG-8	23.3173	0.0	2.48	82.91	14.61	SILT	5.74	6.09	1.68	0.26	0.76	5.5		
NHDG-9	56.0804	1.48	10.51	74.11	13.90	CLAYEY SILT	5.63	5.69	2.20	-0.34	1.86	5.5		
NHDG-10	23.9457	0.0	16.80	68.94	14.25	SANDY SILT	5.74	5.83	2.04	-0.03	-0.03	5.5		
NHDG-11	23.2678	0.0	11.68	76.52	11.81	SILT	5.55	5.76	1.74	0.19	0.38	5.5		
NHDG-12	27.6693	0.30	31.12	57.43	11.14	SANDY SILT	5.14	5.02	2.38	-0.02	-0.42	5.5	1.5	
NHDG-13	23.1214	0.0	18.04	66.56	15.40	SANDY SILT	5.69	5.79	2.07	0.01	-0.16	5.5		
NHDG-14	24.4838	0.0	8.86	72.67	18.48	CLAYEY SILT	5.96	6.20	1.86	0.05	0.02	5.5		
NHDG-15	24.0420	0.0	13.23	79.07	7.69	SILT	5.20	5.41	1.62	0.22	1.04	4.5		
NHDG-16	32.5593	2.84	46.24	46.46	4.46	SANDY SILT	4.05	3.92	2.46	-0.04	-0.16	4.5	1.5	
NHDG-17	26.4969	0.0	11.11	68.75	20.14	CLAYEY SILT	6.22	6.29	2.00	-0.14	0.26	5.5		
NHDG-18	42.6307	0.33	78.21	18.42	3.04	SAND	1.97	2.66	2.13	0.66	1.28	1.5	5.5	
NHDG-19	23.1875	0.0	8.39	75.73	15.89	SILT	5.96	6.12	1.81	-0.01	0.33	5.5		
NHDG-20	23.3202	0.0	7.61	71.60	20.79	CLAYEY SILT	6.44	6.49	1.82	-0.09	0.23	5.5		
NHDG-21	23.8713	0.0	9.02	73.04	17.49	CLAYEY SILT	6.22	6.29	1.84	-0.07	0.28	5.5		
NHDG-22	23.7336	0.0	5.92	74.54	19.54	CLAYEY SILT	6.38	6.48	1.72	-0.01	0.22	5.5		
NHDG-23	22.4520	0.0	7.10	81.30	11.60	SILT	5.63	5.84	1.67	0.11	0.90	5.5		
NHDG-24	22.2888	0.0	4.56	76.98	18.46	SILT	6.11	6.37	1.68	0.13	-0.05	5.5		
NHDG-25	21.7153	0.0	4.26	77.64	18.10	SILT	6.20	6.40	1.66	0.13	0.05	5.5		