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Organic Carbon, Hydrogen, and Nitrogen Concentrations in Surficial Sediments from Western Long Island Sound, Connecticut and New York

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Comments

U.S. Government Document. This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards (or with the North American Stratigraphic Code).

See Also these related documents:

Map Showing the Distribution of Surficial Sediments in Fishers Island Sound, New York, Connecticut, and Rhode Island

Sidescan Sonar Image, Surficial Geologic Interpretation, and Bathymetry of the Long Island Sound Sea Floor off Hammonasset Beach State Park, Connecticut

Sidescan Sonar Image, Surficial Geological Interpretation, and Bathymetry of the Long Island Sea Floor off Milford, CT

The Texture of Surficial Sediments in Central Long Island Sound off Milford, Connecticut

The Texture of Surficial Sediments in Western Long Island Sound off the Norwalk Islands, Connecticut

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U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Organic carbon, hydrogen, and nitrogen concentrations in surficial sediments from western Long Island Sound, Connecticut and New York

by

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ABSTRACT

Total organic carbon, hydrogen, and nitrogen (CHN) analyses were performed on 147 surficial sediment samples from study areas off the Norwalk Islands and Milford, Connecticut, in western Long Island Sound. The CHN data and gross lithologic descriptions of the sediments are reported herein.

The concentrations of total organic carbon (TOC), hydrogen, and nitrogen in these samples average 1.54, 1.40, and 0.17 weight percent, respectively. The individual CHN concentrations vary inversely with grain size, with CHN values increasing with the percent fines. Increasing nutrient inputs and decreasing circulation cause TOC and nitrogen values to generally increase westward within the Sound. C/N molar elemental ratios suggest that, except for the shoreward northwestern corner of the Norwalk Islands survey site, marine phytoplankton are probably the primary source of sedimentary organic matter in the study areas. Concentrations of the sedimentary organic matter are significantly higher in the spring than in the late summer, suggesting that these concentrations vary seasonally.

INTRODUCTION

Although sedimentary organic matter is usually only a quantitatively minor component of marine sediments, it affects many biologic, chemical, and geologic processes and, ultimately, the character of the sediments themselves. For this reason, analyses of total organic carbon (TOC), nitrogen, and hydrogen are conducted as a measure of the total organic material.

Changes in the concentrations of sedimentary organic matter within surficial sediments are primarily governed by the sedimentation rate, the grain size of the sediment, the proximity to the source of organic matter, the rate of production and deposition of the organic matter, and depth and redox state of the overlying water column (Froelich and others, 1971; Mayer and others, 1988; Canfield, 1994). The sedimentation rate controls the length of time that the sediments are exposed to oxidizing conditions, to the intense activity of bottom scavengers, and to the winnowing of fine-grained organic debris by storm and tidally induced wave and current action (Gorsline, 1963; Stein, 1990).

Concentrations of sedimentary organic matter vary inversely with grain size. The relationship between organic content and sediment texture is dependent on the grain surface charge of the sediment, the grain surface area available for adsorption onto fine silt- and clay-sized particles, and the typically fine-grained nature of the organic matter itself (Hulsemann, 1967; Froelich and others, 1971; Premuzic and others, 1982; Poppe and others, 1990; Mayer, 1994). The hydraulic equivalence of the fine-grained particles causes the organic matter, silts, and clays to be separated from the sands and gravels by sedimentary processes, and leads to their subsequent deposition in lower energy environments, such as bathymetric lows and estuaries (Folger, 1972).

The sedimentary organic matter in sediments also reflects important biochemical processes. For example, the concentration of trace metals and other pollutants by organisms has been amply recorded in oceanographic literature (Riley and Skirrow, 1965; Wallace and others, 1977). Cycling of these toxic substances through the food chain and into the sedimentary organic matter may be responsible for the coincidence of areas with higher concentrations of organic carbon in the fine fractions and elevated pollutant loads documented in some areas of the western Sound (LISS, 1994).

The purpose of this study is to report the concentrations and distributions of sedimentary organic matter in the surficial sediments of the sea floor off the Norwalk Islands and Milford, Connecticut, in western Long Island Sound (Fig. 1). The data presented herein were collected and analyzed as part of a State of Connecticut, University of New Haven, U.S. Geological Survey (USGS) cooperative program intended to further understand the surficial sediment distributions and benthic habitats of the Sound.

STUDY AREA

Long Island Sound is a large (about 182 km long by a maximum of 32 km wide) estuary located between the shorelines of southern Connecticut and northern Long Island, New York. Late Wisconsinian-age glaciation extended across the Sound to form the Ronkonkoma and Harbor Hill-Roanoke Point Moraines on Long Island (Schafer and Hartshorn, 1965; Sirkin, 1982). Less prominent recessional moraine segments have also been recognized along the coast of Connecticut and beneath northern Long Island Sound (Flint, 1971; Goldsmith, 1980; Stone and Borns, 1986; Poppe and others, 1995a,b). As the ice retreated from the Long Island Sound basin, glacial Lake Connecticut formed in the depression behind the moraines on Long Island. Varved lake clays and, along the northern shore, deltaic complexes dominated sedimentation and together represent the thick lacustrine section evident in seismic records (Lewis and Needell, 1987; Needell and others, 1987; Lewis and Stone, 1991; Stone and others, 1992; Stone and Schafer, in press). The lake level was gradually lowered by erosion at the spillway and the lake bed was eventually subaerially exposed. Fluvial processes incised the exposed lake bed as streams flowed from the high ground on either side of the Sound to join a central river which drained eastward along the axis.

The Holocene eustatic rise flooded the basin creating Long Island Sound. Finer-grained hemipelagic sediments accumulated in the quieter, lower energy areas of the western Sound; tidal and storm currents dominate the patterns of erosion and transport in shallow areas and the eastern Sound. A much more detailed discussion of the geological history of Long Island Sound has been published by Lewis and Stone (1991).

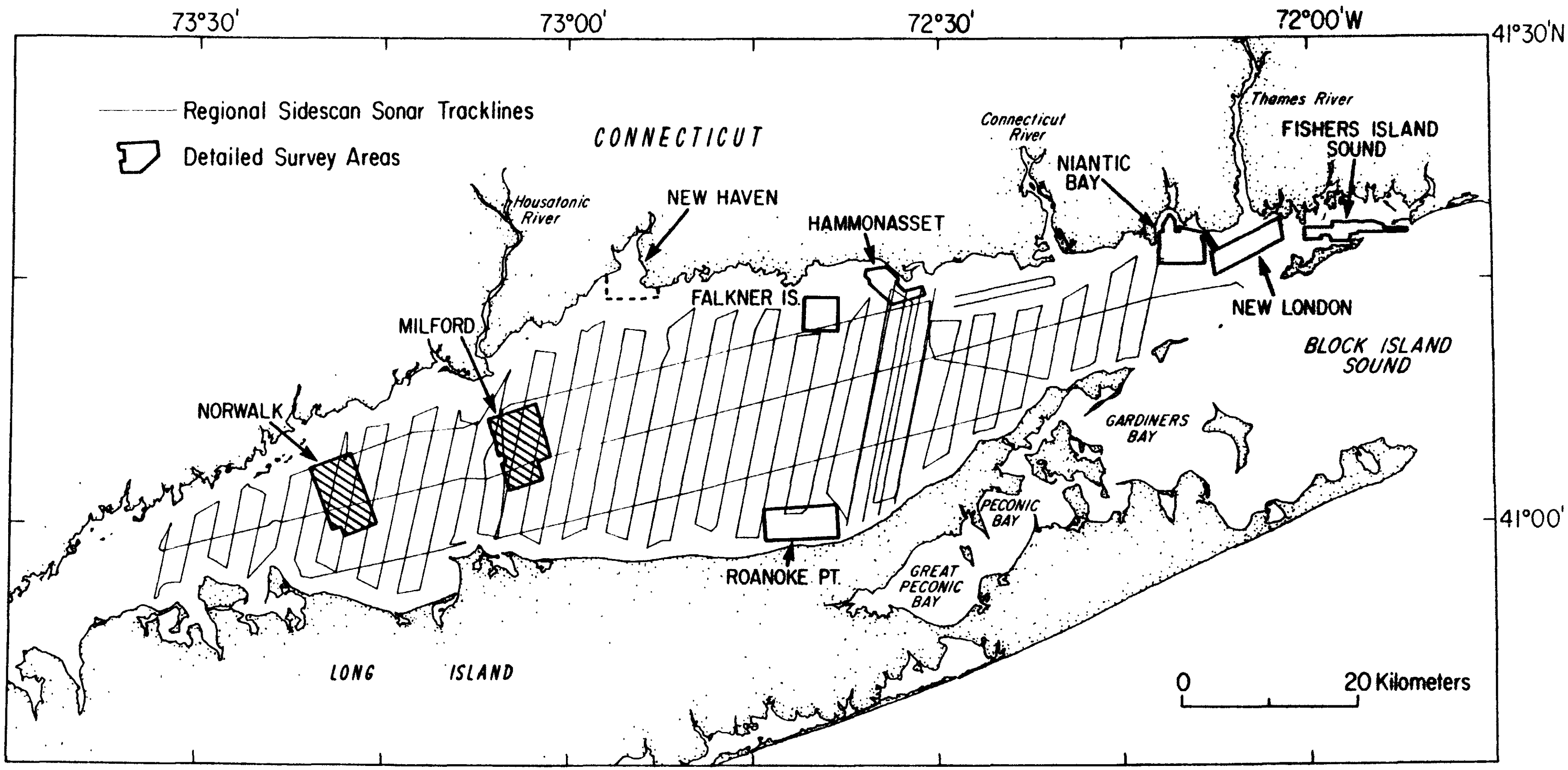

Figure 1. Index map showing the location of the Norwalk and Milford sidescan sonar and sampling studies(hatched polygons)in western Long Island Sound (Twichell and others, 1995, in press; Poppe and others, 1996a,b). Map also shows the locations of other sidescan sonar and sampling surveys (open polygons) being completed as part of this series (Poppe and others, 1993; Moffett and others, 1994; Poppe and others, 1995a,b; Zajac and others, 1995; Poppe and others, 1996c,d) and the reconnaisance sidescan lines completed as part of a regional component to this project.

Elevated nutrient (nitrogen and phosphorous) inputs, primarily from storm water runoff and sewage treatment plants, stimulate abundant phytoplankton growth during the spring (LISS, 1994). The sedimentary organic matter from these algal "blooms" sinks to the bottom where it is incorporated into the sediments. Subsequently, cavenging by bottom-dwelling organisms and decomposition of the sedimentary organic material depletes oxygen and, in conjunction with the formation of a summer pycnocline that enhances water-column stratification, cause the hypoxic conditions that seasonally impact the bottom waters of western Long Island Sound.

METHODS

Bottom photographs and surficial sediment samples for texture and CHN analysis were collected at 147 locations during April and August, 1995 cruises aboard the RV John Dempsey using a Van Veen grab sampler. Seventy two of these samples were collected from the survey area off the Norwalk Islands (Fig. 2); 75 of the samples were collected from a survey area off Milford (Fig. 3). 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.

The frozen sediments were thawed at room temperature and homogenized. A 0.5-g subsample was removed; large animals and shell fragments were avoided during subsampling. The samples were dried overnight in a convection oven at 60°C and then placed in a desiccator containing concentrated HCL and allowed to fume for 24-48 hours to remove the carbonates. This vapor phase acidification converts the calcium carbonate in the sample to water vapor, CO_2, and calcium chloride (Mayer and Macko, 1988; Zimmermann and others, 1992). Techniques that introduce the sample directly into an acid to dissolve the calcium carbonate were avoided because of the loss of dissolved organic carbon with the discarded filtrate (Roberts and others, 1973). After 12 hours of fuming, the samples were removed, disaggregated with a spatula to ensure that all carbonate was exposed to the HCL fumes, and returned to the fuming desiccator.

The decalcified samples were dried at 60°C overnight and ground by mortar and pestle to a fine (<.062 mm) homogeneous powder. The powdered samples were placed into prelabeled glass vials, redried at 60°C, and stored in a desiccator with Drierite until analysis. Analysis was performed on a Perkin Elmer 2400 CHN Elemental Analyzer by analyzing their combustion products (CO_2,H_2O, and N_2). Combustion occurred in pure oxygen under static conditions at 1000°C. About 40 percent of the runs were blanks or standards, run as a means of calibrating the instrument and checking precision. Precision was always better than one standard deviation.

Nitrogen concentrations determined by combustion in an elemental analyzer tend to be slightly higher than those values determined by the microKjeldahl method (Kabat and Mayer, 1948).

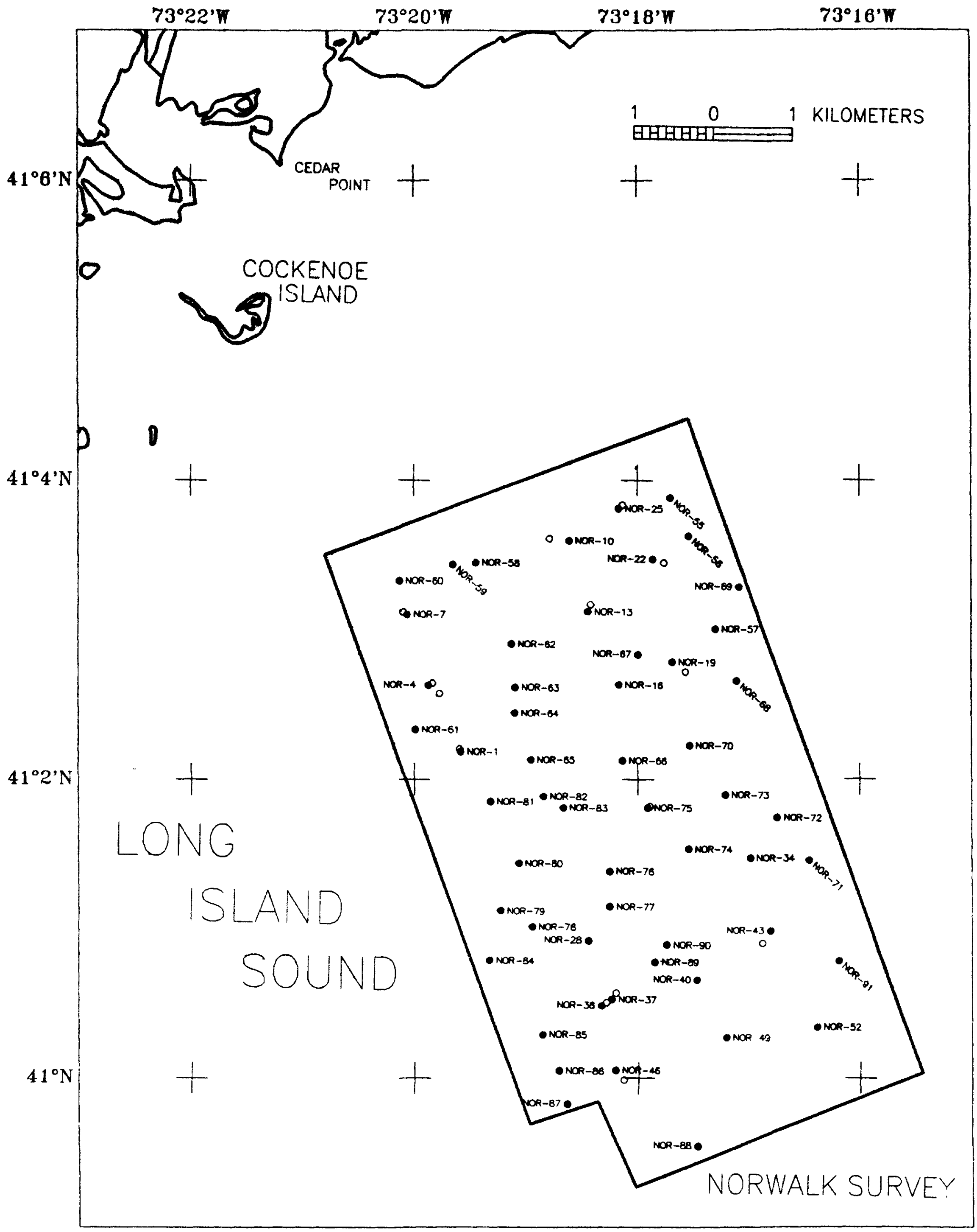

Figure 2. Map of western Long Island Sound off the Norwalk Islands showing the station locations. Stations where surficial sediment samples were collected during April 1995 are shown as solid circles. Stations where samples were taken during August 1995 are shown as open circles.

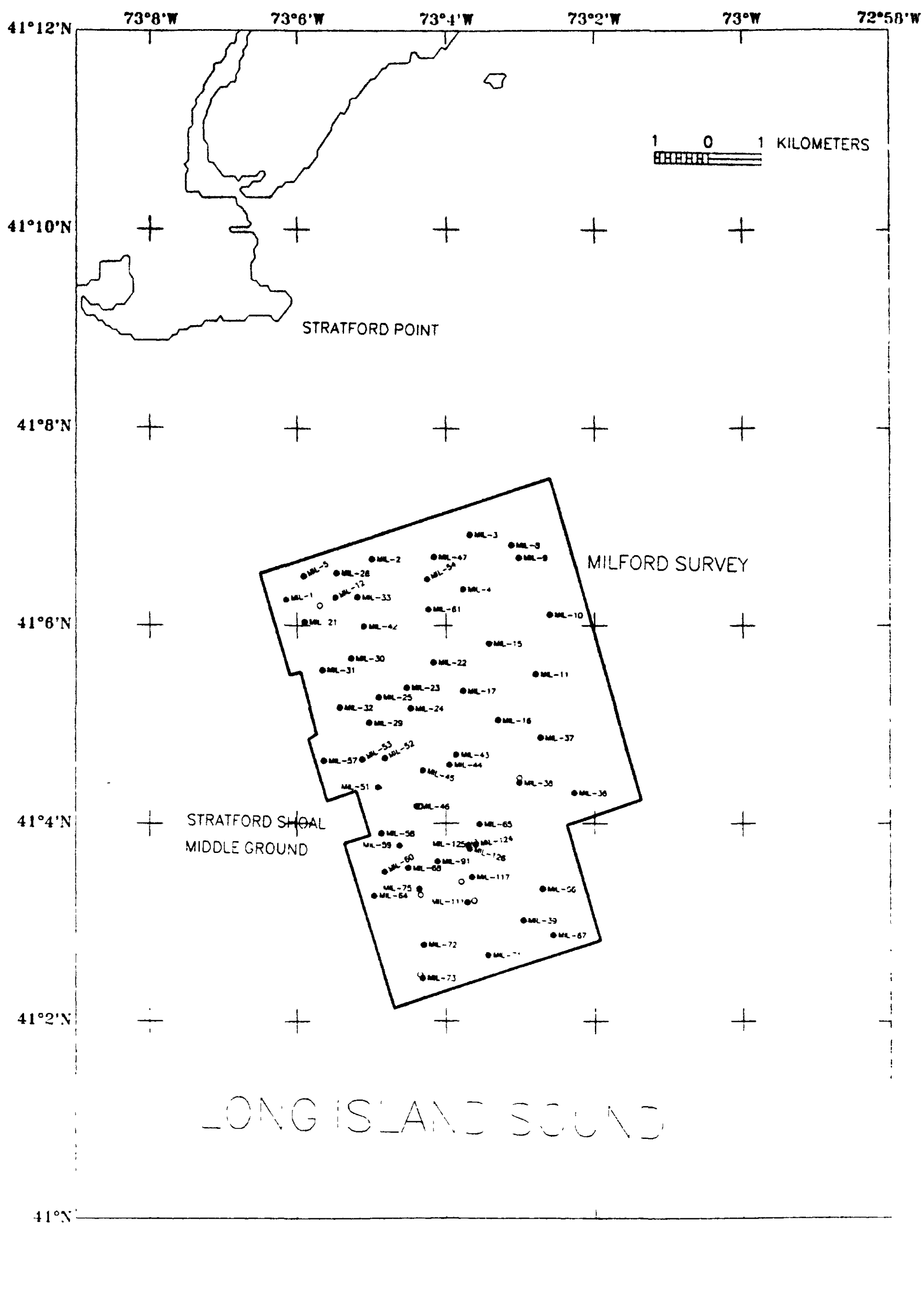

Figure 3. Map of western Long Island Sound off Milford, Connecticut showing the station locations. Stations where surficial sediment locations were collected during April 1995 are shown as solid circles. Stations where samples were taken during August 1995 are shown as open circles.

Lower numbers are produced by the microKjeldahl method because this technique may not detect all of the refractory nitrogen included in the data generated by the combustion method. The ratio of organic carbon content to nitrogen content is given as a molar elemental ratio.

Textural data for these samples and others within the survey sites have been previously reported in Poppe and others (1996a,b). Size classifications are based on the method proposed by Wentworth (1929); verbal equivalents are based on the inclusive graphics statistical method of Folk (1974) and on the nomenclature proposed by Shepard (1954).

RESULTS AND DISCUSSION

Sample locations, water depths, textural classifications, and the TOC, nitrogen, and hydrogen percents are presented in Appendix A for the Norwalk Islands survey and in Appendix B for the Milford survey. The weight percents of TOC, hydrogen, and nitrogen from all of the samples collected from western Long Island Sound as part of this study average 1.54, 1.40, and 0.17 percent, respectively. The TOC results are elevated relative to open marine environments (Poppe and others, 1990), but similar to organic carbon concentrations in the bottom sediments of most other east coast estuaries, which are usually less than 5 percent (Folger, 1972). Natural values of organic carbon commonly exceed this concentration only where vegetal matter is especially abundant or bottom waters are anaerobic.

Our organic carbon, nitrogen, and hydrogen results also generally agree with other previously reported concentrations from the central part of western Long Island Sound. Hathaway (1971) reported average TOC and Kjeldahl nitrogen concentrations of 1.79 and 0.21 percent, respectively. Reid (1982) reported a slightly higher average TOC value of 2.77 percent. Nitrogen is present in relatively high concentrations in the sediments of the Sound compared to the relict sediments of the United States mid-Atlantic continental shelf where values are typically less than 0.015 percent (Poppe and Lane-Bostwick, 1990).

As discussed earlier and reported elsewhere along the United States east coast (Hulsemann, 1967; Froelich and others, 1971; Emery and Uchupi, 1972; Maciolek and others, 1986; Poppe and others, 1990), the CHN concentrations in western Long Island Sound vary inversely with grain size (Fig. 4). Coarser grained sediments, such as gravelly sediments and sands, tend to contain less organic carbon than finer grained sediments, such as clayey silts. For example, TOC averages 1.97 percent in the clayey silts from the study areas, but only 0.86 percent in the sands.

This relationship between the amount of organic carbon and sediment texture is also true for hydrogen and nitrogen (Poppe and Lane-Bostwick, 1990) and, as with the TOC, is dependent on the fine-grained nature of the organic carbon itself, the adsorption of organics onto the charged surfaces of the clay minerals, and the grain surface area available for adsorption (Froelich and others,

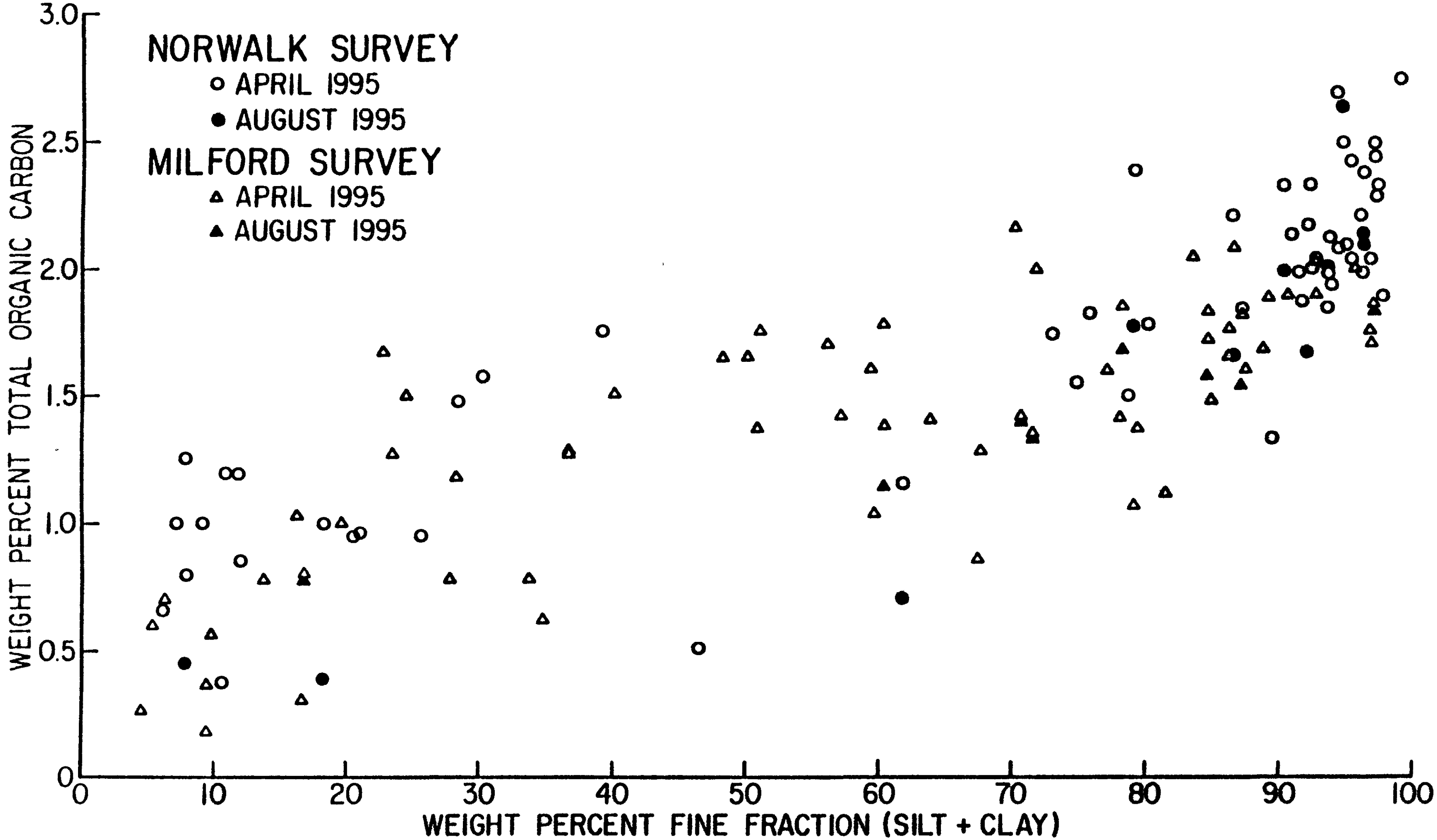

Figure 4. Plot showing the general relationship between increasing TOC and finer sediment textures (Norwalk Islands survey: circles; Milford survey: triangles). Percent fines are from Poppe and others (1996a,b). Open symbols represent samples collected during April 1995; solid symbols represent samples collected during August 1995.

1971; Mayer, 1994). Because of the relatively shallow nature of this estuary and because the finer grained sediments tend to accumulate in the lower energy environments of the deeper parts of the Sound, the depth or redox state of the overlying water column do not appear to be limiting factors in the distribution of sedimentary organic matter in western Long Island Sound.

The data from this study and earlier work (Hathaway, 1971; Reid, 1982) suggest that TOC and nitrogen concentrations increase significantly westward within the Sound. For example, TOC concentrations in clayey silts average only 1.76 percent in the Milford survey, but average 2.11 percent at the more westward Norwalk Islands survey site. Similarly, TOC concentrations in sands average only 0.80 percent in the Milford survey, but average 0.94 percent within the Norwalk Islands survey. This westward increase in TOC and nitrogen contents of the sediments is probably related to higher nutrient inputs, to decreasing circulation, and to seasonal stratification of the water column. The higher nutrient inputs result in a high production rate of organic matter; the decreased circulation lowers the energy of the environment allowing greater sedimentation rates; and the seasonal stratification promotes hypoxia in the bottom waters, which increases preservation by limiting macro- and microbiologic scavenging (Stein, 1990). No clear westward trend was observed in the hydrogen data.

The data collected as part of this study indicate that there was a decrease in the amount of organic matter in the surficial sediments at both survey sites between spring 1995 and late summer 1995. The TOC, hydrogen, and nitrogen concentrations average 1.73, 1.38, and 0.17 percent, respectively, in the samples collected during April, but average only 1.42, 1.00, and 0.16 percent, respectively, in samples collected at the same locations during August. This seasonal variability in the sedimentary organic matter, which has been noted by earlier studies along the United States mid-Atlantic slope and rise (Maciolek and others, 1986), is probably related to oxidation and macro biologic reworking during the late spring and early summer.

Sedimentary organic matter in the marine environment is primarily derived from phytoplankton and to a lesser degree from continental sources. Because marine and land plants contain different amounts of carbon and nitrogen, molar elemental carbon/nitrogen (C/N) ratios have previously been used as a rough means of differentiating between algal and terrigenous organic matter (Premuzic and others, 1982; Meyers, 1994). Aquatic (marine and lacustrine) algae typically have atomic C/N ratios of less than ten; vascular land plants have C/N ratios greater than twenty. This difference arises from the absence of cellulose in algae and its abundance in vascular plant material (Meyers, 1994). The C/N molar elemental ratios from the Milford survey site average 10.775 and suggest that marine algae are the primary source of sedimentary organic matter for this area. Although similar C/N ratios are present in the sediments from most of the southern and central parts of the Norwalk Islands survey site; those from the northwestern corner are much higher(e.g. NOR-1, NOR-4, NOR-7, and NOR-58). The ratios from this shoreward area commonly exceed twenty and suggest a more terrigenous source for the sedimentary organic matter.

CONCLUSIONS

The concentrations of total organic carbon, nitrogen, and hydrogen reported as part of this study generally agree with earlier results reported for west-central Long Island Sound and are similar to the concentrations reported in most other east coast estuaries. These concentrations of sedimentary organic matter vary inversely with grain size and are higher in samples collected during the spring than in samples collected during the late summer. Values for total organic carbon and nitrogen increase westward within the Sound.

Interested parties can obtain more detailed descriptions of the methods used and digital copies of the organic carbon, hydrogen, and nitrogen analysis data in ASCII format and on 3.5" diskettes by contacting any of the authors at the Coastal and Marine Geology Program office of the U.S. Geological in Woods Hole, Massachusetts 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; the weight percents of Total Organic Carbon (TOC), Hydrogen, and Nitrogen; the Carbon/Nitrogen Molar Element ratio, and Gross Lithology (Poppe and others, 1996) from western Long Island Sound off the Norwalk Islands, Connecticut. Stations designated by an letter after the numeric in the sample number represent replicates. Most samples were collected during April 1995; samples with AUG in the character prefix of the sample number were collected during August 1995.

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	TOC	HYDROGEN	NITROGEN	C/N	GROSS LITHOLOGY
NOR-1	41d02.185'	-73d19.586'	18.2	1.00	0.35	0.02	48.777	GRAVELLY SEDIMENT
NOR-4a	41d02.628'	-73d19.872'	16.1	1.27	0.56	0.04	36.345	SAND
NOR-4b	41d02.628'	-73d19.872'	16.1	1.25	0.58	0.03	48.816	SAND
NOR-7	41d03.101'	-73d20.060'	13.6	1.00	0.31	0.01	106.953	GRAVELLY SEDIMENT
NOR-10	41d03.5953'	-73d18.6061'	17.8	1.15	1.14	0.07	19.033	GRAVELLY SEDIMENT
NOR-13	41d03.120'	-73d18.442'	20.1	1.34	1.20	0.10	15.527	CLAYEY SILT
NOR-16	41d02.6311'	-73d18.1674'	20.9	1.87	1.70	0.20	10.443	CLAYEY SILT
NOR-19	41d02.7840'	-73d17.6918'	20.7	2.22	1.75	0.24	10.531	CLAYEY SILT
NOR-22	41d03.470'	-73d17.865'	19.4	2.18	1.70	0.23	10.929	CLAYEY SILT
NOR-25	41d03.8102'	-73d18.1663'	17.6	2.33	1.80	0.26	10.489	CLAYEY SILT
NOR-28	41d00.9202'	-73d18.4396'	36.1	2.05	1.91	0.22	10.902	CLAYEY SILT
NOR-34	41d01.4712'	-73d16.9847'	35.0	2.70	1.79	0.28	11.196	CLAYEY SILT
NOR-37	41d00.5275'	-73d18.2365'	28.2	2.34	2.03	0.27	10.098	CLAYEY SILT
NOR-38	41d00.4869'	-73d18.3262'	28.0	2.38	1.77	0.26	10.450	CLAYEY SILT
NOR-40	41d00.657'	-73d17.472'	29.6	2.77	1.78	0.29	11.031	CLAYEY SILT
NOR-43	41d00.9821'	-73d16.8031'	36.3	2.39	1.88	0.22	12.222	SAND-SILT-CLAY
NOR-46	41d00.0528'	-73d18.2039'	23.8	2.51	1.72	0.30	9.774	CLAYEY SILT
NOR-49	41d00.2700'	-73d17.2042'	26.3	2.43	1.91	0.27	10.395	CLAYEY SILT
NOR-52	41d00.3410'	-73d16.3905'	27.6	2.53	1.88	0.29	10.076	CLAYEY SILT
NOR-55	41d03.8823'	-73d17.7058'	18.2	2.05	1.85	0.23	10.377	CLAYEY SILT

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	TOC	HYDROGEN	NITROGEN	C/N	GROSS LITHQLOGY
NOR-56	41d03.625'	-73d17.540'	19.4	2.34	1.89	0.25	10.898	CLAYEY SILT
NOR-57	41d03.0042'	-73d17.2983'	20.3	1.99	1.75	0.22	10.207	CLAYEY SILT
NOR-58	41d034467'	-73d19.4473'	15.0	1.00	0.49	0.02	40.528	GRAVELLY SEDIMENT
NOR-59	41d03.436'	-73d19.654'	14.2	0.79	0.88	0.05	15.632	GRAVELLY SEDIMENT
NOR-60	41d03.327'	-73d20.132'	12.5	0.66	0.71	0.04	16.226	GRAVELLY SEDIMENT
NOR-61	41d02.333'	-73d19.992'	17.1	0.85	0.97	0.07	12.992	SAND
NOR-62	41d02.905'	-73d19.125'	17.6	0.94	0.81	0.07	14.874	GRAVELLY SEDIMENT
NOR-63	41d02.613'	-73d19.095'	19.4	0.95	1.19	0.07	14.139	GRAVELLY SEDIMENT
NOR-64	41d02.442'	-73d19.098'	19.6	1.16	1.50	0.12	11.226	SAND
NOR-65	41d02.1316'	-73d18.9559	20.9	1.78	1.33	0.20	10.320	SILTY SAND
NOR-66	41d02.1241'	-73d18.1366	21.9	1.80	1.53	0.21	9.583	CLAYEY SILT
NOR-67	41d02.8339'	-73d17.9947	20.0	1.86	1.36	0.23	9.328	SAND-SILT-CLAY
NOR-68	41d02.6582'	-73d17.1056	21.9	2.13	1.53	0.25	9.883	CLAYEY SILT
NOR-69	41d03.284'	-73d17.083'	20.0	2.10	1.46	0.25	9.638	CLAYEY SILT
NOR-70	41d02.2259'	-73d17.5356'	22.3	2.14	1.48	0.25	9.670	CLAYEY SILT
NOR-71	41d01.4545'	-73d16.4605'	35.5	2.05	1.68	0.25	9.346	CLAYEY SILT
NOR-72	41d01.7373'	-73d16.7427'	28.8	1.96	1.53	0.24	9.248	CLAYEY SILT
NOR-73	41d01.8947'	-73d17.2119'	26.7	2.00	1.67	0.26	8.813	CLAYEY SILT
NOR-74	41d01.5322'	-73d17.5465'	31.3	1.85	1.59	0.24	8.979	CLAYEY SILT
NOR-75	41d01.808'	-73d17.913'	26.3	1.86	1.80	0.24	8.985	CLAYEY SILT
NOR-76	41d01.384'	-73d18.254'	30.9	0.50	0.51	0.06	9.833	SILTY SAND
NOR-77	41d01.1483'	-73d18.2534'	44.9	0.37	0.55	0.04	9.228	SAND
NOR-78	41d01.0133'	-73d18.9503'	45.0	1.57	1.32	0.20	9.034	SILTY SAND
NOR-79	41d01.120'	-73d19.228'	39.6	1.77	1.36	0.21	9.554	SAND-SILT-CLAY
NOR-80	41d01.4373'	-73d19.0683'	25.9	1.20	1.19	0.15	9.274	GRAVELLY SEDIMENT
NOR-81	41d01.8494'	-73d19.3202'	20.1	1.20	1.42	0.15	9.235	SAND
NOR-82	41d01.8844'	-73d18.8452'	21.3	1.47	1.60	0.18	9.221	SILTY SAND
NOR-83a	41d01.8069'	-73d18.6665'	25.7	1.41	1.88	0.17	9.578	SAND-SILT-CLAY
NOR-83b	41d01.8069'	-73d18.6665'	25.7	1.60	1.90	0.20	9.275	SAND-SILT-CLAY
NOR-84	41d00.7891'	-73d19.3262'	34.8	1.90	2.64	0.24	9.192	CLAYEY SILT
NOR-85	41d00.2937'	-73d18.8538'	25.5	2.21	2.63	0.27	9.387	CLAYEY SILT
NOR-86	41d00.0488'	-73d18.7064'	24.2	2.11	2.62	0.26	9.184	CLAYEY SILT

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	TOC	HYDROGEN	NITROGEN	C/N	GROSS LITHOLOGY
NOR-87	40d59.8239'	-73d18.6358'	23.0	2.21	1.94	0.29	8.824	CLAYEY SILT
NOR-88	40d59.544'	-73d17.473'	21.5	2.29	2.16	0.29	9.028	CLAYEY SILT
NOR-89	41d00.7766'	-73d17.8501'	31.5	2.05	2.13	0.26	8.788	CLAYEY SILT
NOR-90	41d00.8937'	-73d17.7442'	32.1	1.55	1.52	0.19	9.328	SAND-SILT-CLAY
NOR-91	41d00.7825'	-73d16.1928'	34.6	1.94	2.26	0.25	8.840	CLAYEY SILT
NORAUG-1	41d02.2025'	-73d19.5934'	17.8	0.38	0.82	0.04	0.809	GRAVELLY SEDIMENT
NORAUG-4	41d02.5726'	-73d19.7707'	16.7	0.45	0.54	0.05	9.921	SAND
NORAUG-5	41d02.6429'	-73d19.8369'	15.3	0.57	0.45	0.06	10.851	SAND
NORAUG-8	41d03.1190'	-73d20.0984'	13.4	1.55	1.01	0.16	10.836	GRAVELLY SEDIMENT
NORAUG-10	41d03.6080'	-73d18.7842'	16.7	0.77	0.64	0.08	10.127	GRAVELLY SEDIMENT
NORAUG-15	41d03.1687'	-73d18.4157'	19.4	1.65	0.92	0.18	10.179	CLAYEY SILT
NORAUG-19	41d02.7161'	-73d17.5735'	20.9	1.66	0.97	0.18	10.576	CLAYEY SILT
NORAUG-22a	41d03.4453'	-73d17.7610'	19.0	1.67	1.12	0.21	9.300	CLAYEY SILT
NORAUG-22b	41d03.4453'	-73d17.7610'	19.0	1.68	1.22	0.21	9.294	CLAYEY SILT
NORAUG-25	41d03.8342'	-73d18.1329	17.1	1.99	1.44	0.24	9.508	CLAYEY SILT
NORAUG-38	41d00.5710'	-73d18.1996'	28.6	2.10	1.22	0.25	9.797	CLAYEY SILT
NORAUG-39	41d00.5072'	-73d18.2838'	27.6	2.14	1.28	0.26	9.605	CLAYEY SILT
NORAUG-43	41d00.9008'	-73d16.8741'	33.6	1.81	1.06	0.21	9.803	SAND-SILT-CLAY
NORAUG-46	40d59.9851'	-73d18.1299'	23.2	2.39	1.19	0.31	9.015	CLAYEY SILT
NORAUG-75	41d01.8189'	-73d17.8911'	26.0	2.03	1.11	0.25	9.268	CLAYEY SILT

APPENDIX B

This table contains a list of the sample number; navigation (latitudes and longitudes) in degrees decimal minutes; water depths in meters; weight percents Total Organic Carbon (TOC), Hydrogen, and Nitrogen; Carbon/Nitrogen Molar Element Ratios; and Gross Lithology (Poppe and others, 1996) from western Long Island Sound off Milford, Connecticut. Stations designated by a letter after the numeric in the sample number represent replicates. Most samples were collected during April 1995; samples with AUG in the character prefix of the sample number were collected during August 1995.

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	TOC	HYDROGEN	NITROGEN	C/N	GROSS LITHOLOGY
MIL-1	41d06.2651'	-73d06.1463'	13.0	0.60	0.54	0.05	12.680	GRAVELLY SEDIMENT
MIL-2	41d06.671'	-73d04.994'	15.1	2.03	1.95	0.25	9.341	CLAYEY SILT
MIL-3	41d06.921'	-73d03.682'	16.5	1.99	2.27	0.22	10.483	SAND-SILT-CLAY
MIL-4	41d06.367'	-73d03.770'	18.2	1.65	2.48	0.18	10.583	SILTY SAND
MIL-5	41d06.497'	-73d05.909'	13.4	0.18	0.54	0.02	9.429	GRAVELLY SEDIMENT
MIL-8	41d06.815'	-73d03.118'	17.6	2.05	2.01	0.18	13.061	CLAYEY SILT
MIL-9	41d06.690'	-73d03.018'	18.2	1.86	1.94	0.20	10.653	CLAYEY SILT
MIL-10	41d06.1101'	-73d02.6091'	22.1	1.89	2.07	0.20	10.731	CLAYEY SILT
MIL-11	41d05.5071'	-73d02.7992'	24.4	1.76	2.20	0.20	10.289	CLAYEY SILT
MIL-12	41d06.2810'	-73d05.4781'	16.7	0.81	1.35	0.07	12.888	SAND
MIL-15a	41d05.821'	-73d03.422'	22.8	1.69	1.89	0.18	10.760	CLAYEY SILT
MIL-15b	41d05.821'	-73d03.422'	22.8	1.64	1.25	0.18	10.348	CLAYEY SILT
MIL-16	41d05.0431'	-73d03.2957'	25.3	1.12	1.32	0.10	12.034	CLAYEY SILT
MIL-17	41d05.3398'	-73d03.7761'	23.8	1.40	1.68	0.15	10.412	SAND-SILT-CLAY
MIL-21	41d06.0383'	-73d05.8961'	15.7	0.69	0.81	0.06	12.129	SAND
MIL-22	41d05.6264'	-73d04.1702'	21.3	1.60	2.18	0.17	10.735	SAND-SILT-CLAY
MIL-23	41d05.3726'	-73d04.5351'	28.4	1.76	1.85	0.19	10.657	CLAYEY SILT
MIL-24	41d05.1632'	-73d04.476'	32.6	1.71	1.97	0.18	11.102	CLAYEY SILT
MIL-25a	41d05.005'	-73d04.908'	25.5	1.00	1.53	0.11	10.514	SAND
MIL-25b	41d05.2741'	-73d04.9104'	35.0	1.00	1.51	0.10	10.940	SAND

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	TOC	HYDROGEN	NITROGEN	C/N	GROSS LITHOLOGY
MIL-26	41d06.531'	-73d05.470'	15.5	2.08	2.18	0.23	10.320	CLAYEY SILT
MIL-29	41d05.0180'	-73d05.0285'	26.7	1.03	1.47	0.02	43.142	SAND
MIL-30	41d05.6687'	-73d05.2733'	19.8	1.17	1.18	0.11	12.243	SILTY SAND
MIL-31	41d05.5522'	-73d05.6595'	17.5	0.37	0.49	0.03	12.275	SAND
MIL-32	41d05.1733'	-73d05.4228'	36.5	1.50	1.93	0.17	9.858	SAND
MIL-33a	41d06.2844'	-73d05.1865'	17.5	0.78	0.94	0.09	10.105	SILTY SAND
MIL-33b	41d06.2844'	-73d05.1865'	17.5	0.77	1.94	0.09	9.561	SILTY SAND
MIL-36	41d04.3113'	-73d02.2789'	27.5	2.00	2.36	0.21	10.796	CLAYEY SILT
MIL-37	41d04.8688'	-73d02.7285'	26.5	1.89	2.07	0.20	10.742	CLAYEY SILT
MIL-38	41d04.4098'	-73d03.0107'	25.3	1.85	2.05	0.20	10.522	SAND-SILT-CLAY
MIL-39	41d03.0182'	-73d02.9608'	26.5	1.86	1.86	0.20	10.482	CLAYEY SILT
MIL-42	41d05.9949'	-73d05.1023'	18.8	0.31	1.13	0.03	11.059	SAND
MIL-43	41d04.6959'	-73d03.8609'	25.7	0.62	1.10	0.07	10.046	SILTY SAND
MIL-44	41d04.5944'	-73d03.9542'	26.3	1.47	2.02	0.18	9.081	CLAYEY SILT
MIL-45	41d04.541'	-73d04.313'	26.3	0.84	2.17	0.13	7.235	SAND-SILT-CLAY
MIL-46	41d04.1716'	-73d04.3998'	22.3	1.82	1.61	0.20	10.459	CLAYEY SILT
MIL-47	41d06.691'	-73d04.165'	16.3	1.41	1.98	0.16	10.100	SANDY SILT
MIL-51	41d04.3660'	-73d04.9137'	19.4	1.65	1.65	0.18	10.455	GRAVELLY SEDIMENT
MIL-52	41d04.5326'	-73d04.3270'	25.7	1.69	1.55	0.18	10.456	SAND-SILT-CLAY
MIL-53	41d04.6512'	-73d05.1174'	21.9	0.81	1.71	0.09	9.563	GRAVELLY SEDIMENT
MIL-54	41d06.4662'	-73d04.2571'	16.5	1.83	1.94	0.20	10.419	CLAYEY SILT
MIL-57	41d04.6411'	-73d05.6349'	21.1	0.27	0.73	0.03	9.227	GRAVELLY SEDIMENT
MIL-58	41d03.8996'	-73d04.8714'	19.4	1.28	1.60	0.15	9.800	GRAVELLY SEDIMENT
MIL-59	41d03.7748'	-73d04.6269'	21.9	1.65	1.70	0.17	11.053	SILTY SAND
MIL-60	41d03.5094'	-73d04.8237'	22.8	0.78	0.59	0.08	10.440	SILTY SAND
MIL-61	41d06.1651'	-73d04.2393'	18.0	1.51	1.26	0.15	11.124	SILTY SAND
MIL-64	41d03.272'	-73d04.964'	23.8	0.57	0.75	0.06	10.933	SAND
MIL-65	41d03.9936'	-73d03.5542'	26.1	1.64	1.80	0.18	10.275	CLAYEY SILT
MIL-66	41d03.3376'	-73d02.7066'	34.0	1.60	1.71	0.18	9.966	SAND-SILT-CLAY
MIL-67	41d02.870'	-73d02.570'	36.5	2.16	1.59	0.23	10.860	SAND-SILT-CLAY
MIL-68	41d03.5461'	-73d04.5095'	26.5	1.38	1.14	0.15	10.185	SANDY SILT
MIL-71a	41d02.6668'	-73d03.4375'	35.3	1.77	1.34	0.20	10.150	SILTY SAND

SAMPLE	LATITUDE	LONGITUDE	DEPTH (M)	TOC	HYDROGEN	NITROGEN	C/N	GROSS LITHOLOGY
MIL-71b	41d02.6668'	-73d03.4375'	35.3	1.79	1.35	0.21	9.750	SILTY SAND
MIL-71c	41d02.6668'	-73d03.4375'	35.3	1.72	1.37	0.20	10.080	SILTY SAND
MIL-72	41d02.774'	-73d04.304'	35.0	1.37	0.70	0.15	10.284	SILTY SAND
MIL-73	41d02.4334'	-73d04.3165'	35.1	1.27	0.71	0.14	10.526	SILTY SAND
MIL-75	41d03.3360'	-73d04.3631'	30.1	1.76	0.96	0.20	10.038	SILTY SAND
MIL-82	41d03.1397'	-73d04.3898'	33.6	1.42	0.84	0.16	10.391	SAND-SILT-CLAY
MIL-91	41d03.6193'	-73d04.1146'	27.3	1.36	0.94	0.15	10.238	SAND-SILT-CLAY
MIL-96	41d03.406'	-73d04.062'	29.6	1.02	0.96	0.11	10.138	SAND-SILT-CLAY
MIL-103	41d03.1145'	-73d04.1625'	32.6	1.27	0.97	0.14	10.144	SAND-SILT-CLAY
MIL-111	41d03.2006'	-73d03.7131'	32.1	1.41	1.14	0.15	10.494	SAND-SILT-CLAY
MIL-117	41d03.4580'	-73d03.6531'	28.6	1.29	0.82	0.13	11.021	SAND-SILT-CLAY
MIL-124	41d03.789'	-73d03.600'	26.7	1.72	1.11	0.18	10.635	CLAYEY SILT
MIL-125	41d03.7831'	-73d03.6996'	27.1	1.06	0.78	0.12	9.777	SAND-SILT-CLAY
MIL-126	41d03.7429'	-73d03.6833'	27.1	1.60	1.09	0.18	10.090	CLAYEY SILT
MILAUG-12	41d06.2005'	-73d05.6903'	15.5	0.76	0.51	0.07	11.736	SAND
MILAUG-24	41d05.1678'	-73d04.4770'	32.5	1.87	1.12	0.21	10.094	CLAYEY SILT
MILAUG-38	41d04.4620'	-73d03.0092'	25.3	1.67	1.20	0.19	10.067	SAND-SILT-CLAY
MILAUG-46	41d04.1703'	-73d04.3525'	22.3	1.53	1.29	0.17	10.385	CLAYEY SILT
MILAUG-73	41d02.4680'	-73d04.3529'	33.6	1.28	0.68	0.14	10.071	SILTY SAND
MILAUG-75	41d03.2768'	-73d04.3436'	29.8	1.15	0.78	0.12	10.669	SAND-SILT-CLAY
MILAUG-111	41d03.2194'	-73d03.6188'	32.0	1.38	0.87	0.15	10.183	SAND-SILT-CLAY
MILAUG-117	41d03.4088'	-73d03.7923'	30.5	1.36	1.10	0.15	10.036	SAND-SILT-CLAY
MILAUG-124	41d03.8103'	-73d03.6157'	26.3	1.57	1.25	0.18	9.933	CLAYEY SILT