NORTHEAST MONITORING PROGRAM

ANNUAL REPORT - LEVEL 2

SEDIMENT GRAIN SIZE, ORGANIC CARBON AND NTIROGEN

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INTRODUCTION

Data collected in the Northeast Monitoring Program (NEMP) concerning sediment grain sizes, total organic carbon (TOC) and total Kjeldahl nitrogen (TKN) were contained in four Level 1 NEMP reports, those of 1) the region-wide Benthic Ecology Task, 2) Benthic Monitoring - Northern Gulf of Maine, 3) Ecological Studies at the Delaware Dumpsites, and 4) Assessment of Ecological Impact...at the proposed "Norfolk" dumpsite.

Administrative information concerning these work units (principal investigators, location, funding, task duration and monitor, etc.) and their objectives, methodologies and rationales are presented in the Level 1 reports. This information will not be repeated here except where differences in methods have a bearing on interpretation of results.

RESULTS AND DISCUSSION

1. Region-wide Patterns

Bottom sediment data (mean grain size, skewness, kurtosis, sorting index, percentages of sediment in each of ten size classes, TOC and TKN) for each grab taken on the April 1978 and December 1979 regional cruises and the August 1980 N.Y. Bight cruise are now being listed in printout form. These data should be useful in interpreting results of other NEMP studies, such as those concerning sediment contaminants, seabed oxygen consumption, and benthic macrofauna. Averages for sorting coefficient, skewness, kurtosis, mean grain size, percent silt, percent clay, TOC and TKN for all replicates per station sampled in December 1979 are given in Table 1, to present a composite picture of sediment characteristics at most of the NEMP sites currently being occupied. The mean grain sizes are also shown in Figure 1.

Means and standard deviations for TOC values for the 1978 and 1979 samplings are indicated in Figure 2. TOC is considered one of the better available indicators of anthropogenic input, albeit a semiquantitative one which can be naturally elevated (Gross 1976; Hatcher and Keister 1976). As Figure 2 indicates, some of the highest TOC values are found in the New York Bight sewage deposition area, but high contents are also present in less contaminated areas -- especially in Block Island Sound, the Gulf of Maine (to 1.9%) and the "Mud Patch" south of Nantucket (to 1.5%). Walsh (in press) has proposed use of carbon/nitrogen ratios to determine sources of organic material in sediments. C/N ratios >10 may indicate terrestrial sources, and values <6, marine (planktonic) origins. If this concept holds for our analytical methods and results, then TOC at the sludge deposition area (C/N = 10.9 in December 1979) is mainly from terrestrial sources, that at the Hudson Shelf Valley site (C/N = 7.7) perhaps a combination of sources, and in Block Island Sound (5.8) the Gulf of Maine and the Mud Patch (both 6.9), mostly of marine origin.

Almost all areas with high TOC values are deep, apparently depositional environments with large percentages of silts and clays, with which TOC is usually strongly associated. Figures 3 and 4 demonstrate this correlation of TOC to depth (correlation coefficient $r = 0.60$) and to percent clay ($r = 0.78$). These regressions can be used to identify stations which are relatively "enriched" in carbon compared to expected concentrations for given depths and clay contents. In Figure 3, the three stations having the greatest ratios of observed to predicted (regression line) TOC are all considered impacted: the N.Y. Bight sewage sludge deposition area (station 16B), the mouth of Narragansett Bay (34), and Massachusetts Bay (35). The sewage sludge site is also most enriched in TOC relative to clay content (Figure 4), but it is followed by the Hudson Shelf Valley (station 33) and the "Mud Patch" (20), both of which have been presumed unimpacted. It is doubtful whether the data indicate a major anthropogenic TOC source for these stations. (Note that the data points in Figure 3 and 4 might be better fit by curves than by straight lines, and that this could alter resultant interpretations.) The overall good correlation between TOC and percent clay indicates that the latter should also be taken into account in analysing patterns of contaminant distributions. Mayer and Fink (1980) showed that concentrations of chromium in several Maine estuaries were more strongly correlated to the finest size fractions (such as clays, which are <4 μm) than to all fine sediment (silt plus clay, <63 μm). Chromium concentrations were also closely related to sediment organic carbon contents.

Despite the lack of coincidence between TOC and anthropogenic inputs discussed above (Figure 2), the parameter shows some promise as a monitoring tool; variability is usually low, and future inputs may increase in areas where waivers are granted to allow continued discharge of raw or primary-treated sewage. The data presented in Figure 2 form a baseline against which to measure any such inputs.

2. New York Bight

Stations sampled in the intensive N. Y. Bight benthic survey of July-August 1980 are shown in Figure 5, and pertinent sediment data for these stations are listed in Table 2. Higher TOC maxima were recorded in the bight than in the region-wide surveys, to 3.4% at the southwest edge of the Christiaensen Basin (Figure 6). This is slightly lower than peak values (∿5%) reported by Gross (1976) and Hatcher and Keister (1976). In fact, Figure 6 indicates that most 1980 values were lower than concentrations shown by Gross (1976) for 1971. This is probably due more to methodological differences than to an actual reduction in carbon content during the '70s. Gross (1976) and Hatcher and Keister (1976) used dry combustion measurements, which may include non-organic materials such as carbonate. On the other hand, the chromic acid oxidation used in the present study ordinarily recovers 70-90% of all organic carbon (Holme and McIntyre 1971). Black et al. (1965) use a factor of 1.3 to convert chromic acid-derived carbon to TOC; using this conversion, maximum values measured in 1980 become equivalent to maxima reported for the bight in the earlier studies.

Overall TOC patterns are comparable between the 1971 and 1980 surveys. Both show the expected TOC accumulation in the Christiaensen Basin, which includes the sewage and dredge spoil dumpsites. Highest values were found in the southwestern part of the basin. Elevated TOC concentrations were also found in the Hudson Shelf Valley, especially near its axis. The apparent increase in down-valley TOC shown by the 1980 contour could be explained by minor differences in sampling position relative to the valley's axis. The 1980 sampling was not spatially intensive enough to determine whether or not the 1% contour was continuous down the valley (or to the north of the sewage sludge disposal area). Analysis of dated long cores would provide another means of assessing temporal changes in TOC and other materials in the valley. The Hudson River plume, which typically hugs the New Jersey coast, had no apparent influence on sediment TOC, with the possible exception of higher values off the tip of Sandy Hook in the 1971 survey. Lack of TOC buildup under the plume is at least partly due to the non-depositional nature of this inshore area.

3. Philadelphia Dumpsites (Lear 1980)

Supplementary data are taken from Lear et al. 1980. The industrial acid waste and sewage sludge sites are located on the mid-shelf approximately 72 km off the Delaware-Maryland coast, with the latter site 20 km SSE of the former. The area has a ridge and swale topography. Medium to fine sands predominate, and also present are some gravel and cobble and generally less than one percent silt/clay. Ambient TOC concentrations reported were 0.03-0.08% which agrees well with values found in the region-wide survey (Figure 2). Swales immediately south of the sludge site contained accumulations to 0.1-0.45%; this is still an order of magnitude below highest values we have measured in parts of the N. Y. Bight apex (Figure 6) as well as at uncontaminated sites with high fractions of fine sediments (Figure 2). As Lear (1980) remarks, these dumpsite areas provide an excellent opportunity to study fates and effects of ocean-dumped pollutants. Pollution inputs were known, were small and began recently relative to N. Y. Bight waste disposal, and were to a discrete area which had contained sandy uncontaminated sediments before dumping began. With the cessation of dumping at the Philadelphia sites, recovery of the system can now be studied.

4. Norfolk Proposed Dumpsite (Alden et al. 1980)

This potential dumpsite is located about 27 km from the mouth of Chesapeake Bay, beyond the 60' (18.3 m) isobath. Effort is concentrated on five stations, one at the center of the proposed site and others 5 n mi (9.26 km) north, south, east and west of center. Fine to very fine sands predominate in this area, with some coarser sands also found. This agrees with mean grain sizes found in the regional program for the shelf off the Chesapeake (Figure 1). Not enough clay-size (<4 μm) material was found to warrant analysis, which may indicate that the area's environment is non-depositional and that containment of fine dredge spoils should not be expected. Organic content (ash-free dry weight technique) ranged from 0.40 to 1.30%. These are low values, but still much higher than TOC contents measured on the middle shelf by the region-wide program. Methodological differences are implicated; Alden et al. (1980) used a combustion technique, which typically gives higher values than does the chromic acid method used region-wide (see discussion in the New York Bight section).

5. Northern Gulf of Maine (Larsen and Doggett 1980)

The pilot sampling of almost 60 stations indicated that the predominant sediment type in the Casco Bay area is soft mud, which floors most bays and sounds inside the outer islands. Rocky substrates are also common. Sandier sediments are found at offshore stations, and hard clean sand in the main shipping channel into the bay, where tidal currents are high. Non-dredged bottoms in and near Portland Harbor contained anthropogenic debris and a visible oil sheen, and substrate at one station was almost entirely pulp mill waste. Detailed sediment grain size analyses have not been completed.

Mean sediment carbon content was 2.4%, higher than any values recorded in the NEMP region-wide sampling. This may be due in part to methodological differences (the Maine study used a CHN analyser to ignite the samples, after which the amount of CO_2 formed was measured). The high values were, however, comparable to those found in Long Island Sound muds using the region-wide techniques, and so can probably be explained largely by the muddy nature of the sediments and the anthropogenic and other terrestrial inputs to these inshore sites.

Highest carbon contents were found in the pulp mill waste area (39.3%) and a domestic waste dumping area (15.0%). Mean carbon-nitrogen ratio was 10.3, which may indicate the influence of a terrestrial carbon source (Walsh in press).

SUMMARY

Data on pertinent sediment parameters are presented for the April 1978 and December 1979 regional cruises, and the August 1980 N. Y. Bight sampling. For the overall NEMP sampling, highest TOC values were found in the bight's sewage sludge deposition area, but also at sites such as Block Island Sound, the Gulf of Maine and the Mud Patch, which are not obviously contaminated. TOC was correlated to depth and to percent clay in sediments. Between cruise variability was generally low, so monitoring TOC may enable detection of any large future changes in sewage inputs to NEMP sites.

Exact comparisons of N. Y. Bight TOC concentrations to values found in earlier surveys could not be made due to differences in analytical methods. Patterns of distribution could be compared, however, and TOC distributions in 1980 were shown to be very similar to those found in 1971. Highest levels were seen in the southwestern Christiaensen Basin, and elevated concentrations also extended down the Hudson Shelf Valley. No TOC accumulation was detected along the New Jersey coast under the typical Hudson-Raritan plume; this was presumed due to the coarseness of sediments and strength of bottom water currents on the New Jersey inner shelf.

Information from contract studies off Chesapeake Bay, Delaware and Maine is also summarized. The former two areas were characterized by fine to medium sands, while the Maine inshore sediments were predominantly muddy. Several of the Maine sites showed alteration of sediment characteristics, chiefly by domestic and pulp mill wastes. Swales near the Philadelphia sewage sludge disposal site contained accumulations of TOC; this area lends itself to the study of fates and effects of dumped wastes, and subsequent recovery.

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Table 1. Mean values for several sediment parameters at NEMP benthic stations, April 1978 and December 1979.

Station Description	Number	Depth	Mean grain size (phi units)	Sorting coefficient	Skewness	Kurtosis	% Silt (4-63 μm)	% Clay (<4 μm)	TOC mg/g dry wt.	TKN
Chesapeake Bay:										
5 Mi. S.	2	16								
Dec. 79			1.42	1.00	0.04	1.38	1.5	1.0	1.0	0.2
20 Mi. S	3	17								
Dec. 79			2.53	0.59	0.10	1.57	3.4	1.6	1.2	0.2
15 Mi. E	5	15								
Apr. 78			3.22	0.62	-0.28	0.97	2.1	1.5	1.2	0.2
25 Mi. SE	6	7								
Apr. 78			1.75	0.84	-0.04	0.96	0.1	0.7	0.5	0.1
Midshelf	7	30								
Apr. 78			1.31	0.86	-0.14	1.28	0.1	0.6	0.4	0.1
Dec. 79			1.97	0.67	-0.01	0.76	0.3	1.0	0.9	0.2
Outer Shelf	8	90								
Apr. 78			1.76	0.82	-0.02	1.06	0.1	1.0	0.6	0.1
Dec. 79			1.91	0.87	-0.28	0.98	0.2	1.0	0.8	0.1
Delaware Bay:										
5 Mi. S	31	19								
Dec. 79			0.88	1.86	0.03	1.47	3.7	2.9	2.8	0.3
20 Mi. S	32	15								
Dec. 79			0.89	1.09	-0.25	1.28	0.3	1.0	0.9	0.1
12 Mi. E	10	23								
Apr. 78			1.60	1.02	-0.13	0.86	0.2	1.0	0.8	0.1
Midshelf	11	83								
Apr. 78			2.51	0.50	0.10	1.34	0.8	1.8	1.8	0.3
Dec. 79			2.53	0.52	0.10	1.38	1.3	1.7	2.6	0.3
Outer Shelf	12	69								
Apr. 78			2.16	0.98	-0.30	1.66	1.3	3.1	2.4	0.4
Dec. 79			2.10	1.10	-0.42	1.60	1.3	2.2	1.9	0.3
Philadelphia Dumpsite	9	44								
Apr. 78			0.87	1.07	-0.16	1.0	0.1	0.6	0.7	0.1

Table 1. Continued

Station Description	Number	Depth	Mean grain size (phi units)	Sorting coefficient	Skewness	Kurtosis	% Silt (4-63 μm)	% Clay (<4 μm)	TOC mg/g dry wt.	TKN mg/g dry wt.
New York Bight:										
Sands Near Sludge Dump	16A	24								
Apr. 78			1.83	0.71	0.10	0.94	0.1	0.8	0.6	0.1
Dec. 79			1.81	0.76	0.05	0.97	0.3	1.2	1.4	0.2
Sludge Dumpsite	16B	31								
Apr. 78			3.26	1.01	-0.02	1.92	10.3	2.0	9.6	1.1
Dec. 79			3.10	1.38	0.08	2.12	6.2	4.7	12.2	1.1
Dredge Spoils Dumpsite	16C	15								
Apr. 78			0.64	2.42	-0.10	0.86	3.9	1.7	1.8	0.3
Dec. 79			2.29	0.78	-0.09	1.26	1.1	1.8	1.1	0.2
Hudson Shelf Valley	33	78								
Dec. 79			3.50	1.76	0.38	2.10	12.3	8.6	8.9	1.2
Anoxia Area	17	28								
Apr. 78			1.16	0.90	-0.19	1.18	0.2	0.8	5.7	0.1
Dec. 79			1.50	0.76	-0.07	1.42	0.2	0.9	0.5	0.1
Baltimore Canyon Trough	13	64								
Apr. 78			2.10	1.29	0.15	2.12	2.4	4.0	3.2	0.5
Dec. 79			2.04	1.21	0.08	1.80	1.3	3.5	2.7	0.4
Fire Island Control	15A	32								
Apr. 78			1.86	0.89	0.09	1.06	1.7	1.3	1.5	0.2
Dec. 79			1.43	0.70	-0.05	1.34	0.1	0.8	0.4	0.1
Anoxia Control	14	51								
Apr. 78			1.40	0.71	-0.11	1.46	0.1	0.8	0.4	0.1
Acid Waste Dumpsite	15	28								
Apr. 78			3.05	0.64	-0.05	0.74	1.6	1.7	1.0	0.5

Table 1. Continued

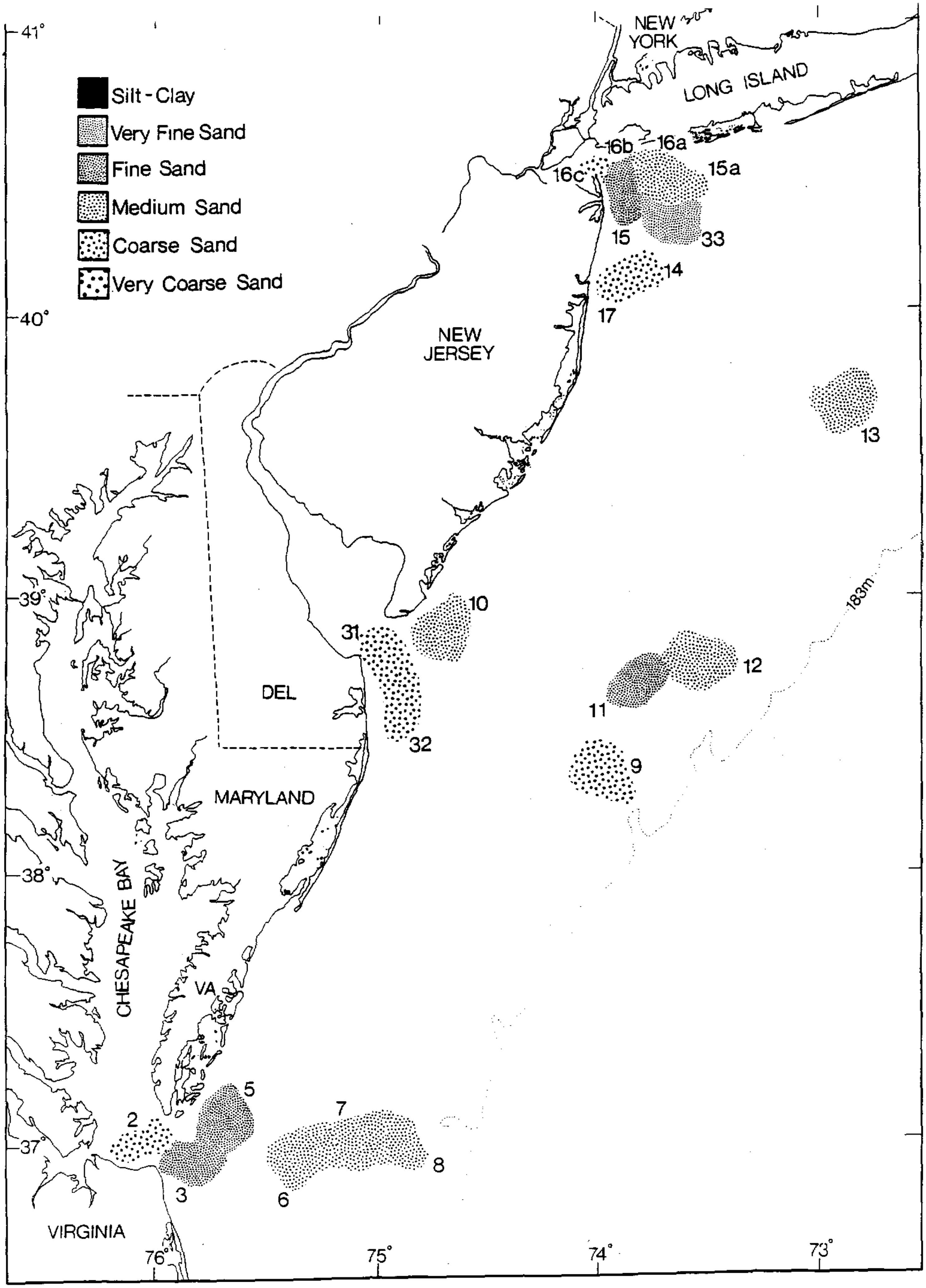
Station Description	Number	Depth	Mean grain size (phi units)	Sorting coefficient	Skewness	Kurtosis	% Silt (4-63 μm)	% Clay (<4 μm)	TOC mg/g dry wt.	TKN mg/g dry wt.
Southern New England:										
Block Island-Inshore	18	47								
Apr. 78			3.48	2.04	0.57	1.80	15.9	6.4	5.6	0.9
Dec. 79			3.76	1.91	0.63	1.56	14.8	11.1	6.8	1.2
Midshelf	19	40								
Apr. 78			1.68	1.28	0.31	1.94	5.5	1.7	2.0	0.3
Dec. 79			1.68	0.71	0.14	11.35	1.4	2.1	1.2	0.2
Outer Shelf	20	119								
Apr. 78			5.63	2.23	0.04	1.12	66.4	15.7	14.0	2.0
Dec. 79			5.90	2.15	0.15	0.90	62.0	22.8	15.2	2.2
Narragansett Bay Mouth	34	30								
Dec. 79			5.69	1.91	0.31	0.92	63.1	17.3	9.1	1.2
Argo Merchant	21	79								
Apr. 79			-0.08	1.84	-0.22	0.67	0.6	0.9	1.4	0.1
Georges Bank:										
Southern Edge	22	114								
Apr. 78			1.31	1.07	0.10	1.40	3.0	1.6	2.5	0.3
Central	23	64								
Apr. 78			2.14	0.64	-0.20	0.80	0.4	1.2	1.2	0.2
North Peak	24	71								
Apr. 78			1.51	0.67	-0.08	1.71	0.2	0.8	0.5	0.1
Dec. 79			1.20	0.92	-0.38	1.97	0.2	0.8	0.5	0.1
Northern New England:										
Massachusetts Bay	35	62								
Dec. 79			5.22	2.19	0.43	1.01	38.6	17.1	9.5	1.3
South Gulf of Maine	28	187								
Apr. 78			6.84	1.69	-0.26	0.62	55.8	41.4	13.0	1.9
Dec. 79			6.97	1.71	-0.44	0.61	49.8	46.8	13.0	1.9
N.E. Channel	25	244								
Apr. 78			2.14	3.85	0.09	0.97	15.1	10.7	5.6	0.7
Central Gulf of Maine	26	213								
Apr. 78			7.19	1.23	-0.11	1.06	73.2	25.0	19.0	2.7

Table 2. Mean values for several sediment parameters at New York Bight benthic stations, July-August 1980. See Figure 5 for station locations. [1]Values are means of single analyses on each of five cores; other values represent single analyses.

Station	Depth m	Mean grain size (phi units)	Sorting coefficient	Skewness	Kurtosis	% Silt (4-63 μm)	% Clay (<4 μm)	TOC mg/g dry wt.
1	27	3.71	1.41	0.44	3.07	12.24	6.17	9.4
2	29	3.35	1.16	0.15	2.75	10.98	3.85	10.1
3	28	3.43	1.08	0.19	2.78	13.21	2.5	7.1
4 (=NEMP 16C)[1]	20	3.12	1.79	0.3	1.59	18.41	3.08	10.0
5	35	4.19	1.59	0.53	1.65	25.06	4.59	16.0
6 (=NEMP 16B)[1]	29	2.3	1.43	0.13	1.59	3.67	3.24	12.0
7 (=NEMP 16A)[1]	25	1.99	0.72	0.15	0.84	0.53	1.03	3.2
8	24	2.37	3.93	0.01	0.88	23.07	9.9	34.0
9	36	3.49	1.62	0.12	1.48	24.1	2.35	13.0
10	61	-0.24	1.64	-0.3	0.94	0.87	1.42	1.6
11	31	3.3	0.96	0.12	2.46	3.12	3.74	5.1
12	38	3.29	1.27	0.12	3.3	5.88	4.88	5.5
13	56	4.25	1.54	0.61	2.85	20.57	3.33	11.0
14	74	2.01	1.69	0.49	2.48	4.89	5.01	4.9
15 (=NEMP 33)[1]	67	3.45	1.31	0.27	3.25	8.4	8.07	9.6
16	71	4.68	1.83	0.67	0.83	28.98	7.92	15.0
17	73	3.62	1.34	0.4	3.35	9.12	8.36	11.0
18	24	2.22	2.73	0.13	1.22	14.81	4.01	14.0
19	14	1.76	0.6	0.26	0.97	0.3	0.71	0.86
20	12	1.96	0.71	0.06	0.8	0.18	0.8	0.95
21	21	3.15	1.4	0.14	2.21	8.17	4.96	12.0
22	24	3.07	0.63	-0.09	0.75	0.9	1.89	2.4
23	16	1.01	0.78	-0.17	0.89	0.05	0.37	0.46
24	18	-0.52	1.36	0.04	0.89	0.04	0.41	1.8
25	19	0.26	1.37	-0.23	1.0	0.13	0.29	0.49
26 (=NEMP 17)[1]	26	1.44	0.71	-0.06	1.36	0.13	0.57	0.53
27	26	1.21	0.8	-0.18	1.18	0.1	0.54	0.58
28	40	2.27	0.56	-0.26	1.08	0.05	0.8	0.82
29	38	1.09	0.93	-0.18	1.12	0.04	0.75	0.63
30	34	1.86	0.72	0.1	0.88	0.14	0.89	0.81
31 (=NEMP 15A)[1]	31	1.3	0.75	-0.09	1.19	0.1	0.67	0.55
32	38	1.19	0.91	-0.19	1.17	0.12	0.63	0.51
33	40	2.37	0.82	-0.18	1.69	0.73	1.68	1.8
34	54	1.77	1.18	0.32	2.0	2.01	3.58	3.4
35	55	2.43	1.55	0.26	3.48	4.29	6.0	3.9
36	56	1.19	0.82	-0.15	1.12	0.19	0.83	0.81

Table 2. Continued.

Station	Depth m	Mean grain size (phi units)	Sorting coefficient	Skewness	Kurtosis	% Silt (4-63 μm)	% Clay (<4 μm)	TOC mg/g dry wt.
37	54	1.41	0.87	-0.1	1.38	0.29	0.84	1.0
38	56	1.05	0.95	-0.19	1.08	0.63	1.25	1.1
39	42	1.42	1.0	-0.14	1.34	0.31	0.89	0.79
40 [1]	29	3.35	1.92	0.28	0.98	29.31	2.67	12.0
41 [1]	21	1.25	0.76	-0.28	1.49	0.08	0.54	0.3
42 [1]	13	0.27	1.98	-0.42	0.7	0.74	0.97	3.4
43 [1]	20	-0.19	1.53	-0.27	0.8	0.12	0.48	1.1
44 [1]	19	-0.2	1.24	-0.05	1.14	0.13	2.3	2.6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Fine Sand
Medium Sand
Coarse Sand
Very Coarse Sand
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40°
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38°
37°
76°
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74°
73°
NEW YORK
LONG ISLAND
NEW JERSEY
DEL
MARYLAND
CHESAPEAKE BAY
VA
VIRGINIA
183m
16b
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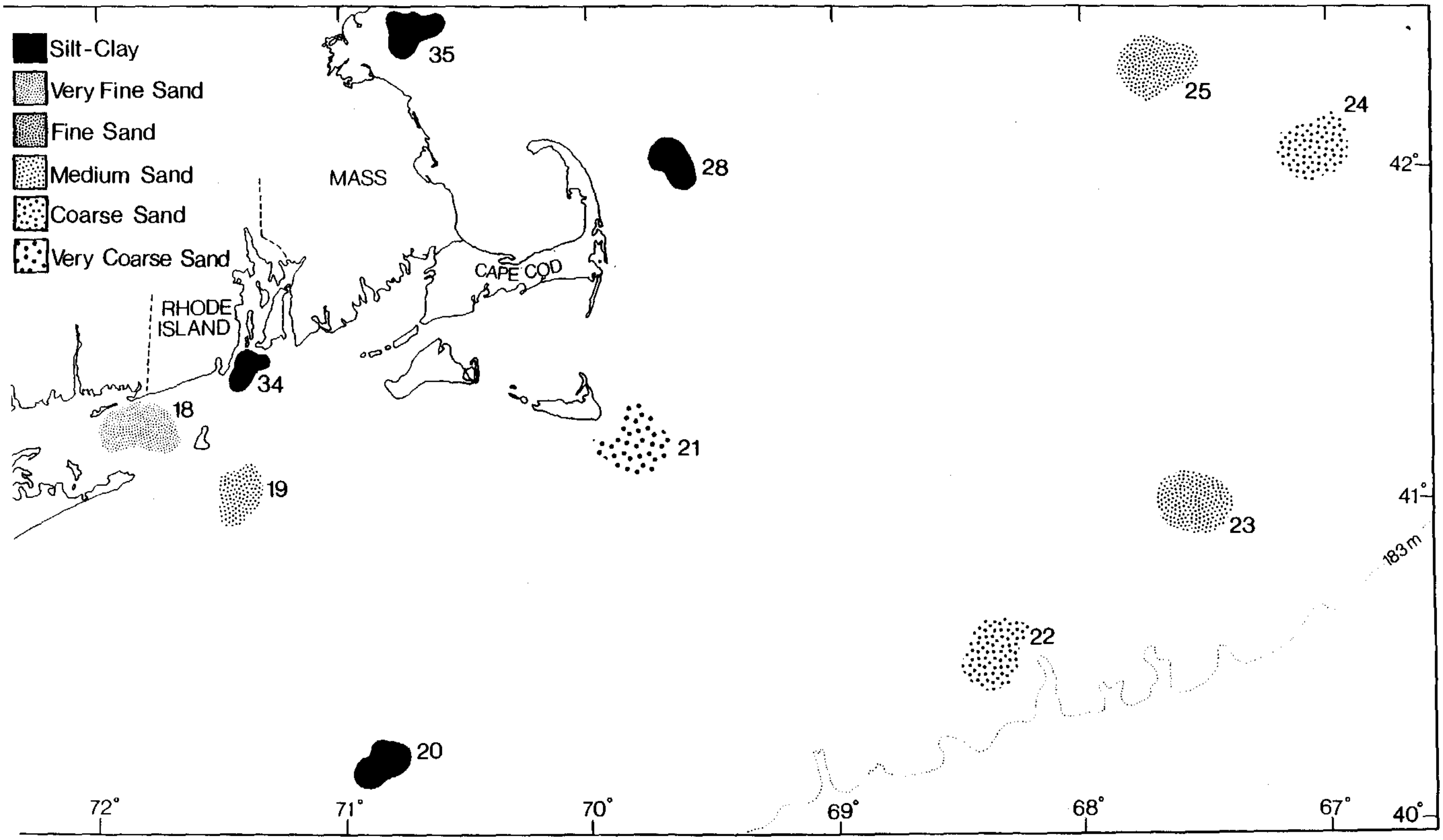

Figure 1, continued.

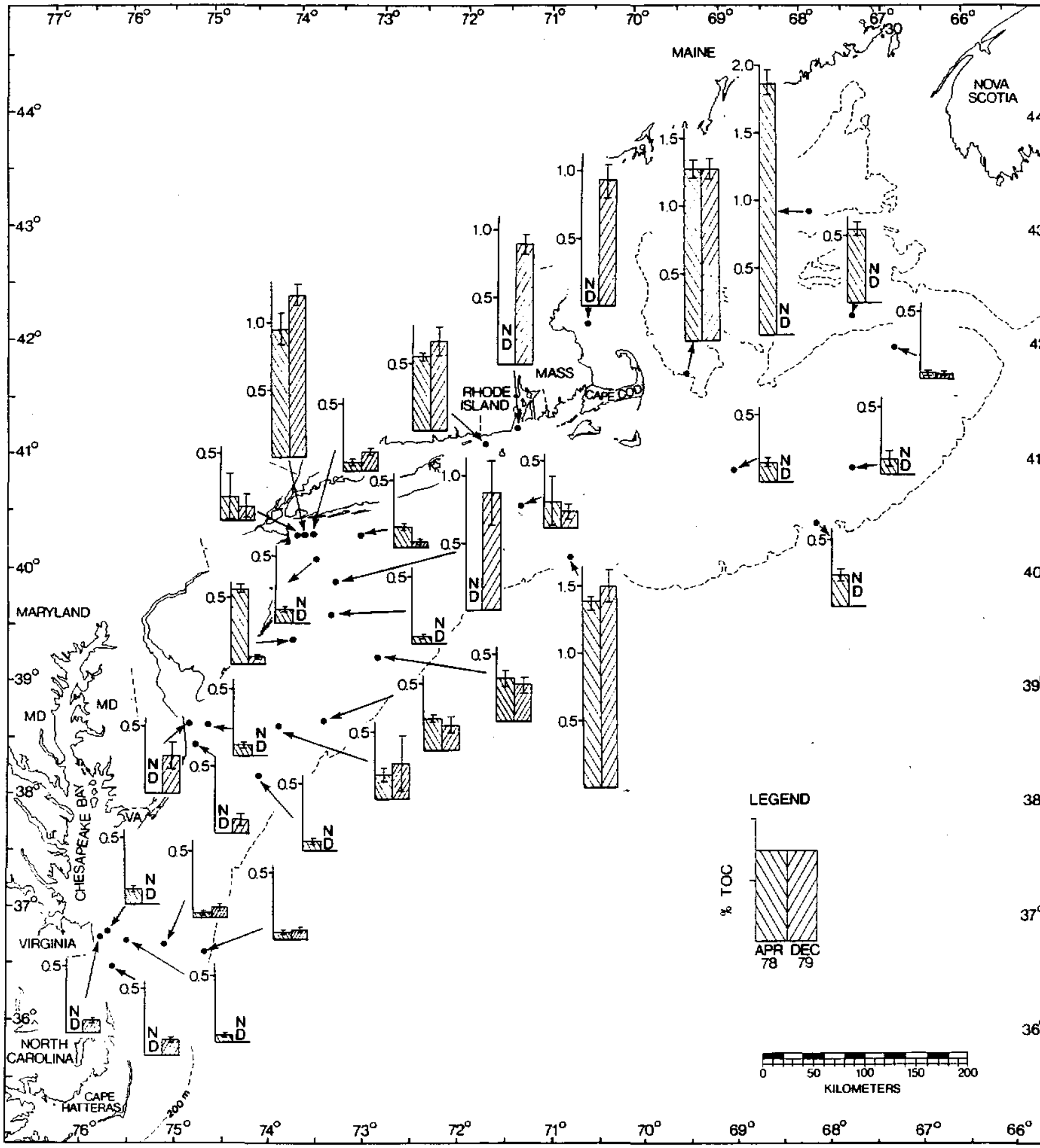

Figure 2. Means and standard deviations for concentrations of total organic carbon (%, dry wt.) found at standard NEMP stations in April 1978 and December 1979. ND = no data.

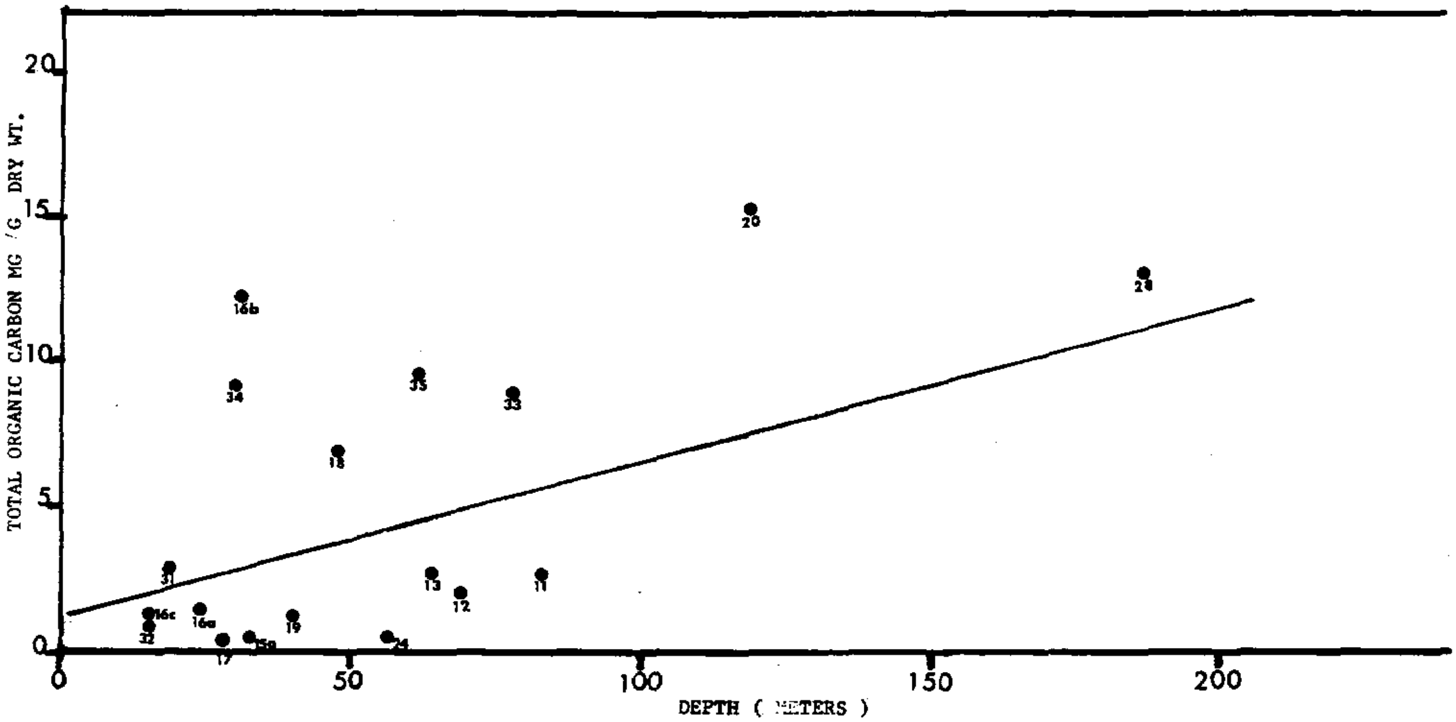

Figure 3. Relationship of total organic carbon to depth for NEMP stations sampled in December 1979.

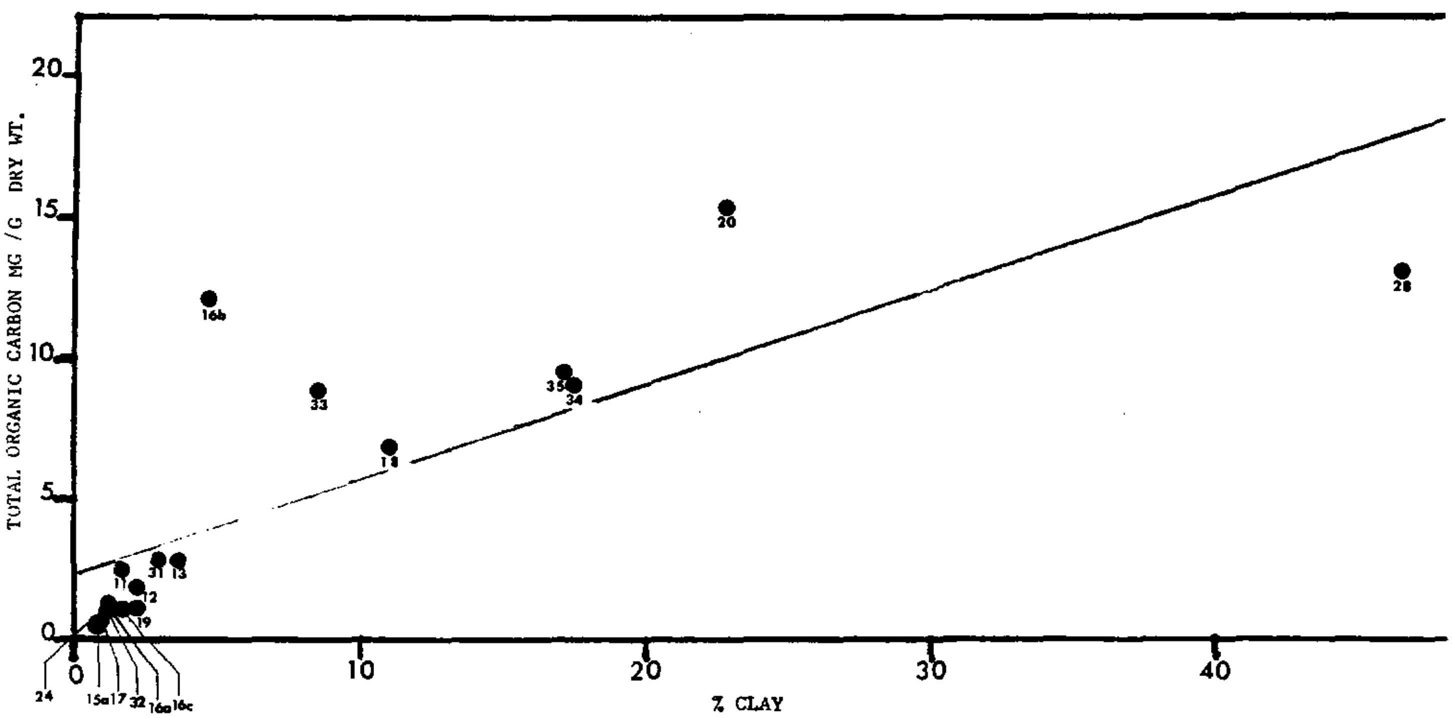

Figure 4. Relationship of total organic carbon to percent clay in sediments for NEMP stations sampled in December 1979.

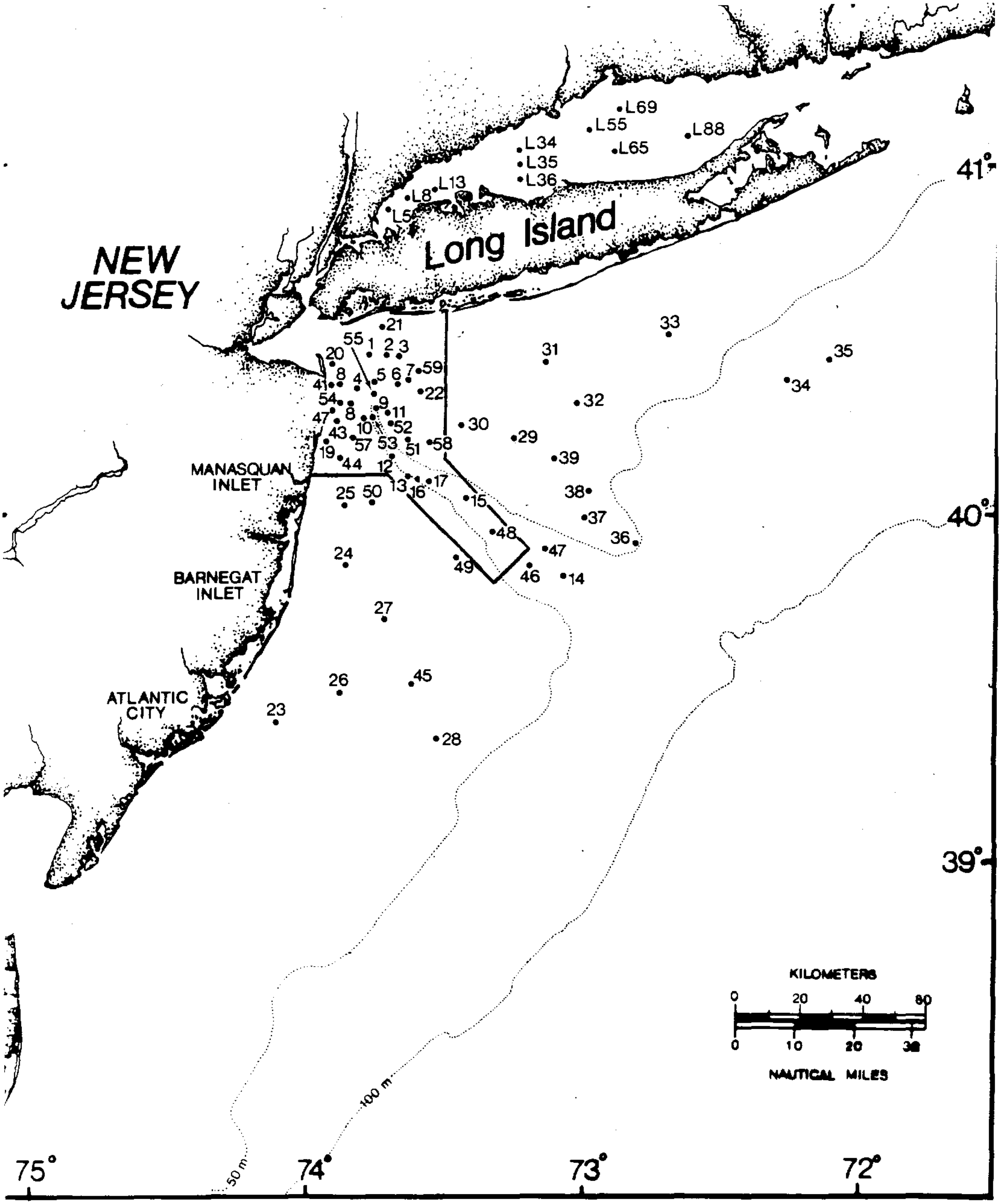

Figure 5. Stations sampled in the intensive New York Bight benthic survey, July-August 1980. Stations within heavy lines in bight apex were tentatively considered "contaminated" for sampling purposes, and those outside the lines, "uncontaminated".

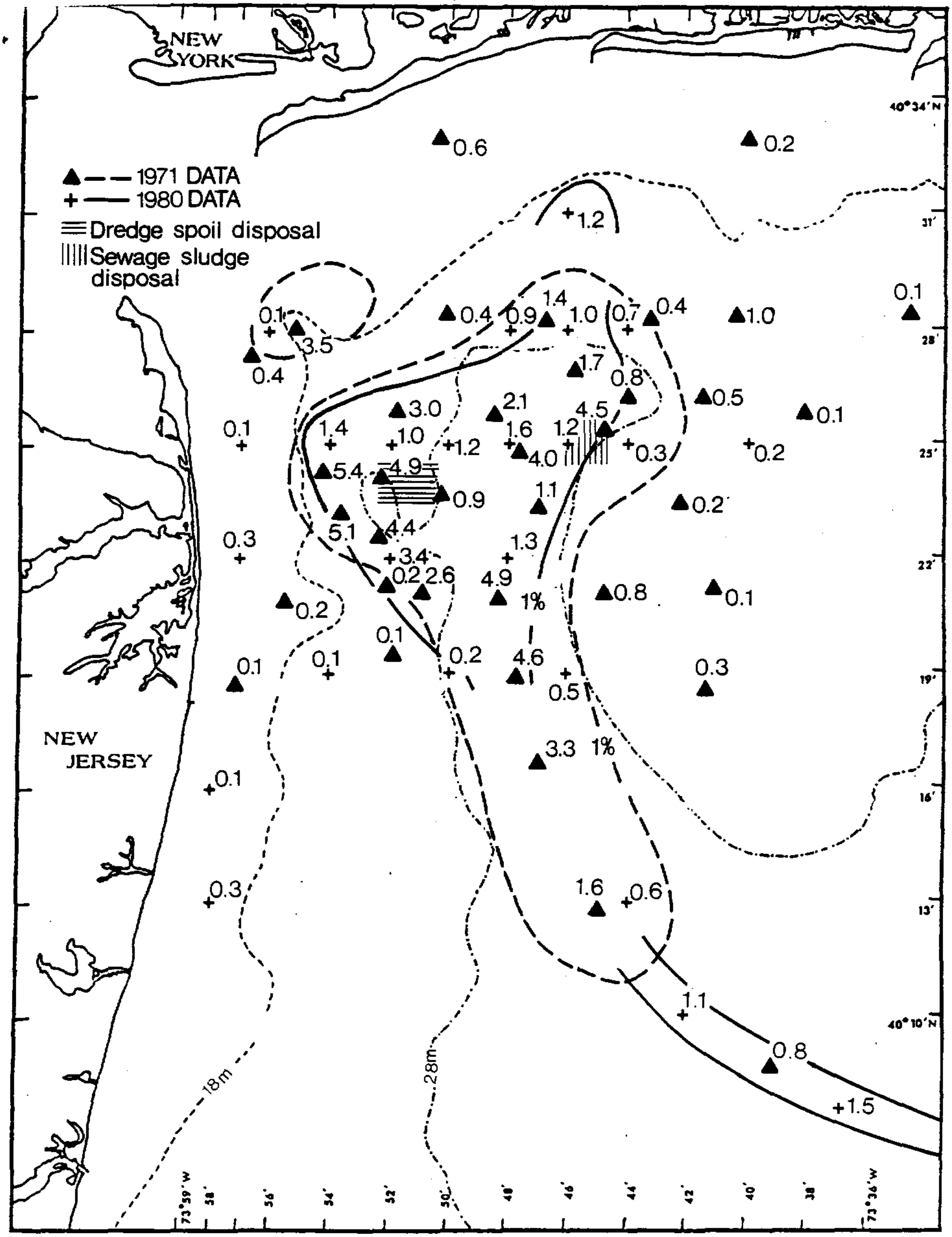

Figure 6. Concentrations of total organic carbon (wt. %) in New York Bight sediments, based on surveys made in 1971 and 1980. Data from each survey are contoured at 1% level. Values and contour for 1971 are from Gross (1976); these values are systematically higher due at least in part to differing analytical methods.