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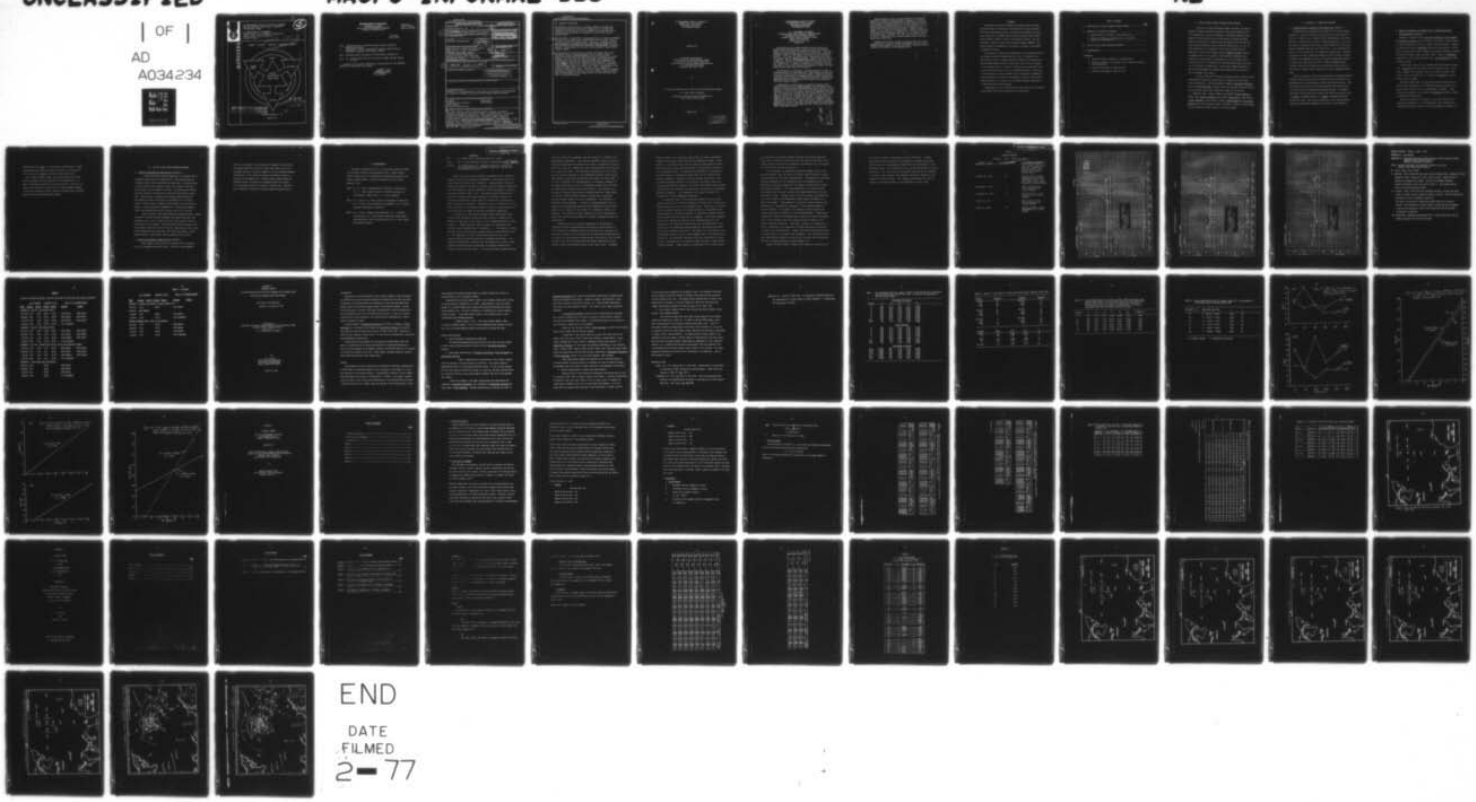

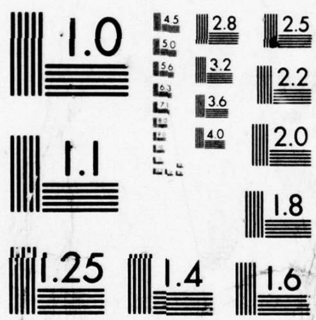
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AN ENVIRONMENTAL SURVEY OF EFFECTS OF DREDGING AND SPOIL DISPOSAL, NEW LONDON, CONNECTICUT: 7TH QUARTERLY REPORT

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region

MIDDLE ATLANTIC COASTAL FISHERIES CENTER

Coastal
SANDY HOOK
MILFORD
CENTER DIRECTORATE SANDY HOOK
The Middle Atlantic
Fisheries Center
OXFORD

Informal Report No. 116

August 1976

DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PENNSYLVANIA 19112

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The Middle Atlantic Coastal Fisheries Center's analysis of benthic macrofauna populations continued to reveal no distinct impact of spoiling outside the immediate disposal area. Only small changes were found between winter 1974 and winter 1975 in species diversity, numbers of individuals and species at four stations located ½ - 1 n.mi from the disposal buoy. Populations of the overall dominant species, Ampelisca vadorum, showed no apparent effects of spoiling. Numbers of individuals

20. Abstract (continued)

and species on the spoil pile in February 1976 were greater than October 1975 values by 200 and 33%, respectively. A cruise was conducted on 25-26 May to provide organisms to the New York Ocean Science Laboratory (NYOSL) for analysis of tissue heavy metals concentrations.

The University of Connecticut, surveying effects of storms on suspended materials in the Thames River, demonstrated that the lower river is not much affected by routine storms. Impacts of dredging on overall concentrations of suspended materials were smaller still, since the area perturbed by the dredge was relatively circumscribed. Suspended material concentrations in the lower river continued to show little temporal change.

Concentrations of heavy metals in tissues of oysters, hard clams and another bivalve, *Pitar morrhuana*, from the Thames showed significant differences both among species and with time for a given species. The data indicates that the species concentrated metals differentially, but that the temporal changes were independent of dredging. No pathological abnormalities were detected in the hard clams sampled in March 1976. Mercury concentrations in river water in February were similar to October 1975 values. Concentrations were highest in bottom waters and in the lower river, suggesting a possible mercury source there. Metals and organic carbon of sediments increased in an upriver direction, and were strongly intercorrelated. Metal concentrations in the dredged portion of the river were lower than in predisposed samples.

AN ENVIRONMENTAL SURVEY OF EFFECTS OF DREDGING AND SPOIL DISPOSAL, NEW LONDON, CONNECTICUT: 7TH QUARTERLY REPORT

Submitted by

Ecosystems Investigations
Middle Atlantic Coastal Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U. S. Department of Commerce
Highlands, New Jersey 07732

to

U. S. Navy, Northern Division, Naval Facilities Engineering Command

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Interagency Scientific Advisory Subcommittee on
Ocean Dredging and Spoiling

August 1976

AN ENVIRONMENTAL SURVEY OF EFFECTS OF DREDGING AND SPOIL DISPOSAL, NEW LONDON, CONNECTICUT: 7th QUARTERLY REPORT

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
MIDDLE ATLANTIC COASTAL FISHERIES CENTER
SANDY HOOK LABORATORY
Informal Report No. 116
August 1976

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Concentrations of heavy metals in tissues of oysters, hard clams and another bivalve, Pitar morrhuana, from the Thames showed significant differences both among species and with time for a given species. The data indicate that the species concentrated metals differentially, but that the temporal changes were independent of dredging. No pathological abnormalities were detected in the hard clams sampled in March 1976. Mercury concentrations in river water in February were similar to October 1975 values. Concentrations were highest in bottom waters and in the lower river, suggesting a possible mercury source there. Metals and organic carbon of sediments increased in an upriver direction, and were strongly intercorrelated. Metal concentrations in the dredged portion of the river were lower than in predisposed samples.

NYOSL deployed an array of current meters at the disposal buoy during a period of stormy weather in February. As in past surveys, both surface and bottom currents had greatest durations in an easterly, or ebbing, direction - surface flow was actually almost halted by strong westerly winds on one flooding tide. Bottom currents during the storm were unusual in having greatest speeds (to 43.9 cm/sec) on flooding tides. Turbidity values were similar to those reported for December 1975. Of the surface drifters released at the disposal buoy, half of the returns reported to date have been to the NE of the buoy, 39% to the SE and 11% to the SW. Seventy per cent of bottom drifter returns have been from the NW, and 30% SW.

Suspended and volatile solids, Eh and pH of the water column in February were similar to values for December 1975 and earlier. Chemical oxygen demand and Kjeldahl nitrogen of sediments tended to increase with proximity to the disposal point.

FOREWORD

This report deals with the seventh three-month period of studies monitoring effects of dredging in the Thames River and spoil disposal at the New London Dumping Ground. Activities and findings of the principal contractor, the Middle Atlantic Coastal Fisheries Center (MACFC), National Marine Fisheries Service, are discussed in detail. All subcontractors' quarterly reports were received by MACFC by 26 Apr 1976. These documents are summarized in the body of the report, and included as appendices thereto.

Overall goals, schedules and methodologies for the monitoring survey are contained in MACFC Informal Report No. 25-A, "A Proposal for an Environmental Survey of Dredging and Spoil Disposal in the Thames River and New London Dumping Ground" (21 May 1974), and will not be repeated in the quarterly reports. Changes or additions will be described in the pertinent quarterly report, but not in subsequent reports. All parties to the operations are again reminded that the stipulation to immediately report any observed violations of the dumping criteria or other impacts judged significant is in effect and an extremely important component of the monitoring and research program.

Reproduction or use of data from these reports must first be approved through MACFC (and through subcontractors if applicable).

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B. Effects of Dredging in the Thames River on Shellfish Resources and Phytoplankton

C. Physical Oceanography of Dump Site Area

D. Chemical Oceanography of Dump Site Area

I. MIDDLE ATLANTIC COASTAL FISHERIES CENTER SUBTASKS

Processing of benthic macrofauna samples continues. We have now analyzed 14 samples taken during the most recent survey (February 1976, or 18 months after the onset of dredging). Preliminary comparisons with January 1975 data indicate that no large changes in species diversity, numbers of individuals or species took place between winters at four stations situated one-half to one mile from the disposal buoy: A3, A9, C9 and F8 (See Figure 6 of Appendix D for locations of these stations). Populations of the overall dominant species, *Ampelisca vadorum*, showed no apparent effects of the dumping. Recolonization continued at the disposal buoy; mean number of individuals per 0.1 m^2 increased from 27 in October 1975 to 87 in February 1976, and mean species number rose from 9.8 to 12.8 during the same period. Data from all samples processed to date are being assembled for computer-based analysis and incorporation into the upcoming final report.

On 25 and 26 May 1976 a hydraulic dredge was used to collect benthic organisms from disposal and control areas for analysis of tissue heavy metal concentrations. Sufficient numbers of quahogs, *Mercenaria mercenaria*, as well as *Pitar morrhuana*, a smaller clam, were collected to permit analysis by both New York Ocean Science Laboratory (NYOSL) and the Milford, Ct., Laboratory, NMFS. Smaller numbers of bloodworms, *Glycera americana*, hermit crabs, *Pagurus pollicaris*, moon snails, *Lunatia heros*, ocean quahogs, *Arctica islandica*, and two smaller bivalves, *Astarte undata* and *Venericardia borealis*, were also provided to NYOSL for analyses. Results of these analyses will be presented in NYOSL's section of the final report.

II. UNIVERSITY OF CONNECTICUT SUBTASKS

A. Suspended Material Transport in the Thames River (Appendix A)

Suspended material concentrations continued to show limited temporal variability. Values were similar to those discussed in prior quarterly reports. In addition to the standard monthly measurements, three surveys were made to study effects of storms on suspended materials. Only one of the storms, an atypically large event in early February 1976, had a major impact on suspended materials in the lower river. It was concluded that this area is for the most part not affected by average storms. Turbidity increases due to major storms were compared to those related to dredging. Increases in the immediate vicinity of an operating dredge were found to be greater than those caused by storms. However, dredging-related increases covered a much smaller area than did those due to storms, so that storms had greater overall impact on the river's suspended material field.

Review of the data on grain size distributions of suspended materials indicates that the Coulter Counter used may have given incorrectly low measurements of the concentrations of small-size particles present. This may necessitate revision of the earlier hypothesis that fine particles were being selectively removed from the dredging plume. An attempt is being made to convert the Coulter Counter data, which are presently based on volumes of suspended materials, to numbers of suspended particles of each size class. The utility of these data in determining dredging impacts and storm effects depends on the success of this conversion.

B. Effects of Dredging in the Thames River on Shellfish Resources and Phytoplankton (Appendix B).

Specimens of three bivalves, *Mercenaria mercenaria*, *Pitar morrhuana* and *Crassostrea virginica*, were collected on 13-15 March 1976 for analysis of tissue concentrations of nickel, cadmium, mercury and copper. Compared to December 1975 samples, *Mercenaria* had 46% and 35% decreases in concentrations of mercury and nickel, respectively, whereas significant increases were found for cadmium (190%) and copper (138%). Nickel in *Crassostrea* decreased 45%, while cadmium increased 340%. *Pitar morrhuana* had a 159% increase in copper.

The March 1976 values were also compared with those obtained in March 1975. *Crassostrea* had lower levels of all five metals in 1976: nickel (-19%), cadmium (-24%), mercury (-34%), zinc (-41%) and copper (-49%). Nickel (+141%) and cadmium (+173%) increased in *Mercenaria*; nickel increased by 180% in *Pitar*.

These data suggest that the three bivalve species concentrate the various metals differentally. The observed changes were thought to be due to natural variation, and to be independent of dredging. Gross pathological examination of the March 1976 *Mercenaria* specimens revealed no discernible abnormalities.

Mercury concentrations in samples of river water collected 19-20 February 1976 averaged 8.2 ± 3.8 nannograms per liter, apparently not significantly different from the 6 ng/l values measured in October 1975.

Mercury values were higher in bottom than in surface waters. Highest concentrations were found on transects II and III, in the lower portion of the river, suggesting a possible mercury source there.

Zinc, copper, cadmium, nickel, lead, mercury and percent organic carbon of sediments are also reported for 19-20 February 1976. All these constituents increased in an upriver direction. There was a reduction in concentrations of metals in lower river sediments compared to July 1974 ("baseline") values. Metals concentrations were in general highly correlated to sediment organic carbon.

III. NEW YORK OCEAN SCIENCE LABORATORY SUBTASKS

A. Physical Oceanography of Dump Site Area (Appendix C.)

A three-current-meter array was deployed at the disposal buoy on 9 February and retrieved on 12 February 1976. The intervening period included two days of fairly high winds and rough seas. As had been found in several prior surveys, surface currents were stronger on ebb tides than on flood, with net movement to the ESE. The surface flood flow was virtually stopped by strong westerly winds during the thrid cycle measured. Bottom currents, although having greatest duration during the ebb (easterly) periods, had highest net and maximum (to 43.9 cm/sec) speeds on flooding tides. Turbidity values obtained on this survey were similar to those encountered in December 1975. Turbidity was slightly lower at the disposal buoy than at a station one n.mi E of the buoy.

Drifter statistics were updated during the reporting period. Twenty-one percent of surface drifters released at the disposal buoy have been recovered to date. Half of these were found in the NE sector, which includes Avery Pt. and eastward. Thirty-nine percent were recovered to the SE or Fishers Island area, and 11% to the SW. Fifty-seven per cent of the bottom drifters have been recovered; 70% of these were found to the NW, between Goshen Pt. and New Haven, and the remaining 30% to the SW.

B. Chemical Oceanography of Dump Site Area (Appendix D)

Water samples were collected on 10 February 1976 for analysis of pH, Eh, suspended and volatile solids. Values for these parameters were as a rule similar to those measured in December 1975 and earlier. The largest change was in volatile solids, which made up 23% of all suspended materials in February, compared to 14% the preceding December. Concentration of the volatile solids was not obviously related to distance from the dumping buoy. Sediment chemical oxygen demand and Kjeldahl nitrogen are reported for September-October 1975 samples, as are preliminary results for nitrogen in February 1976. These data show a tendency for COD and N to increase toward the disposal point.

V. ACKNOWLEDGMENTS

This work is supported by the U. S. Navy through contract #74-00001 with the Middle Atlantic Coastal Fisheries Center. Middle Atlantic Coastal Fisheries Center has subsequently subcontracted portions of the study to UCONN and NYOSL. Principal investigators for the various subprojects are:

UCONN - Dr. W. F. Bohlen (Suspended Material Transport, Thames River); Dr. S. Y. Feng (Dredging Effects on Shellfish Resources and Phytoplankton, Thames River); Dr. J. Cooke (Geofungi).

NYOSL - Dr. S. Karp, Mr. H. DuBois (Chemical Oceanography of Dump Site); Dr. R. Valenti (Fish Distribution and Abundance); Dr. R. Hollman (Physical Oceanography of Dump Site).

MACFC - Mr. A. Draxler (Sediment Trap Experiments); Dr. J. Graikoski (Microbiology); Mr. R. Reid (Benthic Macrofauna, SCUBA Surveys, Cage Experiments, Contract Representative); Mr. R. Greig (Lobster Heavy Metals Analysis).

APPENDIX A

To: Dr. Robert Reid, Monitoring Project Leader

From: Dr. W. Frank Bohlen, Principal Investigator W. F. Bohlen.

Subject: The investigation of suspended material transport in the Thames Estuary: Progress report for the quarter ending March 31, 1976.

During the past quarter monthly surveying of the suspended material field and concurrent hydrographic conditions within the lower Thames River has been continued. Concentrations observed during this period continue to display limited temporal variability with characteristic values similar to those discussed in previous quarterly reports (Figs. 1-3). The monthly data acquired over the last two years are being reviewed to develop estimates of average concentration levels expected during lows, average and high streamflow conditions. These data will be combined with flow data provided by the hydraulic model to assist in computations of mass flux over the range of typical streamflow conditions.

In addition to the monthly surveys three additional field surveys were conducted during the past quarter to examine the effects of aperiodic storm events in the suspended material field (Table 1). These data are being reviewed in combination with previous storm observations to determine: 1. The degree to which routine storm events perturb average material concentrations and 2. The magnitude of storm induced perturbations vis-a-vis concentration variations produced by dredging operations. Preliminary observations indicate that the majority of storm events produce relatively minor variations in average concentration levels within the study area. Of the three events sampled during the past quarter for example, only the storm of 1 February produced major alterations. This was an extremely high energy event with wind velocities in excess of 25 m/sec., atmospheric pressure below 73 cm Hg. and significant tidal perturbations that resulted in a record low tide. The infrequent occurrence of such events and the limited response of the suspended material field during more typical storms (see survey data for March 18, 1976 (Figs. 1-3) e.g.) indicates that considerations of material transport in the lower river may be able to reasonably assume that this area is effectively isolated from storm effects. The salinity and concurrent density distributions characterized by a high degree of vertical stratification despite limited river discharge provide further support for this assumption. Its accuracy is presently being examined. A review of meteorological data designed to quantitatively determine the frequency of major storm events (i.e., similar to the storm of 1 February, 1976) is in progress. The results of this evaluation will be incorporated within the initial calculations of material transport within the study areas.

Comparisons of the relative magnitude of variations in suspended material concentrations produced by storm events to those induced by dredging operations indicate that although concentration levels in the vicinity of the operating dredge are well in excess of those observed during major storm events, the limited spatial scale of the perturbation precludes significant alterations of the concentration field in the lower river. Dredging effects appear to be primarily local with the major variations confined to an area within 150m of the dredge-and barge. Storm events, on the other hand, tend to perturb concentration levels over the entire study area and produce a significant increase in total suspended load. In addition the frequency of occurrence of storm events is typically higher than that of routine maintenance dredging. Although the quantitative character of each of these phenomena remains to be finally evaluated, these preliminary observations suggest that within the Thames River natural storm events will dominate the aperiodic variability of suspended material transport. This dominance will persist despite the presence of routine dredging operations.

An essential part of the sampling program during the past quarter consisted of detailed analyses of grain size distributions characteristic of the *total suspended load*. These data, obtained using a Coulter Counter, are being reviewed in combination with those obtained in previous quarters to determine seasonal trends, storm effects and the influence of dredging. Particular emphasis during this quarter was placed on the determinations of the accuracy of the hypothesis that grain size distributions in the vicinity of the operating dredge-barge are noticeably deficient in the finer grained fractions. (See March 31, 1975 report e.g.) Preliminary results of this study suggest that this hypothesis is incorrect. The observed variations are most probably the result of bias introduced by the Counter during analysis of high concentration samples. Large numbers of particles / unit volume result in significant coincident passage through the sensing aperture. Under these conditions two small particles may be recorded as one large particle and then the resultant distribution will be biased in favor of the coarser fractions.

In the process of examining variations in grain size it was also determined that the plots of counter output provide a false representation of the size distributions. Discussions in previous reports proceeded on the assumption that the graphical data provided an accurate measure of the number of particles in each size range (channel). The investigations of the past quarter have found that the plot actually provides an indication of differential volume. Voltage output from the counter is proportional to the volume of the particles rather than the number in a given size range. Determination of particle counts requires the addition of a "population accessory" to the standard Model TA Coulter Counter. At present, the absence of this device precludes quantitative analysis of size distributions. Qualitative evaluations using the available plots tend to be quite inaccurate since the volumetric data are heavily biased in favor of the larger diameter particles. This bias, evident in virtually all plots, complicates the resolution of small amplitude variations in grain size distributions. These limitations become particularly troublesome as the grain size decreases. The resultant errors can significantly reduce the utility of the data within determinations of dredging impacts, storm effects, etc.

During the past month a study of the absolute resolution of the Coulter Counter techniques has been initiated. A model relating relative volumetric distributions to grain size populations has been developed and applied to the conversion of the previous plots. The accuracy of this conversion process is being evaluated. The utility of the available data within our efforts to resolve small spatial and temporal variations depends on the results of these studies. The complete evaluation will be included in the final report to be presented in June, 1976.

TABLE 1

SURVEY SUMMARY

January 1, 1976 - March 31, 1976

Date	No. of Stations	Parameters Sampled
January 6, 1976	4	After storm survey; susp. load, water temp., salinity, dissolved organic carbon, (DOC) particulate organic carbon (POC).
January 30, 1976	12	Monthly survey, water temperature, salinity, suspended solids, DOC, POC, grain size, ortho-phosphate concentrations.
February 3, 1976	5	After storm survey, same parameters as 1/6/76 survey.
February 25, 1976	12	Monthly survey, same parameters as 1/30/76 survey.
March 18, 1976	5	After storm survey. Same parameters as 1/6/76 survey.
March 26, 1976	12	Monthly survey. Same parameters as 1/30/76 survey.

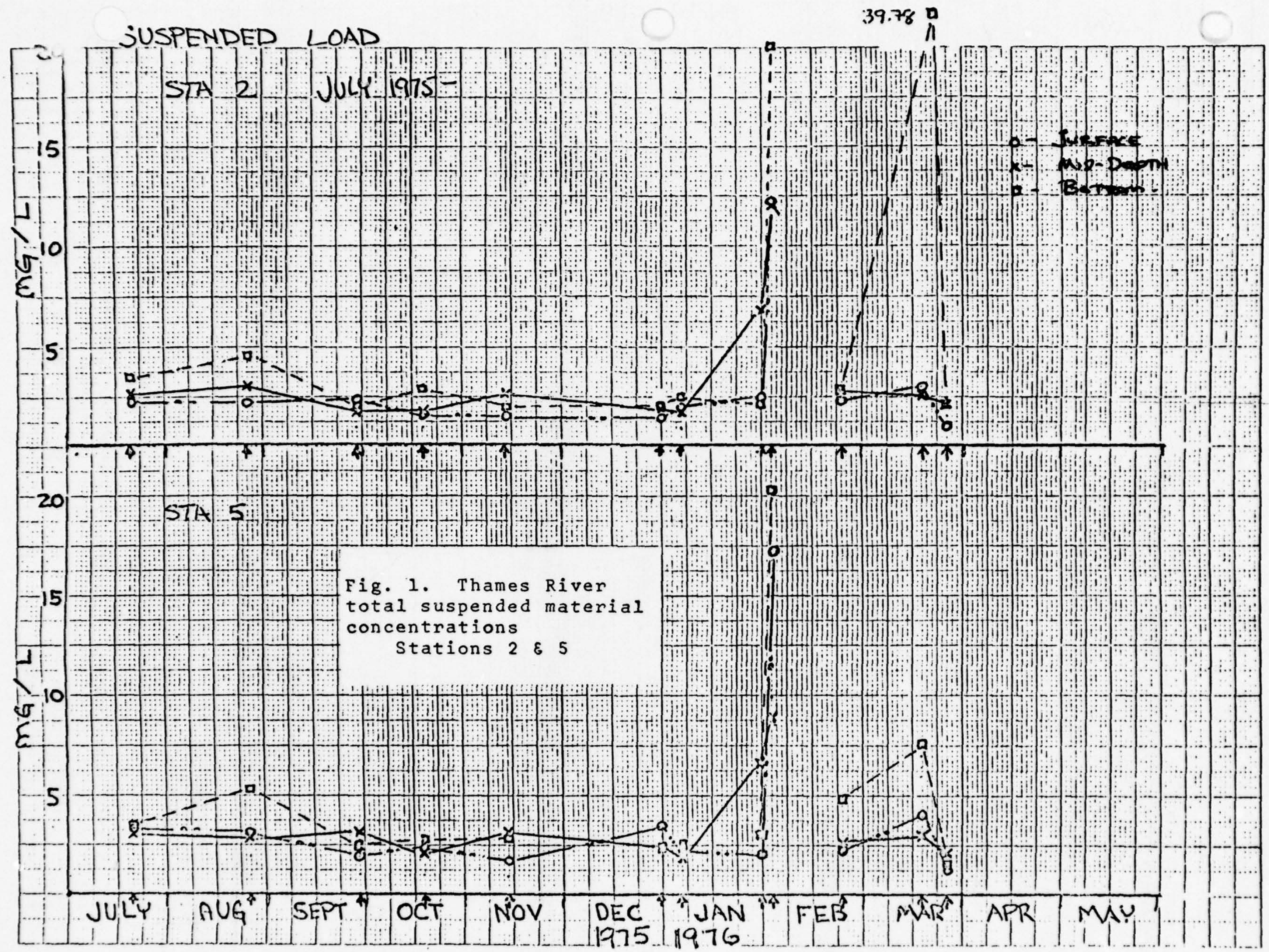

Fig. 1. Thames River total suspended material concentrations Stations 2 & 5

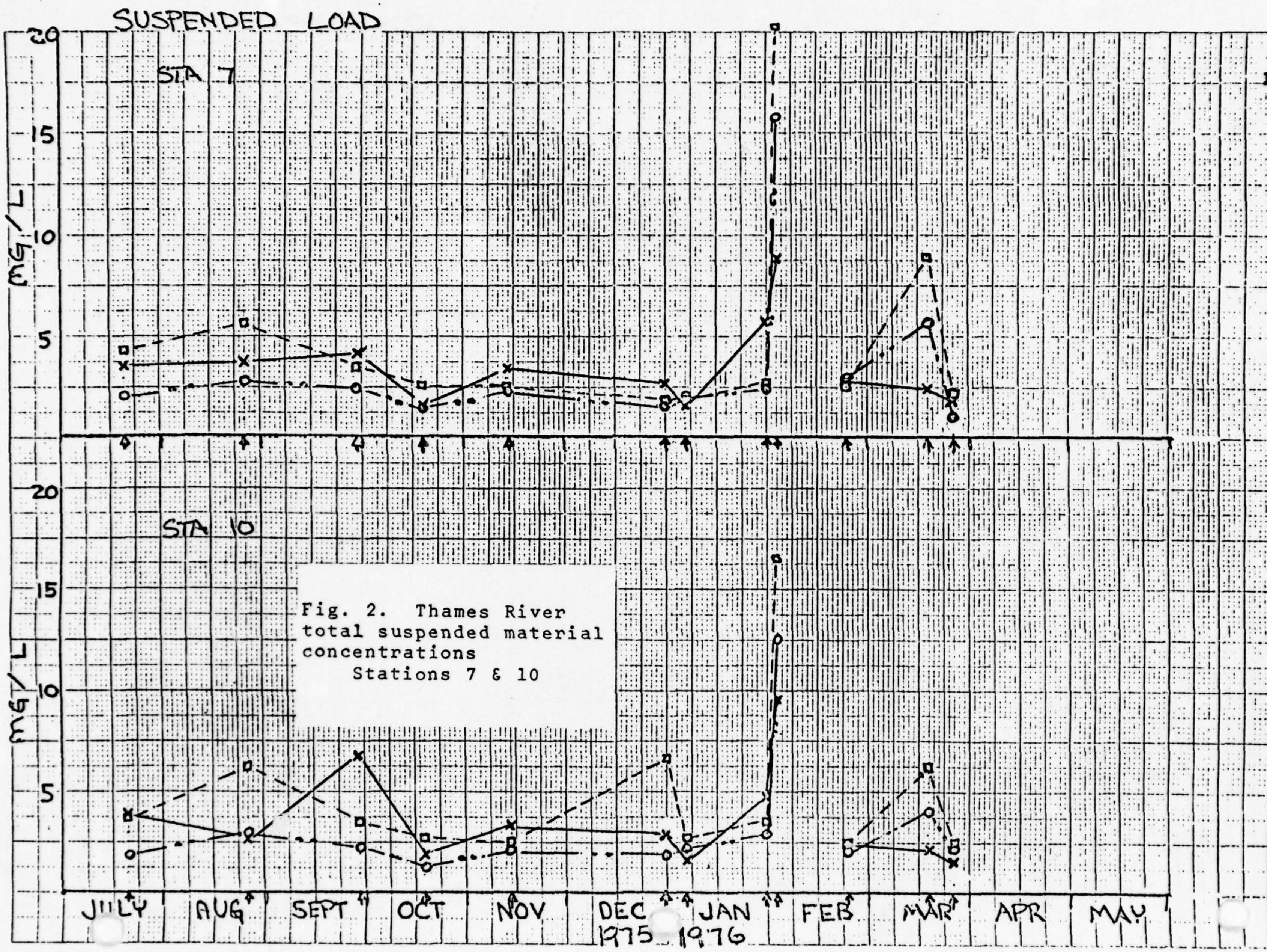

Fig. 2. Thames River total suspended material concentrations Stations 7 & 10

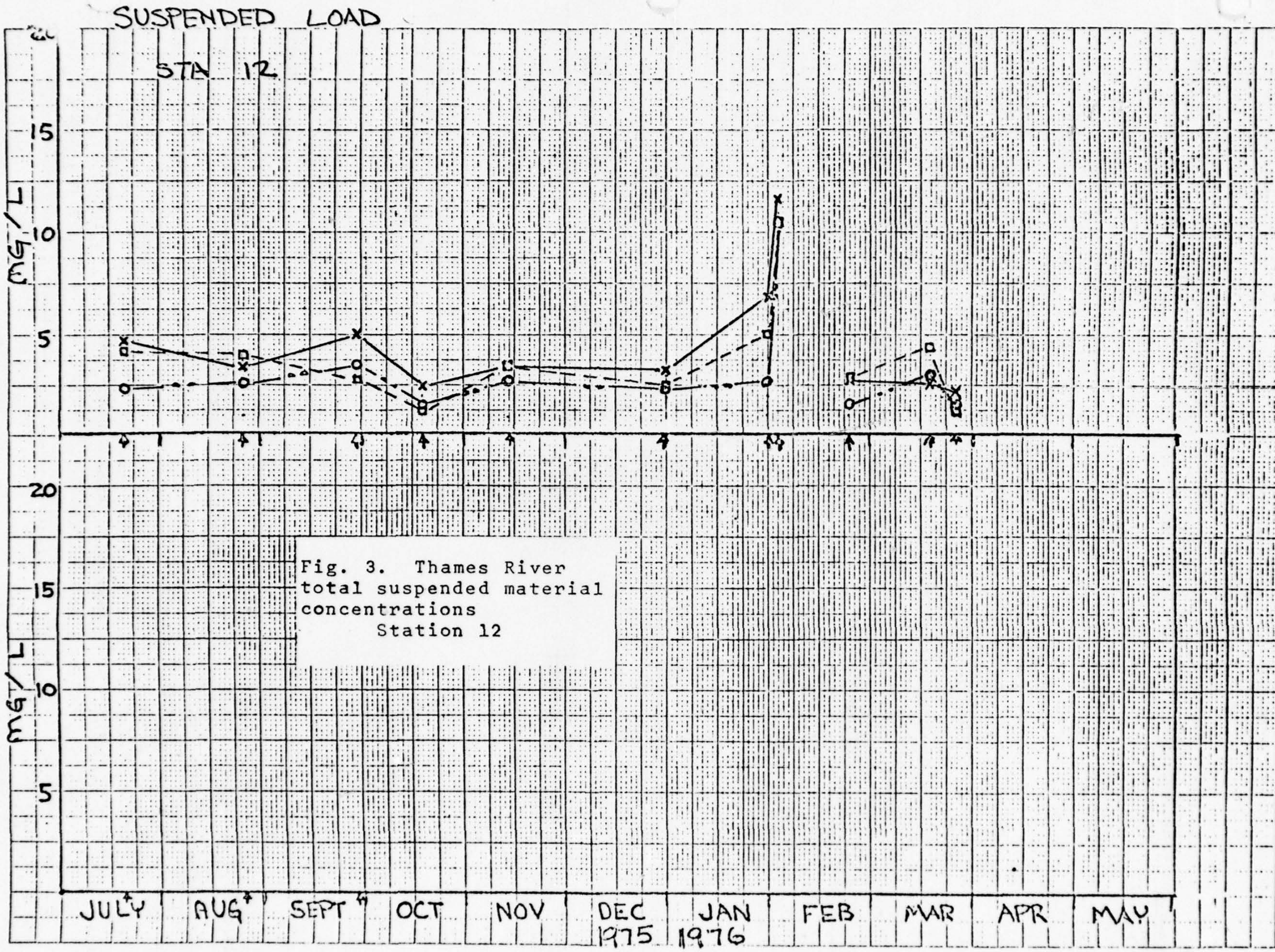

Fig. 3. Thames River total suspended material concentrations Station 12

QUARTERLY REPORT: January - March, 1976.

CONTRACT NO. 03-5-043-302

SUBMITTED TO: Sandy Hook Laboratory, Middle Atlantic Coastal Fisheries Center, National Marine Fisheries Services NOAA/U.S. Department of Commerce

TITLE: Geofungi associated with suspended sediments in the main channel of the Thames River Estuary.

By John C. Cooke, Ph.D. Biology

I. Sampling: Four cruises have been made on the following dates: December 30, 1975; January 30, 1976; February 25, 1976; March 26, 1976. Sampling data for December and January are complete. Data for the November, December, January and February cruises are given in Table I. The methods used are given in the Second Quarterly Report.

II. Results: Table I lists the total suspended sediments, salinity and total number of fungal colonies present for samples collected. Data for February 25 and March 26 are not complete at this time.

The number of colonies per sample were notably high for all sites in January. The differences in colony counts in surface and bottom samples as well as the differences noted in the Estuary and Sound are related to variation in salinity.

III. Future Work: Additional watersamples will be taken during April and May. Further analysis of the data will be made.

TABLE I

Amount of suspended sediment, salinity and number of fungi from each station indicated.

	mg/1 SEDIMENT		SALINITY (S ‰)		TOTAL # OF COLONIES/SAMPLE	
DATE	Surface	Bottom	Surface	Bottom	Surface	Bottom
STATION A: Buoy #2 - New London Harbor						
11-17-75	2.75	2.04	24.27	29.87	67/6 plates	33/6 plates
12-30075	1.98	1.96	25.55	30.26	64/6 plates	38/6 plates
1-30-76	6.81	2.28	12.31	28.38	97/6 plates	84/6 plates
2-25-76	2.82	2.82	27.43	29.33	To be examined	
STATION B: Buoy #6 - New London Harbor						
11-17-75	3.22	3.02	14.49	28.01	74/6 plates	55/6 plates
12-30-75	2.44	2.46	17.03	29.33	75/6 plates	53/6 plates
1-30-76	4.20	3.00	13.73	28.38	130/6 plates	69/6 plates
2-25-76	2.68	4.82	19.87	29.33	To be examined	
STATION D: Buoy #2 - Thames River (North of Gold Star Memorial Bridge)						
11-17-75	3.38	2.58	7.03	28.95	69/6 plates	40/6 plates
12-30-75	2.52	6.66	8.06	29.03	81/6 plates	59/6 plates
1-30-76	4.80	3.53	2.87	27.91	126/6 plates	107/6 plates
2-25-76	2.46	2.15	5.70	29.33	To be examined	
STATION E: Vixen Ledge (Red Buoy Marker)						
11-17-75	1.22		29.87		43/6 plates	
12-30-75	1.36		29.33		54/6 plates	
1-30-76	3.00		28.38		64/6 plates	
2-25-76	1.42		29.33		To be examined	

TABLE I - continued

DATE:	mg/l SEDIMENT Surface	Bottom	SALINITY (S ‰) Surface	Bottom	TOTAL # OF COLONIES/SAMPLE Surface	Bottom
STATION F:	Mumford Cove (West of Channel Marker #5)					
11-17-75	1.29		28.01		25/6 plates	
12-30-75	NOT SAMPLED					
1-30-76	1.75		28.38		46/6 plates	
2-25-76	1.64		27.43		To be examined	
STATION:	INTREPID ROCK (East of Buoy Marker)					
11-17-75	1.84		28.95		24/6 plates	
12-30-75	2.05		30.20		29/6 plates	
1-30-76	4.79		29.32		59/6 plates	
2-25-76	1.78		27.43		To be examined	

APPENDIX B

QUARTERLY REPORT

AN INVESTIGATION ON THE EFFECTS OF DREDGING IN THE THAMES RIVER ON SHELLFISH RESOURCES AND PHYTOPLANKTON

(Contract No. 03-5-043-301)

January 1, to March 31, 1976

Submitted to
Sandy Hook Laboratory, Middle Atlantic Coastal Fisheries Center
National Marine Fisheries Service
N. O. A. A.
U. S. Department of Commerce

by

S. Y. Feng
Marine Research Laboratory
University of Connecticut
Noank, Connecticut, 06340

March 31, 1976

Introduction

Monitoring of the concentration of zinc, copper, cadmium, nickel and mercury in shellfish and sea water samples obtained from Thames River has been continued. In addition, we have determined the concentration of the above mentioned heavy metals as well as the percent organic carbon in the sediment samples. We have also participated in the 1975 Trace Metal Intercalibration Exercise sponsored by the International Council for the Exploration of the Sea. A copy of our report containing the results obtained in this Laboratory was submitted to Dr. John B. Pearce on January 14, 1976.

Fourteen samples of Mercenaria mercenaira (112 clams), 12 samples of Pitar morrhuana (177 individuals) and 4 samples of Crassostrea virginica (32 oysters), were collected from the established stations on March 13-15, 1976. Sampling of shellfish was conducted on board Ellen J. of the Division of Aquaculture, Connecticut State Department of Agriculture.

Twenty four sea water samples for the analyses of heavy metals other than mercury, a duplicate set of 24 sea water samples for mercury determinations as well as 64 water samples for chlorophyll analyses were obtained from the six transects in the River on February 19-20, 1976. These samples represent samplings conducted during high and low water at New London Harbor.

Methods

The procedures for gross examination of pathological conditions, determination of heavy metals in shellfish samples as well as analysis of chlorophyll a, b and c, were detailed in the original proposal. Concentrations of mercury in water samples were determined by the method of Fitzgerlad et al. (1974). Zinc, copper, cadmium, nickel and lead in water samples were determined by a modified APDC-MIBK extraction procedure of Brewer et al. (1969), which was detailed in the fifth quarterly report.

The procedures for analyzing heavy metals in sediment samples were similar to those outlined in the six quarterly report.

Determinations of percent organic carbon in the sediment samples were carried out by the method of Gaudette et al. (1974). Approximately 0.3 gm (oven dried weight) of a sediment sample were oxidized with potassium dichromate and concentrated sulfuric acid. The excess dichromate is titrated with a ferrous ammonium sulfate solution. The percent organic carbon in the sediment sample is then calculated by the following equation:

$$\% \text{ Organic carbon} = 10\,(1 - T/S)\,[1.0N\,(0.003)\,(100/W)],$$ where

W= grams of sediment sample, T= mls of ferrous ammonium sulfate solution titrated and S= mls of ferrous ammonium sulfate solution used to titrate the blank.

Results and Discussion

A. Gross Pathological Examination of Shellfish

No discernible abnormalities were noticed in the inner and outer aspects of gills, palps and the pericardial cavity of the 112 Mercenaria mercenaria examined.

B. Heavy Metal Concentrations in Mercenaria mercenaria, Pitar morrhuana and Crassostrea virginica.

Table I summarizes the concentration of zinc, copper, cadmium, nickel and mercury in the three species of shellfish. The results should be compared with Table I of the previous quarterly report. Of the 15 cases examined for the three species of shellfish (5 metals X 3 species), the metal concentrations in 8 cases were found to be not significantly different from that of the December 1975 samples.

Significant changes in the metal concentration were encountered most frequently in Mercenaria mercenaria, less frequently in Crassostrea virginica and least often in Pitar morrhuana. The mean concentrations of mercury and nickel in

Mercenaria mercenaria show a 46% and 35% decrease respectively as compared with that of the December 1975 samples. Cadmium and copper concentrations, on the other hand indicate a significant increase, i.e., 190% and 138% respectively, from that of the last quarterly samples. The levels of zinc remain essentially unchanged.

In *Crassostrea virginica*, the mean nickel concentration has decreased 47%, while the cadmium level has shown an increase of nearly 340% as compared with that of the December 1975 samples. No significant changes in the concentration of mercury, copper and zinc are apparent.

Copper was the only metal found in *Pitar morrhuana* to exhibit significantly higher levels (159%) than the previous samples.

A comparison of the results from this quarter with that of March 1975 reveals that only 3 out of the 15 cases show increases in heavy metals, 7 cases remain unchanged and 5 cases exhibit a reduction of heavy metal contents. In *Crassostrea virginica*, all five metals are reduced significantly in the following order: nickel (-19%), cadmium (-24%), mercury (-34%), zinc (-41%) and copper (-49%). Nickel and cadmium show 141% and 173% increase respectively in *Mercenaria mercenaria*. In *Pitar morrhuana*, nickel is the only metal showing a 180% increase.

These observations suggest that handling of the five heavy metals by the three species of bivalve molluscs is different and that the observed changes are probably within the limits of normal variations and independent from dredging.

C. Mercury Concentration in Thames River Water Samples

Mercury profile in the surface and bottom water during high and low tide for February 19-20, 1976, is shown in Table II and Figure 1. The mean concentration of mercury in the river water samples is 8.2± 3.8 ng/L, which is probably not significantly different from 6 ng/L of the October 1975 samples. It is also shown that the concentration of mercury in the bottom water is higher than that in the surface water regardless of the phase of tide. This apparent stratification of mercury in the water column is probably associated with the stratified salinity regime of the river. The highest mercury concentration is found in the bottom water at Transect II (LW) and Transect III (HW); this observation may suggest the possible existence of a mercury source in the lower river.

D. Zinc, Copper, Cadmium, Nickel, Lead, Mercury and Percent Organic Carbon Content in the Sediment Samples.

The results of heavy metal and organic carbon content in the sediment samples are summarized in Table III. As shown in the July 1974 samples, heavy metal concentrations in the sediment increase toward upper river. There is a discernible reduction of heavy metal in the lower river transects (I, II and III) as compared with the July 1974 samples; these reductions are particularly noticeable in copper, nickel, lead and mercury. The percent organic carbon content of the sediments in the river shows a similar pattern of distribution as the heavy metals. When the metal and percent organic carbon data are subjected to linear regression analysis, it is revealed that the metal concentration, with the exception of Ni, is correlated with the percent organic carbon content in the sediment. The linear regression equations which describe this relationship, are summarized. Table IV and Figures 2, 3 and 4.

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Brewer, P.G., D.W. Spencer and C.L. Smith 1969. Determination of trace metals in sea water by atomic absorption spectrophotometry. Atomic Absorption Spectros., ASTM, STP. 433, 70-77.

Fitzgerald, W.F., W.B. Lyon and C.D. Hunt 1974. Cold trap preconcentration method for the determination of mercury in sea water and in other natural materials. Anal. Chem., 46, 1882-1885.

Gaudette, H.E. and W.R. Flight 1974. An inexpensive titration method for the determination of organic carbon in recent sediments. J. Sedimentary Petrology 44 (1), 249-253.

TABLE I. The concentration of zinc, copper, cadmium, nickel and mercury in shellfish from the Thames River, March 13-15, 1976. The results are expressed as ppm (freeze-dry weight).

Station	Zn	Cu	Cd	Ni	Hg
			Mercenaria mercenaria		
B	244	16.4	2.07	9.21	0.160
C	287	15.8	2.25	10.23	0.148
D	262	17.6	2.16	8.56	0.167
E	210	20.2	2.24	10.22	0.242
F	281	26.4	2.25	6.82	0.217
G	279	24.5	1.72	6.54	0.314
H	239	35.4	1.81	6.36	0.254
Mean	257	22.3	2.07	8.28	0.214
S.D.	28	7.0	0.22	1.70	0.060
			Pitar morrhuana		
A	231	11.1	4.89	9.54	0.192
B	384	15.6	4.45	11.14	0.232
C	333	15.1	3.74	9.31	0.195
D	524	18.3	3.68	9.32	0.210
E	509	19.0	3.04	8.40	0.217
F	372	18.1	2.90	6.36	0.164
G	406	16.4	3.34	9.08	-----
Mean	396	16.2	3.72	9.02	0.202
S.D.	101	2.7	0.73	1.44	0.024
			Crassostrea virginica		
O-II	11,600	630	4.31	4.09	0.265
O-III	9,000	487	3.69	4.54	0.259
O-VI	6,100	336	3.78	4.09	0.220
O-VII	7,300	437	4.93	4.09	0.220
Mean	8,500	472	4.18	4.20	0.241
S.D.	2,400	122	0.57	0.22	0.024

TABLE II. Mercury concentrations in Thames River Water (ng/L), February 19-20, 1976.

Transect	Hg(ng/L)	Transect	Hg(ng/L)
I-LW-S	9	IV-LW-S	4
-B	8	-B	6
HW-S	14	HW-S	6
-B	8	-B	9
II-LW-S	6	V-LW-S	4
-B	14	-B	8
HW-S	6	HW-S	6
-B	7	-B	12
III-LW-S	7	VI-LW-S	4
-B	7	-B	10
HW-S	4	HW-S	6
-B	19	-B	14

Samples	Mean	S.D.	S.E.	N
LW-S	5.7	2.06	0.84	6
-B	8.8	2.86	1.17	6
HW-S	7.0	3.52	1.44	6
-B	11.5	4.50	1.84	6
LW + HW	8.2	3.85	0.78	24

TABLE III. The concentration of zinc, copper, cadmium, nickel and mercury, and organic carbon content in the sediment samples from the Thames River, February 19-20, 1976. The results are expressed as mean ppm for heavy metals and as mean percent for organic carbon. The mean is calculated from three grab samples from each transect.

Transect	Zn	Cu	Cd	Ni	Pb	Hg	% Organic C
I	96	11.2	0.71	17.00	23.66	0.111	1.64
II	226	14.2	1.45	38.12	32.41	0.089	2.61
III	248	20.9	1.77	47.79	45.67	0.184	3.10
IV	218	16.7	1.48	38.13	34.39	0.200	2.89
V	360	36.1	2.17	45.95	71.47	0.181	4.67
VI	811	85.6	4.45	51.45	150.42	0.729	8.14

TABLE IV. Linear regression analysis of organic carbon (%) vs. heavy metals in the sediment samples, February 19-20, 1976.

% Organic C vs.	Regression Equations	r	n
Zn	Y = 102.79 X - 68.47	0.89	18
Cu	Y = 11.81 X - 14.58	0.96	18
Cd	Y = 0.54 X - 0.07	0.98	18
Ni	Y = 3.92 X + 24.70	0.61	18
Pb	Y = 19.94 X - 16.96	0.96	18
Hg	Y = 0.090X - 0.098	0.84	18

X = % Organic carbon; Y = Concentration of metals

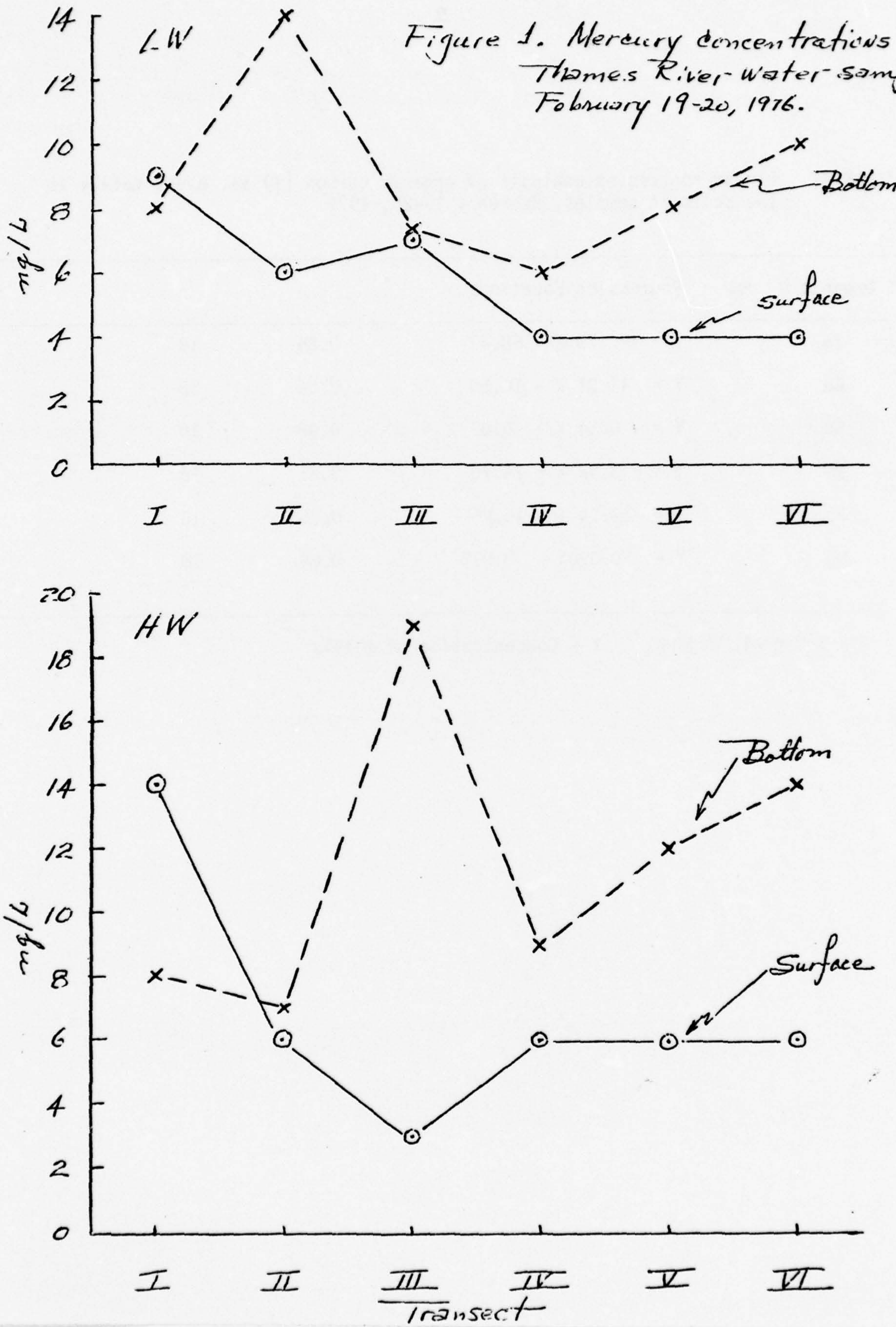
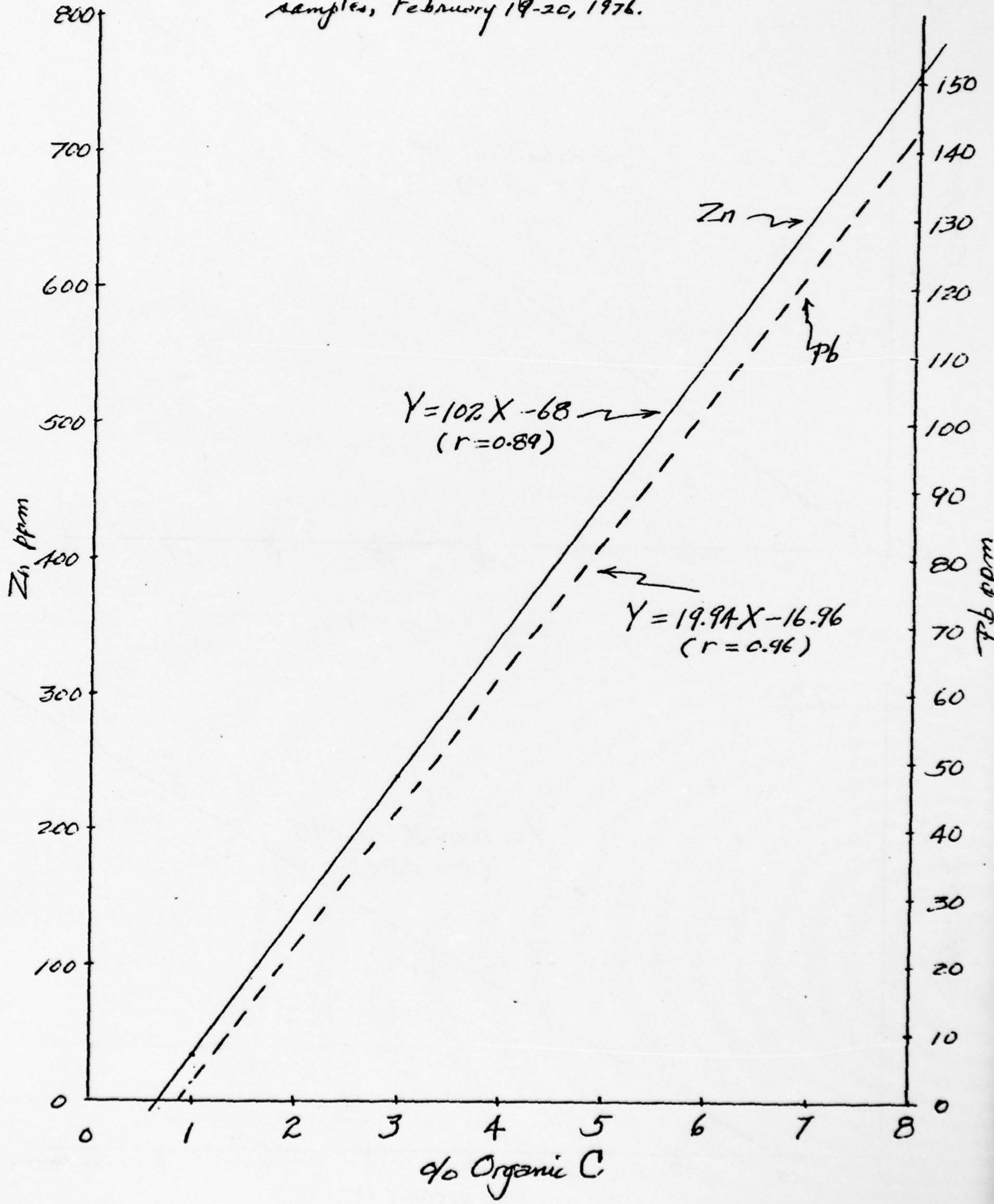


Figure 1. Mercury concentrations in Thames River water samples, February 19-20, 1976.

Figure 2. Linear Regression analysis of the concentration of Zn and Pb vs. % organic carbon in the sediment samples, February 19-20, 1976.



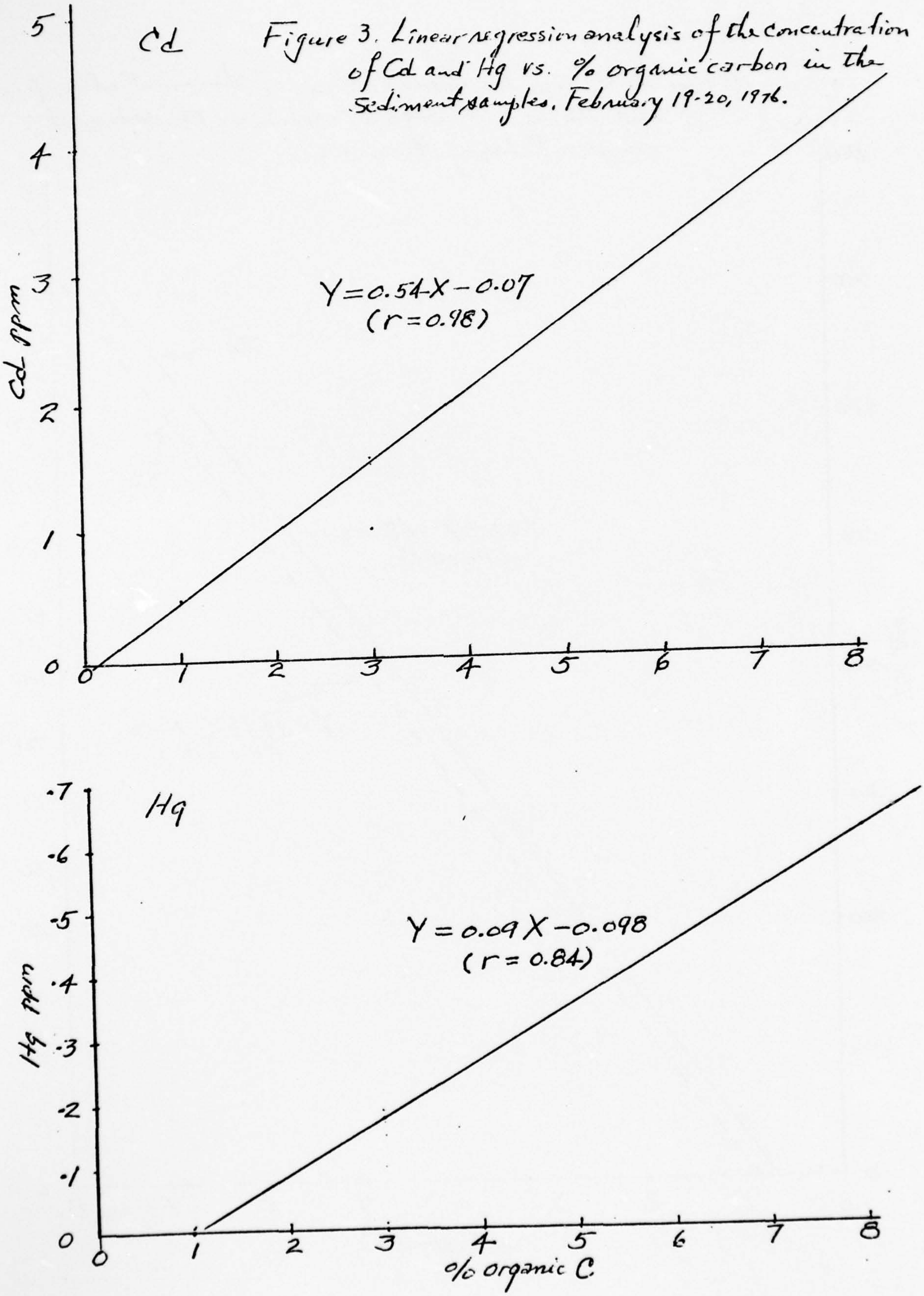
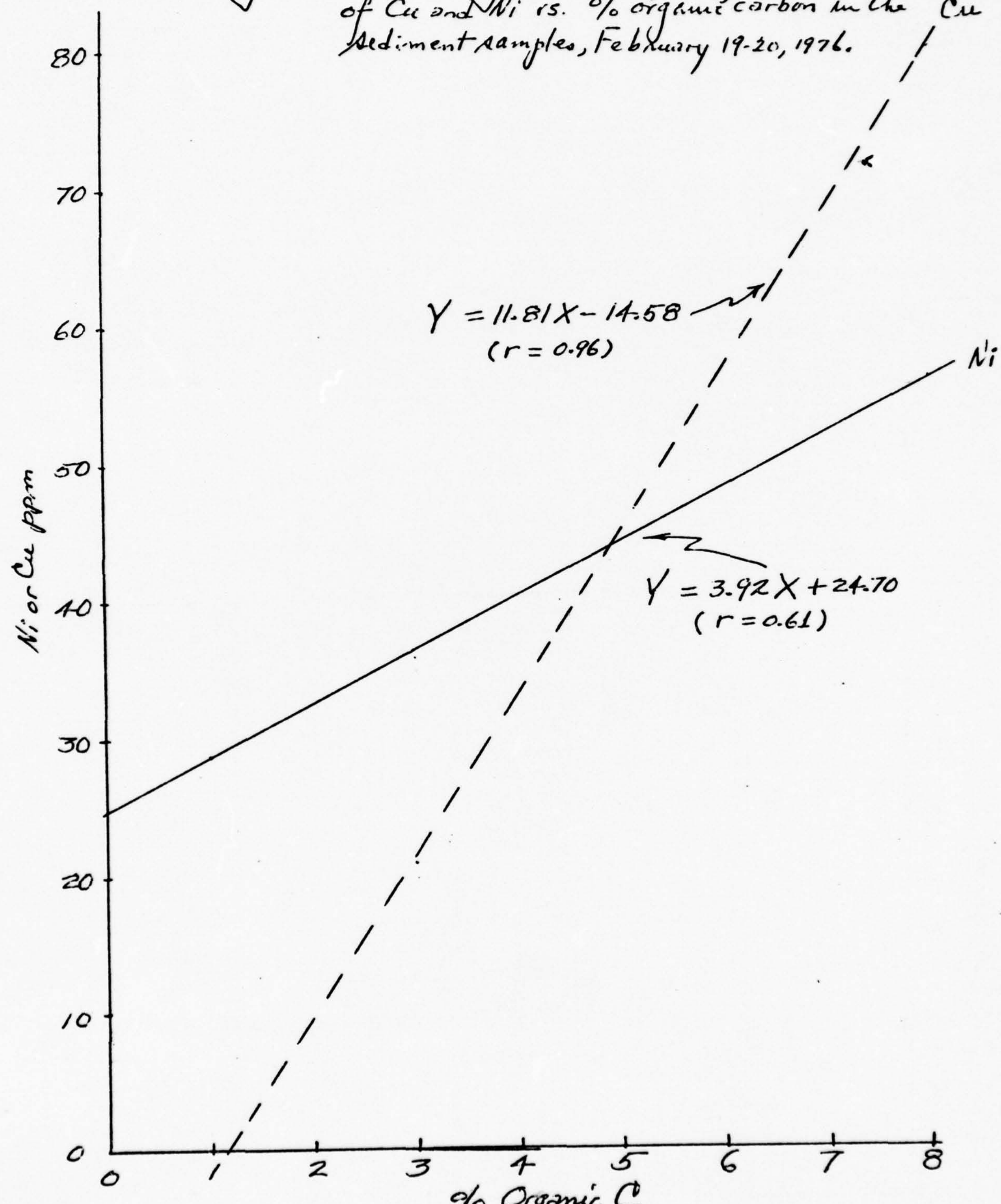


Figure 3. Linear regression analysis of the concentration of Cd and Hg vs. % organic carbon in the sediment samples, February 19-20, 1976.

Figure 4. Linear-regression analysis of the concentration of Cu and Ni vs. % organic carbon in the sediment samples, February 19-20, 1976.



APPENDIX C

QUARTERLY REPORT

Physical Oceanography of the New
London Dump Site Area
January through March, 1976

Submitted to

Sandy Hook Laboratory, Middle Atlantic Coastal
Fisheries Center, National MArine Fisheries Service
NOAA/U.S. Dept. Commerce
under Contract No. 03-5-043-305

by

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A. Cruise Descriptions

A three current meter array was deployed at the Center Station (Fig. 1) on February 9 in anticipation of water column sampling during the following day. Two additional meters were deployed early on February 10th at Stations N, and S, to the north and south of the Center Station respectively (Fig. 1). Water quality measurements were then obtained at the 4 outer stations and the Center Station during the ebb tide cycle in sequence N, CB, S, then E, CB, W, etc. Increased winds with concurrent rough seas caused the termination of the cruise at mid-day. The current meters were therefore left in the water until Thursday, 12 February when conditions were calmer for the safe retrieval of the meters.

B. Discussion and Comments

This experiment was designed to provide data for transport calculations and budget analysis. Weather conditions caused a cancellation just prior to the end of the ebb cycle; however, the data covers most of the ebb and should be adequate for further analysis which is currently in progress with those of 4 and 5 December (1975).

Observed temperatures and salinities together with calculated density (σ_t) are shown in Tables 1 and 2 for the East-West Transect and the North-South Transect respectively. Temperatures are close to their lowest values at this time (approximately an 8°C drop from December values). In general, salinity values have decreased as expected for this time of year. Salinity values sould reach their minimum values during March/April. Concurrent transmissometer values for Station E1 and Center Station are tabulated in Table 3. Unfortunately, only 2 stations were made; one of the transducer cables parted and is now being replaced.

The β values tabulated in Table 3 are not significantly different from the average values encountered in the December cruises.

Current meter records have been reduced and the results tabulated in Tables 4 and 5. These data are being analyzed further for transport and net flow. The period of observation falls between neap and spring tidal conditions so that these results should represent average conditions. As can be seen in Table 4 during cycle 3 however, the flood flow was virtually stopped at the surface meter (3-1/2 hour duration and low speed) due to relatively high winds from the west. Maximum velocities observed during each day are tabulated in Table 5. The wind effect is again noticeable in that bottom speeds are greater than surface during flood conditions whereas during ebb the surface ebb is greater than the bottom by a factor of 2.

Drifter Statistics to date:

a. Surface:

Recovery Rate: 21%

Region to NW of Site: - 0%

Region to SW of Site: -11%

Region to NE of Site: -50%

Region to SE of Site: -39%

b. Bottom:

Recovery Rate: 57%

Region to NW of Site: - 70%

Region to SW of Site: - 30%

Region to NE of Site: - 0%

Region to SE of Site: - 0%

The only sector where there is apparent overlap as to net flow relative to the launch site at the Center Buoy is from areas to the southwest (16% of surface and 30% of bottom finds). These areas are along the shore of Long Island. Major portions of the bottom drifters are found in the northwest sector, those areas from Goshen Pt. west to New Haven whereas the major portion of the surface drifters are found in the northeast sector, involving those areas from Avery Pt. eastward. Fishers Island is included in the southeast sector.

C. Definitions

1. Current Meters

u: east/west velocity component in cm/sec

v: north/south velocity component in cm/sec

R: speed of the current in cm/sec,

$R = [u^2 + v^2]^{1/2}$

θ: direction of the current relative to geographic north,

$\theta = \arctan v/u$

D(R): virtual distance in kilometers of a half-tidal cycle,

$$D(R) = \int_{1/2 \text{ tidal cycle}} R(t)\, dt$$

t: duration of half-tidal cycle in hours

2. Transmissometer

Beam attenuation coefficient, β, is the sum of the absorption coefficient and total scattering coefficient and calculated from

$$\beta = (-1/L) \ln (T/100)$$

where T is the beam transmittance in percent and L is the path length in centimeters.

<u>Table 1</u> : Observed values of temperature, salinity, and resultant σ_t as a function of depth along the east/west transect, 10 February 1976.

Station	E1			C			W1		
Time	0700 hours			0720 hours			0750 hours		
Z(m)	T(°C)	S(°/oo)	σ_t	T(°C)	S(°/oo)	σ_t	T(°C)	S(°/oo)	σ_t
0	0.9	23.19	18.61	1.3	27.23	21.88	-	28.55	-
5	2.2	26.52	21.21	1.8	28.11	22.51	-	28.63	-
10	2.4	29.84	23.85	2.2	29.00	23.18	-	28.71	-
15	2.6	30.19	24.11	2.4	29.81	23.82	-	29.28	-
20	2.6	30.54	24.39	2.7	30.62	24.44	-	29.86	-

Station	E1			C			W1		
Time	0920 hours			0940 hours			1000 hours		
Z(m)	T(°C)	S(°/oo)	σ_t	T(°C)	S(°/oo)	σ_t	T(°C)	S(°/oo)	σ_t
0	1.4	28.21	22.60	1.9	28.60	22.88	2.1	28.79	23.03
5	2.0	28.90	23.12	1.9	29.18	23.35	2.0	28.82	23.06
10	2.0	29.58	23.66	2.1	29.76	23.80	2.0	28.85	23.08
15	2.1	29.94	23.94	2.2	29.93	23.93	2.2	29.35	23.47
20	2.2	30.29	24.22	2.2	29.99	23.98	2.2	29.85	23.87

Table 2 : Observed values of temperature, salinity, and resultant σ_t as a function of depth along the north/south transect, 10 February 1976.

Station	S1			C			N1		
Time	0815 hours			0830 hours			0900 hours		
Z(m)	T(°C)	S(°/₀₀)	σ_t	T(°C)	S(°/₀₀)	σ_t	T(°C)	S(°/₀₀)	σ_t
0	1.8	28.50	22.81	1.7	28.46	22.79	0.7	28.56	22.92
5	1.8	28.76	23.02	2.0	28.86	23.09	0.7	29.14	23.38
10	1.9	29.02	23.22	2.1	29.26	23.40	0.9	29.66	23.79
15	2.0	29.35	23.48	2.2	29.84	23.86	1.1	30.12	24.14
20	2.0	29.73	23.78	2.4	30.42*	24.31			

Station	S1			C		
Time	1025 hours			1045 hours		
Z(m)	T(°C)	S(°/₀₀)	σ_t	T(°C)	S(°/₀₀)	σ_t
0	1.8	28.24	22.61	2.1	28.71	22.96
5	1.8	28.55	22.85	2.1	28.94	23.14
10	2.0	28.85	23.08	2.1	29.17	23.33
15	2.0	29.25	23.40	2.2	29.57	23.64
20	2.1	29.65	23.71	2.2	29.97	23.96

*Extrapolated

Table 3: Beam transmittance (T%) for a 1 meter path length and attentuation coefficient (β) as a function of depth, 10 February 1976.

Station	E1 (0700 hrs)		C1 (0725 hrs)	
Depth(m)	T(%)	β(1/m)	T(%)	β(1/m)
1	32	1.14	34	1.08
5	31	1.17	32	1.14
10	32	1.14	33	1.11
15	26	1.35	31	1.17
20	24	1.43	30	1.20
Avg.	29	1.25	32	1.14

Table 4 : The resultant current velocities at the Center Buoy Station for the period 9 February (cycle 1) through 12 February (cycle 5) 1976.

		Flood						Ebb					
	Cycle	(1) U	(1) V	(1) R	(2) θ	(3) D(R)	(4) t	(1) U	(1) V	(1) R	(2) θ	(3) D(R)	(4) t
Surface (2m)	1	-13.6	-12.5	18.5	227	4.1	5.3	23.5	-9.8	25.5	113	6.8	6.8
	2	-14.9	3.4	15.3	283	3.1	3.8	36.8	-9.6	38.0	105	10.1	7.1
	3	-6.9	-8.0	10.6	221	2.0	3.5	38.2	-6.4	38.7	100	14.5	9.4
	4	-14.4	-28.1	31.6	207	5.8	5.1	31.5	-13.4	34.2	113	11.5	8.6
	5	-13.9	-19.5	24.0	215	5.1	5.1	33.0	-8.5	34.1	104	8.1	6.3
Bottom (16.5m)	1	-15.9	15.6	22.3	315	3.5	4.2	17.8	3.1	18.1	80	5.9	8.0
	2	-19.5	8.7	21.4	294	3.9	5.0	13.6	0.4	13.6	88	5.4	8.5
	3	-23.2	16.6	28.5	306	5.1	5.0	13.6	0.4	13.6	88	4.2	7.0
	4	-18.4	18.7	26.3	315	5.1	5.2	19.5	3.5	19.8	80	6.0	7.7
	5	-24.2	15.9	29.0	303	4.3	4.0	14.1	5.5	15.1	69	4.4	6.5

(1) cm/sec

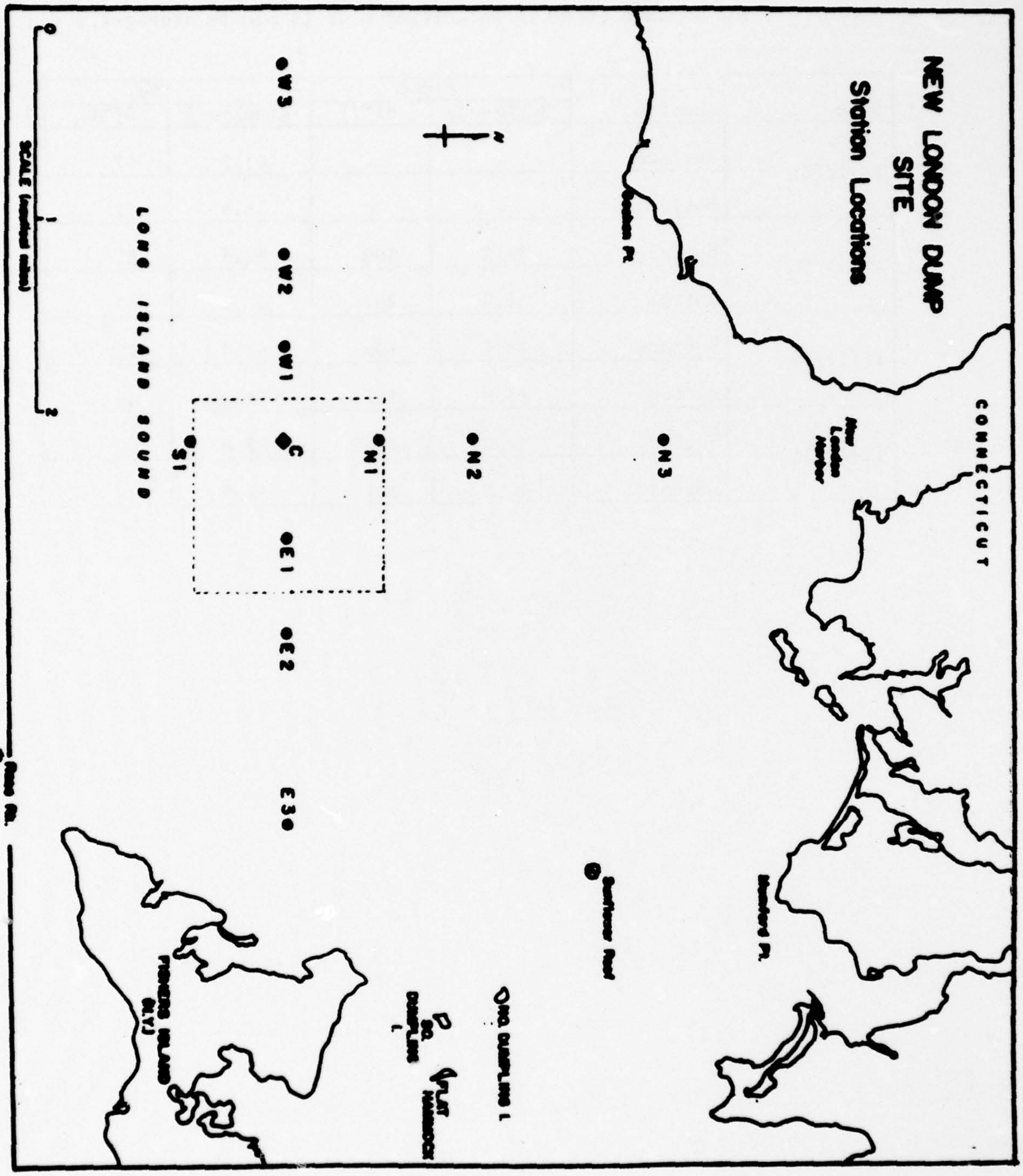
(2) circular degrees relative to geographic north

(3) kilometers

(4) hours

Table 5 : The maximum observed velocities over 15 minute averages.

Date	Location	Flood		Ebb	
		R(cm/sec)	θ(°T)	R(cm/sec)	θ(°T)
9/II/76	Surface	-	-	41.5	97
	Bottom	-	-	36.4	71
10/II/76	Surface	31.2	300	82.3	85
	Bottom	34.3	292	37.4	67
11/II/76	Surface	43.1	198	58.4	90
	Bottom	43.9	312	34.0	69
12/II/76	Surface	44.0	188	82.8	99
	Bottom	40.2	301	33.5	59



<u>Figure 1</u>: Map of the dump site and station locations. "C" is the Center Buoy.

APPENDIX D

QUARTERLY REPORT

Chemical Oceanography of the New London Dumpsite Area

January through March

1976

Submitted to

Sandy Hook Laboratory

Middle Atlantic Coastal Fisheries Center

National Marine Fisheries Service

NOAA/U.S. Dept. of Commerce

Contract No. 03-5-043-303

by

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INTRODUCTION

This report presents the results of the analyses completed to date of water samples collected in February 1976 (NL 22) and of sediment samples collected by the Sandy Hook Laboratory September-October 1975 (NL VI) and February 1976 (NL VII).

In addition to continuing the analysis of samples not completed, a critical review of all data has been initiated. This review is intended to organize the data into an easily comprehended set of tables and figures.

METHODS

Methods of sampling and analysis have been described in previous reports. Precision of the analytical results has been discussed previously and is being reviewed in the overall review of the data.

RESULTS

A. Water

The results of the water quality study (NL 22, 10 February 1976) are presented in Table 1 and Figures 1-5.

1. Eh

Eh values, Table 1 and Figure 1, averaged approximately 60 mv lower than those observed in December 1975 but were similar to those reported for 21 May and 26 August 1975.

2. pH

pH values, Table 1 and Figure 2, averaged to within a few tenths of a unit of those reported for December and August 1975.

3. Suspended Solids and Turbidity

The suspended solids and turbidity data, Table 1 and Figures 3-5, are similar to those found in the December 1975 study.

4. Volatile Solids

Volatile solids , however, are somewhat higher in February 1976; overall mean of 23% compared to 14% in December 1975 for stations at the dump area.

B. Sediments

Limited results on sediment samples collected by Sandy Hook Laboratories September-October 1975 (NL VI) and February 1976 (NL VII) are presented in Tables 2 and 3.

Work on these samples is now in progress.

Table 1
Water Quality Study
New London Dump Study 10 February 1976

Station	Time	Depth (m)	Temp. °C	EH mv	pH	Turbidity FTU	Susp. Solids Total mg/ℓ	Vol. Solids mg/ℓ	Vol. Solids % Total
E1-1S	0700	0	0.9	167	7.57	1.5	2.52	1.22	48
1M		10	2.4	158	7.87	1.5	3.83	.61	16
1B		20	2.6	172	7.20	2.0	5.32	.79	15
C -1S	0725	0	1.3	166	7.96	1.1	2.66	.97	36
1M		10	2.2	178	7.97	1.3	2.73	.48	18
1B		20	2.7	158	8.05	1.7	3.88	.69	18
W1-1S	0750	0	-	155	8.08	1.5	2.97	.69	23
1M		10	-	164	7.75	1.2	2.93	.87	30
1B		21	-	159	7.92	1.4	2.71	.43	16
S1-1S	0815	0	1.8	145	8.15	1.2	2.45	.54	22
1M		12	1.9	147	7.80	1.6	4.58	1.31	29
1B		24	2.3	144	8.11	1.7	4.49	.93	21
C -2S	0830	0	1.7	141	7.98	1.2	2.45	.64	26
2M		10	2.1	140	8.03	1.4	3.49	1.62	46
2B		19	2.3	140	8.05	1.8	3.03	.74	24
N1-1S	0900	0	0.7	138	8.18	1.0	2.40	.68	28
1M		8	0.8	138	7.93	1.3	2.53	.43	17
1B		16	1.1	138	8.06	1.6	4.27	.83	19
E1-2S	0920	0	1.4	142	8.00	1.1	2.11	.51	24
2M		10	2.0	143	8.05	1.4	2.83	.56	20
2B		20	2.3	142	8.08	1.6	2.97	.43	15
C -3S	0940	0	1.9	142	7.95	1.3	2.95	.79	27
3M		11	2.2	142	8.04	1.6	3.36	.78	23
3B		22	2.2	141	8.04	1.4	3.20	.67	21

Table 1 (cont.)

Station	Time	Depth (m)	Temp. °C	EH mv	pH	Turbidity FTU	Susp. Solids Total mg/ℓ	Vol. Solids mg/ℓ	Vol. Solids % Total
W1-2S	1000	0	2.1	145	8.02	1.0	3.20	.86	27
2M		10	2.0	148	8.04	1.3	3.04	.70	23
2B		21	2.2	146	7.86	1.8	4.19	1.03	25
S1-2S	1025	0	1.8	142	8.07	1.3	2.43	.67	28
2M		10	2.0	142	8.08	1.4	2.64	.58	22
2B		21	2.1	143	8.11	1.6	3.38	.77	23
C -4S	1045	0	2.1	144	7.94	1.1	2.80	.71	25
4M		10	2.1	142	8.07	1.3	3.01	.56	19
4B		20	2.2	143	8.55	1.5	3.84	.66	17

Table 2 :

Chemical Oxygen Demand
and Kjeldahl Nitrogen Analysis on
Sediments NLVI Sept.-Oct. 1975

Station	mg O_2/Kg	mg N/Kg
A1	31760	210
A2	18630	726
A3	22520	912
A4	27100	995
A5	29080	1106
A7	44970	1144
A8	22440	786
A9	16180	566
A10	7221	314
B1	7260	346
B2	18580	362
B3	19900	715
C1	22700	920
C3	22860	600
C4	19780	662
C5	15520	779
C6	67420	1583
C7	32780	760
C8	42840	1248
C9	17710	527
D2	1057	65
D3	29780	731
E1	4700	151
E2	-	343
E3	-	482
E4	20250	630
E5	-	830
E7	-	958
E8	- -	793
F3	21500	656
F4	38000	1285
F5	67990	945
F7	-	1513
F8	-	710
F9	8655	601
R1	-	2824
R2	-	2739
R3	-	3558
R3.5	-	3176
R4	-	2187
R5	82660	1020
R6	30160	1047
R7	23960	2549

Table 3 :

Kjeldahl Nitrogen Analysis on
Sediments NL VII February 1976

Station	mg N/Kg
A3	1097
A9	608
C9	787
F8	662
A1	302
C1	622
C3	1425
C6	1542
A10	430
F3	1061
C7	1213
C2	323

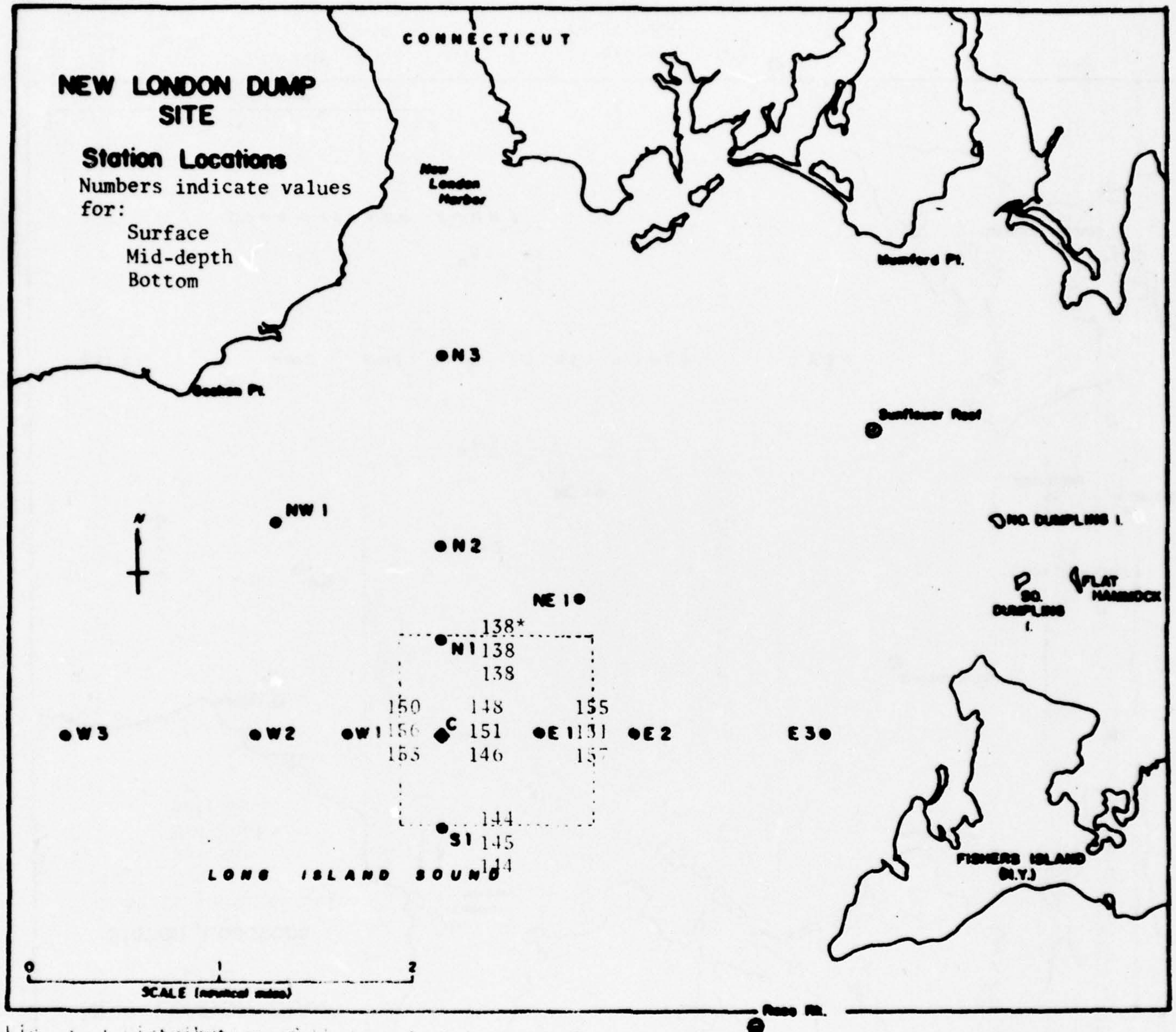

Fig. [illegible] Distribution of [illegible] February 1976 (Average values)
[illegible] period.

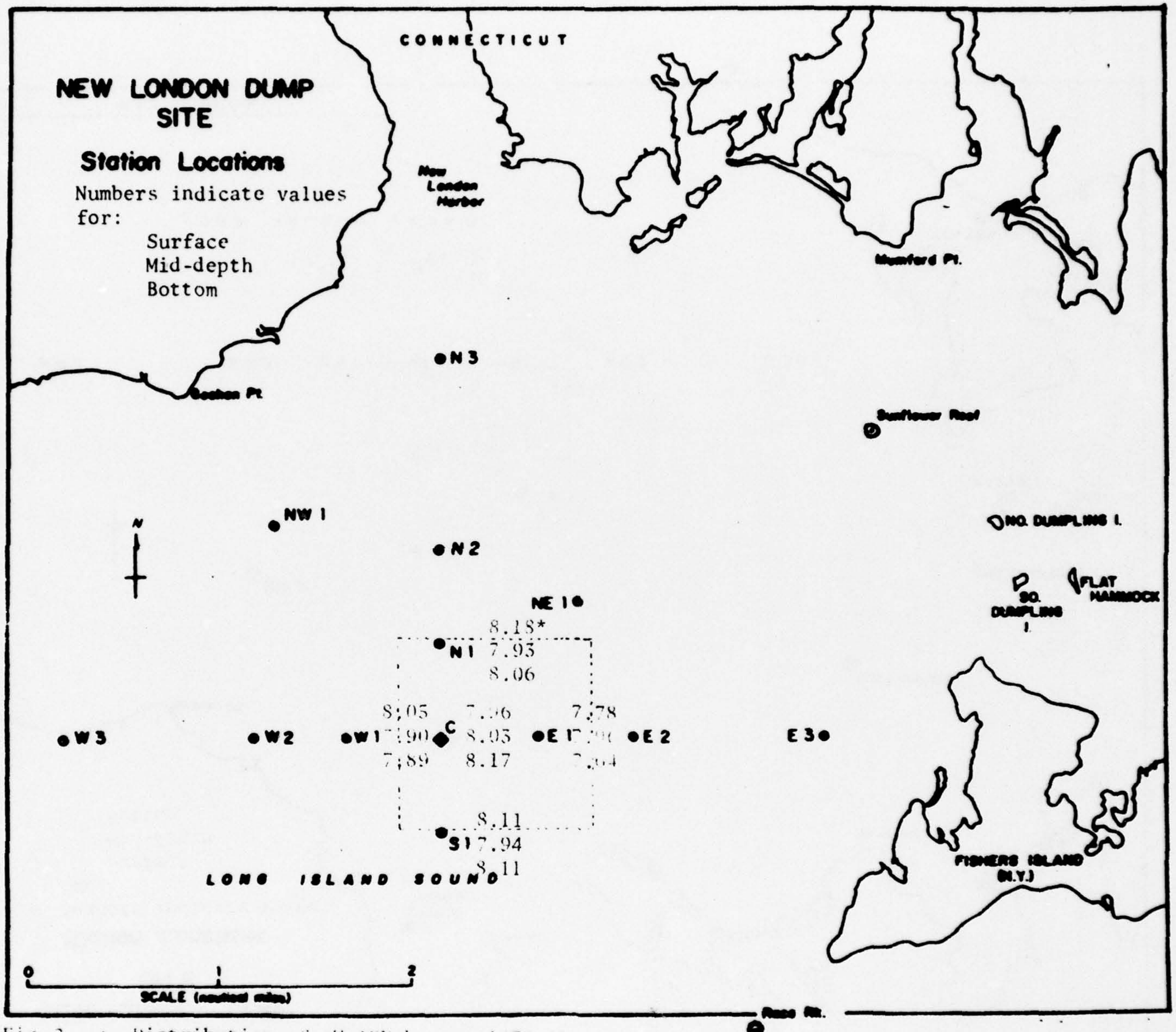

Fig. 2 : Distribution of pH 10February 1976 (Average values) from a single sampling period.

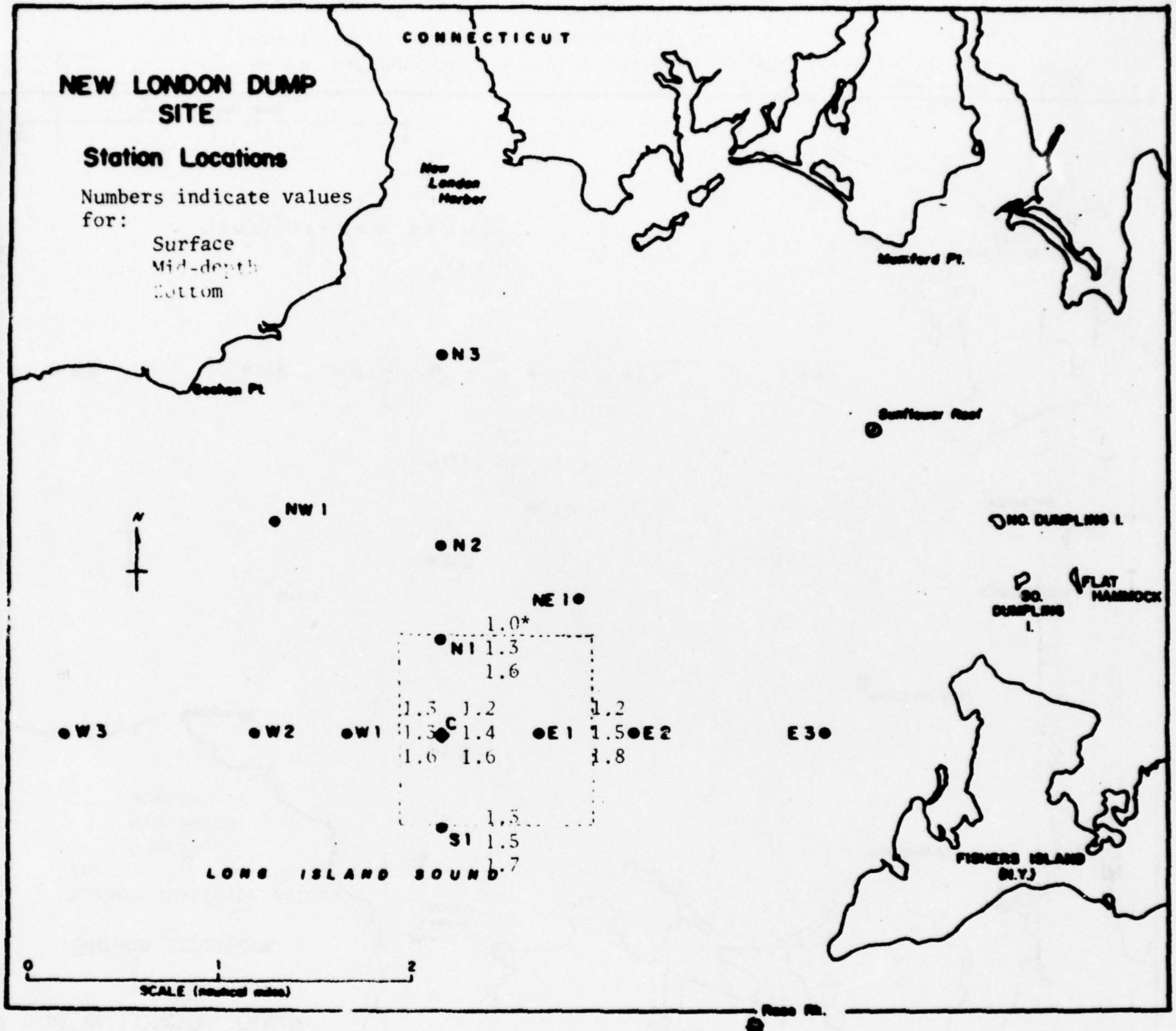

Fig. 5 - Distribution of turbidity (F.T.U.) 10 February 1976 (Average values) [illegible] sampling period.

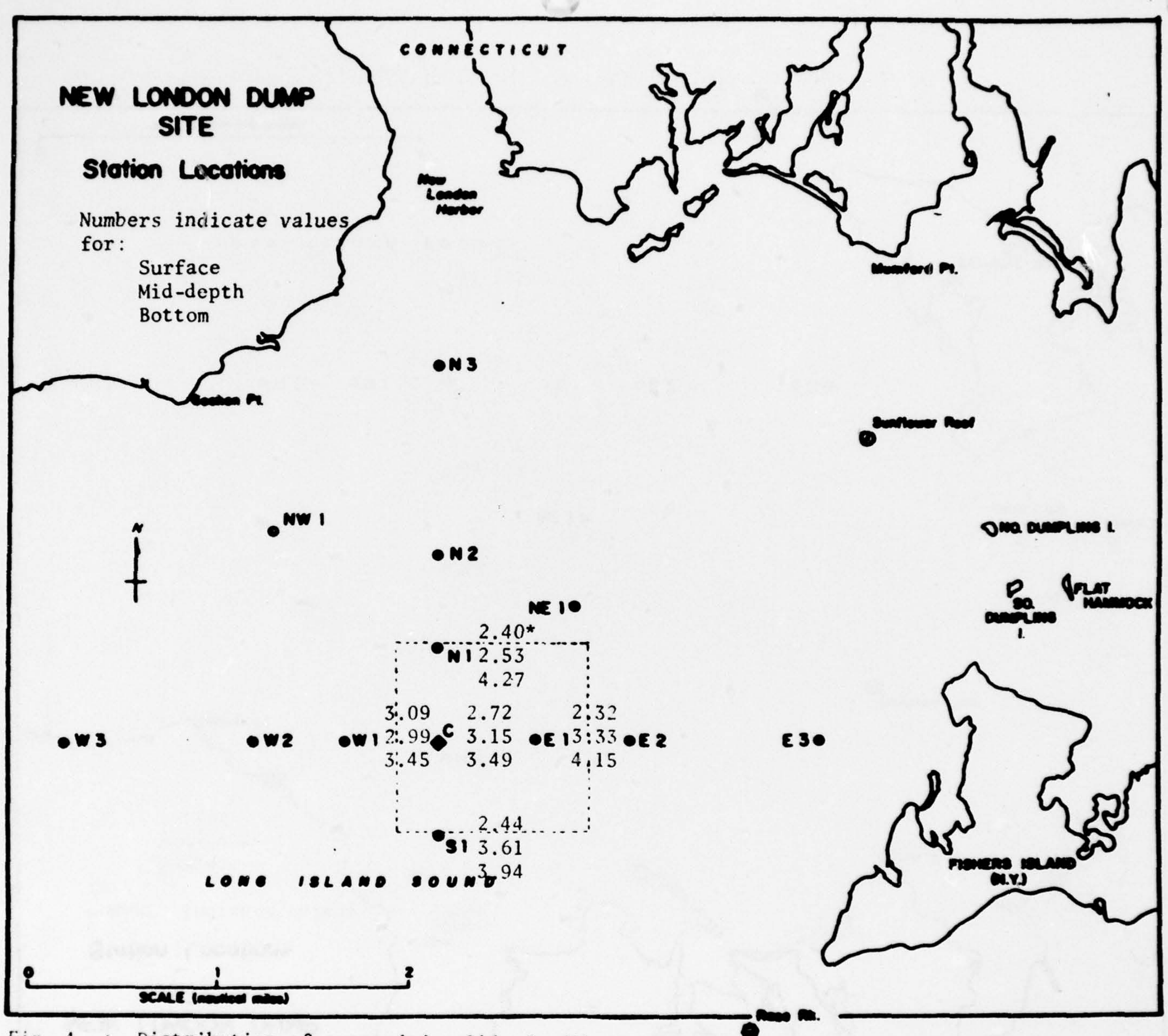

Fig. 4 : Distribution of suspended solids (mg/ℓ) 10 February 1976 (Average values)
*Denotes values from a single sampling period.

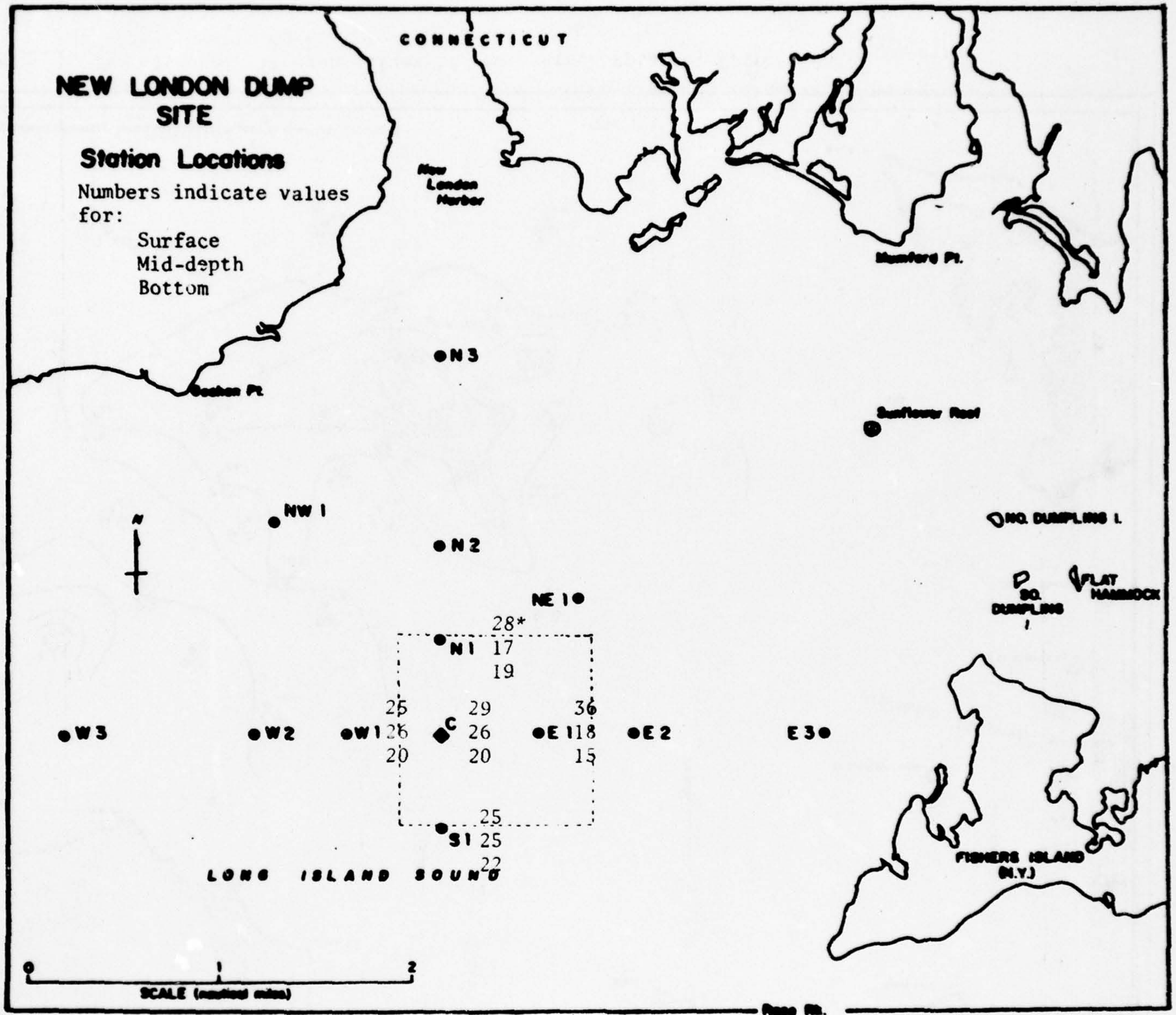

Fig. 5 : Distribution of volatile solids (% total solids) 10 February 1976 (Average values)
*Denotes values from a single sampling period.

Figure 6 : The Kjeldahl nitrogen values of sediments. September-October 1975. (All values in mg/Kg x 10^{-3}).

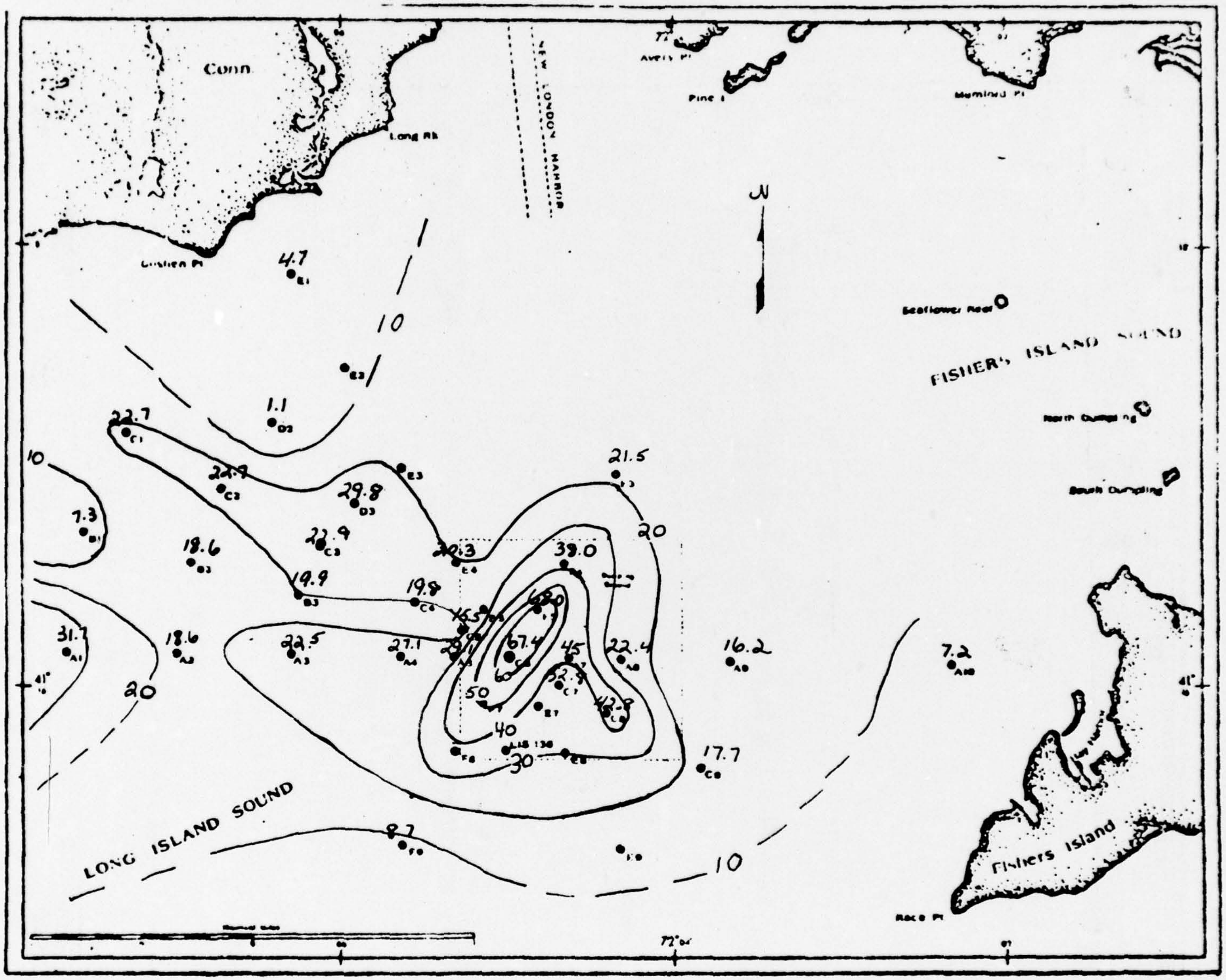

Figure 7 : The chemical oxygen demand of sediments. September-October 1975. (All values in mg/Kg x 10^3).