DAMOS

DISPOSAL AREA MONITORING SYSTEM

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I. Development of the DAMOS Data Base Management System

II. An Assessment of Long-Term Trends of the CLIS Infaunal Community

III. Mussel Watch Program

Edited By:

R. W. Morton
J. H. Parker
W. H. Richmond

Science Applications International Corporation
Admiral's Gate, 221 Third Street
Newport, Rhode Island 02840

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I. DEVELOPMENT OF THE DAMOS DATA BASE MANAGEMENT SYSTEM

AUTHORS:

Craig C. Brandt - SAIC

K. John Scott - SAIC

Charles E. Comiskey - SAIC

I. DEVELOPMENT OF THE DAMOS DATA BASE MANAGEMENT SYSTEM

1.0 INTRODUCTION

Multidisciplinary marine research and monitoring programs such as the Disposal Area Monitoring System (DAMOS) involve many scientific activities which generate large and diverse sets of data. During the past several years of DAMOS work, a wide variety of different data types have been generated, including such information as quantity and composition of dredged materials, disposal schedules and locations, taxonomic abundance, concentrations of geochemicals, and environmental parameters such as bathymetry, hydrography, currents, and sediments. The volume of information generated as a result of the many field programs conducted under DAMOS requires that a centralized information management system be established which integrates the data into a unified and accessible data base. Such a system minimizes the redundancy in the information, aids in standardization of units and formats, permits sharing of information among users, and provides the foundation for standardizing monitoring activities across geographical regions and through time. A responsive information management system permits timely analyses of recently collected data thereby allowing modification of the sampling design for optimization of the study. Finally, an information management system can greatly facilitate the planning and implementation of field programs. Equipment lists, sampling and laboratory methodologies, QC/QA protocols, data forms, and cruise plans can be generated by the information management system and distributed to all participating groups. Status reports of sample processing and data analyses can be produced as an aid to managers in monitoring the performance of the program.

New England Division (NED), U.S. Army Corps of Engineers and Science Applications International Corporation (SAIC) have been working together during the past several months to design and implement a data base management system using the INFO data/file management software currently existing on a Harris minicomputer at the NED facility in Waltham, MA. This section presents the approach to this task, an initial specification of the data base design and an outline of future activities.

SAIC has provided a tested framework within which the DAMOS and related historical data can be assembled into a centralized information resource. This framework is known as the Scientific Information Management and Analysis System (SIMAS) which SAIC has developed over the last seven years. The SIMAS was designed to provide a comprehensive capability for data management which can be readily applied to the DAMOS program.

2.0 AN OVERVIEW OF THE DAMOS SIMAS

The basic organization of the SIMAS is shown in Figure I-2-1. Central to the SIMAS is the Project Data Base (PDB) which is a centralized and integrated repository of all relevant

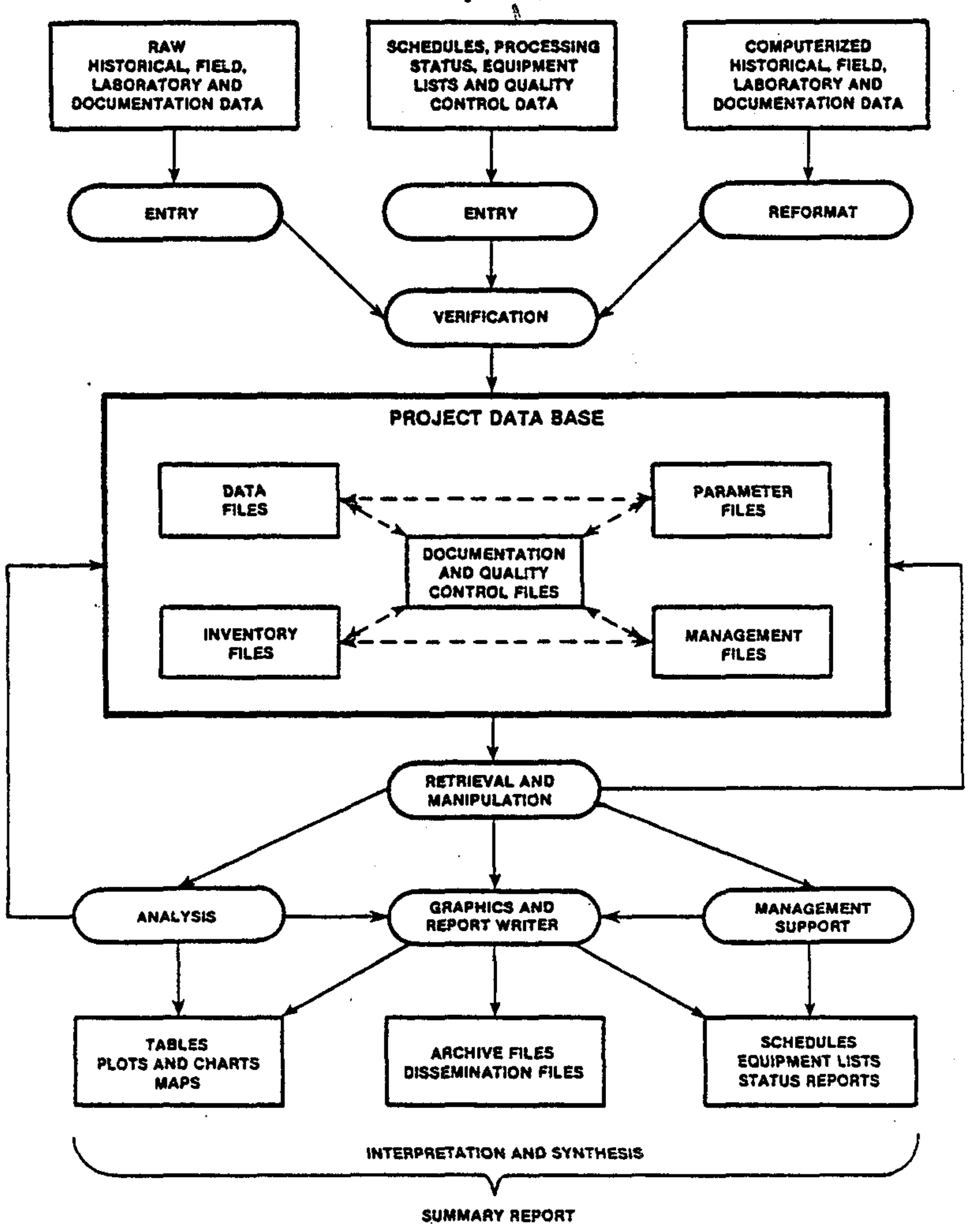

FIGURE I-2-1. Organization of the DAMOS Scientific Information Management and Analysis System.

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information required to design, implement and manage the program, including data available from past studies and data generated during ongoing projects. Since the bulk of ecological data are collected as samples at specific locations and times, the basic unit of organization within the PDB is the sample. Each sample in the PDB is assigned a unique identification code to distinguish it from all other samples. Different types of data generated from the same sample will have the same identification code, thereby permitting the different types to be cross-referenced.

The PDB includes five basic types of files as shown in Figure I-2-1. The dashed lines connecting the file types denote the linkages available for cross-referencing different types of information. The inventory file contains information defining where and when the samples were collected. The data files contain the historical data together with the project-generated field and laboratory observations. Parameter files contain lists of parameters present in some of the data files together with ancillary information about the parameters. The management files contain information pertinent to the technical administration of the program such as cruise tracks, sampling schedules, and sample processing status. Finally, the documentation and quality control files contain detailed information on equipment requirements, methodologies, field logs, equipment performance criteria, instrument calibrations, and field and laboratory QC/QA measurements.

The PDB is based on the relational data model. A file in the PDB can be visualized as a table in which the columns denote attributes or variables and the rows represent observations of these attributes. Various tables can be linked or related via common attributes. As an example, consider hydrographic data. The file for this data type contains fields for the sample identification code, the depth of the measurement, salinity, temperature and conductivity. A record in this file contains specific values or measurements for each of these fields. The hydrographic data could be linked with a sediment data file via the sample identification code.

Interfacing with the PDB are five program modules which address (1) the entry and verification of information in the PDB; (2) retrieval and manipulation of information in the PDB; (3) generation of information required for program management purposes; (4) statistical and mathematical analysis; and (5) graphics and report writing. Implementing such modules on the NED Harris computer system involves coding of programs within INFO as well as linking other software to the INFO system.

3.0 THE DAMOS PROJECT DATA BASE

As mentioned earlier, the DAMOS and selected historical data will be managed with the INFO software package. Like the SIMAS, INFO employs a relational data model to store information. Each file in INFO consists of one record type which can be linked with other files via a common attribute. INFO includes a powerful query language for retrieving information from the files, and a report-writing module which permits the creation of customized displays. Data can be entered into INFO either interactively or via batch.

Building the DAMOS PDB consists of three steps. First, a "needs" analysis is being conducted to define the types and quantities of information which will be incorporated into the data base. Intended uses of the information are also defined as clearly as possible during this step. The second step involves translating the results of the needs analysis into a design of the data base. Finally, using the design, the actual data are computerized or reformatted into the PDB. The scope of each of these steps is discussed in greater detail below.

3.1 Needs Analysis

One objective of the needs analysis is to determine the types, sources, and quantities of data to be incorporated into the PDB. The DAMOS PDB will consist of program-generated data together with selected historical data. The initial effort for the PDB will focus on the data collected at the Central Long Island Sound (CLIS) disposal site. This site will serve as a prototype for a comprehensive PDB which integrates all DAMOS related data. Basic data types collected at the CLIS site include benthic taxonomy, chemistry, sediment grain size and volume of disposal material. SAIC has also identified certain relevant historical data which will be useful in providing a long-term characterization of the CLIS site. Table I-3-1 summarizes the sources and types of historical data of interest to this project.

Defining the intended uses of the PDB is critical to its proper design. It is assumed that the major uses of the data base will be information retrieval and display. Therefore the major emphasis in the design of the PDB is to ensure the easy retrieval of information and the capability of cross-referencing different types of information for display. Some summarization of the data is also anticipated, but sophisticated quantitative analyses will be performed by other software packages.

3.2 Data Base Design

Once the types and intended uses of the data are defined, the next step is the design of the PDB. A major objective in designing the PDB is to implement an 'open-ended' structure which permits the incorporation of other types of data in the future. The design is expressed in a schema which is essentially a "map" depicting the contents of the various files in the PDB and how these files can be cross-referenced and linked together. The schema provides the blueprint by which the PDB is implemented in the subsequent task.

The PDB for DAMOS will contain inventory, data, parameter and documentation files. The management files are not

Table I-3-1

Sources and Types of Historical Date
of Interest to the DAMOS Data Base.

BENTHIC BIOLOGICAL DATA CHARACTERISTICS

STUDY/DATE	# OF SAMPLES	GEAR	ASSOCIATED DATA	FORM
Sanders/1956	4	Anchor Dredge	Grain Size	Raw
Reid/1972-73	12	Smith-Mac	Grain Size Metals, Orgc.	Computer-ized
Rhoads & Michael/ 1972-74	620	Van Veen	---	Raw
McCall & Fisher/ 1973	10	Van Veen	Grain Size	Raw
Brooks/1977-81	90	Anchor Dredge Smith-Mac	Grain Size Metals	Raw
Pratt/1981-82	64-100	Smith-Mac	Grain Size Metals	Computer-ized
Pelligrino & Hubbard/1983	10	Smith-Mac	---	Computer-ized
Pratt(APA)/1982-83	250	Smith-Mac	Grain Size Metals Organics	Computer-ized

required in this effort, since this type of file is generally used only in planning and administrating field efforts. However, the management files can be easily incorporated into the PDB at a later date if desired.

3.2.1 Inventory File

The inventory file contains information describing where and when each sample was collected. A primary function of the inventory is to serve as a central directory for all historical and project-generated samples. Each entry in the inventory file corresponds to a sample from a particular study and contains a sample number, the data type, the collection date and time, the cruise designation, the sampling station designation, and the geographical coordinates of the sampling station. Table I-3-2 lists the structure of the DAMOS inventory file. The inventory files can be cross referenced with the data files via the sample number.

Another principal function of the inventory file is to define spatial and temporal subsets of the data for retrieval. Using the INFO query language, a set of spatial and temporal criteria can be specified and the inventory file searched for those samples satisfying the criteria. The inventory entries satisfying the search criteria can then be merged with the data files to create a data subset. The inventory file can also be used to generate summary tables displaying the types, locations and dates of data present in the PDB.

3.2.2 Data Files

The PDB data files contain the project-generated and historical data. The basic unit of organization within the data files will be the sample. Different types of data such as physical, geological, chemical and biological are stored in different files. Since each sample is identified by a unique number, the information in the data files can be cross referenced with each other or with the appropriate entry in the inventory file.

There are currently four data files in the DAMOS PDB, and Table I-3-3 presents the structure of these files. The taxonomic file contains the benthic taxonomic identification and abundance information. The chemistry file holds the sediment chemistry information, and the sediment file contains the grain size information. The taxonomic and chemistry files utilize a parameter code to denote the organism or chemical measured in a sample. This method allows only non-zero observations to be stored in the PDB thereby saving storage space on the computer. The grain size file utilizes a separate item to store each parameter measured in a sample since the number of parameters per sample is constant. The fourth file contains data on dredged material source, site, volume and date of disposal. Additional files are being developed to contain such information as replicate survey data, Mussel Watch chemical concentration data, and physical oceanography data.

Table I-3-2 Proposed structure of the DAMOS inventory file.

INVENTORY FILE

FILE NAME: INVENTORY

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
SAMP_ID	6		I		Sample Identifier
CRUISE	6		C		Cruise Identifier
STATION	8		C		Station Identifier
REPLICATE	2		C		Replicate Identifier
YEAR	2		I		
MONTH	2		I		Collection Date
DAY	2		I		
HOUR	2		I		Collection Time
MINUTE	2		I		
LAT_DEG	2		I		
LAT_MIN	2		I		Collection Location Latitude
LAT_SEC	2		I		
LAT_HEM	1		C		
LNG_DEG	3		I		
LNG_MIN	2		I		Collection Location Longitude
LNG_SEC	2		I		
LNG_HEM	1		C		
SAMP_TYPE	4		C		Sample Type
STUDY	4		C		Study

Table 1-3-3. Proposed structure of the DAMOS data files.

DATA FILES

FILE NAME: TAXA_DATA

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
SAMP_ID	6		I		Sample Identifier
TAXA_CODE	6		I		Parameter Code
LIFE_STAGE	2		C		Life Stage
COUNT	6		I		Abundance

FILE NAME: CHEM_DATA

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
SAMP_ID	6		I		Sample Identifier
CHEM_CODE	6		I		Parameter Code
MEAS_CODE	2		C		Measurement Code
METH_CODE	2		C		Method Code
TRACE	1		C		Trace Flag
CONC	6		I		Concentration
EXPONENT	2		I		Concentration Exponent

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Table 1-3-3 (Cont.)

FILE NAME: DISPOSAL

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
SAMP_ID	6		I		Sample Identifier
YEAR	2		I		
MONTH	2		I		Disposal Date
DAY	2		I		
DISP_SITE	10		C		Disposal Site
SOURCE	40		C		Material Source
VOLUME	6		I		Volume of Disposed Material

FILE NAME: SEDIMENT

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
SAMP_ID	6		I		Sample Identifier
Q1	6		N	4	25% Quantel
Q2	6		N	4	50% Quantel
Q3	6		N	4	75% Quantel
CLASS	2		C		Soil Class
DIST	1		C		Distribution
FINES	6		N	2	Percent Fines
SPC_GRAV	6		N	2	Specific Gravity
RAD_ACT	6		N	2	Radioactivity
VISUAL	40		C		Visual Observation

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3.2.3 Parameter File

The parameter files are used to identify the parameter codes present in the data files. An entry in a parameter file contains the parameter code, the parameter name, and other ancillary information describing the parameter. A parameter file offers several advantages in addition to efficient use of storage space for the corresponding data files. Parameter files ensure consistent spelling of the parameter name. Changes in a parameter name are confined to the parameter file thus eliminating the need to search for all occurrences of a changed parameter in the data file. Another advantage is that the parameter name does not have to be stored on each observation in the data file.

There are currently two parameter files in the DAMOS PDB (Table I-3-4). The taxonomic parameter file contains the working code, the taxonomic name and the National Oceanographic Data Center (NODC) hierarchical taxonomic code of the organisms collected in the benthic samples. In a similar manner, the chemical parameter file contains the working code, name and Chemical Abstract Service (CAS) code of the substances measured in the chemical data files. Table I-3-5 presents an example of the first 50 species input to the DAMOS taxonomic parameter file. Based on input of benthic data acquired from the sources presented in Table I-3-1, 152 species have been inserted at this time. As more samples are analyzed from different locations, additional species will be added as necessary.

3.2.4 Documentation and Quality Control Files

The purpose of these files is to provide documentation of the methods employed in the collection and processing of the cruise samples. Equipment descriptions and methodology summaries are examples of the type of information present in the files. Quality control information such as instrument calibrations and measurement audits is also stored. This information is essential in assessing the uncertainty of the information in the data files. Table I-3-6 lists the items currently present in the methodology documentation file, which is designed to accompany the chemistry data file.

3.3 Implementing the DAMOS PDB

Both computerized and raw (uncomputerized) data will be incorporated into the DAMOS PDB. Reformatting of the computerized data will be done with the SIMAS on the SAIC VAX 11/780, and submitted to NED on magnetic tape.

Based on a review of the historical (non-DAMOS) data, it is quite evident that they are not recorded in a consistent manner from one study to another. These differences include things such as the form of the data (raw vs. computerized), the types of information recorded, the design of the data recording forms, and the types of parameter codes and station identifiers used. The degree of inconsistency from one study to another will

Table I-3-4. Proposed structure of the DAMOS parameter files.

PARAMETER FILES

FILE NAME: TAXA_LIST

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
TAXA_CODE	6		I		Parameter Code
NAME	40		C		Taxanomic Name
NODC_CODE	12		C		NODC Taxanomic Code
GROUP	2		I		Taxonomic Group

FILE NAME: CHEM_LIST

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
CHEM_CODE	6		I		Parameter Code
NAME	40		C		Chemical Name
CAS_CODE	12		C		CAS Code

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TABLE I-3-5
EXAMPLE OF TAXONOMIC PARAMETER FILE FOR DAMOS DATA BASE

CODE II	SPECIES NAME	NODC CODE II	TAXONOMIC GROUP
1	Acteon punctostriatus	5110010101	60
2	Aligena elevata	55151006??	60
3	Ampelisca	61690201	50
4	Ampelisca vadorum	6169020109	60
5	Ampelisca verrilli	6169020110	60
6	Ampharete acutifrons	5001670208	60
7	Ampharete arctica	5001670201	60
8	Ampharete oculata	50016702??	60
9	Amphipholis squamata	8129030202	60
10	Amphitrite ornata	5001680102	60
11	Anadara	55060102	50
12	Anadara transversa	5506010201	60
13	Anonyx sarsi	6169340314	60
14	Archiannelida	5002	20
15	Aricidea	50014102	50
16	Aricidea jeffreysii	5001410204	60
17	Asabellides oculata	5001670802	60
18	Astarte undata	5515190113	60
19	Asterias forbesi	8117030202	60
20	Asychis elongatus	5001630103	60
21	Axius serratus	6183020301	60
22	Balanus balanoides	6134020101	60
23	Balanus crenatus	6134020104	60
24	Bybilis serrata	6169020203	60
25	Cancer irroratus	6188030109	60
26	Capitella capitata	5001600101	60
27	Caprella	61710107	50
28	Cerebratulus	43030202	50
29	Cerebratulus lacteus	4303020209	60
30	Ceriantheopsis americanus	3743010201	60
31	Chaetozone	50015004	50
32	Chone	50017001	50
33	Clymenella torquata	5001630202	60
34	Corophium	61691502	50
35	Corymorpha pendula	3703030104	60
36	Cossura longocirrata	5001520101	60
37	Crangon septemspinosa	6179220103	60
38	Crepidula	51036402	50
39	Crepidula plana	5103640207	60
40	Cyclocardia borealis	5515170106	60
41	Cylichna oryza	51100402??	60
42	Diastylis polita	6154050121	60
43	Drilonereis longa	5001330103	50
44	Dyopedos monocantha	616944????	60
45	Edotea montosa	6162020701	60
46	Edwardsia elegans	3759010101	60
47	Ensis directus	5515290301	60
48	Epitonium rupicola	5103500108	60
49	Eteone heteropoda	5001130207	60
50	Eudorella truncatula	6154040204	60

Table I-3-6. Proposed structure of the DAMOS documentation file.

DOCUMENTATION FILES

FILE NAME: CRUISE

NAME	WIDTH	OUTPUT WIDTH	TYPE	DECIMAL PLACES	COMMENTS
CRUISE	6		C		Cruise Identifier
VESSEL	40		C		Vessel Name
STR_DATE	8		I		Cruise Start Date
END_DATE	8		I		Cruise End Date
INVESTIGATOR	40		C		Principal Investigator

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determine the amount of effort that must be expended in developing the software modules for entry of data into the system and for data reformatting, as well as the effort required to standardize parameter and station codes.

3.3.1 Computerized Data

The first step in incorporating computerized data is to make a reconnaissance pass through the data set to verify the file structure and generate matrices which show the spatial and temporal extent of the data. The matrices are compared with published reports to ensure that the correct number and types of samples are present. The matrices also help identify problems in the sample identifiers such as erroneous dates and station codes, and eventually form the basis of cross-referencing tables which link the original sample identifiers with those utilized in the PDB.

One of the most demanding tasks encountered in integrating data from numerous sources involves standardization of parameter names and measurement units. This is especially true for taxonomic data in which there may be inconsistencies among the various studies. It must be understood that some taxonomic inconsistencies in the historical data may never be reconciled. To aid in standardizing the nomenclature, a list of taxanomic and chemical names are extracted from the data and reviewed by the appropriate principal investigator to insure the accuracy of the nomenclature. The lists are also used to build a cross reference table which maps the original parameter names to the appropriate entry in the PDB parameter file.

The final step involves reformatting the computerized data into a form compatible with the structure of the DAMOS PDB. This process involves separating the original data into inventory, data parameter and documentation files, accessing the cross-reference tables to find the new sample identifiers and parameter codes, and writing new files wich can be loaded into the PDB. Once the historical data are incorporated into the PDB, summaries of the data will be generated and compared with the appropriate published reports to ensure the integrity of the data. If major or noteworthy discrepancies exist between the computerized data and the reports, an attempt will be made to pinpoint the source and extent of the problem. If the cause of the discrepancies can be isolated, the data in the PDB will be modified accordingly, and the changes documented.

3.3.2 Raw Data

Non-computerized data reside on data sheets or as tables and listings in reports. Each type of data sheet will be evaluated with regard to its utility in data entry. Tabular data will be hand coded onto appropriate data sheets if necessary to facilitate efficient computer entry. Data sheets requiring the assignment of parameter codes will be forwarded to the data coding clerk (e.g., taxonomic data). The clerk consults an alphabetically sorted master parameter list and notes the appropriate parameter code on the data sheets. New parameters not in the master list are assigned temporary codes, and the temporary codes are entered on the data sheet. The list of the new parameters are reviewed, and if needed the appropriate laboratory is consulted for clarification. Permanent parameter codes are assigned and the parameters are incorporated into the parameter files. A parameter cross-reference file is also created in the PDB to convert the temporary parameter codes into the permanent codes.

Non-computerized data will be entered into temporary files by a "key-to-disc" entry system which employs an interactive computer program to display a blank data form identical to the data sheet on the CRT terminal. The entry clerk inputs the data via the keyboard into the form displayed on the terminal screen. As each part of the form is completed, the computer prompts for the next item of information to be entered. There are several advantages in using an interactive program to enter the data. First, since the program formats the data, errors due to mispositioned numbers (as on cards) are virtually eliminated. Second, the program can automatically duplicate the contents of fields which are the same across several records. Third, the program checks the range and internal consistency of the data entered and flags those values which are suspect.

After the data have been computerized, they will be subjected to a series of additional quality control checks to minimize the likelihood of errors. Verification listings will be generated and compared against the original data sheets. Lists of sample identifiers and parameter names will also be generated and reviewed for accuracy and completeness. If necessary, the parameter lists will be sent to the appropriate experts for review. These lists are especially useful for taxonomic data where misspellings and synonymies are likely to occur. Matrices showing the spatial and temporal distribution of samples will also be generated. These matrices are used to check that the proper number and type of samples are present in the PDB.

Any errors identified during the quality control check will be documented on a data correction form. Errors will be corrected using the full-screen data entry software to access the appropriate records and make the required changes. Following correction, the data are transferrred to the NED for loading into the PDB.

3.3.3 Transfer of Data to NED

Data files for dissemination to NED will be produced by the retrieval and report writing modules of the SIMAS. The simplest format for the data consists of one record type per file. The retrieval module will be used to link the necessary information in the inventory, parameter data and documentation files and transfer this information to the report writer. The report writer outputs the information into the appropriate record types and fields. The SIMAS contains a library of report writer programs which generate files in standard formats. These programs will be modified and, if necessary, new programs will be added to the library. The most common media for data archival and dissemination is a 9-track magnetic tape written in either the ASCII or EBCDIC character sèt. A contents directory and description of the file formats accompany the tape. Detailed documentation describing the data type, units of measurement, the location and times of sample collection, and methods are also be included.

4.0 SUMMARY

Initiation of a Data Base Management System for application to DAMOS data should significantly increase the dissemination of data produced under the DAMOS program.

Presently, four types of data have been entered into the database: benthic taxa data, sediment chemistry analysts data, data on the physical characteristics of the sediment, and results of REMOTS imagery analysis. Table I-4-1 presents the samples included in the inventory file at this time. As these files are used to actually arrange and transfer subsets of data, modifications can be made to facilitate data handling. This inventory file will be the key file to determine what data is available to the investigator or manager, and will allow criteria to be set to create subsets of data for analysis.

Table I-4-1

DAMOS Database Sample Inventory File

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
SANDERS	LIS	CHAN IS.	12 23 53	41 11 18	73 06 24	1	TAXA
SANDERS	LIS	8	02 03 54	41 14 36	72 46 24	1	TAXA
SANDERS	LIS	3	02 19 54	41 06 18	73 00 12	1	TAXA
SANDERS	LIS	4	02 19 54	41 04 54	73 05 12	1	TAXA
SANDERS	LIS	5	02 19 54	41 01 24	72 58 36	1	TAXA
SANDERS	LIS	1	04 19 54	41 11 06	73 01 48	1	TAXA
RHOADS1	NEW HAVEN	DS-2	07 11 72	41 09 25	72 53 21	1	TAXA
RHOADS1	NEW HAVEN	DS-3	07 11 72	41 09 26	72 52 08	1	TAXA
RHOADS1	NEW HAVEN	DS-4	07 11 72	41 09 29	72 52 55	1	TAXA
RHOADS1	NEW HAVEN	DS-5	07 11 72	41 09 30	72 52 42	1	TAXA
RHOADS1	NEW HAVEN	DS-6	07 11 72	41 09 32	72 52 29	1	TAXA
RHOADS1	NEW HAVEN	DS-7	07 11 72	41 09 35	72 52 15	1	TAXA
RHOADS1	NEW HAVEN	DS-15	07 12 72	41 09 04	72 53 34	1	TAXA
RHOADS1	NEW HAVEN	DS-17	07 12 72	41 09 07	72 53 07	1	TAXA
RHOADS1	NEW HAVEN	DS-19	07 12 72	41 09 10	72 52 41	1	TAXA
RHOADS1	NEW HAVEN	DS-20	07 12 72	41 09 12	72 52 28	1	TAXA
RHOADS1	NEW HAVEN	DS-21	07 12 72	41 09 14	72 52 15	1	TAXA
RHOADS1	NEW HAVEN	DS-24	07 12 72	41 08 57	72 53 08	1	TAXA
RHOADS1	NEW HAVEN	DS-25	07 12 72	41 08 59	72 52 54	1	TAXA
RHOADS1	NEW HAVEN	DS-26	07 12 72	41 09 00	72 52 41	1	TAXA
RHOADS1	NEW HAVEN	DS-29	07 12 72	41 08 44	72 53 34	1	TAXA
RHOADS1	NEW HAVEN	DS-30	07 12 72	41 08 46	72 53 21	1	TAXA
RHOADS1	NEW HAVEN	DS-31	07 12 72	41 08 47	72 53 08	1	TAXA
RHOADS1	NEW HAVEN	DS-32	07 12 72	41 08 48	72 52 55	1	TAXA
RHOADS1	NEW HAVEN	DS-33	07 12 72	41 08 49	72 52 42	1	TAXA
RHOADS1	NEW HAVEN	DS-34	07 12 72	41 08 52	72 52 29	1	TAXA
RHOADS1	NEW HAVEN	DS-35	07 12 72	41 08 55	72 52 16	1	TAXA
RHOADS1	NEW HAVEN	DS-43	07 12 72	41 08 25	72 53 35	1	TAXA
RHOADS1	NEW HAVEN	DS-44	07 12 72	41 08 26	72 53 23	1	TAXA
RHOADS1	NEW HAVEN	DS-45	07 12 72	41 08 27	72 53 10	1	TAXA
RHOADS1	NEW HAVEN	DS-46	07 12 72	41 08 28	72 52 56	1	TAXA
RHOADS1	NEW HAVEN	DS-47	07 12 72	41 08 30	72 52 43	1	TAXA
RHOADS1	NEW HAVEN	DS-48	07 12 72	41 08 31	72 52 30	1	TAXA
RHOADS1	NEW HAVEN	DS-49	07 12 72	41 08 34	72 52 16	1	TAXA
RHOADS1	NEW HAVEN	S-50	07 12 72	41 07 55	72 53 33	1	TAXA
RHOADS1	NEW HAVEN	S-51	07 12 72	41 07 56	72 53 21	1	TAXA
RHOADS1	NEW HAVEN	S-52	07 12 72	41 07 59	72 52 56	1	TAXA
RHOADS1	NEW HAVEN	S-53	07 12 72	41 08 01	72 52 37	1	TAXA
RHOADS1	NEW HAVEN	S-54	07 12 72	41 08 04	72 52 23	1	TAXA
RHOADS1	NEW HAVEN	S-55	07 12 72	41 08 07	72 51 57	1	TAXA
RHOADS1	NEW HAVEN	S-56	07 12 72	41 08 10	72 51 36	1	TAXA
RHOADS1	NEW HAVEN	S-64	07 12 72	41 07 25	72 53 41	1	TAXA
RHOADS1	NEW HAVEN	S-65	07 12 72	41 07 26	72 53 21	1	TAXA
RHOADS1	NEW HAVEN	S-66	07 12 72	41 07 28	72 53 01	1	TAXA
RHOADS1	NEW HAVEN	S-67	07 12 72	41 07 31	72 52 41	1	TAXA
RHOADS1	NEW HAVEN	S-68	07 12 72	41 07 34	72 52 22	1	TAXA
RHOADS1	NEW HAVEN	S-69	07 12 72	41 07 36	72 52 02	1	TAXA

SAIC

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
RHOADS1	NEW HAVEN	S-70	07 12 72	41 07 39	72 51 42	1	TAXA
RHOADS1	NEW HAVEN	S-73	07 12 72	41 07 13	72 53 04	1	TAXA
RHOADS1	NEW HAVEN	S-74	07 12 72	41 07 15	72 52 45	1	TAXA
RHOADS1	NEW HAVEN	S-75	07 12 72	41 07 17	72 52 25	1	TAXA
RHOADS1	NEW HAVEN	S-78	07 12 72	41 06 54	72 53 47	1	TAXA
RHOADS1	NEW HAVEN	S-79	07 12 72	41 06 56	72 53 28	1	TAXA
RHOADS1	NEW HAVEN	S-80	07 12 72	41 06 58	72 53 08	1	TAXA
RHOADS1	NEW HAVEN	S-81	07 12 72	41 06 59	72 52 05	1	TAXA
RHOADS1	NEW HAVEN	S-82	07 12 72	41 07 01	72 52 29	1	TAXA
RHOADS1	NEW HAVEN	S-83	07 12 72	41 07 04	72 52 08	1	TAXA
RHOADS1	NEW HAVEN	S-84	07 12 72	41 07 08	72 51 48	1	TAXA
RHOADS1	NEW HAVEN	S-92	07 12 72	41 06 23	72 53 54	1	TAXA
RHOADS1	NEW HAVEN	S-93	07 12 72	41 06 26	72 53 35	1	TAXA
RHOADS1	NEW HAVEN	S-94	07 12 72	41 06 27	72 53 15	1	TAXA
RHOADS1	NEW HAVEN	S-95	07 12 72	41 06 29	72 52 55	1	TAXA
RHOADS1	NEW HAVEN	S-96	07 12 72	41 06 31	72 52 35	1	TAXA
RHOADS1	NEW HAVEN	S-97	07 12 72	41 06 34	72 52 14	1	TAXA
RHOADS1	NEW HAVEN	S-98	07 12 72	41 06 37	72 51 55	1	TAXA
RHOADS1	NEW HAVEN	KE-10	07 28 72	41 17 04	72 54 47	1	TAXA
RHOADS1	NEW HAVEN	KE-11	07 28 72	41 17 40	72 54 30	1	TAXA
RHOADS1	NEW HAVEN	KE-13	07 28 72	41 14 01	72 55 05	1	TAXA
RHOADS1	NEW HAVEN	KE-15	07 28 72	41 14 37	72 54 57	1	TAXA
RHOADS1	NEW HAVEN	KE-17	07 28 72	41 14 46	72 54 54	1	TAXA
RHOADS1	NEW HAVEN	KE-18	07 28 72	41 14 59	72 54 58	1	TAXA
RHOADS1	NEW HAVEN	KE-2	07 28 72	41 16 19	72 54 41	1	TAXA
RHOADS1	NEW HAVEN	KE-21	07 28 72	41 15 35	72 54 47	1	TAXA
RHOADS1	NEW HAVEN	KE-23	07 28 72	41 16 58	72 54 48	1	TAXA
RHOADS1	NEW HAVEN	KE-4	07 28 72	41 16 40	72 54 48	1	TAXA
RHOADS1	NEW HAVEN	KE-5	07 28 72	41 13 17	72 54 38	1	TAXA
RHOADS1	NEW HAVEN	KE-6	07 28 72	41 13 38	72 54 52	1	TAXA
RHOADS1	NEW HAVEN	KE-8	07 28 72	41 17 06	72 54 35	1	TAXA
RHOADS1	NEW HAVEN	KE-9	07 28 72	41 17 15	72 54 33	1	TAXA
MCCALL1	LIS	A01	08 16 72	41 14 24	72 43 24	1	TAXA
MCCALL1	LIS	A02	08 16 72	41 13 18	72 43 00	1	TAXA
MCCALL1	LIS	A03	08 16 72	41 11 12	72 42 54	1	TAXA
MCCALL1	LIS	A04	08 21 72	41 09 36	72 44 06	1	TAXA
MCCALL1	LIS	A05	08 21 72	41 08 12	72 41 24	1	TAXA
MCCALL1	LIS	A06	08 21 72	41 07 24	72 41 12	1	TAXA
MCCALL1	LIS	A07	08 21 72	41 05 12	72 40 30	1	TAXA
MCCALL1	LIS	A08	08 21 72	41 03 36	72 40 06	1	TAXA
MCCALL1	LIS	A09	08 21 72	41 01 18	72 40 00	1	TAXA
MCCALL1	LIS	A10	08 21 72	41 00 00	72 39 36	1	TAXA
RHOADS1	NEW HAVEN	NW-100	09 05 72	41 10 52	72 56 54	1	TAXA
RHOADS1	NEW HAVEN	NW-101	09 05 72	41 10 55	72 56 41	1	TAXA
RHOADS1	NEW HAVEN	NW-102	09 05 72	41 10 53	72 56 27	1	TAXA
RHOADS1	NEW HAVEN	NW-103	09 05 72	41 10 55	72 56 12	1	TAXA
RHOADS1	NEW HAVEN	NW-104	09 05 72	41 10 53	72 56 12	2	TAXA

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
RHOADS1	NEW HAVEN	NW-105	09 05 72	41 10 54	72 55 50	2	TAXA
RHOADS1	NEW HAVEN	NW-106	09 05 72	41 10 54	72 55 38	2	TAXA
RHOADS1	NEW HAVEN	NW-107	09 05 72	41 10 53	72 57 19	2	TAXA
RHOADS1	NEW HAVEN	NW-108	09 05 72	41 10 53	72 57 00	1	TAXA
RHOADS1	NEW HAVEN	NW-109	09 05 72	41 10 53	72 56 41	1	TAXA
RHOADS1	NEW HAVEN	NW-110	09 05 72	41 10 53	72 56 22	1	TAXA
RHOADS1	NEW HAVEN	NW-111	09 05 72	41 10 53	72 56 02	1	TAXA
RHOADS1	NEW HAVEN	NW-112	09 05 72	41 10 53	72 55 44	1	TAXA
RHOADS1	NEW HAVEN	NW-113	09 05 72	41 10 55	72 55 25	1	TAXA
RHOADS1	NEW HAVEN	NW-114	09 05 72	41 10 24	72 56 28	1	TAXA
RHOADS1	NEW HAVEN	NW-115	09 05 72	41 10 24	72 56 16	1	TAXA
RHOADS1	NEW HAVEN	NW-116	09 05 72	41 10 25	72 56 04	1	TAXA
RHOADS1	NEW HAVEN	NW-117	09 05 72	41 10 22	72 57 19	1	TAXA
RHOADS1	NEW HAVEN	NW-118	09 05 72	41 10 20	72 56 58	1	TAXA
RHOADS1	NEW HAVEN	NW-119	09 05 72	41 10 20	72 56 39	1	TAXA
RHOADS1	NEW HAVEN	NW-120	09 05 72	41 10 22	72 56 20	1	TAXA
RHOADS1	NEW HAVEN	NW-121	09 05 72	41 10 22	72 56 02	1	TAXA
RHOADS1	NEW HAVEN	NW-122	09 05 72	41 10 23	72 55 43	1	TAXA
RHOADS1	NEW HAVEN	NW-123	09 05 72	41 10 23	72 55 24	1	TAXA
RHOADS1	NEW HAVEN	NW-124	09 05 72	41 09 59	72 56 53	1	TAXA
RHOADS1	NEW HAVEN	NW-125	09 05 72	41 09 59	72 56 41	1	TAXA
RHOADS1	NEW HAVEN	NW-126	09 05 72	41 09 58	72 56 29	1	TAXA
RHOADS1	NEW HAVEN	NW-127	09 05 72	41 09 58	72 56 15	1	TAXA
RHOADS1	NEW HAVEN	NW-128	09 05 72	41 09 56	72 56 06	1	TAXA
RHOADS1	NEW HAVEN	NW-129	09 05 72	41 09 58	72 55 53	1	TAXA
RHOADS1	NEW HAVEN	NW-130	09 05 72	41 09 56	72 55 38	2	TAXA
RHOADS2	NEW HAVEN	DS-1	01 09 73	41 09 06	72 53 34	3	TAXA
RHOADS2	NEW HAVEN	DS-2	01 09 73	41 09 06	72 53 22	3	TAXA
RHOADS2	NEW HAVEN	DS-22	01 09 73	41 08 53	72 53 37	3	TAXA
RHOADS2	NEW HAVEN	DS-23	01 09 73	41 08 54	72 53 22	3	TAXA
RHOADS2	NEW HAVEN	DS-24	01 09 73	41 08 57	72 53 08	3	TAXA
RHOADS2	NEW HAVEN	DS-25	01 09 73	41 08 59	72 52 54	3	TAXA
RHOADS2	NEW HAVEN	DS-26	01 09 73	41 09 00	72 52 41	3	TAXA
RHOADS2	NEW HAVEN	DS-27	01 09 73	41 09 01	72 52 26	3	TAXA
RHOADS2	NEW HAVEN	DS-28	01 09 73	41 09 02	72 52 14	3	TAXA
RHOADS2	NEW HAVEN	DS-3	01 09 73	41 09 26	72 53 08	3	TAXA
RHOADS2	NEW HAVEN	DS-4	01 09 73	41 09 29	72 52 55	3	TAXA
RHOADS2	NEW HAVEN	DS-43	01 09 73	41 08 25	72 53 35	3	TAXA
RHOADS2	NEW HAVEN	DS-44	01 09 73	41 08 26	72 53 23	3	TAXA
RHOADS2	NEW HAVEN	DS-45	01 09 73	41 08 27	72 53 10	3	TAXA
RHOADS2	NEW HAVEN	DS-46	01 09 73	41 08 28	72 52 56	3	TAXA
RHOADS2	NEW HAVEN	DS-47	01 09 73	41 08 30	72 52 43	3	TAXA
RHOADS2	NEW HAVEN	DS-48	01 09 73	41 08 31	72 52 30	3	TAXA
RHOADS2	NEW HAVEN	DS-49	01 09 73	41 08 34	72 52 16	3	TAXA
RHOADS2	NEW HAVEN	DS-5	01 09 73	41 09 30	72 52 42	3	TAXA
RHOADS2	NEW HAVEN	DS-6	01 09 73	41 09 32	72 52 29	3	TAXA
RHOADS2	NEW HAVEN	DS-7	01 09 73	41 09 35	72 52 15	3	TAXA

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
RHOADS2	NEW HAVEN	NW-100	01 09 73	41 10 52	72 56 54	3	TAXA
RHOADS2	NEW HAVEN	NW-101	01 09 73	41 10 55	72 56 41	3	TAXA
RHOADS2	NEW HAVEN	NW-102	01 09 73	41 10 53	72 56 27	3	TAXA
RHOADS2	NEW HAVEN	NW-103	01 09 73	41 10 55	72 56 12	3	TAXA
RHOADS2	NEW HAVEN	NW-104	01 09 73	41 10 53	72 56 03	3	TAXA
RHOADS2	NEW HAVEN	NW-105	01 09 73	41 10 54	72 55 50	3	TAXA
RHOADS2	NEW HAVEN	NW-106	01 09 73	41 10 54	72 55 38	3	TAXA
RHOADS2	NEW HAVEN	NW-114	01 09 73	41 10 24	72 56 28	3	TAXA
RHOADS2	NEW HAVEN	NW-115	01 09 73	41 10 24	72 56 16	3	TAXA
RHOADS2	NEW HAVEN	NW-116	01 09 73	41 10 25	72 56 04	3	TAXA
RHOADS2	NEW HAVEN	NW-124	01 09 73	41 09 59	72 56 53	3	TAXA
RHOADS2	NEW HAVEN	NW-125	01 09 73	41 09 59	72 56 41	3	TAXA
RHOADS2	NEW HAVEN	NW-126	01 09 73	41 09 58	72 56 29	3	TAXA
RHOADS2	NEW HAVEN	NW-127	01 09 73	41 09 58	72 56 15	3	TAXA
RHOADS2	NEW HAVEN	NW-128	01 09 73	41 09 56	72 56 06	3	TAXA
RHOADS2	NEW HAVEN	NW-129	01 09 73	41 09 58	72 55 53	3	TAXA
RHOADS2	NEW HAVEN	NW-130	01 09 73	41 09 56	72 55 38	3	TAXA
RHOADS2	NEW HAVEN	NW-F46	01 10 73	41 10 26	72 56 55	3	TAXA
RHOADS2	NEW HAVEN	NW-F6	01 10 73	41 10 26	72 55 39	3	TAXA
RHOADS2	NEW HAVEN	NW-NW1	01 10 73	41 10 25	72 56 41	3	TAXA
RHOADS2	NEW HAVEN	NW-NW2	01 10 73	41 10 25	72 55 52	3	TAXA
RHOADS2	NEW HAVEN	S-50	01 10 73	41 07 55	72 53 33	3	TAXA
RHOADS2	NEW HAVEN	S-51	01 10 73	41 07 56	72 53 21	3	TAXA
RHOADS2	NEW HAVEN	S-52	01 10 73	41 07 59	72 52 56	3	TAXA
RHOADS2	NEW HAVEN	S-53	01 10 73	41 08 01	72 52 37	3	TAXA
RHOADS2	NEW HAVEN	S-54	01 10 73	41 08 04	72 52 23	3	TAXA
RHOADS2	NEW HAVEN	S-55	01 10 73	41 08 07	72 51 57	3	TAXA
RHOADS2	NEW HAVEN	S-56	01 10 73	41 08 10	72 51 36	3	TAXA
RHOADS2	NEW HAVEN	S-73	01 10 73	41 07 13	72 53 04	3	TAXA
RHOADS2	NEW HAVEN	S-74	01 10 73	41 07 15	72 52 45	3	TAXA
RHOADS2	NEW HAVEN	S-75	01 10 73	41 07 17	72 52 25	3	TAXA
RHOADS2	NEW HAVEN	S-93	01 10 73	41 06 26	72 53 35	3	TAXA
RHOADS2	NEW HAVEN	S-94	01 10 73	41 06 27	72 53 15	3	TAXA
RHOADS2	NEW HAVEN	S-95	01 10 73	41 06 29	72 52 55	3	TAXA
RHOADS2	NEW HAVEN	S-96	01 10 73	41 06 31	72 52 35	3	TAXA
RHOADS2	NEW HAVEN	S-97	01 10 73	41 06 34	72 52 14	3	TAXA
RHOADS2	NEW HAVEN	S-98	01 10 73	41 06 37	72 51 55	3	TAXA
RHOADS3	MILFORD	M-3	01 16 73	41 06 48	73 01 57	2	TAXA
RHOADS3	BRANFORD	B-1	01 17 73	41 10 37	72 47 30	2	TAXA
RHOADS3	BRANFORD	B-10	01 17 73	41 10 18	72 47 04	2	TAXA
RHOADS3	BRANFORD	B-2	01 17 73	41 10 28	72 47 30	2	TAXA
RHOADS3	BRANFORD	B-3	01 17 73	41 10 18	72 47 30	2	TAXA
RHOADS3	BRANFORD	B-4	01 17 73	41 10 08	72 47 30	2	TAXA
RHOADS3	BRANFORD	B-5	01 17 73	41 09 59	72 47 30	2	TAXA
RHOADS3	BRANFORD	B-6	01 17 73	41 10 18	72 47 56	2	TAXA
RHOADS3	BRANFORD	B-7	01 17 73	41 10 18	72 47 43	2	TAXA
RHOADS3	BRANFORD	B-9	01 17 73	41 10 18	72 47 17	2	TAXA

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
RHOADS3	GUILFORD	G-1	01 19 73	41 11 37	72 42 33	2	TAXA
RHOADS3	GUILFORD	G-10	01 19 73	41 11 18	72 42 07	2	TAXA
RHOADS3	GUILFORD	G-2	01 19 73	41 11 28	72 42 33	2	TAXA
RHOADS3	GUILFORD	G-3	01 19 73	41 11 18	72 42 33	2	TAXA
RHOADS3	GUILFORD	G-4	01 19 73	41 11 08	72 42 33	2	TAXA
RHOADS3	GUILFORD	G-5	01 19 73	41 10 59	72 42 33	2	TAXA
RHOADS3	GUILFORD	G-6	01 19 73	41 11 18	72 42 59	2	TAXA
RHOADS3	GUILFORD	G-7	01 19 73	41 11 18	72 42 46	2	TAXA
RHOADS3	GUILFORD	G-9	01 19 73	41 11 18	72 42 20	2	TAXA
MCCALL1	LIS	F02	02 17 73	41 08 48	72 39 48	1	TAXA
MCCALL1	LIS	F03	02 17 73	41 08 48	72 37 48	1	TAXA
MCCALL1	LIS	G01	02 17 73	41 06 18	72 50 00	1	TAXA
MCCALL1	LIS	G02	02 17 73	41 06 18	72 38 00	1	TAXA
MCCALL1	LIS	G03	02 17 73	41 06 18	72 50 00	1	TAXA
MCCALL1	LIS	H02	02 17 73	41 07 24	72 41 12	1	TAXA
MCCALL1	LIS	S01	02 17 73	41 11 12	73 02 48	1	TAXA
MCCALL2	LIS	B01	02 17 73	41 08 36	72 52 54	4	TAXA
MCCALL2	LIS	B02	02 17 73	41 09 24	72 50 18	4	TAXA
MCCALL2	LIS	B03	02 17 73	41 10 12	72 47 36	4	TAXA
MCCALL2	LIS	B04	02 17 73	41 10 48	72 44 54	4	TAXA
MCCALL2	LIS	B05	02 17 73	41 11 12	72 42 54	4	TAXA
MCCALL2	LIS	B06	02 17 73	41 11 24	72 40 42	4	TAXA
MCCALL2	LIS	B07	02 17 73	41 11 24	72 38 42	4	TAXA
MCCALL2	LIS	B08	02 17 73	41 11 24	72 37 42	4	TAXA
MCCALL2	LIS	F01	02 17 73	41 09 06	72 44 54	2	TAXA
MCCALL2	LIS	S03	02 17 73	41 06 36	73 00 30	2	TAXA
MCCALL2	LIS	S04	02 17 73	41 05 06	73 05 12	5	TAXA
MCCALL2	LIS	S05	02 17 73	41 01 36	72 58 42	2	TAXA
MCCALL2	LIS	S07	02 17 73	41 12 36	72 51 12	2	TAXA
MCCALL2	LIS	S08	02 17 73	41 14 48	72 46 12	2	TAXA
MCCALL1	LIS	A07	03 26 73	41 05 12	72 40 30	1	TAXA
MCCALL1	LIS	A08	03 26 73	41 03 36	72 40 06	1	TAXA
MCCALL1	LIS	A10	03 26 73	41 00 00	72 39 36	1	TAXA
MCCALL1	LIS	C01	03 26 73	41 05 48	72 53 12	2	TAXA
MCCALL1	LIS	C02	03 26 73	41 05 00	72 53 12	2	TAXA
MCCALL1	LIS	C03	03 26 73	41 01 42	72 53 12	2	TAXA
MCCALL1	LIS	C04	03 26 73	41 00 36	72 53 12	2	TAXA
MCCALL2	LIS	C05	03 26 73	40 59 06	72 55 42	2	TAXA
RHOADS4	NEW HAVEN	KE-1	07 16 73	41 17 13	72 54 46	4	TAXA
RHOADS4	NEW HAVEN	KE-13	07 16 73	41 14 01	72 55 05	2	TAXA
RHOADS4	NEW HAVEN	KE-14	07 16 73	41 14 17	72 54 59	2	TAXA
RHOADS4	NEW HAVEN	KE-15	07 16 73	41 14 37	72 54 57	2	TAXA
RHOADS4	NEW HAVEN	KE-20	07 16 73	41 15 16	72 54 48	2	TAXA
RHOADS4	NEW HAVEN	KE-22	07 16 73	41 15 41	72 54 47	2	TAXA
RHOADS4	NEW HAVEN	KE-5	07 16 73	41 13 17	72 54 38	4	TAXA
RHOADS4	NEW HAVEN	KE-6	07 16 73	41 13 38	72 54 52	4	TAXA
RHOADS4	NEW HAVEN	KE-7	07 16 73	41 13 51	72 54 59	6	TAXA

SAIC

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
RHOADS4	NEW HAVEN	KE-9	07 16 73	41 17 15	72 54 33	4	TAXA
RHOADS4	NEW HAVEN	DS-2	07 23 73	41 09 25	72 53 21	2	TAXA
RHOADS4	NEW HAVEN	DS-25	07 23 73	41 08 59	72 52 54	2	TAXA
RHOADS4	NEW HAVEN	DS-4	07 23 73	41 09 29	72 52 55	2	TAXA
RHOADS4	NEW HAVEN	DS-7	07 23 73	41 09 35	72 52 15	2	TAXA
RHOADS4	NEW HAVEN	DS-43	07 24 73	41 08 25	72 53 35	2	TAXA
RHOADS4	NEW HAVEN	DS-46	07 24 73	41 08 28	72 52 56	2	TAXA
RHOADS4	NEW HAVEN	DS-49	07 24 73	41 08 34	72 52 16	2	TAXA
RHOADS4	NEW HAVEN	S-50	07 25 73	41 07 55	72 53 33	2	TAXA
RHOADS4	NEW HAVEN	S-51	07 25 73	41 07 59	72 52 56	2	TAXA
RHOADS4	NEW HAVEN	S-52	07 25 73	41 07 59	72 53 21	2	TAXA
RHOADS4	NEW HAVEN	S-74	07 25 73	41 07 15	72 52 45	2	TAXA
RHOADS4	NEW HAVEN	NW-100	08 02 73	41 10 52	72 56 54	2	TAXA
RHOADS4	NEW HAVEN	NW-101	08 02 73	41 10 55	72 56 41	2	TAXA
RHOADS4	NEW HAVEN	NW-102	08 02 73	41 10 53	72 56 27	2	TAXA
RHOADS4	NEW HAVEN	NW-103	08 02 73	41 10 55	72 56 12	2	TAXA
RHOADS4	NEW HAVEN	NW-105	08 02 73	41 10 54	72 55 50	2	TAXA
RHOADS4	NEW HAVEN	S-92	08 02 73	41 06 23	72 53 54	2	TAXA
RHOADS4	NEW HAVEN	S-94	08 02 73	41 06 27	72 53 15	2	TAXA
RHOADS4	NEW HAVEN	S-95	08 02 73	41 06 29	72 52 55	2	TAXA
RHOADS4	NEW HAVEN	S-96	08 02 73	41 06 31	72 52 35	2	TAXA
RHOADS4	NEW HAVEN	S-98	08 02 73	41 06 37	72 51 55	2	TAXA
RHOADS4	NEW HAVEN	NW-104	08 07 73	41 10 53	72 56 03	2	TAXA
RHOADS4	NEW HAVEN	NW-106	08 07 73	41 10 54	72 55 38	2	TAXA
RHOADS4	NEW HAVEN	NW-114	08 07 73	41 10 24	72 56 28	2	TAXA
RHOADS4	NEW HAVEN	NW-116	08 07 73	41 10 25	72 56 04	2	TAXA
RHOADS4	NEW HAVEN	NW-129	08 07 73	41 09 56	72 55 53	2	TAXA
MCCALL2	LIS	A01	08 09 73	41 14 24	72 43 24	2	TAXA
MCCALL2	LIS	A02	08 09 73	41 13 18	72 43 00	2	TAXA
MCCALL2	LIS	A03	08 09 73	41 11 12	72 42 54	1	TAXA
MCCALL2	LIS	A04	08 09 73	41 09 36	72 44 06	2	TAXA
MCCALL2	LIS	A05	08 09 73	41 08 12	72 41 24	2	TAXA
MCCALL2	LIS	A06	08 09 73	41 07 24	72 41 12	2	TAXA
MCCALL2	LIS	A07	08 09 73	41 05 12	72 40 30	2	TAXA
MCCALL2	LIS	A08	08 09 73	41 03 36	72 40 06	2	TAXA
MCCALL2	LIS	A09	08 09 73	41 01 18	72 40 00	2	TAXA
MCCALL2	LIS	A10	08 09 73	41 00 00	72 39 36	2	TAXA
MCCALL2	LIS	A12	08 09 73	41 06 18	72 53 12	1	TAXA
MCCALL2	LIS	B01	08 09 73	41 08 36	72 52 54	2	TAXA
MCCALL2	LIS	B02	08 09 73	41 09 24	72 50 18	2	TAXA
MCCALL2	LIS	B03	08 09 73	41 10 12	72 47 36	2	TAXA
MCCALL2	LIS	B04	08 09 73	41 10 48	72 44 54	2	TAXA
MCCALL2	LIS	B05	08 09 73	41 11 12	72 42 54	1	TAXA
MCCALL2	LIS	B06	08 09 73	41 11 24	72 40 42	2	TAXA
MCCALL2	LIS	B07	08 09 73	41 11 24	72 38 42	2	TAXA
MCCALL2	LIS	C01	08 09 73	41 05 48	72 53 12	2	TAXA
MCCALL2	LIS	C02	08 09 73	41 05 00	72 53 12	2	TAXA

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
MCCALL2	LIS	C03	08 09 73	41 01 42	72 53 12	2	TAXA
MCCALL2	LIS	C04	08 09 73	41 00 36	72 53 12	2	TAXA
MCCALL2	LIS	F01	08 09 73	41 09 06	72 44 54	2	TAXA
MCCALL2	LIS	G01	08 09 73	41 06 18	72 50 00	2	TAXA
MCCALL2	LIS	S01	08 09 73	41 11 12	73 02 48	2	TAXA
MCCALL2	LIS	S02	08 09 73	41 07 30	73 03 24	2	TAXA
MCCALL2	LIS	S03	08 09 73	41 06 36	73 00 30	2	TAXA
MCCALL2	LIS	S04	08 09 73	41 05 06	73 05 12	2	TAXA
MCCALL2	LIS	S05	08 09 73	41 01 36	72 58 42	2	TAXA
MCCALL2	LIS	S07	08 09 73	41 12 36	72 51 12	2	TAXA
MCCALL2	LIS	S08	08 09 73	41 14 48	72 46 12	2	TAXA
RHOADS5	NEW HAVEN	KE-1	02 02 74	41 17 13	72 54 46	2	TAXA
RHOADS5	NEW HAVEN	KE-13	02 02 74	41 14 01	72 55 05	2	TAXA
RHOADS5	NEW HAVEN	KE-14	02 02 74	41 14 17	72 54 59	2	TAXA
RHOADS5	NEW HAVEN	KE-15	02 02 74	41 14 28	72 54 57	2	TAXA
RHOADS5	NEW HAVEN	KE-17	02 02 74	41 14 46	72 54 54	2	TAXA
RHOADS5	NEW HAVEN	KE-18	02 02 74	41 14 59	72 54 58	2	TAXA
RHOADS5	NEW HAVEN	KE-2	02 02 74	41 16 19	72 54 41	2	TAXA
RHOADS5	NEW HAVEN	KE-21	02 02 74	41 15 35	72 54 47	2	TAXA
RHOADS5	NEW HAVEN	KE-22	02 02 74	41 15 41	72 54 47	2	TAXA
RHOADS5	NEW HAVEN	KE-23	02 02 74	41 16 58	72 54 05	2	TAXA
RHOADS5	NEW HAVEN	KE-4	02 02 74	41 16 40	72 54 48	2	TAXA
RHOADS5	NEW HAVEN	KE-5	02 02 74	41 13 17	72 54 38	2	TAXA
RHOADS5	NEW HAVEN	KE-6	02 02 74	41 13 38	72 54 52	2	TAXA
RHOADS5	NEW HAVEN	KE-7	02 02 74	41 13 51	72 54 59	2	TAXA
RHOADS5	NEW HAVEN	DS-1	02 06 74	41 09 06	72 53 34	2	TAXA
RHOADS5	NEW HAVEN	DS-3	02 06 74	41 09 26	72 53 08	2	TAXA
RHOADS5	NEW HAVEN	DS-43	02 06 74	41 08 25	72 53 35	2	TAXA
RHOADS5	NEW HAVEN	DS-45	02 06 74	41 08 27	72 53 10	2	TAXA
RHOADS5	NEW HAVEN	DS-5	02 06 74	41 09 30	72 52 42	2	TAXA
RHOADS5	NEW HAVEN	NW-101	02 21 74	41 10 55	72 56 41	2	TAXA
RHOADS5	NEW HAVEN	NW-103	02 21 74	41 10 55	72 56 12	2	TAXA
RHOADS5	NEW HAVEN	NW-104	02 21 74	41 10 53	72 56 03	2	TAXA
RHOADS5	NEW HAVEN	NW-106	02 21 74	41 10 54	72 55 38	2	TAXA
RHOADS5	NEW HAVEN	NW-114	02 21 74	41 10 24	72 56 28	2	TAXA
RHOADS5	NEW HAVEN	NW-F46	02 21 74	41 10 26	72 56 55	2	TAXA
RHOADS5	NEW HAVEN	NW-F6	02 21 74	41 10 26	72 55 39	2	TAXA
RHOADS5	NEW HAVEN	NW-NW1	02 21 74	41 10 25	72 56 41	2	TAXA
RHOADS5	NEW HAVEN	S-53	03 26 74	41 08 01	72 52 37	2	TAXA
RHOADS6	NEW HAVEN	DS-11	07 15 74	41 09 06	72 53 34	2	TAXA
RHOADS6	NEW HAVEN	DS-2	07 15 74	41 09 25	72 53 21	2	TAXA
RHOADS6	NEW HAVEN	DS-23	07 15 74	41 08 54	72 53 22	2	TAXA
RHOADS6	NEW HAVEN	DS-24	07 15 74	41 08 57	72 53 08	2	TAXA
RHOADS6	NEW HAVEN	DS-27	07 15 74	41 09 01	72 52 26	2	TAXA
RHOADS6	NEW HAVEN	DS-3	07 15 74	41 09 26	72 53 08	2	TAXA
RHOADS6	NEW HAVEN	DS-43	07 15 74	41 08 25	72 53 35	2	TAXA
RHOADS6	NEW HAVEN	DS-45	07 15 74	41 08 27	72 53 10	2	TAXA

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
RHOADS6	NEW HAVEN	DS-5	07 15 74	41 09 29	72 52 55	2	TAXA
RHOADS6	NEW HAVEN	DS-6	07 15 74	41 09 32	72 52 29	2	TAXA
RHOADS6	NEW HAVEN	KE-13	07 15 74	41 14 01	72 55 05	2	TAXA
RHOADS6	NEW HAVEN	KE-14	07 15 74	41 14 17	72 54 59	2	TAXA
RHOADS6	NEW HAVEN	KE-15	07 15 74	41 14 37	72 54 57	2	TAXA
RHOADS6	NEW HAVEN	KE-16	07 15 74	41 17 13	72 54 46	2	TAXA
RHOADS6	NEW HAVEN	KE-18	07 15 74	41 14 59	72 54 58	2	TAXA
RHOADS6	NEW HAVEN	KE-19	07 15 74	41 14 52	72 54 53	2	TAXA
RHOADS6	NEW HAVEN	KE-21	07 15 74	41 15 35	72 54 47	2	TAXA
RHOADS6	NEW HAVEN	KE-5	07 15 74	41 13 17	72 54 38	2	TAXA
RHOADS6	NEW HAVEN	KE-6	07 15 74	41 13 38	72 54 52	2	TAXA
RHOADS6	NEW HAVEN	KE-7	07 15 74	41 13 51	72 54 59	2	TAXA
RHOADS6	NEW HAVEN	NW-102	07 16 74	41 10 53	72 56 27	2	TAXA
RHOADS6	NEW HAVEN	NW-103	07 16 74	41 10 55	72 56 12	2	TAXA
RHOADS6	NEW HAVEN	NW-104	07 16 74	41 10 53	72 56 03	2	TAXA
RHOADS6	NEW HAVEN	NW-105	07 16 74	41 10 54	72 55 50	2	TAXA
RHOADS6	NEW HAVEN	NW-106	07 16 74	41 10 54	72 55 38	2	TAXA
RHOADS6	NEW HAVEN	NW-115	07 16 74	41 10 24	72 56 16	2	TAXA
RHOADS6	NEW HAVEN	NW-124	07 16 74	41 09 53	72 56 53	2	TAXA
RHOADS6	NEW HAVEN	NW-126	07 16 74	41 09 58	72 56 29	2	TAXA
RHOADS6	NEW HAVEN	NW-129	07 16 74	41 09 58	72 55 53	2	TAXA
RHOADS6	NEW HAVEN	NW-F46	07 16 74	41 10 26	72 56 55	2	TAXA
RHOADS6	NEW HAVEN	NW-F65	07 16 74	41 10 26	72 55 39	2	TAXA
RHOADS6	NEW HAVEN	S-51	07 17 74	41 07 56	72 53 21	2	TAXA
RHOADS6	NEW HAVEN	S-52	07 17 74	41 07 59	72 52 56	2	TAXA
RHOADS6	NEW HAVEN	S-54	07 17 74	41 08 04	72 52 23	2	TAXA
RHOADS6	NEW HAVEN	S-55	07 17 74	41 08 07	72 51 57	2	TAXA
RHOADS6	NEW HAVEN	S-56	07 17 74	41 08 10	72 51 36	2	TAXA
RHOADS6	NEW HAVEN	S-73	07 17 74	41 07 13	72 53 04	2	TAXA
RHOADS6	NEW HAVEN	S-74	07 17 74	41 07 15	72 52 45	2	TAXA
RHOADS6	NEW HAVEN	S-75	07 17 74	41 07 17	72 52 25	2	TAXA
RHOADS6	NEW HAVEN	S-76	07 17 74	41 07 20	72 52 05	2	TAXA
RHOADS6	NEW HAVEN	S-77	07 17 74	41 07 23	72 51 44	2	TAXA
RHOADS6	NEW HAVEN	S-92	07 17 74	41 06 23	72 53 54	2	TAXA
RHOADS6	NEW HAVEN	S-93	07 17 74	41 06 26	72 53 35	2	TAXA
RHOADS6	NEW HAVEN	S-94	07 17 74	41 06 27	72 53 15	2	TAXA
RHOADS6	NEW HAVEN	S-95	07 17 74	41 06 29	72 52 55	2	TAXA
RHOADS6	NEW HAVEN	S-96	07 17 74	41 06 31	72 52 35	2	TAXA
RHOADS6	NEW HAVEN	S-97	07 17 74	41 06 34	72 52 14	2	TAXA
RHOADS6	NEW HAVEN	S-98	07 17 74	41 06 37	72 51 55	2	TAXA
BROOKS	NEW HAVEN	CTR	04 13 78	41 08 49	72 52 53	3	TAXA
BROOKS	NEW HAVEN	REF	04 13 78	41 09 08	72 53 12	3	TAXA
BROOKS	NEW HAVEN	CTR	07 29 78	41 08 49	72 52 53	3	TAXA
BROOKS	NEW HAVEN	REF	07 29 78	41 09 08	72 53 12	3	TAXA
BROOKS	NEW HAVEN	CTR	01 19 79	41 08 49	72 52 53	5	TAXA
BROOKS	NEW HAVEN	REF	01 26 79	41 09 08	72 53 12	5	TAXA
BROOKS	STNH-S	1000E	01 26 79	41 08 29	72 52 05	5	TAXA

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Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
BROOKS	STNH-S	1000W	01 26 79	41 08 29	72 53 30	5	TAXA
BROOKS	STNH-S	CTR	01 26 79	41 08 29	72 52 47	5	TAXA
BROOKS	STNH-N	CTR	03 21 79	41 09 15	72 51 41	5	TAXA
BROOKS	NEW HAVEN	CTR	05 21 79	41 08 49	72 52 53	5	TAXA
BROOKS	NEW HAVEN	REF	05 21 79	41 09 08	72 53 12	5	TAXA
BROOKS	STNH-S	1000E	05 21 79	41 08 29	72 52 05	5	TAXA
BROOKS	STNH-S	100UW	05 22 79	41 08 29	72 53 30	5	TAXA
BROOKS	STNH-S	1000E	08 09 79	41 08 29	72 52 05	5	TAXA
BROOKS	STNH-S	1000W	08 09 79	41 08 29	72 53 30	5	TAXA
BROOKS	STNH-S	CTR	08 09 79	41 08 29	72 52 47	5	TAXA
BROOKS	CLIS	REF	04 01 80	41 07 57	72 52 44	7	TAXA
BROOKS	NORWALK	CTR	04 01 80	41 08 55	72 53 29	3	TAXA
BROOKS	STNH-N	CTR	04 01 80	41 09 15	72 51 41	3	TAXA
BROOKS	STNH-N	200E	04 02 80	41 09 15	72 51 33	3	TAXA
BROOKS	STNH-N	400E	04 02 80	41 09 15	72 51 24	4	TAXA
BROOKS	STNH-S	300E	09 03 80	41 08 29	72 52 35	3	TAXA
BROOKS	STNH-N	200E	09 04 80	41 09 15	72 51 33	3	TAXA
BROOKS	STNH-N	CTR	09 04 80	41 09 15	72 51 41	3	TAXA
BROOKS	CLIS	REF	09 05 80	41 07 57	72 52 44	3	TAXA
BROOKS	STNH-S	100E	09 05 80	41 08 29	72 52 43	3	TAXA
BROOKS	STNH-S	CTR	09 05 80	41 08 29	72 52 47	3	TAXA
PRATT(81-82)	STNH-S	CTR	01 25 81	41 08 29	72 52 44	3	TAXA
PRATT(81-82)	STNH-S	IE	01 25 81	41 08 29	72 52 40	3	TAXA
PRATT(81-82)	CLIS	CLISREF	01 26 81	41 07 57	72 52 44	3	TAXA
PRATT(81-82)	STNH-N	CTR	01 28 81	41 09 14	72 52 45	3	TAXA
PRATT(81-82)	STNH-N	IE	01 28 81	41 09 14	72 52 36	3	TAXA
PRATT(81-82)	STNH-N	OE	01 28 81	41 09 14	72 52 28	3	TAXA
PRATT(81-82)	STNH-S	OE	01 28 81	41 08 29	72 52 27	3	TAXA
PRATT(81-82)	CLIS	CLISREF	08 19 81	41 07 57	72 52 44	3	TAXA
DAMOS	NORWALK	300E	01 29 82	41 08 55	72 53 16	5	CHEM
DAMOS	NORWALK	450E	01 29 82	41 08 55	72 53 10	5	CHEM
DAMOS	NORWALK	CTR	01 29 82	41 08 55	72 53 29	9	CHEM
DAMOS	STNH-S	100E	01 29 82	41 08 29	72 52 43	8	CHEM
DAMOS	STNH-S	100N	01 29 82	41 08 32	72 52 47	3	CHEM
DAMOS	STNH-S	100S	01 29 82	41 08 26	72 52 47	3	CHEM
DAMOS	STNH-S	150W	01 29 82	41 08 29	72 52 53	3	CHEM
DAMOS	STNH-S	200N	01 29 82	41 08 36	72 52 47	3	CHEM
DAMOS	STNH-S	250S	01 29 82	41 08 21	72 52 47	3	CHEM
DAMOS	STNH-S	250W	01 29 82	41 08 29	72 52 58	3	CHEM
DAMOS	STNH-S	300W	01 29 82	41 08 29	72 53 00	3	CHEM
DAMOS	STNH-S	400E	01 29 82	41 08 29	72 52 30	3	CHEM
DAMOS	STNH-S	400W	01 29 82	41 08 29	72 53 04	3	CHEM
DAMOS	STNH-S	CTR	01 29 82	41 08 29	72 52 47	8	CHEM
PRATT(81-82)	STNH-S	CTR	01 29 82	41 08 29	72 52 44	3	TAXA
PRATT(81-82)	STNH-S	IE	01 29 82	41 08 29	72 52 40	3	TAXA
PRATT(81-82)	STNH-S	OE	01 29 82	41 08 29	72 52 27	3	TAXA
PRATT(81-82)	CLIS	CLISREF	01 30 82	41 07 57	72 52 44	3	TAXA

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	NORWALK	100E	02 04 82	41 08 55	72 53 25	3	CHEM
DAMOS	NORWALK	100N	02 04 82	41 08 58	72 53 29	3	CHEM
DAMOS	NORWALK	100S	02 04 82	41 08 51	72 53 29	3	CHEM
DAMOS	NORWALK	100W	02 04 82	41 08 55	72 53 34	3	CHEM
DAMOS	NORWALK	200E	02 04 82	41 08 55	72 53 20	3	CHEM
DAMOS	NORWALK	200N	02 04 82	41 09 01	72 53 29	3	CHEM
DAMOS	NORWALK	200S	02 04 82	41 08 48	72 53 29	3	CHEM
DAMOS	NORWALK	200W	02 04 82	41 08 55	72 53 38	3	CHEM
DAMOS	NORWALK	50S	02 04 82	41 08 53	72 53 29	3	CHEM
FVP	FVP	1000E	05 04 82	41 09 23	72 50 58	3	TAXA
FVP	FVP	100E	05 04 82	41 09 23	72 51 37	1	TAXA
FVP	FVP	100S	05 04 82	41 09 20	72 51 41	1	TAXA
FVP	FVP	100W	05 04 82	41 09 23	72 51 45	1	TAXA
FVP	FVP	150E	05 04 82	41 09 23	72 51 35	1	TAXA
FVP	FVP	150S	05 04 82	41 09 18	72 51 41	1	TAXA
FVP	FVP	150W	05 04 82	41 09 23	72 51 48	1	TAXA
FVP	FVP	200E	05 04 82	41 09 23	72 51 33	1	TAXA
FVP	FVP	200S	05 04 82	41 09 17	72 51 41	1	TAXA
FVP	FVP	200W	05 04 82	41 09 23	72 51 50	1	TAXA
FVP	FVP	250E	05 04 82	41 09 23	72 51 30	1	TAXA
FVP	FVP	250S	05 04 82	41 09 15	72 51 41	1	TAXA
FVP	FVP	250W	05 04 82	41 09 23	72 51 52	1	TAXA
FVP	FVP	300E	05 04 82	41 09 23	72 51 28	1	TAXA
FVP	FVP	300S	05 04 82	41 09 14	72 51 41	1	TAXA
FVP	FVP	300W	05 04 82	41 09 23	72 51 54	1	TAXA
FVP	FVP	350E	05 04 82	41 09 23	72 51 26	1	TAXA
FVP	FVP	350S	05 04 82	41 09 12	72 51 41	1	TAXA
FVP	FVP	350W	05 04 82	41 09 23	72 51 56	1	TAXA
FVP	FVP	400E	05 04 82	41 09 23	72 51 24	1	TAXA
FVP	FVP	400S	05 04 82	41 09 10	72 51 41	1	TAXA
FVP	FVP	400W	05 04 82	41 09 23	72 51 58	1	TAXA
FVP	FVP	450E	05 04 82	41 09 23	72 51 22	1	TAXA
FVP	FVP	450S	05 04 82	41 09 09	72 51 41	1	TAXA
FVP	FVP	450W	05 04 82	41 09 23	72 52 00	1	TAXA
FVP	FVP	500E	05 04 82	41 09 23	72 51 20	1	TAXA
FVP	FVP	500S	05 04 82	41 09 07	72 51 41	1	TAXA
FVP	FVP	500W	05 04 82	41 09 23	72 52 03	1	TAXA
FVP	FVP	50E	05 04 82	41 09 23	72 51 39	1	TAXA
FVP	FVP	50S	05 04 82	41 09 22	72 51 41	1	TAXA
FVP	FVP	50W	05 04 82	41 09 23	72 51 43	1	TAXA
FVP	FVP	600E	05 04 82	41 09 23	72 51 15	1	TAXA
FVP	FVP	CNTR	05 04 82	41 09 23	72 51 41	1	TAXA
FVP	FVP	REFS	05 04 82	41 07 57	72 52 44	3	TAXA
FVP	FVP	1000E	08 24 82	41 09 23	72 50 58	4	TAXA
FVP	FVP	100N	08 24 82	41 09 26	72 51 41	1	TAXA
FVP	FVP	150N	08 24 82	41 09 28	72 51 41	1	TAXA
FVP	FVP	200E	08 24 82	41 09 23	72 51 33	4	TAXA

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
FVP	FVP	200N	08 24 82	41 09 30	72 51 41	8	TAXA
FVP	FVP	250N	08 24 82	41 09 31	72 51 41	1	TAXA
FVP	FVP	300N	08 24 82	41 09 33	72 51 41	1	TAXA
FVP	FVP	350N	08 24 82	41 09 35	72 51 41	1	TAXA
FVP	FVP	400E	08 24 82	41 09 23	72 51 24	4	TAXA
FVP	FVP	400N	08 24 82	41 09 36	72 51 41	1	TAXA
FVP	FVP	50N	08 24 82	41 09 25	72 51 41	1	TAXA
FVP	FVP	600E	08 24 82	41 09 23	72 51 15	4	TAXA
FVP	FVP	REFS	08 24 82	41 07 57	72 52 44	4	TAXA
DAMOS	CLIS	REF	09 02 82	41 07 57	72 52 44	5	CHEM
DAMOS	NORWALK	150W	09 02 82	41 08 55	72 53 35	3	CHEM
DAMOS	NORWALK	300E	09 02 82	41 08 55	72 53 16	11	CHEM
DAMOS	NORWALK	300W	09 02 82	41 08 55	72 53 42	3	CHEM
DAMOS	NORWALK	450E	09 02 82	41 08 55	72 53 10	11	CHEM
DAMOS	NORWALK	CTR	09 02 82	41 08 55	72 53 29	14	CHEM
DAMOS	STNH-S	100E	09 02 82	41 08 29	72 52 43	3	CHEM
DAMOS	STNH-S	150W	09 02 82	41 08 29	72 52 53	3	CHEM
DAMOS	STNH-S	250W	09 02 82	41 08 29	72 52 58	3	CHEM
DAMOS	STNH-S	400E	09 02 82	41 08 29	72 52 30	3	CHEM
DAMOS	STNH-S	400W	09 02 82	41 08 29	72 53 04	3	CHEM
DAMOS	STNH-S	CTR	09 02 82	41 08 29	72 52 47	3	CHEM
FVP	FVP	1000E	12 08 82	41 09 23	72 50 58	5	TAXA
FVP	FVP	200E	12 08 82	41 09 23	72 51 33	5	TAXA
FVP	FVP	400E	12 08 82	41 09 23	72 51 24	5	TAXA
FVP	FVP	CNTR	12 08 82	41 09 23	72 51 41	5	TAXA
FVP	FVP	REFS	12 08 82	41 07 57	72 52 44	5	TAXA
DAMOS	NORWALK	450E	12 15 82	41 08 55	72 53 10	5	CHEM
DAMOS	STNH-S	100E	12 15 82	41 08 29	72 52 43	3	CHEM
DAMOS	STNH-S	400E	12 15 82	41 08 29	72 52 30	5	CHEM
DAMOS	STNH-S	CTR	12 15 82	41 08 29	72 52 47	3	CHEM
FVP	FVP	1000E	03 15 83	41 09 23	72 50 58	5	TAXA
FVP	FVP	200E	03 15 83	41 09 23	72 51 33	5	TAXA
FVP	FVP	400E	03 15 83	41 09 23	72 51 24	5	TAXA
FVP	FVP	CNTR	03 15 83	41 09 23	72 51 41	5	TAXA
FVP	FVP	REF	03 15 83	41 07 57	72 52 44	5	TAXA
DAMOS	NORWALK	100E	08 22 83	41 08 55	72 53 25	3	CHEM
DAMOS	NORWALK	100N	08 22 83	41 08 58	72 53 29	3	CHEM
DAMOS	NORWALK	100S	08 22 83	41 08 51	72 53 29	3	CHEM
DAMOS	NORWALK	100W	08 22 83	41 08 55	72 53 34	3	CHEM
DAMOS	NORWALK	200E	08 22 83	41 08 55	72 53 20	3	CHEM
DAMOS	NORWALK	200N	08 22 83	41 09 01	72 53 29	3	CHEM
DAMOS	NORWALK	200S	08 22 83	41 08 48	72 53 29	3	CHEM
DAMOS	NORWALK	200W	08 22 83	41 08 55	72 53 38	3	CHEM
DAMOS	NORWALK	50S	08 22 83	41 08 53	72 53 29	3	CHEM
DAMOS	NORWALK	CTR	08 22 83	41 08 55	72 53 29	3	CHEM
DAMOS	WLIS IIIB	100E	03 15 84	40 59 20	73 29 15	3	REMO
DAMOS	WLIS IIIB	100N	03 15 84	40 59 24	73 29 19	3	REMO

Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	WLIS IIIB	100S	03 15 84	40 59 17	73 29 19	3	REMO
DAMOS	WLIS IIIB	100W	03 15 84	40 59 20	73 29 24	3	REMO
DAMOS	WLIS IIIB	200E	03 15 84	40 59 20	73 29 11	3	REMO
DAMOS	WLIS IIIB	200N	03 15 84	40 59 27	73 29 19	4	REMO
DAMOS	WLIS IIIB	200S	03 15 84	40 59 14	73 29 19	3	REMO
DAMOS	WLIS IIIB	200W	03 15 84	40 59 20	73 29 28	3	REMO
DAMOS	WLIS IIIB	400E	03 15 84	40 59 20	73 29 02	3	REMO
DAMOS	WLIS IIIB	400N	03 15 84	40 59 33	73 29 19	3	REMO
DAMOS	WLIS IIIB	400N400E	03 15 84	40 59 33	73 29 02	3	REMO
DAMOS	WLIS IIIB	400N400W	03 15 84	40 59 33	73 29 37	3	REMO
DAMOS	WLIS IIIB	400S	03 15 84	40 59 07	73 29 19	2	REMO
DAMOS	WLIS IIIB	400S400W	03 15 84	40 59 07	73 29 37	5	REMO
DAMOS	WLIS IIIB	400W	03 15 84	40 59 20	73 29 37	3	REMO
DAMOS	WLIS IIIB	CTR	03 15 84	40 59 20	73 29 19	3	REMO
DAMOS	CLIS	REF	03 16 84	41 07 57	72 52 44	5	REMO
DAMOS	FVP	1000E	03 16 84	41 09 23	72 50 58	3	REMO
DAMOS	FVP	1000E50N	03 16 84	41 09 25	72 50 58	3	REMO
DAMOS	FVP	1000W	03 16 84	41 09 23	72 52 24	2	REMO
DAMOS	FVP	100W	03 16 84	41 09 23	72 51 45	3	REMO
DAMOS	FVP	150E	03 16 84	41 09 23	72 51 34	3	REMO
DAMOS	FVP	200N	03 16 84	41 09 30	72 51 41	3	REMO
DAMOS	FVP	200N300E	03 16 84	41 09 30	72 51 28	2	REMO
DAMOS	FVP	200N300W	03 16 84	41 09 30	72 51 54	3	REMO
DAMOS	FVP	200S	03 16 84	41 09 17	72 51 41	1	REMO
DAMOS	FVP	200S300E	03 16 84	41 09 17	72 51 28	3	REMO
DAMOS	FVP	200S300W	03 16 84	41 09 17	72 51 54	3	REMO
DAMOS	FVP	250E	03 16 84	41 09 23	72 51 30	3	REMO
DAMOS	FVP	250N	03 16 84	41 09 31	72 51 41	3	REMO
DAMOS	FVP	250W	03 16 84	41 09 23	72 51 52	3	REMO
DAMOS	FVP	300S	03 16 84	41 09 14	72 51 41	3	REMO
DAMOS	FVP	400E	03 16 84	41 09 23	72 51 24	3	REMO
DAMOS	FVP	400N	03 16 84	41 09 36	72 51 41	3	REMO
DAMOS	FVP	400S	03 16 84	41 09 10	72 51 41	3	REMO
DAMOS	FVP	500E	03 16 84	41 09 23	72 51 19	3	REMO
DAMOS	FVP	500W	03 16 84	41 09 23	72 52 02	3	REMO
DAMOS	FVP	750W	03 16 84	41 09 23	72 52 13	3	REMO
DAMOS	FVP	CTR	03 16 84	41 09 23	72 51 41	3	REMO
DAMOS	CLIS	REF	06 07 84	41 07 57	72 52 44	6	REMO
DAMOS	FVP	1000E	06 07 84	41 09 23	72 50 58	3	REMO
DAMOS	FVP	1000W	06 07 84	41 09 23	72 52 24	3	REMO
DAMOS	FVP	100W	06 07 84	41 09 23	72 51 45	3	REMO
DAMOS	FVP	150E	06 07 84	41 09 23	72 51 34	3	REMO
DAMOS	FVP	200N	06 07 84	41 09 30	72 51 41	3	REMO
DAMOS	FVP	200N300E	06 07 84	41 09 30	72 51 28	3	REMO
DAMOS	FVP	200N300W	06 07 84	41 09 30	72 51 54	3	REMO
DAMOS	FVP	200S	06 07 84	41 09 17	72 51 41	3	REMO
DAMOS	FVP	200S300E	06 07 84	41 09 17	72 51 28	3	REMO

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Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	FVP	200S300W	06 07 84	41 09 17	72 51 54	3	REMO
DAMOS	FVP	250E	06 07 84	41 09 23	72 51 30	3	REMO
DAMOS	FVP	250N	06 07 84	41 09 31	72 51 41	3	REMO
DAMOS	FVP	250W	06 07 84	41 09 23	72 51 52	3	REMO
DAMOS	FVP	300S	06 07 84	41 09 14	72 51 41	3	REMO
DAMOS	FVP	400E	06 07 84	41 09 23	72 51 24	3	REMO
DAMOS	FVP	400N	06 07 84	41 09 36	72 51 41	3	REMO
DAMOS	FVP	400S	06 07 84	41 09 10	72 51 41	3	REMO
DAMOS	FVP	500E	06 07 84	41 09 23	72 51 19	3	REMO
DAMOS	FVP	500W	06 07 84	41 09 23	72 52 02	3	REMO
DAMOS	FVP	750W	06 07 84	41 09 23	72 52 13	3	REMO
DAMOS	FVP	CTR	06 07 84	41 09 23	72 51 41	3	REMO
DAMOS	DGC	100E	06 22 84	41 16 15	72 04 10	2	REMO
DAMOS	DGC	100N	06 22 84	41 16 18	72 04 14	1	REMO
DAMOS	DGC	100S	06 22 84	41 16 12	72 04 14	2	REMO
DAMOS	DGC	100W	06 22 84	41 16 15	72 04 18	2	REMO
DAMOS	DGC	200E	06 22 84	41 16 15	72 04 05	2	REMO
DAMOS	DGC	200N	06 22 84	41 16 21	72 04 14	1	REMO
DAMOS	DGC	200S	06 22 84	41 16 08	72 04 14	1	REMO
DAMOS	DGC	200W	06 22 84	41 16 15	72 04 22	2	REMO
DAMOS	DGC	400S	06 22 84	41 16 02	72 04 14	2	REMO
DAMOS	DGC	CTR	06 22 84	41 16 15	72 04 14	2	REMO
DAMOS	NL	100E	06 22 84	41 16 29	72 04 30	2	REMO
DAMOS	NL	100N	06 22 84	41 16 32	72 04 34	2	REMO
DAMOS	NL	100W	06 22 84	41 16 29	72 04 38	2	REMO
DAMOS	NL	300N	06 22 84	41 16 38	72 04 34	2	REMO
DAMOS	NL	300S	06 22 84	41 16 19	72 04 34	2	REMO
DAMOS	NL	300W	06 22 84	41 16 29	72 04 47	2	REMO
DAMOS	NL	400S	06 22 84	41 16 25	72 04 34	2	REMO
DAMOS	NL	CTR	06 22 84	41 16 29	72 04 34	1	REMO
DAMOS	NL	REF	06 22 84	41 16 29	72 03 51	3	REMO
DAMOS	NL3	100E	06 22 84	41 16 22	72 03 59	2	REMO
DAMOS	NL3	100N	06 22 84	41 16 26	72 04 03	2	REMO
DAMOS	NL3	100S	06 22 84	41 16 19	72 04 03	2	REMO
DAMOS	NL3	100W	06 22 84	41 16 22	72 04 08	2	REMO
DAMOS	NL3	200E	06 22 84	41 16 22	72 03 55	2	REMO
DAMOS	NL3	200N	06 22 84	41 16 29	72 04 03	2	REMO
DAMOS	NL3	200S	06 22 84	41 16 16	72 04 03	2	REMO
DAMOS	NL3	200W	06 22 84	41 16 22	72 04 12	2	REMO
DAMOS	NL3	300E	06 22 84	41 16 22	72 03 50	2	REMO
DAMOS	NL3	300N	06 22 84	41 16 32	72 04 03	2	REMO
DAMOS	NL3	300S	06 22 84	41 16 13	72 04 03	2	REMO
DAMOS	NL3	300W	06 22 84	41 16 22	72 04 16	2	REMO
DAMOS	NL3	CTR	06 22 84	41 16 22	72 04 03	1	REMO
DAMOS	NLON	200E	06 22 84	41 16 30	72 04 27	2	REMO
DAMOS	NLON	200N	06 22 84	41 16 37	72 04 35	1	REMO
DAMOS	NLON	200S	06 22 84	41 16 24	72 04 35	2	REMO

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Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	NLON	200W	06 22 84	41 16 30	72 04 44	2	REMO
DAMOS	NLON	400E	06 22 84	41 16 30	72 04 18	1	REMO
DAMOS	NLON	400N	06 22 84	41 16 43	72 04 35	1	REMO
DAMOS	NLON	400S	06 22 84	41 16 17	72 04 35	2	REMO
DAMOS	NLON	400W	06 22 84	41 16 30	72 04 52	2	REMO
DAMOS	SE.REF	200E	06 22 84	41 15 30	72 03 31	1	REMO
DAMOS	SE.REF	200N	06 22 84	41 15 42	72 03 39	1	REMO
DAMOS	SE.REF	200S	06 22 84	41 15 30	72 03 39	1	REMO
DAMOS	SE.REF	200W	06 22 84	41 15 30	72 03 47	1	REMO
DAMOS	SE.REF	400E	06 22 84	41 15 30	72 03 22	1	REMO
DAMOS	SE.REF	400N	06 22 84	41 15 49	72 03 39	2	REMO
DAMOS	SE.REF	400W	06 22 84	41 15 30	72 03 56	1	REMO
DAMOS	SE.REF	CTR	06 22 84	41 15 36	72 03 39	1	REMO
DAMOS	WLIS IIIB	100E	06 26 84	40 59 20	73 29 25	2	REMO
DAMOS	WLIS IIIB	100N	06 26 84	40 59 24	73 29 29	2	REMO
DAMOS	WLIS IIIB	100S	06 26 84	40 59 17	73 29 29	2	REMO
DAMOS	WLIS IIIB	100W	06 26 84	40 59 20	73 29 34	2	REMO
DAMOS	WLIS IIIB	200E	06 26 84	40 59 20	73 29 20	2	REMO
DAMOS	WLIS IIIB	200N	06 26 84	40 59 27	73 29 29	3	REMO
DAMOS	WLIS IIIB	200S	06 26 84	40 59 14	73 29 29	3	REMO
DAMOS	WLIS IIIB	200W	06 26 84	40 59 20	73 29 38	3	REMO
DAMOS	WLIS IIIB	300E	06 26 84	40 59 20	73 29 16	2	REMO
DAMOS	WLIS IIIB	300N	06 26 84	40 59 30	73 29 29	2	REMO
DAMOS	WLIS IIIB	300S	06 26 84	40 59 11	73 29 29	2	REMO
DAMOS	WLIS IIIB	300W	06 26 84	40 59 20	73 29 42	2	REMO
DAMOS	WLIS IIIB	400E	06 26 84	40 59 20	73 29 12	3	REMO
DAMOS	WLIS IIIB	400N	06 26 84	40 59 33	73 29 29	3	REMO
DAMOS	WLIS IIIB	400N400E	06 26 84	40 59 33	73 29 12	2	REMO
DAMOS	WLIS IIIB	400N400W	06 26 84	40 59 33	73 29 46	2	REMO
DAMOS	WLIS IIIB	400S	06 26 84	40 59 07	73 29 29	3	REMO
DAMOS	WLIS IIIB	400S400E	06 26 84	40 59 07	73 29 12	2	REMO
DAMOS	WLIS IIIB	400W	06 26 84	40 59 20	73 29 46	3	REMO
DAMOS	WLIS IIIB	CTR	06 26 84	40 59 20	73 29 29	3	REMO
DAMOS	WLIS IIIB	REF	06 26 84	40 59 42	73 27 45	6	REMO
DAMOS	CLIS	REF	09 04 84	41 07 57	72 52 44	8	REMO
DAMOS	FVP	1000E	09 05 84	41 09 23	72 50 58	3	REMO
DAMOS	FVP	1000W	09 05 84	41 09 23	72 52 24	3	REMO
DAMOS	FVP	100E	09 05 84	41 09 23	72 51 37	3	REMO
DAMOS	FVP	100W	09 05 84	41 09 23	72 51 45	3	REMO
DAMOS	FVP	1500E	09 05 84	41 09 23	72 50 37	3	REMO
DAMOS	FVP	1500W	09 05 84	41 09 23	72 52 45	3	REMO
DAMOS	FVP	150E	09 05 84	41 09 23	72 51 34	3	REMO
DAMOS	FVP	150W	09 05 84	41 09 23	72 51 47	3	REMO
DAMOS	FVP	200E	09 05 84	41 09 23	72 51 32	3	REMO
DAMOS	FVP	200S	09 05 84	41 09 17	72 51 41	3	REMO
DAMOS	FVP	200S100E	09 05 84	41 09 17	72 51 37	3	REMO
DAMOS	FVP	200S300E	09 05 84	41 09 17	72 51 28	3	REMO

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Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	FVP	200S500E	09 05 84	41 09 17	72 51 19	3	REMO
DAMOS	FVP	200W	09 05 84	41 09 23	72 51 49	3	REMO
DAMOS	FVP	250E	09 05 84	41 09 23	72 51 30	3	REMO
DAMOS	FVP	250W	09 05 84	41 09 23	72 51 52	3	REMO
DAMOS	FVP	300E	09 05 84	41 09 23	72 51 28	3	REMO
DAMOS	FVP	300W	09 05 84	41 09 23	72 51 54	3	REMO
DAMOS	FVP	400E	09 05 84	41 09 23	72 51 24	3	REMO
DAMOS	FVP	400S	09 05 84	41 09 10	72 51 41	3	REMO
DAMOS	FVP	400S100E	09 05 84	41 09 10	72 51 37	3	REMO
DAMOS	FVP	400S100W	09 05 84	41 09 10	72 51 45	3	REMO
DAMOS	FVP	400S300E	09 05 84	41 09 10	72 51 34	3	REMO
DAMOS	FVP	400S300W	09 05 84	41 09 10	72 51 54	3	REMO
DAMOS	FVP	400S500E	09 05 84	41 09 10	72 51 19	3	REMO
DAMOS	FVP	400S500W	09 05 84	41 09 10	72 52 02	3	REMO
DAMOS	FVP	400W	09 05 84	41 09 23	72 51 58	3	REMO
DAMOS	FVP	500E	09 05 84	41 09 23	72 51 19	3	REMO
DAMOS	FVP	500W	09 05 84	41 09 23	72 52 02	3	REMO
DAMOS	FVP	750E	09 05 84	41 09 23	72 51 09	3	REMO
DAMOS	FVP	750W	09 05 84	41 09 23	72 52 13	3	REMO
DAMOS	FVP	100N	09 06 84	41 09 26	72 51 41	3	REMO
DAMOS	FVP	100S	09 06 84	41 09 20	72 51 41	3	REMO
DAMOS	FVP	150N	09 06 84	41 09 28	72 51 41	3	REMO
DAMOS	FVP	150S	09 06 84	41 09 18	72 51 41	3	REMO
DAMOS	FVP	200N	09 06 84	41 09 30	72 51 41	3	REMO
DAMOS	FVP	200N100E	09 06 84	41 09 30	72 51 37	3	REMO
DAMOS	FVP	200N100W	09 06 84	41 09 30	72 51 45	3	REMO
DAMOS	FVP	200N300E	09 06 84	41 09 30	72 51 28	3	REMO
DAMOS	FVP	200N300W	09 06 84	41 09 30	72 51 54	3	REMO
DAMOS	FVP	200N500E	09 06 84	41 09 30	72 51 19	3	REMO
DAMOS	FVP	200N500W	09 06 84	41 09 30	72 52 02	3	REMO
DAMOS	FVP	200S100W	09 06 84	41 09 17	72 51 45	3	REMO
DAMOS	FVP	200S300W	09 06 84	41 09 17	72 51 54	3	REMO
DAMOS	FVP	200S500W	09 06 84	41 09 17	72 52 02	3	REMO
DAMOS	FVP	250N	09 06 84	41 09 31	72 51 41	3	REMO
DAMOS	FVP	250S	09 06 84	41 09 15	72 51 41	3	REMO
DAMOS	FVP	300N	09 06 84	41 09 33	72 51 41	3	REMO
DAMOS	FVP	300S	09 06 84	41 09 14	72 51 41	3	REMO
DAMOS	FVP	400N	09 06 84	41 09 36	72 52 41	3	REMO
DAMOS	FVP	400N100E	09 06 84	41 09 36	72 51 37	3	REMO
DAMOS	FVP	400N100W	09 06 84	41 09 36	72 51 45	3	REMO
DAMOS	FVP	400N300E	09 06 84	41 09 36	72 51 28	3	REMO
DAMOS	FVP	400N300W	09 06 84	41 09 36	72 51 54	3	REMO
DAMOS	FVP	400N500E	09 06 84	41 09 36	72 51 14	3	REMO
DAMOS	FVP	400N500W	09 06 84	41 09 36	72 52 02	3	REMO
DAMOS	FVP	CTR	09 06 84	41 09 23	72 51 41	3	REMO
DAMOS	STNH-N	100S	09 06 84	41 09 11	72 52 44	3	REMO
DAMOS	STNH-N	150W	09 06 84	41 09 14	72 52 51	3	REMO

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Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	STNH-N	200E	09 06 84	41 09 14	72 52 36	3	REMO
DAMOS	STNH-N	200N	09 06 84	41 09 14	72 52 44	3	REMO
DAMOS	STNH-N	250S	09 06 84	41 09 06	72 52 44	3	REMO
DAMOS	STNH-N	300W	09 06 84	41 09 14	72 52 58	3	REMO
DAMOS	STNH-N	400E	09 06 84	41 09 14	72 52 28	3	REMO
DAMOS	STNH-N	CTR	09 06 84	41 09 14	72 52 44	3	REMO
DAMOS	CS-2	100E	09 07 84	41 09 34	72 54 04	3	REMO
DAMOS	CS-2	100W	09 07 84	41 09 34	72 54 13	3	REMO
DAMOS	CS-2	200E	09 07 84	41 09 34	72 54 00	3	REMO
DAMOS	CS-2	200N	09 07 84	41 09 34	72 54 08	3	REMO
DAMOS	CS-2	200S	09 07 84	41 09 21	72 54 08	3	REMO
DAMOS	CS-2	200W	09 07 84	41 09 34	72 54 17	3	REMO
DAMOS	CS-2	300N	09 07 84	41 09 37	72 54 08	3	REMO
DAMOS	CS-2	300S	09 07 84	41 09 18	72 54 08	3	REMO
DAMOS	CS-2	400W	09 07 84	41 09 34	72 54 26	3	REMO
DAMOS	CS-2	500E	09 07 84	41 09 34	72 54 47	3	REMO
DAMOS	CS-2	500W	09 07 84	41 09 34	72 54 30	3	REMO
DAMOS	CS-2	CTR	09 07 84	41 09 28	72 54 08	3	REMO
DAMOS	MQR	100E	09 07 84	41 08 24	72 53 49	3	REMO
DAMOS	MQR	100N	09 07 84	41 08 38	72 53 53	3	REMO
DAMOS	MQR	100S	09 07 84	41 08 32	72 53 53	3	REMO
DAMOS	MQR	100W	09 07 84	41 08 24	72 53 58	2	REMO
DAMOS	MQR	200N	09 07 84	41 08 41	72 53 53	3	REMO
DAMOS	MQR	300E	09 07 84	41 08 24	72 53 41	3	REMO
DAMOS	MQR	300S	09 07 84	41 08 25	72 53 53	3	REMO
DAMOS	MQR	300W	09 07 84	41 08 24	72 54 07	3	REMO
DAMOS	MQR	350S	09 07 84	41 08 24	72 53 53	3	REMO
DAMOS	MQR	400E	09 07 84	41 08 24	72 53 37	3	REMO
DAMOS	MQR	400N	09 07 84	41 08 48	72 53 53	3	REMO
DAMOS	MQR	500W	09 07 84	41 08 24	72 54 15	3	REMO
DAMOS	MQR	CTR	09 07 84	41 08 35	72 53 53	3	REMO
DAMOS	STNH-N	100N	09 07 84	41 09 17	72 52 44	3	REMO
DAMOS	STNH-S	100E	09 07 84	41 08 29	72 52 40	3	REMO
DAMOS	STNH-S	100N	09 07 84	41 08 32	72 52 44	3	REMO
DAMOS	STNH-S	100S	09 07 84	41 08 26	72 52 44	3	REMO
DAMOS	STNH-S	150W	09 07 84	41 08 29	72 52 50	3	REMO
DAMOS	STNH-S	200N	09 07 84	41 08 35	72 52 44	3	REMO
DAMOS	STNH-S	250S	09 07 84	41 08 22	72 52 44	3	REMO
DAMOS	STNH-S	250W	09 07 84	41 08 29	72 52 55	3	REMO
DAMOS	STNH-S	300E	09 07 84	41 08 29	72 52 31	3	REMO
DAMOS	STNH-S	400E	09 07 84	41 08 29	72 52 27	3	REMO
DAMOS	STNH-S	400W	09 07 84	41 08 29	72 53 01	3	REMO
DAMOS	STNH-S	CTR	09 07 84	41 08 29	72 52 44	3	REMO
DAMOS	CS-1	200E	09 13 84	41 09 05	72 54 00	3	REMO
DAMOS	CS-1	200N	09 13 84	41 09 13	72 54 08	3	REMO
DAMOS	CS-1	200S	09 13 84	41 08 58	72 54 08	3	REMO
DAMOS	CS-1	200W	09 13 84	41 09 05	72 54 17	3	REMO

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Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	CS-1	400E	09 13 84	41 09 05	72 53 52	3	REMO
DAMOS	CS-1	400S	09 13 84	41 08 52	72 54 08	3	REMO
DAMOS	CS-1	500S	09 13 84	41 08 49	72 54 08	3	REMO
DAMOS	CS-1	500W	09 13 84	41 09 05	72 54 30	3	REMO
DAMOS	CS-1	600W	09 13 84	41 09 05	72 54 34	3	REMO
DAMOS	CS-1	CTR	09 13 84	41 09 05	72 54 08	3	REMO
DAMOS	NH-74	200E	09 13 84	41 08 49	72 52 44	3	REMO
DAMOS	NH-74	200N	09 13 84	41 08 56	72 52 53	3	REMO
DAMOS	NH-74	200S	09 13 84	41 08 43	72 52 53	3	REMO
DAMOS	NH-74	200W	09 13 84	41 08 49	72 53 49	3	REMO
DAMOS	NH-74	400E	09 13 84	41 08 49	72 52 35	3	REMO
DAMOS	NH-74	400N	09 13 84	41 09 02	72 52 53	3	REMO
DAMOS	NH-74	400S	09 13 84	41 08 36	72 52 53	3	REMO
DAMOS	NH-74	400W	09 13 84	41 08 49	72 53 10	3	REMO
DAMOS	NH-74	CTR	09 13 84	41 08 49	72 52 53	3	REMO
DAMOS	NH-83	200E	09 13 84	41 08 30	72 53 10	3	REMO
DAMOS	NH-83	200N200E	09 13 84	41 08 37	72 53 10	3	REMO
DAMOS	NH-83	200N200W	09 13 84	41 08 37	72 53 28	3	REMO
DAMOS	NH-83	200S200E	09 13 84	41 08 24	72 53 10	3	REMO
DAMOS	NH-83	200S200W	09 13 84	41 08 24	72 53 28	3	REMO
DAMOS	NH-83	200W	09 13 84	41 08 30	72 53 28	3	REMO
DAMOS	NH-83	250N	09 13 84	41 08 39	72 53 19	3	REMO
DAMOS	NH-83	250S	09 13 84	41 08 24	72 53 19	3	REMO
DAMOS	NH-83	400N	09 13 84	41 08 43	72 53 19	3	REMO
DAMOS	NH-83	500S	09 13 84	41 08 14	72 53 19	3	REMO
DAMOS	NH-83	600E	09 13 84	41 08 30	72 52 53	3	REMO
DAMOS	NH-83	600W	09 13 84	41 08 30	72 53 45	3	REMO
DAMOS	NH-83	700W	09 13 84	41 08 30	72 53 49	3	REMO
DAMOS	NH-83	CTR	09 13 84	41 08 30	72 53 19	3	REMO
DAMOS	NORWALK	100N	09 13 84	41 08 58	72 53 30	3	REMO
DAMOS	NORWALK	150E	09 13 84	41 08 55	72 53 23	3	REMO
DAMOS	NORWALK	150S	09 13 84	41 08 50	72 53 30	2	REMO
DAMOS	NORWALK	150W	09 13 84	41 08 55	72 53 37	4	REMO
DAMOS	NORWALK	300E	09 13 84	41 08 55	72 53 17	3	REMO
DAMOS	NORWALK	300N	09 13 84	41 09 05	72 53 30	3	REMO
DAMOS	NORWALK	400W	09 13 84	41 08 55	72 53 47	3	REMO
DAMOS	NORWALK	450S	09 13 84	41 08 40	72 53 30	3	REMO
DAMOS	NORWALK	CTR	09 13 84	41 08 55	72 53 30	3	REMO
DAMOS	CLIS	REF	12 17 84	41 07 57	72 52 44	21	REMO
DAMOS	FVP	1000E	12 19 84	41 09 23	72 50 58	3	REMO
DAMOS	FVP	1000W	12 19 84	41 09 23	72 52 24	3	REMO
DAMOS	FVP	100W	12 19 84	41 09 23	72 51 45	1	REMO
DAMOS	FVP	150E	12 19 84	41 09 23	72 51 34	3	REMO
DAMOS	FVP	200N	12 19 84	41 09 30	72 51 41	3	REMO
DAMOS	FVP	200N300E	12 19 84	41 09 30	72 51 28	2	REMO
DAMOS	FVP	200N300W	12 19 84	41 09 30	72 51 54	2	REMO
DAMOS	FVP	200S	12 19 84	41 09 17	72 51 41	3	REMO

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Table I-4-1 (cont.)

STUDY	SITE	STATION	DATE (MMDDYY)	LAT (DDMMSS)	LONG (DDMMSS)	# OF SAMPLES	TYPE
DAMOS	FVP	200S300E	12 19 84	41 09 17	72 51 28	3	REMO
DAMOS	FVP	200S300W	12 19 84	41 09 17	72 51 54	3	REMO
DAMOS	FVP	250E	12 19 84	41 09 23	72 51 30	1	REMO
DAMOS	FVP	250N	12 19 84	41 09 31	72 51 41	3	REMO
DAMOS	FVP	250W	12 19 84	41 09 23	72 51 52	1	REMO
DAMOS	FVP	300S	12 19 84	41 09 14	72 51 41	2	REMO
DAMOS	FVP	400E	12 19 84	41 09 23	72 51 24	2	REMO
DAMOS	FVP	400N	12 19 84	41 09 36	72 51 41	3	REMO
DAMOS	FVP	400S	12 19 84	41 09 10	72 51 41	3	REMO
DAMOS	FVP	500E	12 19 84	41 09 23	72 51 19	3	REMO
DAMOS	FVP	500W	12 19 84	41 09 23	72 52 02	3	REMO
DAMOS	FVP	750W	12 19 84	41 09 23	72 52 13	3	REMO
DAMOS	FVP	CTR	12 19 84	41 09 23	72 51 41	3	REMO

II. AN ASSESSMENT OF LONG-TERM TRENDS OF THE CLIS INFAUNAL COMMUNITY

AUTHORS:

K. John Scott - SAIC

Charles E. Comiskey - SAIC

Terrell A. Farmer - SAIC

Albert L. Brooks - NUSC

Sheldon D. Pratt - URI

Donald C. Rhoads - MSI

SAIC

II. AN ASSESSMENT OF LONG-TERM TRENDS OF THE CLIS INFAUNAL COMMUNITY

1.0 INTRODUCTION

As described in the overview of the DAMOS program (Volume I), the success of this monitoring effort relies heavily on continually assessing and improving monitoring techniques and their focus as related to regulatory needs. With new "state of the art" sampling techniques becoming available, monitoring programs must be flexible enough to incorporate these advances without losing perspective on previously collected data.

The benthic macrofauna have long been considered as excellent indicators of environmental change because of their sessile nature and intimate association with near-bottom sediments and particulate-assocated contaminants (Pearson and Rosenberg, 1978). Changes in the numbers and types of species, as a result of an environmental perturbation, integrate a wide range of effects on the biological hierarchy from the individual, to the population, to the interactions of populations which are manifested as the community structure. Populations of organisms may respond to perturbations either positively or negatively, or not at all; however, similar types of benthic species tend to respond in a similar fashion. For example, benthic deposit feeders may increase in numbers as a result of the deposition of nutrient enriched sediments, while suspension feeders, as a whole, may decrease in numbers because of a high sediment load. The detection of how different populations respond as groups provides insight into what types of impacts are occurring.

Benthic community studies have been an integral part of the DAMOS program (Brooks, 1983) at most of the dredged material disposal sites throughout New England. Also, prior to the inception of benthic studies in 1977, the New England Division independently supported benthic work in Central Long Island Sound from 1972 to 1974. Much of the data which has been collected, however, has not been synthesized, in a historical sense, with previous work in Long Island Sound or with more current studies. This program was initiated because of the unique opportunity to evaluate the long term trends in benthic communities at this site and to assess the impact of environmental perturbations including dredged material disposal which have occurred there. When considering the role of benthic studies in the future of the DAMOS program, in light of the costly nature of benthic sampling, in general, an assessment of the long term benthic data base has become necessary. Therefore, the two major objectives of this program are:

- o to assess the long term impacts of dredged material disposal on the benthos of Central Long Island Sound, and

- to determine the effectiveness of benthic sampling design and methods for use in future monitoring programs.

This report describes the preliminary phase of the study, i.e. a determination of the scope of the historical data in terms of numbers of samples, sample locations, dates, sample size, sample methods and form of the data. To proceed with the analysis, however, a computer data base had to be designed and implemented. The broader application of the NED Data Base Management System is described in Section I of this volume.

2.0 COMPILATION OF DATA SOURCES

Although DAMOS has conducted benthic studies at many sites throughout coastal New England, the majority of work has been done in Long Island Sound, primarily at the Central Long Island Sound (CLIS) disposal site. Many of the studies that are briefly described here collected benthic samples Sound-wide, but it was determined that, to narrow the scope of the study, only samples in and around the CLIS site (Fig. II-2-1) would be considered. The primary concern for focusing on one site at this time was to remain within one hydrographic and sedimentary regime. A review of the literature was conducted as well as personal contacts with principal investigators regarding unpublished data. Table II-2-1 lists the principal investigators and the time periods of their studies. What follows is a brief description of each study.

The earliest study conducted in Long Island Sound is that of Sanders (1956). Table II-2-2 shows the sampling characteristics of this study. Sanders used a Forrester Anchor Dredge which sampled a 0.1 m^2 surface area of the bottom. Station locations are shown in Figure II-2-2 which is taken from Sanders' original study. Although this work was done throughout the central part of the Sound, only Stations 2 and 3, which are on the same depth contour, would be relevant to the CLIS historic data base that is considered here. Sanders sampled Station 2 twice in one year and Station 3 bimonthly. The mesh size through which the samples were sieved was 1.0 mm. In addition to the data on the benthic community, grain size information was collected. The data are in the raw form.

The studies of Reid and his colleagues are quite extensive (Fig. II-2-3) and span a period from 1972 to 1978 (Reid 1979; Reid, Frame and Draxler 1979). The most pertinent data are those collected during 1972 and 1973 at stations 69 and 70, since these stations are in and immediately adjacent to the CLIS disposal site. These studies were conducted using a Smith-MacIntyre grab sampler covering a 0.1m^2 area and were sieved through a 1.0 mm mesh screen (Table II-2-3). The stations were sampled only once per year, but in addition to benthic and grain size data, heavy metal and organic content values for the samples are available. The data are on computer tape.

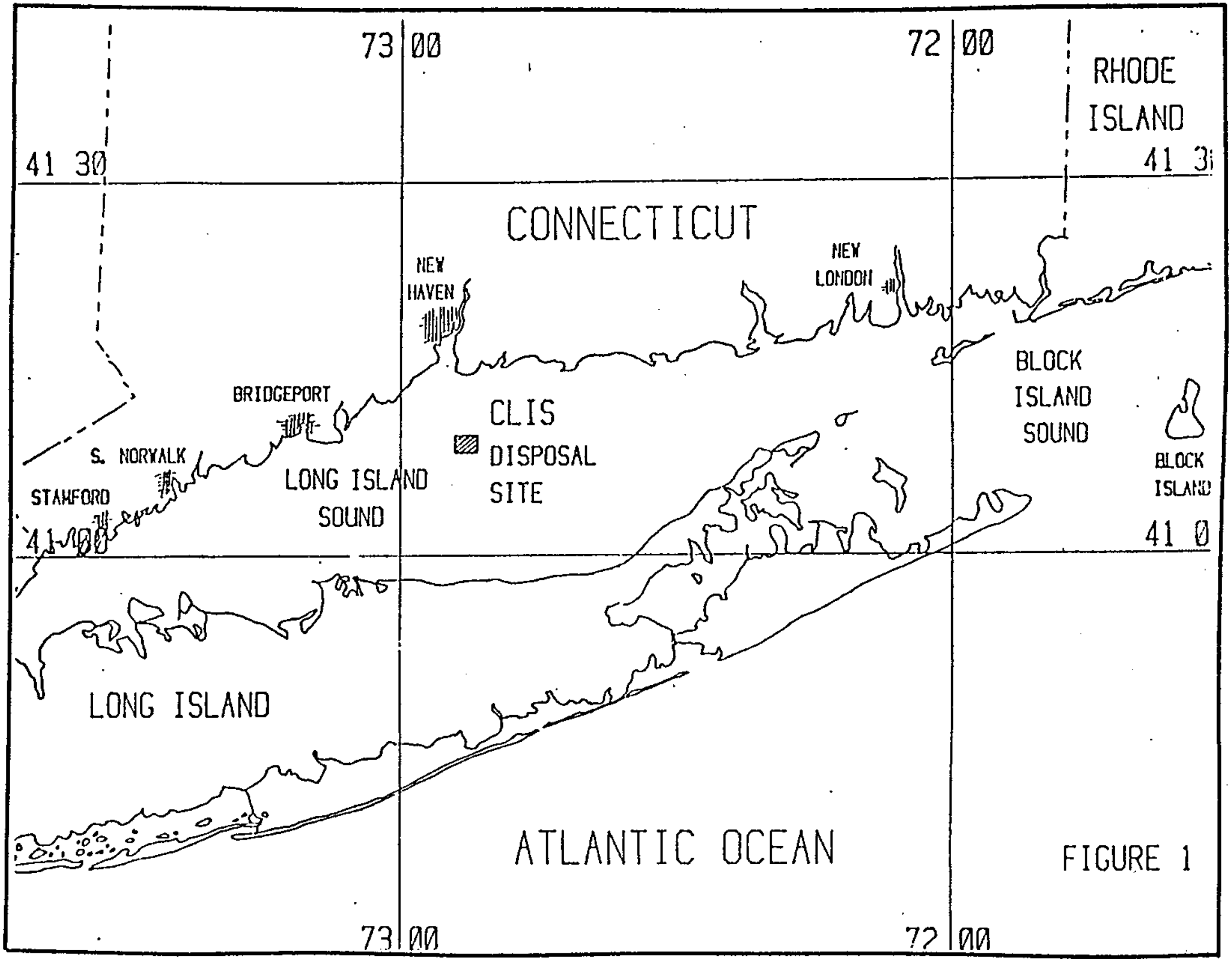

FIGURE II-2-1. LOCATION OF CENTRAL LONG ISLAND SOUND DISPOSAL SITE.

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TABLE II-2-1

LONG ISLAND SOUND
BENTHIC STUDIES

SANDERS	1956
REID	1972-1973
RHOADS & MICHAEL	1972-1974
MCCALL & FISHER	1973
BROOKS	1977-1981
PRATT	1981-1982
PELLIGRINO & HUBBARD	1983
PRATT - EPA	1982-1985

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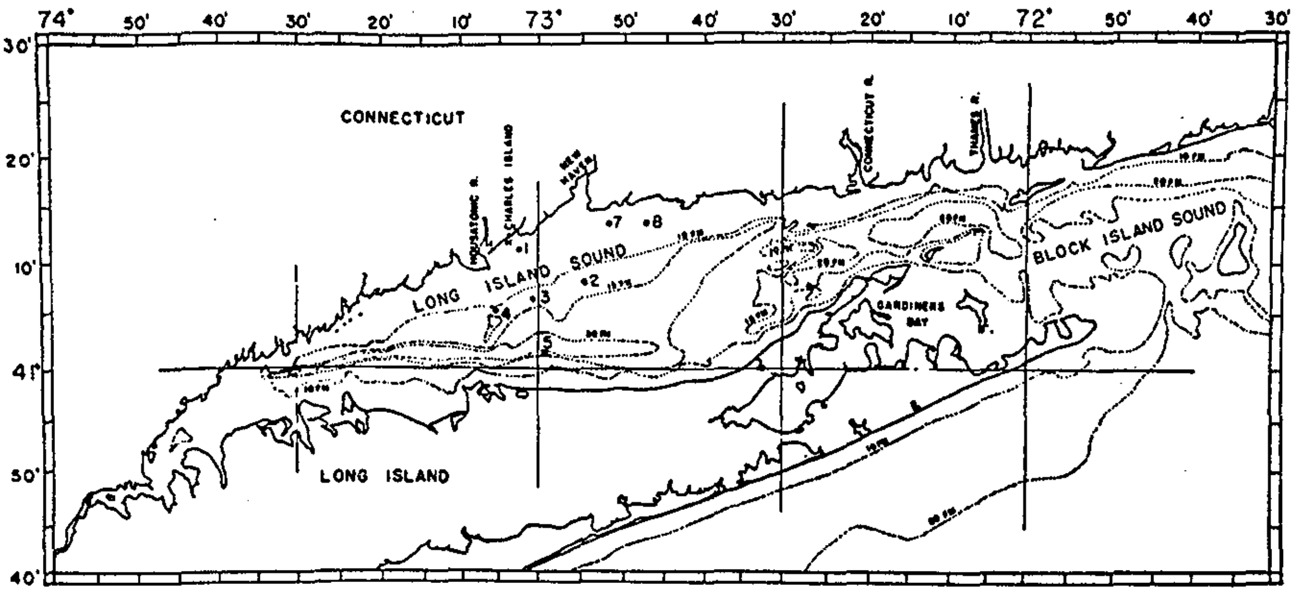

FIGURE II-2-2. SANDERS STATION LOCATIONS.

TABLE II-2-2

SAMPLING CHARACTERISTICS

SANDERS 1956

SAMPLING GEAR: ANCHOR DREDGE

AREA: $0.1M^2$

SIEVE: 1.0MM

FREQUENCY: STN 3 - 6
STN 2 - 2

ASSOCIATED MEASUREMENTS: GRAIN SIZE

DATA FORMAT: DATA SHEETS

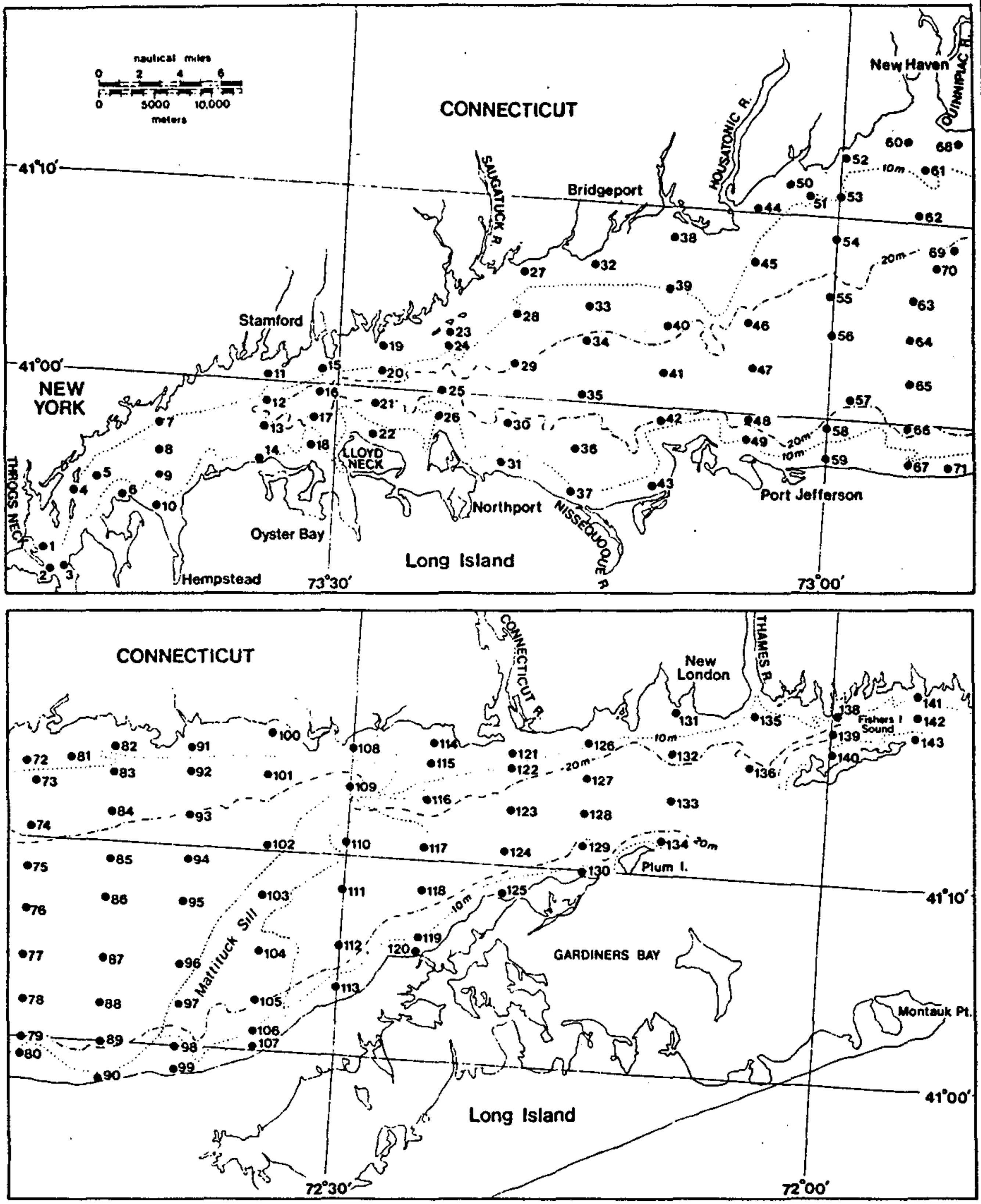

FIGURE II-2-3. REID SAMPLING STATIONS.

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TABLE II-2-3

REID SAMPLING CHARACTERISTICS

REID 1972-73

SAMPLING GEAR: SMITH MAC

AREA: $0.1M^2$

SIEVE: 1MM

FREQUENCY: ONCE/STN/YEAR

ASSOCIATED MEASUREMENTS: GRAIN SIZE
HEAVY METALS
ORGANIC CONTENT

DATA FORM: COMPUTERIZED

Benthic community studies continued during 1972 through 1974 with the studies of Rhoads (NED Reports SR9-18) and Michael (unpublished). These were site specific studies (Table II-2-4), funded by the New England Division, to examine baseline and post-disposal conditions of the first regulated disposal activites at the CLIS site in 1974 (Fig. II-2-4). For these studies, another type of sampler was used, the Van Veen grab sampler. Two different sample sizes were used, but were both sieved to 1.0 mm. This work was continued by Rhoads colleagues McCall and Fisher in 1973, who sampled the disposal area plus two stations to the east and one to the south (Fig. II-2-5, McCall 1977). Sampling characteristics were similar to those of Rhoads and Michael (Table II-2-5) and the data are still in the raw form and need to be computerized.

With the increased use of the CLIS disposal site, sampling of the area (Fig. II-2-6) was continued by Brooks (1983) and Pratt (Volume II, Section I of this report) under the DAMOS program. Initially, the Anchor Dredge was used and then later sampling was done using a Smith-MacIntyre sampler. All sample areas were 0.1 m^2 and sieved to 1.0 mm (Table II-2-6). These studies specifically addressed the disposal activities at the CLIS and sampled stations that were located on the mound(s), on the flanks, and at a control site. Samples were taken twice/year, either in spring and summer or winter and summer. Grain size data and heavy metal analyses accompany these data, which are in both the raw form and computerized.

Another Sound-wide survey, funded by the State of Connecticut, was conducted in 1981-83 by Pelligrino and Hubbard (1983). One sample was taken at each Loran-C intersection throughout Long Island Sound with a Van Veen grab sampler. Although only a few samples fall within the scope of this study, sampling characteristics were similar to previous studies (Table II-2-7), and the data are computerized, allowing for easy entry to the Data Base and subsequent analysis.

The most extensive benthic study in the CLIS site (Fig. II-2-7) conducted to date is ongoing and is being done as part of the Field Verification Program (FVP, Volume II, Section 3 of this report), with joint funding from the New England Division and Environmental Protection Agency. The samples are being collected with a 0.1 m^2 Smith MacIntyre grab sampler and sieved on a 0.5 mm mesh screen (Table II-2-8). Samples are then processed to include a 1.0 mm fraction in the laboratory, for comparison with previous studies. Pre-disposal samples were taken to determine large and small scale variability and then stations were located at the center of the mound, 200, 400, and 1000 meters east, and at the South Reference Control Site. Sampling started in March 1982 and has continued on a quarterly basis throughout the post-disposal phase to the present. A large number of associated benthic parameters are being collected which include heavy metals, organics and grain size. All data are computerized.

TABLE II-2-4

RHOADS & MICHAEL SAMPLING CHARACTERISTICS

RHOADS & MICHAEL 1972-74

SAMPLING GEAR: VAN VEEN

AREA: 1972 - 0.15M^2
1973-74 - 0.0413M^2

SIEVE: 1.0MM

FREQUENCY: TWICE/YEAR

ASSOCIATED MEASUREMENTS: NONE

DATA FORM: DATA SHEETS

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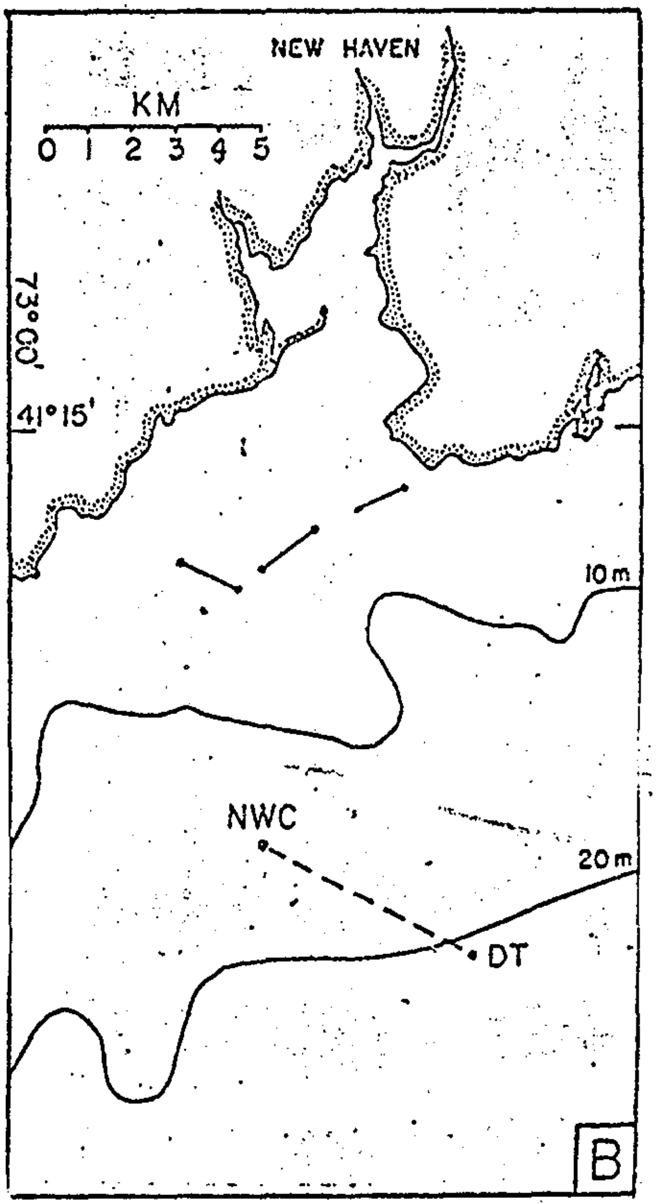

FIGURE II-2-4. RHOADS & MICHAEL SAMPLING STATIONS.

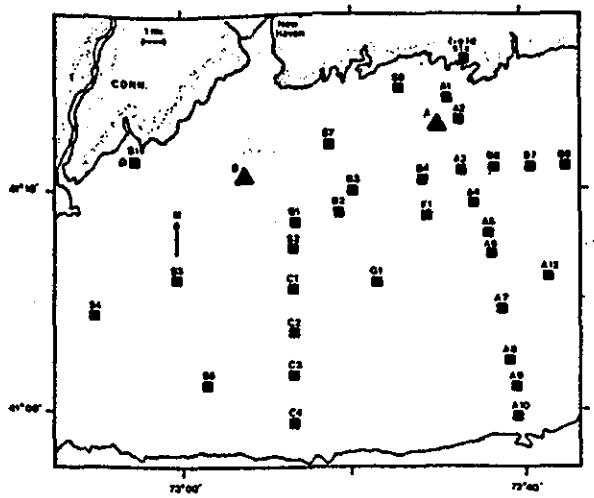

FIGURE II-2-5. McCALL SAMPLE STATIONS.

TABLE II-2-5

McCALL & FISHER SAMPLING CHARACTERISTICS

<u>McCALL & FISHER 1973</u>

SAMPLING GEAR: VAN VEEN

AREA: $0.147M^2$ AND $0.041M^2$

SIEVE: 1.0MM

FREQUENCY: TWICE/SUMMER, WINTER

ASSOCIATED MEASUREMENTS: GRAIN SIZE

DATA FORMAT: DATA SHEETS

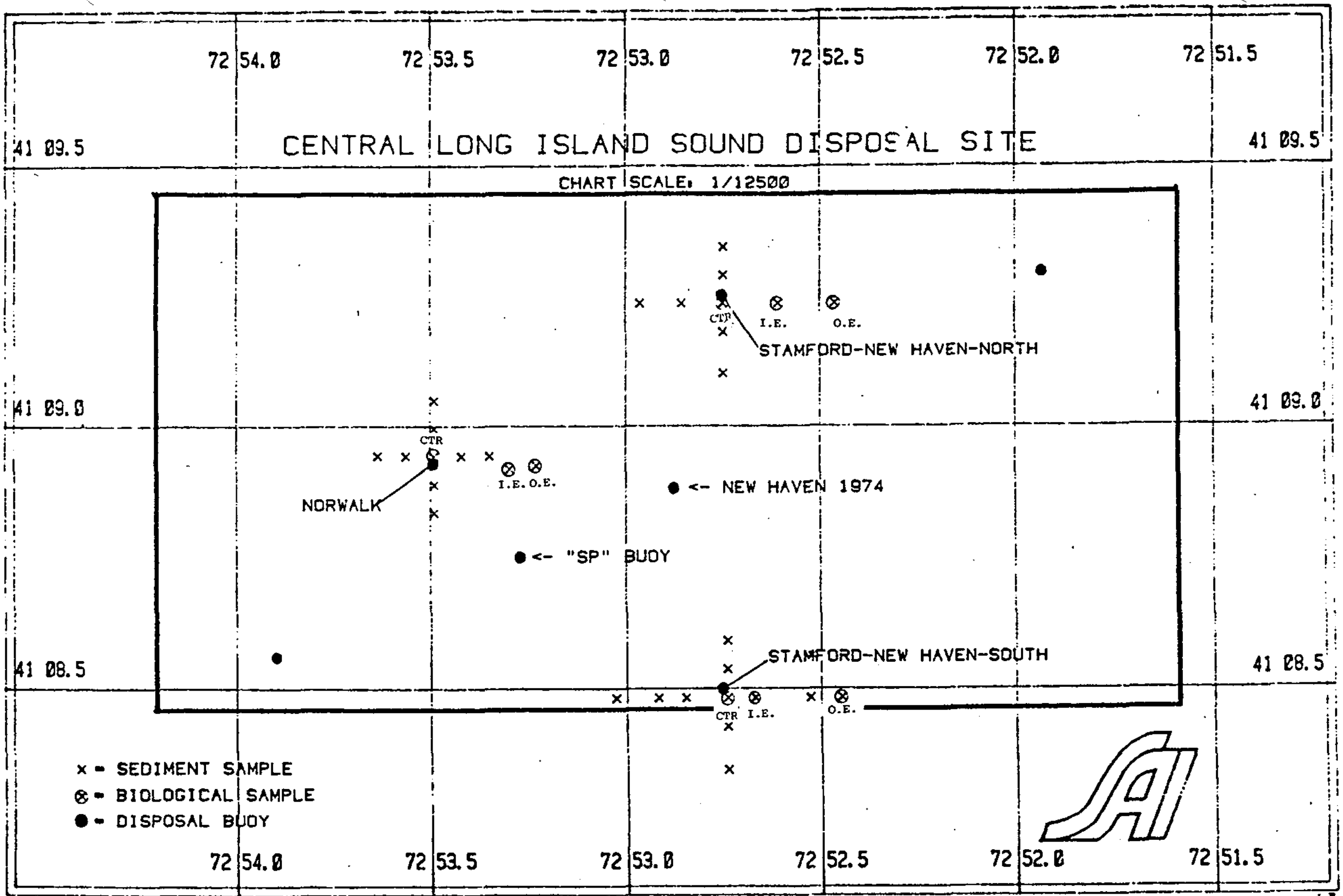

FIGURE II-2-6. DAMOS SAMPLING STATIONS.

TABLE II-2-6

DAMOS SAMPLING CHARACTERISTICS

BROOKS 1977-81

SAMPLING GEAR: 1977-78 ANCHOR DREDGE
1979-81 SMITH MAC

AREA: $0.1M^2$

SIEVE: 1.0MM

FREQUENCY: TWICE/YEAR SPRING-SUMMER
WINTER-SUMMER

ASSOCIATED MEASUREMENTS: HEAVY METAL
GRAIN SIZE

DATA FORM: DATA SHEETS

PRATT 1981-82

SAME AS BROOKS EXCEPT DATA IS COMPUTERIZED

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TABLE II-2-7

PELLIGRINO & HUBBARD SAMPLING CHARACTERISTICS

PELLIGRINO & HUBBARD 1983

SAMPLING GEAR: VAN VEEN

AREA: 0.041 M^2

SIEVE: 1.0MM

FREQUENCY: ONCE

ASSOCIATED MEASUREMENTS: NONE

DATA FORM: COMPUTERIZED (FLOPPY DISK)

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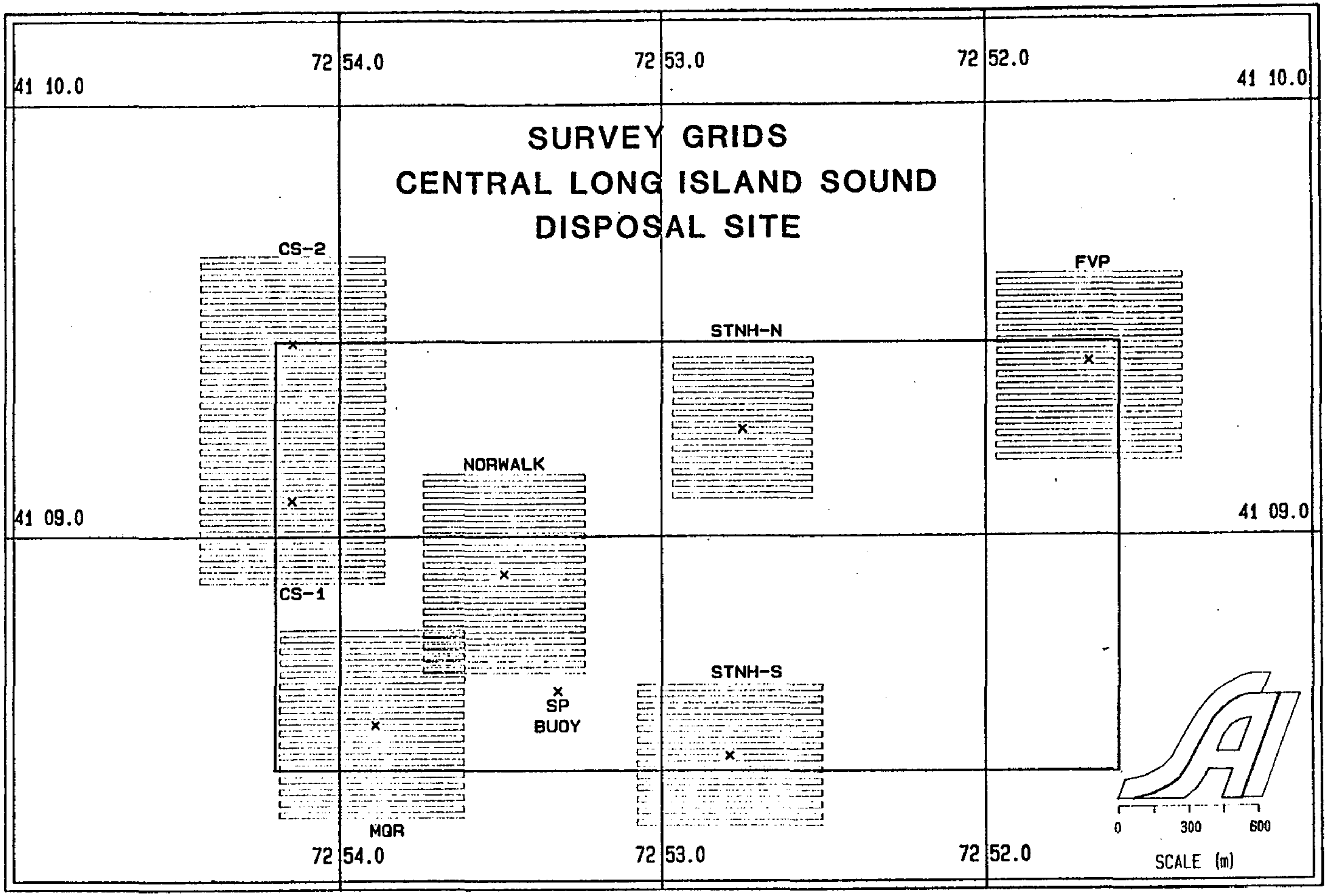
SURVEY GRIDS
CENTRAL LONG ISLAND SOUND
DISPOSAL SITE
41 10.0
72 54.0
72 53.0
72 52.0
41 10.0
CS-2
FVP
STNH-N
NORWALK
41 09.0
41 09.0
CS-1
STNH-S
SP
BUOY
MQR
72 54.0
72 53.0
72 52.0
0
300
600
SCALE (m)

FIGURE II-2-7.

TABLE II-2-8

FVP SAMPLING CHARACTERISTICS

PRATT - EPA 1982-85

SAMPLING GEAR: SMITH MAC

AREA: $0.1M^2$

SIEVE: 1.0MM - 0.5MM

FREQUENCY: QUARTERLY

ASSOCIATED MEASUREMENTS: HEAVY METALS
ORGANICS
GRAIN SIZE

DATA FORM: COMPUTERIZED

3.0 DATA ANALYSIS

A summary of the total number of samples is shown in Table II-2-9, which indicates a potentially large data set, but one which is not so extensive as to preclude analysis. Although three different types of grab samplers were used, the sample surface areas and sieve sizes were fairly consistent from study to study. The taxonomic problems, normally expected in an analysis of this type, are minimal because of the concentration of work in one area and the professional and academic relationships of the consecutive investigators.

Another major concern in any community study is the sieve size, which in most studies was 1.0 mm. Although a smaller sieve size has been shown to produce greater numbers of species and individuals in any given data set (Germano 1983), the use of 1.0 mm mesh provides ecologically valid data for the following two reasons. One, the larger animals typically have a greater effect, at least in this area, on sediment processing (Rhoads and Boyer, 1982), and, consequently, the fate and effects of particle associated contaminants. This is especially important here because of the potential effects of dredged material on the benthos. Secondly, the over-wintering populations, adults, form the breeding group which is responsible for subsequent recruitment which may be missed by a sieve size of 0.5 mm. In this case, the stable population is represented by the larger animals, most of which are retained by a 1.0 mm mesh.

With the above restrictions in mind, i.e. variable samplers and 1.0 mm mesh size, it is recommended that all the data sets described here are being entered into the NED data base for the stations adjacent or in the CLIS disposal site. Complete computerized data sets are being entered along with selected raw data.

The primary objectives of the analysis of the CLIS benthic infaunal data, as stated in the introduction to this section, are to assess the long-term impacts of dredged material disposal and secondly to assess the effectiveness of this type of data for describing these impacts. The primary components of the data are species numbers, species abundances, and any associated physical or chemical parameters that were collected with each sample. Ancilliary data related to dredged material disposal are also being compiled. These data include disposal mound locations, dates of disposal, volume of material and physical, chemical parameters of the dredged material. Data analysis procedures have been developed by SAIC and will be used to analyze these data in terms of stated objectives.

The overall structure of the data analysis system is shown in Figure II-2-8, indicating five main "levels" of analysis. These are:

- Exploratory Analysis

TABLE II-2-9

SUMMARY

STUDY	SAMPLES	FORM
SANDERS	4	RAW
REID	12	COMPUTERIZED
RHOADS & MICHAEL	620	RAW
MCCALL & FISHER	10	RAW
BROOKS	90	RAW
PRATT	64-100	COMPUTERIZED
PELLIGRINO & HUBBARD	10	COMPUTERIZED
PRATT - EPA	250	COMPUTERIZED

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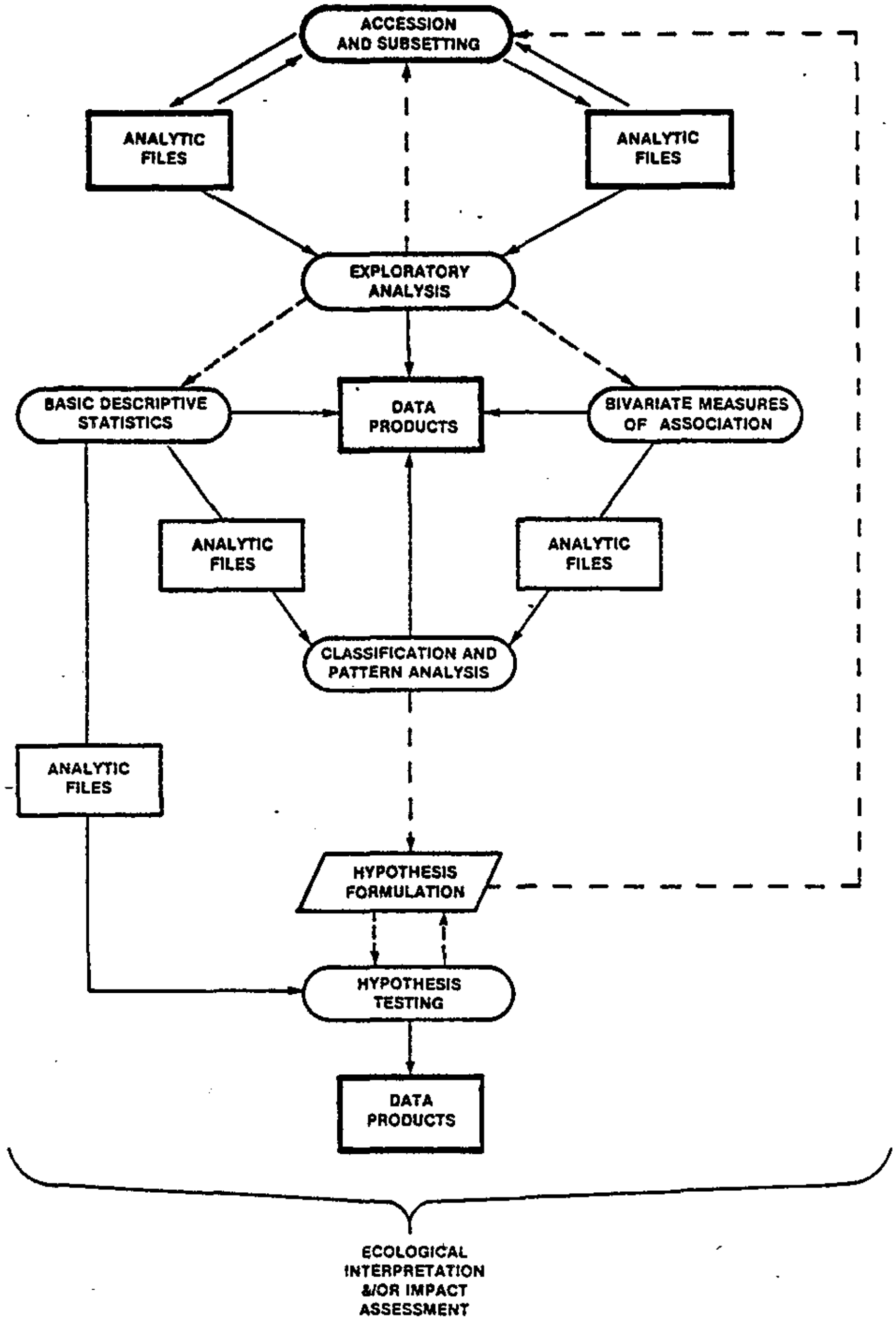

FIGURE II-2-8. FLOW CHART OF A STRUCTURED DATA ANALYSIS SYSTEM.

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- o Basic Descriptive Statistics
- o Bivariate Measures of Association
- o Classification and Pattern Analysis
- o Hypothesis Testing

Exploratory analysis has, as its main goal, the characterization of the overall community in space and time and to determine from this initial characterization what parameters (species, higher taxonomic groups, etc.) will be utilized in subsequent analyses. Any and all analyses requiring the total species assemblage at each station (or replicate) such as diversity or total number of species will be calculated during this stage, and descriptive statistics for these derived parameters (mean, variance, n) will be calculated and stored. Exploratory analysis defines the criteria for subsetting of the original data sets.

In the second stage of the analysis, for those chosen data sets and parameters, basic descriptive statistics will be calculated. These statistics will help define the statistical nature of the data (especially the variation), define the potential need for data transformation (to satisfy the criteria of additivity, normality and equality of variance), and serve as inputs to hypothesis testing (concerning natural, spatial and temporal variation and/or dredged material impacts). Bivariate measures of assocation will be calculated in the third phase of the analysis, yielding temporal, spatial and taxonomic groupings. These measures suggest community associations and serve as input data to the classification and pattern analyses.

Once the community-associations have been determined, the higher level of classification and pattern analysis will be conducted. Classification and pattern analysis techniques are statistical tools for reducing complex data to a set of dominant trends which should be further studied using hypothesis testing techniques. Trends in the data resulting from effects of time of year (temperature) or grain size (sand vs. mud) will be determined in these analyses. These analyses are also very useful in identifying outlier samples which should then be examined more closely. Without classification and pattern analysis, the most important trends in the data are often ignored, leading to erroneous hypotheses and conclusions.

At the final stage of analysis, all the information from previous stages is utilized for formulation of hypotheses which can be tested by a number of techniques (ANOVA, ANCOVA, regression) that represent applications of the general linear model. By virtue of the experimental design of the monitoring program, some initial and general hypotheses have already been formulated. These inlude testing for significant differences in benthic macrobenthos parameters (1) among groups of stations in different sediment types and (2) among groups of stations spatially isolated but with similar sediments. Of particular importance for this study will be the differences among disposal mound stations and those at a control site over time. These initial hypotheses will be refined, expanded, or truncated, depending on the prior results from the application of the data analysis scheme. Many of the parameters required for hypothesis testing will have been calculated earlier (in basic descriptive statistics) and stored. Analysis of variance and t-tests can be used to test differences for class variables while analysis of covariance can be used to remove extraneous variance from the main effects.

Hypothesis testing has, as an additional feature, the ability for calculating the number of samples required for significance testing and also the optimization of the sampling design based on analyses of variances. A very important component is its predictive capability, expressed through multiple regression analysis and discriminant function analysis. In this way, samples can be classified or dependent variables of interest can be predicted from sets of independent variables. This phase of the analysis will address the second major objective of this study, the optimization of a sampling design for assessing the impacts of dredged material disposal.

4.0 ANALYSIS OF THE PATTERNS IN THE DISTRIBUTION OF MACROINFAUNAL TAXA AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE DURING THE PERIOD 1979 TO 1983

4.1 Analytic Approach

After reviewing the data set incorporated into the DAMOS Project Database to date (Table II-4-1), data for 46 collections at a total of 13 stations were selected from the Brooks/1979-1980 data, Pratt/1981-1982 data, and the Field Verification Program (FVP) data for analysis of patterns in the distribution of macroinfaunal taxa in and around the Central Long Island Sound Disposal Site for the period Winter 1979 to Spring 1983 (Table II-4-2). These data were collected with consistent gear types and methodologies and constitute a time series for many of the stations in the Central Long Island Sound Disposal Site. Since community analyses require that the number of replicates be the same for all, three replicates were randomly selected in those instances when more than three replicates were collected. This resulted in the selection of 46 station collections of 3 replicates each for a total of 138 samples. Mean counts were then calculated for each taxon over the three replicates at each station, and all analyses presented below were performed on these mean data. While this analysis did not reveal information concerning within-collection variability, it is appropriate as an initial attempt to discern major trends in community structure with respect to time, habitat variables, and dumping operations.

4.2 Relative Composition and Abundance

The community composition of all samples combined is summarized in Table II-4-3. A total of 31,293 individuals

TABLE II-4-1. SUMMARY OF THE MACROINFANAL DATA SETS INTEGRATED INTO THE DAMOS PROJECT DATA BASE.

DAMOS STUDY/DATE	NO. OF STATIONS	NO. OF REPLICATES	DATA NO. OF SAMPLES	DATES OF SAMPLE COLLECTION	SUMMARY GEAR TYPE	ASSOCIATED DATA	COMMENTS
Sanders/1953-54	6	1	6	4/19/54-Sta.1 2/19/54-Sta.3,4,5 2/3/54-Sta.8 2/23/53-Charles I.	Anchor Dredge(0.1m^2); 2.0 mm and 0.3 mm sieves	Grain Size	The dredge dug to 7.6 cm in all sediment types and the square area sampled was obtained by dividing the volume by digging depth. The sample was divided into three parts, a large fraction (13,000 cc) was sieved through a 2.0 mm mesh, a small fraction (1,500 cc) was sieved through a 0.3 mm mesh.
Reid/1972-73	143	1	143	Winter	Smith-McIntyre (0.1m^2); 1 mm sieve	Grain Size, Metals	
McCall & Fisher/ 1973	17	1-4	137	Summer/Winter	Van Veen(0.147m^2 and 0.041 m^2); 1 mm sieve	Grain Size	
Rhoads/Summer 1972 (Rhoads 1)	116	1	116	7/11/72 7/12/72 7/28/72 9/5/72	Van Veen(0.15 m^2); 1 mm sieve	NONE	These pre-disposal data were collected at the following New Haven Sites: South Control, Dump Site, Harbor Ship Channel, and Northwest Control. Complete taxonomy was done on 25 samples collected at the Dump Site, with the remaining samples consisting of the molluscan fraction only. Data are recorded as counts per m^2.
Rhoads/Winter 1973 (Rhoads 2)	65	3	195	1/9/73 1/10/73	Van Veen (0.0413 m^2); 1 mm sieve	NONE	These pre-disposal data were collected at the New Haven South Control, Dump Site, and Northwest Control Sites. Data are molluscs only, and are recorded as counts per m^2.
Rhoads/Summer 1973 (Rhoads 4)	49	2	98	7/16/73 7/23/73 7/24/73 7/25/73 8/2/73 8/7/73	Van Veen(0.0413 m^2 1 mm sieve	NONE	These pre-disposal data were collected at the New Haven South Control, Dump Site, Harbor Ship Channel, and Northwest Control sites. Data are molluscs only, and are recorded as counts per m^2.
Rhoads/Winter 1974 (Rhoads 5)	28	2	56	2/2/74 2/6/74 2/21/74 3/26/74	Van Veen (0.0413 m^2); 1 mm seive	NONE	Collected during disposal operations at the New Haven South Control, Dump Site, Harbor Ship Channel, and Northwest Central sites. Data are molluscs only, and are recorded as counts per m^2.

TABLE II-4-1. CONTINUED

DAMOS DATA SUMMARY

STUDY/DATE	NO. OF STATIONS	NO. OF REPLICATES	NO. OF SAMPLES	DATES OF SAMPLE COLLECTION	GEAR TYPE	ASSOCIATED DATA	COMMENTS
Rhoads/Summer 1974 (Rhoads 6)	48	2	96	7/15/74 7/16/74 7/17/74	Van Veen (0.0413 m^2); 1 mm seive	NONE	Collected at the New Haven South Control, Dump Site, Harbor Ship Channel, and Northwest Control sites. Data are molluscs only, and are recorded as counts per m^2.
Brooks/Spring 1978	2	3	6	4/13/78	Anchor Dredge (0.1 m^2); 1 mm sieve	Grain Size, Metals	Collected at the New Haven Dump Site and Reference Site (N.W. Control).
Brooks/Summer 1978	2	3	6	7/29/78	Smith-McIntyre (0.1 m^2); 1 mm sieve	Grain Size, Metals	Collected at the New Haven Dump Site and Reference Site (N.W. Control).
Brooks/Winter 1979	5	5	25	1/19/79 1/26/79	Smith-McIntyre (0.1 m^2); 1 mm sieve	Grain Size, Metals	Collected at the New Haven Dump Site, Reference Site, Stamford New Haven-S-CTR, Stamford New Haven-S-(1000m E), and Stamford New Haven-S-(1000m W).
Brooks/Spring 1979	5	5	25	3/21/79 5/21/79 5/22/79	Smith-McIntyre (0.1 m^2); 1 mm sieve	Grain Size, Metals	Collected at the New Haven Dump Site, Reference Site, Stamford New Haven-S-CTR, Stamford New Haven-S-(1000m E), and Stamford New Haven-S-(1000m W).
Brooks/Summer 1979	3	5	15	8/9/79	Smith-McIntyre (0.1 m^2); 1 mm sieve	Grain Size, Metals	Collected at the Stamford New Haven -S-CTR, Stamford New Haven-S-(1000m E), and Stamford New Haven-S-(1000m W).
Brooks/Spring 1980	5	3-7	27	4/1/80 4/2/80	Smith-McIntyre (0.1 m^2); 1 mm sieve	Grain Size, Metals	Collected at Central Long Island Sound Reference, Stamford New Haven-N-CTR, Stamford New Haven-N-(200m E), Stamford New Haven-N-(400m E), and Norwalk-New Haven-CTR.
Brooks/Summer 1980	6	3	18	9/4/80 9/5/80	Smith-McIntyre (0.1 m^2); 1 mm sieve	Grain Size, Metals	Collected at Central Long Island Sound Reference, Stamford New Haven-N-CTR, Stamford New Haven-N-IE (200m E), Stamford New Haven-S-CTR, Stamford New Haven-S-IE (100m E), and Stamford New Haven-S-OE (300m E).
Pratt/Winter 1981	7	3	21	1/25/80 1/26/80 1/28/80	Smith-McIntyre (0.1 m^2); 1.0 mm sieves	Grain Size, Metals,	Collected at Central Long Island Sound Reference, Stamford New Haven-N-CTR, Stamford New Haven-N-IE (200m E), Stamford New Haven-N-OE (400m E), Stamford New Haven-S-CTR, Stamford New Haven-S-IE (100m E), and Stamford New Haven-S-OE (400m E).
Pratt/Summer 1981 1982	1	3	30	8/19/81	Smith-McIntyre (0.1 m^2); 1 mm sieve		Collected at Central Long Island Sound Reference.

TABLE II-4-1. CONTINUED

DAMOS DATA SUMMARY

STUDY/DATE	NO. OF STATIONS	NO. OF REPLICATES	NO. OF SAMPLES	DATES OF SAMPLE COLLECTION	GEAR TYPE	ASSOCIATED DATA	COMMENTS
Pratt/Winter 1982	7	3	21	1/29/82 1/30/82 2/4/82	Smith-McIntyre ($0.1\ m^2$); 1 mm sieve		Collected at Central Long Island Sound Reference, Stamford New Haven-N-CTR, Stamford New Haven-N-IE (200m E), Stamford New Haven-N-OE (400m E), Stamford New Haven-S-CTR, Stamford New Haven-S-IE (100m E) and Stamford New Haven-S-OE (400m E).
Pratt FVP/Spring 1982	34	3-1	38	5/4/82	Smith-McIntyre ($0.1\ m^2$); 5 and 1.0 mm sieves		Collected at varying distances; from the center of the FVP site which is located in the northeast corner of the Central Long Island Sound Disposal Site.
Pratt FVP/Summer 1982	13	1-8	35	8/29/82	Smith-McIntyre ($0.1\ m^2$); 5 and 1.0 mm sieves		
Pratt FVP/Winter 1982	5	5	25	12/8/82	Smith-McIntyre ($0.1\ m^2$); 5 and 1.0 mm sieves		
Pratt FVP/Spring 1983	5	5	25	3/15/83	Smith-McIntyre ($0.1\ m^2$); 5 and 1.0 mm sieves		

TABLE II-4-2. SPATIAL AND TEMPORAL DISTRIBUTION OF THE 46 STATION COLLECTIONS SELECTED FOR ANALYSES OF THE PATTERNS IN THE DISTRIBUTION OF MACROINFAUNAL TAXA AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE.

STATION NAME	STATION ACRONYM		WINTER 1978-79	SUMMER 1978	SPRING 1979	SUMMER 1979	SPRING 1980	SUMMER 1980	WINTER 1980-81	SUMMER 1981	WINTER 1981-82	SPRING 1982	SUMMER 1982	WINTER 1982	SPRING 1983
New Haven Dump Site (Original)	New Haven	CTR	X	X	X	—	—	—	—	—	—	—	—	—	—
New Haven Reference (N.W. Control)	New Haven	REF	X	X	X	—	—	—	—	—	—	—	—	—	—
Central Long Island Sound Reference	CLIS	CLISREF	—	—	—	—	X	X	X	X	X	X	X	X	X
Stamford-New Haven North (Center)	STNH-N	CTR	—	—	X	—	X	X	X	—	X	—	—	—	—
Stamford-New Haven North Inner Ridge (200m E)	STNH-N	IE	—	—	—	—	X	X	X	—	X	—	—	—	—
Stamford-New Haven North Outer Ridge (400m E)	STNH-N	OE	—	—	—	—	X	—	X	—	X	—	—	—	—
Stamford-New Haven South (Center)	STNH-S	CTR	X	—	—	X	—	X	X	—	X	—	—	—	—
Stamford-New Haven South Inner Ridge (100m E)	STNH-S	IE	—	—	—	—	—	X	X	—	X	—	—	—	—
Stamford-New Haven South Outer Ridge (300m E)	STNH-S	OE	—	—	—	—	—	X	—	—	—	—	—	—	—
Stamford-New Haven South Outer Ridge (400m E)	STNH-S	OE	—	—	—	—	—	—	X	—	X	—	—	—	—
Stamford-New Haven South (1000m E)	STNH-S	1000E	X	—	X	X	—	—	—	—	—	—	—	—	—
Stamford-New Haven South (1000m W)	STNH-S	1000W	X	—	X	X	—	—	—	—	—	—	—	—	—
Field Verification Program (1000E)	FVP	1000E	—	—	—	—	—	—	—	—	—	X	X	X	X

TABLE II-4-3. OVERALL RELATIVE COMPOSITION OF MACROINFAUNAL TAXA COLLECTED AT 46 STATIONS AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE FROM 1979 TO 1983.

TAXON NAME	MEAN PERCENT COMPOSITION	CUMULATIVE PERCENT COMPOSITION	POOLED PERCENT COMPOSITION	FREQ. OF OCCURRENCE	CUMULATIVE ABUNDANCE	MEAN DENSITY (#/M**2)	INDEX OF DISPERSION
Mediomastus ambiseta	3.913	3.913	26.833	0.152	8397.	608.48	1325.74
Mulinia lateralis	13.481	17.395	20.295	0.703	14748.	460.22	403.39
Nucula annulata	8.498	25.893	11.996	0.319	18502.	272.03	108.80
Nephtys incisa	21.920	47.812	9.667	0.913	21527.	219.20	40.74
Yoldia limatula	3.282	51.094	3.375	0.529	22583.	76.52	35.87
Tellina versicolor	4.479	55.573	2.541	0.145	23378.	57.61	67.62
Nucula proxima	5.578	61.151	2.269	0.254	24088.	51.45	49.27
Paraonis gracilis	0.909	62.060	1.946	0.254	24697.	44.13	32.66
Tubulanus pellucidus	0.395	62.455	1.882	0.174	25286.	42.68	53.71
Macoma tenta	1.658	64.113	1.448	0.268	25739.	32.83	24.55
Oligochaeta	0.304	64.417	1.349	0.116	26161.	30.58	61.09
Pitar morrhuana	3.132	67.549	1.272	0.391	26559.	28.84	11.86
Melinna cristata	2.365	69.915	1.042	0.399	26885.	23.62	11.23
Pherusa affinis	0.932	70.847	0.853	0.428	27152.	19.35	9.11
Phoronis architecta	2.156	73.003	0.786	0.290	27398.	17.83	13.64
Pectinaria gouldii	1.030	74.033	0.658	0.210	27604.	14.93	22.38
Ceriantheopsis americanus	1.194	75.227	0.636	0.312	27803.	14.42	4.23
Polydora ligni	1.016	76.243	0.633	0.058	28001.	14.35	64.08
Ampharete arctica	1.373	77.617	0.614	0.145	28193.	13.91	26.26
Ampelisca vadorum	1.819	79.435	0.572	0.203	28372.	12.97	14.50
Retusa canaliculata	0.508	79.943	0.569	0.254	28550.	12.90	10.63
Owenia fusiformis	1.391	81.335	0.562	0.174	28726.	12.75	23.68
Nassarius trivittatus	1.424	82.758	0.553	0.319	28899.	12.54	7.73
Unciola irrorata	0.619	83.377	0.412	0.109	29028.	9.35	18.54
Pandora gouldiana	0.287	83.664	0.367	0.210	29143.	8.33	16.25
Edwardsia elegans	0.961	84.625	0.300	0.326	29237.	6.81	3.34
Balanus crenatus	0.217	84.842	0.294	0.022	29329.	6.67	78.75
Ceriantharia	1.612	86.454	0.284	0.188	29418.	6.45	4.50
Corymorpha pendula	0.702	87.156	0.259	0.167	29499.	5.87	4.69
Spiophanes bombyx	0.470	87.626	0.256	0.094	29579.	5.80	10.50
Saccoglossus kowalevskii	0.938	88.565	0.252	0.246	29658.	5.72	3.21
Cylichna oryza	0.134	88.699	0.243	0.159	29734.	5.51	6.47
Sigambra tentaculata	0.184	88.883	0.236	0.203	29808.	5.36	4.33
Nephtys picta	0.366	89.249	0.224	0.080	29878.	5.07	9.62
Tharyx	0.085	89.334	0.217	0.130	29946.	4.93	5.84
Streblospio benedicti	0.037	89.371	0.211	0.080	30012.	4.78	8.92
Loimia medusa	0.382	89.752	0.185	0.145	30070.	4.20	5.41
Micrura	0.265	90.017	0.163	0.087	30121.	3.70	10.27
Euclymene collaris	0.382	90.399	0.157	0.087	30170.	3.55	8.63
Ceriantharia A	0.998	91.397	0.134	0.101	30212.	3.04	3.67
Pagurus longicarpus	0.528	91.925	0.118	0.116	30249.	2.68	4.55
Asabellides oculata	0.180	92.106	0.112	0.123	30284.	2.54	3.23
Phyllodoce arenae	0.180	92.285	0.109	0.080	30318.	2.46	3.96
Cossura longocirrata	0.023	92.309	0.105	0.051	30351.	2.39	12.37
Phoronis muelleri	0.118	92.427	0.105	0.159	30384.	2.39	1.50
Crepidula plana	0.079	92.506	0.105	0.022	30417.	2.39	27.38
Ensis directus	0.224	92.730	0.102	0.087	30449.	2.32	3.48
Neomysis americana	0.390	93.120	0.102	0.101	30481.	2.32	4.05
Ampelisca abdita	0.531	93.651	0.096	0.087	30511.	2.17	4.21
Retusa obtusa	0.016	93.667	0.089	0.065	30539.	2.03	4.76
Glycera americana	0.236	93.903	0.083	0.109	30565.	1.88	2.29
Balanus amphitrite	0.153	94.056	0.080	0.022	30590.	1.81	16.46
Polycirrus	0.128	94.184	0.077	0.080	30614.	1.74	2.51
Acteon punctostriatus	0.068	94.253	0.077	0.058	30638.	1.74	4.11
Polydora socialis	0.091	94.344	0.070	0.043	30660.	1.59	7.53
Turbonilla interrupta	0.040	94.384	0.070	0.080	30682.	1.59	2.86
Leptocheirus pinguis	0.119	94.503	0.070	0.072	30704.	1.59	4.23
Lyonsia hyalina	0.037	94.539	0.067	0.087	30725.	1.52	2.58
Yoldia sapotilla	0.407	94.947	0.064	0.058	30745.	1.45	4.89
Brada villosa	0.099	95.045	0.061	0.022	30764.	1.38	12.32
Upogebia affinis	0.114	95.160	0.058	0.072	30782.	1.30	2.11
Archiannelida	0.084	95.244	0.058	0.022	30800.	1.30	6.70
Balanus balanoides	0.151	95.394	0.054	0.022	30817.	1.23	8.59
Ceriantharia B	0.160	95.554	0.054	0.043	30834.	1.23	3.49
Ninoe nigripes	0.173	95.727	0.051	0.109	30850.	1.16	1.02
Caulleriella fillariensis	0.096	95.823	0.051	0.051	30866.	1.16	3.28
Asychis elongatus	0.084	95.908	0.051	0.080	30882.	1.16	1.90
Platyhelminthes	0.071	95.978	0.048	0.036	30897.	1.09	6.00
Cerebratulus	0.302	96.280	0.045	0.072	30911.	1.01	1.48
Ampelisca	0.049	96.329	0.038	0.065	30923.	0.87	1.59
Oxyurostylis smithi	0.015	96.345	0.038	0.029	30935.	0.87	4.78
Pinnixa chaetopterana	0.050	96.395	0.038	0.058	30947.	0.87	2.09

TABLE II-4-3. CONTINUED

TAXON NAME	MEAN PERCENT COMPOSITION	CUMULATIVE PERCENT COMPOSITION	POOLED PERCENT COMPOSITION	FREQ. OF OCCURRENCE	CUMULATIVE ABUNDANCE	MEAN DENSITY (#/M**2)	INDEX OF DISPERSION
Spiochaetopterus oculatus	0.035	96.430	0.035	0.051	30958.	0.80	2.21
Caprella linearis	0.071	96.500	0.035	0.007	30969.	0.80	11.00
Clymenella torquata	0.043	96.543	0.035	0.058	30980.	0.80	1.48
Sabellaria vulgaris	0.034	96.577	0.035	0.022	30991.	0.80	3.86
Haloclava producta	0.088	96.665	0.032	0.065	31001.	0.72	1.14
Yoldia lucida	0.220	96.885	0.032	0.051	31011.	0.72	1.54
Glycera dibranchiata	0.045	96.930	0.029	0.036	31020.	0.65	2.06
Aricidea neosuecica	0.046	96.976	0.029	0.022	31029.	0.65	4.52
Crangon septemspinosa	0.286	97.263	0.029	0.058	31038.	0.65	1.17
Cerebratulus lacteus	0.006	97.269	0.026	0.022	31046.	0.58	4.73
Clymenella zonalis	0.192	97.461	0.026	0.029	31054.	0.58	2.71
Balanus	0.050	97.511	0.026	0.007	31062.	0.58	8.00
Paranaitis speciosa	0.046	97.557	0.026	0.058	31070.	0.58	0.95
Cancer irroratus	0.190	97.747	0.026	0.043	31078.	0.58	1.45
Rhynchocoela	0.143	97.890	0.026	0.043	31086.	0.58	1.70
Protodrilus	0.036	97.927	0.022	0.014	31093.	0.51	5.27
Periploma papyratium	0.035	97.961	0.022	0.022	31100.	0.51	2.97
Ovalipes ocellatus	0.041	98.003	0.022	0.043	31107.	0.51	1.24
Aglaophamus circinata	0.048	98.051	0.022	0.029	31114.	0.51	2.11
Tubulanus	0.034	98.085	0.019	0.029	31120.	0.43	1.97
Pholoe minuta	0.023	98.108	0.019	0.029	31126.	0.43	1.64
Spio filicornis	0.003	98.111	0.019	0.029	31132.	0.43	1.97
Lumbrineris fragilis	0.078	98.189	0.016	0.036	31137.	0.36	0.97
Axius serratus	0.300	98.489	0.016	0.029	31142.	0.36	1.37
Euclymeninae	0.072	98.562	0.016	0.014	31147.	0.36	3.39
Hutchinsoniella macracantha	0.003	98.565	0.016	0.029	31152.	0.36	1.37
Polinices triseriata	0.016	98.581	0.016	0.022	31157.	0.36	2.18
Callianassa atlantica	0.034	98.615	0.016	0.022	31162.	0.36	2.18
Tellina agilis	0.029	98.644	0.016	0.029	31167.	0.36	1.37
Pelia mutica	0.021	98.665	0.013	0.007	31171.	0.29	4.00
Aricidea neosuecica	0.028	98.693	0.013	0.014	31175.	0.29	2.49
Lepidonotus sublevis	0.023	98.716	0.013	0.022	31179.	0.29	1.48
Polinices duplicatus	0.020	98.736	0.013	0.029	31183.	0.29	0.98
Solen viridis	0.094	98.830	0.010	0.022	31186.	0.22	0.99
Ampelisca agassizi	0.039	98.869	0.010	0.022	31189.	0.22	0.99
Scoloplos fragilis	0.024	98.893	0.010	0.022	31192.	0.22	0.99
Edotea montosa	0.008	98.901	0.010	0.014	31195.	0.22	1.66
Nereis grayi	0.016	98.916	0.010	0.014	31198.	0.22	1.66
Jassa falcata	0.023	98.939	0.010	0.014	31201.	0.22	1.66
Asterias forbesi	0.015	98.954	0.006	0.014	31203.	0.14	0.99
Harmothoe imbricata	0.008	98.962	0.006	0.014	31205.	0.14	0.99
Syllis cornuta	0.030	98.992	0.006	0.014	31207.	0.14	0.99
Polydora caulleryi	0.007	98.999	0.006	0.007	31209.	0.14	2.00
Halocla va	0.029	99.029	0.006	0.014	31211.	0.14	0.99
Ampharete oculata	0.015	99.043	0.006	0.014	31213.	0.14	0.99
Eteone heteropoda	0.004	99.048	0.006	0.014	31215.	0.14	0.99
Scoloplos acutus	0.126	99.174	0.006	0.014	31217.	0.14	0.99
Polinices heros	0.018	99.191	0.006	0.014	31219.	0.14	0.99
Brachyura	0.010	99.202	0.006	0.007	31221.	0.14	2.00
Maldanidae	0.009	99.211	0.006	0.014	31223.	0.14	0.99
Mysidopsis bigelowi	0.072	99.284	0.006	0.007	31225.	0.14	2.00
Asteroidea B	0.011	99.295	0.006	0.014	31227.	0.14	0.99
Acteocina canaliculata	0.016	99.311	0.006	0.014	31229.	0.14	0.99
Opisthobranchia	0.006	99.317	0.006	0.014	31231.	0.14	0.99
Harmothoe extenuata	0.011	99.328	0.006	0.014	31233.	0.14	0.99
Ptilanthura tenuis	0.013	99.341	0.006	0.014	31235.	0.14	0.99
Epitonium rupicola	0.005	99.345	0.006	0.014	31237.	0.14	0.99
Asterias vulgaris	0.013	99.358	0.006	0.007	31239.	0.14	2.00
Neopanope texana sayi	0.006	99.364	0.003	0.007	31240.	0.07	1.00
Tharyx sp. A	0.003	99.368	0.003	0.007	31241.	0.07	1.00
Scalibregma inflatum	0.003	99.371	0.003	0.007	31242.	0.07	1.00
Natica pusilla	0.003	99.374	0.003	0.007	31243.	0.07	1.00
Golfingia minuta	0.020	99.393	0.003	0.007	31244.	0.07	1.00
Cancer borealis	0.012	99.406	0.003	0.007	31245.	0.07	1.00
Panopeus herbstii	0.004	99.410	0.003	0.007	31246.	0.07	1.00
Nucula tenuis	0.021	99.431	0.003	0.007	31247.	0.07	1.00
Thracia septentrionalis	0.010	99.440	0.003	0.007	31248.	0.07	1.00
Maldane sarsi	0.006	99.447	0.003	0.007	31249.	0.07	1.00
Polydora caeca	0.003	99.450	0.003	0.007	31250.	0.07	1.00
Boreotrophon	0.121	99.571	0.003	0.007	31251.	0.07	1.00
Odostomia sumneri	0.003	99.574	0.003	0.007	31252.	0.07	1.00
Diastylis sculpta	0.010	99.584	0.003	0.007	31253.	0.07	1.00
Asteroidea A	0.005	99.589	0.003	0.007	31254.	0.07	1.00
Phascolion strombi	0.045	99.634	0.003	0.007	31255.	0.07	1.00
Corophium bonellii	0.004	99.638	0.003	0.007	31256.	0.07	1.00

TABLE II-4-3. CONTINUED

TAXON NAME	MEAN PERCENT COMPOSITION	CUMULATIVE PERCENT COMPOSITION	POOLED PERCENT COMPOSITION	FREQ. OF OCCURRENCE	CUMULATIVE ABUNDANCE	MEAN DENSITY (#/M**2)	INDEX OF DISPERSION
Pagurus pollicaris	0.002	99.641	0.003	0.007	31257.	0.07	1.00
Diplocirrus hirsutus	0.004	99.644	0.003	0.007	31258.	0.07	1.00
Mitrella lunata	0.019	99.663	0.003	0.007	31259.	0.07	1.00
Hydrobia salsa	0.008	99.670	0.003	0.007	31260.	0.07	1.00
Caudina arenata	0.006	99.677	0.003	0.007	31261.	0.07	1.00
Ampharete acutifrons	0.005	99.682	0.003	0.007	31262.	0.07	1.00
Hydrobia	0.002	99.684	0.003	0.007	31263.	0.07	1.00
Scoloplos	0.003	99.687	0.003	0.007	31264.	0.07	1.00
Amphitrite cirrata	0.017	99.704	0.003	0.007	31265.	0.07	1.00
Anadara transversa	0.007	99.711	0.003	0.007	31266.	0.07	1.00
Aricidea	0.008	99.719	0.003	0.007	31267.	0.07	1.00
Busycon canaliculatum	0.004	99.722	0.003	0.007	31268.	0.07	1.00
Chithropanopeus harrisii	0.016	99.739	0.003	0.007	31269.	0.07	1.00
Terebellidae	0.033	99.772	0.003	0.007	31270.	0.07	1.00
Amphiporus	0.020	99.791	0.003	0.007	31271.	0.07	1.00
Anthozoa	0.020	99.811	0.003	0.007	31272.	0.07	1.00
Phyllodoce	0.005	99.816	0.003	0.007	31273.	0.07	1.00
Potamilla reniformis	0.005	99.821	0.003	0.007	31274.	0.07	1.00
Eteone longa	0.006	99.827	0.003	0.007	31275.	0.07	1.00
Sthenelais boa	0.009	99.836	0.003	0.007	31276.	0.07	1.00
Pista palmata	0.016	99.852	0.003	0.007	31277.	0.07	1.00
Hexapanopeus angustifrons	0.004	99.856	0.003	0.007	31278.	0.07	1.00
Cirratulidae	0.004	99.860	0.003	0.007	31279.	0.07	1.00
Pinnixa sayana	0.020	99.879	0.003	0.007	31280.	0.07	1.00
Hiatella arctica	0.010	99.889	0.003	0.007	31281.	0.07	1.00
Mya arenaria	0.024	99.913	0.003	0.007	31282.	0.07	1.00
Sesarma reticulatum	0.005	99.918	0.003	0.007	31283.	0.07	1.00
Mercenaria mercenaria	0.006	99.924	0.003	0.007	31284.	0.07	1.00
Caprella	0.004	99.928	0.003	0.007	31285.	0.07	1.00
Turbonilla	0.004	99.933	0.003	0.007	31286.	0.07	1.00
Syllis	0.002	99.935	0.003	0.007	31287.	0.07	1.00
Tharyx acutus	0.006	99.942	0.003	0.007	31288.	0.07	1.00
Pandora	0.005	99.947	0.003	0.007	31289.	0.07	1.00
Flabelligera affinis	0.009	99.955	0.003	0.007	31290.	0.07	1.00
Macoma	0.036	99.992	0.003	0.007	31291.	0.07	1.00
Heteromysis formosa	0.005	99.997	0.003	0.007	31292.	0.07	1.00
Edotea triloba	0.003	100.000	0.003	0.007	31293.	0.07	1.00

SAMPLE SUMMARY: SAMPLES = 138 TOTAL TAXA = 184 TOTAL DENSITY = 2267.61

representing 184 taxa were identified from the 138 samples included in the analysis. As is typical for benthic macroinfauna, the overall community was numerically dominated by a relatively small number of taxa, with the majority of the taxa represented by only a few individuals each. The five most abundant taxa accounted for greater than 51% of the cumulative percent composition, and the 22 most abundant taxa accounted for greater than 81% of the cumulative percent composition. An examination of frequency of occurrence values revealed that only the polychaete worm Nephtys incisa and the bivalve molluscs Mulinia lateralis and Yoldia limatula occurred in greater than 50% of the samples, with frequencies of occurrence of 0.91, 0.70, and 0.53, respectively. As will be discussed below, this indicates that most of the numerically dominant taxa showed considerable habitat fidelity.

The polychaete worm Mediomastus ambiseta was by far the most abundant taxon, with 8,397 individuals collected. This taxon accounted for greater than 26% of the pooled percent composition, but only 3.9% of the mean percent composition. Pooled percent composition is calculated on all of the samples lumped (pooled) together, whereas mean percent composition is a mean of the percent composition calculated for each sample. This difference in pooled versus mean percent composition is a reflection of the tendency for this species to numerically dominate a limited number of samples. Mediomastus ambiseta occurred in just over 15% of the samples collected (frequency of occurrence = 0.15), and was numerically dominant in all samples from the FVP study.

The bivalve molluscs Mulinia lateralis and Nucula annulata were the next most abundant taxa, accounting for 20% and 12% of the pooled percent composition, respectively. The polychaete worm Nephtys incisa accounted for greater than 10% of the pooled percent composition and almost 22% of the mean percent composition. This was by far the highest mean percent composition for any taxon in the study, and reflects the fact that this polychaete was the most widely distributed organism collected in the study. The bivalve molluscs Yoldia limatula, Tellina versicolor, and Nucula proxima each accounted for greater than 3% of the mean percent composition. Some of the other numerically prominent taxa were the nemertean Tubulanus pellucidus, the polychaete worm Paraonis gracilis, and the bivalve mollusc Macoma tenta. The prominence of molluscan taxa is consistent with results from previous studies conducted in the Central Long Island Sound region (Sanders, 1956; McCall, 1978).

A number of taxa with pooled percent compositions of around one or less were found in relatively large numbers of collections. Those found in greater than 30% of the samples included the anemones Ceriantheopsis americanus and Edwardsia elegans, the polychaete worms Mellina cristata and Pherusa affinis, the bivalve mollusc Pitar morrhuana, and the gastropod mollusc Nassarius trivittatus. Taxa occurring in greater than 20% of the collections included the phoronid Phoronis architecta, the polychaete worms Pectinaria gouldii and Sigambra tentaculata, the amphipod Ampelisca vadorum, the gastropod mollusc Retusa canaliculata, the bivalve mollusc Pandora gouldiana, and the hemichordate Saccoglossus kowalevskii. Even though these taxa generally occurred in low numbers, they displayed some of the most ecologically meaningful distributions as revealed in the pattern and classification analyses that follow.

4.3 Two-Way Indicator Species Analysis (TWINSPAN)

4.3.1 Introduction

An important application of the relative composition and abundance analysis and other exploratory analysis techniques is the selection of taxa to be included in subsequent community analyses. Based on the results shown in Table II-4-3, all taxa represented by a single individual were removed from consideration. From the remaining 135 taxa, those taxa representing higher levels of taxonomic resolution (e.g., phylum, class, order, and family level identifications) and those taxa not normally included in the macroinfaunal community (e.g., jellyfish, barnacles, copepods) were also excluded. In a few select cases where the majority of taxonomic identifications were made at a higher taxonomic level, the higher level was included in the analysis. This process resulted in the selection of 96 of the most numerically abundant taxa, with the overwhelming majority of the taxa consisting of species level identifications. A hierarchical taxa list for these 96 taxa is presented in Table II-4-4.

After the suite of 96 taxa were selected, a Two-Way Indicator Species Analysis (TWINSPAN) was run, which resulted in an ordered data matrix with stations and taxa ordered along gradients of community structure (Figure II-4-1). In Figure II-4-1, the collections are listed across the top, and the taxa are listed down the side. Each collection is identified by an identification number which is read from the top down along each column of the display. The sample identification number is cross-referenced with the appropriate station name in Table II-4-5, where the collections are ordered and grouped in the same manner as in the TWINSPAN display.

The numbers 1 through 5 in the TWINSPAN display represent categories of increasing relative percent composition of each taxon in each collection (i.e., 1 = 0-2%, 2 = 2-5%, 3 = 5-10%, 4 = 10-20%, and 5 = 20%). No numerical entry (a dash) indicates that the taxon did not occur in the collections. The groupings of collections and taxa in Figure II-4-1 result from a series of reciprocal averaging ordinations and hierarchical dichotomizations of the stations and taxa, and represent a progressive refinement of the relationships of collection groups (i.e., habitat types) to taxa groups (i.e., communities).

The community parameters ordered in Table II-4-5 provided insight into different community structure among the several TWINSPAN groups. Where environmental data was not consistently collected with the faunal samples taken during 1979

TABLE II-4-4. HIERARCHICAL LIST OF 96 SELECTED MACROINFAUNAL TAXA COLLECTED AT 46 STATIONS AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE FROM 1979 TO 1983.

	Taxon	NODC Code
	Annelida	50
*	Archiannelida	5002
	Protodrilidae	500202
*	Protodrilus	50020201
	Polychaeta	5001
	Ampharetidae	500167
*	Ampharete arctica	5001670201
*	Ampharete oculata	50016702??
*	Asabellides oculata	5001670802
*	Melinna cristata	5001670501
	Capitellidae	500160
*	Mediomastus ambiseta	5001600401
	Chaetopteridae	500149
*	Spiochaetopterus oculatus	5001490303
	Cirratulidae	500150
*	Caulleriella fillariensis	5001500204
	Flabelligeridae	500154
*	Brada villosa	5001540102
*	Pherusa affinis	5001540304
	Glyceridae	500127
*	Glycera americana	5001270104
*	Glycera dibranchiata	5001270105
	Lumbrineridae	500131
*	Lumbrineris fragilis	5001310102
*	Ninoe nigripes	5001310204
	Maldanidae	500163
*	Asychis elongatus	5001630103
*	Clymenella torquata	5001630202
*	Clymenella zonalis	5001630203
*	Euclymene collaris	5001631102
	Nephtyidae	500125
*	Aglaophamus circinata	5001250304
*	Nephtys incisa	5001250115
*	Nephtys picta	5001250117
	Nereidae	500124
*	Nereis grayi	5001240409
	Orbiniidae	500140
*	Scoloplos fragilis	5001400303
	Oweniidae	500164
*	Owenia fusiformis	5001640102
	Paraonidae	500141
*	Aricidea neosuecica	5001410210
*	Paraonis gracilis	5001410301
	Pectinariidae	500166
*	Pectinaria gouldii	5001660302
	Phyllodocidae	500113
*	Paranaitis speciosa	5001130801
*	Phyllodoce arenae	5001130108
	Pilargiidae	500122
*	Sigambra tentaculata	5001220201

TABLE II-4-4. CONTINUED

	Taxon	NODC Code
	Polynoidae	500102
*	*Harmothoe extenuata*	5001020803
*	*Lepidonotus sublevis*	5001021104
	Sabellariidae	500165
*	*Sabellaria vulgaris*	5001650202
	Sigalionidae	500106
*	*Pholoe minuta*	5001060101
	Spionidae	500143
*	*Polydora ligni*	5001430411
*	*Polydora socialis*	5001430402
*	*Spiophanes bombyx*	5001431001
	Terebellidae	500168
*	*Loimia medusa*	5001682001
*	*Polycirrus*	50016808
	Arthropoda	58
	Crustacea	61
	Amphipoda	6168
	Caprellidae	617101
*	*Caprella linearis*	6171010703
	Ampeliscidae	616902
*	*Ampelisca abdita*	6169020108
*	*Ampelisca agassizi*	6169020111
*	*Ampelisca vadorum*	6169020109
	Aoridae	616906
*	*Leptocheirus pinguis*	6169060702
*	*Unciola irrorata*	6169150703
	Ischyroceridae	616927
*	*Jassa falcata*	6169270302
	Axiidae	618302
*	*Axius serratus*	6183020301
	Decapoda	6175
	Callianassidae	618304
*	*Callianassa atlantica*	6183040205
*	*Upogebia affinis*	6183040102
	Paguridae	618306
*	*Pagurus longicarpus*	6183060230
	Pinnotheridae	618906
*	*Pinnixa chaetopterana*	6189060405
	Portunidae	618901
*	*Ovalipes ocellatus*	6189010502
	Cancridae	618803
*	*Cancer irroratus*	6188030108
	Majidae	618701
*	*Pelia mutica*	6187011301
	Crangonidae	617922
*	*Crangon septemspinosa*	6179220103

TABLE II-4-4 CONTINUED

	Taxon	NODC Code
	Mysidacea	6151
	Mysidae	615301
*	Mysidopsis bigelowi	6153012101
*	Neomysis americana	6153011508
	Mollusca	5085
	Bivalvia	55
	Myoida	5516
	Lyonsiidae	552005
*	Lyonsia hyalina	5520050206
	Pandoridae	552002
*	Pandora gouldiana	5520020107
	Periplomatidae	552007
*	Periploma papyratium	5520070104
	Nuculoida	5502
	Nuculanidae	550204
*	Yoldia limatula	5502040511
*	Yoldia lucida	55020405??
*	Yoldia sapotilla	5502040513
	Nuculidae	550202
*	Nucula annulata	5502020205
*	Nucula proxima	5502020204
	Veneroida	5515
	Mactridae	551525
*	Mulinia lateralis	5515250301
	Solenidae	551529
*	Ensis directus	5515290301
	Tellinidae	551531
*	Macoma tenta	5515310120
*	Tellina agilis	5515310205
*	Tellina versicolor	5515310209
	Veneridae	551547
*	Pitar morrhuana	5515471201
	Gastropoda	51
	Cephalaspidea	5110
	Acteonidae	511001
*	Acteon punctostriatus	5110010101
	Retusidae	511013
*	Retusa canaliculata	51101301??
	Scaphandridae	511004
*	Acteocina canaliculata	5110040103
*	Cylichna oryza	51100402??
	Mesogastropoda	5103
	Calyptraeidae	510364
*	Crepidula plana	5103640207
	Naticidae	510376
*	Polinices duplicatus	5103760407
*	Polinices triseriata	5103760409

TABLE II-4-4. CONTINUED

	Taxon	NODC Code
	Neogastropoda	5104
	Nassariidae	510508
*	Nassarius trivittatus	5105080103
	Pyramidellida	5108
	Pyramidellidae	510801
*	Turbonilla interrupta	5108010209
	Echinodermata	81
	Asteroidea	8104
*	Asteroidea A	8104999999
	Cnidaria	37
	Anthozoa	3740
*	Ceriantharia	3743
*	Ceriantharia A	3743999999
*	Ceriantharia B	3743999998
	Cerianthidae	374301
*	Ceriantheopsis americanus	3743010102
	Actiniaria	3758
	Edwardsiidae	375901
*	Edwardsia elegans	3759010101
	Halcampidae	375904
*	Halcampa duodecimicirrata	37590401??
	Haloclavidae	375903
*	Haloclava producta	375903????
	Hydrozoa	3701
	Hydroida	3702
	Tubulariidae	370303
*	Corymorpha pendula	3703030104
	Rhynchocoela	43
	Anopla	4301
	Heteronemertea	4303
	Lineidae	430302
*	Cerebratulus	43030202
*	Micrura	43030205
	Palaeonemertea	4302
	Tubulanidae	430201
*	Tubulanus pellucidus	4302010104

TABLE II-4-4 CONTINUED

	Taxon	NODC Code
	Phoronida	77
	Phoronidae	770001
*	Phoronis architecta	7700010203
*	Phoronis muelleri	77000102??
	Hemichordata	82
	Enteropneusta	8201
	Harrimaniidae	820101
*	Saccoglossus kowalevskii	8201010302

* designates the taxa collected and used in the analyses.

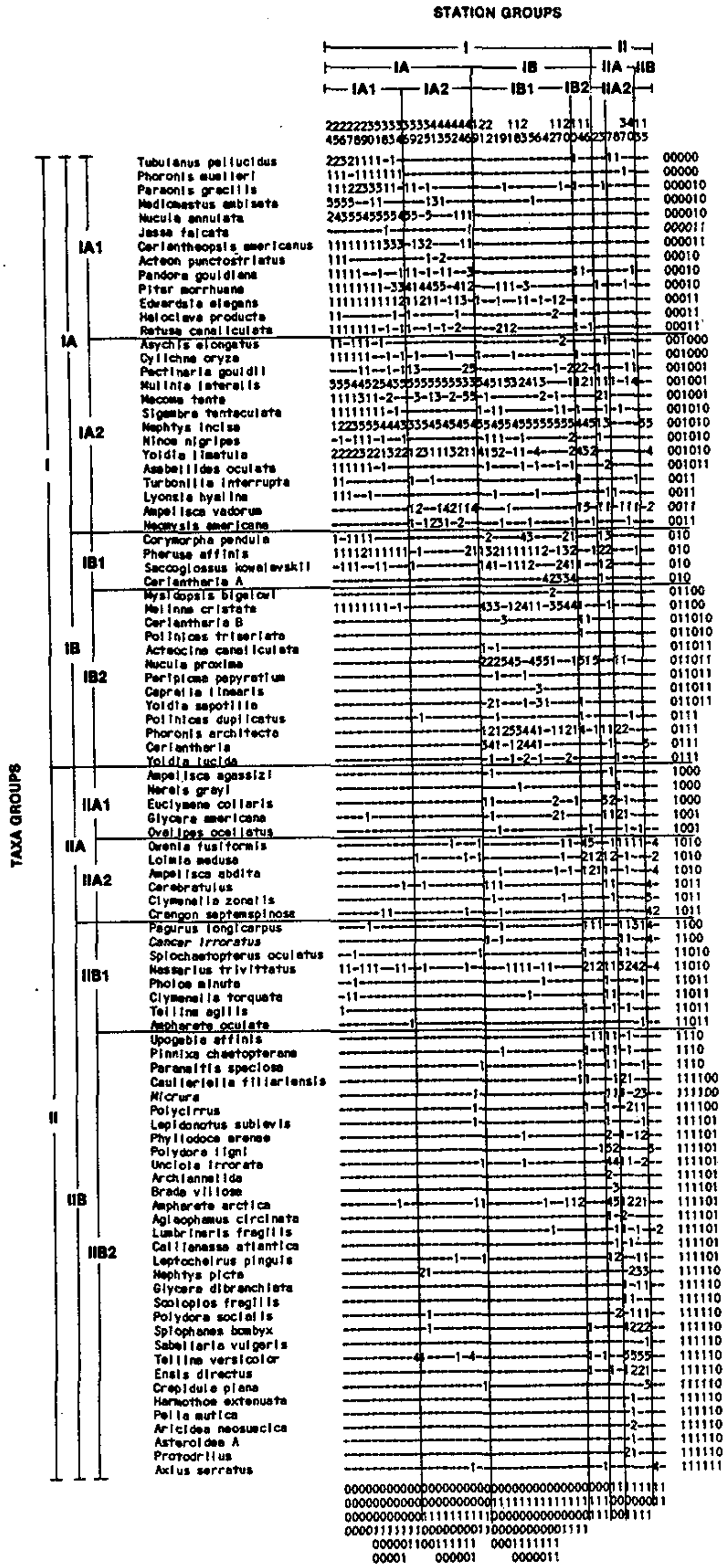

FIGURE II-4-1. ORDERED TWO-WAY DISPLAY RESULTING FROM TWINSPAN ANALYSIS OF RELATIVE ABUNDANCE OF 96 SELECTED MACROINFAUNAL TAXA COLLECTED AT 46 STATIONS AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE FROM 1979 TO 1983.

TABLE II-4-5. ORDERED TABLE OF COMMUNITY PARAMETERS CALCULATED FOR 46 STATIONS COLLECTED AT THE CENTRAL LONG ISLAND SOUND DISPOSAL SITE FROM 1979 TO 1983.

Station Group	Sample ID	Study	Station		Date (YYMM)	Taxa	Count	Diversity (H')	Richness	Evenness
I / IA / IA1	24	FVP	FVP	1000E	82 12	27.7	3043.0	1.4489	3.3303	0.4422
IA1	25	FVP	FVP	CLISREF	82 12	25.3	1025.0	1.7016	3.5239	0.5284
IA1	26	FVP	FVP	1000E	83 03	26.3	1204.3	1.9488	3.5694	0.6003
IA1	27	FVP	FVP	CLISREF	83 03	19.3	491.3	1.9761	2.9795	0.6704
IA1	28	FVP	FVP	1000E	82 05	21.3	422.0	2.0664	3.3687	0.6779
IA1	29	FVP	FVP	CLISREF	82 05	18.7	362.3	1.6560	2.9972	0.5663
IA1	30	FVP	FVP	1000E	82 08	17.0	330.0	1.5909	2.7566	0.5652
IA1	31	FVP	FVP	CLISREF	82 08	17.0	542.7	1.5971	2.5405	0.5638
IA1	38	PRATT	STNH-N	OE	82 02	9.0	48.0	1.5239	2.1083	0.7964
IA1	33	PRATT	CLIS	CLISREF	81 08	10.7	69.7	1.7409	2.3015	0.7451
IA1	34	PRATT	CLIS	CLISREF	82 01	12.0	61.0	1.9664	2.7073	0.8088
IA2	36	PRATT	STNH-N	IE	81 01	11.7	181.7	1.5395	2.0677	0.6324
IA2	39	PRATT	STNH-N	IE	82 02	13.7	208.0	1.8161	2.3805	0.6959
IA2	32	PRATT	CLIS	CLISREF	81 01	5.3	31.7	1.3078	1.2808	0.7882
IA2	35	PRATT	STNH-N	OE	81 01	9.7	113.3	1.4844	1.8398	0.6602
IA2	41	PRATT	STNH-S	OE	81 01	5.0	27.0	1.3137	1.2952	0.8403
IA2	43	PRATT	STNH-S	CTR	81 01	8.3	36.3	1.6462	2.0280	0.7991
IA2	45	PRATT	STNH-S	IE	82 01	4.7	18.0	1.1430	1.2678	0.7758
IA2	42	PRATT	STNH-S	IE	81 01	7.3	42.7	1.4023	1.6804	0.7194
IA2	44	PRATT	STNH-S	OE	82 01	7.7	38.7	1.5601	2.0888	0.8537
IA2	46	PRATT	STNH-S	CTR	82 01	13.0	135.0	1.9302	2.4215	0.7832
IB / IB1	19	BROOKS	STNH-S	1000E	79 08	11.3	86.7	1.7778	2.4081	0.7390
IB1	21	BROOKS	STNH-S	1000W	79 05	12.0	39.3	2.1092	2.9928	0.8554
IB1	22	BROOKS	STNH-S	1000W	79 08	14.0	170.0	1.5373	2.5294	0.5869
IB1	1	BROOKS	CLIS	CLISREF	80 09	9.7	63.3	1.4879	2.0927	0.6550
IB1	9	BROOKS	STNH-N	IE	80 04	9.7	70.0	1.6454	2.0425	0.7357
IB1	11	BROOKS	STNH-N	OE	80 04	10.7	102.0	1.5104	2.1453	0.6408
IB1	18	BROOKS	STNH-S	1000E	79 05	10.7	44.3	1.8405	2.5442	0.7822
IB1	23	BROOKS	CLIS	CLISREF	80 04	6.3	32.3	1.3974	1.4964	0.8196
IB1	5	BROOKS	NEW HAVEN	REF	79 05	8.3	56.0	1.3464	1.7612	0.6972
IB1	6	BROOKS	STNH-N	CTR	79 03	7.3	29.0	1.4811	1.8850	0.7472
IB1	4	BROOKS	NEW HAVEN	REF	79 01	5.3	18.7	0.9952	1.4884	0.5847
IB1	12	BROOKS	STNH-S	CTR	79 01	9.7	45.3	1.5106	2.2641	0.6935
IB1	17	BROOKS	STNH-S	1000E	79 01	8.3	26.3	1.6722	2.2540	0.7933
IB1	20	BROOKS	STNH-S	1000W	79 01	9.3	30.0	1.7376	2.4683	0.7804
IB2	10	BROOKS	STNH-N	IE	80 09	25.0	226.0	2.2981	4.4335	0.7166
IB2	14	BROOKS	STNH-S	CTR	80 09	9.3	56.7	1.6965	2.0191	0.8171
IB2	16	BROOKS	STNH-S	OE	80 09	8.7	64.0	1.2947	1.8514	0.6007
II / IIA / IIA1	2	BROOKS	NEW HAVEN	CTR	79 01	24.7	152.7	2.1637	4.7310	0.6778
IIA1	3	BROOKS	NEW HAVEN	CTR	79 05	28.0	112.3	2.7068	5.8215	0.8143
IIA2	7	BROOKS	STNH-N	CTR	80 04	17.3	104.0	1.9121	3.5756	0.6709
IIA2	8	BROOKS	STNH-N	CTR	80 09	27.7	141.0	1.9809	5.4056	0.5965
IIA2	37	PRATT	STNH-N	CTR	81 01	13.3	72.7	1.9137	2.9074	0.7535
IIA2	40	PRATT	STNH-N	CTR	82 02	27.7	236.3	2.1515	4.9073	0.6483
IIB	13	BROOKS	STNH-S	CTR	79 08	5.0	7.0	1.4631	2.0097	0.9329
IIB	15	BROOKS	STNH-S	IE	80 09	6.0	13.3	1.5839	2.0277	0.9151

to 1981, the data reported by Brooks (1983) was used to characterize these stations for further analyses. Limited conclusions can be drawn regarding the relationships between station and taxa ordering and trends in the distributions of environmental variables.

4.3.2 Station Groupings

These results indicated that the ordering of collections across the top of the TWINSPAN display (Figure II-4-1) was mainly related to disturbances from dredged material disposal activities and sediment texture, with year and season of collection being important in the ordering and grouping of stations with similar sediment texture. The collections on the far right of the TWINSPAN display (Station Group II in Figure II-4-1 and Table II-4-5) were generally coarser textured (fine sands and coarse silts), with all the collections indicating an influence of dredged material disposal. The stations on the left and along the center of the display (Group I) were primarily finer-textured (coarse, medium and fine silts and clays), with those located furthest left (Group IA1) representing relatively undisturbed bottoms of Long Island Sound.

Station Group IA1 in the TWINSPAN display (Figure II-4-1) and corresponding ordered table (Table II-4-5) included all collections at both of the Field Verification Program (FVP) stations (i.e., 1000E and CLISREF) collected during spring, summer, and winter of 1982 and spring of 1983. In addition, the collections at the CLISREF station from summer 1981 and winter 1982 and collections at STNH-N-OE in winter were included in Group IA1. Group IA1 included the majority of the most recent collections in the analysis. The sediment data available for these collections indicates that both the CLISREF and FVP 1000E stations were among the finest textured samples in the analysis, with percent fines usually exceeding 95%. The collections made in the FVP study at CLISREF and FVP 1000E yielded the greatest number of species in the entire study and were also characterized by very high numbers of individuals. No collection outside the FVP program yielded as many organisms as the FVP collection with the lowest number of individuals. These very large numbers of individuals of several taxa led to the low values for evenness in these collections (Table II-4-5).

Station Group IA2 of the TWINSPAN display (Figure II-4-1) and ordered table (Table II-4-5) was entirely comprised of collections from the winters of 1981 and 1982 at the Stamford New Haven-North Outer Edge (STNH-N-OE)and Inner Edge (STNH-N-IE) stations, the Central Long Island Sound Reference Site (CLISREF), and the Stamford New Haven-South Outer Edge (STNH-S-OE), Inner Edge (STNH-S-IE) and Center (STNH-S-CTR) stations. Except for the collections from the center (CTR) stations at the Stamford-New Haven North dumpsite (in Station Group IIA2) which was very coarse textured, reflecting the presence of the sand cap, and the several collections in Group IA1 from CLISREF and STNH-N-OE located nearby in Station Group IA1, all the collections from the winter of 1981 and 1982 were in Group IA2.

Compared to the collections in Station Group IA1, those in Group IA2 were much lower in numbers of taxa and individuals. The sediment texture at the STNH-N-OE, STNH-N-IE, STNH-S-OE, and STNH-S-CTR stations generally ranged from coarse to medium silts.

Station Group IB1 included collections from winter, spring and summer of 1979 at STNH-S-1000E and 1000W, the pre-disposal collections (winter 1979) at STNH-N-CTR and STNH-S-CTR stations, the collections at New Haven REF in winter and spring 1979, the collections from CLISREF during spring and summer of 1980 and the STNH-N-IE and OE collections from spring 1980. Sediment texture in this group generally ranged from coarse to fine silts, with several collections (e.g., STNH-N-IE) showing the high sand content of the capping material. Based on community statistics (Table II-4-5), these collections were not distinquishable from those in Group IA1, which were collected over the previous two years (i.e., 1979 and 1980).

Station Group IB2 consisted of three collections from summer 1980 that exhibited a rather divergent sediment texture. Two of these collections were made at STNH-S-CTR and OE stations 3 months after final capping. The collection from the center station was somewhat coarser textured than the OE station, but neither was as sandy as the STNH-N-IE collection. These sediment differences are attributable to the different capping materials used at the STNH-N and STNH-S disposal sites, and (at the STNH-S site) distance from the disposal mound. The collections from STNH-N-IE had about three times the numbers of individuals of either of the two STNH-S collections. Taxa richness values for the coarser textured STNH-N-IE collection were similar to those for the very coarse textured collections in Station Group II.

Station Group IIA1 was comprised of the collections at the New Haven CTR station during winter and spring of 1979, whereas Station Group IIA2 was comprised of all of the post-disposal collections made at Station STNH-N-CTR (spring 1980 - winter 1982). Station STNH-N-CTR was capped with fine sand during the summer of 1979, and the sediment texture (greater than 90% sand) reflects this capping material. Since this capping material was much coarser textured than the surrounding bottoms of the Central Long Island Sound Disposal Site, the community structure at this station remained somewhat unique through time. The data indicates only minor changes in sediment texture over the almost two year period. Compared to the single collection made at STNH-N-CTR in spring 1979 prior to disposal (in Station Group IB1), these post-capping collections had much greater species diversity, had higher densities of macroinfauna, and higher diversity and richness.

Station Group IIB included two summer post-disposal collections, one made at Station STNH-S-CTR in 1979 2 months after initial capping, and the other at Station STNH-S-IE in 1980. The sediments at Stations STNH-S-CTR and STNH-S-IE in the summer of 1980 were primarily coarse and medium silts, with some sand, again reflecting the texture of the capping material used at the site. These two collections were among the most depauperate of any collected in the study (Table II-4-5), with very low numbers of taxa and individuals. This trend might be expected for the STNH-S-CTR collection, since it was collected soon after capping. Compared to the other STNH-S-IE collections located in Station Group IA2 (winter 1981 and 1982), there was not a lot of difference in the number of taxa, but the numbers of individuals was greater in the later collections. Given their different locations in the display, these collections at STNH-S-IE in 1980 and 1981-82 were characterized by different taxa, as discussed below.

4.3.3 Taxa Groupings

The taxa located along the left side of the TWINSPAN display (Figure II-4-1) were ordered such that those taxa most characteristic of Station Group IA are located along the upper portion, those taxa most characteristic of Station Group IB are located along the central portion, and those taxa most characteristic of Station Groups IIA and IIB are located along the bottom portion of the display. In general, the habitat specificity is striking and is partially due to differences in the texture of the capping material and bottom sediments in this part of Long Island Sound.

The taxa included in Group IA1 were most characteristic of the FVP stations (Station Group IA1), with a few of the taxa also well represented at the other stations collected in 1981 and 1982 (Station Group IA2). Virtually all of these taxa were generally restricted to the collections made after 1980. Therefore, the trends for these taxa includes a strong temporal component. However, the FVP and CLISREF stations were also among the finest textured of the stations studied, and this may have played a role in determining the unique taxonomic composition of these collections. The bivalve molluscs Nucula annulata, Pitar morrhuana, Pandora gouldiana, the gastropod mollusc Retusa canaliculata and the anemone Edwardsia elegans were widespread across Station Group IA. The polychaete worms Mediomastus ambiseta and Paraonis gracilis and the nemertean Tubulanus pellucidus were more restricted to the FVP and other CLISREF collections (Station Group IA1). The temporal and spatial trends for Mediomastus ambiseta were especially dramatic, since this species "bloomed" in very large densities in the four collections in winter 1982 and spring 1983. Since there is a considerable distance between the FVP 1000E station and the CLISREF station, it appears that this polychaete may have "bloomed" over a substantial area.

Taxa Group IA2 included taxa that were generally more widely distributed across the Station Group I collections than were those in Taxa Group IA1. Among these taxa, the bivalve molluscs Mulinia lateralis and Yoldia limatula and the polychaete worm Nephtys incisa were the most widely distributed over the fine to medium textured sediments in the study area, and numerically dominated the majority of these collections. The bivalve mollusc Macoma tenta was also widely distributed over the collections in Station Group I, while several taxa that were also found in some of the collections from the coarse textured stations in Station Group II (i.e., the amphipod Ampelisca vadorum and the mysid shrimp Neomysis americana) were not found at the FVP and CLISREF stations in Station Group IA1, probably indicating an avoidance of the very fine textured bottoms.

Taxa Group IB1 included only four taxa all of which exhibited a preference for the collections in Station Group IB1 (Figure II-4-1). While the anemone Ceriantharia A was restricted to collections in spring 1979 from STNH-N-CTR (pre-disposal) and in winter 1979 at STNH-S-CTR, 1000E and 1000W and New Haven REF, the other three taxa were also found at the fine textured FVP and CLISREF collections in Station Group IA1 in winter of 1981 and 1982. Because these three taxa (the hydroid Corymorpha pendula, the polychaete worm Pherusa affinis and the hemichordate Saccoglossus kowalevskii) were absent from the post-capping collections at STNH-S-CTR, but were present in the same area prior to disposal and at the reference site after disposal, it appears that their absence in some of the collections in Station Group IA2 may be, in part, related to disposal operations.

The taxa in Group IB2 were best characterized by being more or less restricted to the collections in Station Group IB, and especially those in Station Group IB1. Except for the several collections from STNH-N in spring 1980 (post-disposal), most of these stations were ones that should not have been affected by disposal operations. All were collected in 1979 and 1980. Taxa most characteristic of this trend were the bivalve mollusc Nucula proxima, the phoronid Phoronis architecta, and the anemone Ceriantharia. The polychaete worm Mellina cristata also showed greatest relative abundance in the collections from Station Group IB1, but was also well represented in the collections in 1982 and 1983 from the finer textured stations at the FVP 1000E and CLISREF stations. The absence of these taxa in the collections in Station Group IA2 may indicate a negative response to the disposal operations at STNH-N and STNH-S.

The taxa in Taxa Group II were, for the most part, restricted to the collections from the coarser textured stations in Station Group II. Going from the middle of the display toward the bottom (i.e., from Taxa Group IIA1 to Taxa Group IIB2), the taxa become more restricted to the collections from the coarse textured stations.

Because of the small number of coarse textured collections, it is difficult to differentiate trends in the several taxa groups within the major Taxa Group II. A number of the taxa in Groups IIA2 and IIB1 characterized the post-capping collections at the STNH-S-CTR and IE stations in addition to the collections in Station Group IIA. The two collections in Station Group IIB were finer textured than those in Station Group IIA, which were from the coarsest textured stations (STNH-N-CTR and New Haven CTR). These taxa included the polychaetes Owenia fusiformis, Clymenella zonalis, and Loimia medusa, the nemertean genus Cerebratulus, the decapods Crangon septemspinosa, Pagurus longicarpus, and Cancer irroratus, the amphipod Ampelisca abdita, and the gastropod mollusc *Nassarius trivittatus.* With a couple of notable exceptions, these taxa characterized the depauperate community in these two collections. The taxa in Taxa Groups IIA2 and IIB1 appeared to differ most by the general absence of Group IIA2 taxa in collections from the STNH-N-CTR station in Station Group IIA2, indicating that they did not prefer the sandy habitat at this station that resulted from capping operations.

The Group IIB2 taxa were virtually restricted to collections from the New Haven CTR and STNH-N-CTR stations in Station Groups IIA1 and IIA2. These taxa appear to be related to the coarser textured sediments (fine sands) introduced by capping operations at these stations. Some of the taxa most indicative of this trend included the polychaete worms *Ampharete arctica, Spiophanes bombyx, Unciola irrarata,* and *Nephtys picta,* and the bivalve molluscs *Tellina versicolor,* and *Ensis directus.*

4.4 Q-Mode Hierarchical Cluster Analysis

The dendrogram resulting from the Q-mode (collection) clustering of the taxa density data (log X+1 transformed) from the 46 Central Long Island Sound collections is shown in Figure II-4-2. This analysis employed the same 96 selected taxa that were used in the TWINSPAN analysis discussed above (Figure II-4-1). The cluster analysis was used to provide a more precise definition of station groupings than is provided by the dichotomus classifications in TWINSPAN.

There are several differences in the methodologies for the TWINSPAN and cluster analyses, including input data (i.e., relative composition vs. counts) and data standardization procedures. With regard to sample classification, cluster analysis agglomerates the collections and groups of collections along a continuous gradient of association, yielding results that can be used to identify a number of station groupings at a given, ecologically meaningful level of association. This type of information (i.e., the relative similarity of subgroups) is lost in TWINSPAN, where each group and subgroup is dichotomized at each step, regardless of the relative levels of association of the resulting subgroups. The reader should also keep in mind that the exact order of the stations in the dendrogram is arbitrary, and cannot be interpreted as indicating a gradient of conditions. Cluster analysis is a classification technique, not an ordination technique. TWINSPAN orders the samples using ordination techniques, thereby providing more ecologically meaningful gradients. The two types of analyses are best applied together and the results compared.

At the level of association chosen in Figure II-4-2, seven collection groups were formed. The collections in Cluster Groups I and II included the vast majority of those from Stations STNH-S and STNH-N either prior to dumping or outside the zone of influence of the dumped material (Figure II-4-2). All of these collections were made prior to Fall of 1980. Except for one collection, Cluster Groups I and II are equivalent to TWINSPAN Group IB1 (Figure II-4-1). These collections were mainly

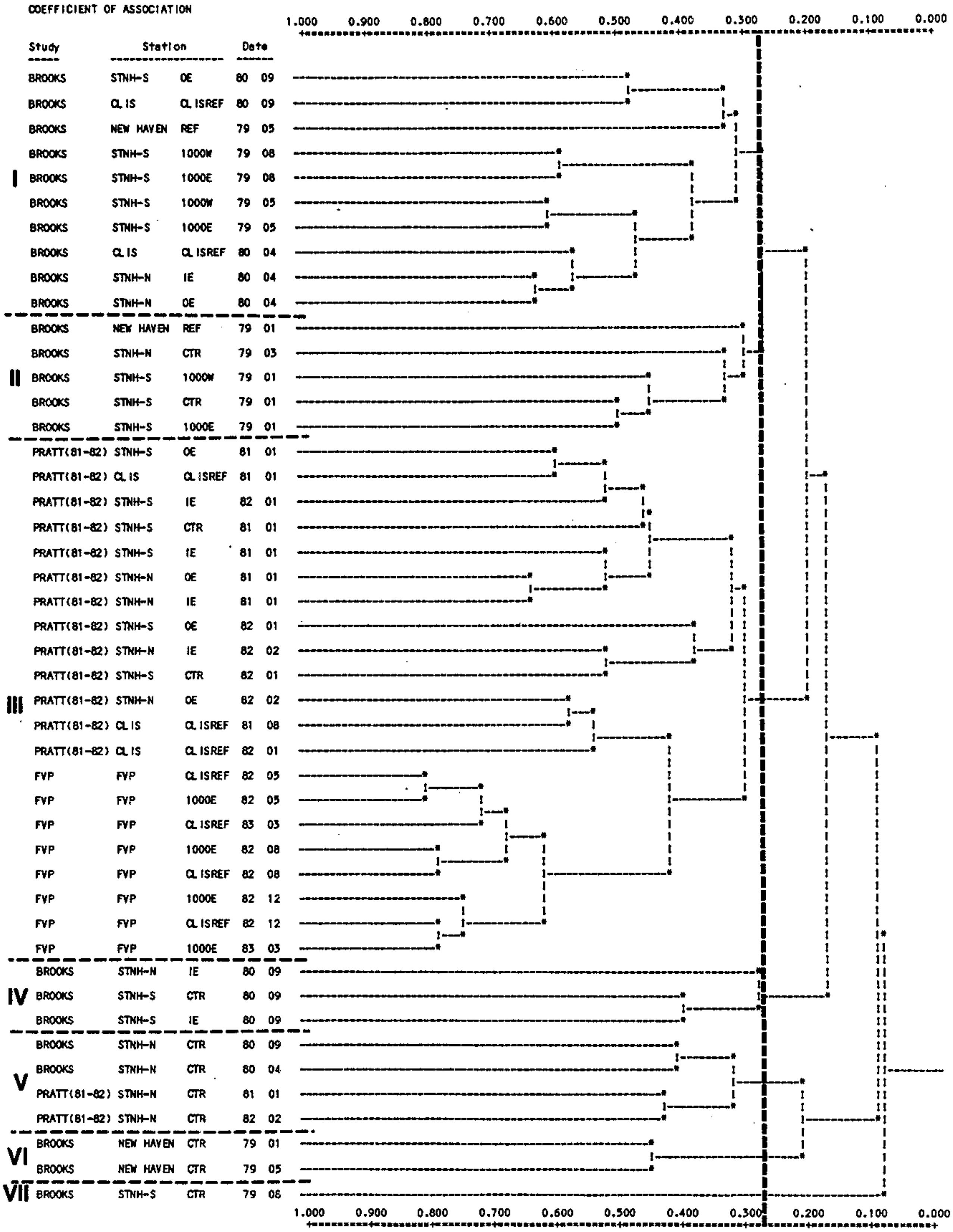

FIGURE II-4-2. DENDROGRAM RESULTING FROM Q-MODE CLUSTER ANALYSIS OF 96 SELECTED MACROINFAUNAL TAXA COLLECTED AT 46 STATIONS AT THE CENTRAL LONG ISLAND DISPOSAL SITE FROM 1979 TO 1983.

characterized by taxa in TWINSPAN Taxa Groups IA2, IB1 and IB2 (Figure II-4-1), with the taxa in Group IB2 showing the highest fidelity to these collections. These collections showed a range of sediment texture, but few were very fine or very sandy. These collections were mainly characterized by low numbers of taxa (Table II-4-5).

Cluster Group III was the largest group in the dendrogram (Figure II-4-2), and includes several more or less distinct subgroups. In fact, the distinct subgroup comprised of mainly FVP and other CLISREF collections is equivalent to TWINSPAN Station Group IA1, and the other two subgroups in Cluster Group III are equivalent to TWINSPAN Group IA2 (Figure II-4-1). Groups III includes virtually all of the collections made after 1980, and no collections made before 1980. The exceptions were the collections from very the sandy Station STNH-N CTR in 1981 and 1982 (in Cluster Group 5, Figure II-4-2). Cluster Group III includes all of the collections included in Group IA in the corresponding TWINSPAN display (Figure II-4-1). The collections in Cluster Group III were characterized by the taxa in TWINSPAN Taxa Group IA (Figure II-4-1), with the major differences in the collections in the several subgroups in Cluster Group III being the absence of some of the taxa characteristic of the the very fine textured FVP and CLISREF stations at other Group III stations.

Cluster Group IV includes three collections from the summer of 1980 at the STNH-N and STNH-S disposal mounds (Figure II-4-2). This group was generally similar to TWINSPAN Station Group IB1 (Figure II-4-1). The collections at STNH-S CTR and IE were made soon after final capping, and were relatively similar faunistically, to the predisposal collections at these same stations. Compared to the collections at these stations after 1980 (in Cluster Group III, Figure II-4-2), the earlier postdisposal collections (in Group IV) included more taxa characteristic of the sandy bottoms and fewer taxa characteristic of fine textured bottoms.

Cluster Groups V and VI (Figure II-4-2) were exactly equivalent to TWINSPAN Station Groups IIA2 and IIA1, respectively (Figure II-4-1). These groups were comprised of the four postdisposal collections from Station STNH-N-CTR and the two collections in 1979 from the Station New Haven CTR. These collections were characterized by the large number of taxa in TWINSPAN Taxa Group IIB, and especially those in TWINSPAN Taxa Group IIB1 that clearly preferred the sandy sediments deposited on the CTR stations in capping operations(Figure II-4-1). They were among the most speciose collections in the study (Table II-4-5).

Cluster Group VII was comprised of the most unique collection in the analysis, Station STNH-S-CTR sampled in August 1979. This station was sampled only two months after initial capping operations, and was very depauperate. The low numbers of taxa and individuals account for its outlying position in the cluster dendrogram (Figure II-4-2). In the corresponding TWINSPAN display (Figure II-4-1), this collection was included in Station Group IIB, along with the very depauperate collection from Station STNH-S-IE in summer of 1980. The taxa found in this collection were included in Taxa Groups IIA2 and IIB1 of the corresponding TWINSPAN display (Figure II-4-1). In (Figure II-4-1), this collection was included in Station Group IIB, along with the very depauperate collection from Station STNH-S-IE in summer of 1980. The taxa found in this collection were included in Taxa Groups IIA2 and IIB1 of the corresponding TWINSPAN display (Figure II-4-1).

In summary, the grouping of collections in the cluster analysis was generally similar to the TWINSPAN groupings.

4.5 Summary and Synthesis

4.5.1 Introduction

The analysis of 138 macroinfauna samples collected at 13 stations in the vicinity of the Central Long Island Sound Disposal Site during the period 1979 to 1983 revealed that the overall community was numerically dominated by the polychaete worms Mediomastus ambiseta and Nephtys incisa, and the bivalve molluscs Mulinia lateralis, Nucula annulata, and Yoldia limatula. A total of 31,293 individuals representing 184 taxa were identified in 138 samples. Nephtys incisa, Mulinia lateralis and Yoldia limatula were the most widespread taxa, occurring in greater than 50% of the samples. Mediomastus ambiseta exhibited an extremely limited distribution, occurring in only 15% of the samples.

The results of the pattern analysis indicated that the taxa distributions were most strongly affected by bottom disturbances, related to dredged material disposal, and sediment texture, with year and season of station collection also important. These analyses revealed the existence of at least five distinct macroinfaunal communities.

4.5.2 Definition of Macroinfaunal Communities in the Study Area

The first community was characteristic of very fine textured sediments collected across all seasons in 1982 and 1983 at stations FVP 1000E and CLISREF. Some of the taxa most characteristic of this community included the polychaete worms Paraonis gracilis, Mediomastus ambiseta, Sigambra tentaculata, Nephtys incisa, Asabellides oculata, Pherusa affinis, Asychis elongatus and Ninoe nigripes; the bivalve molluscs Nucula annulata, Pandora gouldiana, Mulinia lateralis, Macoma tenta and Yoldia limatula; the gastropod mollusc Retusa canaliculata; the anthozoans Ceriantheopsis americanus and Edwardsia elegans; the nemertean Tubulanus pellucidus; and the phoronid Phoronis muelleri. Mediomastus ambiseta numerically dominated and was virtually restricted to the winter 1982 and 1983 collections at stations FVP 1000E and CLISREF.

The second community was characteristic of fine textured sediments collected in the winters of 1981 and 1982 at stations STNH-N-IE, STNH-N-OE, STNH-S-IE,STNH-S-OE,STNH-S-CTR and CLISREF.The collections at STNH-S-CTR, which was located at the center of a dump site, were made approximately 6 months and 18 months after this site was capped with coarse and medium silts. Some of the taxa characteristic of this community included the polychaete worms Nephtys incisa and Pectinaria gouldii; the bivalve molluscs Pitar morrhuana, Mulinia lateralis, Yoldia limatula, Macoma tenta and Nucula annulata; the gastropod mollusc Retusa limatula; the amphipod Ampelisca vadorum; the mysid shrimp Neomysis americana; and the anthozoan Edwardsia elegans.

The third community encompassed the taxa characteristic of the fine textured sediments collected in the winter, spring, and summer of 1979 and 1980 at stations STNH-S-CTR, STNH-N-IE, STNH-N-OE, STNH-N-CTR, CLISREF and New Haven REF. The collections at stations STNH-N-CTR and STNH-S-CTR, which were located at the centers of dump sites, represent pre-disposal collections Some of the taxa characteristic of this community included the polychaete worms Nephtys incisa, Melinna cristata and Pherusa affinis; the bivalve molluscs Mulinia lateralis, Yoldia limatula, Nucula proxima, Yoldia sapotilla and Yoldia lucida; the hemichordate Saccoglossus kowalevskii; the phoronid Phoronis architecta; and the anthozoan order Ceriantharia.

The taxa that comprised the fourth community were virtually restricted to the coarser textured post-disposal samples collected from 1979 to 1982 at the centers of two dump sites (i.e., stations New Haven CTR and STNH-N-CTR). Some of the taxa most characteristic of this community were the polychaetes Ampharete arctica, Nephtys picta, Spiophanes bombyx, Phyllodoce arenae, Polydora ligni, Polydora socialis and Polycirrus; the bivalve molluscs Tellina versicolor and Ensis directus; the gastropod mollusc Nassarius trivittatus; the crab Pagurus longicarpus; the amphipod Unciola irrorata; and the nemertean Micrura.

The fifth and final community encompassed the taxa most characteristic of the finer textured samples collected shortly after disposal operations at stations STNH-S-CTR, STNH-S-IE and STNH-S-OE. Many of the taxa characteristic of this habitat represent the "opportunists" or early colonizers of defaunated sediments. Some of the taxa most characteristic of this habitat included the polychaete worms Owenia fusiformis, Loimia medusa, Nephtys incisa, Euclymene collaris, Clymenella zonalis and Polydora ligni; the bivalve mollusc Yoldia limatula; the gastropod mollusc Nassarius trivittatus; the amphipods Ampelisca vadorum, Ampelisca abdita and Axius serratus; and the crabs Crangon septemspinosa and Cancer irroratus.

The first three communities described above bear a strong resemblance to the Nephtys incisa-Yoldia limatula community defined by Sanders (1956) as characteristic of the fine-textured sediments of Long Island Sound. Some of the taxa in common with the Sanders (1956) community were the polychaetes

Nephtys incisa, Melinna cristata, Pectinaria gouldii and Ninoe nigripes, the bivalve molluscs Mulinia lateralis, Nucula proxima, Macoma tenta and Pitar morrhuana, the gastropod mollusc Retusa canaliculata, and the anthozoan Cerianthеopsis americanus. These similarities are a good indication that the three fine textured communities described above represent the natural communities present in fine textured sediments in Central Long Island Sound.

The fourth community described above, which was characteristic of the coarser textured sediments introduced as capping material, is generally comprised of taxa that are characteristic of coarser textured sediments. Some of the taxa that are known to inhabit sandy sediments in other areas include the polychaete worms Ampharete arctica, Spiophanes bombyx and Nephtys picta and the suspension feeding bivalve molluscs Tellina versicolor and Ensis directus.

The fifth community primarily includes opportunistic and early colonizing taxa that rapidly repopulate defaunated sediments. The polychaete worms Owenia fusiformis and Nephtys incisa, and the amphipod Ampelisca abdita were identified by McCall (1975) as early colonizers of defaunated sediments in Central Long Island Sound. Polychaete species of the genus Polydora have also been identified as early colonizers of defaunated sediments (Pearson and Rosenberg, 1978). More motile species such as the crabs Crangon septemspinosa and Pagurus longicarpus may quickly migrate into defaunated habitats.

4.5.3 Impact Assessment

The most obvious effect of dredged material disposal on the macroinfauna at the Central Long Island Sound Disposal Site was the change in sediment texture created by the disposal of coarser textured (sandy) sediments in an area of naturally occurring finer textured sediments. The capping of the STNH-N mound with fine sand created a coarser-textured benthic habitat that was colonized by a distinct community. A similar situation was evident at the New Haven Dumpsite, indicating that the benthic habitat at this station was also considerably different from that of the surrounding area. Another possible influence of dredged material disposal was evident at the STNH-S-CTR station. The community characteristic of this station during the pre-disposal sampling conducted during the winter of 1979 was considerably richer than that evident immediately after capping operations, with recovery of the community evident during the post-disposal sampling conducted during the winters of 1981 and 1982. However, the pre-disposal and post-disposal sediment textures at this station were generally similar, and the changes in community structure could be due to natural variability. Apart from the disposal related changes in sediment texture and associated changes in community composition, no long-term effects of disposal operations on the benthic communities were immediately apparent in these analyses.

Past investigations of the macroinfaunal community structure and distribution in Central Long Island Sound have identified sediment texture, bottom disturbance, seasonality, predation, and hydrographic factors operating on planktonic life stages as important factors in determining macroinfaunal community structure, distribution, and variability in space and time (Sanders, 1956; McCall, 1975; 1978; Rhoads, 1973; 1974).

Central Long Island Sound and similar nearshore marine habitats are typically characterized by species populations that are highly variable in space and time. Rhoads (1973, 1974) and McCall (1978) have documented the extreme natural variability in macroinfaunal species populations in the vicinity of the Central Long Island Sound Disposal Site. These researchers found that 85% of the bivalve mollusc species and 20% of the polychaete species experienced severe population reductions in 1972 and 1973 that were unrelated to dredging activities. An examination of the larval life histories of the macroinfaunal taxa indicated that hydrographic factors operating on planktonic larval stages may have been responsible for these drastic population crashes. At the same time, populations of some taxa can undergo massive "blooms", as was the case for Mediomastus ambiseta and Nucula annulata in winter 1982 and spring 1983 at the FVP 1000E at CLISREF stations.

In a pioneering study of the macroinfauna in Long Island Sound, Sanders (1956) found that suspension feeding taxa tended to be associated with coarser textured sediments, whereas selective and non-selective deposit feeding taxa tended to be associated with finer-textured sediments. In a more recent investigation, McCall (1978) also found a relationship between macroinfaunal community structure and distribution and changes in sediment texture. However, McCall (1978) concluded that bottom disturbances primarily caused by storm-generated currents and the ensuing macroinfaunal community successional processes were more important in accounting for macroinfaunal community structure and distribution. Intense winter storms create high near-bottom currents that differentially resuspended and defaunate different types of sediment, thereby creating a patchy environment. The defaunated habitats are quickly recolonized by small, short-lived opportunistic macroinfaunal taxa. In the absence of continued disturbance through time, these opportunistic macroinfaunal taxa are gradually succeeded by larger, more long-lived equilibrium type taxa.

Samples of defaunated mud placed on the bottom of Central Long Island Sound yielded opportunistic communities within 10 days, and within three months the community was similar to that of the surrounding bottom with respect to number of species and species diversity (McCall, 1975). Within a year, the colonized sediment community was similar to that of the surrounding bottom. Thus, the patchy distributions of macroinfaunal communities may represent previously disturbed habitats that are in varying stages of ecological succession. Shallow water areas are more susceptible to current-induced bottom disturbance than are deeper water areas, however, bottom disturbance during storms were seen in depths of 20 m, which would generally include the Central Long Island Sound Disposal Site.

The effects of storm-generated, near-bottom currents are especially significant with respect to potential impacts related to dredged material disposal. Strong currents may erode and then subsequently redeposit sediments, thereby substantially changing the sediment texture in some areas. This erosion-deposition process can result in the erosion of coarser textured sediment introduced by dredged material disposal and the subsequent deposition of finer textured sediments over those of coarser texture. Sediment texture data for Station STNH-N-CTR, which was capped with fine sand, and Station STNH-S-CTR, which was capped with coarse silt, indicates that these sediments are becoming progressively finer-textured as resuspended sediments are deposited over the capping material.

In view of the results of the analyses presented above and those obtained from previous invesigations of the macroinfauna in the Central Long Island Sound vicinity, it is unlikely that the past disposal of dredged material at the Central Long Island Sound Disposal Site will have any long-term deleterious effects on the macroinfaunal populations or communities. The macroinfaunal populations area are highly variable in space and time, and are adapted to a benthic environment that is characterized by frequent natural bottom disturbances. The variability induced by the disposal of dredged material is well within that to be expected from natural processes. The erosional-depositional sedimentary processes caused by storm-generated currents may gradually cover the dredged material with natural sediments, eventually making these areas indistinquishable from the surrounding bottoms both in terms of sediment texture and community structure and distribution.

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III. MUSSEL WATCH PROGRAM

AUTHORS:

Sung Y. Feng - UCONN

Stephen Tettelbach - UCONN

Robert E. DeGoursey - UCONN

III. MUSSEL WATCH PROGRAM

1.0 INTRODUCTION

Mussels are now globally established as acceptable indicator organisms for monitoring pollutant levels in the marine environment (Goldberg *et al.,* 1978). Most field investigations have involved only samplings of intertidal or subtidal populations on a short term basis and few investigators have attempted long term, *in situ* monitoring of *Mytilus* sp. because of the obvious weather-related and logistical difficulties confronting such field studies. However, the DAMOS program has developed a system for the long-term *in situ* monitoring of *Mytilus edulis* at offshore dredged material disposal sites in Long Island Sound.

Several other investigators have also incorporated *in situ* monitoring in temperate-water field investigations. Young *et al.* (1976) used a taut moor buoy system in a survey of synthetic organic compounds in *M. californianus* off Palos Verdes Peninsula, CA. Mussels were maintained in a metal cage on the bottom at a depth of 35m and in nylon mesh bags along the buoy line at depths of 0.5m, 4m, 15m and 25m. Phelps and Galloway (1980) maintained *M. edulis* in plastic baskets secured to subsurface buoy arrays at four stations in Narragansett Bay, RI. The mussels were held approximately one meter off the bottom at stations along a pollution gradient in the Bay. The stations were sampled monthly by divers for an eight month deployment. In a Danish fjord, Riisgard and Poulsen (1981) measured growth of *M. edulis* held in net bags. The bags were secured to a buoy chain by steel brackets which kept them from chafing against the chain. They were attached to the chain one meter from the bottom and were sampled by divers after a three week deployment.

The objective of the present study is to monitor the possible deleterious effects of the disposal activities in Long Island Sound. To accomplish this, the following questions have been investigated:

- Is there any evidence suggesting that increases in trace metals and polychlorinated biphenyls (PCB) in *M. edulis* are associated with open water disposal of dredged materials, or other environmental factors?

- Is there an physiological change, e.g., tissue wet/dry weight ratio, gonadal development in *M. edulis* that can be attributable to the increase in tissue trace metal and PCB concentrations or to other biological factors?

- Is there any discernible histopathological change that can be correlated with the increase in tissue trace metal and PCB concentrations?

Results of the tissue concentrations of heavy metals and polychlorinated biphenyls have been reported elsewhere by Feng (1980a, b) and Arimoto and Feng (1980, 1983a, b) and will be discussed later in this section. However, prior to that discourse, details of the construction, rigging, deployment and sampling of mussel monitoring platforms will be presented.

Mussels on the DAMOS program are held in plastic mesh bags attached to free standing polyvinylchloride (PVC) platforms at selected locations around each disposal site and at a reference station (Feng 1980a, b). A monthly sampling interval is attempted at all stations. SCUBA diving was chosen as the sample recovery method because: (1) samples could be obtained without removing the entire platform from the water allowing minimal extrinsic stress on the mussels; (2) divers could visually assess general bottom conditions (e.g., hydrography, predominant sediment type, benthic assemblages, etc.) as well as the orientation of the platform to the sea floor and to current flow and estimate the relative proximity of the platform to the dredged material; (3) periodic direct observations could assess platform damage, if any, and possible effects of sedimentation or predation on the mussels.

As a result of taut moor buoys which marked the disposal sites to ensure point dumping by the dredge scow, it became apparent that well defined mounds of material were created at each site. Periodic bathymetry surveys conducted by SAIC delineated the topography and margins of the dredged material and platforms were positioned just beyond the periphery of the mounds. Subsequent observations showed the platforms were generally 0-100 meters from the margin of the dredged material.

2.0 DESCRIPTION OF STUDY SITES

DAMOS mussel cages have been deployed primarily in three different disposal sites in Long Island Sound.

The New London (NLON) disposal site is located two nautical miles south of the mouth of the Thames River, Groton CT, 41°16'N, 72°05'W (Fig III-2-1). It covers approximately a one nautical mile square area with the natural bottom ranging in depth from 21 meters in the northwest corner to 26 meters in the southeast. The predisposal bottom was relatively flat, featureless and composed of medium to fine grain sand with patches of relatively soft cohesive mud from previous disposal operations. The tidal amplitude is one meter and the average maximum bottom current velocities reach 45 cm/s at the site. Underwater visibility varied between 0.5-5 meters during the study period.

Ram Island reference site (RIr) (Fig. III-2-1) located 259 meters south of Ram Island, serves as a master monitoring

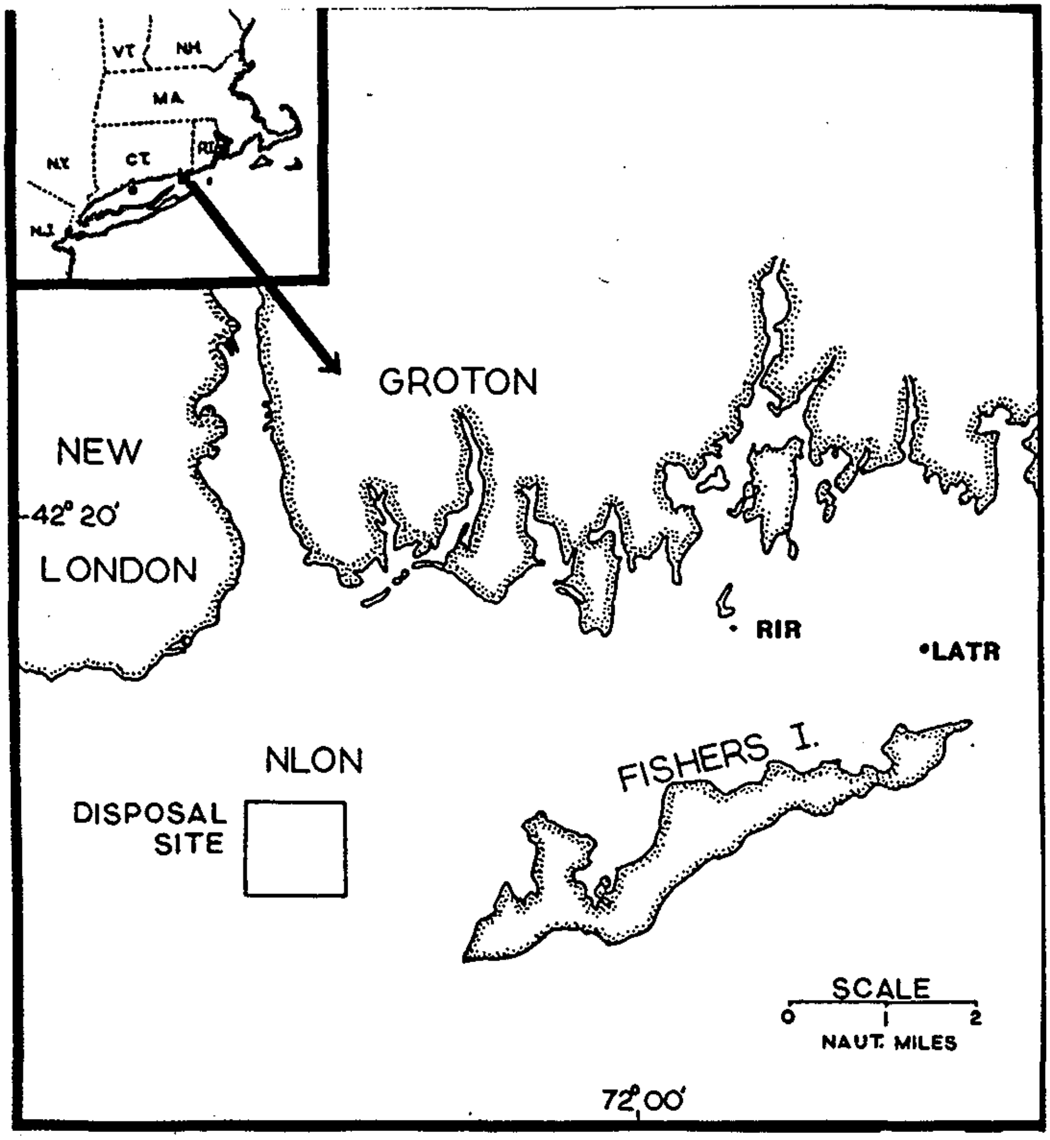

Figure III-2-1. The Eastern Long Island Sound reference sites showing the locations of RIr and LATr.

reference for the three mussel monitoring platforms which contain Ram Island mussels and were deployed at WLIS in July 1984 (WLISrN, WLISc and 500 MW). The depth of the site varies from 10 to 12 meters. The sea bottom is generally paved with shell hash mixed with mud, also the boulder-dotted surroundings are interspersed with outcrops of relic clay banks. Of similar sea bottom features as the Ram Island site is the Latimers Light reference site (LATr) which serves as the source of mussels deployed at CLIS disposal site. The site is located 3.7 kilometers east of RIr in Fishers Island Sound.

The Central Long Island Sound (CLIS) disposal site is located 5.5 nautical miles south of New Haven, CT at 41°09'N, 72°52'W (Fig. III-2-2). It covers a two nautical mile square area and varies in depth from 21 meters in the northwest corner gradually sloping to 23 meters in the southeast. The bottom is flat, featureless and composed of very soft unconsolidated mud. The tidal amplitude is two meters and current velocities approach 20 cm/s. Water transparency ranged between 0-3 meters during the study period.

The Western Long Island Sound (WLIS III) site was established in 1982 approximately 3 nautical miles south of Stamford, CT at 40°59'N, 73°29'W (Fig III-2-3). The mean depth is approximately 35m at the bottom of an east-west trending trough. Bottom sediments are geneally fine silts and clays often composed of dredged material deposited in the past.

2.1 Disposal Operations

Dredged material disposal operations at the NLON site were conducted in three phases over a three year period. Monitoring studies included the period between October 1977 and May 1981. Approximately 3.5 x 10^6 m^3 of material was dumped at this site.

Dredged material at the CLIS disposal site was removed from a number of harbors along the Connecticut coast during the period from March 1979 to May 1983. The dredge sites (volumes) include: Norwalk Harbor (244,000 m^3), Stamford Harbor (352,000 m^3), Black Rock Harbor, Bridgeport (55,000 m^3), and the confluence of the Mill River and Quinnipiac River in the New Haven Harbor (1,000,000 m^3) (Table III-2-1). A separate mound was created with the material removed from each dredging location. Dredged material from Stamford Harbor was dumped at two separate locations (STNH-S, STNH-N) to facilitate a "capping" containment study (Morton, 1980). For the period October 1983 to September 1984, 448,436 cubic yards of dredged materials were placed at the CLIS site. The disposal operation was initiated in October 1983 and terminated in April 1984; by the end of November 1983, 50% of the dredged material had already been deposited. Table III-2-2 summarizes the monthly deposits of dredged materials at this site. Monitoring at the Norwalk and Stamford sites included the period between April 1980 and June 1981. Monitoring began at the Mill-Quinnipiac River site in August 1982 and at the Black Rock Harbor site in February 1983. Monitoring

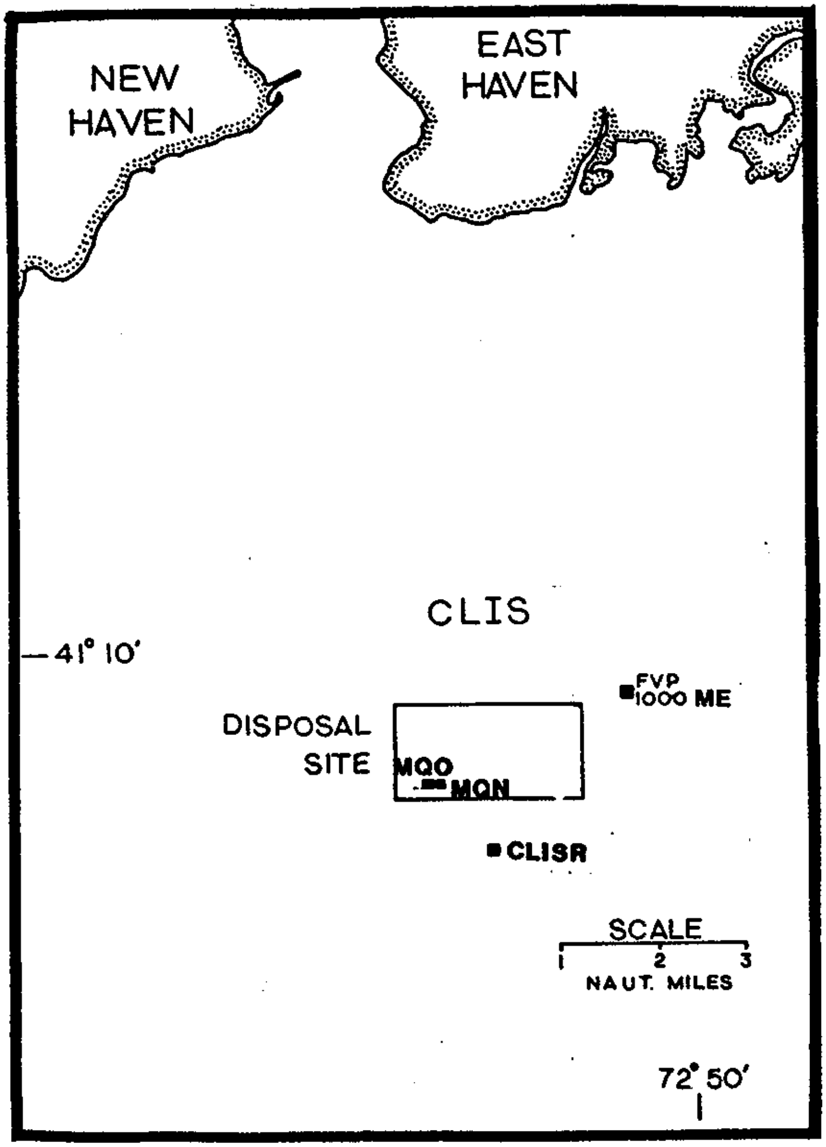

Figure III-2-2. The Central Long Island (CLIS) disposal site showing the locations of four mussel monitoring platforms at 1000ME, MQO, MQN, and CLISr.

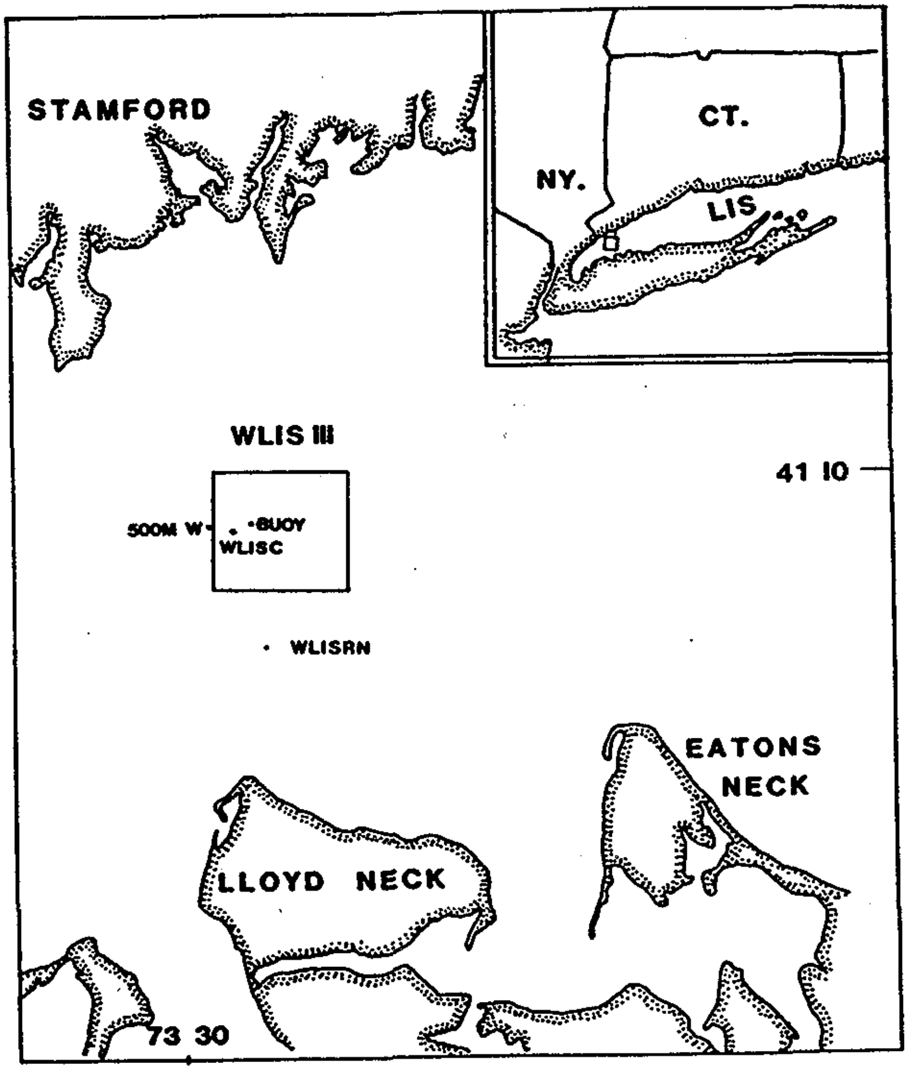

Figure III-2-3. The Western Long Island Sound (WLIS) disposal site depicting the locations of three monitoring platforms at WLISc, 500MW, and WLISrN, as well as the dump buoy.

TABLE III-2-1. Time and quantities of dredge material from Black Rock Harbor, Bridgeport Harbor and New Haven Harbor being deposited at the Central Long Island Sound Disposal Site.

A. Black Rock Harbor Project

Disposal Location	Date	Quantity (cy)	Harbor Area/Reach No.
MQR	3/10 - 5/19/83	87,388	Bridgeport Anchorage Black Rock; 2^E, 2^W, 4^E, 4^W
CS-1	4/6 - 4/16/83	43,420	Black Rock; 2^E, 2^W, 3, 4^E, 4^W, 5
CS-2	4/18 - 5/18/83	49,871	Cedar Creek; 12^E, 12^W, 13^E, 13^W, 10
FVP	4/26 - 5/14/83	77,056	Black Rock, 6^E, 6^W Cedar Creek; 10^E, 10^W, 9, 8^E, 8^W, 7
SP Buoy	5/20 - 6/4/83	23,355	Shoal Removal

B. New Haven Harbor Project

Disposal Location	Date	Quantity (cy)	Harbor Area/Reach No.
MQR	3/29 - 5/16/83	523,400	Turning Basin and E. Shoal; 8, 9, 7^E, 7^W, 10, 12, 13
CS-1	5/17 - 5/23/83	70,300	E. Shoal, E. Limits; 7^E, 7^W
CS-2	5/30 - 6/3/83	55,000	Breakwater Area (sand)
SP Buoy	4/14 - 6/7/83	174,400*	Entire Area

*including 17,250 cy from Wyatt and N.H. Terminal.

at these latter two sites was terminated in June 1984.

Disposal of dredged material at the WLIS III was initiated in 1982 with the Mamaroneck Harbor project. A total of 56,325 cubic yards of dredged materials was deposited that year. During the calendar year 1983, 149,635 cubic yards of dredged materials were dumped, while 166,008 cubic yards were deposited in 1984 (Table III-2-2). Therefore, from 1982 to the end of 1984, a grand total of 371,968 cubic yards of dredged materials were disposed at this site; in contrast, this represents only 27% of the dredged materials the CLIS disposal site received for the calendar year 1983 and 1984. Most of the dredged materials were generated from various Connecticut and New York marinas and boat yards operating in Western Long Island Sound, and differed presumably in their chemical contents from those disposed at CLIS disposal site, which originated from industrial harbors and water ways.

3.0 EXPERIMENTAL DESIGN

Genetic and other variations such as temperature-dependent filtering rates and reproductive cycles in natural populations of mussels contribute to variations in trace metal concentrations in mussel tissue (Martin, 1979). Because genetically defined stocks of *Mytilus* were not available, large numbers of mussels that were morphologically identified as *Mytilus edulis* were collected from a subtidal population at Latimer Light (LAT), Fishers Island Sound. These mussels were used as baseline samples and to stock experimental platforms at the disposal sites. Ten baseline samples were collected before each deployment of experimental platforms; each baseline sample consisted of eight mussels. Samples from the experimental platforms as well as a reference platform located at Latimer Light were obtained concurrently. Data on shell length and width, tissue wet/dry weight ratios, and trace metal concentration and, in some cases, PCB concentrations were obtained from all samples. At the NLON disposal site three monitoring stations (D-I, D-II, D-III) were established and a reference station (D-IV) was maintained off the south shore of Fishers Island, six nautical miles ESE of the disposal site (Fig. III-2-1). At the CLIS site, monitoring programs were conducted during two separate disposal periods. A monitoring station was established adjacent to each dredged material mound and a reference station in adjacent waters during each study period. At WLIS III, stations were established adjacent to the disposal mound and at a reference station north of the disposal site. Station designations and LORAN-C coordinates are shown in Table III-3-1.

3.1 Experimental Platforms

The mussel platforms (Fig III-3-1) were constructed of 4.7 cm O.D. polyvinylchloride pipe (Type 1, ASTM Schedule 40) and polyvinylchloride fittings. They were 100 cm x 100 cm square on top and fitted with 80 cm legs. Cross members in the middle of

TABLE III-2-2. Monthly dredge materials (in cubic yards) deposited at the Central and Western Long Island Sound disposal sites from October 1983 to September 1984.

CLIS

Date	83 OCT	NOV	DEC	84 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Monthly volume	2,200	227,000	84,311	19,100	13,400	67,075	35,350	---	---	---	---	---
Cumulative vol.	2,200	229,200	313,511	332,611	346,011	413,086	448,436	---	---	---	---	---
% Cumulative vol.	0.5	51.1	69.9	74.2	77.2	92.1	100.0					

WLIS

Date	83 OCT	NOV	DEC	84 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Monthly volume	---	5,810	8,800	43,455	19,675	6,750	24,740	63,388	8,000	---	---	---
Cumulative vol.	---	5,810	14,610	58,065	77,740	84,490	109,230	172,618	180,618	---	---	---
% Cumulative vol.		3.2	8.1	32.1	43.0	46.8	60.5	95.6	100.0			

SAIC

TABLE III-3-1. Loran-C coordinates and depth of mussel platforms deployed at the New London, CLIS, and WLIS disposal sites.

Station Designation	Loran-C Coordinates	Depth (meters)
New London Disposal Site		
D-I	26129.6 43970.7	26
D-II	26124.3 43975.0	19
D-III	26142.8 43980.1	21
D-IV	26057.0 43965.5	10
Latimer Reef (LAT)	26064.0 43977.2	5
Central Long Island Sound Disposal Site		
Phase I		
Stamford-New Haven, north pile (SNHN)	26544.2 44000.7	21
Stamford-New Haven, south pile (SNHS)	15033.4 43994.5	25
Norwalk (NOR)	26549.3 43999.5	23
Reference (REF1)	26550.4 44005.1	20
Phase II		
Mill R-Quinnipiac R (MQO)	26550.4 43996.8	23
Mill R-Quinnipiac R (MQN)	26549.6 43996.3	22
Black Rock Harbor (FVP1000E)	26528.9 43998.9	23
Reference (REF2)	26504.4 43989.7	28

TABLE III-3-1 (cont.)

Western Long Island Sound III

Phase I		
WLIS III Dumpsite	26823.3 32976.9	32
WLIS III Reference	26824.3 43963.0	21
Phase II		
WLIS III "B" Center	26831.9 43975.2	34
WLIS III "B" 500W	26835.0 43975.8	36
WLIS III Reference	26824.3 43963.1	21

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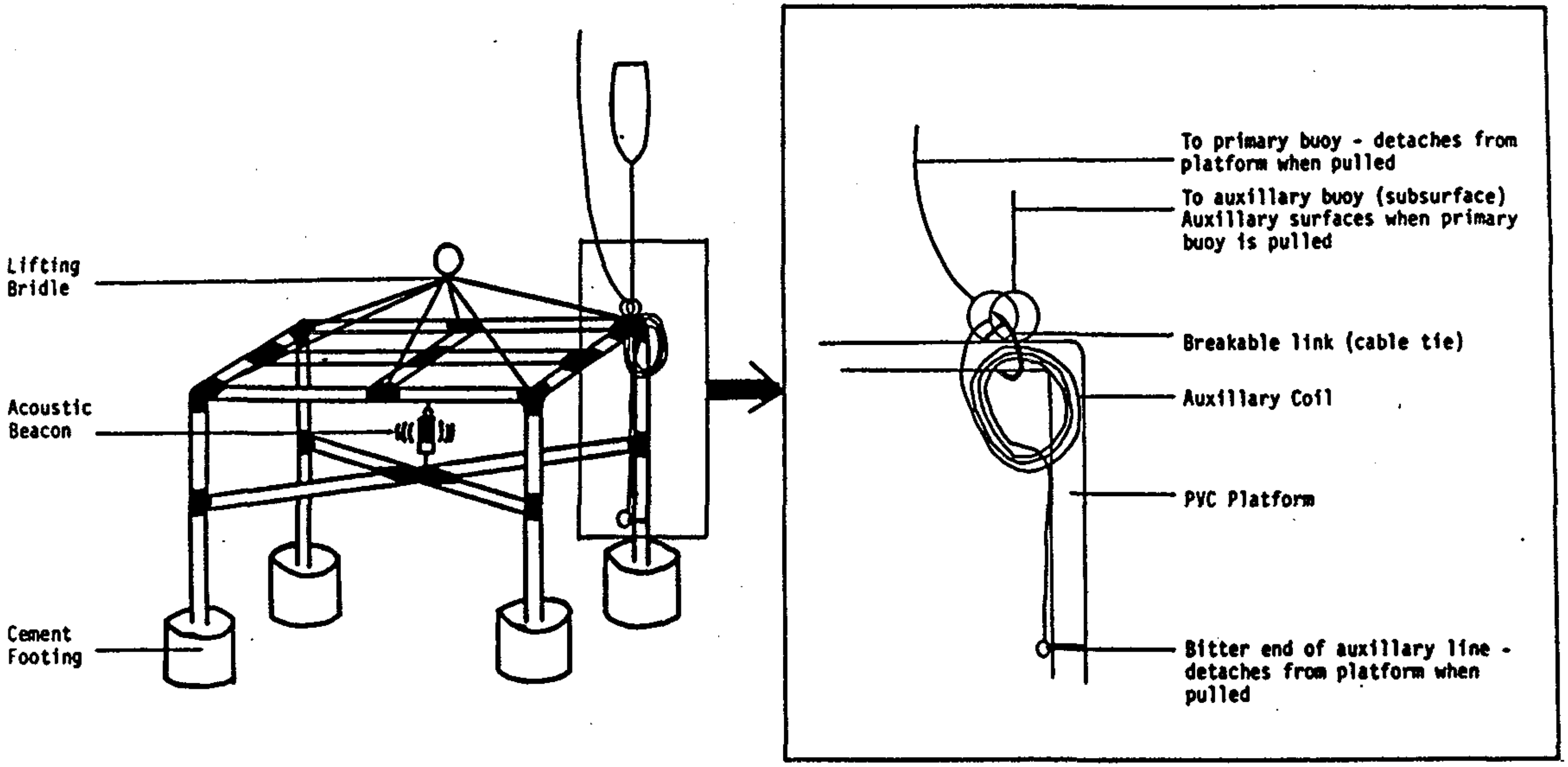

FIGURE III-3-1. Schematic diagram of the PVC sampling platform. Inset shows detail of buoy release rigging.

the legs and top provided reinforcement. Circular cement footings weighing 20 kg each were poured around the base of each leg for stability and weight. A polypropylene bridle was attached to the top of each platform for lifting purposes and to provide a point of attachment for surface buoys. The completed platforms with mussels weighed 115-140 kg in air.

Mussels were placed in commercially available polypropylene mesh bait bags (.5 meter long with 2.5 cm stretched mesh) and secured to the top of the platform with all-plastic electrical "cable ties" (41-659, Ideal Industries, Inc.). As many as forty bags could be mounted on each platform. Mussels greater than 2 cm shell length were selected to avoid loss through the mesh bag. Each bag contained 50 mussels. In order to obtain growth data, all mussels in three randomly selected bags were measured before deployment. Bags containing measured mussels were coded with knotted polypropylene line so that divers could identify specific bags even under zero visibility conditions.

In the initial stages of the study, large buoy systems were used to mark the location of the experimental platforms. They consisted of 1.5 meter diameter hemispherical steel buoys attached with 2.3 cm nylon line to 700-900 kg cement anchors. The anchor was secured to the platform by a 10 m polypropylene groundline staked to the bottom. A radar reflector and anchor light were affixed to a 1 m high tower atop each buoy. This buoy system proved to be grossly inadequate due to its vulnerability to ship traffic. Two of three experimental arrays initially deployed at the NLON disposal site were destroyed within four weeks. In one instance a ship dragged the buoy and anchor 1/2 mile off station.

It became evident that a buoy system less susceptible to ship damage would have to be devised. Hence a redundant system was designed consisting of a primary buoy (1 cm polypropylene line with a 28 cm spongex float) and a subsurface auxillary safety float (same material as the primary buoy) which was secured to the platform. These floats made the platforms less conspicuous and less vulnerable to ships since they often remained underwater except during slack current and were identical to lobster gear set in the area. The line for the auxillary buoy was coiled and attached to the platform with a single cable tie. A loop was tied in the bitter end of the primary line and this was also secured to the auxillary coil with the same cable tie (see Fig III-3-1). If sufficient pressure was applied (50 lbs) to the primary line, it would break away releasing the auxillary coil and buoy, thus causing the auxillary buoy to float to the surface. The bitter end of the auxillary buoy was also attached with a single cable tie allowing it to break away from the platform. The breaking strength of the cable ties enabled divers to descend on the buoy lines in currents less than 1/2 kt without detaching the buoys.

An acoustic pinger (model PMC-55, Johnson Laboratories, Inc., Southold, Long Island, NY) was attached to each platform to aid divers in locating it when the buoys were submerged or missing. The pingers operated at 40 kHz and had a working range of approximately 1/4 nautical mile. Divers followed the signal using a hand-operated variable frequency acoustic receiver (Model 512, Burnett Electronics, Inc., San Diego, CA). In areas where the platforms were established close enough to have acoustic interference from other stations, pingers of different pulse rates (1, 3, or 6 pulses per second) were used to differentiate them.

3.2 Deployment and Sampling Procedures

Stations were chosen by predeployment dive surveys to determine suitable bottom type. Every effort was made to deploy platforms as close as possible to the disposal mound and yet avoid complete burial of the platform by the direct barge release. Before deployment, two bags from the stock of mussels to be used as the baseline sample were removed for laboratory analysis. The remaining bags of mussels, acoustic pinger and buoy system were attached to the platform while aboard the ship. The complete unit was lowered to the seafloor using a ship's winch. Divers then entered the water to release the surface cable, inspect the rigging and record the orientation of the platform. Finally, a brief visual survey was made of the immediate area before surfacing.

Stations were relocated using Loran-C coordinates. Visual sighting of either the primary or auxillary floats confirmed the station locations in approximately 50% of the samplings. Divers carefully descended the buoy line to avoid detaching it from the platform. If surface floats were not observed, a reference buoy was deployed at the Loran-C coordinates of the station and an in-water search performed using the acoustic receiver. The dive team towed an additional buoy to remark the station.

Once a platform was located, divers collected the required number of sample bags, removed accumulated sediment, and the remaining bags were counted. Divers also re-rigged the buoy system, inspecting the platform for damage and replaced the acoustic pinger as required. The amount of in-water time required to locate, sample and service each platform ranged from 5 to 25 minutes. In some cases, predation by the tautog, *Tautoga onitis*, and by starfish, *Asterias* sp., seriously depleted the mussels and necessitated restocking by divers. Station D-I at the New London Site was the most susceptible to predation and was restocked four times during a 36 month period.

3.3 Platform Deployments

A summary chart of the deployment periods for all sites is presented in Figure III-3-2.

The longest continuous deployment at a disposal site was maintained at station D-III in New London which lasted for 44 months including nearly 21 months (except for April 1980) of continuous sampling. The sampling period at D-I spanned 36 months with only five missing samples. A continuous 20-month data set was obtained at the D-I and LAT stations. Stations D-I, D-III and the two reference stations, D-IV and Lat were terminated in May 1981 when the research was completed. Station D-II was phased out in January 1979 following a nine month monitoring period.

The first phase of monitoring at the CLIS site was conducted for 15 months (Stations NOR, STNH-S, STNH-N and Ref 1). An earlier sampling record at this site was incomplete, principally due to Hurricane David in October 1979, which damaged the platforms so that all four platforms had to be restocked. Following the storm high mortality was caused by excessive sediment accumulation in the bags and many bags were detached from the platform and lost. One platform, STNH-S was inverted and buried, smothering the bagged mussels. Poor weather, zero visibility conditions and mechanical problems with the acoustic receiver also impaired sampling on several occasions. Again, these stations were discontinued due to completion of the research.

A second phase of monitoring at CLIS began at MQR-1 in August 1982 and stations MQR-2, FVP, 1000E as well as REF-2 in February 1983. These stations were terminated in June 1984. A continuous data set has been obtained from stations MQR-1 and FVP 1000E through June 1984. Stations MQR-2 was not sampled from January to March 1984 and REF-2 was not sampled in March 1984. After June 1984, the priority of monitoring efforts was shifted from CLIS to WLIS. Therefore, field operations of the Mussel Watch Program at the CLIS disposal site were terminated with the removal of four experimental platforms in June 1984 (Table III-3-2). The mussels remaining on three of the platforms: MQN, 1000ME and CLISr, were consolidated and transferred to the reference platform at Latimers Light (LATr) in Fishers Island Sound. They have since been sampled monthly and samples are either analyzed or archived for future reference. The sampling will continue until the mussels are depleted. Although this work is in addition to the scheduled tasks, the result obtained could contribute to the better understanding of the process of depuration by the mussels. The fourth platform designated as MQO, which was first deployed in August 1982, had no mussels remaining when it was recovered on 8 June 1984.

At WLIS III, deployment of a mussel platform first took place from March through July of 1982 at which time the platform was lost. A replacement platform was installed in November 1982 which remained in place through June 1984.

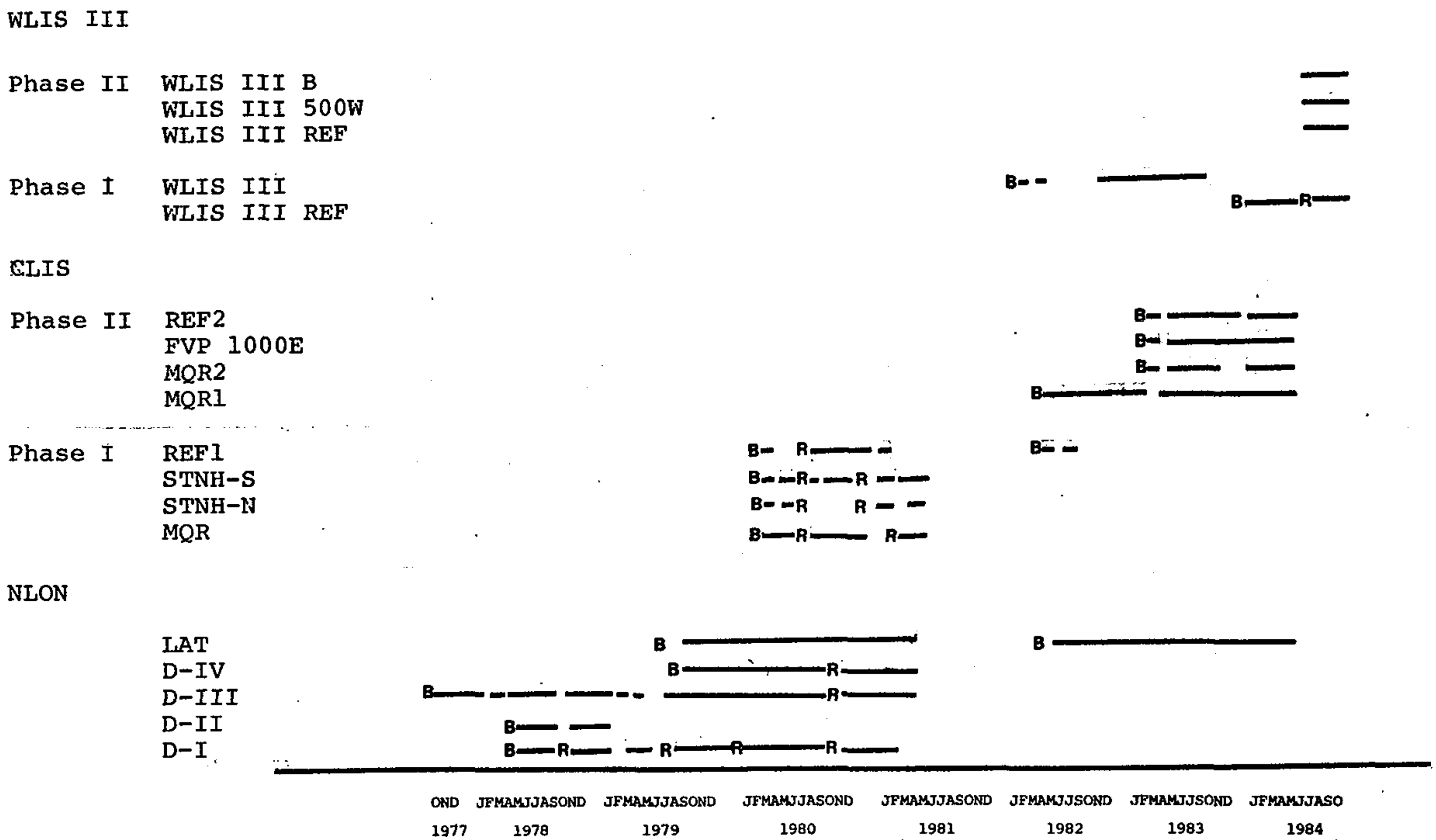

FIGURE III-3-2. Chronology of sampling dates at the New London (NLON) and Central Long Island Sound (CLIS) and Western Long Island Sound (WLIS) Disposal Sites. Solid line indicates that a sample was obtained. "B" denotes baseline sample. "R" denotes that restocking of mussels was performed in addition to sampling.

TABLE III-3-2. Mussel Watch Program: Chronology of Field Operations at CLIS.

Station Loran-C Coordinates	16 Aug 1982	28 Feb 1983	8 June 1984	20 June 1984	21 June 1984	26 July 1984	22 Aug 1984	19 Sept 1984
Mill Q OLD 26550.4 43996.8	platform deployed		platform recovered no mussels remained					
Mill Q NEW 26549.6 43996.3		platform deployed		platform recovered	mussels transferred to LAT reference FIS		sampled	sampled
CLIS-Reference 26528.9 43989.7		platform deployed		platform recovered	mussels transferred to LAT reference FIS	sampled	sampled	sampled
CLIS 1000 m East of FVP center 26528.9 43998.7		platform deployed		platform recovered	mussels transferred to LAT reference FIS	sampled	sampled	sampled

A new phase of monitoring at the WLIS III disposal site, which required the deployment of three experimental platforms and a new reference platform in Fishers Island Sound, was initiated in June 1984. Dive-surveys at Latimers Light revealed that there were not sufficient mussels of the required size class (>2.5 cm) to stock four platforms. Subsequently, an extensive subtidal population of older mussels was located at Ram Island Reef (RIr) in the western end of Fishers Island Sound; these mussels exhibited similar trace metal concentrations as those found in the Latimers Light population. Over 6,000 mussels were collected from the vicinity of RIr station; they were sorted, counted, bagged and held at the Marine Research Laboratory dock until they were deployed at the WLIS disposal site.

The deployment of the three mussel platforms at WLIS III took place on 27 June 1984 at the following designated locations: (1) Center "Bravo" pile (WLISc), (2) 500 m west of the center "Bravo" pile (500MW) and (3) a reference station located 2.22 kilometers south of "Bravo" pile (WLISrN). On 28 June, a platform was also placed at Ram Island Reef (RIr) serving as a master reference station for the WLIS stations. All these four platforms were each stocked with 1350 mussels in 27 bags (50 mussels per bag). On the same day, two old mussel platforms: WLISr and WLISd, which had previously been deployed in January 1984, were also recovered. The remaining mussels on these platforms were transferred to the reference platform at LATr to be handled in the similar manner as those recovered from the terminated CLIS stations.

As shown in Tables III-3-2 and 3, all field sampling of mussels for the fiscal year 1983-1984 werew completed on 19 September 1984

It has been an established procedure that when the experimental stations were first established, ten replicate baseline samples were collected from the reference site for trace metal, PCB and wet/dry weight ratio determinations. Whenever the restocking of the platform was deemed necessary due to predation, mortality and irretrievable losses of the platform, replicate baseline samples were always obtained.

3.4 Discussion of Platform Performance

The PVC platform is simple to construct, lightweight, relatively easy to deploy and has proven to be quite stable underwater. Platforms are easily transported if the cement footings are not attached until just prior to deployment. The footings can be cemented to the platform minutes before being lowered into the water. The PVC schedule 40 pipe proved to be very durable during the summer months but was susceptible to cracking in freezing or subfreezing temperatures. Schedule 80 pipe was found to be much more reliable during cold weather deployment.

TABLE III-3-3. Mussel Watch Program: Chronology of Field Operations at WLIS.

Station Loran-C Coordinates	20 Jan 1984	21 June 1984	27 June 1984	28 June 1984	25-56 July 1984	21-22 Aug 1984	18-19 Sept 1984
WLIS-III Reference 26824.3 43963.0	platform deployed		platform deployed	mussels transferred to LAT reference FIS	sampled	sampled	sampled
WLIS-III Dumpsite 26823.3 32976.9	platform deployed		platform recovered	mussels transferred to LAT reference FIS	sampled	sampled	sampled
Ram I. Reef Reference 26084.4 43991.8		mussels collected to stock WLIS-III		platform deployed	sampled	sampled	sampled
WLIS-III Reference 26824.3 43963.1			platform deployed		sampled	sampled	sampled
WLIS-III Center Bravo pile 26831.9 43975.2			platform deployed		sampled	sampled	sampled
WLIS-III 500m west of center Bravo 26835.0 43975.8			platform deployed		sampled	sampled	sampled

Ram I = Ram Island; LAT = Latimers Light

Aside from mechanical damage to the platforms by commercial trawling activities, only the loss of one platform could be attributed to bad weather over a combined total of 261 months of deployment, although in several instances platforms were damaged and had to be hauled for repairs or replacement.

The platforms are well suited for monitoring heavy metals because contamination from the array itself is minimal. The acoustic beacon is the only metal object in contact with the array. The beacon is small (14.0 cm length x 4.5 cm diameter)and is housed in a bronze case with a magnesium alloy power electrode. The beacons must be attached directly to the platform and cannot be suspended above it. Initial attempts by divers to locate beacons suspended in the water column were unsucessful due to the difficulty of trying to home in on an acoustic signal in three dimensional situation. Divers must maintain contact with the sea floor to properly orient to the acoustic source, especially in limited or zero visibility conditions. Pingers were secured with polypropylene line between the upper and lower cross members (see Fig. III-3-1) to minimize the chance of burial in the event the platform is over-turned.

The acoustic pingers were highly reliable. Divers were nearly 100% successful in locating platforms as long as an acoustic signal could be received. Signal loss was principally caused by fishing trawlers moving the platforms off station. In one instance (Station D-II, Sept 1978) the entire array was hauled by a fishing trawler. In another case, signal loss at the STNH-S station occurred because of the almost total burial of the platform following the severe storm in October 1980. Loss of signal was never caused by malfunctioning of the acoustic beacon. It should be noted that there is a definite learning curve associated with the use of the acoustic receiver. Depth, water temperatures, current, visibility and experience affect the performance and the ability of the diver to use instrumentation effectively. In general, the divers needed two to four months of sampling experience to become proficient with the acoustic receiver.

The sampling system demands a high level of diving effort. Continuous monitoring often requires between-sampling maintenance, and diving to remove fouling organisms and to insure buoy arrays are in good working order. The mesh bags occasionally were heavily fouled by hydroids, colonial ascideans, ecoprocts, and juvenile mussels and it was necessary to clean the bags by hand. Resuspension of bottom sediments also caused an accumulation of material which required periodic removal. This problem was especially acute at the CLIS site because of the predominantly fine silty sediments which are easily resuspended by storm induced turbulence.

Both the NLON and CLIS disposal sites are located near highly urbanized areas and are subject to anthropogenic disturbances. Intense sport fishing, lobstering, and commercial dragging take place on a seasonal basis. Both areas are also traversed continually by heavy tonnage ship traffic which make it extremely difficult to maintain platforms and associated buoy arrays in position during long term deployments.

The selection of the type of surface buoys used should be based upon the type of arrays being deployed and the duration of the experiment. Large buoys and anchoring arrays are especially susceptible to damage by ship traffic but they may be the most reliable for short term deployments. Small buoy arrays, though inexpensive and easier to deploy, are easily cut or detached. Unbuoyed platforms require the support of an acoustic location system and may be highly vulnerable to trawling operations. The redundant, detachable buoy system combines the advantages of small buoys and unbuoyed arrays, thus improving the chance of sample recovery.

The buoy array was recently modified on platforms deployed at the WLIS III disposal ground off Stamford, CT Initially, the rate of sample recovery at this site was low because the depth (40 meters) severly limited the diving effort. Also, attempts to maintain surface buoys in the platforms were unsuccessful due to heavy shipping traffic traversing the site. To alleviate this problem, a subsurface buoy array with an in-line acoustic release (Innerspace Model 431 Innerspace Technology, Inc., Waldwick, NJ) was attached to each platform.

The acoustic release can be triggered to surface by a discrete signal generated from a surface-operated coding device. The entire array is then hauled to the surface to remove the sample and to rearm the acoustic release. After surfacing, the array is then lowered to the sea floor on a double purchase cable at the predesignated Loran-C coordinates of the station. Diving is employed at this site only if the acoustic release malfuctions, necessitating an in-water search with the acoustic receiver.

4.0 ANALYTICAL PROCEDURES

Mussel platforms were deployed at five locations within the CLIS Site as shown in Figure III-2-2 with the following designations:

- o MQO - Mill-Quinnipiac River - Old
- o MQN - Mill-Quinnipiac River - New
- o FVP - Center of FVP site
- o FVP-1000E - 1000m East of the FVP Site
- o CLIS-REF - Reference Station, 1NM South of CLIS Site

Additional platforms were deployed at the WLIS III site also as shown in Figure III-2-3 with the designations:

- WLIS III - Center of Disposal site
- WLIS III-REF - 1.2 NM south of the disposal site
- WLIS III "B" - Center of Disposal site for Milton Harbor sediments
- WLIS III 500W - 500m west of Disposal site for Milton Harbor sediments

Platforms were established and sampled according to the procedures described above. When the experimental stations were first established, ten replicate baseline samples were collected from Latimers Light reference site for trace metals and PCB analysis, as well as wet/dry weight ratio determination. During the subsequent monthly sampling, one or two bags of mussels were removed for processing in the laboratory. Whenever restocking of the platform was deemed necessary due to predation, mortality, and irretrievable losses of the platform, replicate baseline samples were obtained.

Core samples of bottom sediment were also obtained from the location of each platform to determine the trace metal and PCB concentrations in the immediate vicinity which might be available to the mussels as natural background levels.

During each monthly sampling period, triplicate samples of eight mussels were collected. For baseline data, 10 replicates were used. In the laboratory, the mussels were cleaned, measured, shucked, and homogenized. An aliquot of the homogenized sample was weighed (wet-weight) and lyophilized using a Virtis Model 10-010 freeze drier; after being dried overnight in the apparatus, the freeze-dried tissue was weighed again and designated as the "dry weight." In calculating the wet/dry weight ratio, the wet-weight of the tissue is divided by the freeze-dried tissue weight.

4.1 Trace Metal Analysis

A 0.8 g sample of freeze-dried tissues placed in an acid-cleaned glass volumetric flask was digested in 5 ml Ultrex concentrated nitric acid for six hours at 50° C and then diluted to a final volume of 50 ml with deionized distilled water (DIDW). The diluted sample was filtered through an acid-cleaned and pre-rinsed Millipore glass-fiber filter to remove particulate materials which tend to block the aspirator particularly when performing flame atomic absorption spectrophotometry.

Copper, iron and zinc were analyzed by the conventional flame atomic absorption spectrophotometry using an Instrumentation Laboratory Model 151 Atomic Absorption Spectrophotometer. Cadmium, chromium, cobalt, nickel and vanadium were analyzed by graphite furnace flameless atomic absorption spectrophotometry (Perkin Elmer Model 5000 AA and HGA 500 Graphite Furnace). Mercury was determined using a cold vapor flameless atomic spectrophotometer (Coleman MAS-50) after reduction of oxidized mercury to Hg^o with stannous chloride. Results were corrected for reagent blanks and calibrated by comparison with standard solutions of metal salts in 10% vol/vol nitric acid in DIDW. Similarly prepared samples of standardized reference material (NBS 1566 Oyster Tissues) were analyzed concurrently with the mussel samples as quality control of the analytical results.

Throughout the analysis of trace metals, meticulous care was taken to minimize contamination, particularly in cleaning laboratory glassware and plastic ware (Gill, 1980).

In analyzing trace metals in the cores collected from the platforms at CLIS, the cores were sectioned according to the coloration of each layer. One gram of the wet sample was processed for mercury analyses using the same procedure outlined for mussel tissues. The remaining sectioned core samples were weighed to obtain the wet-weight of the samples. They were subsequently dried in a 90°C oven overnight and reweighed to determine their dry weight. One gram of the dried sample was wet-digested in 5 ml Ultrex concentrated nitric acid and processed in a similar manner as the tissue samples. Copper, chromium, iron, nickel and zinc were analyzed by the flame atomic absorption spectrophotometry and the concentrations of cadmium, cobalt and vanadium were determined by graphite furnace flameless atomic absorption spectrophotometry. In addition, the concentration of total organic carbon in sectioned core samples was also determined by the method of Gaudette, Flight, Toner and Folger (1974).

4.2 Analysis of Polychlorinated Biphenlys (PCB)

Triplicate freeze-dried tissue samples prepared for trace metal analysis were pooled and analyzed for PCB content. One gram of the pooled freeze-dried tissue was soxhlet-extracted for 3 hrs with nanograde petroleum ether (Mallinckrodt Inc., St. Louis, Missouri). The extract was contentrated with Kuderna-Danish apparatus to 2 ml. One ml of the concentrate was archived and stored in the refrigerator; the remaining aliquot was cleaned by chromatography with a Florisil (Fisher Scientifiv Co., Fair Lawn, New Jersey) packed column (Reynolds, 1969). The extract was eluted with nanograde n-hexane (Mallinckrodt Inc.); the eluent was concentrated to 1 ml with Kuderna-Danish apparatus and followed by gas chromatography using a 2m x 4mm packed glass column of 3% OV-1 (methyl silicone gum) on a silane-treated diatomite support of 100/120 mesh Gas Chrom Q (Applied Science Labs, State College, Pennsylvania). The analyses were carried out isothermally using a Hewlett Packard 7620A or 7610A gas chromatograph (Hewlett Packard, Avondale, Pennsylvania) equipped with a ^{63}Ni electon capture detector (detector, 300°C; injection port, 225°C; oven, 200 °C). A mixture of 95% argon and 5% methane was used as the carrier gas. Aroclors 1242, 1254 and 1260 were used as standards for quantification purposes. During the latest period of study, quantifications of Aroclors were achieved by employing an Apple II + microcomputer equipped with two disk drives, an ADALAB data acquisition/control card, 128K RAM card and CHROMATOCHART software (Interactive Microware, Inc., State College, PA). After the data collection is completed, the software first computes retention time and actual concentrations for each peak of Aroclors 1242 1265 and 1260 to be used as external standards and stored in the memory. The data collected from the injection of prepared samples are computed in the same manner as the standards; the retention time of each peak is compared with that of the standards and then identified. A comparison of the results obtained from the manual method with the present procedure has shown a deviation of no more than 5%.

4.3 Histopathological Studies

To aid fast penetration of the neutral buffered formalin into the soft tissues of the mussels, one valve of each animal was cracked with a sharp blow using the handle of a knife, and the shell liquor drained. The mussel was immersed in the fixative making sure that air was not trapped inside the mantle cavity. To standardize the section, cross-sections of the mussels were cut just anterior to the foot. The sections were further processed and stained with hemotoxylin and eosin using the standard histological procedures by the Histology Laboratory of the Department of Pathobiology.

Finished histological preparations were examined with an Olympus VANOX microscope at magnifications of 4X, 20X and 40X. Each specimen was critically scrutinized for stages of gonadal development, staining characteristics of the Leydig tissue, tissue integrity of the gill, kidney tubules, and intestinal epithelium, as well as the degree of leucocytic infiltrations. In addition, the prevalence of parasitic infections by *Proctoeces maculatus* and *Chytridiopsis mytilovum* was also noted.

4.4 Statistical Analysis of the Data

In the interpretation of the field expermental data on the uptake of trace metals and PCB in mussels, it is desirable, though often difficult, to separate the effects of normal physiological activities from those which are truly ascribable to perturbations resulting from anthropogenic activities. Implicit also in a field experiment is the fact that the data set is correlational; thus, causation cannot be assumed. In addition, field investigations are unlike laboratory experiments in which independent variables can be controlled and the response of the organism to them accurately measured.

Prior to performing statistical procedures on this program, the data set was tested for normality using the procedure of Shapiro and Wilk (1965). Where normality of the data set was not satisfied either the ln x or $\sqrt{x}$ transformations were employed to satisfy the condition that the proper statistical procedures required. Statistical analyses were performed using an IBM S-370 computer with the software for two-way analysis of variance (two-way ANOVA) and the stepwise multiple regression program outlined in SAS User's Guide: Statistics (SAS Inst. Inc.).

For the two-way ANOVAs, the data were classified by station (spatial) and sampling period (temporal), i.e. during or after dumping. The data for the predumping period were not included in the analyses because samples were either too small or unavailable for experimental populations. The two-way ANOVAs were used to test whether the mean trace metal or PCB concentrations of the mussels from the six monitoring populations were different either during or after dumping. If so, Scheffe's multiple range test (Sokal and Rohlf, 1969) was applied to discern which station(s) were different.

Stepwise multiple regression analysis was then applied to examine between trace metal and PCB concentrations, and intrinsic (physiological) or extrinsic (environmental) parameters. The intrinsic variables examined were wet/dry weight ratio and length of the mussels. The extrinsic variables were the volume of dredged material dumped, the ambient water temperature and the month the samples were collected. Based on previous work, wet/dry weight ratio and length of the mussels accounted for a major portion of the observed variance of trace metal concentrations. The procedure should factor out contributions of the known intrinsic variables to the observed variance of the trace metal concentrations and allow determination of which extrinsic factor(s) contributes significantly to the variance. Therefore, the intrinsic factors were programmed to enter the regression model first and the other extrinsic variables or independent variables were sequentially entered into the regression functions depending on their correlations with the concentration of trace metals. For analysis of PCB data, the intrinsic factors were not forced into the regression model because correlations between PCB concentrations and the intrinsic variables were not as clear as those in the trace metal data.

5.0 RESULTS AND DISCUSSION

5.1 Central and Western Long Island Sound March to September 1983

5.1.1 Trace Metals

The mean concentrations of the nine trace metals in mussels from Latimers Light (LAT), Central Long Island Sound Reference Station (CLIS-REF), 1000 Meters East of FVP station (1000E), Mill-Quinnipiac River Old (MQO), Mill-Quinnipiac River New (MQN), and Western Long Island Sound station (WLIS) are presented in two ways: first as a summary of mean tissue metal concentrations from March to September 1983 (Table III-5-1) and second as a summary of mean tissue trace metal concentrations during and after dumping operations (Table III-5-2). The data set organized on temporal basis is presented in Appendix III.

The two-way ANOVAs (Table III-5-3) showed that significant differences were noted between populations for the

TABLE III-5-1. Summary of mean wet/dry ratios (W/D), shell lengths (L) and tissue trace metal concentrations in *Mytilus edulis* deployed at six stations in Long Island Sound, March to September 1983.

	STATIONS					
	LAT	CLISr	1000ME	MQO	MQN	WLIS
W/D	7.61 ± 0.68[1]	7.75 ± 1.30	7.61 ± 0.69	8.47 ± 1.16	7.84 ± 1.38	7.95 ± 0.60
L	6.29 ± 0.18	5.91 ± 0.21	6.43 ± 0.41	6.28 ± 0.16	5.93 ± 0.70	6.28 ± 0.13
Cd*	1.00 ± 0.18	1.57 ± 0.63	1.46 ± 0.24	1.75 ± 0.60	1.36 ± 0.47	2.26 ± 0.66
Cr	4.00 ± 2.23	2.31 ± 1.03	2.99 ± 1.27	4.13 ± 3.30	2.87 ± 1.92	2.36 ± 0.66
Co	0.43 ± 0.13	0.49 ± 0.12	0.48 ± 0.11	0.59 ± 0.17	0.64 ± 0.20	0.57 ± 0.14
Cu*	9.08 ± 1.69	10.69 ± 2.12	12.23 ± 3.12	11.65 ± 3.10	12.51 ± 1.88	14.00 ± 2.36
Fe	243 ± 92	264 ± 112	252 ± 80	318 ± 155	303 ± 109	277 ± 88
Hg	0.17 ± 0.02	0.15 ± 0.01	0.14 ± 0.01	0.14 ± 0.01	0.14 ± 0.03	0.18 ± 0.03
Ni	3.13 ± 1.41	2.50 ± 0.55	2.54 ± 1.29	3.78 ± 1.91	3.37 ± 1.28	3.87 ± 0.94
Zn*	131 ± 12	159 ± 11	161 ± 12	165 ± 24	149 ± 28	188 ± 17
V	1.49 ± 1.12	1.27 ± 0.97	0.96 ± 0.76	1.34 ± 1.14	1.51 ± 1.26	0.77 ± 0.51
n	7	6	5	6	5	8

1. Expressed as mean ± 1 S.D.
* Two-way ANOVA significant

TABLE III-5-2. Summary of mean wet/dry ratios (W/D), shell lengths (L) and tissue metal concentrations found in *Mytilus edulis* during (D) and after (A) disposal operations at six stations in Long Island Sound. March to September 1983

		STATIONS					
		LAT	CLISr	1000ME	MQO	MQN	WLIS
Cd*	D	0.90 + 0.11	1.25 + 0.29	1.33 + 0.17	1.58 + 0.74	1.13 + 0.26	2.24 + 0.70
	A	1.15 ± 0.14	1.88 ± 0.77	1.54 ± 0.27	1.93 ± 0.50	1.70 ± 0.60	2.28 ± 0.73
Cr	D	4.37 + 2.63	1.92 + 0.97	3.76 + 0.69	5.76 + 4.24	3.43 + 2.45	2.06 + 0.54
	A	3.50 ± 1.98	2.70 ± 0.97	2.47 ± 1.41	2.50 ± 1.10	2.02 ± 0.62	2.66 ± 0.70
Co	D	0.49 + 0.15	0.54 + 0.16	0.58 + 0.06	0.68 + 0.22	0.58 + 0.16	0.56 + 0.14
	A	0.35 ± 0.04	0.44 ± 0.06	0.42 ± 0.10	0.50 ± 0.03	0.72 ± 0.31	0.58 ± 0.18
Cu*	D	10.16 + 1.14	12.58 + 0.66	15.42 + 0.49	14.21 + 1.53	13.63 + 1.43	15.76 + 1.12
	A	7.63 ± 1.06	8.81 ± 0.40	10.11 ± 1.55	9.10 ± 1.46	10.84 ± 0.89	12.22 ± 1.84
Fe	D	287 + 92	298 + 99	271 + 52	408 + 164	286 + 68	291 + 100
	A	184 ± 62	231 ± 136	238 ± 104	228 ± 94	328 ± 191	262 ± 85
Hg	D	0.19 + 0.01	0.16 + 0.01	0.15 + 0.01	0.15 + 0.02	0.13 + 0.01	0.18 + 0.04
	A	0.16 ± 0.03	0.15 ± 0.02	0.14 ± 0.01	0.14 ± 0.01	0.16 ± 0.04	0.17 ± 0.02
Ni*	D	3.77 + 1.36	2.64 + 0.72	3.03 + 1.90	5.03 + 1.93	3.95 + 1.41	3.81 + 0.68
	A	2.77 ± 1.13	2.37 ± 0.43	2.21 ± 1.07	2.53 ± 0.87	2.50 ± 0.18	3.94 ± 1.26

TABLE III-5-2 (Cont.)

		STATIONS					
		LAT	CLISr	1000ME	MQO	MQN	WLIS
Zn*	D	127 ± 13	152 ± 8	161 ± 7	148 ± 13	137 ± 8	182 ± 15
	A	136 ± 11	166 ± 11	160 ± 16	182 ± 22	166 ± 45	195 ± 17
V*	D	2.26 ± 0.82	2.04 ± 0.69	1.74 ± 0.49	2.19 ± 1.03	2.15 ± 1.29	0.94 ± 0.52
	A	0.46 ± 0.16	0.51 ± 0.31	0.45 ± 0.24	0.49 ± 0.22	0.56 ± 0.14	0.60 ± 0.52
W/D*	D	7.86 ± 0.57	6.89 ± 0.66	6.97 ± 0.24	7.99 ± 1.20	7.11 ± 0.91	7.83 ± 0.80
	A	7.28 ± 0.79	8.62 ± 1.25	8.04 ± 0.48	8.95 ± 1.11	8.92 ± 1.45	8.07 ± 0.39
L	D	6.18 ± 0.12	5.93 ± 0.32	6.23 ± 0.72	6.31 ± 0.15	5.67 ± 0.75	6.31 ± 0.06
	A	6.44 ± 0.13	5.88 ± 0.10	6.57 ± 0.11	6.26 ± 0.19	6.32 ± 0.55	6.24 ± 0.18

1 Expressed as mean ± 1 S.D.
* Two-way ANOVA significant

TABLE III-5-3

Summary of Two-Way ANOVA for Cd, Cu, Zn, Ni, V and W/D.

	Cd[1]	Cu	Zn[1]	Ni[2]	V	W/D
Station (S)	***	***	***	NS	NS	NS
Time (T)	*	***	**	**	***	**
SXT	NS	NS	NS	NS	NS	NS
Scheffe Grouping	WLIS	WLIS	WLIS			
α = 0.05	MQO	MQN	MQO			
	CLISr	1000ME	CLISr			
	1000ME	MQO	1000ME			
	MQN	CLISr	MQN			
	LAT	LAT	LAT			
	D≤A	D>A	D≤A	D>A	D>A	D≤A

1. ln Cd; 2. $\sqrt{Ni}$; NS = non significant; * p<0.05; **p<0.01; ***p<0.001; D = during disposal; A = after disposal; 2-way ANOVA for Cr, Co, Fe and Hg were not significant.

concentrations of Cd ($p < 0.01$), Cu and Zn ($p < .001$). The results of Scheffe's multiple range test (Table III-5-3) indicated that the concentrations of Cd, Cu and Zn differed significantly only between the Latimer Light and the WLIS mussel monitoring populations and that little or no difference was noted among the mussels held at the four stations in Central Long Island Sound. These conclusions are illustrated graphically in Figure III-5-1. The data, therefore, suggest that, within the Central Long Island Sound Disposal Site, the disposal of the dredged material did not induce a significant localized elevation in the trace tissue concentrations of the mussels at the experimental dumpsites.

The two-way ANOVAs did indicate, however, that the mean concentrations of Cd, Cu, Zn, Ni and V, as well as the wet/dry ratios of the mussel populations, varied during and after dumping operations. The levels of Cu (Fig III-5-2) and V (with the exception of WLIS) (Fig III-5-3) were higher during the dumping operations than after the completion of disposal. The nickel concentrations (Fig III-5-4) followed the general pattern of Cu and V, but the differences were significant only in mussel populations maintained at MQO and MQN where the disposal activities were the greatest. The concentrations of Zn (Fig III-5-5) were lower during the disposal operations than after the cessation of dumping but the differences were significant only at MQO. The interpretaion of these results must consider the behavior of the reference populations, e.g. LAT and CLIS-REF showed seasonal changes in trace metal levels similar to the experimental populations. Thus, it is likely that the elevated levels of the trace metals observed in the experimental populations were probably associated with a combination of intrinsic and extrinsic factors: volume of dredged material, feeding, spawning, physiological and biochemical lability, seasonal availability of trace metals in the environment, and their chemical forms and species.

Temporal variabilities in lead, cadmium and nickel concentrations as well as wet/dry weight ratios of mussels in Narragansett Bay have long been reported by Farrington et al. (1983). Such variabilities in Long Island Sound mussels were observed since 1977 (Feng, 1982). In assessing the possible impact of dredging on the environment, knowing the temporal variability of trace metals is imperative, for it provides a framework within which proper interpretation of the data can be unambiguously rendered. Also, where temporal fluctuations were noted, the concept of bioaccumulation of trace metals should be examined carefully because available evidence indicates that bioaccumulation is a dynamic process.

Stepwise multiple regression analyses (Table III-5-4) showed that the volume of dredged material disposed was correlated with the concentrations of chromium and zinc at 1000E, of copper and iron at MQN and MQO respectively, and of cadmium, zinc and vanadium at WLIS. In contrast, for the reference population held at LAT and CLIS-REF, two major extrinsic factors, the month when the populations were sampled and the ambient water

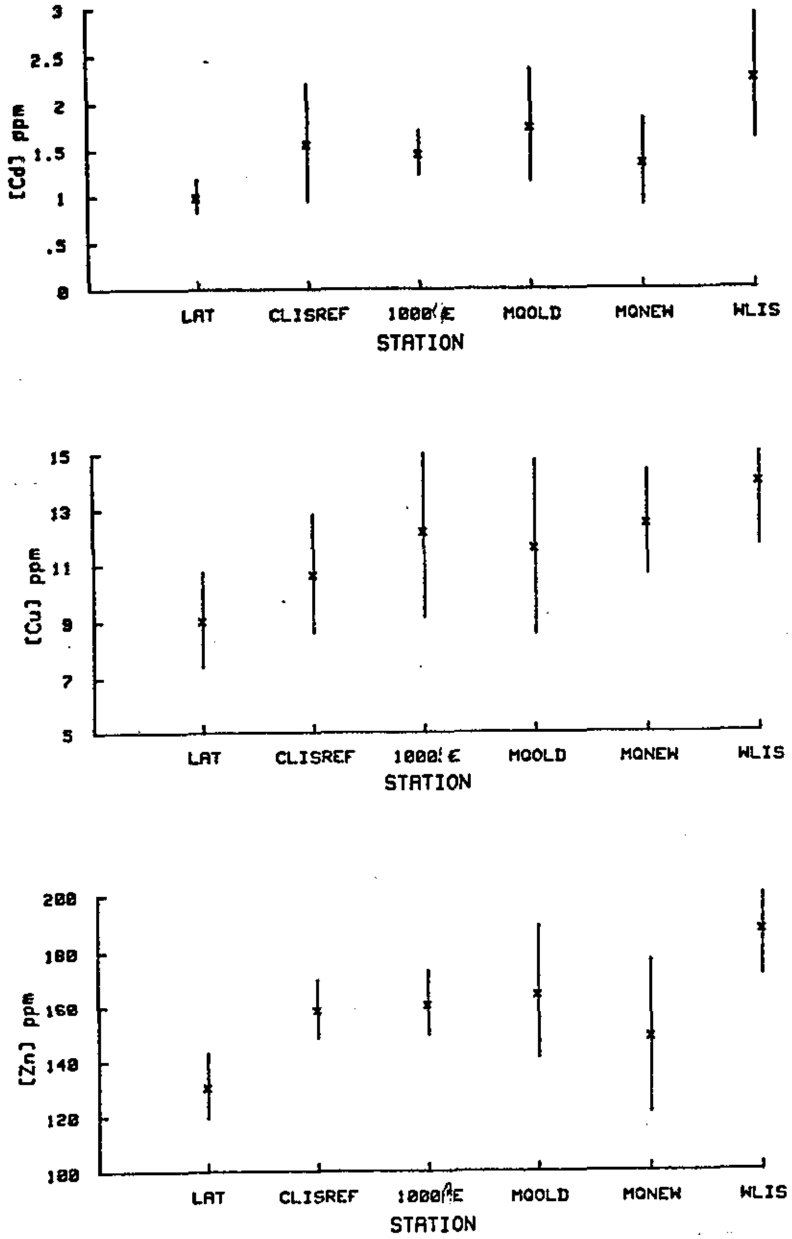

FIGURE III-5-1. Graphic representations of the mean concentrations of Cd, Cu, and Zn in mussels deployed at LAT, CLIS-REF, 1000E, MQO, MQN and WLIS.

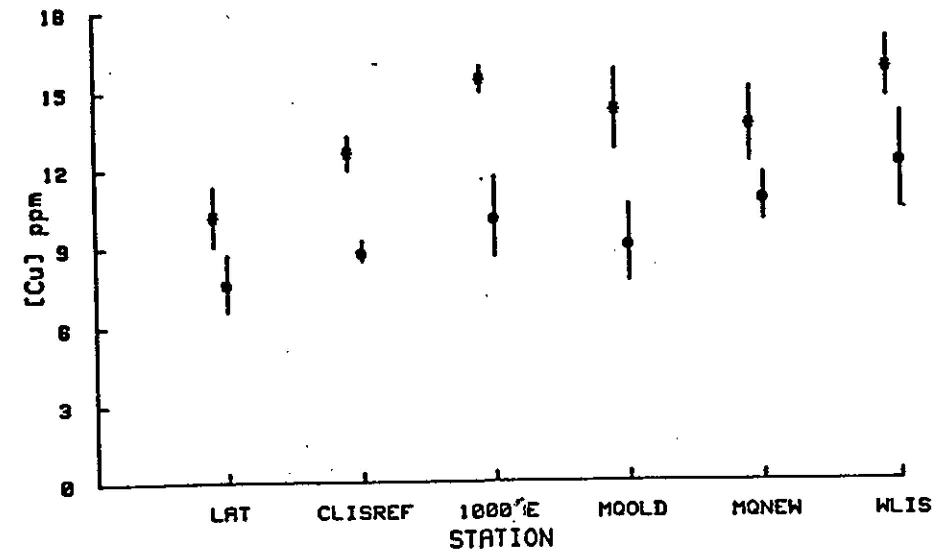

FIGURE III-5-2. The mean concentrations of Cu during (*) and after (o) dumping operations in the six mussel populations maintained at the Eastern, Central and Western Long Island Sound sites.

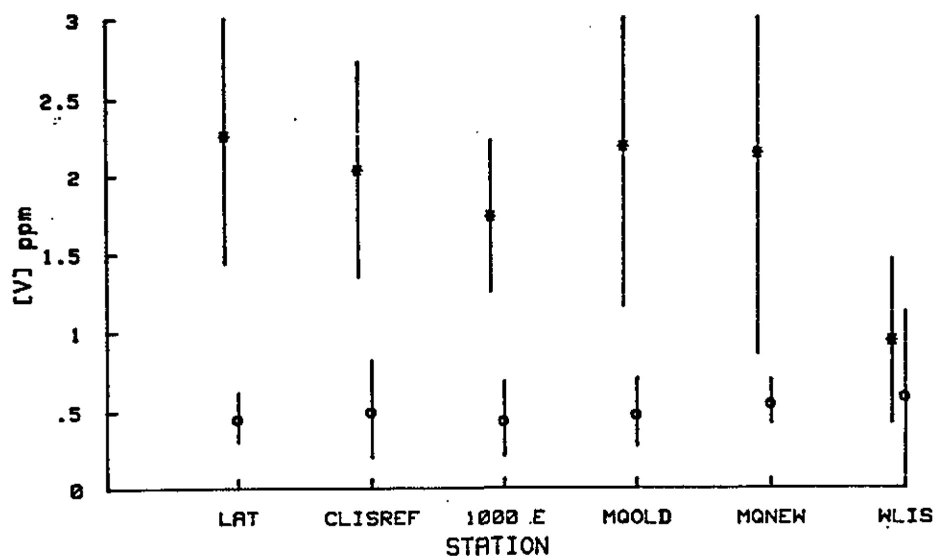

FIGURE III-5-3. The mean concentration of Vanadium during (*) and after (o) dumping operations in the six mussel monitoring populations maintained at the Eastern, Central and Western Long Island Sound sites.

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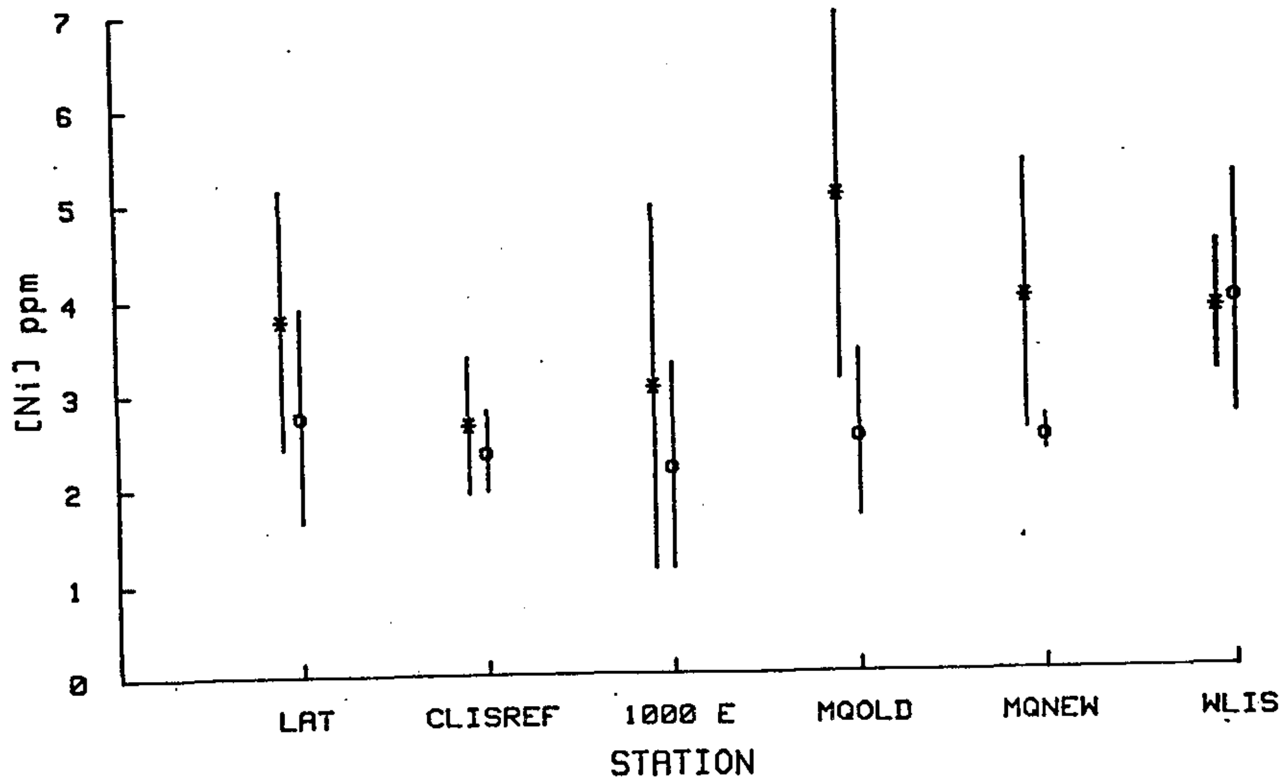

FIGURE III-5-4. The mean concentration of nickel during (*) and after (o) dumping operations in the six mussel populations maintained at the Eastern, Central and Western Long Island Sound sites.

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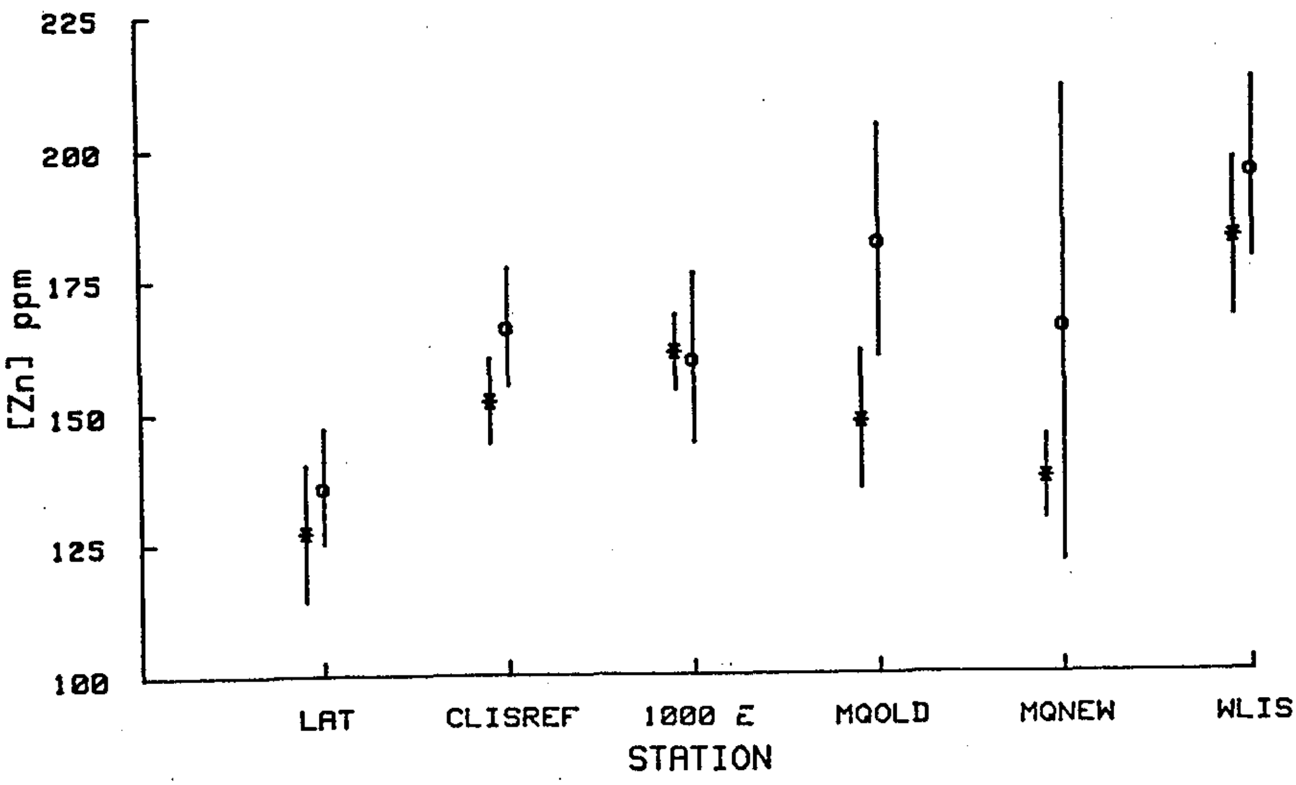

FIGURE III-5-5. The mean concentration of zinc during (*) and after (o) dumping operations in the six mussel populations maintained at the Eastern, Central and Western Long Island Sound sites.

SAIC

TABLE III-5-4

Stepwise multiple regression models for Cd, Cr, Co, Cu, Fe, Hg, Ni, and V at six stations: LAT, CLIS-REF, 1000E, MQO, MQN and WLIS. %=the ammount of variance in the trace metal concentration explained by the model after the variable on the same row has entered the model. Variable code: L = shell length; W/D wet/dry ratio, T = ambient water temperature, D - disposal volume; M = month Transformation code: 1 = ln[x], 2 = Ni.

		STATIONS											
		LAT		CLIS-REF		1000E		MQO		MQN		WLIS	
Metal	Variables		%		%		%		%		%		%
Cd[1]	1	W/D	6.9	W/D	92.2	W/D	74.3	W/D	54.9	W/D	97.2	W/D	0.4
	2	L	94.7	L	92.4	L	79.5	L	62.3	L	97.3	L	0.8
	3					M	99.9					D	49.5
	4					D	100.0						
Cr[1]	1	W/D	0.0	W/D	7.5	W/D	76.4	W/D	0.7	W/D	8.4	W/D	3.8
	2	L	4.4	L	44.2	L	76.6	L	19.1	L	10.0	L	7.0
	3					D	99.6						
	4					M	100.0						
Co	1	W/D	1.2	W/D	8.3	W/D	46.2	W/D	6.6	W/D	82.6	W/D	1.5
	2	L	2.2	L	8.4	L	50.5	L	34.1	L	87.6	L	1.9
Cu	1	W/D	0.7	W/D	58.2	W/D	95.7	W/D	12.4	W/D	24.0	W/D	5.2
	2	L	35.0	L	64.8	L	96.3	L	64.8	L	28.8	L	8.4
	3			T	99.2	M	99.9			D	99.6	M	85.8
	4					T	100.0						

TABLE III-5-4 (Cont.)

Metal	Variables	STATIONS LAT %	CLISr %	1000ME %	MQO %	MQN %	WLIS %
Fe	1	W/D 0.0	W/D 5.4	W/D 31.7	W/D 2.0	W/D 5.5	W/D 54.4
	2	L 14.1	L 46.3	L 54.7	L 32.8	L 51.4	L 59.2
	3				D 84.0		T 85.4
	4				T 99.4		
Hg	1	W/D 24.0	W/D 13.4	W/D 21.3	W/D 26.2	W/D 73.3	W/D 29.3
	2	L 45.0	L 20.4	L 45.4	L 29.4	L 92.3	L 33.1
	3			T 99.5			
	4			D 100.0			
Ni[2]	1	W/D 0.7	W/D 0.4	W/D 20.3	W/D 0.1	W/D 2.6	W/D 31.2
	2	L 12.4	L 75.1	L 92.5	L 30.4	L 8.4	L 31.9
	3			D 99.8		M 99.3	
	4			T 100.0			
Zn[1]	1	W/D 4.6	W/D 91.3	W/D 13.7	W/D 81.6	W/D 85.8	W/D 3.6
	2	L 12.2	L 94.6	L 31.0	L 94.5	L 97.5	L 70.6
	3			D 98.7			D 84.8
	4			T 100.0			
V	1	W/D 2.9	W/D 13.7	W/D 44.7	W/D 5.2	W/D 10.8	W/D 2.4
	2	L 48.7	L 36.4	L 60.0	L 61.8	L 13.8	L 18.5
	3	M 81.5	T 99.9	M 99.4			D 61.5
	4			T 100.0			

temperature, entered into the copper and vanadium regression models. The concentrations of cobalt in all the monitoring populations were not correlated with any of the extrinsic independent variables. If the disposal of dredged material was the major source of trace metals found in the dumpsite monitoring populations (MQN, MQO, 1000E and WLIS), the dredged volume would be expected to enter all 36 stepwise multiple regression analyses (4 populations x 9 trace metals). The fact that the dredged volume entered only seven times or ca. 20% of the cases (Table III-5-4) strongly suggests that the activity of dredged material disposal was not a major factor in the uptake of trace metals by the mussels.

Even in cases where large percentages of variance in trace metal concentrations were attributed to dredged material disposal, there was evidence indicating that losses of certain trace metals occurred after the cessation of dumping; such examples are copper and iron at MQN and MQO respectively (Fig III-5-6), chromium and cadmium at 1000E and WLIS respectively (Fig III-5-7), as well as vanadium at WLIS (Fig III-5-8).

Zaroogian and Johnson (1983) reported chromium uptake and loss by Mytilus edulis in a flow-through seawater system. They showed that the concentration of chromium in mussel tissues reached 4.83 ±1.32 g/g dry weight following 12-week treatment with seawater containing 5 ppb Cr. This level is comparable to the concentration (4.24 ± 0.86 g/g dry weight) found in mussels maintained at 1000E following exposure to dumping for less than 3 weeks. However, the tissue chromium level decreased during the next 21 weeks following completion of disposal to 0.98 + 0.21 g/g or a reduction of 77% of the previous concentrations. These results are roughly comparable to the 61% loss in 28 weeks reported by Zaroogian and Johnson (1983). The similarity in the trend of tissue chromium losses for the two experiments was remarkable considering the fact that the two studies differed in approaches, e.g., laboratory versus field experiments, controlled vs. non-controlled exposure in term of chromium concentrations and the duration of exposure, as well as defined vs. undefined contaminants. One important difference between the two studies was the behavior of the chromium concentrations of their control populations as compared to the reference populations of this program. No discernible temporal variations of chromium concentrations in mussels were apparent in Zaroogian and Johnson's control group. In this field experiment, the temporal variations of certain tissue trace metal concentrations was a prominent feature in the reference population and suggested that dumping of dredged material could enhance the amplitude of the temporal fluctuations.

Marine sediments are the ultimate depository of trace metals resulting from the weathering of the earth crust and from anthropogenic activities. The determination of trace metal concentrations in the sediments from the reference and disposal sites is important because the release of trace metals from the sediments through physical or biological perturbations could be the source of contaminants in the mussels deployed in the area.

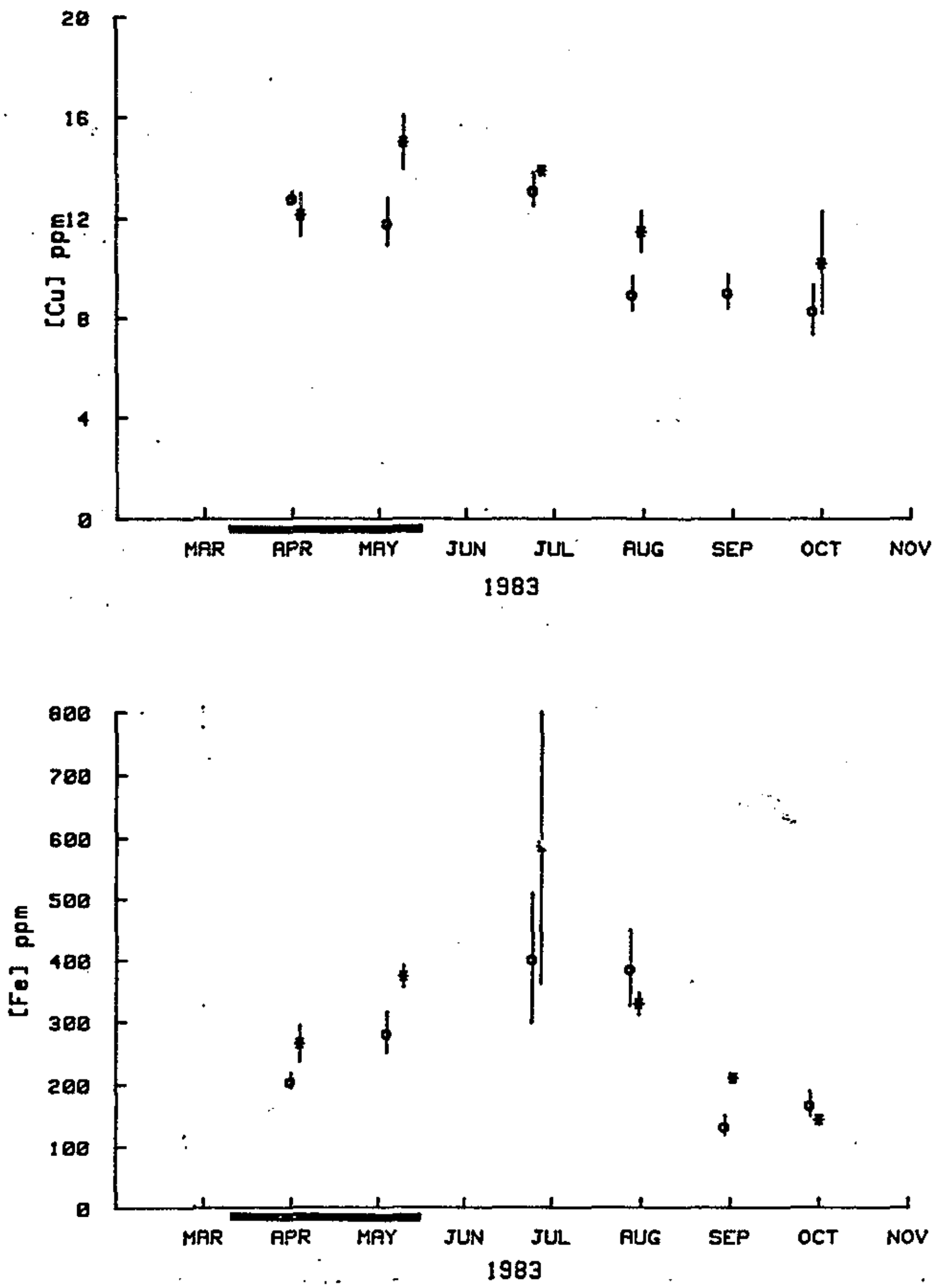

FIGURE III-5-6. Temporal variations of copper and iron in MQO and MQN mussel monitoring populations (*) in contrast with the CLIS-REF reference population (o). Black horizontal bar denotes the period of dumping activity.

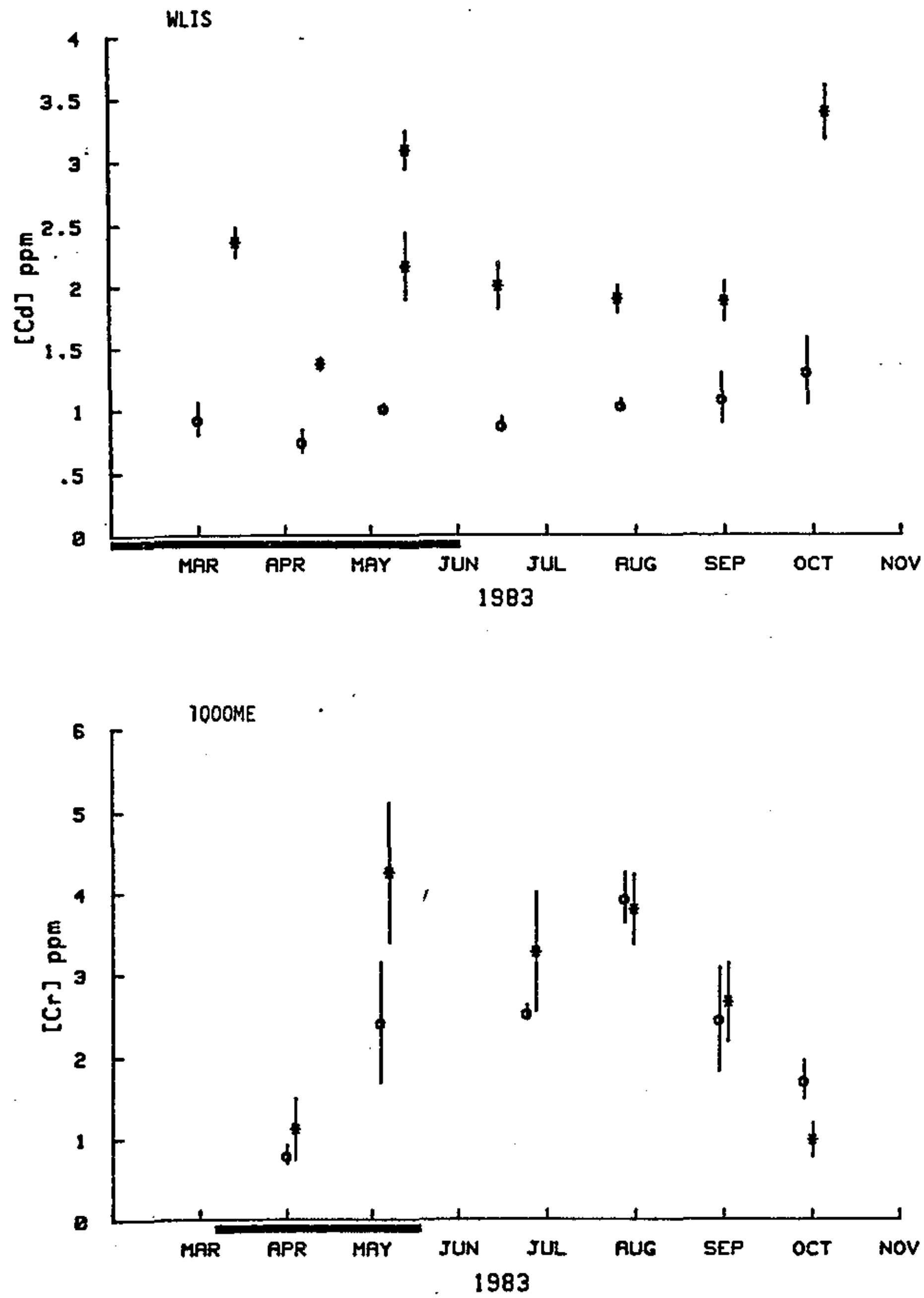

FIGURE III-5-7. Temporal variations of cadmium and chromium in WLIS and 1000E mussel monitoring populations (*) in contrast with the LAT and CLIS-REF reference populations (o) respectively. Black horizontal bar denotes the period of dumping activity.

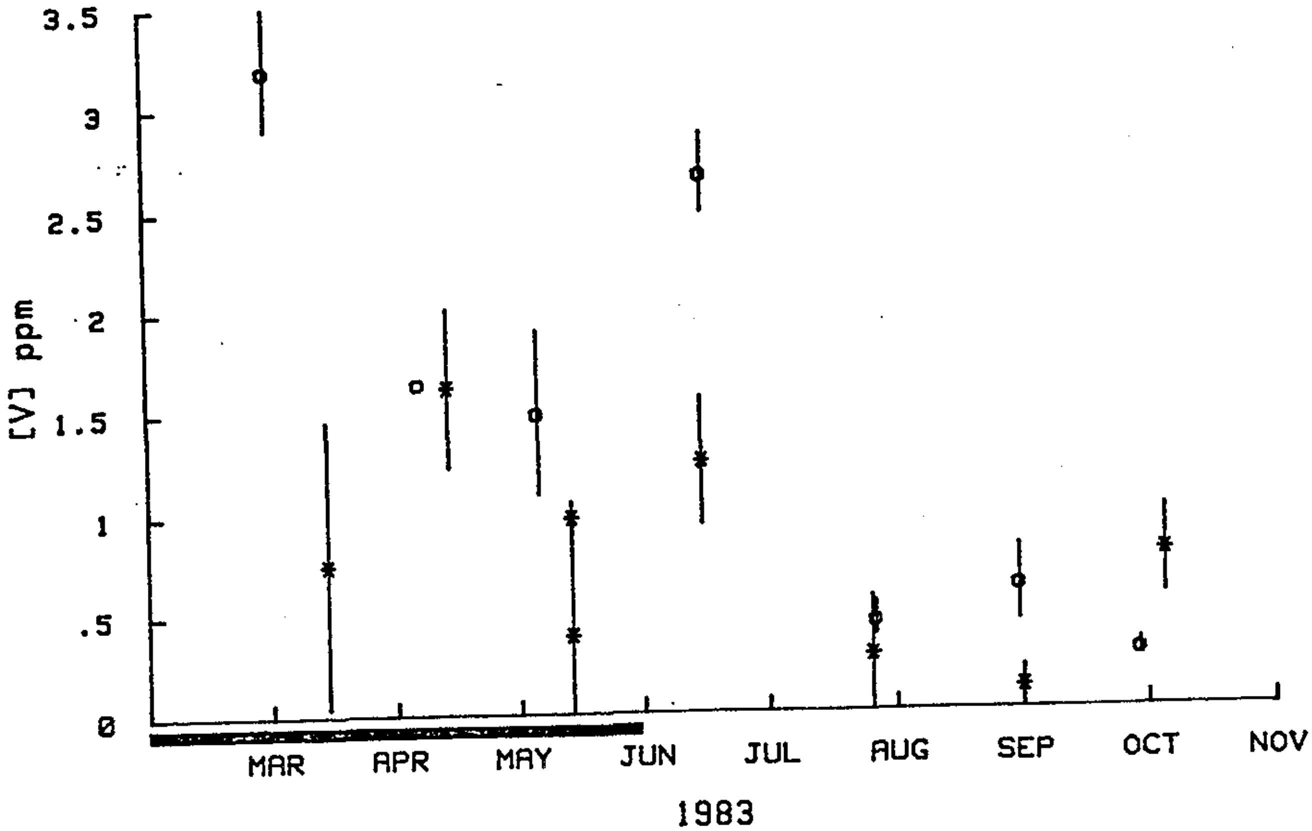

FIGURE III-5-8. Temporal variations of vanadium in WLIS mussel monitoring population (*) in contrast with the LAT reference population (o). Black horizontal bar denotes the period of dumping activities.

During the sampling of mussels at 1000E, divers (SCUBA) reported that unspecified quantities of dredged material were observed at the station even though it was well beyond the designated disposal location. To verify whether dumping did in fact take place at this station or others, core samples were collected in the immediate vicinity of the deployed mussel platforms. Figure III-5-9 depicts the profile of the six cores. With the exception of the CLIS-REF core which showed a uniform brown coloration and texture, all cores from the dumpsite stations were covered with a 0.5 to 4 cm veneer of oxidized layer and immediately below there was a black section of varying thickness with a characteristic hydrocarbon smell. The LAT core consisted mainly of fine sands with no hydrocarbon smell.

Trace metal levels and percent organic carbon (TOC) measured in the cores are shown in Table III-5-5. Spatial variations in the sediment trace metal concentrations were readily observed associated with eastern, central and western Long Island Sound. Generally, the highest concentrations were found in the western end of the Sound, the intermediate concentration at the central region, and the lowest level in the far eastern end of the Sound. Also, in terms of the concentration profile within the cores, the trace metal concentrations and TOC levels in the reference cores were higher in the surficial layer than in any other layer, while, in the dumpsite cores, the middle or the lower layers had much higher concentrations of trace metals and TOC.

In order to assess the degree of contamination of the sediments at each platform site, an enrichment factor (EF) was calculated. The enrichment factors are used to compare trace metal ratios in sediments with those in the reference materials, i.e. average crustal trace metal concentration (Taylor, 1964). Both the crustal and observed sediment element concentrations were normalized against iron because it is abundant and its anthropogenic sources are small as contrasted with natural sources. The EF is derived from the following equation:

$$EF = \frac{\dfrac{[x]}{[Fe]_s}}{\dfrac{[x]}{[Fe]_c}}$$

where [x] / [Fe] is the ratio of a given elemental concentration to the concentration of iron in the sediment (s) and the crustal (c) material. If the source of x in sediments were due to weathering of crustal material alone, one would expect an EF of unity which suggests no enrichment relative to the crustal values. In practice, elements with enrichment factors equal to or less than 5 are considered non-enriched.

Table III-5-6 summarizes elemental enrichment factors of surficial sediments found at the six stations. Cobalt, nickel, mercury and vanadium were not enriched at any station.

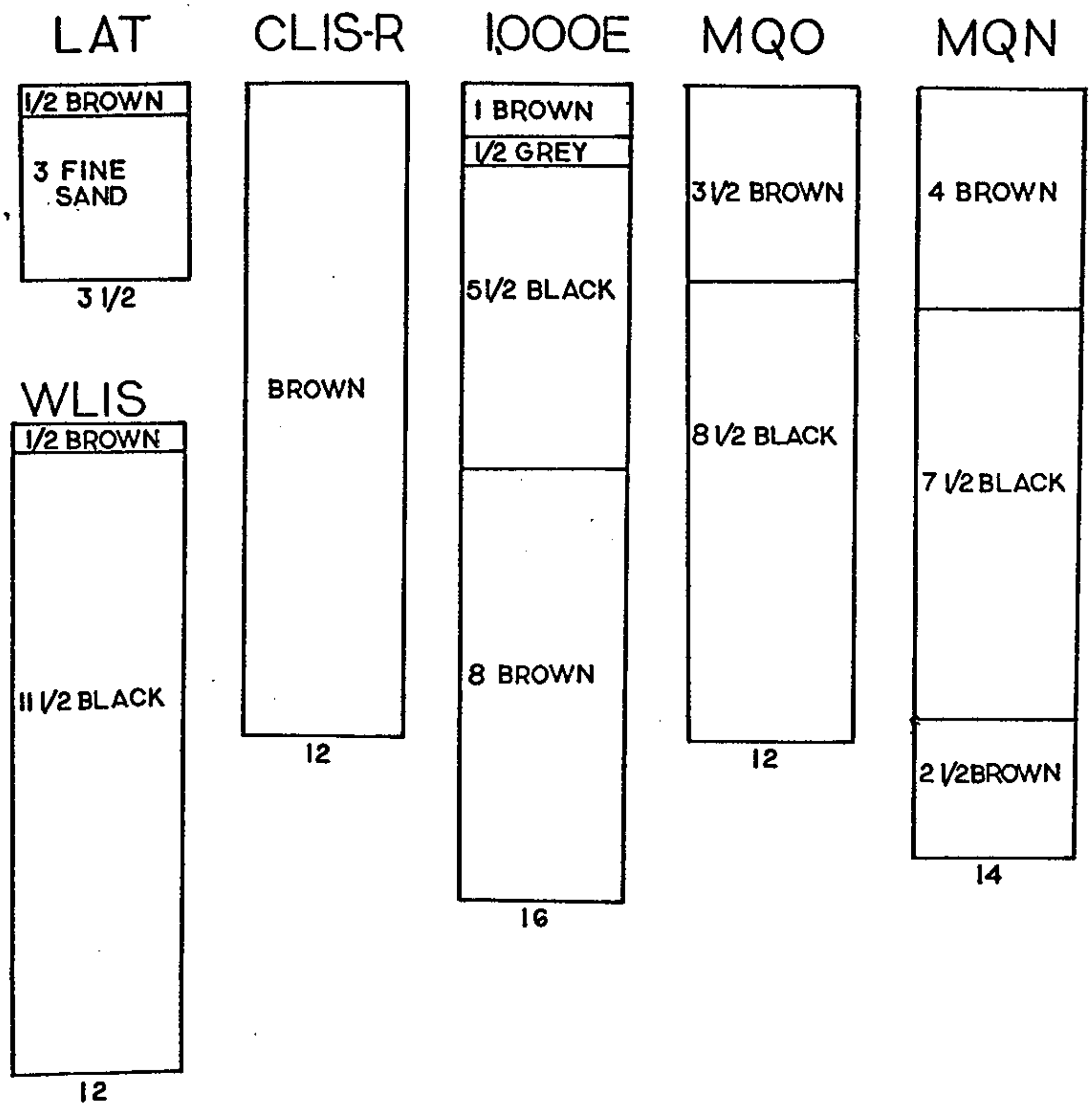

FIGURE III-5-9. Profiles of the sediment cores collected from LAT, CLIS-REF, 1000E, MQN, and WLIS on September 27, 1983.

TABLE III-5-5

The concentrations of trace metals and total organic carbon (TOC) in the six cores collected from Latimers Light (LAT), Central Long Island Sound reference site CLIS-REF, 1000E east of FVP site (1000E), Mill-Quinnipiac Old site (MQO), Mill-Quinnipiac new site (MQN) and Western Long Island Sound site (WLIS) on September 27, 1983. T = top layer of the core, M = mid layer, B = bottom layer.

		μg/g dry weight									
Station		Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V	TOC(%)
LAT	T	0.16	64.9	3.16	33.0	10945	--	12.5	80.8	21.8	2.67
	B	0.03	14.0	1.71	44.4	1988	0.083	3.4	8.1	4.0	0.40
	T	0.14	172.6	4.75	71.7	22905	0.148	24.1	161.9	22.8	2.90
CLIS-REF	M	0.16	108.5	4.48	66.7	18604	0.153	21.8	129.6	17.5	1.58
	B	0.08	103.7	2.82	68.1	18983	0.180	19.4	113.2	18.6	2.08
	T	3.63	483.1	4.21	550.7	18002	0.135	40.5	300.9	21.8	2.72
1000E	M	24.00	2161.6	4.40	2934.0	24003	0.584	135.5	1349.0	32.7	5.92
	B	0.25	144.4	4.54	68.2	18998	0.131	24.1	137.7	22.6	1.64
	T	2.28	418.6	4.19	263.2	18593	0.102	31.1	268.1	24.3	3.31
MQO	M	2.89	483.1	4.54	304.5	25765	0.216	31.1	375.6	29.2	3.40
	B	3.11	802.8	4.23	614.4	22910	0.185	39.1	309.0	27.1	3.28
	T	0.92	353.8	4.58	139.1	22272	0.145	24.1	186.4	23.8	4.09
MQN	M	3.98	611.8	4.69	404.8	27356	0.200	40.5	375.0	29.4	4.54
	B	1.21	289.2	4.41	127.0	20213	0.158	21.1	202.9	24.1	2.84
	T	0.39	354.0	4.74	90.9	21867	0.112	21.8	178.4	23.1	2.84
WLIS	M	0.57	288.5	4.69	138.1	25943	0.137	31.0	267.7	32.4	5.60
	B	0.81	353.5	4.71	145.1	23753	0.139	31.0	243.3	28.2	3.01

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TABLE III-5-6

Enrichment Factors in Surficial Sediments relative to Crustal Materials.

	Station					
Element	LAT	CLIS-REF	1000E	MQO	MQN	WLIS
Cd	4	2	81	33	11	5
Co	0.6	0.4	0.5	0.5	0.4	5
Cr	3	4	14	11	9	9
Cu	3	3	30	14	6	4
Hg	-	4	5	4	4	3
Ni	0.8	0.8	0.6	1	0.8	0.7
Zn	6	5	13	11	6	6
V	0.8	0.4	0.5	0.5	0.4	0.4

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Most of the trace metals at the two reference stations (LAT and CLIS-REF) were considered not enriched except for zinc at LAT which was marginally enriched. In contrast, the surficial sediment was contaminated with chromium and zinc at WLIS. This general trend of increasing sediment trace metal concentrations in the Sound was observed by Greig et al. (1977), and probably reflects the pattern of urban and industrial development with cadmium, chromium, copper and zinc. The degree of enrichment was greatest at CLIS dumpsite stations, reflecting the higher metal concentration of the dredged material and the heightened disposal activities in the region. Within the dumpsite, the apparent lower enrichment factors at MQO and MQN as compared with that of 1000E could be correlated with the character of the dredged material and the manner in which the material was treated, i.e. capped or exposed. These physical observations provide supporting evidence in understanding the spatial and temporal variations of trace metals encountered in the mussel populations discussed in the previous sections.

5.1.2 Polychlorinated Biphenyls (PCB)

The mean concentrations of the Aroclors and the total PCB from the six mussel monitoring populations are shown in Table III-5-7. Concentrations of the total PCB, Aroclor 1242 and Aroclors 1254 + 1260 in mussels at 1000E and WLIS were higher during the disposal operations than after the cessation of dumping and the differences were significant (Table III-5-8) suggesting uptake and depuration of PCB's by the mussel. Mussels maintained at LAT, CLIS-REF and MQO did not show higher levels of the Aroclors or the total PCB during dumping (Figures III-5-10, 11, and 12). However, regardless of whether the differences were significant or not, there was an element of consistency for the pattern of higher levels during disposal operations in all the experimental monitoring populations (Figures III-5-13 to 18 and III-5-19 and 20). Arimoto and Feng (1983) also observed a higher level of Aroclor 1254 ($p = 0.07$) in the mussels deployed at the Eastern Long Island disposal site during disposal at this site.

The two-way ANOVAs were used to test whether there were spatial or temporal differences in the PCB concentrations between the six mussel populations maintained at the six stations. Significant spatial differences were detected in the Aroclors 1254 + 1260 between MQN and the two reference sites LAT and CLIS-REF, and no differences were found among 1000E, WLIS, CLIS-REF and LAT, a finding similar to that of the trace metal data discussed in the previous section.

Due to the availability of an extensive data base for mussels maintained at LAT, MQO and WLIS (from November 1982 to September 1983) as compared with the other three mussel populations, two-way ANOVAs were also carried out for the former three populations (Table III-5-9). The results showed significant spatial variations for the Aroclor (1254 + 1260) concentrations and temporal variations for the total PCB concentrations. Between station differences occurred in mussels held at LAT and WLIS; but no differences were apparent between WLIS and MQO, or

TABLE III-5-7

Total polychlorinated biphenyl (PCB) and Aroclor concentrations in *Mytilus edulis* (± 1 S.D.) March to September 1983.

Station	n	Aroclor 1242	Aroclors 1254+1260	Total PCB
LAT				
D	4	367 ± 210*	307 ± 97	674 ± 212
A	3	417 ± 308	286 ± 108	703 ± 414
D+A	7	388 ± 233	297 ± 94	686 ± 282
CLIS-REF				
D	3	288 ± 10	311 ± 47	600 ± 38
A	3	287 ± 183	424 ± 195	711 ± 376
D+A	6	288 ± 116	368 ± 141	655 ± 247
1000E				
D	2	450 ± 103	834 ± 199	1284 ± 96
A	3	157 ± 153	543 ± 97	700 ± 246
D+A	5	274 ± 200	659 ± 200	933 ± 367
MQO				
D	3	465 ± 100	531 ± 237	993 ± 311
A	3	191 ± 14	346 ± 52	537 ± 49
D+A	6	329 ± 163	439 ± 184	765 ± 320
MQN				
D	3	638 ± 383	1127 ± 540	1765 ± 912
A	2	464 ± 477	562 ± 189	1026 ± 666
D+A	5	568 ± 373	901 ± 501	1469 ± 830
WLIS				
D	3	498 ± 119	820 ± 301	1318 ± 415
A	4	238 ± 176	403 ± 187	641 ± 351
D+A	7	349 ± 199	581 ± 312	932 ± 502

D = During disposal, A = After disposal

* Expressed as ng per g of freeze-dried tissue

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TABLE III-5-8

Summary of two-way ANOVAs for the Aroclor and total polychlorinated biphenyl (PCB) concentrations in six populations of *Mytilus edulis*, March to September 1983.

	Aroclor 1242	Aroclor 1254+1260	PCB TOTAL[1]
Station (S)	NS	**	NS
Time (T)	*	**	**
S X T	NS	NS	NS
Scheffe Grouping $\alpha = 0.05$		MQN 1000ME WLIS MQO CLISr LAT	
	D > A	D > A	D > A

[1] ln total PCB ; NS = not significant; $*p \leq 0.05$; $**p < 0.01$;
D = during disposal concentrations; A = after disposal concentrations.

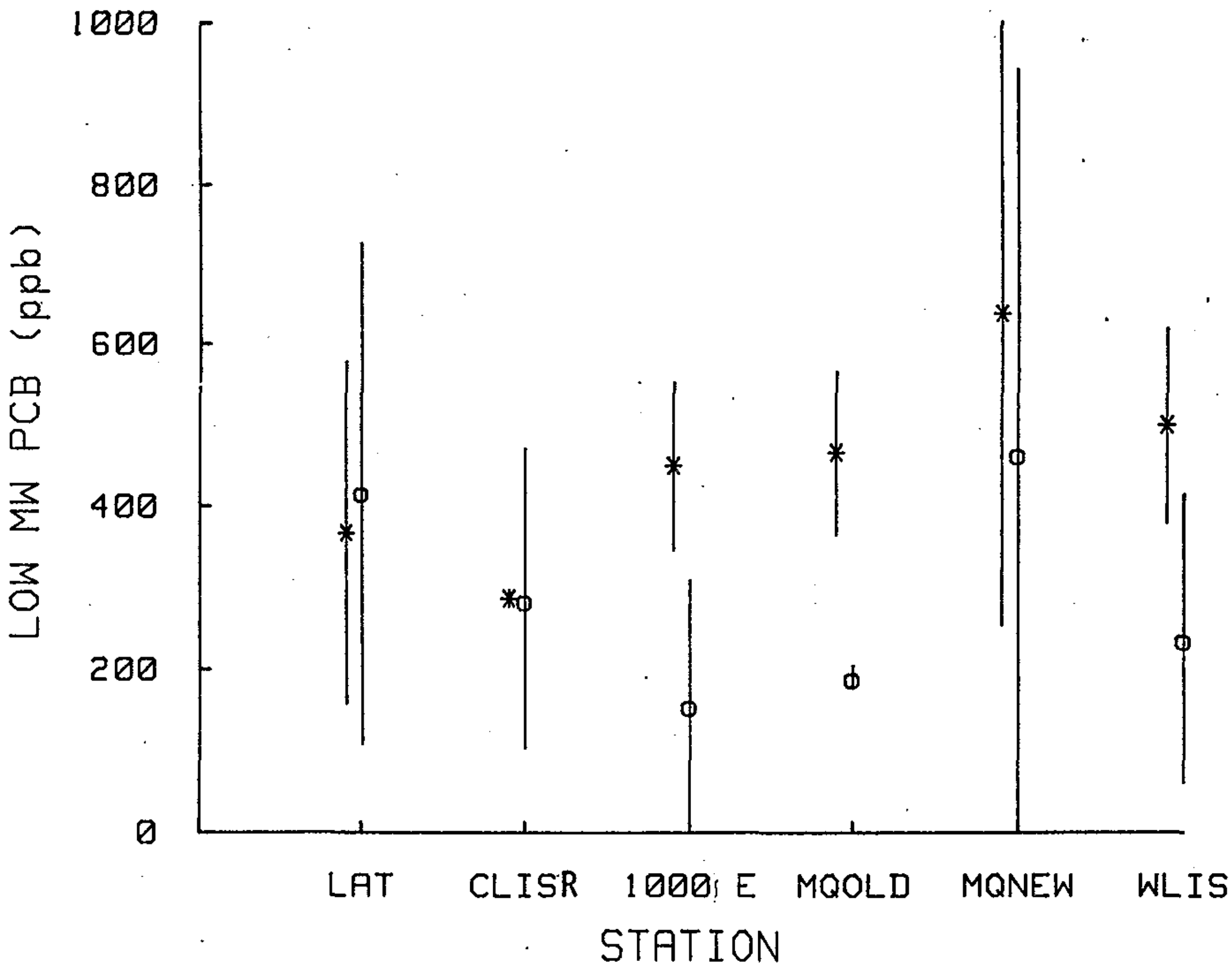

FIGURE III-5-10. The mean concentration of low molecular weight PCB (Aroclor 1242) during (*) and after (o) dumping operations in the six mussel monitoring populations maintained at the Eastern, Central and Western Long Island Sound sites.

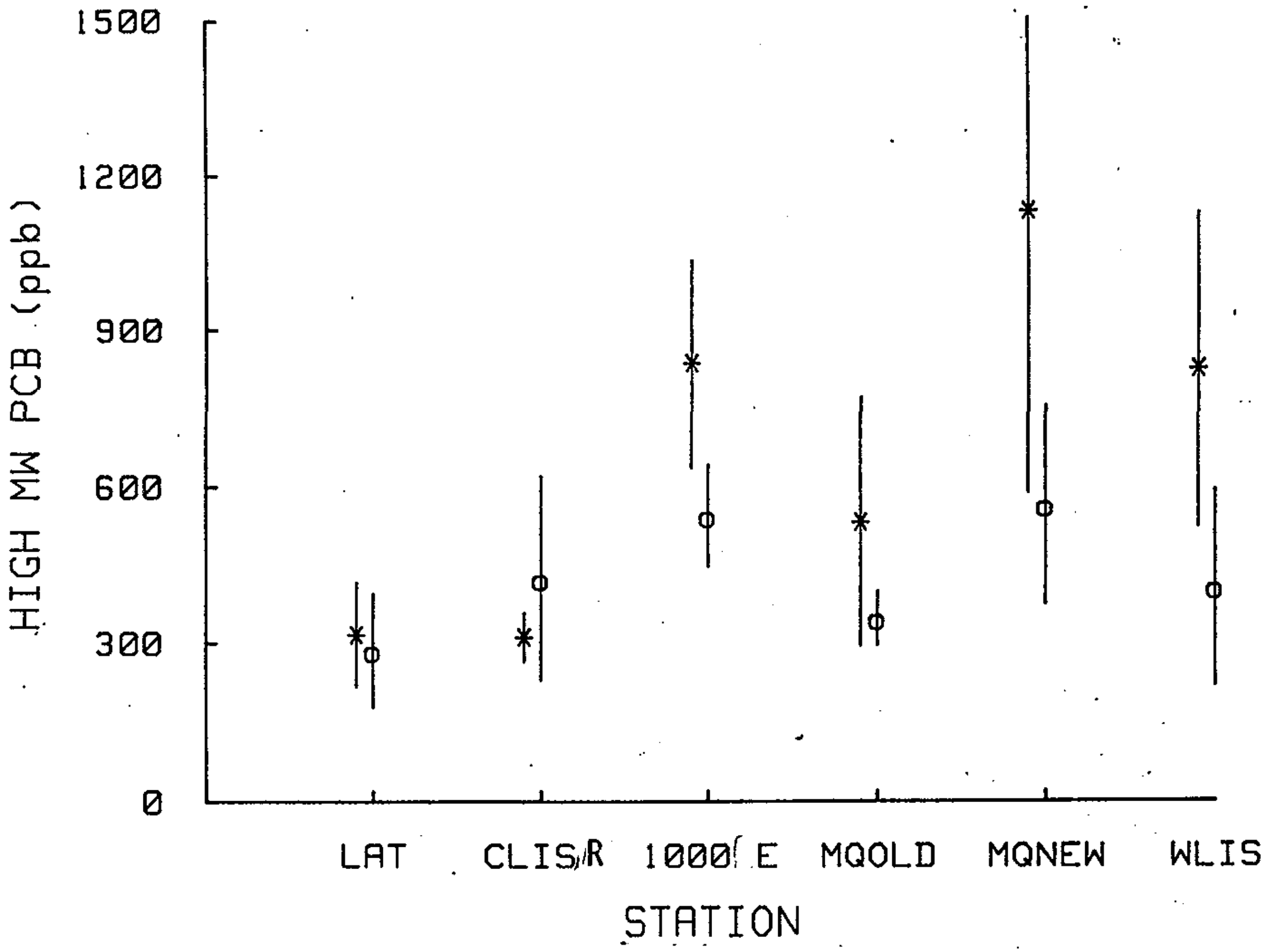

FIGURE III-5-11. The mean concentrations of high molecular weight PCB (Aroclors 1254 and 1260) during (*) and after (o) dumping operations in the six mussel monitoring populations maintained at the Eastern, Central and Western Long Island Sound sites.

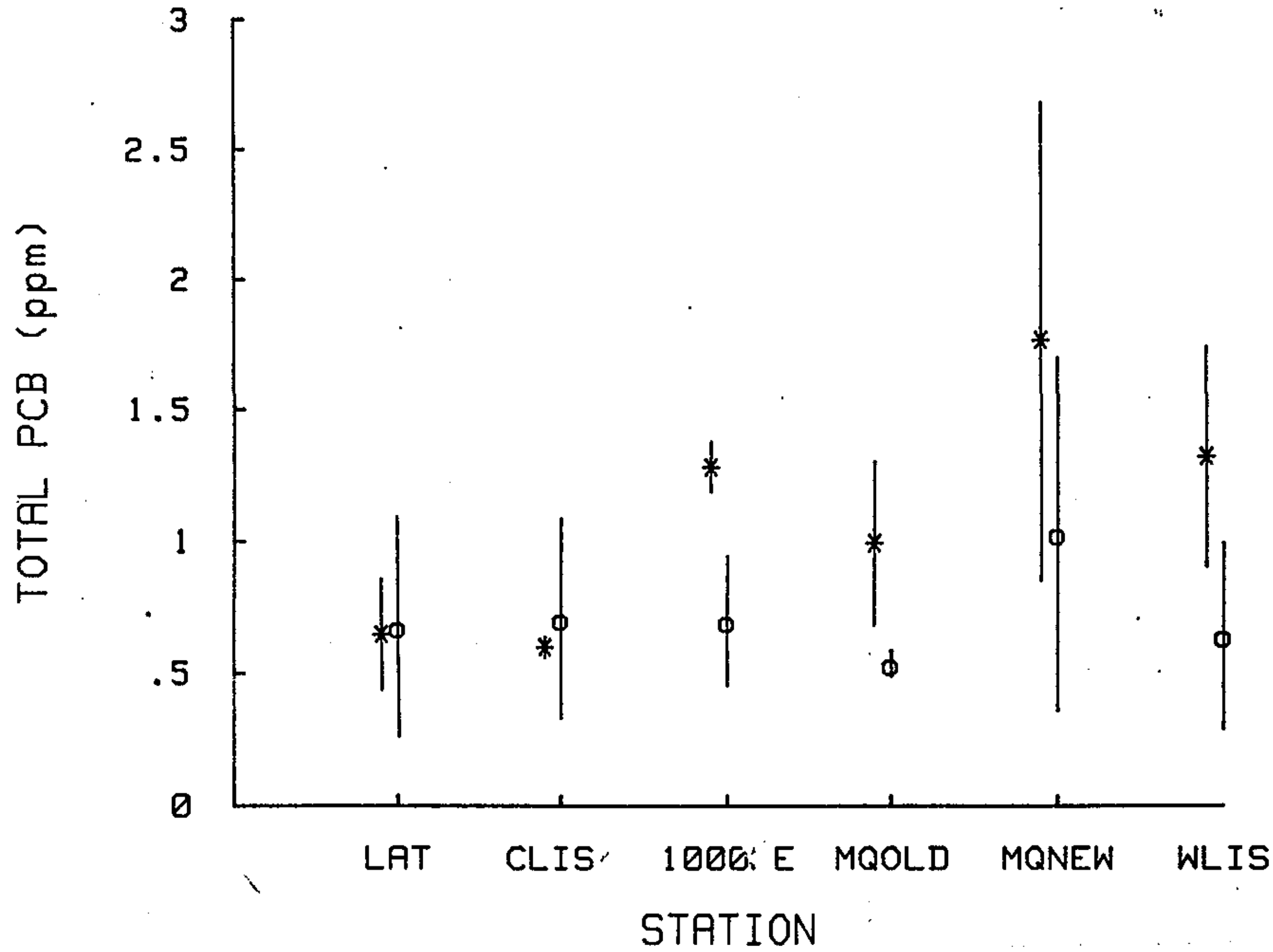

FIGURE III-5-12. The mean concentrations of total PCB during (*) and after (o) dumping operations in the six mussel monitoring populations maintained at the Eastern, Central and Western Long Island Sound sites.

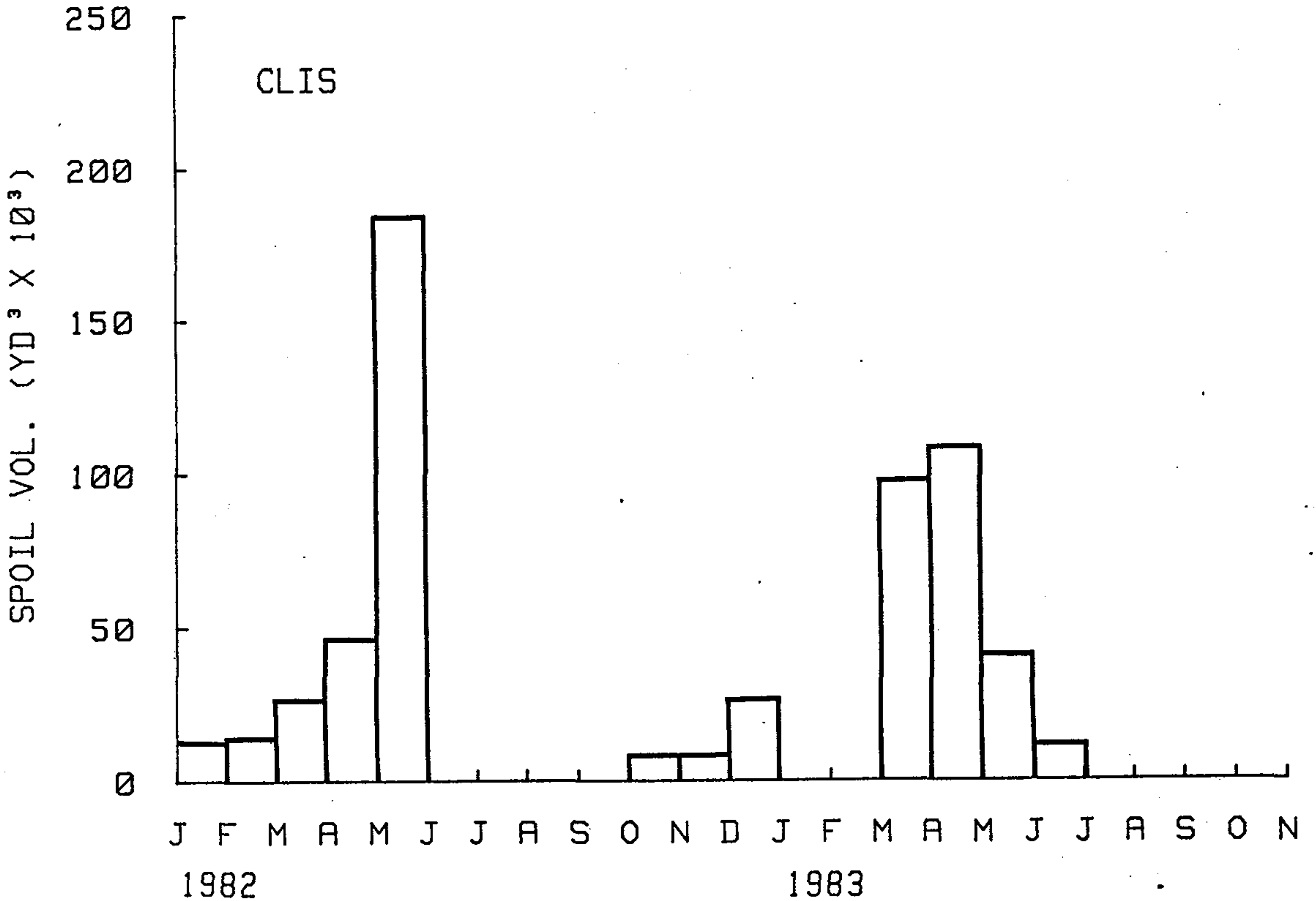

FIGURE III-5-13. A temporal record of dredged material deposited at Central Long Island Sound Disposal Site.

FIGURE III-5-14. Temporal variations of Aroclor 1242 (+), Aroclors 1254 and 1260 (o) and and total PCB (*) in the LAT mussel reference population.

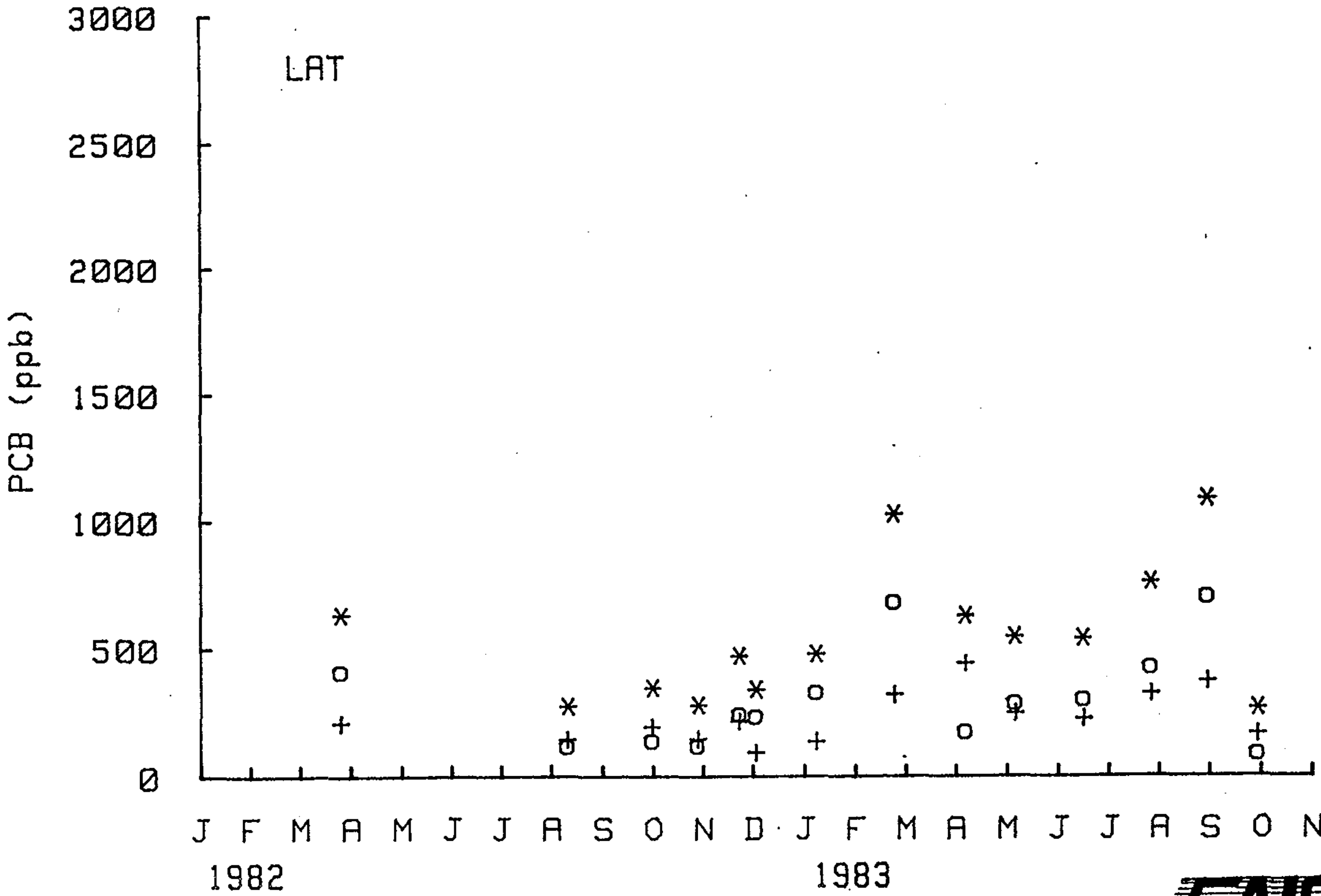

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FIGURE III-5-15. Temporal variations of Aroclor 1242 (+), Aroclors 1254 and 1260 (o) and total PCB (*) in the CLIS-REF mussel monitoring population.

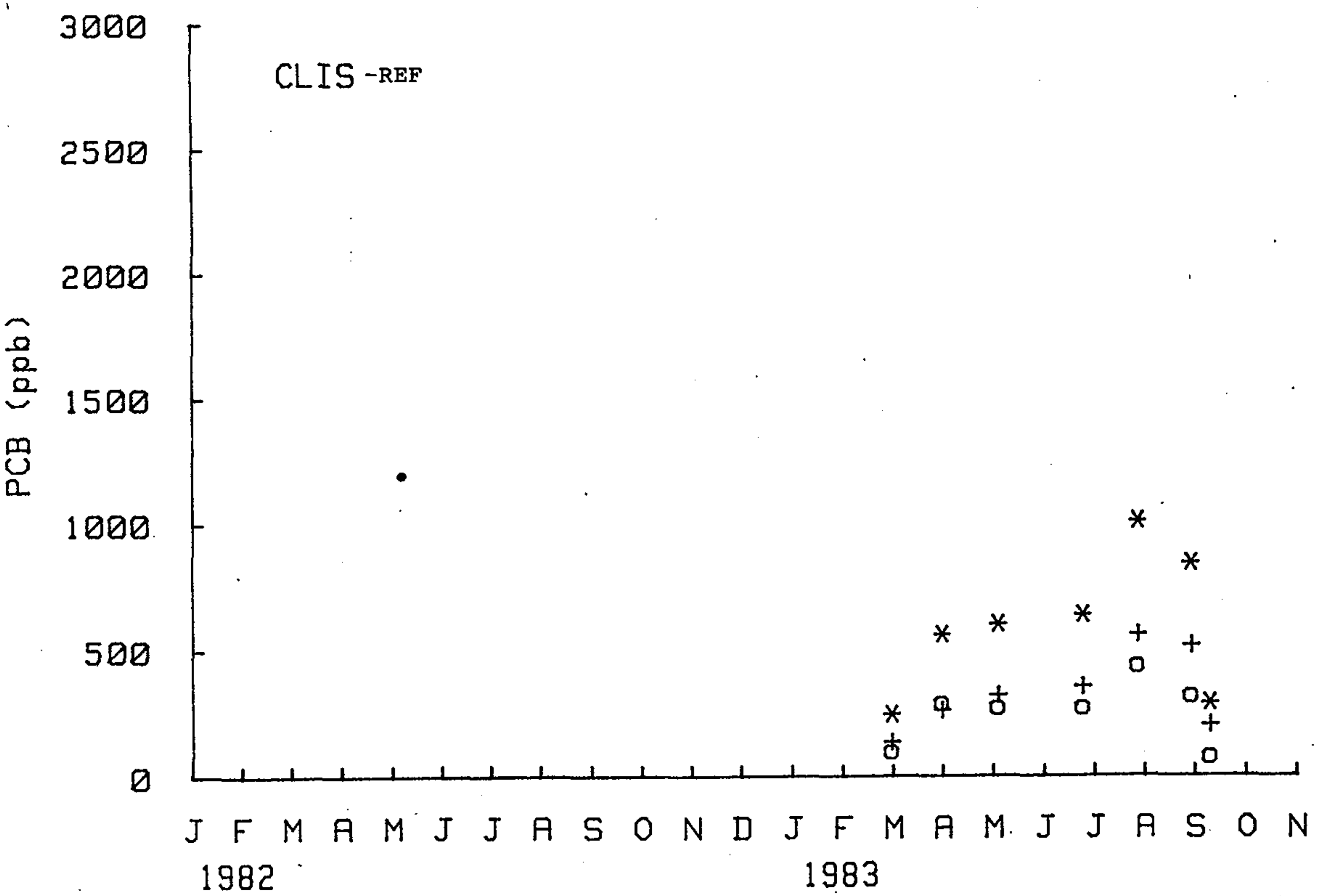

FIGURE III-5-16. Temporal variations of Aroclor 1242 (+), Aroclors 1254 and 1260 (o) and total PCB (*) in the 1000'E mussel monitoring population.

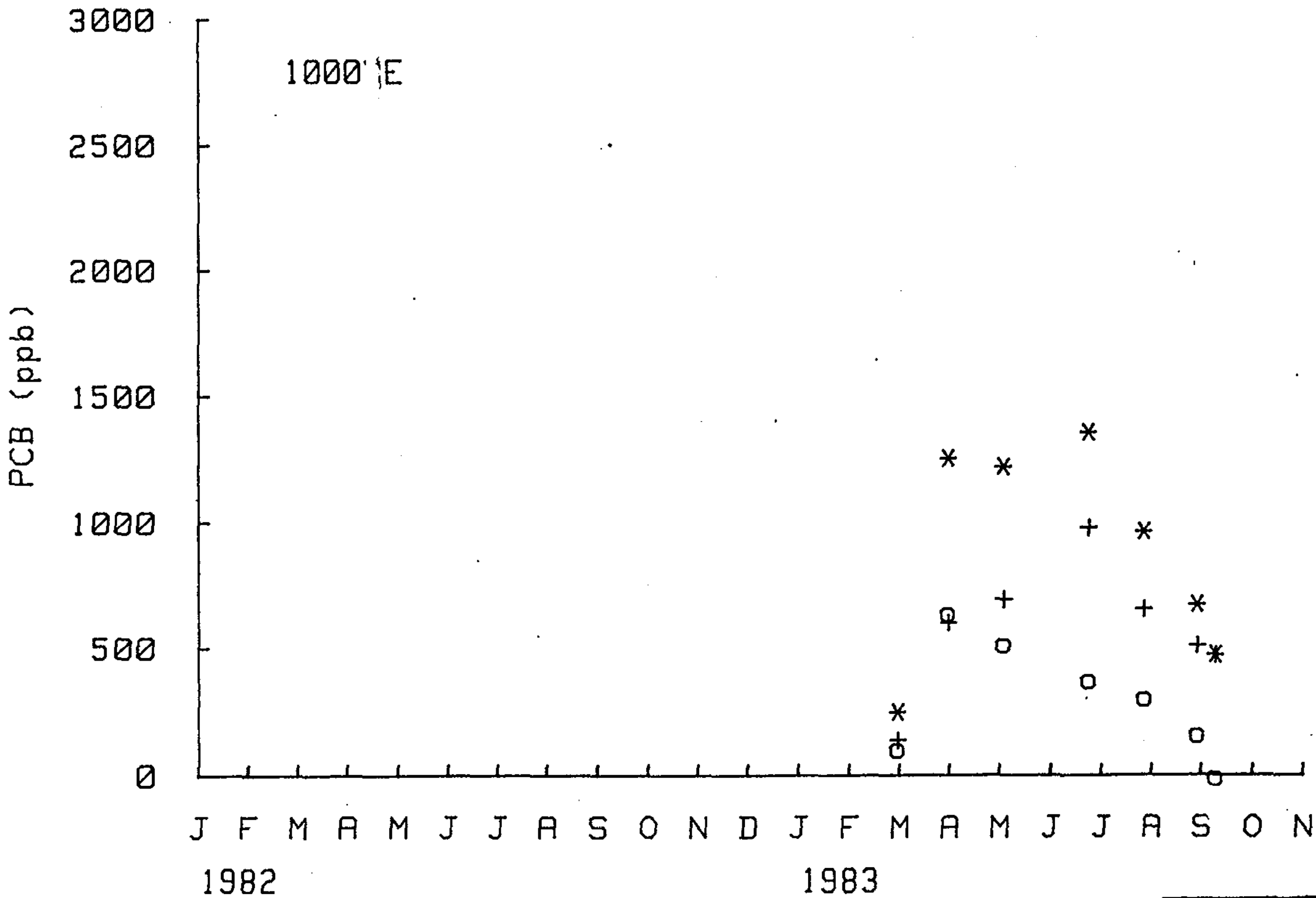

FIGURE III-5-17. Temporal variations of Aroclor 1242 (+), Aroclors 1254 and 1260 (o) and total PCB (*) in the MQO mussel monitoring population.

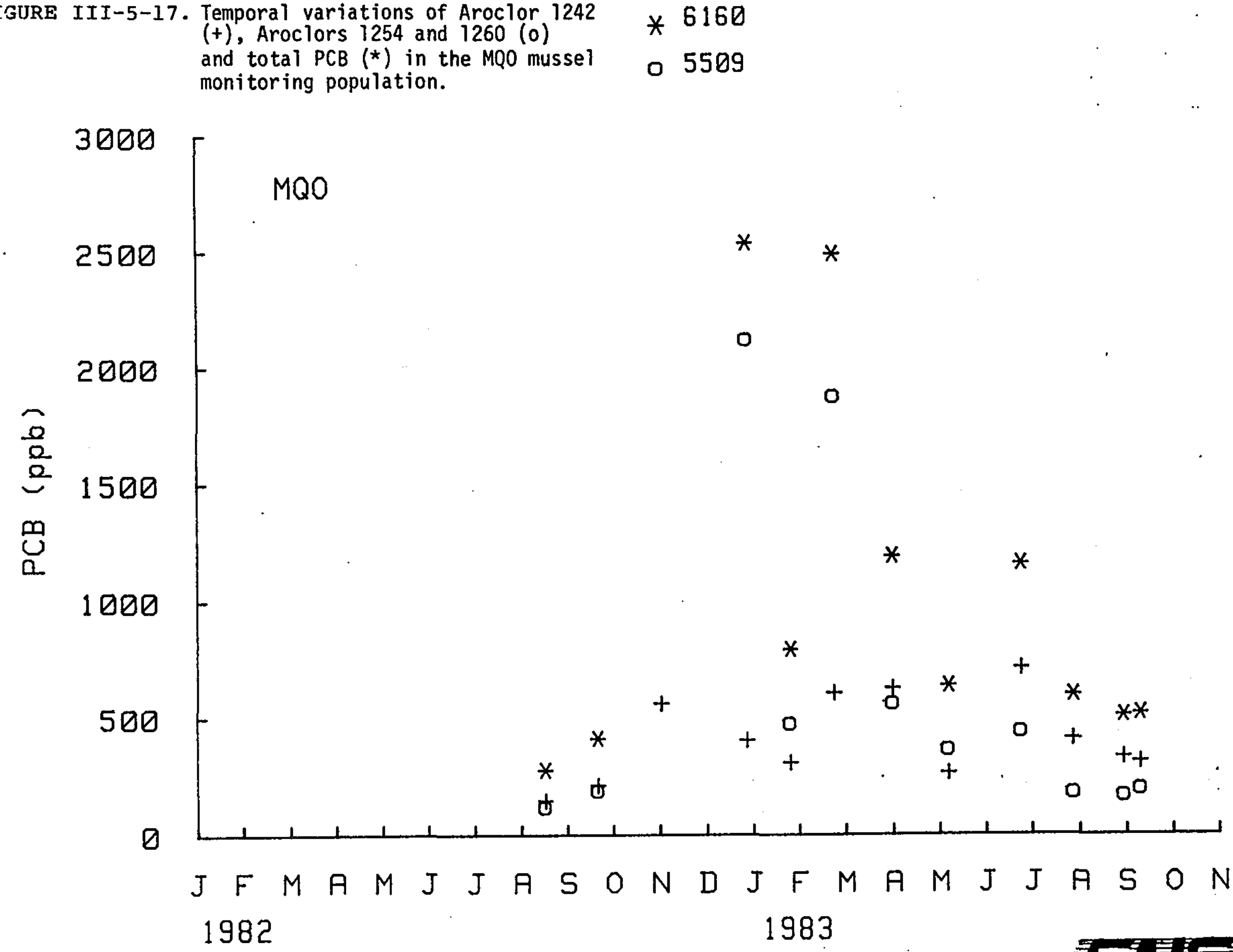

FIGURE III-5-18. Temporal variations of Aroclor 1242 (+), Aroclors 1254 and 1260 (o), and total PCB (*) in the MQN mussel monitoring population.

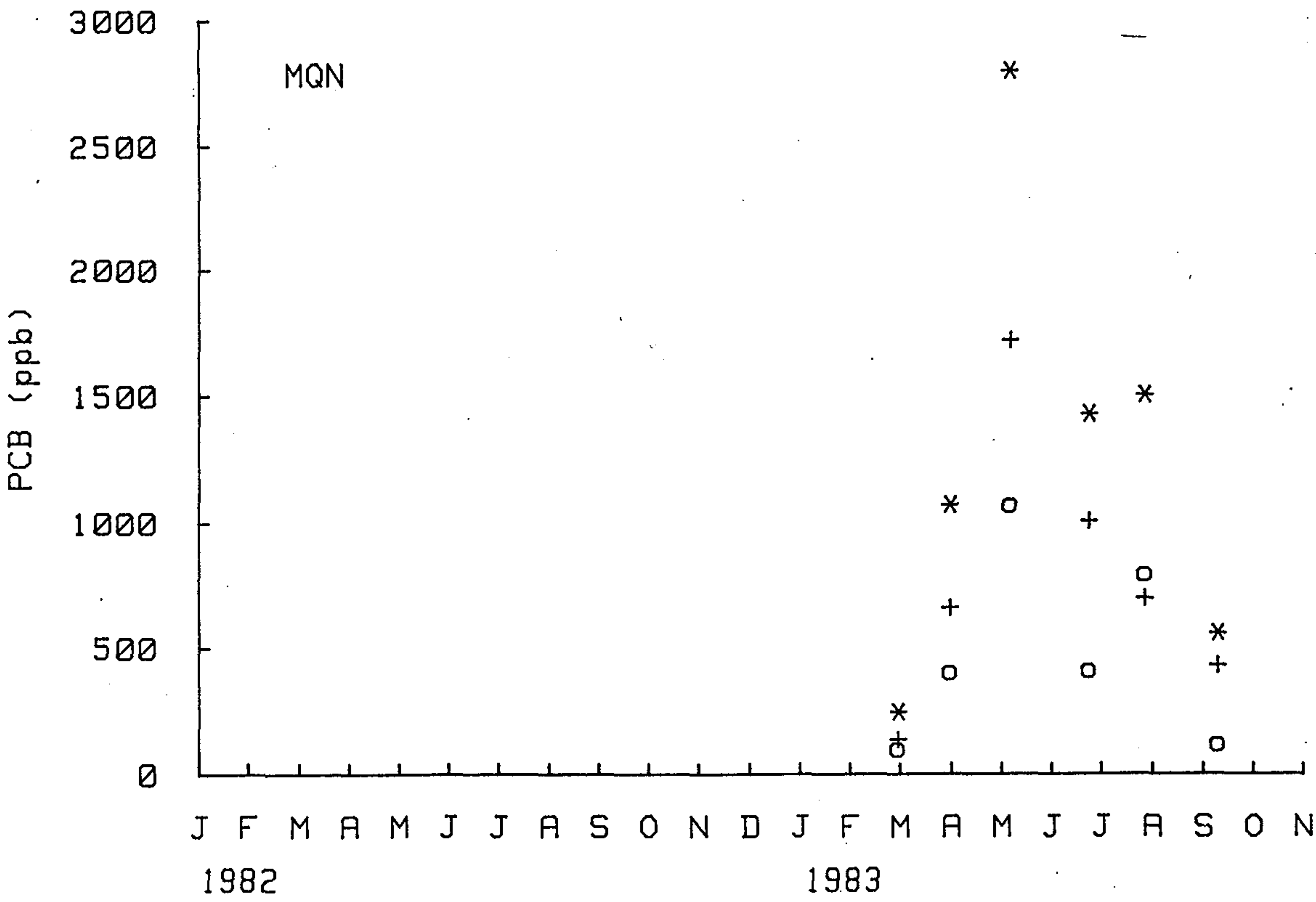

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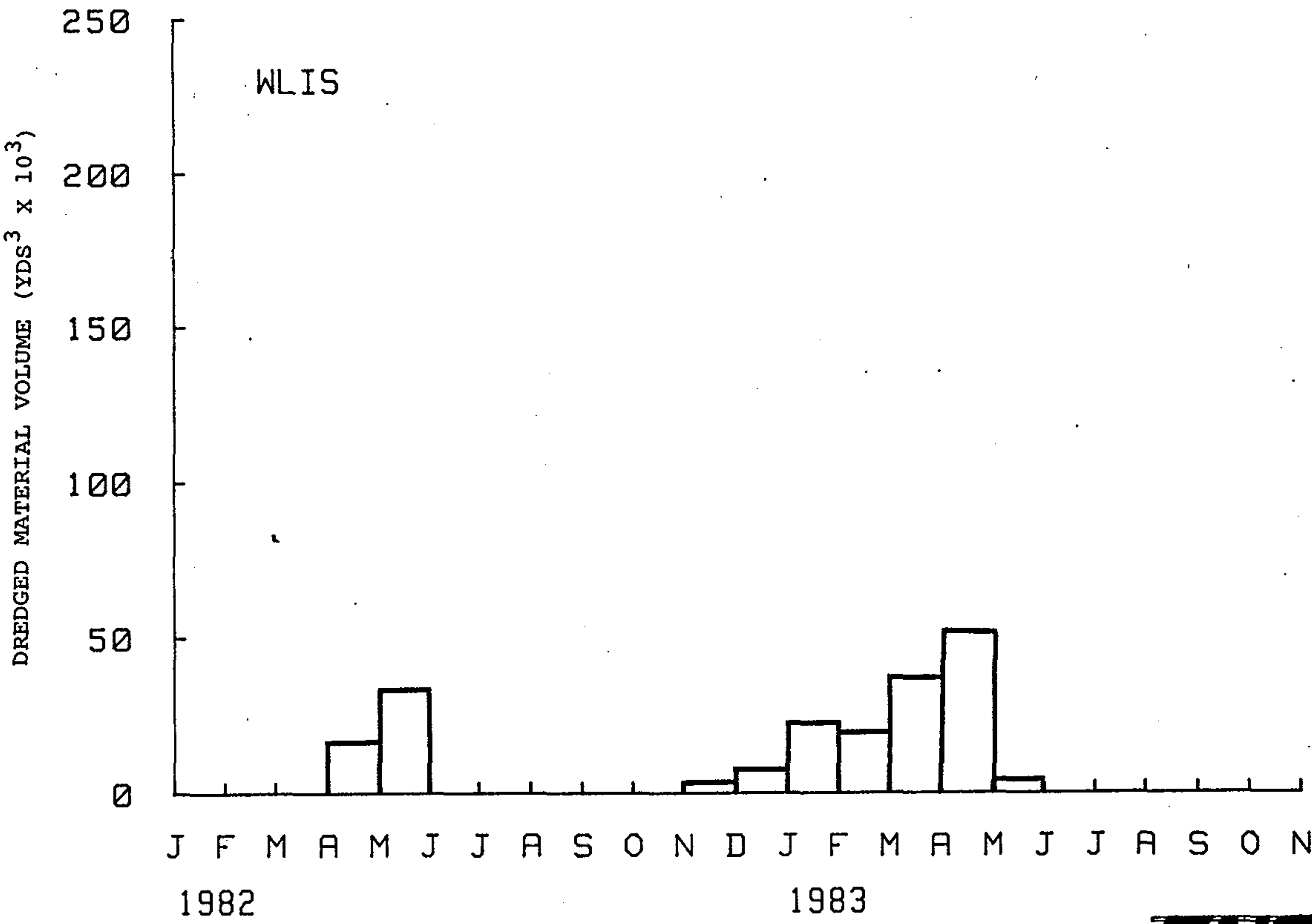
FIGURE III-5-19. Temporal record of dredged material deposited at the Western Long Island Sound disposal site.



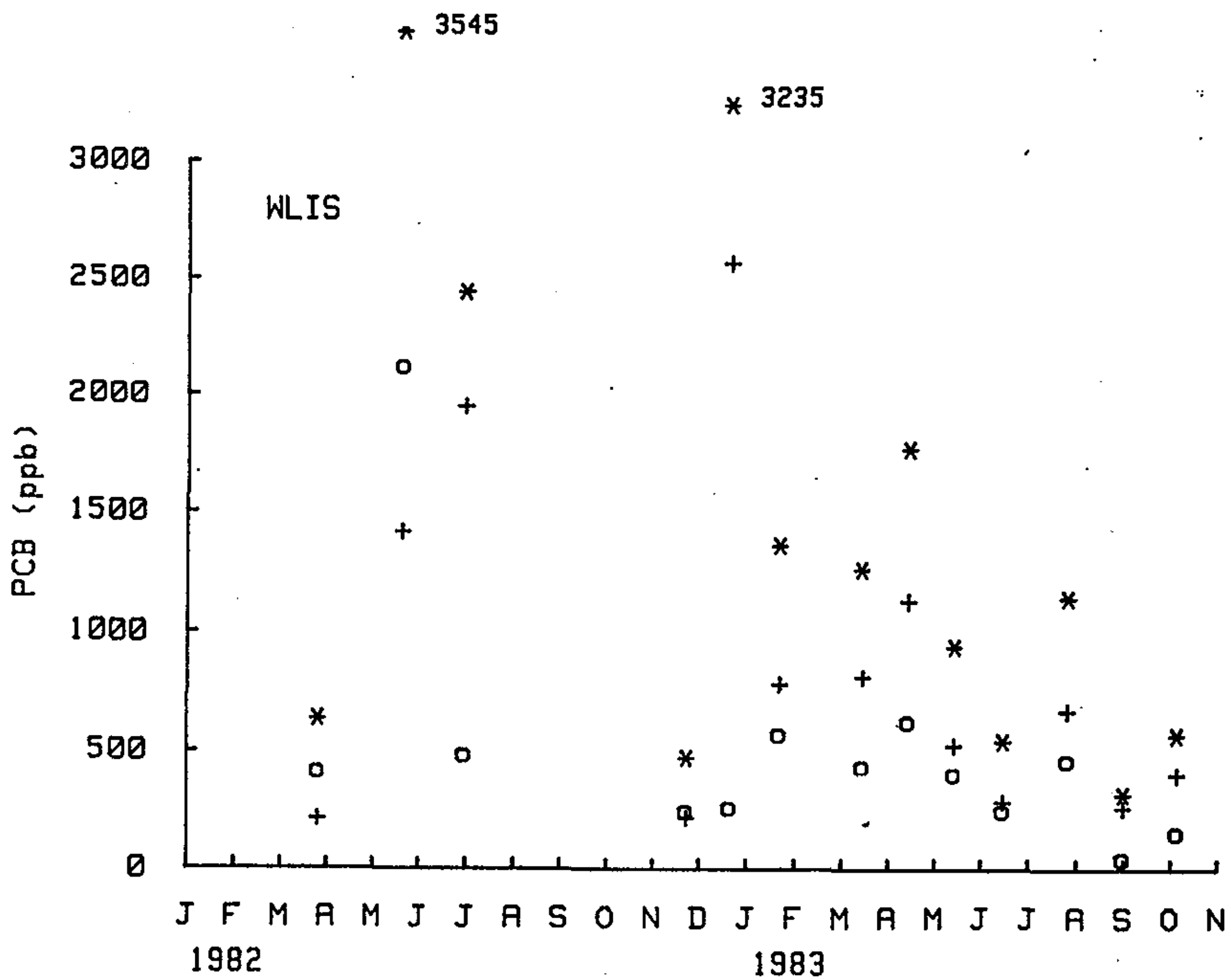


FIGURE III-5-20. Temporal variations of Aroclor 1242 (+), Aroclor 1254 and 1260 (o), and total PCB (*) in the WLIS mussel monitoring population.

TABLE III-5-9

Summary of two-way ANOVAs for the Aroclor and total polychlorinated biphenyl (PCB) concentrations in *Mytilus edulis* deployed at three stations: LAT, MQO, and WLIS in Long Island Sound, November 1982 to September 1983.

	Aroclor 1242	Aroclor 1254+1260	PCB TOTAL[1]
Station (S)	NS	*	NS
Time (T)	NS	NS	*
S X T	NS	NS	NS
Scheffe Grouping		WLIS MQO LAT	D > A

[1] In total PCBs; * $p \leq 0.05$; NS = not significant; D = during disposal concentrations; A = after disposal concentrations.

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between MQO and LAT. In general, the results revealed by the ANOVAs were similar to that of the trace metal data discussed in the previous section, that is, the mussels held at MQN, a site receiving the highest load of dredged material, exhibited a considerably higher level of Aroclor 1242 + 1260 than the reference mussels.

Stepwise multiple regression (Table III-5-10) for the data collected from March to September 1983 showed that the intrinsic variables W/D ratio and shell length explained more than 90% of the variance in the concentrations of Aroclor 1242, Aroclor 1254 + 1260 and total PCB in the 1000E population. The volume of dredged material was related only to the concentration of total PCB. At the WLIS site, the volume of material dumped, which was the first variable entering the model, was associated with the concentration of Aroclor 1254 + 1260 and accounted for 79% of the observed variance. Furthermore, as much as 86% of the variance in the concentrations of Aroclor 1242 and the total PCB were explained by temperature and shell length at this dumpsite. In contrast, only the temperature was correlated with Aroclor 1254 + 1260 (37.7%) in the LAT population. No variables were related to the concentrations of the Aroclors or of the total PCB in the mussel populations maintained at CLIS-REF and MQN.

In the three populations (LAT, MQO and WLIS) with more extensive data sets (Table III-5-11), the month was the only major variable that correlated with all three concentrations at WLIS, and it accounted for 70, 53, and 68% of the variance observed in the two Aroclors and the total PCB, respectively. At MQO, the variables month and temperature contributed 86 and 89% of the variance associated with Aroclors 1242 and the total PCB, respectively. However, none of the independent variables was related to the concentrations of Aroclor 1242, Aroclors 1254 + 1260, or to the total PCB at LAT. Based on the multiple regression analysis, it is evident that the disposal activity was not a major factor for the heightened level of PCB in the monitoring populations. This conclusion is consistent with that of the two-way ANOVAs. A similar conclusion was reached for dredged material disposal monitoring studies in San Fransico Bay (Anderlini et al., 1975), in Puget Sound (Engler, 1979), and in Eastern Long Island Sound (Arimoto and Feng, 1983). Dumping did not affect the level of PCB in mussels maintained at the San Francisco Bay site. Although mussels exhibited higher levels of PCB than the background concentration during the three-week monitoring period in Puget Sound, these increases were not considered significant, In the Eastern Long Island Sound Disposal site, dredged material disposal could account for only 20% of the variance observed in the mussel tissue concentration of PCB during a two-year period of monitoring. In spite of the fact that the volumes and properties of dredged material were different in the San Francisco Bay, Puget Sound and Long Island Sound, it is significant that all these studies have led to the same conclusion that the effects of dredged material disposal in the uptake of PCB by the mussels were minor.

When the LAT mussels were transplanted to CLIS and

TABLE III-5-10

Stepwise multiple regression analyses for the Aroclor and the total PCB concentration in six mussel monitoring populations deployed at LAT, CLIS-REF, 1000 E, MQO, MQN, and WLIS for the period from March to September 1983. % denotes the amount of variance in the PCB concentration explained by the model after the variable on the same row has entered the model. Variable code: W/D = wet/dry weight ratio, L = mean shell length, T = ambient water temperature, D = disposal volume, M = month.

		STATIONS					
Aroclor	Variable	LAT %	CLIS-REF %	1000 E %	MQO %	MQN %	WLIS %
1242	1			W/D 98.8	T 82.4		T 47.7
	2						L 86.5
1254 + 1260	1	T 37.7		W/D 55.5			D 79.0
	2			L 94.5			L 96.8
TOTAL PCB	1			W/D 92.2	M 53.5		T 51.5
	2			D 99.2			L 86.8

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TABLE III-5-11

Stepwise multiple regression analyses for the Aroclor and the total PCB concentrations in three mussel monitoring populations deployed at LAT, MQO and WLIS for the period from November 1982 to September 1983. % denotes the amount of variance in the PCBs concentration explained by the model after the variable on the same row has entered the model. Variable code: W/D = wet/dry weight ratio, L = mean shell length, T = ambient water temperature, D = disposal volume, M = month.

		STATION					
Aroclor	Variable	LAT		MQO		WLIS	
			%		%		%
1242	1			M	56.7	M	70.5
	2			T	89.7		
1254 + 1260	1					M	53.2
	2						
TOTAL PCB	1			M	70.6	M	68.3
	2			T	86.3		

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WLIS, a significant compositional change was noted in the Aroclors. Aroclor 1242 is considered to be the low molecular weight Aroclor and the combination of Aroclors 1254 and 1260 as the high molecular weight Aroclor. At all stations at CLIS and WLIS, the percentages or the relative concentrations of Aroclor 1242 were significantly reduced and the Aroclors 1254 + 1260 increased (Table III-5-12). Temporally, it was also evident that the relative concentrations of Aroclors 1254 + 1260 were considerably higher than the Aroclors 1242 during and after dumping (Table III-5-13 and Fig III-5-21). In contrast, the relative levels of low and high molecular weight Aroclors in the LAT mussels were unchanged. Assuming that the relative concentration of Aroclors in mussels reflects the environmental availability of these Aroclors, the CLIS and WLIS waters could contain higher proportions of Aroclor 1254 and 1260 than those of the ELIS waters (LAT). Selective uptake or preferential depuration of the low molecular weight Aroclor by the mussels could occur, but these biological processes should not affect the observed relative concentrations. Some di-, tri- and tetrachlorobiphenyls (or Aroclor 1242) eluding before the peak No. 84 have been found as major components in river waters (Duinker et al., 1982a, b), and pentachloro- and higher chlorinated biphenyls are not water soluble. Therefore, the high relative concentrations of Aroclors with higher molecular weight found in dumpsite mussels suggest that they are probably of dietary and/or sedimentary origin and indicate that the uptake of lower molecular weight Aroclors through the exposed tissue from the surrounding seawater is probably of lesser importance. Similar observations were reported in seston, Macoma balthica, Arenicole marine and Crangnon crangon from the Dutch Wadden Sea (Duinker et al., 1983). Thus, in order to resolve the problem of whether the Aroclor compositional change in mussel tissues in CLIS and WLIS is due to environmental availability of the Aroclors or to biological processes, data on the composition of Aroclors in water samples (including dissolved Aroclors and Aroclors associated with suspended material), reference sediments and dumpsite sediments are needed.

Evidently, the PCB concentration of the dumpsite sediments were lower than those of the mussels. Sediments from the New London Dumpsite have a mean PCB concentration of 0.14 g/g dry weight (140 ppb) which was not significanly higher than those sampled from control areas (Chytalo, 1979). Sediment samples obtained from a trace metal-impacted station in Portland Harbor, Maine showed a level of 100 ppb of Aroclors 1242 and 1260 (Larsen et al., 1983). Limited data on the PCB concentrations in the dumpsites sediments from CLIS and WLIS showed that the samples contained 58.0 $\pm$ 10.4% of Aroclor 1242 and 42.0 $\pm$ 11% of Aroclors 1254 + 1260 with a mean PCB concentration of 104 $\pm$ 30 ppb (COE, NED Winter 1982-83 cruise).

Mean concentrations of PCB in mussel populations deployed at the ELIS, CLIS and WLIS exceeded the U.S. Mussel Watch criterion for "polluted" areas, i.e., 600 ppb (Goldberg, et al., 1978). Farrington, et al. (1983) suggested a northeast megalopolis effect reflected in the elevated PCB concentrations

TABLE III-5-12

Summary of mean percent Aroclors in *Mytilus edulis* deployed at LAT, CLIS-REF, 1000 E, MQO, MQN and WLIS in Long Island Sound for the period from March to September 1983.

Aroclor	STATIONS LAT	CLIS-REF	1000 E	MQO	MQN	WLIS
1242	53.3* (13.8)	42.9 (8.1)	26.5 (13.6)	42.0 (11.7)	36.7 (12.1)	35.5 (10.8)
1254 + 1260	46.7 (14.2)	57.1 (8.0)	73.5 (11.6)	58.0 (9.8)	63.3 (11.2)	64.5 (10.0)
n	7	6	5	6	5	7

* based on means derived from Arc Sin $\sqrt{x}$ transformed data. ( ) denotes 1 S.D.

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TABLE III-5-13

Summary of mean percent Aroclors in *Mytilus edulis* deployed at LAT, CLIS-REF, 1000 E, MQO, MQN and WLIS in Long Island Sound during and after disposal operations for the period from March to September 1983.

Aroclor	LAT	CLIS-REF	1000' E	MQO	MQN	WLIS
	STATIONS					
I. During Dumping						
1242	52.8*	48.4	35.2	48.6	35.9	38.4
	(16.1)	(5.1)	(11.0)	(10.1)	(5.2)	(5.0)
1254 + 1260	47.2	51.6	64.6	51.4	64.1	63.3
	(16.4)	(5.0)	(10.2)	(10.0)	(5.1)	(4.8)
II. After Dumping						
1242	54.0	37.6	21.2	35.6	37.9	33.4
	(14.1)	(7.3)	(12.7)	(4.0)	(22.8)	(14.0)
1254 + 1260	46.0	62.4	72.8	64.4	62.1	66.4
	(14.4)	(7.1)	(10.4)	(4.0)	(20.3)	(12.8)

* based on means derived from Arc Sin $\sqrt{x}$ transformed data.
( ) denotes 1 S.D.

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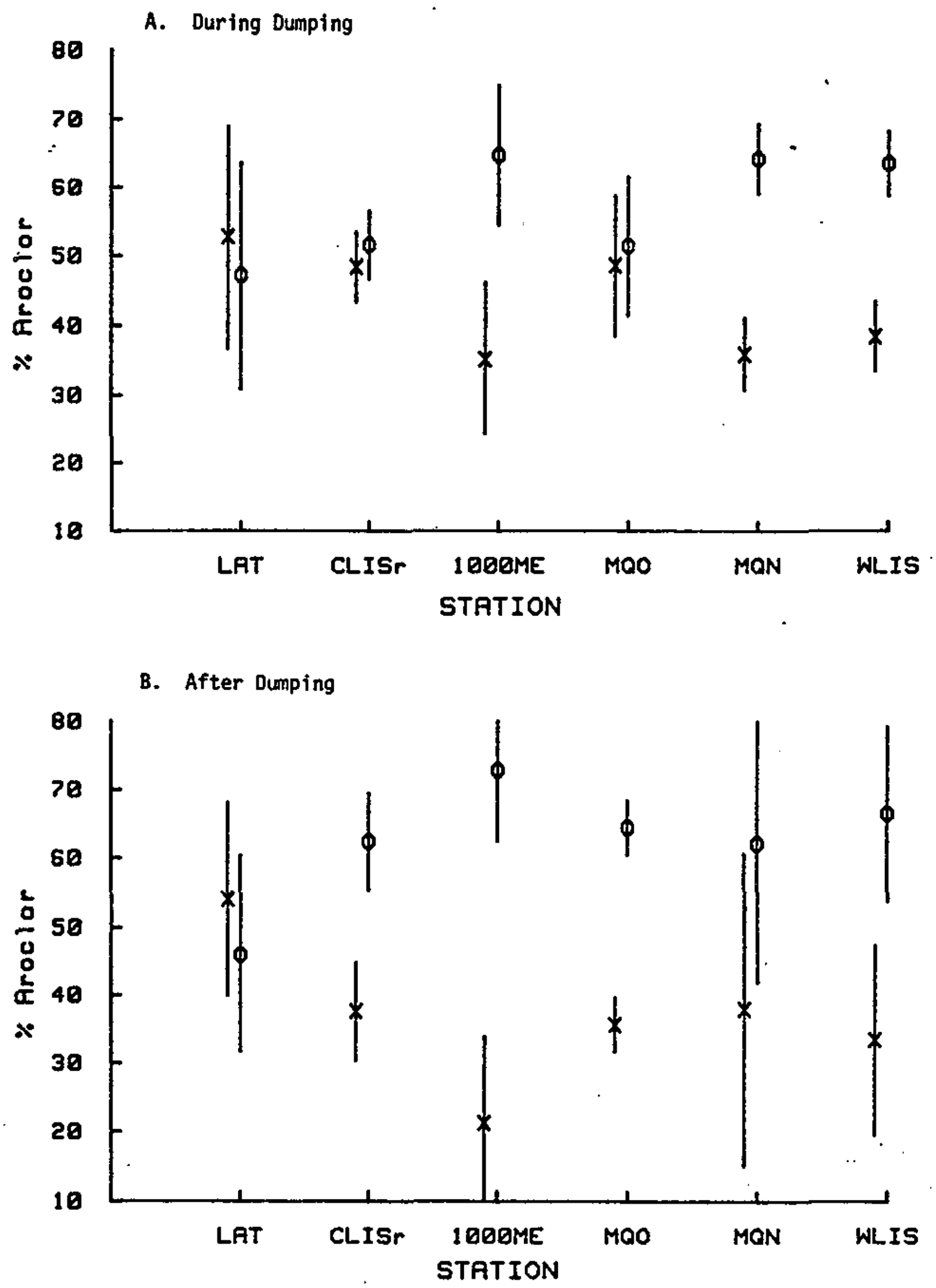

FIGURE III-5-21. Variations of the relative concentration of Aroclor 1232 (*) and Aroclor 1265 (o) during (A) and after (B) dumping operations in the six mussel monitoring populations.

frequently found in samples from the Chesapeake Bay area to Cape Ann, MA. Long Island Sound, considered as an urban sea, certainly fits this description. Within the Sound, the concentrations of PCB in most of the mussel samples (32 out of 54 samples) were less than 1000 ppb. The occurrence of the samples with greater than 1000 ppb PCB is clearly associated with the designated disposal sites (Table III-5-14), with WLIS and MQN with the highest percentages.

5.2 Central and Western Long Island Sound October 1983 - September 1984

5.2.1 Trace Metal Concentrations

The mean concentrations of nine trace metals in Mytilus edulis from Latimers Light reference station (LATr), Central Long Island Sound reference station (CLISr), 1000 meters east of FVP station (1000ME), Mill-Quinnipiac River Old (MQO), Mill-Quinnipiac New (MQN), Western Long Island Sound disposal station (WLISd) and Western Long Island Sound reference station (WLISr) are presented in two ways: (1) Summary of mean tissue trace metal concentrations, and results of two-way ANOVA and Tukey's test from October 1983 to September 1984 (Table III-5-15) and (2) summary of mean tissue trace metal concentrations classified by during (D) and after (A) disposal operations (Table III-5-16). In addition, data sets organized on temporal basis and presented in terms of ug per g of either wet or freeze-dried weight for each station are available in the Appendix. All sampling at the above mentioned seven stations were terminated either in May or June 1984. The remaining mussels were consolidated and redeployed to Latimers Light reference site from which the mussels were collected originally.

Table III-5-15 shows that significant differences (one-way ANOVA) were detected among the seven populations for the concentration of Cd (p 0.0003), Cu ($p < 0.01$), Zn ($p < 0.004$), and Hg ($p < 0.05$); the concentrations of Cr, Co, Fe, Ni, and V, however, did not differ significantly during the dumping operation. The results of Tukey's multiple range tests reveal that the significant differences observed in Cd and Cu were contributed solely by the LATr population which exhibited the lowest concentration of most trace metals. For Zn and Hg, no significant difference among the populations was apparent. But the trend of the LATr population having the lowest concentration of Zn was maintained as compared with the other six populations which manifested a general uniformity in the concentrations of Cd, Cu and Zn. The analyses, therefore, suggest that the disposal of the dredged material did not induce a significant localized increase in the trace metal concentrations of the monitoring populations in CLIS and WLIS. It is noteworthy that a similar inference was reached for Cd, Cu and Zn in the experimental populations during the 1983 dumping operation at CLIS (Feng, 1984) in spite of the fact that dredged materials ten times greater in volume than that of the 1984 operation were dumped. Conventional wisdom would expect the concentration of trace metals in the mussels deployed at the dumpsite to show "a dose -

TABLE III-5-14

Frequency distribution of mussel samples which contain > 1000 ppb of PCB in the monitoring populations deployed at six stations in Long Island Sound.

Station	No. of Samples with PCB concentrations > 1000 ppb	%
LAT	1	4.6
CLIS-REF	1	4.6
1000E	3	13.6
MQO	5	22.7
MQN	4	18.2
WLIS	8	36.3
	22	100.0

TABLE III-5-15

Summary of mean wet/dry ratios (W/D), shell length (L) and tissue trace metal concentrations (ppm ± 1 S.D.) in *Mytilus edulis* deployed at seven stations in Eastern, Central and Western Long Island Sound from October 1983 to September 1984. All samplings at CLIS were terminated on May or June 1984. The monitoring platforms were redeployed at Latimers Light and sampling was resumed in July 1984.

	Stations						
	LATr	CLISr	1000ME	MQO	MQN	WLISd	WLISr
W/D	8.53 ± 2.19	9.77 ± 1.71	8.84 ± 1.72	9.06 ± 1.24	9.26 ± 0.70	8.82 ± 1.00	7.91 ± 1.49
L	6.56 ± 0.30	6.29 ± 0.39	6.35 ± 0.33	6.34 ± 0.13	6.53 ± 0.19	6.23 ± 0.28	6.15 ± 0.53
Cd*	1.47 ± 0.70	2.52 ± 0.76	2.30 ± 0.49	2.72 ± 0.49	2.49 ± 0.20	2.09 ± 0.93	1.64 ± 0.34
Cr	3.58 ± 1.92	2.04 ± 1.11	2.82 ± 1.65	1.73 ± 0.69	1.85 ± 0.95	2.42 ± 1.05	1.76 ± 0.44
Co	0.68 ± 0.39	0.67 ± 0.40	0.62 ± 0.38	0.67 0.40	0.57 ± 0.25	0.50 ± 0.17	0.53 ± 0.09
Cu*	9.24 ± 1.67	14.00 ± 3.43	14.10 ± 3.14	14.64 ± 3.50	13.14 ± 2.30	13.46 ± 2.07	15.08 ± 2.66
Fe	225 ± 123	368 ± 207	470 ± 202	515 ± 335	392 ± 317	235 ± 59	208 ± 68
Hg*	0.189 ± 0.050	0.210 ± 0.051	0.199 ± 0.038	0.178 ± 0.065	0.216 ± 0.065	0.192 ± 0.039	0.179 ± 0.058
Ni	2.78 ± 1.18	2.38 ± 0.72	3.01 ± 1.35	2.57 ± 1.10	2.50 ± 1.02	3.57 ± 1.18	2.73 ± 0.71
Zn*	144 ± 35	193 ± 29	193 ± 28	186 ± 26	177 ± 26	181 ± 16	165 ± 20
V	1.74 ± 1.12	1.52 ± 0.94	1.84 ± 0.80	1.60 ± 0.77	1.79 ± 0.96	1.13 ± 0.26	1.30 ± 0.23
n	14	8	9	8	4	5	5

* Two-way ANOVA significant.

TABLE III-5-15 (cont.)

Tukey Groupings ($\alpha = 0.05$):

Cd	MQO	CLISr	MQN	1000ME	WLISd	WLISr	LATr
	2.72	2.52	2.49	2.30	2.09	1.64	1.47
Cu	WLISr	MQO	1000ME	CLISr	WLISd	MQN	LATr
	15.08	14.64	14.10	14.00	13.46	13.14	9.24
Zn	CLISr	1000ME	MQO	WLISd	MQN	WLISr	LATr
	193	193	186	181	177	165	144
Hg	MQN	CLISr	1000ME	WLISd	LATr	WLISr	MQO
	0.216	0.210	0.199	0.192	0.189	0.179	0.178

TABLE III-5-16

Elemental enrichment factors in surficial sediments obtained from Central Long Island Sound disposal sites (derived from September 1984 Cruise data).

Element	STNH-N	STNH-S	NOR	CS-2	NH-74	MQR[1]	REF[1]
			Station				
Cd	338	*	136	344	146	41	*
Cr	2	2	2	2	3	4	1
Cu	3	3	6	2	7	9	2
Hg	24	8	41	54	27	18	4
Ni	4	2	2	4	2	1	*
Zn	11	7	10	27	10	15	6

* Concentration below detection limit; EF not calculated. EF $\leq$ 5 is considered not enriched.

[1] Fe concentrations supplied by the author.

effect." The apparent lack of such an effect in the monitoring mussel populations could have at least two possible explanations. First, the capping procedure employed during the 1983 operation could effectively reduce or inhibit the release of toxic metals into the water column, thus reducing the available trace metals to the mussels and thereby mitigating or modulating the environmental impact of dumping large quantities of relatively poor-grade dredged material, e.g., the Black Rock Harbor material. A second possible explanation is that the amount of dredged materials deposited at the site could be relatively small in comparison with the amount deposited by the natural process of sedimentation. Moreover, releasing of trace metals from the sediment by the process of bioturbation over a vast area of seafloor in the region (as evidenced by the presence of the nepheloid layer) coupled with the tidal currents traversing the area may render the environment more uniform. Such a hypothesis of quick rendering of uniformity of the CLIS and WLIS environs (or the assimilative capacity of CLIS and WLIS) by physical and biological processes could be tested conclusively by conducting field and laboratory experiments. Partial evidence supporting such a hypothesis has been suggested in analysis of the Enrichment Factors presented in Table III-5-16. Foci of Cd, Hg, Zn and Cu enrichment of the disposal sites are readily identifiable, but the tissue concentrations of Cd, Cu, Hg and Zn in the experimental monitoring populations are undistinguishable.

Table III-5-17 depicts tissue trace metal concentrations found in reference and experimental populations of M. edulis during (D) and after (A) dumping operations. Owing to the small sample size available for the after-dumping period (due to termination of the experiments), no meaningful comparisons could be made between the two sampling periods.

5.2.2 Polychlorinated Biphenyl (PCB) Concentrations

The mean concentrations of Aroclors and the total PCB levels from the six mussel monitoring populations are shown in Table III-5-18. Temporal variations in tissue PCB concentrations are summarized in the Appendix. The mean concentration of Aroclor 1242 and Aroclors 1254 + 1260, and the total PCB levels vary from 61 to 104 ng/g, 173 to 245 ng/g and 234 to 318 ng/g, respectively. As expected, the population placed at LATr contains the least amount of PCB, while the highest levels are associated with WLISd and 1000ME mussel populations; 1000 ME is a site where a load of Black Harbor dredged material was released accidentally. However, analysis of the data by one-way ANOVA detected no spatial difference in the Aroclors and total PCB concentrations among the six mussel populations. In comparing the concentrations of Aroclor 1242, Aroclors 1254 + 1260 and total PCB in the mussels maintained at the same locations over two different time periods, i.e., from March to September 1983 (see Table III-5-7) and from October 1983 to February 1984, there is a significant lowering of PCB concentrations in all the monitoring populations during the latter period, reflecting presumably the greatly reduced dumping activities and/or seasonal

TABLE III-5-17

Summary of mean wet/dry ratios (W/D), shell length (L) and tissue metal concentrations found in *Mytilus edulis* during (D) and after (A) disposal operations at seven stations in Eastern, Central and Western Long Island Sound from October 1983 to September 1984. All samplings at CLIS were terminated on May or June 1984. The monitoring platform were redeployed at Latimers Light and sampling was resumed in July 1984.

		Stations						
		LATr	CLISr[1]	1000ME[1]	MQO[2]	MQN[1]	WLISd[1]	WLISr[1]
Cd	D	1.64 ± 0.77	2.56 ± 0.81	2.30 ± 0.53	2.72 ± 0.49	2.51 ± 0.25	1.91 ± 0.95	1.64 ± 0.34
	A	1.06 ± 0.26	2.23	2.31		2.45	2.28	
Cr	D	3.54 ± 2.13	2.13 ± 1.16	2.48 ± 1.38	1.73 ± 0.69	1.48 ± 0.74	2.38 ± 1.21	1.76 ± 0.44
	A	3.69 ± 1.55	1.39	5.57		2.94	2.56	
Co	D	0.72 ± 0.46	0.67 ± 0.44	0.61 ± 0.40	0.67 ± 0.40	0.53 ± 0.29	0.56 ± 0.11	0.53 ± 0.09
	A	0.58 ± 0.17	0.69	0.72		0.68	0.25	
Cu	D	9.90 ± 1.39	14.42 ± 3.47	14.64 ± 2.89	14.64 ± 3.50	13.17 ± 2.81	13.42 ± 2.39	15.08 ± 2.66
	A	7.60 ± 1.17	11.02	9.81		13.03	13.62	
Fe	D	298 ± 122	392 ± 211	488 ± 208	515 ± 335	436 ± 372	224 ± 61	208 ±68
	A	148 ± 14	204	325		261	282	
Hg	D	0.202±0.052	0.196±0.036	0.190±0.029	0.178±0.038	0.185±0.027	0.189±0.045	0.174±0.058
	A	0.158±0.023	0.306	0.272		0.307	0.202	
Ni	D	3.01 ± 1.32	2.47 ± 0.72	2.93 ± 1.42	2.57 ± 1.10	2.05 ± 0.60	3.78 ± 1.24	2.73 ± 0.71
	A	2.22 ± 0.54	1.72	3.71		3.84	2.73	1.00

TABLE III-5-17 (cont.)

		Stations						
		LATr	CLISr[1]	1000ME[1]	MQO[2]	MQN[1]	WLISd[1]	WLISr[1]
Zn	D	150 ± 36	192 ± 32	192 ± 24	186 ± 26	169 ± 26	177 ± 16	165 ± 20
	A	130 ± 35	203	203		201	196	
V	D	1.69 ± 0.93	1.28 ± 0.71	1.67 ± 0.66	1.60 ± 0.77	1.46 ± 0.86	1.10 ± 0.29	1.30 ± 0.23
	A	1.88 ± 1.68	3.18	3.22		2.77	1.22	
W/D	D	8.84 ± 2.43	9.90 ± 1.80	8.97 ± 1.80	9.06 ± 1.24	9.29 ± 0.85	8.55 ± 0.92	7.91 ± 1.49
	A	7.78 ± 1.40	8.88	7.84		9.17	9.90	
L	D	6.50 ± 0.30	6.23 ± 0.39	6.33 ± .035	6.34 ± 0.13	6.57 ± 0.27	6.30 ± 0.27	6.15 ± 0.53
	A	6.72 ± 0.29	6.61	6.46		6.41	5.93	
n	D	10	7	8	8	3	4	5
	A	4	1	1	0	1	1	0

1. Terminated in June 84; 2. At the time when sampling was terminated, mussels were exhausted.

TABLE III-5-18

Mean wet/dry ratios (W/D), shell length (L), concentrations of total polychlorinated biphenyl (PCB) and Aroclors in Mytilus edulis deployed at LATr, CLISr, 1000ME, MQO, WLISd and WLISr from October 1983 to June 1984.

Station	n	Mean Concentrations ± S.D.* Aroclor 1242	Aroclor 1254+1260	Total PCB	W/D	L
LATr	10	61 ± 19	173 ± 85	234 ± 93	8.84 ± 2.43	6.50 ± 0.30
CLISr	5	90 ± 32	225 ± 94	315 ± 88	10.54 ± 1.75	6.09 ± 0.37
1000ME	5	73 ± 25	245 ± 46	318 ± 42	9.96 ± 1.31	6.37 ± 0.18
MQO	5	62 ± 23	188 ± 53	250 ± 74	9.61 ± 1.25	6.33 ± 0.15
WLISd	2	104 ± 32	189 ± 66	293 ± 98	9.91 ± 0.01	6.08 ± 0.20
WLISr	5	98 ± 23	191 ± 66	289 ± 89	7.91 ± 1.49	6.15 ± 0.53

* Expressed as ng/g freeze-dry wt. L expressed as cm.
All samples except one at WLISd were obtained during the dumping period.

variations.

For the mussel populations studied during the March to September 1983 time period, a significant compositional change in tissue Aroclors in favor of high molecular weight Aroclors (1254+1260) occurred when the mussels were transplanted from LATr to CLIS and WLIS disposal sites. No such dramatic shift in the relative concentration of low molecular weight Aroclor (LMW) to high molecular weight Aroclors (HMW) was encountered in the populations maintained in the present period. In fact, a ratio of 25:75 in favor of HMW was maintained from October 1983 to Febraury 1984 in mussel populations held at LATr, CLISr, 1000ME and MQO (Table III-5-19). This discrepancy from the previous observations which were conducted from February to September 1983 could be attributed to seasonal conditions as well as the intensity of dumping activities. Therefore, there are signficant qualitative and quantitative differences in tissue PCB concentration between the two study periods.

5.3 Western Long Island Sound June 1984 and Continuing

A new monitoring effort was initiated at this site in June 1984 immediately after the cessation of dumping operations, which spanned a period of eight months from November 1983 to June 1984. Three mussel monitoring populations were placed at WLISrN, WLISc and 500 MW on 27 June (Fig. III-2-3); a master reference population was deployed at RIr on 28 June 1984 (Fig. III-2-1, Table III-3-3). Prior to the next dumping operations which began in the Fall/Winter of 1984, the mussel population held at the center "Bravo" pile was moved to the 500 MW station. When the dumping is completed in June 1985, they will be returned to the "Bravo" pile. Because this data set consists of only three sampling periods (July, August and September 1984), any comments presented herein must be regarded as preliminary.

5.3.1 Trace Metal Concentrations

The concentrations of nine metals organized by stations for the three-month period are presented in Table III-5-20. Results of one-way ANOVA indicate that all trace metals except Zn were not significantly different. Even for the concentrations of Zn, the observed significant difference between stations is a borderline case. This is borne out by the non-significant Turkey's groupings (Table III-5-20). Such a homogeneity of trace metal concentrations found among the mussel populations deployed at WLIS disposal sites and outside the confines of the dumpsite is probably attributable to the uniformity exhibited by the trace metal contents of the sediment. Based on the enrichment factors (EFs) presented in Table III-5-21, no discernible differences between stations were noted; the EFs varied in similar manner for all WLIS stations, i.e. Cd highly enriched, Zn moderately enriched, Hg marginally so, and Cr, Cu, Ni and Hg (at some stations) not enriched at all.

5.3.2 Polychlorinated Biphenyl Concentrations

TABLE III-5-19

Changes in relative tissue concentrations of Aroclors when the mussels of Latimers Light were deployed at CLISr, 1000ME, and MQO.

Station	Date		Aroclor Relative Concentrations (%) 1242	1254+1260
LATr	10/18/83		27.7	72.3
	11/30/83		27.7	72.3
	12/27/83		16.7	83.3
	01/18/84		22.0	78.0
	01/20/84		23.7	76.3
	02/23/84		20.3	79.7
		$\bar{x}$	23.0	77.0
		S.D.	4.3	4.3
CLISr	10/17/83		23.7	76.3
	11/28/83		60.0	40.0
	12/20/83		23.0	77.0
	01/18/84		19.7	80.3
	02/17/84		26.4	73.6
		$\bar{x}$	30.6	69.4
		S.D.	16.6	16.6
1000ME	10/17/83		13.4	86.6
	11/28/83		23.2	76.8
	12/20/83		16.2	83.8
	01/17/84		32.7	67.3
	02/17/84		29.9	70.1
		$\bar{x}$	23.1	76.9
		S.D.	8.4	8.4
MQO	10/17/83		26.2	73.8
	11/28/83		29.8	70.2
	12/20/83		20.9	79.1
	01/17/84		21.4	78.6
	02/17/84		26.7	73.3
		$\bar{x}$	25.0	75.0
		S.D.	3.8	3.8

TABLE III-5-20

Summary of wet/dry ratios (W/D), shell length (L) and tissue metal concentrations (ppm) in *Mytilus edulis* deployed at four stations in Eastern and Western Long Island Sound from June to September 1984.

	Stations			
	RIr	WLISrN	WLISc	500 MW
W/D	7.11 ± 0.78	8.08 ± 1.39	7.31 ± 0.36	7.79 ± 0.81
L	6.95 ± 0.24	6.92 ± 0.14	7.00 ± 0.03	7.09 ± 0.32
Cd	0.72 ± 0.19	1.30 ± 0.51	1.06 ± 0.31	1.02 ± 0.30
Cr	3.25 ± 0.99	7.88 ± 11.46	2.06 ± 1.06	1.85 ± 1.42
Co	0.43 ± 0.20	0.76 ± 0.51	0.48 ± 0.27	0.40 ± 0.25
Cu	8.29 ± 0.89	8.94 ± 0.25	8.56 ± 0.33	8.49 ± 0.36
Fe	227 ± 77	203 ± 95	136 ± 18	146 ± 15
Hg	0.184 ± 0.015	0.176 ± 0.007	0.170 ± 0.019	0.152 ± 0.014
Ni	3.23 ± 0.92	5.39 ± 4.84	2.25 ± 0.32	2.89 ± 1.03
Zn*	121 ± 18	152 ± 8	142 ± 18	120 ± 10
V	2.04 ± 2.54	0.91 ± 0.50	0.75 ± 0.14	0.69 ± 0.17
n	5	3	3	3

* One-way ANOVA significant. $F = 3.76$, d.f. = 6, $p < 0.049$

Tukey's Groupings ($\alpha = 0.05$):

Zn	WLISrN	WLISc	RIr	500MW
	152	142	121	120

TABLE III-5-21

Elemental enrichment factors in surficial sediments obtained from Western Long Island Sound disposal sites (derived from March/April and June 1984 Cruise data).

Element	A-CTR	400MW	REF	A-CTR	200MW	B-CTR	400MW	REF
	March/April 1984			June 1984				
Cd	24	*	*	54	22	*	34	*
Cr	2	2	1	1	1	1	2	1
Cu	3	3	1	3	3	4	3	3
Hg	7	3	3	5	6	5	2	2
Ni	1	1	1	2	2	2	1	1
Zn	6	8	4	13	10	11	10	6

* Concentrations below detection limits; EF not calculated.
EF $\leq$ 5 is considered not enriched.

Preliminary results of the mean tissue PCB concentrations for June through September 1984 at the four stations: RIr, WLISrN, WLISc and 500 MW, are presented in Table III-5-22. For the ensemble of all samples, the compounds identified as Aroclors 1242, 1254 and 1260 differed markedly. Examinations of the means revealed that the concentration of 1260 was the lowest, 1242 intermediate and 1254 the highest. Similar findings have bee presented in the previous sections as well as by Arimoto and Feng (1983).

The data were scrutinized for spatial variability by one-way ANOVA. This is achieved by grouping the samples according to stations. The ANOVAs showed that only the difference in the concentrations of Aroclor 1260 was significant at $p < 0.05$ (Table III-5-22). But Tukey's test did not conclusively demonstrate differences between stations. It is, however, sufficient to say that the mussel population at RIr appears to have the lowest concentration of Aroclor 1260 among the four populations.

In contrast, the percent relative concentrations of Aroclors 1242, 1254 and 1260 showed significant differences among stations as revealed by one-way ANOVAs (Table III-5-23). Further analyses of the data by Tukey's test indicated unambiguously that the RIr mussel population is significantly different from the other three dumpsite populations in their relative tissue concentrations of Aroclors 1242, 1254 and 1260. In the RIr population, the mean percent Aroclor 1254 are significantly higher, and Aroclors 1254 + 1260 markedly lower than the three WLIS populations (Fig. III-5-22). The high percentage of Aroclors 1254 and 1260 found in the dumpsite populations could be associated with high concentrations of suspended matters in the regions. A similar trend has been seen with earlier deployments.

5.3.3 Histopathological Studies

Prior to examining the prepared slides for histopathological studies, mortalities of mussels held at the four stations were analyzed to discern whether mortalities are associated with the stations. This is an attempt to obtain a first approximation of the possible adverse effects on the mussels. The G-test statistics obtained by the R x C contingency table (Table III-5-24) clearly showed that the mortalities were associated with the stations. At the reference site (RIr), the mortality was significantly lower than that at the dumpsites; the mortalities were rather uniform among the dumpsite populations.

Histological sections from the reference and dumpsite populations were examined by using eight parameters: (1) the stage of gonadal development, (2) staining and morphological characteristics of Leydig tissue, (3) abnormality of the mature ova, (4) integrity of the gill and intestinal epithelium, and intestinal content, (5) integrity of the style sac epithelium and the presence of crystalline style, (6) changes in kidney tubules, (7) degree of leucocytic infiltrations, as well as (8) prevalence of parasitism. The first three parameters are indices of the

TABLE III-5-22

Mean wet/dry (W/D), shell length (L), concentrations of total polychlorinated biphenyl (PCB) and Aroclors in *Mytilus edulis* deployed at RIr, WLISc, and 500MW from June to September 1984.

Station	n	Aroclor 1242	Aroclor 1254	Aroclor 1260**	Aroclor 1254+1260	Total PCB	W/D	L
		Mean Concentrations ± S.D.*						
RIr	4	59 ± 34	90 ± 46	8 ± 02	98 ± 47	157 ± 81	7.26 ± 0.82	6.98 ± 0.27
WLISrN	3	54 ± 25	128 ± 42	20 ± 10	148 ± 51	202 ± 76	8.08 ± 1.39	6.92 ± 0.14
WLISc	3	48 ± 09	124 ± 23	16 ± 03	140 ± 26	188 ± 35	7.31 ± 0.86	7.00 ± 0.03
500MW	3	51 ± 10	134 ± 21	18 ± 02	152 ± 22	203 ± 31	7.79 ± 0.80	7.09 ± 0.32

*Expressed as ng/g freeze-dry wt; L expressed as cm.

** One-way ANOVA significant: $F_{3,9} = 3.87$, $p < 0.05$
Tukey's Grouping: ($\alpha = 0.05$)

/WLISrN	500MW	WLISc	RIr
20	18	16	8

TABLE III-5-23

Changes in relative tissue concentrations of Aroclors when Ram Island mussels were deployed at WLISrN, WLISc, and 500MW.

Station	Date		Aroclor Relative Concentrations (%) 1242	1254	1260	1254+1260
RIr	4/26/84		35.8	59.5	4.7	64.2
	6/27/84		38.8	56.4	4.8	61.2
	7/26/84		40.6	55.9	3.5	59.4
	8/22/84		35.1	57.0	7.9	64.9
	9/19/84		38.0	56.3	5.7	62.0
		$\bar{x}$	37.7	59.0	5.3	62.3
		S.D.	2.2	1.4	1.6	2.2
WLISrN	7/25/84		29.6	62.6	7.8	70.4
	8/21/84		26.5	67.5	12.0	71.5
	9/18/84		20.7	69.0	10.3	79.3
		$\bar{x}$	25.4	64.4	10.3	73.7
		S.D.	4.9	4.0	2.1	4.9
WLISc	7/25/84		25.5	66.5	8.0	74.5
	8/21/84		25.6	65.1	9.4	74.5
	9/18/84		25.5	65.8	8.7	74.5
		$\bar{x}$	25.5	65.8	8.7	74.5
		S.D.	0.1	0.7	0.7	0.0
500MW	7/25/84		26.3	66.1	7.6	73.7
	8/21/84		23.5	66.5	10.0	76.5
	9/21/84		25.4	65.3	9.3	74.6
		$\bar{x}$	25.1	66.0	9.0	74.9
		S.D.	1.4	0.6	1.2	1.4

One-way ANOVA highly significant:

Aroclor 1242: $F = 24.81$, d.f. = 3, 10, $p<0.0001$

Aroclor 1254: $F = 26.95$, d.f. = 3, 10, $p<0.0001$

Aroclor 1260: $F = 7.34$, d.f. = 3, 10, $p<0.007$

Aroclor 1254+1260: $F = 21.94$, d.f. = 3, 10, $p<0.0001$

Turkey's tests indicate that the concentrations of all Aroclors at RIr are significantly different from that of the three WLIS stations and that no significant differences were detected among the three WLIS stations.

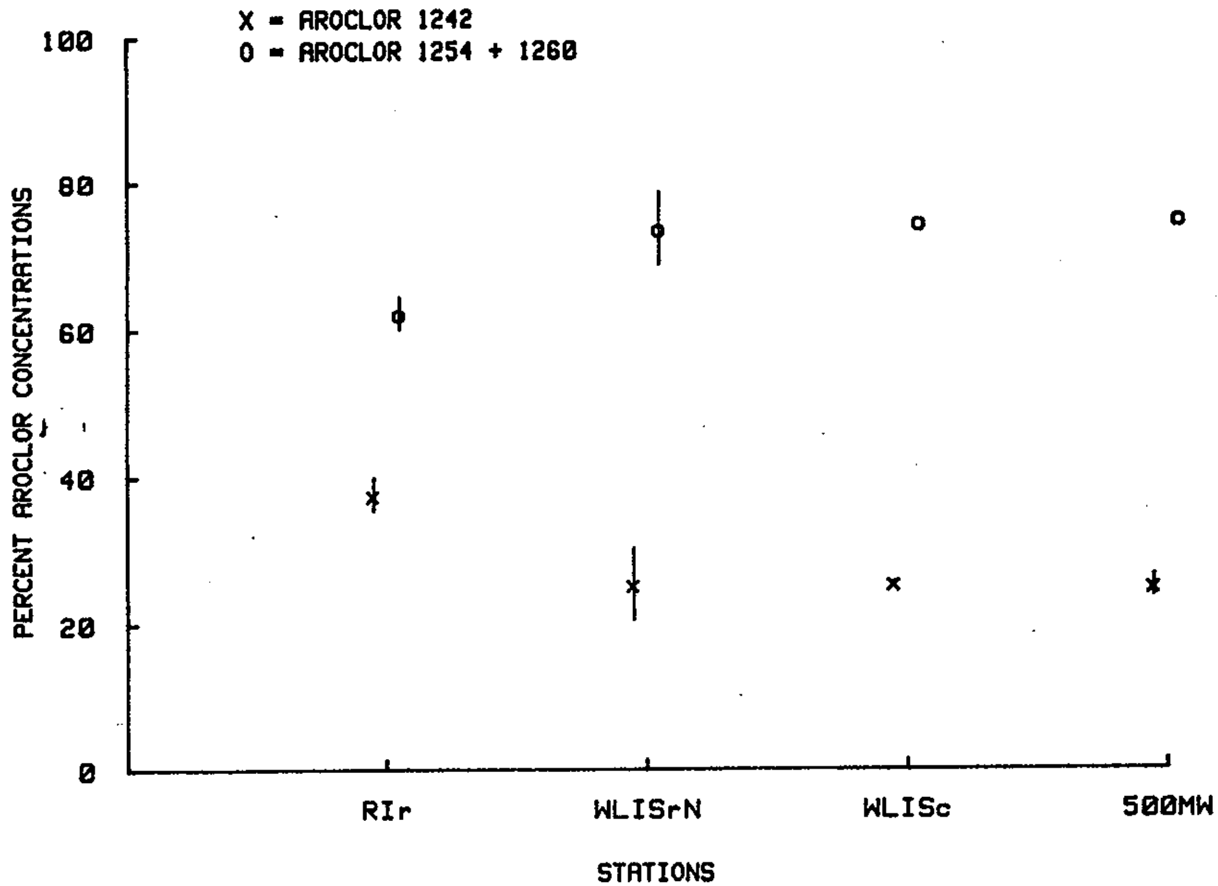

FIGURE III-5-22. Percentages of Aroclors 1242, and 1254 + 1260 in Mytilus edulis from dumpsite and reference populations after dumping.

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TABLE III-5-24

The number of dead mussels found in populations maintained at RIr, WLISrN, WLISc and 500 MW from June through September 1984.

Station	Dead	Alive	Totals	% Dead	% Alive	Totals
RIr	49	101	150	32.7	67.3	100
WLISrN	95	104	199	47.7	52.3	100
WLISc	90	107	197	45.7	54.2	100
500 MW	99	104	203	48.8	51.2	100
Totals	333	416	749			

G-test Statistics: $G = 11.192$, d.f. = 3, $\chi^2_{0.025(3)} = 9.348$, $p < 0.025$

Frequencies and/or percentages of occurrence within the box are not associated with the stations where the mussels were maintained.

mussel's reproductive status, while the well being of feeding and excretion is determined by the parameters 4, 5 and 6. The degree of leucocytic infiltrations, except during the post spawning resorption of reminant ova, is an indicator of inflammation which may lead to overt destruction of tissues. The last parameter (8) is to assess any tissue damage inflicted upon the host (mussels) by the parasites; this information is important in separating environmentally-induced histopathological manifestations from those caused by parasitism. Whenever possible, the parameters were scored for quantitative presentation and subjected to statistical treatment.

The stages of gonadal development may be affected in mussels living on or near dredged material disposal sites by the physical and chemical factors of the environment. It has been demonstrated by Bayne et al. (1978) that when mussels were experimentally subjected to temperature and food ration stresses, they produced smaller and fewer eggs than unstressed controls. Also the ripe gametes of the stress animals occupied a smaller proportion of the mantle tissue than that of the controls. The purpose of this study is to determine whether gonadal development of mussels deployed at or near dumpsites differed from those of reference mussels. For scoring the degree of reproductive conditions, the gonads were categroized in four classes: early development, intermediate stage, mature stage and spent. These stages are defined as follows:

a. Early development stage (E): only germinal tissue present; sex undifferentiated.

b. Intermediate stage (I): clearly recognizable germinal follicles; male follicles with a thick layer of spermatids around the periphery and a few spermatozoa in the center; female follicles with peripheral oocytes; follicles relatively small occupying rather limited areas of the mantle tissue.

c. Mature stage (M): Male follicles with or without a thin layer of spermatids but filled with mature spermatozoa; female follicles packed with mature ova; both male and female follicles having displaced most of the Leydig tissue in the mantle; gametes in gonoducts.

d. Spent (S): empty or near empty follicles with extensive leucocytic infiltration and phagocytosis.

In examining the histological slides from all stations, early development stage was not encountered in any of the specimens. The frequencies of the three developmental stages: I, M, and S in the four mussel populations are presented in Table III-5-25. It is clearly shown that the general gonadal development of the RIr population is significantly less advanced than that of the WLIS populations. Nearly 38% of the RIr mussels

TABLE III-5-25

Gonadal development of *Mytilus edulis* maintained at RIr, WLISrN, WLISc and 500 MW from June through September 1984. I = intermediate stage, M = matured stage and S = spent.

Station	Gonadal Development			Totals	% Gonadal Development			Totals
	I	M	S		I	M	S	
RIr	11	15	3	29	37.9	51.7	10.4	100
WLISrN	3	18	7	28	10.7	64.3	24.5	100
WLISc	4	17	6	27	14.8	63.0	22.2	100
500 MW	3	15	10	28	10.7	53.6	35.7	100
Totals	21	65	26	112				

G-test Statistics: G = 20.256, d.f. = 6, $\chi^2_{0.005(6)}$ = 18.548, $p < 0.005$

Frequencies and/or percentages of occurrence with the box are not associated with the stations where the mussels were maintained.

were still in the intermediate development stage, while 85-90% of the WLIS mussels had already advanced beyond this stage. In the WLIS mussels, individuals which became spent were two to three times that of the RIr mussels. Therefore, the reproductive development of the mussels is clearly asynchronous and associated with the locations, reflecting differences in ambient temperatures and other associated parameters. According to Reid et al. (1979), the bottom temperatures of WLIS and Fishers Island Sound in September 1972 were 18°-20° and 16°-18°C, respectively. However, during winter, the bottom temperatures were rather uniform throughout the LIS and varied within a narrow limit of 4° to 6°C.

In order to ascertain whether the mussels held at WLIS, particularly at the dumpsites, were stressed, the histological slides classified as mature females from all stations were evaluated for the area of the mantle occupied by the follicles. Only 17 specimens were considered as mature females, therefore, the results presented here should be viewed as preliminary. The mussels could be easily classified in two groups according to the median percent area occupied by mature follicles: for the RIr and WLISrN populations it was 75% and for the WLISc and 500 MW populations, 40%. Therefore, it appears that the mussels deployed at the latter two sites were stressed. Similar observations made by Arimoto and Feng (1983) revealed that the New Haven dumpsite mussel population had significantly smaller ova ($1180 \pm 200\,\mu^2$) than the New Haven reference mussel population ($1520 \pm 140\,\mu^2$) ($p < 0.01$). Such a reduction of areas occupied by the gametic follicles or of ovum size could also be induced by biological means, i.e., food ration (Bayne et al. 1978) and the infection caused by *Proctoeces maculatus*. It has been noted that in light infections, the development of gametic follicles is inhibited while in severe cases, the mussels are totally castrated. Moreover, the infection among the four populations was not significantly different as to be presented later in the section discussing the prevalence of parasitic infections. Parasitism, thus, probably exerted limited stress on the host.

While it is difficult to conduct food rationing experiments in a field situation, it is possible to determine whether the mussels were feeding and carrying out normal extracellular digestion by examining the Parameter Nos. 4 and 5 in the histological slides. There were no discernible differences among the four mussel populations in as far as these parameters were concerned. Moreover, at WLISc and 500 MW where the depth is greater than 30 meters, diatom tests were readily identifiable in the intestinal contents, indicating that feeding was not inhibited and food was not wanting. It is, therefore, inferred that the stress shown in the dumpsite mussel populations cannot be attributed to temperature, food rationing and parasitic infections. Some factor(s) yet to be identified at the dumpsite could be responsible for the observed reproductive inhibition.

In the course of conducting histopathological studies, the staining characteristics of the Leydig tissue, the site of glycogen storage, ranged from light to intense red. On close inspection, it was revealed that the intense red staining was due to the presence of many large amoeboid cells with eosinophilic cytoplasm in the region. In the RIr mussel population, the frequency of occurrence of the Leydig tissue stained lightly (L), moderately (M) and heavily (H) was clearly different from that of the WLISrN, WLISc and 500 MW populations (Table III-5-26). In the latter three populations, however, the frequency distribution of the staining characteristics was not associated with the stations. These findings are similar to those observed in the gonadal develoment of the mussels. Furthermore, when one reviews the data presented in Table III-5-25 with Table III-5-26 jointly, there is a close association between the intensity of Leydig tissue staining and the stage of reproductive development; the lightly stained Leydig tissue appears to be related to the intermediate stage of gonadal development, the moderately stained with the mature follicles, etc.

A survey of the histological slides for parasitic infections had yielded the following information: (1) the prevalence of <u>Proctoeces maculatus</u> and <u>Pinnotheres maculatus</u> in the four mussel monitoring populations was not significantly different (Tables III-5-27 and III-5-28), while (2) the prevalence of <u>Chytridiopsis mytilovum</u> (a sporozoan parasite) differed significantly between the RIr population and the ones deployed at WLISrN, WLISc and 500 MW (Table III-5-29). There was a ca. 30% reduction of <u>C. mytilovum</u> infection in the transplanted populations as compared to the RIr population. This observation suggests that <u>C. mytilovum</u> is more susceptible or sensitive to the changing environment than the other two parasites. However, the reduction of percent infections could also be interpreted as lacking new parasitic invasions into the mussel host. Since only examination of the three months' slides has been completed, more definitive interpretations must wait until the last sample to be taken at the end of June 1985 is analyzed.

Definitive histopathological alterations of the tissues have been noted only in a few cases, consequently, they are not considered statistically significant. As more data is available, they may manifest themselves otherwise. Descriptions of tissues which show abnormal changes are presented as follows.

Gill - Fourteen of 119 mussels examined (or 12%) from all four stations were found to show abnormalities. The severity of the tissue damages ranged from detachment of cilia to sloughing and necrosis of the epithelium. In some cases, only the chitinous rod of the gills remained.

Ova - Fifty-one percent of the mature female mussels (26 of 51 animals) showed some degrees of abnormality in ova. They were characterized by loss of cytological details, leaking of cytoplasmic contents into the follicles and detachment of the egg membrane.

TABLE III-5-26

The staining characteristics of Leydig tissue of *Mytilus edulis* maintained at RIr, WLISrN, WLISc and 500 MW from June through September 1984. L = lightly stained, M = moderately stained and H = heavily stained.

Station	Staining Characteristics			Totals	% Staining Characteristics			Totals
	L	M	H		L	M	H	
RIr	18	10	2	30	60.0	33.3	6.7	100
WLISrN	10	8	13	31	32.2	25.8	42.0	100
WLISc	9	9	11	29	31.0	31.0	38.0	100
500 MW	14	5	10	29	48.3	17.2	34.5	100
Totals	51	32	36	119				

G-test Statistics: G = 15.760, d.f. = 6, $\chi^2_{0.025(6)}$ = 14.449, $p < 0.025$

Frequencies and/or percentages of occurrence within the box are not associated with the stations where the mussels were maintained.

TABLE III-5-27

Frequencies of *Proctoeces maculatus* infection in *Mytilus edulis* maintained at RIr, WLISrN, WLISc and 500 MW from June through September 1984.

Station	*Proctoeces* Infection		Totals	% *Proctoeces* Infection		Totals
	Infected	Non-infected		Infected	Non-infected	
RIr	6	24	30	20.0	80.0	100
WLISrN	7	24	31	22.6	77.4	100
WLISc	10	19	29	34.5	65.5	100
500 MW	2	27	29	6.9	93.1	100
Totals	25	94	119			

G-test Statistics: $G = 7.284$, d.f. = 3, $\chi^2_{0.05(3)} = 7.815$, $p > 0.05$

TABLE III-5-28

Frequencies of Pinnotheres maculatus infection in Mytilus edulis maintained at RIr, WLISrN and WLISc from June through September 1984.

Station	Pinnotheres Infection		Totals	% Pinnotheres Infection		Totals
	Infected	Non-infected		Infected	Non-infected	
RIr	56	16	72	77.8	22.2	100
WLISrN	59	7	66	89.4	10.6	100
WLISc	16	4	20	80.0	20.0	100
Totals	131	27	158			

GT - test Statistics: $G = 3.564$, d.f. $= 2$, $\chi^2_{0.1(2)} = 4.605$, $p > 0.10$

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TABLE III-5-29

Frequencies of *Chytridiopsis mytilovum* infection in female *Mytilus edulis* maintained at RIr, WLISrN, WLISc and 500 MW from June through September 1984.

Station	*Chytridiopsis* Infection		Totals	% *Chytridiopsis* Infection		Totals
	Infected	Non-infected		Infected	Non-infected	
RIr	8	1	9	88.9	11.1	100
WLISrN	5	13	18	27.8	72.2	100
WLISc	3	7	10	30.0	70.0	100
500 MW	6	10	16	37.5	62.5	100
Totals	22	31	53			

G-test Statistics: $G = 11.00$, d.f. = 3, $\chi^2_{0.025(3)} = 9.348$, $p < 0.025$

Frequencies and/or percentages of occurrence within the box are not associated with the stations where the mussels were maintained.

Intestine - Three of 119 mussels (3%) showed disintegration and necrosis of the epithelium. In one specimen, the basement membranes of the pithelium was detached from the underlying connective tissues.

Kidney Tubules - The invasion of Proctoeces maculatus sporocysts generally elicited intense leucocytic infiltration and caused enlargement of the tubules.

6.0 SUMMARY OF RESULTS

The results obtained over the past several years from all three major disposal areas have shown a discernible transitory increase of certain trace metals associated with disposal activities as well as a long term seasonal cycle in the concentration of Cd, Cu, Hg, Ni and Zn. Elevated levels of these trace metals generally coincided with tissue wet/dry weight ratios, shell length, periods of heightened disposal activities and river runoff (particularly at the New London disposal site). A similar cyclic elevation of trace metals occurred during the winter of 1979 and 1980 at the New London site when there was little dredging in the Thames River and no disposal activities at the site. This observation suggests that the seasonal cycle of trace metal concentrations is an endogenous process dictated by a complex array of intrinsic and extrinsic factors including the availability of trace metals in the environment.

The results obtained during 1983 at CLIS and WLIS bear remarkable similarities to those of the Stamford/New Haven capping experiment conducted in 1980-1981 at CLIS. No significant persistent elevated levels of trace metals were detected in the mussels deployed at the four stations in CLIS and one station in WLIS, regardless of whether the mussel populations were maintained at the capped, uncapped or reference site. Whenever significant differences in tissue metal concentrations were noted, they occurred between the mussel populations maintained at the two extreme ends of the Sound, i.e. WLIS and Latimer Light (LAT). There appears to be a concentration gradient for trace metals which increases from New London to WLIS. Transient heightened levels of Cu, Cd, and Ni associated with dumping events as noted at New London were also detected at CLIS and WLIS.

At New London the mean PCB concentrations of the dumpsite populations during the dumping operations varied from 520 to 800 ng/g dry weight, whereas those of reference populations ranged from 700 to 720 ng/g. After dumping had ceased, the mean PCB concentrations of the dumpsite mussels decreased (510-590 ng/g) as did those of the reference mussels (480-510 ng/g). The difference between the mean PCB concentration for the sampling periods was significant at P = 0.07, however, there was no significant difference between the disposal and reference sites.

During the dumping operations at the CLIS and WLIS sites, the reference mussels at LAT and CLIS-REF contained 670 and 600 ng/g PCB respectively while mussels maintained at 1000E, MQO, MQN and WLIS showed PCB levels 1.5 to 3 times greater, i.e., 1280, 990, 1760, and 1320 ng/g, respectively. After the termination of disposal activities, the mean PCB levels of the reference populations statistically remained unchanged (700-710 ng/g) while those of the experimental populations showed a significant reduction ($P < 0.05$) (540-1030 ng/g). Results such as these support the general conclusions that impacts from disposal operations are short term, that, following disposal, contaminants are contained within the disposal mound, and that mussels are, in fact, a sensitive monitoring tool.

Because the tissue concentrations of trace metals and PCB could be correlated with a number of intrinsic and extrinsic factors, it is important, particularly from an environmental manager's viewpoint, to assess the relative importance of these factors so the management decisions can be based on quantitative results. Such an assessment was accomplished by subjecting the data to a stepwise multiple regression analysis which accounts for the variance of trace metals and PCB associated with various independent variables, e.g. wet/dry tissue weight ratios, dredged volume disposed, river runoff, etc. Available evidence suggests that dumping, at most, has a minor influence on the long term uptake of trace metals and PCB. Certain factors, such as the lack of a "dose-response" to changes in disposal volumes, support this conclusion.

The most recent results from the histological examination of mussels held at WLIS and the reference sites indicate some significant differences in gonadal development and prevalence of parasitism. Sufficient data is not yet available to determine the cause of these differences.

In summary, the Mussel Watch Program continues to be the primary monitoring tool for assessing the dispersion of contaminants both during and after disposal operations. Combined with the work being accomplished at the Narragansett Environmental Research Laboratory of EPA as part of the FVP project, the DAMOS data provides a basis for future management decisions.

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APPENDIX III

Concentrations of Trace Metals and PCB's Found in *Mytilus edulis* Deployed Under the DAMOS Program

TABLE 1a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Latimer Light

Sampling Date	Mean Metal Concentrations ± S.D. (µg/g wet tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
2/28/83	.12 (.02)	.20 (.08)	.05 (.02)	1.21 (.08)	32.25 (4.08)	.023 (.002)	.28 (.06)	.41 (.05)	17.73 (1.91)
4/6/83	.09 (.01)	.44 (.10)	.04 (.01)	1.10 (.08)	22.30 (1.50)	.021 (.002)	.40 (.07)	.20 (.01)	13.47 (.160)
5/5/83	.12 (.01)	.96 (.06)	.08 (.01)	1.25 (.07)	37.90 (2.87)	.024 (.002)	.64 (.18)	.18 (.04)	16.10 (1.75)
6/15/83	.13 (.01)	.63 (.16)	.09 (.10)	1.66 (.06)	56.87 (5.44)	.027 (.001)	.62 (.16)	.38 (.02)	17.67 (4.61)
7/26/83	.13 (.12)	.65 (.19)	.05 (.01)	.959 (.112)	31.94 (9.89)	.024 (.000)	.37 (.24)	.06 (.01)	18.87 (4.40)
8/30/83	.17 (.03)	.65 (.09)	.06 (.02)	1.38 (.28)	28.57 (3.14)	.023 (.007)	.47 (.06)	.10 (.03)	21.65 (.55)
9/28/83	.17 (.03)	.17 (.05)	.04 (.02)	.869 (.061)	16.16 (1.42)	.018 (.003)	.12 (.03)	.04 (.01)	16.37 (2.68)

TABLE 1a (cont.)

	Mean Metal Concentrations ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/18/83	.13 (.02)	.13 (.03)	.02 (.02)	.90 (.18)	14.74 (3.17)	.021 (.002)	.15 (.03)	16.37 (1.56)	.03 (.03)
11/30/83	.15 (.02)	.54 (.28)	.05 (.01)	.83 (.12)	30.00 (4.93)	.020 (.001)	.40 (.15)	16.77 (2.25)	.10 (.05)
12/27/83	.29 (.02)	.29 (.05)	.15 (.02)	1.04 (.06)	46.02 (4.60)	.025 (.002)	.36 (.05)	15.65 (3.97)	.28 (.03)
1/18/84	.21 (.03)	.16 (.03)	.12 (.02)	.87 (.14)	30.45 (1.73)	.021 (.001)	.22 (.05)	11.28 (.90)	.21 (.09)
1/20/84*	.16 (.02)	.14 (.04)	.04 (.01)	.91 (.14)	30.31 (7.57)	.025 (.003)	.14 (.05)	14.70 (2.53)	.08 (.03)
2/23/84	.23 (.14)	.59 (.10)	.07 (.03)	1.51 (.27)	51.30 (27.84)	.024 (.004)	.56 (.14)	26.31 (21.34)	.36 (.06)
3/26/84	.18 (.01)	.15 (.04)	.07 (.01)	1.40 (.08)	25.16 (6.21)	.022 (.002)	.31 (.27)	18.23 (1.83)	.26 (0)
4/15/84	.13 (0)	1.02 (.44)	.13 (.02)	1.41 (.07)	43.02 (7.57)	.023 (.002)	.67 (.25)	19.76 (.69)	.20 (0)
4/19/84	.12 (.01)	.48 (.14)	.08 (0)	1.41 (.21)	29.94 (5.18)	.025 (.001)	.26 (.06)	15.02 (1.10)	.15 (.02)
5/30/84	.22 (.01)	.98 (.11)	.10 (.01)	1.59 (.15)	38.64 (3.56)	.026 (.004)	.58 (.06)	21.15 (4.58)	.33 (.08)

TABLE 1a (cont.)

	Mean Metal Concentrations ± S.D. (µg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
6/21/84	.13 (.02)	.65 (.22)	.07 (.02)	1.30 (.34)	22.38 (4.59)	.028 (.008)	.39 (.17)	16.30 (3.84)	.14 (.03)
7/26/84	.13 (.04)	.26 (.03)	.06 (.04)	1.33 (.02)	21.76 (2.08)	.022 (.001)	.24 (.10)	14.62 (.65)	.70 (.16)
8/22/84	.13 (.02)	.41 (.04)	.08 (.02)	.84 (.15)	16.14 (1.23)	.017 (.003)	.29 (.02)	18.01 (4.45)	.09 (.02)
9/19/84	.15 (.02)	.57 (.29)	.08 (.01)	.67 (.03)	18.05 (2.61)	.018 (.001)	.23 (.21)	17.99 (2.31)	.16 (.00)

* Baselines for WLISd and WLISr

TABLE 1b

Summary of Metal Concentrations in Mussels (Mytilus edulis) Deployed at the Latimers Light Site.

Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
	Mean Metal Concentration ± 1 S.D. (μg/g dry tissue)								
2/28/83	.93 (.13)	1.58 (.57)	.36 (.12)	9.57 (.53)	253.70 (21.91)	.182 (.014)	2.16 (.40)	3.21 (.29)	140.16 (16.16)
4/6/83	.75 (.09)	3.64 (.81)	.36 (.08)	9.03 (.61)	182.77 (11.00)	.177 (.025)	3.28 (.73)	1.65 (.00)	110.56 (14.88)
5/5/83	1.02 (.06)	7.89 (.25)	.64 (.10)	10.36 (.83)	313.14 (19.87)	.198 (.018)	5.30 (1.36)	1.51 (.35)	133.32 (16.92)
6/15/83	.88 (.06)	4.37 (.86)	.60 (.10)	11.67 (.18)	399.25 (38.29)	.190 (.013)	4.35 (.90)	2.67 (.19)	124.16 (33.44)
7/26/83	1.04 (.05)	5.07 (1.32)	.38 (.07)	7.46 (.71)	247.58 (69.95)	.190 (.009)	2.84 (1.83)	.46 (.08)	146.19 (29.42)
8/30.83	1.09 (.20)	4.14 (.56)	.35 (.11)	8.77 (1.86)	182.17 (20.89)	.147 (.045)	3.00 (.37)	.63 (.19)	137.97 (2.82)
9/28/83	1.31 (.27)	1.28 (.43)	.31 (.12)	6.67 (.58)	123.92 (12.21)	.140 (.033)	.96 (.29)	.30 (.04)	125.04 (16.36)

TABLE 1b (cont.)

Sampling Date	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/18/83	1.06 (0.21)	1.10 (0.23)	0.15 (0.12)	7.49 (1.75)	121.76 (27.75)	.168 (.003)	1.20 (0.26)	136.00 (24.57)	0.22 (0.24)
11/30/83	1.68 (0.20)	6.19 (3.26)	0.51 (0.10)	9.32 (1.52)	338.18 (47.22)	.223 (.008)	4.47 (1.69)	189.18 (21.89)	1.18 (0.59)
12/27/83	3.22 (0.27)	3.33 (0.80)	1.65 (0.08)	11.61 (0.64)	515.44 (23.63)	.273 (.012)	4.12 (0.71)	174.23 (36.17)	3.13 (0.27)
1/18/84	2.49 (0.32)	1.95 (0.27)	1.40 (0.17)	10.50 (1.40)	369.03 (15.07)	.250 (.010)	2.70 (0.55)	136.74 (11.71)	2.49 (0.96)
1/20/84	1.79 (0.26)	1.56 (0.38)	0.51 (0.12)	10.36 (1.55)	342.93 (80.14)	.286 (.030)	1.55 (0.56)	166.74 (28.65)	0.96 (0.24)
2/23/84	1.94 (1.22)	4.85 (0.89)	0.60 (0.20)	12.36 (2.53)	422.38 (237.51)	.195 (.030)	4.62 (1.24)	217.23 (180.17)	2.92 (0.39)
3/26/84	1.22 (0.11)	1.05 (0.34)	0.46 (0.04)	9.49 (.83)	170.16 (44.81)	.149 (.016)	2.11 (1.95)	123.03 (12.37)	1.71 (0.11)
4/15/84	0.80 (0.06)	6.47 (3.52)	0.80 (0.40)	9.01 (0)	273.68 (49.03)	.150 (.007)	4.25 (1.92)	126.60 (15.15)	1.29 (0.07)
4/19/84	0.85 (0.01)	3.22 (0.64)	0.55 (0.06)	9.61 (1.25)	203.59 (22.59)	.173 (.010)	1.73 (0.26)	103.44 (16.91)	1.06 (0.22)

TABLE 1b (cont.)

Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
	Mean Metal Concentration ± S.D. (µg/g dry wt of tissue)								
5/30/84	1.30 (0.05)	5.70 (0.52)	0.57 (0.06)	9.21 (.35)	224.30 (12.76)	.153 (.020)	3.36 (0.36)	123.73 (32.42)	1.93 (0.33)
6/21/84	0.92 (0.05)	4.40 (1.03)	0.48 (0.05)	8.80 (1.05)	152.84 (2.65)	.187 (.033)	2.74 (1.31)	110.82 (5.53)	0.93 (0.07)
7/26/84	0.81 (0.29)	1.61 (0.19)	0.39 (0.24)	8.20 (0)	134.66 (11.39)	.133 (.006)	1.49 (0.62)	90.53 (3.19)	4.36 (1.05)
8/22/84	1.13 (0.24)	3.52 (0.14)	0.73 (0.07)	7.31 (0.61)	140.84 (11.28)	.148 (.038)	2.50 (0.34)	155.03 (23.05)	0.78 (0.10)
9/19/84	1.40 (0.27)	5.22 (2.77)	0.73 (0.09)	6.11 (0)	165.28 (29.50)	.163 (.003)	2.15 (1.98)	163.84 (18.57)	1.45 (0.06)

TABLE 2a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at the Western Long Island Sound Site.

		Mean Metal Concentrations $\pm$ 1 S.D. (μg/g wet tissue)								
Platform	Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
B	3/14/83	.36	.24	.10	2.57	24.39	.023	.50	.12	26.22
		(.04)	(.10)	(.01)	(.18)	(4.52)	(.003)	(.12)	(.12)	(2.80)
B	4/13/83	.17	.33	.05	1.83	33.27	.018	.41	.20	20.98
		(.01)	(.13)	(.01)	(.15)	(.71)	(.002)	(.04)	(.05)	(3.34)
A	5/13/83	.37	.28	.08	1.95	47.35	.026	.57	.12	24.23
		(.02)	(.00)	(.01)	(.06)	(7.08)	(.001)	(.05)	(.01)	(.59)
B	5/13/83	.26	.19	.07	1.81	40.82	.025	.47	.05	21.89
		(.08)	(.06)	(.02)	(.17)	(7.65)	(.002)	(.03)	(.07)	(.63)
B	6/14/83	.23	.20	.08	1.71	42.94	.023	.67	.14	21.57
		(.01)	(.07)	(.01)	(.10)	(10.59)	(.001)	(.08)	(.02)	(.93)
B	7/25/83	.25	.36	.07	1.64	35.85	.022	.49	.04	28.61
		(.03)	(.09)	(.00)	(.26)	(2.57)	(.001)	(.07)	(.01)	(23.63)
B	8/31/83	.23	.43	.05	1.29	22.51	.017	.39	<.01	23.63
		(.02)	(.09)	(.01)	(.07)	(.73)	(.003)	(.11)	---	(3.05)
B	10/4/8~~4~~3	.43	.33	.10	1.43	27.20	.024	.39	.10	23.53
		(.01)	(.05)	(.07)	(.05)	(2.20)	(.002)	(.07)	(.02)	(4.87)

TABLE 2b

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at the Western Long Island Sound Site.

		Mean Metal Concentrations ± 1 S.D. (μg/g dry tissue)								
Platform	Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
B	3/14/83	2.36 (.12)	1.60 (.76)	.65 (.07)	17.05 (.23)	162.78 (36.07)	.150 (.008)	3.34 (1.00)	.75 (.71)	173.94 (14.40)
B	4/13/83	1.37 (.05)	2.66 (1.14)	.38 (.05)	14.68 (1.03)	266.45 (8.62)	.145 (.018)	3.25 (.31)	1.62 (.39)	167.55 (22.44)
A	5/13/83	3.08 (.15)	2.37 (.12)	.68 (.08)	16.33 (.18)	395.02 (49.31)	.218 (.003)	4.73 (.49)	.98 (.08)	202.74 (11.91)
B	5/13/83	2.16 (.27)	1.61 (.50)	.55 (.15)	14.97 (1.01)	339.82 (69.59)	.203 (.012)	3.92 (.30)	.39 (.55)	181.79 (6.84)
B	6/14/83	2.00 (.19)	1.80 (.80)	.64 (.08)	14.66 (.95)	376.23 (134.28)	.197 (.018)	5.77 (1.09)	1.25 (.31)	184.79 (16.16)
B	7/25/83	1.89 (.11)	2.74 (.61)	.51 (.04)	12.54 (.07)	276.11 (28.83)	.172 (.003)	3.76 (.30)	.28 (.29)	220.11 (35.25)
B	8/31/83	1.87 (.16)	3.50 (.63)	.38 (.10)	10.46 (.53)	183.24 (4.56)	.142 (.025)	3.15 (.84)	.11 (.10)	192.01 (20.11)
B	10/4/83	3.38 (.22)	2.60 (.29)	.79 (.55)	11.22 (.29)	213.79 (22.07)	.188 (.012)	3.07 (.64)	.78 (.22)	184.71 (38.79)

TABLE 3a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound Reference Site (WLISr). The sampling was terminated on June 27, 1984. The platform was redeployed at Latimers Light and sampling was resumed in July 1984.

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
1/20/84	.16 (.02)	.14 (.04)	.04 (.01)	.91 (.14)	30.31 (7.57)	.025 (.003)	.14 (.05)	14.70 (2.53)	.08 (.03)
2/21/84	.14 (.02)	.14 (.03)	.05 (.02)	1.85 (.12)	19.17 (2.28)	.025 (.002)	.22 (.04)	18.83 (2.65)	.13 (.02)
3/22/84	.19 (.01)	.23 (.03)	.07 (.01)	1.97 (.17)	18.27 (1.08)	.017 (.001)	.28 (.02)	21.37 (1.74)	.12 (.01)
4/11/84	.18 (.01)	.18 (.02)	.09 (.01)	1.91 (.16)	42.19 (18.54)	.027 (.002)	.27 (.03)	20.69 (2.67)	.17 (.03)
6/1/84	.35 (.01)	.26 (.07)	.07 (.01)	2.23 (.34)	31.81 (3.12)	.016 (.002)	.57 (.18)	24.61 (1.24)	.26 (.05)
6/27/84	.25 (.05)	.34 (.26)	.07 (.01)	1.65 (.14)	24.37 (4.13)	.024 (.000)	.49 (.19)	20.03 (3.18)	.17 (.03)
7/26/84	.19 (.02)	.27 (.06)	.06 (.01)	1.08 (.12)	22.91 (.37)	.016 (.000)	.32 (.10)	20.11 (1.12)	.70 (.02)
8/22/84	.21 (.04)	.67 (.10)	.10 (.01)	.75 (.10)	21.28 (1.14)	.016 (.003)	.43 (.01)	21.38 (1.20)	.12 (.04)
9/19/84	.17 (.03)	.48 (.21)	.09 (.00)	.86 (.26)	21.24 (2.30)	.018 (.004)	.42 (.09)	26.25 (5.10)	.16 (.02)

TABLE 3D

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound Reference Site (WLISr). The sampling was terminated on June 27, 1984. The platform was redeployed at Latimers Light and sampling was resumed in July 1984.

Sampling Date	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
1/20/84	1.79 (0.26)	1.56 (0.38)	0.51 (0.12)	10.36 (1.55)	342.93 (80.14)	.286 (.030)	1.55 (0.56)	166.74 (28.65)	0.96 (0.24)
2/21/84	1.37 (0.09)	1.40 (0.19)	0.48 (0.10)	18.81 (1.07)	194.92 (13.68)	.253 (.037)	2.23 (0.35)	191.06 (14.25)	1.31 (0.14)
3/22/84	1.55 (0.12)	1.91 (0.37)	0.56 (0.03)	16.20 (0.48)	151.32 (16.04)	.142 (.003)	2.30 (0.07)	176.70 (16.43)	1.00 (0.03)
4/11/84	1.36 (0.14)	1.37 (0.17)	0.67 (0.07)	14.74 (0.51)	324.42 (130.84)	.205 (.000)	2.11 (0.31)	160.58 (25.37)	1.32 (0.13)
6/1/84	2.18 (0.05)	1.67 (0.46)	0.43 (0.06)	14.04 (1.94)	200.41 (21.83)	.102 (.014)	3.59 (1.06)	155.09 (11.07)	1.64 (0.30)
6/27/84	1.73 (0.26)	2.44 (1.94)	0.52 (0.08)	11.62 (1.26)	171.58 (32.61)	.170 (.004)	3.42 (1.43)	140.33 (19.43)	1.21 (0.21)
7/26/84	1.54 (0.04)	2.22 (0.37)	0.48 (0.11)	8.80 (0.42)	188.52 (16.66)	.130 (.014)	2.62 (0.82)	166.16 (31.30)	5.76 (0.38)
8/22/84	1.89 (0.35)	6.17 (1.17)	0.94 (0.12)	6.80 (0.59)	194.72 (14.22)	.145 (.017)	3.98 (0.28)	195.57 (13.31)	1.15 (0.39)
9/19/84	1.41 (0.45)	3.89 (1.26)	0.73 (0.07)	6.97 (1.08)	175.25 (6.99)	.150 (.025)	3.46 (0.84)	214.97 (15.27)	1.33 (0.35)

TABLE 4a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound Disposal Site (WLISd). The sampling was terminated on June 27, 1984. The platform was redeployed at Latimers Light and sampling was resumed in July 1984.

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
1/20/84	.16 (.02)	.14 (.04)	.04 (.01)	.91 (.14)	30.31 (7.57)	.025 (.003)	.14 (.05)	14.70 (2.53)	.08 (.03)
4/11/84	.18 (.01)	.12 (.01)	.07 (.01)	1.81 (.13)	21.07 (1.86)	.021 (.003)	.26 (.09)	19.86 (1.33)	.13 (.01)
6/1/84	.23 (.03)	.45 (.17)	.07 (.03)	1.72 (.30)	27.67 (2.98)	.017 (.002)	.47 (.09)	21.20 (2.39)	.17 (.02)
6/27/84	.13 (.01)	.38 (.03)	.05 (.04)	1.22 (.17)	23.94 (2.44)	.029 (.003)	.60 (.05)	22.29 (3.13)	.15 (.02)
7/26/84	.15 (.03)	.34 (.08)	.06 (.01)	1.09 (.19)	26.70 (3.62)	.022 (.002)	.25 (.13)	21.67 (.59)	1.05 (.03)
8/22/84	.21 (.02)	.69 (.10)	.10 (.00)	.84 (.17)	22.47 (2.06)	.018 (.001)	.45 (.06)	23.44 (5.53)	.13 (.03)
9/19/84	.20 (.03)	.61 (.12)	.09 (.02)	.71 (.06)	20.18 (1.37)	.015 (.001)	.47 (.04)	18.14 (1.51)	.14 (.01)

TABLE 4b

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound disposal site (WLISd). The sampling was terminated on June 27, 1984. The platform was redeployed at Latimers Light and sampling was resumed in July 1984.

Sampling Date	Mean Metal Concentration ± S.D. (µg/g dry wt of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
4/11/84	1.40 (0.04)	0.96 (0.02)	0.60 (0.08)	14.60 (1.00)	169.87 (14.47)	.170 (.018)	2.07 (0.82)	160.57 (16.41)	1.09 (0.01)
6/1/84	1.86 (0.20)	3.58 (1.30)	0.62 (0.04)	13.63 (2.18)	219.57 (24.09)	.138 (.015)	3.74 (0.64)	168.00 (16.90)	1.37 (0.13)
6/27/84	1.09 (0.14)	3.16 (0.26)	0.40 (0.34)	10.01 (1.05)	197.16 (9.85)	.242 (.014)	4.95 (1.27)	184.60 (30.47)	1.25 (0.12)
7/26/84	1.00 (0.25)	2.26 (0.55)	0.37 (0.06)	7.19 (0.69)	177.78 (31.64)	.143 (.012)	1.71 (1.06)	144.02 (14.64)	6.96 (0.76)
8/22/84	1.89 (0.35)	6.17 (1.17)	0.94 (0.12)	7.50 (1.31)	201.71 (34.81)	.165 (.018)	3.98 (.28)	207.91 (47.00)	1.15 (0.39)
9/19/84	1.92 (0.20)	6.01 (0.91)	0.86 (0.25)	6.97 (0.60)	199.54 (17.34)	.150 (.005)	4.61 (.53)	179.71 (21.37)	1.41 (0.12)

TABLE 5a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound new reference site (WLISrN).

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/25/84	.11 (.02)	.22 (.07)	.04 (.03)	1.24 (.20)	25.49 (3.22)	.025 (.002)	.42 (.03)	21.62 (1.02)	.20 (.03)
8/25/85	.23 (.02)	.13 (.04)	.09 (.03)	1.10 (.11)	16.23 (1.10)	.022 (.004)	.30 (.04)	18.99 (1.53)	.06 (.02)
9/18/84	.15 (.01)	2.45 (3.03)	.13 (.04)	.87 (.26)	30.94 (13.14)	.019 (.004)	1.09 (.78)	17.15 (5.97)	.09 (.01)

TABLE 5b

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound new reference site (WLISrN).

	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/25/84	.75 (.11)	1.54 (.46)	.28 (.24)	8.70 (1.39)	178.44 (23.17)	.182 (.015)	2.95 (0.16)	151.40 (6.39)	1.43 (.22)
8/21/84	1.75 (.10)	1.00 (.30)	.70 (.26)	8.40 (0.35)	123.41 (10.37)	.168 (.020)	2.26 (0.39)	144.02 (5.54)	.44 (.10)
9/18/84	1.41 (.14)	21.11 (25.26)	1.30 (.51)	8.21 (1.60)	307.73 (171.53)	.178 (.029)	10.96 (9.13)	160.32 (34.68)	.86 (.05)

TABLE 6a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound Center B pile (WLISc).

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/25/84	.11 (.01)	.16 (.05)	.04 (.02)	1.25 (.03)	22.36 (2.78)	.024 (.003)	.30 (.03)	18.01 (3.39)	.13 (.01)
8/21/84	.17 (.05)	.28 (.06)	.05 (.04)	1.45 (.47)	18.41 (2.14)	.023 (.003)	.30 (.03)	20.66 (2.69)	.11 (.07)
9/18/84	.16 (.03)	.39 (.19)	.10 (.01)	1.03 (.27)	16.25 (4.41)	.026 (.006)	.33 (.07)	20.19 (4.96)	.08 (.02)

TABLE 6b

Summary Of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound Center B pile (WLISc).

Sampling Date	Mean Metal Concentration ± S.D. (µg/g dry wt of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/25/84	0.72 (.03)	1.10 (0.31)	.29 (.15)	8.70 (0.35)	155.44 (16.52)	.167 (.023)	2.11 (0.22)	127.42 (25.36)	0.89 (0.09)
8/21/84	1.13 (.27)	1.89 (0.44)	.37 (.18)	8.80 (2.18)	121.90 (8.95)	.153 (.015)	2.02 (0.09)	136.65 (11.52)	0.76 (0.42)
9/18/84	1.32 (.14)	3.20 (1.70)	.79 (.08)	8.19 (0.53)	129.72 (12.54)	.190 (.000)	2.61 (0.10)	162.08 (26.09)	0.61 (0)

TABLE 7a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at 500 meters west of B pile (500MW) in Western Long Island Sound.

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/25/84	.10 (.01)	.12 (.04)	.03 (.02)	1.23 (.16)	18.65 (1.56)	.019 (.001)	.43 (.14)	14.96 (1.18)	.12 (.01)
8/21/84	.14 (.02)	.16 (.03)	.04 (.02)	1.12 (.09)	18.87 (3.33)	.023 (.003)	.24 (.04)	17.37 (3.33)	.09 (.03)
9/18/84	.15 (.02)	.40 (.02)	.08 (.01)	.97 (.15)	18.82 (.53)	.017 (.002)	.44 (.06)	14.48 (3.60)	.06 (.02)

TABLE 7b

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at 500 meters west of the B pile (500MW) in Western Long Island Sound.

	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/25/84	0.73 (.008)	0.90 (.35)	0.25 (.15)	8.90 (.35)	137.05 (24.96)	.142 (.008)	3.05 (0.76)	108.97 (8.45)	0.88 (0.15)
8/21/84	0.99 (.15)	1.17 (.26)	0.26 (.15)	8.20 (.61)	138.56 (25.11)	.168 (.021)	1.79 (0.30)	127.42 (25.36)	0.63 (0.25)
9/18/84	1.33 (.14)	3.49 (.17)	0.69 (.09)	8.37 (.82)	164.02 (11.25)	.145 (.009)	3.83 (0.29)	125.06 (23.84)	0.56 (0.19)

TABLE 8a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at Ram Island reference site (RIr).

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
4/26/84	.14 (.03)	.60 (.25)	.09 (.02)	1.30 (.17)	52.25 (10.71)	.027 (.004)	.53 (.26)	19.01 (6.12)	.19 (.04)
6/27/84	.07 (.01)	.29 (.09)	.03 (.02)	1.28 (.18)	26.71 (4.60)	.031 (.003)	.33 (.13)	15.18 (2.77)	.15 (.05)
7/26/84	.11 (.07)	.54 (.16)	.06 (.03)	1.29 (.28)	37.20 (4.57)	.031 (.002)	.40 (.08)	21.55 (1.63)	1.03 (.20)
8/22/84	.10 (.01)	.33 (.04)	.05 (.01)	1.18 (.16)	19.53 (.90)	.021 (.001)	.57 (.26)	13.43 (2.32)	.04 (.04)
9/19/84	.12 (.01)	.52 (.14)	.08 (.01)	.87 (.15)	27.23 (1.89)	.022 (.001)	.44 (.18)	16.09 (2.24)	.11 (.01)

TABLE 8b

Summary of Metal Concentrations in Mussels (Mytilus edulis) Deployed at Ram Island reference site (RIr).

	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
4/26/84	0.68 (0.23)	4.04 (1.77)	0.58 (0.10)	8.75 (1.02)	349.56 (59.79)	.184 (.014)	3.60 (1.89)	133.76 (20.76)	1.37 (0.23)
6/27/84	0.45 (0.07)	1.90 (0.57)	0.15 (0.10)	8.32 (.74)	173.21 (24.04)	.201 (.013)	2.14 (0.78)	98.65 (16.25)	1.00 (0.28)
7/26/84	0.71 (0.40)	3.45 (1.06)	0.36 (0.16)	8.20 (1.81)	238.25 (31.20)	.195 (.009)	2.49 (0.39)	136.65 (6.39)	6.54 (1.06)
8/22/84	0.77 (0.03)	2.58 (0.40)	0.43 (0.08)	9.21 (0.92)	153.61 (4.59)	.163 (.014)	4.44 (2.00)	105.29 (14.64)	0.36 (0.34)
9/19/84	0.99 (0.18)	4.26 (1.31)	0.65 (0.05)	6.97 (0.79)	218.02 (7.56)	.175 (.025)	3.46 (1.34)	130.35 (29.13)	0.91 (0.19)

TABLE 9a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at the Mill-Q R (old) Site.

Sampling Date	Mean Metal Concentrations ± 1 S.D. (g/g wet tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
3/31/83	.11 (.02)	.40 (.14)	.07 (.01)	1.91 (.11)	40.08 (3.78)	.020 (.001)	.45 (.08)	.28 (.05)	20.18 (1.35)
5/6/83	.22 (.02)	1.24 (.06)	.10 (.02)	1.67 (.06)	43.66 (6.44)	.017 (.000)	.80 (.08)	.16 (.01)	18.28 (1.04)
6/23/83	.24 (.02)	.46 (.09)	.09 (.01)	1.78 (.07)	64.33 (27.03)	.019 (.001)	.60 (.06)	.39 (.11)	14.88 (5.32)
7/27/82	.24 (.01)	.38 (.07)	.07 (.01)	1.36 (.10)	43.10 (3.36)	.018 (.001)	.39 (.12)	.07 (.02)	20.56 (2.02)
8/29/83	.15 (.08)	.35 (.03)	.06 (.01)	.99 (.06)	21.92 (.64)	.014 (.001)	.32 (.00)	.03 (.02)	19.78 (3.95)
9/27/83	.26 (.02)	.12 (.04)	.05 (.02)	.79 (.03)	15.10 (.86)	.016 (.002)	.16 (.02)	.07 (.04)	20.76 (2.27)

TABLE 9a (cont.)

Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
	Mean Metal Concentration ± S.D. (µg/g wet weight of tissue)								
10/17/83	.23 (.01)	.09 (0)	.03 (.02)	1.10 (.13)	22.51 (.38)	.017 (.000)	.16 (.02)	22.32 (3.81)	.04 (.02)
11/28/83	.45 (.05)	.25 (.06)	.09 (.02)	1.80 (.28)	32.74 (1.31)	.021 (.001)	.37 (.06)	21.95 (3.51)	.10 (.07)
12/20/83	.27 (.08)	.29 (.15)	.29 (.24)	1.46 (.09)	36.76 (3.43)	.019 (.001)	.47 (.14)	20.40 (.44)	.21 (.03)
1/17/84	.27 (.02)	.13 (.03)	.03 (.01)	1.91 (.15)	67.69 (14.42)	.022 (0)	.25 (.05)	17.98 (1.25)	.11 (.02)
2/17/84	.24 (.03)	.16 (0)	.05 (.01)	1.99 (.32)	126.61 (22.11)	.024 (.002)	.25 (.03)	22.51 (4.08)	.16 (.04)
3/6/84	.34 (.02)	.26 (.09)	.07 (.01)	1.88 (.14)	87.25 (27.24)	.016 (.004)	.30 (.08)	20.66 (1.90)	.30 (.09)
4/14/84	.27 (.01)	.16 (.02)	.10 (.01)	1.61 (.14)	59.10 (7.75)	.022 (.001)	.23 (.06)	18.80 (3.31)	.31 (.05)
5/31/84	.35 (.08)	.19 (.07)	.07 (.02)	1.26 (.17)	23.64 (1.87)	.018 (.001)	.23 (.04)	20.15 (5.07)	.20 (.07)

TABLE 9b

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at the Mill-Q R (old) Site.

Sampling Date	Mean Metal Concentrations ± 1 S.D. (µg/g dry tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
3/31/83	.74 (.10)	2.63 (.86)	.43 (.10)	12.65 (.62)	265.30 (28.81)	.130 (.009)	2.97 (.54)	1.83 (.36)	133.31 (4.88)
5/6/83	1.85 (.13)	10.59 (.70)	.81 (.14)	14.27 (.63)	372.85 (19.31)	.143 (.008)	6.81 (.91)	1.39 (.07)	156.12 (10.18)
6/23/83	2.14 (.15)	4.07 (1.22)	.80 (.15)	15.71 (1.50)	587.27 (226.53)	.167 (.014)	5.30 (1.03)	3.35 (.78)	155.09 (27.18)
7/27/83	1.82 (.06)	2.89 (.58)	.51 (.06)	10.39 (.70)	329.62 (17.86)	.140 (.013)	2.96 (.95)	.53 (.20)	157.63 (18.49)
8/29/83	1.49 (.74)	3.35 (.38)	.53 (.06)	9.39 (.46)	210.77 (7.27)	.135 (.013)	3.11 (.14)	9.62 (.43)	190.51 (39.54)
9/27/83	2.47 (.19)	1.26 (.35)	.47 (.19)	7.51 (.29)	144.31 (8.09)	.158 (.014)	1.53 (.24)	.69 (.39)	198.43 (22.24)

TABLE 9b (cont.)

Sampling Date	Mean Metal Concentration $\pm$ S.D. ($\mu g/g$ dry weight of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/17/83	2.24 (0.08)	0.87 (0.03)	0.31 (0.15)	10.64 (1.31)	216.74 (5.81)	.160 (.000)	1.52 (0.21)	215.09 (38.68)	0.36 (0.16
11/28/83	3.51 (0.31)	1.91 (0.36)	0.66 (0.07)	13.79 (1.52)	251.98 (20.21)	.162 (.006)	2.87 (0.65)	168.04 (19.65)	0.76 (0.52)
12/20/83	2.95 (1.11)	3.19 (1.96)	1.58 (.16)	15.35 (0.56)	390.85 (75.69)	.195 (.005)	5.07 (2.00)	215.72 (22.95)	2.22 (0.48)
1/17/84	2.98 (0.24)	1.40 (0.31)	0.37 (0.04)	20.68 (1.69)	734.46 (155.84)	.237 (.003)	2.65 (1.49)	194.98 (10.83)	1.36 (0.43)
2/17/84	2.24 (0.20)	1.45 (0.05)	0.44 (0.06)	18.44 (2.73)	1181.32 (233.75)	.221 (.010)	2.36 (0.33)	209.07 (35.97)	1.49 (0.35)
3/20/84	2.59 (0.15)	2.03 (0.75)	0.54 (0.10)	14.44 (0.73)	667.47 (191.13)	.120 (.026)	2.30 (0.68)	158.78 (14.21)	2.41 (0.40)
4/14/84	2.14 (0.19)	1.34 (0.12)	0.82 (0.08)	13.00 (0.73)	475.91 (46.63)	.177 (.016)	1.86 (0.50)	151.64 (24.20)	2.49 (0.30)
5/31/84	3.10 (0.92)	1.68 (0.70)	0.65 (0.18)	10.81 (0.92)	203.49 (9.93)	.152 (.018)	1.96 (0.40)	177.22 (60.87)	1.75 (1.32)

TABLE 10a

Summary of Metal Concentrations in Mussels (Mytilus edulis) Deployed at the Mill-Q R (new) Site

Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
	Mean Metal Concentrations $\pm$ 1 S.D. (μg/g wet tissue)								
3/31/83	.14 (.02)	.33 (.05)	.07 (.01)	2.00 (.20)	40.68 (6.82)	.021 (.002)	.40 (.20)	.29 (.07)	21.16 (.80)
5/6/83	.15 (.02)	.83 (.14)	.09 (.04)	2.01 (.30)	48.90 (6.31)	.017 (.001)	.69 (.12)	.15 (.12)	18.66 (3.87)
6/23/83	.18 (.03)	.27 (.05)	.09 (.02)	1.78 (.12)	31.69 (5.86)	.018 (.001)	.55 (.07)	.47 (.17)	17.97 (3.12)
7/27/83	.16 (.02)	.31 (.05)	.06 (.01)	1.45 (.10)	58.63 (10.73)	.016 (.001)	.33 (.10)	.06 (.00)	17.09 (1.09)
9/27/83	.21 (.03)	.16 (.03)	.09 (.05)	1.02 (.16)	19.46 (1.19)	.019 (.008)	.24 (.04)	.07 (.04)	19.94 (1.35)

TABLE 10a (cont.)

(The sampling was terminated on June 20, 1984. The platform was redeployed at Latimers Light and sampling was resumed in July 1984.)

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/17/83	.26 (.03)	.11 (.07)	.03 (.01)	1.00 (.11)	20.38 (2.95)	.018 (.001)	.18 (.05)	14.65 (1.28)	.06 (.04)
4/12/84	.45 (.29)	.28 (.02)	.10 (.04)	1.88 (.23)	103.41 (14.80)	.025 (.004)	.33 (.06)	23.32 (1.70)	.28 (.08)
5/31/84	.29 (.02)	.11 (.02)	.05 (0)	1.48 (.19)	25.35 (1.46)	.017 (.001)	.17 (.02)	17.40 (.09)	.17 (0)
6/20/84	.26 (.05)	.31 (.07)	.07 (.01)	1.40 (.44)	28.14 (1.04)	.033 (.001)	.41 (.06)	21.68 (1.71)	.30 (.06)
8/8/84*	.24 (.09)	.41 (.09)	.06 (.02)	1.04 (.10)	19.67 (.41)	.020 (.002)	.42 (.10)	22.10 (.88)	.17 (.06)
8/22/84	.20 (.04)	.32 (.02)	.08 (.02)	.85 (.13)	16.79 (2.62)	.016 (.001)	.23 (.03)	21.53 (9.05)	.12 (.02)
9/19/84	.23 (.01)	.48 (.11)	.08 (.01)	.74 (.12)	19.21 (2.27)	.010 (.000)	.44 (.07)	15.22 (4.26)	.12 (.03)

* in lieu of the July samples which were discarded due to mislabelling.

TABLE 10b

Summary of Metal Concentrations in Mussels (Mytilus edulis) Deployed at the Mill-Q R (new) site.

	Mean Metal Concentration ± 1 S.D. (µg/g dry tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
3/31/83	.87 (.14)	1.97 (.27)	.40 (.05)	12.11 (.81)	246.22 (33.03)	.127 (.014)	2.41 (1.16)	1.78 (.37)	127.43 (0)
5/6/83	1.13 (.28)	6.26 (1.62)	.68 (.24)	14.95 (1.07)	364.95 (41.08)	.130 (.005)	5.17 (.88)	1.08 (.85)	138.21 (19.54)
6/23/83	1.40 (.27)	2.07 (.46)	.66 (.14)	13.83 (.18)	247.43 (55.35)	.142 (.003)	4.27 (.42)	3.58 (1.16)	144.73 (24.65)
7/27/83	1.28 (.18)	2.45 (.39)	.50 (.04)	11.47 (.80)	462.81 (87.69)	.123 (.006)	2.63 (.72)	.46 (.00)	134.80 (9.82)
9/27/83	2.13 (.38)	1.58 (.39)	.94 (.47)	10.21 (2.05)	193.10 (4.04)	.187 (.094)	2.37 (.53)	.66 (.36)	198.33 (17.78)

TABLE 10b (cont.)

(The sampling was terminated on June 20, 1984. The platform was redployed at Latimers Light and sampling was resumed in July 1984.)

	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/17/83	2.65 (0.32)	1.10 (0.62)	0.28 (0.12)	10.15 (1.31)	206.93 (26.58)	.182 (.011)	1.81 (0.53)	148.79 (11.08)	0.56 (0.42)
4/12/84	2.22 (0.26)	2.34 (0.19)	0.85 (0.24)	15.72 (0)	865.71 (15.95)	.213 (.008)	2.73 (0.31)	198.28 (34.21)	2.27 (0.41)
5/31/84	2.65 (0.25)	1.01 (0.25)	0.46 (0.01)	13.64 (2.57)	234.03 (20.65)	.160 (.007)	1.60 (0.20)	160.62 (0)	1.56 (0)
6/20/84	2.45 (0.38)	2.94 (0.63)	0.68 (0.08)	13.03 (4.19)	260.98 (8.60)	.307 (.019)	3.84 (0.53)	201.20 (16.90)	2.77 (0.59)
8/8/84	1.98 (0.77)	3.39 (0.62)	0.51 (0.17)	8.60 (0.93)	162.83 (8.01)	.163 (.018)	3.47 (0.73)	182.76 (5.54)	1.38 (0.55)
8/22/84	1.83 (0.61)	2.81 (0.34)	0.76 (0.21)	7.49 (0.30)	148.28 (23.66)	.143 (.021)	2.00 (0.13)	197.33 (104.03)	1.06 (0.27)
9/19/84	2.32 (0.15)	4.84 (1.08)	0.85 (0.05)	7.49 (1.09)	194.23 (25.71)	.102 (.003)	4.46 (0.73)	153.27 (40.39)	1.25 (0.31)

TABLE 11a

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at the 1000 m East Site.

Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
	Mean Metal Concentration ± 1 S.D. (g/g wet tissue)								
3/31/83	.15 (.01)	.17 (.04)	.06 (.01)	2.14 (.17)	44.60 (2.81)	.018 (.001)	.30 (.02)	.34 (.01)	21.51 (1.52)
5/3/83	.18 (.01)	.62 (.10)	.09 (.01)	2.32 (.20)	34.41 (2.44)	.024 (.002)	.24 (.18)	.20 (.04)	24.33 (2.86)
6/23/83	.20 (.04)	.46 (.11)	.07 (.01)	2.11 (.08)	43.13 (6.25)	.020 (.002)	.61 (.14)	.29 (.04)	21.90 (2.83)
7/27/83	.18 (.02)	.50 (.07)	.06 (.01)	1.55 (.13)	46.47 (4.83)	.017 (.000)	.44 (.14)	.06 (.02)	18.98 (3.42)
8/29/83	.18 (.01)	.33 (.06)	.04 (.01)	1.23 (.04)	27.11 (2.68)	.017 (.000)	.28 (.14)	.03 (.02)	20.17 (2.31)
9/27/83	.22 (.04)	.11 (.02)	.06 (.02)	1.01 (.07)	17.25 (1.05)	.017 (.000)	.13 (.13)	.08 (.02)	20.54 (1.92)

TABLE 11a (cont.)

(The sampling was terminated on June 20, 1984. The platform was redeployed at Latimers Light and sampling was resumed in July 1984.)

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/17/83	.22 (.01)	.15 (.06)	.03 (.02)	1.27 (.08)	41.94 (8.71)	.019 (.001)	.20 (.01)	18.83 (.41)	.09 (.03)
11/18/83	.23 (.02)	.21 (.09)	.06 (.03)	1.56 (.21)	37.29 (15.61)	.017 (.001)	.23 (.02)	19.02 (4.62)	.11 (.01)
12/20/83	.22 (.02)	.61 (.11)	.18 (.03)	1.78 (.18)	55.95 (15.84)	.026 (.001)	.67 (.13)	22.23 (2.52)	.30 (.10)
1/17/84	.20 (.03)	.13 (.03)	.02 (.01)	1.60 (.14)	40.06 (8.22)	.021 (0)	.21 (.05)	18.68 (4.19)	.13 (.04)
2/17/84	.22 (.02)	.21 (.03)	.04 (.01)	1.64 (.22)	73.34 (14.00)	.018 (.002)	.28 (.12)	18.19 (3.34)	.14 (.02)
3/20/84	.49 (.03)	.58 (.19)	.09 (.03)	2.22 (.06)	101.80 (1.80)	.029 (.002)	.63 (.24)	33.86 (3.25)	.36 (.03)
4/14/84	.26 (.02)	.28 (.14)	.10 (0)	1.92 (.09)	83.84 (2.54)	.026 (.003)	.28 (.04)	26.42 (7.29)	.32 (.17)
5/31/84	.28 (0)	.19 (.07)	.07 (.01)	1.29 (.16)	19.64 (1.75)	.019 (.003)	.23 (.04)	19.78 (2.41)	.16 (.04)

TABLE 11a (cont.)

Sampling Date	Mean Metal Concentration $\pm$ S.D. (µg/g wet wt of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
6/20/84	.29 (.04)	.71 (.29)	.09 (.01)	1.25 (.16)	41.56 (2.62)	.035 (.002)	.47 (.11)	26.00 (2.60)	.41 (.03)
7/26/84	.17 (.03)	.22 (.02)	.09 (.02)	1.14 (.08)	26.05 (.57)	.022 (.001)	.17 (.03)	18.26 (.81)	.93 (.31)
8/22/84	.22 (.03)	.49 (.05)	.12 (.01)	.84 (.10)	26.17 (.73)	.020 (.002)	.30 (.08)	22.10 (1.93)	.15 (.02)
9/19/84	.20 (.03)	.42 (.28)	.07 (.01)	.66 (.04)	13.89 (2.11)	.015 (.002)	.33 (.06)	14.22 (.58)	.08 (.02)

TABLE 11b

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at the 1000 m East Site.

Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
	Mean Metal Concentration ± 1 S.D. (μg/g dry tissue)								
3/31/83	.94 (.10)	1.12 (.39)	.38 (.01)	13.72 (.40)	286.04 (15.27)	.113 (.019)	1.89 (.04)	2.21 (.23)	138.20 (12.92)
5/3/83	1.21 (.12)	4.24 (.86)	.62 (.01)	15.76 (1.08)	233.74 (6.15)	.163 (.019)	1.68 (1.30)	1.39 (.36)	165.92 (24.64)
6/23/83	1.45 (.32)	3.27 (.73)	.53 (.12)	15.07 (.96)	307.78 (43.25)	.145 (.009)	4.37 (1.00)	2.08 (.26)	156.55 (22.79)
7/27/83	1.35 (.09)	3.79 (.43)	.49 (.04)	11.77 (1.33)	351.86 (29.77)	.132 (.006)	3.27 (.92)	.46 (.16)	144.55 (30.40)
8/29/83	1.43 (.07)	2.65 (.48)	.31 (.06)	9.85 (.46)	216.76 (25.59)	.133 (.006)	2.24 (1.12)	.20 (.16)	160.91 (15.84)
9/27/83	1.85 (.38)	.98 (.21)	.47 (.15)	8.69 (.77)	148.14 (11.24)	.148 (.006)	1.13 (.23)	.69 (.16)	176.11 (12.84)

TABLE 11b (cont.)

(The sampling was terminated on June 20, 1984. The platform was redeployed at Latimers Light and sampling was resumed in July 1984.)

	Mean Metal Concentration ± S.D. (µg/g dry wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/17/83	1.97 (0.13)	1.32 (0.50)	0.25 (0.13)	11.31 (0.29)	371.87 (58.55)	.168 (.015)	1.77 (0.15)	168.13 (10.06)	0.76 (0.22)
11/28/83	2.20 (0.23)	2.00 (0.80)	0.58 (0.28)	15.11 (1.49)	357.86 (133.13)	.160 (.005)	2.31 (0.28)	186.04 (55.35)	1.05 (0.06)
12/20/83	1.85 (0.18)	5.16 (0.85)	1.54 (0.25)	15.16 (1.40)	476.35 (133.60)	.225 (.009)	5.72 (1.08)	189.28 (20.27)	2.59 (0.81)
1/17/84	2.32 (0.31)	1.44 (0.25)	0.27 (0.06)	18.14 (2.40)	454.31 (106.47)	.230 (.009)	2.39 (0.48)	212.73 (56.86)	1.49 (0.47)
2/17/84	2.44 (0.13)	2.41 (0.35)	0.44 (0.06)	18.60 (2.20)	833.14 (177.09)	.208 (.026)	3.12 (1.30)	205.46 (32.95)	1.57 (0.19)
3/20/84	3.37 (0.31)	4.00 (1.29)	0.62 (0.21)	15.40 (0.55)	705.44 (39.67)	.200 (.009)	4.36 (1.62)	234.25 (19.49)	2.50 (0.07)
4/14/84	1.67 (0.09)	1.80 (0.91)	0.65 (0.06)	12.36 (0.48)	538.82 (27.88)	.168 (.023)	1.79 (0.32)	169.59 (46.93)	2.05 (1.17)
5/31/84	2.57 (0.09)	1.68 (0.70)	0.56 (0.05)	11.02 (0.35)	169.17 (27.34)	.163 (.008)	1.96 (0.40)	169.85 (26.15)	1.37 (0.40)
6/20/84	2.31 (0.18)	5.57 (2.53)	0.72 (0.02)	9.81 (1.26)	325.08 (10.76)	.272 (.003)	3.71 (1.05)	203.05 (8.45)	3.22 (0.18)

TABLE 11b (cont.)

Sampling Date	Mean Metal Concentration ± S.D. (µg/g dry wt of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/26/84	1.19 (0.18)	1.61 (0.12)	0.61 (0.11)	8.20 (.61)	186.91 (7.18)	.155 (.005)	1.18 (0.21)	131.11 (8.45)	6.66 (2.28)
8/22/84	1.78 (0.33)	3.93 (0.23)	0.98 (0.04)	6.80 (1.07)	210.65 (5.62)	.165 (.017)	2.39 (0.49)	177.95 (17.00)	1.23 (0.20)
9/19/84	2.18 (0.64)	4.34 (2.39)	0.73 (0.23)	7.15 (1.47)	152.64 (46.05)	.160 (.000)	3.01 (0.55)	155.03 (29.91)	1.35 (0.59)

TABLE 12a

Summary of Metal Concentrations in Mussels (Mytilus edulis) Deployed at the CLIS Reference Site.

	Mean Metal Concentration ± 1 S.D. (μg/g wet tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
3/31/83	.15 (.03)	.13 (.02)	.07 (.01)	2.06 (.14)	33.37 (3.73)	.025 (.002)	.33 (.10)	.25 (.03)	23.12 (3.47)
5/3/83	.20 (.04)	.35 (.09)	.11 (.01)	1.73 (.14)	41.32 (4.30)	.024 (.001)	.35 (.22)	.26 (.02)	22.04 (3.09)
6/23/83	.19 (.03)	.34 (.02)	.06 (.02)	1.74 (.15)	54.03 (16.99)	.021 (.002)	.46 (.02)	.37 (.03)	21.22 (1.86)
7/27/83	.17 (.01)	.50 (.05)	.06 (.01)	1.14 (.05)	49.25 (10.50)	.017 (.001)	.37 (.07)	.04 (.01)	19.71 (.62)
8/29/83	.19 (.01)	.31 (.09)	.05 (.01)	1.15 (.11)	17.13 (1.54)	.022 (.001)	.26 (.08)	.04 (.02)	20.83 (5.14)
9/27/83	.28 (.11)	.17 (.02)	.04 (.01)	.834 (.122)	16.93 (1.23)	.014 (.001)	.22 (.06)	.09 (.04)	17.64 (1.36)

TABLE 12a (cont.)

(The sampling was terminated on June 20, 1984. The monitoring platform was redeployed at Latimers Light and sampling was resumed in July 1984.)

	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/17/83	.16 (.01)	.14 (.04)	.03 (.02)	1.05 (.12)	22.80 (2.37)	.017 (.001)	.23 (.03)	16.76 (1.56)	.03 (.01)
11/28/83	.39 (.04)	.10 (.01)	.07 (.02)	1.71 (.20)	28.91 (1.37)	.023 (.002)	.27 (.06)	22.05 (2.19)	.16 (.06)
12/20/83	.33 (.05)	.34 (.20)	.14 (.02)	1.40 (.27)	34.54 (6.00)	.016 (.002)	.31 (.13)	17.59 (2.12)	.23 (.05)
1/17/84	.28 (.01)	.11 (.01)	.05 (0)	1.55 (.24)	36.18 (4.73)	.022 (.001)	.18 (.05)	19.13 (3.57)	.09 (.02)
2/17/84	.19 (.03)	.20 (.07)	.03 (.01)	1.60 (.15)	64.91 (11.10)	.017 (.002)	.27 (.05)	19.95 (3.19)	.07 (.03)
4/12/84	.27 (.04)	.42 (.14)	.07 (.02)	1.57 (.09)	59.52 (12.32)	.024 (.001)	.31 (.07)	21.85 (3.48)	.12 (.04)
5/31/84	.25 (.03)	.16 (.02)	.08 (.02)	1.35 (.22)	23.15 (1.58)	.020 (.001)	.19 (.07)	19.25 (2.34)	.36 (.03)
6/20/84	.17 (.02)	.20 (.04)	.03 (.02)	1.24 (.26)	23.05 (2.03)	.034 (.001)	.28 (.08)	22.78 (.98)	.78 (.03)

TABLE 12a (cont.)

	Mean Metal Concentration ± S.D. (μg/g wet wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/26/84	.22 (.02)	.19 (.06)	.08 (.01)	1.00 (.10)	19.87 (.77)	.017 (.001)	.18 (.07)	17.75 (3.57)	.23 (.03)
8/22/84	.21 (.03)	.70 (.16)	.10 (.01)	.80 (.06)	27.69 (1.52)	.018 (.003)	.36 (.07)	17.68 (3.18)	.18 (.02)
9/19/84	.22 (.03)	.41 (.21)	.07 (.02)	.71 (.11)	14.19 (.57)	.015 (.001)	.37 (.06)	15.91 (4.23)	.12 (.02)

TABLE 12b

Summary of Metal Concentrations in Mussels (*Mytilus edulis*) Deployed at the CLIS Reference Site.

Sampling Date	Mean Metal Concentration ± 1 S.D. (μg/g dry tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	V	Zn
3/31/83	.92 (.14)	.80 (.12)	.42 (.04)	12.79 (.23)	207.29 (12.00)	.153 (.006)	2.08 (.65)	1.54 (.12)	144.73 (26.90)
5/3/83	1.37 (.22)	2.42 (.73)	.72 (.12)	11.84 (.92)	283.47 (32.91)	.163 (.006)	2.38 (1.52)	1.76 (.07)	151.24 (23.12)
6/23/83	1.47 (.28)	2.53 (.09)	.48 (.16)	13.10 (.65)	404.40 (106.26)	.160 (.023)	3.45 (.11)	2.83 (.33)	161.00 (21.92)
7/27/83	1.36 (.11)	3.93 (.31)	.50 (.09)	9.00 (.70)	386.51 (62.04)	.133 (.003)	2.87 (.41)	.33 (.09)	155.89 (7.45)
8/29/83	1.51 (.17)	2.45 (.63)	.38 (.09)	9.08 (.70)	135.25 (16.25)	.172 (.006)	2.09 (.66)	.33 (.16)	164.23 (40.09)
9/27/83	2.77 (.91)	1.72 (.23)	.44 (.03)	8.35 (1.02)	170.46 (19.94)	.143 (.021)	2.15 (.55)	.87 (.31)	177.81 (23.42)

TABLE 12b (cont.)

(The sampling was terminated on June 20, 1984. The monitoring platform was redeployed at Latimers Light and sampling was resumed in July 1984.)

	Mean Metal Concentration ± S.D. (μg/g dry wt of tissue)								
Sampling Date	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
10/17/83	1.52 (0.16)	1.36 (0.40)	0.32 (0.28)	9.98 (0.76)	216.92 (13.43)	.165 (.009)	2.14 (0.23)	160.08 (22.84)	0.32 (0.06)
11/28/83	3.09 (0.19)	0.77 (0.03)	0.58 (0.08)	13.62 (1.31)	231.00 (8.97)	.185 (.017)	2.21 (0.42)	176.15 (16.77)	1.24 (0.49)
12/20/83	3.63 (0.74)	3.84 (2.33)	1.62 (0.21)	15.53 (3.08)	384.66 (84.19)	.178 (.025)	3.44 (1.54)	194.91 (25.92)	2.47 (0.67)
1/17/84	3.37 (0.29)	1.39 (0.14)	0.57 (0.06)	18.52 (1.41)	433.38 (22.75)	.270 (.022)	2.10 (0.52)	232.83 (62.22)	1.10 (0.10)
2/17/84	2.28 (0.03)	2.49 (1.12)	0.40 (0.09)	19.08 (0.96)	791.84 (245.20)	.207 (.200)	3.36 (1.09)	236.04 (6.25)	0.87 (0.30)
4/12/84	1.81 (0.11)	1.58 (0.56)	0.65 (0.07)	13.00 (0.55)	493.20 (112.49)	.202 (.006)	1.46 (0.60)	180.65 (30.52)	1.94 (0.24)
5/31/84	2.21 (0.26)	3.46 (0.99)	0.52 (0.11)	11.22 (1.81)	192.41 (5.44)	.168 (.006)	2.61 (0.44)	160.62 (24.12)	1.06 (0.36)
6/20/84	2.23 (0.28)	1.39 (0.07)	0.69 (0.21)	11.02 (2.12)	204.30 (12.00)	.306 (.011)	1.72 (0.65)	203.05 (8.45)	3.18 (0.36)

TABLE 12b (cont.)

Sampling Date	Mean Metal Concentration $\pm$ S.D. (μg/g dry weight of tissue)								
	Cd	Cr	Co	Cu	Fe	Hg	Ni	Zn	V
7/26/84	1.26 (0.23)	1.53 (0.43)	0.26 (0.13)	7.60 (1.28)	151.31 (3.24)	.130 (.014)	2.11 (0.84)	135.73 (43.04)	5.83 (0.45)
8/22/84	2.01 (0.32)	6.68 (1.56)	0.98 (.09)	7.66 (.53)	265.14 (14.02)	.175 (.026)	3.42 (0.65)	169.13 (29.12)	1.72 (0.22)
9/19/84	2.42 (0.14)	4.55 (2.52)	0.82 (.22)	7.67 (1.05)	154.46 (10.96)	.162 (.003)	3.98 (0.47)	172.66 (45.59)	1.32 (0.27)

TABLE 13a

Total polychlorinated biphenyls (PCB) and Aroclor concentrations in *Mytilus edulis* (± 1 S.D.) March to September 1983

Station	n	Aroclor 1242	Aroclors 1254+1260	Total PCB
LAT				
D	4	47 ± 26*	39 ± 11	86 ± 26
A	3	60 ± 50	40 ± 18	100 ± 68
D+A	7	53 ± 35	39 ± 13	92 ± 44
CLISr				
D	3	42 ± 06	47 ± 03	87 ± 03
A	3	36 ± 25	52 ± 28	87 ± 52
D+A	6	39 ± 16	48 ± 17	87 ± 33
1000ME				
D	2	65 ± 17	119 ± 24	184 ± 07
A	3	20 ± 20	68 ± 16	88 ± 36
D+A	5	38 ± 29	89 ± 32	127 ± 58
MQO				
D	3	60 ± 23	68 ± 33	128 ± 53
A	3	22 ± 03	40 ± 11	61 ± 14
D+A	6	41 ± 26	54 ± 27	95 ± 50
MQN				
D	3	89 ± 48	156 ± 65	244 ± 112
A	2	57 ± 63	65 ± 32	123 ± 95
D+A	5	76 ± 50	120 ± 69	196 ± 114
WLIS				
D	3	65 ± 15	108 ± 40	174 ± 55
A	4	30 ± 23	51 ± 26	80 ± 47
D+A	7	45 ± 26	75 ± 43	121 ± 68

D = During disposal, A = After disposal
* Expressed as ng/g of wet weight tissue

TABLE 13b

Total polychlorinated biphenyl (PCB) and Aroclor concentrations in *Mytilus edulis* (± 1 S.D.) March to September 1983.

Station	n	Aroclor 1242	Aroclors 1254+1260	Total PCB
LAT				
D	4	367 ± 210*	307 ± 97	674 ± 212
A	3	417 ± 308	286 ± 108	703 ± 414
D+A	7	388 ± 233	297 ± 94	686 ± 282
CLISr				
D	3	288 ± 10	311 ± 47	600 ± 38
A	3	287 ± 183	424 ± 195	711 ± 376
D+A	6	288 ± 116	368 ± 141	655 ± 247
1000ME				
D	2	450 ± 103	834 ± 199	1284 ± 96
A	3	157 ± 153	543 ± 97	700 ± 246
D+A	5	274 ± 200	659 ± 200	933 ± 367
MQO				
D	3	465 ± 100	531 ± 237	993 ± 311
A	3	191 ± 14	346 ± 52	537 ± 49
D+A	6	329 ± 163	439 ± 184	765 ± 320
MQN				
D	3	638 ± 383	1127 ± 540	1765 ± 912
A	2	464 ± 477	562 ± 189	1026 ± 666
D+A	5	568 ± 373	901 ± 501	1469 ± 830
WLIS				
D	3	498 ± 119	820 ± 301	1318 ± 415
A	4	238 ± 176	403 ± 187	641 ± 351
D+A	7	349 ± 199	581 ± 312	932 ± 502

D = During disposal, A = After disposal

* Expressed as ng per g of freeze-dried tissue

TABLE 14

Total polychlorinated biphenyls (PCB) and Aroclor concentrations in *Mytilus edulis*, March 1982 to January 1983.

		LAT			MQO			WLIS		
Date		1242	1254+1260	T PCB	1242	1254+1260	T PCB	1242	1254+1260	T PCB
3/82	W	75	37	112*	--	--	--	--	--	--
	D	424	210	634						
5/82	W	--	--	--	--	--	--	369	245	614
	D							2130	1415	3545
6/82	W	--	--	--	--	--	--	64	254	318
	D							494	1947	2440
8/82	W	19	21	40*	--	--	--	--	--	--
	D	130	144	275						
9/82	W	18	23	41	20	21	41	--	--	--
	D	152	194	346	200	210	410			
10/82	W	16	18	34	--	--	--	--	--	--
	D	133	147	280						
11/82	W	34	29	63	543	65	608	--	--	--
	D	256	216	471	5500	660	6160			
12/82	W	31	12	43*	196	37	233	63	241	304
	D	246	94	340	2133	400	2533	671	2565	3235
1/83	W	41	16	57	53	33	86	59	79	138
	D	341	137	478	485	305	790	581	780	1360

* denotes baseline samples
W = ng/g wet weight tissue
D = ng/g dry weight tissue

TABLE 15

Summary of PCB Concentrations in Mussels (*Mytilus edulis*)

LATr

Sampling Date	1242		1242 + 1254		Total	
10/18/83	62*	8**	163*	21**	225*	28**
	(11)	(1)	(39)	(6)	(44)	(7)
11/30/83	62	5	163	14	225	28
	(11)	(1)	(34)	(3)	(42)	(3)
12/27/83	68	6	338	31	406	37
	(22)	(2)	(146)	(14)	(126)	(12)
1/18/84	74	6	263	22	337	22
	(9)	(1)	(43)	(3)	(42)	(10)
1/20/84	67	6	215	19	282	25
	(38)	(4)	(49)	(4)	(51)	(5)

CLIS-REF

Sampling Date	1242		1242 + 1254		Total	
10/17/83	75*	8**	242*	25**	317*	33**
	(7)	(1)	(17)	(2)	(23)	(3)
11/28/83	143	18	95	12	238	30
	(16)	(2)	(24)	(3)	(12)	(2)
12/20/83	58	5	194	17	240	23
	(22)	(2)	(97)	(8)	(115)	(9)
1/18/84	82	7	337	28	420	35
	(15)	(1)	(45)	(4)	(58)	(6)

* expressed in mean ng/g dry wt ± S.D.   ** expressed in mean ng/g wet wt ± S.D.

TABLE 15 (cont.)

1000E

Sampling Date	1242		1242 + 1254		Total	
10/17/83	58* (16)	7** (2)	246* (19)	27** (3)	337* (109)	37** (14)
11/28/83	82 (7)	8 (1)	270 (35)	28 (4)	352 (28)	36 (3)
12/20/83	57 (13)	7 (2)	297 (38)	35 (4)	354 (31)	42 (3)

WLIS III

Sampling Date	1242		1242 + 1254		Total	
10/27/83	134* (17)	14** (2)	250* (25)	25** (3)	384* (29)	39** (4)
12/2/83	86 (2)	9 (0)	150 (25)	15 (2)	236 (23)	24 (2)

* expressed in mean ng/g dry wt ± S.D. ** expressed in mean ng/g wet wt ± S.D.

TABLE 15 (cont.)

MQO

Sampling Date	1242		1242 + 1254		Total	
10/17/83	59*	6**	168*	18**	227*	24**
	(8)	(1)	(40)	(4)	(40)	(4)
11/28/83	63	8	150	20	213	28
	(20)	(3)	(19)	(3)	(22)	(4)
12/20/83	51	5	193	18	244	22
	(14)	(1)	(28)	(1)	(23)	(1)
1/17/84	(only 1 replicate calculated)					

MQN

Sampling Date	1242		1242 + 1254		Total	
10/17/83	84*	8**	224*	24**	328*	32**
	(5)	(0)	(20)	(2)	(22)	(2)

* expressed in mean ng/g dry wt ± S.D. ** expressed in mean ng/g wet wt ± S.D.

TABLE 16

Summary of PCB Concentrations in Mussels (Mytilus edulis) Deployed at Latimers Light (LATr).

	Mean PCB Concentrations ± S.D.					
Sampling Date	Aroclor 1242		Aroclor 1254+1260		Total	
10/18/83	59* (11)	7** (1)	154 (37)	19 (6)	212 (42)	26 (7)
11/30/83	59 (13)	5 (1)	154 (39)	14 (3)	212 (48)	19 (4)
12/27/83	64 (24)	6 (2)	319 (159)	29 (15)	383 (137)	35 (13)
1/18/84	70 (10)	6 (1)	248 (45)	21 (4)	318 (44)	26 (3)
1/20/84***	63 (44)	6 (4)	203 (57)	18 (5)	266 (59)	23 (6)
2/23/84	67 (45)	6 (4)	270 (221)	24 (21)	337 (178)	30 (17)
3/26/84	102 (17)	15 (2)	127 (7)	19 (0)	229 (20)	34 (2)
4/15/84	30 (14)	5 (2)	64 (24)	10 (3)	94 (38)	15 (5)
4/19/84	61 (5)	9 (1)	102 (14)	15 (3)	163 (9)	24 (3)
5/30/84	38 (2)	7 (1)	87 (18)	15 (4)	126 (19)	22 (5)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.
*** baseline

TABLE 17

Summary of PCB Concentrations in Mussels (*Mytilus edulis*) Deployed at Central Long Island Sound Reference Site (CLISr).

	Mean PCB Concentrations ± S.D.					
Sampling Date	Aroclor 1242		Aroclor 1254+1260		Total	
10/17/83	71* (7)	7** (1)	228 (16)	24 (2)	299 (22)	31 (3)
11/28/83	135 (15)	17 (2)	90 (22)	11 (3)	225 (12)	28 (1)
12/20/83	55 (24)	5 (2)	184 (106)	16 (9)	239 (116)	21 (10)
1/18/84	78 (16)	7 (1)	318 (49)	27 (5)	396 (63)	33 (6)
2/17/84	110 (20)	9 (2)	307 (99)	99 (11)	417 (115)	36 (14)

*expressed in ng/g dry wt ± S.D.
**expressed in ng/g wet wt ± S.D.

TABLE 18

Summary of PCB Concentrations in Mussels (*Mytilus edulis*) Deployed at 1000 meters east (10000ME) of the FVP site in CLIS.

Sampling Date	Mean PCB Concentrations ± S.D. Aroclor 1242		Aroclor 1254+1260		Total	
10/17/83	36* (26)	4** (3)	232 (21)	26 (4)	268 (28)	30 (5)
11/28/83	77 (7)	8 (1)	255 (33)	26 (4)	332 (27)	34 (3)
12/20/83	54 (12)	6 (1)	280 (35)	33 (4)	334 (29)	39 (3)
1/17/84	81 (22)	7 (2)	167 (28)	13 (1)	248 (49)	22 (4)
2/17/84	107 (24)	9 (12)	251 (30)	19 (4)	358 (49)	32 (5)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.

TABLE 19

Summary of PCB Concentrations in Mussels (*Mytilus edulis*) Deployed at Mill-Quinnipiac River Old Site (MQO) in CLIS.

	Mean PCB Concentrations ± S.D.					
Sampling Date	Aroclor 1242		Aroclor 1254+1260		Total	
10/17/83	56* (9)	6** (1)	159 (44)	17 (8)	214 (44)	22 (5)
11/28/83	60 (24)	8 (3)	141 (22)	18 (4)	201 (25)	26 (4)
12/20/83	48 (15)	4 (2)	182 (30)	17 (1)	230 (26)	21 (1)
1/17/84	48 (7)	4 (1)	177 (29)	16 (2)	224 (22)	21 (2)
2/17/84	102 (17)	11 (2)	279 (57)	30 (6)	382 (73)	41 (8)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.

TABLE 20

Summary of PCB Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound Reference Site (WLISr).

	Mean PCB Concentrations ± S.D.					
Sampling Date	Aroclor 1242		Aroclor 1254+1260		Total	
1/20/84*	64** (60)	6*** (6)	147 (34)	13 (3)	211 (64)	19 (6)
2/21/84	76 (10)	8 (1)	130 (54)	13 (7)	205 (64)	21 (8)
3/22/84	99 (12)	12 (2)	182 (30)	22 (4)	281 (26)	34 (5)
4/11/84	84 (14)	11 (2)	157 (38)	20 (6)	242 (51)	31 (8)
6/1/84	96 (5)	20 (7)	182 (14)	29 (2)	278 (14)	6 (0)
6/27/84	137 (142)	19 (19)	302 (201)	43 (27)	439 (343)	7 (0)

* baseline
** expressed in ng/g dry wt ± S.D.
*** expressed in ng/g wet wt ± S.D.

TABLE 21

Summary of PCB Concentrations in Mussels (*Mytilus edulis*) Deployed at Western Long Island Sound Disposal Site (WLISd).

	Mean PCB Concentrations ± S.D.					
Sampling Date	Aroclor 1242		Aroclor 1254+1260		Total	
10/27/83	127 (20)	13 (2)	236 (29)	24 (3)	363 (34)	36 (4)
12/2/83	81 (2)	8 (0)	142 (23)	14 (2)	223 (21)	22 (2)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.

TABLE 22

Summary of PCB Concentrations in Mussels (Mytilus edulis) Deployed at Mill-Quinniiac River New Site (MQN) in CLIS.

Sampling Date	Aroclor 1242		Aroclor 1254+1260		Total	
	Mean PCB Concentrations ± S.D.					
10/17/83	79* (5)	8** (0)	231 (19)	23 (1)	310 (21)	31 (1)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.

TABLE 23

Summary of PCB Concentrations in Mussels (Mytilus edulis) Deployed at Ram Island reference site (RIr).

Mean PCB Concentrations ± S.D.

Sampling Date	Aroclor 1242		Aroclor 1254		Aroclor 1260		Aroclor 1254+1260		Total	
4/26/84	68* (7)	10** (0)	113 (15)	17 (3)	9 (2)	1 (0)	122 (17)	18 (3)	190 (17)	28 (3)
6/27/84***	54 (18)	8 (3)	79 (9)	12 (2)	8 (1)	1 (0)	87 (8)	13 (2)	140 (21)	21 (4)
7/26/84	103 (85)	16 (13)	142 (89)	22 (13)	8 (2)	1 (0)	150 (88)	23 (13)	254 (179)	39 (26)
8/22/84	40 (0)	5 (0)	65 (4)	8 (0)	9 (3)	1 (0)	74 (1)	9 (0)	114 (1)	15 (1)
9/19/84	27 (12)	3 (2)	40 (18)	5 (3)	5 (4)	1 (1)	45 (20)	6 (3)	71 (32)	9 (5)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.
*** baseline

TABLE 24

Summary of PCB Concentrations in Mussels (Mytilus edulis) Deployed at Western Long Island Sound new reference site (WLISrN).

Sampling Date	Aroclor 1242		Aroclor 1254		Aroclor 1260		Aroclor 1254+1260		Total	
	Mean PCB Concentrations ± S.D.									
7/25/84	68* (14)	10** (2)	144 (21)	21 (3)	18 (4)	3 (1)	162 (25)	23 (3)	230 (19)	33 (3)
8/21/84	69 (39)	9 (5)	160 (60)	21 (7)	31 (25)	4 (3)	191 (61)	25 (7)	260 (97)	34 (12)
9/18/84	24 (8)	2 (0)	80 (12)	8 (2)	11 (8)	1 (1)	92 (17)	10 (2)	116 (23)	12 (2)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.

TABLE 25

Summary of PCB Concentrations in Mussels (Mytilus edulis) Deployed at Western Long Island Sound Center B pile (WLISc).

Sampling Date	Mean PCB Concentration ± S.D.									
	Aroclor 1242		Aroclor 1254		Aroclor 1260		Aroclor 1254+1260		Total	
7/25/84	51* (14)	7** (2)	133 (44)	19 (6)	16 (10)	2 (1)	149 (54)	21 (8)	200 (68)	29 (10)
8/21/84	55 (17)	8 (2)	140 (27)	21 (4)	20 (0)	3 (0)	160 (27)	24 (5)	215 (37)	32 (5)
9/18/84	38 (16)	5 (3)	98 (39)	13 (8)	13 (7)	2 (1)	111 (45)	15 (9)	149 (61)	20 (12)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.

TABLE 26

Summary of PCB Concentrations in Mussels (Mytilus edulis) Deployed at 500 meters west of B pile (500MW) in Western Long Island Sound.

	Mean PCB Concentrations ± S.D.									
Sampling Date	Aroclor 1242		Aroclor 1254		Aroclor 1260		Aroclor 1254+1260		Total	
7/25/84	62* (81)	9* (2)	156 (30)	22 (5)	18 (4)	2 (1)	173 (34)	24 (6)	236 (41)	33 (8)
8/21/84	47 (7)	6 (1)	133 (20)	18 (3)	20 (0)	3 (0)	153 (20)	21 (3)	200 (27)	27 (4)
9/18/84	44 (10)	5 (1)	113 (46)	13 (6)	16 (8)	2 (1)	129 (54)	15 (7)	173 (64)	20 (8)

* expressed in ng/g dry wt ± S.D.
** expressed in ng/g wet wt ± S.D.

TABLE

Mean trace metal concentrations and PCB levels found in the sediment samples obtained from the eight dredge material foci and the reference area in Central Long Island Sound during September 1984 cruise (After data supplied by New England Division, U.S. Army Corps of Engineers).

Station	Hg	Pb	Zn	As	Fe	Cd	Cr	Cu	Ni	V	PCB
STNH-N	0.20 ± 0.12	43 ± 14	77 ± 36	1.8 ± 0.2	5837 ± 1092	7	22	17 ± 4	34 ± 7	*	-
STNH-S	0.22 ± 0.02	62 ± 11	178 ± 58	4.5 ± 1.1	19600 ± 1778	*	60 ± 11	55 ± 11	47 ± 4	*	13
NOR	1.32 ± 0.68	102 ± 27	272 ± 104	5.1 ± 1.1	22833 ± 950	11 ± 2	90 ± 23	130 ± 51	47 ± 5	*	*
NH83	0.33 ± 0.08	42	190 ± 61	4.5 ± 1.1	---	*	63 ± 18	66 ± 18	28	-	-
CS-1	0.35 ± 0.23	49 ± 10	208 ± 12	4.9 ± 1.5	---	*	81 ± 7	85 ± 9	27 ± 2	-	-
CS-2	0.44 ± 0.23	40	190 ± 231	3.1	5730 ± 5692	7	16 ± 9	13 ± 4	31 ± 4	*	*
NH-74	0.73 ± 0.15	87 ± 25	231 ± 109	6.8 ± 0.1	19267 ± 451	10 ± 3	112 ± 34	129 ± 56	40 ± 6	*	*
MQR	0.52 ± 0.27	93 ± 27	387 ± 93	5.3 ± 0.6	---	3	159 ± 49	184 ± 63	34 ± 22	-	-
REF	0.14 ± 0.04	95	173 ± 21	3.3 ± 0.2	---	*	56 ± 01	47 ± 2	*	-	-

Trace metal concentrations - expressed as ppm
PCB concentrations - expressed as ppb
* Below detection limit
- not available

TABLE

Mean trace metal concentrations and PCB levels found in the sediment samples obtained from the center of dredge material piles, 200 and 400 meters west of the piles, as well as the reference site in Western Long Island Sound during March/April and June 1984 cruises (After data supplied by New England Division, U.S. Army Corps of Engineers).

Station	Hg	Pb	Zn	As	Fe	Cd	Cr	Cu	Ni	V	PCB
A. March/April 1984											
A-CTR	0.25 ± 0.08	65 ± 10	177 ± 37	6.8 ± 0.8	23967 ± 1501	2.0 ± 0.0	70 ± 07	60 ± 11	36 ± 01	*	-
400W	0.14 ± 0.02	77 ± 03	307 ± 19	11.3 ± 0.6	29267 ± 839	*	104 ± 02	93 ± 04	38 ± 02	*	-
REF	0.12 ± 0.01	42 ± 01	127 ± 36	8.5 ± 1.8	25467 ± 3002	*	51 ± 11	28 ± 03	36 ± 04	*	-
B. June 1984											
A-CTR	0.16 ± 0.07	60 ± 20	343 ± 94	7.1 ± 2.1	20667 ± 2723	4.0 ± 1.0	45 ± 15	62 ± 16	42 ± 10	*	93
200W	0.22 ± 0.09	139 ± 51	310 ± 56	7.5 ± 3.5	25633 ± 3156	2.0	59 ± 18	64 ± 22	52 ± 3	-	-
B-CTR	0.19 ± 0.04	159 ± 30	339 ± 59	7.1 ± 3.7	24950 ± 6010	*	63 ± 17	100 ± 27	54 ± 11	*	-
400W	0.05	48 ± 10	272 ± 41	9.1 ± 3.1	20867 ± 1617	2.5 ± 0.7	63 ± 03	68 ± 07	29 ±11	*	-
REF	0.06 ± 0.01	59 ± 02	185 ± 30	8.9 ± 2.5	24068 ± 802	*	49 ± 02	60 ± 42	38 ± 03	*	*

CTR = Center of dump pile; A,B denote locations of the disposal pile.
400W = 400 meters west of CTR
200W = 200 meters west of CTR
REF = Reference Site
Trace metal concentrations expressed as ppm
PCB concentrations expressed as ppb
* Below detection limit
- not available