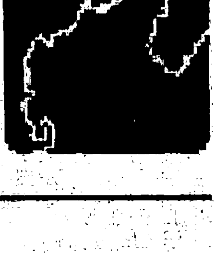
Evaluation of *GULFWATCH*
1992

Second Year
of the
Gulf of Maine
Environmental Monitoring Plan

The Gulf of Maine Council on the Marine Environment

June 1994



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INTRODUCTION

In 1989, the Gulf of Maine Council on the Marine Environment endorsed the concept of a Gulf-wide environmental health monitoring project and funded a pilot project consistent with the goals of the Gulf of Maine Environmental Monitoring Plan. This paper presents the findings of the second full year of this pilot project. Results of the first year of the pilot project are presented in "Evaluation of Gulfwatch - 1991 Pilot Project of the Gulf of Maine Marine Environmental Monitoring Plan" (GMCME 1992a). The Monitoring Plan is based on a mission statement provided by the Council:

> **It is the mission of the Gulf of Maine Marine Environmental Quality Monitoring Program to provide environmental and resource managers with information to support sustainable use of the Gulf, and allow assessment and management of risk to public and environmental health from current and potential threats.**

Three monitoring goals were established to meet the mission statement:

- to provide information on the status, trends, and sources of risks to the marine environment in the Gulf of Maine;
- to provide information on the status, trends, and sources of marine-based human health risks in the Gulf of Maine; and
- to provide appropriate and timely information to environmental and resource managers that will allow both efficient and effective management action and evaluation of such action.

GULFWATCH OBJECTIVES

The objectives of Gulfwatch (Gulf of Maine mussel watch) are three-fold:

- to evaluate the feasibility of using a mussel watch approach as one means of assessing the Gulf-wide environmental health;
- to determine the level of logistical cooperation needed between jurisdictions, identify weaknesses, and recommend measures to strengthen cooperation; and
- to initiate testing of simple hypotheses and collect comparative data from different locations in the Gulf of Maine.

The initial 1991 Gulfwatch Project was based on three hypotheses relating to mussel growth and contaminant levels in caged and indigenous mussels at test and reference sites (GMCME 1992a). Shell growth was selected as perhaps the most important biological indicator of the organism's response to different levels of contaminant burdens. The procedural aspects of studying shell growth utilized marked mussels held in suspended cages for a 2-month period at test and reference sites. Condition index (CI) was also used in the assessment process as an indicator of the physiological status of the mussels for both caged and indigenous mussels. The 1992 Gulfwatch Project was essentially a continuation of the 1991 study both in terms of hypotheses and methodology. It was, however, recognized that there should be a latitudinal or Gulf-wide orientation of the mussel watch in addition to the assessment of test and reference sites within each jurisdiction.

The three hypotheses chosen for testing were:

1. Tissue concentrations of select contaminants in mussels from "polluted" (test) areas are higher than those in mussels from "clean" (reference) areas.
2. Growth rates of mussels from "polluted" (test) areas are lower than those of mussels in "clean" (reference) areas.
3. Mussels collected from "clean" locations and grown in submerged cages at "polluted" (test) sites have lower contamination levels than those collected from adjacent subtidal areas.

The first two hypotheses were intended to test the presumption that contamination of mussels exists and that growth is affected by this contamination. The third hypothesis was aimed at testing the method of assessment itself.

1992 SITES

Within each of the states of Maine, New Hampshire, and Massachusetts and the provinces of New Brunswick and Nova Scotia, paired sites were selected (Table 1 and Figure 1) to represent extremes of environmental health in each jurisdiction. Reference sites were defined as those presumed to be free of contamination based on the knowledge and judgement of investigators familiar with the site. Test sites were defined as those identified by prior work to be affected by contamination or those

TABLE 1. Study site locations.

Code	Site location	Status[1]	Latitude	Longitude
MASA	Sandwich, MA	R	41°45.0'N	70°24.0'W
MASN	Sandwich, MA	P	41°45.73'N	70°28.38'W
MANI	Nut Island, at permanent buoy in Boston Harbor, MA	T	42°17.10'N	70°58.20'W
NHLH	Little Harbor, NH	R	43°2.0'N	70°43.0'W
NHOP	Odiorne Point, NH	P	43°3.2'N	70°43.1'W
NHSI	Shapleigh Island, NH	T	43°5.0'N	70°44.0'W
MESH	Sheepscot River, ME	R	43°51.26'N	69°42.10'W
MEKN	Kennebec River, ME	T	43°47.5'N	69°47.6'W
MEBC	Broad Cove, ME	P	43°45.95'N	70°10.75'W
NBHI	Hospital Island Northern, N.B.	R	45°07.42'N	67°00.53'W
NBSI	Machias Seal Island, N.B.	R	44°30.1'N	69°06.1'W
NBMI	Manawagonish Island, N.B.	T	45°13.0'N	66°6.0'W
NSBC	Broad Cove, N.S.	R	44°40.0'N	65°50.0'W
NSDI	Digby, N.S.	T	44°38 0'N	65°45 0'W

[1] Status: P = indicates subsample of mussels used in the cage experiment (preset)
T = Test or presumed contaminated site
R = Reference or presumed uncontaminated site

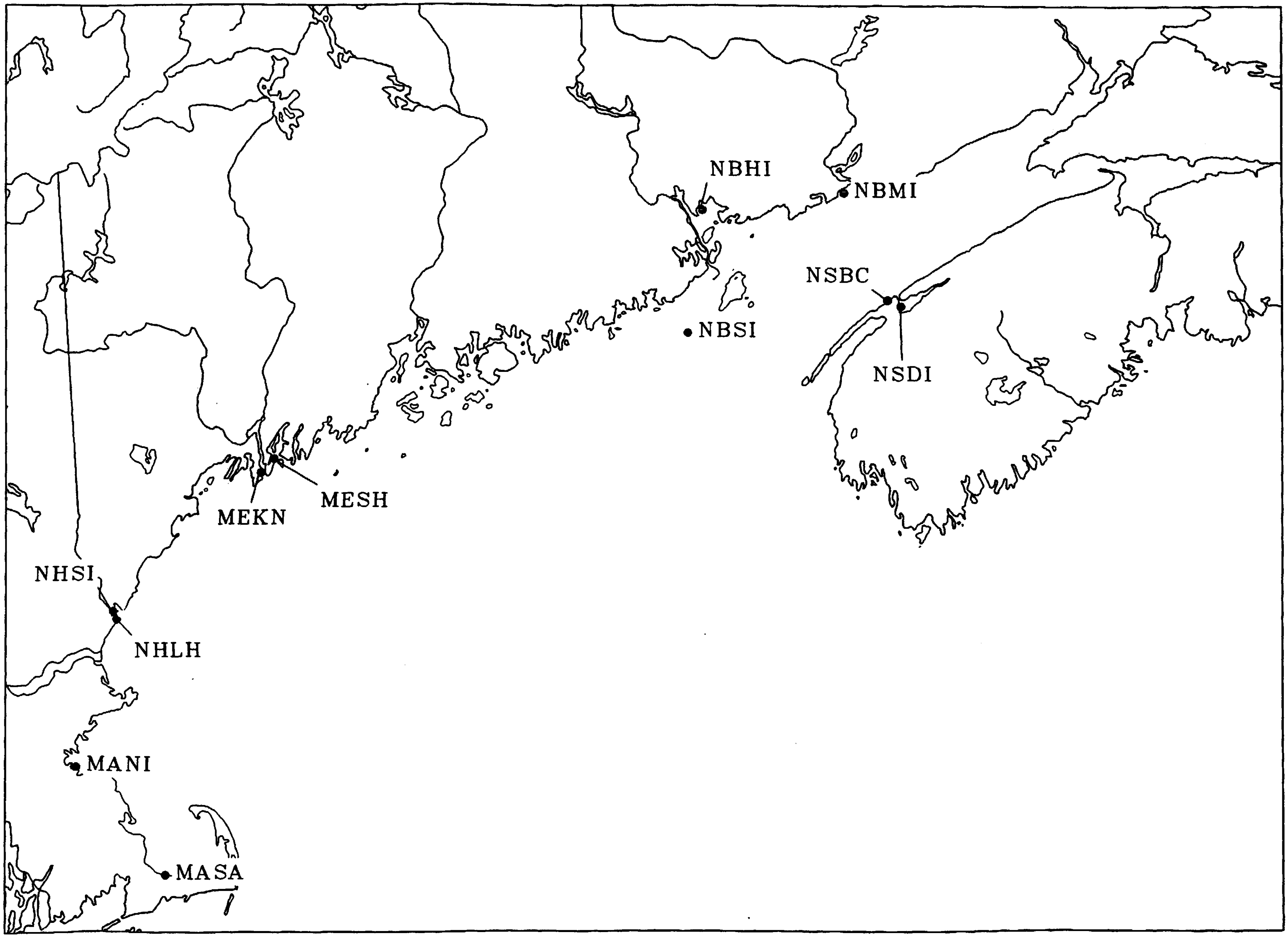

FIGURE 1. Location of Gulfwatch mussel test and reference sites occupied in 1992, Gulf of Maine.

suspected of being contaminated based on the proximity of known contamination sources.

Almost all sites selected were subtidal because mussel growth is known to be negatively affected by aerial exposure time (Phillips 1976). In Nova Scotia, the mussel samples were collected necessarily in the low intertidal zone because of the extreme tidal range. The reader is referred to our manual for more detail (GMCME 1992b).

METHODS

The Gulf of Maine 1992 mussel watch survey encompasses sampling sites from Massachusetts to Nova Scotia and involves both caged (C) and indigenous or native (N) mussels. All animals collected with the exception of the Machias Seal Island, N.B., site (Station NBSI) were either *Mytilus edulis* or *Mytilus trossulus*. Identification of *Mytilus* species at various locations around the Gulf of Maine was confirmed by either allozyme analysis or morphometrics (Mallet Research Services, 100 Columbo Ave., Dartmouth, N.S. B2X 1P7). Machias Seal Island samples of *Modiolus modiolus* (common horse mussel) were analyzed for contaminants for comparison with other sites.

The field operations of sampling, cage deployment, mussel measurement, and sample preparation used in 1992 were similar to the 1991 pilot project. Details of these procedures have been published in the field manual "Standard Procedures for Field Sampling, Measurement and Sample Preparation," Gulfwatch pilot project period 1991-1992 (GMCME 1992b). Additional monitoring at the stations included: continuous temperature recording (Hobo Temp^{R}), salinity, and turbidity. In some jurisdictions measurements of nutrient and chlorophyll levels were made at the time of cage deployment and retrieval but not included in this report. Accordingly, a summary follows.

FIELD PROCEDURES

Mussels for cage deployment were collected within each jurisdiction from an area determined to have lower contaminant levels. An attempt was made to select mussels between 50 and 60 mm in length for study (GMCME 1992b). These mussels were cleaned of all external growth and accretions and measured to the nearest 1 mm in the laboratory. Marked and measured mussels were redeployed in the field in polyethylene baskets over the mid-August to mid- October period (GMCME 1992b). Three baskets per site were moored 1 m off the bottom. At the end of the deployment period (approximately 60 days), caged mussels were retrieved and indigenous mussel composites were collected. The valves of each mussel were forced slightly open, either in the field or on return to the laboratory, and drained for approximately 1 minute before being placed in prepared containers and frozen for later processing.

Several adjustments to Gulfwatch procedures were made after examining the results of the first year of the pilot project:

1. Three replicate composite mussel samples from the uncontaminated transplant stock site were collected for chemical analysis (preset).
2. Mussels were deployed at Kennebec River, ME, to follow a start, 30-, and 60-day time series in order to test the adequacy of a 60-day deployment; this was an issue identified in the evaluation of the 1991 study.
3. The 50-60 mm size range restriction for deployed mussels was to be more strictly adhered to in order to reduce the variability observed in growth rates in 1991.
4. The number of animals measured per composite was 15 individuals for both caged and indigenous mussels.

LABORATORY PROCEDURES

In the laboratory, individual mussel length, width, and height (as defined by Seed 1968) was determined to the nearest 0.1 mm using vernier callipers. Mussels were then shucked with either plastic (metals) or stainless steel (organics) wedges directly into appropriately prepared containers (GMCME 1992b). Composite samples were capped, labelled, and returned to the freezer and stored at -15°C. Metals and organics were analysed approximately 2 and 4 months later, respectively.

A measure of CI was identified as a potential biological indicator of the effect of pollutants on mussel health in the Gulf of Maine. In this study the CI has been defined as tissue wet weight/length * height * width (after Seed 1968). CI was determined in the laboratory only on mussels collected at the time of cage retrieval. This includes both caged and indigenous mussels at the test and reference sites. As the CI is a ratio, the logarithm (base 10) of the variable has been used in statistical analyses.

ANALYTICAL PROCEDURES

Analytical procedures used followed those reported for the previous year (GMCME 1992a). A summary of those procedures and an explanation of exceptions follows.

Metals

Inorganic contaminants were analyzed at the State of Maine Health and Environmental Testing Laboratory (Augusta, ME). With a few exceptions noted below, procedures followed those of Gulfwatch 1991 (GMCME 1992a). Analyses for all metals except mercury were conducted on 5 to 10 g of wet tissue dried at 100°C. After preparation, metals were analyzed by furnace atomic absorption using standard additions when necessary. Major metals were done by flame. Analyses for mercury were done on a subsample of 1 to 2 g of wet tissue and measured by cold vapour atomic absorption.

Differences from the previous year included changes in laboratory facilities, equipment, and personnel. Tissues were digested in a microwave digester which replaced the former hot plate technique. Comparison data for the two techniques are provided below in Table 2.

TABLE 2. Comparison of hotplate digestion with microwave digestion for metal determinations (μg/g dry weight).

Technique	Sample No.	Cd	Pb	Ni	Cu	Cr	Zn	Fe
Hotplate*	640	3,2.5	2,1	21,23	7,7.1	45,44	69,67	520,520
Microwave	640	2.2	1	21	5.6	36	61	550
Hotplate*	655	2.9,3	1,2	17,17	7,7.2	29,29	83,79	500,500
Microwave	655	2.4	2	16	6.5	9.3	75	470

*Duplicate determinations were made.

Mercury was measured using cold vapour atomic absorption on a Perkin Elmer Model 503 whereas in 1991 a Perkin Elmer 603 was used. Zinc and iron were measured by flame atomic absorption using a Perkin Elmer Model 1100 whereas in 1991 a Perkin Elmer 603 was used. All remaining metals (Ag, Al, Cd, Cu, Cr, Ni, and Pb) were run as before using Zeeman background corrected furnace atomic absorption on a Varian Spectra AA 400. In 1992, aluminum was added to the suite of metals analysed to better enable us to assess the possibility of sediment contamination of mussel guts. Laboratory performance results are comparable to the 1974 standard reference material (Table 3).

TABLE 3. Comparisons of Maine health and environmental testing laboratory results of Gulfwatch 1992 stations to non-certified concentrations of inorganic constituents in 1974 standard reference materials (SRM) (values in $\mu g/g$ dry weight).

	Ag	Pb	Cd	Cr	Ni	Cu	Fe	Zn
Gulfwatch 1992 Values:								
Mean	0.95	11.7	1.6	3.33	1.06	13.1	468	116.1
±SD	0.07	1.1	0.1	0.4	0.24	0.9	32	6.9
1974 SRM Values:								
Mean	0.85	9.7	1.4	2.61	1.00	9.2	500	91.6
±SD	0.02	0.6	0.4	0.21	0.08	1.9	27	3.8

Organics

Organic contaminants in mussel samples were analyzed at the Environment Canada Environmental Protection Laboratory in Dartmouth, N.S., with the exception of dioxins and furans which were analysed on contract by Axys Analytical Services Ltd. in Sydney, B.C.

Modifications to the analytical method for organic contaminants have been made since the 1991 Gulf of Maine mussel watch effort (GMCME 1992a). Major changes include: 1) lowering the target analyte detection limit for aromatic hydrocarbons to 10 ng/g (20-30 ng/g for some lower molecular weight aromatics); 2) addition of 17 chlorinated pesticides to the variable list including alpha and beta endosulfan; and

3) identification and quantitation of PCB congeners which include 18 National Oceanographic and Atmospheric Administration (NOAA) designated congeners and 6 other congeners including some coplanar PCBs. The specific compounds are listed in Table 4. Organic compounds selected for analysis are consistent, for the most part, with NOAA status and trends mussel monitoring (NOAA 1989).

TABLE 4. Organic compounds.

Aromatic Hydrocarbons	Chlorinated Pesticides
Naphthalene	Hexachlorobenzene (HCB)
1-Methylnaphthalene	gamma-Benzenehexachloride (BHC)
2-Methylnaphthalene	Heptaclor
Biphenyl	Heptachlor epoxide
2,6-Dimethylnaphthalene	Aldrin
Acenaphthylene	Lindane
Acenaphthene	cis-Chlordane
2,3,5-Trimethylnaphthalene	trans-Nonachlor
Fluorene	Dieldrin
Phenanthrene	alpha-Endosulfan
Anthracene	beta-Endosulfan
1-Methylphenanthrene	
Fluoranthene	**DDT and Homologues**
Pyrene	
Benzo [a] anthracene	2,4'-DDE 4,4'-DDE
Chrysene	2,4'-DDD 4,4'-DDD
Benzo [b] fluoranthrene	2,4'-DDT 4,4'-DDT
Benzo [k] fluoranthrene	
Benzo [e] pyrene	**PCB Congeners**
Benzo [a] pyrene	
Perylene	PCB 8, PCB 18, PCB 28, PCB 29,
Indeno [1,2,3-cd] pyrene	PCB 44, PCB 50, PCB 52, PCB 66,
Dibenzo [ah] anthracene	PCB 77, PCB 87, PCB 101, PCB 105
Benzo [ghi] perylene	PCB 118, PCB 126, PCB 128, PCB 138
	PCB 153, PCB 169, PCB 170, PCB 180,
	PCB 187, PCB 195, PCB 206, PCB 209

The analyses of mussel tissue samples follow the diagram shown in Figure 2, and are summarized below. A description of the full analytical method and accompanying performance based QA/QC method are found in Appendix A.

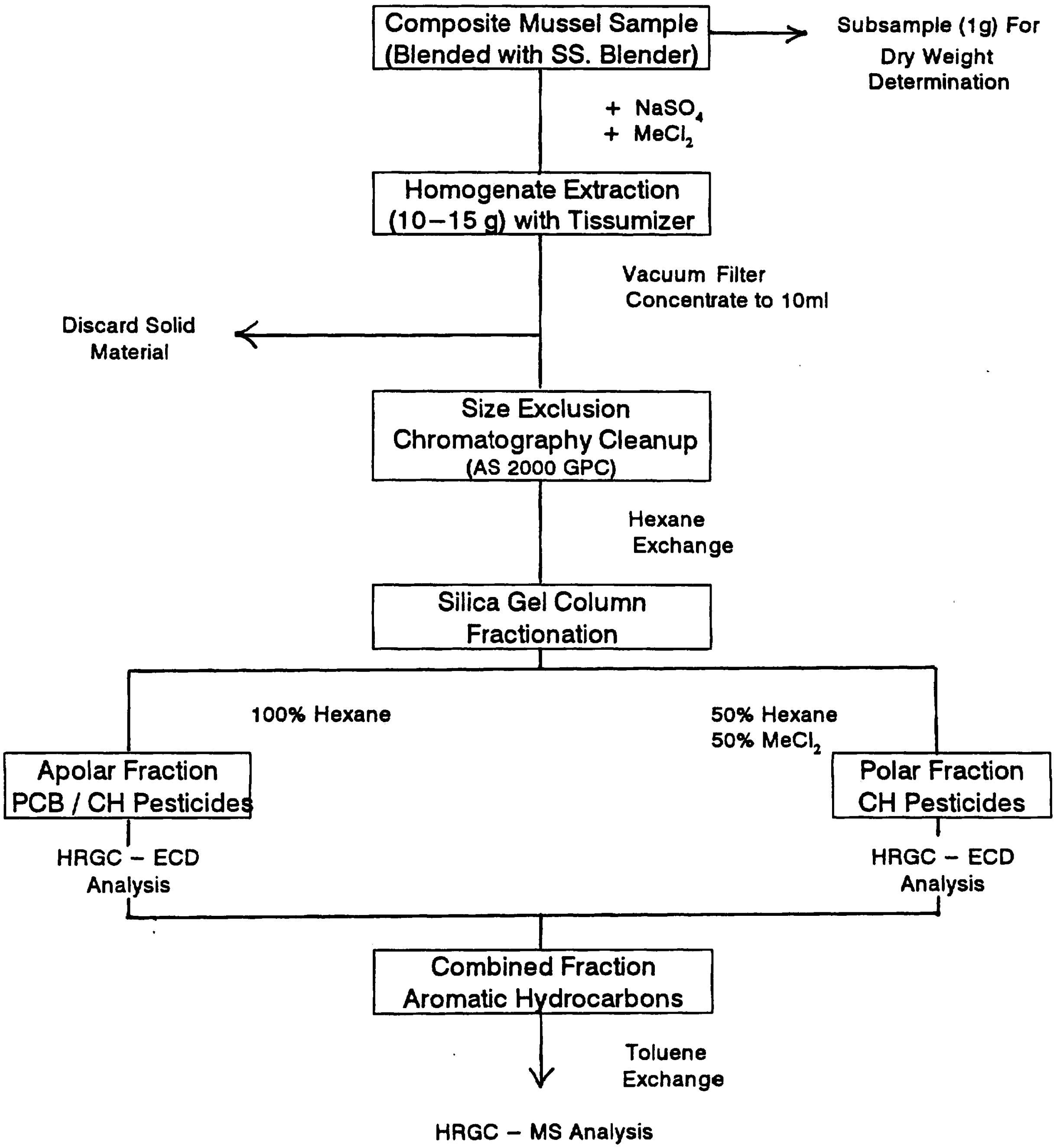

FIGURE 2. Analytical flow chart for organic analyte determination at the Environment Canada laboratory in 1992.

Tissue samples were extracted by homogenization with an organic solvent and a drying agent. Solvent extracts were obtained by vacuum filtration, and biomatrix interferences were separated from target analytes in extracts by size exclusion chromatography. Purified extracts were subjected to silica gel liquid column chromatography which provided a non-polar PCB/chlorinated pesticides fraction and a polar chlorinated pesticides fraction. PCBs and/or pesticides in each fraction were analyzed by high-resolution dual-column gas chromatography/electron capture detection (HRGC/ECD). Following PCB and pesticides analysis, the two fractions were combined and the resulting extract was analyzed for aromatic hydrocarbons by high-resolution gas chromatography/mass spectrometry (HRGC/MS).

QUALITY ASSURANCE/QUALITY CONTROL

The laboratory participated in the NIST Status and Trends Intercomparison Marine Sediment Exercise IV and Bivalve Homogenate Exercise V.

Internal quality control and method performance specifications are described in the Environment Canada Shellfish Surveillance Protocol (Appendix B). The Protocol includes mandatory QC measures with every sample batch including method blanks, spike matrix samples, duplicate samples, surrogate addition, and standard reference materials.

STATISTICAL METHODS

Arithmetic means were used to summarize the results of replicate samples. Total PAH and PCB values were created from the sum of all individual compounds or isomers with non-detected observations equal to 0. Geometric means were calculated for regional analyses. Student t-tests were conducted on the log-transformed data (Wilkinson 1990). Statistical analyses were not performed on organic variables for which detectable levels were not observed. For compounds which were occasionally below the detection limit, a value one-half of the detection limit was used. TDDT is the sum of o,p'-DDT and p,p'-DDT. TPCB is the sum of all congeners.

RESULTS AND DISCUSSION

FIELD OPERATIONS AND LOGISTICS

It was anticipated that fewer problems would be encountered because the field procedures used in the Gulfwatch Project were very similar to those used in the 1991 study. Cage retrieval was more successful in 1992. The sites, dates of cage deployment, retrieval, and duration are shown in Table 5. From a total of 33 cages deployed in the various jurisdictions, 30 were retrieved. The period of deployment was generally 2 months (ranged 58 to 75 days).

TABLE 5. Gulfwatch cage deployment and retrieval information, 1992.

Station	Category	Deployment date (m/d)	Retrieval date (m/d)	Days deployed	No. of cages retrieved
MASA	Reference	08/24	10/23	58	3
MANI	Test	08/25	10/29	63	3
NHLH	Reference	08/23	10/21	59	3
NHSI	Test	08/23	10/21	59	3
MESH	Reference	08/20			0
MEKN	Test	08/20	09/24	34	3
			10/23	64	3
NBHI	Reference	08/19	11/02	75	3
NBMI	Test	08/20	10/30	71	3
NSBC	Reference	08/19	10/21	63	3
NSDI	Test	08/19	10/22	64	3

Mussels deployed in cages at Kennebec River (Station MEKN) were intended to test differences in growth and contaminant uptake between 30- and 60-day deployments. Unfortunately, the cages were swept 1 mile upstream and across the river from their original location. The results, therefore, could not be used to determine if a 30-day deployment could be used to replace a standard 60-day set.

The logistics of shipping the samples to the laboratories in Halifax, N.S., and Augusta presented difficulties, and there was a loss of composite samples from three cages due to courier service delays and deficient packaging. Additional problems occurred due to the lack of standardization in the data-entry format and associated software.

SPECIFIC IDENTIFICATIONS OF *MYTILUS*

Mytilus species collected at several sites in Massachusetts, New Brunswick, and Nova Scotia were identified to species by either allozyme analysis (Hebert and Beaton 1989) and/or morphometric characters (MacDonald et al. 1991). Individuals were classified on the basis of electrophoresis of two alleles whenever possible; specifically, *M. edulis*: 100/100 or 100/90, and *M. trossulus*: 94/94. Some of the specimens were thawed and refrozen which deactivated the MPI enzyme and negated the allozyme analysis. All individuals were identified from the measurement of eight shell characteristics and evaluated by discriminant analysis, which confirmed the allozyme technique where possible.

The Massachusetts and Manawagonish Island, N.B., sites were populated entirely with *M. edulis* (Table 6). Broad Cove and Digby, N.S., sites contained a mixture of *M. trossulus* and *M. edulis* with *M. edulis* predominating. Both species were about equally represented at the Hospital Island, N.B., site.

GROWTH AND CONDITION INDEX

In addition to the potential effects of contaminants on shell growth it should be recognized that growth is influenced by many naturally occurring factors including: seasonal and annual cycles of temperature, food supply, aerial exposure, salinity, etc., and effects of age, size, and population density (Bayne 1976). Other studies have shown the plasticity of growth in mussels from or grown in different locations (Seed 1968; 1973; Freeman and Dickie 1979; Dickie et al. 1984; Mallet and Carver 1989). In addition, with the relatively recent taxonomic finding that two species and their hybrids exist in the Gulf of Maine (Koehn et al. 1984; Lobel et al. 1990), further potential complications are introduced into the interpretation of the Gulfwatch growth data. However, the consensus at a recent Gulfwatch workshop was that measure of growth and CI should remain as an integral part of the project.

TABLE 6. Specific identifications of *Mytilus* using either allozymes and/or morphometric characters.

Location	Number of Individuals		Percentage *M. edulis*
	M. edulis	*M. Trossulus*	
Broad Cove, N.S. (Station NSBC)	33	1	97
Digby, N.S. (Station NSDI)	7	3	70
Hospital Island, N.B. (Station NBHI)	8	10	44
Manawagonish Island, N.B. (Station NBMI)	20	0	100
Red Island, MA	10	0	100
Sandwich Island, MA (Station MASA)	17	0	100

Shell Growth

For seven stations the mean shell length at deployment ranged from 55.0 to 57.7 mm, but at Stations MASA and MANI mean deployment lengths were 61.0 and 60.4 mm, respectively (Table 7 and Figure 3). The size of the caged mussels at the Massachusetts stations was significantly different from mussels deployed at the other stations (ANOVA, Tukey test - $P<0.001$). However, within each jurisdiction the difference in mean deployment length between the test and reference sites was not significant ($P>0.05$).

TABLE 7. Morphometric comparison of caged mussels before and after deployment at Gulf of Maine stations.

		Station								
Variable	Stage	MASA	MANI	NHLH	NHSI	MEKN	NBHI	NBMI	NSDI	NSBC
		Ref.	Test	Ref.	Test	Test	Ref	Test	Test	Ref
Length (mm)	Deploy	61.0(2.6)	60.4(2.1)	56.7(3.7)	57.7(2.9)	55.6(2.7)	55.0(4.0)	56.1(4.0)	55.1(2.4)	56.3(2.3)[1]
	n	45	45	45	45	90	45	45	45	45
	Retrieve	63.1(2.7)	62.4(2.7)	57.5(3.8)	58.7(3.0)	58.1(2.7)	58.6(4.2)	57.5(4.2)	56.8(2.6)	57.4(2.6)
	n	43	37	44	45	45	41	43	43	45
Height (mm)	Deploy	30.6(1.6)	30.1(2.0)	30.9(2.5)	31.3(2.2)	27.9(1.6)	25.8(2.9)	27.1(3.2)	31.0(2.5)	30.9(1.9)
	Retrieve	31.1(1.7)	31.1(2.3)	30.8(2.5)	31.3(2.6)	28.9(1.9)	27.6(3.6)	28.0(3.3)	31.7(2.4)	31.1(2.1)
Width (mm)	Deploy	26.0(1.8)	25.5(1.8)	22.8(2.0)	24.0(2.6)	21.3(1.6)	23.1(2.0)	23.7(2.4)	23.7(1.5)	24.2(1.5)
	Retrieve	26.2(2.0)	26.7(1.3)	23.1(2.0)	23.8(2.1)	23.1(1.9)	5.5(2.0)	24.6(2.3)	25.1(1.3)	25.0(1.6)
Tissue weight (g)	Retrieve	11.0(1.7)	10.4(2.1)	6.6(1.1)	7.0(1.4)	9.1(2.1)	11.5(2.5)	5.8(1.3)	6.6(1.2)	7.4(1.6)
	n	43	37	41	45	45	11	15	43	45
Cond.[2] index	Retrieve	0.214 (0.025)	0.200 (0.035)	0.162 (0.021)	0.160 (0.026)	0.236 (0.050)	0.240 (0.032)	0.153 (0.018)	0.145 (0.018)	0.165[1] (0.029)
Duration (d)		58	63	59	59	64	75	71	64	63
Growth[3] rate (mm/d)		0.035 (0.021)	0.031 (0.024)	0.014 (0.017)	0.016 (0.019)	0.034 (0.020)	0.051 (0.037)	0.022 (0.023)	0.027 (0.021)	0.018[1] (0.023)

[1] Means (standard deviation)
[2] Condition index = wet tissue weight/L*H*W
[3] Growth rate = length (r)-length(d)/deployment days

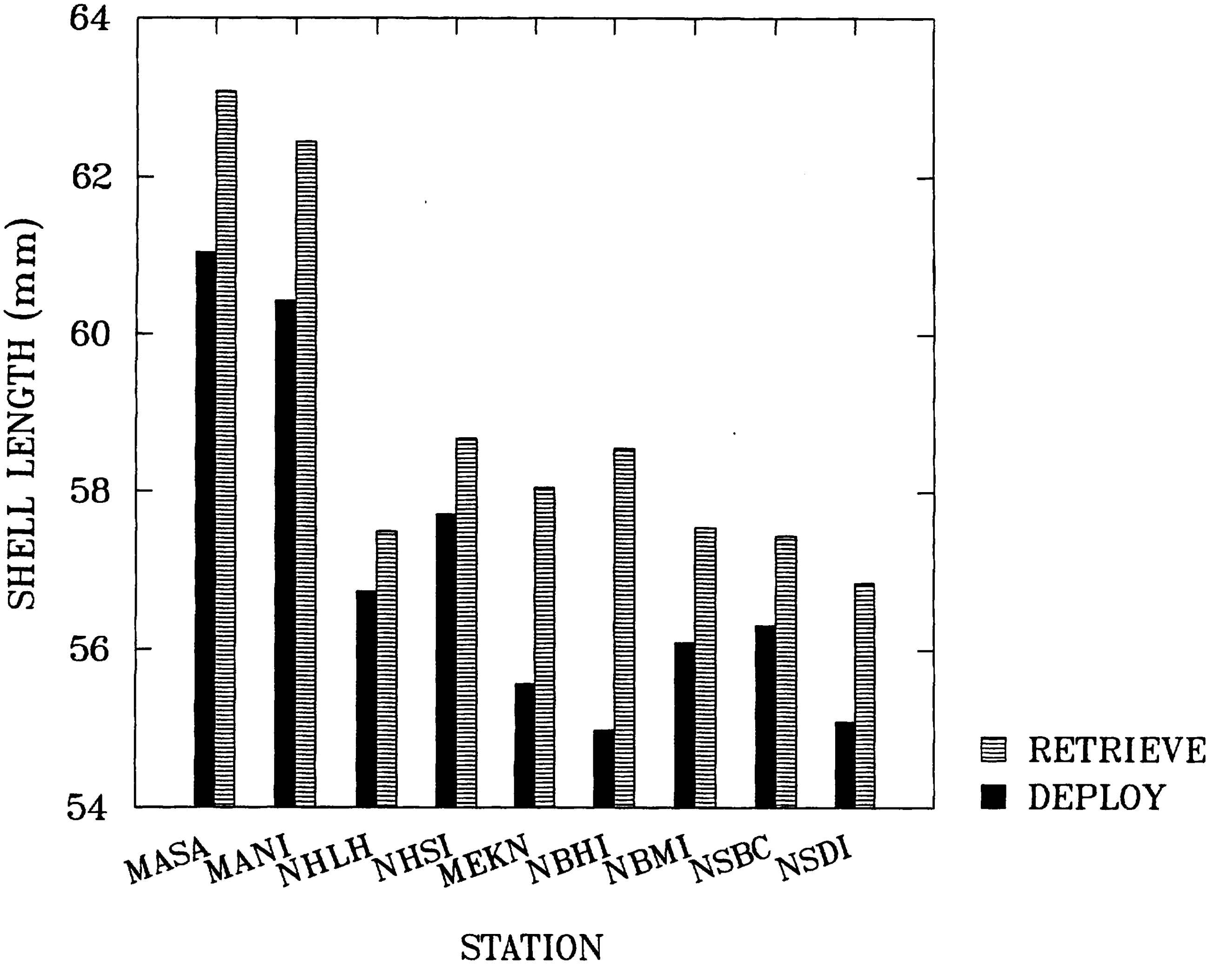

FIGURE 3. Mean length of marked mussels at deployment and retrieval in the Gulf of Maine, 1992.

For all stations at which caged mussels were recovered, the mean length had increased significantly, based on paired t-tests of deployment and retrieval lengths of marked mussels ($P<0.001$).

Due to the different deployment periods, growth was normalized on the basis of growth rate in millimetres per day. The possible influence of initial size on growth rates of mussels was also examined through regression analysis of growth rate on size at deployment. For each station separately the relationship was not significant ($P>0.05$), but for all stations combined the regression was significant ($P<0.05$), due presumably to the influence of the large size of the Massachusetts mussels. Analysis of slope homogeneity among the stations indicated that the slopes were not significantly different (ANCOVAR test). It is recognized that size of mussel influences growth; however, the growth rates have not been adjusted here for size.

In a comparison of all Gulfwatch stations the highest growth rate occurred at Station NBHI and the lowest at Station NHLH, at mean rates of 0.051 and 0.014 mm/day, respectively (Table 7 and Figure 4). The growth rates were further analyzed through $\log_{10}$ transformation and application of ANOVA testing, with Tukey HSD multiple comparison. There were significant differences between stations in growth rates (ANOVA, $P<0.001$). However, in a station comparison test, the growth rates at Stations MASA, MANI, MEKN, NBHI, and NSDI were not significantly different ($P>0.05$). The lowest values occurred at Stations NHLH, NHSI, NBMI, and NSBC; and these were not significantly different ($P>0.05$). In the 1991 Gulfwatch study the highest growth rates occurred at two stations in Maine, and these rates were approximately twice the highest value recorded in 1992 at Station NBHI (GMCME 1992a).

Mussel growth at reference and test stations

Growth rates of mussels at the reference stations in different jurisdictions were significantly different from each other (ANOVA, $P<0.001$). The Tukey test showed that the reference stations in New Hampshire (NHLH) and Nova Scotia (NSBC) had lower growth rates than mussels deployed at stations in Massachusetts (MASA) and New Brunswick (NBHI), with $P<0.001$-0.05 (Table 7).

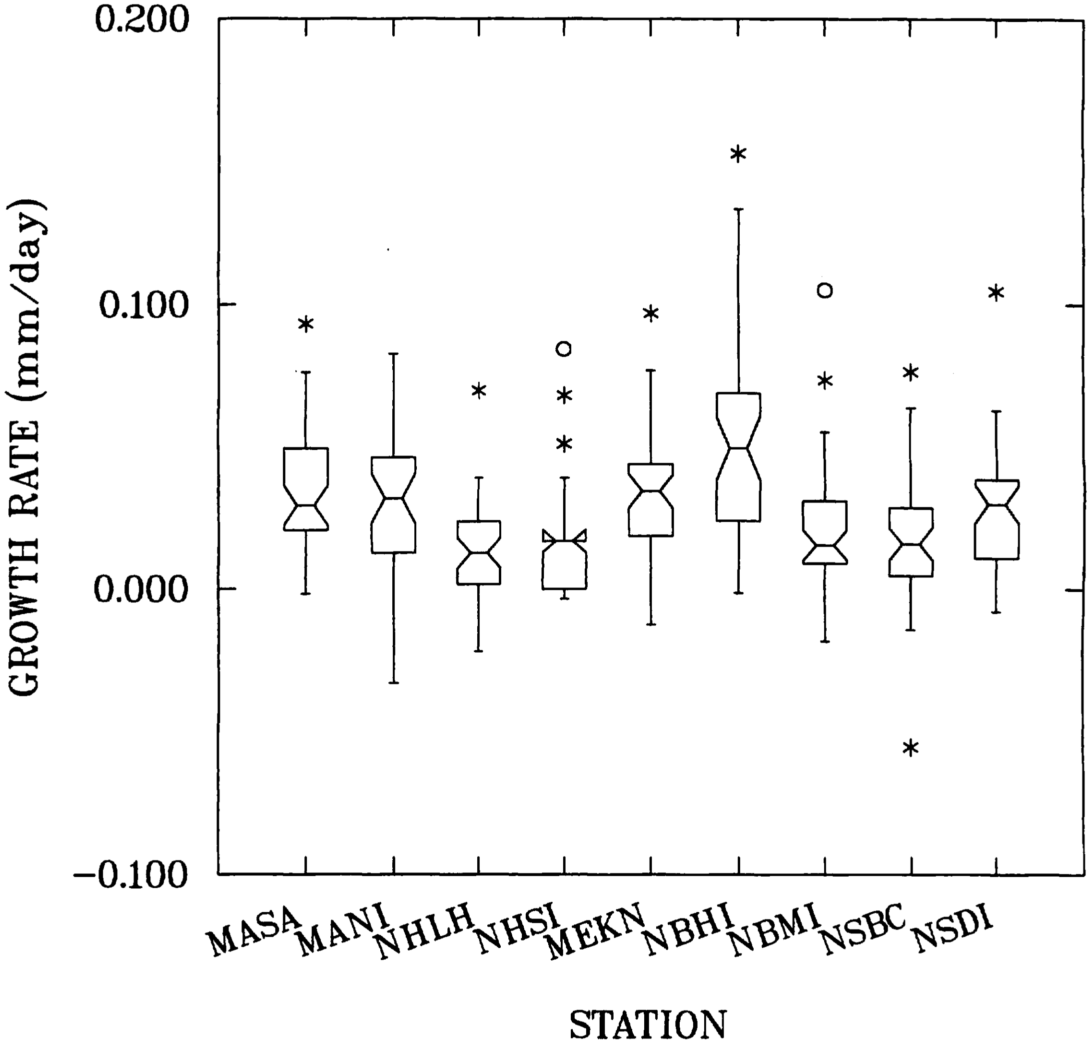

FIGURE 4. Notched box-and-whisker plots of growth rate for caged mussels from the Gulf of Maine stations, 1992. The notched sections of the box correspond to the 95% confidence interval around the median. The box gives the range of the middle 50% of the values. The whiskers indicate the range of growth rates, except for outliers (beyond 1.5 times the box height) which are plotted as individual points.

Overall, the mussel growth rates at test stations were also significantly different from each other (ANOVA, $P=0.001$); however, three of these stations (MANI, MEKN, and NSDI) exhibited similar mussel growth. Mussels at the New Hampshire station (NHSI) had a significantly lower growth rate compared to those at Stations MANI and MEKN ($P<0.001$-0.05).

Shell growth was compared between all averaged reference and test sites. The overall mean daily growth rate for mussels at reference and test stations was 0.029±0.029 and 0.026±0.022, respectively, and this difference was not significant (t-test, $P>0.05$). However, within some jurisdictions there were differences in the growth rates of caged mussels at the test and reference stations. In New Brunswick the growth rate at the reference station, NBHI, was significantly higher than recorded at the test station, NBMI (t-test, $P<0.001$). In Nova Scotia, however, the reverse applied with mussel growth rate being higher at the test station in the Annapolis Basin (NSDI) compared to the reference station (NSBC) outside the Basin (t-test, $P<0.05$). For Massachusetts and New Hampshire the growth rates at the test and reference sites were not significantly different (t-test, $P>0.05$). It is evident that there is no consistent trend in the growth patterns for test and reference sites. A similar conclusion was noted in the 1991 Gulfwatch evaluation (GMCME 1992a). There are a variety of factors that could be influencing the growth rates of caged mussels at the test and reference sites. The time of exposure may be too short and the narrow size range of mussels selected may have reduced the chances of obtaining significant growth effects. Contaminant levels at test sites do not appear to be growth inhibiting, but this may be because nutrient levels and temperature effects override contaminant burdens. The presence of both *M. edulis* and *M. trossulus* in some jurisdictions (Table 6) will probably alter the growth rates and CI compared to that of pure species samples (Freeman et al. 1992).

Condition Index (CI)

Caged mussels

The CI of caged mussels at retrieval throughout the Gulf of Maine was significantly different (ANOVA, $P<0.001$). The highest CI was observed in caged mussels from Reference Station NBHI in New Brunswick (Figure 5). The sample sizes for both New Brunswick stations, however, were small (N=11 and 15) in comparison to the other stations (Table 7). Mussels of intermediate CI occurred at stations in Massachusetts and Maine; and the lowest values were recorded at Stations NHLH, NHSI, NBMI, NSBC, and NSDI (Figure 5).

Comparison of indices at the reference and test sites showed that in New Brunswick and Nova Scotia the CI of caged mussels at reference stations was significantly higher than recorded at test sites (Tukey test, $P<0.01$). However, in Massachusetts and New Hampshire the test and reference CIs were not significantly different ($P>0.05$).

Some of the variability in CI may be due to inaccuracies involved in determining tissue wet weights if mussels were incompletely drained prior to freezing. Examination of wet to dry weight ratios, however, indicates that this is not a major problem because the variability observed within is just as great as between jurisdictions and therefore personnel (Figure 6).

The variability in CI of the caged mussels at the various stations does not appear to be directly related to contaminant levels but is more likely a consequence of genetic and environmental factors specific to a bay or site, e.g. temperature, nutrient concentrations, phytoplankton type and density, etc. Factors such as these vary on a regional and seasonal basis with impacts on growth, CI, and reproduction (Freeman and Dickie 1979; Dickie et al. 1984; Mallet and Carver 1991; 1993).

Indigenous mussels

As with the caged mussels, there were some significant differences in the CI of indigenous mussels sampled at the various stations around the Gulf of Maine (ANOVA, $P<0.001$; Figure 7). The highest mean CI was recorded at Station MEKN (0.192) and the lowest at Stations NSDI and NBMI (0.126 and 0.134, respectively). Generally, intermediate levels were recorded at Stations MANI, MASA, NHLH, NHSI, NBHI, and NSBC.

Within each jurisdiction, differences in the CI between test and reference sites were variable. The CI was significantly different at test and reference stations in New Brunswick and Nova Scotia (Tukey test, $P<0.05$ and 0.001, respectively), and in both regions the CI was higher at the reference site. However, for stations in Massachusetts

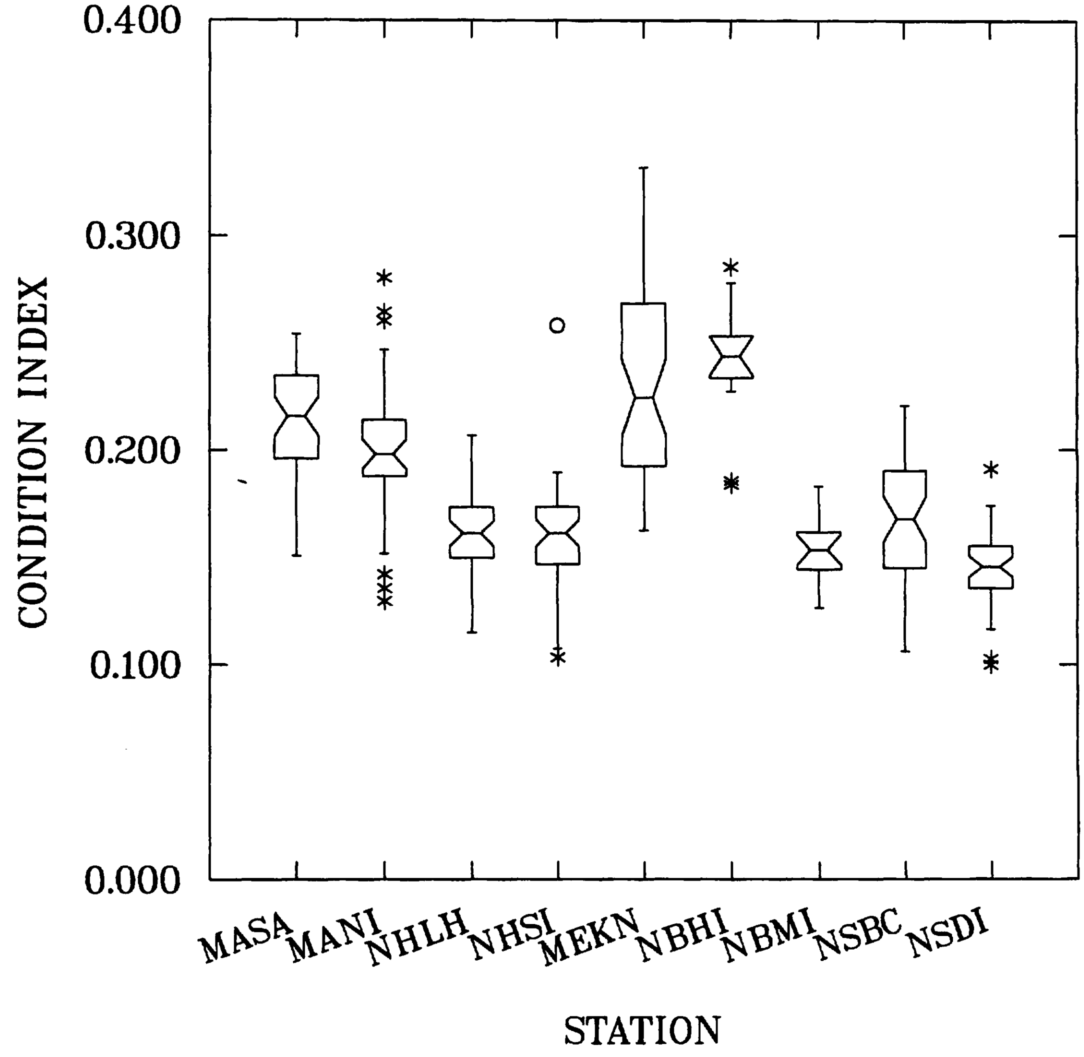

FIGURE 5. Notched box-and-whisker plots of condition index of caged mussels in the Gulf of Maine, 1992, at retrieval. Symbols and explanation as in Figure 3.

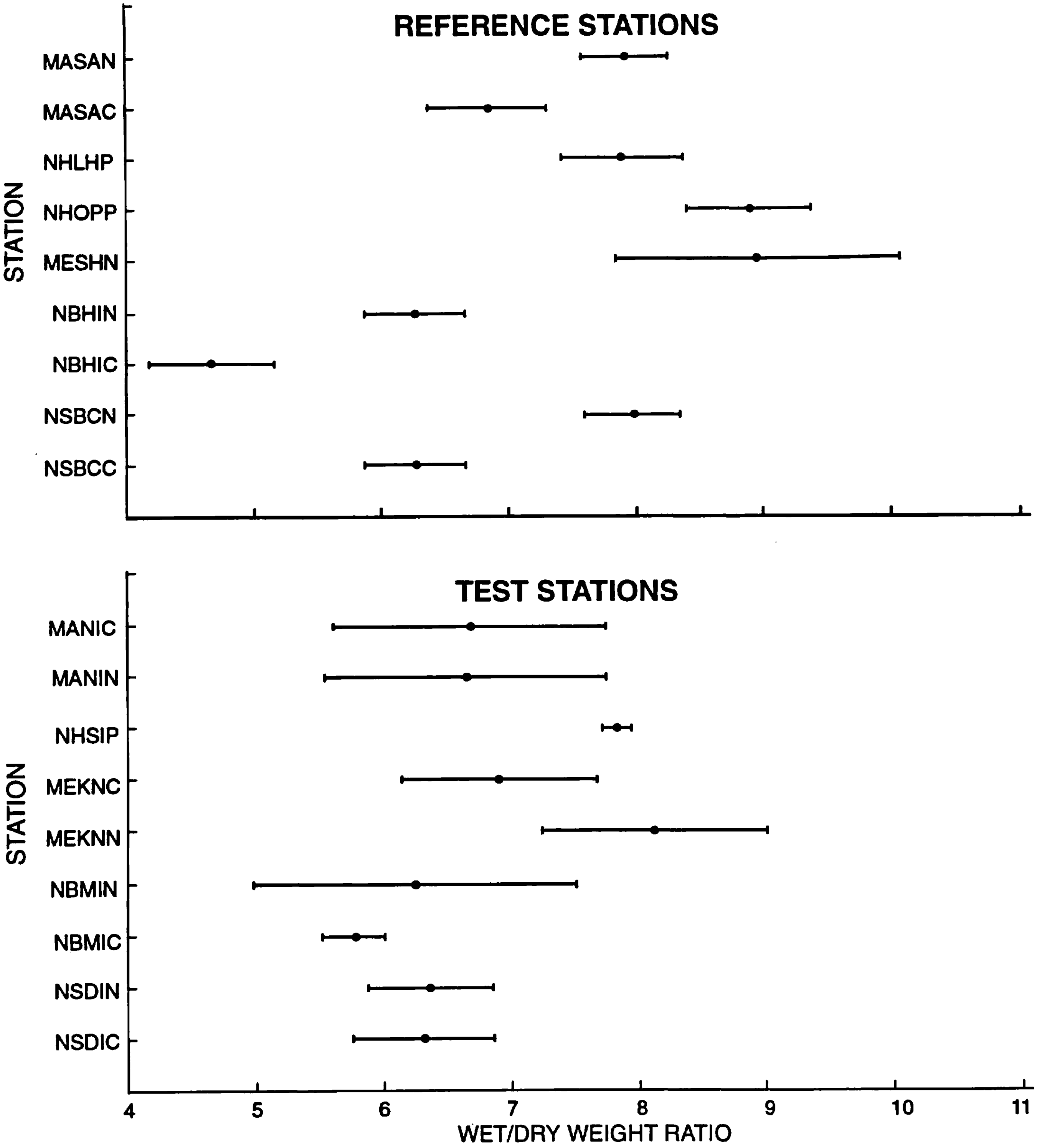

FIGURE 6. Variability ($\bar{x} \pm 95\%$ cl) in the wet to dry weight ratio of indigenous and caged mussels sampled in various jurisdictions around the Gulf of Maine during 1992.

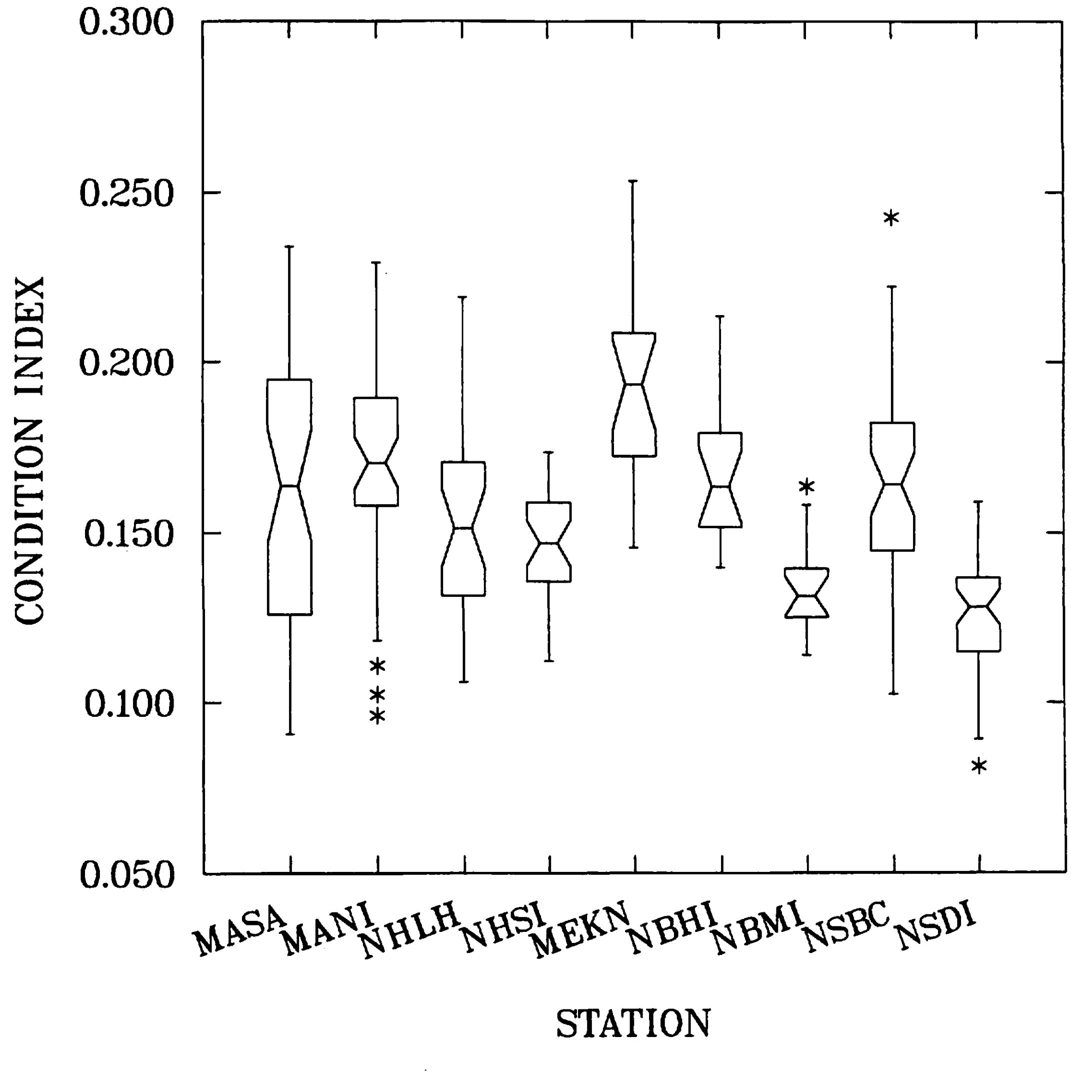

FIGURE 7. Notched box-and-whisker plots of condition index of indigenous mussels in the Gulf of Maine, 1992, at the time of cage retrieval. Symbols and explanation as in Figure 3.

and New Hampshire the CI of samples at the test and reference stations was not significantly different (Figure 7). There does not appear to be a consistent trend such as a higher CI at supposed "clean" reference locations in all jurisdictions. As previously stated with respect to the caged mussels, this is not surprising given the variety of other factors that relate to growth and CI.

Caged versus indigenous mussels

As in the 1991 study there was a general tendency for the caged mussels to have a higher CI than adjacent indigenous mussels (Figure 8). For six of the nine stations the mean CI of the caged mussels was significantly higher than for the indigenous mussels (t-test, $P<0.01$-0.001), but at Stations MEKN, NHLH, and NSBC the differences were not significant. Various studies (Seed 1968) and commercial mussel growers have noted the enhanced growing conditions in suspended cultures versus benthic sites.

ENVIRONMENTAL VARIABLES

Continuous water temperature recording units (Hobo Temp^R) were deployed at the cage sites in each jurisdiction. The data from five stations were recovered, and the mean temperatures plus range are shown in Figure 9. The lowest mean temperature for the deployment period was at Nova Scotia Station NSBC (10.0°C) and the highest at Massachusetts Station MANI (13.7°C). The range in temperature at the latter station was 17.9°C compared to only 2.2°C at Station NSBC. The mean temperatures at New Brunswick Stations NBHI and NBMI were slightly higher than Station NSBC; and at Maine Station MEKN the mean temperature was 12.6°C, with a range of 11.1°C. There is another aspect of the temperature conditions that distinguished the Gulf of Maine cage sites. At some stations (NSBC and NBMI) the temperature change associated with the tidal flux was <1.0°C; but at Stations NBHI, MANI, and MEKN the temperature change was in the order of 2 to 4°C. This type of tidal flux continued from deployment in late August to the end of September and is presumably associated with a fluctuating thermal stratification during late summer and early fall. The hydrodynamic effects due to tides at Stations NSBC and NBMI are so strong that

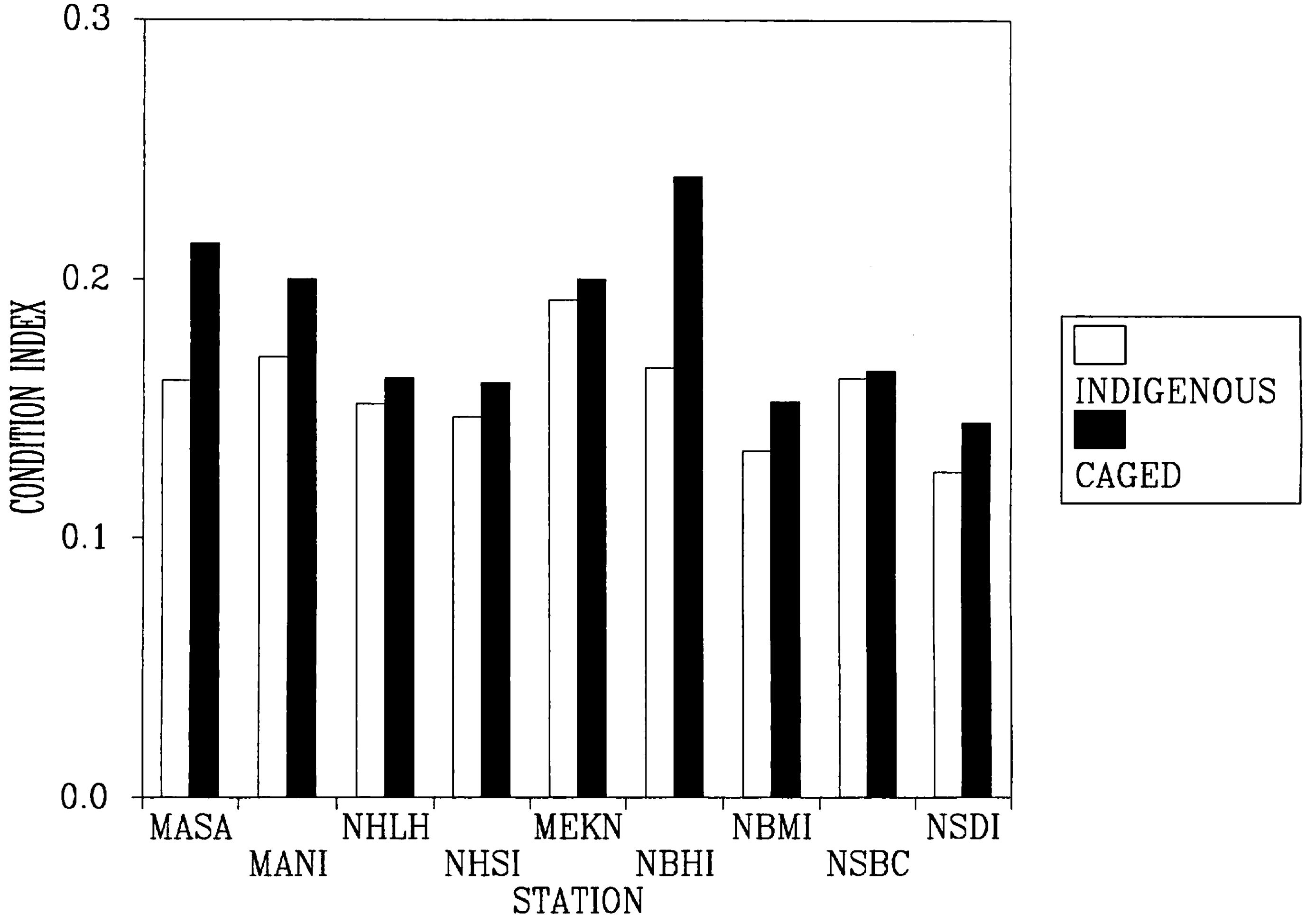

FIGURE 8. Comparison of mean condition index of caged and indigenous mussel samples at the Gulf of Maine stations, 1992.

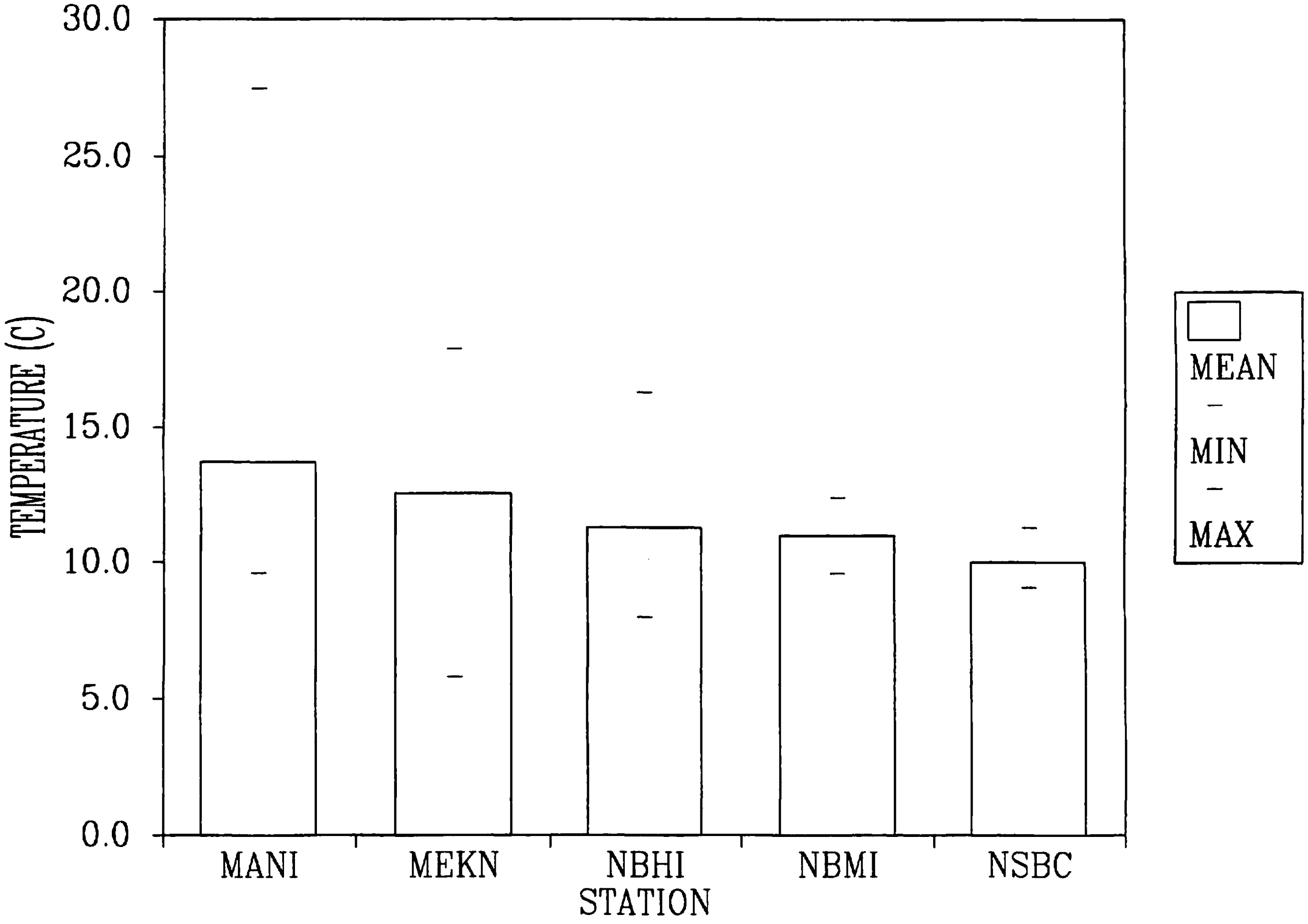

FIGURE 9. Mean temperature recordings (Hobo Temp^R) during the cage deployment period at five of the Gulf of Maine stations in 1992.

thermal stratification is not highly developed in these regions. The caged mussels were subjected to different temperature regimes during the deployment period, which likely affected both growth and CI (Bayne 1976).

Salinity, nutrient, and chlorophyll data are available for the interested reader for some of the Nova Scotia, New Hampshire, and Massachusetts stations but are not used or reported here (contact authors from those regions).

CONTAMINANTS

Metals

Initial results revealed unexpectedly high variability in the element copper. Upon investigation, it was determined that one blade of the several blenders used to homogenate the samples contained a metal bushing which disintegrated and resulted in unacceptable levels of copper and lesser levels of nickel, chromium, and zinc contamination (Table 8; Appendix C). As there was no way of knowing the relative contamination of the samples by the blending process, all copper values were deleted from further analysis. The lesser amounts of contamination by nickel, chromium, and zinc were not sufficiently large in relation to measured tissue levels and were retained.

Overall metal levels for the present Gulfwatch, given as geometric means (Table 8), are higher than NOAA 1990 National Status and Trends Program (NS&T) levels for the Gulf of Maine (Table 9) and the coast of Maine reference stations (Table 10) with the exception of silver, lead, and aluminum. This result is not surprising given that one-half of the Gulfwatch stations were located in potentially contaminated areas, whereas both the NS&T and Maine reference stations were located in areas away from acute human activity or known sources of contamination (NOAA 1992 pers. comm.; Sowles and Murray pers. comm.).

Aluminum and iron

In 1991, iron was the only metal analysed which could be used to determine bottom contamination of mussels through feeding on resuspended sedimentary material. Aluminum was analyzed in the 1992 field season to complement and corroborate the information iron provides. Note that indigenous mussels at Manawagonish Island (Station NBMI) had elevated levels of both Fe and Al whereas their caged counterparts

TABLE 8. Tissue concentrations ($\bar{x}\pm SD$) for Gulfwatch mussels in 1992 (μg/g dry weight).

Station	Ag	Cd	Cr	Pb	Hg	Ni	Zn	Fe	Al	% Solids
MASA-N	0.44±0.13	1.40±0.26	0.87±0.12	0.87±0.12	0.13±0.06	1.23±0.40	97±12	270±17	62±3	13.67±0.58
MANI-N	0.63±0.36	0.90±0.11	2.10±0.42	4.95±4.03	0.25±0.07	1.15±0.21	140±28	335±7	120±14	17.00±0.00
MANI-C	1.79±1.92	0.89±0.10	1.60±0.35	6.13±0.84	0.20±0.10	1.00±0.10	130±10	360±17	126±26	15.67±1.53
NHLH-N	0.06±0.00	1.60±0.10	4.20±1.15	4.23±0.15	0.50±0.00	3.10±0.62	217±72	543±81	343±75	13.00±0.00
NHLH-C	0.11±0.02	1.80±0.10	4.10±0.60	3.73±0.60	0.60±0.10	3.43±0.25	207±64	700±17	340±26	12.33±0.58
NHSI-N	0.08±0.01	2.20±0.36	4.53±0.71	5.63±0.84	0.67±0.06	2.73±0.59	167±15	750±61	370±46	12.00±1.00
NHSI-C	0.13±0.02	1.87±0.12	4.20±0.35	3.43±0.21	0.57±0.06	3.10±0.36	163±15	687±42	353±15	11.67±0.58
MESH-N	0.05±0.01	1.90±0.26	11.20±14.55	1.77±0.12	0.43±0.06	2.10±0.56	133±32	387±31	223±55	10.23±1.66
MEKN-N	0.06±0.01	1.63±0.06	6.53±4.35	1.60±0.53	0.20±0.10	1.43±0.75	77±5	257±21	96±16	11.00±1.73
MEKN-C	0.06±0.01	1.30±0.10	7.57±9.91	1.10±0.44	0.13±0.06	2.07±1.07	74±7	257±15	105±13	12.67±0.58
NBHI-N	0.13±0.02	1.77±0.21	0.67±0.15	0.60±0.17	0.20±0.00	1.50±0.44	89±7	387±67	160±36	13.67±0.58
NBHI-C	0.20±0.01	1.57±0.06	0.43±0.12	0.33±0.06	0.10±0.00	0.63±0.12	55±31	97±21	97±20	21.67±0.58
NBMI-N	0.04±0.00	1.53±0.06	10.07±3.49	1.50±0.80	0.23±0.06	6.60±1.51	127±12	1833±306	903±86	8.37±4.88
NBMI-C	0.13±0.03	1.53±0.25	0.97±0.06	0.83±0.12	0.10±0.10	1.97±0.38	85±13	593±65	347±31	16.67±0.58
NSBC-N	0.02±0.00	2.00±0.42	3.90±0.14	2.35±0.49	0.10±0.00	3.10±0.14	97±18	590±113	315±49	12.50±0.71
NSBC-C	0.03±0.00	2.03±0.06	7.70±6.74	1.87±0.12	0.13±0.06	2.43±0.64	83±10	453±31	230±26	16.33±0.58
NSDI-N	0.15±0.09	1.03±0.06	16.30±18.62	4.73±4.21	0.10±0.10	3.07±2.21	222±151	507±67	260±70	19.33±0.58
NSDI-C	0.03±0.00	1.30±0.14	2.05±0.49	1.60±0.00	0.10±0.00	2.40±0.28	66±5	605±7	340±71	18.50±0.71
Geometric Mean	0.09	1.6	2.9	1.8	0.22	2.2	112	441	187	

TABLE 9. National status and trends mussel watch summary statistics for Gulf of Maine mussel samples collected in 1990 (μg/g dry weight) (NOAA 1992 pers. comm.).

	Ag	Cd	Cr	Pb	Hg	Ni	Zn	Fe	Al
Geometric mean	0.22	1.10	1.39	2.97	0.13	1.18	92	312	203
"High value"*	0.51	1.52	2.78	6.75	0.31	1.72	113	482	387

*Logarithmic mean (geometric) plus one standard deviation (O'Connor 1992).

TABLE 10. Summary statistics for mussels collected at twenty-three Maine reference stations (μg/g dry weight) (Sowles and Murray pers. comm.).

	Ag	Cd	Cr	Pb	Hg	Ni	Zn	Fe	Al
Arithmetric mean	0.12	1.75	1.53	2.60	0.12	1.80	89	-	-
"Anomalous value"*	0.40	3.14	3.51	6.00	0.48	2.90	136	-	-

*Value greater than the mean plus three times the standard deviation.

did not (Figure 10). It was concluded, therefore, that Manawagonish Island animals contained unusually high levels of sediment in their guts, making them unsuitable for inclusion in our comparisons of metal content with the rest of the Gulf population (Robinson et al. 1993). This supports the view that caged rather than indigenous mussels should be used in areas with marked sediment resuspension because they can be held off the bottom.

Cadmium

Mussel cadmium levels in 1992 did not show a geographic trend or any particular anomalous concentrations (Figure 10), although the overall Gulfwatch geometric mean (1.6 μg/g dry weight) was at the "high" level (1.5 μg/g) compared to the NS&T Gulf of Maine mussels (Tables 9 and 10; NOAA 1992 pers. comm.). However, cadmium levels in mussels from all stations were below the concentration used by Maine to define an anomalous (3.1 μg/g) level (Sowles and Murray pers. comm.).

Chromium

Chromium concentrations showed a general "reverse" geographic trend with levels increasing as one moves north and east, which is opposite to the previous year's results (GMCME 1992a) (Figure 11). New Hampshire, Maine, and Nova Scotia sites had levels of chromium exceeding the "anomalous" levels for the Maine coastal reference sites (3.6; Sowles and Murray in prep.) and well above the 2.8 μg/g dry weight "high" of the NS&T (Table 9). Where 1991 stations were reoccupied in 1992 there appeared to be a decrease in chromium concentrations (GMCME 1992a; Figure 11). Nut Island, Boston Harbor, MA (Station MANI), Little Harbor, NH (Station NHLH), and Shapleigh Island, NH (Station NHSI) chromium concentrations in 1992 were about 50% of the 1991 values. All three areas and the two Maine sites are known to have had leather tanning and/or metal finishing industries.

Lead

Lead concentrations show a general increasing trend as one moves toward population centres such as in Massachusetts and New Hampshire (Figure 11). The

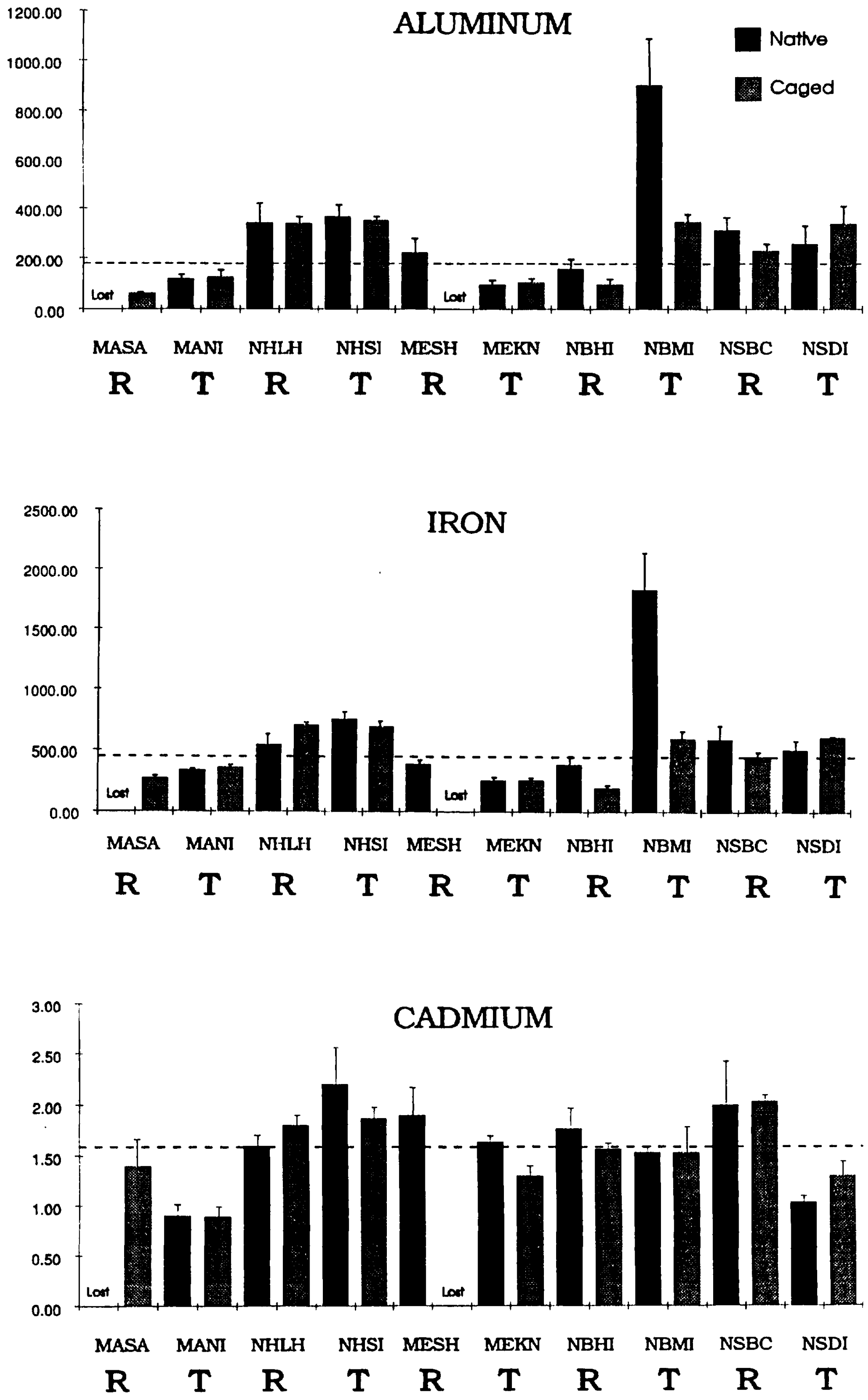

FIGURE 10. Distribution of iron, aluminum, and cadmium tissue concentrations ($\bar{x}$+SD, µg/g dry weight) in caged and indigenous mussels at the Gulf of Maine stations, 1992. Average concentration in the Gulf indicated by the dashed line.

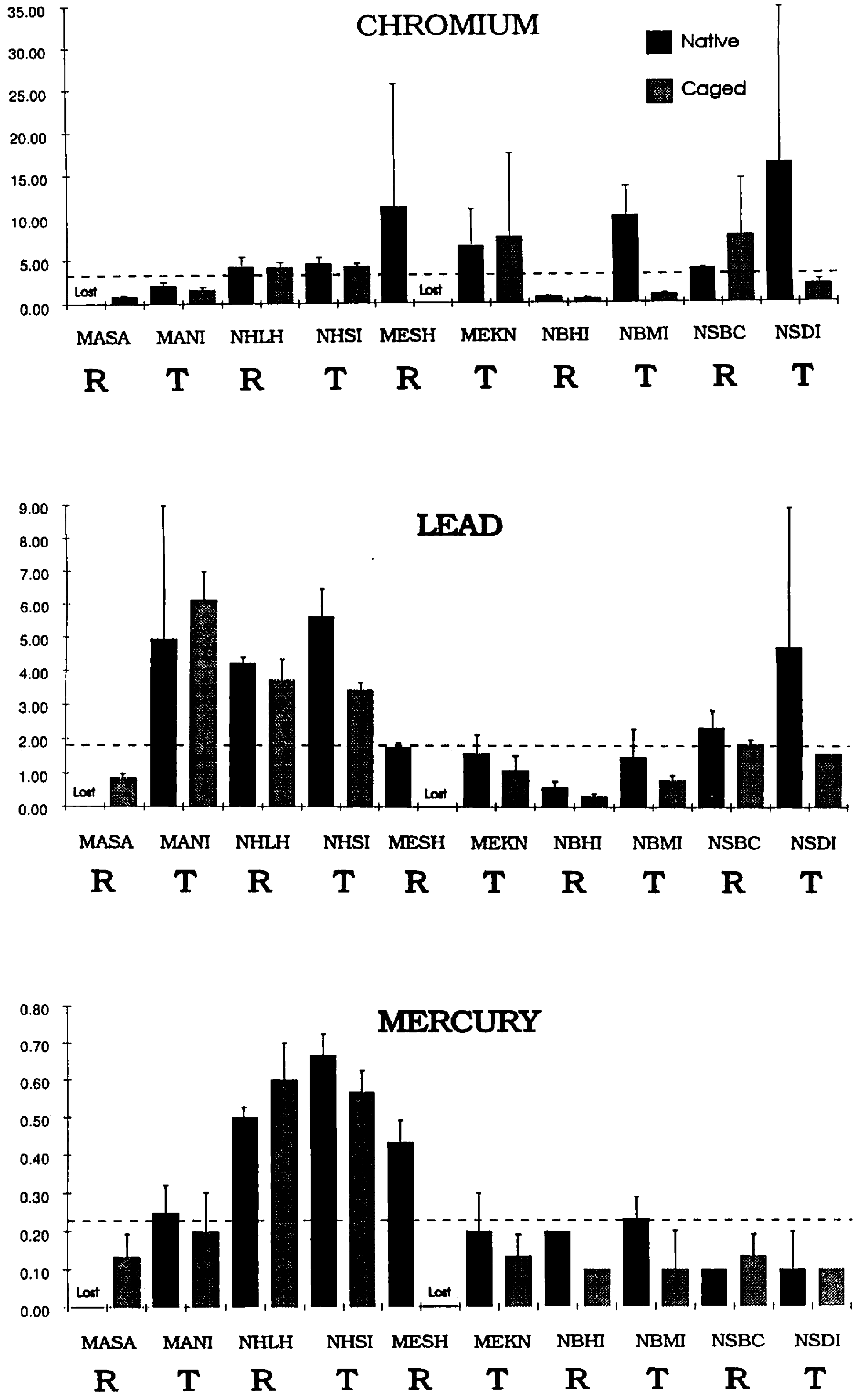

FIGURE 11. Distribution of chromium, lead, and mercury tissue concentrations ($\bar{x}$+SD, μg/g dry weight) in caged and indigenous mussels at the Gulf of Maine stations, 1992. Average concentration in the Gulf indicated by the dashed line.

close proximity of the Portsmouth naval shipyard may account for the elevated lead levels in mussels at both New Hampshire sites. The Jamaica Island landfill and the Defense Reutilization and Marketing Office on Seavy Island are sites of known sources of lead contamination to Portsmouth Harbor where waste plating sludges and lead batteries, respectively, were disposed or stored (NCCOSC 1994). Lead levels in mussels at Shapleigh Island (Station NHSI) in 1992 (cages at 3.7 μg/g dry weight and indigenous at 5.0 μg/g) were similar to those found in 1991 (cages at 3.4 μg/g and indigenous at 5.6 μg/g). In Boston Harbor (Station MANI), the station is located near a municipal wastewater outfall which serves a large portion of greater Boston's population and industry. It is not known why the lead levels in indigenous mussels from Digby (Station NSDI) are elevated to levels comparable to those of Boston Harbor. Concentrations in mussels at the above-discussed locations are up to twice the geometric means for the Gulf of Maine national status and trends mussel watch (3.0 μg/g; NOAA 1992 pers. comm.) and twice the arithmetic mean of the Maine coast reference stations data (2.0 μg/g; Sowles and Murray in prep.).

Mercury

Highest levels of mercury were found in mussels from areas known to have been contaminated by mercury (Figure 11). Both the New Hampshire (Stations NHLH and NHSI) and the Sheepscot River, ME, locations lie downstream of known historical mercury sources. The Sheepscot River location (Station MESH), selected as a reference site, was thought to be sufficiently distant (ca. 10 miles downstream) from a coal-fired electric-generating facility to not be effected by the plant. Given the elevated mercury levels, it would appear that the site may be impacted by the power plant. The levels encountered at Station MESH, 0.42 μg/g dry weight, are comparable to the levels (0.47 μg mercury/g dry tissue weight) found in mussels upstream and near the plant in 1989 (Sowles and Murray in prep.).

Mercury values for mussels at the two New Hampshire locations exceeded the 0.48 μg/g dry weight level used to distinguish normal from anomalous levels along the Maine coast (Table 10) and the Gulf of Maine NS&T mussel watch high level of 0.31 μg/g dry weight (Table 9). Sources of mercury contamination at the two New Hampshire locations are suspected to be related to the Portsmouth Naval Shipyard

(NCCOSC 1994), which has recently been designated a United States Environmental Protection Agency Superfund site for future clean-up.

Nickel

Nickel levels in mussels at reoccupied New Hampshire Stations NHLH and NHSI in 1992 were slightly elevated above the geometric mean (Figure 12) in contrast to the 1991 results (GMCME 1992a). The elevated nickel value for indigenous mussels at the Manawagonish Island site (Station NBMI) is likely from gut sediment contamination because of the turbulent environment. Indigenous mussels from Nova Scotia Sites NSBC and NSDI also contained high concentrations of nickel which are well above the NS&T high level of 1.7 μg/g dry weight (Table 9) and approach "anomalous" level of Sowles and Murray (Table 10).

Silver

Estimated silver levels have been shown to coincide with regions receiving municipal sewage (USEPA 1980). In both 1991 and 1992, Boston (Station MANI) had the highest levels of Ag in the Gulf study (Figure 12) which exceeded the "high" level (0.51 μg/g dry weight) of the NS&T sites (NOAA 1992 pers. comm.) as well as the designated "anomalous" level (0.40 μg/g dry weight) for the Maine reference stations (Sowles and Murray pers. comm.). This should not be surprising given the fact that this is located near one of the municipal outfalls for Boston and hence within the immediate influence of the largest population in the Gulf of Maine. This Nut Island outfall discharges 150 million gallons per day. Caged mussels, located closer to the Nut Island treatment plant than the indigenous mussels analysed, had more than twice the silver content. Even mussels from the Massachusetts reference site at Sandwich, MA (Station MASA), had higher levels of silver than the rest of the Gulf, presumably a result of being situated downcurrent of the metropolitan Boston area.

Zinc

Digby (Station NSDI), Nut Island (Station MANI), and both New Hampshire (Stations NHLH and NHSI) and Sheepscot River (Station MESH), mussels contained levels of zinc (Figure 12) that exceeded both the NS&T geometric mean (114 μg/g dry

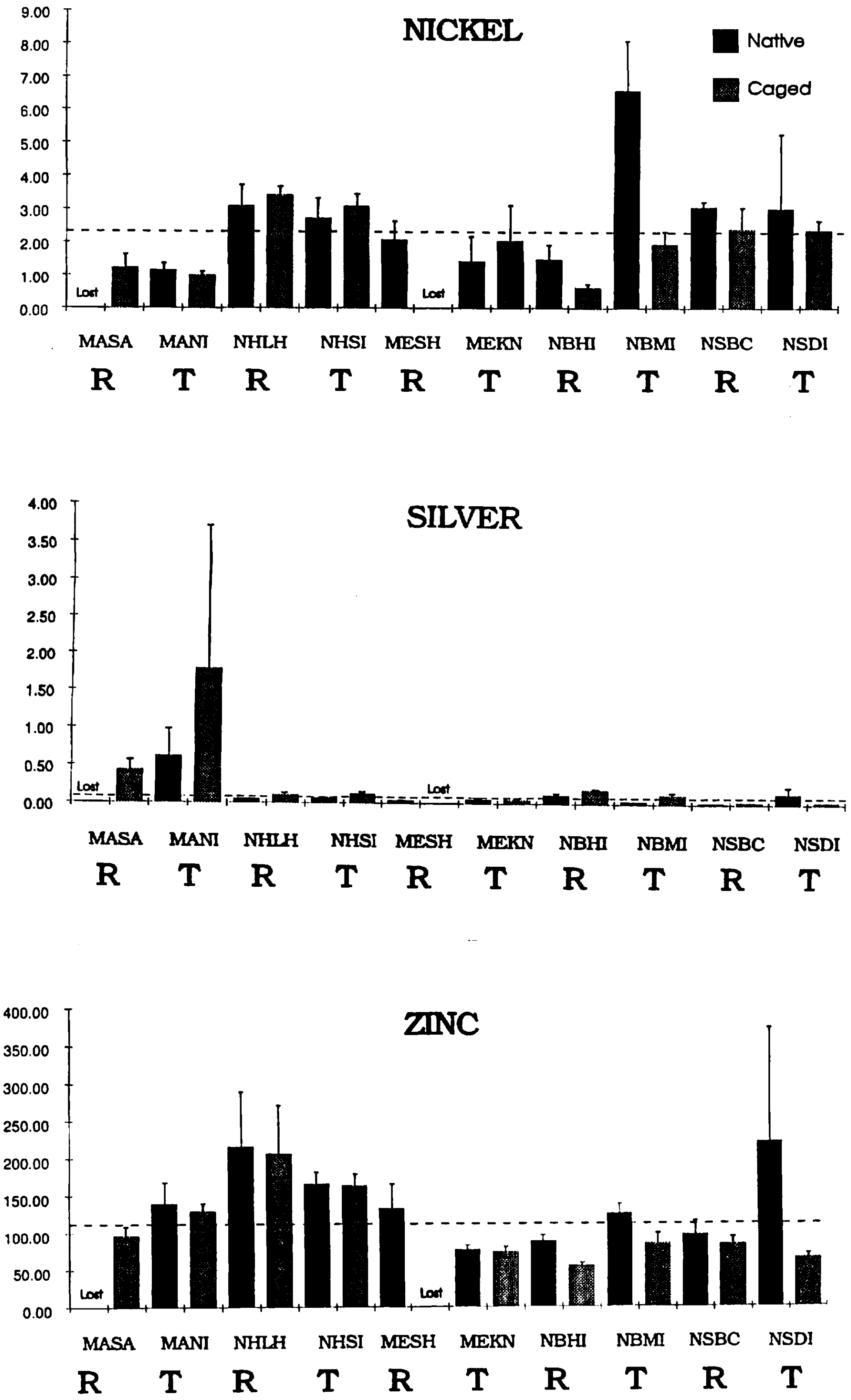

FIGURE 12. Distribution of nickel, silver, and zinc tissue concentrations ($\bar{x}$+SD, µg/g dry weight) in caged and indigenous mussels at the Gulf of Maine stations, 1992. Average concentration in the Gulf is indicated by the dashed line.

weight, NOAA 1992 pers. comm.) and the "anomalous" level (136 μg/g dry weight) for the Maine reference stations (Sowles and Murray pers. comm.). Zinc levels generally reflect human activity associated with tire wear, galvanized materials, and industrial discharges, all of which occur within the drainage basins of these stations. Kennebec River (Station MEKN) mussels were well within the "normal" range for mussels from reference sites, although industrial and urban areas, including five cities, six pulp and paper mills, and a shipbuilding facility occurred upstream. Reoccupied sites (Stations MANI, NHSI, NHLH, and NBHI) reflect similar values to those found in 1991 (GMCME 1992a).

STATISTICAL ANALYSES

Due to the possibility of laboratory contamination, we tested the data for outliers using the Anscombe-Tukey method (Snedecor and Cochran 1967). Using the pooled within-group standard deviations, this method deletes values with individual residuals that are too large. Accordingly, the three hypotheses involving metals were tested using a Student-t test at the 5% significance level.

Mussels at Reference Versus Test Sites

The levels of individual metals in indigenous mussels were compared between test and reference sites in each jurisdiction. Of the 50 paired comparisons of indigenous reference versus test sites, 22 were significantly different. Of the 22 differences, 8 indicated that the reference site was more contaminated than the test site. While it is probably not realistic to expect that a single reference station should be consistently lower in all ten metals tested, the validity of continuing to use mussels at a station as a reference should be questioned if higher concentrations are found in several metals. Two stations, Sheepscot River (Station MESH) and Broad Cove (Station NSBC), are significantly higher than their corresponding test site in mercury, zinc, iron, aluminum, and cadmium, nickel, iron respectively. In both cases, however, concentrations of iron and in the case of Sheepscot River, aluminum as well, were significantly higher suggesting feeding had occurred on resuspended sediment.

Comparison of caged mussel reference and test sites can be used to overcome the problem of sediment contaminated guts. Of the 18 significant differences found in metal concentrations, only three differences were due to the reference mussels having higher concentrations than mussels in the test site. Cadmium and chromium levels in caged mussels from Broad Cove and cadmium levels from Sandwich (Station MASA) mussels were higher than in their corresponding test locations. In both cases, iron and aluminum were significantly lower in the reference site indicating that sediment contamination would not satisfactorily explain the differences. Broad Cove, N.S., Sheepscot River, ME, and perhaps Sandwich, MA, were intended to be clean locations with which to base comparisons; yet results from 1991 and 1992 suggest that their choice as reference stations was not appropriate.

Caged Versus Indigenous Mussels

The final hypothesis was to examine any differences between transplanted caged mussels and indigenous mussels of an area. Of the 80 metal contents examined, 17 were significant and indigenous mussels were significantly higher in 14 of these comparisons. One would expect that indigenous mussels from a contaminated area would have higher metal concentrations than introduced caged mussels from a reference site. In the three cases where caged mussels had higher concentrations than indigenous mussels, lead concentrations at Nut Island (Station MANI) were not surprising given the closer proximity of caged mussels at this location to a Boston sewage outfall. The other two exceptions were iron at Little Harbor (Station NHLH) and aluminum at Digby (Station NSDI). Elevated levels of either of these metals could be used to indicate resuspended sediment consumption by mussels in turbulent regions. However, both of the metals should be present in elevated levels if this were the case.

At Manawagonish Island (Station NBMI), where we have already eliminated the indigenous mussel set from our comparisons of metals due to probable sediment contamination, the cages had significantly lower levels of Fe and Al (593 versus 2,000 and 347 versus 805 μg/g dry weight, respectively). This difference is meaningful and validates the use of cages where indigenous mussels occur in a turbulent environment subject to sediment resuspension.

ORGANICS

Individual concentrations of aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs), and organochlorine pesticides in mussels from the various coastal locations around the Gulf of Maine are presented in Appendices D, E, F, and G. A summary of mean concentrations of the major contaminant groups are given for each site in Table 11. In general, there is a southward tendency for higher contaminant concentrations in the Gulf of Maine (Figures 13 to 18). Lowest concentrations were measured at sites in Nova Scotia and New Brunswick while the highest concentrations were detected at sites in Massachusetts, a region of high population density and industrialization. It is also of note that the contaminant concentrations in *Modiolus* at Machias Seal Island were comparable to those recorded in *Mytilus* at the adjacent reference site at Hospital Island.

There are many observational and experimental studies documenting the concentrations of contaminants, predominantly PAH, PCB, and DDT, in mussels as they relate to point sources and diffuse sources from many locations under field, semi-field, and laboratory conditions. However, there is a paucity of data relating contaminant concentrations of indigenous mussels to sublethal physiological effects. A summary of selected literature is given in Appendix H.

Aromatic Hydrocarbons

Total PAH concentrations (TPAH) ranged from undetected to 782 ng/g dry weight (Appendix D). Mean TPAH concentrations at test sites were comparable to concentrations observed in areas influenced by oil spills and municipal sewage outfalls (148 ng/g, in Rainio et al. 1986; 63-1060 ng/g, in Kveseth et al. 1982) but were one to two orders-of-magnitude lower than industrialized areas affected by coking operations in Sydney Harbour, N.S. (Environment Canada 1986; 1400-16000 ng/g, in Environment Canada unpubl. data) or Norwegian smelting operations (5111-225163 ng/g, in Bjorseth et al. 1979).

The highest mean TPAH concentrations detected in mussels were at the Nut Island (Station MANI) test site (400 [N]-721([C] ng/g) (Table 11; Figures 13 and 14). Although high in comparison to other Gulf of Maine sites, concentrations are lower than those reported elsewhere in northern areas of Boston Harbor (Dorchester Bay,

TABLE 11. Organic contaminants in mussel tissues (ng/g dry weight) from the sites sampled in the Gulf of Maine in 1992.

Location	Species	TPAH (Mean±Sd)	TPCB (Mean±Sd)	TDDT (Mean±Sd)	Other pesticides (Mean±Sd)	TPEST (Mean±Sd)
MASAC[1]	Me	12±1	77.9±9.0	23.4±4.4	1.4±1.2	24.8±5.3
MASAN[2]	Me	18±3	69.4±8.1	35.4±1.3	2.8±1.3	38.1±2.5
MANIC	Me[4]	721±53	408.3±68.0	85.1±2.0	35.9±1.7	120.8±1.5
MANIN	Me	400±12	362.0±116.0	53.2±5.6	20.3±1.7	73.3±7.0
NHLHP[3]	Me	174±18	48.0±7.2	15.1±2.5	ND	15.1±2.6
NHSIP	Me	378±68	73.6±15.8	17.9±5.0	ND	17.9±5.0
NHOPP	Me	129±52	32.4±8.7	8.9±1.5	ND	8.8±1.6
MEKNC	Me	99±15	45.3±11.5	11.2±1.9	ND	11.2±1.9
MEKNN	Me	100±17	52.6±8.3	12.5±2.9	ND	12.7±3.1
MEKNP	Me	128±8	40.0±7.5	9.1±2.1	ND	9.1±2.1
MESHN	Me	202±83	63.3±21.7	13.9±2.6	ND	13.9±2.6
NBSIN	Mm[5]	ND[6]	12.7±6.0	4.8±3.3	ND	4.8±3.3
NBHIC	Me	ND	9.1±1.7	4.5±1.2	ND	5.3±1.3
NBHIP	Me	ND	9.4±2.2	4.5±1.6	ND	4.8±1.4
NBHIN	Me	ND	6.3±4.3	3.2±0.5	ND	3.2±0.5
NBMIC	Me	ND	20.8±2.0	8.5±2.9	ND	8.5±2.8
NBMIN	Me	118±117	20.6±5.6	9.6±3.4	ND	9.6±3.4
NSBCC	Me	39±17	2.6±0.2	5.1±2.3	ND	5.1±2.3
NSBCN	Me	395±7	14.1±0.7	4.5±1.3	ND	4.5±1.3
NSDIC	Me	131±56	8.5±2.0	5.0±2.9	ND	5.0±2.9
NSDIN	Me	278±36	17.0±3.6	5.2±1.4	ND	5.2±1.4

[1] C = caged mussels
[2] N = indigenous mussels
[3] P = subsample of mussels that were placed in cages, preset
[4] Me = *Mytilus edulis* or *trossulus* (see Table 6).
[5] Mm = *Modiolus modiolus*
[6] ND = not detected

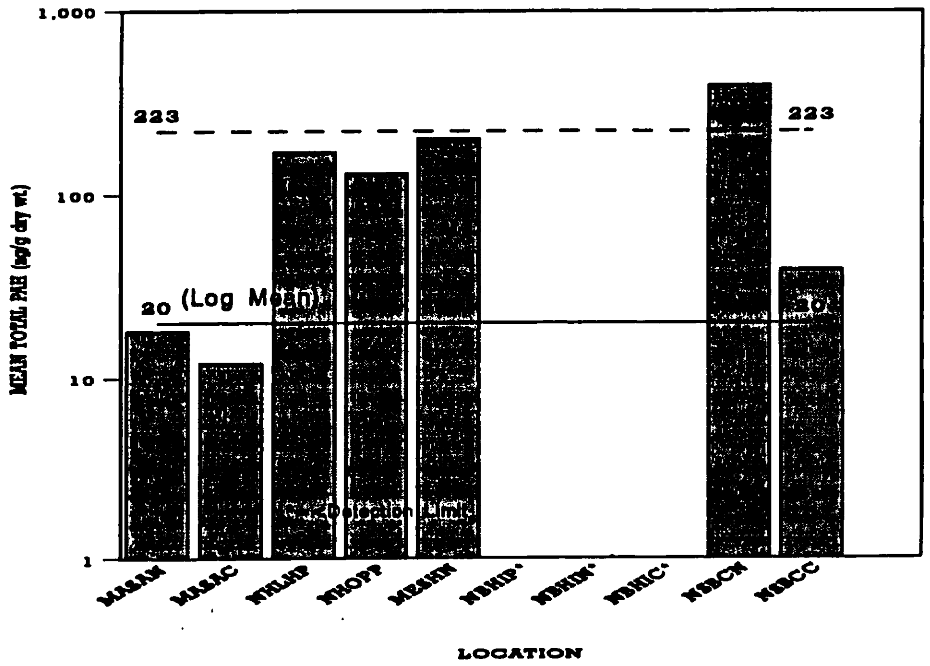

FIGURE 13. Geometric mean and standard deviation of TPAH tissue concentrations (ng/g dry weight) in mussels at the reference sites in the Gulf of Main 1992.

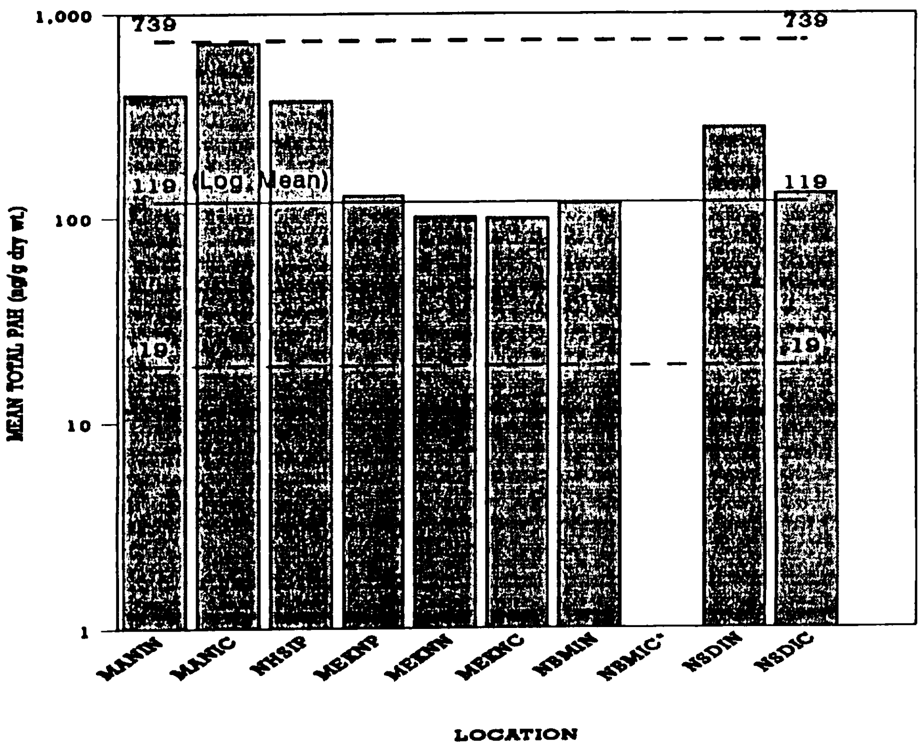

FIGURE 14. Geometric mean and standard deviation of TPAH tissue concentrations (ng/g dry weight) in mussels at the test sites in the Gulf of Maine, 1992.

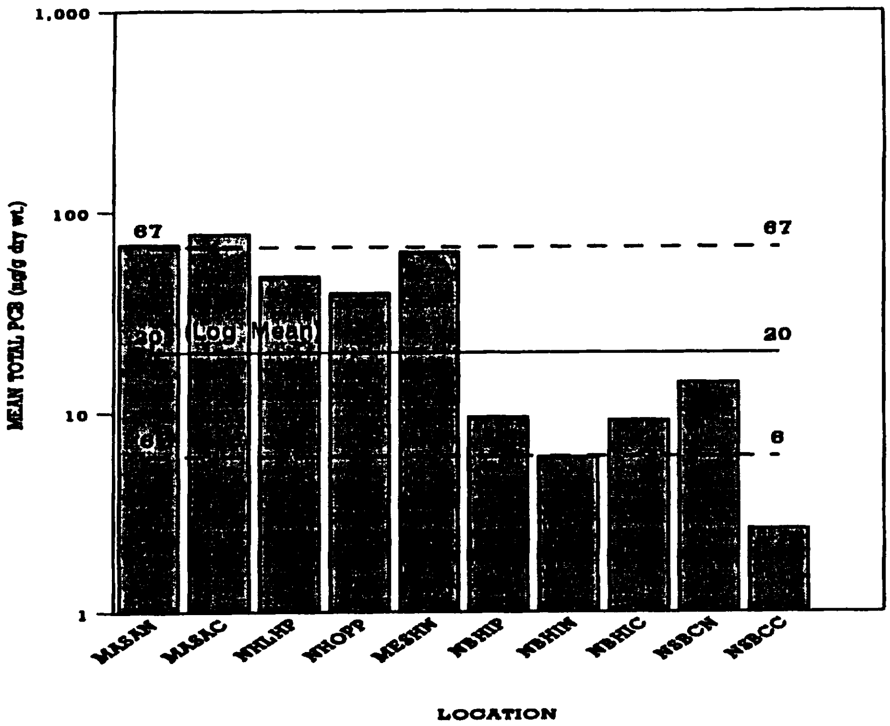

FIGURE 15. Geometric mean and standard deviation of TPCB tissue concentrations (ng/g dry weight) in mussels at the reference sites in the Gulf of Maine, 1992.

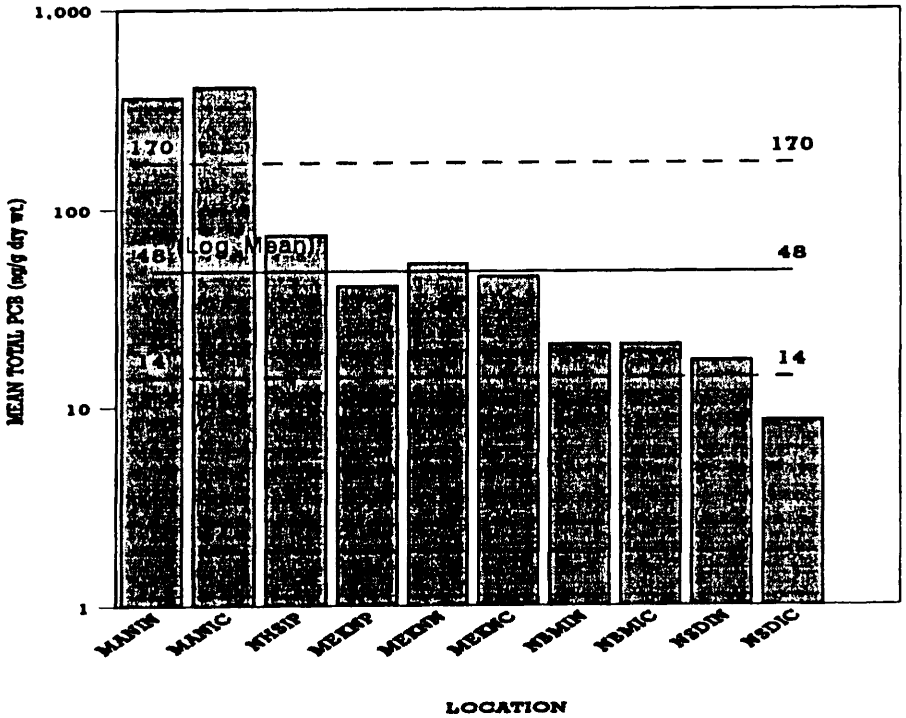

FIGURE 16. Geometric mean and standard deviation of TPCB tissue concentrations (ng/g dry weight) in mussels at the test sites in the Gulf of Maine, 1992.

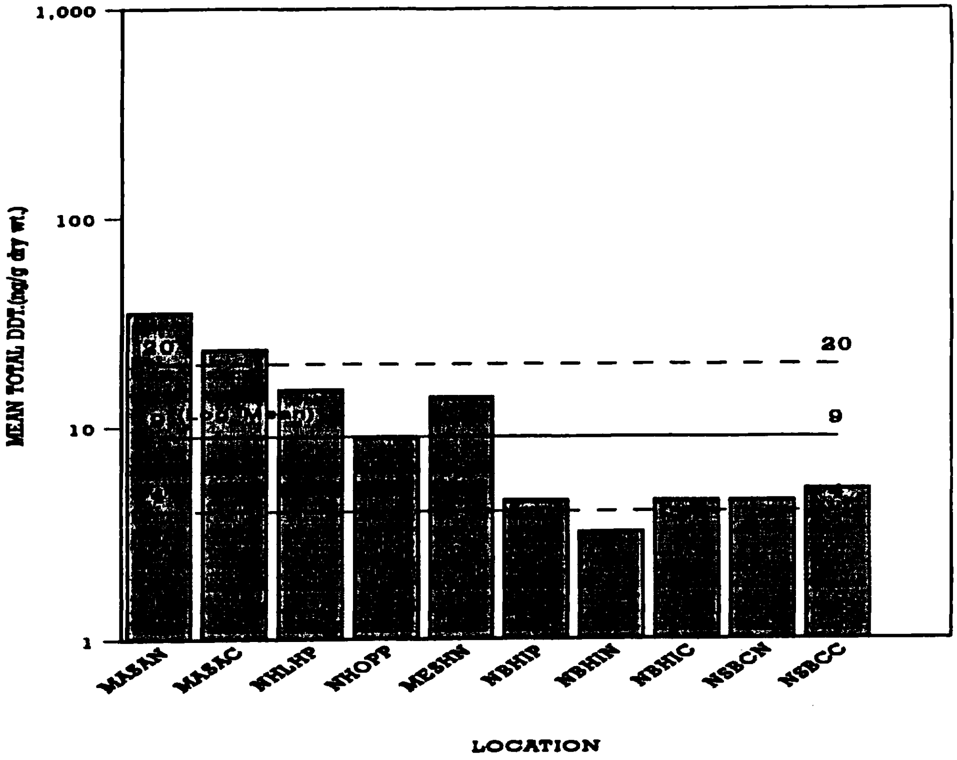

FIGURE 17. Geometric mean and standard deviation of TDDT concentrations (ng/g dry weight) in mussels at the reference sites in the Gulf of Maine, 1992.

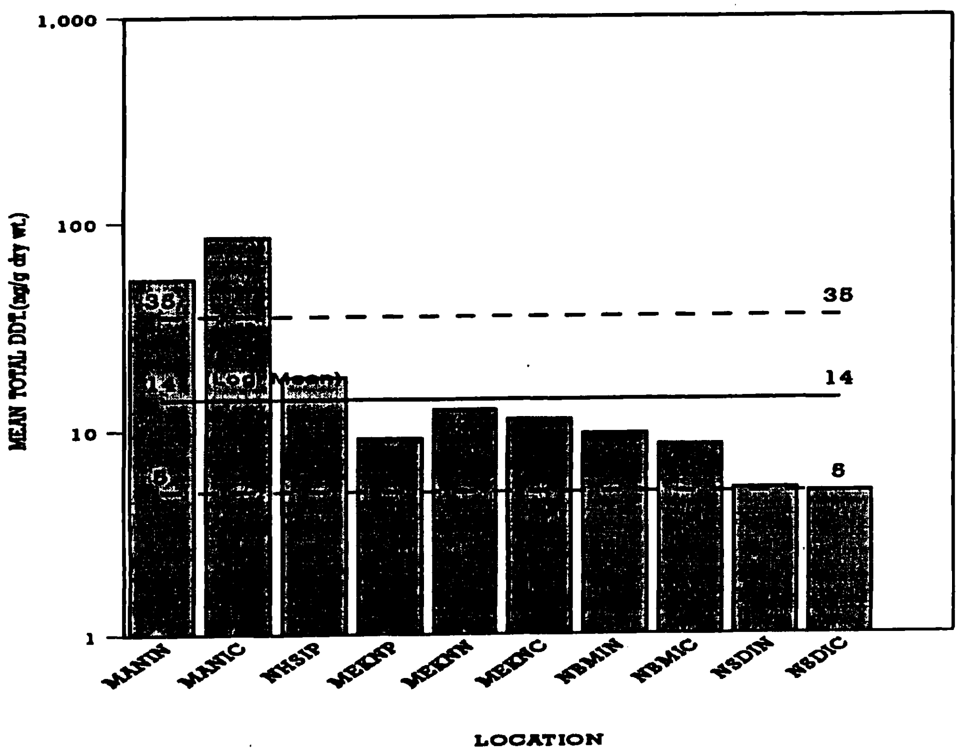

FIGURE 18. Geometric mean and standard deviation of TDDT concentrations (ng/g dry weight) in mussels at the test sites in the Gulf of Maine, 1992.

1865 ng/g; Deer Island, 2226 ng/g, in NOAA 1990 pers. comm.) but are consistent with concentrations observed in samples from a closer Boston Harbor locale (Hingham Bay, 744 ng/g, in NOAA 1990 pers. comm.). Notably, low TPAH concentrations of 18±3 and 12.0±0.3 ng/g dry weight were found in the Massachusetts reference site (Station MASA) in indigenous and caged mussels, respectively.

Other sites of significant TPAH contamination, Shapleigh Island (Station NHSI, 376 ng/g), Sheepscot River (Station MESH, 203 ng/g), Digby (Station NSDI, 131[C]-278[N] ng/g), and Manawagonish Island (Station NBMI, ND-118[N] ng/g), are in the range of concentrations also typical of point source urban and agricultural contamination. An exception is the elevated PAH concentrations in indigenous mussels measured at the Broad Cove (Station NSBC), reference site where no apparent PAH source could be identified. Levels were lower in the caged mussels than in the indigenous stock which suggests a historical rather than a current source. The history of wharves and the associated tar, fuel, and lubricants may offer an explanation of the elevated concentration at this site (Eaton and Zitko 1978). The higher PAH method detection limits used in the 1991 survey precludes useful comparison with the present results (GCMCE 1992a).

Polychlorinated biphenyls

The mean TPCB concentrations (total PCB) for the Gulf of Maine mussels ranged from 2.4 to 486 ng/g (Appendix E). Mean TPCB levels in mussels at our sites were comparable to areas under urban and agricultural influence (Appendix H) but were lower than concentrations in the Dutch Delta of the North Sea (Hummel et al. 1990; de Kock 1983), San Francisco Bay (Martin et al. 1984), and sites near pulp and paper activity (Herve et al. 1988).

The highest mean TPCB tissue concentrations in mussels at individual sites were measured at the Nut Island test site (Station MANI) (Figures 15 and 16; Table 11). Mussels at the Nut Island site had TPCB levels of 362±116 and 408±68 ng/g dry tissue weight ($\bar{X}$±Sd) in indigenous and caged samples, respectively. This is similar to our 1991 results, when corrected for surrogate recoveries, and very close to the NOAA 1990 (pers. comm.) Hingham Bay site mean concentration of 403 ng/g (Table 12).

Other reference and test site TPCB concentrations in mussels from the New England states range from 32 to 78 ng/g, dropping to 2.6 to 20.6 in the Canadian Maritime Provinces (Table 11). Higher values tend to be reported in areas of industrial and recreational activity while sites of lower concentrations, mostly within Canada, may reflect a global atmospheric transport phenomenon.

Pesticides

The total pesticide concentrations in mussels ranged from 2.7 to 122.2 ng/g dry tissue in the present Gulf of Maine study (Appendix F). DDT and its homologues were detected in mussels at every site in 1992, spanning a range of 2.7 to 87.2 ng/g dry weight tissue. DDT and its homologues were the sole contributors to total pesticide concentrations in mussels at all sites except Boston Harbor and downstream at Sandwich (Appendix F).

Average DDT concentrations at test sites (Figures 17 and 18) were comparable to those observed in England (Wharfe et al. 1978), the Gulf of Thailand (Menasveta and Cheevaparanapiwat 1981), the Northern Adriatic (Nadjek and Bazulek 1988), and South India (Ramesh et al. 1990) but were lower than levels observed in Scotland (Cowan 1981) and one order of magnitude lower than observations in Mexico (Baez and Bect 1989).

The Nut Island test site had the highest mean pesticide concentrations with 73±7 and 121±2 ng/g dry tissue weight of indigenous and caged mussels (Table 11). Nut Island (Station MANI) and Sandwich (Station MASA) mussel samples also contained concentrations of gamma-BHC, cis-chlordane, trans-nonachlor, and dieldrin. A similar variety of pesticides has been reported in previous NOAA mussel watch surveys (NOAA 1990 pers. comm.). The present Boston Harbor mean concentrations of DDTs and other pesticides were similar to those measured by NOAA (1990 pers. comm.) at Hingham Bay (Table 12). Unfortunately, chlorinated pesticides were not measured in our 1991 Gulf of Maine monitoring program (GCMCE 1992a).

TABLE 12. Comparison of organic contaminant levels found in mussels in 1991 and 1992 in the Gulf of Maine and in Boston Harbor in 1990 (NOAA 1990 pers. comm.).

	TPAH	TPCB	TDDT	Other Pesticides	TPEST
Massachusetts - MANI(C)/MANI(N):					
GCMCE 1992	721/400	408/362	85/53	36/20	121/73
GCMCE 1991	-	451[1]/362[1]	-	-	-
NOAA 1990[2]	744	403	108	57	165
New Hampshire - NHSI(C)/NHSI(N):					
GCMCE 1992	377[3]	76[3]	18[3]	ND[3]	18[3]
GCMCE 1991	-	48[1]/56[1]	-	-	-
Maine - MEKN(C)/MEKN(N):					
GCMCE 1992	99/100	45/53	11/13	ND	11/13
New Brunswick - NBMI(C)-NBMI(N):					
GCMCE 1992	ND/118	21/21	8.5/9.6	ND	8.5/9.6
Nova Scotia - NSDI(C)-NSDI(N):					
GCMCE 1992	131/278	8.5-17	5.0/5.2	ND	5.0/5.2

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[1] Corrected for surrogate recovery
[2] Hingham Bay, Boston Harbor
[3] Preset

PHYSIOLOGICAL EFFECTS

A review of the literature concerning the physiological effects of these organic contaminants on mussels indicates several important potential effects. Veldhuizen-Tsoerkan et al. (1991) found evidence for decreased glycogen and increased succinate production at PCB concentrations of 7000 ng/g wet weight after 6 months' exposure. Anoxic survival time was decreased but the CI was not reduced. The scope for growth was reduced at concentrations of 32 PCB ng/g dry weight at a Bermuda site near an automobile waste site, although this was not statistically significant (Widdows et al. 1990). Scope for growth was significantly negatively correlated with chlordane (51-83 ng/g wet weight) and dieldrin (20-50 ng/g wet weight) but not with PCB (510-1800 ng/g wet weight) along a pollution gradient in San Francisco Bay (Martin et al. 1984). Structural and functional alterations of the digestive gland of the blue mussel were noted in Norway at PCB concentrations of 275 ng/g wet weight (Capuzzo and Leavitt 1988). Implications from all of these studies are that it is possible the mussels near Nut Island are adversely affected physiologically by present contamination. The mean PCB concentrations reported for Nut Island in both caged and indigenous mussels (408 to 362 ng/g dry weight=82 to 68 ng/g wet weight) are close to probable threshold values.

SEASONAL VARIATION

The effect of seasonal factors such as reproductive condition in the present results is unclear. The literature suggests that the lysosomal membrane condition was highly correlated with chemical variables in the St. Lawrence Estuary; however, seasonal variation is a possible confounding factor (Pelletier et al. 1991). The seasonal variation in lipid concentration in relation to reproduction was also determined to influence contaminant concentrations, implying that only quasi-steady-state concentrations are attained in the field (Nadjek and Bazulek 1988; Capuzzo et al. 1989; Pelletier et al. 1991). However, other studies suggest too little seasonal variation in lipid to affect PCB concentrations (Hummel et al. 1990; de Kock 1983). Seasonal variation will vary with latitude and must be considered when making comparisons between laboratory and field studies.

MUSSELS AT REFERENCE VERSUS TEST SITES

In order to test whether mussels in presumed "clean" sites had lower contamination levels than test sites, paired t-tests were performed. TPAH concentrations in indigenous mussels at test and reference sites are significantly different ($P<0.05$) in all jurisdictions (Table 13). The concentrations in mussels at test sites are higher in Massachusetts and New Brunswick and lower in Maine and Nova Scotia. TPCB and pesticides concentrations are significantly ($P<0.05$) higher at the test site in Massachusetts. There were no other significant differences in the jurisdictional pairs. In caged mussels, concentrations of all three contaminant groups were significantly higher at the test compared to the reference site in Massachusetts; but no other differences were significant.

CAGED VERSUS INDIGENOUS MUSSELS AT EACH SITE

Caged and indigenous shellfish were different at some test sites and some contaminant groups (paired t-test; Table 14). The TPAH concentrations were significantly ($P<0.05$) higher in indigenous than in caged mussels at the Manawagonish Island, Digby, and Broad Cove sites but unexpectedly higher in caged over indigenous mussels at Nut Island. No difference was found between caged and indigenous mussels at the Kennebec River test site. PAH levels were below the detection level at two of the reference sites: Sandwich and Hospital Island. Caged mussels also contained significantly higher concentrations of TPCB and TPEST than indigenous mussels at the Nut Island site. There was no difference between the TPCB concentrations in caged and indigenous mussels at any of the other sites in the Gulf of Maine (Table 14). The only other significant difference in TPEST between caged and indigenous mussels occurred at Sandwich, where pesticides were higher in the indigenous populations. In most cases where a significant difference existed between organic contaminant levels in caged and indigenous mussels, the indigenous mussels were more contaminated, as one

TABLE 13. The results of paired comparison t-test of contaminant concentrations in indigenous (A) and caged (B) mussels at test and reference sites.

Location	Site	TPAH	TPCB	TPEST
A) Indigenous:				
	sd[1]	43.82	30.47	2.98
	df[2]	42	42	42
MANI	Test	399.83*	361.80*	73.33*
MASA	Reference	18.33	69.37	38.13
MEKN	Test	100.17*	52.60	12.67
MESH	Reference	202.17	63.33	13.85
NBMI	Test	118.00*	20.60	9.57
NBHI	Reference	0.00	6.27	3.17
NSDI	Test	278.33*	17.03	5.20
NSBC	Reference	395.33	14.10	4.52
B) Caged:				
	sd[1]	43.82	30.47	2.98
	df[2]	42	42	42
MANI	Test	721.33*	408.27*	120.78*
MASA	Reference	12.17	77.85	24.77
MEKN	Test	99.83	45.27	11.17
MESH	Reference			
NBMI	Test	0.00	20.87	8.48
NBHI	Reference	0.00	9.10	5.30
NSDI	Test	130.83	8.53	5.00
NSBC	Reference	39.00	2.63	5.05

[1] sd - standard deviation

[2] df - degree of freedom

*=Significant ($P<0.05$)

TABLE 14. The results of paired comparison t-test of contaminant group concentration in caged and indigenous mussels.

Location	Type	TPAH	TPCB	TPEST
MANI	N[1]	399.83*	361.80*	73.33*
	C[2]	721.33	408.27	120.78
MASA	N	18.33	69.37	38.13*
	C	12.17	77.85	24.77
MEKN	N	100.17	52.60	12.67
	C	99.33	42.27	11.17
NBMI	N	118.00*	20.60	9.57
	C	0.00	20.87	8.48
NBHI	N	0.00	6.27	3.50
	C	0.00	9.10	5.30
NSDI	N	278.33*	17.03	5.20
	C	130.83	8.53	5.00
NSBC	N	395.33*	14.10	4.52
	C	39.00	2.63	5.05

[1] N - indigenous mussels

[2] C - caged mussels

*=Significant ($P<0.05$)

would expect. The reverse was true for all three organic contaminant categories at Nut Island. The indigenous mussels, in this case, were located 0.3 km further from the Nut Island sewage outfall than the caged mussel deployment. Although both caged and indigenous mussels were within the influence of the sewage outfall, the more remote location of the indigenous mussels could explain their lower contaminant concentrations.

ACCEPTABLE LEVELS AND STANDARDS OF MUSSEL CONTAMINATION

Limited information is available for human health effects. In general, most levels reported in the literature are on a wet weight basis in contrast to Gulfwatch dry weight values. To facilitate general comparisons with Gulfwatch values, an average moisture content of 85% has been applied to wet weight health values to derive dry weight equivalents. The reported organic concentrations are within acceptable levels for those compounds which have established action limits in fish and shellfish. Total PCB values found (Appendix E) are less than the action level of 13 ppm dry weight or 2 ppm wet weight (USFDA 1990; CSSP 1992). Action level for the pesticides dieldrin, aldrin, chlordane, heptachlor, and heptachlor epoxide is 2.0 ppm dry weight or 0.3 ppm wet weight (USFDA 1990). The total DDT levels found are several orders-of-magnitude below the action level of 33 ppm dry weight or 5 ppm wet weight (USFDA 1990; CSSP 1992). Canadian limits for agricultural chemicals exclusive of DDT are 0.67 ppm dry weight or 0.1 ppm wet weight, and the dioxin limit is 133 ppt dry weight or 20 ppt wet weight (CSSP 1992), also well above present values found in Gulfwatch (Appendix F).

Admissible levels of methyl mercury, expressed as mercury, are less than 6.7 ppm dry weight or 1 ppm wet weight in the United States (USFDA 1990) and less than 3.3 ppm dry weight or 0.5 ppm wet weight (CSSP 1992). The highest concentration of mercury found in the 1992 Gulfwatch Project was 0.7 μg/g dry weight, well below the lower of the two federal action levels.

Recently, a series of "Guidance Documents" (USFDA 1993) for cadmium, chromium, lead, and nickel has been released in the United States to complement the mercury action level. These levels, however, are guidelines and by themselves do not warrant the issuance of health advisories. In Table 15, guidance concentrations are reported on both a wet weight basis and dry weight equivalent and compared to the highest observed concentration of any single replicate analysed in the 1992 Gulfwatch Project. With the exception of lead which is represented by one high replicate concentration from Digby (Station NSDI), no other value approaches the guidelines. The other replicates contained 2.3 μg lead/g dry weight. It would, therefore, be prudent to look into conditions at Digby as that station generally contains higher levels of metals than most other eastern Gulf stations.

Table 15. A comparison of United States Food and Drug Administration guidelines for various metals with Gulfwatch results.

Metal	Guideline (Wet Weight Basis)	Guideline (Dry Weight Basis)	Highest Observed 1992 Gulfwatch Value (Dry Weight)	Location
Cadmium	3.7 μg/g	25 μg/g	2.7 μg/g	MEKN
Chromium	13 μg/g	87 μg/g	37 μg/g	NSDI
Lead	1.7 μg/g	11.5 μg/g	9.6 μg/g	NSDI
Nickel	80 μg/g	533 μg/g	8.3 μg/g	NBMI

CONCLUSIONS

In a comparison of all Gulfwatch stations, the highest shell growth rate occurred at Hospital Island and the lowest at Little Harbor. The hypothesis assumption that growth would be affected at the test sites was not confirmed, since there was no consistent trend in the growth patterns for test and reference sites. In New Brunswick, the growth rate at the reference station was significantly higher than recorded at the test station; but in Nova Scotia the reverse was noted. For Massachusetts and New Hampshire, the growth rates at the test and reference sites were not significantly different.

As with the growth data, there was no overall relationship between the CI of caged and indigenous mussels at test and reference sites in each jurisdiction. However, there was a general tendency for caged mussels to have a higher CI than for adjacent indigenous mussels.

Continuous temperature recording at five stations indicated a north-south temperature gradient, with the warmest waters recorded at Nut Island during the cage deployment.

Logistically, the 1992 sampling was more standardized than during the 1991 pilot project. Fewer tissue samples were lost during deployment and fewer samples were lost to breakage. The higher number of samples overall resulted in stronger statistical analyses than was possible in 1991. Nevertheless, new problems arose. Most notably, an accident in tissue preparation for metal analysis caused unacceptable contamination by copper and to a lesser extent chromium, nickel, and zinc thus compromising our results.

Overall, concentrations of metals were lower Gulfwide than those measured in 1991. Some reference sites were found to contain more heavy metals than previously thought. In particular, Broad Cove (Station NSBC) and Sheepscot River (Station MESH) should not be used as reference sites again. In areas of high turbulence, such as Manawagonish Island (Station NBMI), cages were shown to elevate mussels above the effects of sediment resuspension thus enabling the collection of contamination information from an otherwise unsuitable site.

Human health issues due to metal contamination in the areas studied were found to be minimal. One exception is where one replicate [redacted] approached the United States health guidelines for lead. All samples fell well below any Canadian or American guideline or advisory level. A new geographic area of concern emerged in 1992 in Digby, where levels of metals were generally high. Resource managers responsible for this area might consider further evaluation and follow-up.

There is a southward trend of increasing organic contaminant concentrations, with the lowest in Nova Scotia and the highest in Massachusetts. PAH levels were highest in Boston Harbor, MA, and significantly elevated in Shapleigh Island, Sheepscot River, Broad Cove, Digby, and Manawagonish Island. PCBs were highest in Boston Harbor where they were close to NOAA (1990 pers. comm.) reported levels. The total pesticide concentrations were composed mostly of DDT homologues and were highest in Boston Harbor and agreed well with the previous NOAA (1990 pers. comm.) data. Levels of PCBs recorded in Boston Harbor are within the range which could cause sublethal effects in the host organism. American or Canadian fishery/health action levels of PCB, PAH, or pesticides were not exceeded.

Contaminant levels, particularly PAH, in indigenous mussels tended to be significantly higher than those recorded in the caged mussels. Contaminant levels at the test sites were not consistently higher than those recorded at the reference sites. TPAH concentrations in indigenous mussels were significantly different at test and reference sites in all pairs, but test sites were not higher in all cases. The test site in Boston Harbor was significantly higher in all contaminant groups.

In general, similarities among the sites for both metal and organic contaminants were based on geography and may reflect the importance of major regional point sources or latitudinal influences over local site differences.

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APPENDIX A. METHODS FOR MUSSEL EXTRACTION AND ANALYSIS OF ORGANIC CONTAMINANTS

Compounds for organic analysis were selected to be consistent with NOAA status and trends mussel monitoring. All samples were analyzed at the Environment Canada Atlantic Regional Laboratory in Dartmouth, N.S., with the exception of dioxins and furans which were analyzed on contract by Axys Analytical Services Ltd. in Sidney, B.C.

ANALYTICAL METHODS

Modifications to the methods for organic contaminants have been made since the 1991 Gulf of Maine Mussel Watch Effort (GMCME 1992a and b). The major changes include: 1) lowering target analyte detection limits to 10 ng/g for most aromatic hydrocarbons (20-30 ng/g for some of the lower molecular weight aromatics); 2) the addition of 17 chlorinated pesticides to the variable list including alpha and beta endosulfan; 3) identification and quantitation of PCB by congener analysis which include 18 NOAA designated congeners and 6 other congeners including some co-planar PCBs. The specific compounds and their detection limits are listed in Tables A1 and A2.

METHOD DESCRIPTION

Sample Preparation and Extraction

Composite samples of shucked-mussel meats from various coastal locations were provided to the laboratory in solvent-cleaned glass sample jars and stored at -20°C until samples were processed.

Prior to analyzing mussel tissue samples, the laboratory verified that all glassware, chemical reagents, and solvents used in the analysis of tissue samples were free of contamination which could interfere with the identification and quantitation of target analytes.

A frozen composite sample (5-200 g) was thawed and homogenized in a Waring blender at high speed for 3 minutes (for details on sample homogenization refer to Shrimpton 1988). Ten grams of homogenate were transferred to a 300 ml Berzelius

TABLE A1. Aromatic hydrocarbons.

Compound	Quantitation ion	Confirmatory ion	Spike* concentration (ng/g)
Naphthalene	128	127 [15]	50
2-Methylnaphthalene	142	141 [90]	"
1-methylnaphthalene	142	141 [90]	"
Biphenyl	154	152 [35]	"
2,6-Dimethylnaphthalene	156	155 [30]	"
Acenaphthylene	152	151 [20]	"
Acenaphthene	153	154 [90]	"
2,3,5-trimethylnaphthalene	170	169 [90]	"
Fluorene	166	165 [90]	"
Phenanthrene	178	176 [20]	"
Anthracene	178	176 [20]	"
1-Methylphenanthrene	192	191 [50]	"
Fluoranthene	202	200 [20]	"
Pyrene	202	200 [20]	"
Benzo(a)anthracene	228	226 [20]	"
Chrysene	228	226 [25]	"
Benzo(b)fluoranthene	252	250 [20]	"
Benzo(k)fluoranthene	252	250 [20]	"
Benzo(e)pyrene	252	250 [20]	"
Benzo(a)pyrene	252	250 [20]	"
Perylene	252	250 [25]	"
Indeno(123cd)pyrene	276	277 [25]	"
Dibenzo(ah)anthracene	278	279 [25]	"
Benzo(ghi)perylene	276	277 [25]	"

*Spike Matrix Samples
[ ] % of base peak

SURROGATES:			Amount* (ng/g)
Naphthalene-d8	136	137	80
Acenaphthene-d10	164	162	80
Chrysene-d12	240	241	40
Benzo(a)pyrene-d12	264	265	40
Benzo(ghi)perylene-d12	288	289	40

*Added to sample homogenate

.../Cont.

TABLE A1. Cont...

Compound	Quantitation ion	Confirmatory ion	Spike* concentration (ng/g)
INTERNAL STANDARDS:			Concentration* (ng/ml)
Fluorene-d10	176	174	350
Pyrene-d12	212	210	350
Perylene-d12	264	260	350

*In calibration curve

TABLE A2. Polychlorinated biphenyls.

IUPAC	Congener	Spike* concentration (ng/g)
8/5	2,4'-dichloro	35
18/15	2,2',5-trichloro	"
28	2,4,4'-trichloro	"
29	2,4,5-trichloro	"
44	2,2',3,5-tetrachloro	"
50	2,2',4,6-tetrachloro	"
52	2,2',5,5'-tetrachloro	"
66/95	2,3',4,4'-tetrachloro	"
77**	3,3',4,4'-tetrachloro	"
87	2,2',3,4,5-pentachloro	"
101/90	2',2,4,5,5'-pentachloro	"
104	2,2',4,6,6'-pentachloro	"
105**	2,3,3',4,4'-pentachloro	"
118	2,3',4,4',5-pentachloro	"
126**	3,3',4,4',5-pentachloro	"
128	2,2',3,3'4,4'-hexachloro	"
138**/163/164	2,2',3,4,4',5'-hexachloro	"

.../Cont.

TABLE A2. Cont...

IUPAC	Congener	Spike* concentration (ng/g)
153/132	2,2',4,4',5,5'-hexachloro	"
169*	2,2',4,4',5,6'-hexachloro	"
170/190	2,2',3,3',4,4',5-heptachloro	"
180	2,2',3,4,4',5,5'-heptachloro	"
187	2,2',3,4',5,5',6-heptachloro	"
188	2,2',3,4',5,6,6'-heptachloro	"
195/208	2,2',3,3',4,4',5,6-octchloro	"
200	2,2',3,3',4,5',6,6'-octachloro	"
206	2,2',3,3',4,4',5,5',6-nonachloro	"
209	decachloro	"

* Spike matrix samples

SURROGATE:	Amount* (ng/g)
3,4,5-trichlorobiphenyl-2',3',4',5',6'-d5	25

*In all samples

INTERNAL STANDARDS:	Concentration* (pg/μl)
4,4'-dibromooctafluorobiphenyl	9.2
octachloronaphthalene (ref time only)	10.4

*In calibration curve

beaker and 100 ml of methyl chloride added. Two grams of homogenate were put aside for dry weight determination.

One hundred microlitres of surrogate solution containing five deuterated aromatic hydrocarbon recovery standards (Table A1) and 100 μl of surrogate solution containing one pesticide and two PCB congener recovery standards (Table A2) were added to the homogenate. Anhydrous sodium sulphate (7 g/g of homogenate) was added and the contents of the beaker and blended for 2 minutes at high speed with a Polytron tissumizer. The mixture along with methylene chloride rinsings were vacuum filtered through a Whatman GF/C glass microfibre filter. The extract was concentrated to about 3 ml, transferred to a 10 ml glass syringe, and forced through a 0.5 μm Millex SR filter unit into a 15 ml ABC AS2000 System GPC-autovap loading tube. The final volume of extract was made exactly to 8.0 ml with methylene chloride.

EXTRACT CLEAN-UP AND FRACTIONATION

Gel Permeation Chromatography

Lipids, elemental sulphur, and other larger molecular-size compounds derived from the biomatrix were removed by gel permeation chromatography using an Autovap AS2000 GPC Sample Processing System (Analytical Bio-Chemistry Laboratories). The system included a low-pressure GPC column packed with methylene chloride pre-swollen SX-3 envirobeads and was run in dual GPC/auto-evaporation mode with an end-of-run hexane solvent exchange. A sample matrix effect helped reduce analyte losses during the evaporation stage; and a keeper, therefore, was not used.

Silica Column Chromatography

PCB congeners and apolar pesticides were fractionated from more polar pesticides on 1 cm x 10 cm silica gel columns. Columns were prepared by sandwiching a pentane slurry of 7% deactivated silica gel (Davidson 923, mesh 100/200) between two 1 cm layers of anhydrous sodium sulphate.

A column was pre-rinsed with 30 ml of pentane, and 1 ml of concentrated sample extract in pentane was placed on top of the column bed. Twenty millilitres of pentane were passed through the column which eluted most PCB congeners and apolar pesticides. This was followed by 20 ml of pentane/methylene chloride (1:1) which eluted the more polar pesticides.

Each fraction was collected separately and concentrated to 0.5 ml. Ten microlitres of PCB/pesticide internal standard solution (Tables A2 and A3) were added to each fraction prior to analysis by high-resolution gas chromatography-ECD.

After completion of the PCB/pesticide GC-ECD analysis, the two fractions were combined and concentrated to 0.5 ml in toluene. Ten microlitres of internal standard solution containing five deuterated aromatic compounds (Table A1) were added to the extract and reanalyzed by GC-MS for aromatic hydrocarbons.

INSTRUMENTAL ANALYSIS

Polychlorinated Biphenyls and Pesticides

PCB congeners and pesticides in mussel tissue extracts were analyzed by high-resolution gas chromatography-electron capture detection. A four-point calibration curve was constructed covering the concentration range 2 to 500 pg/μl for these analyses.

Apolar PCB congeners and pesticides contained in fraction one and the more polar compounds contained in fraction two were analyzed on two different fused silica capillary columns. Column 1 contained a 5% phenylmethyl polysiloxane stationary phase while Column 2 contained a 50% phenylmethyl polysiloxane stationary phase. PCB congeners analyzed on Column 1 were identified and quantified individually or as co-eluting pairs (Table A2). Pesticides detected on Column 1 were confirmed on Column 2. PCB congeners and pesticides which co-eluted on Column 1 were resolved on Column 2 for identification and quantitation.

Gas Chromatograph-Electron Capture Detector Operating Conditions

Gas chromatograph: HP 5890 Series 11
Column 1: DB-5, 30 m x 0.20 mm fused silica, 0.33 μ film
Injection: Splitless
Temperature program: 90°C for 0 minutes, to
175°C at 10°C/minute, to

TABLE A3. Pesticides.

Compound	Concentration* (ng/g)
Hexachlorobenzene	35
Heptachlor	"
Aldrin	"
4,4'-DDE	"
Mirex	"
Lindane	"
Heptachlor Epoxide	"
cis-Chlordane	"
trans-Nonachlor	"
Dieldrin	"
2,4'-DDE	"
2,4'-DDD	"
4,4'-DDD	"
2,4'-DDT	"
4,4'-DDT	"
alpha-Endosulfan	"
beta-Endosulfan	"

*Spike matrix samples

SURROGATES:	Amount* (ng/g)
3,4,5-trichlorobiphenyl 2',3',4',5',6'-d5	40

*Added to sample homogenate

INTERNAL STANDARDS:	Concentration* (pg/μl)
4,4'-dibromooctafluorobiphenyl	9.2
Octachloronaphthalene (ref time only)	10.4

*In calibration curve

	280°C at 2.5°C/minute, and hold 5 minutes
Carrier gas:	Helium

Secondary Analysis

Gas chromatograph:	HP 5880
Column 2:	HP-17, 25 m x 0.32 fused silica, 0.26 μ film
Injection:	Splitless
Temperature program:	As above
Carrier gas:	Helium

Polyaromatic Hydrocarbons

Analysis of aromatic hydrocarbons was conducted by high-resolution capillary gas chromatography and low-resolution quadruple mass spectrometry in selective ion mode. A five-point calibration curve was constructed for analysis covering the concentration range 10 to 1000 pg/μl.

Gas Chromatograph and Mass Spectrometer Operating Conditions

Gas chromatograph:	HP 5890 Series 11
Column:	DB-5, 30 m x 0.25 mm fused silica, 0.25 μ film or equivalent
Injection:	Cool on column
Temperature program:	70°C for 1 minute, to 250°C at 10°C/minute, to 290°C at 20°C/minute, and hold 12 minutes
Carrier gas:	Helium,
Mass spectrometer:	HP 5971A MSD
Ionization mode:	Electron impact 70 ev
Ion dwell time:	150-250 msec (optimized for maximum sensitivity)
Scan speed:	1 cps

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APPENDIX B. QUALITY ASSURANCE/QUALITY CONTROL PROTOCOL

1.0 INTRODUCTION

The quality assurance provisions of this performance-based standard are intended as a guide for the generation of acceptable analytical data for use in Canadian shellfish contaminants monitoring. The standard permits flexibility in the selection of an analytical method for the generation of chemical data, provided laboratory institutes the quality control measures identified and the method can attain the minimum performance stated.

2.0 SPECIFIED VARIABLES

Essential target analytes required for reporting are listed in the following tables:

- Polyaromatic Hydrocarbons (Table A1 and Appendix D)
- PCB Congeners and Chlorinated Pesticides (Tables A2 and A3 and Appendices E and F)
- Dioxins and Furans (Appendix G)
- Metals (Appendix C)

3.0 EXTERNAL CHECK SAMPLE PROGRAM PARTICIPATION

A laboratory providing analytical data for use in shellfish contaminants monitoring is required to demonstrate proficiency in contaminant analysis through yearly participation in a refereed interlaboratory check sample program if available. Exercise results are provided to the regional project coordinator for review. Deficiencies in check sample performance must be discussed with the project coordinator and corrective action taken where necessary.

The check sample program must be relevant to the analysis of organic and inorganic contaminants at trace concentrations in marine shellfish matrices. The National Institute of Standards and Technology (NIST) (Gaithersburg, Md.) conducts a QA intercomparison exercise program for both government and private laboratories engaged in the measurement of organic and inorganic contaminants in marine sediment, fish, and shellfish samples.

4.0 INTRALABORATORY QUALITY CONTROL: INSTRUMENT OPERATING REQUIREMENTS AND PERFORMANCE CRITERIA

4.1 AROMATIC HYDROCARBON ANALYSIS

Gas chromatography-mass spectrometry: Aromatic hydrocarbons in mussel tissue extracts are analyzed on a GC-mass spectrometer in selective ion mode. The gas chromatograph must be capable of ramp temperature programming up to 290°C and accommodating a 25 m or longer DB-5 capillary column or equivalent. It is recommended that on-column injection is used in order to avoid mass discrimination of higher molecular weight aromatic hydrocarbons which can occur with flash vaporization injection. It also is advisable that deactivated retention gaps are used and routinely replaced in order to maintain column performance.

4.1.1 Initial Set-Up

- MS Tuning: The mass spectrometer is tuned to standard specifications with perfluorotributylamine (PFTBA). Periodic retuning after initial set-up should be performed to ensure MS calibration consistency. Recalibration of the calibration curve is necessary after each retuning.

  Following PFTBA tuning, it may be necessary to manually tune the mass spectrometer, maximizing sensitivity in the low- to mid-mass range (e.g., maximizing the absolute abundance of mass 264) in order to achieve analyte target detection.
- Calibration Curve: A five-point calibration curve is constructed for every target and surrogate analyte. The concentration range covered is 10 to 1000 pg/μl. The curve should not be forced through the origin. *Linearity is verified when the relative standard deviation of response factors for each analyte is less than 30%.*
- Detection Limits: Laboratories must verify that the method and instruments achieve target method detection limits of 30 ng/g (dry weight) or lower for low molecular weight aromatic hydrocarbons (two-ring aromatic compounds) and 10 ng/g or lower for higher molecular weight aromatic compounds.
- Analyte Identification: *Positive identification is assumed when relative to an internal standard, the analyte retention time is within ±0.05 minutes of the corresponding standard retention time; the ratio of quantitation ion and confirmatory ion (Table A1) is within ±20% of the calculated theoretical value except when the abundance of the*

confirmation ion is too low to permit detection; and the peak maxima for quantitation and qualifier ions coincide within 3 seconds. Identified analytes which fail to meet these criteria should be flagged.

- Quantitation: An internal standard method is recommended for the quantitation of sample data. A minimum of three internal standards should be spiked into sample extracts prior to GC-MS analysis. Suggested internal standards and spiking concentrations are given Table A1.

  Analyses are conducted within the range of the standard calibration curve. Sample extracts with concentrations of analytes greater than the highest calibration standard must be diluted to bring analyte concentrations within the calibration range.

4.1.2 Method Performance Test

Prior to processing any samples, a laboratory must demonstrate that its method and instrument operating conditions will provide acceptable recoveries of surrogate and target analytes. Three replicate uncontaminated tissue homogenate samples are spiked with surrogates and target analytes and analyzed by the full procedure. *Recovery of target analytes and surrogates must meet the performance criteria stated in Section 4.1.2 under "Matrix Spike Sample" and "Surrogate Spikes." Method precision (RSD) for each analyte should not be greater than 25%.*

4.1.3 Daily Performance Checks

- Calibration Curve Check: At least one calibration standard is run prior to each batch analysis. *The calculated amount for each analyte must be within ±15% on average and not exceed ±25% for any one analyte.*
- Chromatographic Column Performance: Chromatographic resolution is verified on a daily basis. *Adequate resolution is demonstrated if for the highest peak there is no more than a 1% valley between the phenanthrene/anthracene peaks and less than a 25% valley between the Benzo(a)anthracene/chrysene peaks.* If these performance criteria are not met, column resolution must be restored before any further sample analyses can proceed.

4.1.4 Batch Analysis

A laboratory is required to analyze tissue samples for organic contaminants in batches of no more than 15 samples including quality control samples. The following quality control measures are required for each batch of sample analyses:

- Method Blank (1): *The method blank must be free of contamination at or above the method detection limit.* If contamination is greater than the MDL a correction may be made by subtracting the average amount in the blanks from the amount in samples when the blank contamination can be shown to be constant over a number of batch runs. If blank contamination is greater than two times the MDL, corrective action must be taken to eliminate the source of contamination.
- Duplicate Samples (1 set): *The relative percent difference between the analytical results for duplicate samples should be no more than 25% for measured values greater than five times the MDL.*

  The percent difference is calculated by dividing the absolute difference of the duplicate values by their average value.
- Spiked Matrix Sample (1): A matrix spike is prepared for all the analytes of interest (Table A1). If possible, spike matrix concentrations should be in the same proximity as sample concentrations. Otherwise, the addition of 75 ng of each analyte to matrix homogenates is usually sufficient. *Spike recoveries must fall into the range of 40-120% for 80% of analytes.* If more than 20% of recoveries are outside the range, instrument response, sample chromatograms and surrogate recoveries for each sample in the batch are checked to ensure that batch analysis is in control. Failing performance criteria will result in individual samples or the entire batch being reanalyzed.
- Standard Reference Material: Ideally, one mussel tissue SRM should be included with each batch of sample analyses. Availability and cost of bivalve reference material, however, may preclude a SRM in every batch. As a minimum at least one SRMs is analyzed with every two or three batches. For projects with higher numbers of samples, a SRM is run at the beginning, mid-point, and end of the analytical project. Marine bivalve certified reference material (SRM 1974) can be obtained from NIST (United States Department of Commerce, Gaithersberg Md.).

On average, laboratory results (corrected for surrogate recoveries) should be within ±30% of the certified value's confidence range for all analytes and may not exceed ±35% for more than 30% of individual analytes.

- Surrogate Spikes: Deuterated surrogate analytes (Table A1), representative of each aromatic hydrocarbon group of the same ring number, are spiked into each sample homogenate and method blank prior to extraction. *Surrogate recoveries must be in the acceptable range of 30-150%.* Samples with surrogate recoveries outside the range are reanalyzed.

4.2 PCB CONGENER AND CHLORINATED PESTICIDES ANALYSIS

The following QC and performance standards are intended for the analysis of PCB congeners and chlorinated pesticides by high-resolution gas chromatography and electron capture detection. Requirements for the gas chromatograph are the same as described in Section 4.2. If flash vaporization injection is used, care should be exercised in selecting the injection port temperature in order to minimize degradation of thermally labile compounds such as 4,4'-DDT.

Gas chromatographic analysis is performed on a 30-m or longer 5% phenylmethyl polysiloxane column (DB-5 or equivalent).

It is highly recommended that a laboratory include in its analytical method provision for the absorptive column fractionation of apolar PCB congeners and chlorinated pesticides from more polar pesticides. The laboratory must verify the PCB and pesticide column elution pattern for every new batch of absorptive material used. Correction of analytical results based on the distribution of some analytes in the two fractions may be required.

4.2.1 Initial Set-Up

- Calibration Curve: For every target analyte a five-point calibration curve is constructed which covers the concentration range 2 to 500 pg/μl. *Calibration curve linearity is verified when the relative standard deviation of response factors for each analyte is less than 30%.*

- Detection Limit: The laboratory must verify that methods and instrument operating conditions can achieve target method detection limits of 2 ng/g for individual PCB congeners and chlorinated pesticides.
- Chromatographic Column Performance: *Chromatograms of standard analytes are checked regularly to ensure that analyte peak shape, resolution, and sensitivity have not degraded with time.*
- Analyte Identification: PCBs in mussel tissue are analyzed as selected congeners (Table A2). Co-eluting congeners are identified in data reports.

  Analysis with a second capillary column possessing a stationary phase different from DB-5 type columns such as 50% phenylmethyl polysiloxane (DB-17 or equivalent) is required in order to resolve and accurately identify and quantify PCB congeners and pesticides which co-elute on DB-5 type columns.

  The positive identification of a PCB congener or pesticide is assumed when relative to an internal standard, the analyte retention time is within ±0.05 minutes of the corresponding standard retention time.
- Quantitation: An internal standard method is recommended for the quantitation of sample data. Suggested internal standards and concentrations for the GC-ECD analysis of PCB congeners and pesticides are given in Tables A2 and A3.

4.2.2 Method Performance Test

The same as per section.

4.2.3 Batch Analysis

Laboratories are required to analyze tissue samples in batches of 15 individuals or less. The following quality control measures are required with each batch:

- Method Blank (1): The same as in Section 4.1.4.
- Duplicate Samples (1 SET): Performance criteria as in Section 4.1.4.
- Spiked Matrix Sample (1): A matrix spike is analyzed for all PCB and pesticide target analytes (Table 3A). Performance criteria are the same as in Section 4.1.4.
- Standard Reference Material: The same as in Section 4.1.4.

- Surrogate Spikes: PCB congener and pesticide surrogates (Table A2) are spiked into each sample homogenate prior to extraction. Performance criteria as in Section 4.1.4.

4.3 DIOXINS AND FURANS ANALYSIS

A laboratory undertaking the analysis of chlorinated dibenzodioxins and chlorinated dibenzofurans (Appendix G) is referred to the quality control measures and performance criteria provided in the Environment Canada report titled "Internal Quality Assurance Requirements for the Analysis of Dioxins in Environmental Samples" (Environment Canada 1992a). Reference also is made to the quality control provisions found in the Environment Canada report titled "Reference Method for the Determination of Polychlorinated Dibenzo-para-dioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) in Pulp and Paper Mill Effluents" (Environment Canada 1992b).

All samples were spiked with ^{13}C-labelled surrogates (tetrachlorodioxin, tetrachlorofuran, pentachlorodioxin, hexachlorodioxin, heptachlorodioxin, and octachlorodioxin) prior to analysis. Tissue samples were ground with sodium sulphate, packed in a glass chromatographic column and eluted with solvent. The extracts were subject to a series of clean-up steps prior to analysis by gas chromatography with mass spectrometric detection (GC/MS).

4.3.1 Extraction Method

A subsample of tissue was dried to determine moisture content.

A wet tissue sample was spiked with an aliquot of surrogate standard and ground with anhydrous sodium sulphate to a free-flowing powder. The mixture was loaded into a glass chromatographic column containing dichloromethane:hexane and the column eluted with additional solvent. The extract was concentrated and subsampled for gravimetric lipid analysis. The remaining extract was loaded onto a calibrated Biobeads SX-3 column and eluted with dichloromethane/hexane. The 150-300 mL fraction was retained and concentrated prior to chromatographic clean-up.

4.3.2 Column Chromatography

a) Silica Gel Column

The extract was transferred to a 10-g layered silica gel column (layers: activated silica gel, silica gel treated with sodium hydroxide, activated silica gel, silica gel treated with sulfuric acid, activated silica gel) and eluted with hexane.

b) Alumina Column

The extract from the silica gel column was loaded onto a 10-g basic alumina column. The first fraction, eluted with 3% dichloromethane:hexane, was discarded. The next fraction, eluted with 1:1 dichloromethane:hexane, was retained.

c) Carbon/Celite Column

The extract from the alumina column was loaded onto a carbon:celite column. The first fraction (F1), which eluted with cyclohexane:dichloromethane followed by toluene:ethyl acetate, was discarded. The column was inverted and eluted with toluene. This fraction (F2) was evaporated to near dryness and redissolved in hexane.

d) Alumina Column

The extract from the carbon/celite column procedure was loaded onto an alumina column. The first fraction, eluted with 3% dichloromethane:hexane, was discarded. The next fraction, eluted with 1:1 dichloromethane:hexane, was retained and concentrated to 1 mL.

e) Preparation for GC/MS Analysis

The extract was evaporated just to dryness and an aliquot of ^{13}C-labelled recovery standards (^{13}C-labelled 1,2,3,4-tetrachlorodibenzodioxin; 1,2,3,6,7,8-hexachlorodibenzodioxin and 1,2,3,4,6,7,8-heptachlorodibenzofuran) was added.

4.3.3 GC/MS Analysis

Polychlorinated dibenzodioxins (PCDD) and dibenzofurans (PCDF) were analyzed on a Finnigan INCOS 50 mass spectrometer equipped with a Varian 3400 GC, a CTC autosampler, and a DG 10 data system running Incos 50 (Rev 9) software. Data were acquired in the Multiple Ion Detection (MID) mode to enhance sensitivity. At least three ions were monitored for each group of isomers. Two were from the parent cluster while the third was from the loss of COC1 (i.e. M-COC1 or M-63). Two ions were used to monitor each of the ^{13}C-labelled surrogate standards, and five additional ions were monitored to check for interference from chlorinated diphenyl ethers.

High-Resolution GC/MS Analysis

High-resolution analysis of polychlorinated dibenzodioxins (PCDD) and dibenzofurans (PCDF) was required for some samples to improve detection limits. The analysis was carried out using a VG 70SE mass spectrometer equipped with a Hewlett Packard 5890 GC, a 60 m DB-5 chromatography column (0.25 mm i.d. x 0.1 μm film thickness) and a CTC autosampler. Data were acquired in the Multiple Ion Detection (MID) mode to enhance sensitivity.

4.3.4 Quality Control/Quality Assurance

QA/QC Samples

- Batch Size: Analyses were carried out in batches. Each batch consisted of up to nine samples, one blank, one duplicate, and one spiked sample or reference material.
- Blanks: One procedural blank was analyzed for each batch of samples.
- Duplicates: Results for duplicates (10%) are presented along with the analysis results.
- Reference Materials: Standard reference materials for most matrix types are not yet available for dioxin/furan analysis; consequently, spiked samples are relied on to demonstrate the accuracy of the data. Spiked samples were analyzed at regular intervals (one per batch samples).
- External Standards: NBS SRM #1614 (2,3,7,8-T_4CDD in iso-octane) was analyzed to verify the accuracy of our 2,3,7,8-T_4CDD quantification.

Instrumental Analysis

- Instrument Linearity: Quantification linearity of the GC/MS was periodically verified by a five-point calibration covering a concentration range of 5 to 1000 pg/μL.

- Instrument Sensitivity: Regular verification that 5 pg of 2,3,7,8-T_4CDD was observed at greater than three times the noise.
- Isomer Specificity: Mixture of four T_4CDD isomers (1,2,3,4; 1,2,3,7; 1,2,3,8; and 2,3,7,8) was analyzed to verify isomer specificity for 2,3,7,8-T_4CDD.
- Calibration: Instrument mass range was calibrated daily, every 8 h at the beginning of the day and every 8 h thereafter and at the end of run. RRFs at the beginning and end of the sample suite must agree to within 15% (RSD).
- Column Carryover: Periodic assessment of column carryover by running solvent blanks.
- Interferences: The M+ ion of the chlorodiphenyl ethers were monitored to demonstrate the lack of interference from them.

Data Reporting

- Windows: A chromatogram of a "window-defining" mixture was run periodically to define the "window" during which each dioxin or furan group elutes.
- Surrogate Recoveries: Internal standard recoveries (reported with each sample result) were required to be in the range of 40% to 120%. If recoveries were outside the range, the analysis was repeated.
- Ions Monitored: Response of at least three ions, including the COC1 loss ion, was monitored for each dioxin/furan of interest. Peak maxima for ions monitored coincided within one scan for peak to be included in total congener summation. Peak area ratios for the two monitored molecular ions for each congener group were within ±20% of the ratio obtained for the corresponding ions in the day's calibration runs for the peak to be included.
- Detection Limits: Detection limits were monitored and reported for all congener groups on a sample-specific basis. The detection limit was calculated as the concentration corresponding to the area reject. The area reject, determined from the ion chromatogram of each congener group, was the area of a peak with height three times the maximum height of the noise. Only peaks with responses greater than three times the background noise level were quantified.

4.4 REPORTING

- Analytical results are reported individually on a dry weight basis. All surrogate recoveries and results of duplicate analysis must be reported with the relevant sample data. Data corrected for surrogate recoveries (done in agreement with the project coordinator) must be identified as such.
- The results of check sample exercises are reported and discussed with project coordinators.
- The results of all performance tests, matrix spike samples, and surrogate spiked method blanks are tabulated and provided at the request of the project coordinator.
- A laboratory should be prepared to provide a copy of the analytical method including handling, storage, and any modifications required to accommodate problems encountered (example matrix interferences). A laboratory also should maintain on file all relevant sample, standard, and blank chromatographic and related QC data as well as tables of all calibration standard and surrogate solution concentrations for possible future examination.

4.5 REFERENCES

Environment Canada. 1992a. Internal quality assurance requirements for the analysis of dioxins in environmental samples. October 1992, Rep. EPS 1/RM/23.

Environment Canada. 1992b. Reference method for the determination of polychlorinated dibenzo-*para*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in pulp and paper mill effluents. February 1992, Rep. EPS 1/RM/19.

APPENDIX C. TISSUE CONCENTRATIONS OF HEAVY METALS IN *MYTILUS EDULIS* IN THE GULF OF MAINE, 1992 (µG/G DRY WEIGHT: MEAN, AND STANDARD DEVIATION).

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
MASSACHUSETTS											
MASA1P	0	1.1	0.7	2.2	0.2	1	0.67	95	190	14	13.00
MASA2P	0	0.9	1.0	2.4	0.1	1	0.81	100	200	18	12.00
Mean		1.0	0.9	2.3	0.2	1	0.74	98	195	16	12.50
s		0.2	0.2	0.1	0.1	0	0.10	4	7	3	0.71
MANI1N	60	0.82	1.8	2.1	0.2	1.3	0.88	120	340	130	17.00
MANI2N	60	0.98	2.4	7.8	0.3	1.0	0.37	160	330	110	17.00
Mean		0.90	2.1	5.0	0.3	1.2	0.63	140	335	120	17.00
s		0.11	0.4	4.0	0.1	0.2	0.36	28	7	14	0.00
MANI1C	60	0.9	1.4	5.7	0.1	1	0.8	120	350	130	14.00
MANI2C	60	0.8	2.0	7.1	0.3	1	4.0	140	380	98	17.00
MANI3C	60	1.0	1.4	5.6	0.2	1	0.6	130	350	150	16.00
Mean		0.9	1.6	6.1	0.2	1	1.8	130	360	126	15.67
s		0.1	0.4	0.8	0.1	0	1.9	10	17	26	1.53
MASA1C	60	1.3	0.8	0.8	0.1	1	0.41	86	250	65	14.00
MASA2C	60	1.7	1.0	1.0	0.1	1	0.33	94	280	60	13.00
MASA3C	60	1.2	0.8	0.8	0.2	2	0.58	110	280	62	14.00
Mean		1.4	0.9	0.9	0.1	1	0.44	97	270	62	13.67
s		0.3	0.1	0.1	0.1	0	0.13	12	17	3	0.58

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
NEW HAMPSHIRE											
NHSI1C	0	2.4	4.4	4	0.6	3.2	0.11	190	760	410	11.00
NHSI2C	0	2.5	5.9	4	0.7	4.6	0.15	160	770	380	11.00
NHSI3C	0	2.3	5.1	5	0.5	3.8	0.15	150	750	430	12.00
Mean		2.4	5.1	5	0.6	3.9	0.14	167	760	407	11.33
s		0.1	0.8	1	0.1	0.7	0.02	21	10	25	0.58
NHSI1N	0	2.3	4.4	5.1	0.6	2.7	0.07	190	850	460	12.00
NHSI2N	0	1.4	5.7	6.1	0.6	3.1	0.06	190	690	360	13.00
NHSI3N	0	2.3	3.7	6.1	0.6	2.5	0.09	180	530	230	13.00
Mean		2.0	4.6	5.8	0.6	2.8	0.07	187	690	350	12.67
s		0.5	1.0	0.6	0.0	0.3	0.02	6	160	115	0.58
NHSI1C	60	2	4	3.5	0.5	2.8	0.14	150	640	350	12.00
NHSI2C	60	2	5	3.6	0.6	3.5	0.14	180	700	370	12.00
NHSI3C	60	2	4	3.2	0.6	3.0	0.10	160	720	340	11.00
Mean		2	4	3.4	0.6	3.1	0.13	163	687	353	11.67
s		0	0	0.2	0.1	0.4	0.02	15	42	15	0.58
NHSI1N	60	1.8	4.4	5.2	0.6	2.3	0.08	150	720	380	12.00
NHSI2N	60	2.5	5.3	6.6	0.7	3.4	0.08	180	820	410	11.00
NHSI3N	60	2.3	3.9	5.1	0.7	2.5	0.07	170	710	320	13.00
Mean		2.2	4.5	5.6	0.7	2.7	0.08	167	750	370	12.00
s		0.4	0.7	0.8	0.1	0.6	0.01	15	61	46	1.00

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
NHLH1N	0	2.6	3.7	5.5	0.7	2.9	0.03	170	500	210	11.00
NHLH2N	0	2.3	4.5	5.0	0.5	2.8	0.05	170	550	280	13.00
NHLH3N	0	2.4	8.2	6.1	0.6	4.3	0.06	220	530	200	12.00
Mean		2.4	5.5	5.5	0.6	3.3	0.05	187	527	230	12.00
s		0.2	2.4	0.6	0.1	0.8	0.02	29	25	44	1.00
NHLH1C	0	1.9	3.4	3.6	0.6	3.3	0.1	180	670	300	12.00
NHLH2C	0	1.8	2.9	3.6	0.6	2.9	0.1	150	640	340	13.00
NHLH3C	0	1.9	3.7	3.6	0.7	3.0	0.1	140	640	310	12.00
Mean		1.9	3.3	3.6	0.6	3.1	0.1	157	650	317	12.33
s		0.1	0.4	0.0	0.1	0.2	0.0	21	17	21	0.58
NHLH1N	60	1.5	3.8	4.1	0.5	2.9	0.06	300	530	340	13.00
NHLH2N	60	1.7	5.5	4.2	0.5	3.8	0.06	180	630	420	13.00
NHLH3N	60	1.6	3.3	4.4	0.5	2.6	0.06	170	470	270	13.00
Mean		1.6	4.2	4.2	0.5	3.1	0.06	217	543	343	13.00
s		0.1	1.5	0.2	0.0	0.6	0.00	72	81	75	0.00
NHLH1C	60	1.9	4.1	4.3	0.6	3.4	0.14	280	680	320	12.00
NHLH2C	60	1.8	3.5	3.8	0.7	3.2	0.10	160	710	330	13.00
NHLH3C	60	1.7	4.7	3.1	0.5	3.7	0.10	180	170	370	12.00
Mean		1.8	4.1	3.7	0.6	3.4	0.11	207	700	340	12.33
s		0.1	0.6	0.6	0.1	0.3	0.02	64	17	27	0.58

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
MAINE											
MEBC1P	0	1	1.2	0.3	0.1	1.5	0.02	92	220	73	15.00
MEBC2P	0	1	1.0	0.5	0.1	1.7	0.02	91	260	100	15.00
MEBC3P	0	1	0.9	0.5	0.2	1.8	0.02	84	230	67	15.00
Mean		1	1.0	0.4	0.1	1.7	0.02	89	237	80	15.00
s		0	0.2	0.1	0.1	0.2	0.00	4	21	18	0.00
MEKN1P	0	2.7	1	1	0.2	1.7	0.05	77	340	120	11.00
MEKN2P	0	1.9	1	1	0.1	1.6	0.06	79	290	120	12.00
MEKN3P	0	1.3	1	0	0.1	1.6	0.06	75	340	130	15.00
Mean		2.0	1	1	0.1	1.6	0.06	77	323	123	12.00
s		0.7	0	0	0.1	0.1	0.01	2	29	6	1.00
MEKN1N	30	2.2	1.6	0.7	0.2	1.7	0.04	73	280	130	6.70
MEKN2N	30	1.6	2.1	0.3	0.2	1.5	0.05	56	290	110	11.00
MEKN3N	30	1.6	3.8	1.0	0.1	2.1	0.05	65	300	120	9.40
Mean		1.8	2.5	0.7	0.2	1.8	0.05	65	290	120	9.03
s		0.4	1.2	0.4	0.1	0.3	0.01	9	10	10	2.17
MEKN1C	30	1.1	2.2	1	0.1	2.2	0.05	82	330	140	12.00
MEKN2C	30	1.1	2.1	1	0.1	2.1	0.06	82	370	250	12.00
MEKN3C	30	1.4	2.7	1	0.1	2.2	0.07	93	370	230	14.00
Mean		1.2	2.3	1	0.1	2.2	0.06	86	357	207	12.67
s		0.2	0.3	0	0.0	0.1	0.01	6	23	59	1.15

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
MESH1N	60	2.1	3.1	1.9	0.4	2	0.05	110	420	250	8.70
MESH2N	60	1.6	2.5	1.7	0.4	2	0.04	120	380	260	12.00
MESH3N	60	2.0	28.0	1.7	0.5	3	0.05	170	360	160	10.00
Mean		1.9	11.2	1.8	0.4	2	0.05	133	387	223	10.23
s		0.3	14.6	0.1	0.1	1	0.01	32	31	55	1.66
MEKN1C	60	1.3	2.3	0.9	0.2	1.5	0.07	68	240	100	13.00
MEKN2C	60	1.2	1.4	0.8	0.1	1.4	0.06	73	260	120	12.00
MEKN3C	60	1.4	19.0	1.6	0.1	3.3	0.05	81	270	95	13.00
Mean		1.3	7.6	1.1	0.1	2.1	0.06	74	257	105	12.67
s		0.1	9.9	0.4	0.1	1.1	0.01	7	15	13	0.58
MEKN1N	60	1.6	6.3	2	0.3	1	0.05	83	240	110	10.00
MEKN2N	60	1.6	11.0	2	0.2	2	0.07	74	250	100	13.00
MEKN3N	60	1.7	2.3	1	0.1	1	0.07	75	280	78	10.00
Mean		1.6	6.5	2	0.2	1	0.06	77	257	96	11.00
s		0.1	4.4	1	0.1	1	0.01	5	21	16	1.73
NEW BRUNSWICK											
NBH12N	0	1.5	1	0.3	0.1	1.7	0.27	66	270	90	17.00
NBH13N	0	1.6	1	0.3	0.1	1.7	0.29	66	270	110	17.00
Mean		1.6	1	0.3	0.1	1.7	0.28	66	270	100	17.00
s		0.1	0	0.0	0.0	0.0	0.01	0	0	14	0.00

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
NBMI1C	60	1.8	1	0.9	0	2.4	0.14	100	660	340	17.00
NBM12C	60	1.3	1	0.9	0	1.7	0.09	81	530	320	17.00
NBM13C	60	1.5	1	0.7	0	1.8	0.15	74	590	380	16.00
Mean		1.5	1	0.8	0	2.0	0.13	85	593	347	16.67
s		0.3	0	0.1	0	0.4	0.03	14	65	31	0.58
NBMI1N	60	1.5	6.2	0.7	0.2	5.4	0.04	120	1500	730	14.00
NBMI2N	60	1.6	13.0	2.3	0.3	8.3	0.04	140	1900	880	5.40
NBMI3N	60	1.5	11.0	1.5	0.2	6.1	0.04	120	2100	1100	5.70
Mean		1.5	10.1	1.5	0.2	6.6	0.04	127	1833	903	8.37
s		0.1	3.5	0.8	0.1	1.5	0.00	12	306	186	4.88
NBHI1N	60	2	0.7	0.4	0.2	1.8	0.13	91	370	150	13.00
NBH12N	60	2	0.5	0.7	0.2	1.0	0.10	81	330	130	14.00
NBH13N	60	2	0.8	0.7	0.2	1.7	0.14	95	460	200	14.00
Mean		2	0.7	0.6	0.2	1.5	0.12	89	387	160	13.67
s		0	0.2	0.2	0.0	0.4	0.02	7	67	36	0.58
NBHI1C	60	1.5	0.5	0.3	0.1	0.7	0.2	52	220	120	22.00
NBH12C	60	1.6	0.3	0.3	0.1	0.5	0.2	58	180	89	22.00
NBH13C	60	1.6	0.5	0.4	0.1	0.7	0.2	56	190	82	21.00
Mean		1.6	0.4	0.3	0.1	0.6	0.2	55	197	97	21.67
s		0.1	0.1	0.1	0.0	0.1	0.0	3	21	20	0.58

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
NOVA SCOTIA											
NSBC1P	0	2.4	2	1	0.2	3.1	0.03	110	540	170	10.00
NSBC2P	0	2.1	5	1	0.1	3.7	0.04	100	570	210	11.00
NSBC3P	0	2.3	31	2	0.2	5.7	0.04	140	620	190	12.00
Mean		2.3	13	1	0.2	4.2	0.04	117	577	190	11.00
s		0.2	16	1	0.1	1.4	0.01	21	40	20	1.00
NSBC1N	60	2.3	4	2.7	0.1	3.2	0.02	110	670	280	12.00
NSBC3N	60	1.7	4	2.0	0.1	3.0	0.02	84	510	350	13.00
Mean		2.0	4	2.4	0.1	3.1	0.02	97	590	315	12.50
s		0.4	0	0.5	0.0	0.1	0.00	18	113	50	0.71
NSBC1C	60	2	1.7	1.8	0.2	1.7	0.03	73	460	250	16.00
NSBC2C	60	2	15.0	2.0	0.1	2.9	0.03	85	480	200	17.00
NSBC3C	60	2	6.4	1.8	0.1	2.7	0.03	92	420	240	16.00
Mean		2	7.7	1.9	0.1	2.4	0.03	83	453	230	16.33
s		0	6.8	0.1	0.1	0.6	0.00	10	31	27	0.58
NSDI1C	60	1.4	2.4	1.6	0.1	2.6	0.03	69	610	290	19.00
NSD13C	60	1.2	1.7	1.6	0.0	2.2	0.03	62	600	390	18.00
Mean		1.3	2.1	1.6	0.1	2.4	0.03	66	605	340	18.50
s		0.1	0.5	0.0	0.0	0.3	0.00	5	7	71	0.71

Station	Days Deployed	Cd	Cr	Pb	Hg	Ni	Ag	Zn	Fe	Al	% Solids
NSDI1N	60	1	0.9	2.3	0.1	1	0.1	96	490	260	20.00
NSDI2N	60	1	11.0	2.3	0.0	3	0.3	180	450	190	19.00
NSDI3N	60	1	37.0	9.6	0.2	5	0.1	390	580	330	19.00
Mean		1	16.3	4.7	0.1	3	0.2	222	507	260	19.33
s		0	18.6	4.2	0.1	2	0.1	151	67	70	0.58
ADDITIONAL SAMPLES											
Machias Seal Island specimens were *Modiolus* sp. and therefore not comparable with rest of data set											
NSMS1N	0	11	11	2.8	0.2	11	0.35	860	370	250	16.00
NSMS2N	0	11	8	2.3	0.2	9	0.40	710	380	130	15.00
NSMS3N	0	12	5	2.3	0.3	11	0.42	720	690	240	15.00
Mean		11	8	2.5	0.2	10	0.39	763	480	207	15.33
s		1	3	0.3	0.1	1	0.04	84	182	67	0.58

APPENDIX D. TISSUE CONCENTRATIONS OF POLYAROMATIC HYDROCARBONS IN *MYTILUS EDULIS* (NG/G DRY WEIGHT).

PAHs	MASA(N)1 #10200	MASA(N)2 #10201	MASA(N)3 #10202	MASA(C)1 #10203	MASA(C)2 #10204	MASA(C)3 #10205	MANI(C)1 #10206
Naphthalene	<30	<30	<30	<30	<30/<30	<30	<30
2-Me naphthalene	<30	<30	<30	<30	<30/<30	<30	<30
1-Me naphthalene	<30	<30	<30	<30	<30/<30	<30	<30
Biphenyl	<20	<20	<20	<20	<20/<20	<20	<20
2,6-Dime naphthalen	<20	<20	<20	<20	<20/<20	<20	<20
Acenaphthylene	<10	<10	<10	<10	<10/<10	<10	<10
Acenaphthene	<10	<10	<10	<10	<10/<10	<10	<10
2,3,5-Trime naphthal	<20	<20	<20	<20	<20/<20	<20	24
Fluorene	<10	<10	<10	<10	<10/<10	<10	<10
Phenanthrene	<10	<10	<10	<10	<10/<10	<10	23
Anthracene	<10	<10	<10	<10	<10/<10	<10	<10
1-Me phenanthrene	<10	<10	<10	<10	<10/<10	<10	27
Fluoranthene	22	17	16	12	12/11	13	138
Pyrene	<10	<10	<10	<10	<10/<10	<10	113
Benzo(a)anthracene	<10	<10	<10	<10	<10/<10	<10	<10
Chrysene	<10	<10	<10	<10	<10/<10	<10	124
Benzo(b)fluoranthen	<10	<10	<10	<10	<10/<10	<10	82
Benzo(k)fluoranthen	<10	<10	<10	<10	<10/<10	<10	51
Benzo(e)pyrene	<10	<10	<10	<10	<10/<10	<10	57
Benzo(a)pyrene	<10	<10	<10	<10	<10/<10	<10	19
Perylene	<10	<10	<10	<10	<10/<10	<10	<10
Indeno(123cd)pyren	<10	<10	<10	<10	<10/<10	<10	14
Dibenzo(ah)anthrace	<10	<10	<10	<10	<10/<10	<10	<10
Benzo(ghi)perylene	<10	<10	<10	<10	<10/<10	<10	18
SURROGATE RECOVERY (%)							
Naph-d8	43	44	49	52	49/39	46	48
Anap-d10	52	64	58	65	64/64	61	65
Chry-d12	56	61	66	71	69/75	71	68
BaP-d12	57	59	67	72	71/80	74	73
BghiP-d12	63	72	74	81	79/83	77	77

PAHs	MANI(C)2 #10207	MANI(C)3 #10208	MANI(N)1 #10209	MANI(N)2 #10210	MANI(N)3 #10211	NHLH(P)1 #10212	NHLH(P)2 #10213
Naphthalene	<30/<30	<30	<30	<30	<30/<30	<30	<30
2-Me naphthalene	<30/<30	<30	<30	<30	<30/<30	<30	<30
1-Me naphthalene	<30/<30	<30	<30	<30	<30/<30	<30	<30
Biphenyl	<20/<20	<20	<20	<20	<20/<20	<20	<20
2,6-Dime naphthalen	<20/<20	<20	<20	<20	<20/<20	<20	<20
Acenaphthylene	<10/<10	<10	<10	<10	<10/<10	<10	<10
Acenaphthene	<10/<10	<10	<10	<10	<10/<10	<10	<10
2,3,5-Trime naphthal	26/33	32	<20	25	25/<20	<20	<20
Fluorene	<10/<10	<10	<10	<10	<10/<10	<10	<10
Phenanthrene	22/22	26	15	16	16/15	<10	<10
Anthracene	<10/25	19	<10	<10	<10/<10	<10	<10
1-Me phenanthrene	22/24	24	21	<10	17/<10	<10	<10
Fluoranthene	118/130	141	94	85	80/86	39	35
Pyrene	89/100	105	65	57	56/60	30	26
Benzo(a)anthracene	100/106	118	66	63	64/64	16	14
Chrysene	96/102	113	62	59	60/60	27	23
Benzo(b)fluoranthen	60/66	72	36	34	40/38	26	22
Benzo(k)fluoranthen	38/41	45	23	22	26/25	12	10
Benzo(e)pyrene	48/52	50	32	30	28/29	18	18
Benzo(a)pyrene	<10/17	18	<10	<10	<10/<10	<10	<10
Perylene	<10/<10	<10	<10	<10	<10/<10	<10	<10
Indeno(123cd)pyren	<10/14	<10	<10	<10	<10/<10	12	<10
Dibenzo(ah)anthrace	<10/<10	<10	<10	<10	<10/<10	<10	<10
Benzo(ghi)perylene	16/17	19	<10	<10	<10/<10	14	12
SURROGATE RECOVERY (%)							
Naph-d8	39/41	37	21	31	32/30	37	56
Anap-d10	63/64	60	39	53	47/40	66	67
Chry-d12	66/74	66	49	62	59/76	79	80
BaP-d12	66/76	70	47	61	61/81	83	83
BghiP-d12	69/72	63	48	61	57/76	85	87

PAHs	NHLH(P)3 #10214	NHSI(P)1 #10215	NHSI(P)2 #10216	NHSI(P)3 #10217	NHOP(P)1 #10218	NHOP(P)2 #10219	NHOP(P)3 #10220
Naphthalene	<30/<30	45	39	39/34	39	46	71
2-Me naphthalene	<30/<30	37	31	37/32	<30	32	40
1-Me naphthalene	<30/<30	<30	<30	<30/<30	<30	<30	<30
Biphenyl	<20/<20	<20	<20	<20/<20	<20	<20	<20
2,6-Dime naphthalen	<20/<20	20	<20	<20/<20	<20	<20	<20
Acenaphthylene	<10/<10	<10	<10	<10/<10	<10	<10	<10
Acenaphthene	<10/<10	<10	<10	<10/<10	<10	<10	<10
2,3,5-Trime naphthal	<20/<20	<20	<20	<20/<20	<20	<20	<20
Fluorene	<10/<10	<10	<10	<10/<10	<10	<10	<10
Phenanthrene	<10/<10	11	<10	10<10	<10	<10	<10
Anthracene	<10/<10	<10	<10	<10/<10	<10	<10	<10
1-Me phenanthrene	<10/<10	15	<10	16/17	<10	<10	<10
Fluoranthene	34/32	50	41	60/54	20	21	20
Pyrene	27/25	45	37	56/51	14	15	20
Benzo(a)anthracene	15/14	21	19	30/27	<10	<10	<10
Chrysene	25/23	34	30	46/42	<10	<10	<10
Benzo(b)fluoranthen	24/23	36	36	67/57	<10	<10	<10
Benzo(k)fluoranthen	11-<10	15	18	33/18	<10	<10	<10
Benzo(e)pyrene	18/16	28	25	38/36	<10	<10	<10
Benzo(a)pyrene	<10/<10	<10	<10	13/<10	<10	<10	<10
Perylene	<10/<10	<10	<10	<10/<10	<10	<10	<10
Indeno(123cd)pyren	12/<10	15	13	16/14	<10	<10	<10
Dibenzo(ah)anthrace	<10/<10	<10	<10	<10/<10	<10	<10	<10
Benzo(ghi)perylene	13/12	19	15	18/16	<10	<10	<10
		SURROGATE RECOVERY (%)					
Naph-d8	48/46	44	48	53/48	46	51	46
Anap-d10	63/61	61	64	65/62	64	62	60
Chry-d12	77/77	74	74	77/77	73	68	66
BaP-d12	82/83	79	83	85/83	77	73	68
BghiP-d12	84/84	80	83	90/91	80	85	74

PAHs	NHOP(P)4 #10221	NHOP(P)5 #10222	NHOP(P)6 #10223	MEKN(C)1 #10224	MEKN(C)2 #10225	MEKN(C)3 #10226	MEKN(N)1 #10227
Naphthalene	63	79	42/56	<30	<30	<30	<30/<30
2-Me naphthalene	42	52	<30/37	<30	<30	<30	<30/<30
1-Me naphthalene	<30	<30	<30/<30	<30	<30	<30	<30/<30
Biphenyl	<20	<20	<20/<20	<20	<20	<20	<20/<20
2,6-Dime naphthalen	<20	<20	<20/<20	<20	<20	<20	<20/<20
Acenaphthylene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Acenaphthene	<10	<10	<10/<10	<10	<10	<10	<10/<10
2,3,5-Trime naphthal	<20	<20	<20/<20	<20	<20	<20	<20/<20
Fluorene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Phenanthrene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Anthracene	<10	<10	<10/<10	<10	<10	<10	<10/<10
1-Me phenanthrene	<10	18	<10/<10	<10	<10	<10	<10/<10
Fluoranthene	17	24	19/21	13	20	15	16/18
Pyrene	<10	18	<10/17	18	27	20	21/24
Benzo(a)anthracene	<10	<10	<10/<10	<10	<10	<10	<10/15
Chrysene	<10	14	<10/<10	20	24	21	22/25
Benzo(b)fluoranthen	<10	15	<10/<10	17	21	20	19/27
Benzo(k)fluoranthen	<10	<10	<10/<10	<10	<10	11	<10/14
Benzo(e)pyrene	<10	<10	<10/<10	15	19	17	19/19
Benzo(a)pyrene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Perylene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Indeno(123cd)pyren	<10	<10	<10/<10	<10	<10	<10	<10/<10
Dibenzo(ah)anthrace	<10	<10	<10/<10	<10	<10	<10	<10/<10
Benzo(ghi)perylene	<10	<10	<10/<10	<10	<10	<10	<10/<10
SURROGATE RECOVERY (%)							
Naph-d8	46	47	36/41	46	42	43	44/44
Anap-d10	62	64	54/58	63	61	63	61/65
Chry-d12	71	73	66/68	69	72	72	70/75
BaP-d12	75	78	71/69	76	82	80	77/81
BghiP-d12	79	82	78/76	77	76	85	75/86

PAHs	MEKN(N)2 #10228	MEKN(N)3 #10229	MESH(N)1 #10230	MESH(N)2 #10231	MESH(N)3 #10232	MEKN(P)1 #10233	MEKN(P)2 #10234
Naphthalene	<30	<30	<30	<30	<30/<30	<30	<30
2-Me naphthalene	<30	<30	<30	<30	<30/<30	<30	<30
1-Me naphthalene	<30	<30	<30	<30	<30/<30	<30	<30
Biphenyl	<20	<20	<20	<20	<20/<20	<20	<20
2,6-Dime naphthalen	<20	<20	<20	<20	<20/<20	<20	<20
Acenaphthylene	<10	<10	<10	<10	<10/<10	<10	<10
Acenaphthene	<10	<10	<10	<10	<10/<10	<10	<10
2,3,5-Trime naphthal	<20	<20	<20	<20	<20/<20	<20	<20
Fluorene	<10	<10	<10	<10	<10/<10	<10	<10
Phenanthrene	<10	<10	<10	<10	<10/<10	<10	<10
Anthracene	<10	<10	<10	<10	<10/<10	<10	<10
1-Me phenanthrene	<10	<10	<10	<10	<10/<10	<10	<10
Fluoranthene	13	11	17	14	21/24	23	28
Pyrene	15	12	17	12	23/24	27	31
Benzo(a)anthracene	<10	<10	16	<10	16/19	<10	<10
Chrysene	22	25	29	25	32/38	26	22
Benzo(b)fluoranthen	16	17	43	23	45/52	19	22
Benzo(k)fluoranthen	10	10	25	14	28/30	11	13
Benzo(e)pyrene	15	15	27	21	25/28	16	17
Benzo(a)pyrene	<10	<10	14	<10	13/16	<10	<10
Perylene	<10	<10	13	<10	13/19	<10	<10
Indeno(123cd)pyren	<10	<10	13	<10	13/19	<10	<10
Dibenzo(ah)anthrace	<10	<10	<10	<10	<10/<10	<10	<10
Benzo(ghi)perylene	<10	<10	17	<10	15/20	<10	<10
SURROGATE RECOVERY (%)							
Naph-d8	44	41	31	26	60/40	39	38
Anap-d10	64	63	54	41	86/62	60	53
Chry-d12	71	72	67	55	98/74	68	60
BaP-d12	77	80	74	57	104/80	68	62
BghiP-d12	74	90	79	60	120/76	79	68

PAHs	NBSI(N) #10073	NBSI(N) #10074	NBSI(N) #10075	NBHI(P) #10093	NBHI(P) #10094	NBHI(P) #10095	NBHI(N) #10103
Naphthalene	<30	<30	<30	<30/<30	<30	<30	<30
2-Me naphthalene	<30	<30	<30	<30/<30	<30	<30	<30
1-Me naphthalene	<30	<30	<30	<30/<30	<30	<30	<30
Biphenyl	<20	<20	<20	<20/<20	<20	<20	<20
2,6-Dime naphthalen	<20	<20	<20	<20/<20	<20	<20	<20
Acenaphthylene	<10	<10	<10	<10/<10	<10	<10	<10
Acenaphthene	<10	<10	<10	<10/<10	<10	<10	<10
2,3,5-Trime naphthal	<20	<20	<20	<20/<20	<20	<20	<20
Fluorene	<10	<10	<10	<10/<10	<10	<10	<10
Phenanthrene	<10	<10	<10	<10/<10	<10	<10	<10
Anthracene	<10	<10	<10	<10/<10	<10	<10	<10
1-Me phenanthrene	<10	<10	<10	<10/<10	<10	<10	<10
Fluoranthene	<10	<10	<10	<10/<10	<10	<10	<10
Pyrene	<10	<10	<10	<10/<10	<10	<10	<10
Benzo(a)anthracene	<10	<10	<10	<10/<10	<10	<10	<10
Chrysene	<10	<10	<10	<10/<10	<10	<10	<10
Benzo(b)fluoranthen	<10	<10	<10	<10/<10	<10	<10	<10
Benzo(k)fluoranthen	<10	<10	<10	<10/<10	<10	<10	<10
Benzo(e)pyrene	<10	<10	<10	<10/<10	<10	<10	<10
Benzo(a)pyrene	<10	<10	<10	<10/<10	<10	<10	<10
Perylene	<10	<10	<10	<10/<10	<10	<10	<10
Indeno(123cd)pyren	<10	<10	<10	<10/<10	<10	<10	<10
Dibenzo(ah)anthrace	<10	<10	<10	<10/<10	<10	<10	<10
Benzo(ghi)perylene	<10	<10	<10	<10/<10	<10	<10	<10
SURROGATE RECOVERY (%)							
Naph-d8	44	36	33	33/31	33	32	32
Anap-d10	60	59	62	58/57	60	59	57
Chry-d12	67	71	74	68/68	67	71	73
BaP-d12	67	64	69	64/63	63	64	66
BghiP-d12	71	77	77	76/73	71	90	89

PAHs	NBHI(N) #10104	NBHI(N) #10105	NBHI(C) #10116	NBHI(C) #10117	NBHI(C) #10118	NSBC(N) #10131	NSBC(N) #10132
Naphthalene	<30/<30	<30	<30	<30	<30	<30	<30
2-Me naphthalene	<30/<30	<30	<30	<30	<30	<30	<30
1-Me naphthalene	<30/<30	<30	<30	<30	<30	<30	<30
Biphenyl	<20/<20	<20	<20	<20	<20	<20	<20
2,6-Dime naphthalen	<20/<20	<20	<20	<20	<20	<20	23
Acenaphthylene	<10/<10	<10	<10	<10	<10	<10	<10
Acenaphthene	<10/<10	<10	<10	<10	<10	<10	<10
2,3,5-Trime naphthal	<20/<20	<20	<20	<20	<20	24	21
Fluorene	<10/<10	<10	<10	<10	<10	18	17
Phenanthrene	<10/<10	<10	<10	<10	<10	51	46
Anthracene	<10/<10	<10	<10	<10	<10	19	20
1-Me phenanthrene	<10/<10	<10	<10	<10	<10	18	16
Fluoranthene	<10/<10	<10	<10	<10	<10	85	79
Pyrene	<10/<10	<10	<10	<10	<10	66	61
Benzo(a)anthracene	<10/<10	<10	<10	<10	<10	21	18
Chrysene	<10/<10	<10	<10	<10	<10	41	37
Benzo(b)fluoranthen	<10/<10	<10	<10	<10	<10	23	19
Benzo(k)fluoranthen	<10/<10	<10	<10	<10	<10	16	14
Benzo(e)pyrene	<10/<10	<10	<10	<10	<10	20	17
Benzo(a)pyrene	<10/<10	<10	<10	<10	<10	<10	<10
Perylene	<10/<10	<10	<10	<10	<10	<10	<10
Indeno(123cd)pyren	<10/<10	<10	<10	<10	<10	<10	<10
Dibenzo(ah)anthrace	<10/<10	<10	<10	<10	<10	<10	<10
Benzo(ghi)perylene	<10/<10	<10	<10	<10	<10	<10	<10
SURROGATE RECOVERY (%)							
Naph-d8	30/29	40	38	33	34	38	44
Anap-d10	56/51	64	57	56	58	57	59
Chry-d12	66/67	71	73	57	69	65	74
BaP-d12	62/58	68	65	56	63	64	72
BghiP-d12	83/72	95	92	82	81	91	82

PAHs	NSBC(N) #10133	NSDI(N) #10137	NSDI(N) #10138	NSDI(N) #10139	NSBC(C) #10146	NSBC(C) #10147	NSBCC #10148
Naphthalene	<30/<30	<30	<30	<30	<30/<30	<30	<30
2-Me naphthalene	<30/<30	<30	<30	<30	<30/<30	<30	<30
1-Me naphthalene	<30/<30	<30	<30	<30	<30/<30	<30	<30
Biphenyl	<20/<20	<20	<20	<20	<20/<20	<20	<20
2,6-Dime naphthalen	<20/<20	38	23	26	<20/<20	<20	<20
Acenaphthylene	<10/<10	<10	<10	<10	<10/<10	<10	<10
Acenaphthene	<10/<10	<10	<10	<10	<10/<10	<10	<10
2,3,5-Trime naphthal	24/21	52	44	35	<20/<20	<20	<20
Fluorene	18/18	<10	<10	16	<10/<10	<10	<10
Phenanthrene	66/63	47	41	39	31/18	<10	21
Anthracene	27/19	19	<10	<10	<10/<10	<10	<10
1-Me phenanthrene	17/17	35	30	25	<10/<10	<10	<10
Fluoranthene	92/82	69	64	67	36/21	20	23
Pyrene	65/59	33	31	32	<10/<10	<10	<10
Benzo(a)anthracene	19/19	<10	<10	<10	<10/<10	<10	<10
Chrysene	35/31	27	21	21	<10/<10	<10	<10
Benzo(b)fluoranthen	20/20	<10	<10	<10	<10/<10	<10	<10
Benzo(k)fluoranthen	14/12.	<10	<10	<10	<10/<10	<10	<10
Benzo(e)pyrene	18/16	<10	<10	<10	<10/<10	<10	<10
Benzo(a)pyrene	<10/<10	<10	<10	<10	<10/<10	<10	<10
Perylene	<10/<10	<10	<10	<10	<10/<10	<10	<10
Indeno(123cd)pyren	<10/<10	<10	<10	<10	<10/<10	<10	<10
Dibenzo(ah)anthrace	<10/<10	<10	<10	<10	<10/<10	<10	<10
Benzo(ghi)perylene	<10/<10	<10	<10	<10	<10/<10	<10	<10
SURROGATE RECOVERY (%)							
Naph-d8	50/47	40	42	54	56/53	36	38
Anap-d10	73/70	59	60	67	64/71	58	43
Chry-d12	72/65	66	65	70	42/75	58	48
BaP-d12	67/63	67	65	69	34/71	51	38
BghiP-d12	77/83	75	69	91	68/103	71	70

PAHs	NSDI(C) #10152	NSDI(C) #10153	NSDI(C) #10154	NBMI(N) #10083	NBMI(N) #10084	NBMI(N) #10085	NBMI(C) #10122
Naphthalene	<30	35	<30/36	<30	<30	<30	<30/<30
2-Me naphthalene	<30	<30	<30/30	<30	<30	<30	<30/<30
1-Me naphthalene	<30	<30	<30/<30	<30	<30	<30	<30/<30
Biphenyl	<20	<20	<20/<20	<20	<20	<20	<20/<20
2,6-Dime naphthalen	<20	<20	<20/<20	<20	<20	<20	<20/<20
Acenaphthylene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Acenaphthene	<10	<10	<10/<10	<10	<10	<10	<10/<10
2,3,5-Trime naphthal	<20	<20	<20/<20	<20	<20	<20	<20/<20
Fluorene	<10	<10	<10/20	15	<10	<10	<10/<10
Phenanthrene	29	28	17/30	34	<10	<10	<10/<10
Anthracene	<10	<10	<10/<10	17	<10	<10	<10/<10
1-Me phenanthrene	<10	<10	<10/<10	13	<10	<10	<10/<10
Fluoranthene	29	26	20/31	30	<10	<10	<10/<10
Pyrene	41	<10	<10/17	29	14	13	<10/<10
Benzo(a)anthracene	<10	<10	<10/<10	21	<10	<10	<10/<10
Chrysene	28	<10	<10/16	26	15	<10	<10/<10
Benzo(b)fluoranthen	<10	<10	<10/<10	33	21	16	<10/<10
Benzo(k)fluoranthen	<10	<10	<10/<10	22	13	10	<10/<10
Benzo(e)pyrene	27	<10	<10/<10	12	<10	<10	<10/<10
Benzo(a)pyrene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Perylene	<10	<10	<10/<10	<10	<10	<10	<10/<10
Indeno(123cd)pyren	<10	<10	<10/<10	<10	<10	<10	<10/<10
Dibenzo(ah)anthrace	<10	<10	<10/<10	<10	<10	<10	<10/<10
Benzo(ghi)perylene	41	<10	<10/<10	<10	<10	<10	<10/<10
SURROGATE RECOVERY (%)							
Naph-d8	38	76	60/55	41	38	37	37/40
Anap-d10	52	71	73/65	70	64	63	63/57
Chry-d12	64	51	73/71	83	83	81	81/74
BaP-d12	53	42	56/63	87	88	84	75/76
BghiP-d12	83	108	109/82	92	94	90	101/97

PAHs	NBMI(C) #10123	NBMI(C) #10124					
Naphthalene	<30	<30					
2-Me naphthalene	<30	<30					
1-Me naphthalene	<30	<30					
Biphenyl	<20	<20					
2,6-Dime naphthalen	<20	<20					
Acenaphthylene	<10	<10					
Acenaphthene	<10	<10					
2,3,5-Trime naphthal	<20	<20					
Fluorene	<10	<10					
Phenanthrene	<10	<10					
Anthracene	<10	<10					
1-Me phenanthrene	<10	<10					
Fluoranthene	<10	<10					
Pyrene	<10	<10					
Benzo(a)anthracene	<10	<10					
Chrysene	<10	<10					
Benzo(b)fluoranthen	<10	<10					
Benzo(k)fluoranthen	<10	<10					
Benzo(e)pyrene	<10	<10					
Benzo(a)pyrene	<10	<10					
Perylene	<10	<10					
Indeno(123cd)pyren	<10	<10					
Dibenzo(ah)anthrace	<10	<10					
Benzo(ghi)perylene	<10	<10					
SURROGATE RECOVERY (%)							
Naph-d8	39	44					
Anap-d10	57	64					
Chry-d12	64	74					
BaP-d12	67	77					
BghiP-d12	83	89					

APPENDIX E. TISSUE CONCENTRATIONS OF POLYCHLORINATED BIPHENYLS IN *MYTILUS EDULIS* (NG/G DRY WEIGHT).

Congener No.	MASA(N)1 #10200	MASA(N)2 #10201	MASA(N)3 #10202	MASA(C)1 #10203	MASA(C)2 #10204	MASA(C)3 #10205	MANI(C)1 #10206
8 ; 5	<2	<2	<2	<2	<2 <2	<2	9.9
18 ; 15	<2	<2	<2	<2	<2 <2	<2	2
28 ;	<2	<2	<2	<2	<2 <2	<2	5.5
29 ;	<2	<2	<2	<2	<2 <2	<2	2.1
44 ;	<2	<2	<2	<2	<2 <2	<2	8.2
50 ;	<2	<2	<2	<2	<2 <2	<2	<2
52 ;	<2	<2	<2	<2	<2 <2	<2	14
66 ; 95	6.4	6.5	5.5	6.8	5.6/6.5	7.1	35
77 ;	3.4	2.9	2	3.8	3.1/3.3	4.1	35
87 ;	<2	<2	<2	2.7	<2 <2	<2	18
101 ; 90	6.3	5.9	5.1	7.5	5.7/6.8	7.3	44
105 ;	5.5	5.3	4.5	5.5	5.0/<2	<2	26
118 ;	12	9.8	9.1	13	11/10	12	59
126 ;	<2	<2	<2	<2	<2/<2	<2	<2
128 ;	4.2	3.6	2.2	4.1	3.9/3.8	4.5	17
138 ;	16	14	13	17	14/14	17	71
153 ; 132	19	17	16	21	17/19	20	69
169 ;	<2	<2	<2	<2	<2 <2	<2	3.2
170 ; 190	<2	<2	<2	<2	<2 <2	<2	14
180 ;	<2	<2	<2	<2	<2 <2	<2	20
187 ;	4.7	4.2	4	5.6	4.1/5.3	5.5	<2
195 ; 208	<2	<2	<2	<2	<2 <2	<2	<2
206 ;	<2	<2	<2	<2	<2 <2	<2	<2
209 ;	<2	<2	<2	<2	<2 <2	<2	<2
Surrogate Recovery	81%	70	53	83	83/67	86	90

Congener No.	MANI(C)2 #10207	MANI(C)3 #10208	MANI(N)1 #10209	MANI(N)2 #10210	MANI(N)3 #10211	NHLH(P)1 #10212	NHLH(P)2 #10213
8 ; 5	4.2/5.6	9	3.3	3.6	3.4	<2	<2
18 ; 15	<2/<2	<2	<2	<2	<2	<2	<2
28 ;	5.4/7.1	4.6	2.7	3.5	4.9	<2	<2
29 ;	2.4/2.7	<2	<2	<2	<2	<2	<2
44 ;	6.4/9	6.8	3.9	4.9	7.7	<2	<2
50 ;	<2/<2	<2	<2	<2	<2	<2	<2
52 ;	13/17	11	7.5	9.9	15	<2	<2
66 ; 95	31/40	27	21	27	38	5.8	4.5
77 ;	27/37	26	18	25	37	3	<2
87 ;	14/19	13	9.9	13	19	<2	<2
101 ; 90	41/52	33	27	35	50	5.5	4.7
105 ;	19/25	19	15	20	27	<2	<2
118 ;	49/63	43	37	48	65	8.2	6.9
126 ;	<2/<2	<2	<2	<2	<2	<2	<2
128 ;	12/17	12	9.4	13	18	3	<2
138 ;	61/80	50	43	59	83	12	9.9
153 ; 132	62/81	49	43	59	83	14	12
169 ;	<2	<2	<2	<2	<2	<2	<2
170 ; 190	3/4	2.6	<2	<2	2.3	<2	<2
180 ;	13/17	10	4.5	6.3	9.7	<2	<2
187 ;	19/25	14	11	16	23	4.1	3.5
195 ; 208	<2/<2	<2	<2	<2	<2	<2	<2
206 ;	<2/<2	<2	<2	<2	<2	<2	<2
209 ;	<2/<2	<2	<2	<2	<2	<2	<2
Surrogate Recovery	85%102%	74	58	78	73/115	70	48

Congener No.	NHLH(P)3 #10214	NHSI(N)1 #10215	NHSI(N)2 #10216	NHSI(N)3 #10217	NHOP(P)1 #10218	NHOP(P)2 #10219	NHOP(P)3 #10220
8 ; 5	<2/<2	<2	<2	<2/<2	<2	<2	<2
18 ; 15	<2/<2	<2	<2	<2/<2	<2	<2	<2
28 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
29 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
44 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
50 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
52 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
66 ; 95	5.1/4.7	6.4	4.9	7.2/6.4	3.6	3.7	3.9
77 ;	2.7/2.4	4.4	3.5	5.2/4.5	3	<2	<2
87 ;	<2/<2	2.7	2	3.1/2.7	<2	<2	<2
101 ; 90	4.4/3.9	6.8	5.1	9.3/7.9	2.6	2.6	2
105 ;	<2/<2	<2	<2	<2/<2	4.3	3.9	3.9
118 ;	7.6/7.2	11	8.4	14/12	6.4	6.2	5.2
126 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
128 ;	2.9/2.4	4.1	3.4	4.4/4.1	2.2	<2	<2
138 ;	11/9.3	15	12	20/17	7.3	6.7	5.7
153 ; 132	12/11	17	14	23/19	8.2	8.1	6.2
169 ;	<2	<2	<2	<2	<2	<2	<2
170 ; 190	<2/<2	<2	<2	<2/<2	<2	<2	<2
180 ;	<2/<2	2.4	<2	2.7/2.6	<2	<2	<2
187 ;	3.2/2.9	4.8	4	6.8/5.8	2.2	2.3	<2
195 ; 208	<2/<2	<2	<2	<2/<2	<2	<2	<2
206 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
209 ;	<2/<2	<2	<2	<2/<2	<2	<2	<2
Surrogate Recovery	76%/75%	87	86	73/70	87	62	77

Congener No.	NHOP(P)4 #10221	NHOP(P)5 #10222	NHOP(P)6 #10223	MEKN(C)1 #10224	MEKN(C)2 #10225	MEKN(C)3 #10226	MEKN(N)1 #10227
8 ; 5	<2	<2	<2/<2	<2	<2	<2	<2/<2
18 ; 15	<2	<2	<2/<2	<2	<2	<2	<2/<2
28 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
29 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
44 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
50 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
52 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
66 ; 95	3.1	5.3	3.7/4.1	<2	<2	<2	<2/<2
77 ;	<2	2.1	<2/<2	2	3.3	2.9	2.4/2.9
87 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
101 ; 90	<2	3.2	2/2.3	3.6	5.9	5.3	5.6/6.2
105 ;	3.9	5.1	<2/<2	<2	<2	<2	<2/<2
118 ;	5	7.4	5.4/5.6	4.7	6.8	6.1	6.9/7.1
126 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
128 ;	<2	2.4	<2/<2	<2	2.5	2.1	<2/2.3
138 ;	5.6	8.1	5.7/5.9	7.3	12	10	12/13
153 ; 132	6.3	9.2	6.3/7	9.3	15	13	16/17
169 ;	<2	<2	<2	<2	<2	<2	<2
170 ; 190	<2	<2	<2/<2	<2	<2	<2	<2/<2
180 ;	<2	<2	<2/<2	2.9	4.3	4.4	4.9/5.2
187 ;	<2	2.5	<2/2	2.8	5.2	4.4	5.7/6.4
195 ; 208	<2	<2	<2/<2	<2	<2	<2	<2/<2
206 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
209 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
Surrogate Recovery	85%	91	78/82	89	94	103	74/85

Congener No.	MEKN(N)3 #10228	MEKN(N)3 #10229	MESH(N)1 #10230	MESH(N)2 #10231	MESH(N)3 #10232	MEKN(P)1 #10233	MEKN(P)2 #10234
8 ; 5	<2	<2	<2	4.8	<2/<2	<2	<2
18 ; 15	<2	<2	<2	<2	<2/<2	<2	<2
28 ;	<2	<2	<2	<2	<2/<2	<2	<2
29 ;	<2	<2	<2	<2	<2/<2	<2	<2
44 ;	<2	<2	<2	<2	<2/<2	<2	<2
50 ;	<2	<2	<2	<2	<2/<2	<2	<2
52 ;	<2	<2	<2	<2	<2/<2	<2	<2
66 ; 95	<2	<2	<2	<2	<2/<2	<2	<2
77 ;	2.7	2.1	2.9	<2	<2/<2	2.2	2.3
87 ;	<2	<2	<2	<2	<2/<2	<2	<2
101 ; 90	6.1	4.3	5.4	3.4	6.1/6.7	3.8	4.5
105 ;	<2	<2	<2	<2	<2/<2	<2	<2
118 ;	6.9	6.1	8.3	6	8.4/9.5	4.9	6
126 ;	<2	<2	<2	<2	<2/<2	<2	<2
128 ;	2.2	<2	23	<2	2.8/3.4	<2	<2
138 ;	12	9.5	14	8.7	14/16	7.8	10
153 ; 132	17	13	19	11	19/21	9.8	14
169 ;	<2	<2	<2	<2	<2	<2	<2
170 ; 190	<2	<2	<2	<2	<2/<2	<2	<2
180 ;	4.8	3.9	4.2	3.1	3.9/4.5	3.2	4
187 ;	6.2	4.2	7.2	3.7	7.2/8.1	3	4.5
195 ; 208	<2	<2	<2	<2	<2/<2	<2	<2
206 ;	<2	<2	<2	<2	<2/<2	<2	<2
209 ;	<2	<2	<2	<2	<2/<2	<2	<2
Surrogate Recovery	89%	87	83	56	89/89	83	71

Congener No.	NBSI(N) #10073	NBSI(N) #10074	NBSI(N) #10075	NBHI(P) #10093	NBHI(P) #10094	NBHI(P) #10095	NBHI(N) #10103
8 ; 5	<2	<2	<2	<2/<2	<2	<2	<2
18 ; 15	<2	<2	<2	<2/<2	<2	<2	<2
28 ;	<2	<2	<2	<2/<2	<2	<2	<2
29 ;	<2	<2	<2	<2/<2	<2	<2	<2
44 ;	<2	<2	<2	<2/<2	<2	<2	<2
50 ;	<2	<2	<2	<2/<2	<2	<2	<2
52 ;	<2	<2	<2	<2/<2	<2	<2	<2
66 ; 95	2.6	2.6	2.4	3/4.2	3	3.1	2.7
77 ;	<2	<2	<2	<2/<2	<2	<2	<2
87 ;	<2	<2	<2	<2/<2	<2	<2	<2
101 ; 90	<2	<2	<2	<2/<2	<2	<2	<2
105 ;	2.8	<2	<2	<2/<2	<2	<2	<2
118 ;	3.7	2.3	<2	<2/<2	<2	2.5	<2
126 ;	<2	<2	<2	<2/<2	<2	<2	<2
128 ;	<2	<2	<2	<2/<2	<2	<2	<2
138 ;	4.3	3	2.3	2.3/2.4	2.5	3.1	<2
153 ; 132	5.8	3.6	2.7	2.3/2.4	2.5	3.2	<2
169 ;	<2	<2	<2	<2/<2	<2	<2	<2
170 ; 190	<2	<2	<2	<2/<2	<2	<2	<2
180 ;	<2	<2	<2	<2/<2	<2	<2	<2
187 ;	<2	<2	<2	<2/<2	<2	<2	<2
195 ; 208	<2	<2	<2	<2/<2	<2	<2	<2
206 ;	<2	<2	<2	<2/<2	<2	<2	<2
209 ;	<2	<2	<2	<2/<2	<2	<2	<2
Surrogate	88%	48	44	38/45	48%	58	32
Recovery							

Congener No.	NBHI(N) #10104	NBHI(N) #10105	NBHI(C) #10116	NBHI(C) #10117	NBHI(C) #10118	NSBC(N) #10131	NSBC(N) #10132
8 ; 5	<2/<2	<2	<2	<2	<2	<2	<2
18 ; 15	<2/<2	<2	<2	<2	<2	<2	<2
28 ;	<2/<2	<2	<2	<2	<2	<2	<2
29 ;	<2/<2	<2	<2	<2	<2	<2	<2
44 ;	<2/<2	<2	<2	<2	<2	<2	<2
50 ;	<2/<2	<2	<2	<2	<2	<2	<2
52 ;	<2/<2	<2	<2	<2	<2	<2	<2
66 ; 95	4.3/3.6	3.6	2.7	2.6	2.5	3.8	3.3
77 ;	<2/<2	<2	<2	<2	<2	<2	<2
87 ;	<2/<2	<2	<2	<2	<2	<2	<2
101 ; 90	<2/<2	<2	<2	<2	<2	<2	<2
105 ;	<2/<2	<2	<2	<2	<2	<2	<2
118 ;	<2/<2	2.1	2.2	2	<2	2.8	3.4
126 ;	<2/<2	<2	<2	<2	<2	<2	<2
128 ;	<2/<2	<2	<2	<2	<2	<2	<2
138 ;	<2/<2	2.5	2.5	2.4	2.2	3.2	3.6
153 ; 132	2.1/<2	2.9	3	2.7	2.5	3.6	4.4
169 ;	<2/<2	<2	<2	<2	<2	<2	<2
170 ; 190	<2/<2	<2	<2	<2	<2	<2	<2
180 ;	<2/<2	<2	<2	<2	<2	<2	<2
187 ;	<2/<2	<2	<2	<2	<2	<2	<2
195 ; 208	<2/<2	<2	<2	<2	<2	<2	<2
206 ;	<2/<2	<2	<2	<2	<2	<2	<2
209 ;	<2/<2	<2	<2	<2	<2	<2	<2
Surrogate	44/41	58	49	54	53%	51	52
Recovery							

Congener No.	NSBC(N) #10133	NSDI(N) #10137	NSDI(N) #10138	NSDI(N) #10139	NSBC(C) #10146	NSBC(C) #10147	NSBC(C) #10148
8 ; 5	<2/<2	<2	<2	<2	<2/<2	<2	<2
18 ; 15	<2/<2	<2	<2	<2	<2/<2	<2	<2
28 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
29 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
44 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
50 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
52 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
66 ; 95	3.2/3.3	3.5	3.1	3.2	2.8/2.6	2.4	2.8
77 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
87 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
101 ; 90	<2/<2	2.1	<2	<2	<2/<2	<2	<2
105 ;	3/<2	3	<2	3	<2/<2	<2	<2
118 ;	3.3/2.5	4	3.5	3.5	<2/<2	<2	<2
126 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
128 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
138 ;	3.3/2.7	4.1	3.6	3.4	<2/<2	<2	<2
153 ; 132	4/3.1	4.3	3.8	3	<2/<2	<2	<2
169 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
170 ; 190	<2/<2	<2	<2	<2	<2/<2	<2	<2
180 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
187 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
195 ; 208	<2/<2	<2	<2	<2	<2/<2	<2	<2
206 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
209 ;	<2/<2	<2	<2	<2	<2/<2	<2	<2
Surrogate	54/54	60%	58	49	42/45	43	40
Recovery							

Congener No.	NSDI(C) #10152	NSDI(C) #10153	NSDI(C) #10154	NBMI(N) #10083	NBMI(N) #10084	NBMI(N) #10085	NBMI(C) #10122
8 ; 5	<2	<2	<2/<2	<2	<2	<2	<2/<2
18 ; 15	<2	<2	<2/<2	<2	<2	<2	<2/<2
28 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
29 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
44 ;	<2	<2	<2/<2	2.7	3.4	<2	<2/<2
50 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
52 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
66 ; 95	2.8	3.1	2.6/3	<2	7.6	5.6	5.4/4.8
77 ;	<2	<2	<2/<2	<2	<2	<2	2.1/<2
87 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
101 ; 90	<2	<2	<2/<2	2.9	3.6	2.7	3.7/2.6
105 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
118 ;	2.3	2.6	2.1/2.5	2.7	3	2.4	4.2/3.1
126 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
128 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
138 ;	2.1	2.1	<2/<2	4.3	4.6	3.3	4.9/4.1
153 ; 132	2.2	2.2	<2/2.2	4.6	4.9	3.5	6/4.9
169 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
170 ; 190	<2	<2	<2/<2	<2	<2	<2	<2/<2
180 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
187 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
195 ; 208	<2	<2	<2/<2	<2	<2	<2	<2/<2
206 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
209 ;	<2	<2	<2/<2	<2	<2	<2	<2/<2
Surrogate	48	54%	28/40	42	46	33	30/45
Recovery							

Congener No.	NBMI(C) #10123	NBMI(C) #10124					
8 ; 5	<2	<2					
18 ; 15	<2	<2					
28 ;	<2	<2					
29 ;	<2	<2					
44 ;	<2	<2					
50 ;	<2	<2					
52 ;	<2	<2					
66 ; 95	4.5	4.5					
77 ;	<2	<2					
87 ;	<2	<2					
101 ; 90	2.8	3.3					
105 ;	<2	<2					
118 ;	3.6	3.8					
126 ;	<2	<2					
128 ;	<2	<2					
138 ;	3.5	3.6					
153 ; 132	4.5	5.6					
169 ;	<2	<2					
170 ; 190	<2	<2					
180 ;	<2	<2					
187 ;	<2	<2					
195 ; 208	<2	<2					
206 ;	<2	<2					
209 ;	<2	<2					
Surrogate							
Recovery							

APPENDIX F. TISSUE CONCENTRATIONS OF CHLORINATED PESTICIES IN *MYTILUS EDULIS* (NG/G DRY WEIGHT).

Chlorinated pesticides	MASA(N)1 #10200	MASA(N)2 #10201	MASA(N)3 #10202	MASA(C)1 #10203	MASA(C)2 #10204	MASA(C)3 #10205	MANI(C)1 #10206
HCB	<2	<2	<2	<2	<2/<2	<2	<2
r-BHC	<2	<2	<2	<2	<2/<2	<2	2.6
Heptachlor	<2	<2	<2	<2	<2/<2	<2	<2
Aldrin	<2	<2	<2	<2	<2/<2	<2	<2
Hepta epoxide	<2	<2	<2	<2	<2/<2	<2	<2
o,p'-DDE	<2	<2	<2	<2	<2/<2	<2	<2
a-Endosulfan	<2	<2	<2	<2	<2/<2		<2
cis-Chlordane	2.1	2	2	2	<2/<2	2.1	15
trans-Nonachlor	2	<2	<2	<2	<2/<2	<2	14
p,p'-DDE	15	14	13	10	8/9	10	35
Dieldrin	<2	<2	<2	<2	<2/<2	<2	4.4
o,p'-DDD	8	7	7	8	5.6/6.7	2.1	14
b-Endosulfan	<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDD	9.1	8.6	8.6	5.4	4.9/4.6	8.5	30
o,p'-DDT	<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDT	4.7	5.7	5.6	4.7	<2/<2	2.1	7.2
Mirex	<2	<2	<2	<2	<2/<2	<2	<2

Chlorinated pesticides	MANI(C)2 #10207	MANI(C)3 #10208	MANI(N)1 #10209	MANI(N)2 #10210	MANI(N)3 #10211	NHLH(P)1 #10212	NHLH(P)2 #10213
HCB	<2/<2	<2	<2	<2	<2/<2	<2	<2
r-BHC	2.1/2.6	2.5	<2	<2	<2/<2	<2	<2
Heptachlor	<2/<2	<2	<2	<2	<2/<2	<2	<2
Aldrin	<2/<2	<2	<2	<2	<2/<2	<2	<2
Hepta epoxide	<2/<2	<2	<2	<2	<2/<2	<2	<2
o,p'-DDE	<2/<2	<2	<2	<2	<2/<2	<2	<2
a-Endosulfan	<2/<2	<2	<2	<2	<2/<2	<2	<2

cis-Chlordane	12/16	16	8.1	8.9	7.1/12	<2	<2
trans-Nonachlor	11/15	14	7.9	9.1	7.2/12	<2	<2
p,p'-DDE	28/36	28	19	24	20/30	9	9
Dieldrin	4.2/5.4	5	2.5	2.6	2.3/3	<2	<2
o,p'-DDD	18/20	16	11	9.7	9.7/10	<2	3.3
b-Endosulfan	<2/<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDD	25/32	30	14	17	15/22	6.6	5.1
o,p'-DDT	<2/<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDT	7.3/7.1	7.8	3	4.2	3.5/4.3	<2	<2
Mirex	<2/<2	<2	<2	<2	<2/<2	<2	<2
Chlorinated pesticides	NHLH(P)3 #10214	NHSI(P)1 #10215	NHSI(P)2 #10216	NHSI(P)3 #10217	NH0P(P)1 #10218	NHOP(P)2 #10219	NH0P(P)3 #10220
HCB	<2/<2	<2	<2	<2/<2	<2	<2	<2
r-BHC	<2/<2	<2	<2	<2/<2	<2	<2	<2
Heptachlor	<2/<2	<2	<2	<2/<2	<2	<2	<2
Aldrin	<2/<2	<2	<2	<2/<2	<2	<2	<2
Hepta epoxide	<2/<2	<2	<2	<2/<2	<2	<2	<2
o,p'-DDE	<2/<2	<2	<2	<2/<2	<2	<2	<2
a-Endosulfan	<2/<2	<2	<2	<2/<2	<2	<2	<2
cis-Chlordane	<2/<2	<2	<2	<2/<2	<2	<2	<2
trans-Nonachlor	<2/<2	<2	<2	<2/<2	<2	<2	<2
p,p'-DDE	8/7.5	9.5	7	12/11	6	7.5	5.2
Dieldrin	<2/<2	<2	<2	<2/<2	<2	<2	<2
o,p'-DDD	<2/<2	2	<2	3.7/3.2	<2	<2	<2
b-Endosulfan	<2/<2	<2	<2	<2/<2	<2	<2	<2
p,p'-DDD	4.8/4.3	8	5.3	7.4/6.5	3	3.1	2
o,p'-DDT	<2/<2	<2	<2	<2/<2	<2	<2	<2
p,p'-DDT	<2/<2	<2	<2	<2/<2	<2	<2	<2
Mirex	<2/<2	<2	<2	<2/<2	<2	<2	<2

Chlorinated pesticides	NHOP(P)4 #10221	NHOP(P)5 #10222	NHOP(P)6 #10223	MEKN(C)1 #10224	MEKN(C)2 #10225	MEKN(C)3 #10226	MEKN(N)1 #10227
HCB	<2	<2	<2/<2	<2	<2	<2	<2/<2
r-BHC	<2	<2	<2/<2	<2	<2	<2	<2/<2
Heptachlor	<2	<2	<2/<2	<2	<2	<2	<2/<2
Aldrin	<2	<2	<2/<2	<2	<2	<2	<2/<2
Hepta epoxide	<2	<2	<2/<2	<2	<2	<2	<2/<2
o,p'-DDE	<2	<2	<2/<2	<2	<2	<2	<2/<2
a-Endosulfan	<2	<2	<2/<2	<2	<2	<2	<2/<2
cis-Chlordane	<2	<2	<2/<2	<2	<2	<2	<2/<2
trans-Nonachlor	<2	<2	<2/<2	<2	<2	<2	<2/<2
p,p'-DDE	4.8	6.8	5.2/6	5	7.2	6.5	7.7/8.2
Dieldrin	<2	<2	<2/<2	<2	<2	<2	<2/<2
o,p'-DDD	<2	<	<2/<2	<2	<2	<2	2.6/2.5
b-Endosulfan	<2		<2/<2	<2	<2	<2	<2/<2
p,p'-DDD	2.4	3.9	2.7/2.4	4.1	5.7	5	4.9/5.9
o,p'-DDT	<2	<2	<2/<2	<2	<2	<2	<2/<2
p,p'-DDT	<2	<2	<2/<2	<2	<2	<2	<2/<2
Mirex	<2	<2	<2/<2	<2	<2	<2	<2/<2

Chlorinated pesticides	MEKN(N)3 #10228	MEKN(N)3 #10229	MESH(N)1 #10230	MESH(N)2 #10231	MESH(N)3 #10232	MEKN(P)1 #10233	MEKN(P)2 #10234
HCB	<2	<2	<2	<2	<2/<2	<2	<2
r-BHC	<2	<2	<2	<2	<2/<2	<2	<2
Heptachlor	<2	<2	<2	<2	<2/<2	<2	<2
Aldrin	<2	<2	<2	<2	<2/<2	<2	<2
Hepta epoxide	<2	<2	<2	<2	<2/<2	<2	<2
o,p'-DDE	<2	<2	<2	<2	<2/<2	<2	<2
a-Endosulfan	<2	<2	<2	<2	<2/<2	<2	<2
cis-Chlordane	<2	<2	<2	<2	<2/<2	<2	<2
trans-Nonachlor	<2	<2	<2	<2	<2/<2	<2	<2

p,p'-DDE	7.3	6.2	8.9	7	9.2/9.7	4.3	6.2
Dieldrin	<2	<2	<2	<2	<2/<2	<2	<2
o,p'-DDD	<2	<2	<2	<2	<2/2.2	<2	<2
b-Endosulfan	<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDD	5	3.6	4.9	4.3	5.4/6.4	3.3	4.3
o,p'-DDT	<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDT	<2	<2	<2	<2	<2/<2	<2	<2
Mirex	<2	<2	<2	<2	<2/<2	<2	<2
Chlorinated pesticides	NBSI(N) #10073	NBSI(N) #10074	NBSI(N) #10075	NBHI(P) #10093	NBHI(P) #10094	NBHI(P) #10095	NBHI(N) #10103
HCB	<2	<2	<2	<2/<2	<2	<2	<2
r-BHC	<2	<2	<2	<2/<2	<2	<2	<2
Heptachlor	<2	<2	<2	<2/<2	<2	<2	<2
Aldrin	<2	<2	<2	<2/<2	<2	<2	<2
Hepta epoxide	<2	<2	<2	<2/<2	<2	<2	<2
o,p'-DDE	<2	<2	<2	<2/<2	<2	<2	<2
a-Endosulfan	<2	<2	<2	<2/<2	<2	<2	<2
cis-Chlordane	<2	<2	<2	<2/<2	<2	<2	<2
trans-Nonachlor	<2	<2	<2	<2/<2	<2	<2	<2
p,p'-DDE	4.3	3	2.7	3.4/3.4	3.7	4.2	2.9
Dieldrin	<2	<2	<2	<2/<2	<2	<2	<2
o,p'-DDD	<2	<2	<2	<2/<2	<2	<2	<2
b-Endosulfan	<2	<2	<2	<2/<2	<2	<2	<2
p,p'-DDD	2.1	<2	<2	2/<2	<2	2.1	<2
o,p'-DDT	<2	<2	<2	<2/<2	<2	<2	<2
p,p'-DDT	2.2	<2	<2	<2/<2	<2	<2	<2
Mirex	<2	<2	<2	<2/<2	<2	<2	<2

Chlorinated pesticides	NBHI(N) #10104	NBHI(N) #10105	NBHI(C) #10116	NBHI(C) #10117	NBHI(C) #10118	NSBC(N) #10131	NSBC(N) #10132
HCB	<2/<2	<2	<2	<2	<2	<2	<2
r-BHC	<2/<2	<2	<2	<2	<2	<2	<2
Heptachlor	<2/<2	<2	<2	<2	<2	<2	<2
Aldrin	<2/<2	<2	<2	<2	<2	<2	<2
Hepta epoxide	<2/<2	<2	<2	<2	<2	<2	<2
o,p'-DDE	<2/,2	<2	<2	<2	<2	<2	<2
a-Endosulfan	<2/<2	<2	<2	<2	<2	<2	<2
cis-Chlordane	<2/<2	<2	<2	<2	<2	<2	<2
trans-Nonachlor	<2/<2	<2	<2	<2	<2	<2	<2
p,p'-DDE	3.0/2.8	3.7	3.7	3.8	3.8	3.8	4
Dieldrin	<2/<2	<2	<2	<2	<2	<2	<2
o,p'-DDD	<2/<2	<2	<2	<2	<2	<2	<2
b-Endosulfan	<2/<2	<2	<2	<2	<2	<2	<2
p,p'-DDD	<2/<2	<2	2.6	2	<2	<2	2
o,p'-DDT	<2/<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<2/<2	<2	<2	<2	<2	<2	<2
Mirex	<2/<2	<2	<2	<2	<2	<2	<2

Chlorinated pesticides	NSBC(N) #10133	NSDI(N) #10137	NSDI(N) #10138	NSDI(N) #10139	NSBC(C) #10146	NSBC(C) #10147	NSBC(C) #10148
HCB	<2/<2	<2	<2	<2	<2/<2	<2	<2
r-BHC	<2/<2	<2	<2	<2	<2/<2	<2	<2
Heptachlor	<2/<2	<2	<2	<2	<2/<2	<2	<2
Aldrin	<2/<2	<2	<2	<2	<2/<2	<2	<2
Hepta epoxide	<2/<2	<2	<2	<2	<2/<2	<2	<2
o,p'-DDE	<2/<2	<2	<2	<2	<2/<2	<2	2.5
a-Endosulfan	<2/<2	<2	<2	<2	<2/<2	<2	<2
cis-Chlordane	<2/<2	<2	<2	<2	<2/<2	<2	<2
trans-Nonachlor	<2/<2	<2	<2	<2	<2/<2	<2	<2

p,p'-DDE	3.9/3.6	4	3.6	3.6	2.8/2.7	2.4	2.7
Dieldrin	<2/<2	<2	<2	<2	<2/<2	<2	<2
o,p'-DDD	<2/<2	<2	<2	<2	<2/<2	<2	<2
b-Endosulfan	<2/<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDD	<2/<2	2.3	<2	2.1	<2/<2	2.6	<2
o,p'-DDT	<2/<2	<2	<2	<2	<2/<2	<2	<2
p,p'-DDT	<2/<2	<2	<2	<2	<2/<2	<2	2.2
Mirex	<2/<2	<2	<2	<2	<2/<2	<2	<2

Chlorinated pesticides	NSDI(C) #10152	NSDI(C) #10153	NSDI(C) #10154	NBMI(N) #10083	NBMI(N) #10084	NBMI(N) #10085	NBMI(C) #10122
HCB	<2	<2	<2/<2	<2	<2	<2	<2/<2
r-BHC	<2	<2	<2/<2	<2	<2	<2	<2/<2
Heptachlor	<2	<2	<2/<2	<2	<2	<2	<2/<2
Aldrin	<2	<2	<2/<2	<2	<2	<2	<2/<2
Hepta epoxide	<2	<2	<2/<2	<2	<2	<2	<2/<2
o,p'-DDE	2.3	<2	<2/<2	<2	<2	<2	<2/<2
a-Endosulfan	<2	<2	<2/<2	<2	<2	<2	<2/<2
cis-Chlordane	<2	<2	<2/<2	<2	<2	<2	<2/<2
trans-Nonachlor	<2	<2	<2/<2	<2	<2	<2	<2/<2
p,p'-DDE	2.7	3	<2/2.7	4.5	5.1	3.2	6.3/3.9
Dieldrin	<2	<2	<2/<2	<2	<2	<2	<2/<2
o,p'-DDD	<2	<2	<2/<2	<2	<2	<2	<2/3.2
b-Endosulfan	<2	<2	<2/<2	<2	<2	<2	<2/<2
p,p'-DDD	3.4	<2	2.2/2.3	3.9	3.3	2.5	4.3/3.7
o,p'-DDT	<2	<2	<2/<2	<2	<2	<2	<2/<2
p,p'-DDT	<2	<2	<2/<2	3.1	3.1	<2	2.1/<2
Mirex	<2	<2	<2/<2	<2	<2	<2	<2/<2

Chlorinated pesticides	NBMI(C) #10123	NBMI(C) #10124					
HCB	<2	<2					
r-BHC	<2	<2					
Heptachlor	<2	<2					
Aldrin	<2	<2					
Hepta epoxide	<2	<2					
o,p'-DDE	<2	<2					
a-Endosulfan	<2	<2					
cis-Chlordane	<2	<2					
trans-Nonachlor	<2	<2					
p,p'-DDE	4.2	3.4					
Dieldrin	<2	<2					
o,p'-DDD	<2	<2					
b-Endosulfan	<2	<2					
p,p'-DDD	2.7	3.4					
o,p'-DDT	<2	<2					
p,p'-DDT	<2	<2					
Mirex	<2	<2					

APPENDIX G. POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS IN *MYTILUS EDULIS* TISSUE.

Variable (Isomers)		Manawagonish Island, N.B.					
		Concentration pg/g wet wt.	SDL	Concentration pg/g wet wt.	SDL	Concentration pg/g wet wt.	SDL
DIOXINS:							
Total	T4CDD	ND	0.8	ND	0.8	ND	0.9
	2378	ND		ND		ND	
Total	P5CDD	ND	1.6	ND	1.6	ND	2.0
	12378	ND		ND		ND	
Total	H6CDD	ND	1.8	ND	1.9	ND	3.3
	123478	ND		ND		ND	
	123678	ND		ND		ND	
	123789	ND		ND		ND	
Total	H7CDD	ND	2.5	ND	2.0	ND	2.6
	1234678	ND		ND		ND	
	08CDD	ND	4.6	ND	3.6	ND	3.8
TOTAL DIOXINS		ND		ND		ND	
FURANS:							
Total	P4CDF	ND	0.5	ND	0.5	ND	0.5
	2378	ND		ND		ND	
Total	P5CDF	ND	0.8	ND	0.8	ND	1.0
	12378	ND		ND		ND	
	23478	ND		ND		ND	
Total	H6CDF	ND	1.5	ND	1.6	ND	2.9
	123478	ND		ND		ND	
	123678	ND		ND		ND	
	123789	ND		ND		ND	
Total	H7CDF	ND	2.7	ND	2.1	ND	2.6
	1234678	ND		ND		ND	
	1234789	ND		ND		ND	
	08CDF	ND	3.7	ND	2.5	ND	2.6
TOTAL FURANS		ND		ND		ND	
TOTAL CDD AND CDF		ND		ND		ND	
% Moist.		90		88		90	
% Lipid		0.4		0.4		0.4	

SDL = Sample detection limit; ND = Not detected

Variable (Isomers)		Machias Seal Island, N.B. (#1)		(#2)		(#3)	
		Concentration pg/g wet wt.*	SDL	Concentration pg/g wet wt.	SDL	Concentration pg/g wet wt.	SDL
DIOXINS:							
Total	T4CDD	ND	0.1	ND	1.4	ND	0.9
	2378	ND		ND		ND	
Total	P5CDD	ND	0.2	ND	3.5	ND	2.6
	12378	ND		ND		ND	
Total	H6CDD	ND	0.1	ND	2.3	ND	1.7
	123478	ND		ND		ND	
	123678	ND		ND		ND	
	123789	ND		ND		ND	
Total	H7CDD	1.1	0.1	ND	2.4	ND	2.4
	1234678	0.5		ND		ND	
	08CDD	2.1	0.1	ND	4.1	ND	2.8
TOTAL DIOXINS		3.2		ND		ND	
FURANS:							
Total	P4CDF	1.4	0.1	ND	0.7	ND	0.7
	2378	0.3		ND		ND	
Total	P5CDF	ND	0.3	ND		ND	1.0
	12378	ND		ND		ND	
	23478	ND		ND		ND	
Total	H6CDF	ND	0.3	ND	3.5	ND	1.4
	123478	ND		ND		ND	
	123678	ND		ND		ND	
	123789	ND		ND		ND	
Total	H7CDF	ND	0.3	ND	2.2	ND	2.4
	1234678	ND		ND		ND	
	1234789	ND		ND		ND	
	08CDF	0.3	0.1	ND	4.1	ND	3.2
TOTAL FURANS		1.7		ND		ND	
TOTAL CDD AND CDF		4.9		ND		ND	
	% Moist.	83		81		80	
	% Lipid	1.7		1.6		2.0	

* = High-resolution analysis required to improve detection limits; SDL = Sample detection limit; ND = Not detected

APPENDIX H. REPORTED LEVELS OF ORGANIC CONTAMINATION IN BIVALVES FROM AROUND THE WORLD.

Location	Authors	Species and year collected	Results (ng/g)	Observations
South India	Ramesh et al. 1990	*Perna viridis* 1988-89	wet wt. PCB: <1.0-7.1 DDT:2.8-39 BHC:4.3-16.0	
Thermaikos Gulf, Greece	Iosifidou et al. 1982	*Mytilus galloprovincialis*	wet wt. avg. PAH: 91	
northwest coast of Spain	Soler et al. 1989	*Mytilus galloprovincialis*	dry wt. PCB: 41-630	No correlation to a specific industrial source.
Bahia, Brazil	Tavares et al. 1988	Various bivalves, 1985-86	wet wt. DDT:nd-5.1, PCB: nd-2.1	Differential bioaccumulation of PCB congeners between species. PCB and DDT suggested to have different sources based on distribution pattern.
Gulf of Thailand	Menasvets et al. 1981	*Mytilus viridis*, 1979	wet wt. DDT: 32-42, PCB:2-43	Levels observed suggested to have no effects on mussels or consumers.
Corio Bay and Melbourne, Australia	Murray et al. 1991	*Mytilus edulis*, 1986 transplanted from farm to test sites for 3 months	dry wt. Benzo(a)pyrene: clean: 0.43-0.96 urban: 0.43-0.96 oil refinery: 52-172	
Gulf of Paria, Trinidad	Singh et al. 1992	*Mytella guyanensis* 1987-88	wet wt. Hydrocarbons 3600-16210	No change over 1 year.
Punta Banda Estuary, Mexico	Baez and Bect 1984	*Mytilus edulis* 1984	dry wt. DDT:345	Determined 20 individuals as optimum sample size to minimize variance.
Castle and Hamilton Harbours, Bermuda	Widdows et al. 1990	*Arca zebra*, 1988 Transplanted in cages for 12 days	dry wt. PCB: 1-32	reduction in scope for growth at site influenced by automobile waste, $P>0.05$.

Location	Authors	Species and year collected	Results	Observations
Northern Adriatic Sea	Nadjek and Bazulek 1988	Unspecified, 1984-86	dry wt. PCB: 3.2-12.1 DDT 2.1-18.3	Pollutant content changes with reproductive cycle. General decrease in DDT over 3 years.
Adriatic Sea	Picer and Picer 1990, 1991	*Mytilus edulis*, 1972-90	wet wt. DDT: 5.2-75.2, max=337 PCB:78-210, max=771	Significant correlations bewteen PCB and DDT suggested same source. Contaminants near 1990 levels by 1975.
Eastern Scheldt, Netherlands	Veldhuizen- Tsoerkan et al. 1991	*Mytilus edulis* semi-field cond., fed algae grown @ 0.5 g/L PCB,	wet wt. PCB: 3000 @ 3mos 6000 @ 6 mos	Glycogen decrease, succinate increase, condition index not affected, survival decrease at 6 months.
Rhine-Meuse-Scheldt Delta, North Sea, Netherlands	Duursma et al. 1986	*Mytilus edulis*	fat basis PCB: 30-530 BHC: 0-10 Dieldrin: 1-8	Contaminants correlated to salinity,suggesting freshwater source
Rhine-Meuse-Scheldt Delta, North Sea	de Kock et al, 1983	*Mytilus edulis*, 60 days transplant	dry wt. Arochlor 1254: 3300-9950	Lipid variability between samples and seasons is too small to affect PCB uptake substantially.
Dutch Delta, North Sea	Hummel et al. 1990	*Mytilus edulis*	fat basis PCB: 2000-48000	PCB content remained constant while fat content varied seasonally.
Saudafijord, Norway	Bjorseth et al. 1979	*Mytilus edulis, Modiolus modiolus*	dry wt. PAH: 5111-225163	0.5-17 km from ferro alloy smelter.
Langesundfijord Norway	Capuzzo and Leavitt 1988	*Mytilus edulis*	wet wt. PCB:77-275	Structural and functional alterations of the digestive gland in reponse to a pollution gradient.

Location	Authors	Species and year collected	Results	Observations
Norway	Kveseth et al. 1982	*Mytilus edulis* 1980-81, transplanted to sewage outfall	wet wt. PAH: 63-1030	Lower concentrations after a precipitation event.
Finnish Archipelage Sea	Rainio et al. 1986	*Mytilus edulis*, 1978-79	wet wt. PAH: nd-148	Highest PAH values observed in region affected by an oil spill. Individual PAH unequally distributed among samples.
Central and Southern Finland	Herve et al. 1986	*Anodonta piscinalis*	fat basis PCB: 0-2045 Lindane 0-283	Highest PCB levels associated with pulp mill. Chlordanes non-detected at 2 ng/g.
Lower Medway Estuary, Kent, England	Wharfe et al. 1978	*Mytilus edulis* 1973	wet wt. DDT: 11-71.8 Dieldrin: 4-11.5 PCB: 70.4-162	No seasonal variation, no detection of BHC, heptachlor, epoxide, aldrin, eldrin, endosulfan, limits unspecified.
Scotland	Cowan 1981	*Mytilus edulis*, 1977	avgs., dry wt. PCB: <76(west coast)-646(Moray Firth) Dieldrin: 6(north coast)-344(Clyde) DDT: <18(north coast)-91(Tay)	Dieldrin max. = 2430 suggested to be result of moth-proofing at wool and carpet facilities. DDT showed localized distribution.
San Francisco Bay, USA	Martin et al. 1984	*Mytilus californianus*	wet wt. PCB:510-1800 Dieldrin: 20-50 Chlordane: 51-83	Scope for growth was significantly negatively correlated with dieldrin and chlordane, negative correlation with PCB not significant.

Location	Authors	Species and year collected	Results	Observations
Estuary and Northwestern Gulf of St.Lawrence	Cossa et al. 1983	*Mytilus edulis*, 1977		Most samples had low PAH levels as determined by fluorescence. High levels related to saw mill and smelting activity.
Baie-Comeau, St.Lawrence Estuary	Delval et al. 1986	*Mytilus edulis*, 1984	wet wt. PCB: 2-46	Aluminum plant suggested as the PCB source.
New Brunswick	McLeese and Burridge 1987	*Mytilus edulis*	wet wt. PAH 4 d exposure to sediment from wood treatment plant: 100-5700	PAH uptake from water greater than from sediment. No transport across shells during 4 days of exposure to contaminated sediment.
Sydney Harbour, NS	Sirhota et al. 1984	*Mytilus edulis*, 1981-82	wet wt. PAH:1981/1982 South Bar: 33875/13873 Seal Island:1024/24	
Nantucket Sound and Buzzards Bay, MA, USA	Capuzzo et al. 1989	*Mytilus edulis*	dry wt. PCB: 100	Decline in PCB in autumn related to spawning, differentially affecting congeners. Suggested only quasi-steady state concentrations due to lipid content seasonality.
Puget Sound, Washington, USA	Mowrer et al. 1977	*Mytilus edulis*, 1975	wet wt. PCB:10-210	Highest PCB levels correlated with urban influence.

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APPENDIX I. MONITORING STATION DATA-ENTRY FORMS FOR 1992.

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: MASA $_{1}$

Station Name: TOWN BEACH SANDWICH MASS $_{2}$

Latitude: 41.4573 $_{3}$ *(DD.MMMM)*

Longitude: 70.2838 $_{4}$ *(DDD.MMMM)*

Pos. Method: C $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* MUSSEL MATS ON SANDY SUBSTRATE ALONG TIDAL CREEK BANK $_{6}$

Geographic Location

Access Road: FREEMAN AVENUE $_{7}$

Township: SANDWICH $_{8}$

County: BARNSTABLE $_{9}$

Province/State: MA $_{10}$

Nearest Centre: SANDWICH $_{11}$

Population:

Distance from Centre: 2.0 $_{13}$ km

Distance from shore: 0.1 $_{14}$ km

Pollution Source: NPO $_{15}$

Distance from source: . $_{16}$ km

Basin Name: $_{17}$

Basin Area: . $_{18}$ km²

Distance from river mouth: 0.5 $_{19}$ km

Physical Characteristics

Substrate: MUSSEL MATS ON SAND $_{20}$

Station Exposure: 110 ° $_{21}$

Tidal Range: 2.7 $_{22}$ m

Audit Information

Established By: J PEDERSON $_{23}$

Agency: MCZM $_{24}$

Date: 91.08.20 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: MANI 1

Station Name: NUT ISLAND SPINDLE MASS 2

Latitude: 42.1710 3 (DD.MMMM)

Longitude: 70.5820 4 (DDD.MMMM)

Pos. Method: C 5 (C,G,T,O)

Station Description: NAVIGATION SPINDLE #2 4 SEC
(120 Characters Max) FLASH NEAR SUNKEN LEDGE QUINCY
BAY MUSSEL TRANSPLANT STATION
(NO INDIGENOUS MUSSELS) 6

Geographic Location

Access Road: 7

Township: QUINCY 8

County: 9

Province/State: MA 10

Nearest Centre: QUINCY 11

Population:

Distance from Centre: 2.0 13 km

Distance from shore: 0.8 14 km

Pollution Source: MUN 15

Distance from source: 0.1 16 km

Basin Name: WEYMOUTH FORE RIVER 17

Basin Area: . 18 km²

Distance from river mouth: 3.0 19 km

Physical Characteristics

Substrate: STEEL NAVIGATION SPINDLE 20

Station Exposure: 035 ° 21

Tidal Range: 3.0 22 m

Audit Information

Established By: J PEDERSON 23

Agency: MCZM 24

Date: 91.08.20 25 (YY.MM.DD)

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: MAMH $_{1}$

Station Name: DEVEREUX BEACH MARBLEHEAD MASS $_{2}$

Latitude: ▨42.2944 $_{3}$ *(DD.MMMM)*

Longitude: 70.5092 $_{4}$ *(DDD.MMMM)* Pos. Method: C $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* ROCKY/COBBLE OUTCROP MIDWAY ALONG CAUSEWAY $_{6}$

Geographic Location

Access Road: $_{7}$

Township: MARBLEHEAD $_{8}$

County: $_{9}$ Province/State: MA $_{10}$

Nearest Centre: MARBLEHEAD $_{11}$ Population: 5000 $_{12}$

Distance from Centre: 0.8 $_{13}$ km Distance from shore: . $_{14}$ km

Pollution Source: MUN $_{15}$ Distance from source: 40 $_{16}$ km

Basin Name: $_{17}$

Basin Area: . $_{18}$ km² Distance from river mouth: . $_{19}$ km

Physical Characteristics

Substrate: BOULDERS AND COBBLE $_{20}$

Station Exposure: 180 ° $_{21}$ Tidal Range: 2.7 $_{22}$ m

Audit Information

Established By: WM ROBINSON $_{23}$ Agency: UMASS $_{24}$

Date: 93.09.01 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: MANH $_{1}$

Station Name: EAST POINT NAHANT MASS $_{2}$

Latitude: 42.2507 $_{3}$ *(DD.MMMM)*

Longitude: 70.5428 $_{4}$ *(DDD.MMMM)*

Pos. Method: C $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* ROCKY SHORE NE OF COBBLE BEACH NEAR PUMPHOUSE AT NORTHEASTERN UNIVERSITY MARINE LABS $_{6}$

Geographic Location

Access Road: $_{7}$

Township: NAHANT $_{8}$

County: $_{9}$

Province/State: MA $_{10}$

Nearest Centre: NAHANT $_{11}$

Population: 1500 $_{12}$

Distance from Centre: 0.5 $_{13}$ km

Distance from shore: . $_{14}$ km

Pollution Source: MUN $_{15}$

Distance from source: 1.5 $_{16}$ km

Basin Name: $_{17}$

Basin Area: . $_{18}$ km²

Distance from river mouth: . $_{19}$ km

Physical Characteristics

Substrate: ROCK OUTCROP $_{20}$

Station Exposure: 110 ° $_{21}$

Tidal Range: 3.0 $_{22}$ m

Audit Information

Established By: J PEDERSON $_{23}$

Agency: MCZM $_{24}$

Date: 91.08.20 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NHLH 1

Station Name: LITTLE HARBOUR, NEW HAMPSHIRE 2

Latitude: 43.0322 3 (DD.MMMM)

Longitude: 70.4310 4 (DDD.MMMM) Pos. Method: C 5 (C,G,T,O)

Station Description: (120 Characters Max) NEAR THE MOUTH OF LITTLE HAR. ON THE NORTH SIDE OF THE CHANNEL INSIDE THE BREAKWATER APPROXIMATELY 20 METERS 6

Geographic Location

Access Road: FORT STARK ROAD 7

Township: NEW CASTLE 8

County: ROCKINGHAM 9 Province/State: NH 10

Nearest Centre: NEW CASTLE 11 Population: 831

Distance from Centre: 1.6 13 km Distance from shore: 0.3 14 km

Pollution Source: NPO 15 Distance from source: 0.6 16 km

Basin Name: PISCATAQUA RIVER 17

Basin Area: 2409.00 18 km² Distance from river mouth: 0.7 19 km

Physical Characteristics

Substrate: MUDDY SAND 20

Station Exposure: 90 ° 21 Tidal Range: 2.8 22 m

Audit Information

Established By: STEPHEN JONES 23 Agency: UNH 24

Date: 91.08.15 25 (YY.MM.DD)

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NHOP $_{1}$

Station Name: ODIORNE POINT NEW HAMPSHIRE $_{2}$

Latitude: 43.0322 $_{3}$ *(DD.MMMM)*

Longitude: 70.4310 $_{4}$ *(DDD.MMMM)* Pos. Method: C $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* LOCATED ON THE OCEAN SIDE OF ROUTE #1A JUST SOUTH OF ODIORNE STATE PARK AT SHALLOW EMBAYMENT $_{6}$

Geographic Location

Access Road: STATE ROUTE #1A $_{7}$

Township: RYE $_{8}$

County: ROCKINGHAM $_{9}$ Province/State: NH $_{10}$

Nearest Centre: RYE $_{11}$ Population: 4555

Distance from Centre: 1.1 $_{13}$ km Distance from shore: 0.1 $_{14}$ km

Pollution Source: NPO $_{15}$ Distance from source: 0.9 $_{16}$ km

Basin Name: PISCATAQUA RIVER $_{17}$

Basin Area: 2409.00 $_{18}$ km^{2} Distance from river mouth: 2.4 $_{19}$ km

Physical Characteristics

Substrate: SAND AND ROCKS $_{20}$

Station Exposure: 90 °$_{21}$ Tidal Range: 2.8 $_{22}$ m

Audit Information

Established By: STEPNEN JONES $_{23}$ Agency: UNH $_{24}$

Date: 91.08.15 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NHSI $_{1}$

Station Name: SHAPLEIGH ISLAND NEW HAMPSHIRE $_{2}$

Latitude: 43.0410 $_{3}$ *(DD.MMMM)*

Longitude: 70.4400 $_{4}$ *(DDD.MMMM)* Pos. Method: C $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* SHAPLEIGH ISLAND TO SOUTH OF ROUTE #1B BRIDGE IN THE BACK CHANNEL OFF SOUTH TIP OF ISLAND $_{6}$

Geographic Location

Access Road: STATE ROUTE 1B $_{7}$

Township: PORTSMOUTH $_{8}$

County: ROCKINGHAM $_{9}$ Province/State: NH $_{10}$

Nearest Centre: PORTSMOUTH $_{11}$ Population: 22342

Distance from Centre: 0.9 $_{13}$ km Distance from shore: 0.1 $_{14}$ km

Pollution Source: MUN $_{15}$ Distance from source: 1.4 $_{16}$ km

Basin Name: PISCATAQUA RIVER $_{17}$

Basin Area: 2409.00 $_{18}$ km² Distance from river mouth: 2.5 $_{19}$ km

Physical Characteristics

Substrate: MUDDY SAND $_{20}$

Station Exposure: 180 ° $_{21}$ Tidal Range: 2.8 $_{22}$ m

Audit Information

Established By: STEPHEN JONES $_{23}$ Agency: UNH $_{24}$

Date: 91.08.15 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: MEKN $_{1}$

Station Name: KENNEBEC RIVER $_{2}$

Latitude: 43.4750 $_{3}$ *(DD.MMMM)*

Longitude: 69.4760 $_{4}$ *(DDD.MMMM)* Pos. Method: T $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* SOUTH TIP OF PERKINS ISLAND $_{6}$

Geographic Location

Access Road: ACCESS FROM BOAT $_{7}$

Township: GEORGETOWN $_{8}$

County: SAGADAHOC $_{9}$ Province/State: ME $_{10}$

Nearest Centre: BATN $_{11}$ Population: 12000

Distance from Centre: 16.0 $_{13}$ km Distance from shore: 0.5 $_{14}$ km

Pollution Source: MUN $_{15}$ Distance from source: 16.5 $_{16}$ km

Basin Name: KENNEBEC $_{17}$

Basin Area: 24171 $_{18}$ km² Distance from river mouth: . $_{19}$ km

Physical Characteristics

Substrate: LEDGE MIXED WITH SAND $_{20}$

Station Exposure: 030 ° $_{21}$ Tidal Range: 3.0 $_{22}$ m

Audit Information

Established By: J SOWLES $_{23}$ Agency: MDEP $_{24}$

Date: 92.08.20 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: MESH $_{1}$

Station Name: SHEEPSCOT RIVER $_{2}$

Latitude: 43.5126 $_{3}$ *(DD.MMMM)*

Longitude: 69.4210 $_{4}$ *(DDD.MMMM)*

Pos. Method: T $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* NORTH TIP OF WHITTUM ISLAND $_{6}$

Geographic Location

Access Road: ACCESS BY BOAT $_{7}$

Township: WESTPORT $_{8}$

County: LINCOLN $_{9}$

Province/State: ME $_{10}$

Nearest Centre: BOOTHBAY HARBOR $_{11}$

Population: 6000

Distance from Centre: . $_{13}$ km

Distance from shore: 0.5 $_{14}$ km

Pollution Source: $_{15}$

Distance from source: 1.0 $_{16}$ km

Basin Name: SHEEPSCOT RIVER $_{17}$

Basin Area: 591.00 $_{18}$ km²

Distance from river mouth: 7.0 $_{19}$ km

Physical Characteristics

Substrate: LEDGE $_{20}$

Station Exposure: 030 ° $_{21}$

Tidal Range: 3.0 $_{22}$ m

Audit Information

Established By: J SOWLES $_{23}$

Agency: MDEP $_{24}$

Date: 92.08.20 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NBHI $_{1}$
Station Name: HOSPITAL ISLAND $_{2}$
Latitude: ▨45.1208 $_{3}$ *(DD.MMMM)*
Longitude: 67.0083 $_{4}$ *(DDD.MMMM)*
Pos. Method: C $_{5}$ *(C,G,T,O)*
Station Description: *(120 Characters Max)* BACK OF HOSPITAL ISLAND $_{6}$

Geographic Location

Access Road: GLEBE ROAD $_{7}$
Township: $_{8}$
County: CHARLOTTE $_{9}$
Province/State: NB $_{10}$
Nearest Centre: SAINT ANDREWS $_{11}$
Population: 1500
Distance from Centre: . $_{13}$ km
Distance from shore: 1.5 $_{14}$ km
Pollution Source: MUN $_{15}$
Distance from source: . $_{16}$ km
Basin Name: PASSAMAQUODDY BAY $_{17}$
Basin Area: . $_{18}$ km²
Distance from river mouth: . $_{19}$ km

Physical Characteristics

Substrate: SANDY $_{20}$
Station Exposure: ° $_{21}$
Tidal Range: . $_{22}$ m

Audit Information

Established By: KAREN COOMBS $_{23}$
Agency: NBDFA $_{24}$
Date: 94.03.14 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NBMI 1

Station Name: MANAWAGONISH ISLAND 2

Latitude: ▨42.2055 3 (DD.MMMM)

Longitude: 66.1083 4 (DDD.MMMM)

Pos. Method: C 5 (C,G,T,O)

Station Description: INSIDE OF MANAWAGONISH ISLAND OFF BEACH 6
(120 Characters Max)

Geographic Location

Access Road: CHESLEY DRIVE 7

Township: 8

County: SAINT JOHN 9

Province/State: NB 10

Nearest Centre: SAINT JOHN 11

Population: 50000

Distance from Centre: . 13 km

Distance from shore: . 14 km

Pollution Source: IND 15

Distance from source: 5.0 16 km

Basin Name: 17

Basin Area: . 18 km²

Distance from river mouth: . 19 km

Physical Characteristics

Substrate: 20

Station Exposure: ° 21

Tidal Range: . 22 m

Audit Information

Established By: KAREN COMBS 23

Agency: NBDFA 24

Date: 94.03.14 25 (YY.MM.DD)

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NBSC $_{1}$

Station Name: SAINT CROIX RIVER $_{2}$

Latitude: 45.1002 $_{3}$ *(DD.MMMM)*

Longitude: 67.0965 $_{4}$ *(DDD.MMMM)*

Pos. Method: ☐ $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)* TODDS POINT AT MOUTH OF SAINT CROIX OPPOSITE BAYSIDE TERMINAL $_{6}$

Geographic Location

Access Road: GLEBE ROAD $_{7}$

Township: $_{8}$

County: CHARLOTTE $_{9}$

Province/State: NB $_{10}$

Nearest Centre: $_{11}$

Population: 8000

Distance from Centre: . $_{13}$ km

Distance from shore: . $_{14}$ km

Pollution Source: $_{15}$

Distance from source: . $_{16}$ km

Basin Name: SAINT CROIX ESTUARY $_{17}$

Basin Area: . $_{18}$ km²

Distance from river mouth: . $_{19}$ km

Physical Characteristics

Substrate: ROCKY $_{20}$

Station Exposure: ° $_{21}$

Tidal Range: . $_{22}$ m

Audit Information

Established By: KAREN COOMBS $_{23}$

Agency: NBDFA $_{24}$

Date: 94.03.14 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number:	NBSI	1			
Station Name:	MACHIAS SEAL ISLAND	2			
Latitude:	44.5016	3 (DD.MMMM)			
Longitude:	65.1016	4 (DDD.MMMM)	Pos. Method:	T	5 (C,G,T,O)
Station Description: *(120 Characters Max)*	UNINHABITED OFFSHORE ISLAND BIRD COLONY AND NESTING AREA	6			

Geographic Location

Access Road:	N/A	7			
Township:		8			
County:		9	Province/State:	NB	10
Nearest Centre:	SEAL COVE	11	Population:	50	
Distance from Centre:	26.0	13 km	Distance from shore:	19.0	14 km
Pollution Source:	NPO	15	Distance from source:	.	16 km
Basin Name:	BAY OF FUNDY	17			
Basin Area:	.	18 km²	Distance from river mouth:	.	19 km

Physical Characteristics

Substrate:	INTERTIDAL ROCK	20			
Station Exposure:	270	° 21	Tidal Range:	6.0	22 m

Audit Information

Established By:	J. MACHELL	23	Agency:	EC/EP	24
Date:	93.07.20	25 (YY.MM.DD)			

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NSDI $_{1}$

Station Name: DI GBY, ANNAPOLIS BASIN $_{2}$

Latitude: ▨44.3810 $_{3}$ *(DD.MMMM)*

Longitude: 65.4465 $_{4}$ *(DDD.MMMM)*

Pos. Method: C $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)*
CAGE SITE OFF OLD WEIR . 6 METER
FROM SOUTH END POST BEARING
S 340 FIGBUOY 270 FI12BUOY 120
BEAR ISLAND 315 GRAPPLE LINE $_{6}$

Geographic Location

Access Road: $_{7}$

Township: $_{8}$

County: DI GBY $_{9}$

Province/State: NS $_{10}$

Nearest Centre: DI GBY $_{11}$

Population: 5000

Distance from Centre: 1.4 $_{13}$ km

Distance from shore: 1.1 $_{14}$ km

Pollution Source: MUN $_{15}$

Distance from source: . $_{16}$ km

Basin Name: ANNAPOLIS $_{17}$

Basin Area: 1600.00 $_{18}$ km²

Distance from river mouth: 24.0 $_{19}$ km

Physical Characteristics

Substrate: MUD BOTTOM $_{20}$

Station Exposure: 360 ° $_{21}$

Tidal Range: 8.0 $_{22}$ m

Audit Information

Established By: B CRAWFORD $_{23}$

Agency: NSDOF $_{24}$

Date: 92.08.19 $_{25}$ *(YY.MM.DD)*

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NSBC 1

Station Name: BROAD COVE 2

Latitude: 44.6639 3 (DD.MMMM)

Longitude: 65.8312 4 (DDD.MMMM)

Pos. Method: ☐ 5 (C,G,T,O)

Station Description: *(120 Characters Max)* BROAD COVE: ALONG ROAD TO MOUNT PLEASANT, SMALL COVE ON BAY OF FUNDY 6

Geographic Location

Access Road: MOUNT PLEASANT ROAD 7

Township: 8

County: DIGBY 9

Province/State: NS 10

Nearest Centre: DIGBY 11

Population: 2311 12

Distance from Centre: 7.0 13 km

Distance from shore: .1 14 km

Pollution Source: NPO 15

Distance from source: .5 16 km

Basin Name: DIGBY–1DB 17

Basin Area: . 18 km²

Distance from river mouth: . 19 km

Physical Characteristics

Substrate: BASALT 20

Station Exposure: 60 ° 21

Tidal Range: 24.0 22 m

Audit Information

Established By: J. MACHELL 23

Agency: EC/EP 24

Date: 93.05.31 25 (YY.MM.DD)

Gulf of Maine
Monitoring Committee
GulfWatch Project

MONITORING STATION
Data Entry Form

Station Designation

Station Number: NSBC $_{1}$

Station Name: BROAD COVE, BAY OF FUNDY $_{2}$

Latitude: 44.4005 $_{3}$ *(DD.MMMM)*

Longitude: 65.4975 $_{4}$ *(DDD.MMMM)*   Pos. Method: C $_{5}$ *(C,G,T,O)*

Station Description: *(120 Characters Max)*
CAGE SITE EAST OF WHARF. SIXTY
METERS EAST OF LAST BUOY
GRAPPLING LINE RUNS FROM LAST
BUOY TO CAGES $_{6}$

Geographic Location

Access Road: CULLODEN BROAD COVE ROAD $_{7}$

Township: $_{8}$

County: DIGBY $_{9}$ Province/State: NS $_{10}$

Nearest Centre: DIGBY $_{11}$ Population: 5000

Distance from Centre: 15.0 $_{13}$ km   Distance from shore: 0.1 $_{14}$ km

Pollution Source: $_{15}$ Distance from source: . $_{16}$ km

Basin Name: BAY OF FUNDY $_{17}$

Basin Area: . $_{18}$ km²   Distance from river mouth: . $_{19}$ km

Physical Characteristics

Substrate: LEDGE AND ROCK $_{20}$

Station Exposure: 135 °$_{21}$ Tidal Range: 8.0 $_{22}$ m

Audit Information

Established By: B CRAWFORD $_{23}$ Agency: NSDOF $_{24}$

Date: 92.08.19 $_{25}$ *(YY.MM.DD)*