EVALUATION OF GULFWATCH 1998:

EIGHTH YEAR OF THE GULF OF MAINE ENVIRONMENTAL MONITORING PLAN

Gulf of Maine Council on the Marine Environment
December 2001

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1.0 INTRODUCTION

1.1 Rationale

The Gulf of Maine extends from Cape Sable, Nova Scotia, through New Brunswick, Maine, and New Hampshire to Cape Cod, Massachusetts, and includes the Bay of Fundy and Georges Bank. The combined productivity of seaweed, salt marsh grasses, and phytoplankton make it one of the world's most productive ecosystems that supports a vast array of animal species, including some of great commercial importance. Commercial fisheries are its principal income generating enterprises, tourism is also a significant source of income to coastal communities and marine aquaculture is rapidly expanding. Increases in coastal populations and industrial and residential development have contributed to the deteriorating quality of sections of the Gulf's coastal environment (Crawford and Sowles 1992, Dow and Braasch 1996). One important factor is the steady input of toxic chemicals, either mobilized or synthesized by man, into the estuarine and coastal environments, despite efforts to improve pollution treatment. Many human-made chemicals are bioaccumulated to concentrations significantly above ambient levels. Furthermore, some of these environmental contaminants may also be present at toxic concentrations, and thus induce adverse biological effects on productivity, reproduction and survival of marine organisms and humans (Kawaguchi et al. 1999, Wells and Rolston 1991).

To protect water quality and commercial uses in the Gulf of Maine, the *Agreement on the Conservation of the Marine Environment of the Gulf of Maine* was signed in December 1989 by the premiers of Nova Scotia and New Brunswick and the governors of Maine, New Hampshire and Massachusetts establishing the Gulf of Maine Council on the Marine Environment. The overarching mission of this council is to maintain and enhance the Gulf's marine ecosystem, its natural resources and environmental quality. To help meet the council's mission statement, The Gulf of Maine Environmental Monitoring Committee was formed and charged with the development of the Gulf of Maine Environmental Monitoring Plan (Hayden, 1991). The monitoring plan is based on a mission statement provided by the council:

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

Three monitoring goals were established to meet the mission statement:

(1) To provide information on the status, trends, and sources of risk to the marine environment in the Gulf of Maine;
(2) To provide information on the status, trends and sources of marine based human health risks in the Gulf of Maine; and
(3) 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.

In support of the mission and as a first step towards meeting the desired goals, a project named Gulfwatch was established to measure chemical contamination Gulfwide.

1.2 Gulfwatch Objectives

Gulfwatch is presently a program in which the blue mussel, *Mytilus*, is used as an indicator for habitat exposure to organic and inorganic contaminants. Bivalves such as *M. edulis* have been successfully used as an indicator organism in environmental monitoring programs throughout the world (see NAS, 1980; NOAA, 1991; and Widdows and Donkin, 1992) to identify variation in chemical contamination between sites, and contribute to the understanding of trends in chemical contamination (NOAA, 1991; O'Connor, 1998; Widdows et al., 1995). The blue mussel was selected as an indicator organism for the Gulfwatch program for the following reasons:

(1) mussels are abundant within and across each of the 5 jurisdictions bordering the Gulf and they are easy to collect and process;
(2) much is known about mussel biology and physiology;
(3) mussels are a commercially important food source and therefore a measurement of the extent of chemical contamination is of public concern;
(4) mussels are sedentary, thereby eliminating the complications in interpretation of results introduced by mobile species;
(5) Mussels are suspension feeders that pump large volumes of water and concentrate many chemicals in their tissues. Therefore, the presence of trace contamination is easier to document, and the measurement of chemicals in bivalve tissue provides an assessment of biologically available contamination that is not always apparent from measurement of contamination in environmental compartments (water, sediment, and suspended particles).

Throughout the history of the program, Gulfwatch has taken different approaches to using mussels as bioindicators of anthropogenic contamination. During the first two years of the program (1991-1992), both transplanted and native mussels sampled from areas adjacent to the transplant sites were analyzed for organic and inorganic contaminants (GOMC, 1992). Transplanted mussels were initially collected

from relatively pristine sites in each jurisdiction, moved to sites selected for monitoring and held there for approximately 60 days. Because of the logistics and the analytical costs, however, only two sites per jurisdiction could be monitored each year using this transplant technique. Transplant provided an assessment of the short-term exposure (on the order of weeks to months) to bioavailable contaminants throughout the region whereas sampling of native mussels provided an assessment of long-term exposure to bioavailable contaminants (on the order of months to a year). It was therefore decided to design a sampling program, which included transplant experiments to assess short-term exposure. However, in order to assess the degree and extent of contamination in the Gulf of Maine many sites need to be monitored throughout the Gulf of Maine. As such a sampling scheme involving a three-year rotation of sites (see below) was implemented in 1993 and continued until 1998. In 1996, a five-year review of the program assessed the feasibility of continuing transplant studies (Jones et al., 1998). Considering the cost of performing transplant experiments, the low rate of return, missing data, and the complications with the interpretation of the data it was decided that (at least for the present) transplant studies would be abandoned. For the 1998 year this meant that additional (previously unsampled) sites could be added to the program to increase the coverage in certain areas of concern. New sample sites were therefore established in New Hampshire and New Brunswick. Sampling of the New Hampshire sites was in conjunction with the New Hampshire Gulfwatch program. Associations with such programs are advantageous to the Gulfwatch program and only serve to highlight the usefulness of such an endeavor. The New Brunswick sites were chosen so as to provide better coverage of Saint John, New Brunswick's inner harbour which is a major population and industrial centre on the Bay of Fundy and a potentially significant contaminant contributor to the Bay.

In addition to documenting the level of contaminants in mussel tissue, biological variables, including shell growth and condition index, were measured as a means to determine the response of organisms to stress under different concentrations of contaminant burden. Growth is often one of the most sensitive measures of the effect of a contaminant on an organism (Sheehan, 1984; Sheehan et al., 1984; Howells et al., 1990). Shell growth has often been used as a measure of environmental quality and pollution effects as the rate of growth is a fundamental measure of physiological fitness/performance (Widdows and Donkin, 1992; Salazar and Salazar, 1995) and therefore is a direct, integrative measure of the impairment of the organisms physiology. Condition index (CI) was used as an indicator of the physiological status of the mussels. It relates the tissue wet weight to shell volume and is a measure traditionally used by shellfishery biologists (Widdows, 1985). Because gonadal weight is a significant contributor to total body weight just prior to spawning, CI also reflects differences in the reproductive state of sampled mussels. Since gonadal material tends to have low concentrations of metals (LaTouche and Mix, 1981), tissue metal concentrations may be reduced in mussels having a high CI due to ripened gonads. Organic contaminants, however, would tend to partition into both somatic and gonadal lipids, and may be less impacted by changes in CI that are due to the presence of ripe gametes. Since variable amounts of ripe gametes may be found in some mussel

populations even in late fall (Kimball, 1994), the relationship between CI and contaminant concentrations must be carefully considered.

The objective of the first two years (1991 and 1992) of the Gulfwatch program was to evaluate the feasibility of the project and the level of co-operation required through collecting comparative data from different locations in the Gulf of Maine. The sites that were selected fell into two categories; test sites that were suspected or known to be contaminated and reference sites that were free of any known contaminant source. After the success of the pilot studies in 1991 and 1992, it was recognised that there should be a broader or Gulf-wide orientation of the mussel watch in addition to known contaminated and reference sites within each jurisdiction. As such, a three-year cycle was initiated in 1993. In the first two years of the three-year cycle, only indigenous mussels are sampled. In 1993 and 1994 as many as 7 new locations within each jurisdiction (state or province) where feasible, were sampled to increase the geographic coverage. However, one location in each jurisdiction was chosen as a baseline station to be resampled every year. This approach increased the chance of locating unforeseen environmental contamination. In the third year of the three-year cycle transplant experiments are conducted at two sites in each jurisdiction. This three-year cycle, with transplants being conducted at two sites during one year and indigenous mussels alone being sampled at 2-7 sites per jurisdiction during the other two years, was to be repeated for the remaining years of the Gulfwatch Program to allow for the assessment of both short-term and long-term contaminant exposure. However, as mentioned above the loss of the transplant study to the program has allowed for expansion of study sites within select regions of concern in two Jurisdictions in 1998.

2.0 METHODS

2.1 1998 Sampling Locations

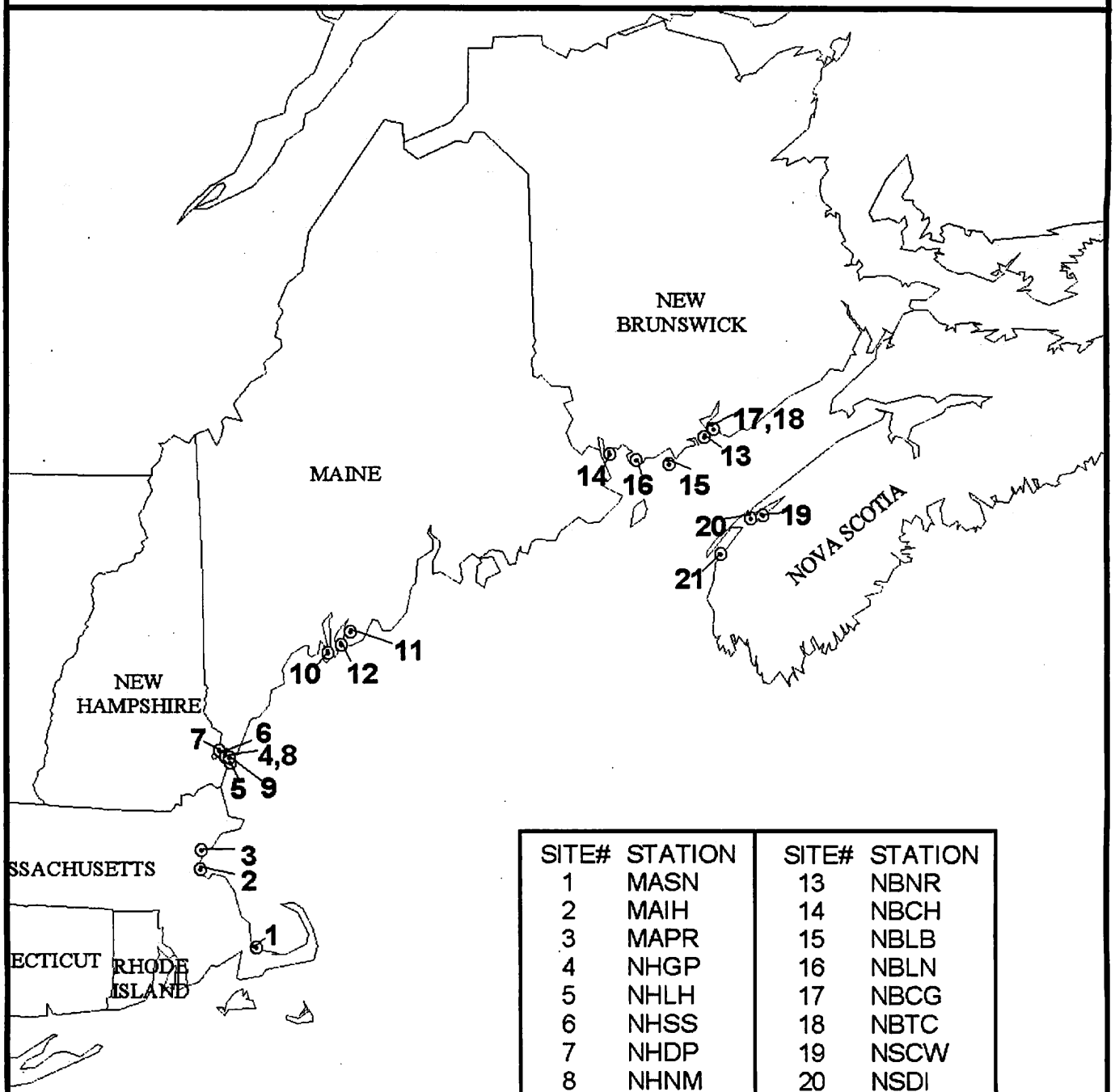
The 1998 Gulf of Maine mussel survey is the sixth year of the nine year sampling design (see Sowles et al., 1997). The 1998 sampling represents the third year of the second 3-year cycle. As such, some stations that were sampled in 1998 were the same stations sampled in 1995. Therefore, in addition to spatial analysis, temporal analysis can be performed on the contaminant concentrations for comparable sites. In addition to repeating the sites sampled in 1995 three new sites were sampled in New Hampshire (NHGP, NHSS, NHNM) and two in New Brunswick (NBCG, NBTC). In New Hampshire samples were also taken at Dover Point (NHDP) and Little Harbor (NHLH). These sites are sampled as part of the New Hampshire Gulfwatch Program and were included to provide a more comprehensive assessment of toxic contaminant exposure, especially oil, to biota in New Hampshire estuarine waters. Sites sampled in 1995 that were not sampled in 1998 include NHHS, MEBC, and NBMI. NHHS and MEBC were used in the past as "clean sites" for the transplant experiment. As mentioned above, the transplant experiments were not carried out as scheduled in 1998. The New

Brunswick Manawagonish site (NBMI) was not sampled on 1998 because no mussel populations could be found. The stations sampled in 1998 are presented in Table 1 with reference to site numbers in Fig. 1.

TABLE 1.
Gulf of Maine Gulfwatch study site locations sampled in 1998

CODE	LOCATION	LATITUDE	LONGITUDE
MASN	Sandwich, MA	41°45.73'N	70°28.38'W
MAIH	Boston, Inner Harbor, MA	41°21.53'N	71°2.94'W
MAPR	Pines River, MA	42°25.87'N	70°58.76'W
NHGP	Gypsum Point, NH		
NHLH	Little Harbor, NH	43°2.00'N	70°43.0'W
NHSS	Schiller Station, NH		
NHDP	Dover Point, NH		
NHNM	North Mill Pond, NH		
MECC	Clarks Cove, ME	43°04.00'N	70°43.40'W
MEKN	Kennebec River, ME	43°47.5'N	69°47.6'W
MEDM	Damariscotta, ME	43°56.30'N	69°34.90'W
MEBB	Boothbay Harbor, ME		
NBNR	Niger Reef, NB	43°51.35'N	69°35.41'W
NBCH	Chamcook, NB	45°07.4'N	67°03.2'W
NBLB	Limekiln Bay, NB		
NBLN	Letang Estuary, NB	45°04.6'N	66°48.0'W
NBCG			
NBTC			
NSCW	Cornvallis, NS	44°65.70'N	65°66.77'W
NSDI	Digby, NS	44°38.1'N	65°44.7'W
NSBE	Belliveaus Cove, NS	44°24.15'N	66°02.45'W

FIGURE 1. Gulfwatch site locations sampled in 1998.



SITE#	STATION
1	MASN
2	MAIH
3	MAPR
4	NHGP
5	NHLH
6	NHSS
7	NHDP
8	NHNM
9	MECC
10	MEKN
11	MEDM
12	MEBB

SITE#	STATION
13	NBNR
14	NBCH
15	NBLB
16	NBLN
17	NBCG
18	NBTC
19	NSCW
20	NSDI
21	NSBE

2.2 Field and Laboratory Procedures

Details regarding the mussel collection, measurement, and sample preparation are published in Sowles et al. (1997).

Gulfwatch attempts to control confounding variables by collecting organisms within a specific size range, at the same site, at similar tidal levels and at the same time of the year, early fall, after major spawning has occurred (GOMC, 1997). Details regarding the field procedures, including mussel collection, measurement and sample preparation, for the Gulfwatch program are published in GOMC (1997) and summarised below.

The mussels collected were intended to be *Mytilus edulis*. However, a related species, *Mytilus trossulus*, was identified in some Bay of Fundy samples (GOMC, 1994; Mucklow, 1996). Gulfwatch results could be confounded by inadvertent selection, by field personnel, of the wrong species. To alleviate this problem, a description of *M. edulis* was developed for the Gulfwatch program using shell criteria such as length:height ratio, internal color, weight, and location and size of the adductor scars (GOMC, 1998).

Field sampling occurred between mid-September and mid-November. Mussels were collected from four discrete areas within a segment of the shoreline that is representative of local water quality. Using a wooden gauge or a ruler, 45-50 mussels of 50-60 mm shell length were collected. The mussels were cleaned of all sediment, epibiota, and other accretions in clean seawater from the collection site, placed in clean containers, then transported to the lab in coolers with ice packs. They were not depurated prior to processing.

In the laboratory the mussels were divided into 4 replicate composites of 50 individuals. From each replicate, 20 mussels were analysed for trace metals and 20 for organic contaminants. Mussels were washed to remove easily detached external growth, sediment and debris using clean seawater at the site. They were drained of excess seawater in their mantle either at the site or later in the laboratory, and then measured for length (anterior umbo to posterior growing lip), height (distance dorsal-ventral) and maximum width to the nearest 0.1mm in the laboratory. A subset of mussels (10) used for metal analysis was shucked and weighed wet (±0.1g) for reporting contaminant concentrations and for calculation of a condition index. Condition index was calculated using the following formula (after Seed, 1968):

Condition index (CI) = wet tissue weight (mg) / [length (mm) * width (mm) * height (mm)]

All samples for trace metal and organic contaminant analysis were placed in pre-cleaned or quality assured bottles (GOMC, 1997) and stored at -15□C for 3-6 months prior to analysis. Composite samples (20 mussels/composite; 4 composites/station) were capped, labelled and stored at -15°C for 3-6 months prior to analysis

2.3 Analytical Procedures

Analytical procedures used followed those reported for the previous years (Chase et al. 1998, Jones et al. 1998). Table 2 contains a summary of trace metal and organic compounds measured.

2.3.1 Metals

Inorganic contaminants were analyzed at the State of Maine Health and Environmental Testing Laboratory (Augusta, ME). Analyses for mercury were done on a sub-sample of 1 to 2 g of wet tissue and measured by cold vapor atomic absorption on a Perkin Elmer Model 503 atomic absorption spectrometer. Analyses for all other metals were conducted on 5 to 10 g of wet tissue dried at 100°C. Zinc and iron were measured by flame atomic absorption using a Perkin Elmer Model 1100 atomic absorption spectrometer. All remaining metals (Ag, Al, Cd, Cr, Cu, Ni and Pb) were run using Zeeman background corrected graphite furnace atomic absorption on a Varian Spectra AA 400. The analyte detection limits for the metals in μg/g dry weight are as follows; Ag, 0.1; Al, 3.0; Cd, 0.2; Cr, 0.3; Cu, 0.6; Fe, 6.0, Hg, 0.1, Ni, 1.2, Pb, 0.6; and Zn, 1.5.

2.3.2 Organics

Organic contaminants in mussel samples were analyzed at the Environment Canada regional laboratory at Bedford Institute of Oceanography in Dartmouth, Nova Scotia (1991-1995) and the Environment Canada Environmental Quality Laboratory in Moncton, New Brunswick (1996-1998). The analyte detection limits ranged from 3.6-12.6 ng/g for aromatic hydrocarbons, from 0.7-2.8 ng/g for PCB congeners, and from 0.9- 2.0 ng/g for chlorinated pesticides (GOMC, 1998). Eighteen of the PCB congeners identified and quantified correspond to congeners analyzed by the National Oceanographic and Atmospheric Administration's (NOAA) National Status and Trends (NS&T) Program designated congeners. Other organic compounds selected for analysis are also consistent, for the most part, with NOAA National Status and Trends mussel monitoring (NOAA 1989).

The analyses of mussel tissue samples follow the diagram shown in Figure 2 and are summarized below. A description of the full analytical protocol and accompanying performance based QA/QC procedures are found in Sowles et al. (1997), and more comprehensively in Jones et al. (1998). Tissue samples were extracted by homogenization with an organic solvent and a drying agent. Solvent extracts were obtained by vacuum filtration, and biomatrix interference was separated from target analytes in extracts by size exclusion chromatography. Purified extracts were subjected to silica gel liquid chromatography, which provided a non-polar PCB/chlorinated pesticides fraction and a polar chlorinated pesticide fraction. PCBs and pesticides were analyzed by high-resolution dual column gas

chromatography/electron capture detection (HRGC/ECD). Following PCB and pesticide analysis, the two fractions were combined and the resulting extract was analyzed for aromatic hydrocarbons by high-resolution gas chromatography/mass spectrometry (HRGC/MS).

TABLE 2.
Inorganic and Organic compounds analyzed in mussel tissue from the Gulf of Maine in 1998.

INORGANIC CONTAMINANTS

Metals

Ag, Al, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Zn

ORGANIC CONTAMINANTS

Aromatic Hydrocarbons

Naphthalene
1-Methylnaphthalene
2-Methylnaphthalene
Biphenyl
2,6-Dimethylnaphthalene
Acenaphthylene
Acenaphthalene
2,3,5-Trimethylnaphthalene
Fluorene
Phenanthrene
Anthrasene
1-Methylphenanthrene
Fluoranthrene
Pyrene
Benzo [a] anthracene
Chrysene
Benzo [b] fluoranthrene
Benzo [k] fluoranthrene
Benzo [e] pyrene
Benzo [a] pyrene
Perylene
Indo [1,2,3-cd] pyrene
Dibenze [a,h] anthracene
Benzo [g,h,I] perylene

Chlorinated Pesticides

Hexachlorobenzene (HCB)
gamma-Benzenehexachloride (BHC)
Heptachlor
Heptachlor epoxide
Aldrin
Lindane
cis-Chlordane
trans-Nonachlor
Dieldrin
alpha-Endosulfan
beta-Endosulfan

DDT and Homologues

2,4'-DDE	4,4'-DDE
2,4'-DDD	4,4'-DDD
2,4'-DDT	4,4'-DDT

PCB Congeners

PCB 8, PCB 18, PCB 28, PCB 29,
PCB 44, PCB 50, PCB 52, PCB 66,
PCB 77, PCB 87, PCB 101, PCB 105,
PCB 118, PCB 126, PCB 128, PCB 138,
PCB 153, PCB 169, PCB 170, PCB 180,
PCB 187, PCB 195, PCB 206, PCB 209

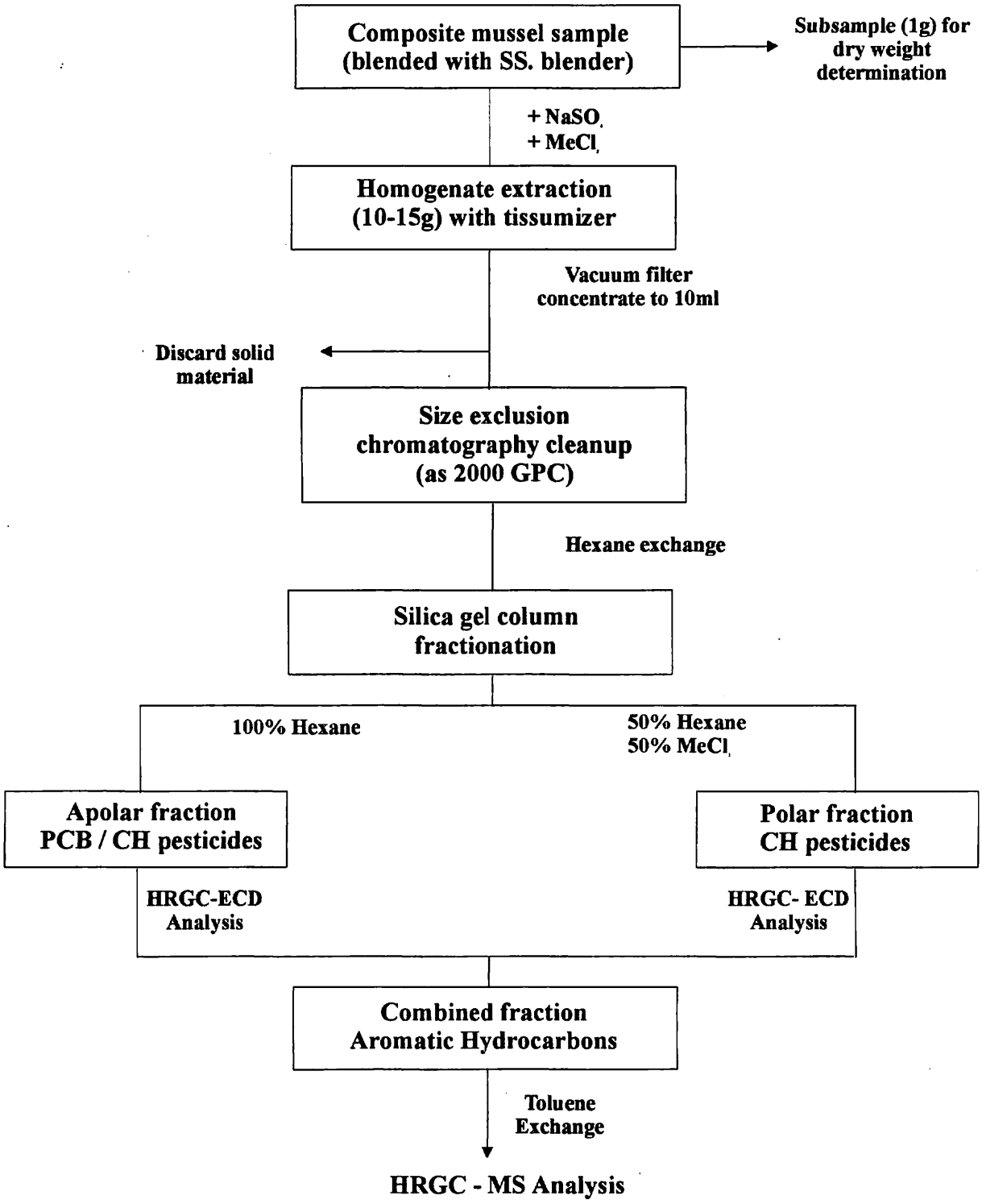


Figure 2. Analytical flow chart for organic analyte determination at the Environment Canada Laboratory in 1995.

2.4 Quality Assurances / Quality Control

Standard laboratory procedures for metals incorporated method blanks, spike matrix samples, duplicate samples, surrogate addition and standard oyster tissue (SRM 1566A). The method blanks were inserted: three at the beginning of the run, one at the end, and six at various intervals during the run. Duplicate samples and matrix spike recoveries were conducted on 15% of the samples. The Moncton laboratory participated in the NIST Status and Trends Intercomparison Marine Sediment Exercise IV and Bivalve Homogenate Exercise. Internal laboratory quality control followed by the Moncton laboratory for the analysis of organic contaminants in mussel samples are in the Environment Canada Shellfish Surveillance Protocol (Dumouchel & Hnnigar, 1995). The guidelines specify mandatory QC measures that are incorporated with each analytical sample batch including method blanks, spike matrix samples, duplicate samples, sample surrogate addition, and the analysis of certified reference materials (SRM, 1974a). The guidelines also specify performance criteria related to method accuracy and precision, detection limits and data reporting for the analysis of organic contaminants in shellfish samples. Appendix A contains the Moncton laboratory's QC sample results for the analyses of the 1998 Gulfwatch samples. The laboratory also participates annually in the NIST/NOAA NS&T EMAP Intercomparison Exercise Program for Organic Contaminants in the Marine Environment.

2.5 Statistical Methods

2.5.1 Data Analysis

Total PAH (ΣPAH_{24}), total PCB (ΣPCB_{24}) and total pesticides ($\Sigma TPEST_{17}$) values were created from the sum of all individual compounds or congeners with values greater than the detection limit for the compound. Total DDT (ΣDDT_6) is the sum of o,p'-DDT and p,p'-DDT and homologues (o,p'-DDE, p,p'-DDE, o,p'-DDD and p,p'-DDD). Several tissue samples for metals and organics were below the detection level. Variables in which all replicate measurements were below the detection limit were treated as zero and recorded as not-detected (ND). However, if at least one of the replicates was greater than the detection limit, then the other replicates were recorded as 1/2 the detection limit.

All metal data, with the exception of Ag and Ni, were $\log_{10}$ transformed to correct for heterogeneity of variances whereas all organic contaminant data, Ag and Ni were $\log_{10}(x+1)$ transformed.

2.5.2 Spatial Analysis

At each site, arithmetic means and standard deviations (SD) were calculated for all metal and organic contaminants. Arithmetic means were calculated since, with a few exceptions, metals and organics at each station were normally distributed as demonstrated by applying Kolmogorov-Smorov test using p=0.05 (SPSS, 1996). Medians (MD) and MD + 1 SD (defined as the 85^{th} percentile) were calculated for both Gulfwide comparisons and National NS&T intercomparisons of mussel contaminants. Electronic files of the NS&T contaminant data for 1991 to 1996 were downloaded from the following Internet address: http://ccmaserver.nos.noaa.gov/. Although medians were calculated for each year, only 1991 values were used as the basis of comparison as it was the last year with a large sample size. Graphs of the mean concentrations (±SD) are presented for all stations sampled. Differences in metal and organic contaminant concentrations among sites within each jurisdiction were analysed by one-way analysis of variance (ANOVA), followed be Tukey-Kramer multiple comparison test of means. A probability of < 0.05 was chosen as the level of significance. For analysis, Clark Cove, Maine (MECC) is discussed as being a New Hampshire site because it is located in the Great Bay / Piscataqua River watershed, and therefore more comparable to other sites in New Hampshire.

2.5.3 Temporal Analysis

Tissue contamination concentrations were analyzed for temporal trends using a repeated-measures Analysis of Variance (ANOVA) using site and year variables. The following sites: MASN, MECC, MEKN, NBHI and NSDI were sampled in consecutive years (1993-1998), a prerequisite for a repeated-measures ANOVA design. The advantage of repeated measures ANOVA is that it controls for variation within sites while searching for common patterns among sites. In addition to looking for whether the pattern in contaminant concentration (metal and organic) was the same among sites, orthogonal polynomial models were added to the repeated measures design to assess whether there were significant relationships between contaminant concentration and time at each site (SAS, 1990).

In addition to temporal analysis of the benchmark sites, tissue concentrations from the 1998 sampling sites were compared to concentrations from samples at these sites taken in 1995. Concentrations in 1995 and 1998 were compared at each site using a Student T test. A probability of $<$ 0.05 was chosen as the level of significance.

3.0 RESULTS AND DISCUSSION

3.1 Field Operations and Logistics

Field collections proceeded as planned in all jurisdictions. The number of sampling stations was low in Massachusetts and Maine as a result of the removal of transplant experiments from this year's protocol. However, additional sites were monitored in New Hampshire (total n=5) and New Brunswick (n=3), in comparison to sampling done in 1995.

3.2 Spatial Variation in Contaminant Concentrations

Table 3 contains the metal concentrations (arithmetic mean ± SD, μg/g dry weight) for mussels from all site composite (n=4) samples in 1998. Metal concentrations for each of the composite samples are provided in Appendix B. Overall metal concentrations for indigenous mussels are given as medians (MD) and MD + 1 SD (Table 3) to allow for both a Gulfwide comparison and a comparison with NOAA National Status and Trends concentrations (Table 4). Table 4 includes values for MD and MD + 1SD from the 1991 NS&T Mussel Watch data (O'Connor, 1998; http://ccmaserver.nos.noaa.gov/). Trace metals were detected at all sites except for Ag, which was below the detection limit (0.1 μg/g dry weight) at 9 of the 21 sites. Using the NS&T MD + 1 SD value as a measure of elevated concentrations, two sites exceeded the Ag value, 7 sites exceeded the Cr value, 6 sites exceeded the Cu value, 17 sites exceeded the Hg value, 2 sites exceeded the Ni value, 7 sites exceeded the Pb value, four sites exceeded the Al value and one site exceeded the Fe value out of the total of 21 sites. Trace metals for which a few sites exceeded the NS&T MD + 1 SD value suggests localized sources of these contaminants at those sites. However, for Cr, Cu, Pb and especially Hg, more widespread elevated levels suggest possible regional sources of these contaminants.

3.2.1 Metals

Figures 3 to 7 show the concentration of the metals measured in the tissue of *M. edulis* at the 1998 sampling stations arranged from south to north. The concentrations of most metals were relatively evenly distributed around the Gulf of Maine (Table 3), with no apparent spatial trends and an occasional hot spot of elevated concentrations.

3.2.1.1 Silver (Ag)

Silver concentrations ranged from below the detection limit (0.1 µg/g dry weight) to 1.82 ± 0.20 (NBCG), and showed a strong geographical hot spots of elevated concentrations in areas in each jurisdiction except New Hampshire along the Gulf of Maine (Table 3; Fig. 3). The highest concentrations were observed in Massachusetts from Boston Harbor south to Sandwich, and in New Brunswick around St. John Harbour. Concentrations at these sites exceeded the MD + 1 SD of both the Gulfwatch and the NOAA NS&T programs. Elevated silver exposure concentrations have been shown to coincide with regions receiving municipal sewage (Sanudo-Wlhelmy and Flegal 1992, Buchholz ten Brink et al. 1996). Because of silver's use in the photographic and jewellery industries, the coastal waters of Massachusetts are up to 1000 times more concentrated in Ag than in Gulf of Maine waters (Krahforst and Wallace 1996). The high levels observed at MASN, which is not near to any significant source of municipal waste, may be a function of transport and deposition of sewage-derived particles (Bothner et al. 1993) that are sequestered in Cape Cod Bay and taken up by mussels. Elevated levels of silver in mussels were measured at sites in Saint John New Brunswick's inner harbour NBCG (1.8±0.2) and NBTC (0.16±0.13). Silver concentrations in mussels at NBCG, in particular were comparable to the highest concentrations measured in past years at Gulfwatch sites in the southern Gulf (Jones et al. 1998). Saint John NB is a major population centre on the Bay of Fundy with a variety of industrial activities that include ship repair, pulp and paper, petroleum refining, oil handling facilities and transportation. The source(s) of elevated silver, as well as, elevated copper in mussels at NBGG and NBTC has not been identified. While residual grit contained in the gut of the mussels from NBCG and NBTC, as well as, NBNR, NBCH, NBLB, and NBLN could influence metal concentrations in samples, it is worth noting that elevated levels of silver, copper, cadmium, and zinc have been reported in lobsters from the inner Bay of Fundy including Saint John Harbour (Chou et al. 2000). The authors of this study report that elevated levels of these metals in lobsters were not correlated with metal concentrations in sediments from lobster capture sites. In contrast, despite the presence of numerous municipal sewage sources in the Great Bay Estuary, Ag was not detected in mussels from any New Hampshire site.

TABLE 3.

Tissue metal concentrations (arithmetic mean ± SD, $\mu g.g^{-1}$ dry weight) from mussels collected throughout the Gulf of Maine in 1998 and ANOVA of concentrations by jurisdiction. Same letter indicates no significant difference among sites within each jurisdiction. ND = not detected. MD ± SD = Median ± 85 percentile

Station	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
MASN	0.83 ± 0.04^{B}	1.9 ± 0.41^{A}	1.13 ± 0.19^{A}	6.2 ± 1.3^{A}	3.15 ± 0.64^{A}	0.37 ± 0.06^{A}	ND^{A}	101 ± 63^{A}	72 ± 17^{A}	218 ± 39^{A}
MAIH	0.13 ± 0.12^{A}	2.65 ± 0.34^{B}	1.75 ± 0.24^{B}	19.5 ± 5.1^{B}	32.3 ± 3.3^{C}	0.55 ± 0.02^{B}	1.30 ± 0.16^{B}	258 ± 41^{B}	133 ± 33^{B}	510 ± 112^{B}
MAPR	ND^{A}	1.9 ± 0.29^{A}	2.93 ± 0.49^{C}	8.7 ± 0.6^{A}	6.65 ± 0.25^{B}	0.51 ± 0.06^{C}	1.40 ± 0.18^{C}	110 ± 8^{A}	195 ± 6^{C}	358 ± 37^{B}
NHGP	ND^{A}	1.93 ± 0.52^{A}	2.08 ± 0.56^{A}	4.7 ± 1.3^{A}	3.33 ± 0.56^{AB}	0.86 ± 0.09^{AB}	1.35 ± 0.24^{AB}	111 ± 25^{A}	175 ± 49^{A}	358 ± 103^{A}
NHLH	ND^{A}	2.43 ± 0.10^{A}	2.75 ± 0.98^{A}	5.1 ± 0.3^{AB}	4.65 ± 0.37^{B}	1.00 ± 0.06^{BC}	1.73 ± 0.17^{AB}	105 ± 17^{A}	163 ± 31^{A}	375 ± 35^{A}
NHSS	ND^{A}	2.25 ± 0.51^{A}	2.30 ± 0.18^{A}	6.1 ± 0.5^{ABC}	3.15 ± 0.48^{A}	1.08 ± 0.10^{C}	1.45 ± 0.24^{AB}	128 ± 10^{A}	193 ± 34^{AB}	385 ± 38^{A}
NHDP	ND^{A}	2.80 ± 0.28^{B}	2.95 ± 0.06^{A}	6.0 ± 0.7^{ABC}	3.03 ± 0.31^{A}	0.97 ± 0.05^{AC}	1.70 ± 0.20^{AB}	130 ± 14^{A}	203 ± 39^{AB}	385 ± 50^{A}
NHNM	ND^{A}	1.98 ± 0.37^{AB}	2.33 ± 0.44^{A}	6.5 ± 0.6^{BC}	5.18 ± 1.45^{B}	0.79 ± 0.12^{A}	1.24 ± 0.20^{A}	135 ± 21^{A}	260 ± 54^{AB}	483 ± 100^{A}
MECC	ND^{A}	2.08 ± 0.13^{A}	3.18 ± 0.70^{A}	7.2 ± 0.7^{C}	5.75 ± 0.70^{B}	0.82 ± 0.11^{AB}	2.33 ± 1.08^{B}	135 ± 24^{A}	298 ± 65^{B}	528 ± 80^{A}
MEKN	0.12 ± 0.05^{A}	2.08 ± 0.43^{B}	1.27 ± 0.23^{A}	5.3 ± 0.6^{A}	1.58 ± 0.40^{A}	0.41 ± 0.09^{AB}	0.71 ± 0.36^{A}	53 ± 10^{A}	117 ± 26^{A}	225 ± 42^{A}
MEDM	0.07 ± 0.04^{A}	1.23 ± 0.10^{A}	1.25 ± 0.21^{A}	5.2 ± 0.4^{A}	1.75 ± 0.19^{A}	0.34 ± 0.10^{A}	1.03 ± 0.15^{A}	67 ± 3^{A}	293 ± 94^{B}	345 ± 102^{A}
MEBB	0.08 ± 0.03^{A}	0.96 ± 0.10^{A}	1.25 ± 0.27^{A}	13.5 ± 1.9^{B}	15.8 ± 2.06^{B}	0.52 ± 0.04^{B}	0.65 ± 0.30^{A}	111 ± 13^{B}	258 ± 103^{B}	380 ± 109^{A}
NBNR	0.08 ± 0.03^{AB}	0.74 ± 0.05^{A}	0.82 ± 0.11^{A}	4.6 ± 0.4^{A}	0.58 ± 0.12^{A}	0.22 ± 0.03^{B}	0.96 ± 0.05^{A}	65 ± 3^{A}	285 ± 45^{A}	358 ± 43^{AB}
NBCH	ND^{A}	0.88 ± 0.17^{A}	0.69 ± 0.06^{A}	5.2 ± 0.5^{A}	0.60 ± 0.20^{A}	0.22 ± 0.05^{B}	0.87 ± 0.08^{A}	68 ± 8^{A}	175 ± 21^{A}	245 ± 24^{A}
NBLB	0.04 ± 0.03^{AB}	1.50 ± 0.10^{B}	2.50 ± 0.50^{AB}	13.0 ± 2.0^{B}	2.70 ± 2.70^{C}	0.14 ± 0.03^{A}	1.40 ± 0.10^{A}	85 ± 11^{AB}	835 ± 53^{B}	609 ± 61^{BC}
NBLN	0.05 ± 0.07^{AB}	1.50 ± 0.10^{B}	17.5 ± 31.4^{AD}	12.0 ± 4.0^{B}	1.60 ± 0.40^{B}	0.11 ± 0.00^{A}	9.80 ± 17.4^{A}	82 ± 8^{A}	777 ± 148^{B}	678 ± 315^{C}
NBCG	1.82 ± 0.20^{C}	2.00 ± 0.30^{C}	4.00 ± 1.00^{AC}	29.0 ± 10.0^{C}	2.30 ± 0.30^{BC}	0.29 ± 0.20^{BC}	1.90 ± 0.40^{A}	139 ± 10^{C}	793 ± 179^{B}	696 ± 160^{C}
NBTC	0.16 ± 0.13^{B}	2.50 ± 0.30^{D}	12.9 ± 7.80^{BCD}	29.0 ± 8.0^{C}	2.30 ± 0.80^{BC}	0.33 ± 0.03^{C}	6.60 ± 3.30^{A}	110 ± 24^{BC}	2925 ± 1870^{C}	2131 ± 764^{D}
NSCW	0.08 ± 0.05^{A}	2.73 ± 0.39^{B}	1.70 ± 0.14^{A}	5.7 ± 1.2^{A}	3.40 ± 0.39^{C}	0.45 ± 0.07^{A}	1.88 ± 0.26^{B}	87 ± 21^{A}	388 ± 46^{A}	523 ± 59^{B}
NSDI	0.08 ± 0.05^{A}	1.60 ± 0.18^{A}	1.43 ± 0.22^{A}	5.3 ± 1.4^{A}	2.70 ± 0.22^{B}	0.46 ± 0.06^{A}	1.63 ± 0.15^{B}	94 ± 16^{A}	338 ± 31^{A}	485 ± 37^{B}
NSBE	ND^{A}	1.70 ± 0.00^{A}	1.27 ± 0.12^{A}	6.7 ± 0.2^{A}	1.67 ± 0.15^{A}	0.37 ± 0.03^{A}	1.20 ± 0.10^{A}	84 ± 8^{A}	180 ± 65^{B}	313 ± 46^{A}
MD±SD	**0.04±0.15**	**1.90±2.50**	**1.90±3.20**	**6.5±16**	**2.80±6.6**	**0.45±0.94**	**1.30±1.90**	**100±140**	**230±7.7**	**400±606**

TABLE 4

Comparison of contaminant concentrations (median (MD) and MD + 1SD) of Gulfwatch and NOAA, National Status and Trends (NS&T) Mussel Watch data (O'Connor, 1998; http://ccmaserver.nos.noaa.gov/). Concentrations of metal contaminants are $\mu g.g^{-1}$ dry weight, concentrations of organic contaminants are $ng.g^{-1}$ dry weight.

	GULFWATCH		NS&T											
	1998 (n=21)		1991 (n=190)		1992 (n=131)		1993 (n=169)		1994 (n=135)		1995 (n=148)		1996 (n=118)	
Contaminant	MD	+1SD	MD	+1SD	MD	+1SD	MD	+1SD	MD	+1SD	MD	+1SD	MD	+1SD
Ag	0.04	0.15	0.08+	0.48+	0.09+	0.55+	0.05+	0.85+	0.12+	0.56+	0.05+	0.76+	NA	NA
Al	230	707	280	653	210	510	120	280	350	1100	480	1577	340	1020
Cd	1.90	2.50	2.33	5.43	2.08	4.46	2.47	4.67	1.97	4.29	2.40	4.39	1.88	4.23
Cr	1.90	3.20	1.43	2.73	1.41	3.50	1.21	2.71	1.16	2.21	1.80	5.18	11.1	3.1
Cu	6.50	16.0	8.83+	11.67+	8.64+	10.11+	8.35+	10.5+	8.69+	10.54+	8.41+	12.62+	7.3+	9.9+
Fe	400	606	400	790	338	690	340	673	350	774	607	1615	424	985
Hg	0.45	0.94	0.11	0.24	0.10	0.23	0.11	0.20	0.10	0.21	0.11	0.23	0.11	0.20
Ni	1.30	1.90	2.07	3.60	2.09	3.85	1.64	2.66	1.46	2.78	1.98	3.46	1.6	3.3
Pb	2.80	6.60	0.77	3.57	0.70	2.30	0.78	2.90	0.99	2.73	0.70	2.36	0.75	2.4
Zn	100	140	130+	200+	120+	170+	120+	200+	120+	170+	115+	169+	102+	148+
ΣPAH	151	575	227	937	233	959	253	1201	210	1291	190	913	274	851
ΣPEST	12.7	58	30	116	37	132	37	131	38	127	31	127	40	126
ΣPCB	50*	104*	26	145	31	186	30	157	39	152	28	207	58	180

*, ΣPCB_{24} calculated as tpcb = tpcbcon x 1.945 + 3.35 (O'Connor, 1998)

+, Median concentrations for Ag, Cu and Zn were calculated for mussels only (O'Connor, 1998)

3.2.1.2 Lead (Pb)

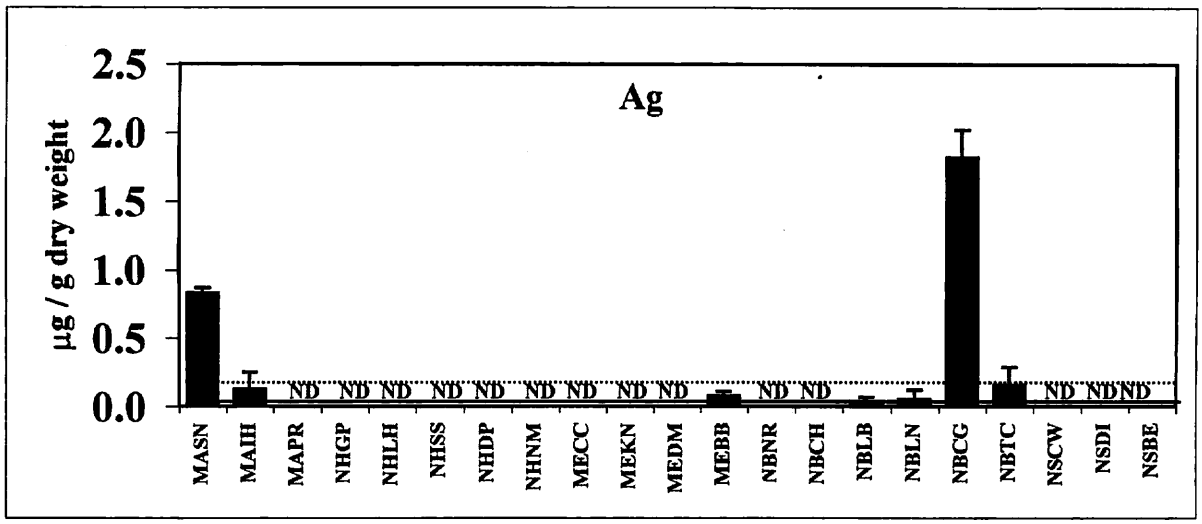
The concentration of lead ranged from a value of 0.58 ± 0.12 µg/g dry weight at NBNR to 32.3±3.3 µg/g dry weight at Boston Inner Harbor (MAIH) (Table 3, Fig. 3). Lead levels at MAIH and Boothbay Harbor, ME (MEBB) exceed the Gulfwatch and NS&T MD + 1 SD. Lead concentrations were generally somewhat higher in the southwestern sites compared to the northern and eastern sites (Fig. 3). Mean concentrations of Pb in mussels from coastal regions generally range from 1 to 16 µg/g dry weight (Fowler, 1990). MAIH is in an area surrounded by heavy industry, marine transport activities and municipal waste discharges. Sediment particles containing Pb may be transported to Boothbay Harbor from the Kennebec-Androscoggin watershed (Larson and Gaudette 1995). Elevated lead in the New Hampshire sites may be related to the close proximity of the sites to the Portsmouth Naval Shipyard where waste plating sludge and lead batteries, respectively were disposed and stored (NCCOSC 1997). The potential for the Shipyard to be a source of lead to estuarine biota was demonstrated in July, 1999, when significant amounts of contaminated soil containing as much as 14.2 mg Pb/g soil dry weight was discovered to be eroding into the Piscataqua River (Cohen, 2000).

3.2.1.3 Chromium (Cr)

The concentration of chromium exceeded the Gulfwatch MD + 1 SD at only two sites, and these were in New Brunswick (NBLN, NBTC) (Table 3; Fig. 4). Whereas sites in all jurisdictions exceeded the NS&T MD + 1 SD. The lowest concentration was at NBCH (0.69 µg/g dry weight) and the highest at NBTC (12.9 µg/g dry weight). Chromium is the primary agent used in the tanning process with untreated wastes discharged throughout much of this century. Chromium persists in the environment as shown by elevated concentrations in the sediments near such sources (Capuzzo, 1974; NCCOSC, 1997). During the 19^{th} and 20^{th} centuries, coastal New Hampshire was one of the hide tanning centres of the United States. Other tannery centres were located in Salem, MA and on the Saco River, ME (Capuzzo, 1996). High Cr was also observed in the sediments of the Gulf of Maine by other studies (Armstrong et al., 1976; Lyons et al., 1978; Mayer and Fink, 1990).

3.2.1.4 Zinc (Zn)

Zinc concentrations generally reflect human activity associated with tire wear, galvanized materials and industrial discharges. Only one site had concentrations that were greater than the Gulfwatch and NS&Ts MD + 1 SD (MAIH). The lowest concentration was measured at MEKN (53 µg/g dry weight) and the highest at MAIH (258 µg/g dry weight) (Table 3; Fig. 4). Concentrations of



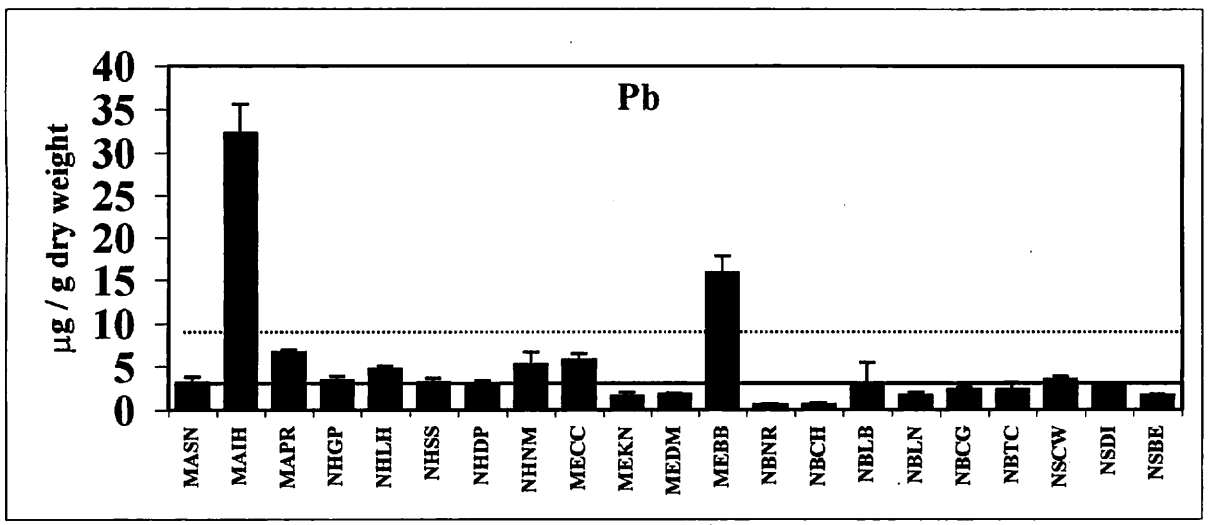


Figure 3. Distribution of silver and lead tissue concentrations (arithmetic mean +/- SD, µg/g dry weight) in mussels at the Gulf of Maine stations in 1998. The median (solid line) and median + 1 SD (dashed line) are shown for comparison. ND = not detected.

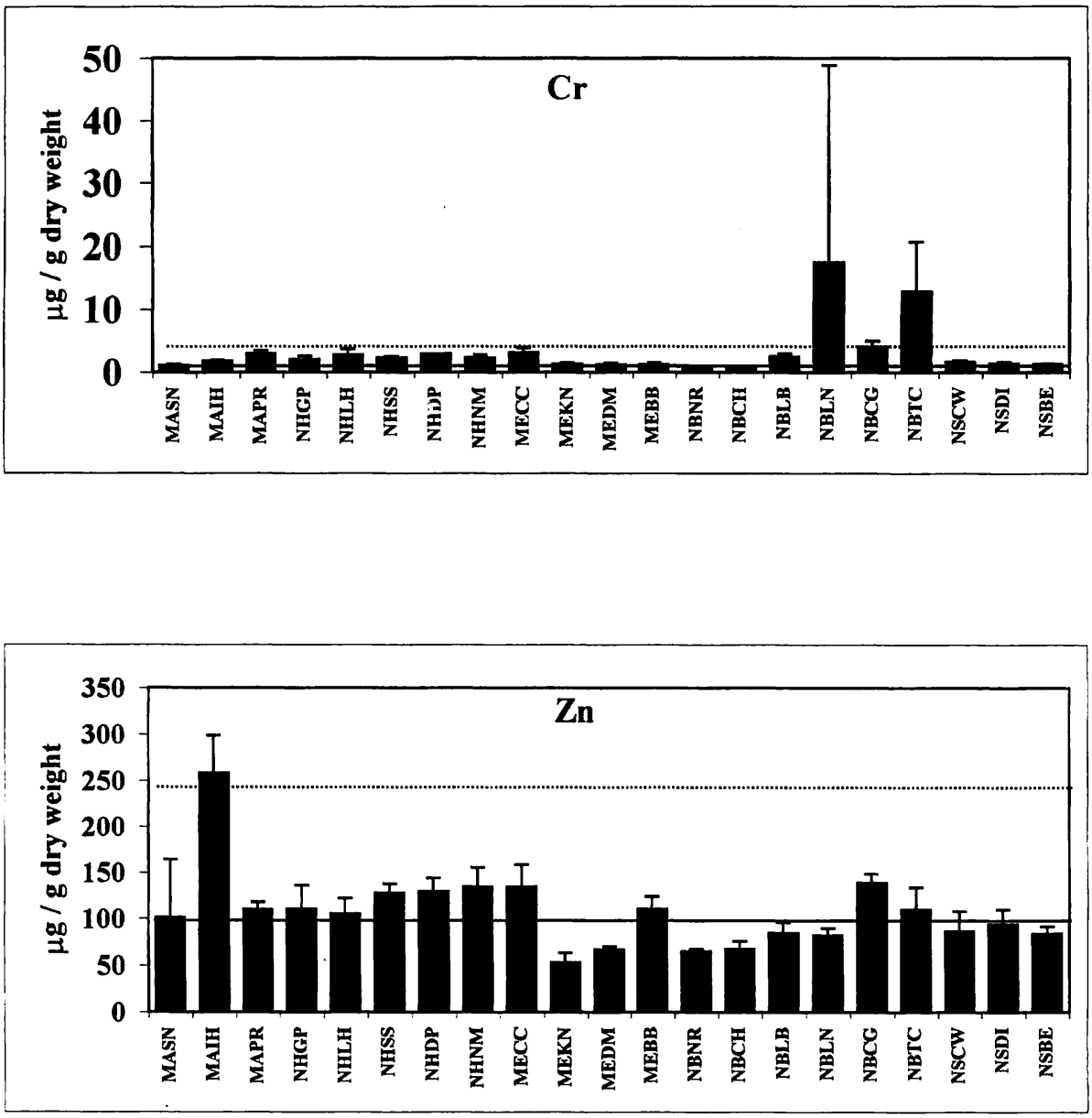


Figure 4. Distribution of chromium and zinc tissue concentrations (arithmetic mean +/- SD, µg/g dry weight) in mussels at the Gulf of Maine stations in 1998. The median (solid line) and median + 1 SD (dashed line) are shown for comparison. ND = not detected.

zinc in bivalves of British estuaries often exceed 1000 μg/g dry weight, but many may be greater than 4000 μg/g dry weight in contaminated systems (Bryan et al., 1992).

3.2.1.5 Nickel (Ni)

The concentration of nickel ranged from ND at MASN to 9.80 μg/g dry weight at NBLN (Table 3; Fig. 5). Two sites (NBLN and NBTC) exceeded the Gulfwatch and NS&Ts MD + 1 SD, however, this is primarily the result of the high concentration (> mean + 2 SD) of one of the composites at each site. These composites should probably be excluded from the analysis. High concentrations were observed in New Hampshire and Nova Scotia. High concentrations in Nova Scotia may reflect the degree of exposed bedrock along the coast (Wells et al., 1996).

3.2.1.6 Mercury (Hg)

The concentration of mercury in mussel tissue ranged from a value of 0.11 μg/g dry weight at NBLN to 1.08 ± 0.10 μg/g at NHSS (Table 3, Fig. 5). No sites exceeded the Gulfwatch MD + 1 SD, however, mercury values exceeded the NS&T MD + 1 SD of 0.24 μg/g dry weight at 17 of the 21 sites. The New Hampshire sites are markedly higher than sites in other jurisdictions. There are several known historical mercury sources in the New Hampshire Seacoast, including some that are suspected to be related to the Portsmouth Naval Shipyard (NCCOSC 1997) and, especially, the PSNH Schiller Station (NHSS) on the Piscataqua River, where mercury steam was used from 1950 to 1968 (Nelson 1986). Analysis of the mussel tissue concentrations of Hg revealed that there was a significant difference in Hg concentrations between NHSS and all other New Hampshire sites except NHLH. Mean values of Hg in *Mytilus* spp. from coastal regions world-wide range from 0.1 to 0.4 μg/g dry weight (Kennish 1997), but can be much higher in areas like the south-west Pacific, where sites average as much as 2.7 μg Hg/g dry weight (Fowler 1990). In a review of the first five years of the Gulfwatch program tissue concentrations of Hg were discussed as being unusually high and a possible concern (Jones et al. 1998).

Recent studies have shown that a mercury problem exists in freshwater systems of the north-east U.S. and maritime provinces of Canada (Welch 1994, DiFranco et al. 1995, Evers et al. 1996). About 47% of mercury deposition in the region originates from sources within the region, 30% from U.S. sources outside the region, and 23% from the global atmospheric reservoir (NESCAUM 1998). On June 8, 1998, the New England governors and eastern Canadian premiers agreed to cut regional mercury emissions from power plants, incinerators, and other sources in half by the year 2003 (Boston Globe -6/9/98). However, until recently few coastal systems have been known to be affected by Hg

pollution. Atmospheric mercury deposition measurements made at New Castle, NH, at the mouth of Portsmouth Harbor, showed ~ 8 ng/m^2 total mercury was deposited during 1998

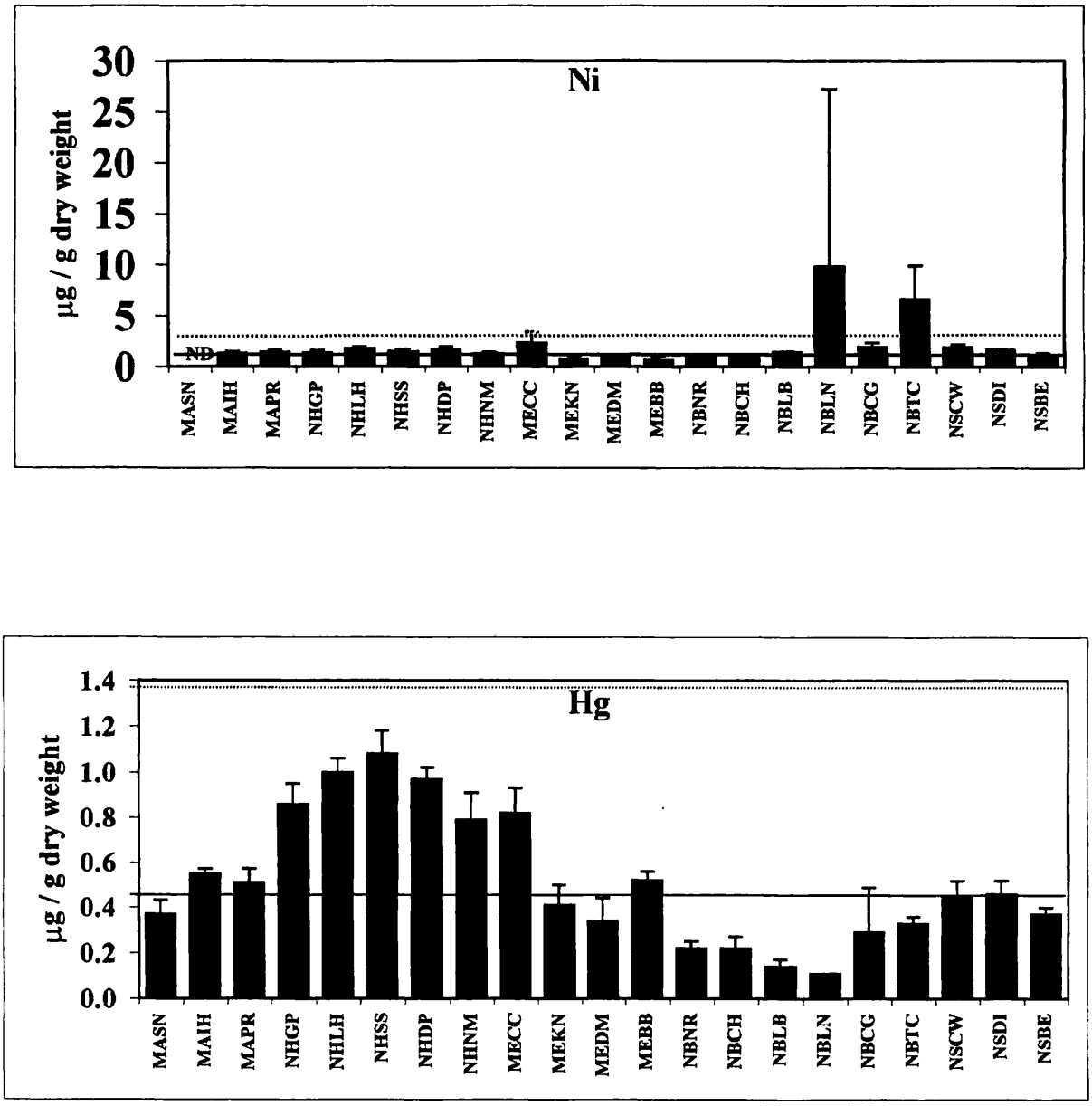


Figure 5. Distribution of nickel and mercury tissue concentrations (arithmetic mean +/- SD, µg/g dry weight) in mussels at the Gulf of Maine stations in 1998. The median (solid line) and median + 1 SD (dashed line) are shown for comparison. ND = not detected.

(http://nadp.sws.uiuc.edu/nadpdata/mdnsites.asp). The New Castle site, along with two other Maine coastal sites in Casco Bay and Acadia National Park, showed somewhat elevated total mercury atmospheric deposition compared to nearby, upstream inland sites. Other areas in the Gulf of Maine have elevated (5-20 ppm) sediment mercury concentrations (Buchholtz ten Brink et al 1997), including the Penobscot River near Orrington, where permitted and accidental discharges from the Holtra-Chem facility have resulted in sediments having much higher (>100 ppm) Hg concentrations (MEDEP, unpublished). Thus, data on mussel tissue mercury levels are important to help assess current contamination problems and the effects of discharge reduction efforts in the future.

3.2.1.7 Cadmium (Cd)

Cadmium is widely used in industry for batteries, plating, stabilizers and as a neutron absorber in nuclear reactors. The concentration of cadmium in mussel tissue ranged from 0.74 µg/g dry weight at NBNR to 2.80 µg/g dry weight at NHLH (Table 3; Fig. 6). Although cadmium concentrations were high in New Hampshire and some sites in Massachusetts, New Brunswick and Nova Scotia no site exceeded the Gulfwatch or NS&T MD + 1 SD. Mean concentrations of cadmium in mussels (*Mytilus* spp.) from several coastal regions world wide range from approximately 1 to 5 µg/g dry weight (Fowler, 1990).

3.2.1.8 Copper (Cu)

The concentration of copper in mussel tissue ranged from 4.6 µg/g dry weight at NBNR to 29.0 µg/g dry weight at NBCG and NBTC (Table 3; Fig. 6). Both NBCG and NBTC exceeded the Gulfwatch and NS&T MD + 1 SD. There were high composite concentrations at each of these sites however the concentrations did not exceed the mean + 2 SD (an indication of outliers in the data). As such, the concentrations are considered to be within the expected range.

3.2.1.9 Iron and Aluminium (Fe & Al)

The concentrations of Fe and Al increased in a south to north direction around the Gulf of Maine (Table 3; Fig. 7). The concentration of Fe ranged from 218 µg/g dry weight at MASN in Massachusetts to 2131 µg/g dry weight at NBTC in New Brunswick. The concentration of Al ranged from 72 µg/g dry weight at MASN in Massachusetts to 2925 µg/g dry weight at NBTC in New Brunswick. The tissue analysis for Al and Fe is included to serve as an indication of the degree of sediment contamination in mussel tissue. The fact that four of the six New Brunswick sites had relatively high concentrations of Al and Fe suggests that the mussel tissue contained elevated levels of inorganic sediments. This suggests that the observed elevated levels of some trace metals are a

function of sediment associated metals or are associated with contaminated sediments (Robinson et al. 1993). Sites in the Bay of Fundy are dominated by extensive intertidal mudflats that can lead to considerable resuspension during windy storm events.

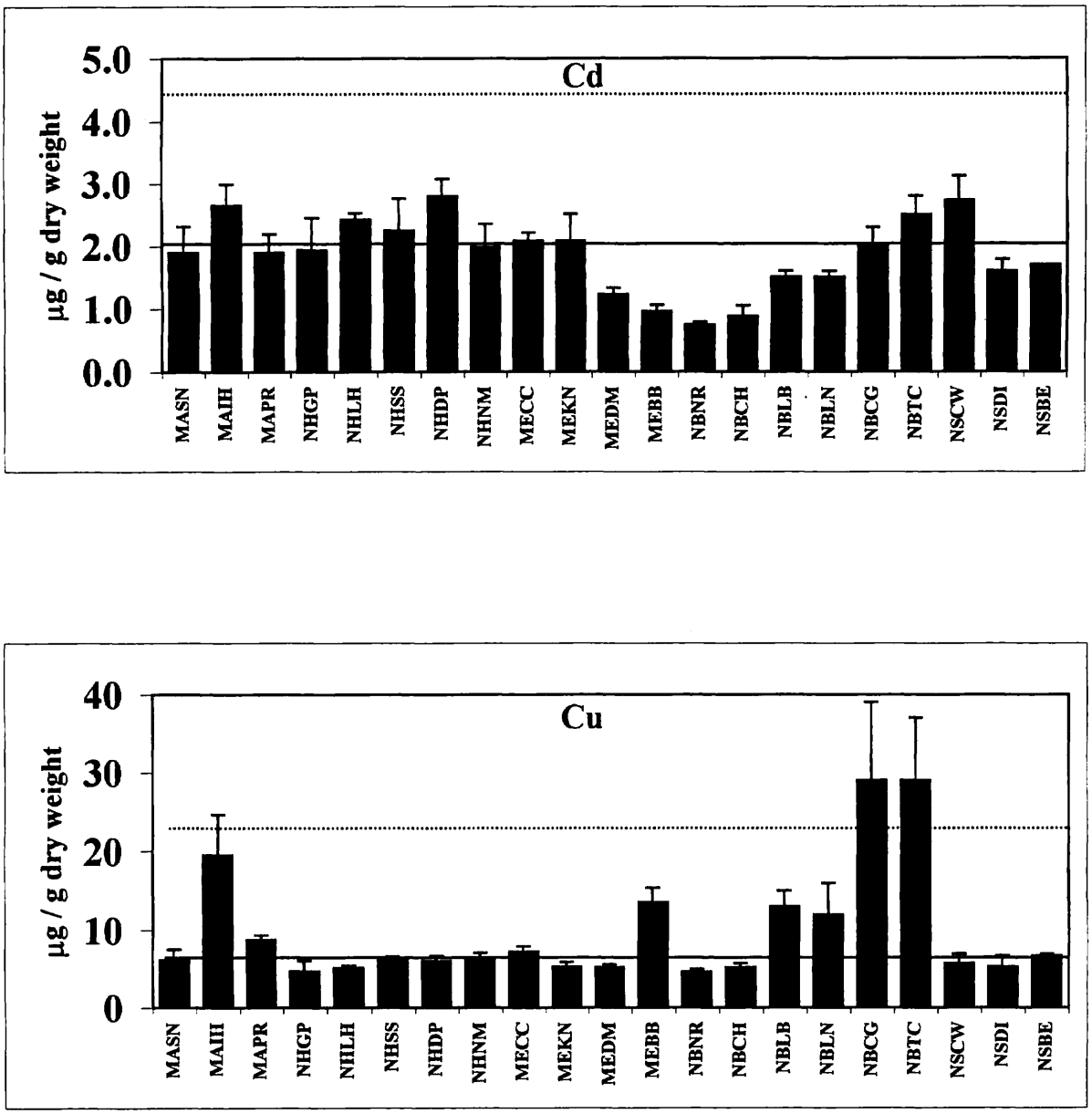
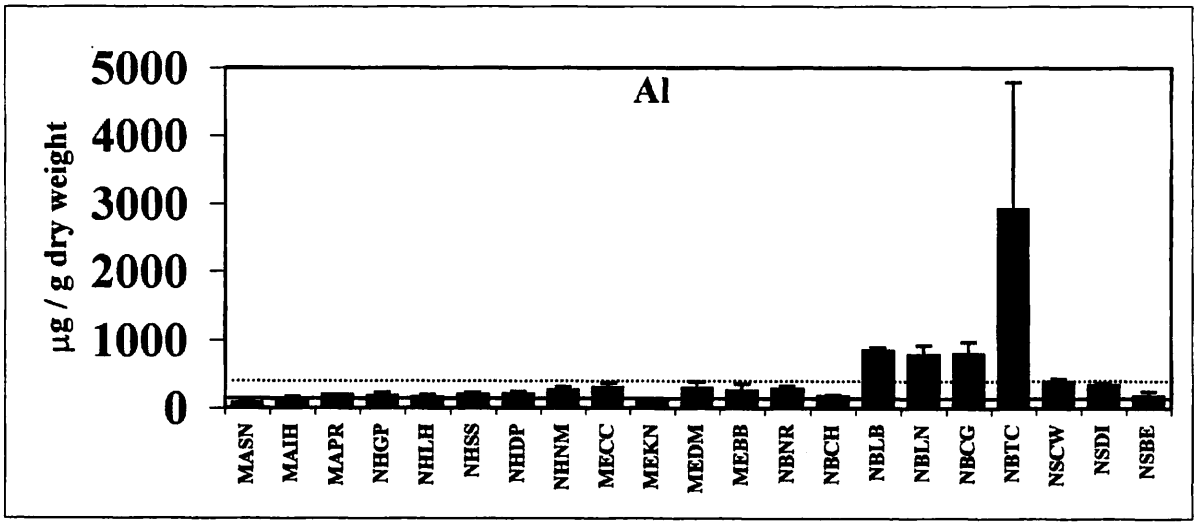


Figure 6. Distribution of cadmium and copper tissue concentrations (arithmetic mean +/- SD, µg/g dry weight) in mussels at the Gulf of Maine stations in 1998. The median (solid line) and median + 1 SD (dashed line) are shown for comparison. ND = not detected.



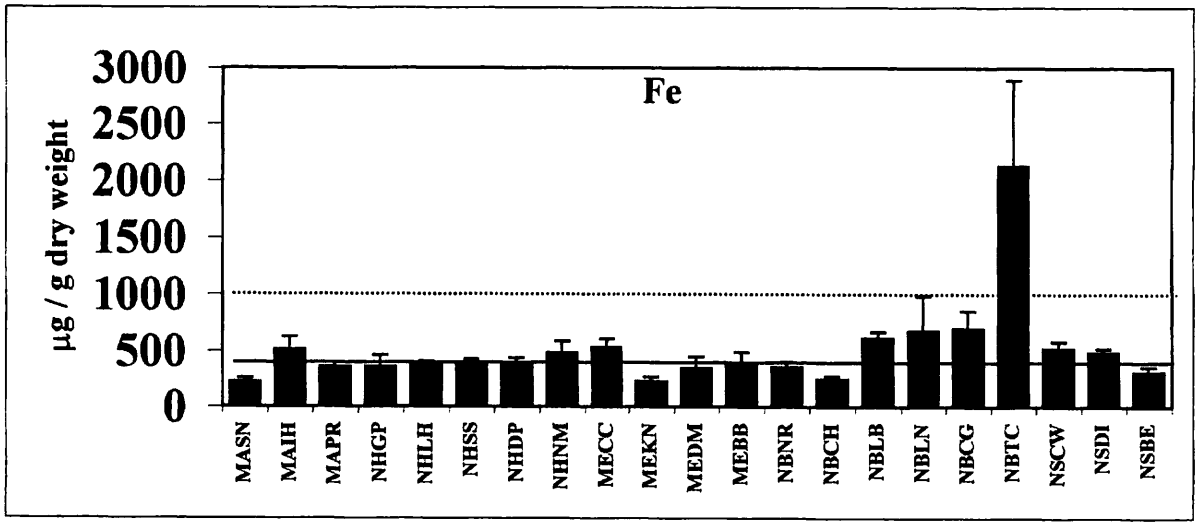


Figure 7. Distribution of iron and aluminum tissue concentrations (arithmetic mean +/- SD, µg/g dry weight) in mussels at the Gulf of Maine stations in 1998. The median (solid line) and median + 1 SD (dashed line) are shown for comparison. ND = not detected.

3.2.2 Organics

3.2.2.1 Polynuclear Aromatic Hydrocarbons (PAH), Polychlorinated Biphenyls (PCB) and Organochlorine Pesticides (TPEST)

The total concentration (arithmetic mean ± SD, ng/g dry weight) of detectable polynuclear aromatic hydrocarbons (ΣPAH_{24}), polychlorinated biphenyls (ΣPCB_{24}) and organochlorine pesticides ($\Sigma TPEST_{17}$) measured in mussel tissue samples of indigenous mussels are presented in Table 5 and Figures 8 and 9. Individual analyte concentrations of each compound class are provided in Appendices C, D and E. Overall organic contaminant concentrations for indigenous mussels are given as medians (MD) and MD + 1 SD (Table 6) to allow for both a Gulfwide comparison and a comparison with NOAA National Status and Trends concentrations (Table 4). Table 4 includes values for MD and MD + 1SD from the 1991 NS&T Mussel Watch data (O'Connor, 1998; http://ccmaserver.nos.noaa.gov/).

TABLE 5.

Tissue organic contaminant concentrations (arithmetic mean ±SD, ng/g dry weight) from mussels collected throughout the Gulf of Maine in 1998 and ANOVA of concentrations by jurisdiction. Same letter indicates no significant difference among sites within each jurisdiction. ND = not detected.

Station	$\sum PAH_{24}$	$\sum PCB_{24}$	$\sum TPEST_{17}$	$\sum OPEST_{11}$	$\sum DDT_6$
MASN	13 ± 2 ^{A}	28±7^{A}	29±3^{A}	6.7±0.4^{A}	22±2.7^{A}
MAIH	3333 ±223^{c}	732±39^{C}	133±15^{C}	27±1.7^{C}	106±14^{C}
MAPR	554 ±327^{B}	131±8^{B}	60±12^{B}	12±0.6^{B}	48±11^{B}
NHGP	165±13^{B}	26±2^{B}	14±2^{B}	4.5±0.8^{AB}	9.6±1.5^{B}
NHLH	79±11^{A}	13±2^{A}	10±1^{A}	5.2±0.5^{BC}	5.0±0.5^{A}
NHSS	192±48^{BC}	31±6^{BC}	15±2^{B}	5.2±0.8^{BD}	9.8±1.1^{B}
NHDP	178±21^{CD}	32±8^{BC}	16±3^{B}	4.6±0.6^{ACD}	12±2.8^{B}
NHNM	647±60^{E}	68±8^{D}	70±8C	5.9±0.6^{BC}	65±5.2^{C}
MECC	200±26^{BD}	43±8^{C}	15±2^{B}	3.8±0.3^{A}	12±2.0^{B}
MEKN	59±20^{B}	17 ± 4^{B}	5 ± 0.5^{A}	ND^{A}	5.2 ± 0.5^{A}
MEDM	ND^{A}	4 ± 0.3^{A}	5 ± 0.5^{A}	ND^{A}	4.7 ± 0.5^{A}
MEBB	1114±58^{C}	44 ± 5^{C}	61 ± 3^{B}	3.5 ± 0.7^{B}	58 ± 3.6^{B}
NBNR	106 ± 12^{B}	2 ± 0.5^{B}	7 ± 1^{A}	4.8 ± 0.8^{B}	2.1 ± 0.2^{A}
NBCH	22 ± 11^{A}	ND^{A}	7 ± 2^{A}	4.1 ± 1.3^{B}	2.6 ± 1.0^{AB}
NBLB	16 ± 5^{A}	7 ± 1^{C}	6 ± 3^{A}	1.5 ± 1.1^{A}	4.4 ± 1.5^{C}
NBLN	13 ± 3^{A}	7 ± 0.5^{C}	5 ± 2^{A}	1.2 ± 0.8^{A}	3.9 ± 1.1^{BC}
NBCG	229 ± 8^{C}	39 ± 2^{D}	37 ± 1^{C}	2.5 ± 0.1^{AB}	34 ± 1.5^{E}
NBTC	164 ± 12^{BC}	33 ± 5^{D}	14 ± 1^{B}	1.3 ± 0.1^{A}	13 ± 0.9^{D}
NSCW	95 ± 146^{A}	ND^{A}	3 ± 0.4^{A}	ND^{A}	2.5 ± 0.4^{A}
NSDI	106 ± 14^{A}	4 ± 0.6^{B}	6 ± 1^{B}	2.6 ± 1.1^{B}	3.5 ± 0.2^{A}
NSBE	137 ± 20^{A}	ND^{A}	5 ± 2^{B}	1.4 ± 0.4^{B}	3.4 ± 1.5^{A}

TABLE 6.

Median (±SD) of tissue organic contaminants for mussels within each jurisdiction and for all the Gulf of Maine, 1998 stations. ND, not detected.

JURISDICTION	$\sum PAH_{24}$	$\sum PCB_{24}$	$\sum TPEST_{17}$	$\sum OPEST_{11}$	$\sum DDT_6$
Massachusetts (n=12)	565 ± 3345	128 ± 749	61 ± 130	12 ± 28	48 ± 104
New Hampshire (n=24)	183 ± 575	32 ± 56	16 ± 58	4.8 ± 5.8	10 ± 58
Maine (n=12)	55 ± 1157	17 ± 45	5.3 ± 63	0 ± 3.7	5.3 ± 60
New Brunswick (n=24)	64 ± 219	6.6 ± 37	6.8 ± 36	2.4 ± 4.6	4.3 ± 32
Nova Scotia (n=11)	108 ± 154	0 ± 4.0	4.9 ± 6.6	1.4 ± 2.9	3.3 ± 4.1
Gulf of Maine (n=83)	151 ± 575	24 ± 52	13 ± 58	3.9 ± 6.4	8.8 ± 55

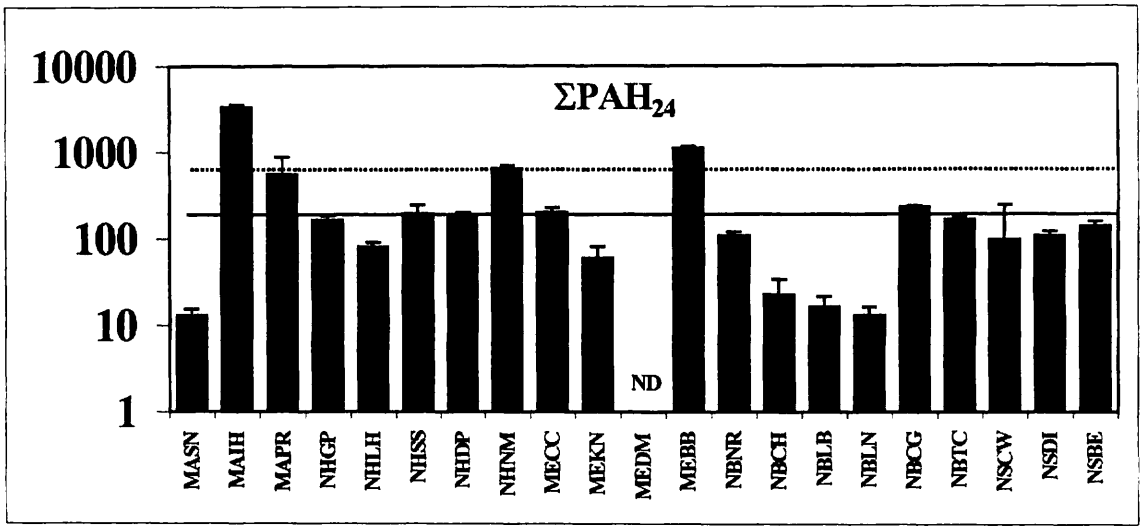
Analytes within each category of organic contaminant were detected at most sites, except for ΣPAH_{24} at MEDM and ΣPCB_{24} at NBCH, NSBC and NSCW. There were much wider ranges in concentrations of organic compared to trace metal contaminants.

There is a pattern of higher concentrations in the south-western Gulf compared to the north-eastern Gulf for ΣPCB_{24} and $\Sigma TPEST_{17}$, and to a lesser extent for ΣPAH_{24} (Table 5). This pattern can be seen in Figures 8 and 9, which show the chemicals measured in the tissue of *M. edulis* from the 1998 sites, presented from south to north. The ΣPAH_{24} concentrations ranged from Not Detected (ND) at MEDM to 3330 ± 3 ng/g dry weight at MAIH. Concentrations of at all but a few of the Maine and New Brunswick sites were as high as those reported from areas influenced by oil spills and municipal sewage outfall (148 ng/g in Rainio et al. 1986; 63-1060 ng/g in Kveseth et al. 1982). However, only MAIH was as high as in industrialized areas affected by coking operations in Sydney Harbor, NS (1400-16,000 ng/g, in Environment Canada 1986) or smelting operations in Saudafijord, Norway (5111 - 225,163 ng/g; in Bjorseth et al. 1979).

Table 6 shows the MD and MD + 1 SD of Gulfwatch stations in 1998. The concentrations that exceeded the Gulfwatch MD + 1 SD were in the southern regions of the Gulf (ΣPAH_{24}: MAIH, MEBB; ΣPCB_{24}: MAIH, MAPR; $\Sigma TPEST_{17}$: MAIH). Comparisons were also made with the NOAA NS&T program (Table 4). For comparison with PCB, a correction factor had to be applied to the Gulfwatch data (O'Connor, 1998). Two sites, MEBB and MAIH, exceeded the NS&T MD + 1 SD for PAH (937 ng/g dry weight, and two other sites, MAPR and NHNM are at concentrations over half of this value. MAIH, and to a lesser degree MAPR, has been subject to high levels of all types of contamination, including oil spills like the recent (June, 2000) spill in Chelsea, MA. Relatively uncontaminated mussels deployed in 1995 had ~1570 ng PAH/g DW after 60 days in cages at MAIH (Chase et al., 1996). MEBB is a site in Boothbay Harbor. The site had not been sampled since 1991 when no organic analyses were conducted. However, analysis of tissue samples showed mussels from MEBB to contain elevated levels of trace metals, especially Pb and Zn (Jones et al. 1998). The source of the PAHs at NHNM is not known. In contrast, mussels at NHDP, which were impacted by the 1996 *Provence* oil spill, and at those at NHSS which is in close proximity to the Schiller Station oil terminal, had much lower ΣPAH_{24} concentrations than at NHNM in 1998. Examination of the individual PAHs detected at NHNM reveals a marked dominance of higher molecular weight and non-alkylated PAHs (Chase et al. 2001). This pattern was consistent for all 1998 New Hampshire sites and suggests that the PAHs may be from pyrogenic, as opposed to fresh petroleum, sources. The pattern also strongly suggests

that the sources may be historical, or reflect past exposure. Lower molecular weight PAHs degrade faster (Shiaris 1989) and are more mobile in the environment, and bivalves tend to metabolize and excrete higher molecular weight PAHs at slower rates (Widdows and Donkin 1992). Sediments from sites in North Mill Pond, especially upstream sites, had ΣPAH_{24} concentrations ranging from <690 to 23,600 ng/g DW (ANMP, 1998). It is possible that PAH-contaminated sediments from upstream sources could be taken up and accumulated by mussels at the downstream NHNM site, especially during high flow or storm events at low tide (Jones and Landry, 2000).

The concentrations of ΣPCB_{24} ranged from not detected at NBCH, NSBC and NSCW to 740 ± 3 ng/g DW at MAIH (Table 5). Fig. 4 shows the MD of ΣPCB_{24} concentrations for all 1998 Gulfwatch sites. The same pattern of elevated concentrations in the southwest compared to the northeast sites can be seen. The Massachusetts sites included the two highest concentrations at MAIH (741 ng/g DW) and MAPR (131 ng/g DW). The corrected concentrations (O'Connor, 1998) of ΣPCB_{24} at MAIH and MAPR exceeded the NS&T MD + 1 SD of 145 ng/g DW (Table 4). As described previously, MAIH is a site in Boston Inner Harbor and has been subject to high levels of various types of contamination. Relatively uncontaminated (~37 ng ΣPCB_{24}/g DW) mussels deployed in 1995 had ~361 ng PAH/g DW after 60 days in cages at MAIH (GOMC, 1996). MAPR is a site north of Boston Harbor. In 1995, ΣPCB_{24} concentrations for MAPR were the highest (131 ng/g DW) of any other indigenous mussels sampled (Chase et al., 1996). Most of the New Hampshire sites exhibited relatively uniform and somewhat elevated concentrations relative to the Gulf-wide geometric mean. The ΣPCB_{24} concentration at NHNM was the third highest of all the 1998 sites at 65 ± 2 ng/g DW. As for PAHs, the source of the PCBs in North Mill Pond is not known. Analysis of sediments from North Mill Pond conducted on samples collected in 1997 showed no detectable PCBs (ANMP, 1998), although detection limits (>2400 ng/g DW for seven Aroclors) were relatively high for that study. Sites in Portsmouth Harbor have had relatively high sediment PCB concentrations compared to other areas, except for Boston Harbor, around the Gulf of Maine (Buchholtz ten Brink et al. 1997). The ΣPCB_{24} concentration at MEBB (44 ± 2 ng/g DW) was also elevated compared to other 1998 sites, as was the case for other contaminants already mentioned.



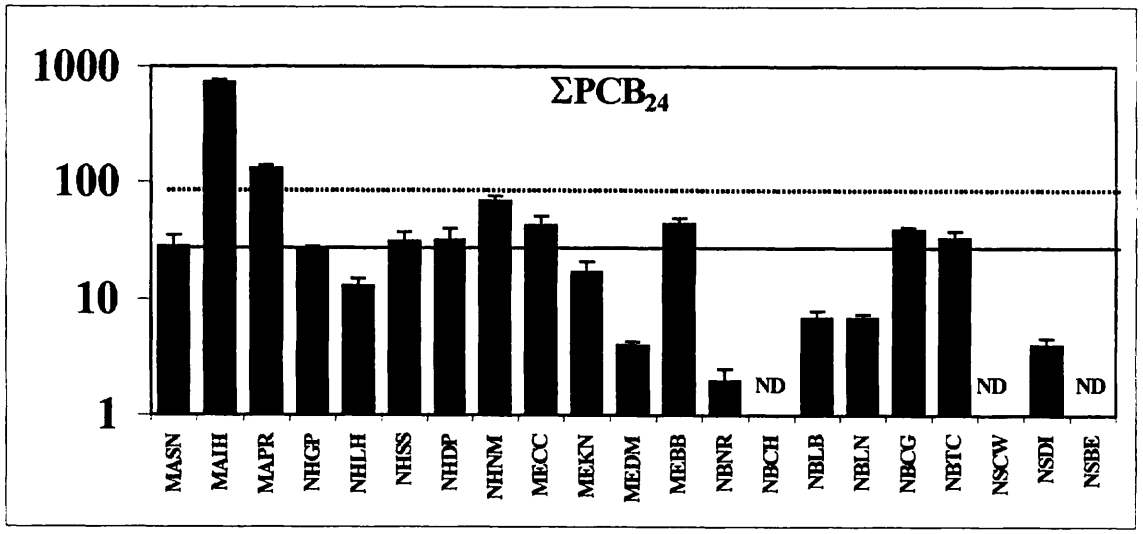


Figure 8. Log distribution of ΣPAH_{24} and ΣPCB_{24} tissue concentrations (arithmetic mean: ng/g dry weight) in mussels at the Gulf of Maine stations in 1998. Median (solid line) and median + 1 SD (dashed line) are shown for comparison. ND = not detected.

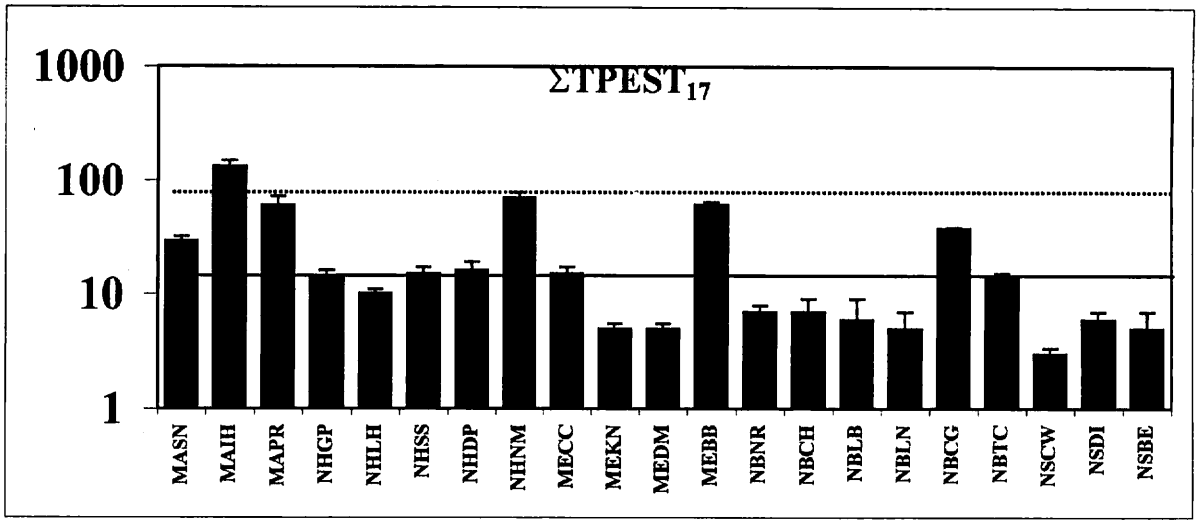


Figure 9. Log distribution of $\Sigma TPEST_{17}$ tissue concentrations (arithmetic mean: ng/g dry weight) in mussels at the Gulf of Maine stations in 1998. Median (solid line) and median + 1 SD (dashed line) are shown for comparison. ND = not detected.

3.2.2.2 Planar Chlorobiphenyl and Polychlorinated Dibenzo-p-dioxin and Dibenzofuran Contaminants

Several non-ortho, mono-ortho and di-ortho PCB congeners, referred to as planar chlorobiphenyls (CBs), are biologically active environmental pollutants with structural and toxic properties similar to the highly toxic dioxin, 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD). Planar CB concentrations are usually found in environmental samples at much lower concentrations than other co-occurring PCB congeners. Planar CBs in biological samples such as mussels are analyzed by high resolution gas chromatography-mass spectrometry (GC-MS) in order to utilize its high sensitivity and peak resolving power. Specialized sample preparation and high resolution GC-MS techniques allow much lower sample detection limits than those generally obtained using standard Mussel Watch analytical methods which were used to generate the PCB congener data provided in Appendix F.

In 1998, mussel samples from several Gulfwatch sites were analyzed for 10 planar chlorobiphenyls (CBs) congeners. Table 7 contains CB concentrations of composite mussel samples collected from ten Gulfwatch sites which are a subset of the 1998 sampling sites. Concentrations of summed planar CBs in indigenous mussels ranged from 152 to 34,042 pg/g wet wt . The highest concentration (34042 pg/g wet wt) was measured in mussels at the Boston Inner Harbor site, MAIH, and is also the highest concentration of summed CBs measured at any site in the Gulf since Gulfwatch began measuring planar CBs in 1995. The lowest CB concentrations were measured in mussels from three relatively uncontaminated reference-sites in Maine (MEDM, 212 pg/g), New Brunswick (NBCH, 152 pg/g) and Nova Scotia (NSBE, 168 pg/g). Overall, Gulf-wide CB concentrations display the similar pattern of southerly increasing contamination that has been observed for other Gulfwatch organic contaminants in this and in past years.

In 1998 polychlorinated dibenzo (p) dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were also measured in Gulf of Maine mussels using high resolution GC-MS analytical methods. The results of these analyses are shown in Appendix F. PCDD and PCDF concentrations in mussels were generally low and in many cases were below the level of detection. The highest PCDD and PCDF congener concentrations were measured in mussels from Massachusetts (MAIH and MAPR) and New Hampshire (NHLH and NHNM). None of the samples had detectable concentrations of the highly toxic 2,3,7,8-TCDD or 1,2,3,7,8-pentachlorodibenzodioxin (1,2,3,7,8-PeCDD). Nor did any samples have detectable concentrations of any other dioxin

congener chlorinated in the 2,3,7,8 positions with the exception of the less toxic 1,2,3,4,6,7,8 heptachloro and octachloro congeners. However, concentrations of 2,3,7,8-terachlorodibenzofuran (2,3,7,8-TCDF) and other chlorinated TCDF congeners were detected in mussels from Boston's Inner Harbor, MAIH and in samples from other sites. Most of the chlorinated dioxin and furan toxicity in mussel samples was derived from chlorinated furans. The relative concentrations of chlorinated dioxins and furans in environmental samples are source related.

Planar CBs and chlorinated dioxins and furans share a similar mode of biological action, i.e., Ah receptor mediated responses, and therefore, their toxicities can be standardized relative to 2,3,7 ,8-TCDD through the use of internationally recognized toxic equivalency factors (TEFs). Planar CB toxicity equivalency concentrations (TEQs) shown in Table 8 were calculated using mussel tissue CB concentrations (Table 8) and WHO interim TEFs compiled by Alborg (Alborg et al. 1994). CB-derived TEQs in mussels from 1998 sites ranged from a high of 4.9 pg/g at the Boston Inner Harbor site (MAIH) to a low of 0.02 pg/g at the Chamcook Harbour (NBCH) reference site in New Brunswick. A graphical representation of CB TEQ distribution in samples collected from GOM sites in 1998 is shown in Figure 10.

TABLE 7

Non-, Mono-, and Di-ortho chlorobiphenyl concentrations (pg/g wet wt) in mussels at 1998 Gulf of Maine Sites

Congener	MAIH	MAIH(D)	MAPR	NHLH	NHNM	*MEDM	*MEDM(D)	MEBB
Non-ortho								
PCB-77	57	NA	15	1.2	5.4	0.64	0.60	2.85
PCB-126	5	NA	1.8	0.18	0.9	0.10	0.10	0.44
PCB-169	0.18	NA	0.15	0.03	0.11	0.04	0.04	0.045
Mono-ortho								
PCB-105	6600	5400	1000	110	420	40	NA	320
PCB-114	560	410	70	10	20	2	NA	20
PCB-118	19000	16000	2800	290	1200	120	NA	830
PCB-156	2600	1800	360	40	170	10	NA	100
PCB-189	120	90	30	8	10	ND	NA	7
Di-ortho								
PCB-170	1600	1100	280	10	120	9	NA	70
PCB-180	3500	2900	820	50	320	30	NA	240
Total	34042		5377	519	2266	212		1590

Congener	*NBCH	NBCG	NBTC	*NSBE	*NSBE(D)
Non-ortho					
PCB-77	0.62	1.5	5.4	0.96	NA
PCB-126	0.99	0.22	0.8	0.12	NA
PCB-169	0.03	0.04	0.3	0.05	NA
					NA
Mono-ortho					
PCB-105	30	250	110	30	110
PCB-114	ND	20	10	2	10
PCB-118	80	70	300	100	300
PCB-156	ND	120	70	10	70
PCB-189	20	6	9	ND	9
Di-ortho					
PCB-170	ND	60	90	5	90
PCB-180	20	140	270	20	270
Total	152	668	866	168	

* Gulfwatch: reference site ND: not detected NA: not analyzed
D: duplicate sample

TABLE 9

Non-, Mono- and Di-ortho Chlorobiphenyl TEQs in Mussels at 1998 Gulf of Maine Sites

Congener	TEF	*MAIH	*MAIH(D)	MAPR	NHLH	NHNM	*MEDM	*MEDM(D)
Non-ortho								
PCB-77	0.0005	0.0285	NA	0.0075	0.0006	0.0027	0.0003	0.0003
PCB-126	0.1	0.5000	NA	0.1800	0.0180	0.0900	0.0100	0.0100
PCB-169	0.01	0.0018	NA	0.0015	0.0003	0.0011	0.0004	0.0004
Mono-ortho								
PCB-105	0.0001	0.6600	0.5400	0.1000	0.0110	0.0420	0.0040	NA
PCB-114	0.0005	0.2800	0.2050	0.0350	0.0050	0.0100	0.0010	NA
PCB-118	0.0001	1.9000	1.6000	0.2800	0.0290	0.1200	0.0120	NA
PCB-156	0.0005	1.3000	0.9000	0.1800	0.0200	0.0850	0.0050	NA
PCB-189	0.0001	0.0120	0.0090	0.0030	0.0008	0.0010	ND	NA
Di-ortho								
PCB-170	0.0001	0.1600	0.1100	0.0280	0.0010	0.0120	0.0009	NA
PCB-180	0.00001	0.0350	0.0290	0.0082	0.0005	0.0032	0.0003	NA
Total (pg/g wet wt)		4.88		0.82	0.09	0.37	0.03	

Congener	TEF	MEBB	*NBCH	NBCG	NBTC	*NSBE	*NSBE(D)
Non-ortho							
PCB-77	0.0005	0.0014	0.0003	0.0008	0.0027	0.0005	NA
PCB-126	0.1	0.0440	0.0099	0.0220	0.0800	0.0120	NA
PCB-169	0.01	0.0005	0.0003	0.0004	0.0030	0.0005	NA
Mono-ortho							
PCB-105	0.0001	0.0320	0.0030	0.0250	0.0110	0.0030	0.0110
PCB-114	0.0005	0.0100	ND	0.0100	0.0050	0.0010	0.0050
PCB-118	0.0001	0.0830	0.0080	0.0070	0.0300	0.0100	0.0300
PCB-156	0.0005	0.0500	ND	0.0600	0.0350	0.0050	0.0350
PCB-189	0.0001	0.0007	0.0020	0.0006	0.0009	ND	0.0009
Di-ortho							
PCB-170	0.0001	0.0070	ND	0.0060	0.0090	0.0005	0.0090
PCB-180	0.00001	0.0024	0.0002	0.0014	0.0027	0.0002	0.0027
Total (pg/g wet wt)		0.23	0.02	0.13	0.18	0.03	

* Gulfwatch: reference site ND: not detected NA: not analyzed
D: duplicate sample
TEF: toxic equivalency factors (Ahlborg et al 1994)

PCDD-PCDF derived TEQs were also calculated using individual PCDD and PCDF concentrations (Appendix F) and international toxic equivalency factors for dioxin and furans (NATO 1988). The spatial distribution of 1998 Gulfwatch mussel PCDD-PCDF TEQs is also presented in Figure 10. Summed PCDD and PCDF TEQs range from a high of 1.01 pg/g at Boston Harbor to not detected at the MEDM reference site in Maine.

Because planar CBs and chlorinated dioxin and furans share a similar mechanism of action it is also assumed their toxicities (TEQs) are additive. Summed TEQs for CBs and PCDD and PCDF are also shown in Figure 10. Total TEQs ranged from a high of is 5.9 pg/g at Boston Harbor (MAIH) to 0.02 pg/g at the Chamcook reference site in New Brunswick (NBCH). At most 1998 Gulfwatch non-reference sites, dioxin-like toxicity in mussels was derived mainly from PCBs.

There is no published US dioxin action level for human consumption of seafood. In Canada, the Canadian Food Inspection Agency regulates chemical contamination in seafood and cites 20 pg/g dioxin (2,3,7,8-TCDD) as the action level for prohibiting the production and trade of adulterated seafood (Health Canada 1993). Total toxic equivalency concentrations in Gulfwatch samples collected in 1998 are below the 20 pg/g tolerance level for the consumption of seafood that is considered protective of human health. The highest summed TEQ measured in mussels from the Gulf was 5.9 pg/g in Boston Harbor that is less than half the Canadian allowable level. However, the US EPA has set a screening value of 0.70 pg/g for dioxin in fish and shellfish (US EPA 1995). The EPA intends that exceedences of its screening valve be taken as an indication that more site-specific evaluation of human health risk should be conducted. Summed TEQs in mussels collected in 1998 from two Massachusetts sites, MAIH (5.9 pg/g) and MAPR (1.04 pg/g), exceed the EPA dioxin screening value.

Additionally, environmental quality guidelines for chemical contaminants have been developed. For example, a PCB tissue residue guideline value of 0.79 pg TEQ/g diet has been developed for the protection of wildlife consumers of aquatic biota (CCME 1999) which is coincidentally similar to the EPA human screening value of 0.70 pg/g dioxin. Of the ten sites sampled in 1998 two sites, MAIH and MAPR, have summed TEQs that exceed the environmental quality guideline reference value.

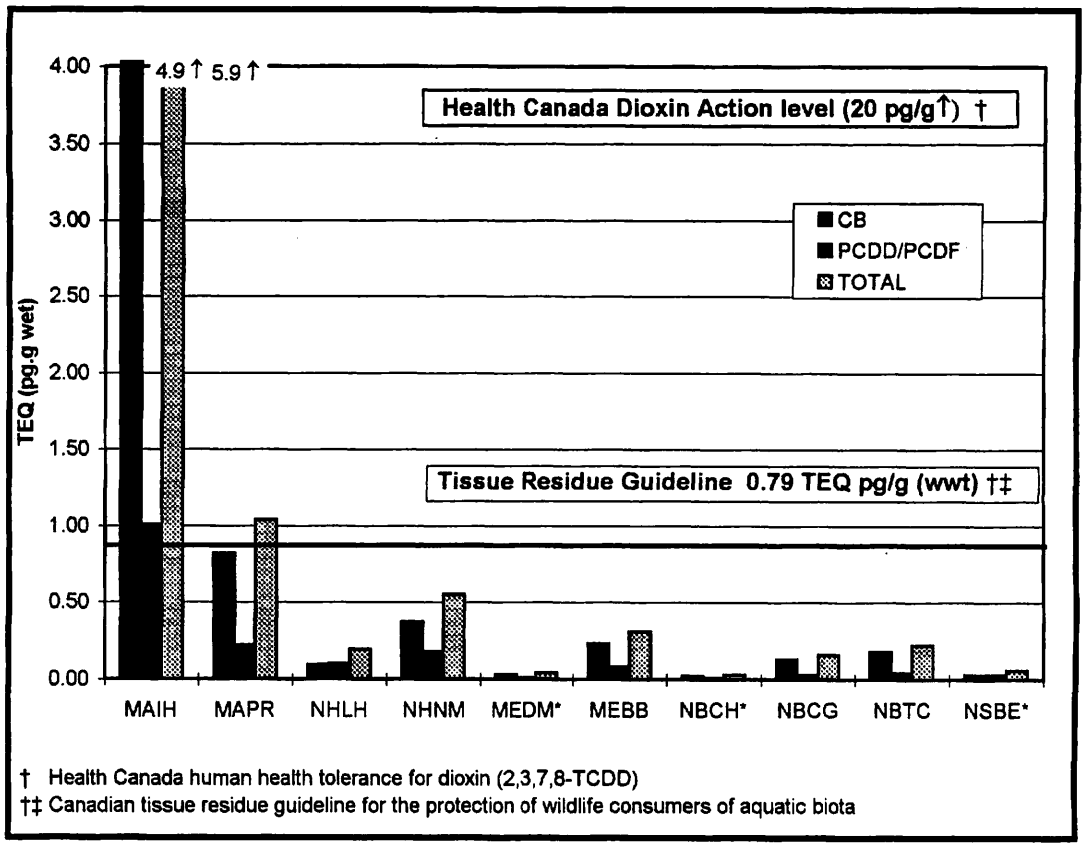


Figure 10. Distribution of CB and PCDD/PCDF Toxic Equavalency Concentrations (TEQ) in mussels at 1998 Gulfwatch Stations

3.3 Temporal Variation in Contaminant Concentrations

3.3.1 Benchmark Sites

Table 10 (metals) and Table 11 (Organics) show the tissue concentrations measured at the 5 benchmark stations from 1993 to 1998. The results of the repeated measures ANOVA comparing metal and organic contaminant concentrations at each of the 5 sites (MASN, MECC, MEKN, NBHI, NSDI) show: (1) there were significant differences among sites (site, $p<0.05$); and (2) there were significant differences in contaminant concentrations over time (time, $p<0.05$); however, the temporal pattern was not the same (year*site, $p<0.05$). This result may be expected given that the sites represent diverse circumstances with different sources and contaminant levels. Each site was therefore examined separately to determine temporal trends (i.e., whether there was a significant increase or decrease in contaminant concentration over time) (Table 9). This was done by repeated measures ANOVA on each site with an orthogonal polynomial model. Only the first-degree model was tested as it is only of interest whether there was a linear increase or decrease in contaminant concentration over this time period. This is equivalent to examining the relationship between the slope of each contaminant and year to determine if they differ significantly from zero (Table 9). Of the 65 comparisons (5 sites, 13 contaminants) the ratio (in percent) of increases:decreases:no change was: 13.8%:40%:46.2%. Decreases were observed for all contaminants with the exception of Al and ΣPAH_{24}. The concentrations of several contaminants increased in at least 1 site: ΣPAH_{24}, ΣPCB_{24}, $\Sigma PEST_{17}$, Zn, and Al. The site with the greatest number of decreases (8 of 13) was Hospital Island (NBHI). NBHI is a site with low mussel contaminant values. Therefore slight deviations, even as a result of yearly protocol, may influence the data and result in significant contaminant*year relationships.

TABLE 9.

Results of Repeated Measures ANOVA on Gulfwatch benchmark sites: Sandwich, MA (MASN), Clark Cove, ME (MECC), Kennebec River, ME (MEKN), Hospital Island, NB (NBHI), and Digby Harbour, NS (NSDI). nc, no change; I, increase; D, decrease.

	BENCHMARK SITES				
Contaminant	**MASN**	**MECC**	**MEKN**	**NBHI**	**NSDI**
Ag	nc	D	nc	D	D
Al	nc	I	nc	I	nc
Cd	nc	nc	nc	D	nc
Cr	D	nc	nc	D	nc
Cu	nc	nc	D	nc	D
Fe	D	nc	D	nc	D
Hg	D	nc	D	D	D
Ni	D	nc	D	D	nc
Pb	nc	nc	nc	D	D
Zn	nc	I	D	D	nc
ΣPAH_{24}	nc	I	nc	I	I
ΣPCB_{24}	nc	D	D	D	I
$\Sigma PEST_{17}$	D	nc	nc	I	I

TABLE 10.

Tissue metal concentrations (arithmetic mean ±SD, µg/g dry weight) for Gulfwatch stations at Sandwich, MA (MASN), Clark Cove, ME (MECC), Kennebec River, ME (MEKN), Hospital Island, NB (NBHI), and Digby Harbour, NS (NSDI) for 1993 to 1998.

Site | Year	Ag	Al	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
MASN 1993	1.64 (0.36)	61 (4)	1.68 (0.25)	1.64 (0.46)	6.1 (0.4)	354 (20)	0.77 (0.73)	2.24 (0.55)	3.78 (0.12)	101 (11)
MASN 1994	1.05 (0.29)	84 (18)	1.60 (0.20)	1.10 (0.10)	7.5 (0.5)	265 (31)	0.51 (0.10)	1.05 (0.06)	2.90 (0.40)	103 (9)
MASN 1995	1.04 (0.40)	110 (14)	1.08 (0.10)	1.75 (0.31)	6.9 (0.7)	245 (6)	0.30 (0.03)	0.88 (0.13)	2.65 (0.34)	98 (6)
MASN 1996	0.98 (0.30)	145 (24)	1.33 (0.22)	1.18 (0.19)	9.3 (2.0)	323 (43)	0.35 (0.04)	1.10 (0.08)	3.38 (0.66)	91 (6)
MASN 1997	1.01 (0.30)	105 (12.5)	1.09 (0.15)	1.00 (0.09)	7.18 (0.40)	265 (17.3)	0.29 (0.06)	0.98 (0.05)	3.10 (0.36)	91 (6)
MASN 1998	0.83 (0.04)	72 (17)	1.90 (0.41)	1.13 (0.19)	6.2 (1.3)	218 (39)	0.37 (0.06)	ND	3.15 (0.64)	101 (63)
MECC 1993	0.10 (0.05)	187 (80)	2.39 (0.36)	3.31 (1.28)	7.5 (0.9)	535 (138)	0.74 (0.06)	2.60 (0.20)	5.35 (2.18)	126 (17)
MECC 1994	0.05 (0.00)	157 (15)	1.50 (0.30)	1.90 (0.10)	7.5 (1.3)	367 (67)	0.58 (0.10)	1.30 (0.35)	4.60 (0.60)	95 (7)
MECC 1995	0.12 (0.05)	345 (26)	1.80 (0.08)	3.33 (0.82)	9.9 (1.4)	535 (39)	0.56 (0.13)	1.65 (0.17)	6.05 (0.68)	135 (10)
MECC 1996	0.08 (0.03)	335 (47)	1.73 (0.19)	2.88 (0.33)	8.2 (0.6)	518 (61)	0.86 (0.31)	1.43 (0.13)	5.10 (0.48)	113 (5)
MECC 1997	ND	428 (57)	1.55 (0.31)	3.01 (0.33)	7.00 (1.18)	611 (112)	0.66 (0.06)	1.87 (0.26)	5.06 (1.07)	124 (24)
MECC 1998	ND	298 (65)	2.08 (0.13)	3.18 (0.70)	7.2 (0.7)	528 (80)	0.82 (0.11)	2.33 (1.08)	5.75 (0.70)	135 (24)
MEKN 1993	0.06 (0.01)	136 (27)	2.16 (0.36)	1.78 (0.58)	7.9 (0.3)	360 (51)	0.61 (0.27)	1.40 (0.11)	1.60 (0.35)	79 (18)
MEKN 1994	0.05 (0.00)	84 (13)	1.40 (0.40)	1.13 (0.20)	6.6 (1.3)	230 (47)	0.80 (0.10)	0.68 (0.13)	1.40 (0.30)	60 (11)
MEKN 1995	0.07 (0.04)	103 (10)	1.90 (0.28)	1.53 (0.34)	7.4 (1.3)	225 (31)	0.53 (0.11)	1.08 (0.15)	1.55 (0.40)	79 (13)
MEKN 1996	0.15 (0.07)	188 (64)	2.35 (0.21)	1.93 (0.33)	7.5 (0.9)	360 (86)	0.67 (0.30)	1.40 (0.18)	1.33 (0.46)	76 (11)
MEKN 1997	ND	122 (59.2)	1.33 (0.13)	1.03 (0.32)	4.98 (1.20)	190 (98.9)	0.33 (0.14)	ND	0.98 (0.31)	45.5 (9.7)
MEKN 1998	0.12 (0.05)	117 (26)	2.08 (0.43)	1.27 (0.23)	5.3 (0.6)	225 (42)	0.41 (0.09)	0.71 (0.36)	1.58 (0.40)	53 (10)
NBHI 1993	0.11 (0.06)	75 (12)	1.68 (0.09)	1.12 (0.12)	5.0 (0.9)	240 (41)	2.11 (0.49)	1.18 (0.19)	0.94 (0.15)	78 (9)
NBHI 1994	0.20 (0.00)	213 (22)	1.90 (0.40)	1.33 (0.30)	7.0 (0.6)	400 (56)	0.48 (0.49)	1.18 (0.13)	1.50 (0.40)	99 (21)
NBHI 1995	0.13 (0.04)	410 (74)	1.09 (0.11)	1.48 (0.40)	6.6 (0.7)	240 (27)	0.27 (0.04)	0.92 (0.09)	1.15 (0.13)	71 (12)
NBHI 1996	0.08 (0.03)	180 (29)	0.93 (0.13)	0.63 (0.16)	4.4 (0.2)	235 (25)	0.41 (0.12)	ND	0.75 (0.06)	70 (10)
NBHI 1997	0.08 (0.03)	180 (38)	1.16 (0.05)	0.68 (0.05)	5.34 (0.30)	226 (47)	0.16 (0.05)	0.47 (0.13)	0.47 (0.13)	58.4 (4.15)
NBHI 1998	1.82 (0.20)	793 (179)	2.00 (0.30)	4.00 (1.00)	29.0 (10.0)	696 (160)	0.29 (0.20)	1.90 (0.40)	2.30 (0.30)	139 (140)
NSDI 1993	0.26 (0.20)	413 (65)	1.77 (0.35)	1.91 (0.29)	7.1 (0.3)	678 (80)	1.82 (1.22)	1.86 (0.22)	3.94 (0.43)	112 (4)
NSDI 1994	ND	325 (84)	1.50 (0.10)	1.43 (0.20)	7.1 (0.3)	573 (145)	0.44 (0.01)	1.33 (0.13)	3.30 (0.30)	83 (7)
NSDI 1995	0.06 (0.03)	303 (75)	1.53 (0.15)	1.60 (1.41)	7.1 (0.3)	480 (84)	0.47(0.05)	1.48 (0.05)	3.25 (0.34)	96 (9)
NSDI 1996	ND	313 (36)	1.43 (0.10)	1.53 (0.10)	7.0 (0.8)	453 (54)	0.38 (0.19)	1.25 (0.13)	3.13 (0.24)	91 (13)
NSDI 1997	ND	392 (44.5)	1.54 (0.60)	1.81 (0.52)	6.57 (0.64)	513 (27.3)	0.32 (0.05)	1.44 (0.04)	2.79 (0.60)	89.3 (14.7)
NSDI 1998	0.08 (0.05)	338 (31)	1.60 (0.18)	1.43 (0.22)	5.3 (1.4)	485 (37)	0.46 (0.06)	1.63 (0.15)	2.70 (0.22)	94 (16)

TABLE 11.

Tissue organic contaminant concentrations (arithmetic mean ± SD, ng/g dry weight) for Gulfwatch stations at Sandwich, MA (MASN), Clark Cove, ME (MECC), Kennebec River, ME (MEKN), Hospital Island, NB (NBHI), and Digby Harbour, NS (NSDI) from 1993-1998.

Site | Year	ΣPAH_{24}	ΣPCB_{24}	$\Sigma TPEST_{17}$
MASN 1993	19.0 (7.0)	28.8 (7.20)	16.3 (5.10)
MASN 1994	42.4 (9.8)	28.6 (6.92)	20.3 (5.06)
MASN 1995	17.5 (11.7)	36.8 (7.63)	26.8 (6.55)
MASN 1996	58.0 (8.3)	40.1 (6.3)	23.3 (7.24)
MASN 1997	29.1 (1.17)	45.2 (6.77)	24.7 (2.42)
MASN 1998	13.0 (2.0)	28.0 (7.0)	29 (3)
MECC 1993	154 (47)	70.3 (10.7)	11.1 (5.30)
MECC 1994	137 (9.54)	66.8 (4.79)	12.5 (1.29)
MECC 1995	158 (38.8)	35.4 (10.20)	13.8 (0.96)
MECC 1996	203 (21.9)	37.6 (1.9)	7.3 (1.5)
MECC 1997	147 (19.0)	37.3 (8.35)	15.3 (4.97)
MECC 1998	200 (26)	43 (8)	15 (2)
MEKN 1993	94.0 (31.0)	27.3 (3.70)	3.50 (2.00)
MEKN 1994	103 (15.2)	42.5 (11.7)	18.3 (4.43)
MEKN 1995	64.0 (25.6)	24.5 (7.19)	17.5 (1.00)
MEKN 1996	155 (53.5)	29.8 (3.8)	5.4 (1.50)
MEKN 1997	46.0 (9.66)	25.3 (0.98)	12.5 (0.69)
MEKN 1998	59 (20)	17 (4)	5 (0.5)
NBHI 1993	ND	3.70 (1.20)	3.00 (1.00)
NBHI 1994	ND	ND	3.43 (0.10)
NBHI 1995	ND	ND	3.86 (0.59)
NBHI 1996	7.0 (8.1)	1.4 (1.6)	3.40 (0.30)
NBHI 1997	ND	ND	4.75 (0.17)
NBHI 1998	22 (11)	ND	7 (2)
NSDI 1993	108 (26)	ND	ND
NSDI 1994	70.5 (8.7)	1.2 (1.4)	1.7 (1.1)
NSDI 1995	129 (38.2)	3.0 (0.0)	1.8 (1.2)
NSDI 1996	211 (28)	7.6 (2.0)	3.6 (0.4)
NSDI 1997	198 (50.2)	0.47 (0.94)	1.7 (0.46)
NSDI 1998	106 (14)	4.0 (0.6)	6 (1)

3.3.2 Annual Sites (1995 vs. 1998)

Figures 11-15 shows the concentrations of all metals at the 7 non-benchmark Gulfwatch sites sampled in 1995 and 1998. Asterisks show sites in which a significant difference in concentration was detected. Significant differences between years were observed for all contaminants. Twelve of the 19 significant results suggested a decrease in contaminant concentration whereas 7 suggested concentrations had increased since 1995. There was only one site that showed an increase in more than one metal. The results of the analysis show that concentrations of 4 metals (Pb, Ni, Hg, and Cd) increased at NSCW between 1995 and 1998. Concentrations of all metals at the Niger River, NB (NBNR) were significantly lower in 1998 versus 1995. It must be noted that this analysis is based on concentrations from only two years. As such it will be sensitive to sampling fluctuations and may not be indicative of true differences.

Figures 16-18 shows the concentrations of all organic contaminants at the 13 non-benchmark Gulfwatch sites sampled in 1995 and 1998. Asterisks show sites in which a significant difference in contaminant concentration was detected. Significant differences between years were observed for all contaminants. In general, the majority reveal significantly higher concentrations in 1998 than observed in 1995. The site with the most significant changes was MAIH. Analysis indicates that concentrations of all organic contaminants at MAIH were significantly higher in 1998.

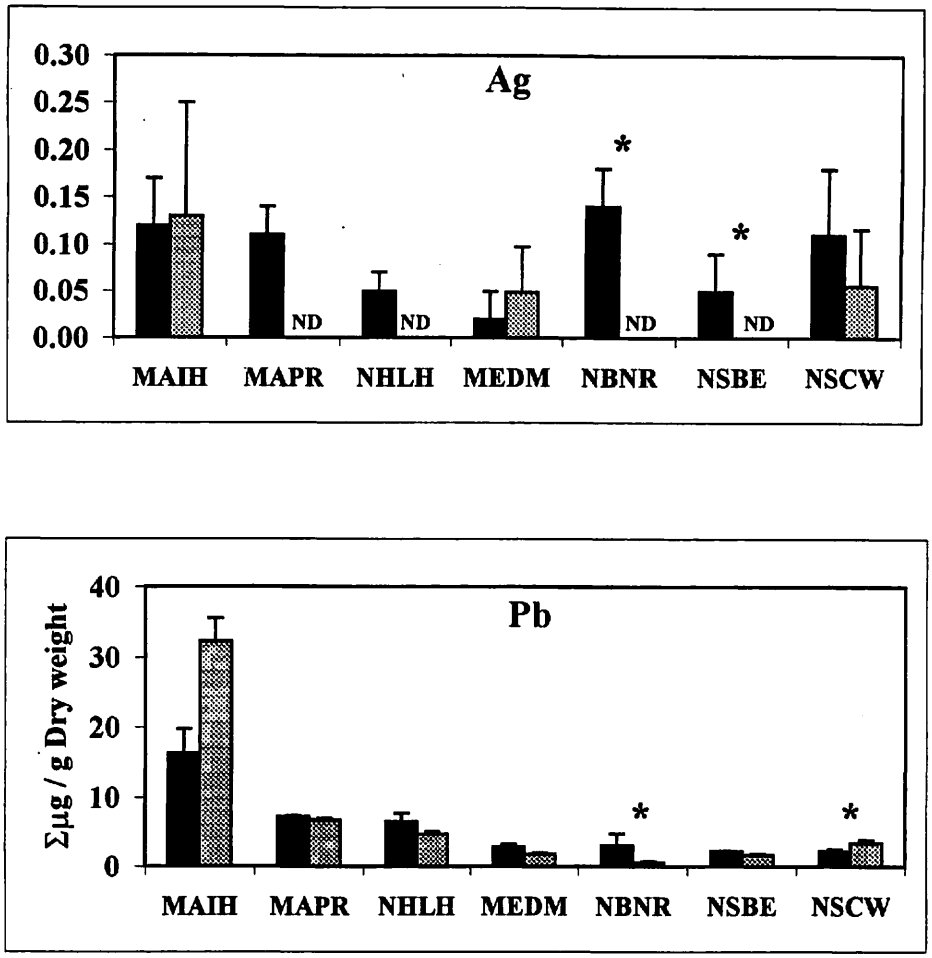


Figure 11. Distribution of silver and lead tissue concentrations (arithmetic mean +/- SD μg/g dry weight) in mussels at the Gulf of Maine Stations in 1995 (black) and 1998 (gray). *, indicates a significant difference between years ($p<0.05$).

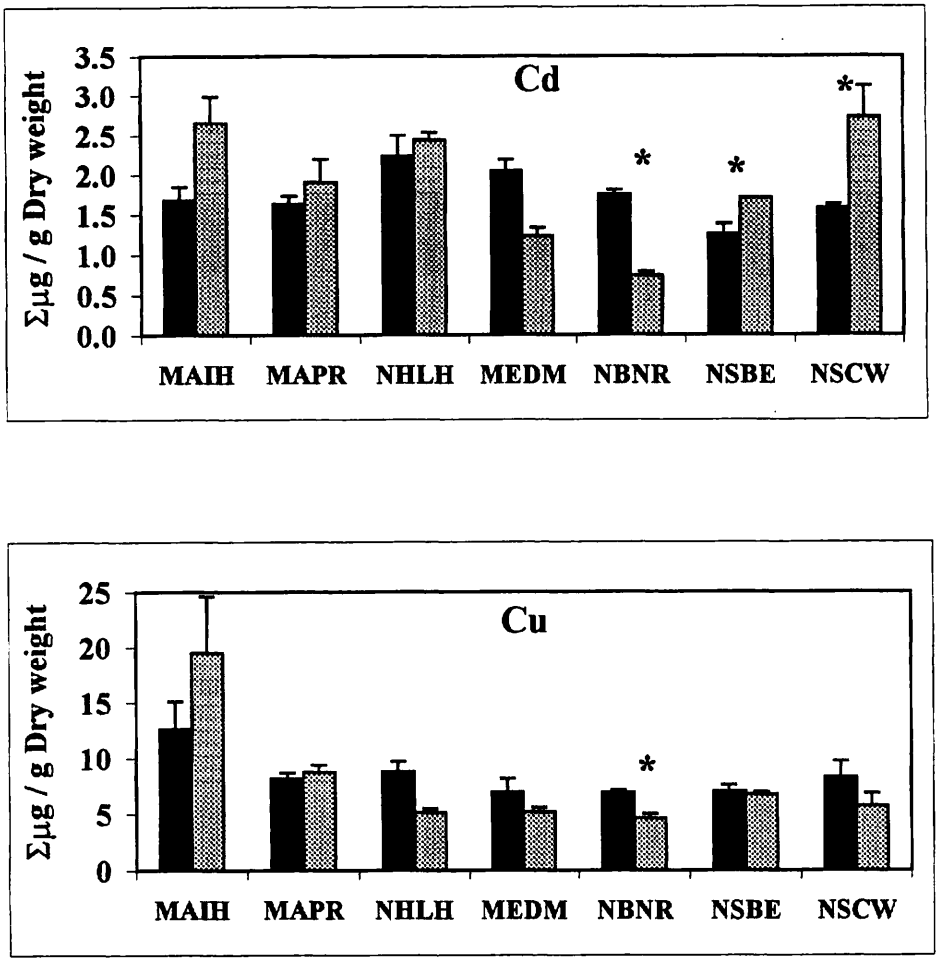


Figure 13. Distribution of cadmium and copper tissue concentrations (arithmetic mean +/- SD μg/g dry weight) in mussels at the Gulf of Maine Stations in 1995 (black) and 1998 (gray). *, indicates a significant difference between years ($p<0.05$).

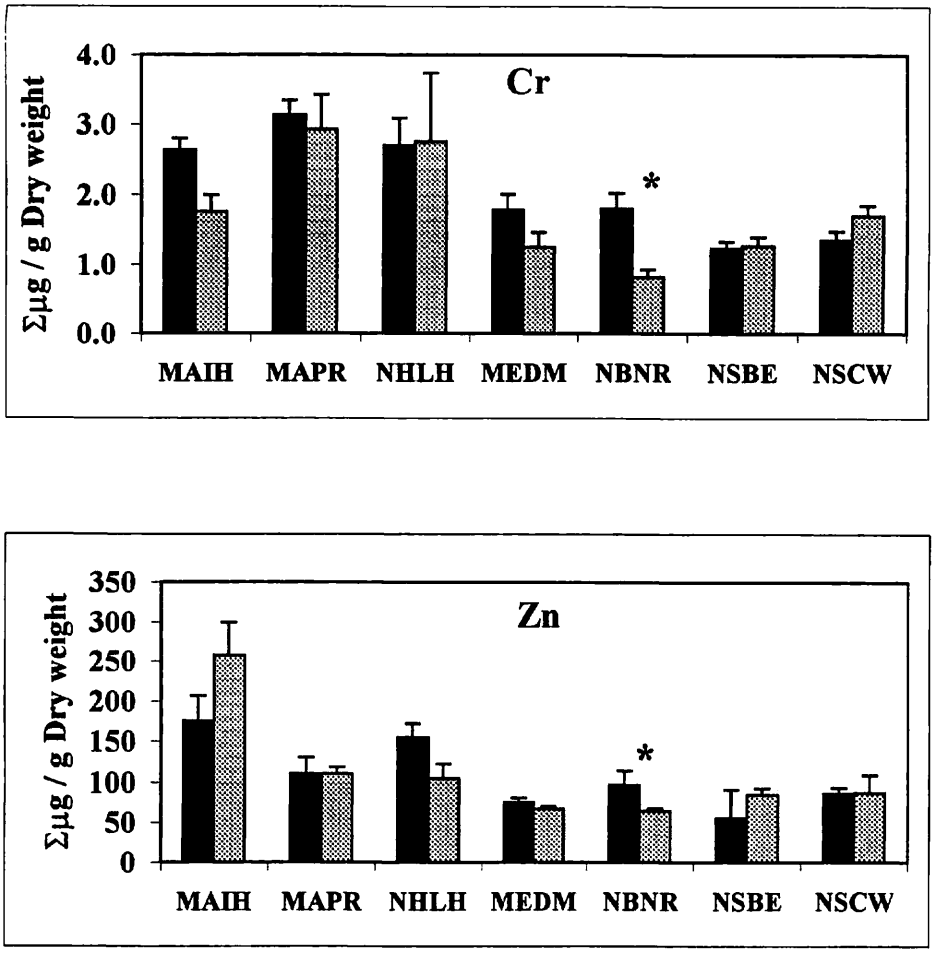


Figure 14. Distribution of chromium and zinc tissue concentrations (arithmetic mean +/- SD μg/g dry weight) in mussels at the Gulf of Maine Stations in 1995 (black) and 1998 (gray). *, indicates a significant difference between years ($p<0.05$).

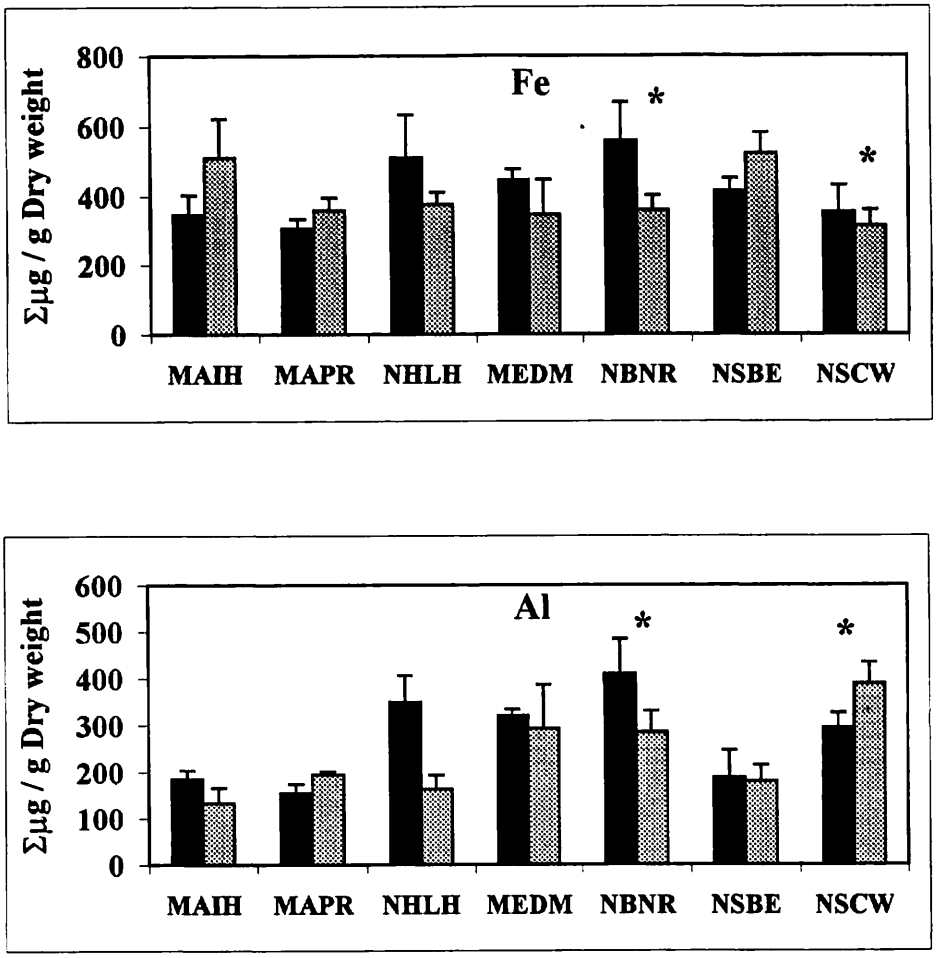
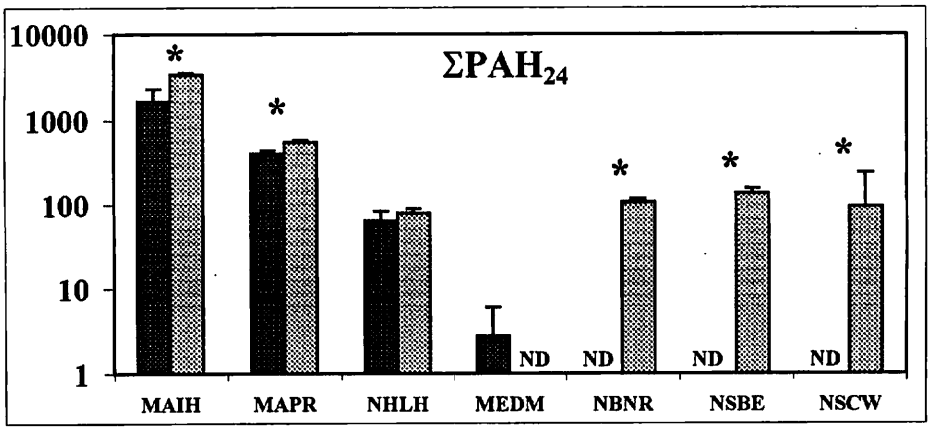


Figure 15. Distribution of iron and aluminum tissue concentrations (arithmetic mean +/- SD μg/g dry weight) in mussels at the Gulf of Maine Stations in 1995 (black) and 1998 (gray). *, indicates a significant difference between years ($p<0.05$).



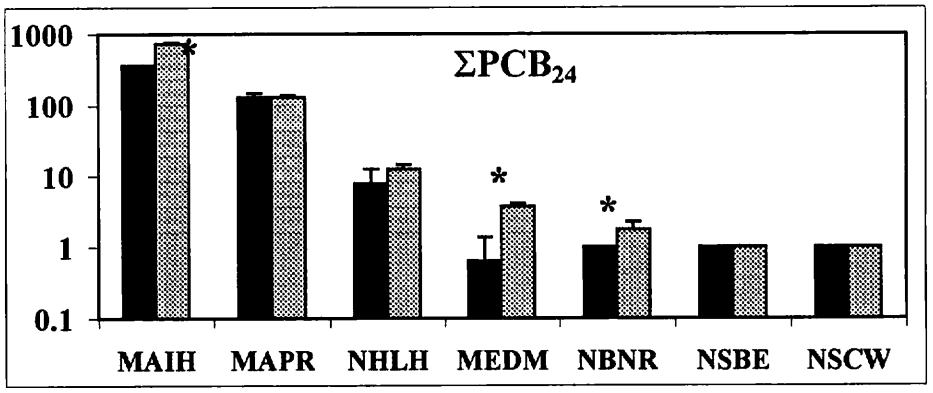
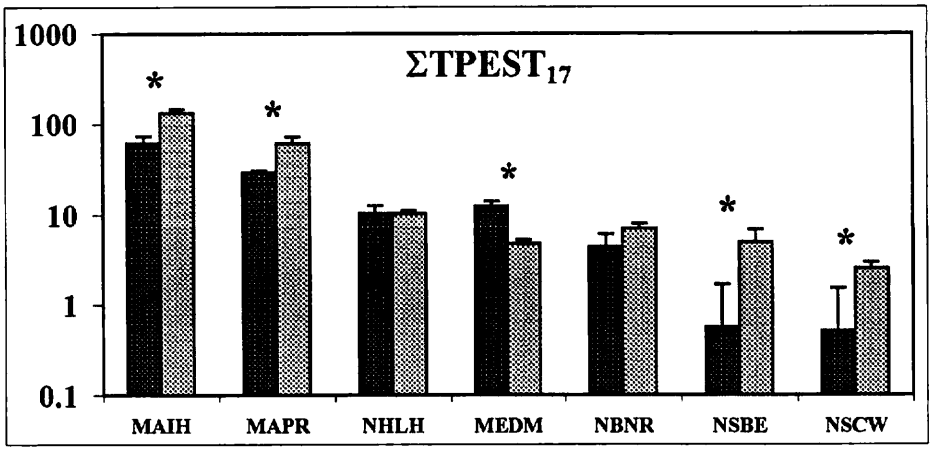


Figure 16. Log distribution of ΣPAH24 and ΣPCB24 tissue concentrations (arithmetic mean: ng/g dry weight) in mussels at the Gulf of Maine stations in 1995 (black) and 1998 (gray). *, indicates a significant difference between years ($p<0.05$).



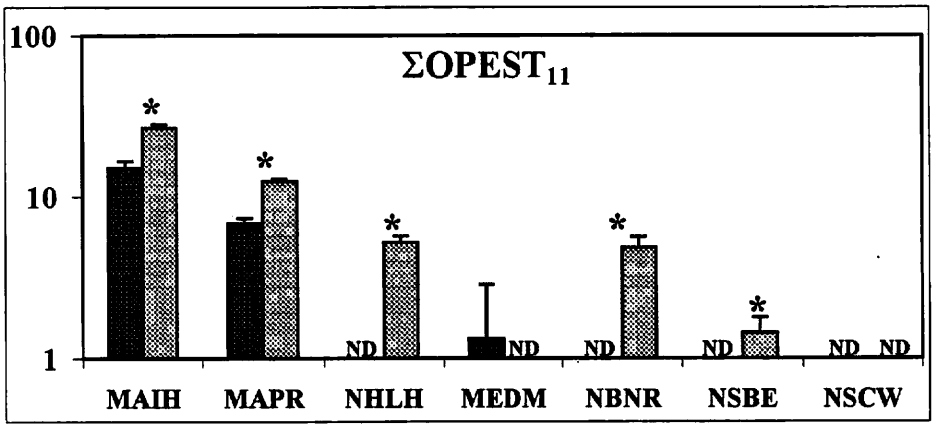


Figure 17. Log distribution of ΣTPEST17 and ΣOPEST11 tissue concentrations (arithmetic mean: ng/g dry weight) in mussels at the Gulf of Maine stations in 1995 (black) and 1998 (gray). *, indicates a significant difference between years ($p<0.05$).

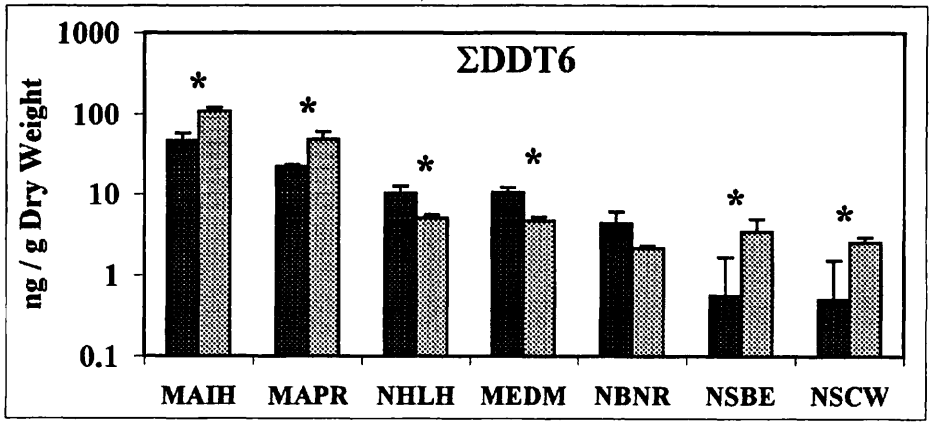


Figure 18. Log distribution of ΣDDT6 tissue concentrations (arithmetic mean: ng/g dry weight) in mussels at the Gulf of Maine stations in 1995 (black) and 1998 (gray). *, indicates a significant difference between years ($p<0.05$).

3.5 Acceptable Levels and Standards of Mussel Contamination

Despite the wealth of information on the effects of toxic contaminants on a variety of species, limited information is available on observed human health effects of consumption of chemically contaminated shellfish. While there may be limited epidemiological documented effects, laboratory assays and isolated occurrences of acute human poisonings are responsible for the focus of attention on human health impacts from eating chemically contaminated marine fish and shellfish. For example in New Hampshire, there are currently human consumption advisories for Hg and PCBs (NHDES 1998). The advisory for Hg is based on a new (2001) US FDA advisory. For marine waters, there is a consumption advisory for both lobsters and bluefish based on elevated levels of PCBs. The PCB advisories for bluefish and lobsters are based on studies done in 1987 and 1991, respectively.

Published tolerance or action levels for PAHs in commercial marine species are not available in Canada or in the United States. In marine areas where PAH contamination may be a human health concern, closure of commercial fisheries as a result of high contamination levels has been dealt with on a case by case basis. In general, most concentrations 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. All reported organic concentrations are within acceptable concentrations for those compounds that have established FDA Action Limits in fish and shellfish. PCB concentrations found in Gulfwatch mussels (Table 12A) are less than the action level of 13 μg/g dry weight (USFDA 1990, CSSP 1992), with MAIH having the highest concentrations of PCBs in mussels, 0.73 μg/g dry weight, during the 1998 survey. The action level for the pesticides dieldrin, aldrin, chlordane, heptachlor, and heptachlor epoxide is 2.0 μg/g dry weight (USFDA 1990). Only dieldrin and chlordane were detected in the 1998 mussel survey, but at concentrations barely above detection limits which are orders of magnitude below the action levels. The total DDT concentrations found are several orders-of-magnitude below the action level of 33 μg/g dry weight (USFDA 1990, CSSP 1992). Again, MAIH had the highest level of $\Sigma PEST_{17}$, 0.133 μg/g dry weight, in 1998. Canadian limits for agricultural chemicals exclusive of DDT are 0.67 μg/g dry weight.

As presented in Table 12A, admissible levels of methyl mercury, expressed as mercury, are less than 6.7 μg/g dry weight, or 1 μg/g wet weight in the United States (USFDA 1990), and less than 3.3 μg/g dry weight, or 0.5 μg/g wet weight in Canada (CSSP, 1992). The highest concentration of mercury found in the 1998 Gulfwatch study was 1.20 μg/g dry weight, in one replicate sample from the Schiller Station, New Hampshire, which is high but still well below both federal action concentrations.

A series of FDA "Guidance Documents" (USFDA 1993) for cadmium, chromium, lead and nickel was released in the United States to complement the FDA Mercury Action Level. These "alert"

levels, however, are guidelines and by themselves do not warrant the issuance of health advisories. In Table 12B, guidance concentrations are reported on both wet weight and dry weight bases and are compared to the highest observed concentration in any single replicate analyzed in the 1998 Gulfwatch Project. All nickel, chromium and cadmium concentrations in 1998 Gulfwatch mussels were well below the guidance values. However, Pb concentrations were above the FDA guidance alert level of 11.5 µg/g DW at MAIH and MEBB, and are thus of regional and local concern. The highest observed concentrations from the 1998 Gulfwatch data for other trace metals for which there is no guidance or action limit are included in Table 12. This highlights hot spots of localized elevated contamination as well as sites where elevated levels may also be associated with excessive sediment in tissue samples such as the New Brunswick sites.

The U.S. EPA has promulgated a series of "screening values" total (EPA, 1993) which were derived using human health risk assessment procedures. The promulgated values on several exposure assumptions (70 kg man, an average consumption rate of 6.5 g/day), and either the most current Reference Dose (RfD) values for non-carcinogens or the most recent Slope Factor plus an acceptable lifetime cancer risk of 1×10^{-5} for the carcinogenic compounds listed. Exceedances of any of the screening values by the Gulfwatch data provide yet another index of possible human health concern. The screening value for ΣPCB_{24} is exceedingly low (Table 12C), and in 1998 no Gulfwatch site exceeded this value.

TABLE 12.

Comparison of Gulfwatch tissue contaminant concentrations with (A) Health Canada (1992) standards; (B) relative levels of concern based on USFDA (1993) provisional intake levels; and (C) USEPA (1993) screening values.

A.

Contaminant	Action level (ww)	Action level (dw)	Highest observed value (dw)	Location
ΣPCB	2 µg / g	13.3 µg / g	0.73 µg / g	Boston Inner Harbor, MA
ΣDDT	5 µg / g	33.3 µg / g	0.11 µg / g	Boston Inner Harbor, MA
Other pesticides	>0.1 µg / g	0.7 µg / g	0.027 µg / g	Boston Inner Harbor, MA
Hg (Canada)	0.5 µg / g	3.3 µg / g	1.08 µg / g	Schiller Station, NH
Hg (USA)	0.1 µg / g	6.7 µg / g		

B.

Contaminant	Guideline (ww)	Guideline (dw)	Highest observed value (dw)	Location
Cd*	3.7 µg / g	25 µg / g	2.80 µg / g	Dover Point, NH
Cr*	13 µg / g	87 µg / g	17.5 µg / g	Letang Estuary, NB
Pb*	1.7 µg / g	11.5 µg / g	32.3 µg / g	Boston Inner Harbor, MA
Ni*	80 µg / g	533 µg / g	9.80 µg / g	Letang Estuary, NB

C.

Contaminant	Guideline (ww)	Guideline (dw)	Values exceeding (dw)	Location
ΣPCB	0.01 µg / g	0.07 µg / g	0.73 µg / g	Boston Inner harbor, MA
			0.13 µg / g	Pines River, MA

3.6 Morphometric Comparison

Table 13 contains a summary of the morphological measurements [length (mm), height (mm), width (mm), wet weight (g) and condition index (CI)] for mussels collected at each site.

3.6.1 Shell Morphology

The field protocol recommended the collection of mussels within the length range of 50-60 mm. This was attained at all sites. The Gulfwide mean length (±SD) at the 15 sites where data were available was 55.1±2.7 mm (Table 13; Figure 19). ANOVA on length of mussels collected among sites was significant ($P<0.05$) suggesting that there were significant differences in length. This significant difference is a reflection of the size range available at the sites at the time of sampling.

3.6.2 Condition Index and Weight

Condition Indicies (CI) of the mussels collected in 1998 are shown in Table 13 and Figure 20. The average CI (±SD) for all sites where data were available was 0.183±0.05. ANOVA on the mean CI of all mussels was significant ($p<0.05$). The CI ranged from a value of 0.132±0.04 at NHLH to 0.285±0.04 at MEBB. There were no significant differences in the CI's of mussels at sites in Massachusetts and Nova Scotia. The mean CI ± SD of all sites in New Hampshire was below the Gulf mean.

Analysis of covariance (ANCOVA) on wet weight, using length, height and width as covariates was performed among sites within each jurisdiction. In Maine and Nova Scotia length, width and height were significant covariates. In Massachusetts width and length were significant and in New Hampshire height and width were significant. As a result wet weight in each jurisdiction was adjusted for the significant covariates. Figure 21 shows the adjusted mean weights for stations sampled in 1998. The Gulfwide mean was 6.85 g. The weights of the New Hampshire mussels were significantly lower than the Gulfwide mean and the majority of sites sampled in 1998. The lower CI at these sites is likely a reflection of the low weight. There is a significant relationship between CI and wet weight for all stations ($P<0.001$).

TABLE 13.

Morphometric characteristics (mean SD) of mussels collected at the Gulf of Maine, 1998 stations and ANOVA of measurements by jurisdiction. Same letter indicates no significant difference among sites within each jurisdiction. Overall mean for all stations given below.

Station	N	Length (mm)	Height (mm)	Width (mm)	Wet Weight (g)	Condition index (CI)
MASN	30	56.6(2.7)^{B}	28.6(1.6)^{A}	26.8(2.6)^{B}	8.10(2.4)^{A}	0.186(0.04)^{A}
MAIH	30	54.0(2.8)^{A}	29.8(1.6)^{B}	24.1(2.3)^{A}	7.15(2.5)^{A}	0.179(0.04)^{A}
MAPR	30	56.6(2.0)^{B}	30.7(2.0)^{B}	23.8(2.0)^{A}	7.22(1.1)^{A}	0.176(0.02)^{A}
NHGP	40	54.5(2.6)^{AB}	28.1(1.4)^{AB}	22.1(2.4)^{A}	4.82(0.90)^{AB}	1.43(0.02)^{AB}
NHLH	40	54.2(2.4)^{AB}	27.9(2.2)^{A}	22.5(1.8)^{A}	4.50(1.37)^{A}	1.32(0.04)^{A}
NHSS	40	55.6(2.7)^{C}	28.7(1.9)^{C}	22.4(2.0)^{A}	5.12(1.04)^{B}	1.46(0.03)^{B}
NHDP	40	53.9(2.2)^{A}	26.7(1.5)^{A}	22.0(5.1)^{A}	4.29(0.84)^{A}	1.37(0.02)^{AB}
NHNM	40	54.5(2.2)^{AB}	28.7(1.7)^{A}	22.3(1.6)^{A}	5.92(1.05)^{C}	1.70(0.02)^{C}
MECC	40	55.0(2.4)^{BC}	29.6(2.0)^{BC}	21.4(2.0)^{A}	5.47(1.03)^{BC}	0.157(0.02)^{B}
MEKN	30	56.2(2.8)^{A}	28.6(1.5)^{A}	23.1(2.0)^{A}	10.2(2.4)^{A}	0.273(0.04)^{A}
MEDM	30	55.6(2.8)^{A}	30.4(1.7)^{B}	24.0(2.1)^{A}	10.6(2.9)^{A}	0.254(0.04)^{A}
MEBB	30	55.5(2.8)^{A}	30.8(3.2)^{B}	23.0(2.3)^{A}	11.1(2.1)^{A}	0.285(0.04)^{A}
NBNR						
NBCH						
NBLB						
NBLN						
NBCG						
NBTC						
NSCW	80	55.0(2.7)^{A}	29.4(1.8)^{A}	22.7(2.1)^{B}	6.77(1.4)^{B}	0.184(0.03)^{B}
NSDI	80	54.8(2.6)^{A}	29.8(2.0)^{A}	21.0(1.6)^{A}	7.02(1.4)^{B}	0.203(0.02)^{C}
NSBE	90	55.5(3.2)^{A}	29.1(2.1)^{A}	21.1(1.7)^{A}	5.80(1.5)^{A}	0.170(0.04)^{A}
MEAN		55.1 (2.7)	29.1 (2.1)	22.5 (2.6)	6.67 (2.4)	0.183 (0.05)

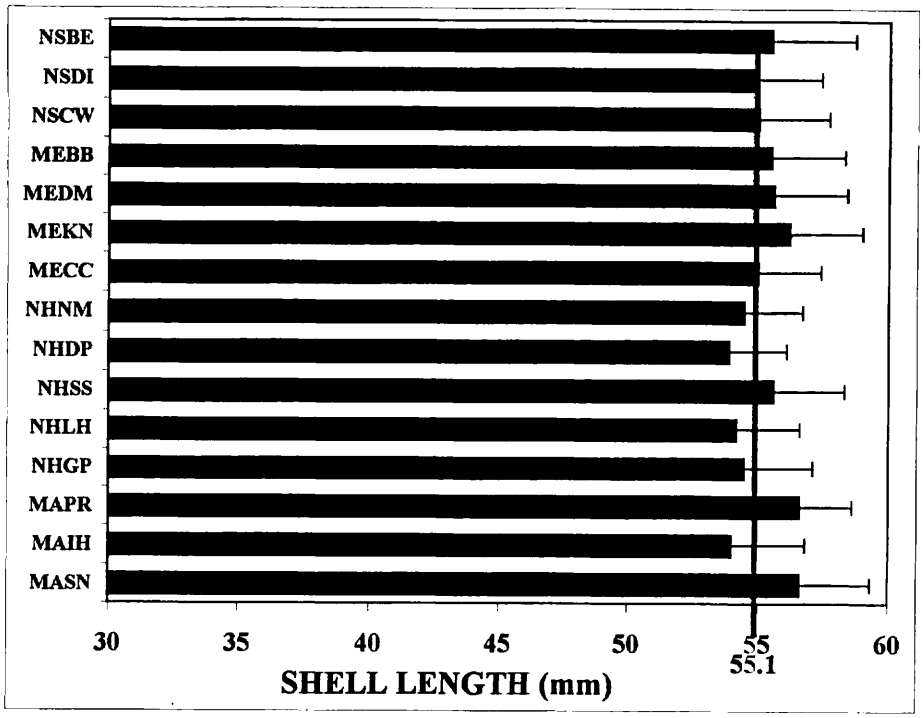


Figure 19. Mean length (+/-SD) of mussels collected at the Gulf of Maine stations, 1998 organised from south to north. Mean length of mussels from all sites is indicated by the straight line.

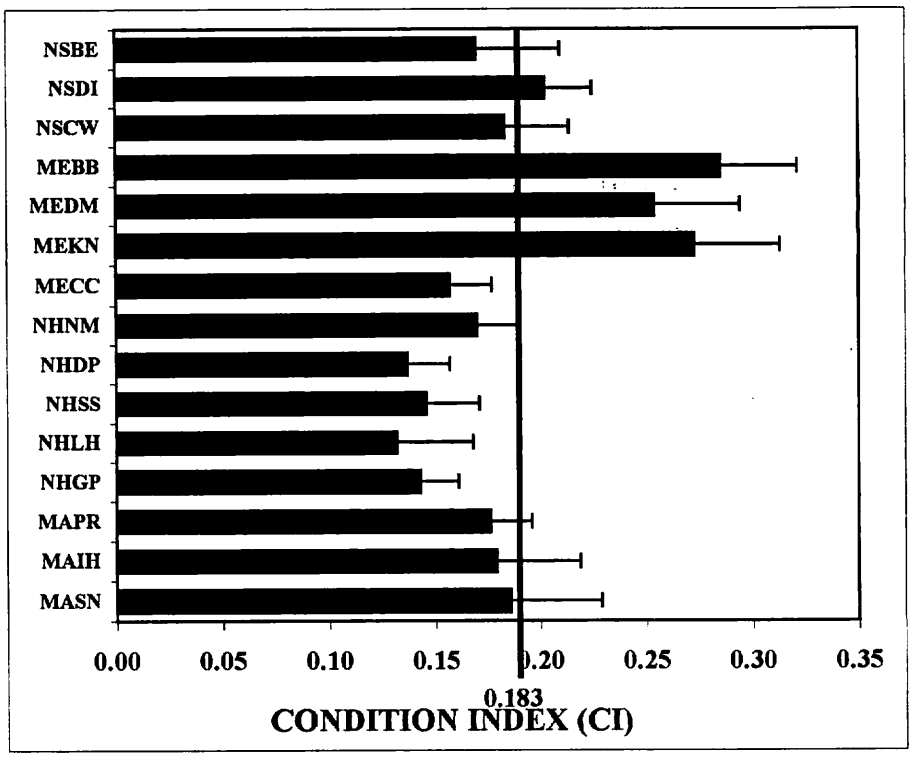


Figure 20. Mean Condition Indices (+/-SD) of mussels collected at the Gulf of Mainestations, 1998 organised from south to north. Mean length of mussels from all sites is indicated by the straight line.

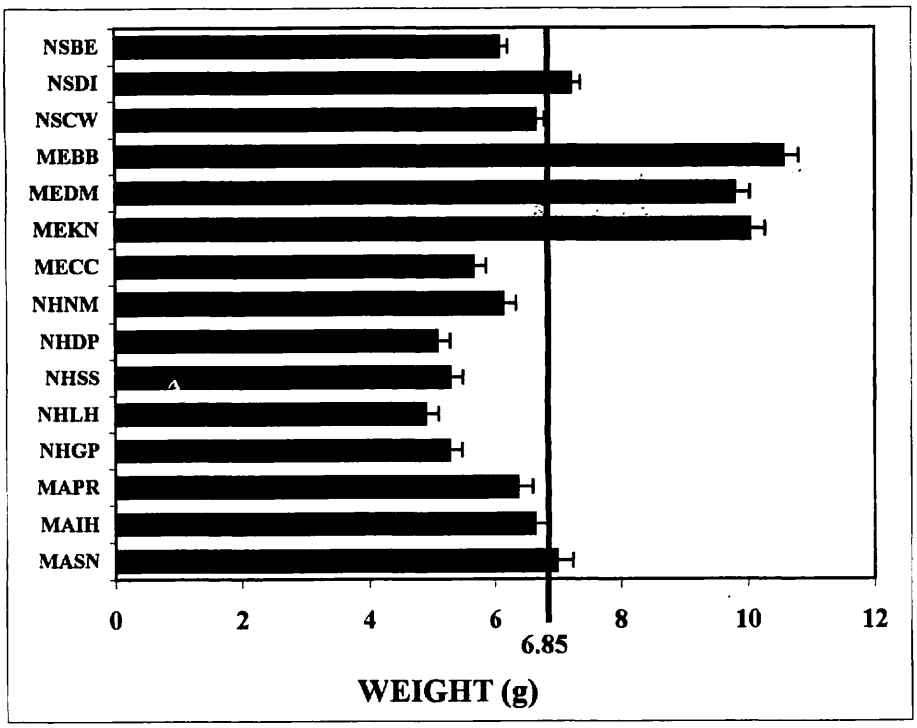


Figure 21. Mean adjusted wet weight (+/-SD) of mussels collected at the Gulf of Maine stations, 1998 organised from south to north. Mean length of mussels from all sites is indicated by the straight line.

4.0 CONCLUSIONS

The field season of 1998 represented the eighth Gulfwatch season overall and the third year of the second three-year rotation sampling plan. The sampling protocol for the third year of rotation typically involves transplant studies to be carried out in each jurisdiction. In the 1998 season, however, no transplant studies were undertaken. The result of a five year review of the Gulfwatch program (Jones et al. 1998) suggested that the transplant studies should be removed from the sampling protocol, at least for the present, as they did not provide as much information as they had intended, mainly as a result of lost samples in the field. As a result of the omission of the transplant studies we were able to sample additional stations in regions of concern. In 1998 that meant additional sites were established in New Hampshire and New Brunswick. Three new sites were added to the New Hampshire list of sampling stations (NHGP, NHSS, and NHNM). In addition, the New Hampshire sites NHDP and NHLH were also sampled. A total of six sites were therefore sampled in the New Hampshire (including MECC) in 1998. This additional sampling was carried out in conjunction with the New Hampshire Gulfwatch program. This program was established after an oil spill in the Great Bay estuary in 1996 generated concern over the health of the ecosystem in that region. Gulfwatch had been sampling sites within the Great Bay estuary since the program began in 1991and the background data on contaminant levels in this region was a vital part of the impact analysis.

The other region in which new sites were added was New Brunswick, specifically the Saint John, NB harbour region. Saint John is a major population centre on the Bay of Fundy and a potentially significant contaminant contributor to the Bay. New Brunswick sites NBCG, NBLN and NBTC had elevated levels of silver, chromium, nickel, copper, ΣPAH and ΣTPEST, the majority of which were higher than the Gulfwide median. This is evidently an area of concern that will need to be monitored in the future.

Sampling in 1998 has revealed a number of sites exceeding the NS&T MD + 1 SD for metal concentration. Widespread elevated levels for Cr, Cu, Pb, and especially Hg suggest possible regional sources of these contaminants. Mercury was highlighted in the five-year review as unusually high and a possible concern. Seventeen of the 21 Gulwatch sites sampled in 1998 exceeded the NS&T MD + 1 SD for Hg. Currently there is no confirmed explanation for the source of the contamination. Although the concentrations of mercury were high they did not exceed the federal action concentration.

The spatial pattern of contaminant concentrations was similar to that observed in previous years. The concentration of metals was relatively uniform with the occasional elevated hot spot. Conversely, the concentration of organic contaminants, especially ΣPCB and ΣPEST, tended to be

higher in the south-western Gulf. Although the addition of the stations located in the Saint John, New Brunswick harbor has meant that contaminant levels in that jurisdiction were likely higher than observed in any other year.

There are now six years of data from the benchmark sites. Analysis revealed decreases in at least one site for all contaminants except Al and ΣPAH. Concentrations of all organic contaminants (ΣPAH, ΣPCB and ΣPEST) increased in at least one site. In addition to looking for temporal patterns in the benchmark sites, the sampling design of Gulfwatch allows for repeated sampling of annual sites every 3 years. Most of the stations sampled in 1998 were the same ones sampled in 1995. For both metal and organic contaminants significant differences were observed between years for all contaminants. The majority of metal concentrations appeared to decrease, however, most organic contaminant concentrations were higher than recorded in 1995. However, temporal patterns based on only two years may not be representative.

Despite the fact that Gulfwatch has had a sampling program in place since 1993, there is some flexibility that allows it to respond to the current problems and concerns for the environment. The sampling of additional sites in New Hampshire and New Brunswick in 1998 is an example of this flexibility. Re-sampling MEBB in 1998 is another example. MEBB was highlighted in a previous Gulfwatch report as a site of concern. Sampling in 1998 confirmed the previously reported high lead concentrations as well as other contaminant concentrations and brought them to the attention of managers in that region.

Coastal monitoring programs such as Gulfwatch provide a valuable measure of the current state of the environment, for identifying future problems which may be prevented by early action, for determining trends in contamination over space and time, and for identifying potential sources of contamination. Gulfwatch results provide a geographically comprehensive, region specific perspective on relative contaminant concentrations in both contaminated and pristine areas. As such, it is a unique and invaluable basis for making management decisions on issues relating to toxic contaminants. Continuation of the Gulfwatch program according to the ten year plan will provide the temporal perspective necessary to determine trends and impacts of remediation efforts.

5.0 ACKNOWLEDGEMENTS

The authors are grateful to the following individuals: Mireille Abi-Khattar for her dedicated effort; Don Walter, Andy Bagnell, Noel Carlson, Andrea Riley, Joanne McLaughlin, Andrea Bowman, Amber Currier, Paul Currier, Rob Livingston, Eric Williams, Deb Lamson, Charles Elvin, Tina Nims, Bob Gaudet and Irma Simon for their assistance in field collection, sample preparation and laboratory analyses. This study was possible through the diligent field work of teams in Massachusetts, New Hampshire, Maine, New Brunswick and Nova Scotia. The study team gratefully acknowledges financial support from the U.S. Environmental Protection Agency through the U.S. Gulf of Maine Association and Environment Canada.

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Appendix A.

Quality Control Results for 1998 Organic Contaminant Analysis

Spiked Mussel Tissue and CRM Recoveries

PAH	Concentration (ng.g)	Sample Batch 205	419	610	629	724	805	CRM (1)	CRM (2)
Naphthalene	42.3	50%	58%	80%	53%	60%	80%	32%	36%
1-Methylnaphthalene	50.9	55%	65%	76%	65%	66%	78%	61%	45%
2-Methylnaphthalene	46.4	53%	56%	66%	55%	67%	78%	49%	60%
Biphenyl	43.0	65%	65%	72%	62%	72%	80%	57%	106%
2,6-Dimethylnaphthalene	44.4	64%	73%	73%	68%	72%	87%	*	*
Acenaphthylene	42.7	69%	78%	80%	81%	81%	102%	147%	40%
Acenaphthene	44.7	54%	81%	86%	82%	92%	114%	84%	89%
2,3,5-Trimethylnaphthalen	40.7	82%	92%	82%	86%	87%	95%	*	*
Fluorene	44.6	60%	108%	102%	106%	113%	132%	102%	63%
Phenanthrene	43.0	81%	81%	96%	88%	100%	96%	75%	76%
Anthracene	48.0	77%	95%	94%	113%	111%	129%	110%	56%
1-Methylphenanthracene	42.7	103%	95%	98%	109%	101%	103%	120%	124%
Fluoranthene	36.3	118%	112%	115%	104%	113%	119%	88%	97%
Pyrene	36.2	99%	97%	102%	102%	108%	116%	95%	99%
Benzo(a)Anthracene	22.1	114%	132%	106%	139%	99%	121%	115%	80%
Chrysene	43.1	91%	123%	103%	102%	102%	97%	90%	86%
Benzo(b)Fluoranthene	32.2	102%	121%	108%	118%	97%	137%	103%	119%
Benzo(k)Fluoranthene	34.2	80%	120%	98%	94%	108%	90%	135%	109%
Benzo(e)Pyrene	34.5	92%	121%	106%	108%	103%	119%	99%	96%
Benzo(a)Pyrene	41.6	74%	118%	106%	110%	106%	123%	108%	94%
Perylene	43.7	95%	130%	122%	127%	121%	135%	117%	87%
Indeno(1,2,3,4-cd)Pyrene	38.6	97%	122%	120%	112%	72%	130%	114%	89%
Dibenz(a,h)Anthracene	31.8	99%	106%	101%	98%	75%	113%	111%	Int
Benzo(ghi)Perylene	32.4	74%	104%	100%	85%	86%	104%	84%	91%

Surrogate Recovery

Napthalene-d8	56%	65%	66%	51%	55%	81%
Acenaphthene-d10	67%	88%	73%	63%	79%	93%
Phenanthrene-d10	85%	107%	98%	85%	102%	104%
Fluoranthene-d10	102%	117%	107%	107%	110%	119%
Chrysene-d12	92%	116%	109%	99%	104%	105%
Benzo(a)pyrene-d12	89%	109%	87%	107%	93%	121%
Benzo(g,h,i)perylene-d12	78%	116%	111%	112%	88%	97%

CRM: NIST SRM 1742a mussel tissue certified reference material analyzed at beginning (1) and end (2) of projec
* certified values not available

Appendix A.

Quality Control Results for 1998 Organic Contaminant Analysis

Spiked Mussel Tissue and CRM Recoveries

PCB	Concentration (ng.g)	Sample Batch 205	419	610	620	724	805	CRM (1)	CRM (2)
#8,5	24.2	77%	76%	74%	79%	95%	69%	*	*
#18,15	24.1	72%	70%	72%	68%	87%	64%	79%	65
#29	24.1	87%	87%	74%	79%	81%	76%	*	*
#28	24.2	92%	95%	82%	83%	91%	81%	104%	76
#50	24.2	76%	80%	81%	76%	79%	76%	*	*
#52	24.2	85%	88%	87%	79%	88%	85%	95%	75
#44	24.2	85%	97%	80%	79%	86%	89%	78%	84
#66,95	24.2	107%	99%	79%	74%	84%	83%	85%	65
#101,90	24.1	88%	95%	86%	83%	92%	83%	115%	83
#87	24.2	88%	95%	88%	82%	87%	84%	92%	95
#77	24.2	108%	106%	92%	79%	95%	93%	*	*
#118	24.2	104%	113%	87%	95%	93%	89%	83%	80
#153,132	24.3	86%	99%	88%	97%	96%	92%	80%	73
#105	24.2	100%	113%	81%	101%	93%	84%	95%	103
#138	24.2	95%	102%	85%	95%	93%	90%	98%	78
#126	24.2	105%	109%	108%	117%	99%	94%	*	*
#187	24.2	83%	99%	83%	85%	90%	87%	94%	81
#128	24.2	89%	111%	81%	83%	94%	86%	98%	93
#180	24.2	93%	103%	83%	90%	88%	82%	100%	69
#169	19.4	103%	111%	89%	103%	90%	86%	*	*
#170,190	24.2	91%	104%	83%	104%	87%	81%	78%	33
#195,208	24.2	89%	101%	82%	101%	90%	82%	*	*
#206	23.7	86%	102%	84%	99%	86%	79%	*	*
#209	24.2	83%	106%	86%	100%	87%	79%	*	*
Surrogate Recovery									
103		105%	110%	87%	105%	100%	103%		
198		108%	115%	83%	108%	87%	94%		

CRM: NIST SRM 1742a mussel tissue certified reference material analyzed at beginning (1) and end (2) of p

* certified values not available

Appendix A.

Quality Control Results for 1998 Organic Contaminant Analysis

Spiked Mussel Tissue and CRM Recoveries

		Sample Batch					
Pesticide	Concentration (ng.g)	205	419	610	629	724	805
HCB	24.4	76%	89%	64%	72%	66%	71%
g-HCH	24.5	86%	99%	81%	94%	68%	104%
Heptachlor	24.5	92%	85%	92%	95%	71%	73%
Hepta Epoxide	24.6	86%	83%	85%	82%	77%	70%
o,p'-DDE	24.5	85%	106%	79%	84%	76%	89%
a-Endosulfan	24.5	87%	109%	98%	98%	72%	82%
cis-Chlordane	19.7	89%	107%	95%	101%	104%	108%
trans-Nonachlor	24.5	97%	104%	89%	100%	83%	95%
p,p'-DDE	24.7	114%	100%	88%	86%	80%	98%
Dieldrin	24.5	101%	109%	106%	95%	86%	79%
o,p'-DDD	24.5	124%	119%	106%	99%	110%	79%
b-Endosulfan	24.5	82%	122%	87%	118%	104%	83%
p,p'-DDD	19.6	138%	119%	85%	88%	95%	64%
o,p'-DDT	24.7	102%	101%	102%	124%	114%	120%
p,p'-DDT	24.3	108%	109%	98%	113%	87%	81%
Mirex	24.4	89%	107%	94%	103%	82%	106%
Surrogate Recovery							
g-Chlordene		86%	111%	87%	87%	107%	98%

CRM Recoveries

	CRM (1)	CRM (2)
o,p'-DDE	86	Int
cis-Chlordane	96	76
trans-Nonachlor	86	69
p,p'_DDE	95	76
Dieldrin	160	108
o,p'-DDD	134	84
p,p'-DDD	115	66
o,p'-DDT	115	109
p,p'-DDT	114	124

CRM: NIST 1742a mussel tissue certified reference material analyzed at beginning (1) and end (2) of
* certified values not available

APPENDIX B.

Tissue concentrations of trace metals in *Mytilus edulis* in the Gulf of Maine, 1998. ($\mu g.g^{-1}$ dry weight; mean and standard deviation (SD))

Station	Ag	Al	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
MASN1	0.5	77	1.8	1.1	5.7	220	0.41	ND	2.9	68
MASN2	1.0	62	1.7	1	6.1	200	0.32	ND	2.8	75
MASN3	0.5	55	1.6	1	5	180	0.33	ND.	2.8	66
MASN4	1.3	92	2.5	1.4	8	270	0.43	0.97	4.1	195
Mean	0.83	71.5	1.9	1.13	6.2	218	0.37	ND	3.15	101
SD	0.4	16.5	0.41	0.19	1.28	38.6	0.06		0.64	62.8
MAIH1	ND	100	2.2	1.5	15	390	0.51	1.1	30	220
MAIH2	ND	110	2.8	1.6	16	440	0.55	1.3	32	310
MAIH3	0.3	150	2.6	1.9	21	610	0.56	1.5	30	230
MAIH4	0.1	170	3.0	2.0	26	600	0.56	1.3	37	270
Mean	0.13	132.5	2.65	1.75	19.5	510	0.55	1.30	32.25	258
SD	0.12	33	0.34	0.24	5.1	111.7	0.02	0.16	3.30	41.1
MAPR1	ND	190	2.2	3.4	8.0	360	0.54	1.3	6.9	110
MAPR2	ND	200	1.6	2.5	9.3	400	0.44	1.5	6.7	110
MAPR3	ND	190	2.1	3.3	8.5	310	0.58	1.2	6.3	100
MAPR4	ND	200	1.7	2.5	9.1	360	0.47	1.6	6.7	120
Mean	ND	195	1.9	2.93	8.73	358	0.51	1.40	6.65	110
SD		5.8	0.29	0.49	0.59	36.9	0.06	0.18	0.25	8.16
NHGP1	ND	230	1.9	2.6	5.4	470	0.84	1.4	3.6	120
NHGP2	ND	110	1.2	1.3	2.8	220	0.99	0.99	2.5	74
NHGP3	ND	180	2.3	2.3	5.2	380	0.78	1.5	3.5	130
NHGP4	ND	180	2.3	2.1	5.4	360	0.83	1.5	3.7	120
Mean	ND	175	1.93	2.08	4.7	358	0.86	1.35	3.33	111.0
SD		49.3	0.52	0.56	1.27	103	0.09	0.24	0.56	25.1
NHLH1	ND	160	2.5	2.3	5.3	400	1.01	1.7	4.3	110
NHLH2	ND	180	2.5	2.4	4.9	410	1.07	1.8	5.1	110
NHLH3	ND	190	2.4	4.2	4.8	450	0.95	1.9	4.8	120
NHLH4	ND	120	2.3	2.1	5.5	340	0.96	1.5	4.4	80
Mean	ND	162.5	2.43	2.75	5.13	375	0.998	1.73	4.65	105
SD		31.0	0.10	0.98	0.33	35.1	0.06	0.17	0.37	17.32
NHSS1	ND	160	2.9	2.4	6.4	360	1.22	1.8	3.8	120
NHSS2	ND	180	1.8	2.1	5.5	360	1.03	1.3	2.9	120
NHSS3	ND	190	1.9	2.2	6.0	380	0.98	1.3	2.7	140
NHSS4	ND	240	2.4	2.5	6.6	440	1.08	1.4	3.2	130
Mean	ND	192.5	2.25	2.30	6.13	385	1.08	1.45	3.15	127.5
SD		34	0.51	0.18	0.49	37.9	0.10	0.24	0.48	9.57
NHDP1	ND	240	2.4	2.9	5.8	450	0.94	1.6	2.6	120
NHDP2	ND	220	3.0	3.0	5.8	390	0.99	2.0	3.2	120
NHDP3	ND	200	2.8	3.0	7.1	370	0.92	1.6	3.3	150
NHDP4	ND	150	3.0	2.9	5.6	330	1.02	1.6	3.0	130
Mean	ND	202.5	2.80	2.95	6.03	385	0.97	1.70	3.03	130
SD		38.6	0.28	0.06	0.72	50	0.05	0.20	0.31	14.14

Appendix B.

Tissue concentrations of trace metals in *Mytilus edulis* in the Gulf of Maine, 1998. ($\mu g.g^{-1}$ dry weight; mean and standard deviation (SD))

Station	Ag	Al	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
NHNM1	ND	180	1.5	1.7	5.7	340	0.64	0.94	3.3	110
NHNM2	ND	280	2	2.5	6.8	520	0.92	1.3	5.1	130
NHNM3	ND	280	2	2.4	6.6	500	0.76	1.3	5.5	140
NHNM4	ND	300	2.4	2.7	7.1	570	0.83	1.4	6.8	160
Mean	ND	260	1.98	2.33	6.55	483	0.79	1.24	5.18	135
SD		54.2	0.37	0.44	0.60	99.5	0.12	0.20	1.45	20.8
MECC1	ND	280	2.2	3.0	7.0	540	0.82	1.8	6.6	140
MECC2	ND	280	2.1	2.8	8.1	500	0.97	3.9	5.7	150
MECC3	ND	240	2.1	2.7	7.2	440	0.77	1.5	4.9	100
MECC4	ND	390	1.9	4.2	6.5	630	0.71	2.1	5.8	150
Mean	ND	297.5	2.08	3.18	7.20	527.5	0.82	2.33	5.75	135
SD		64.5	0.13	0.70	0.67	79.7	0.11	1.08	0.70	23.8
MEKN1	ND	110	2.4	1.2	5.7	200	0.46	ND	1.4	64
MEKN2	0.12	150	2.4	1.5	5.9	270	0.50	1.1	2.0	58
MEKN3	0.13	120	2.0	1.4	5.2	250	0.30	0.93	1.8	46
MEKN4	0.17	87	1.5	0.97	4.5	180	0.39	ND	1.1	43
Mean	0.12	116.7	2.08	1.27	5.33	5.33	225	0.41	0.71	1.58
SD	0.05	26.1	0.43	0.23	0.62	0.62	42	0.09	0.36	0.40
MEDM1	0.12	400	1.3	1.5	5.8	470	0.40	1.20	2.0	64
MEDM2	ND	200	1.3	1.0	5.1	240	0.24	0.89	1.6	66
MEDM3	ND	230	1.1	1.2	4.6	290	0.26	0.93	1.6	66
MEDM4	ND	340	1.2	1.3	5.4	380	0.45	1.10	1.8	72
Mean	0.07	292.5	1.23	1.25	5.15	345	0.34	1.03	1.75	67
SD	0.04	93.6	0.10	0.21	0.40	101.5	0.10	0.15	0.19	3.46
MEBB1	ND	200	1.10	1.1	14	310	0.55	ND	16	110
MEBB2	0.10	150	0.86	1.0	12	280	0.50	ND	13	93
MEBB3	ND	300	0.93	1.3	12	410	0.55	0.80	18	120
MEBB4	0.11	380	0.94	1.6	16	520	0.46	1.00	16	120
Mean	0.08	257.5	0.96	1.25	13.5	380	0.52	0.65	15.75	110.8
SD	0.03	102.8	0.10	0.27	1.92	108.6	0.04	0.30	2.06	12.74
NBNR1	0.10	320	0.69	0.96	4.2	400	0.21	1.00	0.66	65
NBNR2	ND	290	0.77	0.79	4.4	320	0.20	0.99	0.61	70
NBNR3	ND	220	0.70	0.70	5.1	320	0.20	0.90	0.40	64
NBNR4	ND	310	0.78	0.83	4.6	390	0.27	0.95	0.65	62
Mean	0.08	285	0.74	0.82	4.6	358	0.22	0.96	0.58	65
SD	0.03	45	0.05	0.11	0.4	43	0.03	0.05	0.12	3
NBCH1	ND	170	0.70	0.70	5.3	250	0.16	0.90	0.4	73
NBCH2	ND	180	0.80	0.70	5.0	260	0.19	0.97	ND	63
NBCH3	ND	200	1.10	0.74	5.7	260	0.25	0.82	0.7	76
NBCH4	ND	150	0.91	0.61	4.6	210	0.26	0.80	0.6	59
Mean	ND	175	0.88	0.69	5.2	245	0.22	0.87	0.6	68
SD		21	0.17	0.06	0.5	24	0.05	0.08	0.2	8

Appendix B.
Tissue concentrations of trace metals in *Mytilus edulis* in the Gulf of Maine, 1998.
($\mu g.g^{-1}$ dry weight; mean and standard deviation (SD))

Station	Ag	Al	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Zn
NBLB1	0.04	834	1.5	2.9	14	606	0.10	1.5	2.5	93
NBLB2	0.02	761	1.6	2.2	13	529	0.16	1.4	2.8	94
NBLB3	0.03	881	1.5	3.0	11	675	0.15	1.5	2.8	81
NBLB4	0.08	862	1.4	2.0	14	625	0.15	1.3	2.7	71
Mean	0.04	835	1.5	2.5	13	609	0.14	1.4	2.7	85
SD	0.03	53	0.1	0.5	2	61	0.03	0.1	2.7	11
NBLN1	0.15	707	1.5	2.4	11	523	0.11	1.2	1.3	86
NBLN2	0.02	789	1.6	1.7	11	565	ND	1.2	1.6	75
NBLN3	0.02	634	1.4	1.5	8	478	ND	0.9	1.2	75
NBLN4	0.02	978	1.5	64.6	17	1147	0.11	35.9	2.0	92
Mean	0.05	777	1.5	17.5	12	678	0.11	9.8	1.6	82
SD	0.07	148	0.1	31.4	4	315	0	17.4	0.4	8
NBCG1	1.62	1007	2.0	4.3	27	716	0.29	2.0	2.3	124
NBCG2	2.00	669	2.4	3.4	26	854	0.26	1.7	2.6	140
NBCG3	1.98	874	2.0	5.3	43	741	0.28	2.4	2.4	145
NBCG4	1.68	623	1.7	3.2	18	474	0.31	1.6	2.0	145
Mean	1.82	793	2.0	4.0	29	696	0.29	1.9	2.3	139
SD	0.20	179	0.3	1.0	10	160	0.20	0.40	0.3	10
NBTC1	0.30	5638	2.8	19.7	36	2950	0.32	9.4	1.4	145
NBTC2	0.24	2083	2.2	6.6	25	1587	0.31	3.4	2.7	107
NBTC3	0.04	1411	2.4	5.8	20	1382	0.37	4.1	3.3	98
NBTC4	0.07	2566	2.9	19.6	35	2605	0.31	9.4	2.0	91
Mean	0.16	2925	2.5	12.9	29	2131	0.33	6.6	2.3	110
SD	0.13	1870	0.3	7.8	8	764	0.03	3.3	0.8	24
NSCW1	ND	340	2.2	1.5	4.3	460	0.39	1.5	3.5	65
NSCW2	0.15	440	2.7	1.7	5.6	550	0.42	2.1	3.9	100
NSCW3	ND	410	3.1	1.8	7.1	590	0.55	2.0	3.2	110
NSCW4	ND	360	2.9	1.8	5.8	490	0.45	1.9	3.0	73
Mean	0.56	387.5	2.73	1.70	5.70	522.5	0.45	1.88	3.40	87.0
SD	0.06	45.7	0.39	0.14	1.15	58.5	0.07	0.26	0.39	21.4
NSDI1	0.15	320	1.4	1.2	4.7	440	0.48	1.7	2.9	93
NSDI2	ND	380	1.8	1.7	6.7	530	0.5	1.7	2.7	100
NSDI3	ND	340	1.7	1.5	6.3	480	0.48	1.7	2.8	110
NSDI4	ND	310	1.5	1.3	3.6	460	0.37	1.4	2.4	72
Mean	0.056	337.5	1.6	1.43	5.33	485	0.46	1.63	2.7	93.8
SD	0.06	31	0.18	0.22	1.44	37	0.06	0.15	0.22	16.09
NSBE1	ND	200	1.7	1.4	6.8	340	0.35	1.3	1.5	83
NSBE2	ND	200	1.7	1.4	6.5	340	0.35	1.2	1.8	77
NSBE3	ND	140	1.7	1.2	6.9	260	0.40	1.1	1.7	93
NSBE4	-	-	-	-	-	-	-	-	-	-
Mean	ND	180	1.7	1.27	6.73	313.3	0.37	1.20	1.67	84.33
SD		34.6	0	0.12	0.21	46.2	0.03	0.10	0.15	8.08

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	MASN1N	MASN2N	MASN3N	MASN4N	MAIH1N	MAIH2N	MAIH3N	MAIH4N
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Acenaphthylene	<5	<5	<5	<5	28	23	30	23
Acenaphthene	<5	<5	<5	<5	98	80	109	74
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<6	<6	<6	<6	21	15	19	16
Phenanthrene	<9	<9	<9	<9	80	35	42	35
Anthracene	<6	<6	<6	<6	41	24	32	30
1-Methylphenanthracene	<9	<9	<9	<9	25	13	33	12
Fluoranthene	15	13	11	13	844	753	778	764
Pyrene	<15	<15	<15	<15	828	750	754	747
Benzo(a)Anthracene	<9	<9	<9	<9	213	210	201	192
Chrysene	<9	<9	<9	<9	451	411	408	403
Benzo(b)Fluoranthene	<12	<12	<12	<12	240	221	268	232
Benzo(k)Fluoranthene	<7	<7	<7	<7	151	135	143	128
Benzo(e)Pyrene	<12	<12	<12	<12	274	251	275	244
Benzo(a)Pyrene	<8	<8	<8	<8	121	92	89	97
Perylene	<9	<9	<9	<9	37	30	30	29
Indeno(1,2,3,4-cd)Pyrene	<3	<3	<3	<3	85	62	63	59
Dibenz(a,h)Anthracene	<4	<4	<4	<4	21	16	16	17
Benzo(ghi)Perylene	<13	<13	<13	<13	86	67	55	56
Total	15	13	11	13	3644	3186	3345	3157
Surrogate Recovery %								
Naphthalene-d8	83	95	90	81	63	64	83	58
Acenaphthene-d10	91	103	92	84	89	83	103	78
Phenanthrene-d10	101	111	99	84	101	96	109	107
Fluoranthene-d10	122	129	120	96	127	119	131	134
Chrysene-d12	121	121	120	88	120	111	129	124
Benzo(a)pyrene-d12	125	119	119	101	119	115	132	129
Benzo(g,h,i)perylene-d12	125	123	121	107	127	122	115	119

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	MAPR1N	MAPR2N	MAPR3N	MAPR4N	NHGP1N	NHGP2N	NHGP3N	NHGP4N
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Acenaphthylene	<5	<5	<5	<5	<5	<5	<5	<5
Acenaphthene	5.0	<5	6.5	<5	<5	<5	<5	<5
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	8.0	7.0	7.9	6.9	<6	<6	<6	<6
Phenanthrene	37	37	45	36	9.7	<9	9.6	<9
Anthracene	8.7	8.0	9.4	7.4	<6	<6	<6	<6
1-Methylphenanthracene	<9	<9	9.0	9	<9	<9	<9	<9
Fluoranthene	131	125	132	129	37	34	34	33
Pyrene	106	99	104	104	36	30	34	31
Benzo(a)Anthracene	26	22	26	24	11	11	11	11
Chrysene	60	54	53	57	22	20	20	19
Benzo(b)Fluoranthene	38	31	36	40	14	16	14	16
Benzo(k)Fluoranthene	34	29	33	34	16	14	14	14
Benzo(e)Pyrene	49	46	48	51	21	20	18	21
Benzo(a)Pyrene	21	20	25	22	9.3	9.5	9.7	9.7
Perylene	11	<9	10	10	<9	<9	<9	<9
Indeno(1,2,3,4-cd)Pyrene	14	11	14	12	6.1	<3	<3	<3
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(ghi)Perylene	20	18	19	17	<13	<13	<13	<13
Total	570	506	579	559	182	155	165	156
Surrogate Recovery %								
Naphthalene-d8	69	57	68	57	86	76	86	77
Acenaphthene-d10	91	76	85	71	105	80	88	78
Phenanthrene-d10	100	90	97	87	117	101	105	103
Fluoranthene-d10	113	109	108	105	132	114	113	116
Chrysene-d12	109	111	111	107	128	116	110	116
Benzo(a)pyrene-d12	93	99	101	95	118	100	91	102
Benzo(g,h,i)perylene-d12	92	91	90	88	104	121	110	123

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	NHLH1N	NHLH2N	NHLH3N	NHLH4N	NHSS1N	NHSS2N	NHSS3N	NHSS4N
Naphthalene	8.8	7.1	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Acenaphthylene	<5	<5	<5	<5	<5	<5	<5	<5
Acenaphthene	<5	<5	<5	<5	<5	<5	<5	<5
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<6	<6	<6	<6	<6	<6	<6	<6
Phenanthrene	<9	<9	<9	<9	9.2	<9	<9	13
Anthracene	<6	<6	<6	<6	<6	<6	<6	<6
1-Methylphenanthracene	<9	<9	<9	<9	<9	<9	<9	<9
Fluoranthene	26	22	26	25	48	38	36	38
Pyrene	21	19	21	20	48	36	37	36
Benzo(a)Anthracene	<9	<9	<9	<9	20	11	12	12
Chrysene	15	13	14	14	29	19	21	22
Benzo(b)Fluoranthene	<12	<12	<12	<12	27	13	16	15
Benzo(k)Fluoranthene	11	8.4	9.5	10	24	13	16	16
Benzo(e)Pyrene	12	<12	<12	12	30	20	22	20
Benzo(a)Pyrene	<8	<8	<8	<8	13	8.2	9.0	9.1
Perylene	<9	<9	<9	<9	14	<9	9.6	9.0
Indeno(1,2,3,4-cd)Pyrene	<3	<3	<3	<3	<3	<3	<3	<3
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(ghi)Perylene	<13	<13	<13	<13	<13	<13	<13	<13
Total	93	69	70	82	263	160	178	190
Surrogate Recovery %								
Naphthalene-d8	77	92	83	80	76	93	82	72
Acenaphthene-d10	76	89	80	77	73	89	80	75
Phenanthrene-d10	95	104	95	94	92	103	93	96
Fluoranthene-d10	110	115	113	115	114	116	108	112
Chrysene-d12	110	116	116	123	121	113	110	113
Benzo(a)pyrene-d12	95	90	96	112	102	92	85	89
Benzo(g,h,i)perylene-d12	115	112	116	133	124	111	116	117

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* ($ng.g^{-1}$ dry weight)

PAH	NHSS4N	NHDP1N	NHDP2N	NHDP3N	NHDP4N	NHNM1N	NHNM 1N	NHNM2N
	duplicate						duplicate	
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Acenaphthylene	<5	<5	<5	<5	<5	<5	<5	<5
Acenaphthene	<5	<5	<5	<5	<5	<5	<5	<5
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<6	<6	<6	<6	<6	<6	<6	<6
Phenanthrene	<9	10	<9	<9	<9	15	14	18
Anthracene	<6	<6	<6	<6	<6	<6	<6	6
1-Methylphenanthracene	<9	<9	<9	<9	<9	<9	<9	<9
Fluoranthene	31	30	35	34	41	111	105	121
Pyrene	29	35	42	40	47	103	96	113
Benzo(a)Anthracene	10	16	17	18	24	42	39	46
Chrysene	19	21	24	23	29	82	76	88
Benzo(b)Fluoranthene	13	20	22	26	36	80	75	86
Benzo(k)Fluoranthene	14	19	19	21	25	53	49	56
Benzo(e)Pyrene	18	24	25	29	33	71	66	79
Benzo(a)Pyrene	7.9	11	10	12	14	27	26	33
Perylene	<9	14	15	14	16	26	24	28
Indeno(1,2,3,4-cd)Pyrene	<3	7	8	9	8	23	20	23
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(ghi)Perylene	<13	<13	<13	<13	<13	25	22	24
Total	142	207	217	226	272	658	611	721
Surrogate Recovery %								
Naphthalene-d8	84	90	74	64	79	72	86	89
Acenaphthene-d10	83	95	84	73	80	80	90	95
Phenanthrene-d10	103	103	99	91	90	94	101	103
Fluoranthene-d10	117	121	119	109	109	119	121	118
Chrysene-d12	113	113	106	99	104	118	120	115
Benzo(a)pyrene-d12	89	99	87	93	99	112	117	113
Benzo(g,h,i)perylene-d12	115	101	105	110	100	119	114	108

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	NHNM3N	NHNM4N	MECC1N	MECC2N	MECC3N	MECC4N	MEKN1N	MEKN2N
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Acenaphthylene	<5	<5	<5	<5	<5	<5	<5	<5
Acenaphthene	<5	<5	<5	<5	<5	<5	<5	<5
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<6	<6	<6	<6	<6	<6	<6	<6
Phenanthrene	13	11	<9	12	10	9.4	<9	<9
Anthracene	<6	<6	<6	<6	<6	<6	<6	<6
1-Methylphenanthracene	<9	<9	<9	<9	<9	<9	<9	<9
Fluoranthene	107	99	37	49	36	40	17	13
Pyrene	101	92	34	44	32	37	22	19
Benzo(a)Anthracene	41	36	11	12	12	12	<9	<9
Chrysene	77	73	22	28	21	25	11	9.1
Benzo(b)Fluoranthene	86	71	10	17	13	16	<12	<12
Benzo(k)Fluoranthene	55	41	18	19	13	17	<7	<7
Benzo(e)Pyrene	73	65	20	24	16	21	<12	<12
Benzo(a)Pyrene	28	23	9.0	9.2	9.3	9.2	<8	<8
Perylene	29	26	9.5	11	11	10	11	7.8
Indeno(1,2,3,4-cd)Pyrene	22	20	6.1	7.1	7.9	7.1	<3	<3
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(ghi)Perylene	24	18	<13	<13	<13	<13	<13	<13
Total	656	575	176	233	183	206	61	49
Surrogate Recovery %								
Naphthalene-d8	78	54	50	64	79	52	56	63
Acenaphthene-d10	91	64	72	87	95	68	82	91
Phenanthrene-d10	100	78	85	100	104	85	96	94
Fluoranthene-d10	116	99	105	112	112	110	118	115
Chrysene-d12	111	91	106	104	101	111	107	97
Benzo(a)pyrene-d12	107	99	90	90	101	103	108	106
Benzo(g,h,i)perylene-d12	110	101	84	87	82	90	98	68

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	MEKN 3N	MEKN 4N	MEDM 1N	MEDM 2N	MEDM 3N	MEDM 4N	MEBB 1N	MEBB 1N
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	9.3	9.9
Biphenyl	<6	<6	<6	<6	<6	<6	<6	14
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<8	<8	14	36
Acenaphthylene	<5	<5	<5	<5	<5	<5	9.4	13
Acenaphthene	<5	<5	<5	<5	<5	<5	6.7	7.2
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	20
Fluorene	<6	<6	<6	<6	<6	<6	13	24
Phenanthrene	11	<9	<9	<9	<9	<9	34	37
Anthracene	6.5	<6	<6	<6	<6	<6	13	15
1-Methylphenanthracene	<9	<9	<9	<9	<9	<9	17	20
Fluoranthene	17	14	<9	<9	<9	<9	233	222
Pyrene	23	19	<15	<15	<15	<15	215	209
Benzo(a)Anthracene	<9	<9	<9	<9	<9	<9	48	48
Chrysene	10.8	<9	<9	<9	<9	<9	101	103
Benzo(b)Fluoranthene	<12	<12	<12	<12	<12	<12	101	104
Benzo(k)Fluoranthene	<7	<7	<7	<7	<7	<7	60	52
Benzo(e)Pyrene	<12	<12	<12	<12	<12	<12	114	109
Benzo(a)Pyrene	8.1	<8	<8	<8	<8	<8	43	40
Perylene	9.8	7.1	<9	<9	<9	<9	16	16
Indeno(1,2,3,4-cd)Pyrene	<3	<3	<3	<3	<3	<3	38	39
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<4	<4	6.2	7.5
Benzo(ghi)Perylene	<13	<13	<13	<13	<13	<13	38	39
Total	85	40	ND	ND	ND	ND	1129	1185
Surrogate Recovery %								
Naphthalene-d8	55	64	72	70	52	79	90	51
Acenaphthene-d10	79	87	92	93	82	96	102	90
Phenanthrene-d10	97	93	97	107	92	105	104	92
Fluoranthene-d10	129	116	109	119	115	116	119	114
Chrysene-d12	104	103	99	104	109	107	115	114
Benzo(a)pyrene-d12	109	107	110	113	112	113	133	119
Benzo(g,h,i)perylene-d12	85	65	88	91	94	90	104	115

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* ($ng.g^{-1}$ dry weight)

PAH	MEBB 2N	MEBB 3N	MEBB 4N	NBNR1N	NBNR2N	NBNR3N	NBNR4N	NBCH1N
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	8.1	9.4	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	10	11	13	7	8	8	7	<8
Acenaphthylene	8.7	8.8	7.6	<5	<5	<5	<5	<5
Acenaphthene	<5	<5	5.6	<5	<5	<5	3	<5
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	11	11	13	<6	<6	<6	<6	<6
Phenanthrene	32	35	34	9	10	10	10	6
Anthracene	13	14	13	4	4	4	4	<6
1-Methylphenanthracene	16	16	18	10	11	14	18	<9
Fluoranthene	227	237	239	10	11	9	11	9
Pyrene	201	208	217	10	10	10	11	11
Benzo(a)Anthracene	47	41.5	53	12	14	10	13	3
Chrysene	102	96	114	23	27	19	23	6
Benzo(b)Fluoranthene	106	81	98	6	7	4	7	3
Benzo(k)Fluoranthene	58	50	66	5	6	3	6	3
Benzo(e)Pyrene	116	102	121	3	4	3	4	3
Benzo(a)Pyrene	40	39	48	<8	<8	<8	<8	<8
Perylene	14	14	15	<9	<9	<9	<9	<9
Indeno(1,2,3,4-cd)Pyrene	39	37	42	<3	<3	<3	<3	<3
Dibenz(a,h)Anthracene	6.6	6.3	7	<4	<4	<4	<4	<4
Benzo(ghi)Perylene	34	32	36	<13	<13	<13	<13	<13
Total	1081	1049	1169	99	112	94	119	44
Surrogate Recovery %								
Naphthalene-d8	61	68	71	71	73	79	77	68
Acenaphthene-d10	88	88	95	92	96	101	99	85
Phenanthrene-d10	97	99	100	99	103	104	100	99
Fluoranthene-d10	117	123	125	113	119	112	115	120
Chrysene-d12	106	104	112	114	123	107	116	108
Benzo(a)pyrene-d12	120	119	132	101	120	88	104	79
Benzo(g,h,i)perylene-d12	100	97	100	117	131	106	125	105

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	NBCH1N	NBCH2N	NBCH3N	NBCH4N	NBLB1N	NBLB2N	NBLB3N	NBLB4N
	duplicate							
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	<8	<8	<8	<8	<5.4	<5.4	<5.4	<5.4
Acenaphthylene	<5	<5	<5	<5	<5.4	<5.4	<5.4	<5.4
Acenaphthene	<5	<5	<5	<5	<5.4	<5.4	<5.4	<5.4
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<6	<6	<6	<6	<10.8	<10.8	<10.8	<10.8
Phenanthrene	3	<3	4	3	4.60	6.50	4.81	5.41
Anthracene	<6	<6	<6	<6	<7.2	4.04	<7.2	<7.2
1-Methylphenanthracene	<9	<9	<9	<9	<5.4	<5.4	<5.4	<5.4
Fluoranthene	5	4	5	5	6.72	8.42	7.17	7.18
Pyrene	4	<3	3	3	<5.4	3.92	3.15	3.02
Benzo(a)Anthracene	2	<2	2	2	<3.6	<3.6	<3.6	<3.6
Chrysene	4	<3	3	3	<5.4	<5.4	<5.4	<5.4
Benzo(b)Fluoranthene	3	3	3	4	<4.5	<4.5	<4.5	<4.5
Benzo(k)Fluoranthene	3	<2.5	3	3	<4.5	<4.5	<4.5	<4.5
Benzo(e)Pyrene	<12	<12	<12	<12	<4.5	<4.5	<4.5	<4.5
Benzo(a)Pyrene	<8	<8	<8	<8	<5.4	<5.4	<5.4	<5.4
Perylene	<9	<9	<9	<9	<5.4	<5.4	<5.4	<5.4
Indeno(1,2,3,4-cd)Pyrene	<3	<3	<3	<3	<5.4	<5.4	<5.4	<5.4
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<7.2	<7.2	<7.2	<7.2
Benzo(ghi)Perylene	<13	<13	<13	<13	<3.6	<3.6	<3.6	<3.6
Total	24	7	23	23	11.32	22.87	15.13	15.60
Surrogate Recovery %								
Naphthalene-d8	57	71	71	82	71	74	67	79
Acenaphthene-d10	71	85	88	99	75	85	71	84
Phenanthrene-d10	78	93	94	103	78	88	75	86
Fluoranthene-d10	97	111	110	117	103	104	99	103
Chrysene-d12	103	109	107	110	102	93	96	92
Benzo(a)pyrene-d12	91	88	87	94	90	90	83	80
Benzo(g,h,i)perylene-d12	116	113	105	118	69	71	72	73

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* ($ng.g^{-1}$ dry weight)

PAH	NBLN1N	NBLN2N	NBLN3N	NBLN4N	NBLN4N duplicate	NBCG1N	NBCG2N	NBCG3N
Naphthalene	<7	<7	<7	<7	<7	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	<6	<6	<6	<6	<6	<6
2,6-Dimethylnaphthalene	<5.4	<5.4	<5.4	<5.4	<5.4	2.89	3.20	3.21
Acenaphthylene	<5.4	<5.4	<5.4	<5.4	<5.4	<5.4	<5.4	<5.4
Acenaphthene	<5.4	<5.4	<5.4	<5.4	<5.4	<5.4	<5.4	<5.4
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<10.8	<10.8	<10.8	<10.8	<10.8	<10.8	<10.8	<10.8
Phenanthrene	5.27	4.21	4.59	4.73	5.38	21.02	22.71	23.15
Anthracene	<7.2	<7.2	<7.2	<7.2	<7.2	8.51	8.61	9.53
1-Methylphenanthracene	<5.4	<5.4	<5.4	<5.4	<5.4	8.35	8.38	9.22
Fluoranthene	7.11	6.78	4.87	7.38	8.06	36.78	32.44	38.26
Pyrene	<5.4	3.23	<5.4	3.50	3.75	29.31	23.44	30.26
Benzo(a)Anthracene	<3.6	<3.6	<3.6	<3.6	<3.6	21.94	22.44	20.44
Chrysene	<5.4	<5.4	<5.4	<5.4	<5.4	23.72	25.20	22.22
Benzo(b)Fluoranthene	<4.5	<4.5	<4.5	<4.5	<4.5	21.08	21.84	19.88
Benzo(k)Fluoranthene	<4.5	<4.5	<4.5	<4.5	<4.5	12.61	12.32	11.24
Benzo(e)Pyrene	<4.5	<4.5	<4.5	<4.5	<4.5	15.25	11.90	14.21
Benzo(a)Pyrene	<5.4	<5.4	<5.4	<5.4	<5.4	8.55	8.14	7.49
Perylene	<5.4	<5.4	<5.4	<5.4	<5.4	8.31	7.19	7.90
Indeno(1,2,3,4-cd)Pyrene	<5.4	<5.4	<5.4	<5.4	<5.4	5.72	5.48	5.73
Dibenz(a,h)Anthracene	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2	<7.2
Benzo(ghi)Perylene	<3.6	<3.6	<3.6	<3.6	<3.6	6.65	5.72	6.18
Total	12.38	14.23	9.46	15.61	17.18	230.71	219.00	228.92
Surrogate Recovery %								
Naphthalene-d8	77	67	81	58	73	67	59	71
Acenaphthene-d10	85	74	90	63	80	74	77	83
Phenanthrene-d10	86	78	92	70	84	81	88	87
Fluoranthene-d10	104	99	107	95	106	118	116	119
Chrysene-d12	94	94	94	91	98	100	97	97
Benzo(a)pyrene-d12	88	88	87	85	97	105	106	103
Benzo(g,h,i)perylene-d12	74	74	76	73	75	90	87	91

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	NBCG4N	NBTC1N	NBTC2N	NBTC3N	NBTC4N	NSCW1N	NSCW1N duplicate	NSCW2N
Naphthalene	<7	<7	<7	<7	<7	<7	15	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	<8	<8
Biphenyl	<6	<6	6	6	6	<6	<6	<6
2,6-Dimethylnaphthalene	3.19	<5.4	<5.4	<5.4	<5.4	<8	<8	<8
Acenaphthylene	<5.4	<5.4	<5.4	<5.4	<5.4	<5	<5	<5
Acenaphthene	<5.4	<5.4	<5.4	<5.4	<5.4	13	15	<5
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<10.8	<10.8	<10.8	<10.8	<10.8	23	25	<6
Phenanthrene	23.69	16.52	16.56	16.69	13.57	68	56	<9
Anthracene	8.67	7.65	7.47	8.06	6.67	25	27	<6
1-Methylphenanthracene	8.46	3.82	3.56	3.24	2.87	<9	<9	<9
Fluoranthene	37.62	22.92	23.83	27.88	24.45	57	50	12
Pyrene	31.09	16.59	17.15	19.23	16.45	41	33	<15
Benzo(a)Anthracene	22.76	16.50	18.80	16.45	14.28	20	18	<9
Chrysene	23.36	15.73	16.73	15.46	14.25	27	17	<9
Benzo(b)Fluoranthene	21.57	14.67	18.10	14.15	13.45	12	12	<12
Benzo(k)Fluoranthene	12.79	9.14	10.62	9.51	8.33	16	12	<7
Benzo(e)Pyrene	14.83	10.42	12.11	11.63	10.62	<12	<12	<12
Benzo(a)Pyrene	8.47	5.75	6.85	5.76	4.88	17	15	<8
Perylene	7.85	6.25	7.13	6.50	5.73	<9	<9	<9
Indeno(1,2,3,4-cd)Pyrene	6.59	5.40	6.61	5.22	4.89	7.3	5.1	3.1
Dibenz(a,h)Anthracene	<7.2	<7.2	<7.2	<7.2	<7.2	<4	<4	<4
Benzo(ghi)Perylene	6.78	4.53	5.24	4.68	4.01	<13	<13	<13
Total	237.73	155.90	176.95	170.91	150.55	326.3	300.1	15
Surrogate Recovery %								
Naphthalene-d8	71	66	61	65	68	76	86	69
Acenaphthene-d10	83	79	81	76	81	91	95	83
Phenanthrene-d10	86	84	89	83	89	102	105	94
Fluoranthene-d10	118	102	113	107	107	116	119	113
Chrysene-d12	99	90	103	98	96	111	108	108
Benzo(a)pyrene-d12	102	94	109	101	98	100	114	98
Benzo(g,h,i)perylene-d12	90	81	93	87	83	87	91	92

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	NSCW3N	NSCW4N	NSDI1N	NSDI2N	NSDI3N	NSDI4N	NSBE1N	NSBE1N duplicate
Naphthalene	<7	<7	<7	<7	<7	3	<7	<7
1-Methylnaphthalene	<8	<8	<8	<8	<8	<8	8.8	9.6
2-Methylnaphthalene	<8	<8	<8	<8	<8	<8	14	16
Biphenyl	<6	<6	<6	<6	<6	<6	7.1	7.5
2,6-Dimethylnaphthalene	<8	<8	5	5	5	6	16	18
Acenaphthylene	<5	<5	<5	<5	<5	<5	<5	<5
Acenaphthene	<5	<5	<5	<5	<5	<5	55	65
2,3,5-Trimethylnaphthalene	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<6	<6	<6	<6	<6	<6	70	84
Phenanthrene	10	<9	9	9	10	12	240	260
Anthracene	<6	<6	<6	<6	<6	<6	50	60
1-Methylphenanthracene	<9	<9	8	7	8	12	29	23
Fluoranthene	16	14	23	22	25	28	230	240
Pyrene	<15	<15	15	14	17	16	180	180
Benzo(a)Anthracene	<9	<9	6	6	7	8	55	58
Chrysene	<9	<9	11	12	13	15	47	44
Benzo(b)Fluoranthene	<12	<12	8	7	8	9	56	26
Benzo(k)Fluoranthene	<7	<7	6	5	7	7	44	26
Benzo(e)Pyrene	<12	<12	8	8	8	9	<12	21
Benzo(a)Pyrene	<8	<8	<8	<8	<8	<8	29	28
Perylene	<9	<9	<9	<9	<9	<9	<9	13
Indeno(1,2,3,4-cd)Pyrene	6.68	3	<3	<3	<3	<3	<3	6.9
Dibenz(a,h)Anthracene	<4	<4	<4	<4	<4	<4	<4	<4
Benzo(ghi)Perylene	<13	<13	<13	<13	<13	<13	<13	<13
Total	33	17	97	95	108	125	113	118
Surrogate Recovery %								
Naphthalene-d8	88	63	53	60	55	60	63	73
Acenaphthene-d10	95	81	77	85	73	83	81	97
Phenanthrene-d10	100	100	87	91	83	101	99	112
Fluoranthene-d10	115	121	105	110	106	114	113	124
Chrysene-d12	107	107	107	114	110	111	106	118
Benzo(a)pyrene-d12	110	90	94	100	92	92	106	106
Benzo(g,h,i)perylene-d12	91	84	121	124	111	111	98	98

Appendix C.
Tissue Concentrations of Polyaromatic Hydrocarbons in *Mytilus edulis* (ng.g^{-1} dry weight)

PAH	NSBE2N	NSBE3N	NSBE3N
			duplicate
Naphthalene	<7	<7	<7
1-Methylnaphthalene	<8	<8	<8
2-Methylnaphthalene	<8	<8	<8
Biphenyl	<6	<6	<6
2,6-Dimethylnaphthalene	<8	<8	<8
Acenaphthylene	<5	<5	<5
Acenaphthene	6.1	7.9	8.2
2,3,5-Trimethylnaphthalene	<10	<10	<10
Fluorene	8.9	8.4	8.4
Phenanthrene	20	19	20
Anthracene	<6	7.4	7.3
1-Methylphenanthracene	<9	<9	<9
Fluoranthene	47	46	46
Pyrene	34	31	31
Benzo(a)Anthracene	<9	<9	<9
Chrysene	12	12	12
Benzo(b)Fluoranthene	15	<12	15
Benzo(k)Fluoranthene	12	<7	<7
Benzo(e)Pyrene	<12	<12	<12
Benzo(a)Pyrene	<8	<8	<8
Perylene	<9	<9	<9
Indeno(1,2,3,4-cd)Pyrene	<3	<3	<3
Dibenz(a,h)Anthracene	<4	<4	<4
Benzo(ghi)Perylene	<13	<13	<13
Total	154	133	147
Surrogate Recovery %			
Naphthalene-d8	62	67	64
Acenaphthene-d10	76	86	90
Phenanthrene-d10	94	98	103
Fluoranthene-d10	114	110	109
Chrysene-d12	110	106	107
Benzo(a)pyrene-d12	96	90	87
Benzo(g,h,i)perylene-d12	88	84	80

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	MASN1N	MASN2N	MASN3N	MASN4N	MAIH1N	MAIH1N	MAIH2N	MAIH3N
8;5	<2	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	11	11	9.1	9.6
29	<1	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	23	23	20	22
50	<2	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	55	55	48	51
44	<2	<2	<2	<2	30	30	26	26
66;95	2	<2	<2	<2	38	38	33	34
101;90	3.7	2.5	3.6	3	118	118	107	105
87	<1.5	<1.5	<1.5	<1.5	34	34	33	30
77	<2	<2	<2	<2	31	31	28	30
118	4.3	3	4.8	3.6	91	91	90	85
153;132	10	6.6	11	8.6	120	120	122	114
105	1	<1	1.1	<1	30	30	29	28
138	8.4	5	7.9	6.2	116	116	118	107
126	<1.5	<1.5	<1.5	<1.5	8.4	8.4	10	8.3
187	2.9	1.8	2.8	2.2	31	31	32	30
128	1.2	<1	1.4	<1	20	20	19	18
180	<1	<1	<1	<1	17	17	21	15
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	2.6	2.6	3.5	3
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	34	19	33	24	776	776	749	716
Surrogate Recovery %								
103	105	101	85	100	138	138	131	100
198	98	94	88	91	93	93	105	83

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	MAIH4N	MAPR1N	MAPR2N	MAPR3N	MAPR4N	NHLH1N	NHLH2N	NHLH3N
8;5	<2	<2	<2	<2	<2	<2	<2	<2
18;15	7.2	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1	<1
28	18	<2	<2	2.01	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2	<2
52	45	3.8	4.0	4.6	3.9	<2	<2	<2
44	22	2.0	2.0	2.2	1.9	<2	<2	<2
66;95	32	4.4	4.7	5.1	4.6	<2	<2	<2
101;90	100	13.4	13	14	13	1.5	1.6	<1.5
87	30	4.7	4.8	5.3	4.7	<1.5	<1.5	<1.5
77	28	4.0	4.3	4.8	4.2	<2	<2	<2
118	83	13	13	15	13	2	2.1	1.7
153;132	113	29	30	33	30	4.7	5	4
105	27	4.9	5.0	5.4	5.1	<1	<1	<1
138	104	25	26	29	26	3.8	3.9	3.3
126	10	3.0	3.0	3.1	2.9	<1.5	<1.5	<1.5
187	31	12	11	11	10	1.6	1.6	1.4
128	18	3.0	3.3	3.5	3.2	<1	<1	<1
180	15	4.5	4.6	4.6	4.5	<1	<1	<1
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	2.7	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	686	126	128	143	127	14	14	10
Surrogate Recovery %								
103	108	96	89	95	88	88	93	82
198	94	88	83	88	86	76	80	72

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NHLH4N	NHSS1N	NHSS2N	NHSS3N	NHSS4N	NHSS4N duplicate	NHGP1N	NHGP2N
8;5	<2	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1	<1
28	<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
44	<2	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2	<2
101;90	<1.5	4.8	3.6	4.6	3.7	3.3	3.6	3.2
87	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
77	<2	<2	<2	<2	<2	<2	<2	<2
118	1.9	5.3	4	5	4.1	3.8	4	3.8
153;132	4.6	11	8.6	9.4	8.3	7.8	7.9	7.3
105	<1	1.4	<1	1.3	<1	<1	<1	<1
138	3.6	8.8	6.7	7.9	6.5	6.1	6.5	6.2
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	1.6	3.7	2.9	3	2.7	2.5	2.6	2.4
128	<1	1.8	1.4	1.6	1.4	1.4	1.4	1.4
180	<1	1.1	<1	1.1	1	<1	<1	<1
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	12	38	27	34	28	25	26	24
Surrogate Recovery %								
103	87	83	87	82	86	91	84	84
198	79	82	81	81	82	84	84	84

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NHGP3N	NHGP4N	NHDP1N	NHDP2N	NHDP3N	NHDP4N	NHNM1N	NHNM1N duplicate
8;5	<2	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	<2	<2	2.1	2
44	<2	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2	<2
101;90	3.6	3.3	2.9	4.6	4.1	5.6	6.9	6.6
87	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	2.1	2.1
77	<2	<2	<2	<2	<2	<2	<2	<2
118	4	3.7	3	5	4.3	5.7	7.1	7.4
153;132	8.1	7.4	7.1	11	9.6	13	14	14
105	<1	<1	<1	1.5	1.3	1.6	2.3	2.3
138	6.7	6.1	5.9	8.4	7.4	11	12	13
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	2.6	2.5	2.6	3.2	3	4	4.7	4.6
128	1.5	1.3	<1	<1	<1	1	1.8	1.8
180	1	<1	<1	<1	<1	<1	2	1.9
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	28	24	22	34	30	42	55	56
Surrogate Recovery %								
103	78	82	99	101	89	104	99	89
198	82	83	91	104	95	110	109	86

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NHNM2N	NHNM3N	NHNM4N	MECC1N	MECC2N	MECC3N	MECC4N
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	2.8	2.7	3.6	<2	<2	<2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	2.4	2.2	3.1	<2	<2	<2	<2
101;90	9.1	8.9	9.5	4.8	4.8	4.4	5.6
87	2.8	2.7	2.8	<1.5	<1.5	<1.5	2.1
77	<2	<2	<2	<2	<2	<2	<2
118	9.4	9.2	9.5	5.1	5.0	4.6	6.2
153;132	17	18	17	13	12	10	14
105	3.3	3	3.5	2.4	1.7	1.6	4.7
138	15	15	15	11	10	8	12
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	5.3	5.4	5.1	4.9	4.6	3.9	5.2
128	2	2.1	2.1	1.1	<1	<1	1.1
180	2.1	2.1	2.1	2.0	1.7	1.5	1.7
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	71	71	73	44	40	34	52
Surrogate Recovery %							
103	86	80	NOT ADDED	117	100	114	103
198	87	80	NOT ADDED	112	97	96	111

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	MEKN1N	MEKN2N	MEKN3N	MEKN4N	MEDM1N	MEDM2N	MEDM3N
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	<2	<2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2
101;90	2.8	2.3	1.8	2.7	<1.5	<1.5	<1.5
87	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
77	<2	<2	<2	<2	<2	<2	<2
118	1.9	1.4	1.2	1.6	<1	<1	<1
153;132	6.9	5.2	4.4	6.2	2.1	1.9	2.1
105	<1	<1	<1	<1	<1	<1	<1
138	4.9	3.8	3.2	4.6	1.5	1.5	1.6
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	2.6	1.6	1.5	2.1	<1	<1	<1
128	<1	<1	<1	<1	<1	<1	<1
180	1.6	1.1	<1	1.5	<1	<1	<1
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	20.7	15.4	12.1	18.7	3.6	3.4	3.7
Surrogate Recovery %							
103	93	92	74	102	94	101	86
198	86	76	64	87	92	89	81

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	MEDM4N	MEBB1N	MEBB1N duplicate	MEBB2N	MEBB3N	MEBB4N	NBNR1N
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	2.1	<2	<2	2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2
101;90	<1.5	7.8	6.9	6.6	5.5	6.9	<1.5
87	<1.5	2.7	1.9	2.4	1.7	2.7	<1.5
77	<2	2.2	<2	2	<2	2	<2
118	<1	6.4	5.6	5.8	5.1	6.1	<1
153;132	2.5	11	8.8	9.9	8.3	9.9	2
105	<1	2.6	2.6	2.6	2.6	3.1	<1
138	1.7	8.9	7.5	8.5	7.1	8.6	<1.5
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	<1	4.5	3.8	4.3	3.4	4.3	<1
128	<1	1.4	<1	1.2	1	1.4	<1
180	<1	1.7	1.5	1.9	1.5	1.7	<1
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	4.2	49.2	40.7	45.2	36.2	48.7	2
Surrogate Recovery %							
103	103	112	97	99	85	103	89
198	91	92	77	88	81	88	92

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NBNR2N	NBNR3N	NBNR4N	NBCH1N	NBCH2N	NBCH2N duplicate	NBCH3N
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	<2	<2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2
101;90	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
87	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
77	<2	<2	<2	<2	<2	<2	<2
118	<1	<1	<1	<1	<1	<1	<1
153;132	2	1	2	<1.5	<1.5	<1.5	<1.5
105	<1	<1	<1	<1	<1	<1	<1
138	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	<1	<1	<1	<1	<1	<1	<1
128	<1	<1	<1	<1	<1	<1	<1
180	<1	<1	<1	<1	<1	<1	<1
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	2	1	2	ND	ND	ND	ND
Surrogate Recovery %							
103	87	85	89	92	92	93	77
198	91	90	93	87	88	95	73

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* ($ng.g^{-1}$ dry weight)

PCB Congener	NBCH4N	NBLN1N	NBLN2N	NBLN3N	NBLN4N	NBLN4N	NBLB1N
						duplicate	
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	<2	<2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2
101;90	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
87	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
77	<2	<2	<2	<2	<2	<2	<2
118	<1	1.1	1.1	1.1	1.1	1.2	<1
153;132	<1.5	3.5	2.9	3.1	3.2	3.5	3.0
105	<1	<1	<1	<1	<1	<1	<1
138	<1.5	2.4	2.1	2.2	2.2	2.5	2.2
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	<1	<1	<1	<1	<1	<1	<1
128	<1	<1	<1	<1	<1	<1	<1
180	<1	<1	<1	<1	<1	<1	<1
169	<1.5	<1	<1	<1	<1	<1	<1
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	ND	7.0	6.0	6.3	6.4	7.2	5.2
Surrogate Recovery %							
103	92	82	92	86	90	88	85
198	94	85	85	88	77	80	91

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NBLB2N	NBLB3N	NBLB4N	NBCG1N	NBCG2N	NBCG3N	NBCG4N
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	<2	<2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2
101;90	<1.5	<1.5	<1.5	5.6	6.7	6.1	5.9
87	<1.5	<1.5	<1.5	2.0	2.4	2.3	2.2
77	<2	<2	<2	<2	<2	<2	<2
118	1.3	1.0	1.1	6.6	8.1	7.3	7.1
153;132	4.3	3.2	3.3	8.3	8.9	8.5	8.0
105	<1	<1	<1	1.9	2.3	2.1	2.1
138	2.8	2.3	2.2	8.3	9.0	8.8	8.3
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	<1	<1	<1	1.4	1.4	1.2	1.2
128	<1	<1	<1	1.4	1.5	1.5	1.4
180	<1	<1	<1	1.1	1.4	1.0	1.0
169	<1	<1	<1	<1	<1	<1	<1
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	8.4	6.6	6.5	36.5	41.7	38.6	37.3
Surrogate Recovery %							
103	92	82	92	83	86	82	80
198	86	86	89	87	81	85	83

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NBTC1N	NBTC2N	NBTC3N	NBTC4N	NSCW1N	NSCW2N	NSCW3N
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	<2	<2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2
101;90	2.2	2.6	3.1	3.0	<1.5	<1.5	<1.5
87	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
77	<2	<2	<2	<2	<2	<2	<2
118	2.2	2.8	3.1	3.1	<1	<1	<1
153;132	9.6	10.8	13.0	13.4	<1.5	<1.5	<1.5
105	<1	<1	<1	<1	<1	<1	<1
138	6.6	7.3	8.8	9.0	<1.5	<1.5	<1.5
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	4.5	5.3	5.8	6.6	<1	<1	<1
128	<1	<1	<1	<1	<1	<1	<1
180	1.8	1.9	2.6	2.9	<1	<1	<1
169	<1	<1	<1	<1	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	26.8	30.6	36.6	38.0	ND	ND	ND
Surrogate Recovery %							
103	84	93	93	85	115	122	120
198	83	90	90	83	115	115	111

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NSCW4N	NSDI1N	NSDI2N	NSDI3N	NSDI4N	NSBE1N	NSBE2N
8;5	<2	<2	<2	<2	<2	<2	<2
18;15	<2	<2	<2	<2	<2	<2	<2
29	<1	<1	<1	<1	<1	<1	<1
28	<2	<2	<2	<2	<2	<2	<2
50	<2	<2	<2	<2	<2	<2	<2
52	<2	<2	<2	<2	<2	<2	<2
44	<2	<2	<2	<2	<2	<2	<2
66;95	<2	<2	<2	<2	<2	<2	<2
101;90	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
87	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
77	<2	<2	<2	<2	<2	<2	<2
118	<1	<1	<1	<1	<1	<1	<1
153;132	<1.5	2	2	2	2	<1.5	<1.5
105	<1	<1	<1	<1	<1	<1	<1
138	<1.5	1	2	1	2	<1.5	<1.5
126	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
187	<1	<1	<1	<1	<1	<1	<1
128	<1	<1	<1	<1	<1	<1	<1
180	<1	<1	<1	<1	<1	<1	<1
169	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
170;190	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
195;208	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
206	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
209	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	ND	3	4	3	4	ND	ND
Surrogate Recovery %							
103	97	85	89	88	90	119	109
198	88	92	93	90	95	109	105

Appendix D.
Tissue Concentrations of Polychlorinated biphenyls in *Mytilus edulis* (ng.g^{-1} dry weight)

PCB Congener	NSBE3N	NSBE3N duplicate
8;5	<2	<2
18;15	<2	<2
29	<1	<1
28	<2	<2
50	<2	<2
52	<2	<2
44	<2	<2
66;95	<2	<2
101;90	<1.5	<1.5
87	<1.5	<1.5
77	<2	<2
118	<1	<1
153;132	<1.5	<1.5
105	<1	<1
138	<1.5	<1.5
126	<1.5	<1.5
187	<1	<1
128	<1	<1
180	<1	<1
169	<1.5	<1.5
170;190	<1.5	<1.5
195;208	<1.5	<1.5
206	<1.5	<1.5
209	<1.5	<1.5
Total	ND	ND
Surrogate Recovery %		
103	127	112
198	114	104

Appendix E.

Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* ($ng.g^{-1}$ dry weight)

Pesticide	MASN1N	MASN2N	MASN3N	MASN4N	MAIH1N	MAIH2N	MAIH3N	MAIH4N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	2.3	2	2.4	2.1	10	8.5	11	9.7
trans-Nonachlor	2.5	1.95	2.5	2.2	11	9.7	7.2	11
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	<1.2	<1.2	<1.2	<1.2	2.3	2.3	2.7	2.7
p,p'-DDE	12	9	13	11	26	26	25	23
Dieldrin	2.2	2.4	2.1	2.1	6.5	7.1	7.7	8.1
o,p'-DDD	2.9	2.2	3	2.7	27	19	20	24
o,p'-DDT	3.2	2.7	3.5	3.1	7	4.7	6.7	6.4
p,p'-DDD	4.9	5.1	6.1	5.3	61	40	47	39
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<1	<1	<1	<1	2.7	2.3	3	3.9
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	30	25	33	29	154	120	130	128
Surrogate Recovery %								
g-Chlordene	121	119	101	117	78	93	90	82

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	MAPR1N	MAPR2N	MAPR3N	MAPR4N	NHLH1N	NHLH2N	NHLH3N	NHLH4N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	4.7	5	5.2	4.8	2.12	2.48	2.1	2.11
trans-Nonachlor	4	4.2	4.6	4.1	1.1	1.25	1.14	1.34
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	4.1	3.9	4.3	3.6	<1.2	<1.2	<1.2	<1.2
p,p'-DDE	12	13	13	11	3.12	3.38	2.73	3.14
Dieldrin	4.5	3	2.5	3	1.4	2.1	1.7	1.8
o,p'-DDD	13	13	6.4	5.9	<1	<1	<1	<1
o,p'-DDT	3.1	3	3.3	3.2	<1.2	<1.2	<1.2	<1.2
p,p'-DDD	23	27	14	12	2.07	2.04	1.63	1.92
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<1	<1	<1	<1	<1	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	68	72	53	48	9.8	11	9.3	10
Surrogate Recovery %								
g-Chlordene	88	87	91	78	102	93	80	90

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* ($ng.g^{-1}$ dry weight)

Pesticide	NHSS1N	NHSS2N	NHSS3N	NHSS4N	NHSS4N duplicate	NHGP1N	NHGP2N	NHGP3N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	2.84	2.05	2.36	2.16	2.1	2.16	2.18	2.52
trans-Nonachlor	1.62	1.15	1.35	1.27	1.28	1.27	1.17	1.38
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
p,p'-DDE	5.82	5.23	6.16	5.51	6.26	5.33	4.95	5.5
Dieldrin	1.5	1.3	2.1	1.9	<1.2	1.2	1.2	1.5
o,p'-DDD	1.38	1.03	1.5	<1	1.16	2.72	<1	1.4
o,p'-DDT	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
p,p'-DDD	3.67	2.61	2.91	2.31	2.38	3.28	2.71	3.15
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<1	<1	<1	<1	<1	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	17	13	16	13	13	16	12	15
Surrogate Recovery %								
g-Chlordene	90	93	83	83	87	110	104	109

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	NHGP4N	NHDP1N	NHDP2N	NHDP3N	NHDP4N	NHNM1N	NHNM1N duplicate	NHNM2N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	2.15	2	2.1	1	1.2	2.7	1.7	2.7
trans-Nonachlor	1.25	1.4	1.5	1.5	1.6	2.3	2	2.3
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	<1.2	<1.2	<1.2	<1.2	<1.2	1.8	1.9	2.1
p,p'-DDE	5.15	5.2	7.1	6.3	7.7	14	13	17
Dieldrin	<1.2	1.5	1.6	1.5	1.3	1.9	<1.2	1.6
o,p'-DDD	1.24	<1	<1	1	1.4	10	8.2	12
o,p'-DDT	<1.2	1.31	1.56	1.3	1.9	2.6	2.4	2.7
p,p'-DDD	3.1	<1.5	1.8	2.2	2.1	25	20	31
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<1	1.3	1.3	1.3	1.6	3.6	2.8	2.7
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	13	13	17	16	19	64	52	74
Surrogate Recovery %								
g-Chlordene	115	99	115	87	97	126	104	not added

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	NHNM3N	NHNM4N	MECC1N	MECC2N	MECC3N	MECC4N	MEKN1N	MEKN2N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	2.4	3.1	2.3	2.4	2.1	2.6	<1	<1
trans-Nonachlor	2.4	2.4	1.4	1.5	1.3	1.5	<1	<1
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	2.3	2.8	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
p,p'-DDE	17	18	5.6	5.7	5.2	6.6	3.7	3.4
Dieldrin	1.5	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDD	11	8.3	<1	1.1	1.2	1.1	<1	<1
o,p'-DDT	2.9	2.9	<1.2	1.4	<1.2	1.3	<1.2	<1.2
p,p'-DDD	29	36	4.2	4.3	3.7	5	2.1	1.7
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	3	1.9	<1	<1	<1	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	72	75	14	16	14	18	5.8	5.1
Surrogate Recovery %								
g-Chlordene	81	120	118	121	109	123	92	80

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	MEKN3N	MEKN4N	MEDM1N	MEDM2N	MEDM3N	MEDM4N	MEBB1N	MEBB1N duplicate
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	<1	<1	<1	<1	<1	<1	2	2.9
trans-Nonachlor	<1	<1	<1	<1	<1	<1	2	1.8
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	1.5	1.3
p,p'-DDE	2.7	3.2	2.5	2.5	2.8	2.6	7.6	6.1
Dieldrin	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDD	<1	<1	<1	<1	<1	<1	13	14
o,p'-DDT	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	2.4	1.7
p,p'-DDD	1.9	2	1.9	1.9	2.6	1.8	35	34
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<1	<1	<1	<1	<1	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	4.6	5.2	4.4	4.4	5.4	4.4	61	62
Surrogate Recovery %								
g-Chlordene	87	99	84	91	91	78	100	83

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	MEBB2N	MEBB3N	MEBB4N	NBNR1N	NBNR2N	NBNR3N	NBNR4N	NBCH1N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	1.2	<1.2	<1.2	<1.2	1.2
cis-Chlordane	2.2	1.5	1.4	1.4	1.2	1.0	1.3	1.1
trans-Nonachlor	1.5	1.5	1.5	1.8	1.8	1.5	1.8	1.5
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	1.7	1.2	1.6	<1.2	<1.2	<1.2	<1.2	1.8
p,p'-DDE	5.8	5.6	6.4	2.3	2.2	2.0	2.0	2.2
Dieldrin	<1.2	<1.2	<1.2	1.6	1.7	1.5	1.5	1.8
o,p'-DDD	14	14	11	<1	<1	<1	<1	<1
o,p'-DDT	1.4	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
p,p'-DDD	34	39	35	<1.5	<1.5	<1.5	<1.5	<1.5
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<1	<1	<1	<1	<1	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	61	63	57	8.3	6.9	6.0	6.6	10.0
Surrogate Recovery %								
g-Chlordene	90	70	83	110	107	97	107	114

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	NBCH2N	NBCH2N duplicate	NBCH3N	NBCH4N	NBLB1N	NBLB2N	NBLB3N	NBLB4N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	1.3	1.2	1.0	1.2	<1.2	<1.2	<1.2	<1.2
trans-Nonachlor	1.1	1.0	<1	1.2	<1.2	<1.2	<1.2	<1.2
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1	1.0	<1	<1
o,p'-DDE	<1.2	<1.2	<1.2	<1.2	<1	<1	<1	<1
p,p'-DDE	2.2	2.2	1.9	2.2	3.1	4.3	3.4	3.2
Dieldrin	1.6	1.6	1.4	1.6	<1.2	1.7	1.5	1.6
o,p'-DDD	<1	<1	<1	<1	<1	<1	<1	<1
o,p'-DDT	<1.2	<1.2	<1.2	<1.2	<2	<2	<2	<2
p,p'-DDD	<1.5	<1.5	<1.5	<1.5	<1.5	1.9	1.7	<1.5
b-Endosulfan	<2	<2	<2	<2	<1.2	<1.2	<1.2	<1.2
p,p'-DDT	<1	<1	<1	<1	<1	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	6.2	5.9	4.3	6.2	3.1	8.9	6.5	4.8
Surrogate Recovery %								
g-Chlordene	106	111	85	103	78	90	81	82

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	NBLN1N	NBLN2N	NBLN3N	NBLN4N	NBLN4N duplicate	NBTC1N	NBTC2N	NBTC3N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
trans-Nonachlor	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
a-endosulfan	<1	<1	<1	<1	<1	<1	<1	<1
o,p'-DDE	<1	<1	<1	<1	<1	<1	<1	<1
p,p'-DDE	3.1	2.7	3.2	3.1	3.4	4.7	5.2	6.1
Dieldrin	1.6	<1.2	1.6	1.4	1.5	1.2	1.2	1.4
o,p'-DDD	<1	<1	<1	<1	<1	<1	<1	<1
o,p'-DDT	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDD	1.5	<1.5	<1.5	1.6	1.7	4.3	4.1	4.5
b-Endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
p,p'-DDT	<1	<1	<1	<1	<1	2.5	2.8	3.0
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	6.1	2.7	4.8	6.1	6.6	12.7	13.3	15.0
Surrogate Recovery %								
g-Chlordene	76	76	87	74	80	75	86	81

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	NBTC4N	NBCG1N	NBCG2N	NBCG3N	NBCG4N	NSCW1N	NSCW2N	NSCW3N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	<1.2	<1.2	<1.2	<1.2	<1.2	<1	<1	<1
trans-Nonachlor	<1.2	<1.2	<1.2	<1.2	<1.2	<1	<1	<1
a-endosulfan	<1	<1	<1	<1	<1	<1.2	<1.2	<1.2
o,p'-DDE	<1	<1	<1	<1	<1	<1.2	<1.2	<1.2
p,p'-DDE	5.8	11.2	11.1	10.9	10.1	1.9	2.6	2.6
Dieldrin	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDD	<1	3.5	3.9	3.5	3.1	<1	<1	<1
o,p'-DDT	<2	<2	<2	<2	<2	<1.2	<1.2	<1.2
p,p'-DDD	4.0	14.3	14.2	13.3	13.0	<1.5	<1.5	<1.5
b-Endosulfan	1.3	2.6	2.6	2.5	2.4	<2	<2	<2
p,p'-DDT	2.9	6.1	6.4	6.2	6.1	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	14.0	37.8	38.2	36.4	34.7	1.9	2.6	2.6
Surrogate Recovery %								
g-Chlordene	78	77	82	81	78	121%	115%	118%

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	NSCW4N	NSDI1N	NSDI2N	NSDI3N	NSDI4N	NSBE1N	NSBE2N	NSBE3N
HCB	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
g-HCH	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
Heptachlor	<1	<1	<1	<1	<1	<1	<1	<1
Aldrin	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hepta Epoxide	<1.2	<1.2	<1.2	1.2	<1.2	<1.2	<1.2	<1.2
cis-Chlordane	<1	<1	<1	1.2	1.0	1.1	1.8	1.8
trans-Nonachlor	<1	<1	<1	<1	<1	<1	<1	<1
a-endosulfan	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
o,p'-DDE	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
p,p'-DDE	2.9	2.2	2.4	2.2	2.4	1.7	2.6	2.6
Dieldrin	<1.2	1.6	1.7	1.6	1.9	<1.2	<1.2	<1.2
o,p'-DDD	<1	<1	<1	<1	<1	<1	<1	<1
o,p'-DDT	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	1.2
p,p'-DDD	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	1.5	<1.5
b-Endosulfan	<2	<2	<2	<2	<2	<2	<2	<2
p,p'-DDT	<1	1.1	1.1	1.2	1.3	<1	<1	<1
Mirex	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Total	2.9	4.9	5.2	7.4	6.6	2.8	5.9	5.6
Surrogate Recovery %								
g-Chlordene	92%	89%	91%	91%	90%	114%	119%	108%

Appendix E.
Tissue Concentrations of Chlorinated Pesticides in *Mytilus edulis* (ng.g^{-1} dry weight)

Pesticide	NSBE3N
	duplicte
HCB	<1.2
g-HCH	<1.2
Heptachlor	<1
Aldrin	<1.5
Hepta Epoxide	<1.2
cis-Chlordane	1
trans-Nonachlor	<1
a-endosulfan	<1.2
o,p'-DDE	<1.2
p,p'-DDE	2.5
Dieldrin	<1.2
o,p'-DDD	<1
o,p'-DDT	1.2
p,p'-DDD	1.5
b-Endosulfan	<2
p,p'-DDT	<1
Mirex	<1.5
Total	6.2
Surrogate Recovery %	
g-Chlordene	116%

Appendix F.
Tissue Concentrations of Polychlorinated Dibenzodixons and Dibenzofurans in *Mytilus edulis* (pg.g^{-1} wet weight)

Dioxins	MAIH	MAPR	NHLH	NHNM	MEDM*	*MEDM duplicate	MEBB
T4CDD - Total	1.2	1.6	5.3	12	<0.2	<0.2	0.6
2,3,7,8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
P5CDD - Total	0.6	<0.4	<0.4	0.6	<0.4	<0.4	<0.4
1,2,3,7,8	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
H6CDD - Total	1.3	1.1	1.7	3.1	<0.6	<0.6	<0.6
1,2,3,4,7,8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
1,2,3,6,7,8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
1,2,3,7,8,9	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
H7CDD - Total	12	6.4	5.7	7.3	0.9	0.8	3.3
1,2,3,4,6,7,8	6.1	2.6	2.4	2.9	<0.7	<0.7	1.5
O8CDD	40	13	15	16	2.7	2.8	5.5
total	61.2	24.7	30.1	41.9	3.6	3.6	10.9
Furans							
T4CDF - Total	26	9.2	1.9	7.1	<0.2	<0.2	3.3
2,3,7,8	5.7	1.7	0.5	1.3	<0.2	<0.2	0.6
P5CDF - Total	5.4	1.3	<0.4	2.6	<0.4	<0.4	1.3
1,2,3,7,8	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
2,3,4,7,8	0.6	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
H6CDF - Total	1.8	0.9	<0.6	0.9	<0.6	<0.6	<0.6
1,2,3,4,7,8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
1,2,3,6,7,8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
2,3,4,6,7,8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
1,2,3,7,8,9	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
H7CDF - Total	4.0	1.6	3.1	0.9	<0.7	<0.7	<0.7
1,2,3,4,6,7,8	1.5	0.8	1.5	<0.7	<0.7	<0.7	<0.7
1,2,3,4,7,8,9	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
O8CDF	4.2	<0.8	1.0	0.8	<0.8	<0.8	<0.8
total	49.2	15.5	8	13.6	0	0	5.2
TEQ -Total**	**1.01**	**0.22**	**0.10**	**0.18**	**0.00**	**0.00**	**0.08**

* Gulfwatch: reference site ND: not detected NA: not analyzed D: duplicate sample
** Calculated using WHO international toxic equivalency factors

Surrogate Recoveries (%)							
13C-T4CDF	84	74	68	85	77	80	81
13C-T4CDD	84	76	65	89	78	79	86
13C-P5CDF	78	74	65	81	77	76	81
13C-P5CDD	86	70	61	77	77	74	81
13C-H6CDF	91	79	66	98	91	94	94
13C-H6CDD	87	78	58	95	88	90	89
13C-H7CDF	60	65	45	73	66	59	68
13C-H7CDD	68	70	41	75	69	55	72
13C-O8CDD	48	72	34	67	60	33	66

Appendix F.
Tissue Concentrations of Polychlorinated Dibenzodixons and Dibenzofurans in *Mytilus edulis* (pg.g^{-1} wet weight)

Dioxins	*NBCH	NBCG	NBTC	NSBE
T4CDD - Total	ND	0.4	ND	ND
2,3,7,8	ND	ND	ND	ND
P5CDD - Total	ND	ND	ND	ND
1,2,3,7,8	ND	ND	ND	ND
H6CDD - Total	ND	ND	ND	ND
1,2,3,4,7,8	ND	ND	ND	ND
1,2,3,6,7,8	ND	ND	ND	ND
1,2,3,7,8,9	ND	ND	ND	ND
H7CDD - Total	0.8	1.5	1.4	1.0
1,2,3,4,6,7,8	ND	ND	0.6	ND
O8CDD	3.3	4.0	3.5	2.4
total	4.1	5.9	5.5	3.4
Furans				
T4CDF - Total	ND	0.5	0.5	0.5
2,3,7,8	ND	0.3	0.3	0.3
P5CDF - Total	ND	ND	ND	ND
1,2,3,7,8	ND	ND	ND	ND
2,3,4,7,8	ND	ND	ND	ND
H6CDF - Total	ND	ND	ND	ND
1,2,3,4,7,8	ND	ND	ND	ND
1,2,3,6,7,8	ND	ND	ND	ND
2,3,4,6,7,8	ND	ND	ND	ND
1,2,3,7,8,9	ND	ND	ND	ND
H7CDF - Total	ND	ND	ND	ND
1,2,3,4,6,7,8	ND	ND	ND	ND
1,2,3,4,7,8,9	ND	ND	ND	ND
O8CDF	ND	ND	ND	ND
total	0	0.8	0.8	0.8
TEQ -Total**	**0.00**	**0.03**	**0.04**	**0.03**

* Gulfwatch: reference site ND: not detected NA: not analyzed D: duplicate sample
** Calculated using WHO international toxic equivalency factors

Surrogate Recoveries (%)				
13C-T4CDF	79	80	84	69
13C-T4CDD	83	83	84	71
13C-P5CDF	75	82	92	65
13C-P5CDD	71	79	93	62
13C-H6CDF	87	97	89	79
13C-H6CDD	86	93	86	76
13C-H7CDF	66	73	78	63
13C-H7CDD	68	76	69	59
13C-O8CDD	60	72	76	55