1997 Annual fish and shellfish report

Massachusetts Water Resources Authority

Environmental Quality Department
Report ENQUAD 98-12

1997 Annual Fish and Shellfish Report

submitted to

Massachusetts Water Resources Authority
Environmental Quality Department
100 First Avenue
Charlestown Navy Yard
Boston, MA 02129
(617) 242-6000

prepared by

David F. Mitchell
Kelly A. Sullivan
ENSR
35 Nagog Park
Acton, MA 01720

and

Michael Moore
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

and

Phillip Downey
Aquatec Biological Sciences
South Burlington, VT 05403

December 1998

Environmental Quality Department Technical Report Series 98-12

Citation:

Mitchell DF, Sullivan KA, Moore MJ, Downey PC. 1998. 1997 Annual fish and shellfish report. Boston: Massachusetts Water Resources Authority. Report ENQUAD 98-12. 139 p.

EXECUTIVE SUMMARY

In 1997, the Massachusetts Water Resources Authority (MWRA) conducted a biomonitoring program for fish and shellfish. The 1997 activities represent the latest year in a continuing biomonitoring program which supports evaluation of the future MWRA effluent outfall in Massachusetts Bay. The goal of the biomonitoring program is to obtain baseline data that may be used to assess the potential environmental impact of the effluent discharge on Massachusetts Bay, and to evaluate the facility's compliance against the NPDES effluent discharge permit.

The specific objective of the 1997 fish and shellfish monitoring program was to further define the baseline condition of three indicator species: winter flounder (*Pleuronectes americanus*), Northern lobster (*Homarus americanus*), and blue mussel (*Mytilus edulis*). Specimens were collected from sites in Boston Harbor (Deer Island Flats (DIF), off *Discovery* at the New England Aquarium), Massachusetts Bay (Future Outfall Site (FOS), Nantasket Beach (NB), Broad Sound (BS)), and Eastern Cape Cod Bay (ECCB). Baseline conditions were characterized in terms of biological parameters (length, weight, biological condition); the presence/absence of disease (both internal and external); and concentrations of organic and inorganic compounds in various tissues. These tissues included: for the winter flounder – liver and filet; for the northern lobster – hepatopancreas and tail meat; and for the blue mussel – soft tissue. The monitored parameters were examined for spatial trends between stations in 1997 and interannual variations from previous monitoring data. In addition, body burdens of certain pesticides (DDT, aldrin/dieldrin, chlordane, heptachlor, etc.), PCBs, lead, and mercury were compared to FDA Action limits and monitoring program warning limits to evaluate potential risk or trends. Finally, the results were evaluated for their ability to answer the underlying monitoring hypotheses.

Flounder

Winter flounder were collected at five sites (DIF, NB, BS, FOS, ECCB) for the 1997 monitoring program (Table 3-1). The mean age of fish collected at both DIF and FOS was significantly higher than for BS (Table 3-2). In general, the mean flounder length is very similar between sampling locations (range: 336-344 mm) with average age between 4 to 5 years.

The external condition of the collected fish indicated few abnormalities. Fin erosion varied between stations (range = 0.1 to 0.7), with all Boston Harbor and Massachusetts Bay fish significantly higher than the ECCB (Table 3-2). The amount of fin erosion observed throughout was considered at the low end of the range and well below that observed in the late 1980s.

The flounder liver histology results indicated that DIF and BS fish exhibited the greatest prevalence of lesion hydropic vacuolation (tubular, centrotubular). Interannual comparison of the lesion prevalence at DIF indicated a statistically significant decrease over the period 1987 to 1997 (Table 3-3). Neoplasia was absent

from fish collected in 1997. Neoplasm prevalence in DIF winter flounder has fallen from elevated levels in the 1980s to undetectable levels during the 1992-1997 period.

Fifteen winter flounder were collected at three sites (DIF, FOS, ECCB) for analysis of tissue concentration of organic and inorganic contaminants in filet and liver (Tables 3-4, 3-5). The spatial patterns of tissue contaminant levels in winter flounder were examined. Mean 1997 concentrations of organic compounds in filets and liver tissue were generally highest at DIF and lowest at ECCB. Mercury was higher at DIF and lowest at ECCB; other metals (Ag, Cd, Cr, Cu, Ni, Pb, Zn) detected in liver tissue showed station-to-station variation with no consistent spatial trend.

Interannual comparisons of tissue organic contaminant levels for the period 1992-1997 displayed some station-to-station variability (Figure 3-3 to 3-5). Concentrations of liver contaminants (dry weight-based) total chlordane, total DDT, dieldren, total PAHs, and total PCBs for 1997 flounder sampled through the study area were generally in the range of the previous years (1992-96). For metals, the observed tissue levels were comparable to those observed during the baseline monitoring period.

The relationship between contaminant levels and liver histopathology was explored. Plotting the prevalence of centrotubular hydropic vacuolation (CHV) against winter flounder tissue levels from fish collected across the monitoring area during 1992-1997 (Figure 3-7 and 3-8) indicates a persistent relationship for total PCBs, chlordanes, and DDTs. This supports the notion that tissue burden data are reasonable predictors for histopathological results.

Comparison was made between flounder edible tissue contaminant levels and FDA regulatory action limits. The 1997 levels, like those detected in previous monitoring years (1992-1996), were well below the federal legal limits (Table 3-6, Figure 3-9). Lipid-normalized concentrations of organic contaminant were determined as part of the establishment of baseline pre-discharge reference levels for the FOS location.

Lobster

Fifteen northern lobster were collected at three sites (DIF, FOS, ECCB) for the 1997 monitoring program (Table 3-7). Twenty-two legal size lobsters were collected by direct trapping, 23 others were obtained from commercial traps located at or within 2 km of sampling stations.

The size, sex, and external appearance (i.e., black gill disease, shell erosion, external tumors, etc.) were determined for the collected lobsters. Little difference in length, weight, or sex ratios was observed between stations with the exception of a preponderance of male lobsters at DIF. For all lobsters, no deleterious external conditions were noted (Table 3-8).

The spatial patterns of tissue contaminant levels in northern lobster were examined (Table 3-9). Mean 1997 concentrations of organic compounds in edible tail meat tissue and the hepatopancreas were generally highest at

DIF and lowest at ECCB. Mean mercury concentration in the tail meat was highest at DIF; for the hepatopancreas the highest level was at FOS. Comparison of 1997 data with previous years (1992-1996) indicates that most tissue contaminant levels were comparable to range previously observed (Figure 3-10 to 3-13).

Comparison was made between lobster edible tissue contaminant levels and FDA regulatory action limits for pesticides, PCBs, and mercury (Figure 3-124a; 3-14b). The 1997 levels, like other monitoring years (1992-1996), were well below the federal legal limits and indicate no risk for human consumption (Table 3-11). Body burdens of total DDT, total PAH, and total PCB in lobster hepatopancreas were normalized for lipids to determine baseline pre-discharge reference levels for the FOS location.

Blue Mussel

Mussels were collected at two reference sites (Gloucester, Sandwich) and deployed for 60 days in arrays at three sites (DIF, FOS, and off *Discovery* in Boston Harbor) (Table 3-12). Sandwich mussels were used as reference material to better assess the potential bioaccumulation of mercury and lead. Arrays were successfully retrieved at all three sites. Mussel survival within the deployed arrays was high (>78%) (Table 3-13). Sex determination of the mussels indicated a fairly equal proportion of males and females, and a high proportion of mature individuals.

The 1997 PAH results were similar to previous years in that all observed mussel body burdens of total PAH were highest at *Discovery*, intermediate at DIF, and lowest at FOS (Table 3-17). The years of study indicate that PAH exposure patterns for mussels deployed at DIF have decreased from 1987 to 1997 (Figure 3-15). Pesticide (DDT, chlordane, dieldrin) levels were comparable to earlier data (Figure 3-16). Lead tissue concentrations were similar to those reported in 1996 (Table 3-22). Statistically, mercury was lowest in DIF deployed mussels.

Comparison was made between mussel tissue contaminant levels and FDA regulatory action limits for mercury and lead (Table 3-23). The 1997 levels were well below the federal legal limits and indicate no risk for human consumption.

Evaluation of Monitoring Hypotheses

An integral part of the MWRA fish and shellfish monitoring is a periodic re-evaluation of the adequacy of the current program to fulfill the overall goals of the monitoring program. In particular, this means a re-examination of the adequacy and effectiveness of the underlying monitoring hypotheses to answer questions regarding the potential effects of the relocated MWRA effluent.

Of the five monitoring hypotheses, three are associated with the potential for edible tissue (flounder, lobster, mussel) to exceed warning levels for mercury, lead, or PCBs (Table 4-1). These hypotheses appear to be sufficient. Current tissue concentrations are generally an order of magnitude or more below warning and FDA regulatory levels. Calculation of significantly increased values indicate that tissue levels approaching the warning or action levels should be readily detectable in the program. Similarly, the monitoring hypothesis evaluating the

prevalence of flounder liver CHV at FOS relative to baseline levels measured in outer Boston Harbor also appears to be sufficiently sensitive to detect trends, based on current data.

Following discussion of an EPA recommendation that the caution level for PCBs in edible tissue from animals at the FOS be re-evaluated, the Outfall Monitoring Task Force (OMTF) and MWRA agreed that the caution level for PCBs would be set at a level of appreciable change from the baseline period, while the warning level would remain at 80% of the FDA limit (OMTF meeting minutes, 10/23/97). In interest of simplicity, it is recommended that all caution level thresholds for other contaminants with FDA limits be similarly revised.

The other major group of monitoring thresholds has been for lipid-normalized organic contaminants. The use of lipid-normalized concentrations for organic contaminants was reconsidered as well. The temporal trends in tissue concentration as expressed on a dry weight basis was compared to concentrations expressed on a lipid-normalized basis (Table 4-2). Comparison of the trends for flounder, lobster, and mussel does not indicate appreciable differences in temporal trends expressed in these two different ways. These results indicate that normalizing contaminant concentrations to lipids does not appreciably reduce the variability over the non-normalized values. Comparison of the relative amount of change from year-to-year for dry-weight based and lipid-based tissue concentrations indicates that both metrics show considerable variation in year-to-year results, but that the relative percent different change for the dry weight concentrations is lower and form a more conservative estimator of body burden change. Again in the interests of simplicity, it is recommended that lipid concentrations continue to be measured in the monitoring program, but that the threshold be based upon dry-weight concentrations of contaminants, not lipid-normalized concentrations.

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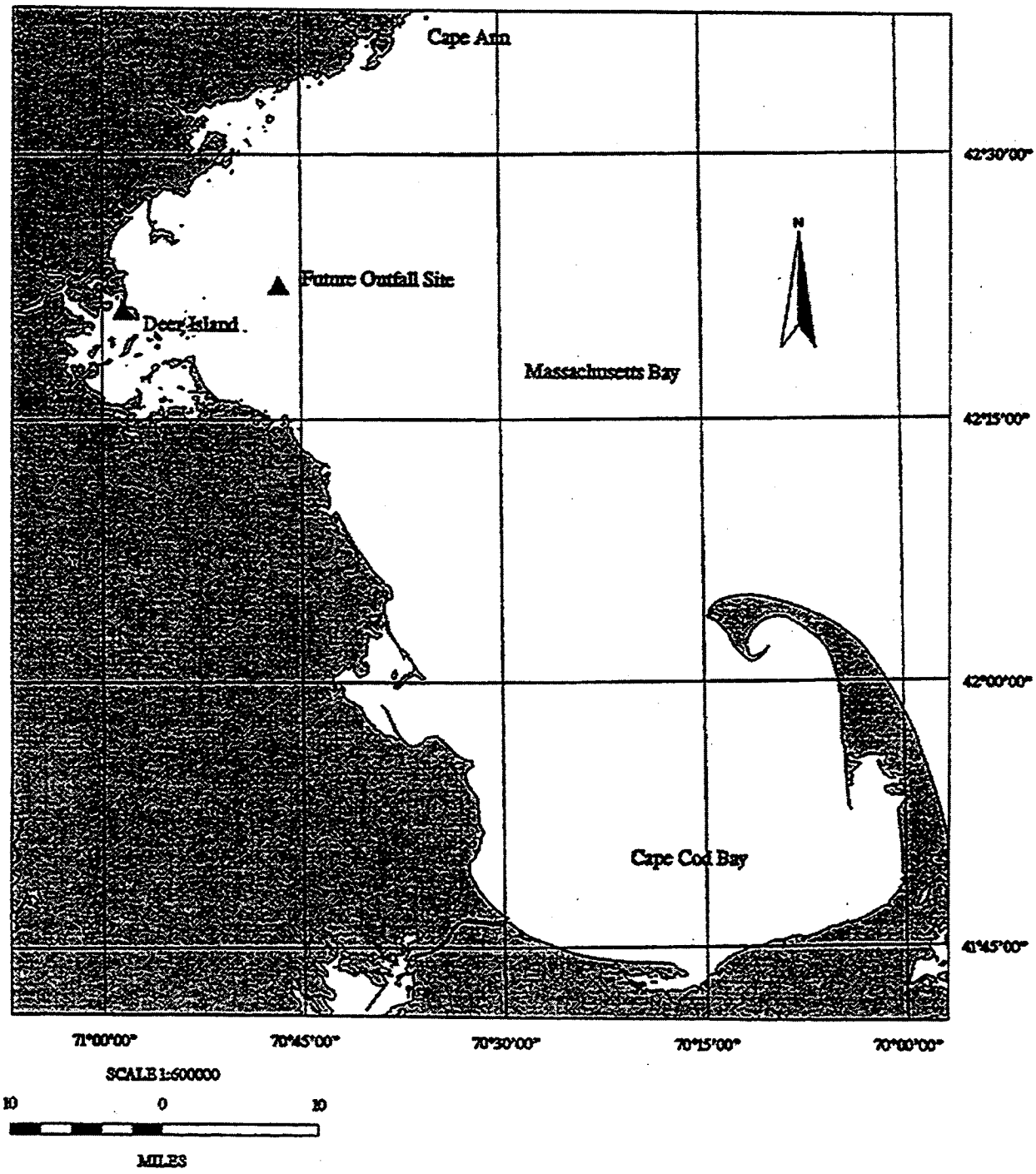
1.0 INTRODUCTION

In 1997, the Massachusetts Water Resources Authority (MWRA) conducted a biomonitoring program for fish and shellfish as one part of a multi-faceted environmental monitoring program (MWRA, 1997). This program is the latest year in a continuing biomonitoring program (MWRA, 1991) which supports evaluation of the future MWRA effluent outfall, located approximately 9½ miles offshore of DIF in Massachusetts Bay (as shown in Figure 1-1). The goal of Phase I of the biomonitoring program is to obtain baseline data that may be used to assess the potential environmental impact of the effluent discharge on Massachusetts Bay, and to evaluate the facility's compliance against the NPDES effluent discharge permit.

The specific objective of the fish and shellfish monitoring is to define the baseline condition of three indicator species [i.e., winter flounder (*Pleuronectes americanus*), Northern lobster (*Homarus americanus*), blue mussel (*Mytilus edulis*)] in terms of biological parameters (length, weight, biological condition), the presence of disease (both internal and external), and the concentrations of organic and inorganic compounds in various tissues, including the liver (winter flounder), hepatopancreas (lobster), and edible tissues (winter flounder filet, blue mussel soft tissue, and lobster tail). This baseline characterization of the health of winter flounder, lobster, and mussel in Boston Harbor, Massachusetts Bay, and Eastern Cape Cod Bay (i.e., Boston Harbor and the Bays) forms the basis for assessing potential changes resulting from the relocation of the outfall discharge.

One survey per indicator species was conducted in 1997 in Boston Harbor and the Bays to determine the body burden of toxic compounds in these three species, and to assess the physiological status of flounder and lobster, following the procedures and protocols described in greater detail in Section 2.0. Section 3.0 presents the results of the 1997 surveys, and discusses the recent data, as well as comparisons with historical data. Section 4.0 presents the conclusions drawn from these 1997 survey results and historical trends. Section 5.0 includes recommendations for the biomonitoring program, while Section 6.0 lists the references cited in this document.

Figure 1-1 1997 Biomonitoring Program Study Area



2.0 METHODS

This section provides an overview of the methods and protocols used in the three surveys. The definitive descriptions of the methods are contained in: *Combined Work/Quality Assurance Project Plan (CW/QAPP) for the Fish and Shellfish Monitoring: 1995-97 (Fish and Shellfish Monitoring CW/QAPP)* (Mitchell *et al.*, 1997).

2.1 Winter Flounder Monitoring

Winter flounder (*P. americanus*) were obtained from five locations in Boston Harbor and the Bays for gross examination, histology, aging, and chemical analyses of liver and fillet tissue. Figure 2-1 depicts the five sampling locations for winter flounder monitoring during 1997.

2.1.1 Stations and Sampling

Fish were collected at Deer Island Flats (DIF, Station 1, located in Boston Harbor), off Nantasket Beach (NB, Station 2), Broad Sound (BS, Station 3), the Future Outfall Site (FOS, Station 4, in Massachusetts Bay), and Eastern Cape Cod Bay (ECCB, Station 5) in sampling conducted between April 4 and April 13, 1997 (Stations 1-5 on Figure 2-1). The F/V *Odessa*, captained by Captain William Crossen, was used to conduct otter trawls at each of the five sites. Table 2-1 presents the trawl data for the flounder surveys including stations, positions, level of effort, etc. Tows were conducted until 50 sexually mature (usually 4- to 5-year old) winter flounder of 30 cm or more in length were obtained. Only 16 fish were obtained at DIF due to the small number of fish available and difficulty with equipment (loss of net). Therefore, after consultation with MWRA approval, 67 fish were collected from the FOS, and 67 fish were collected from ECCB, for a survey total of 250 fish. This modification, occasioned by low catch numbers at DIF, affected only the histopathology data and not the determination of fish tissue body burdens of contaminants. Accordingly, this modification resulted in a less robust estimate of lesion prevalence in the Harbor station than in previous years, but a slightly more robust estimate at FOS and ECCB.

Fifteen fish each from DIF, FOS, and ECCB were selected randomly, identified with a fin clip, and held in static, aerated, ambient seawater prior to dissection for chemical and histopathological analysis at a clean lab. Fish from DIF, and FOS were processed at the Northeastern University Marine Station at Nahant, while those from ECCB were processed in Woods Hole. Remaining fish from those sites, and all fish from BS and NS, were killed on board by cervical section and used for histological processing (see Section 2.1.4).

All specimens from each site were visually examined. External conditions such as for fin rot and other abnormalities (e.g., lymphocystis) were noted. Each fish was weighed and measured for total and standard lengths.

Fish were also assessed for sexual maturity. After each fish was killed by cervical section, an oval incision was made in the ventral body wall overlying the liver and anterior ventral gonad. The gonads were examined, and

their color and sex recorded. Sexual maturity was determined on the basis of the following criteria: gonads are blue-gray in immature fish; pink and elongated in mature females; and white and triangular in mature males. This examination was conducted in the clean lab for the 15 fish held in the live tank and in the field for the remaining fish.

2.1.2 Age Determination

Scale samples were collected from each fish for age determination. Mucus, debris, and epidermis were removed from the dorsum of the caudal peduncle prior to obtaining scale samples. Scales were collected by wiping in the direction of the tail with a blunt-edged knife by applying quick, firm, scraping motions in the direction of the head. Scales were scraped into envelopes labeled for each individual fish. Age was determined by enumerating the annuli on a scale sample taken from each fish.

2.1.3 Dissection of Fish

The fifteen fish held on board in the live tank at each station were delivered to the clean lab established for the project at the Northeastern University Marine Station at Nahant for dissection (fish from Stations DIF and FOS were processed here, while those from ECCB were processed at Woods Hole). Each fish was assigned a sample identification number indicating the date and site of collection. All fish were killed by cervical section. Fish were dissected in a laminar flow hood, using a pre-cleaned titanium knife (pre-cleaning consisted of rinsing with 10% HCl, Milli-Q water, acetone, dichloromethane, and hexane). The fillets (muscle tissue) were removed from the flounder, and the skin removed from the fillet.

2.1.4 Histological Processing

Livers were removed from all fish collected at each site. Each liver was examined for color and gross abnormalities. Three equidistant slices were placed in a separate clearly labeled cassette and preserved in 10% buffered formalin for histological processing.

Liver slices were embedded in paraffin. Two 5 μm sections were cut from each of these three sections, and stained with hematoxylin and eosin according to standard methods (Hillman *et al.*, 1994). The remaining liver tissue from the 15 flounder designated for chemical analysis was retained.

2.1.5 Histological Analysis

The 250 liver samples set aside for histological analysis were initially examined for the prevalence and severity of the following lesions, which were described in Moore, 1991 and Hillman *et al.*, 1994:

- Vacuolation (including centrotubular, tubular hydropic, and focal hydropic);
- Macrophage aggregation;
- Biliary duct proliferation; and

- Neoplasia.

Slides were prepared for each fish, including three liver sections per slide. Each slide was examined under bright-field illumination at 25x, 100x, and 200x. The severity of each lesion was rated on a scale from 0 to 4, as follows:

- 0 = absent
- 1 = minor
- 2 = moderate
- 3 = severe
- 4 = extreme.

For each lesion and each fish, a histopathological index was calculated as the mean of scores from three liver slices on one slide. A lesion index was also calculated for each site, based on the mean scores for each particular lesion at each site.

2.1.6 Tissue Processing

Chemical analyses were performed on three composite samples each of flounder fillet and liver tissues taken from five fish obtained from the 15 fish set aside in the live well for 3 of the 5 sites: DIF, FOS, and ECCB (samples from NB, and BS are analyzed in even years only). Fillet tissues from individual fish were homogenized separately; the liquid from each sample was stored with the homogenate. Fillet composites contained equal portions of dorsal and caudal tissue. Equal amounts of liver (or fillet) were used from each of the five fish per composite. Liver tissue samples were pooled at the time of sampling (i.e., first 5 liver samples = Pool #1, etc). Wet weights were recorded for each liver and fillet sample. After compositing, the tissues were re-homogenized prior to shipment for chemical analysis. Remaining liver and fillet tissues were placed in labeled containers, frozen, and archived.

2.1.7 Chemical Analyses

Chemistry analyses performed on composited flounder tissues are listed in Table 2-2. Flounder fillets were analyzed for mercury, polychlorinated biphenyls (PCBs), chlorinated pesticides, and lipids. Flounder livers were analyzed for trace metals, PCBs, polycyclic aromatic hydrocarbons (PAHs), chlorinated pesticides, and lipids. The composited samples were split for organic and metals analyses at separate laboratories.

2.1.7.1 Organic Compound Analyses

Tissue samples were serially extracted for PAH, chlorinated pesticides, and PCBs. An aliquot of homogenized tissue was extracted with dichloromethane (DCM) and sodium sulfate using a Tekmar tissuemizer. An aliquot of the original sample was retained for dry weight determination. The sample was weighed in a Teflon extraction jar, spiked with the appropriate surrogate internal standards. Sodium sulfate and solvent were added, the samples were macerated for 2 minutes, and centrifuged. The solvent extract was decanted into an Erlenmeyer flask. After each extraction (two homogenizations and a third shake by hand), the centrifuged solvent was combined in the flask. A 10-ml aliquot of the combined extracts was removed for lipid weight determination, and sodium sulfate was added to the extract remaining in the flask. After approximately 30 minutes, the contents of the flask was processed through an alumina column. The elutriate from the column was concentrated to 900 µl (via a Kuderna-Danish apparatus and nitrogen evaporation techniques). The concentrated extract was further cleaned using a high performance liquid chromatographic (HPLC) gel-permeation technique (which removes common contaminants that interfere with the instrument, including lipids). The post-HPLC extract was concentrated to approximately 500 µl under nitrogen gas, and the recovery internal standards were added to quantify extraction efficiency. The tissue final extract was split for analysis, with one half remaining in DCM for PAH analysis, and one half solvent-exchanged with isooctane for PCB/pesticide analysis.

As in previous years (i.e. 1992-1996), co-planar PCB congeners 77 and 126 were reported in the MWRA Fish and Shellfish Monitoring Program data for 1997. The PCB analyses on the fish and shellfish monitoring program from 1995 to 1997 and the shellfish monitoring program from 1992 to 1994 used a dual column confirmation, which minimizes but does not completely eliminate the possibility of other congeners co-eluting with congeners 77 and 126. Thus, there is greater uncertainty associated with the PCB congener 77 and 126 results due to the potential interferences from other PCB congeners. Note: the use of dual column confirmation will continue in future fish and shellfish monitoring.

Sample extracts were analyzed for PAH compounds in the selected-ion monitoring (SIM) mode by gas chromatography/mass spectrometry (GC/MS) using a modification of EPA Method 8270. The modifications include operating the mass spectrometer in the SIM mode, and tuning the mass spectrometer with PFTBA. Pesticides and PCB congeners were analyzed and quantified using gas chromatography/electron capture detection (GC/ECD) using EPA Method 8080, modified to include additional analytes and a second column for qualitative confirmation.

2.1.7.2 Metals Analyses

Tissues were analyzed for the metals indicated in Table 2-2. Approximately 0.75 g of wet tissue (0.3 g dry tissue) were weighed into the Teflon inserts of Parr Bombs. The sample was turned into a slurry upon the addition of 3 ml of superpure aqua-regia. The bombs were sealed and heated for three minutes. The bombs were then cooled, another 2 ml of superpure aqua-regia added, and heated for two minutes. The digestate was diluted to a final volume of 50 ml and transferred to a pre-cleaned 125 ml polyethylene bottle. The digestate was analyzed for silver, cadmium, chromium, nickel, copper, lead, and zinc by inductively coupled plasma-mass

spectrometry (ICP-MS). In order to achieve the low detection limits required for mercury analysis, the EPA method for total recoverable mercury (EPA Method 245.1) was modified. Mercury was analyzed using a flow injection cold vapor technique with atomic absorption detection following preconcentration on gold amalgam (McIntosh, 1993).

2.1.8 Data Reduction and Statistical Analyses

Data reduction was conducted as described in the Fish and Shellfish Monitoring CW/QAPP (Mitchell *et al.*, 1997). Histopathological indices and prevalence of lesions were compared between classes of fish by differences in station, age, sex, and length. Chemical constituents were presented graphically.

Histopathological observations of the livers of the winter flounder from all sites were conducted and, where possible, comparisons of the results with those of previous years were made. Possible relationships between observed lesions and contaminant body burdens were also investigated.

In addition to reporting the prevalence and lesion index of hydropic vacuolation, historical data has included several other lesions, including macrophage aggregates, biliary proliferation, neoplasia, and a lesion unreported before 1993, referred to as "balloon hepatocytes".

The levels of contaminants measured in edible tissues were compared to Food and Drug Administration (FDA) Action Levels (U.S. EPA, 1989) for those contaminants.

2.1.9 Deviations from CW/QAPP

At DIF, only 16 fish were collected during the April survey due to the combined effects of fish availability limitations and fishing gear failure. Therefore, 17 extra fish were collected from the FOS, and 17 extra fish were collected from ECCB, in accordance with MWRA approval. These extra fish will serve to provide more robust estimates of lesion prevalence at FOS and ECCB.

The CW/QAPP states that samples are to be collected under a hood aboard the vessel, at dockside. This has proved to be impracticable in the field. Therefore, fish from DIF, NB, BS and FOS were processed at a clean dissection bench established at the Nahant Marine Laboratory while those from ECCB were processed at Woods Hole.

2.2 Northern Lobster Monitoring

Northern lobsters (*H. americanus*) were collected from three locations for gross examination and chemical analyses of hepatopancreas and edible (tail) tissue. Figure 2-1 presents the sampling locations for the 1997 survey.

2.2.1 Stations and Sampling

Lobsters were collected at three stations for gross examination and analysis of chemical contaminants in the tail and hepatopancreas. Sampled stations included DIF (Station 1, in Boston Harbor), the FOS (Station 4, in Massachusetts Bay), and ECCB (Station 5), (Figure 2-1, Stations 1, 4, and 5). As with previous recent surveys (1994-1996) sampling was conducted in late July- early August (note sampling in 1992 was in April; and that in 1993 was June to early September), with the exception of lobsters from the FOS, where collection was not completed until early September, 1997. The F/V *Tina Marie*, piloted by Captain Alex Brown, was used to set and collect 20 lobster traps at ECCB. The F/V *Windmere*, skippered by Captain Peter Mahoney, was used to initially set and collect 60 lobster traps at the FOS (July 29 – August 1), and to then set and collect an additional 80 traps from the FOS (September 9 – September 12). A total of 20 lobster traps were set and collected at DIF. Table 2-3 contains the trap data for the 1997 surveys. Traps were set for 3-4 days (FOS, DIF) and 5 days (ECCB) to collect 15 legal-size non-berried individuals. The desired number of individuals was supplemented through the purchase of commercially obtained lobsters from traps set in the general area of the target location. Thirteen lobsters were purchased at ECCB from Cape Tip Fisheries, and 10 were purchased at DIF from a local lobsterman. A total of 41 lobsters (5 from the first effort, 36 from the second) were collected from FOS. The first 15 collected were used as the study organisms.

2.2.2 Size and Sex Determination

Immediately upon removal from the traps, lobsters were measured with a commercial lobster gauge to determine if the lobster met the legal size limit. Lobsters which did not meet the legal size limit were enumerated and immediately returned to the sea. Lobsters that met the legal size limit were assigned a unique sample identification number, according to the system established by ENSR in 1995. Lobsters were then measured for carapace length and width, and weighed on a Sartorius® balance (accuracy ± 1 gram).

In addition to length, width, and weight measurements, the sex of individual lobsters was recorded on the field data sheets. External conditions were noted, including the presence or absence of black gill disease, shell erosion, parasites, external tumors, and other external abnormalities. Upon completion of the field observations, lobsters were placed in labeled, doubled plastic bags, and preserved on dry ice. Lobsters were transported to the analytical laboratory and kept frozen until dissected and the tissue composited.

2.2.3 Dissection of Lobster

Because clean conditions could not be satisfied in the field, lobster dissection was conducted in the laboratory setting. Each lobster was assigned a unique laboratory identification number in the field. Lobsters were thawed prior to dissection. The hepatopancreas and edible meat (tail only) were removed from each lobster via ventral incisions in the carapace and tail.

2.2.4 Tissue Processing

Once the hepatopancreas and edible tissues were removed from the carapace, each was homogenized separately. Composite samples were generated by homogenizing the edible tissue of five randomly-selected lobsters, with an equal amount (±5% by weight) of tissue from each lobster. Equal volumes of hepatopancreas homogenate (±5%) from the same five lobsters were composited and re-homogenized prior to chemical analysis. Three composite samples of hepatopancreas and edible tissue were analyzed per station.

2.2.5 Chemical Analyses

The chemical analyses conducted on lobster hepatopancreas and edible tissue samples followed the same procedures used for analysis of flounder tissue described in Section 2.1.7. A list of the chemical analytes is given in Table 2-2. Lobster hepatopancreas tissues were analyzed for trace metals and organic compounds. Edible tissues were analyzed for mercury and organic compounds.

2.2.6 Data Reduction and Statistical Analyses

Data reduction was conducted as described in the Fish and Shellfish Monitoring CW/QAPP (Mitchell *et al.*, 1997). Spatial and temporal trends of contaminants in composites of edible lobster tissue and hepatopancreas tissue were evaluated through available data from 1985 through 1997. Comparisons were made to the FDA Legal Limits and other appropriate levels of regulatory concern.

2.2.7 Deviations From CW/QAPP

All positions were slightly different from those specified. In ECCB, traps were set slightly north of the specified position. The DIF traps were not set in the anchorage area, but rather along the base of the drop-off on the southern edge of the flats. At the FOS, traps were set about 1.5 miles east of the specified position upon the recommendations of two local lobstermen.

Lobster traps were not set repeatedly at each sampling site until 15 lobsters were obtained at DIF or ECCB. Remaining lobsters for these two sites were purchased. At ECCB, only two lobsters were caught in the set traps. The remaining 13 were purchased from Cape Tip Fisheries, a Provincetown company that buys lobsters from local lobstermen fishing along the 12-m contour between Provincetown and Wellfleet. At DIF, only five lobsters were caught in the set traps. The remaining 10 were purchased from a local lobsterman retrieving traps from near the ship's channel south of Governors Island Flats.

Carpace length was measured as the distance from the posterior edge of the eye socket to the posterior edge of the carapace, rather than as the distance from the tip of the rostrum to the posterior edge of the median uropod. This ensured consistency with the measurements taken during the 1995 and 1996 surveys.

Lobsters were not killed and dissected in the field, as the requisite clean conditions could not be guaranteed. Lobsters were immediately assessed for external conditions, placed on dry ice, and delivered to the laboratory frozen, under chain-of-custody, for later thawing and analysis.

2.3 Mussel Bioaccumulation Monitoring

Blue mussels (*M. edulis*) were obtained from two reference stations, deployed at 3 stations, and retrieved for assessment of bioaccumulative contaminants in ambient waters of interest. Secondarily, mussel condition (growth and reproduction) was used to assess the current health of mussel populations in the Boston Harbor and Bay areas. The station locations used in the 1997 survey are shown in Figure 2-1. Short-term soft tissue accumulation of station-specific contaminants was monitored over a period of 60 days. Specimens were collected from reference sites and deployed during a June survey, and the mussels were collected after incubation in August, 1997.

2.3.1 Stations and Reference Areas

Mussels were deployed and retrieved at three sites, including a baseline reference site. Figure 2-1 illustrates the sampling locations in Boston Harbor and Massachusetts Bay. Table 3-12 presents the 1997 mussel survey sampling design.

Mussels were deployed on June 27, 1997 from the R/V *Profile* in replicate arrays at the sites described below:

- Approximately 75 meters east of Deer Island Light within the zone of initial dilution (ZID) of the DIF effluent discharge. This site was selected for monitoring the potential bioaccumulation associated with the DIF effluent discharge;

- The stern of the *Discovery*, anchored at the New England Aquarium in Boston Inner Harbor. This site serves as a "dirty" control, allowing the evaluation of ambient contamination within Boston Inner Harbor; and

- The FOS, anchored at a navigation buoy located approximately one nautical mile (NM) south of the project MWRA offshore discharge installation. This site is monitored for pre-discharge baseline conditions. Following the future shift in the location of the MWRA effluent outfall (anticipated for 1999), a new location for the mussel FOS deployment site will be established in the immediate vicinity of the outfall.

2.3.2 Mussel Collection

Approximately 1000 mussels were collected from the University of Massachusetts Research Station at Hodgkin's Cove, Gloucester, MA on June 25, 1997. Mussels from this location have been shown to be relatively free of organic contamination, and have been used in previous bioaccumulation studies conducted throughout the

Massachusetts coastline (Camp, Dresser and McKee, 1988; MRI, 1989; Downey and Young, 1992; Downey *et al.*, 1993; Downey, 1994a; 1994b). However, concerns have been raised relative to the concentrations of mercury and other metals in Gloucester mussels, therefore approximately 500 mussels were collected at an alternate control site in Sandwich, MA. Accordingly, only tissue derived from Sandwich-harvested mussels was used for all metal analyses. All analyses of organic contaminants were performed on Gloucester-harvested mussels.

Mussels were harvested during low tide. Only mussels between 55 and 70 mm in total length were used. Total length was recorded on 200 mussels collected in Gloucester and 60 of the mussels collected in Sandwich. Approximately 50 Gloucester mussels were randomly distributed to each of 22 plastic cages, and suspended overnight in seawater along the seawall adjacent to the UMass Research Station in Gloucester. Approximately 50 Sandwich mussels were distributed to separate cages and suspended overnight in seawater at the Sandwich collection site. In addition, a sub-sample of 30 Gloucester mussels and 10 Sandwich mussels were sent on ice to the Aquatec facility on June 28, 1996 for initial biological analyses, including total length, sex and sexual maturity, and tissue weights. Samples of Gloucester and Sandwich mussels were stored frozen for chemical analyses.

2.3.3 Mussel Deployment

At DIF, three arrays were deployed on June 27, 1997. Each deployment array consisted of two replicate cages containing approximately 50 Gloucester-harvested mussels per cage (= 100 Gloucester mussels) and one cage containing 50 Sandwich-harvested mussels for a total of approximately 150 mussels per array. The cages were attached to polypropylene line with nylon cable ties. The arrays were positioned within the water column by steel mooring weights and a styrofoam subsurface buoy. The subsurface buoy for each array was located approximately 3 meters above the bottom, and the cages were fixed approximately 1 meter below the buoy (or 2 meters above the bottom). At DIF, the arrays were deployed in approximately 4 to 6 meters mean low water (MLW), approximately 75 meters east of the light. Deployment positions were confirmed with an on-board Loran-C instrument, and latitude and longitude measurements were recorded.

Two arrays were deployed at the *Discovery*, a New England Aquarium vessel, on June 27, 1997. Each deployment array consisted of two replicate cages containing approximately 50 Gloucester-harvested mussels per cage (= 100 Gloucester mussels) and one cage containing 50 Sandwich-harvested mussels for a total of approximately 150 mussels per array. The arrays were suspended on a nylon line off the stern of the vessel. The six cages were attached in 2 sets (0.2 meters between sets); each set was considered to be a deployment array. The arrays were anchored approximately 2 to 2½ meters above the bottom in approximately 7 to 9 meters of water.

Four arrays were deployed at FOS on June 27, 1997. Each array consisted of three cages, with a total of approximately 150 Gloucester and Sandwich mussels, as previously described. The arrays were deployed near the FOS with a mooring and suspension system similar to that deployed at DIF. In addition, a surface buoy was attached to the subsurface buoy, which was deployed approximately 13 meters below the surface.

2.3.4 Mussel Retrieval

On August 7, 1997, mid-deployment period retrieval activities were conducted. One array was collected from each of the study locations. The mussels from each location harvested at 40 days were checked in the field for gross abnormalities and apparent survival, frozen, and archived (they were not used during the remainder of the study since the 60-day retrieval was successful).

Mussels were retrieved on August 26, 1997, for a total deployment period of 60 days. Live mussels were retrieved at all three stations. At the *Discovery*, one array was recovered, containing 93 live Gloucester mussels and 39 live Sandwich mussels. At DIF, one array was recovered, containing 97 live Gloucester mussels and 50 live Sandwich mussels. Three arrays, containing 305 live Gloucester mussels and 156 live Sandwich mussels, were retrieved from FOS. Random sub-samples of mussels from each station were set aside for biological and chemical analyses. Mussels for chemical and biological analysis were stored in separate labeled plastic bags and preserved on ice for transport. All mussels were transported on ice to Aquatec on August 26, 1997, and stored frozen (for chemical analyses) or refrigerated (for biological analyses).

2.3.5 Determination of Biological Condition

Of the mussels collected in Gloucester, the total shell lengths (in millimeters (mm), from umbo to distal gape) were recorded for a sub-sample of 200 mussels. Measurements were made in the field with Vernier calipers to 0.1 mm to obtain an average size estimate for the entire sample population of approximately 1000 mussels. Random sub-samples of mussels harvested at Gloucester were selected from the pre-deployment mussels (30), the mussels retrieved at the full deployment period from DIF (29), the FOS (30), and the *Discovery* (28). Mussels from these sub-sample were processed for biological analyses. These included observations of viability at recovery, shell weight, shell length, total tissue weight (both wet and dry), and gonadal tissue weight (wet and dry). Each mussel was opened by slicing the adductor muscles between the valves with a microtome blade. The gill tissue was drawn back to expose the gonad. A small aliquot of macerated gonadal tissue was transferred to a slide and examined under a compound microscope for sex and sexual maturity. Sexually mature males were identified by sperm motility and immature males by lack of sperm motility. Sexually mature females were identified by the presence of eggs of a diameter greater than 60 microns, while those with egg diameters less than 60 microns were considered to be sexually immature.

Approximately 500 mussels were collected from the alternate control site in Sandwich, MA. At the time of collection, the sizes of a sub-sample of 60 of these mussels were measured and recorded. Ten mussels were retained for sex determinations and measurements of gonadal and non-gonadal wet weights. These alternate control mussels were harvested at FOS, DIF and from the *Discovery* after a 60-day deployment. Biological analyses were conducted as described above for the Gloucester mussels, although mussel dry weights were not measured on the alternate control mussels.

2.3.6 Tissue Processing

A random sub-sample of Gloucester derived mussels (50 mussels per station) were selected from pre-deployment mussels and from each of the three stations' 60-day deployment harvest. Replicate samples for chemical analysis were prepared as composites of ten mussels, for a total of 5 replicate composite samples at each of the four locations. Each individual mussel was clean4red of attached material, all byssal threads removed, and all soft tissue including fluids placed directly into an amber 500-ml I-Chem Certified clean bottle. Mussel composite samples were prepared for chemical analyses by dissection of each of the 10 mussels using disposable Teflon-coated stainless steel blades rinsed with methanol and deionized water prior to use.

A random sub-sample of Sandwich derived mussels (25 mussels per station) were selected from pre-deployment mussels, FOS, DIF, and Discovery full deployment mussels. These were prepared as described above for the Gloucester mussels, although composite samples consisted of 5 mussels per composite, for a total of 5 replicate composite samples at each of the four locations.

2.3.7 Chemical Analyses

Table 2-2 summarizes the chemical analyses conducted on mussel tissues. Samples assigned to each specific pool were homogenized together prior to conducting analyses. Organic and inorganic analyses were conducted according to the procedures described for flounder or lobster chemical analyses (Section 2.1.7).

2.3.8 Data Reduction and Statistical Analyses

The extent of bioaccumulation of contaminants in blue mussels was evaluated, and compared to initial contaminant levels in control mussels. Evaluation focused on spatial and temporal trends in contaminant accumulation. Data were compared to mussel body burdens of contaminants in other studies, including the NOAA Status and Trends Mussel Watch monitoring program, and other available studies. The relationship(s) between biological condition and tissue contamination was also assessed.

2.3.9 Deviations from the CW/QAPP

There were no deviations from the CW/QAPP.

2.4 General Data Treatment and Reduction

This section describes data reduction performed on 1997 Fish and Shellfish data as part of the 1997 MWRA Harbor and Outfall Monitoring Project. Samples were analyzed for trace metals, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. Morphological data were collected for all samples and histopathology data were collected for flounder and lobster samples. Data were presented to ENSR from the analytical laboratories conducting the various analyses in both paper and electronic format.

All data were entered into the database in the required format. Laboratory replicate samples (samples that were diluted and run a second time if instrument detection levels were exceeded) were combined and treated as one sample. Duplicate samples were treated as a separate entry in the database. All analytical data entered into the database were in dry weight units.

For this document, all data for flounder and lobsters were retrieved from the MWRA Database for the years 1993-1997, and mussels for the years 1995-1997. Data from other years were obtained from reports as referenced in individual sections. Flounder and lobster data from the database were summarized into averages per station per analyte. All non-detects were treated as zero. Duplicate samples were averaged and the result treated as an individual sample. Standard error was calculated. Mussel data were summarized using the lowest detection limit value as a proxy for all non-detects.

Lipid normalized concentrations of tissue body burdens were determined for purposes of comparison with dry weight determination and as a part of the evaluation of monitoring hypotheses. Lipid normalized concentrations indicate how much of a chemical has accumulated in the lipids, or fatty tissues, of an organism. This parameter is significant because many chemicals, such as organic compounds, accumulate at a higher rate in the lipids of fish than into other tissue components. Therefore, lipid-normalized contaminant concentrations are often much higher than whole-tissue concentrations. The percentage of lipids in an organism is also important because the bioconcentration of certain organics depends on the content of lipids in an organism. An organism with a higher lipid content will bioaccumulate more of these organics than a fish with a smaller lipid content. Lipid normalized data were calculated for organic compounds using the following formula:

$$\text{Lipid normalized concentration} = \frac{\text{compound concentration (mass compound per mass dry weight)}}{\%\ \text{lipid}}$$

Percent lipids for all indicator species are presented in Table 2-4 (flounder), Table 2-5 (lobster) and Table 2-6 (mussel). Appendix B presents this information on a sample by sample basis.

Wet weight tissue body burdens for organics (used in comparison to FDA action levels) were calculated by multiplying the percentage dry weight of a sample with the analytical result for that sample. Data for inorganics were reported in both wet and dry weights, so no calculation was necessary.

Mussel morphology data were summarized by averaging the biological data reported for each group of mussels (i.e. data from mussels harvested from Gloucester and deployed at DIF were averaged together).

TABLE 2-1

Flounder Survey Collection Data

Station	Trawl Date	Start Time	End Time	Beginning Latitude (degrees)	Ending Latitude (degrees)	Beginning Longitude (degrees)	Ending Longitude (degrees)	Bottom Time (minutes)	Number of Fish >300 mm
Deer Island	4/7/97	1:34 PM	2:10 PM	42.35	42.34	70.97	70.98	35	4
Flats (DIF)	4/7/97	2:28 PM	3:30 PM	42.35	42.35	70.98	70.98	62	10
	4/7/97	3:55 PM	4:00 PM	42.35	42.35	70.97	70.97	5	2
	4/8/97	3:17 PM	4:04 PM	42.35	42.35	70.97	70.97	47	Lost net
							Total:	**149**	**16**
Nantasket Beach	4/8/97	11:47 AM	12:30 PM	42.29	42.28	70.86	70.86	43	15
(NB)	4/8/97	12:57 PM	2:09 PM	42.29	42.29	70.87	70.87	72	35
							Total:	**115**	**50**
Broad Sound	4/8/97	8:07 AM	9:10 AM	42.41	44.42	70.96	70.96	63	36
(BS)	4/8/97	9:33 AM	10:20 AM	42.41	44.41	70.97	70.96	47	29
							Total:	**110**	**65**
Future Outfall Site	4/7/97	9:14 AM	10:13 AM	42.39	42.39	70.83	70.83	59	29
(FOS)	4/7/97	10:42 AM	12:01 PM	42.39	44.39	70.83	70.83	79	83
							Total:	**138**	**112**
Eastern Cape Cod	5/13/97	11:22 AM	12:12 PM	41.96	42.93	70.12	70.15	50	8
Bay (ECCB)	5/13/97	12:25 PM	1:28 PM	41.94	41.98	70.12	70.12	63	31
	5/13/97	1:40 PM	3:08 PM	41.98	41.98	70.13	70.12	88	21
	5/13/97	3:26 PM	4:06 PM	41.98	41.62	70.12	70.12	40	18
							Total:	**241**	**78**
							Total (all):	**753**	**321**

November 9, 1998

TABLE 2-2

Chemistry Analyses for Fish and Shellfish Monitoring - 1997

Organism	Number/Type of Sample	Parameters
Flounder	9 / Fillet	Mercury Polychlorinated Biphenyls Chlorinated Pesticides Lipids
Flounder	9 / Liver	Trace metals Polychlorinated Biphenyls Polyaromatic Hydrocarbons Chlorinated Pesticides Lipids
Lobster	9 / Meat	Mercury Polychlorinated Biphenyls Chlorinated Pesticides Lipids
Lobster	9 / Hepatopancreas	Trace metals Polychlorinated Biphenyls Polyaromatic Hydrocarbons Chlorinated Pesticides Lipids
Mussel	20 / Soft tissue	Mercury Lead Polychlorinated Biphenyls Polyaromatic Hydrocarbons Chlorinated Pesticides Lipids

November 9, 1998

TABLE 2-3

Lobster Survey Collection Data

Station	Date	Start Time	End Time	Latitude (degrees)	Longitude (degrees)
Deer Island Flats	8/1/97	9:00 AM	10:00 AM	42.34	70.98
Future Outfall Site	8/1/97	11:30 AM	12:30 PM	42.39	70.79
Future Outfall Site	9/12/97	8:00 AM	10:00 AM	42.39	70.79
Eastern Cape Cod Bay	7/23/97	10:20 AM	11:20 AM	42.05	70.17

Table 2-4
Summary of Percent Lipid Content in Winter Flounder
1992-1997

Station/Fraction	1992			1993			1994			1995			1996			1997		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Deer Island Flats																		
Liver	13.0	74.0	32.7	34.0	34.0	34.0	75.1	98.5	86.0	25.7	44.9	33.0	20.2	28.3	23.7	11.2	15.0	13.2
Tissue	4.3	9.1	6.1	1.6	5.8	3.2	4.4	5.5	4.9	0.9	2.5	1.9	1.8	2.6	2.1	1.3	1.5	1.4
Future Outfall Site																		
Liver	19.9	52.4	28.1	22.6	22.6	22.6	31.4	37.4	34.8	20.6	25.0	23.2	21.4	27.2	24.2	14.0	16.3	14.8
Tissue	4.6	16.5	10.8	1.5	5.1	2.7	3.6	6.5	5.5	1.8	2.9	2.2	1.5	2.3	1.9	1.5	1.7	1.6
Eastern Cape Cod Bay																		
Liver	15.9	29.9	21.6	20.0	20.0	20.0	14.7	50.0	33.0	11.2	16.4	14.3	20.2	28.9	25.1	15.4	23.2	18.8
Tissue	1.8	5.7	3.6	1.5	4.8	3.0	3.5	6.5	5.4	2.2	2.8	2.5	2.0	2.6	2.3	1.0	2.3	1.5
Nantasket Beach																		
Liver	20.3	46.2	30.3	NA	NA	NA	34.2	41.8	38.3	NA	NA	NA	15.2	24.3	19.6	NA	NA	NA
Tissue	1.3	8.0	5.0	NA	NA	NA	3.4	6.2	5.0	NA	NA	NA	1.7	3.3	2.3	NA	NA	NA
Broad Sound																		
Liver	19.5	49.3	32.8	NA	NA	NA	33.9	104.1	64.0	NA	NA	NA	19.6	24.7	21.6	NA	NA	NA
Tissue	6.8	12.9	9.3	NA	NA	NA	3.8	6.1	5.0	NA	NA	NA	1.4	2.4	1.9	NA	NA	NA

NA - Not Applicable; Stations sampled in even-numbered years only.

Table 2-5
Summary of Percent Lipid Content in Lobster
1992-1997

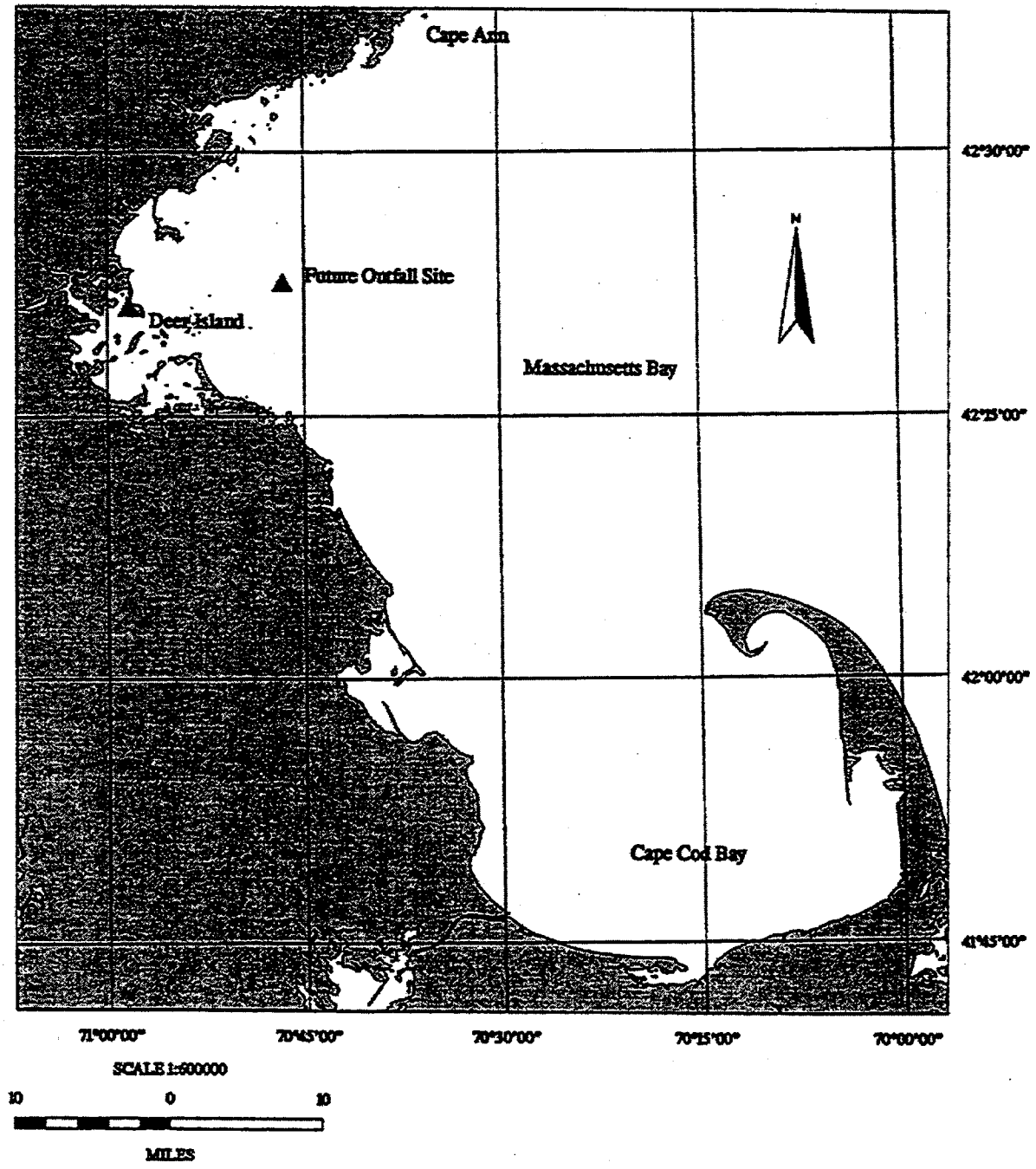
Station/Fraction	1992			1993			1994			1995			1996			1997		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Deer Island Flats																		
Hepatopancreas	65.8	73.7	68.6	34.3	55.8	41.8	67.5	72.4	70.5	55.9	70.8	63.7	49.5	60.1	56.3	44.5	56.5	49.1
Tissue	16.2	21.8	19.2	1.6	3.2	2.5	6.2	10.9	8.9	4.4	5.5	4.9	3.4	4.2	3.8	3.1	4.0	3.4
Future Outfall Site																		
Hepatopancreas	47.1	79.2	61.1	45.3	56.2	50.8	56.5	59.2	57.9	60.4	70.9	64.4	47.4	54.1	51.3	44.7	64.2	57.2
Tissue	12.6	14.8	13.9	3.5	3.8	3.7	9.4	13.4	11.4	3.3	5.2	4.3	3.3	3.4	3.3	3.2	3.6	3.4
Eastern Cape Cod Bay																		
Hepatopancreas	18.8	82.5	43.8	33.6	72.9	51.0	61.7	79.0	69.3	57.7	79.6	67.3	59.1	65.1	61.6	57.7	61.0	59.1
Tissue	8.3	26.9	16.3	0.4	7.6	4.2	4.8	5.0	4.9	4.4	5.1	4.7	3.0	3.3	3.2	3.0	3.5	3.3

Table 2-6
Summary of Percent Lipid Content in Blue Mussel
1992-1997

Station	1991			1992			1993			1994			1995			1996			1997		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Pre-deployment (Gloucester)	1.8	8.4	4.4	3.6	7.5	4.8	6.6	10.7	8.0	3.3	5.0	4.2	8.1	9.6	8.7	6.0	11.6	8.2	8.1	9.1	8.5
Aquarium	4.2	7.9	5.8	4.1	5.8	5.1	4.7	5.8	5.3	4.8	6.6	5.4	8.5	10.4	9.8	8.7	11.4	10.0	7.5	8.8	7.9
Deer Island Flats	2.1	4.5	3.3	3.6	7.5	5.1	4.9	9.2	6.5	4.4	5.2	5.0	10.2	11.9	11.2	9.0	16.6	13.8	7.8	9.7	8.9
Future Outfall Site	--	--	--	3.1	5.4	4.2	6.0	8.6	7.1	3.6	8.1	5.6	--	--	--	8.8	12.2	10.6	7.2	9.6	8.5

No mussels were collected at the Future Outfall Site in 1991.
No mussels were collected at the Future Outfall Site in 1995 due to an array loss.

Figure 2-1 Winter Flounder, Lobster and Mussel Sampling Locations



3.0 RESULTS AND DISCUSSIONS

The results of the three 1997 biomonitoring surveys are reported in this section. The results of the Flounder Survey are given in Section 3.1; the results of the Lobster Survey are given in Section 3.2; and the results of the Mussel Bioaccumulation Survey are presented in Section 3.3.

3.1 Winter Flounder

3.1.1 Fish Collected

Winter flounder, each a minimum 30 cm in length, were collected between April 4 and 13, 1997 at five stations in the study area. Fifty fish were collected at Nantasket Beach (NB) and Broad Sound (BS). Sixty-seven fish were collected from the Future Outfall Site (FOS) and Eastern Cape Cod Bay (ECCB). Sixteen were collected at Deer Island Flats (DIF). The catch per unit effort (CPU), defined as the number of fish obtained per minute of bottom trawling time, was highest at the FOS in 1997 (Table 3-1). The lowest CPU of 1997 was observed at DIF, as is true for many of the years of the fish biomonitoring study. The CPU was determined in order to make a relative comparison of catch efficiency between years.

3.1.2 Age/Length Parameters

The physical characteristics (i.e., mean age, length, weight) of the winter founder collected in 1997 are given in Table 3-2, and the inter-annual trends for mean length and age at the five stations are depicted in Figures 3-1a through 3-1e. The total length and weights were comparable for all stations in 1997; there was less than 5% difference between average station values for length and less than 15% difference between average station values for weight. The average age at BS (4.1 years) was significantly lower than at the FOS (4.5 years) or at ECCB (4.5 years). As shown in Figures 3-1b, 3-1c, and 3-1e, the mean ages of NB, BS, and ECCB flounder increased slightly in 1997 as compared to previous years. At DIF and the FOS, the age declined slightly in 1997 (Figures 3-1a, 3-1d). Mean fish length varied little between years at most stations and generally reflects the minimum size requirement (i.e., minimum 30 cm required for the study).

3.1.3 External Condition

The physical characteristics and external conditions (i.e., fin erosion, gross abnormalities) of winter flounder collected in 1997 are presented as averages per station in Table 3-2. As described in Section 2.1.1, each of the individual winter flounder collected were assessed for external conditions, and rated on a scale of 0 to 4 (no units), with 0 indicating the absence of the condition, and 4 indicating extreme abnormalities (or erosion). As shown in Table 3-2, only a few fish at each station exhibited gross physical abnormalities. Fin erosion varied between station (0.1 to 0.7). Fin erosion at ECCB was significantly lower than at all other stations. Fin erosion at the FOS was significantly higher than at BS, NB, and ECCB. This amount of fin erosion would be considered in

the low end of the range (Murchelano, 1975) and, with respect to the DIF station, apparently well below the fin erosion observed (but not quantified) in the later 1980's (pers. obs. M. Moore).

3.1.4 Inter-station Comparison of Lesion Prevalence

The prevalence of histological changes in winter flounder liver from the 1997 survey is shown in Table 3-3. Neoplasia was absent from all flounder collected. Fish from DIF and BS showed the greatest prevalence of the chemically-associated lesion hydropic vacuolation (i.e., focal, tubular, and centrotubular hydropic vacuolation). Other lesions that were recorded include macrophage aggregation, and biliary, hepatocytic and pancreatic lesions. These lesions did not show a trend that related to the apparent gradient of chemical contamination. They may be part of an undescribed series of pathological process or processes in these fish. The balloon cells appeared much as described previously (Hillman *et al.*, 1994; Hillman and Peven, 1995). They are probably apoptotic cells (i.e., cells that are dying from any of a number of causes).

3.1.5 Temporal Comparison of Lesion Prevalence

The prevalence of toxic chemical-associated liver lesions in winter flounder from DIF was noted by Murchelano and Wolke (1985) in a 1984 study. Annual monitoring of the lesions in winter flounder from Boston Harbor has been ongoing since 1987 (Moore, 1991; Moore *et al.*, 1992; Moore and Stegeman, 1993; Hillman *et al.*, 1994). Four additional locations in Massachusetts Bay and ECCB were added in 1991 (Moore *et al.*, 1992). These studies have provided an internally consistent baseline data set on winter flounder liver pathology for the DIF and FOS, in addition to other sites in the region. This has been critical because of the historic Deer Island outfall's apparent biological effects, such as the hepatocellular hydropic vacuolation and other toxicopathic lesions, and the need to understand and document possible changes in biological impact on this ecosystem from recent and projected changes in sewage management by the MWRA. These changes include cessation of ocean dumping of sludge in December 1991, initiation of primary and planned secondary treatment, and the relocation of the effluent outfall to the future site, now scheduled to occur in 1999.

The rationale and necessary background information on the biology and toxicology of winter flounder have been reported previously (Moore *et al.*, 1992; Moore and Stegeman, 1993; Hillman *et al.*, 1994, Moore *et al.*, 1996). In these previous studies, hydropic vacuolation in the liver of winter flounder was detectable at all stations sampled, but was substantially more prevalent at the contaminated near-urban sites. Moore (1991) has shown a close association between hydropic vacuolation and liver neoplasms in winter flounder, and Johnson *et al.* (1992) and Moore *et al.* (1996) have demonstrated that hydropic vacuolation was closely correlated with a suite of chemical contaminants, particularly chlorinated hydrocarbons. Hydropic vacuolation can be regarded as a harbinger of neoplastic risk, given adequate duration and level of exposure to carcinogens. Hydropic vacuolation appears to be an irreversible change. This is in distinct contrast to hydropic degeneration. The irreversibility of the former was shown convincingly when flounder from DIF were maintained for 5 months on clean water and clean food, with no reduction in vacuolation prevalence over that time (Moore *et al.*, 1996). Therefore, given age-specific analysis and between-year consistency in histopathological interpretation, observation of the prevalence of hydropic vacuolation is an appropriate long-term monitoring parameter for the effects of benthic

contaminants on winter flounder in the Boston Harbor/Massachusetts Bay area. Thus, hydropic vacuolation is one of the principal lesions emphasized in this report.

As in previous years, lesion prevalence is associated with age, length, and years of analysis. Previous Spearman Rank analyses have shown a significant decrease in lesion prevalence within recent years at DIF (MWRA, 1997).

Neoplasm prevalence in winter flounder from DIF has fallen from a persistently elevated level in the 1980's to zero or near-zero levels in the last five years of this study. This trend has been accompanied by a reduction in the prevalence of the three stages of hydropic vacuolation. These temporal trends are summarized in Figures 3-1a through 3-1e.

3.1.6 Relationships Between Age, Length and Lesion Prevalence

As in previous years, age and length is also associated with lesion prevalence, but the age/length distribution is adequately comparable between stations to make spatial comparisons valid. Figure 3-2a illustrates the relationship with age at the DIF study area, in fish spawned from 1980 through 1992. The lines in the figure represent the prevalence of lesions in successive years for a specific age class year. As can be seen, there is a general tendency for increase over years. This tendency was previously discussed in the 1996 Annual Fish and Shellfish Report (Mitchell *et al.*, 1997). One of the potential confounding factors for this type of analysis is the widely-varying number of samples collected between years. Figure 3-2b compares the severity of centrotubular hydropic vacuolation between years and stations.

3.1.7 Spatial Comparison of Tissue Contaminant Levels

The patterns of tissue contaminant levels (i.e., body burdens) were examined for winter flounder collected in the 1997 survey. The mean tissue contaminant levels for winter flounder are given in Table 3-4 as unit of mass contaminant per mass dry weight, and as unit of mass contaminant per mass lipid weight in Table 3-5. The two tissue types of concern were edible tissue (fillets) and liver tissue. Dry weight results for fillet are presented in Figure 3-3, while those for flounder liver are shown in Figures 3-4 and 3-5. Lipid normalized results for contaminants in fillet are shown in Figure 3-6a, and those for liver are shown in Figure 3-6b. The associated lines on the bar graphs represent one standard error.

3.1.7.1 Edible Tissue

The levels of target analytes in winter flounder fillet (total DDT, dieldrin, total chlordane, total PCBs, and mercury from the three survey sites where contaminant analyses were performed in 1997 (DIF, FOS, ECCB) are shown in Figure 3-3 on a dry weight basis. Lipid normalized fillet concentrations of total DDT and total PCBs are presented in Figure 3-6a.

Comparisons of the 1997 mean dry weight concentrations of organic compounds in fillets across the study area indicate that chlordane, total DDT, dieldrin, and PCBs were lowest in ECCB flounder. DIF flounder fillets

consistently contained the highest concentrations of these four organics. In 1997, lipid normalized concentrations of total DDT and PCBs were highest at DIF and lowest at ECCB.

Concentrations of mercury (dry weight) in 1997 followed the same trend as the organics, with the highest concentration in DIF fillets, and the lowest at ECCB.

3.1.7.2 Liver

The levels of organic target analytes (total DDT, dieldrin, total chlordane, total PCBs, total PAHs) on a dry weight basis in winter flounder liver from the 1997 survey are shown in Figure 3-4. Lipid normalized concentrations of total DDT, total PCBs, and total PAHs are shown in Figure 3-6b. As with the edible tissues, an inter-station comparison of dry weight concentrations of organic compounds in flounder livers indicates that the highest mean tissue concentrations of organics were consistently found at DIF, while the lowest occurred in ECCB flounder. Total DDT, total PAH, and total PCB lipid normalized concentrations were highest in 1997 at DIF and lowest at ECCB.

The levels of inorganic target analytes (Ag, Cr, Cu, Hg, Ni, Pb, Zn) on a dry weight basis in winter flounder liver from the 1997 survey are shown in Figure 3-4 and Figure 3-5. An inter-station comparison of inorganics indicates that the distribution of metals did not follow the gradient of tissue burdens established by the organic contaminants. For example, lead, silver, and zinc were highest at the FOS in 1997. Nickel and copper were highest at the ECCB station, while chromium was highest at DIF. Levels of mercury in winter flounder liver were comparable in DIF flounder and in FOS flounder, and slightly lower in ECCB flounder.

3.1.8 Temporal Comparison of Contaminant Levels

The temporal or inter-annual variation of tissue contaminant levels was examined for winter flounder collected from 1992 to 1997 surveys. The data, grouped by sampling station, includes contaminant levels for flounder filet (Figure 3-3, Figure 3-6a) and liver (Figure 3-4, 3-5, 3-6b) on both dry weight and lipid-normalized bases.

3.1.8.1 Edible Tissue

Annual tissue concentrations of organic compounds from 1992 to 1997 were analyzed in winter flounder collected from DIF, the FOS, and ECCB, and at NB and BS in 1992, 1994, and 1996 (Figure 3-3). At DIF, dry weight concentrations of total PCBs total chlordane, total DDT, and dieldrin were all within the range of previously recorded values (1992- 1996). Similarly, dry weight concentrations of these four organics at the FOS and at ECCB fell within the 1992 to 1996 range. The lipid normalized concentrations of total PCBs and total DDT in 1997 were higher than those in 1996 for the three 1997 study areas (DIF, FOS, ECCB).

Mercury was assessed on a dry weight basis in flounder fillets collected in 1997 from these three stations. The concentration of mercury at DIF was the highest of the record period, increasing by 11% from the 1996 value.

The concentration of mercury at the FOS was the lowest of the record period, decreasing from the 1996 value by 50%. Mercury concentrations at ECCB were within the range of previously recorded values (1992-1996).

3.1.8.2 Liver

Annual tissue concentrations of organic compounds in flounder livers from 1992 to 1997 were measured for DIF, the FOS, and ECCB winter flounder, and for NB and BS in 1992, 1994, and 1996 (Figures 3-4, 3-5). Mean dry weight concentrations of total chlordane, total DDT, dieldrin, total PAHs, and total PCBs in 1997 flounder sampled throughout the study area were generally within the range of the previous years (1992-1996). [Note: the 1992 flounder liver PAH values are considered suspect due to potential contamination introduced at the time of dissection and were deleted from consideration. The 1993 PAHs were also anomolously high, but sufficient uncertainty remains as to the cause. To be conservative, these data were retained in the analyses.]

At DIF, concentrations of all five of the above mentioned organics were within the range previously measured. FOS concentrations of total DDT, dieldrin, total PCBs, and total PAHs were within the range previously measured. The concentration of total chlordane was slightly below the range previously measured. At ECCB, total chlordane, total PCBs, and total PAHs were within the range previously measured. Levels of dieldrin and total DDT were elevated from previous years. The lipid normalized concentrations of total DDT and total PCBs at DIF, the FOS, and ECCB were higher in 1997 than in 1996. Lipid normalized concentrations of total PAHs were higher in 1997 than 1996 at DIF, but lower in 1997 at the FOS and ECCB.

Dry weight tissue concentrations of inorganics in livers were also measured at these three stations in 1997. At DIF, mean flounder liver concentrations of chromium, copper, mercury, nickel, and silver were within the range of recorded values (1992-1996). Concentrations of lead and zinc in 1997 were the highest of the record period (1992-1997). Both constituents increased by approximately 45% from the 1996 value.

At the FOS, mercury concentrations (dry weight) in 1997 were the lowest of record (1992-1997). Chromium, copper, lead, nickel, silver, and zinc were within the range previously measured (1992-1996).

At ECCB, flounder liver mean concentrations (dry weight) of silver and chromium increased over the 1996 mean values, and were the highest of the record period (1992-1997). The liver tissue means of copper, lead, mercury, nickel and zinc were within the previously observed range (1992-1996).

3.1.9 Relationship of Contaminant Levels to Histopathology

The relationship between tissue contaminants and indices of histopathological effects was investigated. This relationship provides the linkage between changes in chemical bioavailability and human seafood consumption risk, as indicated by fish body burdens, and potential eco-toxicological impacts, as indicated by fish histopathology. It also tests how one set of measures might predict the other. The prevalence of hydropic vacuolation was compared with chemical contaminant concentrations in fish collected from monitoring stations. Comparable analyses for samples analyzed in 1992, for instance, have shown significant correlations with

halogenated organic compounds such as the DDT and chlordane groups (Moore *et al.*, 1996). Organic contaminant and histology data were compared between all stations for the years 1992-1996 (Moore *et al.*, 1992; Shea, 1993; Hillman *et al.*, 1994; Hillman and Peven, 1995).

These relationships are illustrated in Figures 3-7a to 3-7e for fillet tissue concentrations of selected organic compounds and mercury; and in Figures 3-8a through 3-8c for liver tissue concentrations of selected organic compounds. Each data point in each figure compares a specific chemical or group of chemicals in either the liver or fillet, with the prevalence of hydropic vacuolation at the same station in the same year. Examination of these plots reveals a persistent relationship for total PCBs, chlordanes and DDTs, which support the notion that tissue burden data are reasonable predictors for histopathological results of these compound classes. The data for 1997 fall within the scatter for previous years, suggesting that a representative baseline has been generated for the period 1991 to 1997.

3.1.10 Relationship of Contaminant Levels to FDA Legal Limits

Comparison was made between tissue contaminant levels and regulatory action limits. The U.S. Food and Drug Administration (FDA) has set legal limits for the maximum tissue concentrations of specific organic compounds and pesticides in the edible portions of fish and fishery products. For the MWRA biomonitoring program, Caution Levels are set at 50% of FDA Limits, and Warning Levels are set at 80% of FDA Limits (MWRA 1997). Caution and Warning Levels apply to the FOS only. These three levels provide reference benchmarks for detecting adverse changes (and their potential human health risks) once the new outfall is on line. The 1997 mean concentrations of target analytes per station were compared to the FDA's Legal Limits and are presented in Table 3-6. No exceedances of any of the three benchmarks was noted in 1997.

The available historical data as well as data gathered during this program (1992-1997), were compared to the FDA Legal Limits for mercury and PCBs in FOS flounder in Figure 3-9a, and for DIF flounder in Figure 3-9b. Note that the concentrations in these figures are expressed as mass contaminants per mass wet weight. As both Table 3-6 and Figure 3-9a and 3-9b indicate, the tissue concentrations in winter flounder edible tissues are well below the federal legal limit for fish and shellfish.

3.2 Northern Lobster

3.2.1 Lobster Collected

The 1997 lobster survey was conducted according to the CW/QAPP (Mitchell *et al.*, 1997) with lobster trap lines placed at the station target spatial coordinates. At the FOS , all 15 legal-sized non-berried lobsters were obtained from the survey traps, while two legal-sized non-berried lobsters were obtained at the ECCB, and five were obtained at DIF. The remaining 13 lobsters for ECCB were purchased from Cape Tip Fisheries, and the remaining 10 lobsters from DIF were purchased from a local lobsterman. All purchased lobsters were from traps set in the general area of the stations.

3.2.2 Size, Sex, and External Conditions

The size, sex and external conditions (i.e., black gill disease, shell erosion, parasites, external tumors, etc.) were determined for the lobsters collected in the 1997 survey. The mean length and weight of lobsters collected in 1997 are presented in Table 3-7.

As shown in Table 3-7, little difference in lobster length or weight was observed between the three sampling sites. Although the ratio of males to females was about equal at ECCB, two times more males than females were trapped at the FOS, and 14 of the 15 lobsters collected at DIF were male.

Table 3-8 presents the average values for general external observations made for the 15 lobsters collected at each station in the 1997 survey. No deleterious external conditions were noted in any of the lobsters collected.

3.2.3 Spatial Comparison of Tissue Contaminant Levels

A summary of the lobster mean tissue contaminant levels by station is presented in Table 3-9 in units of mass contaminant per mass dry weight, and in Table 3-10 in units of mass contaminant per mass lipid weight (i.e., lipid-normalized concentration). The spatial pattern of tissue contaminant levels in lobsters collected during the 1997 survey was examined. Figure 3-10 presents a graphic picture of the spatial and temporal trends in lobster edible tissue concentrations (dry weight) of selected organic compounds and mercury on a station-by-station basis. Figure 3-11 shows annual concentrations (dry weight) of target organic analytes and mercury in lobster hepatopancreas tissues, and Figure 3-12 portrays changes in hepatopancreas metals concentrations (dry weight). Figure 3-13a presents lipid normalized concentrations of organics in lobster meat, and Figure 3-13b presents lipid normalized concentrations of organics in lobster hepatopancreas. Each of the figures show data from 1992 to 1997 surveys, grouped according to sampling station. The associated line represents one standard error. If no line is shown, then sample size was insufficient (i.e., <3) to calculate the standard error.

3.2.3.1 Edible Tissue

The spatial pattern of tissue contaminant levels (dry weight) of organic compounds in edible tissue was similar between stations for lobsters collected during the 1997 survey (Figure 3-10, Table 3-9). Dry weight concentrations of most organic compounds were lowest in lobsters collected in ECCB and highest in lobsters collected at DIF. Several pesticides, however, exhibited a different trend. The highest dry weight concentration of hexachlorobenzene (Table 3-9) were found at the FOS, the lowest being found at DIF. Aldrin (Table 3-9) was detected in ECCB lobster meat only. Lipid normalized concentrations of total DDT and total PCBs in lobster meat were greatest at DIF and lowest at ECCB (Figure 3-13a).

Mean mercury concentrations followed the trend of the organics, being highest in DIF lobsters and lowest in ECCB lobsters in 1997.

3.2.3.2 Hepatopancreas

The spatial pattern of tissue contaminant levels of organic compounds (dry weight) in lobster hepatopancreas was similar to that found in the edible tissues (Figures 3-11, 3-12) with one notable exception. The 1997 dry weight hepatopancreas concentrations were generally lowest in lobsters collected in ECCB and highest in lobsters collected at DIF. Dry weight concentrations of dieldrin, hexachlorobenzene, and mirex in lobster hepatopancreas were highest at the FOS and lowest in ECCB, with the exception of hexachlorobenzene, which was lowest at DIF. An anomaly occurred in the concentration of PAHs in ECCB lobster hepatopancreas in that levels were extremely elevated. The mean reported dry weight concentration was approximately 170,000 parts per billion, as opposed to approximately 800 parts per billion in 1996, the previous highest measurement of record. These results are several times those measured in lobster from the Bays during the OHM monitoring. This is especially anamalous in that all other monitoring years, lobsters from this site have consistently had the lowest hepatopancreas PAH levels measured. Thus, the 1997 value is considered to be anomalous. The reason for this anomaly is not known, but does not seem to be due to analytical artifact (i.e., value confirmed by analytical lab – ADL), all three ECCB composite samples were elevated, and PAH levels for lobsters from DIF and FOS were not anomolous (i.e., both slightly declined from previous year). Since the majority of lobsters at ECCB were purchased it is possible that the high PAHs are due to possible contamination of the lobsters during handling and storage. Due to the uncertainty regarding the history of these specimens, the 1997 results from this station were excluded from further analysis. Lipid normalized concentrations of total DDT, total PAHs, and total PCBs for lobster hepatopancreas in 1997 were consistently highest at DIF and lowest at ECCB (Figure 3-13b), with the exception of the apparent anomaly in the PAH concentration at ECCB.

The highest dry weight concentrations of metals in lobster hepatopancreas were seen at DIF for silver, chromium, and copper, the FOS for lead, mercury, and zinc, and ECCB for cadmium and nickel. The lowest concentrations of metals in lobster hepatopancreas tissues were usually seen at ECCB (copper, lead, silver, zinc) or DIF (cadmium, mercury, nickel).

3.2.3.3 Lobster Migration

Each year, a similar contaminant gradient is found, with highest concentrations generally found at DIF, and the lowest generally found at ECCB, indicating either that lobsters are not migrating between the three stations, or that contaminants in lobsters are quickly equilibrated. The following provides information on migration patterns in lobsters to help address this issue.

Adult lobsters exhibit a wide range of movement patterns, perhaps related to seasonal temperature configurations. Understanding of the scale of movement of adults comes principally from mark-capture studies, which have inherent biases (Lawton and Lavalli, 1995). Early studies carried out in inshore areas indicated that the majority of lobsters did not travel more than about 5 kilometers (e.g., Wilder, 1963; Cooper *et al.*, 1975;, Lawton *et al.*, 1984). However, tagging studies on offshore lobsters indicated that as much as 40% of the population, primarily the larger, sexually mature individuals, annually migrate shoalward in the spring and summer, and return offshore in the fall and winter (Cooper and Uzmann, 1971; Cooper *et al.*, 1977; Fogarty *et al.*, 1980; Pezzack *et al.*, 1992).

Studies on inshore populations on the ocean side of Cape Cod also demonstrated the presence of highly mobile lobsters, primarily large berried females (Estrella and Morrissey, 1997). Adult inshore females apparently move to deeper water earlier in the fall than do males (Campbell and Stasko, 1986; Robichaud and Campbell, 1991; Roddick and Miller, 1992). Seasonal migration of ovigerous females into deeper water in the fall and shallower water in the spring and summer is perhaps related to maximizing the temperature regime to which the eggs are exposed (Cooper and Uzmann, 1971).

There is also evidence for a strong homing mechanism, in which animals return to within a few kilometers of their original starting point during a return migration or return from displacement (Lawton and Lavalli, 1995). In several instances, lobsters that were taken in offshore waters, then tagged and released in inshore areas, were recaptured near their original sites of capture (Saila and Flowers, 1968; Fogarty *et al.*, 1980; Pezzack and Duggan, 1986).

Based on the above information, it is reasonable to conclude that, while lobsters may migrate over distances, they eventually return to their original point of departure. Therefore, lobsters caught at a particular station are likely to have been at that station in the past, even if they migrated away during certain times of the year This unconfirmed pattern may contribute to the similar contaminant gradient seen in the MWRA program each year.

3.2.4 Temporal Comparison of Tissue Contaminant Levels

The temporal trends of tissue contaminants (dry weight) in lobster edible tissue and hepatopancreas are shown in Figures 3-10 through 3-12. Figures 3-13a and 3-13b present temporal trends in lobster edible tissue and hepatopancreas normalized for lipid weight .

3.2.4.1 Edible Tissues

In 1997, dry weight concentrations of organic compounds in lobster edible tissues from ECCB were consistently higher than concentrations measured in 1996. Dry weight concentrations in DIF lobster edible tissues were higher in 1997 than 1996 for the organic compounds, with the exception of dieldrin, which was lower in 1997 than in 1996. At the FOS, dry weight concentrations of DDT and PCBs were higher than those measured in 1996, while dry weight concentrations of chlordane and dieldrin were lower than the 1996 levels. Lipid normalized concentrations in 1997 were greater than 1996 at all stations. The lipid normalized concentrations at DIF and FOS were the greatest of the record period (1992-1997) for both DDT and PCBs.

Dry weight concentrations of mercury increased from 1996 to 1997 by 71% in the edible tissues of lobsters collected at DIF. The mean concentration of mercury in lobsters of the FOS increased slightly from the 1996 value, and was the greatest of the record period (1992-1997). The mean concentration of mercury in lobsters at ECCB increased slightly over the 1996 value, and was the highest of record (1992-1997).

3.2.4.2 Hepatopancreas

Dry weight concentrations of organic compounds in lobster throughout the study area were generally observed to be within the range of values observed from 1992 to 1996. At DIF, lobster hepatopancreas dry weight concentrations of chlordane, total DDT, dieldrin, total PAHs, and total PCBs decreased from the 1996 values by 2% (PCBs) to 64% (dieldrin).

At the FOS, the mean dry weight concentrations of total chlordane, total PAH, dieldrin and total PCBs decreased from the 1996 values by 11% (PCBs) to 65% (dieldrin). Dry weight concentrations of total DDT in lobster hepatopancreas increased slightly (6%) over the 1996 value.

Mean dry weight concentrations of chlordane, dieldrin, and total PCBs at ECCB were generally within the range of values observed from 1992 to 1996. The mean concentration of total DDT increased slightly (6%) from 1996 to 1997. As noted earlier, the measured concentration of PAH in lobster hepatopancreas in 1997 is believed to be an anomaly and not a true reflection of conditions at ECCB.

The lipid normalized concentrations of total DDT in the hepatopancreas of lobsters at DIF and ECCB increased from 1996 to 1997 but were slightly reduced at FOS. Lipid normalized concentrations of total PAH decreased from 1996 values at DIF and the FOS. The lipid normalized concentrations of PCBs increased from 1996 values at DIF and ECCB, and decreased at the FOS.

Mean dry weight concentrations of inorganics in lobster hepatopancreas tissues were within the range of values observed from 1992 to 1996. At DIF, the mean tissue concentrations of copper, chromium, lead, mercury, nickel, and zinc increased over the 1996 values. Silver decreased from the 1996 value by 80%.

At the FOS, mean dry weight concentrations of copper, chromium, lead, mercury, nickel, silver and zinc were all within the range of the 1992 to 1996 values. Concentrations of, chromium, copper, nickel, mercury, and zinc increased slightly over the 1996 values, while concentrations of lead and silver decreased slightly from the 1996 values.

At the ECCB station, mean dry weight concentrations of copper, chromium, lead, mercury, nickel, silver and zinc were all within the range of the 1992 to 1996 values. Concentrations of, chromium, copper, nickel, mercury, and zinc increased over the 1996 values, while concentrations of lead and silver decreased slightly from the 1996 values. Note that this trend is the same as that found at the FOS.

3.2.5 Relationship of Contaminant Levels to FDA Legal Limits

The U.S. Food and Drug Administration has set legal limits for maximum concentrations of numerous organic compounds and mercury in the edible portions of fish and fishery products (U.S. EPA, 1989). These organic compounds include: total PCBs (2.0 ppm); aldrin/dieldrin (0.3 ppm); chlordane (0.3 ppm); DDT (5.0 ppm); DDE (5.0 ppm); DDD (5.0 ppm); DDI (5.0 ppm); endrin (0.3 ppm); heptachlor/ heptachlor-epoxide (0.3 ppm); kepone

(0.3-0.4 ppm); mirex (0.1 ppm); and toxaphene (5.0 ppm). For the MWRA biomonitoring program, Caution Levels are set at 50% of FDA Limits, and Warning Levels are set at 80% of FDA Limits (MWRA 1997). Caution and Warning Levels apply to the FOS only. These three levels provide reference benchmarks for detecting adverse changes (and their potential human health risks) once the new outfall is on line.

Table 3-11 compares the mean wet weight concentrations of these organic compounds and mercury in lobster edible tissues collected throughout the study area in 1997 to the applicable FDA Legal Limits. As the table indicates, all organic tissue contaminant levels were far below all applicable benchmarks, normally by 2 or more orders of magnitude. Mercury levels in lobster were also well below the three benchmark levels. The annual trends in the tissue concentrations for lobster from FOS are shown in Figure 3-14a, and for DIF in Figure 3-14b. These figure indicates that concentrations of PCBs and mercury in edible meat tissues are below concern. However, concentrations of PCBs in hepatopancreas slightly exceed the FDA legal limits at one of the sites (i.e., DIF) but not at other survey sites. This potential concern is consistent with the current MA State Advisory regarding consumption of lobster tomalley (i.e., hepatopancreas) for lobsters caught in Massachusetts waters.

3.3 Blue Mussel

3.3.1 Mussels Collected

The final mussel retrieval for 1997 was conducted on August 26, 1997 (60 days after deployment). Mussels were retrieved from DIF (Station 1, in Boston Harbor), the FOS (Station 4), and the *Discovery* (Station 6, a vessel at the New England Aquarium). Further details on mussel retrieval and cage condition are given in Section 2.3.4. The mussels/arrays deployed and recovered at each sampling location are quantified in Table 3-12.

3.3.2 Biological Condition Indices

As part of the 1997 Mussel Bioaccumulation Survey, data were collected on the survival, sexual maturity, size, and weights for pre-deployment and recovered mussels. The results of survival and sexual maturity analyses of the mussels retrieved at each station are summarized in Table 3-13.

3.3.2.1 Survival

As shown in Table 3-13, the percent survival observed in the cages was high (i.e., ≥78%) for both the forty- and sixty day harvested mussels. Survival at the forty-day harvest of the mussels was 95 to 100 percent for the Gloucester mussels, and 95 to 100 percent for the Sandwich mussels. Survival at 60 days was 86 to 98 percent for Gloucester mussels and 78 to 96 percent for the Sandwich mussels. The poorest survival rate (78 percent) was for Sandwich mussels at the *Discovery*.

3.3.2.2 Sexual Maturity

A representative sample of randomly selected mussels was examined from five locations (Gloucester pre-deployment, Sandwich pre-deployment, DIF, the FOS, and *Discovery*) to determine the sex ratio and stage of gametogenesis of mussels (Table 3-13). Sex was determined visually following methods described by Downey *et al.* (1995). The female gonads generally appear orange, while the males are more yellow in color.

Of the 30 pre-deployment mussels from Gloucester which were examined in June, 14 of 17 females collected were mature and 3 were immature. Three of the 13 males collected were mature and 10 were immature. The proportion of mature females in the Gloucester pre-deployment mussels is consistent with observations made earlier in this study (i.e., 1991-95 surveys). After 60 days of deployment, 30 mussels were examined from DIF and the FOS, and 17 mussels were examined from the *Discovery*. At DIF 16 mussels were female (11 mature and 5 immature) and 13 were male (12 mature and 1 immature). At FOS 17 mussels were male (15 mature and 2 immature). Of the 13 female mussels, 11 were mature and 2 were immature. At the Discovery, 15 mussels were female (12 mature and 3 immature) and 13 were male (10 mature and 3 immature).

Ten pre-deployment mussels from Sandwich, MA were also examined in June. Two were immature females, 3 were immature males, and 5 were mature males. After 60 days of deployment, five mussels were examined from each of the three sites. At DIF, there were three mature females and two mature males. At the FOS, there were 5 mature females.. At the Discovery, 1 mature female, 2 immature females and 2 mature males were found.

3.3.2.3 Growth and Condition

The size and growth of the mussels at the various stations were statistically analyzed using a two sample t-test assuming equal variances, using Microsoft Excel® . Table 3-14 presents mean shell length and wet weights of mussels collected from each station. Mean shell length in Gloucester pre-deployment mussels was 64.2 mm. Mean shell length increased in these mussels deployed at DIF (64.4 mm), at the *Discovery* (64.5 mm), and at the FOS (66.2 mm); these observed changes were not statistically significant ($P>0.05$). The mean shell length of DIF, *Discovery*, and FOS mussels were not significantly different from each other ($P>0.05$). Mean wet weight of Gloucester pre-deployment mussels was 16.0 g. Mean wet weights of the shells in these organisms increased at DIF (16.1 g) and at the FOS (16.2 g). The mean shell wet weight decreased in mussels deployed at the *Discovery* (15.8 g). None of these changes were found to be significant ($P>0.05$).

The mean shell length of Sandwich mussels before deployment was 64.4 mm. This value increased in Sandwich mussels deployed at DIF (65.6 mm), the FOS (67.16), and the *Discovery* (67.7 mm). Mean shell weight in Sandwich pre-deployed mussels was13.5 g. Mean shell weights increased from this value at DIF (14.6 g), at the FOS (14.5 g), and at the *Discovery* (14.9 g). These changes were not statistically significant.

The mean non-gonadal soft tissue wet weights of DIF (6.5 g) and FOS (7.4 g) were significantly different ($P<0.05$) from the Gloucester pre-deployment mussels (5.2 g) ($P<0.05$). Mean non-gonadal weights in Discovery

deployed mussels increased to 5.4 g. However, this difference was not significant (P>0.05). The mean gonadal weights of mussels deployed at the three sites were found to differ from each other significantly (P<0.05).

The mean non-gonadal wet weights of Sandwich mussels deployed at DIF (5.2 g) and the FOS (6.1 g) were not significantly different from Sandwich pre-deployment non-gonadal weights (5.5 g) (P>0.05). The mean non-gonadal wet weight of mussels deployed at the *Discovery* decreased to 4.2 g. This decrease was statistically significant (P<0.05). The mean non-gonadal wet weights of *Discovery* deployed and FOS deployed mussels were statistically different from each other (P<0.05).

3.3.3 Spatial Comparison of Tissue Contaminant Levels

The differences in mussel tissue contaminant levels were examined across the various sampling and deployment locations. For purposes of comparison with historical data (Downey et al., 1992; 1993; Downey, 1994a; 1994b; Downey et al., 1995; Mitchell et al., 1996) detection limits were treated as measured values for those compounds reported by ADL/ENSR as not detected. This would likely tend to overestimate actual tissue concentrations.

3.3.3.1 PAH Compounds

The compound list of Low Molecular Weight PAHs (LMW-PAH) (defined as those target 2 and 3 ringed compounds) and High Molecular Weight PAHs (HMW-PAH) (defined as 4, 5 and 6 ringed target compounds) analyzed from 1995 through 1997 differed from the analyses conducted from 1987-1994 (Table 3-15). In order to examine trends in body burdens of mussels harvested with previous studies, the total PAHs (t-PAH), LMW-PAHs, and the HMW-PAHs, were calculated three ways. The sums of LMW-PAHs and HMW-PAHs were calculated by adding all of the LMW- or HMW-PAHs listed in Table 3-16, respectively.

The total NOAA polynuclear aromatic hydrocarbons (PAH's) were calculated to include both an expanded group of analytes and the target compounds used in the Mussel Watch program by NOAA. For comparability purposes with historical data, a " historic NOAA" list of compounds (Table 3-15) was used to calculate body burdens and to discern any apparent spatial and/or temporal trends at the stations. The total historic PAHs (including the total historic LMW-PAHs and the total historic HMW-PAHs) differ from the total NOAA PAHs by the exclusion of C1-, C2-, and C3-Naphthalenes but do include the target list commonly referred to as NOAA analytes.

The "historic NOAA" data are reported at individual sample specific reporting levels when not detected. In previous (1991-1994) years, project specific individual analyte reporting concentrations of 5 μg/kg dry weight were used regardless of whether lower PQLs were obtained. In general, these differences in 1996 and 1997 reporting conventions tend to slightly lower the LMW, HMW and total PAH body burden values compared to the 1991-1994 analyses. In 1995 the analytical reporting levels were higher than either of the 1996-1997 or 1991-1994 reporting levels, averaging around 8 μg/kg dry for individual PAHs. The effect of the higher 1995 detection levels was to inflate LMW-, HMW-, and t-PAH body burden estimates during that year. Also, the 'historic

NOAA' body burdens included the C1-, C2-, C3- methylnaphthalenes due to different analytical methodologies employed further contributing to inflated 1995 body burden averages.

The 1997 average body burdens of historic NOAA Low Molecular Weight (LMW) PAHs were the highest in mussels deployed at Discovery (148 μg/kg dry) ($P<0.05$) (Table 3-17; Figure 3-15). DIF deployed mussels average body burdens (85 μg/kg dry), Gloucester pre-deployment (68 μg/kg dry) average mussel body burdens and FOS average mussel body burdens (58 μg/kg dry) were not significantly differed from one another ($P>0.05$) (Table 3-17; Figure 3-15).

Many of the individual LMW-PAHs were below reportable tissue concentrations in the Gloucester pre-deployment mussels. Naphthalene, phenanthrene, and 2-methylnaphthalene were found in pre-deployment mussel tissue concentrations of 14 μg/kg, 12 μg/kg and 13 μg/kg, respectively. The 2-methylnaphthalene body burdens in DIF, FOS and *Discovery* deployed mussels were comparable among these three stations but numerically lower than pre-deployment mussel body burdens.

The *Discovery* deployed mussel's naphthalene and phenanthrene body burdens were higher than the other station mussels body burdens. *Discovery* and DIF mussel body burdens of 1-methylphenanthrene were comparable averaging about 8 μg/kg dry at each station. In addition to these individual PAH analytes, *Discovery* mussel acenaphthylene (18 μg/kg dry) and anthracene (32 μg/kg dry) body burdens were significantly higher than DIF body burdens for these two compounds. DIF deployed mussels were comparable to pre-deployment tissue concentrations for these two compounds.

Average body burdens of NOAA High Molecular Weight (HMW) PAHs were significantly higher in both DIF (261 μg/kg dry) and *Discovery* (1345 μg/kg dry) deployed mussels when compared to the average body burdens of Gloucester pre-deployment mussels (88.5 μg/kg dry) ($P<0.05$) (Table 3-17). Several individual HMW-PAHs (i.e. chrysene, fluoranthene, and pyrene) were routinely found at significantly higher concentrations in *Discovery* deployed mussels compared to Gloucester pre-deployed and DIF mussels ($P<0.05$). The FOS deployed mussels displayed both LMW-PAH and HMW-PAH tissue concentrations that were substantially lower than mussels harvested from DIF, *Discovery* and the Gloucester pre-deployment mussels ($P<0.05$).

Total PAHs (t-PAH) were highest in the *Discovery* mussel tissues (1493 μg/kg dry) and lowest in the FOS mussels (85 μg/kg dry) ($P<0.05$). DIF mussel t-PAH burdens averaged 346 μg/kg dry which was significantly higher than Gloucester Pre-deployment t-PAH body burdens of 157 μg/kg dry but significantly lower than *Discovery* mussels.

3.3.3.2 Pesticides

Five pesticides; aldrin, endrin, heptachlor epoxide, lindane (gamma-BHC), and 2,4' DDE were not detected at any of the study locations in 1997 (Tables 3-18 and 3-19). Six compounds (2,4-DDT, 2,4-DDD, dieldrin, alpha-chlordane, trans-nonachlor and, heptachlor) were found in significantly higher tissue concentrations in the DIF deployed mussels as compared to the pre-deployment mussels ($P<0.05$).

Dieldrin, alpha-chlordane, hexachlorobenzene, trans-nonachlor, 2,4-DDD, 2,4-DDT, 4,4-DDD, and 4,4-DDE were found at significantly higher levels in *Discovery* mussels, after 60 days of exposure as compared to the pre-deployment mussels ($P<0.05$). Only 4,4-DDT concentrations were significantly higher in DIF mussels as compared to *Discovery* mussels, while dieldrin, hexachlorobenzene, trans-nonachlor, 2,4-DDD, 2,4-DDT, 4,4-DDD and 4,4-DDE concentrations were significantly higher in *Discovery* mussels as compared to DIF mussels. The tissue concentrations for alpha-chlordane and mirex were numerically higher in *Discovery* mussels as compared to DIF mussels.

The tissue concentrations of detectable pesticide were lower at FOS as compared with the Gloucester pre-deployment mussels. The tissue concentrations of alpha-chlordane, heptachlor, hexachlorobenzene, 2,4-DDD, 4,4-DDD, 4,4-DDE and 4,4-DDT were significantly higher in pre-deployment mussels as compared to FOS mussels ($P<0.05$). In addition, the concentrations of dieldrin, mirex, trans-nonachlor, and 2,4-DDT were numerically higher in pre-deployment mussels as compared to FOS mussels.

3.3.3.3 Polychlorinated Biphenyls

Mussel tissues were analyzed for twenty-one polychlorinated biphenyl (PCB) congeners (Tables 3-20 and 3-21). Nine of the twenty-one PCB congeners (BZ #'s 101, 105, 118, 128, 138, 153, 180, 187, and 209) were found in significantly higher tissue concentrations in DIF deployed mussels when compared to the Gloucester pre-deployment mussels ($P<0.05$). *Discovery* mussels had significantly higher tissue concentrations for thirteen (BZ #'s 28, 44, 52, 66, 101, 105, 118, 128, 153, 170, 180, 187, and 138) of the twenty-one PCB congeners examined as compared to pre-deployment mussels. Tissue concentrations for eighteen of the twenty-one PCB congeners examined were numerically equal or higher in *Discovery* mussels as compared to pre-deployment mussels; eleven of the twenty PCB congeners (BZ #'s 28, 44, 52, 66, 101, 105, 118, 128, 153, 180, and 187) were significantly higher in the *Discovery* mussels as compared to DIF mussels ($P<0.05$).

Four congeners (BZ #'s 18, 77, 126 and 195) were not routinely detected in mussel tissues from any of the study locations. Ten PCB congeners (BZ #'s 8, 44, 52, 66, 101, 105, 118, 153, 180, and 187) were found in significantly higher tissue concentrations in pre-deployment mussels as compared to the FOS mussels ($P<0.05$). One congener, BZ # 138, was detected in significantly higher tissue concentrations in FOS mussels as compared to pre-deployment mussels.

3.3.3.4 Mercury and Lead

Mercury tissue concentrations from mussels harvested at the *Discovery* location was the highest observed for 1997 (Table 3-22). The DIF deployed mussel body burdens (0.06 mg/kg dry) were significantly lower than the Sandwich pre-deployment mussel body burdens (0.17 mg/kg dry) but not significantly lower than FOS deployed mussels (0.10 mg/kg dry) ($P<0.05$).

Average lead tissue concentration in *Discovery* deployed mussels (9.9 mg/kg) was significantly higher than the average Sandwich pre-deployment concentrations (2.4 mg/kg) ($P<0.05$). The DIF mussel body burdens of 7.8 mg/kg were not statistically different from the *Discovery* deployed mussels ($P>0.05$) but were significantly higher than Sandwich pre-deployment mussels. The lead tissue body burdens for FOS mussels (2.1 mg/kg) was not significantly different from Sandwich pre-deployment mussels (2.5 mg/kg); however, both the DIF and *Discovery* deployed mussel lead body burdens were significantly higher than FOS mussel body burdens ($P<0.05$).

3.3.4 Temporal Trends in Tissue Contaminants

The differences in mussel tissue contaminant levels were also examined across the various study years. The average body burdens were calculated by three different methodologies since 1996 (Table 3-17). The total PAH's were the sum of all the compounds selected in the analyses. The total historic NOAA PAHs (including total NOAA LMW-PAHs and NOAA HMW-PAHs) were calculated as described in Tables 3-15 and 3-16 and these average body burdens are only comparable to similarly calculated values. The 1995 total historic PAHs (including the total historic LMW-PAHs and the total historic HMW-PAHs) differ from the total historic NOAA PAHs by the inclusion of C1-, C2-, and C3-Naphthalenes as well as the target list commonly referred to as NOAA analytes. The 1995 data, due to the different target analyte list, overestimates PAH body burdens in years when the total historic NOAA PAH target list was used to estimate total body burdens. For consistency and general comparability, the total historic NOAA PAH body burdens have been used to glean temporal trends at the various stations.

3.3.4.1 PAH Compounds

The reported 1997 NOAA tPAH body burdens for both pre-deployment and deployed mussels was the lowest recorded for the Gloucester, DIF and FOS harvested mussels. *Discovery* deployed mussel body burdens were also low. However, body burdens of mussels deployed at *Discovery* in 1993 and 1995 were numerically lower than those body burdens reported for 1997 (Figure 3-15). Overall, 1997 clearly appears to have the lowest body burden concentrations among all of the years of study (1987-1997).

The Gloucester pre-deployment mussel PAH body burdens have been consistently low from 1991 to 1997 (Figure 3-15). The LMW-PAHs body burdens have typically been near detection levels for 1992, 1993, and 1997 harvested mussels. The mussels harvested from Gloucester in 1991, 1994, and 1995 were also low but did display several detectable tissue concentrations of individual LMW-PAHs. The 1996 pre-deployment LMW-PAH's were the highest pre-deployment body burdens recorded and these values probably reflect analytical differences and year-to-year variability in the populations at the reference site.

The 1997 Gloucester pre-deployment mussel HMW-PAH tissue concentrations were the lowest observed with many individual compounds at or near detection. Pre-deployment body burdens for the years of 1991-1995 were roughly comparable with some of the individual HMW-PAHs routinely detected in the mussel tissues. The 1996 HMW-PAH Gloucester pre-deployment body burdens were substantially higher than pre-deployment mussels

harvested during any other year (1991-1997). The overall trend displayed for Gloucester mussels has been one of low t-PAH tissue concentrations from 1991-1995, a sharp rise in tissue concentrations in 1996, and then a sharp decline in 1997 to the lowest t-PAH tissue concentrations recorded for this station.

The reported FOS deployed mussel body burdens in 1997 were the lowest recorded for both LMW-PAHs and HMW-PAHs during 1992-1997 [Note no analyses were conducted on 1995 FOS mussels due to losses of cage arrays]. One factor may be the lower reporting levels used in 1997. Historically, the reporting limits for mussel body burdens had been set at 5 μg/kg dry weight; whereas in 1997, the reported body burden concentrations have been reported as low as 2 μg/kg dry weight. Regardless of the reporting levels, mussels deployed at the FOS site contain very low body burdens of the target PAHs.

The FOS deployed mussels displayed the lowest PAH body burdens of all stations since 1992 (Figure 3-15). Annually, the FOS deployed mussels routinely are lower than the Gloucester pre-deployment mussels suggesting lowered body burdens (on a dry weight basis) at the end of the deployment compared with the beginning of deployment. The apparent decrease in body burdens on a dry weight basis could be the result of a number of factors including dilution of contaminants by increased dry weight (growth) of FOS deployed mussels, depuration process, or a combination of other factors.

The 1997 average tissue wet weight of FOS deployed mussels was 12.28 g wet weight compared to pre-deployment mussel wet weights of 8.66 g, or about a 30 percent increase in average tissue mass. On a strict tissue growth and contaminant dilution calculation basis, this increase in tissue mass could account for about 30 percent reduction in FOS mussel body burdens or nearly 2/3 of the t-PAH body burden reduction for FOS mussels (86 μg/kg dry) compared to pre-deployment mussel body burdens (157 μg/kg dry) reported in 1997. Although it is likely that a combination of factors may be influencing the PAH body burdens in mussels deployed at the FOS station, the 'dilution' of pre-deployment t-PAH body burdens through increased soft tissue growth in FOS mussels appears to be a significant factor in the lower body burdens observed.

The 1997 DIF LMW-PAH body burdens of 85 μg/kg dry were the lowest observed all the years of study (Figure 3-15). The average LMW-PAHs body burdens in DIF deployed mussels seem to be decreasing from the highest tissue concentrations in 1987 to the lowest tissue concentrations in 1997. During the last 5 years (1993 - 1997) LMW-PAHs have remained low with exception of 1995. During this same period, the summer mass loading of LMW-PAHs in the Deer Island facility effluent discharge appear to be decreasing. As noted previously, the 1995 DIF LMW-PAH body burdens were confounded by analytical differences which probably inflated body burden estimates for the LMW-PAH compounds.

Mussel LMW-PAH body burdens deployed at *Discovery* were comparable for 1991-1997 ranging from a low average body burden of 79 μg/kg dry in 1993 to a high of 239 μg/kg in 1991. These results suggest that the exposure potential for deployed mussels in the Inner Harbor far from the Deer Island effluent discharge have been relatively stable during the 1991-1997 years of study.

Mussels deployments have revealed a change in patterns of mussel bioaccumulation (exposure) for DIF deployed mussels which was most noticeable in 1996 and 1997. The DIF 1996 and 1997 deployed mussels have had comparable LMW-PAH body burdens to pre-deployment body burdens suggesting little to no significant tissue accumulations. These DIF deployed mussel body burdens have also been comparable (and in 1997 numerically lower) to *Discovery* deployed mussels, which suggests changes in spatial comparisons relative to previous years results.

Inspection of the individual methylnaphthalenes also suggest changes in exposure patterns in DIF deployed mussels. For 1987 to 1994 DIF deployed mussels, the methylnaphthalene and selected phenanthrene tissue concentrations were highest in DIF mussels. Previous studies (1987-1994) have suggested that these higher DIF mussel body burdens indicate that the effluent is an important source of the LMW-PAHs (Downey and Young, 1992; Downey et al., 1993; Downey, 1994; Downey et al., 1995; and Downey and Moffat, 1996). This trend of significantly higher methylnaphthalenes and phenanthrenes in DIF deployed mussels, was not evident in 1996 and 1997 spatial and/or temporal comparisons. Although the sample size is small (2 years), these results suggest that these compounds may be decreasing in the Zone of Initial Dilution near Deer Island.

The Gloucester pre-deployment HMW-PAH mussel body burdens were highest in 1996 and lowest in 1997 during the years of study (1991-1997). Three compounds, fluoranthene, pyrene, and chrysene, accounted for nearly two thirds of the NOAA HMW-PAHs in 1996. These compounds were nearly three times higher than pre-deployment mussel tissue concentrations reported for previously harvested mussels. The record low HMW-PAH body burdens for 1997 pre-deployed mussels may reflect annual variability and the lower reporting levels in 1997.

Body burdens of HMW-PAHs in mussels deployed at the FOS station have remained consistently low, at or near reporting levels, for the entire study (1992-1997). The unusually low HMW-PAH body burdens reported in 1997 may be, at least partially, an artifact of the lowered reporting limits employed in 1997.

The average NOAA HMW-PAHs burden for 1997 DIF deployed mussels (261 μg/kg) was lower than those burdens reported for 1991-1996 DIF deployed mussels. Previously, the HMW-PAH average burdens ranged from a high of 1507 μg/kg in 1992 to a low of 421 μg/kg in 1995 (Figure 3-15). As discussed by Downey et al. (1993), the unusually high HMW-PAH values detected in 1992 deployed mussels may have actually reflected changes in water quality due to other harbor activities (i.e., visit of the tall ships and the associated dredging that occurred in 1992). With the exception of 1992, it appears that the HMW-PAH body burdens in DIF deployed mussels have been relatively stable during the 1990's (1991-1996). It is unclear whether the low HMW-PAH body burdens reported in 1997 represent the beginning of a trend of further reduction in bioaccumulation in deployed mussels at DIF or primarily a function of annual variability.

The 1997 historic NOAA HMW-PAHs *Discovery* deployed mussels average body burden (1345 μg/kg dry) was comparable to the values obtained in previous years. The HMW-PAH average burdens at this station ranged from a high of 3347 μg/kg in 1992 to a low of 1210 μg/kg in 1993. The higher 1992 body burdens observed probably reflected the perturbations that may have occurred in the Inner Harbor that year.

3.3.4.2 Pesticides

The 1997 t-DDT tissue concentrations at all stations, except *Discovery*, decreased slightly from 1996 levels (Table 3-19). However the 1997 DIF t-DDT levels were still above 1991, 1992, 1994, and 1995 levels (Figure 3-16). Significant decreases in the concentrations of 2,4-DDT and 4,4-DDT in DIF deployed mussels were observed in 1997 as compared to 1996 (4,4-DDD and 4,4-DDE concentrations were numerically lower in 1997 as compared to 1996). The 1997 t-DDT concentrations in *Discovery* mussels were at the highest level observed as compared to all previous study years. The 1997 t-DDT concentrations in pre-deployment mussels were lower as compared to 1996 and 1993 levels but higher as compared to all other study years (Figure 3-16). The 1997 t-DDT concentrations at the FOS were lower than 1996 and 1993 levels but higher than those observed in 1992 and 1994. These data suggest that the t-DDT concentrations in pre-deployment, DIF and FOS mussels are generally increasing. However, analytical variability has made the identification of subtle trends difficult. Yearly variations in the observed t-DDT concentrations may be partly attributable to analytical variations resulting from the use of a different capillary column configuration in 1993 and 1994 as compared to 1991-1992 (see Downey, 1994 for discussion).

Hexachlorobenzene (HCB) tissue concentrations were numerically lower in pre-deployment mussels and significantly lower in DIF, FOS and *Discovery* mussels in 1997 as compared to 1996 mussels. HCB concentrations at all stations were also significantly lower than the HCB concentrations reported in 1993. The 1993 results may have been unreliable due to possible blank contamination with HCB during sample processing and analysis.

The mussel body burdens of total chlordane (trans-nonachlor, alpha-chlordane, heptachlor epoxide, and lindane) at the DIF and *Discovery* stations have varied numerically yearly since 1991, but tissue concentrations have remained generally at the same level through 1997 (Figure 3-16). The 1996 total chlordane levels in DIF mussels were markedly higher as compared to 1997 and all previous years studied. The total chlordane concentrations decreased slightly as compared to the 1995 levels for pre-deployment and *Discovery* mussels but were well within the range of natural annual variability. Total chlordane concentrations at the FOS in 1997 were numerically lower than those observed in all other study years except 1992. Total chlordane levels appear to be relatively stable at the FOS site. ($P<0.05$)

Dieldrin/aldrin concentrations in 1997 DIF mussels were numerically lower as compared to 1996 concentrations and were comparable to those levels reported in 1991-1996. The dieldrin/aldrin tissue concentrations for all stations, including the FOS, were similar to the values reported in 1991-1996. These data suggest that the dieldrin/aldrin tissue concentrations are relatively stable at all deployment sites.

3.3.4.3 Polychlorinated Biphenyls

The average tissue concentrations of one PCB congener (BZ #'s 138) at all stations increased significantly between 1996 and 1997. One PCB congener (BZ # 28) was detected in significantly lower concentrations at all

stations in 1997 as compared to 1996. Six congeners (BZ #'s 8, 138, 153, 170, 180, and 187) were detected in significantly higher concentrations in *Discovery* mussels as compared to 1996 *Discovery* mussels.

The 1997 DIF t-PCB tissue concentrations were at their highest level since the peak level observed in 1987 (Figure 3-17). The t-PCB body burden for *Discovery* mussels was the highest observed among all study years. The t-PCB concentrations in FOS and pre-deployment mussels was consistent with the observations of previous years. DIF PCB body burdens during 1991-1997 have been consistently lower than 1987 burdens suggesting a decrease in t-PCB exposure since 1987. The pattern of t-PCB body burdens in *Discovery* mussels since 1991 suggests that t-PCB concentrations for mussels deployed at this station are relatively stable with slight fluctuations annually. Body burdens of t-PCBs in pre-deployment Gloucester mussels have been consistently higher than the 1991-1992 concentrations, however these data suggest that the concentration of t-PCBs in pre-deployment mussels is relatively constant. The t-PCB concentrations at the FOS, although consistently higher than the 1992 t-PCB levels, appear to be relatively stable.

3.3.4.4 Mercury and Lead

Metal body burdens in indigenous mussels harvested throughout North America have been well described in the Mussel Watch program. Average concentrations and one standard deviation above the average (on a log normal scale), referred to as "high" values, are available for numerous sites throughout the U.S. (O'Conner, 1992, O'Conner and Beliaeff, 1995). There are several sites where indigenous mussels in Boston Harbor (one at DIF) and Cape Ann which are routinely analyzed and burdens reported which are grossly comparable to this study's stations. If the concentrations are above the "high" value, the site is generally considered to have elevated contaminant levels.

The 1997 lead body burdens for deployed mussels were similar to those reported in 1996. *Discovery* deployed mussels had the highest lead concentrations for both 1996 and 1997 (9.4 and 9.9 mg/kg dry respectively) while the FOS mussels had the lowest body burdens (1.6 and 2.1 mg/kg dry, respectively). The 1997 *Discovery* (9.9 mg/kg dry) and DIF (7.8 mg/kg dry) deployed mussel body burdens were comparable statistically, suggesting that there may be other sources of lead available to the Boston Inner Harbor in addition to the DIF POTW effluent discharge. Lead tissue concentrations from mussels harvested from DIF and the *Discovery*, exceeded the NOAA "high" lead concentration of 4.3 mg/kg, reported by O'Connor (1992).

The 1997 mercury tissue concentrations suggest that, statistically, DIF deployed mussels had the lowest body burdens (0.06 mg/kg dry). These DIF mercury body burdens were also about 1/3 of the pre-deployment mercury concentrations. These data could be interpreted to indicate that there are no significant concentrations of bioavailable mercury present near DIF. However, these results are contrary to trends reported by the NOAA for the National Status and Trends Program Mussel Watch Project (O'Connor and Beliaeff, 1995). Since 1990, three out of four annual samplings of indigenous mussels from the DIF location contained average body burdens which exceeded the Mussel Watch "high" concentration of 0.24 mg/kg.

It is difficult to assess why the 1997 DIF mercury body burdens were so low. It may be due to undetected analytical difficulties during the tissue analysis or possibly reflect actual decreases in mercury exposure for the DIF deployed mussels. At this time, there is no definitive answer to explain the apparent differences.

3.3.5 Summary

The overall mussel PAH body burden trends for the 1997 (and 1996) study diverged from previous studies suggesting that PAH contaminant exposure may be changing in Boston Harbor particularly near DIF. Mussels deployed at DIF had, for the first time, numerically lower LMW-PAH body burdens than *Discovery* deployed mussels. Other spatial comparisons (i.e., DIF deployed mussels were not significantly different from Gloucester pre-deployment mussels) also suggest that bioaccumulation of DIF deployed mussels in 1996 and 1997 were lower than previous years particularly for methylnaphthalene and phenanthrene target compounds. Although it is difficult to extrapolate trends with only two years of data, the 1996 and 1997 results suggest that the LMW-PAH exposure potential near DIF may be decreasing.

The overall trends for HMW-PAHs have been relatively consistent for the years of study, 1991-1997. *Discovery* deployed mussels have displayed the highest body burdens during each year. DIF deployed mussel body burdens have been elevated above pre-deployment levels but always significantly less than *Discovery* body burdens. The 1997 data support previous interpretations in that there appears to be other more significant sources of HMW-PAHs in the Inner Harbor contributing to the body burden increases at *Discovery* and DIF. The annual HMW-PAH body burdens at both of these stations are highly correlated (Spearman's Rho of 0.98) suggesting that HMW-PAH body burdens in mussels deployed at the two stations are strongly influenced by similar Inner Harbor background contaminant sources. Consistently higher *Discovery* body burdens and strong correlation in annual body burdens at the two stations, suggest that there are likely more significant sources of HMW-PAHs in the Inner Harbor than the effluent.

The results of the years of study suggest that PAH exposure patterns for deployed mussels at DIF have decreased from 1987 to 1997. It would appear that body burdens of LMW-PAHs in DIF mussels underwent a substantial reduction from 1987 to 1991. The annual results from 1996 and 1997 suggest that these body burdens may be continuing to decrease and that exposure to LMW-PAHs in the vicinity will continue to decrease to near background conditions in future years.

3.3.6 Relationship of Contaminants to FDA Legal Limits

The U.S. Food and Drug Administration has set legal limits for maximum concentrations of mercury in the edible portions of fish and fishery products (U.S. EPA, 1989). The action level for lead is based on an EPA risk assessment of lead in drinking water (MWRA, 1997). For the MWRA biomonitoring program, Caution Levels are set at 50% of FDA Limits, and Warning Levels are set at 80% of FDA Limits (MWRA 1997). Caution and Warning Levels apply to the FOS only. These three levels provide reference benchmarks for detecting adverse changes (and their potential human health risks) once the new outfall is on line.

Table 3-23 compares the mean wet weight concentrations of mercury and lead in mussel tissues collected throughout the study area in 1997 to the applicable action levels. As the table indicates, mercury and lead levels in mussels were below the benchmark levels.

3.3.7 Lipid Normalized Concentrations

Lipid normalized concentrations for mussel tissue are presented in Table 3-24 and Figure 3-18. Total PAH for mussel tissue represents the 24 NOAA PAH analytes listed in the third column of Table 3-15. Lipid normalized concentrations of total DDT, total PCBs, and total PAHs are consistently highest in *Discovery* deployed mussels and lowest in FOS mussels. All values observed in 1997 were within the historic range observed at individual stations, however.

The Caution Level for lipid normalized toxics in the MWRA Outfall Monitoring Program is two times baseline. The mean of the 1992 through 1997 data (Table 3-24) is considered as the current baseline concentration but will eventually include 1992 - 1998 data.

Table 3-1
Catch per unit effort (number of fish per minute of bottom time)
for winter flounder trawled in April 1991-1997

Site	1991	1992	1993	1994	1995	1996	1997
DIF	0.38	0.23	0.15	0.39	0.1	0.16	0.11
NB	0.48	1.29	1.52	0.76	0.88	0.77	0.43
BS	1.26	2.8	0.49	0.42	0.29	0.23	0.59
FOS	0.13	0.48	0.62	0.24	0.6	0.31	0.81
ECCB	0.67	0.49	0.77	0.42	0.21	1.38	0.32

Notes:
The same vessel (F.V. *Odessa*) and fishing gear were used for all surveys.

DIF - Deer Island Flats
NB - Nantasket Beach
BS - Broad Sound
FOS - Future Outfall Site
ECCB - Eastern Cape Cod Bay

Table 3-2
Summary of physical characteristics of winter flounder collected in 1997
from Massachusetts and Cape Cod Bays

Parameter		DIF Station 1	NB Station 2	BS Station 3	FOS Station 4	ECCB Station 5
Number Caught	N	16	50	50	67	67
Total length	Mean	338	337	339	336	344
	S.D.	23	34	25	31	25
	Anova					
Weight	Mean	430	487	474	461	491
	S.D.	63	201	142	135	140
	Anova					
Age	Mean	4.13	4.26	4.06	4.52	4.45
	S.D.	0.7	0.8	0.7	0.8	0.8
	Anova			4,5	3	3
Fin erosion	Mean	0.56	0.36	0.4	0.70	0.09
	S.D.	0.89	0.63	0.70	0.70	0.34
	Anova	5	4,5	4,5	2,3,5	1,2,3,4
Gross score	Mean	0	0.02	0.02	0.02	0
	S.D.	0	0.14	0.14	0.12	0
	Anova					

Notes:
S.D. - Standard Deviation
Significant differences by ANOVA given as the station(s) that differed significantly from the station in that column.
DIF - Deer Island Flats
NB - Nantasket Beach
BS - Broad Sound
FOS - Future Outfall Site
ECCB - Eastern Cape Cod Bay

Table 3-3
Prevalence (%) of histological changes in winter flounder liver from 5 stations in Massachusetts and Cape Cod Bays - 1997.

Parameter	Deer Island Flats Station 1 (n =16 fish)	Nantasket Beach Station 2 (n=50 fish)	Broad Sound Station 3 (n=50 fish)	Future Outfall Site Station 4 (n=67 fish)	Eastern Cape Cod Bay Station 5 (n=67 fish)
Neoplasm	0	0	0	0	0
Focal HV	0	0	0	0	0
Tubular HV	21	19	41	14	3
Centrotubular HV	50	28	40	21	10
Balloons	31	22	24	24	6
Macrophage aggregation	63	66	78	67	39
Biliary proliferation	0	10	22	6	2
Necrosis	25	14	20	10	5
Eosinophilic focus	0	0	0	0	0
Basophilic focus	0	0	0	0	0
Hepatocyte regeneration	44	10	20	10	0

Notes:
HV - Hydropic Vacuolation

TABLE 3-4 (Page 1 of 4)
Summary of Mean Flounder Tissue Contaminant Levels
1997 MWRA Flounder Survey
ng/g dry weight

PARAMETER	Deer Island		Future Outfall		Cape Cod Bay	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
DDTs - Fillet						
2,4-DDD	2.00	1.04	1.47	0.81	1.70	1.12
2,4-DDE	ND	ND	ND	ND	ND	ND
2,4-DDT	ND	ND	ND	ND	ND	ND
4,4-DDD	3.60	0.45	1.33	0.09	0.35	0.18
4,4-DDE	40.67	2.91	19.67	3.93	11.37	3.15
4,4-DDT	ND	ND	ND	ND	ND	ND
TOTAL	46.27	3.75	22.47	4.80	13.41	1.93
DDTs - Liver						
2,4-DDD	42.33	7.54	22.33	5.04	9.73	1.82
2,4-DDE	ND	ND	ND	ND	ND	ND
2,4-DDT	17.53	4.61	12.93	4.21	ND	ND
4,4-DDD	81.00	19.67	27.00	6.03	14.67	3.28
4,4-DDE	470.00	97.13	266.67	40.55	210.00	77.67
4,4-DDT	24.33	5.17	13.47	2.60	2.97	1.86
TOTAL	635.20	130.23	342.40	56.21	237.37	84.22
Pesticides - Fillet						
ALDRIN	ND	ND	ND	ND	ND	ND
DIELDRIN	2.97	0.24	1.73	0.09	1.08	0.11
ENDRIN	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	0.68	0.03	0.63	0.10	0.32	0.16
LINDANE	ND	ND	0.11	0.06	0.23	0.16
MIREX	ND	ND	ND	ND	ND	ND
TOTAL	3.64	0.26	2.47	0.09	1.63	0.11
Pesticides - Liver						
ALDRIN	ND	ND	ND	ND	ND	ND
DIELDRIN	36.67	7.22	18.33	3.33	14.33	1.45
ENDRIN	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	7.47	0.64	6.27	1.17	5.20	0.35
LINDANE	ND	ND	ND	ND	ND	ND
MIREX	11.77	2.62	6.77	0.15	3.40	0.21
TOTAL	55.90	10.32	31.37	4.62	22.93	2.00
Chlordanes - Fillet						
ALPHA-CHLORDANE	5.43	0.66	1.90	0.25	0.52	0.29
HEPTACHLOR	ND	ND	0.06	0.06	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND
TRANS NONACHLOR	8.50	0.78	3.70	0.45	1.47	0.27
TOTAL	13.93	1.27	5.66	0.68	1.99	0.52
Chlordanes - Liver						
ALPHA-CHLORDANE	90.33	17.95	24.67	5.21	10.70	1.42
HEPTACHLOR	ND	ND	ND	ND	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND
TRANS NONACHLOR	153.33	38.44	54.00	10.82	22.00	3.21
TOTAL	243.67	54.73	78.67	15.94	32.70	4.64

ND - Not Detected (considered 0 in calculations).

TABLE 3-4 (Page 2 of 4)
Summary of Mean Flounder Tissue Contaminant Levels
1997 MWRA Flounder Survey
ng/g dry weight

PARAMETER	Deer Island		Future Outfall		Cape Cod Bay	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
PCBs - Fillet						
105	20.00	2.08	10.53	1.58	2.50	0.49
126	ND	ND	ND	ND	ND	ND
138	35.00	4.58	22.67	3.53	5.43	0.45
170	14.00	1.53	9.63	1.48	2.83	0.45
180	65.67	6.33	41.00	6.24	14.00	1.15
195	1.53	0.20	1.60	0.20	0.34	0.01
2,2',3,3',4,4'-HEXACHLOROBIPHENYL (128)	7.27	0.57	4.73	0.88	1.50	0.40
2,2',3,4,5,5',6-Cl7	19.33	1.45	14.33	1.45	5.43	0.32
2,2',3,5'-TETRACHLOROBIPHENYL (44)	0.32	0.32	ND	ND	ND	ND
2,2',4,4',5,5'-HEXACHLOROBIPHENYL (153)	75.00	12.66	50.33	8.57	15.67	1.86
2,2',4,5,5'-PENTACHLOROBIPHENYL	15.67	1.86	9.37	1.84	3.23	0.32
2,2',5,5'-TETRACHLOROBIPHENYL (52)	2.73	0.57	1.21	0.29	0.39	0.20
2,2',5-TRICHLOROBIPHENYL (18)	0.14	0.14	0.09	0.09	ND	ND
2,3',4,4',5-PENTACHLOROBIPHENYL (118)	52.67	6.94	31.00	5.51	8.10	1.26
2,3',4,4'-TETRACHLOROBIPHENYL (66)	8.57	1.23	4.90	0.55	1.63	0.35
2,4'-DICHLOROBIPHENYL (8)	3.40	0.40	1.57	0.15	0.43	0.22
2,4,4'-TRICHLOROBIPHENYL (28)	ND	ND	ND	ND	ND	ND
206	2.73	0.30	2.87	0.15	0.83	0.08
44 DD OLEPHIN (DDMU)	3.33	3.33	ND	ND	ND	ND
77	ND	ND	ND	ND	ND	ND
DECACHLOROBIPHENYL (209)	1.06	0.12	1.17	0.12	0.44	0.05
TOTAL	328.42	36.17	207.00	30.39	62.78	6.69
PCBs - Liver						
105	260.00	61.10	144.00	37.00	39.00	9.54
126	ND	ND	ND	ND	7.67	7.67
138	523.33	133.83	293.33	68.88	80.67	16.22
170	210.00	55.08	125.33	28.20	38.00	7.81
180	920.00	141.07	533.33	181.14	196.67	38.44
195	27.33	6.36	20.33	3.38	6.50	1.33
2,2',3,3',4,4'-HEXACHLOROBIPHENYL (128)	89.33	15.38	45.67	8.95	19.67	4.33
2,2',3,4,5,5',6-Cl7	306.67	62.27	193.33	40.96	87.33	16.83
2,2',3,5'-TETRACHLOROBIPHENYL (44)	9.73	2.92	1.07	1.07	ND	ND
2,2',4,4',5,5'-HEXACHLOROBIPHENYL (153)	1170.00	265.39	690.00	205.99	236.67	40.96
2,2',4,5,5'-PENTACHLOROBIPHENYL	166.67	34.80	95.33	15.76	47.00	13.75
2,2',5,5'-TETRACHLOROBIPHENYL (52)	33.67	8.95	13.17	1.83	8.83	1.79
2,2',5-TRICHLOROBIPHENYL (18)	10.23	2.57	4.83	0.37	2.87	1.44
2,3',4,4',5-PENTACHLOROBIPHENYL (118)	686.67	157.09	330.00	110.60	117.00	28.79
2,3',4,4'-TETRACHLOROBIPHENYL (66)	123.67	28.29	66.00	17.95	20.67	4.26
2,4'-DICHLOROBIPHENYL (8)	47.33	8.65	22.33	5.49	8.00	1.53
2,4,4'-TRICHLOROBIPHENYL (28)	ND	ND	ND	ND	ND	ND
206	39.00	9.02	38.33	5.24	15.33	1.45
44 DD OLEPHIN (DDMU)	ND	ND	ND	ND	ND	ND
77	ND	ND	ND	ND	ND	ND
DECACHLOROBIPHENYL (209)	14.33	3.33	12.87	2.18	6.57	0.52
TOTAL	4637.97	992.24	2629.27	727.44	938.43	177.43

ND - Not Detected (considered 0 in calculations).

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TABLE 3-4 (Page 3 of 4)
Summary of Mean Flounder Tissue Contaminant Levels
1997 MWRA Flounder Survey
ng/g dry weight

PARAMETER	Deer Island		Future Outfall		Cape Cod Bay	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
PAHs - Liver						
ACENAPHTHENE	8.37	0.87	4.30	1.10	2.70	0.38
ACENAPHTHYLENE	2.03	0.23	1.63	0.18	ND	ND
ANTHRACENE	1.93	0.27	1.37	0.09	1.00	0.15
BENZ(A)ANTHRACENE	ND	ND	ND	ND	1.53	1.53
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	1.23	0.03
BENZO(E)PYRENE	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	0.60	0.60	ND	ND	2.80	2.80
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	0.82	0.23
BIPHENYL	13.00	1.53	7.20	0.50	5.87	0.79
C1-CHRYSENE	ND	ND	ND	ND	ND	ND
C1-DIBENZOTHIOPHENES	ND	ND	ND	ND	ND	ND
C1-FLUORANTHENES/PYRENE	ND	ND	ND	ND	ND	ND
C1-FLUORENES	ND	ND	ND	ND	ND	ND
C1-NAPTHALENE	36.00	2.31	24.67	3.38	9.67	1.67
C1-PHENANTHRENES/ANTHRACENE	8.77	1.71	5.13	0.76	6.07	0.28
C2-CHRYSENE	ND	ND	ND	ND	ND	ND
C2-DIBENZOTHIOPHENE	ND	ND	ND	ND	ND	ND
C2-FLUORANTHENES/PYRENE	ND	ND	ND	ND	ND	ND
C2-FLUORENE	ND	ND	ND	ND	ND	ND
C2-NAPTHALENE	37.00	2.31	23.67	1.20	13.33	0.88
C2-PHENANTHRENE/ANTHRACENE	5.33	5.33	ND	ND	ND	ND
C3-CHRYSENE	ND	ND	ND	ND	ND	ND
C3-DIBENZOTHIOPHENE	ND	ND	ND	ND	ND	ND
C3-FLUORANTHENES/PYRENE	ND	ND	ND	ND	ND	ND
C3-FLUORENE	ND	ND	ND	ND	ND	ND
C3-NAPTHALENE	20.67	3.18	7.00	3.51	ND	ND
C3-PHENANTHRENE/ANTHRACENE	ND	ND	ND	ND	ND	ND
C4-CHRYSENE	ND	ND	ND	ND	ND	ND
C4-NAPTHALENE	5.33	5.33	ND	ND	ND	ND
C4-PHENANTHRENE/ANTHRACENE	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	0.87	0.87
DIBENZO(A,H)ANTHRACENE	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	15.67	3.18	10.70	3.15	12.87	4.73
DIBENZOTHIOPHENE	3.50	0.75	ND	ND	ND	ND
FLUORANTHENE	6.43	1.79	4.37	0.54	4.83	0.50
FLUORENE	4.97	0.64	3.90	0.40	2.73	0.41
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND
NAPHTHALENE	45.00	2.52	32.67	3.53	22.67	3.28
PERYLENE	ND	ND	ND	ND	ND	ND
PHENANTHRENE	14.33	1.20	11.67	1.20	12.20	1.94
PYRENE	4.10	1.15	2.53	0.35	2.70	0.06
TOTAL	233.03	20.09	140.80	3.29	103.89	12.26
BENZOTHIAZOLE	27.67	1.45	34.33	0.88	30.33	4.63
Metals - Liver						
Cadmium	2.25	1.50	1.04	0.10	1.83	0.49
Chromium	0.42	0.225	0.30	0.29	0.33	0.32
Copper	54.92	1.71	75.07	11.75	87.01	17.91
Lead	3.06	0.64	4.39	0.64	1.07	0.31
Nickel	0.40	0.12	0.38	0.03	0.42	0.07
Silver	5.47	0.10	9.17	1.36	8.02	1.22
Zinc	127.46	2.55	141.24	6.67	137.22	7.10
Mercury	0.34	0.05	0.34	0.07	0.20	0.02

ND - Not Detected (considered 0 in calculations).

TABLE 3-4 (Page 4 of 4)
Summary of Mean Flounder Tissue Contaminant Levels
1997 MWRA Flounder Survey
ng/g dry weight

PARAMETER	Deer Island		Future Outfall		Cape Cod Bay	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Metals - Fillet						
Mercury	0.51	0.09	0.28	0.20	0.20	0.02

ND - Not Detected (considered 0 in calculations).

Table 3-5
Concentrations of Selected Organic Compounds Normalized for Lipids [1]
Flounder Fillet and Liver, 1992 - 1997
ng/g lipid

Parameter	Year	Deer Island		Future Outfall Site		Eastern Cape Cod Bay		Nantasket Beach		Broad Sound	
		Average	S.E.	Average	S.E.	Average	S.E.	Average	S.E.	Average	S.E.
Flounder Fillet											
Total DDT	1992	953.40	233.24	342.96	132.30	375.28	122.55	837.99	291.81	580.45	159.97
	1993	1193.15	239.74	1096.35	149.81	503.77	76.95	NA	NA	NA	NA
	1994	903.20	34.36	455.14	119.61	276.35	63.67	394.65	64.26	525.14	142.22
	1995	2312.97	519.38	1116.26	248.10	1116.73	152.47	NA	NA	NA	NA
	1996	1529.47	219.21	1015.92	205.73	435.72	93.81	943.33	187.30	925.67	21.64
	1997	3298.02	95.99	1396.70	337.96	998.40	272.31	NA	NA	NA	NA
	Baseline Mean	**1698.37**	**383.30**	**903.89**	**168.68**	**617.71**	**143.22**	**725.32**	**168.11**	**677.09**	**125.32**
Total PCBs	1992	8264.31	3301.67	2765.73	1052.34	1628.51	481.83	8087.49	2904.56	4829.15	1322.63
	1993	7260.70	1070.08	8142.03	1188.41	2214.05	316.74	NA	NA	NA	NA
	1994	10763.66	957.52	5147.91	1713.56	1183.83	229.21	3089.63	183.01	4109.50	1178.71
	1995	33414.02	4950.62	11105.20	1150.12	4346.00	424.96	NA	NA	NA	NA
	1996	13530.82	1895.52	10187.61	1600.64	2920.39	525.55	10951.31	2482.27	7758.11	724.12
	1997	23341.62	1322.78	12822.36	2240.28	4704.00	1298.30	NA	NA	NA	NA
	Baseline Mean	**16095.85**	**4190.56**	**8361.81**	**1554.03**	**2832.80**	**587.40**	**7376.14**	**2297.17**	**5565.59**	**1115.77**
Flounder Liver											
Total DDT	1992	875.11	168.01	781.25	129.97	253.88	35.57	764.70	251.63	1247.14	200.30
	1993	766.15	NC	1104.29	NC	359.05	NC	NA	NA	NA	NA
	1994	472.49	12.24	751.95	113.37	273.58	92.43	439.12	20.06	494.30	81.22
	1995	2742.72	413.92	1951.70	385.24	1149.18	150.98	NA	NA	NA	NA
	1996	1732.62	186.13	1093.77	297.90	433.01	95.70	983.33	64.45	797.57	158.24
	1997	4730.80	596.98	2325.88	420.98	1195.25	281.78	NA	NA	NA	NA
	Baseline Mean	**1886.65**	**661.42**	**1334.81**	**265.84**	**610.66**	**179.59**	**729.05**	**158.11**	**846.34**	**218.69**
Total PAHs	1993	3908.26	NC	3855.00	NC	4274.35	NC	NA	NA	NA	NA
	1994	253.37	28.29	682.40	183.38	649.92	380.62	627.08	253.44	276.18	68.75
	1995	731.10	11.62	273.12	68.91	337.62	28.08	NA	NA	NA	NA
	1996	1179.56	243.31	1460.18	440.18	1133.26	88.26	1778.24	284.29	1401.10	83.10
	1997	1771.40	98.14	956.62	62.85	554.48	30.52	NA	NA	NA	NA
	Baseline Mean	**1568.74**	**636.31**	**1445.46**	**632.52**	**1389.93**	**732.76**	**1202.66**	**364.03**	**838.64**	**355.73**
Total PCBs	1992	11003.29	3238.01	8661.64	1561.96	1834.25	378.69	8055.86	3418.85	11233.89	1861.99
	1993	5330.68	NC	7727.96	NC	1754.25	NC	NA	NA	NA	NA
	1994	4152.55	352.87	6740.30	1413.42	1278.23	442.10	2893.37	220.73	3443.58	684.88
	1995	30442.79	7071.70	26082.16	6944.19	9909.95	5278.49	NA	NA	NA	NA
	1996	15215.93	1320.77	10633.39	1319.94	3142.16	242.23	11228.01	1607.24	7659.93	1601.21
	1997	34582.38	4791.61	17962.83	5378.98	4916.47	358.28	NA	NA	NA	NA
	Baseline Mean	**16787.93**	**5259.76**	**12968.05**	**3093.90**	**3805.88**	**1334.40**	**7392.41**	**2428.76**	**7445.80**	**2251.42**

Notes:
NA - Not Applicable. (Broad Sound and Nantasket Beach flounder are only analyzed for chemicals in even numbered years.)
[1] Formula: concentration/percent lipid.
S.E. - Standard Error.

TABLE 3-6

Comparison of FDA Legal Limits to Mean Concentrations (wet weight) of Select Compounds In Winter Flounder Edible Tissues - 1997

Compound/Analyte	Deer Island Mean	Deer Island S.E.	Future Outfall Site Mean	Future Outfall Site S.E.	Cape Cod Bay Mean	Cape Cod Bay S.E.	FDA Legal Limit [1]	Caution Level [3]	Warning Level [4]
Total DDT (ppb)	8.20	0.67	3.97	0.89	2.39	0.37	5,000 [2]	NA	NA
Total Chlordanes (ppb)	2.47	0.23	1.00	0.14	0.35	0.10	300	NA	NA
Dieldrin (ppb)	0.53	0.04	0.31	0.02	0.19	0.02	300	NA	NA
Total PCBs (ppb)	58.24	6.40	36.56	5.68	11.16	1.30	2,000	1,000	1,600
Mercury (ppm)	0.07	0.01	0.04	0.03	0.03	0.003	1	0.5	0.8

Notes:

[1] U.S. EPA 1989. Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish. EPA-503/8-89-002. Office of Marine and Estuarine Protection (WH-556F) and the Office of Water Regulations and Standards (WH-552), Washington, D.C.

[2] The value represents the FDA Legal Limits for DDT (5 ppm), DDE (5 ppm), and DDD (5 ppm), which comprise the mean total DDT tissue concentration. A total DDT tissue concentration below 5 ppm assumes that all DDT derivations are not exceeded.

[3] Massachusetts Water Resources Authority (MWRA) 1997. Contingency Plan. Caution Level is 50% the FDA Legal Limit, and applies to the outfall site only.

[4] Massachusetts Water Resources Authority (MWRA) 1997. Contingency Plan. Warning Level is 80% of the FDA Legal Limit, and applies to the outfall site only.

December 17, 1998

TABLE 3-7

Mean Length, Weight, and Sex of Lobsters Collected in 1997 [1]

Station	Carapace Length (mm) Mean	S.E.	Weight (g) Mean	S.E.	Sex Ratio M/F
Deer Island Flats	89	1.42	544	40.35	14/1
Future Outfall Site	87	0.76	487	20.05	10/5
Cape Cod Bay	88	0.88	535	12.47	7/8

Notes:
[1] Each mean is based on a sample size of 15 lobsters.
S.E. - Standard Error

December 17, 1998

TABLE 3-8
Mean External Conditions of Lobsters Collected in 1997 [1]

Station	Black Gill	Shell Erosion	Parasites	External Tumors
Deer Island Flats	0	0	0	0
Future Outfall Site	0	0	0	0
Cape Cod Bay	0	0	0	0

Notes:
Values can range from 0 (absent) to 4 (extreme).

December 17, 1998

TABLE 3-9 (Page 1 of 3)
Summary of Mean Lobster Tissue Contaminant Levels
1997 MWRA Lobster Survey
ng/g dry weight

Parameter	Deer Island		Future Outfall		Cape Cod Bay	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
DDTs - Meat						
2,4-DDD	2.23	0.69	ND	ND	0.88	0.12
2,4-DDE	ND	ND	0.18	0.18	0.10	0.10
2,4-DDT	ND	ND	0.32	0.32	0.56	0.04
4,4-DDD	2.97	1.32	1.13	0.32	0.74	0.16
4,4-DDE	41.00	21.13	19.27	6.22	12.33	0.88
4,4-DDT	0.14	0.14	ND	ND	ND	ND
TOTAL	46.34	23.02	20.90	6.43	14.61	1.01
DDTs - Hepatopancreas						
2,4-DDD	40.33	18.94	10.33	5.55	15.33	2.73
2,4-DDE	ND	ND	4.00	4.00	ND	ND
2,4-DDT	ND	ND	ND	ND	ND	ND
4,4-DDD	84.67	23.39	52.33	16.18	36.33	7.17
4,4-DDE	960.00	612.86	1016.67	351.77	730.00	138.68
4,4-DDT	8.03	4.93	5.37	2.91	7.20	1.01
TOTAL	1093.03	644.25	1088.70	359.71	788.87	142.08
Pesticides - Meat						
ALDRIN	ND	ND	ND	ND	0.61	0.50
DIELDRIN	6.80	0.76	6.27	1.07	4.23	0.34
ENDRIN	ND	ND	0.40	0.40	0.56	0.08
HEXACHLOROBENZENE	0.42	0.06	0.63	0.08	0.53	0.06
LINDANE	ND	ND	ND	ND	ND	ND
MIREX	0.32	0.32	ND	ND	0.35	0.06
TOTAL	7.54	1.00	7.30	1.26	6.28	0.23
Pesticides - Hepatopancreas						
ALDRIN	1.50	0.76	ND	ND	ND	ND
DIELDRIN	46.00	4.16	50.67	12.13	32.67	2.19
ENDRIN	ND	ND	ND	ND	ND	ND
HEXACHLOROBENZENE	9.13	0.93	13.27	3.37	11.30	0.91
LINDANE	3.27	0.52	2.33	0.12	ND	ND
MIREX	8.00	1.00	10.37	2.89	7.83	1.06
TOTAL	67.90	4.67	76.63	18.11	51.80	4.06
Chlordanes - Meat						
ALPHA-CHLORDANE	1.87	0.32	1.23	0.55	0.72	0.19
HEPTACHLOR	0.21	0.12	0.03	0.03	ND	ND
HEPTACHLOR EPOXIDE	ND	ND	0.76	0.46	ND	ND
TRANS NONACHLOR	4.33	1.04	1.57	0.34	1.11	0.09
TOTAL	6.41	1.32	3.59	1.07	1.83	0.29
Chlordanes - Hepatopancreas						
ALPHA-CHLORDANE	26.33	4.18	14.10	6.55	12.47	3.15
HEPTACHLOR	4.30	1.10	0.43	0.43	0.13	0.13
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND
TRANS NONACHLOR	107.00	23.07	43.33	7.62	29.00	3.79
TOTAL	137.63	24.88	57.87	11.20	41.59	6.95
PCBs - Meat						
105	22.67	10.81	7.70	1.91	6.13	2.44
126	ND	ND	ND	ND	ND	ND

TABLE 3-9 (Page 2 of 3)
Summary of Mean Lobster Tissue Contaminant Levels
1997 MWRA Lobster Survey
ng/g dry weight

Parameter	Deer Island		Future Outfall		Cape Cod Bay	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
138	34.00	20.01	15.67	2.19	4.00	0.42
170	9.23	3.42	6.83	1.00	2.13	0.18
180	58.33	26.19	26.67	6.06	13.00	0.58
195	0.81	0.34	2.13	0.81	0.73	0.04
2,2',3,3',4,4'-HEXACHLOROBIPHENYL (128)	13.30	6.40	4.57	1.04	2.50	0.10
2,2',3,4,5,5',6-Cl7	19.50	7.86	13.67	1.86	5.87	0.09
2,2',3,5'-TETRACHLOROBIPHENYL (44)	ND	ND	ND	ND	ND	ND
2,2',4,4',5,5'-HEXACHLOROBIPHENYL (153)	59.00	25.87	30.67	6.49	17.67	0.33
2,2',4,5,5'-PENTACHLOROBIPHENYL	8.00	3.00	3.37	0.89	2.33	0.30
2,2',5,5'-TETRACHLOROBIPHENYL (52)	1.37	0.09	1.87	0.38	0.70	0.70
2,2',5-TRICHLOROBIPHENYL (18)	ND	ND	1.17	0.64	0.47	0.47
2,3',4,4',5-PENTACHLOROBIPHENYL (118)	62.33	29.16	21.33	4.81	12.33	0.33
2,3',4,4'-TETRACHLOROBIPHENYL (66)	15.83	6.66	10.00	4.69	3.43	0.20
2,4'-DICHLOROBIPHENYL (8)	3.57	1.32	5.93	3.21	1.04	0.31
2,4,4'-TRICHLOROBIPHENYL (28)	1.30	0.75	3.07	0.64	4.40	0.87
206	2.13	1.34	2.23	0.03	0.54	0.04
44 DD OLEPHIN (DDMU)	ND	ND	ND	ND	ND	ND
77	ND	ND	ND	ND	ND	ND
DECACHLOROBIPHENYL (209)	0.45	0.10	0.75	0.24	0.28	0.01
TOTAL	311.83	141.59	157.62	21.88	77.55	1.47
PCBs - Hepatopancreas						
105	460.00	160.42	230.00	55.08	126.67	8.82
126	ND	ND	ND	ND	ND	ND
138	753.33	324.16	633.33	184.96	213.33	28.48
170	213.33	88.38	260.00	83.27	84.67	10.73
180	1436.67	531.86	813.33	146.21	496.67	49.10
195	19.33	7.42	71.00	44.52	11.93	1.59
2,2',3,3',4,4'-HEXACHLOROBIPHENYL (128)	260.00	90.18	108.00	66.76	97.00	7.51
2,2',3,4,5,5',6-Cl7	483.33	148.36	456.67	72.19	216.67	14.53
2,2',3,5'-TETRACHLOROBIPHENYL (44)	3.03	1.52	0.60	0.60	1.63	0.82
2,2',4,4',5,5'-HEXACHLOROBIPHENYL (153)	1553.33	573.45	976.67	161.69	616.67	63.60
2,2',4,5,5'-PENTACHLOROBIPHENYL	200.00	61.10	105.33	25.33	72.67	11.57
2,2',5,5'-TETRACHLOROBIPHENYL (52)	24.33	5.55	17.73	9.89	16.00	2.00
2,2',5-TRICHLOROBIPHENYL (18)	7.37	2.50	4.97	1.39	3.67	3.67
2,3',4,4',5-PENTACHLOROBIPHENYL (118)	1226.67	487.21	536.67	113.48	366.67	31.80
2,3',4,4'-TETRACHLOROBIPHENYL (66)	326.67	106.82	338.00	203.32	87.67	4.26
2,4'-DICHLOROBIPHENYL (8)	102.67	29.24	273.67	218.52	24.67	1.45
2,4,4'-TRICHLOROBIPHENYL (28)	ND	ND	ND	ND	ND	ND
206	29.00	5.51	82.33	9.60	28.67	3.84
44 DD OLEPHIN (DDMU)	36.33	21.68	57.33	15.94	22.00	7.23
77	ND	ND	ND	ND	ND	ND
DECACHLOROBIPHENYL (209)	10.27	0.73	27.00	9.29	12.50	2.02
TOTAL	7145.67	2594.76	4992.63	298.34	2499.73	221.54
PAHs - Hepatopancreas						
ACENAPHTHENE	32.13	26.94	5.17	1.51	36333.33	2185.81
ACENAPHTHYLENE	7.13	4.43	4.43	0.67	1366.67	88.19
ANTHRACENE	89.63	75.31	8.73	3.69	1600.00	152.75
BENZ(A)ANTHRACENE	238.33	180.90	50.00	11.27	563.33	61.73
BENZO(A)PYRENE	143.33	103.49	51.00	11.72	51.33	1.33
BENZO(B)FLUORANTHENE	241.67	159.31	85.00	11.24	113.33	3.33
BENZO(E)PYRENE	142.67	58.67	120.67	31.52	71.67	1.45
BENZO(G,H,I)PERYLENE	70.33	29.87	64.00	18.19	25.00	2.08
BENZO(K)FLUORANTHENE	96.00	57.05	45.00	8.66	36.67	2.40
BIPHENYL	8.40	2.90	5.50	2.28	3700.00	208.17
C1-CHRYSENE	202.33	138.86	78.33	27.74	67.67	2.73
C1-DIBENZOTHIOPHENES	81.00	49.50	28.00	9.07	256.67	23.33

TABLE 3-9 (Page 3 of 3)
Summary of Mean Lobster Tissue Contaminant Levels
1997 MWRA Lobster Survey
ng/g dry weight

Parameter	Deer Island		Future Outfall		Cape Cod Bay	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
C1-FLUORANTHENES/PYRENE	590.00	405.01	193.33	53.64	2233.33	218.58
C1-FLUORENES	79.67	50.17	37.63	20.92	1600.00	152.75
C1-NAPTHALENE	31.33	11.57	11.93	1.59	10200.00	416.33
C1-PHENANTHRENES/ANTHRACENE	413.33	293.33	77.67	22.36	1766.67	185.59
C2-CHRYSENE	152.67	93.67	142.00	94.71	27.33	3.53
C2-DIBENZOTHIOPHENE	243.33	128.37	65.00	27.50	83.33	42.56
C2-FLUORENE	196.00	87.23	76.00	47.09	596.67	79.65
C2-NAPTHALENE	81.33	39.49	23.67	4.33	9800.00	757.19
C2-PHENANTHRENE/ANTHRACENE	600.00	350.05	139.33	55.92	743.33	92.44
C2F/P	366.67	241.68	267.00	172.65	426.67	46.67
C3-CHRYSENE	56.67	56.67	ND	ND	ND	ND
C3-DIBENZOTHIOPHENE	207.33	106.46	165.00	127.67	41.33	21.62
C3-FLUORENE	230.00	105.36	84.00	48.17	253.33	26.03
C3-NAPTHALENE	199.67	115.17	44.67	18.00	2333.33	240.37
C3-PHENANTHRENE/ANTHRACENE	446.67	231.83	144.00	45.71	200.00	5.77
C3F/P	185.67	112.17	78.67	28.39	78.33	2.03
C4-CHRYSENE	31.67	31.67	ND	ND	ND	ND
C4-NAPTHALENE	259.00	150.65	36.67	13.78	490.00	55.68
C4-PHENANTHRENE/ANTHRACENE	233.33	118.37	97.67	38.43	60.00	30.55
CHRYSENE	396.67	216.74	158.67	35.80	300.00	20.00
DIBENZO(A,H)ANTHRACENE	9.60	6.91	5.97	1.43	2.93	0.24
DIBENZOFURAN	35.00	24.01	13.60	2.91	21333.33	1201.85
DIBENZOTHIOPHENE	31.70	25.16	6.87	2.13	1966.67	176.38
FLUORANTHENE	760.00	420.16	213.33	28.48	10633.33	1225.20
FLUORENE	53.60	43.21	11.67	4.37	17333.33	1201.85
INDENO(1,2,3-CD)PYRENE	90.33	54.96	41.67	8.09	28.00	2.52
NAPHTHALENE	25.33	7.69	21.00	5.51	16666.67	1201.85
PERYLENE	37.67	21.79	31.00	11.06	18.67	1.20
PHENANTHRENE	373.67	313.37	55.67	19.78	15666.67	1763.83
PYRENE	653.33	423.49	270.00	115.33	8700.00	750.56
TOTAL	8424.20	5170.05	3059.50	1153.71	167768.93 (a)	11612.14
BENZOTHIAZOLE	25.67	5.24	1356.33	1321.88	61.67	15.94
Metals - Meat						
Mercury	1.47	0.11	1.12	0.08	0.98	0.07
Metals - Hepatopancreas						
Cadmium	6.98	1.06	11.89	1.89	13.71	0.98
Chromium	0.26	0.02	0.30	0.07	0.10	0.02
Copper	641.20	106.74	513.48	202.59	294.48	40.56
Lead	0.39	0.05	0.30	0.05	0.04	0.02
Mercury	0.43	0.08	0.44	0.04	0.40	0.01
Nickel	0.57	0.07	1.26	0.23	0.89	0.24
Silver	6.52	0.58	13.23	2.41	9.42	2.33
Zinc	84.09	23.69	80.33	13.78	57.92	3.42

ND - Not Dectected (considered as 0 in calculations).

(a) - The 1997 concentration of Total PAH at Eastern Cape Cod Bay was extremely elevated and may reflect contamination during sampling.

Table 3-10
Concentrations of Selected Organic Compounds Normalized for Lipids [1]
Lobster Meat and Hepatopancreas, 1992 - 1997
ng/g Lipid

Parameter	Year	Deer Island		Future Outfall Site		Eastern Cape Cod Bay	
		Average	S.E.	Average	S.E.	Average	S.E.
Lobster Meat							
Total DDT	1992	81.83	0.72	73.45	9.85	174.04	81.93
	1993	1125.78	293.65	251.90	NC	566.03	275.14
	1994	287.26	65.50	191.59	4.59	209.61	25.58
	1995	275.19	45.85	351.51	61.81	280.05	41.12
	1996	694.94	105.32	556.28	87.76	409.09	39.06
	1997	1285.68	525.63	605.91	164.18	445.91	19.09
	Baseline Mean	**625.11**	**201.96**	**338.44**	**85.33**	**347.46**	**61.88**
Total PCBs	1992	521.18	5.61	455.05	95.77	824.96	439.72
	1993	5984.82	1409.89	1802.41	NC	3083.60	1402.08
	1994	1669.58	427.68	1504.61	319.95	1356.43	305.27
	1995	2484.96	458.20	2937.21	620.13	1613.98	184.26
	1996	5875.59	974.60	4439.00	96.97	2160.57	150.09
	1997	8719.73	3180.67	4638.01	496.87	2383.03	149.64
	Baseline Mean	**4209.31**	**1281.91**	**2629.38**	**685.10**	**1903.76**	**328.38**
Lobster Hepatopancreas							
Total DDT	1992	884.52	285.12	830.00	309.74	646.00	141.67
	1993	1601.21	197.45	563.50	NC	598.56	74.71
	1994	578.05	83.62	529.14	193.25	243.56	34.97
	1995	1096.48	331.40	1448.02	39.02	1111.54	106.83
	1996	2253.02	272.40	2005.51	92.98	1143.30	199.44
	1997	2370.42	1398.04	1923.94	564.55	1336.29	245.04
	Baseline Mean	**1463.95**	**301.04**	**1216.69**	**272.33**	**846.54**	**169.65**
Total PAHs	1992	43408.68	7511.37	6911.65	1022.48	14983.88	6833.23
	1993	33395.75	16592.23	11216.54	NC	7065.35	2500.70
	1994	23725.57	4717.22	7971.38	670.81	1141.18	112.87
	1995	8651.85	1684.89	10355.55	1450.59	6440.68	1241.28
	1996	22729.95	3920.18	12109.68	2923.68	3868.67	1177.48
	1997	17872.57	11332.61	5322.97	1729.94	NA [2]	--
	Baseline Mean	**24964.06**	**4947.05**	**8981.30**	**1085.64**	**6699.95**	**2320.99**
Total PCBs	1992	4739.48	739.05	3650.39	1137.97	3817.41	1586.46
	1993	7197.26	1346.41	4354.72	NC	4127.62	925.07
	1994	3537.34	493.79	4179.81	2542.39	959.81	126.52
	1995	7540.79	2718.39	8163.87	636.82	4165.74	474.45
	1996	13083.99	1775.71	10893.80	729.30	4025.39	530.35
	1997	14977.04	5866.27	9003.47	1332.54	4229.54	370.21
	Baseline Mean	**8512.65**	**1865.04**	**6707.68**	**1240.81**	**3554.25**	**522.21**

Notes:
[1] Formula: concentration/percent lipid.
[2] The 1997 concentration of Total PAH at Eastern Cape Cod Bay was extremely elevated and may reflect contamination during sampling. from consideration.
S.E. - Standard Error.
NC - Not Calculated due to small sample size.
NA - Not Applicable.

TABLE 3-11

Comparison of FDA Legal Limits to Mean Concentrations (wet weight) of Select Compounds In Lobster Edible Tissues - 1997

Compound/Analyte	Deer Island Mean	Deer Island S.E.	Future Outfall Site Mean	Future Outfall Site S.E.	Cape Cod Bay Mean	Cape Cod Bay S.E.	FDA Legal Limit [1]	Caution Level [3]	Warning Level [4]
Total DDT (ppb)	6.69	3.71	2.61	0.46	2.30	0.06	5,000 [2]	NA	NA
Total Chlordanes (ppb)	0.89	0.23	0.47	0.11	0.29	0.04	300	NA	NA
Dieldrin (ppb)	0.94	0.16	0.82	0.02	0.66	0.02	300	NA	NA
Total PCBs (ppb)	44.77	23.03	20.78	0.31	12.30	0.87	2,000	1,000	1,600
Mercury (ppm)	0.24	0.03	0.18	0.04	0.17	0.01	1	0.5	0.8

Notes:

[1] U.S. EPA 1989. Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish. EPA-503/8-89-002. Office of Marine and Estuarine Protection (WH-556F) and the Office of Water Regulations and Standards (WH-552), Washington, D.C.

[2] The value represents the FDA Legal Limits for DDT (5 ppm), DDE (5 ppm), and DDD (5 ppm), which comprise the mean total DDT tissue concentration. A total DDT tissue concentration below 5 ppm assumes that all DDT derivations are not exceeded.

[3] Massachusetts Water Resources Authority (MWRA) 1997. Contingency Plan. Caution Level is 50% the FDA Legal Limit, and applies to the outfall site only.

[4] Massachusetts Water Resources Authority (MWRA) 1997. Contingency Plan. Warning Level is 80% of the FDA Legal Limit, and applies to the outfall site only.

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Table 3-12
Mussel harvest and analysis design summary for 1997

Station	Pre-Deployment Analysis				Forty-day Harvest			Sixty-day Harvest		
	Mussels	Arrays	Cages	Biology [1]	Mussels	Arrays	Cages	Mussels	Cages	Biology [1]
Gloucester	NA	NA	NA	30	NA	NA	NA	NA	NA	NA
Sandwich	NA	NA	NA	10	NA	NA	NA	NA	NA	NA
Future Outfall Site										
Gloucester harvested	400	4	8	NA	97	1	2	305	6	30
Sandwich harvested	200	4	4	NA	53	1	1	156	3	5
Deer Island										
Gloucester harvested	300	3	6	NA	103	1	2	97	4	29
Sandwich harvested	150	3	3	NA	52	1	1	50	2	5
Discovery										
Gloucester harvested	200	2	4	NA	103	1	2	93	2	28
Sandwich harvested	100	2	2	NA	52	1	1	39	1	5
Total										
Gloucester harvested	900	9	18	30	303	3	6	495	12	87
Sandwich harvested	450	9	9	10	157	3	3	245	6	15

Notes:
1 Biological analyses included sex, sexual maturity, wet/dry weight of gonad-mantle and non-gonadal soft tissue, and total shell length determinations.

Table 3-13
Survival and stage of gametogenesis of mussels following predeployment, forty-day, and sixty-day collections at specific stations

Station	Number	Percent Survival	Sample Size	Females		Males	
				Mature	Immature	Mature	Immature
Predeployment							
Gloucester	NA	NA	30	14	3	3	10
Sandwich	NA	NA	10	0	2	5	3
Forty-day harvest							
Future Outfall Site							
Gloucester harvested	97	98	NA	NA	NA	NA	NA
Sandwich harvested	52	95	NA	NA	NA	NA	NA
Deer Island							
Gloucester harvested	103	100	NA	NA	NA	NA	NA
Sandwich harvested	53	98	NA	NA	NA	NA	NA
Discovery							
Gloucester harvested	103	95	NA	NA	NA	NA	NA
Sandwich harvested	52	100	NA	NA	NA	NA	NA
Sixty-day harvest							
Future Outfall Site							
Gloucester harvested	305	98	30	11	2	15	2
Sandwich harvested	156	96	5	5	0	0	0
Deer Island							
Gloucester harvested	97	94	30	11	5	12	1
Sandwich harvested	50	91	5	3	0	2	0
Discovery							
Gloucester harvested	93	86	17	12	3	10	3
Sandwich harvested	39	78	5	1	2	2	0

Notes:
NA - Not Applicable.

TABLE 3-14

Mean Shell Length and Mussel Weight of Mussels Collected in 1997

Station	Mean Shell Length (mm)	Mean Wet Weight (g)				
		Total Organism	Gonad-Mantle	Non-gonadal Soft Tissue	Total Soft Tissue	Shell
Predeployment						
Gloucester	64.2	27.8	3.5	5.2	8.7	16.0
Sandwich	64.4	25.6	4.0	5.5	9.5	13.5
60 Day Retrieval						
Deer Island (Gloucester derived)	64.4	31.4	4.0	6.5	10.4	16.1
Deer Island (Sandwich derived)	65.6	26.9	3.7	5.2	8.9	14.6
Future Outfall Site (Gloucester derived)	66.2	30.5	4.9	7.4	12.3	16.2
Future Outfall Site (Sandwich derived)	64.7	26.2	5.2	6.1	11.3	14.5
Discovery (Gloucester derived)	64.5	28.5	2.7	5.4	8.1	15.8
Discovery (Sandwich derived)	64.8	25.5	2.9	4.2	7.1	14.9

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TABLE 3-15

Summary of Low Molecular Weight (LMW) and High Molecular Weight (HMW) Examined in 1997 and the Comparable Analytes from Previous Studies (1991-1996)

1997 PAH Analytes ("Total PAHs")	1997 NOAA PAH Analytes ("Total NOAA PAHs")	Comparable NOAA PAHs Analyzed Prior to 1995 ("Historic NOAA list")
	Low Molecular Weight PAHs	
ACENAPHTHENE	ACENAPHTHENE	ACENAPHTHENE
ACENAPHTHYLENE	ACENAPHTHYLENE	ACENAPHTHYLENE
ANTHRACENE	ANTHRACENE	ANTHRACENE
BENZOTHIAZOLE		
BIPHENYL	BIPHENYL	1,1 BIPHENYL
DIBENZOFURAN		
DIBENZOTHIOPHENE		
C1-DIBENZOTHIOPHENES		
C2-DIBENZOTHIOPHENE		
C3-DIBENZOTHIOPHENE		
2,6-DIMETHYLNAPHTHALENE	2,6-DIMETHYLNAPHTHALENE	2,6-DIMETHYLNAPHTHALENE
FLUORENE	FLUORENE	FLUORENE
C1-FLUORENE		
C2-FLUORENE		
C3-FLUORENE		
1-METHYLNAPHTHALENE	1-METHYLNAPHTHALENE	1-METHYLNAPHTHALENE
2-METHYLNAPHTHALENE	2-METHYLNAPHTHALENE	2-METHYLNAPHTHALENE
1-METHYLPHENANTHRENE	1-METHYLPHENANTHRENE	1-METHYLPHENANTHRENE
NAPHTHALENE	NAPHTHALENE	NAPHTHALENE
C1-NAPTHALENE	C1-NAPTHALENE	
C2-NAPTHALENE	C2-NAPTHALENE	
C3-NAPTHALENE	C3-NAPTHALENE	
C4-NAPTHALENE		
PHENANTHRENE	PHENANTHRENE	PHENANTHRENE
C1-PHENANTHRENES/ANTHRACENE	C1-PHENANTHRENES/ANTHRACENE	
C2-PHENANTHRENE/ANTHRACENE		
C3-PHENANTHRENE/ANTHRACENE		
C4-PHENANTHRENE/ANTHRACENE		
2,3,5-TRIMETHYNAPHTHALENE	2,3,5-TRIMETHYNAPHTHALENE	2,3,5-TRIMETHYNAPHTHALENE
	High Molecular Weight PAHs	
BENZ(A)ANTHRACENE	BENZ(A)ANTHRACENE	BENZ(A)ANTHRACENE
BENZO(A)PYRENE	BENZO(A)PYRENE	BENZO(A)PYRENE
BENZO(B)FLUORANTHENE	BENZO(B)FLUORANTHENE	BENZO(B)FLUORANTHENE
BENZO(E)PYRENE	BENZO(E)PYRENE	BENZO(E)PYRENE
BENZO(G,H,I)PERYLENE	BENZO(G,H,I)PERYLENE	BENZO(G,H,I)PERYLENE
BENZO(K)FLUORANTHENE	BENZO(K)FLUORANTHENE	BENZO(K)FLUORANTHENE
CHRYSENE	CHRYSENE	CHRYSENE
C1-CHRYSENE		
C2-CHRYSENE		
C3-CHRYSENE		
C4-CHRYSENE		
DIBENZO(A,H)ANTHRACENE	DIBENZO(A,H)ANTHRACENE	DIBENZO(A,H)ANTHRACENE
FLUORANTHENE	FLUORANTHENE	FLUORANTHENE
C1-FLUORANTHENES/PYRENE		
C2-FLUORANTHENES/PYRENE		
C3-FLUORANTHENES/PYRENE		
INDENO(1,2,3-CD)PYRENE	INDENO(1,2,3-CD)PYRENE	INDENO(1,2,3-CD)PYRENE
PERYLENE	PERYLENE	PERYLENE
PYRENE	PYRENE	PYRENE

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TABLE 3-16
PAH Concentration in 1997 Mussels
(ng/g dry weight)

Parameter	Gloucester Predeployment				
	M9711H7TC1	M9711H7TC2	M9711H7TC3	M9711H7TC4	M9711H7TC5
Low Molecular Weight PAHs					
1-METHYLNAPHTHALENE	3.3	12	5.6	5.7	2.4
1-METHYLPHENANTHRENE	2.7	3.1	3.9	2.7	2.7
2,3,5-TRIMETHYNAPHTHALENE	10	1.2	1.5	1.8	1.2
2,6-DIMETHYLNAPHTHALENE	1.8	5.1	6.1	2.9	1.5
2-METHYLNAPHTHALENE	6	27	15	14	4.7
ACENAPHTHENE	1.7	1.8	1.2	2.7	1.1
ACENAPHTHYLENE	1.7	2.9	2.5	2.2	2.8
ANTHRACENE	2.8	3.7	3.2	3.2	4.7
BENZOTHIAZOLE	86	17	130	19	17
BIPHENYL	3.8	2.4	3.4	3.2	2.5
C1-DIBENZOTHIOPHENES	2.6	2.9	4.7	2.9	2.3
C1-FLUORENES	4.4	4.8	5.1	5.3	4
C1-NAPTHALENE	7.4	29	15	15	5.1
C1-PHENANTHRENES/ANTHRACENE	11	13	23	12	11
C2-DIBENZOTHIOPHENE	7	8.8	9.7	9.3	8
C2-FLUORENE	4	8.3	11	8.9	4
C2-NAPTHALENE	9.4	25	19	11	8.7
C2-PHENANTHRENE/ANTHRACENE	16	18	25	17	18
C3-DIBENZOTHIOPHENE	6.5	6.5	8.8	7.2	7.7
C3-FLUORENE	4	4	13	4	4
C3-NAPTHALENE	7	16	16	12	12
C3-PHENANTHRENE/ANTHRACENE	13	13	19	14	16
C4-NAPTHALENE	7	7	7	7	7
C4-PHENANTHRENE/ANTHRACENE	13	10	18	12	11
DIBENZOFURAN	4.7	3.2	4.1	4.3	3.1
DIBENZOTHIOPHENE	1.3	1.3	2.2	1.4	2.2
FLUORENE	2.9	3.2	3.4	3	2.4
NAPHTHALENE	13	20	10	18	7.9
PHENANTHRENE	11	10	18	12	9
Total LMW PAHs	265	280.2	404.4	233.7	175.1
Total NOAA LMW PAHs	71.7	127	114.7	94.3	67.2
Total Historic NOAA LMW PAHs	60.7	92.4	73.8	71.4	42.9
High Molecular Weight PAHs					
BENZ(A)ANTHRACENE	5.5	5.8	7.4	6.3	5.6
BENZO(A)PYRENE	3	2.9	3.8	4	1.9
BENZO(B)FLUORANTHENE	6.5	6.6	7.7	7.4	6.8
BENZO(E)PYRENE	7.5	7.4	9.8	9.2	10
BENZO(G,H,I)PERYLENE	4	3.3	7.4	5	5.1
BENZO(K)FLUORANTHENE	2.3	1.6	2.6	3.1	2.9
C1-CHRYSENE	3.9	4.2	10	4.6	3.2
C1-FLUORANTHENES/PYRENE	12	14	19	13	14
C2-CHRYSENE	2.9	3.1	7.1	3.6	6.6
C2F/P	8	7.6	14	7.2	6.6
C3-CHRYSENE	6.6	6.6	6.6	6.6	6.6
C3F/P	6.6	6.6	6.6	6.6	6.6
C4-CHRYSENE	6.6	6.6	6.6	6.6	6.6
CHRYSENE	9.6	11	14	12	11
DIBENZO(A,H)ANTHRACENE	0.64	0.51	0.74	0.7	0.38
FLUORANTHENE	22	24	24	26	29
INDENO(1,2,3-CD)PYRENE	2.8	2.6	3.2	3.8	2.2
PERYLENE	1.1	0.98	1.3	1.4	1
PYRENE	14	14	17	15	14
Total HMW PAHs	125.54	129.39	168.84	142.1	140.08
Total NOAA HMW PAHs	78.94	80.69	98.94	93.9	89.88
Total Historic NOAA PAHs	78.94	80.69	98.94	93.9	89.88
Total PAHs	390.54	409.59	573.24	375.8	315.18
Total NOAA PAHs	150.64	207.69	213.64	188.2	157.08
Total Historic NOAA PAHs	139.64	173.09	172.74	165.3	132.78

Shaded values indicate compound was not detected. The MDL (Method Detection Limit) is used as an estimated concentration. MDLs are not available for 2,3,5 - Trimethylnaphthalene and 2-6 Dimethylnapthalene, so Minumum Reporting Limits are used.

TABLE 3-16
PAH Concentration in 1997 Mussels
(ng/g dry weight)

Parameter	Deer Island, August 1996				
	M9711D1H7TC1	M9711D1H7TC2	M9711D1H7TC3	M9711D1H7TC4	M9711D1H7TC5
Low Molecular Weight PAHs					
1-METHYLNAPHTHALENE	5.3	5.2	5.2	4.8	6.2
1-METHYLPHENANTHRENE	8.6	7.3	6.8	8.3	9
2,3,5-TRIMETHYNAPHTHALENE	3.5	3.6	2.6	3	3.6
2,6-DIMETHYLNAPHTHALENE	5.7	5.8	4.4	4.5	5.4
2-METHYLNAPHTHALENE	9.7	9.6	9.8	9.3	10
ACENAPHTHENE	3.6	3.8	2.8	2.7	2.7
ACENAPHTHYLENE	2.9	2.9	2.9	3.9	4.3
ANTHRACENE	6.7	5.5	5	6.8	10
BENZOTHIAZOLE	16	15	43	14	23
BIPHENYL	3.8	3.2	3.1	1.7	1.7
C1-DIBENZOTHIOPHENES	11	12	12	9	12
C1-FLUORENES	18	18	15	14	18
C1-NAPTHALENE	9.9	11	11	9.8	11
C1-PHENANTHRENES/ANTHRACENE	37	36	30	32	40
C2-DIBENZOTHIOPHENE	44	41	34	32	46
C2-FLUORENE	34	34	24	28	39
C2-NAPTHALENE	25	24	22	16	23
C2-PHENANTHRENE/ANTHRACENE	77	70	59	65	93
C3-DIBENZOTHIOPHENE	62	55	48	42	59
C3-FLUORENE	76	68	64	70	87
C3-NAPTHALENE	48	48	35	33	41
C3-PHENANTHRENE/ANTHRACENE	77	69	63	62	85
C4-NAPTHALENE	86	85	65	55	76
C4-PHENANTHRENE/ANTHRACENE	60	59	52	38	66
DIBENZOFURAN	4.3	4.4	5.3	5.4	5.8
DIBENZOTHIOPHENE	3	3	2.5	2.4	3.9
FLUORENE	4.8	4.6	4.5	4.6	5.4
NAPHTHALENE	11	12	13	13	13
PHENANTHRENE	20	21	21	19	22
Total LMW PAHs	773.8	736.9	665.9	609.2	822
Total NOAA LMW PAHs	172.7	172	150.3	142.5	174.1
Total Historic NOAA LMW PAHs	85.6	84.5	81.1	81.6	93.3
High Molecular Weight PAHs					
BENZ(A)ANTHRACENE	16	16	16	14	22
BENZO(A)PYRENE	9.4	8.5	10	5.7	7.6
BENZO(B)FLUORANTHENE	24	22	24	22	30
BENZO(E)PYRENE	33	32	31	38	41
BENZO(G,H,I)PERYLENE	13	11	14	12	12
BENZO(K)FLUORANTHENE	9.3	7.6	9.6	7.2	9.2
C1-CHRYSENE	14	14	13	10	16
C1-FLUORANTHENES/PYRENE	45	43	39	40	58
C2-CHRYSENE	8.8	8.3	8.7	6.6	12
C2F/P	32	28	28	25	40
C3-CHRYSENE	6.6	6.6	6.6	6.6	6.6
C3F/P	17	20	15	14	19
C4-CHRYSENE	6.6	6.6	6.6	6.6	6.6
CHRYSENE	31	28	29	30	44
DIBENZO(A,H)ANTHRACENE	1.6	1.5	1.8	1.2	1.4
FLUORANTHENE	50	50	43	52	63
INDENO(1,2,3-CD)PYRENE	7.9	6.9	9.5	7	7
PERYLENE	3.2	3.2	3.5	2.7	4.4
PYRENE	58	56	50	57	74
Total HMW PAHs	386.4	369.2	358.3	357.6	473.8
Total NOAA HMW PAHs	256.4	242.7	241.4	248.8	315.6
Total Historic NOAA PAHs	256.4	242.7	241.4	248.8	315.6.
Total PAHs	1160.2	1106.1	1024.2	966.8	1295.8
Total NOAA PAHs	429.1	414.7	391.7	391.3	489.7
Total Historic NOAA PAHs	342	327.2	322.5	330.4	408.9

Shaded values indicate compound was not detected. The MDL (Method Detection Limit) is used as an estimated concentration. MDLs are not available for 2,3,5 - Trimethylnaphthalene and 2-6 Dimethylnapthalene, so Minumum Reporting Limits are used.

TABLE 3-16
PAH Concentration in 1997 Mussels
(ng/g dry weight)

Parameter	Future Outfall Site, August 1996				
	M9711D4H7TC1	M9711D4H7TC2	M9711D4H7TC3	M9711D4H7TC4	M9711D4H7TC5
Low Molecular Weight PAHs					
1-METHYLNAPHTHALENE	2.1	1.6	12	2.7	1.4
1-METHYLPHENANTHRENE	0.9	1.1	1.1	1.2	0.99
2,3,5-TRIMETHYNAPHTHALENE	10	10	1.7	10	10
2,6-DIMETHYLNAPHTHALENE	0.98	10	6.2	10	10
2-METHYLNAPHTHALENE	3.8	2.9	31	5.1	2.5
ACENAPHTHENE	2.7	2.7	2.7	2.7	2.7
ACENAPHTHYLENE	0.97	1.1	0.86	0.94	1.1
ANTHRACENE	1.6	1.8	1.8	2.1	1.8
BENZOTHIAZOLE	19	43	22	88	46
BIPHENYL	1.7	2.2	3.1	1.9	2.6
C1-DIBENZOTHIOPHENES	4	4	4	4	4
C1-FLUORENES	4	4	4	4	4
C1-NAPTHALENE	3.9	3.2	30	5.5	2.8
C1-PHENANTHRENES/ANTHRACENE	3.4	3.7	4.5	4.5	3.7
C2-DIBENZOTHIOPHENE	2.2	2.2	2.2	2.2	2.2
C2-FLUORENE	4	4	4	4	4
C2-NAPTHALENE	7	7	20	7	7
C2-PHENANTHRENE/ANTHRACENE	2.1	2.1	4.6	4.8	4.1
C3-DIBENZOTHIOPHENE	2.2	2.2	2.2	2.2	2.2
C3-FLUORENE	4	4	4	4	4
C3-NAPTHALENE	7	7	13	7	7
C3-PHENANTHRENE/ANTHRACENE	2.1	2.1	2.1	2.1	2.1
C4-NAPTHALENE	7	7	7	7	7
C4-PHENANTHRENE/ANTHRACENE	2.1	2.1	2.1	2.1	2.1
DIBENZOFURAN	3.4	2.9	4.3	3.5	4.1
DIBENZOTHIOPHENE	2.2	2.2	1.3	2.2	2.2
FLUORENE	2.1	1.3	1.7	3	1.4
NAPHTHALENE	8.7	7	22	9.6	7
PHENANTHRENE	6.5	6.3	7.4	10	6.6
Total LMW PAHs	119.25	150.7	222.86	213.34	156.59
Total NOAA LMW PAHs	43.17	43.3	107.06	54.24	43.7
Total Historic NOAA LMW PAHs	42.05	48	91.56	59.24	48.09
High Molecular Weight PAHs					
BENZ(A)ANTHRACENE	2.1	2.7	2.9	3.2	2.5
BENZO(A)PYRENE	0.77	1	0.9	1.4	1.1
BENZO(B)FLUORANTHENE	1.4	2.5	2.2	2.6	2.3
BENZO(E)PYRENE	1.7	2.3	2.6	2.4	2.4
BENZO(G,H,I)PERYLENE	1.2	1.7	1.6	1.7	3
BENZO(K)FLUORANTHENE	0.69	0.81	0.89	0.97	1.1
C1-CHRYSENE	6.6	6.6	6.6	6.6	6.6
C1-FLUORANTHENES/PYRENE	6.6	6.6	6.6	6.6	6.6
C2-CHRYSENE	6.6	6.6	6.6	6.6	6.6
C2F/P	6.6	6.6	6.6	6.6	6.6
C3-CHRYSENE	6.6	6.6	6.6	6.6	6.6
C3F/P	6.6	6.6	6.6	6.6	6.6
C4-CHRYSENE	6.6	6.6	6.6	6.6	6.6
CHRYSENE	2.1	2.8	2.4	2.9	2.3
DIBENZO(A,H)ANTHRACENE	0.11	0.63	0.11	0.81	0.5
FLUORANTHENE	3.7	4.3	4.6	5.2	4.1
INDENO(1,2,3-CD)PYRENE	0.79	1.6	1.3	1.5	1.2
PERYLENE	0.36	0.55	0.48	0.54	0.48
PYRENE	3	3.7	3.6	4.9	3.4
Total HMW PAHs	75.01	70.79	80.67	74.32	70.58
Total NOAA HMW PAHs	28.81	24.59	34.47	28.12	24.38
Total Historic NOAA PAHs	28.81	24.59	34.47	28.12	24.38
Total PAHs	194.26	221.49	303.53	287.66	227.17
Total NOAA PAHs	71.98	67.89	141.53	82.36	68.08
Total Historic NOAA PAHs	70.86	72.59	126.03	87.36	72.47

Shaded values indicate compound was not detected. The MDL (Method Detection Limit) is used as an estimated concentration. MDLs are not available for 2,3,5 - Trimethylnaphthalene and 2-6 Dimethylnapthalene, so Minumum Reporting Limits are used.

TABLE 3-16
PAH Concentration in 1997 Mussels
(ng/g dry weight)

Parameter	Discovery, August 1996				
	M9711D6H7TC1	M9711D6H7TC2	M9711D6H7TC3	M9711D6H7TC4	M9711D6H7TC5
Low Molecular Weight PAHs					
1-METHYLNAPHTHALENE	2.8	4.5	4.9	6.5	4.9
1-METHYLPHENANTHRENE	7	5.6	8	10	7.8
2,3,5-TRIMETHYNAPHTHALENE	1.8	2	1.5	2.9	2.7
2,6-DIMETHYLNAPHTHALENE	2	2.2	2.5	3.6	2.9
2-METHYLNAPHTHALENE	5.6	8.4	9.4	12	8.6
ACENAPHTHENE	6.9	6.2	6.9	8.5	7.8
ACENAPHTHYLENE	19	14	18	20	19
ANTHRACENE	33	25	32	39	33
BENZOTHIAZOLE	76	83	100	91	60
BIPHENYL	3.7	4.1	4.8	5.8	4.9
C1-DIBENZOTHIOPHENES	14	9.8	13	16	17
C1-FLUORENES	12	11	10	14	12
C1-NAPTHALENE	5.6	9	10	12	9.7
C1-PHENANTHRENES/ANTHRACENE	42	34	39	55	48
C2-DIBENZOTHIOPHENE	55	45	49	66	67
C2-FLUORENE	46	32	45	50	46
C2-NAPTHALENE	10	11	13	15	11
C2-PHENANTHRENE/ANTHRACENE	110	86	100	140	120
C3-DIBENZOTHIOPHENE	140	100	120	180	170
C3-FLUORENE	120	96	120	140	110
C3-NAPTHALENE	20	16	18	23	22
C3-PHENANTHRENE/ANTHRACENE	190	150	160	210	190
C4-NAPTHALENE	52	48	49	64	52
C4-PHENANTHRENE/ANTHRACENE	280	200	250	330	290
DIBENZOFURAN	7.5	9	10	11	9.1
DIBENZOTHIOPHENE	2.2	3.4	2.9	5.4	4
FLUORENE	6	7	6.9	9.1	6.8
NAPHTHALENE	14	22	24	30	22
PHENANTHRENE	21	24	28	43	32
Total LMW PAHs	1305.1	1068.2	1255.8	1612.8	1390.2
Total NOAA LMW PAHs	181.2	172.3	200.6	260.4	216.2
Total Historic NOAA LMW PAHs	122.8	125	146.9	190.4	152.4
High Molecular Weight PAHs					
BENZ(A)ANTHRACENE	99	85	99	130	110
BENZO(A)PYRENE	42	43	50	80	67
BENZO(B)FLUORANTHENE	160	150	180	240	210
BENZO(E)PYRENE	180	160	180	220	210
BENZO(G,H,I)PERYLENE	46	54	62	84	73
BENZO(K)FLUORANTHENE	40	43	54	60	54
C1-CHRYSENE	97	84	100	140	100
C1-FLUORANTHENES/PYRENE	220	180	210	270	240
C2-CHRYSENE	75	67	77	99	76
C2F/P	210	170	180	240	210
C3-CHRYSENE	36	40	45	56	44
C3F/P	130	98	120	160	140
C4-CHRYSENE	6.6	6.6	6.6	6.6	6.6
CHRYSENE	170	130	160	200	170
DIBENZO(A,H)ANTHRACENE	6	7	8	12	9.8
FLUORANTHENE	180	150	180	220	200
INDENO(1,2,3-CD)PYRENE	25	32	39	67	53
PERYLENE	19	19	21	27	27
PYRENE	270	220	250	310	280
Total HMW PAHs	2011.6	1738.6	2021.6	2621.6	2280.4
Total NOAA HMW PAHs	1237	1093	1283	1650	1463.8
Total Historic NOAA PAHs	1237	1093	1283	1650	1463.8
Total PAHs	3316.7	2806.8	3277.4	4234.4	3670.6
Total NOAA PAHs	1418.2	1265.3	1483.6	1910.4	1680
Total Historic NOAA PAHs	1359.8	1218	1429.9	1840.4	1616.2

Shaded values indicate compound was not detected. The MDL (Method Detection Limit) is used as an estimated concentration. MDLs are not available for 2,3,5 - Trimethylnaphthalene and 2-6 Dimethylnapthalene, so Minumum Reporting Limits are used.

TABLE 3-17
Summary PAH Concentration in 1997 Mussels
(ng/g dry weight)

	Gloucester Predeployment - June 1997 (Sample size =5)					Deer Island - August 1997 (Sample size = 5)					Future Outfall Site, August 1997 (Sample size = 5)					Discovery, August 1997 (Sample size = 5)				
Parameter	Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range	
Low Molecular Weight PAHs																				
1-METHYLNAPHTHALENE	5.80	3.75	1.68	2.40	12.00	5.34	0.52	0.23	4.80	6.20	3.96	4.52	2.02	1.40	12.00	4.72	1.32	0.59	2.80	6.50
1-METHYLPHENANTHRENE	3.02	0.52	0.23	2.70	3.90	8.00	0.92	0.41	6.80	9.00	1.06	0.12	0.05	0.90	1.20	7.68	1.60	0.72	5.60	10.00
2,3,5-TRIMETHYNAPHTHALENE	3.14	3.84	1.72	1.20	10.00	3.26	0.44	0.20	2.60	3.60	8.34	3.71	1.66	1.70	10.00	2.18	0.60	0.27	1.50	2.90
2,6-DIMETHYLNAPHTHALENE	3.48	2.04	0.91	1.50	6.10	5.16	0.67	0.30	4.40	5.80	7.44	3.97	1.77	0.98	10.00	2.64	0.63	0.28	2.00	3.60
2-METHYLNAPHTHALENE	13.34	8.92	3.99	4.70	27.00	9.68	0.26	0.12	9.30	10.00	9.06	12.31	5.50	2.50	31.00	8.80	2.29	1.03	5.60	12.00
ACENAPHTHENE	1.70	0.64	0.28	1.10	2.70	3.12	0.54	0.24	2.70	3.80	2.70	0.00	0.00	2.70	2.70	7.26	0.90	0.40	6.20	8.50
ACENAPHTHYLENE	2.42	0.49	0.22	1.70	2.90	3.38	0.67	0.30	2.90	4.30	0.99	0.10	0.05	0.86	1.10	18.00	2.35	1.05	14.00	20.00
ANTHRACENE	3.52	0.73	0.33	2.80	4.70	6.80	1.95	0.87	5.00	10.00	1.82	0.18	0.08	1.60	2.10	32.40	4.98	2.23	25.00	39.00
BENZOTHIAZOLE	53.80	51.87	23.20	17.00	130.00	22.20	12.15	5.44	14.00	43.00	43.60	27.61	12.35	19.00	88.00	82.00	15.22	6.80	60.00	100.00
BIPHENYL	3.06	0.60	0.27	2.40	3.80	2.70	0.95	0.43	1.70	3.80	2.30	0.56	0.25	1.70	3.10	4.66	0.81	0.36	3.70	5.80
C1-DIBENZOTHIOPHENES	3.08	0.94	0.42	2.30	4.70	11.20	1.30	0.58	9.00	12.00	4.00	0.00	0.00	4.00	4.00	13.96	2.81	1.26	9.80	17.00
C1-FLUORENES	4.72	0.53	0.24	4.00	5.30	16.60	1.95	0.87	14.00	18.00	4.00	0.00	0.00	4.00	4.00	11.80	1.48	0.66	10.00	14.00
C1-NAPTHALENE	14.30	9.35	4.18	5.10	29.00	10.54	0.63	0.28	9.80	11.00	9.08	11.74	5.25	2.80	30.00	9.26	2.33	1.04	5.60	12.00
C1-PHENANTHRENES/ANTHRACENE	14.00	5.10	2.28	11.00	23.00	35.00	4.00	1.79	30.00	40.00	3.96	0.51	0.23	3.40	4.50	43.60	8.14	3.64	34.00	55.00
C2-DIBENZOTHIOPHENE	8.56	1.08	0.48	7.00	9.70	39.40	6.15	2.75	32.00	46.00	2.20	0.00	0.00	2.20	2.20	56.40	9.89	4.42	45.00	67.00
C2-FLUORENE	7.24	3.12	1.40	4.00	11.00	31.80	5.85	2.62	24.00	39.00	4.00	0.00	0.00	4.00	4.00	43.80	6.87	3.07	32.00	50.00
C2-NAPTHALENE	14.62	7.11	3.18	8.70	25.00	22.00	3.54	1.58	16.00	25.00	9.12	6.17	2.76	4.60	20.00	12.00	2.00	0.89	10.00	15.00
C2-PHENANTHRENE/ANTHRACENE	18.80	3.56	1.59	16.00	25.00	72.80	13.08	5.85	59.00	93.00	3.54	1.34	0.60	2.10	4.80	111.20	20.43	9.13	86.00	140.00
C3-DIBENZOTHIOPHENE	7.34	0.96	0.43	6.50	8.80	53.20	8.17	3.65	42.00	62.00	2.20	0.00	0.00	2.20	2.20	142.00	33.47	14.97	100.00	180.00
C3-FLUORENE	5.80	4.02	1.80	4.00	13.00	73.00	8.94	4.00	64.00	87.00	4.00	0.00	0.00	4.00	4.00	117.20	16.10	7.20	96.00	140.00
C3-NAPTHALENE	12.60	3.71	1.66	7.00	16.00	41.00	7.04	3.15	33.00	48.00	8.20	2.68	1.20	7.00	13.00	19.80	2.86	1.28	16.00	23.00
C3-PHENANTHRENE/ANTHRACENE	15.00	2.55	1.14	13.00	19.00	71.20	9.76	4.36	62.00	85.00	2.10	0.00	0.00	2.10	2.10	180.00	24.49	10.95	150.00	210.00
C4-NAPTHALENE	7.00	0.00	0.00	7.00	7.00	73.40	13.32	5.95	55.00	86.00	7.00	0.00	0.00	7.00	7.00	53.00	6.40	2.86	46.00	64.00
C4-PHENANTHRENE/ANTHRACENE	11.02	5.79	2.59	2.10	18.00	55.00	10.72	4.80	38.00	66.00	2.10	0.00	0.00	2.10	2.10	270.00	48.48	21.68	200.00	330.00
DIBENZOFURAN	3.86	0.70	0.31	3.10	4.70	5.04	0.66	0.29	4.30	5.80	3.64	0.56	0.25	2.90	4.30	9.32	1.30	0.58	7.50	11.00
DIBENZOTHIOPHENE	1.68	0.48	0.21	1.30	2.20	2.96	0.59	0.27	2.40	3.90	2.02	0.40	0.18	1.30	2.20	3.58	1.21	0.54	2.20	5.40
FLUORENE	2.98	0.38	0.17	2.40	3.40	4.78	0.36	0.16	4.50	5.40	1.90	0.69	0.31	1.30	3.00	7.16	1.15	0.52	6.00	9.10
NAPHTHALENE	13.78	5.15	2.30	7.90	20.00	12.40	0.89	0.40	11.00	13.00	10.86	6.33	2.83	7.00	22.00	22.40	5.73	2.56	14.00	30.00
PHENANTHRENE	12.00	3.54	1.58	9.00	18.00	20.60	1.14	0.51	19.00	22.00	7.36	1.53	0.69	6.30	10.00	29.60	8.56	3.83	21.00	43.00
Total LMW PAHs	271.68	84.41	37.75	175.10	404.40	721.56	84.82	37.93	609.20	822.00	172.55	44.07	19.71	119.25	222.86	1326.42	198.87	88.94	1068.20	1612.80
Total NOAA LMW PAHs	94.98	26.12	11.68	67.20	127.00	162.32	14.81	6.62	142.50	174.10	58.29	27.66	12.37	43.17	107.06	206.14	34.80	15.56	172.30	260.40
Total Historic NOAA LMW PAHs	68.24	18.19	8.14	42.90	92.40	85.22	4.90	2.19	81.10	93.30	57.79	19.88	8.89	42.05	91.56	147.50	27.30	12.21	122.80	190.40
High Molecular Weight PAHs																				
BENZ(A)ANTHRACENE	6.12	0.78	0.35	5.50	7.40	16.80	3.03	1.36	14.00	22.00	2.88	0.41	0.19	2.10	3.20	104.60	16.74	7.49	85.00	130.00
BENZO(A)PYRENE	3.12	0.83	0.37	1.90	4.00	8.24	1.69	0.75	5.70	10.00	1.03	0.24	0.11	0.77	1.40	56.40	16.56	7.41	42.00	80.00
BENZO(B)FLUORANTHENE	7.00	0.52	0.23	6.50	7.70	24.40	3.29	1.47	22.00	30.00	2.20	0.47	0.21	1.40	2.60	188.00	37.01	16.55	150.00	240.00
BENZO(E)PYRENE	8.78	1.25	0.56	7.40	10.00	35.00	4.30	1.92	31.00	41.00	2.28	0.34	0.15	1.70	2.60	190.00	24.49	10.95	160.00	220.00
BENZO(G,H,I)PERYLENE	4.96	1.55	0.69	3.30	7.40	12.40	1.14	0.51	11.00	14.00	1.84	0.68	0.30	1.20	3.00	63.80	15.07	6.74	46.00	84.00
BENZO(K)FLUORANTHENE	2.50	0.59	0.26	1.60	3.10	8.58	1.10	0.49	7.20	9.60	0.89	0.16	0.07	0.69	1.10	50.20	8.38	3.75	40.00	60.00
C1-CHRYSENE	5.18	2.74	1.23	3.20	10.00	13.40	2.19	0.98	10.00	16.00	6.60	0.00	0.00	6.60	6.60	104.20	21.08	9.43	84.00	140.00
C1-FLUORANTHENES/PYRENE	14.40	2.70	1.21	12.00	19.00	45.00	7.65	3.42	39.00	58.00	6.60	0.00	0.00	6.60	6.60	224.00	33.62	15.03	180.00	270.00
C2-CHRYSENE	4.66	2.02	0.90	2.90	7.10	8.88	1.96	0.87	6.60	12.00	6.60	0.00	0.00	6.60	6.60	78.80	11.97	5.35	67.00	99.00
C2F/P	8.68	3.02	1.35	6.60	14.00	30.60	5.81	2.60	25.00	40.00	6.60	0.00	0.00	6.60	6.60	202.00	27.75	12.41	170.00	240.00
C3-CHRYSENE	6.60	0.00	0.00	6.60	6.60	6.60	0.00	0.00	6.60	6.60	6.60	0.00	0.00	6.60	6.60	44.20	7.50	3.35	36.00	56.00
C3F/P	6.60	0.00	0.00	6.60	6.60	17.00	2.55	1.14	14.00	20.00	6.60	0.00	0.00	6.60	6.60	129.60	23.04	10.30	98.00	160.00

TABLE 3-17
Summary PAH Concentration in 1997 Mussels
(ng/g dry weight)

	Gloucester Predeployment - June 1997 (Sample size =5)					Deer Island - August 1997 (Sample size = 5)					Future Outfall Site, August 1997 (Sample size = 5)					Discovery, August 1997 (Sample size = 5)				
Parameter	Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range	
C4-CHRYSENE	6.60	0.00	0.00	6.60	6.60	6.60	0.00	0.00	6.60	6.60	6.60	0.00	0.00	6.60	6.60	6.60	0.00	0.00	6.60	6.60
CHRYSENE	11.52	1.63	0.73	9.60	14.00	32.40	6.58	2.94	28.00	44.00	2.50	0.34	0.15	2.10	2.90	166.00	25.10	11.22	130.00	200.00
DIBENZO(A,H)ANTHRACENE	0.59	0.15	0.07	0.38	0.74	1.50	0.22	0.10	1.20	1.80	4.79	5.67	2.54	0.50	11.00	8.56	2.38	1.06	6.00	12.00
FLUORANTHENE	25.00	2.65	1.18	22.00	29.00	51.60	7.23	3.23	43.00	63.00	4.38	0.56	0.25	3.70	5.20	186.00	26.08	11.66	150.00	220.00
INDENO(1,2,3-CD)PYRENE	2.92	0.61	0.27	2.20	3.80	7.66	1.11	0.49	6.90	9.50	1.28	0.32	0.14	0.79	1.60	43.20	16.86	7.54	25.00	67.00
PERYLENE	1.16	0.19	0.08	0.98	1.40	3.40	0.63	0.28	2.70	4.40	0.48	0.08	0.03	0.36	0.55	22.60	4.10	1.83	19.00	27.00
PYRENE	14.80	1.30	0.58	14.00	17.00	59.00	8.94	4.00	50.00	74.00	3.72	0.71	0.32	3.00	4.90	266.00	33.62	15.03	220.00	310.00
Total HMW PAHs	141.19	16.96	7.59	125.54	168.84	389.06	48.78	21.82	357.60	473.80	74.27	4.10	1.83	70.58	80.67	2134.76	332.84	148.85	1738.60	2621.60
Total NOAA HMW PAHs	88.47	8.55	3.82	78.94	98.94	260.98	31.11	13.91	241.40	315.60	28.07	4.10	1.83	24.38	34.47	1345.36	215.73	96.48	1093.00	1650.00
Total Historic NOAA HMW PAHs	88.47	8.55	3.82	78.94	98.94	260.98	31.11	13.91	241.40	315.60	28.07	4.10	1.83	24.38	34.47	1345.36	215.73	96.48	1093.00	1650.00
Total PAHs	412.87	96.37	43.10	315.18	573.24	1110.62	127.40	56.97	966.80	1295.80	246.82	46.57	20.83	194.26	303.53	3461.18	530.23	237.13	2806.80	4234.40
Total NOAA PAHs	183.45	28.69	12.83	150.64	213.64	423.30	40.43	18.08	391.30	489.70	86.37	31.39	14.04	67.89	141.53	1551.50	249.81	111.72	1265.30	1910.40
Total Historic NOAA PAHs	156.71	19.13	8.55	132.78	173.09	346.20	35.78	16.00	322.50	408.90	85.86	23.43	10.48	70.86	126.03	1492.86	241.46	107.98	1218.00	1840.40

TABLE 3-18
Pesticide Concentrations in 1997 Mussels
(ng/g dry weigt)

Parameter	Gloucester Predeployment, June 1997					Deer Island, August 1997				
	M9711H7TC1	M9711H7TC2	M9711H7TC3	M9711H7TC4	M9711H7TC5	M9711D1H7TC1	M9711D1H7TC2	M9711D1H7TC3	M9711D1H7TC4	M9711D1H7TC5
ALDRIN										
DIELDRIN	2	2.4	2.4	2.2	2.4	3.6	3.8	2.5	3.2	3.9
ENDRIN										
TOTAL	3.57	3.97	3.97	3.77	3.97	5.17	5.37	4.07	4.77	5.47
ALPHA-CHLORDANE	4.7	4.4	4	4.7	4.3	11	11	8.2	10	12
HEPTACHLOR						0.68	0.6	0.36	0.5	0.6
HEPTACHLOREPOXIDE										
HEXACHLOROBENZENE	0.53	0.39	0.5	0.61	0.62	0.45	0.44	0.28	0.44	0.58
LINDANE										
MIREX	0.34					0.46	0.53	0.58	0.43	0.52
TRANS_NONACHLOR	4.4	4.6	4.2	3.5	5.2	10	9.6	7.9	9.7	10
TOTAL	11.03	10.9	10.21	10.32	11.63	23.41	22.99	18.14	21.89	24.52
2,4-DDD	6.9	8.2	6.7	6.8	8	11	11	8.4	10	11
2,4-DDE										
2,4-DDT	1.2	2	1.7	1.7	2.1	3.3	3	2.8	2.9	2.7
4,4-DDD	20	27	21	18	21	19	18	14	17	20
4,4-DDE	15	18	16	14	20	24	26	20	26	28
4,4-DDT	4.3	6.4	4.4	4	4.4	4.8	4.6	3.4	4.4	4.9
TOTAL	48.13	62.33	50.53	45.23	56.23	62.83	63.33	49.33	61.03	67.33
TOTAL PESTICIDES	62.73	77.2	64.71	59.32	71.83	91.41	91.69	71.54	87.69	97.32

Shaded values indicate that a concentration of ND (Not Detected) was reported. The MDL (Method Detection Limit) is used as an estimated concentration.

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TABLE 3-18
Pesticide Concentrations in 1997 Mussels
(ng/g dry weigt)

Parameter	Future Outfall Site, August 1997					Discovery, August 1997				
	M9711D4H7TC1	M9711D4H7TC2	M9711D4H7TC3	M9711D4H7TC4	M9711D4H7TC5	M9711D6H7TC1	M9711D6H7TC2	M9711D6H7TC3	M9711D6H7TC4	M9711D6H7TC5
ALDRIN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DIELDRIN	1.8	1.8	2	2.2	2.3	7.5	6.3	6.6	7.6	7.7
ENDRIN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	3.37	3.37	3.57	3.77	3.87	9.07	7.87	8.17	9.17	9.27
ALPHA-CHLORDANE	2.6	2.8	2.6	3	3.4	18	12	11	14	15
HEPTACHLOR	0.071	0.11	0.1	0.1	0.1	0.95	0.59	[illegible]	[illegible]	0.67
HEPTACHLOREPOXIDE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HEXACHLOROBENZENE	0.19	0.24	0.24	0.26	0.24	0.72	0.66	0.63	0.68	0.73
LINDANE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MIREX	0.3	[illegible]	0.31	0.36	0.31	0.65	0.53	[illegible]	[illegible]	[illegible]
TRANS_NONACHLOR	3	3.4	2.8	3.2	3.6	18	12	14	15	14
TOTAL	6.981	7.82	6.87	7.74	8.47	39.14	26.6	27.14	31.19	31.67
2,4-DDD	3.2	3.1	3.1	3.3	3.6	21	16	18	20	22
2,4-DDE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2,4-DDT	0.88	1.1	1.2	1.2	1.6	6.9	3.6	4.5	4.6	5.3
4,4-DDD	5.3	5.7	6	6.6	7.8	77	45	53	62	74
4,4-DDE	8.5	8.7	8.8	9.5	11	52	50	37	40	52
4,4-DDT	2.1	2.5	2.4	1.8	3.1	2.6	1.6	1.8	2.1	2.3
TOTAL	20.71	21.83	22.23	23.13	27.83	160.23	116.93	115.03	129.43	156.33
TOTAL PESTICIDES	31.061	33.02	32.67	34.64	40.17	208.44	151.4	150.34	169.79	197.27

Shaded values indicate that a concentration of ND (Not Detected) was reported. The MDL (Method Detection Limit) is used as an estimated concentration.

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TABLE 3-19
Summary Pesticide Concentration in 1997 Mussels
(ng/g dry weight)

Parameter	Gloucester Predeployment - June 1997 (Sample size = 5)					Deer Island - August 1997 (Sample size = 5)					Future Outfall Site, August 1997 (Sample size = 5)					Discovery, August 1997 (Sample size = 5)				
	Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range	
ALDRIN	1.30	0.00	0.00	1.30	1.30	1.30	0.00	0.00	1.30	1.30	1.30	0.00	0.00	1.30	1.30	1.30	0.00	0.00	1.30	1.30
DIELDRIN	2.28	0.18	0.08	2.00	2.40	3.40	0.57	0.25	2.50	3.90	2.02	0.23	0.10	1.80	2.30	7.14	0.64	0.29	6.30	7.70
ENDRIN	0.27	0.00	0.00	0.27	0.27	0.27	0.00	0.00	0.27	0.27	0.27	0.00	0.00	0.27	0.27	0.27	0.00	0.00	0.27	0.27
TOTAL	3.85	0.18	0.08	3.57	3.97	4.97	0.57	0.25	4.07	5.47	3.59	0.23	0.10	3.37	3.87	8.71	0.64	0.29	7.87	9.27
ALPHA-CHLORDANE	4.42	0.29	0.13	4.00	4.70	10.44	1.44	0.64	8.20	12.00	2.88	0.33	0.15	2.60	3.40	14.00	2.74	1.22	11.00	18.00
HEPTACHLOR	0.24	0.00	0.00	0.24	0.24	0.55	0.12	0.05	0.36	0.66	0.10	0.01	0.01	0.07	0.11	0.54	0.30	0.14	0.24	0.95
HEPTACHLOREPOXIDE	0.45	0.00	0.00	0.45	0.45	0.45	0.00	0.00	0.45	0.45	0.45	0.00	0.00	0.45	0.45	0.45	0.00	0.00	0.45	0.45
HEXACHLOROBENZENE	0.53	0.09	0.04	0.39	0.62	0.44	0.11	0.05	0.28	0.58	0.23	0.03	0.01	0.19	0.26	0.68	0.04	0.02	0.63	0.73
LINDANE	0.37	0.00	0.00	0.37	0.37	0.37	0.00	0.00	0.37	0.37	0.37	0.00	0.00	0.37	0.37	0.37	0.00	0.00	0.37	0.37
MIREX	0.43	0.05	0.02	0.34	0.45	0.50	0.06	0.03	0.43	0.58	0.35	0.06	0.03	0.30	0.45	0.51	0.09	0.04	0.45	0.65
TRANS_NONACHLOR	4.38	0.62	0.28	3.50	5.20	9.44	0.88	0.39	7.90	10.00	3.20	0.32	0.14	2.80	3.60	14.60	2.19	0.98	12.00	18.00
TOTAL	10.82	0.58	0.26	10.21	11.63	22.19	2.45	1.10	18.14	24.52	7.58	0.66	0.29	6.87	8.47	31.15	5.02	2.25	26.60	39.14
2,4-DDD	7.32	0.72	0.32	6.70	8.20	10.28	1.14	0.51	8.40	11.00	3.26	0.21	0.09	3.10	3.60	19.40	2.41	1.08	16.00	22.00
2,4-DDE	0.73	0.00	0.00	0.73	0.73	0.73	0.00	0.00	0.73	0.73	0.73	0.00	0.00	0.73	0.73	0.73	0.00	0.00	0.73	0.73
2,4-DDT	1.74	0.35	0.16	1.20	2.10	2.94	0.23	0.10	2.70	3.30	1.20	0.26	0.12	0.88	1.60	4.98	1.23	0.55	3.60	6.90
4,4-DDD	21.40	3.36	1.50	18.00	27.00	17.60	2.30	1.03	14.00	20.00	6.28	0.97	0.44	5.30	7.80	62.20	13.59	6.08	45.00	77.00
4,4-DDE	16.60	2.41	1.08	14.00	20.00	24.80	3.03	1.36	20.00	28.00	9.30	1.02	0.46	8.50	11.00	46.20	7.16	3.20	37.00	52.00
4,4-DDT	4.70	0.96	0.43	4.00	6.40	4.42	0.60	0.27	3.40	4.90	2.38	0.49	0.22	1.80	3.10	2.08	0.40	0.18	1.60	2.60
TOTAL	52.49	6.83	3.05	45.23	62.33	60.77	6.80	3.04	49.33	67.33	23.15	2.76	1.23	20.71	27.83	135.59	21.48	9.61	115.03	160.23
TOTAL PESTICIDES	67.16	7.24	3.24	59.32	77.20	87.93	9.79	4.38	71.54	97.32	34.31	3.51	1.57	31.06	40.17	175.45	26.48	11.84	150.34	208.44

TABLE 3-20
PCB Concentration in 1997 Mussels
(ng/g dry weight)

Parameter	Future Outfall Site, August 1997					Discovery, August 1997				
	M9711D4H7TC1	M9711D4H7TC2	M9711D4H7TC3	M9711D4H7TC4	M9711D4H7TC5	M9711D6H7TC1	M9711D6H7TC2	M9711D6H7TC3	M9711D6H7TC4	M9711D6H7TC5
105	4.2	3.6	4	4	4.4	50	34	39	42	47
126	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
138	20	20	20	18	20	74	51	66	61	71
170	0.5	0.6	0.57	0.62	0.94	9.3	8.9	9.6	8.3	11
180	14	14	14	13	15	130	100	120	110	130
195	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2
2,2',3,3',4,4'-HEXACHLOROBIPHENYL (128)	3	2.6	2.9	2.2	2.6	24	19	22	24	25
2,2',3,4,5,5',6-Cl7 (187)	5.6	5.7	5.1	5.2	5.8	34	31	36	33	36
2,2',3,5'-TETRACHLOROBIPHENYL (44)	2.3	2.6	2.7	2	2.8	22	17	19	21	22
2,2',4,4',5,5'-HEXACHLOROBIPHENYL (153)	19	19	18	18	20	170	140	150	140	180
2,2',4,5,5'-PENTACHLOROBIPHENYL (101)	9.9	10	9.2	9.6	11	130	77	86	90	140
2,2',5,5'-TETRACHLOROBIPHENYL (52)	3.3	3.6	3.4	3.6	3.9	35	26	30	33	33
2,2',5-TRICHLOROBIPHENYL (18)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2,3',4,4',5-PENTACHLOROBIPHENYL (118)	11	11	11	10	12	120	81	99	98	120
2,3',4,4'-TETRACHLOROBIPHENYL (66)	2.9	3.9	3.4	3	4.4	30	28	30	37	31
2,4'-DICHLOROBIPHENYL (8)	1.1	1.1	1.2	1	1.4	16	12	11	13	15
2,4,4'-TRICHLOROBIPHENYL (28)	[illegible]	0.65	0.28	0.42	0.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
206	[illegible]	0.082	[illegible]	[illegible]	[illegible]	[illegible]	0.53	0.55	0.66	0.63
44 DD OLEPHIN (DDMU)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17	24	40	30	37
77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DECACHLOROBIPHENYL (209)	0.046	0.059	0.054	0.047	0.039	0.34	0.38	0.29	0.34	0.38
TOTAL PCBs	101.316	101.981	99.874	94.957	108.749	865.11	652.7	761.33	744.19	902.4

Shaded values indicate that a concentration of ND was reported (Not Detected. The MDL (Method Detection Limit) is used as an elimated concentration.
The value for DDMU is the Minimum reporting limit (no MDL available.)

TABLE 3-21
Summary PCB Concentration in 1997 Mussels
(ng/g)

Parameter	Gloucester Predeployment - June 1997 (Sample size = 5)					Deer Island - August 1997 (Sample size = 5)					Future Outfall Site, August 1997 (Sample size = 5)					Discovery, August 1997 (Sample size = 5)				
	Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range		Average	SD	SE	Range	
105	6.00	0.60	0.27	5.30	6.50	12.20	1.48	0.66	10.00	14.00	4.04	0.30	0.13	3.60	4.40	42.40	6.35	2.84	34.00	50.00
126	0.62	0.00	0.00	0.62	0.62	0.62	0.00	0.00	0.62	0.62	0.62	0.00	0.00	0.62	0.62	0.62	0.00	0.00	0.62	0.62
138	15.40	1.82	0.81	13.00	17.00	124.00	11.40	5.10	110.00	140.00	19.60	0.89	0.40	18.00	20.00	64.60	9.07	4.06	51.00	74.00
170	0.83	0.08	0.04	0.72	0.95	1.68	1.09	0.49	0.49	2.70	0.69	0.19	0.08	0.50	0.94	9.42	1.01	0.45	8.30	11.00
180	17.80	1.30	0.58	16.00	19.00	41.40	2.07	0.93	38.00	43.00	14.00	0.71	0.32	13.00	15.00	118.00	13.04	5.83	100.00	130.00
195	0.70	0.00	0.00	0.70	0.70	0.70	0.00	0.00	0.70	0.70	0.70	0.00	0.00	0.70	0.70	0.80	0.22	0.10	0.70	1.20
2,2',3,3',4,4'-HEXACHLOROBIPHENYL (128)	3.20	0.37	0.17	2.60	3.60	7.44	0.36	0.16	7.00	7.80	2.66	0.31	0.14	2.20	3.00	22.80	2.39	1.07	19.00	25.00
2,2',3,4,5,5',6-Cl7 (187)	7.34	0.55	0.24	6.60	7.90	14.20	1.10	0.49	13.00	16.00	5.48	0.31	0.14	5.10	5.80	34.00	2.12	0.95	31.00	36.00
2,2',3,5'-TETRACHLOROBIPHENYL (44)	5.76	0.96	0.43	5.10	7.40	8.42	1.21	0.54	6.40	9.40	2.48	0.33	0.15	2.00	2.80	20.20	2.17	0.97	17.00	22.00
2,2',4,4',5,5'-HEXACHLOROBIPHENYL (153)	23.40	1.14	0.51	22.00	25.00	51.20	2.17	0.97	49.00	54.00	18.80	0.84	0.37	18.00	20.00	156.00	18.17	8.12	140.00	180.00
2,2',4,5,5'-PENTACHLOROBIPHENYL (101)	15.00	1.22	0.55	14.00	17.00	31.60	2.19	0.98	28.00	34.00	9.94	0.67	0.30	9.20	11.00	104.60	28.37	12.69	77.00	140.00
2,2',5,5'-TETRACHLOROBIPHENYL (52)	8.20	1.57	0.70	7.30	11.00	11.50	2.29	1.02	7.50	13.00	3.56	0.23	0.10	3.30	3.90	31.40	3.51	1.57	26.00	35.00
2,2',5-TRICHLOROBIPHENYL (18)	0.42	0.00	0.00	0.42	0.42	0.42	0.00	0.00	0.42	0.42	0.42	0.00	0.00	0.42	0.42	0.42	0.00	0.00	0.42	0.42
2,3',4,4',5-PENTACHLOROBIPHENYL (118)	16.40	1.14	0.51	15.00	18.00	34.20	2.59	1.16	30.00	37.00	11.00	0.71	0.32	10.00	12.00	103.60	16.59	7.42	81.00	120.00
2,3',4,4'-TETRACHLOROBIPHENYL (66)	8.50	1.78	0.80	6.10	11.00	11.80	1.79	0.80	10.00	14.00	3.52	0.63	0.28	2.90	4.40	31.20	3.42	1.53	28.00	37.00
2,4'-DICHLOROBIPHENYL (8)	3.20	0.79	0.35	2.70	4.60	5.52	1.02	0.46	3.80	6.50	1.16	0.15	0.07	1.00	1.40	13.40	2.07	0.93	11.00	16.00
2,4,4'-TRICHLOROBIPHENYL (28)	0.40	0.00	0.00	0.40	0.40	0.58	0.16	0.07	0.40	0.79	0.43	0.13	0.06	0.28	0.65	0.40	0.00	0.00	0.40	0.40
206	0.58	0.00	0.00	0.58	0.58	0.41	0.23	0.10	0.14	0.58	0.48	0.22	0.10	0.08	0.58	0.59	0.05	0.02	0.53	0.66
44 DD OLEPHIN (DDMU)	1.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	29.60	9.40	4.20	17.00	40.00
77	0.75	0.00	0.00	0.75	0.75	0.75	0.00	0.00	0.75	0.75	0.75	0.00	0.00	0.75	0.75	0.75	0.00	0.00	0.75	0.75
DECACHLOROBIPHENYL	0.06	0.02	0.01	0.04	0.10	0.24	0.11	0.05	0.12	0.32	0.05	0.01	0.00	0.04	0.06	0.35	0.04	0.02	0.29	0.38
TOTAL PCBs	135.56	11.57	5.18	122.36	152.76	359.87	26.27	11.75	318.56	384.49	101.38	4.95	2.22	94.96	108.75	785.15	99.91	44.68	652.70	902.40

TABLE 3-22
Mercury and Lead Concentrations in 1997 Mussels
(ug/g dry weight)

Sandwich Predeployment			Future Outfall Site		
Sample	Lead	Mercury	Sample	Lead	Mercury
M9711H8TC1 *	1.78	0.09	M9711D4H8TC1	2.02	0.003
M9711H8TC2	2.45	0.17	M9711D4H8TC2	1.85	0.003
M9711H8TC3	1.66	0.20	M9711D4H8TC3	2.04	0.14
M9711H8TC4	2.77	0.17	M9711D4H8TC4	2.38	0.20
M9711H8TC5	3.52	0.24	M9711D4H8TC5	2.19	0.18
Mean	2.44	0.17	Mean	2.09	0.10
Standard Deviation	0.76	0.06	Standard Deviation	0.20	0.10
Standard Error	0.34	0.02	Standard Error	0.09	0.04
Minimum Concentration	1.66	0.09	Minimum Concentration	1.85	0.00
Maximum Concentration	3.52	0.24	Maximum Concentration	2.38	0.20
Deer Island			**Discovery**		
Sample	Lead	Mercury	Sample	Lead	Mercury
M9711D1H8TC1	7.00	0.11	M9711D6H8TC1	5.06	0.39
M9711D1H8TC2	8.42	0.09	M9711D6H8TC2	13.84	0.34
M9711D1H8TC3	9.44	0.06	M9711D6H8TC3	8.25	0.23
M9711D1H8TC4	7.46	0.02	M9711D6H8TC4	9.30	0.23
M9711D1H8TC5	6.84	0.03	M9711D6H8TC5	13.01	0.41
Mean	7.83	0.06	Mean	9.89	0.32
Standard Deviation	1.09	0.04	Standard Deviation	3.59	0.09
Standard Error	0.49	0.02	Standard Error	1.61	0.04
Minimum Concentration	6.84	0.02	Minimum Concentration	5.06	0.23
Maximum Concentration	9.44	0.11	Maximum Concentration	13.84	0.41

Shaded concentrations represent one-half the detection limit.
* Concentration for this sample is the average of the sample and the duplicate.

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TABLE 3-23

Comparison of FDA Legal Limits to Mean Concentrations (wet weight) of Select Compounds In Blue Mussel Tissues - 1997

Compound/Analyte	Deer Island Mean	Deer Island S.E.	Future Outfall Site Mean	Future Outfall Site S.E.	Discovery Mean	Discovery S.E.	Sandwich (predeployment) Mean	Sandwich (predeployment) S.E.	Comparison Values
Lead (ppm)	1.30	0.07	0.41	0.03	1.72	0.22	0.54	0.03	2 [1]
Mercury (ppm)	0.01	0.003	0.02	0.008	0.06	0.007	0.04	0.005	1, 0.8, 0.05 [2]

Notes:

[1] Massachusetts Water Resources Authority (MWRA) 1997. Contingency Plan. The value listed is a Caution Level based on an EPA risk assessement of lead in drinking water.

[2] U.S. EPA 1989. Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish. EPA-503/8-89-002. Office of Marine and Estuarine Protection (WH-556F) and the Office of Water Regulations and Standards (WH-552), Washington, D.C. Values listed are the US FDA Legal Limit, Warning Level (80% of FDA Limit) and Caution Level (50% of FDA Limit), respectively. The Caution and Warning Levels apply to the outfall site.

December 17, 1998

Table 3-24
Concentrations of Selected Organic Compounds Normalized for Lipids [1]
Mussel Tissue, 1992 - 1997
ng/g Lipid

Parameter	Year	Gloucester Average	Gloucester S.E.	Deer Island Average	Deer Island S.E.	Future Outfall Site Average	Future Outfall Site S.E.	Discovery Average	Discovery S.E.
Total DDT	1992	315	18.2	492	46.0	278	15.4	2,020	377.6
	1993	1,024	213.1	966	145.0	421	32.4	2,451	504.2
	1994	631	31.9	999	49.1	335	26.9	1,572	82.4
	1995	328	8.6	400	7.9	NA	NA	925	28.2
	1996	738	151.0	617	21.6	276	8.8	1,207	141.4
	1997	609	40.0	674	18.4	264	14.4	1,719	105.5
	Baseline Mean	**607**	**108.7**	**691**	**100.2**	**315**	**29.3**	**1,649**	**224.4**
Total PAHs	1992	4,494	487.6	37,922	3,332.0	6,548	3,467.5	69,529	8,290.8
	1993	2,350	288.2	10,231	1,144.5	2,338	156.2	24,925	1,409.2
	1994	6,614	1,230.9	16,960	1,487.1	2,191	83.6	41,443	5,513.7
	1995	2,427	164.5	17,981	616.0	NA	NA	30,810	616.5
	1996	8,312	1,803.1	23,533	1,323.3	1,352	52.9	60,939	6,022.7
	1997	3,761	411.4	12,078	518.0	1,049	239.5	43,188	3,301.1
	Baseline Mean	**4,660**	**971.5**	**19,784**	**4,102.5**	**2,695**	**993.4**	**45,139**	**7,014.1**
Total PCBs	1992	1,358	94.6	2,608	167.2	1,057	65.9	12,784	1,744.4
	1993	2,983	512.6	4,944	663.2	1,556	44.2	11,239	981.7
	1994	2,555	77.9	3,214	119.3	1,597	114.8	9,197	1,313.1
	1995	1,018	27.7	1,470	33.2	NA	NA	4,530	135.0
	1996	2,079	430.2	2,006	137.5	939	17.0	5,386	404.9
	1997	1,539	55.5	4,005	94.9	1,150	57.2	9,999	584.7
	Baseline Mean	**1,922**	**307.3**	**3,041**	**526.3**	**1,260**	**133.8**	**8,856**	**1,332.7**

Notes:
[1] Formula: concentration/percent lipid.
NA - Not Available (The 1995 FOS array was lost).

23-Dec-98

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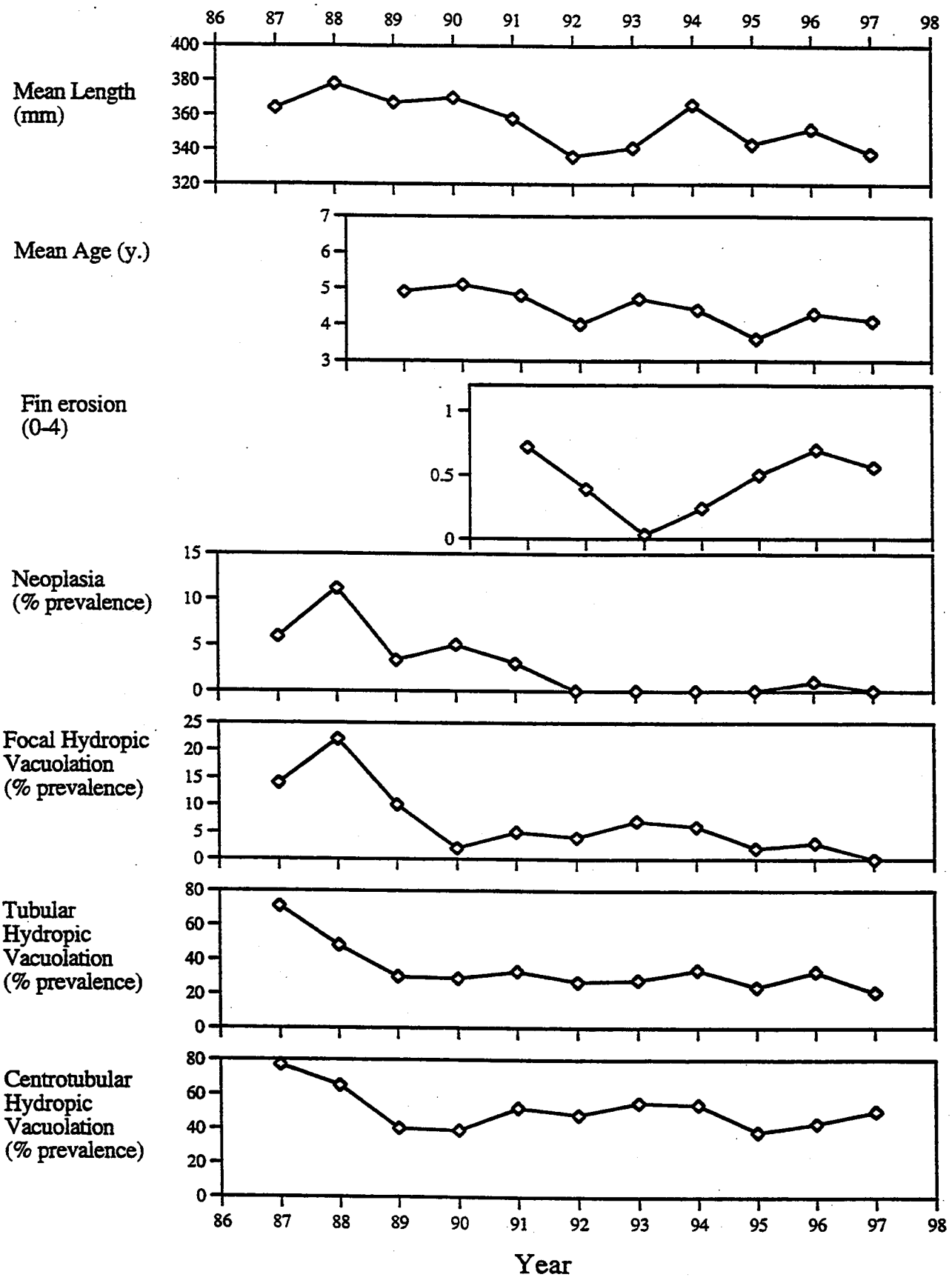


Liver slices examined per fish: 1 for 1987 to 1990, 3 thereafter

Figure 3-1a

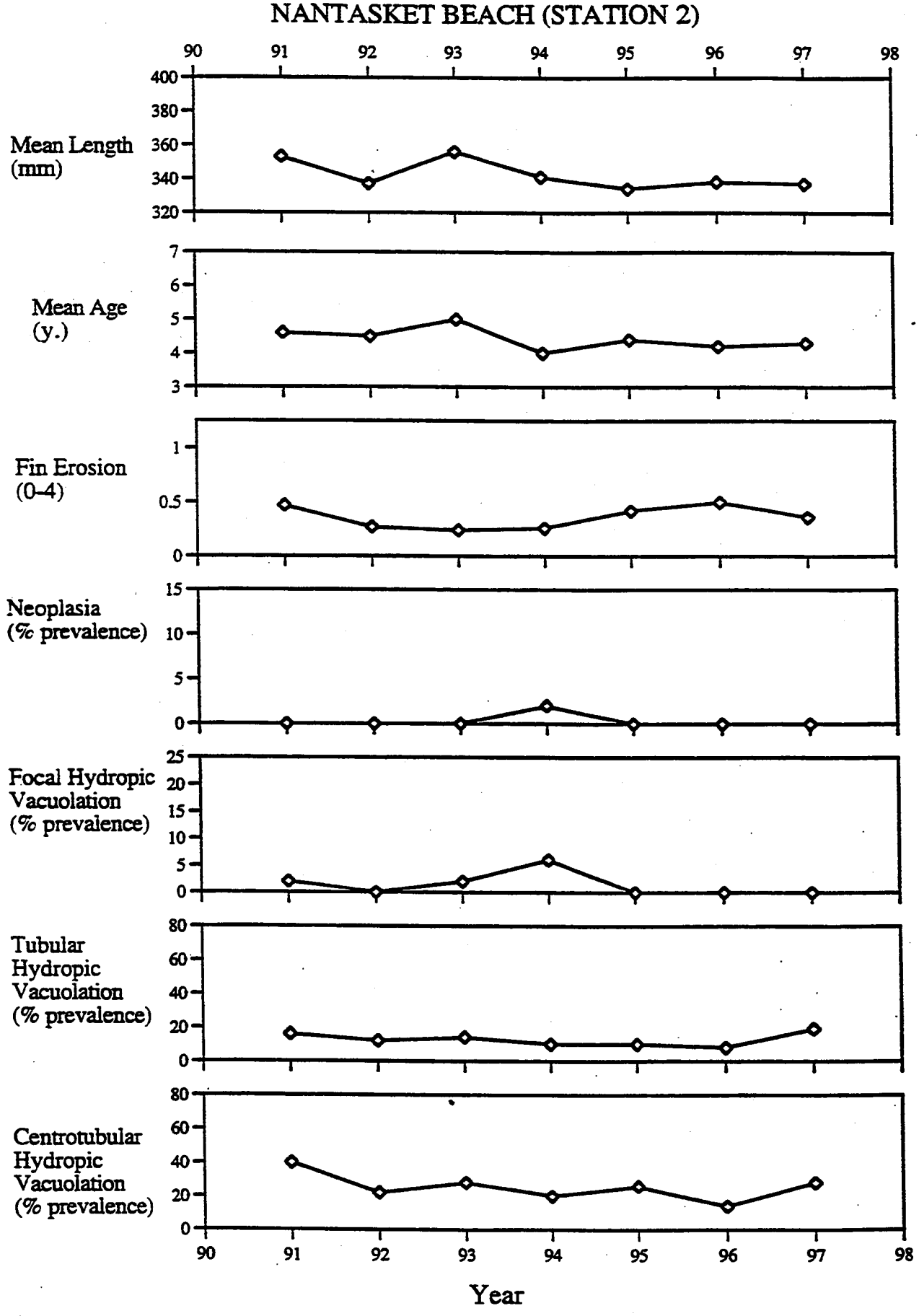

NANTASKET BEACH (STATION 2)
90
91
92
93
94
95
96
97
98
Mean Length (mm)
400
380
360
340
320
Mean Age (y.)
7
6
5
4
3
Fin Erosion (0-4)
1
0.5
0
Neoplasia (% prevalence)
15
10
5
0
Focal Hydropic Vacuolation (% prevalence)
25
20
15
10
5
0
Tubular Hydropic Vacuolation (% prevalence)
80
60
40
20
0
Centrotubular Hydropic Vacuolation (% prevalence)
80
60
40
20
0
Year

FIGURE 3-1b

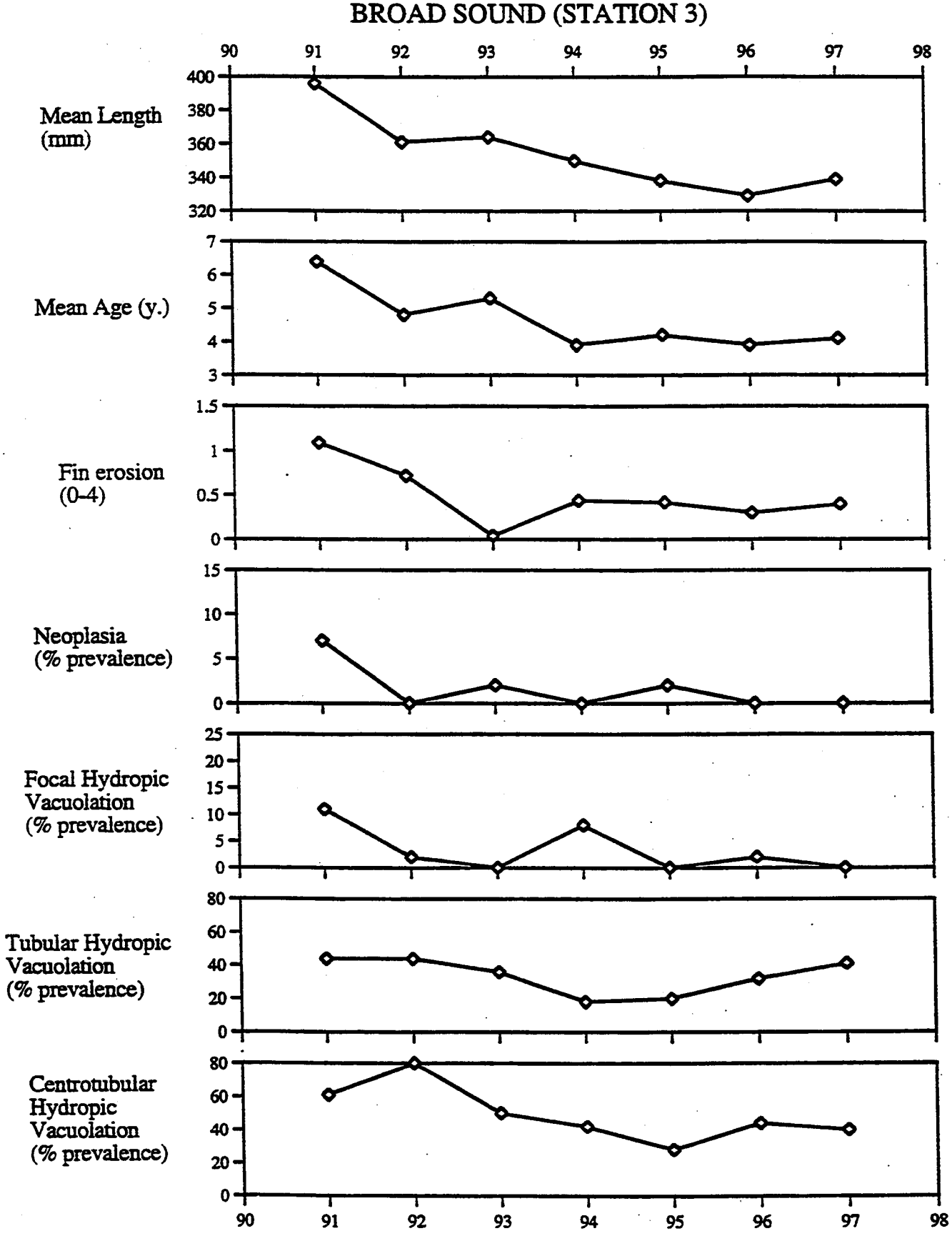

BROAD SOUND (STATION 3)
Mean Length (mm)
Mean Age (y.)
Fin erosion (0-4)
Neoplasia (% prevalence)
Focal Hydropic Vacuolation (% prevalence)
Tubular Hydropic Vacuolation (% prevalence)
Centrotubular Hydropic Vacuolation (% prevalence)
90 91 92 93 94 95 96 97 98
Year

FIGURE 3-1c

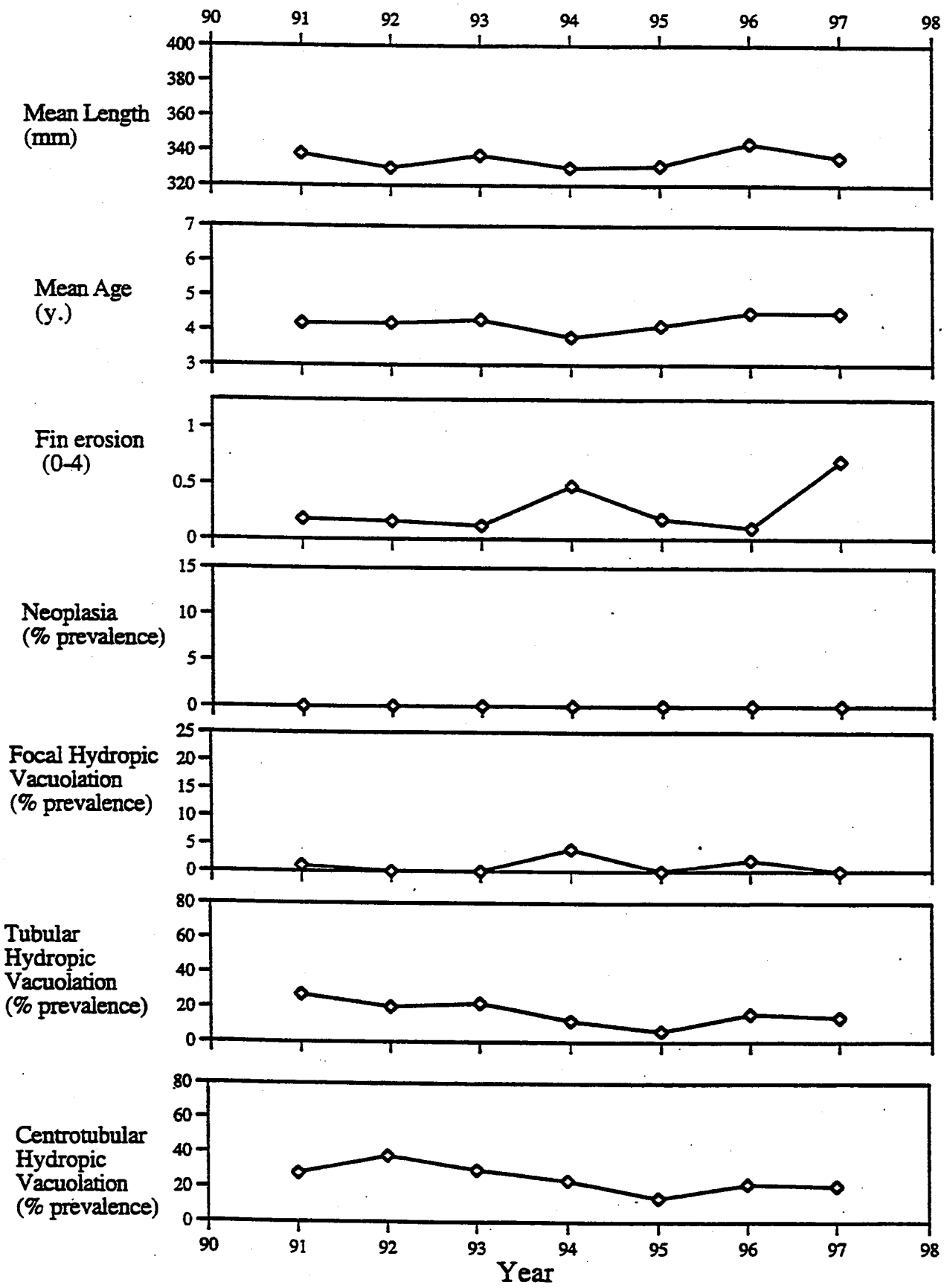
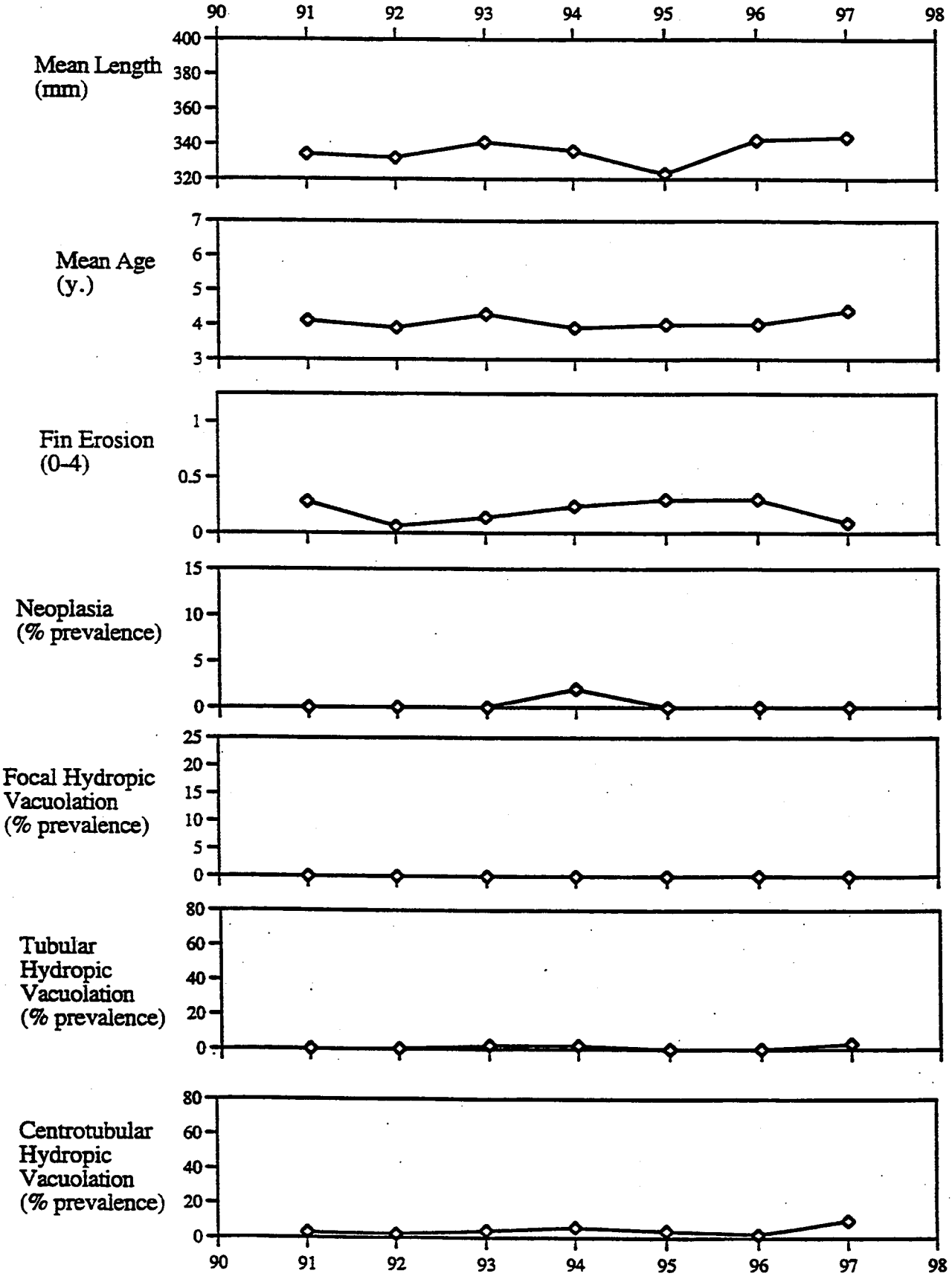

FUTURE OUTFALL SITE (STATION 4)
Mean Length (mm)
Mean Age (y.)
Fin erosion (0-4)
Neoplasia (% prevalence)
Focal Hydropic Vacuolation (% prevalence)
Tubular Hydropic Vacuolation (% prevalence)
Centrotubular Hydropic Vacuolation (% prevalence)
90 91 92 93 94 95 96 97 98
Year

FIGURE 3-1d

EASTERN CAPE COD BAY (STATION 5)



Year

FIGURE 3-1e

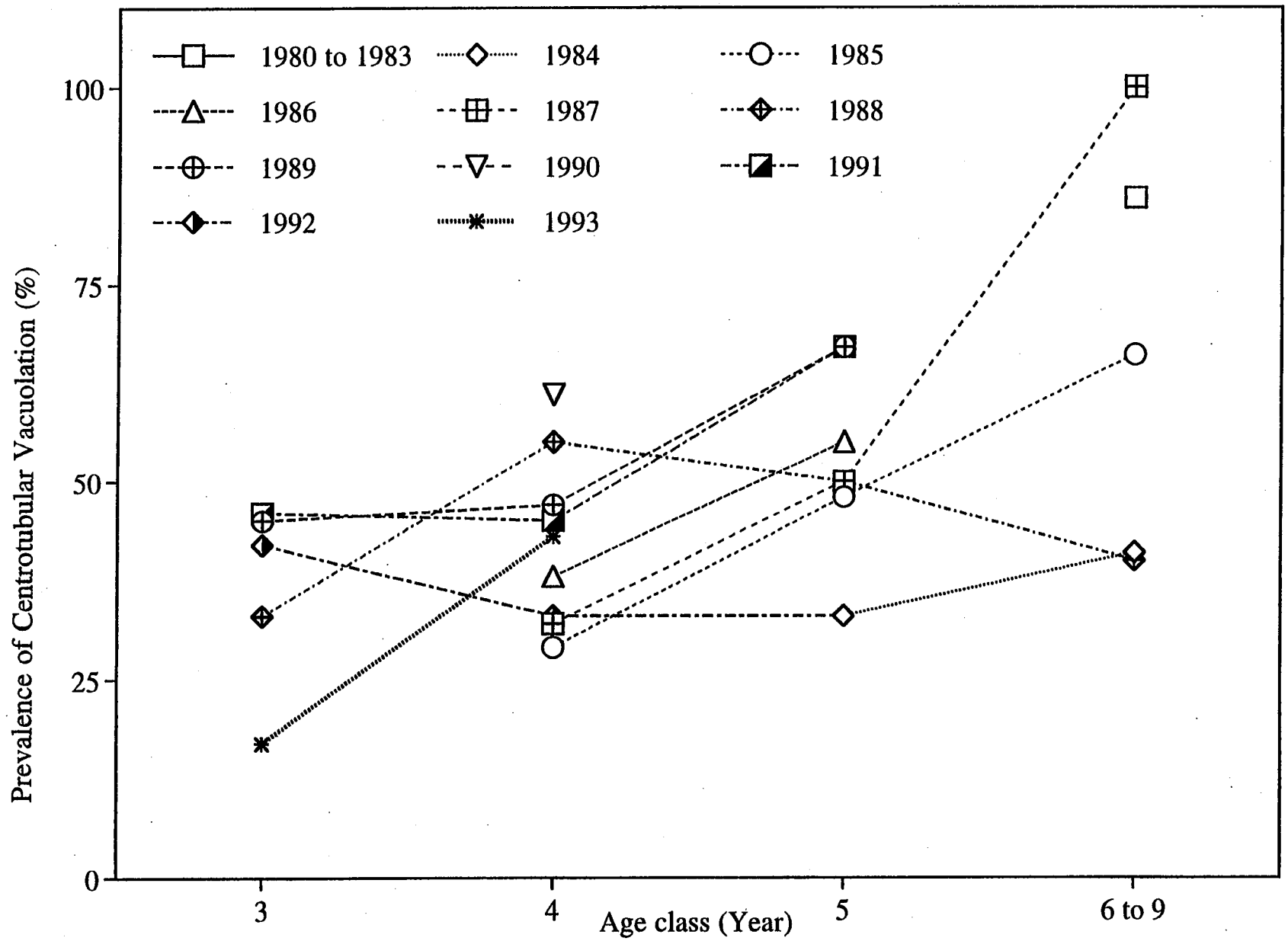


Figure 3-2a Prevalence of hydropic vacuolation through successive cohorts of winter flounder. Data points with N < % omitted.

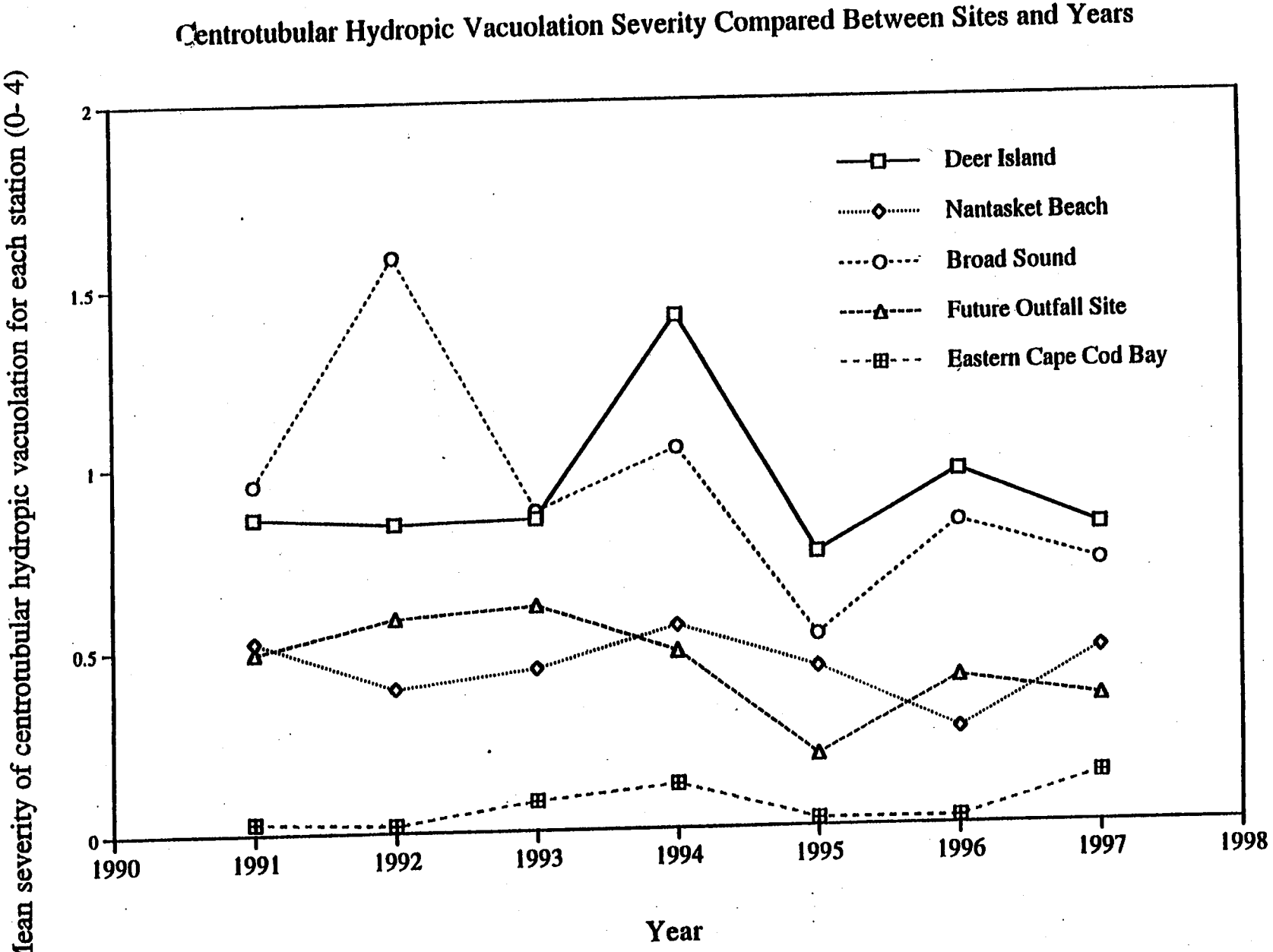

Centrotubular Hydropic Vacuolation Severity Compared Between Sites and Years
Mean severity of centrotubular hydropic vacuolation for each station (0- 4)
2
1.5
1
0.5
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year
Deer Island
Nantasket Beach
Broad Sound
Future Outfall Site
Eastern Cape Cod Bay

Figure 3-2b

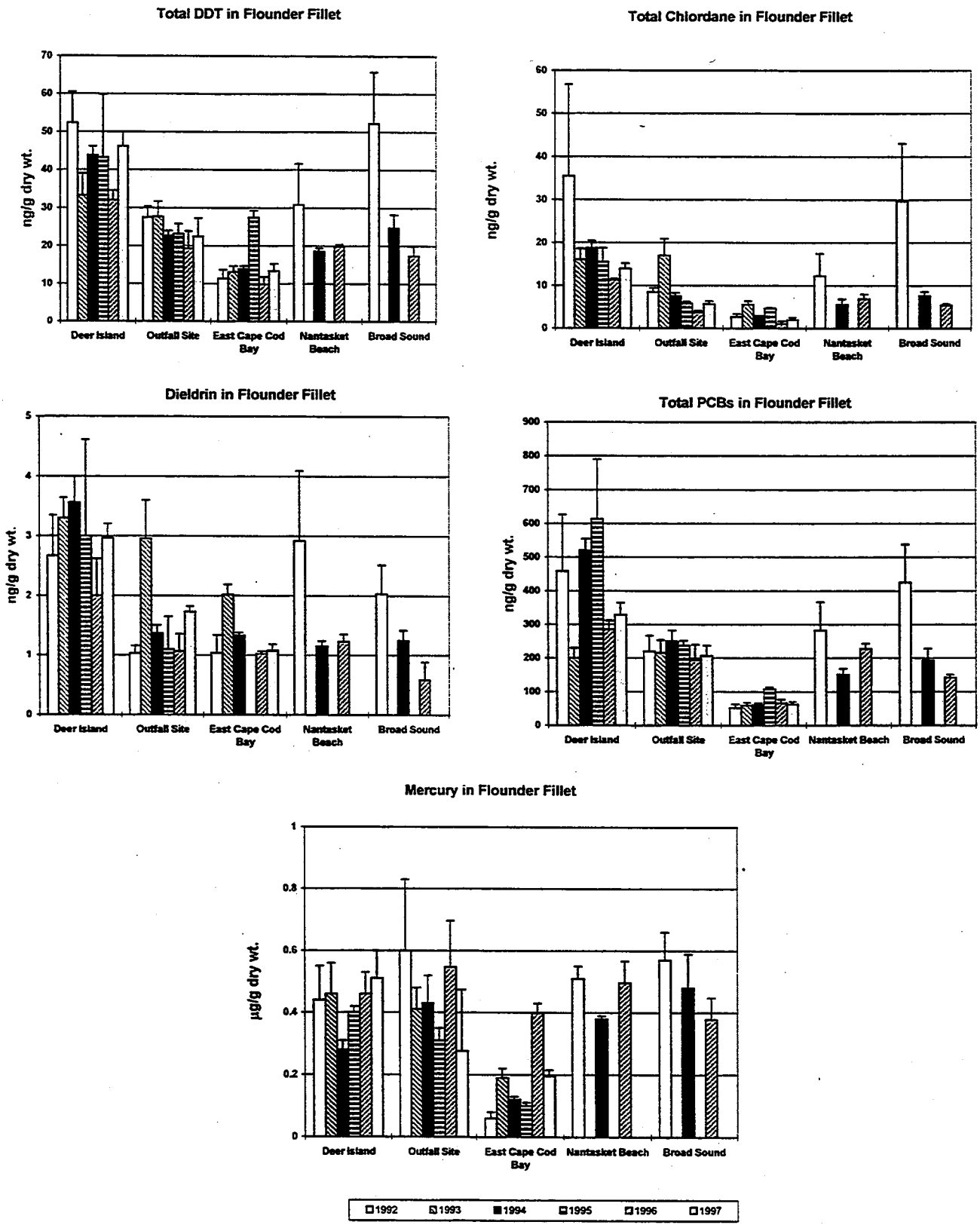


Figure 3-3
Comparison of Target Analytes in Flounder Fillet, 1992-1997

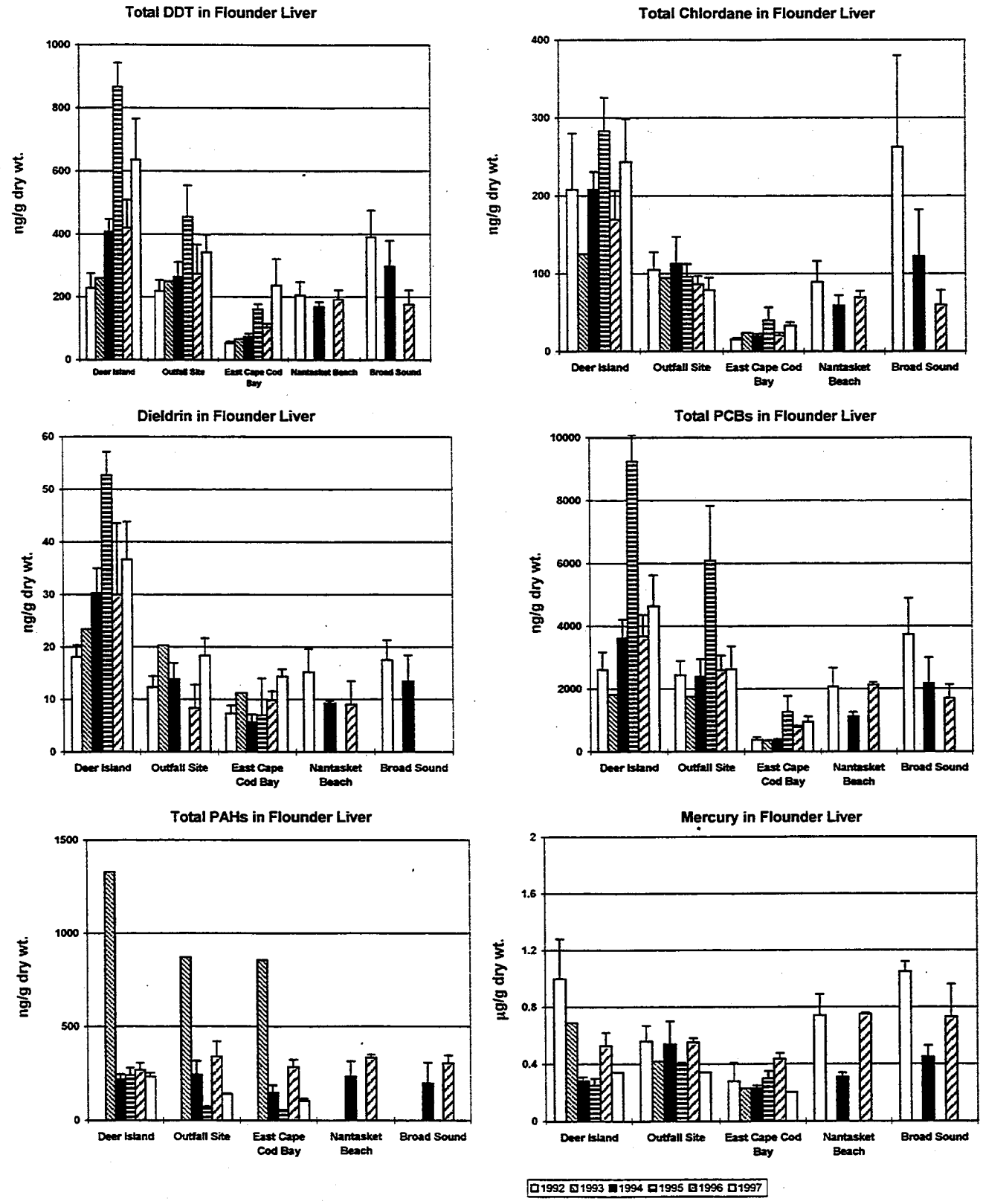


Figure 3-4
Comparison of Target Analytes in Flounder Liver, 1992-1997

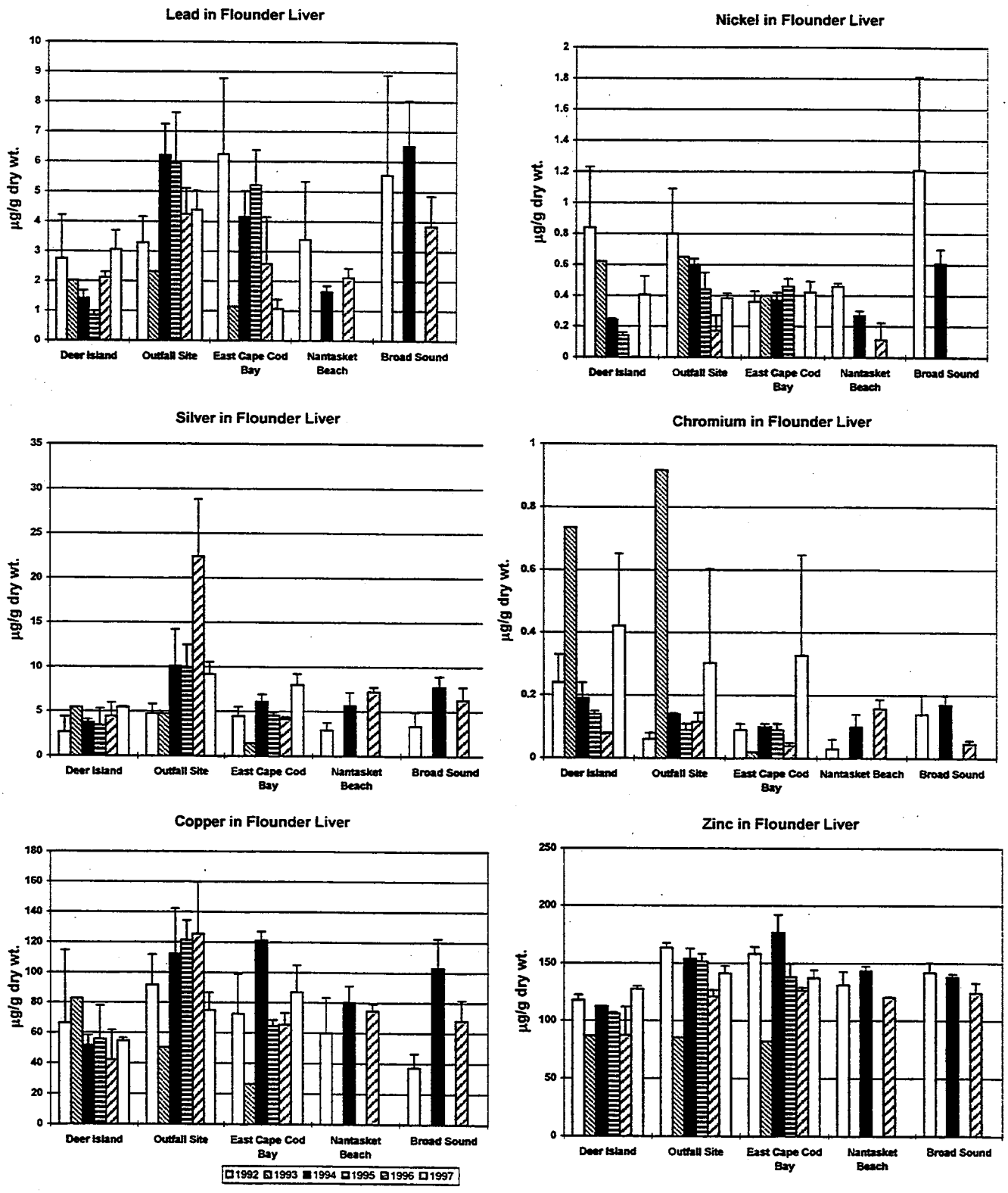
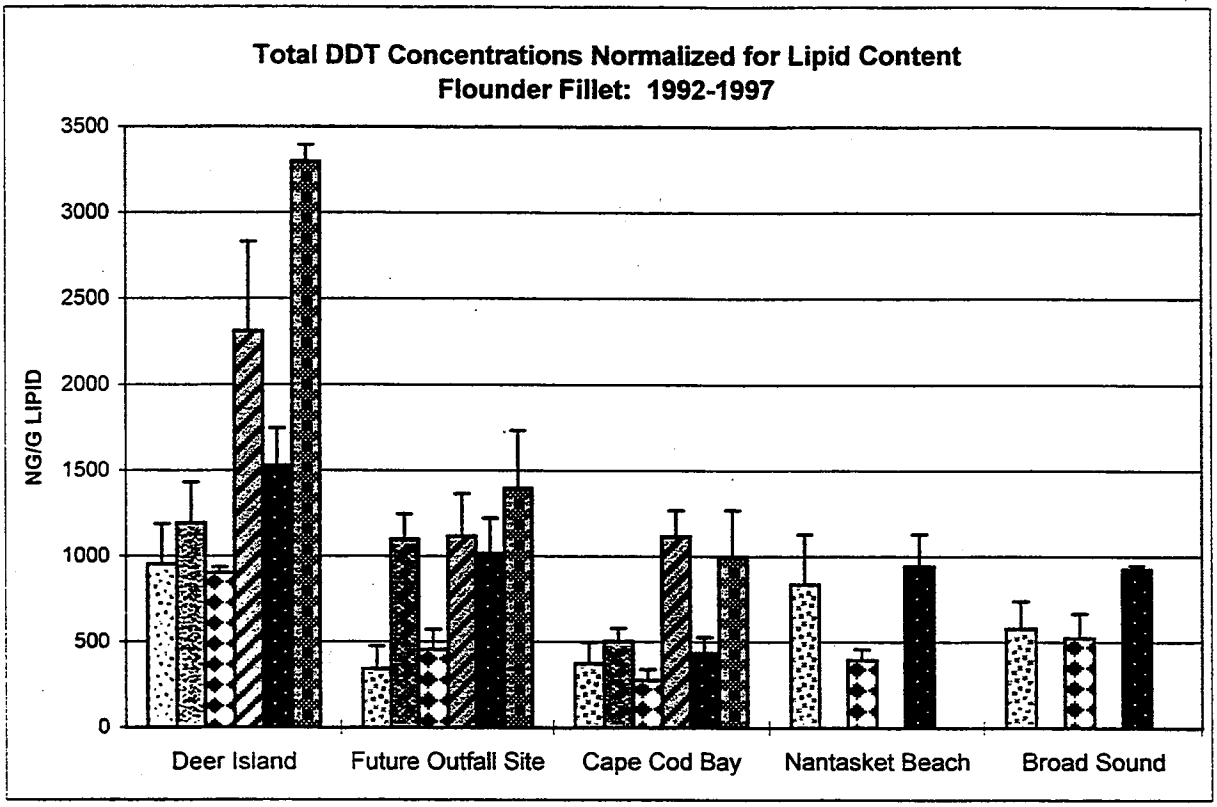


Figure 3-5
Comparison of Trace Metals in Flounder Liver, 1992-1997


Total DDT Concentrations Normalized for Lipid Content
Flounder Fillet: 1992-1997
NG/G LIPID
3500
3000
2500
2000
1500
1000
500
0
Deer Island
Future Outfall Site
Cape Cod Bay
Nantasket Beach
Broad Sound

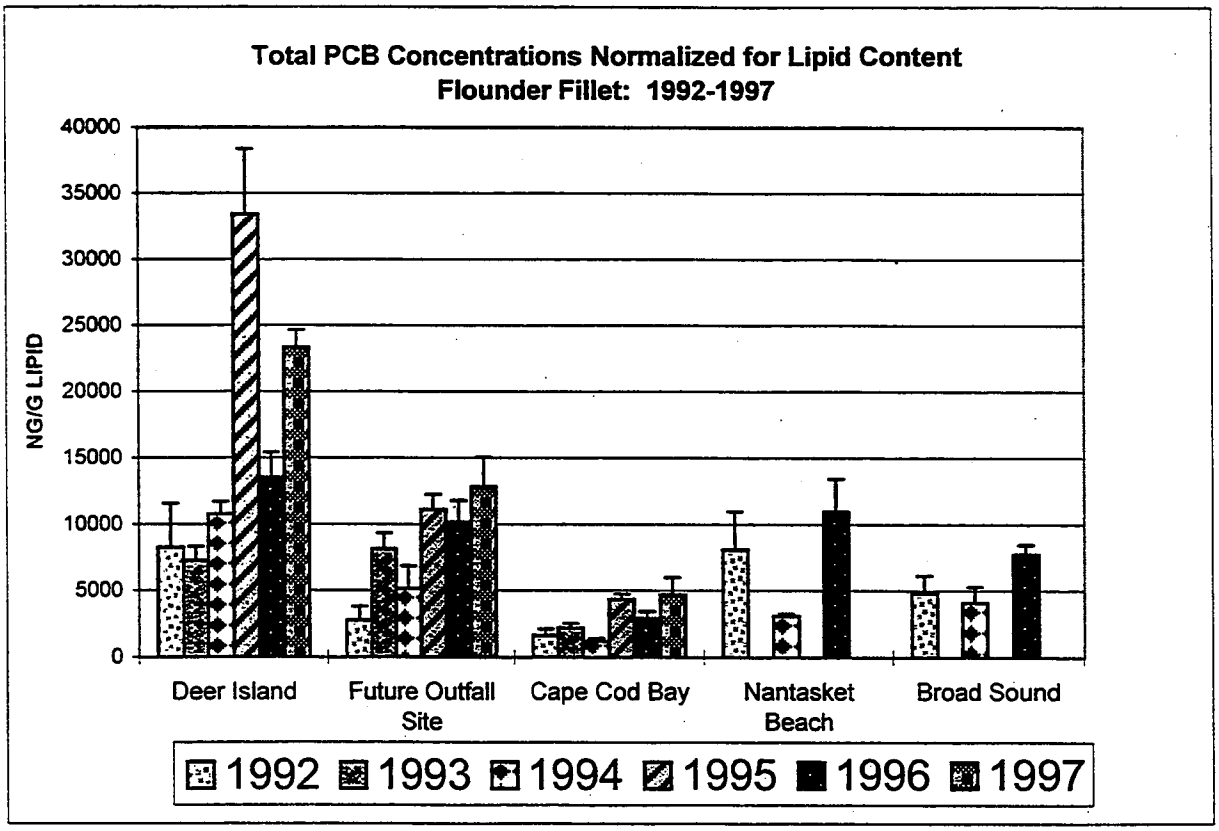
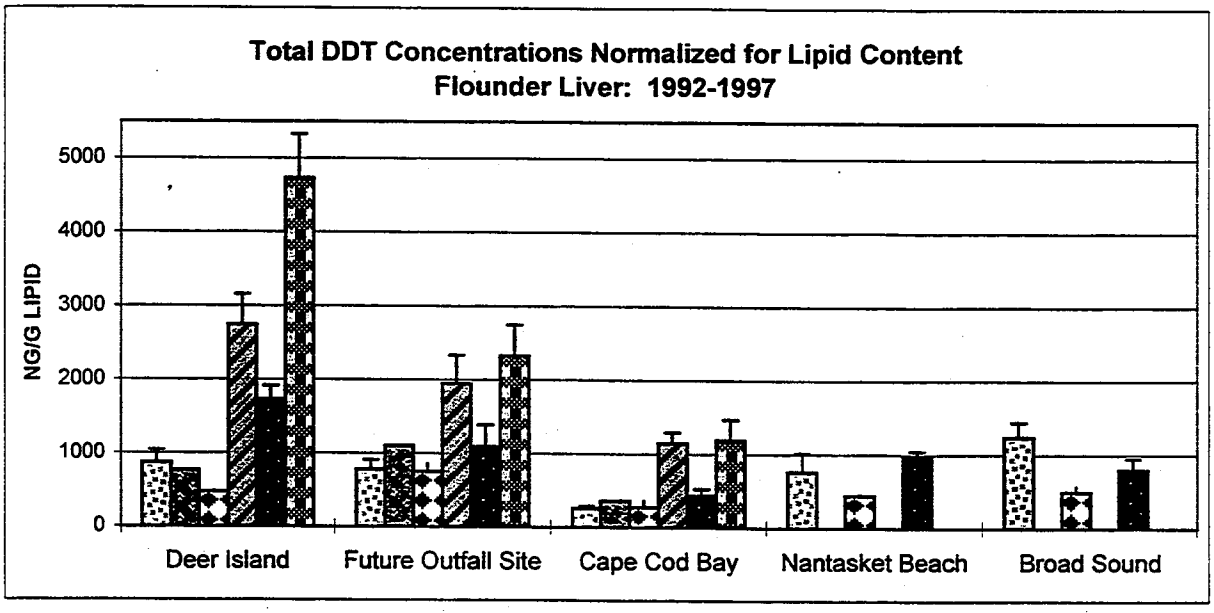
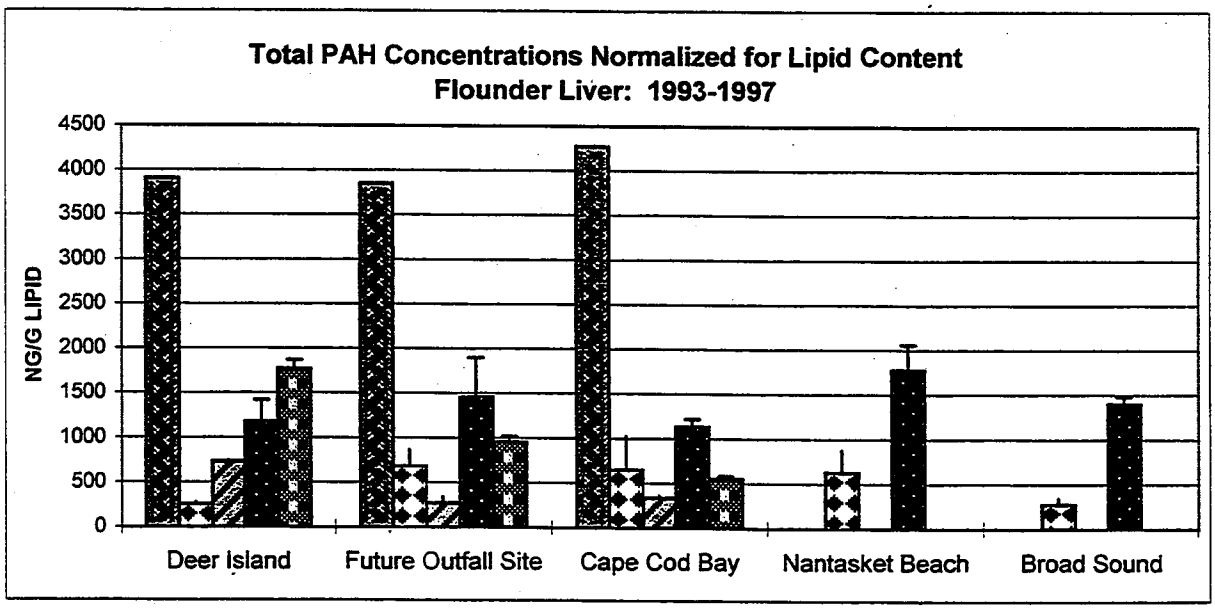

Total PCB Concentrations Normalized for Lipid Content
Flounder Fillet: 1992-1997
NG/G LIPID
40000
35000
30000
25000
20000
15000
10000
5000
0
Deer Island
Future Outfall Site
Cape Cod Bay
Nantasket Beach
Broad Sound
1992
1993
1994
1995
1996
1997

Figure 3- 6a


Total DDT Concentrations Normalized for Lipid Content
Flounder Liver: 1992-1997
NG/G LIPID
5000
4000
3000
2000
1000
0
Deer Island
Future Outfall Site
Cape Cod Bay
Nantasket Beach
Broad Sound


Total PAH Concentrations Normalized for Lipid Content
Flounder Liver: 1993-1997
NG/G LIPID
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Deer Island
Future Outfall Site
Cape Cod Bay
Nantasket Beach
Broad Sound

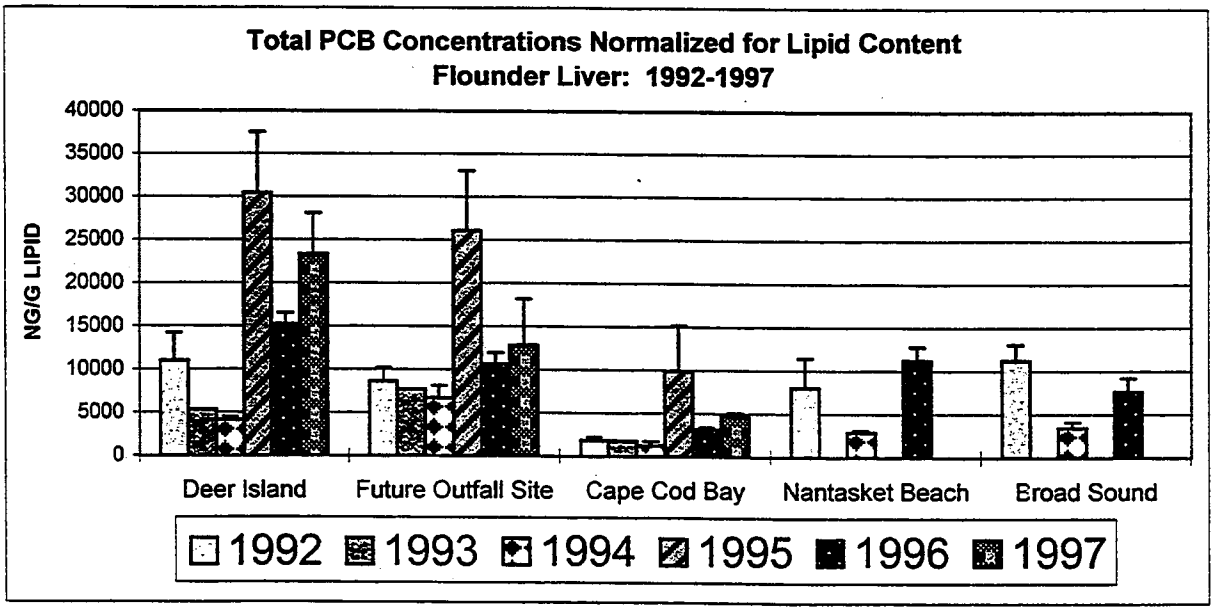

Total PCB Concentrations Normalized for Lipid Content
Flounder Liver: 1992-1997
NG/G LIPID
40000
35000
30000
25000
20000
15000
10000
5000
0
Deer Island
Future Outfall Site
Cape Cod Bay
Nantasket Beach
Broad Sound
1992
1993
1994
1995
1996
1997

Figure 3- 6b

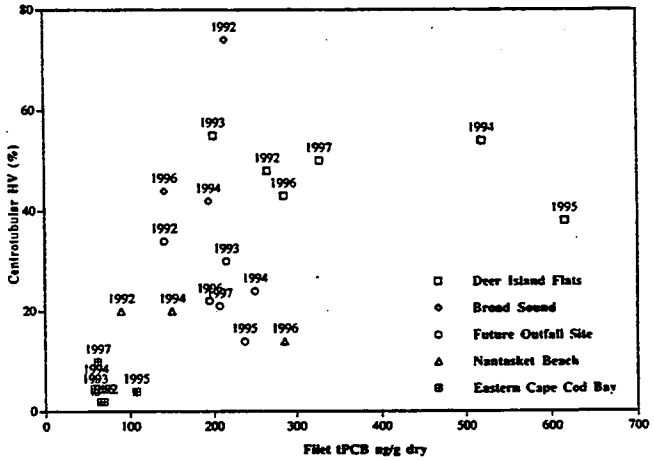


FIGURE 3-7a

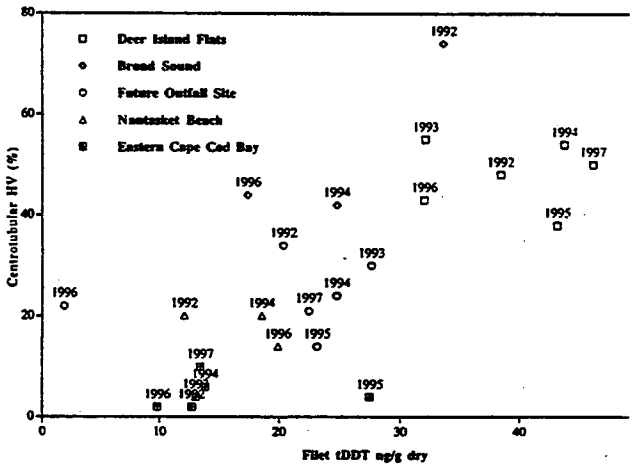


FIGURE 3-7b

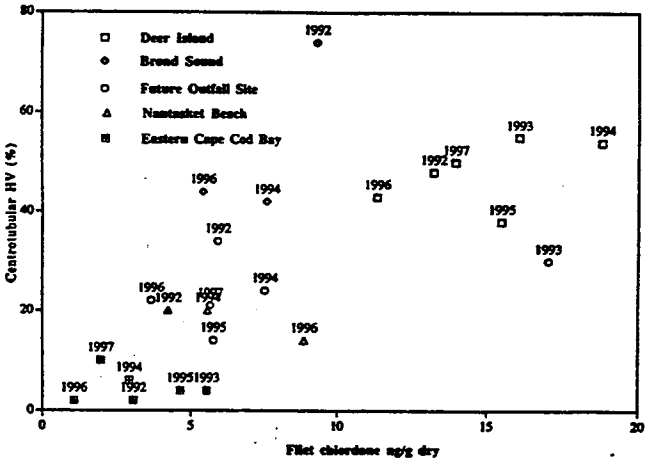


FIGURE 3-7c

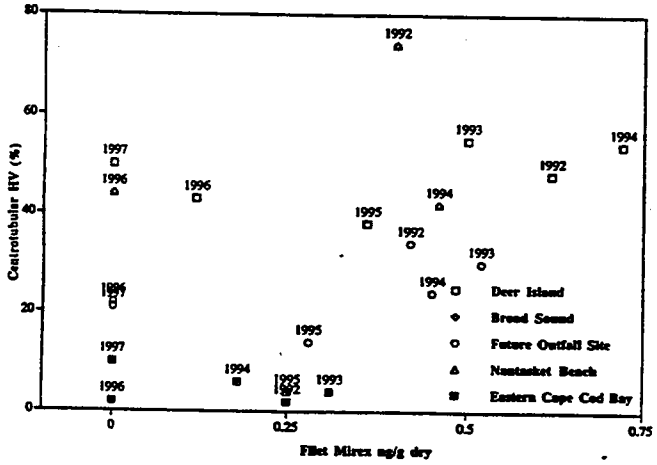


FIGURE 3-7d

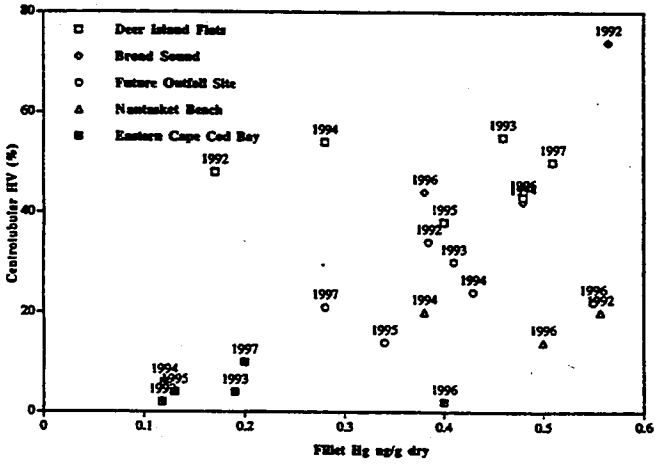


Figure 3-7

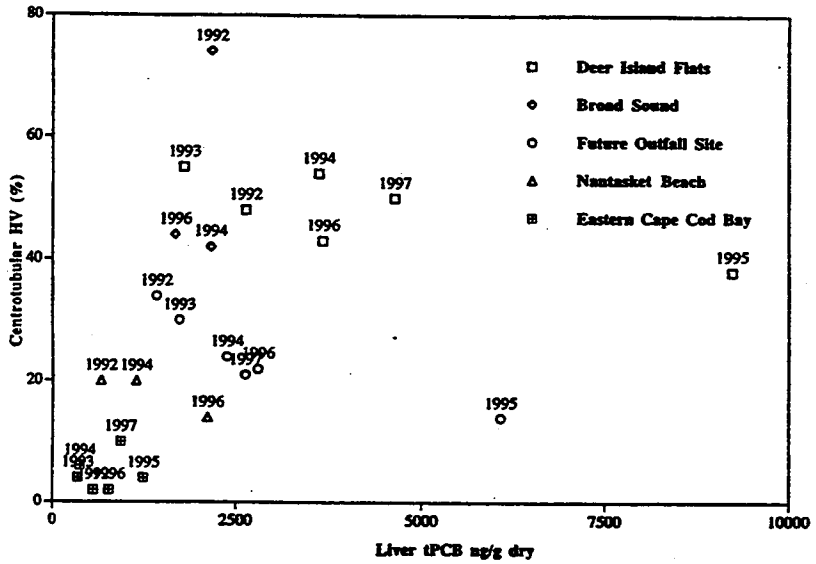


FIGURE 3-8a

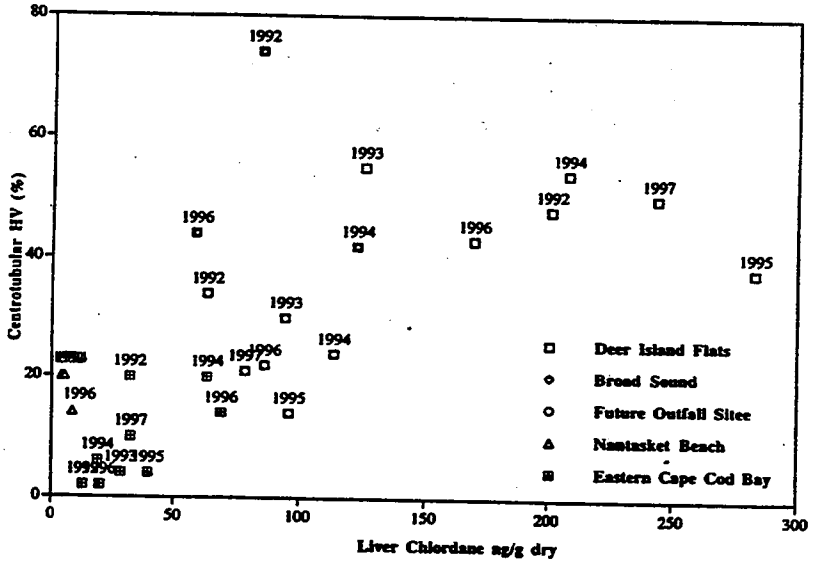


FIGURE 3-8b

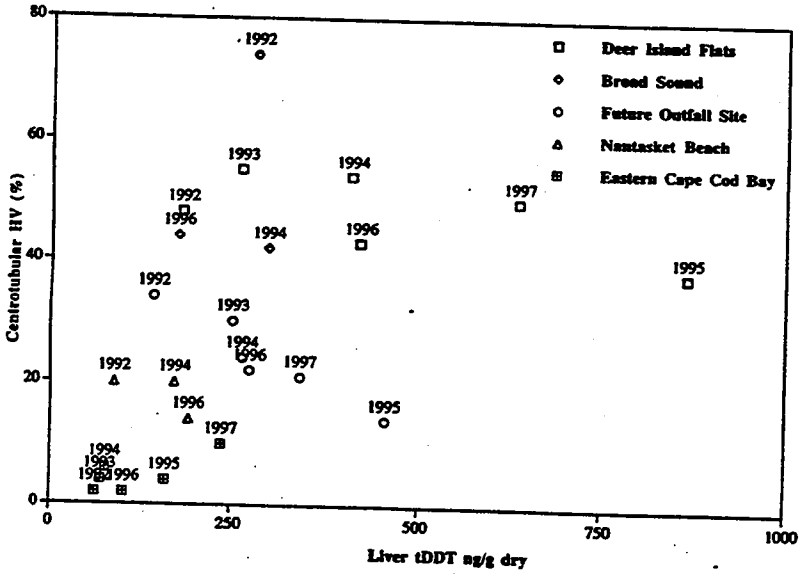
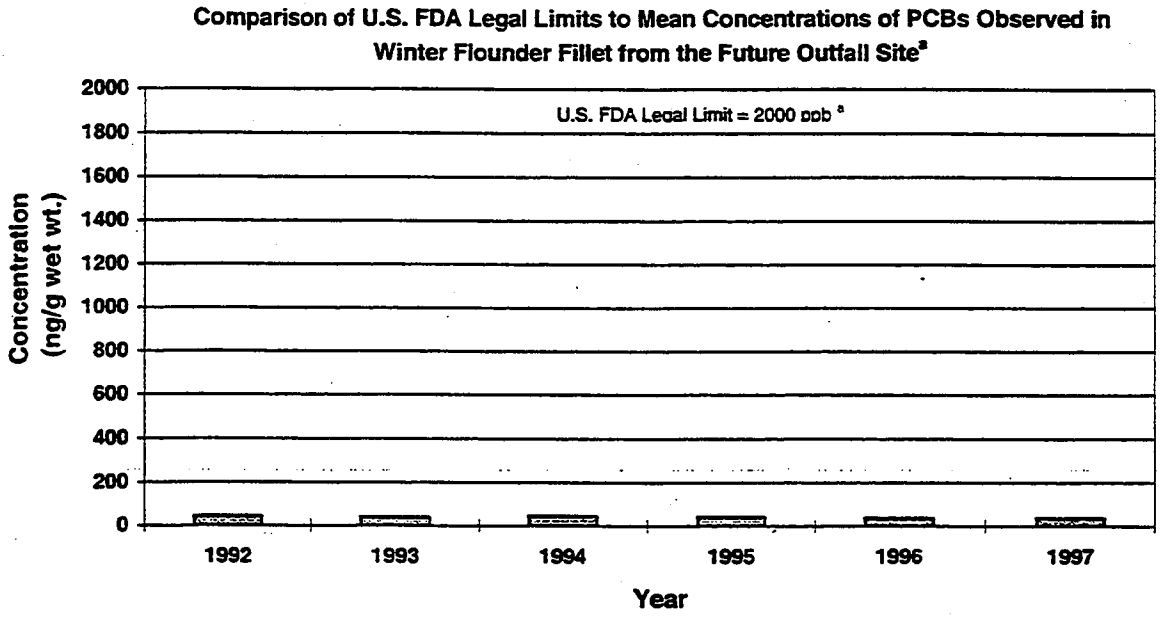
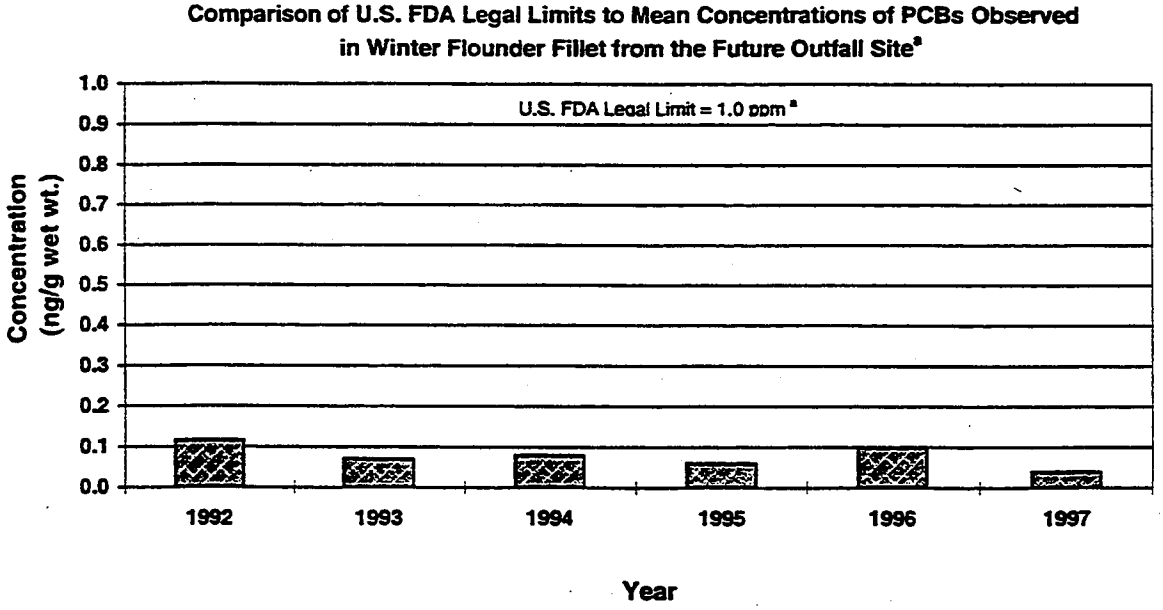


Figure 3-8

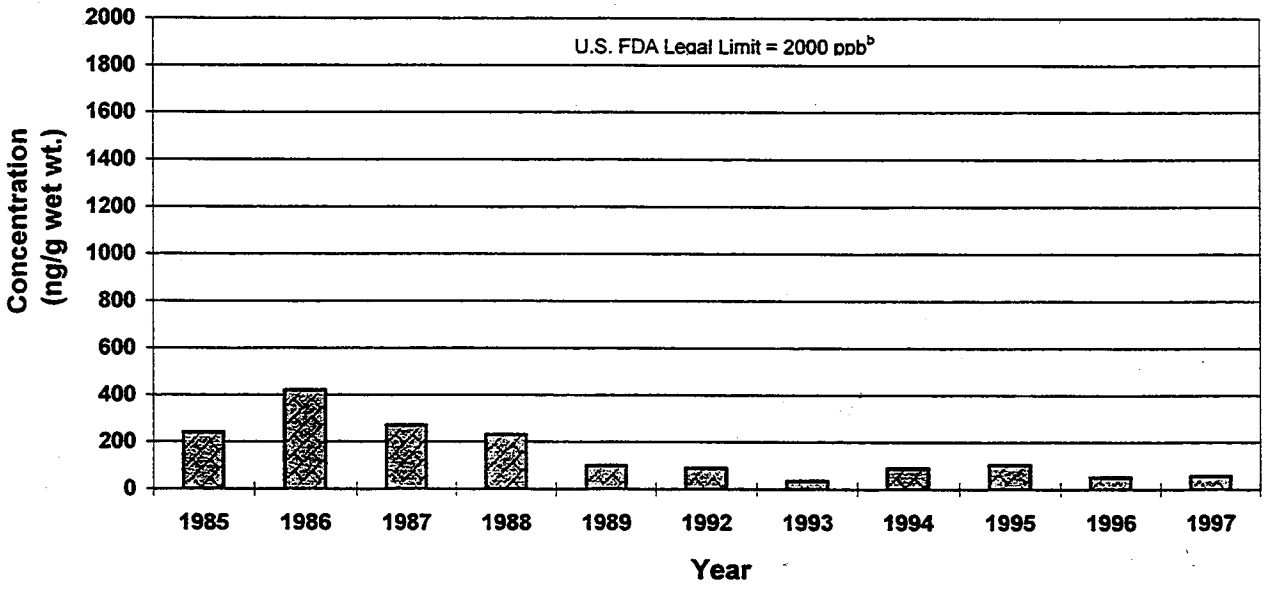




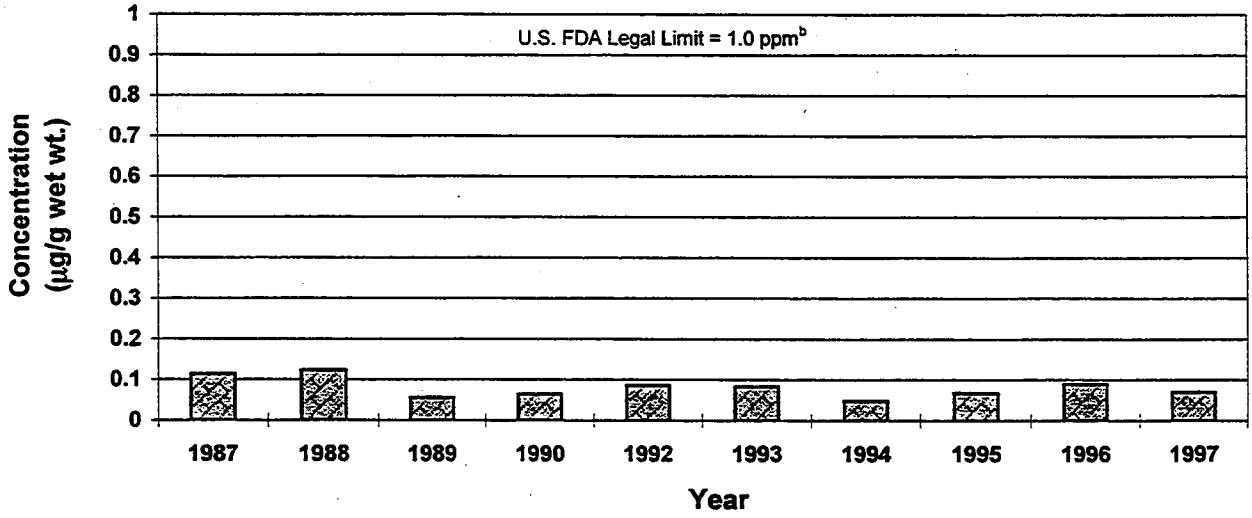
a - U.S. EPA, *Assessing Human Health Risks From Chemically Contaminated Fish and Shellfish, 1989* .

Figure 3-9a
Comparison of Winter Flounder Tissue Concentrations of PCBs and Mercury at the Future Outfall Site to U.S. FDA Legal Limits

Comparison of U.S. FDA Legal Limits to Mean Concentrations of PCBs Observed in Winter Flounder Fillet from Deer Island Flats[a]



Comparison of U.S. FDA Legal Limits to Mean Concentrations of Mercury Observed in Winter Flounder Fillet from Deer Island Flats[a]



[a] 1985-1991 data is from Schwartz et al., *PCBs in Winter Flounder, American Lobster, and Bivalve Molluscs from Boston Harbor, Salem Harbor and Coastal Massachusetts:1984-1989* or *Metal Concentrations in Winter Flounder, American Lobster, and Bivalve Molluscs from Boston Harbor, Salem Harbor and Coastal Massachusetts.*, 1991. 1992-1994 data are from Hillman and Peven, *1994 Annual Fish and Shellfish Report*, 1995. 1995 data are from Mitchell, *1995 Annual Fish and Shellfish Report.* *1996 data are presented in this report.*

[b] U.S.EPA, *Assessing Human Health Risks From Chemically Contaminated Fish and Shellfish*, 1989.

Figure 3-9b
Comparison of Winter Flounder Tissue Concentrations of PCBs and Mercury at Deer Island Flats to U.S. FDA Legal Limits

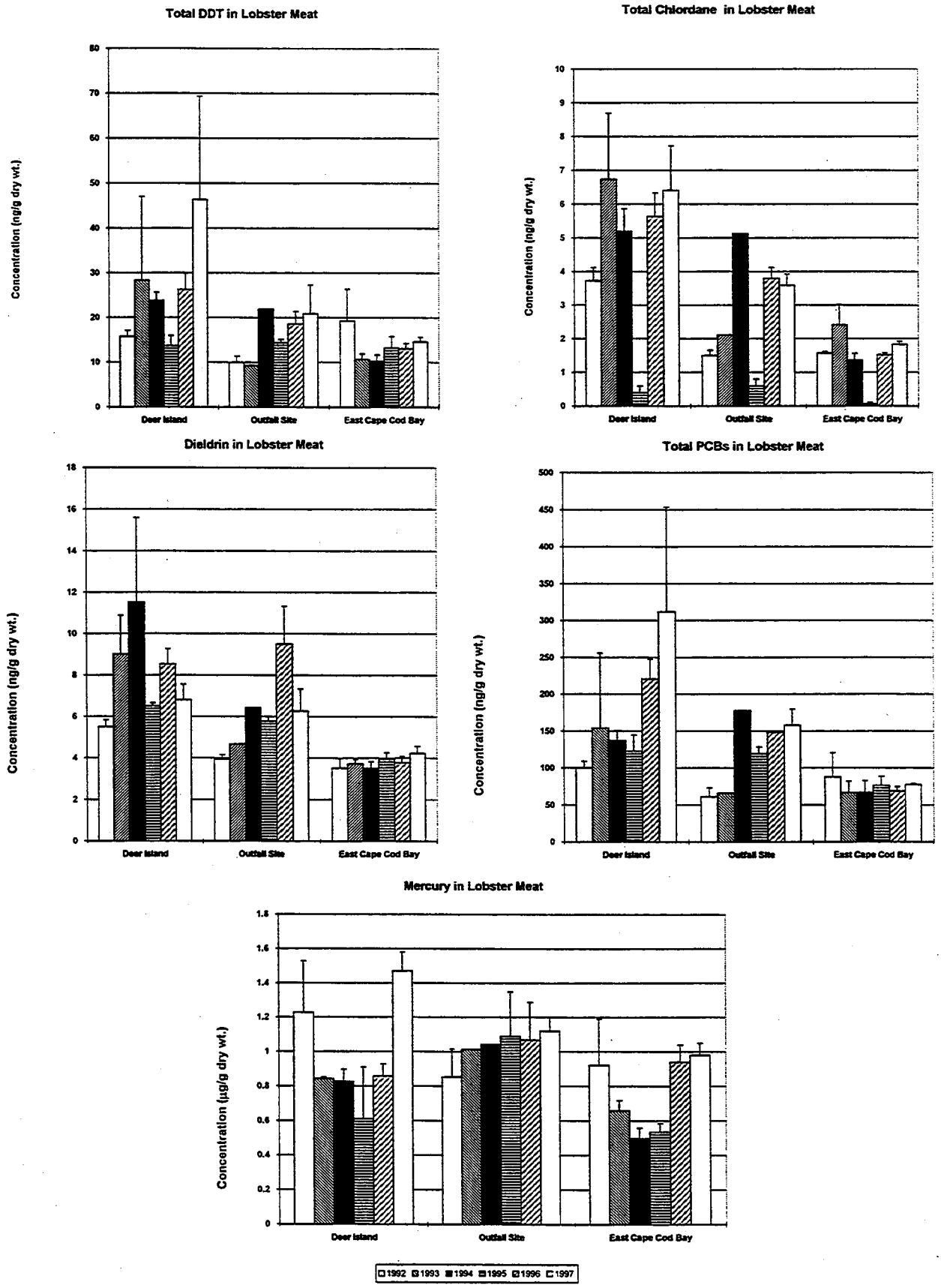
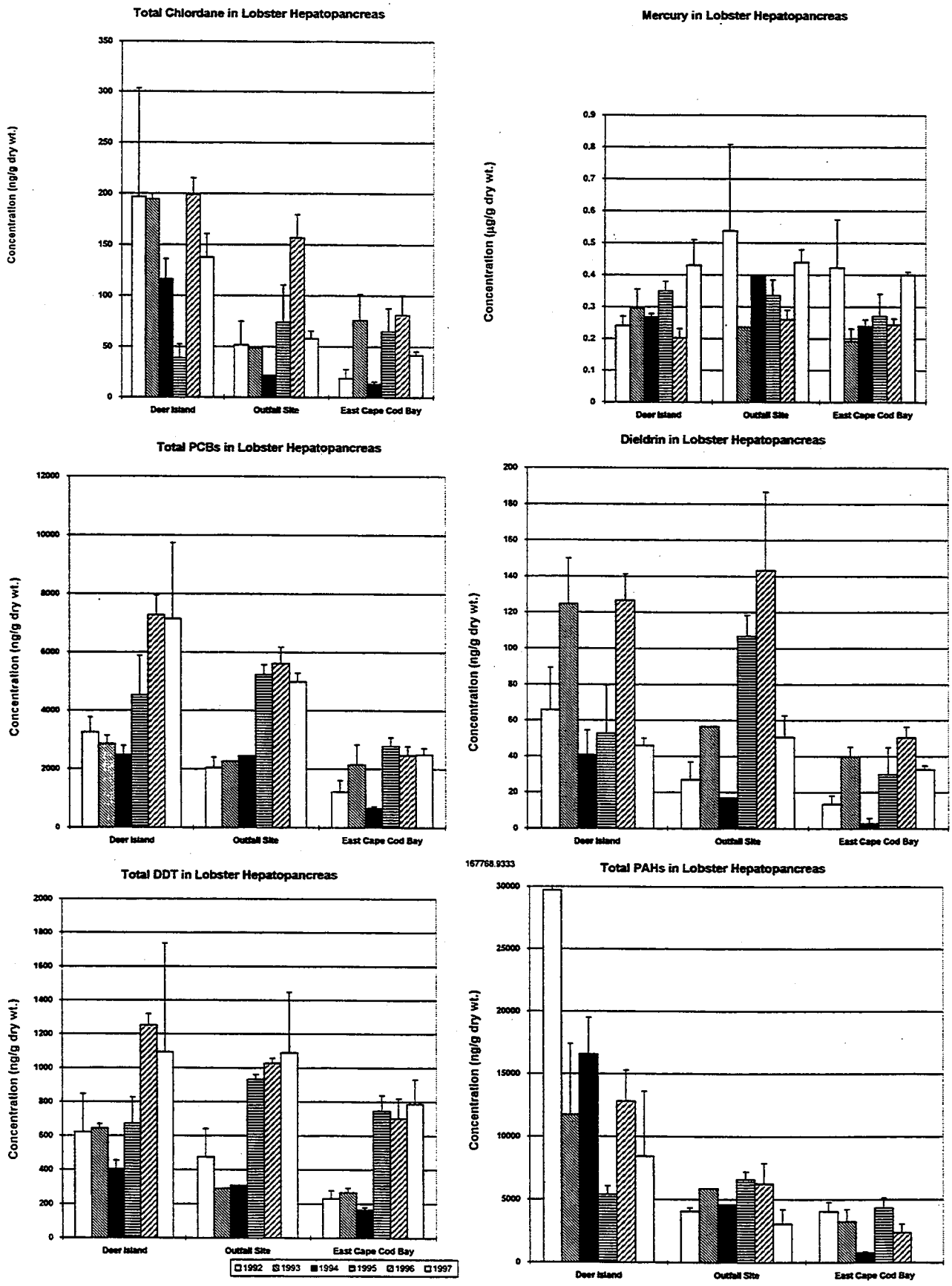


Figure 3-10
Comparison of Target Analytes in Lobster Meat 1992-1997



Note:
The 1997 concentration of Total PAH at Cape Cod Bay was extremely elevated and may reflect contamination during sampling. The value has been removed from consideration and therefore does not appear or

Figure 3-11
Comparison of Target Analytes in Lobster Hepatopancreas, 1992-1997

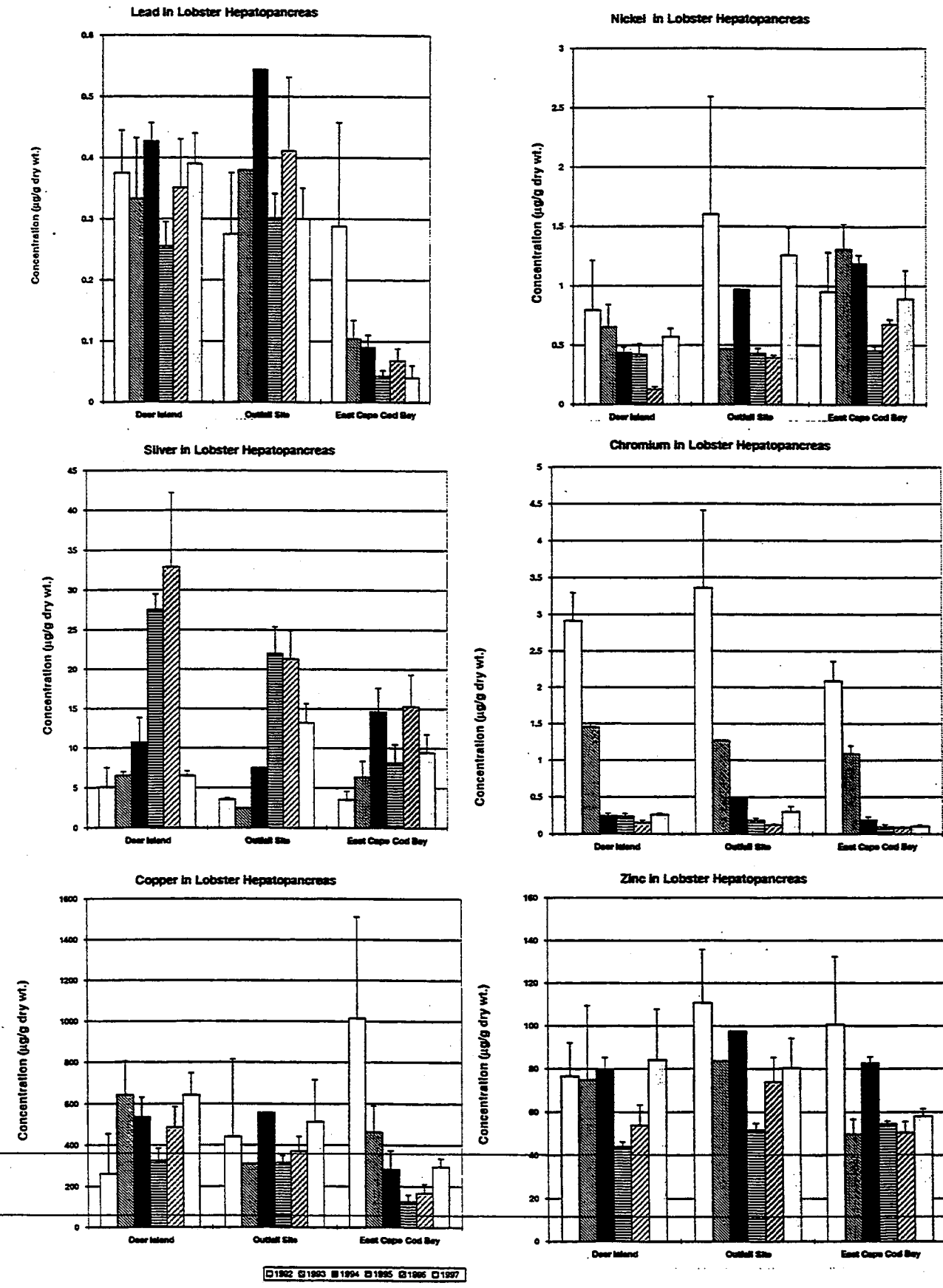
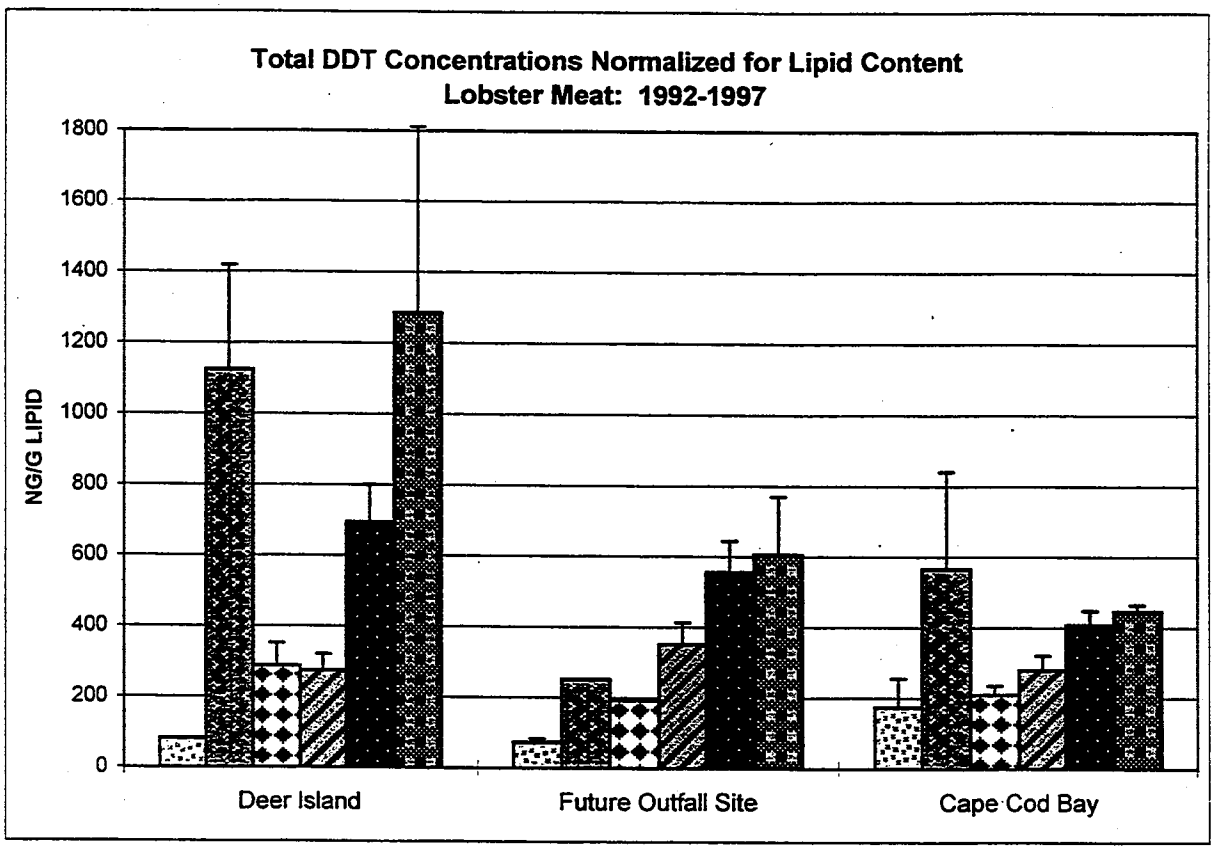


Figure 3-12
Comparison of Trace Metals in Lobster Hepatopancreas, 1992-1997


Total DDT Concentrations Normalized for Lipid Content
Lobster Meat: 1992-1997
NG/G LIPID
1800
1600
1400
1200
1000
800
600
400
200
0
Deer Island
Future Outfall Site
Cape Cod Bay

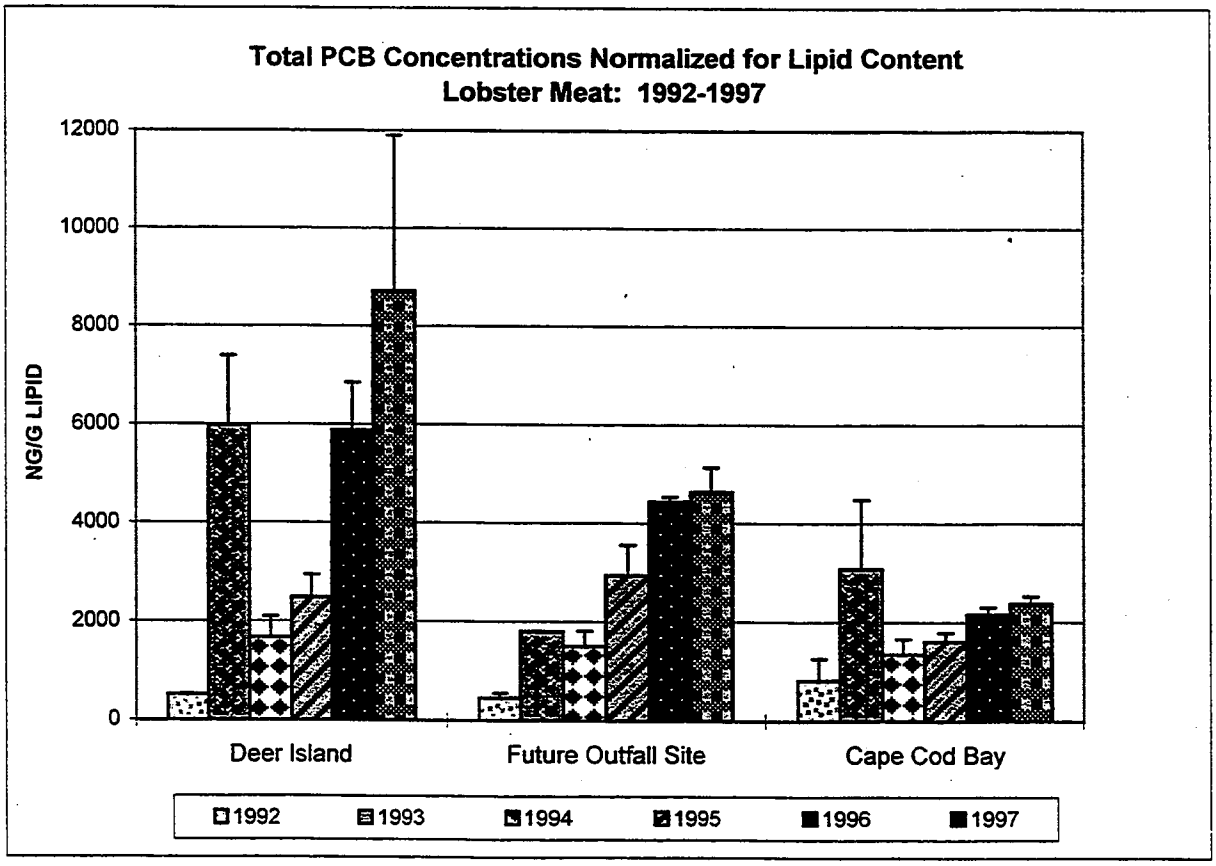
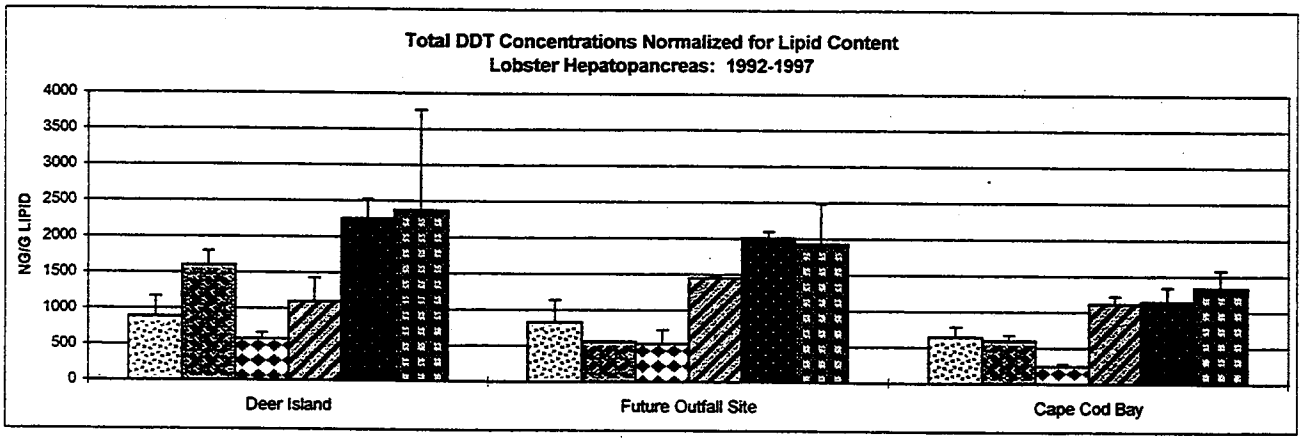
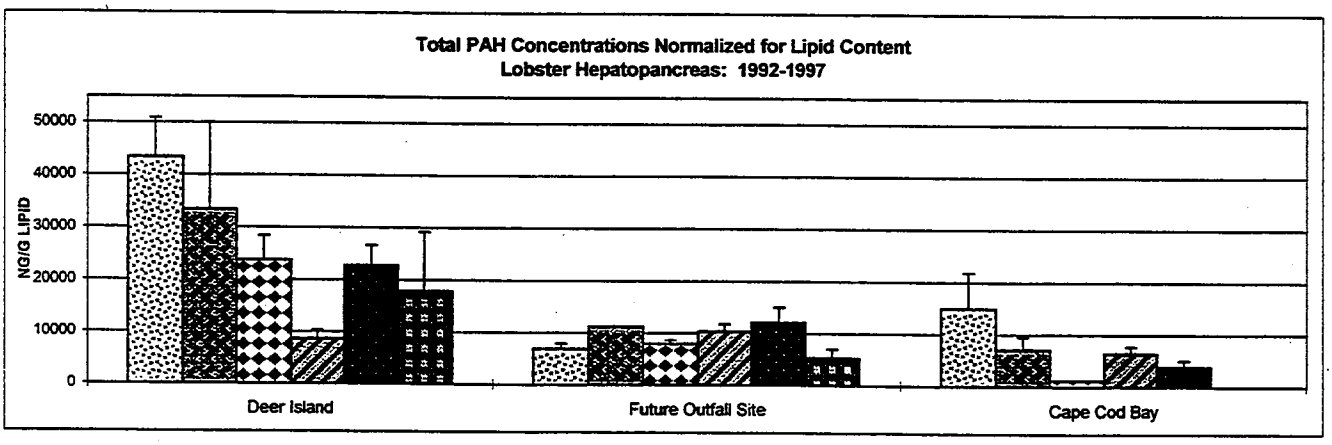
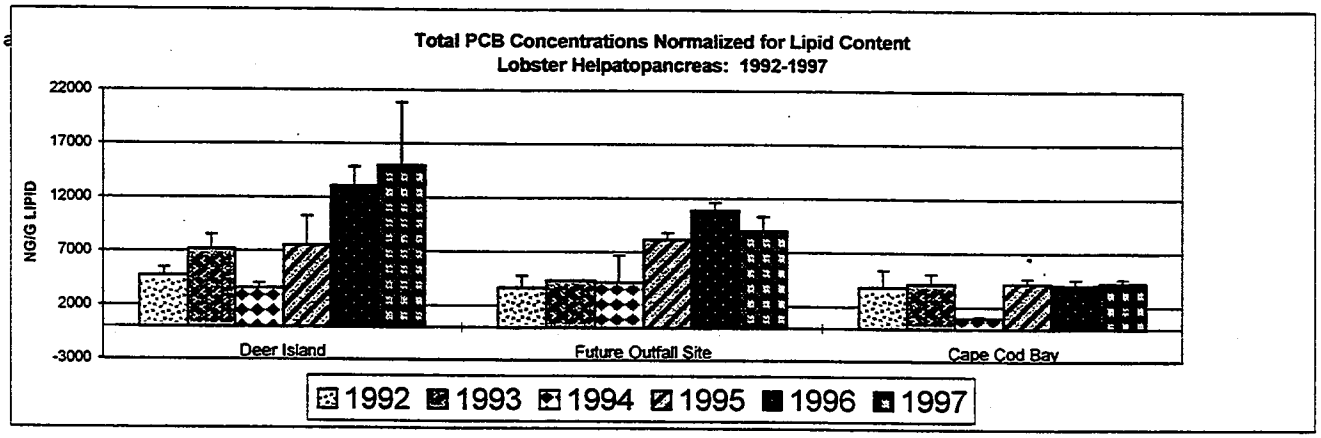

Total PCB Concentrations Normalized for Lipid Content
Lobster Meat: 1992-1997
NG/G LIPID
12000
10000
8000
6000
4000
2000
0
Deer Island
Future Outfall Site
Cape Cod Bay
1992
1993
1994
1995
1996
1997

Figure 13-a







Note:

(a) - The 1997 concentration of Total PAH at Eastern Cape Cod Bay was extremely elevated and may reflect contamination during sampling.

Figure 13-b

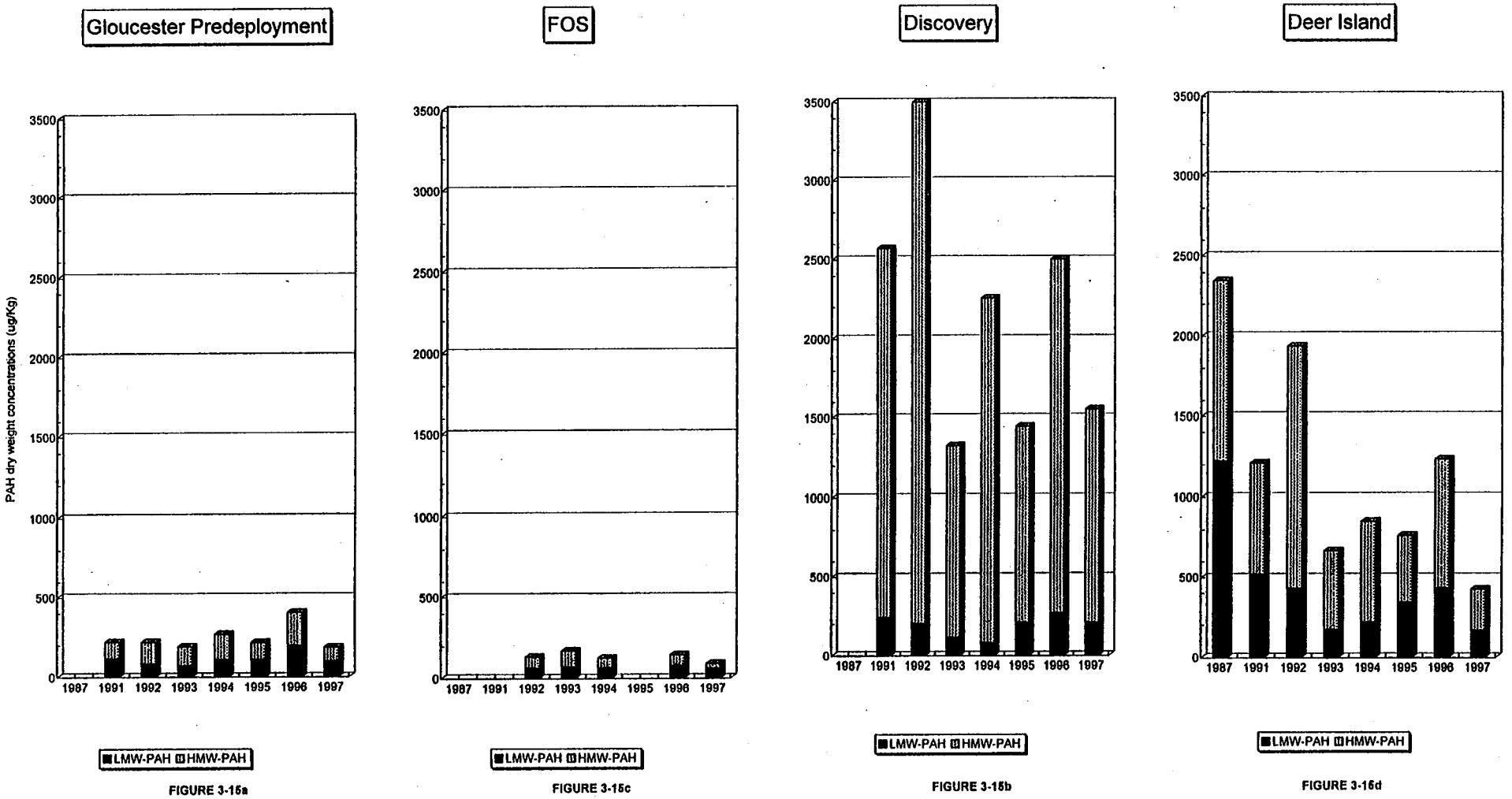


Figure 3-15a-d. Annual average PAH body burdens for 1987-1997 deployed mussels.

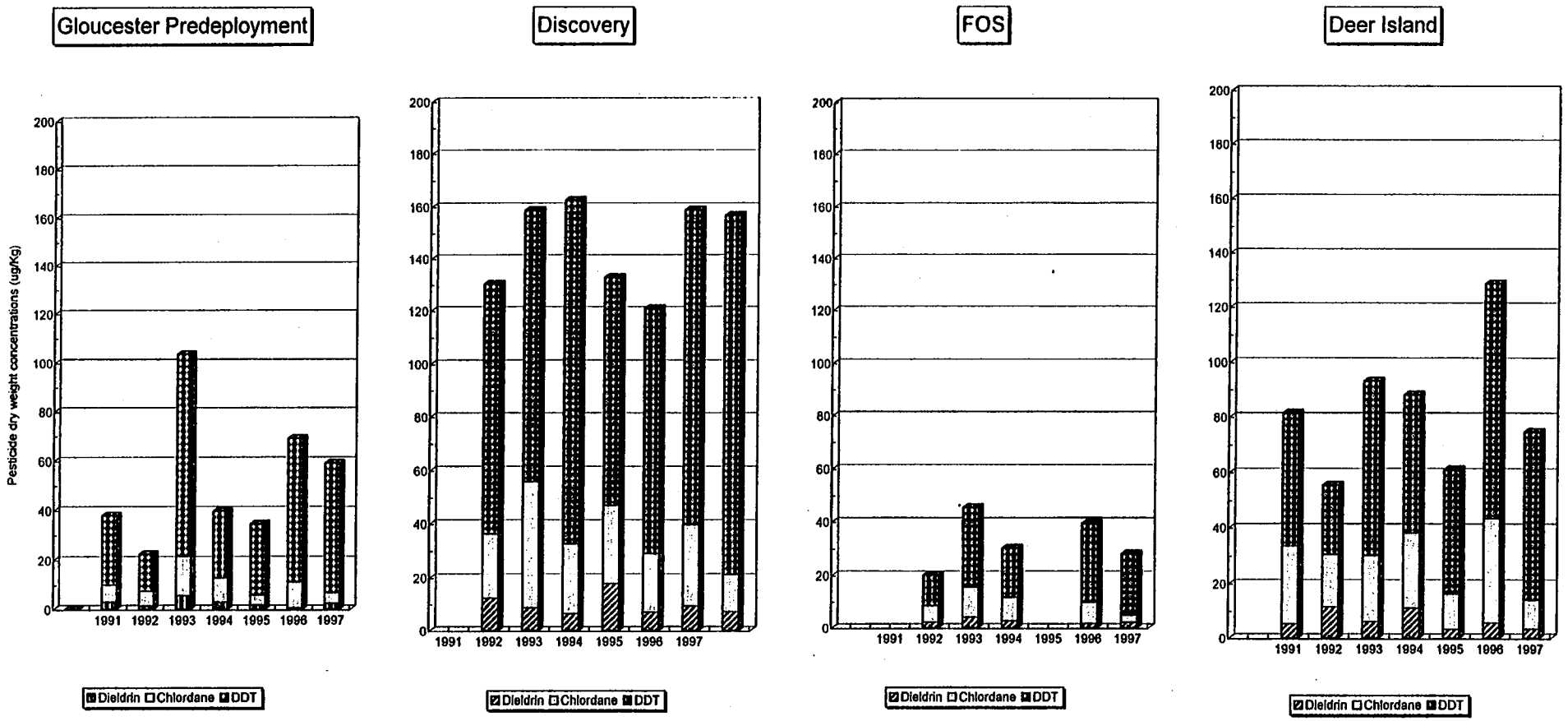


FIGURE 3-16a

FIGURE 3-16c

FIGURE 3-16b

FIGURE 3-16d

Figure 3-16a-d. Annual average pesticide body burdens for 1991-1997 deployed mussels.

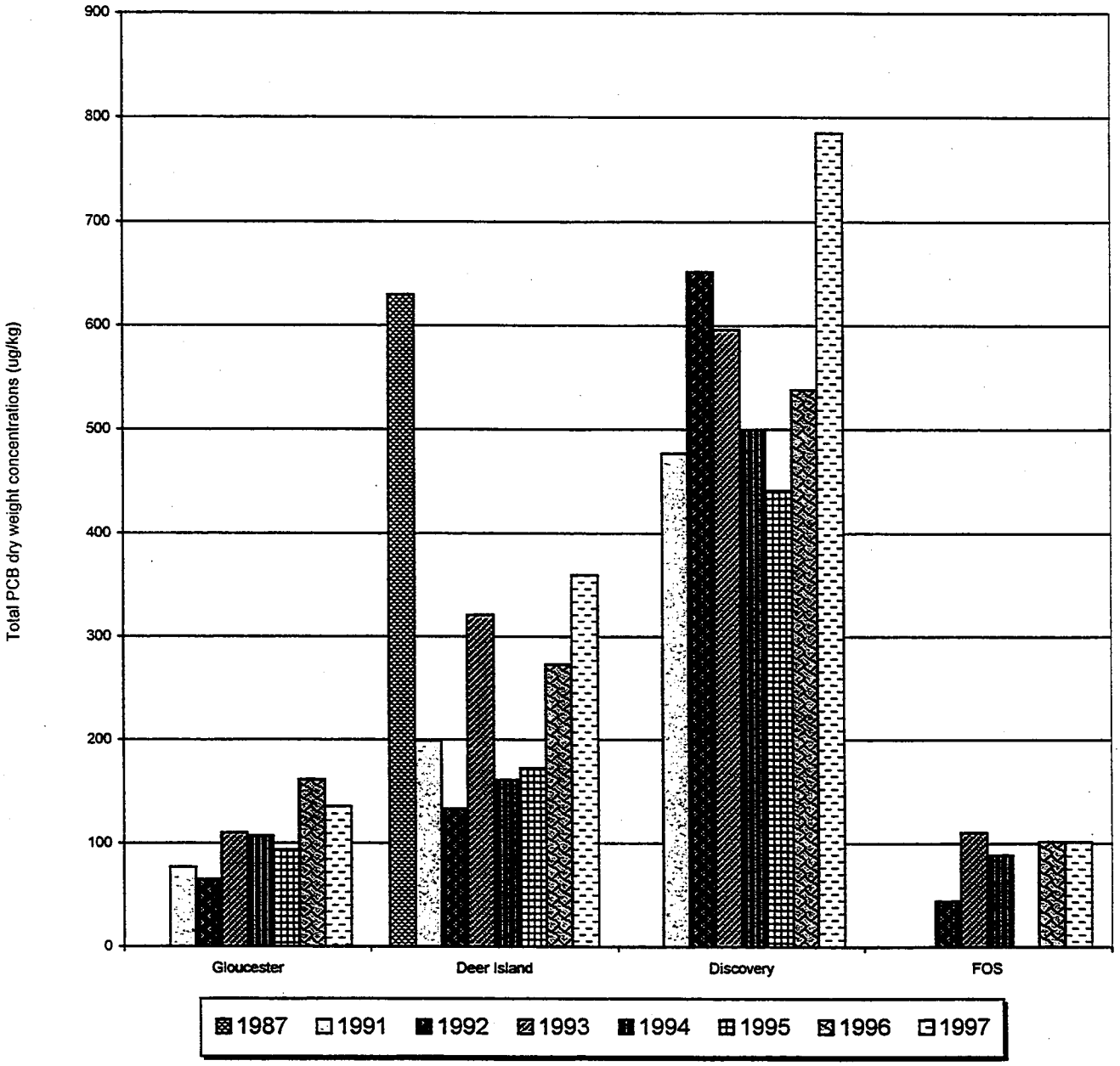
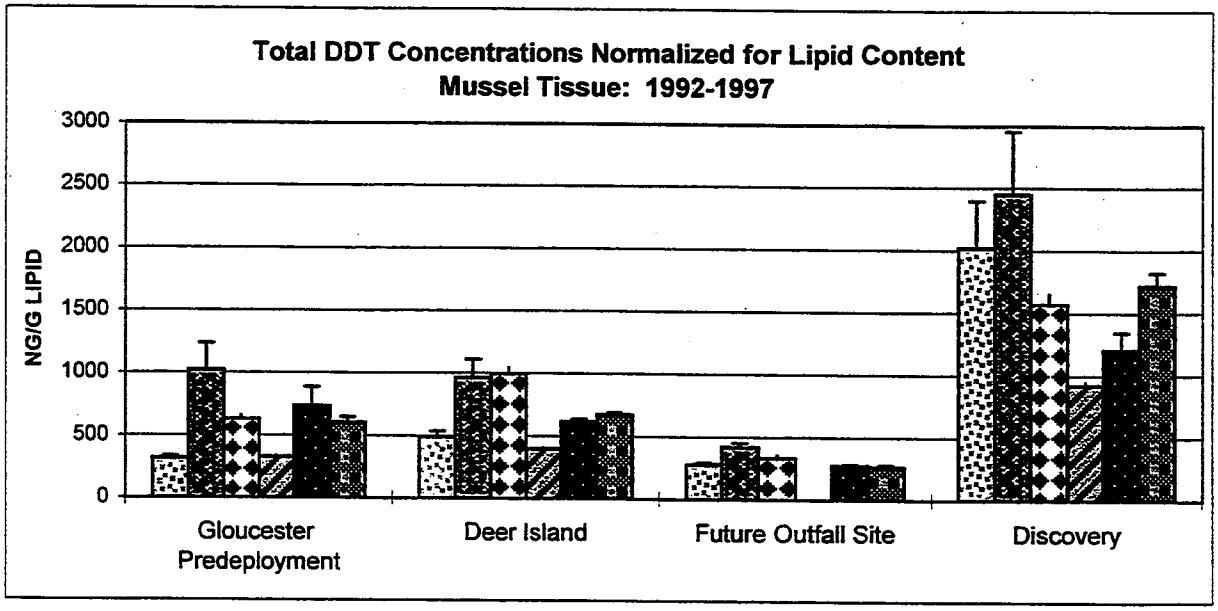
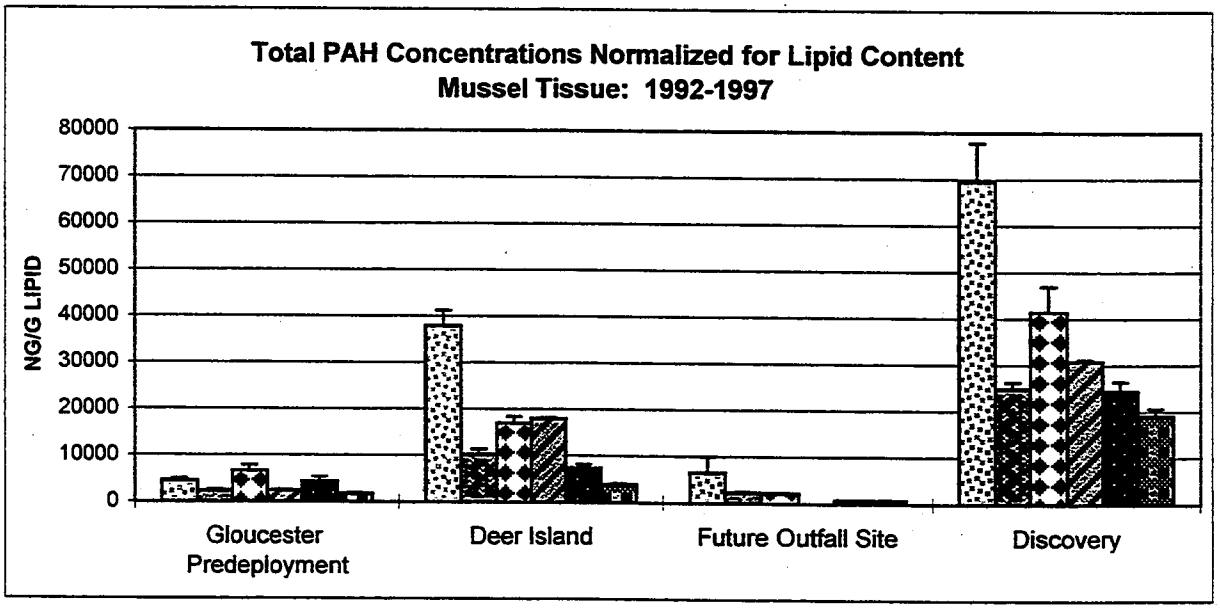


Figure 3-17. Annual average PCB body burdens for 1987-1997 deployed mussels.


Total DDT Concentrations Normalized for Lipid Content
Mussel Tissue: 1992-1997
NG/G LIPID
3000
2500
2000
1500
1000
500
0
Gloucester Predeployment
Deer Island
Future Outfall Site
Discovery


Total PAH Concentrations Normalized for Lipid Content
Mussel Tissue: 1992-1997
NG/G LIPID
80000
70000
60000
50000
40000
30000
20000
10000
0
Gloucester Predeployment
Deer Island
Future Outfall Site
Discovery

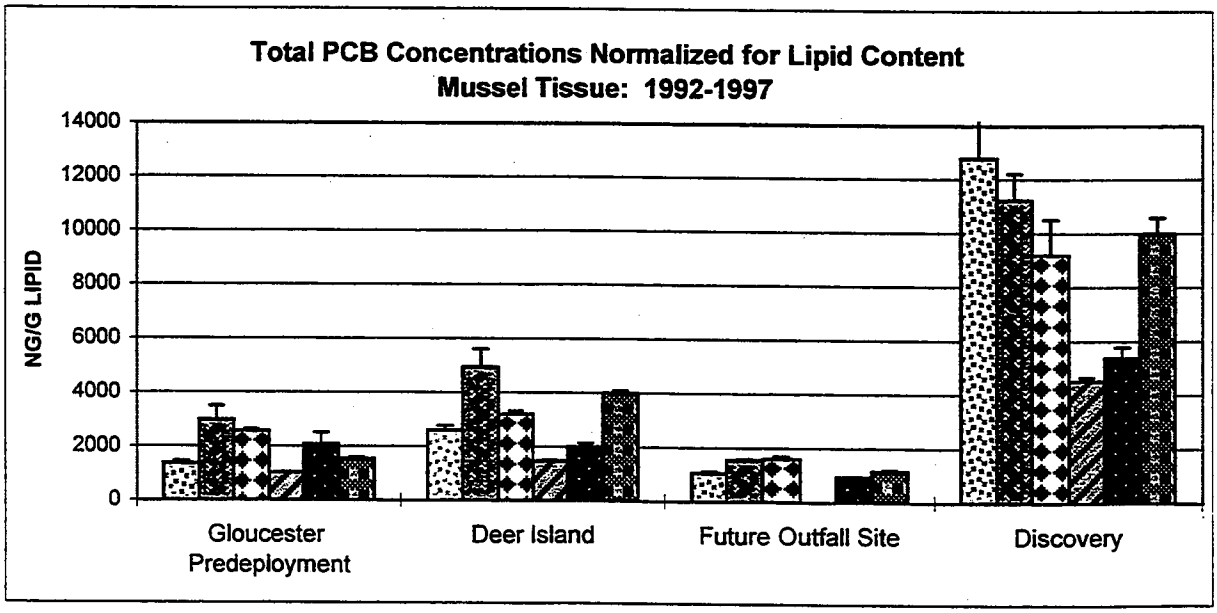

Total PCB Concentrations Normalized for Lipid Content
Mussel Tissue: 1992-1997
NG/G LIPID
14000
12000
10000
8000
6000
4000
2000
0
Gloucester Predeployment
Deer Island
Future Outfall Site
Discovery

Figure 3- 18

4.0 CONCLUSIONS

The 1997 Fish and Shellfish Monitoring program was successful in providing another year's worth of data, further documenting and expanding the existing, pre-effluent diversion baseline conditions and evaluating the monitoring hypotheses. Compared to previous years, most parameters were measured within the range of past efforts. There were some exceptions to this trend, including PAHs in lobster hepatopancreas, that warranted further investigation of analytical variation. More importantly, the tissue contaminant levels in edible portions of flounder and lobster were detected at levels well below the FDA legal limits nor did they exceed the warning or action levels. Further comments on the surveys are given below.

4.1 Winter Flounder

The 1997 Flounder Survey was conducted in a manner consistent with previous years' surveys. The frequency of lesion occurrence appears to be slowly declining in the nearshore area. A statistically significant decreasing relationship between prevalence of neoplasm and survey year was noted in the years 1987-1997 for Deer Island Flats (DIF). Whether this trend is linked to improvement in environmental conditions is an important monitoring issue.

The levels of most tissue contaminant concentrations were comparable to the previous four years of data. Fillet tissue contaminant concentrations were below the FDA legal limits for pesticides, PCBs and mercury (as well as caution and warning limits), thus indicating no risk for human consumption.

Analyses of the last six years of data (1992-1997) histology and tissue chemistry indicate a series of statistically significant relationships between centrotubular hydropic vacuolation and tissue contaminant levels for selected analytes. These suspected causal relationships between contaminant exposure (body burdens) and detectable precursors of neoplasm should be further evaluated in following years to check any corresponding changes in prevalence and body burden following effluent diversion at the Future Outfall Site (FOS).

One problematic aspect of the Flounder Survey has been the increasing difficulty in procuring a complete catch (i.e., 50 fish) of winter flounder at DIF, observed over the baseline period (1991-1997). This can be seen with the decreasing catch per unit effort (CPU) as well as the low CPU relative to other survey stations (see Table 3-1). Total number of flounder caught ranged from 121 (1991) to 16 (1999), with most years capturing between 30 to 50 fish. In 1997 the DIF survey culminated in loss of fishing gear under adverse trawling conditions.

Two concerns have been identified: the diminution of a locally scarce population as an indirect consequence of the means used to identify potential toxic threats to its well-being is counterintuitive at best; and the disruption of the bottom habitat (e.g., physical structure) by the intense trawling often required at DIF to achieve target sample numbers (i.e., 50 fish) may further reduce local populations. While scarcity of local winter flounder is unrelated to the negligible take of MWRA surveys, some consideration may be made to reducing the required catch in the future.

Scarcity of winter flounder at DIF, as with other monitored populations, is subject to year-to-year variation (e.g., 1998 survey at DIF has very high CPU) as a function of natural conditions, strength of year class, and fishing pressure, and other uncontrolled factors. Accordingly, as the outfall shifts to FOS, the numbers required at DIF may be revisited. It should also be recognized that any reduction in sampling effort will result in some reduction in the statistical power to detect significant change. Therefore, the level of reduction in target fish goals should also consider the level of loss in statistical power. For example, if 25 fish are sampled for histopathological conditions instead of 50, there would be a less than 10% reduction in statistical power (Zar, 1996). This may be considered an acceptable value in return for reduced effort at this station. However, reduction in numbers during the first few years following shift of the outfall is not recommended, due to the importance of effectively documenting change in tissue and histopathology following the elimination of the effluent discharge.

4.2 Northern Lobster

The 1997 Lobster Survey collected specimens from the three sampling locations through a combination of trapping and direct shipboard collection from lobstermen. Analyses of the lobster tissue contaminant levels found that body burdens were generally greatest at DIF and lowest at the Eastern Cape Cod Bay (ECCB) reference station. Comparison of 1997 data with previous years (1992-1996) indicates that most tissue levels remained within the range previously observed, with the exception of PAHs in hepatopancreas at ECCB (which were considered so anomalous as to indicate contamination of some point in the sampling process). Lobster edible tissue contaminant concentrations were below the FDA legal limits and action and warning limits for pesticides, PCBs and mercury, thus indicating no risk for human consumption.

The gradient shown in lobster tissue concentrations (i.e., highest values at DIF, lowest at ECCB, and intermediate at FOS) is very constant over the baseline period. Since this gradient also reflects the apparent relative influence of anthropogenic sources, the regularity of these trends suggest that lobsters either do not significantly migrate between these areas (or return to these areas regularly, or that they undergo a rapid equilibration to local ambient conditions. As discussed earlier, studies indicate lobster are capable of a wide range of movement pattern (see Section 3.2.2.3), but exhibit a strong homing mechanism oriented toward a particular location (Lawton and Lavalli, 1995). Based on these findings, it suggests that legal-sized lobsters exhibit sufficient fidelity to an area to allow establishment of a predictable trend in tissue body burdens due to relative contaminant exposure levels. On the other hand, the use of composite samples will decrease the observed heterogeneity of tissue concentrations values and mask the presence of true emigrants.

4.3 Blue Mussel

The 1997 Mussel Bioaccumulation study provided data on the *Discovery*, DIF and the FOS. The overall mussel PAH body burden trends for the 1997 study diverged from previous studies suggesting that PAH contaminant exposure may be changing in Boston Harbor particularly near Deer Island. Mussels deployed at Deer Island had, for the first time, numerically lower LMW-PAH body burdens than *Discovery* deployed mussels. The results of the years of study suggest that PAH exposure patterns for deployed mussels at Deer Island have decreased from

1987 to 1997. It would appear that body burdens of LMW-PAHs in Deer Island mussels underwent a substantial reduction from 1987 to 1991. The annual results from 1996 and 1997 suggest that these body burdens may be continuing to decrease and that exposure to LMW-PAHs in the vicinity will continue to decrease to near background conditions in future years. Pesticide (DDT, chlordane, dieldrin) levels also comparable to earlier data.

The 1997 lead body burdens for deployed mussels were similar to those reported in 1996. The 1997 mercury tissue concentrations suggest that, statistically, Deer Island deployed mussels had the lowest body burdens . These results are contrary to trends reported by the NOAA for the National Status and Trends Program Mussel Watch Project (O'Connor and Beliaeff 1995). It is diffucult to assess why the Deer Island mercury body burdens were so low. It may be due to undetected analytical difficulties during the tissue analysis or possibly reflect actual decreases in mercury exposure for the Deer Island deployed mussels. At this time, there is no definitive answer to explain the apparent differences.

4.4 Evaluation of Monitoring Hypotheses

An integral part of the MWRA fish and shellfish monitoring is a periodic re-evaluation of the adequacy of the current program to fulfill the overall goals of the monitoring program (MWRA 1995; 1997). In particular, this means a re-examination of the adequacy and effectiveness of the underlying monitoring hypotheses to answer questions regarding the potential effects of the relocated MWRA effluent.

Of the five study area monitoring hypotheses (MWRA, 1995), three are associated with the potential for edible tissue (flounder, lobster, mussel) to exceed warning levels (set at 80% of FDA legal limit) for mercury, lead, or PCBs at the FOS. These hypotheses appear to be sufficient for protection of human health via exposure by fish consumption. Current tissue concentrations are generally an order of magnitude or more below warning and FDA regulatory levels (Table 4-1). Similarly, the monitoring hypothesis regarding future increases of the prevalence of flounder liver CHV at FOS relative to baseline levels measured in outer Boston Harbor also appears to be sufficiently sensitive to detect trends, based on current data.

Following discussion of an EPA recommendation that the caution level for PCBs in edible tissues from animals at the FOS be re-evaluated, the Outfall Monitoring Task Force (OMTF) and MWRA agreed that the caution level for PCBs would be set at a level of appreciable change from the baseline period, while the warning level would remain at 80% of the FDA limit (OMTF meeting minutes, 10/23/97). In the interests of simplicity, MWRA recommends that all caution level thresholds for other contaminants with FDA limits be similarly revised.

The other major group of monitoring thresholds has been for lipid-normalized organic contaminants. The use of lipid-normalized concentrations for organic contaminants was reconsidered as well. The temporal trends in tissue concentration as expressed on a dry weight basis was compared to concentrations expressed on a lipid-normalized basis. Comparison of the trends for flounder (see Figure 3-4 vs. Figure 3-6); for lobster (see Figure 3-11 vs. Figure 3-13); and for mussel (see Figures 3-15 through 3-17 vs. Figure 3-18) does not indicate appreciable differences in temporal trends expressed in these two different ways. These results are summarized in Table 4-2,

and indicate that normalizing contaminant concentrations to lipids does not appreciably reduce the variability over the non-normalized values. Comparison of the relative amount of change from year-to-year for dry-weight-based and lipid-based tissue concentrations is shown in Table 4-2. This table contains data on PAHs, PCBs and DDT for each bioassay organisms at the three sampling location regularly surveyed (i.e., FOS, ECCB). Table 4-2 indicates that both metrics show unconsiderable variation in year-to-year results, but that the relative percent different change for the dry-weight concentrations is lower and form a more conservative estimator of body burden change. Comments to this effect have also been received from Dr. Schwartz of Mass. DMF (Schwartz, pers. Comm to K. Keay, 10/23/97). Again in the interests of simplicity, MWRA recommends that lipid concentrations continue to be measured in the monitoring program, but that the threshold testing be based upon dry-weight concentrations of contaminants, not lipid-normalized concentrations.

Table 4-1 contains these recommendations for modified thresholds, and presents baseline mean, standard error, and significant increase values for parameters of concern, as well as the relevant caution and warning levels for trigger parameters (MWRA, 1997). The baseline mean represents the arithmetic averages of annual means (of composite samples) for organisms collected or deployed at the FOS during the period 1992-1997; with the exception of mussels which do not include 1995 data (due to loss of arrays at the FOS site) and the flounder liver lesion prevalence which includes data from 1991-1997. The significant increase value is the 95th percentile upper confidence limit (based on "t" distribution) of the arithmetic mean. As can be seen, the proposed contaminant caution levels (twice the baseline mean) are statistically different from the baseline means. The caution level for flounder liver lesion prevalence has been set equal to the baseline incidence in the Harbor flounder population. It should be noted that eventually 1992-1998 data will be included to the baseline data prior to the initiation of the outfall relocation.

Overall, it appears that the five study areas monitoring hypotheses associated with the fish and shellfish monitoring program are sufficient and do not require replacement. However, these hypotheses should be revisited on a annual basis as data becomes available to check their effectiveness (e.g., if additional data indicate large amounts of inter-annual variability ascribed to natural variation).

TABLE 4-1
Comparison of Baseline Mean Concentrations, Significantly Increased Levels, and Thresholds at the Future Outfall Site

Parameter	Baseline Mean [1]	Baseline Standard Error	Significant Increase [2]	Threshold		Baseline Years With Significant Incease	Baseline Years Which Exceed Caution Level
				Caution Level [3]	Warning Level [4]		
Mercury (ppm wet)							
Flounder	0.08	0.01	0.10	0.16	0.8	1992	No Exceedances
Lobster	0.16	0.02	0.18	0.32	0.8	No Exceedances	No Exceedances
Mussels	0.022	0.002	0.03	0.044	0.8	No Exceedances	No Exceedances
Lead (ppm wet)							
Mussels	0.55	0.12	0.83	1.1	3	No Exceedances	No Exceedances
PCBs (ppb wet)							
Flounder	39.74	1.35	42.47	79.5	1600	1994	No Exceedances
Lobster	18.05	2.79	23.66	36.1	1600	1994	No Exceedances
PAH [5] (ppb dry)							
Mussel	129.38	11.78	157.45	258.76	--	1993	No Exceedances
DDT (ppb dry)							
Flounder	23.77	1.20	26.43	47.55	--	1992, 1993, 1994, 1997	No Exceedances
Lobster	15.82	2.04	20.33	31.63	--	No Exceedances	No Exceedances
Mussel	22.63	3.09	30.00	45.25	--	No Exceedances	No Exceedances
Liver disease incidence							
(flounder only)	24.86	2.68	29.77	>harbor prevalence (1991-1997)	--	1992, 1993	Not Applicable

Notes:
[1] Mean concentration, 1992-1997 (Flounder and Lobster). Mean concentration, 1992-1994, 1996-1997 (Mussels; 1995 array was lost).
[2] Level at which change from the mean is considered significant from baseline mean at 5% level (i.e., 95th percent ULC based on "t" distribution.
[3] Based on "appreciable change from baseline"; see text for discussion.
[4] Massachusetts Water Resources Authority (MWRA) 1997. Contingency Plan. Warning Level is 80% of the FDA Legal Limit.
[5] Representing NOAA PAHs only.

Table 4-2a
Relative Percent Difference in Means (Dry Weight and Lipid Normalized) Between Years
Flounder Liver
1992-1997

Fraction	Analyte	Data Type	Data						Percent Difference Between Years				
			1992	1993	1994	1995	1996	1997	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997
Deer Island / Tissue	Total DDT	Dry Weight (ng/g)	52.38	33.27	43.83	43.23	32.07	46.27	-36.5%	31.7%	-1.4%	-1.4%	44.3%
		Lipid Normalized (ng/g lipid)	**953.40**	**1193.15**	**903.20**	**2312.97**	**1529.47**	**3298.02**	**25.1%**	**-24.3%**	**156.1%**	**156.1%**	**115.6%**
	Total PCB	Dry Weight (ng/g)	458.49	200.39	520.05	613.88	285.76	328.42	-56.3%	159.5%	18.0%	18.0%	14.9%
		Lipid Normalized (ng/g lipid)	**8264.31**	**7260.70**	**10763.66**	**33414.02**	**13530.82**	**23341.62**	**-12.1%**	**48.2%**	**210.4%**	**210.4%**	**72.5%**
Future Outfall Site / Tissue	Total DDT	Dry Weight (ng/g)	27.47	27.64	22.66	23.13	19.28	22.47	0.6%	-18.0%	2.1%	2.1%	16.5%
		Lipid Normalized (ng/g lipid)	**342.96**	**1096.35**	**455.14**	**1116.26**	**1015.92**	**1396.70**	**219.7%**	**-58.5%**	**145.3%**	**145.3%**	**37.5%**
	Total PCB	Dry Weight (ng/g)	220.52	215.05	249.88	237.16	194.68	207.00	-2.5%	16.2%	-5.1%	-5.1%	6.3%
		Lipid Normalized (ng/g lipid)	**2765.73**	**8142.03**	**5147.91**	**11105.20**	**10187.61**	**12822.36**	**194.4%**	**-36.8%**	**115.7%**	**115.7%**	**25.9%**
Eastern Cape Cod Bay / Tissue	Total DDT	Dry Weight (ng/g)	11.42	13.05	13.82	27.47	9.81	13.41	14.3%	5.9%	98.8%	98.8%	36.7%
		Lipid Normalized (ng/g lipid)	**375.28**	**503.77**	**276.35**	**1116.73**	**435.72**	**998.40**	**34.2%**	**-45.1%**	**304.1%**	**304.1%**	**129.1%**
	Total PCB	Dry Weight (ng/g)	51.62	59.24	60.23	107.61	65.69	62.78	14.8%	1.7%	78.7%	78.7%	-4.4%
		Lipid Normalized (ng/g lipid)	**1628.51**	**2214.05**	**1183.83**	**4346.00**	**2920.39**	**4704.00**	**36.0%**	**-46.5%**	**267.1%**	**267.1%**	**61.1%**

Notes:
(a) - No PAH data available for 1992.
(b) - Station Sampled in even years only.
(c) - Percent difference based on 1992-1994.
(d) - Percent difference based on 1994-1996.

Table 4-2b
Relative Percent Difference in Means (Dry Weight and Lipid Normalized) Between Years
Lobster Hepatopancreas and Tissue
1992-1997

Station / Fraction	Analyte	Data Type	Data						Percent Difference Between Years				
			1992	1993	1994	1995	1996	1997	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997
Deer Island / Tissue	Total DDT	Dry Weight (ng/g)	15.72	28.36	23.83	13.62	26.31	46.34	80.4%	-16.0%	-42.9%	93.2%	76.1%
		Lipid Normalized (ng/g lipid)	**81.83**	**1125.78**	**287.26**	**275.19**	**694.94**	**1285.68**	**1275.8%**	**-74.5%**	**-4.2%**	**152.5%**	**85.0%**
	Total PCB	Dry Weight (ng/g)	100.09	154.21	137.15	122.31	220.41	311.83	54.1%	-11.1%	-10.8%	80.2%	41.5%
		Lipid Normalized (ng/g lipid)	**521.18**	**5984.82**	**1669.58**	**2484.96**	**5875.59**	**8719.73**	**1048.3%**	**-72.1%**	**48.8%**	**136.4%**	**48.4%**
Eastern Cape Cod Bay / Tissue	Total DDT	Dry Weight (ng/g)	19.26	10.65	10.30	13.22	13.01	14.61	-44.7%	-3.3%	28.4%	-1.6%	12.3%
		Lipid Normalized (ng/g lipid)	**174.04**	**566.03**	**209.61**	**280.05**	**409.09**	**445.91**	**225.2%**	**-63.0%**	**33.6%**	**46.1%**	**9.0%**
	Total PCB	Dry Weight (ng/g)	87.71	66.46	66.80	76.08	68.88	77.55	-24.2%	0.5%	13.9%	-9.5%	12.6%
		Lipid Normalized (ng/g lipid)	**824.96**	**3083.60**	**1356.43**	**1613.98**	**2160.57**	**2383.03**	**273.8%**	**-56.0%**	**19.0%**	**33.9%**	**10.3%**
Future Outfall Site / Tissue	Total DDT	Dry Weight (ng/g)	9.96	9.24	21.93	14.34	18.53	20.90	-7.2%	137.4%	-34.6%	29.3%	12.8%
		Lipid Normalized (ng/g lipid)	**73.45**	**251.90**	**191.59**	**351.51**	**556.28**	**605.91**	**243.0%**	**-23.9%**	**83.5%**	**58.3%**	**8.9%**
	Total PCB	Dry Weight (ng/g)	60.99	65.79	177.93	118.76	148.09	157.62	7.9%	170.5%	-33.3%	24.7%	6.4%
		Lipid Normalized (ng/g lipid)	**455.05**	**1802.41**	**1504.61**	**2937.21**	**4439.00**	**4638.01**	**296.1%**	**-16.5%**	**95.2%**	**51.1%**	**4.5%**

Notes:
(a) - The 1997 concentration of Total PAH at Eastern Cape Cod Bay was extremely elevated and may reflect contamination during sampling. Therefore, the elevated value is not used in calculations.

Table 4-2c
Relative Percent Difference in Means (Dry Weight and Lipid Normalized) Between Years
Mussel Tissue
1992-1997

Station	Analyte	Data Type	Data						Percent Difference Between Years				
			1992	1993	1994	1995	1996	1997	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997
Deer Island	Total DDT	Dry Weight (ng/g)	25.00	63.00	50.00	44.97	85.13	60.77	152.0%	-20.6%	-10.1%	89.3%	-28.6%
		Lipid Normalized (ng/g lipid)	**492.16**	**966.15**	**999.40**	**399.74**	**616.91**	**674.17**	**96.3%**	**3.4%**	**-60.0%**	**54.3%**	**9.3%**
	Total PAH	Dry Weight (ng/g)	1934.00	665.00	848.00	760.70	1229.88	423.30	-65.6%	27.5%	-10.3%	61.7%	-65.6%
		Lipid Normalized (ng/g lipid)	**37921.57**	**10230.77**	**16960.00**	**17980.57**	**7407.71**	**3886.40**	**-73.0%**	**65.8%**	**6.0%**	**-58.8%**	**-47.5%**
	Total PCB	Dry Weight (ng/g)	133.00	321.00	161.00	172.30	273.19	359.87	141.4%	-49.8%	7.0%	58.6%	31.7%
		Lipid Normalized (ng/g lipid)	**2607.84**	**4944.31**	**3214.00**	**1469.84**	**2005.64**	**4004.68**	**89.6%**	**-35.0%**	**-54.3%**	**36.5%**	**99.7%**
Discovery	Total DDT	Dry Weight (ng/g)	103.00	130.00	86.00	92.00	119.23	135.59	26.2%	-33.8%	7.0%	29.6%	13.7%
		Lipid Normalized (ng/g lipid)	**2019.61**	**2450.94**	**1571.54**	**925.15**	**1206.73**	**1718.92**	**21.4%**	**-35.9%**	**-41.1%**	**30.4%**	**42.4%**
	Total PAH	Dry Weight (ng/g)	3546.00	1320.00	2255.00	1444.00	2500.32	1551.50	-62.8%	70.8%	-36.0%	73.2%	-37.9%
		Lipid Normalized (ng/g lipid)	**69529.41**	**24924.53**	**41443.24**	**30810.34**	**24502.29**	**19143.74**	**-64.2%**	**66.3%**	**-25.7%**	**-20.5%**	**-21.9%**
	Total PCB	Dry Weight (ng/g)	652.00	596.00	500.00	441.10	537.98	785.15	-8.6%	-16.1%	-11.8%	22.0%	45.9%
		Lipid Normalized (ng/g lipid)	**12784.31**	**11239.06**	**9196.72**	**4530.34**	**5385.90**	**9999.08**	**-12.1%**	**-18.2%**	**-50.7%**	**18.9%**	**85.7%**
Future Outfall Site	Total DDT	Dry Weight (ng/g)	11.70	29.90	18.63	NA	29.75	23.15	155.6%	-37.7%	59.7% (a)	NA	-22.2%
		Lipid Normalized (ng/g lipid)	**278.18**	**421.13**	**334.54**	**NA**	**276.01**	**263.91**	**51.4%**	**-20.6%**	**-17.5% (a)**	**NA**	**-4.4%**
	Total PAH	Dry Weight (ng/g)	130.00	167.00	122.00	NA	141.53	86.37	28.5%	-26.9%	16.0% (a)	NA	-39.0%
		Lipid Normalized (ng/g lipid)	**6547.62**	**2338.03**	**2190.75**	**NA**	**745.69**	**744.20**	**-64.3%**	**-6.3%**	**-66.0% (a)**	**NA**	**-0.2%**
	Total PCB	Dry Weight (ng/g)	44.40	110.49	88.93	NA	101.72	101.38	148.9%	-19.5%	14.4% (a)	NA	-0.3%
		Lipid Normalized (ng/g lipid)	**1057.02**	**1556.20**	**1596.92**	**NA**	**938.59**	**1149.81**	**47.2%**	**2.6%**	**-41.2% (a)**	**NA**	**22.5%**

Notes:
NA - Not Available.
(a) - No 1995 data available (cages were lost). Percent difference is based on 1994-1996.

5.0 RECOMMENDATIONS

Evaluation of the 1997 Fish and Shellfish tasks indicates that the program is achieving its monitoring goals. However, refinements to the program may be warranted. Based on the 1997 results, several recommendations for future effort are suggested:

- Since the baseline flounder histopathological database for the Harbor is well established, future collection of flounder for histopathological assays should be evaluated in light of the severely depleted local populations of this species;

- Collection of lobster should be revisited to evaluate effectiveness of trapping vs. other means of collecting geographically-documented specimens without risk of inadvertent contamination during sampling and/or holding processes;

- Continuation of the use of mussels collected from the Sandwich reference site to evaluate the bioaccumulation of mercury and lead;

- Revision of the Caution Levels to a more stringent value based on doubling of baseline mean is recommended to assure a more sensitive means of detecting change in tissue concentrations of monitored species;

- Expression of tissue concentration on both a dry weight and lipid-normalized based is not merited for detection of temporal trends. For purposes of threshold testing dry weight based concentrations will be used. However, lipid concentrations should continue to be measured, to allow calculations of lipid normalized concentrations as desired; and

- All monitoring tasks should be reviewed annually to evaluate whether their scope and effort are commensurate with the HOM goals and ability to address monitoring hypotheses.

These recommendations will be reviewed for inclusion in the 1998 Fish and Shellfish Monitoring Program.

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APPENDIX A

SUMMARY OF CHANGES IN FISH AND SHELLFISH MONITORING

APPENDIX A:
SUMMARY OF CHANGES IN FISH AND SHELLFISH MONITORING
1992-1997

There have been a number of changes in fish and shellfish monitoring over the 5 years of monitoring, The following table summarizes those changes.

Organism / Year	Lab		Composites per Station	Organisms per Composite
	Chemistry	Histology, biology		
Flounder				
1992	Battelle	M. Moore	4	1
1993	Battelle	M. Moore	9-10	1
1994	Battelle	M. Moore	3	1
1995	ADL/ ENVITEC	M. Moore	3	5
1996	ADL/ ENVITEC	M. Moore	3	5
1997	ADL/ ENVITEC	M. Moore	3	5
Lobster				
1992	Battelle	Battelle	3	1
1993	Battelle	Battelle	3	1
1994	Battelle	Battelle	3	1
1995	ADL/ ENVITEC	ENSR	3	5
1996	ADL/ ENVITEC	ENSR	3	5
1997	ADL/ ENVITEC	ENSR	3	5
Mussel				
1992	Battelle	Aquatec	5-8	10
1993	Battelle	Aquatec	3-8	10
1994	Battelle	Aquatec	3-8	10
1995	ADL/ ENVITEC	Aquatec	5	at least 200 g
1996	ADL/ ENVITEC	Aquatec	5	at least 200 g
1997	ADL/ ENVITEC	Aquatec	5	at least 200 g

APPENDIX B

LIPID DATA FOR FLOUNDER, LOBSTER, AND MUSSELS

TABLE B-1
Percent Lipids
Flounder Fillet and Liver, 1992-1997

Year	Station	Fraction	Sample ID	Bottle ID	Percent Lipid
1992	Broad Sound	Liver	92-253	LV22	37.5
1992	Broad Sound	Liver	92-257	LV23	49.3
1992	Broad Sound	Liver	92-258	LV24	25.0
1992	Broad Sound	Liver	92-25..	LV17REP2	19.5
1992	Broad Sound	Tissue	92-253	LV02REP1	7.3
1992	Broad Sound	Tissue	92-253	LV02REP2	10.5
1992	Broad Sound	Tissue	92-257	LV03	9.1
1992	Broad Sound	Tissue	92-258	LV04	6.8
1992	Broad Sound	Tissue	92-25..	LU96	12.9
1992	Deer Island Flats	Liver	92-353	LV28	21.1
1992	Deer Island Flats	Liver	92-354	LV29	13.0
1992	Deer Island Flats	Liver	92-359	LV30	74.0
1992	Deer Island Flats	Liver	92-35..	LV19	22.7
1992	Deer Island Flats	Tissue	92-353	LV08	5.4
1992	Deer Island Flats	Tissue	92-354	LV09	4.3
1992	Deer Island Flats	Tissue	92-359	LV10	9.1
1992	Deer Island Flats	Tissue	92-35..	LU98	5.7
1992	Eastern Cape Cod Bay	Liver	92-451	LV34	15.9
1992	Eastern Cape Cod Bay	Liver	92-452	LV35	18.5
1992	Eastern Cape Cod Bay	Liver	92-456	LV36	29.9
1992	Eastern Cape Cod Bay	Liver	92-45..	LV21	22.1
1992	Eastern Cape Cod Bay	Tissue	92-451	LV14	2.3
1992	Eastern Cape Cod Bay	Tissue	92-452	LV15	4.7
1992	Eastern Cape Cod Bay	Tissue	92-456	LV16	1.8
1992	Eastern Cape Cod Bay	Tissue	92-45..	LV01	5.7
1992	Future Outfall	Liver	92-400	LV31	25.5
1992	Future Outfall	Liver	92-401	LV32	52.4
1992	Future Outfall	Liver	92-409	LV33REP1	19.9
1992	Future Outfall	Liver	92-409	LV33REP2	20.4
1992	Future Outfall	Liver	92-40..	LV20	22.5
1992	Future Outfall	Tissue	92-400	LV11	9.1
1992	Future Outfall	Tissue	92-401	LV12	16.5
1992	Future Outfall	Tissue	92-409	LV13	4.6
1992	Future Outfall	Tissue	92-40..	LU99	12.9
1992	Nantasket Beach	Liver	92-300	LV25	46.2
1992	Nantasket Beach	Liver	92-307	LV26	20.3
1992	Nantasket Beach	Liver	92-308	LV27	26.2
1992	Nantasket Beach	Liver	92-30..	LV18	28.4
1992	Nantasket Beach	Tissue	92-300	LV05	5.0
1992	Nantasket Beach	Tissue	92-307	LV06	5.6
1992	Nantasket Beach	Tissue	92-308	LV07	1.3
1992	Nantasket Beach	Tissue	92-30..	LU97	8.0
1993	Deer Island Flats	Liver	FI1-04	--	34.0
1993	Deer Island Flats	Tissue	F93010017	467	1.8
1993	Deer Island Flats	Tissue	F93010017	468	2.4
1993	Deer Island Flats	Tissue	F93010023	465	2.3
1993	Deer Island Flats	Tissue	F93010023	466	5.8
1993	Deer Island Flats	Tissue	F93010023	470	2.6
1993	Deer Island Flats	Tissue	F93010029	471	3.4

TABLE B-1 (continued)
Percent Lipids
Flounder Fillet and Liver, 1992-1997

Year	Station	Fraction	Sample ID	Bottle ID	Percent Lipid
1993	Deer Island Flats	Tissue	F93010029	472	1.9
1993	Deer Island Flats	Tissue	F93010029	473	4.8
1993	Deer Island Flats	Tissue	F93010029	474	5.4
1993	Deer Island Flats	Tissue	F93010035	469	1.6
1993	Eastern Cape Cod Bay	Liver	FI5-06	--	20.0
1993	Eastern Cape Cod Bay	Tissue	F93010097	625	1.6
1993	Eastern Cape Cod Bay	Tissue	F93010097	626	3.2
1993	Eastern Cape Cod Bay	Tissue	F93010097	627	3.4
1993	Eastern Cape Cod Bay	Tissue	F93010097	628	2.8
1993	Eastern Cape Cod Bay	Tissue	F93010097	629	4.5
1993	Eastern Cape Cod Bay	Tissue	F93010097	630	2.3
1993	Eastern Cape Cod Bay	Tissue	F93010097	631	3.8
1993	Eastern Cape Cod Bay	Tissue	F93010097	632	4.8
1993	Eastern Cape Cod Bay	Tissue	F93010097	633	1.6
1993	Eastern Cape Cod Bay	Tissue	F93010097	634	1.5
1993	Future Outfall	Liver	FI4-05		22.6
1993	Future Outfall	Tissue	F93010059	565	3.6
1993	Future Outfall	Tissue	F93010059	566	1.6
1993	Future Outfall	Tissue	F93010059	567	2.6
1993	Future Outfall	Tissue	F93010059	569	3.1
1993	Future Outfall	Tissue	F93010059	570	4.0
1993	Future Outfall	Tissue	F93010059	571	1.5
1993	Future Outfall	Tissue	F93010059	572	1.6
1993	Future Outfall	Tissue	F93010063	573	5.1
1993	Future Outfall	Tissue	F93010063	574	1.6
1994	Broad Sound	Liver	FI3	OV86	104.1
1994	Broad Sound	Liver	FI3	OV87	33.9
1994	Broad Sound	Liver	FI3	OV88	54.1
1994	Broad Sound	Tissue	FI3	OU34	6.1
1994	Broad Sound	Tissue	FI3	OU35	3.8
1994	Broad Sound	Tissue	FI3	OU36	5.2
1994	Deer Island Flats	Liver	FI1	OV83	98.5
1994	Deer Island Flats	Liver	FI1	OV84	75.1
1994	Deer Island Flats	Liver	FI1	OV85	84.3
1994	Deer Island Flats	Tissue	FI1	OU28	4.4
1994	Deer Island Flats	Tissue	FI1	OU29	4.7
1994	Deer Island Flats	Tissue	FI1	OU30	5.5
1994	Eastern Cape Cod Bay	Liver	FI5	OV95	34.2
1994	Eastern Cape Cod Bay	Liver	FI5	OV96	14.7
1994	Eastern Cape Cod Bay	Liver	FI5	OV97	50.0
1994	Eastern Cape Cod Bay	Tissue	FI5	OU40	6.3
1994	Eastern Cape Cod Bay	Tissue	FI5	OU41	6.5
1994	Eastern Cape Cod Bay	Tissue	FI5	OU42	3.5
1994	Future Outfall	Liver	FI4	OV92	37.4
1994	Future Outfall	Liver	FI4	OV93	35.6
1994	Future Outfall	Liver	FI4	OV94	31.4
1994	Future Outfall	Tissue	FI4	OU37	6.5
1994	Future Outfall	Tissue	FI4	OU38	3.6
1994	Future Outfall	Tissue	FI4	OY39	6.3

TABLE B-1 (continued)
Percent Lipids
Flounder Fillet and Liver, 1992-1997

Year	Station	Fraction	Sample ID	Bottle ID	Percent Lipid
1994	Nantasket Beach	Liver	FI2	OV89	38.9
1994	Nantasket Beach	Liver	FI2	OV90	34.2
1994	Nantasket Beach	Liver	FI2	OV91	41.8
1994	Nantasket Beach	Tissue	FI2	OU31	5.3
1994	Nantasket Beach	Tissue	FI2	OU32	3.4
1994	Nantasket Beach	Tissue	FI2	OU33	6.2
1995	Deer Island Flats	Liver	P95111000	P95111000LC1	28.5
1995	Deer Island Flats	Liver	P95111000	P95111000LC2	44.9
1995	Deer Island Flats	Liver	P95111000	P95111000LC3	25.7
1995	Deer Island Flats	Tissue	P95111000	P95111000TC1	2.3
1995	Deer Island Flats	Tissue	P95111000	P95111000TC2	0.9
1995	Deer Island Flats	Tissue	P95111000	P95111000TC3	2.5
1995	Eastern Cape Cod Bay	Liver	P95115000	P95115000LC1	11.2
1995	Eastern Cape Cod Bay	Liver	P95115000	P95115000LC2	15.2
1995	Eastern Cape Cod Bay	Liver	P95115000	P95115000LC3	16.4
1995	Eastern Cape Cod Bay	Tissue	P95115000	P95115000TC1	2.2
1995	Eastern Cape Cod Bay	Tissue	P95115000	P95115000TC2	2.5
1995	Eastern Cape Cod Bay	Tissue	P95115000	P95115000TC3	2.8
1995	Future Outfall	Liver	P95114000	P95114000LC1	24.0
1995	Future Outfall	Liver	P95114000	P95114000LC2	20.6
1995	Future Outfall	Liver	P95114000	P95114000LC3	25.0
1995	Future Outfall	Tissue	P95114000	P95114000TC1	2.9
1995	Future Outfall	Tissue	P95114000	P95114000TC2	1.9
1995	Future Outfall	Tissue	P95114000	P95114000TC3	1.8
1996	Broad Sound	Liver	P96113000	P96113000LC1	19.6
1996	Broad Sound	Liver	P96113000	P96113000LC2	24.7
1996	Broad Sound	Liver	P96113000	P96113000LC3	20.4
1996	Broad Sound	Tissue	P96113000	P96113000TC1	2.4
1996	Broad Sound	Tissue	P96113000	P96113000TC2	1.4
1996	Broad Sound	Tissue	P96113000	P96113000TC3	1.9
1996	Deer Island Flats	Liver	P96111000	P96111000LC1	28.3
1996	Deer Island Flats	Liver	P96111000	P96111000LC2	22.6
1996	Deer Island Flats	Liver	P96111000	P96111000LC3	20.2
1996	Deer Island Flats	Tissue	P96111000	P96111000TC1	2.6
1996	Deer Island Flats	Tissue	P96111000	P96111000TC2	2.0
1996	Deer Island Flats	Tissue	P96111000	P96111000TC3	1.8

TABLE B-1 (continued)
Percent Lipids
Flounder Fillet and Liver, 1992-1997

Year	Station	Fraction	Sample ID	Bottle ID	Percent Lipid
1996	Eastern Cape Cod Bay	Liver	P96115000	P96115000LC1	28.9
1996	Eastern Cape Cod Bay	Liver	P96115000	P96115000LC2	26.3
1996	Eastern Cape Cod Bay	Liver	P96115000	P96115000LC3	20.2
1996	Eastern Cape Cod Bay	Tissue	P96115000	P96115000TC1	2.2
1996	Eastern Cape Cod Bay	Tissue	P96115000	P96115000TC2	2.0
1996	Eastern Cape Cod Bay	Tissue	P96115000	P96115000TC3	2.6
1996	Future Outfall	Liver	P96114000	P96114000LC1	24.1
1996	Future Outfall	Liver	P96114000	P96114000LC2	27.2
1996	Future Outfall	Liver	P96114000	P96114000LC3	21.4
1996	Future Outfall	Tissue	P96114000	P96114000TC1	1.5
1996	Future Outfall	Tissue	P96114000	P96114000TC2	2.3
1996	Future Outfall	Tissue	P96114000	P96114000TC3	1.9
1996	Nantasket Beach	Liver	P96112000	P96112000LC1	19.3
1996	Nantasket Beach	Liver	P96112000	P96112000LC2	24.3
1996	Nantasket Beach	Liver	P96112000	P96112000LC3	15.2
1996	Nantasket Beach	Tissue	P96112000	P96112000TC1	1.7
1996	Nantasket Beach	Tissue	P96112000	P96112000TC2	3.3
1996	Nantasket Beach	Tissue	P96112000	P96112000TC3	1.9
1997	Deer Island Flats	Liver	P97111000	P97111000LC1	13.3
1997	Deer Island Flats	Liver	P97111000	P97111000LC2	15.0
1997	Deer Island Flats	Liver	P97111000	P97111000LC3	11.2
1997	Deer Island Flats	Tissue	P97111000	P97111000TC1	1.4
1997	Deer Island Flats	Tissue	P97111000	P97111000TC2	1.5
1997	Deer Island Flats	Tissue	P97111000	P97111000TC3	1.3
1997	Eastern Cape Cod Bay	Liver	P97115000	P97115000LC1	15.4
1997	Eastern Cape Cod Bay	Liver	P97115000	P97115000LC2	17.7
1997	Eastern Cape Cod Bay	Liver	P97115000	P97115000LC3	23.2
1997	Eastern Cape Cod Bay	Tissue	P97115000	P97115000TC1	2.3
1997	Eastern Cape Cod Bay	Tissue	P97115000	P97115000TC2	1.3
1997	Eastern Cape Cod Bay	Tissue	P97115000	P97115000TC3	1.0
1997	Future Outfall	Liver	P97114000	P97114000LC1	16.3
1997	Future Outfall	Liver	P97114000	P97114000LC2	14.0
1997	Future Outfall	Liver	P97114000	P97114000LC3	14.1
1997	Future Outfall	Tissue	P97114000	P97114000TC1	1.5
1997	Future Outfall	Tissue	P97114000	P97114000TC2	1.7
1997	Future Outfall	Tissue	P97114000	P97114000TC3	1.7

Notes:
(a) - For each contaminant replicate, an aliquot of tissue was also analyzed for percent lipids.
Please see Attachment A for a list of the number of animals per replicate for each year.

TABLE B-2
Percent Lipids
Lobster Tissue and Hepatopancreas, 1992-1997

Year	Station	Fraction	Sample ID	Bottle ID (a)	Percent Lipid
1992	Deer Island Flats	Hepatopancreas	92-467L	LU92	65.8
1992	Deer Island Flats	Hepatopancreas	92-482L	LU95	66.3
1992	Deer Island Flats	Hepatopancreas	92-469L	LU93	73.7
1992	Deer Island Flats	Tissue	92-467	LU83	16.2
1992	Deer Island Flats	Tissue	92-469	LU84	19.6
1992	Deer Island Flats	Tissue	92-482	LU86	21.8
1992	Eastern Cape Cod Bay	Hepatopancreas	92-465L	LU90	18.8
1992	Eastern Cape Cod Bay	Hepatopancreas	92-466L	LU91	82.5
1992	Eastern Cape Cod Bay	Hepatopancreas	92-476L	LU94	30.1
1992	Eastern Cape Cod Bay	Tissue	92-465	LU81	13.6
1992	Eastern Cape Cod Bay	Tissue	92-466	LU82	26.9
1992	Eastern Cape Cod Bay	Tissue	92-477	LU85	8.3
1992	Future Outfall	Hepatopancreas	92-460L	LU87	57.0
1992	Future Outfall	Hepatopancreas	92-463L	LU88	47.1
1992	Future Outfall	Hepatopancreas	92-464L	LU89	79.2
1992	Future Outfall	Tissue	92-460	LU78REP1	14.8
1992	Future Outfall	Tissue	92-460	LU78REP2	14.8
1992	Future Outfall	Tissue	92-463	LU79	13.2
1992	Future Outfall	Tissue	92-464	LU80	12.6
1993	Deer Island Flats	Hepatopancreas	F93010030	KG34	34.3
1993	Deer Island Flats	Hepatopancreas	S93030417	KI06	35.2
1993	Deer Island Flats	Hepatopancreas	S93030417	KI07	55.8
1993	Deer Island Flats	Tissue	F93010030	KG34	3.2
1993	Deer Island Flats	Tissue	S93030417	KI06	1.6
1993	Deer Island Flats	Tissue	S93030417	KI07	2.7
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KH99	72.9
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI01	33.6
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI02	57.9
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI03	43.5
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI04	65.5
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI05	33.7
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI21	39.4
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI22	40.3
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI23	56.4
1993	Eastern Cape Cod Bay	Hepatopancreas	LOB-FI5	KI24	67.2
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KH99	6.8
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI01	4.8
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI02	4.5
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI03	2.8
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI04	7.6
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI05	2.1
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI21	0.4
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI22	7.1
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI23	4.1
1993	Eastern Cape Cod Bay	Tissue	LOB-FI5	KI24	1.6

TABLE B-2 (continued)
Percent Lipids
Lobster Tissue and Hepatopancreas, 1992-1997

Year	Station	Fraction	Sample ID	Bottle ID (a)	Percent Lipid
1993	Future Outfall	Hepatopancreas	S93030409	KH97	56.2
1993	Future Outfall	Hepatopancreas	S93030409	KH98	45.3
1993	Future Outfall	Tissue	S93030409	KH97	3.5
1993	Future Outfall	Tissue	S93030409	KH98	3.8
1994	Deer Island Flats	Hepatopancreas	FI1LOBSTER	OV42	72.4
1994	Deer Island Flats	Hepatopancreas	FI1LOBSTER	OV43	71.5
1994	Deer Island Flats	Hepatopancreas	FI1LOBSTER	OV44	67.5
1994	Deer Island Flats	Tissue	FI1LOBSTER	OV31	10.9
1994	Deer Island Flats	Tissue	FI1LOBSTER	OV32	9.7
1994	Deer Island Flats	Tissue	FI1LOBSTER	OV33	6.2
1994	Eastern Cape Cod Bay	Hepatopancreas	FI5LOBSTER	OV47	79.0
1994	Eastern Cape Cod Bay	Hepatopancreas	FI5LOBSTER	OV48	67.3
1994	Eastern Cape Cod Bay	Hepatopancreas	FI5LOBSTER	OV49	61.7
1994	Eastern Cape Cod Bay	Tissue	FI5LOBSTER	OV36	5.0
1994	Eastern Cape Cod Bay	Tissue	FI5LOBSTER	OV37	4.8
1994	Eastern Cape Cod Bay	Tissue	FI5LOBSTER	OV38	4.9
1994	Future Outfall	Hepatopancreas	FI4LOBSTER	OV45	59.2
1994	Future Outfall	Hepatopancreas	FI4LOBSTER	OV46	56.5
1994	Future Outfall	Tissue	FI4LOBSTER	OV34	13.4
1994	Future Outfall	Tissue	FI4LOBSTER	OV35	9.4
1995	Deer Island Flats	Hepatopancreas	L95111000	L95111000HC1	70.8
1995	Deer Island Flats	Hepatopancreas	L95111000	L95111000HC2	64.3
1995	Deer Island Flats	Hepatopancreas	L95111000	L95111000HC3	55.9
1995	Deer Island Flats	Tissue	L95111000	L95111000TC1	4.4
1995	Deer Island Flats	Tissue	L95111000	L95111000TC2	5.5
1995	Deer Island Flats	Tissue	L95111000	L95111000TC3	4.9
1995	Eastern Cape Cod Bay	Hepatopancreas	L95115000	L95115000HC1	57.7
1995	Eastern Cape Cod Bay	Hepatopancreas	L95115000	L95115000HC2	64.7
1995	Eastern Cape Cod Bay	Hepatopancreas	L95115000	L95115000HC3	79.6
1995	Eastern Cape Cod Bay	Tissue	L95115000	L95115000TC1	5.1
1995	Eastern Cape Cod Bay	Tissue	L95115000	L95115000TC2	4.4
1995	Eastern Cape Cod Bay	Tissue	L95115000	L95115000TC3	4.5
1995	Future Outfall	Hepatopancreas	L95114000	L95114000HC1	70.9
1995	Future Outfall	Hepatopancreas	L95114000	L95114000HC2	60.4
1995	Future Outfall	Hepatopancreas	L95114000	L95114000HC3	61.8
1995	Future Outfall	Tissue	L95114000	L95114000TC1	5.2
1995	Future Outfall	Tissue	L95114000	L95114000TC2	4.3
1995	Future Outfall	Tissue	L95114000	L95114000TC3	3.3
1996	Deer Island Flats	Hepatopancreas	L96111000	L96111000HC1	49.5
1996	Deer Island Flats	Hepatopancreas	L96111000	L96111000HC2	60.1
1996	Deer Island Flats	Hepatopancreas	L96111000	L96111000HC3	59.4
1996	Deer Island Flats	Tissue	L96111000	L96111000TC1	3.8
1996	Deer Island Flats	Tissue	L96111000	L96111000TC2	3.4
1996	Deer Island Flats	Tissue	L96111000	L96111000TC3	4.2

TABLE B-2 (continued)
Percent Lipids
Lobster Tissue and Hepatopancreas, 1992-1997

Year	Station	Fraction	Sample ID	Bottle ID (a)	Percent Lipid
1996	Eastern Cape Cod Bay	Hepatopancreas	L96115000	L96115000HC1	59.1
1996	Eastern Cape Cod Bay	Hepatopancreas	L96115000	L96115000HC2	65.1
1996	Eastern Cape Cod Bay	Hepatopancreas	L96115000	L96115000HC3	60.6
1996	Eastern Cape Cod Bay	Tissue	L96115000	L96115000TC1	3.3
1996	Eastern Cape Cod Bay	Tissue	L96115000	L96115000TC2	3.2
1996	Eastern Cape Cod Bay	Tissue	L96115000	L96115000TC3	3.0
1996	Future Outfall	Hepatopancreas	L96114000	L96114000HC1	47.4
1996	Future Outfall	Hepatopancreas	L96114000	L96114000HC2	54.1
1996	Future Outfall	Hepatopancreas	L96114000	L96114000HC3	52.4
1996	Future Outfall	Tissue	L96114000	L96114000TC1	3.3
1996	Future Outfall	Tissue	L96114000	L96114000TC2	3.3
1996	Future Outfall	Tissue	L96114000	L96114000TC3	3.4
1997	Deer Island Flats	Hepatopancreas	L97111000	L97111000HC1	46.3
1997	Deer Island Flats	Hepatopancreas	L97111000	L97111000HC2	56.5
1997	Deer Island Flats	Hepatopancreas	L97111000	L97111000HC3	44.5
1997	Deer Island Flats	Tissue	L97111000	L97111000TC1	4.0
1997	Deer Island Flats	Tissue	L97111000	L97111000TC2	3.1
1997	Deer Island Flats	Tissue	L97111000	L97111000TC3	3.1
1997	Eastern Cape Cod Bay	Hepatopancreas	L97115000	L97115000HC1	58.6
1997	Eastern Cape Cod Bay	Hepatopancreas	L97115000	L97115000HC2	61.0
1997	Eastern Cape Cod Bay	Hepatopancreas	L97115000	L97115000HC3	57.7
1997	Eastern Cape Cod Bay	Tissue	L97115000	L97115000TC1	3.4
1997	Eastern Cape Cod Bay	Tissue	L97115000	L97115000TC2	3.0
1997	Eastern Cape Cod Bay	Tissue	L97115000	L97115000TC3	3.5
1997	Future Outfall	Hepatopancreas	L97114000	L97114000HC1	64.2
1997	Future Outfall	Hepatopancreas	L97114000	L97114000HC2	62.8
1997	Future Outfall	Hepatopancreas	L97114000	L97114000HC3	44.7
1997	Future Outfall	Tissue	L97114000	L97114000TC1	3.2
1997	Future Outfall	Tissue	L97114000	L97114000TC2	3.6
1997	Future Outfall	Tissue	L97114000	L97114000TC3	3.3

Notes:
(a) - For each contaminant replicate, an aliquot of tissue was also analyzed for percent lipids.
Please see Attachment A for a list of the number of animals per replicate for each year.

TABLE B-3
Percent Lipids (a)
Mussel Tissue, 1992-1997

Year	Station	Sample ID (a)	Bottle ID	Percent Lipid (c)
1991	Pre-deployment (Gloucester)	143626 (b)	–	4.40
1991	Pre-deployment (Gloucester)	143627 (b)	–	8.10
1991	Pre-deployment (Gloucester)	143628 (b)	–	4.70
1991	Pre-deployment (Gloucester)	143629 (b)	–	1.80
1991	Pre-deployment (Gloucester)	143630 (b)	–	3.90
1991	Pre-deployment (Gloucester)	143631 (b)	–	1.80
1991	Pre-deployment (Gloucester)	143632 (b)	–	2.40
1991	Pre-deployment (Gloucester)	143633 (b)	–	3.90
1991	Pre-deployment (Gloucester)	143634 (b)	–	8.40
1991	Pre-deployment (Gloucester)	143635 (b)	–	4.80
1991	Deer Island Flats (shallow water)	143957 (b)	–	2.10
1991	Deer Island Flats (shallow water)	143958 (b)	–	4.50
1991	Deer Island Flats (shallow water)	143959 (b)	–	4.00
1991	Deer Island Flats (shallow water)	143960 (b)	–	3.20
1991	Deer Island Flats (deep water)	143961 (b)	–	2.80
1991	Deer Island Flats (deep water)	143962 (b)	–	3.40
1991	Deer Island Flats (deep water)	143963 (b)	–	3.10
1991	Deer Island Flats (deep water)	143964 (b)	–	3.00
1991	Aquarium	143739 (b)	–	7.90
1991	Aquarium	143740 (b)	–	4.20
1991	Aquarium	143741 (b)	–	6.80
1991	Aquarium	143742 (b)	–	5.20
1991	Aquarium	143743 (b)	–	4.70
1992	Pre-deployment (Gloucester)	162679 (b)	–	4.50
1992	Pre-deployment (Gloucester)	162680 (b)	–	3.60
1992	Pre-deployment (Gloucester)	162681 (b)	–	4.00
1992	Pre-deployment (Gloucester)	162682 (b)	–	4.40
1992	Pre-deployment (Gloucester)	162683 (b)	–	7.50
1992	Future Outfall	164492 (b)	–	5.40
1992	Future Outfall	164493 (b)	–	3.77
1992	Future Outfall	164494 (b)	–	4.74
1992	Future Outfall	164495 (b)	–	3.27
1992	Future Outfall	164496 (b)	–	5.04
1992	Future Outfall	164497 (b)	–	3.52
1992	Future Outfall	164498 (b)	–	3.12
1992	Future Outfall	164499 (b)	–	4.97
1992	Deer Island Flats	164485 (b)	–	4.58
1992	Deer Island Flats	164486 (b)	–	7.47
1992	Deer Island Flats	164479 (b)	–	4.43
1992	Deer Island Flats	164480 (b)	–	5.48
1992	Deer Island Flats	164481 (b)	–	4.82
1992	Deer Island Flats	164482 (b)	–	5.83
1992	Deer Island Flats	164483 (b)	–	4.81
1992	Deer Island Flats	164484 (b)	–	3.64
1992	Aquarium	164490 (b)	–	5.77
1992	Aquarium	164491 (b)	–	4.60
1992	Aquarium	164487 (b)	–	5.67
1992	Aquarium	164488 (b)	–	5.24
1992	Aquarium	164489 (b)	–	4.13

TABLE B-3
Percent Lipids (a)
Mussel Tissue, 1992-1997

Year	Station	Sample ID (a)	Bottle ID	Percent Lipid (c)
1993	Pre-deployment (Gloucester)	188933 (b)	–	7.74
1993	Pre-deployment (Gloucester)	188934 (b)	–	10.71
1993	Pre-deployment (Gloucester)	188941 (b)	–	8.24
1993	Pre-deployment (Gloucester)	188936 (b)	–	6.69
1993	Pre-deployment (Gloucester)	188937 (b)	–	6.60
1993	Future Outfall	196376 (b)	–	7.17
1993	Future Outfall	196377 (b)	–	6.46
1993	Future Outfall	196378 (b)	–	7.23
1993	Future Outfall	196379 (b)	–	5.98
1993	Future Outfall	196380 (b)	–	6.94
1993	Future Outfall	196381 (b)	–	6.37
1993	Future Outfall	196382 (b)	–	8.57
1993	Future Outfall	196383 (b)	–	8.02
1993	Deer Island Flats	196384 (b)	–	6.00
1993	Deer Island Flats	196385 (b)	–	5.78
1993	Deer Island Flats	196386 (b)	–	9.24
1993	Deer Island Flats	196387 (b)	–	6.78
1993	Deer Island Flats	196388 (b)	–	4.90
1993	Aquarium	196389 (b)	–	5.63
1993	Aquarium	196390 (b)	–	5.82
1993	Aquarium	196391 (b)	–	4.67
1993	Aquarium	196392 (b)	–	5.05
1994	Pre-deployment (Gloucester)	225475 (b)	–	3.33
1994	Pre-deployment (Gloucester)	225476 (b)	–	4.58
1994	Pre-deployment (Gloucester)	225477 (b)	–	4.96
1994	Pre-deployment (Gloucester)	225478 (b)	–	3.99
1994	Future Outfall	233376 (b)	–	3.63
1994	Future Outfall	233377 (b)	–	4.73
1994	Future Outfall	233378 (b)	–	5.18
1994	Future Outfall	233379 (b)	–	4.12
1994	Future Outfall	233381 (b)	–	6.52
1994	Future Outfall	233382 (b)	–	6.44
1994	Future Outfall	233383 (b)	–	8.14
1994	Future Outfall	233384 (b)	–	5.68
1994	Deer Island Flats	233366 (b)	–	4.36
1994	Deer Island Flats	233367 (b)	–	5.16
1994	Deer Island Flats	233368 (b)	–	5.19
1994	Deer Island Flats	233369 (b)	–	5.20
1994	Aquarium	233371 (b)	–	4.76
1994	Aquarium	233372 (b)	–	6.58
1994	Aquarium	233373 (b)	–	5.14
1995	Aquarium	M9511D6H7	M9511D6H7TC1	10.04
1995	Aquarium	M9511D6H7	M9511D6H7TC2	10.09
1995	Aquarium	M9511D6H7	M9511D6H7TC3	10.39
1995	Aquarium	M9511D6H7	M9511D6H7TC4	10.21
1995	Aquarium	M9511D6H7	M9511D6H7TC5	8.54
1995	Deer Island Flats	M9511D1H7	M9511D1H7TC1	10.17
1995	Deer Island Flats	M9511D1H7	M9511D1H7TC2	11.86
1995	Deer Island Flats	M9511D1H7	M9511D1H7TC3	11.56
1995	Deer Island Flats	M9511D1H7	M9511D1H7TC4	11.01
1995	Deer Island Flats	M9511D1H7	M9511D1H7TC5	11.49

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TABLE B-3
Percent Lipids (a)
Mussel Tissue, 1992-1997

Year	Station	Sample ID (a)	Bottle ID	Percent Lipid (c)
1995	Pre-deployment (Gloucester)	M9511H7	M9511H7TC1	9.23
1995	Pre-deployment (Gloucester)	M9511H7	M9511H7TC2	8.10
1995	Pre-deployment (Gloucester)	M9511H7	M9511H7TC3	8.62
1995	Pre-deployment (Gloucester)	M9511H7	M9511H7TC4	8.16
1995	Pre-deployment (Gloucester)	M9511H7	M9511H7TC5	9.58
1996	Aquarium	M9611D6H7	M9611D6H7TC1	8.65
1996	Aquarium	M9611D6H7	M9611D6H7TC2	10.32
1996	Aquarium	M9611D6H7	M9611D6H7TC3	10.85
1996	Aquarium	M9611D6H7	M9611D6H7TC4	8.94
1996	Aquarium	M9611D6H7	M9611D6H7TC5	11.37
1996	Deer Island Flats	M9611D1H7	M9611D1H7TC1	9.00
1996	Deer Island Flats	M9611D1H7	M9611D1H7TC2	14.96
1996	Deer Island Flats	M9611D1H7	M9611D1H7TC3	13.41
1996	Deer Island Flats	M9611D1H7	M9611D1H7TC4	14.85
1996	Deer Island Flats	M9611D1H7	M9611D1H7TC5	16.65
1996	Future Outfall	M9611D4H7	M9611D4H7TC1	8.83
1996	Future Outfall	M9611D4H7	M9611D4H7TC2	10.49
1996	Future Outfall	M9611D4H7	M9611D4H7TC3	12.22
1996	Future Outfall	M9611D4H7	M9611D4H7TC4	10.38
1996	Future Outfall	M9611D4H7	M9611D4H7TC5	10.87
1996	Pre-deployment (Gloucester)	M9611H7	M9611H7TC1	7.08
1996	Pre-deployment (Gloucester)	M9611H7	M9611H7TC2	11.59
1996	Pre-deployment (Gloucester)	M9611H7	M9611H7TC3	6.00
1997	Aquarium	M9711D6H7	M9711D6H7TC1	8.78
1997	Aquarium	M9711D6H7	M9711D6H7TC2	7.65
1997	Aquarium	M9711D6H7	M9711D6H7TC3	7.45
1997	Aquarium	M9711D6H7	M9711D6H7TC4	7.83
1997	Aquarium	M9711D6H7	M9711D6H7TC5	7.47
1997	Deer Island Flats	M9711D1H7	M9711D1H7TC1	9.30
1997	Deer Island Flats	M9711D1H7	M9711D1H7TC2	9.66
1997	Deer Island Flats	M9711D1H7	M9711D1H7TC3	7.76
1997	Deer Island Flats	M9711D1H7	M9711D1H7TC4	8.62
1997	Deer Island Flats	M9711D1H7	M9711D1H7TC5	9.12
1997	Future Outfall	M9711D4H7	M9711D4H7TC1	7.18
1997	Future Outfall	M9711D4H7	M9711D4H7TC2	8.88
1997	Future Outfall	M9711D4H7	M9711D4H7TC3	9.64
1997	Future Outfall	M9711D4H7	M9711D4H7TC4	7.99
1997	Future Outfall	M9711D4H7	M9711D4H7TC5	9.02
1997	Pre-deployment (Gloucester)	M9711H7	M9711H7TC1	8.18
1997	Pre-deployment (Gloucester)	M9711H7	M9711H7TC2	8.14
1997	Pre-deployment (Gloucester)	M9711H7	M9711H7TC3	8.55
1997	Pre-deployment (Gloucester)	M9711H7	M9711H7TC4	8.63
1997	Pre-deployment (Gloucester)	M9711H7	M9711H7TC5	9.13

Notes:
(a) - For each contaminant replicate, an aliquot of tissue was also analyzed for percent lipids.
Please see Attachment A for a list of the number of animals per replicate for each year.
(b) - Lab sample ID (Aquatec Biological).
(c) - Data obtained from Aquatec Biological Lab Reports, 1991-1994. 1993-1994 % Lipids were calculated using the following equation: %Lipid/Total Solids * 100%.

Massachusetts Water Resources Authority
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129
(617) 242-6000