Summary of

Massachusetts Water Resources Authority

Effluent, Fish and Shellfish Workshop

held

May 24, 1996

hosted by

MIT Sea Grant

prepared by
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ENSR

David F. Mitchell
ENSR

and

Ken Keay
MWRA

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OVERVIEW

The Massachusetts Water Resources Authority (MWRA) Effluent, Fish and Shellfish Workshop summarized in this document was held on May 24, 1996. The purpose of the workshop was to present the 1995 data from the Effluent and Fish and Shellfish monitoring tasks as well as provide an initial forum to integrate results across the various disciplines. In addition, Workshop presentations included a review of monitoring questions and hypotheses posed in the Phase II Post Discharge Monitoring Plan (November 30, 1995). To stimulate discussion, meeting participants were provided with "score cards" containing relevant hypotheses, warning levels and action levels used in the MWRA monitoring program. Each participant was asked to evaluate these hypotheses, comment on their validity, and offer suggestions.

During the discussion session which followed the scientific presentations, relevant issues, questions and suggestions raised by participants were considered. These comments were incorporated into a set of issues and recommendations which were discussed at the Outfall Monitoring Task Force meeting held on May 31, 1996.

INTRODUCTION

The 1996 Effluent, Fish and Shellfish Workshop was held at the Massachusetts Institute of Technology on May 24, 1996. This workshop presented 1995 monitoring data and compared these results to data collected in previous years. There were approximately 45 attendees, including MWRA personnel, regulators, academics, nonprofit environmental groups, and project scientists. A list of attendees is included in Appendix A.

Jerry Schubel (New England Aquarium) moderated the workshop and presented the overall goals and objectives of the workshop. Ken Keay (MWRA) provided an overview and discussed the goals of the MWRA monitoring program. Summaries of 1995 effluent, fish and shellfish data and comparisons to previous years were presented by project scientists. A final discussion session led by Jerry Schubel helped to streamline issues and comments posed by workshop participants.

The goals of the workshop were to:

- present and discuss 1995 monitoring data, and provide an initial forum for integration of results by project scientists prior to drafting the annual report;

- evaluate the adequacy of the current monitoring plan for fish and shellfish in meeting the overall goals of the monitoring program;

- determine the adequacy of baseline data in understanding the status of fish and shellfish resources in the Boston Harbor, Massachusetts and Cape Cod Bay ecosystems in order to evaluate the effects of the relocated outfall;

- evaluate existing monitoring parameters and determine if additional (or reduced) set of parameters should be measured;

- assess the adequacy of spatial and temporal coverage in meeting the goals of the Harbor and Outfall Monitoring (HOM) plan;

- discuss appropriate indicators of change, acceptable levels of meaningful change, and assessment endpoints for fish and shellfish resources in the Boston Harbor, Massachusetts, and Cape Cod Bay ecosystems;

- review current methodology and identify issues regarding monitoring, data analysis or data interpretation; and

- review the overall goals of the monitoring program and determine whether they are being attained.

One critical component of this workshop was to reevaluate the hypotheses used in the monitoring program. Project scientists were tasked with discussing relevant hypotheses, whether these hypotheses are appropriate questions for evaluating the effects of the relocated discharge, and whether the draft MWRA post-discharge monitoring design will be able to answer these questions.

The workshop agenda, abstracts from each scientific presentation, Phase II hypotheses, and a summary of key points and discussion items are provided after this section. The list of participants is provided in Appendix A, written correspondence pertaining to the workshop is provided in Appendix B, and copies of overheads and graphics from the presentations are provided in Appendix C.

WORKSHOP AGENDA AND ABSTRACTS

MWRA Harbor and Outfall Monitoring (HOM) Water Quality Workshop

Thursday May 23, 1996

Coordinated by ENSR, Hosted by MIT Sea Grant Office

at MIT, Civil and Environmental Engineering Building (Parsons Lab, Bldg. 48, Room 316)

AGENDA

WELCOME AND INTRODUCTION 08:30 AM - 09:10 AM

08:30 AM Jerry Schubel, New England Aquarium (15 min)

08:45 AM Mike Mickelson, MWRA: Overview & goals of monitoring program (25 min)

PRESENTATIONS 09:10 AM - 02:00 PM

09:10 AM Overview of Transport Processes and Preliminary Results of Boundary Mixing Dye Study - Rocky Geyer, WHOI (30 min)

09:40 AM Physical and Chemical Monitoring Results - Jim Bowen, UNC (Charlotte) (35 min)

10:15 AM Break (15 min)

10:30 AM Nutrient Dynamics - Ted Loder, UNH (30 min)

11:00 AM Productivity and Respiration - Craig Taylor, WHOI (30 min)

11:30 AM Discussion (30 min)

LUNCH (provided) 12:00 PM - 1:00 PM

01:00 PM Phytoplankton Dynamics - Steve Cibik, ENSR (25 min)

01:25 PM Toxic and potentially harmful phytoplankton species in Massachusetts and Cape Cod Bays - Don Anderson, WHOI (25 min)

01:50 PM Zooplankton Dynamics - Steve Cibik, ENSR for Cabell Davis, WHOI (25 min)

02:15 PM Break (15 min)

02:30 PM Recommendations from CCC SAP for Modifications (45 min)

DISCUSSION 03:15 PM - 05:00 PM

ADJOURN 05:00 PM

USING ISOTOPIC RATIOS TO TRACE SOURCES OF NITROGEN AND ORGANIC MATTER TO THE BOSTON HARBOR-MASSACHUSETTS BAY SYSTEM

Anne Giblin, Jane Tucker and Charles Hopkinson, The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA, 02543

We have been measuring nitrogen and sulfur isotopes in sediments, algae and mussels from Boston Harbor and Massachusetts Bay. Our initial assumption were: 1) Macroalgae would integrate the DIN signal of the area where they were attached and that macroalgae would be representative of the phytoplankton nitrogen stable isotope signature, 2) That sulfur isotopes would be relatively constant in primary producers and be close to the value of sulfate in seawater, 3) That sulfur could be used to determine if mussels were assimilating POM from sewage, 4) That the nitrogen isotope signal in sediments could be used to trace POM from sewage, and that this signal would change over time as sludge discharge ceased and sewage treatment was upgraded.

Results

Spatial patterns in surface sediments

The $\delta^{15}N$ signatures from surface sediments (0-1cm) and sediment profiles showed differences between Boston Harbor and Massachusetts Bay. In general, we found the lightest $\delta^{15}N$ values close to the existing outfall site and old sludge dump site. Although the ranges in values from Massachusetts Bay and Boston Harbor nearly overlap, there is clearly a difference in the isotopic signals that is attributable to isotopically light sewage inputs in the harbor.

Temporal patterns in surface sediments

Changes with time emerge from comparing results from samples taken in 1990 and 1991, while sludge was being dumped at BH03, to samples taken after dumping ceased. Samples collected from 5 stations in the northern part of the outer harbor in 1990 and 1991 had an average value of 4.2‰ . Samples collected from the Harbor area in August, 1992, after the cessation of sludge dumping, showed somewhat higher $\delta^{15}N$ values, averaging 4.75‰. By 1994, Harbor sediments showed a continued trend toward heavier values, averaging 4.9 ‰.

Values from Station BH03 alone give the clearest picture of change since dumping ceased at that site. In 1991, surface sediments were 4.8‰. In 1992 the range was 4.5 to 5.5‰, with an average of 4.9‰. In 1993 surface values had increased to 5.2‰, and by 1994 to 5.5‰. The results indicate that nitrogen sources within the Harbor have changed since 1991.

Surface sediments from Mass Bay were variable and revealed no clear pattern with time. Three Mass Bay samples from 1991 averaged 6.8

Sediment Profiles

Profiles from BH03, at the old sludge dump site, were run for 4 dates, once in September, 1991, before dumping ceased, and three times after: April, 1992, August 1992, and October, 1994. The 1991 profile was 4.8‰ at the surface and decreased with depth to a lighter, more sludge-like value of 3.8‰ at about 10 cm. By April, 1992, just four months after dumping ceased, the profile was more uniform with depth than in 1991 and was heavier at all depths except the surface. Profiles from August, 1992, and October, 1994, showed a continued trend towards heavier values over time. The Oct., 1994 profile was 5.5‰ at the surface, decreasing to 4.6‰ at 3.5 cm, a depth which coincides with the thickness of the amphipod mat complex (pers. observation).

Two profiles were run from Station MB01 in Massachusetts Bay. Although these samples were taken after the cessation of sludge dumping, and even though both profiles from MB01 had heavier $\delta^{15}N$ values than those from the Harbor stations, the profiles at MB01 still revealed a sewage influence.

Biota

Primary Producers-$\delta^{15}N$ values

The $\delta^{15}N$ values for the Chlorophytes increased from the harbor to the bay. Values for *Ulva* in the harbor averaged 7.5‰ (range 6.1-9.5). The isotope values for *Laminaria* followed the same pattern as *Ulva* and *Enteromorpha* in that they got heavier with distance from the outfall. The values, however, were not the same as for the Chlorophytes.

The results from Laminaria are surprising. From BH03 and out to two stations in the Bay, there is a transition to heavier $\delta^{15}N$ values. However the values were quite different from those of *Ulva* and *Enteromorpha*, and the difference was not consistent. It is not surprising that the two types of algae would fractionate N differently, given the differences in structural complexity; however the inconsistency in the direction of the difference is puzzling.

Mussels - $\delta^{15}N$ values

Blue mussel $\delta^{15}N$ values also got heavier with distance from the outfall (Fig. 8). Along the buoy transect, values changed from 4.2‰ at B1 to 7.1‰ and 6.9‰ at B3 and B4, respectively. Within the harbor, the range was 5.4‰ to 6.9‰, with the lightest values from mussels from H2 (no mussels were collected at H1) and the heaviest from H5. Mussels from BH03 had an average $\delta^{15}N$ value of 5.9‰.

We had assumed that the Chlorophtye samples would serve as a proxy for PON in the Harbor and Bay, and would give us a stable isotope signal for the base of the food web. The $\delta^{15}N$ values from the blue mussels we collected suggest that macrophytes have a very different $\delta^{15}N$ value than the PON being ingested by the mussels. A trophic shift of about +3‰ occurs with uptake of PON by primary consumers. Rather than being heavier than the Chlorophytes, however, the mussels were in all cases very similar or lighter. Clearly mussels are ingesting something with a $\delta^{15}N$ value lighter than the macrophytes growing in the same location.

Effluent particulates collected in 1994 averaged 1.1 (in October it was 1.8) Adding 3‰ to that gives a value of about 4 to 5‰. Mussels collected at B1, in the path of the effluent plume, were 4.2‰, very suggestive that the diet of these mussels was largely comprised of effluent particulates. Values from all other stations were heavier, roughly corresponding to distance from the outfall, and probably reflecting uptake of a mixture of effluent particulates and heavier PON. In fact the samples taken along the transect out into the bay had increasingly heavier values, until the most seaward station, B4. Mussels at B4 looked isotopically very similar to those from B3, the station just inshore of it. Curiously, chlorophyll levels were higher in the vicinity of B4 than B3, even though nitrogen was nearly depleted there (Libby et al, 1995). The isotope values in the mussels coupled with the nutrient data led us to postulate that the PON at B4 originated closer to the Harbor and had been transported seaward .

$\delta^{34}S$ in mussels and algae

With the exception of the stations receiving fresh water input from the Charles R. and /or from the sewage outfall, algal samples from all stations had $\delta^{34}S$ values near that of seawater, 19.5‰. The stations receiving fresh water were only slightly (<1‰) lighter.

Mussel samples, however, had significantly lighter $\delta^{34}S$ values than seawater. The lightest value was 13.5 and was from mussels collected at B1 in the plume. The other samples followed the pattern we saw with nitrogen of becoming heavier with distance from the outfall, with the heaviest value, 16.9‰ from the outermost station, B4. It is generally considered that there is no trophic shift with the uptake of sulfur, so that a sample should directly reflect the isotope value of its source. A potential source of the light values was effluent particulates, which had $\delta^{34}S$ values ranging from 4.5 to 8.4‰ in 1994 (4.5‰ in Oct). By plotting $\delta^{15}N$ of samples and sources against their $\delta^{34}S$ values in a double isotope plot, the relationship between sample and source may be seen. The graph shows that although the algae varied in their nitrogen signal, they were relatively constant in their sulfur signal, and closely reflected sea water sulfate values. The mussels varied in both isotopes, and plot on the graph just above the mixing line between the effluent particulates and the Georges Bank POM. If we adjust the mixing line for a trophic shift in N of +3‰, the line then passes through the mussel values.

Histopathology and Chemistry of Winter Flounder

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The design of the flounder studies will be reviewed with regard to station, sample size and parameters measured. Selected data for 1995 will be summarized. Temporal trends will then be discussed (1987 to 1995 for Deer Island, 1991 to 1995 for the other four stations). Correlations will be shown between histological and chemical parameters, highlighting both spatial and temporal patterns. The relevant hypotheses to be tested in phase 2 post discharge monitoring will then be described and specific issues relevant to the interpretation of potential outcomes will be discussed.

Lobster Tissue Burdens - Status and Trends

by Dr. David F. Mitchell

Abstract

The results of the 1995 Lobster Survey were reviewed with regard to sampling methodology, station, sample size, and parameters measured. Fifteen lobsters (*Homarus americanus*) were collected from three locations: Deer Island Flats (DIF), Future Outfall Site (FOS), and Eastern Cape Cod Bay (ECCB) in July 1995. Examination of the external conditions of the lobsters indicated healthy individuals with exceedingly few abnormalities.

Spatial and temporal patterns in tissue chemistry for pesticides, PAHs, PCBs, and metals in edible tissue (i.e., tail meat) and hepatopancreas were analyzed. Analysis of the 1995 data indicated that tissue contaminant levels were generally greatest at DIF and least at ECCB. Comparison of the 1995 data to previous years' data indicated that most of the parameters were found at levels within the range of past observations. Higher levels of PCBs and pesticides in hepatopancreas were exceptions to this, as was lower levels of chlordane in edible tissue.

The 1995 data was compared with FDA Legal Limits for several analytes including DDT, chlordane, dieldrin, PCBs, and mercury. The body burdens of edible tissue were well below the legal limits and no action or warning limits were exceeded. Levels of PCBs in hepatopancreas approached the warning limit, however. Consideration of the utility and testability of underlying hypotheses for the lobster monitoring program led to the conclusion that they are generally answerable and provide an unambiguous interpretation of the potential of risk for human consumption of lobster. Further methodology refinement and application of trend analysis may be required to detect significant changes in hepatopancreas tissue concentrations.

1995 Caged Mussel Studies: Bioaccumulation of metals and organic compounds

by Philip C. Downey and Brian D. Moffat
Inchcape Testing Services
Environmental Laboratories

ABSTRACT

The MWRA began a monitoring program in 1987 for the proposed MWRA sewage outfall in Massachusetts Bay using *in situ* caged mussels (*Mytilus edulis*). As part of that continuing program, mussels were deployed at three stations in the summer of 1995. The goal of the study was to establish baseline bioaccumulation levels for mussels deployed near the proposed sewage outfall and to assess the potential for mussels (and other shellfish) to bioaccumulate toxic contaminants from the Deer Island sewage discharge. Mussels were recovered from only two of the three deployment locations forty-nine days after deployment. The soft tissues of the recovered mussels were analyzed for PAHs, pesticides, PCBs and selected heavy metals. Temporal and spatial trends in contaminant levels are discussed. Total PAH tissue body burdens have been consistently higher in mussels deployed in Boston's inner harbor (Discovery) as compared to Deer Island deployed mussels. However, the pattern of PAH bioaccumulation at these two locations differs. Mussels deployed at Deer Island bioaccumulate higher concentrations of low molecular weight PAHs relative to high molecular weight PAHs whereas the reverse trend has been observed for Discovery deployed mussels. Total PAH tissue body burdens have shown a downward trend in concentration since 1987 for Deer Island deployed mussels. No consistent trend in total pesticide levels for Deer Island or Discovery mussels has been observed since 1991, however, total pesticide levels have decreased from the peak concentrations observed in 1993. Total PCB tissue body burdens in Deer Island mussels have remained at approximately the same level since 1991, but, have significantly decreased as compared to the 1987 concentrations.

PHASE II EFFLUENT AND FISH AND SHELLFISH HYPOTHESES

Hypotheses to be tested during Phase II of the MWRA Outfall Monitoring Program

EFFLUENT

E1: The solids concentration in the effluent stream will not exceed 40.5 mg/L on a weekly basis nor 27 mg/L on a monthly basis.

E2: The carbonaceous BOD (cBOD) of the effluent stream will not exceed 36 mg/L on a weekly basis nor 22.5 mg/L on a monthly basis.

E3: Bacteria levels in the effluent will not exceed 90% of the NPDES permit limits.

E4: Total nitrogen load from the Deer Island outfall will not exceed 12,500 mtons/yr.

E5: Toxic contaminant concentrations in the effluent will not exceed 90% of the NPDES permit limits.

E6: Effluent toxicity will not exceed 90% of the NPDES permit limits.

E7: Floatable debris in the final floatable collection device of the treatment plant effluent will not exceed 4.5 gal/day.

E8: The daily mean concentration of oil and grease of petroleum origin in the effluent will not exceed 13.5 mg/L.

Hypotheses to be tested during Phase II of the MWRA Outfall Monitoring Program *(continued).*

FISH AND SHELLFISH

F1: Hg concentrations in tissue of lobster (meat or hepatopancreas), winter flounder (filet or liver) or caged mussels will not increase to greater than 0.5 μg/g wet weight.

F2: PCB concentrations in tissue of lobster (meat or hepatopancreas), winter flounder (filet or liver) or caged mussels will not increase to greater than 1.0 μg/g wet weight.

F3: Pb concentrations in edible tissue of caged mussels will not exceed 2.0 μg/g wet weight.

F4: Pb concentrations in edible tissue of caged mussels will not increase by more than 20% per year relative to baseline conditions.

F5: Concentrations of contaminants than can bioaccumulate in lobster, flounder and caged mussel edible tissue will not increase by more that twice the measured baseline concentration for any consecutive three year period.

F6: The prevalence of centrotubular hydropic vacuolation of the winter flounder livers in the vicinity of the MWRA Massachusetts Bay outfall will not exceed the average condition measured in outer Boston Harbor during the baseline monitoring period.

COMMENTS FROM WORKSHOP DISCUSSION SESSION

After each scientific presentation and in the general discussion session, workshop participants discussed issues, questions, and comments relevant to the effluent and fish and shellfish monitoring program. The main themes from these discussion sessions are highlighted below.

MAJOR TOPICS FROM DISCUSSION SESSIONS:

Effluent Characterization Studies in Massachusetts Bay

- Attention should be paid to individual contaminants as opposed to focusing on summary compilations such as "total PAH".

- From an outfall monitoring perspective, discussions and comparisons should be restricted to the secondary effluent that will eventually be entering the outfall area, not the present primary effluent.

- One reviewer recommended a special study with greatly increased frequency of sample collection (e.g. collect 24-hour composites daily for a month). Another participant suggested evaluating the existing data to determine what factors drive effluent variability and then possibly reducing the existing frequency of sampling to quarterly.

- One participant suggested that split samples should be taken for archiving purposes so that data can be further examined and analyzed in the future.

Stable isotope measurements in Boston Harbor and Massachusetts Bay

- One participant commented that searching for a "perfect" individual sewage tracer is likely to be fruitless, but recommended pursuing multiple indicator approaches.

Histopathology and Chemistry of Flounder

- More than one participant questioned the utility of Centrotubular Hydropic Vacuolation (CHV) as a target parameter, questioning if existing data allow firm linkages to population "health." One participant expressed concern that "high" levels are currently seen in the vicinity of the future outfall site (FOS), while another noted that baseline levels at the FOS are "pretty low", and that action levels could be considered protective.

- Several participants responded to a floor comment regarding the possibility of tracking reproductive effects on and recruitment success of the flounder population. Most expressing an opinion, suggested that costs and difficulty would be prohibitive, although one participant recommended the approach despite the cost.

Lobster tissue burdens

- Two participants suggested that the migratory behavior and extensive mobility of lobster may make them a poor indicator organism for localized outfall effects.

- One participant suggested that tail meat contaminant concentrations are so low that limited statistical power might be acceptable.

Caged mussel studies

- One participant suggested pursuing analyses to "back-calculate" average water column concentrations of contaminants from mussels during the deployment period. On a long-term basis, mussels could be a good representation of water column concentrations.

GENERAL COMMENTS AND QUESTIONS:

- Several hypotheses need revision.

- It may be possible to cluster hypotheses which have obvious overlap and create a "capstone" hypothesis for each cluster. Hypotheses should be created which cross programmatic lines.

- Some participants suggested that formal risk assessment needs to be performed using existing data; others, including the reviewer, suggested target levels should be periodically re-evaluated based on risk assessment work from outside the program.

- One reviewer suggested that target levels (e.g. for PCBs, mercury, and PAHs) need to be reexamined and modified periodically. It would be useful to incorporate a periodic assessment of targets into the program.

- Several participants questioned the appropriateness of outfall monitoring hypotheses linked to tissue concentrations of PCBs and mercury, whose loadings from MWRA secondary effluent will be only a tiny fraction of the environmental reservoirs of these compounds.

- One reviewer reminded the audience that some chemicals tend to be additive and have a common effect on the receptor organism. The potential for cumulative effects should be considered as opposed to focusing solely on a chemical by chemical basis as is done now.

- There was a general consensus that questions of inter-laboratory comparability need to be fully addressed in reporting the 1995 data. Several participants agreeing with this point expressed doubt that the issue will ultimately affect data comparability between 1995 and previous years.

- Several participants and the reviewer suggested that the spatial scale of interest for the monitoring program may need to be reassessed. In addition, the choice of target organisms may then need to be reviewed in light of that assessment.

- Some concerns were raised that organic contaminants in lobster and flounder tissues (especially hepatopancreas) are so variable from site to site and year to year that current levels of analytical replication, even of composited samples, may not be adequate to meet program goals. One participant concluded that the variability in these contaminants and degree of replication are not adequate to meet program goals.

- One participant suggested that a larger sample size is needed in order to make studies statistically valid (i.e. lobster and flounder studies).

- A few participants suggested that concentrations of contaminants should be lipid-normalized to better address questions of year to year and site to site variability.

APPENDIX A

Workshop Attendance

APPENDIX A

Attendance at the MWRA workshops

5/23/96 all day Water Quality
5/24/96 A.M. Effluent; Fish
5/24/96 P.M. Benthos

x		x	Adams, Eric	MIT
x			Anderson, Don	WHOI
x			Anderson, Steve	Anderson & Kreiger
x	x	x	Benaway, Heather	UNH
x	x	x	Blake, Jim	ENSR
	x	x	Boehm, Paul	ADL
x			Bollens, Steve	WHOI
x			Borkman, Dave	URI
	x	x	Bothner, Mike	USGS
x	x	x	Boudrow, Rob	UNH
x			Bowen, Jim	UNC
x			Bridges, Leigh	MDMF
	x	x	Butler, Eric	ENSR
x	x	x	Butman, Brad	USGS
x			Cambareri, Tom	CCC
x	x		Carlisle, Bruce	MCZM
x	x	x	Chen, Bob	UMB
x			Cibik, Steve	ENSR
x			Coniaris, Cathy	UNH
x			Connelly, Brian	WHOI
x	x	x	Connor, Mike	MWRA
x			Daley, Patty	CCC
	x	x	Downey, Phil	Aquatec
	x	x	Estrella, Bruce	MDMF
	x	x	Fredette, Tom	COE
x	x	x	Gallagher, Gene	UMB
x		x	Galya, Don	ENSR
x			Geyer, Rocky	WHOI
	x	x	Giblin, Anne	MBL
x	x	x	Gould, Diane	MCZM
	x	x	Grob, Elizabeth	MCZM
x	x	x	Hall, Maury	MWRA
	x	x	Hecker, Barbara	Hecker Envir.
		x	Hilbig, Brigitte	ENSR
x	x	x	Ho, Nancy	APCC

x		x	Howes, Brian	WHOI
x	x	x	Hunt, Carlton	Battelle
	x	x	Ika, Ravi	Harvard
x			Isaac, Russell	MA DEP
x	x	x	Jaworski, Norbert	EPA
x	x	x	Keay, Ken	MWRA
x			Kelly, Jack	Battelle
		x	Kropp, Roy	Battelle
		x	Krueger, Elaine	MA DPH
x			Lacouture, Richard	ANS
x	x	x	Liebman, Matt	EPA
x	x	x	Loder, Ted	UNH
	x	x	MacLean, Sharon	NMFS
x	x		Malone, Tom	U MD
x			Mayo, Stormy	CCS
x	x	x	McCarthy, Susan	ENSR
	x	x	Menzie, Charlie	MCA
x	x	x	Mickelson, Mike	MWRA
	x	x	Mitchell, David	ENSR
	x	x	Moore, Michael	WHOI
x	x	x	Pederson, Judy	MIT
x	x	x	Redlich, Susan	WWAC
	x	x	Rojko, Alice	DEP
	x	x	Rhoads, Don	SAIC
x	x	x	Schubel, Jerry	NEAq
	x	x	Schwartz, Jack	MDMF
x	x	x	Shine, Jim	Harvard
x	x	x	Studer, Marie	MCZM
x			Sung, Windsor	Sung Assoc.
x		x	Taylor, Craig	WHOI
x	x	x	Taylor, Dave	MWRA
	x	x	Testaverde, Sal	NMFS
x			Tomey, Dave	EPA
x			Trowbridge, Phil	MDPH
	x	x	Tucker, Jane	MBL
x	x	x	Wallace, Gordon	UMB
		x	Watling, Les	U Maine
x			Zavistoski, Becky	ENSR

APPENDIX B

Written Correspondence pertaining to Workshop

Menzie-Cura & Associates, Inc.
One Courthouse Lane
Suite Two
Chelmsford, MA 01824
Telephone (508)453-4300
Fax (508)453-7260

MEMORANDUM

File:

June 27, 1996

To: Mike Mickelson
From: Charlie Menzie
Subject: MWRA Monitoring Workshop Comments

Thank you for inviting me to the workshop. As requested, I have prepared comments on the portions of the monitoring programs that relate to the effects of toxic chemicals on fish and shellfish. I've also included a few comments on these issues that relate to other monitoring components.

1. It may be useful to utilize a conceptual model for conditions in the bay and harbor as a framework for interpreting monitoring results and communicating conditions to the technical community, managers and the public. I thought that much of what was presented could be explained in terms of what we now know about runoff and other sources as well as region-wide conditions. Presentation of results with a narrow focus on the outfall may not provide a large of conceptual framework to understand what has been or will be observed from monitoring. For example, the PAH data presented for mussels agrees well with a multiple-source scenario and matches the various data sets we have on urban runoff from Boston as well as discharge from Deer Island.

2. The monitoring program involves comparisons to specific chemical benchmarks. These benchmarks are mutable and will change in the future. This is likely to be the case for PCBs, PAHs, and mercury. I suggest that the monitoring programs incorporate a periodic reassessment of the benchmarks used for judging conditions. This should probably

occur at a minimum of once every three years.

3. Some of the benchmarks seem high to me. Examples include allowing stations to reach 90% of NOAA ER-M or EPA criteria, 1.6 ug/g PCBs, 0.8 ug/g mercury in flounder, lobster, and caged mussels. These concentrations are usually not employed as "allowable limits" of incremental pollution and I was surprised to see them employed in the monitoring plan in this manner. Are these the bases for permitting the outfall? I would have thought that the monitoring benchmarks would have included expected levels with a margin of safety. In other words, the assessment of impacts presumes that a particular set of conditions would occur around the outfall. Monitoring should serve, in part, to determine if these expectations/prediction are met. I will send you one of my papers on marine monitoring strategy that illustrates my thoughts on this.

4. For body burden data, lipid normalization is recommended along with totals. This may reduce some of the variability observed in the tissue levels of organic chemicals.

5. The use of histopathological observations in flounder is a useful tool for judging potential exposure. However, this part of the monitoring program would be strengthened if these observations could be related to conditions associated with the populations' ability to reproduce and maintain themselves. I recognize that this may be difficult to do. But, this is a key issue.

6. The hypotheses and associated monitoring program need better definition with regard to distance and area from and around the outfall.

7. The effluent quality of the outfall will change once secondary treatment is implemented. For example, based on our sampling, we would expect to see a reduction as well as a shift in the composition of PAHs from lighter molecular weight to higher molecular weight compounds. These kinds of changes should be considered when making inferences about present observations (i.e., around the current outfall) to conditions that might occur offshore.

8. The new outfall will differ from the current outfall in several major

respects. One is an increasing shift of the chemical exposure field from sediments to the water column including suspended particulates. This shift may have important implications for the monitoring strategy. For example, exposure may be via contact with effluent streams in the water column rather than via direct contact with sediment. Animals that might be most exposed include filter feeders on hard substrates and pelagic fish that are attracted to the area. Mike Bothner suggested the use of sediment traps and I think that deserves attention.

9. In a number of places in the monitoring program reference is made to comparisons to "baseline". I do not think that this is a good approach. A simple baseline does not exist in Massachusetts Bay. Rather, conditions can be expected to change continually as a result of short-term and long-term processes. The BLM/MMS offshore program was criticized for adopting this approach. The MWRA program should rely upon a relative spatial measure that can change with time rather that a "baseline".

10. For lobsters, there are common patterns of contaminants which may be instructive for interpretation.

11. For benthos, I suggest some attention be given to the functional aspects of the community. The current hypotheses for benthic monitoring seem both soft and perhaps inappropriate given the nature of the environment.

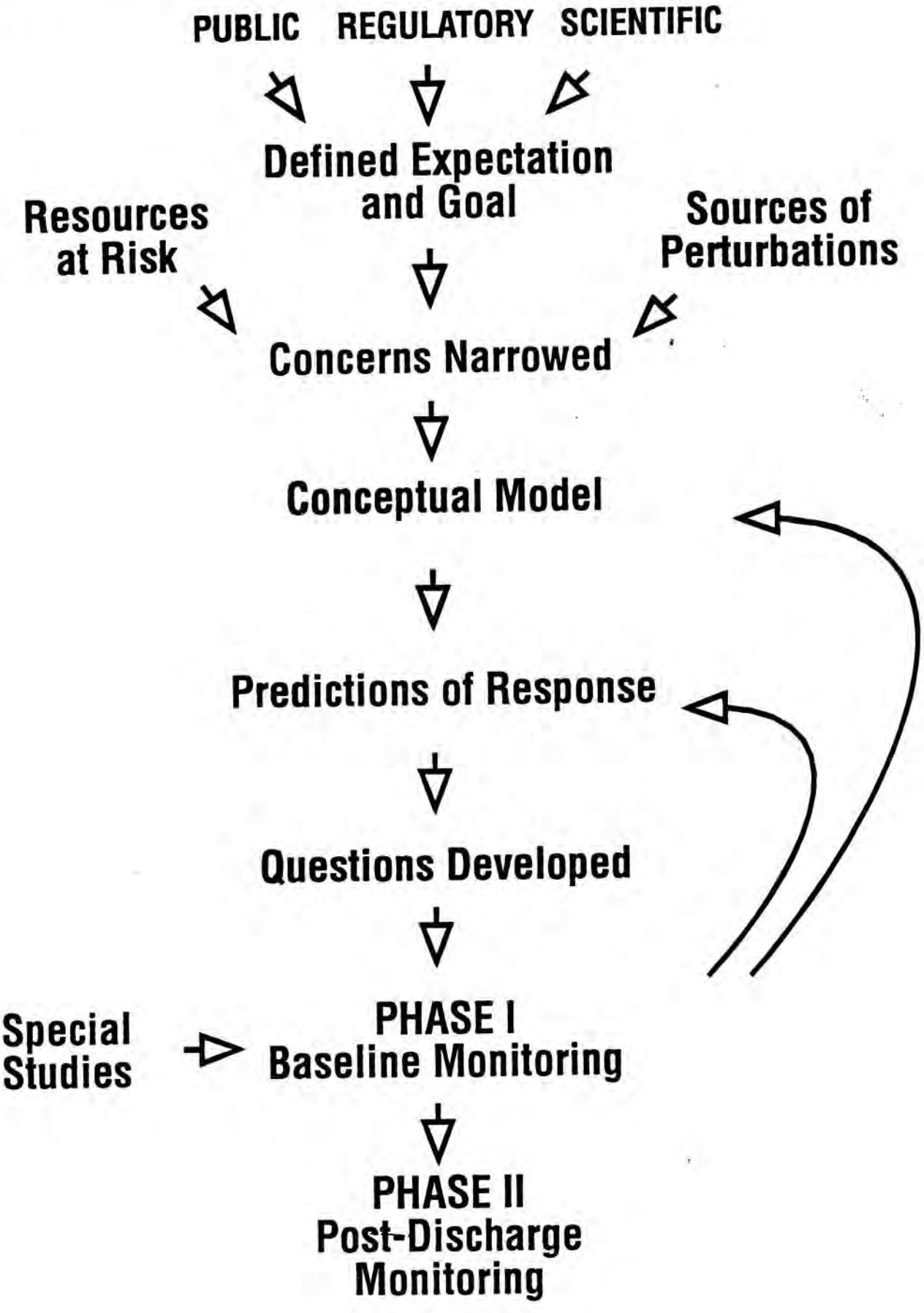
APPENDIX C

Overheads and Graphics from Presentations

APPENDIX C-1

Ken Keay
MWRA

MWRA Monitoring Plan Development



Outfall Monitoring Program study areas

1. Water Column (Focus of workshop, 5/23/96)
2. Effluent (5/24/96, morning)
3. Fish and Studies (5/24/96, morning)
4. Benthic monitoring(5/24/96, afternoon)
5. Special studies (Both days)

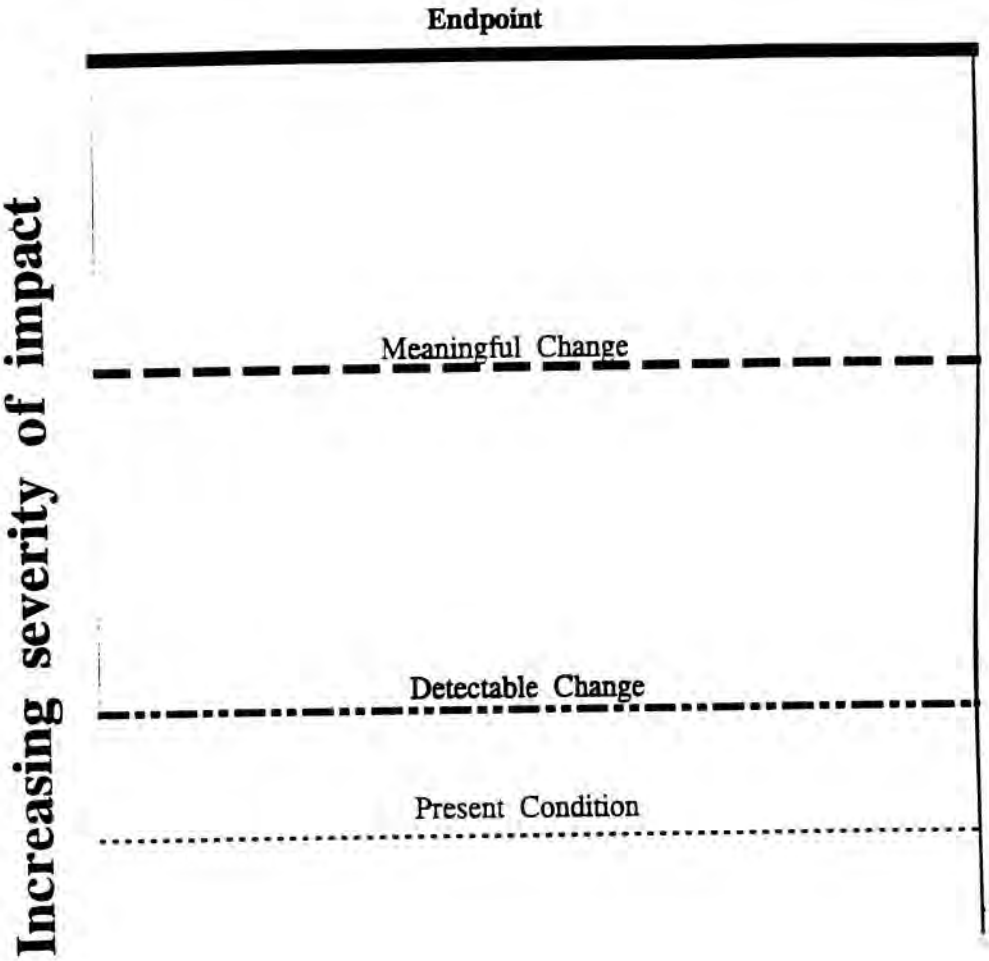


Figure 1-2. Schematic representation of relationship between key factors required to develop monitoring hypotheses.

Effluent Monitoring

Perturbations of concern: All, particularly R9-R10, R14-R16

	Hypotheses/warning levels	Action levels
E1	Total solids concentrations will not exceed 90% of NPDES permit limits.	Permit violation
E2	cBOD concentrations will not exceed 90% of NPDES permit limits.	Permit violation
E3	Bacterial counts will not exceed 90% of the NPDES permit limits	Permit violation
E4	Total nitrogen load will not exceed 12,500 mtons/yr.	14,000 mtons/yr
E5	Contaminant concentrations will not exceed 90% of the NPDES permit limits.	Permit violation
E6	Toxicity will not exceed 90% of the NPDES permit limits.	Permit violation
E7	Floatable debris at final in-plant collection device will not exceed 4.5 gal/day.	5 gal/day
E8	Petroleum-derived oil and grease will not exceed 90% of the NPDES permit limit.	Permit violation

	Measurement Program	Speaker
E1-E8	Routine NPDES and plant process control sampling and analyses.	
E4	Routine NPDES sampling, 1994-95 special study involving detailed breakdown of nutrient forms in effluent.	Mike Mickelson, 5/23
E5	NPDES sampling. Detailed Effluent Characterization study using protocols modified to achieve low detection levels. Special studies of potential sewage tracers, e.g. Linear Alkyl Benzenes, N and S stable isotopes.	Eric Butler, 5/24
	Related special study of N and S stable isotope ratios in high-energy sediments as tracers of sewage additions	Anne Giblin

Detailed Effluent Characterization Study

- Two-24 hour composite effluent samples are collected per month, on two of the three days of the routine NPDES permit sample collection.
- Analyzed for trace metals, PAHs, PCBs, and Pesticides using methods modified to achieve significantly lower detection levels than NPDES methods.
- 12/93-12/95 special study of nutrient forms in effluent; analysis for same nutrients as measured in Water Column monitoring Program.
- Special study of potential sewage tracers in effluent, analyses for Linear Alkyll Benzenes, *Clostridium perfringens* spores, stable isotope ratios of S and N.
- Special study of removal efficiencies at the MWRA permanent Pilot Secondary Treatment plant.

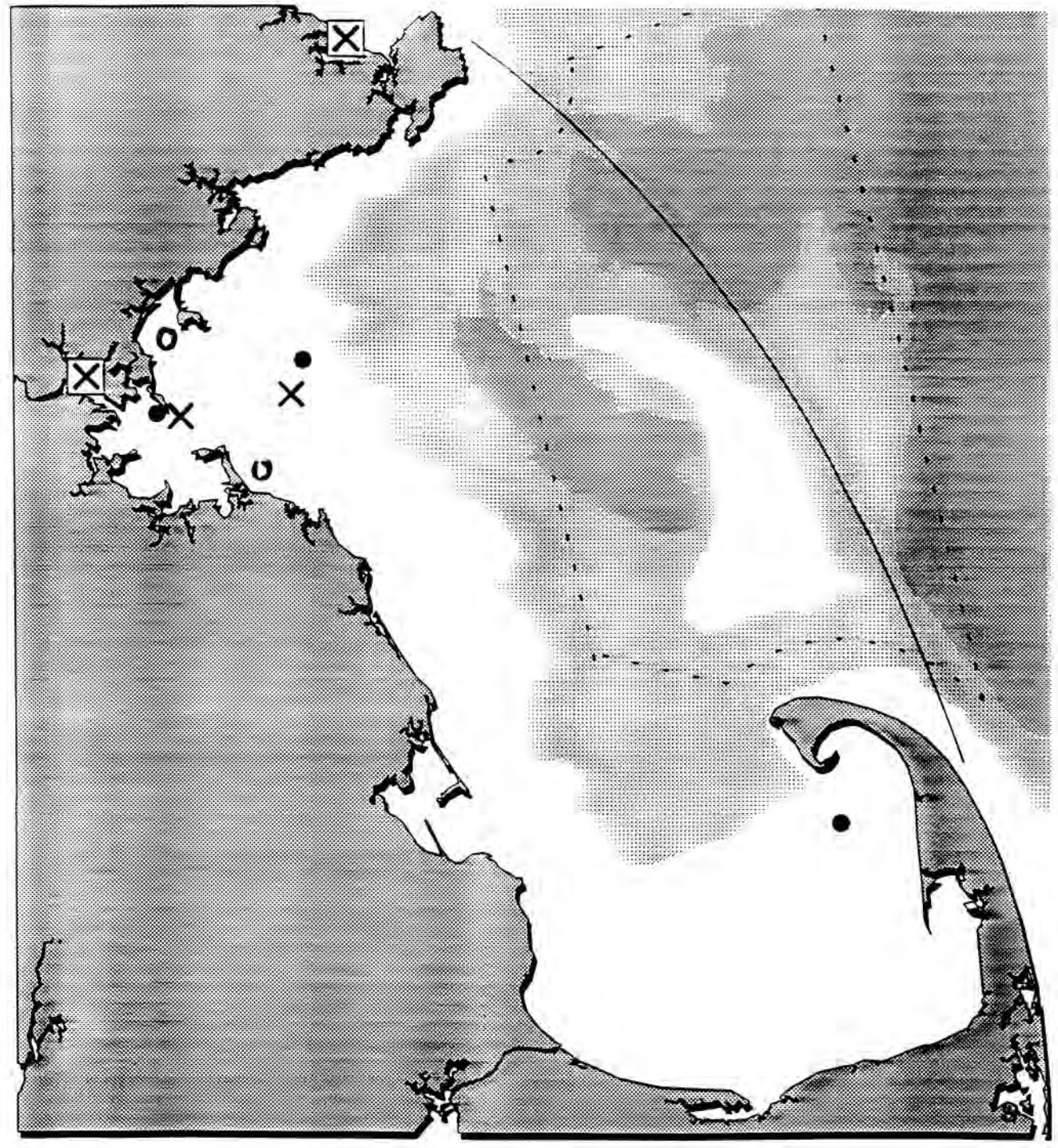
Fish and Shellfish Monitoring

Perturbations of concern: R1, R11

	Hypotheses/warning levels	Action Levels
F1	Mercury in edible tissues of flounder, lobster, or caged mussels from the vicinity of the future outfall will not exceed 0.5 μg/g wet weight.	0.8 μg/g
F2	PCB concentrations in edible tissues of flounder. lobster, or caged mussels will not exceed 1.0 μg/g wet weight	1.6 μg/g
F3	Lead concentrations in edible tissues of caged mussels will not exceed 2.0 μg/g wet weight	3 μg/g
F4	Lead concentrations in edible tissues of caged mussels will not increase by more than 20%/yr relative to baseline conditions	
F5	Lipophilic contaminants in lobster, flounder, or caged mussel edible tissues will not double (over baseline) and remain elevated for 3 consecutive years	
F6	CHV prevalence in livers of flounder from the future outfall site will not reach the average prevalence in Harbor flounder during baseline monitoring (1991-1997)	

	Measurement Program	Speaker
F1, F2, F5, F6	Annual collections of flounder from 5 sites for histological analyses on liver tissue. Contaminant analyses on flounder filet and liver samples from Deer I., Future Outfall, C. C. Bay. Biennial contaminant analyses on fish from the remaining sites (Broad Sound, off Nantasket)	Michael Moore
F1, F2, F5	Annual collections of lobster from the Deer I., Future Outfall, C.C. Bay. Contaminant analyses on meat and hepatopancreas samples.	David Mitchell
F1, F2, F3, F4, F5	Annual 60-day deployment of clean mussels to Future Outfall Site, Deer Island, Inner Harbor, followed by contaminant analyses.	Phil Downey

Fish & Shellfish Monitoring



flounder mussel lobster

J F M A M J J A S O N D

40m

80m

Sanctuary Boundary

Model Boundary

APPENDIX C-2

Eric Butler
ENSR

TABLE 3

Effluent Chemistry Analytes

Metals
- Ag silver
- Cd cadmium
- Cu copper
- Cr chromium
- Hg mercury
- Mo molybdenum
- Ni nickel
- Pb lead
- Zn zinc

Polychlorinated biphenyls
- 2,4,-Cl_2(8)
- 2,2',5-Cl_3(18)
- 2,4,4'-Cl_3(28)
- 2,2',3,5'-Cl_4(44)
- 2,2',5,5'-Cl_4(52)
- 2,3',4,4'-Cl_4(66)
- 3,3',4,4'-Cl_4(77)
- 2,2'4,5,5'-Cl_5(101)
- 2,3,3',4,4'-Cl_5(105)
- 2,3',4,4'5-Cl_5(118)
- 3,3',4,4',5-Cl_5(126)
- 2,2',3,3,4,4'-Cl_6(128)
- 2,2',3,4,4',5-Cl_6(138)
- 2,2'4,4',5,5'-Cl_6(153)
- 2,2'3,3,4,4',5-Cl_7(170)
- 2,2',3,4,4',5,5'-Cl_7(180)
- 2,2',3,4,5,5',6-Cl_7(187)
- 2,2',3,3',4,4',5,6-Cl_8(195)
- 2,2',3,3'4,4',5,5',6-Cl_9(206)
- Decachlorobiphenyl-Cl_{10}(209)

Linear alkyl benzenes (LAB)
- phenyl decanes
- phenyl undecanes
- phenyl dodecanes
- phenyl tridecanes
- phenyl tetradecanes

Polynuclear aromatic hydrocarbons (PAH)
- naphthalene
- C_1-naphthalenes
- C_2-naphthalenes
- C_3-naphthalenes
- acenaphthylene
- acenaphthene
- fluorene
- C_1-fluorenes
- C_2-fluorenes
- C_3-fluorenes

PAH (continued)
- anthracene
- phenanthrene
- C_1-phenanthrenes/anthracene
- C_2-phenanthrenes/anthracene
- C_3-phenanthrenes/anthracene
- C_4-phenanthrenes/anthracene
- dibenzothiophene
- C_1-dibenzothiophenes
- C_2-dibenzothiophenes
- C_3-dibenzothiophenes
- fluoranthene
- pyrene
- C_1-fluoranthenes/pyrenes
- benzo[*a*]anthracene
- chrysene
- C_1-chrysene
- C_2-chrysene
- C_3-chrysene
- C_4-chrysene
- benzo[*b*]fluoranthene
- benzo[*k*]fluoranthene
- benzo[*a*]pyrene
- dibenzo[*a,h*]anthracene
- benzo[*g,h,i*]perylene
- indeno[1,2,3-*c,d*]pyrene
- perylene
- biphenyl
- benzo[*e*]pyrene
- dibenzofuran
- benzothiazole

Pesticides
- hexachlorobenzene
- lindane
- heptachlor
- aldrin
- endrin
- heptachlorepoxide
- alpha-chlordane
- trans-Nonachlor
- dieldrin
- mirex
- o,p'-DDD
- p,p'-DDD
- o,p'-DDE
- p,p'-DDE
- o,p'-DDT
- p,p'-DDT
- DDMU

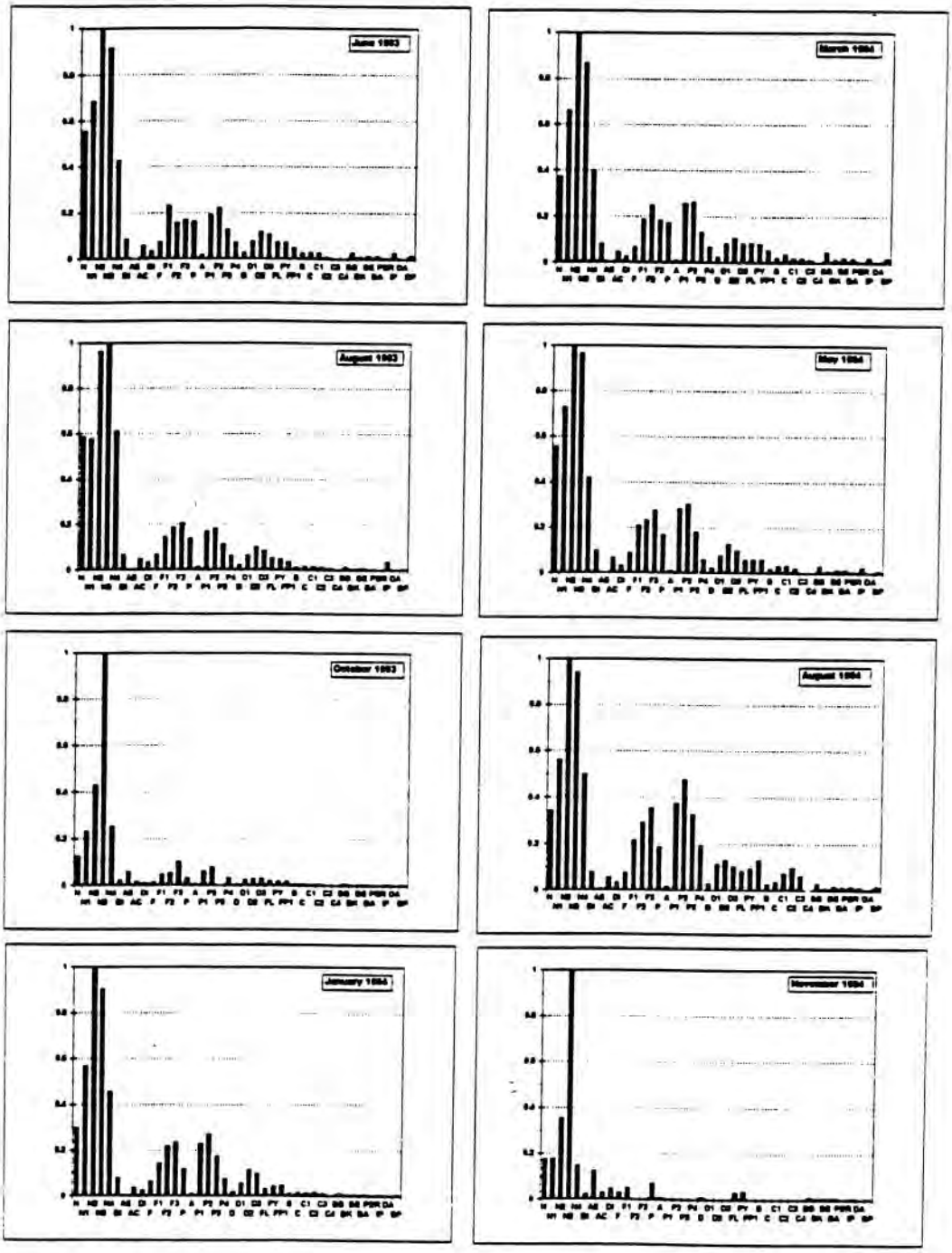


Figure 5. Relative PAH distributions in selected effluent samples. Data is normalized to the compound of highest concentration in each sample.

Key to compound names: Naphthalene (N), C_1-naphthalenes (N1), C_2-naphthalenes (N2), C_3-naphthalenes (N3), C_4-naphthalenes (N4), Biphenyl (DI), Acenaphthylene (AE), Acenaphthene (AC), Fluorene (F), C1-fluorenes (F1), C_2-fluorenes (F2), C_3-fluorenes (F2), C_3-fluorenes (F3), Phenanthrene (P), Anthracene (A), C_1-phenanthrene/anthracenes (P1), C_2-phenanthrene/anthracenes (P2), C_3-phenanthrene/anthracenes (P3), C_4-phenanthrene/anthracenes (P4), Fluoranthene (FL), Pyrene (PY), C_1-fluoranthene/pyrene (FP1), Dibenzothiophene (D), C1-dibenzothiophenes (D1), C_2-dibenzothiophenes (D2), C_3-dibenzothiophenes (D3), C_4-dibenzothiophenes (D4), Benz[*a*]anthracene (B), Chrysene (C), C_1-chrysenes (C1), C_2-chrysenes (C2), C_3-chrysenes (C3), C4-chrysenes (C4), Benzo[*b*]fluoranthene (BB), Benzo[*k*]fluoranthene (BK), Benzo[*e*]pyrene (BE), Benzo[*a*]pyrene (BA), Perylene (PER), Indeno[1,2,3-*c*,*d*]pyrene (IP), Dibenz[*a*,*h*]anthracene (DA), Benzo[*g*,*h*,*i*]perylene (BP).

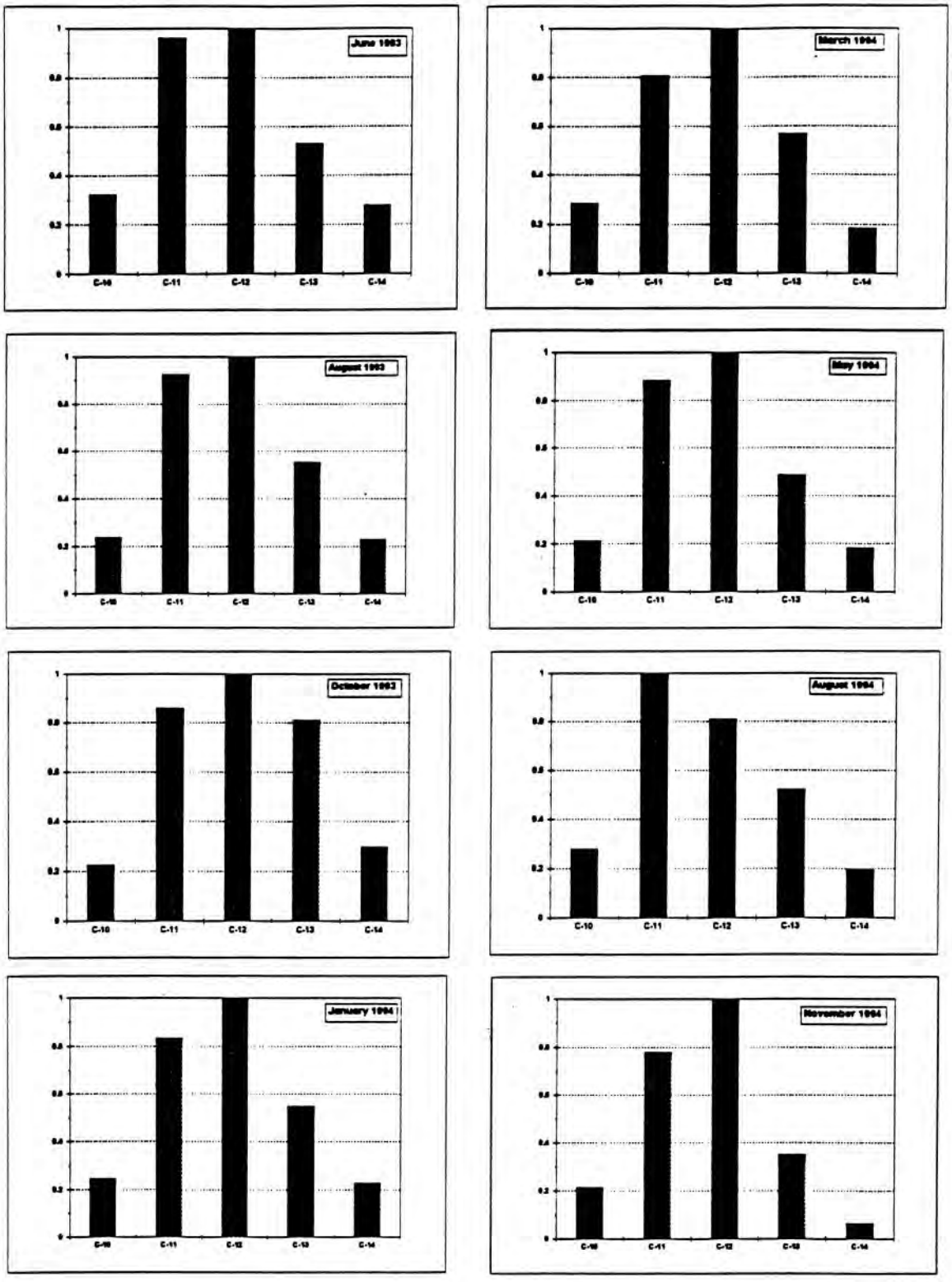


Figure 7. Relative LAB distributions in selected effluent samples. Data is normalized to the compound of highest concentration in each sample.

Table 7. Comparison of 1995 organic contaminant loading (kg/yr) from Deer Island to previous studies

Organic Contaminant	Deer Island				Deer Island Plus Nut Island (1)			
	1995	1994	1993	1993	1995	1994	1993	1993
	This Study	Battelle Study	Uhler et al. (1994)	Albert and Chan (1993)	This Study	Battelle Study	Albert and Chan (1993)	Shea (1993a)
Total PAH	5,929	7,270	5,414	NA	8,893	10,900	NA	4,700
Total Naphthalenes	3,694	4,080	3,692	NA (2)	5,541	6,100	NA	NA
Pyrene	76	78		49	114	117	59	NA
Benzo(a)pyrene	17	15	8	4	26	23	6.3	NA
Total LAB	3297	5,340	NA	NA	4,945	8,000	NA	NA
Total DDT	3.7	21.6	NA	NA	5.6	32	NA	NA
4',4'-DDT	2.2	4.0	2.0	NA	3.3	6	NA	NA
Total Chlordane	2.1	4.6	NA	NA	3.1	7	NA	NA
Lindane	5.3	4.9	4	NA	7.9	7	NA	NA
Dieldrin	ND	0.77	NA	NA	ND	1.2	NA	NA
Total PCB	17	17	18	NA	25	26	NA	36

(1) Estimated by assuming the contamminant concentrations in the Nut Island effluent are the same as the Deer Island effluent and flow proportioning the loading based on the December 1993 to November 1994 flows (Deer Island 225; Nut Island 128 MGD), Deer Island loading estimate was multiplied by 1.5 to get the loading from both treatment plants.

(2) 2-methylnaphthalene estimated at 1,473 Kg/yr.

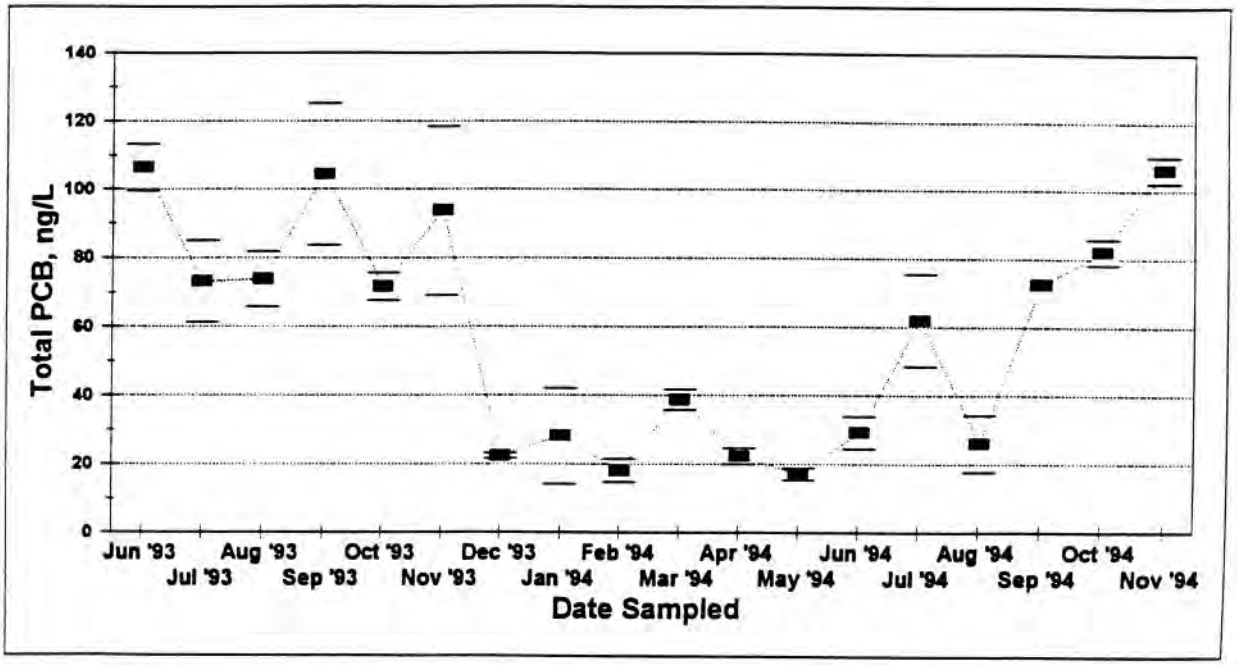


Figure 9 Temporal response in PCB concentrations in Deer Island effluent from June 1993 to November 1994. Mean concentration (rectangle) and the range of concentrations between the two sampling days for each month are shown.

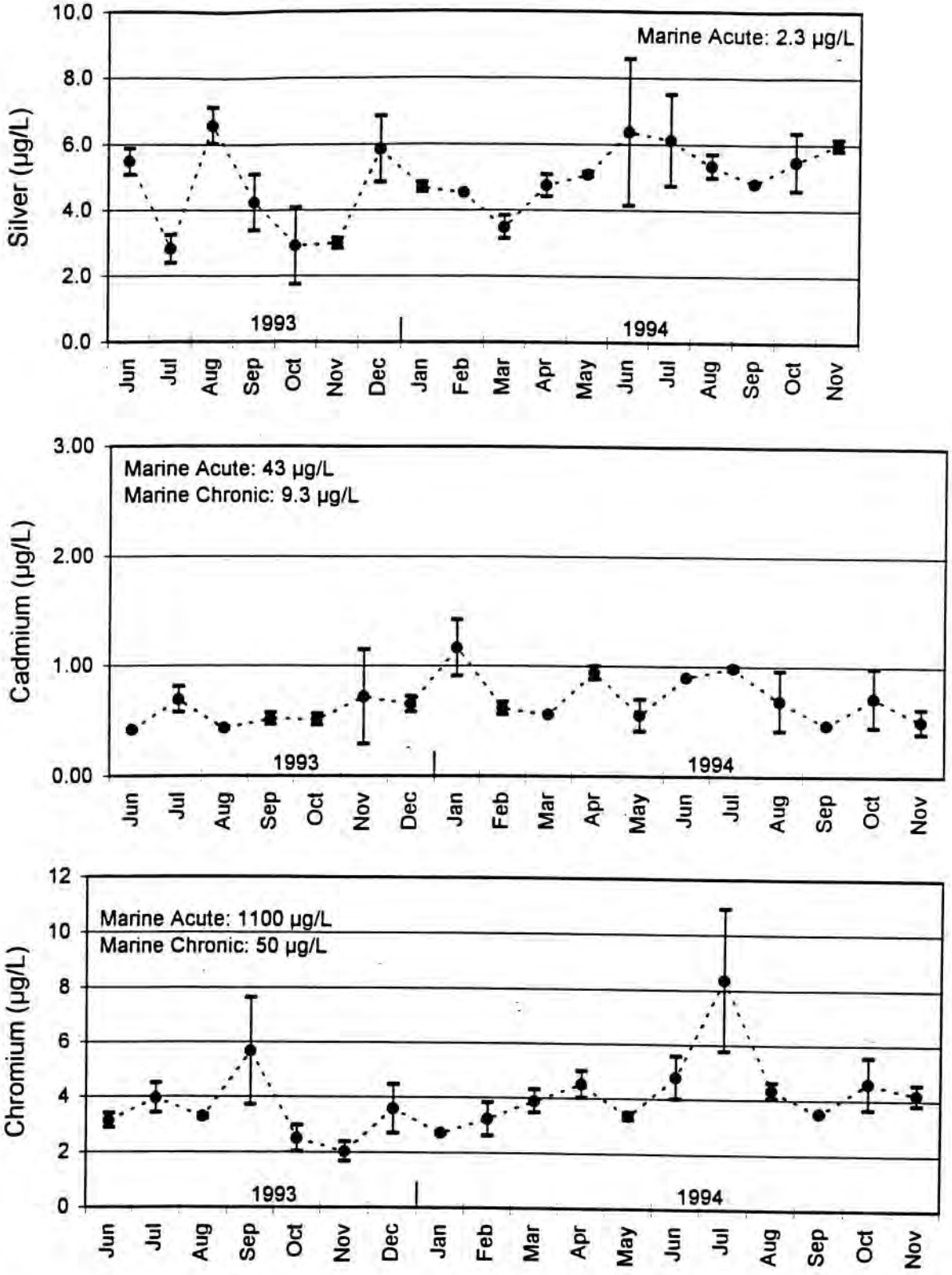


Figure 11a. Temporal response in metals concentrations (Ag, Cd, Cr) in Deer Island effluent from June 1993 to November 1994. Mean concentration (rectangle) and the range of concentrations between the two sampling days for each month are shown.

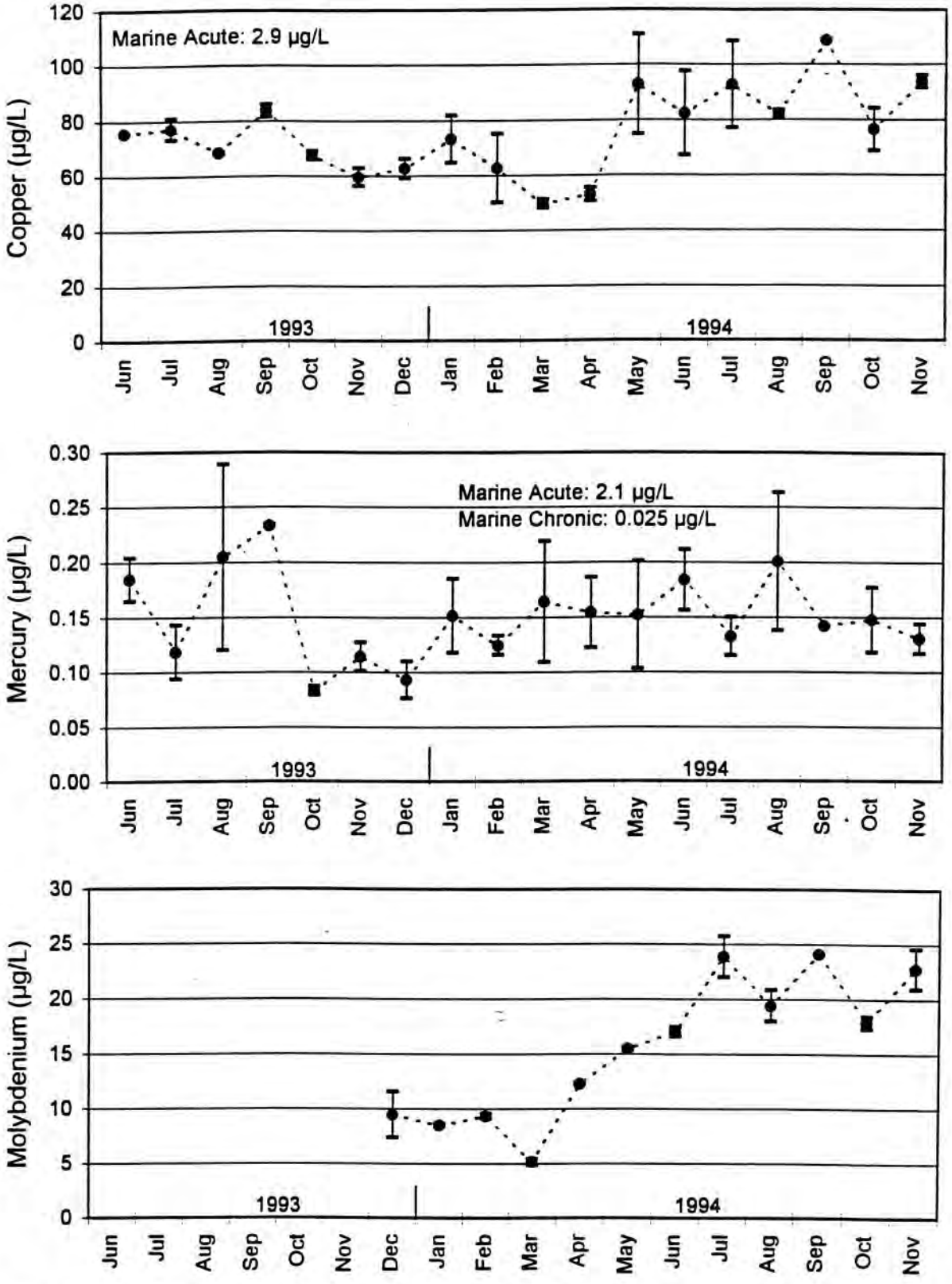


Figure 11b. Temporal response in metals concentrations (Cu, Hg, Mo) in Deer Island effluent from June 1993 to November 1994. Mean concentration (rectangle) and the range of concentrations between the two sampling days for each month are shown.

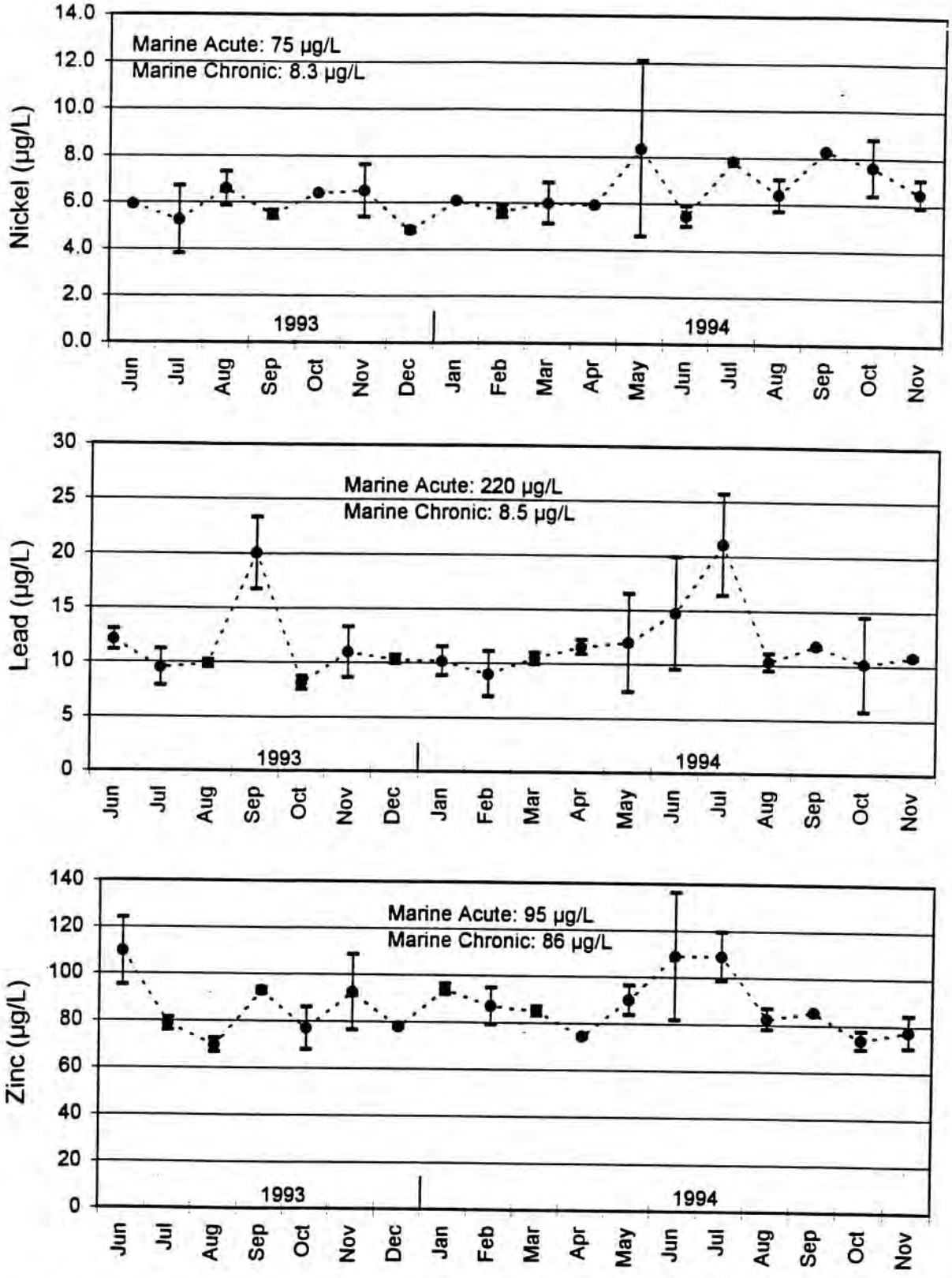


Figure 11c. **Temporal response in metals concentrations (Ni, Pb, Zn) in Deer Island effluent from June 1993 to November 1994. Mean concentration (rectangle) and the range of concentrations between the two sampling days for each month are shown.**

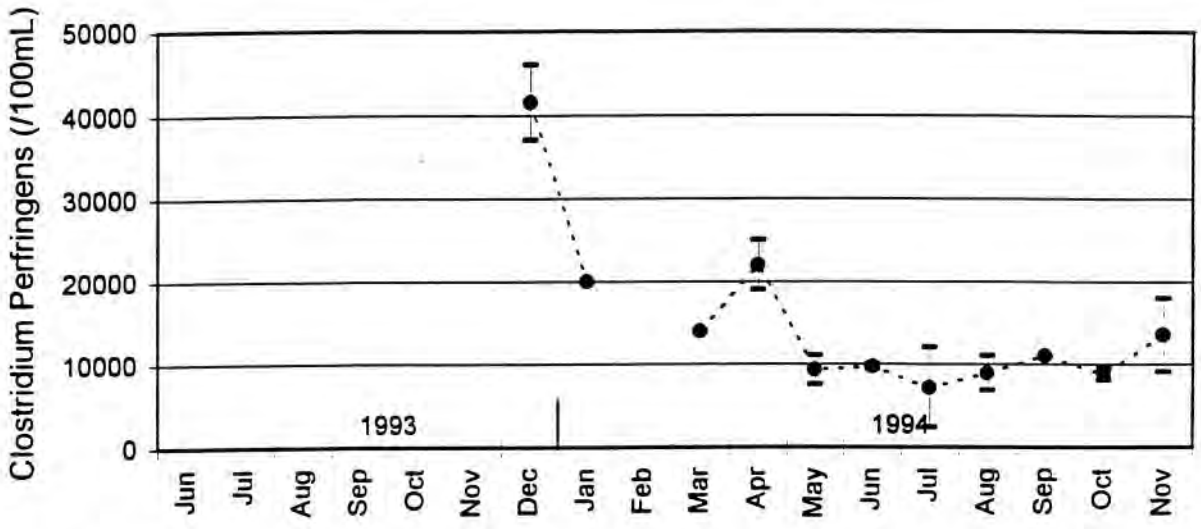


Figure 17. Temporal response in *Clostridium perfringens* concentrations in Deer Island effluent from December 1993 to November 1994.

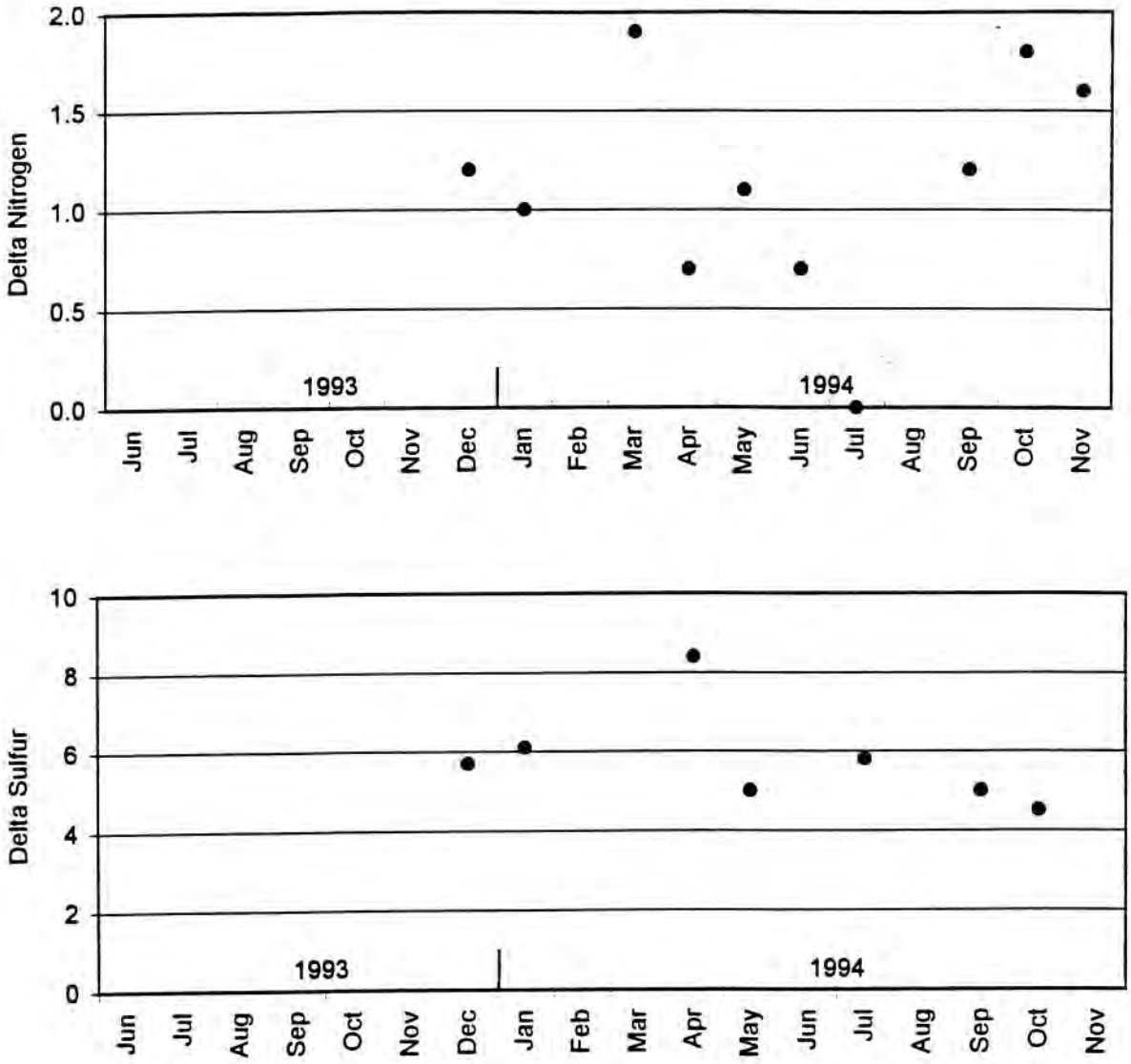


Figure 18. Temporal response in stable nitrogen (upper) and sulfur (lower) isotope ratios in Deer Island effluent particles from December 1993 to November 1994.

Table 8. Comparison of 1995 metals contaminant loading (kg/yr) from Deer Island to previous studies

Metals Contaminant	Deer Island				Deer Island Plus Nut Island (1)			
	1995	1994	1993	1993	1995	1994	1993	1993
	This Study	Battelle Study	Uhler et al. (1994)	Albert and Chan (1993)	This Study	Battelle Study	Albert and Chan (1993)	Shea (1993a)
Ag	1,286	1,730	1,129	NA	1,929	2,600	NA	2,030
Cd	170	250	150	NA	255	370	NA	430
Cr	5,241	1,420	931	NA	7,861	2,100	NA	2,450
Cu	20,685	25,456	19,626	21,500	31,028	38,200	3,140O	30,780
Hg	33	51	42	164	50	75	215	140
Mo	4,521	4,875	1,642	NA	6,782	7,300	NA	NA
Ni	2,052	2,220	1,642.0	NA	3,079	3,300	NA	4,800
Pb	3,839	3,900	3,198	4,320	5,758	6,000	6,100	5,670
Zn	24,944	29,610	23,645	31,460	37,415	44,400	43,800	37,630

(1) Estimated by assuming the contamminant concentrations in the Nut Island effluent are the same as the Deer Island effluent and flow proportioning the loading based on the December 1993 to November 1994 flows (Deer Island 225; Nut Island 128 MGD), Deer Island loading estimate was multiplied by 1.5 to get the loading from both treatment plants.

Table 9. Comparison of 1995 nutrient loading (metric tons/yr) from Deer Island to previous studies

	Deer Island			Deer Island Plus Nut Island (1)		
Nutrient Form	1995	1994	1993	1995	1994	1993
			Albert and Chan			Albert and Chan
	This Study	Battelle Study	(1993)	This Study	Battelle Study	(1993)
Ammonia	4,483	3,710	4,430	6,725	5,570	6,240
Nitrite	9	21	53	13	32	95
Nitrate	75	125	274	113	190	425
Particulate Nitrogen	944	92	NA	1,416	140	NA
Total Dissolved Nitrogen	5725	4,560	NA	8,587	6,840	NA
Total Nitrogen	6,669	5,480	8760 (2)	10,003	8,220	11,470
Phosphate	157	539	806	236	810	953
Particulate Phosphorous	176.1	19.5	NA	264	29	NA
Total Dissolved Phosphorous	755.4	63.2	NA	1,133	95	NA
Total Phosphorous	931	823	1,450	1,397	1,230.0	1,870
Dissolved Silicate	3,392	1,500	NA	5,087	2,250	NA
Biogenic Silicate	209	66	NA	313	100	NA
Particulate Organic Carbon	9355	7910	NA	14,033	11900	NA
Dissolved Organic Carbon	13856	10300	NA	20,784	15500	NA
Total Organic Carbon	23501	18300	NA	35,251	27500	NA

(1) Estimated by assuming the contamminant concentrations in the Nut Island effluent are the same as the Deer Island effluent and flow proportioning the loading based on the December 1993 to November 1994 flows (Deer Island 225; Nut Island 128 MGD), Deer Island loading estimate was multiplied by 1.5 to get the loading from both treatment plants.

(2) As total Keldjhal nitrogen

Table 20. Revised loading estimates to Massachusetts Bay from the combined Deer Island and Nut Island discharge using the secondary treatment plant efficiency relative to primary treated effluents and 1995 primary effluent loading data. SEIS loading estimates and removal efficiencies are included for comparison.

Compound	SEIS loading estimates- primary effluent (EPA, 1988) (kg/yr)	1995 Loading estimate- primary effluent (kg/yr)	1995 Estimated removal efficiency between 1° and 2° (%)	1995 Loading estimate for full secondary treatment (kg/yr)	SEIS Loading estimates- secondary treatment (EPA, 1988) (kg/yr)	SEIS Removal efficiencies between 1° and 2° (%)
Total PAH	NA	8,893	95	458	NA	NA
Total PCB	527	25	65	9	41	92
Total LAB	NA	4,945	85	757	NA	NA
Total Chlordane	NA	3.1	91	0.3	NA	NA
Lindane	NA	7.9	46	4.2	NA	NA
Total DDTs	27	5.6	98	0.1	28	0
Ag	2,081	1,929	84	310	296	86
Cd	1,186	255	58	106	700	41
Cu	43,059	31,028	74	8,184	11,900	72
Cr	8,802	7,861	49	4,031	3,520	60
Hg	643	50	51	24	205	68
Mo	NA	6,782	20	5,424	NA	NA
Ni	11,135	3,079	17	2,557	8,910	20
Pb	6,219	5,758	81	1,074	4,951	20
Zn	86,125	37,415	62	14,053	34,500	60
Total N	12,000,000	10,003,050	10	8,953,711	12,000,000	0
Total P	NA	1,397,152	42	814,811	NA	NA
Silica	NA	5,071,221	34	3,360,119	NA	NA
DOC	NA	20,784,386	69	6,532,709	NA	NA
POC	NA	14,033,243	85	2,122,736	NA	NA

* Removal efficiencies for July metals data were not included because of the uncertainy of bottle identifications for that sampling.