Mussel Tissue Toxicity Monitoring Program

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Casco Bay Estuary Partnership

CASCO BAY NATIONAL ESTUARY PROJECT

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FINAL REPORT

(MUSSEL TISSUE SAMPLING)

CASCO BAY ESTUARY PROJECT'S MUSSEL TISSUE TOXICITY MONITORING PROGRAM

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Background & Project Description:
One of the five goals of the Casco Bay Estuary Project is to "reduce toxic pollution in Casco Bay." By testing for the presence of toxic contaminants in mussel tissue, lobster meat and tomalley (the green liver-pancreas) and sediment, the Project is monitoring progress towards this goal. The overall health of Casco Bay is being assessed by these and other indicators described in the Casco Bay Estuary Project Environmental Monitoring Plan.

The Casco Bay Watershed encompasses a 985 square mile drainage area located in southwestern Maine. It includes 41 towns and is drained by 12 river and lake systems.

Research done in the early 1980's on the sediments of Casco Bay indicated that high levels of toxic contaminants were accumulating, the result of historic and contemporary sources of point and nonpoint source pollution, including petroleum products, agriculture, and industrial sources that date as far back as the mid-1800. An analysis of the historic sources of contamination to the Bay documented that the Portland area waterfront of the past was even more heavily industrialized than it is today. PAHs from coal gas works and later PAHs and PCBs from electrical power production were released into the air via smokestacks and into the water directly and through runoff (Hawes, 1993).

Today there are 17 major and 24 minor licensed point source discharges in the Casco Bay watershed. These licensed discharges contribute a variety of pollutants, including PAHs, heavy metals, chlorine, bacteria, nitrogen and phospohorus. Air emissions in Maine are also licensed and are likely contributors of PAHs, dioxins, pesticides, heavy metals and nutrients. The City of Portland and the Portland International Airport are local emission sources. The East Coast of the United States and industrial sources in western Pennsylvania and Ohio are also potential sources of deposition onto the waters of Casco Bay (CBEP, 1996).

A detailed analysis of contaminants accumulated in marine sediments can help to suggest the sources of contaminants entering the marine environment. In 1991, the Casco Bay Estuary Project

funded a comprehensive inventory and statistical analysis of contaminants within the surficial coastal sediments of the Bay. In 1994, butyltins, dioxin/furans and coplanar PCBs were also tested in selected locations in the Bay. These evaluations were logical steps in the development of a Comprehensive Conservation and Management Plan for the preservation and protection of the resources of Casco Bay.

In 1991 undisturbed sediment samples were collected and analyzed for trace metals, aliphatic and polycyclic aromatic hydrocarbons, pesticides and PCBs. The location of the sampling stations was intended to include representative benthic communities, provide good areal coverage, and include sediments of varying ages and textures (Kennicutt, et. al., 1993). For the purpose of the study, the Bay was divided into five zones: Inner Bay (which includes the densely populated Portland area), the West Bay, the East Bay, Cape Small and the Outer Bay.

Aliphatic hydrocarbons and PAHs were detected at all sampling stations. The PAHs were predominantly highly condensed ring structures with few alkylations, indicating a pyrogenic or combustion source. Total concentrations of PAHs ranged from 16 to 20,778 ppb. Contaminants tended to decrease in concentration with distance from densely populated areas in the Inner Bay. Levels in the Inner Bay, which includes the Portland and Fore River area, were considered high on a national basis and comparable to other contaminated estuaries. PAHs measured in an earlier study were above the PAH concentrations considered toxic to marine benthic organisms (greater or equal to 35,000 ppb) (Doggett 1989 personal communication). There were also regionally elevated sites in East Bay and Cape Small. PCBs and pesticides were also present in highest concentrations in the Inner Bay. The levels of PCBs, at one station in the Inner Bay, were high enough to potentially elict toxic responses in benthic organisms. (Kennicutt et. al., 1992, 1993).

While the trace metal data demonstrated some geographic variability, generally the highest values were in the Inner Bay. The variability in the sediment data largely reflected variations in mineralogy and grain size. The elevated levels of Cd, Pb, Ag, Zn, and Hg found in Casco Bay are believed to be attributable to human activities. In some locations the concentrations of metals found would be considered high on a national basis. (Kennicutt et.al., 1993). See appendix A.

One or more anthropogenic contaminants were detected at all of the sampling locations. Principle components analysis was used to identify geographically consistent contaminant profiles and suggest the source of a variety of trace metals and hydrocarbons. The results indicated that the sediments in several of the Outer and East Bay sites exhibited a predominantly biogenic (natural) influence from detrital and autochthonous sources. Sites in the lower East Bay contained a greater component originating from pyrogenic sources (human combustion of fossil fuels). Inner Bay and shallow water sites near the City of Portland were characterized by inputs of weathered petroleum, probably resulting from chronic inputs from runoff and point sources. The contaminant composition of sediments from Cape Small, far from urbanized sources, was similar to that of the Inner Bay, possibly coming from the Kennebec River. Sites in the West Bay show a relative enrichment of C_{10}-C_{22} *n*-alkanes suggesting a localized source of contamination, perhaps fresh diesel fuel (Kennicutt, et al., 1993).

The widespread distribution of contaminants at elevated concentrations in the Bay, including in areas that are not located near any historical sources on waterborne point or nonpoint source pollution, suggests that atmospheric deposition may have played a significant role in the accumulation of metals and PAHs in the sediments. Point and non-point waterborne sources appear to control the characteristic regional contaminant profiles displayed by the sediments in the five sampling regions (Kennicutt, et al., 1993).

Mussel Sampling:

As a follow-up to sediment testing, the Casco Bay Estuary Project Environmental Monitoring Plan calls for testing for toxic contaminants in the native blue mussel (Mytilus edulis) at various locations around the Bay. Mussels are often used as the second level of screening after sediments to see if contaminants are being concentrated in biological tissues. Compared to sediments, mussel tissues reflect relatively recent increases or decreases in contamination of the surrounding environment. Mussels also have been widely tested for contaminants both in Maine and nationally. Results of testing by the Casco Bay Estuary Project will be compared to other data collected in Casco Bay, Maine and nationally.

While the primary goal of the mussel testing has been to assess the environmental quality of Casco Bay and to establish trends in bioavailability of contaminants, the sampling also has a human health component. While Atlantic coast blue mussels are harvested commericially for human consumption from Maine to Long Island, New York, Maine has historically ranked first in mussel harvested for human consumption. In Maine they are found in densely populated beds just above and below mean low water (MLW), but are restricted to the intertidal zone in many areas because of subtidal predation. In Maine, the best commercial mussel beds are found a few feet above and below MLW between Casco Bay and Jonesport. Casco Bay is one of the most productive areas for wild mussels, which are mostly used for seed, in Maine. While there is no estimate of the standing crop of mussels in Maine that reflects the condition of the resoruce at the present time, earlier surveys have estimated the size of the marketable resource at 320,000 bushels and 544,000 bushels (Maine Division of Marine Resources website – http://www.state.me.us/dmr/rm/bluemussel/html). These probably underestimate the resource. Because mussels are widely harvested in Casco Bay, the risk associated with human consumption is of great interest to the Casco Bay Estuary Project as well as to the Maine Department of Human Services, Bureau of Health.

The eight sites selected for testing by the Casco Bay Estuary Project in 1996 and 1998 (four sites in each year) were based on the results of the sediment contamination study and knowledge of local conditions. Back Cove in Portland was chosen because of the elevated levels of PAHs, lead, cadmium, mercury and silver in its sediments (there are nineteen Combined Sewer Overflows entering into Back Cove). The Harraseeket River in Freeport was chosen because of the huge increase in impervious surfaces in the watershed and heavy vehicle traffic in that area that tend to leak toxic chemicals. Quahog Bay in Harpswell was picked because its sediments had unexpectedly high levels of cadmium. Jewell Island was selected as a potential reference site because it is an uninhabited island in outer Casco Bay where toxic pollution is not expected to be a problem. Falmouth was chosen because of its close proximity to boating and boat yards. Middle Bay is thought to possibly have contamination from PAHs and other toxic chemicals from

the Naval airbase including a toxic plume also from the airbase that may hit the bay at some point. Fresh water macro invertebrates in a brook draining the airbase have been impacted and the brook does not meet water quality standards (305b, 1999). The Basin in the New Meadows River has no known source of toxics and was chosen as a potential reference site. The Wolfes Neck site was chosen because there is the Casco Bay Estuary Project air monitoring station next to the bay in that area and it would be useful to compare the information from the two programs.

The choice of sites also took into account the periodic testing of mussels by Gulfwatch, the environmental monitoring program of the Gulf of Maine Council on the Marine Environment. Their sites and scheduled sampling dates are Broad Cove off of Cumberland Foreside in 1998 and 2001, the Royal River estuary in 1996 and 1999, the Presumpscot River estuary in 1997 and 2000, and the Fore River estuary in 1997 and 2000. The Casco Bay Estuary Project has the Gulfwatch data, and other data collected by the Department of Environmental Protection. CBEP's intent was to target those areas that were not being covered by other studies as well as target some areas where there were known sources of contamination. Through the CBEP mussel sampling, every other year, the goal is to eventually monitor all of the areas in the bay.

Mussels were sampled and analyzed according to the Quality Assurance Project Plan developed by the Casco Bay Estuary Project. The QA Plan was based on methods used by the Maine Department of Environmental Protection's Marine Environmental Monitoring Program and Gulfwatch. University of Maine's Water Research Institute was responsible for the chemical analysis of mussel tissue.

Human Health Results From 1996 & 1998 Data:

Tables 1, 2 and 3 summarize the data on presence of the selected chemical contaminants in edible tissue from mussels collected at the eight sampling sites in Casco Bay. Inspection of these tables reveals the following:

- Levels of the element lead in composite samples collected in Back Cove were slightly above the action level for this neurotoxin.

- Levels of the pesticide dieldrin, a probable human carcinogen, were elevated at all sampling locations except Falmouth and Middle Bay. Levels of dieldrin in mussels collected from Wolfe Neck State Park and Harraseeket stations in Freeport were especially high and may warrant issuance of an advisory upon data confirmation.

- Levels of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs & PCDFs) reported as 2,3,7,8-TCDD Toxic Equivalents were above action levels for both carcinogenicity and non-carcinogenic effects at Wolfe Neck State Park in Freeport, New Meadows, Jewell, Back Cove and Harraseeket. However, the QA/QC surrogate recovery data for all 1996 data was low and highly variable.

- Total PCB levels were elevated in mussels collected from Back Cove and Quahog and less so for Falmouth as well, with the highest level detected approaching 3-times the action level for carcinogenicity. Interestingly, coplanar PCB (the most toxic PCB's) levels were all very low.

- The following PAHs were evaluated for toxicity. Benzo[a]pyrene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]antracene, and indeno[1,2,3-cd]pyrene were evaluated for carcinogenicity using a USEPA toxic equivalency approach relative to the potency of benzo[a]pyrene.[1] The compounds anthracene, fluoranthene, fluorene, and pyrene were evaluated for non-carcinogenic effects using available USEPA RfDs. Of the four compounds evaluated for potential non-carcinogenic effects, none approached levels of concern. With respect to carcinogenicity, toxic equivlent levels were generally no more than twice the action level indicating incremental cancer risks for chronic and frequent intake of mussels of less than 2-in-100,000. The QA/QC data for 1996 indicated relatively poor precision among replicates.

- Cooked mussels exhibited about a 3 to 5-fold increase in the concentration of lead (and other elements) in tissue when cooked. This increase was presumably due to loss of water and possibly lipid during cooking, based on about a 3-fold increase in percent solids for cooked versus uncooked tissue. In contrast, many of the organic pollutants (though notably not dieldrin) appeared to have significant reductions upon cooking. However, these cooking losses for organic compounds were highly variable and need to be confirmed.

Discussion: By far the most noteworthy observation from a public health perspective was the elevated levels of the banned pesticide dieldrin at a number of the sampling locations. Dieldrin is an organochlorine pesticide that was phased out in 1974 except for termite control.[1] In 1985 importation of dieldrin ceased and in 1987 its registration was cancelled. Dieldrin was mainly used on soil dwelling pest and for termite control and reaches the aquatic environment through runoff from both agricultural fields and urban areas. Dieldrin, like DDT, remains in the environment and is extremely persistent. Dieldrin is also a product of aldrin metabolism, a structurally similar pesticide which is also no longer used.[1] Dieldrin is considered a probable human carcinogen by the USEPA. Dieldrin levels were especially high for mussels collected at Harraseeket and Wolfe Neck State Park, where chronic intake of mussels at a rate of one meal per week is estimated to pose a incremental cancer risk of 1-in-10,000. These data are quite different from the monitoring results that have been obtained for mussels sampled as part of the Gulf of Maine Gulfwatch montoring program. GulfWatch has reported dieldrin levels ranging from <2 to 5 ppb on a dry weight basis.[1,2] In contrast, levels detected in mussels collected from Freeport stations were 95 and 155 ppb on a dry weight basis. The other Casco Bay sampling locations had dieldrin levels of 20 to 40 ppb on a dry weight basis (with the exception of Falmouth which had levels less than 5 ppb). As these results are in apparent contrast to those obtained from GulfWatch, an effort will be made to confirm these results as soon as it is possible. As the QA/QC results on precision and accuracy look fairly good for dieldrin, confirmation will involve resampling and analysis.

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[1] Evaluation of GulfWatch – 1996: Sixth Year of the Gulf of Maine Environmental Monitoring Plan. The Gulf of Maine Council on the Marine Environment, December (1997), by Chase M, Jones S, Hennigar P, Sowles J, Coombs K, Crawford R, Harding G, Pederson J, Taylor D.
[2] Evaluation of GulfWatch – 1995: Fifth Year of the Gulf of Maine Environmental Monitoring Plan. The Gulf of Maine Council on the Marine Environment, December (1996), by Chase M, Coombs K, Crawford R, Harding G, Hennigar P, Jones S, Pederson J, Robinson W, Sowles J, Taylor D.

The exceedance of the action level for the neurotoxin lead in the samples from Back Cove is noteworthy, though less surprising. The primary concern is with consumption by young children. BOH analyses indicate that regular consumption (a meal per week) of mussels by young children (ages less than 6 years) could result in a significant chance (>5%) that blood lead would exceed levels of concern (10 μg/dL). Children are more sensitive/vulnerable to the toxic effects of lead because of their actively developing nervous systems and their increased potential for exposure to other lead sources due to hand-to-mouth activity (e.g. lead paint). Importantly, with lead exposure, there is concern about effects on children exposed over a relatively short period of time as compared to the lifetime exposure typically assumed for carcinogenic effects. Comparison of data from Back Cove with results obtained by GulfWatch indicates that the average lead concentrations in mussels collected from Back Cove are atypical. Average lead levels on a dry weight basis for Back Cove versus GulfWatch was 10 ppb versus 2 ppb, respectively. NOAA has used a lead level in excess of 4.5 ppb on a dry weight basis as atypical in their Mussel Watch survey for trends.[3] At present Back Cove is closed for haarvesting shellfish.

It is not immediately apparent whether the apparent increase in the concentration of lead in mussels when cooked is of concern. The relevance of this observation to public health depends on whether this increase in *concentration* also results in an increase in *mass* of ingested lead. An increase in mass of ingested lead would only occur if the assumed consumption rate for mussels was based on an intake rate of cooked meat, as data on chemical content is typically uncooked tissue (hence, a inconsistency). Because of the way the action level for lead was derived (via use of EPA's integrated exposure uptake biokinetic "IEUBK" model for lead described below), it will take some investigation into the details of the IEUBK model to determine the underlying data and assumptions used in modeling dietary intake of meat (including fish and shellfish).

In contrast, the cooking loss seen for some of the organic pollutants is more directly relevant as these losses will represent a reduction in the mass of ingested chemicals. However, while some chemicals exhibited substantial losses (50 to 80%), others exhibited either minimal loss or an apparent increase. There is published literature reporting cooking losses for organic pollutants, as well as apparent increases for metals. So the general findings here are consistent with the literature. Indeed, a number of state health agencies assume a default 50% loss of organic chemicals from fish and shellfish tissue due to cooking.[4] We are just beginning to review these data and assess whether to use a default cooking loss. Additional data on apparent cooking losses and gains would be helpful.

The elevated levels of PCDDs & PCDFs in mussels are of concern as the action level for reproductive & developmental toxicity of 1.8 parts per trillion (ppt) was exceeded (though never by 2-fold) at Wolfe Neck State Park, Jewell Island's Punchbowl, Back Cove and Harraseeket stations. Levels at New Meadows site (the Basin) in Phippsburg were fairly close to the action level. Mussels collected at these five stations also exceeded the cancer action level of 1.5 parts

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[3] O'Connor., T.P. and B. Beliaeff. 1995. Recent Trends in Coastal Environmental Quality : Results from the Mussel Watch Project. National Status and Trends Program. NOAA. Silver Spring, MD.
[4] 1999 American Fisheries Society Forum on Contaminants in Fish,, October 18-20, 1999, Discussion group materials prepared by EVS Environment Consultants, Inc., American Fisheries Society, Bethesda, MD.

per trillion (ppt). These results are noteworthy in several ways beyond the public health significance. First, the concentrations are considerably higher than levels reported in mussel monitoring associated with GulfWatch.[2] Second, on average 60 to 70 percent of the 2,3,7,8-TCDD toxic equivalents are contributed by the PCDD congener 1,2,3,7,8-pentachlorinated dibenzo-p-dioxin. This observation is in contrast to what we typically see in fish collected downstream from pulp and paper mills, where toxic equivalents tend to be dominated by the 2,3,7,8-tetrachlorinated dibenzo-p-dioxin and furan isomers. It is also in contrast to mussels collected in the vicinity of the Kennebec River and Penobscot River, where 2,3,7,8-TCDF and OCDD were the only isomers detected.[2] This may indicate an alternative source of PCDDs and PCDFs is affecting these waters. For example, there are some data indicating that municipal waste incinerators have a tendency to emit pentachlorinated CDDs and CDFs.[5] The municipal waste incinerator in Harpswell was closed down by DEP in 199?. That incinerator is relatively close to the New Meadow site. Freeport and Jewell Island sites are further away but possibly within deposition range.

Total PCB levels in mussels were above the action level at Falmouth, New Meadows, Back Cove and Quahog sampling stations, with the latter two clearly the highest. The primary concern is with an increase risk of cancer from in the 1 to 3 per 100,000 range assuming chronic and routine consumption. The PCB levels look generally consistent with those obtained by GulfWatch for several Maine stations, with two exceptions. First, levels at Back Cove and Quahog were clearly higher by comparison. Second, the PCB congener 2,2',4,6,6'-Pentachlorobiphenyl (IUPAC# 104) was an important contributor to total PCB levels in Casco Bay mussels but was not for any of the Maine GulfWatch stations. Prior PCB sampling of sediments (Doggett 1989) show that there is great variability within replicates, possibly indicating sources that DEP is not aware of. The source at Back Cove is from an old landfill where the sewage treatment plant for Portland is located.

Evaluation of the data on polycyclic aromatic hydrocarbons (PAHs) was complicated by two factors. First, the 1996 data show relatively poor precision among duplicates. This may in part explain the considerable variability among sample replicates for a given location. Second, some the PAHs coelute preventing unique quantification. This is especially a problem for dibenz[a,h]anthracene (D[a,h]A) and indeno[1,2,3-cd]pyrene (I[1,2,3-cd]P) where the former has a toxic equivalency factor of 1.11 and the latter is 0.055, a 20-fold difference. It was therefore necessary to make an assumption about the relative fractions of these two compounds. A 50% split was assumed. A worst case assumption (i.e., assume all present as the more toxic PAH) would only increase the toxic equivalents by 20 to 30 percent. As the action level was never exceeded by a factor of more than 3, incremental lifetime cancer risk from an assumed intake of mussels from these sites at a rate of 1 meal per week for 70 years is estimated to not exceed 3-in-a-100,000. The levels of PAHs detected on a dry weight basis are somewhat similar to levels reported by GulfWatch for mussels obtained from their Clark Cove and Fort Point sampling locations. However, Casco Bay stations tended to have higher levels of the more carcinogenic potent B[a]P and combined D[a,h]A & I[1,2,3-cd]P PAHs along with others.

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[5] Estimating Exposure to Dioxin-Like Compounds, Volume III: Site-Specific Assessment Procedures, U.S. Environmental Protection Agency, Office of Research and Development, June 1994, Review Draft, EPA/600/6-88/005Cc (see pp 3-7 to 3-9, and Figure 3-1).

A few comments are in order for arsenic. Mussels collected from Falmouth and Jewell had arsenic levels about two-times the action level of 0.7 ppm. However, as discussed more fully below, interpretation of arsenic levels in seafood is confounded by uncertainty about the fraction of arsenic present as the toxic inorganic form. Most of the arsenic present in seafood occurs as a relatively non-toxic organic form called arsenobetaine. Data on the fraction of arsenic in mussels present in the inorganic form ranges from 0.5% to 10%, and these data are limited. It has been an assumed 5% in deriving the action level. Based on the available data, it is likely that the percent inorganic arsenic is less than 5%, perhaps closer to 1 or 2%. Arsenic levels seen in the mussels collected from Casco Bay are in general agreement with levels reported by NOAA for Mussel Watch. At present, Maine DEP has set aside funds for a speciation of arsenic experiment to address these health concerns.

Need for shellfish consumption advisories: Based on current data, if the Bureau of Health was to issue a shellfish consumption advisory for Casco Bay, it would likely be a warning to limit intake of mussels from these waters to no more than 1 meal per week or 1 meal every other week. The advisory would be largely driven by the cancer risk posed by dieldrin (representing 50 to 70% of the total cancer risk for 5 of the 8 sampling locations). Dioxins contribute between 7 and 20% of the aggregate risk. PCBs contribute 5 to 47% of the aggregate risk. PAHs contribute 9 to 38% (See Table 4). There is not data to assess the frequency with which mussels are recreationally harvested in Casco Bay and consumed, or the extent to which these areas tend to routinely closed due to bacterial contamination and red tide. Such information would be useful in determining the need for issuing any advisories. The regional biologist from DMR has indicated that there is little direct consumption of mussels from Casco Bay. They are generally harvested as seed mussels for the aquaculture industry.

Cost and Effectiveness:

The project has been successful as a source of scientific information and is also cost effective. As CBEP's DEP technical advisor, Lee Doggett, has said, "the project has been worthwhile to do at this level even though we would love to do it annually and at more sites." We have been and will continue to use NOAA's status and trends data to compare our findings nationally, and to use Maine DEP and Gulfwatch data to compare our findings statewide. Samples from just eight stations in the bay have already provided us with some interesting findings that we can use in our efforts to reduce toxics. We are also putting the information on the DEP web site which will reach a broad audience in an easily accessible format.

Improvements to Approach, Lessons Learned, and Where Do We Go From Here:

-If we had more money it would be more effective to monitor at additional sites and all sites every year. That would give us a more comprehensive look at the Bay.

-We should follow the model of the GulfWatch program in regards to frequency of testing. (We do, however, follow the same protocol as the GulfWatch program for parameters being tested and laboratory QAPPs).

-We should begin sending our data to NOAA for their comprehensive reports.

-"Cheaper lab service doesn't always pay!" It is advisable to scrutinize the detection limits, surrogate recovery data, and consistency among replicates the lab is using and the QA of the labs. We ran into problems with one lab when they were running the butyltins and had to make adjustments. (UME in 1996 appears to be a problem).

-Use the services of your regional EPA QA staff to help with identifying satisfactory labs and review questionable results.

-Be careful in how you present your data on toxics to the public. Make sure you are clear about what your objectives are. Do they address human health issues or are they related to the ecological health of the bay? You have to be very careful not to alarm the public unnecessarily with ecological health issues. A good idea is to poll a selected group of people with options on how to display the data, i.e. a Casco Bay group selected symbols on a map as an effective approach as opposed to showing the data in a graphic format. EPA can help with ways to present the data to the public. They have regional training sessions on this topic. Contact your regional EPA office for information.

-It is important to look at cooked vs. raw samples for testing. This will be helpful when considering the human health affects of the toxics.

-There is a strong need to confirm dieldrin findings. This organochlorine pesticide is a major determinant of aggregate cancer risk. Concentrations in mussels collected in Casco Bay are considerably greater than levels in mussels collected in other Maine locations as part of the GulfWatch program.

-Information on the extent of recreational harvesting of mussels in Casco Bay would be helpful in evaluating the need to issue an advisory and will be followed up on.

-Data to confirm an apparent significant (though variable) cooking loss of organic pollutants from mussel tissue would also be helpful in assessing the need for advisories. The apparent increase in metal concentration is also of interest, though relevance has yet to be clearly established. This issue will be followed up on.

-The PCDD and PCDF results suggest a possible connection with municipal solid waste incineration. Studies to investigate this hypothesis appear warranted. Also, further testing is warented since a municipal incinerator in the area of most of the high levels has recently been removed.

-Data on fraction of arsenic present as the inorganic form in shellfish would be helpful in improving interpretation of such data. State DEP funds have been set aside to deal with this.

-The analytical data (primarily the 1996 data) need to be more carefully reviewed with respect to target data quality objectives. We have noted that some data appear to have relatively poor

surrogate percent recovery and high percent differences among duplicates. Ideally, data quality objectives should be clearly defined at the outset and data either rejected if objectives are not met, or subject to strong caveats. Such reviews should occur in the laboratory *prior* to data being submitted to the Casco Bay Estuary Project or the Bureau of Health for health evaluation. It does not appear that this was done.

-There is a problem with toxics in species that are caught by a certain population as a main source of food, i.e. some of the areas in Portland where immigrant populations are subsistence fishing, then advisories should be posted in that population's primary language.

-On December 2nd the Casco Bay Estuary Project is holding a State of the Bay Conference where we will present this information. At that time a further analysis of the 1998 data will have been made. Maps similar to the 1996 maps shown in appendix B will be made with the 1998 data and comparisons will be made.

-State standards to define elevated samples need to be developed for organic chemicals.

Sources:

Casco Bay Estuary Project, Casco Bay Plan,, 1996.

Doggett, L.F. 1989 Personal Communication.

Hawes, E.D., Historic Sources of Pollution in Portland Harbor: Including the Fore River, the Back Cove and South Portland Watersheds, Casco Bay Estuary Project, December 1993.

Kennicutt, M.C., II, Wade, T.L., Presley, B.J., Requejo, A.G., Brooks, J.M., Denoux, G.J., Sweet, S., McDonald, T.J., Martin, D., and Paul, D., *Assessment of Sediment Contamination in Casco Bay: Interpretive Report and Appendix A*, Geochemical and Environmental Research Group and the Department of Oceanography, Texas A&M University, 1992, Technical Report #92-157, 113 pages plus Appendix.

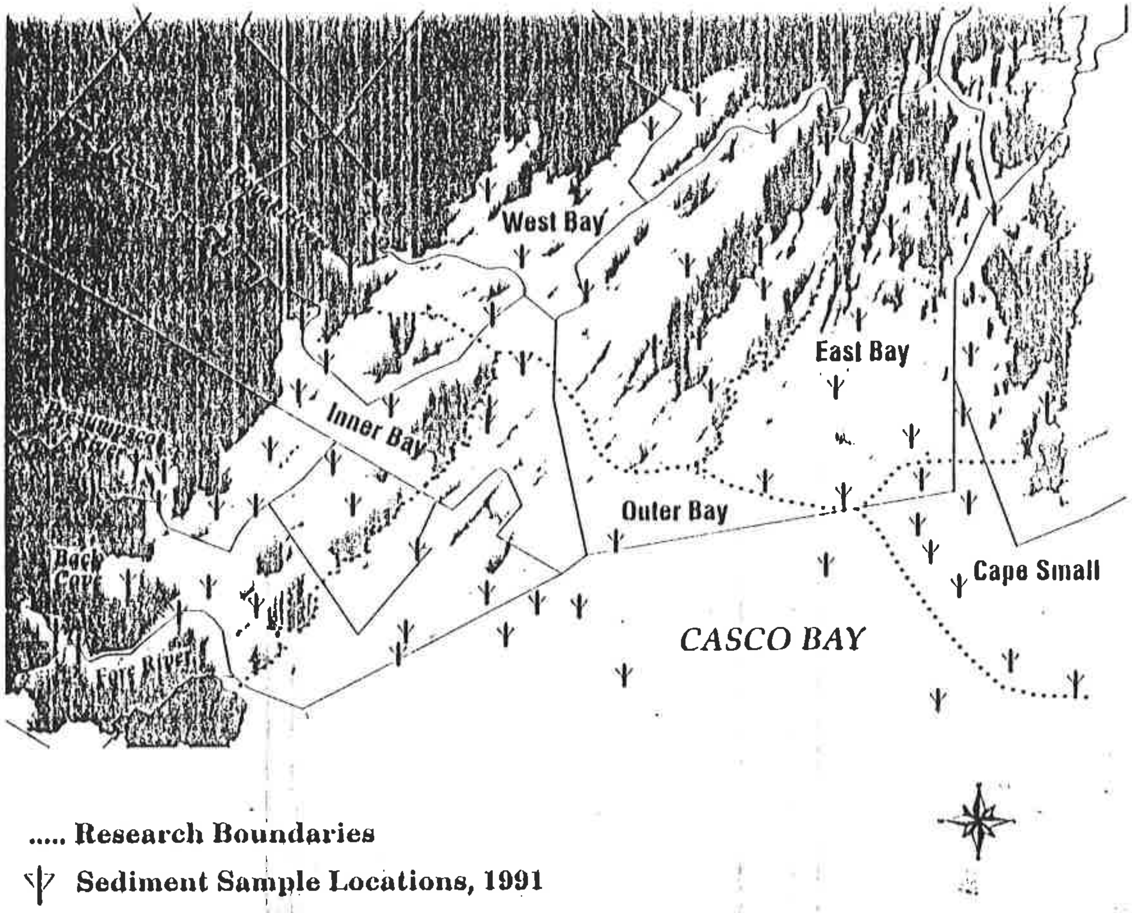
Kennicutt, M.C., II, Wade, T.L., Presley, B.J., Requejo, A.G., Brooks, J.M., and Denoux, G.J., "Sediment Contaminants in Casco Bay, Maine: Inventories, Sources, and Potential for Biological Impact," *Environmental Science and Technology,* 1993, *28*, 1-15

Appendix A

Sediment Sample Locations

Figure 5-1

Sediment Sample Locations, 1991



Sources: Casco Bay Estuary Project and Texas A&M University

Appendix B

1996 Mussel Data

Displayed in Graphic Forms

Mercury in Casco Bay Mussel Tissue

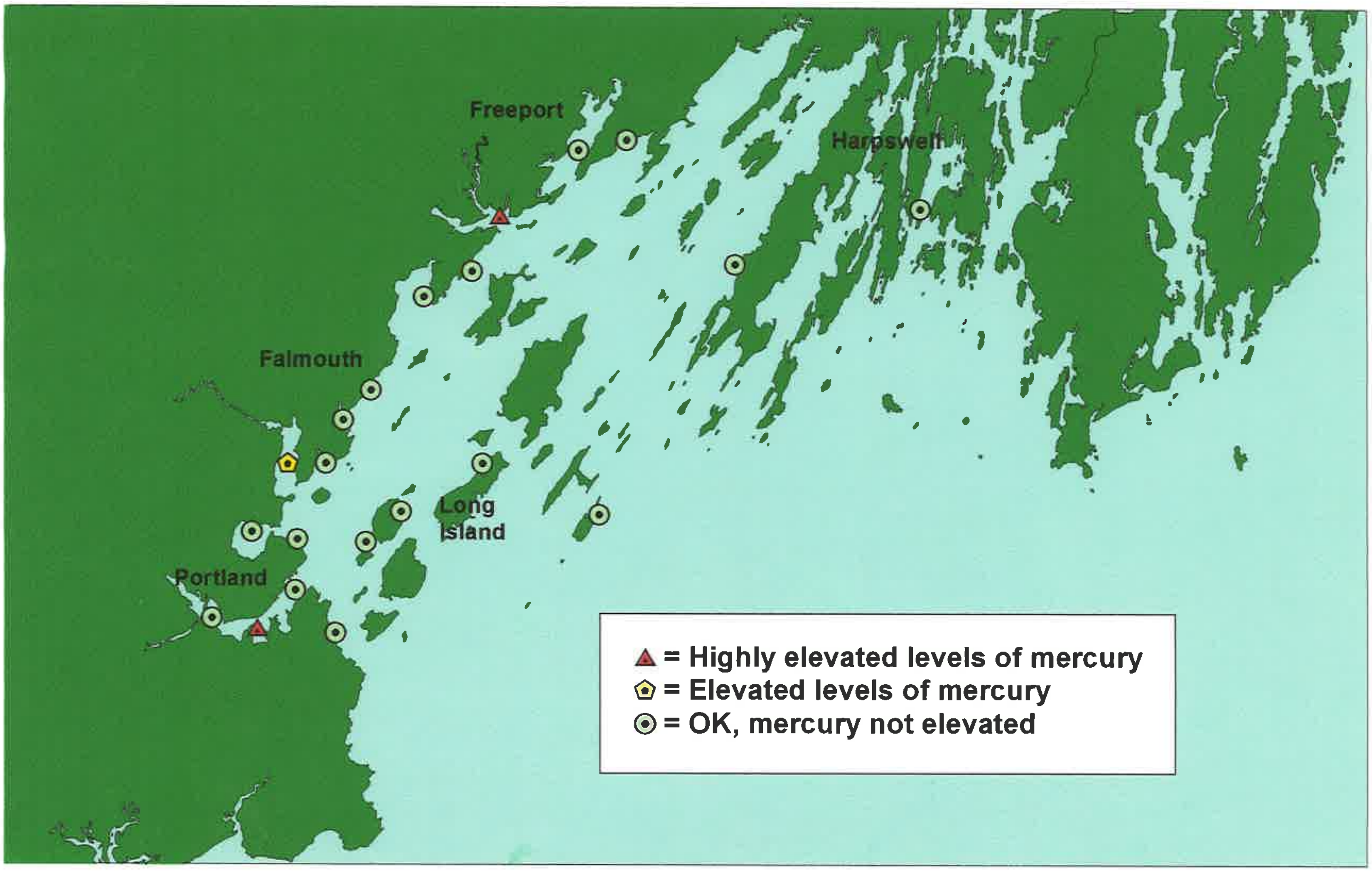
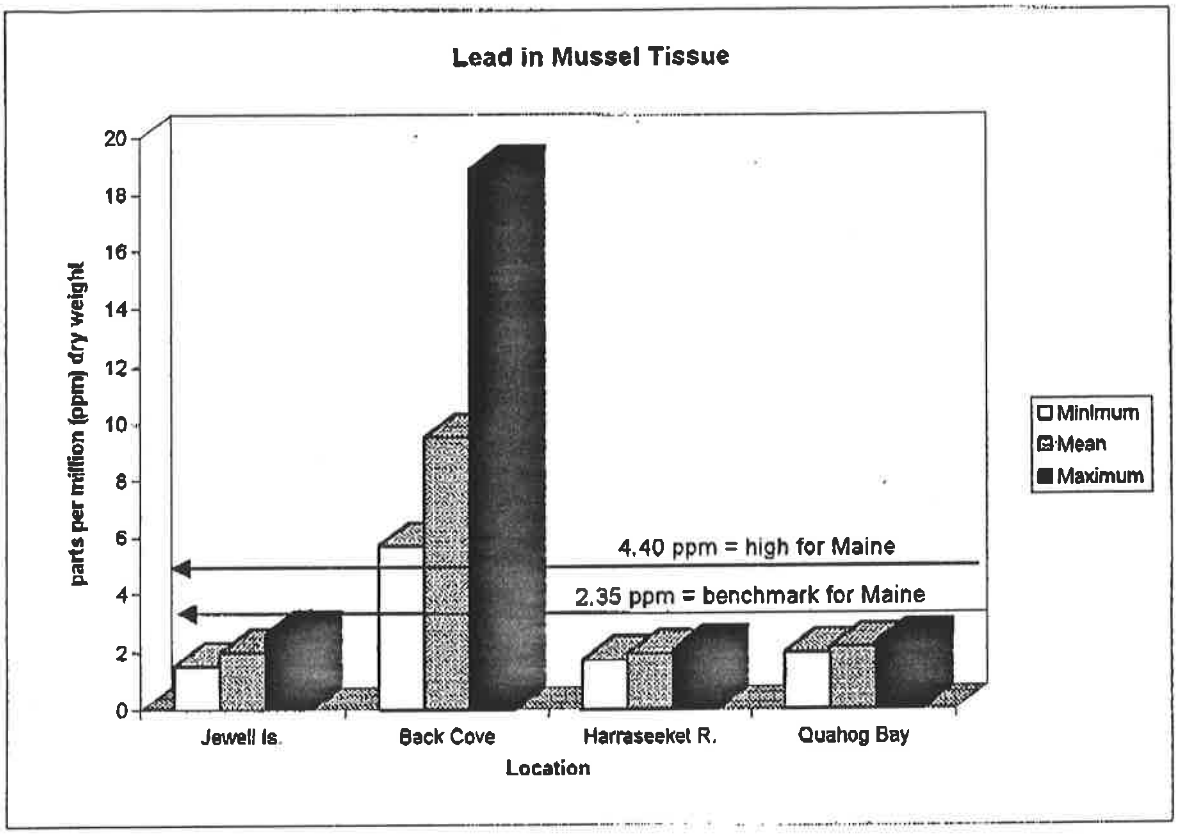


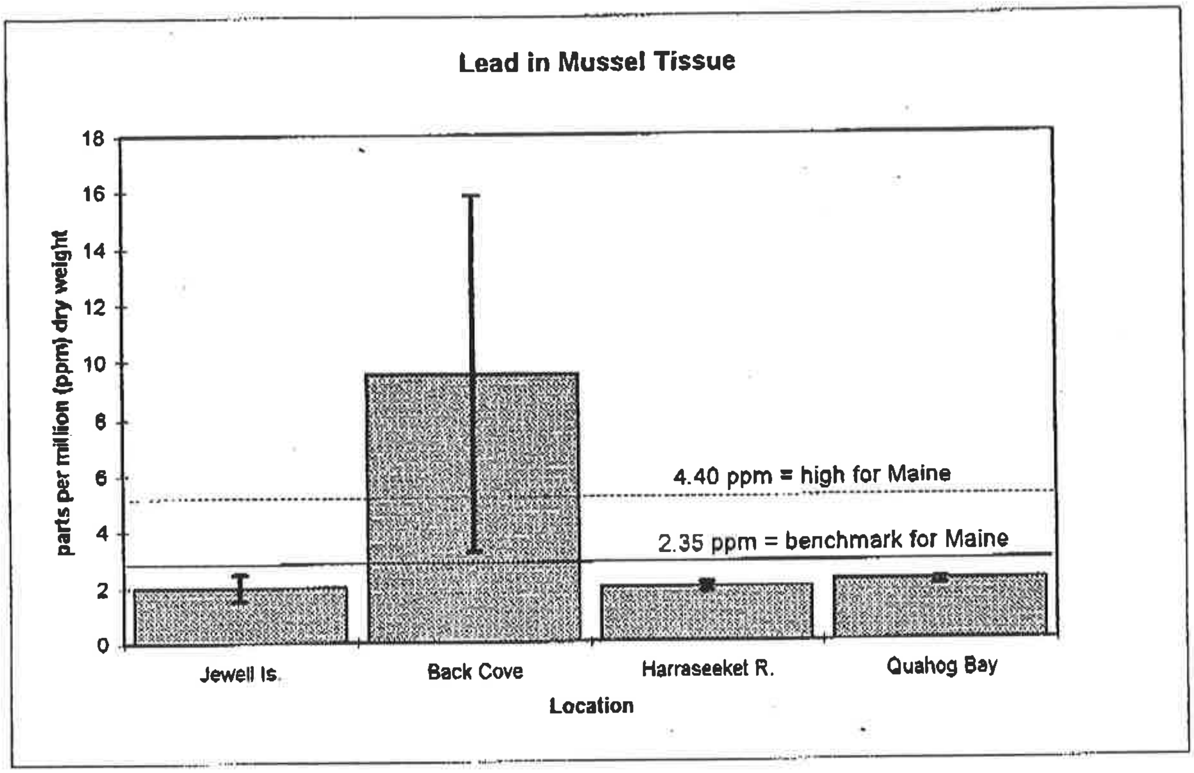
Table 5B - Trace Metal Data for Casco Bay Mussel
Tissue Samples
(mg/Kg dry weight)

Sample ID	Ag	Al	As	Cd	Se	Zn	Fe	Pb	Ni	Cr	Cu	Hg	% solids
Jewell-1	0.083	59.6	17.18	0.347	0.972	103.74	345.8	1.53	7.78	1.63	12.6	0.1681	7.2
Jewell-2	0.069	88.2	16.78	0.444	1.097222	117.88	408.1	2.64	2.60	1.65	17.5	0.1722	7.2
Jewell-3	0.086	64.3	17.41	0.486	0.985714	93.57	413.4	1.86	3.84	3.00	11.3	0.1671	7
Jewell-4	0.069	67.5	17.29	0.986	1.166667	91.11	373.8	1.94	6.31	1.44	12.7	0.1639	7.2
Back Cove-1	0.082	447.3	6.96	0.726	1.150685	133.96	561.8	7.40	14.62	2.08	46.0	0.2904	7.3
Back Cove-2	0.141	758.6	8.66	2.844	1.53125	133.16	921.9	18.91	3.92	4.47	21.9	0.3734	6.4
Back Cove-3	0.079	342.1	8.00	0.937	1.126984	86.14	481.4	5.71	6.41	1.95	18.1	0.2984	6.3
Back Cove-4	0.078	425.0	8.22	0.766	1.09375	102.11	498.1	6.09	5.19	2.28	22.4	0.3078	6.4
Back Cove Cooked-1	0.072	630.8	10.77	1.533	1.015385	175.40	885.7	15.74	2.37	3.19	10.8	0.4872	19.5
Back Cove Cooked-2	0.085	890.5	11.31	1.433	0.781095	140.75	828.0	14.78	1.69	2.66	10.1	0.4403	20.1
Back Cove Cooked-3	0.062	907.2	11.58	1.479	0.958763	156.01	838.8	17.16	1.75	3.25	10.5	0.4985	19.4
Back Cove Cooked-4	0.062	463.9	6.74	1.356	4.159794	138.39	816.2	14.33	1.60	2.05	10.7	0.4629	19.4
Quahog-1	0.019	174.6	5.47	1.155	0.825243	111.49	235.5	2.33	1.09	1.32	11.3	0.0913	10.3
Quahog-2	0.039	147.2	4.16	0.976	0.677165	108.57	209.3	2.28	.71	1.24	12.1	0.0843	12.7
Quahog-3	0.021	152.8	5.60	1.103	0.773196	113.42	206.2	2.06	.67	.96	10.8	0.0990	9.7
Quahog-4	0.038	169.8	4.55	1.057	0.754717	91.93	214.5	1.98	.99	1.05	12.1	0.1075	10.6
Harraseeket-1	0.028	896.3	5.23	0.493	0.985915	87.56	1072.5	1.97	2.87	2.51	14.9	0.1254	7.1
Harraseeket-2	0.014	624.6	5.96	0.565	0.898551	77.03	853.6	2.03	2.06	2.25	16.2	0.1319	6.9
Harraseeket-3	0.014	673.0	5.27	0.514	0.885714	78.40	805.7	1.71	2.13	3.04	27.0	0.1300	7
Harraseeket-4	0.004	466.7	6.78	1.389	0.916667	72.17	649.4	2.08	1.58	2.33	16.1	0.0139	7.2

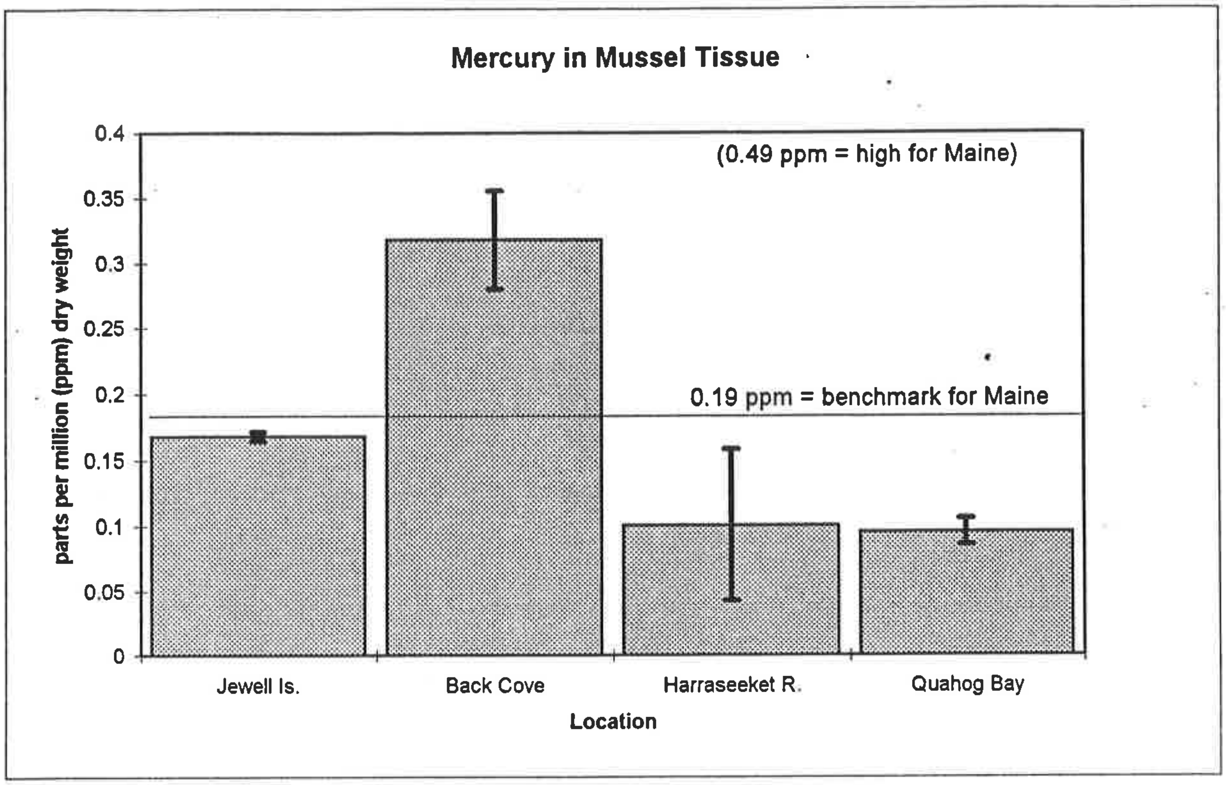
Table 1A - Dioxins/Furans
(ng/Kg wet wt)

DEP ID	DL	Jewell 1	Jewell 2	Jewell 3	Jewell 4	Back Cove 1	Back Cove 2	Back Cove 3	Back Cove 4	Blank
Analytes										
2378-tcdf	0.1	ND	0.67	0.40	ND	0.34	0.31	0.60	0.41	ND
12378-pecdf	0.5	0.25	ND	0.38	ND	ND	ND	ND	ND	ND
23478-pecdf	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123478-hxcdf	0.5	ND	ND	ND	ND	ND	0.14	ND	ND	ND
123678-hxcdf	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
234678-hxcdf	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123789-hxcdf	0.5	0.38	ND	ND	0.45	ND	ND	ND	ND	ND
1234678-hpcdf	0.5	1.02	ND	0.56	ND	0.51	0.41	ND	0.31	ND
1234789-hpcdf	0.5	ND	0.40	0.32	0.61	ND	ND	ND	ND	ND
ocdf	1	0.34	ND	0.78	0.63	ND	ND	ND	ND	ND
2378-tcdd	0.1	0.52	ND	ND	0.35	0.26	0.16	ND	0.14	ND
12378-pecdd	0.5	2.57	0.26	1.21	0.55	1.41	0.20	1.19	0.93	ND
123478-hxcdd	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123678-hxcdd	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123789-hxcdd	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
1234678-hpcdd	0.5	1.14	4.02	3.25	1.65	2.58	ND	2.95	1.84	ND
ocdd	1	1.37	0.94	1.15	0.84	1.16	4.03	2.93	2.70	ND
Surrogates										
13C-2378-tcdf		65.1	31.0	51.0	49.0	56.8	74.3	50.8	60.6	65.3
13c-12378-pecdf		64.2	36.3	53.5	51.3	60.0	79.5	55.1	64.9	83.1
13c-23478-pecdf		73.1	37.6	57.4	56.0	61.5	73.8	63.0	66.1	88.5
13c-123478-hxcdf		86.6	50.5	67.8	68.3	66.4	62.2	58.9	62.5	91.1
13c-123678-hxcdf		60.7	26.7	45.6	44.3	49.3	60.7	36.9	49.0	55.9
13c-234678-hxcdf		68.2	31.9	52.9	51.0	58.7	76.0	48.3	61.0	64.9
13c-123789-hxcdf		65.5	45.3	55.4	55.4	55.3	55.2	46.3	52.3	80.9
13c-1234678-hpcdf		63.7	25.7	45.7	45.0	47.6	53.3	45.8	48.9	50.1
13c-1234789-hpcdf		58.7	27.0	44.2	43.3	46.9	54.9	42.0	47.9	55.1
13C-2378-tcdd		51.1	30.1	42.1	41.1	45.0	53.9	34.9	44.6	58.5
13C-12378-pecdd		77.7	50.1	66.2	64.7	70.8	84.5	68.6	74.6	102.5
13C-123478-hxcdd		79.8	41.5	64.1	61.8	71.1	92.1	60.7	74.6	73.9
13C-123678-hxcdd		53.1	33.6	42.0	42.9	39.2	30.8	35.5	35.1	41.5
13C-123789-hxcdd		50.1	25.3	37.8	37.7	38.1	39.0	40.1	39.1	55.2
13C-1234678-hpcdd		79.6	34.7	60.2	58.2	66.2	84.4	58.0	69.5	87.0
13C-ocdd										
Totals										
Total tetra furans		ND	0.67	ND	ND	1.4	1.41	6.33	3.0	
Total tetra dioxins		0.51	ND	ND	0.35	ND	ND	ND	ND	
Total penta furans		1.85	ND	ND	ND	ND	1.61	2.58	ND	
Total penta dioxins		14.7	0.26	1.21	0.55	ND	ND	ND	ND	
Total hexa furans		1.56	ND	ND	0.45	ND	ND	ND	ND	
Total hexa dioxins		ND	ND	ND	ND	ND	ND	ND	ND	
Total hepta furans		1.02	0.4	1.32	0.61	ND	0.5	0.73	0.6	
Total hepta dioxins		1.14	4.02	3.25	1.65	4.0	ND	16.2	10.1	
Total octa furans		ND	ND	0.78	0.63	ND	ND	ND	ND	
Total octa dioxins		1.37	0.094	1.15	0.84	3.7	4.02	2.92	3.5	
sample weight (g)	50	48.8	49.66	47.51	47.39	49.573	53.635	50.79	47.121	50
% lipid		0.93	1.64	1.25	1.07	0.85	0.76	0.45	0.58	

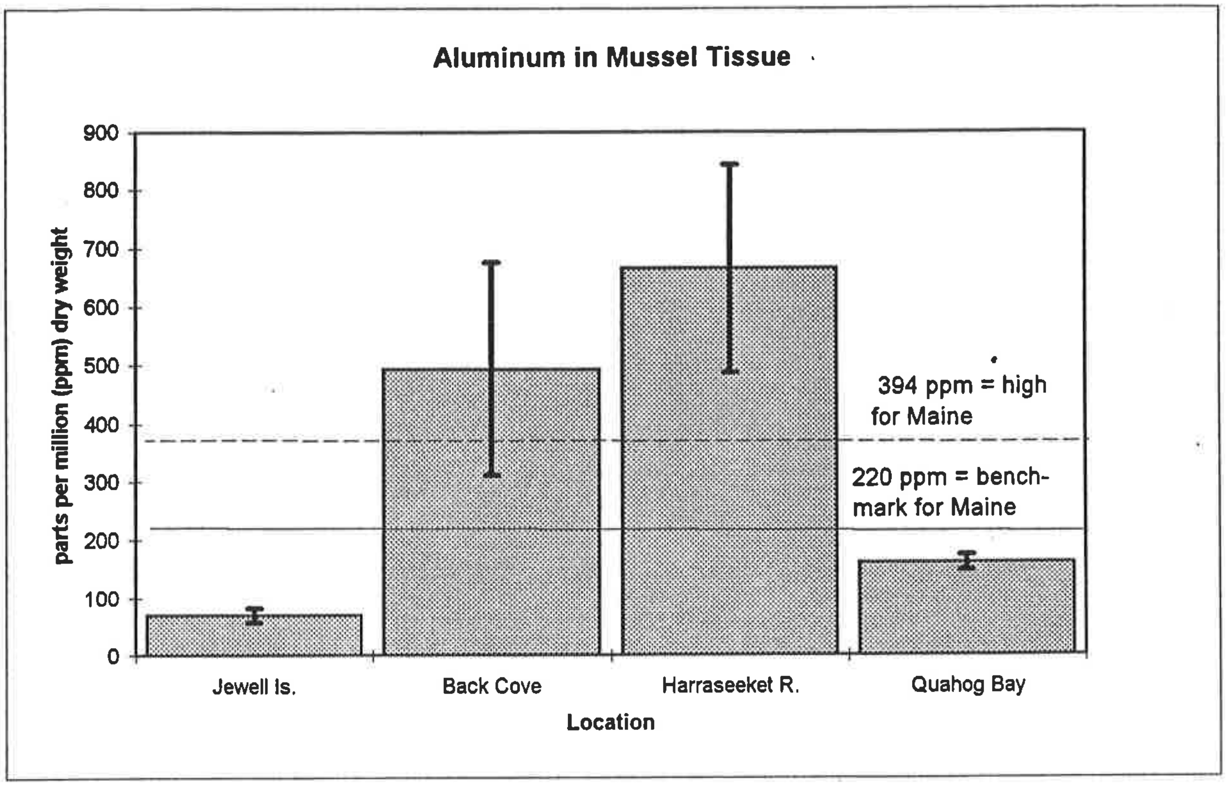

Lead in Mussel Tissue
20
18
16
14
12
10
8
6
4
2
0
parts per million (ppm) dry weight
4.40 ppm = high for Maine
2.35 ppm = benchmark for Maine
Minimum
Mean
Maximum
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



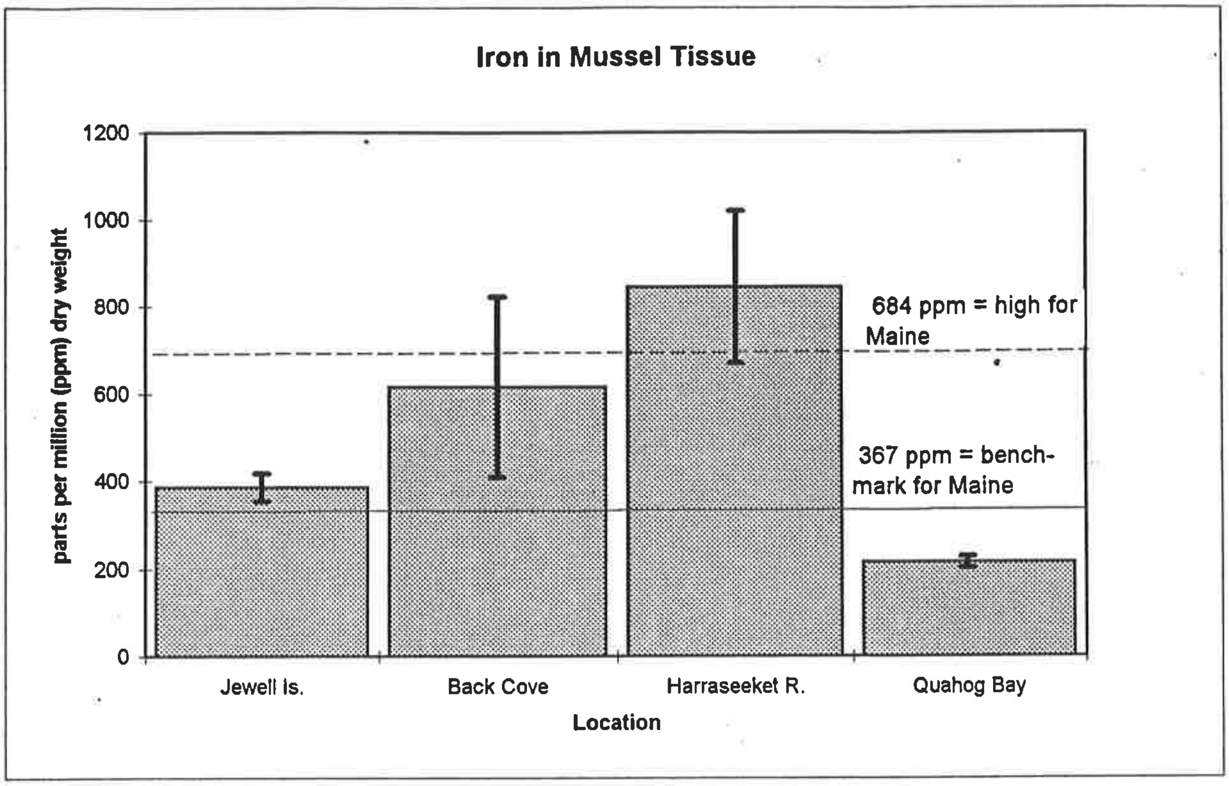
Lead in Mussel Tissue
parts per million (ppm) dry weight
18
16
14
12
10
8
6
4
2
0
4.40 ppm = high for Maine
2.35 ppm = benchmark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

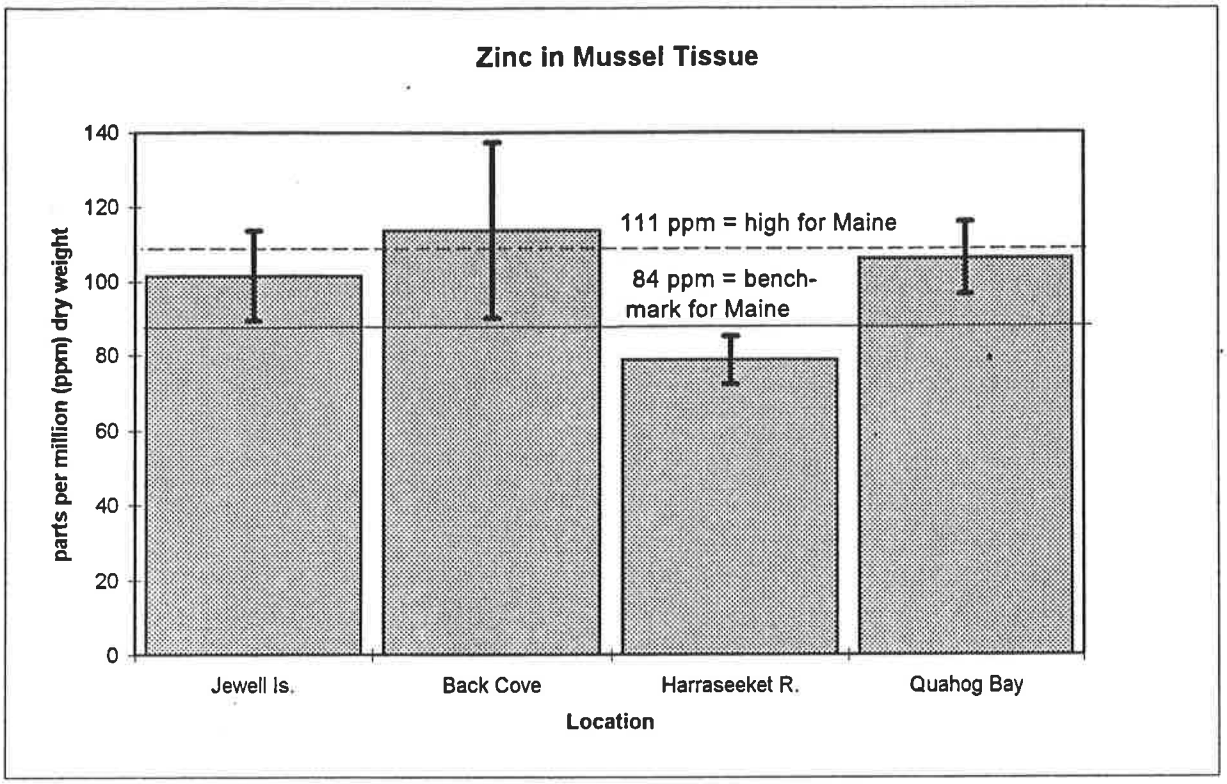


Mercury in Mussel Tissue
(0.49 ppm = high for Maine)
0.19 ppm = benchmark for Maine
parts per million (ppm) dry weight
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

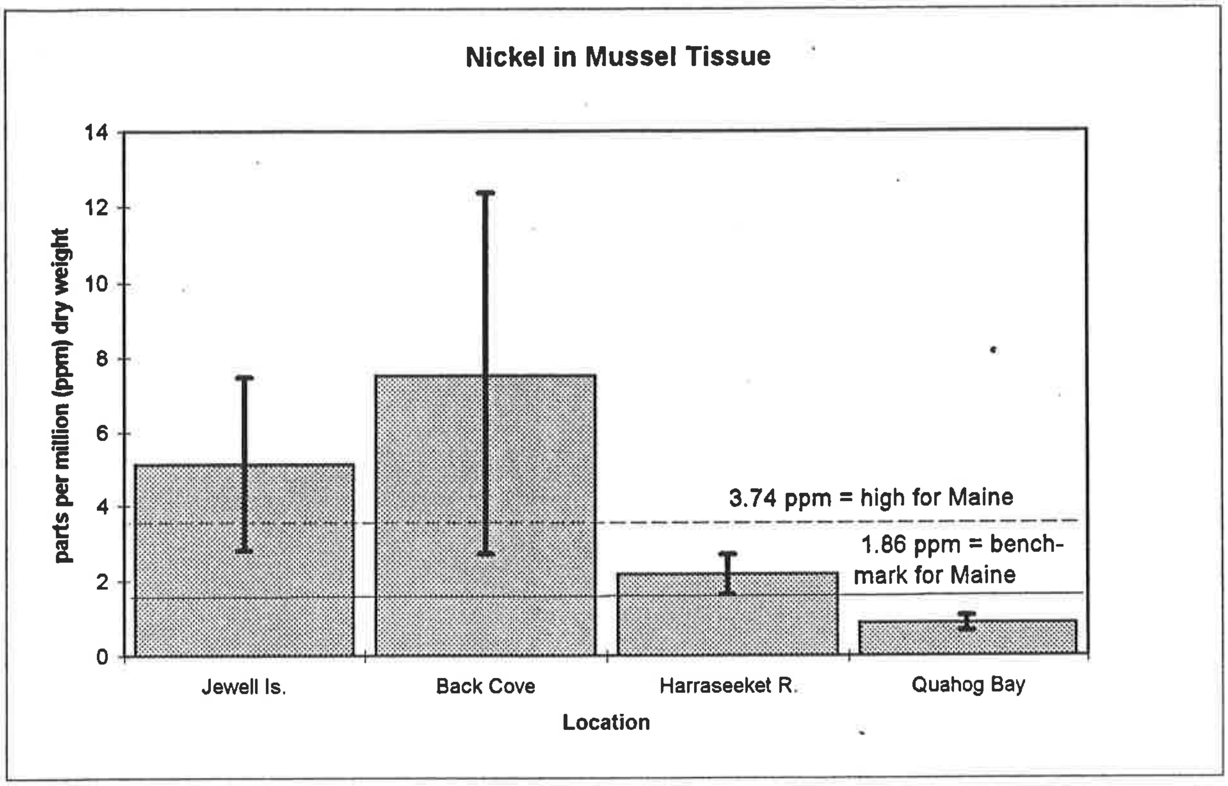


Aluminum in Mussel Tissue
900
800
700
600
500
400
300
200
100
0
parts per million (ppm) dry weight
394 ppm = high for Maine
220 ppm = bench-mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

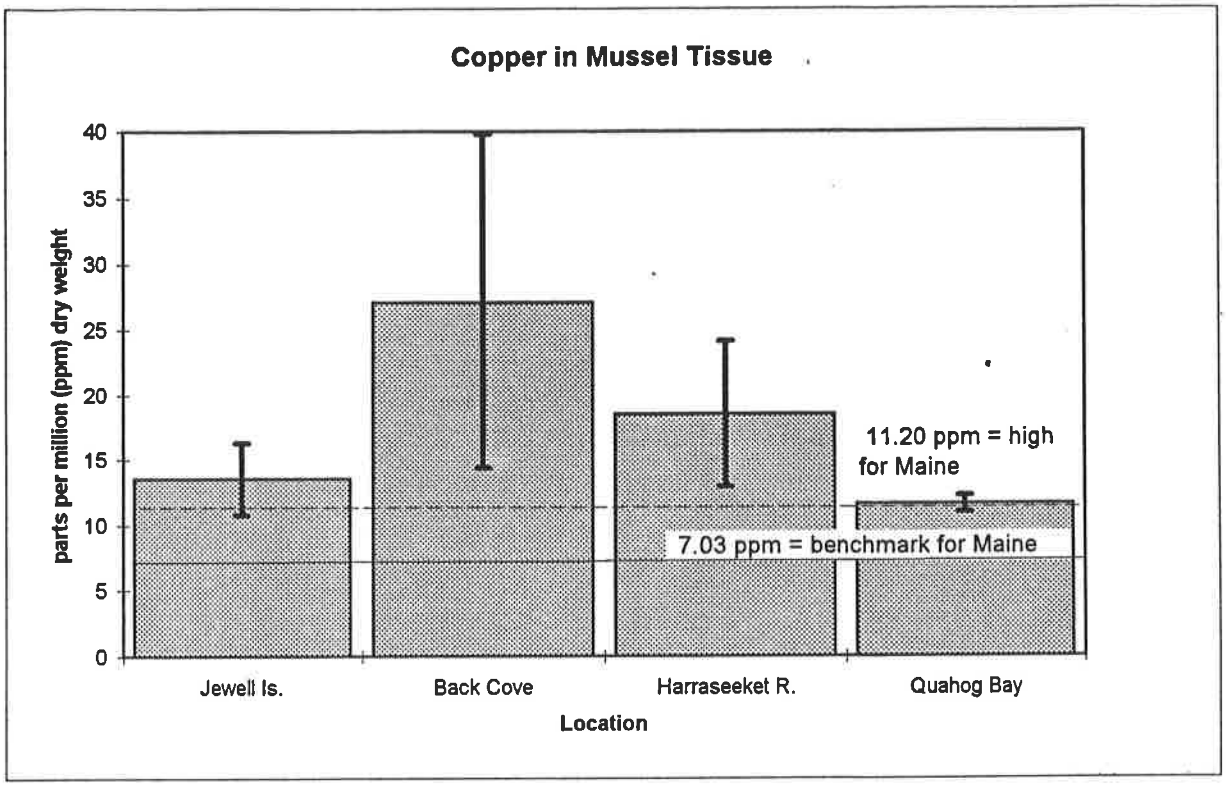

Iron in Mussel Tissue
1200
1000
800
600
400
200
0
parts per million (ppm) dry weight
684 ppm = high for Maine
367 ppm = bench-mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

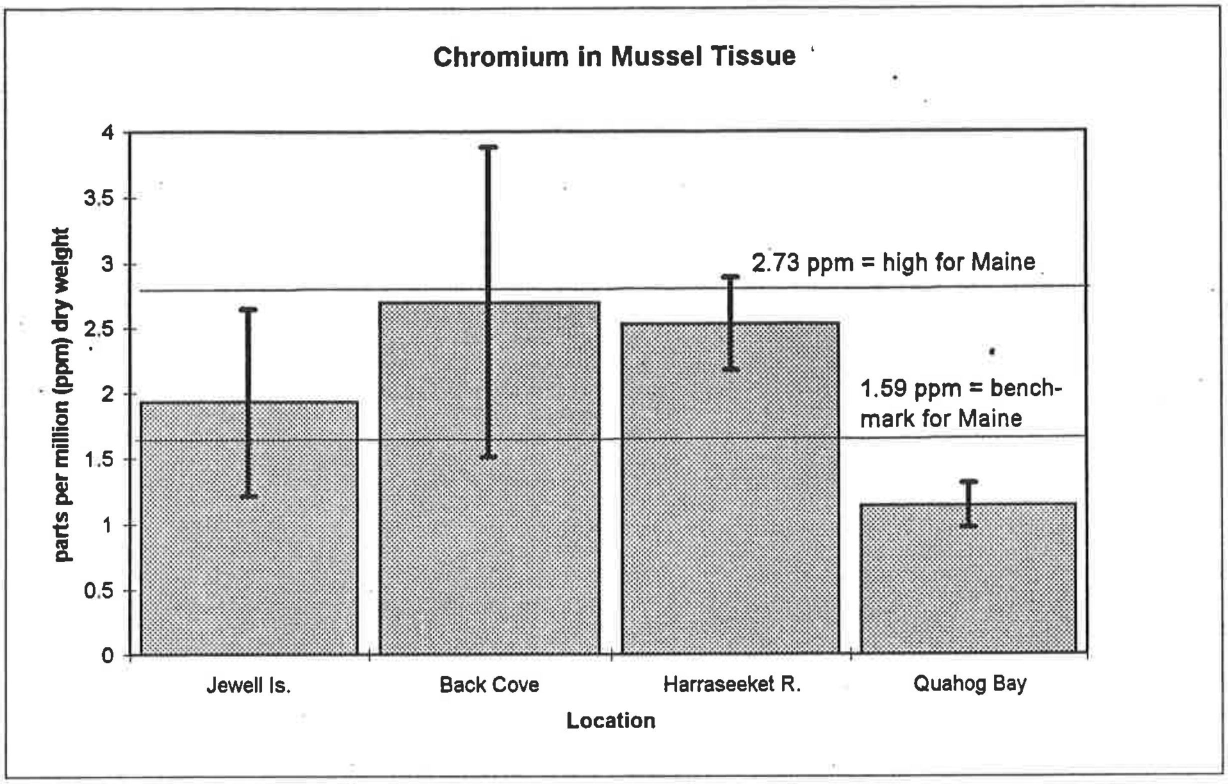


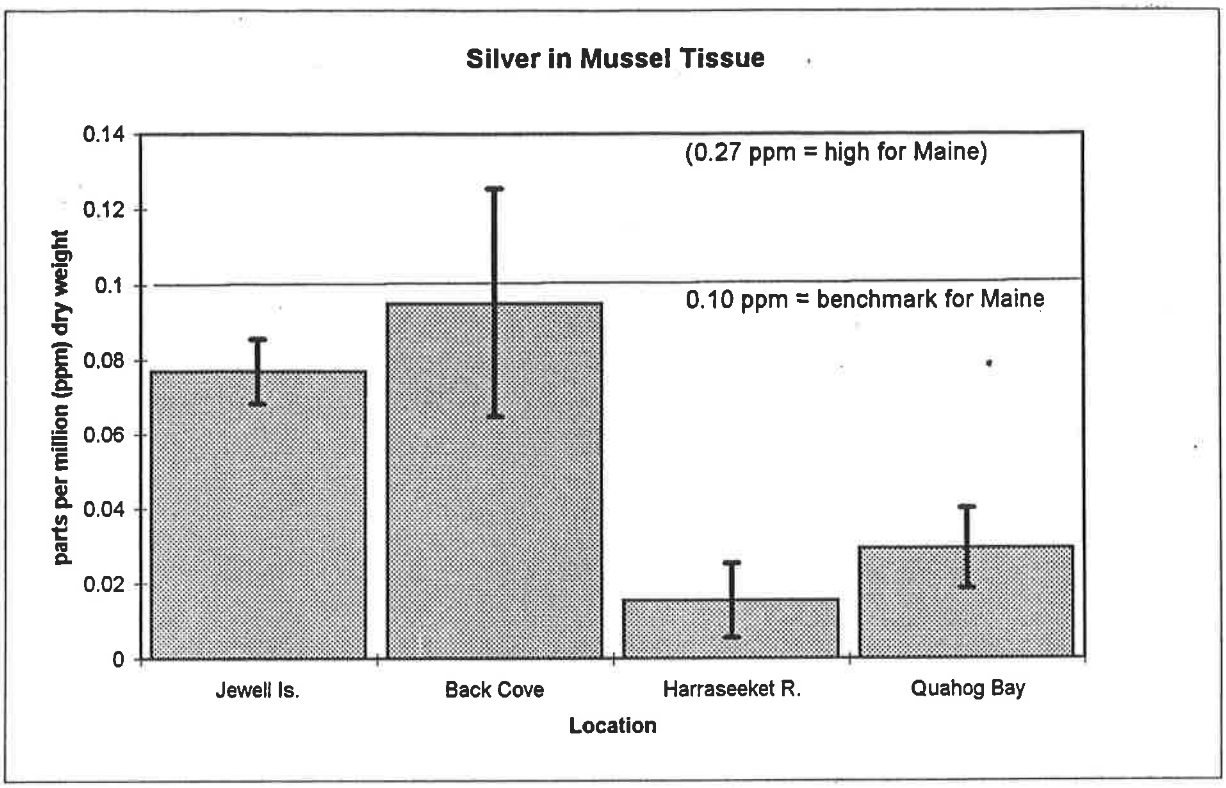
Zinc in Mussel Tissue
140
120
100
80
60
40
20
0
parts per million (ppm) dry weight
111 ppm = high for Maine
84 ppm = bench-
mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



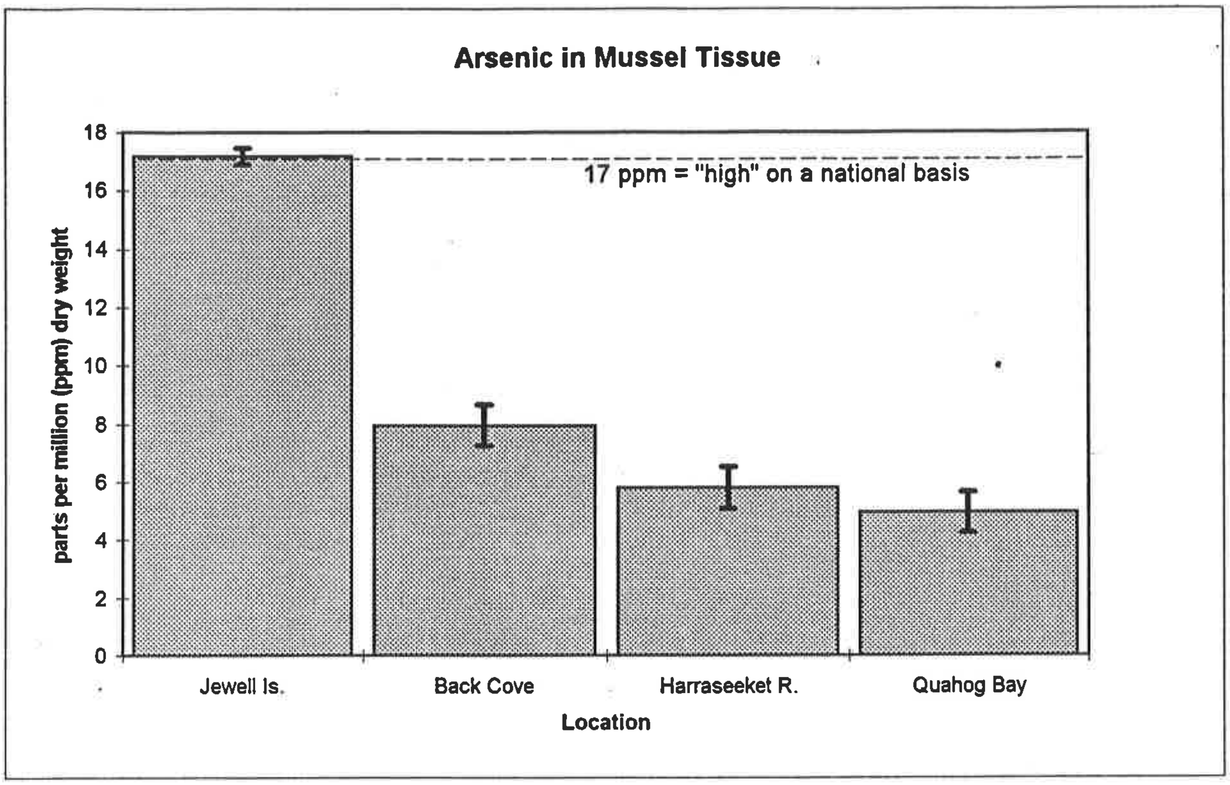
Nickel in Mussel Tissue
parts per million (ppm) dry weight
0
2
4
6
8
10
12
14
3.74 ppm = high for Maine
1.86 ppm = bench-
mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location


Copper in Mussel Tissue
parts per million (ppm) dry weight
40
35
30
25
20
15
10
5
0
11.20 ppm = high for Maine
7.03 ppm = benchmark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

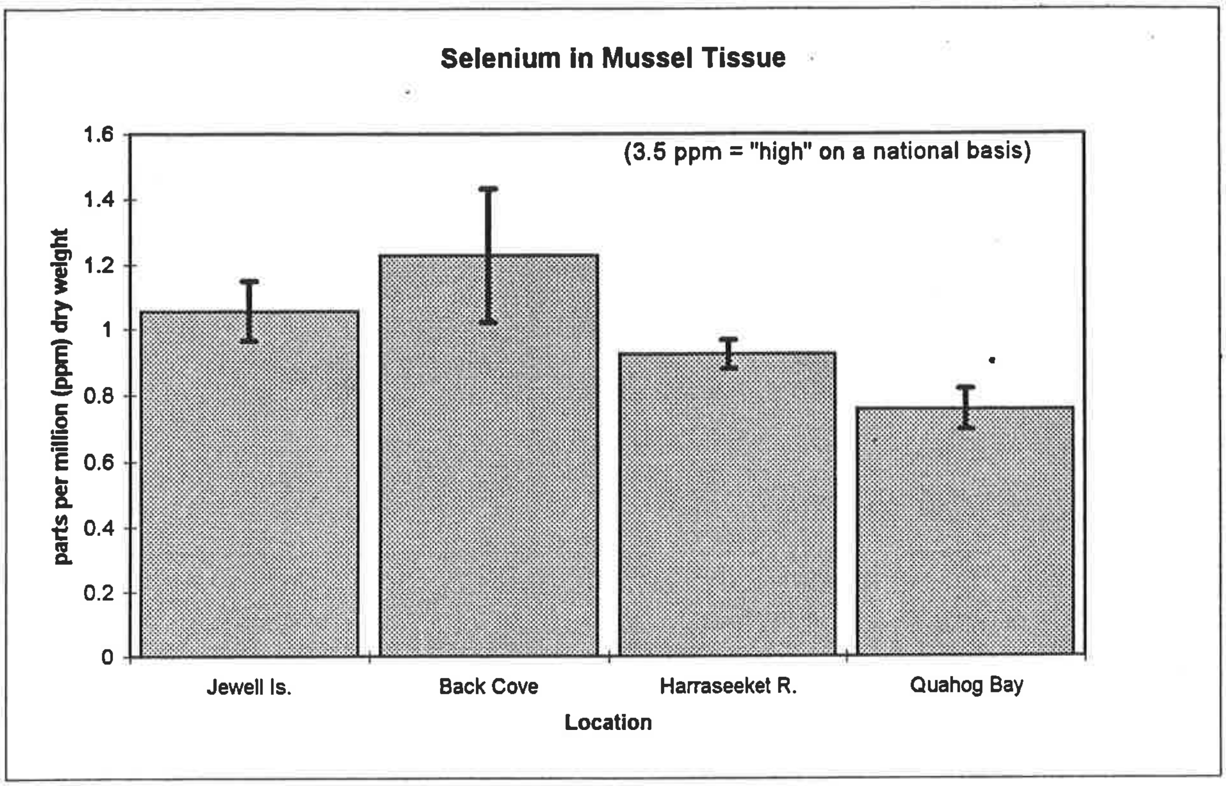

Chromium in Mussel Tissue
parts per million (ppm) dry weight
4
3.5
3
2.5
2
1.5
1
0.5
0
2.73 ppm = high for Maine
1.59 ppm = bench-
mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



Silver in Mussel Tissue
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
parts per million (ppm) dry weight
(0.27 ppm = high for Maine)
0.10 ppm = benchmark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



Arsenic in Mussel Tissue
18
16
14
12
10
8
6
4
2
0
parts per million (ppm) dry weight
17 ppm = "high" on a national basis
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



Selenium in Mussel Tissue
(3.5 ppm = "high" on a national basis)
parts per million (ppm) dry weight
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

Mercury in Casco Bay Mussel Tissue

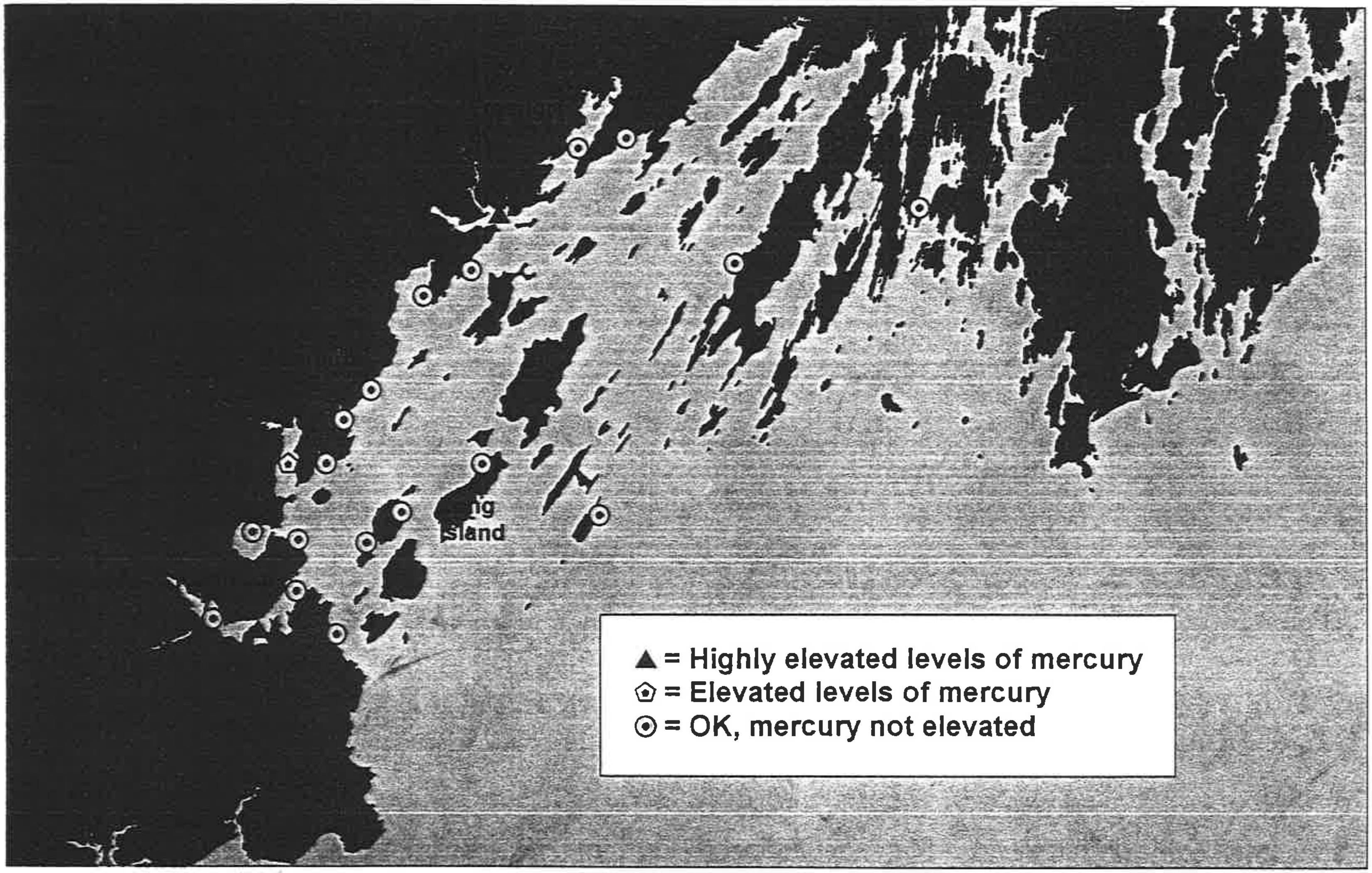
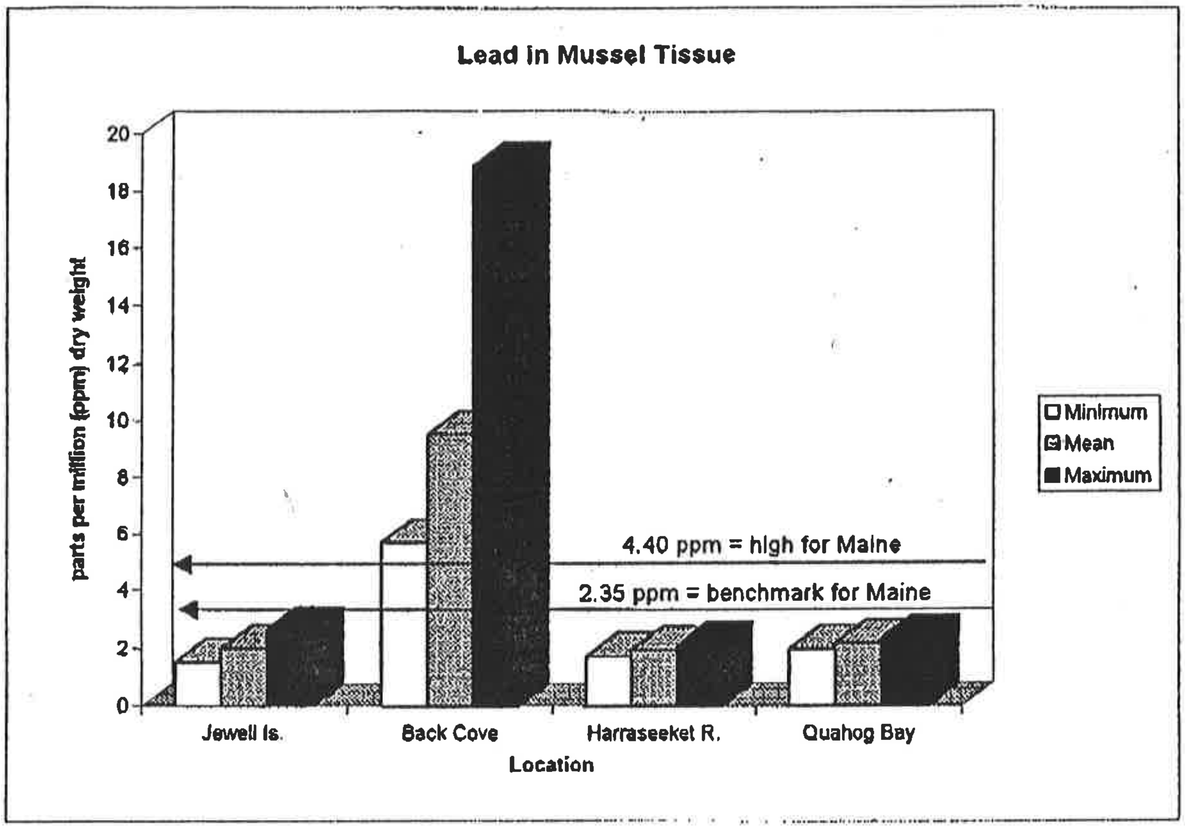


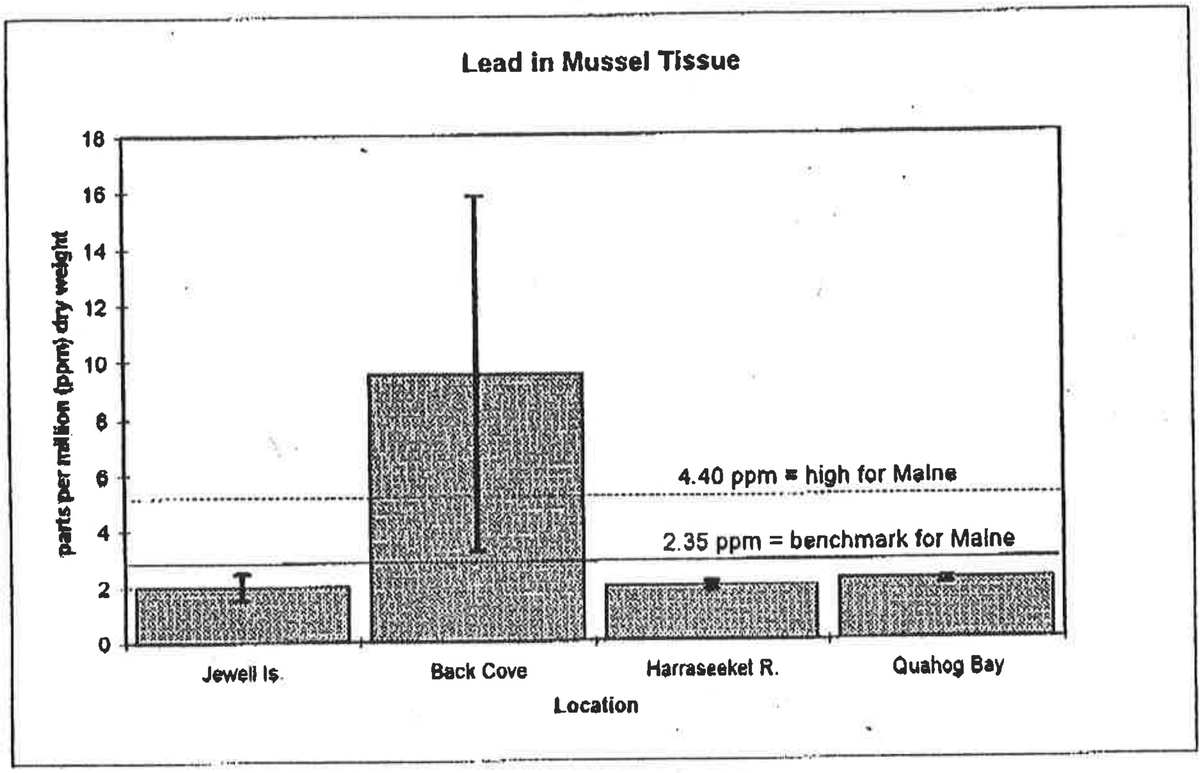
Table 5B - Trace Metal Data for Casco Bay Mussel Tissue Samples (mg/Kg dry weight)

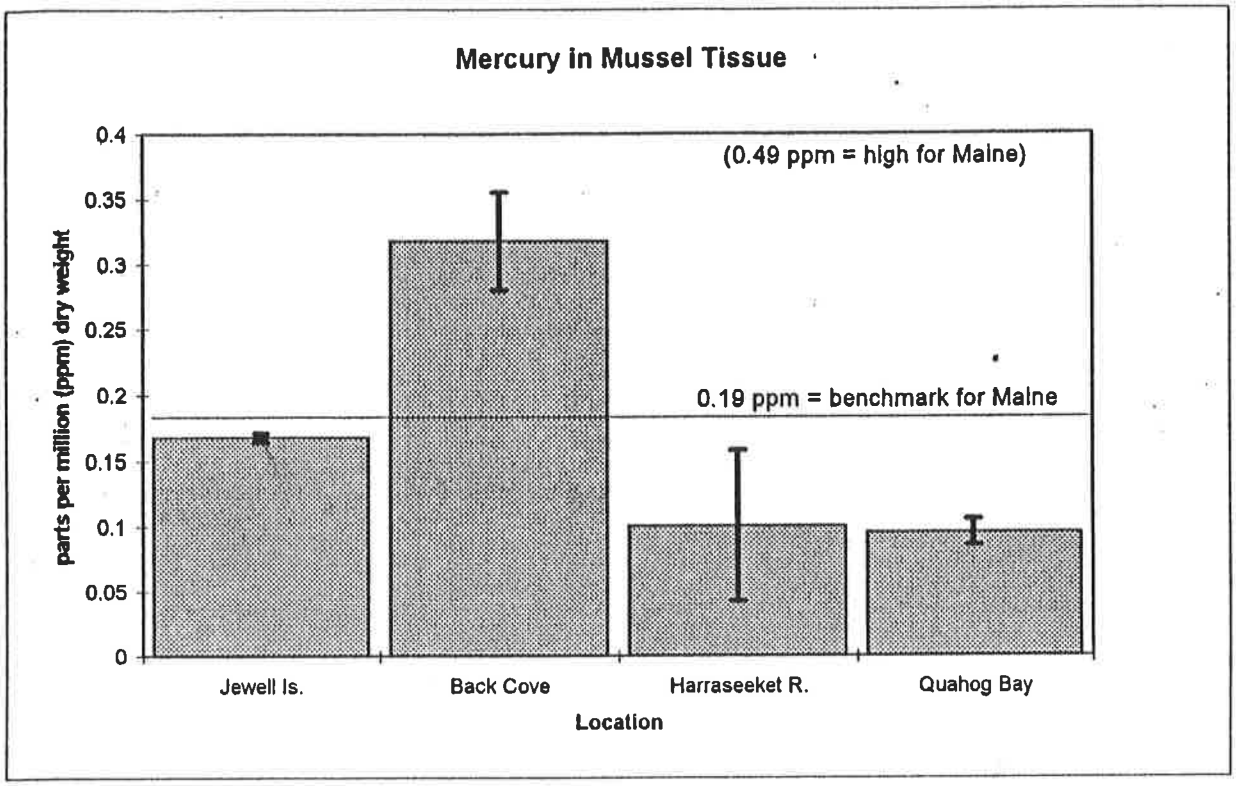
Sample ID	Ag	Al	As	Cd	Se	Zn	Fe	Pb	Ni	Cr	Cu	Hg	% solids
Jewell-1	0.083	59.6	17.18	0.347	0.972	103.74	345.8	1.53	7.78	1.63	12.6	0.1681	7.2
Jewell-2	0.069	88.2	16.78	0.444	1.097222	117.88	408.1	2.64	2.60	1.65	17.5	0.1722	7.2
Jewell-3	0.086	64.3	17.41	0.486	0.985714	93.57	413.4	1.86	3.84	3.00	11.3	0.1671	7
Jewell-4	0.069	67.5	17.29	0.986	1.166667	91.11	373.8	1.94	6.31	1.44	12.7	0.1639	7.2
Back Cove-1	0.082	447.3	6.96	0.726	1.150685	133.96	561.8	7.40	14.62	2.08	46.0	0.2904	7.3
Back Cove-2	0.141	758.6	8.66	2.844	1.53125	133.16	921.9	18.91	3.92	4.47	21.9	0.3734	6.4
Back Cove-3	0.079	342.1	8.00	0.937	1.126984	86.14	481.4	5.71	6.41	1.95	18.1	0.2984	6.3
Back Cove-4	0.078	425.0	8.22	0.766	1.09375	102.11	498.1	6.09	5.19	2.28	22.4	0.3078	6.4
Back Cove Cooked-1	0.072	630.8	10.77	1.533	1.015385	175.40	885.7	15.74	2.37	3.19	10.8	0.4872	19.5
Back Cove Cooked-2	0.085	890.5	11.31	1.433	0.781095	140.75	828.0	14.78	1.69	2.66	10.1	0.4403	20.1
Back Cove Cooked-3	0.062	907.2	11.58	1.479	0.958763	156.01	838.8	17.16	1.75	3.25	10.5	0.4985	19.4
Back Cove Cooked-4	0.062	463.9	6.74	1.356	4.159794	138.39	816.2	14.33	1.60	2.05	10.7	0.4629	19.4
Quahog-1	0.019	174.6	5.47	1.155	0.825243	111.49	235.5	2.33	1.09	1.32	11.3	0.0913	10.3
Quahog-2	0.039	147.2	4.16	0.976	0.677165	108.57	209.3	2.28	.71	1.24	12.1	0.0843	12.7
Quahog-3	0.021	152.8	5.60	1.103	0.773196	113.42	206.2	2.06	.67	.96	10.8	0.0990	9.7
Quahog-4	0.038	169.8	4.55	1.057	0.754717	91.93	214.5	1.98	.99	1.05	12.1	0.1075	10.6
Harrraseeket-1	0.028	896.3	5.23	0.493	0.985915	87.56	1072.5	1.97	2.87	2.51	14.9	0.1254	7.1
Harraseeket-2	0.014	624.6	5.96	0.565	0.898551	77.03	853.6	2.03	2.06	2.25	16.2	0.1319	6.9
Harraseeket-3	0.014	673.0	5.27	0.514	0.885714	78.40	805.7	1.71	2.13	3.04	27.0	0.1300	7
Harraseeket-4	0.004	466.7	6.78	1.389	0.916667	72.17	649.4	2.08	1.58	2.33	16.1	0.0139	7.2

Table 1A - Dioxins/Furans
(ng/Kg wet wt)

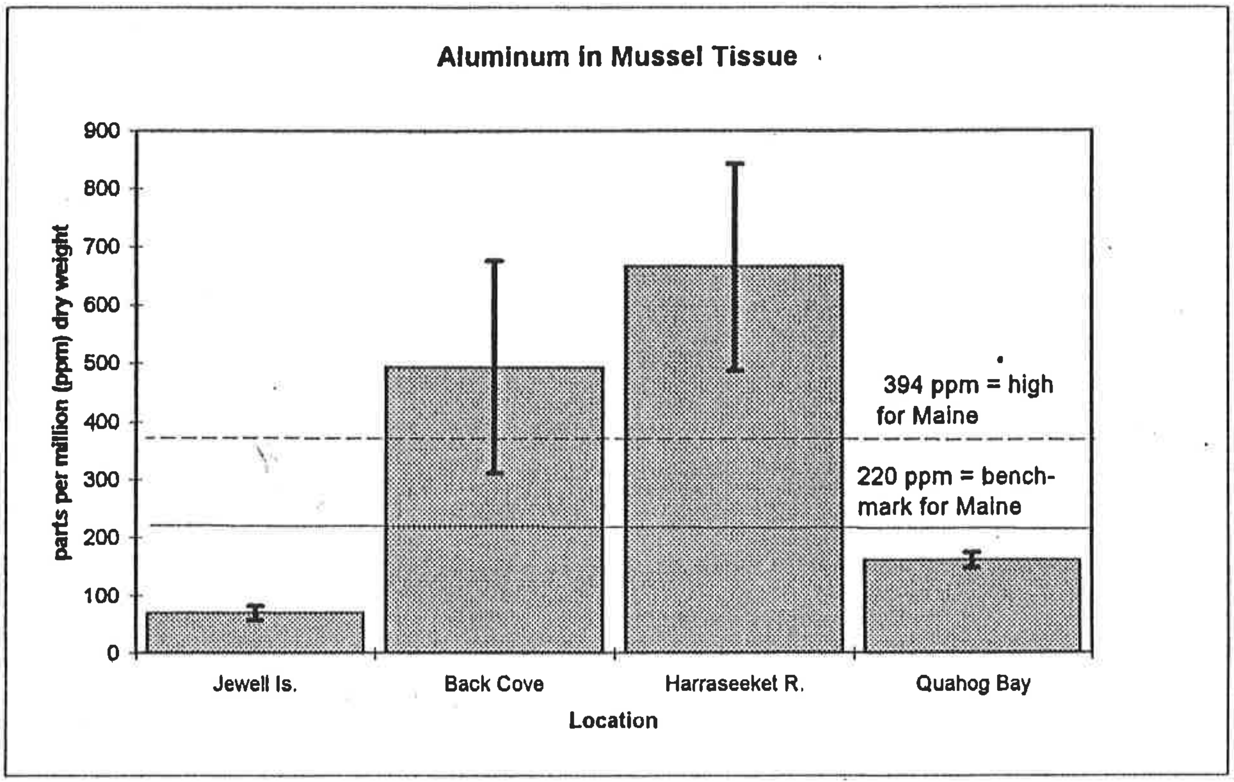
DEP ID Analytes	DL	Jewell 1	Jewell 2	Jewell 3	Jewell 4	Back Cove 1	Back Cove 2	Back Cove 3	Back Cove 4	Blank
2378-tcdf	0.1	ND	0.67	0.40	ND	0.34	0.31	0.60	0.41	ND
12378-pecdf	0.5	0.25	ND	0.38	ND	ND	ND	ND	ND	ND
23478-pecdf	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123478-hxcdf	0.5	ND	ND	ND	ND	ND	0.14	ND	ND	ND
123678-hxcdf	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
234678-hxcdf	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123789-hxcdf	0.5	0.38	ND	ND	0.45	ND	ND	ND	ND	ND
1234678-hpcdf	0.5	1.02	ND	0.56	ND	0.51	0.41	ND	0.31	ND
1234789-hpcdf	0.5	ND	0.40	0.32	0.61	ND	ND	ND	ND	ND
ocdf	1	0.34	ND	0.78	0.63	ND	ND	ND	ND	ND
2378-tcdd	0.1	0.52	ND	ND	0.35	0.26	0.16	ND	0.14	ND
12378-pecdd	0.5	2.57	0.26	1.21	0.55	1.41	0.20	1.19	0.93	ND
123478-hxcdd	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123678-hxcdd	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
123789-hxcdd	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
1234678-hpcdd	0.5	1.14	4.02	3.25	1.65	2.58	ND	2.95	1.84	ND
ocdd	1	1.37	0.94	1.15	0.84	1.16	4.03	2.93	2.70	ND
Surrogates										
13C-2378-tcdf		65.1	31.0	51.0	49.0	56.8	74.3	50.8	60.6	65.3
13c-12378-pecdf		64.2	36.3	53.5	51.3	60.0	79.5	55.1	64.9	83.1
13c-23478-pecdf		73.1	37.6	57.4	56.0	61.5	73.8	63.0	66.1	88.5
13c-123478-hxcdf		86.6	50.5	67.8	68.3	66.4	62.2	58.9	62.5	91.1
13c-123678-hxcdf		60.7	26.7	45.6	44.3	49.3	60.7	36.9	49.0	55.9
13c-234678-hxcdf		68.2	31.9	52.9	51.0	58.7	76.0	48.3	61.0	64.9
13c-123789-hxcdf		65.5	45.3	55.4	55.4	55.3	55.2	46.3	52.3	80.9
13c-1234678-hpcdf		63.7	25.7	45.7	45.0	47.6	53.3	45.8	48.9	50.1
13c-1234789-hpcdf		58.7	27.0	44.2	43.3	46.9	54.9	42.0	47.9	55.1
13C-2378-tcdd		51.1	30.1	42.1	41.1	45.0	53.9	34.9	44.6	58.5
13C-12378-pecdd		77.7	50.1	66.2	64.7	70.8	84.5	68.6	74.6	102.5
13C-123478-hxcdd		79.8	41.5	64.1	61.8	71.1	92.1	60.7	74.6	73.9
13C-123678-hxcdd		53.1	33.6	42.0	42.9	39.2	30.8	35.5	35.1	41.5
13C-123789-hxcdd		50.1	25.3	37.8	37.7	38.1	39.0	40.1	39.1	55.2
13C-1234678-hpcdd		79.6	34.7	60.2	58.2	66.2	84.4	58.0	69.5	87.0
13C-ocdd										
Totals										
Total tetra furans		ND	0.67	ND	ND	1.4	1.41	6.33	3.0	
Total tetra dioxins		0.51	ND	ND	0.35	ND	ND	ND	ND	
Total penta furans		1.85	ND	ND	ND	ND	1.61	2.58	ND	
Total penta dioxins		14.7	0.26	1.21	0.55	ND	ND	ND	ND	
Total hexa furans		1.56	ND	ND	0.45	ND	ND	ND	ND	
Total hexa dioxins		ND	ND	ND	ND	ND	ND	ND	ND	
Total hepta furans		1.02	0.4	1.32	0.61	ND	0.5	0.73	0.6	
Total hepta dioxins		1.14	4.02	3.25	1.65	4.0	ND	16.2	10.1	
Total octa furans		ND	ND	0.78	0.63	ND	ND	ND	ND	
Total octa dioxins		1.37	0.094	1.15	0.84	3.7	4.02	2.92	3.5	
sample weight (g)	50	48.8	49.66	47.51	47.39	49.573	53.635	50.79	47.121	50
% lipid		0.93	1.64	1.25	1.07	0.85	0.76	0.45	0.58	

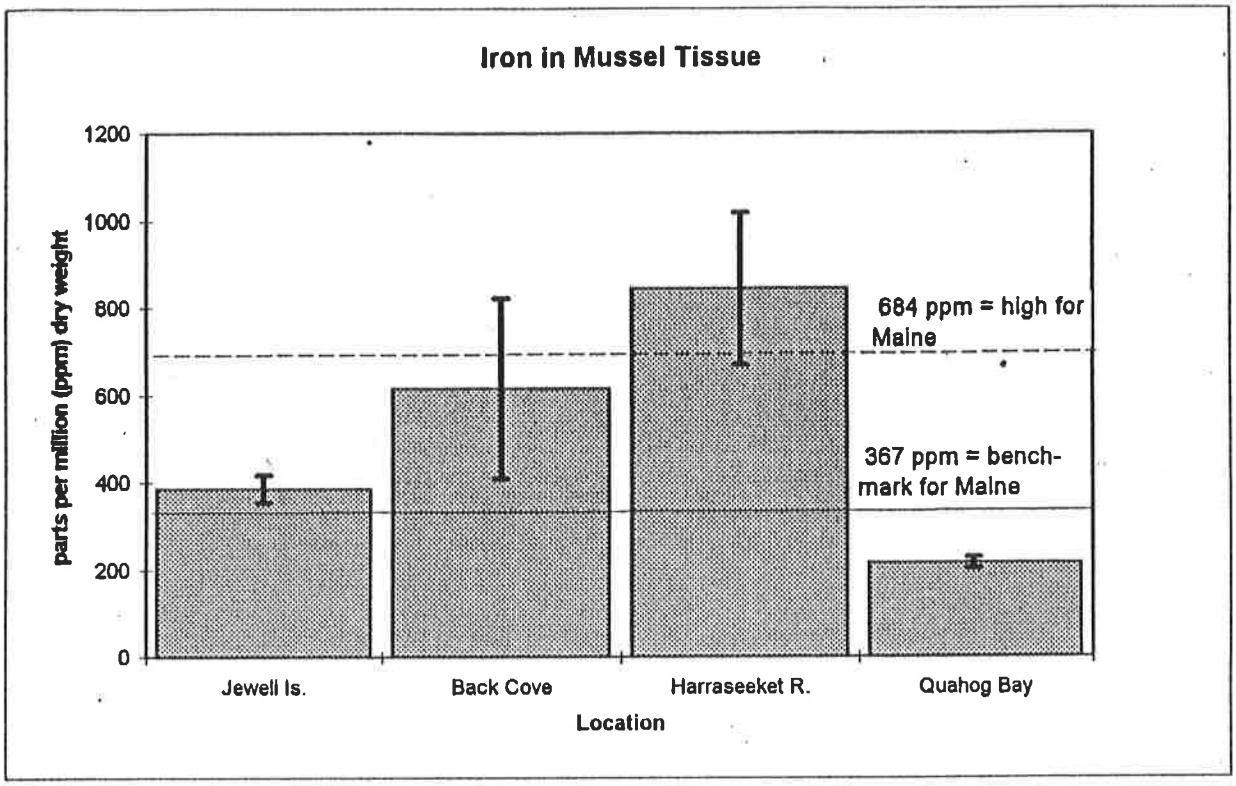

Lead in Mussel Tissue
parts per million (ppm) dry weight
20
18
16
14
12
10
8
6
4
2
0
4.40 ppm = high for Maine
2.35 ppm = benchmark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location
Minimum
Mean
Maximum

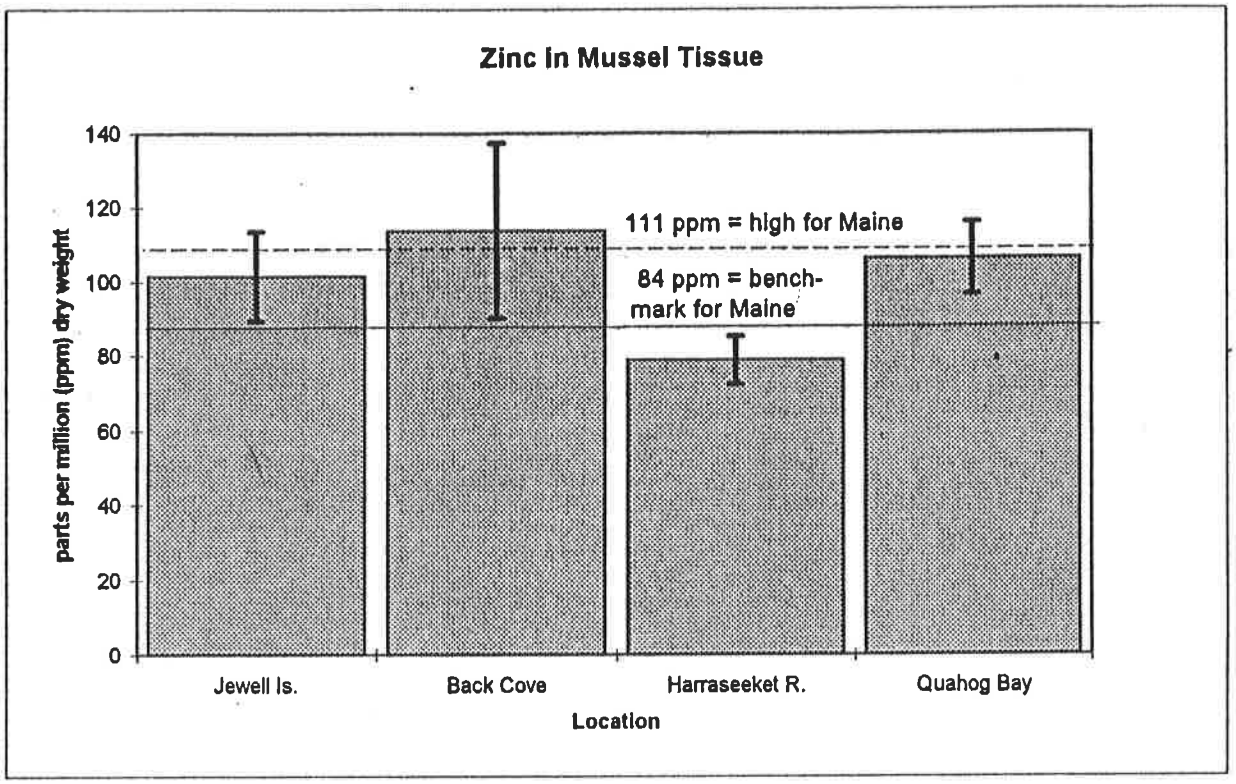

Lead in Mussel Tissue
parts per million (ppm) dry weight
18
16
14
12
10
8
6
4
2
0
4.40 ppm = high for Maine
2.35 ppm = benchmark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



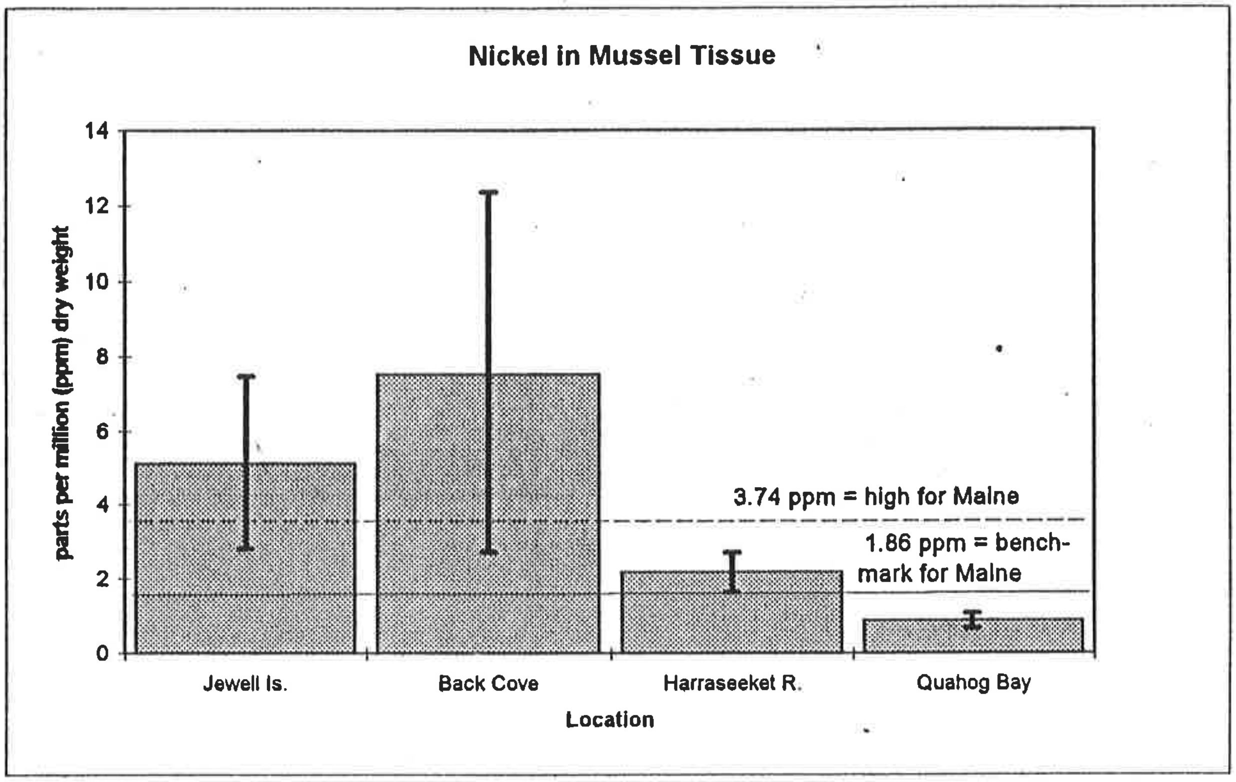
Mercury in Mussel Tissue
(0.49 ppm = high for Maine)
0.19 ppm = benchmark for Maine
parts per million (ppm) dry weight
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location


Aluminum in Mussel Tissue
parts per million (ppm) dry weight
900
800
700
600
500
400
300
200
100
0
394 ppm = high for Maine
220 ppm = bench-mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

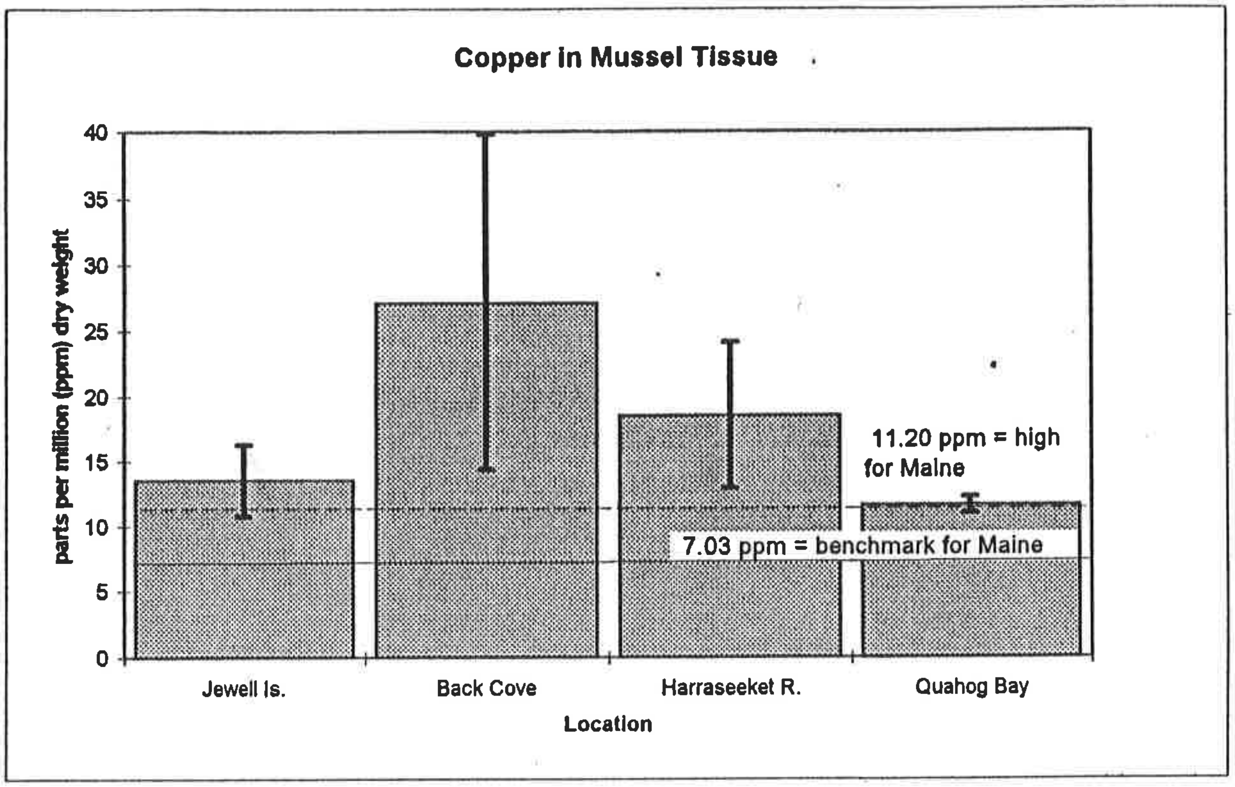

Iron in Mussel Tissue
1200
1000
800
600
400
200
0
parts per million (ppm) dry weight
684 ppm = high for Maine
367 ppm = bench-mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



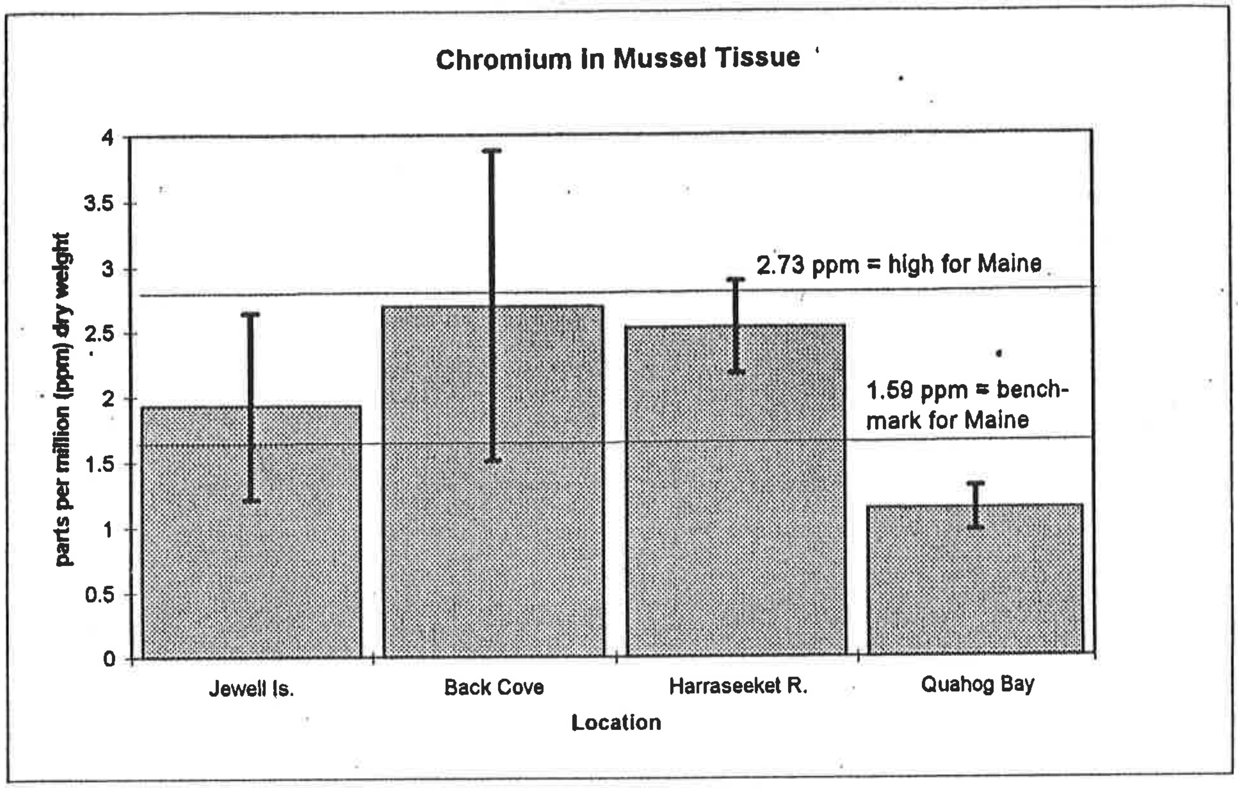
Zinc in Mussel Tissue
111 ppm = high for Maine
84 ppm = bench-mark for Maine
parts per million (ppm) dry weight
140
120
100
80
60
40
20
0
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



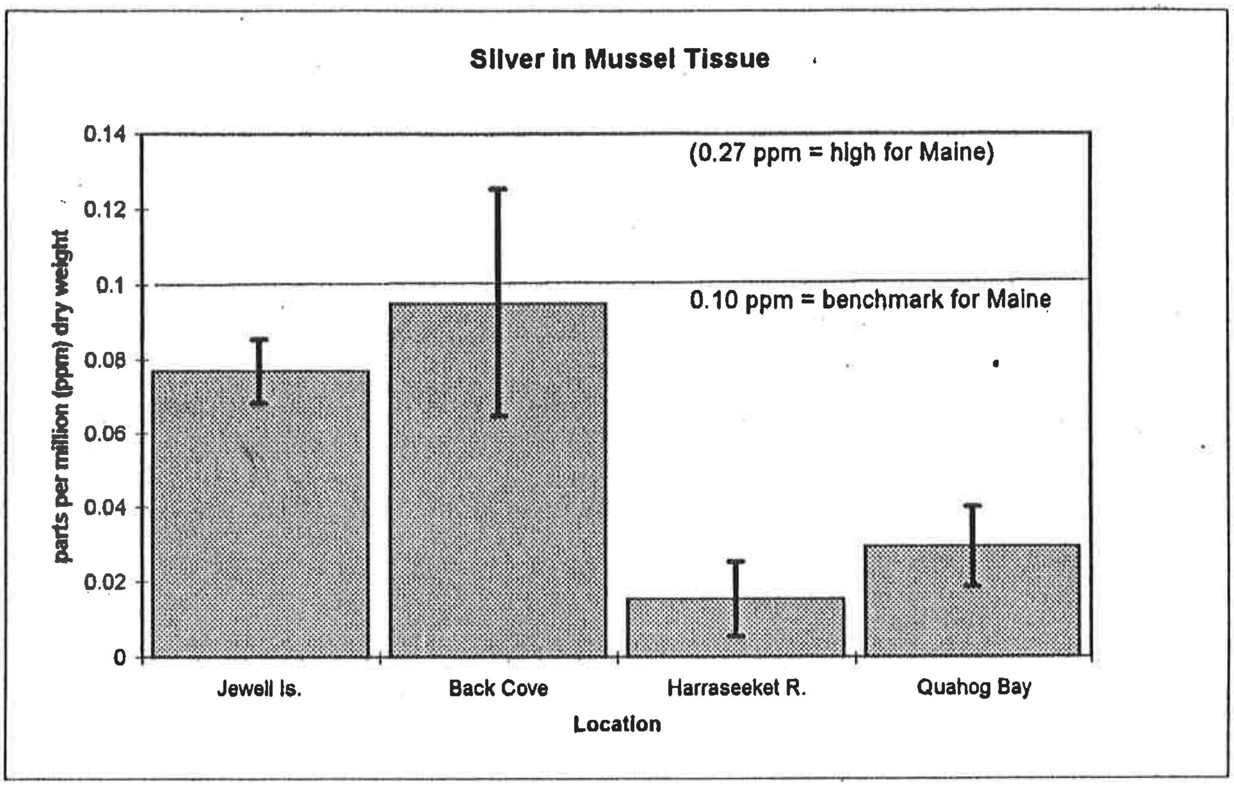
Nickel in Mussel Tissue
parts per million (ppm) dry weight
0
2
4
6
8
10
12
14
3.74 ppm = high for Maine
1.86 ppm = bench-
mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



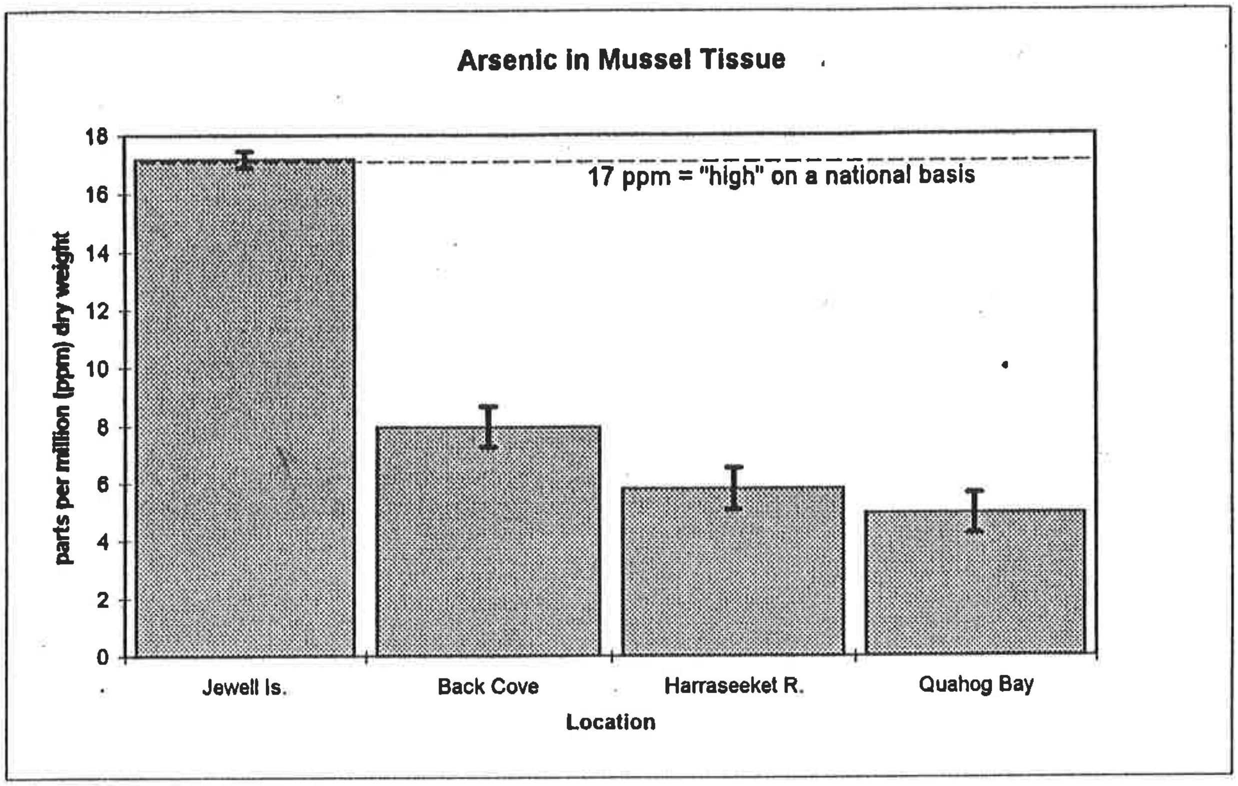
Copper in Mussel Tissue
parts per million (ppm) dry weight
40
35
30
25
20
15
10
5
0
11.20 ppm = high for Maine
7.03 ppm = benchmark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

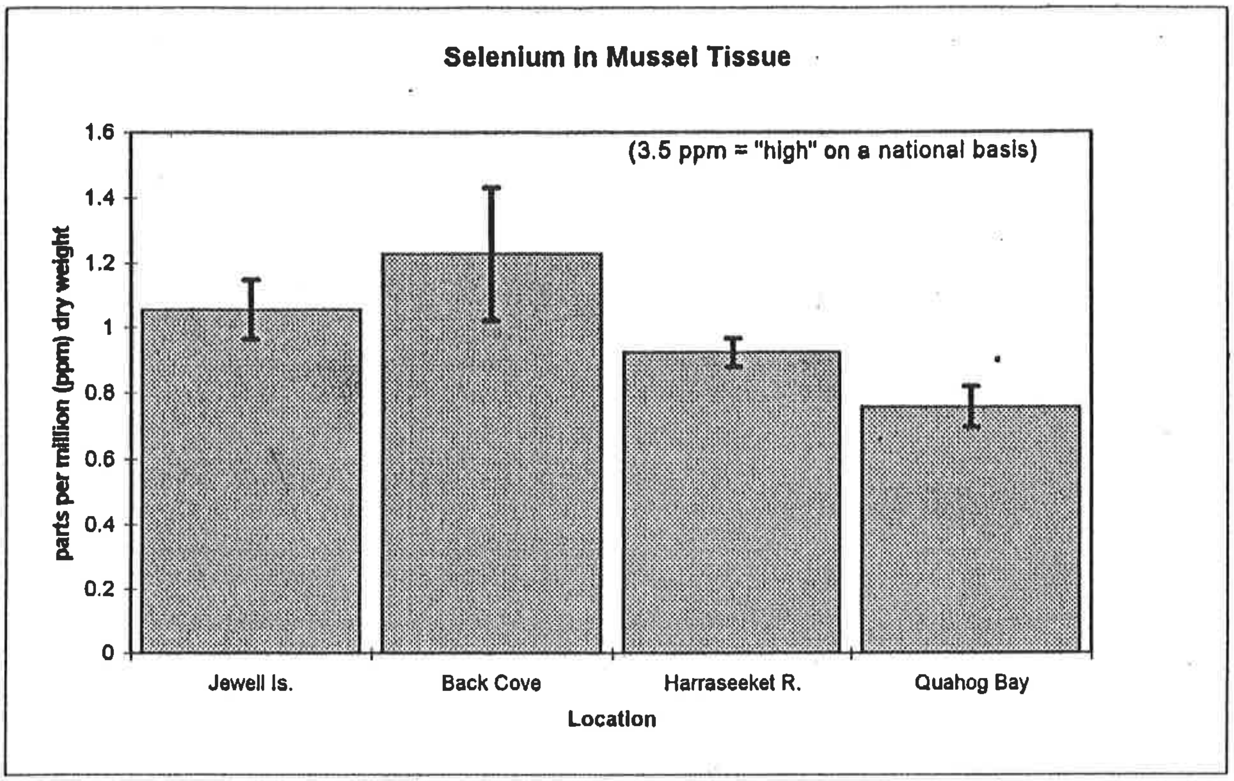


Chromium in Mussel Tissue
parts per million (ppm) dry weight
4
3.5
3
2.5
2
1.5
1
0.5
0
2.73 ppm = high for Maine
1.59 ppm = bench-mark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



Silver in Mussel Tissue
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
parts per million (ppm) dry weight
(0.27 ppm = high for Maine)
0.10 ppm = benchmark for Maine
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location


Arsenic in Mussel Tissue
17 ppm = "high" on a national basis
parts per million (ppm) dry weight
18
16
14
12
10
8
6
4
2
0
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location



Selenium in Mussel Tissue
(3.5 ppm = "high" on a national basis)
parts per million (ppm) dry weight
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jewell Is.
Back Cove
Harraseeket R.
Quahog Bay
Location

Back

A Decade of Monitoring Toxic Contaminants along Maine's Coast

Introduction

Contamination of our environment by toxic chemicals is a serious global concern. By the early 1960s, the public was well aware of the unintended consequences of widespread chemical use. In Minimata Japan, over one hundred people had been tragically poisoned after consuming mercury contaminated fish. Here in the United States, wildlife including the American bald eagle and peregrine falcon were nearly extirpated by pesticides, most notably the persistent organochlorine compounds like DDT. In Maine, human health advisories exist (DHS link here) warning people of the risk of eating sportfish caught from freshwater. On the coast, an advisory warns against eating tomalley or eating large striped bass and bluefish. (for more on toxic contamination in Maine Coastal Waters see MEPP link).

Interpreting toxic contaminant data is not simply a matter of detecting a toxic chemical. With today's advanced laboratory techniques, we are able to detect toxic contaminants in virtually any sample we collect, whether or not they cause toxic effects. Because many toxic contaminants are naturally occurring (eg. all metals and many hydrocarbons), we invariably detect them. Chemicals known to be toxic at higher concentrations are frequently the very same chemicals required for normal cellular functions, but at lower concentrations.

Hundreds of new chemicals are being developed and placed on the market each year. The ubiquitous nature of pesticides, chemical products and byproducts of our technological society presents a continuing challenge to environmental and human health management. Even though some chemicals have been banned from use in the United States, they enter the U.S. on currents of air and water, food products, commerce and waste from other countries where they are still used. Monitoring their presence in our environment is a key step in assessing and managing the threat from toxic contamination.

Objectives

In the late 1980s, we initiated a project to assess the levels and locations of toxic contaminants along the coast.

The project's immediate goals were

1. to gather sufficient information to enable us to define "normal" environmental levels of certain toxic chemicals,

2. to determine whether levels pose an unacceptable risk to humans and/or coastal marine life, and

3. to be able to discriminate between natural sources and human sources.

Maine Mussel Watch

The common blue mussel, *Mytilus edulis*, was selected as our primary tool to assess Maine's coastal water quality. Mussels have been successfully used around the region and world. The large data sets from these other programs (NOAA & Gulfwatch) provide us a context to assess conditions in Maine. Sampling mussels has an advantage over directly sampling seawater in that they filter large volumes of water each day and accumulate contaminants that may not otherwise be detected in the water. Also, water samples represent conditions at the exact time when the water was sampled. Mussels integrate conditions over weeks and months. Mussels are sedentary and therefore reflect local conditions making them suitable for detecting sources of contamination. They occur along the entire coast and are relatively easy to collect. Mussels have an advantage over sediment since they reflect levels of contaminants that are biologically available. And finally, as a food with considerable health benefits to people, by incorporating them into our monitoring program, the public is assured that the areas open to harvest are

safe. (For more on the human health, see section below entitled human health implications.)

Station Selection Considerations

Stations are selected based on five primary factors.

1. Reference Conditions - Since many pollutants are naturally occurring elements and compounds, their presence does not necessarily signify pollution. Understanding the natural concentrations and variability in biota is critical to interpreting monitoring data. Therefore, inclusion of stations along the coast which are located in areas thought to be free of "pollution" is essential to this program. Although the coast of Maine is not entirely pristine, there remain areas that have been spared the impacts associated with either present day or historical industrial or commercial development. These "reference" areas are in relatively remote sections of the coast where anthropogenic contamination is thought to be minimal. Data from the reference stations are used to describe normal background levels which in turn forms the basis on which the other stations are evaluated.

2. Sources of pollution - In areas where contamination is known to have occurred, stations have been established to assess the severity of contamination. Through monitoring these stations over time and comparing them to the reference stations, trends may develop that help evaluate whether environmental management practices are working.

3. Spatial distribution - Because Maine's coast covers a large geographic area and includes many different environments, stations have been distributed throughout the coast.

4. Physiography and hydrography - Maine's coast is highly variable ranging from bold deep water rocky habitats to shallow mud flats in enclosed embayments. Human activity and natural processes affect water quality in very different ways depending on flushing, bottom sediment type, land and water use. Stations have been placed in areas with an assortment of these conditions.

5. Add-on opportunities - Stations are also located on a case by case basis if they address a specific question or there is the potential to compliment work being done elsewhere. Damage assessment after a chemical spill, evaluating shellfish beds, and research into contaminant uptake kinetics are a few examples.

Secondary considerations for station selection include accessibility, condition of mussel population, turbidity from resuspended sediment, and public interest.

Sample Collection

Contaminant body burdens vary with season, age, location in the intertidal zone and reproductive state. Effort was therefore made to standardize these variables so that comparisons between years and locations may be made. Collection is done during an index period that begins at the end of August and continues through early October.

Samples are collected from the low intertidal or shallow sub tidal zone. Mussels are between 50-60mm long. The area of collection is both located and sized to reflect the waterbody of interest. In most cases the area is about 100 to 200 meters long.

Region Descriptions

We have divided the coast into eight regions to collect data that is representative of the various environmental conditions encountered in Maine (Figure 1). Each region roughly reflects an ecological system such as a large estuary or type of coastline or tidal regime. Following the region name is a two letter code that facilitates querying the data.

The Piscataqua Estuary (PQ) is at the southwestern corner of Maine. This is a true estuary that drains southern Maine and New Hampshire. The area has a long and rich industrial history.

The South Coastal (SC) region is mostly sand beach and salt marsh with a straight coastline. Several small rivers drain into this region.

Casco Bay (CB) is a semi-enclosed system and has a deeply indented coastline with many islands. About a quarter of Maine's population lives in this bay's watershed. The western part of the bay is well developed and industrialized while the eastern part has relatively light development.

The Mid Coast (MC) region is also indented but is more open to the ocean. It too, contains a mixture of light development and industry.

Penobscot Bay (PB) is the drowned valley of the Penobscot River. At the head, the river drains the central part of Maine. On the river itself are several large cities. Industry includes pulp and paper and petrochemical facilities. The bay contains several large island communities. Land-use in the areas is widely varied from urban to forest.

Blue Hill-Frenchmans Bay (BF) is generally light to moderately developed. Exceptions include two metal mines. Acadia National Park lies in the center of Frenchman's Bay.

The East Coast (EC) region is a bold coast with several small rivers draining to it. Development is generally light with small towns interspersed along its length.

Passamoquoddy Bay (PB) is semi-enclosed with tides in excess of 20 feet. Cold, nutrient rich waters make this area one of the most productive areas on the Maine coast. The bay supports a large concentration of salmon aquaculture operations. Industrial development in this part of Maine is light.

Station Coding

The underlying mussel database uses a 6 letter code to easily identify stations. The first 2 letters refer to one of the 8 regions discussed above. Within each region, stations are coded with 4 letters following the regional 2 letter code. For example, CBFROF is the Casco Bay region, Fore River, Outer Fore River segment. Table 1 contains the names, towns, and codes of all the stations for which we have data.

Definition of Normal Baseline

To define what we consider to be the normal range of concentrations for each contaminant, we used values from 24 reference stations. Since the data from those stations fit a normal distribution, we were able to take the arithmetic mean and its standard deviation to describe the population. For the purposes of this program, "normal" concentrations for each contaminant was arbitrarily defined as plus and minus 2 standard deviations around the mean of concentrations found in mussels collected at the reference stations (+/-2s). Values outside this range are considered anomalous, although not necessarily a sign of pollution, and are presented in Table 2.

Percent Deviation above the Norm was calculated using the following formula:

% Dev. = (((Cs/Cb)-1) *100) +100

where

% Dev. = Percent Deviation above the Normal Range

Cs = Sample Concentration

Cb = Upper Limit of Normal Range

Continue

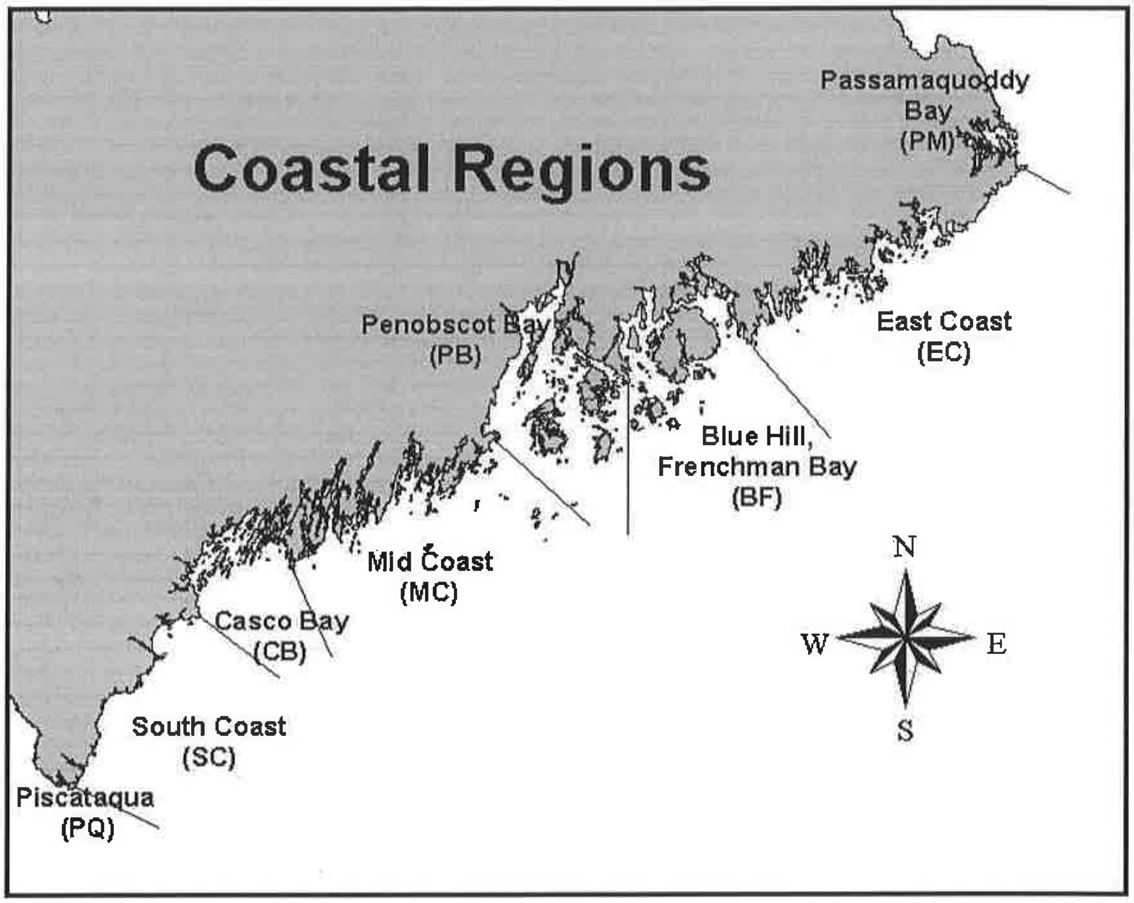

Coastal Regions
Passamaquoddy Bay (PM)
East Coast (EC)
Penobscot Bay (PB)
Blue Hill, Frenchman Bay (BF)
Mid Coast (MC)
Casco Bay (CB)
South Coast (SC)
Piscataqua (PQ)
N
W
E
S

Table 1.

Belfast	Penobscot Bay	Belfast Harbor	Town Docks	PBBFTD
Biddeford-Saco	South Coastal	Saco River	Jetty	SCSAJY
Blue Hill	Blue Hill-Frenchmans Bay	Blue Hill Bay	Blue Hill Falls	BFBHBF
Boothbay Harbor	Mid-Coast	Boothbay Harbor	Mill Cove	MCBBMC
Boothbay Harbor	Mid-Coast	Boothbay Harbor	Outer Harbor	MCBBOH
Boothbay Harbor	Mid-Coast	Boothbay Harbor	Town Cove	MCBBTC
Boothbay Harbor	Mid-Coast	Boothbay Harbor	West Harbor	MCBBWH
Boothbay Harbor	Mid-Coast	Sheepscot River	Clough Point	MCSHCP
Boothbay	Mid-Coast	Damariscotta	Goose Ledge	MCDMGL
Boothbay	Mid-Coast	Damariscotta	Wentworth Point	MCDMWP
Boothbay	Mid-Coast	Linekin Bay	Bayville	MCLBBV
Bristol	Mid-Coast	Muscongus Sound	Round Pond	MCMGRP
Castine-Brookville	Penobscot Bay	Cape Rosier	Goose Falls	PBCRGF
Deer Isle	Penobscot Bay	Pickering Island	East Point	PBPIEP
Edmund TWP	Passamaquoddy Bay	Cobscook Bay	Cobscook Park	PMCKCK
Edmund TWP	Passamaquoddy Bay	Cobscook Bay	Whiting Cove	PMCKWC
Edmund TWP-Pembroke	Passamaquoddy Bay	Cobscook Bay	Dennys River	PMCKDR
Ellsworth	Blue Hill-Frenchmans Bay	Union River	Mouth	BFURMT
Falmouth	Casco Bay	Falmouth Anchorage	Falmouth Anchorage	CBANAN
Falmouth	Casco Bay	Falmouth Foreside	Falmouth Flats	CBFFFF
Falmouth	Casco Bay	Mill Creek	Mill Creek	CBMCMC
Freeport	Casco Bay	Harraseekett	Harraseekett	CBHRHR
Freeport	Casco Bay	Little River	Little River	CBLRLR
Friendship	Mid-Coast	Muscongus Sound	Friendship	MCMGFS

Harpswell	Casco Bay	Harpswell	Navy Pier	CBHWNP
Harpswell	Casco Bay	Quahog Bay	Quahog Bay	CBQHQH
Jonesboro	East Coast	Englishmans bay	Chandler River	ECENCH
Jonesport	East Coast	Englishmans Bay	Dunn Island	ECENDN
Kennebunkport	South Coastal	Kennebunk River	Mouth	SCKBMT
Kittery	Piscataqua Estuary	Back Channel	Back Channel	PQBCBC
Kittery	Piscataqua Estuary	Clarks Cove	Clarks Cove	PQCCCC
Kittery	Piscataqua Estuary	Fort Foster	Fort Foster	PQFFFF
Kittery	Piscataqua Estuary	I-95 to Powerilne	I-95 to Powerilne	PQISIS
Kittery	Piscataqua Estuary	Pepperell Cove	Pepperell Cove	PQPCPC
Kittery	Piscataqua Estuary	Spruce Creek	Spruce Creek	PQSCSC
Kittery-Saco	South Coastal	Brave Boat Harbor	Brave Boat Harbor	SCBHBH
Long Island	Casco Bay	Long Island	Fuel Terminal	CBLNFT
Lubec	Passamaquoddy Bay	Cobscook Bay	Gove Point	PMCKGP
Machiasport	East Coast	Little Kennebec Bay	Collins Branch	ECLKCB
Machiasport	East Coast	Little Kennebec Bay	Grays Beach	ECLKGY
Machiasport	East Coast	Little Kennebec Bay	Johnson/Marston Pts.	ECLKJM
Machiasport	East Coast	Little Kennebec Bay	Point of Main	ECLKPM
Machiasport	East Coast	Machias Bay	Machiasport	ECMCMR
Milbridge	East Coast	Narraguagus	Milbridge	ECNGMB
Phippsburg-Georgetown	Mid-Coast	Kennebec River	Perkins Island	MCKNPI
Portland	Casco Bay	Back Bay	Back Bay	CBBBBB
Portland	Casco Bay	East End Beach	East End Beach	CBEEEE

Portland	Casco Bay	Jewell Island	Punchbowl	CBJWPB
Portland	Casco Bay	Presumpscot	Mouth	CBPRMT
Portland-S. Portland	Casco Bay	Fore River	Inner River	CBFRIR
Portland-S. Portland	Casco Bay	Fore River	Mid River	CBFRMR
Portland-S. Portland	Casco Bay	Fore River	Outer River	CBFROR
Portland	Casco Bay	Great Diamond Island	Cocktail Cove	CBGDCC
Portland	Casco Bay	Great Diamond Island	Southwest End	CBGDSW
Rockland	Penobscot Bay	Rockland Harbor	Crockett Point	PBRKCP
Rogue Bluffs	East Coast	Englishmans Bay	Calf Island	ECENCI
Rogue Bluffs	East Coast	Englishmans Bay	Great Cove	ECENGC
Rogue Bluffs	East Coast	Little Kennebec Bay	Hope Island	ECLKHI
Saco	South Coastal	Goosefare Brook	Mouth	SCGFMT
Scarborough	South Coastal	Scarborough	Rail Road	SCSRRR
Searsport	Penobscot Bay	Sears Island	West Shore	PBSIWS
Sedgewick	Penobscot Bay	Eggemoggin Reach	Billings Cove	PBERBC
South Portland	Casco Bay	Spring Point	Spring Point	CBSPSP
Southwest Harbor	Blue Hill-Frenchmans Bay	Mount Desert	Southwest Harbor	BFMDSW
Stockton Springs	Penobscot Bay	Fort Point	Fort Point	PBFPFP
Stockton Springs	Penobscot Bay	Sandy Point	Sandy Point	PBSPSP
St. George	Mid-Coast	St. George River	Hospital Point	MCSGHP
Tremont	Blue Hill-Frenchmans Bay	Mount Desert	Seal Cove	BFMDSC
Yarmouth	Casco Bay	Royal River	Mouth	CBRYMT
Yarmouth	Casco Bay	Cousins Thorofare	Cousins Thorofare	CBTHTH
Yarmouth-Cumberland	Casco Bay	Broad Cove	Broad Cove	CBBCBC
York	South Coastal	Cape Neddick	Mouth	SCCNMT

York	South Coastal	Perkins Cove	Perkins Cove	SCPCPC
Waldoboro	Mid-Coast	Medomak River	Havener Ledge	MCMRHL
Westport	Mid-Coast	Sheepscot River	Whittum Island	MCSHWT

Falmouth Foreside
Falmouth Anchorage (CBANAN)
Falmouth

CHART **N 43° 43'43" W 70° 12'24.7"**

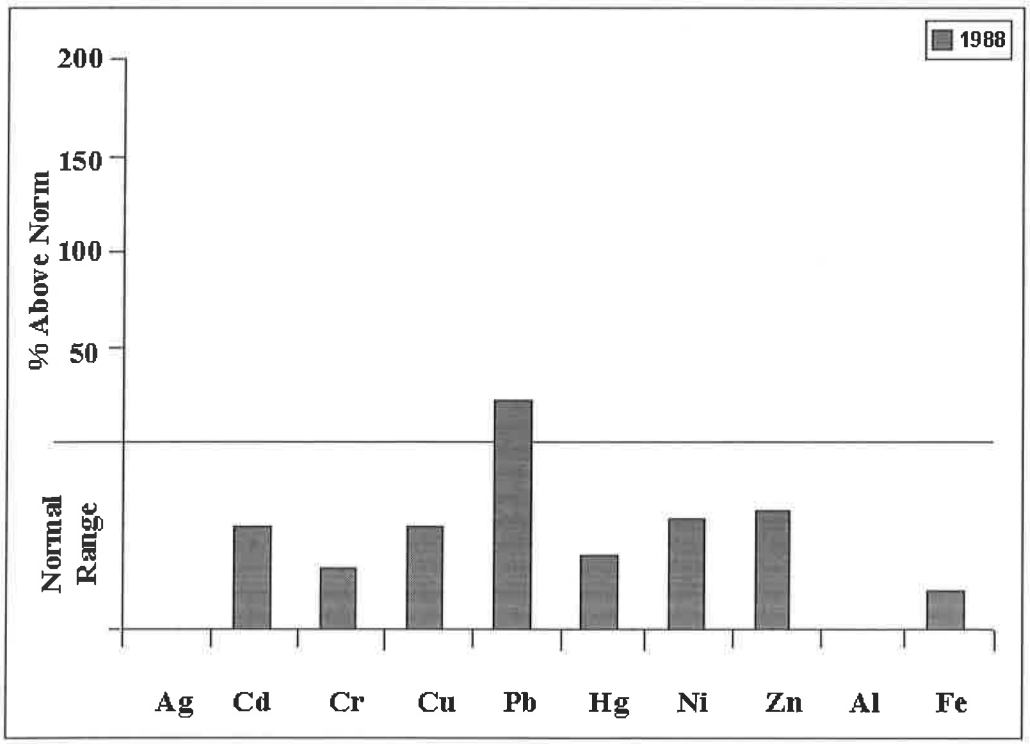
Madockawanda Road to Falmouth Town Landing

The land in this area is moderately developed. The area is largely residential. The shore has a rocky intertidal zone and mud subtidal zone. The shore drops off to 20-ft. deep water.

Discharges to this sample area are not known. However, in this stretch of coastline are approximately 1000 boat moorings. One boat yard, yacht club and town landing result in substantial boating activity.

Antifouling and anticorrosive paints and anodes used on boats release metals to the water. Due to contamination reported from boating activity in other parts of the country, results from this area were expected to be above average.

Sample results indicate that all metals were at or below the Casco Bay average suggesting that this does not appear to be a problem in this area which has fairly unrestricted water movement.



CBANAN

Actual Concentration (µg/g dry weight) of Heavy Metals

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.40	0.90	5.5	5.40	0.15	1.7	75	.	150

Back to Toxic Report

Falmouth Foreside
Falmouth Flats (CBFFFF)
Falmouth

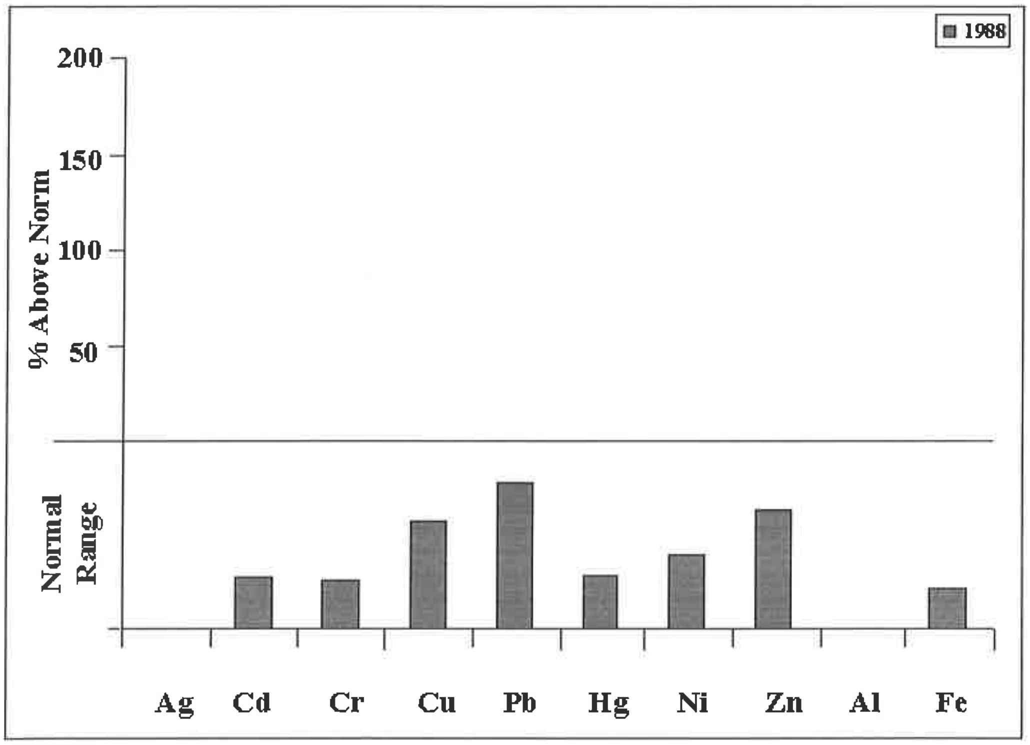
CHART **N 43° 42'58" W 70° 13'17"**

Mackworth Bridge to Portland Country Club

This area is composed of soft (mud and sand) sediments with an expansive intertidal zone.

Land in the sample area between the Portland Country Club and the Mackworth Island Bridge is mostly developed. Land use is about half residential and half golf course. There are no known direct discharges to the area.

All metals analyzed were found to be within the normal range and below metal health action levels indicating that metal contamination in the area does not appear to warrant concern.



CBFFFF

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	0.70	0.70	5.7	3.40	0.11	1.1	75	.	150

Back to Toxic Report

Mill Creek
Mussel Cove (CBMCMC)
Falmouth

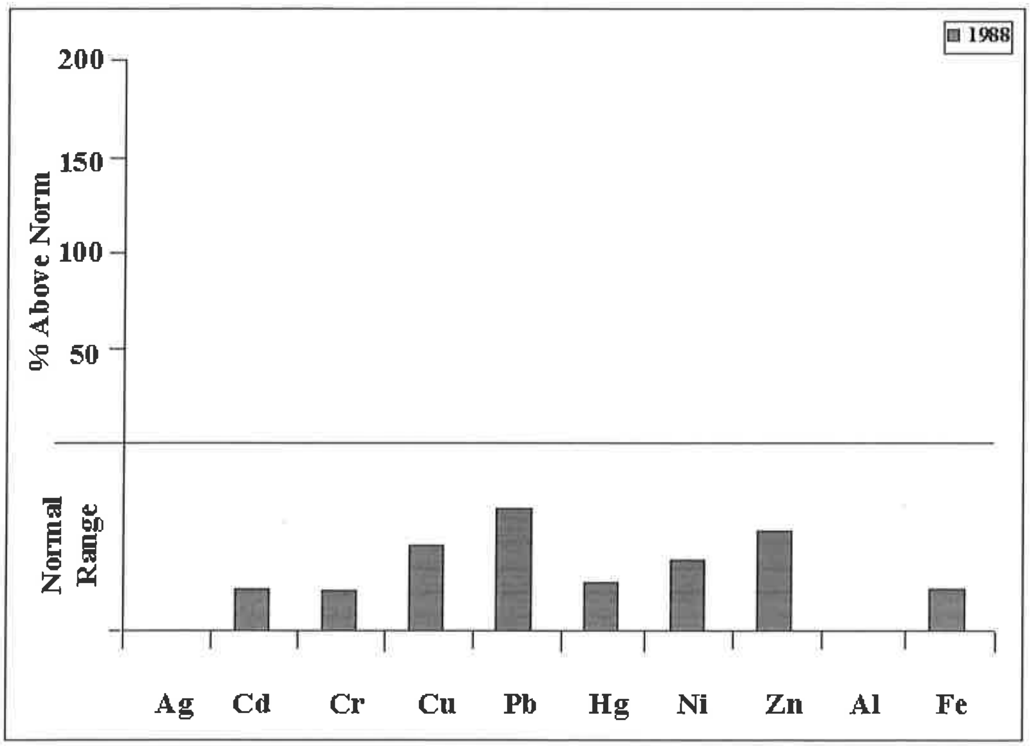
CHART **N 43° 43'11.1" W 70° 13'19.2"**

Mill Creek-Mussel Cove

Mussel Cove, actually an estuary, has a drainage area of 5.4 square miles. The area is comprised largely of intertidal mud flats and is commercially harvested for softshelled clams.

Land use in the drainage area has changed dramatically over the past 15 years. Development has historically been residential however there continues to be considerable commercial development especially along Route 1. There are no known direct discharges, however, the Route 1 business corridor contains large areas of impervious surfaces including those of two shopping centers. This all drains into Mussel Cove.

Sample results from 1988 indicate that the concentrations of metals in mussel tissues are well within the normal baseline conditions. The 1988 data provide a good baseline for comparison to future sample results as development in the area continues. We recommend follow-up monitoring.



CBMCMC

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	0.60	0.60	4.6	2.90	0.10	1.1	64	.	160

Back to Toxic Report

Harraseekett River
(CBHRHR)
Freeport

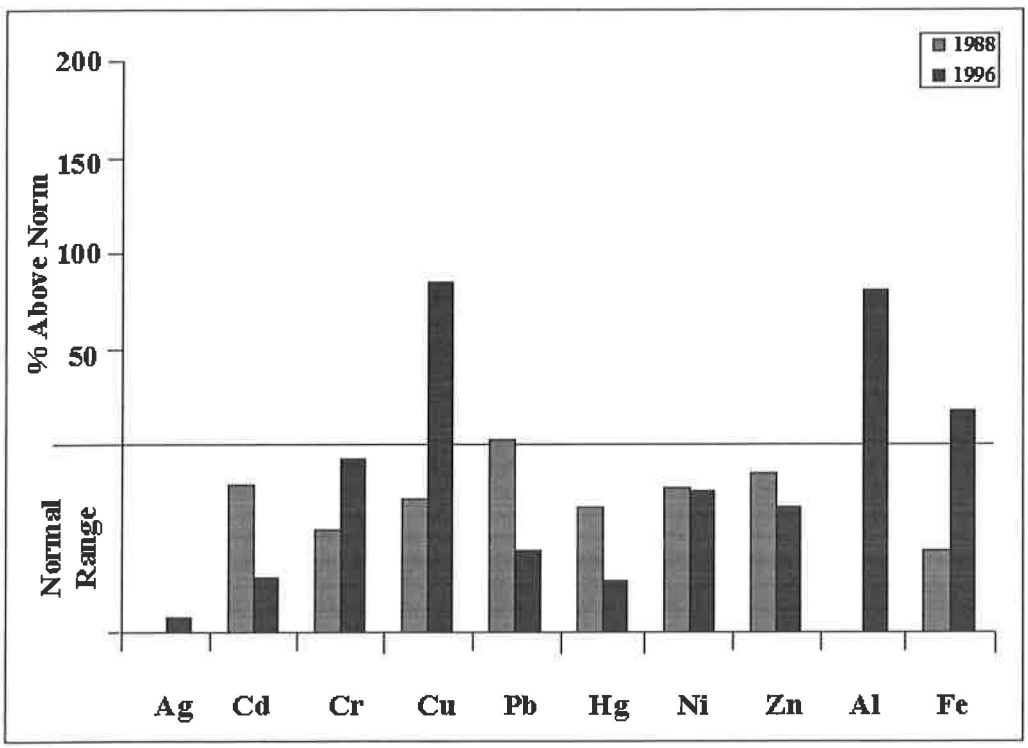
CHART **N 43° 49'23.8" W 70° 5'57.5"**

Harraseeket

The Harraseeket River is actually a semi-enclosed tidal embayment with minor freshwater inflow from Frost Gully Brook (drainage area 2 square miles). The bottom is soft and contains a commercially productive shellfish area.

The watershed for this area contains a mix of residential and urban with the town of Freeport's stormwater draining to the embayment. In addition, the municipal treatment plant discharges. The harbor is used as an anchorage and marina for over 500 boats.

Of particular interest is the change in lead concentrations from 1988 to 1996. In 1988, lead was considered elevated and just above the action level set for protection of human health. Only a single sample was collected, however, inadequate to draw a firm conclusion. The 1996 samples were collected in quadruplicate and all are well within the normal range and more importantly below the health action level. Copper is also elevated in 1996, however, does not pose a health risk. Also noteworthy is the fact that iron and aluminum are elevated indicating that the mussels collected contained sediment in their gut thus inflating some of the values.



CBHRHR

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	2.00	1.50	7.1	4.50	0.25	2.2	100	.	310
1N	1996	0.03	0.49	2.5	14.9	1.972	.13	2.87	88	896	1073
2N	1996	0.01	0.57	2.2	16.2	2.029	.13	2.06	77	625	854
3N	1996	0.01	0.51	3.0	27.0	1.714	.13	2.13	78	673	806
4N	1996	0	1.39	2.3	16.1	2.083	.01	1.58	72	467	649

Back to Toxic Report

Little River
(CBLRLR)
Freeport

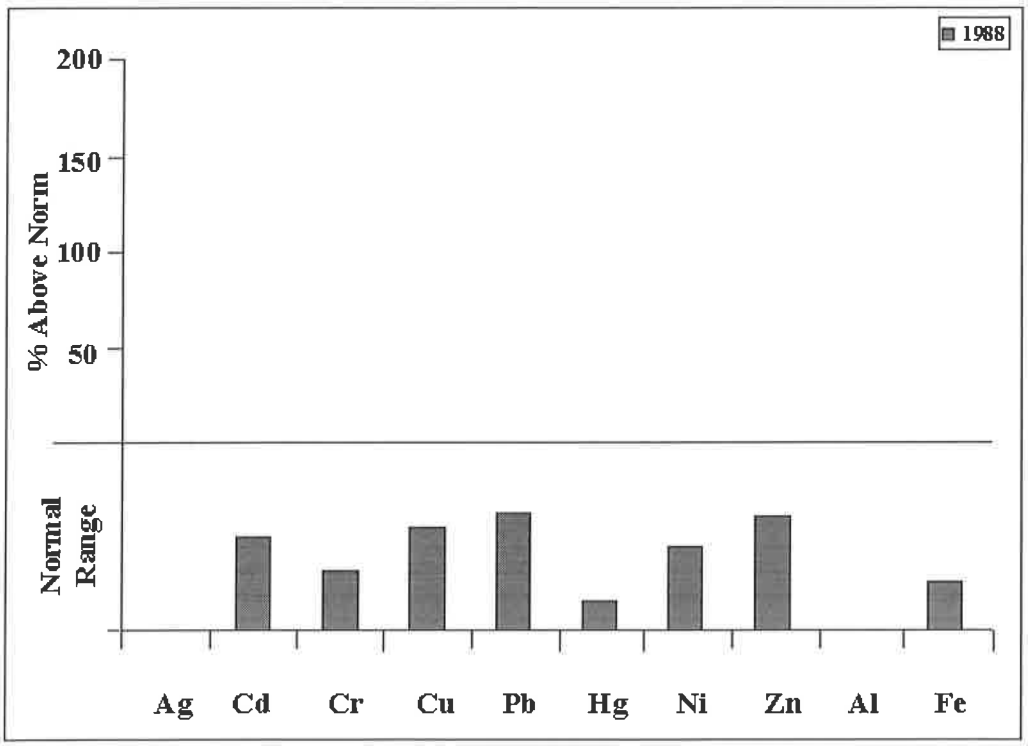
CHART **N 43° 49'36.5" W 70° 4'33"**

Little River

The Little River sample area is an embayment adjacent to and east of the Harraseeket River. It is mostly a mud bottom and contains extensive eelgrass beds. Like the Harraseeket, the Little River itself is small (drainage area 2 square miles) so that freshwater inputs are small.

Landuse in the area is mostly residential or undeveloped. No discharges are known to exist.

Mussel tissue analyses for all metals were within the normal background range.



CBLRLR

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.30	0.90	5.6	2.80	0.06	1.3	75	.	190

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Harpswell
Navy Pier (CBHWNP)
Harpswell

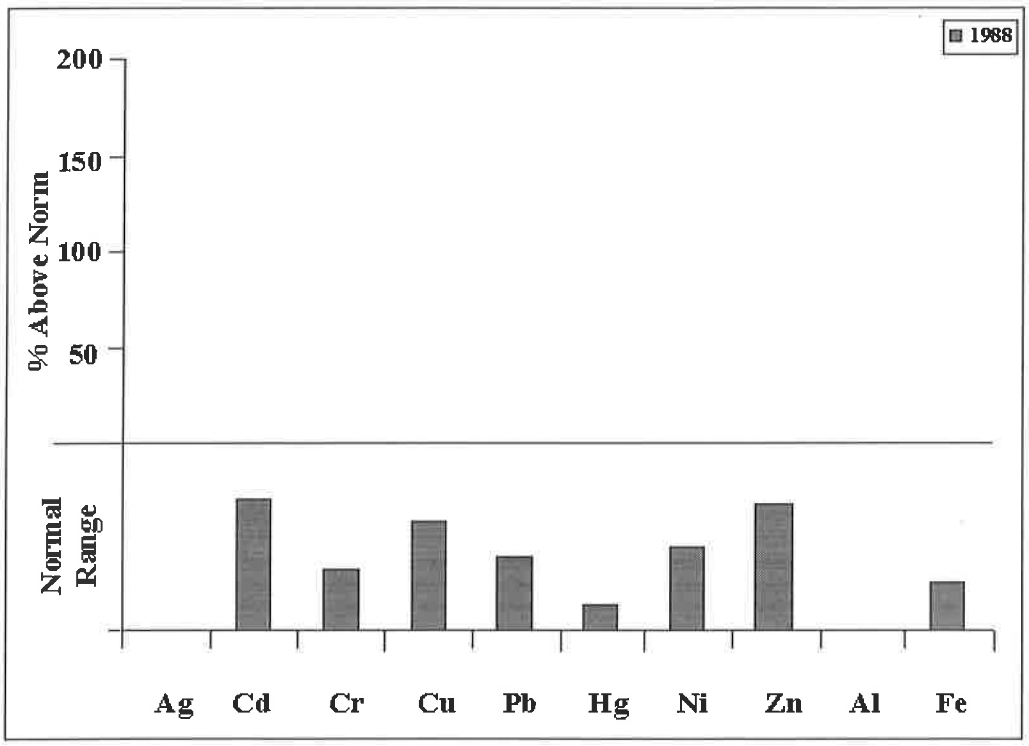
CHART **N 43° 47'13.3" W 70° 00'48.9"**

Harpswell-Navy Pier

The area of the former Brunswick Naval Air Station fuel depot on Harpswell Neck is sandy bottomed with ledge and boulders interspersed in the intertidal zone. The area begins at the north end of Curtis Cove and runs to the unnamed point immediately north of the wharf. Mussels were rare, possibly because this is a high-energy area exposed to southwest winds and a long unprotected fetch.

In addition to the fuel transfer station, landuse in the area is mostly residential.

Concentrations of metals were within the normal range.



CBHWNP

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.80	0.90	5.8	1.80	0.05	1.3	81	.	190

Back to Toxic Report

Quahog Bay
(CBQHQH)
Harpswell

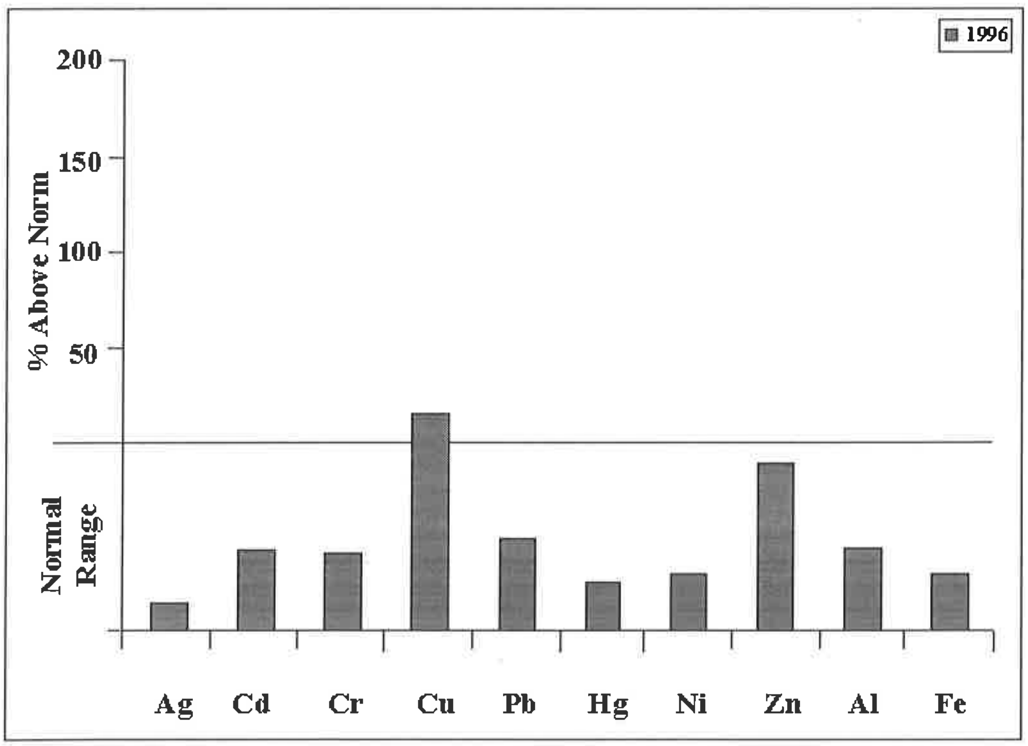
CHART **N 43° 49'7.6" W 69° 54'57.5"**

Pinkham Point-Quahog Bay

Quahog Bay is a closed tidal embayment with a small watershed. Flushing in this bay is somewhat less than most of the rest of the coast. The shore is a mixture of gravel, cobble and boulder interspersed with many bedrock outcrops. Mussels were collected near Pinkham Point and Pole Island.

The watershed is principally residential. There is a boatyard at Pinkham Point for lobster and recreational boats.

Although copper exceeded the normal range, there is reason to believe that copper may have contaminated the sample during the sample preparation phase of analysis. Follow-up samples are recommended. All other metals are within the normal range.



CBQHQH

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1996	0.02	1.16	1.3	11.3	2.33	.09	1.09	111	175	236
2N	1996	0.04	0.98	1.2	12.1	2.283	.08	.71	109	147	209
3N	1996	0.02	1.10	1.0	10.8	2.062	.10	.67	113	153	206
4N	1996	0.04	1.06	1.0	12.1	1.981	.11	.99	92	170	215

Back to Toxic Report

Back Bay
(CBBBBB)
Portland

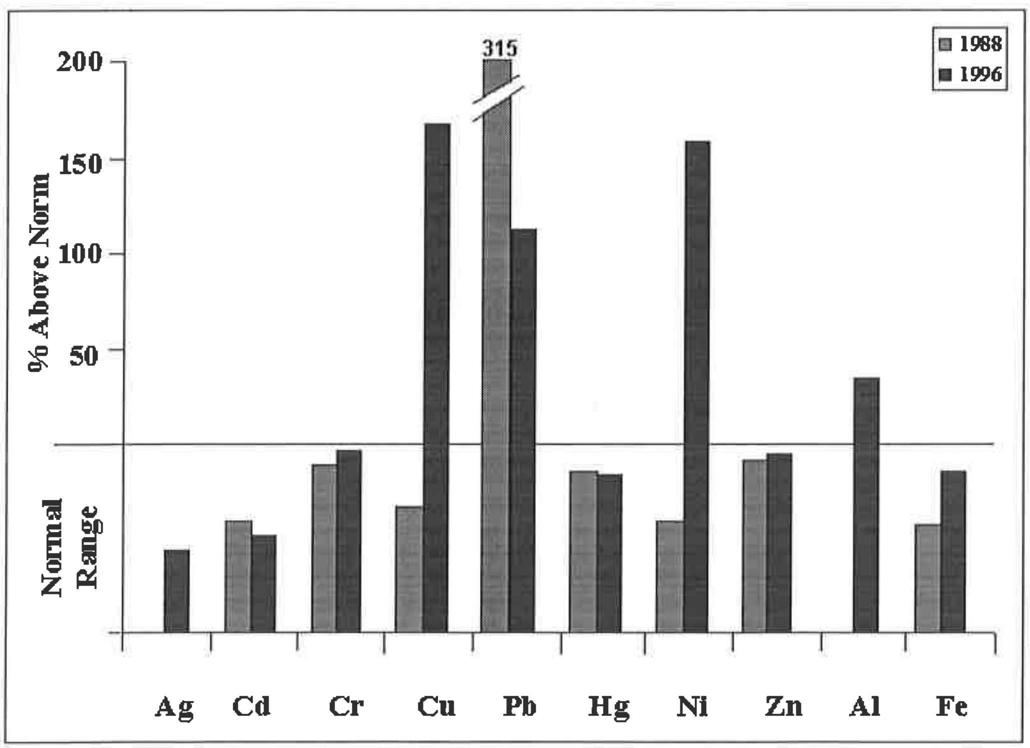
CHART **N 43° 40'43.9" W 70° 15'35.4"**

Back Cove

A shallow tidal mud flat, Back Cove has been filled in over the past hundred years. Today it is a fraction of its original size. Until mid 1970, much of Portland's wastewater flowed directly into Back Cove. Today it is popular recreationally, especially among windsurfers. Back Cove also offers an important marine worm habitat. It is an important migratory waterfowl wintering and stopover area and is designated a wildlife sanctuary.

Land use in adjacent areas is heavily residential. Although sanitary wastewater discharges have been controlled, stormwater continues to discharge to the Cove. In the past few years, many debates have centered on the contribution of pollutants from the municipal snow dump on the shore of Back Cove and its effect on the biota.

Mussels were collected along the east shore adjacent to the main channel and up two central channels. Metal concentrations are generally higher than the Cask Bay average. When first sampled in 1988, lead was highly elevated (315% above the normal range). Eight years later, after the phase-out of leaded gasoline, lead had dropped to 120%. Copper and nickel concentrations are also highly elevated; however, we have no explanation for these large differences. Follow-up samples must be collected to verify levels of these two metals.



CBBBBB

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.50	2.50	6.7	14.00	0.32	1.7	110	.	410
1N	1996	0.08	0.73	2.1	46.0	7.397	.29	14.62	134	447	562
2N	1996	0.14	2.84	4.5	21.9	18.91	.37	3.92	133	759	922
3N	1996	0.08	0.94	2.0	18.1	5.714	.30	6.41	86	342	481
4N	1996	0.08	0.77	2.3	22.4	6.094	.31	5.19	102	425	498

Back to Toxic Report

Great Diamond Island
Southwest End (CBGDSW)
Portland

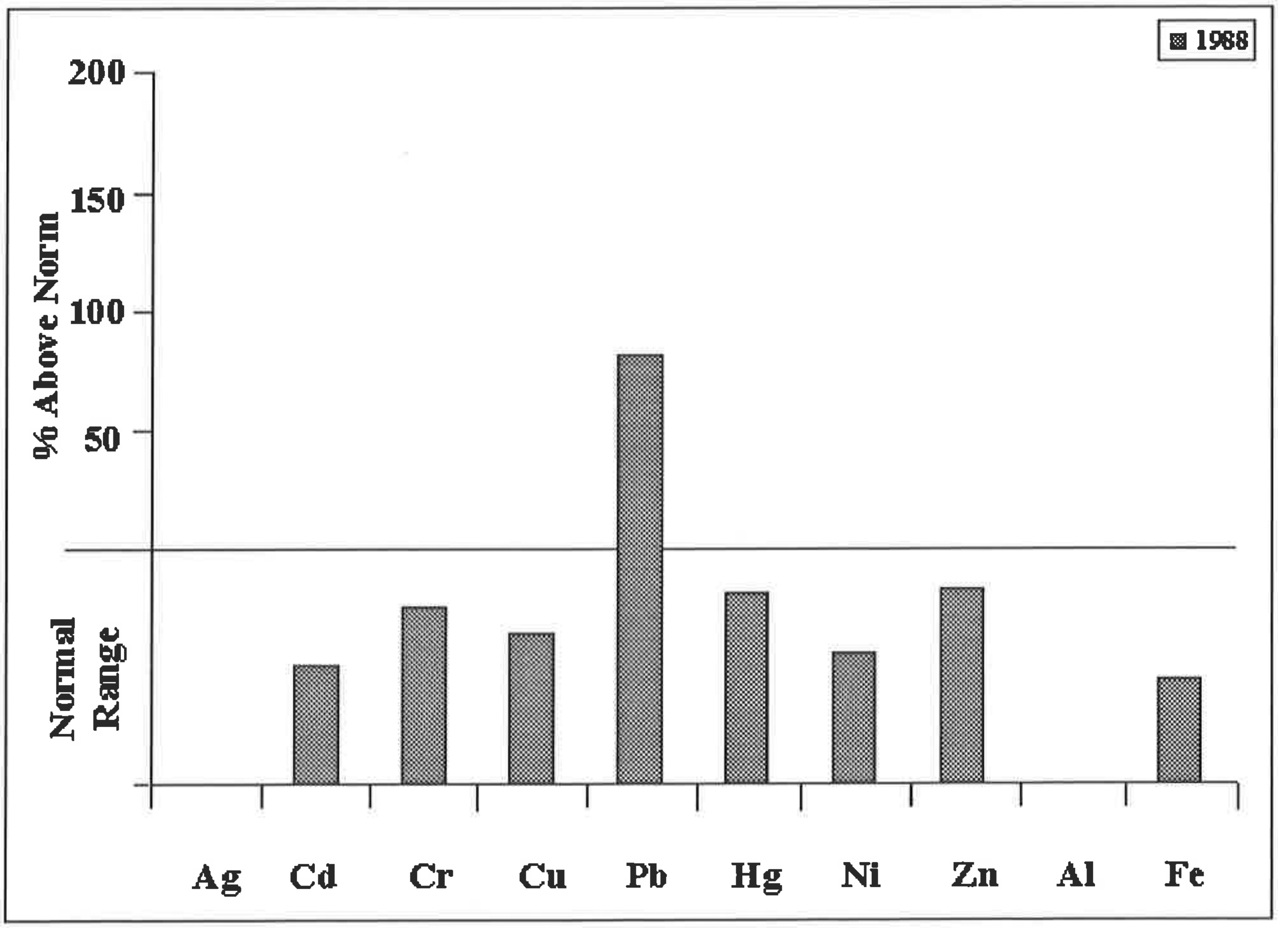
CHART **N 43° 40'41.2" W 70° 11'24.7"**

Great Diamond Island-S.W. shore

The western shore of Great Diamond Island is a mixture of sand and gravel beaches and rocks. Mussels were collected from the southwestern tip to where the pipeline and cable enters the island.

Landuse is typically residential. While no current industrial sources of contamination are known the island was used by the U.S. Navy during World War II.

Lead in the single sample was elevated in 1988 and also exceeded the health action level. We recommend that replicate samples be taken to update this data because of the potential risk to human health.



CBGDSW

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.30	2.10	6.4	8.10	0.31	1.6	100	.	320

Back to Toxic Report

Presumpscot River
(CBPRMT)
Portland

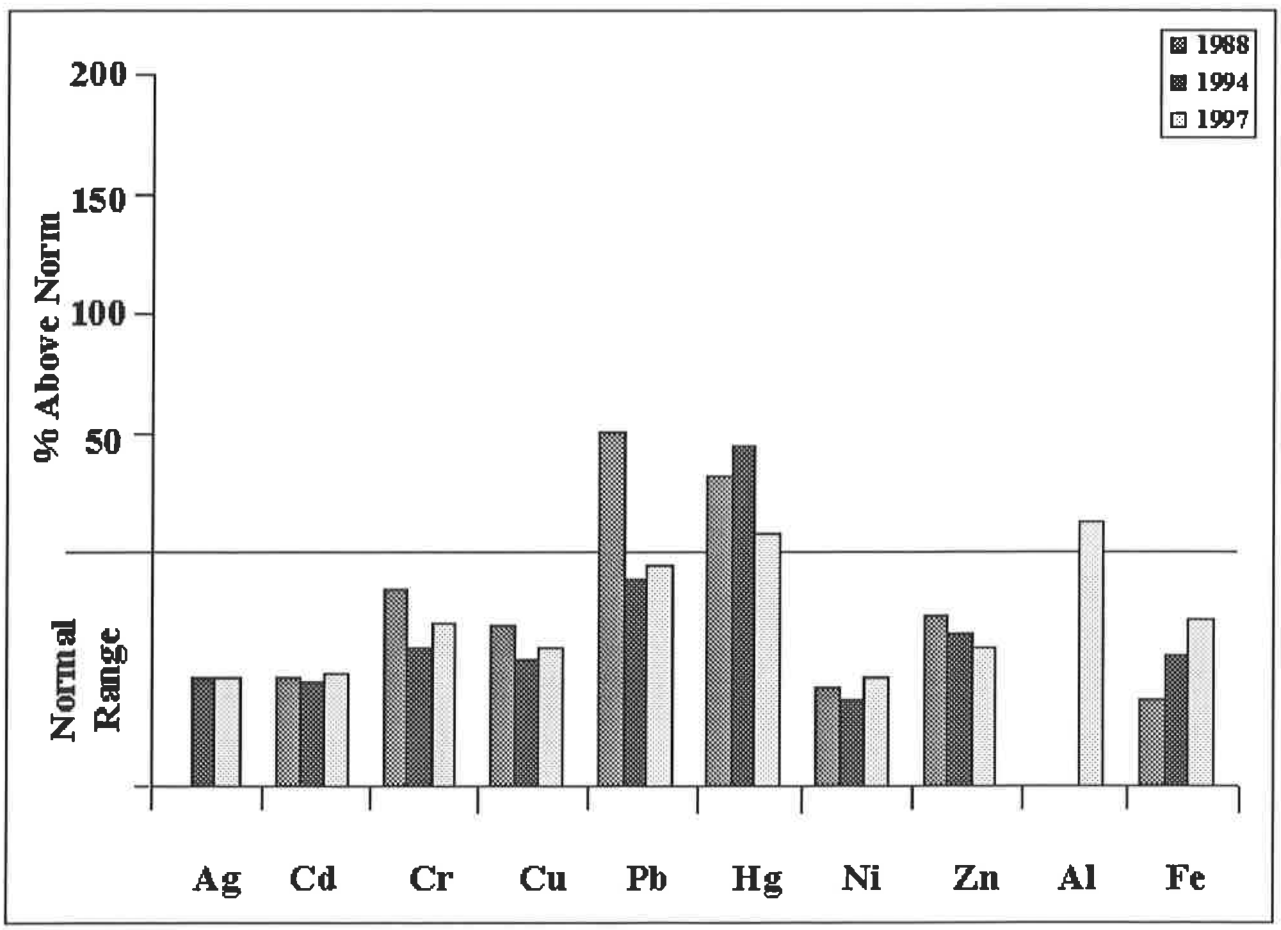
CHART **N 43° 41'36" W 70° 15'00"**

Presumpscot Estuary upstream of Martin Point Bridge

The Presumpscot Estuary has a drainage area of approximately 647 square miles and receives water from the Presumpscot and Squideregusset Rivers. The estuary is mostly intertidal mud flats to head of the tide at Smelt Hill Dam. This habitat is an important feeding area for migratory waterfowl.

Land use around the immediate perimeter is largely residential. Interstate 95 borders the western shore. Although there is moderate development upstream, much land remains forested and undeveloped. One pulp and paper mill, the city of Westbrook, and the town of Falmouth discharge treated waste to the Presumpscot River estuary.

Mercury has been and is currently elevated. Although not elevated today, lead was elevated in 1988 and although within the normal range more recently, is close enough to the health action level to warrant futher analysis if this area is considered for shellfish harvest. Historically, mercury was used as an antifungal agent in the pulp and paper process. Residual material may be present in estuarine sediments in sufficient quantity to be picked up by mussels through resuspension in the water column.



CBPRMT

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.20	2.30	6.8	6.70	0.50	1.2	87	.	270
1N	10/19/94	0.10	1.10	1.40	4.2	3.40	0.13	1.0	60	.	350
2N	10/19/94	0.10	1.00	1.50	5.5	3.40	0.12	0.9	79	.	390
3N	10/19/94	0.10	1.20	1.80	6.4	4.80	0.75	1.1	89	.	440
4N	10/19/94	0.10	1.20	1.80	5.3	4.00	1.20	1.3	80	.	420
1N	1997	0.1	1.1	1.7	5.3	3.9	0.43	1.2	75	370	440
2N	1997	0.1	0.9	1.7	4.5	3.4	0.25	1.2	56	380	430
3N	1997	0.1	1.4	2.4	7.6	5	0.68	1.4	79	500	670
4N	1997	0.1	1.5	2	5.7	4.5	0.27	1.5	67	410	510

Back to Toxic Report

Jewell Island
Punchbowl (CBJWPB)
Portland

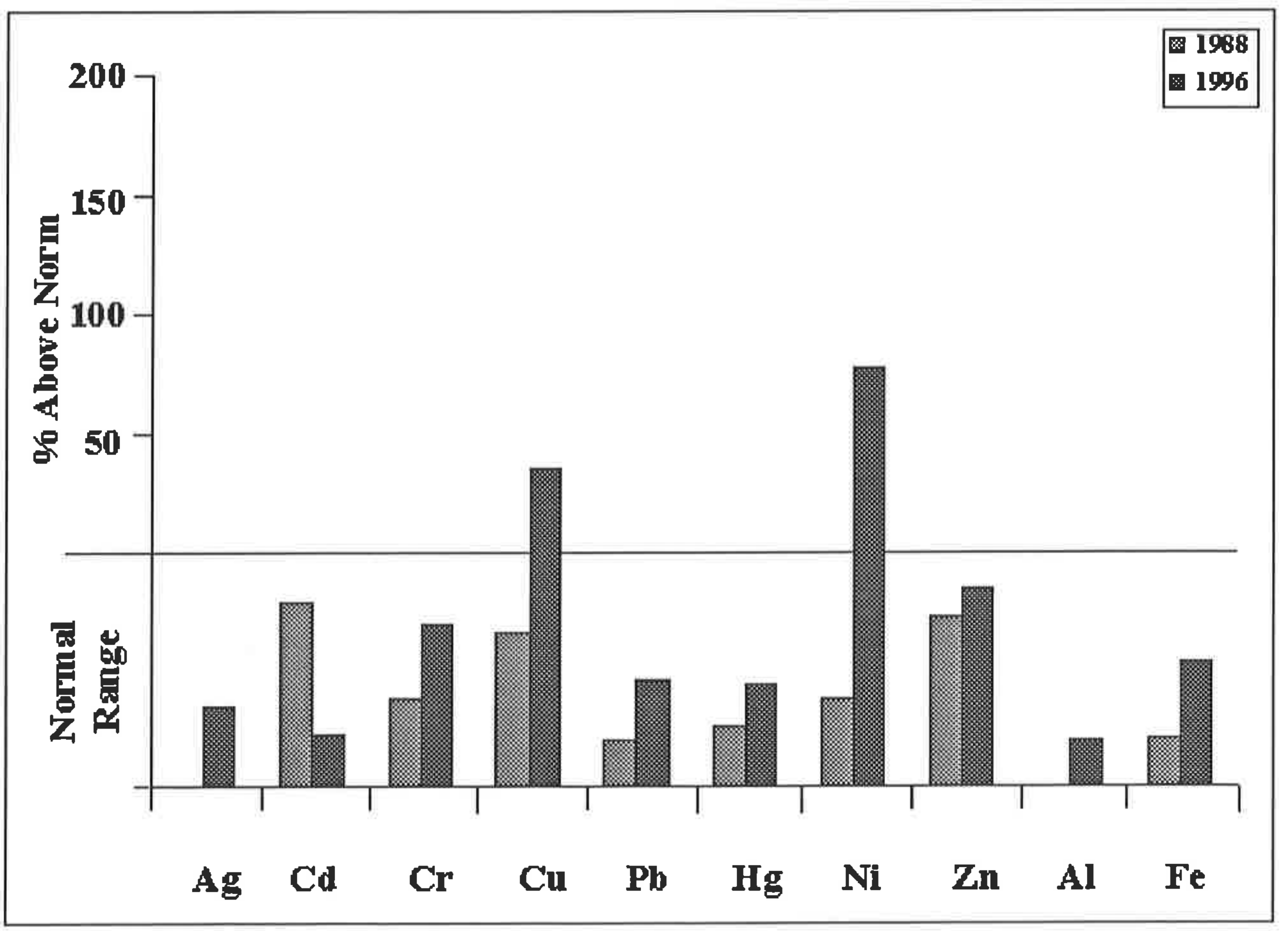
CHART **N 43° 41'9.4" W 70° 5'19.8"**

Jewel Island Punchbowl

Because of its distance from sources of pollution, the Punchbowl was selected as a reference station to establish the original baseline. It is located on the ocean side (east) of Jewell Island in the protected Punch Bowl. The island lies about 5 miles offshore from the mainland. The habitat is rocky and faces open ocean.

The entire island is a Maine Public Reserved Lot and has no development. During World War II, however, the island supported an active lookout and gunnery site.

The recent data from 1996 indicate that copper and nickel are elevated and is inconsistent with the site as a reference station. We recommend sampling again to verify whether these elevated levels are accurate.



CBJWPB

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	2.00	1.00	6.9	0.80	0.16	1.0	87	.	150
2N	1988	.	2.00	1.10	6.4	1.00	0.03	1.2	86	.	150
1N	1996	0.08	0.35	1.6	12.6	1.528	.17	7.78	104	60	346
2N	1996	0.07	0.44	1.7	17.5	2.639	.17	2.60	118	88	408
3N	1996	0.09	0.49	3.0	11.3	1.857	.17	3.84	94	64	413
4N	1996	0.07	0.99	1.4	12.7	1.944	.16	6.31	91	68	374

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East End Beach
(CBEEEE)
Portland

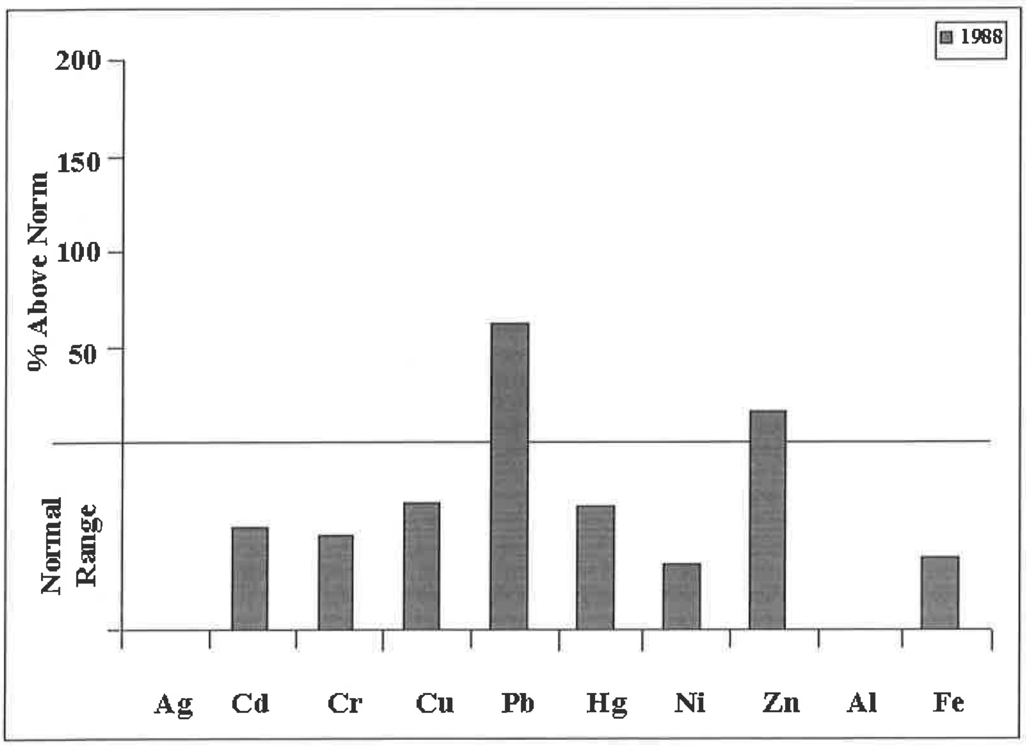
CHART **N 43° 40'15.9" W 70° 17'39.7"**

Fish Point to East End Beach Jetty

The shore off Portland's East End Beach area is composed of a mixture of fine and course rubble, much of it fill from the old city dump. The ocean bottom is soft and shallow.

Land use in the area is dense residential. Water quality is believed to be affected by urban runoff, discharge from the Portland Municipal Treatment Plant just several hundred yards to the southwest of Fish Point, and possibly leachate from the dump and pollutants carried down the Presumpscot River.

With the exception of lead and zinc, heavy metal concentrations in samples from the East End Beach area were slightly above the Casco Bay average. Lead and zinc are both elevated, as is typical of most areas adjacent to urban industrial areas of the coast. Although lead exceeds the human health action level, a single sample must be viewed with caution. The area is already closed to the harvest of shellfish. We recommend replicate samples be collected if the area is considered for any type of digging.



CBEEEE

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.40	1.40	6.8	7.30	0.25	1.0	140	.	280

Back to Toxic Report

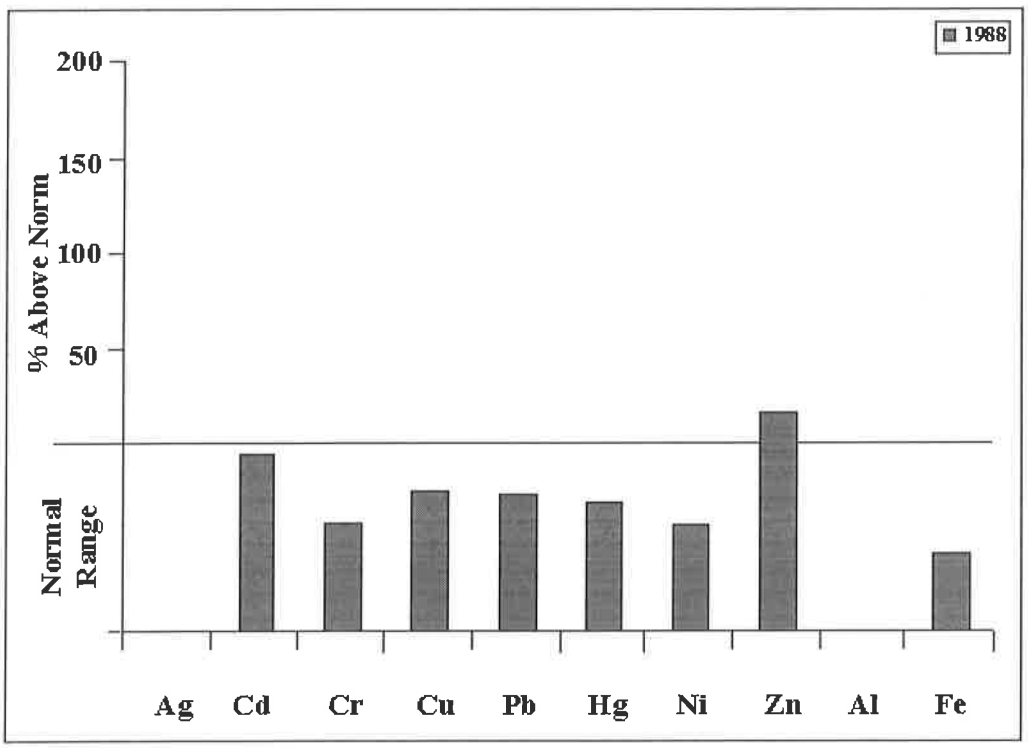
Fore River
Inner River (CBFRIR)
Portland / South Portland

CHART **N 43° 38'30.5" W 70° 16'26.6"**

Upstream of I-295 Bridge

This shallow portion of the inner Fore River contains variable salinities. Because the sample area consists of the predominantly soft mud bottom and receives freshwater inflows from the Stroudwater River, it is not ideal mussel habitat. However, these tidal flats and wetlands are important waterfowl areas for migratory species. The watershed is moderately urban with most of existing development occurring immediately adjacent to the estuary. Although development in the immediate vicinity is primarily residential and commercial, industrial influences from farther upstream are known to affect water quality. Silvex (formerly Maine Metal Finishing) discharged heavy metals directly to the river until 1985. This abandoned site is thought to continue to pollute the river indirectly through the groundwater.

With the exception of zinc, metal concentrations are within the normal range. Zinc is commonly associated with road runoff, zinc also being a common constituent of tire material. Bordering the estuary are the Portland International Jetport and Maine Mall, which involve large expanses of impervious surfaces such as parking lots, highways and runways, all used by vehicles.



CBFRIR

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	2.40	1.60	7.5	3.20	0.26	1.6	140	.	290

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Fore River
Middle River (CBFRMR)
Portland / South Portland

CHART **N 43° 38'45" W 70° 15'30"**

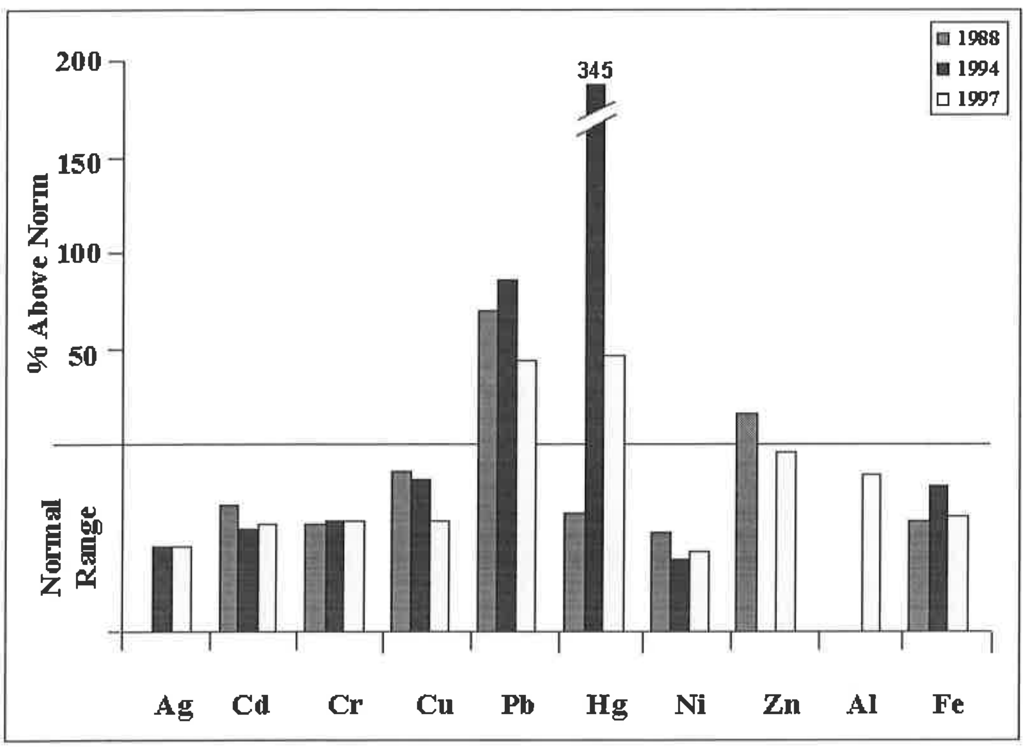
Million Dollar Bridge to I-295

The middle Fore River was selected to represent a waterbody dominated by urban and industrial landuse. The river channel is maintained for navigation and the bottom is primarily soft.

Although this portion of the Fore River has a small direct drainage area, it is densely developed. Industries are primarily oil and cargo transfer terminals. The abandoned Portland Coal Gasification Plant is heavily contaminated with coal. The South Portland Municipal Treatment Plant discharges from the south shore.

Sampling is most easily done by small boat in order to collect from various beds at low tide.

Mussels taken from this sample area contain elevated lead, mercury, and zinc, metals typically associated with urban, industrial, and maritime activities.



CBFRMR

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.70	1.60	8.6	7.60	0.24	1.5	140	.	430
1N	10/13/94	0.10	1.60	1.80	9.1	9.70	1.40	1.1	.	.	520
2N	10/13/94	0.10	1.60	1.40	8.0	8.70	1.30	1.2	.	.	720
3N	10/13/94	0.10	1.60	2.10	9.5	8.50	1.60	1.3	.	.	620
4N	10/13/94	0.10	0.90	1.30	5.7	6.30	0.94	0.9	.	.	370
1N	1997	0.1	1.2	1.3	4.8	4.7	0.53	0.98	100	240	320
2N	1997	0.1	1.7	2.1	7.4	8.1	0.62	1.4	130	340	550
3N	1997	0.1	1.2	1.1	3.7	4.9	0.56	0.9	89	230	330
4N	1997	0.1	1.8	2	7.8	7.8	0.5	1.7	140	410	550

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Fore River
Outer River (CBFROR)
Portland / South Portland

CHART **N 43° 38'39.6" W 70° 15'17.5"**

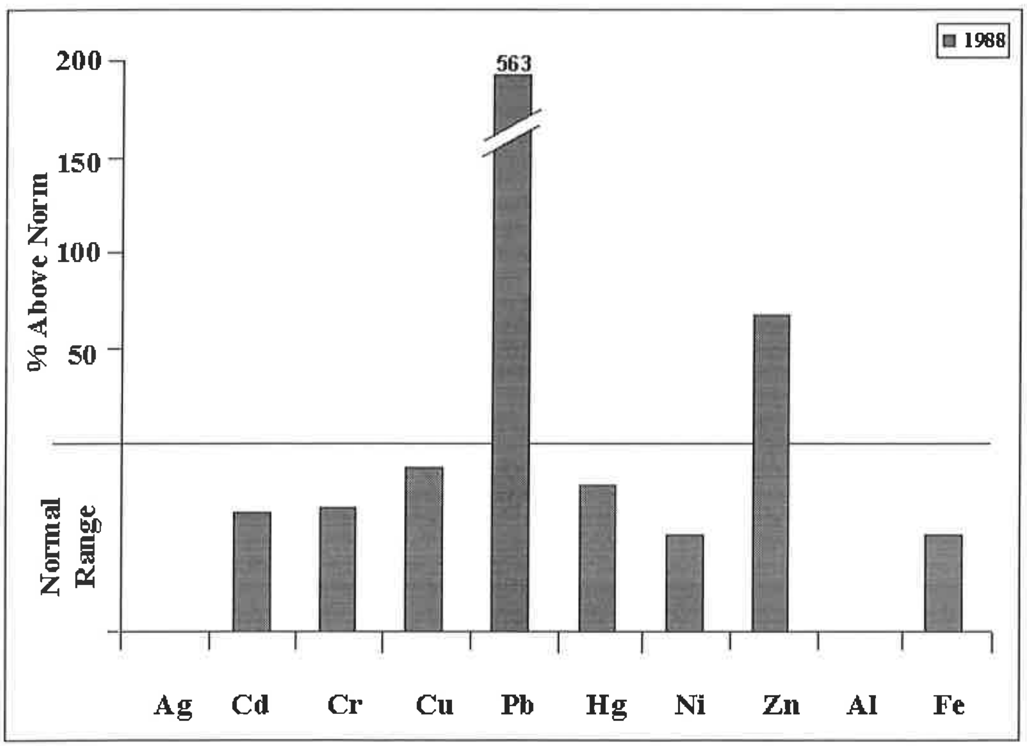
Line from Spring Point Oil Dock to BIW to Million Dollar Bridge

The outer Fore River, more commonly known as Portland Harbor, has historically been the center of Portland's and South Portland's industrial activity. This area contains a variety of marine habitats, many of which have been altered by dredge and fill activities. Few of the original tidal flats and wetlands remain. The bottom is predominantly soft.

Land use in the immediate vecinity is densely urban. The adjacent land hosts a diversity of both marine and non-marine related residential, commercial, and industrial development. Industrial use is heavy and comprised of oil storage, shipyards, marine railways, fishing docks, yacht clubs, and an abandoned power plant. The shore frontage also hosts condominiums, and year round marinas.

Urban stormwater and combined sewer overflows discharge to this section of the bay. This has resulted in the closure of this harbor to the taking of shellfish due to the high potential for contamination by human pathogens.

As expected, mussels from this sample event contained elevated levels of heavy metals when compared to the bay average. Both lead and zinc concentrations exceed the 95 percentile for the bay.



CBFROR

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.60	1.80	8.6	25.00	0.30	1.5	200	.	370

Back to Toxic Report

Great Diamond Island
Cocktail Cove (CBGDCC)
Portland

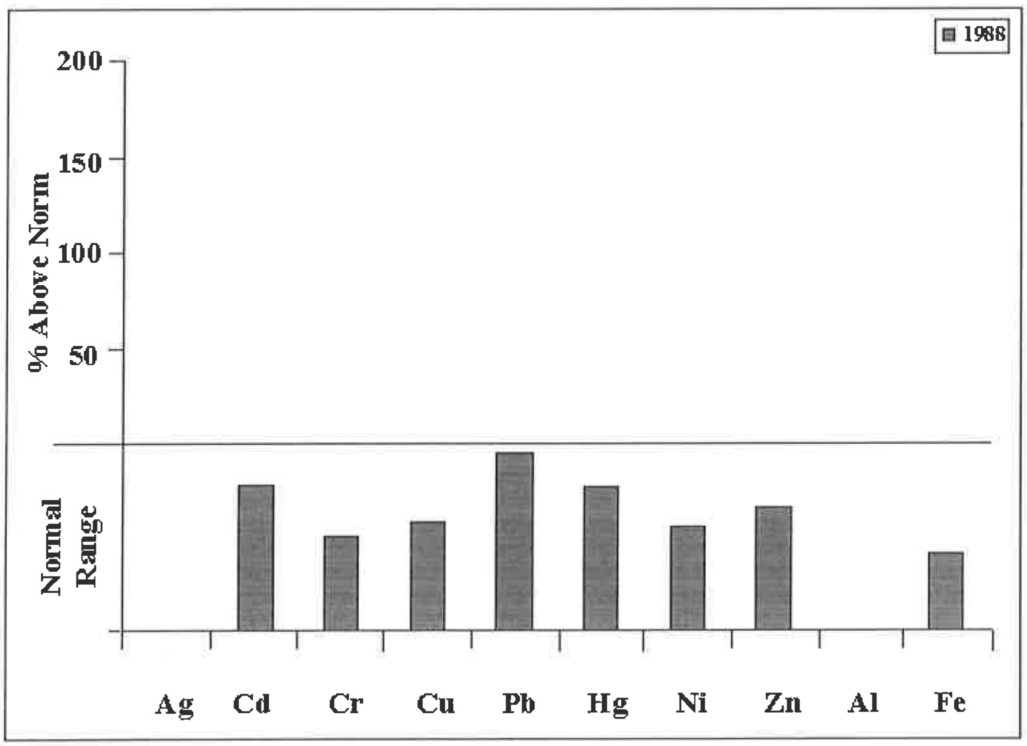
CHART **N 43° 41'2.8" W 70° 11'31.8"**

Great Diamond Island-Diamond Cove

Diamond Cove is a protected cove on the northeast corner of Great Diamond Island. The intertidal zone is ledge with gravel beaches.

This cove is heavily used in the summer by recreational boaters. When the 1988 samples were collected, surrounding landuse was mostly undeveloped. Today, a condominium project has converted the former military base into seasonal and year-round homes. The biggest change is the increase in boat traffic due to the restaurant and marina.

Results of the 1988 sampling indicated that metals in mussels were within normal concentrations. However, because the single sample of lead barely exceeds the human health action level, we advise that more samples be collected to reflect current conditions.



CBGDCC

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	2.00	1.40	5.8	4.20	0.29	1.6	78	.	300

Back to Toxic Report

Great Diamond Island
Southwest End (CBGDSW)
Portland

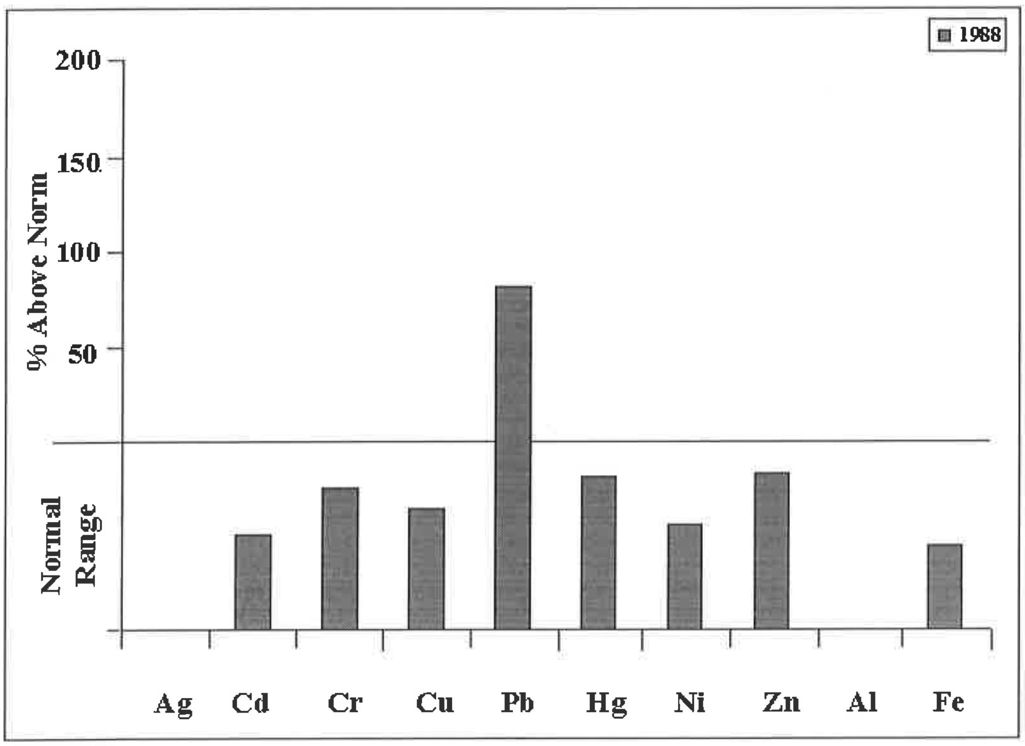
CHART **N 43° 40'41.2" W 70° 11'24.7"**

Great Diamond Island-S.W. shore

The western shore of Great Diamond Island is a mixture of sand and gravel beaches and rocks. Mussels were collected from the southwestern tip to where the pipeline and cable enters the island.

Landuse is typically residential. While no current industrial sources of contamination are known the island was used by the U.S. Navy during World War II.

Lead in the single sample was elevated in 1988 and also exceeded the health action level. We recommend that replicate samples be taken to update this data because of the potential risk to human health.



CBGDSW

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.30	2.10	6.4	8.10	0.31	1.6	100	.	320

Back to Toxic Report

Spring Point
(CBSPSP)
South Portland

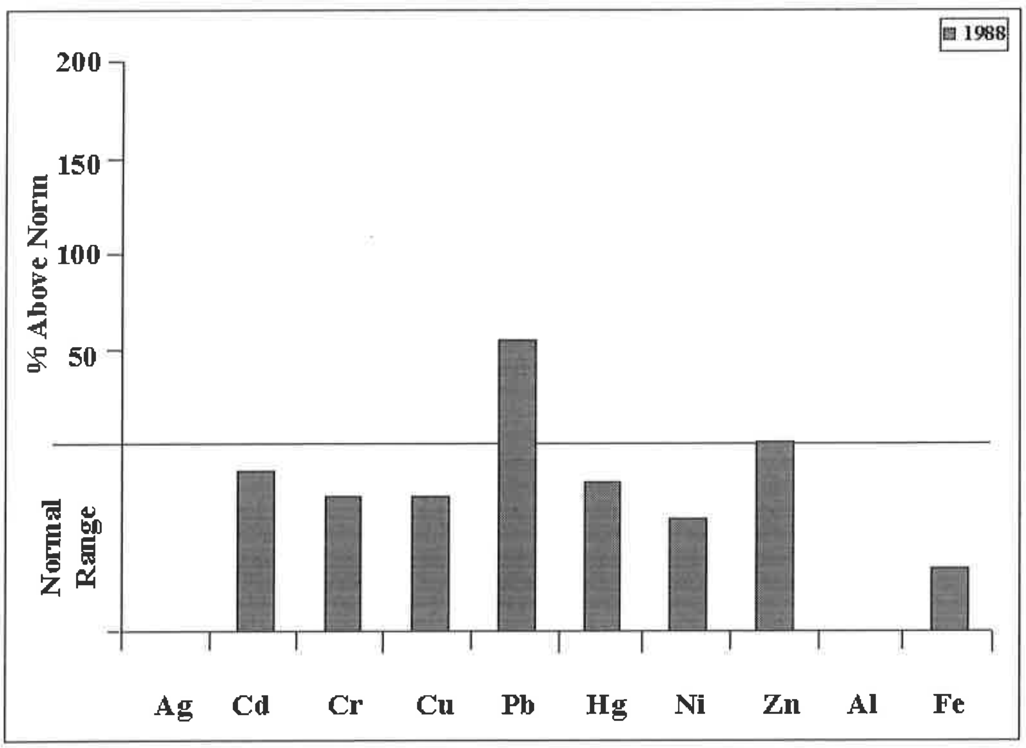
CHART **N 43° 38'57.1" W 70° 13'30.7"**

Cape Elizabeth to Spring Point

This area in South Portland is largely exposed to open ocean to the southeast, somewhat protected by Cushing, Peaks, and House Islands to the northeast. The narrow intertidal shoreline is rocky and the bottom drops off rapidly to deep water. This portion of Casco Bay has a relatively narrow intertidal zone.

Land use in the immediate area is primarily residential with adjacent industrial development. There are no known direct discharges to this reach, although urban runoff is probable and tidal currents through the channel are believed to carry pollutants from the inner harbor area past this sample area on outgoing tides.

Mussel metals levels in 1988 were typical of being downcurrent of an urban/industrial area. Lead was elevated and also exceeded the health action level. Because this was an old and single sample, we recommend that the area be resampled with replicates. One would expect that lead has declined as it has in many other areas of the coast.



CBSPSP

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	2.20	2.00	7.1	6.90	0.30	1.7	120	.	240

Back to Toxic Report

Royal River
(CBRYMT)
Yarmouth

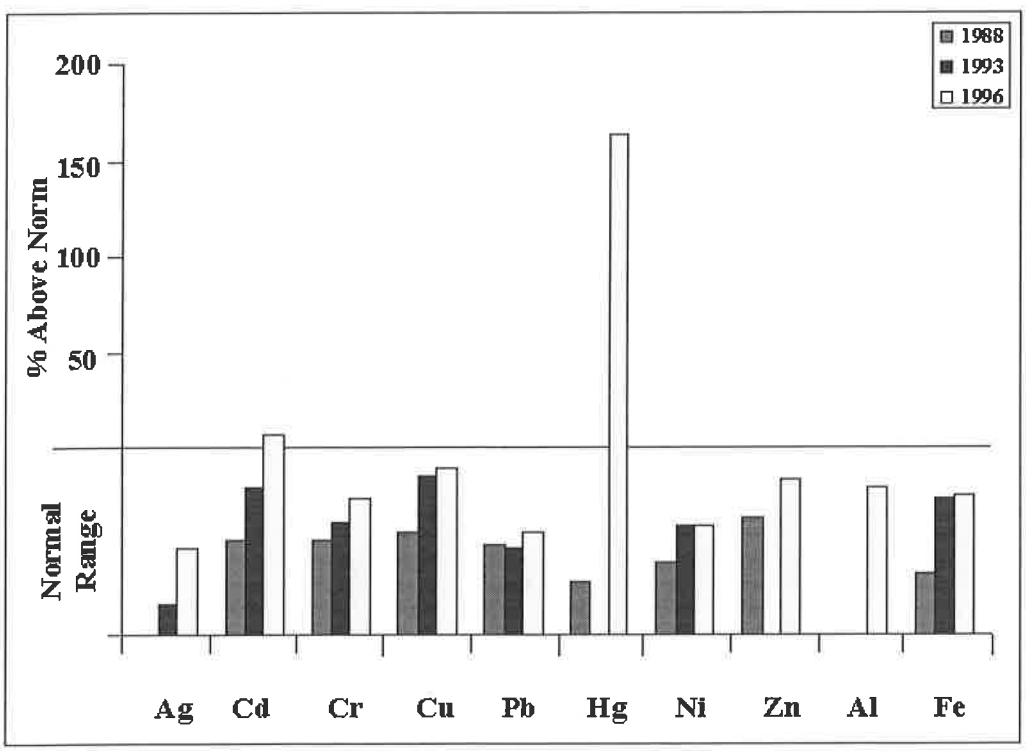
CHART **N 43° 47'48" W 70° 8'48"**

Royal/Cousins Rivers-Mouth

This area at the mouth of the Royal and Cousin Rivers is mostly mud. The drainage area of both the Royal and Cousins Rivers covers about 155 square miles. The area just offshore towards Lane's Island is harvested commercially for softshelled clams. Mussel samples were collected from both the Cousins and Royal Rivers and accessed by boat from the Yarmouth Public Landing. On the Royal River, mussel samples were collected between Browns and Parker Points upstream to the nun buoy, and on the Cousins River from between Browns and Lambert Points upstream to Powell Point.

Land use in the area is mostly rural residential with some urban development. Land along the coast remains lightly developed. The Town of Yarmouth discharges secondary treated wastewater to the Royal River and several single-family homes have overboard discharges to both the Royal and Cousins Rivers. Water related activities to these estuaries have increased over the past few years. The Royal River supports three marinas/boatyards and an anchorage area. On the Cousins River, one boatyard operates. Boating activity has increased significantly over the past decade and the harbor was dredged in 1995 and 1996 to accommodate larger boats

Prior to 1996, all metals were within the normal range. However, in 1996, all metals were above the previous concentrations and mercury was highly elevated. Disturbance of contaminant laden sediments by upstream dredging shortly before samples were collected may partly explain the increase. The mercury levels were just at or below the human health action level. This area will be sampled again in 1999 as part of the Gulfwatch Program.



CBRYMT

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.30	1.40	5.5	2.10	0.11	1.1	75	.	240
1N	9/3/93	0.04	2.31	1.76	8.5	1.87	.	1.9	.	.	484
2N	9/3/93	0.04	2.19	1.77	8.4	2.29	.	1.7	.	.	604
3N	9/3/93	0.04	1.98	1.77	8.8	2.29	.	1.7	.	.	583
4N	9/3/93	0.02	1.61	1.29	8.0	1.83	.	1.4	.	.	430
1N	1996	0.1	3.60	2.50	10.0	3.20	0.63	2.0	120	310	580
2N	1996	0.1	2.90	2.40	11.0	2.60	0.72	1.9	120	400	760
3N	1996	0.1	2.20	1.20	6.9	1.70	1.40	1.2	72	170	330
4N	1996	0.1	2.30	2.00	7.5	2.30	1.30	1.6	86	280	470

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Broad Cove
(CBBCBC)
Yarmouth / Cumberland

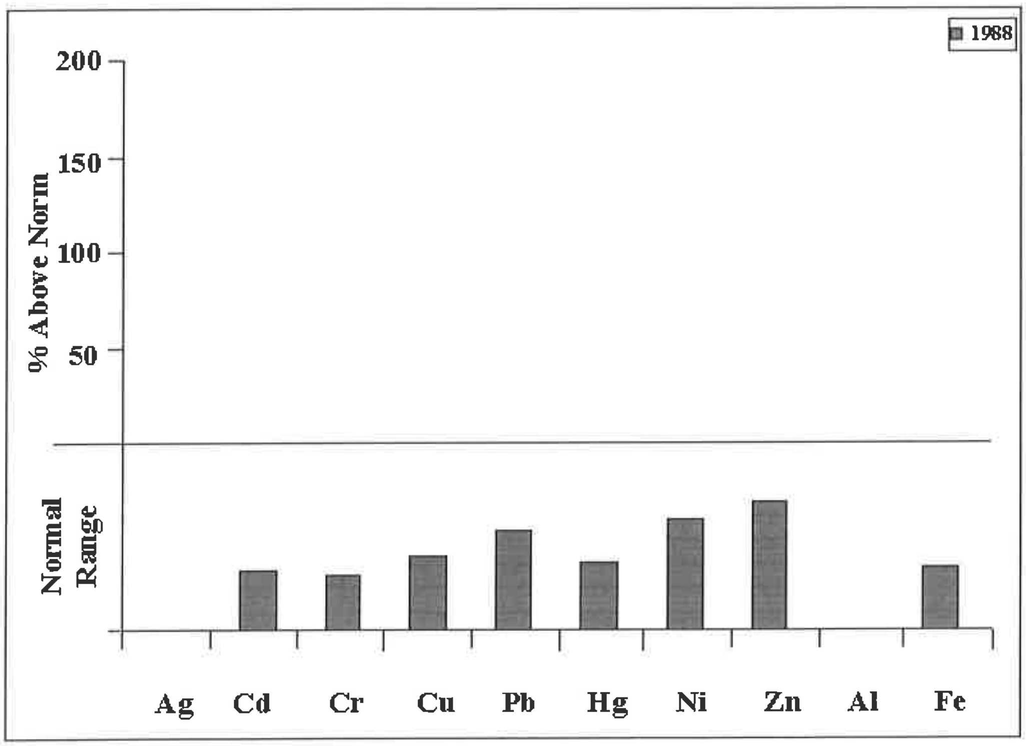
CHART **N 43° 46'57" W 70° 10'45"**

Broad Cove

This area of the bay is mostly a large intertidal mud flat adjacent to a very shallow subtidal area.

In 1988, much of the land surrounding Broad Cove was lightly developed. Since that time, many new homes have been constructed around the perimeter. Central Maine Power's oil fired electric generating Wyman Station is situated on land across from the Cove. There are no known discharges to Broad Cove.

Levels of metals in mussels collected from this area in 1988 are all well within the normal range. Given the increased development since 1988, it is advisable to sample this area again.



CBBCBC

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	0.80	0.80	3.9	2.40	0.14	1.7	83	.	240

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Cousins Thorofare
(CBTHTH)
Yarmouth

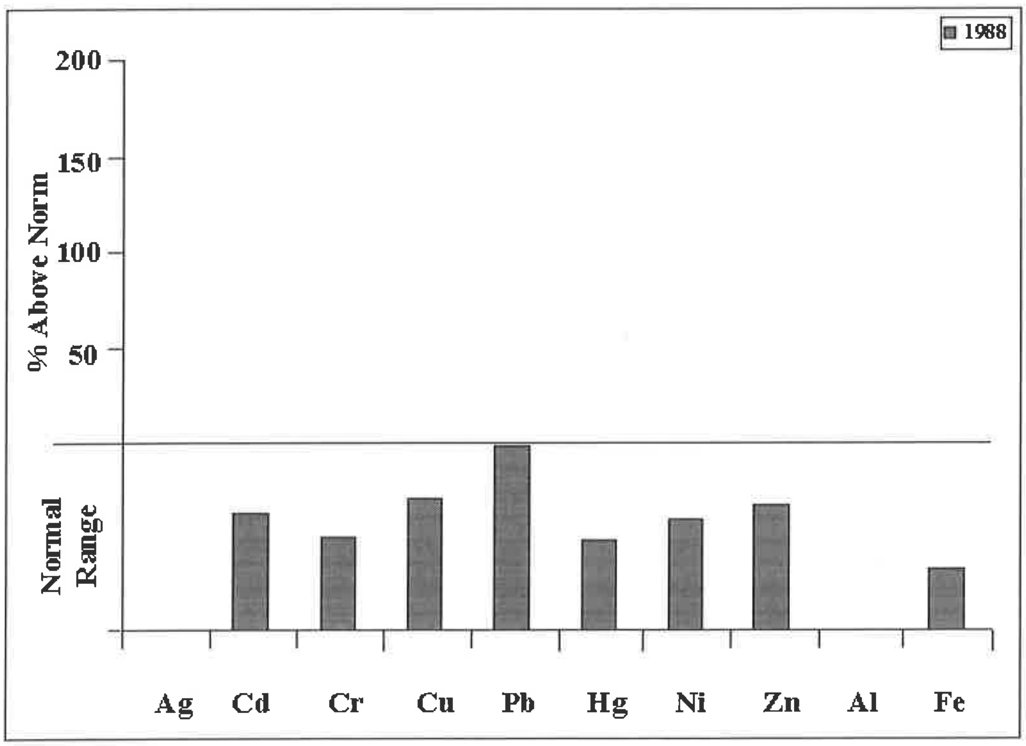
CHART **N 43° 46'5.5" W 70° 9'17.6"**

Both shores east of Cousins Inland bridge to Prince and Birch Points

This area between the mainland and Cousins consists of a composite from both sides of the thorofare. It is mostly rocky with a sand and cobble intertidal zone. Summer boat traffic is marinas on Royal River and other parts of Casco Bay. Mussels from this sample area were collected along both shores of the thoroughfare by small boat.

Land use in the area is moderately residential. Several single family overboard discharges exist, however these should be composed of sanitary waste and not contain measurable quantities of metals or other toxic contaminants. Although the cooling water discharge from the Central Maine Power Station is not within this sample area, currents carry the plume into the thoroughfare under some wind and tidal conditions.

Sample results indicate that all metal concentrations in mussel tissues fall within the Casco Bay average. However, lead, in 1988, was barely above the current lead health action level. Although we expect that today that value is less, repeated sampling should confirm this.



CBTHTH

Actual Concentration (µg/g dry weight) of Heavy Metals in Mussel Tissue

Rep No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	1.60	1.40	6.9	4.30	0.18	1.7	80	.	230

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Long Island
Fuel Terminal (CBLNFT)
Long Island

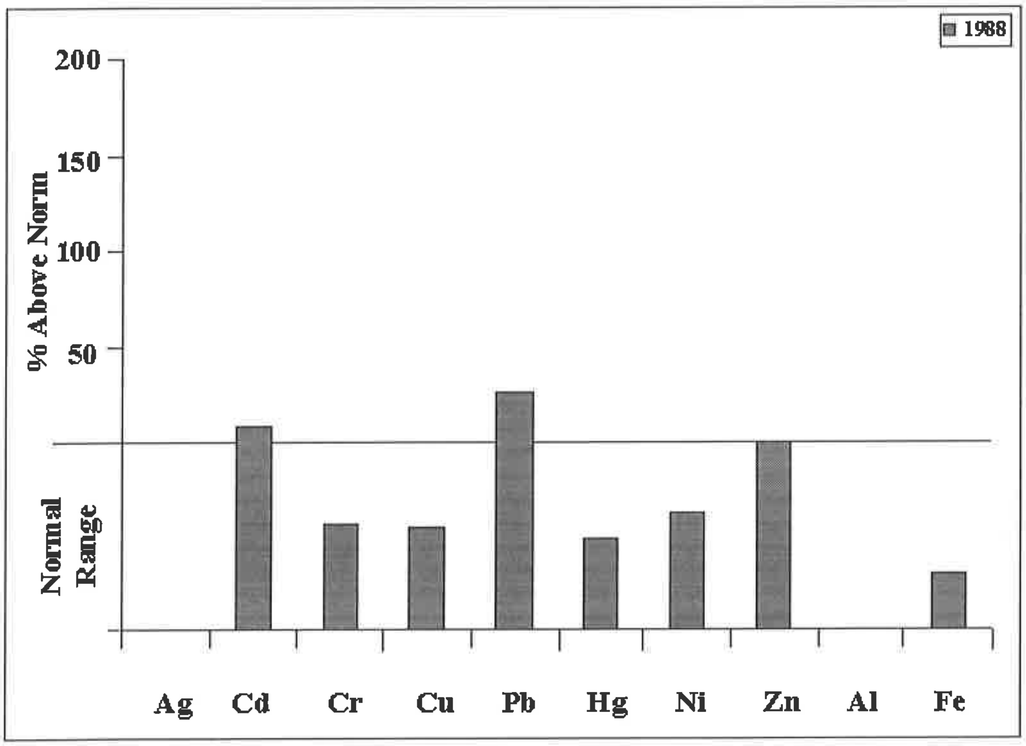
CHART **N 43°41'29.4" W 70°10'1.2"**

Long Island-Fuel Terminal

This area consists of the shore adjacent to the former Navy fuel depot (now Phoenix Resources) on Long Island at Ponce Landing. The habitat is mostly sand and gravel beach interspersed with rock outcrops.

Present land use is residential. All discharges to the area are supposed to have been removed.

Sample results indicate that lead, cadmium and zinc are outside of the normal range. This is not surprising given the history of the site. Lead is above the health screening level. Since only one sample was taken, however, and it was in 1988, we suggest follow-up monitoring to determine levels of these metals with better confidence.



CBLNFT

Actual Concentration (μg/g dry weight) of Heavy Metals in Mussel Tissue

Rep. No.	Date	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
1N	1988	.	2.80	1.60	5.5	5.60	0.19	1.8	120	.	220

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METAL CONCENTRATIONS (UG/G DRY) AT MAINE REFERENCE SITES

Station	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
BFMDSC	0.02	2.1	1.7	7.6	1.2	0.10	1.4	80		218
CBBCBC	0.05	1.1	1.0	5.4	1.5	0.22	1.5	90	120	244
CBJWPB	0.08	1.3	1.5	10.1	1.4	0.13	3.1	94	70	268
CBLRLR		1.3	0.9	5.6	2.8	0.06	1.3	75		190
ECENCH		2.2	2.4	7.8	3.8	0.01	2.3	110		760
ECENCI		1.6	1.5	7.9	2.2	0.08	1.7	81		330
ECENDN		1.7	2.2	9.5	2.9	0.02	2.1	97		680
ECENGC		1.5	2.4	7.1	3.2	0.08	2.3	75		640
ECLKCB		2.4	2.8	6.8	4.5	0.16	2.4	81		620
ECLKGY		2.1	1.0	6.2	2.8	0.09	1.6	105		220
ECLKHI		2.2	1.9	7.8	3.1	0.09	1.9	89		460
ECLKJM		2.2	2.0	6.7	4.3	0.10	1.9	84		580
ECLKPM		2.1	1.0	5.4	3.5	0.12	2.0	85		170
MCDMWP	0.02	2.1	1.8	7.0	2.8	0.55	1.5	75	320	445
PBERBC	0.21	1.3			1.1	0.10				125
PBPIEP	0.10	1.9	1.2	6.6	1.3	0.29	1.2	101	146	268
PMCKCK	0.05	0.9			1.0	0.20				300
PMCKDR	0.05	1.7			1.8	0.30				365
PMCKGP	0.05	1.2	1.0	6.3	1.4	0.11	0.9	72	225	406
SCBHBH	0.26	2.1	2.0	6.9	2.7	0.30	2.1	106	233	370
SCCNMT	0.10	1.6			2.0	0.10				320
MCLBBV	0.03	1.4	1.3	9.6	1.7	0.10	1.3	127		187
MCMGFS	0.03	1.1			2.0	0.10				170
MCMGRP	0.01	1.4			1.0	0.10				190

METAL STATISTICS FOR REFERENCE STATIONS

	Ag	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Fe
n	14	24	18	18	24	24	18	18	6	24
Mean	0.07	1.7	1.6	7.2	2.3	0.15	1.8	90	186	355
s	0.07	0.4	0.6	1.4	1.1	0.12	0.5	15	91	183
X+2s	0.22	2.6	2.8	10.0	4.4	0.38	2.9	120	367	721

Table 2

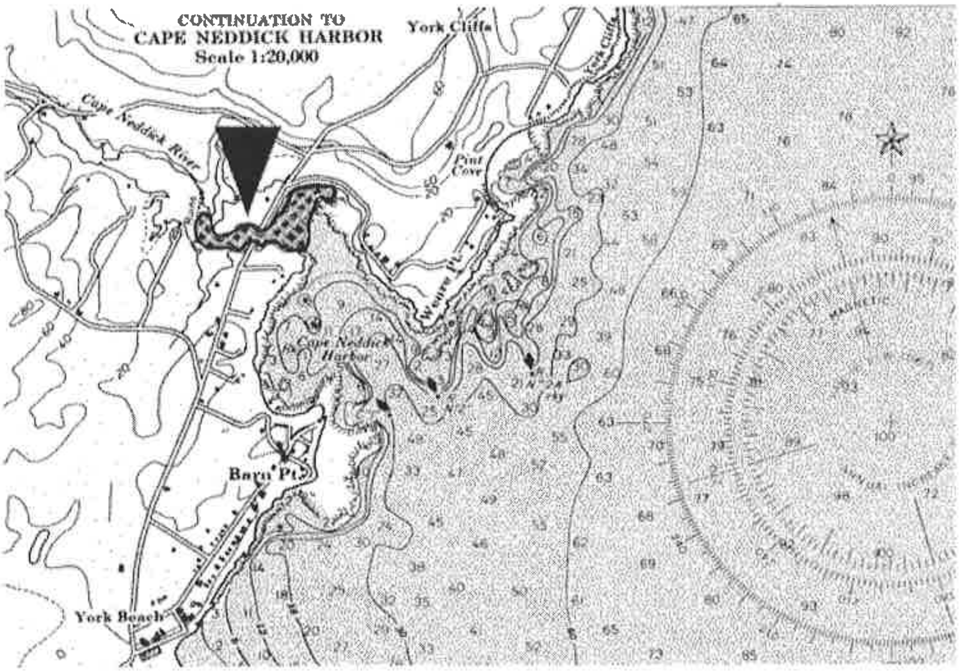
CONTINUATION TO
CAPE NEDDICK HARBOR
Scale 1:20,000
York Cliffs
Cape Neddick River
Pint Cove
Weare Pt.
Cape Neddick Harbor
Barn Pt.
York Beach

Figure 3.

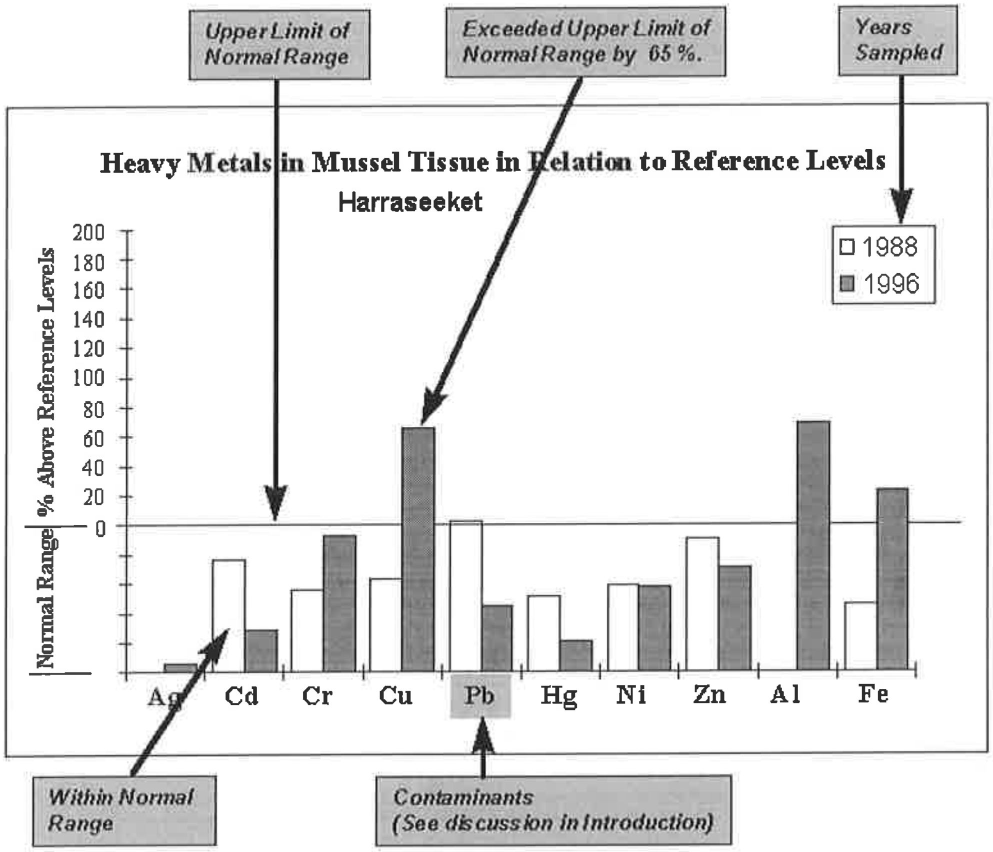
Upper Limit of Normal Range
Exceeded Upper Limit of Normal Range by 65 %.
Years Sampled
Heavy Metals in Mussel Tissue in Relation to Reference Levels
Harraseeket
1988
1996
% Above Reference Levels
Normal Range
200
180
160
140
120
100
80
60
40
20
0
Ag
Cd
Cr
Cu
Pb
Hg
Ni
Zn
Al
Fe
Within Normal Range
Contaminants (See discussion in Introduction)

Table 3. Shellfish tissue levels and clam tissue monitoring data (wet wt.)

Toxicant	Action Level	Units (wet wt.)
.	.	.
Organics	.	.
Total PCBs	11	ug/kg
Carcinogenic PAHs	3	ug/kg
Anthracene	656	ug/kg
Acenapthene	131	ug/kg
Fluoranthene	88	ug/kg
Fluorene	88	ug/kg
Napthalene	88	ug/kg
Pyrene	66	ug/kg
Hexachlorobenzene	13.7	ug/kg
Heptachlor	4.9	ug/kg
Aldrin	1.3	ug/kg
Mirex	12.2	ug/kg
Lindane	16.8	ug/kg
Heptachlor Epoxide	2.4	ug/kg
Chlordane/Nonachlor	16.8	ug/kg
Dieldrin	1.4	ug/kg
Endosulfan	13.1	ug/kg
.	.	.
Metals	.	.
Arsenic [a]	0.02	mg/kg
Aluminum	NA	mg/kg
Cadmium	2.2	mg/kg
Chromium [b]	10.9	mg/kg
Copper	NA	mg/kg
Lead [c]	0.6	mg/kg
Mercury	0.2	mg/kg
Nickel	43.8	mg/kg
Silver	10.9	mg/kg
Selenium	10.9	mg/kg
Tributyltin**	0.66	mg/kg
Zinc	656	mg/kg

** RfD for Tributylin oxide

[a] Arsenic RsD is for inorganic form. Seafood tends to have an organic arsinic form.

Estimates are that <5% of total seafood, as is inorganic.

[b] Chromium RfD is for most toxic form, Cr VI.

[c] Lead fish tissue action level derived using EPA's biokinetic model, that accounts

for exposure to other sources (e.g. diet, water, soil, air).

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How to Read Station Summaries

We assumed that most people are interested in their particular waterbody and less interested in the contaminant itself and have therefore produced reports that discuss conditions at the station that shows which, if any, contaminants warrant attention. On a single graph, we present results for several contaminants in relation to the State of Maine "background."

The chart shows where samples were collected. Two formats are used. The more common format is the cross hatched area that shows the area over which mussels were collected. Less common, is the black triangle, the point of which indicates a small feature such as a ledge, on the chart.

The narrative follows the chart. It is divided up into at least three paragraphs describing the physical features of the site and access considerations, land-use activity in the immediate area and potential sources of contamination, and finally an interpretation of the results.

The graph requires a bit of explanation. A single horizontal line lies about 1/3rd the way up on the graph at 0 on the y-axis. This line is the upper limit of what we consider within the normal baseline range for Maine. Bars exceeding the line are above normal and warrant further investigation. The degree to which the bar exceeds the line is expressed as a percentage above the upper limit of the Maine "baseline." At a glance, then, one can see which, if any, contaminants at a location is higher than what we consider normal. Bars ending below that line indicate that concentrations of that particular contaminant are within what we consider to be normal for uncontaminated areas of the Maine coast.

Raw data are presented in a table below the graph. This may come in useful for those people interested in using these data or comparing these data with data from other programs. Individual replicates are presented so variability may be assessed if desired.

Human Health Implications

The objective of our monitoring is to assess environmental health. However, by reporting test results on popular seafood products, we risk discouraging readers from eating seafood when most nutritionists and medical professionals recommend a varied diet that includes fish and seafood. Seafood is low in fats and cholesterol, is rich in minerals and vitamins, and contains the beneficial omega-3-fatty acids. Several studies have shown that including seafood in the diet is associated with a lower incidence of heart disease. For more on the health benefits of seafood and seafood safety see http://www.ocean.udel.edu/mas/seafood/nutritioninfo.html

Whether or not levels of toxic contaminants are in the "normal" range is generally unrelated to human health. "Normal" levels or some chemicals can be toxic while conversely elevated levels of some contaminants may not be toxic. Human health risk assessment uses a different method from that used to assess environmental contamination.

Interim Shellfish Action Levels to protect human health (Table 3) have been developed by the State Toxicologist at the Maine Bureau of Health. Mercury and lead are the only two metals found to exceed their human health action level and then only at a few stations. Where concentrations are at or above any of these levels, it is noted in the narrative interpretation of that station's results. Interim Shellfish Action Levels are based on wet (live) weights and are not directly comparable to the dry weight values reported in this document. To convert the dry weight data to wet weights, dry weight is multiplied by percent solids.

A Note of Caution Regarding Data Interpretation

An accepted feature of all sample results is variability. For many reasons, separate samples from the same areas yield slightly different results. Although we try to eliminate as many of these reasons through standardization, replication, quality assurance and quality control measures, some are impractical if not

impossible to eliminate. For example, mussels across the state and even at a given site are genetically different with different growth rates, accumulation rates, etc. Even in the laboratory, analyses conducted on different days are slightly different due to varying performance of equipment and staff. Variability introduces uncertainty to the measurement making it difficult to detect trends over time and differences between geographic areas.

Reducing variability costs money. Balancing costs with the degree of confidence necessary to answer this program's objectives was confronted early on. We elected to sacrifice "confidence" in favor of gathering information on more areas of the coast as a first step. Many of the early data represent single samples. These should be considered as screening data only and are often adequate to provide a basis for additional monitoring. Results from single samples, however, are not to be used to make management decisions because of the uncertainty of what they represent.

When comparing these data with data collected by others, be careful to assure that the measurement units are the same. Samples reported here are generally on a dry weight basis. Other programs may report data on a wet weight basis. Sample collection protocols, sample preparation, analysis, detection limits and data summarization techniques influence results.

Station Reports

By Town By Code