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Concentrations of Polycyclic Aromatic Hydrocarbons in Surficial Sediments of the Fore River and Portland Harbor, Maine: A Report to the National Resource Damage Trustees

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Presented by
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Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a class of toxic organic pollutants, and represent the largest group of carcinogens listed by the Environmental Protection Agency (EPA). PAHs are ubiquitous at low concentrations and can occur naturally in the environment. Anthropogenic sources include storm water run-off and atmospheric deposition of compounds formed by the incomplete combustion of petroleum, oil, coal, and wood. In Portland Harbor, the largest oil port on the East Coast of the U.S., oil spills are also a source of PAHs. The EPA lists PAHs as priority pollutants. This class is very hydrophobic and therefore not very soluble in water. Once PAHs enter the marine environment, this low solubility allows them to adsorb to sediment and accumulate.

In 2004, a Natural Resource Damage Assessment grant was awarded to Friends of Casco Bay to establish a baseline for PAH concentrations in Portland Harbor and the Fore River, hereafter referred to as “the harbor.” This task had two basic components: a literature search for existing data, and sediment collection and analysis of PAH concentrations from 20 sites located around the harbor.

Methods

Literature search

A literature search was conducted for historical PAH sediment data from around the harbor. There were two phases of the literature search. First, data was sought from known sources. Second, potential new sources of data were identified. Known reports and studies were identified and reviewed in meetings with representatives from the Casco Bay Estuary Project (CBEP), the Maine Department of Environmental Protection (DEP), and the EPA. Eight categories were used to group the various sources of historical data. See Table 1 for a list of these categories.

Table 1.

Source of Historical Sediment Data	Year
Doggett/Larsen	1980
Maine DEP	1989
Casco Bay Estuary Project	1991 / 1993
Maine DEP – Julie N spill Pre-assessment Report	1996
US Fish and Wildlife – Julie N spill Pre-assessment Report	1996
EPA National Coastal Assessment	2001 - 2002
Piers dredged through 1993 – Normandeau Associates	1950 - 1993
Piers dredged from 1994 to present -Portland Harbormaster	1994 - 2004

When a pier or wharf owner needs to dredge, they must conduct a sediment analysis. This analysis usually includes sediment PAH concentrations, potentially providing sources of data. Normandeau Associates provided PAH data from analyses completed prior to 1994 and the Portland Harbormaster provided FOCB with information on dredging permit applications by pier owners from 1994 to 2004. A list of pier dredging projects from 1994 to 2004 was compiled. Wharf owners were asked for data from their sediment analyses; letters requesting reports and data were sent and each owner was then contacted by telephone, but no data was acquired for this study.

Selection of 2004 sampling sites

Twenty sites in the harbor were selected for sampling in 2004, based on a review of historical stations, adjacent land use, and discussions with DEP, EPA, and CBEP. See Table 2 for a complete list of the 2004 sampling sites, and Figure 1 for a map with locations.

Table 2.

Site Code	Depth (feet)	2004 Site Descriptions
NRDA01	4	Upper Fore River, opposite mouth of Stroudwater River, heavily oiled during Julie N spill
NRDA02	4	Airport Cove, drainage from Jetport
NRDA03	5	Mouth of Long Creek, drainage from Maine Mall area through Clarks Pond, Red Bank
NRDA04	5	Thompson Point Cove, heavily oiled during *Julie N* spill, old industrial site
NRDA05	8	I-295 Cove, northeast corner, oiled during *Julie N* spill, many old industrial sites nearby
NRDA06	6	Global Oil flat, mouth of Barberry Creek, site of varied industrial uses over time, spills
NRDA07	15	Off South Portland *POTW* outfall, non-attainment area: violates aquatic life standards, Federal 303d list category 5A
NRDA08	20	Gasworks, China Clay docks, non-attainment area: violates aquatic life standards, Federal 303d list category 5A, VRAP at Gasworks
NRDA09	47	Mid-channel, Fore River, sampled for PAH in 1980, 1989, 1991, 1996, and 2002
NRDA10	48	Vessel Services at the Fish Pier fueling dock
NRDA11	7	Widgery Wharf – west, lobsterman's dock, needs dredging
NRDA12	15	Widgery Wharf – east, lobsterman's dock, needs dredging
NRDA13	8	South Portland Shipyard, inner site
NRDA14	16	South Portland Shipyard, outer site
NRDA15	17	Casco Bay Ferry Terminal, just off large CSO at Commercial Street
NRDA16	12	Maine State Pier, east side (near Cianbro), just off large CSO
NRDA17	68	Former site of BIW dry dock, future Ocean Gate site
NRDA18	15	Near South Portland Boat Ramp, near old industrial site, tank farms, dredge area BB
NRDA19	8	Mill Cove, South Portland
NRDA20	8	Pleasantdale Cove, South Portland

Sample collection in 2004

Sediment sampling in the harbor was conducted during November 2004, under the Casco Bay Environmental Monitoring Plan, Assessment of Sediment Contamination in Casco Bay (Quality Assurance Project Plan RFA No. ME01223). At each station the boat was either anchored or secured to a pier or piling, and the GPS coordinates were recorded. During sample collection, the boat engine was turned off to prevent atmospheric contamination. A Young-modified Van Veen Grab sampler was used to collect samples. Prior to each deployment, the stainless steel grab and other sampling equipment were washed thoroughly with Alconox and rinsed with ambient seawater. Three replicate samples were collected at each station. The top two centimeters of sediment from each successful grab were removed with a stainless steel spoon and transferred to a labeled 120-milliliter glass jar. The jars were kept in a cooler at 4 degrees Celsius until delivery to the lab. At the end of each sampling day, the samples, accompanied by a chain of custody form, were delivered to Katahdin Analytical Services in Westbrook, Maine, for analysis.

Determination of PAHs

Katahdin Analytical Services analyzed the samples in accordance with "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods, SW-846, U.S. EPA. Data was received from Katahdin reported as ppb (ug/kg) dry weight.

The raw data provided by Katahdin was separated into two categories: analytes with 2 or 3 rings and analytes with 4 or more rings. Those PAHs with only 2 or 3 rings are considered to be the lower molecular weight constituents, while those PAHs with 4 or more rings are the higher molecular weight class. For each site, the average of the three replicates was calculated and presented as the mean concentration. Total PAH was computed as the sum of the 17 individual analytes. Total concentrations were also computed for the low and high molecular weight classes as the sum of each respective group.

Results

Literature search

Compiling the historical data proved to be much more difficult than anticipated. The CBEP, state, and federal studies and project reports were generally available. However, in many cases the reports did not include the methods used or the actual data. And in spite of attempts to obtain data from the various pier dredging projects identified in cooperation with Normandeau Associates and the Portland Harbormaster very little information was able to be collected. The Army Corps of Engineers was contacted to inquire about facilitation of data collection. Ultimately it was determined that the historical dredge data would be incompatible, very difficult to gather, and represented conditions that no longer existed due to removal of the sediment, and therefore not useable for this project.

In addition to being unable to compile a substantial portion of the historical data, it became apparent that comparing what data we could obtain would be difficult due to dissimilarities in methods of sample collection, analysis, and reporting. For example, data was collected at varying sediment depths, by single samples or with replicates, or even by compositing of multiple grabs. Some results were reported as wet weight, while most others were reported as dry weight. Some results were surrogate corrected and some were not, and some studies provided no details about methods used. The US Fish and Wildlife study used 5 cm sediment cores and proved particularly inappropriate to use for comparative purposes. Another challenge in comparing different studies involves the specific PAH constituents included in each of the analyses. Most of the studies we reviewed utilized different numbers of analytes. In order to compare one study to another, the PAH constituents that were analyzed must be the same. Those constituents that overlap from study to study may be used to determine trends if the sampling and laboratory methodology is consistent.

Because of these difficulties, we present in this report only the sources of historical data, and not the actual data from each study.

The following piers have been dredged and have had sediment analyses completed: NorthEast Petroleum, Mobil Oil (three times), Star Enterprises, Merrill Industries (twice), Irving Oil, FPL Energy, Global Petroleum, Proprietors of Union Wharf, DiMillo's, Gulf Oil Ltd (three times), Portland Pipe Line Corporation, South Port Marine (twice), and Sprague Energy (twice). See Appendix C for contact information for the wharf owners that have dredged since 1994.

Sediment PAH concentrations from the 2004 study

Total PAH concentrations (ug/kg dry weight) found at several of the sediment sample sites were very high. Table 3 lists each site with its respective mean total PAH concentration as well as the ratio of mean low molecular weight PAH to mean total PAH. A summary of the data can be found in Appendix A, while all of the data is presented in Appendix B, and the full report from Katahdin Analytical Services is located in Appendix D.

Discussion

The literature search produced many potential sources of sediment PAH information, but unfortunately only a small amount of actual usable data, as mentioned above. Enough comparable data may exist for the mid-channel Fore River site (NRDA09) to establish a trend, although it needs to be noted that it is difficult to reoccupy the same station from study to study. By using only those studies that have employed similar methods, and comparing just those analytes that are consistent throughout, the historical data could prove to be a valuable resource.

The sediment analyses for PAHs at the 20 sites sampled in the harbor in 2004 has yielded an extremely important baseline against which future studies can be compared. In addition to serving as a baseline, this analysis presented intriguing information. Total mean PAH concentration at the Gas Works/Clay Docks (NRDA08) is extremely high at 278,300 ug/kg, as are the concentrations just off the two large combined sewer overflows at the Maine State Pier (NRDA16) and the Casco Bay Ferry Terminal (NRDA15), at 161,990 and 63,533 ug/kg, respectively. The two-site transect at the South Portland Shipyard, NRDA13 and NRDA14, revealed concentrations four times higher at the site closer to the shipyard. Surprisingly, mean total PAH concentration is lowest at the mouth of Long Creek, site NRDA03, which drains much of the Maine Mall area. This suggests that Clarks Pond, at the head of Long Creek, may be a sink for PAHs and potentially other toxics as well.

Table 3.

Site Code	Site Description	Mean Total PAH concentration (ug/kg dry weight)	Ratio of Low Molecular Weight PAH to Mean Total PAH
NRDA01	Upper Fore River	4,957	31%
NRDA02	Airport Cove	15,645	30%
NRDA03	Mouth of Long Creek	2,953	36%
NRDA04	Thompson Point Cove	6,223	31%
NRDA05	I-295 Cove, northeast corner	5,900	28%
NRDA06	Global Oil flat	4,707	24%
NRDA07	Off South Portland treatment outfall	22,800	27%
NRDA08	Gasworks, China Clay docks	278,300	25%
NRDA09	Mid-channel Fore River	13,307	29%
NRDA10	Vessel Services at the Fish Pier	15,723	30%
NRDA11	Widgery Wharf - west	35,000	28%
NRDA12	Widgery Wharf - east	30,767	30%
NRDA13	South Portland Shipyard – inner	25,613	27%
NRDA14	South Portland Shipyard – outer	6,180	31%
NRDA15	Casco Bay Ferry Terminal	63,533	21%
NRDA16	Maine State Pier	161,990	27%
NRDA17	Site of former BIW Dry Dock	7,010	35%
NRDA18	Near South Portland Boat Ramp	8,570	34%
NRDA19	Mill Cove, South Portland	8,370	31%
NRDA20	Pleasantdale Cove, South Portland	16,097	28%

It may be possible to predict, very generally, the potential toxicity of PAHs to benthic organisms using informal guidelines established through the NOAA Status and Trends program (Long *et al.* 1995). Two thresholds are suggested, an “Effects Range-Low” (ERL), the concentration below which toxicity rarely occurs (4,022 ug/kg), and an “Effects-Range-Median” (ERM), as the concentration above which toxicity is very likely (44,792 ug/kg). I have used these two levels to produce three categories: total mean PAH concentrations below the ERL, between the ERL and the ERM, and above the ERM. Only one of the 20 sites sampled in 2004 fell out below the ERL, NRDA03 at the mouth of Long Creek. Figure 2 presents data from all 20 sites grouped into these three categories. Total PAH concentration values from the 2004 study represent the sum of the individual constituents, and we apply these guidelines cautiously, realizing that this may be a conservative total, and that we may be underestimating the potential toxicity. Calculating total PAH as the sum of the constituents is an established method set by previous studies, including the San Francisco Estuary Institute's Regional Monitoring Program for Trace Substances (Oakland, California).

The ratio of low molecular weight PAHs to total PAHs may be used to determine the likely source of the PAHs. Low molecular weight PAHs are generally associated with pre-combustion sources, such as oil spills, while high molecular weight PAHs are associated with run-off and air deposition. Low molecular weight PAHs are even less soluble in the marine environment than the higher molecular weight PAHs and therefore do not persist in the sediment for as long as the higher weight PAHs do. An interesting example is found at the Casco Bay Ferry Terminal site (NRDA15). This site has the lowest ratio of low molecular weight PAHs to total PAHs in this study, yet has one of the highest total concentrations. This suggests a very large source of post-combustion PAHs, which is most likely the CSO located at the site.

A subsequent analysis of the historical data may include a comparison of just those constituants that are similar from study to study, where collection methods allow. Of particular interest may be the NRDA09 site, which has now been sampled six times within the past 25 years

The 2004 sampling effort, supported by the Natural Resource Damage Assessment grant, provides an invaluable data set against which future insults to the Fore River and Portland Harbor may be measured and identifies challenged areas that might warrant particularly close attention through subsequent studies.

References and Literature Cited

Ashley, J.T.F. and J.E. Baker. 1999. Hydrophobic organic contaminants in surficial sediments of Baltimore Harbor: Inventories and sources. Env. Tox. Chem. 18:5.

Ghosh, U., J.S. Gillette, R.G. Luthy, and R.N. Zare. 2000. Microscale location, characterization, and association of polycyclic aromatic hydrocarbons on harbor sediment particles. Env. Sci. Tech. 34: 1729-1736.

Julie N Oil Spill: Preassessment Data Report 1996. Maine Department of Environmental Protection.

Kennicutt, II, M.C., T.L.Wade, and B.J. Presley. 1992. Texas A&M University. Assessment of Sediment Contamination in Casco Bay. Casco Bay Estuary Project

Larsen, P., A. Johnson, and L. Doggett. 1983. Environmental Benchmark Studies in Casco Bay – Portland Harbor, Maine. NOAA Technical Memo. NMFS-F/NEC-19.

Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Env. Mgmt. 19:1897.

Metre, P.C.V., B.J. Mahler, and E.T. Furlong. 2000. Urban sprawl leaves its PAH signature. Env. Sci. Tech. 34: 4064-4070

Papadopoulou, D., and C. Samara. 2002. Polycyclic aromatic hydrocarbons contamination and Lumistox® solvent extract toxicity of marine sediments in the north Aegean Sea, Greece.

Toro, D.D. and J.A. McGrath. 1999. Defining total PAH concentration in a field collected sediments. EPA Document 600R02013, Procedures for the derivation of equilibrium partitioning sediment benchmarks (esbs) for the protection of benthic organisms: PAH mixtures.

San Francisco Estuary Institute, Regional Monitoring Program for Trace Substances, Oakland, California

Sediment Quality Guidelines developed for the National Status and Trends Program 1999. National Oceanic and Atmospheric Administration.

Figure 1 - 2004 Fore River / Portland Harbor Sediment Sampling Sites

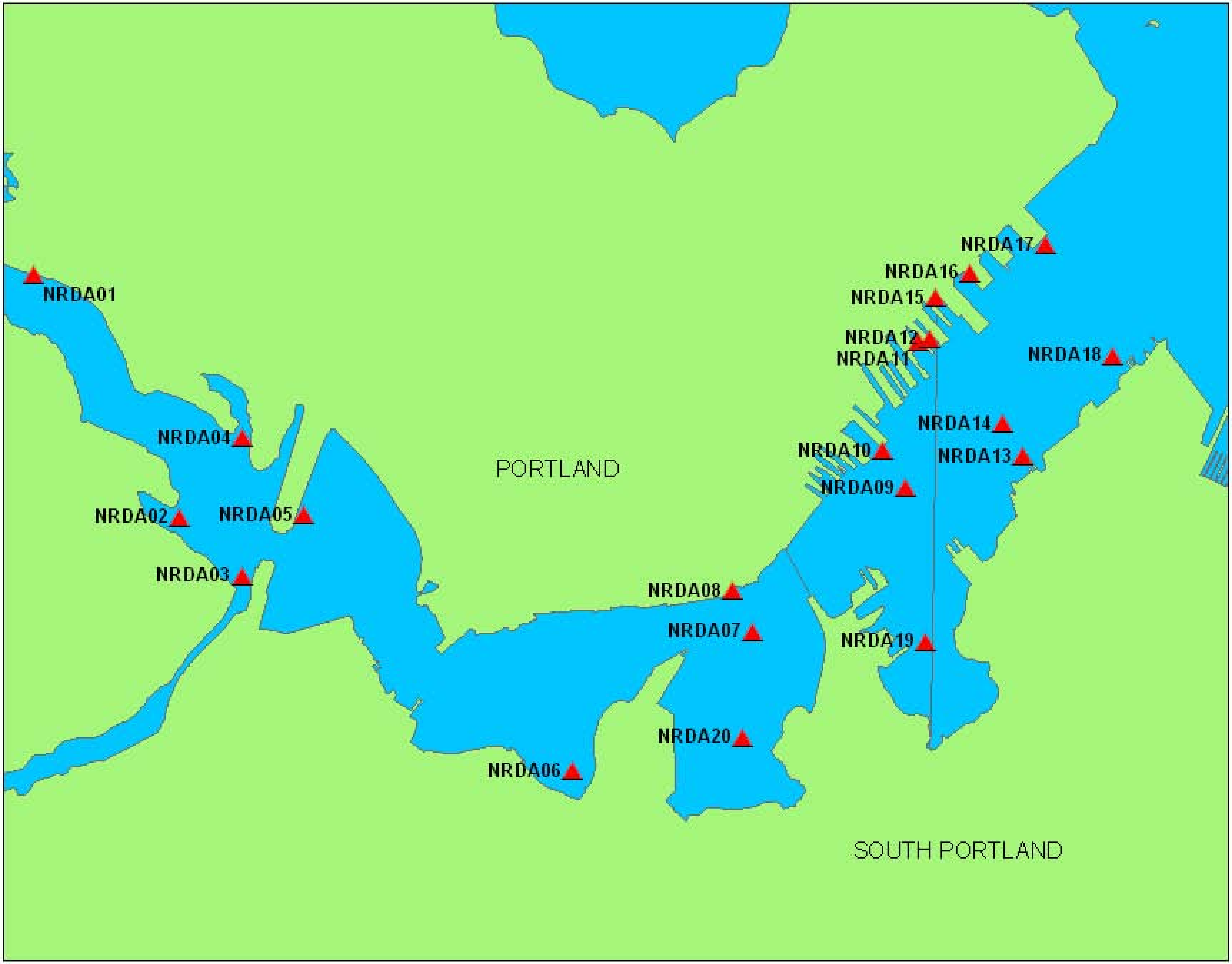
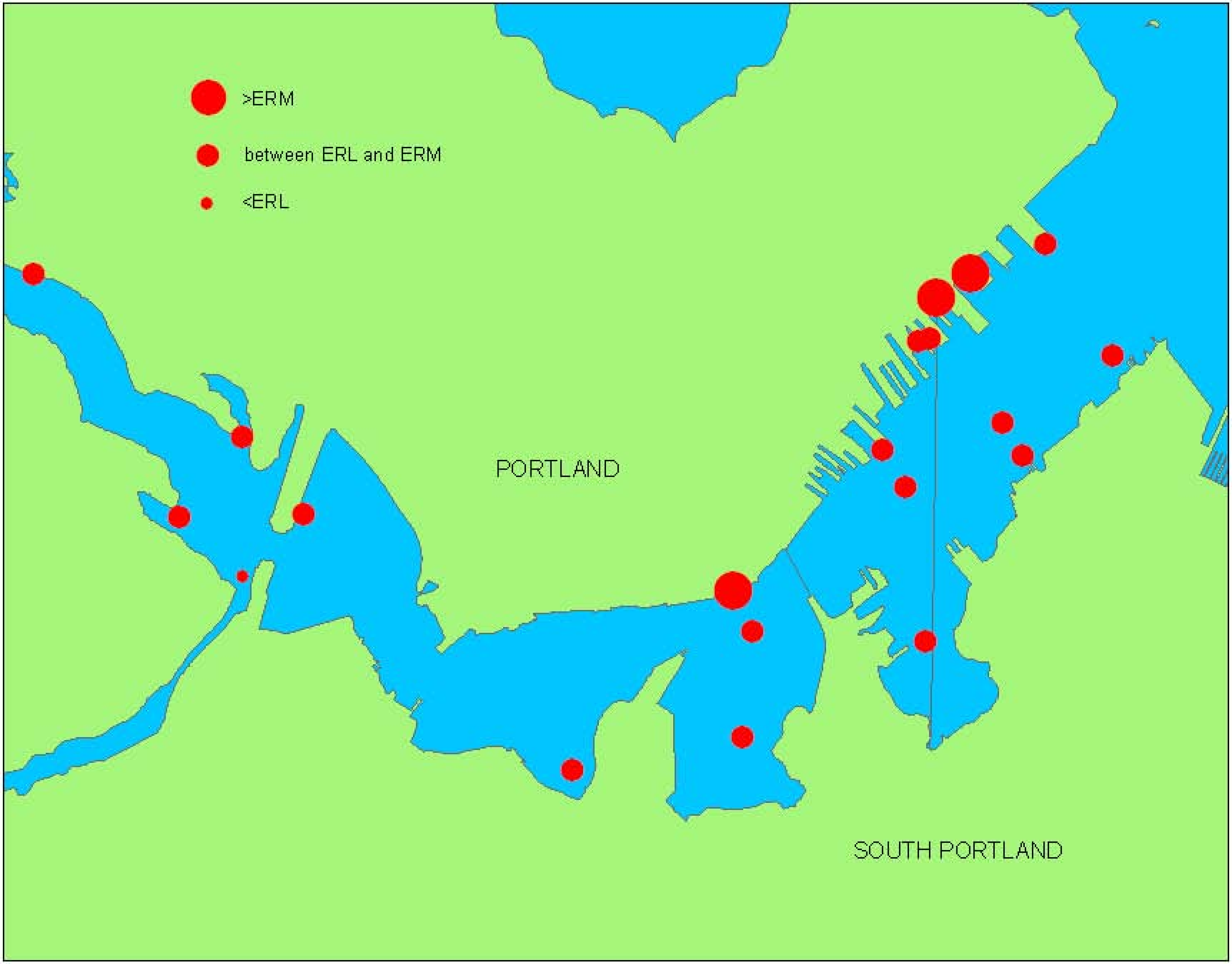


Figure 2 - PAH Concentrations in the Fore River Grouped by ERL and ERM Guidelines



APPENDIX A - 2004 Data Summary					
Units: ug/kg dry weight					
		Ratio of Low MW PAH to Total PAH	Total PAH	Total Low MW PAH	Total High MW PAH
NRDA01	mean	31%	4,957	1,507	3,450
	sd		810	175	678
NRDA02	mean	30%	15,647	4,630	11,017
	sd		1,658	195	1,463
NRDA03	mean	36%	2,953	1,073	1,880
	sd		60	40	36
NRDA04	mean	31%	6,223	2,103	4,120
	sd		3,247	1,696	1,561
NRDA05	mean	28%	5,900	1,643	4,257
	sd		412	228	278
NRDA06	mean	24%	4,707	1,140	3,567
	sd		919	269	651
NRDA07	mean	27%	22,800	6,137	16,663
	sd		2,705	642	2,116
NRDA08	mean	25%	278,300	70,633	207,667
	sd		78,758	20,723	58,358
NRDA09	mean	29%	13,307	3,910	9,397
	mean		3,730	1,330	2,480
NRDA10	sd	30%	15,723	4,730	10,993
	mean		2,460	611	1,892
NRDA11	sd	28%	35,000	9,700	25,300
	mean		854	173	700
NRDA12	sd	30%	30,767	9,300	21,467
	mean		4,952	954	4,038
NRDA13	sd	27%	25,613	6,837	18,777
	mean		1,208	487	733
NRDA14	sd	31%	6,180	1,947	4,233
	mean		1,576	756	859
NRDA15	sd	21%	63,533	13,100	50,433
	mean		11,524	2,666	8,864
NRDA16	sd	27%	161,990	44,990	117,000
	mean		58,714	19,106	39,971
NRDA17	sd	35%	7,010	2,380	4,630
	mean		2,116	440	1,691
NRDA18	mean	34%	8,570	2,980	5,590
	sd		1,900	1,057	851
NRDA19	mean	31%	8,370	2,580	5,790
	sd		1,270	150	1,123
NRDA20	mean	28%	16,097	4,347	11,750
	sd		9,245	2,318	7,518

APPENDIX B - 2004 Data

Units: ug/kg, dry weight

	Total PAH	**Total Low MW PAH**	NAPHTHALENE	2-METHYLNAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	ANTHRACENE	**Total High MW PAH**	FLUORANTHENE	PYRENE	BENZO(A)ANTHRACENE	CHRYSENE	BENZO(B)FLUORANTHENE	BENZO(K)FLUORANTHENE	BENZO(A)PYRENE	INDENO(1,2,3-CD)PYRENE	DIBENZO(A,H)ANTHRACEN	BENZO[G,H,I]PERYLENE
NRDA01-1	5,310	1,680	240	240	240	240	240	240	240	3,630	660	520	270	380	320	340	400	260	240	240
NRDA01-2	4,030	1,330	190	190	190	190	190	190	190	2,700	480	380	200	280	280	230	280	190	190	190
NRDA01-3	5,530	1,510	200	200	200	200	200	310	200	4,020	720	590	310	410	380	370	420	320	200	300
NRDA02-1	17,520	4,850	660	660	660	660	660	890	660	12,670	2,100	2,000	990	1,400	1,400	1,600	1,200	660	660	660
NRDA02-2	15,050	4,560	560	560	560	560	560	1,200	560	10,490	2,000	1,700	920	1,100	920	1,200	970	560	560	560
NRDA02-3	14,370	4,480	640	640	640	640	640	640	640	9,890	1,600	1,500	710	940	1,200	1,100	920	640	640	640
NRDA03-1	3,010	1,120	160	160	160	160	160	160	160	1,890	320	260	160	170	160	170	170	160	160	160
NRDA03-2	2,960	1,050	150	150	150	150	150	150	150	1,910	340	290	150	180	150	170	180	150	150	150
NRDA03-3	2,890	1,050	150	150	150	150	150	150	150	1,840	290	260	150	160	200	150	180	150	150	150
NRDA04-1	4,720	1,190	160	160	160	160	160	230	160	3,530	700	440	290	350	380	310	390	270	160	240
NRDA04-2	4,000	1,060	140	140	140	140	140	220	140	2,940	510	430	250	300	280	290	320	220	140	200
NRDA04-3	9,950	4,060	580	580	580	580	580	580	580	5,890	610	640	580	580	580	580	580	580	580	580
NRDA05-1	5,810	1,770	250	250	250	250	250	270	250	4,040	660	590	300	400	420	380	420	330	250	290
NRDA05-2	6,350	1,780	240	240	240	240	240	340	240	4,570	900	650	360	480	420	430	480	310	240	300
NRDA05-3	5,540	1,380	180	180	180	180	180	300	180	4,160	810	530	350	420	430	360	470	290	180	320
NRDA06-1	5,760	1,450	200	200	200	200	200	250	200	4,310	790	530	320	450	440	380	480	370	200	350
NRDA06-2	4,070	970	130	130	130	130	130	190	130	3,100	570	400	240	320	340	260	340	260	130	240
NRDA06-3	4,290	1,000	130	130	130	130	130	220	130	3,290	600	420	260	340	350	300	360	280	130	250
NRDA07-1	24,100	6,190	460	460	460	460	480	2,900	970	17,910	3,700	4,400	1,700	1,800	1,400	1,400	1,500	830	460	720
NRDA07-2	19,690	5,470	640	640	640	640	640	1,600	670	14,220	3,400	2,600	1,300	1,400	1,200	1,200	1,200	640	640	640
NRDA07-3	24,610	6,750	710	710	710	710	710	2,200	1,000	17,860	3,200	4,800	1,600	1,600	1,300	1,600	1,600	740	710	710
NRDA08-1	210,100	50,500	2,500	2,500	2,500	2,500	4,500	24,000	12,000	159,600	39,000	29,000	17,000	16,000	12,000	14,000	16,000	7,400	2,500	6,700
NRDA08-2	364,500	91,900	6,600	6,600	6,600	6,600	7,500	40,000	18,000	272,600	63,000	55,000	29,000	27,000	20,000	22,000	26,000	13,000	6,600	11,000
NRDA08-3	260,300	69,500	5,700	5,700	5,700	5,700	5,700	27,000	14,000	190,800	46,000	40,000	19,000	19,000	16,000	14,000	19,000	6,300	5,700	5,800
NRDA09-1	15,810	4,420	580	580	580	580	580	940	580	11,390	2,400	2,000	1,600	1,000	970	710	970	580	580	580
NRDA09-2	15,090	4,910	680	680	680	680	680	830	680	10,180	2,200	1,500	1,200	920	720	720	880	680	680	680
NRDA09-3	9,020	2,400	320	320	320	320	320	480	320	6,620	1,400	1,100	870	600	660	430	600	320	320	320
NRDA10-1	13,180	4,030	570	570	570	570	570	610	570	9,150	2,000	1,200	1,100	830	880	660	770	570	570	570

APPENDIX B - 2004 Data

Units: ug/kg, dry weight

	Total PAH	**Total Low MW PAH**	NAPHTHALENE	2-METHYLNAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	ANTHRACENE	**Total High MW PAH**	FLUORANTHENE	PYRENE	BENZO(A)ANTHRACENE	CHRYSENE	BENZO(B)FLUORANTHENE	BENZO(K)FLUORANTHENE	BENZO(A)PYRENE	INDENO(1,2,3-CD)PYRENE	DIBENZO(A,H)ANTHRACEN	BENZO[G,H,I]PERYLENE
NRDA10-2	18,090	5,160	660	660	660	660	660	1,200	660	12,930	3,100	1,800	1,900	1,200	1,100	850	1,000	660	660	660
NRDA10-3	15,900	5,000	700	700	700	700	700	800	700	10,900	2,500	1,500	1,300	1,000	870	730	900	700	700	700
NRDA11-1	35,800	9,800	1,300	1,300	1,300	1,300	1,300	2,000	1,300	26,000	4,400	3,800	2,600	3,400	2,800	2,900	2,100	1,400	1,300	1,300
NRDA11-2	35,100	9,800	1,300	1,300	1,300	1,300	1,300	2,000	1,300	25,300	3,900	3,900	2,700	3,300	3,400	2,000	2,100	1,400	1,300	1,300
NRDA11-3	34,100	9,500	1,300	1,300	1,300	1,300	1,300	1,700	1,300	24,600	4,300	3,500	2,500	3,500	2,800	2,000	2,100	1,300	1,300	1,300
NRDA12-1	27,100	8,400	1,200	1,200	1,200	1,200	1,200	1,200	1,200	18,700	3,000	2,800	1,800	2,100	2,200	1,500	1,700	1,200	1,200	1,200
NRDA12-2	36,400	10,300	1,300	1,300	1,300	1,300	1,300	2,500	1,300	26,100	4,600	4,300	2,600	3,300	3,100	2,000	2,300	1,300	1,300	1,300
NRDA12-3	28,800	9,200	1,300	1,300	1,300	1,300	1,300	1,400	1,300	19,600	2,000	4,800	1,500	2,200	2,100	1,600	1,500	1,300	1,300	1,300
NRDA13-1	26,150	6,960	860	860	860	860	860	1,800	860	19,190	3,500	4,100	1,400	2,100	1,900	1,700	1,600	1,100	860	930
NRDA13-2	26,460	7,250	850	850	850	850	850	2,000	1,000	19,210	3,900	4,100	1,400	2,100	1,900	1,400	1,500	1,100	850	960
NRDA13-3	24,230	6,300	800	800	800	800	800	1,500	800	17,930	3,400	4,100	1,300	1,900	1,800	1,300	1,400	1,000	800	930
NRDA14-1	7,780	2,790	380	380	380	380	380	510	380	4,990	1,000	630	440	480	410	390	500	380	380	380
NRDA14-2	4,630	1,330	170	170	170	170	170	310	170	3,300	640	560	300	320	310	280	340	200	170	180
NRDA14-3	6,130	1,720	200	200	200	200	200	520	200	4,410	940	630	450	440	330	360	470	290	200	300
NRDA15-1	60,400	12,200	1,100	1,100	1,100	1,100	1,100	5,400	1,300	48,200	10,000	10,000	4,000	6,200	4,700	4,600	3,900	2,000	1,100	1,700
NRDA15-2	76,300	16,100	1,100	1,100	1,100	1,100	1,100	8,500	2,100	60,200	13,000	12,000	5,000	7,600	5,700	6,400	5,200	2,200	1,100	2,000
NRDA15-3	53,900	11,000	1,200	1,200	1,200	1,200	1,200	3,800	1,200	42,900	9,200	8,700	3,600	5,500	4,500	3,800	3,400	1,700	1,200	1,300
NRDA16-1	209,730	62,830	4,400	1,500	530	5,000	5,400	36,000	10,000	146,900	33,000	24,000	14,000	17,000	14,000	10,000	14,000	7,200	3,700	10,000
NRDA16-2	179,810	47,310	2,400	1,200	810	4,300	5,200	26,000	7,400	132,500	25,000	24,000	13,000	16,000	13,000	11,000	13,000	6,700	3,500	7,300
NRDA16-3	96,430	24,830	970	930	930	1,600	2,200	14,000	4,200	71,600	15,000	14,000	7,300	8,900	6,300	6,000	6,500	3,200	1,700	2,700
NRDA17-1	6,340	2,360	330	330	330	330	330	380	330	3,980	710	600	340	350	330	330	330	330	330	330
NRDA17-2	5,310	1,950	260	260	260	260	260	390	260	3,360	620	520	310	300	270	260	300	260	260	260
NRDA17-3	9,380	2,830	340	340	340	340	340	790	340	6,550	1,300	1,000	630	650	670	520	670	390	340	380
NRDA18-1	10,750	4,200	600	600	600	600	600	600	600	6,550	1,000	750	600	600	600	600	600	600	600	600
NRDA18-2	7,690	2,400	330	330	330	330	330	420	330	5,290	1,000	890	480	560	420	440	510	330	330	330
NRDA18-3	7,270	2,340	330	330	330	330	330	360	330	4,930	790	630	480	520	550	400	540	360	330	330
NRDA19-1	9,760	2,730	350	350	350	350	350	630	350	7,030	1,600	1,000	780	680	630	620	670	350	350	350
NRDA19-2	8,080	2,580	360	360	360	360	360	420	360	5,500	1,100	820	570	500	520	430	480	360	360	360

APPENDIX B - 2004 Data

Units: ug/kg, dry weight

	Total PAH	**Total Low MW PAH**	NAPHTHALENE	2-METHYLNAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	ANTHRACENE	**Total High MW PAH**	FLUORANTHENE	PYRENE	BENZO(A)ANTHRACENE	CHRYSENE	BENZO(B)FLUORANTHENE	BENZO(K)FLUORANTHENE	BENZO(A)PYRENE	INDENO(1,2,3-CD)PYRENE	DIBENZO(A,H)ANTHRACEN	BENZO[G,H,I]PERYLENE
NRDA19-3	7,270	2,430	340	340	340	340	340	390	340	4,840	1,000	690	480	450	480	380	340	340	340	340
NRDA20-1	15,750	5,880	840	840	840	840	840	840	840	9,870	1,400	1,600	840	840	850	910	910	840	840	840
NRDA20-2	25,510	5,480	450	450	450	450	450	2,700	530	20,030	3,700	3,400	2,000	2,800	1,900	2,000	2,100	920	450	760
NRDA20-3	7,030	1,680	210	210	210	210	210	420	210	5,350	1,000	740	410	560	550	490	590	410	210	390

APPENDIX C - Contact Information for wharves dredged since 1994 in Portland Harbor

Year Dredge Permit Requested	Pier	Company	Previous Owner	Contact	Street Address	City, State, Zip	Phone
1994		South Port Marine	Marine East Marina	Kip Renolds	14 Ocean St	South Portland, ME 04106	207-799-8191
1994		800 Northern Corp.	Irving?	John Caucoulidis	2 Monument Square	Portland, ME 04101	
		Irving Oil Corp		Al Small	700 Maine Ave	Bangor, ME 04401	207-947-9365
1995		Sprague Energy Corp.	Rolling Mills	Tom Dobbins	59 Main St	South Portland, ME 04106	207-799-4899
1995		Gulf Oil Limited Partnership		David Moody	175 Front St.	South Portland, ME 04106	207-799-
1996		City of Portland Department of Transportation & Waterfront		Ben Snow	40 Commercial St., Suite 100	Portland, ME 04101	207-541-6900
1996	South Port Marine	South Port Marine		Kip Renolds	14 Ocean St	South Portland, ME 04106	207-799-8191
1996	Union Wharf	Properties of Union Wharf		Charlie Pool	36 Union Wharf	Portland, ME 04101	207-772-8160
1997		City of Portland Department of Transportation & Waterfront		Ben Snow	40 Commercial St., Suite 100	Portland, ME 04101	207-541-6900
1997		Gulf Oil Limited Partnership		David Moody	175 Front St.	South Portland, ME 04106	207-799-
1998		Mobil Oil Corp.		Bart Wittmer	170 Lincoln St.	South Portland, ME 04106	
1998	Northeast	Global Petroleum Corp.		Bruce Yates	1 Clark Rd.	South Portland, ME 04106	207-883-9196
1998		Sprague Energy Corp.		Tom Dobbins	59 Main St	South Portland, ME 04106	207-799-4899
1998	DiMillo's	DiMillo's		Chris DiMillo	Long Wharf	Portland, ME 04101	207-773-7632
1999		Merrill Industries, Inc.		P.D. Merrill or Armand Demers	601A Danforth St	Portland, ME 04102	207-772-3254
2000		Mobil Oil Corp.		Bart Wittmer	170 Lincoln St.	South Portland, ME 04106	207-767-3251
2000		FPL Energy Maine Hydro LLC	CMP	Al Wiley	160 Capitol St.	Augusta, ME 04330	207-623-8413
2001		Fore River Properties		c/o Bruce Coggeshall Managing Director	Pierce Attwood One Monument Square	Portland, ME 04101	207-791-1234
2003		Portland Pipeline Corporation		Ken Brown	P.O. Box 2590	South Portland, ME 04116-2590	207-767-0449
2003		Gulf Oil Limited Partnership		David Moody	175 Front St.	South Portland, ME 04106	207-799-