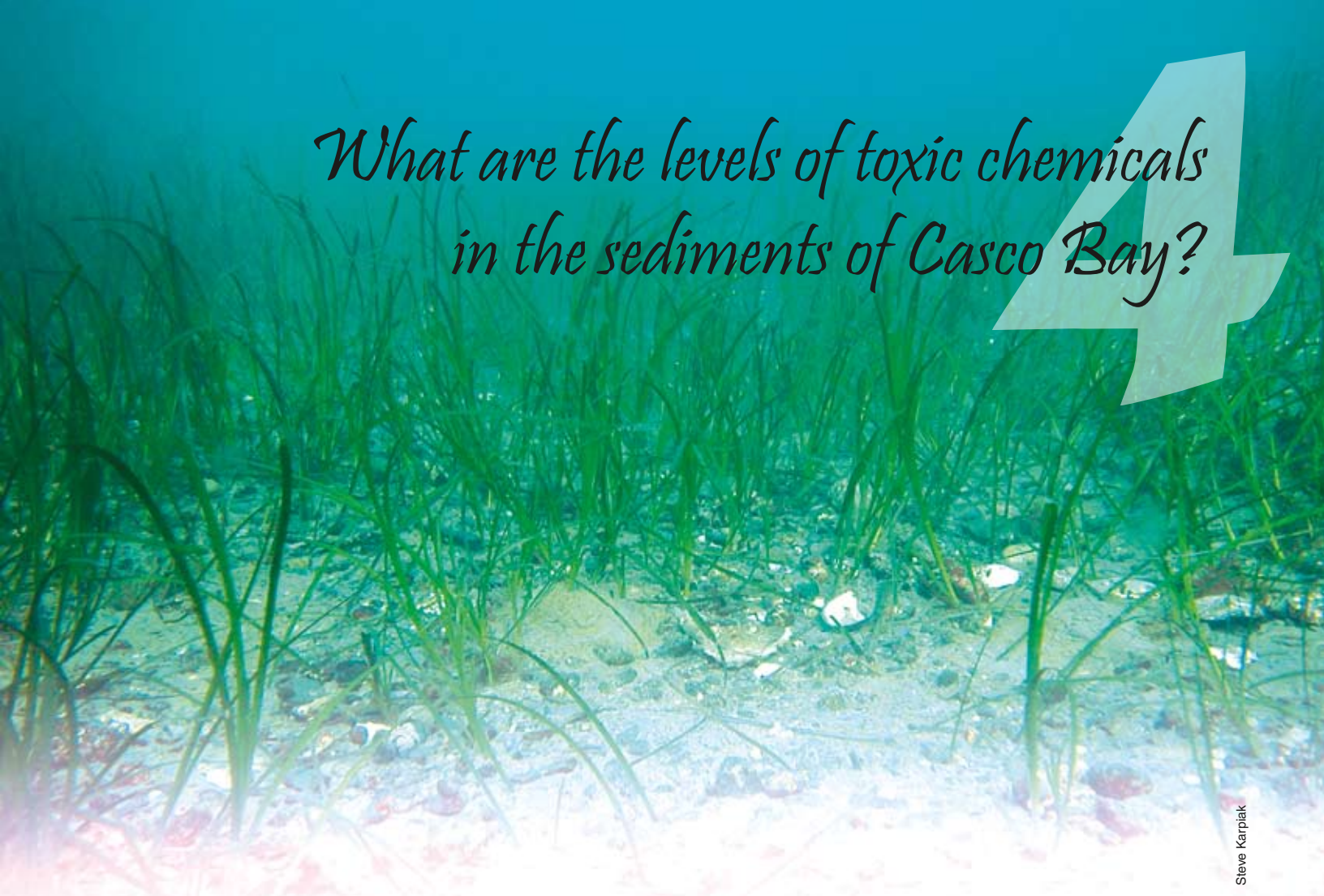
4 What are the levels of toxic chemicals in the sediments of Casco Bay?



Steve Karpiak

Healthy bottom communities have a diverse assemblage of organisms. This healthy shallow water soft bottom benthic community includes eelgrass and multiple species of mollusks and small crustaceans. An impacted community would include fewer species and a predominance of pollution tolerant organisms.

Background

When scientists first analyzed the surface layer of bottom sediments in Casco Bay in 1980, they were surprised to find a wide array of toxic contaminants present, including organic chemicals and heavy metals. These chemicals found their way to the Bay via multiple pathways, including rivers, stormwater runoff, point sources (*e.g.,* outfall pipes), small and large oil spills, and atmospheric deposition. Once in the aquatic environment, many toxic chemicals are hydrophobic (*i.e.,* they do not readily dissolve in water) and can become attached to sediment particles. Unless transported away by currents, the contaminated particles settle to the bottom and remain in the sediments where they may break down chemically over time or become buried under newer layers of sediment. Even when clean sediments are deposited on top of contaminated sediments, dredging and biological activity (such as burrowing and deposit feeding) can bring the contaminants back to the surface.

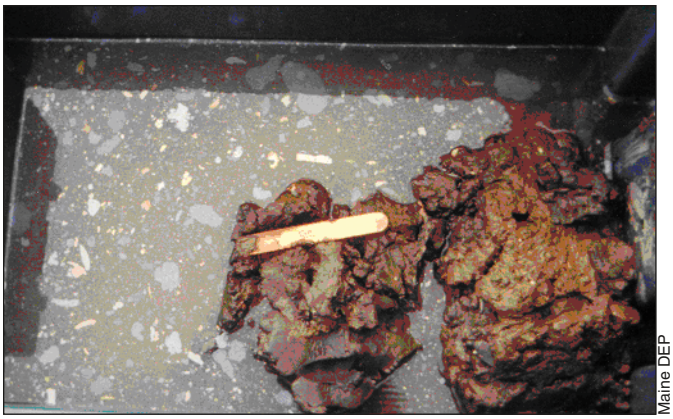
Bottom-dwelling (benthic) animals that are exposed to contaminated sediments can suffer adverse effects. These benthic organisms play an important role in the food chain, recycling organic matter and serving as a food source for groundfish (*e.g.,* flounder, cod, and haddock), lobsters and crabs. By ingesting benthic organisms that live and feed on contaminated sediments, fish and large crustaceans may experience inhibited growth and reproduction, disease vulnerability and even death (EPA 2006). Humans who consume seafood contaminated by toxic chemicals can also potentially be at risk. For example, the presence of dioxins in Casco Bay, largely a byproduct of pulp and paper mills, has resulted in elevated dioxin concentrations in the liver (tomalley) of lobsters (see Chapter 8). Toxic contamination can have an impact at the ecosystem level as well. Highly polluted areas experience shifts in the density and composition of the benthic animal community, with fewer species present and a predominance of hardy, pollution tolerant organisms.

Table 4-1: Analytes Measured During Both the CBEP 1991-1994 and 2001-2002 Sediment Studies

(Wade and Sweet 2005)

PAHs	PCB Congeners (varying configurations of chemical structure)	Pesticides	Trace Metals	Butyltins	Dioxins/ furans	Planar PCBs
9-naphthalene	2,4'-Dichlorobiphenyl (congener 8)	Aldrin	Silver	TBT (tributyltin)	TCDF	PCB 77
1-Methylnaphthelene	2,2',5-Trichlorobiphenyl (congener 18)	Alpha-chlordane	Arsenic	DBT (dibutyltin)	2,3,7,8-TCDF	PCB 126
2,6-Dimehtylnaphthalene	2,4,4'-Trichlorobiphenyl (congener 28)	2,4'-DDT	Cadmium	MBT (monobutyltin)	1,2,3,7,8-PeCDF	PCB 169
2,3,5-Trimethylnaphthalene	2,2',3,5'-Tetrachlorobiphenyl (congener 44)	4,4'-DDT	Chromium	Total butyltin	2,3,4,7,8-PeCDF	
Acenaphthylene	2,2',5,5'-Tetrachlorobiphenyl (congener 52)	2,4'-DDE	Copper		1,2,3,4,7,8-HxCDF	
Acenaphthene	2,3',4,4'-Tetrachlorobiphenyl (congener 66)	4,4'-DDE	Mercury		1,2,3,6,7,8-HxCDF	
Biphenyl	3,3",4,4'-Tetrachlorobiphenyl (congener 77)	2,4'-DDD	Nickel		2,3,4,6,7,8-HxCDF	
Fluorene	2,2',4,5,5'-Pentachlorobiphenyl (congener 101)	4,4'-DDD	Lead		1,2,3,7,8,9-HxCDF	
Anthracene	2,3,3',4,4'-Pentachlorobiphenyl (congener 105)	Dieldrin	Selenium		1,2,3,4,6,7,8,-HpCDF	
1-Methylphenanthrene	2,3',4,4',5-Pentachlorobiphenyl (congener 118)	Endosulfan I	Zinc		1,2,3,4,7,8,9-HpCDF	
Dibenzothiophene	3,3',4,4',5-Pentachlorobiphenyl (congener 126)	Endosulfan II	Iron		OCDF	
Fluoranthene	2,2',3,3',4,4'-Hexachlorobiphenyl (congener 128)	Endosulfan sulfate			2,3,7,8-TCDD	
Pyrene	2,2',3,4,4',5'-Hexachlorobiphenyl (congener 138)	Endrin			1,2,3,7,8-PeCDD	
Benzo[a]anthracene	2,2',4,4',5,5'-Hexachlorobiphenyl (congener 153)	Hexachlorobenzene			1,2,3,4,7,8-HxCDD	
Chrysene	2,2',3,3',4,4',5-Heptachlorobiphenyl (congener 170)	Heptachlor			1,2,3,6,7,8-HxCDD	
Benzo[b]fluoroanthene	2,2',3,4,4',5,5'-Heptachlorobiphenyl (congener 180)	Heptachlor epoxide			1,2,3,7,8,9-HxCDD	
Benzo[k]fluoroanthene	2,2',3,4',5,5',6-Heptachlorobiphenyl (congener 187)	Lindane			1,2,3,4,6,7,8-HpCDD	
Benzo[a]pyrene	2,2',3,3',4,4',5,6-Octochlorobiphenyl (congener 195)	Mirex			OCDD	
Indeno[1,2,3-cd]pyrene	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (congener 206	Trans-nonchlor				
Dibenz[a,h]anthracene	2,2,3,3',4,4',5,5',6,6'-Decachlorobiphenyl (congener 209)	Toxaphene				
Benzo[g,h,i]perylene	Total PCBs	Total pesticides				

Monitoring the Sediments in the Bay


Maine DEP

Sediment pollution can result from past industrial activities. At the site of a former coal gas works plant, which operated in Portland for almost a century, coal tar can still be seen oozing into the Fore River estuary. Remediation is underway at the site (Doggett 2006).

With the publication of *Troubled Waters—A Report on the Environmental Health of Casco Bay* (Hauge 1988), there was a growing awareness that toxic contaminant levels were elevated in the Bay's sediments. Concern over these toxic pollutants and their impacts on the health of the Bay's ecosystem was the impetus for the Maine DEP and the Governor of Maine to submit a nomination package to the US EPA's National Estuary Program in 1989. In 1990, the Casco Bay Estuary Project, now the Casco Bay Estuary Partnership (CBEP), was established, receiving significant federal and state funding. One of the first major studies undertaken by the CBEP was the 1991 baseline assessment of sediment contamination levels at 65 sites in the Bay. The study used state-of-the art analytical and statistical methods. Sampling sites selected were intended to provide good areal coverage of the Bay, to assess sediments of different ages and textures (including erosional features), and to provide a good representation of various bottom communities (Kennicutt *et al*. 1994). The site selection also considered water depth, circulation patterns and historical data, *i.e.*, areas where there was a known "dirty history" such as industrial facilities and point discharges (see Figure 4-1).

Sampling site locations were designated as either Cape Small (CS), East Bay (ES), IB (Inner Bay), Outer Bay (OB), Shallow Water (SW), or West Bay (WB) (see figure 4-1). Undisturbed surface samples were collected using either grab samplers or by hand and were analyzed for heavy metals, polycyclic aromatic hydrocarbons (PAHs), aliphatic hydrocarbons (hydrocarbons lacking a benzene ring, such as plant-derived waxes), polychlorinated biphenyls (PCBs) and pesticides (Kennicutt *et al.* 1992). In 1994, 28 of the original sites and 5 new sites were analyzed for butyltins (organometallic compounds), dioxins and furans, and planar PCBs, the most toxic PCB conformation (*i.e.,* spatial arrangement of atoms and bonds) (Wade *et al.* 1995). See Table 4-1 for a list of analytes measured as part of the studies.

Results of the 1991 and 1994 Sediment Sampling Studies

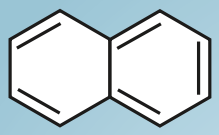
The results of the 1991 and 1994 sediment studies indicated that the most widespread contaminants in the Bay are petroleum and its byproducts, especially PAHs derived from high-temperature combustion processes. Geographically, the contaminants are found in highest concentration near sources such as the mouths of rivers, highly populated areas, and point source outfalls. Some regional differences are also explained by sediment accumulation patterns (Kennicutt *et al*. 1994).

The following data is summarized from Kennicutt *et al*. 1992 and Kennicutt *et al*. 1994:

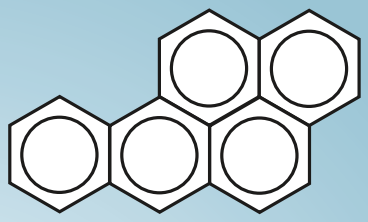
- **PAHs:** PAHs were found at all the sites sampled in the Bay. The predominant PAHs were highly condensed ring structures indicating a pyrogenic (combustion) source associated with urbanized and industrialized locations. High molecular weight four-ring and larger PAHs made up over 60% of the PAHs in the Casco Bay sediments (see Box on p. 34). The Inner Bay had the highest level of PAHs, especially sediments from the Fore River and Portland area, where levels of PAHs were high and comparable to other contaminated estuaries (see Figures 4-2a, 4-3a, and 4-4a) (Macauley *et al*. 1994, USEPA 1997).

  A statistical technique called principle components analysis was used to assess the regional influences of various sources of contaminants (weathered petroleum, fresh diesel fuel, pyrogenic hydrocarbons (from combustion), and biogenic material (such as natural plant waxes of land-based and aquatic origin). Not surprisingly, Inner Bay and shallow water sites nearest to Portland were characterized by higher inputs of low molecular weight PAHs from weathered petroleum than other parts of the Bay, probably from stormwater runoff and point sources associated with urban activities (see Figure 4-3a).

- **PCBs:** Total PCBs, based on the sum of 20 PCB congeners (varying configurations of chemical structure) were highly elevated in the Inner Bay near Portland. Generally the lowest values were in Cape Small and West Bay (see Figure 4-5a).
- **Pesticides:** Total DDT (DDT plus its breakdown products DDD and DDE) were highest in the Inner Bay near Portland and lowest in Cape Small and West Bay. The pesticide chlordane was highest at the Inner Bay sites and the lowest at West Bay and Cape Small. The other organic pesticides (see the list in Table 4-1) were near or below the detection limit of the analytical method [0.25 ng/g or ppb (parts per billion)]. None of the pesticides was highly elevated. (See Figure 4-6a)
- **Trace Metals:** Trace metals are naturally found in sediments. To correct for the natural background level of metals, all samples were normalized to iron. The distribution of metals is strongly influenced by the grain size of the sediments, which was also measured as part of this study. Trace metal levels were generally highest in the Inner Bay. While some of the cadmium, lead, silver, zinc, and mercury values detected in the Casco Bay sediments were elevated above background, likely by human activities, few of the samples were highly elevated above background (See Figure 4-7a).



Naphthalene, an example of a low molecular weight PAH, has two benzene rings.



Benzo[a]pyrene, an example of a high molecular weight PAH

Low and High Molecular Weight PAHs in Casco Bay

PAHs are environmentally persistent organic compounds that are strongly held to solid particles, both suspended in the water and in bottom sediments. Chronic exposure to PAHs can result in cancer and other serious health impacts. In the aquatic environment, PAHs are easily mobilized into the base of the food web by benthic organisms. The toxicity of PAHs tends to increase with increased molecular weight in aquatic systems (US EPA 2006, Eisler 1987). PAHs are often divided into two categories in the aquatic environment—the less toxic, less persistent low molecular weight PAHs and the more toxic, more persistent high molecular weight PAHs.

Low molecular weight PAHs are typically derived from weathered petroleum (biodegraded oil) and diesel fuel that enter the Bay via fuel spills or urban runoff (see Chapter 3). Examples are naphthalene and acenaphthene. Generally the solubility of PAHs decreases with increasing molecular weight. When in the marine environment, PAHs tend to stick to solid particles and settle into the sediments.

High molecular weight PAHs have a highly condensed molecular ring structure (4 rings or larger) that indicates a pyrogenic (combustion) source associated with urbanized and industrialized locations. These PAHs may come from particles in car exhaust, municipal and industrial combustion sites, and coal tar, and may be carried to the Bay via stormwater runoff and atmospheric deposition (see Chapter 2). They include, for example, Benzo[a]pyrene, $C_{20}H_{12}$, a five-ring polycyclic aromatic hydrocarbon that is mutagenic and highly carcinogenic. Benzo[a]pyrene is a product of incomplete combustion and is found, for example, in vehicle exhaust fumes (especially from diesel engines).

The following data is summarized from Wade *et al*. 1995:

- **Butyltins, dioxins and furans, and planar PCBs:** Butyltins, dioxins and furans, and planar PCBs (the most toxic conformation of PCBs) were found throughout Casco Bay. In general, conentrations were in the low range compared to similar estuarine areas, with the highest concentrations near likely sources of contamination. The Inner Bay had the highest concentrations of these contaminants, due to inputs from the Fore and Presumpscot Rivers. Tributyltin (TBT) and its breakdown products dibutyltin (DBT) and monobutyltin (MBT) were at the highest concentrations near marinas and other areas where boats concentrate, since they primarily come from marine anti-fouling paints (see Figure 4-8a). Dioxins and furans and especially 2,3,7,8-TCDD (tetrachlorodibenzodioxin), a potent toxic dioxin, were found in highest concentrations 10 miles downstream of the paper mill in Westbrook. Elevated dioxin/furan concentrations were also noted in East Bay, possibly due to transport from the Androscoggin River or local combustion sources (Wade *et al*. 1995) (see Figure 4-9a). For planar PCBs, the spatial distribution was similar to that measured in 1991 for total PCBs, with the highest levels in the Inner Bay and the lowest in West Bay and Cape Small. In general, total planar PCBs increased with increasing concentration of dioxin and furan. Falmouth Foreside had the highest concentration of planar PCB (see Figure 4-10a).

Average PAH Compositions in Sediments by Region Within Casco Bay Based on 1991 Sampling

The map shows the sampling sites in each of the designated sections of the Bay: Cape Small, East Bay, Inner Bay, Outer Bay, Shallow Water, and West Bay.
(Kennicut *et. al* 1992)

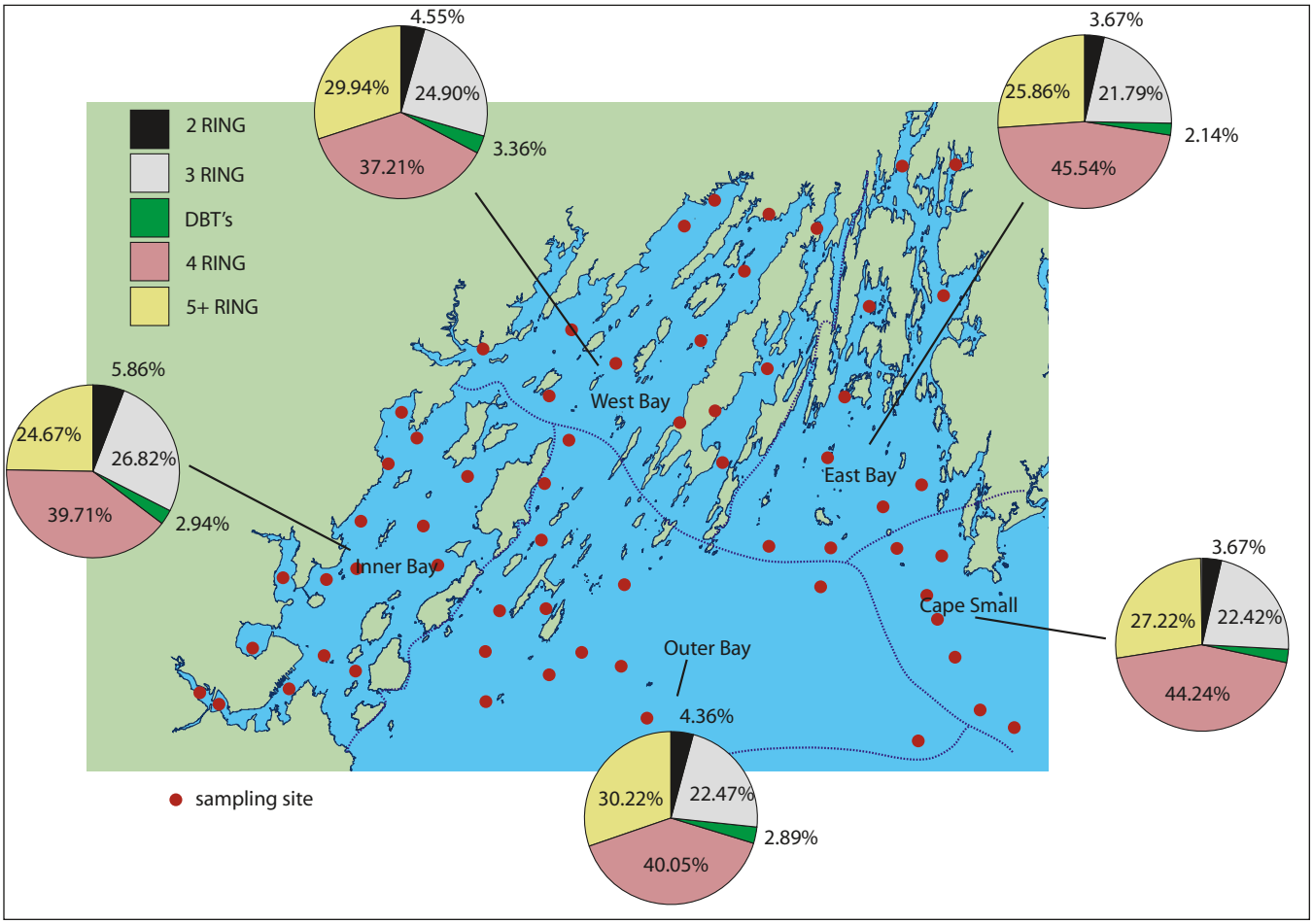


Figure 4-1: *The predominance of High Molecular Weight PAHs indicates that most of the PAHs delivered to the Bay come from post-combustion sources (hydrocarbon fuels burned at high temperature). The Inner Bay area around Portland has the highest percentage of Low Molecular Weight PAHs, likely from weathered petroleum that entered the bay via fuel spills or urban runoff (Kennicutt* et al. *1992).*

Changes in Toxic Contamination over Time: 1991/1994 versus 2000/2001

This section expands on the sediment toxics indicator (contaminant concentration change over time) reported in *State of the Bay* (CBEP 2005). In summer of 2000 and 2001, in partnership with US EPA's National Coastal Assessment, CBEP resampled the sediments at the original sites in Casco Bay for PAHs, PCBs, pesticides, metals, butyltins, dioxins/furans and planar PCBs (see Table 4-1). Scientists from Texas A&M University compared the results of the 1991/1994 sampling data to the 2000/2001 data. They concluded that most toxic chemicals have decreased or stayed the same over time, indicating that pollution control strategies are working in Casco Bay. See Figures 4-2a through 4-10b for a comparison of toxic contaminant levels in 1991/1994 and 2000/2001 samples.

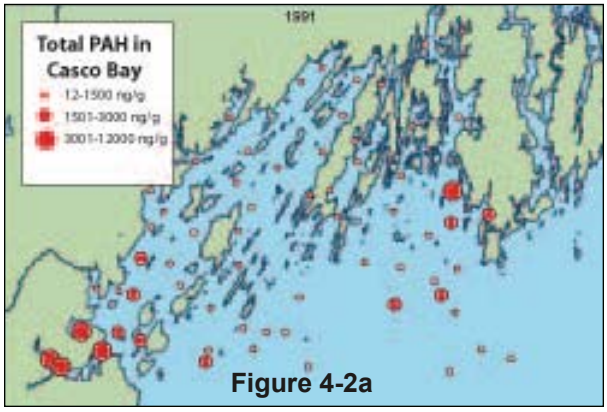


Figure 4-2a

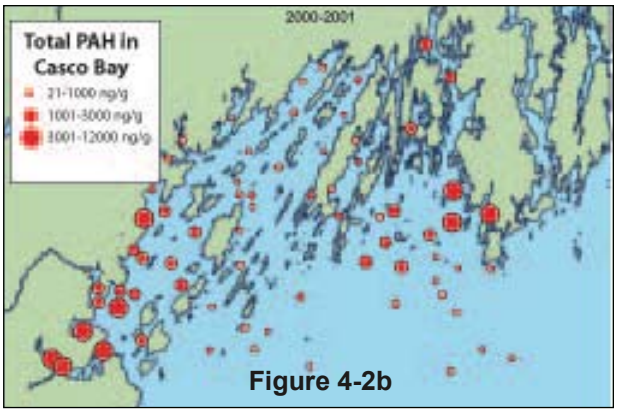


Figure 4-2b

Total PAHs: *For sites with total PAHs elevated above 2000 ng/g (or ppb), 10 sites were higher in 2000/2001 and 2 were higher in 1991, indicating that total PAH increased at some sites and decreased at others (Wade and Sweet 2005).*

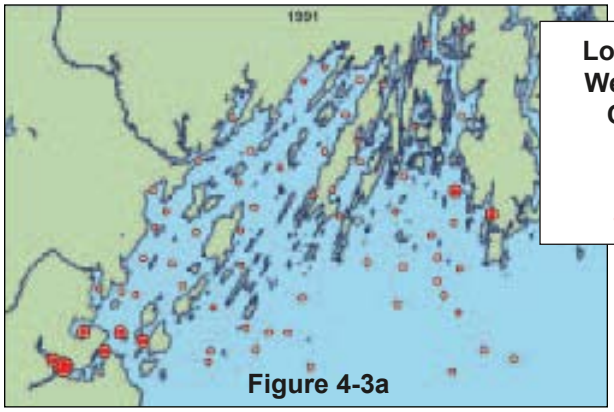


Figure 4-3a

Low Molecular Weight PAH in Casco Bay

- 2-121 ng/g
- 122-409 ng/g
- 410-707 ng/g

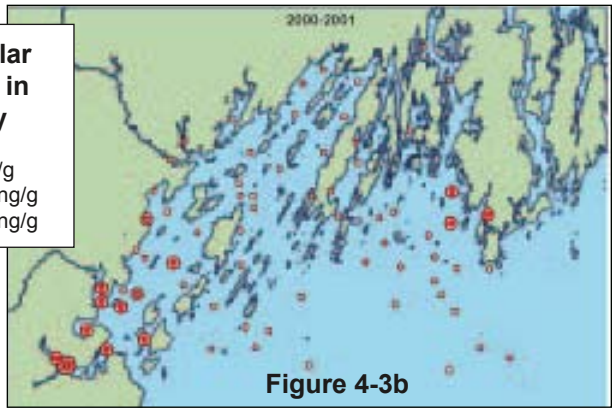


Figure 4-3b

Total Low Molecular Weight PAHs: *Total low molecular weight PAHs (the sum of naphthalene, acenaphthylene, acenaphthene, fluorene, and anthracene) generally decreased between sampling periods (Wade and Sweet 2005).*

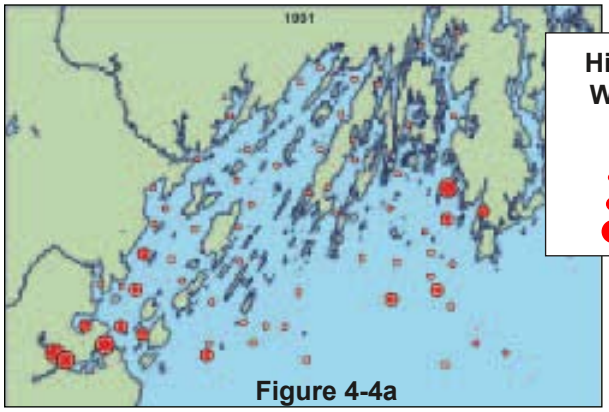


Figure 4-4a

High Molecular Weight PAH in Casco Bay

- 8-1375 ng/g
- 1376-3131 ng/g
- 3132-10314 ng/g

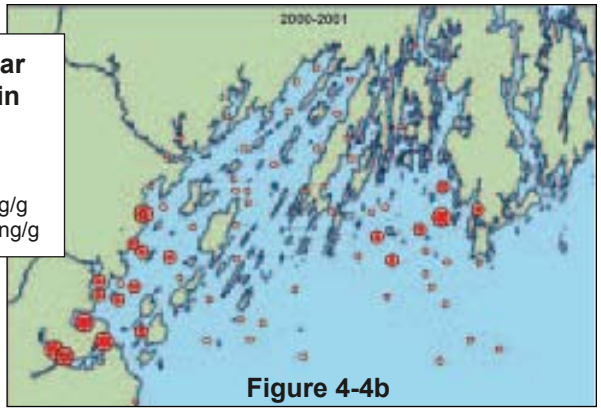


Figure 4-4b

Total high molecular weight PAHs: *The total high molecular weight PAHs (the sum of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoroanthene, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo (g,h,i)pyrelene) increased at most of the sites over the time period. This suggests that the increased use of fossil fuels has been balanced by environmental controls that lower PAH inputs to the Bay (Wade and Sweet 2005).*

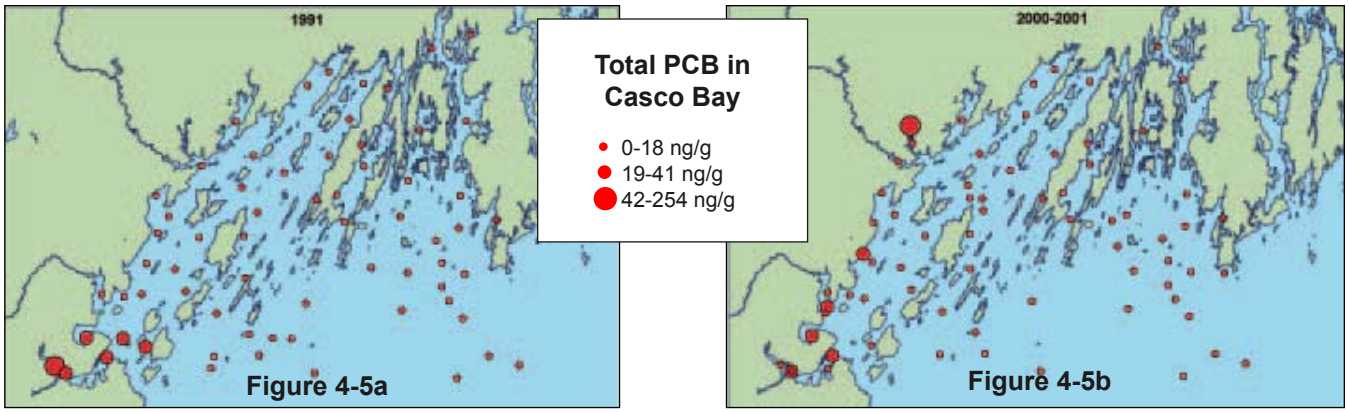


Figure 4-5a

Figure 4-5b

Total PCBs: *Total PCB concentrations for the sum of 20 PCB congeners were generally lower in 2000/2001 than in 1991. Of 65 sites sampled, only 8 had higher concentrations in 2000/2001 (Wade and Sweet 2005). Manufacture of PCBs has been banned in the United States since 1977. Of the estimated 1.2 million tons of PCBs manufactured before the ban, it has been estimated that 65% is still in use in electrical equipment, 31% is in the environment, and 4% has been degraded or incinerated (Tanabe 1988). While residual PCBs are still entering the waters of the Bay from runoff and atmospheric deposition, the ban appears to be effectively decreasing levels in the Bay's sediments (Wade and Sweet 2005).*

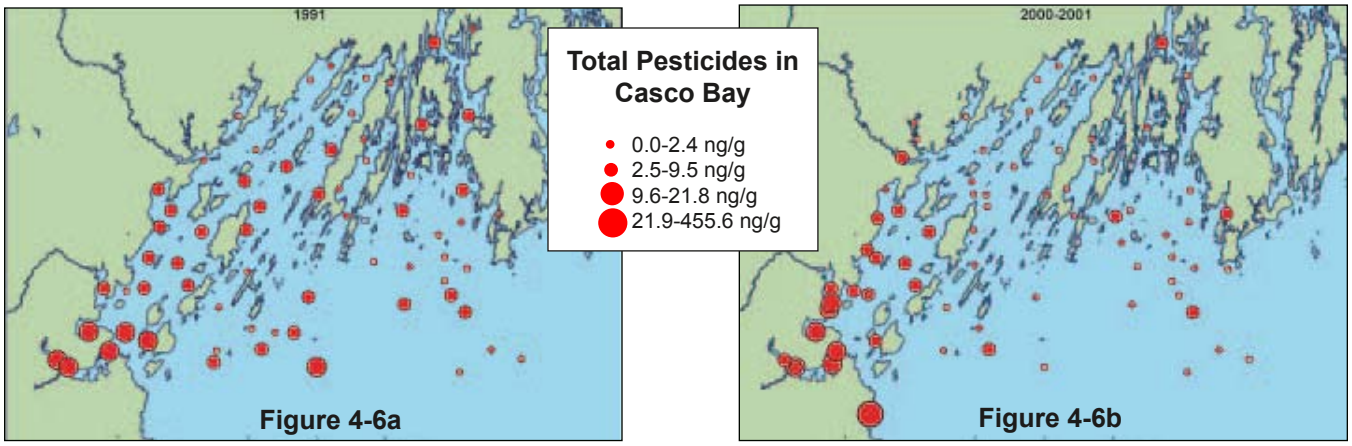


Figure 4-6a

Figure 4-6b

Total Pesticides: *Total pesticide concentrations for 2000/2001 were generally lower compared to 1991. The most significant of the pesticides making up the total were DDTs. Of 59 sites sampled, only 10 had higher total DDT concentrations in 2000/2001, the rest were lower than in 1991. This is not surprising since the pesticides tested have been banned in the United States for decades. For example, use of DDT was discontinued in 1972. While they have long half-lives (on the order of 10 to 20 years for half of the total concentration to break down) these contaminants should slowly decrease in the environment as a result of the ban (Wade and Sweet 2005).*

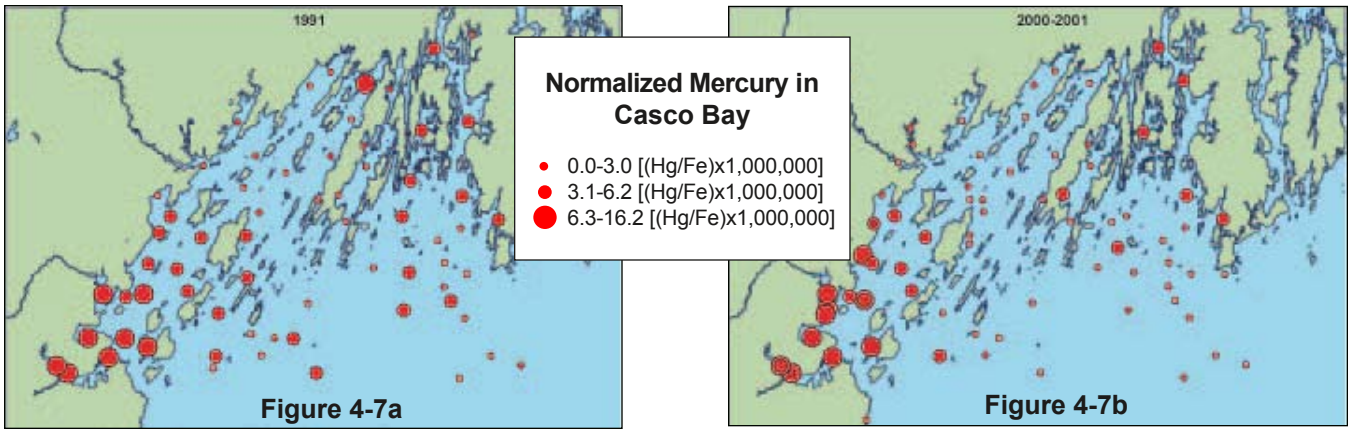
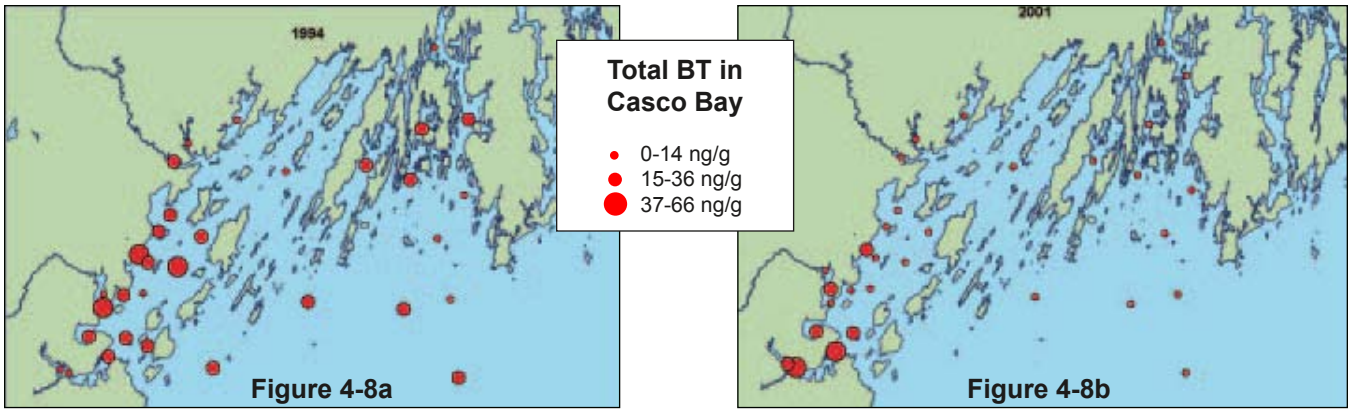


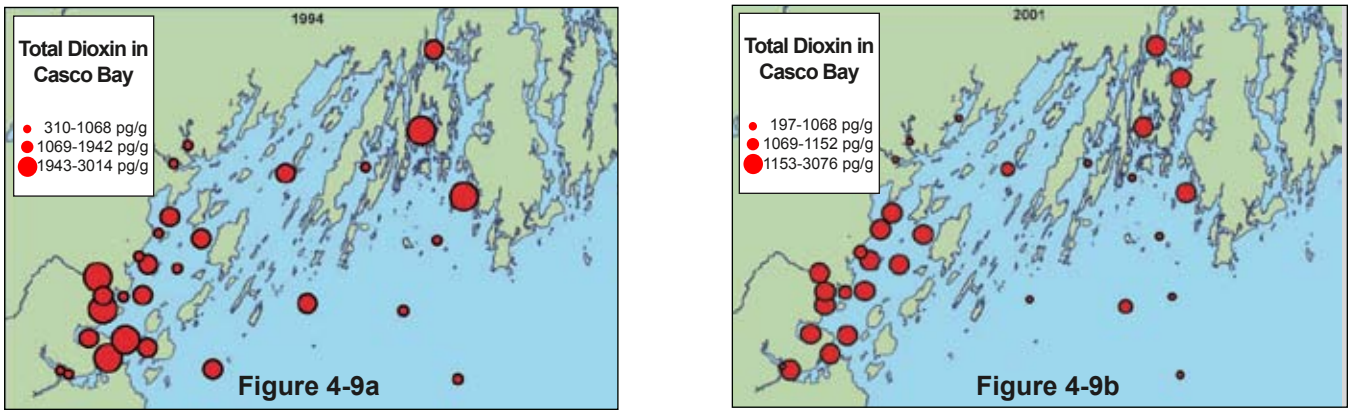
Figure 4-7a

Figure 4-7b

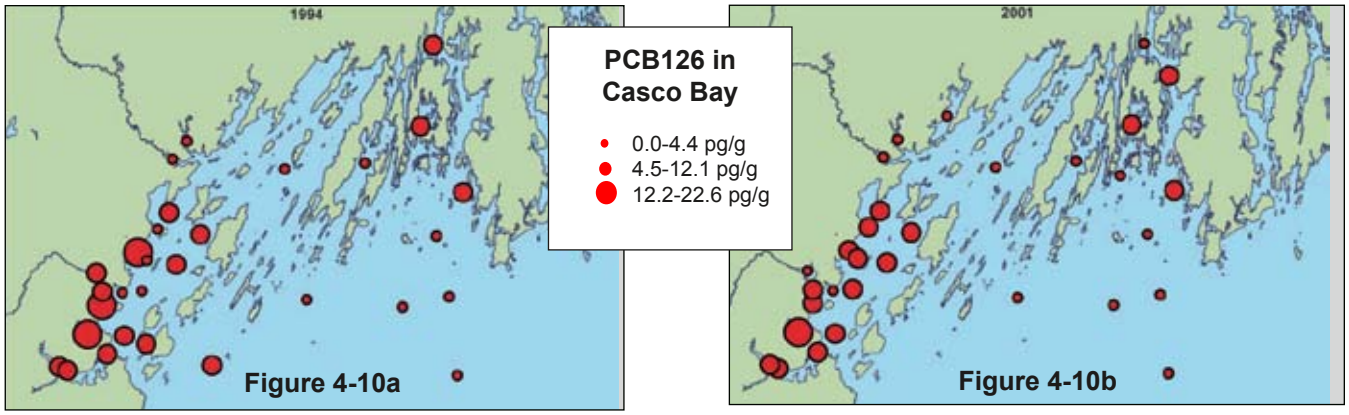
Metals: *This figure illustrates the decline in mercury concentrations over the study period. Between 1991 and 2000/2001, there were decreasing concentrations at the majority of sites for cadmium, chromium, mercury, nickel, and selenium. There was no apparent change between 1991 and 2000/2001 in arsenic, copper, lead and zinc. Silver was the only metal that increased in concentration at most sites during the study period (Wade and Sweet 2005).*



Butyltins: *Concentrations of total butyltin (the sum of TBT, DBT and MBT) were lower in 2000/2001 at 23 of the 29 sites sampled, indicating a general decrease across the Bay. Only six sites were higher in total butyltin in 2000/2001. Of these, five were in the Inner Bay area. TBT is an ingredient in marine anti-fouling paints. The overall decline of TBT concentrations in the Bay's sediments reflects the effectiveness of the federal and Maine laws which now ban the use of paints with TBT for all uses except for vessels longer than 25 meters or having aluminum hulls (Maine DEP 1999). The continued use of TBT paints on large commercial vessels may explain the presence of elevated concentrations of TBT in the sediments of Inner Bay sites (Wade and Sweet 2005).*



Dioxins and Furans: *Differences in concentration were analyzed for 19 dioxin/furans for the 1994 and 2000/2001 sampling periods. Total dioxins for both sampling periods are shown above. Six compounds were higher in 2000/2001, 7 remained about the same, and 3 were higher in concentration in 2000/2001. There was no systematic increase or decrease of dioxins and furans. In the long term, regulations lowering the production of these toxic chemicals should lead to a decrease of concentrations in the environment (Wade and Sweet 2005). With the cessation of the pulping operation at the Westbrook paper mill in 1999 Westbrook, a major source of dioxin has been eliminated.*



Planar PCBs: *Planar PCB 77 showed no overall change between 1994 and 2000/2001. Planar PCB 126 concentrations generally decreased from 1994 to 2001, as illustrated above. The third planar PCB sampled, PCB 169, was not detected in enough samples to observe a change (Wade and Sweet 2005).*

Toxicity of Casco Bay Sediments

The following summary is based on the analysis of the 1991/1994 and 2000/2001 data (Wade and Sweet 2005).

- **PAHs:** While highly elevated above natural background levels, the PAH concentrations seen in the sediments of the inner part of the Bay were between the levels identified by the National Status and Trends Program as Effects Range Low (ERL, possible biological effects = 4,022 ppb) and Effects Range Median (ERM, probable biological effects = 44,792 ppb) (Long *et al*. 1995). The majority of PAHs detected in the Bay's sediments are high molecular weight, combustion-related and sequestered in fine particles.
- **PCBs:** PCB concentrations at almost all sites were below the toxic response threshold (ERL = 22.7 ppb). The exception was the Fore River site sampled in 1991, where the PCB concentration exceeded the ERM (180 ppb dry weight) (Long *et al*. 1995).
- **Pesticides:** Concentrations of pesticides were low compared to concentrations considered toxic (ERL for total DDT = 1.58 ppb (Long *et al*. 1995).
- **Metals:** The concentrations of metals in Casco Bay are lower than levels known to cause harmful effects to organisms. Even in the few areas with elevated metal levels in Casco Bay, the concentrations are lower than the highly contaminated sediments in urban areas like Long Island Sound and Boston Harbor. Silver, cadmium, lead, zinc and mercury concentrations in the Bay indicate that metals resulting from anthropogenic (human) activities have been deposited in a few areas, but at levels that are unlikely to cause toxic effects.
- **Butyltins, dioxins and furans, and planar PCBs:** These chemicals were not present at toxic concentrations. In general, the highest concentrations of these toxic chemicals were found near known sources. For example, elevated butyltin concentrations (a constituent of marine anti-fouling paints) were found near boat anchorages and marinas, while dioxins and furans were found in elevated concentrations downstream of pulp and paper mills (Wade and Sweet 2005). Despite relatively low concentrations of 2,3,7,8-TCDD (a potent toxic dioxin) in most of the Bay, the elevated levels found in lobster tomalley from Casco Bay (Mower 1994) indicate that dioxin is available to organisms in the food chain and is being bioaccumulated (see Chapter 1) (Wade *et al.* 1995).

Steve Karpiak

2004 Portland Harbor/Fore River Study

In addition to the Casco Bay-wide sediment studies described above, sites in Portland Harbor and the Fore River were sampled in 2004 for PAHs and the heavy metals cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. This sampling was conducted by Friends of Casco Bay (FOCB), supported by a Natural Resource Damage Assessment grant and funds from the CBEP. Sites were selected based on the need for future dredging as well as past "dirty history," including the *Julie N* oil spill, industrial uses, proximity to combined sewer overflows (CSOs), and drainage from the Jetport and Maine Mall.

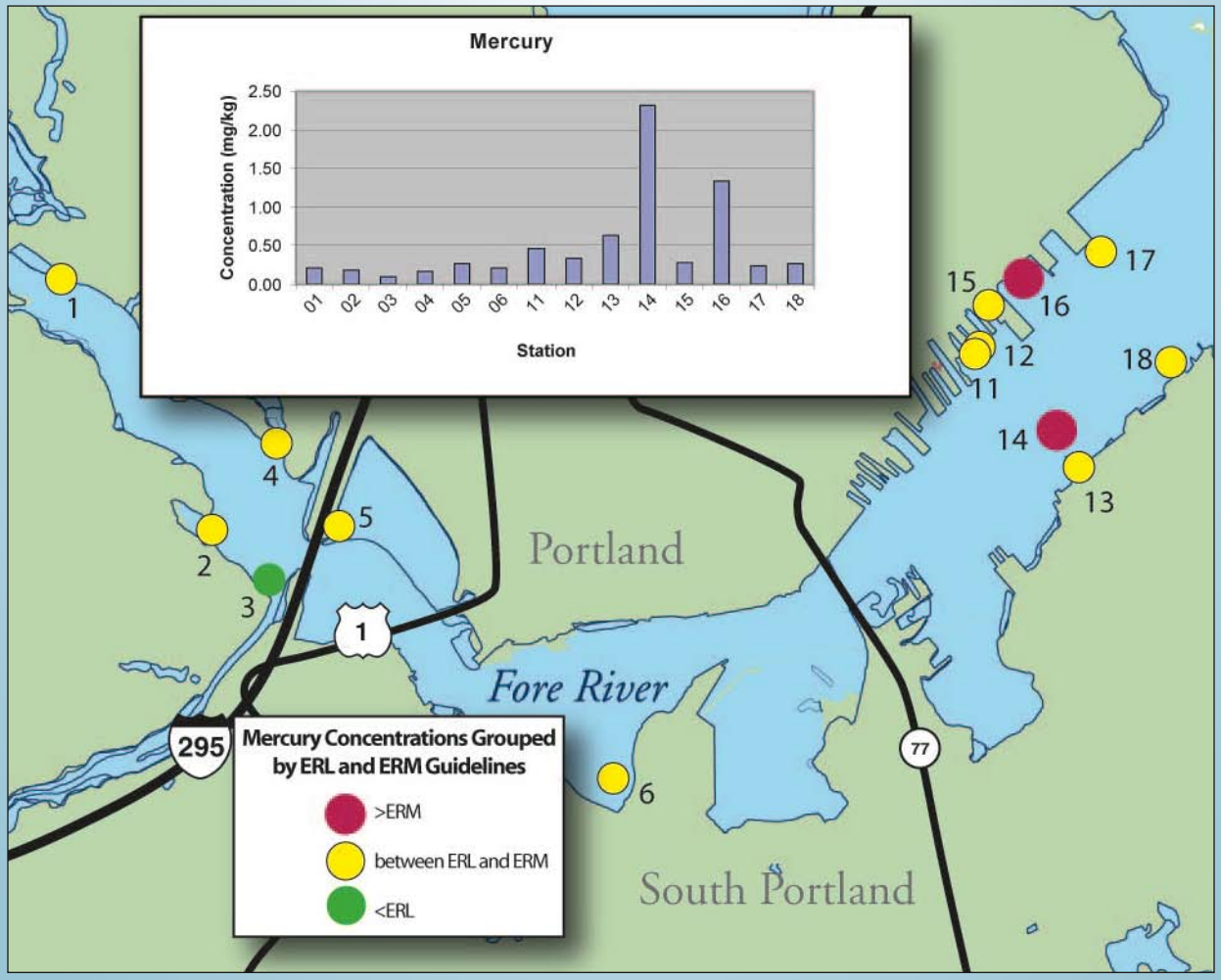
Friends of Casco Bay

Friends of Casco Bay scientist Peter Milholland and volunteer Pam Joy use a grab sampler to collect sediment samples for the Portland Harbor/Fore River study conducted in 2004.

Results

- **Metals:** Mean sediment concentrations were slightly elevated above the ERL (possible biological effects) for cadmium, lead, nickel, silver and zinc for several of the 18 sites sampled. Mercury concentration exceeded the ERL at most sites and was elevated above the ERM (probable biological effects) at two sites: (14) and the Maine State Pier (Station 16). Copper concentrations were elevated above the ERL at 4 sites and exceeded the ERM at the Maine State Pier (Station16) (FOCB 2005a).

Figure 4-9: Mercury Concentrations in the Fore River Grouped by ERL and ERM Concentrations

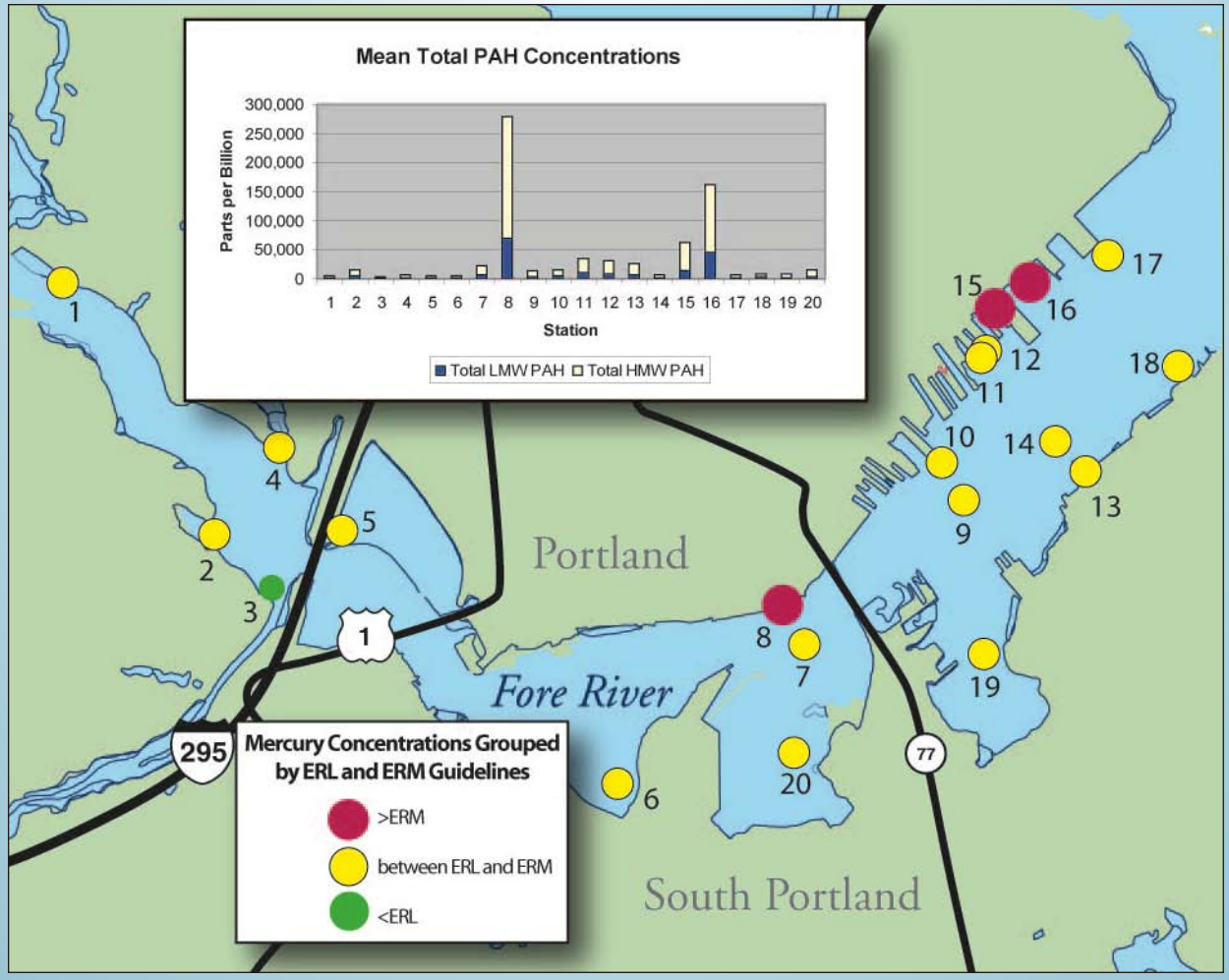


- **PAHs:** Total PAH concentrations at all but one of the 20 sites sampled were elevated beyond the ERL concentration (possible biological effects), while the Gas Works/China Clay Docks (Station 8) and two sites near large CSOs, the Maine State Pier (Station16) and the Casco Bay Ferry Terminal (Station 15), exceeded the ERM concentration (probable biological effects) established by the NOAA Status and Trends program (Long *et al.* 1995).

  The ratio of low molecular weight PAHs to high molecular weight PAHs can be used as a way to "fingerprint" the likely source of pollution. Low molecular weight PAHs are generally from pre-combustion sources such as oil spills, while high molecular weight PAHs are associated with post-combustion products, entering the marine environment via stormwater runoff and atmospheric deposition. The Casco Bay Ferry Terminal site (Station 15), for example, had a "fingerprint" suggesting primarily post-combustion sources, likely from the CSO at the site (FOCB 2005b).

This sampling study has provided baseline data on the current status of the Harbor and Fore River sediments and will be valuable as future dredging needs and potential dredging impacts are evaluated.

Figure 4-10: Total PAH Concentrations in the Fore River Grouped by ERL and ERM Concentrations



Summary/Conclusions

The levels of toxic chemicals in the sediment of Casco Bay are not likely to pose a biological threat to resident biological organisms in most areas of the Bay. However, PAHs and PCBs are elevated in some parts of the Inner Bay, exceeding the thresholds believed to cause biological impacts. While the levels of sediment contamination are low in much of the Bay, toxic pollutants have the potential to become concentrated in higher predator organisms through the processes of biomagnification and bioaccumulation (see Chapter 1). For example, the elevated levels of dioxin in lobster tomalley and PCBs in the tissues of bluefish and striped bass are a result of these processes (see Chapter 8).

CBEP's sediment studies suggest that the levels of many of the toxic pollutants found in the sediments of Casco Bay are declining over time. This is likely the result of successful federal, state and local environmental control strategies, including bans on the manufacture and use of certain chemicals (*e.g.,* DDT, PCBs), regulations which limit the use or release of toxic chemicals (*e.g.,* TBT, dioxin), and ongoing efforts to reduce toxic chemical releases from point and non-point sources. For further discussion of efforts to reduce the loading of toxics to the Bay, see Chapter 9.

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