Casco Bay Sediment Assessment

Casco Bay Estuary Partnership

FACT SHEET

Since 1991, Casco Bay Estuary Partnership (CBEP) has sponsored a monitoring program to track the concentrations of certain pollutants in sediments throughout Casco Bay to answer the following questions:

- *What are the concentrations of chemicals in Casco Bay sediments?*
- *Are chemical concentrations in sediment high enough to harm marine life?*
- *How have chemical concentrations in sediment in the Bay changed over time?*

This fact sheet presents and interprets the results from sediment monitoring conducted from 1991 through 2011, the most recent year for which data are available. The sediment data show that concentrations for legacy pollutants tend to be declining throughout the Bay.

What is sediment and why does it matter?

Sediment is the sand, silt, and mud found at the bottom of the Bay; it is composed of naturally occurring minerals and organic material (e.g., decaying leaves and seaweed) as well as chemicals originating from human activities. Sediment in coastal areas generally comes from the adjacent watershed, transported there by rivers and streams that discharge to the Bay. Chemicals from industrial sources released to storm sewers, wastewater, streams and rivers within the Bay's watershed can ultimately end up in the Bay, typically resulting in higher concentrations closer to the sources from which they originate and in areas where water is slow-moving and finer sediments accumulate. In addition, because sediment is continuously delivered to coastal areas by rivers and streams, it provides a historical record of chemical sources to the Bay. Chemical concentrations near the sediment surface represent the most recent deposits and deeper sediments reflect older deposits.

Coastal sediments provide important habitat for marine life that serves as the base of the marine food chain. Approximately 90% of all marine species live at least part of their lives associated with the bottom of the ocean, including soft shell clams. Therefore, chemicals in sediment can ultimately move up the food chain as they are taken up by plants, invertebrates, and fish. If chemical concentrations are high enough, their presence in sediments can be harmful for aquatic life or the humans and wildlife that consume them.

What substances end up in the sediment?

The Bay's watershed is nearly 1,000 square miles in area and is home to approximately 250,000 people. Because of its industrial legacy and the scale of the watershed, the Bay has numerous potential sources of chemicals. The specific details regarding historical and ongoing sources of chemicals to the Bay are the subject of previous CBEP publications available on CBEP's website: *Reducing Toxic Pollution Factsheet* (2011), *Toxic Pollution in Casco Bay, Source and Impacts* (2007), *The Dirty History of Portland Harbor* (1994)

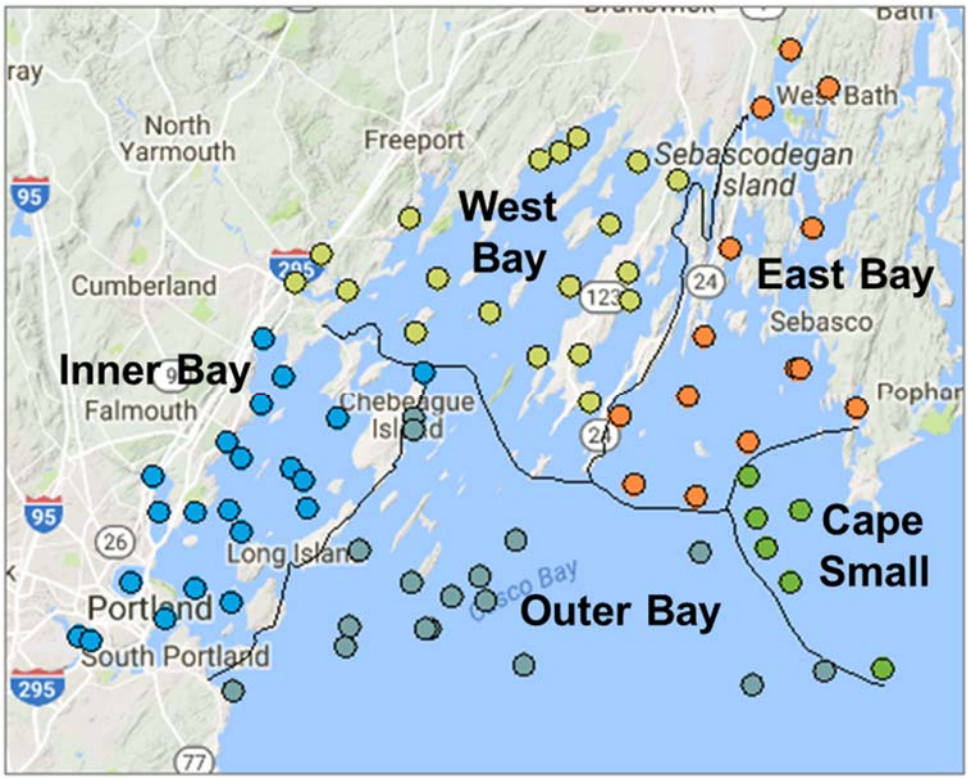
CBEP's sediment monitoring program is associated with one of CBEP's priorities for watershed protection in the original Casco Bay Plan (1996; revised in 2006): to reduce toxic pollution to the Bay. Based, in part, on these monitoring results, CBEP's most recent Casco Bay Plan (2016) shifts priority from some of the legacy pollutants (e.g., DDT and PCBs) to ongoing and emerging sources of chemicals to the Bay (e.g., stormwater and nutrients).

Potential Sources of Legacy Pollutants in Casco Bay

- Polluted stormwater
- Untreated sewage from combined sewer overflows
- Treated sewage from wastewater treatment plants
- Leaching from old industrial sites
- Improperly stored pesticides, oils, and chemicals leaching into groundwater
- Emissions and discharges from industrial and municipal operations
- Deposition of atmospheric pollution from urban sources in and upwind of Maine
- Oil and fuel leaks from automobiles
- Fuel spills in Maine waters
- Household chemicals that enter the waste stream
- Historical discharges prior to modern pollution controls

What is the Casco Bay Monitoring Program?

The Casco Bay Sediment Monitoring Program was designed to provide an estimate of concentrations of pollutants throughout the Bay over a span of time. Therefore, sample locations were evenly distributed throughout the Bay and assigned to one of the following 5 regions in the Bay: Inner Bay, Outer Bay, West Bay, East Bay, and Cape Small.



Surface Sediment Sampling Locations and Regions (2010-2011)

The first samples in the monitoring program were collected in 1991 and 1994 from 70 locations. Those same 70 locations were revised in 2000 through 2002 and an additional 13 locations were added to the sampling program. Finally, in 2010-2011, sediment samples were collected from 70 locations that were sampled during the previous sampling programs.

All samples were collected from the sediment surface, defined as the top two to three inches, in order to characterize the most recent sources to Casco Bay. Each sediment sample was then analyzed for the chemicals listed on the right.

Chemicals evaluated in the Casco Bay Sediment Monitoring Program

The sediment monitoring program (1991-2011) focused on two categories of chemicals—heavy metals and organic compounds:

Heavy metals: Elements such as lead, mercury, arsenic, cadmium, chromium, and zinc enter the Bay from sources such as vehicle emissions and industrial and wastewater discharges. Because heavy metals cannot break down, they accumulate in sediment and may be taken up by marine organisms.

Organic compounds: These wide-ranging chemicals can occur naturally or originate from human activities. Those evaluated during the monitoring program include:

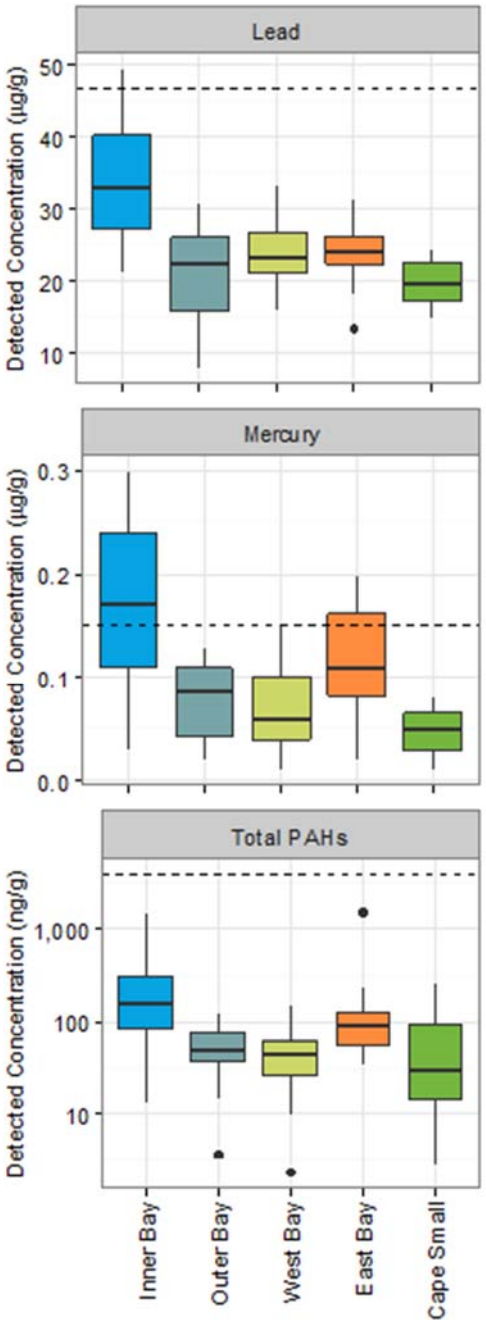
Polycyclic aromatic hydrocarbons (PAHs) are the most widespread toxic pollutants in Casco Bay. They come primarily from the combustion of fossil fuels and wood but also from fuel spills.

Polychlorinated biphenyls (PCBs) are synthetic chemicals that had many industrial uses until they were banned from production in the late 1970s. They are highly resistant to degradation, are frequently detected in environmental samples, and are classified as probable human carcinogens.

Organochlorine pesticides tend to be persistent, toxic, and bioaccumulative. The main source to the Bay is runoff from lawns and fields from historical applications.

Dioxins and furans are formed when organic material is burned in the presence of chlorine. Examples of their sources include waste incinerators, pulp paper mills, and combustion of some fossil fuels.

Butylins are organic compounds that contain tin and were used in marine paints as anti-fouling agents. Though they are no longer in common use, they are commonly found in sediments near shipyards and marinas due to their persistence.



Results for key chemicals from the 2010-2011 sampling event are summarized with "box and whisker plots." The colored boxes represent the range of the middle half of the data (i.e., half the results fall within the colored boxes) and the horizontal line in the middle shows the median concentrations. The "whiskers" show the full range of the results except for extreme (or "outlier") values shown as points.

The dashed lines show screening values, below which adverse effects have rarely been observed.

ng/g: nanograms per gram or parts per billion

µg/g: micrograms per gram or parts per million

What are the concentrations of chemicals in Casco Bay sediments?

Chemicals that are most directly associated with human activities (e.g., lead, mercury, zinc, and PAHs) tended to be at higher concentrations in the regions closer to human sources (see the figures on the left). For example, mercury concentrations were significantly higher in sediments from the Inner Bay (near Portland) than in any other region. Sediment concentrations in East Bay and West Bay tended to fall between those from Inner Bay and those from Outer Bay and Cape Small which are more influenced by the larger Gulf of Maine.

Are chemical concentrations in sediment high enough to harm marine life?

Although chemical concentrations tended to be higher in Inner Bay, they were generally consistent with concentrations that are known to be safe for marine life. The figure on the left shows that most mercury concentrations in Inner Bay exceeded the lowest sediment screening value, but all results were well below the screening value above which adverse effects are typically observed. Based on the chemicals for which screening values have been established (i.e., most metals, PAHs, PCBs, and some pesticides), there is little evidence that chemicals in sediments in Casco Bay are high enough to harm marine life.

How have chemical concentrations in sediment in the Bay changed over time?

Concentrations of most chemicals in the sediments of Casco Bay have either decreased or showed little to no change over time as represented by sediment collected between 1991 and 2011. Organic compounds were not widely detected, and concentrations of most metals tended to be lower in the 2010-2011 dataset compared to earlier sampling efforts.

Chemicals such as metals, dioxins and furans, and PCBs can persist in sediment for decades. Changes in loadings from industry, as well as more advanced regulations, likely explain the declines in sediment concentrations since 1991. Natural processes deliver clean sediment in the Bay and those more recent inputs are deposited over older, more-contaminated sediments. This mechanism, coupled with control of historical sources (e.g., through the nationwide banning of PCBs), is reducing concentrations of most persistent toxic chemicals in surface sediment in Casco Bay.

Due to the diversity of sources of PAHs and their association with fossil fuel consumption, PAHs are less controlled than legacy chemicals such as PCBs, organochlorine pesticides, and some metals. Concentrations of PAHs in sediment in the Bay were relatively stable between the first two monitoring events but declined throughout the Bay in 2010-2011 by about 85%, on average. This observed decline was unexpected and the reason for it is uncertain. It is consistent, however, with the observed decline in carbon emissions in New England between 2005 and 2012. The United States Energy Information Administration estimates there was a 35% decline in energy-related carbon dioxide emissions in New England during that time period.

Summary of Results from Casco Bay Sediment Sampling (1991-2011)

Chemical Group	Most Recent Conditions (2010-2011)	Trends since 1991
Metals	Below concentrations likely to be harmful[a]	Declining or stable[b]
PAHs	Below concentrations likely to be harmful	Decline since 2000-2002
PCBs	Rarely detected	Expected continued decline
Organochlorine Pesticides	Rarely detected	Expected continued decline
Dioxins and Furans	Low concentrations	Decline since 2000-2002
Butyltins	Low concentrations, not detected	Declining

a. For those metals where potentially harmful concentrations have been identified
b. Selenium concentrations were higher in the most recent sampling event but that result could be due to difference in laboratory methods between sampling events.

Remaining Questions

While an overall trend of recovery was observed for most chemicals, deviations from that trend are apparent for some metals. There were isolated locations with elevated concentrations of several metals (cadmium, chromium, cobalt, molybdenum, thallium, vanadium, and selenium) in Quahog Bay and Harpswell Sound. Given that these are isolated samples, however, it is difficult to determine whether these are real increases over time or the result of natural variability or analytical uncertainty. Additional sampling would be required to determine whether concentrations of those metals are, in fact, increasing in West Bay and East Bay.

The Casco Bay Sediment Monitoring Program has focused on legacy chemicals that are actively regulated (e.g., dioxins and furans) or are no longer in production (e.g., PCBs and some pesticides). There are, however, emerging substances of potential concern that are not included in the monitoring dataset such as pyrethroid pesticides, flame retardants, pharmaceutical and personal care products, and microplastics. While most of these emerging substances are not likely to be as persistent in the environment as the legacy chemicals, additional work by CBEP and others is needed to determine whether they may pose risk of harm in Casco Bay.

For More Information

The complete Casco Bay Sediment Assessment report and dataset is available on CBEP's website (cascobayestuary.org).

Partners

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What You Can Do

While existing regulations help to reduce the volume of contaminants entering Casco Bay, we all have a role to play. The following are steps you can take to reduce contaminants in Casco Bay:

- Refuel boats and vehicles carefully to avoid spillage.
- Never pour used motor oil, antifreeze, or other household waste down household drains, into storm drains, or onto soil. Bring them to Household Hazardous Waste disposal days sponsored by your municipality.
- Do not flush unused medications down the toilet. Bring them to Household Pharmaceutical Waste disposal days sponsored by your municipality.
- Minimize or eliminate use of pesticides and fertilizers on your lawn or garden.
- Reduce use of and reliance on fossil fuels.

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