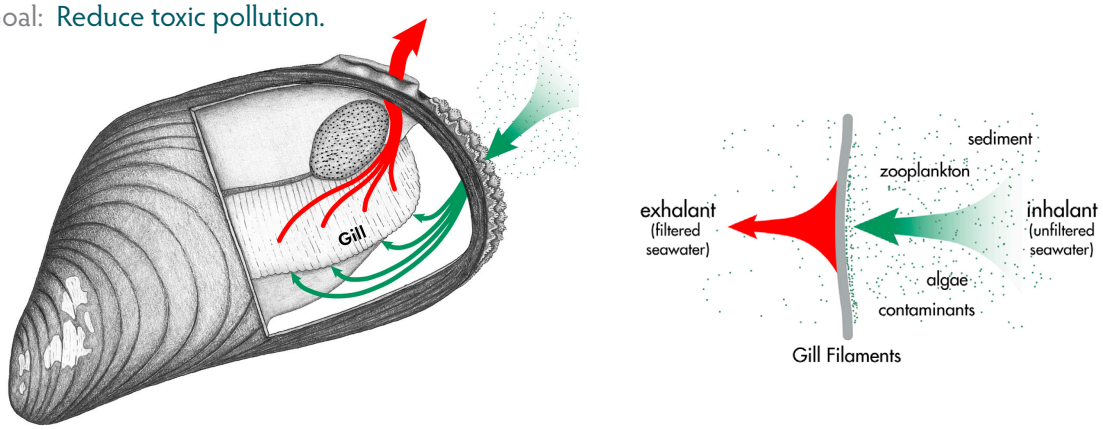
INDICATOR 9

Are there toxic chemicals in the tissues of Casco Bay blue mussels?

CBEP Goal: Reduce toxic pollution.



Ethan Nedeau

The common blue mussel is an excellent indicator of environmental contamination. As a mussel breathes and feeds, its gill filters out and retains small particles, including biologically available contaminants, which can be ingested and assimilated into its tissues.

Why Is It Important to Monitor the Levels of Toxic Chemicals in Blue Mussels in Casco Bay?

The common blue mussel, *Mytilus edulis*, is long lived and sedentary as an adult, accumulating local contaminants through feeding and surface contact. It is common throughout Gulf of Maine coastal areas where it is found in densely populated beds in the intertidal zone—the area between low and high tides. Casco Bay is one of the most productive areas in Maine for wild mussels. The blue mussel is thus a useful "sentinel" species for the Bay. Because many toxic compounds biomagnify (become more concentrated in organisms higher up the food chain), elevated levels of contaminants in the tissues of blue mussels—which are near the base of the food chain—suggest that top-level consumers, including fish and humans, may be at risk from contaminants in the ecosystem.

Andreas Trepte

Data on toxic compounds in mussels from Casco Bay come primarily from statewide and regional monitoring programs. Maine DEP began using *Mytilus edulis* as an indicator species of toxic exposure in 1987, and has analyzed their soft tissues from approximately 65 sites along the Maine coast over the past 23 years. CBEP has periodically provided funding to add additional sites in Casco Bay to the program. Gulfwatch, a joint US/Canada blue mussel monitoring program, began sampling US and Canadian waters in 1991.

Status of Casco Bay Mussels

DEP SWAT Program 2007–2009 Sample Collection

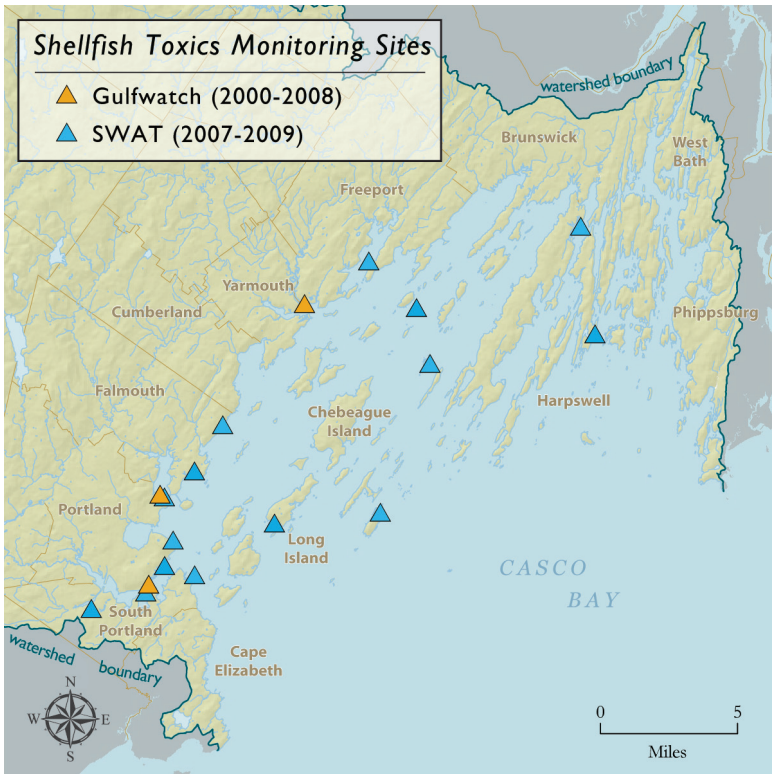
Samples were collected by DEP from sites in Casco Bay in 2007, 2008 and 2009 (see map on p. 39). Sampling was done from mid-October to mid-December each year, at four sites along the shoreline at each of the sampling locales. Mussels selected for analysis were in the 50 - 60 mm size range (DEP 2010). All samples were analyzed for aluminum (Al), arsenic (As), cadmium (Cd), copper (Cu), iron (Fe), nickel (Ni), lead (Pb), zinc (Zn), silver (Ag) and mercury (Hg), PAHs, PCBs pesticides, dioxins and furans. Samples with elevated levels are noted in the table. Note that elevation of Al and Fe (which are common and relatively non-toxic constituents of clay and soil minerals) often corresponds to high intake of suspended sediment and may relate to gut contents rather than tissue levels.

Pesticides sampled include the sum of DDTs (dichlorodiphenyl-trichloroethylene) and breakdown products. While the highest DDT levels were seen in Long Island, all Maine samples were considered to be in the low range nationally, based on National Status and Trends Mussel Watch data (NOAA 2008). Dieldrins and chlordanes were also in the low range in Maine samples. Elevated levels for the sum of organochlorine pesticides as compared to

Toxics Elevated[1,2] in Mussels Collected from Sampling Sites in Casco Bay 2007 – 2009
(Note that only East End Beach was sampled twice during this period)(DEP 2010)

Year Sampled	Sampling Location	Al	Fe	Cr	Cu	Ni	Pb	Zn	Hg	PCBs[3]	PAHs[4]	Organo-chlorine Pesticides[5]
2007	Spring Point, S. Portland				X[2]		X[2]					X[2]
	Middle Fore River, S. Portland				X[2]		X[2]	X[1,2]		X[2]	X[2]	X[2]
	East End Beach, Portland				X[2]		X[2]					X[2]
	Jewell Island, Punch Bowl											
	Falmouth Anchorage				X[2]							
	Harraseeket River, Freeport				X[2]							
	Mare Brook, Harpswell Cove				X[2]							
2008	Presumspcot River, Falmouth				X[2]		X[1,2]		X[2]			X[2]
	Middle Bay, Harpswell											
2009	Inner Fore River, Portland	X[1,2]	X[2]	X[1,2]	X[2]	X[2]				X[2]	X[2]	X[2]
	East End Beach, Portland	X[1,2]	X[2]	X[1,2]		X[2]	X[2]			X[2]		X[2]
	Mill Creek, Falmouth											
	Long Island											X[2]
	Maquoit Bay Freeport											
	Quahog Bay, Harpswell					X[2]						

[1] Elevated based on Maine Reference Conditions, mean + 2 standard deviations (DEP 2005)
[2] Elevated based on Gulf of Maine-wide Gulfwatch 85th percentile value, *i.e.*, 85% of samples fall below the 85th percentile value (GOMC 2009)
[3] Sum of 19 PAHs
[4] Sum of 35 PCB congeners
[5] Sum of Organochlorine pesticides



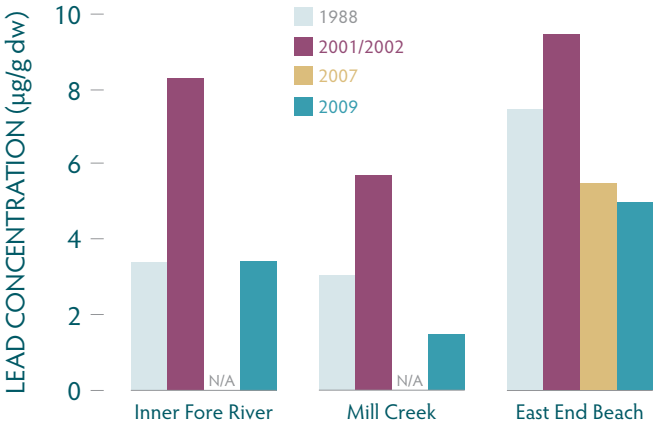
other data from the Gulf of Maine are noted in the table. In 2009, samples were also collected for additional pesticides: organophosphates, triazines, pyrethroids and organonitrogens. Those pesticides were not at detectable levels in the Maine samples tested (DEP 2010).

Temporal Trends in Casco Bay

Where data from the same sites are taken over time, it may be possible to compare the levels of pollutants, and observe whether there is any apparent temporal trend. Maine DEP undertook an analysis of temporal trends for selected metals in mussel samples collected from 1987 to 2008 (DEP 2009). Three Casco Bay sites were included: East End Beach in Portland, and Spring Point and Middle Fore River, both in South Portland. The results indicated that:

- Cadmium showed a stable or decreasing trend.
- Copper was relatively stable through time.
- Zinc was relatively stable through time (DEP 2009).

Changes in Lead Concentration in Mussels from Casco Bay Sampling Sites Over Time



DEP SWAT sampling over time at several Casco Bay sites suggests that while there was an initial increase in lead levels from 1988 to 2001/2002, there has been a decline in lead levels in more recent samples. Units are micrograms per gram dry weight. The Gulfwatch mussel sampling program (see table below) has observed a regional decline in lead levels over the past decade.

Comparison of lead levels in past and recent samples suggests that for some sites in Casco Bay, lead levels have declined over time. (See the bar graph above.)

Trends in Mussel Toxics Across the Gulf of Maine: Gulfwatch Data

Gulfwatch is a joint US/Canada blue mussel monitoring program funded through the Gulf of Maine Council on the Maine Environment. Since 1991, the program has monitored mussels to help identify temporal and spatial trends in ecosystem exposure to toxic compounds throughout the Gulf. Three sites sampled from 2000-2009 lie within the Casco Bay watershed: Portland Harbor (sampled five times in that period), Presumpscot River (sampled three times) and Royal River (sampled twice).

Metals

Concentrations for most metals appear to have decreased over time in the Gulf. In addition, concentrations are generally higher to the south and west, and lower heading downeast. At the Portland Harbor site, most metal concentrations, including lead, decreased from 2000 to 2008 (see the table below). To the extent comparisons can be made, metals at the other sites (data not shown) showed either no change or a decline over time.

PAHs

PAHs in the region (based on the sum of 24 PAHs) were highest for the two sites located in Boston Harbor and Long Island-Boston Harbor. For the most part, sample locations for the remainder of the Gulf of Maine contained relatively low levels of PAHs. However, the fourth highest total PAHs in the Gulf of Maine were observed at Portland Harbor (see the graph on p. 41). Similar high levels of PAHs were noted in the 1993–2001 data analysis (GOMC 2006).

Chlorinated Pesticides and PCBs

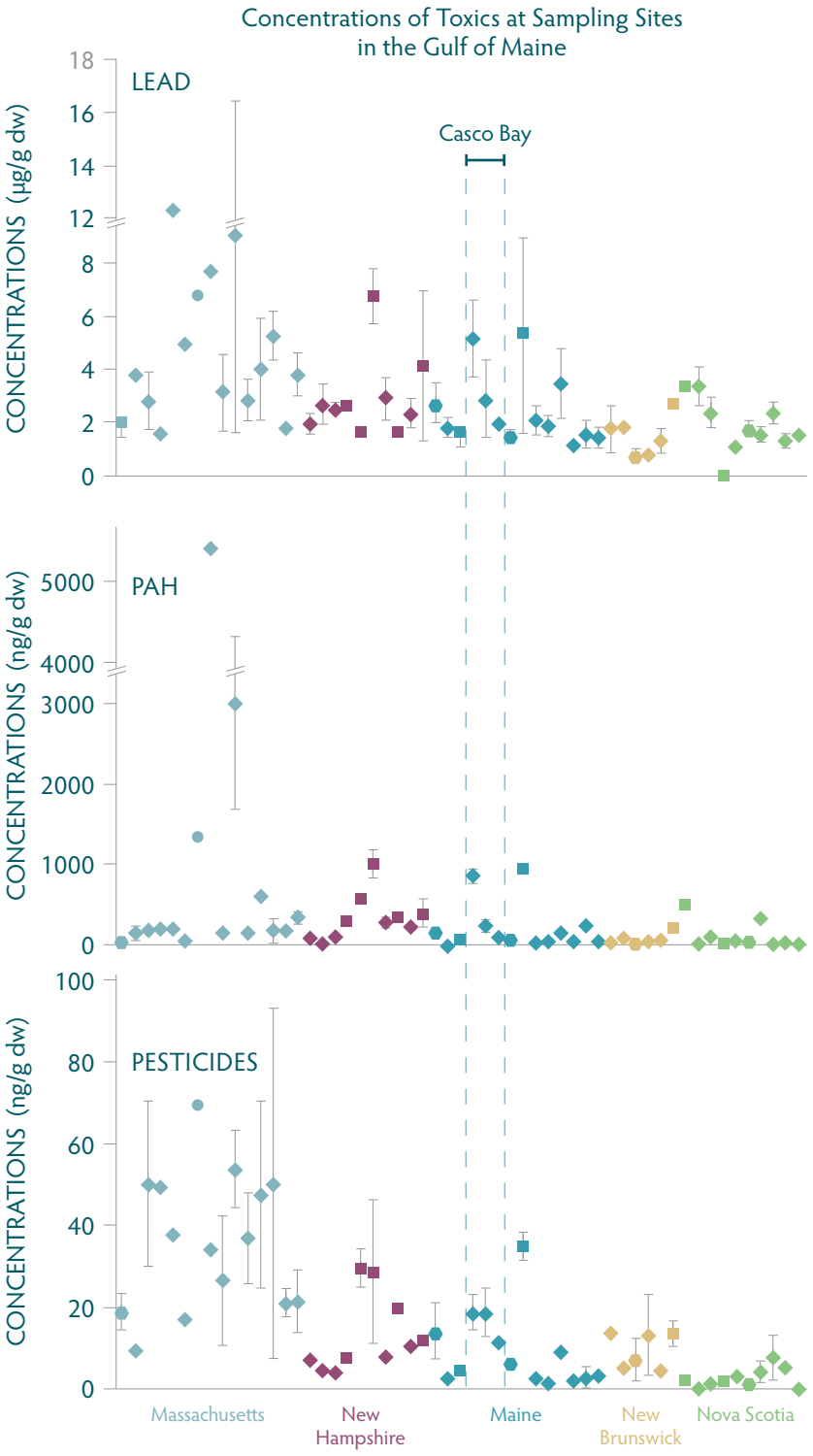
With respect to chlorinated pesticides, values were quite high in Massachusetts, with the largest concentrations observed in Boston's Inner Harbor. Casco Bay samples ranged from a low at the Royal River site to a high at Portland Harbor. In general, concentrations of pesticides decrease with increases in latitude. Similarly, the concentrations of all PCBs summed together decrease with increases in latitude. Highest values were observed in Massachusetts at Neponset River and Boston's Inner Harbor. Casco Bay samples ranged from a low at the Royal River to a high at Portland Harbor.

Gulfwatch Data for Metals in Portland Harbor

Year	Hg	Ag	Cd	Pb	Ni	Zn	Al	Cr	Fe	Cu
2000		0.1	1.78	11.5	2.45	357.5	370	2.3	737.5	12.3
2003	0.30	0.09	1.48	2.33	7.62	107.8	467		668.8	
2005	0.29	0.05	1.89	6.58	1.39	159.5	464	1.8	761.3	8.6
2007	0.2	0.02	1.39	4.34	0.95	146	250	1.7	444	7.6
2008	0.2	0.02	1.48	5.16	1.06	139	483	1.4	606	8.08

Most metals have decreased over time (units are µg/g dry weight).

Corey Templeton



Eight-year (2000-2008) median and median absolute deviations[1] in concentrations in mussel tissues at all Gulfwatch sites, in geographic order (south to north along the x axis from Massachusetts to Nova Scotia).

- ⬣ Benchmark site (sampled every year)
- ◆ Multi-year sites (sampled every 3 years)
- ● Sampled every 6 years
- ■ Occasionally sampled sites

[1] In statistics, the median absolute deviation (MAD) is defined as the median of the absolute deviations from the data's median: $MAD = median_i (|X_i - median_i(X_i)|)$ In words, 50% of observations lie within the range defined by the MAD.

Conclusions

Most areas of Casco Bay and the Maine coastline that are located away from human activity have measurable but not elevated levels of toxic chemicals (based on Maine reference conditions and Gulfwatch 85th-percentile values). Elevated levels tend to occur where past manufacturing has left a legacy of pollutants in the sediment; in harbors and commercial port areas; at the mouths of rivers; and in developed areas where runoff is carried into coastal waters from impervious surfaces (see Indicator 2). In the polluted Inner Fore River, for example, historical upstream industry, inflow from the Stroudwater River, and runoff from the Portland Jetport and the Maine Mall all contribute to the toxic body burden of resident mussels. At East End Beach, another affected area, urban runoff, leachate from a dump, riverine inputs from the Presumpscot, and nearby dense residential development all contribute to pollution levels.

The human activity-related pattern of mussel contamination seen by Maine DEP's mussel sampling efforts and by the Gulfwatch regional sampling program is also observed in the distribution of sediment contamination in the Bay (see Indicator 10). There is some positive news. The Gulfwatch data suggest that metal levels in mussels (and in the ecosystem) are declining across the Gulf of Maine, including Casco Bay. The Maine DEP data also support the conclusion that lead levels have dropped at several Casco Bay sites over time.

References

Casco Bay Estuary Partnership. 2005. *State of the Bay.* http://www.cascobay.usm.maine.edu/sotb05.html

Gulf of Maine Council. 2006. *The Nine-Year Gulfwatch Program 1993-2001: A Review of the Results and Program Design.* L. White, S. Jones, P. Wells, G. Brun, G. Harding, P. Hennigar, C. Krahforst, D. Page, J. Schwartz, S. Shaw, D. Taylor, P. Trowbridge.

Gulf of Maine Council on the Marine Environment. 2009. *Gulfwatch 2008 Data Report: Eighteenth Year of the Gulf of Maine Environmental Monitoring Program.* http://www.gulfofmaine.org/gulfwatch/data/files.php

Maine Department of Environmental Protection. 2005. *A Decade of Toxics Monitoring.* John Sowles.

Maine Department of Environmental Protection. 2009. *2008 Surface Water Ambient Toxic Monitoring Program.*

Maine Department of Environmental Protection. 2010. *2009 Surface Water Ambient Toxic Monitoring Program, Draft.*

National Oceanic and Atmospheric Administration. 2008. *An Assessment of Two Decades of Contaminant Monitoring in the Nation's Coastal Zone.* Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 74. 105 pp. http://nsandt.noaa.gov