GULFWATCH

Monitoring Chemical Contaminants in Gulf of Maine Coastal Waters

Gulfwatch is a chemical contaminants-monitoring program organized and administered by the Gulf of Maine Council on the Marine Environment (GOMC). Since 1991, Gulfwatch has measured contaminants in blue mussels, Mytilus edulis*, to assess the types and concentration of contaminants in the nearshore marine environment. Gulfwatch is conducted and coordinated by scientists and managers from agencies and universities around the Gulf.*

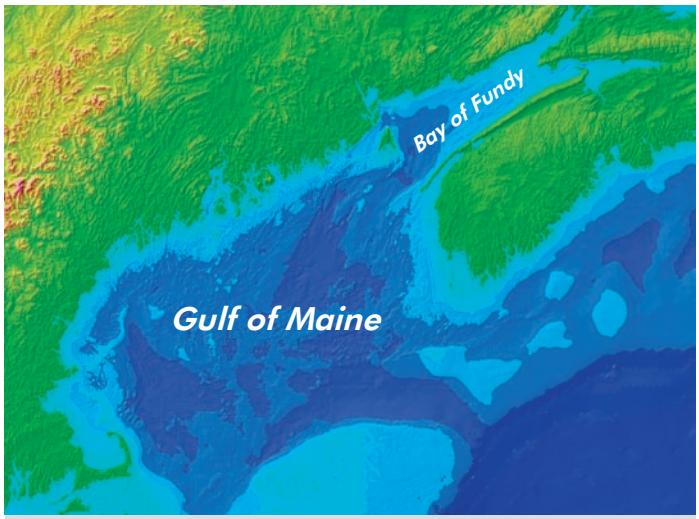
History of Gulfwatch

In December 1989, the premiers of Nova Scotia and New Brunswick and the governors of Maine, New Hampshire, and Massachusetts signed the *Agreement on the Conservation of the Marine Environment of the Gulf of Maine*. This agreement established the GOMC, whose mission is to maintain and enhance environmental quality in the Gulf of Maine. In 1989, the GOMC formed the Environmental Quality Monitoring Committee (EQMC) to provide resource managers with information to support sustainable use of the Gulf and allow assessment and management of risks to public and environmental health. The EQMC established three monitoring goals, which include providing information on:

- The status, trends, and risks of contaminants to the Gulf of Maine ecosystem.
- The human health risks from contaminants in the Gulf of Maine ecosystem.
- Monitoring information to resource managers that will allow both efficient and effective management action and evaluation of such action.

As a step toward meeting these goals, the EQMC established Gulfwatch. At the outset of the Gulfwatch program, an important objective was to test the feasibility and cooperation required for Gulf-wide monitoring. After a two-year pilot project that showed Gulfwatch could succeed, a study design was developed to:

- Conduct regional contaminant monitoring using the blue mussel as an indicator of habitat exposure to organic and inorganic contaminants.
- Assess the status and trends of chemical contaminants in coastal waters of the Gulf of Maine and Bay of Fundy.
- Establish a baseline reference for future monitoring efforts on trace chemicals.



The Gulfwatch Challenge

The Gulf of Maine is a semi-enclosed sea bound on three sides by Massachusetts, Maine, New Hampshire, New Brunswick, and Nova Scotia and flanked on the east by Browns Bank and Georges Bank, and includes the Bay of Fundy. Many environmental, social, and political challenges make it difficult to monitor the health of this ecosystem. Some of these are:

The Gulf of Maine Watershed Is Large
The Gulf of Maine watershed spans 69,115 mi^2 (165,185 km^2) and the Gulf of Maine spans 36,000 mi^2 (90,700 km^2). One challenge is deciding what, where, and how often environmental variables should be monitored.

Pollution Comes from Near and Far
Over 60 rivers pour 250 billion gallons (950 million m^3) of water—and contaminants—into the Gulf each year. Chemicals may also enter the Gulf from the atmosphere, overland runoff, or other human sources. Effectively identifying, quantifying, or remediating many pollution problems is challenging.

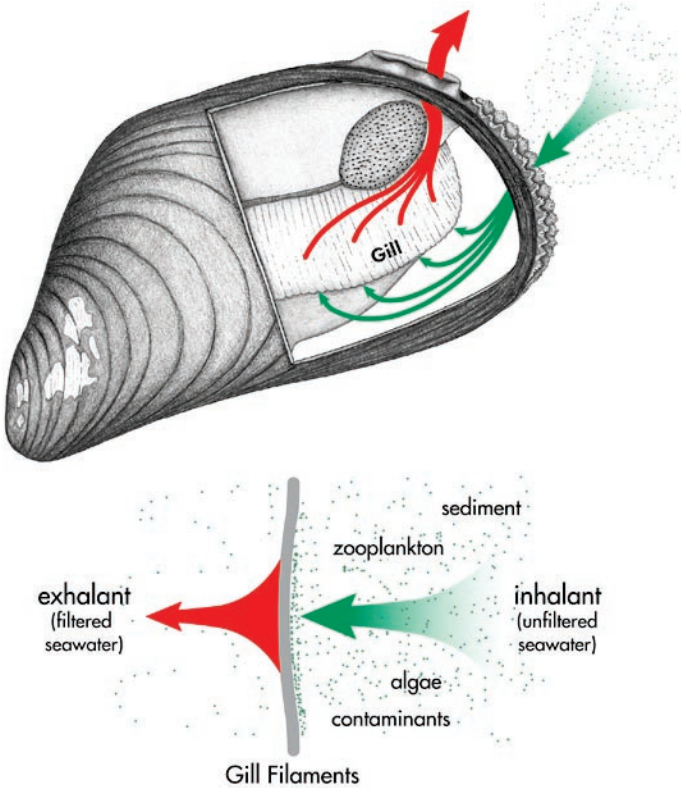
Our Population Is Growing
Nearly six million people live in the watershed, and the population is growing rapidly. Land and water resources in the region face enormous pressure. Monitoring programs must continuously respond to new scientific concerns.

Managing a Shared Resource Is Difficult
U.S. and Canadian government agencies face the challenge of having to collaborate and communicate with each other to manage a shared resource. Cooperation is generally high, but sometimes there is disagreement over management priorities.

The Blue Mussel

Gulfwatch scientists considered different marine species that would indicate contaminant levels in the coastal ecosystem. Such animals are called sentinel species because they act as local monitors of contaminant levels through bioaccumulation through feeding and surface contact. Tissue concentrations of chemicals consequently provide estimates of environmental concentrations. Gulfwatch scientists wanted a sentinel species that was common throughout the Gulf of Maine; that was easy to identify, collect, and process; and whose environmental requirements and feeding mechanism would make it a useful indicator of chemical concentrations in the environment.

Mytilus edulis, the common blue mussel, was chosen to be the sentinel species for the Gulfwatch program. The blue mussel is abundant in a wide variety of habitat types throughout Gulf of Maine coastal areas. It is long-lived and sedentary, which means that its body burden of contaminants reflects local environmental conditions over time. It feeds by filtering seawater to remove tiny plants and animals. These "living filters" are essentially like millions of natural sampling devices placed strategically throughout the coastal zone. The blue mussel is widely used in other environmental monitoring programs and laboratory and field toxicity studies, and it is commercially important. We have a very good understanding of its biology, physiology, and tendency to uptake and store chemical contaminants in its tissue.



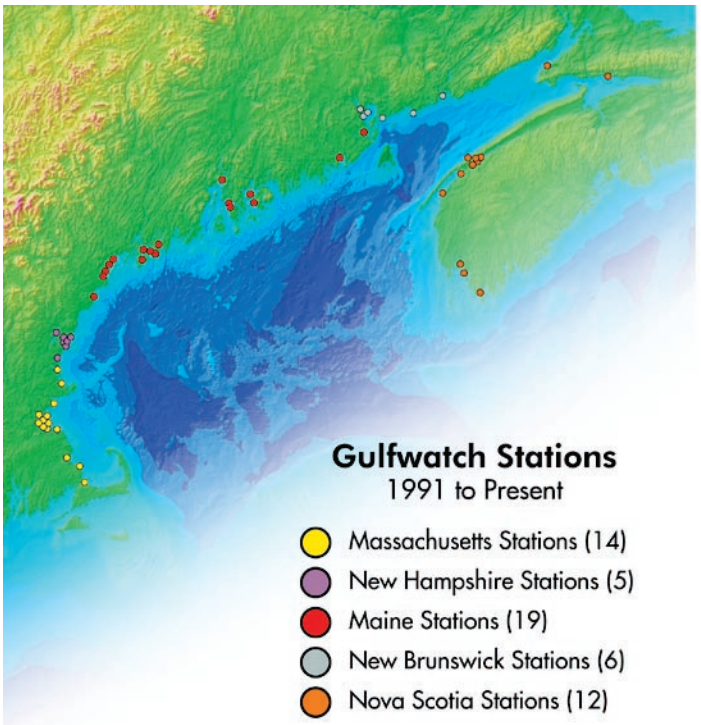
Blue Mussel Filter-Feeding
Blue mussels pump seawater past their gills to filter food items and suspended material, and release filtered water back into the environment. Materials retained by a mucous material on the gills—including tiny organisms, detritus, suspended sediment, and contaminants—are then eaten and assimilated or passed through their bodies undigested.

Gulfwatch Research

Each fall, scientists collect blue mussels, rotating among 56 locations around the Gulf of Maine, and analyze their whole tissues for a variety of contaminants. Data indicate where contaminant concentrations may be high and enable researchers to compare concentrations at different locations. Data also show changes in concentrations over time—time series analysis is continually being conducted as more data become available each year. Sampling and analysis methods, and Gulfwatch databases, are available on the GOMC Web site (www.gulfofmaine.org).

Measured Contaminants

Polycyclic aromatic hydrocarbons (PAHs) come from municipal and industrial effluents, fossil fuel combustion, wastewater from refineries and offshore oil rigs, and petroleum spills. Gulfwatch measures 24 PAHs.
Polychlorinated biphenyls (PCBs) are synthetic chemicals comprised of chlorine atoms arranged on a biphenyl molecule. They are highly persistent in the environment and may be highly toxic. Gulfwatch measures 24 PCBs.
Chlorinated pesticides are synthetic chemicals that have been used as pesticides, such as DDT and dieldrin. Most are highly persistent in the environment. Gulfwatch measures 17 chlorinated pesticides.
Metals occur naturally but human activities may increase their concentration and availability from fertilizers, fossil fuel combustion, metal smelting, industries, and domestic waste. Gulfwatch measures 10 metals.



Gulfwatch Results

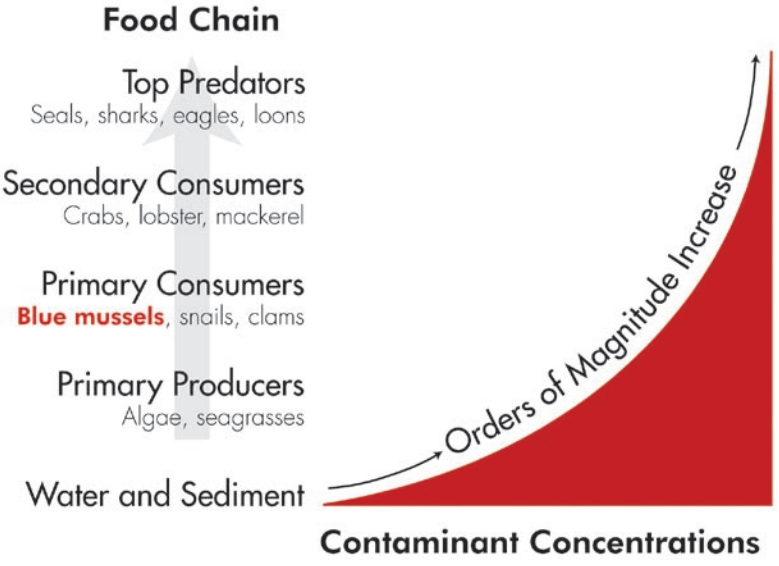
These are a few selected results. Please go to the list of publications and Web sites on page 4 or the Gulfwatch section of the GOMC Web site (www.gulfofmaine.org) for more information.

RESULT	EXPLANATION
Nearly all measured chemical contaminants were detected in mussels from each of the sampling sites.	Some chemicals may be at natural levels, whereas others may be elevated because of polluting sources. Gulfwatch provides this baseline information from which research questions or management actions can be developed.
Organic contaminants and certain metals were more concentrated in mussels collected near cities and large river mouths.	Anthropogenic waste enters aquatic environments and accumulates in aquatic organisms, so it is not surprising to see higher concentrations of contaminants such as silver, PCBs, and PAHs in mussels near cities and river mouths. This result demonstrates one of the consequences of urbanization on shellfish and other marine resources in some areas of the Gulf of Maine.
Tissue concentrations of PCBs, mercury, and lead at some sites were elevated compared to other regions of North America, although except for lead in Boston Harbor, no contaminant concentrations exceeded any US Food and Drug Administration federal action levels for human consumption.	The National Status and Trends (NS&T) Mussel Watch program helps to place Gulfwatch data in a larger regional context. Gulfwatch values that exceed the NS&T MD (median) are higher than the national average, and values that exceed the NS&T MD + 1 SD (standard deviation) are much higher than the national average. Gulfwatch found the following results for 56 of its sites (from Chase et al. 2001): • PCBs: 27 sites exceeded NS&T MD, and 10 exceeded NS&T MD + 1 SD • Mercury: 50 sites exceeded the NS&T MD + 1 SD • Lead: All sites exceeded NS&T MD, and 16 exceeded NS&T MD + 1 SD
Analysis of 5 benchmark sites from 1991-1997 showed that most contaminants in mussels were unchanged or decreasing. Notable exceptions were: • PAHs, PCBs, Al, and Cu significantly increased at the Sandwich, MA, site. • PAHs, PCBs, and chlorinated pesticides significantly increased at the Digby Harbour, NS, site.	Time series analysis has been done for 5 of the 56 Gulfwatch sites, and sufficiently long time-series data is not yet available, so interpreting trend data is still premature. Though the general pattern is that chemical contaminants have either not changed or decreased, exceptions to that pattern may provide important insight into local environmental problems around the Gulf of Maine. The time-series analysis is a good example of how Gulfwatch data might be used to develop specific research or management questions on a local scale—for example, developing research questions to understand why organic contaminants are significantly increasing in mussels in Sandwich, Massachusetts, and Digby Harbour, Nova Scotia.

In Depth: Biomagnification

Some contaminants—such as mercury and PCBs—bind to proteins or lipids and are stored in animals. Microbes, algae, and plants, which form the base of the food chain, can take up these contaminants directly from the water and sediment. Contaminant concentrations increase with each step of the food chain because they bioaccumulate faster than they can be metabolized—meaning that top predators such as eagles, seals, or sharks are at great risk of health effects from such contaminants. Concentration of PCBs or mercury can be over a million times higher in tissues of top predators than in seawater.

High levels of mercury and PCBs in mussels from the Gulf of Maine are a concern. Blue mussels are primary consumers, and a high tissue concentration of mercury and PCBs is a warning sign that top consumers, including humans, may also be at risk.



Biomagnification in the Marine Food Chain
Actual concentrations depend on the contaminant and a complex interaction of physical, chemical, and biological variables.

Case Study: New Hampshire Gulfwatch

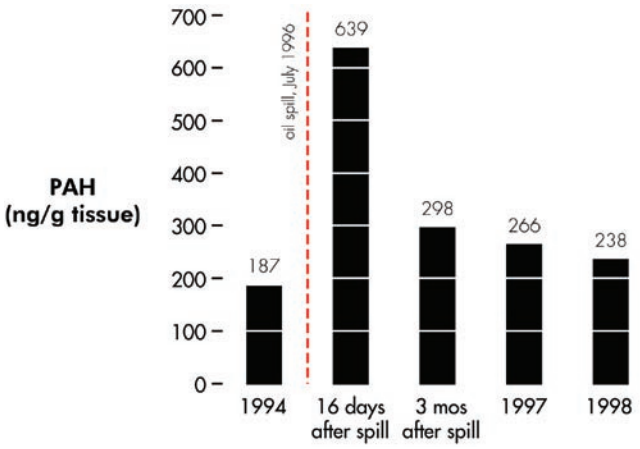
In 1998, the New Hampshire Department of Environmental Services and University of New Hampshire initiated the New Hampshire Gulfwatch program, based on the GOMC Gulfwatch program. The objectives of the New Hampshire program included:

- Developing a baseline database for contaminant exposure concentrations for New Hampshire mussels in coordination with the GOMC Gulfwatch program.
- Determining the impact and fate of spilled oil in the biota of the Great Bay estuary.
- Developing a petroleum contamination baseline to assist in damage assessment in the event of an oil spill.
- Expanding coverage of sampling sites to include mussels in critical habitats along New Hampshire's seacoast.

The joint effort of the Gulf-wide Gulfwatch program and the New Hampshire program provides a model of how a regional database can help interpret local study results. Contaminant concentrations that appear high within New Hampshire may be low compared to other areas in the Gulf of Maine, and the distribution of contaminants within New Hampshire compared with the Gulf of Maine provide clues about local versus regional sources of these contaminants. The joint effort also helped document the effects of an oil spill. In 1996, 1,000 gallons of fuel oil were spilled into the Piscataqua River, causing concern about PAH contamination of the estuary. Gulfwatch had collected and archived mussel tissue samples in 1994, which provided background data on contaminant levels to assess the impact of the oil spill. Gulfwatch quickly responded to the oil spill by collecting blue mussels 16 days and three months after the oil spill, and also in 1997 and 1998 to document recovery. Data show a spike in PAHs in shellfish following the oil spill, followed by a gradual recovery to near-background levels within two years.

Future of Gulfwatch

In the coming years, Gulfwatch will continue its assessment of trends in chemical contaminants throughout the Gulf of Maine, while adapting to meet the evolving needs of resource managers and surrounding communities, and also being responsive to changes in technology and assessments of the environmental integrity of the Gulf of Maine. Gulfwatch is networked to similar programs such as the NS&T Mussel Watch program. It is adding bioeffects measures to its regular sampling, and it is encouraging research and monitoring partnerships to strengthen mussel monitoring and to utilize other indicators of ecosystem health in the Gulf of Maine and Bay of Fundy.



Long-term effects of an oil spill on PAH concentrations in mussels collected from Dover Point, New Hampshire.

Useful References

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Wells, P.G. 2003. Assessing health of the Bay of Fundy: Concepts and Framework. Marine Pollution Bulletin 46(9): *In press*

Web Sites

http://gulfofmaine.org
Gulf of Maine Council on the Marine Environment

http://nsandt.noaa.gov/
NOAA National Status and Trends Program

http://www.des.state.nh.us/wmb/was/gulfwatch.htm
New Hampshire Department of Environmental Services: Gulfwatch

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Gulf of Maine Council on the Marine Environment

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Text: Ethan Nedeau & Christy Finlayson Graphics and design: Ethan Nedeau

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For more information about Gulfwatch, contact:
Steve Jones (shj@cisunix.unh.edu) or Peter Wells (Peter.Wells@ec.gc.ca)

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