EcoSystem Indicator Partnership

Information on change in the Gulf of Maine

Contaminants in the Gulf of Maine

The Gulf of Maine (GOM) coast is home to more than nine million people and stretches from Cape Cod, Massachusetts, to the Bay of Fundy shoreline of Nova Scotia. Prized for its beauty and abundant natural resources, the region has a long history of land development and resource exploitation.

Alterations to the GOM coast began with clear-cutting forests, dyking, and crop cultivation, which led to soil leaching and erosion. Centuries later, the industrial and chemical revolutions introduced new pollutants such as fossil fuels, metals, and synthetic chemicals, including pesticides, polychlorinated biphenyls (PCBs), pharmaceuticals, and personal care products. Although managers and policy makers now realize the negative environmental impacts of these pollutants and are taking steps to reduce damages, there is continual input of newer chemicals and nanoparticles, whose effects are not yet known.

Eliminating or reducing sources of these contaminants presents additional challenges. Chemical and microbial contaminants from human activities enter the GOM through surface runoff and river transport, volatilization, particle settlement and precipitation, or by direct discharge of domestic sewage and industrial effluents. Many of these chemicals are potentially toxic to marine life at low levels. Furthermore, these chemicals and disease-causing microbes can contaminate shellfish, posing a threat to human health.

To evaluate potential risks to human and environmental health, federal, state, and provincial agencies, among others, have been monitoring the GOM for chemical and microbial contaminants for many years. Important future challenges include assessing the toxicity of an ever-increasing number of environmental contaminants, both individually and combined in complex mixtures.

Photo: Dieter Weinelt

Why indicators?

Indicators help monitor conditions in the Gulf of Maine (GOM), and are one of the best tools for understanding and characterizing ecosystem changes. Like warning lights on a car's dashboard, indicators can work in concert with each other to provide an overview of the larger system. They can be combined into complex indices or be relatively simple. The EcoSystem Indicator Partnership (ESIP) has chosen three indicators to assess contaminant risks in the GOM:

1. **Chemical contaminants in mussels**
2. **Sediment contaminants and toxicity**
3. **Shellfish beds approved for harvesting**

Photo: Woods Hole Oceanographic Institution

Chemical Contaminants in Mussels

Indicator 1

Gulfwatch is a chemical contaminants monitoring program developed by the Gulf of Maine Council on the Marine Environment. The blue mussel (*Mytilus edulis*), which ingests and accumulates contaminants from ambient water, was chosen as a widespread indicator species to provide information on local contaminant levels. Since 1993, 71 contaminants have been monitored in blue mussels from sites around the Gulf of Maine/ Bay of Fundy: 9 metals, 24 PAHs, 16 chlorinated pesticides, and 22 PCB congeners.

Mercury

Blue mussels from Maine had the highest mercury levels (570 ng/g [ppb] dry weight [DW]) in the region. With few exceptions most monitoring data on contaminant levels in mussels over an 18-year period (1992–2010) showed either decreases in metals or little change. However, elevated mercury levels at some locations are still a concern for human and ecosystem health.

Polycyclic Aromatic Hydrocarbons (PAHs)

Concentrations of PAHs in the Gulf of Maine (GOM) mussels were higher than other organic contaminants with values for the Sum PAH ranging from below detection to ~5000 ng/g [ppb] [DW]. The highest PAH concentrations were found in the southwest Gulf, likely due to greater urbanization and industrialization. For most of the GOM no temporal trend in PAH values was observed over the 18-year period.

> Of the numerous chemicals that fall within each contaminant group, only a subset are analyzed and reported here as "Sum."

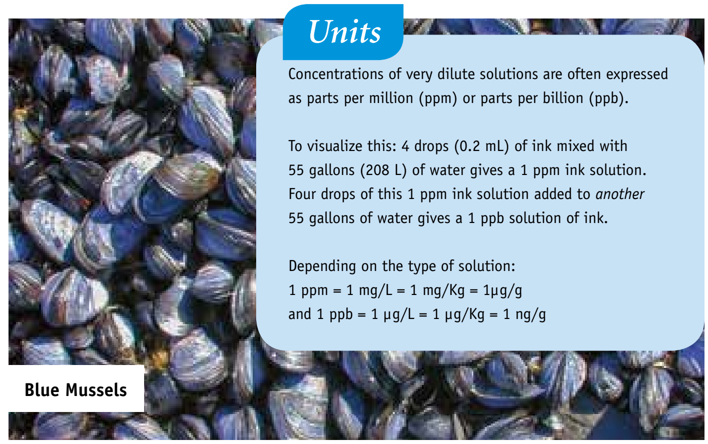
Chlorinated Pesticides

Chlordanes, dieldrin, DDT and its residues were the only chlorinated pesticides consistently detected in mussel tissues. Chlorinated pesticide levels in blue mussels, as in other parts of the environment, have declined since use was restricted in the 1970s. The Sum DDT concentrations ranged from below detection to ~120 ng/g [ppb] [DW]. The highest DDT concentrations in mussels were observed in the southern portions of the GOM.

Polychlorinated Biphenyls (PCBs)

The Sum PCB concentrations in GOM mussels ranged from below detection limits to 637 ng/g [ppb] [DW]. Known for its high chemical and biological persistence, the use of PCBs was restricted in the 1970s.

Together with the National Oceanic and Atmospheric Administration (NOAA) Mussel Watch Program in the US, the Gulfwatch Program provides a critical baseline for assessing future health and environmental risks from chemical contaminants in the GOM. The data from these combined contamination studies are useful for protecting human consumers through interpretation by qualified toxicologists and health specialists.



Blue Mussels

Photo: David Page

Units

Concentrations of very dilute solutions are often expressed as parts per million (ppm) or parts per billion (ppb).

To visualize this: 4 drops (0.2 mL) of ink mixed with 55 gallons (208 L) of water gives a 1 ppm ink solution. Four drops of this 1 ppm ink solution added to *another* 55 gallons of water gives a 1 ppb solution of ink.

Depending on the type of solution:
1 ppm = 1 mg/L = 1 mg/Kg = 1µg/g
and 1 ppb = 1 µg/L = 1 µg/Kg = 1 ng/g

FIGURE 1: Median mercury levels in blue mussels for Gulfwatch sites sampled from 2003 to 2009. Four data bins shown represent the first, second, third, and fourth quartiles of the data.

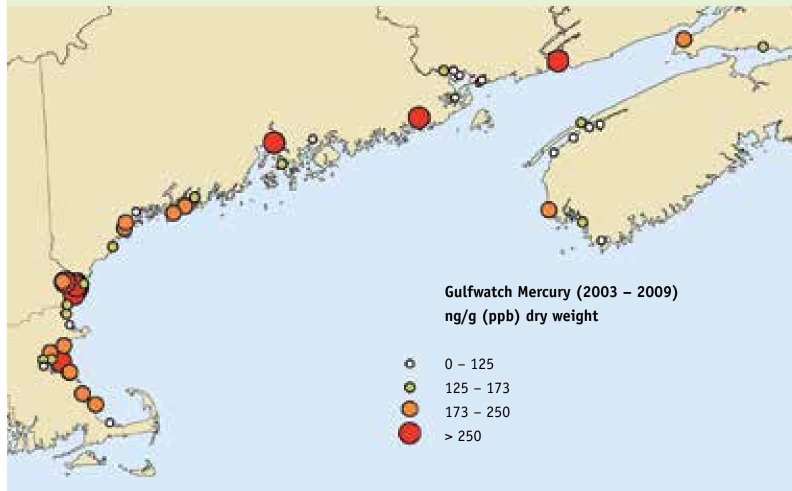
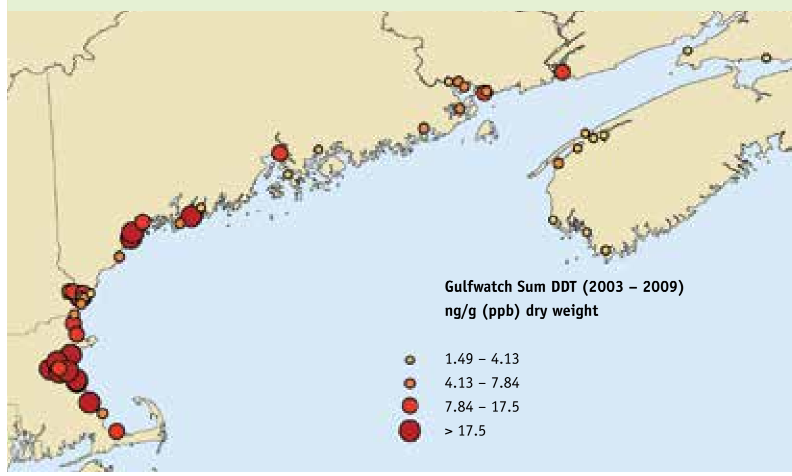


FIGURE 2: Median Sum DDT levels in blue mussels for Gulfwatch sites sampled from 2003 to 2009. Four data bins shown represent the first, second, third, and fourth quartiles of the data.



Sediment Contaminants and Toxicity

Indicator 2

Sediments are a common repository for contaminants and, as such, can be a source of harmful chemicals to aquatic organisms that live in, on, or nearby the sediments. Sediment quality guidelines such as effects range low (ERL) and effects range median (ERM), developed by the National Oceanic and Atmospheric Administration (NOAA), may be used to indicate if the chance of sediment toxicity is low (<ERL) or likely to occur (>ERM). Sediment assessment programs, such as the Environmental Protection Agency's National Coastal Assessment (NCA) program and NOAA's National Status & Trends (NS & T Program), take samples from randomized locations to represent broad areas.

From 2000 to 2006, these surveys indicated that, except for known hotspot areas in Boston Harbor, MA, and the Penobscot River, ME, mercury concentrations in sediments near the Gulf of Maine (GOM) coast seldom exceeded ERM levels. DDT, despite being banned in the US and Canada since the 1970s, was still detectable in sediments near the GOM coastline at levels exceeding the ERL. Several sites in Maine and Massachusetts had sediment concentrations of PAH that exceeded the ERL, with a few sites exceeding the ERM. In New Hampshire, 15 percent of sites had sediment PAH levels that exceeded the ERL (found mainly in rivers flowing into Portsmouth). Sediment concentrations of PCBs were elevated in some rivers and bays around Boston, MA, and Portsmouth, NH.

Evaluating the toxic potential of sediment is complex and involves many modifying factors. Metrics used to assess sediment quality include contaminant concentrations, the diversity and density of benthic organisms, total organic carbon content, and sediment toxicity. In toxicity tests conducted from 2000 to 2006, sediments from the vast majority of sites in the GOM were non-toxic. The few sites with toxic sediments were sparsely distributed and showed no strong relationship with sediment contaminant levels.

FIGURE 3: Mercury values measured in sediment by the NCA program. Levels are evaluated by: effects range low (ERL) or effects range median (ERM).

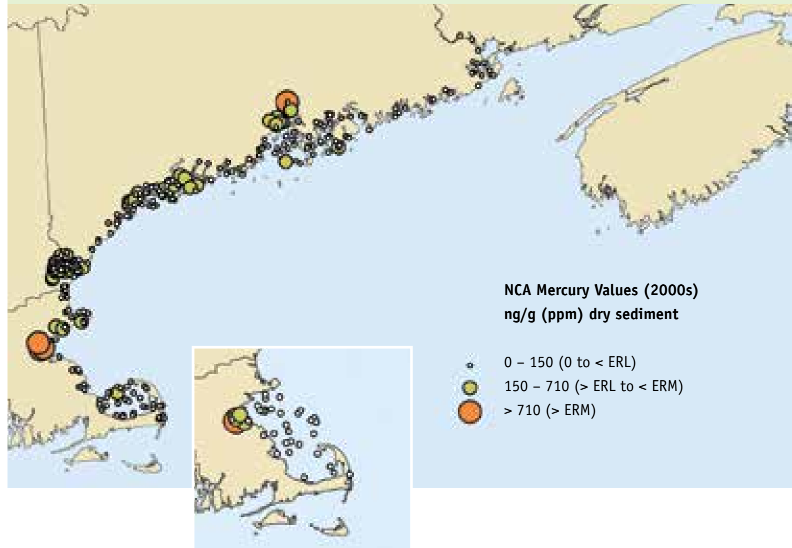
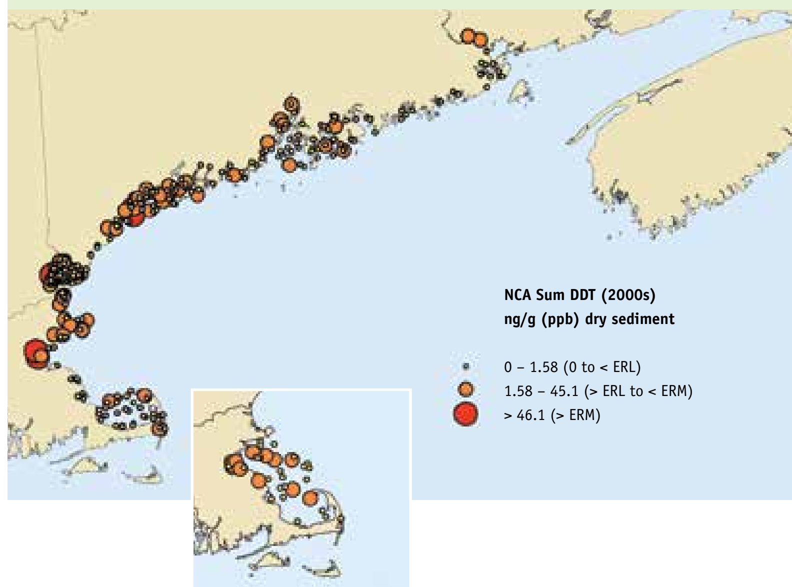


FIGURE 4: Sum DDT in sediment measured by the NCA program (as total of six DDT isomers). Levels are evaluated by: effects range low (ERL) or effects range median (ERM).



Focus on Casco Bay

Due to the industrial legacy of Portland, Maine, pollutants have been a major focus for the Casco Bay Estuary Partnership. In 1991, a baseline assessment detected trace metals, PCBs, and PAHs in sediments throughout Casco Bay (with the highest concentrations in the Fore River and inner bay of Casco Bay). Fortunately, most concentrations were below levels considered harmful to marine life. In 1994, dioxins and furans were detected downstream of pulp and paper mills, but not at levels that would cause adverse effects. In 2000 and 2001, resampling indicated either no change, or significant decreases, for most trace metals (including mercury), pesticides, DDTs, butyltins, PCBs, and low molecular weight PAHs. In 2004, intensive sampling in the Fore River found elevated levels of PAHs near urbanized areas that exceeded the ERL (see text).

Photo: Beverly Bayley Smith, Casco Bay Estuary Partnership

Shellfish Beds Approved for Harvesting

Indicator 3

Shellfish harvesting is an important economic and recreational activity in the Gulf of Maine (GOM). Disease-causing bacteria, viruses, and protozoa can affect shellfish and pose health risks to consumers. Shellfish can be contaminated by naturally occurring pathogens, which may cause illnesses if the shellfish is undercooked or eaten raw, or has unsafe levels of chemicals or natural toxins.

Fecal coliform bacteria are abundant in human and animal feces, and point and non-point sources of fecal contamination remain a problem for shellfish harvesting. Fecal coliform are relatively harmless, but their presence warns that disease-causing microbes may be present. Both Canada and the US measure fecal coliforms in the GOM to safeguard against fecal-borne microbial pathogens. The US National Shellfish Sanitation Program and the Canadian Shellfish Sanitation Program use the same water quality criteria and approach to classifying shellfish growing areas.

Many inshore areas of the GOM are unpolluted and harvesting is approved for licensed harvesters. Coastal areas are closed to shellfish harvest if they are in close proximity to known sources of pathogens or known to have poor water quality. Some other areas are closed periodically after a significant rainfall event that can enhance the transport of pathogens from the coastal watershed. For some slightly polluted areas, harvesting is allowed, but only if the shellfish are cleansed of microbial contaminants under controlled conditions prior to sale. There are also areas where shellfish harvesting is prohibited either because pollution levels are too high or potential pollution point sources, such as wastewater treatment facilities or marinas, are nearby.

As pollution sources have been identified and eliminated, more favorable reclassification of harvest areas has occurred. While the trend for reducing fecal pollution closures is encouraging, Massachusetts recently reported illnesses associated with the bacterium *Vibrio* in people consuming locally harvested shellfish. As a result, Massachusetts has implemented a *Vibrio* Control Plan that will limit harvesting during certain time periods. Water quality problems such as bacteria from fecal contamination may increase as climate change continues (see ESIP's climate change fact sheet).

Working Together to Avoid Illnesses

Emerging food safety risks have encouraged increased collaboration between the US Food and Drug Administration, Health Canada, the Canadian Food Inspection Agency, and Environment Canada. In an effort to better understand and interpret the food safety risks from bivalve molluscan shellfish contaminated with enteric viruses from sanitary sewage, a joint health assessment on noroviruses in shellfish is underway. The goal is to develop a tool that evaluates the impact of preventive controls, thereby avoiding increased human norovirus illnesses that arise from the consumption of bivalve molluscan shellfish grown and harvested in proximity to wastewater system discharges.

Obtaining Data

Indicator Reporting Tool

All data used for the three indicators discussed here are available through ESIP's Indicator Reporting Tool. The Tool (available at www.gulfofmaine.org/esip/reporting) uses familiar mapping platforms to enable users to locate contaminant data in the region. The tool produces snapshots of data that can be the basis of critical information.

The tool helps answer questions such as:

1. **Are contaminants present in sediments near my town's wastewater treatment plant?**
2. **Have concentrations of DDT and its residues in blue mussels near my town gone down since it was banned in the 1970s?**

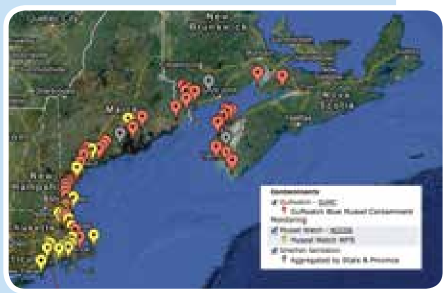


TABLE 1: Percentage of shellfish harvesting beds approved or conditionally approved for harvesting.
Years with no data are left blank.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Massachusetts (includes areas south of Cape Cod)	70					76				79				79						69
New Hampshire	31		34		34	39				34	36	82	83	83	83	83	83	83	86	86
Maine	89					84				89		90	90	90	92	92	92	92	92	
New Brunswick and Nova Scotia (Bay of Fundy only)						60				59	51	50	50	50	50	50	49	50	49	

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The EcoSystem Indicator Partnership (ESIP) is part of the **Gulf of Maine Council on the Marine Environment (GOMC)**. In 2006, the GOMC created ESIP to assess the ecological integrity of the Gulf of Maine through the use of indicators. This fact sheet is one outcome supporting this goal. Funding, in part, was provided by the Department of the Interior, the US Environmental Protection Agency, and Environment Canada. Considerable assistance was provided by the Massachusetts Water Resources Authority staff and the US Environmental Agency Region 1 staff.

For more information on any of the ESIP products, please visit our website at **www.gulfofmaine.org/esip.**

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