Spring 1999 ISSUE # 12

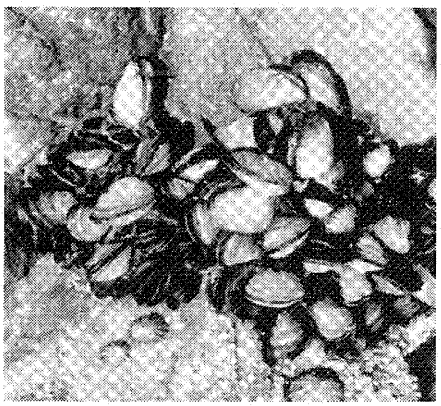
FUNDY ISSUES

Gulfwatch

Putting a little mussel into Gulf of Maine marine monitoring

Each fall, small bands of people crunch over cobbles and mussel shells along the Gulf's coast to pull handfuls of blue mussels from their beds. Later they remove the mussels from their shells and bottle the meats. But rather than being stirred into a spicy marinara sauce, these mussels are sent to laboratories to be analysed for trace metals and toxic organic contaminants. The results are entered in a database available to those looking for information about the Gulf's water and sediment quality.

All of this activity is overseen by Gulfwatch, the marine environmental monitoring program conducted by a committee of Canadian and US government and university scientists established by the Gulf of Maine Council on the Marine Environment (GOMC). The Council launched Gulfwatch in 1991 to collect and monitor information on the status of water quality throughout the Gulf, which has been affected by centuries of development and industrialisation.



Blue Mussels, *Mytilus edulis*

"We're looking at more than human health but also the effects on phytoplankton, marine animals, and other organisms", noted John Sowles, Marine Program Director for the Maine Department of Environmental Protection, and past Co-chair of the GOMC Environmental Quality Monitoring Committee.

"Without the Gulf-wide baseline you have no regional perspective," said Project Manager Steve Jones, a microbiologist at the University of New Hampshire's Jackson Estuarine Laboratory and Co-chair of the monitoring committee. Knowing the level and distribution of certain contaminants in the Gulf's blue mussels helps scientists, government agencies, businesses, and environmental stewardship groups to develop their regional plans and programs. Along with providing baseline data, the information can help determine if and how water and sediment quality in an area has been affected by a specific occurrence such as an oil spill.

Gulfwatch concentrates on collecting and interpreting the data, while making it available to other scientists who evaluate its implications for public health and the health of the ecosystem.

FMESP Fundy Marine Ecosystem Science Project

BOFEP Bay of Fundy Ecosystem Partnership

Bill of health

Regulations enacted in the US and Canada in recent decades have helped cut back on the amounts of some toxic materials entering the Gulf's coastal waters. But certain substances do not decompose, and even if their use in agriculture or industry has been banned or restricted, quantities that entered the environment years ago can remain there. These substances cling to marine sediments, and can continue to be ingested by organisms in the ecosystem, making their way through the food web.

Blue mussels are an indicator of substances in the water that are potentially harmful to the marine ecosystem, and the animals that live there, including humans who eat fish and shellfish. Mercury, polychlorinated biphenyls (PCBs), and some other toxic and persistent substances biomagnify through the food web. Mammals and predatory fish concentrate the highest levels of toxic substances in their tissues, because they eat progressively greater numbers and weights of organisms.

According to a report released by Gulfwatch in September, covering the years 1991-1996, the program has found that some sites that were thought to be relatively clean, in fact, had higher than expected levels of contaminants. Contaminated waters can inflict financial and quality-of-life losses on communities whose identities and economies have been based on fishing, shellfishing, and tourism for generations.

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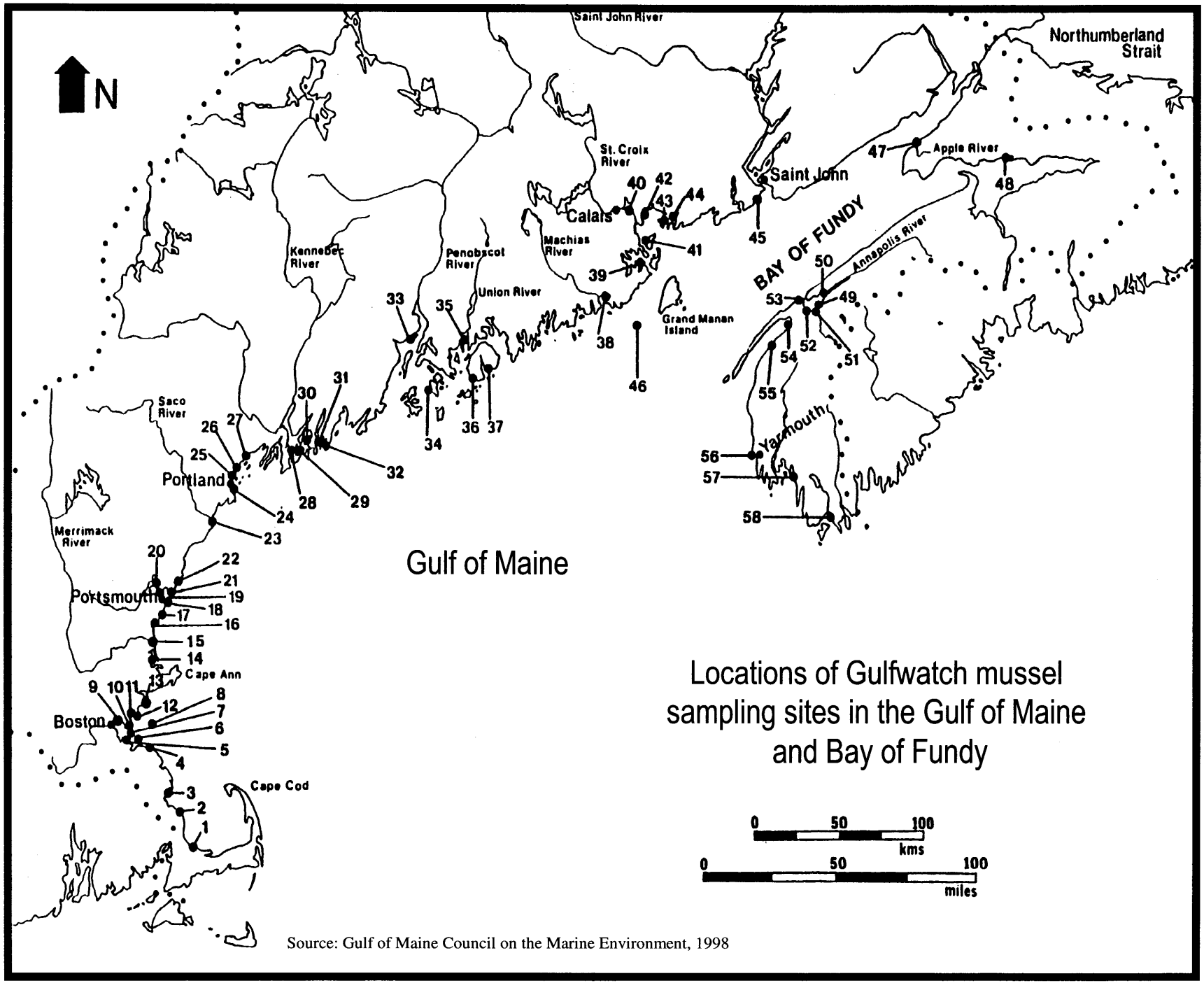
But the contaminant situation in the Gulf is far from bleak, according to Gulfwatch. The five-year report states that, while some levels of certain toxic trace metals and organic contaminants are high enough to be of concern, particularly in areas of the Gulf with high human populations, few contaminant levels measured between 1991 and 1996 exceeded US or Canadian federal guideline limits.

Sentinel species

Gulfwatch tests mussels for certain heavy metals and organic compounds that scientists know or suspect can affect the health of humans and other organisms (*see box,* "Gulfwatch contaminants"). Some of these substances, heavy metals such as iron and zinc, for example, can occur naturally in the environment. "The question isn't whether you're going to find them, but in what form or concentration and in what environmental media," said Sowles, explaining, "Metals can exist in a variety of forms and the different forms may have different effects." To test for the separate forms of the metals would be "extremely expensive," so Gulfwatch measures total amounts of lead, mercury, and so forth, he said. "This is the standard way world-wide to do this. Most risk values are based on total metal," according to Sowles.

Consuming tiny amounts of some of these metals is necessary for human health. But in certain forms, concentrations, and quantities, they can be poisonous. Often the levels in the environment are increased by industrial or manufacturing processes, combustion, and incineration, the same sorts of processes that have introduced toxic organic compounds into the Gulf's waters.

While other marine environmental monitoring programs use species such as lichens, corals, snails, seabirds, or whales, Gulfwatch uses the blue mussel as a "sentinel species" because they are readily found throughout the Gulf, they are easy and inexpensive to collect and process, scientists are well-versed in their biology and physiology, and mussels are suspension feeders that pump large volumes of water, concentrating in their tissues the chemicals contained in the water. Because mussels stay in one place, the accumulation of chemicals found in them can be assumed to be representative of the chemicals present in the water they inhabit.



Source: Gulf of Maine Council on the Marine Environment, 1998

Gulfwatch samples mussels at a total of 58 US and Canadian sites Gulf-wide, near the mouths of major river basins, in areas densely populated by humans, at centres of industrial activity, and at points where wastewater is discharged. Some sites, called "reference sites," are in relatively uncontaminated areas. Monitoring them helps scientists track natural levels of certain toxic substances and the spread of pollution resulting from human activities.

Mussels are collected in the fall, after they have spawned, because changes in their fat content and biochemistry caused by spawning can skew test results. They are also not collected within a few days of a storm. Turbid waters may contain higher concentrations of a particular substance than usual, resulting in tissue levels not truly representative of the mussels' usual environment.

At each site, samplers collect four batches of about 50 mussels each. Most of the mussels are native to that site, but some are transplants, clean mussels that are placed in "cages" that are actually plastic mesh bags or baskets tethered to a buoy and suspended a meter above the ocean floor for 60 days to evaluate the effects of their short-term exposure to those waters.

Several labs are involved in analysing the mussel tissue including Environment Canada's (EC) regional lab in Moncton, New Brunswick; the State of Maine Health and Environmental Testing Lab in Augusta; and commercial laboratories such as Axys Analytical Services Ltd. in Sydney, British Columbia.

The Gulfwatch program samples all of its monitoring sites every three years (about 16 sites per year), with the exception of five "benchmark sites," where sampling takes place annually. Each of the Gulf's five jurisdictions, Nova Scotia, New Brunswick, Maine, New Hampshire, and Massachusetts has one benchmark site.

Looking for answers

Gulfwatch scientists assert that the key to the program's usefulness is longevity, and that the three-year sampling cycle won't reveal any trends for at least 10 years. While data collected so far can help with localised short-term planning, Peter Hennigar of EC's Environmental Protection Branch and Co-chair of the monitoring committee, urged caution in drawing conclusions about contaminant levels measured in mussels and their relation to environmental health. "Further research is needed to understand fully the degree of risk toxic contaminants and their levels pose to the Gulf's ecosystem," he said.

What Gulfwatch scientists do believe is that very few Gulfwatch sampling stations contain mussels with contaminant concentrations high enough to be detrimental to the mussels' health. They say this is important because of the mussels' value as a food source for numerous species in the Gulf. On the other hand, the danger that contaminant levels in mussels pose to the wildlife that eat them is largely unknown, said Hennigar. Wildlife scientists now fear that populations of certain mussel-eating birds may be declining in the Gulf, he said.

Aside from "isolated occurrences of acute human poisonings," there is little information available on how eating chemically contaminated shellfish can affect human health, according to the Gulfwatch report. Scientists also have relatively little information about the combined effects of toxic substances on organisms.

Gulfwatch found that, generally, levels of contaminants increased near human population centres, and that levels escalated from northern to southern sampling sites.

In Boston's inner harbour, levels of the toxic metal lead exceeded US Food and Drug Administration human health "alert levels," but are not yet at levels requiring regulatory action, according to Gulfwatch researchers. Alert levels of PCBs were exceeded at seven Massachusetts, one New Hampshire, and one

Maine site, warranting further investigation. Use of PCBs was curtailed in the 1970s out of concern that they can cause cancer, but they are still circulating in the Gulf's ecosystem.

As public awareness of toxic contamination grows, some scientists predict use of some toxic materials will decline in the region. How soon this happens will depend to some extent on the alternatives available, not just in the Gulf region, but also in other regions near and far, from which contaminants ride into the Gulf on air and ocean currents.

Part of the picture

Other monitoring efforts are also ongoing in the Gulf. In combination with these efforts, Gulfwatch is "contributing a small but vital part to ecosystem-wide monitoring of the Gulf," according to the program's organisers. Canada once ran a similar program, called National Mussel Watch, which covered the Canadian east and west coasts and Maritimes. The program began in 1991, but was funded for only five years, said Amar Menon, head of Environment Canada's shellfish section for the Maritime region.

"Gulfwatch scientists assert that the key to the program's usefulness is longevity"

For a complete picture of water quality in the Gulf of Maine, Gulfwatch organisers say their information should be used in conjunction with the US National Oceanographic and Atmospheric Administration's National Status and Trends (NS&T) Mussel Watch. According to Jones, that 12-year-old program has served as a model for Gulfwatch, though NS&T samples mussels at different sites except for two. Also, NS&T collects mussel samples during the spring, while Gulfwatch collects mussels in early fall.

Because of these different methodologies, information contained in the two databases can't be directly compared. They should be combined to provide a more complete picture of the Gulf, said Jones, asserting, "To connect them we need to process and analyse their samples with our methods." This would require additional funding, he noted.

Financial support for Gulfwatch has come from the Gulf of Maine Council on the Marine Environment, Environment Canada, the US Environmental Protection Agency, the US National Ocean Service of the National Oceanic and Atmospheric Administration, and the State of Maine. Also, groups and organisations will sometimes fund add-ons to Gulfwatch's usual sampling schedule. State, provincial, local, and federal agencies, academic institutions, and non-governmental organisations have made in-kind contributions such as sample processing, data compilation and analysis, report writing and expertise.

Gulfwatch organisers describe the program's fiscal picture as continually in flux. "You can get samples and archive them until you have money for analysis," but the samples are meaningless until they are analysed, said Jones.

Gulfwatch scientists anticipate that demand will increase for the program's sampling results as the marine aquaculture industry grows and aquaculturists look for uncontaminated sites. They also foresee a need to expand the Gulfwatch program to include more contaminants, such as microbial pathogens, as the public becomes concerned about other substances believed or known to affect human health. But any expansion of the program would require more funding.

Results at work

Pointing out the practical applications of their program, Gulfwatch organisers note that government agencies in the US and Canada use Gulfwatch data to develop environmental management plans and policies, and to meet federal reporting requirements. State agencies have used the data in drafting pollution reports required by the US Congress under the

GULFWATCH CONTAMINANTS

Contaminant	Sources	Gulfwatch Findings	Health and Environmental Effects
Heavy Metals	Naturally occurring elements that do not break down or degrade. Natural levels augmented by use in industrial and manufacturing processes and in products such as batteries, gasoline, paints, pesticides, and pharmaceuticals. Enter coastal ecosystems via wastewater discharge, runoff, mining, combustion, incineration, and via direct contact with water (in the case of anti-fouling paint used on vessels).	Distribution of most metals relatively uniform throughout the Gulf. Levels at or near natural levels for most of Bay of Fundy. Mussels in Boston's inner harbour and Portland Harbour contain highest concentrations of lead. Some high lead concentration levels also found at some of the northern Gulf sites.	In certain concentrations, some metals can affect neurological, reproductive, developmental, cardiovascular, kidney, and liver health in humans and other animals. Many heavy metals are suspected or known to cause cancer. Metals of concern for the marine environment include Hg, Pd, Cd, Cu and Ag.
Chlorinated Pesticides	DDT, chlordane, heptachlor and other chlorinated pesticides once widely used in agriculture and forestry. Use of DDT restricted in US and Canada since early 1970s. Enter coastal ecosystems via runoff and disposal. Residues persist in sediments.	Levels decrease from south to north along the Gulf's coast. Despite extensive use of DDT in Maine and N.B. in 1950s and 60s, levels found there not as high as expected. Pesticide concentrations at all sites below human health tolerance levels.	Can cause numerous immediate and long-term illnesses, including cancer. Affect reproductive systems of vertebrates and invertebrates. DDT and other chlorinated pesticides cause thinning of bird egg shells. Due to persistence many remain biologically available for decades.
Polychlorinated Biphenyls (PCBs)	Used to cool electrical capacitors and transformers and as heat and pressure resistant lubricant. Use curtailed in 1970s due to concerns about health effects. Enter coastal ecosystems via point and non-point sources. Persist in coastal sediments and recycle in food chains.	Concentrations decrease from south to north along Gulf's coast. No concentrations in mussels exceed federal human health tolerance levels or levels considered protective of wildlife. Several sites do exceed USEPA screening values for possible human health concerns.	Classified as probable human carcinogens on the basis of animal tests. reproductive, neurological, immunological, endocrine, liver and other health effects are suspected for humans and other species. Toxicity of certain PCBs are similar to the highly toxic 2,3,7,8-dioxin.
Dioxins and Furans	By-products of chemical manufacturing processes including incineration, metals refining, combustion, manufacture and bleaching of paper, and herbicide production. US Government has banned herbicidal products containing dioxin and regulates it under the Clean Water Act. Enter coastal ecosystems via direct discharge, combustion and incineration.	As of 1998, mussels at 32 Gulf sites have been tested. Levels decrease from south to north along the Gulf's coast and are below Canadian health limit for highly toxic 2,3,7,8-dioxin. No equivalent US federal health limit exists. Summed toxicities of dioxins, furans and planar PCBs at some sites exceed a proposed Canadian guideline for protection of birds and mammals.	Scientists disagree over degree of danger to human health posed by dioxins. A variety of health effects have been observed in terrestrial and aquatic animals. Growing scientific evidence suggests that much of the chlorinated hydrocarbon toxicity in aquatic ecosystems is due to dioxins and similar contaminants.
Polycyclic Aromatic Hydrocarbons (PAHs)	Come from petroleum and its refined products. Enter coastal ecosystems as a result of wood, coal and petroleum combustion, urban runoff and sewage discharge.	Most highly concentrated and frequently detected in southern part of Gulf and near population/industrial centres.	Due to their toxicity, 16 PAH's are on EPA's priority pollutant list. Suspected human carcinogen and immune system suppressant. Suspected to affect health of other species in ecosystem due to their persistence, bioavailability and toxicity at very low levels.

Clean Water Act. Government agencies in Canada and the US have used them in making sanitary survey reports to determine whether it is safe to harvest and eat shellfish; developing licensing requirements for industrial discharges; developing nonpoint source pollution controls; and issuing dredge disposal permits and assessing disposal sites.

Gulfwatch also plays a role in assessing the effects of specific activities on water quality, such as discharges from sewage treatment plants and paper mills, and environmental accidents such as oil and chemical spills. Samples collected after spills and compared with baseline data can show how a spill has affected water quality. Samples taken after cleanup efforts are under way help track the environmental recovery taking place and help with the development of wildlife protection guidelines.

Amar Menon of EC's shellfish section said his office has used Gulfwatch data for the last five years in evaluating whether Fundy shellfish beds are suitable for harvesting. "We do our own bacteriological analysis [and] use their information to get an idea of the chemical contamination in some of the shellfish areas," he said

Canadian Wildlife Service researchers are using the data to study the effects of contaminants on sea ducks that eat blue mussels, as well as in a program that monitors wildlife for the presence of the chlorinated pesticide DDT in their tissues.

"the entire fishing industry ..... has relied on Gulfwatch data to assure the public that monitoring of marine environmental quality is being performed."

Researchers in Canada are also using the data to assess rising concerns about endocrine disrupters, substances known to affect the endocrine organs, such as the thyroid, pituitary, and adrenal glands, that regulate the body's functions.

Gulfwatch has also found a place in natural resources assessment and management. Data from the program were used in "finding what problems we have," said New Hampshire Estuary Project Director Chris Nash. And, he said, "It probably will be used if toxics monitoring becomes part of our monitoring plan." Also in New Hampshire, as part of a new partnership to protect water quality in the Great Bay Estuary, that state is funding increased Gulfwatch monitoring in the Great Bay and in Hampton Harbour.

Growers of shellfish, finfish, and sea vegetables in Nova Scotia and Maine have used Gulfwatch data to find clean sites for hatcheries and growout facilities. And, according to the Gulfwatch five-year report, "In general, the entire fishing industry (oceanic and aquaculture) has relied on Gulfwatch data to assure the public that monitoring of marine environmental quality is being performed."

Community collaboration

Along with providing information to government agencies and private businesses, Gulfwatch has recently begun collaborating with community-based environmental organisations on some projects. Hennigar established a link between Gulfwatch and two New Brunswick community-based groups. The groups contributed funding to Gulfwatch so that it could augment its Fall 1998 analysis to include issues of concern to their communities. "The object of this and future collaborations is to enhance environmental monitoring in the Bay of Fundy/Gulf of Maine by helping to address local and community environmental concerns," said Hennigar.

"Gulfwatch expanded their parameters in tissue analysis to include aquaculture biocides," which are chemical compounds used to kill sea lice and other parasites, said Susan Farquharson, Executive Director of Eastern Charlotte Waterways in Saint George, New Brunswick. "We paid for the lab analysis for those parameters," and volunteers

from the organisation also helped collect mussels and process them for lab analysis, she said.

Atlantic Coastal Action Program (ACAP)-Saint John also joined in this fall, contributing funds to collect and analyse mussels at two new sites in Saint John Harbour, said Executive Director Sean Brillant. The funding comes from an Environment Canada program that allows ACAP groups to collaborate with EC scientists, in this case, Peter Hennigar. Said Brillant, "It's an opportunity to have a few water quality monitors trained in mussel sampling and take part in a Gulf of Maine initiative and at same time it allows us to get some valuable data" that the group can use in its own studies.

Several groups have used Gulfwatch as a model in developing their own monitoring programs. According to Gulfwatch organisers, these include the Canadian Department of Fisheries and Oceans, US Fish & Wildlife Service, the US National Estuaries Program, and the Casco Bay Estuary Project in Maine.

According to Jones, Gulfwatch has documented information on the region's water quality that can help agencies and organisations throughout the Gulf with their management and restoration efforts. "Little was known on a regional basis about toxic contaminants in the Gulf," before Gulfwatch, notes the five-year report. Jones adds, "What we found are things that are not that surprising but are incredibly useful as a backbone for a lot of stuff now."

This Fundy Issue was written by
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and is reprinted with permission from:
Gulf of Maine Times
Volume 2, Number 2 (Winter 1998)

The Fundy Issues series is financially supported by:

The Environmental Conservation Branch
Environment Canada - Atlantic Region
Dartmouth, Nova Scotia

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Further Reading

Gulf of Maine Council on the Marine Environment website. For more on Gulfwatch, visit <www.gulfofmaine.org/council/monitoring.htm>

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The Fundy Issues Series is an initiative of the Bay of Fundy Ecosystem Partnership. These publications describe our present scientific understanding of some of the environmental issues confronting the Bay. We hope that they will enhance your understanding of the biological richness and complexity of this unique marine area and the problems confronting it. Such awareness may encourage you to help in protecting it for the use and enjoyment of all, so that future generations may also share and appreciate its bounty and rare beauty.

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