Autumn 1996 ISSUE # 8

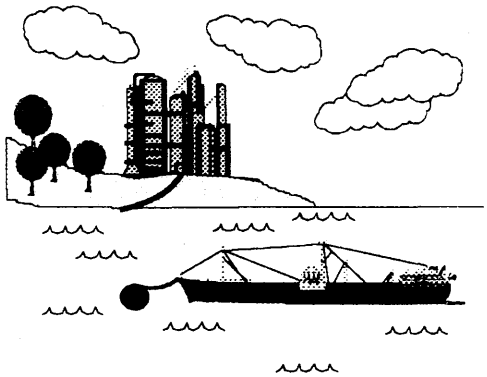
FUNDY ISSUES

FUNDY'S WATERY WASTES?

Pollution in the Bay of Fundy

Contaminated or polluted?

The coastal waters and ecosystems of the Bay of Fundy are relatively healthy in comparison with those along much of the eastern seaboard of North America. However, we who live on its shores should not be overly hasty in congratulating ourselves for being such exemplary stewards of the marine environment. This situation is largely fortuitous, due to a favourable combination of historical, geographic and oceanographic factors, rather than to any special efforts on our part. To begin with, the human population density is low in the region, and the few urban centres are small by world standards. A smaller population dumps less waste into coastal waters. Also, there are very few large seaports or industrial complexes spewing toxic chemicals into the sea. And finally, any municipal, industrial and food-processing wastes that are purposely or accidently dumped into the sea are usually quickly swept out of coastal embayments by Fundy's high tides and powerful currents, a process aptly termed "flushing". Nevertheless, there are some areas in the Bay where oceanographic and geological conditions are such that contaminants can accumulate to levels that may cause problems.



Coastal refineries and tanker terminals, such as Canoport, regularly spill small quantities of oil into the sea, but also have the potential for catastrophic oil spills.

Scientists studying toxic wastes in the marine environment are usually careful to distinguish between the terms "contamination" and "pollution". "Contamination" indicates that a particular poisonous or noxious material is present in the environment in readily detectable amounts. In contrast, the term pollution implies that the noxious material is not only present, but that there is enough of it to measurably harm the animals or plants living there. Using these definitions, Peter Wells, a pollution scientist with Environment Canada, has concluded that "the Bay is clearly contaminated" but that "there is relatively little evidence to date of pollution". Although this is welcome news, we should not be complacent, for the boundary line between "contamination" and "pollution" is fuzzy and easily crossed. And the phrase "harm to the animals and plants" doesn't necessarily mean killing them outright; it may involve subtle disruptions in a wide range of physiological or biochemical processes involved in their growth, reproduction and behaviour (called "sublethal effects"). However, scientists cannot possibly measure every biological process in all species, and it is very likely that they have missed many of the more subtle, long-term effects of toxic wastes on marine organisms. Often,

> ***"the Bay is clearly contaminated but ..... there is relatively little evidence to date of pollution".***

The
Gulf of Maine Council
on the Marine Environment

Clean Annapolis River Project

only after ecological disasters have struck, are we able to recognize the warning signals that might have alerted us to the impending catastrophe. A good example of this was the thinning of shells of bird eggs, now known to be caused by the pesticide DDT. This was found only after populations of raptors, such as peregrine falcons and bald eagles, and of seabirds, such as gannets, declined alarmingly. These subtle, almost undetectable effects of pollutants may be the most dangerous, because we don't recognize the ecological damage until it is almost too late. Frequent monitoring of populations of animals, plants and their habitats may allow us to detect such adverse changes in the Fundy ecosystem before they become critical.

Seeking sources

Scientists are also quick to distinguish between "point sources" and "diffuse sources" in describing how toxic chemicals find their way into the Bay. "Point source" contaminants are dumped into the sea at a single, readily recognized place, often at high concentrations. A municipal sewage outfall, a factory waste-water pipe or a grounded tanker leaking oil are good examples. In contrast, "diffuse source" contaminants seep into the sea in small amounts at many different locations that are hard to pinpoint. Examples include insecticide sprayed over large tracts of forests from aircraft, or fertilizer spread thinly over fields of crops. Eventually, much of this dispersed material washes into nearby rivers or streams and then finds its way to the sea. However, not all the toxic chemicals fouling Fundy's waters originate along its coastline or in its watershed. Many come from far away and are transported here on currents of air or water. The Bay lies downwind from major industrial centres in the northern United States. Some of the chemicals belching from their smokestacks eventually end up in raindrops falling on the Maritimes. Air monitoring stations at Kejimkujik Park, and elsewhere in the region, clearly show that various acids, heavy metals, such as mercury, and organic chemicals, such as organochlorines, come to us by this route. The seawater that sweeps into the Bay on tidal currents also contains a variety of contaminants picked up during its slow passage along the industrialized eastern seaboard. Also, in terms of the oceanographic circulation patterns in the region, the Bay is effectively "downstream" from the notoriously polluted St. Lawrence River. To complicate the situation even further, many fish, seabirds and marine mammals spend only part of each year in the Bay. They migrate great distances along the industrialized east coast. There is no way of knowing where they picked up some of the chemicals that scientists are able to measure in their tissues.

The occasional massive "point source" inputs, such as oil spilled from grounded tankers, are usually dramatic and highly visible. Thus, they tend to arouse immediate public concern and are often cleaned up quickly. However, such large spills are only a part of the pollution problem. Nowadays, the countless occasional, or continuous, "diffuse inputs" of small amounts of toxic chemicals are responsible for most of the environmental contamination. Individually, these inputs are practically undetectable and arouse little public concern or regulatory attention. Added together, however, and if unchecked, these many small "insults" may eventually cause serious and widespread degradation of the Bay of Fundy ecosystem.

Potential problems

Although the Bay as a whole is still fairly "clean" in comparison to some coastal areas, there are, nevertheless, a number of worrisome contamination problems that need to be addressed now. Some are already having serious environmental or economic impacts, while others are only "disturbing trends" at present. Here we can briefly examine only a few of these contaminant issues.

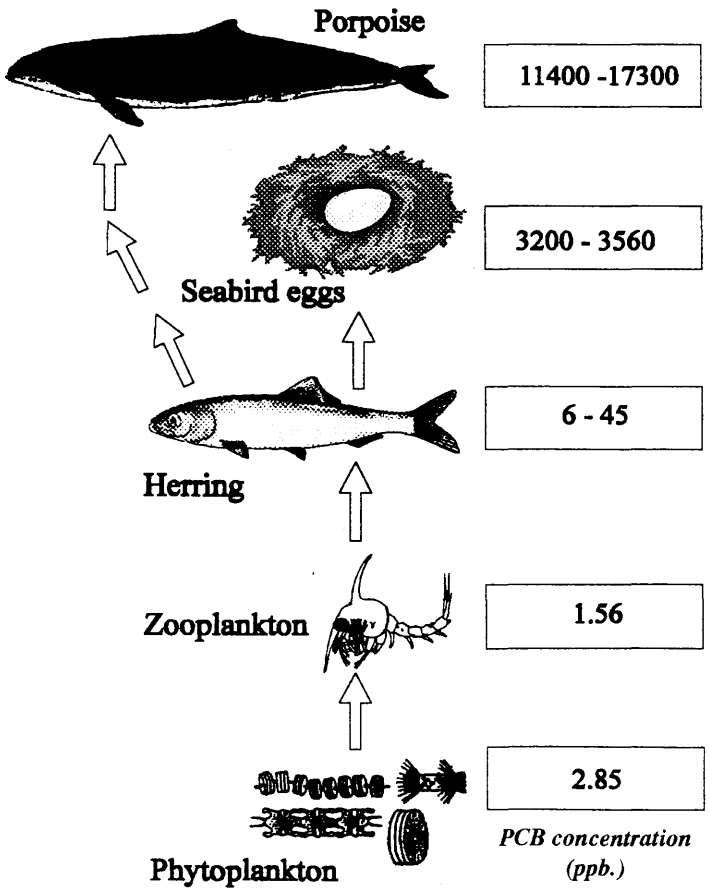
Closed to clamming - The term "pollution" reflects a human perspective. Thus, sometimes waste dumped into the environment has little effect on the animals living there, but can pose a clear threat to human health. An example of this is the widespread contamination of clam beds in the Bay of Fundy by municipal sewage. Where such inputs are relatively small, the clams may thrive on the added organic matter, becoming large and plentiful. However, these seemingly succulent clams are unmarketable because they could contain fecal bacteria that cause fatal or debilitating diseases in humans. The maritime soft-shell clam fishery is largely centred in the Bay of Fundy. However, many of the most productive clam beds on both sides of the Bay are now closed to harvesting because of sewage contamination. All around the Bay, communities dump untreated, or minimally treated, sewage directly into the sea, or into the rivers and estuaries that flow into it. For example, before 1994 the city of Moncton, New Brunswick dis-

"The maritime soft-shell clam fishery is largely centred in the Bay of Fundy. However, many of the most productive clam beds on both sides of the Bay are now closed to harvesting because of sewage contamination."

charged over 100,000 cubic litres per day of untreated sewage into the Petitcodiac River Estuary at the head of the Bay. This effluent is now treated to remove solids, but this has done little to reduce the input of organic matter, toxic chemicals and noxious bacteria. Further down the Bay, over half the sewage from Saint John, New Brunswick is dumped untreated into the harbour, and the remainder receives only minimal treatment. The situation is depressingly similar for most communities around the Bay. Environment Canada monitors bacteria levels on the clam flats, while the Department of Fisheries and Oceans (DFO) posts warning notices when contamination is detected. There has been a steady decline in clam landings over the past decade, largely because more and more beds are being seasonally or permanently closed. DFO scientists suggest that if contamination problems could be eliminated, clam landings could dramatically increase. Attempts have been made to cleanse tainted clams by holding them in tanks of clean water for a few weeks, or by transplanting them to uncontaminated mudflats. However, these are stopgap measures at best. In the long run we must treat all municipal sewage and thereby protect our valuable clam flats and the coastal environment.

Toxic cocktails - A wide variety of other toxic chemicals are continually being flushed into the Bay from different sources. Many originate from industrial centres such as Saint John, New Brunswick. Oil refineries, pulp mills, port activities and manufacturing plants together release a complex cocktail of heavy metals, chlorinated hydrocarbons, petroleum products and many other chemicals into nearby coastal waters. For example, in Saint John, three large pulp mills discharge 130,000 cubic metres of effluent into the estuary each day. Much of this is woody, organic material that settles, smothers bottom communities and deoxygenates the water. A variety of other toxic chemicals in the effluents mingle with untreated sewage wastes from the city and are swept downstream to the sea. Fishermen used to claim that they could see the plume of the St. John River far out in the Bay; nowadays, many claim that they can also smell it. Yet other contaminants leach into the Bay at points far removed from the urban centres. Indiscriminate and widespread spraying of pesticides (particularly DDT) over vast areas of forests and farmlands, particularly in the decades after World War II has left a legacy of chemical contamination still detectable in many parts of the Bay's ecosystem.

Keeping tabs on toxins - Although these varied contaminants have been measured in many different animals and plants, most of the emphasis has been on seabirds and marine mammals. This is largely because they are situated at the top of their food chains. In other words, they mostly eat fish which eat zooplankton, which in turn eat microscopic marine plants. Small amounts of some contaminants absorbed by organisms low in the food chain tend to accumulate in greater concentrations in the animals that eat them, and so on up the chain. Thus, measuring contaminants in seabirds (or their eggs) and marine mammal tissues is a useful indicator of their levels in the rest of the ecosystem. The Canadian Wildlife Service, in particular, has been keeping careful tabs on contaminant levels in seabirds. Every four years they measured levels of eight different pesticides and other chemicals in the eggs of seabirds such as cormorants, puffins and storm petrels nesting near the mouth of the Bay. The concentrations of all these chemicals declined between 1972 and 1984, long after the excess usages during the 50's and 60's were largely curtailed. Most contaminants eventually levelled off at low, but readily detectable, concentrations that stubbornly persist



The concentration of PCB's tends to increase in the tissues of organisms at higher levels in the marine food chain, a phenomenon termed 'biomagnification'.
[From: Percy, Wells and Evans MS, 1996: see Further Reading]

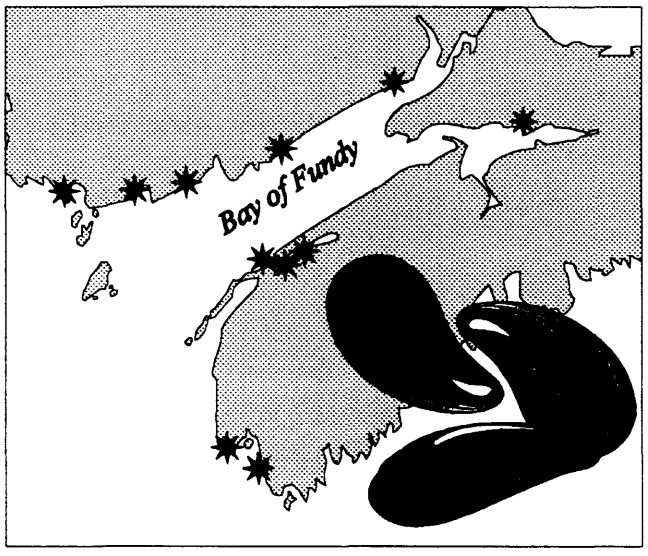
in the ecosystem today. Comparison with monitoring of seabird eggs in the Gulf of St. Lawrence allowed Environment Canada scientists to conclude that "In general, contaminant residue levels (e.g. PCBs) are lower at Bay of Fundy sites (2-5ppm) than in the St. Lawrence Estuary (9-10ppm)". This is no reason to relax our vigilance, as concentrations more than 2 ppm are unfit for human consumption.

"Small amounts of some contaminants absorbed by animals low in the food chain tend to accumulate at greater concentrations in the animals that eat them, and so on up the chain. Thus, measuring contaminants in seabirds..... and marine mammal tissues is a useful indicator of their levels in the rest of the ecosystem."

Other researchers, particularly from the University of Guelph, have been measuring chemical contaminants in the tissues of harbour seals and harbour porpoises for the past 25 years. These are also top-of-the-food chain animals that reflect contaminant levels in their food supply. These fish-eating predators also live mostly in coastal waters, where contaminant levels are likely to be elevated. However, they do travel extensively, sometimes out of the Bay, making it difficult to pinpoint the source of contaminants in their tissues. The researchers measured concentrations of heavy metals (copper, cadmium, zinc, mercury etc.) and organochlorine compounds (complex carbon compounds that have chlorine in their chemical structures and includes many of the common pesticides and industrial chemicals such as PCB's) in various organs and tissues of the animals. Heavy metals were comparable in amounts to those measured in animals in other places along the eastern seaboard. More reassuring was the fact that mercury levels measured in the early 90's were much lower than those measured a decade earlier. The picture for organochlorines was a little more complicated, as over 90 different substances were involved. PCB's were the most prominent organic contaminants in porpoises from this region. However, encouragingly, concentrations of many organochlorines, particularly DDT, were substantially lower than when measured almost two decades previously. Environment Canada's Peter Wells feels that these decreases in contaminant levels in birds and whales "likely reflect similar changes in the [rest of the] Fundy ecosystem". However, he is quick to add that "the wide range of contaminants [still remaining] in these and other mammals is reason for urgent concern". Perhaps not surprisingly, significant levels of all these contaminants have also been found in the blubber and other tissues of some of the large whales in the Bay. However, it is not yet clear how much of this poison they are accumulating from the Bay, as most of them migrate up and down the eastern seaboard each year, passing close by some of the most industrialized coastline in the northwest Atlantic.

Researchers have also measured the concentrations of heavy metals in sediment samples collected at 83 different sites around the Bay. Phil Yeats, a marine chemist at the Bedford Institute of Oceanography, concludes that the available data indicate that "the levels are, except for local anomalies, at or near natural levels for unpolluted coastal sediments". The anomalies include an area near Grand Manan, where higher concentrations of some metals result from their occurrence in rock formations in the area. Another area, off Saint John, where concentrations of metals are higher than normal, is a dump for dredged harbour sediments. Sediments in Passamaquoddy Bay are also higher in some metals, because fine contaminated sediments in the Saint John River plume are swept into the area by coastal currents and deposited there.

Mussel Watch - In order to monitor changing levels of heavy metals and chlorinated hydrocarbons in the Bay, scientists have launched a "mussel watch" monitoring program. Mussels are periodically collected from several sites around the Bay and analyzed for a variety of different chemicals. This is part of a world-wide monitoring effort that uses the common blue mussel as an indicator of what is happening in the surrounding environment. Mussels are



Some of the locations in the Bay of Fundy where mussels are collected for contaminant analysis as part of the "Mussel Watch Program"

particularly good for this. They filter hundreds of litres of water every day, extracting oxygen and food, as well as any contaminants that happen to be present. They can accumulate these contaminants to levels much higher than in the surrounding seawater, making it easier for scientists to detect and measure them. Also important is the fact that the mussels remain securely attached in one place throughout their life. Thus, any contaminants present in their body must have been acquired at that place. Other more mobile organisms, such as fish, may roam over large areas making it difficult to know exactly where they may have picked up the chemicals observed in their tissues. By collecting mussels periodically at specific sites, and measuring contaminants in their flesh, it is possible to keep track of how the amounts of these materials in the environment are changing over time. Because mussels are being sampled and tested worldwide, it is also possible to see how Bay of Fundy contamination compares to that in other places.

"Mussels are periodically collected from several sites around the Bay and analyzed for a variety of different chemicals. This is part of a world wide monitoring effort"

Slicks and seabirds- Oil spills are an ever present threat in the Bay of Fundy. Vessels of every description battle strong tidal currents as they navigate to and from Saint John and various smaller ports scattered around the Bay. Large oil tankers off-load cargoes of crude oil at the offshore terminal (Canoport) of a refinery located near Saint John. Large bulk oil storage tanks are present in many coastal communities. There has also been recent discussion about lifting the moratorium on drilling for hydrocarbons on Georges Bank, nearby in the Gulf of Maine. Fortunately there have been no catastrophic spills in the Bay- comparable to the *Exxon Valdez* or *Arrow*. However, there are frequent worrisome small spills from a variety of sources that threaten harbours, aquaculture sites and seabird colonies in the region. Observations after some of these small spills indicate that the flora and fauna of the rocky shores of the outer Bay, where wave action is very intense, would probably recover quickly from a major spill. However, the impacts of any spilled oil that penetrates into the inner Bay, and fouls saltmarshes and mudflats, are likely to be much more serious and longer lasting. The persistence of oil buried in sediments was clearly demonstrated when the tanker *Arrow* grounded in Chedabucto Bay, Nova Scotia in 1970 and lost its cargo of oil. Subsequent studies showed that significant quantities of the oil remained buried in the beach sediments for a decade or more after the spill.

CANDU Concerns? - A number of radioactive compounds are found in low concentrations throughout the Bay of Fundy marine ecosystem. Some are natural in origin, while many are derived from nuclear weapons testing in distant parts of the world, and the Chernobyl reactor accident in 1986 in the Soviet Union. However, there are also isotopes that are clearly attributable to the Point Lepreau Nuclear Generating Station located to the southwest of Saint John. This 660 megawatt CANDU reactor uses seawater for cooling and releases small amounts of radioactive material into the Bay and into the atmosphere. Both the Department of Fisheries and Oceans and the New Brunswick Electric Power Commission began regular environmental monitoring in the region before the reactor became operational in 1982. A range of radionuclides are regularly measured in air, seawater and sediments, as well in many species of marine, freshwater and terrestrial animals and plants. The annual reports of these studies provide a most detailed picture of radioactivity levels in the Bay of Fundy over time. Most of the radioactive compounds measured are at or close to their background levels and pose minimal health risks. Slight increases in some elements were clearly related to specific distant nuclear bomb tests. There is little evidence that the reactor has contributed to a significant increase in radionuclides, except in the immediate vicinity of the outflow pipe. Katherine Ellis, of the Bedford Institute of Oceanography, reports that "levels of tritium in marine organisms near the outfall were found to be higher than baseline levels and reflect releases from the reactor", however these "elevated levels are rarely measured at distances greater than a few kilometres from the reactor outfall" and "these levels do not constitute a radiological hazard". However, several recent operational problems, that have resulted to the temporary shutting down of the reactor, have heightened public concern about the possibility of accidental releases of more significant amounts of radioisotopes into the atmosphere and marine environment.

Aquacultural additives - There are rising concerns that the burgeoning aquaculture industry may be adversely affecting water quality in many areas. Accumulations of "mariculture sludge" (a mixture of fish feces and uneaten food) in the vicinity of salmon cages can cause depletion of oxygen and production of toxic gases leading to localized impoverishment of benthic communities. A variety of chemicals, such as pesticides to control parasites, hormones to enhance growth and antifoulants to control foul-

ing organisms on cages, are used routinely by the aquaculture industry. Particularly worrisome are recent reports about the illegal use of highly toxic, unapproved pesticides by some fish farm operators to control parasites. The death of 60,000 lobsters, being held in a pound in southeastern New Brunswick this past July, has been blamed on heavy applications of the agricultural pesticide cypermethrin, which is not approved for marine use, to control sea lice in nearby salmon farms. Concentrations of this chemical in tissues of the lobsters were 10-20 times above the animals' lethal level. There is little information about, or monitoring of, the effects of such chemicals on natural populations in the vicinity of aquaculture sites. It is even more worrisome that the potential human health implications of the routine use in aquaculture of even the approved toxic chemicals are not well known.

Compromised but curable?

Peter Wells has concluded that "the environmental quality of the Bay of Fundy has been compromised due to widespread chemical contamination of waters, sediments and biota". However, we presently have "relatively little understanding or monitoring of the biota's response to such contamination". In other words, the toxic chemicals are there, but we don't really know what effects, if any, they are having on the animals and plants. This is disturbing, given the great economic importance of the Bay's living resources, and the fact that we ourselves consume large quantities of them. We must continue studying the effects of the many contaminants that are present in the marine environment in order to find out which ones threaten us and the ecosystem. We must also identify the main sources of these toxic contaminants and take steps to reduce or eliminate their discharge into the sea. In order to have a yardstick to measure our progress, we must also expand monitoring programs that periodically measure the concentration of these compounds in seawater, sediments and selected marine organisms. We cannot, however, turn back the clock. As long as humans dwell on its shores, the Bay will likely always be "contaminated". But if we are careful about what we dump into it, it need not inevitably be "polluted".

Further Reading

Mercury, DDT and PCB in harbour seals (*Phoca vitulina*) from the Bay of Fundy and Gulf of Maine. D.E. Gaskin, R. Frank, M. Holdrinet, K. Ishida, C.J. Walton and M. Smith. Journal of the Fisheries Research Board of Canada Volume 30 pages 471-475. 1973.

Fundy Issues: Information Update and Workshop Synthesis. J.A. Percy, P.G. Wells and A. Evans. Canadian Wildlife Service Interpretation Series [In preparation].1996.

Contaminants in Canadian seabirds. D.G. Noble and S.P. Burns. A State of the Environment Fact Sheet. Environment Canada, Conservation and Protection, Ottawa, Ontario, EN1-12/90-1E. 12 pages. 1990.

Mercury accumulation in relation to size and age of Atlantic herring *Clupea harengus harengus* from the Southwestern Bay of Fundy, Canada. B.M. Braune. Archives of Environmental Contamination and Toxicology. Volume 16 Number 3, pages 311-320. 1987.

Health of our oceans. A status report on Canadian marine environmental quality. Editors P.G. Wells and S.J. Rolston. Conservation and Protection Branch, Environment , Canada, Dartmouth NS. 1991.

BoFEP

Bay of Fundy Ecosystem Project

The Fundy Issues Series is an initiative of the Bay of Fundy Ecosystem Project. 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. Such awareness may encourage you to help in protecting it for the use and enjoyment of all, particularly future generations who may also come to rely on its bounty and rare beauty. The origin, evolution and aims of the Bay of Fundy Ecosystem Project are described in the first issue of this series.

Written and produced by J.A. Percy
The Clean Annapolis River Project, P.O. Box 395, Annapolis Royal, Nova Scotia B0S 1A0
Tel: (902)532-7533 Fax: (902)678-1253 e-mail: shawboldt@fox.nstn.ns.ca

The Bay of Fundy Ecosystem Project is supported by Environment Canada, the Department of Fisheries and Oceans Canada and the Acadia Centre for Estuarine Research.

This publication is financially supported by the Gulf of Maine Council on the Marine Environment.