Troubled Waters: Municipal Wastewater Pollution on the Atlantic Coast

by Martin Nantel

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Troubled Waters: Municipal Wastewater Pollution on the Atlantic Coast, by Martin Nantel, examines the environmental and socioeconomic effects caused by the daily discharge of 1.1 million cubic metres of treated and untreated sewage in the waters of the Atlantic region. The report also addresses governments’ failure to enforce the legislation intended to regulate sewage treatment plants and proposes a solution to alleviate sewage pollution on the East Coast. Appendix A further illustrates the report’s findings using Halifax harbour as a case study.

In Brief

- Forty-four per cent of the wastewater generated by residents and businesses of the four Atlantic provinces ends up in septic systems, 29 per cent is directed to sewage treatment plants (STPs), and the remaining 27 per cent is spewed raw into our coastal waters.

- On an annual basis, this means that our coastal waters receive 122 million cubic metres of “treated” wastewater, 32 million cubic metres of which only undergoes primary treatment before discharge. Over 600,000 people living in some 194 cities, towns, and municipalities of the Atlantic region discharge an additional 100 million cubic metres a year of raw sewage into the coastal waters.

- Effluents containing raw or improperly treated sewage pose environmental and public health threats:
  
  - In addition to degrading and destroying aquatic habitat, sewage pollution causes both acute and chronic toxicity in aquatic organisms. Cancerous lesions and other symptoms associated with chemical mixtures have been reported in Halifax and St. John’s harbours. Despite chlorine’s proven harmful environmental effects, STPs in the Atlantic region use at least 692,200 kg/year of chlorine-based products to disinfect municipal wastewater effluents.
  
  - Sewage pollution is also a health hazard for people swimming at beaches that have been contaminated by sewage effluent. Pathogenic micro-organisms found in wastewater can cause serious diseases such as hepatitis and meningitis, as well as less serious conditions such as diarrhea and skin and ear infections.

- In Atlantic Canada, most shellfish closures are caused by bacteriological pollution.
  
  - Indeed, the sole cause of approximately 20 per cent of all shellfish closures in the Maritimes, municipal wastewater is also implicated as a contributing pollution source in over 50 per cent of the contaminated shellfish areas.

  - As of April 1995, there were about 580 closures comprising a total surface area of over 2,000 square kilometres, and representing 35 per cent of the Atlantic region shellfish areas.
• These closures represent a public health threat and cause significant economic loss to the shellfish industry, in addition to preventing recycling earnings into the local economy. For example, the Department of Fisheries and Oceans estimates that an income of over $8 million is forgone every year due to health-related closures of the soft shell clam fishery in southwest New Brunswick alone.

• Shellfish closures also increase pressures on the open areas, reduce employment, increase consumer prices, and impose severe demands on enforcement agencies to patrol the closed areas for illegal fishing.

• The lax enforcement of many powerful regional, provincial, and federal laws have ensured that municipal sewage polluters go mostly unpunished and that unnecessary environmental degradation persists. Provincial Crowns and federal authorities have never filed any prosecution against municipal sewage offenders on the East Coast, despite the fact that many STP operators are chronically violating the laws.

• As the population of the Atlantic region grows, as the volume of sewage increases, as STPs exceed their designated operating capacities, and as older system deteriorate, STPs run the risk of being further stressed, and so does the environment. If provincial Crowns cannot afford to cleanup our coastal waters, they should invite the private sector to do the job. Here's why:

• Owing to operational advantages, tax benefits, and timing and construction costs efficiencies, the private sector can provide most municipal services at a 10 to 30 per cent lower cost than municipalities can.

• More importantly, privatizing municipal wastewater utilities would eliminate the inherent conflict of interest that exists when a regulatory agency assumes financial responsibility for the same activity it regulates. The poor enforcement records of regulatory agencies are barely surprising when it is realized that these same agencies are financially responsible for up to 80 per cent of the capital costs of sewage infrastructure projects.

• By limiting governments’ interventions to the direct control of private wastewater utilities, i.e., by enacting strong and effective legislation preventing the erosion of environmental standards, pricing abuses, and services, privatization would allow governments to enforce long-ignored standards without fear of being asked to finance the improvements.

• Governments should empower everybody affected by sewage pollution to sue polluters. Faced with the threat of private lawsuits and government sanctions, private entrepreneurs would find innovative ways to eliminate sewage pollution. Technological innovations, educational campaigns, financial incentives, water-pricing reforms, source control, and monitoring programs are only a few of the ways in which sewage pollution would improve.
From the “Home of Anne of Green Gables” to the beautiful beaches of “Canada’s Ocean Playground,” from Newfoundland’s rocky shores to the picturesque coast of New Brunswick, the ocean relentlessly carves the physical and cultural landscape of the Atlantic provinces. In addition to nurturing a vibrant coastal-oriented tourism industry, the waters off Canada’s East Coast also long-supported a vital fin and shell fishery. Unfortunately, these waters, on which so many rely, are increasingly becoming polluted. One of the culprits is municipal wastewater pollution.

Consider the following examples: In Nova Scotia, Halifax and Dartmouth have been discharging raw sewage into Halifax harbour for the past 250 years. Currently, about 54.8 million cubic metres a year, or 150,000 cubic metres a day, of untreated industrial and municipal sewage from the twin cities is discharged directly into the harbour from about 40 outfalls.1 If spread over the city of Halifax, the total volume of raw sewage discharged annually would cover the city to a depth of .66 metres. (See Appendix A for more details.) Similarly, St. John’s, Newfoundland’s provincial capital, dumps 38.3 million cubic metres a year of raw sewage into its harbour.2 In Saint John, New Brunswick, more than 8.5 million cubic metres of raw sewage—a volume equivalent to 204 Exxon Valdez oil spills—ends up annually in the St. John River or in the Bay of Fundy.3

These are by no means isolated cases. In fact, more than six hundred thousand people living in some 194 cities, towns, and municipalities of the Atlantic region dispose of their sewage in the same way.4 Of the approximate 1.1 million cubic metres of wastewater generated daily by residents, businesses, and industries of the four Atlantic provinces, about a quarter is released raw into our coastal waters. Because these enormous quantities of wastewater are hazardous to aquatic life, pose a public health threat, and contribute to socioeconomic problems, this paper reviews the Atlantic province’s ongoing municipal sewage pollution, and suggests an alternative to the status quo.

**Sanitary Sewage**

Various debris such as gravel, wood, plastic containers, condoms, tampons, and rags find their way into the sewerage system. Yet, the bulk of sanitary sewage consists of human excrement and water, and contributes mostly innocuous organic matter to the receiving environment—usually a body of water. Under normal circumstances, micro-organisms break down the organic matter that comes out of a municipal outfall.

Municipal wastewater causes problems, however, when the volumes discharged are greater than those the receiving waters can assimilate. Excess quantities of undissolved solids—also called suspended solids—will smother the habitat of bottom-dwelling organisms, degrade fish habitat, and fatally clog fish gills and abrade the exposed membranes of aquatic organisms. Excess organic matter may well kill fish and other aquatic species if the biological oxygen demand—the amount of oxygen used by micro-organisms breaking down the organic matter—reaches very high levels, i.e., if the dissolved oxygen level required by aquatic life
becomes depressed.

Too much nutrients, by stimulating excessive and undesirable plant growth such as algal blooms—a phenomenon referred to as eutrophication—can put additional pressures on dissolved oxygen levels due to the increased number of oxygen-consuming micro-organisms required to decompose these aquatic plants. Certain species of non-tolerant organisms abandon these waters due to depressed oxygen levels. Unsightly growths of algae are also a nuisance to boaters and bathers.

In addition, pathogenic micro-organisms thrive in wastewater. These bacteria, parasites, and viruses found in human and animal stools, i.e., in wastewater, represent a latent threat to weaker fish that are more susceptible to bacterial invasion. If ingested by humans, these pathogens can cause many serious diseases such as hepatitis, myocardia, and meningitis and are implicated in infections such as chronic fatigue syndrome and diabetes. Less serious diseases such as diarrhea, skin and ear infections also ensue. (See Appendix B.)

Treated and untreated municipal wastewater released into Canadian waters also contains over 200 chemicals and other toxins that are dumped into sewers by households, businesses, and industries. Added to this witches’ brew is urban runoff—a combination of oils, animal wastes, and poisonous substances that further contaminates our environment when inadequately treated. Appendix C summarizes the potential health effects associated with various toxins.

Wastewater Treatment

The purpose of wastewater treatment is to strip sewage of as much of its harmful elements as possible before releasing it to the receiving environment, especially when large volumes are involved. Municipal wastewater treatment can range from the most basic to more advanced. The difference lies in how much is taken out of the effluent, with each added level resulting in a cleaner effluent.

Primary treatment involves slowing down the wastewater and directing it to a sedimentation tank where larger suspended solids settle naturally due to gravitation. Secondary treatment consists of supplying oxygen to micro-organisms to enable them to grow and to eat organic matter in the sewage. This ensures that once released, the sewage effluent does not provide food for the micro-organisms that would consume excessive amounts of oxygen required by aquatic biota. Lastly, tertiary treatment uses a mechanical or a sand filtration to achieve a similar but more thorough treatment than secondary processes.

In certain cases, provincial regulators may decide to add extra steps to one of these three treatments in order to obtain an effluent of better quality. If an effluent is too rich in nutrients and adversely affects the receiving waters, the sewage treatment plant’s (STP’s) operators may have to further clean the effluent with a nutrient removal process. Similarly, to counter the potential risks associated with an effluent rich in pathogenic organisms that could harm recreational users, an STP’s effluent may be disinfected and subsequently analysed for fecal coliforms—bacteria
present in the intestines of all warm-blooded animals, including humans, that can function as an indicator of fecal pollution in water bodies.

Forty four per cent of the total population of the Atlantic Provinces, or over one million people, is serviced by septic systems. The remaining 56 per cent is divided almost equally between those who are serviced by a municipal STP, and those who see their wastewater entering the environment directly, without any treatment. While approximately 32 million cubic metres of wastewater receives primary treatment before discharge, or 26 per cent of the total 122 million cubic metres treated every year in the region, an additional 100 million cubic metres a year is discharged raw into our coastal waters.

**Effects of Sewage on Fish**

As mentioned above, sewage pollution harms fish and other aquatic life by degrading and destroying aquatic habitat. When an aquatic ecosystem reaches excessive pollution levels, some or all of its organisms may die. But fish mortality and acute toxicity are by no means the only indicators, although they are the most obvious ones, used to determine whether a substance is harmful to marine biota. A not so extreme and much more appropriate (but more expensive and more complicated) way to assess the health of aquatic life is to look at the multitude of sublethal effects that pollutants cause.

The sublethal effects of water pollution on fish have been documented worldwide for a great many species. They can take many forms—physiological, biochemical, pathological, and behavioural. Physiological abnormalities include reduction or inhibition of reproductive capacity, growth retardation, and reduced resistance to infection from pathogens. Biochemical disturbances cause alterations in metabolism, body fluids, and enzyme activities, leading to subtle organ impairments and physical abnormalities in developing young. Some common pathological disturbances include fin erosion, ulcerations, liver tumors, and skeletal anomalies caused by damaged genetic material. Also, by altering external surfaces, pollutants can facilitate invasion of pathogens. Behavioural changes such as altered feeding and migrating patterns are often due to chemical damage to fish sensory equipment and to their abilities to react to subtle chemical changes in water composition. As one investigator put it, the toxic effects of pollutants on sensory organs “are significant even if they do not cause permanent neurological damage, for [even] a temporary disability that prevents an organism from relating to a viable environment for only moments can be disastrous.”

Most of these sublethal effects have been associated with chemical mixtures from a variety of sources including municipal and industrial outfalls, urban runoff, pulp mills, and petroleum sites. Nonetheless, it is difficult to separate the effects of mill effluents from those of urban runoff and sewage pollution. However, a recent fish health study in and around St. John’s harbour revealed that many of the fish caught had been severely affected by pollution. In addition to evident fluid retention in fish gills, a general indication of a disturbed pathological condition, more than half the flounder caught inside the harbour had eroded fins. Severe liver
lesions were found in fish from the entire study area.\textsuperscript{12} Although the funds available for the study did not allow for the establishment of direct links between pollutants in the harbour and the effects seen in fish, the fact that Saint John’s does not have “heavy” industrial effluents entering its harbour suggest that the effects observed are likely linked to sewage and/or to traditional runoff chemicals.\textsuperscript{13}

In the long-term, sublethal effects can adversely affect the community structure and dynamics of the fish population as well as ecosystem structures and functions.\textsuperscript{14} Although the fish population may also be affected, individual responses to stress do not provide a basis for predicting population impacts.\textsuperscript{15} Harm to individual fish does demonstrate, however, the presence of deleterious substances, and this in itself is a cause for concern. As they may produce subtle impacts over broader geographic areas, sublethal effects associated with chemical mixtures may be more significant than localized fish mortality.\textsuperscript{16}

\textbf{Disinfection}

Since 1903, when Allen Hazen determined the role that chemically treated water could play in reducing the death rate of the human population, disinfection of potable and wastewater has become widespread. Owing to chlorine’s powerful disinfecting capabilities, ease of application, and low cost, chlorination has become the most common method of disinfecting wastewater effluents in Canada and in the U.S., thus making water safer for recreational activities.\textsuperscript{17} The use of chlorine-based bactericides in municipal water and sewage treatment is now the single largest use of pesticide in the Atlantic region.\textsuperscript{18} In 1990, Environment Canada estimated STPs in the region used approximately 692,200 kg a year of chlorine-based products to disinfect municipal wastewater effluents.\textsuperscript{19} These quantities are probably much higher today since over-chlorination is common, particularly at STPs that malfunction because of age, mechanical breakdown, overloading, or general neglect.\textsuperscript{20}

However, Hazen’s successors did not foresee that chlorinated wastewater effluents, unless they undergo a final dechlorination process prior to discharge into the receiving waters, adversely affect aquatic life. Indeed, chlorine itself is toxic, as evidenced by the kill in 1991 of thousands of fish in Nova Scotia’s East River, due to the flushing of an industrial water line with a chlorine solution.\textsuperscript{21} In addition, when added to water, chlorine and its various compounds do not remain in their original form. Instead, they react with various pollutants in the water, and can lead to the formation of numerous compounds in the effluent, many of which may be highly toxic and detrimentally affect the biota and public health.\textsuperscript{22}

By “burning” fish tissues, especially gill structures, chlorine damages the biochemical ability of fish to uptake oxygen. To protect itself from the irritation, a fish secretes mucus that rapidly builds up and clogs its respiratory surface. Eventually, the fish dies of asphyxiation. At high doses, chlorinated effluents result in immediate fish kills.\textsuperscript{23} Severe burning has also been observed to cause convulsions in fish, which die of a broken back.\textsuperscript{24} Exposure to residual chlorine also increases gill permeability. In turn, this may lead to increased accumulation, and
hence toxicity, of other chemical substances found in STP effluents. Chlorine is also thought to affect the nervous system of fish.25

In the 1970s, studies using caged sockeye and pink salmon fingerlings were conducted in three tributaries of British Columbia’s Fraser River downstream of STPs discharging chlorinated effluents. Mortality rates of up to 100 per cent were observed at the farthest station, 277 metres downstream from the effluent outfalls. When chlorination was not performed, mortality did not occur, or it decreased significantly.26

In Nova Scotia, biological surveys conducted near three municipal STPs discharging chlorinated wastewater effluents revealed that the community structure of bottom-dwelling organisms was significantly altered at the furthest station sampled.27 For example, although scientists could not prove a causal relation, the total number of invertebrates sampled 100 metres from a chlorinated effluent outfall discharging in Halifax harbour was significantly reduced when compared to a control station located 2.5 kilometres away from the outfall. The total number of several annelid, crustacea, and mollusc species frequenting the area was also significantly reduced.28

Although the average concentration of residual chlorine in STP effluents from the Atlantic provinces nears the recommended concentration of 0.5 mg/l, and although it is well below the levels known to have physiological effects in mammals and humans, it is still far above what aquatic invertebrates can tolerate. Acute toxicity tests have shown that concentrations as low as 0.002 mg/l can kill aquatic invertebrates.29

The available scientific data on the effects of chlorinated wastewater effluents led the federal Minister of Environment and the Minister of National Health and Welfare, in 1993, to declare chlorinated wastewater effluents “toxic” as defined under the Canadian Environmental Protection Act.30 Unfortunately, until the federal government implements management strategies, chlorinated wastewater effluent will remain legal, and the more environmentally-friendly, but more expensive, disinfection techniques using ozone or ultraviolet irradiation will not gain popularity.

Effects of Sewage on Shellfish

Sewage pollution also harms bivalve molluscs and crustaceans, two classes of invertebrate fish that are referred to as shellfish. Bivalve molluscs are soft bodied aquatic invertebrates enclosed by two shells joined by a hinge, and crustaceans are mostly aquatic invertebrates with segmented bodies, jointed limbs, and a firm, crustlike shell. In the four Atlantic provinces, clams, mussels, oysters, and quahogs are the most common type of bivalve molluscs harvested from the miles of beaches and rocky coastline. The most common type of crustaceans harvested are lobsters and crabs.

Except for some crustaceans, shellfish are nonmigratory or only weakly migratory, so the
environment in which they are found as adults is the one to which they have been exposed for much of their existence. Shellfish are, therefore, a good sentinel species for water pollution and sediment contamination; they are better markers and can more directly demonstrate cumulative or chronic effects than fish can. Toxic contaminants that exceed shellfish tolerances may result in their immediate or protracted deaths. And as with finfish, the body of literature documenting the varied subacute and chronic effects of pollution on shellfish fecundity, physiological processes, body structures, and behaviour is steadily growing.31

Cellular damage and deformities are two of the many pollution-associated diseases to afflict molluscan shellfish. Others include shell abnormalities and various cancers. Several studies using commercial shellfish species including oysters and periwinkles have disclosed a direct relationship between the developmental abnormalities in embryos and the degree of pollution.32

In California, black abalone in a sewage-polluted area were compared with those from a clean area. Abalone at the sewage outfall site demonstrated slow growth and high mortality rates. Starving abalones with eroded shells were also reported. Individuals relocated from the clean site to the polluted area failed to grow and eventually died from undetermined causes.33 Studies also suggest that chronic exposure of molluscs to physiological stress, including toxic pollutants, decreases resistance to bacterial infection. Investigations conducted on mussels harvested from polluted areas of the northeast coast of the United States showed an increase in parasitism that correlated with centres of population density and industrial activity.34

Crustaceans have their own set of pollution- or stress-related diseases. Prominent among them is a condition associated with badly degraded estuarine and coastal waters known as “shell disease.” Caused by bacterial or fungal destruction of portions of the protective outer shell, this condition often results in mortalities due to the deterioration of underlying tissues, secondary infections by opportunistic pathogens, erosion and loss of gill membranes, lost appendages, and increased vulnerability to predators.35

Another abnormality found to increase in prevalence in suboptimal or stressful growing conditions is “black gill disease,” characterized by sediment accumulation in the gills and darkening of filaments in response to microbial growth and gill necrosis. Outer shell deterioration also ensues. Other stress-related pathology may include, but is not limited to, muscle and/or blood opacity, molt retardation, and abnormal or disoriented behaviour.36

As clearly stated by Carl J. Sindermann, a leading authority on parasitology, “Despite the relative lack of robustness of the data base, it is becoming apparent that many of the disorders of molluscs and crustaceans in degraded habitats are stress related and are often expressions of a stress syndrome, quite distinct from that of fish, yet similar in that heterostasis—a heightened, energy-demanding physiological response to continuing stress—is achieved.”37 And, although the Atlantic region has seen very little eco-toxicological shellfish research, reflecting the funding priorities of our government, there is no reason to believe that the elevated level of pollution
encountered in some areas does not exert similar stress-related responses in exposed shellfish to those observed in other parts of the world.38

**Shellfish Closures**

Perhaps the most noticeable consequence of water contamination by municipal sewage, agricultural, and industrial wastes is the closure to shellfish harvesting of most of the productive estuaries of the Atlantic region.39 Although the shellfish growing in contaminated areas may not themselves be harmed by wastewater pollution, the health-related closures of these areas to harvesting do cause socioeconomic hardships.

Because bivalve molluscs feed by filtering the water that surrounds them, they readily accumulate chemical and bacterial pollutants in addition to naturally occurring toxins enclosed in algae, even at a considerable distance from pollution sources. When waters are polluted by sewage, sewage-related bacteria and viruses are concentrated to high levels in the shellfish tissue. Since consumers prefer shellfish that are partially cooked, such as steamed clams, or raw, as in the case of oysters, there is the possibility of ingesting contaminated tissue and live pathogens. To ensure that bivalve molluscs are harvested from clean waters, Environment Canada closely monitors water quality in shellfish areas and prohibits harvesting when fecal coliforms reach levels that represent a risk to public health.

In Atlantic Canada, most shellfish closures are caused by bacteriological pollution. Indeed, the sole cause of approximately 20 per cent of all shellfish closures in the Maritime provinces, municipal wastewater is also implicated as a contributing pollution source in over 50 per cent of the contaminated shellfish areas.40 As seen in Appendix D, other sources of bacteriological pollution include: industrial wastes; landwash from agricultural and urban areas; seepage from poorly operating septic tank and tile field disposal systems; direct discharges of raw sewage from pleasure crafts, fishing boats, and shore-side residences; and excrement of wildlife and domestic animals.

Since the 1940s, the number of closures has been escalating steadily, in large part reflecting increased monitoring. However, increased monitoring in turn reflects a higher demand for areas available for harvesting. Unfortunately, previously unmonitored shellfish grounds that become monitored in order to meet the increased demand are often found to be bacteriologically contaminated. In 1995, there were about 580 closures comprising a total surface area of approximately 2,009 square kilometres, and representing 35 per cent of the Atlantic region shellfish areas.41

**Socioeconomic Effects of Sewage Pollution**

The molluscan shellfish industry is important to the economy of many rural coastal communities in Atlantic Canada. In 1994 alone, the commercial landings of oysters, clams, quahogs, and scallops generated over $165.3 million to the economy of the Atlantic provinces.42
Shellfish aquaculture, on the other hand, generated much less. The landed value of farmed bivalve molluscs for the same year barely reached $12.2 million. The farmed molluscan shellfish industry is nonetheless growing rapidly and reflects a more general trend of the aquaculture sector as a whole.

The economic repercussions of wild and farmed shellfish closures are felt throughout the region. In New Brunswick’s Caraquet Bay and in Nova Scotia’s Annapolis Basin, fecal pollution precludes almost 50 per cent of the potential shellfish harvesting activities. It is estimated that the shellfish resources in these closures are valued over $2 million. The Department of Fisheries and Oceans (DFO) estimates that the clam fishery in the now closed areas in Yarmouth Sound and harbour, Nova Scotia, has a potential of generating $500,000 annually.

In south west New Brunswick, the drop in landings of Mya arenaria, a soft shell clam that has brought record landings since 1880, has dramatically affected the local economy. Despite 1995 landings of 1,203 million tonnes that DFO values at $2.5 million, an estimated income of over $8 million is forgone every year due to health-related closures of the soft shell clam fishery. This income loss affects not only the diggers themselves but also the local economy: The small overhead expenses related to harvesting (a bucket and a rake) ensure that the local economy, rather than the servicing of fishing-related debt, directly recycles the bulk of the earnings.

Bacterial-related closures have a two-fold effect on the clam fishery: They remove the clams from the wild harvesting base, and they concentrate the diggers on the other open flats. In other words, digging areas are compressed. And while the digging rate on the most productive, but contaminated, beaches decreases, harvesting rate and pressures on the less productive beaches, which are usually the last ones to remain open, increase.

In summary, shellfish closures not only result in the loss of millions of dollars to fisheries and in increased pressures on the environment, but also reduce employment and increase consumer prices. They also discourage tourists from digging clams, an exciting recreational opportunity. Shellfish closures also impose severe demands on enforcement agencies to patrol the closed areas for illegal fishing.

Remedial Actions

Enough resources have already been spent documenting the ills caused by municipal wastewater pollution. Bookshelves full of literature documenting the adverse effects of sewage pollution in many different regions already exist. And although each city, town, or community has its own specific environmental and socioeconomic conditions, the available research points to a common conclusion: Sewage pollution is harming the environment, and it is affecting our health and our economy.

Provincial economic wizards argue that their governments’ coffers are empty and that
plans for municipal sewage treatment have to await flusher days. But clearly, as the volume of sewage and the pressures on the environment and on society increase, waiting for public funds to become available prior to initiating any action is a foolish strategy. To reduce sewage pollution in the Atlantic provinces, alternative methods of financing and operating major capital projects are needed. The private sector has proven again and again that this is what they know how to do best. Here's why:

First, privatizing municipal wastewater utilities would allow the construction of infrastructure that would do much towards eliminating national embarrassments such as Halifax and St. John's harbours. Indeed, owing to operational advantages, tax benefits, and timing and construction costs efficiencies, the private sector can provide most municipal services at a 10 to 30 per cent lower cost than municipalities can . . . without an investment of scarce tax revenues.51

This proposition is even more attractive when one considers that in Canada, experts estimate that the deterioration of wastewater assets, their deferred maintenance, unreliable water quality, inadequate and inefficient wastewater collection and treatment, underpricing in services, plus the cost of meeting increasing standards for water supply and wastewater treatment will require municipal wastewater utilities to almost double their investments in physical plants by the year 2015.52 Securing private funds will become even more enticing as existing systems exceed their designed capacities and costly upgrades are needed.

Privatization also answers one basic question that public ownership, because of its nature, ignores: Quis custodiet ipsos custodes? Who will keep the keepers themselves? Indeed, as soon as a provincial regulator assumes financial responsibility for a certain activity, it automatically becomes entangled in a conflict of interest. Because prosecuting non-complying STPs may force an already financially strapped government agency to inject more money into cleaning up wastewater, bureaucratic reasoning holds it that it is far better to turn a blind eye than to prosecute.

In order to fulfill their mandate many provincial governments now attempt to remedy municipal wastewater pollution cooperatively with STP operators. Unfortunately, business-friendly cooperation seems to achieve little regarding STPs' performance. In Nova Scotia, despite many notices to non-complying STP operators, non-complying STPs make up the norm, and yet, none has ever been prosecuted for violating provincial and/or federal legislation.53 Unsurprisingly, the province of Nova Scotia finances up to 50 per cent of the capital costs of municipal wastewater projects.54 A similar situation exists in the other Atlantic provinces where the various provincial departments of the environment provide up to 80 per cent of the capital costs of STPs' upgrades and construction.55 More examples can be found in Quebec, British Columbia, and most likely in the other provinces as well.56

Were the onus to build and operate STPs put in private hands, the above situation would be turned on its head. In the same way therapy relieves patients afflicted with Multiple Personality Disorder, privatization would liberate provincial Crowns from their financial
personae and help them find their true regulatory selves. Thus liberated, governments could do what only they can do: regulate others and enforce the law. By limiting their interventions to the direct control of private wastewater utilities, i.e., by enacting strong and effective legislation preventing the erosion of environmental standards, pricing abuses, and services, governments, through regulatory boards, could finally enforce long ignored standards without fear of being asked to finance the improvements.

Conjointly, governments should empower everybody affected by sewage pollution to sue polluters.57 Facing both the threat of private lawsuits and government sanctions, private entrepreneurs would find ways to eliminate sewage pollution: Technological innovation would spring up, education campaigns would become good investments, financial incentives not to discard harmful substances into sewers would become common, and comprehensive commercial and industrial source control and monitoring programs would be set up in order to exercise tight control over the substances discharged into the sewerage system. Moreover, by reforming the pricing system, privatization would increase consumers’ awareness of the true costs of providing wastewater treatment services, and would encourage them to reduce their demands on the sewage system.

On the other hand, despite improved sewage treatment, or sewage treatment where none was previously available, customers are likely to object to any price hike. It is worth remembering, however, that we are already paying a high price for the costs of unabated sewage pollution. We pay in terms of forgone income to the fishery and to the tourism industry. We also pay in terms of a degraded environment, loss of aquatic habitat, and loss of enjoyment of public beaches and of other recreational pursuits. Privatization would ensure that individual, commercial, or industrial polluters, rather than their victims, pick up the tab for protecting and restoring our rivers, estuaries, and coastal waters from unabated sewage pollution.
Appendix A: Halifax Harbour

In 1749, in an attempt to offset French control over the approaches of the St. Lawrence River, Sir Edward Cornwallis and his bastion set sail from Cape Breton to found the new colony of Halifax. Along with military installations, the colonists started building the infrastructure that would shape their new town: roads, school, church, and so on. Haligonians would have to wait until the early 1800s for the first underground sewer: stone walled, wooden floored, and harbour bound. By the end of the 19th century, 50 combined sewers flushing straight into Halifax harbour had been constructed.58

Since these early innovations, wastewater disposal and treatment practices kept pace neither with the knowledge of the adverse effects of raw sewage on receiving waters nor with sewage treatment practices elsewhere in Canada. Indeed, almost 250 years after Haligonians first pondered where to empty their chamberpots, Halifax harbour is still a popular dumping site for local liquid waste: Some 220,000 Haligonians annually pour about 54.8 million cubic metres of raw sewage—80 per cent of the Halifax/Dartmouth metropolitan area’s total wastewater—into the harbour.59

In addition to residential dwellings, modern-day facilities that release wastes directly into the sewerage system, and thus directly into the harbour, include automobile dealerships, battery and electrical repair shops, autobody shops, car washes, carpet cleaners, chemical toilet rental firms, jewellery makers, analytical labs, dry cleaners, laundromats, printers, and photofinishing shops. Institutional users such as government research labs, universities, community colleges, schools, and hospitals also discharge directly into sewers. In addition to 40 municipal outfalls, about 60 commercial and industrial outfalls also discharge into Halifax harbour.60

The size of the harbour and its huge assimilative capacity have allowed it to withstand centuries of abuse. However, because of mounting quantities of a complex mixture of sewage and other waste, water and sediment quality have slowly degraded, directly affecting the marine habitat, its fauna, and the other uses of the harbour. The low diversity of species on the floor of the Bedford Basin in Halifax harbour, for example, can, in part, be attributed to sewage-induced low oxygen levels in the deeper waters. Similarly, surface sediments near sewage outfalls are in some instances entirely devoid of oxygen and laced with heavy metals such as mercury.61 A recent sampling study showed that in the inner harbour, polychaetes (marine annelid worms) and bivalve molluscs, both tolerant of low oxygen and reduced sediments of relatively high organic content common in polluted areas, dominated the bottom-dwelling communities. Polychaetes are widely accepted as pollution indicators.62

Sediments in Halifax harbour, the Northwest Arm, and Bedford Basin of Halifax inlet, are all contaminated with organic matter, high levels of heavy metals, and organic contaminants. Petroleum hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), both highly mutagenic and carcinogenic organic compounds, also sully the water and sediments of Halifax harbour. Along with sewer outfall discharges, the transportation, refining, and burning of petroleum in and
around the harbour have resulted in harbour water with PAH levels often 10 times higher than that on the continental shelf.\textsuperscript{63} In the harbour sediments, PAH concentrations are as high as 100 times the proposed Canadian Environmental Protection Act Interim Screening Level for ocean disposal, and can therefore potentially affect certain biological processes and sensitive marine organisms.\textsuperscript{64}

Consider the mean concentrations of zinc, copper, lead, and mercury in sediments of Halifax inlet: They exceed environmental quality guidelines developed by the Halifax Harbour Task Force by factors of 5.7, 2.3, 3.6, and 1.3, respectively. Areas of maximum concentration exceed the guidelines even further.\textsuperscript{65} Like organic contaminants such as PAHs, some of the potential effects of trace metals include acute and chronic toxicity, and bioaccumulation in the food chain. (See Appendix C.)

While the extensive contamination of the harbour’s water and sediments by chemical pollutants is no longer disputed, much less is known about the adverse short- and long-term effects of this pollution on the harbour’s marine life. Indeed, contaminants are processed quite differently, with varying effects, when they are absorbed by finfish, crustaceans, or molluscs. Mussels probably demonstrate the most obvious and immediate adverse effects of poor water quality. Studies have determined that mussels collected from the outer harbour appear to be healthier than those from the inner harbour. Cellular damage increases with the mussels’ proximity to contaminants in the inner reaches of the harbour.\textsuperscript{66} But even though mussels have accumulated levels of some metals that are a cause for public health concern, the main threat to public health comes from contamination by organic matter.\textsuperscript{67} In fact, the harvesting of clams and mussels in the entire harbour area has been permanently closed since 1965 owing to bacteriological contamination.\textsuperscript{68}

As for lobsters, changes in habitat quality have resulted in more subtle effects. The concentrations of cadmium, copper, zinc, mercury, and lead in the digestive gland and cooked meat of lobsters from Halifax harbour are, for the most part, below levels judged to be hazardous to human health.\textsuperscript{69} Nonetheless, the contamination levels are elevated, and were the lobsters to become unfit for human consumption, it would spell catastrophe for the local lobster industry: Halifax harbour supports the largest annual lobster fishery of all the Maritimes harbours; it is worth about $1 million a year.\textsuperscript{70} Curiously enough, this intense lobster fishery may well be responsible for the relatively few effects of contaminants observed in lobsters. Indeed, the high exploitation rate may prevent the lobsters from being exposed long enough to contaminants before these build up in their tissues.\textsuperscript{71}

Numerous studies have documented the effects of wastewater pollutants on many of the world’s fish. Unfortunately, because the transient nature of fish makes them more difficult and more expensive to assess than bottom-dwelling organisms, little research has looked at how sewage pollution has affected Halifax harbour’s fish. One of the important recreational fish species for which data is available is winter flounder. Although no data on the accumulation of potentially harmful substances is available, pollution-linked lesions were observed in 1991 in the livers of some flounders.\textsuperscript{72} These lesions were not as serious as those recorded in flounders and other fish
from Boston harbour, where advisories regarding consumption are issued. Nonetheless, the
presence of fish with lesions in Halifax harbour definitely indicates an ongoing problem.

Furthermore, since winter flounder are site feeders and prey largely upon polychaetes,
bivalves, and crustaceans living in, or on, contaminated sediments, the potential for
biomagnification through their food resources is high. It is difficult to extrapolate these results
to the commercial finfish fisheries located in the outer part of the harbour; however, if pollution
persists, and if increasing loads of contaminants are pumped into Halifax harbour, the fish of
future generations may well be affected more seriously. In any case, harm to individual fish
should be a sufficient cause for concern.

In addition to degrading the marine habitat, damaging its aquatic fauna, and discouraging
activities associated with seafood harvesting, sewage pollution also severely affects recreational
activities and the aesthetic quality of the harbour. Beaches on the harbour and Northwest Arm are
periodically closed to swimming in the summer because of bacterial contamination, and in
certain areas of the harbour, bacterial and viral concentrations are high enough to occasionally
cause problems for swimmers and scuba divers. Some windsurfing occurs within the harbour, but
contcerns about contamination have discontinued competitions.

Odours and floating debris, such as condoms and tampon applicators, also cause aesthetic
concerns for sailors, rowers, and canoeists. Up to one third of the shoreline litter in Halifax
harbour is attributable to sewage discharges. Concurrently with projected growth in sewage
flows, the aesthetic problems of the harbour water and shoreline will most likely increase. As
the present poor aesthetic quality of the water is already often said to interfere with tourists’

e njoyment, additional sewage pollution may well have adverse repercussions for the future of
this prosperous industry; tourism is the prime industry in Nova Scotia.

As early as 1924, the federal department of Marine and Fisheries prepared a report on the
physical oceanography of the harbour as the receiving body for untreated sewage. It is only
since the late 1960s, however, that the provincial, federal, and municipal governments have
attempted to deal with Halifax’s raw sewage problem. In their efforts to come up with an action
plan for Halifax, these three levels of government have conducted many studies, initiated
numerous proposals, held public meetings and hearings, and suggested various recommendations
towards establishing a waste management strategy for the harbour, including appropriate sewage
treatment.

Over the past ten years, these efforts have steadily intensified. In 1987, the Metro Area
Planning Commission published a study on the environmental effects of one regional sewage
treatment facility at Sandwich Point. This led to a federal-provincial cost-sharing agreement for a
$200 million project, just in time for the federal and provincial elections of the fall of 1988. A
string of panels set up to assess Halifax’s sewage problem followed: the Halifax Harbour
Cleanup Review Committee of the Nova Scotia Environmental Control Council, the Halifax
Harbour Task Force, and Halifax Harbour Cleanup Inc. (HHCI), the crown corporation
registered in 1989 to plan and oversee the construction of a regional sewage treatment facility. However, by the time a joint federal-provincial Environmental Assessment Review Panel (EARP) was appointed in late 1991, the HHCI plan had ballooned to a $400 million megaproject consisting of a single regional sewage treatment plant. This plant was to be located on an artificial extension of McNab’s Island near the southern entrance of Halifax harbour.

This latest salvo of activity slowly fizzled out from September 1993 to March 1995. The September 3, 1993, EARP review found that the HHCI megaproject could proceed but attached a string of 70 conditions, the first of which required the full $400 million to be in place prior to launching the project. It was not. Indeed, the political stripes of both the Ottawa and Halifax governments had changed and so had their commitment to a very expensive and over-engineered megaproject. HHCI closed down on January 31, 1995, its furniture went off to the G-7 Planning office, and the 1988 federal-provincial agreement was allowed to expire without a word of possible extension or renegotiation. The plan for Halifax harbour sewage treatment once more ran aground.

Responsibility for providing sewage treatment for the new Halifax Regional Municipality (HRM), created in April 1996 by the merging of Dartmouth, Halifax, and Halifax County, has returned to the municipality. In February 1996, a source control study for the area was commissioned and the final report is expected soon. A second report is to discuss the first steps the HRM can take on its own. Meanwhile, the week before the April merger, the City of Dartmouth proceeded with a $6 million sewer amalgamation plan which will redirect 70 per cent of its sewage to the deeper waters of the harbour, with nothing more than pretreatment, which will remove grit and floatable materials. In October 1996, all parties interested in cleaning up the harbour will meet at a “consensus conference” in an attempt to give a new direction to the Halifax harbour cleanup.

There also appears to be a recognition by the HRM’s Council, its voters, and the engineers that HHCI’s megaproject was ill-conceived at best and that an integrated, decentralized approach using new sustainable technologies may be a better and cheaper route to follow. Both Dartmouth and Halifax have had, for the past 10 and 20 years respectively, a water bill surcharge for a pollution control fund. The HRM has approximately $40 million in the fund, enough to go ahead with certain components of a decentralized and rethought project. And every time a HRMer flushes the toilet, another tenth of a penny goes towards the fund.

For 15 years now, the public has been ahead of the politicians in wanting to get on with the job of cleaning up Halifax harbour. But public concern alone cannot slow down or stop the harbour’s downhill slide. If public servants cannot commit to cleaning up Halifax harbour, they should invite the private sector to do the job. Otherwise, like Sisyphus who was condemned to eternally roll a stone up a hill, we will keep on wasting our energies and resources. With only an ever-growing pile of ignored studies to show for our efforts, we will be left with worsening environmental quality and mounting socioeconomic costs—hardly an honourable legacy to bequeath to future generations.
Appendix B: Diseases associated with pathogenic micro-organisms found in domestic sewage

<table>
<thead>
<tr>
<th>Type</th>
<th>Disease or syndrome caused</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BACTERIA</strong></td>
<td></td>
</tr>
<tr>
<td><em>Aeromonas hydrophila</em></td>
<td>Enteritis (inflammation of the intestine)</td>
</tr>
<tr>
<td><em>Campylobacter</em></td>
<td>Enteritis, diarrhea</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em></td>
<td>Enteritis (indicator)</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>Enteritis, diarrhea</td>
</tr>
<tr>
<td><em>Francisella tularensis</em></td>
<td>Tularemia</td>
</tr>
<tr>
<td><em>Leptospira</em></td>
<td>Jaundice, meningitis</td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td>Listeriosis</td>
</tr>
<tr>
<td><em>Mycobacterium</em></td>
<td>Tuberculosis, skin</td>
</tr>
<tr>
<td><em>Pseudomonas</em></td>
<td>Skin, ear infections</td>
</tr>
<tr>
<td><em>Salmonella (1700 types)</em></td>
<td>Enteritis, typhoid</td>
</tr>
<tr>
<td><em>Shigella (4 species)</em></td>
<td>Enteritis, diarrhea</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>Skin infections</td>
</tr>
<tr>
<td><em>Vibrio cholerae and parahemolyticus</em></td>
<td>Cholera, skin infections</td>
</tr>
<tr>
<td><em>Yersinia enterocolitica &amp; pseudotuberculosis</em></td>
<td>Enteritis</td>
</tr>
<tr>
<td><strong>HELMINTHS</strong></td>
<td></td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>Ascariasis</td>
</tr>
<tr>
<td><em>Ancylostoma duodenale</em></td>
<td>Hookworm infections</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td>Trichiuriasis</td>
</tr>
<tr>
<td><em>Taenia</em></td>
<td>Taeniasis</td>
</tr>
<tr>
<td><em>Toxocara</em></td>
<td>Abdominal pains</td>
</tr>
<tr>
<td><em>Strongyloides</em></td>
<td>Abdominal pains</td>
</tr>
<tr>
<td><strong>PROTOZOANS</strong></td>
<td></td>
</tr>
<tr>
<td><em>Entamoeba histolytica</em> and coli*</td>
<td>Enteritis, chronic diarrhea, dysentery, liver abscess</td>
</tr>
<tr>
<td><em>Giardia lamblia</em></td>
<td>Giardiasis, enteritis</td>
</tr>
<tr>
<td><em>Cryptosporidium parvum</em></td>
<td>Enteritis, diarrhea</td>
</tr>
<tr>
<td><em>Ballantidium coli</em></td>
<td>Enteritis, diarrhea</td>
</tr>
<tr>
<td><em>Naegleria fowleri</em></td>
<td>Meningoencephalitis</td>
</tr>
<tr>
<td><em>Acanthamoeba spp.</em></td>
<td>Meningoencephalitis</td>
</tr>
<tr>
<td><strong>VIRUSES</strong></td>
<td></td>
</tr>
<tr>
<td><em>Polioviruses</em> (3 types)</td>
<td>Paralysis, meningitis</td>
</tr>
<tr>
<td><em>Echoviruses</em> (34 types)</td>
<td>Meningitis, diarrhea</td>
</tr>
<tr>
<td><em>Coxackieviruses A and B</em> (30 types)</td>
<td>Meningitis, conjunctivitis, chronic fatigue syndrome, myocardia, diabetes</td>
</tr>
<tr>
<td><em>Hepatitis A and E viruses</em></td>
<td>Epidemic hepatitis</td>
</tr>
<tr>
<td><em>Enteroviruses 68-71</em></td>
<td>Meningitis, conjunctivitis</td>
</tr>
<tr>
<td><em>Rotaviruses</em> (+4 types)</td>
<td>Enteritis</td>
</tr>
<tr>
<td><em>Reoviruses</em> (3 types)</td>
<td>Enteritis, respiratory</td>
</tr>
<tr>
<td><em>Adenoviruses</em> (+40 types)</td>
<td>Enteritis, eye and respiratory</td>
</tr>
<tr>
<td><em>Norwalk and like viruses</em></td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td><em>Caliciviruses and Astroviruses</em></td>
<td>Enteritis</td>
</tr>
<tr>
<td><em>Coronaviruses</em></td>
<td>Enteritis</td>
</tr>
<tr>
<td><em>Parvoviruses</em> (2 types)</td>
<td>Enteritis, respiratory in children</td>
</tr>
</tbody>
</table>
### Appendix C: Potential health and environmental effects of toxins found in STP effluents

<table>
<thead>
<tr>
<th>Toxins</th>
<th>Potential health and environmental effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy metals</strong></td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>neurotoxin (attacks nerve cells), teratogen (causes birth defects)</td>
</tr>
<tr>
<td>Chromium</td>
<td>carcinogen (causes cancer)</td>
</tr>
<tr>
<td>Lead</td>
<td>neurotoxin, teratogen, affects female fertility, bioaccumulative (builds up in the food chain)</td>
</tr>
<tr>
<td>Mercury</td>
<td>neurotoxin, teratogen, affects female fertility, bioaccumulative</td>
</tr>
<tr>
<td>Zinc</td>
<td>excessive ingestion is uncommon but can cause gastrointestinal distress and diarrhea</td>
</tr>
<tr>
<td><strong>Agricultural chemicals</strong></td>
<td></td>
</tr>
<tr>
<td>2,4-D</td>
<td>teratogen</td>
</tr>
<tr>
<td>Lindane</td>
<td>carcinogen, teratogen, immunotoxicity (damages immune system)</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>reduces fertility, bioaccumulative</td>
</tr>
<tr>
<td>DDD and DDE</td>
<td>neurotoxin, affects fertility, immunotoxicity, carcinogen</td>
</tr>
<tr>
<td><strong>Industrial chemicals</strong></td>
<td></td>
</tr>
<tr>
<td>PCBs</td>
<td>neurotoxin, carcinogen, suppresses immune system in animals, causes skin disorders, liver damage, depression and internal bleeding, affects fertility</td>
</tr>
<tr>
<td>Chloroform</td>
<td>carcinogen, affects female reproductive capacity</td>
</tr>
<tr>
<td>Xylene</td>
<td>affects male reproductive capacity</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>affects respiratory system, very persistent in the environment</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>poisonous by ingestion or absorption through skin, skin irritant</td>
</tr>
<tr>
<td>Cresol, Phenol</td>
<td>poisonous by ingestion or absorption through skin</td>
</tr>
<tr>
<td>PAHs</td>
<td>carcinogens, biotransformable (shift forms once in the organism)</td>
</tr>
<tr>
<td>LABs</td>
<td>persistent in the environment, effects not yet known</td>
</tr>
</tbody>
</table>

### Appendix D: Relative composition of contributing sources to shellfish closures in the four Atlantic provinces, 1993

<table>
<thead>
<tr>
<th>Province</th>
<th>Source category in square kilometres and (%) of total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Multiple</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>703.3 (80.3)</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>595.4 (90.6)</td>
</tr>
<tr>
<td>Prince Edward Is.</td>
<td>54.7 (53.6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Province</th>
<th>Source category in square kilometres and (%) of total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Multiple</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>164.0 (40.0)</td>
</tr>
</tbody>
</table>
Notes


2. Personal communication with Michelle Parsons, Executive Director of St. John’s Harbour Atlantic Coastal Action Program, Inc.


4. Data for the entire paragraph have been compiled from a variety of sources: Environment Canada, *Municipal Water Use Database*; personal communication with Bruce Fisher, Engineer, Environmental Management Division, Department of Environment and Labour, Government of Newfoundland and Labrador; personal communication with Phil Leech, Financial Assistance Officer, Infrastructure, Water and Wastewater Section, New Brunswick Department of the Environment; personal communication with Aileen Waller-Hebb, Planning Engineer, Municipal Services Division, Nova Scotia Department of Housing and Municipal Affairs; personal communication with Jim Young, Engineer, Engineering and Utilities, Water Resources Division, Prince Edward Island Department of Environmental Resources.

5. Ibid.

6. Ibid.


10. Personal communication with Jerry F. Payne, Toxicology Section, Environmental Sciences Division, Department of Fisheries and Oceans, Newfoundland.


12. Ibid.

13. Personal communication with Jerry F. Payne, Toxicology Section, Environmental Sciences Division, Department of Fisheries and Oceans, Newfoundland.


   Personal communication with Jerry F. Payne, Toxicology Section, Environmental Sciences Division, Department of Fisheries and Oceans, Newfoundland.


19. Water treatment plants also use similar quantities of chlorine.
   Garron, Christine A., *Disinfectant Chemical Use in Domestic Water and Wastewater Treatment in the Atlantic Region in 1990*, pp. 9, 12.
   Arnold, Sarah H., *A Survey of Biocides Used For Biofouling Control in the Atlantic Region*, p. 5.

20. Personal communication with Paul Klaasen, Environmental Engineer, Pollution Reduction Division, Environmental Protection Branch, Environment Canada, Atlantic Region.


22. One such example is chloroform, which is a proven carcinogen. Others are trihalomethanes such as bromoform and chlorodibromomethane which are suspected carcinogens.

23. Personal communication with Brent J. Moore, Environmental Protection Biologist, Lower Mainland Region, B.C. Ministry of Environment, Lands and Parks.

24. Ibid.

25. Ibid., p. 15.


27. Ibid., p. 18.

28. Ibid.

29. The tests in question are called LC50s, and they are used to determine the maximum concentration of an undiluted effluent required before it is fatal to 50 per cent of the test fish. These tests do not take into account subacute effects.
30. Paragraph 11(a) of CEPA reads as follows: For the purposes of this Part, a substance is toxic if it is entering or may enter the environment in a quantity or concentration or under conditions (a) having or that may have an immediate or long-term harmful effect on the environment;


32. Ibid., pp. 72, 73.


34. Ibid., pp. 70, 71.

35. Ibid., p. 178.

36. Ibid., pp. 65, 178.

37. Ibid., p. 77.

38. Personal communication with Peter Wells, Coastal Research Scientist, Environmental Conservation Branch, Environment Canada, Dartmouth.

   Personal communication with Jerry F. Payne, Toxicology Section, Environmental Sciences Division, Department of Fisheries and Oceans, Newfoundland.


40. Ibid., p. 7.

41. An additional 3,507 square km, or 63 per cent of the surveyed waters, is classified as approved, and 96 square km, representing 2 per cent of the surveyed waters, could be conditionally managed depending on rainfall, STP breakdown, and so on. It is estimated that approximately 80 per cent of the closed areas can be exploited if the harvest undergoes a biological purification process (deputation or relaying). However, it increases the harvesting costs by 10 to 20 per cent.

   Personal communication with Amar Menon, Head of Shellfish Program, Environmental Protection Branch, Environment Canada, Nova Scotia.


   Machell J.R. et al., *The Impact of Coastal Pollution on Atlantic Molluscan Shellfish Growing Area Water Quality,* figure 1.

42. In comparison, the 1994 landed value for the molluscan and crustacean commercial catch (wild caught shellfish) in the Atlantic Provinces equals $787,318,000.

   Department of Fisheries and Oceans, 1994 Canadian Landed Values for Commercial (Wild Caught) Fisheries.

43. Department of Fisheries and Oceans, 1994 Canadian Aquaculture Production Statistics.


47. For the whole Scotia Fundy region of DFO, the total landings of the clam resource is much higher. In 1995, it was estimated at $3.45 million, based on landings of 1,660 metric tons. Nevertheless, in south west New Brunswick alone, today’s landings of *Mya arenaria* represent an 80 per cent drop of the yearly average 5,700 metric tons landed between 1945 and 1955. As it is common knowledge that only half of the actual landings get recorded by DFO, because much of the product is sold directly from diggers to individuals or businesses that do not submit purchase slip, the lost income is probably much higher.

Personal communication with Marianne Janowicz, Resource Specialist, Resource and Planning Branch, New Brunswick Department of Fisheries and Aquaculture.

Robinson, Shawn M.C., Clam Enhancement Trials in the Bay of Fundy, to be published in late 1996 in *Department of Fisheries and Oceans Science Review 1994-1995*.


49. Personal communication with Shawn M.C. Robinson, Research Scientist, Invertebrates, St. Andrews Biological Station, New Brunswick, Department of Fisheries and Oceans.


53. Personal communication with M.T. Grant, Engineer, Environmental Management and Support Services, Resources Management and Pollution Control, Nova Scotia Department of the Environment.

54. Personal communication with Aileen Waller-Hebb, Planning Engineer, Municipal Services Division, Nova Scotia Department of Housing and Municipal Affairs.

55. In Newfoundland, the provincial Department of the Environment and Labour finances between 30 and 80 per cent of the capital costs municipalities require to build or upgrade sewage infrastructures. The New Brunswick Department of the Environment also finances up to 80 per cent of the costs of municipal wastewater projects. In Prince Edward Island, the province subsidize up to one third of the capital costs.

Personal communications with Bruce Fisher, Senior Environmental Engineer, Environmental Management Division, Department of Environment and Labour, Government of Newfoundland and Labrador; Phil Leech, Financial Assistance Officer, Infrastructure, Water and Wastewater Section, New Brunswick Department of the Environment; and Jim Young, Engineer, Engineering and Utilities, Water Resources Division, Prince Edward Island, Department of Environmental Resources.

56. In Quebec, the provincial Crown finances and “regulates” STPs which are owned and operated by the municipalities. There has never been any law suit against non-complying STPs although 43 per cent of STPs received unacceptable grades from the Ministry of Environment (data from 1993, the latest available). There has never been a single prosecution under s.36 (3) of the federal Fisheries Act. More details in *Sewage Treatment and*

In British Columbia, the provincial department of Municipal Affairs contributes between 25 and 75 per cent of the construction and upgrade costs of STPs, which are regulated and mandated by B.C. Environment and B.C. Health. In the past six years, B.C. Environment has convicted only two non-complying STP permittees, although more than half the B.C. facilities are either known to be out of compliance, or as defined by B.C. Environment, deemed to be out of compliance for not submitting the required monitoring data to the province. For additional details, see Municipal Wastewater Pollution in B.C., by Martin Nantel, May 1996.

57. Regulatory boards enforcing environmental legislation are not the only way to protect the environment. Centuries old Common Law property rights, by giving property owners rights to clean water, and by empowering them to ensure that their rights are not encroached on by other interests, essentially acts as an environmental protection law. Unfortunately, although property rights historically did a great job at protecting the environment, our governments have passed regulations that in many instances overrode them.

For more information, see Brubaker, Property Rights in the Defence of Nature, pp. 32, 84, 85.


65. The Halifax Harbour Task Force was established in 1989 by the provincial government to review the environmental effects of the proposed regional sewage treatment facilities and to involve the public in the process. Environment Canada, State of the Environment in the Atlantic Region, p. 216.

66. Ibid., p. 18.


68. Personal communication, Ecology Action Centre, Nova Scotia.


70. Prouse, Nicholas J., Ranking Harbours in the Maritime Provinces of Canada for Potential To Contaminate American Lobster (Homarus americanus) with Polycyclic Aromatic Hydrocarbons, in Canadian Technical Report of Fisheries and Aquatic Sciences 1960, p. 4.

71. This is the case in certain areas of Boston harbour.

Personal communication with Bruce Estrella, Senior Marine Fisheries Biologist, Coastal Office Investigation Project, State of Massachusetts.
72. Personal communication with Kok-Leng Tay, Head of Waste Management Section, Environmental Protection Branch, Environment Canada, Atlantic Region.

73. Especially in Quincy Bay.
   Ibid.
   Other pathological alterations in fish from Quincy Bay involved the circulatory, excretory, musculature, nervous, and integument systems. Some of the fin rays caught in the same study showed cancerous morphological alterations in the stomach, liver, and nerves.


75. Personal communication with Kok-Leng Tay, Head of Waste Management Section, Environmental Protection Branch, Environment Canada, Atlantic Region.
   Similar data has also recently been reported for St. John’s, Newfoundland.


77. Ibid.

78. The remainder is attributed to littering from shore and from vessels.

79. The population of the Halifax-Dartmouth metropolitan area is expected to reach 358,000 in 20 years, and 512,000 in fifty years.


82. Ibid.

83. Personal communication with Alan Ruffman, Volunteer Coordinator, Metro Coalition for Halifax Harbour Cleanup.

84. Ibid.

85. Ibid.

86. Ibid.

87. Payment, *Wastewater Chlorination from a Public Health Microbiology Perspective*, p. 6, 7; and Payment, *Risques d’Exposition des Travaillers à des Virus Entériques à la Suite d’Épandage de Bones Provenant de Stations d’Épuration d’Eaux Usées Municipales*, p. 5.
88. Data from Thao Pham, Environmental Project Manager, St. Lawrence Centre, Environment Canada. All of the industrial and agricultural chemicals listed in Table 2 are organic ones, and although not monitored, at every STPs in the Atlantic region, they are most likely found in most of them—just as they are in the wastewater effluents of other large cities.

89. Machell J.R. et al., *The Impact of Coastal Pollution on Atlantic Molluscan Shellfish Growing Area Water Quality*, Table 1. Personal communication with Jim Roberts, Environmental Quality Officer, Environmental Protection Branch, Environment Canada, Newfoundland.
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The Impact of Coastal Pollution on Atlantic Molluscan Shellfish Growing Area Water Quality, Environmental Protection Branch, Environment Canada, presented at the Coastal Zone Canada 94 at Halifax, Nova Scotia, September 20-23.

Garron, Christine A.
1992  
Menon, Amar S.

**Government of Canada**

****

**Halifax Harbour Task Force**

**Hatfield, Belle**

**Heath, Alan G.**

**Jacques Whitford Environment Limited**


**MacLaren, James**

**Oceans Ltd.**

**Payment, Pierre**


**Sierra Legal Defence Fund**

**Sindermann, Carl J.**

**Personal and Written Communications**

Armand Frappier Institute, Research Centre in Virology  
Pierre Payement, Professor.

British Columbia Ministry of Environment, Lands and Parks  
Brent J. Moore, Environmental Protection Biologist, Lower Mainland Region.

Canadian Department of Fisheries and Oceans, Atlantic Region  
Jerry F. Payne, Toxicology Section, Environmental Sciences Division, Newfoundland.  
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Ecology Action Centre  
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Government of Newfoundland and Labrador, Department of Environment and Labour  
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New Brunswick Department of the Environment  
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Andre Chenard, Environmental Officer, Operations Division, Water and Wastewater Section.  
Phil Leech, Financial Assistance Officer, Infrastructure, Water and Wastewater Section.

New Brunswick Department of Fisheries and Aquaculture  
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Nova Scotia Department of the Environment  
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Nova Scotia Department of Housing and Municipal Affairs  
Aileen Waller-Hebb, Planning Engineer, Municipal Services Division.

Prince Edward Island, Department of Environmental Resources  
Jim Young, Engineer, Engineering and Utilities, Water Resources Division.
State of Massachusetts
Bruce Estrella, Senior Marine Fisheries Biologist, Coastal Office Investigation Program.

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