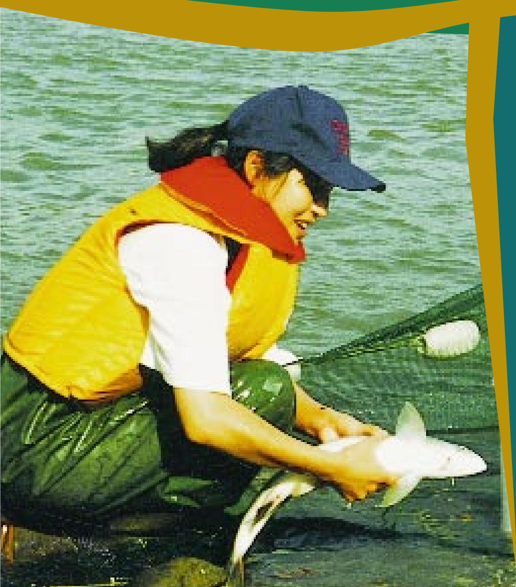
Environment Canada Environnement Canada

Aquatic Science



FRASER RIVER

ACTION PLAN

Canada

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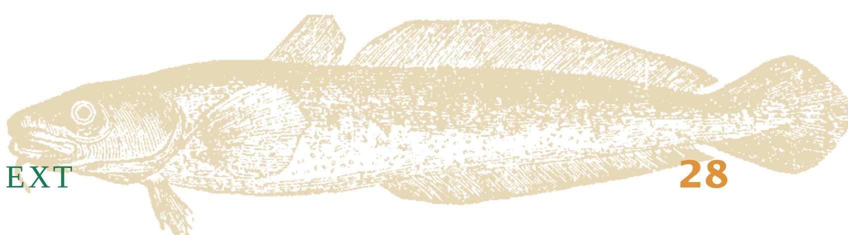


FRASER RIVER BASIN

Aquatic Science

RESEARCH DIRECTIONS

The research sponsored by the Fraser River Action Plan (FRAP) has had three broad branches:

- At the centre was a select team of aquatic scientists who assessed pollution in water, sediments, benthic life, fish, and birds throughout the Fraser Basin.

- FRAP also commissioned scientific studies on bird and wildlife habitat: its significance and vulnerability; its reduction and elimination by urban development, agriculture, and forest industries; and methods by which it can be restored, preserved, and managed.

- Finally, recognizing the interconnections between the natural and human environments, FRAP commissioned an array of studies on the economic and social implications, barriers, and opportunities that affect the management of pollution and habitat.

This module outlines the main findings of this seven-year aquatic science inquiry. The studies and findings of the other research branches are presented in other sections.

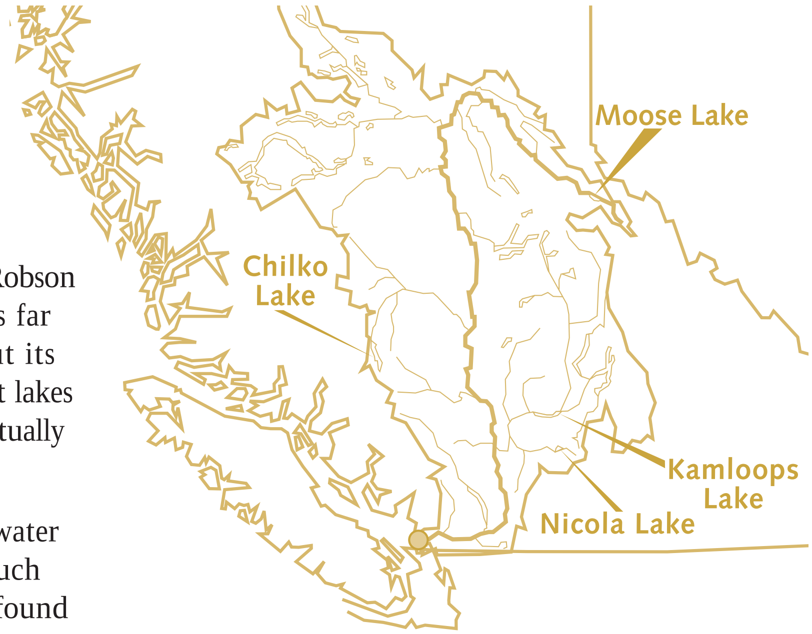
To tell the aquatic science story, we begin with the Fraser River's headwaters and move downstream to the ocean.

AN UNCONVENTIONAL INSTITUTE

FRAP fostered a collaborative effort of over forty researchers, including Fisheries and Oceans scientists, faculty from University of British Columbia, Simon Fraser University, University of Victoria, and University of Waterloo, and researchers from regional offices of Environment Canada and from the National Water Research Institute and the National Hydrology Research Institute. These researchers were bound by annual workshops, electronic networks, and a common pool of resources. For five years they brought their diversity of expertise to bear on the shared goal of improving our understanding of the Fraser Basin Ecosystem.

With FRAP ended, the researchers have gone on to other work. But their research will be available on the Internet (www.pyr.ec.gc.ca/ec/frap/index.html) through a meta-database and CD ROM containing over 200 technical reports including a bibliography of scientific information.

LAKES



HEADWATER LAKES AS POLLUTION TRAPS

Picturesque Moose Lake near Mount Robson high in the Rocky Mountains seems far removed from human pollution. But its waters revealed to FRAP scientists that lakes commonly regarded as pristine may actually be far from it.

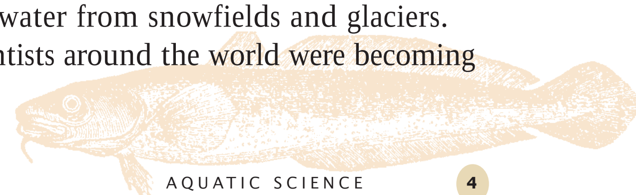
The scientists caught burbot (a freshwater cod at the top of the food chain in such lakes) and sampled their livers. They found toxic chemicals in startling amounts. The burbot livers contained levels of a long-banned insecticide, toxaphene. They also contained very high levels of another banned pesticide, DDT, and of PCBs, which are toxic chemicals found in old electrical equipment and in traces in industrial effluent. These findings were of more than academic concern. Burbot is valued as a sports fish, and burbot livers are favoured as food by some First Nations people.

EC AQUATICS SECTION

Moose Lake

These fish lived undisturbed in a remote mountain lake. The puzzle was: where were the poisons coming from?

Further investigation provided some clues. Significantly absent from the fish livers (as well as from bed sediment deposits), despite the high DDT levels, were correspondingly high DDE and DDD levels, the two break-down products of DDT. This suggested the DDT had arrived recently and had not yet been degraded to any extent. Attention then turned to the water sources for the lake: meltwater from snowfields and glaciers. Scientists around the world were becoming

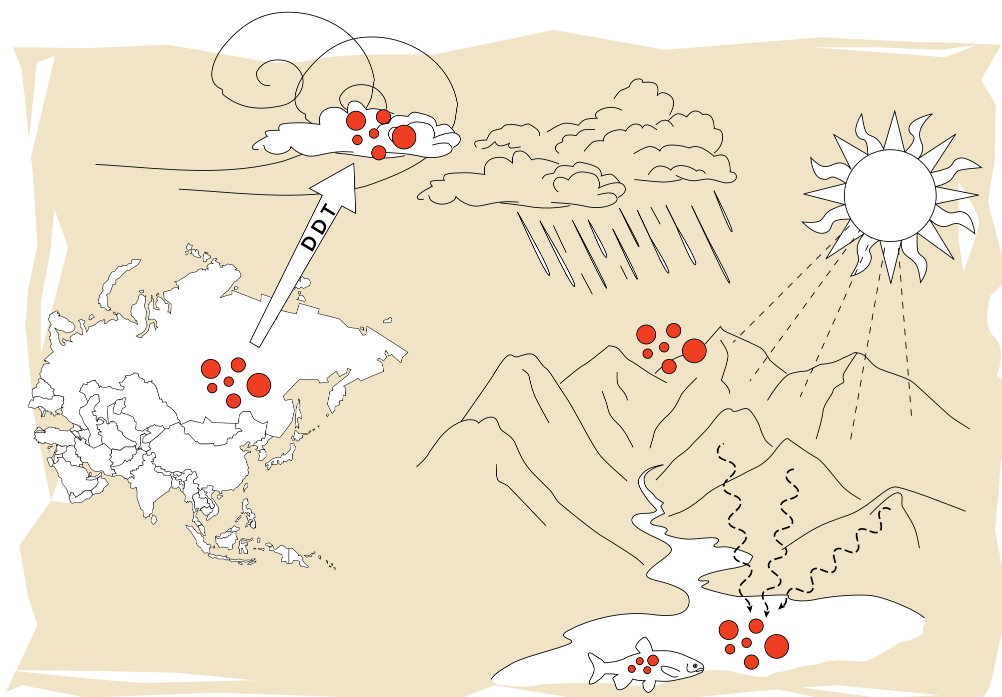


aware of long-range atmospheric transport of pollutants, the ability of contaminants to be distributed globally through the air. Could the DDT reaching Moose Lake have originated in Asia, where it is still in use? DDT was also found in suspended (waterborne) sediments in Fraser River water in the McBride area, downstream from Moose Lake, suggesting that some of it is being carried through the ecosystem.

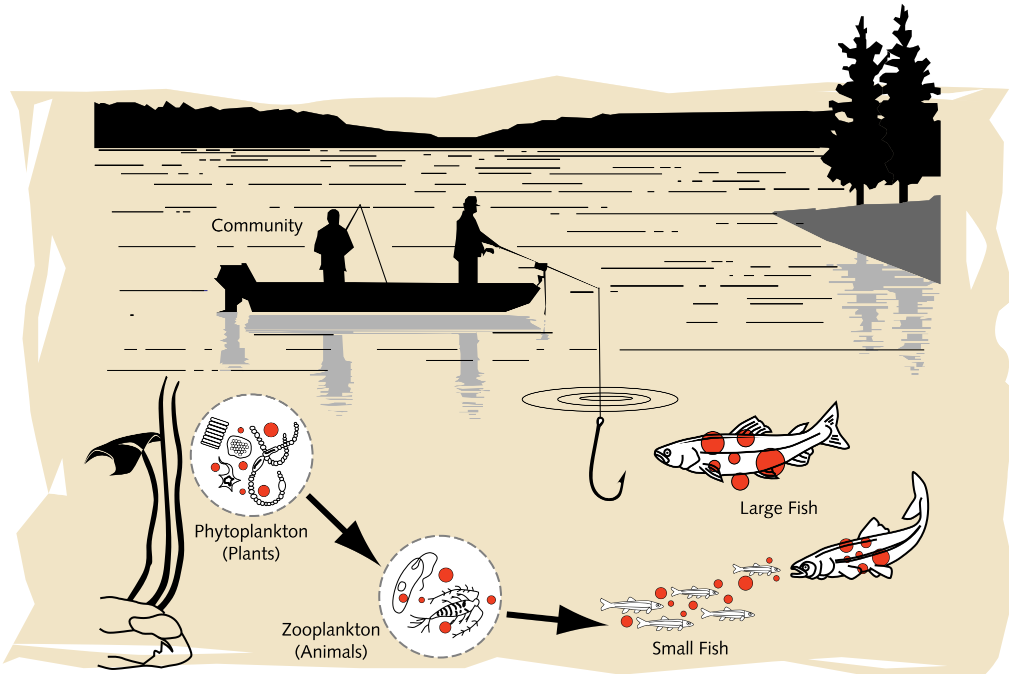
At Moose Lake, scientists tested sediment cores – vertical columns of lake bottom sediment showing layers deposited over time. The results showed only average "background" levels of PCBs and DDT. This suggested that the high PCB and DDT levels in burbot livers were being caused by biomagnification, which occurs because animal tissues act like filters to accumulate and concentrate the PCBs and DDT ingested in food. These concentrations increase as these animals are eaten by other animals on up the food chain. Burbot, at the top of the food chain, would ingest PCBs already concentrated by its prey – and by its prey's prey – and therefore would accumulate the highest concentrations of all. (Unless, of course, the burbot were eaten by human beings ...)

The scientists caught burbot and found toxic chemicals in startling amounts

Somehow, the PCBs, like DDT, were finding their way into the food chain. It seems most likely that they are carried globally by the atmosphere, descend into the snowfields and glaciers with precipitation, and are then released into the ecosystem in meltwater.



Even pristine locations can't escape global atmospheric pollution.



The food chain concentrates pollutants.

Toxaphene presented a similar riddle. There is no historic record of its concentration levels because it doesn't adhere to sediment

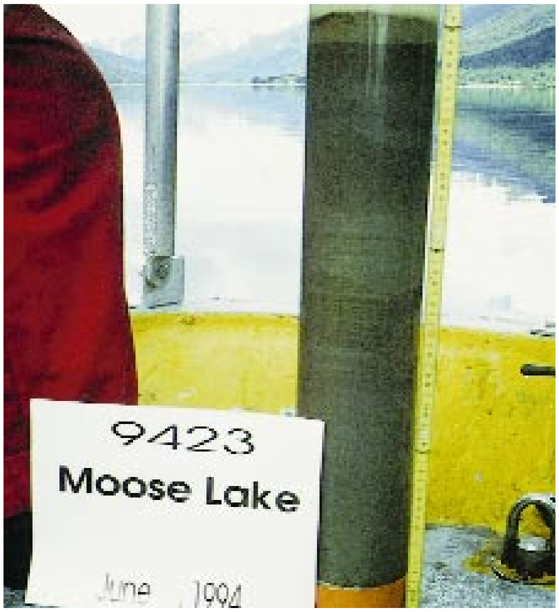
Glaciers and snowfields act as first-tier traps for contaminants arriving by air

particles very well and so does not show up in sediment cores. But it does bioaccumulate readily, so even small amounts in water can lead to surprising concentrations in fish. But how did toxaphene get into the water, because it has not been used in Canada or the United States for many years? Scientists suggest that it too probably comes from another continent, carried by the winds and deposited by rain and snow in our watersheds.

Atmospheric sources are also suspected for contaminants found in Stuart Lake, near Fort St James, and in Chilko Lake, on the inland side of the Coast Mountains. Research shows that fish in headwater lakes tend to have higher contaminant levels. Scientists suspect that, just as glaciers and snowfields act as first-tier traps for contaminants arriving by air, so the headwater lakes into which the meltwater flows act as second-tier traps, where contaminants that adhere to sediments can be deposited in the lake bed. If so, lower regions in the watershed are being protected from contamination by these high-altitude barriers. The "pristine" mountain lake may be just the opposite: a protective but contaminated reservoir. British Columbians can no longer regard their environment as isolated from polluted regions of the world.

There is a link here to global warming. As awareness grows of the global atmospheric distribution of pollution, climate change acquires a special significance in mountainous watersheds like the Fraser Basin.

Accelerated melting of glaciers and snowfields could speed up the release of their long-gathered store of contaminants into the headwater lakes, raising the levels of toxic pollution downstream.



ROB MACDONALD

A Moose Lake sediment core in which contaminants were found

FRAP findings indicate that a chemical may continue to contaminate long after it is banned

OTHER POLLUTANT SOURCES

Another kind of contaminant source was suggested by findings from similar sampling in Nicola Lake, near Merritt in the Thompson watershed. Testing of sediments and burbot livers indicated that the lake has low levels of most contaminants, with the surprising exception of DDT. An atmospheric pathway seems unlikely, because the concentrations of other related contaminants (known as "organochlorines") should also be elevated, but they are not. Moreover, the lake is situated in a relatively dry area of the province and is not surrounded by a big catchment system of mountains and snowfields. Yet the data indicated that a release of a large amount of fresh DDT occurred in the lake relatively recently, some time between the late 1970s and the mid-1980s, at least ten years after DDT use was banned in Canada. There is suspicion that, after DDT was banned, some stocks were illegally used or dumped.

In any case, these FRAP findings indicate that a chemical may continue to contaminate the environment long after its use has been banned.

Sediment cores from Stuart Lake show the historical cycle of mercury contamination from mine tailings dumped into Pinchi Creek upstream during the Second World War. At one time, mercury contamination spread throughout the lake. It has declined only gradually, and a half century later has still not quite returned to normal levels. A similar historic pattern is revealed for PAHs, a byproduct of combustion, in Harrison Lake adjacent to urban, agricultural, and industrial regions in the Lower Fraser Valley. Scientists believe that PAH levels reflect not only fossil fuel combustion in vehicles but also local slash burning and beehive burning of wood waste. Sediment layers show PAH accumulations beginning in the 1890s and rising to a peak in the 1950s, when coal began to give way to petroleum products as fuel. Since then, PAH contamination in sediment core layers has decreased somewhat.

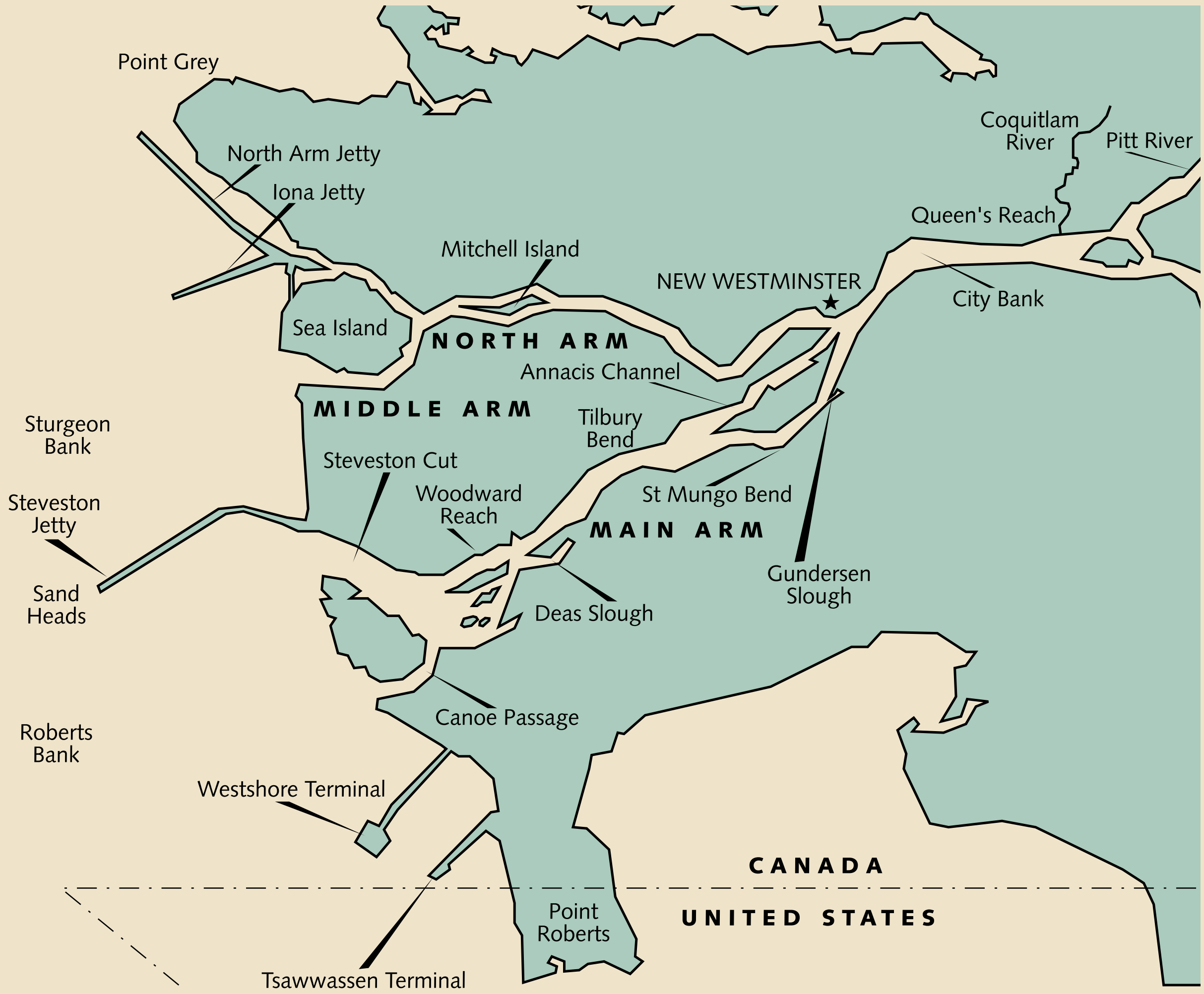
coarse sand

SEDIMENT

MOVEMENTS

The Fraser River shifts sediment into the ocean at an average rate of one metric ton (2200 lbs) every two seconds. This rate is equivalent to the weight of the Titanic every day. In years of high flow, the delivery can double. This sediment, suspended in the waterflow, can be seen from aloft as a brown plume pushing from the arms of the Fraser out into and across the Strait of Georgia. Sediment that did not make it all the way to the sea (at least not yet) has settled and gradually filled the wide fertile bottom of the Lower Fraser Valley and spread out to form the delta (floodplain) and estuary (tidal reaches).

Throughout the watershed, streams and rivers scour their banks and pick up sediment, which consists of particles of coarse sand, fine silt, smooth clay, and organic material. The particles are carried downstream in suspension for distances that vary with their size, and then settle out, the heavier particles first. Later, when the flow increases, they may be lifted and carried again. The currents, scouring and eddying, lifting and depositing, sculpt the river bottoms and banks into shapes that change with water levels and current velocities.



Much fine sediment is stored seasonally in the riverbed or in sand bars along the channel bank through much of the river's length. Then, during seasons of exceptionally high flow, several years' worth of stored sediments may be carried off.

In the Fraser estuary, not all sediment transport goes downstream. FRAP scientists have observed upstream movement of sediments in some channels carried by flooding tides. A net flow of sediment up the Pitt River has produced a reverse delta at the mouth of Pitt Lake. In some areas that have been dredged (eg Queen's Reach near New Westminster and Main Arm by Steveston Cut and Steveston Jetty), some scientists suggest there are signs of an upriver return of sediment quantities removed by dredging. This would support the general observation that sediment configurations on river bottoms are developed into a state of equilibrium over time and tend to re-establish themselves when disturbed. Some observers argue that the use of sandy dredged sediment for construction may be effectively starving the delta.

The Fraser estuary has been shaped and has in the past been maintained by continuing deposition of silt as the river flow interacts with tidal currents. But this natural process has been curtailed and may have ceased. Studies show that dikes, training walls, and dredging have channelled the arms of the Fraser and redirected flows and sediment transport. Only at tiny Canoe Passage, a channel too small to have been altered and accounting for only 5 per cent of the total Fraser flow, can natural deltaic processes still be seen. The intertidal flats of Roberts and Sturgeon banks show signs of sediment depletion. Evidence of erosion in the vicinity of the Westshore and Tsawwassen terminals warns of possible long term threats to those structures.

The Westshore marine terminal at Roberts Bank

CONTAMINANT TRANSPORT

Apart from large-scale physical alterations in shoreline, delta, and estuary habitats, the main significance of sediment movement for FRAP is as a carrier of pollution. Many contaminants adhere to sediment particles and therefore are carried with them. When sediments settle and build up gradually into deep stable layers, as in lake and ocean bottoms, they eventually sequester the attached contaminants, removing them from the biosphere and providing sample cores with the historic record of depositions. But when sediments are scoured and move, they bring contaminants with them.

> Sediment deposits in rivers are good indicators of recent contaminant exposure

Sediment deposits in rivers are good indicators of recent contaminant exposure, especially for contaminants that are insoluble in water. Moreover, sediments are sometimes regarded as better indicators of pollution sites than fish or wildlife because of the predictability of their movement with the streamflow.

Contaminants adhering to settled sediments, instead of being sequestered in the slow layering of the bottom, may be diverted into the food chain. The upper layers of sediments are the habitat of algae and bacteria, which become food for benthic (bottom-dwelling) organisms, such as shellfish, worms, and insect larvae, which are in turn eaten by fish and birds. In this pathway, the contaminants enter animal tissues, where some accumulate and are biomagnified with each step. Scientists found these benthic organisms to be excellent indicators of environmental disturbance.

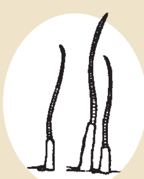
Unless they are directly and acutely toxic, pollutants usually do more damage by entering the food chain, with its biomagnifying power, than by remaining suspended in the water. Contaminated sediments are a pathway leading water pollutants into the food chain and therefore into fish and birds (and humans) at harmful concentrations. For this reason, scientists paid close attention to the tendency of sediments to be deposited or to remain suspended.

Since larger particles settle out more quickly and smaller particles remain suspended longer due to their dynamics, anything that makes particles larger will increase the rate of deposition. One thing that does this is a tendency for particles to flocculate (clump), which increases a particle's mass more than its surface area. Scientists found that pulp mill effluents contain substances that encourage flocculation. Suspended sediment samples collected upstream of pulp mills had a higher proportion of single particles, while samples from downstream had a higher proportion of clumped particles. These clumped particles were more likely to settle to the riverbed sooner, especially in the low flows of winter. Laboratory tests showed that flocculation increases the rate of deposition by up to 30 per cent. These effluents therefore not only add pollutants to the river but also, by encouraging flocculation, help them reach benthic organisms.

EC AQUATICS SECTION

A centrifuge used for studying sediments

BENTHIC ORGANISMS



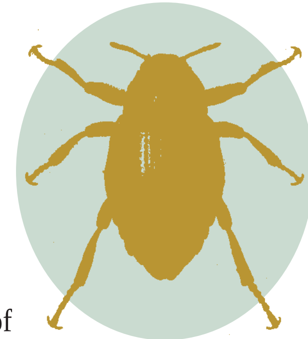
Animals living in the sediment on streambeds and lakebeds can be subdivided between vertebrates (having a backbone) and invertebrates (lacking a backbone). The invertebrates can be arbitrarily subdivided further between macro (big) and micro (small), with the dividing line being visibility to the naked eye or, scientifically, at 0.4mm. The macroinvertebrates were the ones most useful to FRAP's scientists, because they can be easily netted, identified, and counted. They range in size from clams and crayfish down to wormlike and buglike insect larvae and beetles. FRAP scientists also made use of algae and bacteria, which form visible groups or colonies.

BENTHIC ORGANISMS AS ENVIRONMENTAL INDICATORS

Bottom-dwelling organisms are an important point of entry for contaminants into the food chain. Since they don't move around like fish, they can represent conditions at a particular location. They would be useful indicators of exposure to pollution, except for the difficulty of collecting the large number of individual organisms needed to make a reliable sample.

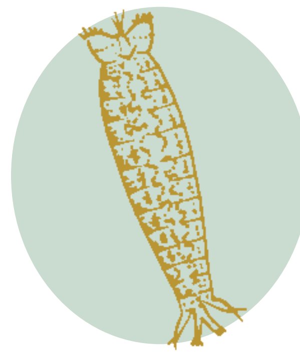
Nevertheless, scientists developed two innovative ways to use benthic organisms as environmental indicators. The first way focuses on the relative abundances of macroinvertebrate populations. By extensive research, scientists developed a model of the species composition expected in a healthy community under specified conditions, such as rock size, stream width, water velocity, stream gradient, altitude, and water conductivity and acidity. This model allows researchers at a particular location to measure these conditions and predict the relative species abundances if the community were healthy. They can then collect samples of bottom sediment at a selected site and count the species and numbers they actually contain.

Bottom-dwelling organisms are an important point of entry for contaminants into the food chain

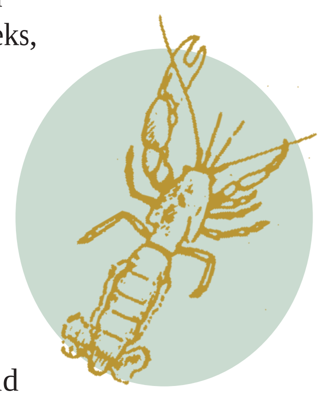


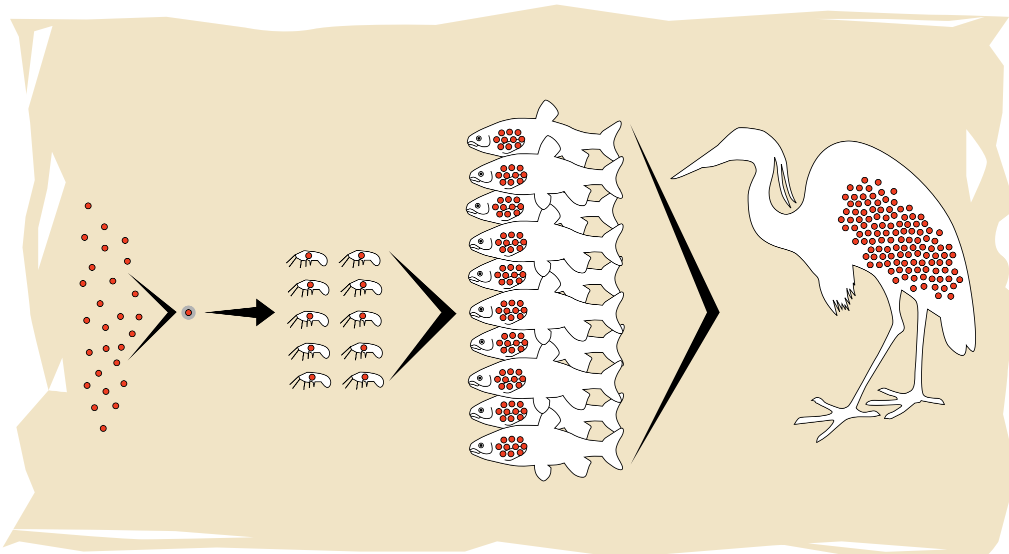
Differences between expected and actual populations indicate disturbances at the site such as pollutants in water and sediments.

For example, an examination of numerous Fraser Basin sites with this model revealed five locations with signs of benthic disturbance. Scientists were able to propose probable causes. At Guichon Creek in the Thompson Basin, the likely cause was mine drainage. On the Salmon River near Salmon Arm, disturbances were attributed to agricultural activities. At sites in the Bowron, Torpy, and Tyaughton watersheds, disturbances were linked to habitat disruption from logging.



The second method of measuring pollution uses an experimental approach in a device called a mesocosm ("mid-sized world"). Essentially an artificial stream in a tank, the mesocosm allows organisms in samples from river bottoms to be exposed directly to effluents at different controlled concentrations. After three weeks, the organisms in a mesocosm are removed, identified, counted, and weighed. These features are compared to those of a parallel set of organisms from the same sample (the sample was split) which were placed as a control group in another mesocosm and





Contaminants become more concentrated with each step up the food chain.

exposed to water drawn straight from the river. The differences in species, numbers, and total weight (biomass) between the control group and the effluent-exposed groups indicate the effects of the various exposure concentrations on organism survival and growth. The mesocosm can also be used to determine how different effluent concentrations affect the rate of growth of algae and bacteria colonies on clean rocks.

In FRAP's case, eight mesocosm tanks and their associated plumbing were mounted on a flatbed truck, which could be moved to a site of interest. In this way, industrial effluent, for example, could be tested under varying degrees of dilution. Mesocosm tests were used to show the effects of dilution on standard pulp mill effluent. At a 1 to 3 per cent effluent-to-water ratio, a dilution found in low-flow conditions, benthic biomass shows unusual growth compared to the control population. At about 3 per cent, extra growth ceases. At 5 per cent and higher, symptoms of toxicity begin.

Although benthic organisms can be used to detect and measure contamination in these ways, such tests do not identify the contaminants involved. But careful monitoring of variables such as dissolved oxygen, acidity, temperature, and selected contaminants can help scientists narrow the list of possibilities.

Left–An enlargement of a benthic invertebrate: a Water Boatman

mesocosm

NHRI

A mesocosm in operation

EC AQUATICS SECTION

FISH

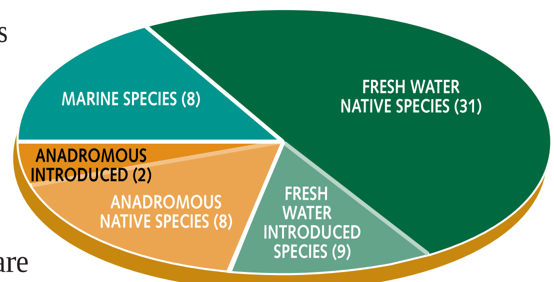
SPECIES AND DISTRIBUTION

Most studies of fish in the Fraser Basin have been confined to salmon and trout, the species important to commercial and recreational fishing. Little was known about other resident species. A FRAP project therefore drew together published and unpublished records to make an atlas showing the distribution of all species in the Basin.

Half the species disappeared from Wright Creek near Prince George

The atlas showed that the Fraser watershed has 58 fish species in all: 40 freshwater species (31 native and 9 introduced), 10 anadromous species (8 native and 2 introduced), and 8 marine species that enter the river regularly. Eight species are found only downstream of the Fraser Canyon, and 7 are found only upstream of the Canyon (some ranging only to the junction with the Bowron River, around the curve from Prince George). Only 10 species are found throughout the Basin: mountain whitefish and peamouth chub (which were selected as indicators partly for their wide distribution), white sturgeon, and some trout and salmon species.

Scientists found evidence of decline in some species in some areas of the basin over the last 30 years. One study concluded that, from the 1960s to the 1990s, half the species disappeared from Wright Creek, a tributary of the Salmon River near Prince George, and that the disappearing species required cool, clear water. Other studies inferred similar reductions in species in Lower Fraser Valley tributaries and probably in the Thompson system as well. It is believed that some disappearances were due to overfishing, but that habitat degradation and exposure to contaminants were more often to blame.



Loss of species has not been recorded in the main stem of the Fraser. But some species are in trouble. Eulachon (also called oolikan) and white sturgeon have been severely reduced in numbers. The sturgeon has been listed as “vulnerable” by the Committee on the Status of Endangered Wildlife in Canada and is no longer fished commercially. The Salish sucker has declined so dramatically that it is listed as “endangered.”

CONTAMINANTS IN FISH

Mountain whitefish and peamouth chub were selected as the main fish indicators for contaminant research. They are found throughout the Basin; they live long enough to accumulate measurable quantities of pollutants; they feed primarily on benthic organisms; and mountain whitefish usually stick to the same summer foraging sites.

FRAP's studies raised many questions. Scientists were unable to show a clear relationship between fish condition and contaminant exposure – to demonstrate that the pollution harmed the fish. Both chub and whitefish were found to be in the best condition and size for their age in the Nechako, Thompson, and Lower Fraser. Yet fish in the Thompson and Lower Fraser are exposed to some of the highest cumulative levels of contamination in the Basin. Scientists attributed the good condition of the fish in these reaches to their having better food sources, as a result of higher temperatures in all three and clearer water as well in the Nechako and Thompson.

Fish health assessments were even less conclusive. For three years (1994–96), scientists tested fish using a health assessment index composed of a set of measurements

NEW CONTAMINANTS CONTINUE TO EMERGE

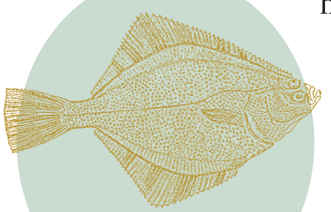
The peamouth chub swims throughout the watercourses of the Fraser Basin. Like the mountain whitefish, it was used by FRAP scientists as an indicator of contamination in the basin's rivers and streams. When scientists examined female chub taken from the lower reaches of the Fraser, they found, as expected, a blood protein known as vitellogenin, indicating the presence of female hormones. But they also found vitellogenin in male fish taken from the same reaches. They hypothesized that some estrogen-like chemical was causing the males to produce it.

Scientists concluded the fish were being exposed to endocrine-disrupting chemicals (EDCs), substances that can enhance or counter the effect of natural hormones that are essential for many bodily processes in animals and fish. There is concern that EDCs can lead to cancer, decreased fertility, and birth abnormalities.

EDCs have been traced to pesticides such as DDT, to additives that make plastics flexible and soft, to wetting agents in detergents designed to help water penetrate fabrics, and to natural and synthetic estrogens such as those found in birth control pills. EDCs are widely used and may produce effects at very low concentrations.

Male peamouth chub taken from the estuary in July 1996 showed concentrations of vitellogenin four times higher than chub taken elsewhere in the basin. Yet fish taken from the estuary two months later showed no elevated levels of the chemical.

Peamouth Chub



Starry Flounder

Burbot

Mountain Whitefish

FISHERIES AND OCEANS CANADA

of selected characteristics, such as liver pigmentation. Significant variation was noted, and again there was no consistent relation between contaminant exposure and health as measured by this composite index. One study using this technique in 1993 and 1994 cited a high incidence of abnormalities in Lower Fraser fish and ascribed it to human activities. However, FRAP research, using similar data but covering a larger geographic area, found no higher incidence of abnormalities in the Lower Fraser than in other parts of the Basin. Abnormalities are common, but they seem to be evenly distributed, as frequent upstream from major urban areas as downstream from them. Researchers believe the abnormalities are probably caused by factors other than pollution, such as physical conditions in the main stem river (high flow, high suspended sediment content) or cycles of parasitic infection.

An observation that might be related to contamination is that fish downstream from pulp mills at Woodpecker and Marguerite have highly pigmented organs. This finding is supported by a similar study on the Columbia River.

FRAP research shows that since the 1970s and 1980s there have been decreases in fish tissue concentrations of certain contaminants on which action was taken. Declining contaminants include PCBs (which have been banned), lead (which has been removed from gasoline), arsenic (following the closing of a copper smelter in Tacoma), and mercury (following industrial process changes). Dioxins and furans have decreased following changes in pulp mill effluents.

Yet symptoms in fish continue to indicate likely contaminant exposure. For example, contaminant stress was observed in tests on the levels of mixed function oxygenases (MFOs), enzymes produced in fish livers to remove toxic organic chemicals. The MFO levels in peamouth chub and mountain

EC AQUATICS SECTION

A Peamouth Chub

whitefish varied consistently with observed organic chemical levels in fish tissue and in sediment where the fish were found. The MFO induction could not be traced to any specific chemical, though the correlation between MFOs and traces of dioxins, furans, and PCBs in mountain whitefish liver was considered statistically reliable. Nevertheless, MFO induction in fish livers provides a warning of organic contaminant exposure in the environment. And in the Fraser Basin this particular alarm is sounding.

Some chemicals in industrial use are indeed highly toxic to some life stages of some species. DDAC, recently introduced as an ingredient in anti-sapstains (anti-fungicides used to prevent discoloration of new lumber), has been shown to be very toxic to early life stages of sturgeon (40- to 60-day old fry), though other species, such as the starry flounder, common to the Fraser estuary, are much less affected by the chemical. But the pathways taken by pollutants affect species' exposure. During high flow periods DDAC disappears very quickly from the water because it binds readily to particles. Some areas in the estuary may therefore be toxic to some organisms because of the accumulation of DDAC in sediments deposited there. The toxicity of sediments exposed to DDAC is still being studied.

Some chemicals in industrial use are indeed highly toxic to some life stages of some species

DDAC is an example of the continuing challenges posed by technological change. It was welcomed as a much less toxic substitute for PCP (pentachlorophenol), a traditional anti-sapstain chemical. The much higher cost of DDAC has had the additional advantage of stimulating its conservation and reuse, greatly reducing releases to the environment. But concerns are reappearing as scientists begin to take a closer look at the effects of this new chemical. For example, DDAC has not been studied enough to derive sediment-concentration standards.

RALF BÜRGLIN

Around for eons, Sturgeon are found throughout the Fraser, may live 100 years, and may grow to six metres.

Much attention is focused on the toxicity assessment of DDAC on the Lower Fraser, where the chemical is mainly used. The lumber industry is very concerned about further restrictions on the use of a chemical on which it relies heavily. There are many interested parties watching the results of further toxicity testing on DDAC, now the third most-used pesticide in the province.

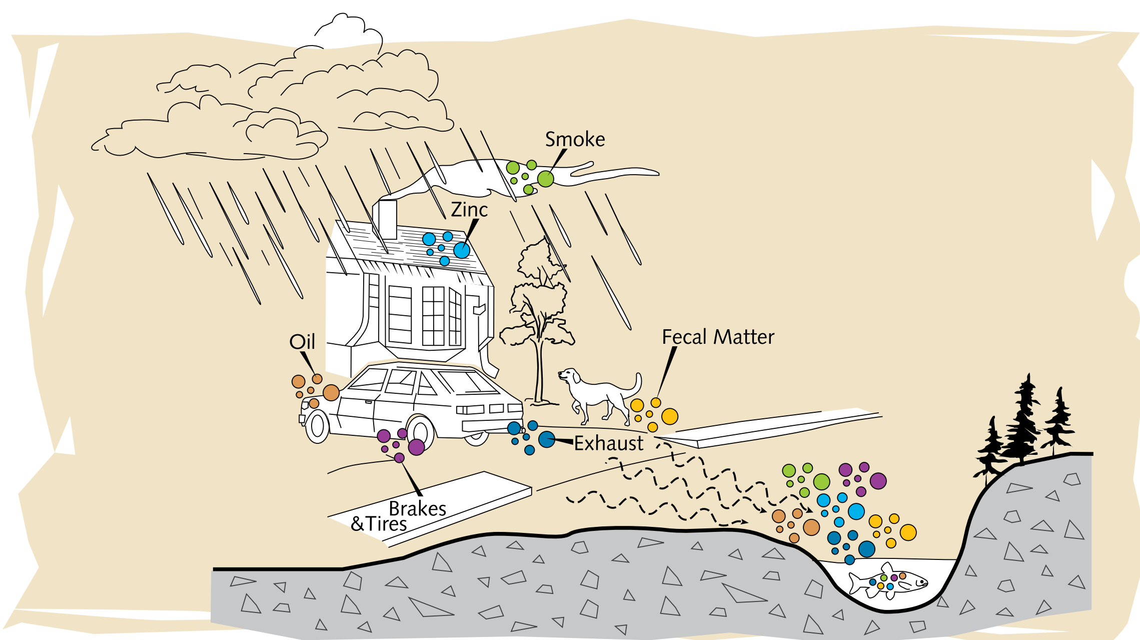
POLLUTION SOURCES

The findings of FRAP scientists suggested that pollution in the Fraser River system comes mainly from urban runoff, agricultural activities, and the forest products industry.

URBAN RUNOFF

The paved surfaces and roofs in cities and towns collect precipitation and direct it into storm sewers, through which it drains into watercourses. On the way, the rain or snow gathers contaminants from gases and dust in the air, from roofs, streets, and gutters, and carries them with it, especially in the first wash of rain after a dry spell.

Lakes and streams in urban areas become degraded by this pollution flowing into them. The contaminants often include coliforms (fecal bacteria), metals, and a wide variety of carbon compounds associated with fossil fuel combustion, in vehicles, furnaces, barbecues, and so on. Elevated concentrations of dioxins, furans, PAHs, and metals are measured in urban watercourses and suspended sediment during rainstorms. PAHs and metals deposited from the air also are washed into urban streams by rain. During storms, copper, zinc and sometimes lead frequently exceed water quality objectives.



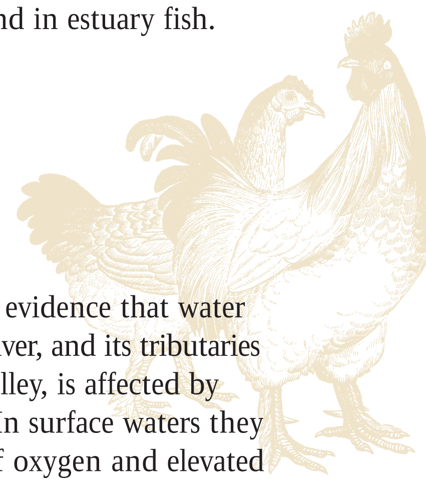
By studying layered sediment in cores taken from Burnaby Lake, in the urban Brunette watershed, FRAP researchers determined that some kinds of contamination are declining. Loadings of PCBs and DDT have decreased from their peaks in the 1950s and 1960s. Both fish and sediment show a decrease in lead levels compared with the 1970s and early 1980s, declines that coincided with the gradual elimination of lead as a fuel additive.

EC AQUATICS SECTION

Lakes and streams in urban areas become degraded by pollution flowing into them

Bottom-dwelling species in the lakes and streams of the Brunette Basin tend to be less sensitive than others to heavy metal contamination, indicating that metal toxicity is eliminating sensitive species and influencing the composition of the underwater communities.

In the Brunette Basin, where city traffic is heavy, much of the pollution comes from vehicles. Though some improvement has occurred, such as with the removal of lead from gasoline, urban stresses continue. In the region as a whole, the human population is projected to grow strongly, and the use of vehicles is projected to increase faster than the population. Even the quality of the Fraser River itself is being affected by the urban development through which it flows: there are elevated levels of PAHs in the water, in estuary sediment, and in estuary fish.



AGRICULTURE

FRAP scientists found evidence that water quality in the Sumas River, and its tributaries in the Lower Fraser Valley, is affected by agricultural practices. In surface waters they measured low levels of oxygen and elevated levels of nitrates, ammonia, phosphorus, and coliforms. In surface waters as well were high levels of zinc and copper, for which hog feed was considered a likely source. Elevated levels of nitrates were also found in groundwater. Frog's eggs would not hatch in some areas of the central Sumas Basin even though habitat there appeared acceptable.

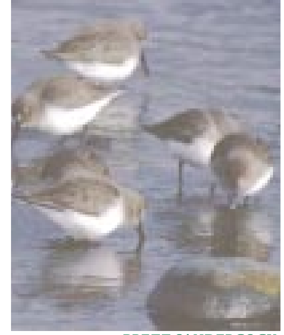
To the south, some toxicity was detected in sediments at the international boundary with the United States, but it was not clear that agricultural practices are to blame. The area is also affected by City of Sumas (Washington) sewage treatment plant discharge, and there are high levels of nickel and chromium in the area from geological sources.

FOREST INDUSTRIES

Dramatic declines in dioxin and furan levels have been measured since the 1980s when the pulp and paper industry, prompted by public concerns and tighter regulations, began to change its bleaching processes. Declines in anti-sapstain chemicals and heavy duty wood preserving chemicals used by the lumber industry have been almost as impressive.

FRAP monitoring has shown that the effect of pulp mill contaminants on ospreys is decreasing. From 1992 to 1997, the difference between higher osprey fledgling success upstream from pulp mills and lower success downstream has narrowed to the point where they can no longer be distinguished.

Effluent quality is much better, but challenges remain.



Dunlin BRETT SANDERCOCK

POLLUTION IN THE FRASER ESTUARY

FRAP researchers examined the ecology of the delta foreshore – Sturgeon and Roberts Banks – to look for indicators of exposure from contaminants, and to establish the current condition of Sturgeon Bank. Until 1988 Vancouver's major sewage outfall (from the Iona Island treatment plant) released its effluent onto the intertidal flats, causing obvious degradation.

Since the Iona Island outlet pipe was extended, moving the outfall location into the Strait beyond the estuary, Sturgeon Bank has been recovering. Life has returned to the former outfall point. Invertebrates are becoming dense again, and algal populations have changed from blue-green or green algae (usually indicative of polluted

DUNLIN

The vast intertidal flats of the Fraser estuary, from Iona Island to Boundary Bay, provide critical habitat for millions of migratory and overwintering shorebirds that feed on marine invertebrates. What, and how well, they eat are vital factors in their survival and success in breeding. But little is known about their feeding habits.

As a migratory bird that spends half of every year on the delta, the dunlin seemed a possible candidate to show the effects of exposure to contaminants on the sand flats. FRAP scientists watched the little bird with the long, thick bill, observing its feeding habits.

The dunlin foraged both day and night, as expected. But researchers were surprised to find that after dark it often left the flats for nearby agricultural fields. Perhaps the prowling falcons kept it away from the fields during the day. Or maybe there was something in the fields it preferred. Researchers don't know.

Furthermore, they found that on the sand flats the dunlin eat prey that is lower on the food chain than they had expected, so its exposure to contaminants could be very low.

The scientists decided they would have to learn more about the dunlin's habits before they could use it to interpret the effects of estuary pollution.

At Iona Island, the sewage outfall has been extended to deep water.

conditions) to silica-walled diatoms, as found in other areas of the banks.

Until 1988, Vancouver's major sewage outfall released its effluent onto the intertidal flats

Sediment concentrations of metals have remained constant or decreased. Tests of the intertidal clam Macoma have shown reduced concentrations of copper, mercury, and zinc.

Sediment tests have confirmed reduced concentrations of copper, lead, silver, mercury, and cadmium. Oxygen concentrations in overlying waters have risen, though nitrate, nitrogen and ammonia levels are still relatively high because of the high concentration of organic carbon still in the sediments.

The contaminated sediments still stimulate an unnatural amount of algal growth on Sturgeon Bank, especially during the summer. But it is hoped the supply of nitrogen will decline to "natural" levels once occasional sewer overflows stop and the organic matter accumulated from 24 years of sewage discharge is finally decomposed.

INDICATORS OF ECOSYSTEM HEALTH

Since a FRAP objective was to measure the ecosystem health of the Fraser Basin, scientists had to select health indicators. Their focus was on the effects of pollution, and their choice was influenced in part by the indicators previously used in the Basin, for which long-term data were available on contaminant exposure. At the same time, the scientists explored new species and sampling methods to address newer pollution issues and to use the latest technologies.

In this enterprise, scientists gained some valuable insights into the merits and the disadvantages of different techniques for assessing ecosystem health. Their findings about the relative merits of, for example, sediments, benthic organisms, fish, and birds as indicators of contaminant levels, and about the value of using certain natural populations as indicators of ecosystem health, will be used to focus future monitoring efforts.

EC AQUATICS SECTION

EC AQUATICS SECTION

WHAT'S NEXT

RESEARCH QUESTIONS

FRAP-sponsored research, while helping settle some matters, has raised further questions about pollution in the Fraser Basin that need future attention. For example:

- With the emergence of urban runoff and non-point sources as the predominant pollution mechanism in the Fraser Basin, what are the new contaminants and pathways of concern?
- What is causing the anomalies in fish liver function and pigmentation?
- How dangerous is the new anti-sapstain fungicide DDAC?
- How extensive are the effects of the agricultural pesticides still in use in the Lower Fraser Valley?
- Will manure management programs restore the Abbotsford aquifer?
- How are changes in sediment transport affecting the coastline around the Fraser?
- How significant is the threat of pollution if glacier and snowpack melting rates increase?
- Can water quality be protected from the effects of new urban growth?
- Are endocrine-disrupting substances harming fish health?

Aquatic science is moving beyond the investigation of conspicuous individual chemicals to consider more subtle effects of low chemical concentrations and chemical combinations in the ecosystem. This more sophisticated research will be made possible by more sensitive detection capabilities and improved knowledge of chemicals, their pathways and effects.

Climate change presents a second challenge. The effects of climate change could be deeply felt in a mountainous watershed like the Fraser Basin: from the possibility of a rise in pollution levels with increased glacier melting, to changes in sandbars and riverbanks as sediment flow alters, to increased urban runoff contaminating streams or increased stress on agricultural watersheds from irrigation, to the effects on the estuary and delta of rising ocean levels. These changes, combined with the pressures of rapid urban growth, intensified agriculture, and industrial change, will keep aquatic scientists busy in the Fraser Basin over the next generation.