The Beluga Whales of the St. Lawrence River

FLIP NICKLIN *Minden Pictures*

by Pierre Béland

Although they are protected by law from hunters, these whales must struggle to survive the threat of industrial pollution

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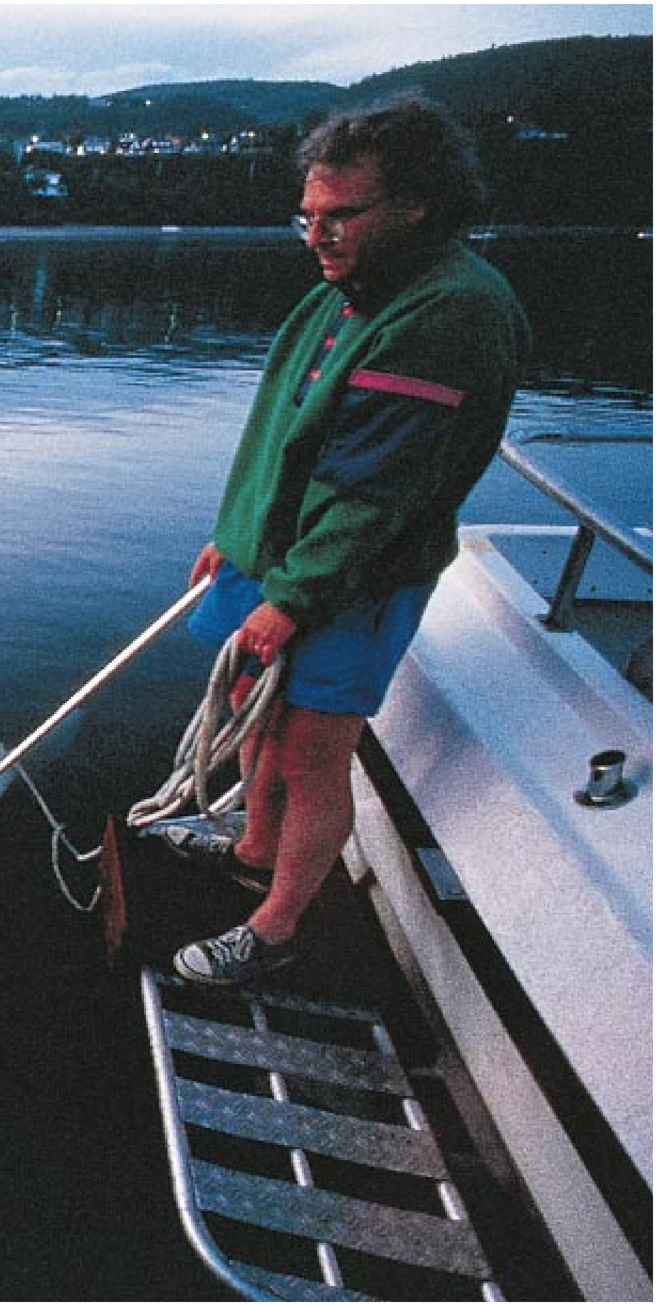
In 1535, on his second voyage to America, the French explorer Jacques Cartier sailed up the St. Lawrence River, guided by two Amerindians. Beyond the mouth of the Saguenay River, adverse winds and tidal currents stalled his progress for a full day. Cartier was forced to moor for the night near a low-lying island in the middle of the river. In the morning, he was startled to see large white porpoises surrounding the ship. The native pilots said they were good to eat and called them *Adothuys*. The animals were beluga whales, an Arctic species that had lived in the St. Lawrence for millennia.

These small, toothed whales first came to the river from the Atlantic Ocean, shortly after the Ice Age ended. When the climate warmed, the Atlantic rose, flooding much of North America's eastern seaboard. The water washed over a huge area of land beyond the Gulf of St. Lawrence, almost as far as the Great Lakes and into New York and Vermont. Many species of seals and whales ventured into this inland sea, called the Champlain. In time, the land reemerged, the basin dried and the St. Lawrence took form.



BELUGA WHALES that die in the St. Lawrence, such as the one the author has roped in the photograph, are most often victims of toxic chemical waste from the area's industries. Fourteen of the whales that Béland's group has autopsied bore cancerous tumors—representing more than half of all malignancies ever reported among whales, dolphins and porpoises.

Belugas and other whales continued to swim up the estuary and the river as far as they could, but they did not roam undisturbed for long. About 8,500 years ago nomadic tribes came to the edge of the river from the southwest and gathered next to shores where the belugas passed in the summer. There the people made seasonal dwellings, remnants of which are now buried under the grass and soil, along with bones from the seals and belugas they hunted.

In the 1600s Basque sailors came ashore near the Saguenay to render right whales and probably beluga whales as well. The sailors were followed in the next century by fur traders and settlers, for whom fishing provided a good income. The representative for the king of France gave concessions for catching belugas to a few hunters, who typically used fixed weir nets. These giant meshings took advantage of the falling tides to trap belugas over the river's extensive mudflats. By 1721 there were 15 such fisheries on both shores of the St. Lawrence.

For some communities, hunting belugas became a way of life, and the whale became a subject of lore. One tale has it that after catching more than 100 belugas in a single day, a village held a party in a barn near the river. Rum, whiskey and wine kept everyone lively, and laughter and music wafted over the beach, where the rising tide had started to lap at the dead whales. Around midnight, one reveler saw fleshless hands trying to seize the dancers. Everyone fled from the barn to find with dismay that the tide had reclaimed their catch. Rising from the moonlit waves, human ghosts appeared, riding the whales. The belugas' eyes shone like hot coals, and their blowholes spit flames as they swam away into the night, leaving glowing trails on the dark water.

No one knows how many belugas were killed before the 1800s. It has been estimated, though, that between 1866 and 1960 some 16,200 belugas, or an average of 172 a year, were landed. This annual yield suggests that the population must have been 5,000 to 10,000 strong near the turn of the 20th century. When catches became sparse and the demand for whale products waned, the St. Lawrence beluga was almost forgotten. By the 1970s, it is now believed, there were only 500 of the whales left.

In 1979 the Canadian government afforded the whales total protection from hunters. Despite that measure, the population has not recovered. There are still only 500 whales in the St. Lawrence today. Why this number fails to increase has been a mystery. Some marine biologists have pointed to low reproductive rates among the small population or to the degradation of their habitat by hydroelectric projects. But over the past dozen years, my colleagues and I have uncovered another reason.

Victims of Pollution

My investigations began in the fall of 1982, when I went with a local veterinarian, Daniel Martineau, to see a dead beluga beached on the St. Lawrence shore. The whale was relatively small but stood out clearly on a bed of dark pebbles in the late afternoon sun. It seemed smooth as plastic and whiter than the froth on the breaking surf. "Let's open it," Martineau suggested. The subsequent laboratory work showed that the whale had probably died from renal

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failure. Tissue samples revealed that it was heavily contaminated with mercury and lead as well as polychlorobiphenyls (PCBs), DDT, Mirex and other pesticides. Two dead belugas found later that same season were similarly poisoned.

In a way, the discovery was nothing new. Many scientists had documented high levels of PCBs and DDT in harbor seals and harbor porpoises elsewhere. These compounds, known as organohalogens, are highly soluble in lipids. Because they are not broken down in an animal's body, they accumulate in fatty tissues. The chemicals travel up the food chain, ultimately reaching the highest levels in top predators. A vast literature described sundry diseases associated with organohalogens—among them liver damage, gastric erosions, lesions of the skin and glands, and hormonal imbalances. But during the early 1980s, most experts believed that organohalogens posed little threat to marine mammals.

LAURIE GRACE

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ST. LAWRENCE SHORES support numerous chemical manufacturers (*photograph*). Some 25 potentially toxic compounds—including PCBs and DDT—have been found in belugas living in the river. Many whales are further laden with Mirex. The pesticide was made throughout the 1970s near Lake Ontario. Mirex contaminated eels that migrated down the St. Lawrence (*map*), where they were taken as food by the belugas. The whales stay near the mouth of the Saguenay in summer (*red*) and spread out in winter (*blue*).

Still, curious as to why the population of St. Lawrence belugas had remained low despite protective measures, we continued our studies. Over the next 15 years or so, we recorded 179 deaths and examined 73 carcasses at the Faculty of Veterinary Medicine of the University of Montreal. Subsequent analyses confirmed that the entire population was highly contaminated with an array of chemicals. The salient pathological observations were stunning. Forty percent of the animals bore tumors, 14 of which were cancerous, representing more than half of all malignancies ever reported in cetaceans. There was also a high incidence of stomach ulcers, including three cases of perforated ulcers, a condition never before documented in whales. Forty-five percent of the females produced only small amounts of milk because of infection, necrosis or tumors in their mammary glands. Lesions of the thyroid and adrenal glands were common. And many animals seemed to suffer from compromised immunity: a disproportionate number had opportunistic bacterial and protozoan infections; others had multisystemic diseases; and several had lost teeth. One whale we examined was a true hermaphrodite.

In comparison, other species of Arctic belugas did not display any of these conditions. Nor did other species of whales or seals living in the St. Lawrence. Both groups did, however, contain the same toxic substances as the belugas, albeit in lesser amounts. The maximum levels of PCBs in Arctic belugas

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EXTENSIVE HUNTING of beluga whales once took place along the St. Lawrence River, as this photograph from 1918 shows. Whaling records indicate that more than 16,000 belugas were landed between 1866 and 1960.

were only some five parts per million (ppm), whereas St. Lawrence belugas had concentrations up to 100 times greater. Most tissue contained more than 50 ppm, which, according to Canadian regulations, made it toxic waste! We also discovered that the toxics were not confined to the fat in the blubber, as had been expected. Small amounts were found in the lipids present in other tissues, where they might have more readily injured vital organs.

Ill Effects of Organohalogens

Despite our findings, many marine biologists maintained that toxics were not at fault. They argued that even though the diseases and lesions we observed in the belugas matched the known effects of toxic chemicals, we had not yet demonstrated a cause-and-effect relationship. To do so, we had to single out a specific compound and the mechanism by which it might lead to disease. We turned our attention to the most striking disorder, cancer. Its incidence in the belugas was twice as high as in humans, higher than in horses and cats and only slightly lower than in dogs. If we restricted our comparison to cancers in the organs most often affected in whales—those of the gastrointestinal tract—the prevalence was more startling. It was exceeded only by that seen in sheep in Australia and New Zealand. There the high disease rate was attributed to treating pastures with carcinogenic herbicides.

We proposed that we had found a parallel situation of sorts. The sediments of the Saguenay contain tons of an extremely potent carcinogen, benzo(a)pyrene (BaP), which collects in invertebrates. For decades, one of the world's largest aluminum-producing complexes released BaP into the Saguenay.

We were able to demonstrate its presence in the belugas, but we were not certain how the BaP had entered their systems. The belugas are, however, unique among toothed whales in that in addition to eating fish, they dig into sediments to feed on bottom-dwelling invertebrates. Thus, it seemed reasonable to suggest that BaP had entered their systems in this way and had caused the higher rates of cancer found among the St. Lawrence belugas, ultimately

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PHOTOGRAPHIC RECORDS have helped researchers Robert Michaud and Natalie Boudreau to identify more than 150 animals living in the St. Lawrence. By monitoring known whales, they hope to learn how often the females give birth and how many of those calves survive. They can also estimate the size of the herds and study their social structure and preferred habitats.

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contributing to their decreased numbers overall.

Industry officials, of course, disagreed with our suggestions, and, to be fair, the cancer data were confounding. A variety of organs—the stomach, intestine, bladder, salivary gland, liver, ovary and mammary gland—were affected. But exposure to a given carcinogen usually harms a specific tissue. So it seemed probable that other toxics might be at work. We looked first to organohalogens, the chemicals that were most abundant in the whales. Although they were not directly carcinogenic, there was evidence that they could disrupt the expression of certain genes. Also, in many animals, organohalogens impeded the activity of killer *T* cells, immune cells that ordinarily destroy malignant tumor cells.

Moreover, when given to experimental animals during embryonic, fetal and early postnatal stages, the chemicals caused defects in the nervous, endocrine and reproductive systems. They further stunted the production of needed immune proteins and immune cells. It was highly likely that organohalogens had such effects on whales, which would explain why the St. Lawrence belugas had been susceptible to various cancers and many other types of disease as well. Some lesions observed among our samples indeed appeared to result from immunodeficiency.

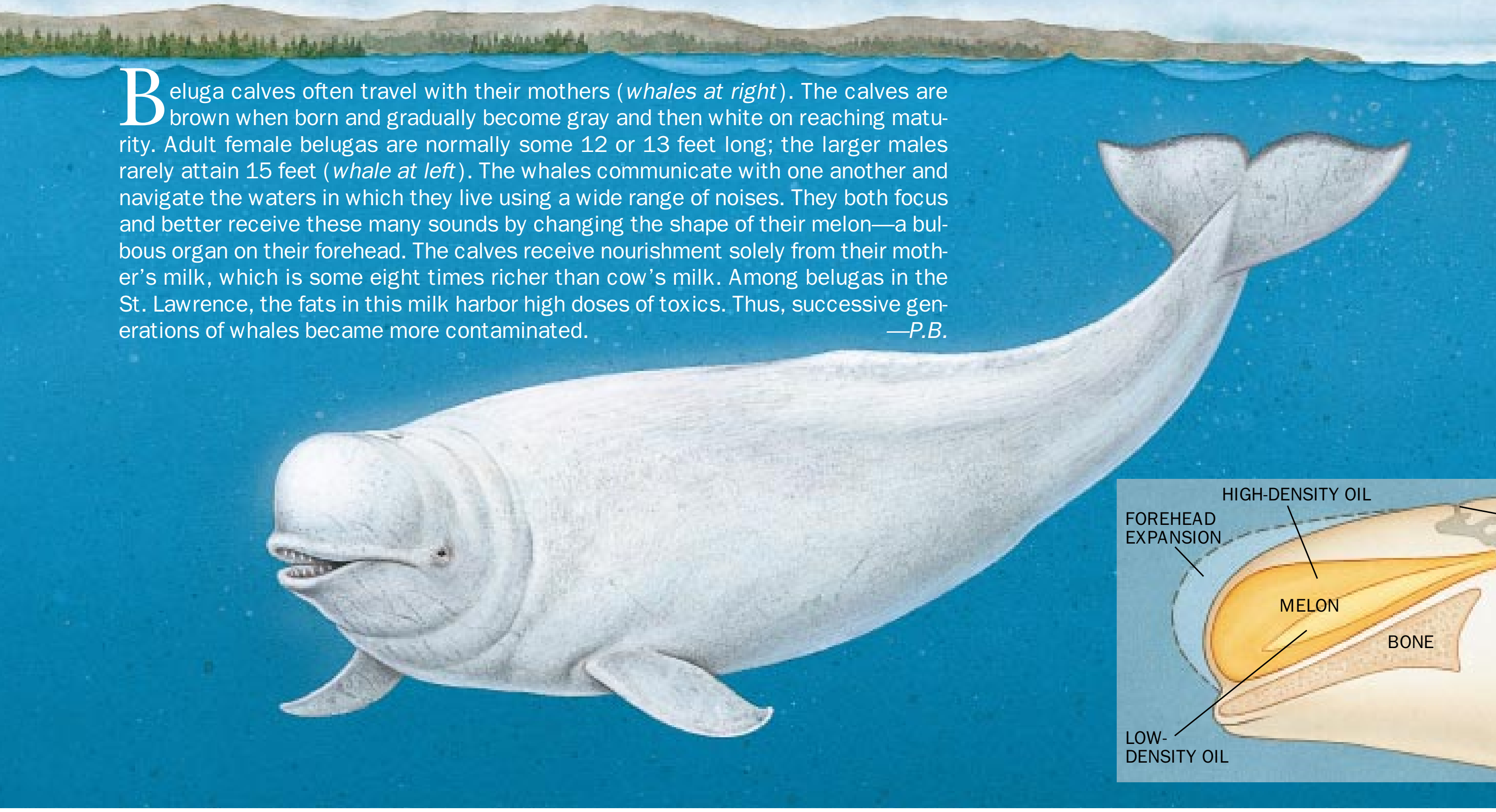
Pathologist Sylvain De Guise, who had already autopsied dozens of the whales we found, joined a team directed by Michel Fournier at the University of Quebec in Montreal. This group was analyzing blood samples from live animals to count the types of immune cells present and to test whether these cells were functional. We decided to use similar methods to examine blood samples from the contaminated whales to look for a relation between the levels of organohalogens in the plasma and the numbers and response of immune cells.

First, we needed to describe the immune cells in a beluga's blood and adapt the tests to them. For this, we used blood samples from Arctic whales held captive at the Shedd Aquarium in Chicago and from wild ones that we momentarily restrained in their natural habitat. Then we adapted our analytical methods to measure minute amounts of toxics in the plasma. In cultures from Arctic beluga, we saw that their immune cells underwent changes when they were exposed to organohalogens in the laboratory. A recent study in the Netherlands also showed that captive seals suffered a suppression in immune function when fed naturally contaminated fish. The chemical levels in these fish were comparable to those in the St. Lawrence fish. We hope to get a definitive answer by sampling a number of live whales in the St. Lawrence in the near future.

We are particularly interested in determining the minimum levels at which the ill effects of organohalogens arise. All the whales and seals in the St. Lawrence system carry organohalogens to various degrees, but not all experience as much trouble as do the beluga. We know that the larger animals typically have lower levels of toxics. For instance, the smallest whale, the harbor porpoise, is the most contaminated, whereas the largest, the blue whale, is the least affected. The reason is that the smaller whale requires more food per pound of its body weight than does the larger whale. Moreover, the harbor porpoise takes

Characteristics of Belugas

Beluga calves often travel with their mothers (*whales at right*). The calves are brown when born and gradually become gray and then white on reaching maturity. Adult female belugas are normally some 12 or 13 feet long; the larger males rarely attain 15 feet (*whale at left*). The whales communicate with one another and navigate the waters in which they live using a wide range of noises. They both focus and better receive these many sounds by changing the shape of their melon—a bulbous organ on their forehead. The calves receive nourishment solely from their mother's milk, which is some eight times richer than cow's milk. Among belugas in the St. Lawrence, the fats in this milk harbor high doses of toxics. Thus, successive generations of whales became more contaminated. *—P.B.*



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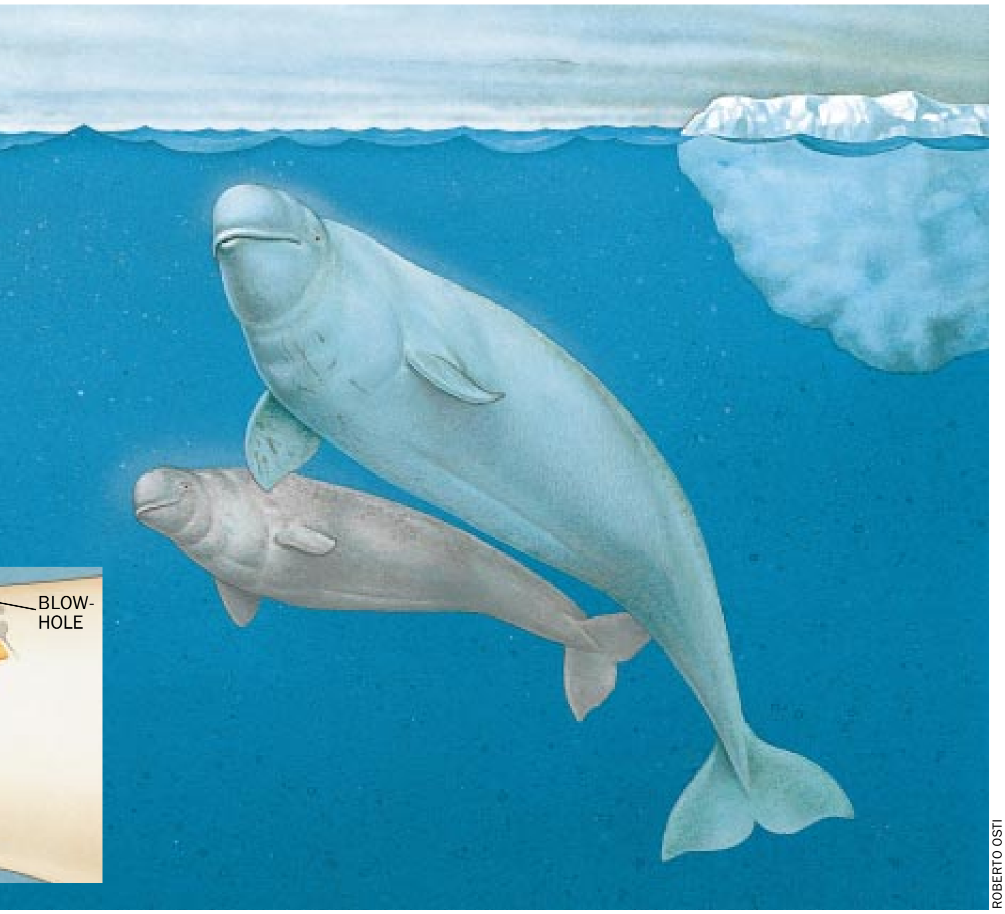
fish from high in the food chain, where organohalogens accrete. The blue whale consumes base-level plankton.

Beluga whales are in fact far more contaminated than their size would indicate, which we originally found quite puzzling. Knowing the typical chemical contents in a pound of blubber, we estimated the total amount of each chemical within the entire population of 500 animals. Allowing for all the food they have taken in over 15 years, our model showed that the concentrations of toxics in local fish were much too low to account for the total burden we saw. So there was very likely another source.

We found that source by researching one particular chemical, called Mirex. We had been surprised earlier in the 1980s to find this insecticide—used against fire ants in the southern U.S.—in whales in eastern Canada. A follow-up study revealed that all the Mirex detected in the belugas was made at a chemical plant in New York State near Lake Ontario. It had seeped into the lake, where eels collected it in their tissues. Every October the adult eels migrated to the Atlantic to reproduce, first swimming down the St. Lawrence through the beluga habitat.

Turning back to our model, we found that if the belugas had fed on eels for only 10 days each year over the course of 15 years, they would have taken in the amounts of Mirex we were measuring in their tissues. The model also indicated that other chemicals in the eels—such as PCBs and DDT—explained half of the total organohalogen concentration seen in the whales. At this juncture, I felt like a naive detective who had been trying to figure out how packages move between cities by searching highway vehicles at random. I got nowhere until I chanced on a mail truck.



By the late 1980s the amount of organohalogens measured in Great Lakes fauna had decreased substantially. But we saw no similar reduction in the belugas. At first we assumed that perhaps improvements in the whales would occur only after some delay. They are, after all, removed from the Great Lakes, both geographically and in terms of the food chain. But eventually, an alternative explanation came to mind, and it does not bode very well for the future.

Up to 40 percent of the body weight of a beluga is blubber, and some 85 percent of that blubber is fat tissue, in which organohalogens concentrate. We noticed that organohalogen levels were often higher in very young animals than in older ones, contradicting the normal assumption that the toxics accumulated over the course of an animal's lifetime. We also found that the females were consistently less contaminated than the males. Taken together, these facts implied that the females passed significant amounts of chemicals on to their calves. We were able to prove the supposition by happening on a few females who had died shortly after giving birth. They were still producing milk, and it was some 35 percent fat. When tested, this fat held on average 10 ppm of PCBs, as well as other toxics.

Toxic Legacy of the St. Lawrence

The amount of toxics in the milk was only about a third of that normally found in the blubber of a female beluga. Still, it was an astounding amount—by human standards, anything containing more than 2 ppm of PCBs is considered unfit for consumption. It also meant that the toxics were transferred rapidly from mother to calf. The calf grows from about 50 kilograms at birth to 150 kilograms in one year by feeding on about four kilograms of milk each day. Assuming that the mother's blubber had 30 ppm of PCBs (and many adult females have more than three times that), that her milk fat had 10 ppm of PCBs and that roughly 70 percent of the PCBs were being passed on, over one year the mother would deliver to her calf about 3.8 grams of PCBs—translating into a concentration of 60 ppm in the blubber of the calf, or twice that found in the mother. All the while, the mother would consume 10 kilograms of fish a day, replenishing her own PCB load.

The milk provided the explanation. The suckling calf ingests food that is far more contaminated than its mother's food. In ecological terms, the calves feed at a higher echelon in the food chain, where the toxics have been further concentrated. Toxics first entered the St. Lawrence system in the 1930s and 1940s. We have a sample of beluga blubber oil from the early 1950s that contains 5 ppm of PCBs. We now know that every new wave of calves started out with a blubber level of toxics above that of their mothers. They then took in

Canaries of the Arctic Seas

Because belugas make an extraordinary range of noises—from whistles and creaks to clicks and warbles—the seafarers who first heard them named them sea canaries.

Although the number of belugas living in the St. Lawrence River has remained below 500 since the 1970s, experts estimate that some 100,000 belugas roam the Arctic seas around Alaska, Canada, Greenland, Scandinavia and Russia. One herd is shown in the bottom photograph at the right.

By tracking individual whales, scientists have learned that the whales often travel great distances, sometimes for several miles under the Arctic ice (*photograph below*). In place of a dorsal fin, belugas sport a long ridge of fibrous tissue on their back (*top photograph at right*). Using this ridge, they can break through several inches of ice to create a breathing hole. —*P.B.*

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fish that also contained progressively higher levels of toxics every year. So each new generation started from a less advantageous position than had the one before it.

This reasoning should apply to all predatory aquatic mammals, depending to some extent on their strategy regarding fat reserves and lactation. Lipids are a valuable substance—especially in cold seas—to be hoarded and passed on to the next generation. But when fats contain nonbiodegradable toxics, this legacy may be as poisonous as bad genes. In theory, the young animals should show more evidence of the acute effects of toxics in the St. Lawrence. But unfortunately, few belugas in their first years have been found.

In fact, we believe not many calves are being produced. The females, and perhaps the males as well, may not be as fertile as expected. The toxics they were exposed to in the womb could have stunted their reproductive development. And the toxics they ingest as adults could be disrupting hormonal cycles essential for reproduction. Some years ago it was shown that captive seals fed naturally contaminated fish did not produce offspring. The seals had low levels of vitamin A and its precursors—elements that are necessary for growth, reproduction and infection resistance.

Obviously, calving and maturing of the young to adulthood are the keys to a population's survival. Robert Michaud and Daniel Lefebvre of the St. Lawrence National Institute of Ecotoxicology spend months on the St. Lawrence every year, observing the lives of belugas. They conduct surveys from the air, estimating the sizes of herds and identifying their preferred habitats. They also work from a small boat, calculating the proportion of young whales. They have used photographs to identify more than 150 animals, several of whom are females with offspring of various ages. It is hoped in the years ahead that they will be resighted, giving us some measure of how often the females give birth and how many of these calves survive. Also, by following known whales, we can study the social structure of the population and, using skin biopsies as well, assess the degree of genetic relatedness in social groups.

We have no definite answers yet, but all the evidence indicates that the St. Lawrence belugas have failed to increase in number because of long-term exposure to a complex mixture of toxic chemicals. We have approached the problem from various angles and intend to pursue each one further. Studying whales anywhere requires a great deal of dedication. On the St. Lawrence, it also takes a strong heart and some degree of aloofness. Because we know many of the belugas individually, sailing among them is somewhat like visiting relatives. We do not find ourselves in foreign waters surrounded by swarms of whales as in the days of Jacques Cartier. They come to greet us in small groups, and we realize how important each one is for the future. We can afford to spend time with them, for there are no new lands to be discovered—only old ones to be understood and preserved, a task for which there is no one to guide us. SA

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