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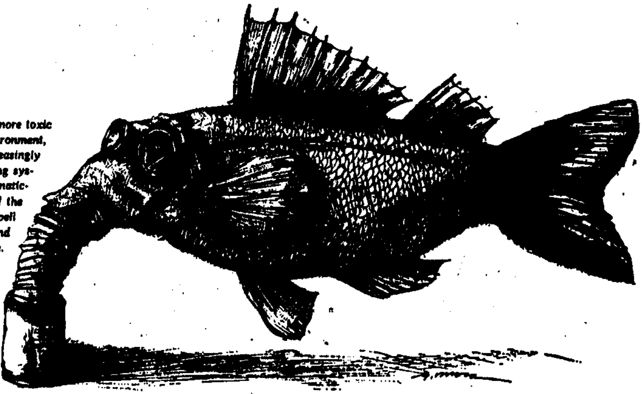
As man pours more and more toxic chemicals into the environment, scientists are turning increasingly to fish as an early-warning system. For fish reveal dramatically the hidden erosion of the environment that can spell slow death for them—and perhaps someday for man. Abigail Trafford Brett is a writer with the American Chemical Society.



Scientists fish for toxic clues

HOW MAN IS CHANGED BY WORLD HE CHANGES

By Abigail Trafford Brett

Mirex, the most effective insecticide against fire ants, initially passed all the standard screening tests and was regarded as nontoxic to marine life. Then, at a government laboratory in Florida, juvenile blue crabs, fed corncob grits contaminated with low levels of mirex, displayed an ominous delayed reaction.

They could no longer use their pinchers to catch prey for food.

The crabs became disoriented and more and more paralyzed. In the sea "jungle" a paralyzed predator quickly becomes prey, and a crab that cannot use its scissors does not survive.

In the controlled water tank of the laboratory the crippled crab becomes scientific testimony to the invisible erosion of the environment.

ACUTE POISONINGS such as a big fish kill are easy to see. It is what you don't see that may have a more devastating impact on the future. The slow, sublethal, almost invisible changes caused by pollutants in the environment produce slow, sublethal, almost invisible changes in living creatures. It is precisely these subtle changes that one government scientist describes as "dying over a long period of time . . . chronic mortality."

Just how fish respond to new factors in the environment is a clue to how man also is being changed by a world he is constantly changing.

In the North Sea eels have cauliflower growths on their lips. Soles and flounders along the U.S. Pacific Coast have large lesions on their skin. White croakers feeding around sewage outfalls along the coast of California develop tumors around the mouth. Thousands of halibut have had to be thrown away because they were listless, underweight, their skin soft to touch.

In Japan the goby fish develop mouth tumors, cunner in Rhode Island have cancerous tooth tumors. Large catfish in the central lakes of Florida grow tumors the size of a finger joint. Oysters are found with leukemia. A dogfish in Maine has a brain tumor. In the tributaries of the Chesapeake Bay a cancer epidemic has broken out among the small, inedible clams that live in the sand flats.

Channel catfish in Arkansas have broken backs. Oysters have trouble growing thick enough shells. Finless fish are seen off both coasts — victims of fin-rot disease. Two species of fish in the Chesapeake [illegible] have increased the overall size of their liver by [illegible]. In fish, as in humans, [illegible] beings, the liver is the organ that handles toxic materials.

"Diseases in fish have been directly linked with chemicals in the environment," said Dr. John C. Harshbarger, pathobiologist with the Smithsonian Institution. "While no one has directly linked a pollutant with cancer in fish, the circumstantial evidence is there."

Since the 1950s marine explorer Capt. Jacques Cousteau has been diving in the waters of the Mediterranean, Red Sea, Indian Ocean, North and South Atlantic, Pacific, Arctic and Antarctic. He estimates that the over-all fish population of the world has decreased at least 30 per cent in the last 20 years.

Since World War II man has been living in a chemical age. New drugs and chemical therapy have successfully treated mental illness and cancer. Insecticides have increased food production and eradicated greatly reduced diseases like malaria, yellow fever and encephalitis. Plastic bags, vinyl seat covers and instant freeze-dried food are household words.

AT THE SAME TIME, according to the National Cancer Institute, an estimated 70 to 90 per cent of all human cancers are associated with environmental factors. Many birth de-

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Fish an early-warning system

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fects and neurological disorders have been linked to chemical causes.

The National Institute for Occupational Safety and Health has put over 12,000 compounds on its toxic-substances list; 1,500 of these chemicals are suspected of causing tumors. Before Congress is a toxic-substance bill to regulate the registration, production and use of new chemicals.

A variety of government agencies such as the Environmental Protection Agency, the Food and Drug Administration, the Fish and Wildlife Service and the National Cancer Institute are trying to determine what th risks really are in the environment and to do something about them.

More and more scientists and government officials are turning to fish as an early-warning system. Midway on the predator-prey food chain, fish serve a dual purpose — first as indicators of what chemicals persist in the environment, second as test animals in the laboratory.

FISH ARE A DICK-AND-JANE textbook of human physiology. Metabolically speaking, they are like mammals in slow motion. But simplicity aside, the basic functions are similar.

"If you have an effect on the liver of a fish, which is a vertebrate, then you might expect to have the same effect on mammals, including human beings," explained research ecologist Del Wayne Nimmo of the EPA's Gulf Breeze Environmental Research Laboratory in Florida.

Scientists know, for example, that DDT attacks the nervous system of fish and shellfish. Stored up in the liver, it can send a lobster under stress into convulsions.

In the laboratory, low levels of the toxic compound polychlorinated biphenyls (PCB) affect the thyroid gland in fish. In higher amounts, PCBs cause the fins of fish to rot off.

Low levels of the insecticides aldrin and dieldrin alter the amino acid metabolism in fish and produce signs of mental retardation.

The critical difference between nature and the laboratory is that, in the environment, no one chemical exists in isolation. In the central lakes of Florida, for example, where the large catfish are found with tumors, more than 80 toxic compounds were analyzed in the water.

WHAT'S MORE, ONLY the strong survive. In the polluted Mississippi River, the largemouth bass have disappeared and the mosquito fish is king.

It turns out that this rugged little fish has built up virtual immunity to toxic chemicals. In laboratory tests, scientists find that the 1½-inch-long mosquito fish is 100 to 1,000 times more resistant to insecticides than the larger — and commercially edible — fish.

In this survival of the fittest what makes the largemouth bass a modern dinosaur? The key to adapting to a new chemical environment may lie in how often an organism reproduces. The little mosquito fish produces young every month. The larger fish produce only once or twice a year.

"The phenomenon of the mosquito fish is a sign that one species is better able to cope with pollution than another," said David J. Hansen, aquatic ecologist with EPA's Florida laboratory. "Resistance may go to those species who can reproduce the most often so the resistance trait is passed on."

is the largemouth bass, America's top game fish, leaping toward oblivion at the same time the rugged little mosquito fish is thriving?

In general, fish are much more vulnerable to disease and biochemical change than human beings. If a chemical is toxic in low levels to fish, it does not automatically mean that it is toxic to man. At the same time, it is a red flag.

The national pesticide-monitoring program of the Fish and Wildlife Service has 100 stations across the country. Whole bodies of fish from the local areas are ground up and analyzed.

Instead of isolated water-quality measurements, fish residues give an average profile of what exists in the environment on a quasi-permanent basis. And since waterways are a major chemical "sink," if there is a pollutant in the environment, fish are likely to get it first.

A REGIONAL MAP of pollution emerges. In industrial areas of the Northeast and Midwest — the Great Lakes region or along the Hudson River — scientists find high levels of the toxic industrial residues of insecticides like DDT, aldrin, dieldrin and toxaphene.

The residue levels of these compounds are then supplied to research laboratories to study the response of living organisms to these persistent chemicals. The Interior Department's Fish-Pesticide Research Laboratory in Columbia, Mo., for example, works with fresh-water fish. The Mt. Desert Island Biological Laboratory in Maine and EPA's Gulf Breeze Laboratory in Florida concentrate on marine species.

A major emphasis is on chronic effects. It is one thing to expose a rat or a monkey to high levels of a chemical and produce a tumor. It is another to relate that phenomenon to the realities of nature.

With fish, the levels that are detected in the environment are used in the experiments. The laboratory becomes a microcosm of what is actually taking place.

About six years ago a strange phenomenon cropped up in the commercial fish farms of Arkansas. Some of the channel catfish had broken backs. They couldn't swim properly. They flopped from side to side. They couldn't maintain their normal position in the water.

Under nature's law of survival, these crippled creatures quickly disappeared. But the mystery of the so-called broken back syndrome remained.

Recently two government scientists at Missouri's Fish-Pesticide Laboratory linked this crippling in fish with one of the most widely used insecticides in the United States — toxaphene.

WHAT'S MORE, the broken back syndrome was only the tip of the iceberg. Foster L. Mayer Jr. and Paul M. Mehrle discovered that the over-all size of the fish was stunted by almost a third. Reproduction was down by 30 per cent. Skeletal deformation was so widespread that 30 per cent showed signs of broken back syndrome.

At first the fish appeared to be normal, but X-rays revealed that dramatic anatomical changes had taken place. It was only a question of time before the bones became so brittle that the spine snapped.

All it took to produce these changes were low levels of the insecticide over a long period of time — levels that correspond to what has been measured in the environment.

Since DDT and aldrin and dieldrin have been banned by the EPA, toxaphene is now the country's leading pesticide. It is used predominantly in the South on cotton.

According to EPA figures, 78 million pounds of toxaphene are produced a year. Since the chemical revolution began after World War II, more than 1 billion pounds have been added to the environment.

In Arkansas many commercial catfish farms are next to the cotton fields.

ANOTHER QUASI-PERMANENT factor in the environment are the industrial PCBs, essential in the electronics industry. Highly resistant to heat, PCBs are used, for example, in hydraulic fluid for high-energy transformers. An efficient plasticizer, PCBs have also been used in household paints, caulking materials and copy paper.

In 1970 Monsanto Co. produced 85 million pounds of the superchemical.

Meanwhile, scientists discovered that high amounts of PCBs caused liver damage in experimental animals and affected reproduction. An outbreak of PCB poisoning from contaminated rice oil occurred in Japan, where roughly 1,000 people suffered from a skin disease and more than a dozen died.

Monsanto alerted its customers to the toxic effects of PCBs and limited the use of the compound to closed-system heat exchangers. The FDA set regulations of 5 parts per million or under for food and animal feed. Production is now down to 40 million pounds a year.

But the damage has been done. Results from the national pesticide monitoring program show that PCBs are still a major pollutant in the environment. High residues exist in fish, particularly in industrial areas.

The environmental problem is that PCBs accumulate in the tissues of fish. While water samples may only show trace amounts of the chemical, fish are a living storehouse of the toxic substance.

What haunts scientists is not just that PCBs are lethal in high amounts. Of far greater significance may be the biochemical changes produced by even very low amounts of PCBs.

At EPA's Florida laboratory scientists determined that roughly 1-100th of the lethal dose seriously affects reproduction of salt-water species. In one experiment sheepshead minnows were exposed to 11 p.p.m. of PCBs for a month. After the fish spawned, the eggs were placed in clean water. Only 20 per cent of the young from these eggs survived.

WHILE NO SUCH DRAMATIC effect took place with fresh-water fish, significant changes occurred. In channel catfish exposed to only 2.4 ppm the thyroid activity increased by 40 to 80 per cent. In salmon the same effect was seen with one-half of a part per million — 1-1,000th of the lethal dose.

The thyroid gland is the key regulator in fish. It is associated directly or indirectly with all physiological functions, such as oxygen consumption and carbohydrate metabolism.

"We are looking at the sublethal, biochemical effects that are not really causing mortality," said Paul Mehrle at the Fish-Pesticide Laboratory in Missouri. "But when the sublethal effects concern a parameter like the thyroid gland which controls the behavior of fish, you are talking about chronic mortality."

Aldrin and dieldrin produce a similar story. In 1972, 12 million pounds were produced in the United States. The two insecticides have been banned because they caused cancerous tumors in experimental animals.

But like DDT, PCBs and toxaphene, aldrin and dieldrin seem to be persistent in the environment and residues still are found in fish. The levels are relatively low, but these low levels are capable of producing significant physiological changes.

At the Fish-Pesticide Laboratory in Missouri scientists showed that dieldrin alters the amino acid metabolism of fresh-water fish.

In rainbow trout, for example, dieldrin produces all the biochemical trademarks for PKU, the metabolic disorder in human beings that leads to mental retardation.

It only took 3-100ths p.p.m. for 300 days to produce this effect. Scientists noticed no visible changes in the fish in terms of over-all size or in general behavior. Nor could they say that a change in amino acid metabolism was not a healthy adaptive response for a fish to a chemical change in its environment.

"The point here is that the residues of dieldrin it took in the fish to affect the amino acids and produce the biochemical signs for PKU were in the same range of the dieldrin residues measured in fish by the national monitoring program," Mehrle said.

THERE ARE FOUR QUESTIONS scientists ask about each chemical tested: (1) Does the compound degrade, leaving no chemical trace, or does some form of it persist, becoming a quasi-permanent factor in the environment? (2) If the compound persists, is it readily absorbed by living organisms, starting at the bottom of the food chain in plants and on up to man? (3) If the chemical is taken in, does it build up inside the organism (4) What are the biochemical consequences?

Scientists quietly are testing chemical after chemical on fish. Only in the last three years has this type of research taken on a major responsibility in the screening of toxic substances. The process is slow.

"If we see an accumulation of a chemical in food or in fish, it's a red flag," said B. Thomas Johnson, microbiologist at the Fish-Pesticide Laboratory in Missouri. "We're not saying a compound should not be used. We are saying it should be more extensively studied before it is released into the environment."

Last year the Missouri laboratory tested 70 chemicals for effects on fish. The majority turned out to be benign, with a few notable exceptions, and it is the exceptions that are significant. The object not only is to determine the consequences of chemicals already in the environment, but to assess the potential damage in new compounds.

— Washington Post

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Pollution takes its toll: large skin lesions . . . tumors . . . broken backs.

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