WHAT'S HAPPENING TO OUR FISH?

A Seattle laboratory is searching for answers

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Chemicals keep us alive, but they can also maim and kill. Some poisons continually threaten the fish in our waters and wetlands.

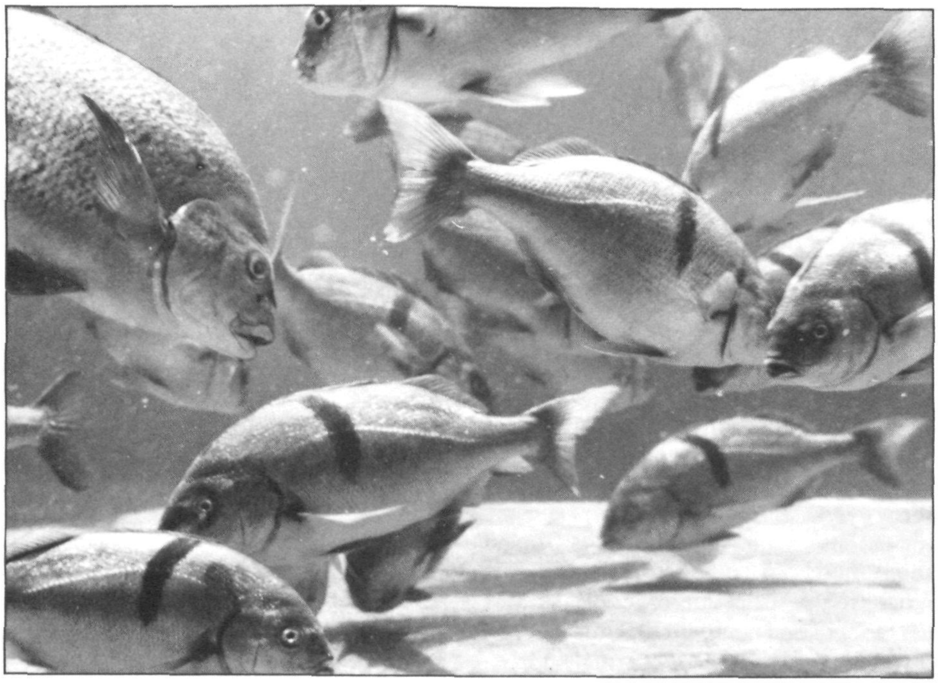
Catastrophic oil or chemical spills traumatically poison the environment. Other persistent low-level substances slowly and silently erode the well-being of humans, animals, and plants.

Pollutant interactions with living beings are complex. About 63,000 chemicals are commonly used today, and any one of them is a potential pollutant. So important are the effects of pollution on fish and fish habitats that the National Marine Fisheries Service, with its many divisions, has mounted a national program to study them. Its Environmental Conservation Division tries to understand how environmental stresses affect marine life—stresses such as petroleum, sewage, and many other organic and inorganic chemicals. We try to find out how much of the various contaminants a particular animal absorbs, what happens to the absorbed chemicals, and what changes they cause in behavior or tissue.

We work in the field and in the laboratory, comparing the functioning of normal and perturbed ecological systems. Our basic question: which pollutants are present in the environment and in what quantities? Our basic problem: many pollutants entering the environment turn into other potentially harmful compounds, all but eluding detection. How to find them?

National Analytical Facility scientists, directed by Dr. William MacLeod, are working to overcome this problem. Using new methods and sophisticated instruments, they have tracked down a wide array of pollutants put by man into the environment.

''Many of these contaminants are present at extremely low levels, down to one part in a billion,'' says MacLeod. ''This may seem innocuous, but marine plants and animals can accumulate certain hazardous chemicals in their tissues to many thousands of times the levels found in the environment. Because of this concentration effect, ex-



Ewing Galloway

tremely low levels of environmental contaminants may pose a serious threat to marine organisms directly and to humans indirectly."

Wouldn't highly mobile marine animals, given a choice, stay clear of harmful pollution? Not necessarily, says Douglas Weber of the Behavior and Developmental Biology Group: "Our studies showed that salmon, flatfish, and crabs often did not move away from water or sediment contaminated with crude oil, even at harmful levels."

In laboratory experiments, Weber's research group studied young Pacific salmon's reaction to water-soluble poisons in crude oil, mainly aromatic hydrocarbons. Given a choice between clean water and oil-contaminated water, the fish chose the clean water only after the hydrocarbon content exceeded the rather high level of 2.5 parts per million.

In other lab experiments, flatfish were released in a clean-sediment area but, to the scientists' surprise, fed just as actively in heavily oiled sediments. From these and other studies, it was concluded that salmon, flatfish, and crabs are potential victims of oil pollution.

Field tests on Pacific salmon migrating upstream to spawn bore out these findings. Controlled low-levels of hydrocarbons were added to the water in a fish ladder on one side of a dam; clean water flowed through a ladder on the other side.

Early in the migration, the fish avoided the contaminated ladder even when the hydrocarbon concentration was low. Later in the run, some salmon used the contaminated ladder despite higher levels of hydrocarbons.

In other field studies, our scientists found some flatfish with abnormalities such as liver tumors and worn fins. Many of these fish had come from waters high in municipal and industrial wastes containing PCB's (polychlorobiphenyls), metals, and petroleum hydrocarbons. Pathology Group scientists under Dr. Bruce McCain sought a causal relationship between poisons and abnormalities.

In laboratory experiments, English sole, which spend much of their lives buried in the sea bottom, were exposed to crude-oil-contaminated sediment for four months. They lost weight; some died. A control group of non-exposed fish lost less weight and looked healthy. The exposed fish also developed greater changes in liver-cell structure than did the controls.

Flatfish exposed to contaminated sediments for long periods indeed suffered harmful changes, including loss of weight and damage to skin and internal organs, the studies showed.

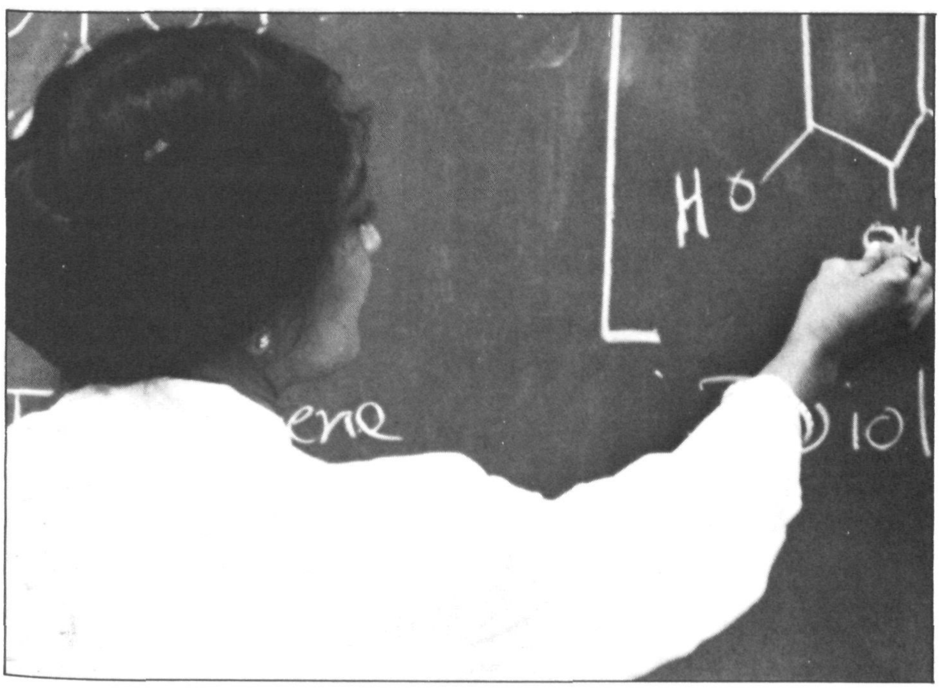
But changes in the behavior of fish and other marine life, as well as development of lesions, are not the only consequences of pollutants. Those easily seen changes are often accompanied by subtle shifts in the inner workings of cells and structural alterations visible only by electron microscopy. Dr. Joyce Hawkes, head of the Electron Microscopy Research Group, uses scanning and transmission electron microscopy to monitor the effects of pollutants on cells. [See "The Small World of Joyce Hawkes," **NOAA**, January 1979.] Structural changes are correlated with other changes, such as alterations in behavior or physiology.

In laboratory experiments, fish were fed food containing crude oil. Dr. Hawkes and her group found that the livers of those fish lost carbohydrates and accumulated abnormally large amounts of fat. Apparently the hydrocarbons had disrupted normal liver functions. Some fish also developed cataracts.

Moving from the cell to the molecule, Dr. Usha Varanasi and the staff of the Biochemical Effects Group are asking how pollutants, particularly petroleum hydrocarbons and metals, interact with molecules in the cells of live animals.

All living cells contain protein and nucleic acids, such as DNA (deoxyribonucleic acid), which carry hereditary characteristics. Enzymes, a type of protein, serve as biochemical catalysts and are essential to cell viability. Chemical interactions change the structures of enzymes and DNA and their functions.

Dr. Varanasi's group found that flatfish can transform petroleum pollutants into new, oxygenated, highly toxic compounds that interact with DNA. Many scientists believe these new compounds cause irreversible cell damage, which sometimes leads to tumors. Such



Dr. Usha Varanasi (left), research chemist at the Northwest and Alaska Fisheries Center, discusses chemical effects of pollution on fish.

changes could disrupt the feeding and reproductive behavior essential to survival in the wild. PCB's, persistent contaminants in the marine system, cause concern about their effects on aquatic organisms. Dr. Edward Gruger of the Biochemical Effects Group studied the effects of low PCB levels on young coho salmon. He found that PCB's eaten in food accumulated in the fish and triggered changes in aromatic hydrocarbons in the liver. The results suggest that hydrocarbons (absorbed from oil spills, for example) are more readily metabolized in fish exposed to PCB's.

Dr. Harold Hodgins and the staff of the Contaminant Effects on Life Processes Group are studying the effects of pollutants on fish resistance to disease. "Changes in the health of fish," Dr. Hodgins comments, "reflect interactions among disease-producing agents, environmental factors, and the mechanisms by which fish resist disease. Any environmental change that unbalances these interactions may lower the fish's ability to resist disease."

In one study, fish were first exposed to pollutants, then to a marine bacterium that had devastated salmon on fish farms in the Pacific Northwest. Differences in the numbers of bacteria needed to kill pollutant-exposed and non-exposed fish were considered a pollutant's resistance-lowering quotient.

Coho salmon, flounder, and rock sole exposed to oil contaminants showed no marked changes in disease resistance. Nevertheless, under environmentally induced stress, food scarcity, for example, exposure to pollutants may heighten susceptibility to infections.

The extraordinary complexity of the marine environment becomes more apparent every day. Pollution caused by humans further complicates the system. Unraveling these puzzles calls for sophisticated ideas, methodical tests, and rigorous analysis.

Contaminants will always enter our environment. New chemicals to satisfy technological and economic demand will add to the environmental load.

NOAA scientists are working to deepen understanding of the behavior of contaminants in the ecosystem. With such information, sound decisions can be made to prevent or ease the effects of contamination on our world.

William D. Gronlund, fisheries biologist, takes sample from Elliott Bay, Seattle (opposite page) and (below, top photo) places young salmon in "decisions chamber" to see if it will enter water containing hydrocarbons. Another biologist, Mark S. Myers (bottom photo), dissects sole to determine effect of pollutants.