RADIOECOLOGY: NEW TOOLS YIELD ANSWERS TO OLD PROBLEMS

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Radioactivity is not new to our planet. It has been here since the earth was formed. Manmade radioactivity, in the form of nuclear fallout, appeared 25 years ago when the first atomic bomb exploded. In the northern hemisphere, about 60 percent of this radioactive material falls into the ocean (about 60 percent of the earth's surface in our hemisphere is covered with water). Additional fallout is leached from the soil and carried by rivers to estuaries and the ocean.

More recently, as man has learned to use atomic energy for peaceful means, radioactivity has become a waste product of nuclear power plants, and nuclear fuel production plants. Although the radioactive wastes from nuclear power plants are very carefully controlled, some radioactivity is released into the rivers that supply the water required by the reactors. For example, the Hanford Atomic Production Plant in Washington State releases radioactivity directly into the Columbia River. Much of this radioactivity is carried to the Pacific Ocean 350 miles downstream.

This radioactivity, whether from fallout or from reactor effluents, eventually enters the marine environment, where it is cycled continuously through sediments, water, plants, and animals. What happens to these materials? Are they accumulated by fish or other animals to a level that might be harmful to the animal or to man?

BCF Beaufort Research

To answer these and other questions, scientists at the BCF National Center for Estuarine and Menhaden Research, Beaufort, North Carolina, directed by Dr. Ted Rice, are studying the movements of these radioactive materials in the estuarine environment. The purpose of their research is twofold: (1) to determine the fate of radioactive elements released into the estuarine environment and the effect of this radioactivity on estuarine plants and animals, and (2) to develop and apply radioisotopic methods to studies of estuarine ecology. The laboratory also evaluates the radio-biological effects of the construction and operation of nuclear reactors on fishery resources. The work is jointly sponsored by BCF and Atomic Energy Commission.

Emphasis is placed on estuarine areas because fishery scientists have found that the bays, sounds, and associated nearshore areas that surround our coasts are among the world's most productive areas. Estuaries provide essential living space for more than 70 kinds of fish and shellfish that contribute 3 billion pounds, or two-thirds, of the total U.S. commercial fishing catch. Seven of the ten species most in demand, including shrimp, our most valuable fishery, and menhaden, our largest fishery, must have suitable estuarine nurseries.

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Radioecology

Dr. Thomas Duke, chief of BCF's Pesticide Field Station, Gulf Breeze, Florida, explains: "The study of radioactivity in our environment and the use of radioisotopes in ecological studies is called 'radioecology'. The term is composed of two words, 'radio' which refers to radioactivity, and 'ecology' which is derived from the Greek 'Oikos', meaning 'house' or 'place to live'." Ecology is usually defined as the study of plants, animals, and other organisms and their relationship to their environment.

Research Results

The scientists have found that some organisms are 'biological indicators' of radioactivity in the environment because of their affinity for certain elements. For example, oysters accumulate zinc 65; scallops, manganese 54; clams and mussels, cerium 144; and tuna, iron 55. The oyster concentrates zinc to about 100,000 times its normal concentration in sea water. Because of the oyster's ability to concentrate radioactive elements, scientists were able to detect increased levels of radioactivity in oysters within 8-12 days after the Chinese nuclear tests!

Radioactive elements act essentially the same as their nonradioactive counterparts when released into the marine environment. Therefore, if radioisotopes are present in the environment, the organisms will be unable to distinguish them from nonradioactive forms, and the radioisotopes will be accumulated also.

Whither Radioactive Elements?

The fate of radioactive elements in the estuarine environment depends upon the route they take. Radioactive elements can remain in solution or settle to the bottom. Laboratory studies have shown that organisms accumulate radioactivity in different way: plants accumulate radioactivity directly from water; clams and oysters by feeding on suspended material that contains radioactivity; large fish, such as tuna, by feeding on other animals that are radioactive. Thus, radioactive elements are detectable in marine organisms, even though their concentrations in sea water are generally too low to measure.

Effects On Organisms

How do these radioactive accumulations affect these organisms? To determine the effects of radioactivity on the body chemistry and shapes of plants and animals, BCF scientists began carefully controlled experiments. They found that radiation interacts with salinity and temperature to affect survival, growth, and body shape of estuarine organisms. In one experiment, brine shrimp exposed to low-level radiation grew faster, were more uniform in size, and reached sexual maturity more quickly than those not exposed to radiation. In another study, young fish exposed to low-level radiation were longer and deeper bodied than those exposed to more radiation or to no radiation. Low levels of radiation actually made these animals healthier and bigger!

Further studies showed that many estuarine organisms, such as clams and oysters, could tolerate extremely high doses of radiation. The fatal radiation dose for oysters was approximately 300 times the fatal dose for white mice. The fatal dose for clams was 220 times that for white mice. Mammals (including man) are much more sensitive to radiation than most estuarine organisms. Therefore, it is generally assumed that so long as environmental radioactivity is safe for man, other animals will not be endangered.

Other Uses for Radioisotopes

In the course of their work, the scientists found other uses for radioisotopes. These isotopes (tracers) have been particularly valuable in studying the food and feeding habits of clams and oysters. Says Dr. Duke: "Before radioisotopes became available, it was difficult and time consuming to compare the suitability of different kinds of phytoplankton (minute plants that float in water) as food for oysters and clams. Some of the plants consumed by these animals are used for nutrition. Others are quickly discarded without being used. To test the nutritive value of different types of phytoplankton, these plants are labeled with radioactive elements and then fed to oysters and clams. After several hours the animals are dissected. The muscles that control the opening and closing of the shell are removed and analyzed for radioactivity. If radioactivity from the labelled plants appears in the muscle, then the phytoplankton was presumably used for nutrition by the animal."

Many of the experiments were done on animals held in the laboratory. Dr. Duke adds: "To better understand how radioactive materials move through the aquatic ecosystem, experiments ideally should be conducted in the natural environment, such as a sound or bay. For obvious reasons, however, the natural environment cannot be made radioactive for such studies."

To avoid contaminating the environment, experiments are conducted in a 40 by 60 foot salt-water pond in which a marine habitat is simulated. Several kinds of fish, crabs, and marsh grasses, along with oysters, clams, and snails, are placed in the pond. By introducing certain radiosotopes and using sensitive instruments, scientists can follow these materials as they are carried throughout the pond.

In one experiment, DDT, labeled with radioactive carbon, was traced through several steps in the food chain. Such studies enable scientists to explain how DDT moves in the aquatic environment and how organisms acquire DDT concentrations.

The scientists discover new research possibilities in the field of ecology as new radioactive materials become available. Instruments that measure radioactivity are highly sensitive. The application of radioactive tracers to problems beyond the range of standard methods has been possible.

BCF scientists are aware that radioecological studies will become more important as radioactivity in our environment increases.