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Sublethal Toxic Effects of Water Pollution on Red Abalone

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Summary

Though difficult to quantify, chemicals in agricultural and urban runoff are contributing to population declines of commercially valuable marine species. Although these pollutants may not be immediately lethal to marine organisms, they can impair key biological processes, hindering reproduction and causing early death.

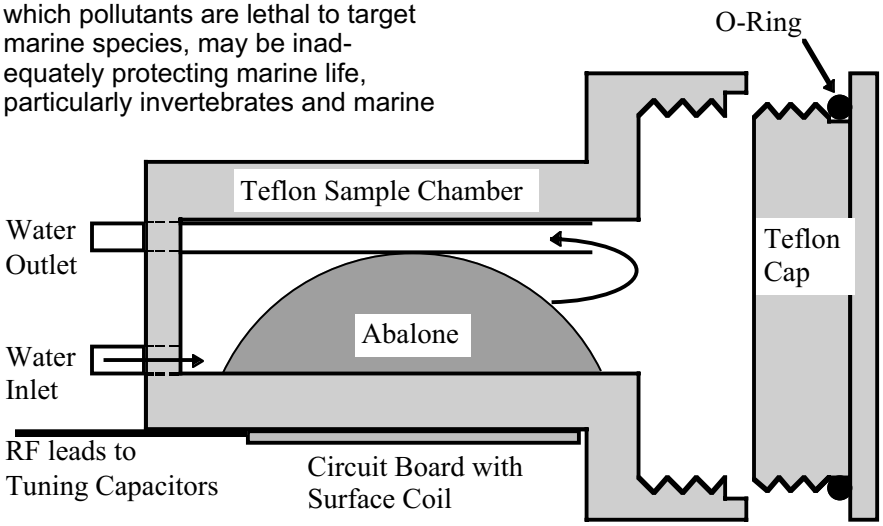
Using technologies developed for the medical profession, Dr. Ron Tjeerdema of the University of California at Davis has been able to show that low levels of chemical pollutants impair red abalones' metabolic processes. Although not immediately lethal, a significant loss of muscle function can eventually be fatal.

His findings suggest that current water-testing methods, because they focus on identifying the point at which pollutants are lethal to target marine species, may be inadequately protecting marine life, particularly invertebrates and marine larvae. His findings support a growing interest in developing techniques that make it possible to evaluate nonlethal effects of runoff along the coast.

Abalones were once one of California's most lucrative fisheries before overfishing and disease forced the California Department of Fish and Game to place a moratorium on all commercial abalone diving.

Goals

The overall goal of this project was to show the feasibility of measuring the chronic effects of low-levels of chemical pollution on marine life. For this project, Dr. Tjeerdema demonstrated that it is possible to use nuclear magnetic resonance (NMR) spectroscopy (a technique commonly used to visualize sports injuries) to characterize the cellular response of red abalone to high concentrations of wood preservative and copper. He then tracked the cellular damage caused by lower concentrations of these same toxins.



Most instruments for measuring the nonlethal effects of water pollution have been designed for air-breathing subjects. The diagram above shows how Dr. Ron Tjeerdema modified a nuclear magnetic resonance probe to image the effects of copper pollution on abalone. Illustration: Ron Tjeerdema.


Dr. Ron Tjeerdema.
Photo: UC Davis.

The magnetic imaging showed that nonlethal exposure to toxins reduced adenosine triphosphate (ATP) production in the abalone's foot muscle. ATP, a molecule found in all living organisms, is the primary source of usable energy for cells. As ATP production declines, muscle function is lost.

Dr. Tjeerdema then tested the possibility of using the common owl limpet as a biological indicator of chemical pollution. Unlike abalone, owl limpets are still abundant in the subtidal rocky habitat in both Northern and Southern California. He was able to calibrate decreasing rates of ATP production in limpets with increasing levels of chemical contamination.

Implications

This project represents an important step toward documenting the effects of chronic pollution on marine organisms. The project's findings can be used "to establish scientifically sound criteria for

stricter, more protective, water-quality standards," Dr. Tjeerdema said. The California Department of Fish and Game, the State Water Resources Control Board and the Department of Health Services have expressed interest in using the NMR technique to characterize the nonlethal effects of toxins on aquatic animals.

Some of Dr. Tjeerdema's other research projects have resulted in new regulations on pesticide runoff from agriculture.

Cooperating Organizations

The California Department of Fish and Game

Publications

Martello, L.B., and R.S. Tjeerdema. 2001. Combined effects of pentachlorophenol and salinity stress on chemiluminescence activity in two species of abalone. *Aquat. Toxicol.* 51:351–362.

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Graduate Trainees and Theses

Martello, Linda, Ph.D. in Biology, University of California, Santa Cruz, Sept. 1999. "The Combined Effects of Chemical and Natural Stressors on Phosphagens and Nonspecific Immunity in Two Species of Abalone."

TenBrook, Patti, Ph.D. in Agricultural and Environmental Chemistry, University of California, Davis, anticipated 2004.

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