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From: United States Geological Survey

Endocrine Disruptors in Fish Focus Of New USGS Studies
Results of two studies that document a potential link between endocrine disruption in fish and the occurrence of certain contaminants in water, sediments, and fish tissue were released this week by the U.S. Geological Survey.

The long-term effects of these apparent endocrine disruptions in fish, however, are not known. More detailed follow-up studies are needed to determine whether fish populations are being affected.

USGS scientists presented findings from the multi-agency studies this week (Nov. 19, 1996) at the annual meeting of the Society of Environmental Toxicology and Chemistry in Washington, D.C. The studies are part of a broad-based effort led by the USGS to investigate the effectiveness of new methods for monitoring endocrine disruption in fish in freshwater environments.

The methods, developed by researchers at the University of Florida, were used to gather evidence on how widespread endocrine disruption in fish may be in the United States and to evaluate potential relationships between endocrine disruption and levels of contaminants.

Both studies focused on carp, a common and widely distributed fish species.

Carp are bottom-dwelling fish whose feeding habits expose them to contaminants found in the water, sediments and food. The studies were based on data on contaminants and other water-quality characteristics that were collected as part of the USGS National Water Quality Assessment Program.

One study, a national reconnaissance of sex steroid hormones in fish, investigated evidence of endocrine disruption at 25 sites that represented a wide range of environmental conditions in selected watersheds across the country. The national study represents the largest data set to date looking at endocrine disruption in fish, particularly carp. The other study looked specifically at contaminants and potential endocrine disruption effects on fish in the Las Vegas Bay of Lake Mead, Nev., a popular public recreation area managed by the National Park Service.

The national study showed significant differences in sex steroid hormones from many streams within major regions of the country. The study also identified significant differences in vitellogenin, an estrogen-controlled protein necessary for egg development in fish and birds, among the 25 sampling sites. Although some of these differences probably result from natural variability, correlations between contaminants and the levels of hormones and vitellogenin in carp indicate that some of the site-to-site differences were associated with certain environmental contaminant groups.

The second study examined the occurrence of organic chemicals -- pesticides and other compounds -- in water, bottom sediments and carp in Las Vegas Wash and two nearby bays -- Las Vegas and Callville -- in Lake Mead. Pesticide concentrations were found to be higher in Las Vegas Wash and Las Vegas Bay than in Callville Bay, the study's reference site. Similarly, several industrial chemicals were detected in higher

concentrations in bottom-sediment samples from Las Vegas Bay than in samples from Callville Bay. Many of the detected compounds have been linked in other studies to the disruption of endocrine systems, which control reproductive functions in the fish.

The most notable evidence of endocrine disruption that was determined by the USGS study is the presence of female egg protein in blood-plasma samples of male carp from Las Vegas Wash and Bay and elevated concentrations in female carp from Las Vegas Bay.

USGS officials cautioned that while the findings are an important guidepost, they cannot begin to answer questions about human health, pointing the way to a need for more detailed study. "Endocrine disruptors have become a popular concern," said Dr. Dennis Fenn, USGS chief biologist, "and these findings suggest the potential for a significant problem. We are committed to continuing our biologic and hydrologic role in directing, conducting, and coordinating studies to help managers of America's landscape better understand and manage our common heritage."

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(Note to Editors: Review copies of both studies will be provided on request to news organizations by calling the USGS Outreach/Public Affairs Office at 703-648-4460. The Lake Mead study is now available; the national study is in press and is expected by year's end.)

Technology News - September 1, 2004

U.K. to tackle endocrine disruptors in wastewater

England and Wales are likely to become the first places in the world to actively remove endocrine-disrupting chemicals from their sewage. The Environment Agency of England and Wales has proposed a £40 million demonstration project to assess how estrogenic substances can be prevented from entering sewage effluent or can be removed from effluent. The effort follows a report released in July that finds that sexual disruption in fish is widespread throughout rivers in England and Wales (Environ. Sci. Technol. 2003, 37, 331A–336A).

“We know fish are affected, and the source is sewage effluent,” says Geoff Brighty, the science manager of the Environment Agency’s ecosystems section. “We now have enough data to act as a policy trigger for taking action. But what we need to do to sewage treatment to remove these chemicals is not well understood and potentially very costly. We now need water companies to evaluate the potential for sewage treatment to remove these substances.” The most significant substances were the natural steroid hormones 17-estradiol and estrone and the synthetic hormone ethinylestradiol, which are excreted from women either naturally or as a result of taking medicines such as the contraceptive pill or hormone-replacement therapy.

The agency is working with water companies and advocating the construction at two sites of full-scale demonstration projects that will use enhanced granular-activated-carbon treatment. The proposal also calls for 17 smaller projects in which existing treatment options will be monitored. “This would be ground-breaking and could result in a step change in sewage effluent treatment,” says Brighty. “Treatment would be applied to achieve environmental benefits, not to meet specific standards or regulations. Applying drinking-water treatment technology to effluents put back into rivers for environmental purposes has never been done before.”

Zoologist Louis Guillette of the University of Florida agrees that enough data now exist to warrant action of some kind. “[The report] now shows categorically for the first time that the [endocrine-disruption] phenomena is widespread, not just isolated to a few rivers or species or sewage treatment facilities,” he adds. “It is the definitive work in this field.” However, he is optimistic that the endocrine disruptors can be treated. “It should take a couple of years for demonstration projects to tell us what we need to know. But fish could start feeling the benefits of any removal technology after three or four years,” he says.

However, Thomas Ternes at the Bundesanstalt für Gewässerkunde in Koblenz, Germany, points out that although the activated-carbon technology removes endocrine disrupters very efficiently, it is an extremely expensive option for wastewater treatment because the carbon needs to be replaced regularly. He favors ozonation techniques instead, which involve adding ozone gas to water. “We found in two pilot ozone trials that this technique removed 99% of estrogens,” he reports.

The independent water-industry regulator in the United Kingdom will decide in September whether to include the removal program in the industry's plan of work for 2005–2010. Funding would come from water companies' customers through higher bills. Full costs for installation and operation of the additional treatment over a five-year period are on the order of £20 million per plant. But Brighty says that only a "few tens of plants" would need this highly effective, top-of-the-range approach; other plants that emit lower estrogen levels could use cheaper techniques. The program would also study the most appropriate regulatory approach: a biological test based on fish response, or a chemical limit based on minimum concentrations.

"We have set a threshold exposure limit for steroid estrogens, which we use in risk assessment, but because of estrogenic substances' interactions, a bioassay may be the best regulatory approach for discharges," says Brighty. The thresholds are 0.1 nanograms per liter (ng/L) for ethinylestradiol, 1 ng/L for 17-estradiol, and 3 ng/L for estrone. A total threshold value based on 17-estradiol has also been set, because endocrine-disrupting effects are additive. No other country has set standards for steroid estrogens in sewage effluent.

Some sections of the water industry remain to be convinced that endocrine disrupters are a priority and have voiced concerns about how their removal could be managed and funded. However, a spokesperson for the industry association Water UK took a more cautious approach: "We are taking the issue very seriously and are committed to investigating implications for wastewater treatment."

The move to treat wastewater arises from research by the agency and Exeter and Brunel Universities, which surveyed more than 1500 roach fish at 50 river sites and found that over one-third of male fish exhibited female characteristics and were less able to reproduce (Environ. Sci. Technol. 2002, 36, 270A). The number of fish affected and the severity of the effects were related to the amount of sewage effluent in the river. They observed these effects in a range of coarse fish—freshwater fish caught only for sport—and noticed that young fish were particularly vulnerable to duct disruption. Some effects, such as eggs in male testes, worsened with age and exposure. The team has used these data to develop a risk-assessment model to predict estrogenic impacts on roach for any effluent discharge. This means the agency could identify high-risk sites and target cleanup efforts.

"This is the only complete data set of its kind in the world, with a long history and significant findings," says Taisen Iguchi from Japan's National Institute of Basic Biology. "The whole world is following closely this research." —MARIA BURKE

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Endocrine Disruption in Fish (Hardcover)
by David E. Kime (Author)

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Editorial Reviews

Book Description
There is increasing concern in the media, among politicians and within environmental organizations, about the effects of chemicals in our environment that affect the endocrine systems of wildlife and humans. At its simplest these are referred to as `gender-bending' chemicals or `environmental estrogens'. The chemicals in question (pesticides, PCBs, plasticizers, petrochemicals, and a variety of industrial chemicals) have been known to decrease human sperm counts, cause fish to `change sex', and increase male genital abnormalities.

A great deal of pressure has been placed on environmental protection agencies to devise regulatory tests for the effects of these chemicals and to require limitations on their manufacture and release. Fish are increasingly recognized as an excellent model for such tests, in that the aquatic environment may provide early warnings of the effects that these chemicals will have on human health. In addition, the large number of eggs which fish produce provides an excellent model to examine the effects on female fertility. Endocrine Disruption in Fish provides a simple yet extensive background to the field of fish endocrinology in order to assist those toxicologists who have a limited background in either mammalian or fish endocrinology. It shows that environmental estrogens do not simply affect male reproductive potential, but that they may equally well affect the female. It is possible that these chemicals may have a complex effect on the brain, hypothalamus, pituitary, gonad and liver of both sexes.
There are many other chemicals which affect both the gonads and other parts of the endocrine system to cause decreased fertility, abnormal sexual differentiation and behavior, decreased response to stress, immune deficiency or altered basal metabolism. Many thousand man-made chemicals are released into the

environment, but very few have been tested for endocrine disrupting activity. This book covers only the minute fraction for which evidence has been collected.

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