

Summary of U.S. Geological Survey (USGS) Information Related to the Intersex Characteristics of Fish in the Potomac Watershed

Summary

- In recent years, there have been a number of fish-health problems within the Chesapeake Bay and its watershed that are associated with changing water quality and habitat conditions. One of the major findings is the presence of intersex characteristics in smallmouth and largemouth bass in the Potomac River.
- The term “intersex”, or intersex characteristics, describes a range of abnormalities in which both male and female characteristics are present within the same fish. The occurrence of intersex fish has been related to chemicals, often termed endocrine disruptors, which affect the reproductive system.
- As the science bureau for DOI, the USGS provides science to help understand the environment including the factors affecting the habitat and health of fish. The USGS has worked with USFWS and the states of WVA, VA, and MD to better define the extent of the problem.
- The preliminary findings suggest that intersex characteristics in fish are widespread throughout the Potomac and Shenandoah Rivers, but are at a much lower incidence in other rivers sampled in West Virginia.
- Potential causes of intersex characteristics in fish include chemical contamination and changes in the temperature regime or habitat. The chemical contaminants include previously banned compounds, such as DDT and chlordane, natural and anthropogenic hormones, herbicides, fungicides, industrial chemicals, and an emerging group of compounds including personal care products and pharmaceuticals that may act as endocrine disruptors in fish as well as other organisms.
- A limited amount of information is available on the distribution of endocrine disruptors in the Chesapeake Bay and its major river basins.
- There is a need to further document the extent and causes of intersex within the Chesapeake Bay watershed. Identifying the compounds that are impacting the fish, and their sources, fate, and transport will help managers develop solutions for the problem.
- A Congressional Hearing was held on October 4, 2006 to better understand causes and solutions to the issue.

What is the problem?

In recent years, there have been a number of fish-health problems within the Chesapeake Bay and its watershed that are associated with changing water quality and habitat conditions. One of the major findings is the presence of intersex characteristics in smallmouth and largemouth bass in the Potomac River.

The term “intersex”, or intersex characteristics, describes a range of abnormalities in which both male and female characteristics are present within the same fish. Intersex characteristics are most commonly described as the presence of female germ cells, which are the precursor to mature eggs, within a male reproductive organ and/or malformed reproductive ducts.

The occurrence of intersex fish has been related to chemicals, often termed endocrine disruptors, which affect the reproductive system. Endocrine disruptors are chemicals that interfere with the natural balance of hormones that regulate development, reproduction, metabolism, behavior, and internal state of living organisms. Occasionally these abnormalities can be noted externally but most often the main reproductive organs must be examined under a microscope for diagnosis of intersex characteristics. The presence of this abnormality has been used as an indicator of exposure to estrogenic compounds and has been documented in a variety of wild fish species in a number of rivers and estuaries around the Nation (e.g. Florida, Colorado, California), as well as other countries, including United Kingdom, France, and China.

What is the role of the USGS and who are our partners?

The USGS, as the science bureau for Department of the Interior (DOI) provides science to help understand the environment including the factors affecting the habitat and health of fish. The information is used by U.S. Fish and Wildlife Service (USFWS) and other partners so they can better manage and restore fish, wildlife, and their habitats and protect human health.

The fish-health investigations in the Potomac that led to the discovery of intersex characteristics in fish are part of the USGS Chesapeake Bay studies <http://chesapeake.usgs.gov/>. The USGS has a role to provide integrated science for effective ecosystem conservation and restoration in the Chesapeake Bay watershed. The USGS Chesapeake Bay studies depend on collaboration between multiple USGS Programs, and partners in the Chesapeake Bay Program <http://www.chesapeakebay.net/index.cfm>, to address the complex relation of landuse, water quality, and habitats to support fish and bird populations. Some of the USGS Programs collaborating on the occurrence and causes of intersex characteristics in fish include: Fisheries <http://biology.usgs.gov/farp/index.htm>, Toxics Substances Hydrology <http://toxics.usgs.gov/>, Priority Ecosystems Science <http://access.usgs.gov/index.html> and Contaminants Biology <http://biology.usgs.gov/contam/index.htm>. Some of the primary partners include the USFWS, VA Departments of Game and Inland Fisheries (VAGIF) and Environmental Quality (VADEQ), Maryland Department of Natural Resources (MD DNR), and WV Division of Natural Resources (WVDNR).

What has been found so far?

In 2003 and 2004, in response to fish kills and increased observations of external lesions on smallmouth bass and other species, WV DNR and USGS initiated fish-health assessments at selected sites in the South Branch of the Potomac River. Samples were collected, and pieces of all tissues, including reproductive organs, were removed for evaluation. During this time period, 16 out of 24 sampling events showed more than 25 percent of the male bass possessing intersex characteristics. Sampling also indicated seasonal differences in the ratio of male bass possessing intersex characters. Fish sampled in the spring months had a 25-40 percent higher occurrence of intersex characteristics than those sampled during the summer months.

In 2005, through collaboration among USGS, the USFWS, VA GIF, VADEQ, MD DNR, and WVDNR, sampling was expanded to additional sites in the Shenandoah and Potomac watersheds for determination of the extent of the intersex problem. During the late summer/early fall of 2005, samples were collected at sites farther downstream in the Potomac, specifically to look at areas associated with intersex characteristics (see figure 1). These included sites at wastewater treatment outflows; major fish kill sites; and other drainage sites for use as possible background sites. The preliminary findings suggest that intersex characteristics in fish are widespread throughout the Potomac and Shenandoah Rivers, but are at a much lower incidence in other rivers sampled in West Virginia.

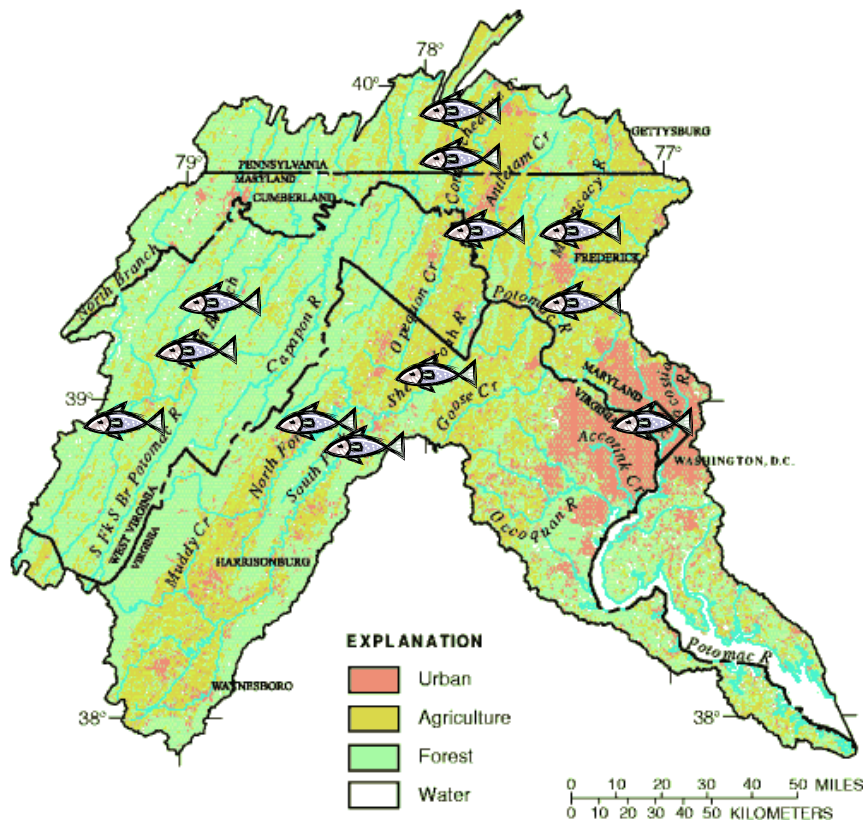


Fig 1: Map of the Potomac River Basin.

Samples sites of fish to study intersex characteristics were collected from the South Branch of the Potomac, North and South Forks of the Shenandoah River, Conococheague Creek, Monocacy River, and one site near the Washington D.C.

What are some of the potential causes of intersex characteristics?

Potential causes of intersex characteristics in fish include chemical contamination and changes in the temperature regime or habitat. Lack of dissolved oxygen due to an overabundance of nutrients, and excess sedimentation, have also degraded water-quality conditions for fish. Additionally, the altered physical conditions of stream channels and riparian zones have caused changes in hydrology, water temperature, and a decreased ability of stream corridors to absorb nutrients, sediment, and contaminants.

Current research on the intersex characteristics of fish has related numerous chemical reproductive effects in fish. These compounds, often termed endocrine disruptors, include previously banned compounds, such as DDT and chlordane, natural and anthropogenic hormones, herbicides, fungicides, industrial chemicals, and an emerging group of compounds including personal care products and pharmaceuticals that may act as endocrine disruptors in fish as well as other organisms. Potential sources of these endocrine disruptors include agricultural, as well as individual use of herbicides and pesticides, animal wastes that may reach the aquatic environment through runoff, human waste (discharges from wastewater treatment facilities), leachates from landfills, and even atmospheric deposition.

Laboratory studies have indicated that the chronic effects of exposure to low levels of these chemicals can result in negative reproductive effects on zebrafish and fathead minnows. In addition, laboratory studies of fathead minnows, medaka, rainbow trout, common carp and zebrafish have shown other negative effects on reproductive activity by endocrine disruptors. Some results indicate that exposure to environmental contaminants may be affecting both growth and reproductive physiology of individual white sturgeon in the Columbia River. However, we have not been able to conclude from field studies, like the Potomac River study, that endocrine disrupting chemicals have impacts on wild fish populations. In addition, the interactive effects of multiple endocrine disruptors on aquatic organisms are unknown.

What do we know about the distribution of endocrine disruptors?

A limited amount of information is available on the distribution of endocrine disruptors in the Chesapeake Bay and its major river basins. During 1992-1996, the USGS conducted extensive sampling of the Potomac and the Susquehanna River Basins through the National Water Quality Assessment (NAWQA) Program. Chlordane, DDT, and PCBs were detected in streambed sediment and aquatic tissues in the Potomac Basin. Sediment from over one half of the sites contained concentrations of these compounds that posed an intermediate probability of having adverse effects on aquatic life.

In 1999 and 2000, the USGS undertook a nationwide study to provide information on the occurrence of a larger group of chemicals that may be entering the Nation's streams through wastewater. The USGS sampled streams at 139 sites across the Nation and one site in the Potomac River basin. The samples were analyzed for 95 different emerging contaminants including human and veterinary drugs, hormones, detergents, disinfectants, insecticides, and fire retardants. At least one of these compounds was found in 80 percent of the streams, with mixtures of the chemicals occurring at 75 percent of the sites. Most common groups detected were steroids, nonprescription drugs and insect repellent. Only 14 compounds have human or ecological health criteria and measured levels rarely exceeded any of the standards or criteria. However, little is known about the majority of the compounds or their mixtures.

The USGS has also been active in developing methods to measure hormonally active or endocrine disrupting chemicals in water sediment and tissue, as well as in developing integrative samplers such as Semi-Permeable Membrane Devices (SPMDs) and Polar

Organic Chemical Integrative Samplers (POCIS). These new methods are used to assess the environmental occurrence of these chemicals. The USGS has published a significant number of journal articles on the environmental occurrence of endocrine disruptors that provide useful information to researchers in determining the concentrations and mixtures of these chemicals for laboratory studies.

Although the effects of endocrine disruptors can be replicated in the laboratory under controlled conditions using synthetic hormones or other chemicals, it has not been possible to demonstrate a cause of the intersex characteristics in the field. Laboratory studies that discern the causative mechanisms for endocrine disruption are also underway at several USGS Science Centers. USGS is developing new molecular and other techniques to determine the causative agents of multiple stressor situations.

Research by other scientists around the world has shown that endocrine disrupting chemicals in aquatic environments affect various fauna, from mussels to fish to birds. Some of the aspects of this issue are being addressed by the European Commission and the U.S. Food and Drug Administration to determine the potential risks of human and veterinary drugs on the environment.

What other information is needed?

There is a need to further document the extent and causes of intersex within the Chesapeake Bay watershed. Identifying the compounds that are impacting the fish, and their sources, fate, and transport will help managers develop solutions for the problem. The USGS is conducting a study to address some aspects of the issue in Shenandoah Valley of the Potomac River Basin. What is learned in the Shenandoah Valley may be able to be applied and expanded to other areas of the Bay watershed.

To help coordinate federal research activities related to endocrine disruption in the environment, the USGS is leading the planning effort for an interagency workshop in February 2007 at the USGS Headquarters in Reston, Virginia. This workshop is being organized under the Office of Science and Technology Policy and the Council on the Environment and Natural Resources. Eight federal agencies will be participating in this workshop. The major goals are to review the current knowledge about endocrine disruption in the environment, what type of research and studies each agency is currently doing and planning in this area, and most importantly, to develop specific opportunities for collaboration between agencies. The workshop will involve a variety of federal scientists and managers in every aspect of endocrine disruption, including developing methods to detect Endocrine Disrupting Chemicals (EDC) in the environment; basic research on how they affect fish and wildlife; developing methods for monitoring and identifying sources; and different ways the discharge of EDCs can be minimized or removed from the environment.

Given our current scientific understanding of intersex in fish, the areas in which USGS science can make a valuable contribution include determining:

- What effects these endocrine disruptors have on the ability of fish to reproduce, thrive and sustain populations in the wild;
- What aquatic organisms are being affected (e.g., are only benthic feeders or fish that lay eggs in the sediment affected or are other aquatic organisms at risk), and the implications for the aquatic ecosystem;
- What chemicals and other stressors are implicated in these effects;
- How to improve our ability to predict causes of endocrine disruption in the field;
- The consequences of these effects at the population and ecosystem levels; and
- Potential causes of intersex characteristics in fish, including chemical contamination, and changes in the temperature regime or habitat.

For more information see:

The USGS Chesapeake Bay Web site has information related our science activities in the Chesapeake Bay watershed: <http://chesapeake.usgs.gov/> . The site has links to the USGS Programs <http://chesapeake.usgs.gov/plans.html> that collaborate on USGS Chesapeake Bay Studies and to the Leetown Science Center <http://www.lsc.usgs.gov/>, where the majority of the science about intersex characteristics and fish health in the Bay watershed is being conducted.

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