

# Emerging Water Quality Concerns: Mixtures and Sublethal Effects

Michael Focazio PhD  
Deputy Program Coordinator,  
Toxic Substances Hydrology Program  
USGS

2/28/13

# Extent and Severity

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- Widespread:
  - PCBs, PAHs, Mercury
  - some herbicides (atrazine, simazine, metochlor, and their degradation products)
- Localized:
  - Dioxins/furans, petroleum hydrocarbons
  - Insecticides (aldrin, chlordane, dieldrin, DDT/DDE, heptachlor epoxide, mirex)
  - Metals: Al, Cr, Fe, Pb, Mn, Zn
- Uncertain: pharmaceuticals, care products, flame retardants, some pesticides, hormones

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**Atrazine induces complete feminization and chemical castration in male African clawed frogs (*Xenopus laevis*):**

Hayes *et al.*, *Proceedings of the National Academy of Sciences*, March 1, 2010

**Demasculinization and feminization of male gonads by atrazine: Consistent effects across vertebrate classes.**

Hayes *et al.*, *The Journal of Steroid Biochemistry and Molecular Biology*, 2011; 127 (1-2)

**Atrazine reduces reproduction in fathead minnow (*Pimephales promelas*).**

Tillitt *et al.*, *Aquatic Toxicology*, 2010

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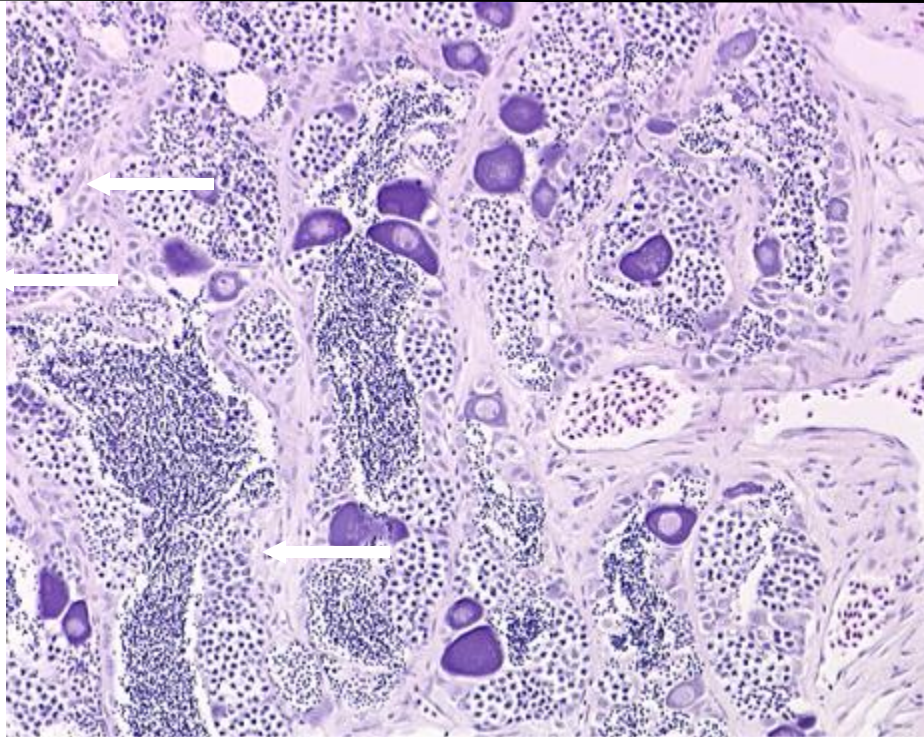
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# Sublethal Effects

## Intersex in Normally Gonochoristic Fishes



Oocytes shown in spermatogenic tissue

# Sublethal Effects

**Chemical contaminants in water and sediment near fish nesting sites in the Potomac River basin:  
Determining potential exposures to smallmouth bass (*Micropterus dolomieu*)**

Kolpin *et al.*, 2013 *Science of the Total Environment*

**Atrazine** in water at  
nesting sites  
significantly correlated  
with intersex

**Sterol hormones** in  
sediment at nesting  
sites significantly  
correlated with intersex

# Sublethal Effects

**Identification of centrarchid hepcidins and evidence that 17 $\beta$ -estradiol disrupts constitutive expression of hepcidin-1 and inducible expression of hepcidin-2 in largemouth bass (*Micropterus salmoides*)**

Robertson *et al.*, 2009 *Fish and Shellfish Immunology*

**Estrogen** exposure  
linked to immune  
suppression in fish



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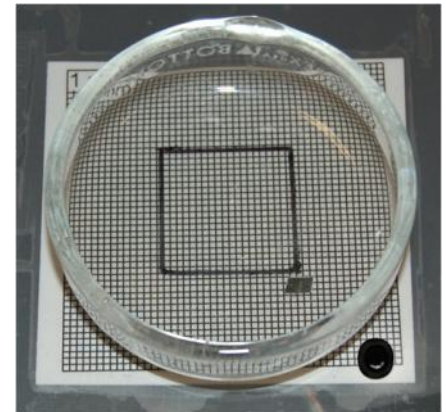
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# Sublethal Effects

12- day fathead larval exposure experiments

Exposed to relevant concentrations (and mixtures) of wastewater-related contaminants previously measured in streams

**Antidepressants slowed predator avoidance behaviors in larval fish**



(Painter *et al.*, 2009)

# Sublethal Effects

## Dilute Concentrations of Psychiatric Drug Alters Behavior of Fish from Natural Populations

Brodin *et al.*, Feb. 15, 2013: *Science*

Here we show that a benzodiazepine anxiolytic drug (oxazepam) alters behavior and feeding rate of wild European perch (*Perca fluviatilis*) at concentrations encountered in effluent-influenced surface waters. Individuals exposed to water with dilute drug concentrations (1.8 micrograms liter<sup>-1</sup>) **exhibited increased activity, reduced sociality, and higher feeding rate.** As such, our results show that anxiolytic drugs in surface waters alter animal behaviors that are known to have ecological and evolutionary consequences.



# Sublethal Effects

## Traces of Anxiety Drug May Affect Behavior in Fish

New York Times Feb 14, 2013

U.S. Environmental Protection Agency:

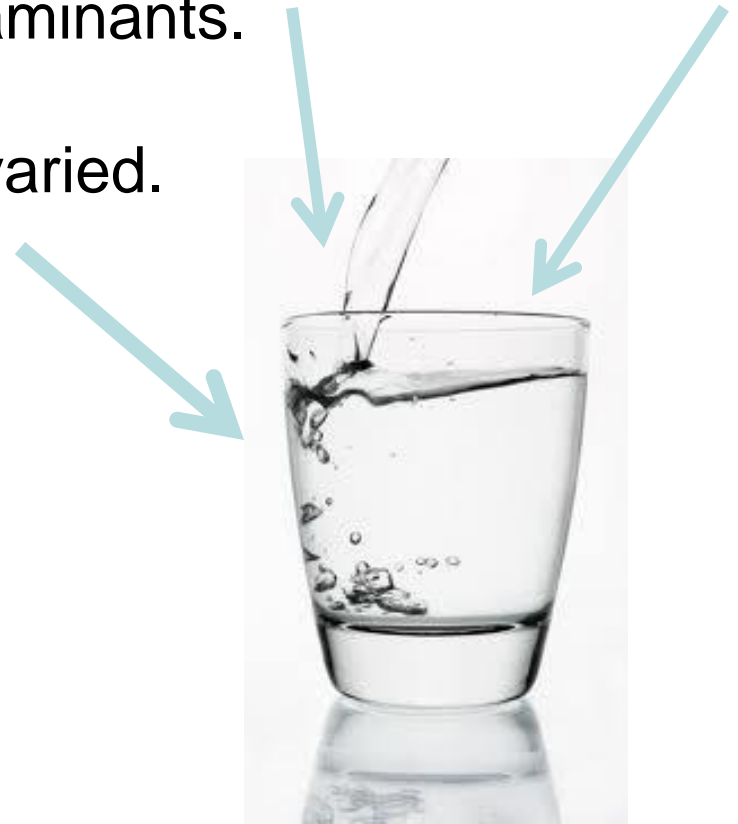
“...the relevance of their study to the real world is unclear,” the United States Environmental Protection Agency said in written answers to questions. The agency said that while “most pharmaceuticals do not seem to pose known risks to humans, animals or the rest of the ecosystem” at the levels they occur in the environment, there are some medications “for which some researchers have noted physiological effects in fish exposed to levels close to those occasionally reached in the environment. These include some ingredients used for contraception, hypertension and mood disorders.”

# Mixtures

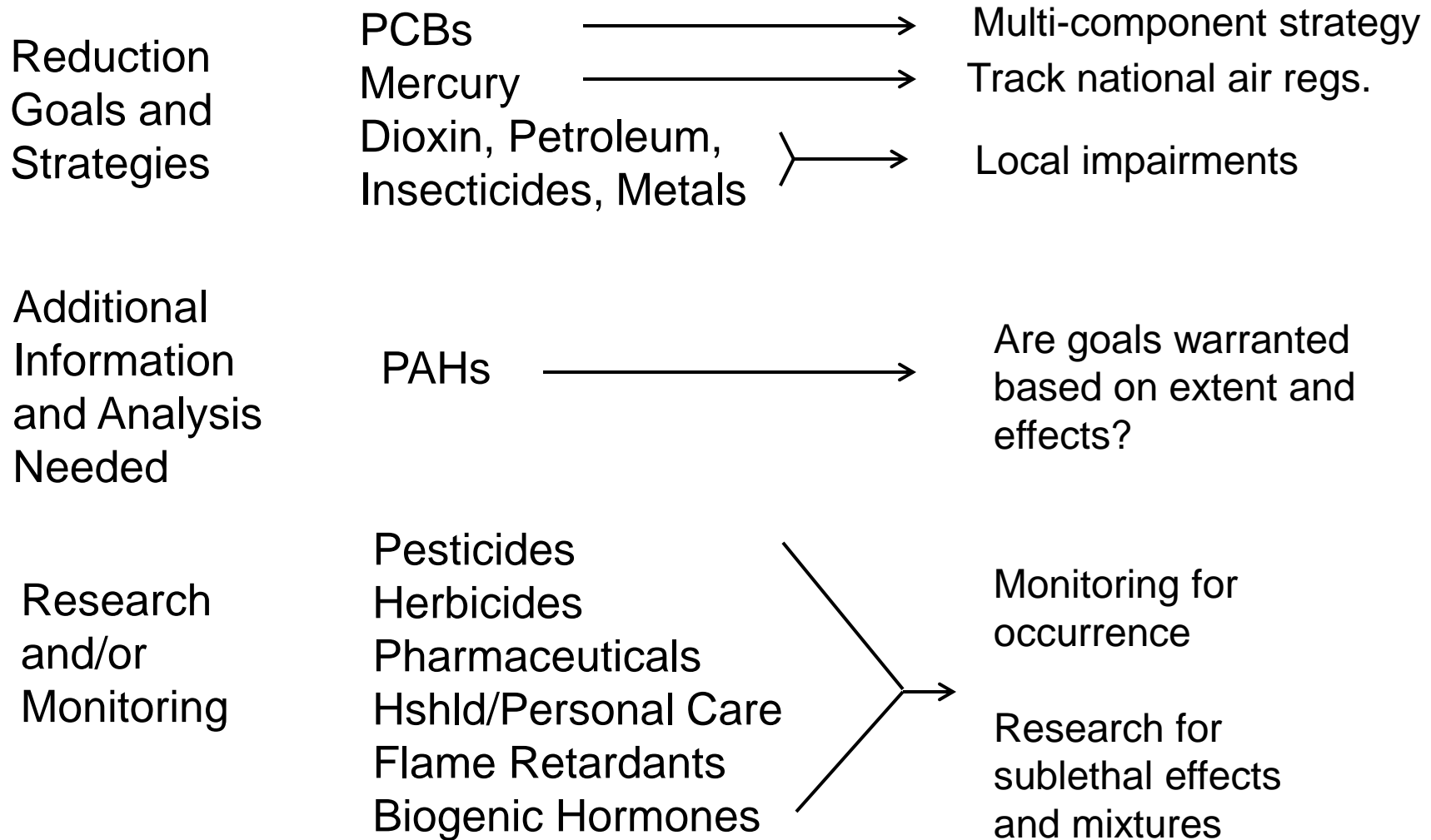
Environmental contaminants rarely occur alone.

Water and sediment samples often contain complex mixtures of natural and anthropogenic contaminants.

Sources of the contaminants are varied.



# Concept for Goal Types



***DRAFT For discussion purposes only. Final goal decisions TBD***