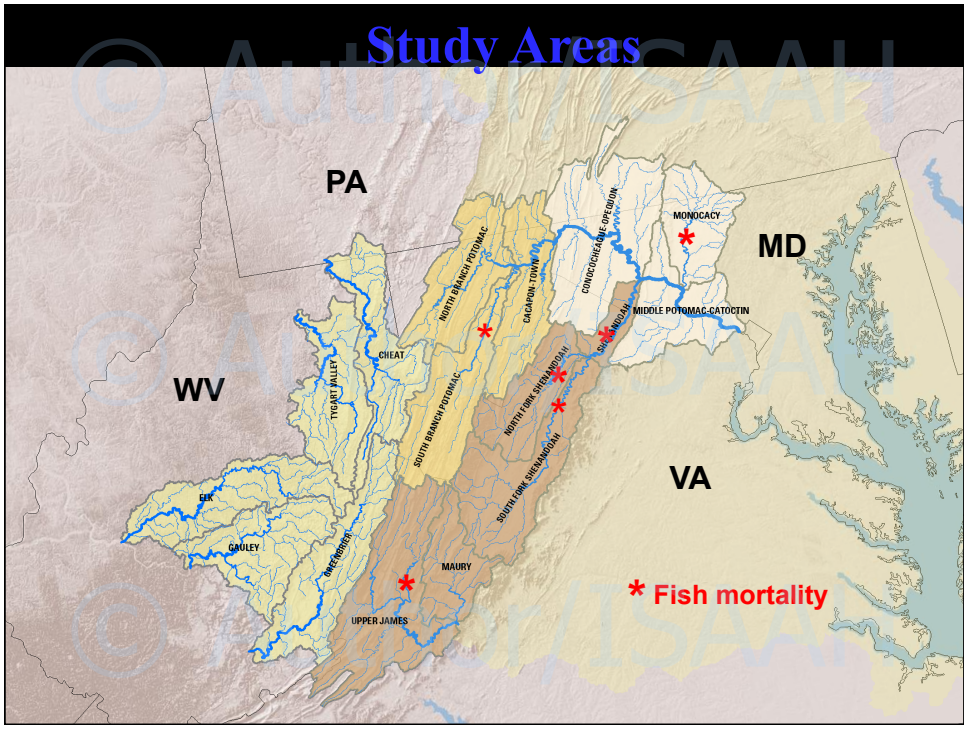
Mortalities, Skin Lesions and Intersex in Smallmouth Bass: Possible Associations with Contaminants of Emerging Concern

Vicki Blazer, L. Iwanowicz, D. Iwanowicz and H. Ellery
U.S. Geological Survey
National Fish Health Research Laboratory
Kearneysville, WV

USGS
science for a changing world

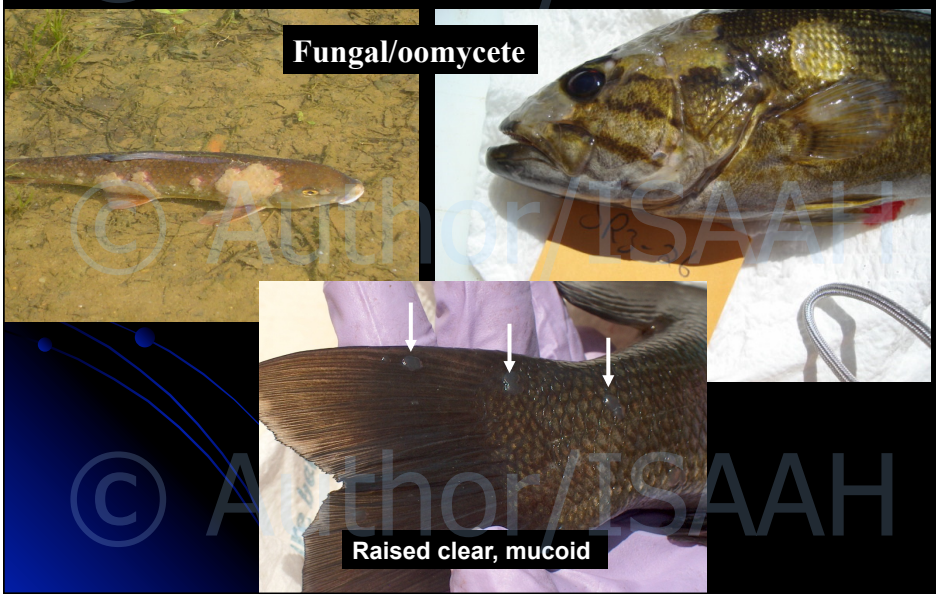
Potomac River Fish Kills

- Spring 2002 – South Branch Potomac, WV
  - Smallmouth bass and suckers
- Shenandoah River
  - 2004 – North Fork
  - 2005 – South Fork
  - 2007 - present - lower severity, throughout
- Shenandoah and South Branch
  - 2006 – Sucker kills
- Monocacy River
  - 2009 – primarily smallmouth bass


Study Areas
PA
WV
MD
VA
MONOCACY
MIDDLE POTOMAC-CATOCTIN
CONOCOCHEAGUE-OPEQUON
CACAPON - TOWN
NORTH BRANCH POTOMAC
SOUTH BRANCH POTOMAC
CHEAT
TYGART VALLEY
NORTH FORK SHENANDOAH
SOUTH FORK SHENANDOAH
SHENANDOAH
EEK
GAULEY
GREENBRIER
MAURY
UPPER JAMES
* Fish mortality


Variety of Lesions
Raised reddened or pale
Erosion of epidermis and dermis

Variety of Skin Lesions



Fish Kills Potomac Drainage

- Characteristics
  - **Kills/lesions begin in early spring**
  - **Adult fishes**
  - **Not reported from smaller tributaries**
  - **Primarily affected smallmouth bass, red breast sunfish, redhorse suckers**
- South Branch of Potomac in WV
  - **moderate and sporadic**
- Shenandoah River, VA and Monocacy River, MD
  - **Initial year severe, >50% of the adult SMB and RBS populations lost**

Bacteria

- *Flavobacterium columnare*
- *Aeromonas hydrophila* – and other motile Aeromonads
- *Aeromonas salmonicida*

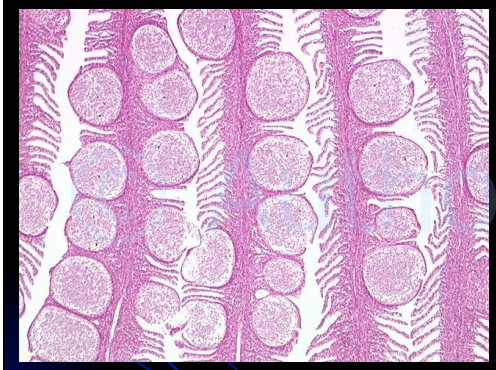
No consistent findings - LMBV and *A. salmonicida* have not been found in the South Branch, WV

Various bacteria have been cultured sporadically – at times when there were kills and when there were not

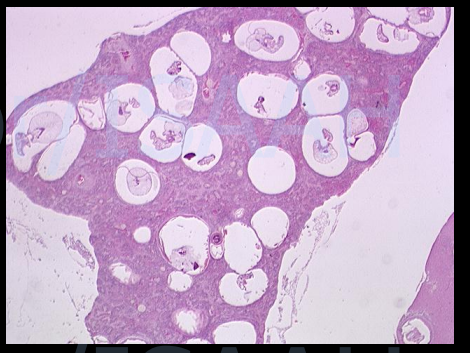
Skin/Mucous Samples

- March - prior to actual fish kills or a high prevalence of skin lesions and kills
  - Change in the normal flora
  - *A. hydrophila* and other motile aeromonads proliferate first
  - May also be a change in innate skin disease resistance mechanisms

Parasites

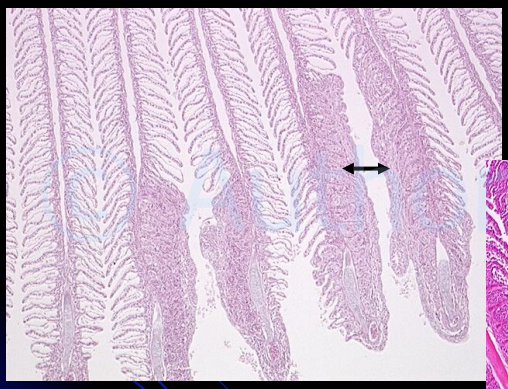


Gill myxozoans

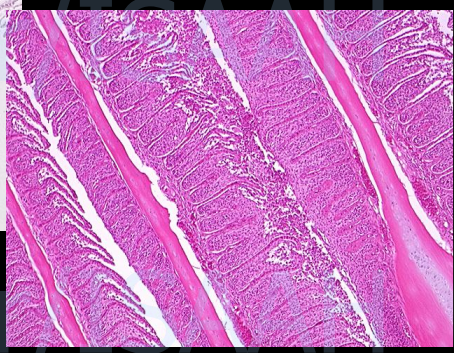


Heavy trematode infestations
60% of liver/spleen replaced by parasite cysts

Gill Lesions Environmental

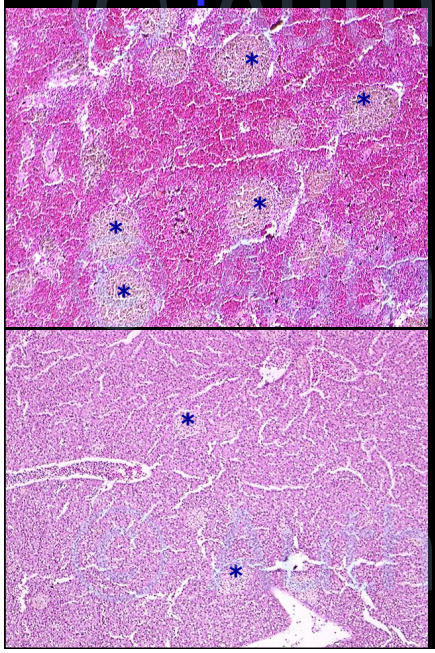


Epithelial lifting, hypertrophy and Hyperplasia leading to fusion, mucous cell proliferation

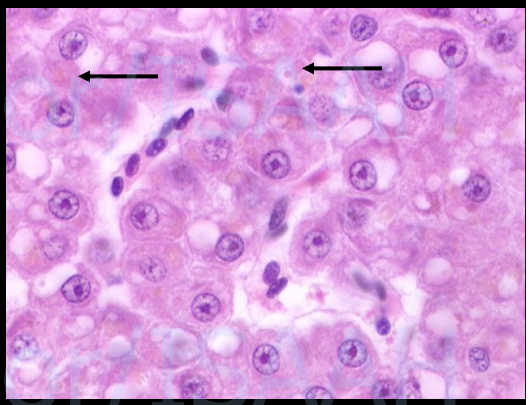


Severe lamellar fusion and inflammation

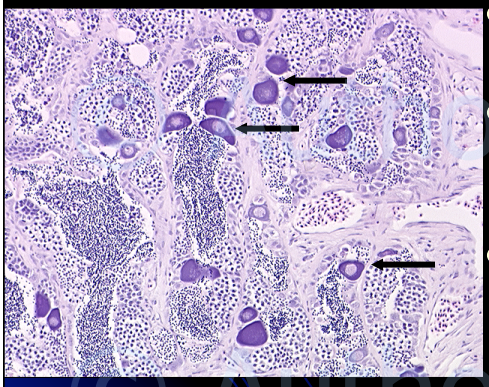
Liver/Spleen Pathology - Environmental



Oxidative damage



Intersex in Normally Gonochorist Fishes



- Suggested as a marker of endocrine disruption
- Most often associated with exposure to estrogenic compounds
- Probably induced early in life, but may occur due to exposure later in life

Fish Kill Issues Related to Intersex and Other Reproductive Findings?

- Estrogens and estrogenic chemicals are most often associated with intersex and vitellogenin production in male fishes
- Increasing evidence that estrogenic chemicals and other endocrine-disrupting substances modulate the immune response and disease resistance

Findings Suggest:

- There are stressed populations of sensitive species and at some point the "perfect storm" of conditions and pathogens overwhelms the fish and mortalities occur
- Multiple infectious agents/parasites
- Environmental stressors:
  - Water quality issues – high pH, ammonia, increased water temperatures, nutrients,
  - Chemicals that cause immunosuppression leading to a variety of infections

Chemicals of "Emerging (Emerged) Concern"

- Defined as synthetic or naturally occurring chemicals (or microorganisms) that are not commonly monitored in the environment, are generally not regulated, but have the potential to enter the environment and cause adverse effects
- Many are chemicals that are produced to have a biological effect and hence may have biological effects on nontarget organisms at very low (ppb-ppt) levels

"Emerging Contaminants"

- Pharmaceuticals – Human and Animal
  - Synthetic Hormones – birth control, hormone replacement therapy
  - Antibiotics
  - Viagra to Prozac
- Personal care products
  - Antimicrobials – soap, detergent, toothpaste
  - Fragrances
  - Organic UV filters
  - DEET
- Current-use pesticides
- Brominated flame retardants
- Plastic compounds

Effects

- Endocrine disruption
- Cancer/Neoplasia
- Numerous physiological and pathological effects
- Behavior
- Immune system/disease resistance

Complexities in Wild Fishes

- Endocrine/Immune systems - chemical communication and feedback mechanisms
- Lack of classic dose response curve – hormesis
- Newly recognized effects of legacy compounds
- Multiple contaminant exposure routes - water, sediment, food (yolk sac)
- Complex mixtures – additive, synergistic, antagonistic effects

Passive Samplers

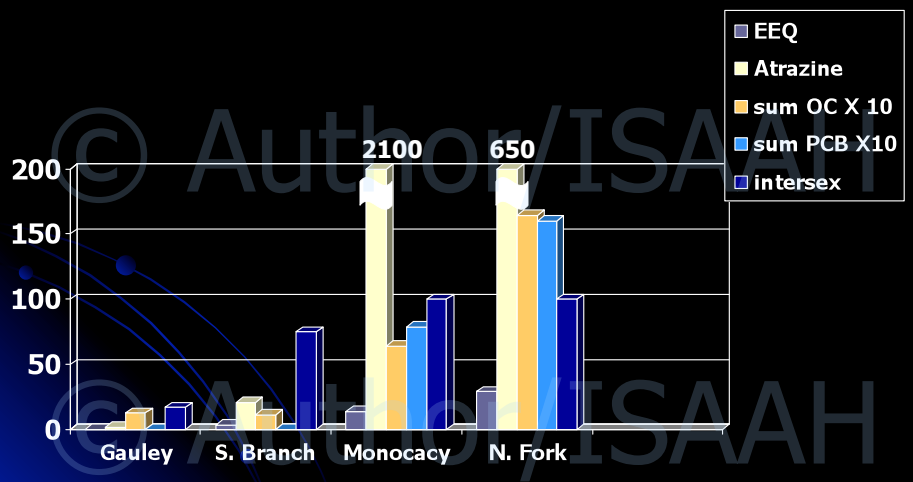
- Semi permeable Membrane Devices (SPMDs)- accumulate hydrophobic compounds
- Polar Organic Compound Integrative Samplers (POCIS)—accumulate hydrophilic compounds

Dave Alvarez, Columbia Environmental Research Laboratory WRD Chemists

Issue of Complex Mixtures

- Screening either grab water extracts or the extracts from the passive samplers using in vitro cell assays
  - YES, BLYES, breast cancer cells – total estrogenicity – estrogen equivalents
  - Total androgenicity
- Passive sampler hormone results – no hormones above method quantification levels (N. Fork Shen)
  - 17β estradiol, 17α-ethynylestradiol, estrone, estriol
- Estrogen equivalents ranged from 14-79 ng estradiol/ sample depending on the site

Gradient Spring 2006-2007
Passive Sampler Results/Intersex



Agricultural Pesticides
Fall 2005 (Spring 2006)

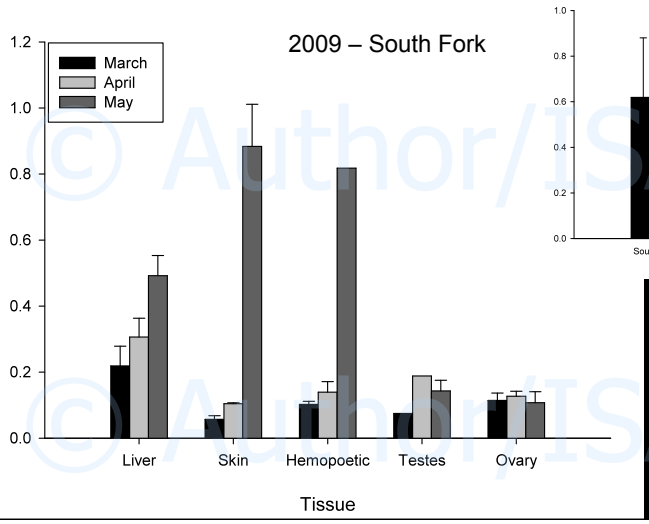
Chemical Estimated ng/L	Con Up	Con Down	Mon Up	Mon Down
Metolachlor	0.73 (7.5)	1.1 (9.0)	12.0	10.8 (97)
Atrazine	47 (380)	110 (430)	92	2 (2100)
Prometon	1.1 (1.2)	3.2 (1.4)	2.1	1.4 (1.8)

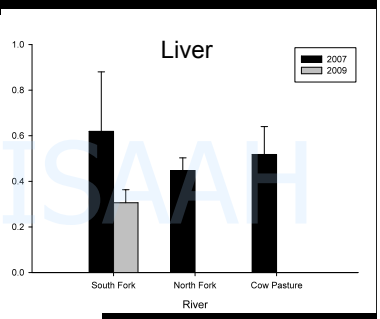
2.5 ppb recently shown to induce complete feminization and chemical castration in frogs - Hayes et al. (March 2010)

Earlier work found 0.1 ppb induced intersex in certain amphibians

Also shown to affect disease resistance

Arsenic Tissue Contaminants Smallmouth Bass





Conclusions

- Basin-wide issue – requires landscape level analyses for better management
- Spatial/site differences – to understand site specific chemical inputs, landuse and habitats influences
- Multiple sources of chemicals/environmental stressors
  - WWTP and other point sources, agricultural runoff, urban/suburban stormwater runoff
- Multiple pathogens/parasites – better understand how their presence and/or virulence is influenced by numerous environmental factors
- Temporal effects – annual/seasonal on chemical concentrations and pathogen presence – compounded by climate change

Acknowledgements

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  - Toxic Substance Hydrology Program, Columbia Environmental Research Lab, National Wetlands Center, WV Coop Unit
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