SYNTHESIS EFFORTS FOR BIOLOGICAL EFFECTS MONITORING AND ASSOCIATED RISK FACTORS

Vicki Blazer

National Fish Health Research Laboratory
U.S. Geological Survey, Kearneysville, WV

Fish Health Issues

Potentially Associated with Contaminant Exposure

- Fish Kills, chronic mortality and skin lesions of centrarchids and other fishes
- Signs of exposure to estrogenic endocrine disruptors – intersex (testicular oocytes, vitellogenin in male fishes)
- Lack of reproductive success in certain yellow perch populations in urban tributaries

Centrarchid Fish Kills/Skin Lesions/Endocrine Disruption

- In 2003 at the request of WV DNR we began sampling adult smallmouth bass in the South Branch Potomac because of spring fish kills and skin lesions
- In 2004 at the request of VA DGIF we began sampling smallmouth in the Shenandoah River because of adult fish kills and skin lesions
- In 2005 PA F & B sent samples of diseased YOY smallmouth bass

Adverse Effects Monitoring

- Sensitive species – not all fish are created equal
  - Species sensitivity due to genetic, physiological factors
  - Habitat usage, spawning habitat and timing
- Indicators of effects (adverse outcome pathways) at various levels of organization

- Understand the effects of complex mixtures of chemicals and other environmental stressors
- Evaluate the efficacy of restoration, remediation or other management actions

Importance of Wild Fish Monitoring

- Integrate the various environmental stressors over time
  - Complex mixtures of chemical contaminants
  - Temporal changes – short term (weekly/monthly) and annual
  - Cumulative over the life span

Levels of Organization

Population

Organism → Visible lesions, condition factor, relative weight, growth

Tissue → Gonadosomatic index, parasite load, microscopic pathology – pathogens, tumors, inflammation

Cellular → Histopathology – necrosis (cell death), hypertrophy, cytoplasmic vacuoles/inclusions
Function of immune cells such as lymphocytes and macrophages

Molecular → Expression of genes – estrogen and androgen receptors, metabolic, contaminant-responsive, immune regulatory

Subcellular → Plasma vitellogenin, hormones, proteins

Estrogenic Effects in Male Fish

- **Intersex or testicular oocytes** – most likely induced early in life, first few weeks, severity may increase with age
- **Plasma vitellogenin** – indicative of more short term exposure – days to months
- **Vitellogenin mRNA** – indicative of current conditions

Adult Fish in the Potomac

- Multiple bacterial pathogens, but no consistent findings
  - *Aeromonas hydrophila* and other motile Aeromonads
  - *Aeromonas salmonicida*
  - *Flavobacterium columnare*
- Multiple, often heavy parasite infestations
  - Leeches, trematodes, myxozoans, cestodes
- Opportunistic fungal infections
- Skin papillomas
- Largemouth Bass Virus
- High prevalence of intersex, vitellogenin in male fishes

Impaired Ecosystem
Immunosuppression

Young of Year in the Susquehanna

- *Aeromonas hydrophila* and other motile Aeromonads
- *Flavobacterium columnare*
- Other bacteria
- Largemouth Bass Virus
- Trematodes
- Myxozoan parasites

Adult Smallmouth Bass Susquehanna

- High prevalence and severity of intersex
- Various skin lesions including erosions, mucoid plaques, melanistic areas and tumors

Synthesis Products

- **Numerous studies between 2003 – 2010**

1. **Wild fish monitoring/studies**
2. **Hormone activity analyses using discrete and passive sampler extracts**
   - **Primarily estrogenic activity (bioluminescent yeast assay and estradiol equivalents)**
   - **Also measured androgen, thyroid and glucocorticoid activity**
   - **For both the plan is to produce a database and a paper that synthesizes the results**
3. **Young-of year smallmouth bass – pathology, pathogens, tissue chemical analyses, passive sampler data – Walsh/Blazer – to be submitted in Sept.**

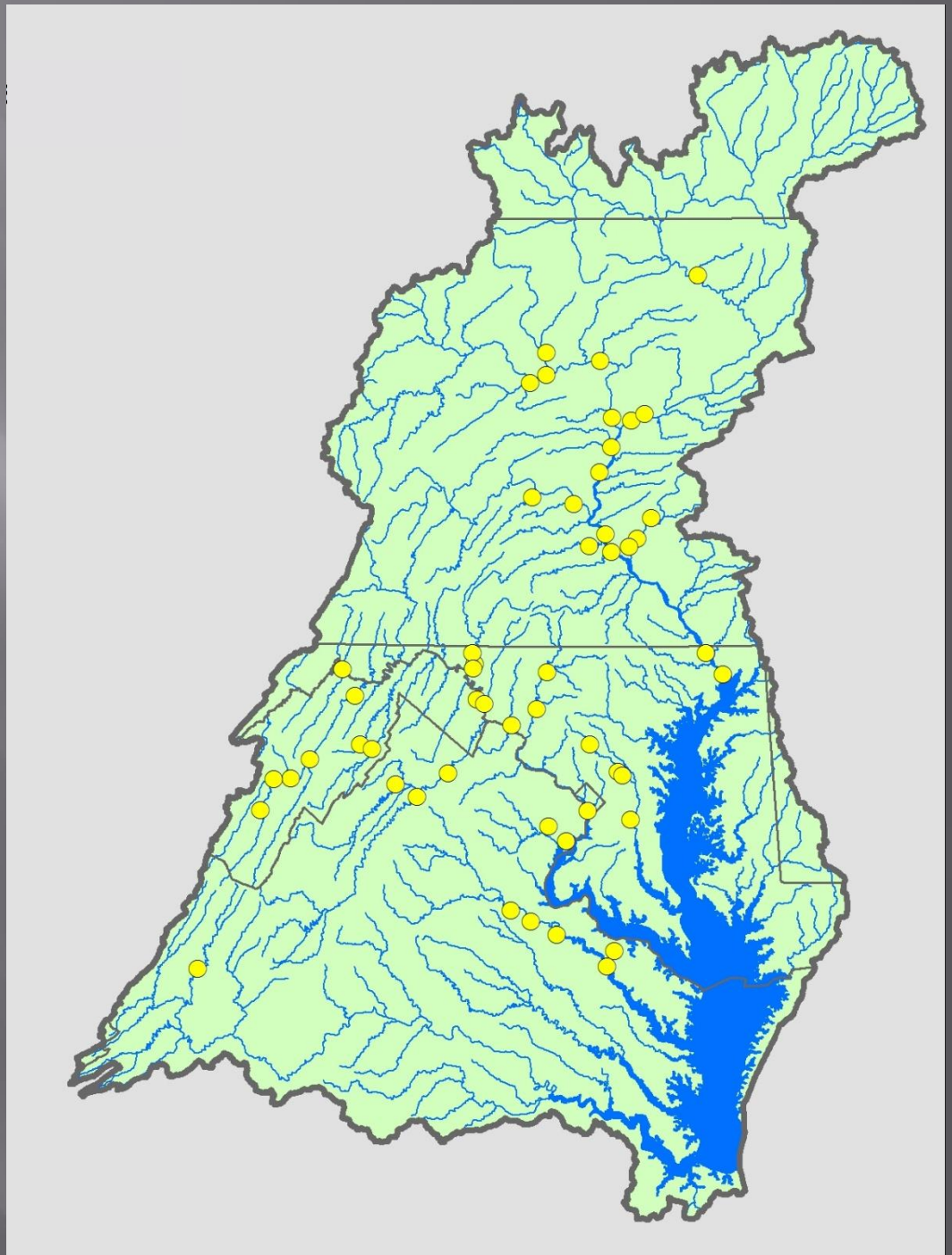
Estrogenicity Database
Lead - Luke Iwanowicz

- Currently data for over 600 discrete samples and 40 passive sample extracts
- About 1/3 also have results for thyroid, glucocorticoid and androgens
- Some is in published reports, much is not:
  - Shenandoah small watersheds – Ciparis et al. 2012
  - Androgen and glucocorticoids – Stavreva et al. 2012
  - Potomac/landuse – Young et al. 2014
  - South Branch temporal – Blazer et al. (in prep)

Wild Fish Monitoring

- Data – length, weight, sex, age, year class, condition factor, relative weight, visible abnormalities including parasites, hepatosomatic index, gonadosomatic index, testicular oocyte presence and severity, plasma vitellogenin concentrations
- Data from approximately 2,300 adult smallmouth bass and 200 adult largemouth bass
  - Potomac/Shenandoah/Monocacy
  - Susquehanna/Juniata
  - Rappahannock
  - James
  - Patuxent

Bass Sampling Sites



Fish Biological Summary Data

- Represents a total 52 sites within the Chesapeake drainage
- 31 of those were snap shoots – only one sampling time
  - Most of these had no associated water or sediment chemical monitoring
- 21 had at least two sampling times
  - Some have multiple seasons, multiple years
  - Many of these have some type of associated chemicals analyses (grab water, passive sampler, sediment, tissue)

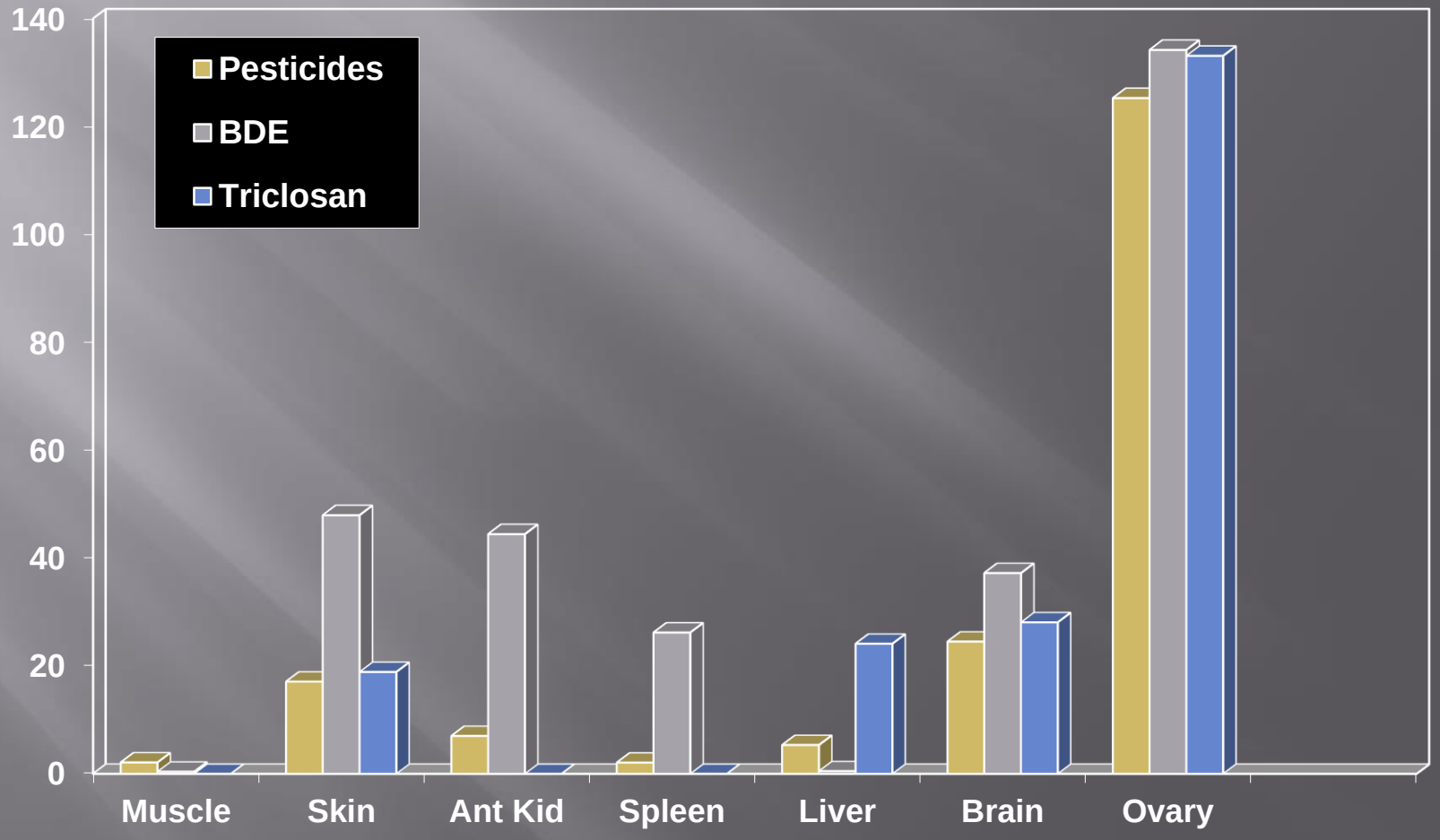
Synthesis Efforts - Biological

- **Much of the data has been published but much has not.**
  - **Potomac/out of basin comparison – Blazer et al. 2007**
  - **MD WWTP study – Iwanowicz et al. 2009; Alvarez et al. 2009**
  - **Summary of adult fish kill findings in Potomac and Shenandoah – Blazer et al. 2010**
  - **Spring spawning study – MD, VA and WV – Blazer et al. 2012 ; Kolpin et al. 2013**
  - **PA study – 16 sites in 3 river drainages – Blazer et al. 2013;**
  - **Northeast wildlife refuge project - sites in multiple rivers within the Chesapeake – Iwanowicz et al. 2015**

Synthesis

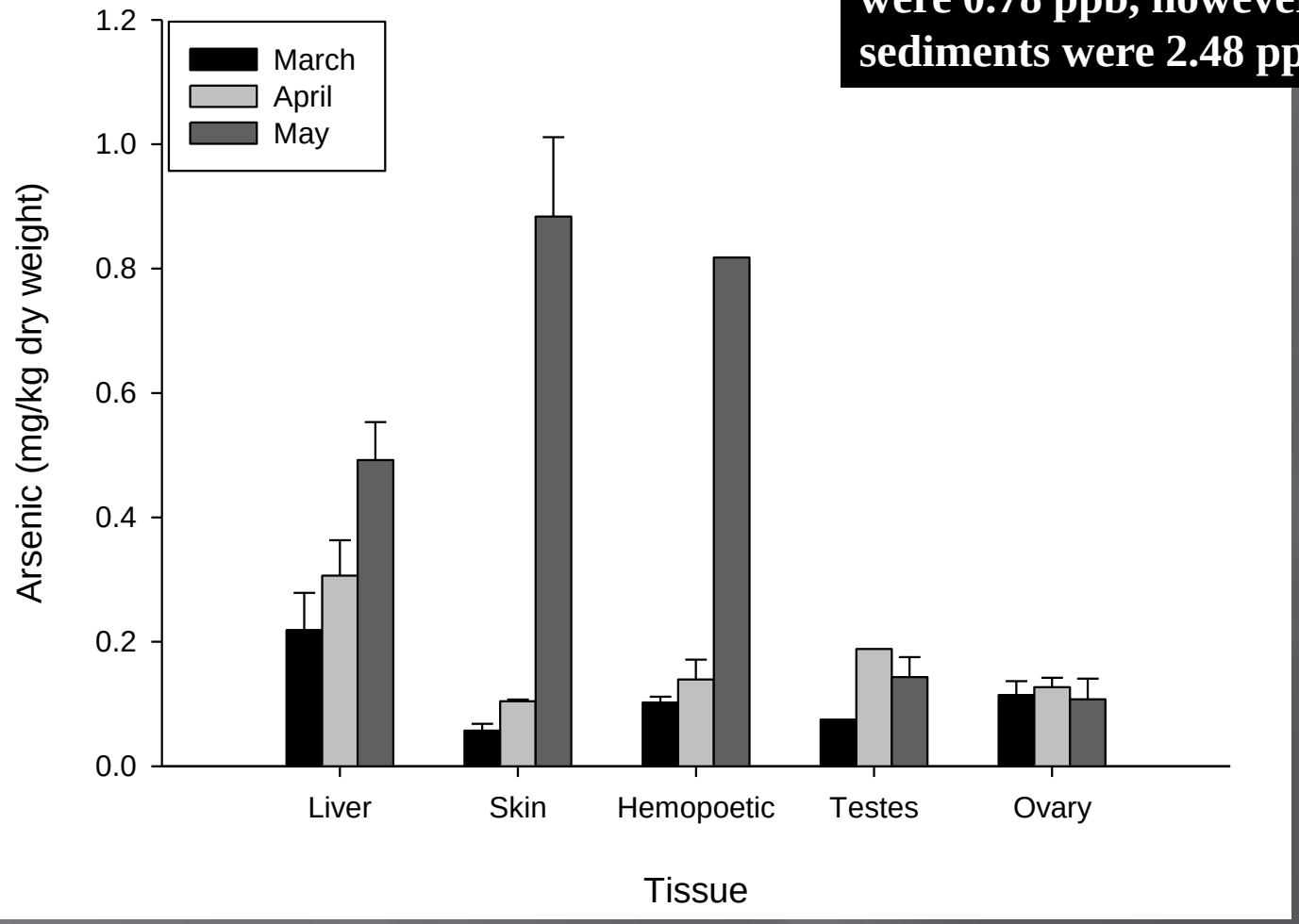
- **Synthesize the data collected from wild bass in regards to:**
  - **Landuse**
    - **Chemical concentrations in water and sediment when available**

Comparison of Tissue Contaminant Concentrations



Arsenic Tissue Contaminants Smallmouth Bass

Water concentrations even during storm runoff were 0.78 ppb, however, levels in the suspended sediments were 2.48 ppm



Better Understanding

- Integration of long term biological data sets
  - Few sites with > 10 years of biological data

  - Chemical data (water, sediment)
  - Tissue contaminant concentrations
  - Nutrient data
  - Climatic data – flow, temperature
  - Landscape analyses – land use, land use change, changes in agricultural practices, BMPs etc.

Understanding of the most important risk factors for the fish health issues and identify steps that could be used to restore healthy ecosystems

Ongoing Research
EDC and Other Contaminants

- Agricultural Integrator Sites – through 2017
  - Long term data set of water contaminants monthly plus storm samples
    - Identify key windows of sensitivity and exposure
    - Spring (prespawn), Fall (recrudescence)
    - Late spring/summer – YOY endocrine and immune system development
  - Exposure and pathway (biological) analyses
    - Contaminant analyses of eggs and YOY together with water and sediment concentrations
    - Tissue concentrations of current use pesticides – testes, skin, blood – together with gene expression and other biomarkers

Acknowledgements

USGS Programs, Centers

USFWS, Chesapeake Bay Field Office

EPA, NOAA, NCI

WV Division of Natural Resources

WV Department of Environmental Protection

VA Division of Game and Inland Fisheries

MD Department of Natural Resources

PA Fish and Boat Commission

PA Department of Environmental Protection

West Virginia University

Penn State University

Baylor University

Carnegie Institute

Potomac/ Shenandoah River Keeper

Friends of the Shenandoah