



**pennsylvania**  
DEPARTMENT OF ENVIRONMENTAL PROTECTION



Bureau of Point and  
Non Point Source Management

# Causal Analysis of the Smallmouth Bass Decline in the Susquehanna and Juniata Rivers

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# Introduction

- History:
  - PA Fish and Boat Commission and anglers found issues with Smallmouth Bass
    - Low numbers
    - Lesions
    - Other maladies
- DEP began unprecedented sampling and research to determine cause of these issues



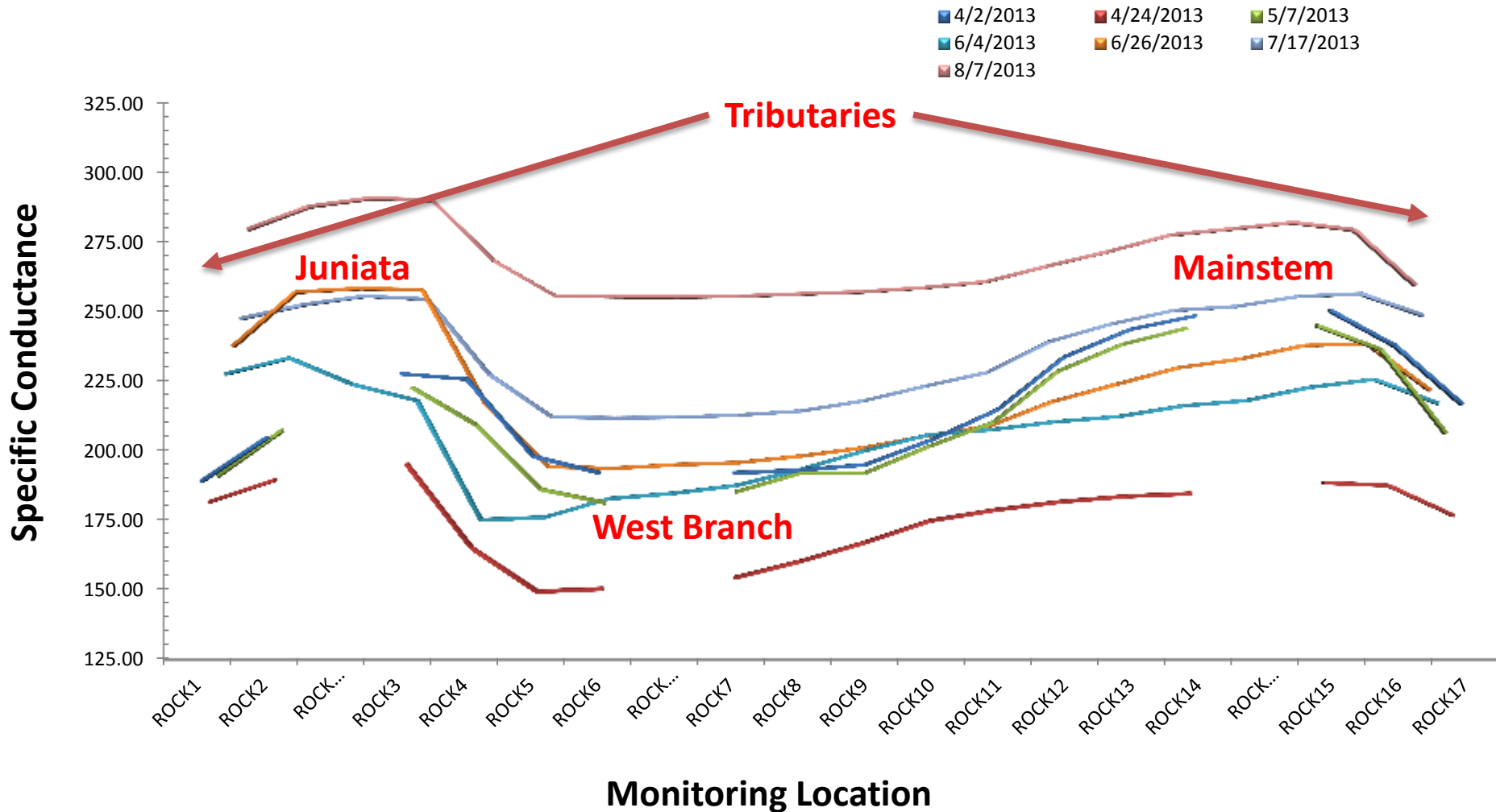


# Introduction: Complex System



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## Susquehanna River at Rockville, PA



# Introduction: Complex System





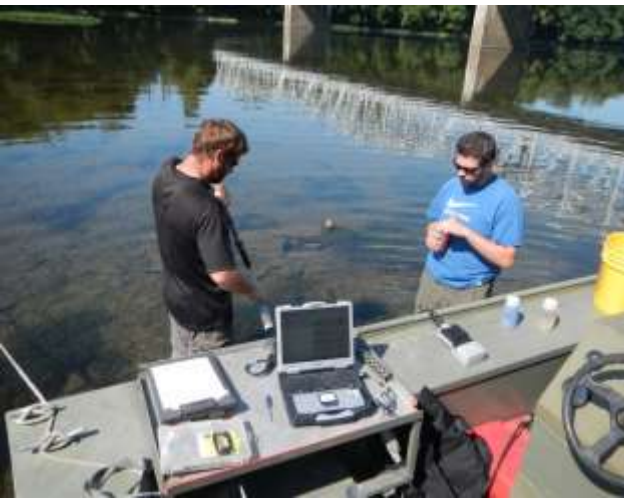
# Introduction

- DEP developed new sampling methods
  - Continuous instream monitoring
  - New tests to track water and sediment chemistry
  - Increased monitoring sites from 11 to more than 30



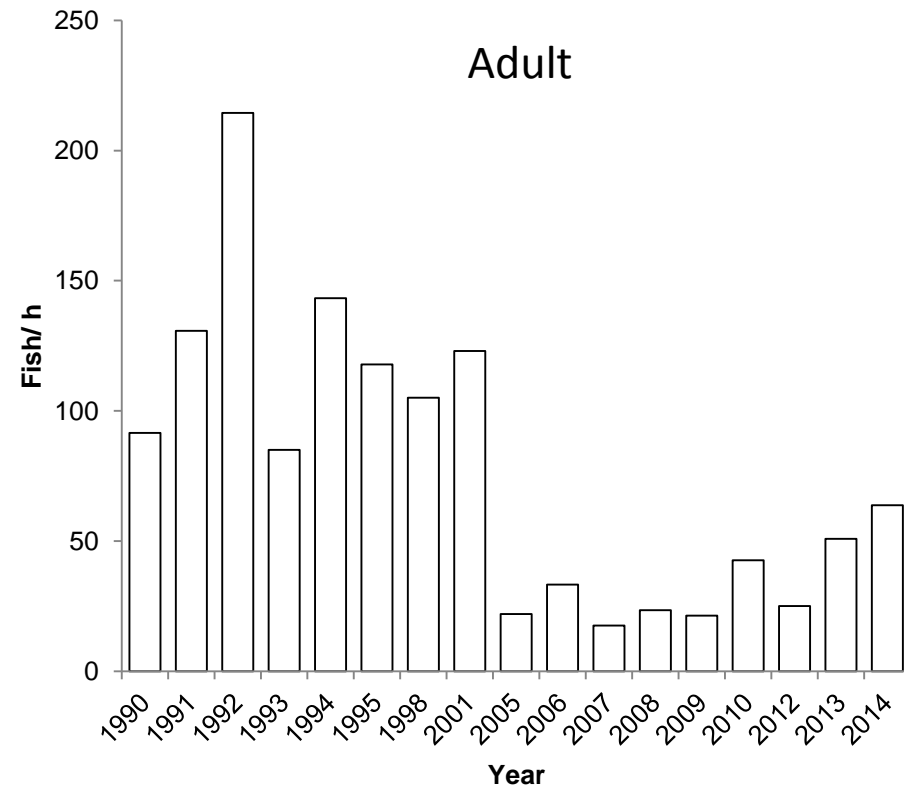
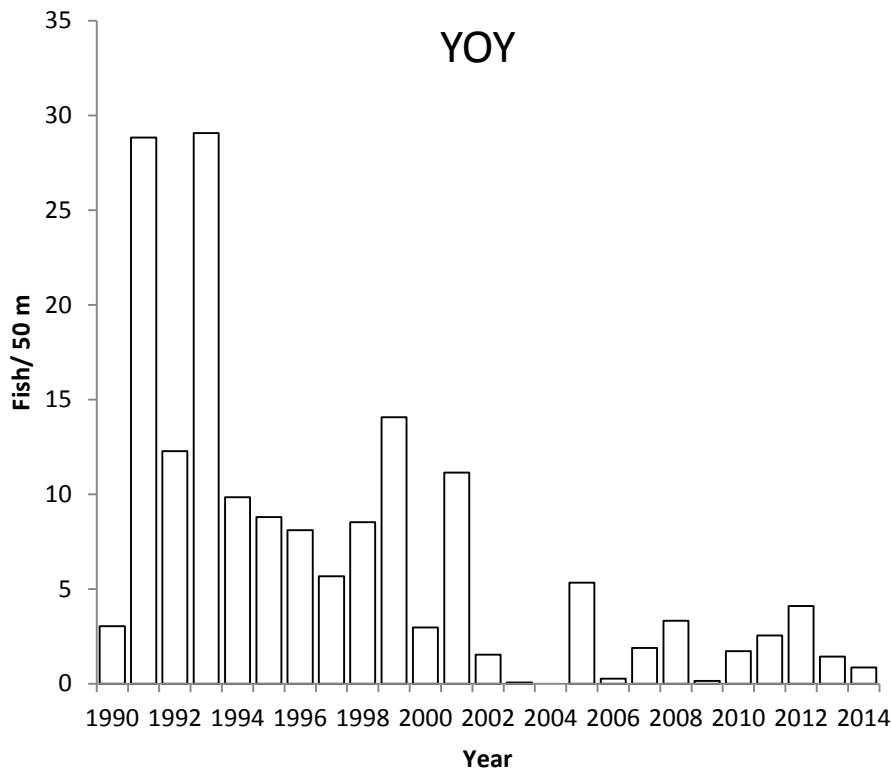
# Introduction

- Some causes have been eliminated, some are now considered less likely, while other have risen to the top.
- Studies can now focus on the most likely causes.
- Expand focus on tributary streams



# Introduction: Population Decline

Catch per unit effort for both adult and young-of-year (YOY) Smallmouth Bass (SMB) have decreased during the post-2005 era.





# Introduction: Additional Concerns



Disease outbreaks among YOY SMB

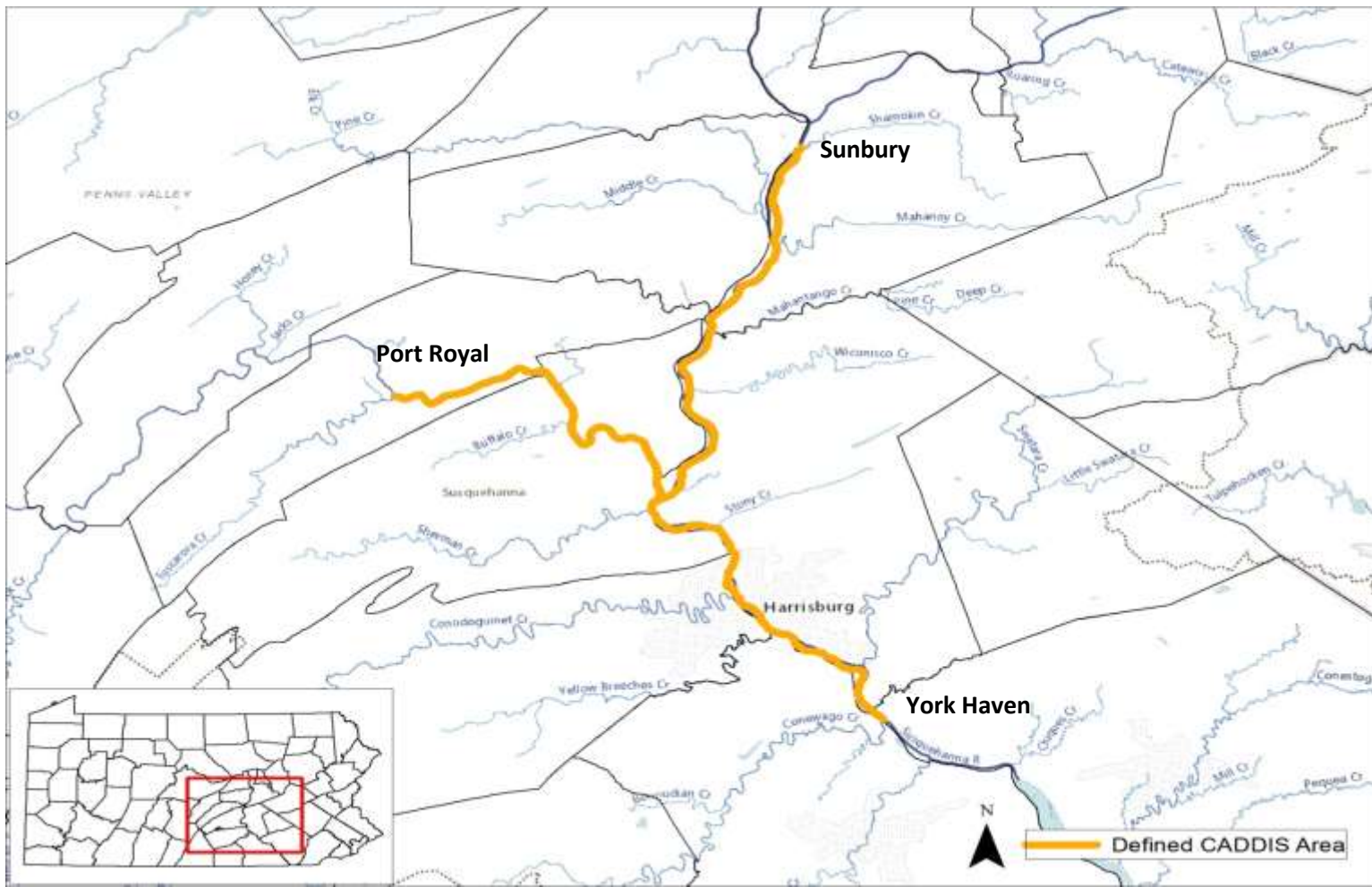
- Fish swimming weakly near the surface
- white lesions
- sores
- eroded fins
- mortality

Conditions observed in adult bass

- Parasite infections
- Melanistic Areas (black splotches)
- Intersex

# The Case

Decrease in abundance of SMB as a result of poor recruitment into the adult SMB population.



# Introduction: Purpose

- There was a significant need to consolidate agencies and resources to interpret the large amount of data collected since 2005.
- As a result, in 2014 PADEP requested USEPA assistance in identifying the causes of the SMB declines on the Susquehanna River.
- The USEPA's Causal Analysis/Diagnosis Decision Information System (CADDIS) <http://www3.epa.gov/caddis/> was the vehicle by which these goals could be achieved.

## Over 50 participants, Susquehanna CADDIS Partners

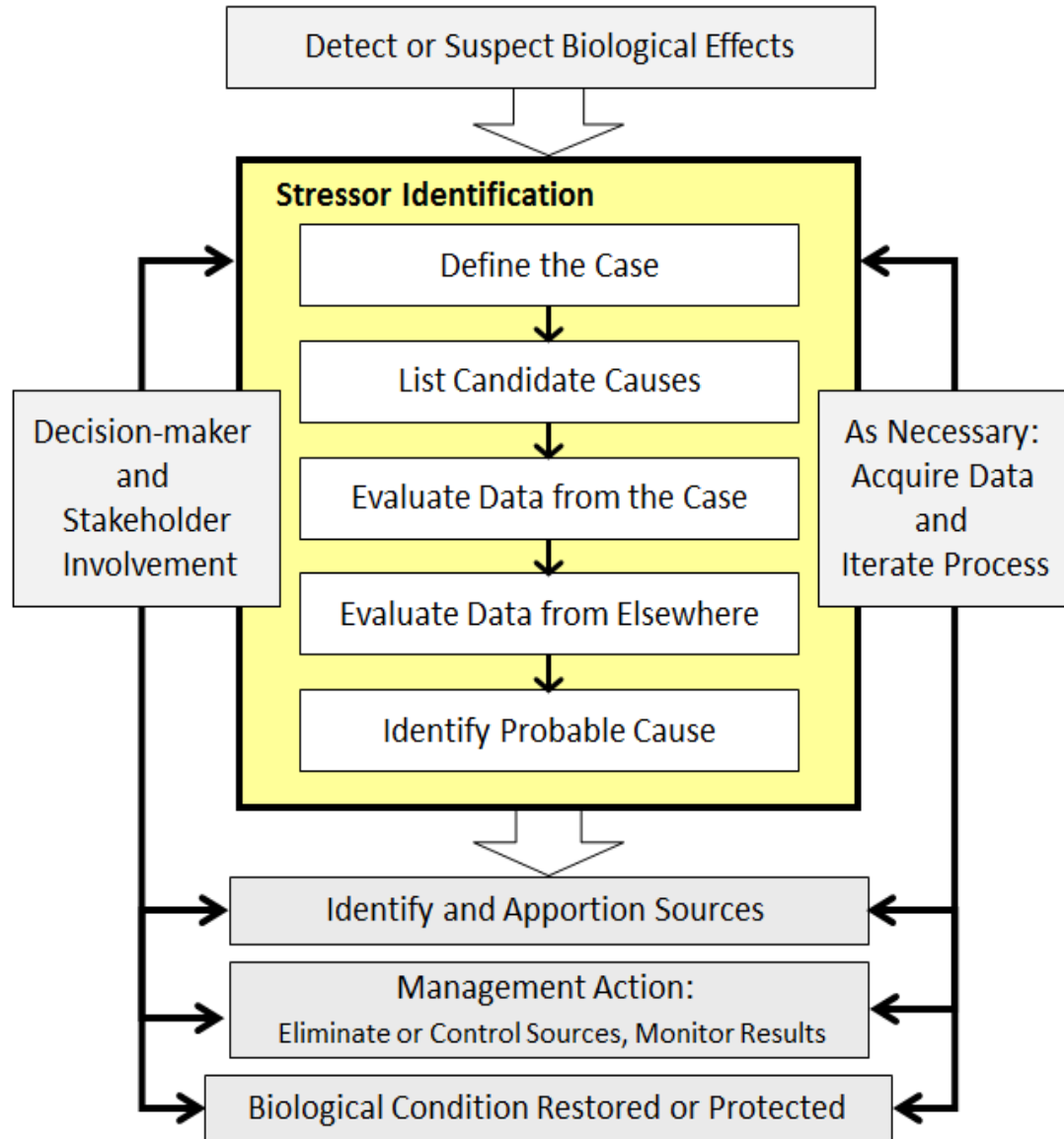




# Candidate Causes

1. High Flows
2. Intraspecific Competition (Overpopulation)
3. Interspecific Competition (Other species, possibly invasive)
4. YOY Food quality
5. Egg Quality
6. YOY Habitat Degradation
7. High Temperature
8. High pH
9. Low Dissolved Oxygen
10. High Ammonia
11. Algal and Bacterial Toxins
12. Toxic Chemicals: Pesticides/ Polychlorinated Biphenyls (PCBs)/Metals
13. Toxic Chemicals: Herbicides/Endocrine Disrupting Compounds (EDCs)
14. Pathogens and Parasites

# The CADDIS Process



# Scoring Evidence

Over 50 worksheets consisting of almost 400 pages of information were used in the Susquehanna CADDIS

## Types of Evidence Considered

Evidence Type	Definition
<b>Spatial Co-occurrence</b>	The biological effect is observed where the cause is observed, and not where the cause is absent
<b>Temporal Co-occurrence</b>	The biological effect is observed when the cause is observed, and not when the cause is absent
<b>Stressor-Response from Elsewhere</b>	At the affected sites, the cause must be at levels sufficient to cause similar biological effects in laboratory or other field studies
<b>Evidence of Exposure or Evidence of Mechanism</b>	Measurements of the biota show that relevant exposure to the cause has occurred, or that other biological mechanisms linking the cause to the effect have occurred
<b>Causal Pathway</b>	Measurements or models demonstrate the occurrence of steps in the causal pathway linking sources to the cause, increased susceptibility of the organism(s), or conditions permitting interaction of the cause and the organism(s).



# Results: Unlikely Candidate Causes

- **High Flows** – High spring flows (which could wash YOY SMB downstream) have not significantly changed over time and do not appear to be the factor driving reduced YOY recruitment into the adult population.
- **Intraspecific Competition** – Measures of fish health (length/weight) remained within optimum ranges before and after 2005.
- **YOY Food Quality (Fatty Acids)** – Food base  $\omega 3/\omega 6$  fatty acid ratios were within healthy ranges.
- **Temperature** – Water temperatures do not exceed the upper lethal limits for YOY SMB

# Results: Unlikely Candidate Causes

- **pH** – pH levels have increased over time at some sites, but highest pH observations were not within the area of concern.
- **Dissolved Oxygen** – Levels were not low enough to cause direct mortality.
- **Ammonia** – Measured concentrations are well below levels of concern for YOY SMB.
- **Toxic Chemicals** – Concentrations of metals and organic toxicants were not clearly higher within the area of concern.

# Results: Uncertain Candidate Causes

- **Interspecific Competition** – Not enough community data and invasive species relationships to determine clear links.
- **YOY Food Quality (Thiaminase)** – High levels of thiaminase were observed in the Mimic Shiner (invasive to the Susquehanna Drainage), but there's not enough evidence to suggest SMB are consuming Mimic Shiner.
- **Egg Quality** – Some egg thiamine levels were low enough to suggest immune suppression, but no benchmarks are established specifically for SMB.
- **YOY Habitat** – YOY habitat quantity and quality need to be documented in order to evaluate this candidate cause.



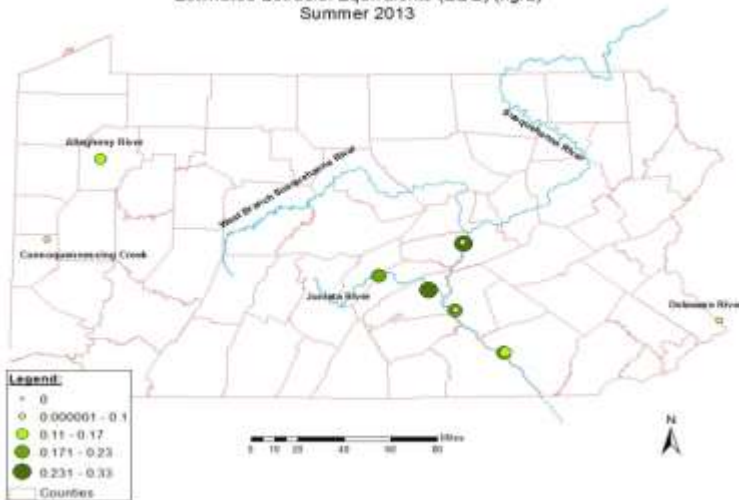
# Results: Uncertain Candidate Causes

- **Temperature (non-lethal)** – Higher temperatures are generally observed within the area of concern, possibly causing stress or optimum temperatures for pathogens. However, more data are required.
- **Dissolved Oxygen (non-lethal)** – Lower concentrations were observed at some locations, possibly causing stress. More data are required.
- **Algal & Bacterial Toxins** – Available evidence was inconclusive and more data are needed.
- **Pathogens & Parasites (acting alone)** – Other factors or interactive effects may influence the impact of pathogens and parasites, but more research is needed.

# Results: Likely Candidate Causes

## Endocrine Disruption Compounds and Herbicides

Susquehanna Study Passive Samplers  
Estimated Estradiol Equivalents (EEQ) (ng/L)  
Summer 2013



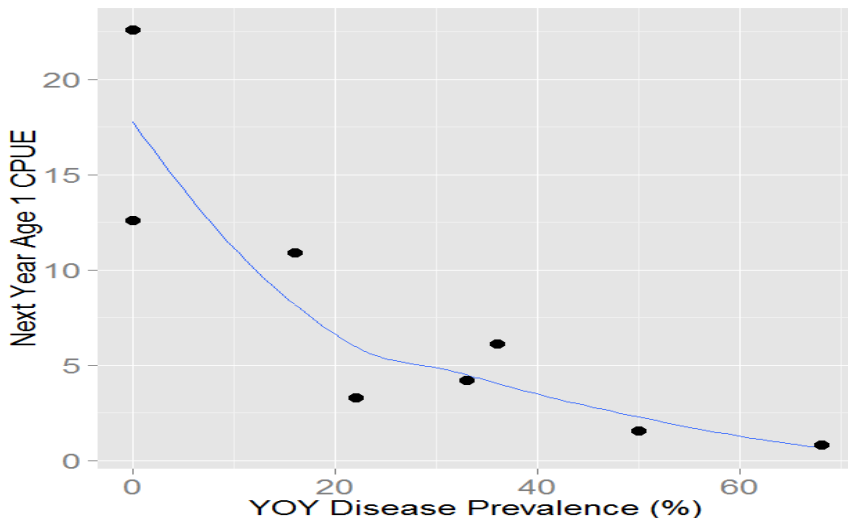
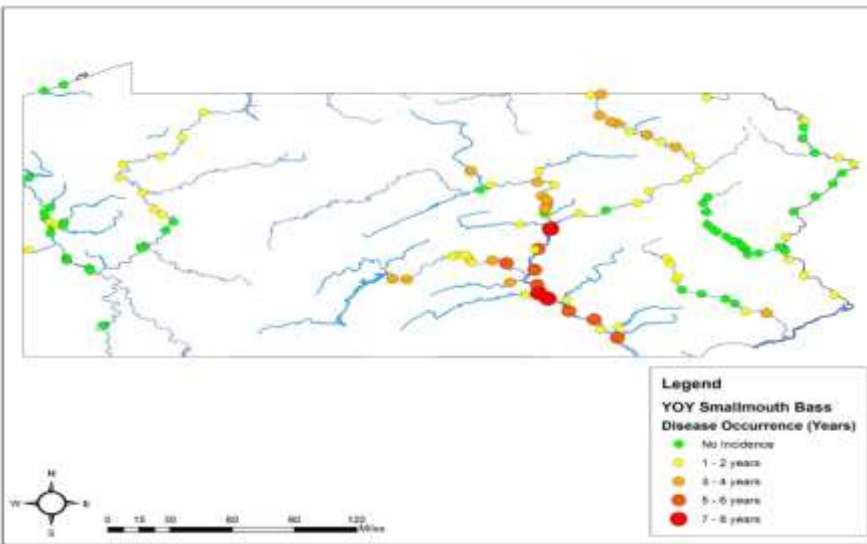
Susquehanna Study Passive Samplers  
Triazine Pesticides (ng/L)  
(Atrazine, Prometon, Desethylatrazine, Simazine)  
Summer 2013



- Concentrations of potential EDCs and herbicides are higher at the subject sites than comparison sites.
- Higher frequency of testicular oocyte formation in adult SMB from subject sites lends support that exposure to EDCs is at biologically meaningful concentrations
- However, much more data need to be collected and there needs to be evidence that links this cause to the SMB issues.

# Results: Likely Candidate Causes

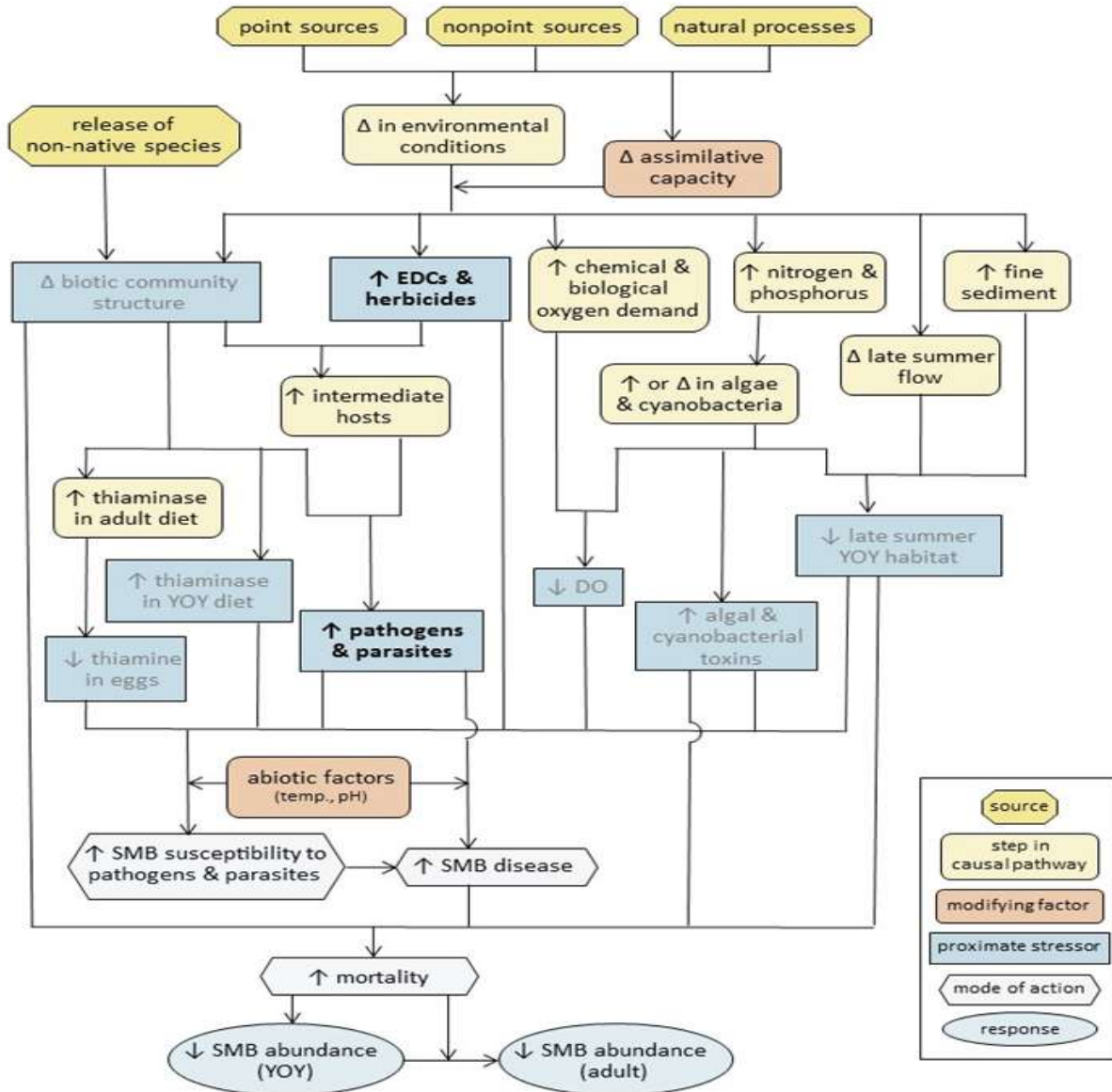
## Pathogens and Parasites



- There is a considerable linkage between observed disease of YOY SMB and recruitment into the adult population as demonstrated by a high correlation.
- More data on specific pathogens and their virulence are needed.
- General consensus that Pathogens and parasites were likely interacting with other candidate causes in order to produce the disease.



# Results: Likely Candidate Causes



1. The evidence available for herbicides was limited and future monitoring is planned to obtain more data.

2. The workshop participants concluded that pathogens and parasites were likely interacting with other candidate causes in order to produce the disease. It is uncertain whether they would be capable of doing so alone.

# Accomplishments and Recommendations

- Reduced the likelihood of 8 candidate causes allowing for stronger focus on uncertain and likely causes.
- Provided a chance to consolidate research and coordinate future studies between multiple agencies and organizations.
- Created greater transparency on what work has been completed thus far.
- As more data are obtained, results of this CADDIS process are understood to be dynamic.



# Current and Future Work

## Needs

- Determine whether SMB have suppressed immune systems.
- Clarify interactions between water quality parameters and their relationship to SMB health.
- Need a greater understanding of conditions within YOY SMB microhabitats.
- Biological endpoints for emerging contaminants and how different ones interact

## Studies conducted in 2015

- Evaluation of immune function in wild and laboratory raised SMB
- SMB egg contaminant analysis
- Population genetics
- Movement and habitat selection studies
- Myxozoan life cycle research
- Intense water and sediment collections
- Analyzing the susceptibility of SMB to LMBV
- Determining cyanotoxin levels in YOY
- Determining if YOY SMB have diets high in thiaminase

# Conclusion and Next Steps

- There will be a number of on-going efforts in the lower main stem of the river that will be pursued for the foreseeable future.
- Move some of the effort into the tributaries where sources of problems are more likely to occur.
- Expand new river methodologies statewide for more appropriate water quality assessments.
- Continue to assist with and fund PFBC projects





# Conclusion and Next Steps

## Impairment

- CADDIS findings do not equal impairment
- “Impairment” doesn’t help if the cause is not identified
- Listing will not bring immediate help to the bass or the river
- DEP will release list of impaired waterways in early 2016





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## Mission Statement

**The Department of Environmental Protection's mission is to protect Pennsylvania's air, land and water from pollution and to provide for the health and safety of its citizens through a cleaner environment. We will work as partners with individuals, organizations, governments and businesses to prevent pollution and restore our natural resources.**