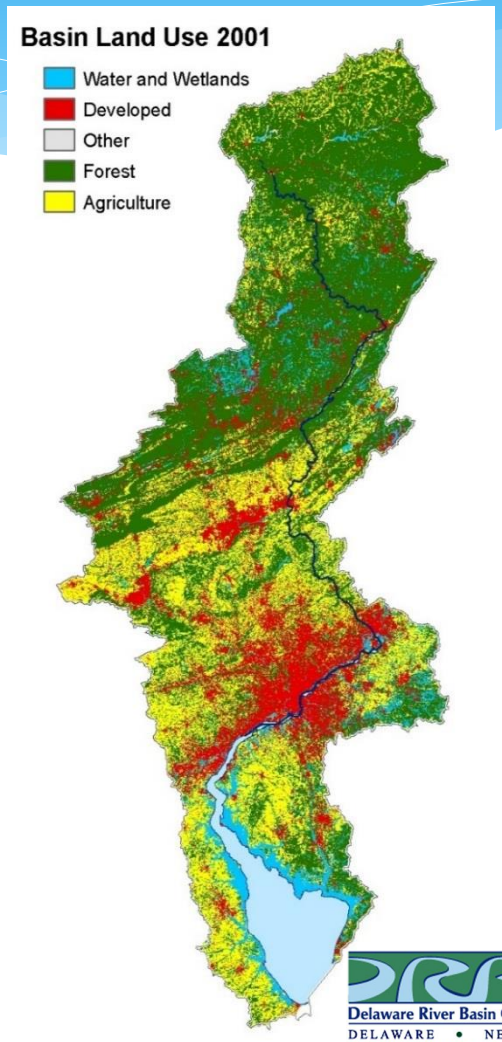
Water Quality Monitoring & Assessment in the Delaware River & Bay

Ron MacGillivray, Ph.D.
Senior Environmental Toxicologist
Delaware River Basin Commission
Temple University WET Center Seminar
April 12, 2018



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Outline

* DRBC
  * Regulations
  * Monitoring Goals
  * Data Uses
* Status and Trend
  * Water, Fish, Sediment
  * Biological Monitoring
  * Ambient Toxicity Bioassay
* Environmental Management
  * Legacy Pollutants
  * Dissolved Oxygen
* Criteria Development
  * Metal bioavailability
* Occurrence in River
  * Emerging contaminants

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Why was the DRBC created?

- Water supply shortages and disputes over the apportionment of the basin's waters;
- Severe pollution in the Delaware River and its major tributaries;
- Serious flooding

The 1937 *Philadelphia Record* editorial page cartoon depicts the time when the tidal Delaware was an open sewer, where pollution in some stretches robbed the river of all its oxygen needed to support fish and other aquatic life.

Five Equal Members:
Delaware
New Jersey
Pennsylvania
New York
Federal Government

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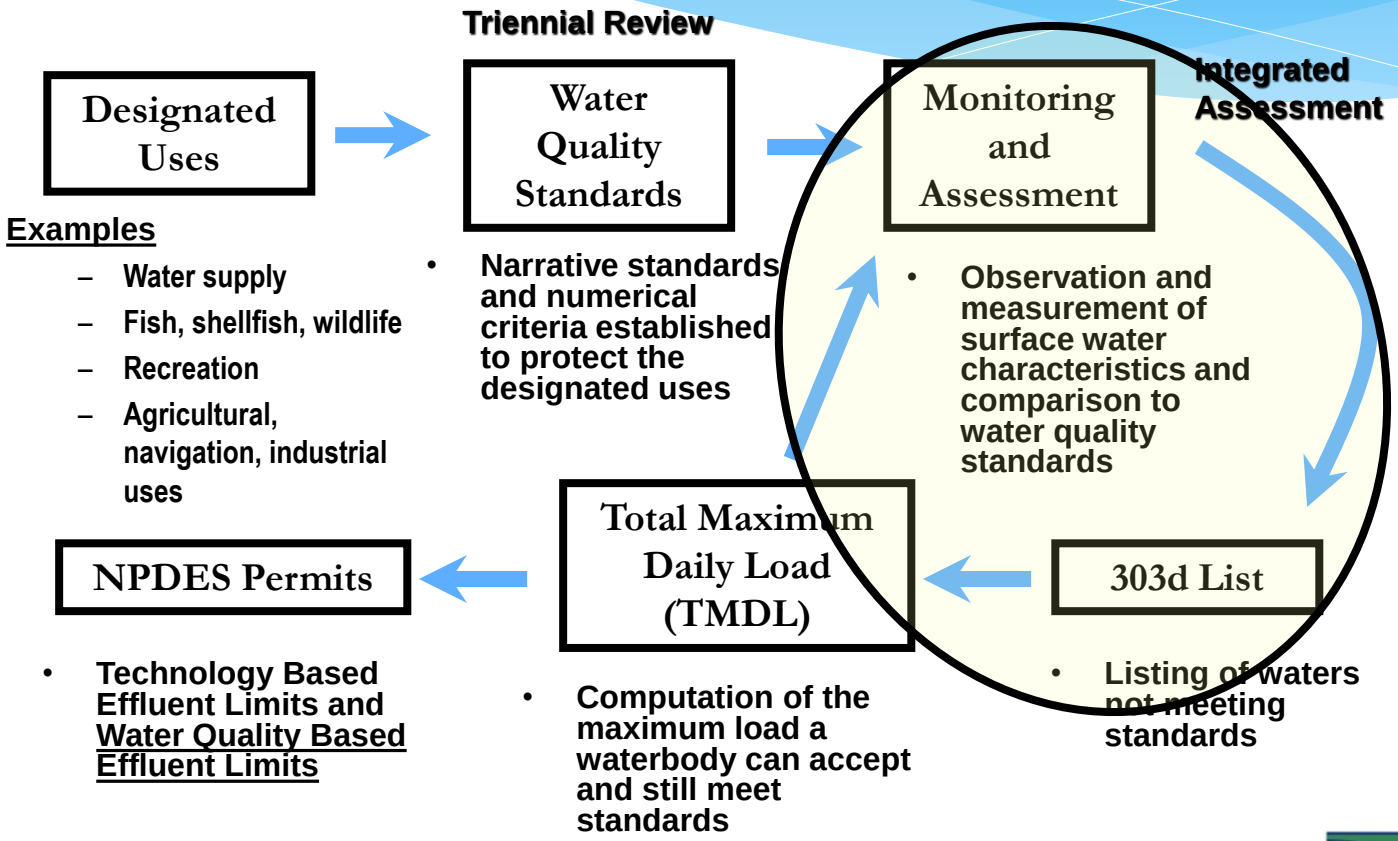
Clean Water Act Framework for Water Quality Management



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Clean Water Act Framework for Water Quality Management

Water Quality Standards

anti-degradation policies to prevent deterioration of high-quality waters

WQS Objectives:

* protection or preservation of **uses** associated with the water body
* protection or preservation of the **water quality** with the intent of sustaining currently existing conditions
* preservation of the water resources for **future or intended uses**

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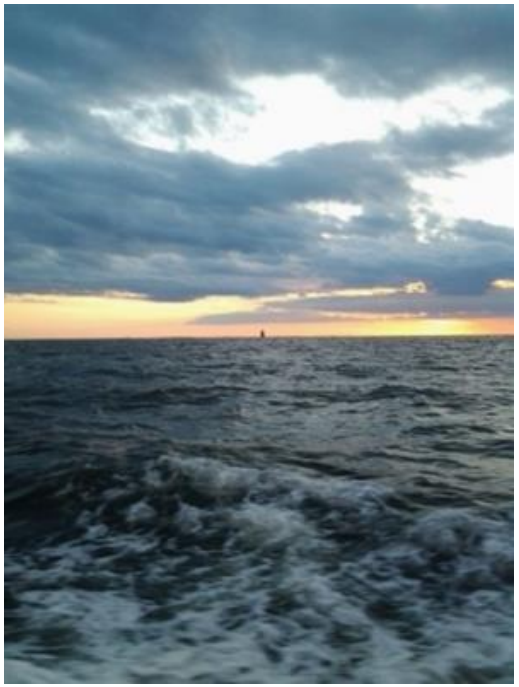
Monitoring Goals

* Use current scientific knowledge and technology
* Measure regulatory objectives of sustainable healthy waters
* Assessment (status and trends)
* Inform adaptive management
* Data coordination



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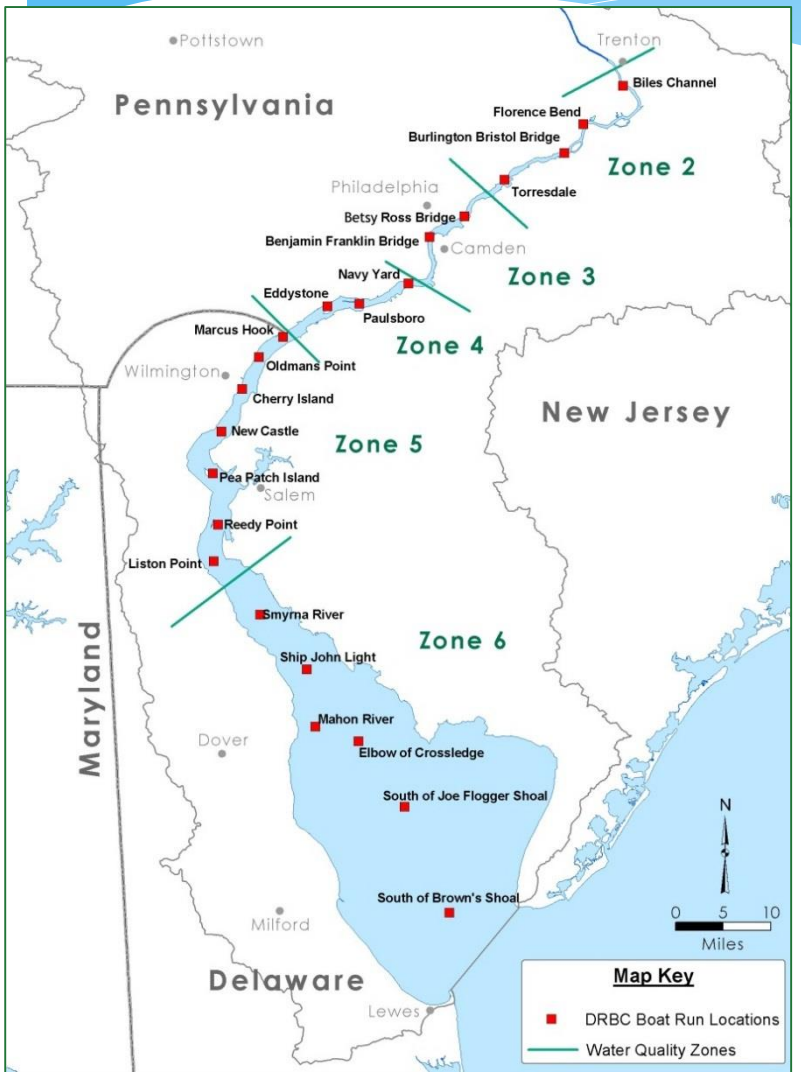
Delaware Estuary Water Quality Monitoring (Boat Run)
Surface Water Monitoring



* Since mid-1960's (in some format)

* 22 Sites per month
* Parameter Groups
  - Routine
  - Nutrients
  - Bacteria
  - Metals
  - Other parameters
* Sampling & Analysis performed by DNREC under contract to DRBC

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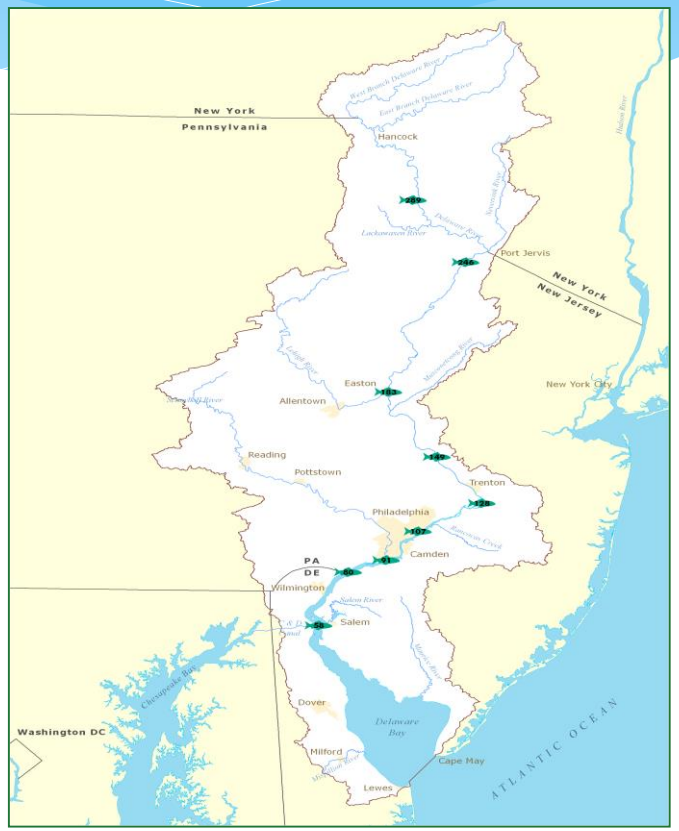
Fish Tissue Monitoring

* Tidal and non-tidal in Delaware River.
* Frequency: Yearly 2000 - 2007, 2010, 2012, 2015, 2016 (Bay), 2018 (planned)
* Two fish species at each site
  - Tidal: white perch, channel catfish
  - Non-tidal: smallmouth bass, white sucker
* PCBs, Mercury, Methylmercury, Chlorinated pesticides, Dioxins/Furans, PFAS, Metals
* Data used for fish consumption advisories by states



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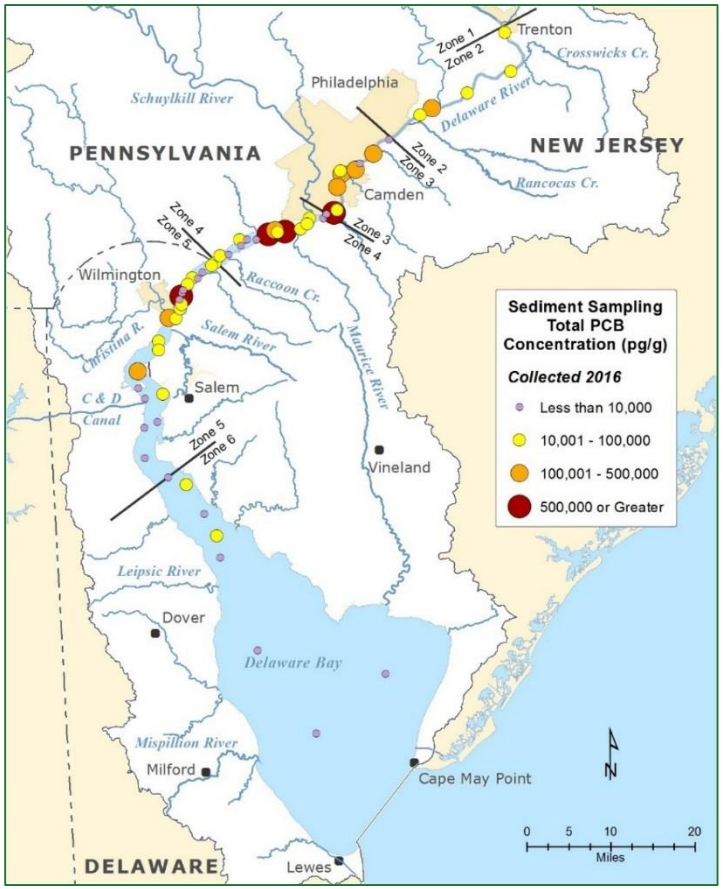
Sediment Monitoring



* Periodic
* PCBs, PAHs, PFAS, Pesticides

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Biological Monitoring Program

* Macroinvertebrates
* Periphyton/Phytoplankton
* 25 riffle sites in non-tidal Delaware River
* Water Quality Parameters
* Every 2 or 3 years
* Assessment included in Delaware River Water Quality Assessment (305(b))

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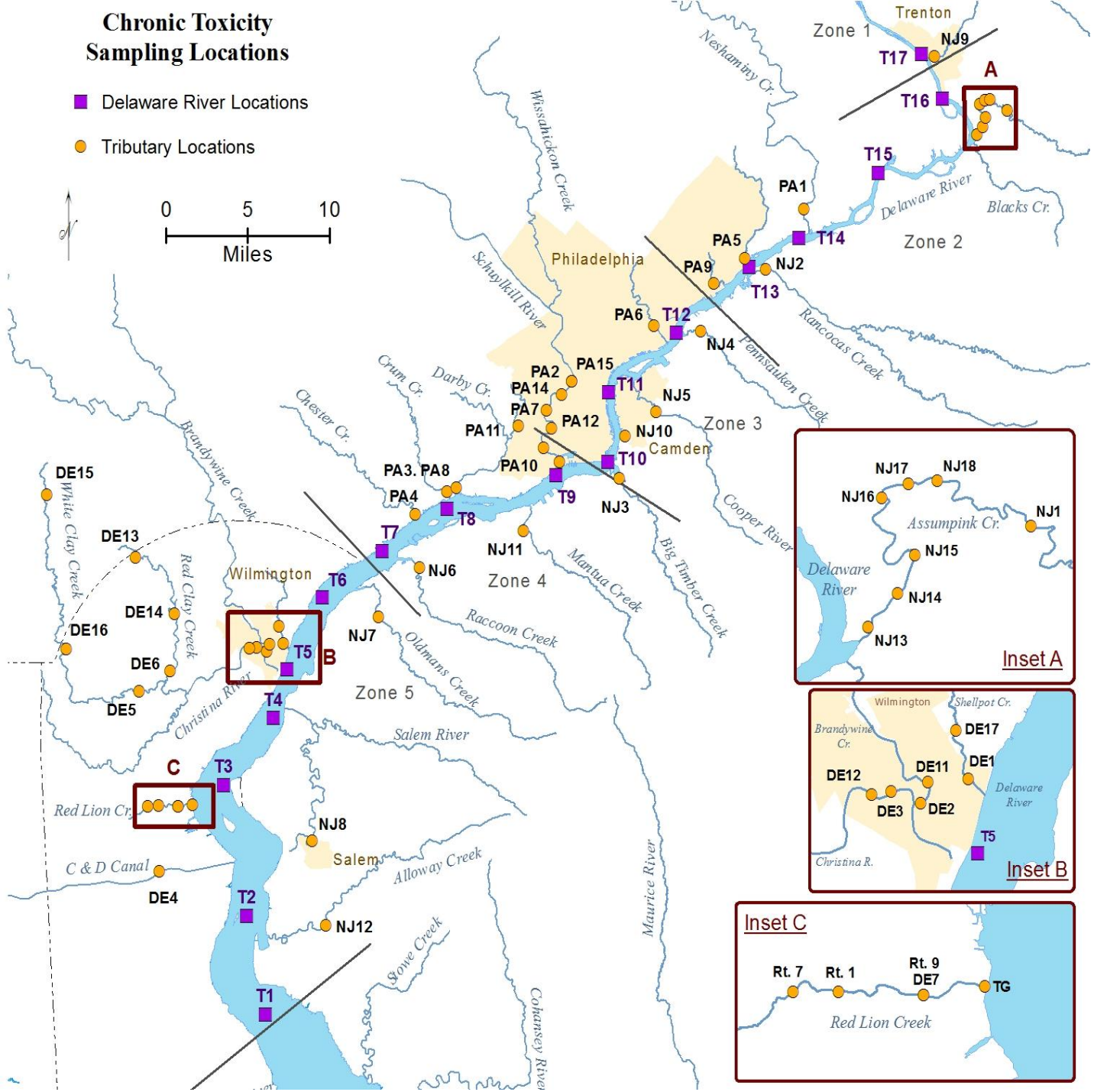

Surface Water Toxicity (survival, growth, reproduction)

- 1990 to present
- Mixtures
- Unknown contaminant
- Cumulative
- Effect- based testing (other tools)
- 2018 survey

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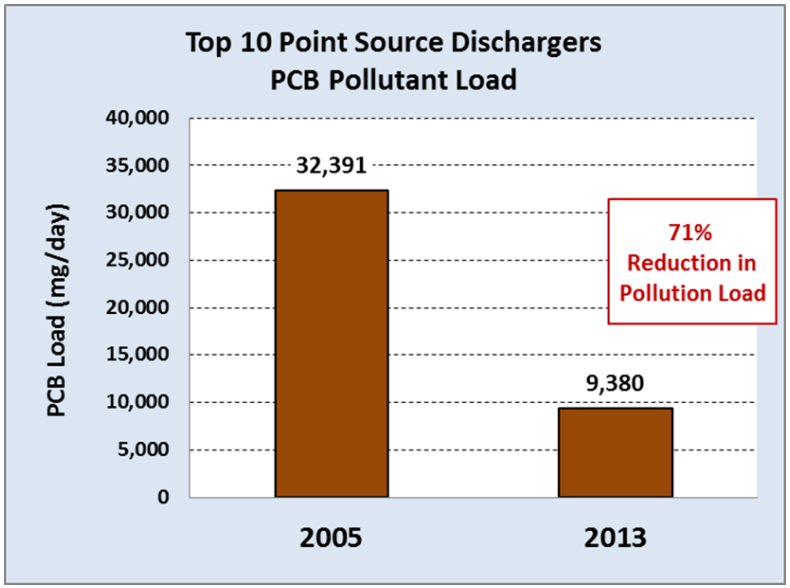
Polychlorinated Biphenyls (PCBs) Legacy Pollutant

* **Problem:** Early 2000's ambient concentrations exceeding criteria by 2 to 3 orders of magnitude; Fish consumption advisories;
* **Action:** DRBC developed TMDLs adopted by EPA in 2003 and 2006;
* **Implementation:** Pollutant minimization plans (**PMPs**)– facilities identify and implement means of achieving maximum practicable reductions
* **Status:**
  - 10 largest point sources reduced by over 70%
  - Nationally recognized program



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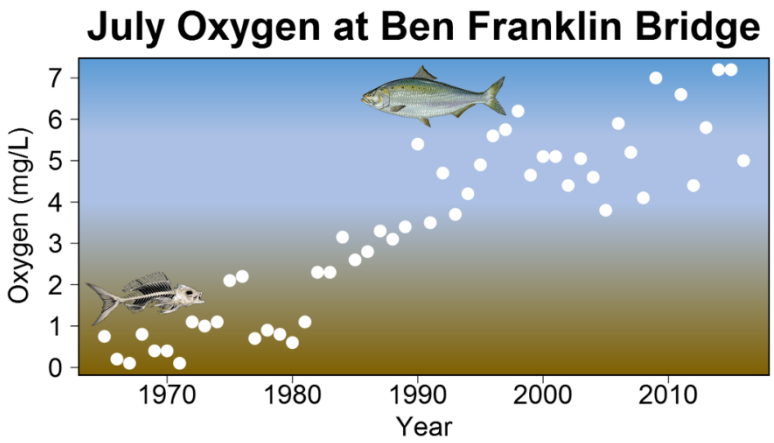
Dissolved Oxygen hypoxia and eutrophication model



* Improvement in DO levels in the Delaware River since 1965
* Currently examining if current criteria for DO need revision to better protect fish reproduction

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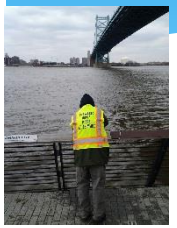
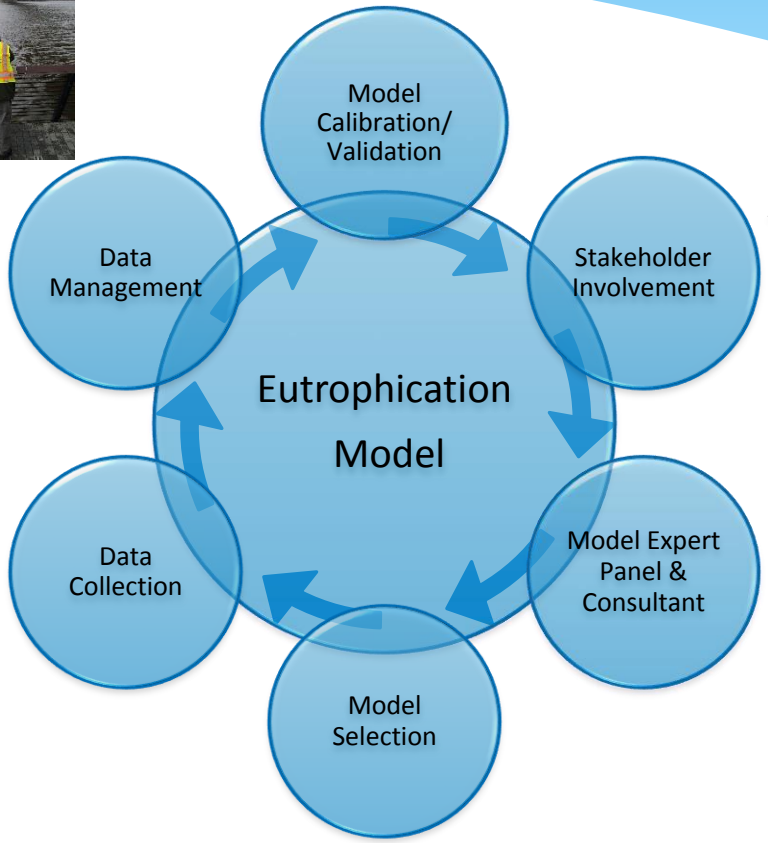
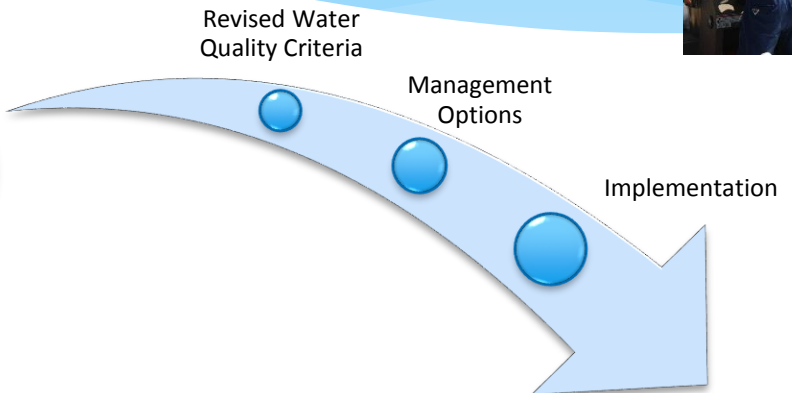
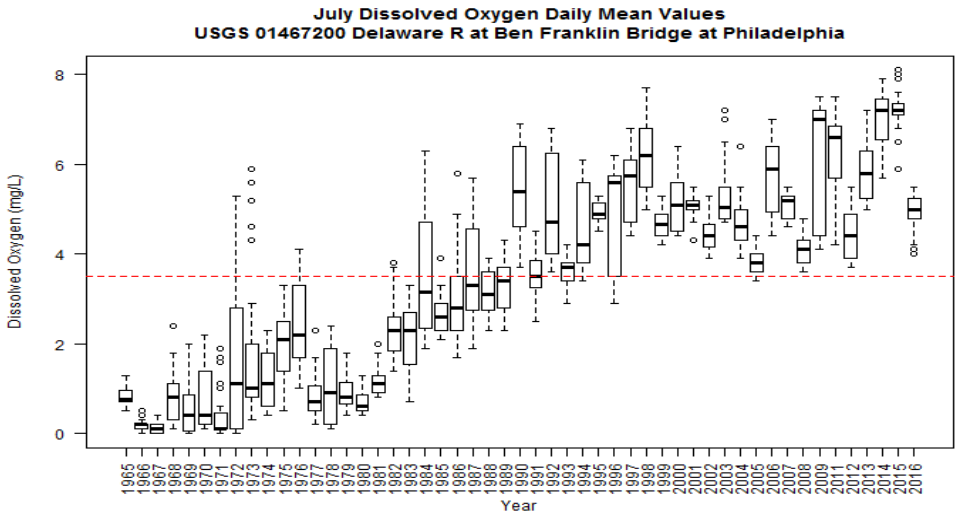
Modeling Eutrophication Processes in the Delaware Estuary to Link Watershed Efforts to Control Nutrient Impacts Environmental Management









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US Army Corps of Engineers®

25 Years of Science-based Metals Policy

slide courtesy of Mary Reiley, USEPA

Criteria Development

Early 1980's

Total Recoverable Metals

Not optimal but stable, reproducible, implementable

(USEPA 1985)

1985

Acid Soluble Metals

An acknowledged improvement (USEPA 1985)

1993

Dissolved Metal Concentration

Base metals criteria on bioavailable metal

(USEPA, 1993)

1994

Water Effect Ratios

Filled the chemistry gap between lab and ambient water

(Davies, 1994)

2007

Biotic Ligand Model

Accounts for the variety of water chemistry parameters that impact metals bioavailability (USEPA, 2007)

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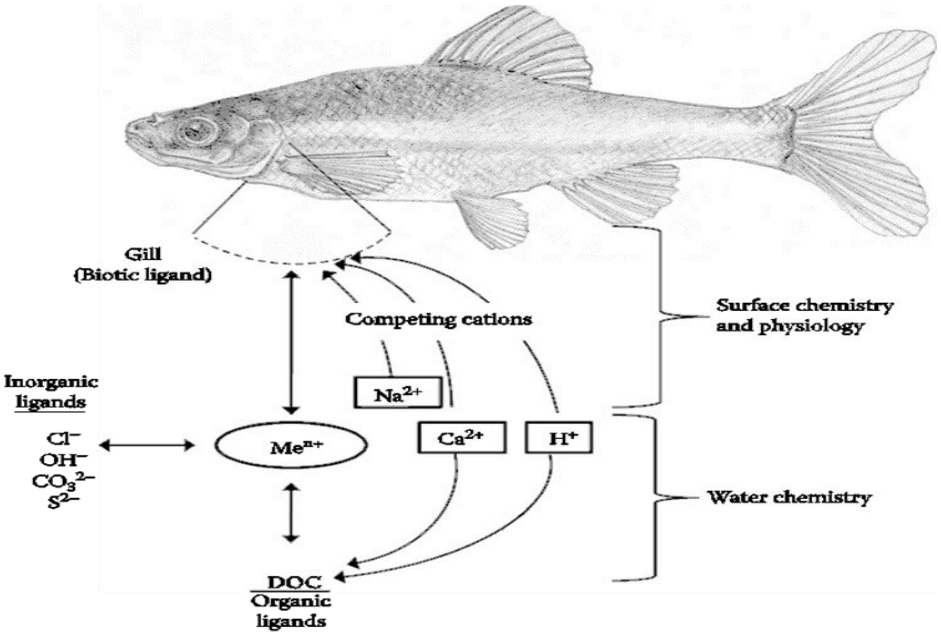
EPA Aquatic Life Ambient Freshwater Quality Criteria – Copper 2007 Revision Biotic Ligand Model Based



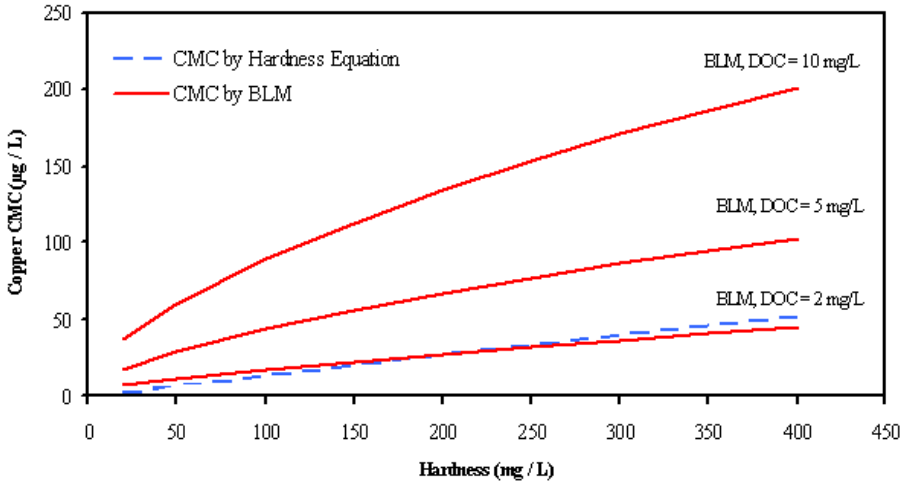


Figure 5. Comparison of CMC calculated by BLM or Hardness Equation Alkalinity (11 - 245 mg CaCO3/L) and pH (7.3 - 8.7) Covary with Hardness

EPA-822-R-07-001 Feb 2007

Comp. Biochem. Physiol. C, 133, 3-35, 2002

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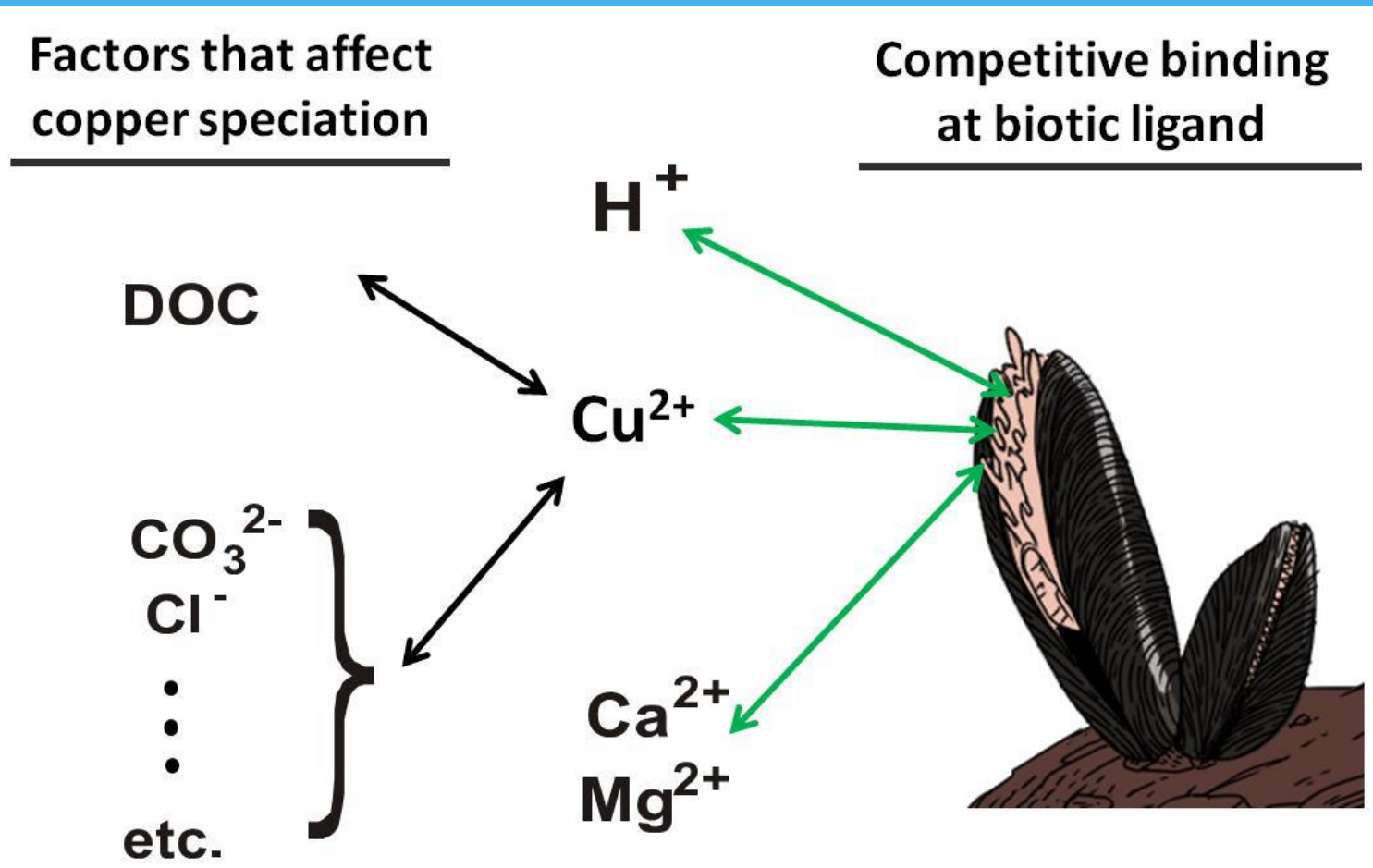
Draft Estuarine/ Marine Copper Aquatic Life Ambient Water Quality Criteria July 2016



(Adapted from Santore et al. 2001).

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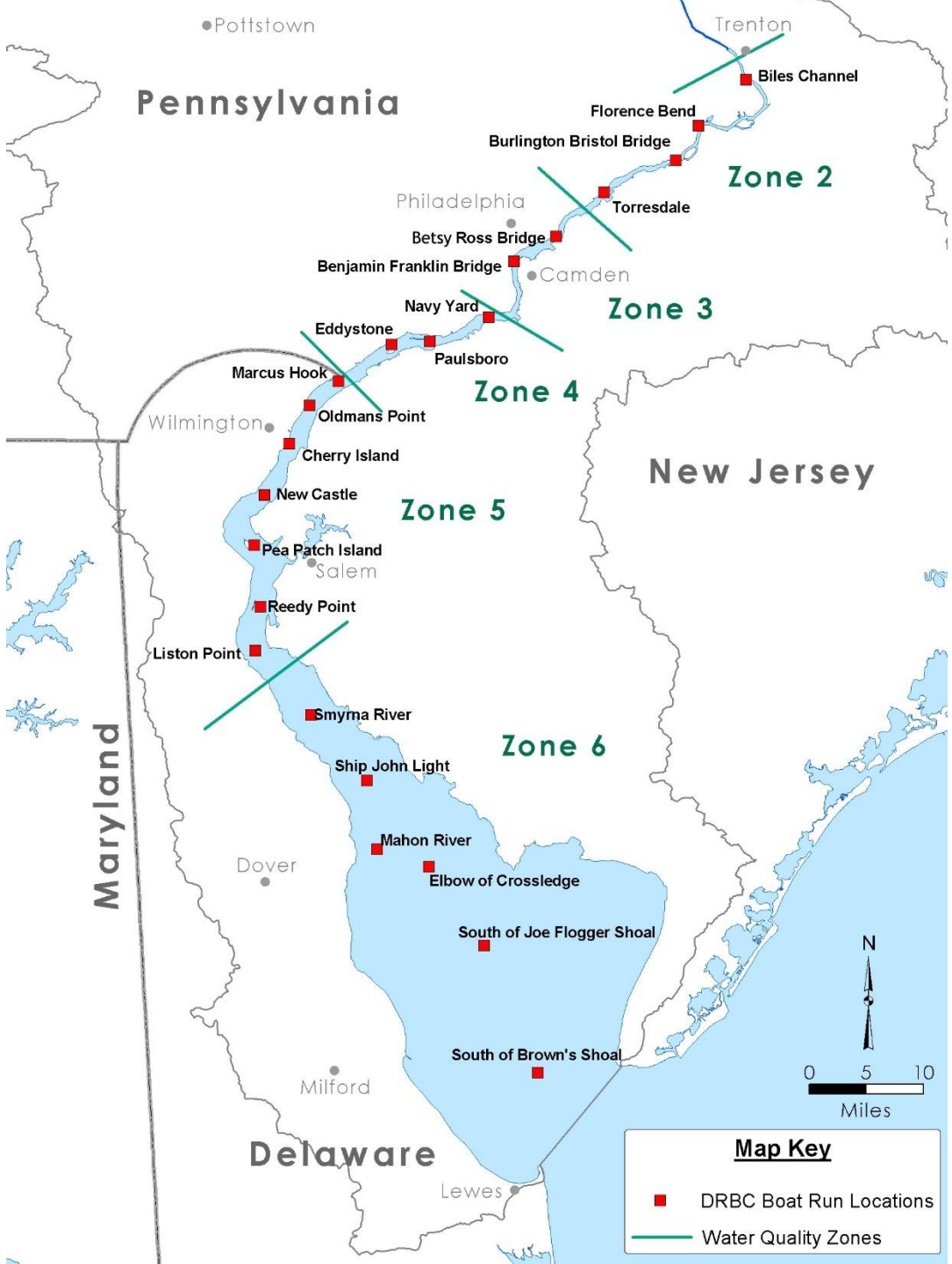

How would BLM based criteria be implemented?

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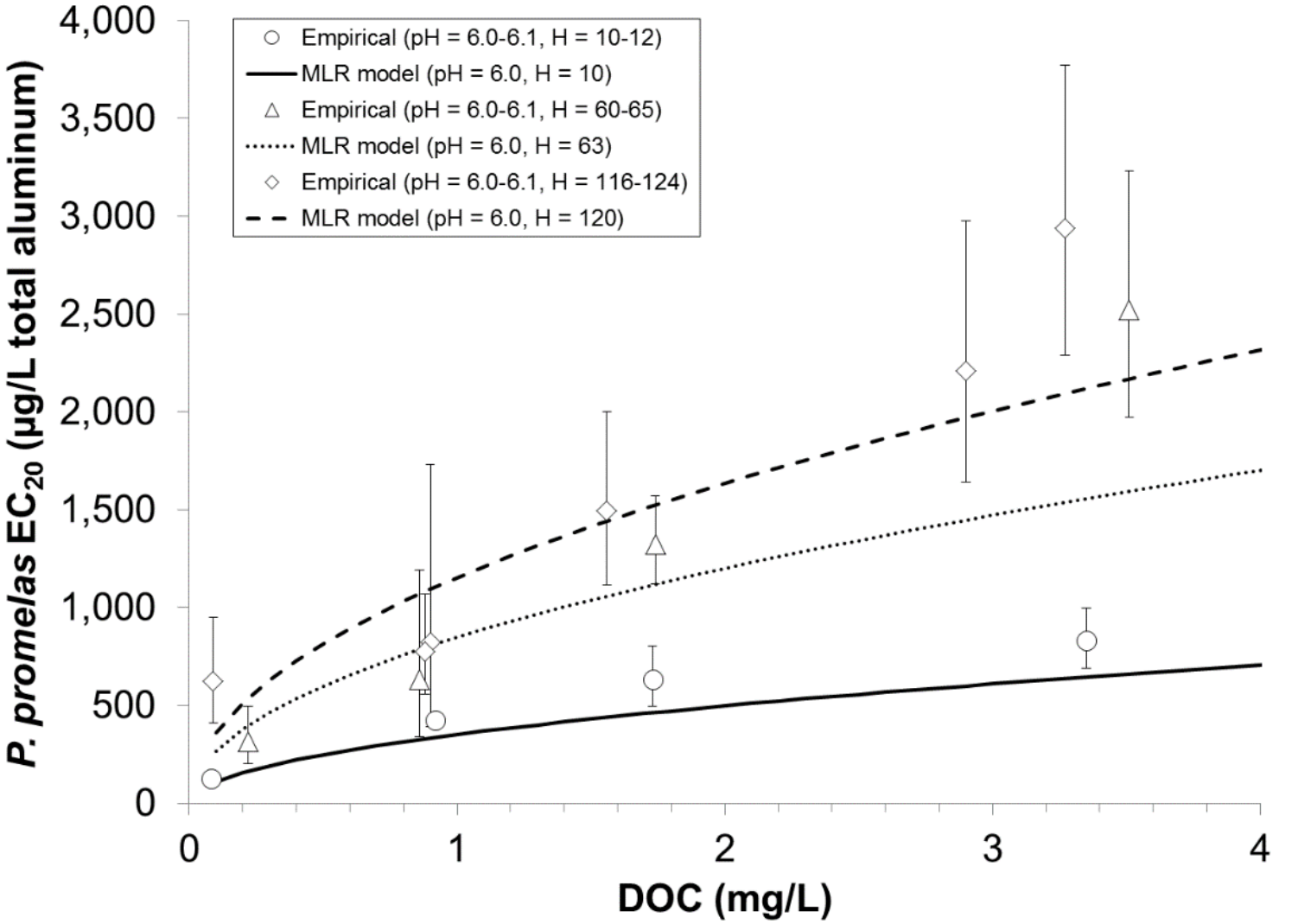
Multiple Linear Regression (MLR)

Observed and MLR-Predicted Aluminum EC20s for *P. promelas* where DOC was Varied

$$EC20 = e[-14.029 + [0.503 \times \ln(DOC)] + [3.443 \times \ln(hard)] + (3.131 \times pH) - [0.494 \times pH{:}\ln(hard)]]$$



Adapted from DeForest et al. 2017

USEPA DRAFT AQUATIC LIFE AMBIENT WATER QUALITY CRITERIA FOR ALUMINUM 2017

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Contaminants of Emerging Concern
Why are Pharmaceuticals and Personal Care Products (PPCP) of concern?

* Biological effects (diclofenac, triclocarban)
* Resistant to degradation (carbamazapine)
* Widespread and increasing use (ibuprofen, metformin)
* Wastewater treatment plants are not designed to remove (trimethoprim, erythromycin)
* Effects on aquatic life (hormone EE2)

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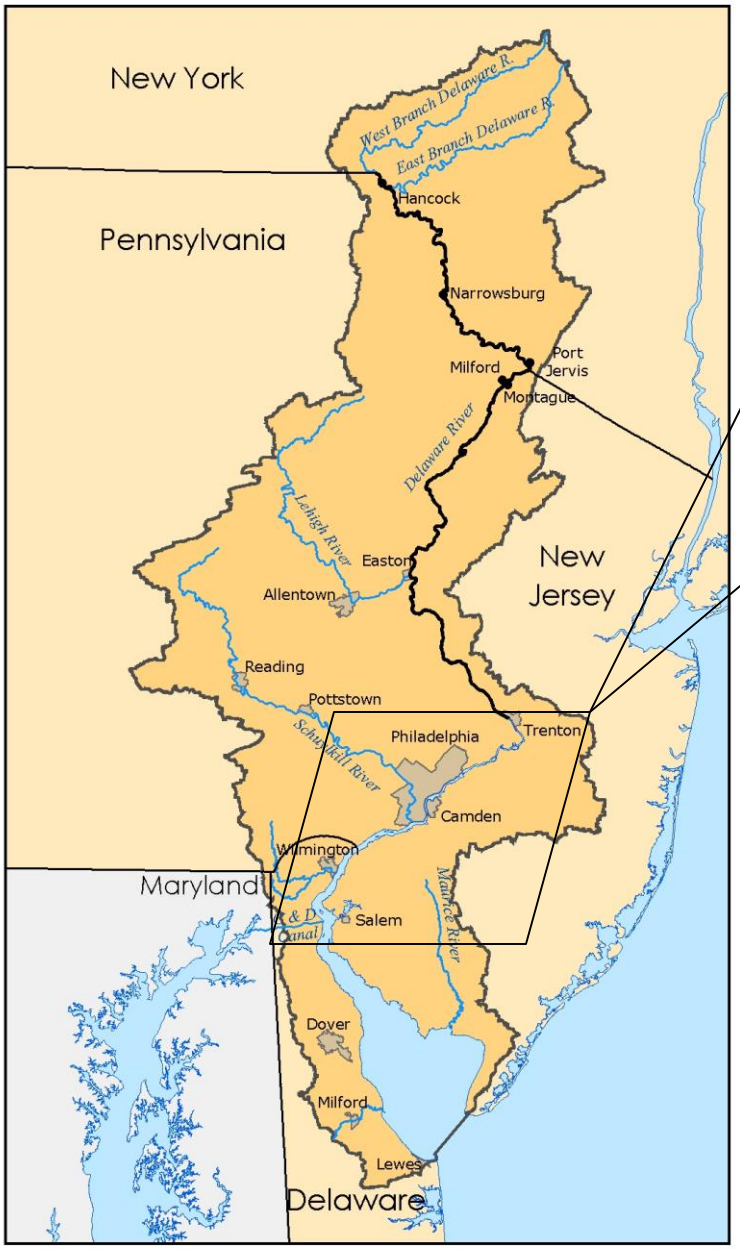
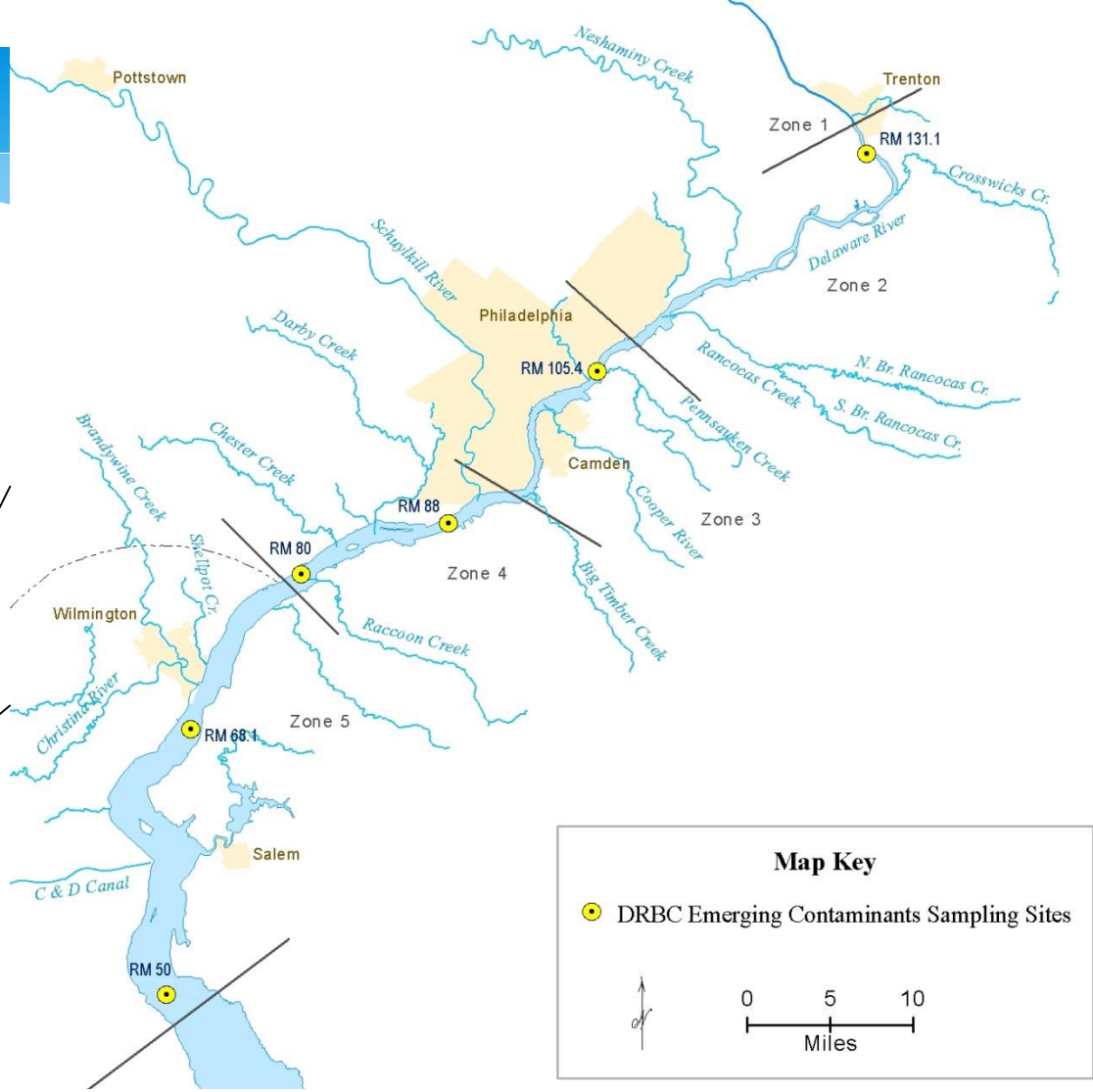
Delaware River Basin





PPCP occurrence surveys 2007, 2008, 2009 and 2017

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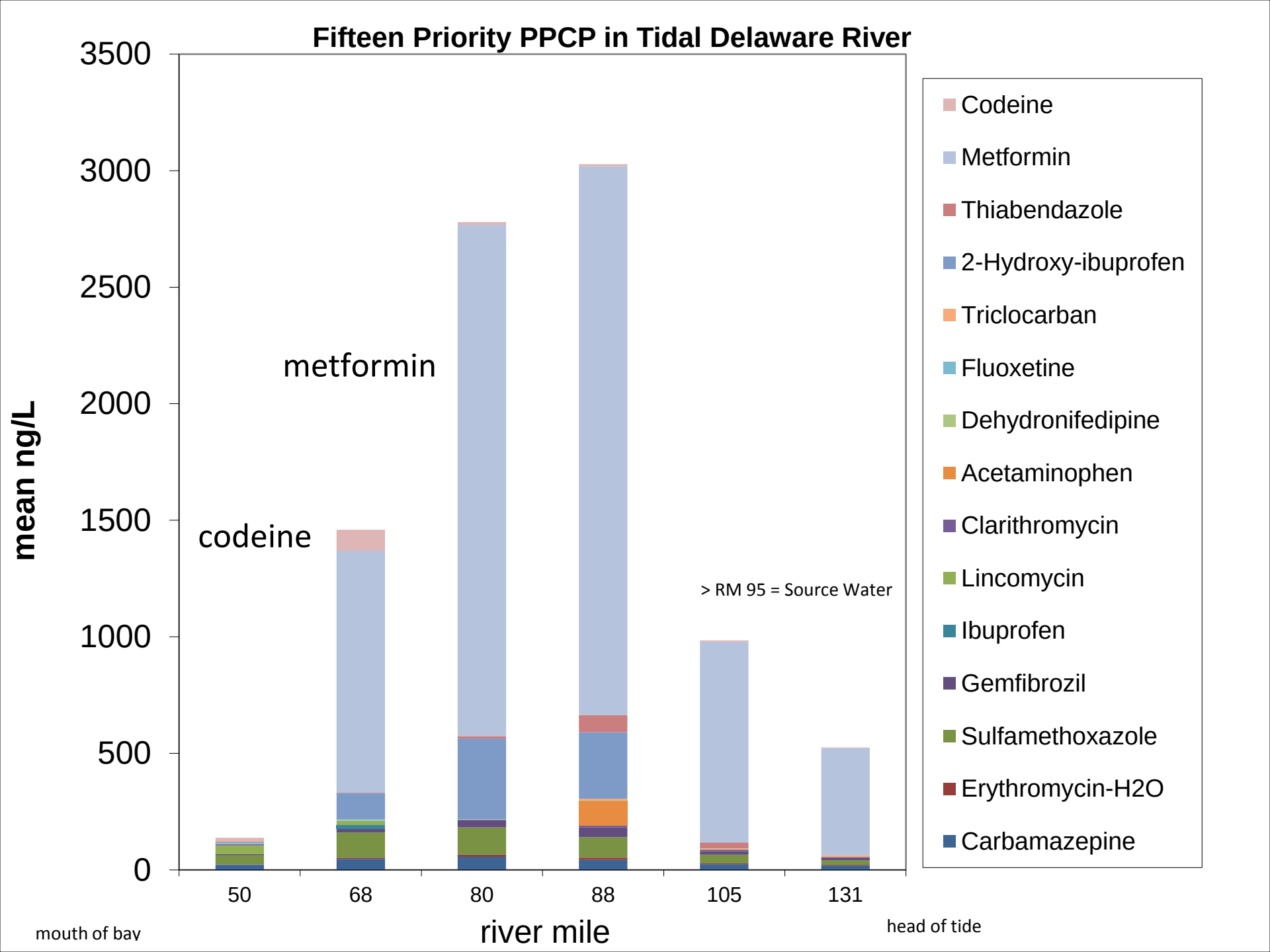
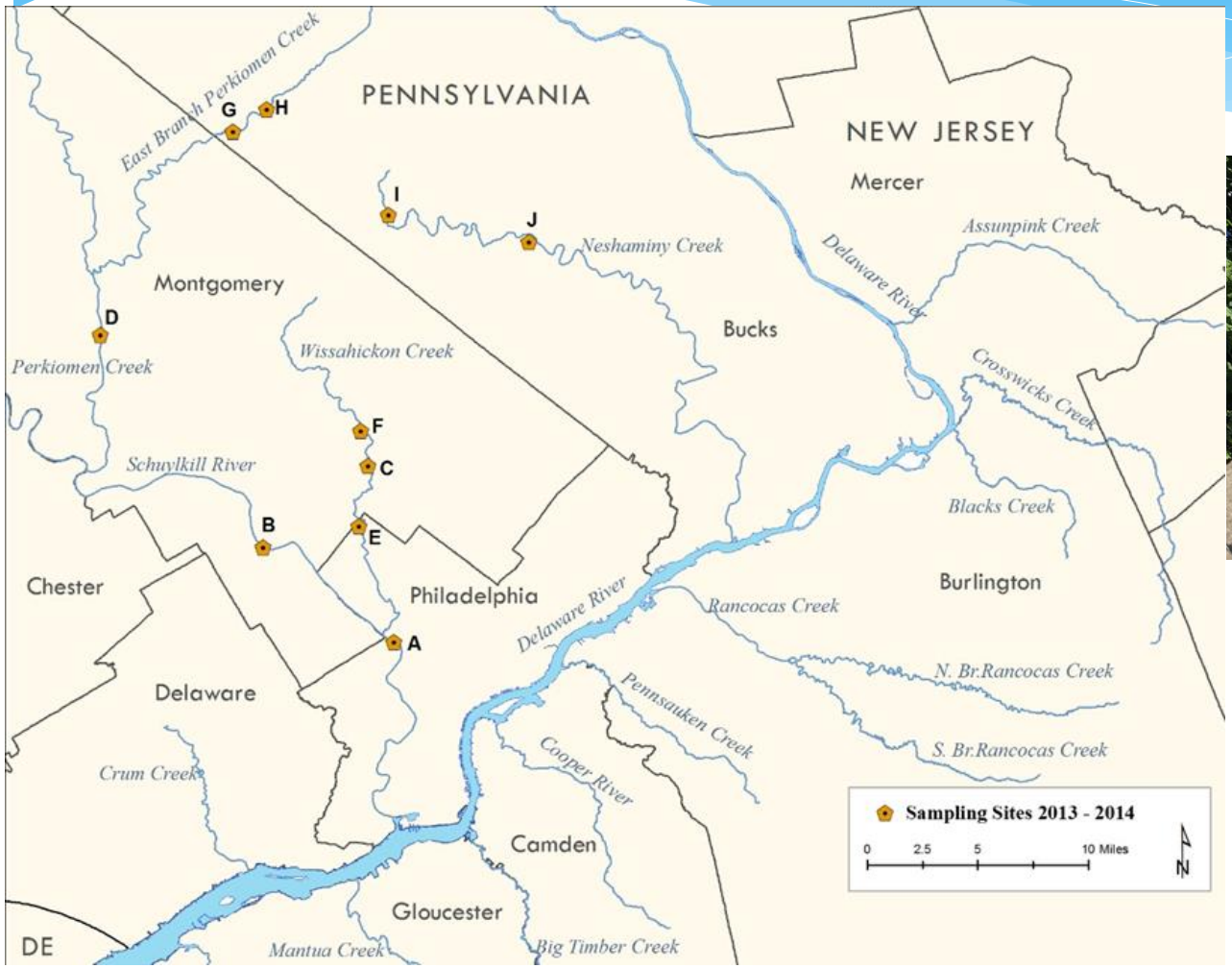

Fifteen Priority PPCP in Tidal Delaware River
mean ng/L
3500
3000
2500
2000
1500
1000
500
0
metformin
codeine
> RM 95 = Source Water
50
68
80
88
105
131
river mile
mouth of bay
head of tide
Codeine
Metformin
Thiabendazole
2-Hydroxy-ibuprofen
Triclocarban
Fluoxetine
Dehydronifedipine
Acetaminophen
Clarithromycin
Lincomycin
Ibuprofen
Gemfibrozil
Sulfamethoxazole
Erythromycin-H2O
Carbamazepine

Temple U. and DRBC
Occurrence Survey for Emerging Contaminants of Concern in Pennsylvania Tributaries of the Delaware River

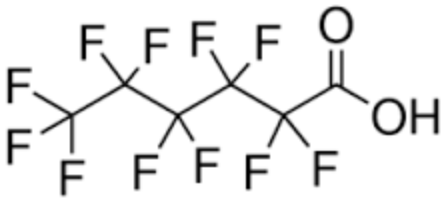


Funded by
Pennsylvania Water Resources Research Center and Pennsylvania Sea Grant

Contaminants of Emerging Concern
Why are Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) of Concern?

* Properties
* Uses
* Sources
* Stewardship
* Alternatives

* Discharges
* Persistence
* Toxicity
* Bioaccumulation
* Sinks



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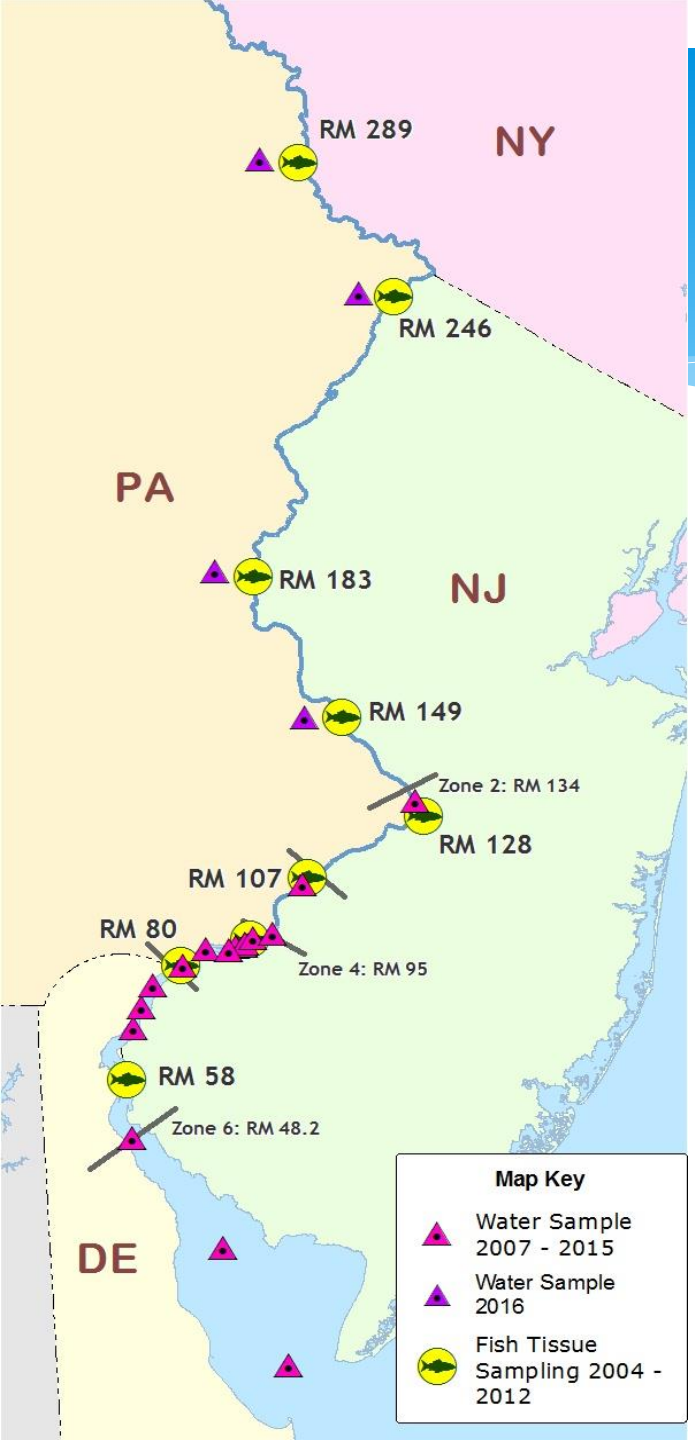
PFAS Occurrence Surveys



Surface Water Samples

- Six tidal sites in 2007 - 2009
- Fifteen tidal sites in 2015
- Four non-tidal sites in 2016

Fish Samples 2004 - 2015

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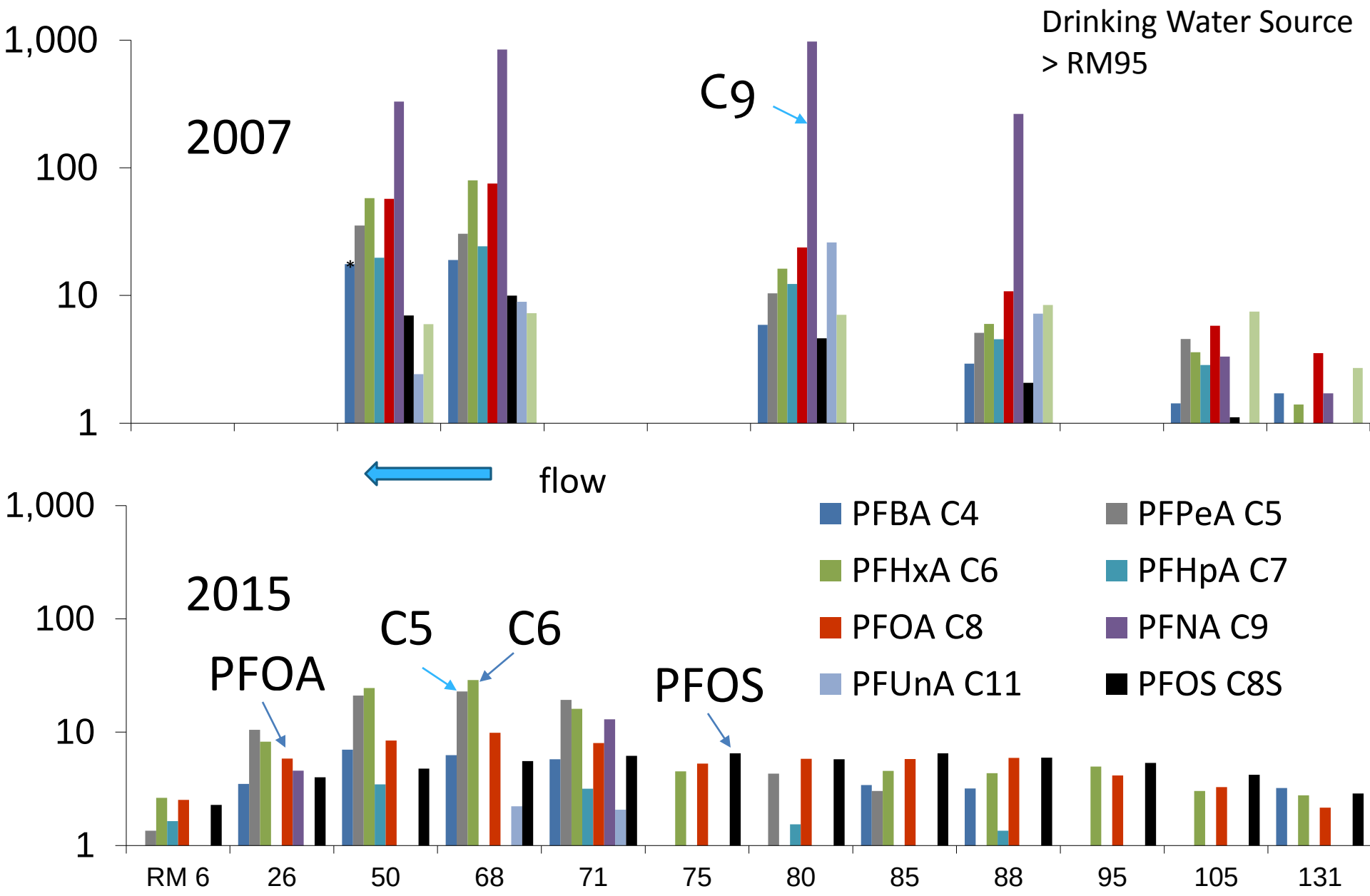
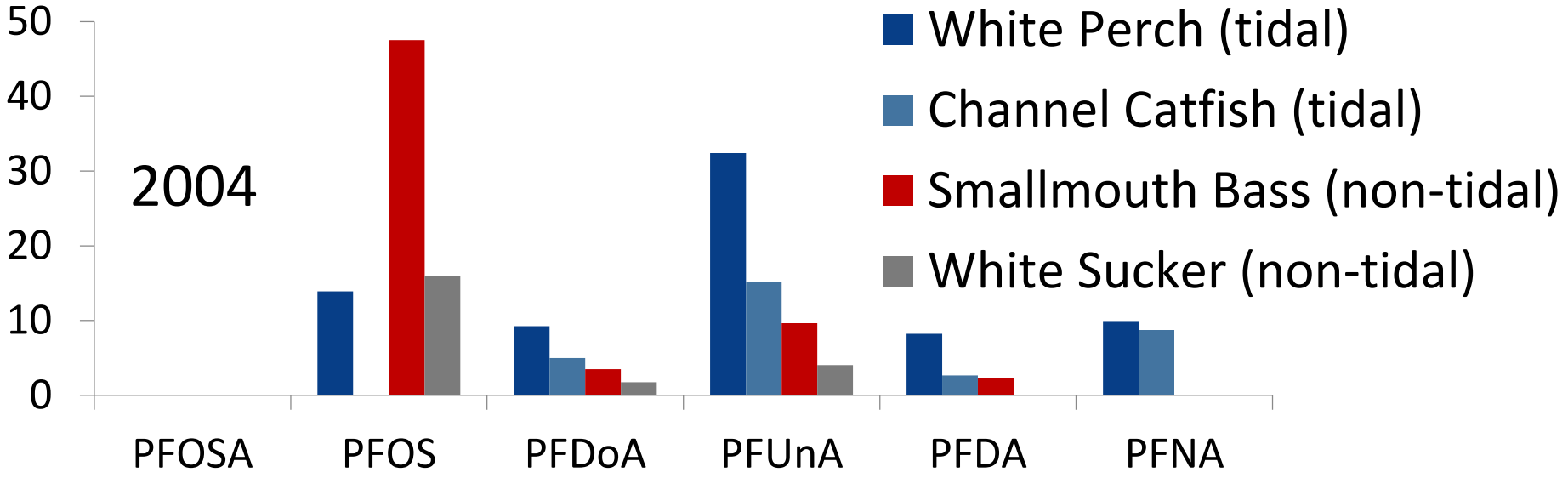
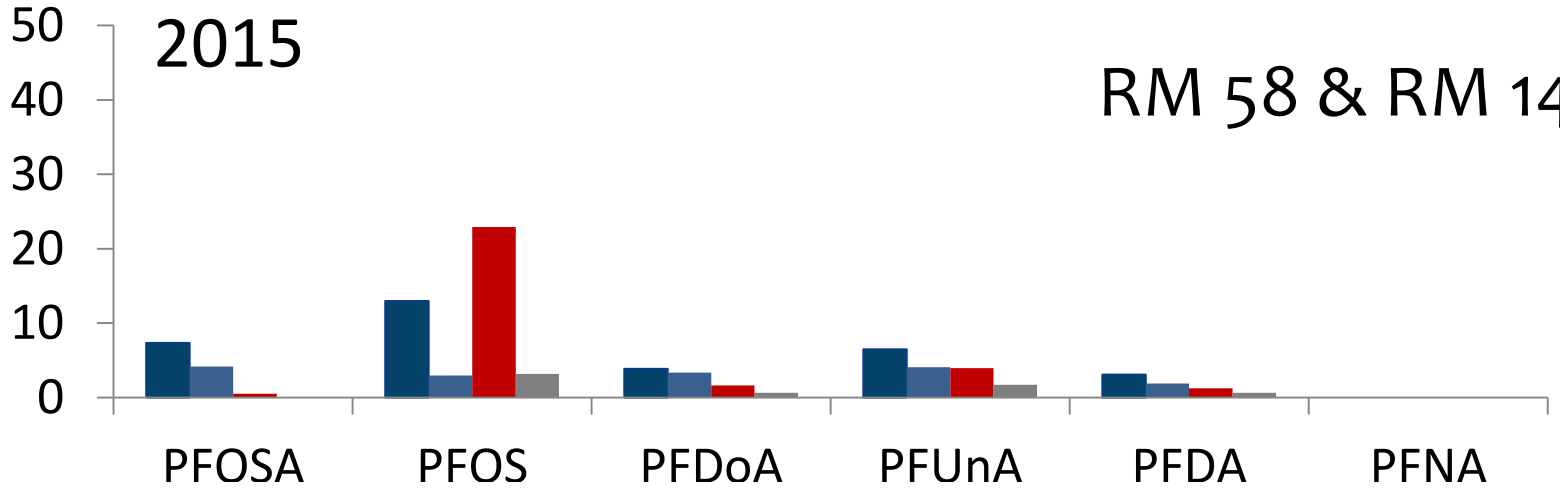
PFAS (ng/L) decreases in surface water vary by compound



PFAS (ng/g) in fish fillet vary by species, location and year





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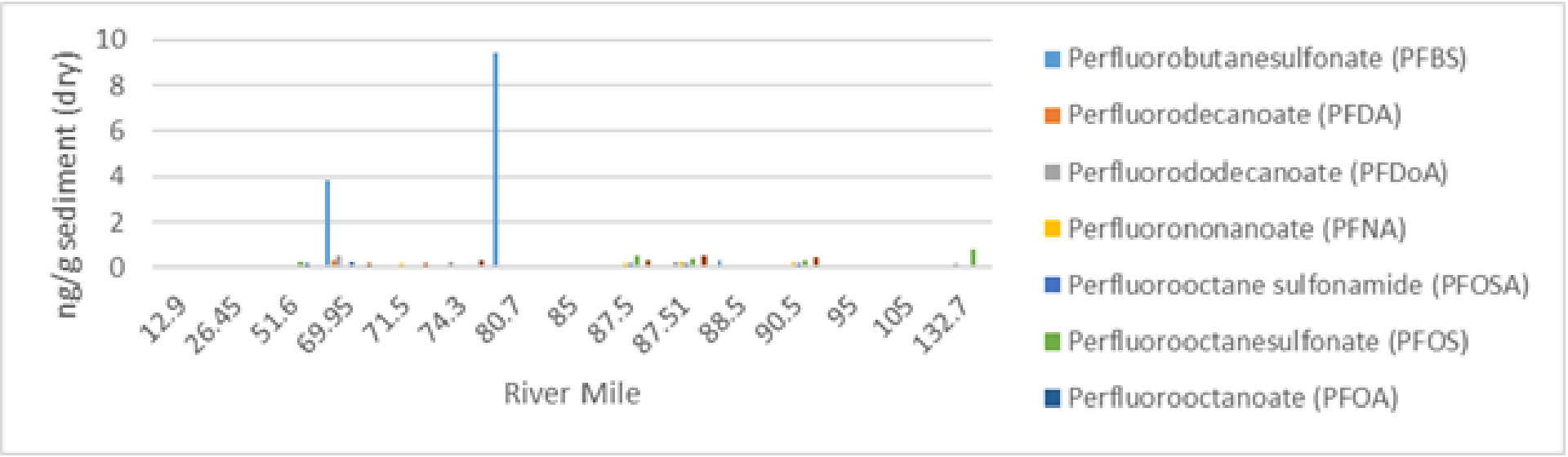
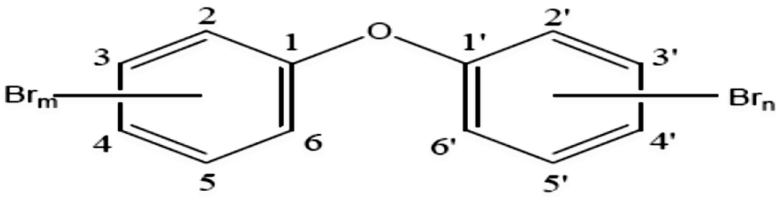
PFAS in main stem sediment - 2016



PFBS maximum concentration of 9.41 ng/g at RM 80.7.
PFOS, PFOA and PFNA maximum concentrations of 0.8, 0.169 and 0.2 ng/g

Contaminants of Emerging Concern
Why are Polybrominated Diphenyl Ethers (PBDE) Flame Retardants of Concern?

* Used in consumer products such as television casings and polyurethane foam inside furniture cushions.
* **Indoor dust** is believed to be the primary source of human exposure (~ 90%) but **dietary exposure** is also a concern
* PBDEs are characterized as persistent, bioaccumulative, toxic compounds.
* High PBDE levels in serum alter steroid hormones levels and thyroid function, motor and cognitive deficits in children
* Voluntary phase-outs, EPA action plan and SNUR, state bans including NY



where m + n = 1–10

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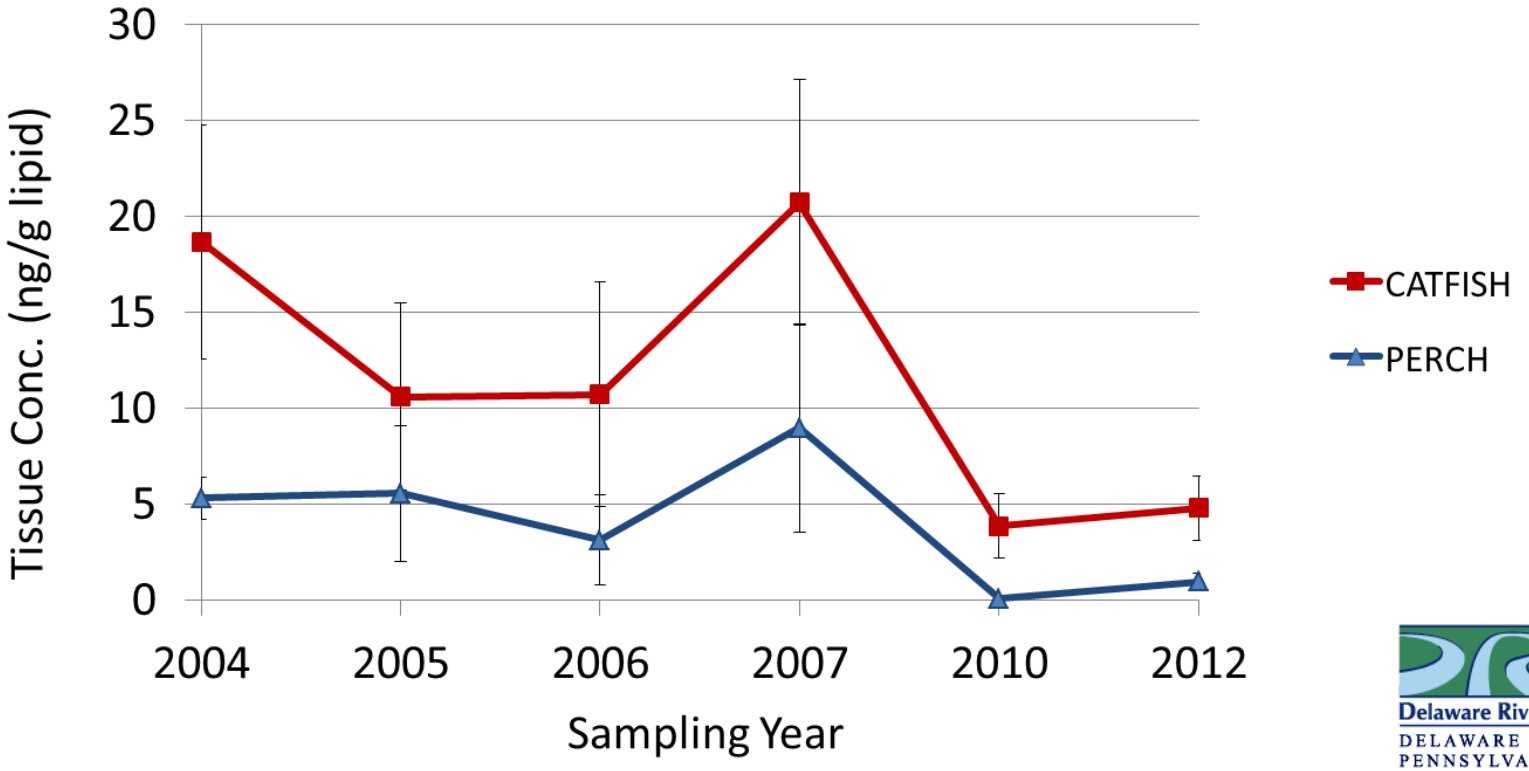
Polybrominated Diphenyl Ethers (PBDE) Flame Retardants

Lipid normalized tissue concentrations of BDE 209 in catfish and perch by year sampled



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Delaware River and Bay Water Quality Data Uses

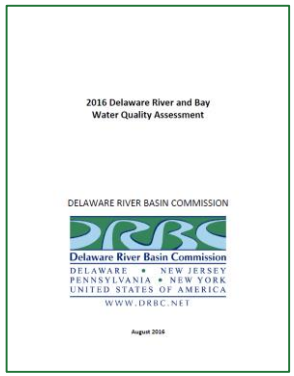
http://www.nj.gov/drbc/

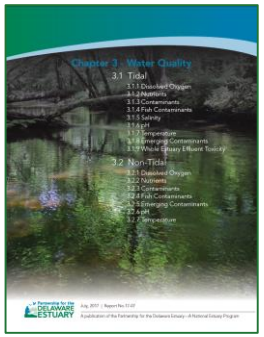
* Delaware River & Bay Water Quality Assessment Report [Status]

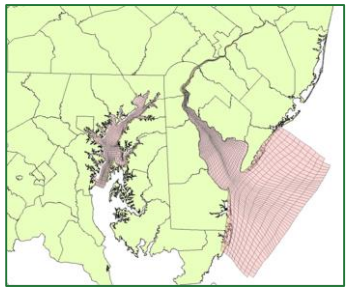
* State of the Estuary Report
  - Cooperation with Partnership for the Delaware Estuary (PDE) [Trends]

* Model development (PCB TMDL and eutrophication) [Environmental Management]

* Interactive data - Estuary Water Quality Explorer at https://johnyagecic.shinyapps.io/BoatRunExplorer/ [Data Sharing]







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Threats & Concerns

* Contaminants of Emerging Concern (prioritization & strategy)
* Increases in salinity, chlorides, conductivity (national problem)
* Metals (implementing BLM & MLR bioavailability based WQ criteria)

* Monitoring to better understand the magnitude & frequency of problems.
* Coordination with other government agencies.
* Collaboration with universities and other organizations.

DRBC Science and Water Quality Management Staff

* Namsoo Suk
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* Greg Cavallo
* Li Zheng
* Jake Bransky
* Elaine Panuccio
* Ron MacGillivray

* Interns
  * Victoria Trucksess
  * Julia Ragazzo
  * Scott Jedrusiak

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Questions?


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