WELCOME

TO THE JANUARY EDITION

OF THE 2018 M&R SEMINAR SERIES
BEFORE WE BEGIN

• SAFETY PRECAUTIONS
  – PLEASE FOLLOW EXIT SIGN IN CASE OF EMERGENCY EVALUATION
  – AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LOCATED OUTSIDE

• PLEASE SILENCE CELL PHONES OR SMART PHONES

• QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION

• PLEASE FILL EVALUATION FORM

• SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ Reports ⇒ M&R Data and Reports ⇒ M&R Seminar Series ⇒ 2018 Seminar Series)

• STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)
William A. Battaglin

Bill Battaglin is currently a Research Hydrologist for the U. S. Geological Survey in Lakewood, Colorado.

Bill received a B.A. in Geology from the University of Colorado, Boulder, in 1984, and a M. E. in Geological Engineering, from the Colorado School of Mines, in 1992. He has worked with various offices of the USGS since 1982. He has helped design and conduct numerous studies investigating the occurrence of pesticides and other contaminants in streams, reservoirs, groundwater, rain, and the air. He is currently working on investigations of the occurrence of contaminants of emerging concern in National Parks, the effects of pesticides on amphibian populations in North America, and the potential effects of contaminant occurrence on the migration of invasive Asian Carp in the Illinois River.

Bill has been an active member of the American Water Resources Association (AWRA) since 1993, serving on several conference committees, the board of directors, State section President in 2009, and National President in 2012. Bill was a founding member of Consortium for Research and Education on Emerging Contaminants and is currently the Treasurer.

Bill enjoys hiking, skiing, camping, ultimate, golf and just about anything else that can be enjoyed outdoors.
Differences in Numbers, Concentrations, and Loads of Anthropogenic Bioactive Chemicals (ABCs) in the Illinois Waterway Upstream and Downstream of the Bigheaded Carp Population Front

William Battaglin, USGS, Denver, CO
James Duncker, USGS, Urbana, IL
Paul Terrio, USGS, Urbana, IL
Larry Barber, USGS, Boulder, CO
Michelle Hladik, USGS, Sacramento, CA
Paul Bradley, USGS Columbia, SC
Steven Corsi, USGS, Middleton, WI
Elizabeth Murphy, USGS Urbana, IL
Presentation Outline

- Background on Science Questions and Bigheaded Carp stalled population front
- Sites and Methods
- Anthropogenic Bioactive Chemicals and Contaminant Mixtures
- Results by chemical class
- Results for specific chemicals
- Results of toxCast “EARs” analysis

This study is supported by the Great Lakes Restoration Initiative, the USGS Toxics Program, the USGS Chemical Mixtures project, and other sources.
Invasive Bigheaded carp could have serious negative impacts to Great Lakes ecosystem/economy

Poor water quality may be contributing to the stalling of their upstream movement near River Mile 278

Is upstream movement limited by hormones, pharmaceuticals, or other contaminants?

What are the sources of contaminants?

Do contaminants persist, degrade or dilute?

What happens to specific chemicals?
Invasive Bigheaded carp population front has been stalled in the general vicinity of RM 278 in the Dresden Island Pool since 2008 or earlier.

This reach characterized by sharp changes in water chemistry.

Can water chemistry be an environmental factor affecting fish physiology, spawning, behavior, or movement?
Study Methods – 1 Study Sites

- Chicago Sanitary and Ship Canal at Lockport, IL – RM 291.1
  - Most upstream
- Des Plaines River below Lock and Dam at Rockdale, IL – RM 285.9
  - Just upstream of RM 278
- Kankakee River at Wilmington, IL
  - Tributary downstream of RM 278
- Illinois River at Minooka, IL – RM 270
- Illinois River at Marseilles, IL – RM 243
- Illinois River at Henry, IL – RM 195.6
- Illinois River at Florence, IL – RM 55.9

Map showing sampling locations and locks and dams
Study Methods – 2 Flow Conditions

- 4 sampling events
- Lagrangian sampling over 5-7 day period
- May, June, August, October
- Higher flows for first 2 events

Graph showing hydrographs from sampling sites and 4 sampling events
Study Methods – 3 Water Quality Sampling

- Sampled using EWI methods from bridges or boats
- Analyzed water for 638 parameters using 4 USGS laboratories:
  - 105 Pharmaceuticals
  - 251 Pesticides
  - 30 Metals
  - 22 Hormones
  - 116 VOCs
  - 55 Wastewater indicators
  - 29 DBPs
  - 9 Nutrients
  - 8 major ions
  - 8 field parameters
  - 5 carboxylic acids

Sampling the Illinois River at Florence, IL
Why worry about ABC in the Illinois? What are ABC?

- **Anthropogenic Bioactive Chemicals (ABC)**
  - includes: drugs, personal care products, pesticides, hormones, industrial chemicals, DBPs

- Hormones released by animals (humans) and plants.
  - Many also used by humans as “supplements”
  - Some hormones used only by humans, stock, pets (EE2)

- A fraction of ABC/hormones end up in water/sediment

- Some ABC and hormones can:
  - persist for months or years
  - affect wildlife at very low concentrations
  - alter ecosystem functions at low concentrations
  - move far from their point-of-deposition

Field processing water quality samples
Why worry about low concentrations of some contaminants?

- Is the Paracelsian presumption that “the dose makes the poison” wrong?
  - For some ABC/hormones, answer is “yes”
  - U-shaped, n-shaped, biphasic responses common for ABC
- In review by Vandenberg et al., 2012 “non-monotonic responses and low-dose effects are remarkably common in studies of natural hormones and EDCs”
  - Also states “the timing of exposure is profoundly important to detect low-dose effects of EDCs”
- Mixtures – usually many chemicals - many issues
  - Combinations of ABC can have effects when individual chemicals do not
- Degradation – persistence controls fate
Most frequent detections for most classes at Lockport or Rockdale
Most frequent detections for pesticides at Henry
Less frequent detections for most classes at most locations
Even though streamflow was less
More detections of pharmaceuticals downstream
Results 3 – Illinois Waterway Schematic/Streamflow

- Simplified Illinois Waterway schematic
- Flow, flux, concentrations
  - all scaled the same way
- Flow in May - cone shape
- Flow in October – coke bottle
- June – rocket ship
- August – lava lamp
- Flow at Lockport between 5.5 and 45.5% of flow at Florence
Results 4 – Chloride Flux

Plots show chloride flux with streamflow as the blue line.

May results indicate higher relative flux from upper basin.

June results similar to May even though streamflow is 3x greater.

August – more lava lamp like.

October much smaller fluxes.

Flux at Lockport between 33.6% and 67.8% of flux at Florence.

Results confirm Lagrangian sampling.
**Results 5 – Nutrients Flux**

- Plots show Nitrate as N flux with streamflow as the blue line.
- June results indicate conservative transport.
- August results show greater influence of upper river inputs – much lower fluxes.
- Dissolved Phosphorous as P.
- June results show greater influence of upper river inputs.
- Even more pronounced in August – with much lower fluxes.
Results 6 – VOC, Pesticide, Pharmaceutical Flux

- **VOCs flux**
  - Greatest at Rockdale
  - Decreases downstream
  - Not conservative
  - Flux at Lockport between 109% and 440% of flux at Florence

- **Pesticide flux**
  - Greatest at Henry
  - Increases downstream
  - Flux at Lockport between 3% and 47% of flux at Florence

- **Pharmaceutical flux**
  - Greatest at Rockdale
  - Decreases downstream
  - Not conservative
  - Flux at Lockport between 51% and 359% of flux at Florence
Results 7 – Atrazine, Metformin, etc

- **Atrazine (herbicide)** can
  - Disrupt pituitary-ovarian function (Cooper, 2000)
  - Induce gonadal malformation (Hayes, 2006)

- **Metformin (diabetes)** can
  - Cause intersex and reduced fecundity in fish (Niemuth, 2015)

- **Venlafaxine (antidepressant)** can
  - Adversely affect predator avoidance (Painter, 2009)

- **Citalopram (SSRI)** can
  - Can bioaccumulate in fish brains (Arnnok, 2017)
High Throughput Screening assays: ToxCast/Tox21

EPA National Center for Computational Toxicology (NCCT)

Goal: Tool for assessing chemicals based on potential health or environmental risks

- Utilizes High Throughput Screening to rapidly and efficiently assess the potential activity of thousands of chemicals
- Helps prioritize which chemicals in complex mixtures are potential problem

Current ToxCast database contains

- > 300 assays with > 1100 endpoints
- >8000 chemicals
- Evaluating effects on Cells, proteins, DNA, RNA, mitochondria, receptors, enzymes
ToxCast Exposure Activity Ratios (EARs)

- Incorporates ABC exposure concentration (e.g., measured concentration in water)
- And potential ABC potency ACC (Activity Concentration at Cutoff) from the bioassays in simple ratio
- Results from multiple assays are simplified for analysis
- Strong relations between EARs and Toxicity quotients calculated from water quality guidelines
- Use USGS toxEval R-tool to access ToxCast information and visualize results
Results 8 - EARs for Round 1 (May) Samples

- Plot shows maximum EARs by ABC class (y-axis) and site (x-axis)
- Looking for ABC that are high above RM 278 or in the tributary, but low or decreasing below RM 278
  - Pesticides high always
  - The other groups show that pattern
- Pesticides – metolachlor, atrazine, 2,4-D
  - Not many are high up and low down
- Pharmaceuticals – Benadryl, metformin
  - Many show occurrence pattern of interest
- Other WWI – triphenyl phosphate, bisphenol A,
  - Several show pattern of interest
Results 9 – Cumulative Exposure Activity Ratios

**Total EARs During June 2015 Sampling**
- Lockport EAR = 0.60
- Rockdale EAR = 0.20
- Kankakee EAR = 0.20
- Marseilles EAR = 0.19
- Florence EAR = 0.23

**Total (sum of) EARs for May Sampling**
- Highest individual EARs – Metolachlor (0.40)
- Triphenyl phosphate (0.17)
- Kankakee dilutes upper Illinois EARs

**Total EARs for June Sampling**
- Lower totals than for May
- Highest individual EARs – 4-nonylphenol (0.16)
- Metolachlor (0.11)
Conclusions and Questions?

- We used a Lagrangian sampling strategy to investigate how water quality changes in the Illinois Waterway from Lockport to Florence.
- For most chemical classes fluxes and concentrations decreased in the downstream direction.
- Pesticides are an exception.
- Several pharmaceuticals showed a pattern of occurrence that suggests a potential for them to be affecting carp spawning or migration.
- We use EPA ToxCast data and the USGS toxEval tool to evaluate the potential effects of mixtures of chemicals and prioritize those chemical for further study.
The questions we are trying to answer

Is water chemistry the primary factor stalling the Bigheaded carp population front?

Preliminary analysis of water quality data indicate that there are several chemical classes and many ABC that occur in a pattern such that they could be affecting carp spawning or movement upstream, either as individual chemicals or as complex chemical mixtures.
Future Plans

- Add some tissue analysis (with Cory Suski)
- Identify WQ changes post WWTP upgrades
- Reports with 2015 results
- Methods Paper – USGS OFR 2017-1019
- Data Release – contact Bill
- Journal Article – in preparation
Your Questions?

Lock and Dam at Rockdale, IL

Dam on Kankakee River

Birds hunting in Kankakee River

For more information contact William Battaglin, wbattagl@usgs.gov or Jim Duncker, jduncker@usgs.gov