

# LONG TERM MEASURES OF REMEDY EFFECTIVENESS

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# Weight of Evidence Approach using Multiple Lines of Evidence

- ❑ Biological LOE – assesses biological endpoints, e.g., fish reproduction, diversity of species, toxicity
- ❑ Chemical LOE – measures that relate to contaminant concentrations, e.g., post-remedial surface weighted concentrations, reductions in fish tissue levels
- ❑ Physical LOE – volume and mass removed, e.g. pounds of PCBs dredged
- ❑ Modeling - physical and hydrodynamic modeling, performance modeling, food web modeling

# Biological lines of evidence

## Current practice

- Fish tissue for human consumption
- Standard sediment tox. and bioacc. testing
- Benthic survey
- Histopathology, common endpoints for biota

## Innovative (examples)

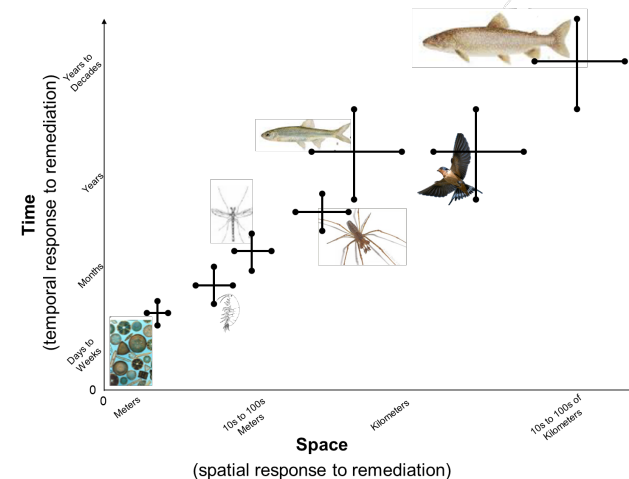
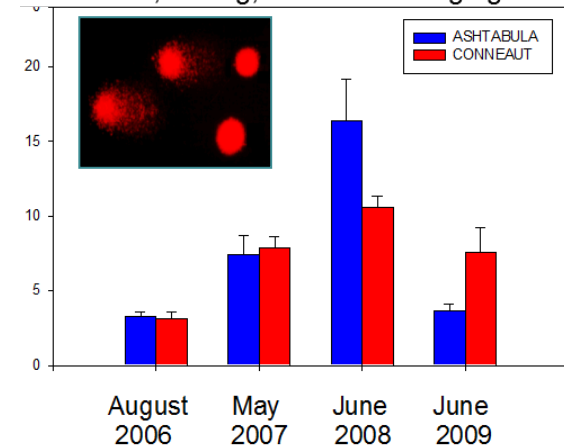
- Benthic body burden
- Short lived fish
- Bioaccumulation – alternative biological and surrogate measures (Tenax, SPMEs, etc)
- Fish (IBI)/habitat quality/Genetic damage
- Benthic survey (e.g. L-ICI)
- Bivalve uptake
- Riparian indicators (avian, spiders, etc)
- SOP (performance based)/QAQC/Interlab comparisons
- Reference locations

Current



Innovative

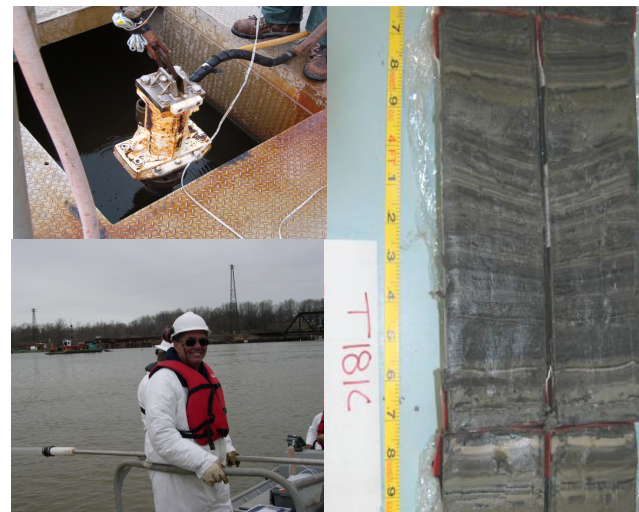
DNA Damage in Brown Bullhead Before, During, and After Dredging



# Chemical lines of evidence

## Current practice

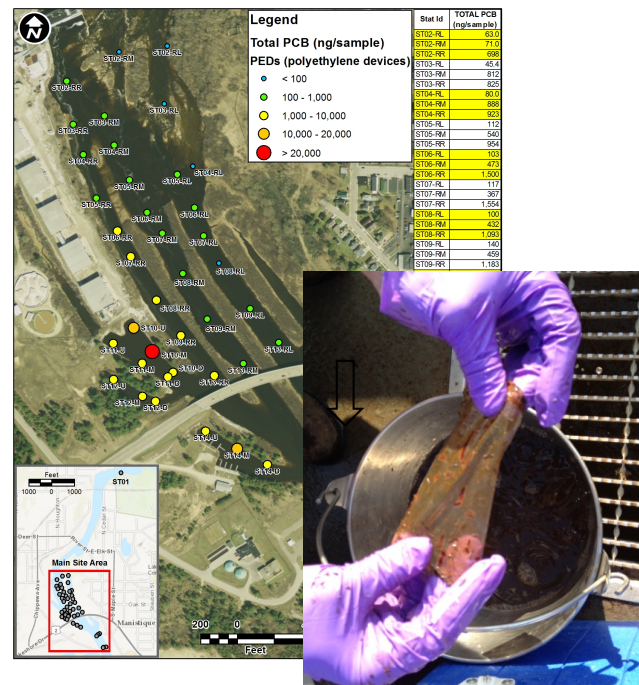
- Sediment chemistry – surface and segmented core sampling
- Water Chemistry



Current

## Innovative (examples)

- Passive samplers (e.g., PEDs, SPMEs)
- Porewater (direct and passive)
- Groundwater intrusion
- Legacy contaminants versus CECs
- Rapid screening – direct analysis techniques
- Qualitative level screening for additional contaminants (legacy and CECs)
- Advanced Chemical Forensics
- Common SOPs/QA



Innovative

# Physical lines of evidence

## Current practices

- Single-beam Bathymetry
- Turbidity
- Sediment transport modeling

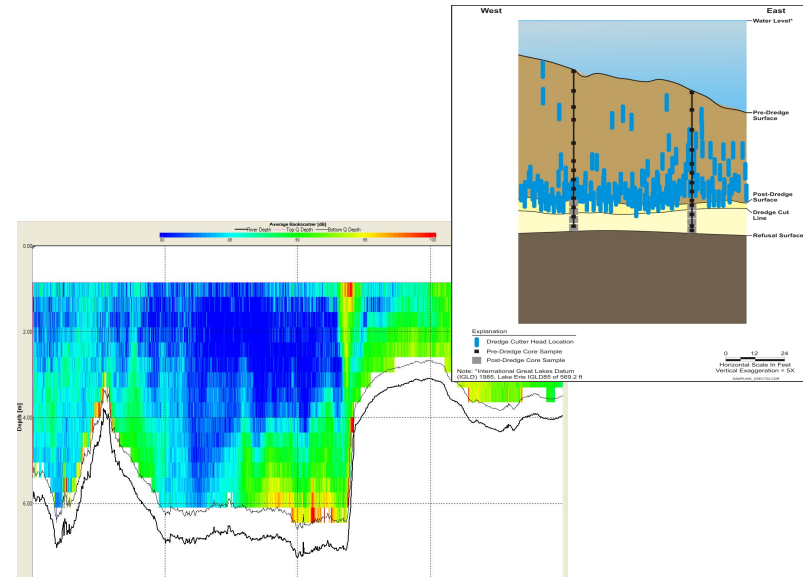
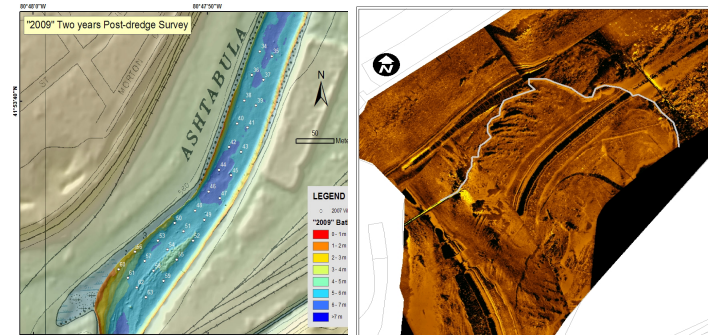
## Innovative (examples)

- Grain size analyses of dredge materials and “residuals”
- Particle tracking
- Hydrodynamics & plume monitoring
- GW-surface water interactions
- Sediment traps for transport of sediment and COCs
- Multi-beam Bathymetry/side scan sonar
- Diver assisted probing and SPI camera for residuals

Current



Innovative



# GLLA Ottawa River remediation project (Maumee River AOC)

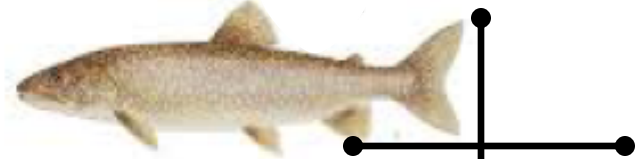
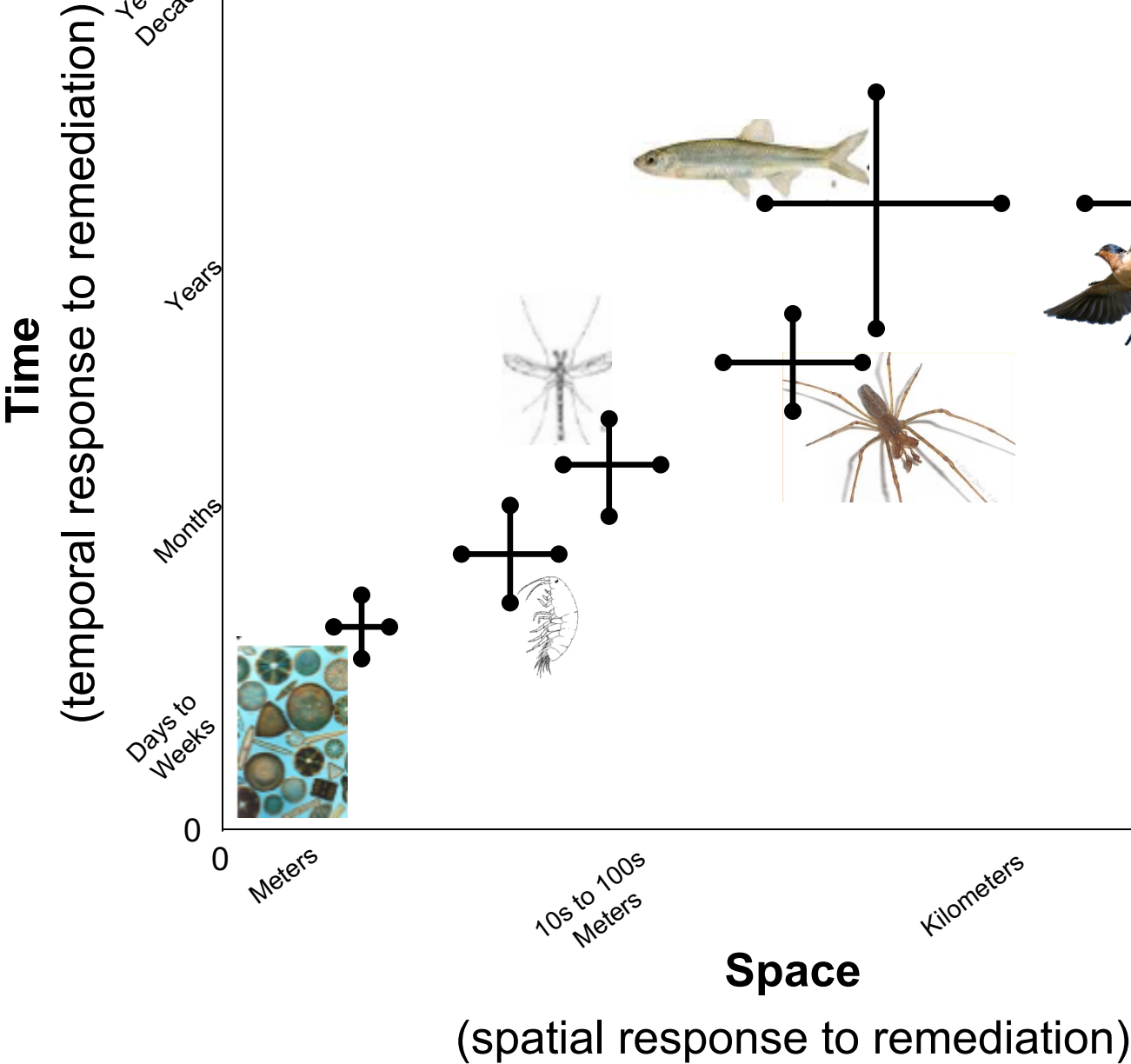
- The 2009-2010 GLLA remediation project was over 5 miles in Reaches 2-4.
- The primary Contaminants of Concern (COC) at the site were PCBs, PAHs, inorganics (principally lead), and oil/grease.
- ~ 260,000 yd<sup>3</sup> of contaminated sediments were removed from the project area.
- Removal was through dredging in targeted areas within Reaches 2-4 of the river where COCs exceeded a threshold level.



# ORD Monitoring Stations



# Biological LOE: Food web



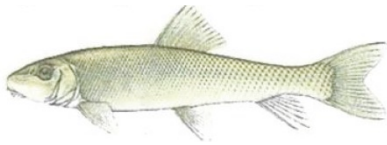


# Biological LOE's: Food Web Tissue Sampled

## Fish Composited Across Each of the 3 Reaches

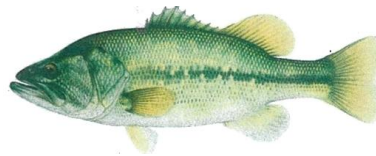
### White Sucker (WS) Redhorse (RH)

3-5/Reach > 200 mm



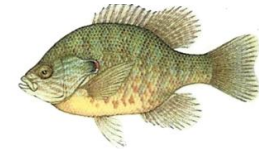
### Large Mouth Bass (LMB)

3-5/Reach > 250 mm



### Pumpkinseed (PS)

3-5/reach > 80 mm



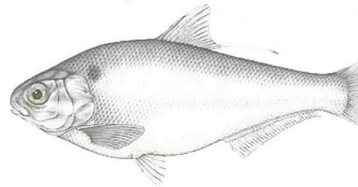
### Brown Bullhead (BB)

> 10/reach > 250 mm



### Gizzard Shad (GS)

3-5/Reach > 180 mm



### Emerald Shiner (ES)

2-3 reps >25 g/reach



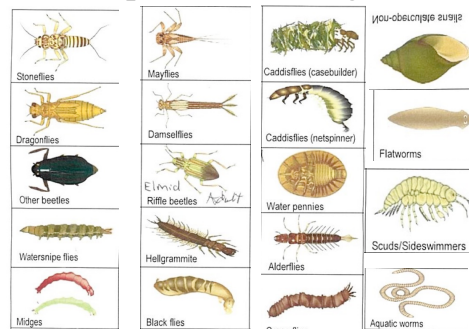
### Spiders Tetragnathids (Sp)

4 Reps per station >2 gm



### Macroinvertebrates (Inv)

2 reps/Station > 1gm



### Bluntnose Minnow (BN)

2-3 reps >25 g/reach



# COCs in Biomass Methods

Fish

**EPA & FWS Electroshocking**



**EPA Fyke Netting**



**Logged and processed**



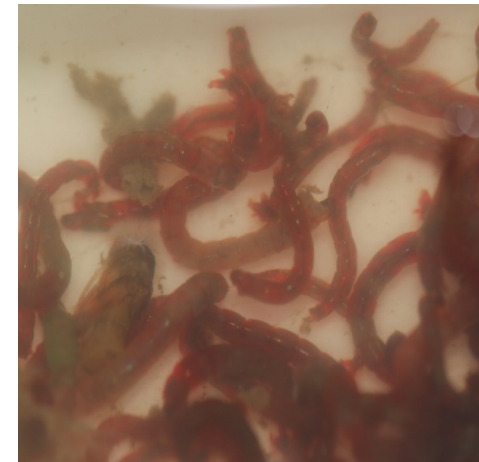
**20 HDs/rep 2 reps/site  
18 sites over 3 reaches**



**Deployed 6 weeks and  
processed in field**

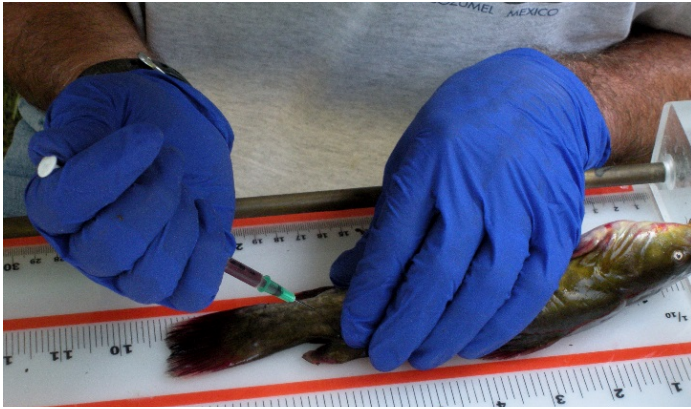


**Time sorted to  
> 1gm wet wt**

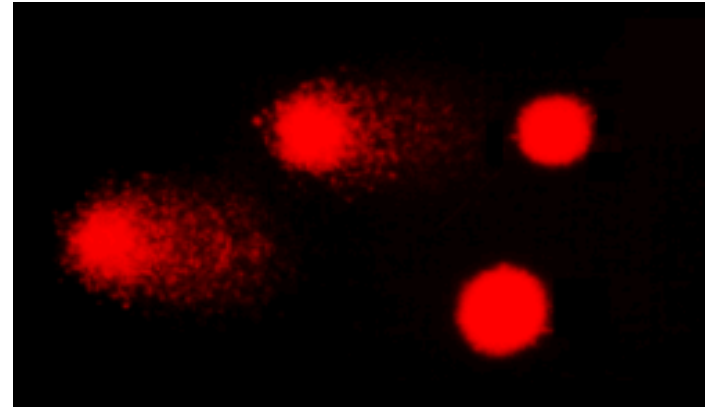


Macrobenthos

# Biological LOE's: Comet Assay to evaluate genotoxic response



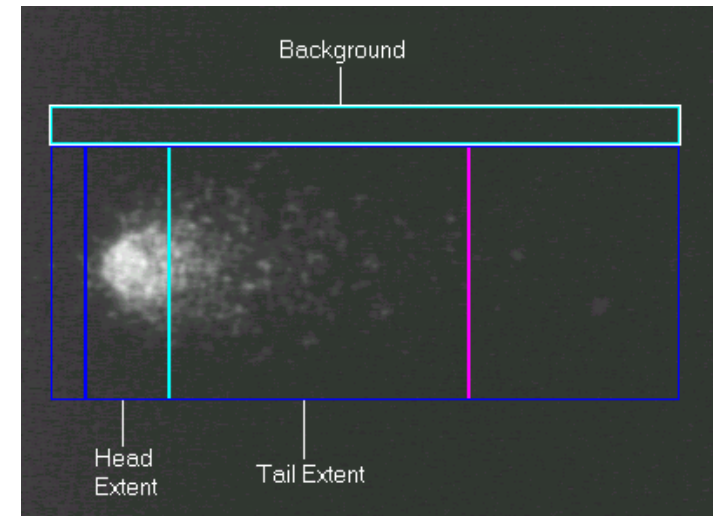
**Collect Blood and Liver in Field**



**Fluorescence microscopy image of Comet Assay blood cells**



**Preserve samples in the field**



**Measuring DNA damage parameters using image analysis**

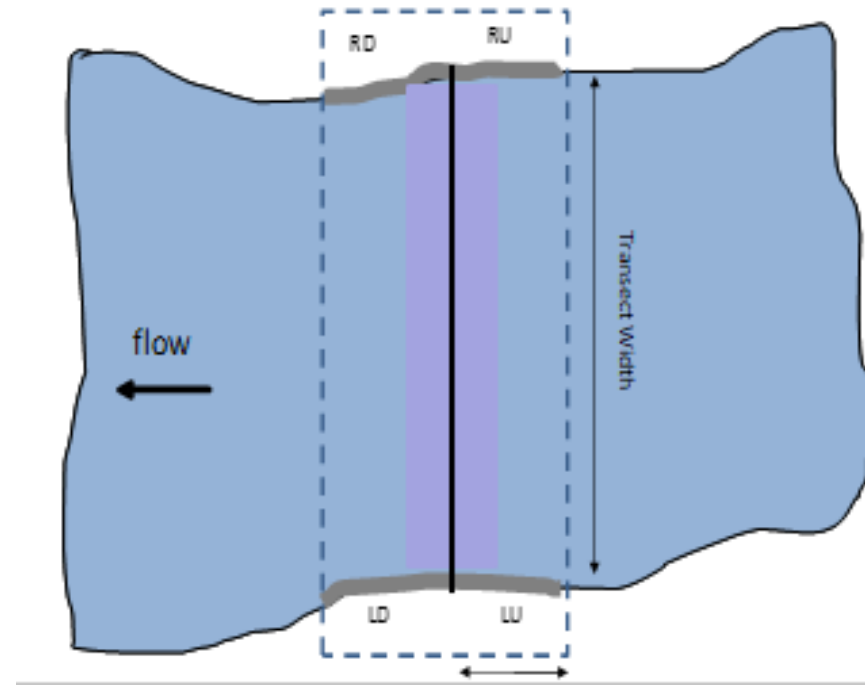
# Biological LOE's: Riparian predators - Spiders

Tetragnathid (longjaw spider)

riparian specialist

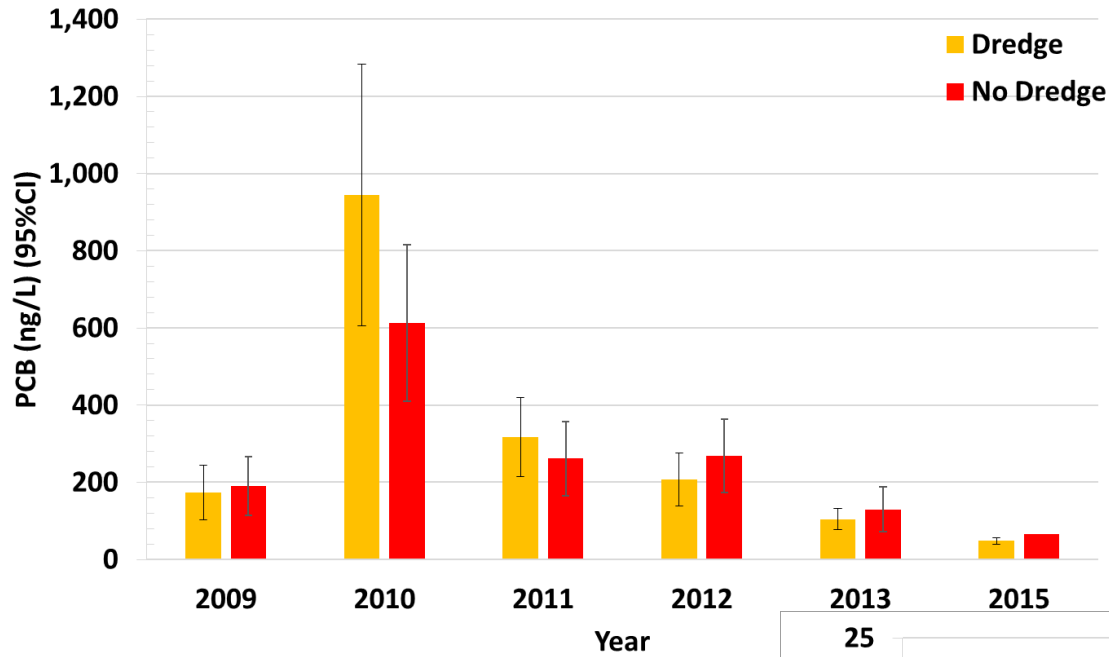
aquatic insect specialist

riparian vegetation and human structures

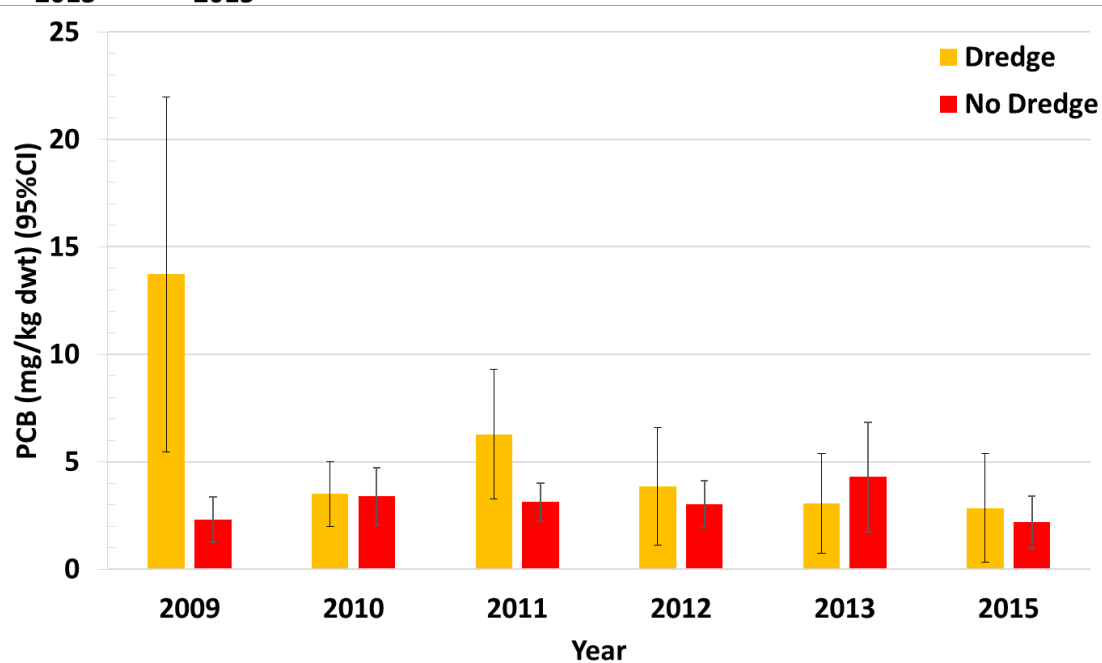


# Chemical LOE's

## PCBs in water

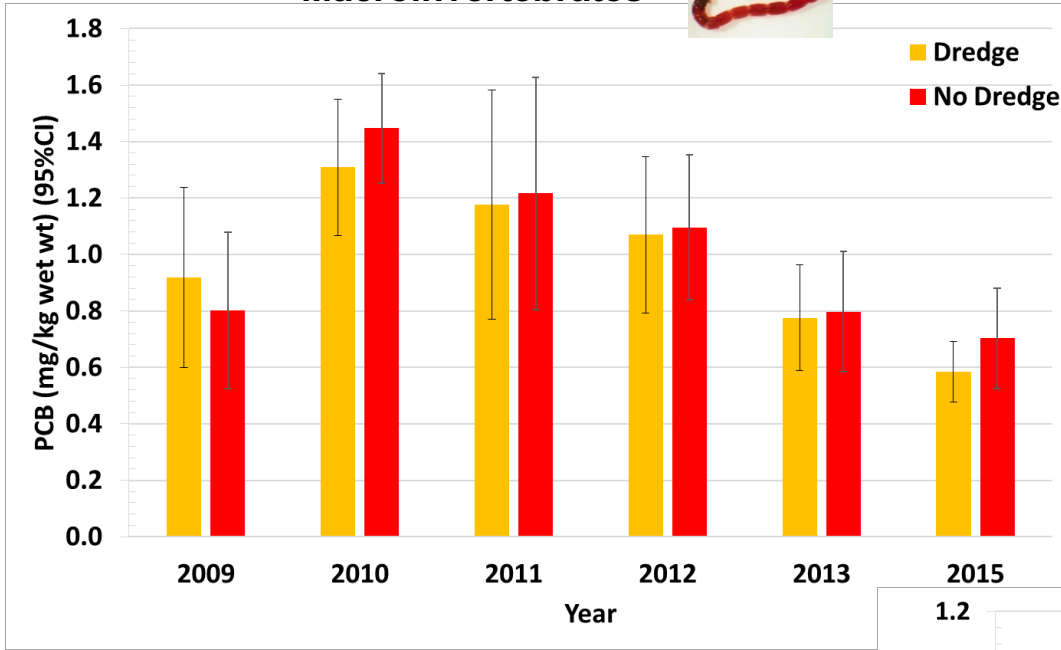


## PCBs in sediment

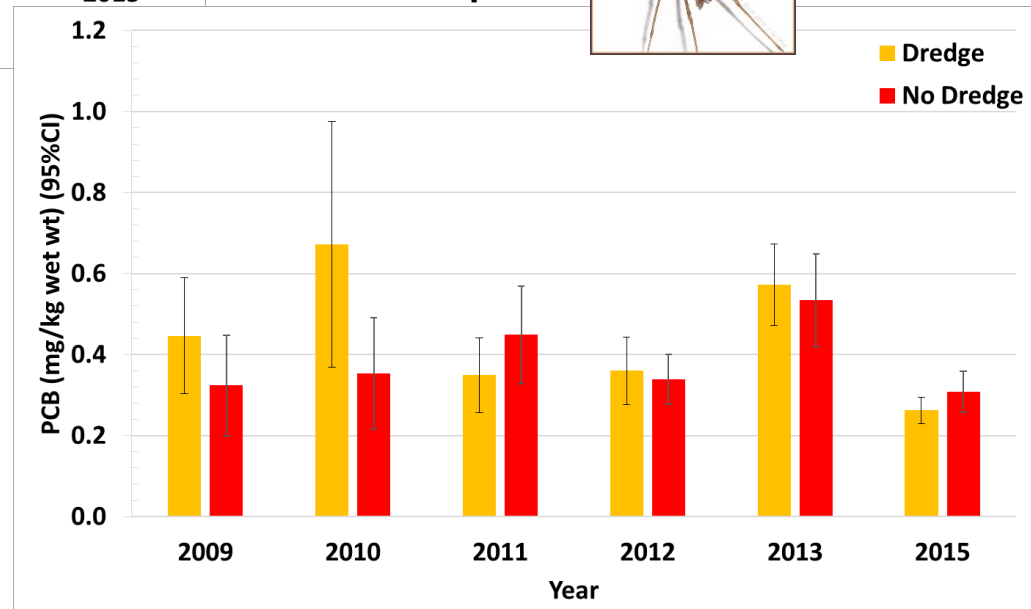


# Chemical LOE's: COCs in Macroinvertebrates & Spiders

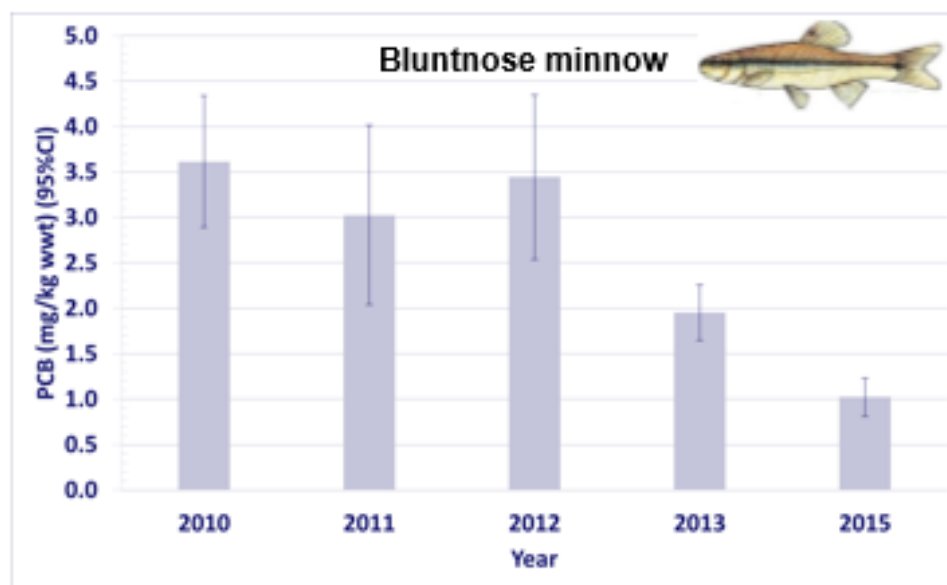
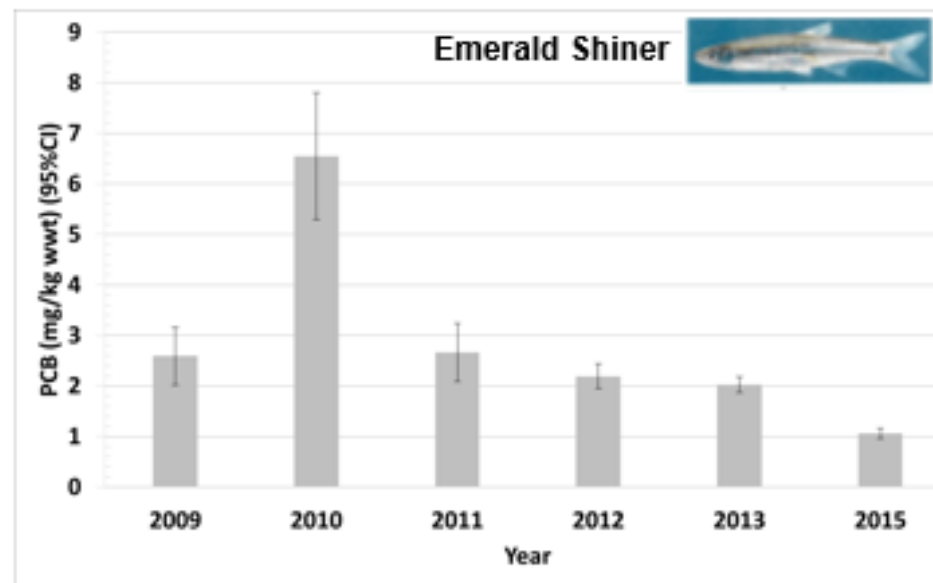
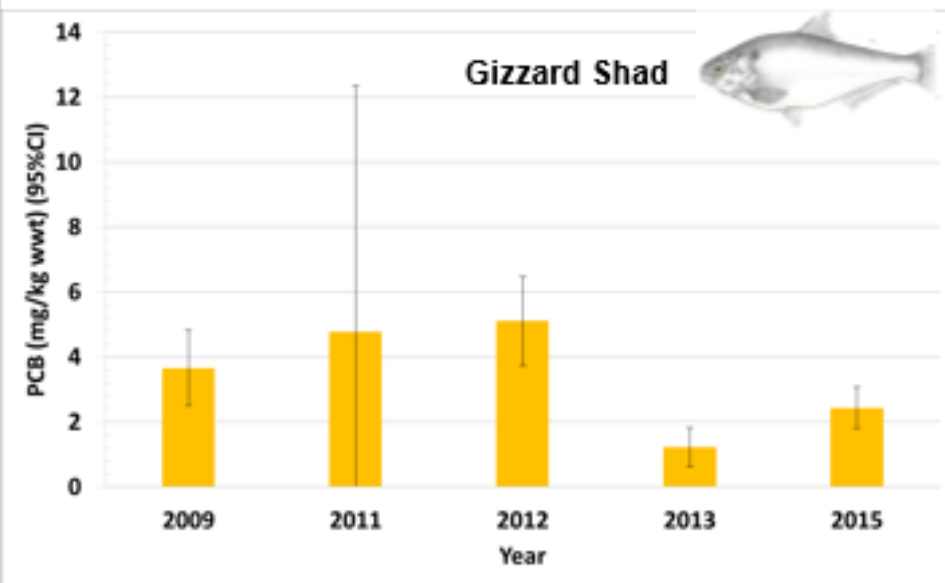
## Macroinvertebrates



## Spiders

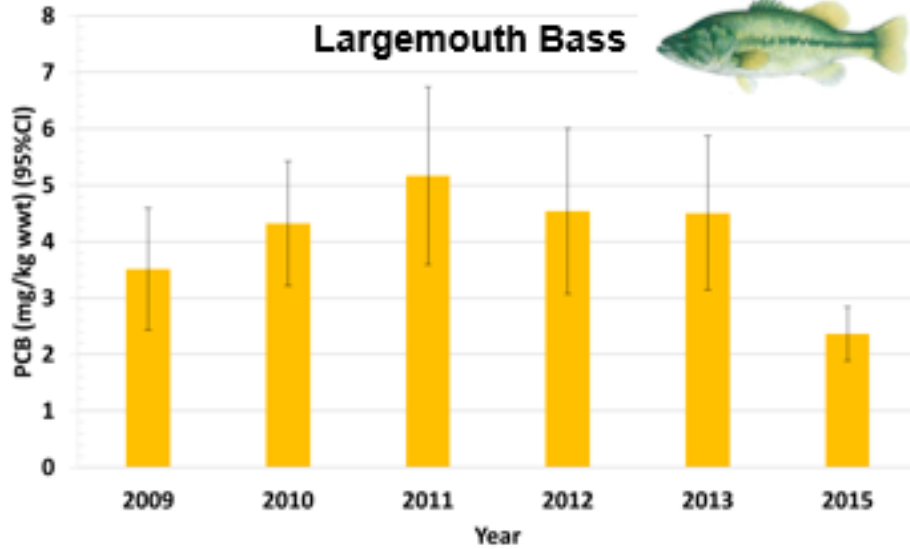


# Chemical LOE's: Small short lived fish

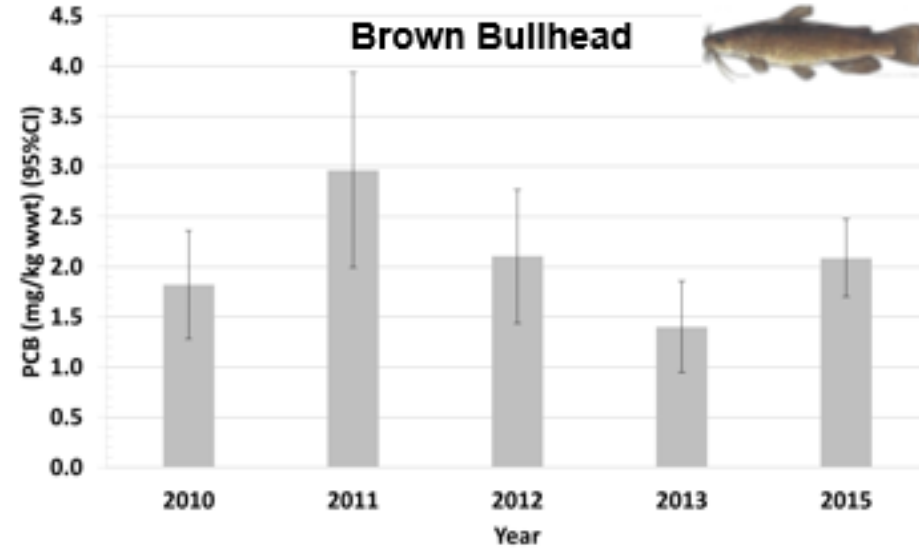


# Chemical LOE's: Higher trophic fish

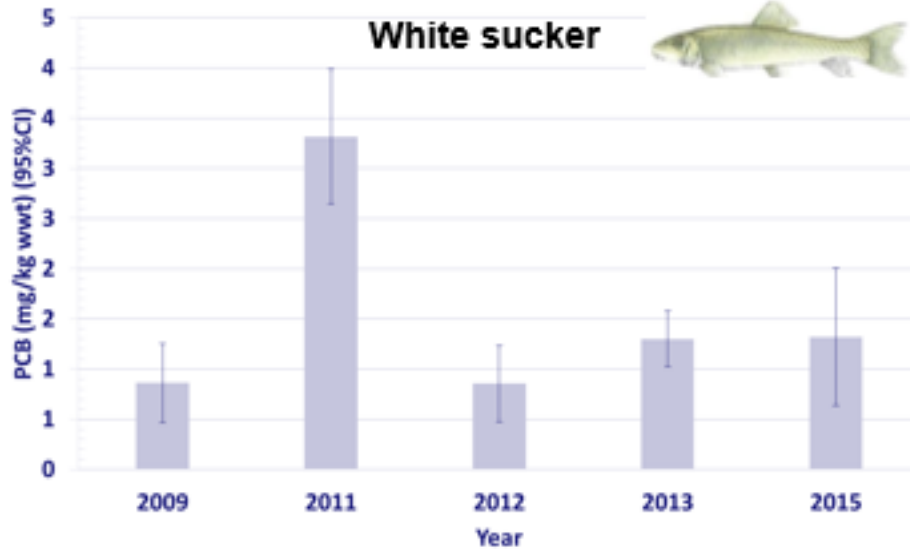
## Largemouth Bass



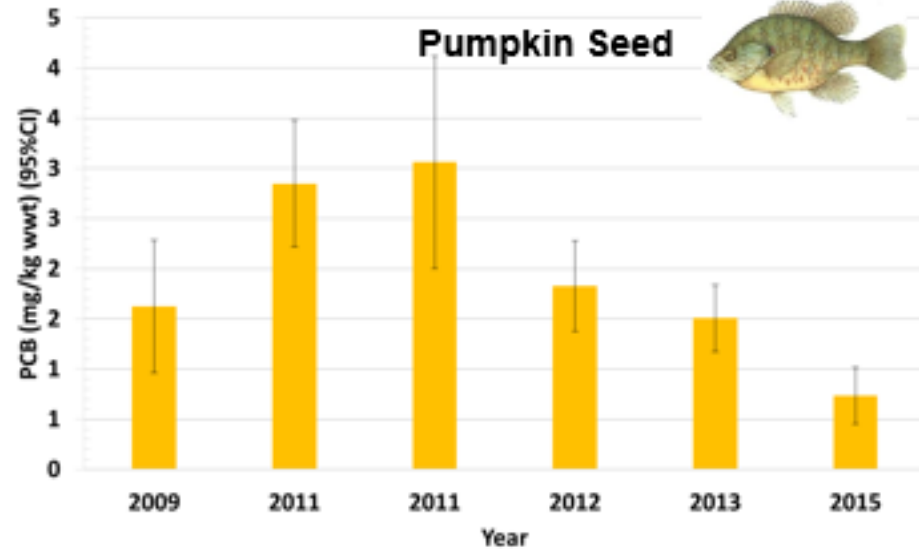
## Brown Bullhead



## White sucker

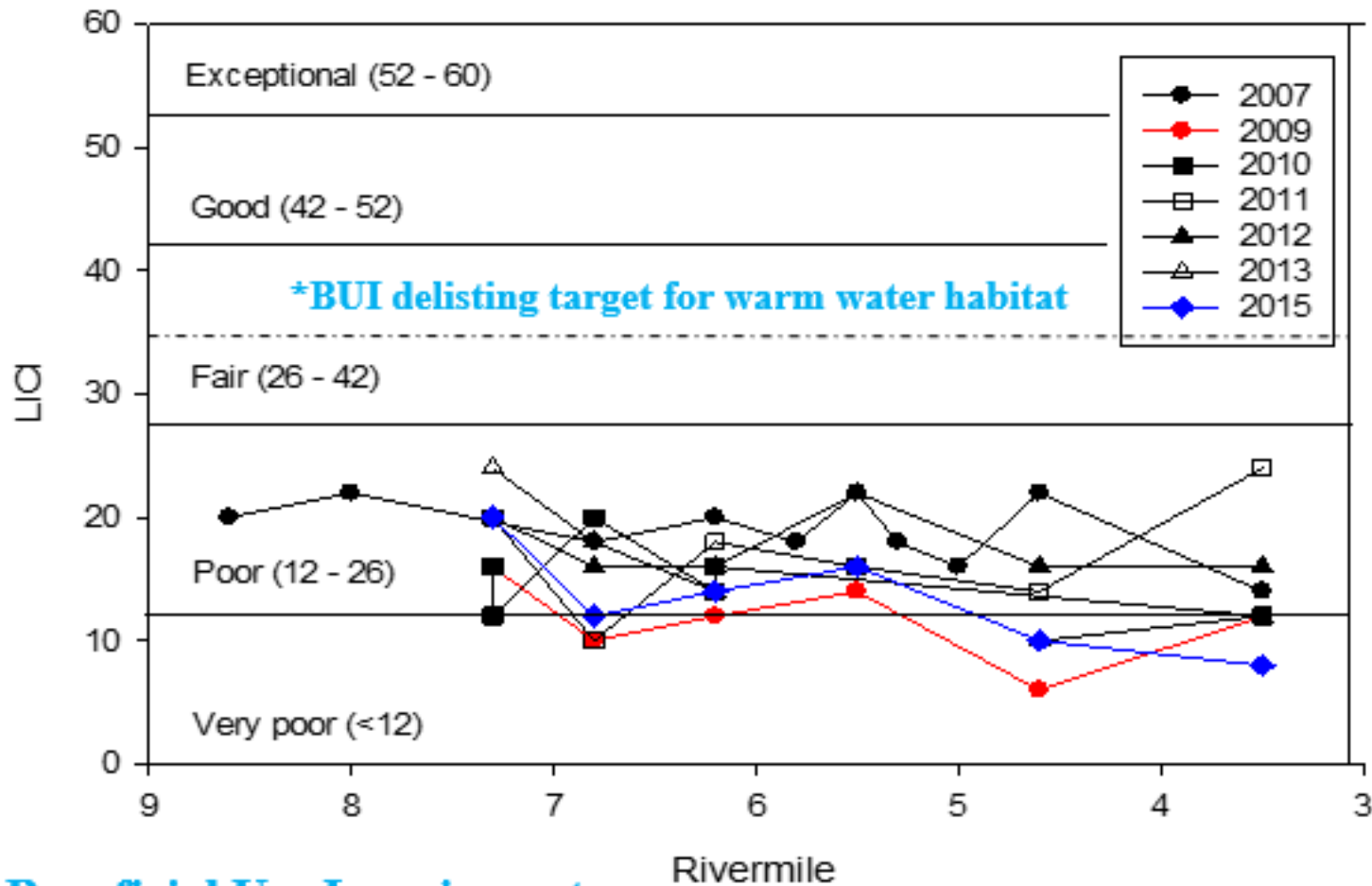


## Pumpkin Seed



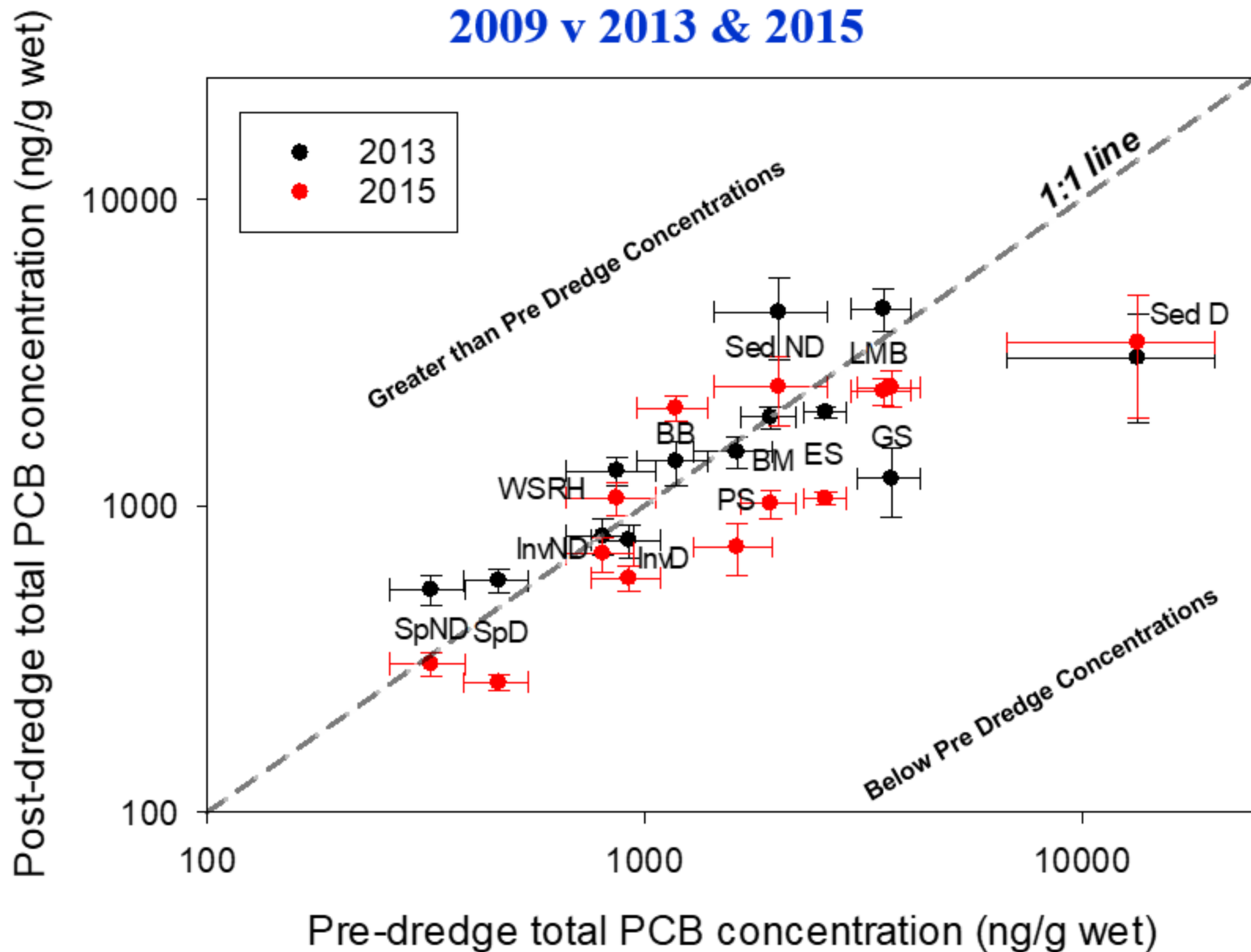


# Biological LOE: Macroinvertebrates Lacustrary Invertebrate Community Index (LICI)



**\*BUI Beneficial Use Impairment**

# Biological and Chemical LOE's: Trophic Level PCB Concentrations 2009 v 2013 & 2015



# Preliminary Findings

- Sediment concentrations decreased after remediation  
Water concentrations unchanged/slightly decreased after remediation
- **Macroinvertebrate and Spider tissue levels were lower than pre dredge conditions**
- Despite the large physical disruption associated with remediation (dredging) there was no decline in the LICI score.
- **Brown bullhead showed a trend toward a decrease in DNA damage across all reaches from the 2011 high (data not presented)**
- **2015 Gizzard Shad, Emerald Shiners, Bluntnose Minnows, Largemouth Bass, tissue levels were lower than pre dredge conditions**
- **Based on modeling performed during the design phase, it was anticipated that the long-term clean up goals would be met approximately 10 years (2020) after the completion of dredging activities**



# QUESTIONS

07.09.2012



07.09.2012

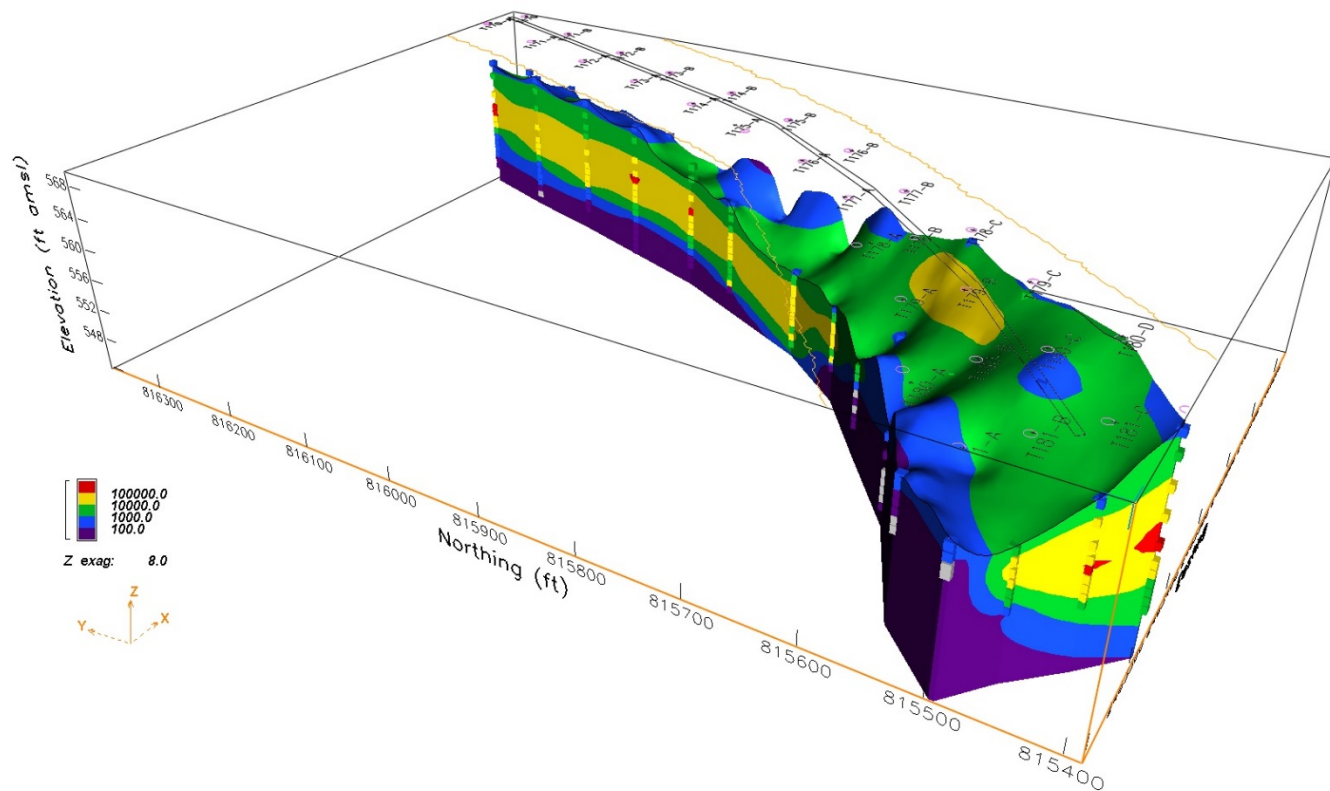
07.09.2012

# Chemical LOE's

Deep coring to  
characterize COC  
distributions

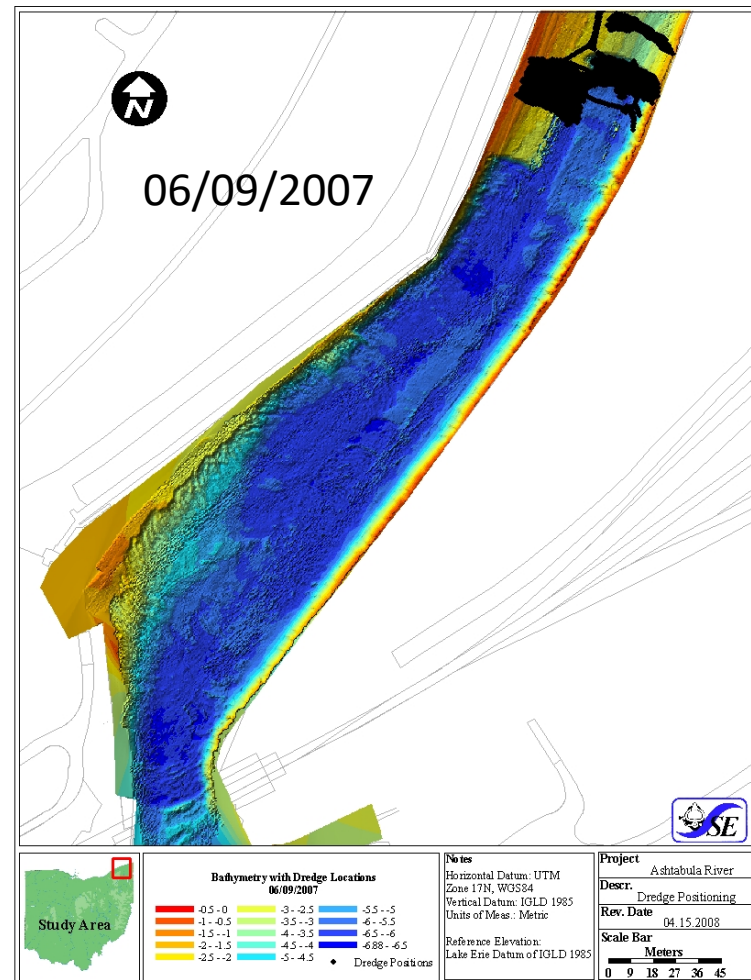
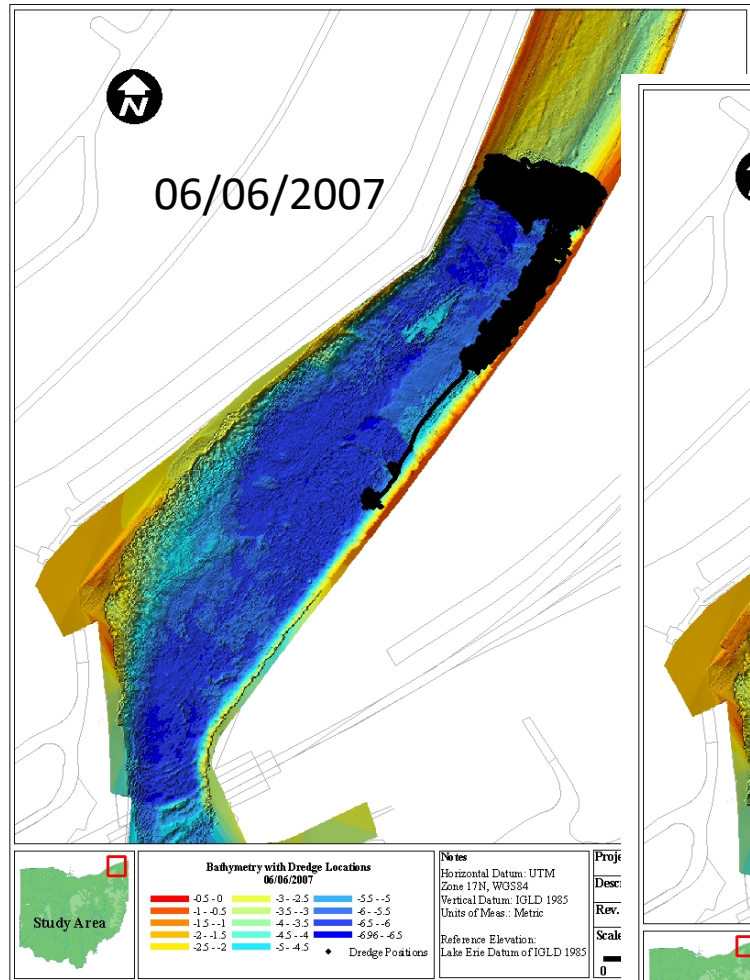
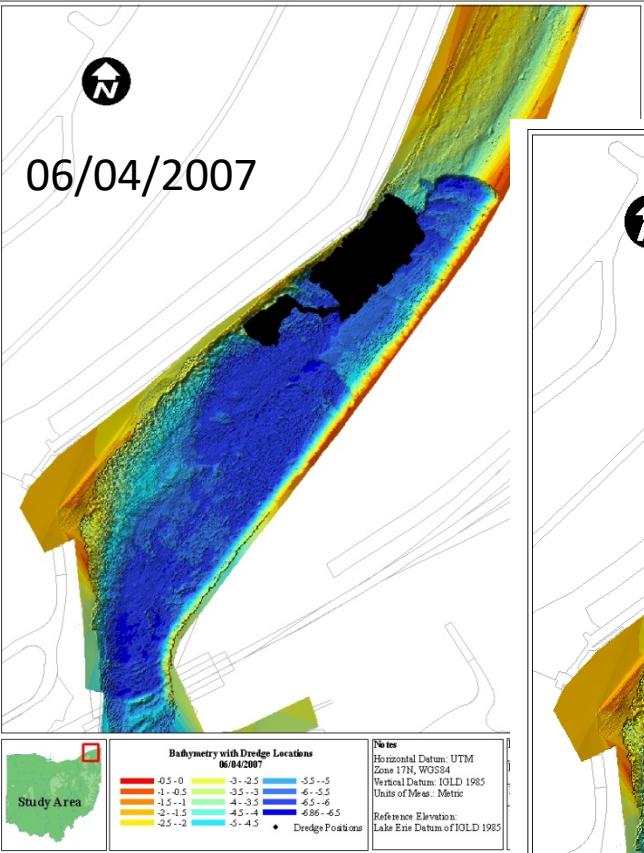


## PCB Contaminant profiling



# Physical LOE: High resolution bathymetry to evaluate mechanism for residuals

Daily dredge progress

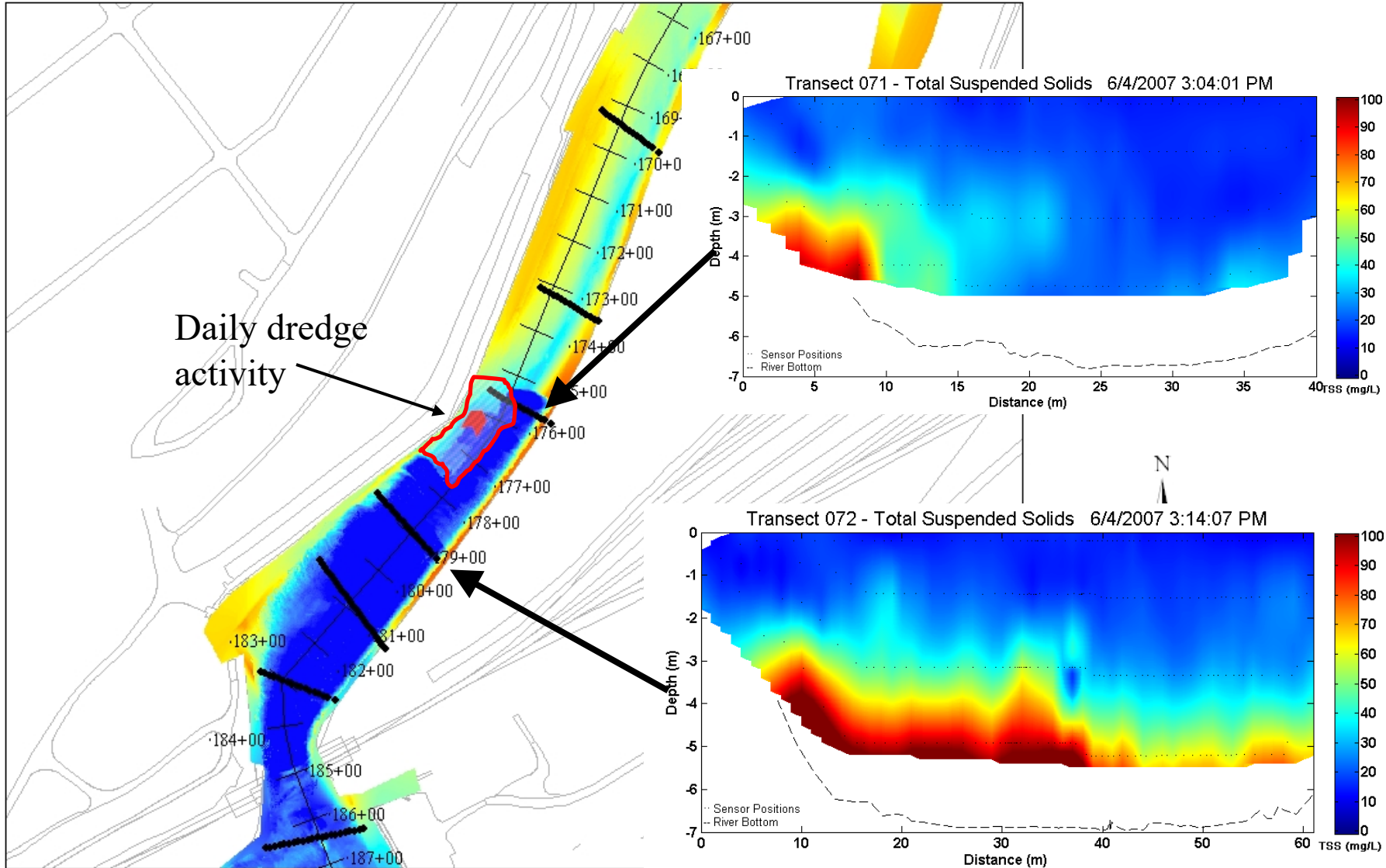


# Physical LOE: Side scan sonar to evaluate mechanism for residuals



Side scan sonar surveys conducted to identify near-bed dredging features.

# Physical LOE: TSS Measurements to evaluate resuspension of sediment





# Physical LOE: Characterizing sediment (pre-dredge) and residuals (post-dredge)

## Lithography



## Subsurface profile imaging (SPI) to characterize residuals (NHEERL-Narr and NRMRL-Cinc)

