Assessing Environmental Windows using Effects Data

Burton Suedel
USACE-ERDC-EL
Vicksburg, MS

DOTS Webinar
29 January 2014

US Army Corps of Engineers
BUILDING STRONG®

Environmental Windows: District Needs

- EWs are the most frequently cited concern
- EWs impose restrictions on dredging schedules

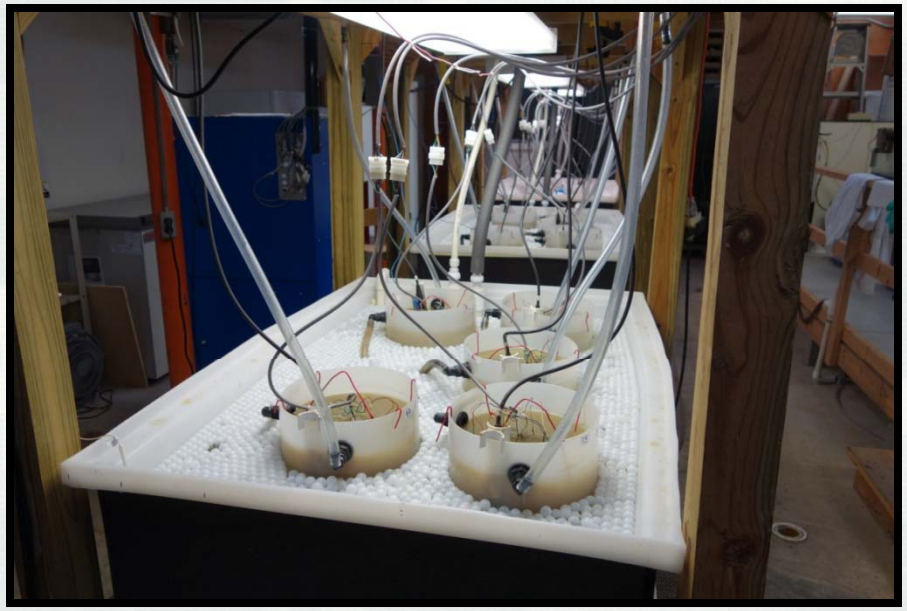
Exposure to suspended sediments may affect or disrupt:

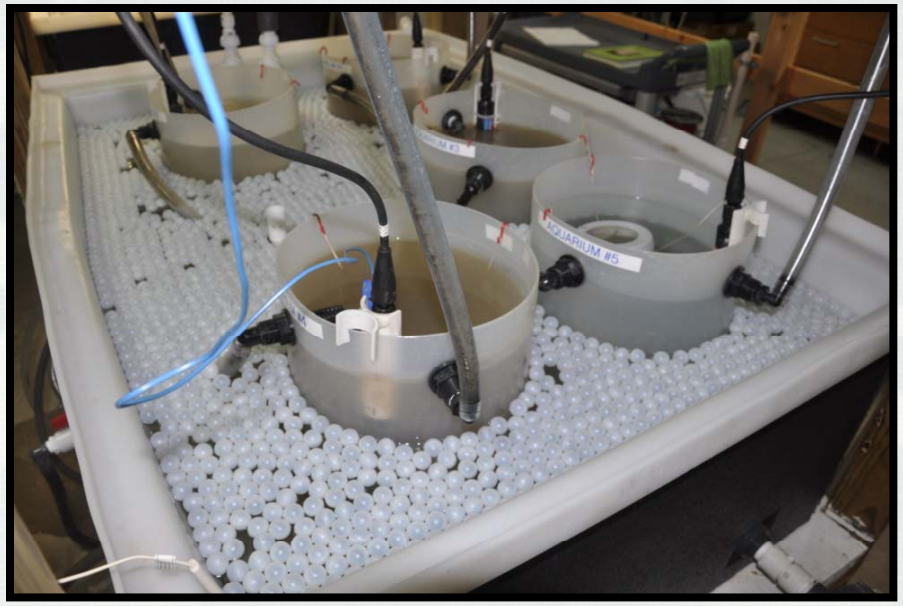
- Spawning or foraging behavior
- Egg hatching success and larval development
- Anadromous fish migrations
- Habitat by changing sedimentation rates

Environmental Windows (EW)

- EW: Time periods that allow dredging
- Setting of EWs is controversial
- No consistent, widely accepted methodology for objectively setting EWs
  - Often set without scientific basis
  - Established by negotiations emphasizing conservative professional judgments
- **Data Gap:** Lack of effects data for suspended sediments on species used to set EWs

Fish Larvae and Egg Exposure System (FLEES)





Unique System

- Three (3) modules
- Three (3) 500 L water baths
- 15 total aquaria
- 20 L polyethylene carboy aquaria
- Modules insulated on sides and water surface to control temperature
- Each aquarium utilizes pump to suspend sediment
- Transportable

FLEES: State-of-the-Art

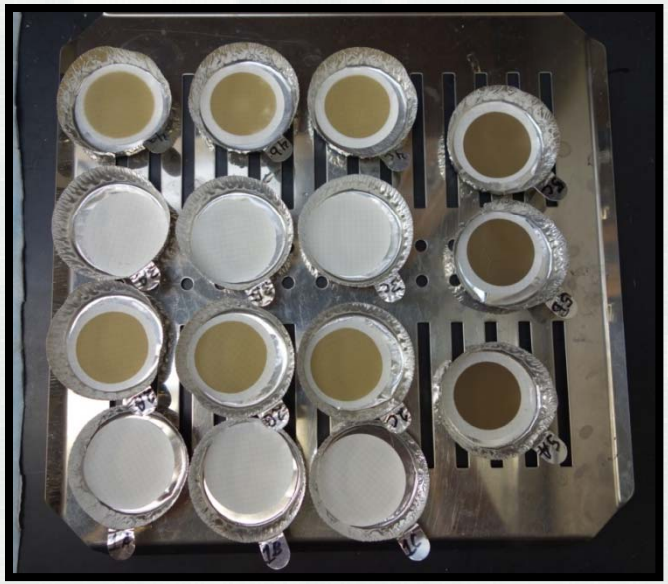
- Pump recirculates water and suspended sediment into aquaria
- Sediment mixed with water and stored in 375 L tank via double diaphragm pump
- Slurry routed through FLEES
- Sediment concentrations monitored using OBS

[redacted]

Computer-Controlled

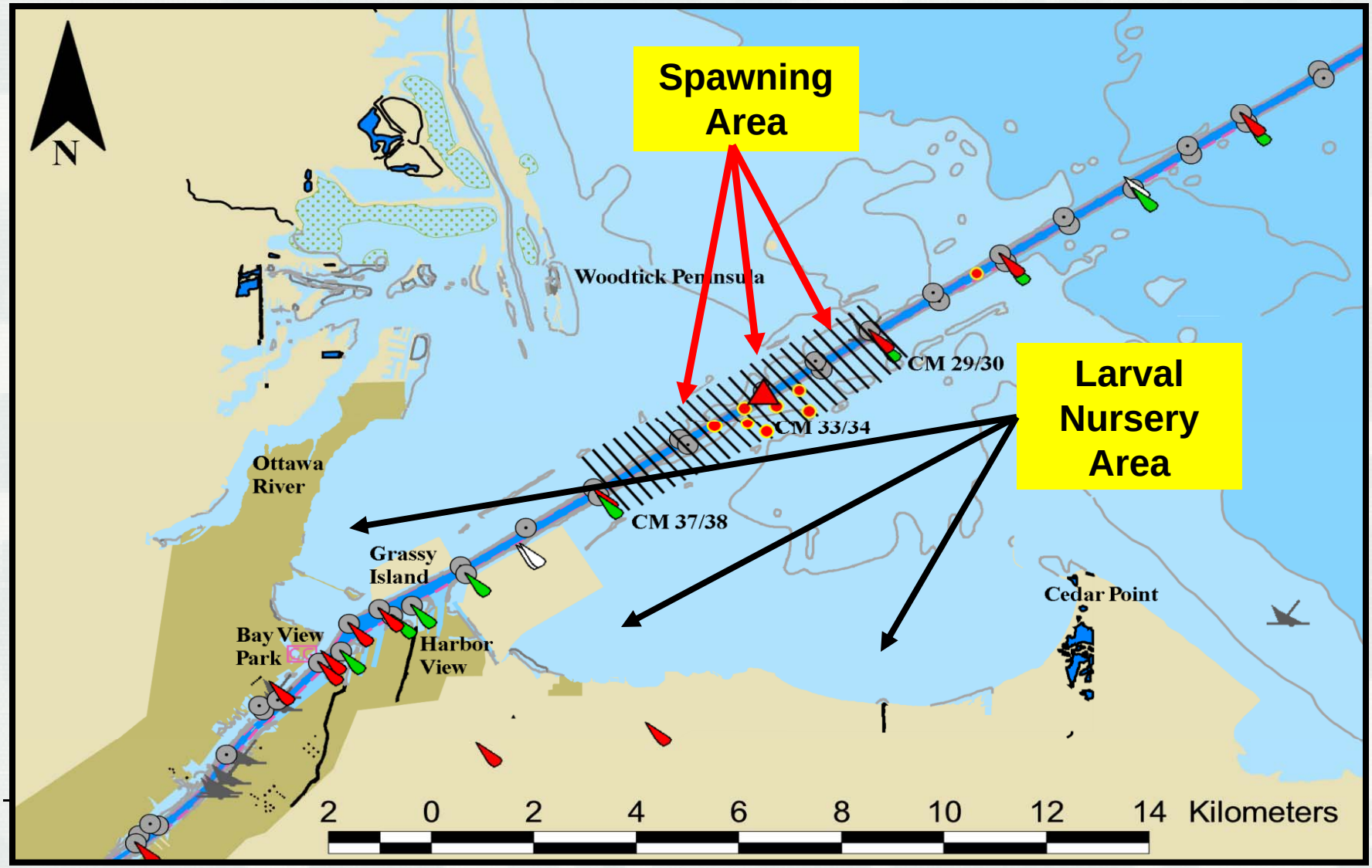
- Customized software program interfaces through a data acquisition and control system
- Permits each aquarium to be controlled for suspended sediment concentration and water inflow rate
- Input parameters into software
- Program monitors sediment concentration in each aquarium

FLEES: Mimics Field Conditions

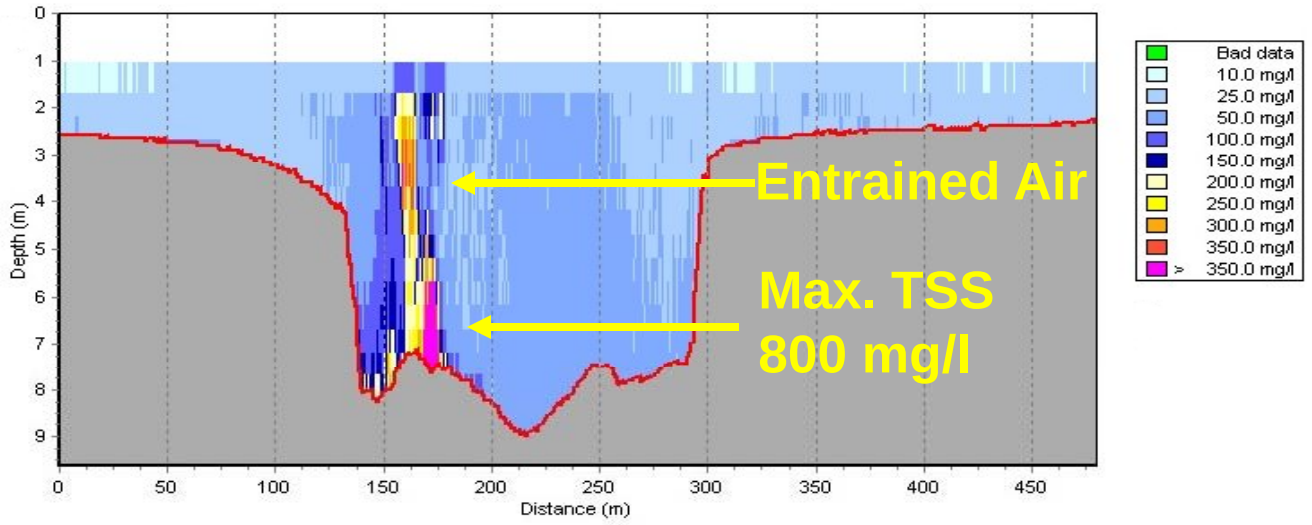


- Requires small quantities of sediment
- Uses project sediment
- Establishes a turbidity/TSS relationship

Case Study: Walleye EW
Maumee Bay, OH

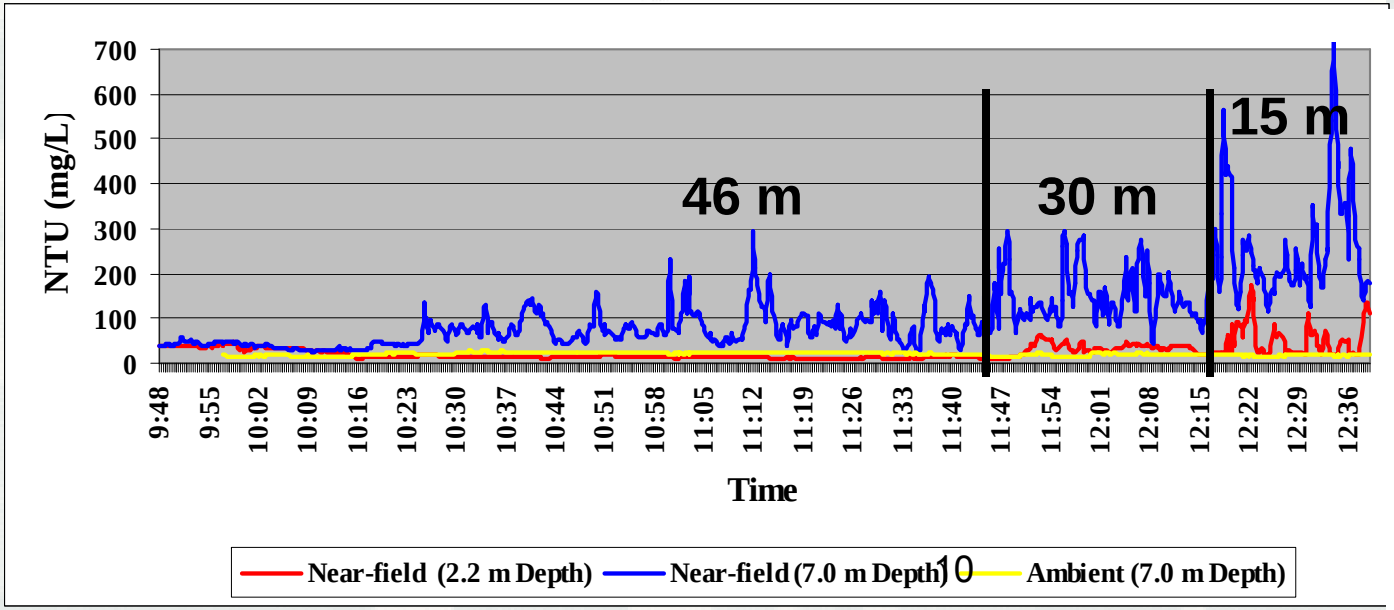


Near-field Plume Conditions
Maumee Bay Study Area



Distance from Dredge: 3m

Plume Width: 50 m

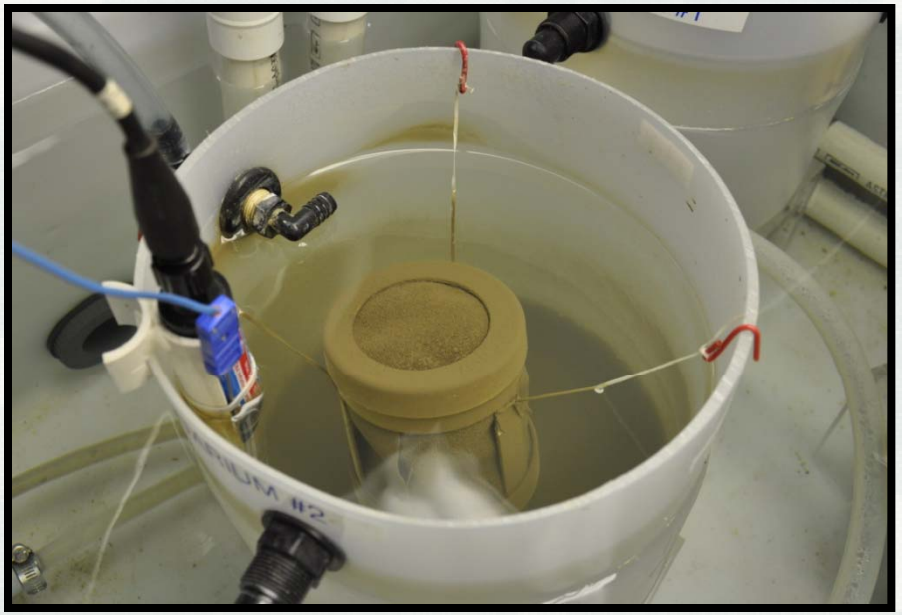


<u>LWC Max. Turb.</u>
700 NTU (15 m)
< 300 NTU (30m)

<u>UWC Max. Turb.</u>
175 NTU (15 m)
50 NTU (30m)
Ambient < 50 m

Materials and Methods

- Walleye (*Sander vitreus*)
- Four experiments: northern and southern strain eggs (newly spawned) and fingerlings (45-60 days)
- Sediment: Maumee Bay, Ohio (Lake Erie)
- Concentrations: 0, 100, 250, 500 mg/L TSS
- Duration: 3 days (72 h)
- Temp: 10 - 13°C eggs; 14 - 17°C fingerlings
- PVC cups for containment



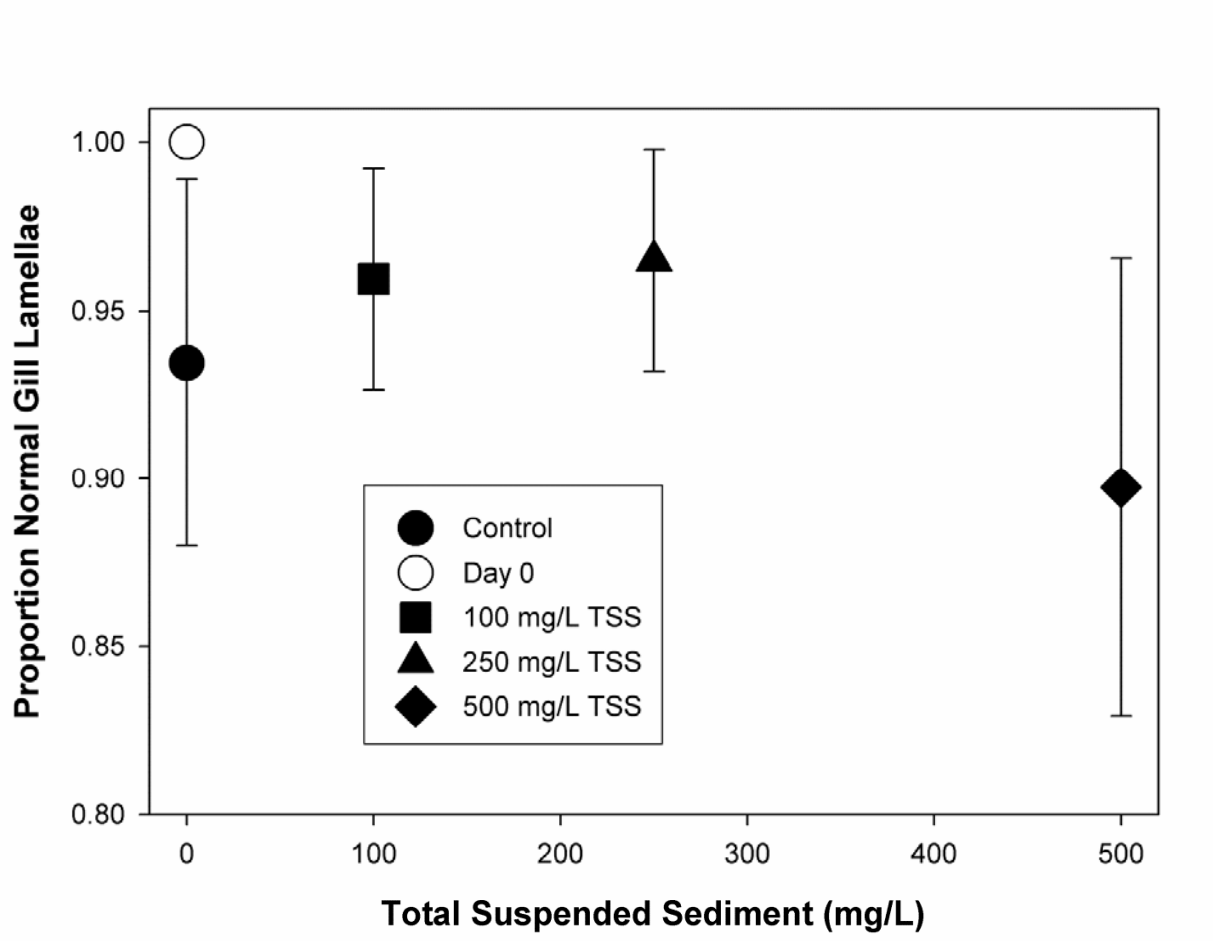
Experiments and Endpoints

- Two Experimental Phases
  - 2010
  - 2011

- Endpoints: Northern & Southern Strains
  - Fingerlings: survival, coiling, scoliosis, lordosis/kyphosis, gill integrity
  - Eggs: viability and hatchability, wet and dry mass

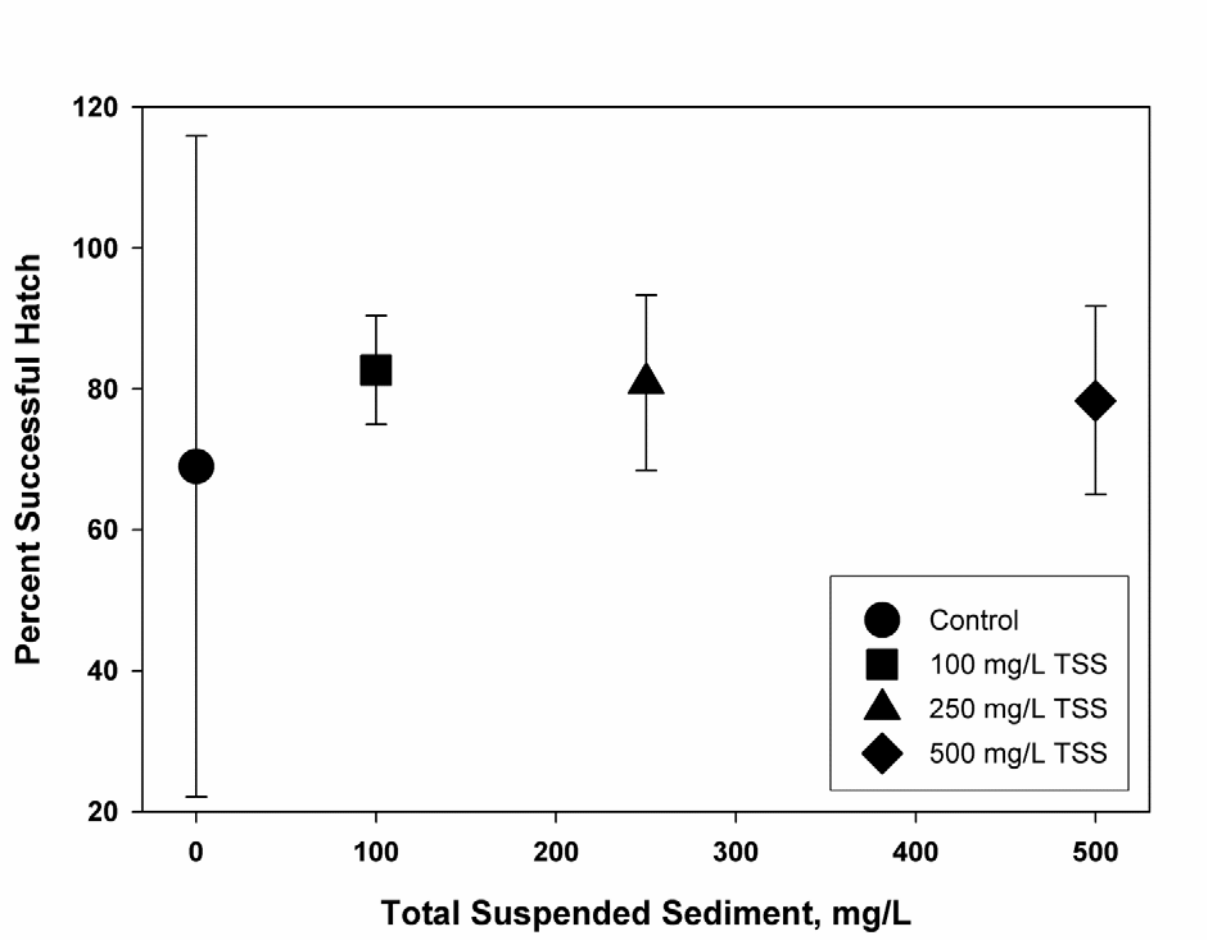
Northern Strain Fingerling Gill Lamellae

Fingerling gill lamellae did not differ significantly among TSS treatments



Percent Hatch of Northern Strain Eggs

No significant differences among treatments were observed for percent hatch (Anova, F=1.15, P=0.386)

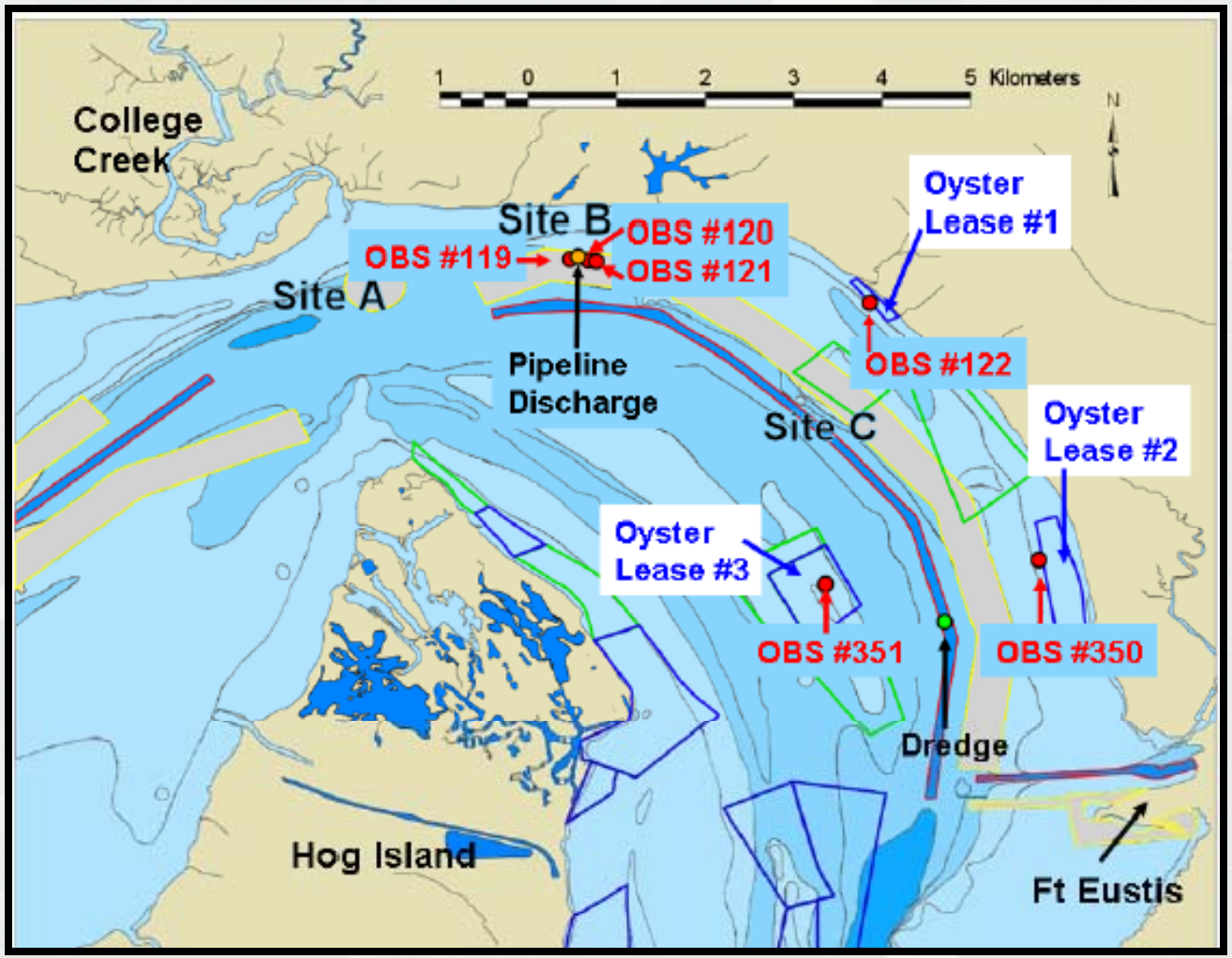


Walleye: EW Study Status

- Generating effects data
- Published results having positive impact

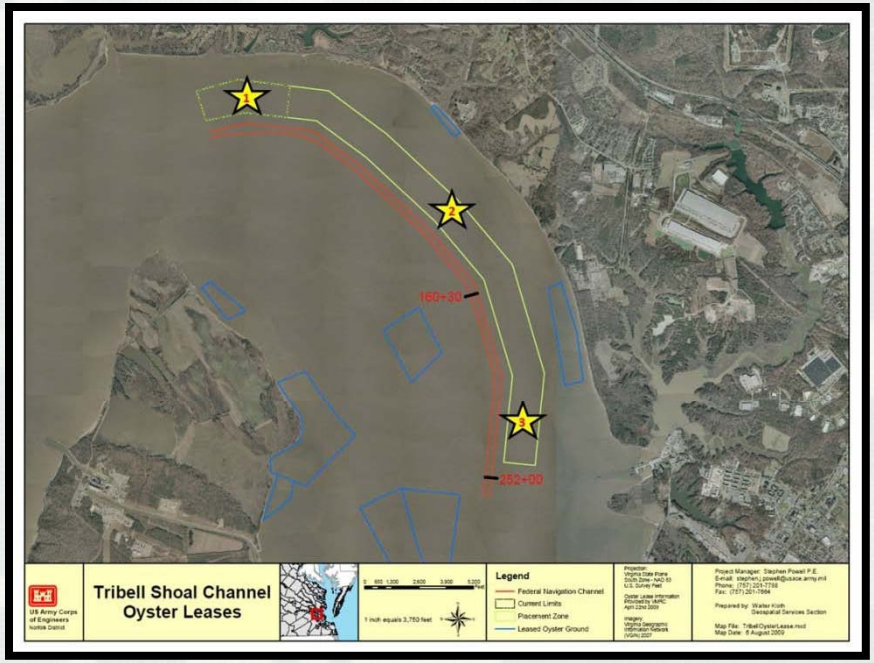
- Ohio DNR considering 1-yr waiver to an EW based on USACE exposure and effects data for walleye (2015)

Case Study: Oyster EW
James River, VA



Oysters: Exposure Simulations

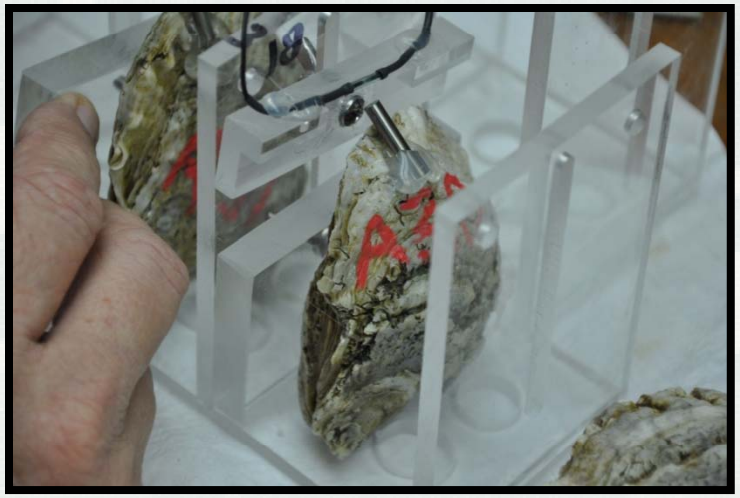
- Determine exposure from dredging operation pipeline placement near an oyster lease
- Use Particle Tracking Model (PTM) to simulate resuspended dredged sediment transport considering three placement locations



Oysters: Exposure Simulations

- Particle Tracking Model
  - One week of dredging
  - Simulated during February
  - Dredging 10,000 cy/day
  - Example PTM output

Oysters: Effects Experiments

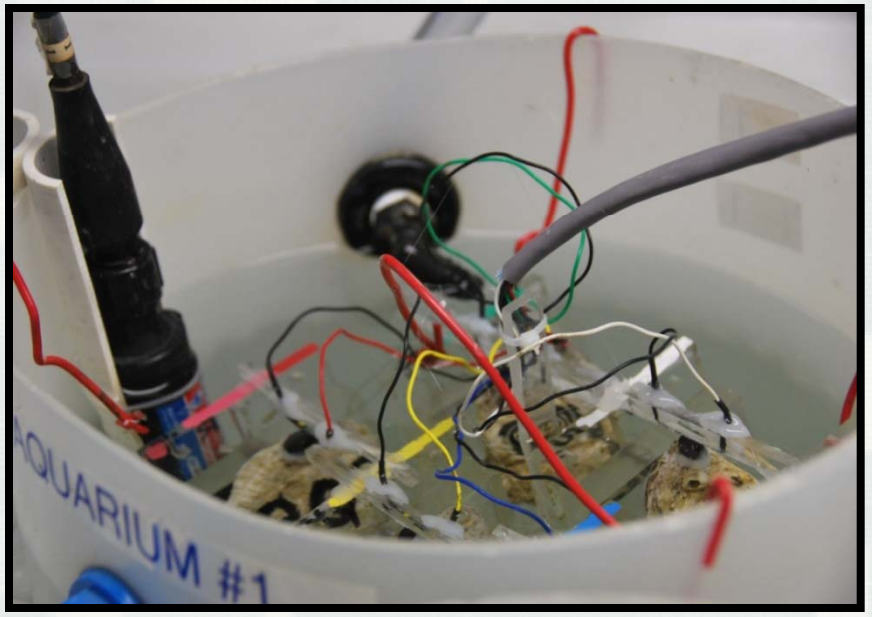


Range-finding experiments

- Oysters in spawning condition (high observed mortality)
  - ► July – November depending on local conditions
- Valuable information obtained
  - ► Sensors refined
  - ► Bugs ironed out

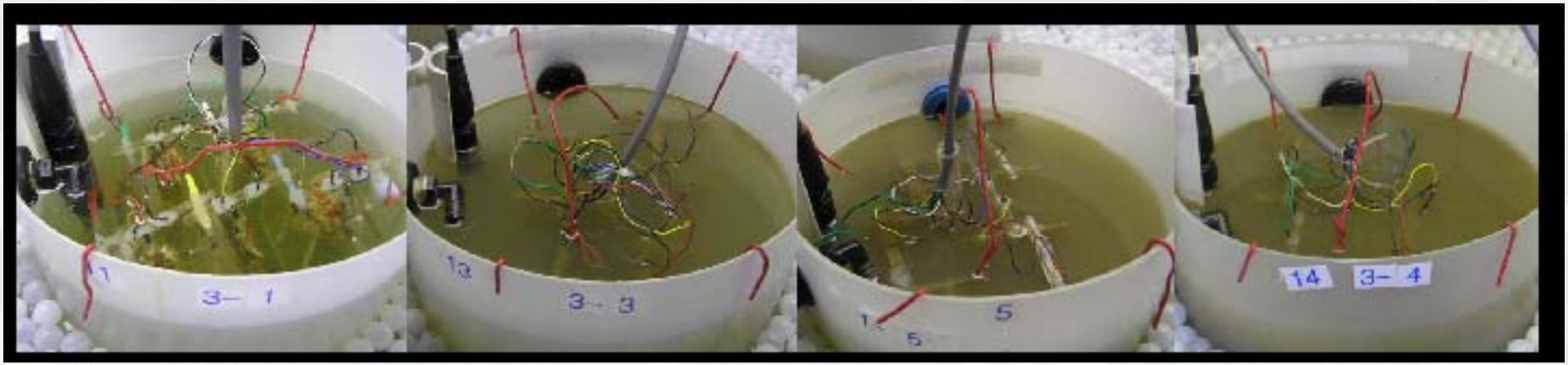
Oysters: Experimental Parameters

- December 2012
  - James River oyster fishery not yet open
  - Used Rappahannock River oysters (VIMS approval)
  - Used 3-inch oysters (legal)
  - High survival during shipping and acclimation
  - Test conditions: 7-day exposure, 12°C, 15 ppt salinity, James River sediment
  - Continuous monitoring of suspended sediment and oyster feeding (5 min intervals)



Oysters: Experimental Treatments

- Suspended sediment concentrations (mg/L TSS) mimic field conditions during dredging

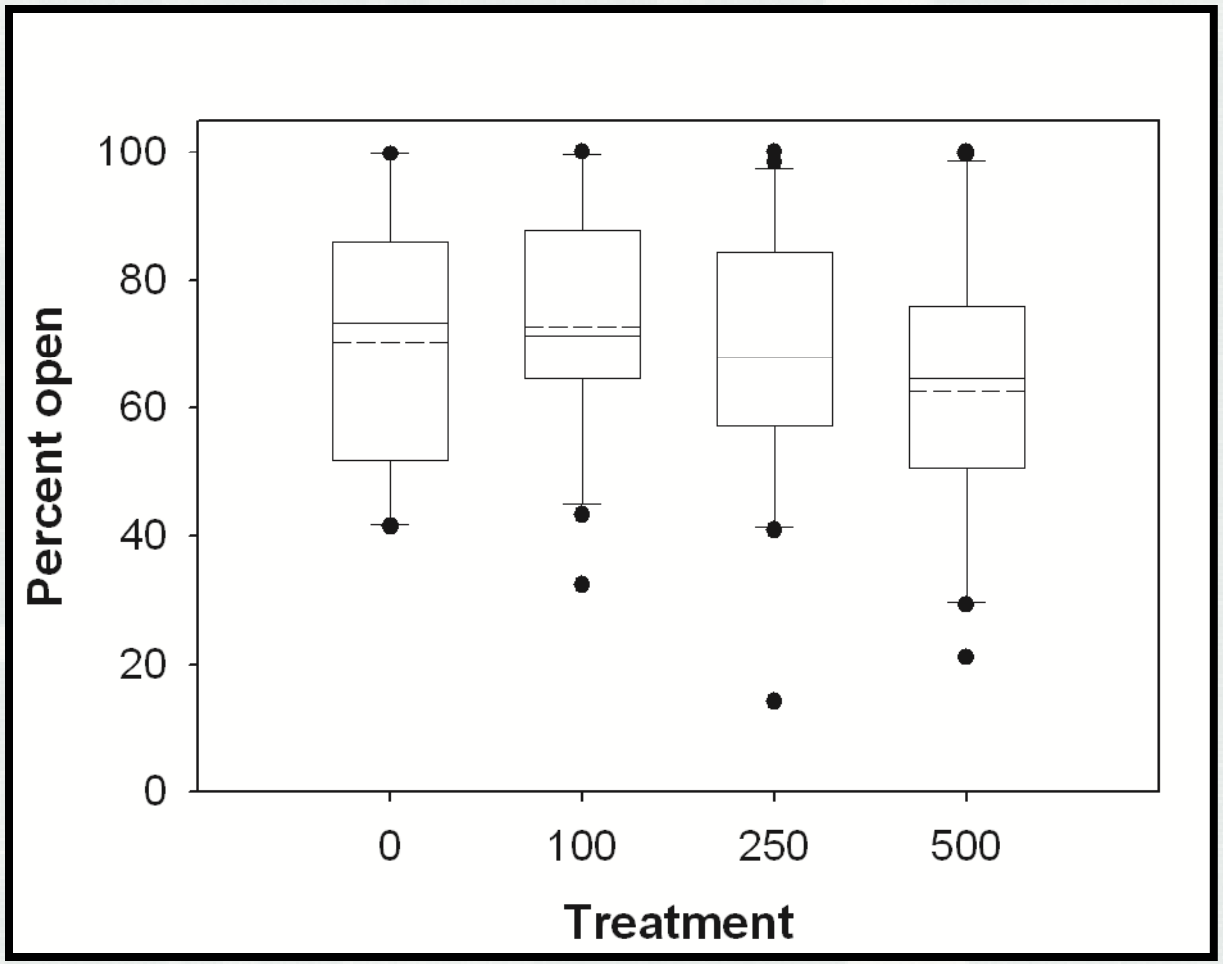


Control 100 mg/L 250 mg/L 500 mg/L

Oysters: Endpoints

- Survival
- 24-h monitoring open/close oyster shells
- Length
- Weight
- Condition index at VIMS after 30-day grow-out period

Oysters: Shell Opening Data



Oysters: EW Strategy

- Open lines of communication between the ERDC and stakeholders, especially researchers at VIMS
- Collaboration with ULM – Barry Marcel, Ph.D. candidate in toxicology
- Publication of results in 2014
- Integrate effects data with exposure modeling

Atlantic Sturgeon EW
Savannah River and Harbor, GA

Atlantic Sturgeon: EW

Problem

- Suspended sediment effects are driving EWs in the Savannah River, GA area
- Suspended sediment threshold data are lacking for sturgeon
- Robust risk assessments and risk management are impossible without effects characterizations

Objective

- Develop suspended sediment effects data for sturgeon
- Revise EWs

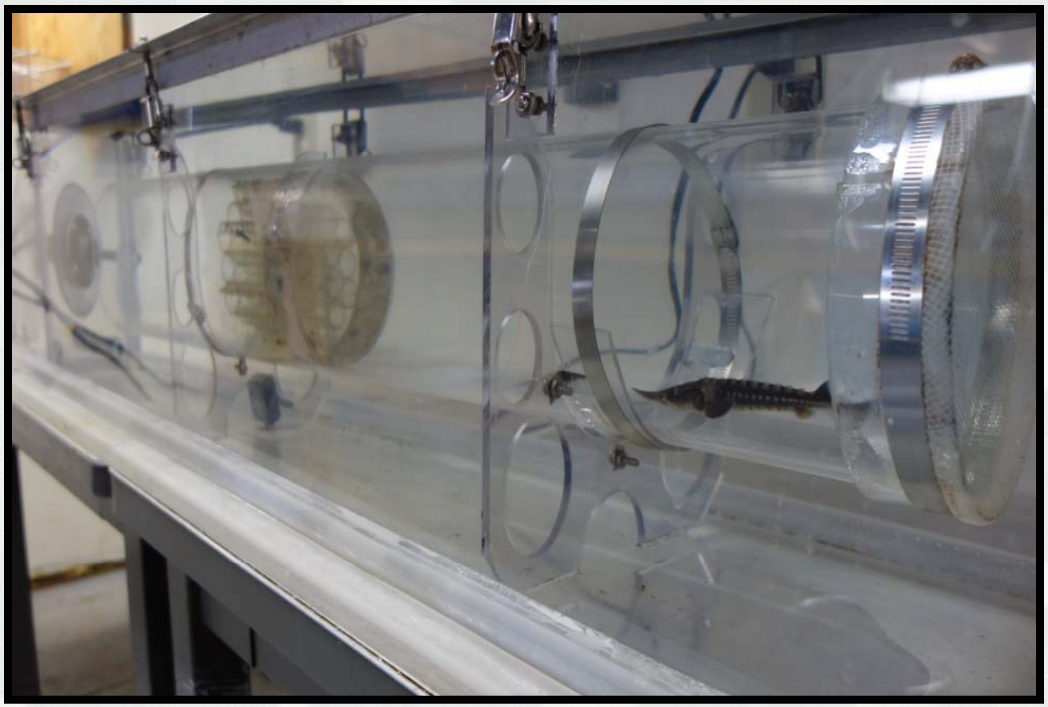
Atlantic Sturgeon: EW

Approach

- Experimentally determine suspended sediment effects using FLEES
- Fill knowledge gaps supporting risk assessments
- Collaborate with regulatory agencies and publish results
- Support District EW negotiations

Sturgeon: Endpoints

- Survival
- Growth
  - Total length (mm)
  - Standard length (mm)
  - Weight (g)
- Swim performance
  - Rheotaxis
  - Endurance
  - Swim speed



[redacted]

Sturgeon: Preliminary Results

Response of Atlantic sturgeon to 3-day sediment exposures. Values are means. Means for any variable were not significantly different from those of other treatments based on ANOVA (p > 0.05).					
Treatment (TSS)	**0**	**100**	**250**	**500**	**ANOVA PR > F**
Survivorship during exposure (% of all fish tested)	**100%**	**100%**	**96%**	**92%**	**n/a**
Post-exposure survival time (mean proportion of 14 day monitoring period)	**0.89**	**0.78**	**0.76**	**0.71**	**0.3285**
$Ucrit_{ABS}$ (cm/s)	**21.0**	**23.3**	**31.3**	**29.6**	**0.4874**
$Ucrit_{REL}$ (BL/s)	**1.24**	**1.62**	**1.84**	**1.74**	**0.5819**

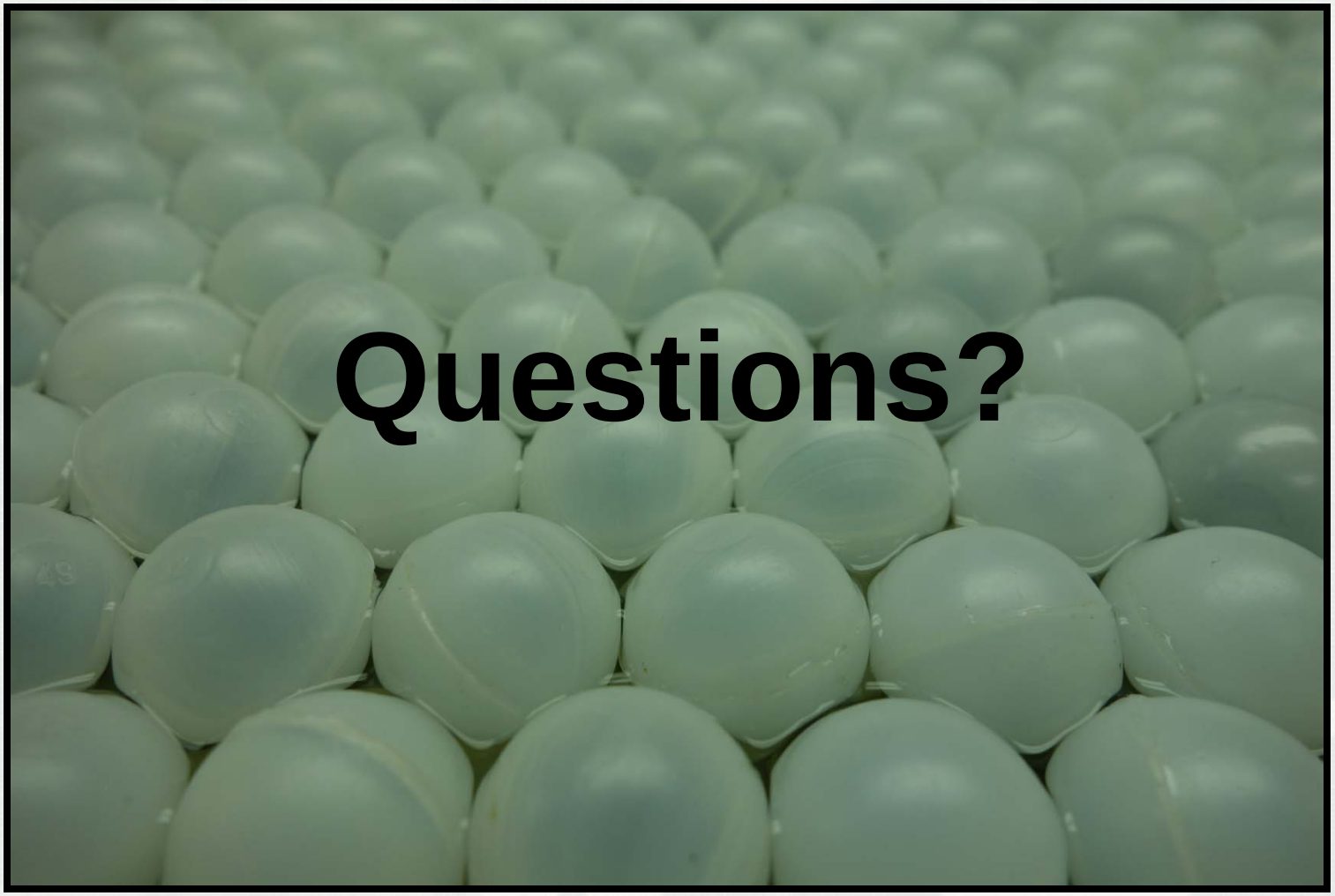
No significant effects observed for endpoints measured.

Cumulative Findings

- These experimental data can be used with dredge plume characterization data to assess risk to aquatic species driving EWs
- Current EW restrictions may merit review in light of reduced uncertainty regarding risk associated with effect thresholds within the range of dredging-induced perturbations
- Job not done until EWs are revised and dredging risks are managed based on sound science

Products and Deliverables

- Webinars
  - Field data collections and modeling applications
- Collaborations with other agencies
  - Ohio DNR (walleye); USFWS (sturgeon)
- Collaborations with universities
  - VIMS, Auburn, ULM (oysters)
- Journal papers
  - JGLR (walleye); MEPS (oysters); JAI (sturgeon)
- Agency and stakeholder meetings
- ERDC Technical Notes and reports
  - ERDC TN-DOER-E32


Questions?