Environmental Windows Research Update

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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)
FLEES is a 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 is 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
FLEES is 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 can Mimic Field Conditions

- Requires small quantities of sediment
- Uses project sediment
- Establishes a turbidity/TSS relationship
Case Study: Walleye EW Maumee Bay, OH

Spawning Area

Larval Nursery Area
Walleye: EW

Problem

- The EW in Maumee Bay, OH in western Lake Erie is restricting dredging operations
- Suspended sediment threshold data are lacking for walleye relevant to dredging
- Effects data are essential for conducting risk assessments and managing dredging risks

Objective

- Develop suspended sediment effects data for walleye early life stages to reduce uncertainty about effects and to better inform the EW
**Near-field Plume Conditions**

Maumee Bay Study Area

Distance from Dredge: 3m

Plume Width: 50 m

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**Entrained Air**

Max. TSS 800 mg/l

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**LWC Max. Turb.**

700 NTU (15 m)  
< 300 NTU (30m)

**UWC Max. Turb.**

175 NTU (15 m)  
50 NTU (30m)  
Ambient < 50 m

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**Graph Details:**

- **NTU (mg/L):**
  - Near-field (2.2 m Depth)
  - Near-field (7.0 m Depth)
  - Ambient (7.0 m Depth)

- **Distance from Dredge:**
  - 3m

- **Plume Width:**
  - 50 m

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**Graph Notes:**

- Distance (m)
- Time
- Depth (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

![Graph showing the proportion of normal gill lamellae against total suspended sediment (TSS) levels. The graph includes data points for Control, Day 0, 100 mg/L TSS, 250 mg/L TSS, and 500 mg/L TSS.]
Percent Hatch of Northern Strain Eggs

No significant differences among treatments were observed for percent hatch (Anova, F=1.15, P=0.386)
Atlantic Sturgeon EW
Savannah River and Harbor, GA
Atlantic Sturgeon: EW

Problem

- Suspended sediment effects on sturgeon are restricting dredging operations (via EWs) in the Savannah River, GA area
- Suspended sediment threshold data are lacking for sturgeon
- Effective risk management of dredging operations is not possible without effects characterizations

Objective

- Develop suspended sediment effects data for sturgeon to reduce uncertainty about effects and to better inform EWs
Sturgeon: Endpoints

- Survival
- Growth
  - Fork length (mm)
  - Condition (K)
  - Wet weight (g)
- Swim performance
  - Rheotaxis
  - Endurance
  - Swim speed
Sturgeon: Initial 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).

<table>
<thead>
<tr>
<th>Treatment (TSS)</th>
<th>0</th>
<th>100</th>
<th>250</th>
<th>500</th>
<th>ANOVA PR &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survivorship during exposure (% of all fish tested)</td>
<td>100%</td>
<td>100%</td>
<td>96%</td>
<td>92%</td>
<td>n/a</td>
</tr>
<tr>
<td>Rheotaxis (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>96</td>
<td>n/a</td>
</tr>
<tr>
<td>Ucrit$_{ABS}$ (cm/s)</td>
<td>21.0</td>
<td>23.3</td>
<td>31.3</td>
<td>29.6</td>
<td>0.4874</td>
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<tr>
<td>Ucrit$_{REL}$ (BL/s)</td>
<td>1.45</td>
<td>1.89</td>
<td>2.15</td>
<td>2.09</td>
<td>0.5819</td>
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</tbody>
</table>

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.

- Increased understanding about project dredging risks can be used to better manage this risk based on sound science.
Products and Deliverables

- Stakeholder meetings
- ERDC Technical Publication ERDC TN-DOER-E32
FLEES Applications

- Multiple species
  - Fish (e.g., walleye, sturgeon)
  - Bivalves (e.g., oysters)
  - Submerged aquatic vegetation
- Freshwater, estuarine, marine
- Life stages
  - Adult
  - Fingerlings
  - Fry
  - Eggs
- Suspended sediment and burial exposures
- Continuous and pulsed exposures
Next Steps

- **Smallmouth Bass**
  - **Concern:**
    - Turbidity impacts to early life stages in spawning grounds on shoals along waterway margins
  - **Locations:**
    - Lake Michigan – Grand Haven Harbor, MI sediment
    - Lake Erie – Fairport Harbor, OH sediment
  - **Fish collections:**
    - East Texas
    - Illinois
  - **Early life stages:**
    - Eggs
    - Swim-up fry
Questions?