Recent Dredging Studies Relevant to Environmental Windows

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RISK FRAMEWORK

RISK ASSESSMENT PARADIGM

Problem Formulation

Exposure Assessment

Risk Characterization

Effects Assessment

Risk = \( f(\text{Exposure} + \text{Effect}) \)

Risk Management

Management Practices (Precautions)

Economic Analysis, Socio-Political, Engineering Feasibility
TOPICS

• Characterization of spatial scales and temporal dynamics of bucket dredging plumes in Maumee Bay, Toledo, OH

• Determination of response thresholds of walleye eggs and fry to exposures to elevated suspended sediment concentrations

• Characterization of spatial scales and temporal dynamics of bucket dredging plumes in the Cuyahoga River, Cleveland, OH
Maumee Bay Dredging Study

Characterize the spatial extent, concentration gradient structure, and temporal dynamics of suspended sediment plumes during bucket dredging operations.
15 cubic yard open bucket
1. Acoustic Doppler current profiler (ADCP) surveys to map plumes.
2. Deployment of optical backscatter sensors (OBS) for time series records of turbidity.
3. Water samples collected for gravimetric analysis and used to calibrate the acoustic backscatter data.
4. Fisheries hydroacoustics surveys to examine distributions of fishes in the vicinity of operating dredges.
ADCP and Fisheries
Hydroacoustics Transducers
ADCP transect in close proximity to the operating bucket
Ambient Conditions
(Maumee River and Adjacent Shoals)

Channel Consistently 20-25 mg/L
Shoals Typically 10-20 mg/L (~25)

Distance: 300 m
Dredge: Idle

Channel
Avg. = 19
Max. = 27

Shoal
Avg. = 13
Max. = 15
Near-Field Plume Conditions

Peak Lower Water Column Turbidity:
700 NTU (15 m) < 300 NTU (30m)

Peak Upper Water Column Turbidity:
175 NTU (15 m) 50 NTU (30m)
Ambient in < 50 m
Near-Field Plume Conditions

- Max. TSS: 800 mg/l
- Plume Width: 50 m
- Distance from Dredge: 3 m

Entrained Air

Max. TSS 800 mg/l
Near-Field ADCP Plume Transect
(27 Meters from Bucket Dredge)

- TSS decreased to < 300 mg/l at a distance of 24 m
- Highest TSS concs. found in lower 3-m of water column
- No detection of plume migration over shoals
- Very narrow surface plume 25 mg/l above background

Note Change in Scale
• Plume movement limited to channel basin and lower side slopes
• Plume footprint <75 m wide and <200 m up or down-channel
Fisheries Hydroacoustics

200 kHz Transducer

Insonified Water

Fish Targets
Example Fisheries Echogram
(Maumee Bay Navigation Channel)

Channel Bottom

Fish Targets
Fish length distribution for two surveys (TCSB in the early morning and TCSD late afternoon) conducted in August 2005.
Maumee Bay Fish Target Density

Transects 1-10 occupied 2 to 261 m downriver from dredge
Transects 11 and 12 occupied port and starboard
Transects 13-22 occupied 2 to 254 m upriver from dredge

Mean = 0.23 fish/100 cu m
Distribution of Fish Targets

Fish Per Cu. M.
- 0
- 0 - 0.002
- 0.002 - 0.005
- 0.005 - 0.01
- > 0.01
Maumee Bay Summary

• Plumes produced by bucket dredging as conducted in this study can be described as relatively narrow bands of elevated TSS concentration that decayed rapidly within short distances from the source.
• The plan-view “footprint” of the plume was typically less than 75 m wide and extended no more than 200 m down-drift.
• Surface plumes were not detected beyond 60 m from the source.
• Plume movement was effectively confined between the navigation channel side-slopes.
• Detectable plumes decayed to ambient conditions within 200 m of the source.
• Average fish density at the study site was low (0.23 fish/100 cu m).
• Fish targets were comprised primarily of small (5-15 cm TL) fishes, and the majority of targets were bottom oriented.
Exposure of Walleye (*Sander vitreus*) Eggs and Fry to Suspended Sediment

- Experimental conditions not indicative of field conditions
  - Exposure concentrations <500 mg/L TSS
  - Exposure duration <3-4 days
- Few species (salmonids mostly)
- Life stage relevancy issues
- Walleye data lacking
Materials and Methods

- **Flow-through Fish Larvae and Egg Exposure System (FLEES)**
- 3 modules/15 aquaria/3 500 L water baths
- Aquaria (15) constructed from 20 L polyethylene carboys
- Pump recirculated water and suspended sediment in aquaria
- Sediment mixed with water and stored in 375 L cone bottom tank via dbl diaphragm pump
- Slurry routed through FLEES and reused
- Sediment concs monitored using optical OBS® sensors
Materials and Methods

- Walleye (*Sander vitreus*)
- Four experiments: northern and southern strain eggs (newly spawned) and fry (45-60 d)
- 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 larvae
- PVC cups for eggs
No significant differences among treatments were observed for viable eggs (Anova, $F=0.38$, $P=0.7678$).
Fry survival did not differ significantly among TSS treatments (Anova, F=1.53, P=0.2605).
Summary of 2010 Data

• **FLEES provided a means to simulate a dredge plume in the laboratory**

• **Southern strain:**
  – No effects on egg viability or hatchability
  – Slight but not significant effect on egg viability at 500 mg/L TSS

• **Northern strain:**
  – No effects on egg viability or hatchability, or fry survival

• **Path forward:**
  – Repeat experiments to increase sample size
  – Assess sublethal endpoints: morphological and gill effects
Cuyahoga River Study Site

Dredging Site
Typical Echogram

Acoustic targets primarily emerald shiners, gizzard shad, and carp
Challenge: Distinguish Fish from Debris
Fish (Target) Density Plot

Fish per 100 cu. m.
- 0
- >0 - 50
- >50 - 100
- >100 - 200
- >200 - 500
- >500 - 1000
- >1000

100 0 100 200 Meters
Questions?

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