LABORATORY TEST OF SUSPENDED SEDIMENT EFFECTS ON SHORT-TERM SURVIVAL AND SWIMMING PERFORMANCE OF JUVENILE ATLANTIC STURGEON

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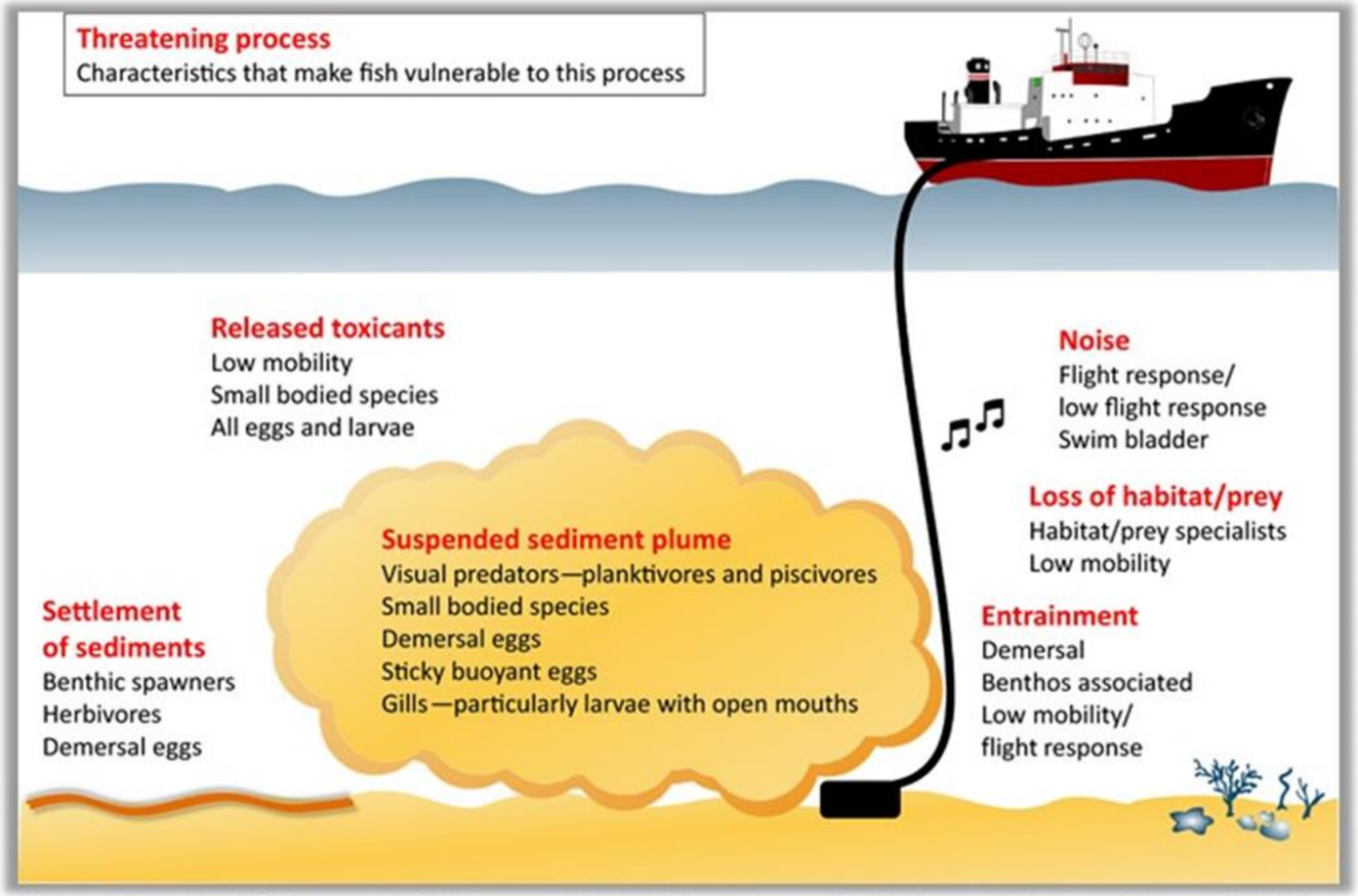
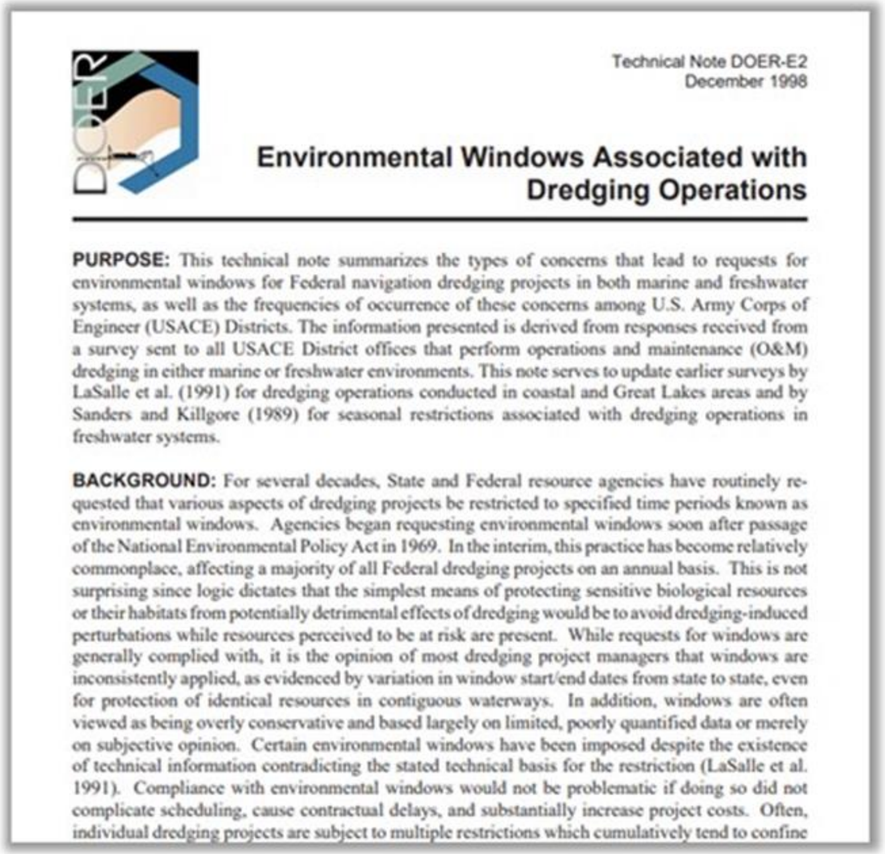


Figure from "A critical analysis of the direct effects of dredging on fish, Volume: 18, Issue: 5, Pages: 967-985, First published: 27 March 2017, DOI: (10.1111/faf.12218)"

ENVIRONMENTAL WINDOWS



Technical Note DOER-E2
December 1998

Environmental Windows Associated with Dredging Operations

PURPOSE: This technical note summarizes the types of concerns that lead to requests for environmental windows for Federal navigation dredging projects in both marine and freshwater systems, as well as the frequencies of occurrence of these concerns among U.S. Army Corps of Engineer (USACE) Districts. The information presented is derived from responses received from a survey sent to all USACE District offices that perform operations and maintenance (O&M) dredging in either marine or freshwater environments. This note serves to update earlier surveys by LaSalle et al. (1991) for dredging operations conducted in coastal and Great Lakes areas and by Sanders and Killgore (1989) for seasonal restrictions associated with dredging operations in freshwater systems.

BACKGROUND: For several decades, State and Federal resource agencies have routinely requested that various aspects of dredging projects be restricted to specified time periods known as environmental windows. Agencies began requesting environmental windows soon after passage of the National Environmental Policy Act in 1969. In the interim, this practice has become relatively commonplace, affecting a majority of all Federal dredging projects on an annual basis. This is not surprising since logic dictates that the simplest means of protecting sensitive biological resources or their habitats from potentially detrimental effects of dredging would be to avoid dredging-induced perturbations while resources perceived to be at risk are present. While requests for windows are generally complied with, it is the opinion of most dredging project managers that windows are inconsistently applied, as evidenced by variation in window start/end dates from state to state, even for protection of identical resources in contiguous waterways. In addition, windows are often viewed as being overly conservative and based largely on limited, poorly quantified data or merely on subjective opinion. Certain environmental windows have been imposed despite the existence of technical information contradicting the stated technical basis for the restriction (LaSalle et al. 1991). Compliance with environmental windows would not be problematic if doing so did not complicate scheduling, cause contractual delays, and substantially increase project costs. Often, individual dredging projects are subject to multiple restrictions which cumulatively tend to confine

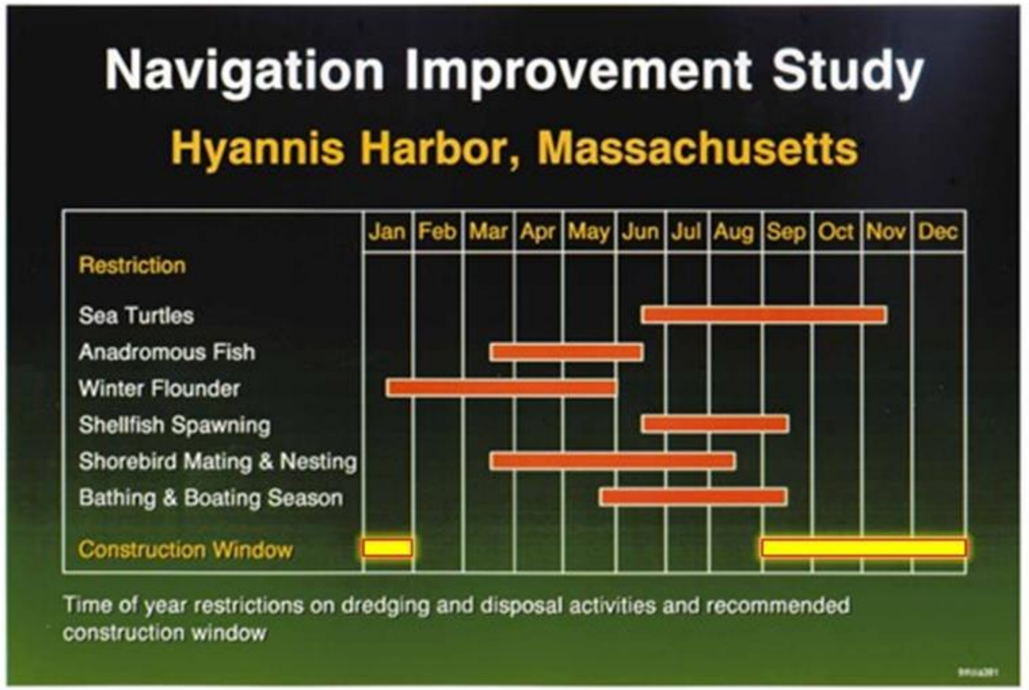
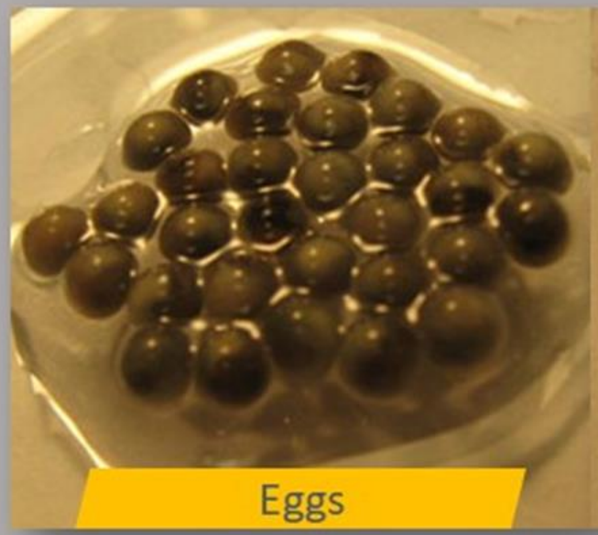


Figure 1. An example of the cumulative effect of multiple environmental windows applied to the same dredging project. In this example the dredging operation could not be completed within the remaining unrestricted period, necessitating an "exemption" during September through mid-November and the latter half of January

Reine, K. J., Dickerson, D. D., and Clarke, D. G. (1998). "Environmental windows associated with dredging operations." DOER Technical Notes Collection (TN DOER-E2). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

ENDANGERED ATLANTIC STURGEON (ATS)
Acipenser oxyrinchus oxyrinchus



Credit: NOAA; website: https://www.greateratlantic.fisheries.noaa.gov/protected/scutes/sturgeon/lifecycle/lifecycle2/index.html

Credit: ERDC

STUDY **QUESTION**

Does suspended sediment generated from dredging activities affect short-term survival or swimming performance of Atlantic sturgeon?

HYPOTHESIS:

Juvenile ATS would exhibit no response in short-term survival or swimming performance when exposed to varying concentrations of suspended sediment simulating dredge plumes in waterways where this species may be impacted by dredging operations.

OBJECTIVE:

To investigate the survival and swimming performance of juvenile ATS after exposure to varying concentrations of suspended sediment in FLEES.

FISH LARVAE AND EGG **EXPOSURE SYSTEM** (FLEES)

The laboratory system was developed to expose early life history stages of fish and shellfish to specified concentrations and durations of suspended sediment in a controlled laboratory environment.

01

Capability

SUSPENDED SEDIMENT

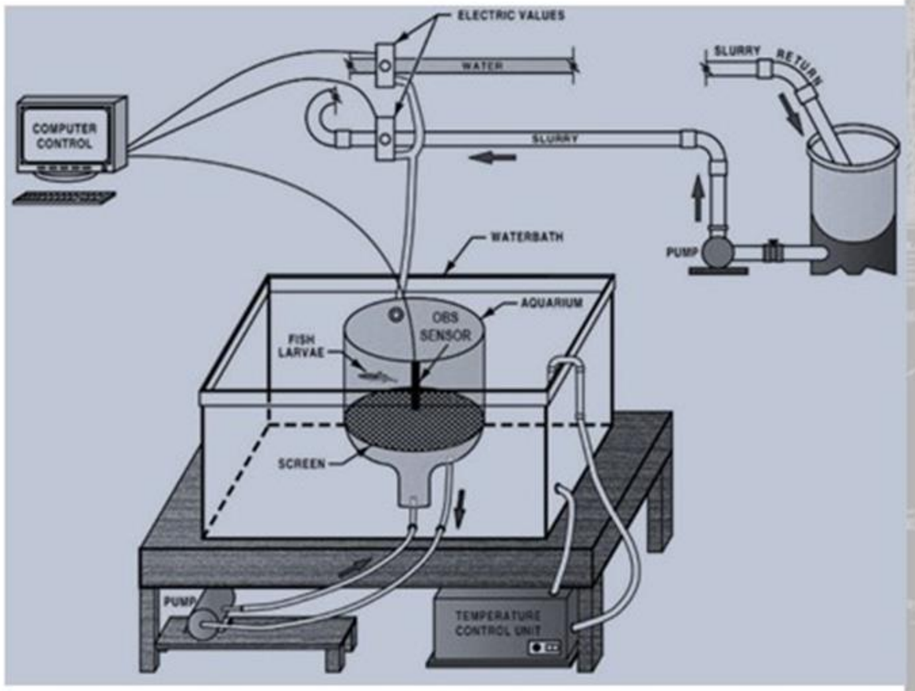
FLEES allows for the design of experiments that simulate resuspension of sediment as a result of dredging operations or other factors such as vessel traffic, freshets, or storms.

02

Capability

SEDIMENTATION

FLEES can be quickly retrofitted to accommodate the design of experiments that simulate sedimentation.



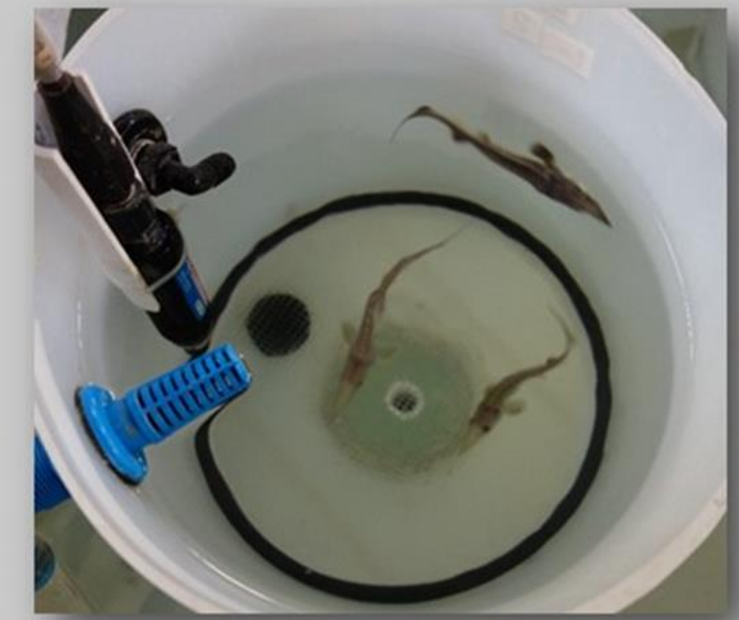
WHY **FLEES** WORKS

AND

SUSPENDED SEDIMENT

A data acquisition device and LabVIEW software is used to integrate turbidity sensors with solenoid valves to build a computer application that both continuously monitors and records turbidity in each aquarium while introducing sediment from the slurry tank to maintain specific NTUs.

WORST CASE SCENARIO



Fish contained for a prolonged periods, with limited opportunity for movement in field-collected sediment of varying concentrations.

METHODS

SOURCE OF FISH

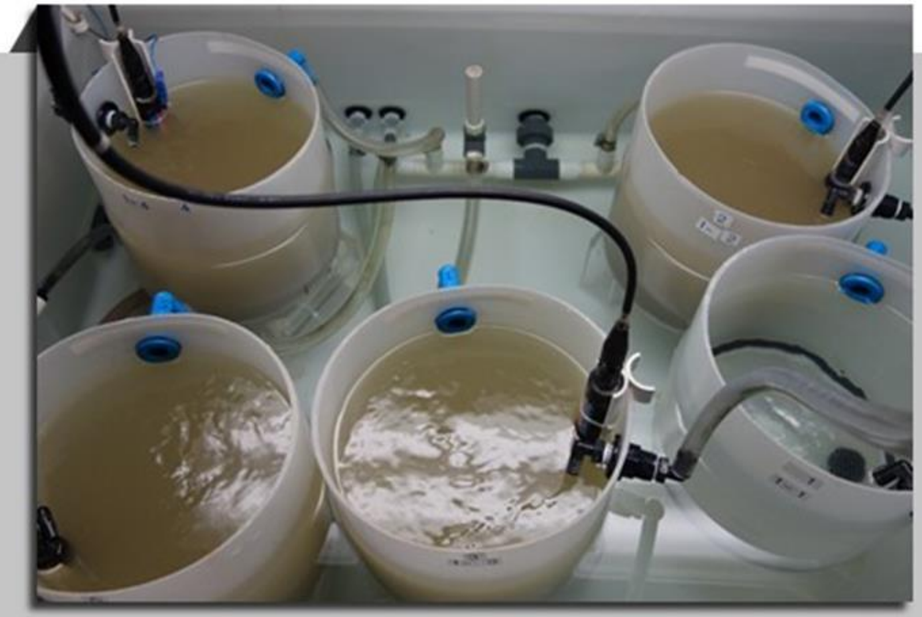
Atlantic sturgeon approximately 100-175 mm fork length were obtained in June 2013 from USFWS Bear's Bluff National Fish Hatchery, South Carolina, where they were spawned from broodstock collected in the Altamaha River, Georgia, September 2012

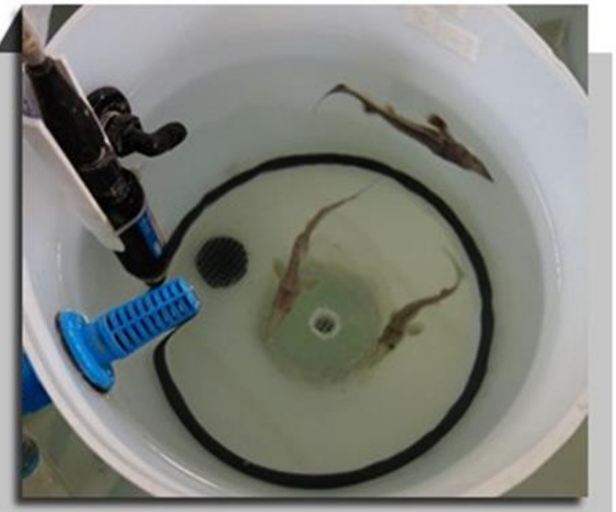
METHODS

EXPOSURE

Fish exposed to three concentrations of total suspended solids (100, 250, 500 mg/L) plus controls (0 mg/L) for 72 h (16 h light: 8 h dark). Three control replicates and four replicates of each TSS were arranged randomly using three fish per aquarium (N = 45 fish)

Response metric: short-term survival



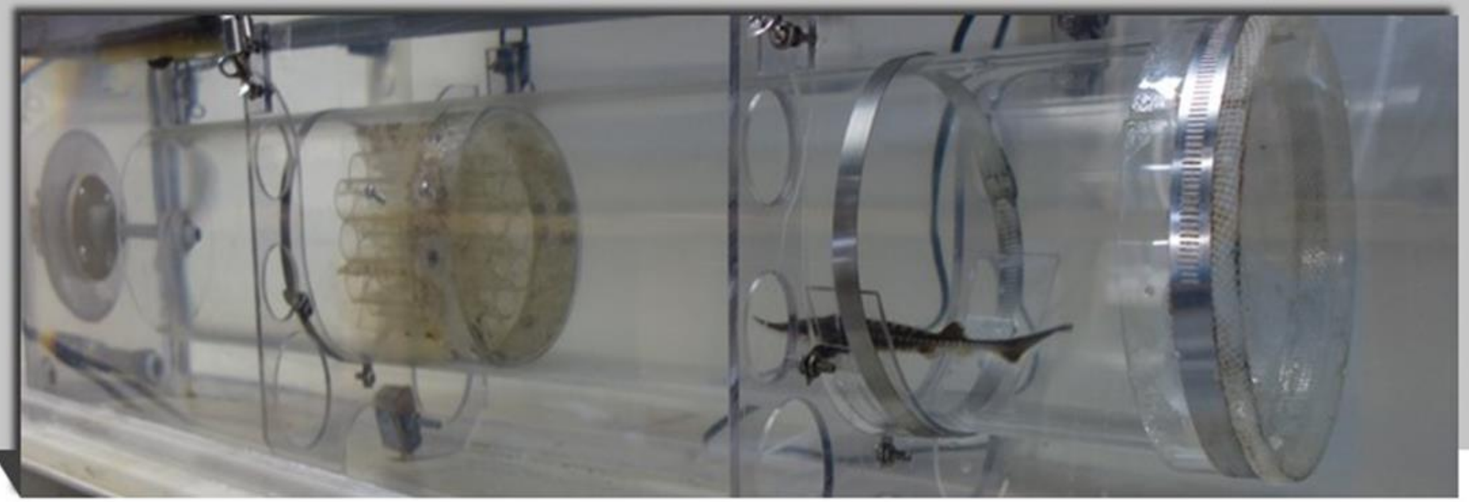


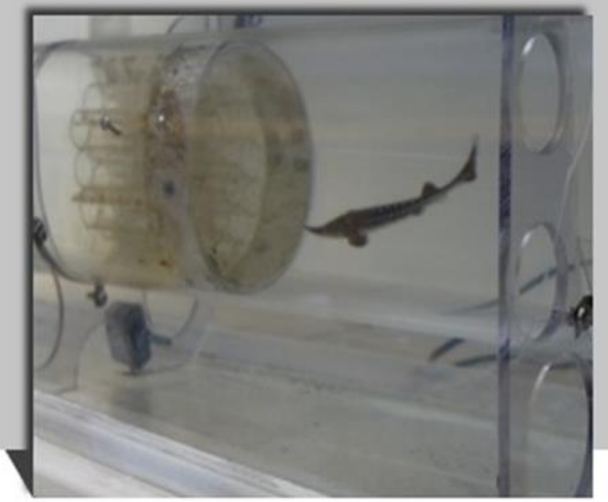
METHODS

SWIM TUNNEL

Swimming performance was tested for one fish selected randomly from each concentration replicate. It was placed immediately after the 72-h exposure period into the test section of a Blazka swim tunnel.

Response metrics: (i) positive rheotaxis head first orientation into the direction of water flow; (ii) critical swim speed – endurance at successively higher water velocities; and (iii) station-holding behavior – proportion of time spent in various modes of locomotion.





RESULTS

	Suspended Sediment Concentration (mg/L)			
Size of sturgeon	0	100	250	500
Fork length (mm)	140 ± 14	128 ± 19	143 ± 13	142 ± 14
Wet weight (g)	11.6 ± 3.4	9.4 ± 3.8	12.2 ± 3.3	12.5 ± 4.2
Condition (K)	0.424 ± 0.023	0.433 ± 0.036	0.409 ± 0.021	0.424 ± 0.038
Environmental conditions				
TSS (mg/L)	*0 ± 3*	*115 ± 10*	*275 ± 11*	*528 ± 18*
Temperature (C)	21.1 ± 0.4	21.4 ± 0.4	21.4 ± .04	21.3 ± 0.5
Dissolved oxygen (mg/L)	6.9 ± 0.9	7.5 ± 0.5	7.5 ± 0.8	8 ± 0.4
pH	8.1 ± 0.1	8.2 ± 0.1	8.2 ± 0.1	8.2 ± .01
Un-ionized ammonia (mg/L)	<0.01	<0.01	<0.01	0.01
Nitrite (mg/L)	ND	ND	ND	ND
Light intensity (lux)	2145 ± 333	2234 ± 214	1774 ± 284	1912 ± 180

RESULTS

	Suspended Sediment Concentration (mg/L)			
Endpoint	**0**	**100**	**250**	**500**
FLEES				
Survival (%)	100	100	96	88
Swim tunnel				
Rheotaxis (%)	100	100	100	96
U_{crit} (cm/s)	21.02 ± 12.59	23.32 ± 9.38	31.34 ± 14.69	29.58 ± 19.24
U_{crit} (BLS)	1.45 ± 0.72	1.89 ± 0.88	2.15 ± 0.91	2.09 ± 1.29
Contact-based station-holding (%)	81.7 ± 40.1	51.0 ± 51.9	75.7 ± 44.9	69.3 ± 47.5

DISCUSSION

MAIN TAKEAWAY

Effects of suspended sediment on ATS survival and swimming performance were, respectively, negligible and undetectable. Deaths of only 1/24 sturgeon exposed to 250 mg L and 3/24 to 500 mg/L suggest that the tested concentrations of Savannah Harbor sediment are unlikely to be lethal.

WHAT ABOUT SIMILAR STUDIES?

Mortality in fishes has been observed when they are exposed to an increasing duration and/or concentration of suspended sediments. However, mortality usually occurs when TSS concentrations far exceed those found near dredging operations or due to other turbidity sources (i.e. >10,000 mg/L).

INDIVIDUAL FITNESS

The variation observed in U_{crit} values and post-exposure mortality for ATS shows that exposure to these TSS concentrations may introduce slight changes that are difficult to measure but eventually affect survival of an individual fish rather than a group of fish from the same treatment as might be expected. At this duration and TSS concentrations individual fitness of juvenile ATS and capacity to persist in the presence of suspended sediments may be more important.

CONCLUSIONS

THIS LABORATORY EXPERIMENT SIMULATED A WORST-CASE SCENARIO

Juvenile ATS contained for a prolonged period (3 days), with limited opportunity for movement in field-collected sediment of varying concentrations.

ABSENCE OF SUBSTANTIAL/SIGNIFICANT EFFECTS ON SURVIVAL AND SWIMMING PERFORMANCE

Data suggest that impacts of sediment plumes in nature, where fish have freedom of movement and the power to rapidly escape, are minimal, although it should be noted, direct avoidance of such plumes by nekton are undocumented.

PATH FORWARD

High survivability of various fish species, including the ATS in this study, to concentrations of suspended sediments in short-term exposures provides evidence that sublethal changes in physiology, morphology, and behavior, and avoidance of suspended sediments are perhaps more important to investigate as these could affect long-term survival of the species after exposure.

ACKNOWLEDGEMENTS

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Kent Ware, Bears Bluff National Fish Hatchery, Wadmalaw Island, South Carolina, USA for supplying the fish used in this study (https://www.fws.gov/bearsbluff/); Cynthia Williams, U.S. Fish and Wildlife Service, for assistance in facilitating the permitting process (Permit No. 17367); and to Dennis Riecke and Charles Silkwood, Mississippi Department of Wildlife Fisheries and Parks, for the loan of the fish hauler (https://www.mdwfp.com/).

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https://doer.el.erdc.dren.mil/

Journal Article

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