

Development and Evaluation of Underwater Acoustic Deterrent Systems for Invasive Carp Control

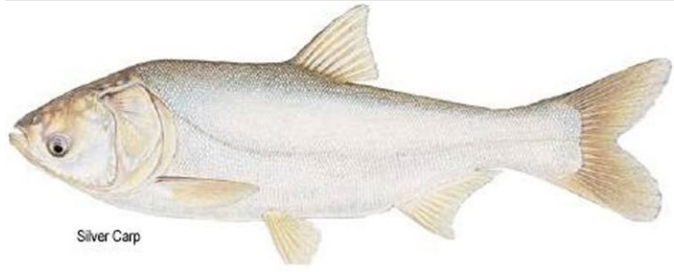
Marybeth K. Brey¹, Christa M. Woodley², Matthew Sholtis³, Andrea K. Fritts¹,
Jessica C. Stanton¹, and Theodore Castro-Santos⁴

¹U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI

²U.S. Army Engineering Research and Development Center, Vicksburg, MS

³U.S. Geological Survey, Western Fisheries Research Center, Columbia River Research Lab, Cook, WA

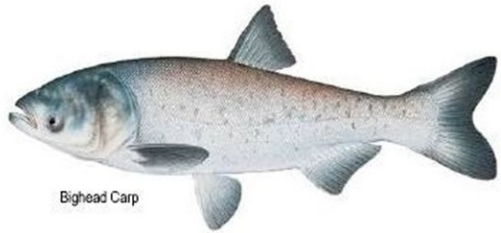
⁴U.S. Geological Survey, Eastern Ecological Science Center, S.O. Conte Anadromous Fish Research Lab, Turners Falls, MA



Silver Carp



Grass Carp



Bighead Carp

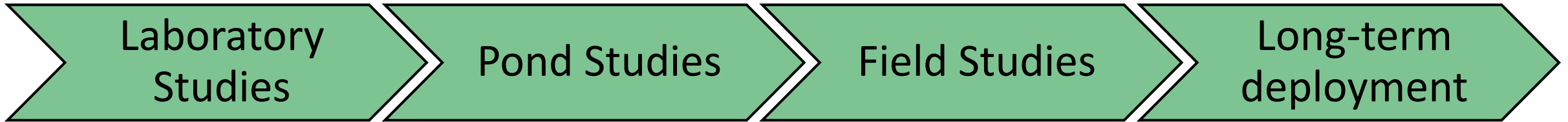


Black Carp



Research and Development Approach

Goal: Develop acoustic playbacks that alter invasive carp behavior in a predictable manner, while limiting impacts to native fishes.



Small scale

- Proof of concept
- Indoor tanks/small ponds
- Fish behavior, non-targets
- Hearing testing

Medium scale

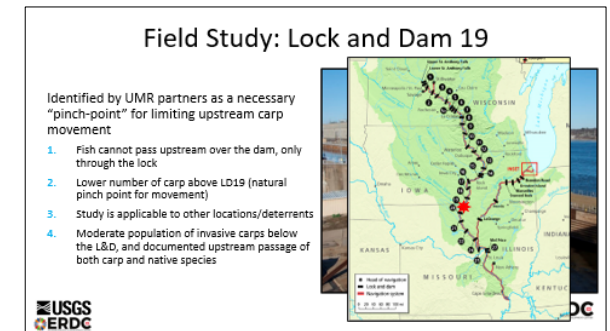
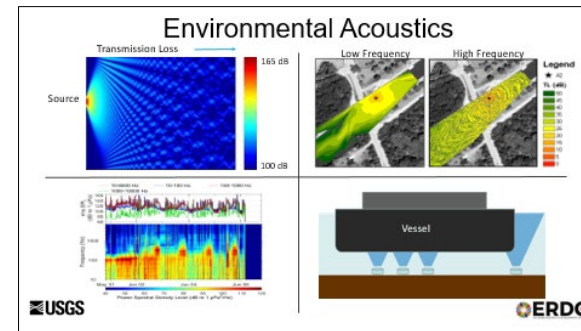
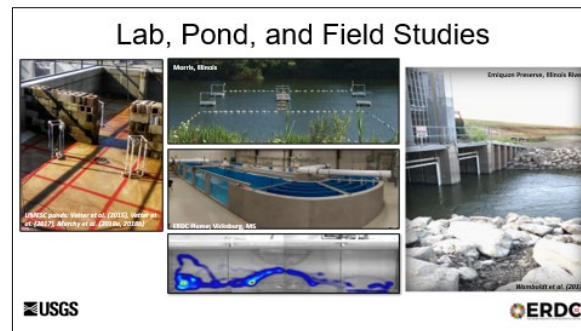
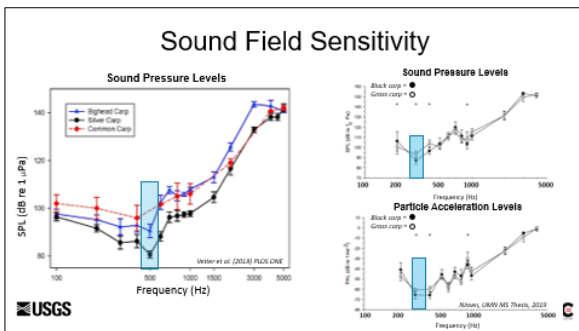
- Outdoor ponds
- Fish behavior
- Acoustic monitoring

Large scale

- Acoustic engineering
- Acoustic monitoring
- Fish behavior
- Human health

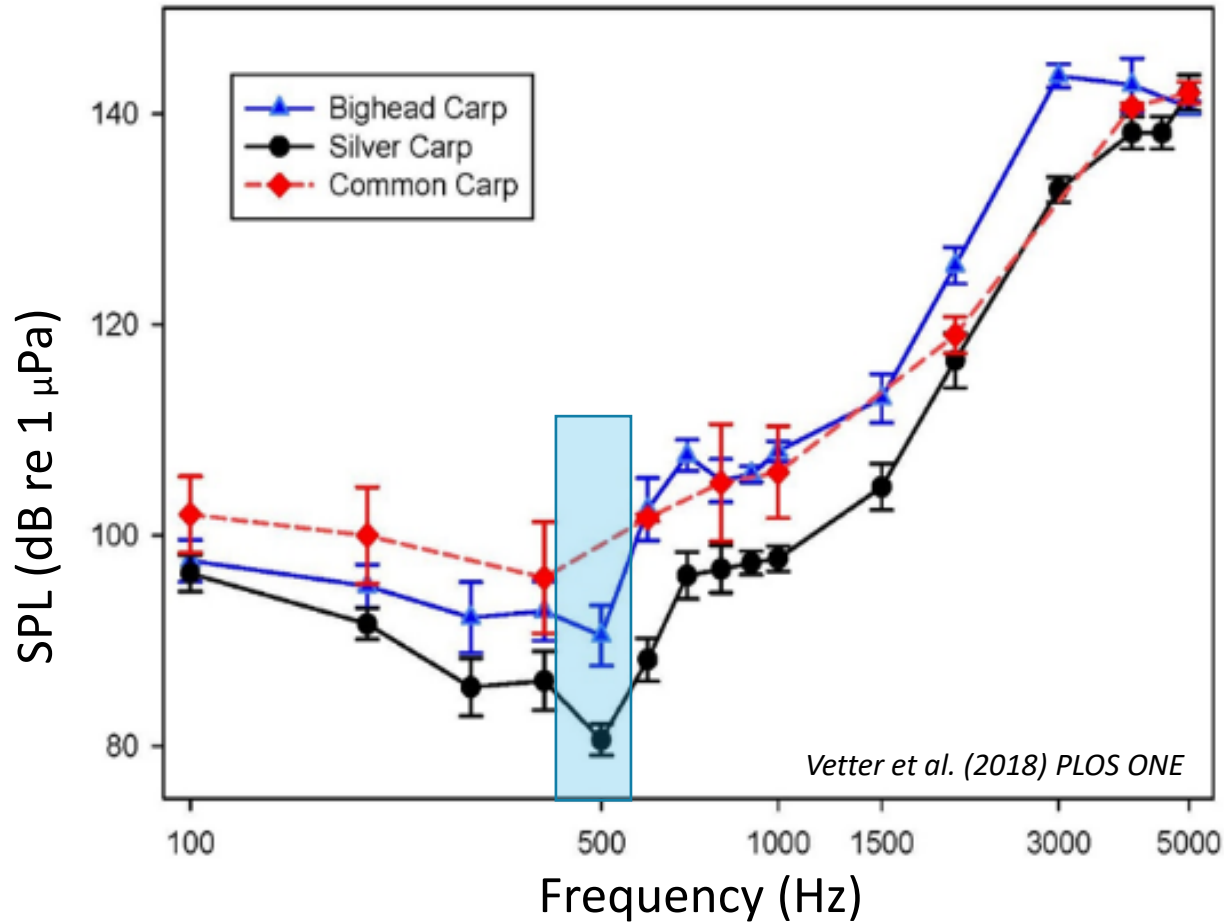
Full scale

- Navigation lock
- Engineering, design, construction, permitting
- Fish and acoustic monitoring
- TRL 7

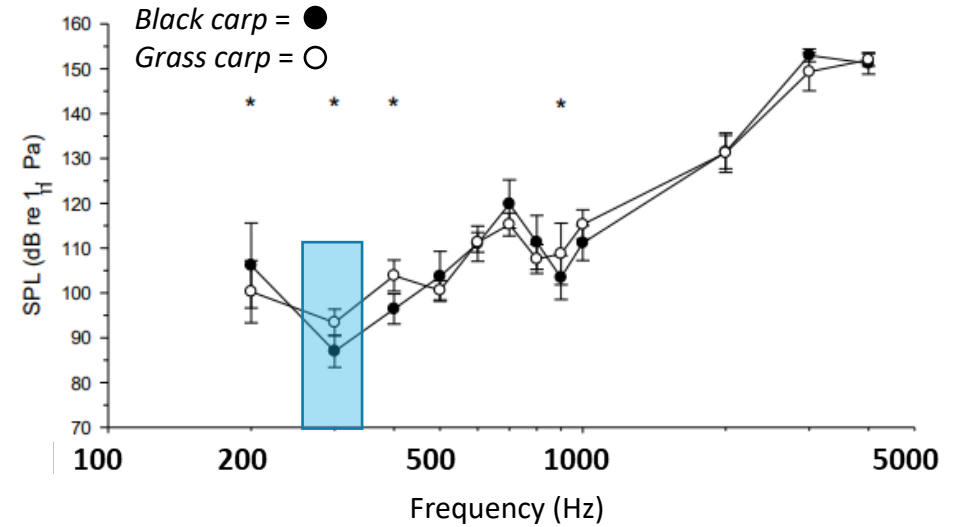


Sound Field Sensitivity

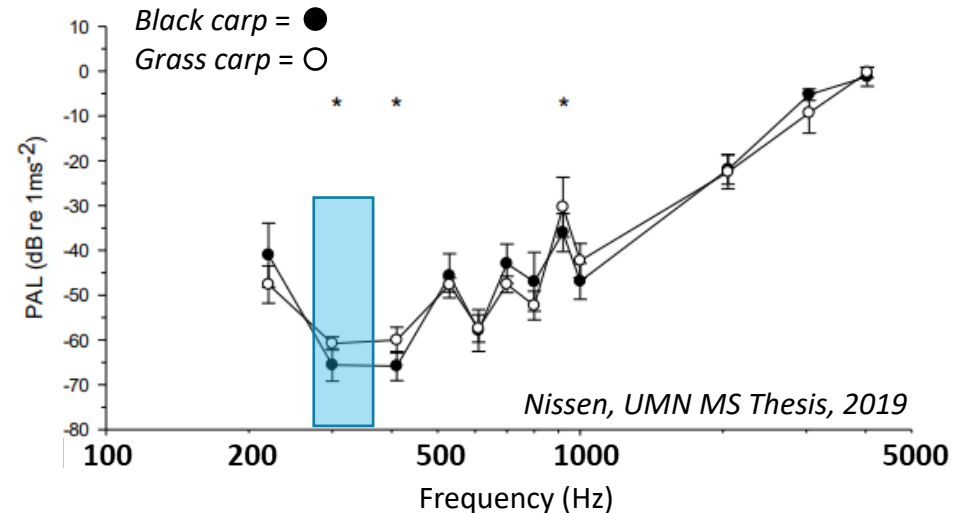
Sound Pressure Levels



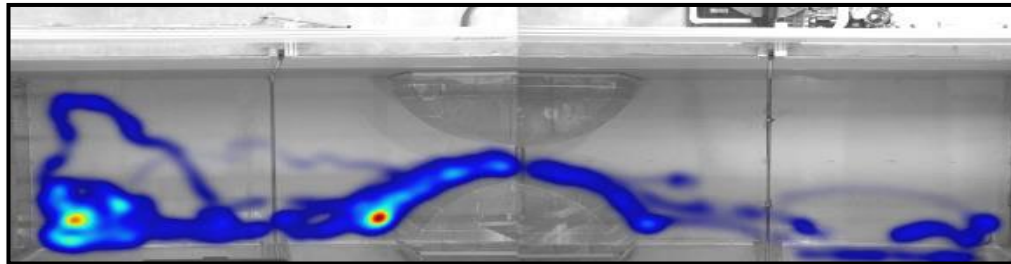
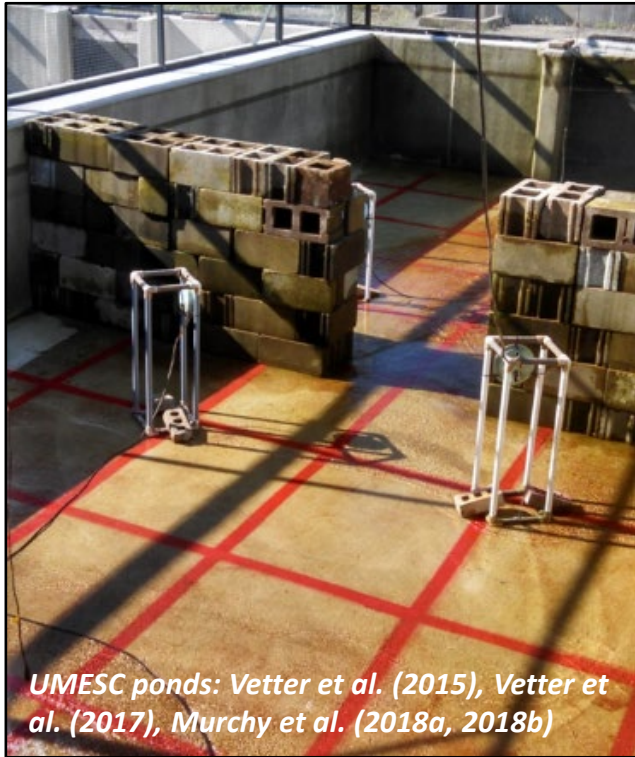
Sound Pressure Levels



Particle Acceleration Levels

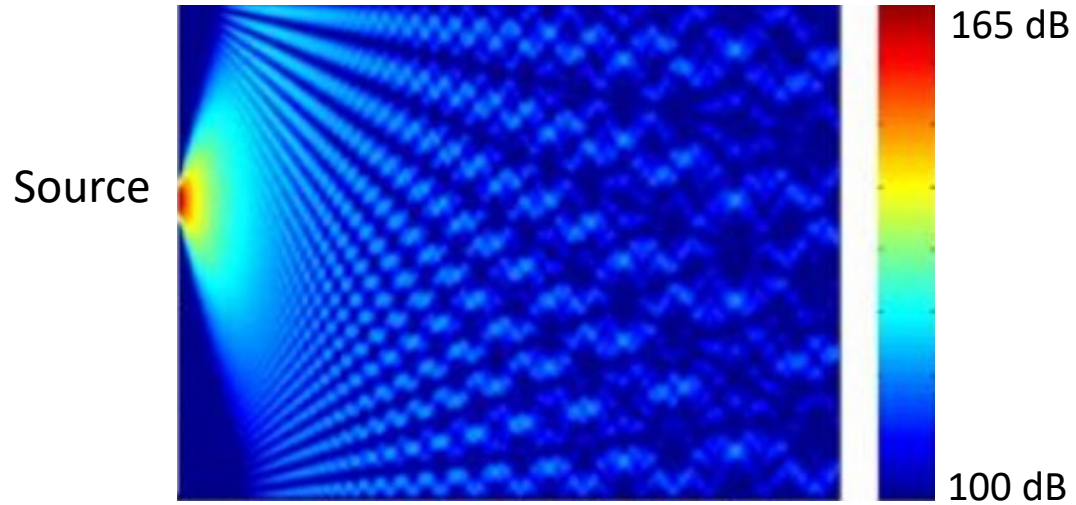


Lab, Pond, and Field Studies



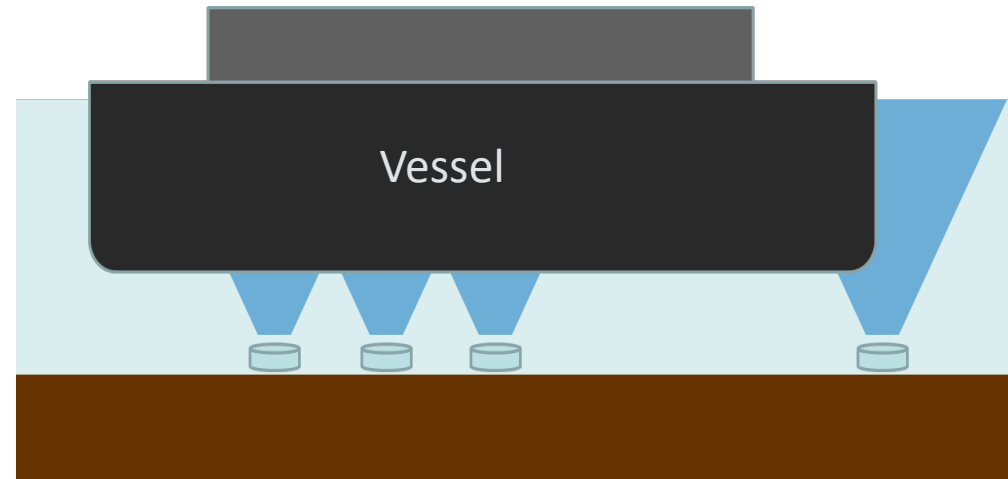
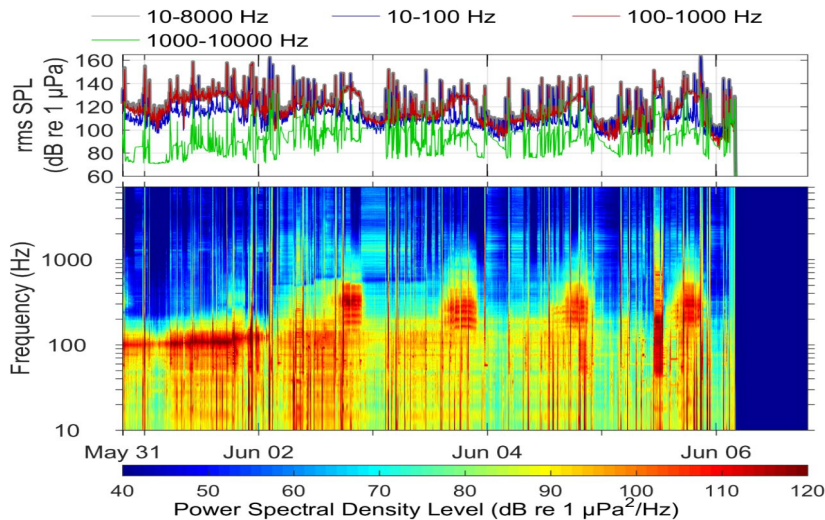
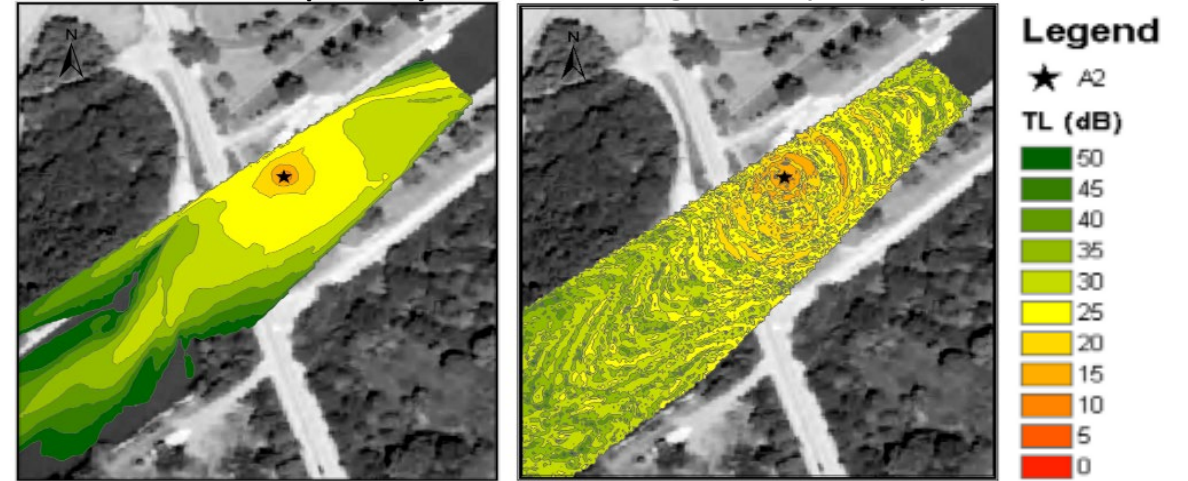
Environmental Acoustics

Transmission Loss \longrightarrow



Low Frequency

High Frequency



Field Study: Lock and Dam 19

Identified by UMR partners as a necessary “pinch-point” for limiting upstream carp movement

1. Fish cannot pass upstream over the dam, only through the lock
2. Lower number of carp above LD19 (natural pinch point for movement)
3. Study is applicable to other locations/deterrents
4. Moderate population of invasive carps below the L&D, and documented upstream passage of both carp and native species

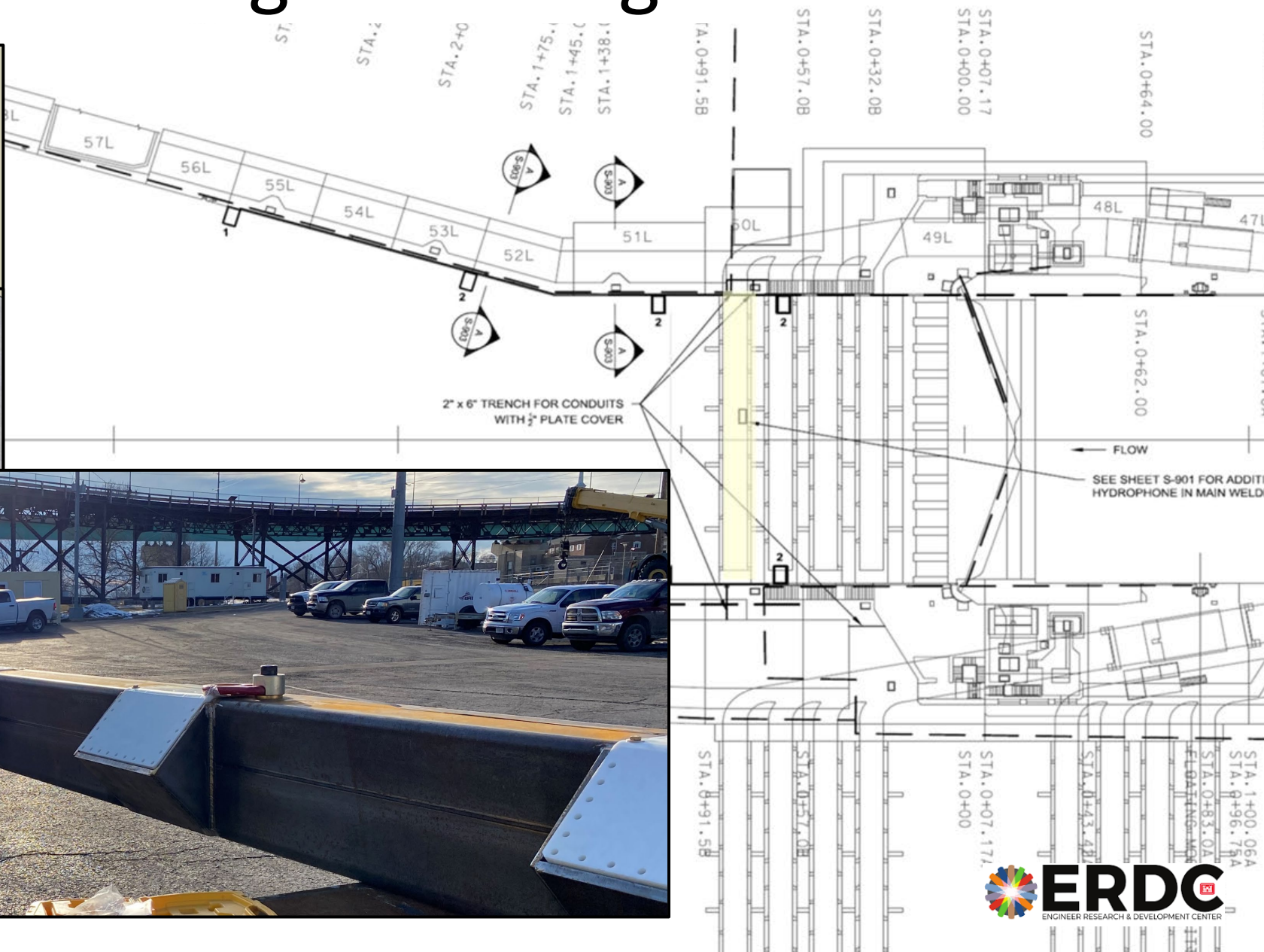
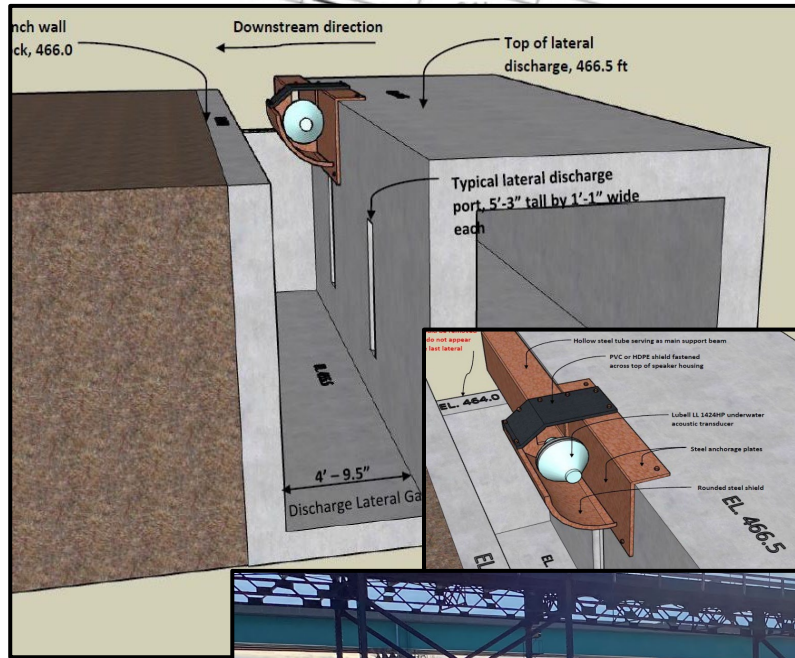


Objectives

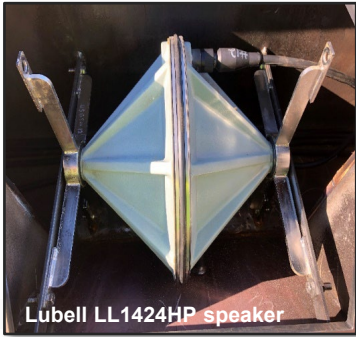
- Design and install an uADS in the downstream lock approach channel
- Evaluate the effectiveness of the uADS to deter upstream passage of fish into the lock chamber
- Evaluate the behavior of invasive carps and native fishes relative to uADS operation and covariates
- Evaluate the uADS operational performance over the study duration
 - Study period for up to 3 years



Engineering and Design



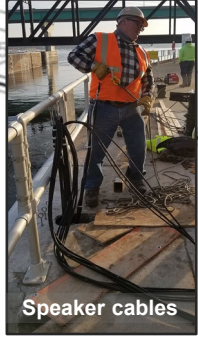
Engineering and Design



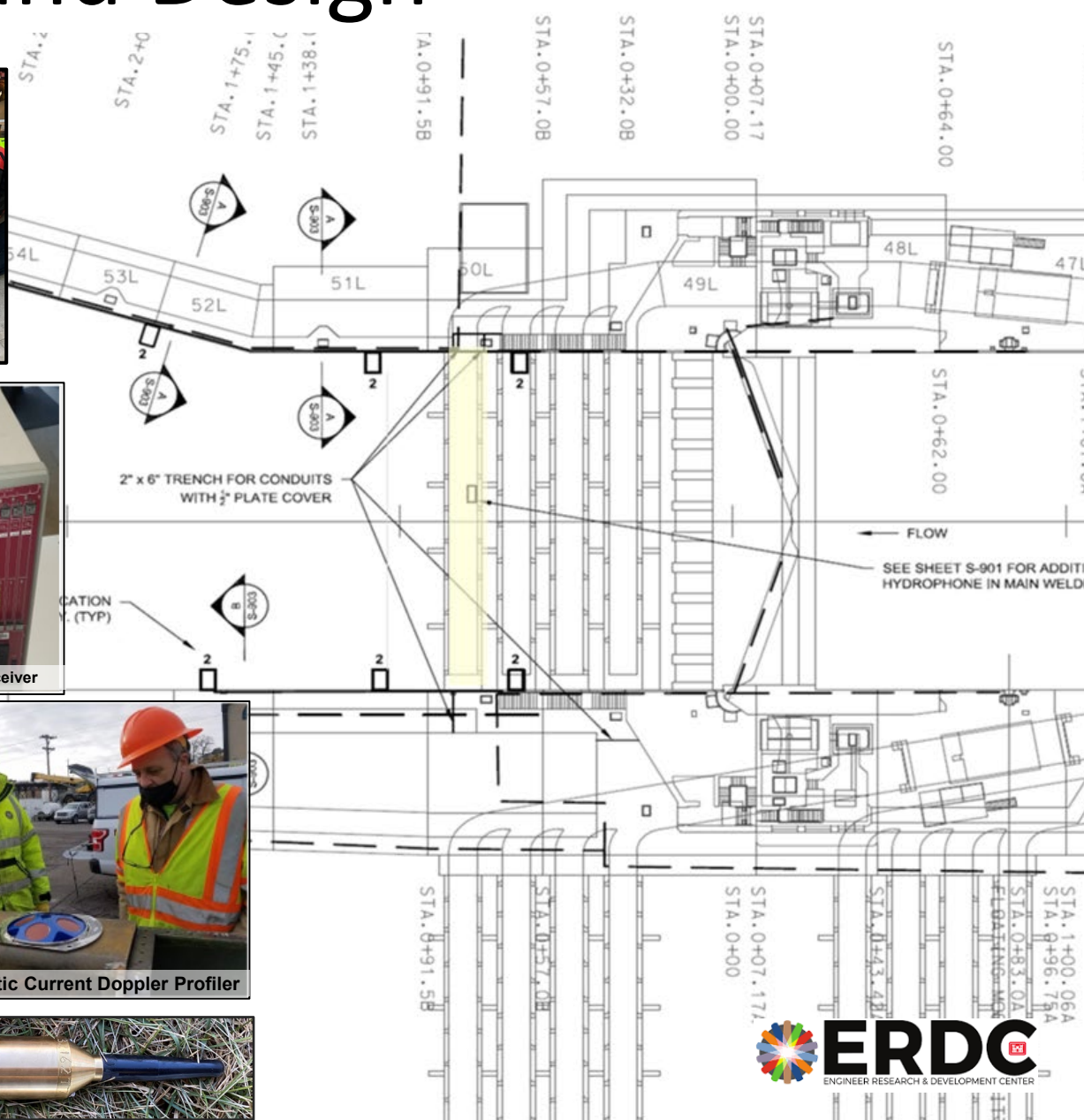
Lubell LL1424HP speaker



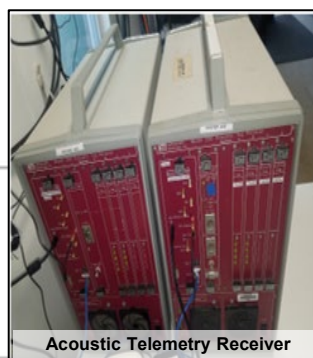
Soundbar speaker housing



Speaker cables



Transformers and Amplifiers



Acoustic Telemetry Receiver



Sound monitoring



Ladder well hydrophones



Bottom mounted hydrophone design



Acoustic Current Doppler Profiler



Sound monitoring hydrophone

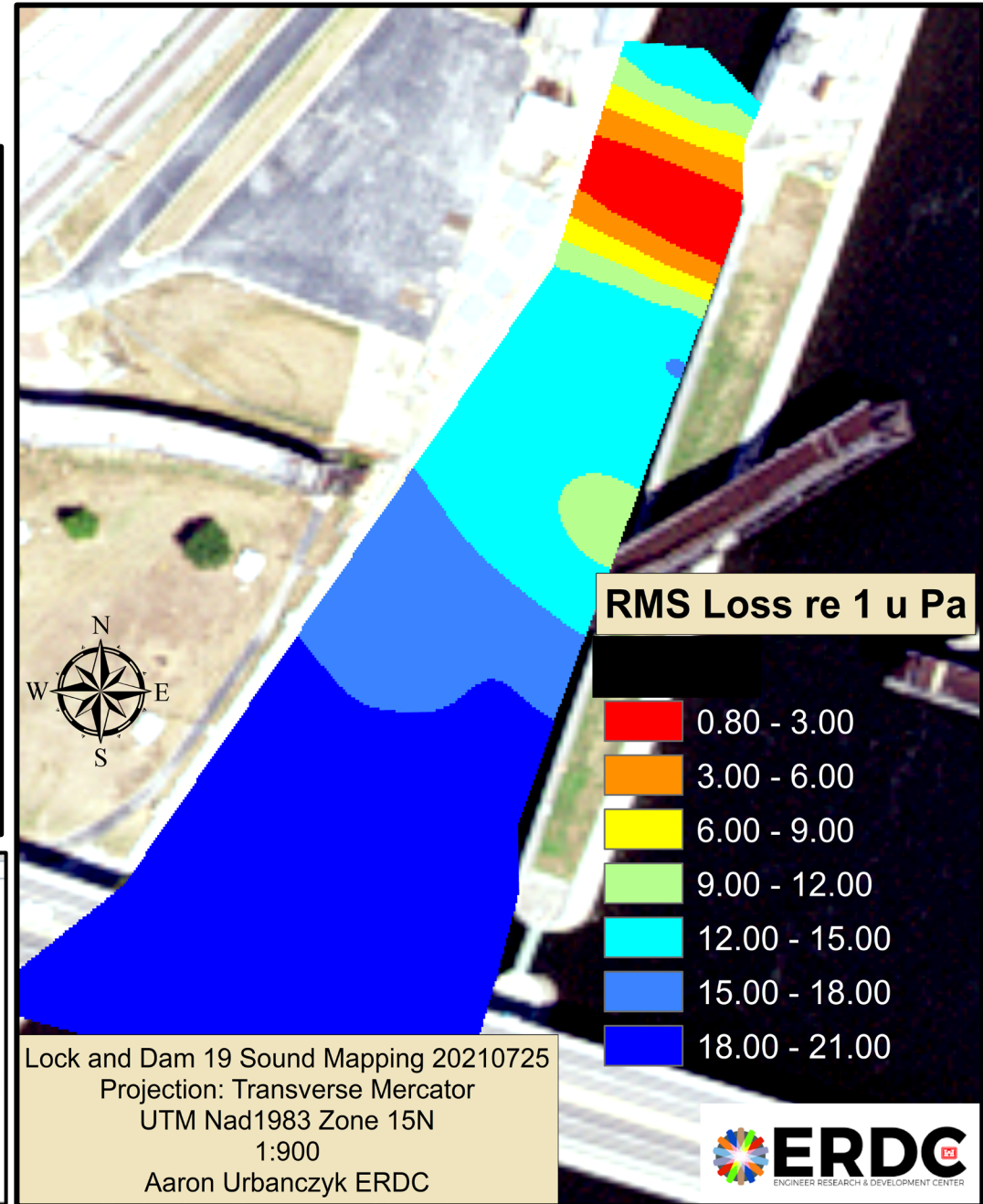
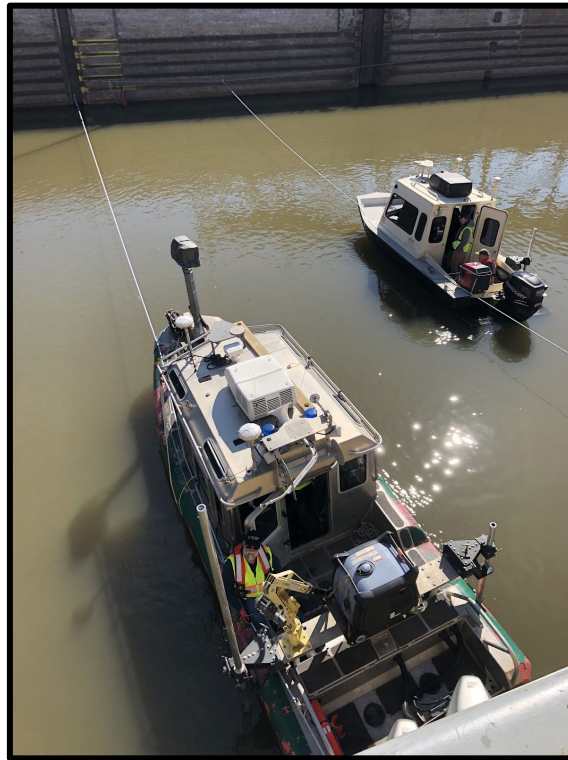


Fish monitoring hydrophone

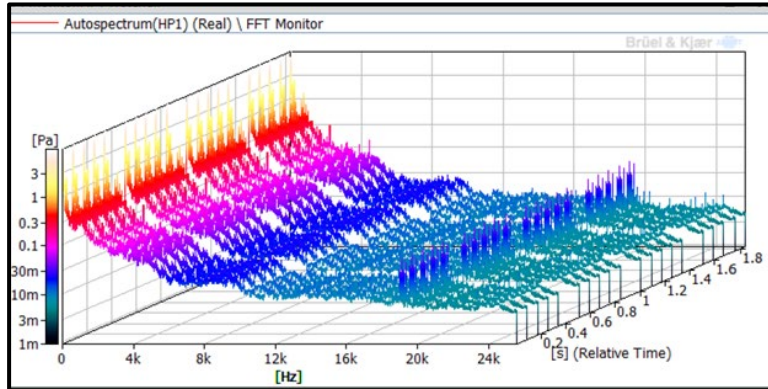
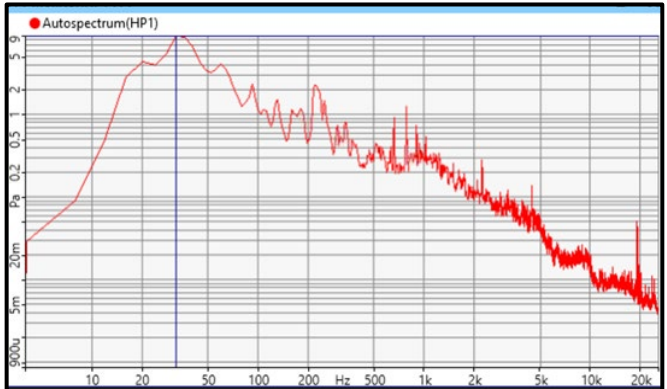


Soundbar

- 16 Lubell LL1424HP underwater speakers
- Designed for continuous sound at 180 SPL_{rms} dB re 1μPa
- Signals developed by ERDC and the 100hp boat motor signal
- 80 hours ON-OFF schedule
- Assess “received sound using hydrophones
 - soundbar (1), gates (4), approach channel (5)



Lock and Dam 19 Sound Mapping 20210725
 Projection: Transverse Mercator
 UTM Nad1983 Zone 15N
 1:900
 Aaron Urbanczyk ERDC



*Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Fish Tagging



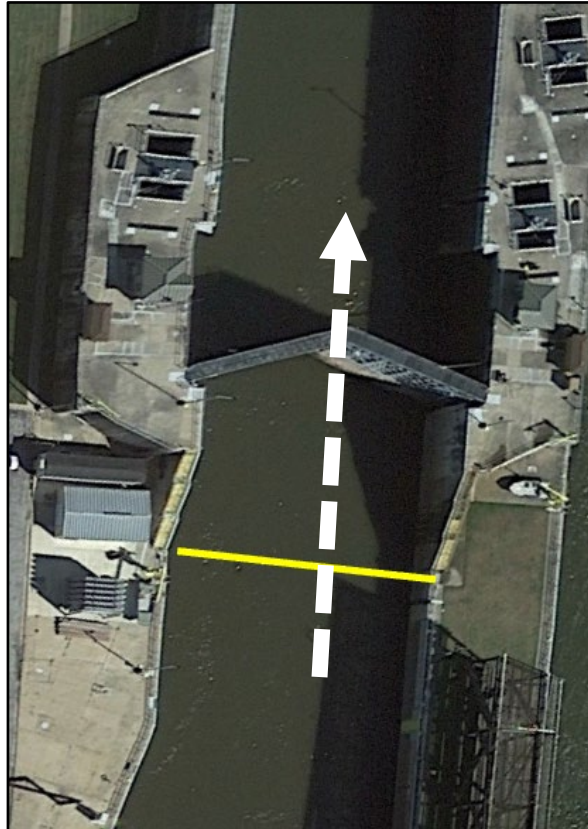
Species	2021	2022
<i>Invasive Carps</i>	401	501
Bighead Carp	50	52
Grass Carp	100	100
Silver Carp	251	349
<i>Native Species</i>	208	234
Bigmouth Buffalo	120	121
Blue Sucker	16	16
Flathead Catfish	25	25
Freshwater Drum	16	16
Lake Sturgeon	5	19
Northern Pike	--	9
Paddlefish	4	6
Sauger	--	2
Striped Bass-White Bass	--	2
Walleye	7	3
White Bass	15	15
<i>Total tagged</i>	609	735



**Preliminary Information—Subject to Revision. Not for Citation or Distribution.*

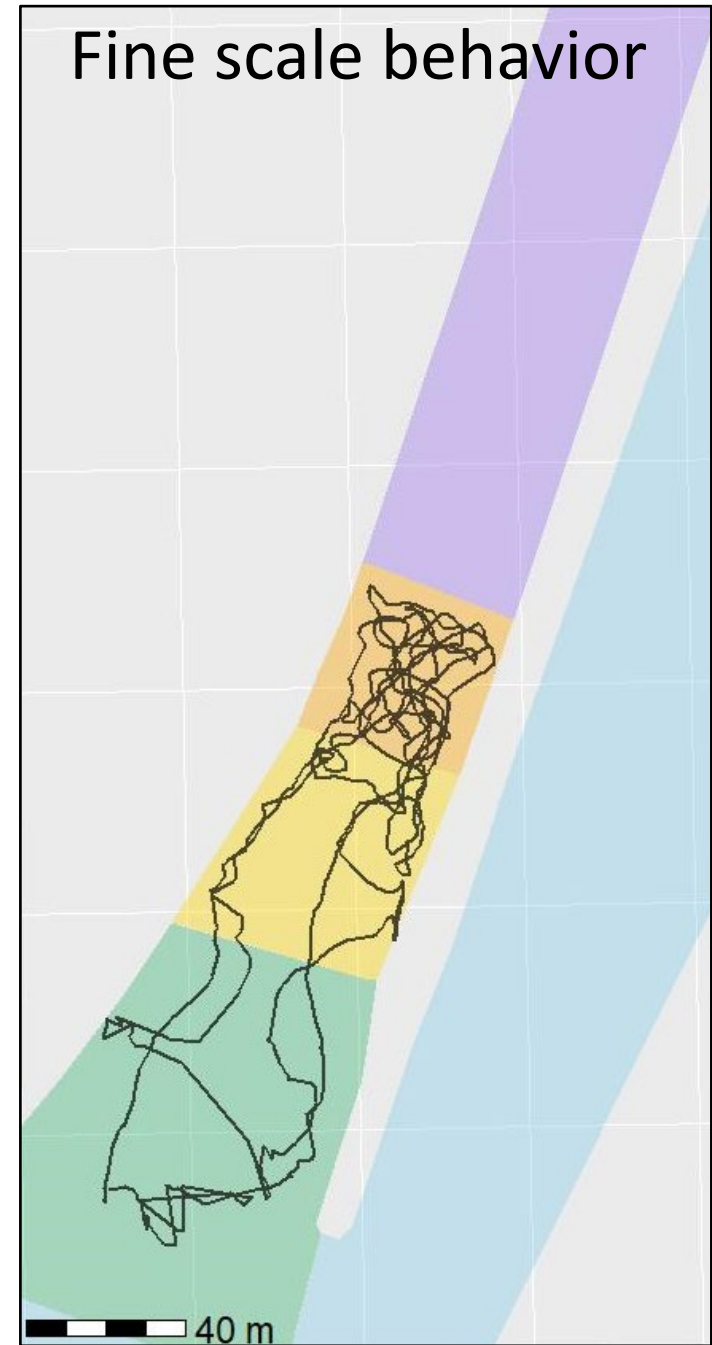
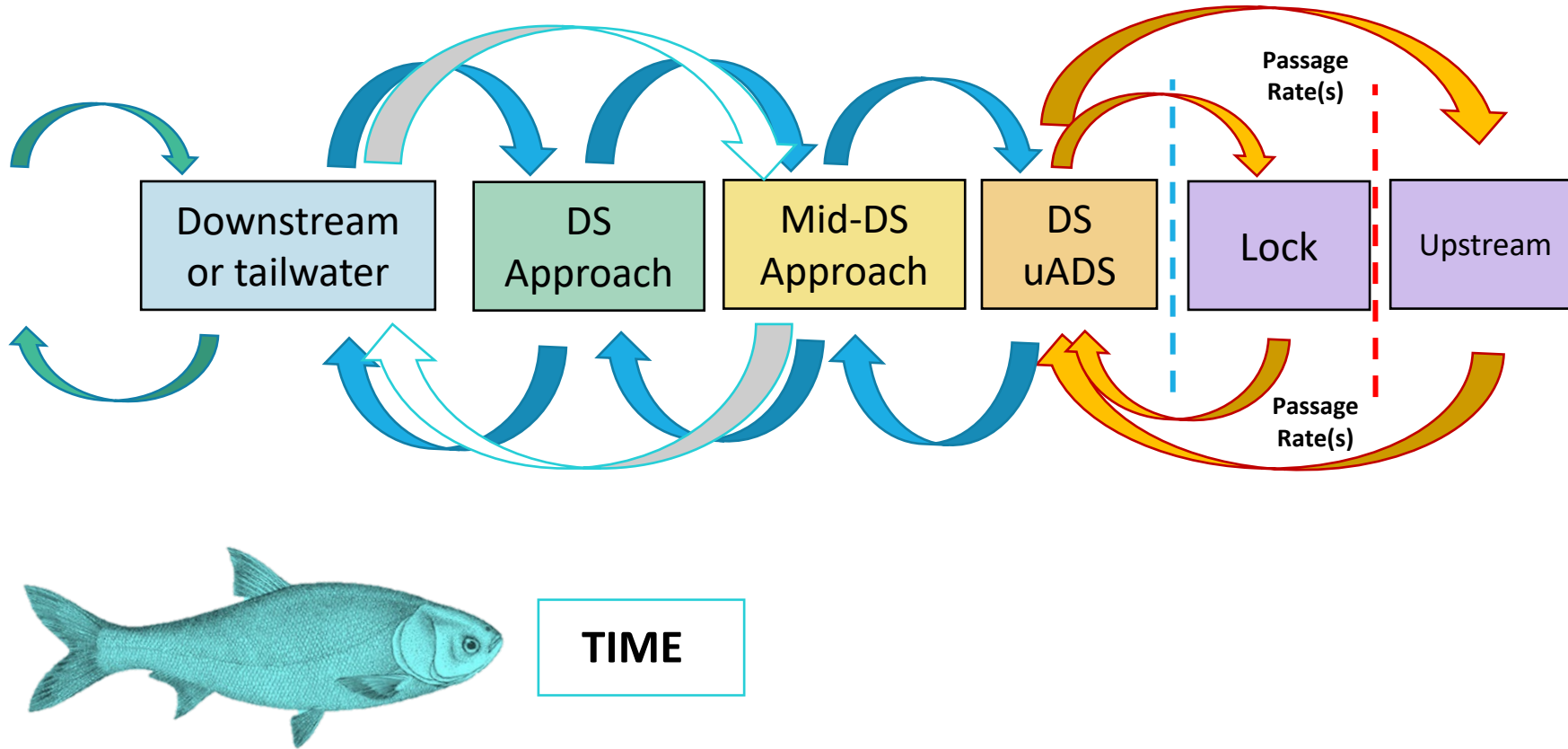
Upstream uADS crossings

Objective 2: Evaluate the effectiveness of the uADS at deterring upstream passage of fish into the lock chamber



Number of Individuals	HTI (307 kHz)		Vemco (69 kHz)	
	OFF	ON	OFF	ON
<i>Invasive carps</i>	21	7	3	0
Bighead Carp	8	1	3	0
Grass Carp	1	0	0	0
Silver Carp	12	6	1	0
<i>Native species</i>	30	31	4	8
Bigmouth Buffalo	20	17	3	6
Freshwater Drum	5	8	--	--
Paddlefish	3	4	1	2
White Bass	2	2	--	--

Time-to-Event Analysis

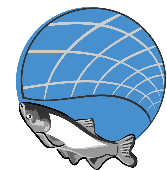
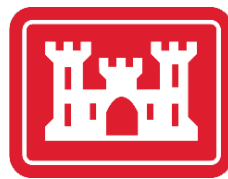




Dr. Marybeth Brey
mbrey@usgs.gov

Dr. Christa Woodley
christa.m.woodley@usace.army.mil

Dr. Andrea Fritts
afritts@usgs.gov



UNIVERSITY OF MINNESOTA DULUTH
 Driven to Discover

ILLINOIS
 Illinois Natural History Survey
 PRAIRIE RESEARCH INSTITUTE

