Fish Movement and Passage on the Alabama River

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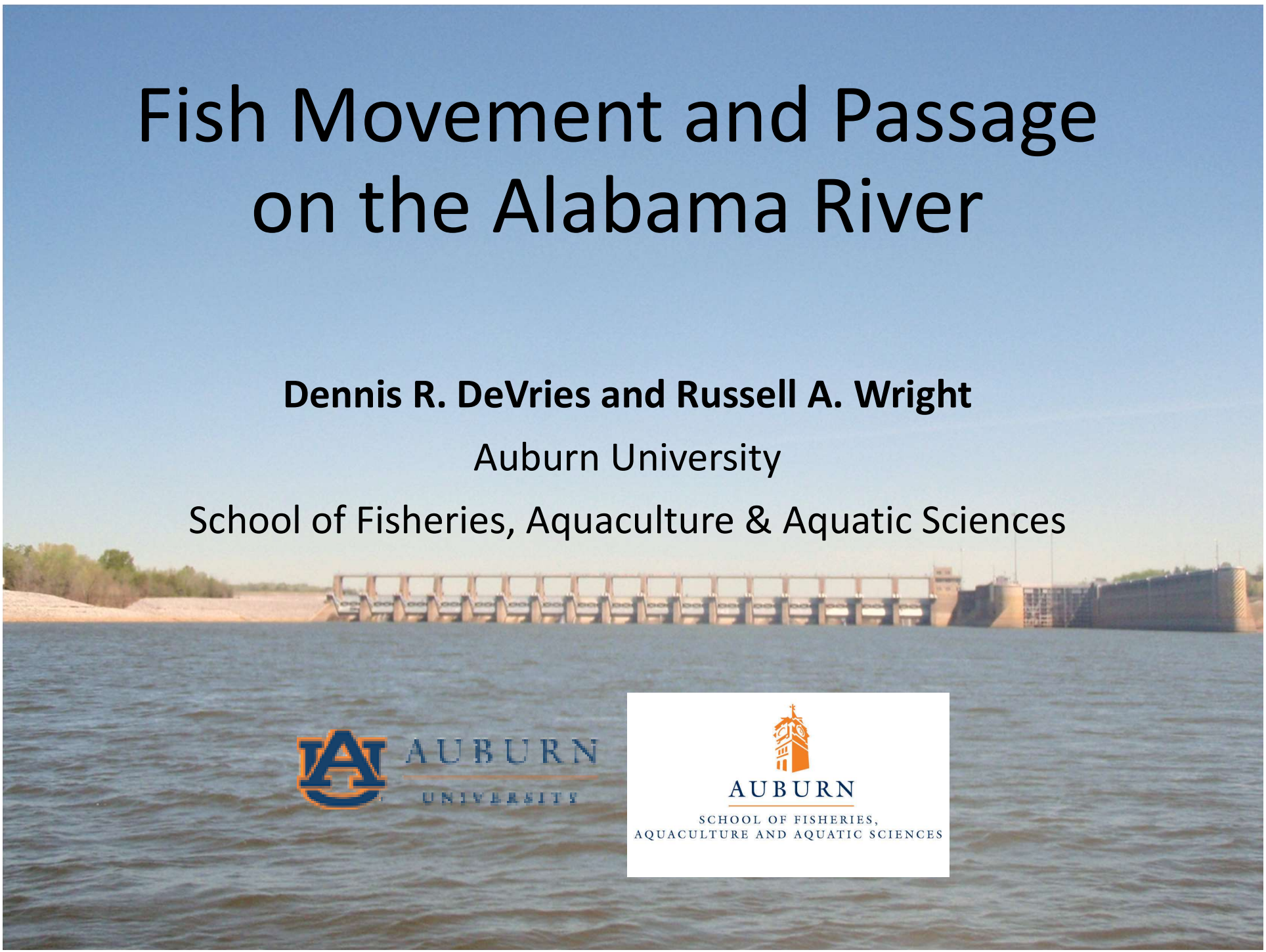


Students and Staff

Henry Hershey	MS completed 2019; current PhD student
Garett Kratina	MS completed 2019
Dustin McKee	MS completed 2019
Colin Laubach	MS Student
Chris Rotar	MS Student
Ehlana Stell	PhD Student
Daniel Thomas	MS Student
Tom Hess	Technician
Tammy DeVries	Technician

Current Project Questions

1. How do **individual** fish respond to the barrier provided by a lock and dam structure?
2. How are fish **populations** impacted by the presence a lock and dam structure?
3. What tools do we have to **mitigate** *or* **take advantage** *of* these impacts?

Current model species for this project

(other species to be included soon)

Paddlefish, *Polyodon spathula*

Smallmouth buffalo, *Ictiobus bubalus*

Southeastern Blue Sucker, *Cycleptus meridionalis*

Freshwater Drum, *Aplodinotus grunniens*

Measuring Individual Responses

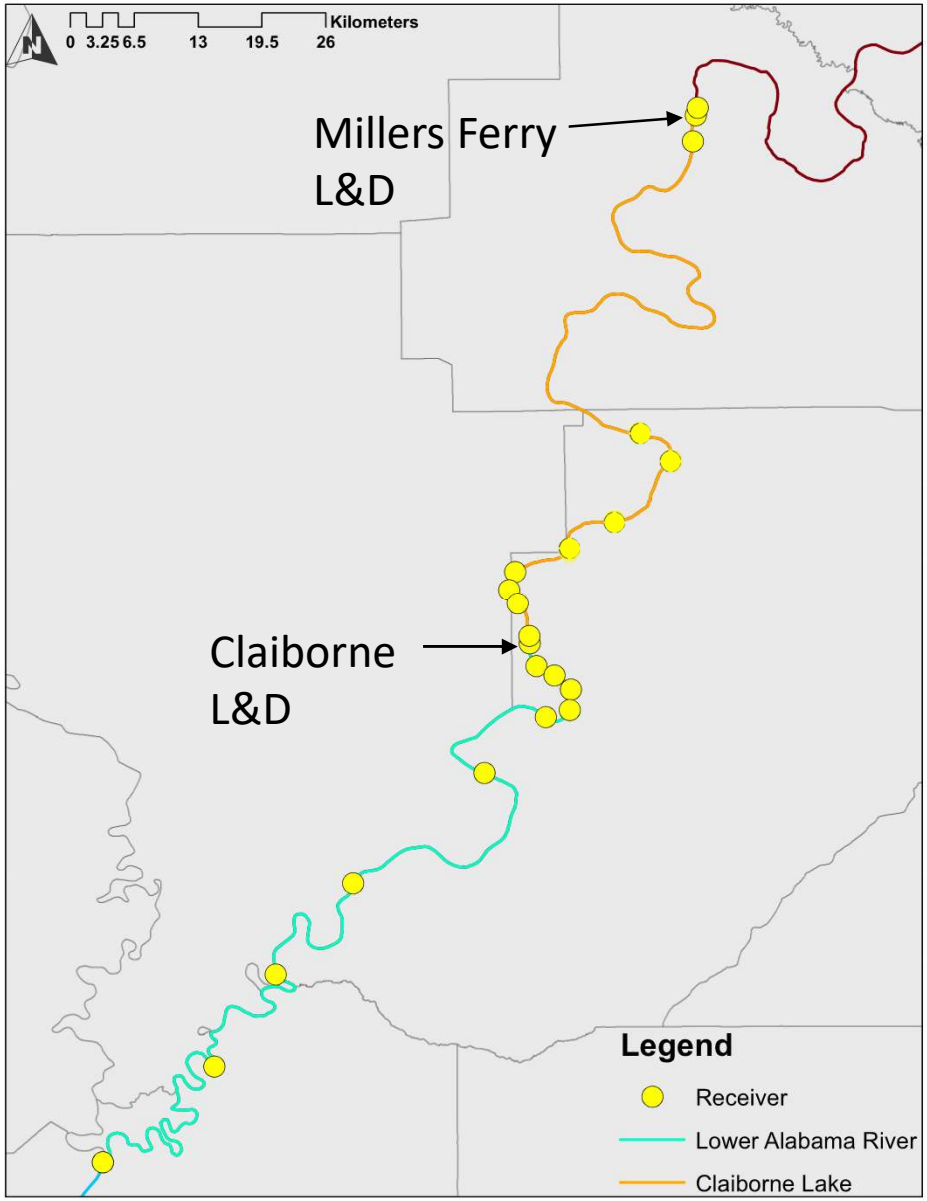
- Field tagging and tracking
- Fine-scale movement/tracking below and past dam structures
- Activity and energetics- field measures
- Respirometry and swim stress challenges- laboratory measures
- Energetics- laboratory combination of movement and respirometry
- Behavioral modelling

Fish Movement and Passage

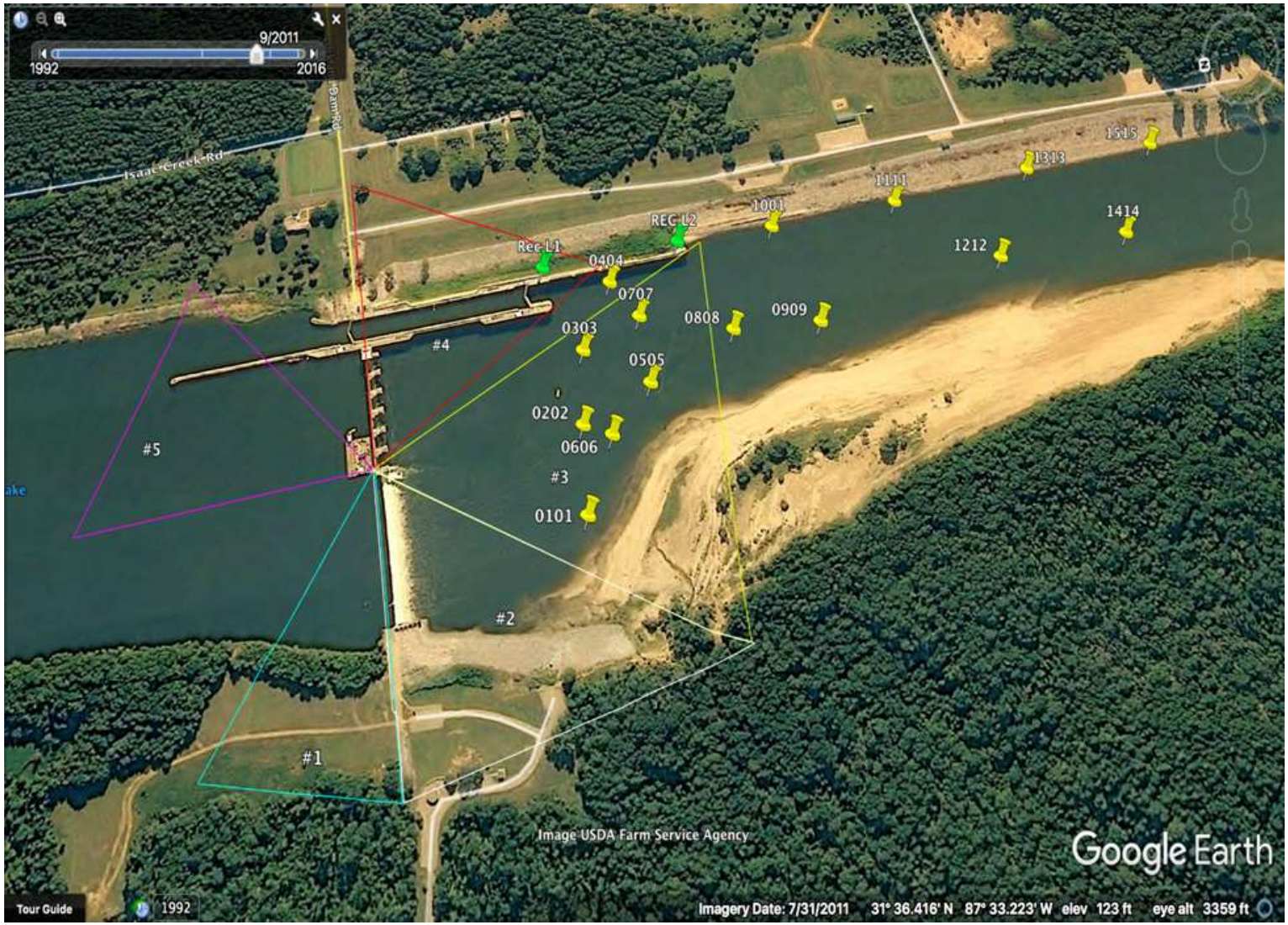
River Position Receivers

Millers Ferry to Confluence

- 22 Submersible Acoustic Receivers
  - Rkm 250 to rkm 0
  - Centered around Claiborne Dam
  - 10 SAR within 10 km surrounding Claiborne Dam



Fine-scale Position Array

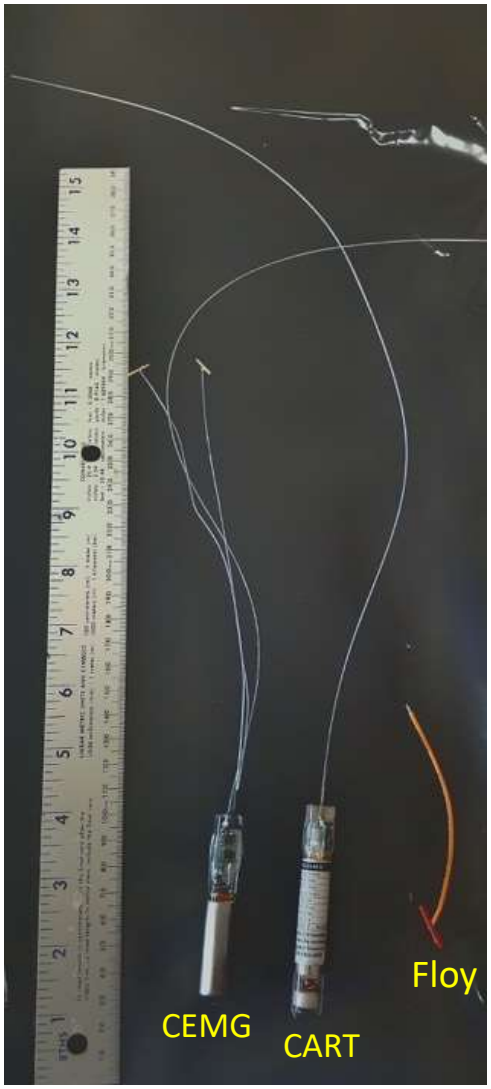


The tailrace of Claiborne Lock and Dam with the placement of acoustic receivers
Triangles around the dam indicate vectors of radio signal coverage.

Radio and acoustic tags are implanted surgically

Number of Transmitters

- 330 fish tagged with combined acoustic and radio transmitters (CART)
  - 165 Smallmouth Buffalo
  - 165 Paddlefish
- 181 fish dual tagged with both CART and coded electromyogram transmitters (CEMG)
  - 92 Smallmouth Buffalo
  - 89 Paddlefish
- All fish received a Floy Anchor tag



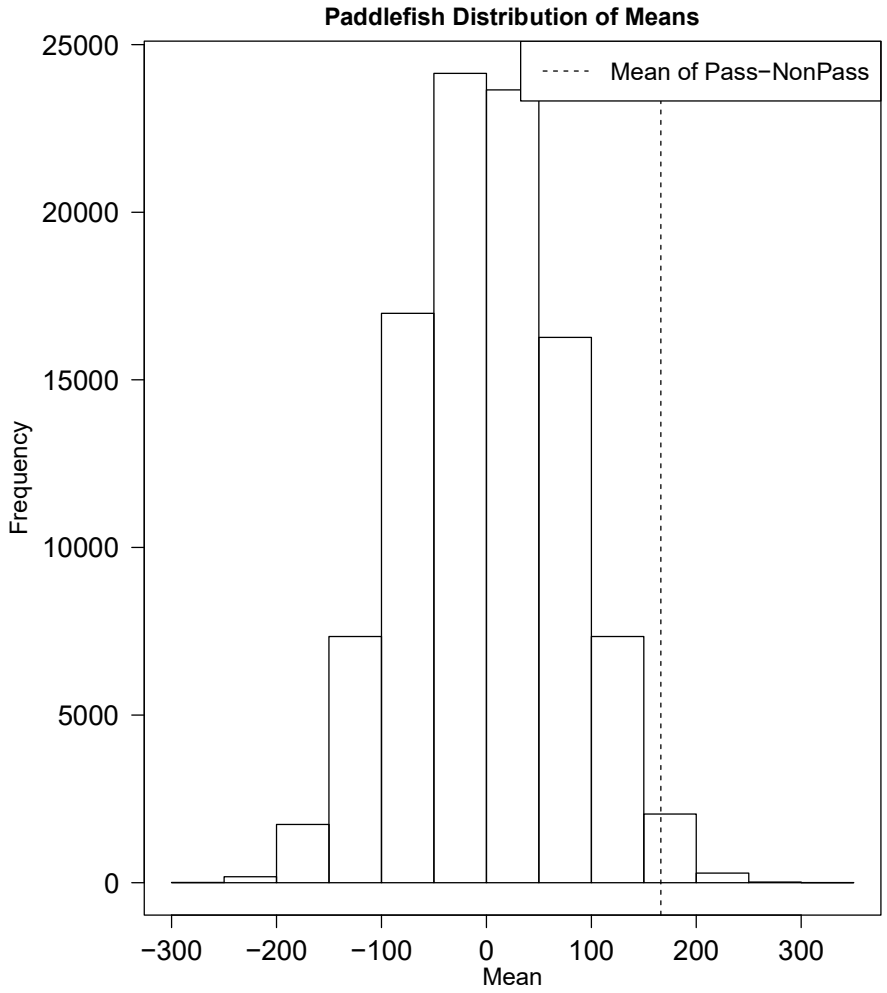
Paddlefish and Smallmouth Buffalo that Passed Claiborne Dam

Category	2018	% of Total	2019	% of Total
Passed	85	37.5	53	16.1
Attempted	119	49.6	43	13.0
No Attempts	36	12.9	234	70.9
Total	240	100	330	100

- > 6 million observations
- Passage numbers represent potential maxima.

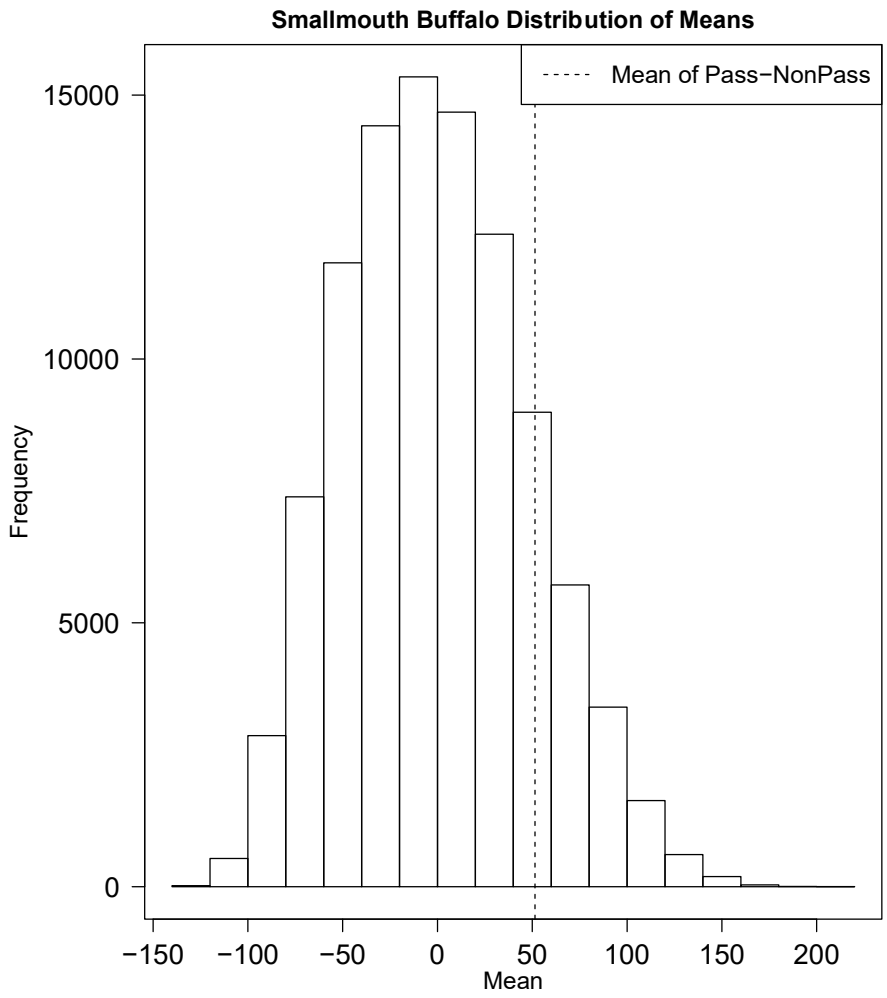
Paddlefish Residence Time

- Passed
  - Mean 365 hours
- Did not pass
  - Mean 198 hours
- Difference in means significantly different from zero
  - 166.26 hours (P=0.023)

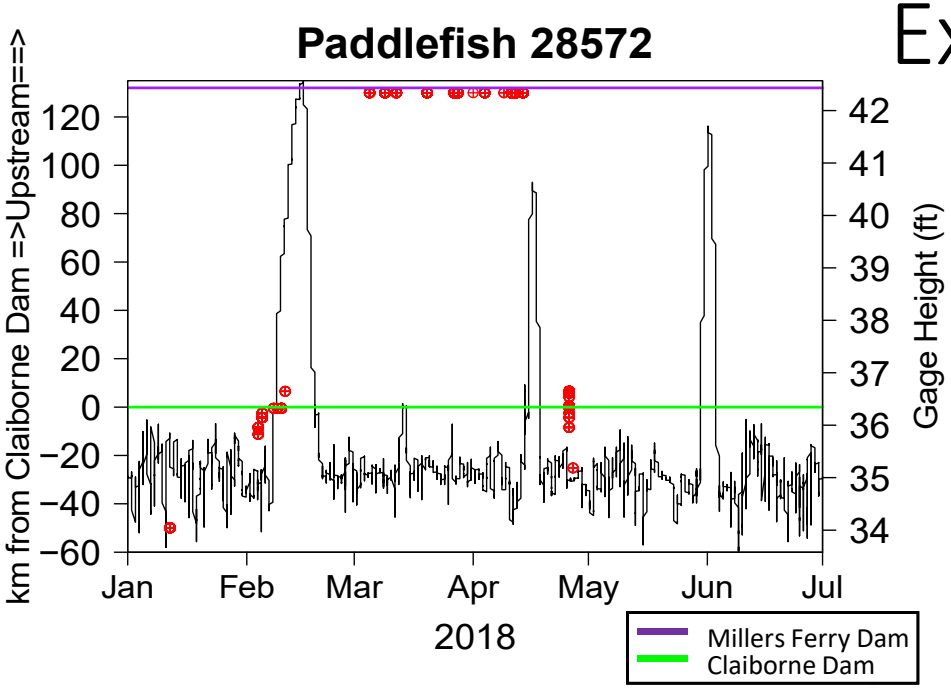


Smallmouth Buffalo Residence time

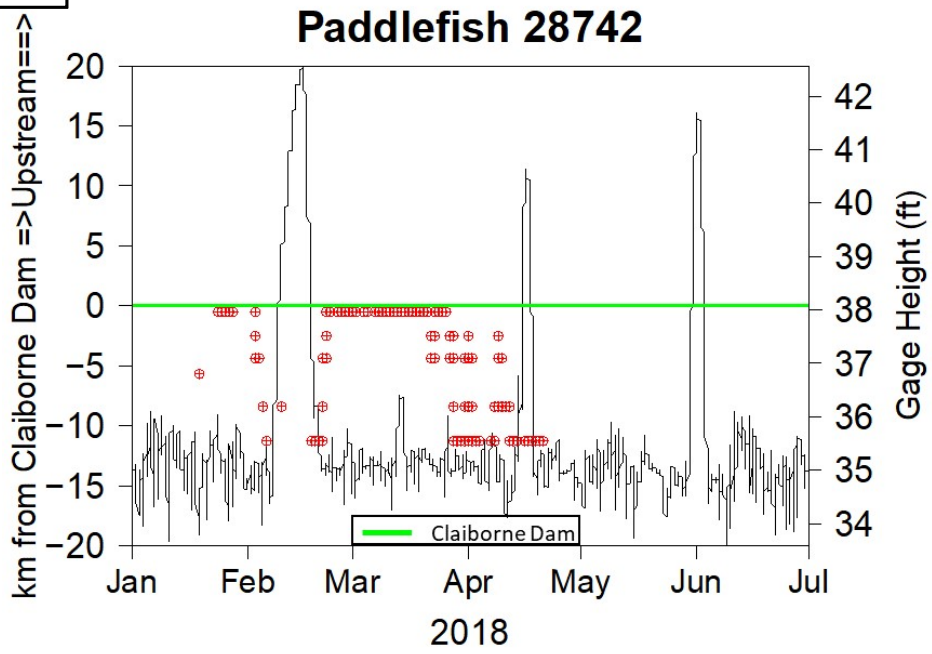
- Passed
  - Mean 139.78 hours
- Did not pass
  - Mean 88.32 hours
- Difference in means not significantly different from zero
  - 51.45 hours (P=0.30)



Examples: Passage vs. Non-passage

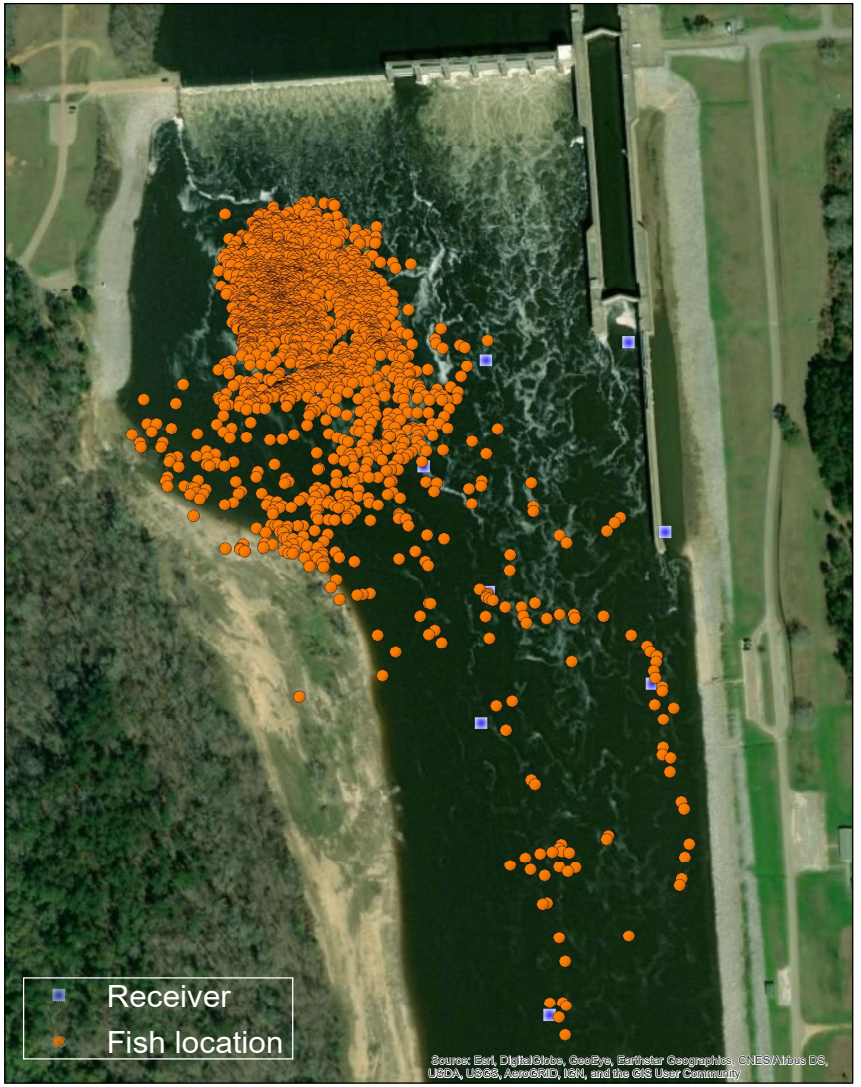


→ Only 1 fish was ever quantified to have passed Millers Ferry L&D

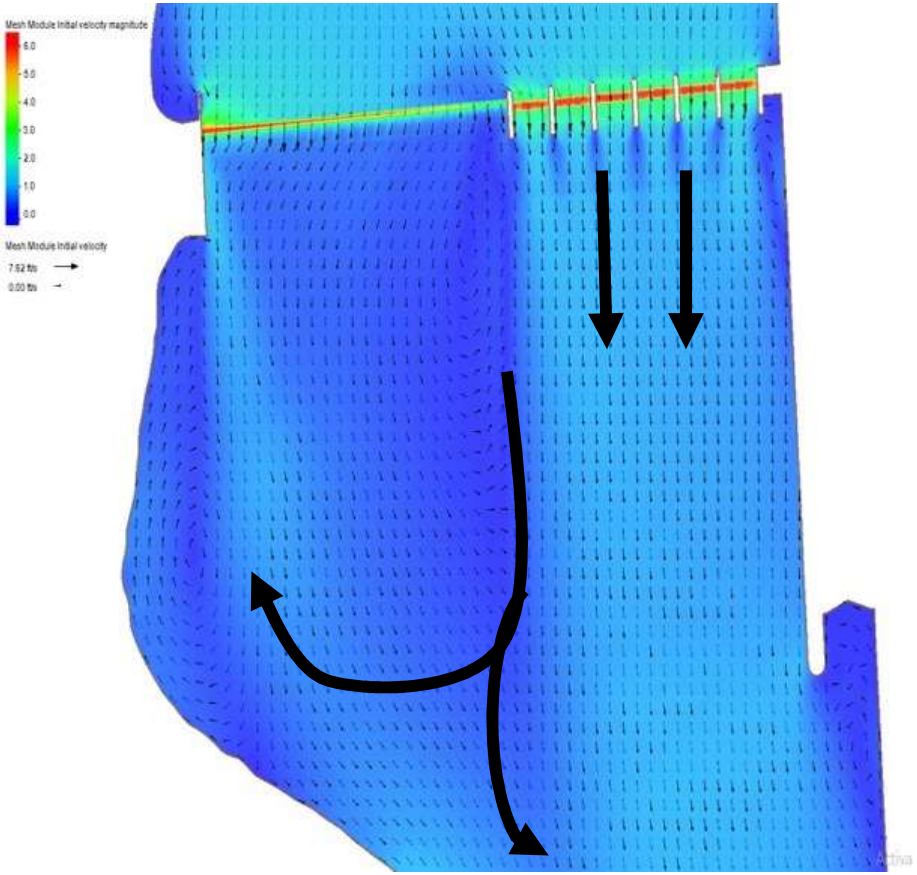


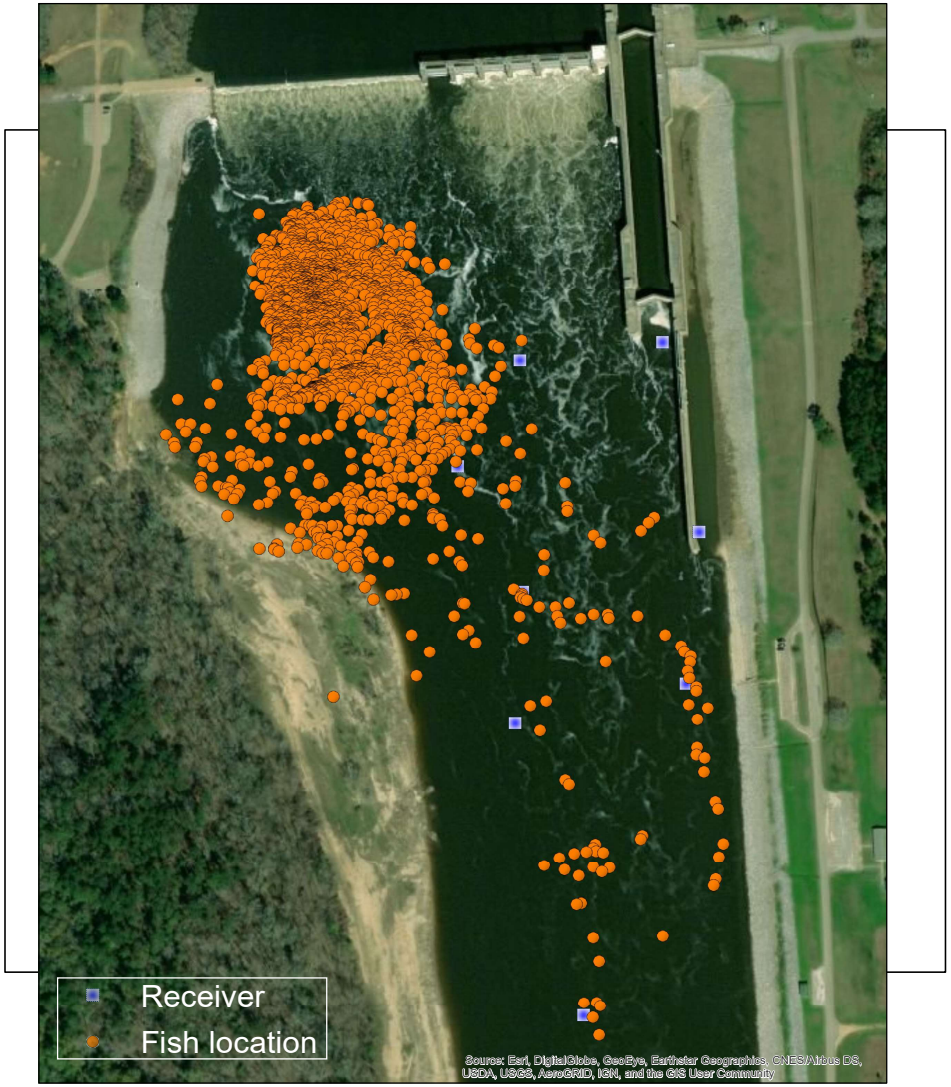
Fish Locations

- Used the 17 acoustic receivers in the tailrace of Claiborne Dam
  - When 3 or more receivers can see a fish a 2D location can be built
- Provides a detection map of fish locations



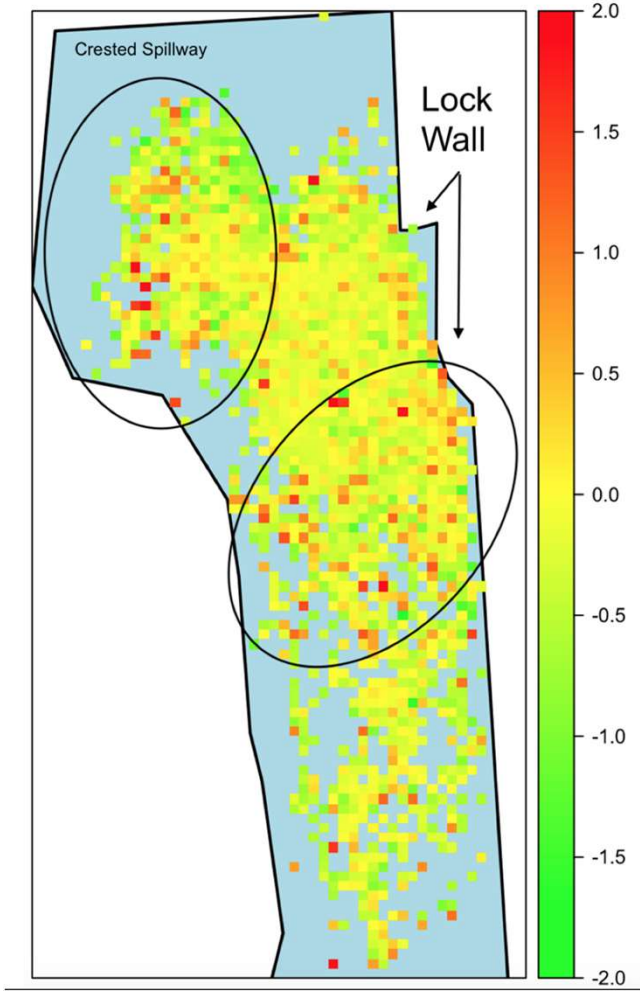
Fish Locations



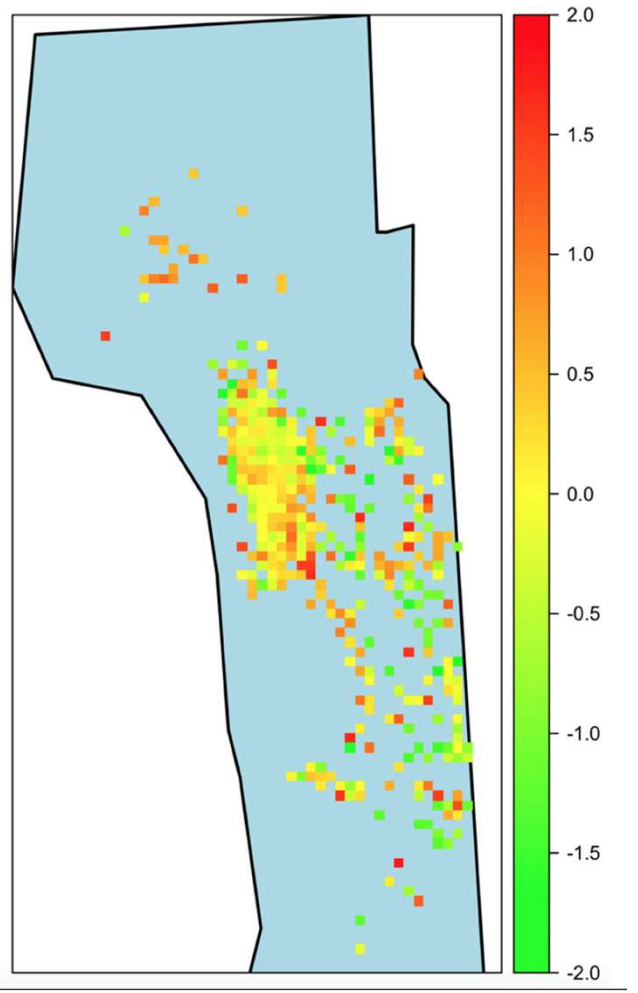


Combined position and EMG (effort)

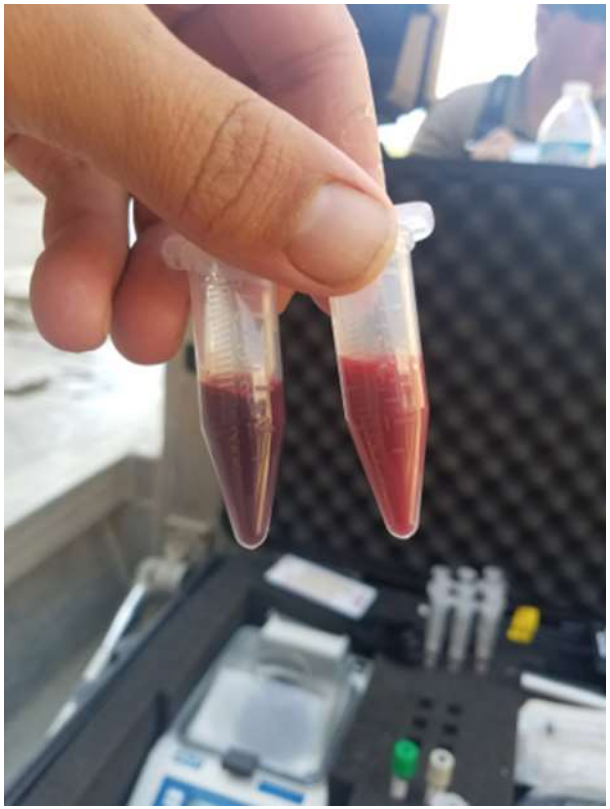
Paddlefish



Smallmouth Buffalo

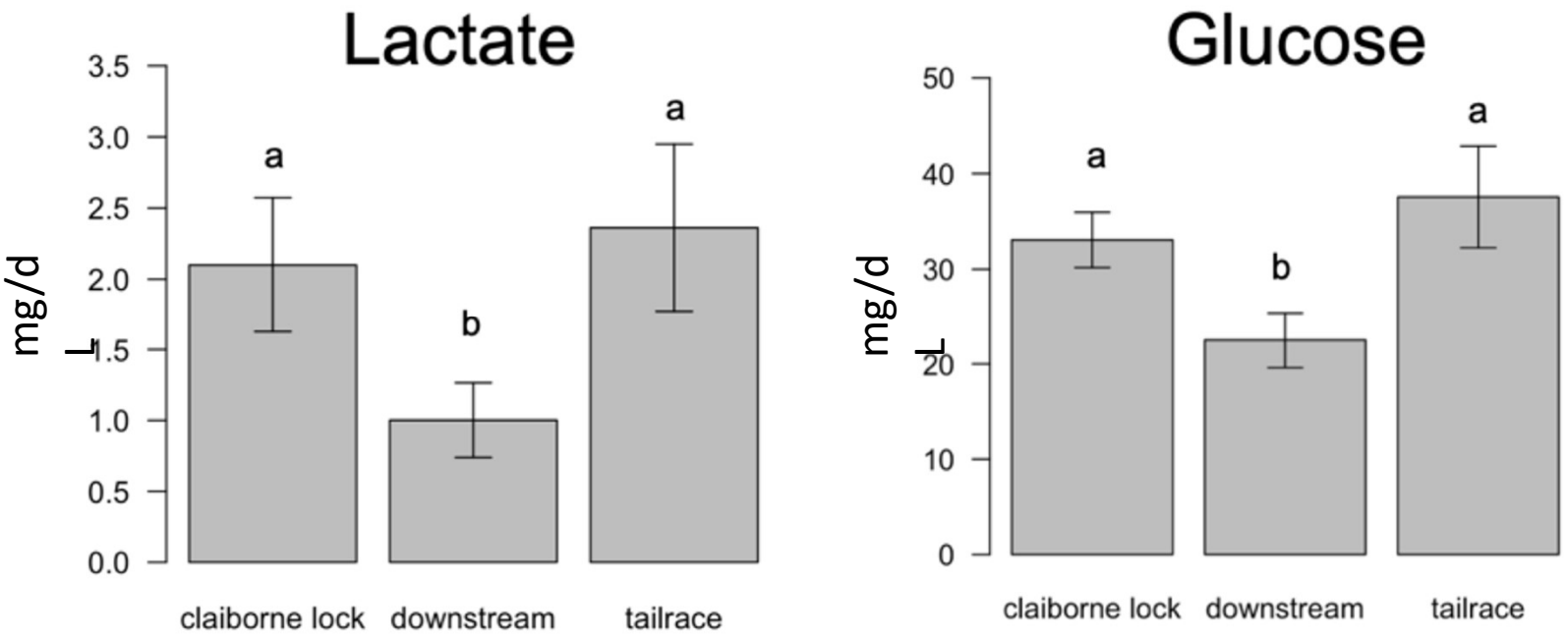


Fish Blood Chemistry

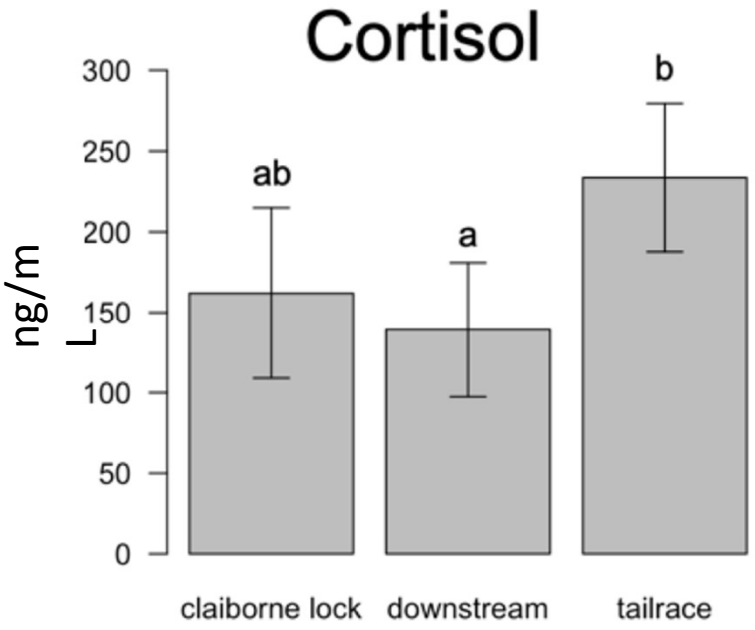


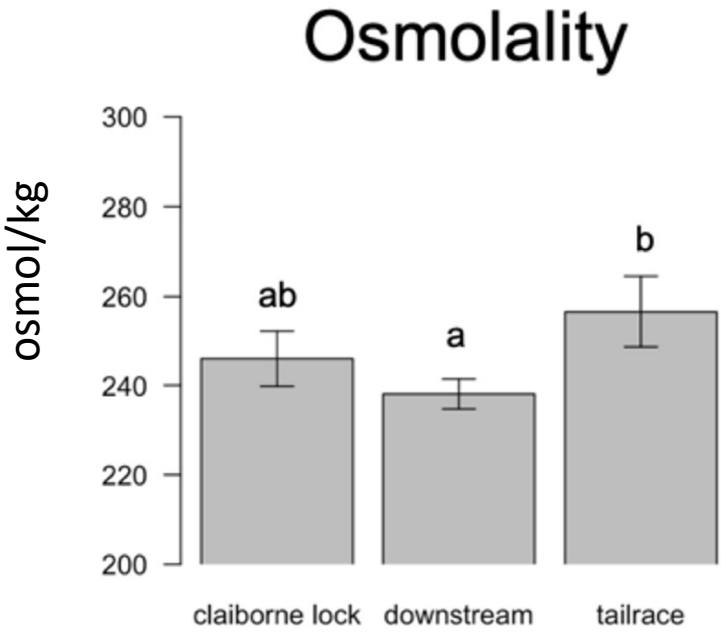
- 81 paddlefish
- 29 smallmouth buffalo
- 3 locations
  - tailrace
  - lock chamber
  - downstream

Paddlefish Blood Chemistry



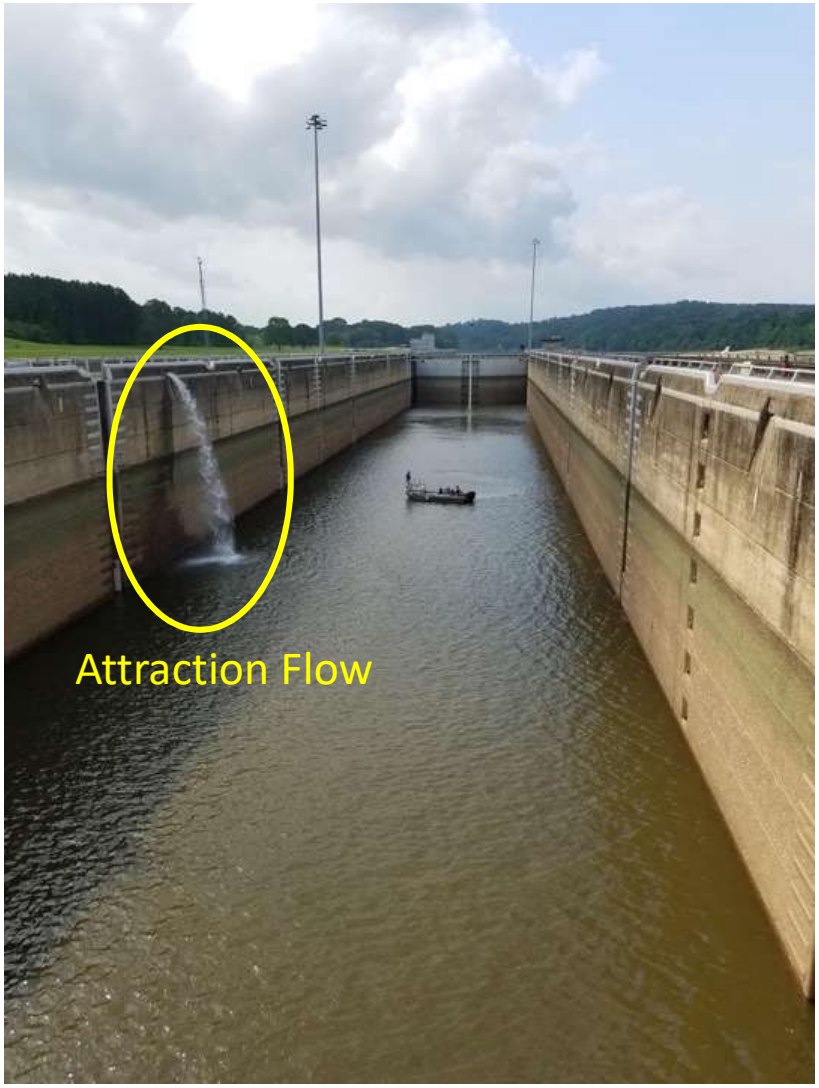
Paddlefish Blood Chemistry





Lock Usage

- Conservation lockages can be performed as conditions permit from Feb 1 - June 30
- Only performed if water level is below 4.6 m at Claiborne L&D
  - 2017 only 13 of 79 days
  - 2018 only 13 of 86 days
  - 2019 only 2 of 71 days
- 23 fish detected in the lock
- Only 1 fish passed through the lock



Fish Passage Summary

- Fish are able to pass Claiborne Dam during high water events
- Only 1 passage beyond Millers Ferry has been documented in 2.5 years of sampling
- Conservation lockages generally not successful at passing fish
- Residence time is important as fish stage in areas of low velocity water prior to passage

Fish Passage Summary (con't)

- Blood chemistry- fish in the lock chamber did not differ from that in the tailrace.
- Calibration to respiration and swimming performance is needed to determine the limits of these species' capabilities relative to passage
- Improving the coverage of the acoustic/radio array, may allow us to observe the exact pathways that fish take over/through the dam.

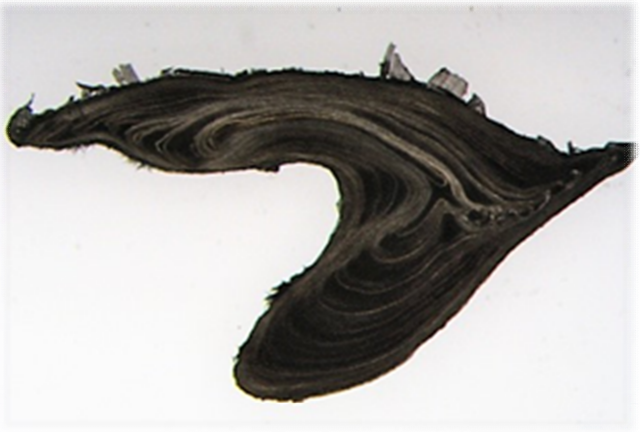
Population Impacts

- Comparison of hard part (dentary bones or otoliths) microchemistry across low-use lock-and-dam structures
- Comparison of genetics along the river across low-use lock-and-dam structures - Do these structures act as partial/complete barriers?
- Fate of fish that pass or are transported past the lock-and-dam structures

Fish Hard-parts

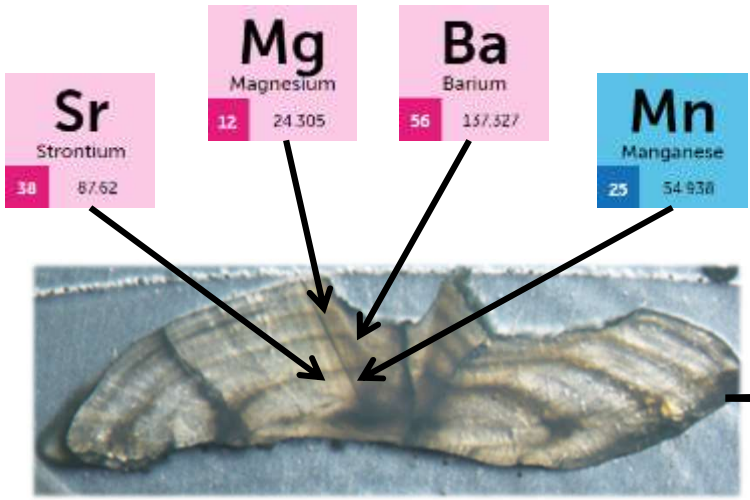
Otoliths (SBF)

Dentary Bones (PAD)



Hard-part Microchemistry

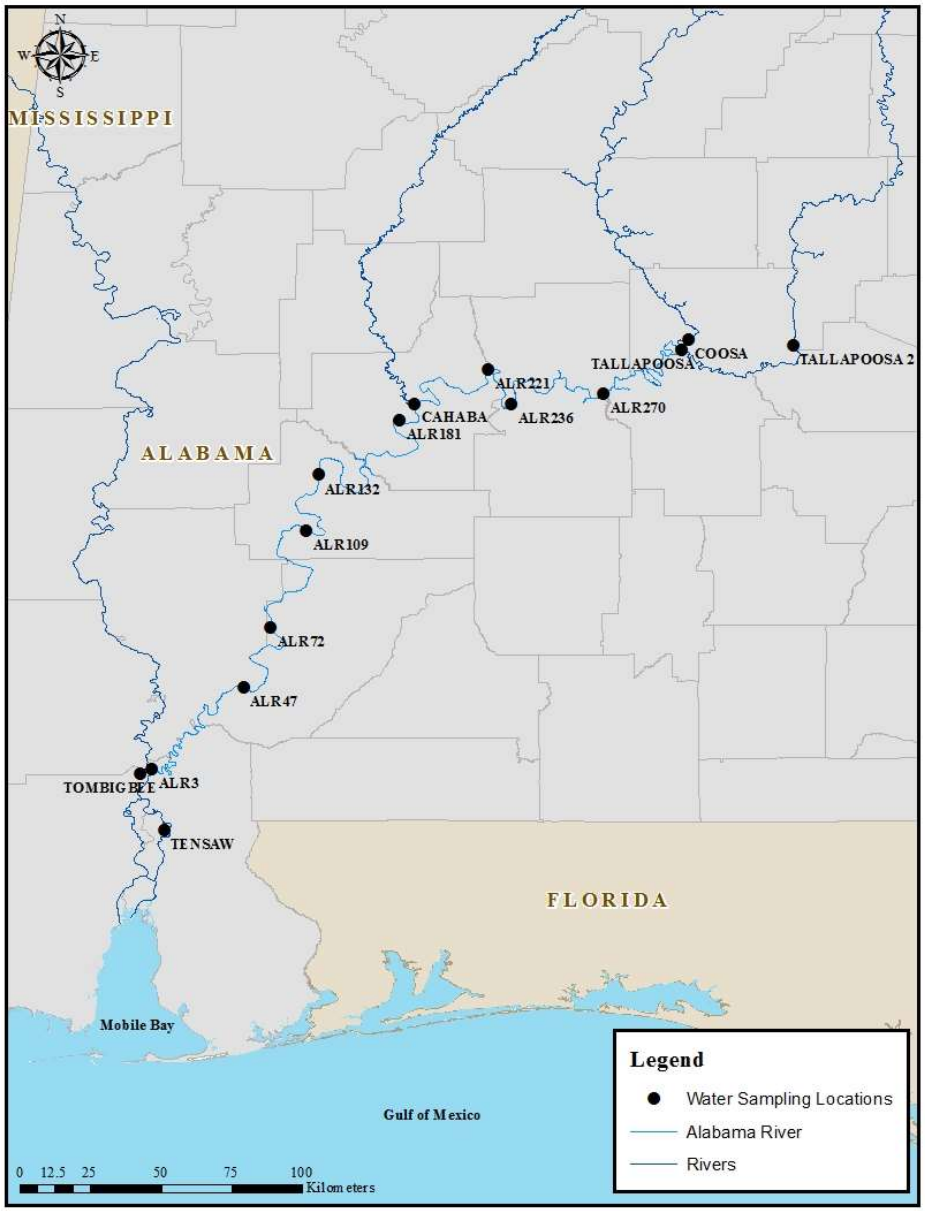
- Powerful tool for looking at fish environmental histories



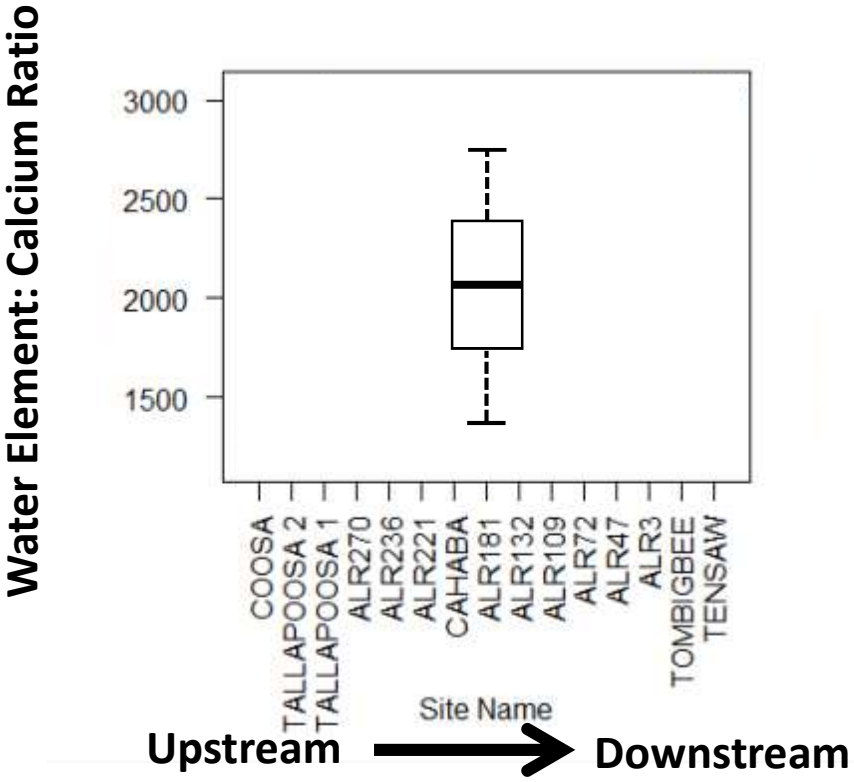
Natal origins
Population connectivity
Movement/migration patterns
Stock enhancement evaluation
Entrainment
Pollution exposure
Transgenerational marking

- Need to assess water chemistry

Water collection sites for elemental analysis

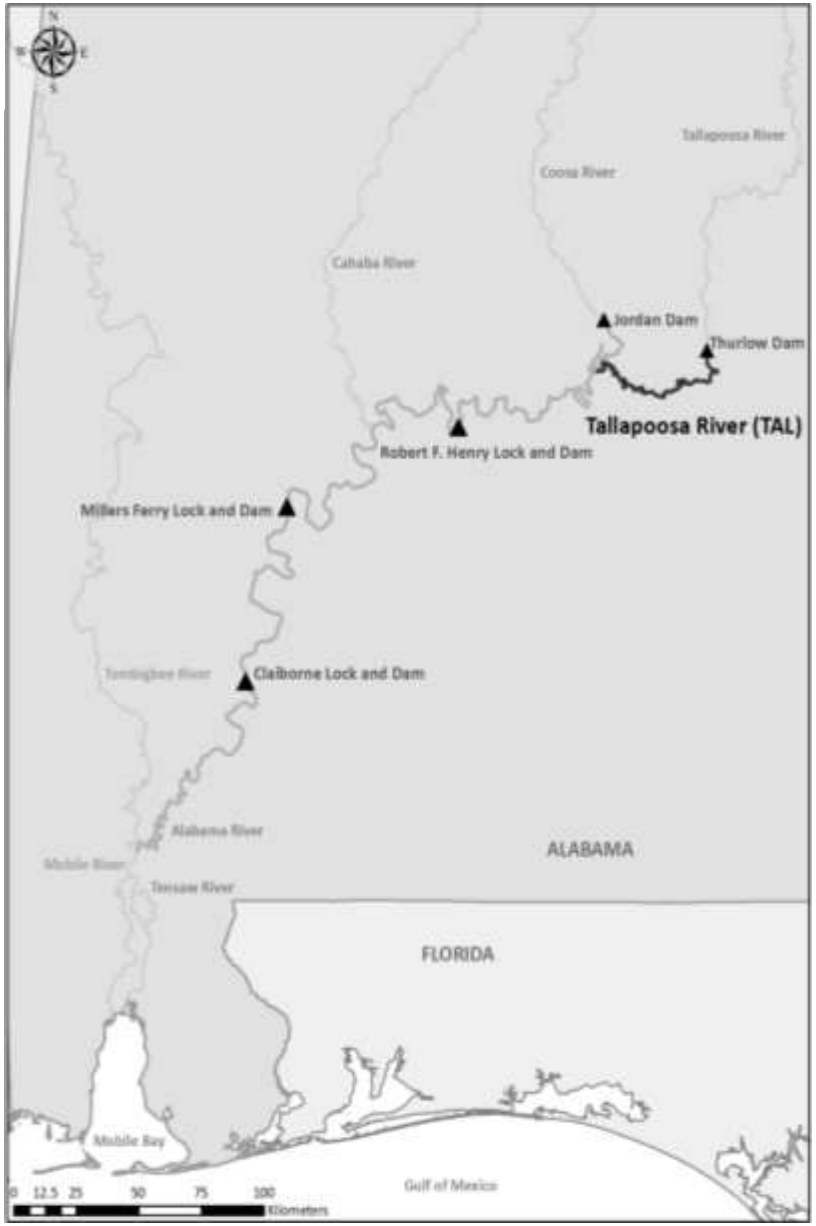


Water Samples

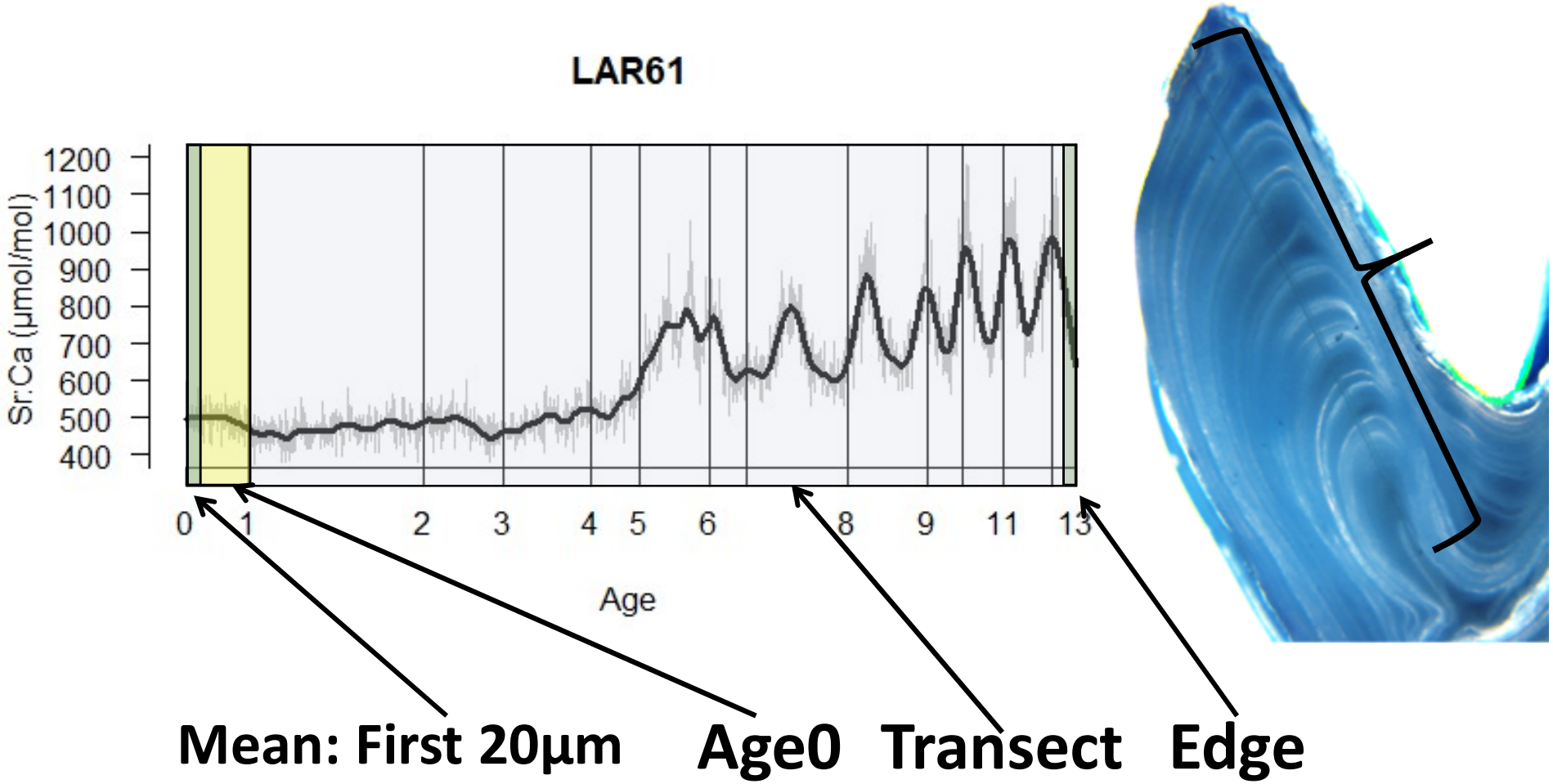


Fish Collections

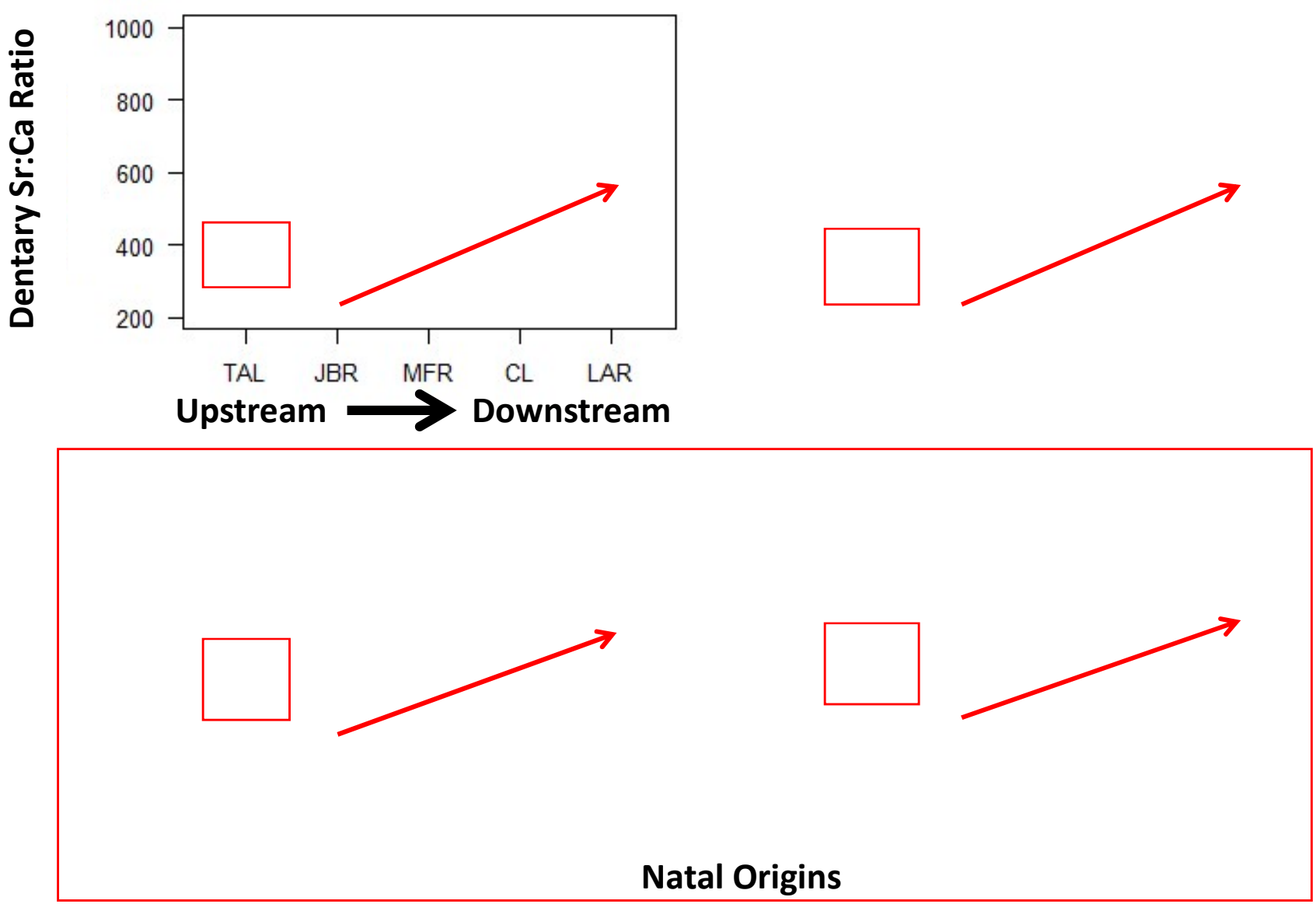
- During 2017-2019
  - PAD – **186**
  - SBF – **209**
- River Sections:
  - **Lower Alabama River (LAR)**
  - **Claiborne Lake (CL)**
  - **Millers Ferry Reservoir (MFR)**
  - **Jones Bluff Reservoir (JBR)**
  - **Coosa River (CSA)**
  - **Tallapoosa River (TAL)**



Example Dentary Laser Ablation Transect Profile



Sr:Ca Dentary Bone Microchemistry

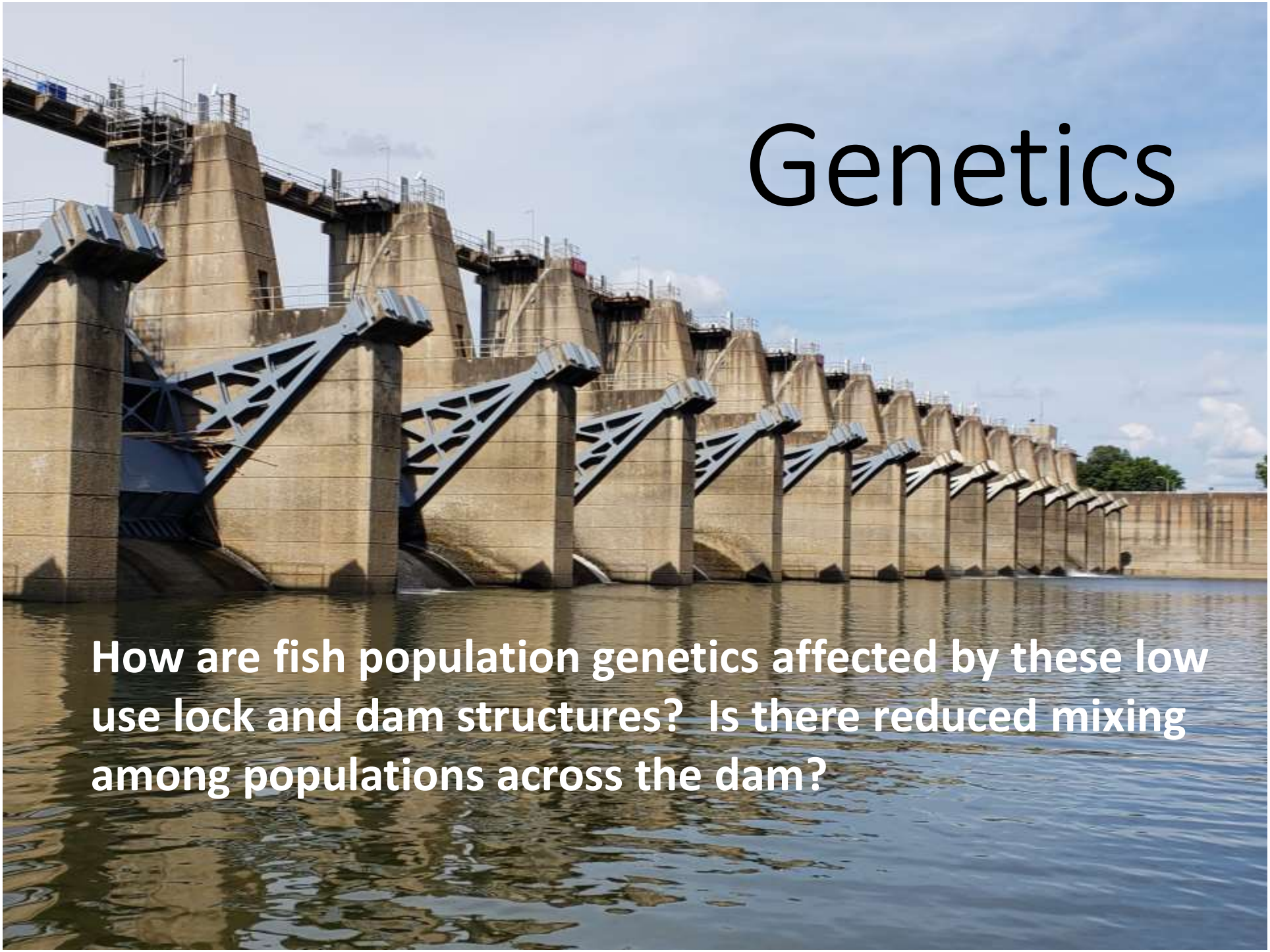


Discriminant Function Analysis (DFA)

Multivariate: Sr, Ba, Mg, and Mn

Upstream → Downstream

Transect Analysis	Upstream ↓ Downstream	Capture Location	LDA Classification (%) JBR	MFR	CL	LAR	Total Classification Accuracy (%)
Mean Transect		JBR					
		MFR					
		CL					
		LAR					

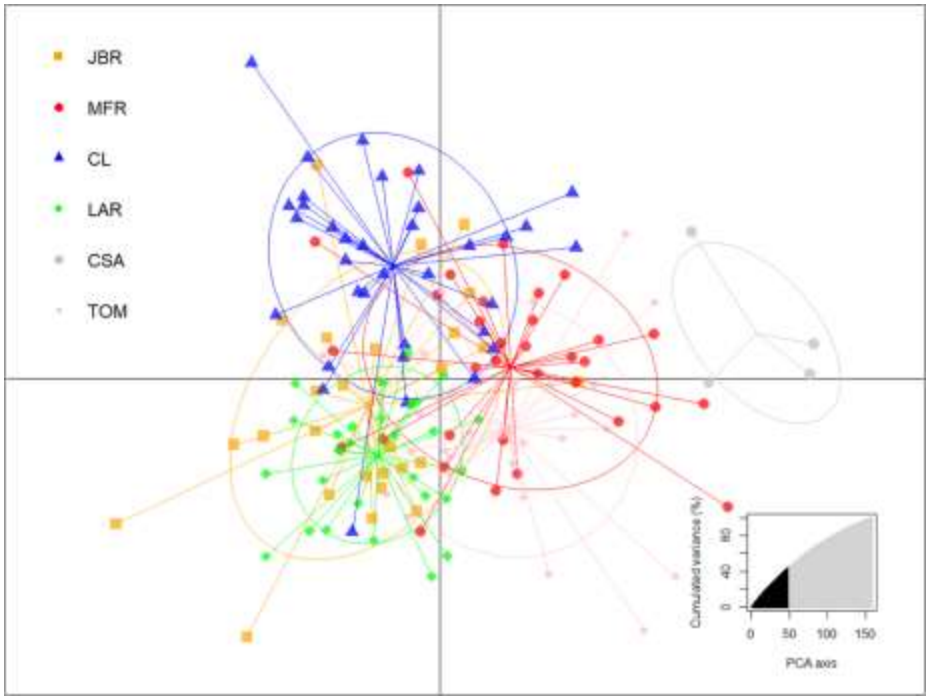

Genetics
How are fish population genetics affected by these low use lock and dam structures? Is there reduced mixing among populations across the dam?

Fin clips collected			
	Lower AL River	Claiborne &Miller's Ferry	Upper AL River
Smallmouth Buffalo	86	135	62
Paddlefish	130	149	39 + 87 from the Tombigbee

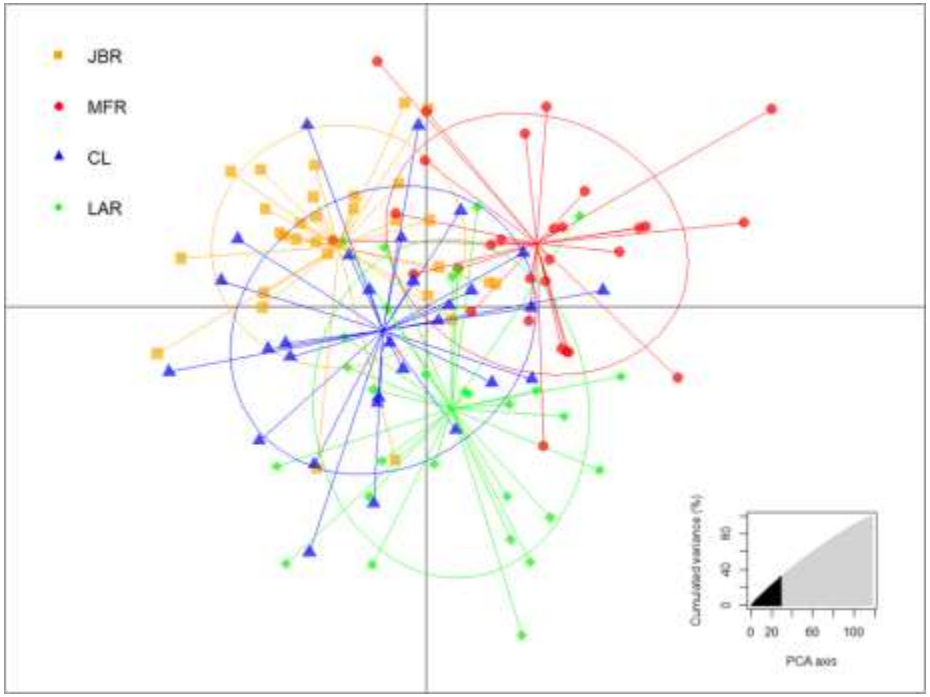
- Entire genomes mapped for Paddlefish and Smallmouth Buffalo
- First population genetics assessment of Paddlefish using SNP markers
- 1,889 SNPs in Paddlefish and 3,737 SNPs in Smallmouth Buffalo were identified

Genetic clusters relative to river section

Paddlefish



Smallmouth Buffalo



Each color represents fish from a section of the river

No clear separation or clusters among river sections

Fate of fish that pass or are transported past the dam

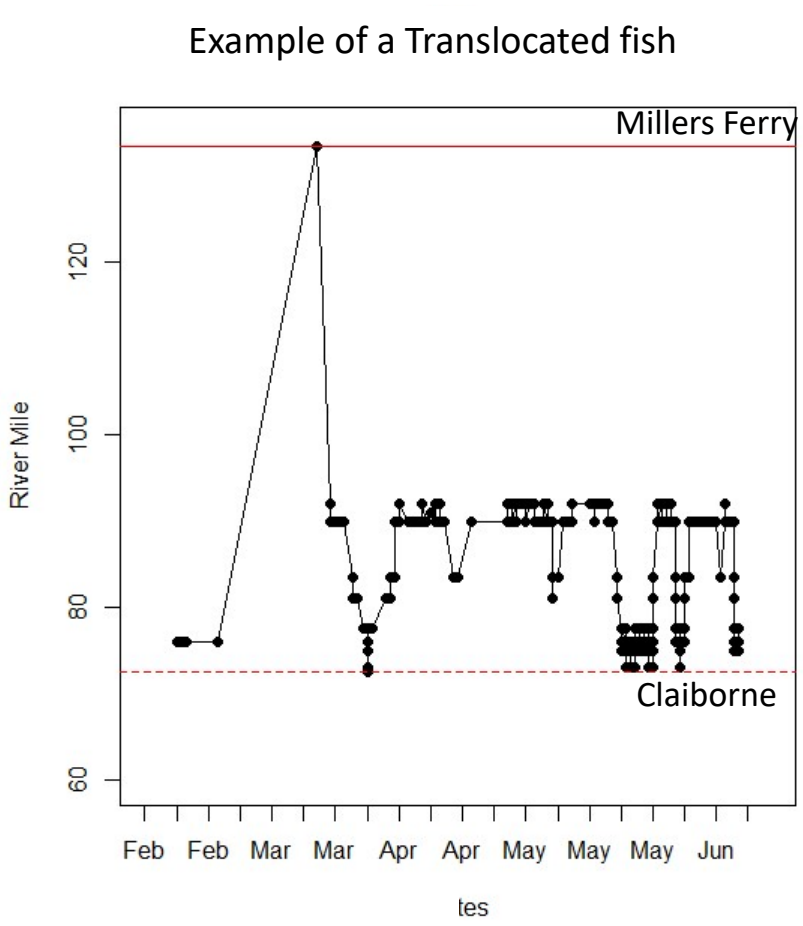
Southeastern Blue Sucker, *Cycleptus meridionalis*

Paddlefish, *Polyodon spathula*

Approach

- Capture and radio/acoustic tag fish below Claiborne Dam
- Transport via boat upstream past the dam
- Release in a backwater approximately 4 km upstream of Claiborne Dam
- Track released fish using passive acoustic receivers and manually using radio
- Determine fall-back downstream, delays to migration, continuation of spawning migration

Results



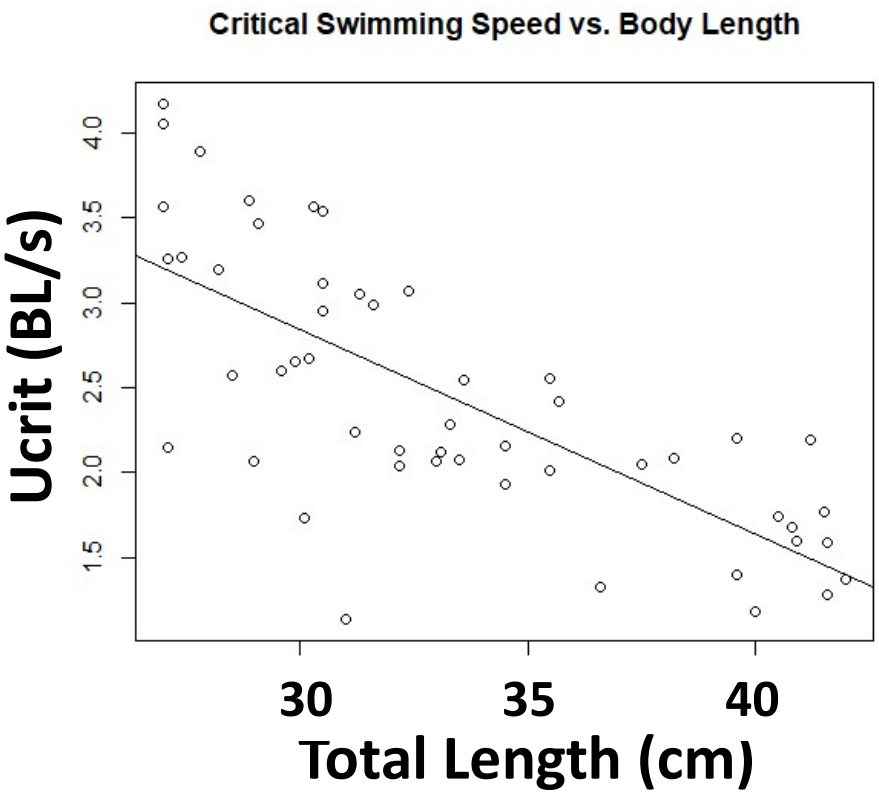
- 50% of fish moved into the river 2 days post tagging and translocation
- No apparent fall back behavior
- Similar movements as fish tagged and released below Claiborne Dam
- 17% of fish moved upstream to Millers Ferry within 1 month

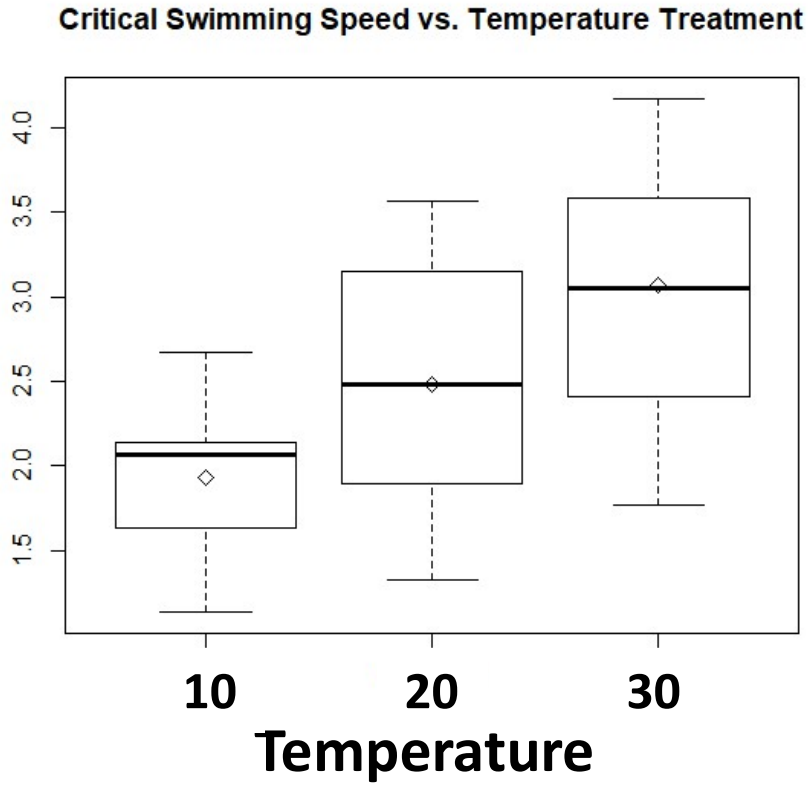
Swim Challenges

Auburn swimming respirometers
(90 L and 850 L)

Large-scale flume at the US Army Corps of Engineers, Engineer Research and Development Center (ERDC), Vicksburg

Swim challenges with freshwater drum





Further swim challenges will include

- Respirometry
- Blood chemistry
- Optimal path analysis (can fish find the lower cost path through a flow field)
- Other species including paddlefish and smallmouth buffalo with the largest scale trials at ERDC

Next steps for the project

- 5 current graduate students (3 MS and 2 PhD) are in various stages of their graduate program
- Extend point recording array further upstream to include detailed array in Millers Ferry tailrace
- Continue to tag additional fish
- Further analyze fish movement data in combination with flow field data (in collaboration with ERDC personnel)

Next steps for the project (cont.)

- Expand the project to include an additional field site
- Continue swim trials and respirometry at AU and begin trials at ERDC
- Expand and calibrate blood chemistry analyses as related to stress and exertion – multiple species
- Continue microchemical and genetic analyses on new mostly shorter-lived species
- Further study fate of fish after tagging and after movement past the dam

Acknowledgments