Use of otolith microchemistry to assess mixed-origins of channel catfish in an open river-tributary network

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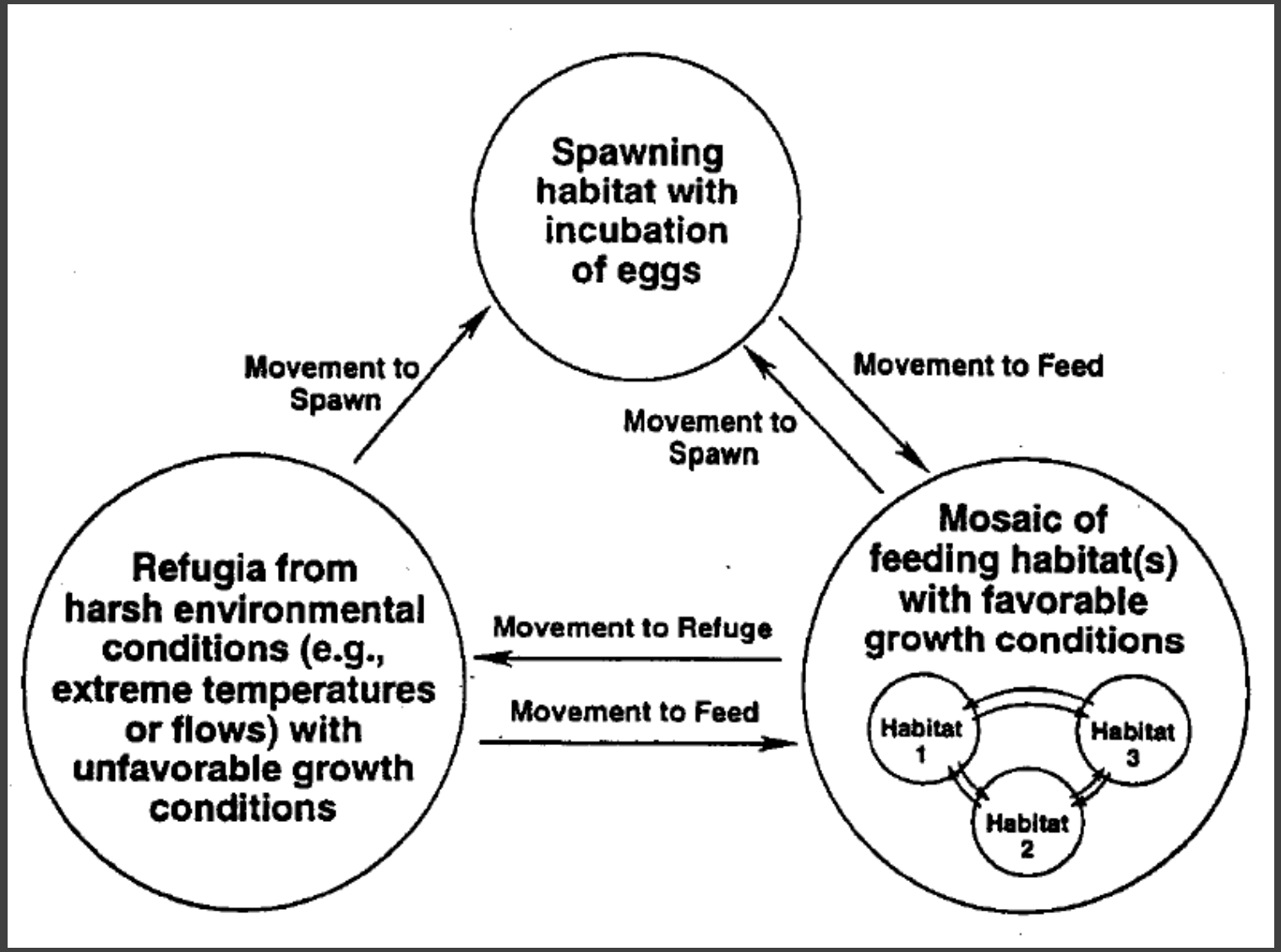
Jonathan J. Spurgeon

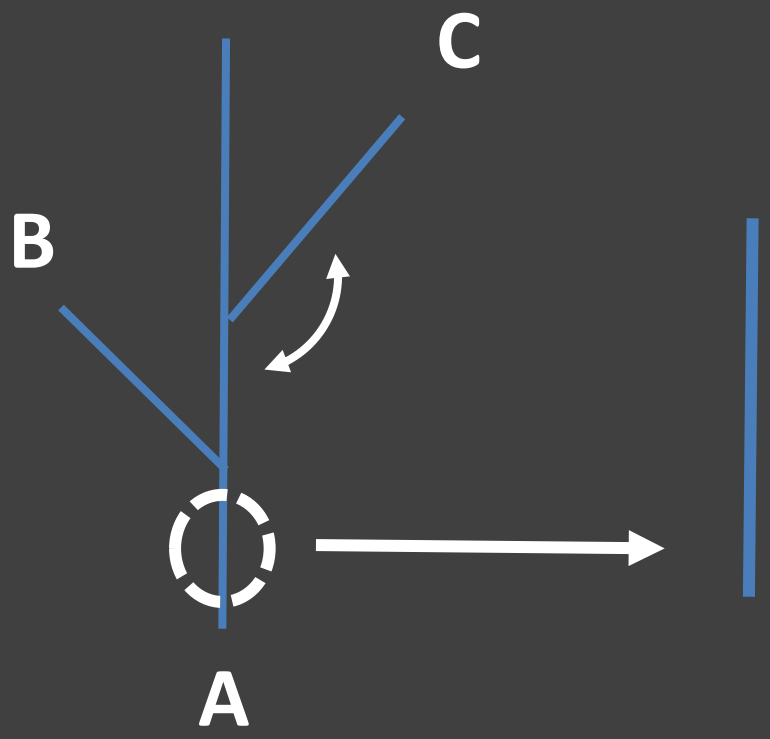
University of Arkansas at Pine Bluff

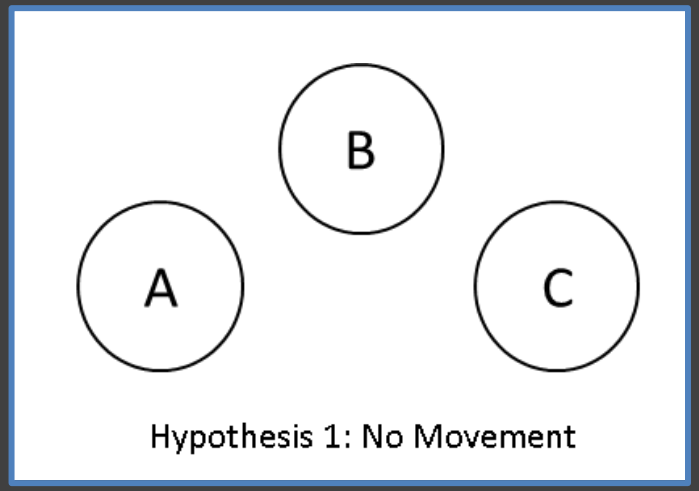
Habitat Needs of River Fishes

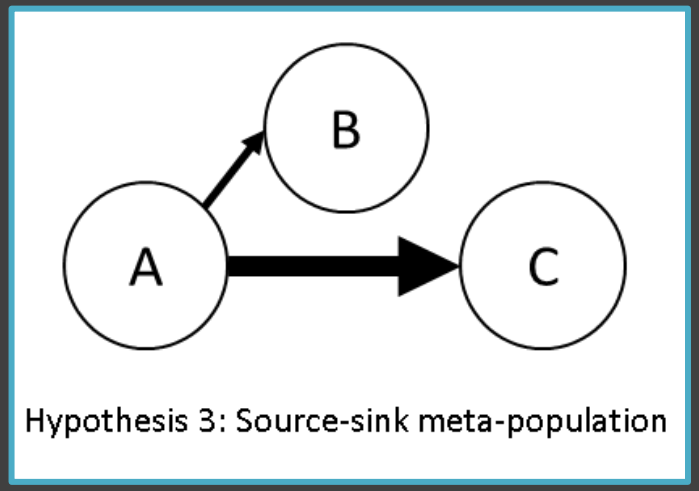


Schlosser and Angermeier 1995

Spatial extent of at which life-stages are carried out is critical to understanding population structure across a river-network







Spurgeon et al. 2018
River Research and Application *Accepted*

Spatial Structure of River Fish Populations

- Importance to management
  - Movement may facilitate population structure across spatial scales
    - Influence on population dynamics
  - Movements between tributary and mainstem environments
    - Roles of tributaries in large-river networks?
  - Inform harvest regulations and habitat restoration

Channel Catfish

- Commercial and recreationally important
- Mobile species
- Potential exist for substantial mixing of individuals

Life History Cycle	Restricted Winter Movement			Migration	Spawn		Feeding and Growth			Migration	Restricted Winter Movement	
Month	J	F	M	A	M	J	J	A	S	O	N	D
Small Platte River Tributaries												
Large Platte River Tributaries												
Platte River												
Missouri River												

Photo Credit: J Spurgeon

Otolith Microchemistry

- Tool to assess transitions across an individuals lifetime
- Dependent on gradients in water chemistry among river segments
  - Sr, Ba, Mg, and Mn commonly used in freshwater environments

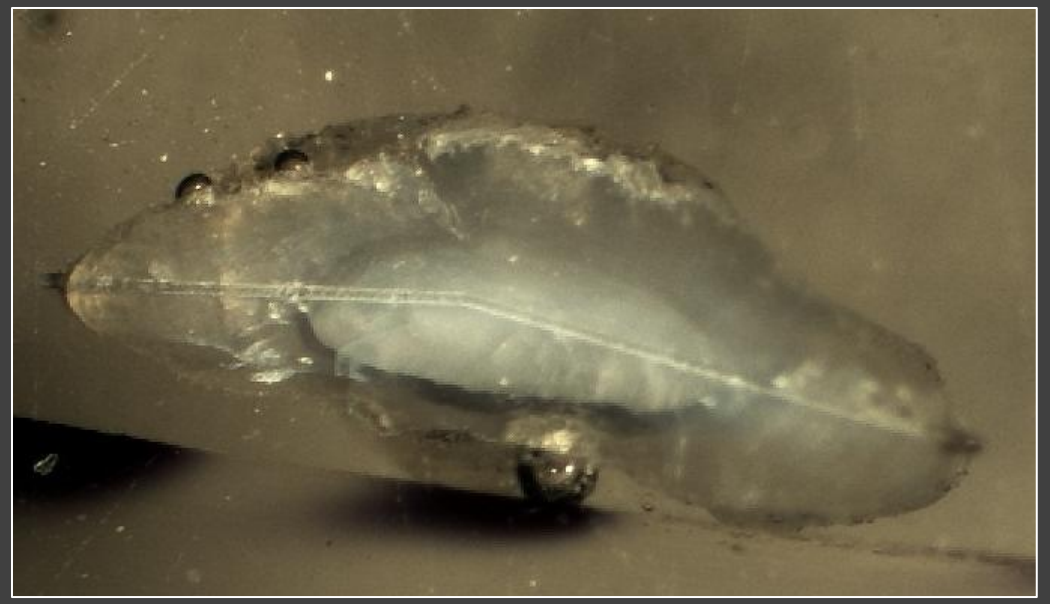


Photo Credit: J Spurgeon

Research Questions

- Are there differences in microchemistry signatures in both water and channel catfish otoliths between river segments in the Platte and Missouri rivers?
- What is the prevalence of mixing across main-stem and tributary systems

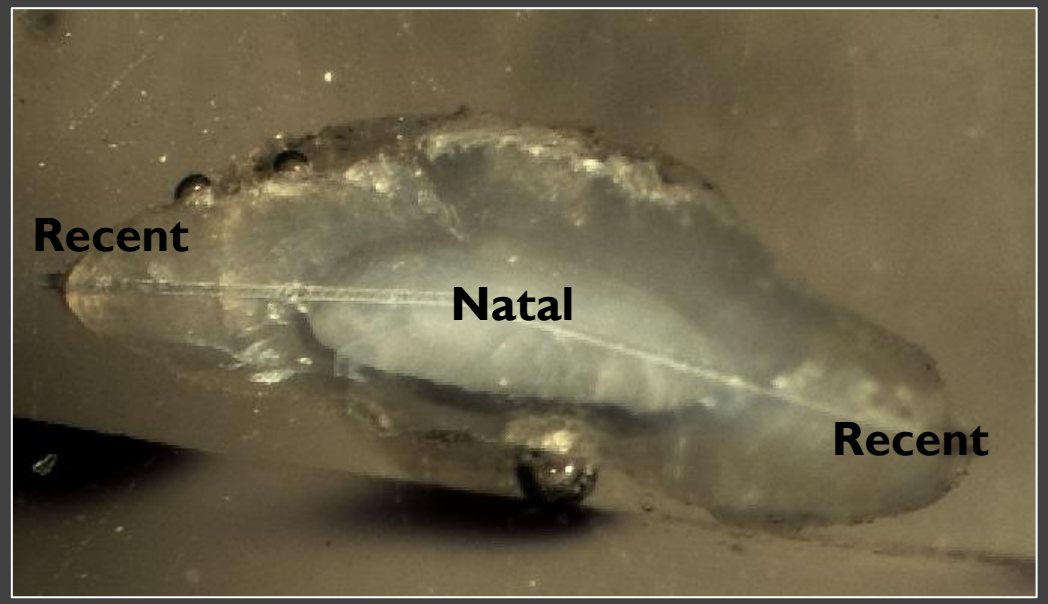
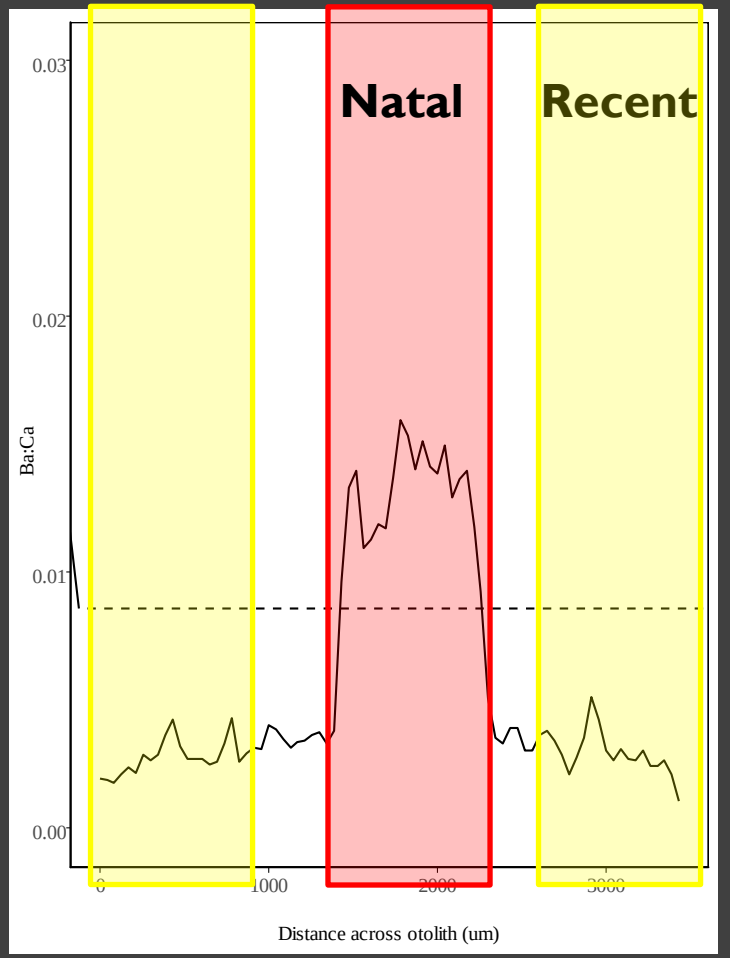
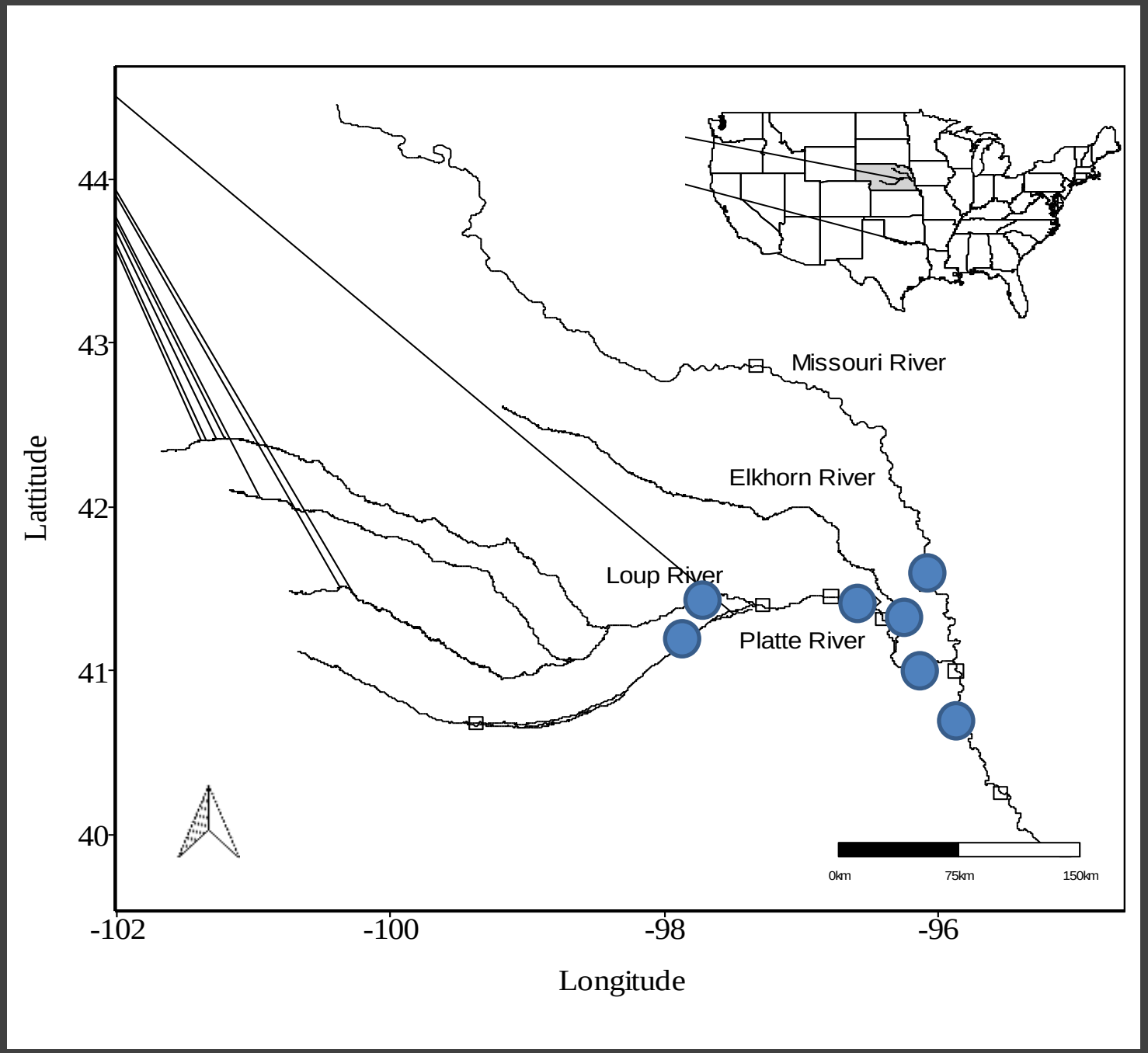
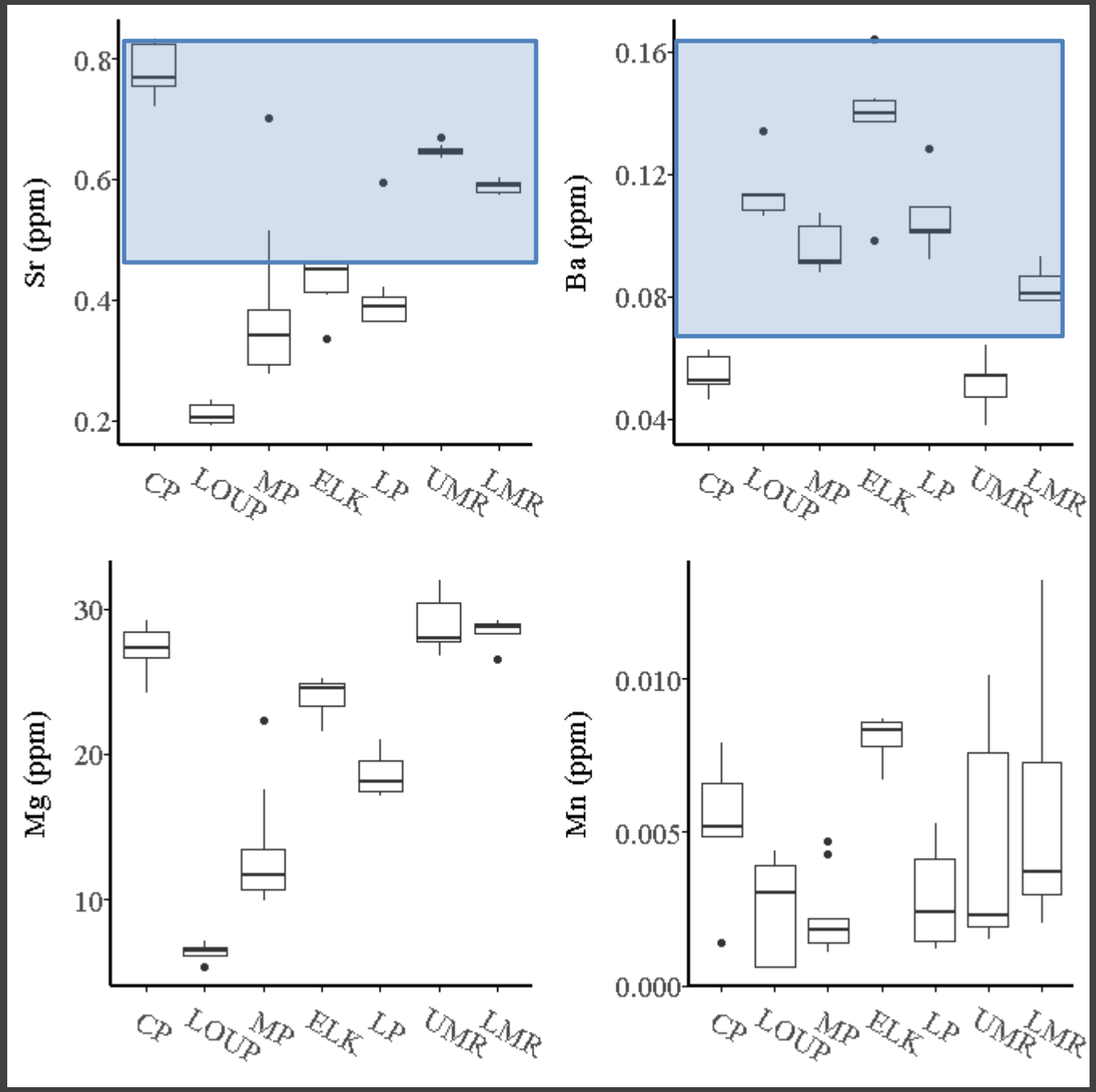


Photo Credit: J Spurgeon





- **Water samples from Platte River and tributaries (i.e., Loup River and Elkhorn River) and Missouri River.**

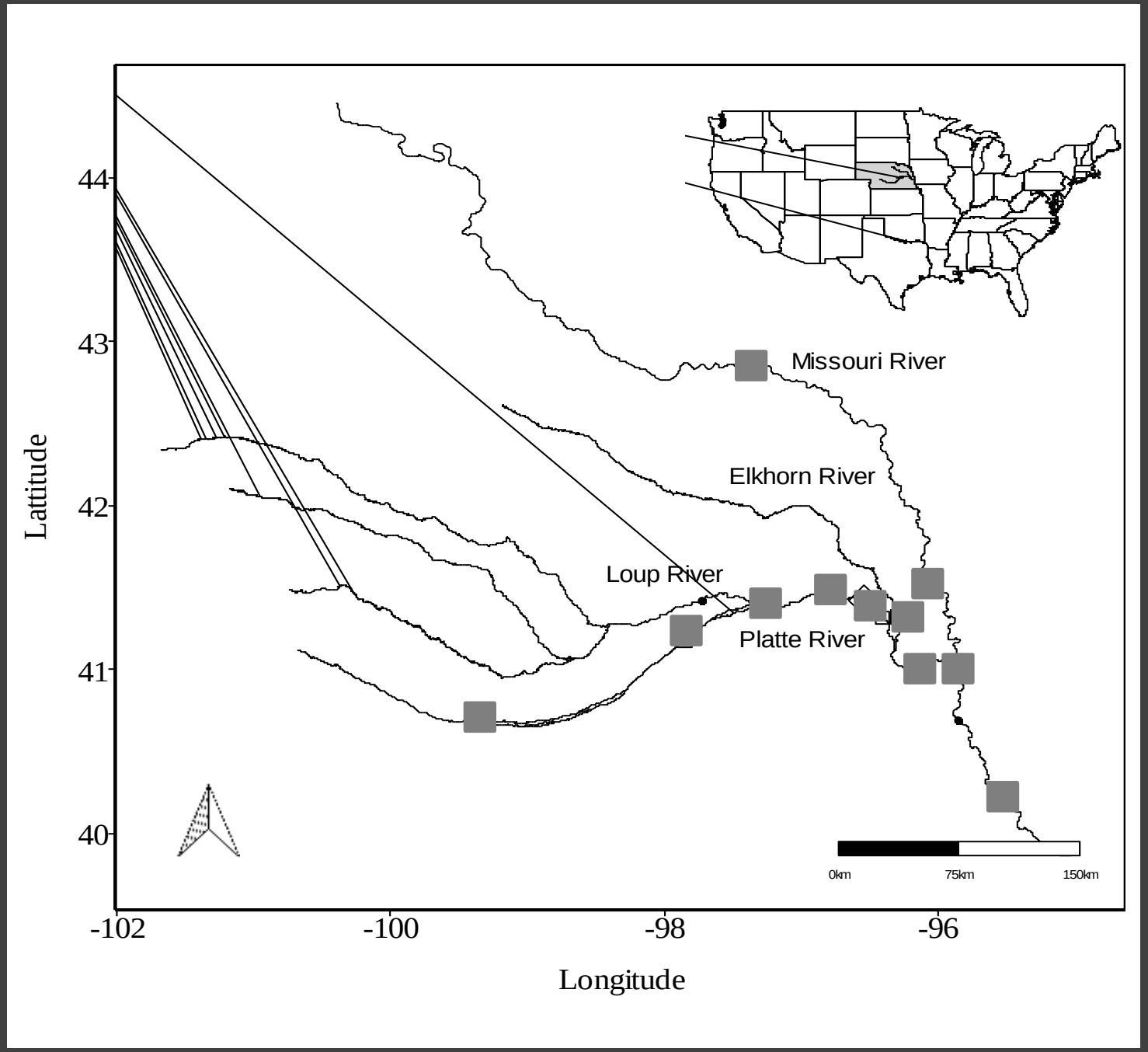


Differences existed among river segments for Sr:Ca, Ba:Ca, and Mg:Ca (MANOVA, Wilks=0.006, NumDF = 15, DenDF = 135.67, $P < 0.0001$)

Ba:Ca signatures highest in the lower Platte River and tributaries

Sr:Ca signatures highest in the central Platte River and Missouri River

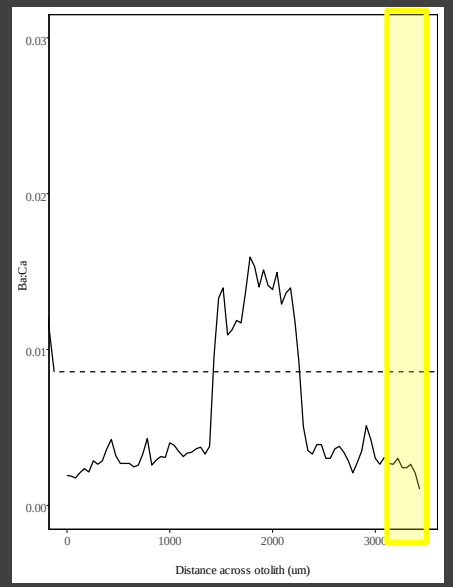
Spurgeon et al. 2017
Fisheries Research 198: 195-202



- **Channel catfish from Platte River and tributaries (i.e., Loup River and Elkhorn River) and Missouri River.**

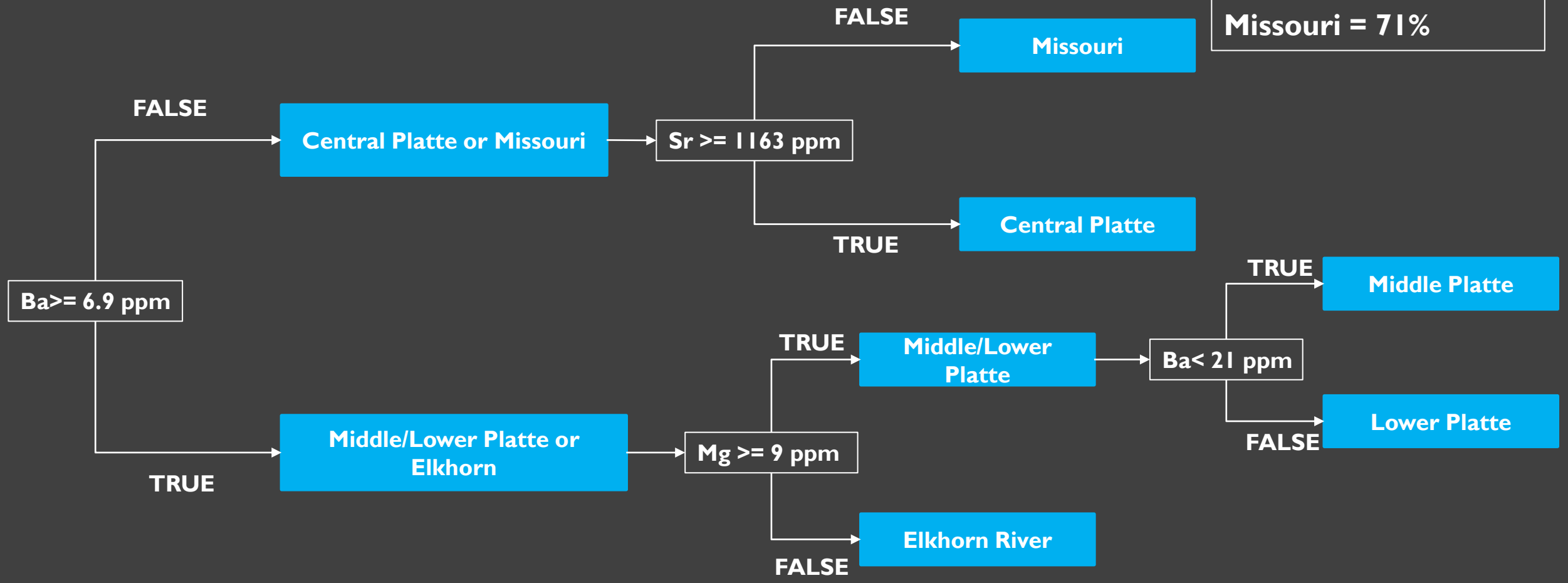
Differences existed among river segments for Sr:Ca, Ba:Ca, and Mg:Ca (MANOVA, Wilks=0.19881, NumDF = 9, DenDF = 90, P < 0.0001)

Ba:Ca signatures highest in the lower Platte River and tributaries similar to water chemistries

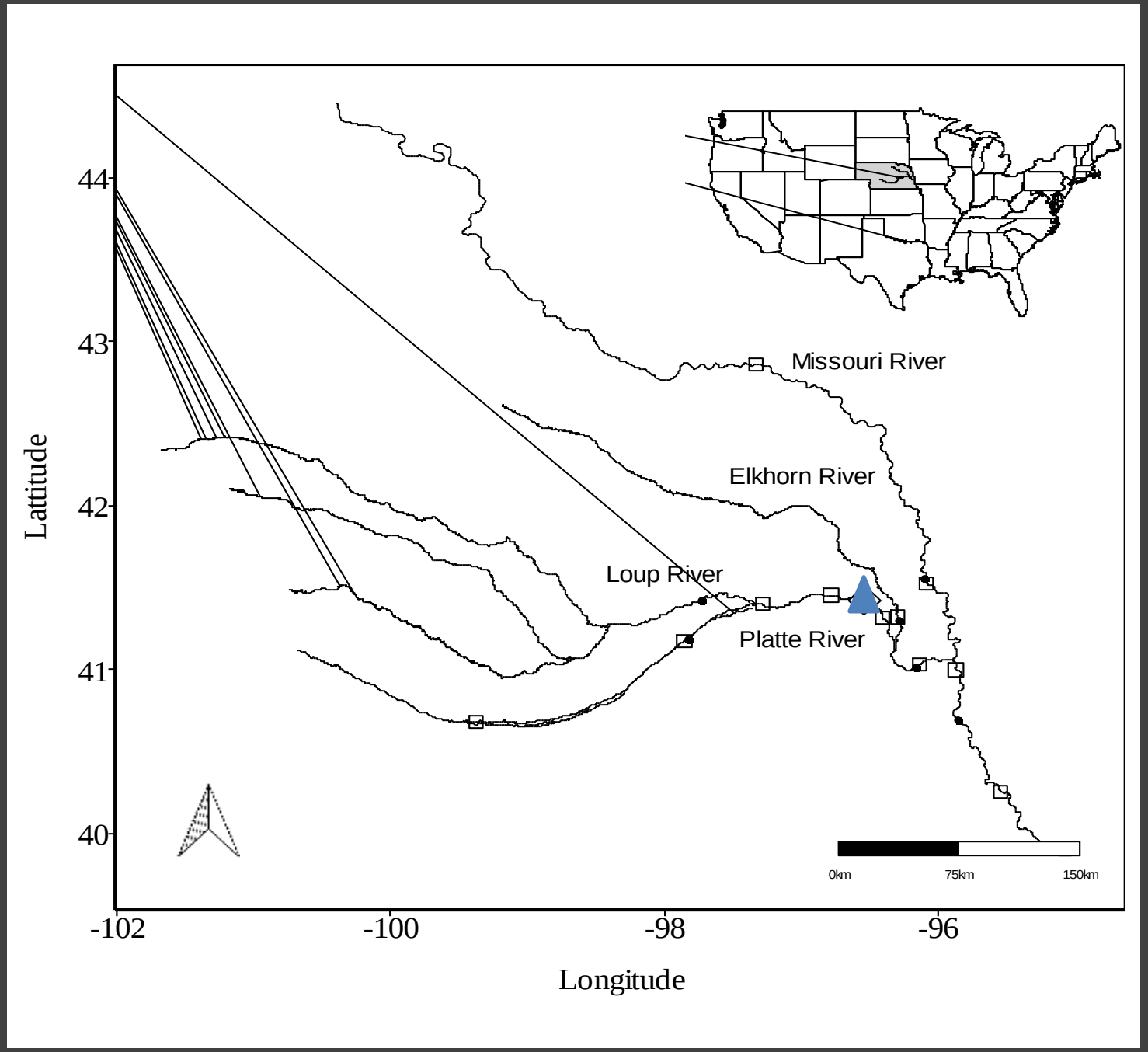


Classification Tree

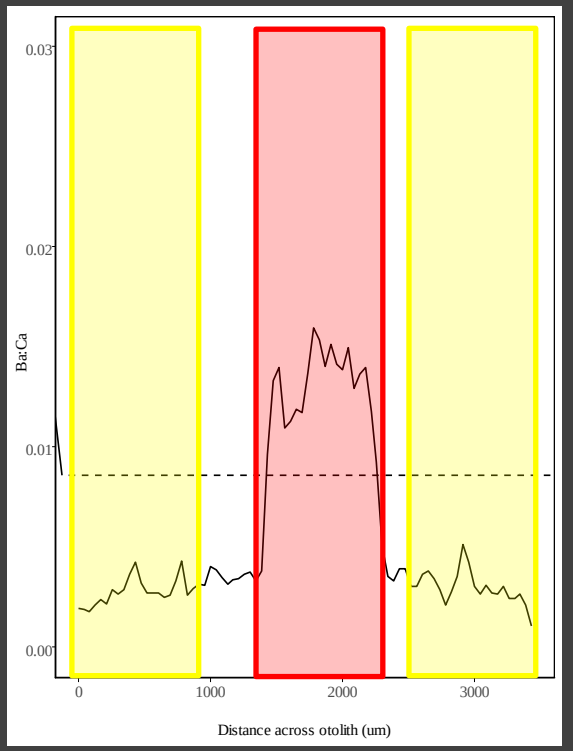
Classification Accuracy:
Lower Platte = 44%
Middle Platte = 79%
Elkhorn = 80%
Central Platte = 88%
Missouri = 71%



*Classification rule based on sampled juvenile channel catfish



- **Channel catfish collected from a recreational catfish tournament in Platte river – larger individuals**
  - **Sampled**
    - **N=43**
    - **Mean Length = 189 mm TL**
  - **Angled**
    - **N=30**
    - **Mean Length = 630 mm TL**



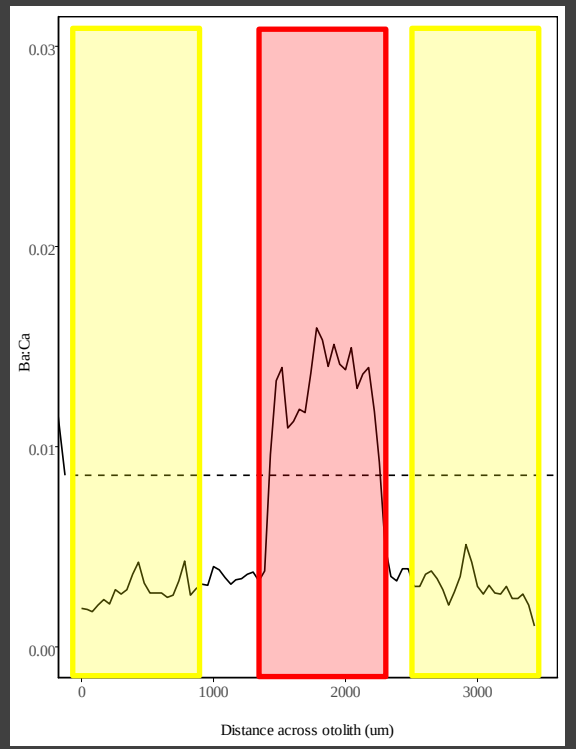
Mixed-origins in Lower Platte

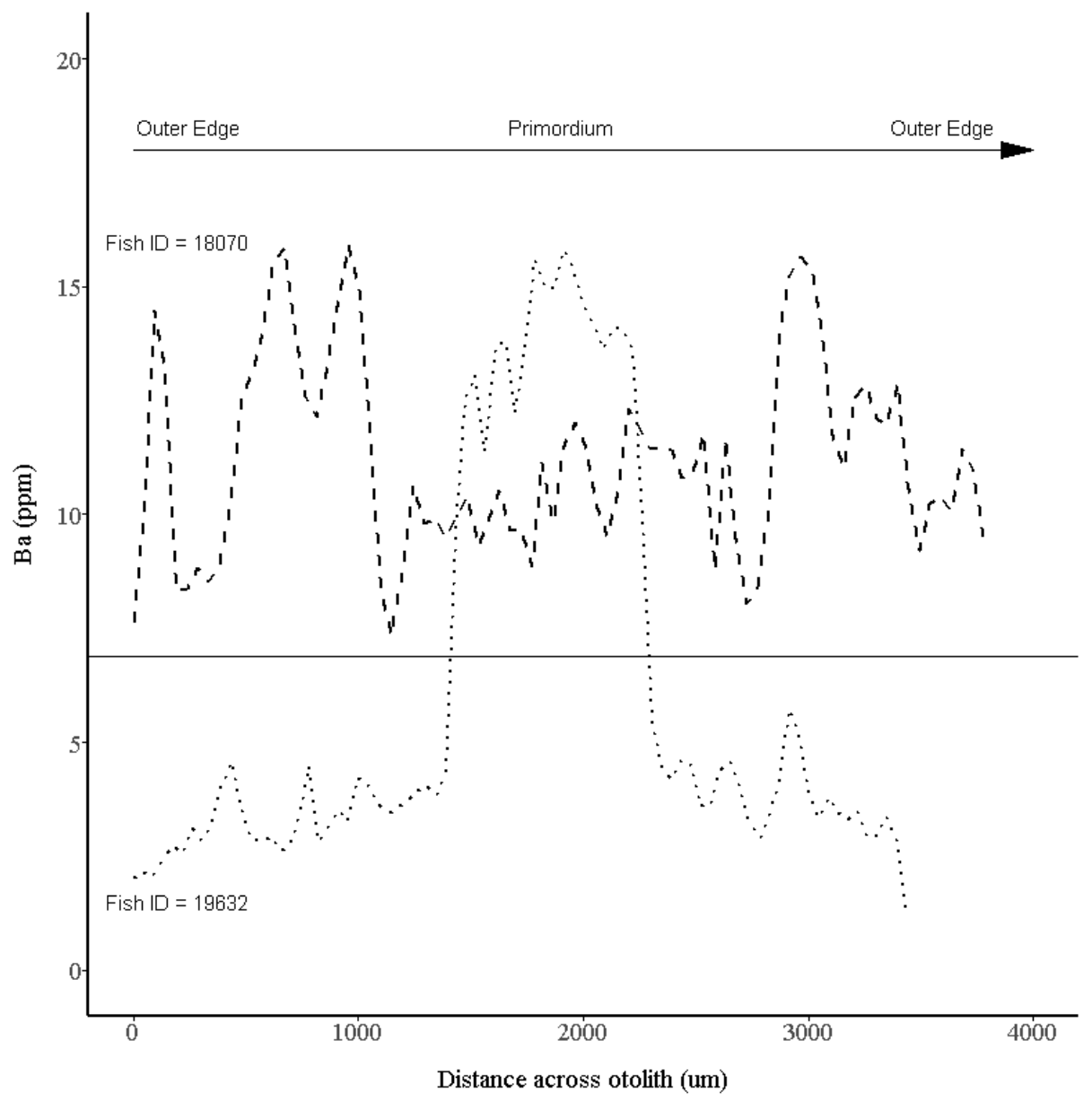
- **Channel catfish angled in lower Platte River**
  - **30 individuals sampled from catfish tournament near Fremont, NE in spring (~May 20-25, 2015)**

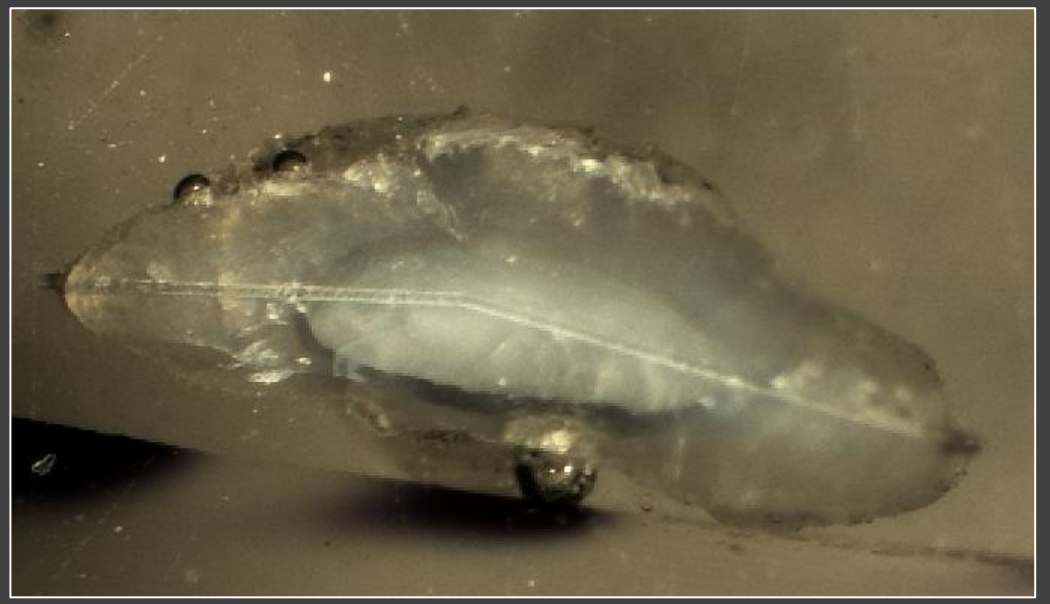
Predicted Recent Environment	Percent (Sample Size)
Lower Platte River	3% (1)
Middle Platte River	50% (15)
Central Platte River	10% (3)
Elkhorn River	6% (2)
Missouri River	30% (9)

Of the Recent Missouri River Fish →

Predicted Natal Environment	Percent (Sample Size)
Lower Platte River	30% (9)
Middle Platte River	66% (20)
Central Platte River	0% (0)
Elkhorn River	0% (0)
Missouri River	3% (1)







Spurgeon et al. 2017
Fisheries Research 198: 195-202

Summary

Photo Credit: J. Spurgeon

Population Structure

- Considerable mixing occurs between Missouri and Platte rivers
- Channel Catfish population spans Missouri River and Platte River boundaries
- Movement into the Platte River may be tied to spawning period
  - ✓ Returners to natal origins

Concluding Thoughts

- Assess populations at ecologically meaningful scales
- Tributary systems likely important for conservation and management of river fishes...but cannot be used solely

  - ✓ Population dynamics of river fishes may be connected across tributary and main-stem systems

  - ✓ Need exist to quantify the extent of influence of tributary systems on main-stem river

    - What role does tributary size play?

Photo Credit: J Spurgeon

Acknowledgements

- Nebraska Game and Parks Commission
- University of Nebraska-Lincoln
  - Institute of Agriculture and Natural Resources
- Lab members and undergraduate technicians

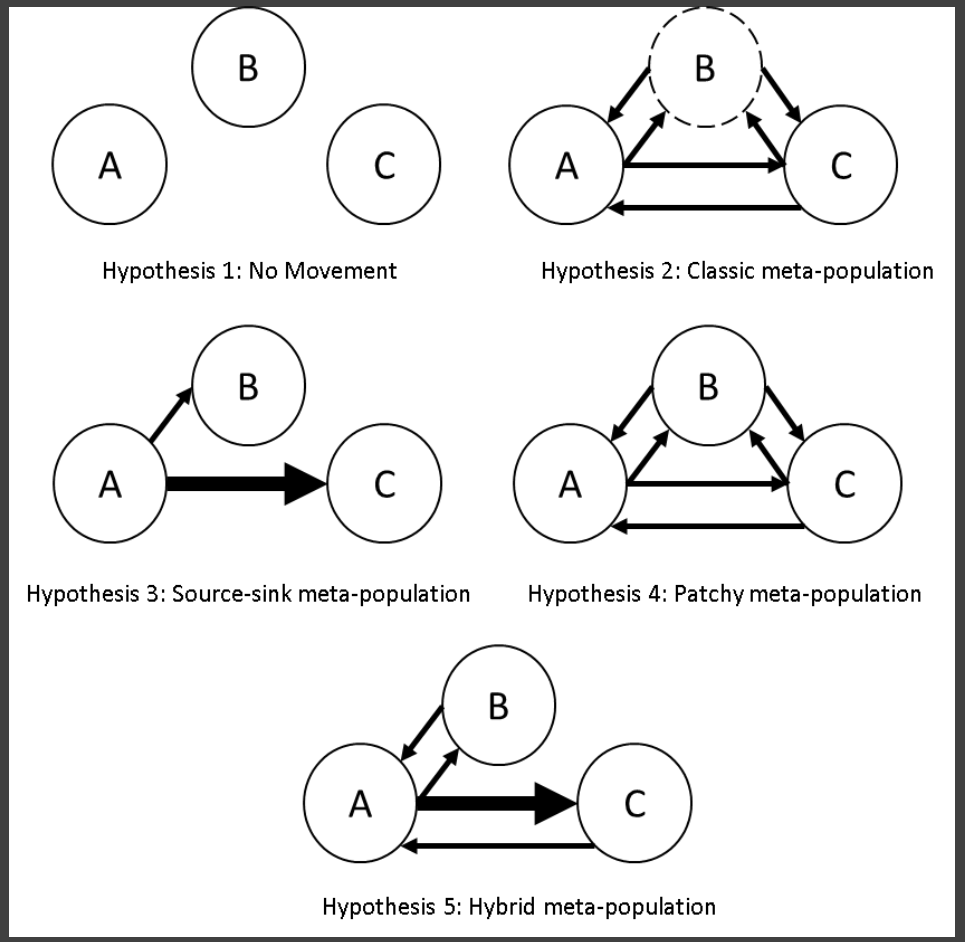
SCHOOL OF NATURAL RESOURCES

SPORT FISH RESTORATION

NEBRASKA GAME PARKS

Research Questions

- What is the level of channel catfish connectivity across the river-scape?
  - Is there a prevalence of directed movement?
  - Evidence of meta-population structure?

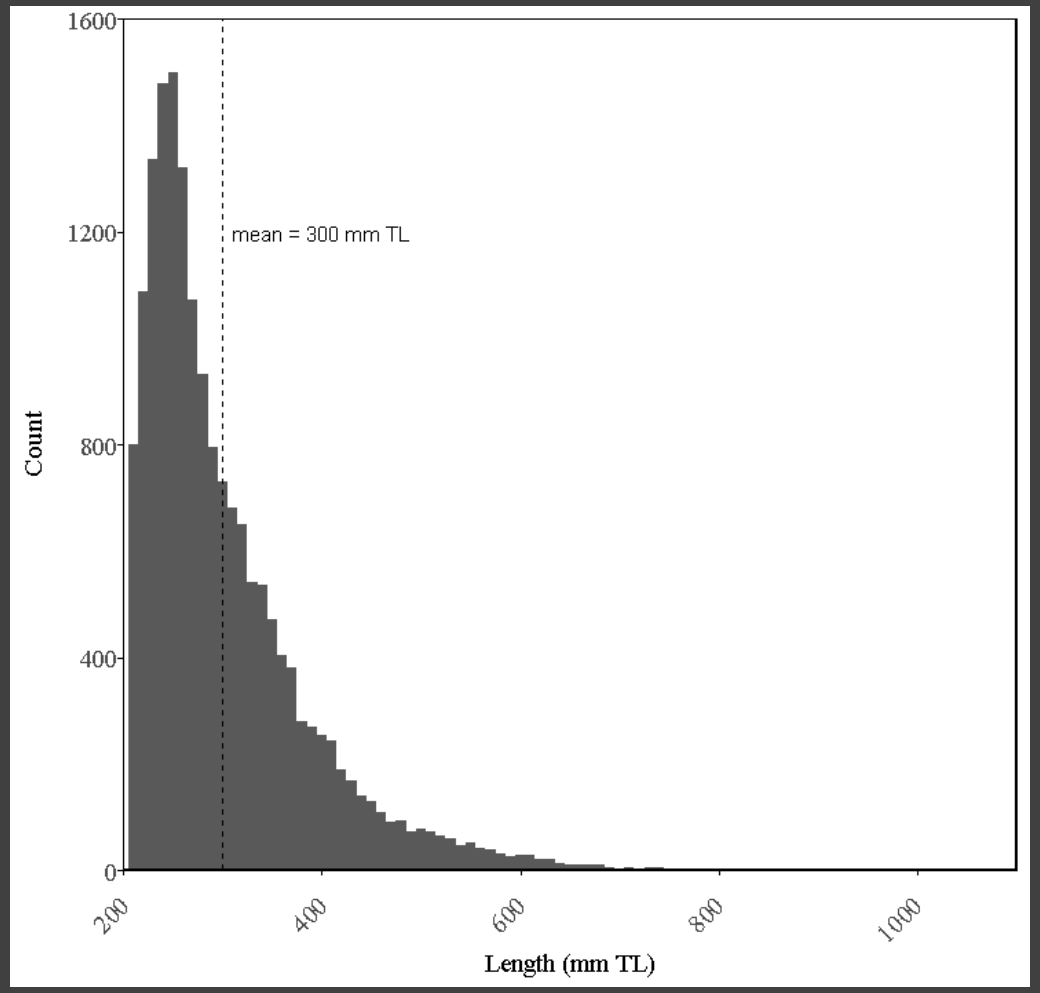


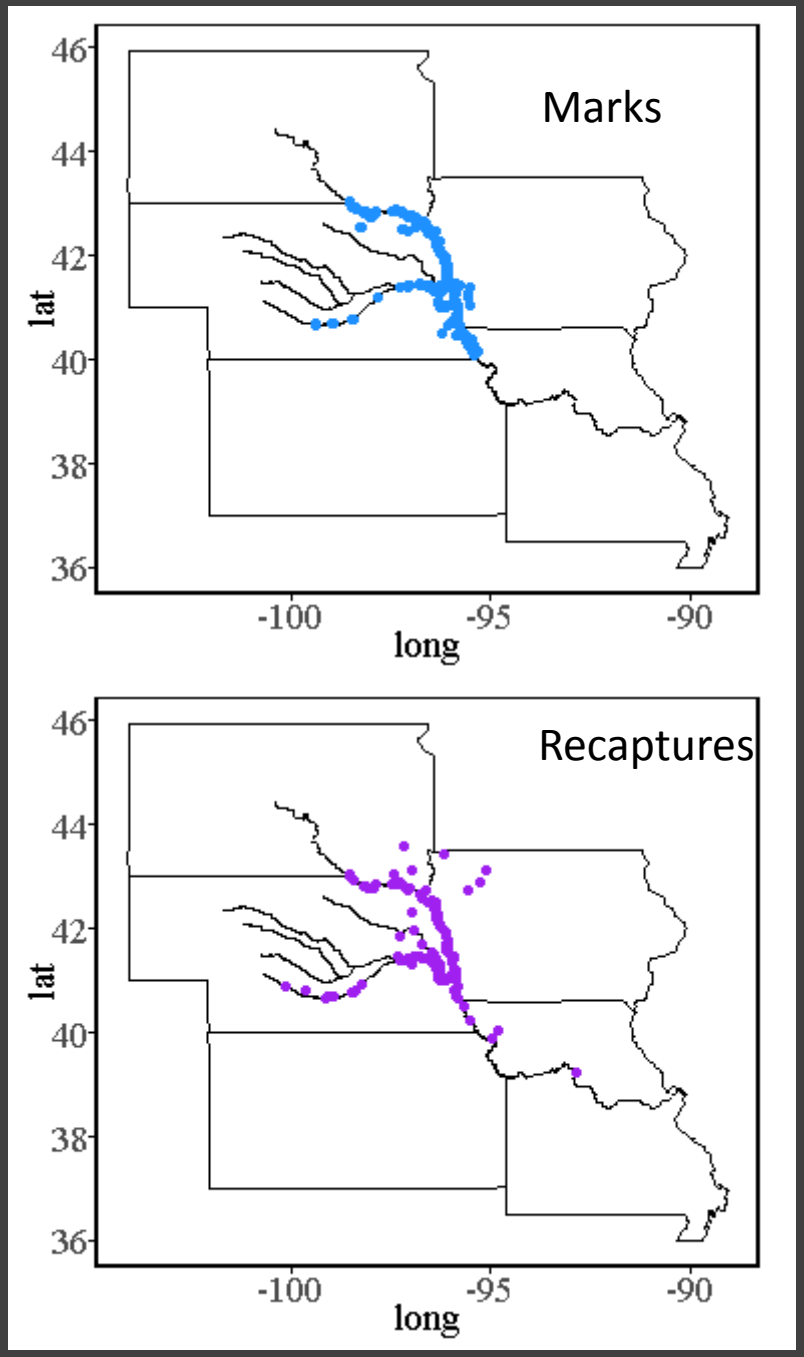
A = Missouri River above Platte River
B = Missouri River below Platte River
C = Platte River Basin

Spurgeon et al. *In Prep*

Mark-Recapture

- 17,849 channel catfish from 2010-2015
- 692 channel catfish recaptured





Multi-state Models

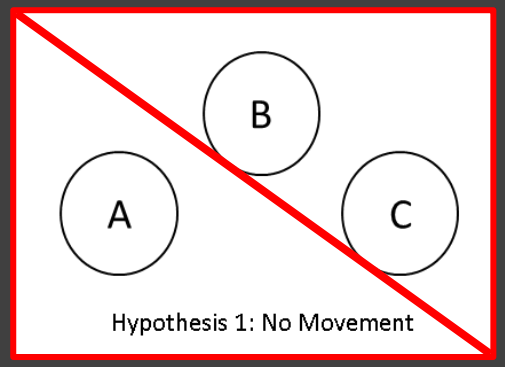
- Constrained model parameters to test hypotheses

Hypothesis	**Parameter constraints**
No Movement	Transition set to 0
Classical Meta-population	No constraints
Source-Sink	No survival constraints; Restrict movement between 2 of 3 states
Patchy-dynamics model	Equal transition and equal survival
Hybrid model	Combinations of Source-Sink and Patchy-dynamics

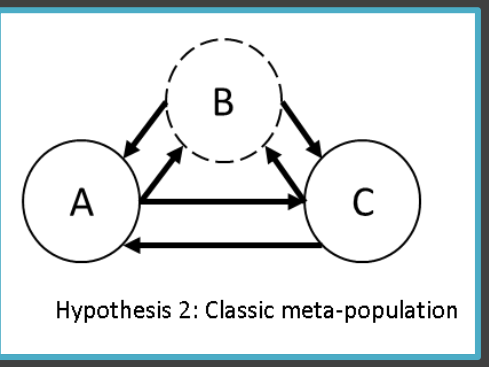
Model Comparisons

Model	AICc	ΔAICc	Wt.	L.	# Par.	Dev.
Classic Meta-population	4707.45	0.00	0.53	1.00	11	4685.44
Source Sink Meta-population	4709.40	1.95	0.20	0.38	9	4691.39
Hybrid Meta-population	4709.69	2.24	0.17	0.33	9	4691.68
Patchy Meta-population	4794.71	87.25	0.00	0.00	5	4784.70
No Movement	4796.55	89.10	0.00	0.00	7	4782.54

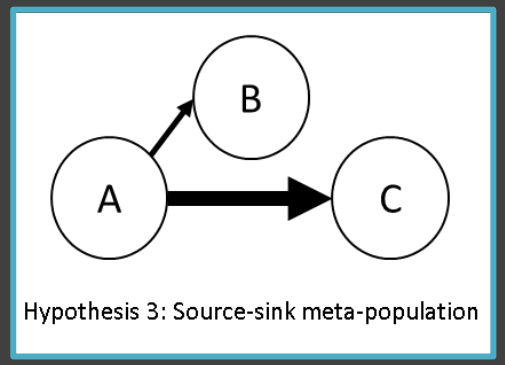
- Support for multiple models
- Model average parameter estimates



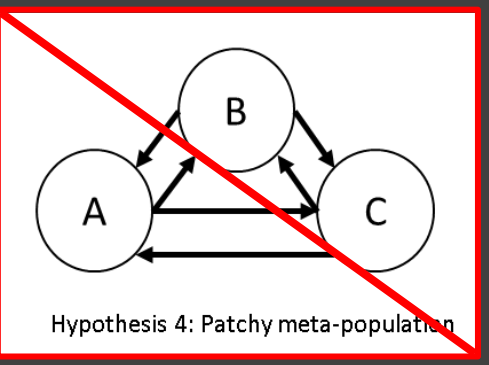
Hypothesis 1: No Movement



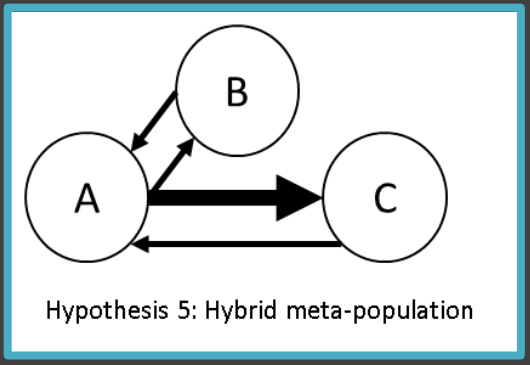
Hypothesis 2: Classic meta-population



Hypothesis 3: Source-sink meta-population



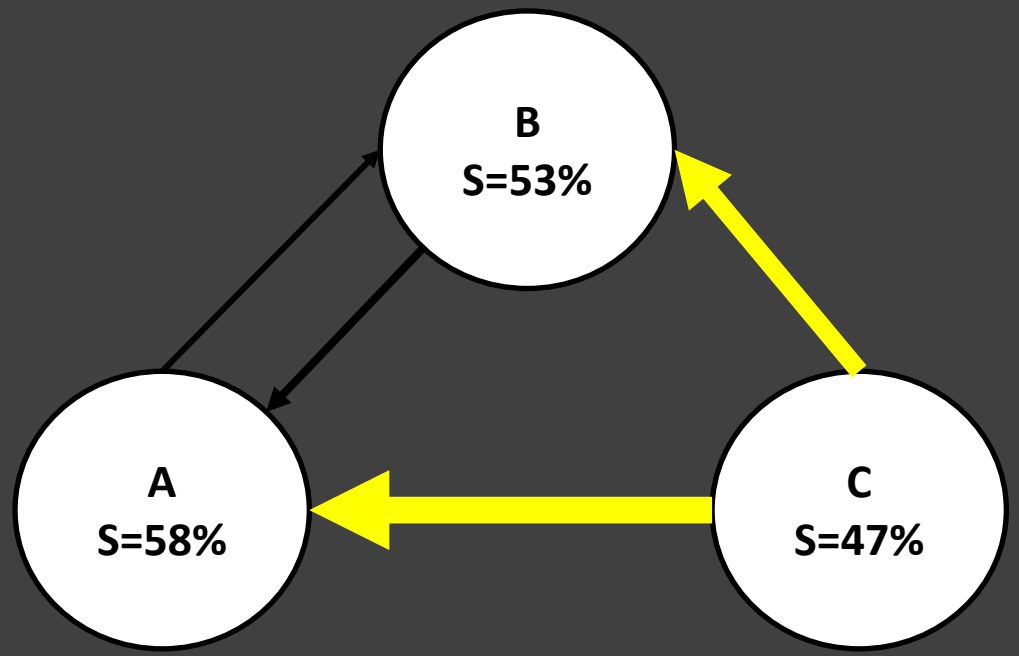
Hypothesis 4: Patchy meta-population



Hypothesis 5: Hybrid meta-population

Channel Catfish Movement:

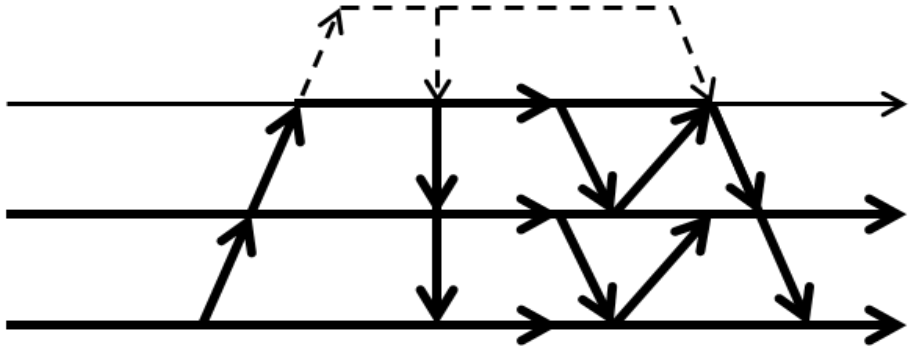
Parameter	Estimate	SE	LCI	UCI
S(A)	0.58	0.06	0.46	0.70
S(B)	0.53	0.12	0.30	0.75
S(C)	0.47	0.05	0.37	0.57
ψ(A to B)	0.02	0.02	0.01	0.10
ψ(A to C)	0.00	0.00	0.00	0.00
ψ(B to A)	0.04	0.04	0.00	0.26
ψ(B to C)	0.00	0.00	0.00	0.00
ψ(C to A)	0.26	0.06	0.16	0.38
ψ(C to B)	0.16	0.07	0.07	0.35

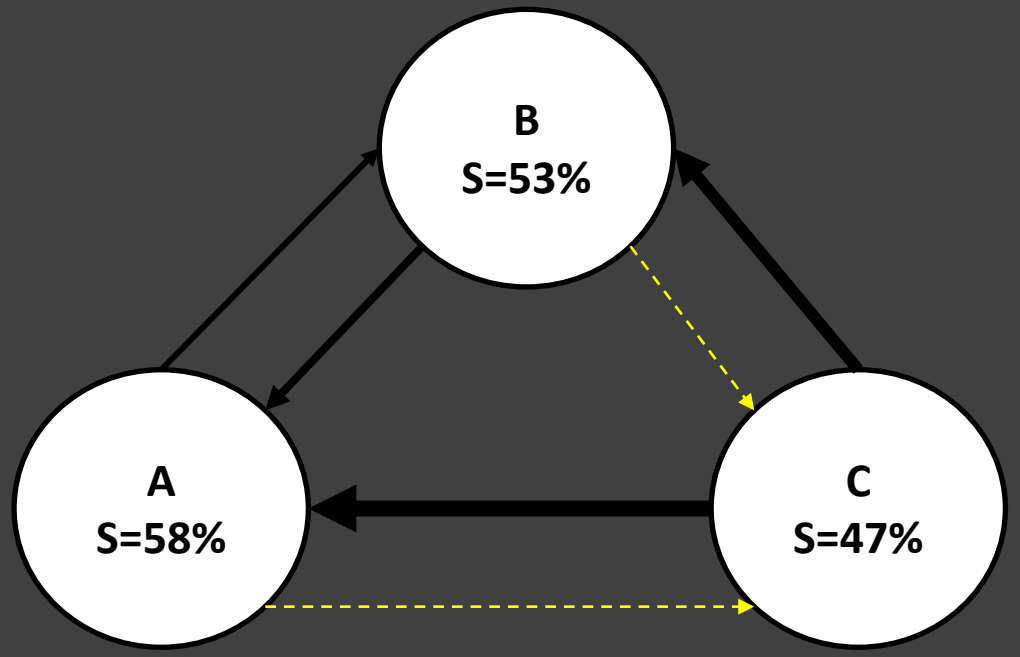


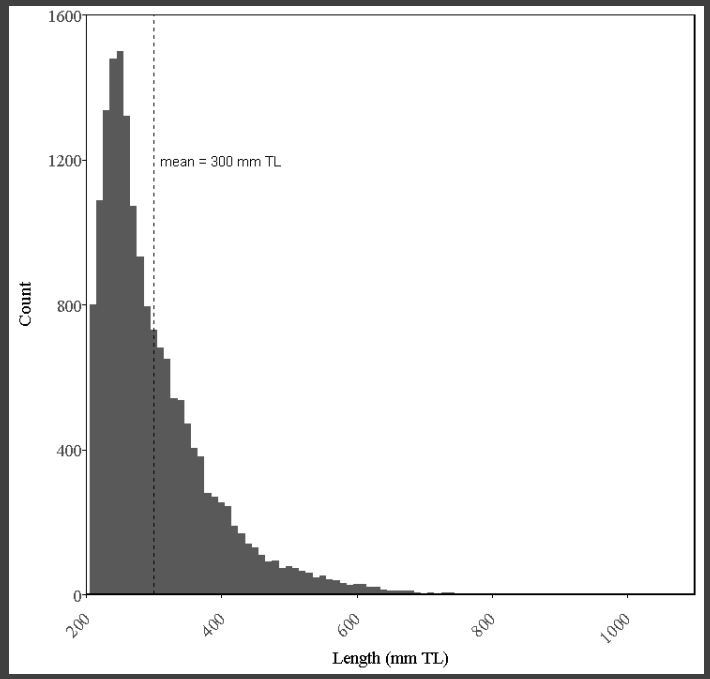
- Similar survival among different states
- Similar transitions up and down Missouri River
- Directional movement from Platte to Missouri River

A = Missouri River above Platte River
B = Missouri River below Platte River
C = Platte River Basin

Life History Cycle	Restricted Winter Movement			Migration	Spawn		Feeding and Growth			Migration	Restricted Winter Movement	
Month	J	F	M	A	M	J	J	A	S	O	N	D
Small Platte River Tributaries												
Large Platte River Tributaries												
Platte River												
Missouri River												







- **Movement from the Missouri River into the Platte River appears limited**
- **Literature suggests movement does occur**
  (Newcomb 1989 NAJFM)