Measuring and Modelling Multiscale Movements of Fishes to Inform Ecological ~~Models~~ Applications

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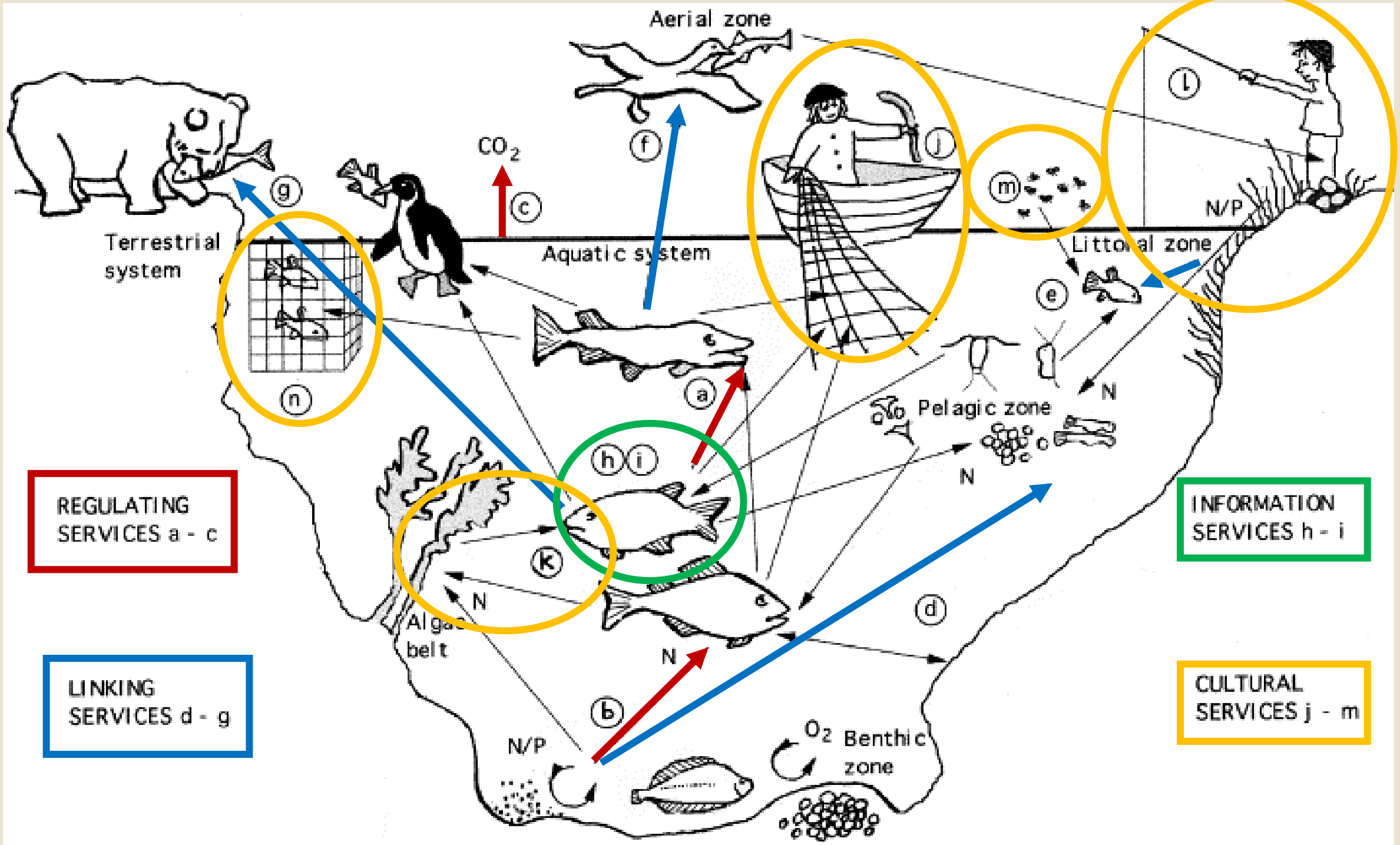
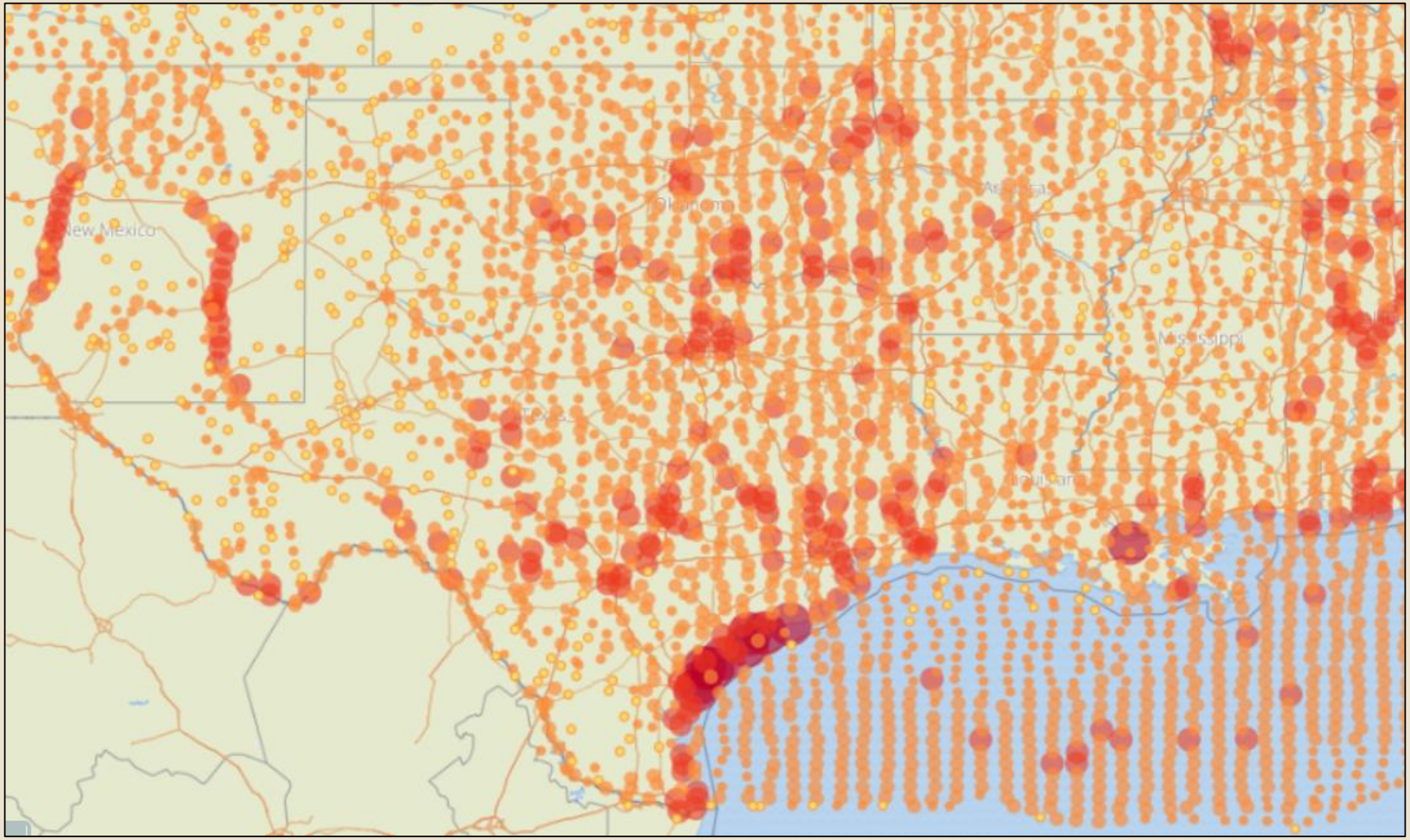
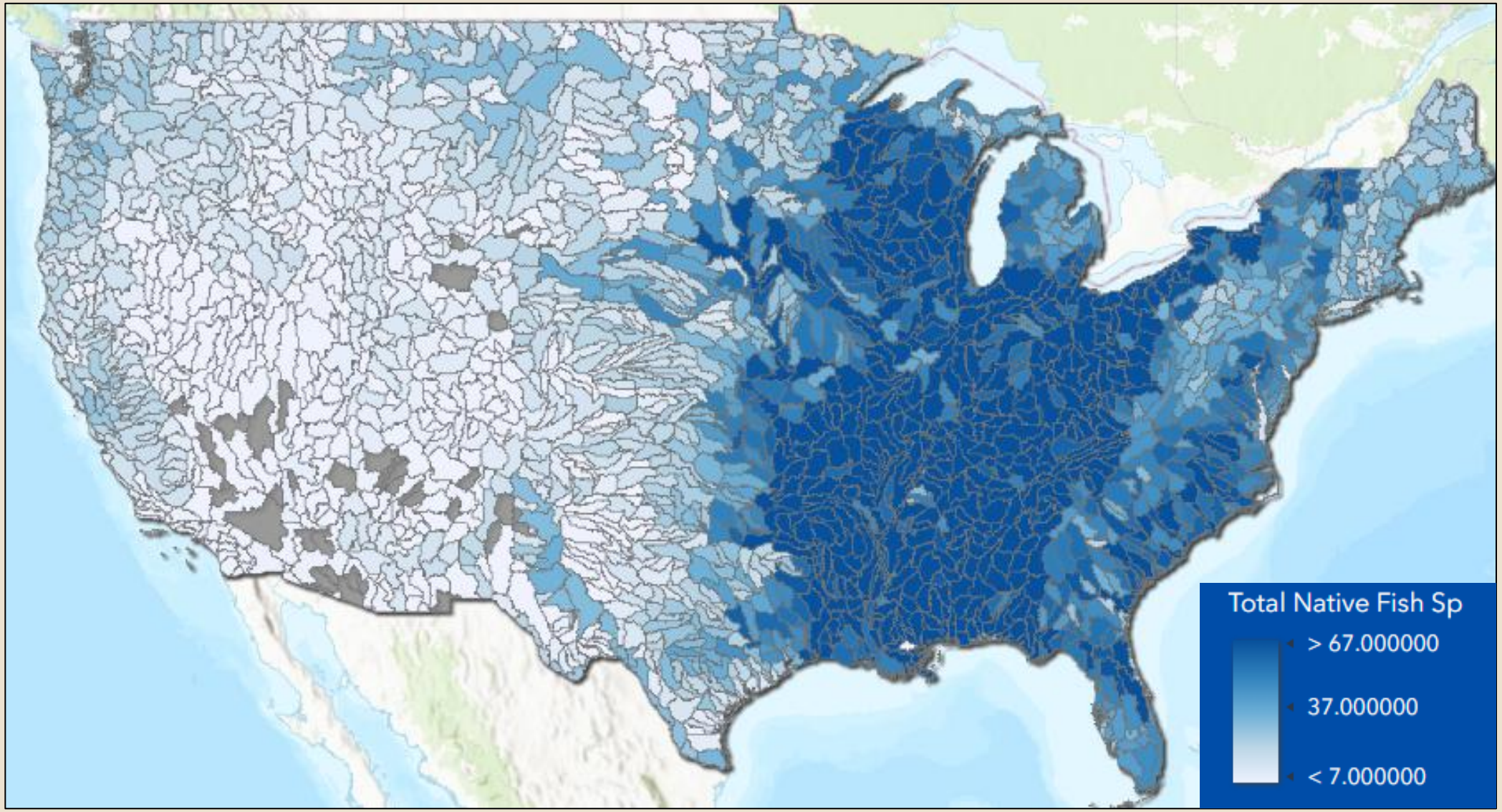

Aerial zone
CO_2
Terrestrial system
Aquatic system
Littoral zone
N/P
Pelagic zone
N
Algal belt
N
N/P
O_2 Benthic zone
a
b
c
d
e
f
g
h
i
j
k
l
m
n
REGULATING SERVICES a - c
INFORMATION SERVICES h - i
LINKING SERVICES d - g
CULTURAL SERVICES j - m

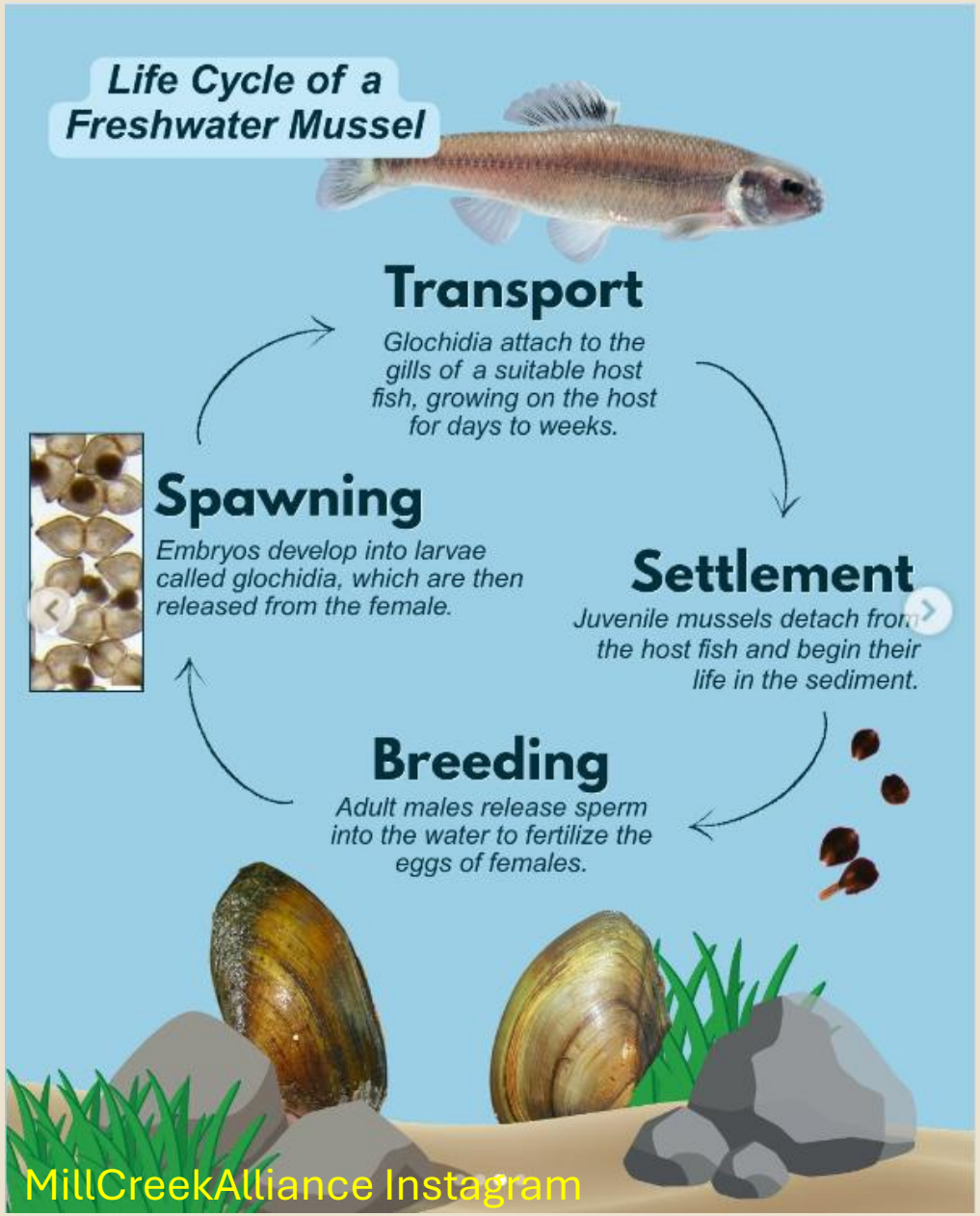
Example coverage of >12.2M ray-fined fish GBIF records for USA

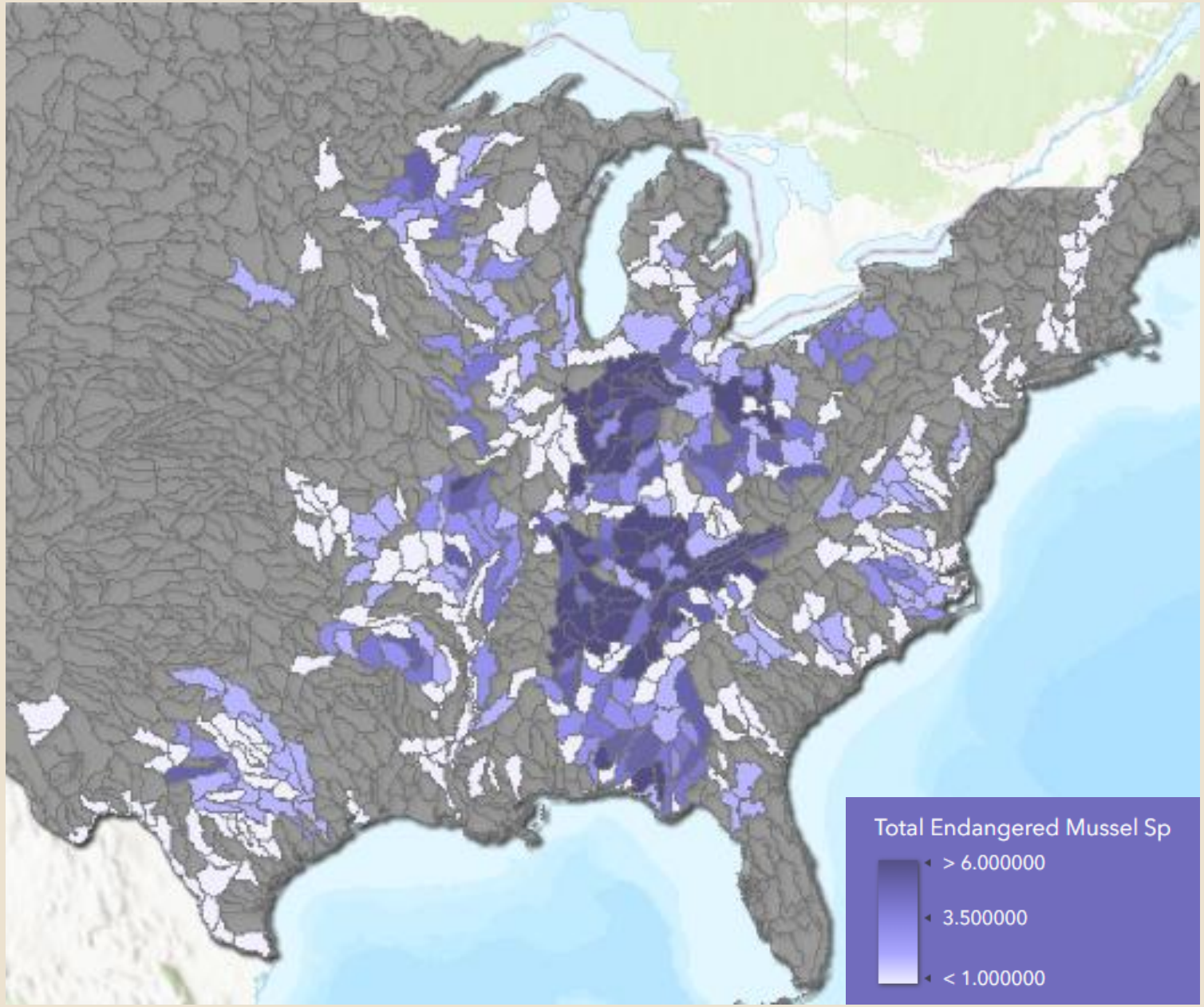


US Forest Service data on number of native fishes



Fish hosts are critical to most freshwater mussel species





Mission Reach

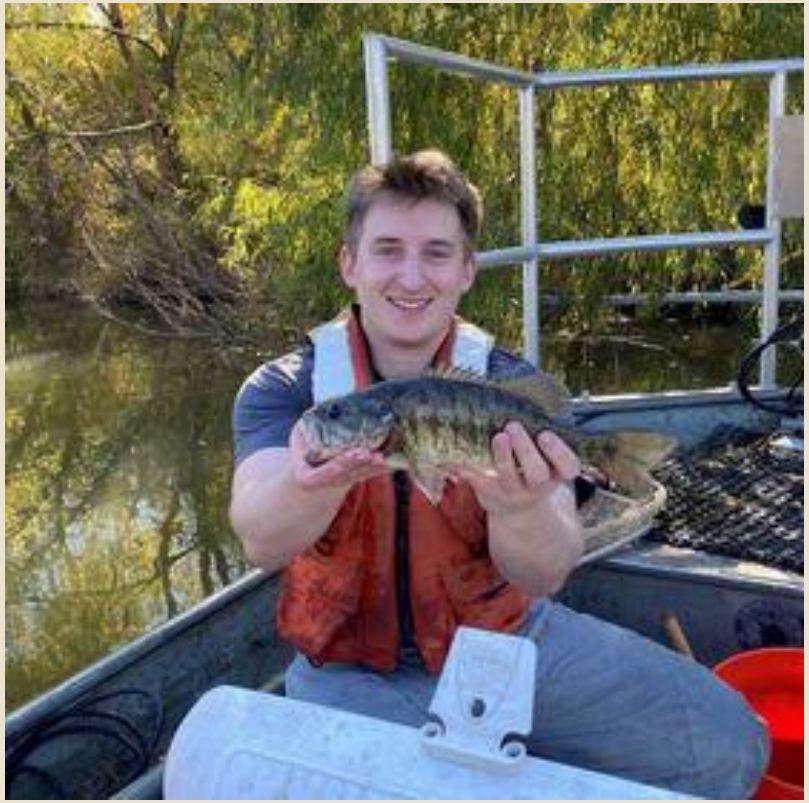
STATE/TERRITORY: Texas

The San Antonio River was historically modified to reduce flooding, leaving it devoid of its ecological function. The Mission Reach Ecosystem Restoration and Recreation Project aimed to reduce flooding, restore the riverine ecosystem, and provide recreational opportunities to a 13-kilometer stretch of the river. This project was funded by a $384.1 million investment by CoSA, Bexar County, the River Authority, the San Antonio River Foundation, and the U.S. Army Corps of Engineers (USACE). The project area can contain a 100-year flood event, supports an abundance of wildlife and native vegetation, and has served over 5 million visitors since its opening.

San Antonio River Authority and U.S. Fish and Wildlife Service Make History with First-Ever Freshwater Mussel Reintroduction in Texas

Case Study 1: San Antonio River

Fish passage occurs under baseflow conditions in a restored but serially fragmented ecosystem



Jacob P. Barrett[1], Thomas Dodson[1], Megan DiNicola[2], Belize Lane[2], Mitchell R. Magruder[3], Austin M. Davis[3], David L. Smith[4], and Joshuah S. Perkin[1]

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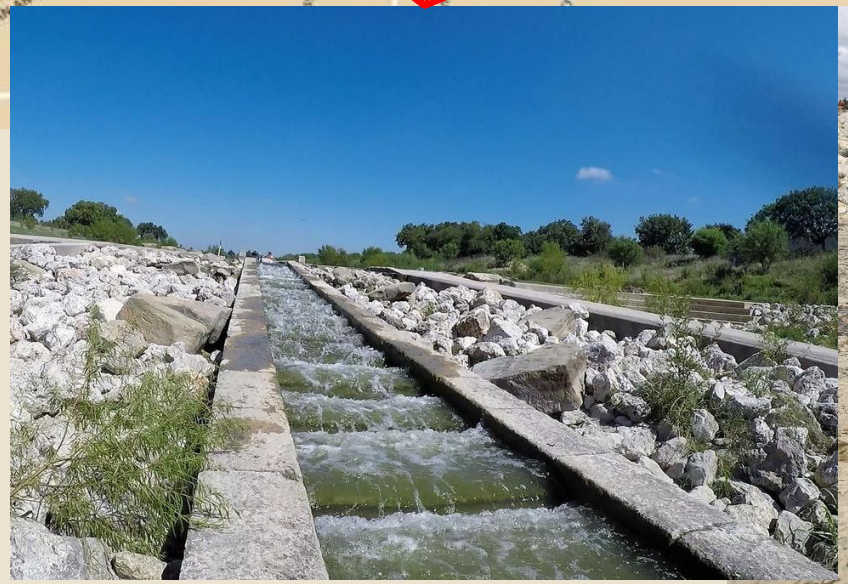
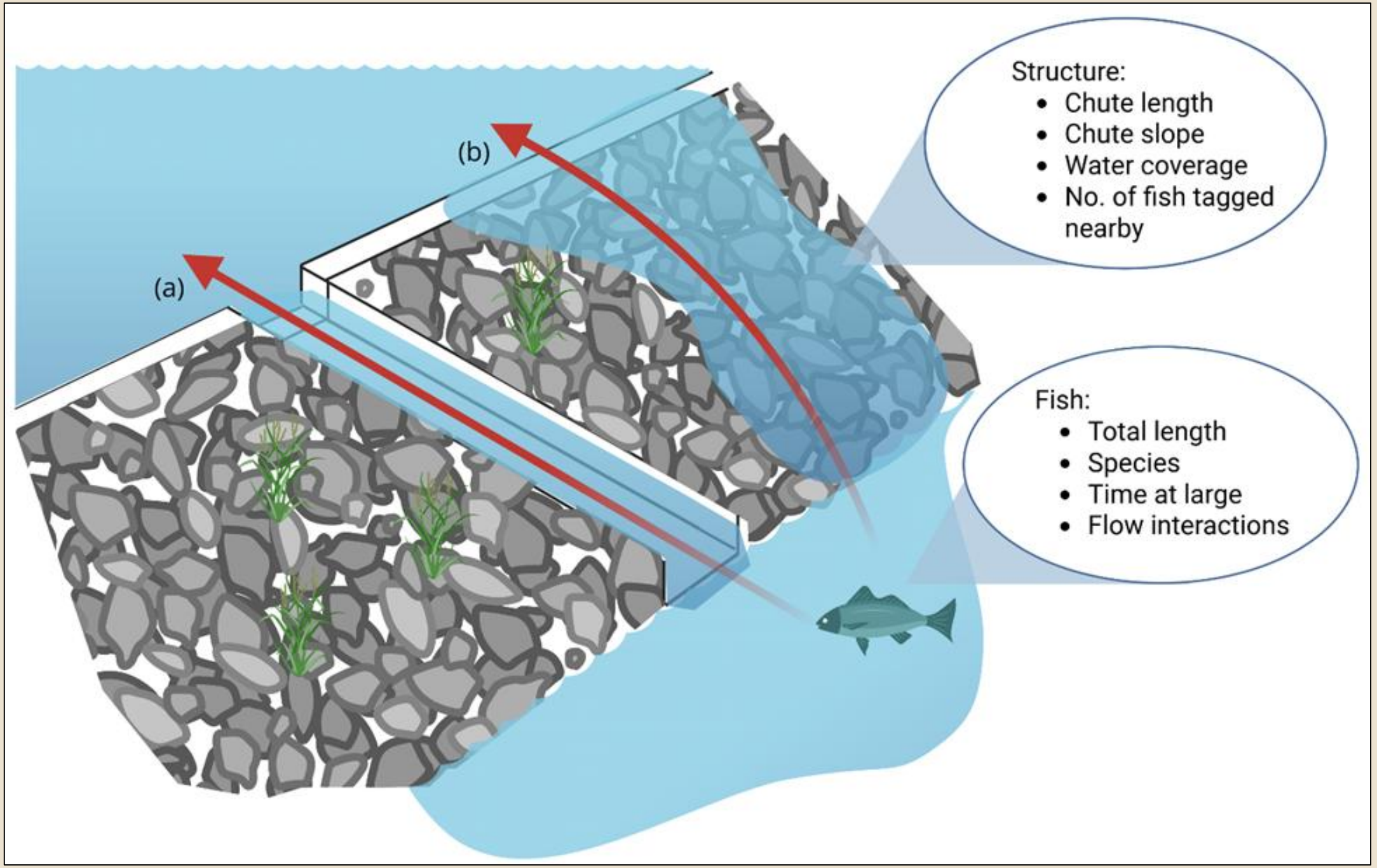
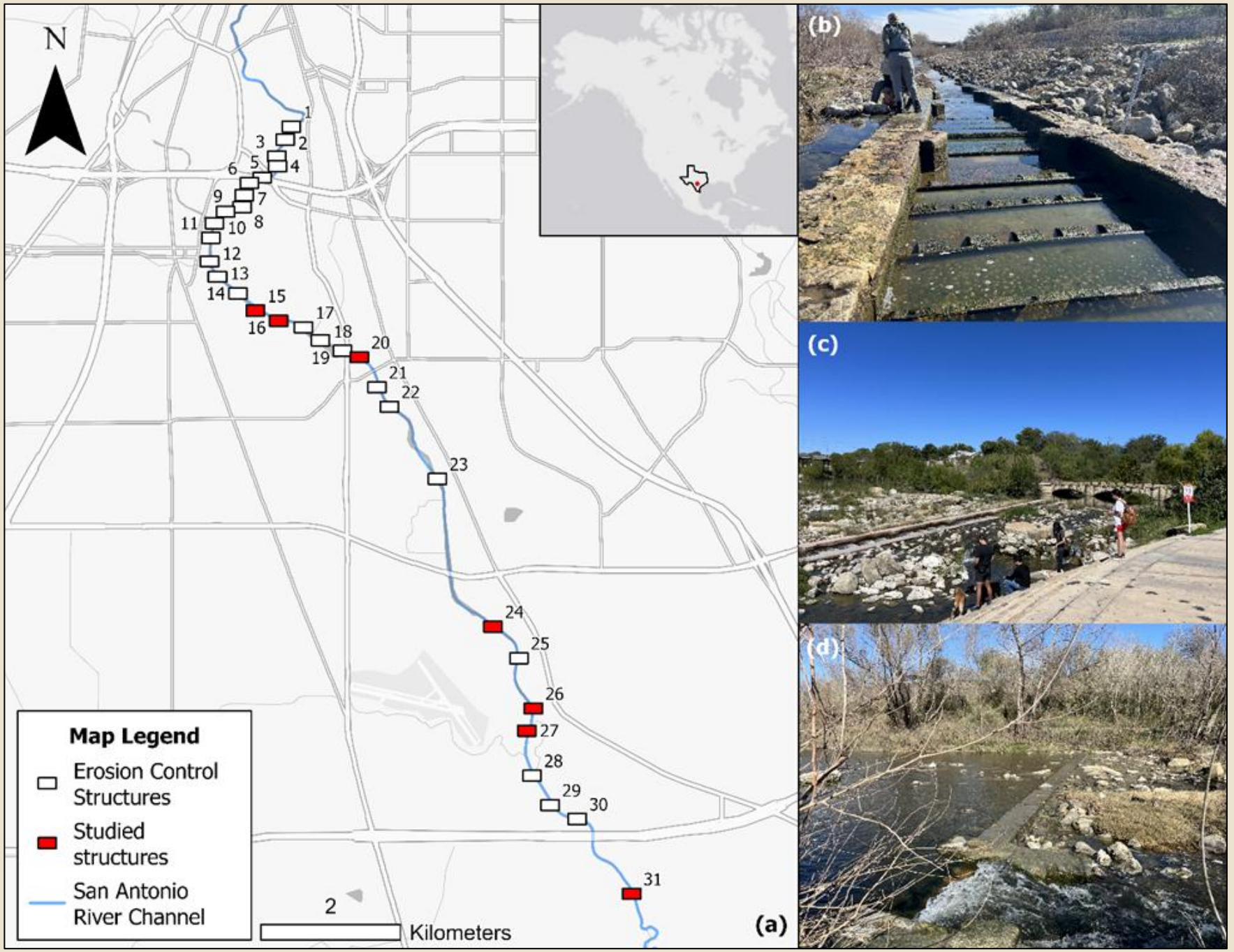
Does improve navigation for humans benefit fishes?



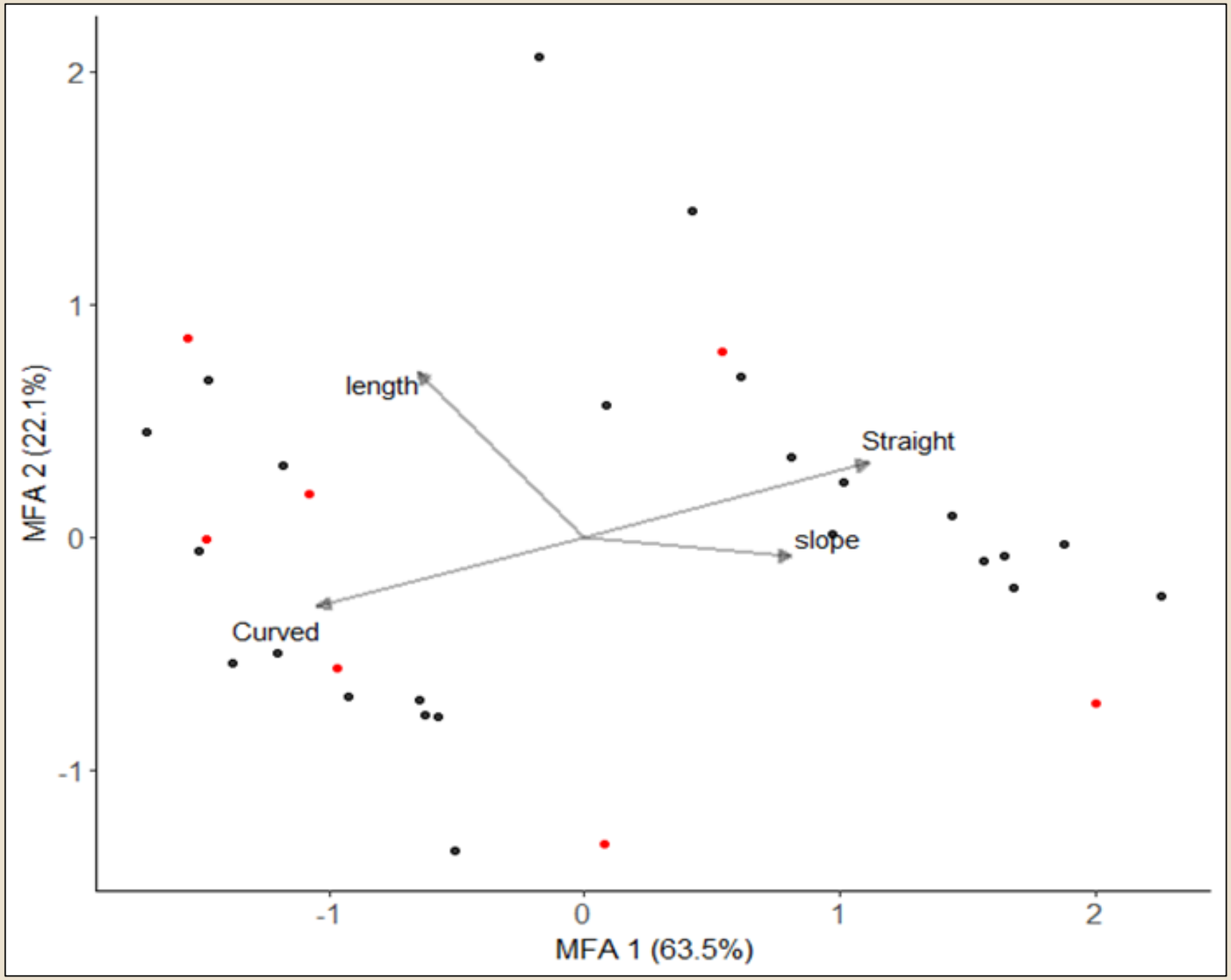

(b)
(a)
Structure:
Chute length
Chute slope
Water coverage
No. of fish tagged nearby
Fish:
Total length
Species
Time at large
Flow interactions

31 structures occur along the Mission Reach and we focused on 7

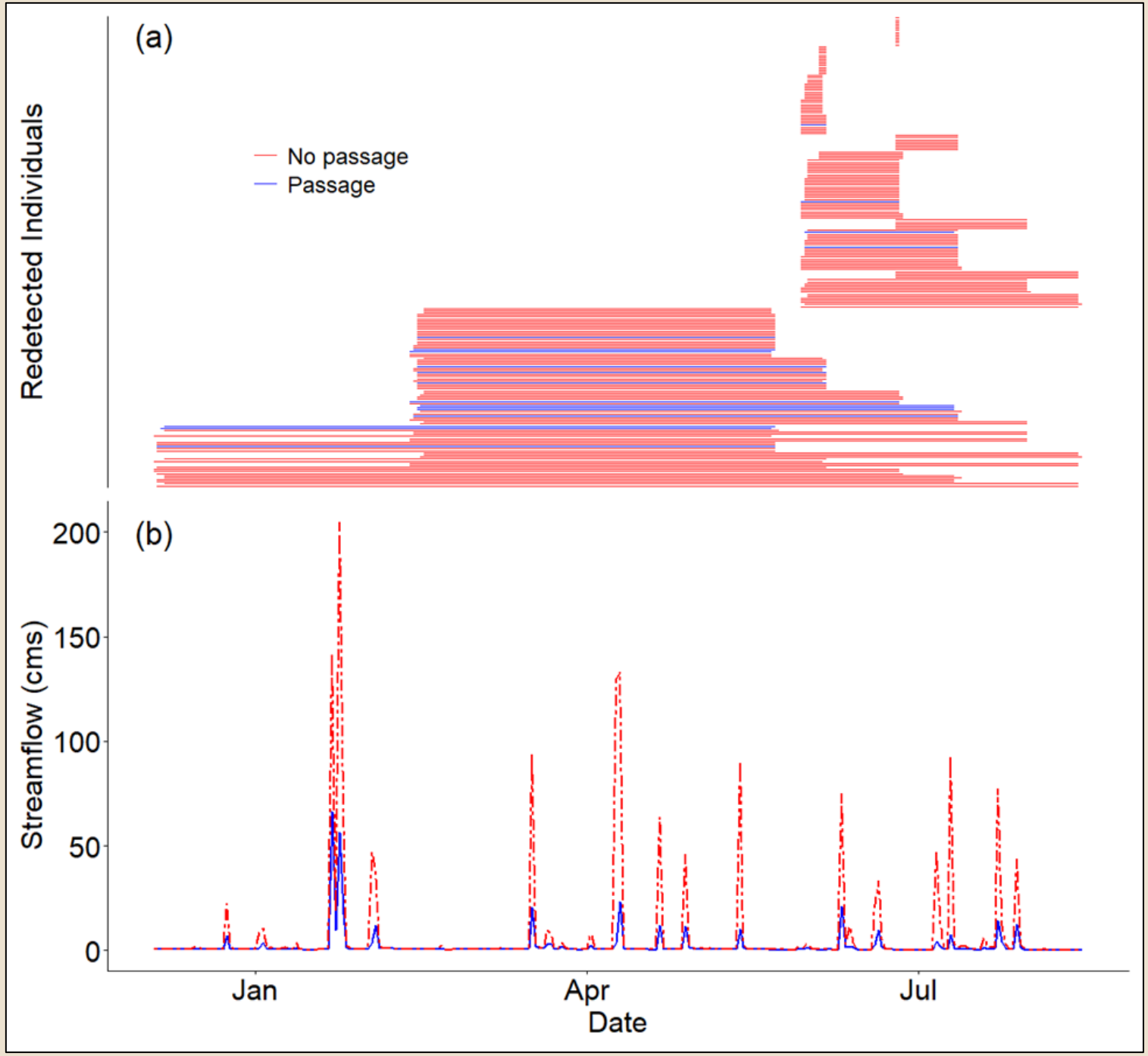


31 structures occur along the Mission Reach and we focused on 7

These 7 were representative of the larger set of structures

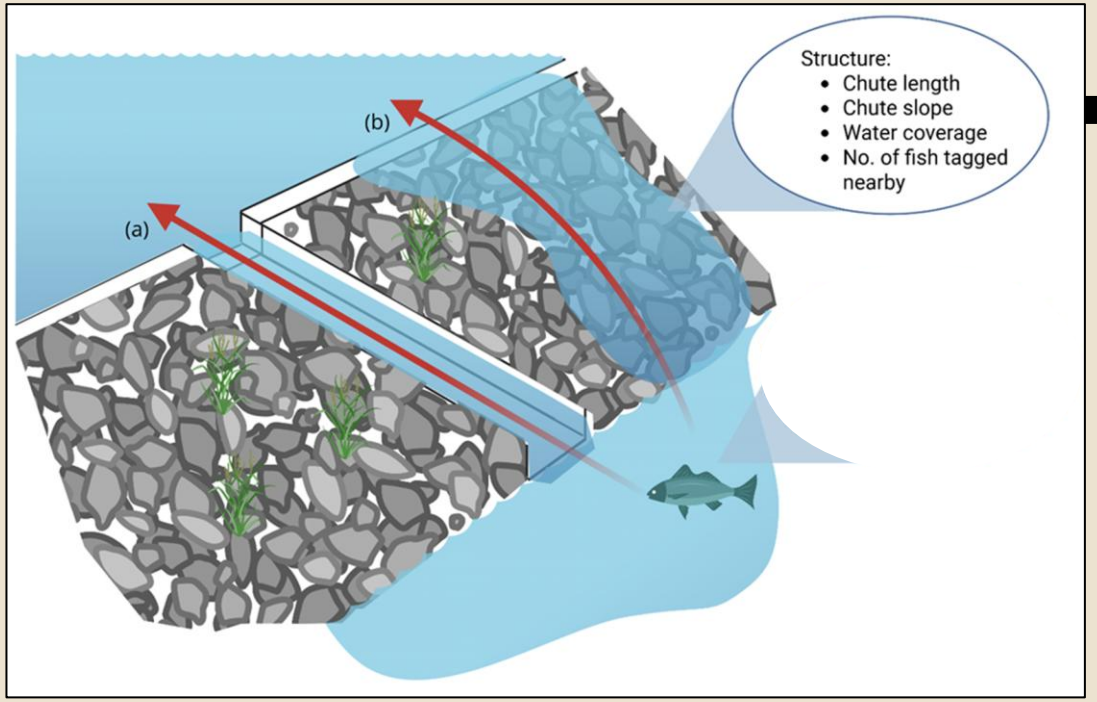


- We used mark-recapture to track fish movements
- December 2023 through August 2024
- Tagged 1,124 fish
- Recaptured 228
- 20 passed a structure

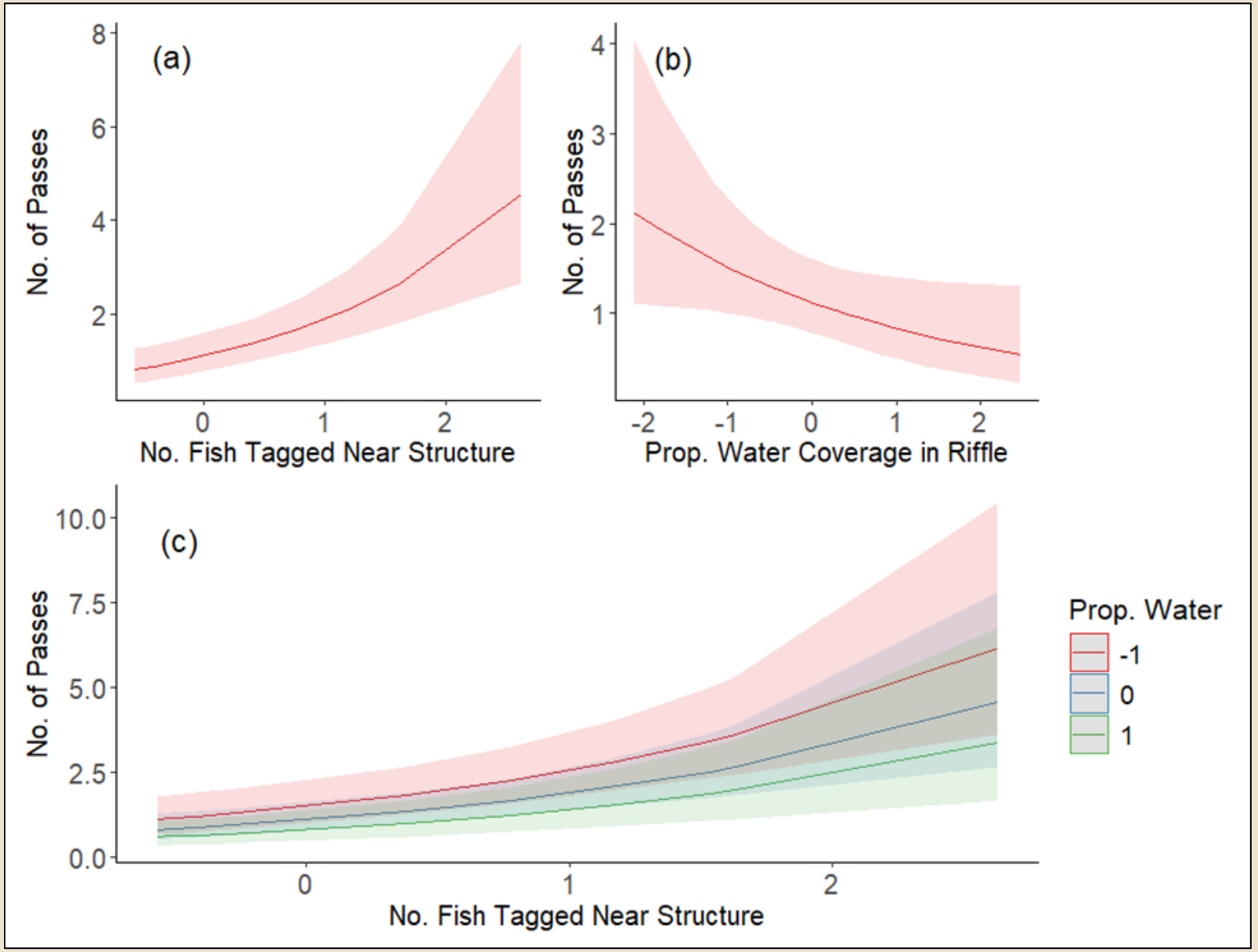


We developed two models for predicting fish passage:

Count of passes~ length + slope + water coverage + fish tagged



- More fish passed when nearby fish density was higher
- More fish passed when water was concentrated in the chute



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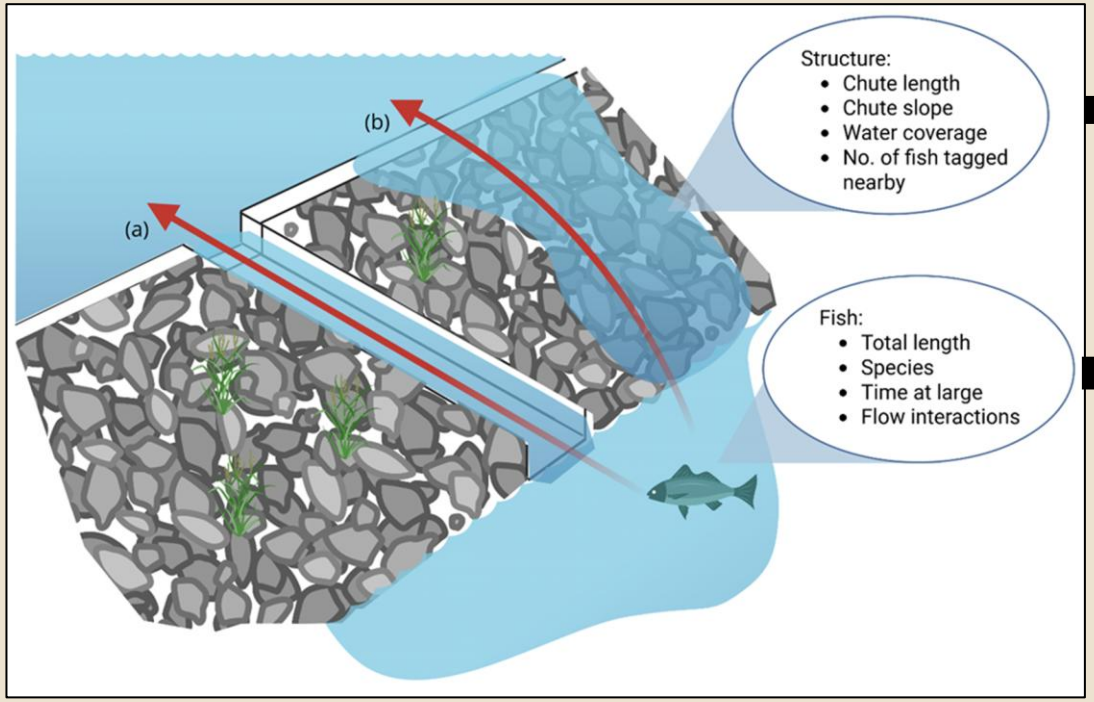
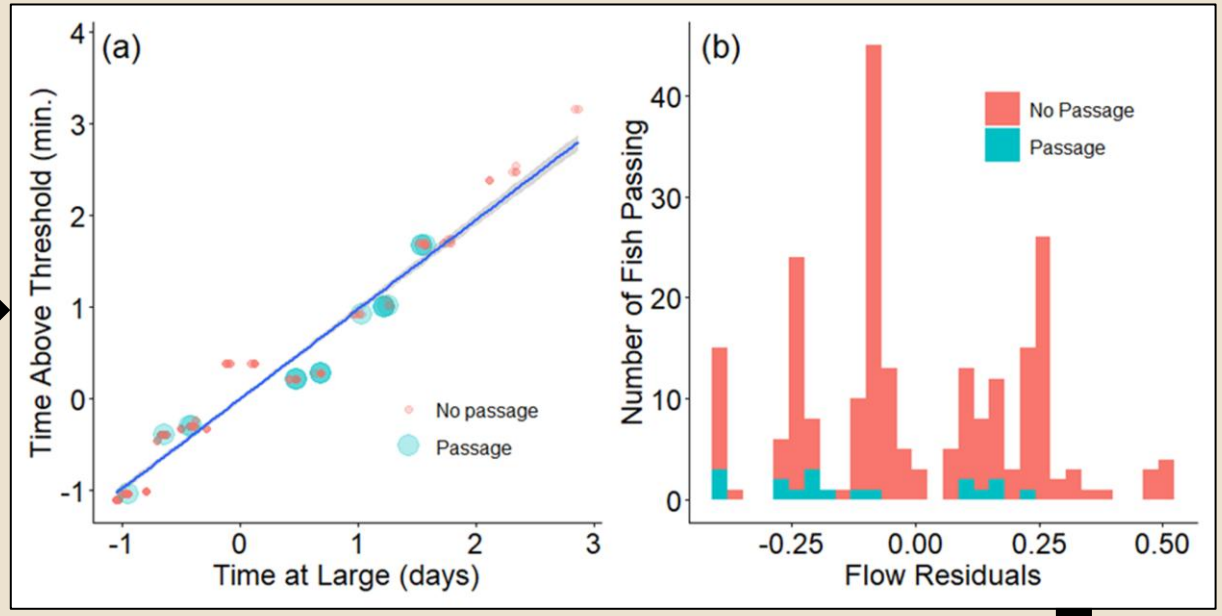
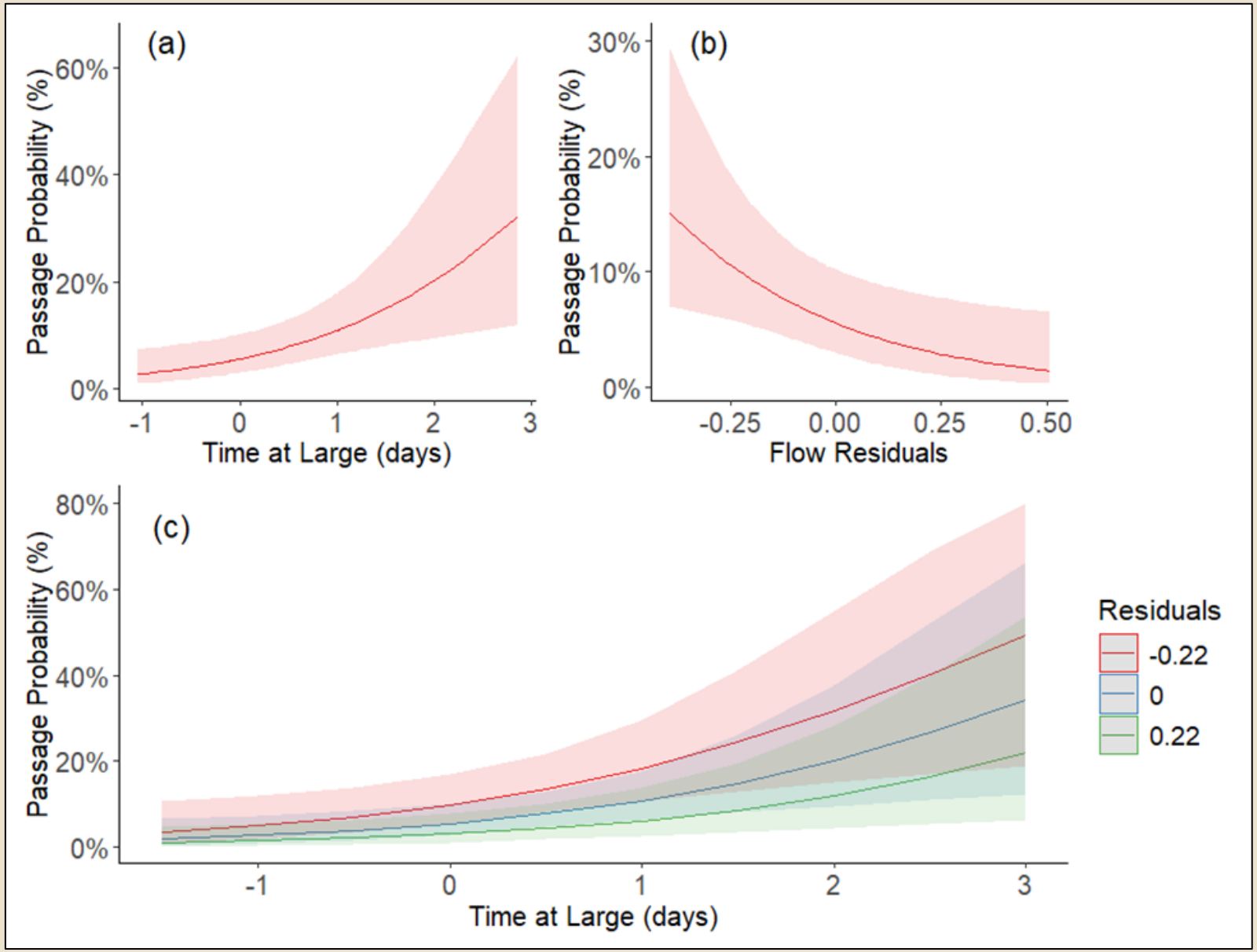




Probability of passage ~ total length + species + time at large+ flow residuals

- Passage was more likely when fish were at larger for longer
- Passage was more likely when fish experienced lower flows for longer



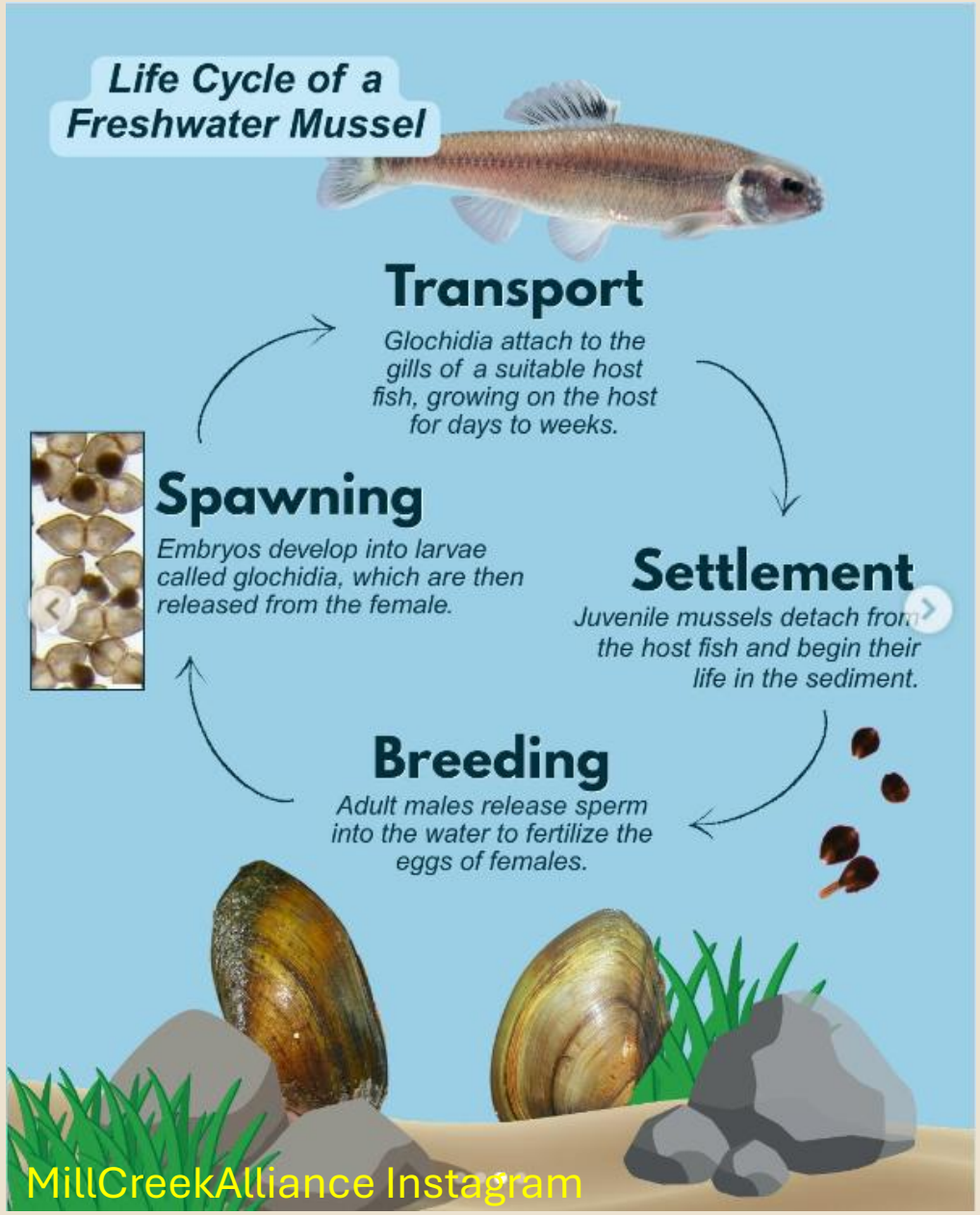
Mission Reach Movement Conclusions

1. Structures associated with canoe chutes allow fish passage

2. The greatest number of fish passed structures that had their water concentrated in the chute and when lager numbers of fish were nearby

3. Fish were most likely to pass when they were in the river for longer and when they experienced relatively low flows

4. Chutes might be operating as attractants to fish with motivation to move

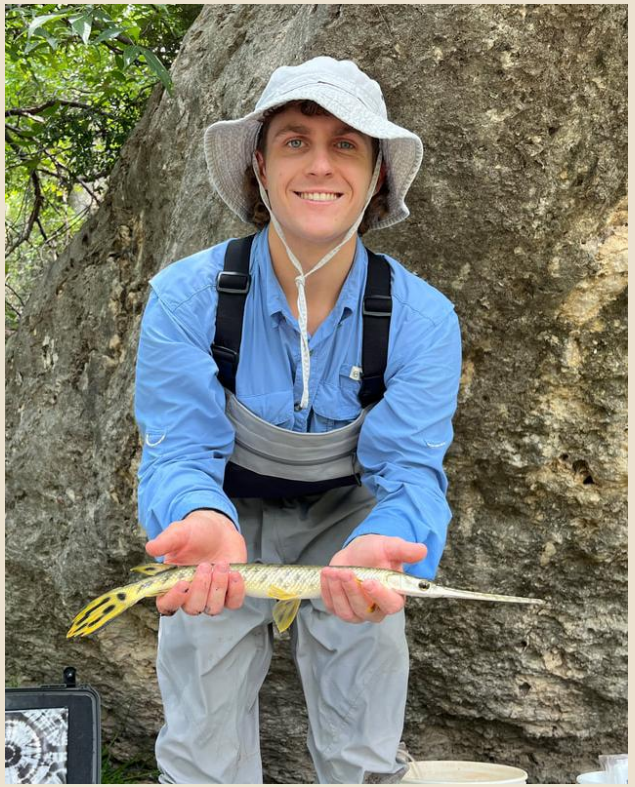


Fish overlap with mussels in both space and time occurs below the surface of water and is challenging to observe

More information is needed regarding how often fish move to mussel patches and how long fish spend there

Case Study 2: San Saba River

Stream fish movement in relation to mussel density and local environmental conditions



Calvin J. Young[1], Thomas A. Dodson[1], Jacob P. Barrett[1], Justin Greenfield[2], Astrid N. Schwalb[2], Todd M. Swannack[2,3], David Smith[3], Kirk O. Winemiller[1], and Joshuah S. Perkin[1]

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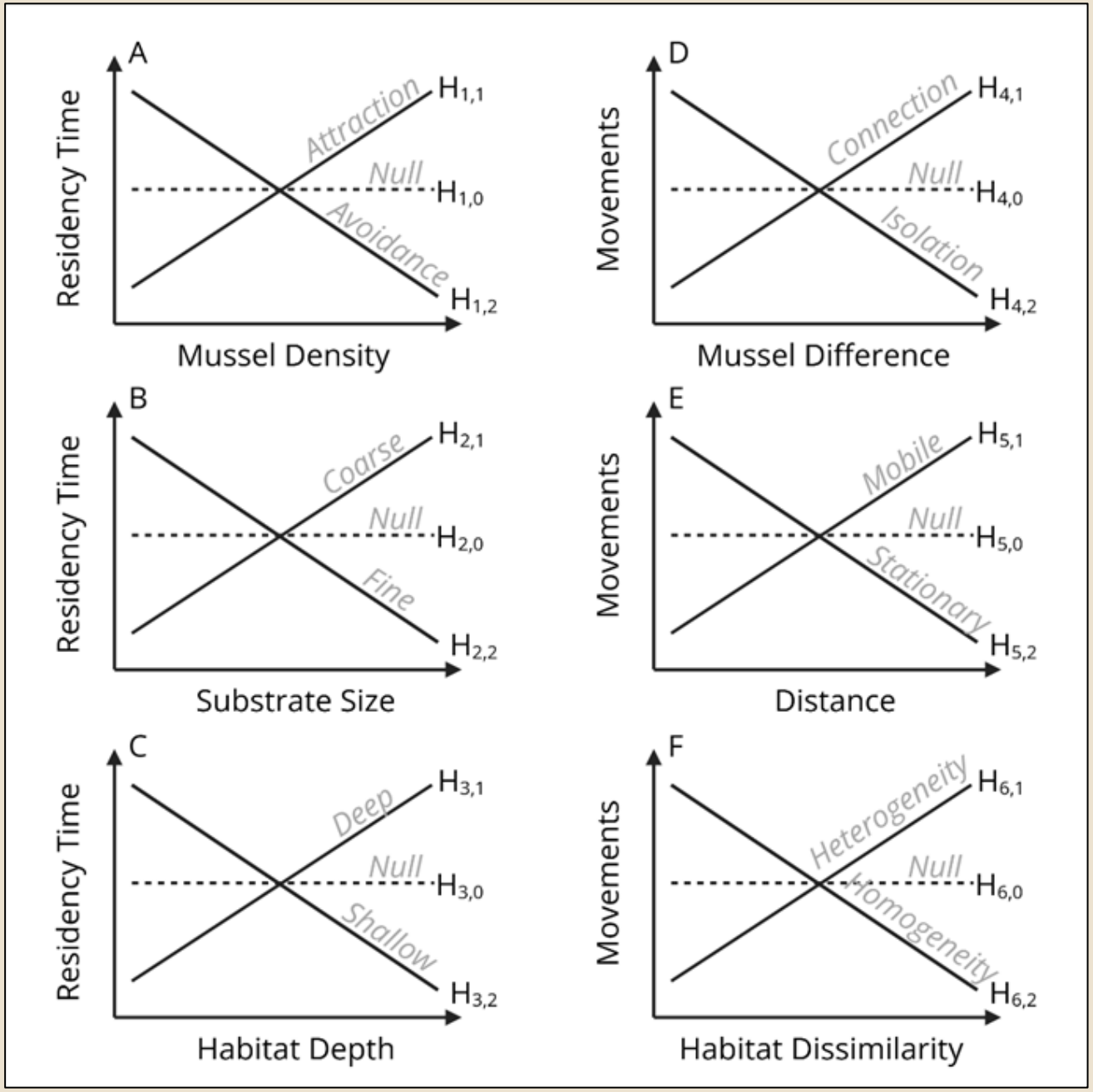
Fishes might spend time:

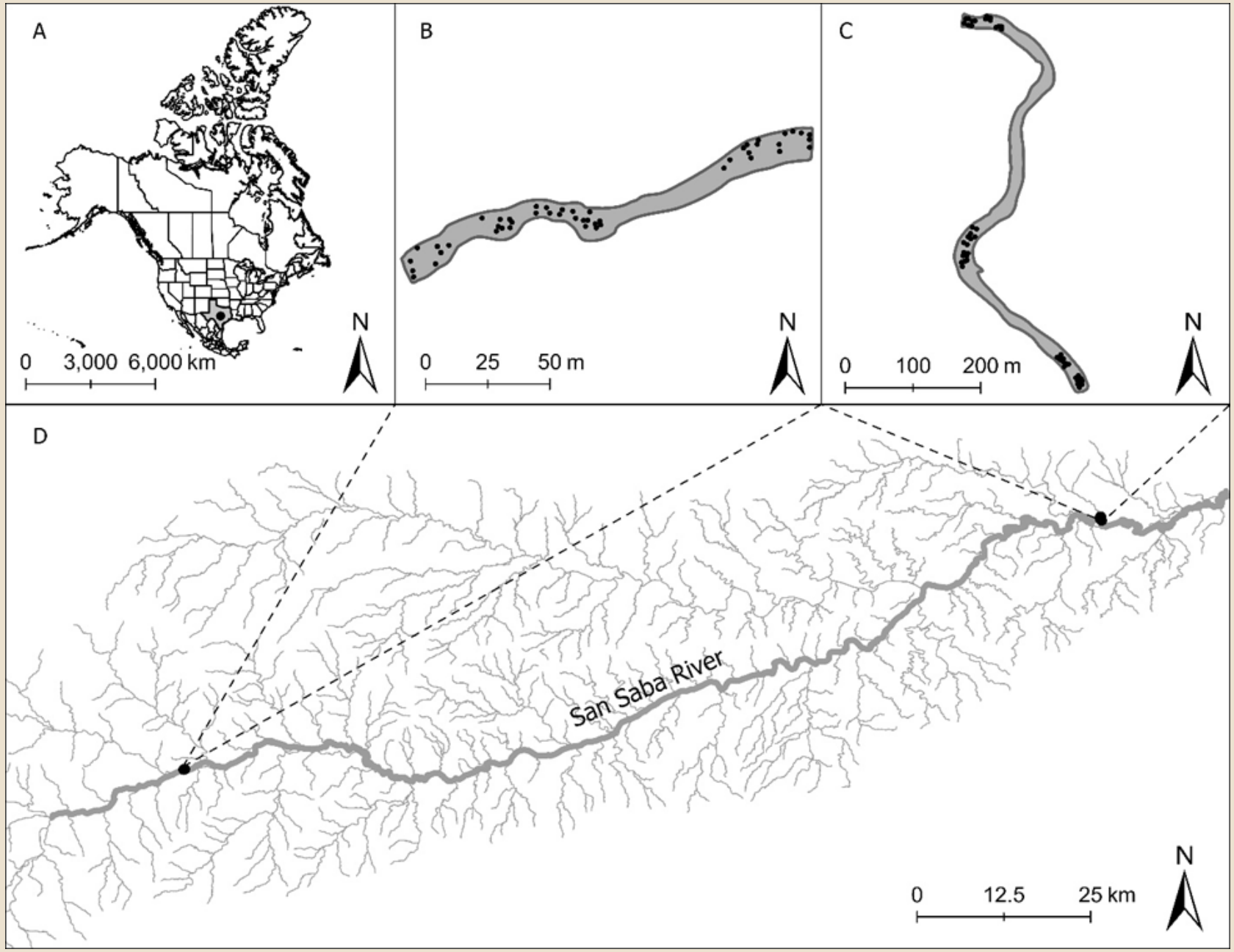
1. Near or away from mussels
2. Over course or fine substrates
3. In deep or shallow water

Fish might move to:

1. Connect or isolate mussels
2. Be stationary or mobile
3. Similar or unique habitats



- We studied fish movement in two reaches of the San Saba River



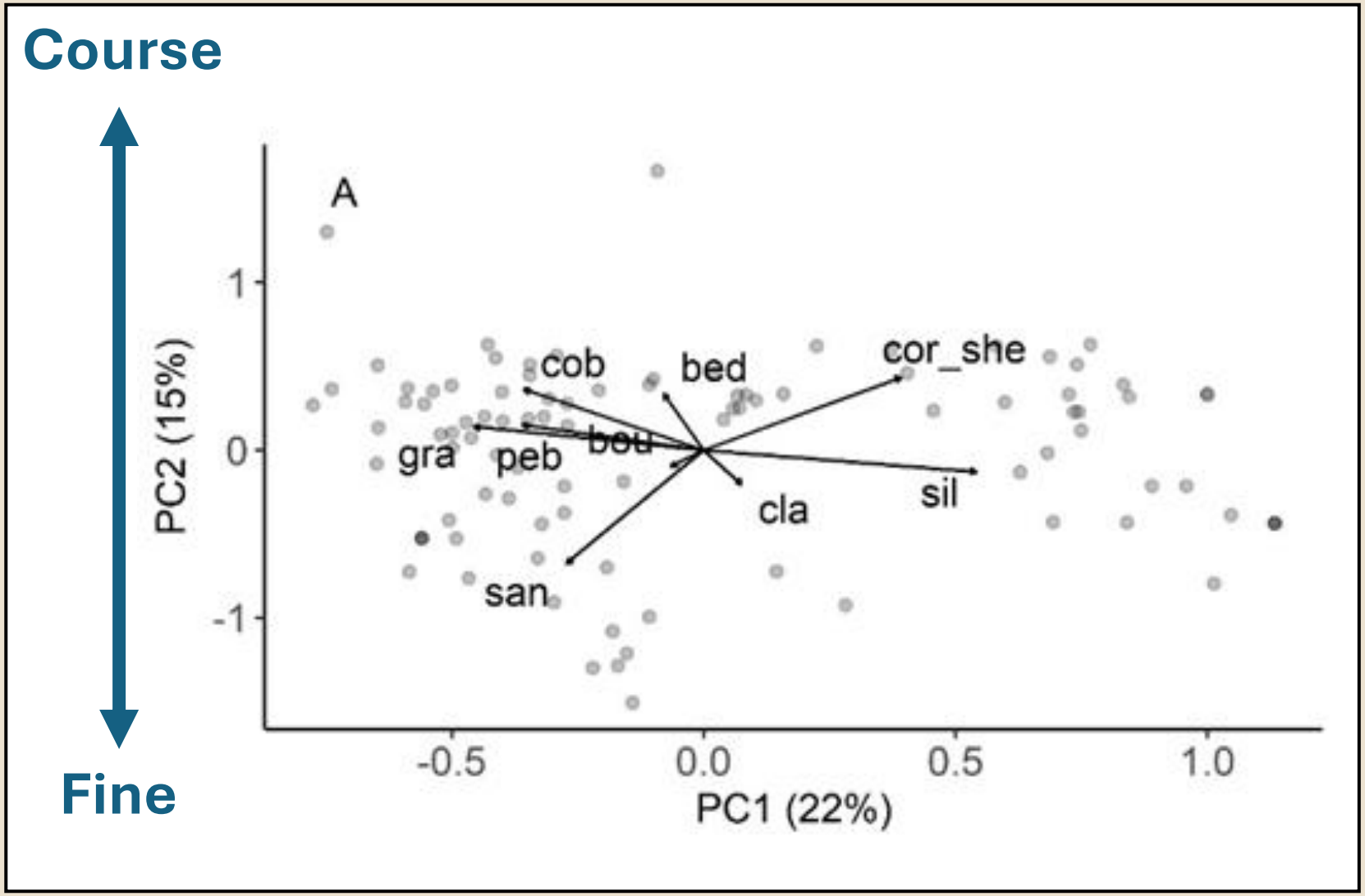
- We studied fish movement in two reaches of the San Saba River

- Each reach had different habitat gradients

- We studied fish movement in two reaches of the San Saba River
- Each reach had different habitat gradients
- We deployed small antennas in 96 habitats

Across antenna locations we characterize:

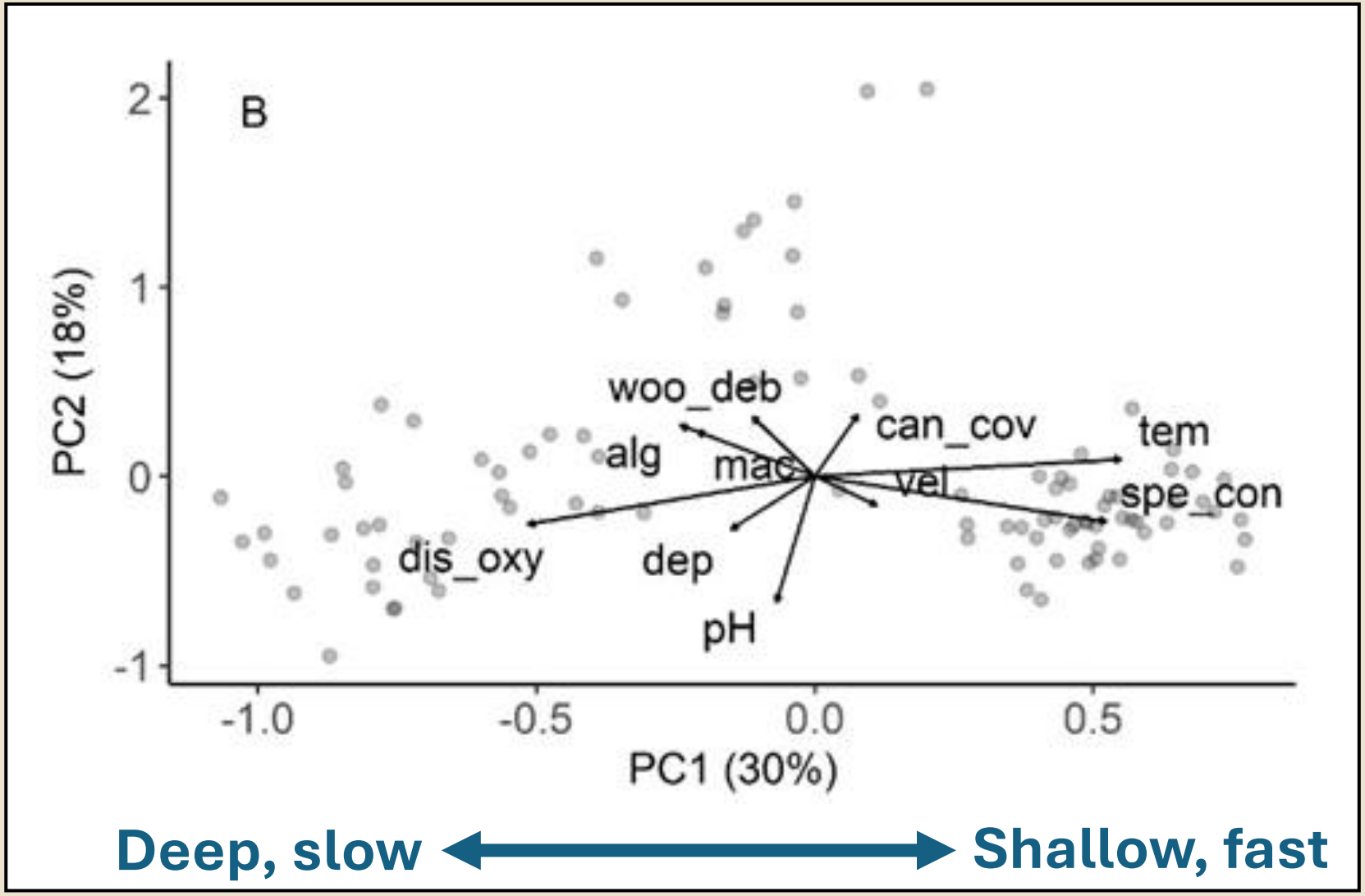
1. Substrate gradients



Across antenna locations we characterize:

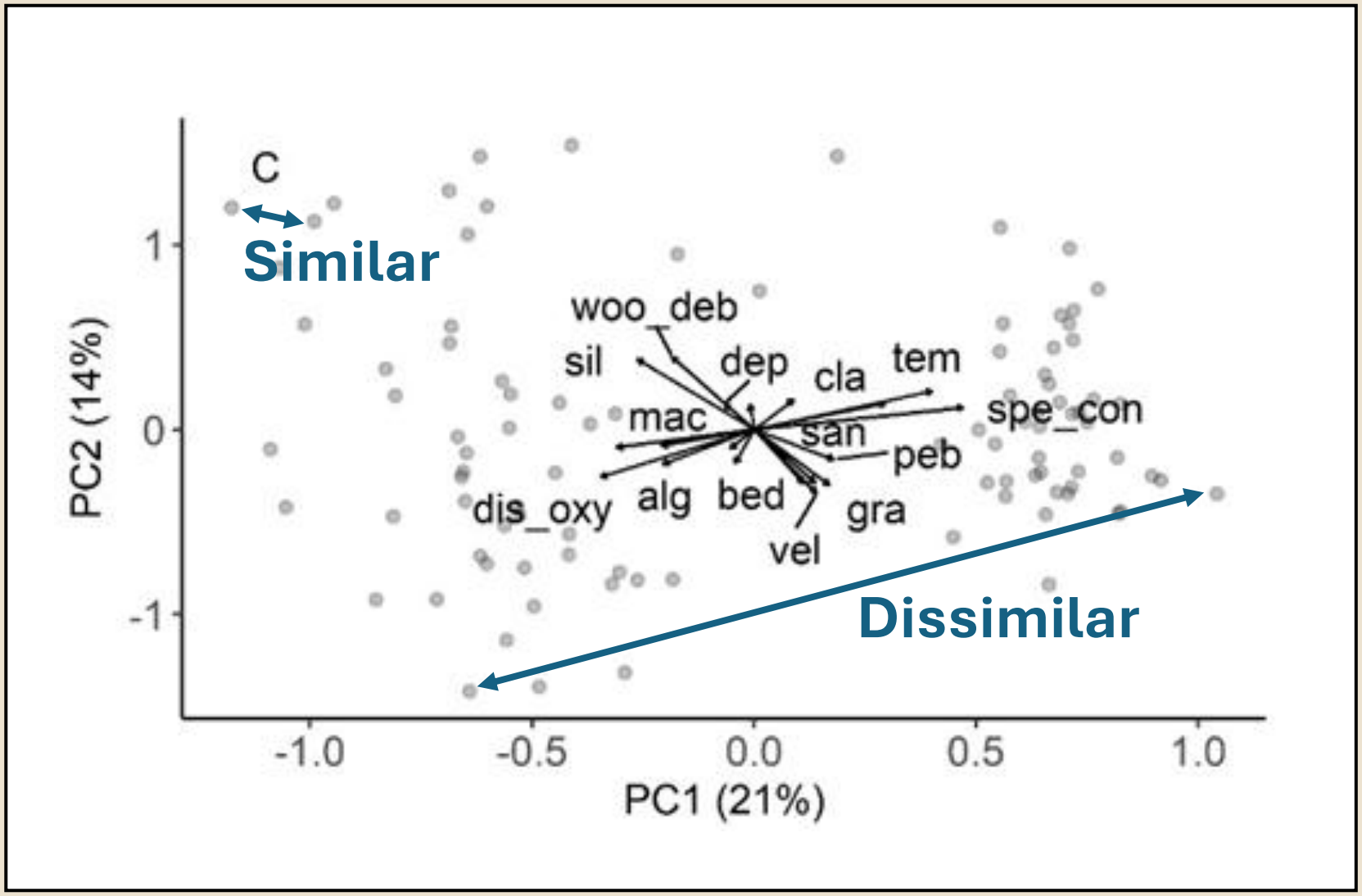
1. Substrate gradients

2. Physiochemical gradients

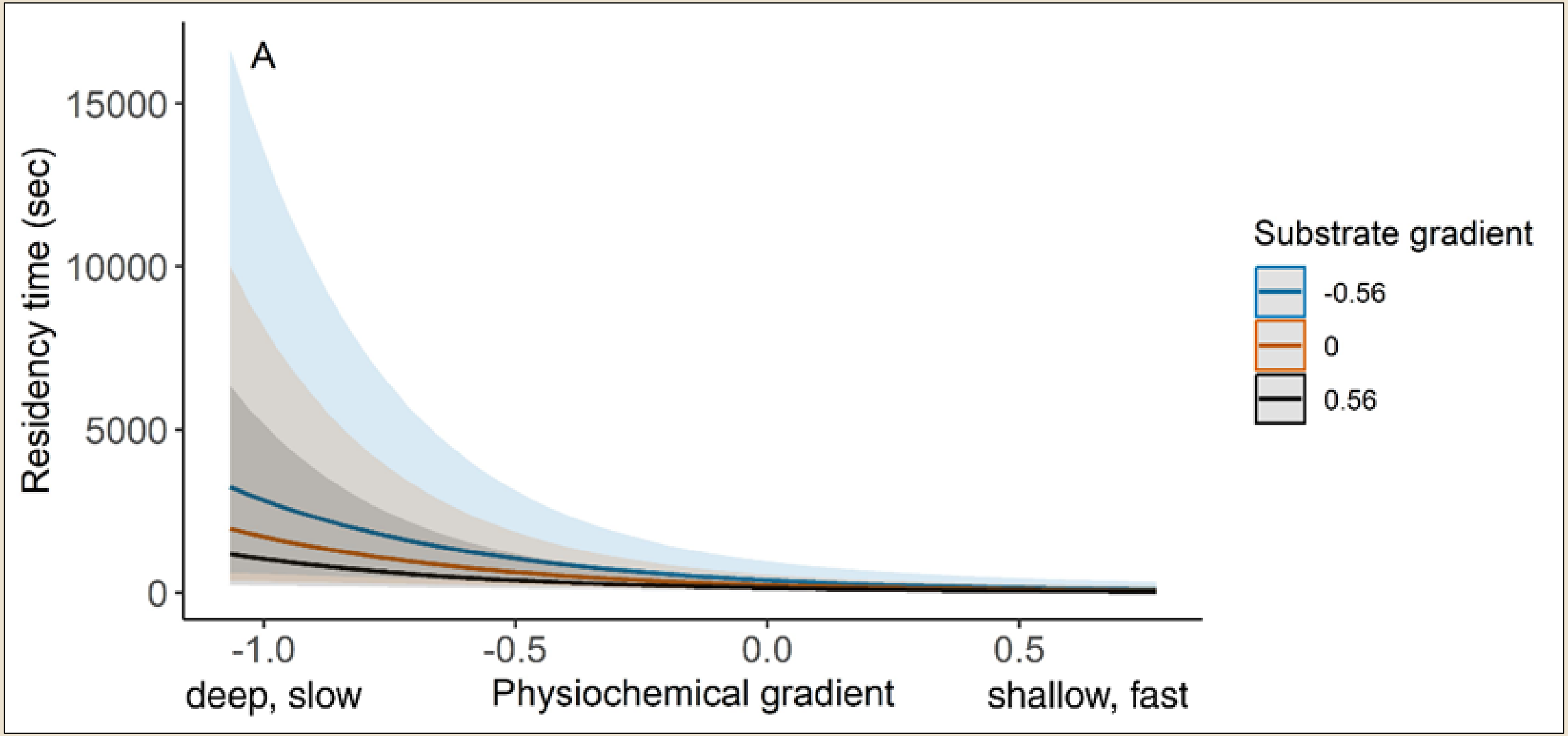


Across antenna locations we characterize:

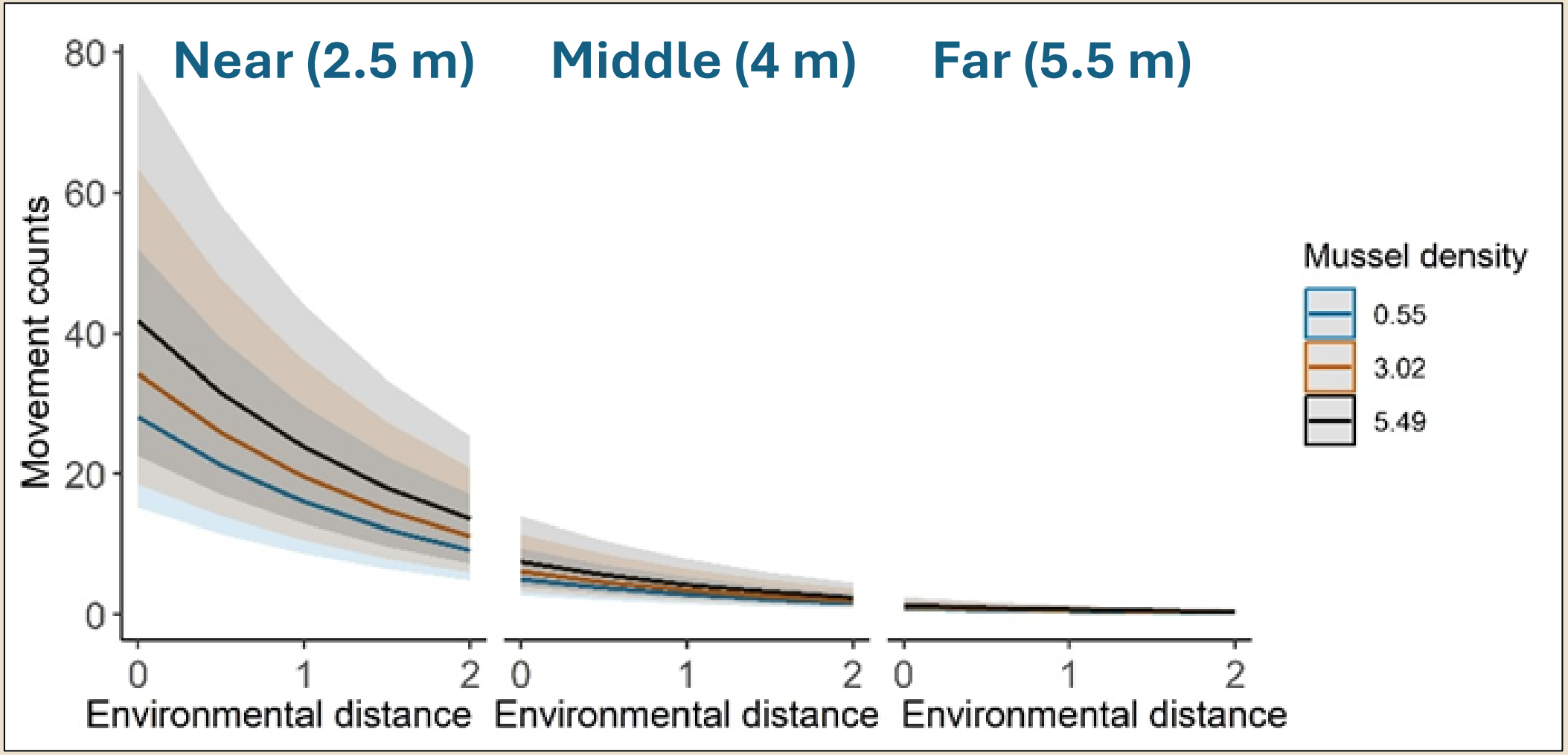
1. Substrate gradients
2. Physiochemical gradients
3. Total environmental dissimilarity among antenna locations



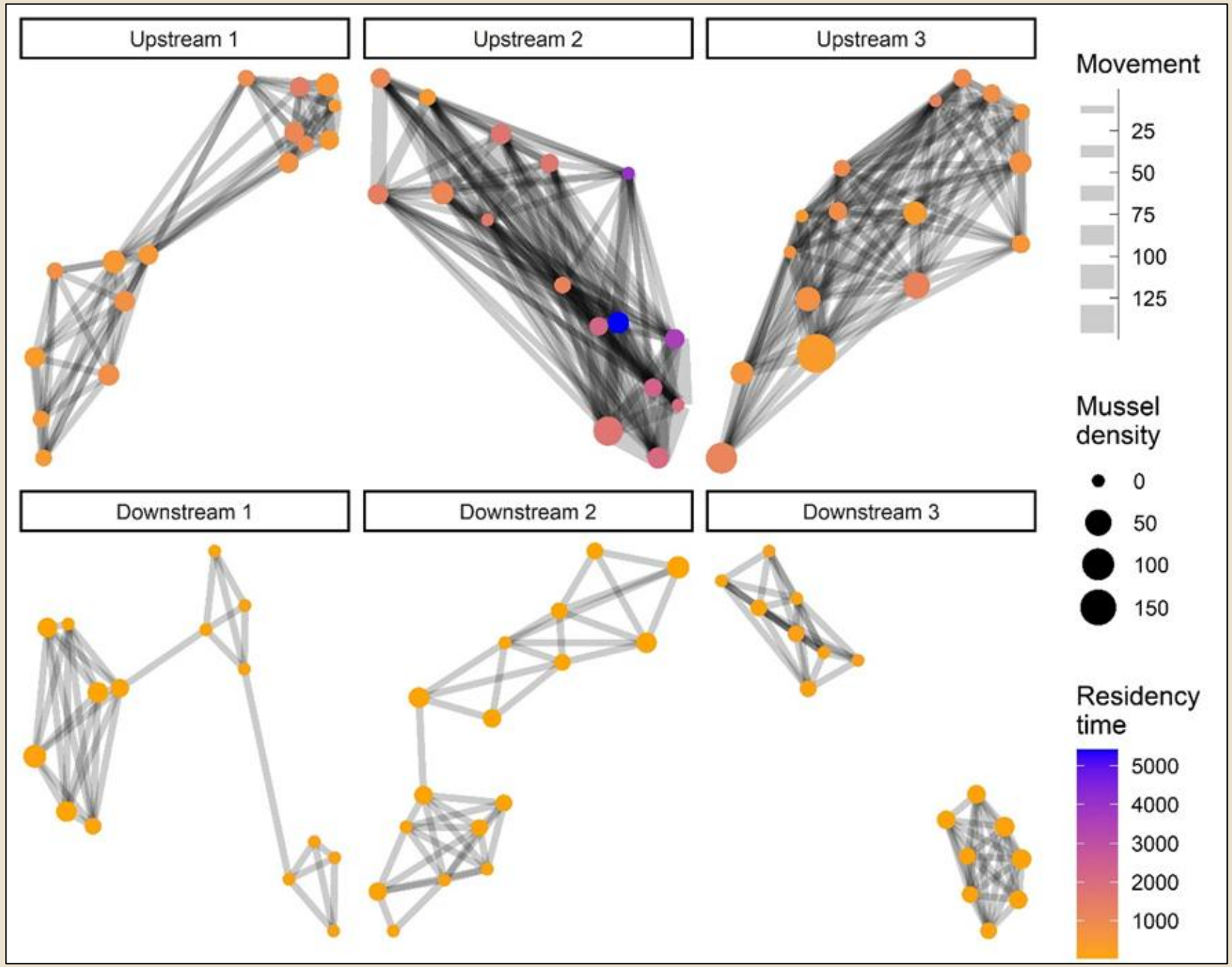
Fish spent the most time in pools (deep, slow, fine substrate)



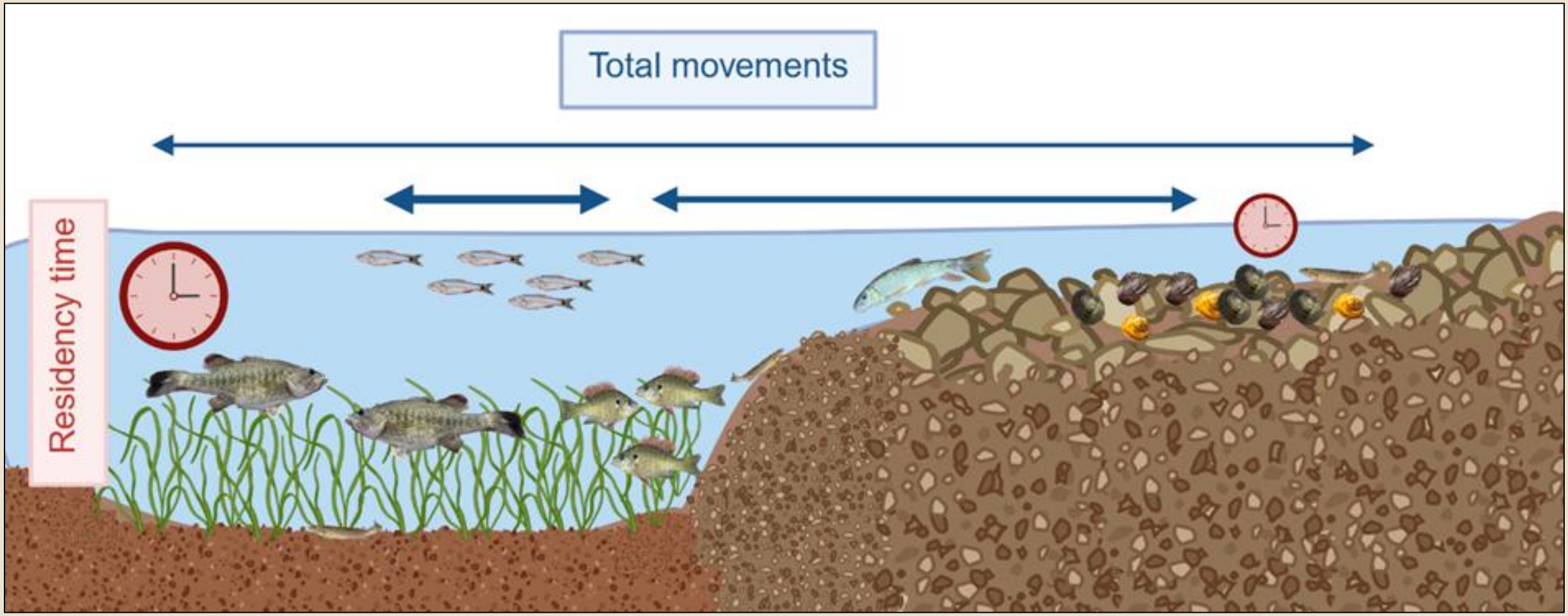
Fish moved most between nearby and similar habitats with differing mussel densities



Fish-based connections of habitats were strongest at the upstream site, particularly where mussel densities differed the most

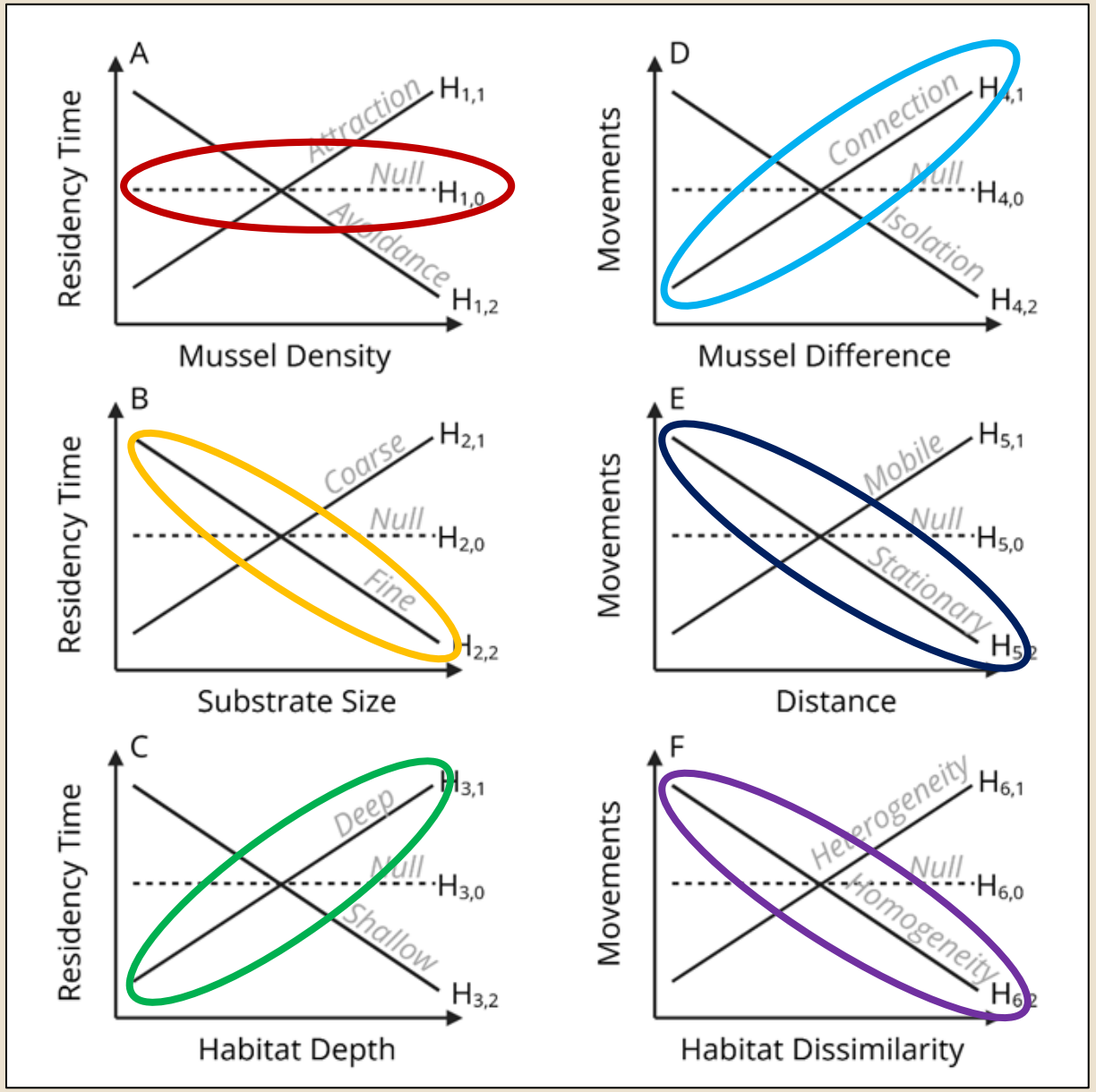


Conceptually, fishes remain in pools for longer where deeper water and structure provide refuge, then temporarily move to nearby riffles where mussel densities are higher



San Saba Movement Conclusions:

1) Fish residency time was unrelated to mussel density
2) Fishes resided longer over fine substrates
3) Fish spent more time in deeper habitat
4) Fishes connected mussel patches
5) Fishes were largely stationary
6) Fish used the same habitats consistently



How can this information advance Army Corps projects?

1. Improved decision making for structure design in restoration projects
   - Upcoming Westside Creeks Restoration near the Mission Reach
   - Future restoration of urban rivers such as the Los Angeles River

2. Integration into ecological models to improve knowledge of fish passage
   - Ground-truthing of models fit using flume data from the Environmental Lab

3. Guidance for future restoration projects
   - Belize Lane and Meghan DiNicola have leveraged these data in a planning framework that considers tradeoffs between local mussel habitat suitability and fish-based recolonization potential across riverscapes

Acknowledgements

- Funding provided by US Army Corps of Engineers' Aquatic Nuisance Species Research Program's focus on Next Generation Ecological Modelling

- TRIAGE and Environmental Laboratory collaborators

- Dave Smith for serving on multiple student committees!

- Todd Swannack and Brook Herman for project administration

- Many student technicians and volunteers for assistance in the field