Dispersal of zebra mussels

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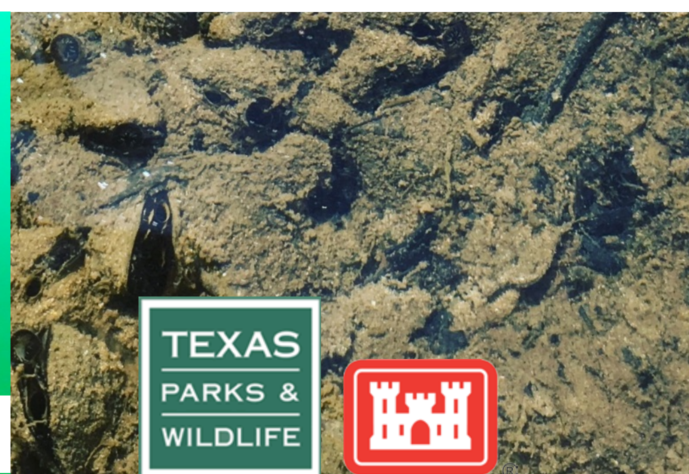
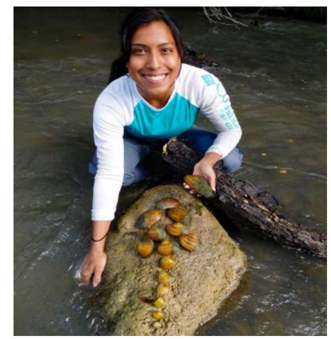


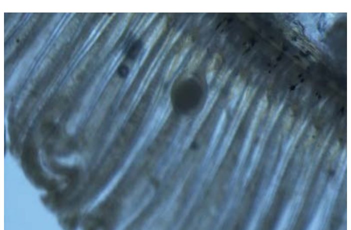
Josi Robertson

Schwalb Stream Ecology lab

Dispersal, ecology of zebra mussels

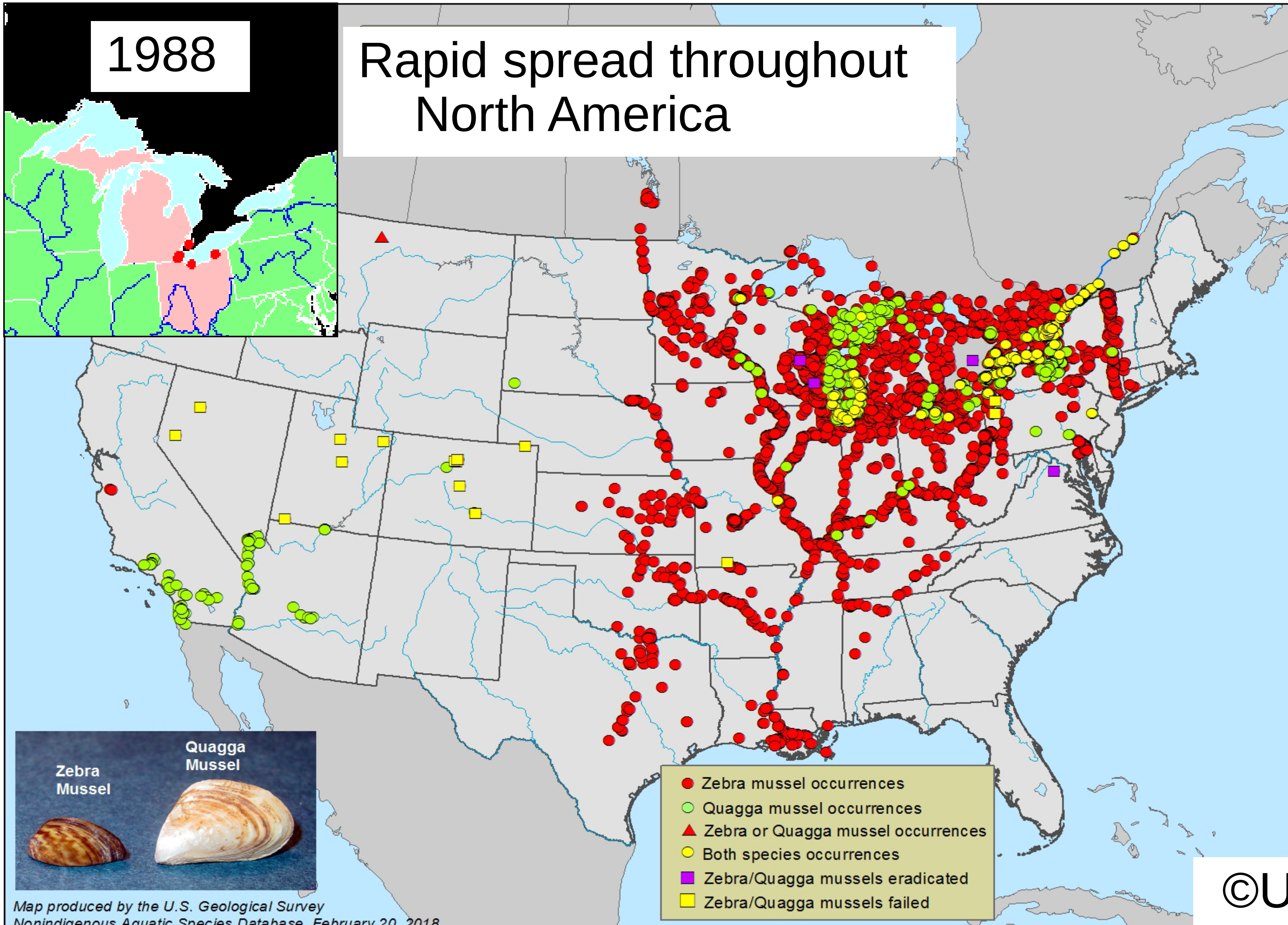
Unionid mussel distribution,
Reproductive ecology and behavior



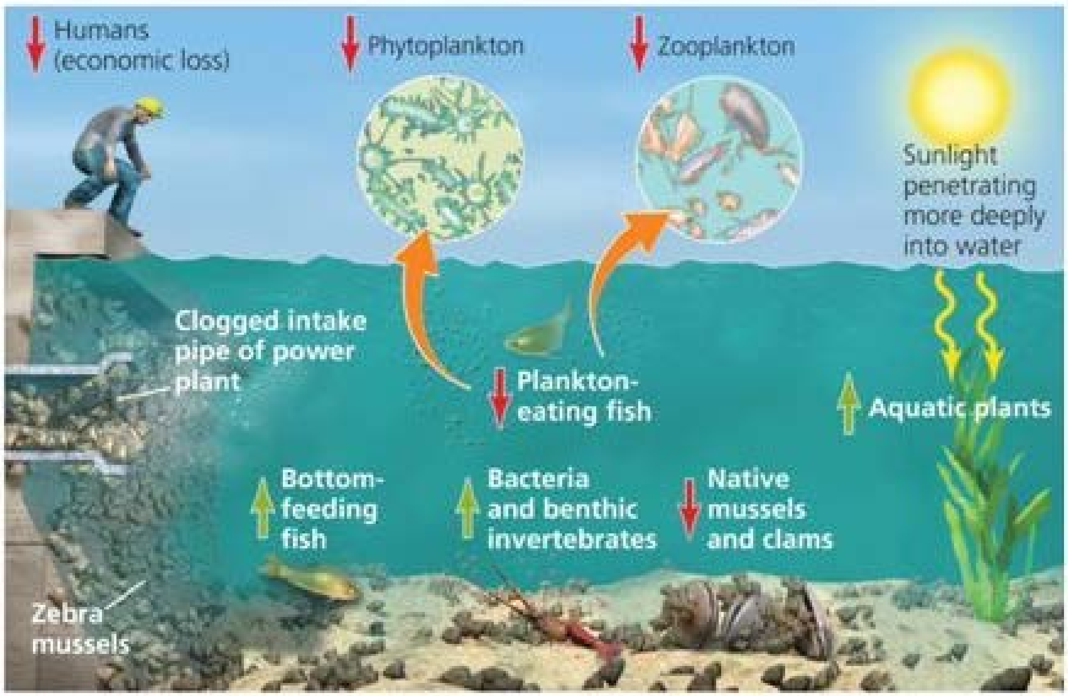


Collaborative projects:
Environmental contaminants
Genetics to assess status of unionid mussels

Invasion of dreissenid mussels



Impact of dreissenid mussels

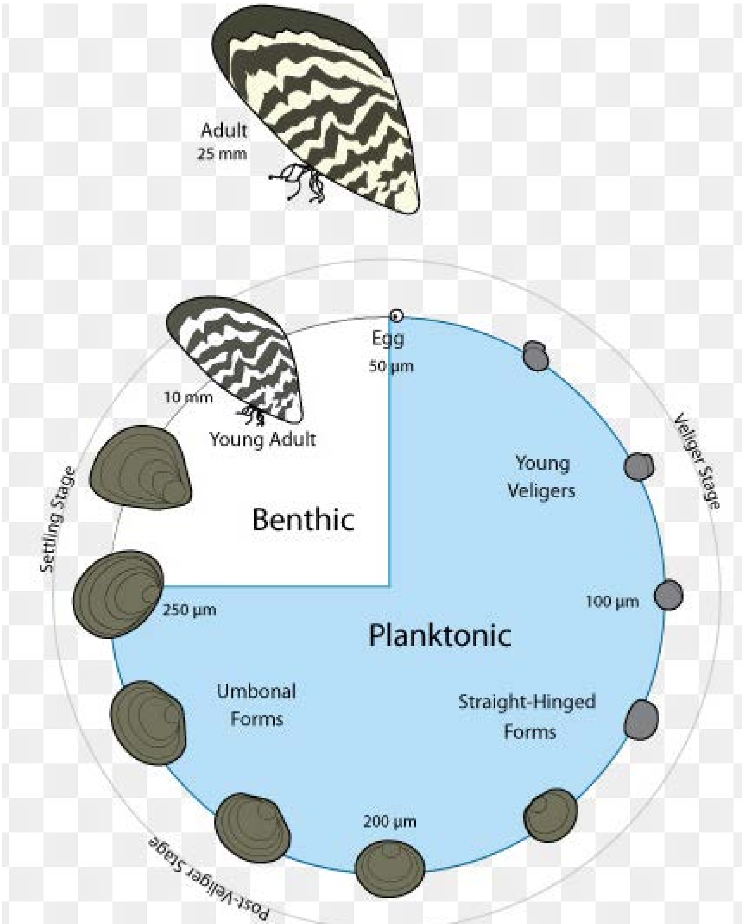


(a) Impacts of zebra mussels on members of a Great Lakes nearshore community

Ecosystem engineers

Benthification

Dispersal

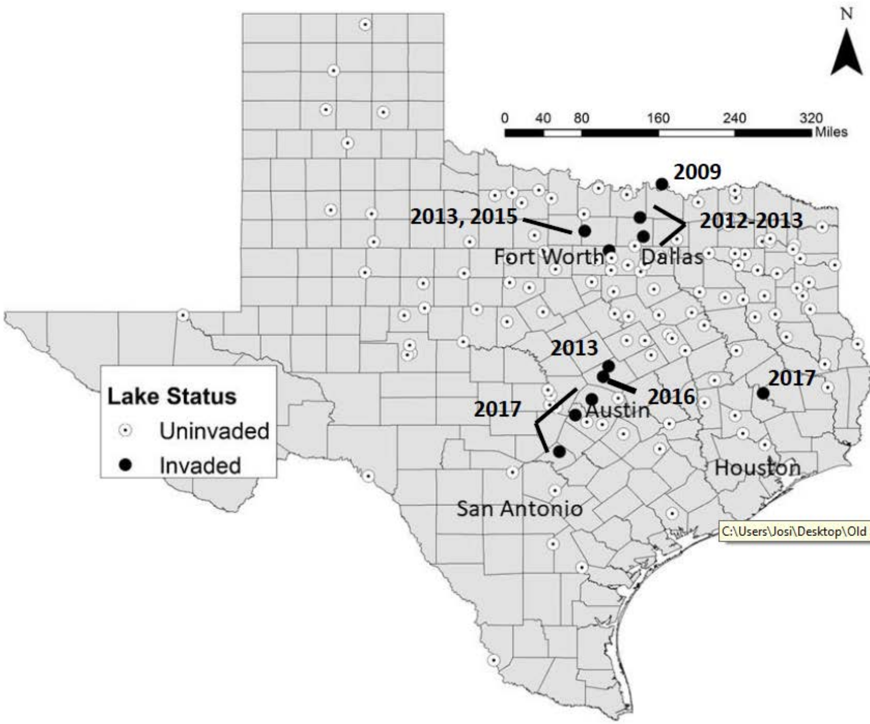


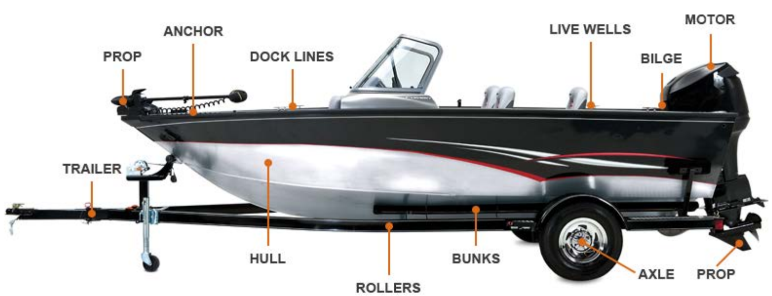
Life stages:
planktonic larvae (veligers)
Juvenile settlement
Adults

Dispersal via:
Boats
Water current

Source:100th Meridian Initiative

Modelling dispersal via boats





Collaboration with Todd Swannack, USACE

Previous attempts to predict zebra mussel invasion:
Dispersal model via boats (e.g., Bossenbroek et al. 2001).

Habitat suitability (e.g., McMahon 2015)

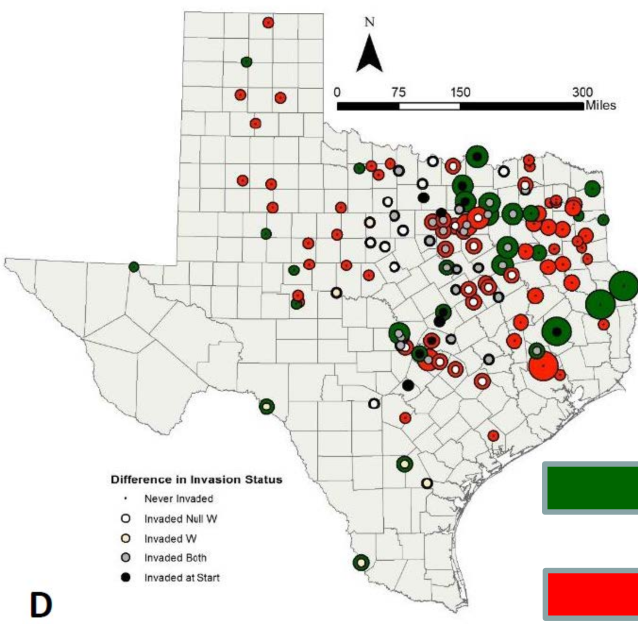
→ Our goal: Dispersal model + habitat suitability

Invasions since 2012, mostly close to urban centers.
→ Social aspect needs to be considered

The model

<u>1. Number of infested boats travelling from invaded reservoir to another lake, which depends on:</u>

Number of boats per lake (based on registered boats per county)
Distance between lakes
Lake attractiveness (most attractive: large lakes near urban centers)



D

Lake attractiveness changes number of boats arriving at a lake considerably

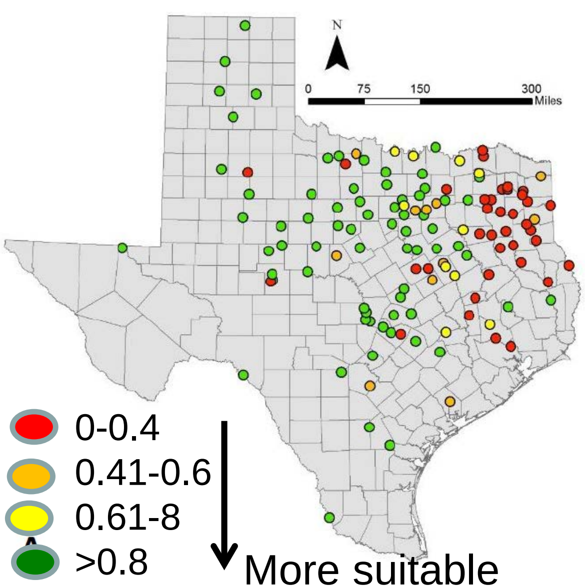
More boats arriving

Less boats arriving

The model

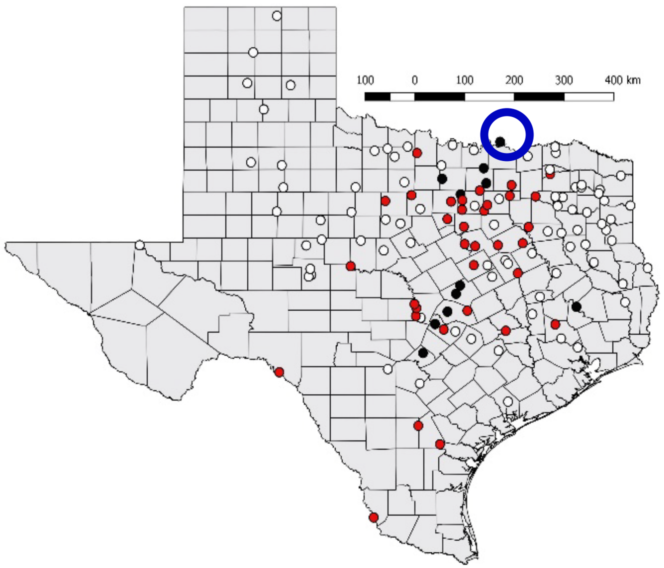
<u>2. Whether a lake becomes invaded depends on 1 (number of infested boats arriving) and:</u>

Threshold for invasion (number of infested boats required to guarantee a successful invasion)
+ **Habitat suitability** (dissolved calcium/hardness, maximum lake depth, pH, conductivity)



Habitat suitability index
→ affects survival probability of arriving zebra mussels

Model predictions



New reservoirs predicted to become invaded

Starting with Lake Texoma,

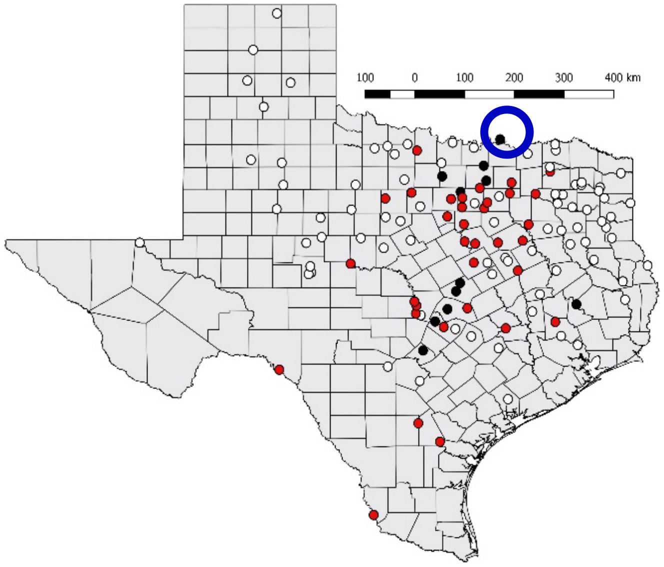
Model correctly predicted the invasion of the 11 reservoirs that had been invaded at the start of our study

+ 30 others.

Of those 1 has since been invaded (Lake Austin)

+ 4 are on watch list (Lake Lavon, Richland-Chambers Lake, Lake Worth; and Grapevine Lake)

Spatial variation in predicted lake invasions



New reservoirs predicted to become invaded

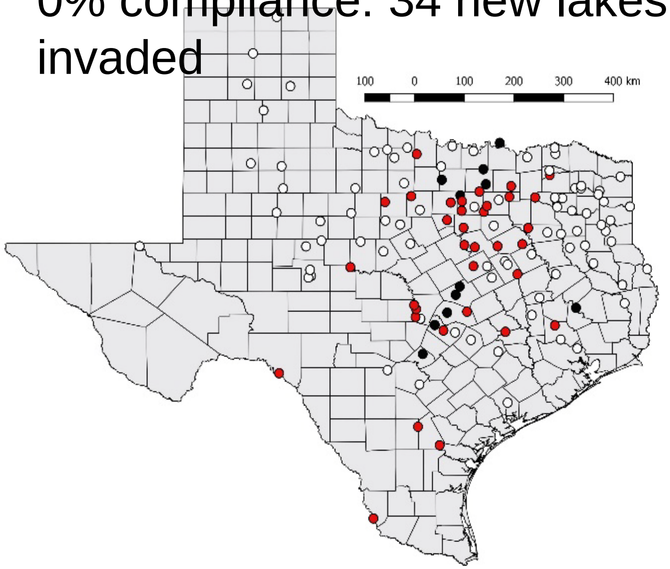
Zebra mussel spread to East Texas mostly habitat limited,

Further West more dispersal limited.

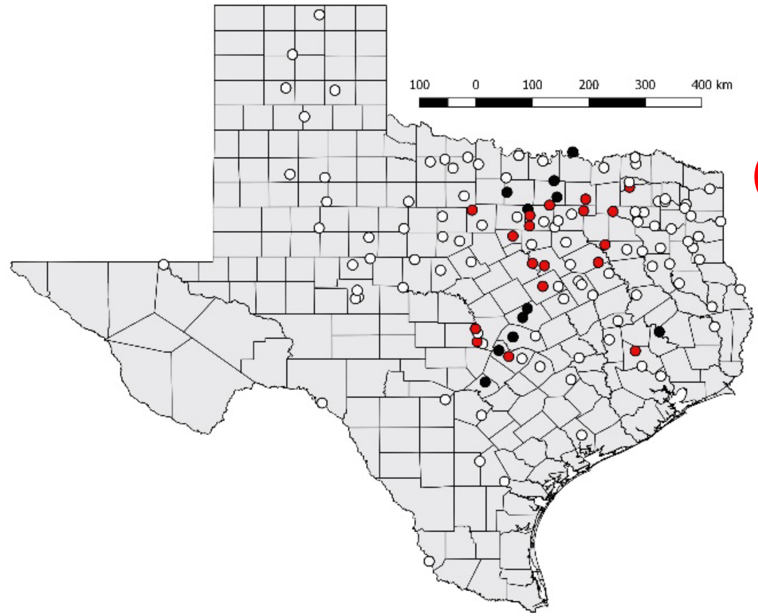
Most lakes in Central Texas are predicted to become invaded in the near future.

Preventive efforts: Boater compliance

0% compliance: 34 new lakes invaded

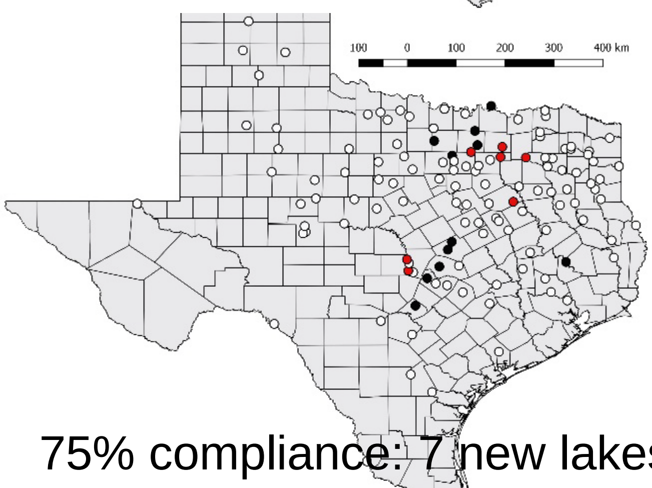


50% compliance: 18 new lakes invaded



New reservoirs predicted to become invaded

High compliance (86%) needed to completely prevent new invasions.



75% compliance: 7 new lakes invaded

Austin, Lavon, Ray-Hubbard, Tawakoni, Richland-Chambers, LBJ, Buchanan, Grapevine.

Summary dispersal model

Lake attractiveness important parameter

Model predicts restricted spread to East Texas due to habitat limitation, and to West Texas due to dispersal limitation

Most lakes in Central Texas are predicted to become invaded unless boater compliance with preventive measures is very high.

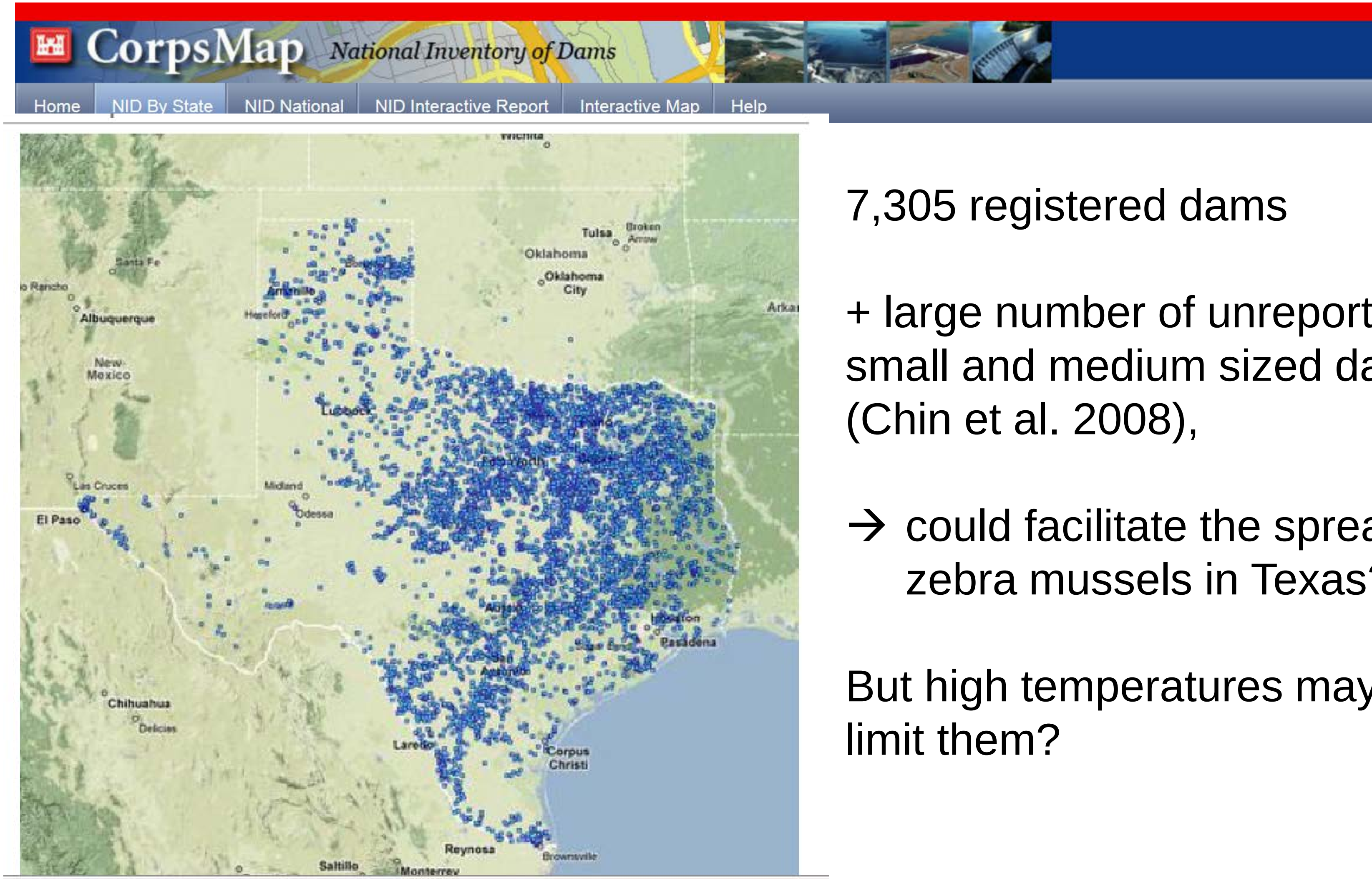
Downstream dispersal

In streams: zebra mussel populations depend on recruitment from an upstream located lake or reservoir

→ Impoundments facilitate persistence of zebra mussels in larger rivers (Allen & Rancharan 2001)

→ Low-head dams could act as stepping stones (Smith et al. 2015)

Texas' large number of dams: zebra mussel heaven



7,305 registered dams

+ large number of unreported small and medium sized dams (Chin et al. 2008),

→ could facilitate the spread of zebra mussels in Texas?

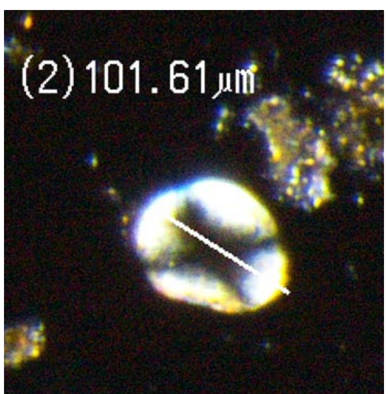
But high temperatures may limit them?

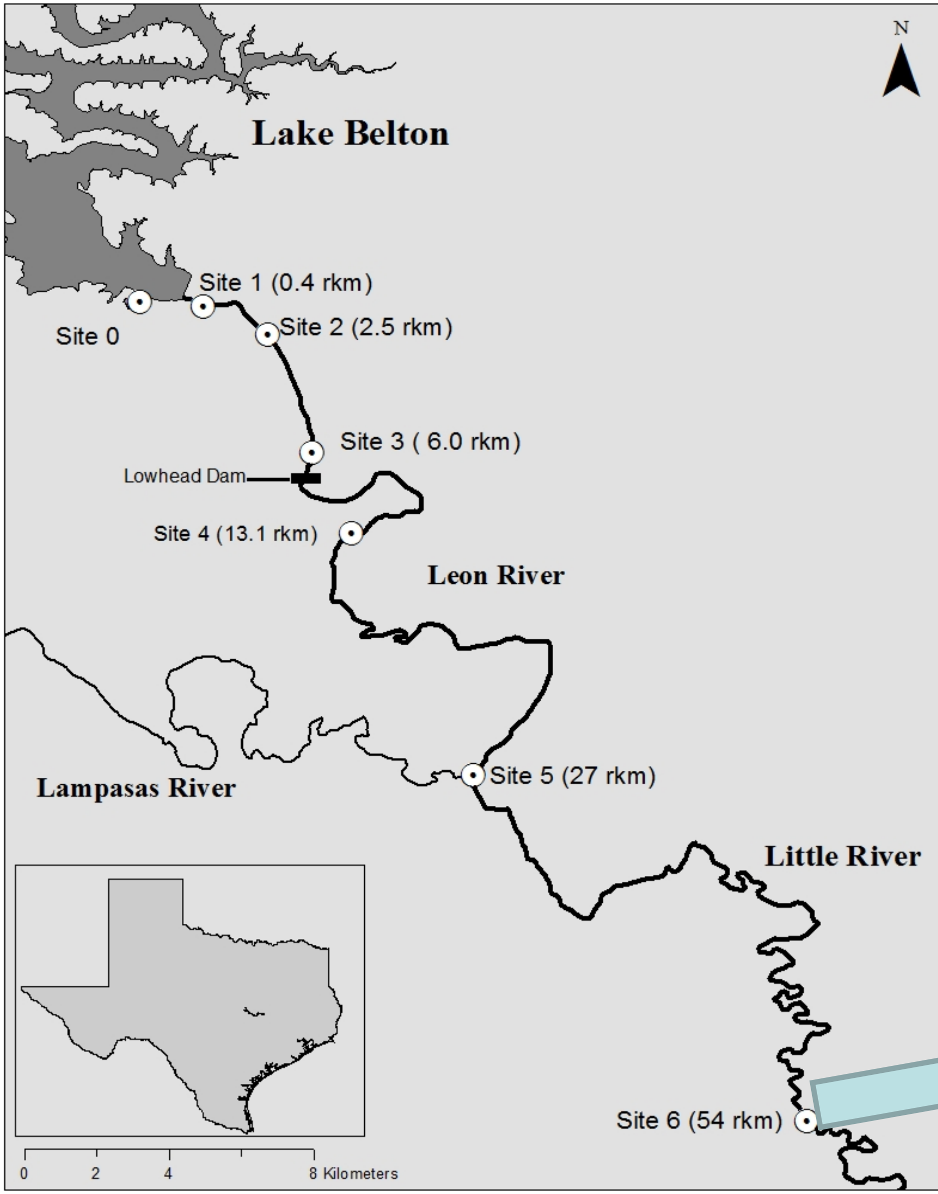
Dispersal and settlement rates

Objective:

Quantify dispersal and settlement rates

Veliger sample = filtered ~100 gal site water through plankton net



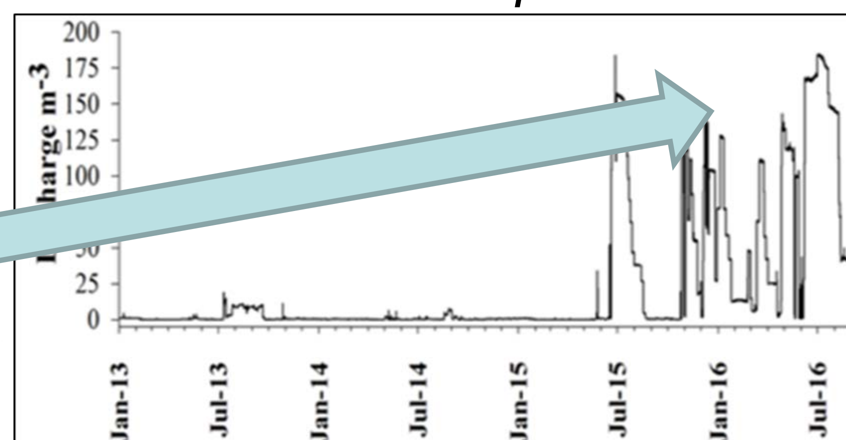


Initial findings
2015-2016

Juvenile settlement
restricted to ≤ 6rkm in 2015.
Up to 54 rkm in April 2016.

→ Prolonged periods of increased river discharge may have facilitated their dispersal further downstream in 2016.

Olsen et al. 2018. Aquatic Invasions



What drives veliger dispersal?

2018: Largest dispersal distances: April-June
when highest lake veliger densities occurred

Analysis based on Lake Belton data 2015-2018:

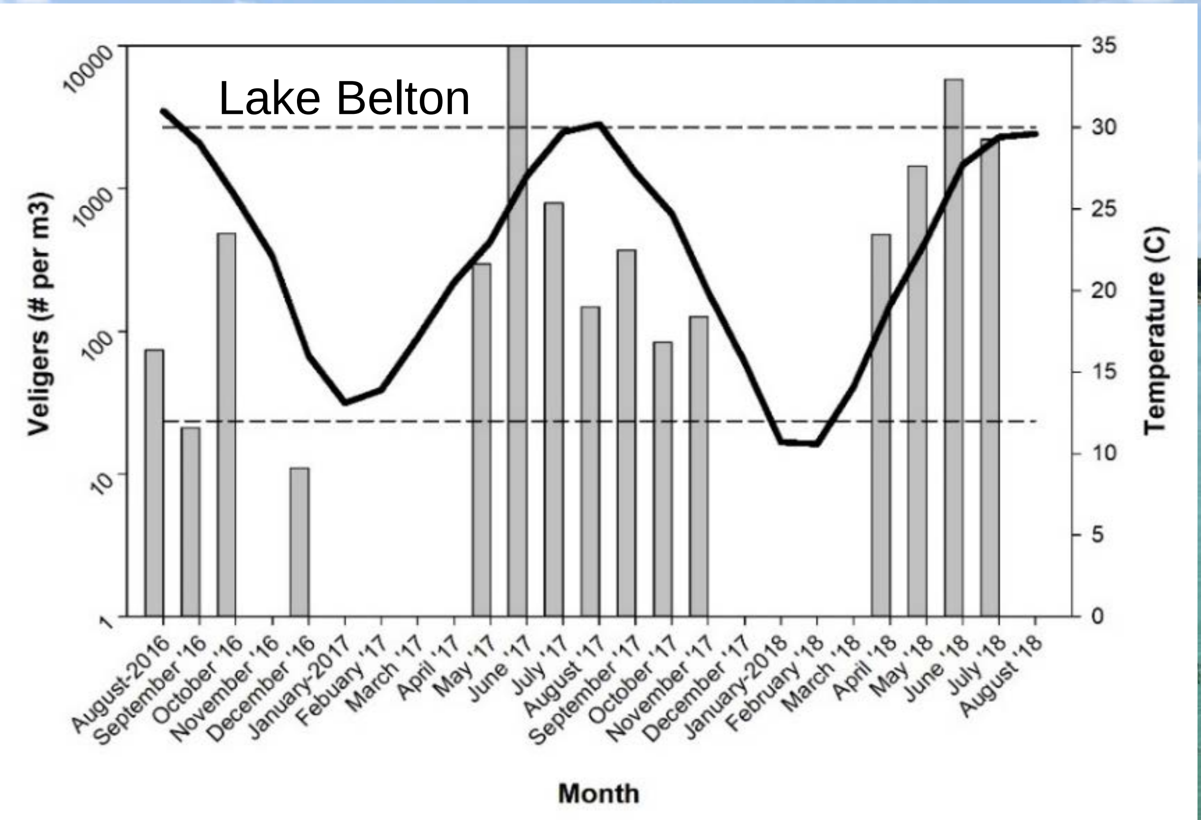
Veliger densities in the lake

explained 57% of the variation in furthest downstream veliger density ($F_{1,22}$ = 30.9, $p<0.01$).

and 37% of variation in maximum distances ($F_{1,22}$ = 14.64, $p<0.01$, R^2=0.37).

Discharge was not a significant factor ($F_{1,22}$ = 0.202, p=0.66, R^2 = 0.04)

Seasonal variation in lake veliger densities

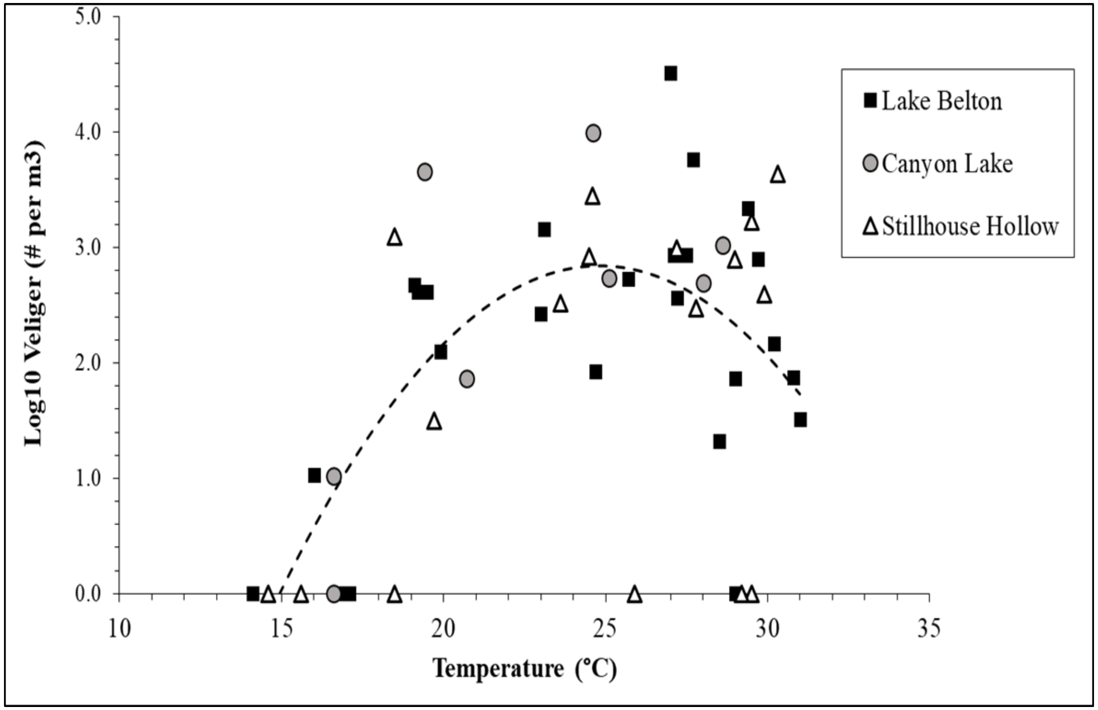


Seasonal variation: Highest densities usually May/June,

Usually lower in July/August

Another increase in Sep/Oct

Lake veliger densities vs. temperature



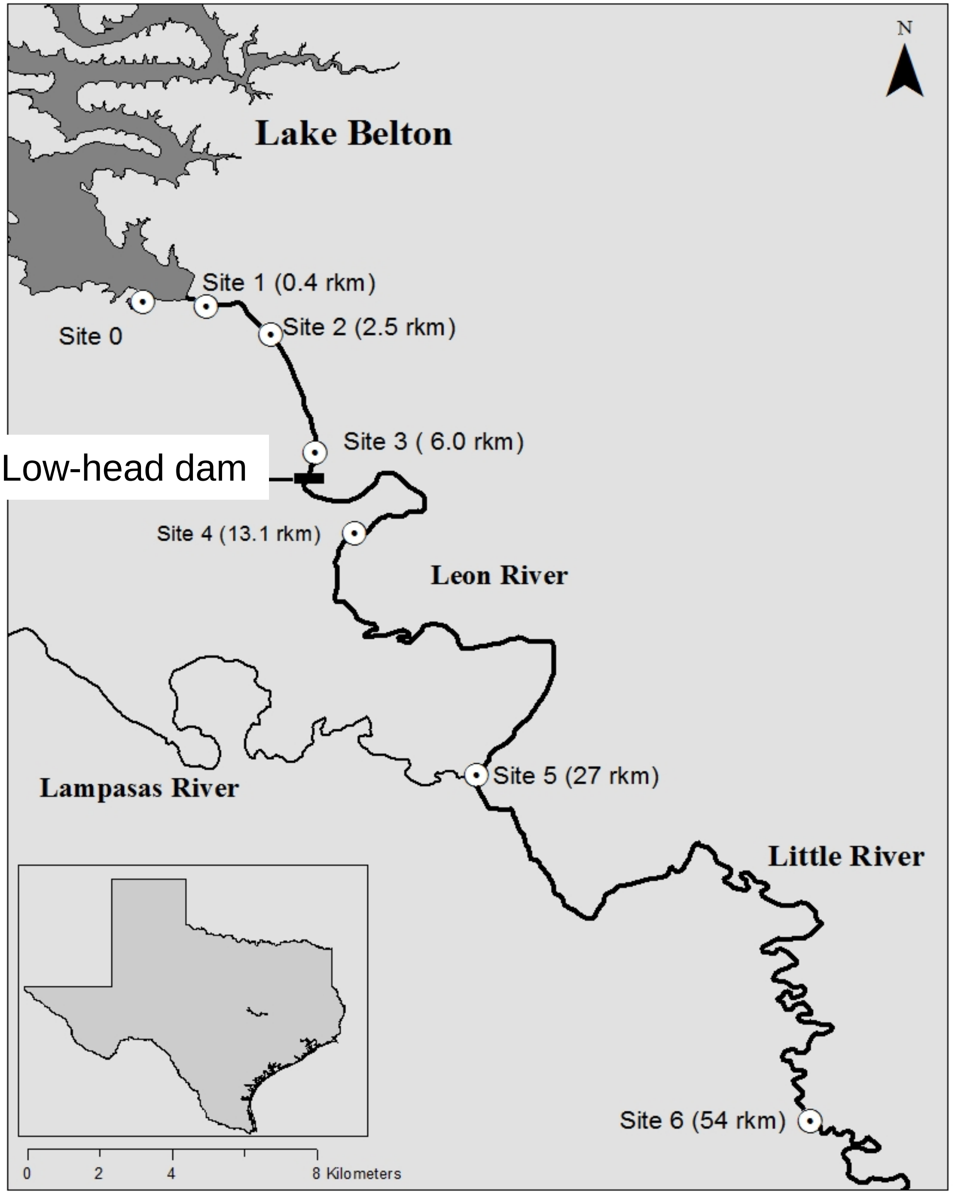
Canyon Lake:
R^2= 0.53, p=0.07, n = 6

Lake Belton:
R^2= 0.40, p=0.002, n = 26

Stillhouse Hollow:
R^2= 0.66, $p<0.01$, n = 14
For March 2017 to August 2018 (no veligers before then)

Temperature = Key variable for zebra mussel reproduction,
Moderate densities around 30°C (up to 31°C in Lake Belton)

Temperature is a major driver for lake veliger densities, which affect downstream dispersal



Initial findings 2015-2016

Substantial settlement limited to sites upstream of low-head dam

→ More lentic conditions may have enhanced recruitment

→ Potentially important role of low-head dams.

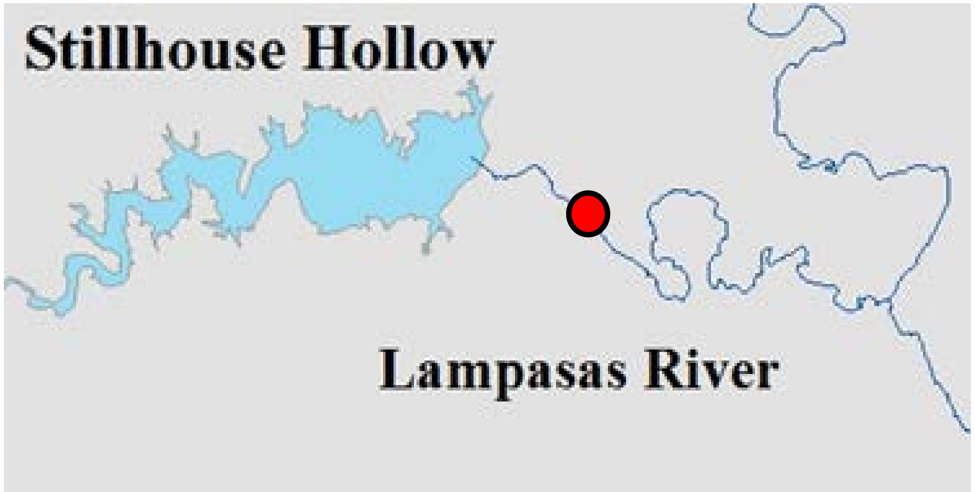
→ Prediction: Higher recruitment where low-head dams are present (Canyon Lake>Belton>Stillhouse)

Riverine recruitment: Dispersal limitation

Belton lake (invaded 2013)
Juvenile settlement up to 54rkm, 1.2-46 ind./m^2/week

Stillhouse Hollow (invaded 2016)
up to 4.8 rkm, 0.8-4.1 ind./m^2/week

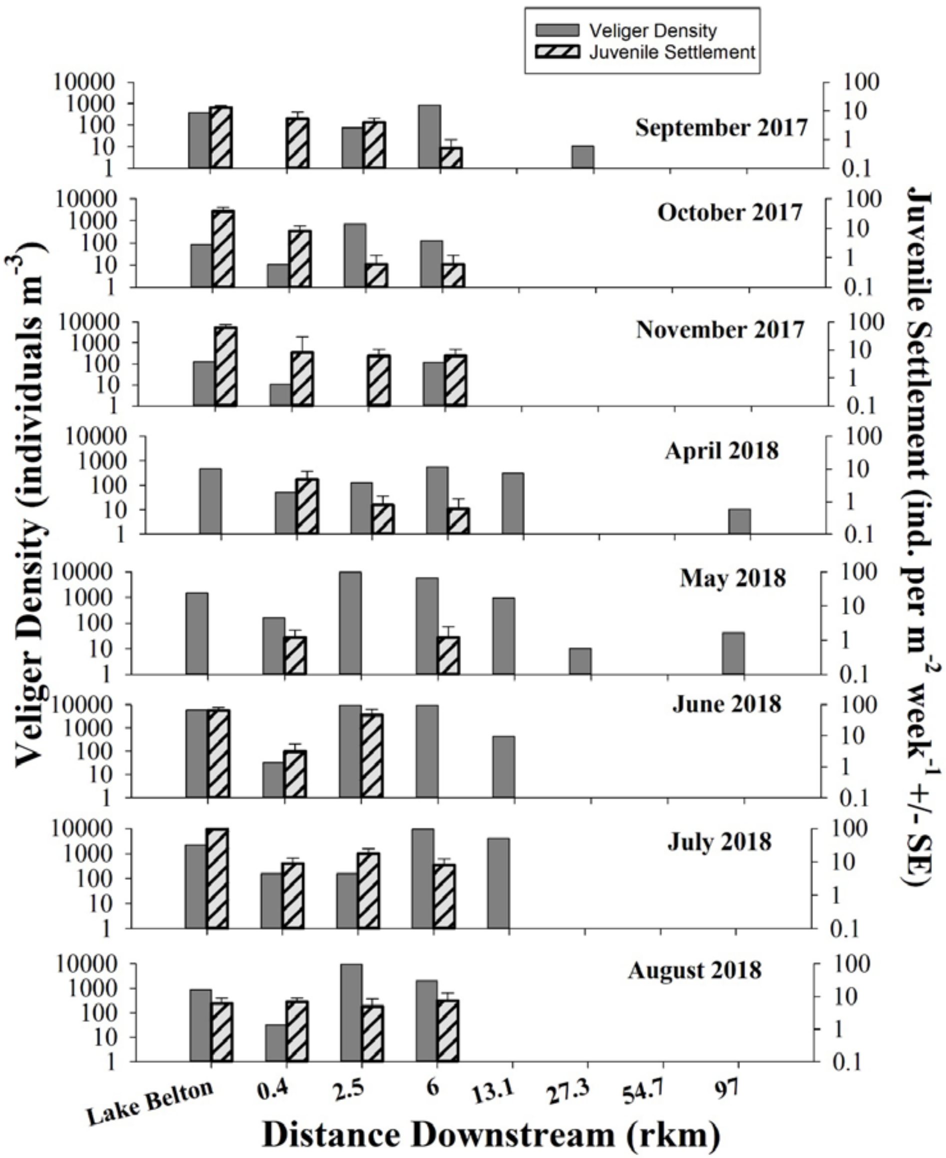
Canyon Lake (invaded 2017)
up to 0.2rkm, only 1 juvenile



Riverine recruitment currently depends on how long ago lake was invaded.

→ Role of low-head dams may become more important in the future.

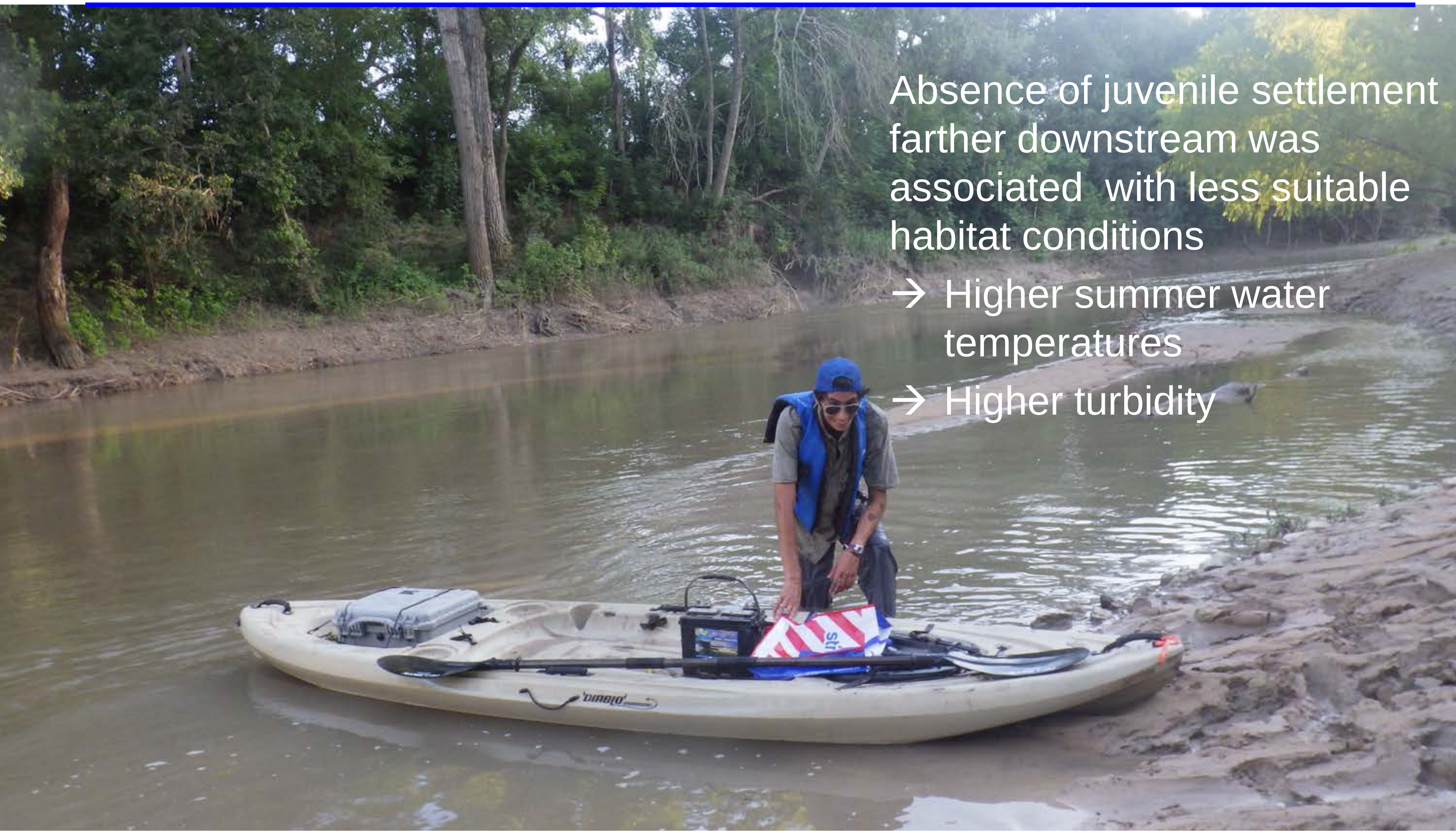
Veligers vs. juveniles



Veliger dispersal farther downstream than juvenile settlement.

→ Habitat limitation?

Riverine recruitment: Habitat limitation?

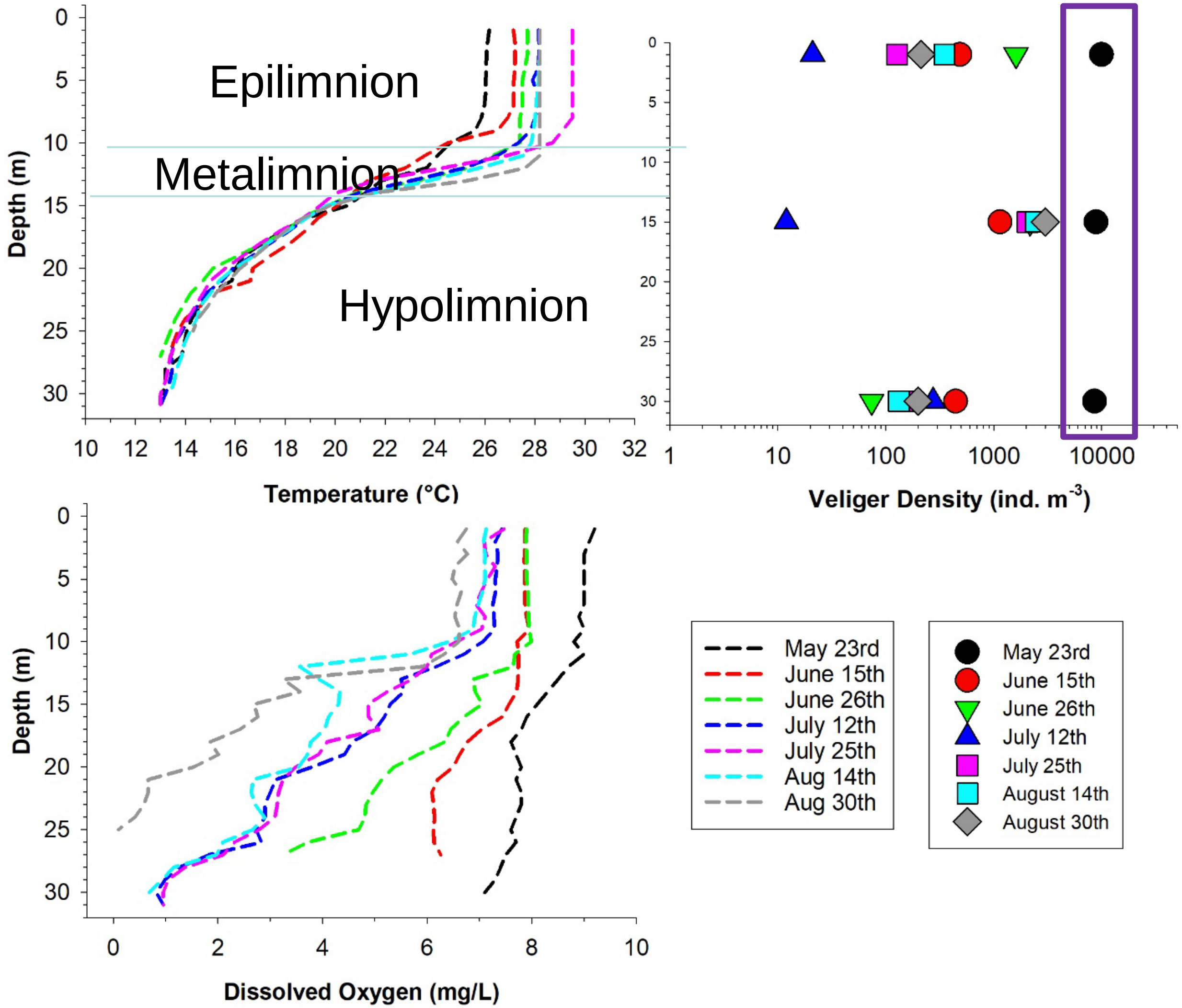


Absence of juvenile settlement farther downstream was associated with less suitable habitat conditions

→ Higher summer water temperatures

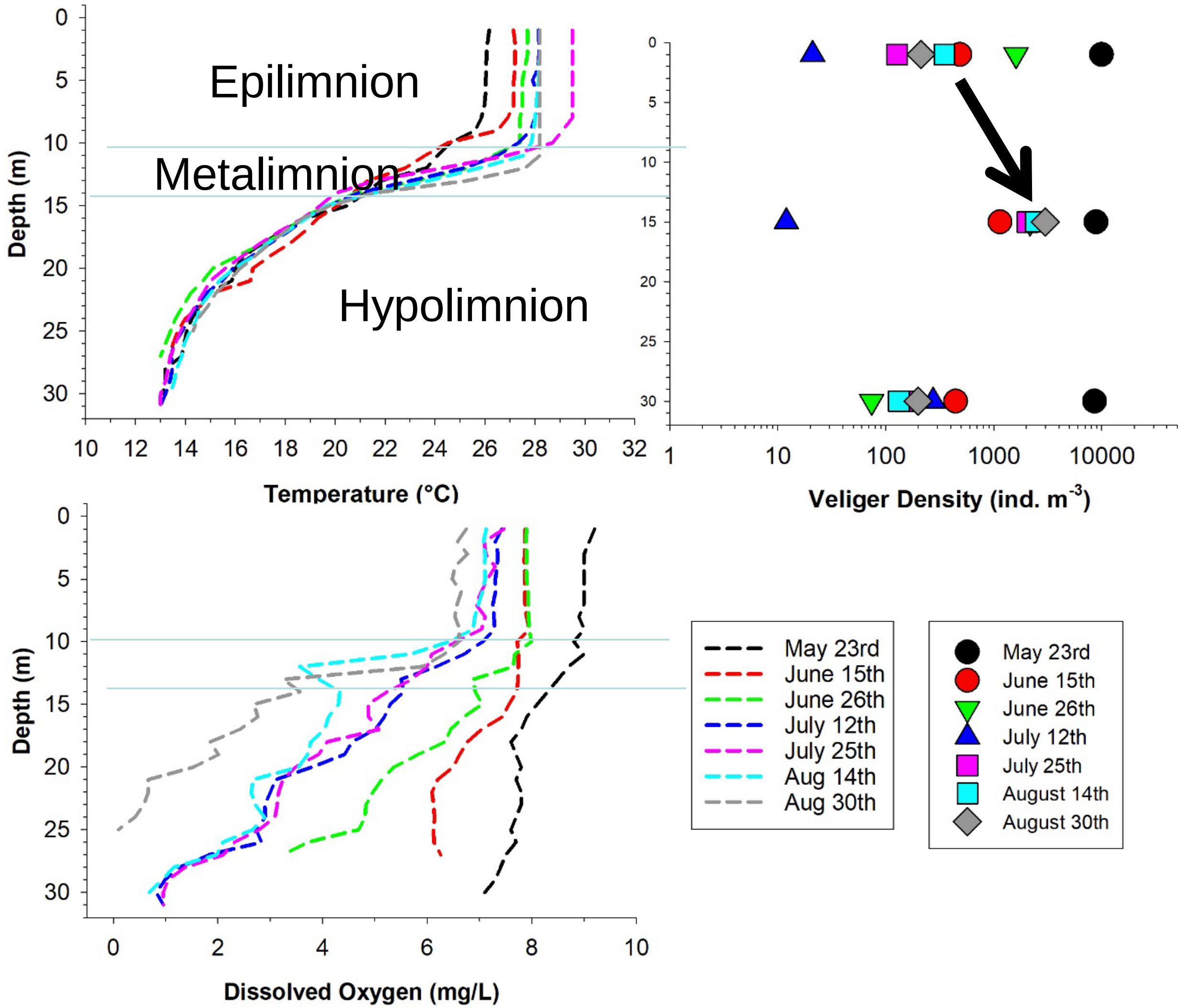
→ Higher turbidity

Variation with depth



May: Highest veliger densities, especially in epilimnion, but still high in hypolimnion (high DO)

Variation with depth

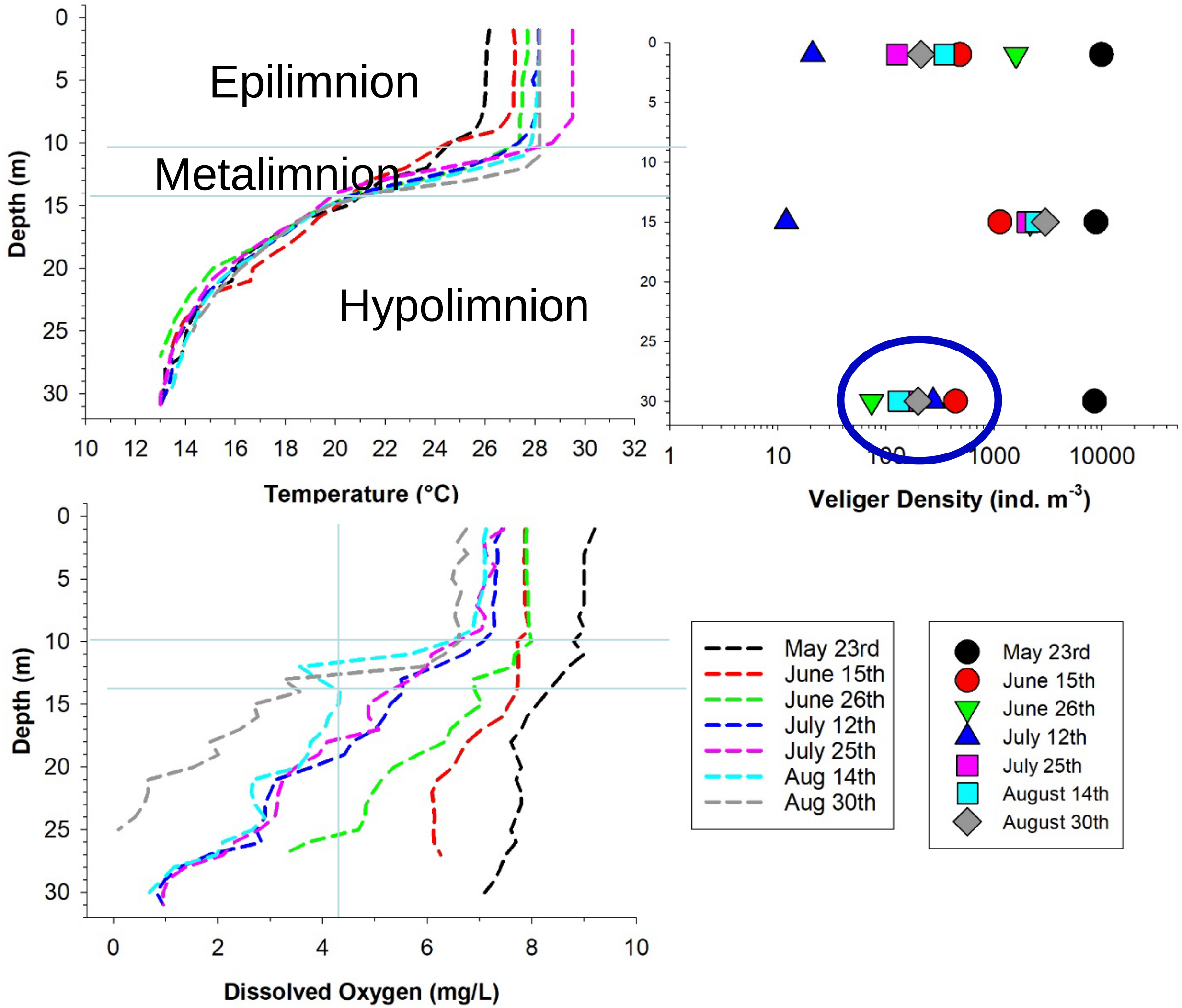


May: Highest veliger densities, especially in epilimnion, but still high in hypolimnion (high DO)

As temperature increase shift towards metalimnion
→ lower temperature than epilimnion, higher DO than hypolimnion

Do veligers choose the "Goldilocks" layer in summer?

Variation with depth



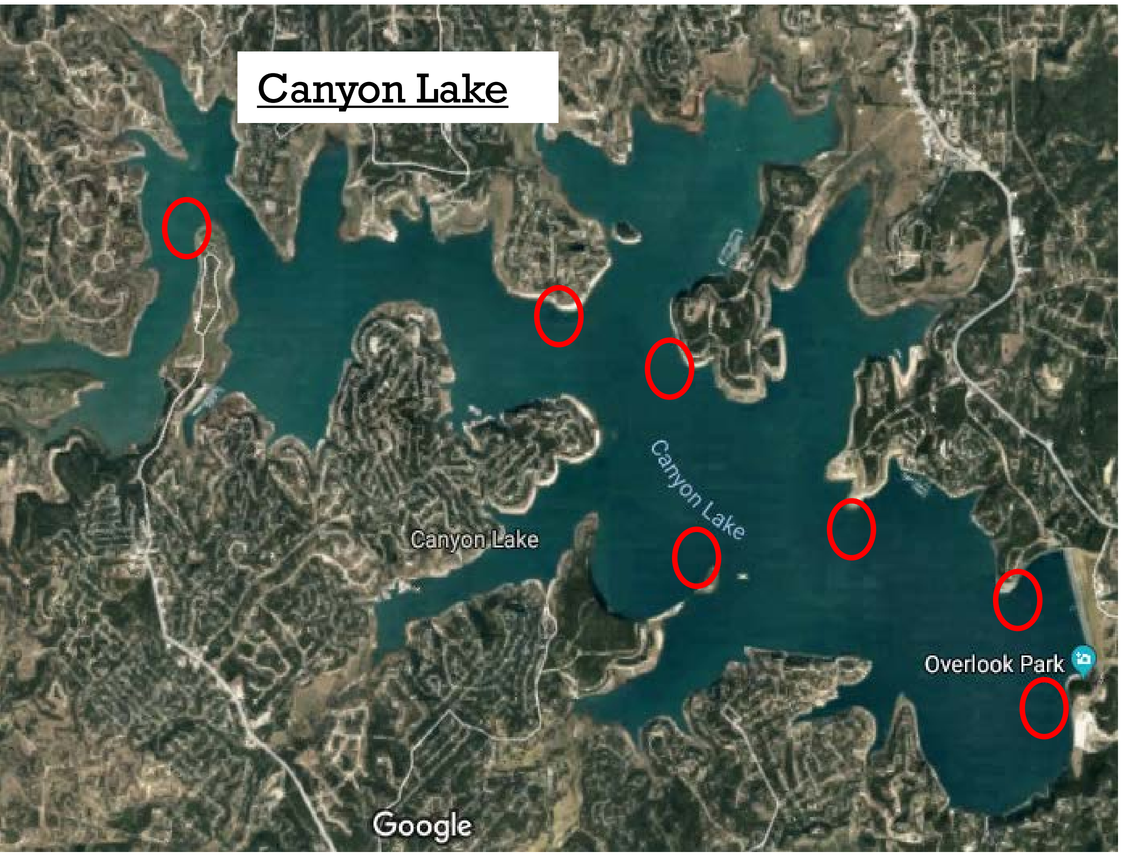
May: Highest veliger densities, especially in epilimnion, but still high in hypolimnion (high DO)

As temperature increase shift towards metalimnion
→ lower temperature than epilimnion, higher DO than hypolimnion

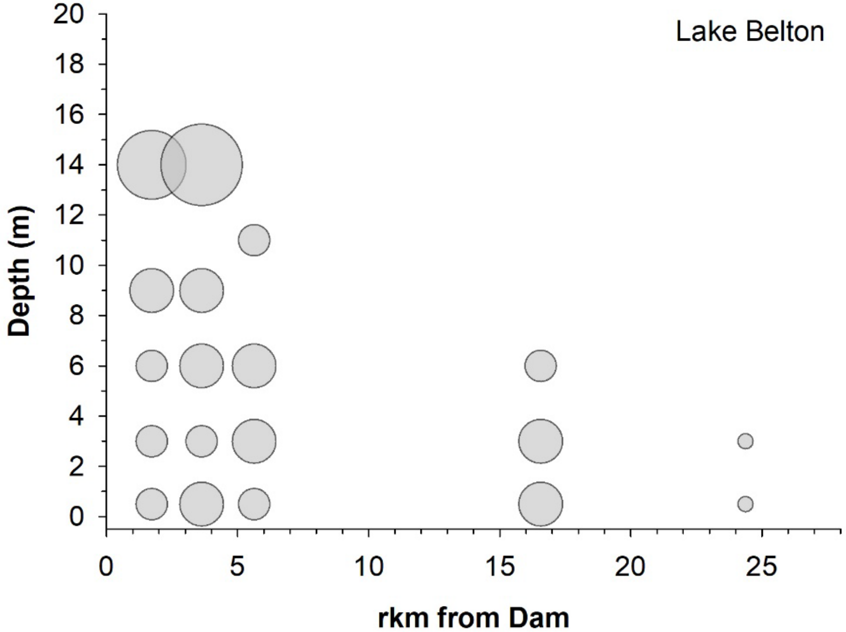
Moderate densities in hypolimnion even when DO < 4mg/L late July/August

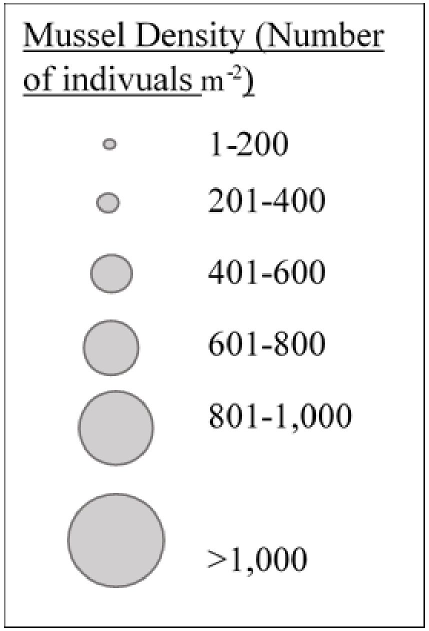
Zebra Mussel Distribution in Two Texas Reservoirs

Scuba surveys from close to dam up to 12rkm (Canyon Lake) and 24rkm (Lake Belton) upstream



Zebra mussels in Lake Belton



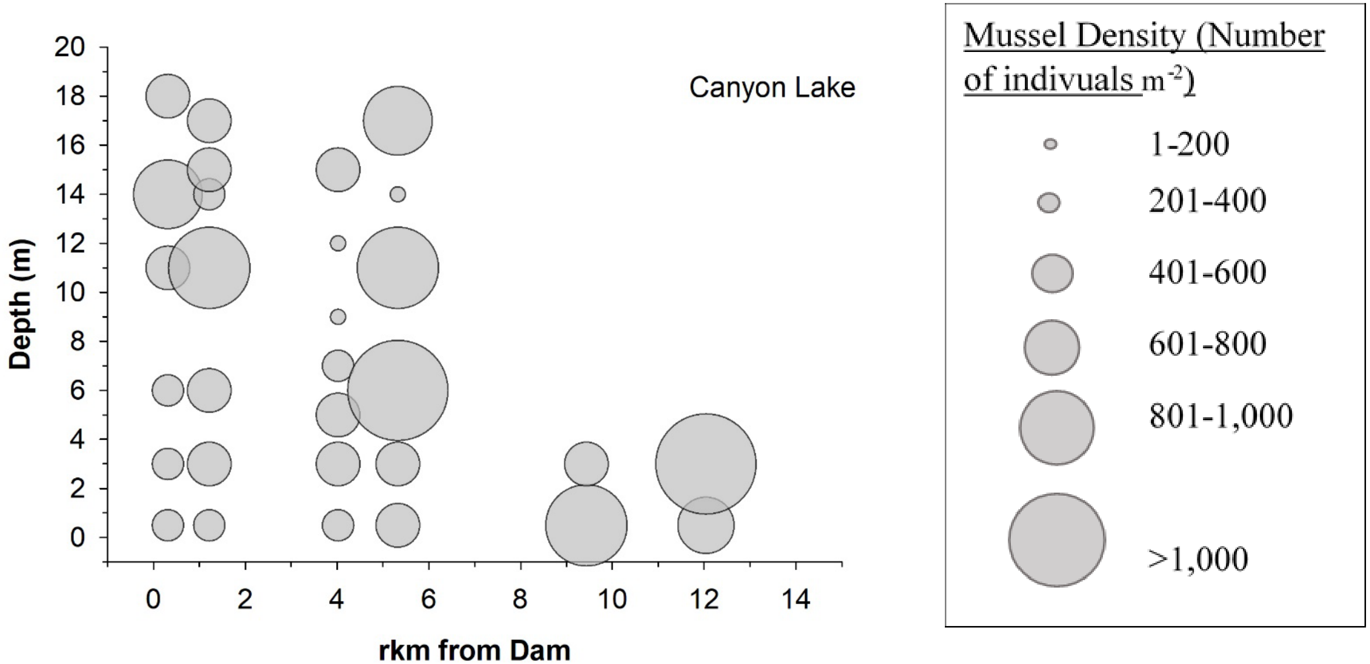


Mussels not found >14m depth (associated with soft sediment and low visibility)

Higher densities only closer to the dam in greater depths

→ Temperature limitation?

Zebra mussels in Canyon Lake



Mussels not found >18m depth in Canyon

Mussels found in higher densities up to 12 rkm upstream

Closer to dam, higher densities at greater depths

→ Temperature limitation?

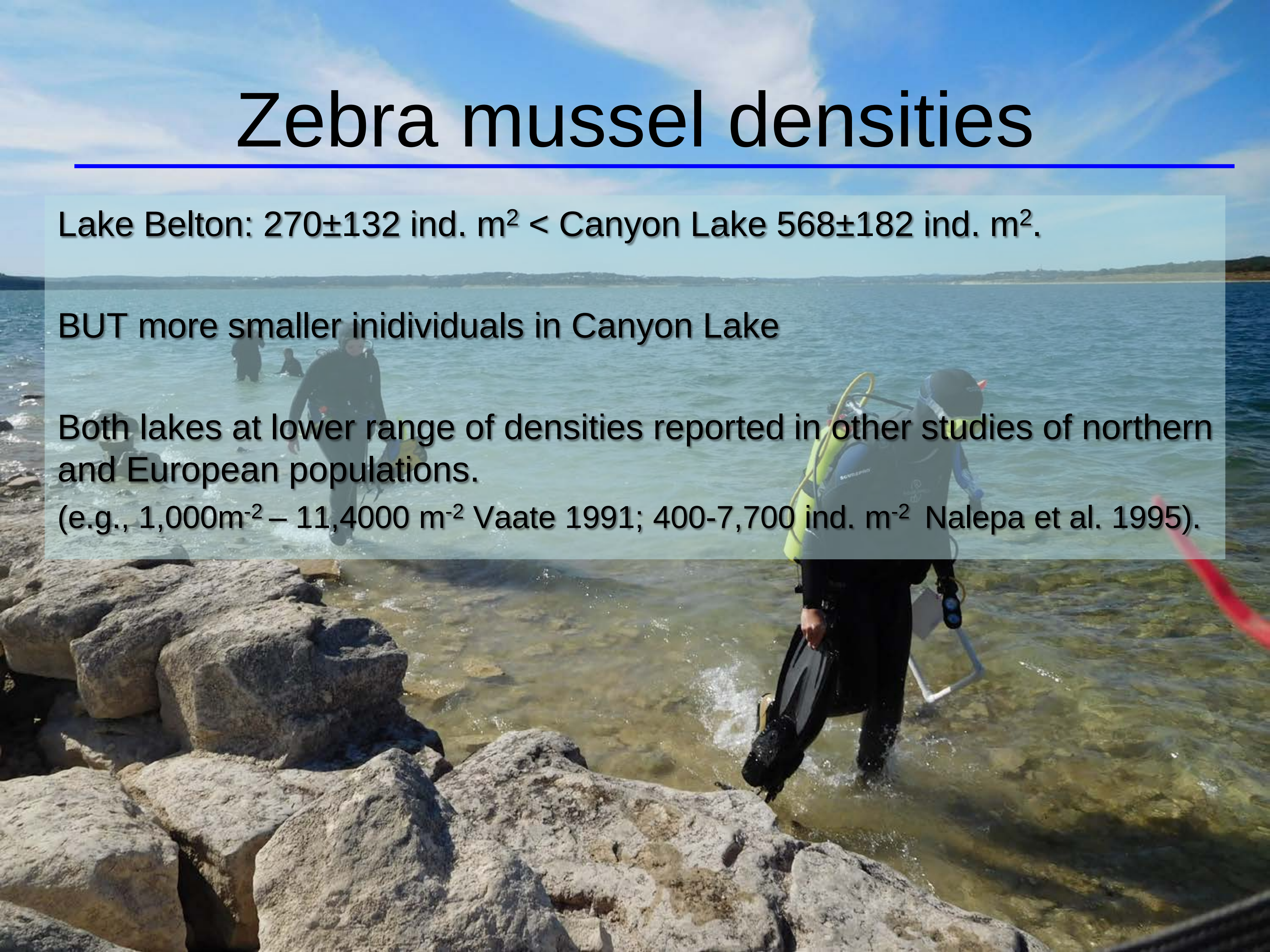
Zebra mussel densities

Lake Belton: 270±132 ind. m^2 < Canyon Lake 568±182 ind. m^2.

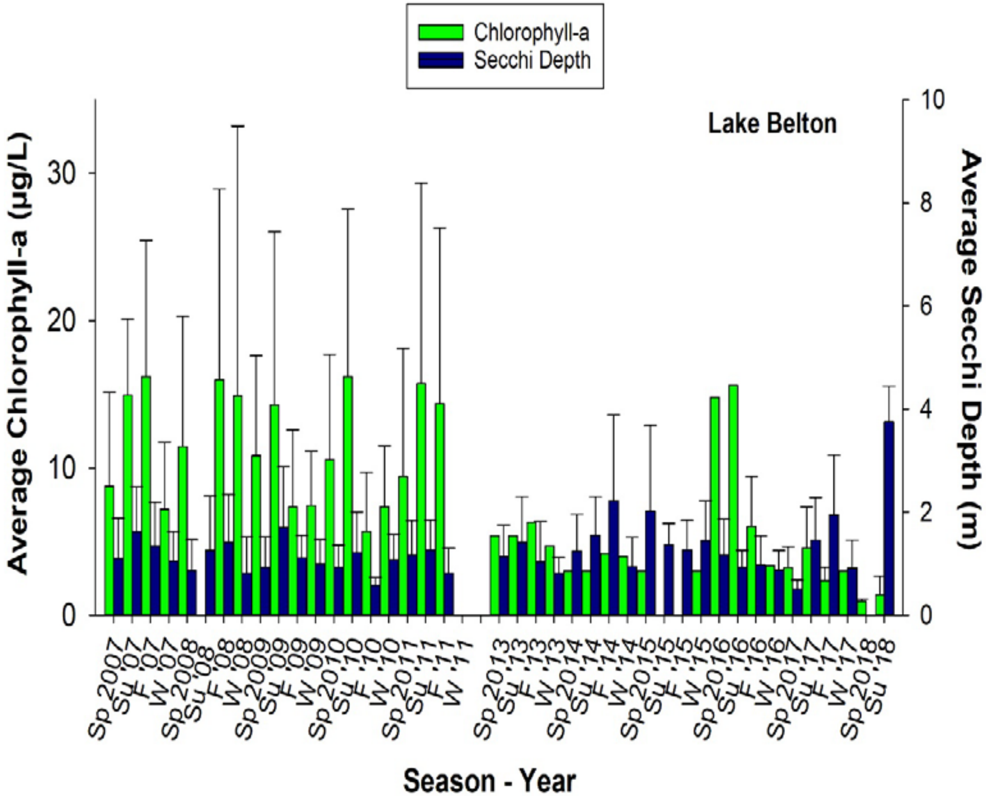
BUT more smaller inidividuals in Canyon Lake

Both lakes at lower range of densities reported in other studies of northern and European populations.

(e.g., 1,000m^{-2} – 11,4000 m^{-2} Vaate 1991; 400-7,700 ind. m^{-2} Nalepa et al. 1995).



Impact of zebra mussels



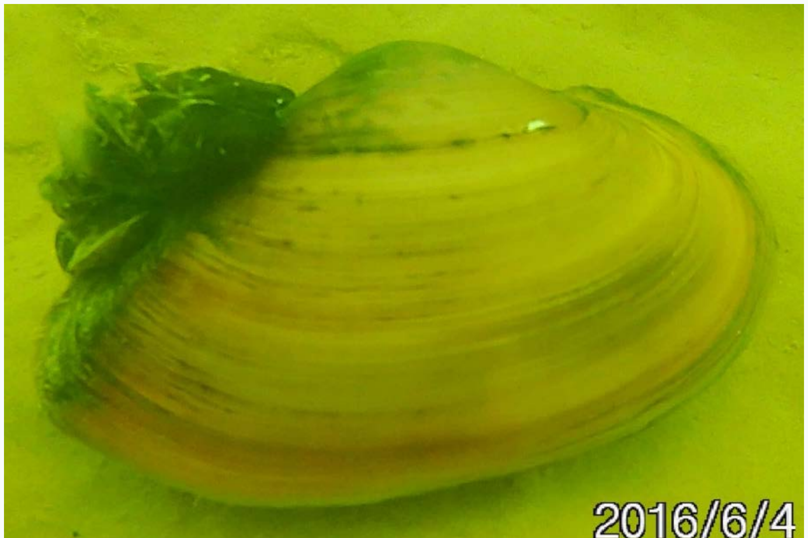
Decline of Chl a from
11.3 ± 0.9 to 4.2±0.6
post- invasion.

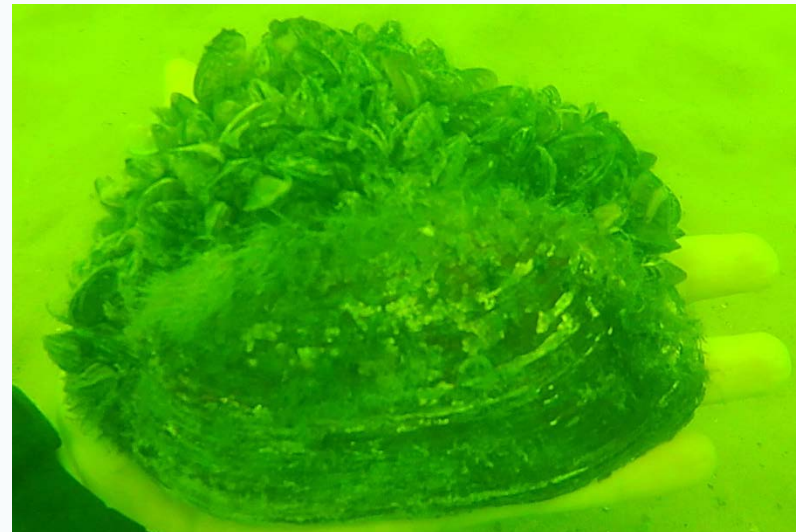
No significant difference in water transparency.

Decline in phytoplankton likely also caused a decline in zooplankton, which may affect fish recruitment (Higgins and Vander Zanden 2010)

Impact on Unionid Mussels in Lake Belton?

- Several live individuals of at least 5 different species found
(Yellow Sandshell, Three-Ridge, Pondshell, Southern Maple Leaf, Tampico Pearly Mussel)





Conclusions downstream dispersal and distribution

Riverine recruitment:

- depends on source population and the factors affecting reproduction in the lake.

- associated with optimal temperatures in lake relatively high DO in hypolimnion (bottom-release dams).

Experimental studies needed to examine potential role of habitat limitations.

Role of low-head dams may become more important in coming years.

Adult zebra mussel population and ecological impacts should be monitored.

Thanks!

Thanks to all our helpers:
David Swearington
Michaela Moss
Kayla Hayes
Jackie McGuire
Aaron McGuire
Stephen Harding
Somerly Swarm
Natalia Montero
Don Apodaca

TEXAS PARKS & WILDLIFE