Update: Population Dynamics of Zebra Mussels in Texas

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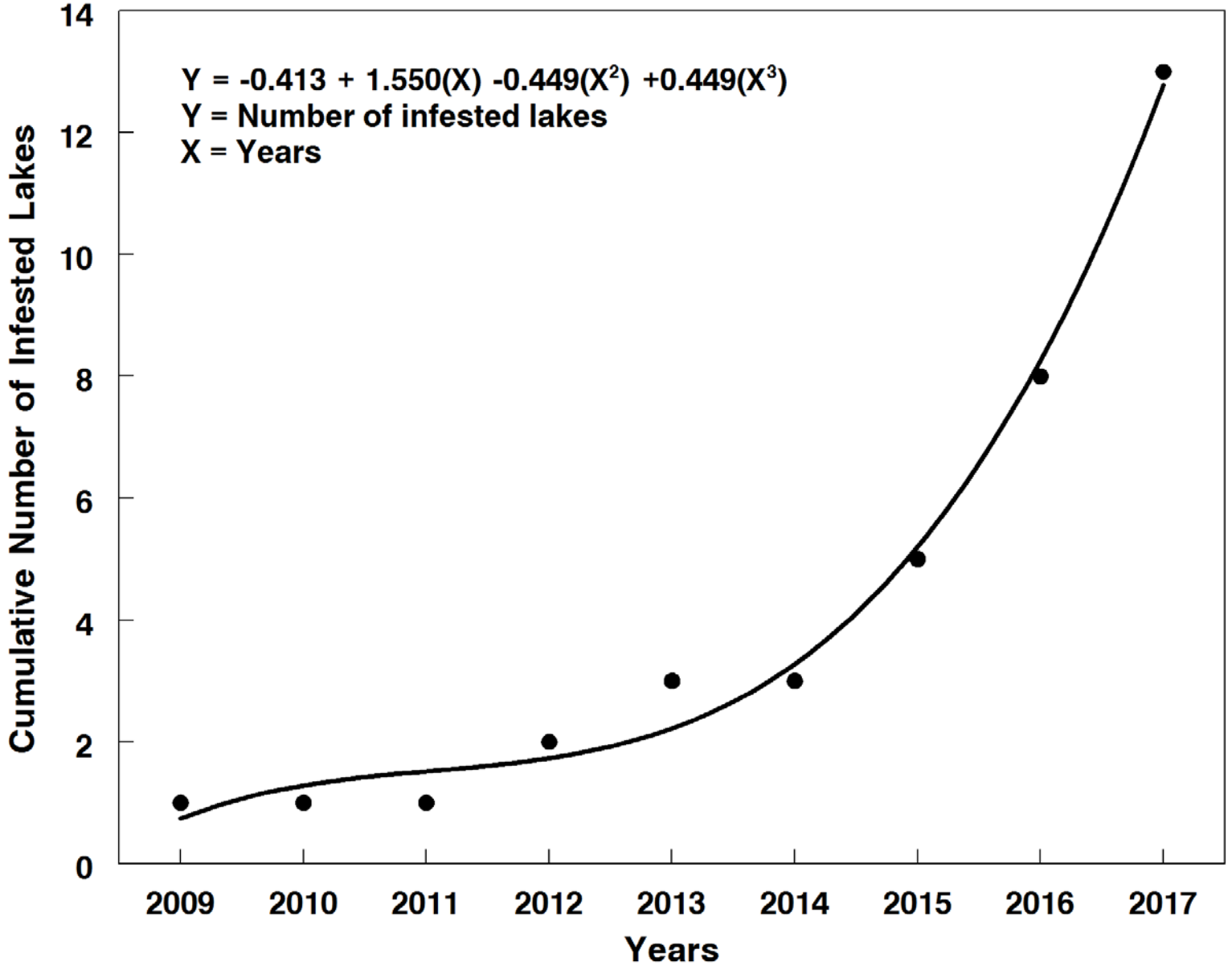
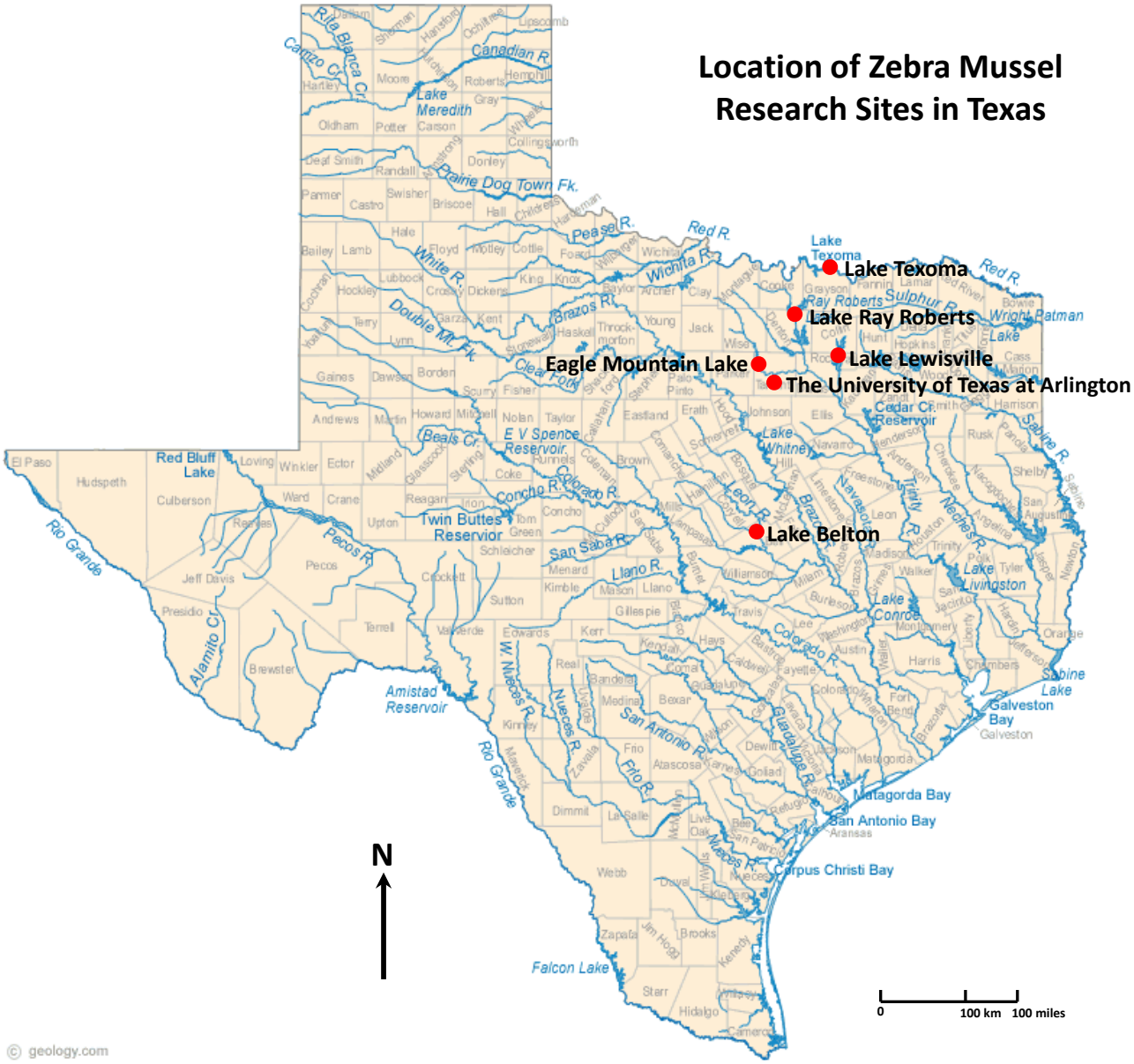
Dreissena polymorpha, Zebra Mussel

Number of Texas Water Bodies Infested by Zebra Mussels



Study of Zebra Mussel Population Dynamics in Texas Water Bodies Funded by the Texas Parks and Wildlife Department

- Duration: August 2016-August 2017
- Zebra mussel population dynamics investigated in five mussel infested water bodies
  - Lakes Texoma (2009), Ray Roberts (2012) and Belton (2013) with established mussel populations
  - Newly invaded Lakes Lewisville (2015) and Eagle Mountain (2016)
- Sampling sites were marinas on each studied lake
- Approximately monthly samples
  - Physical-chemical characteristics of surface water temperature, pH, O_2 concentration, and calcium concentration
  - Spring and fall mussel cohort shell growth rates and life spans
  - Veliger presence and size distributions
  - Settlement and densities of juveniles on settlement monitors
  - Total chlorophyll *a* and phosphorus concentrations
  - Seasonal variation in dry tissue weights
- Compared results to previous studies of zebra mussel population dynamics in Lakes Texoma, Ray Roberts and Belton
- Examined the possible environmental causes for zebra mussel population collapses and recoveries in Lakes Texoma, Ray Roberts and Belton


Location of Zebra Mussel Research Sites in Texas
Lake Texoma
Lake Ray Roberts
Eagle Mountain Lake
Lake Lewisville
The University of Texas at Arlington
Lake Belton
Twin Buttes Reservoir
Red Bluff Lake
Amistad Reservoir
Falcon Lake
Lake Meredith
E V Spence Reservoir
Cedar Cr Reservoir
Lake Whitney
Lake Livingston
Lake Conroe
Sabine Lake
Galveston Bay
Matagorda Bay
San Antonio Bay
Corpus Christi Bay
Canadian R.
Red R.
Prairie Dog Town Fk.
Pease R.
Wichita R.
White R.
Double Mt. Fk.
Clear Fork
Brazos R.
Sulphur R.
Wright Patman Lake
Cedar Cr.
Beals Cr.
Concho R.
Colorado R.
Leon R.
Navasota R.
Trinity R.
Neches R.
Sabine R.
San Saba R.
Llano R.
Pecos R.
Rio Grande
Alamito Cr.
W. Nueces R.
Nueces R.
San Antonio R.
Guadalupe R.
Frio R.
Medina R.
Arroyo Colorado
Rita Blanca Cr.
Canizo Cr.
N
0
100 km
100 miles
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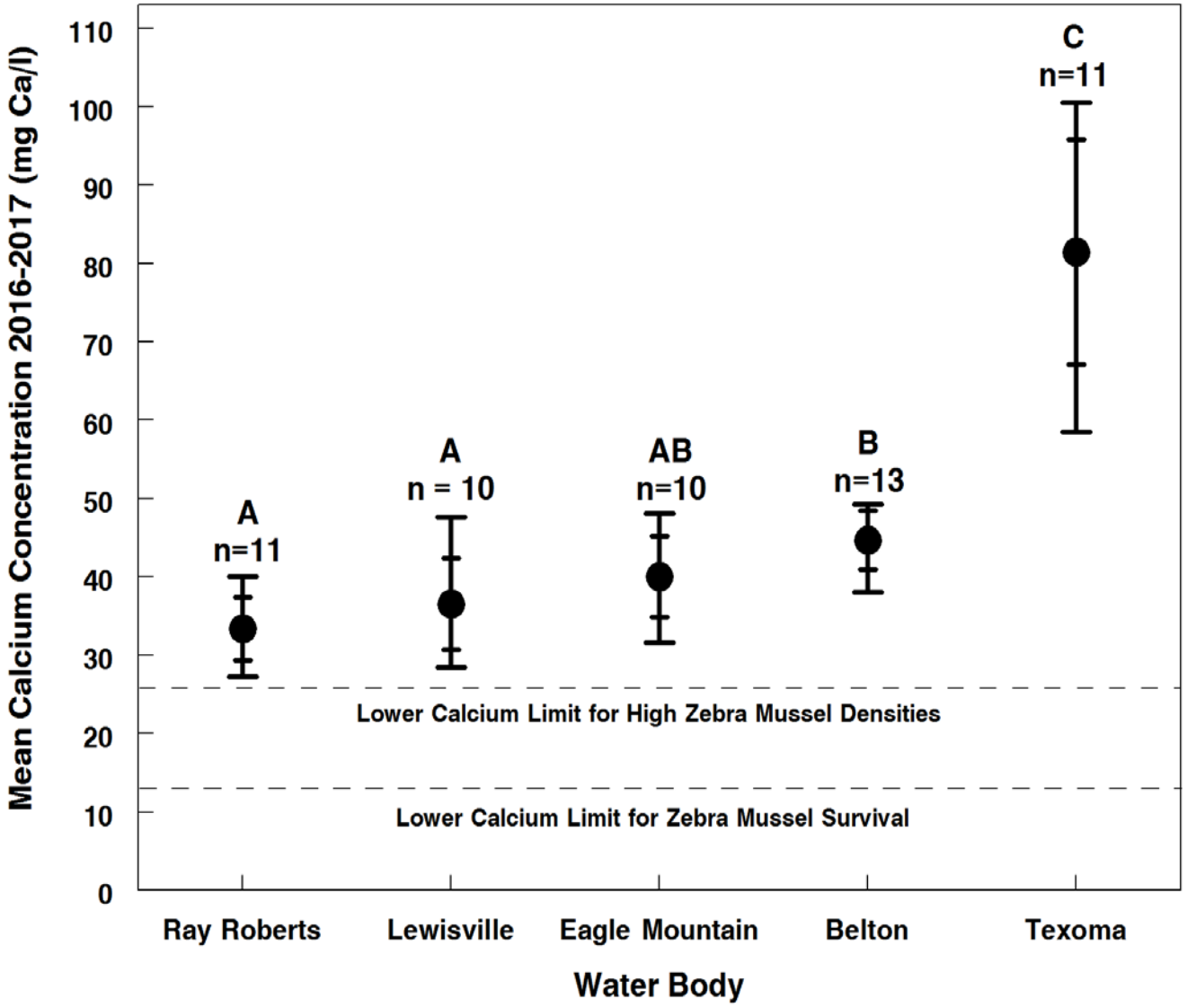
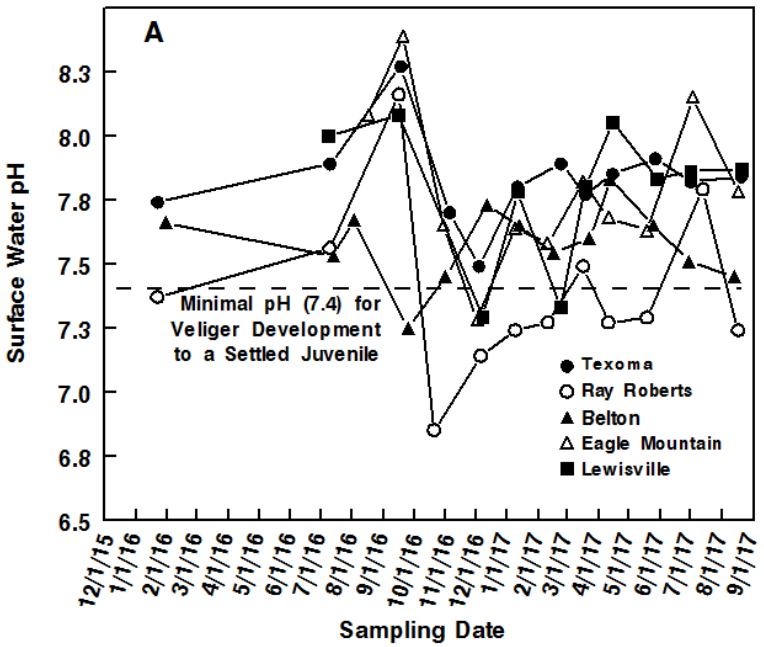
Physical-Chemical Parameters

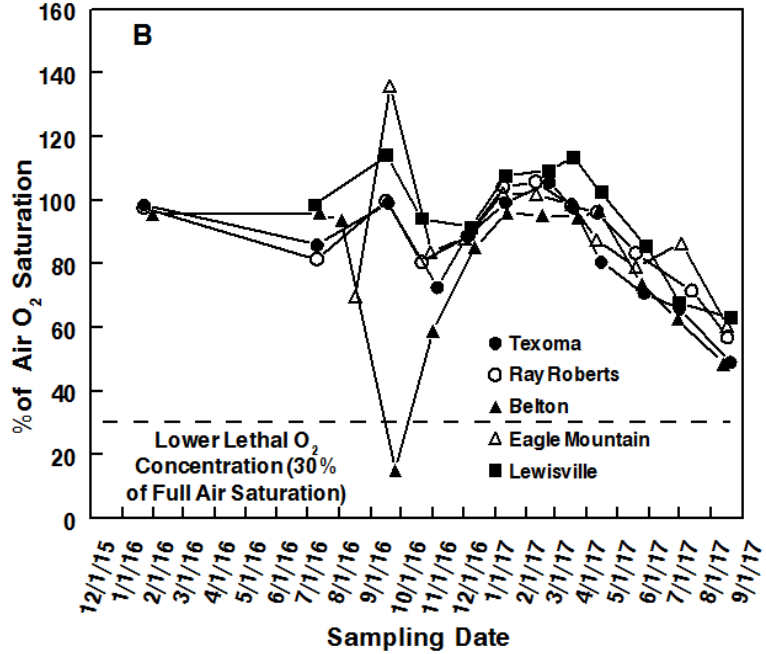
Risk assessment parameters for zebra mussel invasion of Texas and other southwestern United States water bodies (McMahon 2015).

Physical Parameter	Unsuitable	Marginal	Suitable	Reference
Average August Water Temperature	>32°C	31-32°C	<31°C	de Kozlowski et al. 2002
pH	<6.8 or >9.5	6.8-7.4	7.4-9.5	de Kozlowski et al. 2002
Calcium Ion Concentration.	<12 mg L^{-1}	12-28 mg L^{-1}	>28 mg L^{-1}	Whittier et al. 2008
Dissolved Oxygen as % of Air O_2 Saturation	<30% O_2	30-50% O_2	>50% O_2	Johnson and McMahon 1998

Calcium concentrations remained above the lower limit of 28 mg/l for a sustainable zebra mussel infestation at all five lakes







Physical-Chemical Parameters

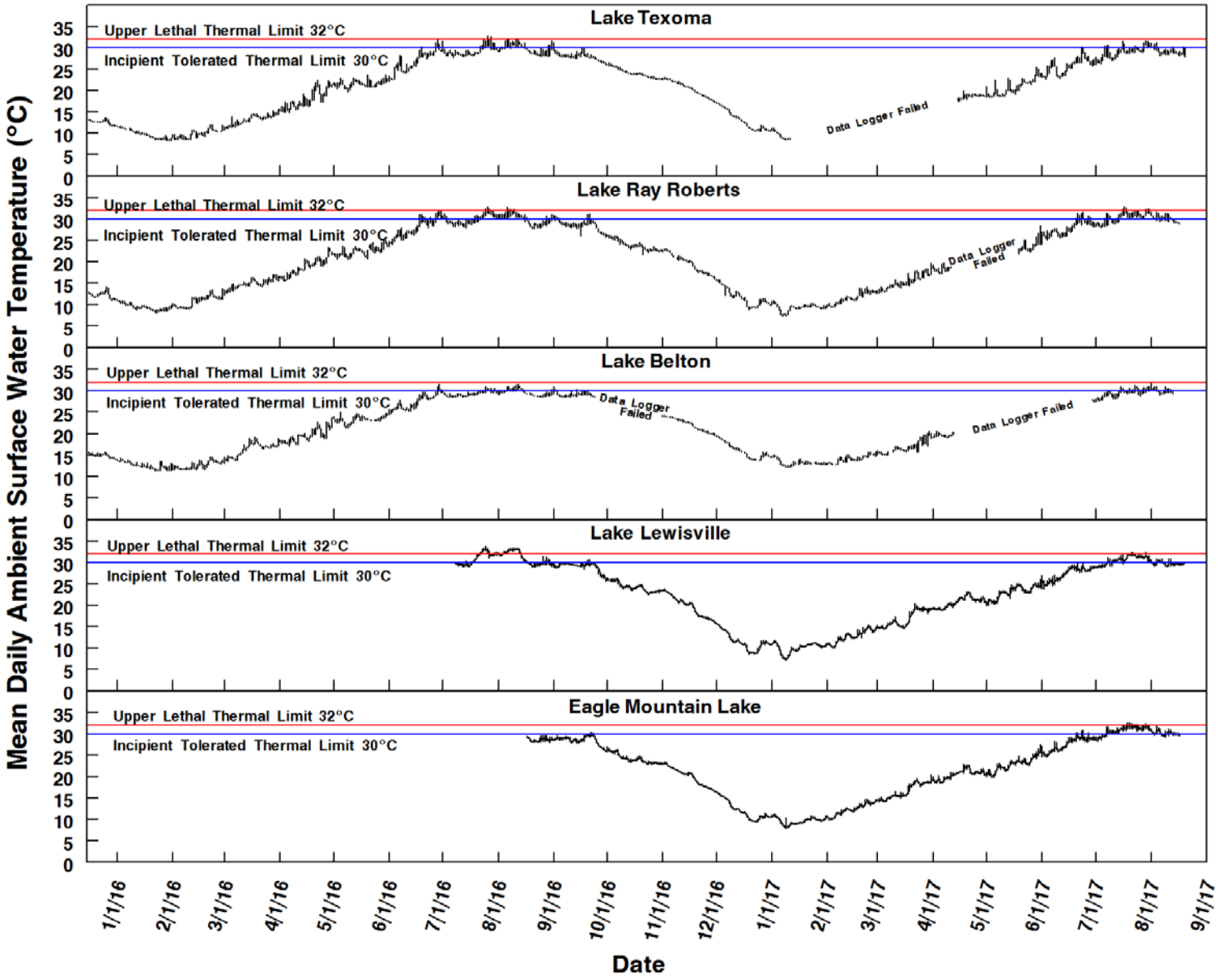
- pH remained above 7.4 considered suitable for establishment of a sustainable zebra mussel population at Lakes Texoma, Belton, Eagle Mountain and Lewisville
- pH fell below 7.4 at Lake Ray Roberts in October 2016 and generally remained <7.4 until last sampled in August 2017
- Surface water oxygen concentration as % of full air O_2 saturation remained above the incipient lower lethal limit of 30% for zebra mussels throughout the sampling period at Lakes Texoma, Ray Roberts, Lewisville and Eagle Mountain
- Surface water O_2 concentration fell to 15.1% of full air saturation at Lake Belton on 09/25/2016 well below the 30% considered to be the incipient lower lethal limit for zebra mussels.


Settlement
Monitor
Data Logger
Brick Weight

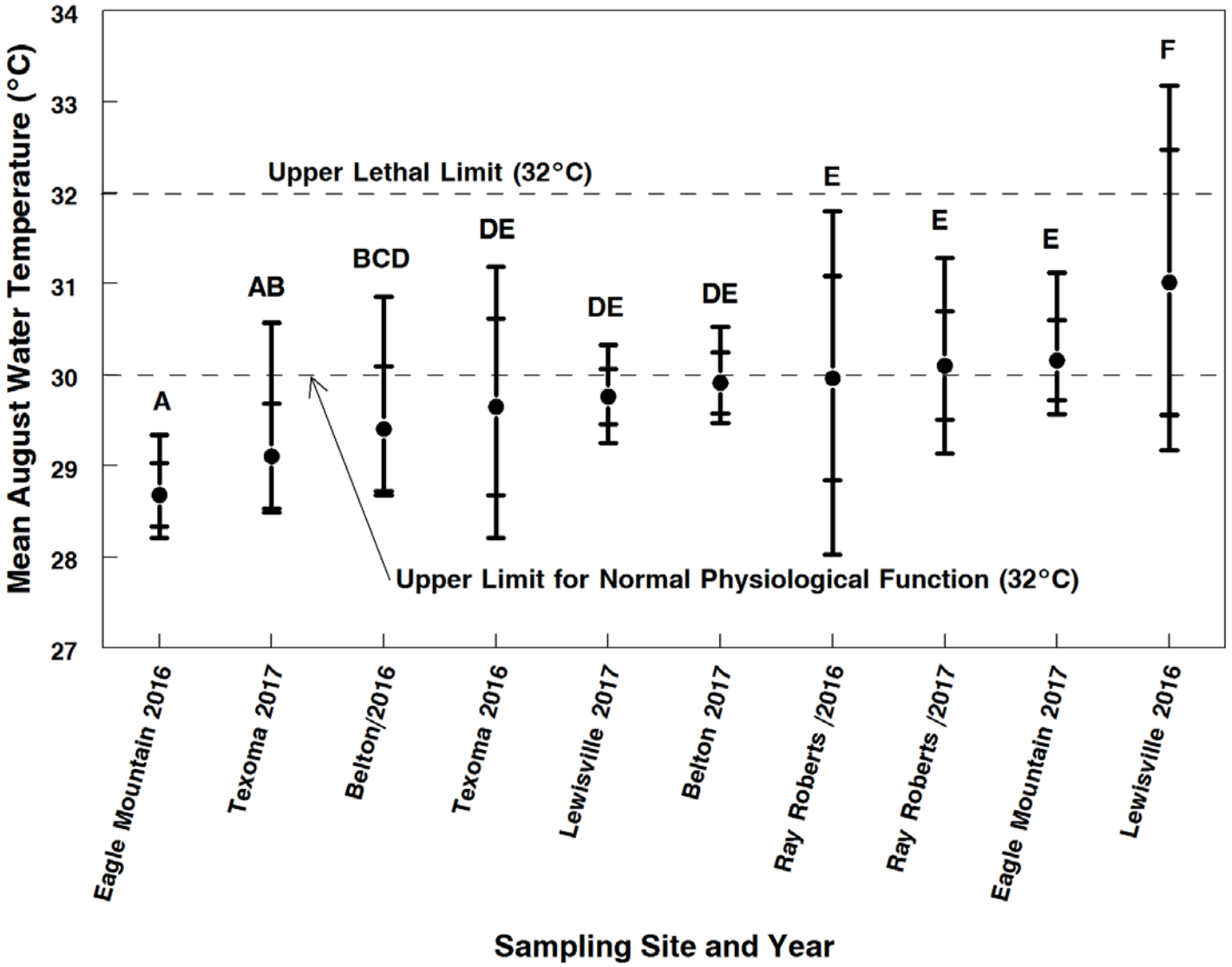

Mussel Infested Brick Weight

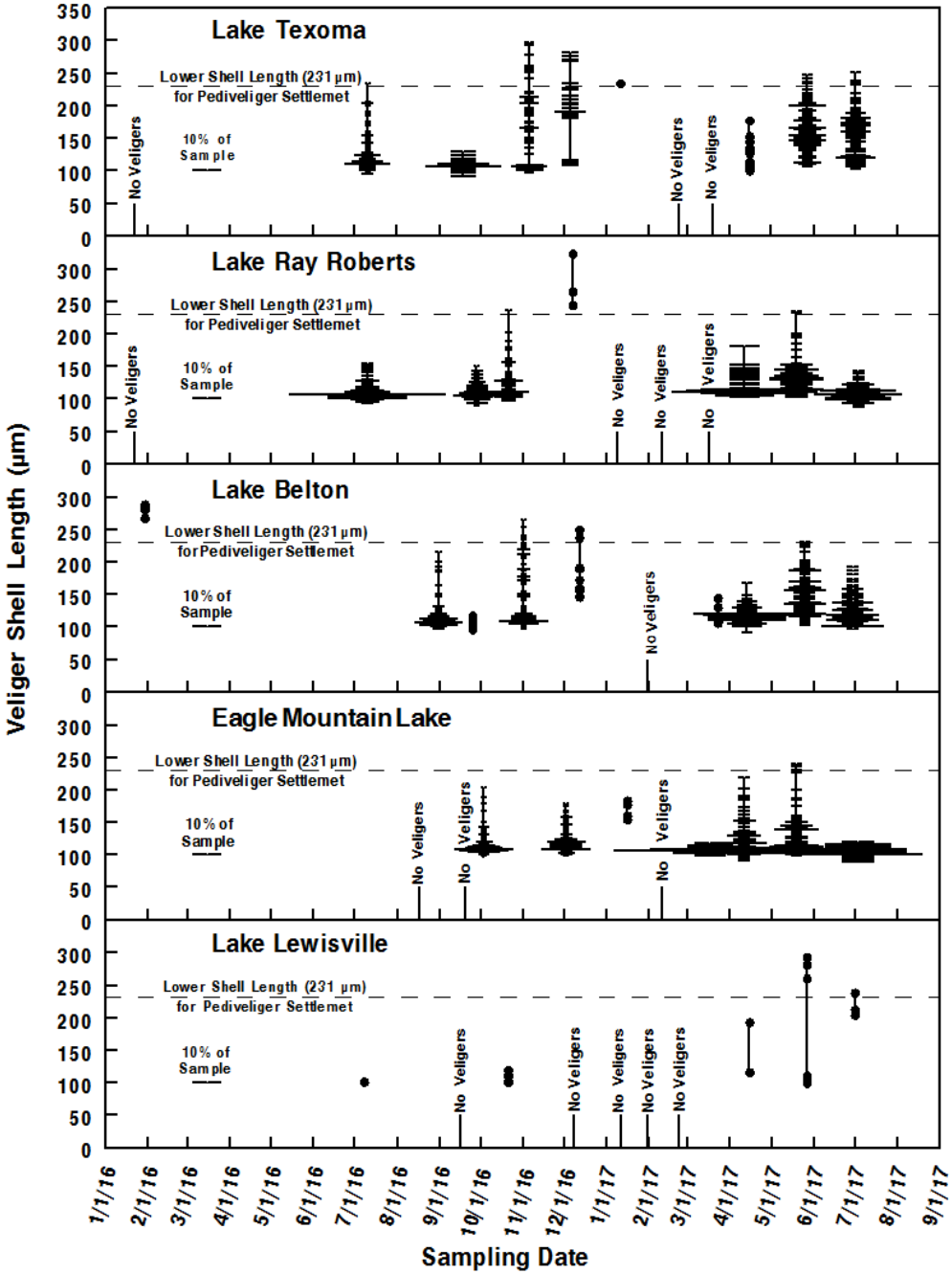

Hobo
Temperature
Data Logger

Daily mean surface water temperatures at sampled lakes



August monthly mean of daily mean surface water temperatures with standard deviation and range in 2016 and 2017

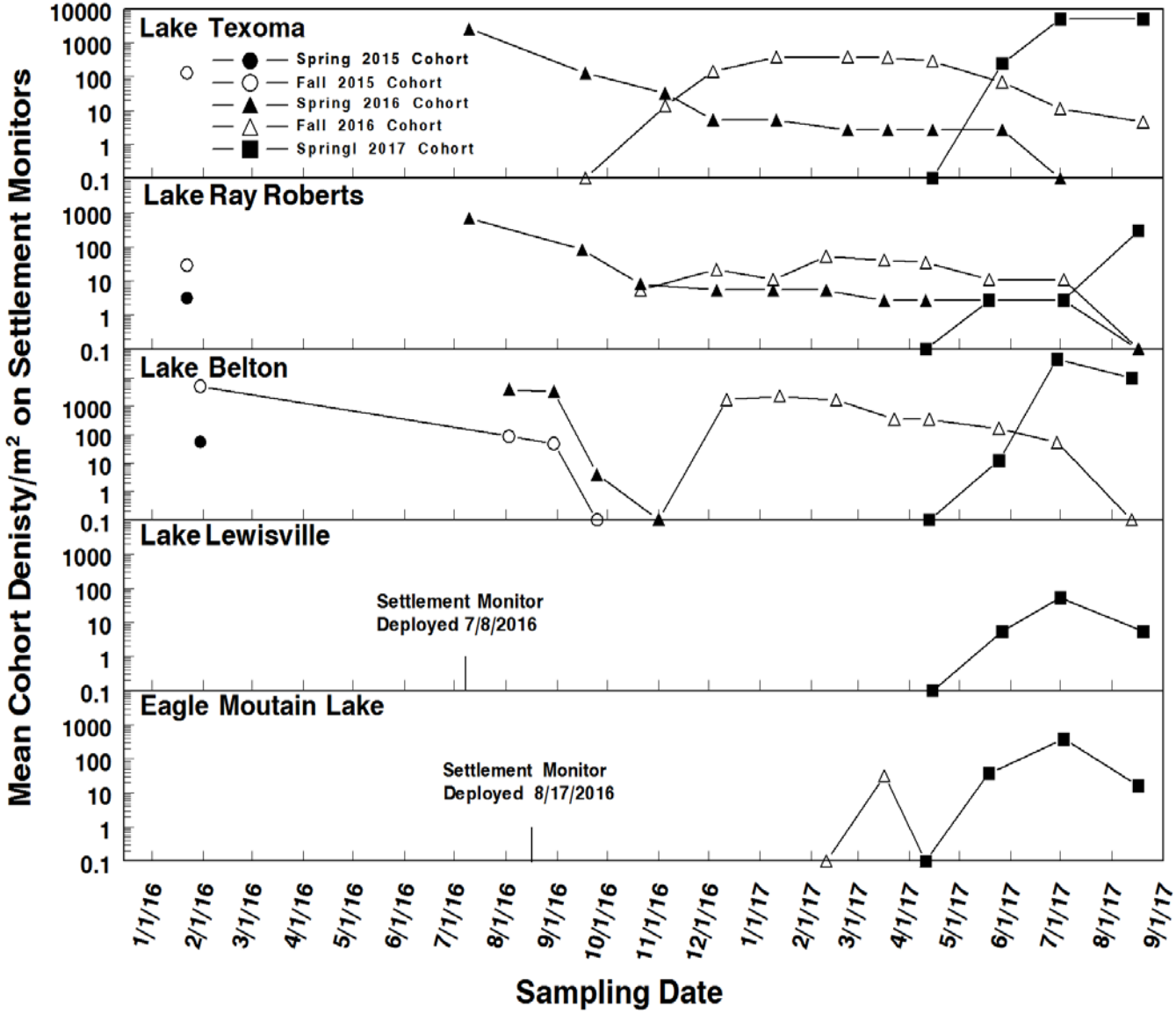




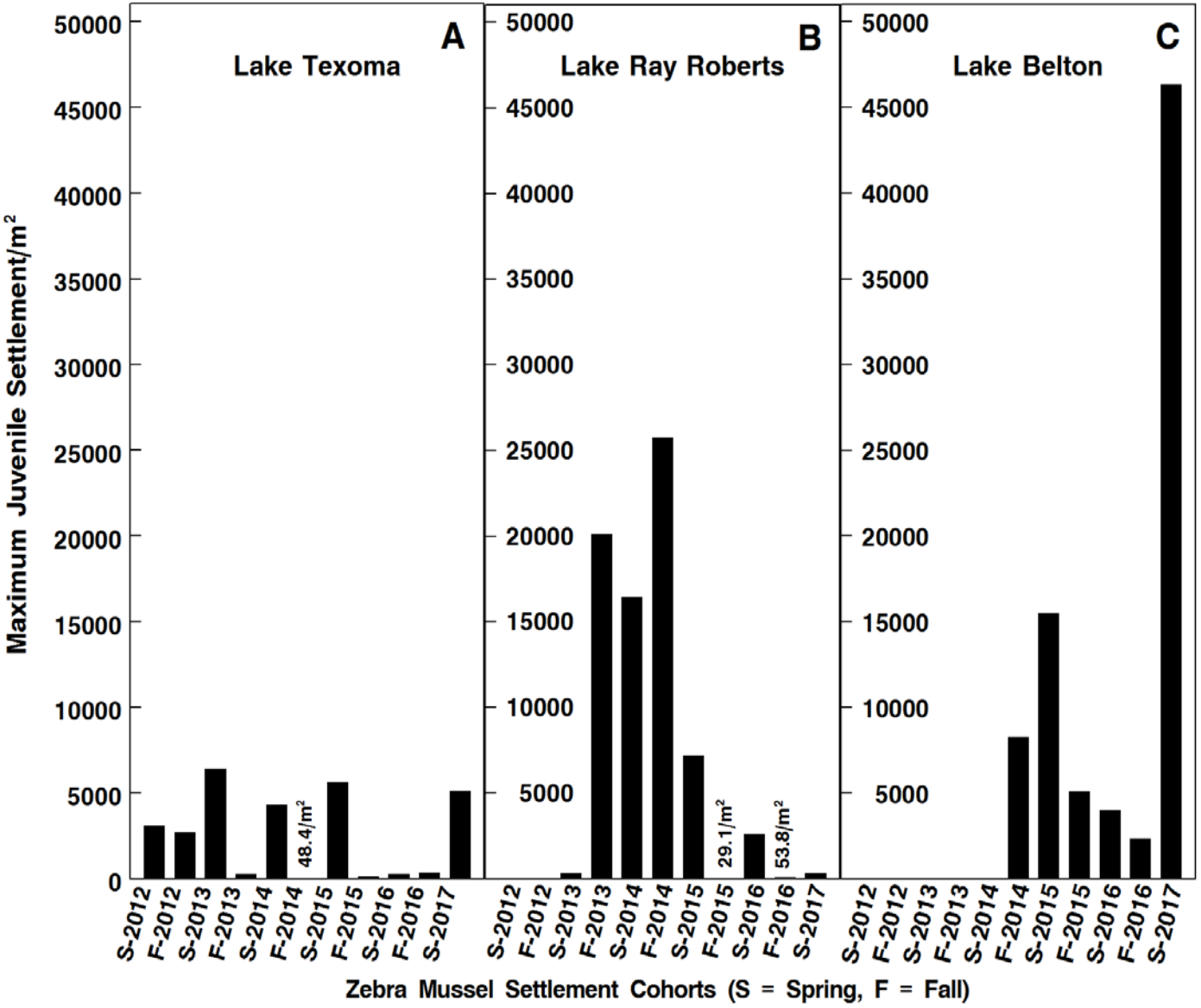
Veliger shell length (SL) distributions (n ≥100 if available in sample)

- Two distinct spawning periods: spring-early summer and fall-early winter
- Where <10 veligers occur in samples their SLs are indicated by points
- Settlement-competent pediveligers (SL ≥231 µm) occur in plankton samples 1-2 months after the first appearance of veligers
- Initiation of juvenile mussel settlement occurred coincidentally with or one month after first appearance of settlement-competent pediveligers in the plankton
- Examination of routine plankton samples for presence of pediveligers could be used to determine periods of juvenile settlement and molluscicide application to prevent mussel macrofouling

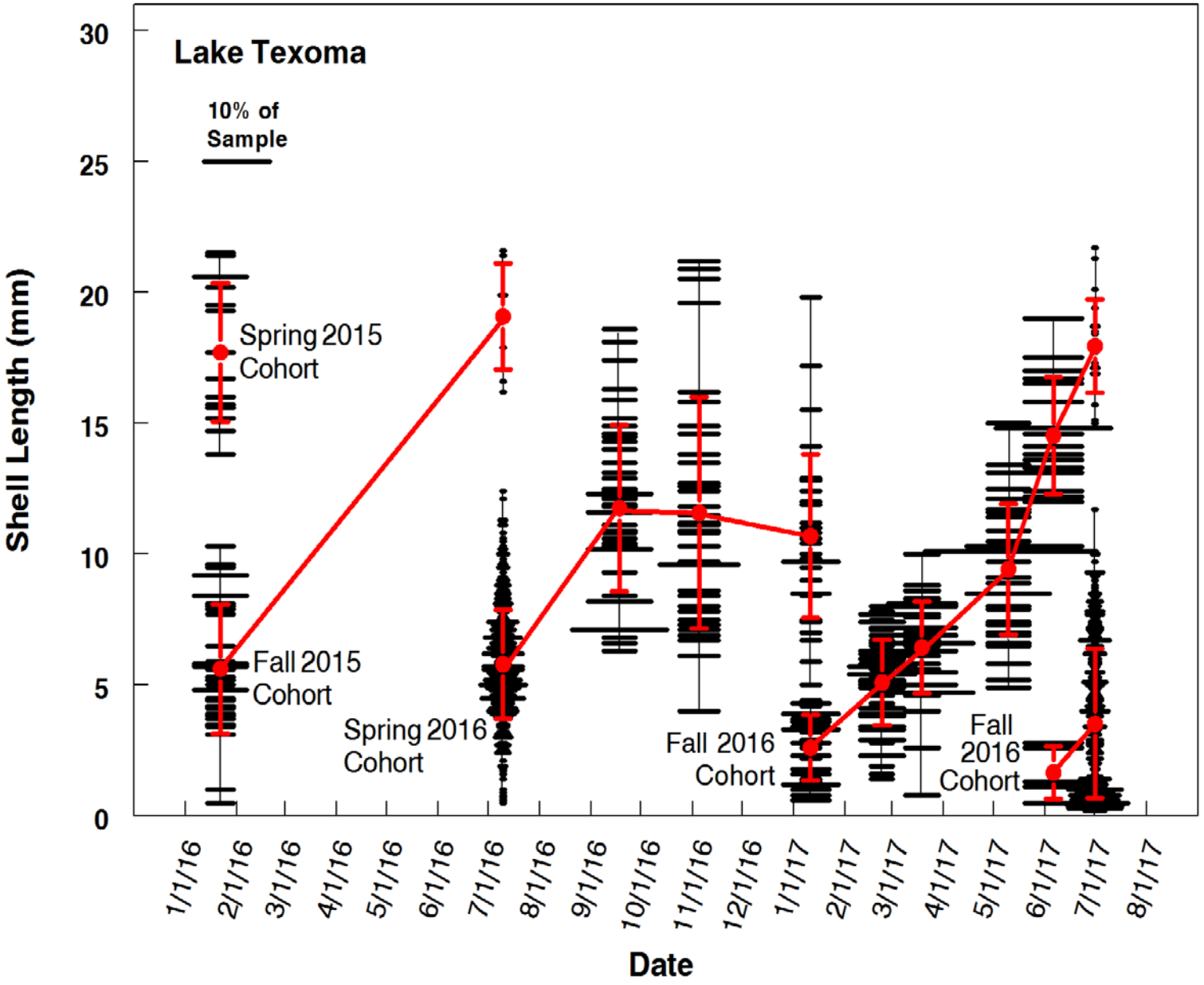
Densities of annual spring and fall juvenile mussel cohorts on settlement monitors



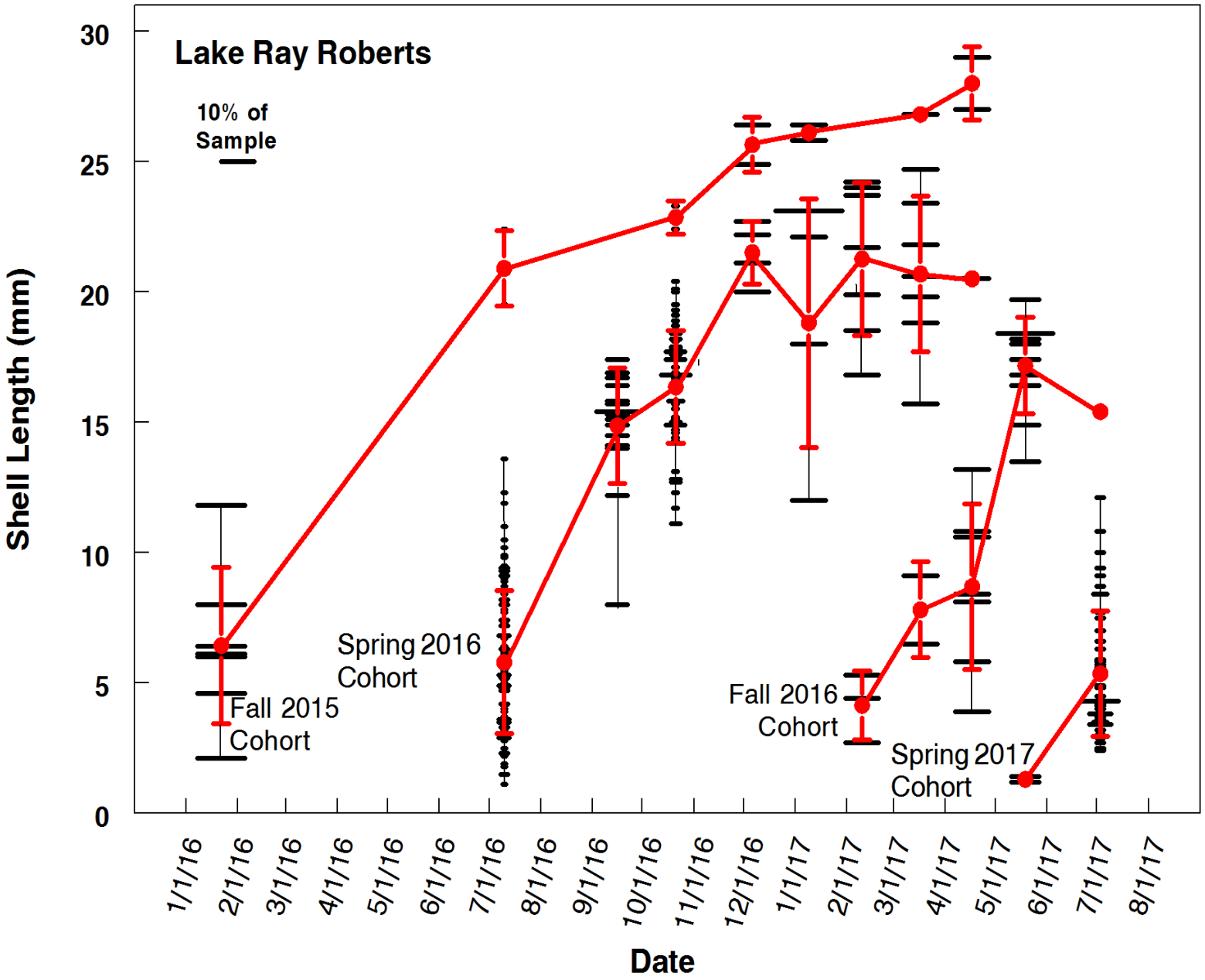
Peak annual spring (S) and fall (F) juvenile mussel cohort settlement densities in Lakes Texoma, Ray Roberts and Belton



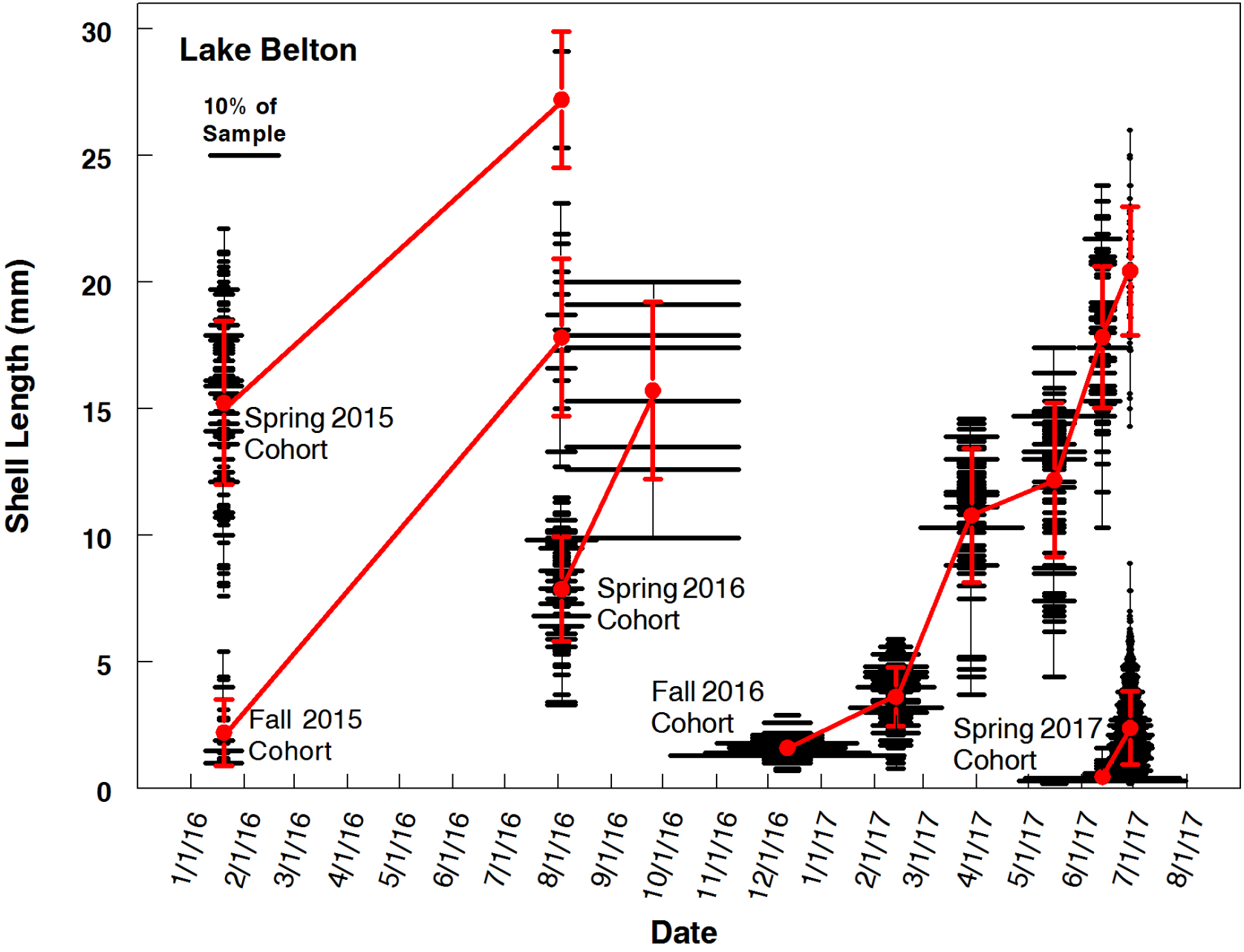
Spring and fall cohort growth rates and life spans in Lake Texoma



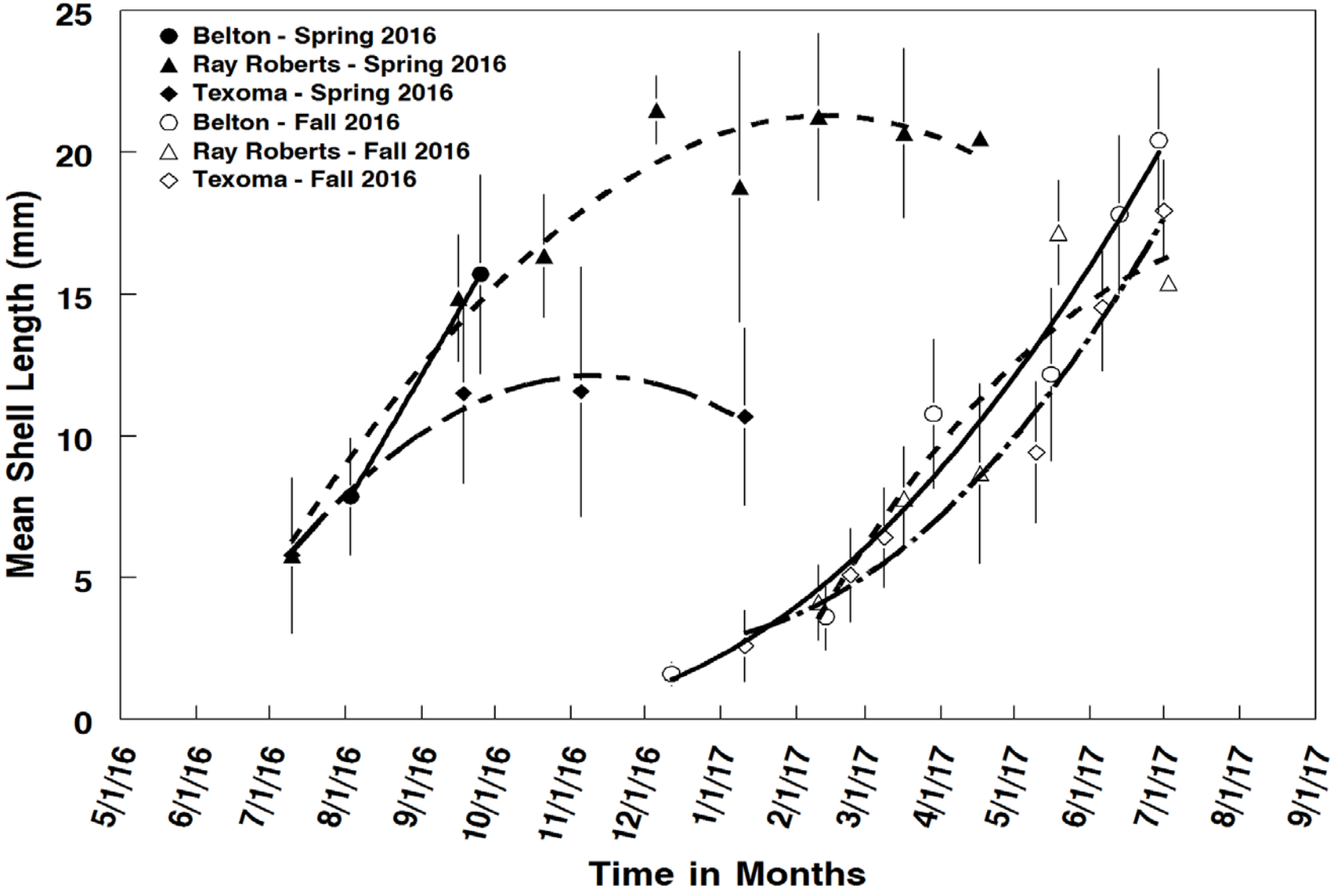
Spring and fall cohort growth rates and life spans in Lake Ray Roberts



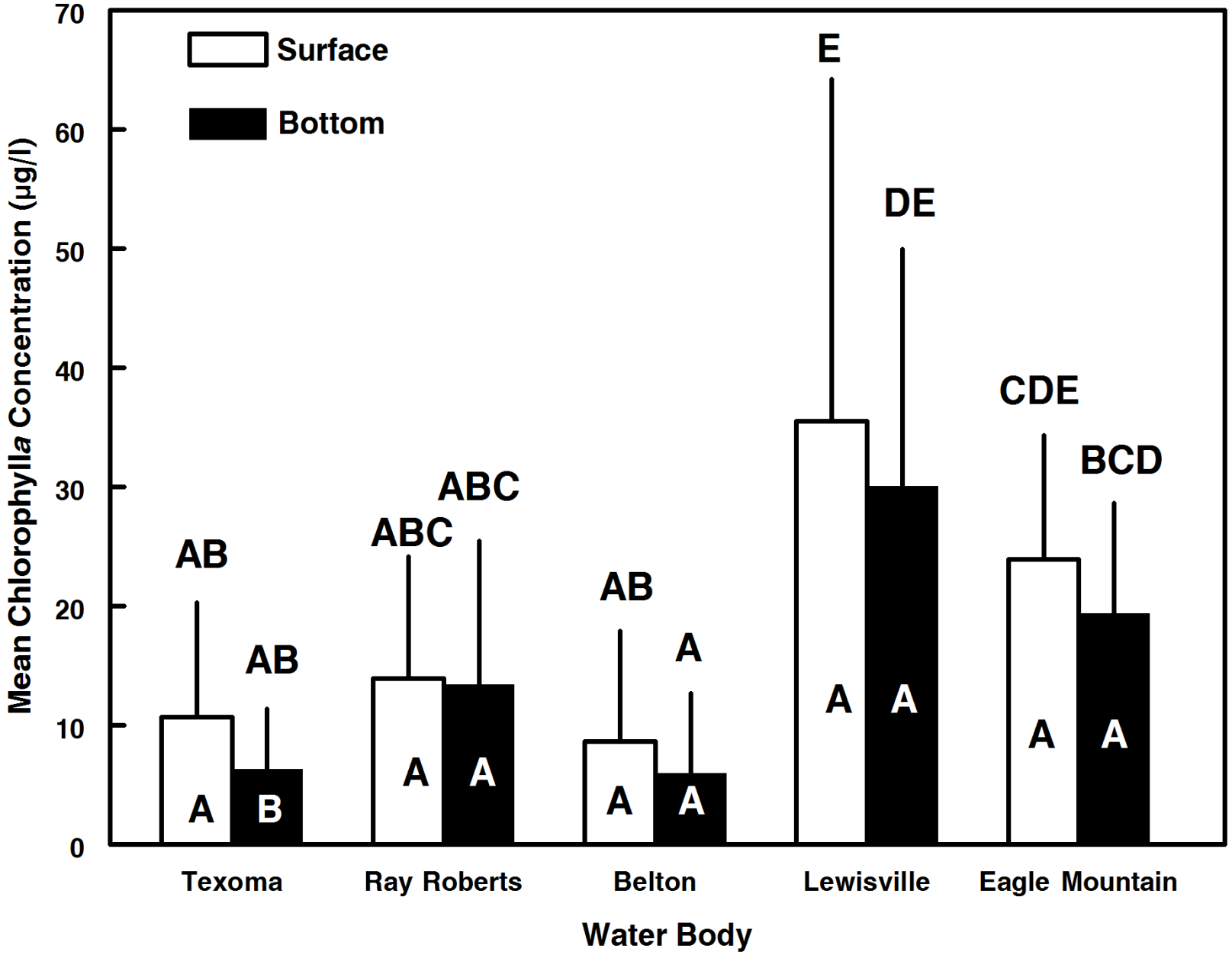
Spring and fall cohort growth rates and life spans in Lake Belton



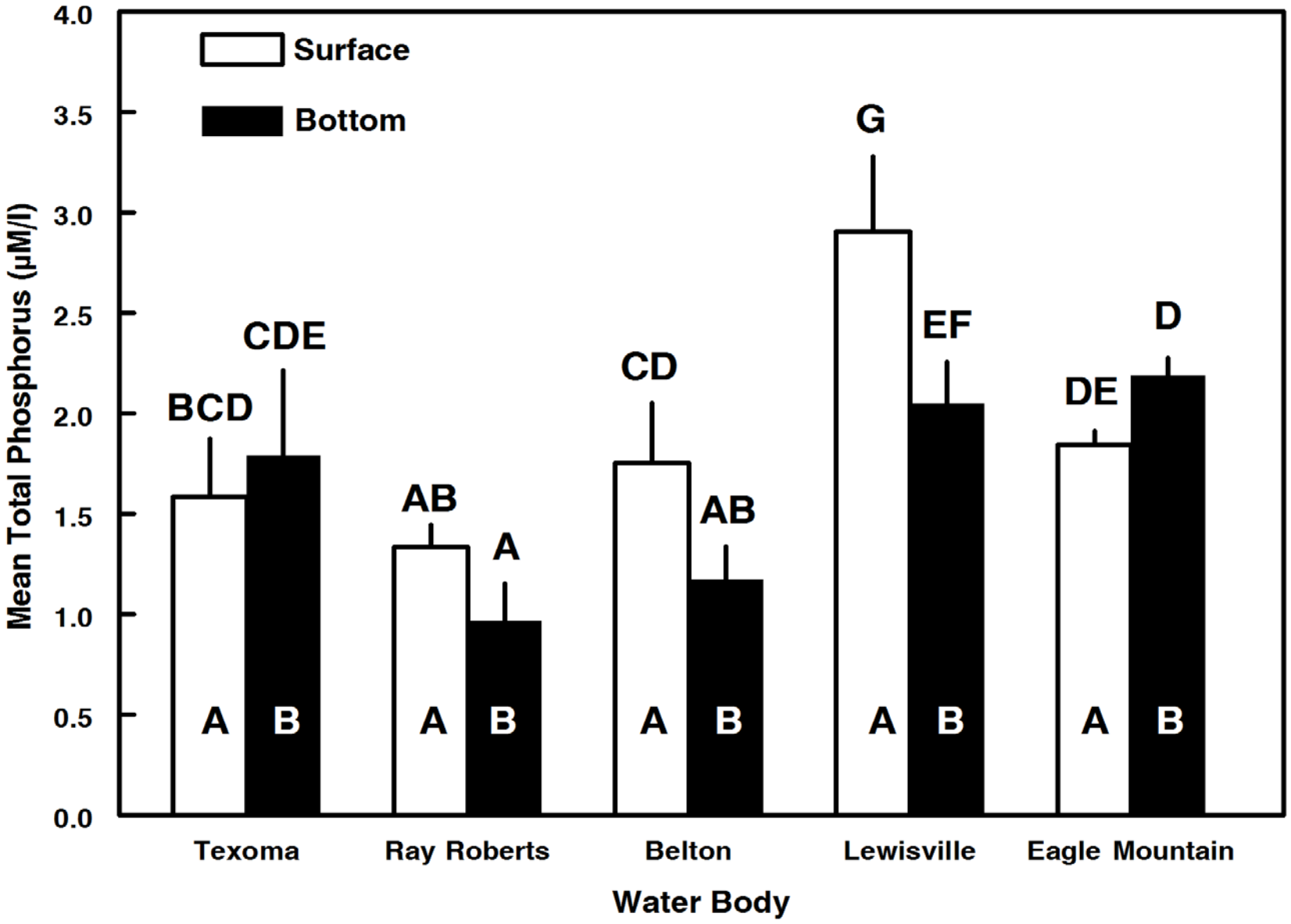
Comparison of spring and fall 2016 cohort growth rates and life spans in all three lakes

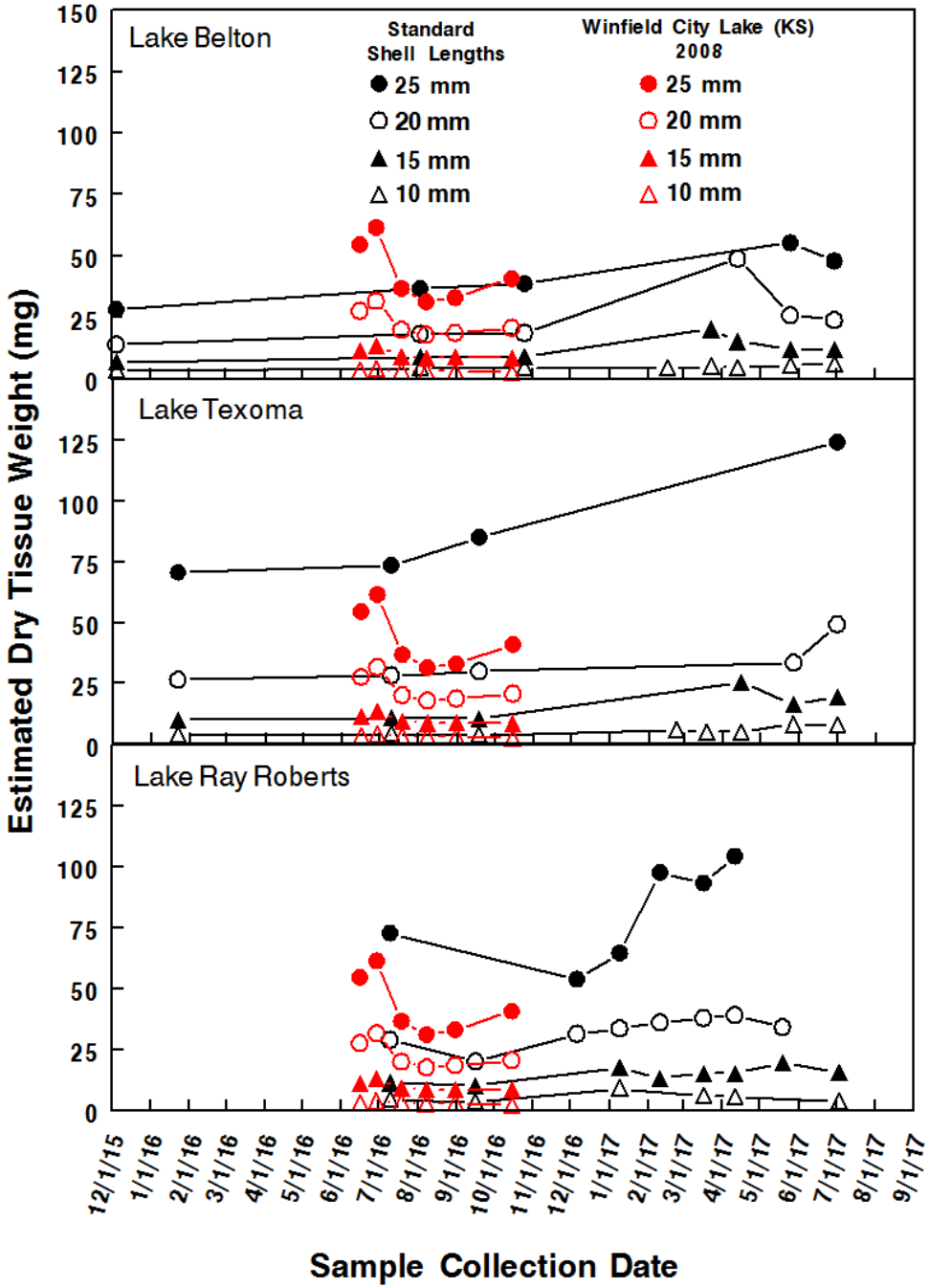


Overall Mean surface and benthic chlorophyll *a* concentrations



Overall mean surface and benthic total phosphorous concentrations

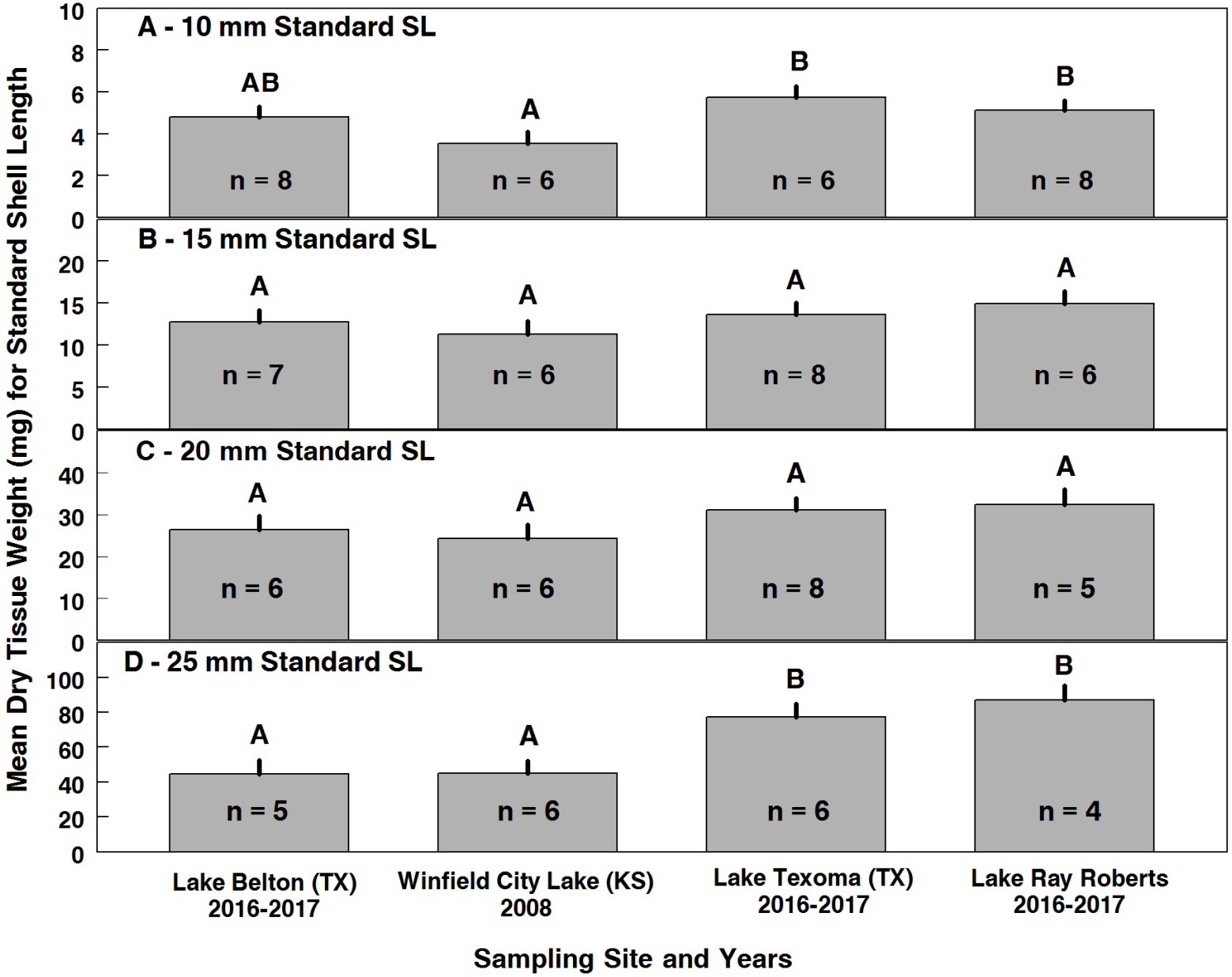




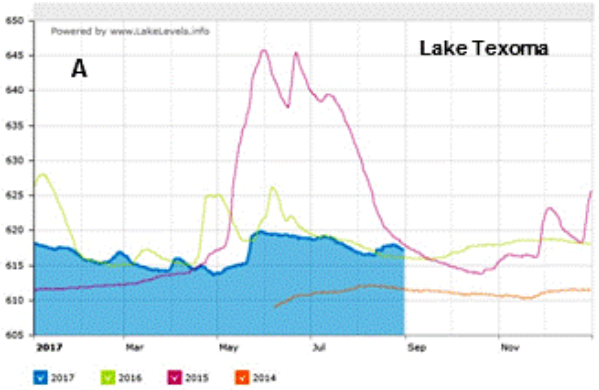
Estimated dry tissue weights for standard individuals with 10, 15, 20 or 25 mm shell lengths

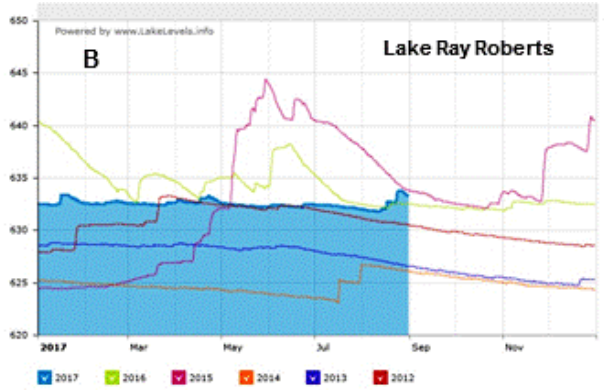
- Dissolved shell in 15% nitric acid and dried tissues at 65°C after removal of periostracum and byssus
- ≥50 individuals ranging from ≥8 mm in shell length to largest individuals in sample
- Data fitted to a semi-log regression of SL length (X) versus Log_{10} dry tissue weight (Y) from which dry tissue weights (mg) were estimated for individuals with SLs of 10, 15, 20 or 25 mm at each sampling date
- Also show in red is data from 2008 for a mussel population in Winfield City Lake southern Kansas at the height of its population density two years after invasion
- Note tendency for mussels to lose DTW in summer months and regain it over fall, winter and spring

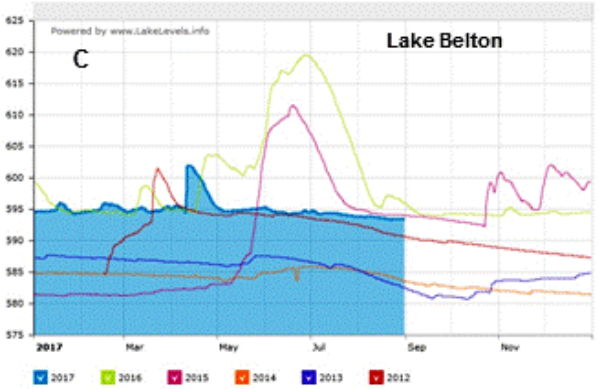
Overall mean standard mussel dry tissue weights

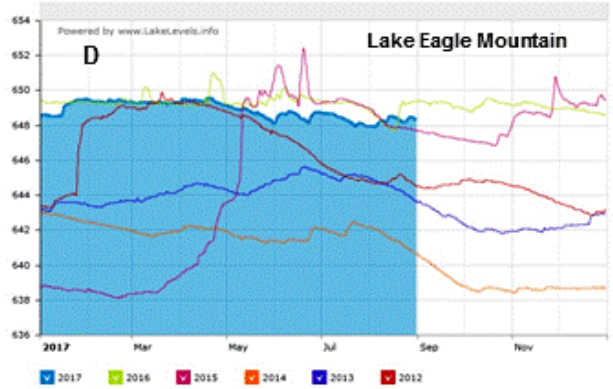


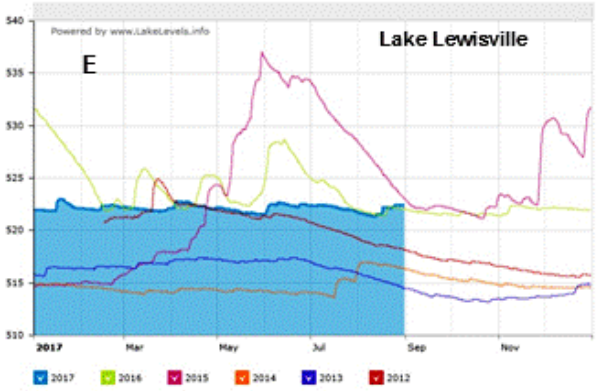
Can lake level variation impact zebra mussel population dynamics?

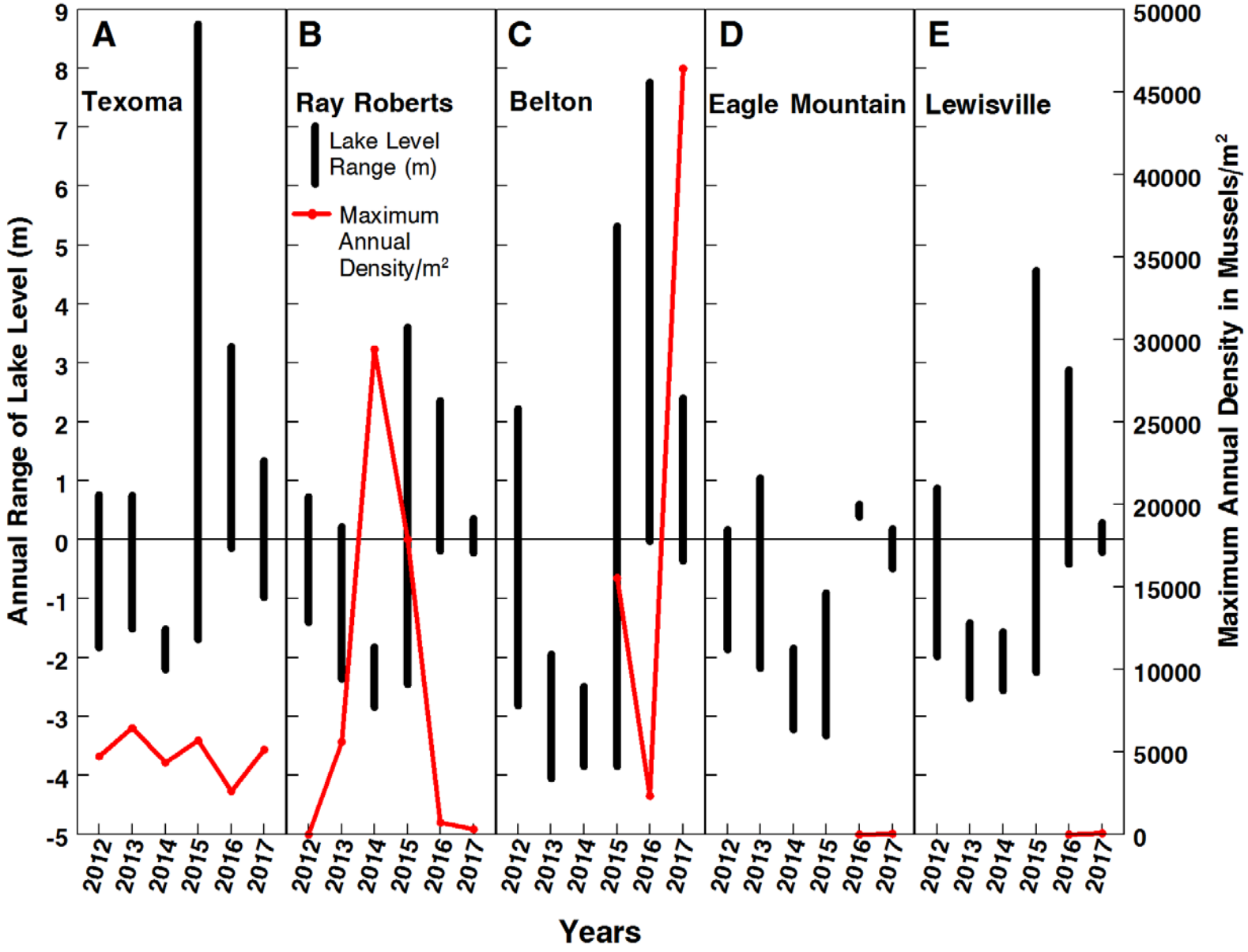











A
Texoma
B
Ray Roberts
Lake Level Range (m)
Maximum Annual Density/m²
C
Belton
D
Eagle Mountain
E
Lewisville
Annual Range of Lake Level (m)
Maximum Annual Density in Mussels/m²
Years
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
2012
2013
2014
2015
2016
2017

Conclusions

- Zebra mussels in Texas water bodies have two spawning periods (i.e., spring and fall) leading to settlement of distinct spring and fall juvenile cohorts
- The life spans of spring cohorts are 15-16 months and fall cohorts 10-11 months
  - Spring and fall cohort life spans last until July or August of the following year
  - May be associated with elevated summer temperatures leading to lethal tissue loss.
- Juvenile mussel settlement does not occur until settlement-competent pediveligers (SL = 231 µm) are present in the plankton 1-2 months after the initiation of spawning periods
  - Molluscicide treatments can be coordinated with pediveliger presence
- Exposure to severe hypoxia (Lake Belton) and prolonged exposure to low pH (<7.4, Lake Ray Roberts) can lead to major reductions in zebra mussel densities
- Summer surface water temperatures in shallow Texas water bodies (<10 m max. depth) can exceed the zebra mussel's incipient upper thermal limit of 32°C making them resistant to mussel invasion compared to deeper lakes with cooler surface waters.
- Lakes with established mussel populations (Texoma, Ray Roberts, Belton) tended to have lower chlorophyll *a* and total phosphate concentrations than newly invaded lakes (Lewisville, Eagle Mountain) suggesting that mussel filter feeding can lower primary productivity and energy flow to higher trophic levels
- Extensive annual water level variation appears to cause major reductions in mussel populations creating boom-bust mussel population cycles.
  - Mussel populations can recover from major density reductions within 2-3 years

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- **Maria Boren**, Office Manager and the staff of the **Eisenhower Yacht Club** on Lake Texoma

- **Bill Williams**, Manager of the **Lake Ray Roberts Marina** on Lake Ray Roberts

- **Staff of Franks Marina** on Lake Belton

- **Ryan Miller**, Manager, and the staff of the **Cottonwood Creek Marina** on Lake Lewisville

- **Casey Trimble**, Harbor Master and **Brant Briggs**, General Manager, and the staff of the **Fort Worth Boat Club** on Eagle Mountain Lake