A survey of native freshwater mussels affected by the 2017 winter drawdown of Lake Austin, Texas.

SR-18-09, December 2018

Liz Johnston, City of Austin, Watershed Protection Department, 505 Barton Springs Dr.
liz.johnston@austintexas.gov

Todd Jackson, City of Austin, Watershed Protection Department, 505 Barton Springs Dr.
todd.jackson@austintexas.gov

Abstract

Frequent winter drawdowns of Lake Austin lower the level of the reservoir twelve feet below normal pool elevation. These drawdowns have been implemented as a reservoir management tool since the 1950s to allow homeowners to more easily maintain docks and to control aquatic invasive plants such as Eurasian milfoil. Drawdowns have historically occurred as frequently as every one- to two-years when hydrologic conditions have allowed them. The population and distribution of Unionids (native freshwater bivalves) in Lake Austin have not been well characterized, and therefore the impacts of drawdowns on native mussel populations have not been systematically documented. In 2011, City of Austin (CoA) Watershed Protection Department (WPD) biologists surveyed 26 sites and found mussels composed of two species that were alive or recently dead (Pyganodon grandis and Utterbackia imbecilis) at 15 sites, suggesting that the extant mussel population within Lake Austin was sparse and lacked diversity. After a six-year hiatus in drawdowns, Lake Austin was lowered ten feet for 42 days beginning in early January 2017. During this drawdown period, WPD biologists replicated the original survey at 23 of the same or similar sites as the 2011 survey. Researchers discovered more individuals and a greater diversity of species at more of the survey sites than during the 2011 survey. Results from this work suggest that the population of freshwater mussels in Lake Austin may have expanded in both numbers and diversity during the 5-year period with no drawdown and was likely negatively affected by frequent drawdowns in the past. Future monitoring of the mussel populations under varying drawdown regimes would be necessary in order to confirm this hypothesis.

Introduction

Freshwater mussels were once abundant in Texas, including the Colorado River, but they have experienced declines over the past century starting with harvesting for use in the clothing button industry in the early 1900s and continuing into the present as contributing watersheds have developed.

The construction of dams has been identified as a primary stressor for Unionid populations due to subsequent changes in hydrology, water temperature, fishery, and increased presence of invasive species (Howells et al. 1996). Typically, the species of Unionids that are tolerant of reservoir hydrology differ significantly from riverine species that require flowing water and fish hosts adapted to rivers.

Lake Austin, the primary source of drinking water for the City of Austin, Texas, is a 1,599-acre flow-through reservoir located at the bottom of the chain of Highland Lakes on the Colorado River in Texas. Lake Austin demonstrates many management concerns that are typical for reservoirs, including dominance of invasive macrophytes, bank erosion, disconnection of the shoreline, hard-armoring of the bank, frequent algae blooms, degraded macroinvertebrate communities, and lack of quality shoreline habitat. (USEPA 2012; Austin Lakes Index Report)

Winter drawdowns have historically been used to control nuisance aquatic macrophytes, particularly Eurasian milfoil (*Myriophyllum spicatum*) and Hydrilla (*Hydrilla verticillata)* (Texas Parks and Wildlife [TPWD] 2012), and to allow lakefront property owners the opportunity to maintain docks and conduct shoreline clean-up more easily. Dewatering events have been found to cause negative impacts to native mussel populations in both reservoir (Samad and Stanley 1986; Howells et al. 2000; Burlakova and Karatayev 2007) and riverine (Newton et al. 2015) systems. In Lake Austin between the years of 1976 and 2017, there were 18 years when the reservoir level was drawn down during the months of January and February (see Fig 1). Of note, there was a five-year period (2001-2005) when twelve-foot drawdowns occurred annually during the winter months. However, following those years of annual drawdowns, no drawdowns occurred between the years of 2012 and 2017. This hiatus was primarily due to water conservation during drought conditions within the Highland Lakes region, but also because of the lack of need to control nuisance aquatic plants, which were adequately controlled through the introduction of triploid grass carp starting in 2013 (TPWD 2012). Although the presence of triploid grass carp and their control of nuisance aquatic plants persists, in 2017 a drawdown of ten feet occurred beginning January 2, 2017, with the reservoir completely full by February 13, 2017. Reasons for the drawdown included an upcoming multi-year gate maintenance project of the Tom Miller Dam by the Lower Colorado River Authority (LCRA) during which time no drawdowns were allowed.

Winter drawdowns are a potential stressor for mussel populations due to the extended period of desiccation (up to six weeks), the high likelihood of freezing temperatures within the drawdown period, and increased predation. Because of the ecosystem services provided by mussels, such as the filtration of particulates and added stabilization of stream beds (Vaughn et al 2004), as well as lack of historic success by others to re-establish breeding populations once they have been extirpated in a river basin (Hoftyzer et al 2008), reservoir managers should consider their protection when formulating policy decisions related to scheduled drawdowns. However, prior to this study, it was not known whether Lake Austin contained a significant population of Unionids so they were not a factor in drawdown policy.

During the preceding winter drawdown of 2011, City of Austin (CoA) biologists conducted a visual survey for the presence of freshwater mussels at 26 sites along the shoreline of Lake Austin (Fig. 2). The results of the 2011 study did not suggest that mussels were of significant abundance within the reservoir. To verify the results of the 2011 survey, in 2017 staff conducted a similar survey at 23 sites (Fig. 3). The primary purpose of the study was to confirm whether the same species were present in similar abundance in 2017 as were found in 2011. A secondary goal of the survey was to characterize the habitat where mussels might be found within the reservoir to better gauge whether the impacts of

development, such as dredging, shoreline stabilization projects, and boat dock construction, might affect mussel populations.

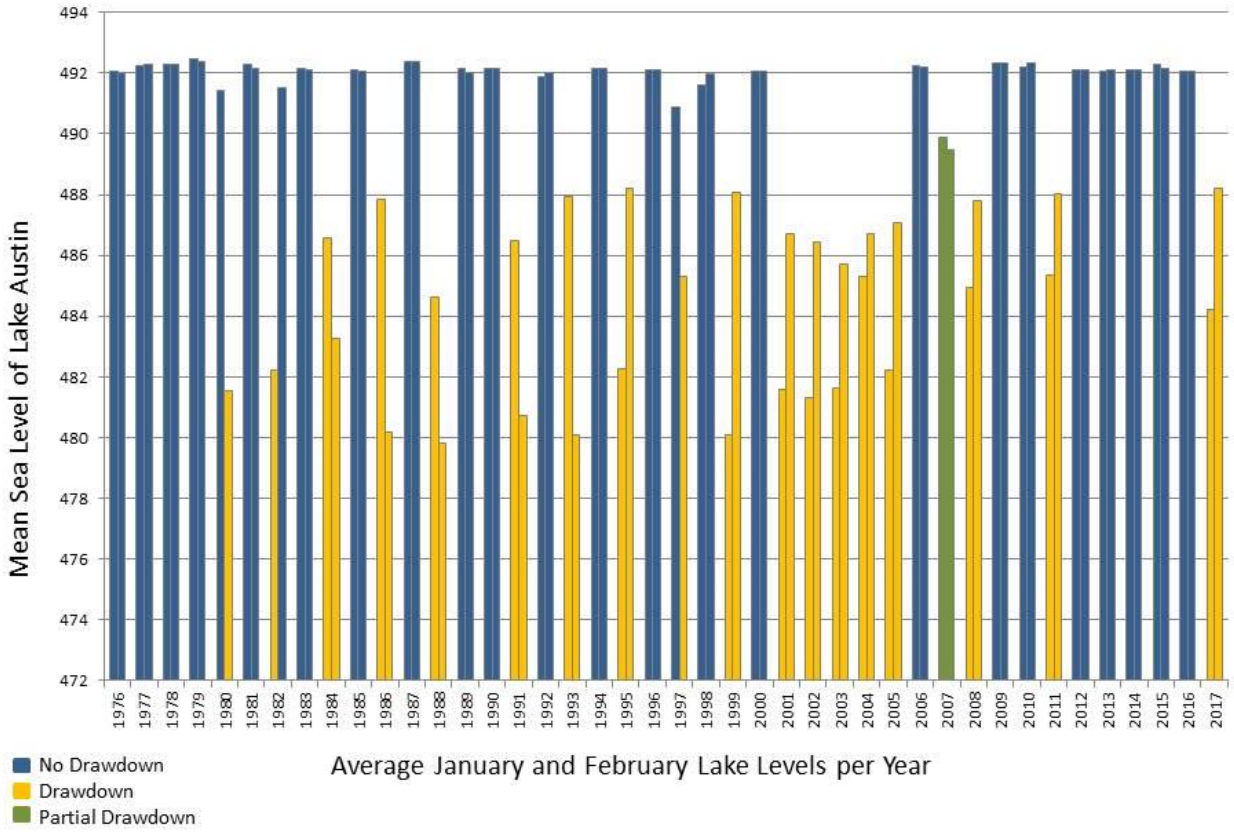

Figure 1. Average monthly mean sea level (msl) of Lake Austin during January and February between years 1976-2017. Drawdowns occurred during the years when the lake levels were on average lower than the typical 492.0' msl-492.8' msl operating level. Data provided by the Lower Colorado River Authority, Austin, Texas.

Methods

Survey sites were divided into three habitat types: main channel, creek delta and backwater sites. Main channel sites were selected based on previous survey locations that occurred along the main channel of the former Colorado River. Creek delta sites were those located within 500' of the confluence of a major tributary with the main channel, and backwater sites were those located greater than 500' above the tributary confluence with the main channel. All survey locations are considered within the banks of Lake Austin during normal pool elevation, which is defined as 492.8' above mean sea level. Primary substrate type (e.g., gravel, sand, silt) was also noted at each survey site. Because the project was intended to determine presence or absence of species and relative abundance, neither the size nor gravidity of the mussels were documented.

Most of the 2017 survey locations were similar to the sites that were surveyed in 2011 (Fig. 2), though there were fewer sample sites during the 2017 survey in the upper reaches of the reservoir due to time constraints and difficulties in accessing the sites (Fig. 3). Also, during the 2017 survey, an additional site (Laguna Gloria) was added to the existing Mayfield Park Taylor Slough delta due to difficulties in sampling in the deep sediment in the backwater area.

Timed visual surveys were conducted by walking multiple transects that were parallel and between the drawdown water's edge and the normal pool water's edge. Times were not standardized across survey areas. Mussels were collected by each surveyor during the pedestrian transects for identification and enumeration and to determine whether mussels were alive or dead. Difficult identifications of dead species were verified by mussel experts at the Texas Parks and Wildlife Department (TPWD). Live stranded mussels were relocated to submerged areas of the lake after being identified and counted. When partial (?) shells were collected, they were counted as 0.5 of an individual. The approximate survey area for each site was later estimated using ArcGIS ArcMap with georeferenced aerial imagery (CoA 2003 aerial imagery and Google 2017 aerial imagery).

The total number of individuals of each species collected within each sediment type and location were determined along with the amount of effort per acre.

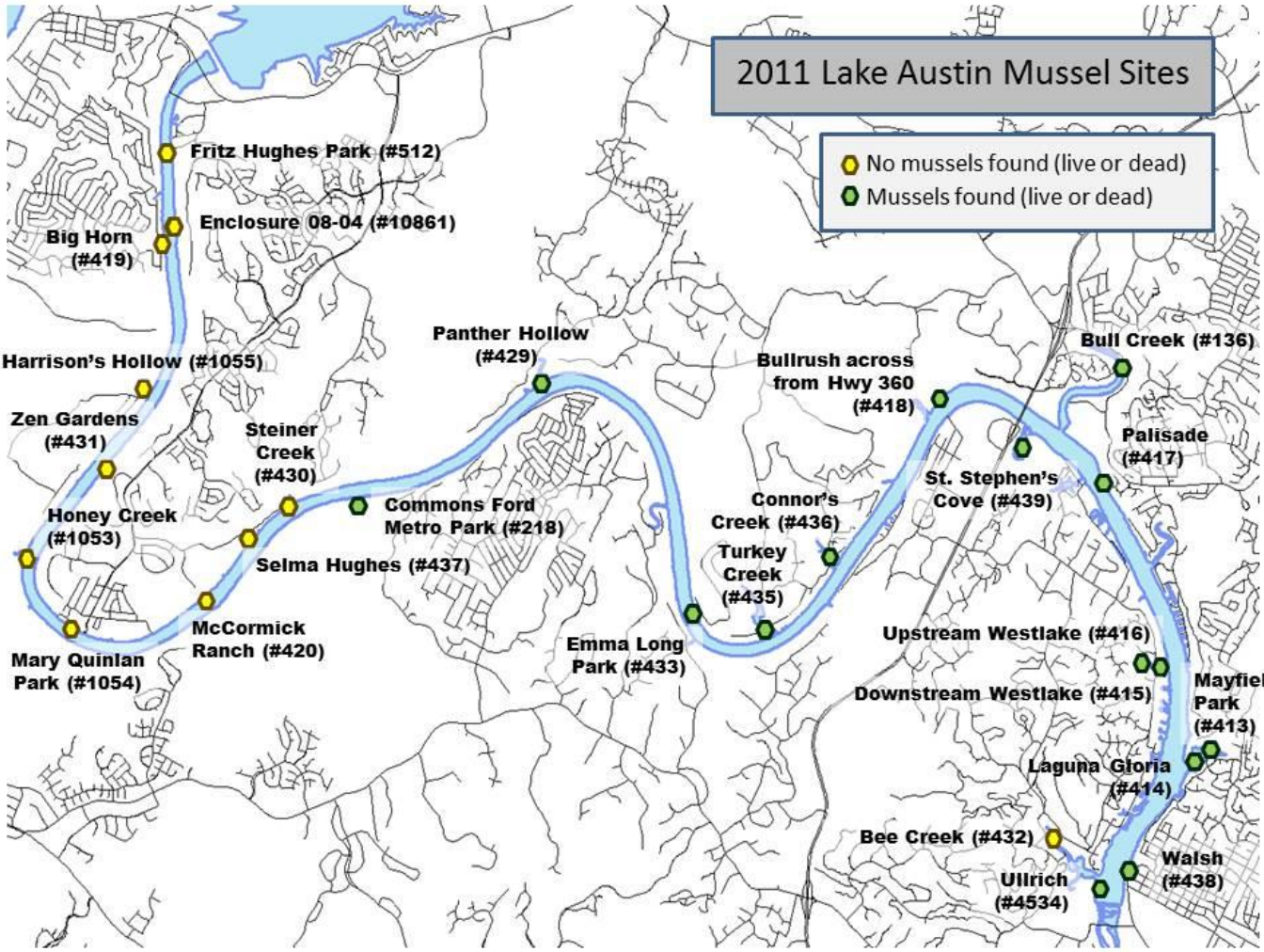

Figure 2. 2011 Drawdown Mussel Survey Sites

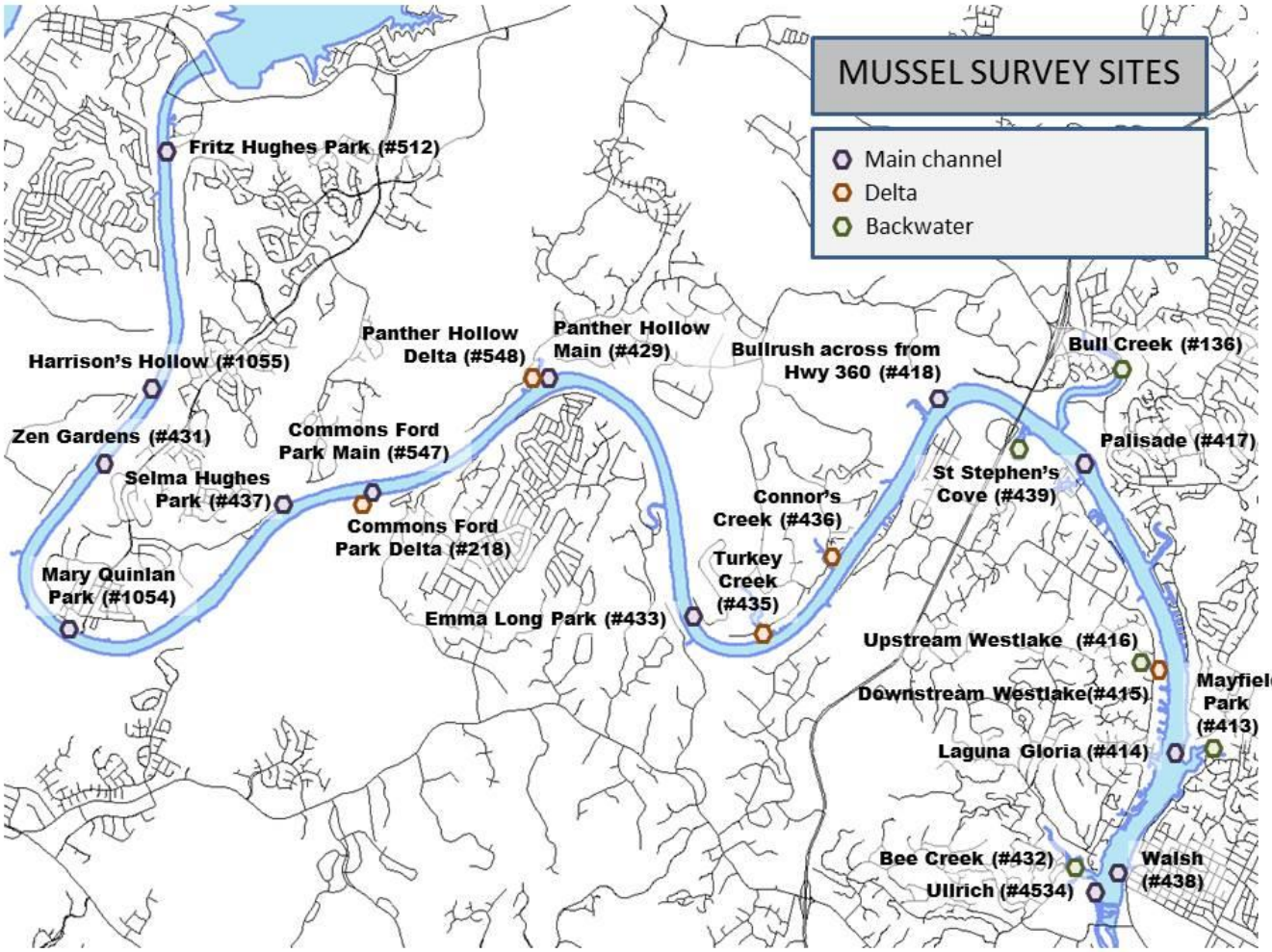

Figure 3. 2017 Drawdown Mussel Survey Sites

Results

Following a six-year hiatus from winter drawdowns, the 2017 survey provided evidence of a greater diversity of mussel species, greater number of individuals, and more survey locations inhabited by native freshwater mussels than the 2011 survey. In 2011, only 58% of the survey sites had living or dead mussels, compared with 100% of the sites in 2017. There was an increase in the total number of individuals encountered in 2017 (3,118) relative to the 2011 survey (153) as well. Of the individuals encountered in 2011, living individuals represented only two species. For comparison, in 2017, there were six species found to be living in the reservoir and, of those extant species, there were 3,118 individuals encountered. During the 2017 survey, four additional species with live or recently dead individuals were encountered within the reservoir that were not encountered in 2011: *Leptodea fragilis*, *Cyrtonaias tampicoensis*, *Quadrula apiculata*, and *Toxolasma texasiensis* (See Figure 4). Dead individuals (2,623) within the extant species were largely described as recently dead and it is assumed that dessication, along with the sub-freezing temperatures that occurred early in the drawdown, caused significant mortalities among the living individuals within the drawdown area.

The most common species encountered was *Pyganodon grandis*, followed in decreasing order by *Utterbackia imbecilis*, *Leptodea fragilis*, *Cyrtonaias tampicoensis*, *Quadrula apiculata*, and *Toxolasma texasiensis* (Fig. 4). A previous published survey that included Lake Austin did not encounter *L. fragilis*, *Q. apiculata*, or *T. texasiensis* within the Lake Austin basin (Perry et al 2010).

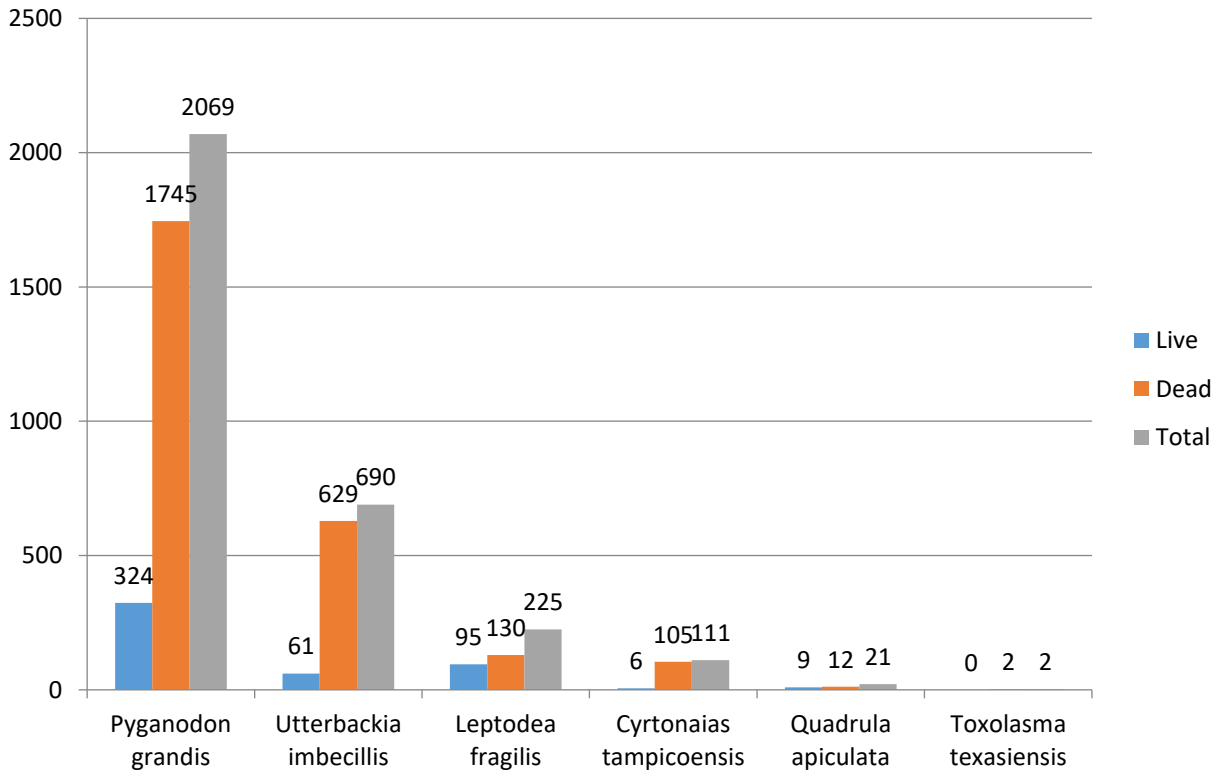

Figure 4. Total number of extant species found across all survey sites in 2017.

There were certain species including *Potamilus purpuratus*, *Lampsilis teres*, and *Quadrula houstonensis* that were only characterized as long dead or subfossil and are thus not considered to be currently extant within the reservoir.

Both substrate type and habitat type appeared to affect mussel density within a particular search area. When considering habitat type, mussel density was greater at creek delta sites (597 individuals/acre) than main channel sites (160 individuals/acre) and backwater sites (214 individuals/acre, Fig 7). Silt substrate types contained a larger density of mussels (396 mussels/acre) than either sand (179 mussels/acre) or gravel habitat types (161 individuals /acre, Fig 8). It is unclear what the reasons for differences in relative densities are for either substrate type or habitat type. However, one potential reason for differences between habitat types might be the recreational use common within the main body of the lake. The intense wake-generating boat use (i.e. wake-surfing and wake-boarding) within the main channel of the lake is likely to generate habitat characteristics that differ from areas of the lake within sloughs that experience fewer wakes and contain finer sediments.

Generally, mussel density for main channel sites remained relatively similar for the upper two thirds of the basin and averaged 34 individuals per acre, but density increased throughout the lower third,

reaching a high point of greater than 600 individuals per acre at the furthest downstream site downstream of the Ullrich Water Treatment Plant intake facility (Fig 5). This downriver increase in mussel density was caused almost entirely by the increase in *P. grandis* density (Fig. 6).

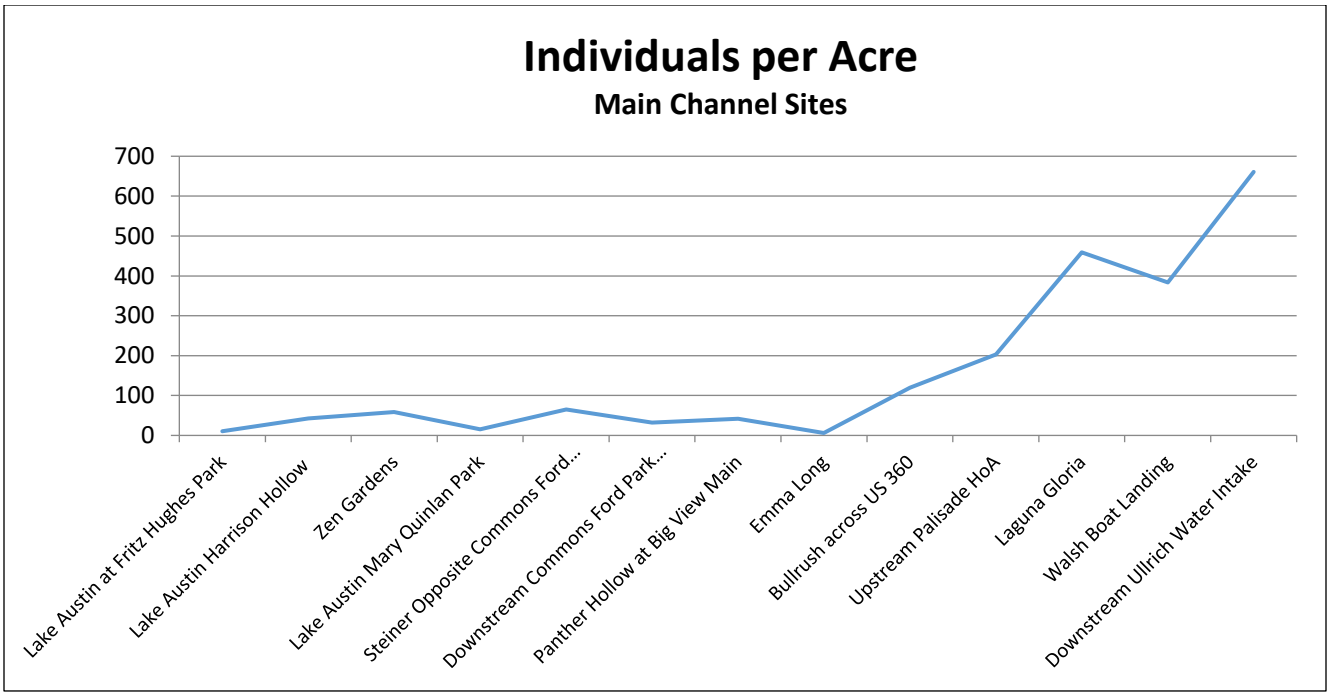

Figure 5. Mussel density (individuals/acre) by location within the basin. Main Channel survey sites are represented linearly from most upstream sites on the left and most downstream sites on the right.

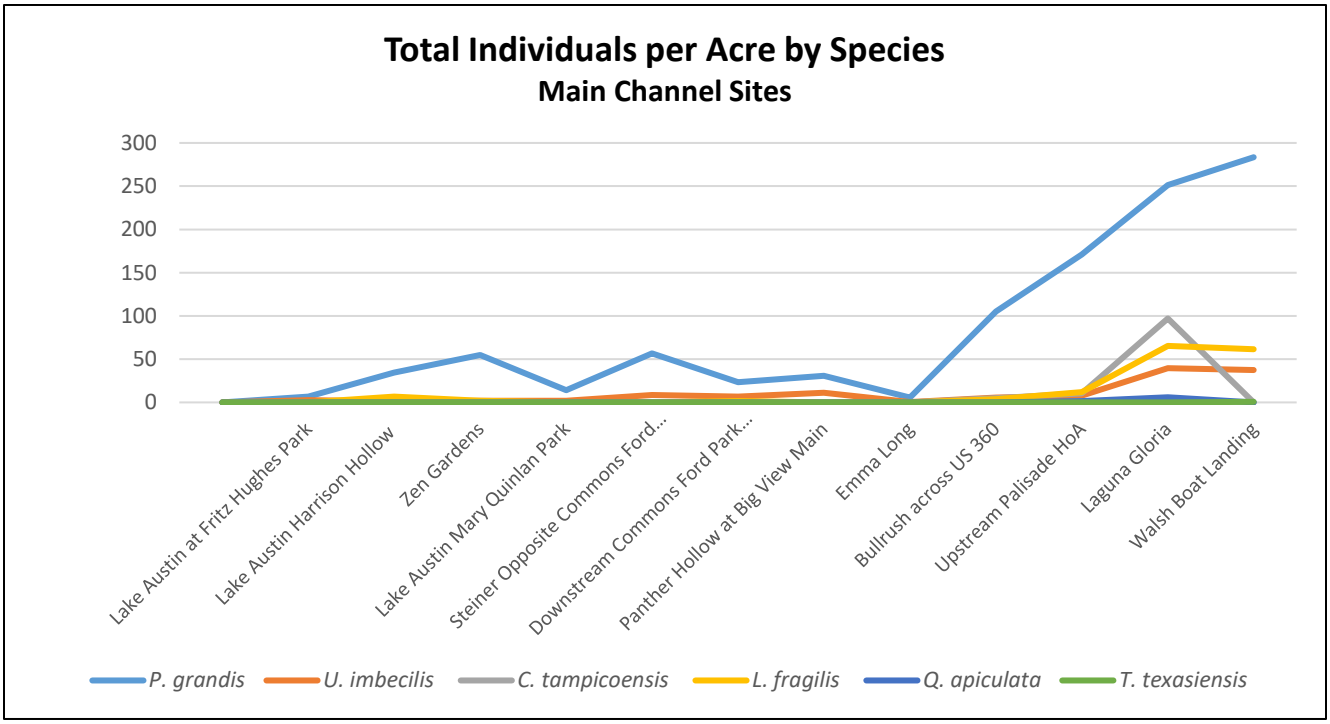

Figure 6. Mussel density (individuals/acre) by location within the basin by species. Main Channel survey sites are represented linearly from most upstream sites on the left and most downstream sites on the left.

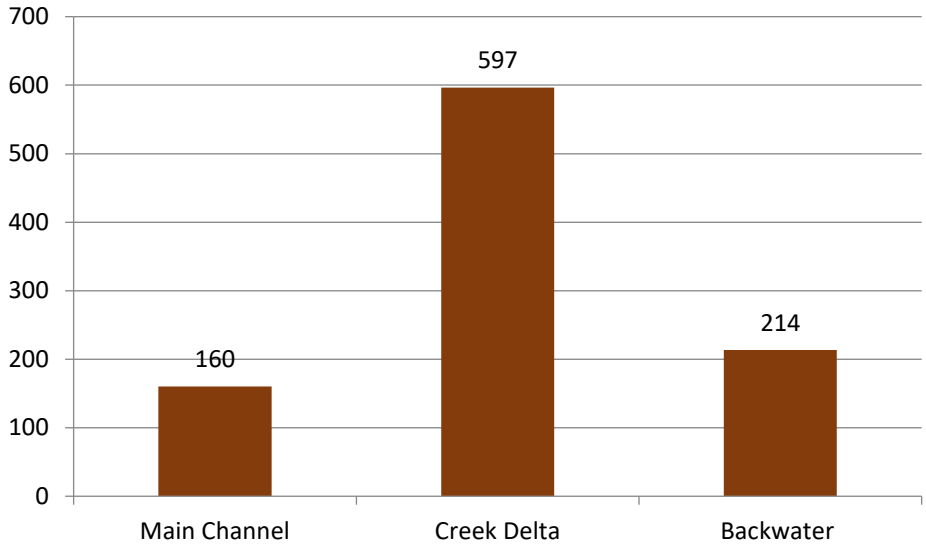

Figure 7. Mussel density (individuals/unit effort) by habitat type.

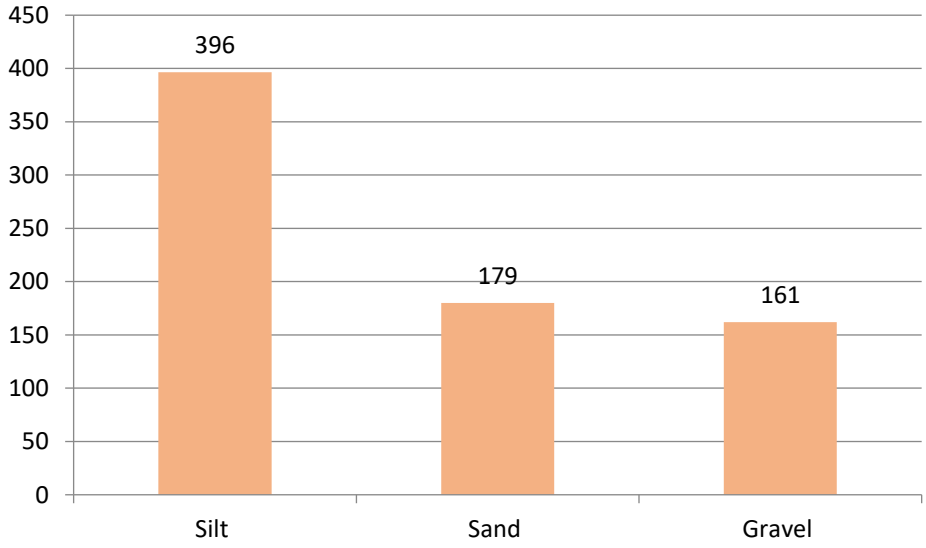

Figure 8. Mussel density (individuals/unit effort) by substrate type.

Conclusions

Based on a comparison between a mussel survey preceded by frequent annual drawdowns (2011) and a survey following a six-year hiatus of drawdowns (2017), it appears that mussel species density, diversity, and distribution may be negatively affected by more frequent drawdowns and that some populations may recover when drawdowns cease. A more long-term survey using quantitative survey methods to document populations both prior to and after a drawdown, as well as follow-up studies to

determine long-term recovery of mussels, would be necessary to better demonstrate the impacts of drawdowns on mussel populations.

In addition to potential negative impacts on mussels, drawdowns have also been found to affect physicochemical conditions of the littoral zone due to increases in erosion on exposed shorelines, decreasing nutrients due to loss of fine sediments, decreases in taxonomic richness of macrophytes and benthic invertebrates (Carmignani and Roy 2017). While the effects of drawdowns on general littoral zone health have not been examined in Lake Austin, the relative importance of dock and shoreline maintenance versus the negative impacts to water quality and ecology should be carefully considered by lake management staff in the City of Austin. Given that invasive aquatic vegetation will likely continue to be controlled with triploid grass carp, future drawdowns will be of limited use for the management of aquatic invasive plants.

It should be noted that changes in aquatic macrophyte density during the drawdown hiatus may have contributed to the results of this study, however these impacts are thought to be small for several reasons. Past researchers have found that that mussel populations can be negatively affected by the dominant presence of Eurasian watermilfoil (Burlakova and Karatayev 2007). It is therefore possible that the coincidental control of both hydrilla and Eurasian watermilfoil during the last half of the drawdown hiatus was a factor that helped aid the recovery of mussel populations. In 2011, the amount of vegetation (primarily hydrilla) on Lake Austin peaked at 642 acres; a condition that persisted until vegetation levels began dropping dramatically in late 2013. Submerged aquatic vegetation in Lake Austin has been effectively eliminated (0 acres of vegetation in TPWD surveys, reference?) since 2014. However, considering that only half of the years during the drawdown hiatus experienced low macrophyte coverage, while the previous years experienced significant macrophyte coverage, it is likely the mussel rebound is at best only partially related to the loss of invasive macrophytes. Additionally, a rebound of mussel populations occurred across the entire reservoir of Lake Austin, whereas hydrilla and Eurasian milfoil were only a nuisance in the upper reaches of the reservoir where mussel abundance was found to be lower in both surveys. The upper reaches of Lake Austin are also shallower and therefore a greater proportion of the upper basin is completely dewatered during drawdowns, thus preventing as many refuge opportunities for mussels during dewatering events.

Recommendations

Given the importance of mussels to ecology and water quality, and the fact that Lake Austin is one of two drinking water reservoirs for the City of Austin, the impacts of drawdowns on the integrity of the reservoir, including impacts to native mussels, should be considered by lake managers if future drawdowns are considered. One of the frequently-cited reasons that the City of Austin has requested that the LCRA drawdown the level of Lake Austin is to provide lakefront homeowners the opportunity to more easily maintain docks and shorelines. If such requests are made in future years, WPD should consider organizing lakefront homeowners to conduct mussel relocations early on during the drawdown. The results of this study suggest that, while mussels are found throughout the reservoir, focusing most relocation efforts downstream of Emma Long Park, would likely benefit a larger number of mussels than higher up in the basin.

The summer following the survey (August 2017), *Dreissena polymorpha* (zebra mussels) were found to occur within Lake Austin. Drawdowns might be a future management tool to help minimize the negative effects of the zebra mussel infestation, and to allow for lakefront property owners to remove zebra

mussels from private infrastructure. However, there are some concerns to consider. Drawdowns on Lake Austin are typically only possible during winter months to avoid peak recreational boating times and to avoid fish spawning in the spring. For control of zebra mussels, the optimal drawdown period would occur during zebra mussel spawning periods, which typically occur in the late spring and late summer months. These periods are not likely to be possible for Lake Austin given the importance of recreational boating and fishing. Further, given the high rate of reproduction of zebra mussels combined with the relatively infrequent nature of drawdowns, zebra mussels are likely to colonize pipes and other lake infrastructure more quickly than a drawdown would be able mitigate their infestation. However, future studies should be conducted to ascertain whether zebra mussel populations could be temporarily reduced by winter drawdowns.

If drawdowns are considered in the future for reasons not related to the control of nuisance macrophytes, (e.g. maintenance of docks for homeowners due to zebra mussel infestations), the drawdown level should be minimized as much as possible in order to provide refuge for mussel populations in deeper water and the rate of lowering should be as slow as possible (Howells et al 2000).

Lake Austin Drawdown Considerations

The 2017 Lake Austin drawdown provided the opportunity to not only assess impacts to Unionids, but also to derive recommended actions for future drawdowns.

Reduce impacts to Unionids

- Lake Austin should be drawn down no more than 8’-9' to allow Unionid populations at lower depths to survive.
- Lake Austin officials should request that LCRA dam operation staff maintain the lowest drawdown rate possible (one foot per day maximum).
- If freezing temperatures are anticipated for short periods while lake levels are decreasing, WPD staff should request that the drawdown be paused until temperatures increase above freezing to reduce the number of stranded mussels
- Public outreach should occur prior to the drawdown to educate homeowners about the importance of unionids. Such outreach efforts include:
  - Organized mussel rescue events at Walsh Boat Landing or Commons Ford Metro Park
  - Social Media posts to educate the public about the importance of mussels and how to relocate mussels into deeper water
  - Citizen science efforts should be considered to provide the public with ways to report the location and species of mussels.

Zebra mussel control

- Drawdowns may be an effective way to temporarily reduce zebra mussel populations.
- WPD staff should consider methodology by which zebra mussel response to drawdowns can be observed by drafting any necessary QAPPs prior to the drawdown.
- Lakefront homeowners will benefit from education regarding the proper disposal of zebra mussels if maintenance is conducted on boat docks, bulkheads, or water intakes.
- A replicate study should be conducted to assess the impacts of zebra mussels on the Unionid population.

Interdepartmental and Interagency Coordination

- Staff from Watershed Protection and Austin Water should include officials from other departments, such as the Development Services Department, Austin Code, APD Lake

Patrol, AFD, and Austin Energy several months prior to making the final decision to conduct a lake drawdown, in order to inform and engage partners that might be affected by increased permit requests, inspections, and code violations.

- WPD staff should aid other departments with outreach to lakefront homeowners to better educate homeowners about what permits are necessary prior to dock and bulkhead repair.
- Staff from WPD and AW should communicate with officials from the LCRA in the spring prior to an anticipated drawdown to gauge basin-wide hydrological conditions necessarily to allow a drawdown the following winter in order to allow the above-listed interdepartmental coordination to occur.

To assess the relative importance of drawdowns on the overall population of Unionids within the reservoir, it will be important to determine general population densities at deeper levels of the lake. To date, no surveys have been done to assess whether there is a significant population of mussels that persist in the deeper areas of the reservoir that are not dewatered by the historic drawdowns. If significant populations of Unionids exist in deeper areas, it is possible that mussel populations may recover more quickly during non-drawdown years, expanding from these deeper populations into shallower water. It will also be important to document the impact of zebra mussels on the population of native mussels. Zebra mussels arrived in Lake Austin in the summer of 2017 and have been expanding quickly throughout Lake Austin and the receiving reservoir Lady Bird Lake (personal observation), They are hypothesized to have a negative impact on native mussel populations. In subsequent years, native mussels may experience a decline in population due to zebra mussels, but zebra mussels are also potentially controlled with drawdowns, so whether there is a net positive or neutral effect on native mussel populations is unknown.

Future studies to quantitatively assess the populations of mussels in Austin's reservoirs are recommended to help inform policy decisions not only related to drawdowns. One such consideration, is the possibility of Lady Bird Lake storing reclaimed water as part of future water supply planning efforts (Water Forward, 2018). Previous research has shown that municipal wastewater effluent has a negative effect on native mussel growth and longevity (Duncan and Nobles 2012) and may be a significant threat to our reservoir unionid populations.

References

Austin Water Utility. 2018. Water Forward: Integrated Water Resource Plan. A Water Plan for the next 100 years. City of Austin, Texas. http://austintexas.gov/sites/default/files/files/Water/WaterForward/Water_Forward_Plan_Report_-_A_Water_Plan_for_the_Next_100_Years.pdf

Burlakova LE, Karatayev AY. 2007. The effect of invasive macrophytes and water level fluctuations on Unionids in Texas impoundments. Hydrobiologia 586:291–302. doi:10.1007/s10750-007-0699-1

Carmignani JR, Roy AH. 2017. Ecological impacts of winter water level drawdowns on lake littoral zones : a review. Aquatic Sciences DOI:10.1007/s00027-017-0549-9

Duncan A and Nobles T. 2012. Effects of Municpal Wastewater Effuent of Freshwater Mussel Growth and Survival. SR-13-02 Austin (TX): City of Austin Watershed Protection Department.

Hoftyzer E, Ackerman JD, Morris TJ, Mackie GL. 2008. Genetic and environmental implications of reintroducing laboratory-raised unionid mussels to the wild. Canadian Journal of Fisheries and Aquatic Sciences 65:1217-1220 DOI:10.1139/F08-024

Howells RG., Mather, CM., Bergmann AM. 2000. Impacts of Dewatering and Cold on Freshwater Mussels (Unionidae) In B. A. Steinhagen Reservoir, Texas. Texas Journal of Science 52:93–104.

Howells RG, Neck RW, Murray HD. 1996. Freshwater Mussels of Texas. Austin (TX): Texas Parks and Wildlife Department Inland Fisheries Division 218 p.

USEPA. 2016. National Lakes Assessment 2012: A Collaborative Survey of Lakes in the United States. EPA 841-R-16-113. U.S. Environmental Protection Agency, Washington (DC). [cited Dec. 2016] available from https://www.epa.gov/sites/production/files/2016-12/documents/nla_report_dec_2016.pdf

Newton TJ, Zigler SJ. 2014. Mortality, movement and behaviour of native mussels during a planned water-level drawdown in the Upper Mississippi River. Freshwater Biology DOI: 10.1111/fwb.12461.

Perry H, Jackson T, Scoggins M. 2010. Inventory of Freshwater Mussels (Unionidae) in Austin, Texas. SR-11-02 Austin (TX): City of Austin Watershed Protection Department.

Samad F, Stanley JG. 1986. Loss of Freshwater Shellfish After Water Drawdown in Lake Sebasticook, Maine. Journal of Freshwater Ecology 3(4):519-523.

TPWD 2012. Fisheries Management Survey Report Austin Reservoir Performance Report As Required by Federal Aid in Sport Fish Restoration Act Texas Federal Aid Project F-221-M-3. San Marcos (TX): Texas Parks and Wildlife Inland Fisheries Division; [cited July 31, 2013] available from https://tpwd.texas.gov/publications/pwdpubs/media/lake_survey/pwd_rp_t3200_1241_2012.pdf

Vaughn CC, Gido KB, Spooner DE. 2004. Ecosystem processes performed by Unionid mussels in stream mesocosms: species roles and effects of abundance. Hydrobiologia 527:35-47.