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Technical Report

To
Wasatch Front Water Quality Council

By
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Introduction

North America supports the richest diversity of freshwater mollusks on the planet, particularly southeastern USA (Johnson et al. 2013, FMCS 2015, Richards 2020, Richards 2017). In contrast, Western USA is relatively mollusk depauperate; the one exception is the historically rich molluskan fauna of the Bonneville Basin area, including waters that enter terminal Great Salt Lake and in particular those waters within the Jordan River-Utah Lake drainage (Oliver and Bosworth 1999, Richards 2017, Richards 2020). These molluscan taxa and assemblages serve(d) vital ecosystem functions and are truly a Utah natural heritage (Johnson et al. 2013, Mock et al. 2004, Huryn et al. 1995, Brown and Lydeard 2010, Richards 2017, http://molluskconservation.org).

Unfortunately, freshwater mollusks are also the most imperiled animal groups in the world, including those found in UT and in particular, native populations that historically occurred in the Jordan River-Utah Lake drainage (NatureServe 2014, http://molluskconservation.org, Richards 2020). Only two mussel taxa were native to this drainage, the Western Pearlshell, *Margaritifera falcata*, and the Floater mussel, *Anodonta* sp.[1] (Richards 2017, 2020). Both species are listed for protection[2] in Utah and both are implicitly protected under the Clean Water Act[3]. Very few mollusk surveys have been conducted in the Jordan River-Utah Lake drainage despite their importance and status.

Severely degraded conditions, secondary host-dependency, dispersal- limited metapopulation dynamics, and absence of past monitoring, legal protection, and adequate management have likely removed the possibility of their continued existence in these waters (Richards 2017a and b, USEPA 2013a, Miller and Richards 2019, Richards 2020). There are no historical records of *M. falcata* occurring in the Jordan River and only one historical record of *Anodonta* sp. potentially occurring at a single location in the Jordan River, in 1942 (UDWQ 2017b). Richards (2017, Richards 2020) and Richards and Miller (2019) conducted the most extensive native mussel surveys in the Jordan River to date but did not find any live or recently dead native mussels, although several highly weathered *Anodonta* sp. shell fragments were found throughout the drainage indicating that this species could have occurred in these or nearby waters in the past. Even though Richards (2020) and Richards and Miller (2019) concluded that native mussels were likely absent in the Jordan River, absolute determination of absence is not possible without a complete and thorough examination of the entire riverbed (Richards 2017, USEPA 2013a, 2013b). However, probability of detection and survey efficiency statistical models in conjunction with knowledge of native mussel ecology and population dynamics can be employed to help justify a presence or absence conclusion for the lower Jordan River (UDWQ 2017a, Richards and Miller 2019, Richards 2017, Smith 2006, Smith et al. 2001).

Justification

The USEPA published updated Clean Water Act § 304 (a) recommended water quality criteria for ammonia in 2013. The calculation of these criteria included updated toxicity data for members of the Mollusca phylum. Results of these tests and incorporation into criteria calculations and particularly for mussels of the superfamily, Unionoidea,

[1] We consider *Anodonta* sp. to be *A. californiensis/nutalliana* clade (Mock et al. 2002, 2010)

[2] See Richards 2017 for status of these two taxa. NatureServe considers *M. falcata* to be 'Critically Imperiled' and *Anodonta* sp. to be 'Imperiled' in Utah.

[3] Sections 101(a) of the Clean Water Act (1987) legally mandates USEPA to protect the physical chemical, and ***biological integrity*** of our nation's waters. In addition, the Clean Water Act necessitates protection and enhancement of **shellfisherie**s, which many water quality managers fail to realize, includes freshwater mollusks (mussels, snails, clams).

resulted in much more stringent ammonia criteria (USEPA 2013a). Recognizing that these species may be absent from many of the nation's waters, EPA published a supplemental technical support document (TSD; "Technical support document for conducting and reviewing freshwater mussel occurrence surveys for the development of site-specific water quality criteria for ammonia", August 2013, EPA 2013b), that outlines survey procedures to determine presence or absence of native mollusks on a site-specific basis. In turn, this may allow site-specific criteria modification of ammonia criteria.

Subsequently, OreoHelix Ecological and the Wasatch Front Water Quality Council conducted the most extensive and intensive mollusk surveys to date in the Jordan River drainage (Richards 2020) to determine if mussels are currently present or if the presence of unweathered or weathered empty shells indicate that they were extant in the recent or historic past. These intensive (intrusive) surveys were more than adequate to demonstrate 'absence' of native mussels in the Jordan River based on UDWQ criteria (Richards 2020), however in 2020 UDWQ requested that additional surveys be conducted in two sections of the river in Spring of 2021 (UDWQ 2020).

Objectives

The specific objective of this study was for OreoHelix Ecological and Wasatch Front Water Quality Council to provide additional site-specific survey data in two sections of the Jordan River, 800 South to 700 North, and the upper section of the river from its headwaters in Utah Lake to the 'Narrows' section downstream. This survey combined with past surveys would be sufficient to determine a likelihood estimate of presence or absence of mussels in the entire Jordan River using the most appropriate EPA approved survey methods, including Eckman and Ponar grabs (dredges) and shovel/nets. Our objectives were to also perform recommended probability statistical analyses following that of Smith et al. (2001) and Smith (2006) as adopted by UDWQ (2017) and then provide a detailed report of survey methods used, summary statistics, data interpretation and recommendations to UDWQ and USEPA. It is intended that this additional report contain sufficient quality data and analysis for UDWQ/USEPA to make a regulatory determination of the presence or absence of native mussels in the Jordan River.

Methods

Survey Areas

We excavated 17.5 m^2 of the lower Jordan River between 800 South and 700 North (Figure 1) and 50.0 m^2 of the upper Jordan River from its headwaters at Utah Lake downstream to the beginning of Narrows section (Figure 2) using shovel/net method approved by EPA. GPS locations in the figures are general locations; samples may have been collected 50 meters upstream or downstream of recorded latitude/longitude.

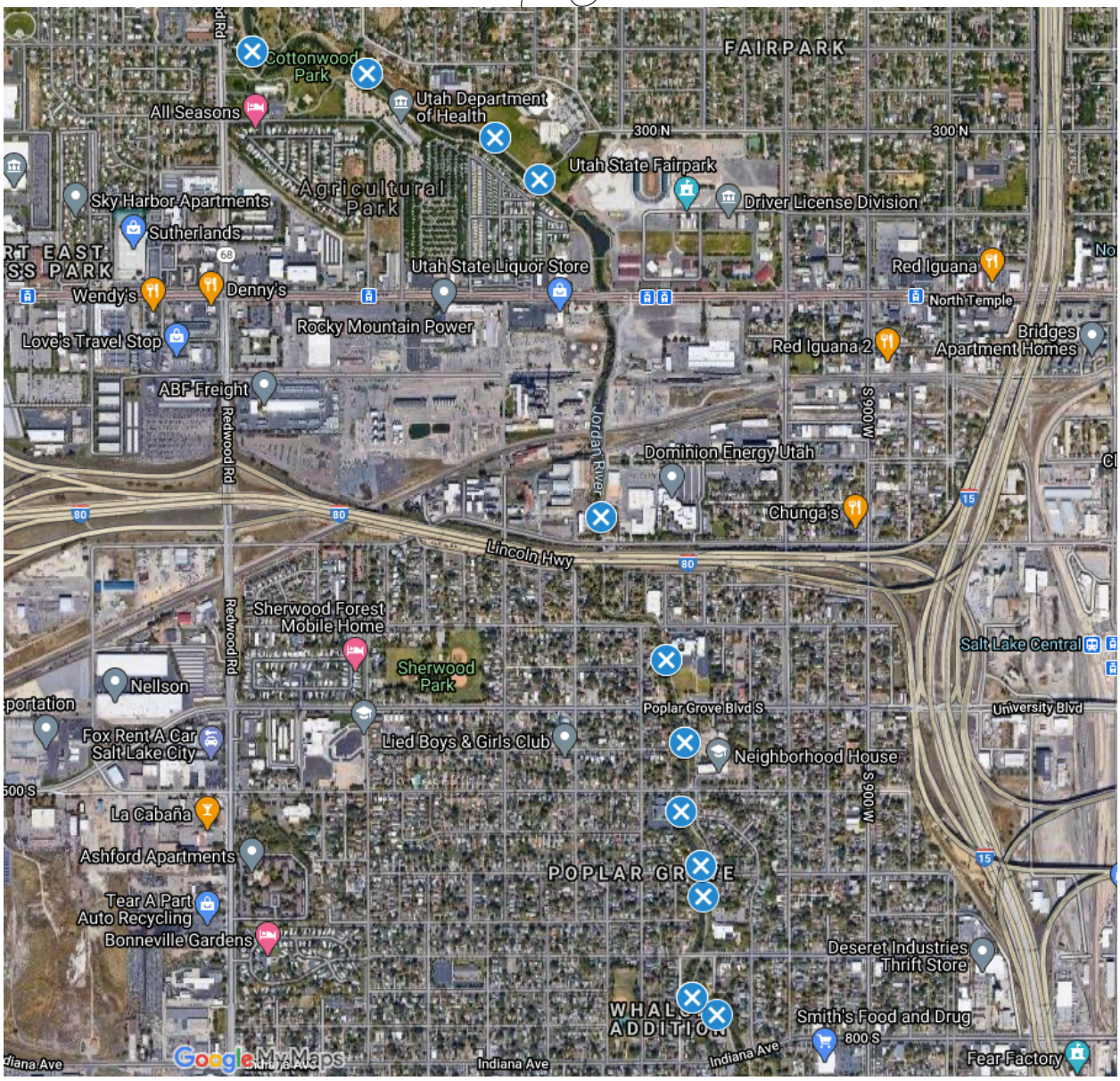

Figure 1. Lower Jordan River native mussel survey locations between 800S and 700N. Surveyed March 2nd through 5th, 2021.

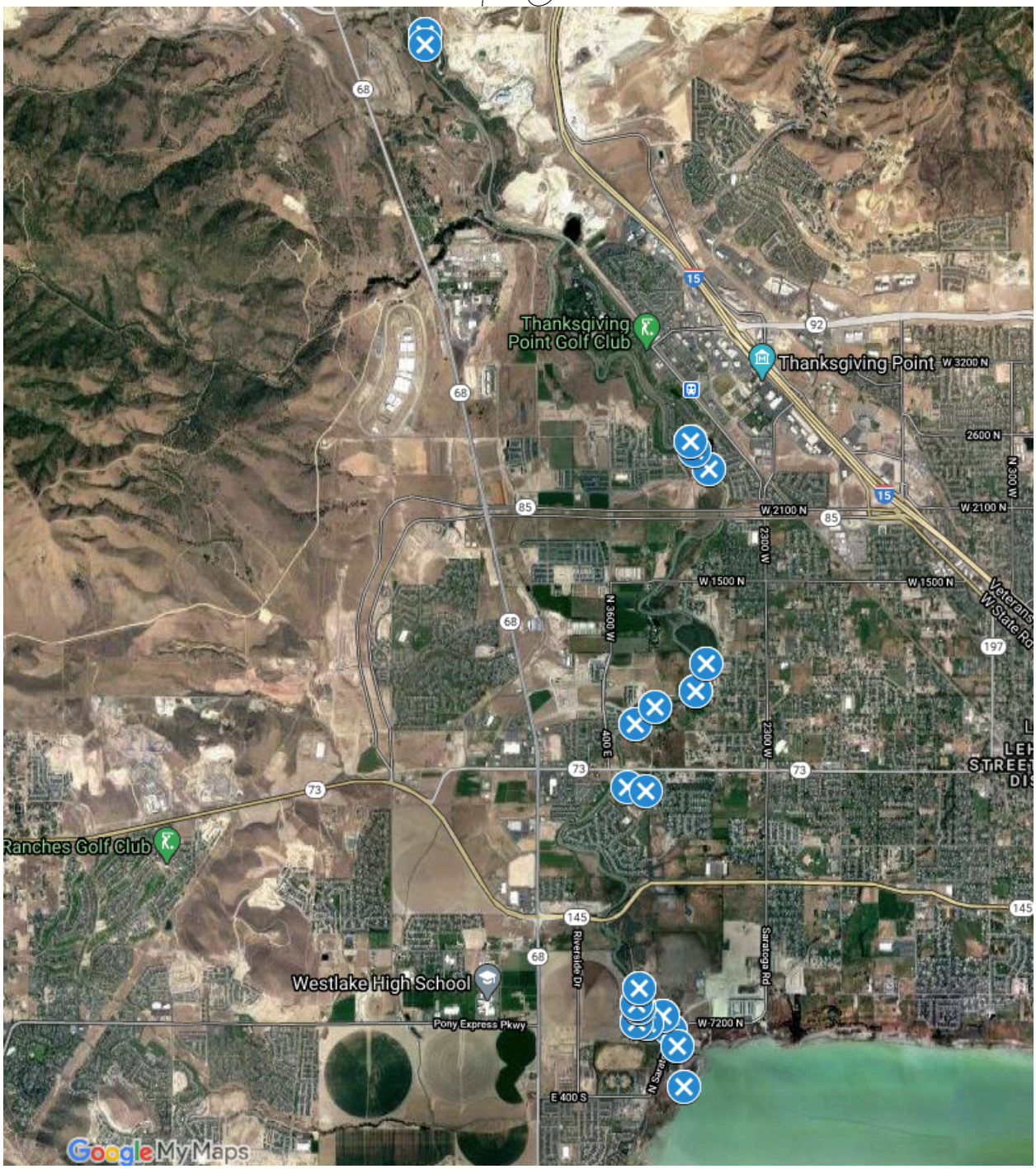

Figure 2. Upper Jordan River native mussel survey locations from headwaters of Utah Lake to confluence with Narrows section of the river. Surveyed March 3rd through 5th, 2021.

Survey Methods

We used the shovel/kick net method that was employed by Richards (2018). This method is considered to be an intrusive excavation survey as suggested by UDWQ and USEPA (2013b) with a search efficiency (SE) = 1.0. The survey was conducted between March 2nd and 5th, 2021. We used a flat- bottom shovel with 10 cm depth line marked across the blade (Figure 3). In effect, a shovel is a large trowel. It is thus, one of the primary excavation

methods recommended by USEPA (2013b, page 24). One surveyor demarcated a 0.5 m^2 area of substrate using the known width of the shovel blade and then sank the shovel up to a penetrable depth up to 10 cm and scooped sediment in the 0.5 m^2 area into a heavy framed 4 mm mesh net (Figure 3) held by a second surveyor standing directly downstream of the first surveyor. This was repeated if several surveyors were present.

Figure 3. Shovel/net method tools. Flat-bottomed shovel with 10 cm demarcation used for scooping sediments into 4 mm mesh net.

Contents of net samples were vigorously rinsed on site in the river to remove sediments < 4 mm. Remaining contents were then spread onto bare substrate along the shoreline and examined for live native mussels, recently dead, and weathered shells and shell fragments. If any were present, they were recorded as was substrate type and GPS coordinates.

Note: Survey data and findings are included in a Supplementary Spreadsheet.

Probability of Detection and Search Efficiency as Related to Density Estimates

Estimating search efficiencies given known or assumed densities with probability of detection (POD) estimates is problematic when mussel population densities are at critically low levels or when mussels are expected to be absent based on historical data and literature review (Richards 2017, 2020). However, UDWQ (2017a) recommends using methods such as those proposed by Smith (2006) for estimating these values. UDWQ recommends surveying enough area with 100% search efficiency to obtain a 90% POD at mussel densities of 0.1 m^{-2} based on formulas presented by Smith (2006). We used the Smith (2006) formula (equation 4 page 703):

$$POD = 1\text{-}e^{-\beta\alpha\mu}$$

where POD = probability of detecting at least on individual mussel; β =search efficiency (SE), α =search area; and μ = density m^{-2} to develop a probability of detection (POD) model as a function of density m^{-2} at search efficiency of 1.00.

UDWQ (2017) states that "When feasible, survey designs that have at least an 90% probability of detecting unionid mussels when they are present at a density of 0.1 m^2 are desired" (see Table 1). This equates to a total area sample = 16 m^2 for a stream length of 50 miles and 15 m wide (UDWQ 2017(Table 1), which is almost exactly the length and width of the Jordan River.

The methods of Smith (2006) can be used to estimate the level of effort required to detect rare mussels. The table below shows the how much of a stream needs to be sampled to have a 90% probability of detecting the mussels. These estimates assume 100% capture efficiency and a stream length of 50 miles and 15 m wide.

Mussel Density /m^2	Fraction of Total Area Sampled %	Total Area Sampled m^2
0.0001	1.8	16,071
0.001	0.18	1,608
0.01	0.018	161
0.1	0.0018	16
1	0.00018	2

Table 1. This table shows that DWQ requires a total area needed to be sampled to detect mussels at 0.1 m^2 would be 16 m^2 at POD = 90% and at SE = 100%, and a stream length of 50 miles and 15 m wide, almost exactly the same length and width as the Jordan River. Table from DWQ (2017).

Results

No live or recently dead *Margaritifera falcata* or *Anodonta californiensis/nutalliana* were encountered either in the lower Jordan River or upper Jordan River survey areas. Several dozen *Anodonta* highly weathered fragments were found and were most abundant in upper Jordan River upstream of Narrows and directly downstream of Utah Lake (see Supplemental Spreadsheet), supporting our conclusion that *Anodonta* was very abundant in Utah Lake in the past (Richards 2020).

By including survey results from other sections of the Jordan River that had SE = 1.0 (see Supplementary Spreadsheet) (Richards 2020), estimated densities in the entire Jordan River using the Smith (2006) formula were ≤ 0.0103 m^2 at UDWQ required 0.9 POD, and total area surveyed = 224.08 m^2 (Figure 4). This estimate is 9.7 times lower density than UDWQ's viable population density (absence determination) = 0.1 m^2 (Table 1). Even at a 99.7% POD, estimated densities were ≤ 0.0258 m^2, substantially lower than UDWQ absent criteria. Our total area

surveyed for the entire Jordan River (224.08 m^2) was also fourteen times more area than was recommended by UDWQ for a river (stream) the size of the Jordan River (Table 1).

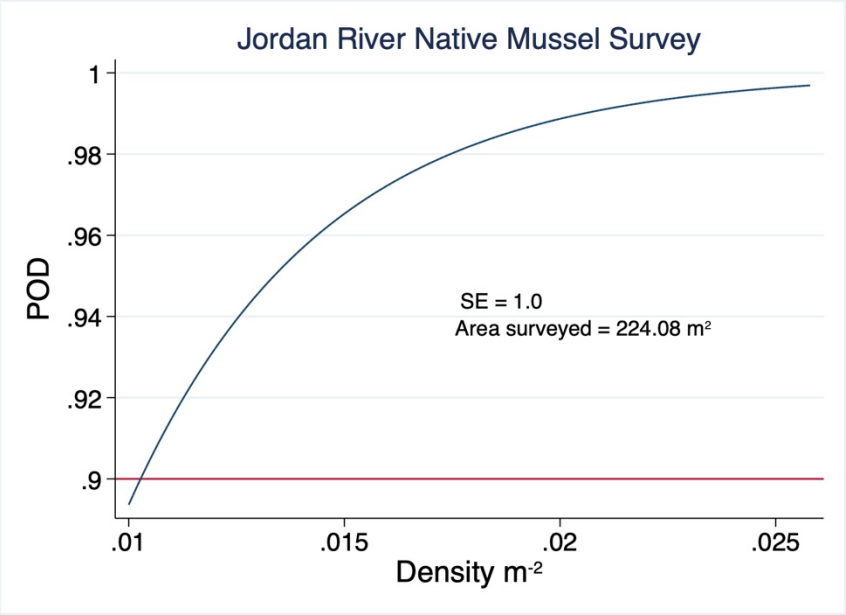

Figure 4. POD, SE = 1.0, area surveyed = 224.08 m^2 and estimated densities per m^2 for Jordan River. Only those samples with 1.0 SE were used. Red line is UDWQ recommended POD = 0.9.

Discussion

If we include Surplus and State Canals as extensions of the lower Jordan River then estimated densities were < 0.0047 m^2 at 0.9 POD, SE = 1.0, at a total area surveyed = 491.5 m^2 (Figure 5)(Richards 2018, Richards et al. 2020c). This is 21.3 times lower density than UDWQ viable population density (absence determination) = 0.1 m^2. Even at a 99.7% POD, estimated densities were < 0.0115 m^2, which we consider to evidence that native mussels in the Jordan River are either extinct (absent) or if they do occur to be a nonviable population and soon to be extinct because no live or recently dead mussels were found (Richards 2020, 2017).

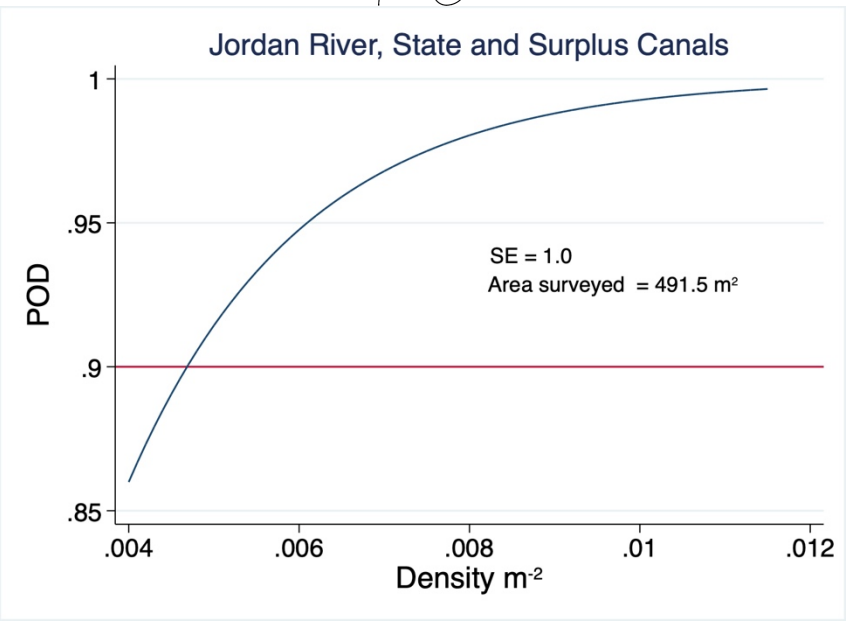

Figure 5. POD, SE = 1.0, area surveyed = 491.5 m^2 and estimated densities per m^2 for Jordan River and State and Surplus Canals combined. Only those JR, State and Surplus Canal samples with 1.0 SE were used. Red line is UDWQ recommended POD = 0.9.

Surplus and State Canals can be considered extensions of the lower Jordan River and are somewhat ecologically similar to lower JR because lower JR is also channelized and the canals have been in existence almost as long as the JR has been channelized, at least as long needed to ecologically resemble lower JR (Richards 2018, Richards et al. 2020a, 2020c) and both are managed as warmwater or non-game fisheries similarly to lower JR.

Richards (2020) compiled all of OreoHelix Ecological and WFWQC mollusk survey reports and estimated native mussel densities within the Utah Lake-Jordan River drainage $\leq$ 0.0000027 m^{-2} to 0.0000035 m^{-2} using a median SE = 0.50, area surveyed = 1,721,621 m^2, and target POD between 0.90 and 0.95 for all survey data combined. These disappointing survey results lead us to conclude that native mussel populations within the drainage are disappearing quickly and are threatened with extinction throughout the state.

Conclusion

Using DWQ (2017) absence criteria, Utah's two native mussel species, *Margaritifera falcata* and *Anodonta* sp. are clearly 'absent' from the entire Jordan River from its headwaters in Utah Lake to its confluence with wetlands ponds and Farmington Bay of Great Salt Lake including two major diversion canals, State Canal and Surplus Canal. Reasons for the extinction of this once unique and ecologically important molluskan assemblage are numerous and almost entirely due to human economic activity and poor management (Richards 2020).

Literature Cited

Brown, K. M., and C. E. Lydeard. 2010. Mollusca: Gastropoda. Pages 277–307 in J. H. Thorpe and A. P. Covich, editors. Ecology and classification of freshwater invertebrates of North America. Elsevier.

Freshwater Mollusk Conservation Society (FMCS). 2015. Home page, http://molluskconservation.org/.

Huryn, A. D., Benke, A. C. and G. M. Ward. 1995. Direct and indirect effects of geology aon the distribution, biomass, and production of the freshwater snail *Elimia*. Journal of the North American Benthological Society. 14: 519-534.

Johnson, P, D, Arthur E. Bogan, Kenneth M. Brown , Noel M. Burkhead , James R. Cordeiro , Jeffrey T. Garner, Paul D. Hartfield, Dwayne A.W. Lepitzki, Gerry L. Mackie, Eva Pip ,Thomas A. Tarpley, Jeremy S. Tiemann ,Nathan V.Whelan and Ellen E. Strong. 2013. Conservation Status of Freshwater Gastropods of Canada and the United States, Fisheries,38:6,247-282, DOI:10.1080/03632415.2013.785396

Mock, K. E., J. C. Brim-Box, M. P. Miller, M. E. Downing, and W. R. Hoeh. 2004. Genetic diversity and divergence among freshwater mussel (*Anodonta*) populations in the Bonneville Basin of Utah. Molecular Ecology. 13: 1085-1098.

Mock, K.E., J.C. Brim Box, J.P. Chong, J.K. Howard, D.A. Nez, D. Wolf, and R.S. Gardner. 2010. Genetic structuring in the freshwater mussel *Anodonta* corresponds with major hydrologic basins in the western United States. Molecular Ecology: 1-23.

NatureServe. 2014. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org.

Oliver, G. V. and W. R. Bosworth, III. 1999. State of Utah Department of Natural Resources, "Rare, Imperiled, and Recently Extinct or Extirpated Mollusks of Utah: A Literature Review" (1999). All U.S. Government Documents (Utah Regional Depository). Paper 531. http://digitalcommons.usu.edu/govdocs/531.

Richards, D.C. 2015. Unionoida Mussel and Non-Pulmonate Snail Survey and Status in the Jordan River, UT. Final Draft Report to Wasatch Front Water Quality Council, Salt Lake City. OreoHelix Consulting, Moab, UT.

Richards, D.C. 2016. Jordan River Watershed Mollusk Surveys: "Last of the Anodonta".2016 Annual Report to Jordan River/Farmington Bay Water Quality Council. Salt Lake City, UT. OreoHelix Consulting. Vineyard, UT.

Richards, D.C. 2017. Native Unionoida Surveys, Distribution, and Metapopulation Dynamics in the Jordan River-Utah Lake Drainage, UT. Report to Wasatch Front Water Quality Council, Salt Lake City. OreoHelix Consulting, Vineyard, UT.

Richards, D.C. 2018. Surplus Canal Native Mussel Survey 2018 As it Relates to the Central Valley Water Reclamation Facility Discharge. Report to Wasatch Front Water Quality Council, Salt Lake City. OreoHelix Ecological, Vineyard, UT.

Richards, D.C. 2020. A Compendium of Mollusk Surveys Conducted in the Jordan River-Utah Lake Drainage by OreoHelix Ecological and the Wasatch Front Water Quality Council. Focus: Native Mussels. Report to Wasatch Front Water Quality Council, Salt Lake City. OreoHelix Ecological, Vineyard, UT.

Richards, D.C. and T. Miller. 2019. Apparent extinction of native mussels in Lower Mill Creek and Mid-Jordan River, Utah. Western North American Naturalist 79(1): 72-84.

Richards, D.C. et al. 2020a. Lower Jordan River Mollusk Survey as it Relates to South Davis Sewer District South Plant Effluent. Progress Report to Wasatch Front Water Quality Council, Salt Lake City. OreoHelix Ecological, Vineyard, UT.

Richards, D.C. et al. 2020b. Jordan River Native Mussel Survey Compilation 2015 to 2020. Report to Wasatch Front Water Quality Council, Salt Lake City. OreoHelix Ecological, Vineyard, UT.

Richards, D.C. et al. 2020c. State Canal Mollusk Survey as it Relates to South Davis Sewer District North Plant Effluent. Progress Report to Wasatch Front Water Quality Council, Salt Lake City. OreoHelix Ecological, Vineyard, UT.

Smith, D. R. 2006. Survey design for detecting rare freshwater mussels. J. N. AM. Benthol. Soc. 25(3):701-711.

Smith, D. R., R. F. VILLELLA, D. P. LEMARIE´, AND S. VON OETTINGEN. 2001. How much excavation is needed to monitor freshwater mussels? Pages 203–218 in R. A. Tankersley, D. I. Warmolts, G. T. Watters, B. J. Armitage, P. D. Johnson, and R. S. Butler (editors). Freshwater Mollusk Symposium Proceedings. Ohio Biological Survey, Columbus, Ohio.

UDWQ. 2017. Utah Implementation Guidance for the 2013 USEPA Ammonia Criteria for the Protection of Aquatic Life. Version 1.0. September 20. Utah Division of Environmental Quality. Water Quality. DWQ-2017-002062.Docx

UDWQ. 2020. "Additional data needs to support potential revisions to the ammonia water quality criteria for the Jordan River". Letter addressed to Leland Meyers. December 1, 2020.

USEPA 2013b. Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys for the Development of Site-specific Water Quality Criteria for Ammonia. U.S. Environmental Protection Agency Office of Water Office of Science and Technology Standards and Health Protection Division National Water Quality Standards Branch Washington, DC. August 2013. EPA 800-R-13-003.

USEPA. 2013a. Aquatic life ambient water quality criteria for ammonia-freshwater 2013. USEPA, Office of Water, Office of Science and Technology, Washington, DC. EPA-822-R-13-001