State of Utah
DEPARTMENT OF NATURAL RESOURCES
Division of Wildlife Resources - Native Aquatic Species

Native Mollusk Statewide Surveys and Monitoring Summary 2019

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Native Mollusk Statewide Surveys and Monitoring Summary 2019

December 2019

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Information provided in this report covers surveys and monitoring by the Utah Division of Wildlife (UDWR) and its partners between December 2018 and December 2019. UDWR biologists provided brief summaries of their mollusk surveys and monitoring and provided monitoring plans for the next three years (Strategic Monitoring Plans). Associated collection data is housed in the UDWR Mollusk Database (curated by Kate Holcomb; kholcomb@utah.gov). Partners also provided updates and reports for their mollusk projects. Due to taxonomic uncertainty for many of Utah's mollusks, some specimens could not be confidently identified to species and some specimen identifications were not verified. A summary of agencies and partners with their associated target mollusk species is provided:

Agency or partner	**Target species**
UDWR - Northern Region	*Margaritifera falcata, Anodonta californiensis, Colligyrus greggi, Fluminicola coloradoensis, Stagnicola montanensis, S. traski, Catinella stretchiana, Succinea rusticana, Vertigo concinnula, Oreohelix haydeni*
UDWR - Northeastern Region	No surveys conducted
UDWR - Central Region	*Tryonia porrecta, Planorbella oregonensis, Gastrocopta quadridens, Vertigo concinnula, Oreohelix eurekensis, O.howardi*
UDWR - Southeastern Region	*Vertigo concinnula, Oreohelix yavapai*
UDWR - Southern Region	*Pyrgulopsis anguina, P. chamberlini, P. deserta, P. hamlinensis, P. inopinata, P. saxatilis, potamopyrgus antipodarum, Gastrocopta quadridens, Vertigo concinnula, Oreohelix parawanensis*
Utah State University	*Margaritifera falcata* and *Anodonta*
Dugway Proving Grounds	Springsnails (Hydrobiidae)
Wasatch Front Water Quality Council and Oreohelix Ecological	Mollusk surveys in Utah Lake, Lower Jordan River, and the State Canal
Utah Geological Survey	Mollusk surveys during wetland surveys in the Central Basin and Range ecoregion
Eric Wagner	Utah mollusks
Dale Nielson	*Margaritifera falcata* and *Anodonta*
Wyoming Game and Fish Department	*Anodonta californiensis*

The 2019 Native Mollusk Workgroup (led by Kate Holcomb, UDWR) met at the Salt Lake City UDWR office on December 10, 2019, to review mollusk survey and monitoring efforts in Utah and neighboring states since the last Native Mollusk Workgroup meeting in December 2018. The workgroup also discussed and prioritized mollusk conservation activities for the UDWR during fiscal year 2021 (July 1, 2020 – June 30, 2021). A summary of the 2019 Native Mollusk Workgroup meeting and a list of annual mollusk priorities is provided in this report.

ANNUAL NATIVE MOLLUSK WORKGROUP MEETING SUMMARY

Meeting attendees:

Phone: Kevin Wheeler, Emilie Blevins, and Keith Lawrence

In person: Jordon Detlor, Eric Wagner, Dan Keller, Cynthia Tait, Peter Hovingh, Miles McCoy-Sulentic, Dale Nielon, Paul Thompson, Paul Badame, Matt Breen, Robert Delph, George Oliver, Chanté Lundskog, Chance Broderius, Frank Fluckiger, Jordan Holcomb, Hannah Finley, Cassie Mellon, Chris Penne, and Kate Holcomb.

Kate Holcomb presented the State of the Mollusks for Utah and Wyoming. Questions about project details were discussed during and after the presentation.

Upcoming mollusk meetings, events, and news

- UT-NV Springsnail Conservation Strategy should be completed in spring 2020.
- Utah AFS – Feb 25-27, 2020 in St. George, UT – consider presenting mollusk information.
- Pacific Northwest Mussel Workgroup symposium (**Free registration**) – March 26, 2020 in Vancouver, WA.
- Freshwater Mollusk Conservation Society workshop – survey techniques; Henry Horton State Park, TN (Aug 10-13, 2020).
- 2020 Snail ID days – March 18 and Oct 13; interest in an additional day in January or February? An email and Doodle Poll will be sent to determine additional Snail ID day date and snail families that people want to focus on during the March 18, 2020 date.
- Freshwater Mollusk Conservation Society meeting – April 2021 in Portland, OR.
- The Western AFS meeting in 2021 will be held in Ogden; the group may want to see about organizing a water issues and/or snail symposium at this meeting.

What to do with your mollusk specimen collections – contact Kate Holcomb. She will take specimens and will ultimately send them to the Natural History Museum of Utah.

Using iNaturalist for incidental mollusk collections – please use the Biodiversity of Utah, Mollusca distribution in Utah, and Freshwater Mussels of the Western U.S. projects for mollusk observations. Also, take three pictures of a snail – one of the front, one of the back, one of the aperture. Having these three pictures will make it easier to identify specimens using just pictures.

Cody Edwards' Species Distribution Modeling project - Cody would like data for *Margaritifera falcata* and Anodonta in Utah. Emails regarding this request should come your way in December or January.

New UDWR mollusk reporting was briefly discussed. This will likely be a work in progress for the next few years.

The group discussed mollusk conservation priorities and created a list of the top priorities (provided on page 7).

The Taxonomy Team met December 9, 2019 to discuss taxonomic issues among some of the UT aquatic snails. Ask Kate Holcomb for the Taxonomy Team minutes for details.

Other notes from the meeting:

- George Oliver noted that the Raft River has a native crayfish that is not *Pacifastacus gambelii.* Keith Crandall (BYU) might be able to help with any crayfish genetics needs.
- Cynthia Tait will send the group a crayfish ID guide.
- Dale Nielson noted that *Utterbackia imbecillis* have been present in Cutler Reservoir for about 40 years.
- George Oliver noted that it will be important to be looking for the invasive decollate snail (it is a predator to native snails).
- Cynthia Tait noted that snail poison is a major cause of poisoning in dogs in the summer.

The 2020 Native Mollusk Workgroup meeting will be held December 9th. Kate will look into holding the meeting at the Living Planet Aquarium.

ANNUAL MOLLUSK PRIORITIES LIST

Topics 1-3 are top conservation priorities for Utah Division of Wildlife Resources during fiscal year 2021 (July 1, 2020-June 30, 2021). Items listed under topic 4 are viewed as important by the workgroup, but these items require some research and planning before full implementation. Involvement with the Springsnail Conservation Team and incorporating mollusk priorities into the Wildlife Action Plan are high priorities and are ongoing activities among workgroup members.

1. Threat abatement at Gandy Warm Springs (control non-native fishes; SRO, BLM)

2. Continue planned UDWR surveys and threat assessment
    a. Beaver Creek Western Pearlshells – more surveys, learn more about host fish in the creek (NRO, USFS, Trout Unlimited)
    b. Surveys to better understand distribution and abundance of Anodonta (SRO, CRO, NRO, SERO?)
    c. Finish mollusk surveys at historical sites (all regions)

3. Monitoring
    a. Western Pearlshells (NRO)

4. Salt Lake Office/Statewide
    a. Update/review mollusk survey datasheets (emphasize threat assessment) – All regions
    b. Begin working with Living Planet aquarium on mollusk (mussels and snails) exhibits/refuge populations – Kate Holcomb
    c. Review data to identify genetic needs and survey gaps (to direct future surveys) – Kate Holcomb
    d. Develop a UT mollusk database and specimen collection process (Kate Holcomb)
    e. Update mollusk monitoring plan and protocol – Kate Holcomb, all UDWR Regions
    f. Develop a reintroduction plan for mussels (is it feasible?)
    g. University research projects
        1. *Physa utahensis* (need better understanding of genetics, distribution and status)
        2. *Physa microstriata* (Is the species extinct at historical location? Are there other new locations?)
    f. Ongoing activities
        1. Springsnail Conservation Team involvement
        2. Incorporate priorities with Wildlife Action Plan

Note:
CRO – UDWR Central Region
NRO – UDWR Northern Region
SERO – UDWR Southeast Region
SRO – UDWR Southern Region

ANNUAL REPORTS

Utah Division of Wildlife Resources

Northern Region

Survey date range: April 2019 – November 2019

UDWR biologists: Chanté Lundskog, Chance Broderius, Chris Penne, and Matt McKell

Objective

Determine the presence/absence of *Oreohelix haydeni, Colligyrus greggi, Fluminicola coloradoensis, Vertigo concinnula, Stagnicola montanensis, Succinea rusticana, Catinella strechiana, Stagnicola traski, Anodonta californensis, and Margaritfera falcata* in the Northern Region.

Methods

We followed the presence/absence methods provided in the Duncan (2008) protocol for *O. haydeni, C. greggi, F. coloradoensis, V. concinnula, S. montanensis, S. rusticana, C. strechiana,* and *S. traski*. We followed the Sada (2011) protocol for *A. californiensis and M. falcata.*

Results

Four sites were surveyed for *O. haydeni* and hybrids (*Oreohelix haydeni hybrida*), and less than 80 live individuals were observed. *Oreohelix haydeni* individuals appeared abundant (>50) at one site, and scarce (<5) at the other three sites.

China Row Spring was surveyed for *C. greggi,* and less than 30 live individuals were observed.

East Canyon Creek was surveyed for *F. coloradoensis,* and less than 20 live individuals were observed. The stream was running very high and fast, which limited our ability to adequately survey the entire site.

Four sites were surveyed in the Clear Creek mountain range for *V. conncinnula,* and 70 live individuals were observed. *Vertigo conncinnula* individuals appeared common (>20) at sites where aspen and willow were the primary vegetation types.

We surveyed a tributary to Beaver Creek (Rich County) for *S. montanensis,* and less than 15 live individuals were observed. The tributary was running very high and fast, which limited our ability to adequately survey the entire site.

Ponds one mile west of Devil's Slide in Weber Canyon were surveyed for *S. rusticana,* and 482 live individuals were observed. *Succinea rusticana* was abundant throughout the entire site.

We surveyed one site on the Bear River Migratory Bird Refuge for *C. stretchiana,* and 140 live individuals were observed. *Catinella stretchiana* were oriented primarily on or near stands of cattails.

We surveyed a spring one mile south of the mouth of Ogden Canyon for *S. traski*, and two Lymnaeids were observed.

Six sites along Cutler Reservoir for *A. californiensis.* No live individuals were observed, but eight shells were collected.

Eleven sites were surveyed along Beaver Creek (Summit County) for *M. falcata,* and 355 live individuals were observed and 79 shells were collected.

Additional information including a summary of the dates, locations, and species encountered during surveying is provided in Table 1.

Notes

- There is one additional location that needs to be surveyed for *C. greggi.*
- During the *F. coloradoensis* survey, *Potamopgyrus antipodarum* was observed for the first time in East Canyon Creek. *Potamopyrgus antipodarum* individuals appeared abundant (>200) at the survey site.
- There are four additional locations that need to be surveyed for *F. coloradoensis*.
- A *Lymnaeid* was observed in East Canyon Creek during the *F. coloradoensis* survey. *Stagnicola montanensis* is historically known to occur in East Canyon Creek above Mormon Flat. Further examination could reveal whether this species is truly *S. montanensis.*
- According to the taxonomy discussion (December 2019), *S. traski* is synonymous with *S. elodes.* The individuals found during this survey do not appear to be *S. elodes*, but rather a different species in the family Lymnaeidae.
- The *A. californiensis* surveys were conducted during the Cutler Reservoir drawdown. *Anodonta californiensis* shells were found in areas where there was a current and 4-6 inches of silt substrate with a hardened bottom underneath.
- During the *A. californiensis* survey, *Corbicula fluminea* was observed for the first time in Cutler Reservoir. *Corbicula fluminea* individuals appeared abundant (>50) at Benson Marina.
- Snorkeling equipment was used to survey 100 meter stretches during the *M. falcata* surveys. *Margaritifera falcata* were found 1.25 miles above and .35 miles below where this species have been previously observed.

References

Duncan, N. 2008. Survey protocol for aquatic mollusk species: preliminary inventory and presence/absence sampling. Unpublished USDA Forest Service and USDI Bureau of Land Management, Oregon and Washington Report.

Sada, D. 2011. Monitoring protocols for Utah's rare aquatic and terrestrial mollusks. Prepared for the Utah Division of Wildlife Resources, Salt Lake City, by the Desert Research Institute.

Table 1. Date, general location, and species collected during mollusk surveys in the Northern region.

Date	Location	Species
4/19/2019	Bear River Migratory Bird Refuge	Sierra Ambersnail (*Catinella stretchiana*)
		Marsh Pond Snail (*Stagnicola elodes*)
5/7/2019	Weber Canyon	Rustic Ambersnail (*Succinea rusticana)*
		Rocky Mountainsnail (*Oreohelix strigosa*)
		Physidae
		Gastrodontidae or *Oxychilidae* sp.
5/7/2019	Quarry Cottonwood	Lyrate Mountainsnail (*Oreohelix haydeni*)
		Rocky Mountainsnail (*Oreohelix strigosa*)
5/9/2019	Clear Creek	Mitered Vertigo (*Vertigo concinnula*)
		Gastrodontidae or Oxychilidae
		Brown Hive Snail (*Euconulus fulvus*)
5/30/2019	Flat Canyon	Deseret Mountainsnail (*Oreohelix peripherica*)
		Rocky Mountainsnail (*Oreohelix strigosa*)
		Western Glass Snail (*Vitrina pellucida*)
		Lyrate Mountainsnail (*Oreohelix haydeni*)
6/4/2019	Big Canyon	Lyrate Mountainsnail (*Oreohelix haydeni hybrida*)
		Deseret Mountainsnail (*Oreohelix peripherica*)
		Rocky Mountainsnail (*Oreohelix strigosa*)
6/4/2019	Cooper's Gulch	Lyrate Mountainsnail (*Oreohelix haydeni hybrida*)
		Rocky Mountain Mountainsnail (*Oreohelix strigosa*)
		Gastrodontidae or Oxychilidae
6/18/2019	Cooper's Gulch	Lyrate Mountainsnail (*Oreohelix haydeni hybrida*)
		Rocky Mountain Mountainsnail (*Oreohelix strigosa*)
6/18/2019	Mormon Flat, East Canyon Creek	Green River Pebblesnail (*Fluminicola coloradoensis*)
		New Zealand Mudsnail (*Potamopyrgus antipodarum)*
		Lymnaeidae
		Physidae
6/19/2019	Mile south of Ogden Canyon	*Lymnaeidae sp.*
7/8/2019	China Row Spring	Rocky Mountain Duskysnail (*Colligyrus greggi*)
		Lymnaeidae
		Cochlicopidae or *Pupillidae*
		Sphaeriidae
7/8/2019	Tributary to Beaver Creek	*Pyrgulopsis pilsbryana* or *Colligyrus greggi*
		Mountain Marshsnail (*Stagnicola montanesis*)
7/31-8/7 2019	Beaver Creek, Summit County	Western Pearlshell (*Margaritifera falcata*)
10/28-11/8 2019	Cutler Reservoir	Paper Pondshell (*Utterbackia imbecillis*)
		Asian Clam (*Corbicula fluminea*)
		California Floater (*Anodonta californiensis)*

Northeast Region

Survey date range: December 2018- December 2019

UDWR biologists: Matt Breen, Mike Fiorelli, Jordon Detlor

Objectives

Conduct surveys for presence of Unnamed Fossaria (*Galba techella*), Course Ramshorn (*Planorbella binneyi*), and Eureka Mountainsnail (*Oreohelix eurekensis*) in northeastern Utah.

Results

No mollusk surveys were performed in 2019. Above average snowpack during 2019 precluded Utah Division of Wildlife Resources personnel from completing any mollusk surveys during the first half of the year, while personnel vacancies prevented survey activities later in the year.

Notes

ESMF (Endangered Species Mitigation Fund) funding from 2019 will be carried over to fund mollusk survey activities in 2020.

Strategic monitoring plan

Efforts in 2020 will be focused on surveying previously identified sites for these species in the Ashley National Forest in Daggett, Uintah, and Duchesne counties, as well as the East Tavaputs Plateau in Grand County. Other opportunistic surveys will be conducted as they arise (i.e., during amphibian surveys, sportfish work, and other aquatics surveys where the Native Aquatics Biologist is present).

In subsequent years, survey locations will be targeted by mountain range (i.e., surveys will be focused in the Uinta Mountains one year, and in the Book Cliffs/Tavaputs Plateau the next).

Central Region

Monitoring date range: November 2018 - June 2019

UDWR biologists: Keith Lawrence, Jake Mecham, Kate Holcomb

Objectives

Monitor populations of Lamb's Ramshorn (*Planorbella oregonensis*), Desert Tryonia (*Tryonia porrecta*), Cross Snaggletooth (*Gastrocopta quadridens*), Mitered Vertigo (*Vertigo concinnula*), Mill Creek Mountainsnail (*Oreohelix howardi*) and Eureka Mountainsnail (*Oreohelix eurekensis*).

Methods

We followed lentic/lotic gastropod methods for aquatic species and terrestrial gastropod methods for terrestrial species provided in Sada (2011).

Results

The presence of Lamb Ramshorn could not be confirmed at the Salt Springs/Blue Lake complex in Tooele County during two separate visits in November-December 2018 because most living specimens were immature. No living Desert Tryonia were found. Hovingh (2018) last reported Tyronia at the site in 1998. The author has not collected this species at this locality since then (P. Hovingh, pers. comm.).

Mill Creek Mountainsnails were found at most of the sites we surveyed in Mill Creek Canyon during May 2019. They were abundant at sites along the canyon road, particularly at two sites along the more shaded and forested south side where Clarke (1993) had surveyed previously. Counts at those sites were 148 live individuals in an approximately 7,000 m^2 area and 378 individuals in a 950 m^2 area. Another site, on the north side of the road in more exposed conditions where Clarke (1993) also sampled, harbored mountainsnails but at a lower density of 96 individuals in an approximately 2,800 m^2 area. Numbers at all three sites were substantially higher than observed by Clarke (1993). We also found live snails on the west side of the hiking trail in Church Fork, a tributary to Mill Creek entering on the north side. These were considerably less abundant than on the south side of Mill Creek, with nine individuals in a 3,200 m^2 area. A small area on the west end of Porter's Fork, a small tributary entering Mill Creek from the south, was also surveyed. Only seven live snails were observed in a 2,500 m^2 area, although snow inhibited the search effort.

Two separate searches were conducted for Eureka Mountainsnail at Lime Peak and Mammoth Peak in Juab County at locations also surveyed by Clarke (1993). We failed to find any live or empty specimens at Lime Peak within a 18,000 m^2 search area. Clarke (1993) had also reported no live snails. A search at Mammoth Peak did reveal the presence of snails. We found 52 in a 3,300 m^2 area where a large portion had been disturbed by past mining activity.
Cross Snaggletooth were not found during one visit to Lamb's Canyon in Salt Lake County along the hiking trail in June 2019. Four different sites located within approximately 500 m of each other were surveyed. Mitered Vertigo were found to be quite common in Lamb's Canyon in

areas we searched. We counted and collected a total of 115 live individuals in a total area of approximately 300 m^2.

Data from monitoring efforts are provided in an Excel spreadsheet that will be entered into UDWR's mollusk database. A summary of the dates, locations and species encountered during monitoring is provided in Table 2.

Notes

Expanded searches are recommended at Blue Lake to determine whether Lamb Ramshorn and Desert Tryonia are indeed absent. We make the same recommendation for Cross Snaggletooth in Lamb's Canyon. Expanded searches should also be considered for Eureka Mountainsnail in suitable habitats to better describe their distribution.

References

Clarke, A. H. 1993. Status survey of fifteen species and subspecies of aquatic and terrestrial mollusks from Utah, Colorado and Montana. Prepared for the U.S. Fish and Wildlife Service by Ecosearch, Inc. Portland, Texas.

Hovingh, P. 2018. Extant (1984-2000) freshwater mollusk distributions from the Great Basin and adjacent regions in the Natural History Museum of Utah collection and the supplement field data sheets surveys in Western North America for leeches, mollusks, and amphibians. Prepared for the Invertebrate Section of Natural History Museum of Utah. Salt Lake City, Utah.

Sada, D. 2011. Monitoring protocols for Utah's rare aquatic and terrestrial mollusks. Prepared for the Utah Division of Wildlife Resources, Salt Lake City, by the Desert Research Institute.

Table 2. Date, general location and species collected during surveys in the Central Region.

Date	**Location**	**Species**
11/19/2018	Salt Spring	Red-rimmed Melania (*Melanoides tuberculata*)
11/20/2018	Blue Lake	Red-rimmed Melania (*Melanoides tuberculata*)
		Bear Lake Springsnail (*Pyrgulopsis pilsbryana*)
		Western Glass-Snail (*Vitrina pellucida*)
12/13/2018	Blue Lake	Red-rimmed Melania (*Melanoides tuberculata*)
		Unidentified Ramshorn
		Bear Lake Springsnail (*Pyrgulopsis pilsbryana*)
5/9/2019	Mill Creek Canyon (road)	Mill Creek Mountainsnail (*Oreohelix howardi*)
5/13/2019	Mill Creek Canyon (Church Fork)	Mill Creek Mountainsnail (*Oreohelix howardi*)
5/15/2019	Mill Creek Canyon (Porter's Fork)	Mill Creek Mountainsnail (*Oreohelix howardi*)
6/3/2019	Mammoth Peak	Eureka Mountainsnail (*Oreohelix eurekensis*)
6/20/2019	Lamb's Canyon	Mitered Vertigo (*Vertigo concinnula*)
		Brown Hive (*Euconulus fulvus*)
		Western Glass-Snail (*Vitrina pellucida*)
		Rocky Mountain Column (*Pupilla blandi*)
		Quick Gloss (*Zonitoides arboreus*)
		Forest Disk (*Discus whitneyi*)
		Mud Amincola (*Amnicola limnosus*)

Southeast Region

Survey date range: 24-26 June, 2019 and 6-8 August, 2019

UDWR Biologist: Dan Keller

Objectives

1) To determine the presence, distribution, and abundance of mollusk species, especially those listed in the Utah Wildlife Action Plan (WAP) in Southeastern Utah by surveying sites with historical occurrences as well as searching nearby suitable habitats.
2) Complete surveys on the Abajo Mountains in San Juan County to document occurrence of Yavapai Mountainsnail (*Oreohelix Yavapai*) and Mitered Vertigo (*Vertigo concinnula*).

Methods

We used historical Yavapai Mountainsnail locations as a starting point for our surveys. After locating historical sites, team members split up and searched the immediate area. Survey methods consisted of walking slowly while searching for likely microhabitats, turning over rocks and logs, and sifting through leaf litter. We collected UTM coordinates, habitat description, and photos when target species were encountered.

Results

Both Yavapai Mountainsnail and Mitered Vertigo were found within the Montezuma Hydrologic Unit (HUC8 14080203). Nine living *Oreohelix* specimens were collected at different locations and preserved in EtOH for genetic testing. Mitred Vertigo were found in many of the same locations as Yavapai Mountainsnail, additionally numerous dead and living Mitred Vertigo were found near North Creek.

Notes

The microhabitats containing living Yavapai Mountainsnail consistently had broken rock piles nearby with both open canopy and overhead shading, typically with a currant bush or other shrubs present. Surveys in June were much more successful in locating living Yavapai Mountainsnail compared to our second survey in August; this might be related to the wet spring followed by a very dry summer and fall 2019 season. During our surveys, Yavapai Mountainsnail occurrence ranged from 8,540 to 10,370 feet. Future surveys should investigate potential upper and lower elevation limits.

Southern Region

Monitoring date range: May 2019 – November 2019

UDWR biologists: Melinda Bennion, Graham BeVier, Lukas Brooks, Kevin Bunnell, Kody Callister, Daniel Cole, Lis Cordner, Christian Edwards, Kate Holcomb, Jon Hudson, Julie Sabattis, Martin Schijf, Izzie Speer, Sarah Siefken, Ellie Swanson, Eric Wagner, Kevin Wheeler, Erik Woodhouse (Utah Division of Wildlife Resources); Paul Thompson (Utah Department of Natural Resources); George Weekley (U.S. Fish and Wildlife Service); Meghan Lyons, Cassie Mellon, Eric Reid, Reggie Swenson (Bureau of Land Management); Kevin Guadalupe (Nevada Department of Wildlife); Nathan Cahoon, Maddox Schijf (volunteers)

Objectives

1) Monitor populations of Desert Springsnail (*Pyrgulopis deserta*), Longitudinal Gland Pyrg (*Pyrgulopsis anguina*), Hamlin Valley Pyrg (*Pyrgulopsis hamlinensis*), Sub-globose Snake Pyrg (*Pyrgulopsis saxatilis*) in the Southern Region.
2) Inventory locations to document presence and distribution of Smooth Glenwood Pyrg (*Pyrgulopsis chamberlini*), Carinate Glenwood Pyrg (*Pyrgulopsis inopinata*), Brian Head Mountainsnail (*Oreohelix parawanensis*), Cross Snaggletooth (*Gastrocopta quadridens*), and Mitered Vertigo (*Vertigo concinnula*).
3) Conduct surveys to detect New Zealand Mudsnail (*Potamopygrus antipodarum*) within Southern Region watersheds.

Methods

We followed crenobiontic gastropod methods for springsnails and terrestrial gastropod methods provided in the Sada (2011) protocol. For springsnails, multiple samples were taken in each spring habitat, and relative abundance of springsnails determined by averaging the springsnails per sample in each habitat, using the following scale: 1-6 springsnails = scarce; 7-20 springsnails = common; greater than 20 springsnails = abundant. For terrestrial gastropods, rocks and logs were turned in appropriate habitat in shady or moist areas, and mollusks underneath were counted and collected for later identification, if necessary.

The UDWR New Zealand Mudsnail sampling protocol dictates that technicians search an aquatic target area (stream length, lake shore, spring source, or wetland) for a minimum of one hour, focusing primarily on submerged sticks, rocky substrates, and macrophytes. If the survey is conducted in an area with soft sediments, the technicians sift into the substrate to a depth of one inch.

Results

Desert Springsnails were found along 30 meters of channel surveyed, with the number of snails observed in each sample ranging between zero and 45. Relative abundance was determined to be common.

Longitudinal Gland Pyrgs were found in 25 meters of stream at Clay Spring, which is a shorter distance than what was observed in previous surveys (2005, 2009, 2012, and 2016). Numbers of snails observed in samples varied between 0 and 140; relative abundance was determined to be

abundant (greater than 20 springsnails), and was similar to other sampling events. At Stateline Springs, Longitudinal Gland Pyrgs were found in 14 of the 16 springs surveyed. Springsnails were found to be relatively scarce (1-6 springsnails per sample) in four springs, common in six springs, and abundant in four springs. In comparison, Sada (2017) found springsnails in 13 springs, with none in Stateline Spring B, Stateline Spring M, or Stateline Spring N. Sada considered them to be scarce in ten springs and common in three (Sada 2017).

Hamlin Valley Pyrgs were found in seven of nine springheads surveyed. Springsnails were distributed at various distances from springheads, from being found only in the springhead to being found up to 80 meters downstream. Relative abundance was not determined; however, seven springsnails were observed in Spring 1, hundreds of springsnails were observed in Spring 2, and 17 springsnails were observed on one rock in Spring 11. Springsnails observed in other springs were not counted.

On May 28, eight Sub-globose Snake Pyrgs were found in a sample taken in the stream 35 meters downstream from the primary Gandy Warm Springs springhead, but were not found in samples at 5 meters or 59 meters downstream from the springhead. Additional searching near 60 meters downstream did not reveal additional springsnails. Eight samples were taken in the northwestern-most spring outflow. No springsnails were found, although six were observed on a single rock in a small man-made pool below the springhead. In the second springhead from the north, springsnails were found on rocks in the outflow, and two samples taken in the springbrook at 12 meters and 25 meters below the springhead contained one and six springsnails, respectively. No springsnails were found in the third springhead or springbrook, but one was found in the main channel near the third spring confluence. Sub-globose Snake Pyrgs were less common than in previous visits and had a reduced distribution along the main stream (35 meters in 2019, 250 meters in 2005, and 1.19 km in 2012). Springsnails continued to occupy the two northwestern springs where they were documented in 2012 and were also found in the main channel upstream of the primary springhead.

A follow-up visit was made to Gandy Warm Springs on August 16 to better understand whether the decline in distribution and abundance of Sub-globose Snake Pyrg observed on May 28 was due to seasonal variation or resulted from some unknown disturbance. Six sites were sampled downstream of the main spring pool, but very few springsnails were found. Two surveyors examined the reach between the BLM-private property line and upstream about 0.6 km for springsnails and found none (living or dead) after 1.17 hours of searching with fine-mesh nets. Three live springsnails were found on floating vegetation 192 meters downstream after 2 hours of searching by one surveyor with a D-frame net. Surveys were not conducted in the smaller springs and spring outflows uphill and west of the main spring; it was assumed that the snail distribution remained similar to what was observed in May. In twenty points sampled within the spring pool, only one live springsnail was found. Two surveyors spent two hours sampling the spring pool. The springsnail was collected along the northern edge of the pool where water enters the pool from upstream springs. Empty springsnail shells were common, with as many as 45 shells being found in one sample. A small (<20 mm length) armored catfish (Family Loricariidae, also known as Plecostomus or pleco) was captured in one sieve sample while searching for springsnails. This was the first time that this species was documented in the Warm Spring complex. Later efforts were made to better understand the abundance and distribution of

armored catfish and Pearl Cichlid (*Geophagus brasiliensis*) within the Gandy Warm Springs area.
Surveys for Brian Head Mountainsnail on August 22 resulted in four locations with shells present. One additional shell was found on the rocky slope above the first survey location. Probable live individuals were documented in three of these locations.

Smooth Glenwood Pyrgs and Carinate Glenwood Pyrgs were observed in both the lower and upper Parcell Springs on September 4-5. Springsnails were found throughout the entire 180 m length of the lower springbrook.The number of springsnails in samples varied between 25 and 652, with an average count of 263. Although springsnails were not all identified to species during counts, the majority of springsnails found were Smooth Glenwood Pyrgs. Springsnails were found at both sample sites along the upper springbrook. The number of springsnails in samples varied between 19 and 84. The majority of springsnails found were Smooth Glenwood Pyrgs.

Land snail populations were not found in many of the habitats around Fish Lake that were surveyed on September 12-13. Only two locations along Fish Lake yielded mollusk populations. Neither of the target species, Cross Snaggletooth (*Gastrocopta quadridens*) nor Mitered Vertigo (*Vertigo concinnula*), were found. Additional surveys need to be conducted to search for these species. Because the documented locality "Fish Lake" from historic records may be a general reference to the area, additional surveys should be conducted in appropriate habitats further from Fish Lake itself. Two locations were also searched along the Fremont River on September 13, and neither Cross Snaggletooth nor the Mitered Vertigo were found.

New Zealand Mudsnail surveys were conducted at 16 sites within the Virgin Basin of Utah (and adjoining sites in Nevada and Arizona) in conjunction with Virgin Spinedace (*Lepidomeda mollisinus*) monitoring and Aquatic Invasive Species surveys for Fish Transfer Requests. Mudsnails were documented at one site (Beaver Dam State Park in Nevada) where they have been established since 2012. Although they have been documented in other localities in the Beaver Dam Wash in previous years (Motoqua and Lytle Ranch), they were not observed at those sites in 2019 and are likely in much smaller densities.

A summary of the dates, locations, and species encountered during 2019 monitoring is provided in Table 3.

Notes

Armored Catfish were found at Gandy Warm Springs in August. While the threat of these fish to the Sub-globose Snake Pyrg population is unknown, it will be important to further assess the armored catfish population at Gandy Warm Springs and evaluate control methods. UDWR and BLM biologists sampled Gandy Warm Springs with minnow traps and a hoop net over two nights (August 26-28) and were able to remove eight armored catfish. UDWR and BLM biologists used backpack electroshockers to remove 197 additional armored catfish on September 27, 2019. UDWR biologists returned again on November 12-14 to attempt a large-scale control, and removed another 562 armored catfish, and in the process, another non-native fish was discovered. This fish is tentatively identified as the Pearl Cichlid (*Geophagus brasiliensis*), and has only been found below the diversion.

References

Sada, D. 2011. Monitoring protocols for Utah's rare aquatic and terrestrial mollusks. Prepared for the Utah Division of Wildlife Resources, Salt Lake City, by the Desert Research Institute.

Sada, D.W. 2017. Environmental and biological factors influencing Great Basin and surrounding areas springsnail (Gastropoda: Rissooidea) abundance and distribution. Report to U.S. Fish and Wildlife Service. 33 pp + appendices.

Table 3. Date, general location, and species observed during mollusk surveys in the Southern Region in 2019.

Date	Location	Species
5/2/2019	City Creek	Desert Springsnail (*Pyrgulopsis deserta*) *Physa* sp.
5/22/2019	Stateline Springs	Longitudinal Gland Pyrg (*Pyrgulopsis anguina*) *Physa* sp.
5/22/2019	Clay Spring	Longitudinal Gland Pyrg Lymnaid (Family Lymnaeidae) Peaclam (Family Sphaeriidae) *Physa* sp.
5/23/2019	White Rock Cabin Springs	Hamlin Valley Pyrg (*Pyrgulopsis hamlinensis*)
5/28/2019	Gandy Warm Springs	Sub-globose Snake Pyrg (*Pyrgulopsis saxatilis*) Red-rimmed Melania (*Melanoides tuberculata*)
8/16/2019	Gandy Warm Springs	Sub-globose Snake Pyrg Red-rimmed Melania *Gyraulus* sp. *Ferrissia* sp.?
8/22/2019	Brian Head Peak	Brian Head Mountainsnail (*Oreohelix parawanensis*) Rocky Mountainsnail (*Oreohelix strigosa depressa*) Lovely Vallonia (*Vallonia pulchella*) Crestless Column (*Pupilla hebes*) Rocky Mountain Column (*Pupilla blandi*) Forest Disc (*Discus whitneyi*) Western Glass Snail (*Vitrina pelluicida*)
9/4-5/2019	Parcell Springs	Smooth Glenwood Pyrg (*Pyrgulopsis chamberlini*) Carinate Glenwood Pyrg (*Pyrgulopsis inopinata*) Ambersnail (Family Succeinidae) Milky Slug (*Deroceras reticulatum*) Quick Gloss (*Zonitoides arboreaus*)
9/12-13/2019	Fish Lake	*Galba* sp. Ash Gyro (*Gyraulus parvus*) Ambersnail Quick Gloss Western Glass Snail
9/13/2019	Fremont River	Lovely Vallonia *Galba* sp. Marsh Slug (*Deroceras laevae*)
9/19/2019	North Fork Virgin River	*Physa* sp.
9/20/2019	East Fork Virgin River	-
10/2/2019	Virgin River at Rockville	*Physa* sp.
10/3/2019	North Creek	*Physa* sp.
10/3/2019	Virgin River at Virgin Gauge	*Physa* sp.
10/4/2019	Ash Creek	*Physa* sp.

Table 3, continued. Date, general location, and species observed during mollusk surveys in the Southern Region in 2019.

Date	Location	Species
10/7/2019	La Verkin Creek	Lymnaeid (Family Lymnaeidae)
10/8/2019	Moody Wash	*Physa* sp. Brown Garden Snail (*Cornu aspersum*)
10/8/2019	Quail Creek	-
10/9/2019	Santa Clara River above Gunlock Reservoir	*Physa* sp. Planorbid (Family Planorbidae)
10/9/2019	Santa Clara River below Gunlock Reservoir	*Physa* sp. Planorbid
10/9/2019	Santa Clara River at Shivwits	*Physa* sp. Lymnaeid *Ferrissia* sp.?
10/24/2019	Beaver Dam Wash at Lytle Ranch	-
10/28/2019	Beaver Dam Wash at Motoqua	*Physa* sp. Planorbid
10/29/2019	Beaver Dam Wash at Beaver Dam State Park (NV)	New Zealand Mudsnail (*Potamopyrgus antipodarum*) *Physa* sp. Planorbid
11/5/2019	Santa Clara River at Tonaquint Park	Asian Clam (*Corbicula fluminea*) *Physa* sp.
11/5/2019	Virgin River below Gorge Barrier (AZ)	Asian Clam

ANNUAL REPORTS

Partners

Utah State University

Torrey Rodgers and Karen Mock

I wanted to let you know that I found some live Anodonta in the E fork of the Sevier in the Kingston Canyon WMA when collecting eDNA samples down there in October. I was excited to find them as my understanding was that we only knew them to be extant in the reservoirs (although obviously they were in the river originally).

Since I was focused on collecting eDNA samples, I did not do all that much searching for live mussels, but I found 2 live individuals, and quite a few hinged shells. I imagine I would have found more if I did more focused searching.

I found one small individual (about 20 mm length) above the canyon, I believe on the private stretch with walk in access. Coordinates 38.16676 -112.05953.

And a larger individual (about 55 mm) further down in the WMA at 38.17686 -112.07660
I also collected 16 eDNA samples (about every kilometer) throughout the length of the WMA. And I collected a few samples from the main Sevier, and from otter creek above the reservoir. I have not run them yet, but will let you know what I find. The eDNA samples from the WMA should give us a better idea of the special extent of the population.

I think this spot is an excellent site for focusing management of Sevier Basin Anodonta. It seems ideal because it is already a WMA, and since it is currently managed for fish, there should hopefully be ample host fish for recruitment. Also, as the reservoirs will doubtlessly experience dry downs more and more frequently, this river population might be even more important.
Let me know if you have any questions, and I will let you know once I analyze the eDNA samples.

Dugway Proving Grounds (DPG)

Robert Delph

Here is a brief summary of DPG's involvement so far. In 2018 we worked with Danielle Finlayson (graduate student at BYU) to survey as many springs within the MOA (Military Operating Area) as possible. She conducted a type II rapid assessment of 91 springs, which included invertebrate sampling using hand held dip nets. The aquatic inverts were stored in vials of 70% EtOH then sent to me for sorting and identification. Of the 91 samples (sites) I sorted through, I found mollusks in 23 of them. I identified them to the lowest level I could using the 2017 UDWR's Mollusks of Utah guide. Based on just shell morphology, identifications were mostly family and genus level. All specimens were 3D imaged at MNA by Gary Alpert. The images will be available online soon, possibly on iverteweb. Species determination is still pending. DNA testing will most likely be needed for much of what we have in our collection. All specimens are currently housed in our Natural History repository here at DPG. Taxa that "I think" we have are: *Gyraulus circumstriatus*, *Galba modicella*, *Planorbella subcrenata*, *Pyrgulopsis* (multiple species), *Stagnicola elodes*, *Physella gyrina*, *Physella* (multiple species), and *Melanoides tuberculata*. Again this is solely based on shell morphology, not to mention I'm not a snail expert.

Eric Wagner

Retired Utah Division of Wildlife Resources

Eric Wagner made collections and observations of mollusks throughout Utah between December 2018 and December 2019. His observations can be found in the “Mollusca distribtuion in Utah” iNaturalist project (https://www.inaturalist.org/projects/mollusca-distribution-in-utah).

Dale Nielson

Retired entomologist
USDA Agricultural Research Service

Location 1.

The primary objective of the 2019 field season was to locate living specimens or remnants of *Anodonta* mussels in The Little Bear river or adjacent waterways in Cache County, Utah.

In the early 1930's two examples of *Anodonta* were collected at a location described as "The Little Bear river near Mendon, Utah". The specimens were part of a laboratory taxonomy collection in the College of Science at Utah State University. I examined these specimens in the 1970's and again in the mid 1980's. Unfortunately at some time in the last 30+ years the specimens have been misplaced or lost.

During the past 70 years the Little Bear river has been periodically diverted for irrigation purposes and at times is completely dry for weeks at a time in the Mendon area. There are probably no living *Anodonta* remaining in this part of the river. I spent several days searching for shells in this area and also downstream to where the river empties into Cutler marsh. I also searched nearby Spring creek and other natural waterways adjacent to the Bud Phelps WMA. I was unsuccessful in finding any evidence of native freshwater mussels.

Location 2.

The Cub river in Franklin County, Idaho, is a tributary of the Bear River that has remained relatively unchanged since early settlers arrived in the area in the 1860's. Native *Anodonta* mussels occur (or occurred) in the Bear River above and below its confluence with the Cub river. I have never read any reports or heard of any first hand accounts of native mussels occurring in this river so I decided to make an initial survey. Searching began at Willow Flat and continued intermittently downstream, depending upon access, to the forest service boundary for evidence of western pearlshell (*Margaritifera* spp.) mussels. Additional sections of the lower stretch of the river were searched for *Anodonta* in both Idaho and Utah at areas where again access was available. No shells of either genera were found at any of the locations.

Location 3.

The water level in Cutler marsh in Cache and Box Elder county was drawn down in late October and I revisited several locations in the Cache Junction area where I have found *Anodonta* shells in the past. I was able to locate additional mussel shells in this area but didn't find any living specimens. I also searched along the abandoned railroad grade walking trail located south of the Benson marina and observed what I believed to be the shell of a large floater mussel lying on the surface of the mud. However, due to rising water and the softness of the mud I was unable to collect it.

Wyoming Game and Fish Department

Stephen Siddons

Here is a brief update on Wyoming mussel efforts for the western drainages.

Wyoming Game and Fish Department mussel sampling efforts for 2019 were focused on California Floater Mussels (CFM) in the Bear River drainage. Wyoming Game and Fish Department biologist, Stephen Siddons, continued with a second year of mark-recapture work on a known population of CFM at Cokeville Meadows National Wildlife Refuge on the Bear River. The mark-recapture site is a one kilometer reach that will be sampled annually to monitor the status of CFM in this portion of the Bear River. Four CFM were sampled and tagged in 2018 by two surveyors. Three live mussels were captured and tagged in 2019 by four surveyors, but no previously marked individuals were found. The goal of this effort is to eventually equate a catch-per-effort value to mussel abundance or density for future monitoring protocols. The Wyoming Game and Fish Department also assisted Lusha Tronstad, of the Wyoming Natural Diversity Database, with an environmental DNA survey for CFM. The survey will encompass the known and suspected range of CFM in the Bear River drainage in Wyoming. Positive samples will be followed with field surveys in 2020 or 2021 to determine presence and abundance of CFM throughout the Bear River drainage.

Thank you for organizing all of this and passing along our update. Please keep me in the loop and let folks know I am happy to collaborate as needed.

Utah Geological Survey

Miles McCoy-Sulentic

Appendix A. Annual Utah Geological Survey Mollusk Survey and Monitoring Report. Utah Geological Survey.

Wasatch Front Water Quality Council

Jordan Holcomb, Hannah Finely, Frank Fluckiger

Appendix B. Historic Gastropod Assemblages in Goshen Bay, Utah Lake based on Relict Shells.

OreoHelix Ecological

David Richards

Appendix C. State Canal Mollusk Survey as it Relates to South Davis Sewer District North Plant Effluent.

Appendix D. Lower Jordan River Mollusk Survey as it Relates to South Davis Sewer District South Plant Effluent.

STRATEGIC MONITORING PLANS

Northern Region

H.U.C. (Level 6 up to 10)	Location	Species	Monitoring or Survey Cycle (years)	FY 2020												FY 2021												FY 2022											
				SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING		
				J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
	Bivalves																																						
	Cutler Reservoir	California Floater	as draw downs occur																																				
	Big Spring Creek	California Floater	N/A																																				
	Raft River	California Floater	N/A																																				
	Beaver Creek	Western Pearlshell	1																																				
	Spring/Pond Snails																																						
	NRO	Green River Pebblesnail	3																																				
	NRO	Mountain Marshsnail	3																																				
	NRO	Widelip Pondsnail	3																																				
	NRO	Fat-Whorled Pondsnail	2																																				
	NRO	Northwest Bonneville Pyrg	3																																				
	NRO	Bear Lake Springsnail																																					
	NRO	Utah Physa																																					
	NRO	Rocky Mountain Duskysnail																																					
	Terrestrial snails																																						
	NRO	Lyrate Mountainsnail	3																																				
	NRO	Mitered Vertigo	3																																				
	NRO	Rustic Ambersnail	3																																				
	NRO	Sierra Ambersnail	3																																				
	NRO	Deseret Mountainsnail	3																																				
	NRO	Eureka Mountainsnail	3																																				

Northeast Region

Location	Species	Monitoring or Survey Cycle (years)	FY 2020												FY 2021												FY 2022											
			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING		
			J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Spring/Pond Snails																																					
Greens Lakes	Course Ramshorn	1																																			
Book Cliffs/Tavaputs Plateau	Course Ramshorn	1																																			
Uinta Mountains	Course Ramshorn	1																																			
Farm Creek	Unnamed Fossaria	1																																			
Book Cliffs/Tavaputs Plateau	Unnamed Fossaria	1																																			
Uinta Mountains	Unnamed Fossaria	1																																			
Terrestrial Snails																																					
Hill Creek	Eureka Mountainsnail	1																																			
Ashley Nat. Forest	Eureka Mountainsnail	1																																			
Hominy Creek	Eureka Mountainsnail	1																																			
Book Cliffs/Tavaputs Plateau	Eureka Mountainsnail	1																																			
Uinta Mountains	Eureka Mountainsnail	1																																			

Central Region

Location	Species	Cycle (years)	FY 2020												FY 2021												FY 2022											
			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING		
			J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Bivalves, Mussels, clams, floaters...or Stream Related Species...Choices TBD																																					
Redden Springs	California Floater	3																																			
Mona Springs	California Floater	3																																			
Spring/Pond Snails																																					
Ninemile Reservoir	Ninemile Pyrg	3																																			
Fountain Green	Southern Bonnevile Pyrg	3																																			
Thistle Creek	Southern Bonnevile Pyrg	3																																			
Lee Creek	Southern Bonnevile Pyrg	3																																			
Clover Creek	Southern Bonnevile Pyrg	3																																			
Indian Springs	Southern Bonnevile Pyrg	3																																			
Sixmile Springs	Southern Bonnevile Pyrg	3																																			
Iosepa	Desert Tryonia	3																																			
Saratoga Springs	Desert Tryonia	3																																			
Horseshoe Springs	Desert Tryonia	3																																			
Warm Springs	Desert Tryonia	3																																			
Fish Springs	Desert Tryonia	3																																			
Middle Spring	Desert Tryonia	3																																			
North Spring	Desert Tryonia	3																																			
House Spring	Desert Tryonia	3																																			
Mirror Spring	Desert Tryonia	3																																			
Crater Spring	Desert Tryonia	3																																			
Lost Spring	Desert Tryonia	3																																			
Percy Spring	Desert Tryonia	3																																			
South Spring	Desert Tryonia	3																																			
Mud Spring	Desert Tryonia	3																																			
Scuba Spring	Desert Tryonia	3																																			
Provo	Course Ramshorn	3																																			
Riverton Bridge	Course Ramshorn	3																																			
Utah Lake	Course Ramshorn	3																																			
Salt Lake City	Course Ramshorn	3																																			
Beck's Hot Springs	Course Ramshorn	3																																			
Alsop's Pond	Course Ramshorn	3																																			
City Creek Canyon	Course Ramshorn	3																																			
Murray	Course Ramshorn	3																																			
Salamander Lake	Course Ramshorn	3																																			
Wood's Cross	Course Ramshorn	3																																			
Terrestrial Snails																																					
Black Rock Canyon	Lyrate Mountainsnail	3																																			
Big Canyon	Lyrate Mountainsnail	3																																			
Mill B Flat	Lyrate Mountainsnail	3																																			
Skull Valley	Lyrate Mountainsnail	3																																			
Salt Lake City	Rustic Ambersnail	3																																			
Hogom Branch	Mitered Vertigo	3																																			
Brighton	Mitered Vertigo	3																																			
Silver Lake	Mitered Vertigo	3																																			
Clinton's Cave	Southern Tightcoil	3																																			

Southeast Region

H.U.C. (Level 6 up to 10)	Location	Species	Monitoring or Survey Cycle (years)	FY 2020												FY 2021												FY 2022											
				SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING		
				J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
14080203	North Fork of Montezuma Creek	Yavapai Mountainsnail	3						.	.	.										.	.	.										.	.	.				
14070006	Navajo Mountain	Yavapai Mountainsnail							.	.	.										.	.	.										.	.	.				
14030001, 14060008	Bookcliffs	Eureka Mountainsnail	3						.	.	.										.	.	.										.	.	.				
14060008	Green River	Green River Pebblesnail	3						.	.	.										.	.	.										.	.	.				
14080203	Abajo Mountains	Mitred Vertigo	3						.	.	.										.	.	.										.	.	.				

Southern Region

H.U.C. (Level 6 up to 10)	Location	Species	Monitoring or Survey Cycle (years)	FY 2020												FY 2021												FY 2022											
				SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING		
				J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
	Bivalves, Mussels, clams, floaters...or Stream Related Species...Choices TBD																																				
	Piute Reservoir	Floater	3																																		
	Otter Creek Reservoir	Floater	3																																		
	Pruess Lake	Floater	3																																		
	Koosharem Reservoir	Floater	3																																		
	Spring/Pond Snails																																				
	White Rock Cabin Springs	Hamlin Valley Pyrg	3																																		
	Clay Spring	Longitudinal Gland Pyrg	3																																		
	Gandy Warm Spring	Sub-globose Snake Pyrg	3																																		
	Black Canyon	Black Canyon Pyrg	3																																		
	Glenwood Springs	Smooth Glenwood Pyrg/ Carinate Glenwood Pyrg	3																																		
	Brian Head	Brian Head Snail	3																																		
	Bishop Springs	Cloaked Physa	3																																		
	Copley's Cove	Bifid Duct Pyrg	3																																		
	Antelope Spring	Bifid Duct Pyrg	3																																		
	Big Spring	Bifid Duct Pyrg	3																																		
	Maple Grove	Bifid Duct Pyrg	3																																		
	Red Cedar Spring	Bifid Duct Pyrg	3																																		
	Green Springs GC	Desert Springsnail	3																																		
	Red Hills GC	Desert Springsnail	3																																		
	Zion NP	Wet-rock Physa	3																																		
	Junction	Course Ramshorn	3																																		
	Beaver	Mountain Marshsnail	3																																		
	Burr Creek	Otter Creek Pyrg	3																																		
	Little Lost Creek	Otter Creek Pyrg	3																																		
	Otter Creek	Otter Creek Pyrg	3																																		
	Sunset Point	Fossaria techella	3																																		
	Mammoth Creek	Fossaria techella	3																																		
	Junction Spring	Utah Physa	3																																		

Southern Region, continued

H.U.C. (Level 6 up to 10)	Location	Species	Monitoring or Survey Cycle (years)	FY 2020												FY 2021												FY 2022											
				SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING			SUMMER			FALL			WINTER			SPRING		
				J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
	Zion NP	Sluice Snaggletooth/ Striate Gem/ Thin-lip Vallonia/ Top-heavy Column	3																																				
	Fish Lake	Cross Snaggletooth/ Mitred Vertigo	3																																				
	Asay Creek	Ribbed Dagger	3																																				
	Kings Ranch	Ribbed Dagger	3																																				
	Cannonville	Ribbed Dagger	3																																				
	Three Lakes Canyon	Kanab Ambersnail	3																																				
	Kanab Creek	Kanab Ambersnail	3																																				
	Asay Creek	Striate Gem/ Thin-lip Vallonia	3																																				

Appendix A. Annual Utah Geological Survey Mollusk Survey and Monitoring Report. Utah Geological Survey.

Survey date range: 6/17/19-8/21/19

UGS Biologists: Miles McCoy-Sulentic, Diane Menuz

Objectives

1) Objective 1: Increase Utah Geological Survey's (UGS) capacity to survey and identify mollusks.
2) Objective 2: Conduct rapid mollusk surveys during planned wetland surveys in the Central Basin and Range ecoregion.

Methods

Mollusk surveys were conducted as part of UGS wetland assessment work in the Central Basin and Range ecoregion to explore the range of wetland conditions likely to be found in the ecoregion. We conducted a 15-minute focused survey for mollusks where water was present and collected data from incidental detections during vegetation surveys, which lasted up to 80 minutes. Shells and live individuals were collected and stored in water from the site if available and identified after returning to the office. Live collections were preserved for genetics using the hot water method, in which live snails were placed in a strainer within a larger Tupperware container and allowed to come out of their shells before pouring boiling water over them and placing them in storage containers with ethanol. Preservation was carried out within 24 hours of collection.

Results

We conducted wetland surveys at 18 sites in the summer of 2019 and visited several additional sites that may be only seasonally or historically wet, such as during the wet period Utah experienced in the 1980s, where we did not conduct a full survey. Incidental shell collections were made at these sites even if a full wetland survey was not conducted. Collections of shells or live mollusks were made at 12 of these sites in Tooele, Millard, Box Elder, Juab, and Utah counties (table 1). In total, we made 33 collections from 9 different families of aquatic mollusks. All sites were in valley basin locations ranging in elevation from 4232 to 4780 ft, and most collections consisted of shells only.

Kate Holcomb, Utah Division of Wildlife Resources Native Aquatic Biologist, joined UGS staff Miles McCoy-Sulentic and Lydia Keenan on July 3 to help survey a spring and wetland site and give instruction on how to survey and identify aquatic mollusks. Kate has also provided generous support to the UGS and the native mollusk working group in the form of technical identification keys and guides, as well as organizing meetings with experts in mollusk identification to help review and confirm identifications of specimens collected during field surveys.

Specimens of the family Hydrobiidae (spring snails) were collected at three locations but were not identified to species; the only collection of live individuals was made at a spring adjacent to Highway 83 west of Corrine, Utah. Empty spring snail shells were found at Blue Lake Waterfowl Management Area (WMA) and at a dry site west of Delta, Utah. Species of Lymnaeidae were collected at five sites, including Connor Spring, Clear Lake WMA, Fish Springs National Wildlife Refuge (NWR), a site in Snake Valley, and a site west of the town of Delta in the Sevier Desert. Most of these collections were identified as *Stagnicola elodes* (marsh pond snail) or unknown

Lymnaeidae. *Stagnicola utahensis* (S. *bonnevillensis,* fat-whorled pondsnail) was encountered at the Connor Spring site, with both live and shell collections made. Physidae species were collected at five sites, with two of these collections believed to be *Pysella gyrina* (tadpole physa), though these identifications are based on shell morphology rather than soft tissue anatomy. These sites included Fish Springs NWR, Blue Lake WMA, Clear Lake WMA, Donnor Spring near the base of the Pilot Range, and Connor Spring. Five species of Planorbidae were collected at four sites, including Fish Springs NWR, Blue Lake WMA, Clear Lake WMA, and the Sevier Desert. All Planorbidae collections consist of shells only, including two collections taken from soil pits below the surface, and only the Blue Lake location had surface water at the time of collection. Species of Planorbidae were identified as coarse ramshorn (*Planorbella binneyi*), meadow ramshorn (*Planorbula campetris*), and ash gyro (*Gyraulus parvus*). There was some uncertainty in species identification within Planorbidae, because some specimens of *Planorbella binneyi* may in fact be young *Planorbella trivolvis* (marsh ramshorn). New Zealand mudsnail (*Potamopyrgus antipodarum*) was found at three sites including Blue Lake WMA, a spring in a wet meadow in Snake Valley, and Connor Spring. Observed populations ranged from shells only to abundant live individuals. One collection of shells of red-rimmed melania (Melanoides tuburculata) was found at the Blue Lake WMA. One collection of shells of *Valvata humeralis* was made in the Sevier Desert in an area that is intermittently inundated. Sphaeriidae collections were made at five sites: along the Sevier River southwest of Delta, Utah, in Snake Valley, Tule Valley, and at Donnor Spring near the Pilot Range. There was low confidence in identification below the Sphaeriidae family level, with only two collections identified to the genus *Pisidium*. One incidental collection of shell fragments believed to be from the Unionidae family based on their size were made in the historical floodplain of the Sevier River near its confluence with Sevier Lake.

Notes

Qualitative data on site disturbances were recorded using metrics adapted from Sada (2011) during 2019 field surveys. In future surveys, the UGS will adopt the protocol and data sheets currently being developed by Kate Holcomb. The UGS plans to continue to improve its capacity to survey and identify aquatic mollusks by attending mollusk working group meetings and identification sessions.

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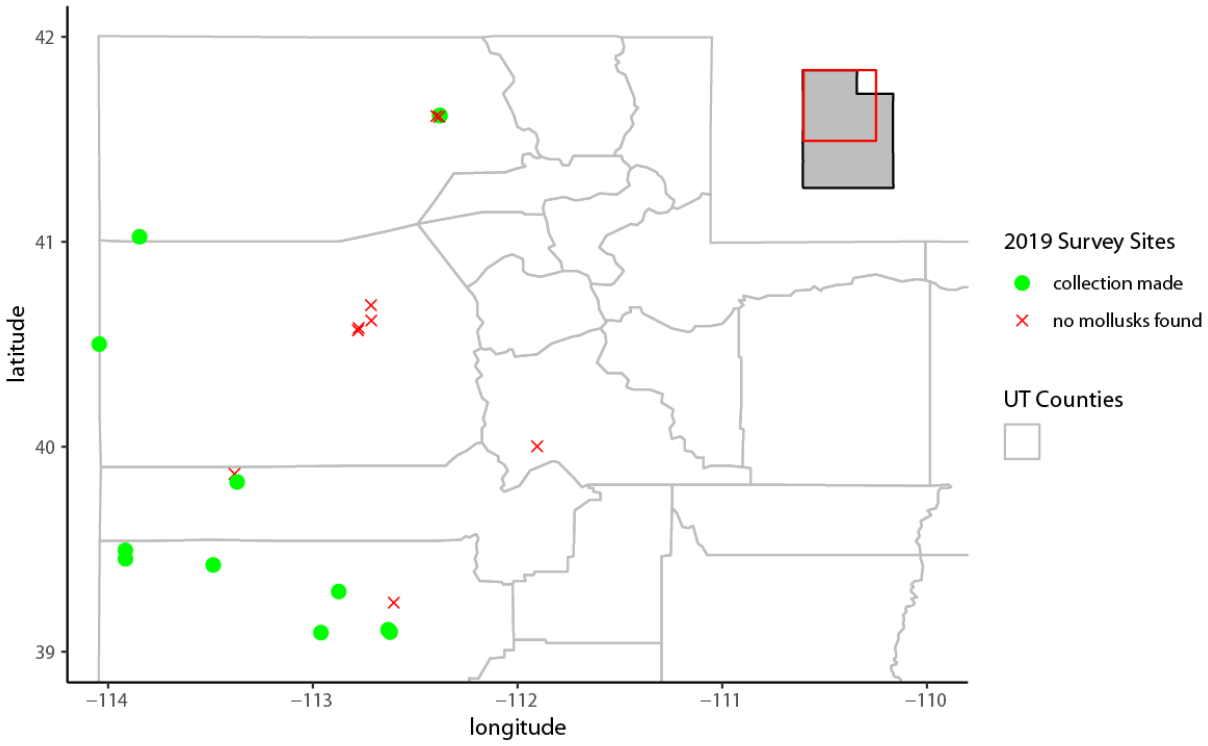

Figure 1. Locations in Utah visited by Utah Geological Survey in 2019.

Table 1. Date, general location, and species collected during wetland and mollusk surveys in the Central Basin and Range ecoregion in 2019.

Date	Location	Species
7/30/2019	Snake Valley	Unknown Lymnaeidae
8/1/2019	Tule Valley	Unknown Pisidium
7/30/2019	Fish Springs WMA	Unknown Physa
7/30/2019	Fish Springs WMA	*Planorbella binneyi*
7/29/2019	Fish Springs WMA	*Stagnicola elodes*
6/25/2019	Blue Lake WMA	Unknown Hydrobiidae
6/25/2019	Blue Lake WMA	Unknown Physidae
6/25/2019	Blue Lake WMA	*Planorbula campestris*
6/25/2019	Blue Lake WMA	*Potamopyrgus antipodarum*
6/25/2019	Blue Lake WMA	*Melanoides tuburculata*
7/9/2019	Sevier Desert	Unknown Hydrobiidae
7/9/2019	Sevier Desert	*Stagnicola elodes*
7/9/2019	Sevier Desert	*Gyraulus parvus*
7/9/2019	Sevier Desert	*Planorbella binneyi*
7/9/2019	Sevier Desert	Unknown Sphaeriidae
7/9/2019	Sevier Desert	*Valvata humeralis*
7/8/2019	Clear Lake WMA	*Gyraulus parvus*
7/9/2019	Along Sevier River	Unknown Sphaeriidae
7/9/2019	Along Sevier River	Unknown Unionoida
7/10/2019	Clear Lake WMA	Unknown Lymnaeidae
7/10/2019	Clear Lake WMA	*Physella gyrina*
6/24/2019	Donnor Spring	Unkonwn Physella
6/24/2019	Donnor Spring	Unknown Sphaeriidae
7/31/2019	Snake Valley	Unknown Pisidium
7/31/2019	Snake Valley	*Potamopyrgus antipodarum*
7/3/2019	Connor Spring North	Unknown Hydrobiidae
7/3/2019	Connor Spring North	*Stagnicola elodes*
7/3/2019	Connor Spring North	*Stagnicola bonnevillensis*
7/3/2019	Connor Spring North	*Potamopyrgus antipodarum*
7/3/2019	Connor Spring South	Unknown Hydrobiidae
7/3/2019	Connor Spring South	*Stagnicola elodes*
7/3/2019	Connor Spring South	Unknown Physidae
7/3/2019	Connor Spring South	*Potamopyrgus antipodarum*

Appendix B. Historic Gastropod Assemblages in Goshen Bay, Utah Lake based on Relict Shells. Wasatch Front Water Quality Council.

Wasatch Front Water Quality Council

January 8, 2020

Historic Gastropod Assemblages in Goshen Bay, Utah Lake based on Relict Shells

Progress Report 2019

Jordan Holcomb, Hannah Finely, Frank Fluckiger

Wasatch Front Water Quality Council

and

David Richards

OreoHelix Ecological

Rationale

There have been few attempts to characterize historical snail assemblages that include relative abundance of the constituents of the Great Basin's former snail assemblages. Utah Lake was once a snail diversity hotspot and the purpose of this study was to closely examine relict snail shells collected from Goshen Bay on Utah Lake to characterize historical assemblage composition to provide managers with baseline data by which to compare current snail assemblages and water quality conditions, and to provide reintroduction goals.

Methods

Dr. David Richards collected a one-liter sample of relict snail shells from the shoreline of Goshen Bay, Utah Lake (approx. 40.11987, -111.84602). The sample was spread out in a 9"x13" dish and randomly subsampled into 10- approximately 15 ml sub samples. Each sub sample was sorted, and all snails identified to the lowest practical taxon with a dissecting microscope following taxonomy of Mollusks of Utah a Simple Guide, and a UDWR unpublished draft gastropod key (Kate Holcomb and Eric Wagner pers comm). Due to taxonomic uncertainty of certain groups (e.g. Physidae, Sphaeriidae), some were not taken to species. Processed vouchers are stored at the Utah Lake Research Lab at Timpanogos Special Service District Water Reclamation Facility in Pleasant Grove, UT.

Results

Examination of Goshen Bay relict snail samples resulted in identification of 11 snail taxa (Table 1). The most numerically dominant species were *Gyraulus parvus* (38%), *Pyrgulopsis* sp. (26%), *Valvata*

humeralis (26%) (Figure 1; Table 1). Several relict shells of rare taxa including the now presumably extinct *Valvata utahensis* and Great Basin Ramshorn, *Helisoma newberryi* were also common.

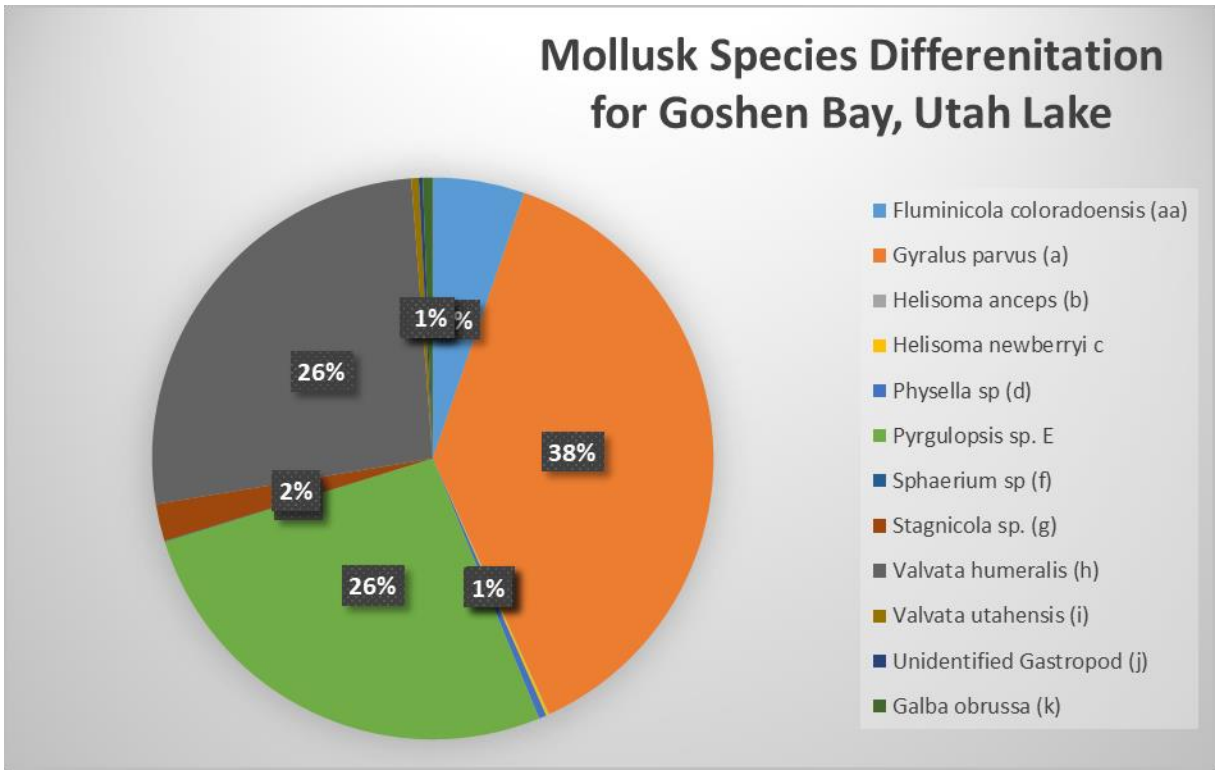

Figure 1. Percent composition of relict snail taxa from Goshen Bay, Utah Lake.

Table 1. List of taxa, their total number and percent composition from subsamples from Goshen Bay, Utah Lake.

Taxon	Total #	% of Total
Fluminicola coloradoensis	351	5.29
Galba obrussa	38	0.57
Gyralus parvus	2513	37.90
Helisoma anceps	2	0.03
Helisoma newberryi	10	0.15
Physella sp	29	0.44
Pyrgulopsis sp.	1750	26.40
Sphaerium sp.	3	0.05
Stagnicola sp.	142	2.14
Valvata humeralis	1749	26.38
Valvata utahensis	28	0.42
Unidentified Gastropod	15	0.23

Discussion

Our findings of almost a dozen relict snail taxa shows that at least along the shoreline of Goshen Bay, a rich and diverse gastropod assemblage existed until recently. Reasons for their disappearance are unknown but we suggest that a combination of several factors are responsible including; introduction of fish predators, increased water temperatures, decreased aquatic vegetation, decreased dissolved oxygen, droughts in the 1930s, increased harmful cyanobacteria blooms, and decreased water quality. Feedback loops of loss of this rich gastropod diversity also contributed to their eventual demise because they were an integral component of the functioning of the lake and were no longer able to contribute to Utah Lakes biological integrity and health.

Conclusion

The loss of what was once a rich and functionally diverse molluskan assemblage in Utah Lake that helped maintain its integrity and health is a Utah natural heritage travesty. Every effort should be may to improve conditions and begin a reintroduction program in earnest.

Appendix C. State Canal Mollusk Survey as it Relates to South Davis Sewer District North Plant Effluent. OreoHelix Consulting.

[Begins on next page.]

Filename: State Canal Mollusk Survey as it Relates to South Davis Sewer District North Plant Effluent

Version: 1.0

State Canal Mollusk Survey as it Relates to South Davis Sewer District North Plant Effluent

Progress Report 2020

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January 3, 2020

Table of Contents

Introduction

Freshwater mollusk diversity is depauperate in the western USA with the exception of waters in the Bonneville Basin, including the Jordan River drainage, UT (Richards 2015, 2017a, 2017b, 2018, 2019, Miller and Richards 2019). No intensive mollusk surveys have ever been conducted in State Canal, a man-made conveyance canal of lower Jordan River water.

In addition to the importance of understanding the status of native mollusks in the Jordan River drainage, including State Canal, native mussel surveys documenting their presence/absence are critical for ammonia criteria development and regulation. Two species of native mussels, *Anodonta* sp. and *Margaritifera falcata* may have occurred in the lower Jordan River, UT in the past but were unlikely to have occurred in State Canal. Unfortunately, severely degraded ecological conditions; host-dependent, dispersal- limited metapopulation dynamics; absence of past monitoring and legal protection; and inadequate management have likely eliminated the possibility of their continued existence in the lower Jordan River (Richards 2017a and b, USEPA 2013a, Miller and Richards 2019). Even though there are no historical records of *M. falcata* or *Anodonta* sp. occurring in State Canal, their present status in the canal is unknown.

Richards (2017a, b), Richards et al. 2020, and Richards and Miller (2019) conducted the most extensive native mussel surveys in the Jordan River drainage to date but did not find any live or recently dead native mussels. However, several highly weathered *Anodonta* sp. shell fragments were found indicating that this species occurred in these or nearby waters in the past. Even though Richards and Miller (2019) concluded that native mussels were likely absent in the Jordan River, absolute determination of absence in any water body, including State Canal, is not possible without a complete and thorough examination of the entire substrate (Richards 2017, USEPA 2013a, 2013b); an unrealistic endeavor. 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 management purposes in State Canal (UDWQ 2017a, Richards and Miller 2017, Richards 2017).

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 phylum Mollusca, particularly for mussels of the superfamily, Unionoidea. This 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 would allow site-specific criteria modification of the ammonia criteria. Consequently, the Wasatch Front Water Quality Council and Utah Division of Water Quality (UDWQ) concluded that a site-specific survey of State Canal be performed 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.

Objectives

The specific objective of this study was for us to provide site-specific survey data sufficient to determine a likelihood estimate of presence or absence of mussels near the South Davis Sewer District North Plant

discharge (ammonia zone of influence) in State Canal using the most appropriate EPA approved survey methods, including Eckman and Ponar grabs (dredges). Our objectives were to also perform recommended probability statistical analyses following that of Smith et al. (2001) and Smith (2006) as adopted by UDWQ (2017a) 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 progress 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 survey area.

Methods

Survey Area

Mollusk surveys were conducted in State Canal beginning at the diversion dam downstream of SDSD North Plant at 40.910854° latitude; -111.928022° longitude and continued every 100 m upstream to the State Canal diversion (latitude = 40.871337°; longitude = -111.964996°) (N = 162 transects) (Figure 1). Surveys were conducted in late summer and early autumn 2019.

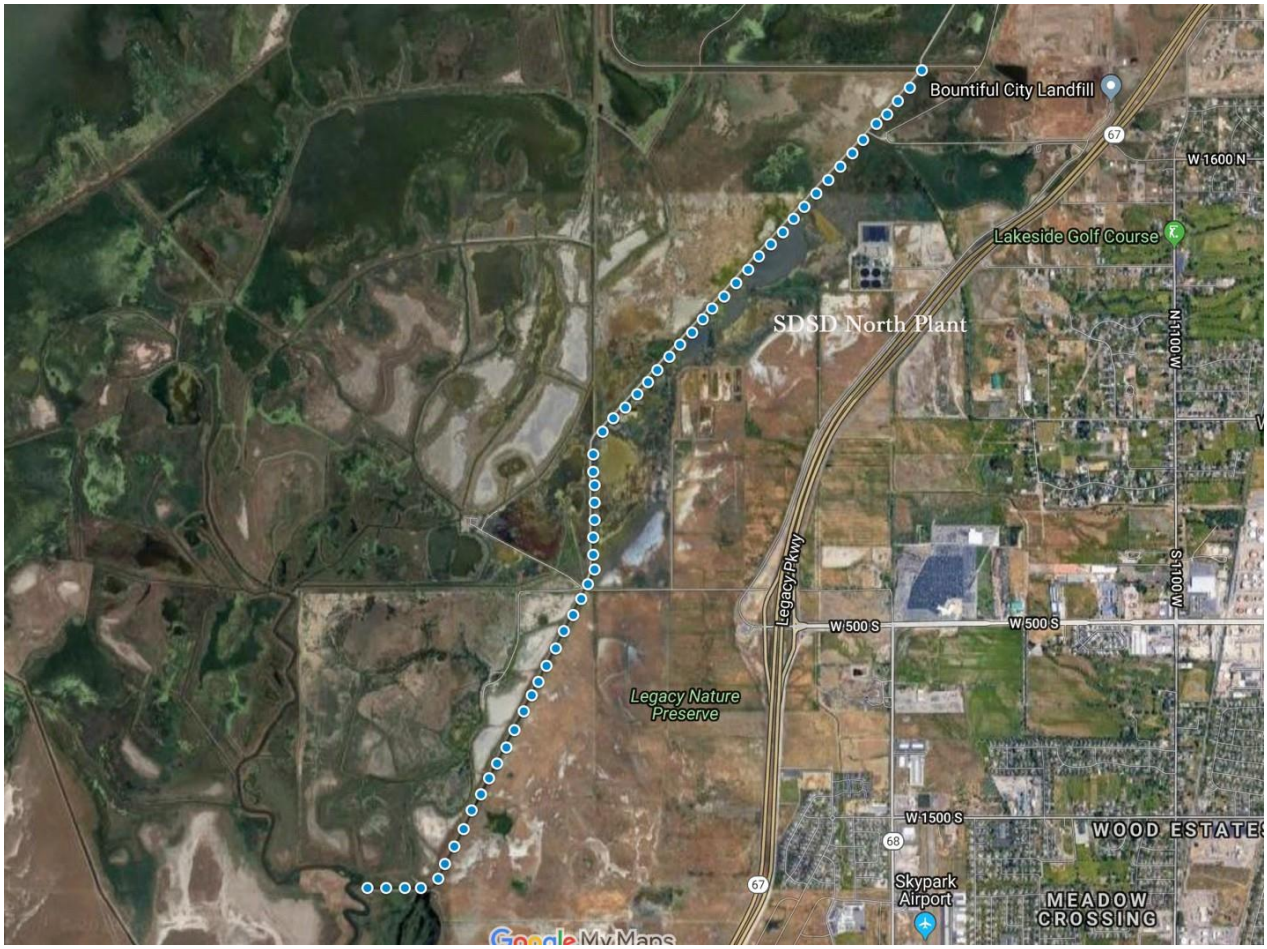

Figure 1. Mollusk survey locations in State Canal 2019. Blue circles are transect locations. N = 162 transects, nine dredge samples collected at each transect.

Mollusk Survey

Mollusks were sampled using a long handled 15.24 x 15.24 cm Ekman Dredge operated from a small john boat. Three dredge samples were taken at each site: one near the left descending bank, one in approximately the center of the channel, and one near the right descending bank for a total of 486 samples processed, which accounted for approximately 11.29 m^2 of substrate sampled. Spoils from each dredge sample was processed independently by sieving through a 3.2 mm mesh dip net. Material retained in the dip nets was examined for presence of live, fresh dead, and relict empty shell mussels. Non-native Asian Clam (*Corbicula fluminea*) were also counted and recorded.

Substrate Evaluation

Dominant and subdominant substrate types in each dredge sample were also recorded. Substrate categories included combinations of silt, sand, detritus, clay, gravel, concrete, cobble, large woody debris, and smaller wood fragments (e.g. twigs and branches). Substrate analysis will be provided in an additional pending report.

Probability of Detection and Search Efficiency as Related to Density Estimates

Estimating probability of detection (POD) given known or assumed search efficiencies, densities, and known search area 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). However, given these admonitions, 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 at density = 0.1 m^{-2} to obtain a 90% POD based on formulas presented by Smith (2006).

We used the Smith (2006) formula (equation 4 page 703):

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

where POD = probability of detecting at least on individual mussel; b =search efficiency (SE), a =search area = 37.59 m^2 (State Canal and lower Jordan River combined)[1]; 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.

Excavation tools, including Ekman dredge, are considered the most effective sampling methods used to detect mussel communities (USEPA 2013b). When sieved materials from dredges are thoroughly examined; survey results are considered to be at 100% search efficiency (USEPA 2013b).

Results

No live native mussels were found in the survey. The only living bivalves found in the survey were invasive, non-native Asian Clams, *Corbicula fluminea* (N = 28). Two weathered *Anodonta* sp. shell fragments were found.

[1] State Canal and lower Jordan River mussel survey areas were combined for the Smith (2006) model (Figure 2) because the lower Jordan River mussel survey was a continuation of State Canal survey and the lower Jordan River habitat was considered superior to State Canal, consequently any live mussels were more likely to have occurred in the lower Jordan River than State Canal (see Richards et al. 2020).

Control vs. Impacted Sites

The apparent absence of native mussels in the control site of State Canal and lower Jordan River upstream of SDSD North Plant strongly suggests that factors other than SDSD North Plant discharge, including chronic dredging, prevent viable native mussel populations from becoming established anywhere in State Canal. For example, as a surrogate for native mussels, the prolific *Corbicula* clam only occurred at about 2.5 live individuals m^{-2} in State Canal, whereas in the lower Jordan River estimated *Corbicula* densities were 34.4 m^{-2}. See Richards (2017) for a detailed discussion of other likely factors affecting native mussel declines and absence in the drainage.

Probability of Detection, Search Efficiency, and Density Models

Mussel densities in the lower Jordan River and State Canal only had to be ≥ 0.06 m^{-2} to obtain a UDWQ recommended POD of 0.90 using the Smith (2006) model (Figure 2). Based on the Smith (2006) model (Figure 2), we should have observed at least one mussel if they occurred in the lower Jordan River-State Canal survey area at densities ≥ 0.06 m^{-2}, which is less than UDWQ's recommended density = 0.1 m^{-2}. Thus, our mussel survey results clearly exceed UDWQ recommendations for a determination of 'absence' of live or recently dead native mussels in the lower Jordan River.

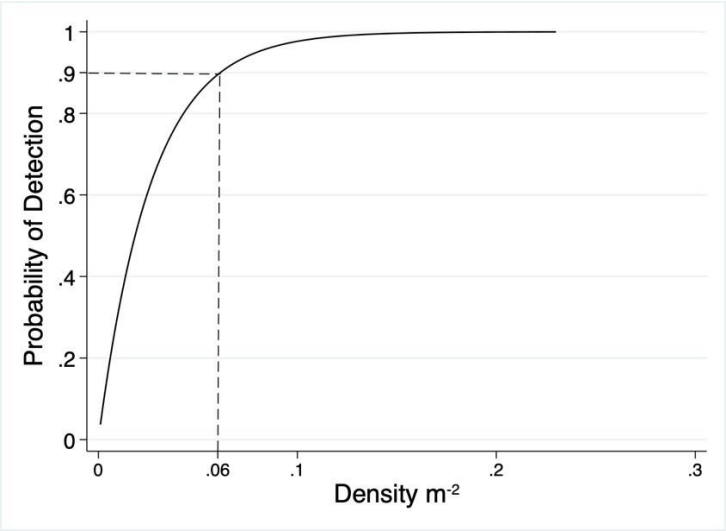

Figure 2. Mussel probability of detection (POD) in the lower Jordan River and State Canal as a function of density (m^{-2}) at 1.00 search efficiency and search area = 37.59 m^2. POD equates to a density estimate of 0.06 m^{-2} at DWQ recommended POD = 0.90 (dashed lines). Based on Smith (2006).

Discussion

Results presented in this progress report and results from other mussel surveys on Mill Creek and Jordan River provided multiple- lines- of- evidence in support of mussel absence in State Canal. Richards (2017) included multiple lines of evidence surveys from several agencies including UDWQ and USU/USGS that showed 'absence' of native mussels in the Jordan River. Richards et al. (2020) recently conducted mollusk surveys in the lower Jordan River and did not find any live mussels. These lines of evidence are directly applicable to State Canal and further support our conclusion of 'absence'. In addition, State Canal is a man-made conveyance canal and is highly ecologically impaired relative to the Jordan River. Subsequently, State Canal is not expected to support viable native mussel populations. Most of the

substrate in State Canal is composed of chronically dredged, hard-pan clay that is poor mussel habitat (see pending report). Potential obligate fish host densities are very low, as well (Richards 2019).

Conclusion

Results of this native mollusk survey combined with other surveys provide a multiple-lines-of-evidence that clearly show that viable native mussel populations do not occur in State Canal such that no live individuals have ever been documented. Reasons for their rapid decline, decreased metapopulation viability, and potential complete demise throughout the Jordan River drainage are numerous and have been discussed at length by Richards (2017a, b and Richards and Miller 2019).

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Appendix D. Lower Jordan River Mollusk Survey as it Relates to South Davis Sewer District South Plant Effluent. OreoHelix Consulting.

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Filename: Lower Jordan River Mollusk Survey as it Relates to South Davis Sewer District South Plant Effluent

Version: 1.1

Lower Jordan River Mollusk Survey as it Relates to South Davis Sewer District South Plant Effluent

Progress Report 2020

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Table of Contents

Introduction

Freshwater mollusk diversity is depauperate in the western USA with the exception of waters in the Bonneville Basin, including the Jordan River drainage, UT (Richards 2015, 2017a, 2017b, 2018, 2019, Miller and Richards 2019). No intensive mollusk surveys have been conducted in the Jordan River other than by Richards (2017a, 2017b) and Richards and Miller (2019) in upper sections of the Jordan River and no surveys have been conducted in the lower Jordan River.

In addition to the importance of understanding the status of mollusks in the lower Jordan River, native mussel surveys documenting presence/absence are critical for ammonia criteria development and regulation. Two species of native mussels, *Anodonta* sp. and *Margaritifera falcata* may have occurred in the lower Jordan River, UT in the past. Unfortunately, severely degraded conditions, host-dependent, 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). There are no historical records of *M. falcata* occurring in the lower 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 (2017a, b) 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 indicating that this species could have occurred in these or nearby waters in the past. Even though Richards and Miller (2019) concluded that native mussels were likely absent in Mill Creek and upper portions of the Jordan River and likely did not occur downstream, absolute determination of absence is not possible without a complete and thorough examination of the entire creek and river beds (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 2017, Richards 2017).

The USEPA published updated Clean Water Act § 304 (a) recommended water quality criteria for ammonia in 2013. The calculation of these criteria included new toxicity data for members of the Mollusca phylum. Results of these new tests and incorporation into criteria calculations and particularly for mussels of the superfamily, Unionoidea, 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 the ammonia criteria. Consequently, the Wasatch Front Water Quality Council and Utah Division of Water Quality (UDWQ) concluded that a site-specific survey of lower Jordan River be performed 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.

Objectives

The specific objective of this study was for us to provide site-specific survey data sufficient to determine a likelihood estimate of presence or absence of mussels near the South Davis Sewer District South Plant discharge (ammonia zone of influence) using the most appropriate EPA approved survey methods including Eckman and Ponar grabs (dredges). Our objectives were to also perform recommended probability statistical analyses following that of Smith et al. (2001) and Smith (2006) as adopted by UDWQ (2017a) and then provide a detailed report of survey methods used, summary statistics, data interpretation and recommendations to UDWQ and USEPA. It is intended that the final 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 survey area.

Rationale

The primary rationale for this project was to determine if and how many live native freshwater mussels, specifically *Anodonta sp.*, were present in the lower Jordan River. A secondary goal was to establish a historical account of the mollusks of the lower Jordan River

Methods

Study Area

Mollusk surveys were conducted in the lower Jordan River beginning at the State Canal diversion (latitude = 40.871337°; longitude = -111.964996°) and continued every 100 m upstream to the 700 N bridge crossing in northern Salt Lake City (40.784495°; 40.784495°) (N = 127 transects) (Figure 1). Surveys were conducted in late summer and early autumn 2019.

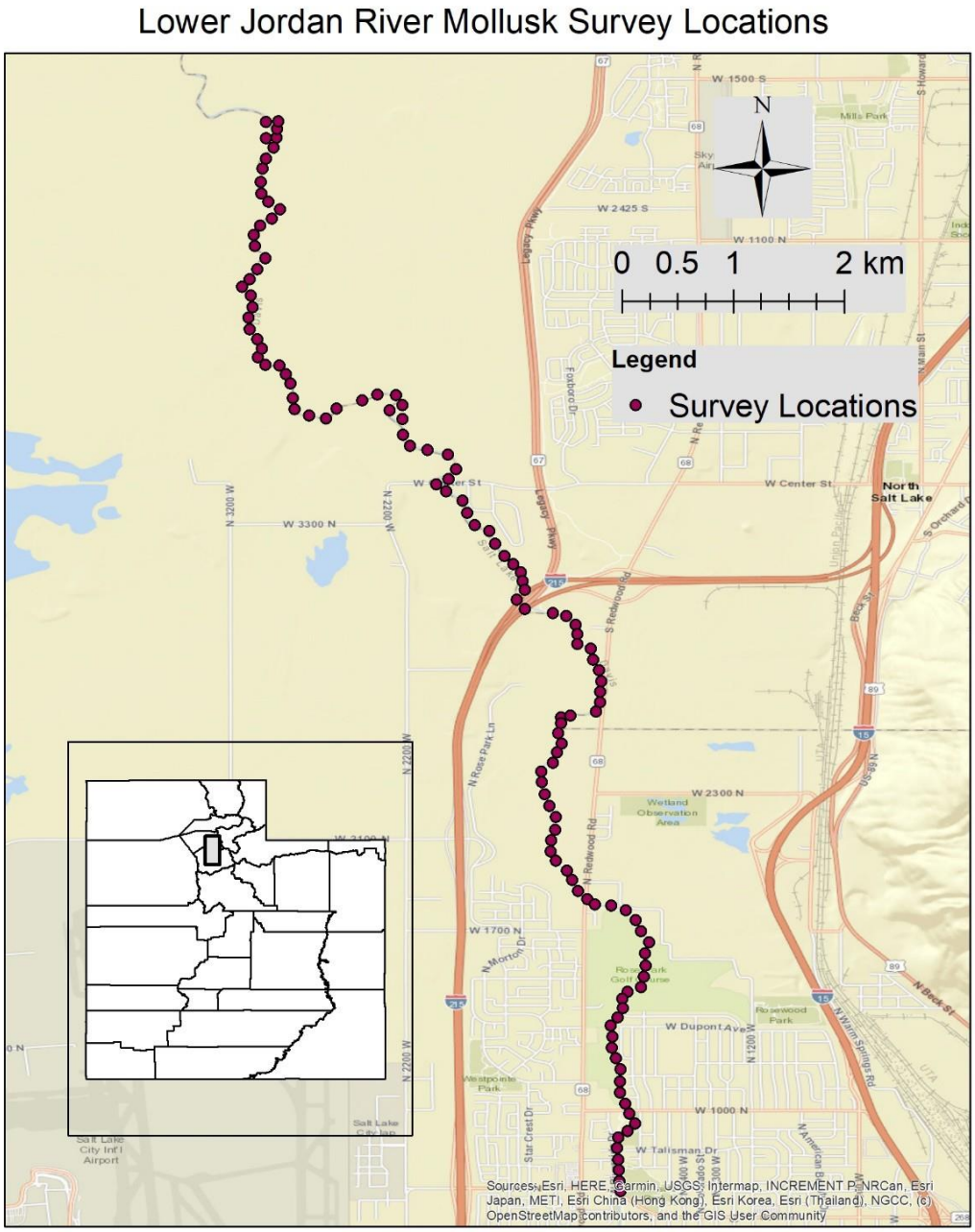

Figure 1. Mollusk survey locations in lower Jordan River 2019. Red circles are transect locations. South Davis Sewer District South Plant is located at just north of W. Center St river crossing. N = 127 transects, nine dredge samples collected at each transect.

Mollusk Surveys

Mollusks were sampled using a long handled 15.24 x 15.24 cm Ekman Dredge operated from a small john boat. Nine dredge samples were taken at each site: 3 near the left descending bank, 3 in approximately the center of the channel, and 3 near the right descending bank for a total of 1,143 samples processed, which accounted for approximately 26.3 m^2 of substrate sampled. Occasionally the water exceeded the depth of the Ekman Dredge handle and a 15.24 x 15.24 cm Ponar Grab was used instead. Spoil from each dredge sample was processed independently by sieving through a 3.2 mm mesh

dip net. Material retained in the dip nets was examined from presence of live, fresh dead, and relict empty shell mollusks. Presence of relict mollusk shells was noted and relict mollusk vouchers were taken at nearly every site in the Jordan River between ~200 m downstream of the Interstate 215-Legacy Parkway crossing (site # JR57 in data file) upstream to the 700 N bridge crossing (site # 127 in data file) in northern Salt Lake City. Non-native Asian Clam (*Corbicula fluminea*) were counted and recorded. Relict mollusk vouchers were identified to the lowest practical taxon with a dissecting microscope following taxonomy of *Mollusks of Utah a Simple Guide*, and a UDWR unpublished draft gastropod key (Kathryn Holcomb and Eric Wagner pers comm). Due to taxonomic uncertainty of certain groups (e.g. Physidae, Sphaeriidae), some were not identified to species. Processed vouchers are stored at the Utah Lake Research Lab at Timpanogos Special Service District Water Reclamation Facility in Pleasant Grove, UT. Because taxonomic keys for Utah mollusks are being revised and there is no consensus on species level taxonomy based solely on morphological characteristics, taxonomic identifications used in this report may be subject to change. Also, our protocol was in development during the course of this study, and as such, all pieces of data were not simultaneously and consistently recorded until about halfway through the survey season. Consequently, final identification of mollusk vouchers is ongoing.

Substrate Evaluation

Dominant and subdominant substrate types in each dredge sample were also recorded. Substrate categories included combinations of silt, sand, detritus, clay, gravel, concrete, cobble, large woody debris, and smaller wood fragments (e.g. twigs and branches). Substrate analysis will be provided in an additional pending report.

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). 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 at 0.1 m^{-2} to obtain a 90% POD based on formulas presented by Smith (2006). We used the Smith (2006) formula (equation 4 page 703):

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

where POD = probability of detecting at least on individual mussel; b =search efficiency (SE), a =search area = 26.3 m^2; and μ = density m^{-2} to develop a probability of detection (POD) model as a function of density m^{-2} at six search efficiency of 1.00.

Results

No live native mussels were encountered and only one highly weathered *Anodonta* sp. shell fragment was found. Of the bivalves, only live non-native Asian Clams, *Corbicula fluminea* (N=904) were found. Additionally, relict mollusk vouchers yielded potentially 22 taxa including potentially seventeen snail taxa, and the fingernail clam, *Pisidium* sp. (Family Sphaeriidae) (Table 1).

Table 1. List of relict mollusk taxa and total abundance of each species. Final taxonomic identification is ongoing pending revisions in the literature.

Amnicola limosus	1
Anodonta sp.	1
Ferrissia rivularis	83
Fluminicola coloradoensis	42
Gastropod sp.	3
Galba obrussa	9
Gyraulus parvus	41
Heliosoma sp.	6
Lymnaea stagnalis	1
Lymnanea sp.	1
Planorbidae sp.	2
Menetus/Promenetus sp.	1
Physella sp.	609
Pisidum sp.	17
Potamopyrgus antipodarum	7
Pyrgulopsis sp.	41
Sphaeriidae	45
Stagnicola elodes	79
Stagnicola utahensis	4
Valvata humeralis	122
Valvata utahensis	3

Control vs. Impacted Sites

No native mussels were found in the control site in lower Jordan River upstream of SDSD South Plant. This apparent absence strongly suggests that factors other than SDSD South Plant discharge have reduced native mussel populations to non-detect levels. See Richards (2017) for a detailed discussion of likely factors affecting native mussel declines and absence in the drainage.

Probability of Detection, Search Efficiency, and Density Models

Mussel densities only had to be 0.087 m^{-2} to obtain a POD of 0.90 (UDWQ recommended POD value) using the Smith (2006) model (Figure 2). The excavation methods (i.e. Eckman and Ponar grabs) are considered the most effective sampling methods used to detect an entire mussel community (USEPA 2013b) and when sieved materials are thoroughly examined; survey results are considered at 100% search efficiency. Based on the Smith (2006) model (Figure 2), we should have observed at least one mussel if they occurred in the survey area at densities > 0.087 m^{-2} which is less than UDWQ's recommended density = 0.1 m^{-2}. Thus, our mussel survey results clearly exceed UDWQ recommendations for a determination of 'absence' of live or recently dead native mussels in the lower Jordan River.

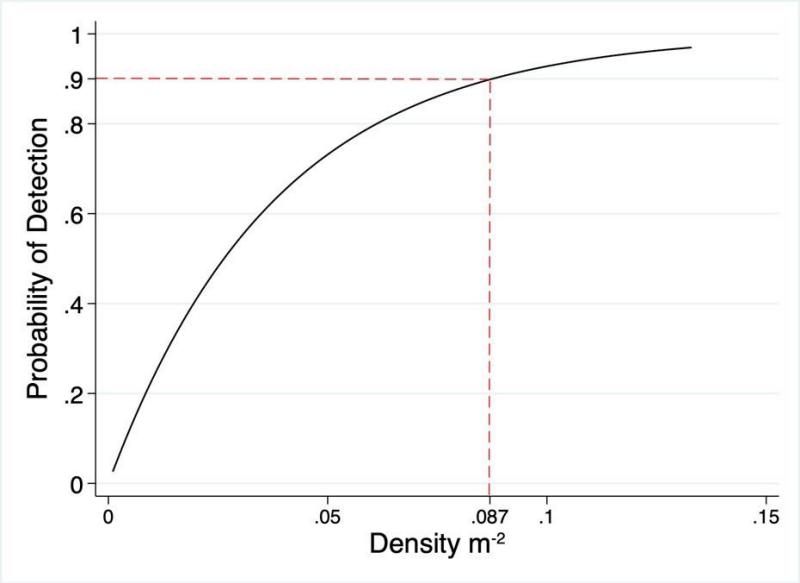

Figure 2. Mussel probability of detection (POD) in the lower Jordan River as a function of density (m^{-2}) at 1.00 search efficiency and search area = 26.3 m^2. POD equates to a density estimate of 0.087 m^{-2} at DWQ recommended POD = 0.90 (red dashed lines). Based on Smith (2006).

Discussion

Even though this intrusive survey produced no native mussels and our POD, search efficiencies, and density estimate models strongly support a UDWQ regulatory decision of live or recently dead mussels 'absent', results from other mussel surveys on Mill Creek and Jordan River provided multiple- lines- of-evidence support. Richards (2017) included multiple lines of evidence surveys from several agencies including UDWQ and USU/USGS that showed 'absence' of native mussels in the Jordan River. These lines of evidence are applicable to the lower Jordan River and enforce our conclusion of 'absence'. In addition, the lower Jordan River is highly impaired, more so than upper sections. Most of the substrate is composed of hard pan clay that is poor mussel habitat (pending report). Potential fish host densities are very low, as well (Richards 2019).

We also found very few live or recently dead mollusk taxa given our substantial efforts, including finding no other non-pulmonate snails. We found weathered empty shells of the prosobranch, *Fluminicola coloradoensis* and two heterobranchs, *Valvata humeralis* and *Valvata utahensis,* which suggests that until relatively recently (<100 ybp) the lower Jordan River, including upstream of SDSD South Plant was in much better health than it is now.

Conclusion

Results of this native mollusk survey combined with other surveys provide a multiple-lines-of-evidence that clearly show that native mussels in lower Jordan River are extinct or are so extremely rare that as far as is known, no live individuals have ever been documented, at least since 1942. Other native mollusks including clams and non-pulmonate snail populations are either in sharp decline or also extinct. This is a Utah natural heritage travesty. Reasons for their rapid decline, decreased metapopulation viability, and potential complete demise throughout the drainage are numerous and have been discussed at length by Richards (2017).

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