



# Big Hole Watershed Committee

Monthly Meeting Minutes  
October 16, 2019 – 7:00pm  
Divide Grange – Divide, Montana

## In Attendance

Pedro Marques, BHWC; Tana Nulph, BHWC; Ben LaPorte, BHWC; Dave Stagliano, Montana Biological Survey; Paul Driscoll, DEQ; Bill Kemp, BHWC/Outfitter; Chris Edgington, MTU; Matt Norberg, DNRC; Paul Cleary, BHWC; Sandy Cleary, Resident; Mike Cleary, Resident; Stephen Frazee, WET; Roy Morris, BHWC/GGTU; Dean Peterson, BHWC/Rancher; Jim Hagenbarth, BHWC/Rancher; John Reinhardt, BHWC/Rancher; Tom Bowler, Resident; Betty Bowler, Resident; Michelle Anderson, UM-Western; Craig Jones, Great Divide Outfitters; Lia Jones, Great Divide Outfitters; Andy Suenram, BHWC/Resident; Wade Fellin, BHRF/Big Hole Lodge; Craig Fellin, Big Hole Lodge; David Dockery, Wild Rivers Consulting; Steve Luebeck, BHWC/Sportsman; and Brian Wheeler, BHRF.

**Introductions**      *Attendees introduced themselves.*

**Meeting Minutes**      *September 2019 meeting minutes were reviewed, no additions or corrections.*

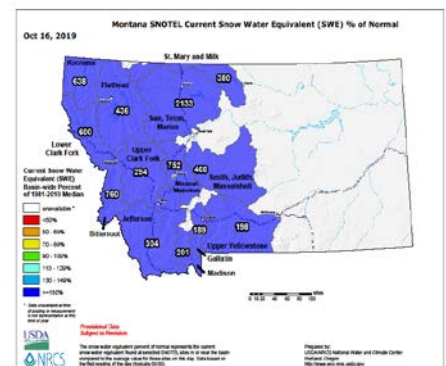
## Reports

*Streamflow/Snowpack Report – Matt Norberg, Department of Natural Resources and Conservation*

- Streamflow:** Streamflows in the upper Big Hole basin are generally average to above-average for this time of year. Streamflows in the lower Big Hole basin are above-average for this time of year. A couple of large early fall storms, decreased air temperatures, decreasing evapotranspiration, and irrigation shutdowns have elevated streamflows throughout the basin.

<a href="#">06023500</a>	Big Hole River near Jackson MT	10/16 12:15 MDT	0.89	15.9	20.0	--
<a href="#">06023800</a>	Big Hole River ab Spring Creek nr Jackson MT	10/16 12:00 MDT	1.41	19.3	24.0	--
<a href="#">06024020</a>	Big Hole River at Miner Creek nr Jackson MT	10/16 12:15 MDT	1.28	92.7	65.0	--
<a href="#">06024450</a>	Big Hole River bl Big Lake Cr at Wisdom MT	10/16 11:45 MDT	2.49	162	65.0	4.8
<a href="#">06024540</a>	Big Hole River bl Mudd Cr nr Wisdom MT	10/16 11:30 MDT	2.87	230	203	--
<a href="#">06024580</a>	Big Hole River near Wise River MT	10/16 11:30 MDT	2.91	347	290	<a href="#">Ssn</a>
<a href="#">06025250</a>	Big Hole River at Maiden Rock nr Divide MT	10/16 11:45 MDT	3.24	559	450	<a href="#">Ssn</a>
<a href="#">06025500</a>	Big Hole River near Melrose MT	10/16 11:15 MDT	2.02	617	460	5.3
<a href="#">06026210</a>	Big Hole River near Glen MT	10/16 11:30 MDT	2.75	652	532	<a href="#">Ssn</a>
<a href="#">06026420</a>	Big Hole R bl Hamilton Ditch nr Twin Bridges, MT	10/16 11:30 MDT	1.590	519	430	7.0

- Drought Management Plan actions:** Montana FWP opened Section 1 (Skinner Meadows Road to Wisdom Bridge) of the Big Hole River to fishing on September 25, 2019 due to increased streamflows. The fishing closure was in effect from August 31st until September 25th. Hoot Owl restrictions were put into place on the lower Big Hole River (Notch to the Mouth) from August 8th, 2019 until September 12th, 2019 due to elevated water temperatures.
- Precipitation:** June, July, and August precipitation levels were below average for the Wisdom area. September precipitation was below average for the majority of the month until a mid/late September storm provided snow/rain mix across the basin. October storms have also provided an early boost to the snowpack with the Jefferson basin as a whole at 304% and 352% for the Big Hole specifically. Keep in mind these values can change rapidly and reflect early water year conditions.



- *Forecast:* ENSO-neutral conditions are favored during the Northern Hemisphere fall 2019 (~85% chance), continuing through spring 2020 (55-60% chance). Given the ENSO-neutral conditions, be sure to closely watch upcoming forecasts as we move into the fall and winter months. Most recent NOAA 1-month outlook is for below normal temperatures and above average precipitation. Most recent NOAA 3-month outlook is for equal chances of above/below/or normal precipitation and above average temperatures.

*Director's Report – Pedro Marques, Executive Director*

- BHC has been updating administrative systems to increase efficiency.
- Pedro has been working on securing BOR funding for the French Creek project, including some additional mesic area restoration.
- Collaborative Forest Landscape Restoration Program (CFLRP) proposal for USFS forestry work based in the Big Hole watershed was denied.
- Regional Conservation Partnership Program (RCPP) proposal through High Divide Collaborative focusing on BHC forestry projects as well as forestry efforts in other watersheds. Consistent and long-term pot of money through NRCS. About \$350 million annually (Farm Bill money). Working with High Divide Collaborative, SW MT Sagebrush Collaborative, potentially some other watershed groups, potentially the Lemhi Valley Land Trust. Lemhi expressed interest in potentially being an easement holder for smaller land easements in the Big Hole watershed.
- Pedro working with the Streamgauge Working Group.
- Proposal to update Section V drought triggers (increase each trigger by 50 cfs to reflect wetted perimeter inflection points) – actively soliciting input from board members. (Proposal attached.)

*Steering Committee – Jim Hagenbarth, Vice-Chairman; Steve Luebeck, Treasurer; and Roy Morris, Secretary*

- The steering committee is happy with the progress BHC is making.

*Wildlife Report – Jim Hagenbarth, Rancher/BHC; Dean Peterson, Rancher/BHC; and Tana Nulph, Associate Director*

- Range Rider season ended September 30<sup>th</sup> – no confirmed losses on enrolled allotments in 2019
- Additional funding available for nonlethal livestock loss prevention (wolves) if anyone has any ideas or needs.
- Wolf pack near Doolings caused a lot of trouble – 3 have been lethally removed in the last few weeks.
- Wolves and grizzlies in the Gravelles – dogs are effective against both, but have had some problems with wolves killing dogs. Wolves kill sheep, bear eat sheep, wolves kill more sheep – it's a real problem and this is the area where multiple hunters have been attacked by grizzlies in the last couple months.
- Western Landowner's Alliance is holding a predator workshop November 15<sup>th</sup> in Alder. \$35 to attend; RSVP required. Register here: <https://westernlandowners.typeform.com/to/OqWLQ4>

*Restoration Report – Ben LaPorte, Program Manager*

- The weather in the last month made it interesting for the ground crews on Mount Haggin. They were dealing with 18" of snow at one point; still have about 6".
- Ben met with FWP to do planning for 2020 aspen work on Mount Haggin.
- This winter, Ben will be working on our 2020 restoration work plan.
- Ben set up a game camera overlooking the French Creek project area so we will have time lapse photos.
- Ben participated in the NRCS local working group – NRCS is transitioning to "Montana-focused conservation". They are writing a long-term restoration plan called a "Targeted Implementation Plan". Goal is to focus on a specific goal in a specific area. Ben has been working with the group to get conifer encroachment in the Eastern Pioneers included in the TIP, which will allow us to access funding.
  - If any landowners in the Eastern Pioneers have conifer encroachment issues, please let us know and we may be able to help you remove some of those conifers.

**Discussion** *(Comments of meeting attendees do not necessarily represent the opinions of BHWC.)*

- *HB 286: Bill to prevent DNRC from attaching name to private water rights that border DNRC land. A group representing schools have filed an injunction to keep the bill from being enforced.*
- *Weather Modification: In March 2015, BHWC and the Beaverhead Watershed Committee co-hosted an informational seminar on cloud seeding. Jim Hagenbarth has been discussing cloud seeding with the Water Policy Interim Committee and Senator Welbourne and suggests having a meeting to gauge BHWC's level of support for potential legislative action in support of cloud-seeding.*
  - *National Weather Modification Council met in Bozeman in early October – had reps from several Western states. The technology has come a long way and may carry some real potential for the state of Montana.*
  - *Cloud-seeding is generally not a government program; in Idaho, it is done by Idaho Power and several other private entities.*
- *Section V Proposal to Update Triggers:*
  - *BHWC's Drought Subcommittee reviews drought issues each year and makes recommendations for changes and updates as needed.*
    - *The subcommittee has made a recommendation to update Section V triggers based on inflection points. (Recommendation attached.)*
  - *As you get to the lower river, the river is very braided and experiences a lot of evaporation.*
  - *There are also 2 ditches that carry water over to the Beaverhead River. That water is lost to the Big Hole River system. The groundwater recharge from that water also goes into the Beaverhead (but comes back into the Jefferson). (Pageville Ditch, Big Hole Ditch)*
  - *Two slough channels on private land used as private fisheries – these people may be hesitant to turn water back to the Big Hole, which means the burden on ranchers in Section V would be fairly heavy.*
  - *However; invertebrate populations in the Big Hole River are very important.*
  - *Concerns that if the river is shut down too many times in the lower Big Hole, FWP might want to implement Murphy Rights.*
  - *If this is approved by BHWC, staff & board will work on providing outreach to lower Big Hole outfitters and residents. Also working on reviewing an irrigation infrastructure prioritization report written in 2008 to see how we can help landowners conserve water efficiently in that section.*
  - *It seemed to the drought subcommittee that there are some folks who don't have very good headgates and potentially some that haven't been brought into the fold in terms of the Big Hole Drought Management Plan and importance of returning water to the river when possible. BHWC will look at helping repair or replace damaged headgates and will increase outreach efforts.*
  - *There has been a lack of participation in terms of voluntary water conservation in the lower Big Hole River. The hope is that this will wake up that group a little bit and get them involved.*
  - *There is opportunity to involve outfitters & guides in the Twin Bridges area that haven't been previously involved with the watershed committee.*
  - *The key is cooperation among all stakeholders to keep water in the river.*
  - *All of the outfitters on this river will want to have a say in this – this will have a huge effect on us. If multiple sections of the river are closed, it will cause overcrowding on the sections that are still open, and that doesn't help the river at all. I don't think river closures are playing the role that you hope they are. There is no drought insurance for outfitters, so we stand to lose a lot when river sections shut down. An easier method of communication with outfitters & guides would be helpful so we know what's going on.*
    - *BHWC: That is our goal too, please let us know if you have ideas on how we can improve our communication with outfitters & guides.*
  - *In other communities, I've noticed some animosity about always having meetings in the same place. Perhaps you could have meetings in other locations to include more stakeholders (Twin, Melrose, Wisdom, Jackson).*

- *BHWC: That is certainly possible and something that we will try to accomplish in 2020.*

## New Business

- 2019 Big Hole Stewardship Award presented to Tom & Betty Bowler of Butte.
  - Thank you, Tom and Betty, for being steadfast supporters of BHWC. Your dedication inspires us.



## Meeting Topic: Western Pearlshell Mussels & Aquatic Invertebrates

*Presented by: Dave Stagliano, Montana Biological Survey*

**Background:** The Western Pearlshell (WEPE) is Montana's only cold-water trout stream mussel and the only native mussel found on the west-side of the state (west of the Continental Divide). Dave has been surveying and studying mussels for nearly 20 years, and has recently been collaborating on a WEPE study with a variety of partners. Dave has also conducted macroinvertebrate surveys throughout the state.

## Western Pearlshell Mussels across Montana's Watersheds: Big Hole Updates and Research Notes

Study collaborators: Al Zale, MSU; Michelle Anderson, UM-Western; Zach Shattuck; Jim Olsen, FWP; Paul Hooper, USFS; Kristin, MSU Graduate Student; and helpers (Levi Jeschke, Mike Grover, Reno Lindesmith, Sam Dexter, and others)

Clam vs. Mussel: freshwater mussels need a fish host, whereas clams do not. Pearlshell mussels need salmonid hosts. Mussels ride on the host fish for a few weeks. Fish will only host mussels once; they attach at the gills and the fish have an immune response that prevents them from being infested again.

### Why should we care about mussels?

1. They can be functionally important species providing aquatic ecological services (feed furbearers, filter water).
2. Sensitive, long-lived species (average life span 40-80 years) good indicators of long-term water quality, habitat change, and fish host density.
3. They are amazing animals!

### Why are mussel populations declining?

1. Dams, diversions, and dewatering



2. Silt and pollution (metal toxicity)
3. Loss of fish host
4. Climate change related factors

Our knowledge of mussels in Montana is fairly new. There are 3 native species in Montana:

1. Western Pearlshell mussels (*Margaritifera falcate*)
2. Fatmuckets (*Lampsilis siliquoidea*)
3. Giant Floaters (*Pyganodon grandis*)

WEPE Conservation Status: Species of potential concern in Montana

Host fish: Westslope cutthroat trout, Rainbow/Brown trout, Grayling?

Prefer low-gradient streams with a lot of willows.

#### Objectives:

- Revisit 90 % of the known populations statewide not visited in the last few years.
- Determine current population numbers, viability, and short-term trends by watershed, FWP Region, and statewide
- Search for new populations and refine the distributional boundaries of existing populations.
- Report on the conservation status of the WEPE using the NatureServe model with the new short-term trend analysis.

WEPE in the Big Hole Watershed: The Big Hole Watershed hosts 11 streams (16 populations) in which WEPE have been identified. More than any other watershed in Montana.

#### Study hypotheses:

1. Environmental and/or habitat conditions differ significantly between sites with stable (viable) versus declining (non-viable) WEPE populations.
2. WEPE viability trends are correlated with reproductive status (presence/absence of gravid mussels and presence/absence of conglomerates).
3. WEPE viability trends are correlated with host fish density and rates of glochidia infection in host fish.

#### 2019 Research Sites:

- Clam Creek
- Deep Creek (Upper)
- Deep Creek (Lower)
- French Creek
- Thompson Creek
- California Creek

#### Methods:

- Open up mussels, check marsupial gill for baby mussels (gravidity)
- Shock fish, check gills for baby mussels
- User grab nets/ zooplankton?

#### Results

- H1: Habitat and environmental conditions are positively correlated with WEPE viability.
  - Habitat data collected at the 30 WEPE stream sites have not yet been evaluated to see how it correlates with WEPE viability.
  - Temperature suitability (data loggers).
  - % benthic sediments in riffles and pools and channel stability.
- H2: Gravidity and Conglomerate release is positively correlated with WEPE viability.

- By revisiting WEPE populations numerous times, we determine the reproductive status and timing of 30 WEPE populations across 5 watersheds with varying elevation, stream temperature regimes and variability status (A: long-term viable to D: non-viable/declining populations).
- In the Big Hole, by June 10<sup>th</sup> most populations were gravid. Higher elevation WEPE in the Rock-Flint watersheds had gravidity of 50% into early-July.
- In the Big Hole, gravidity paralleled population viability- highest gravidity at A sites (peak of 90-100% fully gravid mussels checked), intermediate gravidity at B/C sites (peak of 33% fully gravid and 63 – 83% partially gravid mussels checked), and lowest gravidity at the D site (peak of 0% fully gravid and 10% partially gravid mussels checked).
  - All population viability ranges (A-D) exhibited some gravidity across their individuals.
  - The paired zooplankton net samples taken at each site for detecting glochidia in the drift have not yet been processed.
- H3: Host fish density is positively correlated with WEPE viability. **TRUE**
  - Higher viability streams also had higher density of host fish.
  - In declining populations, very few salmonids were counted through shocking.
  - Studying ideal size of host fish.
  - Future analysis: percentage of glochidia infected fish, proper size range of fish (juveniles to adults) and particular species susceptibility
  - A and B viable WEPE populations across watersheds are maintaining reproductive capacity by solely using brook trout as their host fish.

#### *Discussion:*

- *Does Rotenone affect mussels?*
  - *It can in high concentrations, but at the concentrations FWP generally uses they will usually survive.*
- *What are the harvest regulations?*
  - *You cannot possess or take a live WEPE anywhere West of the Central region of Montana.*
- *Does the host fish have to be fry?*
  - *No, we found some larger fish with WEPE infestations.*
    - *So is it also important to have a broad age range of fish?*
      - *Yes, and in some areas juvenile fish moved out of the area before mussels became gravid, which prevent recruitment.*
- *Do you have any pre- and post- monitoring plans related to the Westslope Cutthroat restoration efforts in the Big Hole?*
  - *We've already done the pre-monitoring (that's this study). We have moved several mussels out of streams prior to stream restoration efforts (including French Creek).*
- *Is it a possibility to stock streams with fish that are already infested with mussels?*
  - *That is the ultimate goal, but timing has to line up just right.*

#### **Macroinvertebrate Community Monitoring**

- Macroinvertebrates have been used to measure stream health conditions for a long time.
- Replicated study done in 1960s that sampled 2 sites on the Big Hole River.
- Monitoring and evaluation of benthic macroinvertebrate in the Big Hole River and tributaries, Montana (Bias 2012): methods were not consistent – great starter point data but needs to be resampled.
- Research action items/recommendations:
  - Recommend one year of seasonal sampling (spring, late-summer) at the original and Big Hole sites: then sampling during 1 season for 4 years.
  - Compare macroinvertebrate densities (Hess samples n = 3) and other metrics to other samples previously collected.
  - Correspondence between the macroinvertebrate sampling timing and sites with water quality samples.

#### *Discussion:*

- *When is the last good data that we have on the Big Hole?*

- *Sadly, I think it's near 2005 – maybe 2007.*
  - *Study is happening in Twin, Kalsta bridge, Deep Creek, Wisdom, and Jackson through Big Hole River Foundation. Planning to repeat it each year.*
  - *What do macroinvertebrates eat?*
    - *Anything from each other to dead stuff, fish or tadpoles, etc.*
  - *What could you discern from replicating these studies?*
    - *If you see a particular species or taxa that is present in some sites but not others, or present at one time but then no longer present, that tells you something. What is happening that's different in that site?*
- 

### **Upcoming Meetings**

- November 20, 2019, 6pm @ the Divide Grange. BHWC Monthly Meeting. Topic: CCAA Update.
  - *Note the time change from 7pm to 6pm due to daylight savings time.*
- *BHWC does not meet in December.*

### **Adjourn**

Dear Big Hole Watershed Committee Board Members,

The Big Hole River Drought Subcommittee met Monday, September 16<sup>th</sup>, to inform BHWC staff of priority drought issues. At the meeting, the subcommittee identified an issue with the Big Hole River Drought Management Plan and proposed a solution. The next step is for the full committee to review and decide on the proposal.

*The issue:* Drought Management Plan triggers in Big Hole River Sections I-IV are based on the river's wetted perimeter and upper & lower inflection points for those sections. Section V (Notch Bottom to Big Hole River mouth) drought triggers were chosen arbitrarily and are not based on that section's lower inflection point.

*The solution:* The Drought Subcommittee proposes to update Section V triggers to be consistent with triggers in the other four river sections. Proposed Section V triggers are displayed in the table, below. Section V's lower inflection point is 260 cfs, which loosely translates to the "Prepare for Conservation" trigger. At Jim Olsen's suggestion, the proposed Section V triggers match Section III triggers.

### Proposed Drought Management Plan Update

Drought Status	Current Triggers	Proposed Triggers
"Prepare for Conservation"	200	250
"Conservation"	150	200
"River Closure"	100	150

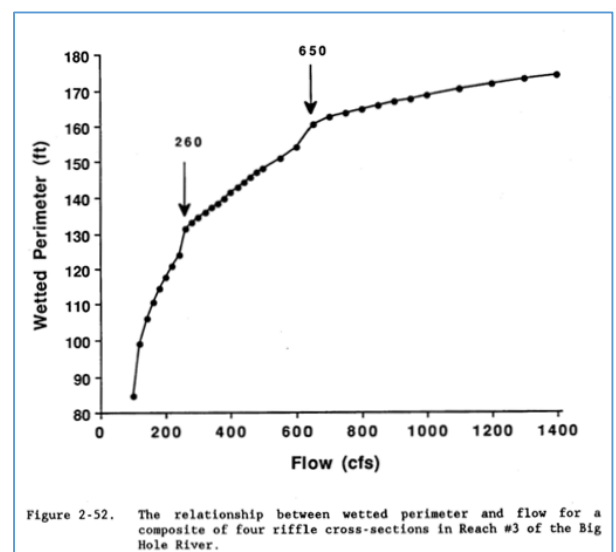
*Notes:* This change would take effect summer 2020. It may result in earlier fishing closures, but it would also help to protect the fishery and hopefully would draw attention to the Lower Big Hole River to increase conservation efforts in that section. BHWC staff will work with irrigators and the general public to get everyone up-to-date and on-board with this change.

*Note on inflection points:* "The upper and lower inflection points bracket those flows needed to maintain the high and low levels of habitat potential." Lower inflection point: "That flow regime which will provide for only a low population of the species present."

To support this motion, please respond:

***"I approve the drought subcommittee's recommendation to update drought triggers for Big Hole River Section V: Notch Bottom to Big Hole River mouth."***

If you do not support the recommendation, please respond as such and explain your position.





# One Small Step for Mussels, One Giant Leap for Western Pearlshells in Montana

Freshwater mussels are in the midst of a mass extinction. Approximately 72% percent of freshwater mussels in North America are extinct or imperiled; this is in comparison to 17% of mammals and 15% of bird species.<sup>1</sup> Mussels provide a lot of benefits to various aquatic organisms including trout. They increase biodiversity of aquatic communities,<sup>2</sup> filter water,<sup>3</sup> recycle nutrients,<sup>4</sup> improve habitat conditions for fish,<sup>5</sup> and act as bio-indicators for aquatic ecosystem health.<sup>6</sup>

Western pearlshell mussels have been eradicated from much of their historical range in the United States and are a species of concern in Montana.<sup>7,8</sup> Populations of western pearlshells in Montana have declined across the state at an estimated 19%.<sup>9</sup> Most of the populations left in Montana are small, isolated, geriatric, and at risk for extirpation.



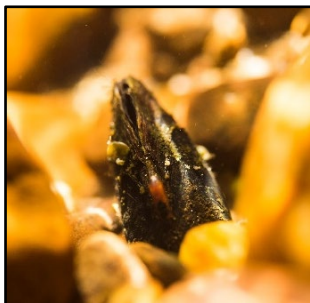
C. Guy. Western pearlshells in Montana.

The decline of western pearlshells in Montana is particularly alarming considering it is the only freshwater mussel found in western Montana's streams, and only one of three native mussels to the state. They are also found in streams containing U.S. Fish and

Wildlife priority species such as bull trout, cutthroat trout, and Arctic grayling.

Future conservation efforts will likely involve restoring pearlshell populations by propagating mussels or stocking native fish that are hosting pearlshell glochidia. However, little is known about western pearlshells in Montana, such as when they reproduce and which species of fish they are using for hosts. Information on these basic life-history traits is critical in making these future conservation efforts a reality.

Multiple agencies and universities have formed a collaborative partnership to investigate reproductive and life-history traits of western pearlshells across five watersheds in Montana and to determine why this ecologically important species is declining.



C. Guy. A western pearlshell siphoning.

## Collaborators

U.S. Fish and Wildlife Service  
Montana Biological Survey  
U.S. Geological Survey,  
Montana Cooperative Research Unit  
University of Montana Western  
Montana Fish, Wildlife and Parks  
U.S. Forest Service



D. Stagliano. A western pearlshell on the move.

## Life cycle

Most freshwater mussels have a complex life cycle. Mature male mussels will release sperm into the water current. When reproductive females siphon the sperm, their eggs become fertilized. Gravid mussels are females that are brooding fertilized eggs. Mature eggs, or glochidia, are released into the water current where they can attach to the gills of fish. Glochidia require a specific species of fish to transform into juvenile mussels. Once they have transformed, they will drop off of their fish host and settle onto the streambed. Western pearlshells can live to 100 years old and become sexually mature between approximately 12 – 20 years old<sup>9</sup>.

**KRISTEN COOK**

**FISH & WILDLIFE BIOLOGIST,  
ENNIS NFW**

**M.S. CANDIDATE,  
MONTANA STATE UNIVERSITY**

**KRISTEN\_COOK@FWS.GOV**

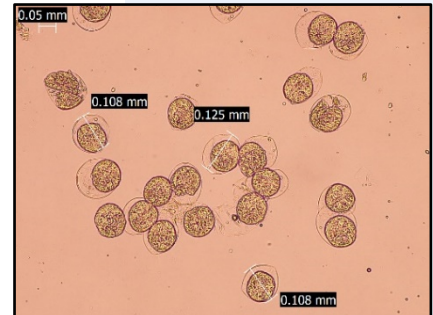
**OBJECTIVE 1: Determine the timing of western pearlshell reproductive events in Montana.**

To propagate mussels or infect native fish with glochidia, biologists have to be able to collect gravid females. However, it is unknown when western pearlshells reproduce in Montana, and the timing and duration for pearlshell populations in other states varies greatly.<sup>10,11,12</sup>

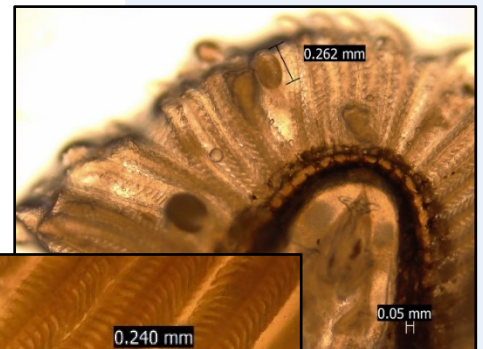
Biologists will be able to determine the timing and duration of egg fertilization, gravidity, and glochidial release by visually surveying females for gravidity, nonlethally extracting eggs, sperm, and glochidia from the mussels, and sampling stream drift for released glochidia.



D. Staglano. Sampling stream drift for glochidia with zooplankton nets.



K. Cook. Eggs extracted from a western pearlshell's gonad.



K. Cook. Various fish gills with attached glochidia.



M. Anderson. A rainbow trout highly infected with western pearlshell glochidia.

**OBJECTIVE 3: Identify the limiting life-stage of declining western pearlshell populations in Montana.**

While it is clear the majority of populations in Montana are declining, it is unclear why. Questions arise such as: Are they no longer reproducing? Is there a disconnect between the glochidia and the host fish? Are juvenile mussels dropping off of fish in poor habitat?

By investigating reproductive and host fish patterns on declining pearlshell populations, biologists will be able to address some of these questions.

#### References:

1. Master, L. 1990. The imperiled status of North American aquatic animals. *Biodiversity Network News* 3(3):5-8.
2. Spooner, D. E., C. C. Vaughn & H. S. Galbraith, 2012. Species traits and environmental conditions govern the relationship between biodiversity effects across trophic levels. *Oecologia* 168: 533–548.
3. Welker, M., and N. Walz. 1998. Can mussels control the plankton in rivers? A planktological approach applying a Lagrangian sampling strategy. *Limnology and Oceanography* 43: 753–762.
4. Howard, J. K., and K. M. Cuffey. 2006. The functional role of native freshwater mussels in the fluvial benthic environment. *Freshwater Biology* 51: 460–474.
5. Limm, M. P., and M. E. Power. 2011. Effect of the western pearlshell mussel *Margaritifera falcata* on Pacific lamprey *Lametra tridentata* and ecosystem processes. *Oikos* 120:1076-1082.
6. Nedeau, E. J., A. K. Smith, J. Stone, and S. Jepsen. 2009. *Freshwater Mussels of the Pacific Northwest* 2<sup>nd</sup> Ed. The Xerces Society, Portland, OR.
7. <http://www.xerces.org/western-pearlshell/>, accessed November 21, 2018
8. <http://fieldguide.mt.gov/speciesDetail.aspx?elcode=IMBIV27020>, accessed November 21, 2018
9. Stagliano, D. 2015. Re-evaluation and Trend Analysis of Western Pearlshell Mussel (SWG Tier 1) Populations across Watersheds of Western Montana Report of State Wildlife Grant (SWG) FY2015 Activities to Montana Fish, Wildlife and Parks. 38 pp.
10. Bauer, G. 1987. Reproductive strategy of the freshwater pearl mussel *Margaritifera margaritifera*. *Journal of Animal Ecology* 56:691-704.
11. Karna, D. W., and R. E. Millemann. 1978. Glochidiosis of salmonid fishes III. Comparative susceptibility to natural infection with *Margaritifera margaritifera* (L.) (Pelecypoda: Margaritanidae) and associated histopathology. *Journal of Parasitology* 64:528-537.
12. O'Brien, C., D. Nez, D. Wolf, and J. Brim Box. 2013. Reproductive biology of *Anodoonta californiensis*, *Gonidea angulata*, and *Margaritifera falcata* (Bivalvia: Unionoida) in the Middle Fork John Day River, Oregon. *Northwest Science* 87:59-72.
13. Allard, D. J., T. A. Whitesel, S. C. Lohr, and M. L. Koski. 2017. Western Pearlshell Mussel Life History in Merrill Creek, Oregon: Reproductive Timing, Growth, and Movement. *Northwest Science*, 91(1):1-14.
14. Gustafson, D.R. 2001. Westslope cutthroat hypothesis. Presentation to the American Fisheries Society Meeting, Bozeman, MT.