

Qualitative Survey of Western Pearlshell Mussel Populations in the Trinity River

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Introduction

Freshwater mussel populations have experienced recent, well-documented declines across their historic range in North America. Many watersheds support a fraction of both the richness and abundance found just a few decades ago, and mussel populations in the western United States are believed to have experienced a 35% decline in richness since 1990 (Blevins et al. 2017).

Freshwater mussels are valuable to both river systems and for the numerous ecosystem services they provide. They filter and store excess nutrients, stabilize river sediment, and increase food web complexity (Vaughn 2018). Freshwater mussels are also valuable to watershed managers as indicator species and are often used in studies of freshwater toxicity.

The western pearlshell mussel (*Margaritifera falcata*) is one of the most abundant freshwater mussels in the west. While downward *M. falcata* population trends are evident in some river systems, little is known about their distribution within the Trinity River. Confronting any species decline requires addressing knowledge gaps related to abundance and distribution; establishing baseline population metrics of mussels within the watershed will facilitate a better understanding of the system and the consequences of anthropogenic activities, including changing land use, increasing recreation and reliance upon freshwater reservoirs, and river restoration activities.

This survey was designed to provide the Trinity River Restoration Program (TRRP) with an overview of the distribution and relative abundance of western pearlshell mussels within the Trinity River. We focused on relatively large, high-density beds because of their importance as source populations for much of the river. Knowing the distribution of both large mussel colonies, as well as river reaches where mussels are absent, will better inform TRRP's decision-making process as it relates to local mussel populations. Documenting their spatial distributions will also provide insight into the impacts of construction and other management activities on mussel populations within the reach. Further, the results of this project will serve as a baseline for future, finer-scale freshwater mussel surveys. The survey was conducted as an activity by BLM under our agreement with TRRP.

Survey Area

The Trinity River Restoration Reach is a 40-mile section of the Trinity River that spans from the Lewiston Dam (mile marker 112) to the confluence with the North Fork Trinity River (mile marker 72.6). Of the roughly 40-mile restoration reach we surveyed all but two miles; we began our survey at mile marker 111, and were unable to survey a one-mile section located just upriver of Evans Bar (Mile marker 86-85) due to logistical constraints (Figure 11). Our surveys were conducted primarily between Early August and mid-September when lower flows provided easier navigation and better visibility. We surveyed the 2.25 miles between Evans Bar and Sheridan Creek in early October following the completion of the 2020 river restoration work within the reach.

Objectives

1. Document a course spatial description of large, high-density mussel beds within the Trinity River restoration reach.
2. Identify river reaches with exceptionally low mussel populations.

Methods

Beginning just below the Lewiston Dam, we inventoried mussel beds in a downstream direction using survey methods adapted from established protocols (Furnish et al. 1997 and May, C. L., & Pryor, B. S. 2016). Because our goal was to document significant mussel beds rather than provide a complete, fine-scale description of Trinity River mussel populations, we relied upon qualitative parameters to document and best describe mussel occupancy.

A survey team consisted of two snorkel surveyors and two kayakers serving as data recorders and safety lookouts. Surveyors focused efforts along the banks of the river where the majority of likely mussel habitat is located. Where mussels were encountered, they were considered a bed and recorded only if the following criteria were met: (1) minimum mussel coverage of 10% and (2) mussel occupation occurring continuously over a minimum of five yards. A GPS point was recorded at both the upstream and downstream end of the bed. Each bed recorded received a numerical ID, as well as a letter to indicate the beginning and end points of the bed (e.g. 101S/ 101E). We categorized each bed via ocular cover estimates using the following density classes: 1. high (coverage 50% or greater) (figure 1), 2. medium (coverage 30%-50%) (Figure 2), 3. low (coverage 10%-

30%). We also documented substrate into the following categories: 1. Sand, 2. Gravel (average substrate diameter .5-5 in.), 3. Cobble (6-10 in.), 4. Boulder (>10 in.), 5. Bedrock.

Where density fluctuated within larger beds, or where continuous mussel occupancy was interrupted by small gaps, surveyors made subjective assessments to best describe mussel occupancy at the site. Riffles and rapids were generally not formally surveyed due to difficulties associated with conducting a thorough search while navigating sometimes hazardous water, but beds were noted where they were observed. We attempted to include side channels in our survey where possible using the methods described. Surveys were conducted at a rate of roughly 1 river mile per hour, although this varied based upon factors including river conditions and mussel abundance.



Figure 1: Example of a high-density bed



Figure 2: Example of a medium density bed

Results and Discussion

We documented a total of 245 unique mussel beds. Distribution maps of mussel beds are provided throughout the report and in appendix A (Figure 4-7,10-11). Of the 245 beds documented, 65 were categorized as high density, 82 as medium density, and 98 as low density. A breakdown of mussel beds by density and substrate can be found in figure 3. Raw and geospatial data are available upon request, and can be found at the pathname:

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With few exceptions, we documented mussel occupancy in at least

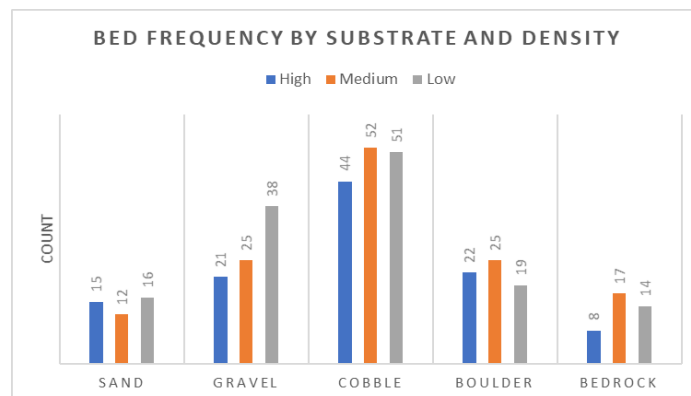


Figure 3: Frequency of beds by substrate and density

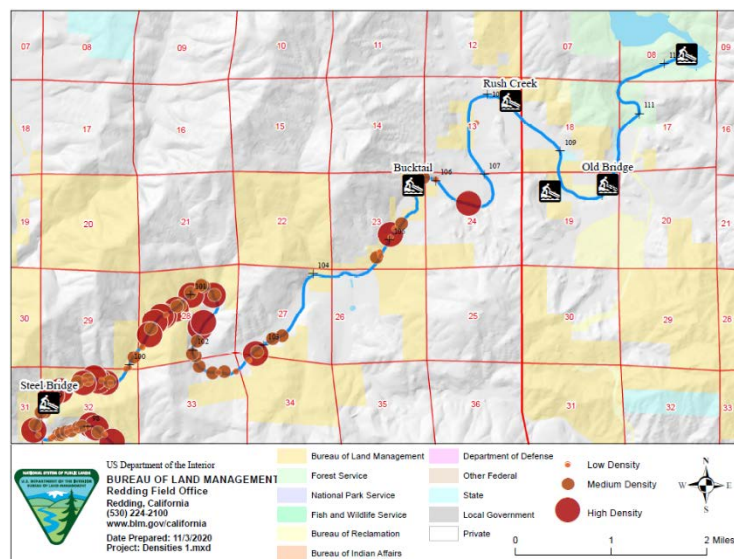


Figure 4: Mussel beds from mm 112-mm 9

low densities throughout much of the survey area. The 3 miles between mile marker 111 and the Rush Creek boat access (mm 108) were a particularly noteworthy exception in that we identified no mussel beds, and nearly no mussels at all (Figure 4). Although mussels were documented in low densities somewhat consistently below Rush Creek, high and medium-density beds remained relatively rare through the Poker Bar area. The upper portions of the TRRP Restoration Reach may therefore represent a potential target for future relocation efforts and study sites.

Although a more thorough analysis could be conducted to compare relative availability of each habitat type versus use, our data appear to be consistent with general observations made elsewhere that sandy bottoms are less stable and more prone to scouring during flooding events, which is a

possible explanation for the relatively low frequency of beds found in these areas. Bedrock substrate rarely afforded enough suitable habitat for the establishment of significant mussel beds, which may explain some of the gaps in mussel occupancy throughout the river, particularly between Mill Creek (mm 81.5) and mile marker 79 (Figure 7). Aside from these general observations, our survey methods did not allow for delineation of beds by substrate; many beds were found in areas where substrate was not homogenous and our data therefore do not necessarily indicate whether one substrate was more suitable than others. In general, where suitable habitat exists, mussels are present; areas where this is not the case are detailed below and could also represent areas where follow-up surveys could be conducted.

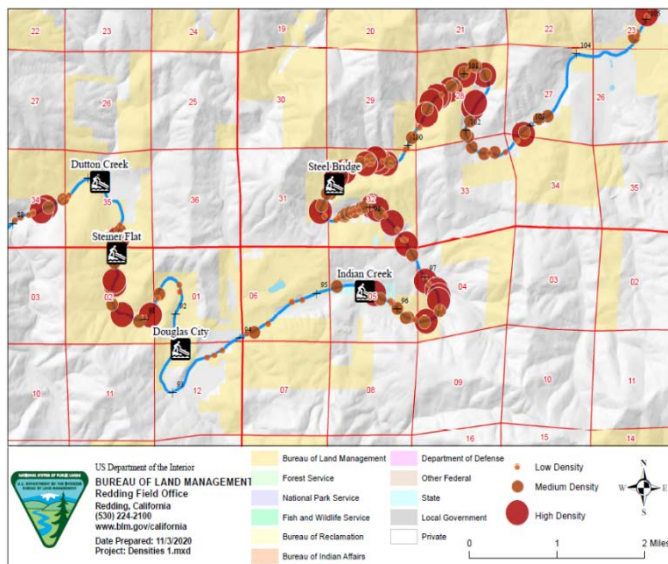


Figure 5: Mussel beds from mm 105- mm 88

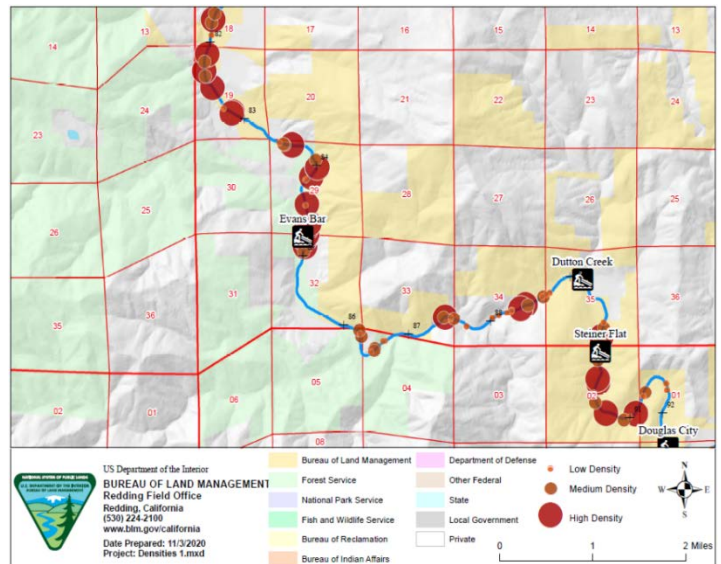


Figure 6: Mussel beds from mm 92-mm 82

High Density Reaches

- Beginning at Poker Bar (mm 102.5) and through Indian Creek (mm 92.5), the frequency and densities of beds encountered was exceptionally high (Figure 5). Throughout this approximately 10-mile stretch we documented near-uninterrupted occupancy, predominantly in the form of high and medium-density mussel beds.
- From mile marker 91.7 through Steiner Flat (mm 89.7).
- Evans Bar (mm 85)- Mill Creek (mm 81.5) represents an area with exceptionally high mussel densities (Figure 6). We documented over a dozen high-density beds in this 3.5-mile reach, including mussels tagged and relocated in 2017 across 4 release sites (May and Madison, 2017).
- Just upriver of Coopers Bar (mm 77)- Baghdad boat launch (mm 72.6). While there were gaps in occupancy, the final 5.5 miles of our survey area contained numerous high and medium density mussel beds (Figure 7).

Low Density Reaches

- Indian Creek (mm 95.5) marked the beginning of a stretch with exceptionally infrequent mussel occurrence; through mile marker 91.7 we documented no high-density beds and only a handful of medium density beds (Figure 5). In several portions of this 3.8-mile section we documented no mussel occurrence whatsoever.
- Mill Creek (mm 81.5) through mile marker 79 (Figure 7).

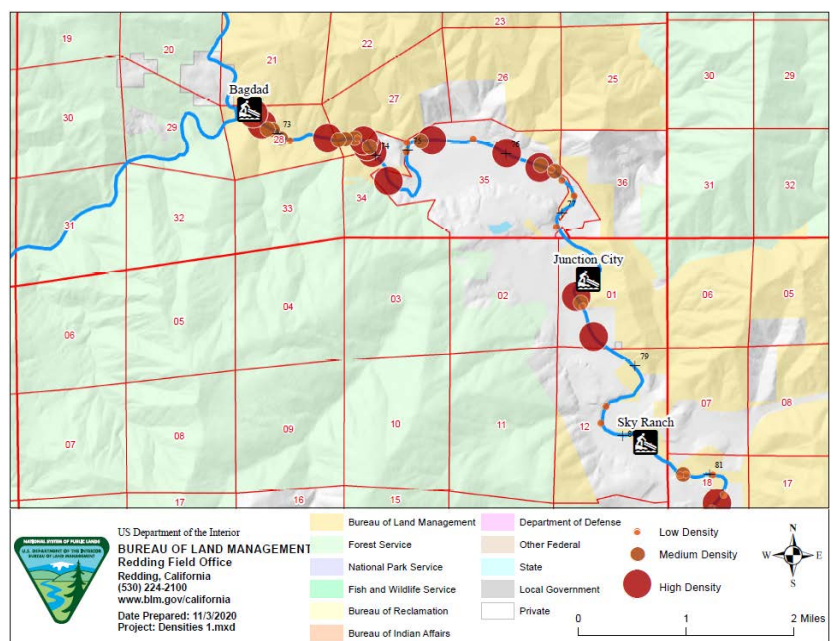


Figure 7: Mussel beds from mm 81-mm 73

Moving Forward

The lack of knowledge related to historical mussel distribution on the Trinity River makes assessment of current population dynamics difficult and raises questions about what constitutes a ‘normal’ population. We do not know, for example, if the damming of the Trinity has created conditions more suitable for mussel occupancy throughout the river. The resulting drops in both the frequency and intensity of flooding events may very well have created more stable banks, providing supplementary mussel habitat where it did not previously exist.

While our findings seem to indicate that mussel populations are stable within the Trinity River, the information collected in this survey will enable TRRP and BLM to identify and mitigate any potential future downward trends in mussel populations within the river. Areas where we identified low or nonexistent mussel occupancy could potentially inform future research or provide targets for mussel introductions or restoration work. Follow-up surveys could be designed to better understand why mussels were or were not present in specific locations. Further, analogous surveys conducted in other watersheds could yield valuable insights into management activities that promote or impede mussel occupation.

Our data can also be used to make determinations regarding efforts aimed at mitigating negative impacts to mussel populations. Relocating mussel colonies is a cost and time-consuming endeavor, and the efficacy of such actions is not well understood. Work conducted in proximity to an area identified as having significant mussel occupancy may not require such mitigation efforts if recolonization of disturbed areas may be likely to occur over a reasonable time frame. Analyzing our findings in conjunction with previous restoration work may shed light on the rate and extent to which recolonization occurs naturally.

Conclusion

This survey successfully mapped and inventoried significant mussel beds throughout the TRRP restoration reach providing information that will better inform management activities. Because mussels play a vital role in water filtration and can serve as an indicator species, this inventory may also provide important insights into overall system health. It will serve as baseline data for future surveys or studies aimed at understanding long-term dynamics of mussel ecology.

As this survey was aimed at providing a general description of mussel occupancy within the Trinity River, it has several inherent limitations. This study was a survey not a census. Qualitative descriptions of mussel densities provide rough estimates of bed extent, but cannot be used to describe population abundance, nor do they describe the composition of mussel colonies in terms of age class. We estimated substrate type and as a result this data likely do not have any statistical power; rather, they can be viewed as general observations providing baseline data that may lend themselves to the development of future hypotheses and studies.

Acknowledgements

The successful completion of these surveys would not be possible if it were not for the contribution of various partners. Thank you to the following partners for your collaborative efforts to make this project possible: Trinity River Restoration Program, United States Forest Service, Yurok Tribe, and Hoopa Valley Tribe.

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Figure 8: Devonie plummer recording data



Figure 9: Erin Faiferlick

Literature Referenced

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Schedule and Personnel

Surveys were conducted primarily between early August and mid-September when lower flows provided easier navigation and better visibility. The exact survey period took place from 08/03/2020 to 10/05/2020 and required a total of 13 workdays to complete all 40 miles of the survey area. The schedule in which this survey was conducted is detailed below in Table 1.

Several surveys required sections being re-surveyed or completed due to obstacles such as sections of high turbidity obstructing vision underwater or malfunctions with equipment. The section of river from Tom Lang Gulch to Steel Bridge Fishing Access that was initially surveyed on 08/12/2020 was unable to be completed due to malfunctions with equipment. The remaining 0.84 miles of this stretch was completed on 09/15/2020. The section of river from Junction City Campground to Bagdad River Access that was first surveyed on 09/09/2020 was cut short due to immense wildfire smoke from the North Complex Fire (the Bear Fire and Claremont Fire at the time). Wildfire smoke was so dense that it was so dark that it impaired surveyors' vision to find and detect mussel beds. This remaining 3.40 miles of this section was re-visited and completed on 09/14/2020. The section of river from Dutton Creek to Evans Bar that was initially surveyed on 09/02/2020 was disrupted by the Dutch Creek Restoration Project. Construction efforts created a lot of disturbance that made the water turbid and uncondusive to find mussel beds. The remaining 3.34 miles of this section was completed on 10/05/2020.

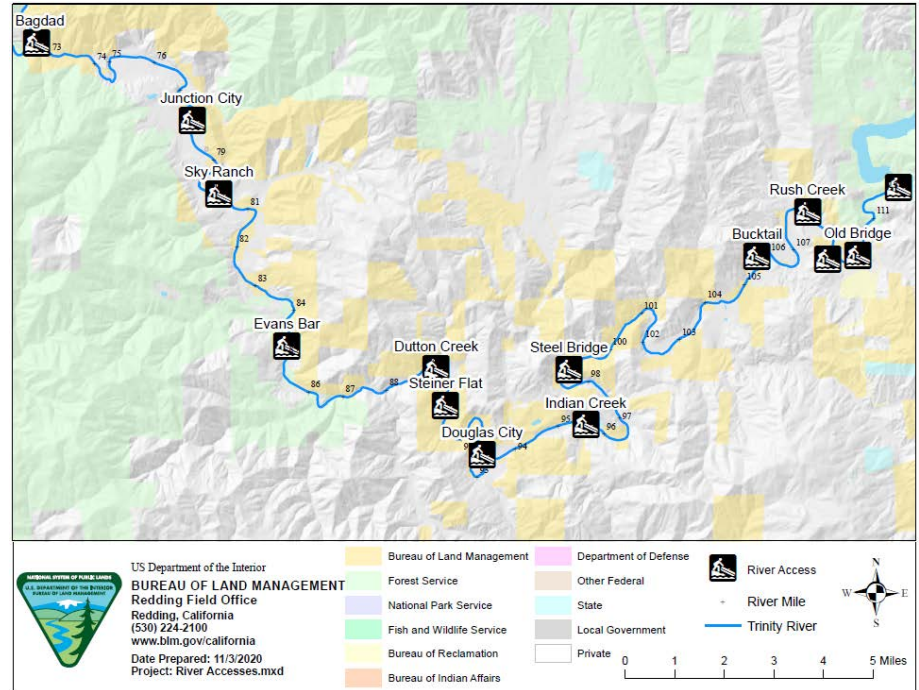


Figure 10: River access points

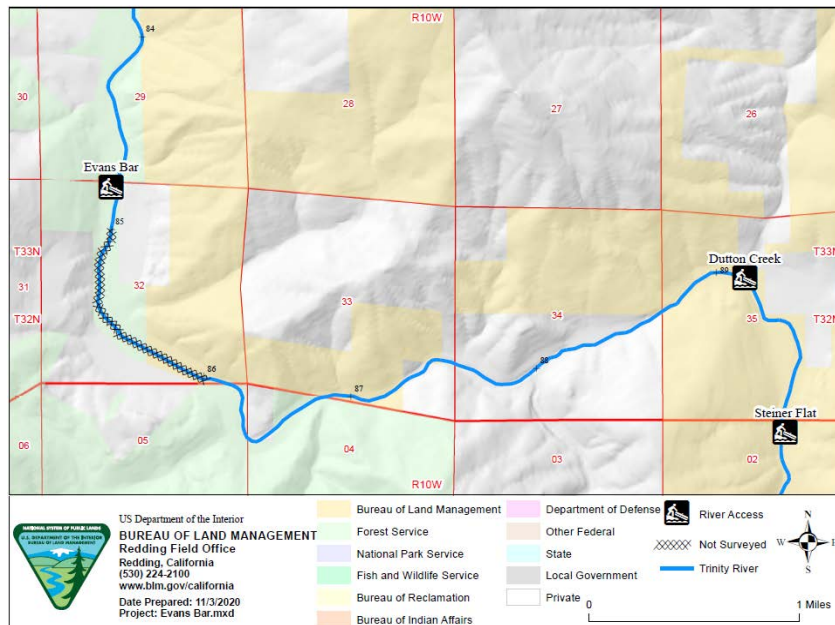


Figure 11: River reach upstream of Evans Bar not surveyed

Table 1: Survey details

Date	Start Point	End Point	Miles	Start Time	End Time	Duration
08/03/2020	Lewiston Dam	Rush Creek	2.81	11:30	15:30	4 hours
08/07/2020	Rush Creek	Bucktail Hole	2.16	09:30	12:30	3 hours
08/10/2020	Bucktail Hole	China Gulch	2.77	09:45	14:00	4.25 hours
08/12/2020-	Tom Lang Gulch	Steel Bridge	3.15	10:30	14:30	4 hours
08/18/2020	Steel Bridge	Indian Creek	3.52	10:00	13:30	3.5 hours
08/19/2020	Indian Creek	Douglas City	2.81	09:45	14:00	4.25 hours
08/31/2020	Douglas City	Dutton Creek	3.62	10:00	13:00	3 hours
09/02/2020-	Dutton Creek	Evans Bar	3.04	09:15	13:45	4.5 hours
09/03/2020	Evans Bar	Junction City	3.35	10:00	13:30	3.5 hours
09/09/2020-	Junction City	Bagdad River Access	2.20	09:30	13:15	3.75 hours
09/14/2020*	Junction City Campground	Bagdad River Access	3.40	10:15	12:30	2.25 hours
09/15/2020*	-	-	0.84	10:00	11:00	1 hour
10/05/2020*	Evans Bar	Sheridan	3.34	10:00	13:00	3 hours

*Portions resurveyed due to complications during initial surveys

Table 2: Survey dates and personnel

Date	Personnel	Surveyors/Snorkelers	Data Recorders/Kayakers
08/03/2020	2	Tobias Felbeck	Kevin Hauser
08/07/2020	2	Tobias Felbeck	Kevin Hauser
08/10/2020	3	Tobias Felbeck, Kevin Hauser	Tyler Schroyer
08/12/2020	4	Tobias Felbeck, Kevin Hauser, Amelia Fleitz	Heidi Rogers
08/18/2020	4	Tobias Felbeck, Kevin Hauser	Amelia Fleitz, Devonie Plummer
08/19/2020	4	Tobias Felbeck, Kevin Hauser	Erin Faiferlick, Mike Hoffman
08/31/2020	3	Tobias Felbeck, Kevin Hauser	Tyler Schroyer
09/02/2020	4	Tobias Felbeck, Kevin Hauser	Devonie Plummer, Tyler Schroyer
09/03/2020	4	Tobias Felbeck, Kevin Hauser	Leana Weissberg, Tyler Schroyer
09/09/2020	4	Tobias Felbeck, Kevin Hauser	Erin Faiferlick, Tyler Schroyer
09/14/2020	4	Tobias Felbeck, Kevin Hauser	Devonie Plummer, Tyler Schroyer
09/15/2020	4	Tobias Felbeck, Kevin Hauser	Devonie Plummer, Tyler Schroyer
10/05/2020	4	Tobias Felbeck, Kevin Hauser	Devonie Plummer, Jessica Tyra

Materials and Equipment Used

Personal protective equipment (PPE) used during these surveys are as follows:

- Type II, III, or V Life Jacket
- Drysuit
- Neoprene Hood
- Neoprene Gloves
- Snorkel
- Goggles

Other equipment necessary to conduct these surveys consist of:

- Inflatable Kayak (Sonar)
- Air Pump
- Patch Kit
- Throwable
- Dry Bag
- Waterproof Camera (Olympus TG-5)
- GPS Unit (Garmin Montana 680t)
- Clipboards
- Water-resistant Datasheets (Rite in the Rain)
- Pencils
- Shout Device



Figure 12: Kevin Hauser in Proper PPE for snorkeling.



Figure 13: Tyler Schroyer and Erin Faiferlick preparing for a day of mussel surveys.

Safety Considerations

Safety is paramount when conducting these surveys. There are several risks and potential hazards associated with conducting fieldwork outdoors, particularly in an aquatic environment. Surveyors should adhere to appropriate safety precautions each day to minimize the risk of injury or death.

The Trinity River is a high-flowing cold-water river that poses several safety concerns such as drowning, hypothermia, and dehydration. The most obvious concern is drowning. Swimming, snorkeling, and kayaking are all major components to these surveys. All surveyors should feel comfortable and have experience doing these activities to successfully perform these surveys. It is preferable for those snorkeling to obtain Swiftwater Rescue Training before conducting surveys. Experience and comfortability swimming and snorkeling will be important to mitigate the risk of drowning. There are a variety of obstacles in the water, such as strong currents, underwater and above water tree snags, and boulders that are easy to collide with. These obstacles serve as a safety concern as they can inflict bodily harm or damage to equipment that is essential to keeping you safe. Avoiding these obstacles by being alert and focused can help prevent issues that could lead to drowning and loss of life. Wearing proper personal protective equipment, such as life jackets while kayaking, will also help prevent incidents of drowning. Hypothermia is another concern, particularly for those snorkeling underwater. Surveys require long periods of time spent in the water. Dry suits are essential for this project and were provided by Amelia Fleitz from the U.S. Forest Service, Shasta-Trinity National Forest out of Weaverville, California. Several layers of clothing including thermal layers should be worn underneath the dry suit to help maintain body temperature and prevent hypothermia. Dehydration is a concern for both snorkelers and kayakers as there will be a lot of physical exertion for both duties. As a snorkeler, it is easy to forget to drink enough water because you are submerged in it all day. As a kayaker, you are above the water all day in high temperatures and sometimes extreme heat. These conditions are conducive to over-heating and becoming dehydrated. Being prepared and ensuring that you are bringing enough potable water is essential to help prevent these safety issues.

Human performance is restricted in water. Whether the surveyor is snorkeling underwater or kayaking upstream, it is critical to have situational awareness of the rest of the team and your surroundings in the environment. Situational awareness will help avoid mishaps in the field and help prevent unforeseen dangers. It is important to be communicative and keep an eye out for your field partners. Senses such as sight and hearing can be limited when in rough water or submerged underwater.

Weather is an important safety consideration. Check local weather forecasts prior to surveys to determine if it is safe and appropriate to conduct fieldwork. In the chance of severe weather, such as lightning and thunder, get off of the water and seek shelter immediately.

This field season saw an unprecedented amount of wildfire activity in northern California, including the Zogg Fire, North Complex, and August Complex. It is critical to stay informed and up to date on current fire activity in order to make a decision if it is safe to survey. Even when there is not a wildfire in the immediate vicinity of surveys, it is important to consider that other wildfire suppression activities may occur, such as helicopters using the Trinity River as a water source for dipping.

As with all fieldwork, it is important to practice safe driving practices to and from field sites. There are public river accesses that will take several hours to drive to from the Redding Field Office and require a lengthy amount of travel time. It is important to be alert, obey speed limits, refrain from driving when feeling fatigued, wear seatbelts, check mirrors frequently, and check blind spots when changing lanes.

A unique safety issue present during the time of these surveys was the Covid-19 global pandemic. Current established protocols list that social distancing should be practiced and there should be only one individual per government vehicle. If there is an instance in which this cannot be upheld, such as shuttling surveyors from the ending river access to the beginning river access, individuals should wear approved facial coverings to prevent the spread of the infectious disease. All government vehicles should be cleaned and sanitized at the beginning and end of each field day. If one experiences symptoms of Covid-19, they should refrain from surveying and quarantine at home. Most of these surveys naturally adhere to social distancing guidelines due to the snorkelers surveying on opposite sides of the river and the kayakers staying an appropriate distance upstream of the snorkelers on each side of the river

Prior to each survey, it is necessary to complete and share a float plan, establish a point of contact, and check in/out with someone at the beginning and end of each field day.

