Independent Scientific Review Panel
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ISRP webpage

ISRP Master Plan and Proposal Follow-up Review: *Freshwater Mussel Research and Restoration* (#2002-037-00)

ISRP 2021-1
February 23, 2021

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ISRP Master Plan and Proposal Follow-up Review: *Freshwater Mussel Research and Restoration* (#2002-037-00)

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Background

In response to the Northwest Power and Conservation Council's December 8, 2020 request, the ISRP provides a follow-up and Step Master Plan review regarding the Confederated Tribes of the Umatilla Indian Reservation's (CTUIR) project, *Freshwater Mussel Research and Restoration* (#2002-037-00).

As described in the CTUIR's 2019 proposal:

> "Since its inception in 2003, the Freshwater Mussel Project of the CTUIR has conducted research designed to understand the biology and ecology (both biotic and abiotic) of freshwater mussels…The long-term goal of this project has been to utilize project findings for development and implementation of restoration actions for freshwater mussels in the Umatilla River and other mid-Columbia basins on ceded lands. The restoration of freshwater mussels is a part of an ongoing efforts to rebuild ecosystem diversity, function, and traditional cultural opportunities in the context of First Foods."

One primary section of our review below addresses a follow-up evaluation of the CTUIR's response titled, *The Confederated Tribes of the Umatilla Indian Reservation's response to the Independent Scientific Review Panel's, Final Report: Mainstem and Program Support Category Review (ISRP 2019-02, May 29, 2019), review of the Freshwater Mussel Research and Restoration project* (also see the CTUIR's Cover letter dated December 4, 2020). That response is part of an iterative review intended to address the Council's qualifications placed on this project as part of the Mainstem and Program Support Project Review from August 2019: "Sponsor to address ISRP qualifications [2019-2, pages 68-69] and submit in a report to Council for ISRP review by January 30, 2020." The ISRP's 2019 review listed six qualifications, some of which originated in a previous ISRP review (ISRP 2018-8, page 69). The CTUIR responded point-by-point to the ISRP's qualifications in February 2020. The ISRP found that, although the project had significant implications for both the region and the CTUIR, the responses raised significant concerns and did not satisfy the ISRP's qualifications (ISRP 2020-5). In large part, the concerns stemmed from having direct responses postponed until the development of a master plan, which is a subject of this current review.

As part of the 2020 review, the ISRP requested an audio-visual teleconference with the CTUIR proponents to discuss the responses to past qualifications and understand anticipated content of the Master Plan. ISRP reviewers and CTUIR staff and contractors met on June 12, 2020 to gain a better understanding of the status of the Mussel Project and master planning effort, to discuss approaches to addressing the qualifications from the ISRP's 2018 and 2019 reviews, and to clarify any questions about the ISRP's comments. After that meeting, the ISRP also provided feedback on a draft outline of the Master Plan. The Master Plan and responses reflect the ISRP's input from the meeting and demonstrate the Mussel Project's efforts to develop a scientifically sound program.

The second primary section of our review is an evaluation of the *DRAFT Master Plan: Freshwater Mussel Conservation, Supplementation, Aquaculture, Restoration, and Research* using the Council's Step Review criteria. The Master Plan is intended to provide "a framework to guide freshwater mussel conservation, aquaculture (including artificial propagation), supplementation, restoration, and research to make progress towards supplementation and restoration." The plan is also intended to "facilitate coordination among any parties involved in propagation and/or population restoration efforts supporting recovery of three genera of western freshwater mussels (e.g., *Anodonta*, *Gonidea*, and *Margaritifera*) and to ensure those efforts are based on sound science." The ISRP's review comments are provided in the Council and ISRP's standard Step Review format below.

ISRP Overall Recommendation on Follow-up and Step Reviews

The ISRP's overall recommendation is Response Requested. The ISRP requests the Freshwater Mussel Research and Restoration Project (hereafter "Mussel Project") to continue to revise the Draft Master Plan and submit a Final Master Plan to the ISRP for review by December 31, 2021.

The CTUIR's efforts to protect and restore freshwater mussels in their ceded lands in five basins in Oregon and Washington are one of the most extensive in the western United States. The Mussel Project integrates assessments of distribution and abundance, habitat relationships, genetic analysis, salvage and translocation, and artificial propagation and reintroduction of native mussels. As well, this project provides critical information for other projects in the Pacific Northwest and is developing methods that could increase the effectiveness of mussel conservation throughout the Columbia River basin.

This 90% draft of the Master Plan is a major step forward for the Mussel Project. The Draft Master Plan displayed careful thinking about how and why mussels should be propagated to support their restoration in CTUIR ceded lands. Positive aspects of the draft Plan include:

1. The general biology of mussels and characteristics of basins generally are well explained.
2. Detailed past research on taxonomy and genetics of the species, which are needed for conservation aquaculture and restoration, is well presented.
3. Collaboration with scientists from the USGS lab in Columbia, Missouri on the best methods for increasing rearing success is a positive development.
4. Objectives presented are mostly SMART objectives (Specific, Measurable, Achievable, Relevant, Time Bound).
5. The experimental design, with treatments and two types of controls (lab and field) presented in a table, is carefully planned and logical.
6. The use of research vessels to conduct pilot outplanting during a first year to determine suitability of habitat is an excellent plan.
7. The phased approach that incorporates adaptive management allows learning and mid-course corrections at every step.

The CTUIR Response adequately addresses most of the qualifications from the ISRP 2020-5, ISRP 2019-2, and ISRP 2018-8 reviews, but several important elements of the qualifications require major revision and addition of critical information, which are detailed in the following section. The ISRP is requesting the Mussel Project to revise and complete this draft Master Plan to address these issues as part of the Step Review Process and explain where changes in the Master Plan were made to address the specific issues. Given the substantial revisions and additions of technical information required, the ISRP expects the Mussel Project to submit the final Master Plan for review by December 31, 2021.

Recommendations for Revision of the Master Plan

The Master Plan should provide a strategic framework for the protection, conservation, and restoration of mussels and clearly identify the relative priorities for 1) sustaining current habitats, populations, and ecosystem processes, 2) restoring habitats, populations, and ecosystem processes that are impaired, and 3) anticipating future risks and developing adaptive actions. The Plan currently identifies eight co-equal project components, but addresses only the Restoration Component and focuses primarily on artificial propagation of mussels for reintroduction into selected sites.

Conservation of existing mussel populations and restoration of populations that have severely declined or been extirpated will require scientifically sound implementation of three fundamental project components:

- Monitoring the distribution and abundance of mussels
- Salvage and translocation of mussels
- Artificial propagation and augmentation/reintroduction of mussels

The Master Plan should provide a more balanced approach that thoroughly describes the three conservation actions, each of which should be explicitly linked to the six Scientific Principles of the 2014 Fish and Wildlife Program. This will require integration of these three primary components of the Mussel Project and development of SMART objectives for all three components rather than just the artificial propagation program. The ISRP provides specific recommendations for each of these primary components and expects the project proponents to explain which recommendations are incorporated into the Final Master Plan, which are not feasible with existing funds and expertise, and which will be pursued under external funding opportunities or budget reallocation.

The following section explains the ISRP's recommendations for improvements in these three components in the Master Plan.

I. Monitoring the distribution and abundance of mussels

To a large extent, the entire plan rests on measures of mussel distribution and abundance. However, the basinwide surveys of mussels were initially conducted nearly two decades ago, in 2003, and the methods used are not fully documented (e.g., Glidewell 2017, Maine 2020), so the data may not be accurate for current conditions. For example, mussels are cryptic, so false absences may be common. It is not clear from the Master Plan or annual reports whether the distribution of mussels is assessed on a

regular schedule and how it relates to the measurement of status and trends of the five monitored reintroduction sites. Given this, the data are likely not sufficient or accurate enough to: a) address the current status of mussels at sites, and among river segments and subbasins, to allow planning strategic conservation, including translocations, supplementation, and reintroductions; b) measure changes in distribution and abundance over time; and c) develop an accurate model of distribution and abundance based on habitat.

Given this, the ISRP requests the proponents to include the following in their Master Plan:

A. For measuring mussel distributions across ceded subbasins:

1. Develop and document a suitable probabilistic sampling design for assessing the true distribution (i.e., presence/absence) of mussels across each of the five subbasins on ceded lands. For example, one option might be a Generalized Random Tessellated Stratified (GRTS) design (see Stevens and Olson 2004 and an application at WEST-inc.com). Other designs also may be suitable. If some types of habitat are excluded from the sampling frame as unsuitable (e.g., areas embedded in silt, bedrock), provide a robust scientific justification for how and why this was done.

2. Develop, validate, and document a suitable method for detecting the presence/absence of mussels at each sample site, such as snorkeling surveys along transects (Wisniewski et al. 2014) to detect certain size classes (e.g., adults, and juveniles larger than a specific size) or eDNA sampling. If a transect method is used, determine the detection probability of the given size class of mussels, such as by using repeated transects (Wisniewski et al. 2014). Also, see Smith (2006) for another survey design to ensure a high probability of detecting rare mussels.

   Detecting the presence or absence of mussels in the field is challenging because of the small size of young mussels, their cryptic use of subsurface habitat, and the risk of destroying habitat and mussels by excavating the streambed. However, eDNA offers a rapid, non-destructive method for detecting the presence of mussel species. Methods for eDNA detection of *Anodonta nuttalliana, A. oregonensis, Gonidia angulata*, and *Margaritifera falcata* have been developed in the region, including studies in the CTUIR ceded area (Dysthe et al. 2018, Rodgers et al. 2020, Sansom and Sassoubre 2017). The Mussel Project should consider refining these methods as needed and incorporating eDNA sampling to provide a low cost, rapid, non-destructive method for measuring the presence or absence of mussel species across subbasins.

3. Specify relevant habitat variables important to mussels that will be measured at each site (onsite or with GIS), such as depth, gradient, flow, substrate composition, temperature, frequency of scour (e.g., using scour chains), mesohabitat composition, riparian condition, and presence of host species.

4. Develop a plan for fitting formal occupancy models to the data gathered (MacKenzie et al. 2017), including relating presence/absence to the habitat variables (see Wisniewski et al. 2014 for an example). Such models allow defining the probability that mussel species were detected, and the habitat variables that account for their distribution.

B. For measuring mussel density at long-term monitoring sites

1. For long-term monitoring sites, or other sites where proponents seek to measure mussel densities, first develop, validate, and document a suitable sampling method for estimating density of specific size classes of mussels. One example is the two-stage sampling design of Smith et al. (2001a, b) that includes validating density beneath the substrate surface using excavation at a sample of sites. Although the proponents prefer not to disturb rare mussels, such validation would be possible at sites where mussels are to be salvaged. Smith et al. (2010, 2011) provide additional guidance on sampling mussels. The ISRP encourages publication of the project's methods and their validation in a peer-reviewed journal to provide scientific support for the monitoring program.
2. Develop and document a method for estimating the long-term trend in abundance at each long-term monitoring site. For example, this might involve appropriate time-series regression of the CPUE data collected to date and the improved estimates of density collected in the future.

C. For all methods used to measure distribution and abundance

1. Develop relationships between results of former sampling methods versus revised methods to allow comparing the results to identify changes in distribution and abundance.
2. Fully document the sampling methods in the Master Plan, and in MonitoringMethods.org. To date, it has not been possible to determine precisely what methods were used. Examples include the number of transects, their orientation with the channel, and how detection probability was estimated.
3. Update the maps for each subbasin (Figures 4.2-4.6) to show all sites sampled, including those where no mussels were detected (i.e., apparent absences).
4. Developing suitable methods for sampling and analysis will require consultation or collaboration with experts in these fields. Options include Dr. Jim Peterson, a current collaborator, Dr. Mary Conner at Utah State University, or Dr. Nick Bouwes of the Eco Logical Research lab at Utah State.

II. Salvage and translocation of mussels

A more balanced approach is needed to make full use of the large numbers of salvaged mussels and to protect existing strongholds of mussel populations. The CTUIR Response indicates that translocation projects will be used to study "population dynamic uncertainties" and "translocated mussels from habitat restoration will be used to investigate population dynamics."

The proponents indicate in their annual reports that thousands of mussels are apparently destroyed during construction activities or habitat restoration, and are available for salvage. These numbers far exceed the numbers of mussels that are planned to be produced by artificial propagation annually (500 adults). For example, Maine (2020) reported that >10,000 mussels were relocated from the Bird Track Springs site in the Grande Ronde River. Of these, 80 were tagged to evaluate effectiveness of this method. The Master Plan states that relocating adults is one of the most effective restoration strategies tested, as reported in the medium-term study by Carey et al. (2015).

The project should identify and protect strongholds of mussels and salvage those that will be destroyed. This will require a careful prioritization of potential sites for translocation of salvaged mussels in advance of any planned or unplanned alterations of mussel habitats. The plan should include criteria for translocations based on requirements for different mussel species, needs for translocation into gaps in their distribution, habitat quality, adjacency and logistics for moving mussels from the salvage site to the translocation site, and potential future risks (e.g., climate change, environmental contaminants, land use change).

The Mussel Project should carefully evaluate and document sites in each basin where mussels of each species could be relocated for reintroduction or augmentation, so the information is readily available when opportunities for salvaging mussels become available. These sites should be prioritized based on habitat conditions, fish hosts, and water quality that are required for successful reintroduction or augmentation. Prioritization of potential translocation sites should be coordinated with the ongoing field surveys of mussel distribution, status, and trends so that translocations can meet strategic needs to either build out from healthy populations, fill in gaps in mussel distributions, or prevent local extirpations in the basins of the ceded lands.

Translocation efforts should be treated as experiments and monitored to inform future efforts for either translocation or reintroduction of artificially propagated mussels. Translocated mussels may fare better (or possibly worse) than propagated mussels that are outplanted because although both are transported and introduced into the new habitat, translocated mussels are wild and have been exposed to natural selection. Likewise, these individuals may not reflect the responses and behaviors of mussels in intact populations. See the ISRP's suggestions for improving the experimental design and analysis of reintroduction/augmentation in the following section.

III. Artificial propagation and augmentation/reintroduction of mussels

The draft Master Plan addresses the relationships and consistencies of the Mussel Project to the 2014 Fish and Wildlife Program's six scientific principles (Step 1), with a focus largely on artificial propagation. Overall, the Plan displays careful thinking about how and why mussels should be propagated to support their restoration on CTUIR ceded lands. Nevertheless, the ISRP feels that there are additional options for achieving a healthy ecosystem with mussels, ones that are not fully considered. These may include restoration actions such as the strategic translocation of the apparently large numbers of mussels available for salvage to expand mussel distribution.

The ISRP found the detailed phased plan for mussel propagation and experimental outplantings to be very informative. The decision process outlined in Table 5-4 provided a clear image of points to act upon, to monitor specifically, and to evaluate as guides for program actions. Nevertheless, the Master Plan still needs to establish a regular schedule for program meetings where progress and results are reviewed, and where documented decisions are made about the degrees of success/failure and the subsequent actions taken.

The ISRP identified seven positive aspects related to artificial propagation in the draft Master Plan (see the ISRP Overall Recommendation section) but has raised several points about the details that the final Master Plan needs to address:

1. As long as artificial propagation remains a major component of the Mussel Project, approaches for adding new (or redesigning existing) laboratory and hatchery space should be explored. Existing space (23 sq. ft. of 1,250 sq. ft. wet lab) is likely to be inadequate for the efforts required in the coming years. The Mussel Project could negotiate arrangements with regional hatcheries, such as the new CTUIR hatchery on the South Fork Walla Walla River, the Umatilla Hatchery in Irrigon, or other hatcheries near the CTUIR ceded areas. Until expanded facilities can be obtained, the Master Plan should document the long-term arrangement with Walla Walla Community College and assurances for future access.

2. The Master Plan provides a series of goals and quantitative objectives with explicit timeframes. However, the Master Plan does not explain how the targets were developed for numbers of juvenile, subadult, and adult mussels. The Master Plan should be clear about the basis for the quantitative objectives. The biological basis for the specific quantitative objectives for artificial propagation (i.e., determination of the number of organisms to be produced for reintroduction) should be explained and empirically justified. For instance, how was it determined that 500 propagated adult mussels would be adequate for reintroductions each year (p. 85)? As well, is it 500/site or 500 total for all sites?

   The draft Master Plan indicates that the proponents will defer development of hypotheses to their final Master Plan submission. The ISRP considers testable hypotheses to be important for critical research questions in their experimental design and expects rigorous hypotheses to be included in the final Master Plan.

   The Master Plan does a good job of establishing SMART biological objectives for the stated production targets, as well as developing a plan for adaptive management of the experimental outplanting of propagated mussels. Nevertheless, one potential problem is that for Phase 2, Goal 2, Objective 2, by 2027 there may be too few adult mussels propagated for ecologically effective outplanting. The Master Plan should identify actions that would be taken in that situation. One alternative might be to use adults salvaged from construction or restoration sites for the experimental outplantings. Another alternative would be to identify facilities or locations where the adults could be held until adequate numbers are propagated (e.g., regional hatcheries, Walla Walla Community College, Mt. Hood Community College).

3. Even if enough mussels are produced artificially, their complex life history, especially requirements for specific fish hosts and habitat characteristics, make it difficult or unlikely that most reintroductions or augmentations will be successful. The ISRP feels that the Master Plan needs to address measures that ensure an adequate population of fish hosts so that the entire life history can be successful, such as available knowledge of the distribution and abundance of host species within the ceded basins.

4. The experimental design for reintroduction/augmentation is a good start, but better methods of analysis are needed to detect trends that indicate success or failure. The proposed design includes lab and field controls for reintroductions/augmentations, and the use of research vessels for pilot work on habitat suitability, which are excellent. However, several improvements are needed to provide the statistical power required to determine whether the restoration method was successful or not.

   The problem is that the experiments have minimal replication (n=2 each for reintroduction and augmentation sites), so differences compared to controls in metrics like survival would need to be very large to detect them statistically with sufficient confidence, using traditional methods such as analysis of variance.

   In contrast, new methods based on mark-recapture allow robust estimates of abundance and survival, and significance of trends in these metrics among small numbers of sites while also accounting for less-than-perfect detection of mussels. These methods involve:

   a. Marking mussels with external tags or PIT tags to allow identifying individuals

   b. Repeated surveys each year at each site to estimate detection probability. This could involve making several "passes" through the site by independent observers to detect and record tagged mussels. Such sampling may not be onerous, depending on methods and field conditions. For example, Wisniewski et al. (2014) reported that sampling ten 1 X 10 m transects averaged 1.4 person-hours (range: 0.35 – 5.65 h) per site in a southeastern US river.

   c. Analysis of the set of data over 5 years of sampling would involve using Program MARK (White and Burnham 1999) to jointly estimate detection probability, abundance, and survival, using an open-population model such as Pollock's Robust Design, a variant of the Cormack-Jolly-Seber model (Kendall and Pollock 1992). Rates of increase or decline (i.e., trends), compared to controls, can also be estimated and tested statistically.

   d. This analysis would also allow considering the entire set of sites simultaneously to generate better estimates of detection and capture probability, using information across all sites, often called "borrowing information across sites."

   Dr. Jim Peterson (Oregon State University), Dr. Mary Connor (Utah State University), or other scientists with comparable expertise could advise on design and use of these methods.

5. The draft Master Plan generally addresses Annual Program Review (APR) standards. Nevertheless, a risk assessment process or criteria for risk assessment are not described explicitly. Mussels propagated in the laboratory will not be under natural selection, so it is likely that mortality will be high when introduced into the natural environment. It is also likely that the laboratory propagation will cause unanticipated artificial selection that may reduce fitness in natural settings. This occurs for fish and is likely for mussels. The Master Plan does not articulate an effort to expose the animals to natural selection during propagation. Certainly, the laboratory environment creates novel conditions that influence the biology and genetic diversity of the target organisms. It will be critical

to assess carefully the genetic consequences and effects on fitness in mussel populations supplemented by artificial propagation.

6. The draft Master Plan indicates that it is not subject to the completion of a Hatchery Genetic Management Plan (HGMP) because none of these species are listed as Endangered or Threatened under the ESA. However, in August 2020 the Xerces Society petitioned to have *Gonidea angulata* listed as Threatened under the ESA. In addition, the status of *Margaritifera falcata* is categorized as Vulnerable (S3) by the states of Oregon and Washington and Imperiled (S2) by Idaho (see NatureServe map). Given widespread concerns for the declines of these species, the ISRP feels that the Mussel Project should proactively develop an HGMP, which includes several elements the project has already completed. The project has conducted studies of the genetic structure of the mussel species and populations and plans to investigate the genetics of reintroduced and reference populations after reintroduction. Another aspect of an HGMP is to examine the fitness of artificially propagated organisms. This would include biological performances other than survival, and the final Master Plan should contain a component comparing the fitness of artificially propagated mussels with wild mussels.

7. The draft Master Plan focuses on Alternative 3 - Implement Modest Expansion of Supplementation, Aquaculture, and Restoration Efforts, which is appropriate at this time. The final Master Plan could describe the Mussel Project's vision for the future, which would identify anticipated expansion or additions once the program has accomplished several critical elements: 1) better understanding of the distribution, abundance, and habitat needs of mussels; 2) identification of declines in populations and the environmental changes responsible for them; and, most importantly 3) quantification of effectiveness of different restoration actions.

   The ISRP encourages the Mussel Project to think strategically and develop a comprehensive program. The future vision in the final Master Plan could identify strategies to train and retain staff, expand the facilities and subcontracts that will be needed in the near future, and add new personnel in response to new data and issues. If the Mussel Project evolves to include broader goals and objectives and develops additional funding sources, the project should consider forming an external advisory group of recognized scientists and managers to advise them on developing future funding opportunities and contacts beyond the Council and BPA.

ISRP Summary of the Review of the Draft Master Plan

The ISRP recommends that the Mussel Project create a final Master Plan where assessment of status and trends, salvage and translocation, and artificial propagation methods are balanced and integrated components of the overall restoration efforts. Once the ecological needs of mussels are better understood, the environmental changes causing declines are identified, and the effectiveness of the restoration actions are well quantified, the Mussel Project could consider modifying or expanding their efforts as guided by the initial research results, adaptive management, and cultural drivers.

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Specific Comments on CTUIR's December 2020 Responses to the ISRP's Six Qualifications

The ISRP provides the following responses to the CTUIR's December 2020 responses for suggestions that may be useful for revising the Master Plan and implementing the Mussel Project. Note that many of the comments duplicate the ISRP's overall recommendations for revising and completing the Master Plan.

ISRP 2019 Qualification 1: *Provide satisfactory responses to qualifications from the previous ISRP review (ISRP 2018-8, page 69). This includes establishing quantitative restoration objectives and specific timelines, establishing testable hypotheses, and formulating a plan to provide empirical information on factors causing population declines. Prior to the official release of the Master Plan, these objectives, hypotheses, and plans can be labeled as "provisional."*

ISRP 2021 Comments: Qualification will be met upon approval of the final Master Plan.

The Master Plan has developed specific implementation phases, goals, and quantitative objectives with explicit timelines (SMART objectives) for artificial propagation. SMART objectives need to be developed for assessment of status and trends and salvage and translocation as well. For the most part, the stated objectives for artificial propagation are clear and appropriate, but a quantitative biological basis for the number of mussels to be produced by artificial propagation in each of the steps is not explained.

Better sampling methods, and thorough descriptions of them, are needed to generate estimates of distribution and abundance that will allow detecting changes through time, as well as developing models of habitat suitability. The entire foundation of the program rests on estimates of distribution and abundance. Current estimates of distribution were begun nearly two decades ago, and methods used to estimate presence/absence and abundance likely are not adequate and need improvement.

There is a great opportunity to use mussels salvaged from restoration and construction projects for reintroduction or augmentation, but there is no integrated plan or specific SMART objectives for their use.

ISRP 2019 Qualification 2: *Provide an adequate description of an adaptive management (AM) process, either for the current activities or the Master Plan to be developed in 2019. The use of SMART objectives, a Gantt chart, or another decision-making process would be especially helpful in illustrating the project's quantitative objectives, deliverables and timelines. The AM process should include explicit stages for actions and decisions and, as well, explicit schedules and decision processes for each stage.*

ISRP 2021 Comments: Qualification will be met upon approval of the final Master Plan.

Four implementation phases, five goals and five SMART objectives will be used to adaptively manage the project. These are substantial improvements and should be incorporated in a

formal scheduled process for project review and adjustment. The detailed phased plan for propagation and experimental outplantings of mussels was among the better we have seen from a funded project. The detailed decision process outlined in Table 5-4 provides a clear view of the decision points for this project. This plan lays out clearly how the proponents will use the Plan, Act, Monitor, Evaluate model to guide their project.

Timeframes for these adaptive actions are long-term (2025, 2027, 2030) and do not identify near-term adaptive decision-making processes. It would strengthen the Master Plan to develop regular annual schedules for project meetings, review of progress and results, decisions about degree of success and subsequent actions, and documentation of decisions.

ISRP 2019 Qualification 3: *It remains unclear to the ISRP if the proponents have an approach for integrating the research components. Therefore, the ISRP reiterates its suggestion that the development of population models and landscape analyses of habitat suitability would provide a context for integrating results from investigations of population trends, reintroduction success, host specificity, and artificial propagation. The ISRP requests direct responses to these suggestions. If population models and landscape analysis of habitat suitability are not appropriate or other approaches are more appropriate, the proponents should inform the ISRP and provide adequate description of their approach for integration.*

ISRP 2021 Comments: Qualification will be met upon approval of the final Master Plan.

The CTUIR Response indicates that data collected by past field surveys will be used in the future habitat suitability model, but past reports and publications do not provide information on the development, calibration, and validation of the methods and analyses. Habitat suitability models at the landscape scale depend on accurate measures of mussel distribution (presence/absence at sites throughout subbasins) and abundance at specific sites. Overall, basinwide surveys need to be repeated using new methods to update the status and distribution of mussels and compare them to earlier surveys. Likewise, better methods need to be employed to measure abundance at monitoring sites and to detect effects of the experimental outplantings compared to field and lab controls. The ISRP has suggested improvements to these methods above.

The CTUIR Response indicates that translocation projects will be used to study “population dynamic uncertainties” and “translocated mussels from habitat restoration will be used to investigate population dynamics.” Translocated individuals may produce biased estimates of these parameters because the organisms are responding not only to the new habitat but to the effects of being captured, held, transported, and introduced into the new habitat. These individuals may not reflect the responses and behaviors of mussels in intact populations.

ISRP 2019 Qualification 4: *Provide a response to the following ISRP concern and suggestion: Much of the effort on restoring mussels to the Columbia River Basin appears to rest on developing laboratory culture methods, which to date have not been successful. Other methods such as field inoculation of host fish and translocating adult mussels are discussed as options if mussel culture proves unsuccessful. The ISRP feels that it would be prudent to develop all possible methods concurrently and to use an adaptive*

management framework to assess them in tandem and further develop those that are successful, while phasing out or making major modifications to those that are not.

ISRP 2021 Comments: Qualification will be met upon approval of the final Master Plan.

The proponents focus almost exclusively on laboratory propagation in their Plan, giving short shrift to adult translocation, despite the apparent availability of thousands of mussels from salvage at each site compared to a few hundred that might be available from lab propagation after many years of research. A better balance could be struck between A) identifying and protecting strongholds of mussels, and salvaging those that will be destroyed, vs. B) developing propagation methods and experiments to measure success of outplantings.

The laboratory environment creates novel conditions that influence the biology and genetic diversity of the target organisms. It will be critical to assess carefully the genetic consequences and effects on fitness in mussel populations supplemented by artificial propagation.

ISRP 2019 Qualification 5: *Identify specific publications, authors, intended journals, and timelines for analysis, writing, and submission of peer-reviewed publications as well as for agency reports (e.g., technical bulletins) and other significant grey literature. Indicate how each planned publication is linked to specific objectives and work areas.*

ISRP 2021 Comments: Qualification met.

The proponents have continued to publish papers from their work. The past and planned publications are described adequately. A synthesis paper from the substantial body of work done to date would be timely. Development, calibration, and validation of the field methods should be documented in annual reports and considered for publication in the peer-reviewed literature.

ISRP 2019 Qualification 6: *The third goal of incorporating mussel monitoring in other monitoring efforts remains vague and weakly linked to the subsequent eight objectives. Explain how observations about mussels based on other monitoring efforts (building on their training of other programs) will be recorded, verified, incorporated into a spatially explicit database, and used in a landscape analysis of mussels (i.e., presence/absence, abundance, diversity, recolonization, extirpation, trends). As well, the proponents should devise ways to be sure that mussel and environmental monitoring are conducted in tandem.*

ISRP 2021 Comments: Qualification met.

The Mussel Project provides guidance on mussel monitoring for stream restoration projects in their lands and other projects in the Pacific Northwest. This qualification was well explained, and the project clearly has devoted considerable attention to this issue.

ISRP Comments on Step Review Elements

The Council has emphasized that an important part of the Three Step Review Process includes an ISRP review of the responses to the technical elements listed below. The ISRP comments on how the draft Master Plan addresses the Step Review elements follow below.

A. All Projects

Does the Master Plan:

1) address the relationship and consistencies of the proposed project to the 2014 Fish and Wildlife Program's six scientific principles (Step 1)?

The Scientific Principles:
1. Healthy ecosystems sustain abundant, productive, and diverse plants and animals distributed over a wide area.
2. Biological diversity allows ecosystems to adapt to environmental changes.
3. Ecosystem conditions affect the well-being of all species including humans.
4. Cultural and biological diversity is the key to surviving changes.
5. Ecosystem management should be adaptive and experimental.
6. Ecosystem management can only succeed by considering people.

Master Plan Section 6.1 (pages 95-100) addresses the six scientific principles.

The Master Plan addresses the F&W Program's six scientific principles. It does not explain how "annual and long-term population monitoring" will be conducted and used to develop a landscape context for conserving existing populations and reintroducing mussels into sites with declining or extirpated populations. The Master Plan should fully consider other options for achieving a healthy ecosystem with mussels and restoration actions, such as careful translocation of mussels that are available from salvage of restoration and construction projects.

2) describe the link of the proposal to other projects and activities in the subbasin and the desired end-state condition for the target subbasin (see 2014 Columbia River Basin Fish and Wildlife Program, Part Three, Section II) (Step 1)?

The Master Plan's Section 4.5 (pages 56-58) covers Programmatic Guidance, and Sections 2.2 (page 5) and 4 (pages 28-60) cover Related Projects.

The Master Plan adequately describes relationships with other projects in the subbasins, but it does not explicitly identify the desired end-state condition of the target basins in terms of population characteristics for the three mussel species or habitat conditions to support stable mussel populations. The Master Plan should include more information about their sampling for presence/absence and abundance at sites throughout the five subbasins in CTUIR ceded area as well as at selected long-term monitoring sites and identify potential improvements in their methods.

3) define the biological objectives with measurable attributes that define progress, provide accountability and track changes through time associated with this project (see 2014 Fish and Wildlife Program, Part Three, Section III) (Step 1)?

Biological objectives are covered in Master Plan Sections 3.2 (pages 21-22) and 5.5 and 5.6 (pages 66-73).

The Master Plan provides a series of goals and quantitative objectives with explicit timeframes. The proponents did a very good job of defining SMART biological objectives, by and large, and developing a plan for adaptive management of their experimental outplanting of propagated mussels.

One potential problem is that for Phase 2, Goal 2, Objective 2, by 2027 they may have too few adult mussels propagated to outplant. There are apparently hundreds of adults salvaged from construction or restoration sites, so a much more careful plan needs to be prepared to conduct experimental outplantings with these animals.

The draft Master Plan does not explain how the targets were developed for numbers of juvenile, subadult, and adult mussels. The Master Plan should be clear about the scientific basis for the quantitative objectives.

4) define expected project benefits (e.g. preservation of biological diversity, fishery enhancement, water optimization, and habitat protection) (Step 1)?

Master Plan Section 3 Program Justification (pages 11-27).

The Master Plan provides a valuable description of the taxonomy, biology, and ecology of freshwater mussels in the five subbasins in the CTUIR ceded area. The plan does a very good job at defining expected project benefits for laboratory propagation and experimental outplanting. In contrast, the draft Plan inadequately describes basinwide surveys of distribution and abundance based on sound sampling designs, detailed maps of where mussel species apparently are absent, analysis of trends though time, or monitoring of abundance at long-term sites.

Conservation and restoration of natural stream habitats of freshwater mussel should be the foundation of the CTUIR's conservation program. Assessment of status and trends, translocation, and artificial propagation should be integrated and balanced in their strategy to conserve and restore habitats and existing mussel populations. This is more than a formatting issue. It is a fundamental recognition of the biological foundation and priorities of the program.

5) describe the implementation strategies as they relate to the current conditions and restoration potential of the habitat for the target species and the life stage of interest (Step 1)?

See Master Plan Section 4 (pages 28-60)

The Master Plan presented detailed plans for implementing their laboratory propagation and experimental outplantings, but it does not adequately describe the ongoing actions to monitor and assess mussel populations or the value of using available mussel from salvage of restoration projects for translocation. The project will collaborate with Jim Peterson of OSU to develop a habitat suitability

model, which if based on accurate data will be an important tool to develop habitat-based restoration of mussel populations.

6) address the relationship to the habitat strategies (Step 1)?

See Master Plan Section 4 (pages 28-60) [and elsewhere?].

The proponents provide little or no information about protecting habitat for existing mussel populations, which should be high priority. The importance of this far outweighs that of propagating mussels, because even if mussels are produced their complex life history, requirement for specific fish hosts, and unknown habitat requirements may make it unlikely that most reintroductions or augmentations will be successful.

7) ensure that cost-effective alternate measures are not overlooked and include descriptions of alternatives for resolving the resource problem, including a description of other management activities in the subbasin, province and basin (Step 1)?

See Master Plan Section 3.4 Alternatives Considered (pages 24-27).

The draft Master Plan does not directly evaluate cost effectiveness. Several measures and alternatives have been overlooked that would allow the project to develop a balanced alternative that includes a) detecting and protecting existing mussel populations, and b) judicious trials with salvaged mussels as equal (or greater) priorities than propagation. These different approaches have different costs and effectiveness, which should be evaluated explicitly.

8) provide the historical and current status of anadromous and resident fish and wildlife in the subbasin most relevant to the proposed project (Step 1)?

See Master Plan Section 4 (pages 28-60) [and elsewhere?].

The Master Plan describes the conditions and history of the subbasins in the ceded lands and the current knowledge about the status and trends of these three mussel species in the Pacific Northwest. The proponents provide generally useful information on the current status in the CTUIR ceded area, although the sampling of mussels to establish status was begun nearly two decades ago (2003), and methods used in the surveys may not have been based on an adequate sampling design.

9) describe current and planned management of anadromous and resident fish and wildlife in the subbasin (Step 1)?

See Master Plan Section 4 (pages 28-60) [and elsewhere?].

The Master Plan describes the current and planned management of freshwater mussels in these river basins.

10) demonstrate consistency of the proposed project with NOAA Fisheries recovery plans and other fishery management and watershed plans (Step 1)?

See Master Plan Section 7 and elsewhere?

The Master Plan describes current populations of mussels. Currently, there is no direct management of freshwater mussels in other recovery plans.

11) describe the status of the comprehensive environmental assessment (Step 1 and 2)?

Not applicable.

12) describe the monitoring and evaluation plan (Step 1, 2 and 3)?

See Master Plan Section 5, especially Sections 5.4-5.8 and 5.9 (pages 65-74).

The Master Plan explains the monitoring and evaluation of the phases of freshwater mussel artificial propagation and reintroduction experiments, but it does not explain how "annual and long-term population monitoring" will be conducted and used to develop a landscape context for conserving existing populations and reintroducing mussels into sites with declining or extirpated populations. The draft Master Plan does not describe the annual and ongoing surveys for mussel presence, absence, and abundance and ongoing habitat monitoring. The monitoring methods for mussels in these basins need improvement based on a substantial literature on sampling mussels.

13) describe and provide specific items and cost estimates for ten fiscal years for planning and design (i.e. conceptual, preliminary and final), construction, operation and maintenance and monitoring and evaluation (Step 1, 2 and 3)?

See Master Plan Section 3.4 Alternatives Considered (pages 24-27).

The Master Plan only provides general estimates of total annual costs. No specific estimates are given for planning and design, construction, operation and maintenance and monitoring and evaluation. There is no description of how costs will be phased over the initial 10 fiscal years.

B. Artificial Production Initiatives

Does the Master Plan:

1) address the relation and link to the artificial production policies and strategies (see 2014 Fish and Wildlife Program, Part Three, Section IV, B and C1, 2, 4, 5, and 6) (Step 1)?

See Master Plan Section 6.2 (pages 101-103).

The draft Master Plan generally addresses Annual Program Review standards. Mussels propagated in the lab will not be under natural selection, so it is likely that mortality will be high when introduced into the wild environment. It is also likely that the laboratory propagation will cause unanticipated artificial

selection that may reduce the fitness of these animals in the wild, which is well known for fishes and likely could occur with mussels as well. The Plan did not describe any efforts to expose the animals to natural selection during propagation.

2) provide a completed Hatchery and Genetic Management Plan (HGMP) for the target population(s) (Step 1)?

The Master Plan (page 4) states:

> *The intent of Hatchery Genetic Management Plans (HGMPs) is to outline how an artificial propagation strategy will protect a species and assist in recovery. Templates for these plans target anadromous salmonids and have considerable drawbacks and limitations when applying them to programs for other organisms such as freshwater mussels. Pacific Northwest freshwater mussel species are not listed under the Endangered Species Act (ESA) and therefore approval of the Master Plan should not be subject to the completion of an HGMP. At a future phase, dependent on the outcome and findings of the proposed work, the development of an HGMP could potentially be initiated after review and approval of other components of this Master Plan.*

The draft Master Plan indicates that it is not subject to the completion of an HGMP because none of these species is listed as Endangered or Threatened under ESA. In August 2020, the Xerces Society petitioned to have *Gonidea angulata* listed as Threatened under the ESA. In addition, the status of *Margaritifera falcata* is categorized as Vulnerable (S3) by the states of Oregon and Washington and Imperiled (S2) by Idaho (see NatureServe map). Given the concerns for the declines of these species, the Mussel Project should develop an HGMP. The project has conducted studies of the genetic structure of the populations of these three mussels and plans to study the genetics of reintroduced and reference populations after reintroduction. Another aspect of an HGMP is to examine the fitness of artificially propagated organisms. This would include biological performance other than survival. The final Master Plan should develop a component to compare the fitness of artificially propagated mussels with wild mussels.

3) describe the harvest plan (see 2014 Columbia River Basin Fish and Wildlife Program, Part Two, Section II) (Step 1)?

The Master Plan (page 4) states: Freshwater mussel harvest is minimal and limited to traditional and cultural needs of tribes. No additional harvest is expected to occur as a result of actions described in this plan.

Not applicable.

4) provide a conceptual design of the proposed facilities, including an assessment of the availability and utility of existing facilities (Step 1)?

The Master Plan (page 5) states: This Master Plan has not been developed for a large, capital construction project. No new facilities are planned for freshwater mussels. A summary of the existing facility is presented, operated by the CTUIR, and potential need for expansion of existing or future facilities.

As long as artificial propagation remains a major component of the Mussel Project, approaches for adding new (or redesigning existing) laboratory and hatchery space should be explored. Existing space

(23 sq. ft. of 1,250 sq. ft. wet lab) is likely to be inadequate for the efforts required in the coming years. The Mussel Project could negotiate arrangements with regional hatcheries, such as the new CTUIR hatchery on the South Fork Walla Walla River, the Umatilla Hatchery in Irrigon, or other hatcheries near the CTUIR ceded areas. Until expanded facilities can be obtained, the Master Plan should document the long-term arrangement with Walla Walla Community College and assurances for future access.

5) provide a preliminary design of the proposed facilities (Step 2)?

Not applicable.

6) provide a final design of the proposed facilities, including appropriate value engineering review, consistent with previous submittal documents and preliminary design (Step 3)?

Not applicable.