Priest Rapids Fish Forum

Conference Call

Wednesday, 3 December 2025
9:00 a.m. – 11:00 a.m.

FINAL MINUTES

PRFF Members

Michael Lucid, USFWS
Ralph Lampman, Keely Murdoch, YN
Nathan and Clayton Buck, Wanapum
Jason McLellan, Bret Nine, CTCR
Mike Clement, Chris Mott, Grant PUD
Tracy Hillman, Chair
Patrick Verhey, Laura Heironimus, WDFW
Melissa Peterson, Chad Brown, Ecology
Aaron Jackson, Carl Merkle, CTUIR
Steve Lewis, BIA
Pete McHugh, CRITFC

Meeting Attendees

Mike Clement, Grant PUD
Melissa Peterson, Ecology
Amber Jackson, Ecology
Chris Mott, Grant PUD
Tygh Schuster, YN
Michael Lucid, USFWS
Erin Harris, GPUD
Ralph Lampman, YN
Nate Patterson, YN
Laura Heironimus, WDFW
Jason, McLellan, CTCR
Patrick Verhey, WDFW
Todd Miller, WDFW
Tracy Hillman, Chair

Action Items:

- Laura Heironimus will update the White Sturgeon Spontaneous Autopolyploidy Guidance document based on recently published literature.
- Grant PUD will consider the request to collect genetic samples (e.g., fin clips) from a subsample of adult lamprey collected at Priest Rapids Dam for analysis by CRITFC.
- Jason McLellan will share the user-manual for the White Sturgeon life-cycle model with the PRFF.

- Laura Heironimus will update her Bonneville Reservoir White Sturgeon spreadsheet to include adult sturgeon per km.
- Tracy Hillman will request permission from Douglas PUD to share their "Juvenile Pacific Lamprey Passage Study Plan Outline" with the PRFF.
- PRFF members will discuss the spatial scale of a juvenile Pacific Lamprey survival study and the appropriate model to use within their respective agencies. They will share those results with the group during the January meeting.
- PRFF members will consider the size of the survival standard error for a valid juvenile Pacific Lamprey survival study and identify appropriate sample sizes.

I. Welcome and Introductions

Tracy Hillman welcomed everyone to the meeting and identified all attendees.

II. Agenda Review

The PRFF reviewed and approved the December agenda with no additions.

III. Approve October Meeting Notes

The PRFF reviewed and approved the 1 October 2025 meeting minutes. In addition, the PRFF approved the 5 November White Sturgeon Subgroup meeting notes.

IV. Review Action Items

The PRFF reviewed the following action items from the October meeting:

- Laura Heironimus will update the White Sturgeon Spontaneous Autopolyploidy Guidance document based on recently published literature. **Ongoing.**
- Laura Heironimus will share with the PRFF the White Sturgeon reports that document passage of sturgeon through dams. **Complete.**
- PRFF Members will evaluate the advantages and disadvantages of conducting a juvenile Pacific Lamprey survival study at the project scale versus the dam passage scale. Members will also assess whether the assumptions of the Virtual/Paired Release (ViPRe) Model and Virtual Release/Dead-Fish Correction (ViRDCt) Model can be met. Members will send their evaluations to Tracy Hillman by 26 November 2025, in preparation for the 3 December 2025, PRFF meeting. **Complete.**
- Tracy Hillman will compile the model evaluation responses from members and distribute them to the PRFF prior to the December meeting. **Complete.**
- Tracy Hillman will seek approval of the 6 August Pacific Lamprey Subgroup draft meeting notes from the Rocky Reach Fish Forum and the Aquatic Settlement Work Group. **Complete.**
- Ralph Lampman will share a link to the video recordings of the Pacific Lamprey Subgroup meeting. **Complete.**
- Grant PUD will consider the request to collect genetic samples (e.g., fin clips) from a subsample of adult lamprey collected at Priest Rapids Dam for analysis by CRITFC. **Ongoing.**

V. Water Quality

Columbia River Water Temperature TMDL – Tracy Hillman reported that Tim Taylor was unable to attend the meeting; however, Tim provided the following updates to Tracy:

- Grant PUD submitted their Water Quality Attainment Plan (WQAP) schedule to Ecology. The schedule was approved in late October 2025.
- The next task for Grant PUD is to complete Tasks No. 1 and 2a by mid-December. Grant PUD has assembled the project team (PRFF and Grant PUD's contractor [Four Peaks Environmental Science and Data Solutions]) to assist them with WQAP development.
- Grant PUD identified a list of project concepts—nearly all of them have been concepts considered within the federal WQAP process. Project ideas were also taken from approved WQAPs previously submitted to Ecology. Grant PUD is currently developing their evaluation criteria.
- Grant PUD will have criteria drafted within the next few weeks for internal review. They will then submit everything to Ecology.
- The PRFF will have many opportunities to engage in this process. Grant PUD will provide monthly updates to the PRFF. The first major coordination with the PRFF will be in March. Grant PUD will present on the first stage of the project concept screening process.

Melissa Peterson reiterated that the PRFF will have opportunities to review criteria and identify possible project ideas for consideration.

Other Water Quality Items – No additional items were discussed.

VI. White Sturgeon

White Sturgeon Hatching and Rearing – Tygh Schuster provided an update on the status of juvenile White Sturgeon at the Yakama Nation Sturgeon Facility. He said the fish are looking good and they are growing (they have doubled in size since last month). Tygh said the current tank counts and average fish weights are as follows:

- Tank 1: 454 fish at 20.30 grams/fish
- Tank 2: 551 fish at 14.19 grams/fish
- Tank 3: 36 fish at 19.40 grams/fish
- Tank 4: 1,067 fish at 13.20 grams/fish
- Tank 5: 255 fish at 13.97 grams/fish
- Tank 6: 301 fish at 11.99 grams/fish

White Sturgeon Subgroup Meeting – Tracy Hillman provided a summary from the White Sturgeon Subgroup meeting that was held on 5 November. He said the group walked through the 2016 White Sturgeon SOA and reminded themselves of the approach that was used to identify stocking levels, including the adult sturgeon density (adults per river kilometer) within Bonneville Reservoir that was used as the rebuilding target for the project area. They also reviewed the recommendations and assumptions within the SOA.

During the Subgroup meeting, Paul Grutter, WSP, gave a presentation titled, "White Sturgeon Population Stock Assessment in the Priest Rapids Project Area." The purpose of the presentation was to

summarize stocking rates (2011-2015), describe what is known about population genetic structure and diversity, summarize the 2025 catch distribution, describe population size and survival, identify any evidence of density dependence in growth rates, and indicate whether the population is trending toward achieving adult abundance goals. The results presented were based on using juvenile sampling gear. Based on growth modeling, Paul noted that the sturgeon in Priest Rapids Reservoir may be experiencing density dependence. Density dependence was less apparent within Wanapum Reservoir.

Members in the Subgroup discussed the results and requested additional information on fish growth. They also recommended that WSP try to integrate adult sampling into the analysis. Paul will provide additional information as soon as possible. Subgroup members also discussed the consequences of overstocking within the project area and identified two management actions that need to be evaluated: (1) reducing stocking rates and (2) targeted removals. These actions may be necessary in Priest Rapids Reservoir where it appears there may be density dependence.

During the Subgroup meeting, members began the process of defining what is meant by "adult" (i.e., the size of a sturgeon at which it is considered an adult) and identifying an appropriate adult abundance target for the project area. This included a discussion on density (e.g., fish per km or fish per surface area). The Subgroup recommended adapting the LGL/Chelan PUD/CTCR model for the Priest Rapids project area. Here is a link to the model: https://analytics.lglsidney.com/chelan-sturgeon/. The Subgroup identified the following next steps:

- Laura will compile adult White Sturgeon abundance and biomass data from Bonneville Reservoir. WDFW defines an adult sturgeon as >167 cm FL.
- Jason will compile adult White Sturgeon abundance and biomass data from the Rocky Reach project area.
    - For both Bonneville and Rocky Reach reservoirs, abundance and biomass will be reported as number per area (density) and weight per area (biomass).
- Jason and Laura will research effective population size (N_e) for White Sturgeon. They will evaluate whether N_e can be estimated for the project area.
- Paul will provide separate growth figures for each brood year in each of the Priest Rapids and Wanapum reservoirs. The figures will show the lengths by age, the fit of the von Bertalanffy growth curve to the data, precision of the model (e.g., PI or CI), the parameter estimates (i.e., L_∞, K, and t_0), and sample size.
- Paul will evaluate the effects of juvenile sampling gear on growth data and consider ways to incorporate data from adult sampling gear.
- Paul will generate figures showing the relationship between length classes (X-axis) and mean annual growth rates (mean cm/yr on Y-axis) for sturgeon in the project area.
    - Laura will provide Paul with an example figure.
- The Subgroup will familiarize themselves with the White Sturgeon life-cycle model.
- The Subgroup will consider different slot limits for harvest.

The Subgroup will reconvene once the action items are complete.

Laura Heironimus indicated that she provided a spreadsheet with adult White Sturgeon abundance and biomass data from Bonneville Reservoir. She said they (WDFW) define an adult sturgeon as >167 cm FL. She added that although it is useful to research adult sizes in other areas, it is also appropriate to define

an adult based on the size of sturgeon in the Priest Rapids project area. Jason McLellan noted that his group typically uses the median length of a mature female (166 cm) from the Beamesderfer paper.

Laura indicated that she ran into some challenges running the White Sturgeon life-cycle model. She said it took time to figure out how to input data. Jason indicated that there is a user-manual, and he will share it with the group. One can also access the model and manual on the Upper Columbia White Sturgeon Recovery Initiative website (https://www.uppercolumbiasturgeon.org/).

Mike Clement reported that he has been in communication with Paul Grutter and Paul should have additional information available by the end of January 2026. Paul is currently working on the White Sturgeon annual report.

Ralph Lampman indicated that using density based on fish per surface area may be best; however, he would like to see density in terms of both fish per surface area and fish per length of reservoir. Laura said she can easily include fish per length of reservoir within her spreadsheet.

Other White Sturgeon Items – No additional items were discussed.

VII. Pacific Lamprey

Juvenile Pacific Lamprey Survival Studies – Tracy Hillman said that last month the PRFF was charged with identifying the advantages and disadvantages (pros and cons) of conducting juvenile Pacific Lamprey survival studies at the project scale (includes the reservoir and dam) and dam scale (includes only the dam). In addition, the PRFF was tasked with evaluating the assumptions of the Virtual/Paired Release (ViPRe) and Virtual Release/Dead-Fish Correction (ViRDCt) models. This assignment was a recommendation from the Pacific Lamprey Subgroup. Tracy indicated that he received responses from YN/CRITFC, WDFW, Grant PUD, and Chelan PUD. He combined the responses into Word tables (Attachments 1 and 2) and shared them with the PRFF on 1 December 2025.

Tracy walked through the reported advantages and disadvantages of conducting a juvenile survival study at the project versus the dam scales (see Attachment 1). Tracy said that based on the responses, entities appear to favor a juvenile survival study at the dam. This is because of the smaller sample size of juveniles needed to conduct a valid study, it incorporates “lessons learned” from the Snake and Columbia River studies, it provides information on survival directly affected by dam operations, and is logistically simpler than conducting a study at the project scale. Tracy noted that this is the same approach that Douglas PUD is proposing, as described in their juvenile Pacific Lamprey survival study outline memo. That is, Douglas PUD intends to conduct their study at the dam.

Tracy noted that during the Aquatic Settlement Work Group meeting yesterday, Jason McLellan questioned how a juvenile lamprey survival study will address predation. Tracy asked Jason to expand on this concern. Jason said he brought up the issue because of the predation bias associated with acoustic tagging studies. He said they have been conducting tagging studies with age-0 White Sturgeon (12-15 g) and initially assumed that predation would be low on tagged fish. However, after incidentally capturing a Walleye that contained 10% of the juvenile White Sturgeon tags, they decided to use Innovasea’s V3D predation tags. These tags are small and equipped with a trigger mechanism designed to dissolve during digestion of the tagged fish. Using these tags, they found that most of the released sturgeon were consumed within 7 days and all were consumed within 10 days. Jason noted that we need to be careful assuming predation is low on tagged fish.

Tracy asked members for their thoughts on the spatial scale of a juvenile lamprey survival study in the Priest Rapids project area. Ralph Lampman stated that he believes conducting the study at the scale of the dam is appropriate; however, he would like the survival studies to be coordinated among the three

PUDs and conducted within the same year to take advantage of tagged fish that more through several project areas. This may allow for possible estimates of survival through the reservoirs. Laura Heironimus agreed with Ralph and said a coordinated study among the PUDs should provide opportunities to evaluate reservoir survival, which could be a secondary goal. She also supported the use of the ViRDCt model, because it has already been tested in the Snake and Columbia rivers. Patrick Verhey agreed with Laura. Jason indicated that he would like to discuss this with Kirk Truscott and others within CTCR. Michael Lucid agreed with the idea of conducting a coordinated study among the PUDs but would like to discuss the study internally with USFWS staff. Mike Clement said he is on board with conducting the study at the dam but questioned whether there will be enough juveniles to conduct a coordinated study among the three PUDs. He believes a coordinated study may require about 5,000 juveniles. There is no certainty that we will be able to acquire 5,000 juveniles. Mike asked whether the Douglas PUD memo can be shared with the PRFF. Tracy said he will contact Douglas PUD and see if they are willing to share the memo with the PRFF. Mike also questioned whether the tag batteries will last long enough to get useful information on reservoir survival.

Ralph indicated that the number of tagged live fish should be much less than 5,000 juveniles but will depend on what level of precision we select for the survival estimate. A precision of 5% (standard error of 0.05) would require about 250-350 live juveniles and 100 dead fish per project. Ralph added that the Douglas PUD memo indicates a total sample size of 350 live juveniles is needed to achieve a survival standard error of 5%. Douglas believes they can acquire live fish from traps upstream from Wells Dam (rotary screw traps in the Methow and Okanogan basins). The dead fish can come from anywhere provided they are of similar length and/or weight as the live fish. Ralph stated that the Douglas PUD memo notes that if the standard error of 5% is not met, it will not immediately trigger a new study. Ralph indicated that this is reasonable. Mike responded that this information is helpful, but Grant PUD's position is that the fish must be run-of-the-river fish (active migrants) collected upstream from the project area.

Mellisa Peterson said there is an advantage to doing a coordinated study among the PUDs and agreed with doing the study at the dam because it requires fewer fish; however, she needs more time to think about the study and wants to discuss it internally with Ecology staff.

Tracy then walked through the responses as to whether the assumptions of the two models can be met (see Attachment 2). Because the group tends to favor a study at the scale of the dam, Tracy focused on the ViRDCt model. Although it was noted that some of the assumptions of the ViRDCt model can be met, several were questionable. Some of the questionable assumptions can be addressed through study design, consistent with the studies conducted in the Snake and Columbia rivers. Mike noted his greatest concern is whether they can acquire an adequate number of upstream run-of-the-river juveniles to conduct a valid survival study. He said Grant PUD has no way to collect juvenile lamprey at their dams. Laura responded that Ralph's juvenile source spreadsheet is useful and if the PRFF agrees to do the study at the dam scale and use the ViRDCt model, there should be a suitable number of juveniles available for a juvenile survival study.

Regarding the "questionable" comments associated with the assumption "the effects of marks (tags) and handling on fish must not be present or be very minimal," Ralph said this assumption can be met if there are criteria for weight or length of juveniles tagged. This is what the Pacific Northwest National Laboratory (PNNL) did in their studies. This means that the results from the study can only be generalized to the sizes of juveniles used in the study. Ralph also noted that PNNL successfully conducted juvenile survival studies in the Snake and Columbia rivers and provided information on how to meet the assumptions of the ViRDCt model. He recommended that Grant PUD start developing a juvenile lamprey survival study plan. Mike said that he can develop a draft study plan but will need more

information on sample sizes, precision, and source fish. He thought he could begin preparing a study plan in January or February 2026.

Laura said that she is in favor of using the ViRDCt model. She said WDFW studied the work conducted by PNNL and also asked for input from the WDFW Science Program. Based on this, they believe the ViRDCt model is appropriate. She also noted that we need to remember that survival studies will not meet all the assumptions of the model perfectly. Thus, we should not strive to meet each assumption perfectly, because no survival study can do that. Patrick agreed with Laura. Jason said he believes the ViRDCt model is the most appropriate and agreed with Laura's comments about meeting model assumptions. He added that where we cannot meet an assumption, we need to identify the uncertainty it creates and how we will use the information to make informed decisions. That is, if not meeting an assumption creates large uncertainty, will the results be unusable? Mike said the ViRDCt model is appropriate, and Grant PUD would like to see a high level of precision in the survival estimates.

Tracy summarized the discussion by pointing out that members generally agree that a juvenile survival study should be conducted at the dam, it should be coordinated among the three PUDs, and the ViRDCt model is the most appropriate model to use given the spatial scale of the study. Although there is general agreement, some members need to discuss these suggestions within their respective agencies. Tracy said the next recommendation from the Pacific Lamprey Subgroup was to identify the precision of the survival estimates and then identify sample sizes. Once we identify sample sizes, we can discuss sources of live juveniles. He asked members to be prepared to discuss precision and sample sizes during the January meeting. Ralph reminded members that Douglas PUD is looking at a standard error of 5%, which is consistent with survival studies conducted by PNNL in the Snake and Columbia rivers. He said there is a relatively small difference in sample sizes between a standard error of 2.5% and 5%. Mike said he will work with LGL Environmental on calculating sample sizes. He thought he would have something available by February or March.

Regarding source fish, Laura indicated that we will need to discuss whether the dead fish used in the study must come from upstream sources. She believes dead juveniles could be sourced from any location provided they are similar in size (length and/or weight) to live juveniles. Ralph added that the PRFF will also need to discuss what happens if we only collect 50-80% of the necessary sample size from upstream sources. Would the study be postponed until we collect the necessary sample size from upstream locations, or will the sample be supplemented with downstream "nearest neighbor" sources? If the study is postponed, battery life of the tags can be preserved by freezing the tags.

For budgeting purposes, Ralph asked when Grant PUD would need to know that a juvenile lamprey survival study would be initiated in the following year (e.g., 2027). Chris Mott indicated that Grant PUD would need a budget by at least June the year before the study is conducted. Ralph said that we will have about five months to develop an approved study plan if we intend to do a survival study in 2027. Mike agreed and noted there are several uncertainties (e.g., source fish) that Grant PUD will need to resolve before they are comfortable conducting a juvenile lamprey survival study. He added that even if Douglas PUD moves forward with a survival study in 2027, that does not mean that Grant PUD must do a survival study in the same year. Mike said Grant PUD will do a survival study, but it may not be at the same time as the other PUDs. Ralph noted that there are benefits, as discussed earlier, of coordinating the studies among the PUDs. Ralph also pointed out the benefits of conducting a juvenile lamprey study in 2027 or 2028 when Grant PUD will be conducting juvenile salmonid survival studies in the project area (juvenile salmon survival studies will occur in 2026 and 2027, and possibly in 2028, at Wanapum and Priest Rapids dams). The equipment used to detect tagged salmonids can also be used to detect tagged juvenile lamprey. Thus, there is a cost savings associated with doing a juvenile lamprey study in 2027 or 2028.

Other Pacific Lamprey Items – Ralph Lampman reported that the 2025 Lamprey Information Exchange will be held on 9-11 December in Portland, OR. There will be a free Lamprey 101 Workshop and a field trip to Willamette Falls on Tuesday, 9 December. The symposium will be held on Wednesday and Thursday. He said there will be a virtual option for those who cannot attend in person.

VIII. Adjourn

With no additional business to discuss, Tracy Hillman adjourned the meeting at 11:00 am.

IX. Next Meeting

The next meeting of the PRFF will be on Wednesday, 7 January 2026.

Attachment 1

Juvenile Lamprey Survival Studies

Spatial Scale

Project Scale (Reservoir and Dam)	
Advantages	**Disadvantages**
Addresses the entire project areas (reservoir and dam). Potentially provides information about the behavior of migrating juvenile lamprey within impoundments, beyond the immediate forebay/tailrace area. Potentially provides insight about hot spots for losses (e.g., due to predation) beyond the immediate forebay/tailrace area. Provides reach (inter-dam) survival estimates that can inform lamprey population assessment and planning on a larger scale (e.g., a step towards life cycle models - which are a priority action [17] for the TPLRP). Addresses the entire project areas (reservoir and dam) and allows for a more in-depth evaluation of where the highest sources of mortality are for fish moving through the project area, thus better informing conservation recommendations. Allows for more time to disperse if released further up in the reservoir compared to only the dam passage scale. May help inform testable hypotheses for potential causes of mortality: slower vs faster flows, variable habitat types, low DO at depth, predation? How are these fish moving through the reservoir? This scale provides the best bang for your buck - fully utilizing the data available and collecting more information to fill major data gaps.	Requires a larger sample size of tagged fish (as well as hydrophones, assuming ViPRe/ViRDCt combo study with routing). Requires more tags, fish, hydrophones (increased cost). Uncertainty on whether sufficient numbers of tagged lamprey will reach the dam. May be more challenging to manage dead fish releases to mirror passage timing of virtual releases, due to greater spread on passage timing for fish released at the head of the project (a hybrid survival model could potentially be used where live and dead fish releases are also carried out at the dam). Sourcing an adequate number of fish may become more challenging with the increased sample size needs of the project-scale study (as ViPRe/ViRDCt hybrid design or otherwise). Could require further study to determine if losses within the impoundment are project related (e.g., stranding due to impoundment fluctuation) and solvable through intervention. This is not a disadvantage per se, but it creates some open-endedness or uncertainty regarding what is done with the information collected. Assuming use of a Vipre model (as recommended by Ryan H) - Requires a larger sample size of tagged fish.

Project Scale (Reservoir and Dam)	
Advantages	**Disadvantages**
If all PUDs are doing this together, you could leverage resources and automatically incorporate the reservoir based on detections at the downstream project. For example: the R1 for the downstream project could serve as the R2 of the upstream project. It would be a great comparison across projects to evaluate cumulative impacts. Informs if/where mortality increases within the series of dams/reservoirs for juvenile lamprey.	- No dead fish to evaluate drift distances and ensure detections of live fish are realistic and accurate. No NNI context -- not relevant to the point of the study. Requires a larger sample size of tagged fish. May be unattainable to reach sample size. Warrants a desktop analysis to determine actual numbers of fish available throughout the migration period. Harder to interpret Project Effects or a mechanism of mortality. May require longer battery life which is already limited by the current technology. Larger scale study will require greater logistical complexity. Tag effect would likely be very difficult to measure. Battery life issues may create compounding issues with added bias to a battery life test or predation. No way to measure predation other than boat-based tracking. This is not a requirement of Grant PUD's PLMP (GPUD interpretation). This is not yet feasible without numerous assumed biases.

Dam Passage Scale	
Advantages	**Disadvantages**
Requires a smaller sample size of tagged fish. Provides information on survival within the portion of the project area under the most immediate influence by dam owners/operators (arguably). Lower cost (a restatement of smaller N above). May be easier (logistically) to manage dead fish releases to mirror the virtual fish passage experience, due to their (likely) passage over a narrower window. Potentially tighter control/easier execution of study, given smaller spatial domain of study (question for PNNL?). Potentially easier to execute given lower N requirement for dam passage survival study. Previously executed already for the US Corps dams on mainstem Snake and Lower Columbia River by PNNL, so there is a precedent. Although not the main focus, these PNNL studies were also able to estimate survival in the reservoir reaches as well (after the tagged lamprey passed the target dam). If a joint study is conducted (for all PUD dams), this approach is even more attractive as the upstream study will help provide more study fish for the downstream reach reservoirs. Assuming use of a Virdct model (as recommended by Ryan H): - Requires a smaller sample size of tagged fish. - Dead fish allow for evaluation of drift/settling and ensure more accurate evaluation of live fish detection data. Requires a smaller sample size of tagged fish. Still may be unattainable to reach even smaller sample size. May warrant a desktop analysis to determine actual numbers of fish available throughout the migration period. Closer to implementing with current tag life capabilities.	Only address passage through the dam, not the entire project area. Only address passage through the dam, not the entire project area and therefore, may not capture largest sources of mortality for lamprey moving through the project. We will be unable to understand the full impact of the hydropower system and the cumulative impacts as fish pass through the various projects. We are not fully utilizing the data that could be available. Requires an extensive array(s) of telemetry equipment deployment and maintenance. Difficult to measure potential of predation effects.

Dam Passage Scale	
Advantages	**Disadvantages**
May be easier to interpret results to Project Effects. Simpler study design / smaller scale logistically. Identifies and measures specific routes of passage preferred. This is a requirement of Grant PUD's PLMP (GPUD interpretation). When enough juvenile fish (that are representative of the population at large) are available, this model is feasible.	

Comments:

My comments assume that a Project Scale (Reservoir and Dam) study would be conducted along the lines of the combined ViRDCt/ViPRe combo study discussed in the subgroup meeting and thus that it is not an either/or scenario, but rather one that provides both dam passage and reservoir survival insights. This means that the sample size and hydrophone build outs required to maintain precision at desirable levels are part of the design.

Notes:

CRITFC/YN = Blue

WDFW = Green

CPUD = Red

GPUD = Purple

Attachment 2

Juvenile Lamprey Survival Studies

Model Assumptions

Virtual/Paired Release (ViPRe) Model			
Assumption	**Yes**	**No**	**Questionable**
The virtual release (V_1) is composed of fish known to have arrived alive and passed through the dam	Yes, if a detection array is deployed on the upstream face of the dam and can track the movement of tagged juvenile lamprey to their ultimate passage route through the dam. Yes Yes	No. The Fish Passage Center (FPC 2014) rejects utilizing juvenile lamprey from non-representative locations for survival estimation because the fish do not represent the run-at-large and because effects have been documented on juvenile salmon and steelhead from marking, handling, and transporting the juvenile fish.	
The virtual release (V_1) has a dam passage distribution representative of run-of-river fish	Yes, provided the tagged juvenile lamprey are released far enough upstream to provide the fish with an opportunity to redistribute themselves within the flow like the other in-river juvenile lamprey and arrive at the face of the dam in a similar distribution. Yes, if released far enough upstream. Yes, provided the fish have enough time to redistribute.		Questionable. Depends on release location and sourcing (i.e., art prop vs. natural origin). Questionable.

Virtual/Paired Release (ViPRe) Model			
Assumption	**Yes**	**No**	**Questionable**
Reach survival estimates S_1, S_2, and S_3 are unbiased	Yes Yes	The ability to meet this assumption is unknown but may be violated because of the possibility of tag failure during the study. Tag life studies would be needed, and survival estimates would then need to be adjusted accordingly. Some fish may delay movement and tag life may be an issue in some cases (especially given the longer distances required to approach the target dam). Tag life has been studied. There remain some uncertainties associated with juvenile lamprey behavior. Importantly, tag life applies to the R1 release group for both the ViPRe and ViRDCt models.	Questionable. The potential for delayed passage-related mortality could undermine equivalency of S2, S3 between V1 and R2/R3 fish. Questionable.

Virtual/Paired Release (ViPRe) Model			
Assumption	**Yes**	**No**	**Questionable**
The paired release (R_2 and R_3) provides an unbiased estimate of survival between the tailrace and the first downstream detection array (first tailwater array)	Yes, provided the paired releases of R2 and R3 juvenile lamprey are timed and distributed across the tailrace and first tailwater array locations to provide an estimate of survival between the tailrace and the first tailwater array that is comparable to the survival of the V1 juvenile lamprey in the same reach. Yes. Yes. Yes.		Questionable. The potential for delayed passage-related mortality could undermine equivalency of S2, S3 between V1 and R2/R3 fish.
The first downstream detection array (first tailwater array) is far enough below the dam to avoid false-positive detections of tagged fish that died during dam passage	Yes, provided the first tailwater array is located far enough downstream of the dam that any V1 juvenile lamprey that die during dam passage with still-active tags do not drift downriver and become detected. This would positively bias survival estimates. The release of tagged dead juvenile lamprey under the ViRDCt model corrects this bias. Yes, if the first array is far enough downstream. Yes. Yes.		Questionable. It may require some assessment relevant to Mid-C dams, given that this will be a first go for this kind of study using lamprey here.

Virtual/Paired Release (ViPRe) Model			
Assumption	**Yes**	**No**	**Questionable**
The tagged fish are representative of the population of inference			Questionable. It will depend on release location and sourcing (art prop vs. natural origin). Past PNNL studies indicate minimal differences in ROR vs transplanted wild juvenile vs hatchery, so long as the sizes are similar. Questionable. Questionable because of the limited amount of source fish for a study. There may be introduced biases if relying heavily on fish from other systems or from hatchery-origin fish. Questionable.
All tagged fish act independently	Yes, to the extent it is met for almost any M-R survival study. Yes Yes Yes		
Fish within a release have homogeneous survival and detection processes	Yes.		Questionable. Homogeneity will be hard to meet in practice, but a thoughtful selection of fish (without violating representativeness objectives/assumptions) may help. Investigators need to make sure size, condition, behavior, etc. are as similar

Virtual/Paired Release (ViPRe) Model			
Assumption	**Yes**	**No**	**Questionable**
			as possible among release groups. Random assignment of fish to treatment and control (including dead fish group) is necessary to reduce bias. Questionable. Questionable. There could be an issue if there is a bias in individual lamprey to have long or short migratory delay.
There is no tag loss or failure	Yes. This assumption could be addressed through use of proper tagging procedures and monitoring for tag loss before juvenile lamprey are released (e.g., 60-day laboratory study). There have been tag retention studies that demonstrate that juvenile lamprey retain their tags (no loss of tag). Tag loss is likely not an issue, but tag failure is potentially an issue.	No.	Questionable. One should be able to know the level of issue here and account for it accordingly. Questionable. Questionable. A high degree of migratory delay in the population will complicate interpretation of the survival estimates and increase the bias and uncertainty in the tag life corrections. Questionable. Ability to meet this assumption is unknown. Rates of tag loss or tag retention through the study reaches are unknown for migrating juvenile lamprey. Tag battery failure or exceedence of battery life due to long migration times of tagged fish through test and control reaches would result in "tag loss" resulting in bias that cannot be detected by the researcher with

Virtual/Paired Release (ViPRe) Model			
Assumption	**Yes**	**No**	**Questionable**
			unknown directionality of effect on survival estimates.
The effects of marks (tags) and handling on fish must not be present or be very minimal			Questionable. It may be hard to have no effect, so it will be important to understand how big any violations here might be, and whether they introduce measurable bias. Tag size is likely not an issue and the tag appears to have limited effects on juvenile behavior and survival based on past lab studies. Tagging is also limited to specific size and weights of fish. Questionable. Questionable. This assumption may be violated if holding times between individual fish are inconsistent to the degree that it biases things by not standardizing the collection, transport, and holding protocols. Questionable. Ability to meet this important assumption is unknown but is expected to incorporate negative bias (reduce survival estimate) at some level due to small fish and small body cavity space. Migration performance, swimming performance, health, physiology, behavior and survival probability of tagged individuals in the test and control reaches cannot be

Virtual/Paired Release (ViPRe) Model			
Assumption	**Yes**	**No**	**Questionable**
			affected by the presence and burden of a tag (acoustic tag), or the surgery and incision to apply the tag (presence of sutures, post-surgery infection, etc.).

Virtual Release/Dead-Fish Correction (ViRDCt) Model			
Assumption	**Yes**	**No**	**Questionable**
The virtual release (V_1) is composed of fish known to have arrived alive and passed through the dam	Yes, if a detection array is deployed on the upstream face of the dam and can track the movement of tagged juvenile lamprey to their ultimate passage route through the dam. Yes Yes	No. The Fish Passage Center (FPC 2014) rejects utilizing juvenile lamprey from non-representative locations for survival estimation because the fish do not represent the run-at-large and because effects have been documented on juvenile salmon and steelhead from marking, handling, and transporting the juvenile fish.	
The virtual release (V_1) has a dam passage distribution representative of run-of-river fish	Yes, provided the tagged juvenile lamprey are released far enough upstream to provide the fish with an opportunity to redistribute themselves within the flow like the other in-river juvenile lamprey and arrive at the face of the dam in a similar distribution. Yes, if released far enough upstream. Yes, as long as enough time to redistribute. Yes.		Questionable. It depends on release location and sourcing (art prop vs. natural origin).
The tagged fish are representative of the population of inference			Questionable. It depends on release location and sourcing (art prop vs. natural origin). Past PNNL studies indicate minimal differences in ROR vs transplanted wild juvenile vs hatchery, so long as the sizes are similar. Questionable.

Virtual Release/Dead-Fish Correction (ViRDCt) Model			
Assumption	**Yes**	**No**	**Questionable**
			Questionable because of the limited amount of source fish for a study. There may be introduced biases if relying heavily on fish from other systems or from hatchery origin fish. Questionable.
All tagged fish act independently	Yes, to the extent it is met for almost any M-R survival study. Yes Yes Yes		
Fish within a release have homogeneous survival and detection processes	Yes.		Questionable. Homogeneity will be hard to meet in practice, but a thoughtful selection of fish (without violating representativeness objectives/assumptions) may help. Investigators need to make sure size, condition, behavior, etc. are as similar as possible among release groups. Random assignment of fish to treatment and control (including dead fish group) is necessary to reduce bias. Questionable.

Virtual Release/Dead-Fish Correction (ViRDCt) Model			
Assumption	**Yes**	**No**	**Questionable**
			Questionable. This could be an issue if there is a bias in individual lamprey to have long or short migratory delay.
There is no tag loss or failure	Yes, this assumption could be addressed through use of proper tagging procedures and monitoring for tag loss before juvenile lamprey are released (e.g., 60-day laboratory study). There have been tag retention studies that demonstrate that juvenile lamprey retain their tags (no loss of tag). Tag loss is likely not an issue, but tag failure is potentially an issue.	No.	Questionable. One should be able to know the level of issue here and account for it accordingly. Questionable. Questionable. A high degree of migratory delay in the population will complicate interpretation of the survival estimates and increase the bias and uncertainty in the tag life corrections. Questionable. Ability to meet this assumption is unknown. Rates of tag loss or tag retention through the study reaches are unknown for migrating juvenile lamprey. Tag battery failure or exceedence of battery life due to long migration times of tagged fish through test and control reaches would result in "tag loss" resulting in bias that cannot be detected by the researcher with unknown directionality of effect on survival estimates.

Virtual Release/Dead-Fish Correction (ViRDCt) Model			
Assumption	**Yes**	**No**	**Questionable**
The effects of marks (tags) and handling on fish must not be present or be very minimal		Likely cannot be met.	Questionable. It may be hard to have no effect, so it will be important to understand how big any violations here might be, and whether they introduce measurable bias. Tag size is likely not an issue, and the tag appears to have limited effects on juvenile behavior and survival based on past lab studies. Tagging is also limited to specific size and weights of fish. Questionable. Questionable. This assumption may be violated if holding times between individual fish are inconsistent to the degree that it biases things by not standardizing the collection, transport, and holding protocols. Questionable. Ability to meet this important assumption is unknown but is expected to incorporate negative bias (reduce survival estimate) at some level due to small fish and small body cavity space. Migration performance, swimming performance, health, physiology, behavior and survival probability of tagged individuals in the test and control reaches cannot be affected by the presence and burden of a tag (acoustic tag), or the surgery and

Virtual Release/Dead-Fish Correction (ViRDCt) Model			
Assumption	**Yes**	**No**	**Questionable**
			incision to apply the tag (presence of sutures, post-surgery infection, etc.).
The probabilities of dead-released fish arriving at the tailrace array (ω) and being detected (p_D) are representative of the probabilities of arrival and detection of fish from the V_1 group that die during dam passage	Yes, provided that a sufficient number of dead tagged juvenile lamprey can be released into each passage route in proportion to the expected distribution of V1 fish that died during dam passage. Even if the proportion is not 100% accurate, samples can be taken out post-hoc to adjust the proportion of routes, so long as a sufficient number of dead tagged juvenile lamprey are released in the first place. Yes. Yes.		Questionable. This will require careful planning and adequate numbers of dead fish to ensure they are released in a similar spatial-temporal (i.e., route and timing) distribution as the dead V1 fish show. Questionable because of unknown passage route.
Dead tagged fish do not drift as far downstream as the first tailwater array (only if using a "Reduced" ViRDCt model)	Yes. The farther downstream from the dam the better.		Questionable. This will require some assessment relevant to Mid-C dams, given that this will be a first go for this kind of study using lamprey here. The ability to meet this assumption is based on the placement of the downstream array. The farther the downstream array from the dam the better. However, even if this assumption is not met, a "full ViRDCt model can still be used instead of a "reduced" model.

Virtual Release/Dead-Fish Correction (ViRDCt) Model			
Assumption	**Yes**	**No**	**Questionable**
			Questionable. Dependent on moving the downstream array far enough away but still within the capabilities of the tag as far as tag life. Questionable.

Comments:

Regarding representative fish, our preference is to get as many as possible from upriver fish (Methow - Mariah indicated they catch quite a few). If we canot get enough, the preference would be to get fish from Yakama, Wenatchee, etc. (close by rivers). Hatchery origin is next choice (try to select similarly sized fish). LCR fish would not be representative (different morphological stage and shorter migration - small transformers on the coast).

Notes:

CRITFC/YN = Blue

WDFW = Green

CPUD = Red

GPUD = Purple