Response to ISRP 2002-13 Mainstem and System Preliminary Review:

Project: 35036
Identify the mechanisms of stranding of juvenile fall chinook salmon in the Hanford Reach
Sponsor: USGS-CRRL; USFWS

Short Description: Predict stranding-related mortality using a GIS and statistical approach by incorporating fish behavior and ramping rate information.
Response Needed? Yes
ISRP Preliminary Comments:
Generally fundable, but a response is needed which would more adequately describe how this proposal might meet a management information need which is not available from previous studies.
The proposal focuses on "mechanisms" that might be involved in stranding of juvenile chinook in the Hanford Reach, and puts an emphasis on behavioral mechanisms of the fish that might affect rates of stranding. It appears that the proposal is in response to previous studies that have focused on features of the habitat that might lead to stranding. If this is so, then the proposal should provide more detail on shortcomings of previous studies, and more specifically identify the expected outcomes of this proposed project that might lead to improved management of flows or other measures. It appears that the previous studies, which might be termed habitat studies, may have provided a more direct approach to identifying what might be the same solution or set of solutions to the stranding problem. One of the solutions that has already been identified and adopted is provision of stabilized flows during the time of emigration of fry from the Hanford Reach. While the proposal implies that this provision has not been adequate and the proposal provides some estimates of numbers of juveniles estimated to have been stranded in the previous three-year period in support of the claim, no information is provided on corresponding patterns of flow at the time of stranding other than to state that "This [previous study] has been used by hydropower operators to liberalize fish protection programs since 1999."

Response:

We would like to update the reviewers on progress toward completion of collection of bathemetry data using the Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) in the Reach. High quality bathymetry data is key to the hydrodynamic modeling of flows and water elevations in the Reach. Earlier work accomplished by the Principal Investigator and staff of WDFW resulted in quantification of flow-dependent changes in juvenile fall chinook rearing habitat for a 17-mile reach of the Hanford Reach (Tiffan et al. 2002). Recently the U.S. Fish and Wildlife and the U.S. Geological Survey signed an interagency agreement to complete the bathymetry surveys in October 2002 and place the data in a Geographic Information System using other funding sources. We believe this is an excellent opportunity for the region to provide matching funds through BPA by funding this proposal.

The reviewer correctly concludes that the proposal *"puts an emphasis on behavioral mechanisms of the fish that might affect rates of stranding."* We believe that to fine tune the fish Protection Program, a better understanding of fish behavior would more clearly identify the appropriate limitations and opportunities for flexibility in fish protection measures. A good

example of this is our observation based on underwater video showing juvenile fall chinook salmon at one size are relatively inactive at night, resting on the bottom in small depressions in the sand or coble substrates. We believe this behavior during a limited time of the day may cause juvenile fall chinook to be especially susceptible to standing at that time of the day. On the other hand, at the same size during certain times of the day they are actively feeding and are very surface oriented. We believe that when they are in the water column and surface oriented, perhaps they are less susceptible to stranding during water elevation declines. This may provide an opportunity to identify a time of day when water fluctuations would have a minimal effect on juvenile fall chinook and allow hydropower operators to reposition the water levels in the Reach for the next 24 hours of a load following cycle. A recent example of field experiments on stranding of juvenile Atlantic salmon is described by Saltveit (2001). In that study, Saltveit (2001) found that temperature, season, and light conditions had the most pronounced effect on stranding of juvenile salmonids. The current monitoring program and Protection Program generally disregards these factors and treats fish as if they are inanimate objects. Gaining a more thorough understanding of how these, and other, factors operate in the Hanford Reach may result in operations that both better protect fish and provide greater flexibility to the hydro operators.

Although the ISRP terms earlier studies as "habitat studies", another interpretation of the previous studies and the continuing monitoring program is that they have been a "body count". The body count approach was necessary after this problem was identified to assess the extent of the problem and continues to be a valuable approach in a continuing assessment of the Protection Program (Lukas 2001a, 2001b). In a recent estimate of the total number of dead juvenile fall chinook salmon due to river flow fluctuations for the 2002 field season, investigators concluded the number of mortalities recorded in 2002 was similar to that found in 1999 and 2000 field seasons (Murray 2002). If the conclusion is correct, it may lead the objective reviewer to question the effectiveness of the Protection Program. An alternative interpretation is that policy makers and fisheries managers find the level of estimated mortalities at an acceptable level. The following summary is from Murray (2002).

Table 1. Estimated mortalities of juvenile fall chinook salmon in the Hanford Reach, Washington.

Year	Mean	Mean - 1.96 SE	Mean + 1.96 SE
2002	67,409	28,623	106,195
2001	2,013,638	-746,334	4,773,611
2000	45,487	12,866	78,108
1999	93,943	21,393	166,493

The reviewer correctly observed that *"One of the solutions that has already been identified and adopted is provision of stabilized flows during the time of emigration of fry from the Hanford Reach"*. The amount that flows have stabilized since implementation of the fish protection measures in 1999 is only slight when the years are compared (Figure 1). The most obvious

observation is the lack of fluctuations in 2001, a year of drought, that resulted in flows during April 2001 being exceptionally stable. Otherwise, a pattern of stable flows in not apparent. However, associated with the minimal fluctuations in 2001 is the highest estimate of mortality during the last four years -- 2,013,638 juvenile fall chinook salmon. In search of an obvious effect that the fish protection measures have had on the daily fluctuation within a 24-hour period, we plotted the change in hourly discharges at Priest Rapids Dam over one-day periods during April and May for the past six years (Figure 2). Again, the most obvious effect was from the drought in 2001. The changes in hourly flow appeared to be the most successful in 2002 when daily fluctuations were most suppressed at discharges below 100 kcfs, but still an estimated 67,409 juvenile fall chinook were killed in 2002.

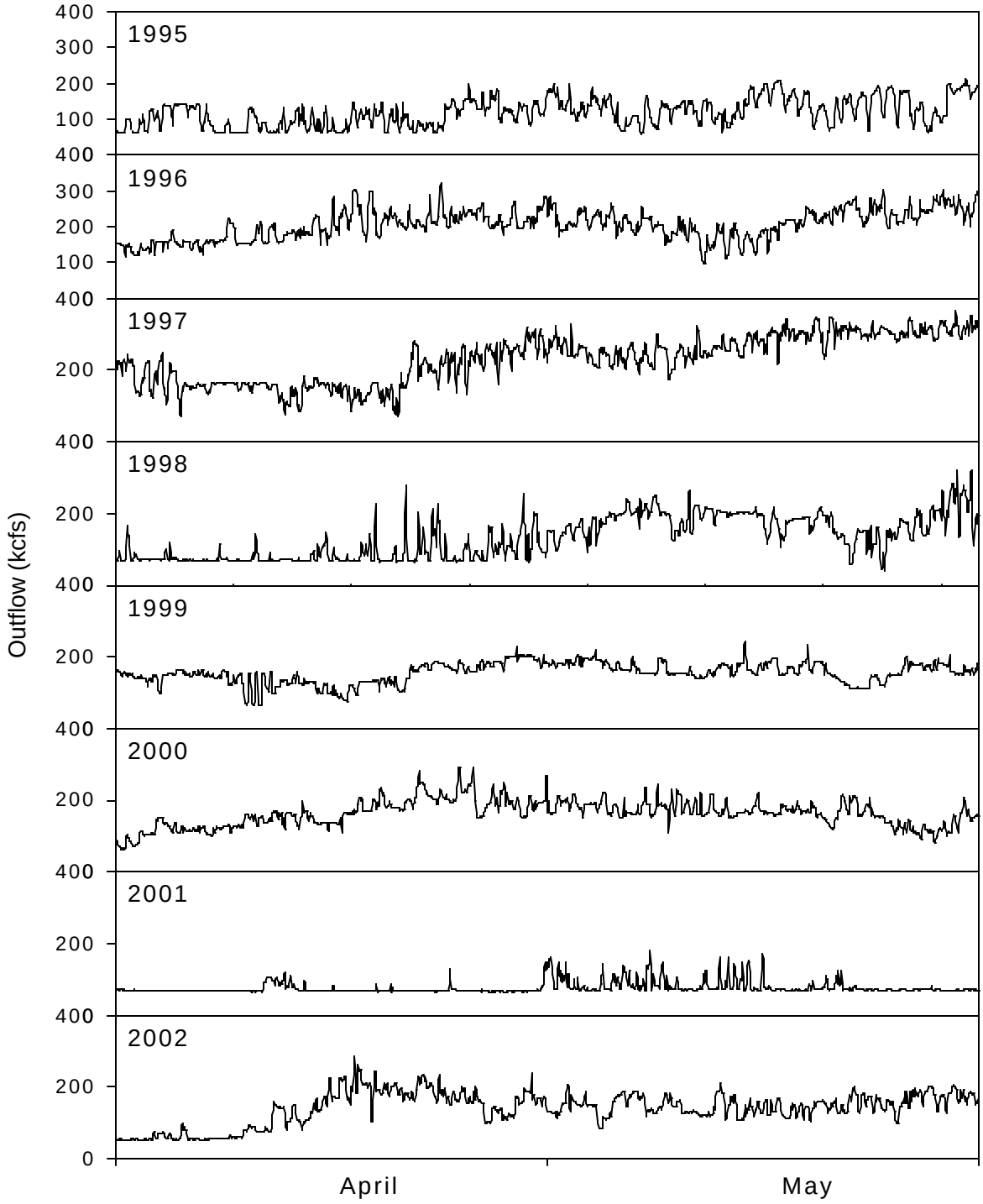

Figure 1. – Hourly outflow from Priest Rapids Dam for the months of April and May from 1995 to 2002. Data courtesy of the U.S. Army Corps of Engineers.

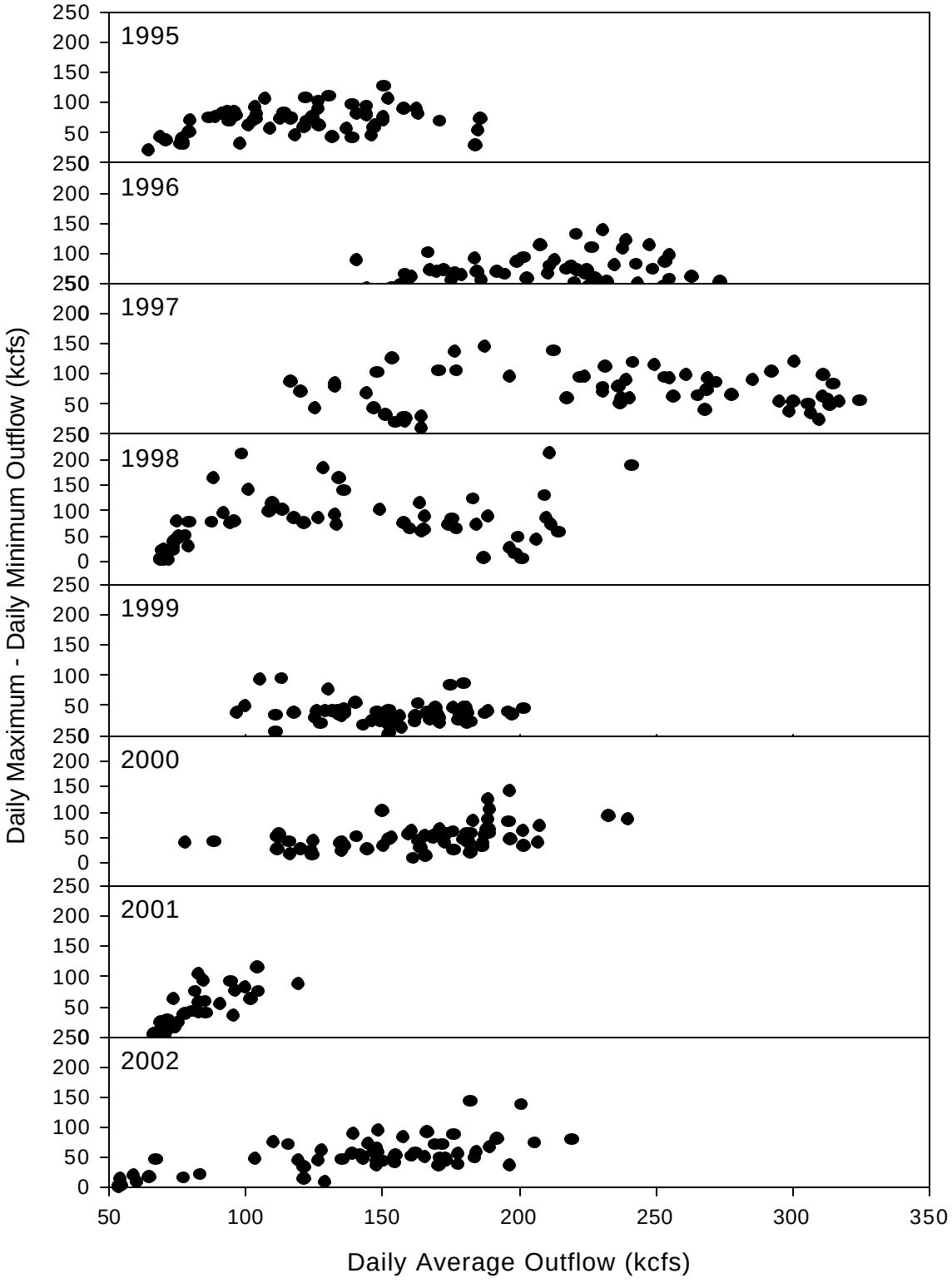

Figure 2. – Daily maximum minus daily minimum outflows from Priest Rapids Dam for the months of April and May for the years of 1995 thru 2002. Data courtesy of the U.S. Army Corps of Engineers.

Response to ISRP

ISRP Preliminary Comments:
The NMFS and Council's ISAB has a particular interest in this stranding issue (ISAB 99-5) and made a recommendation to the Council that a revision of the Vernita Bar Agreement be adopted to extend protection to emigrating fry. We understand that Grant County P.U.D. led in the development of a revised agreement among all of the (numerous) affected parties in 1999. In addition to studies under the Council's program, funded by BPA, Grant County P.U.D. continues ISRP 2002-13 Mainstem and Systemwide Preliminary Review to monitor fall chinook at Vernita Bar during spawning, incubation, fry emergence, and now fry emigration. Before recommending this study for funding, the reviewers will need to be assured that the principal investigators are familiar with provisions of the Vernita Bar Agreement and its revision, including the monitoring and evaluation provisions that are ongoing.

Response:
The principal investigators are familiar with the provisions of the Agreement and we have attached a copy of the Juvenile Fall Chinook Protection Program for the benefit of the reviewers. *(ISRP: the reviewers will need to be assured that the principal investigators are familiar with provisions of the Vernita Bar Agreement and its revision, including the monitoring and evaluation provisions that are ongoing.)* Some aspects of the Protection Program can lead to substantial deviations from what the casual reader or reviewer of the Program might expect. For example, the operating "day" at Priest Rapids Dam begins at 1:00 am. Under the current fish protection plan a drop in flow of 40 kcfs is allowed prior to 1 am within the 110-140 kcfs flow band. The astute hydropower operator decreases discharge 40 kcfs prior to 1 am and then decreases discharge another 40 kcfs after 1 am resulting in a total decrease of 80 kcfs at a time when fish may be most vulnerable. Flow decreases during this time period are common and the true impacts are often masked because flows are generally increasing again by morning when monitoring crews begin their work (Paul Hoffarth, WDFW, personal communication). Another aspect of the fish protection plan is the duration of averages. For example, the use of a 5-day average (footnote 1 in Protection Program), or 7-day average, can make a substantial difference because weekend operations and power requirements are very different from weekday operations. This generally results in substantial fluctuations as the hydropower system positions itself for weekend or weekday operations. These manipulations are not an uncommon response to attempted constraints to load following, and plague fish protection evaluations on the main stem throughout the Basin. In fact, it is our experience that hydropower operators have become much more sophisticated at load following within the constraints of fish protection measures or special System Operational Requests in recent years.

ISRP Preliminary Comments:
There is a need to more fully describe the measures that are in place to stabilize flows in the

Hanford Reach as a result of the "Vernita Bar Agreement", which calls for stabilized flows during spawning, incubation, fry emergence, and emigration in the Vernita Bar portion of the Hanford Reach. (See ISG 2000 "Return to the River 2000", NWPPC Doc 2000-12, p. 451-2). The proposal does not present a convincing argument for the need to deliberately manipulate flows in order to study their effects on stranding, particularly since they are planned for times when fry are expected to be present (Task 1.a, p. 7). If on-the-ground studies are necessary, it should be possible to observe the effects on chinook fry of ramping rates and duration of flow reductions of various magnitudes during periods not encompassed by the Vernita Bar Agreement (as modified in 1999). The Agreement is not designed to protect down to the last fish. And the power operators are certain to undertake load following as soon as restrictions on operations are relaxed.

Response:

We agree to some extent with the reviewer comment **"***The proposal does not present a convincing argument for the need to deliberately manipulate flows in order to study their effects on stranding, particularly since they are planned for times when fry are expected to be present (Task 1.a, p. 7).* It seems that the reviewer is hesitant to support experimental field tests when fry are present, but what would be the point of conducting a test when there are no fish around? The reviewer is correct that load following resumes after restrictions are relaxed, but this usually occurs in June after the risk of stranding is over and when most small fish are gone. The obvious concern is that an experimental flow manipulation may result additional stranding related mortality. We agree with the suggestion made during the oral presentation that field tests might be planned within the normal scope of operations rather than making specific operational requests. This may be possible given the somewhat predictable nature of operations, but risk of failure is higher if the right experimental conditions are not obtained. We do concede that flow manipulation may not be the best strategy in the first year of the study, but we also feel the reviewer underestimates the effectiveness of a well-planned test using manipulation. This is a common approach used in recent years to test structures and operations at hydroelectric dams. For example, evaluations of the prototype surface bypass and behavioral guidance structure at Lower Granite Dam were evaluated using a long series of tests using operational changes (Johnson et al. 2000; Adams et al. 2001). Manipulation of flow for experimental purposes does not necessarily preclude load following and within some constraints load following would be a positive aspect because that is how the hydropower system operates. Manipulation does allow repeated measures with some control of factors such as time of day, discharge, river mile, flow band, lateral slope, and water level fluctuation. The intent is not to turn the Reach into a large experimental setting that does not reflect the reality of load following by the hydropower operators.

ISRP Preliminary Comments:

Further to this point, the proposal raised questions about the potential for extraction of further important information from existing data. This should be discussed in the proposal. From the discussion on page 2 and the oral presentation it appears that estimates of entrapment area and estimates of stranded fry were pursued somewhat independently, with the result that knowledge

of the effects of hydropower operations is not sufficient to be able to predict numbers of stranded fry to be expected under various operating scenarios. The possibility of using existing data to arrive at such a capability should be discussed in the proposal. It ought to be possible to relate estimates of stranded numbers and estimates of entrapment area, each that relates to the same operating conditions, i.e. develop a table that shows a set of conditions of ramping rate, duration, and relative volume of reduction (%), and corresponding estimates of numbers of fry stranded during each such episode, and estimated area of potential entrapment. Such a table could be used to develop a regression equation to estimate numbers of fry expected to be stranded under those scenarios. If this effort should prove to be successful, the pursuit of behavioral studies to identify mechanisms involved in stranding would not be necessary.

Response:
We agree that existing data sets are a treasure trove of information that has not yielded the maximum amount of information. However, as with many projects, earlier years of mortality estimates were not made because the data was entirely observational without a robust design. We agree that "It ought to be possible to relate estimates of stranded numbers and estimates of entrapment area, each that relates to the same operating condition." However, this is not as straightforward as it appears. While Tiffan et al. (2002) did estimate the amount of entrapment area formed by flow reductions at different discharges, they made no attempt to estimate subsequent mortality that might occur in those entrapments. This would be difficult because mortality is influenced by pool size, drainage rate, rate of warming, predation, time to reflooding, etc. The information to do this for the entire reach, or even a third of the reach where we have detailed bathymetry, does not currently exist. In addition, the reviewer uses the terms "entrapment" and "stranding" interchangeably, but we see an important distinction. We apply the term "stranded" to fish dewatered on exposed substrate and we use the term "entrapment" to refer to pools that form. The time to mortality is much greater for stranded fish than entrapped fish. As such, understanding the mechanisms and extent of "stranding" may be the more critical issue. Finally, we believe that the current Protection Program (Attachment 1) could be modified using refined mortality estimates, unless we have an increased understanding of juvenile fall chinook behavior relative to load following, no great leaps forward will be made.

ISRP Preliminary Comments:
With information already available from previous studies, it ought to be possible to identify certain areas responsible for major strandings. Has thought been given to the possibility of opening these up with a dozer or other mechanical means, deepening a downstream outlet end of the pool to facilitate emigration of fry?

Response:
The reviewer is correct to suggest the use of existing data to identify certain stranding areas. We certainly would make the maximum use of existing data so as not to "reinvent the wheel." The next logical steps would be to examine those areas in more detail to determine the physical aspects of the sites that contribute to stranding, to determine how representative those sites are of other potential stranding sites, and to determine if fish use of those sites are consistent with use of other potential stranding sites. To address the second concern, the Reach has received protection as a National Monument and is managed by the U.S. Fish and Wildlife Service. Dozing selected portions of the reach in lieu of implementing effective fish protection measures on hydropower load following may be problematic. We believe the strategy of understanding

fish behavior better to optimize hydropower load following and fish protection measures is a more pragmatic solution.

References

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Lukas, J.A. 2001. Operations and Monitoring of the 2000 Hanford Reach Juvenile Fall Chinook Protection Program. Public Utility District No. 2 of Grant County, Ephrata, Washington.

Saltveit, S.J., J.H. Halleraker, J.V. Arnekleiv, and A. Harby. 2001. Field experiments on stranding in juvenile Atlantic salmon *(Salmo salar)* and brown trout *(Salmo trutta)* during rapid flow decreases caused by hydropeaking. Regulated Rivers: Research and Management 17:609-622.

Tiffan, K.F., R.D. Garland, and D.W. Rondorf. 2002. Quantifying flow-dependent changes in subyearling fall Chinook salmon rearing habitat using two-dimensional spatially explicit modeling. North American Journal of Fisheries Management 22:713-726.

Attachment 1:

Proposed 2002 Hanford Reach Juvenile Fall Chinook Protection Program

February 25, 2002

The objectives for development of this program as proposed by the mid-Columbia hydroelectric operators are:

1. Provide a high level of protection for rearing fall chinook fry;
2. Maintain reasonable load following capability at all 7 projects;
3. Monitoring and evaluation that allows evaluation of the program relative to its effect on entrapment and stranding; and
4. A monitoring program that allows in-season changes of operations if substantial mortality is detected.
5. If possible, within the requirements of flood control, power generation, project operating constraints, and the BO, a goal of the program will be to incorporate the objective of releasing GCL weekly average discharge in a constant or steadily increasing manner.

2002 Program Elements

Starting Program Operating Constraints

1. Begin index seining (6 standard beach seine hauls at pre-determined locations) one week prior to the calculated start of emergence under the Vernita Bar Agreement. Index seining will be conducted daily to define the beginning of susceptibility.

2. Start operational constraints for 2002 program when a daily total of 50 or more sub-yearling chinook is sampled from the 6 index seining stations. During each index seining sample, sub-yearling fork length will be reported. After program is initiated, decrease index seining to one time per week.

When PRD discharge[1] is between Vernita Bar Agreement minimum and 80 kcfs:

When discharge at Priest Rapids is between VBA minimum and 80 kcfs, the mid-Columbia projects will limit flow fluctuations at Priest Rapids to no more than 20 kcfs.

When PRD discharge is between 80 and 110 kcfs:

When discharge at Priest Rapids is between 80 and 110 kcfs, the mid-Columbia projects will limit flow fluctuations at Priest Rapids to no more than 30 kcfs.

When PRD discharge is between 110 and 140 kcfs:

[1] Priest Rapids discharge will be calculated in 2 separate ways: for weekdays it will be a rolling 5-day average of the previous 5 weekdays; for weekends it will be the BPA Friday PRD estimates for Saturday and Sunday.

When discharge at Priest Rapids is between 110 and 140 kcfs, the mid-Columbia projects will limit flow fluctuations at Priest Rapids to no more than 40 kcfs.

When PRD discharge is between 140 and 170 kcfs:

When discharge at Priest Rapids is between 140 and 170 kcfs, the mid-Columbia projects will limit flow fluctuations at Priest Rapids to no more than 60 kcfs.

When PRD discharge is greater than 170 kcfs:

When discharge at Priest Rapids is greater than 170 kcfs, the mid-Columbia projects will maintain a 150 kcfs minimum hourly discharge at Priest Rapids.

Ending Program Operating Constraints

When 400 or more temperature units (°C) have accumulated following the end of emergence under the Vernita Bar Agreement, the operating constraints identified above will end.

2. Monitoring will continue depending on presence of subyearling chinook as identified below.

Monitoring, Evaluation and Adaptive Management

1. **Monitoring under this program would consist of random sampling on a 8.5 mile subsection of the Hanford Reach (RM 364.5 to RM 373). This stretch runs from approximately the upstream end of Locke Island down to an area just upstream of Hanford Slough. Crews would consist of a two person crew consisting of WDFW and Grant PUD personnel sampling seven days a week. Random samples will be taken within this 8.5 RM sampling area based on previously established protocols for selecting from a list of possible random sampling plots within each 10 kcfs flow band. Grant PUD will provide funding for this effort and a weekly summation will be provided to Grant PUD.**

2. If the field monitoring crew observes that a significant fall chinook mortality event is occurring or imminent, they will immediately notify the designated representative of the Washington Department of Fish and Wildlife (WDFW) and explain the situation. The WDFW representative will confirm whether a significant fall chinook mortality event is occurring or imminent and decide whether to request a modification of operations. If alteration of operations appears appropriate, the WDFW representative will notify Grant County PUD immediately to discuss a remedy. If Grant County PUD concurs that a significant fall chinook mortality event is occurring or imminent, it will consult, as necessary, with other operators and an operational remedy will be implemented expeditiously.

3. Until stranding susceptibility ends, a weekly report for the Monday through Sunday time period will be produced by Grant County PUD and the WDFW. This report will be available on the Technical Management Team (TMT) website at the following URL:
< www.nwd-wc.usace.army.mil/cgi-bin/proposal.cgi?type=index>

and will be presented at the weekly TMT meetings. This report will also be distributed to the Hanford Reach Stranding Policy Group each Tuesday morning by e-mail. The TMT will serve as a forum for information exchange and will not be involved in decision making under this Program. It is anticipated that TMT decisions will facilitate and support activities under this Program. The authority for implementing any changes under this Program rests with the mid-Columbia projects and any disputes will be handled through meetings of the Hanford Reach Stranding Policy Group.

A. The weekly report will include the following operational information for each day: minimum hourly discharge from Priest Rapids Dam (PRD), maximum hourly discharge from PRD and day average discharge at PRD. The report will also provide weekly average discharge at PRD for each day which will be calculated as a rolling seven day average.

B. The weekly reports will also include the following field monitoring information for each day: number of samples taken, number of stranded or entrapped chinook fry and number of chinook mortalities.