Grant County
PUBLIC UTILITY DISTRICT
Excellence in Service and Leadership

# Fall Chinook Work Group

**Tuesday, 5 August 2014**

**Grant PUD (USBOR Building)**

**Ephrata, WA**

## Technical members

Paul Wagner, NMFS
Jeff Fryer, CRITFC
Holly Harwood, BPA
Keith Truscott, CPUD
Bill Tweit, WDFW
Patrick McGuire, WDOE
Peter Graf, GCPUD
Steve Hemstrom, CPUD
Joe Skalicky/Don Anglin, USFWS
Paul Ward/Bob Rose, YN
Brett Swift, American Rivers
Tom Kahler, DPUD
Paul Hoffarth, WDFW
John Clark, ADFG
Todd Pearsons, GCPUD

## Attendees: (*Denotes Technical member)

Peter Graf, GCPUD*
Paul Hoffarth, WDFW* (Phone)
John Clark, ADFG*
Tom Kahler, DPUD*
Tom Skiles, CRITFC (Phone)
Patrick McGuire, WDOE*
Tracy Hillman, Facilitator
Russell Langshaw, Ecosystem Insights
Jeff Fryer, CRITFC* (Phone)
Paul Wagner, NMFS* (Phone)
Ryan Harnish, Battelle
Todd Pearsons, GCPUD
Geoff McMichael, Cascade Aquatics

## Action Items:

1. **Russell Langshaw will provide the FCWG with a draft study plan for assessing density dependence in the Hanford Reach.**
2. **Russell Langshaw will conduct retrospective analysis on historical stranding and entrapment work.**
3. **Grant PUD will begin drafting the Final Report and Implementation Feasibility Study/Implementation Feasibility Plan.**

# Meeting Minutes

**I. Welcome and Introductions** – Tracy Hillman welcomed attendees to the meeting. Attendees introduced themselves.

**II. Agenda Review** – The agenda was reviewed and approved.

**III. Approval of Meeting Minutes**

- The July Meeting Minutes were reviewed and approved.

**IV. Review of Action Items** - Action items identified during the July meeting were discussed.

- Russell Langshaw will send his comments on the Predation Report to Blue Leaf. **Complete.**
- Russell Langshaw will provide the FCWG with a draft study plan for assessing density dependence in the Hanford Reach. **Ongoing.**
- Russell Langshaw will conduct retrospective analysis on historical stranding and entrapment work. **Ongoing.**
- Ryan Harnish and Geoff McMichael will work with Grant PUD on providing more detail on the five density dependence studies identified in John Clark's Phase III study suggestions. **Complete.**

**V. Update on Wanapum Dam Issues**

Peter Graf provided a brief update on the current status of Wanapum Dam issues. Peter noted that the engineers continue to install tendons in the monolith piers. Peter also said that the modified ladders continue to operate smoothly and there have been more than 600,000 fish that have passed the dam (based on counts at Rock Island Dam). He indicated that Grant PUD is currently evaluating adult lamprey passage at the project. This includes trapping of adult lamprey at Priest Rapids and Wanapum dams and transporting those fish upstream of Rock Island Dam. In addition, about 14 adult lamprey collected at John Day Dam and 14 collected at Priest Rapids Dam were tagged with HD PIT tags and released into the left-bank ladder at Wanapum Dam to evaluate passage efficiency.

Peter reported that about two weeks ago one of the four water pumps on the left ladder failed, possibly because of aquatic vegetation plugging the intake screens. The pump was ultimately replaced, resulting in no more than three days of intermittent interruptions. Peter noted that the three pumps continued to water the left-bank ladder even when the fourth pump was non-functional.

Peter indicated that Grant PUD will request an interim reservoir elevation of 560-562 feet, which would allow normal operation of the adult fish ladders at Wanapum Dam, but could create problems with meeting reverse load factoring requirements (see discussion under Section VIII). The interim elevation must be approved by the Board of Consultants and FERC. If approved, the interim elevation would likely occur during the fourth quarter this year. Russell Langshaw noted that “normal” reservoir levels are up to 571 feet.

## VI. Phase II Study Updates

**Predation Report** – Tracy Hillman reported that Blue Leaf completed the final predation report. The report was sent to the FCWG on 30 July. Grant PUD intends to incorporate the results from the predation report into their final report to Ecology (see discussion below under Section VII and Attachment 1).

**Density Dependence** – Russell Langshaw said that he is working on a study plan to address the density dependence that was identified in the productivity assessment. He is proposing to sample otoliths from juvenile Chinook that die during the CWT/PIT tagging efforts. He intends to look at growth and condition factor at time of tagging. These data would then be compared to otoliths collected from returning adults, which are sampled on the spawning grounds. Russell has otoliths from juvenile fall Chinook that died during recent tagging studies.

Russell indicated that he will provide the FCWG with a draft study plan in September 2014. The study plan will be included in the final report to Ecology.

## VII. Implementation Feasibility Study/Implementation Feasibility Plan

Russell Langshaw gave a presentation on the structure and development of the final report to Ecology on the phased study plan for the Hanford Reach Fall Chinook Protection Program (see Attachment 1). Russell described the 401 reporting requirements including the investigation of reasonable and feasible measures to avoid, reduce, or mitigate for adverse effects (Implementation Feasibility Study; IFS) and a plan to implement approved measures (Implementation Feasibility Plan; IFP). He also provided an outline for the final report. The outline includes an introduction, conceptual framework for the study plan, flow conditions in the Hanford Reach, productivity assessment and related studies, annotated bibliography and recent studies, synthesis of mechanisms for high productivity, and adaptive management, future monitoring, and the HRFCPPA. Russell provided examples of the information that will be included under each section of the final report (see the detailed table of contents at the end of Attachment 1). Finally, Russell provided the following timeline:

- August—Outline of final report and IFS/IFP

- September—Density dependence review
- October—Stranding and entrapment summary
- November—Fall Chinook monitoring and evaluation plan and draft final report and IFS/IFP to FCWG (begin 90-day review)
- December-January—Targeted discussion on report topics
- February—Comments on draft final report are due
- March—Report revisions and responses to comments
- April—Final report and IFS/IFP due to Ecology and FERC

Because the IFS is due to Ecology in a couple weeks, Peter Graf indicated that Grant PUD is requesting a time extension from Ecology. The intent is to provide Ecology with the final report and IFS/IFP in April 2015. Todd Pearsons said that details on the fall Chinook hatchery M&E program will be included in the final report and IFS/IFP. Pat McGuire indicated that Grant PUD has been in communication with Ecology on the requested time extension and proposed reporting outline. ***All members of the FCWG that were present approved the timeline and final report outline.*** John Clark requested that the draft final report be available for review by 4 November. Russell indicated that the draft report should be available by then.

## VIII. HRWG Activities

**Update on Reverse Load Factoring** – Peter Graf said that Grant PUD will be proposing an interim reservoir elevation of 560-562 feet for Wanapum Dam. As noted earlier, 560 feet is the minimum normal operation level for the adult fish ladders at Wanapum Dam. Operators need a four foot elevation band to accommodate Reverse Load Factoring (RLF). Thus, if the interim elevation is 560-562 feet, daily operations to accommodate RLF could range from 558-562 feet. This means that the reservoir elevation could drop below the minimum normal operation level for the adult ladders (560 feet); however, the ladder exits, which are at 554 feet, would remain under at least 4 feet of water and flow would continue uninterrupted through the ladders. Peter showed time series plots of Wanapum Reservoir elevations and discharges downstream from Priest Rapids Dam that indicate that low elevations (<560 feet) would be brief and that the reservoir refills quickly (see Attachment 2).

**Stranding and Entrapment Retrospective Analysis** – Russell Langshaw reported that he did not have time to work on the retrospective analysis in July. He said that he will work on this assignment soon, because the stranding and entrapment summary report is due in October. He intends to explore the use of hurdle models. The hurdle model is a two part process. The first part models the presence/absence of Chinook within entrapment sites. This is usually accomplished with multiple logistics regression or discriminant analysis. If a pattern is found (successfully jumped the first hurdle), then the second part is to model the numbers of fish entrapped in sites with fish presence. This could be accomplished with regression techniques. The hurdle model may be a simpler and more easily explainable approach than the zero-inflated negative binomial distribution model.

## IX. 2014 Return-Year Studies and Funding Opportunities

**Update on Battelle's Predation Studies** – Ryan Harnish provided a brief update on the tagging study conducted by Battelle. He said they tagged (both PIT and acoustic) 200 hatchery fall Chinook. The fish were all larger than 85 mm. Of the 200 fish tagged, 164 left the hatchery channel and 84 of those were detected in the McNary forebay. This indicates a survival rate of about 51%. Ryan noted that the McNary arrays have a detection probability of about 100%; therefore, the survival rate will not change much.

Ryan indicated that they tagged 198 wild fall Chinook salmon, all between 85 and 100 mm in size. Of the 198 fish tagged, 101 were detected at the McNary arrays, indicating a survival rate of 51%. Ryan noted that the detection probability of the arrays is about 100%.

Ryan will continue to analyze the data, including calculation of travel times for the hatchery and wild fish. He will also compare his finding with results from CRITFC's tagging studies.

**High-Escapement, Density-Dependence Studies** – Ryan Harnish and Geoff McMichael provided a summary of the five proposed high-escapement, density-dependent studies identified during the July meeting. The proposed studies are described in Attachment 3. The first three studies deal with evaluating egg loss due to redd superimposition. Of the three egg-loss studies, the second one is the cheapest. The fourth study deals with the physical characteristics of juvenile fall Chinook salmon and ties in nicely with the density-dependence study plan (otoliths study) being prepared by Russell Langshaw (see Section VI). The fifth study examines historic effects of escapement on fish size through the development of a model that incorporates multiple predictor variables.

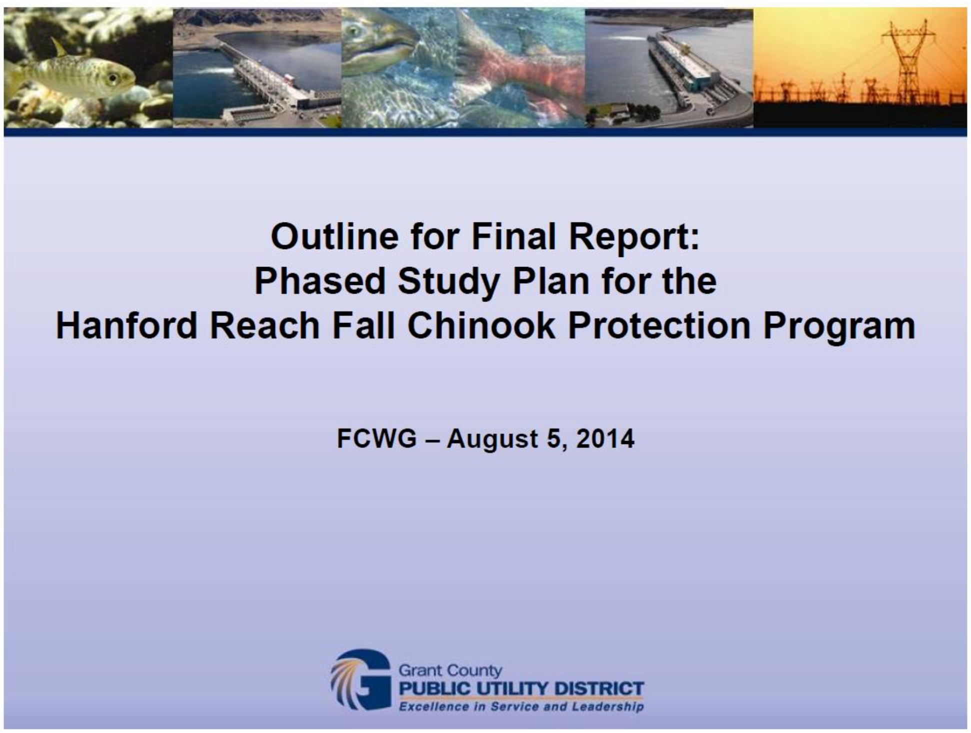
The FCWG recognized that securing funding for redd superimposition studies this fall will be difficult. Geoff McMichael will check with the ACOE and see if they have funding available. John Clark will check with Alaska Department of Fish and Game and see if they have funding available for the study. Russell Langshaw indicated that a proposal could be submitted to the PRCC seeking NNI funds; however, it may be difficult to secure NNI funds because of the poor link between the proposed studies and the intent of the NNI funds. John Clark indicated that a proposal seeking funds for the fourth study (combined with the otoliths study) could be submitted through the LOA process. Regardless of the funding source, members of the FCWG agreed that the proposed studies are valuable and they indicated that they would support them.

Russell Langshaw indicated that he sent a proposed study to Troy Baker with NOAA, who then shared it with the Hanford Reach Natural Resource Damage Assessment Trustees. The purpose of the study is to use spawning density and advanced analytical techniques to improve predictions of suitable spawning habitat for fall Chinook salmon in the Hanford Reach. Russell said that it does not look like the Trustees will have funding for the study this year.

**X.** **Next Meeting**: Tuesday morning, 2 September 2014 at Grant PUD in Ephrata, WA.

# Attachment 1

## Presentation by Russell Langshaw on the Phased Study Plan for the Hanford Reach Fall Chinook Protection Program

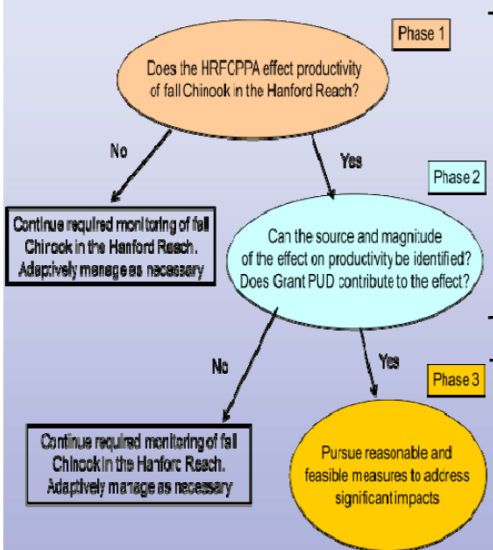


# 401 Reporting Requirements

If flow fluctuations under the HRFCPPA "*are causing significant harm… and the Project contributes to such flow fluctuations, then the Grant PUD shall to the extent reasonable and feasible adaptively manage Project operations to address its contribution.*"

- **Implementation Feasibility Study**
  - Investigate reasonable and feasible measures to avoid, reduce or mitigate for adverse effects
- **Implementation Feasibility Plan**
  - Plan to implement approved measures

# 401 Reporting Requirements




1. **Study Identification**
2. **Comment Period**
3. **Study Plan**
4. **Draft/Final Design**
5. **Final Reports**
   - ***Phase II Plan and Summaries in 2012***

6. **Implementation Feasibility Study**
7. **Implementation Feasibility Plan**

# Final Report Outline
***IFS/IFP and Future Monitoring***

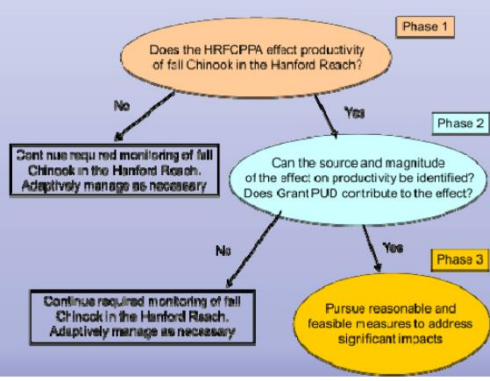
1. **Introduction**
2. **Conceptual Framework for the study plan**
3. **Flow Conditions in the Hanford Reach**
4. **Productivity Assessment and Related Studies**
5. **Annotated Bibliography and Recent Studies**
6. **Synthesis of mechanisms for high productivity**
7. **Adaptive management, future monitoring, and the HRFCPPA**

# 1. Introduction

a) Hanford Reach and History of Protections

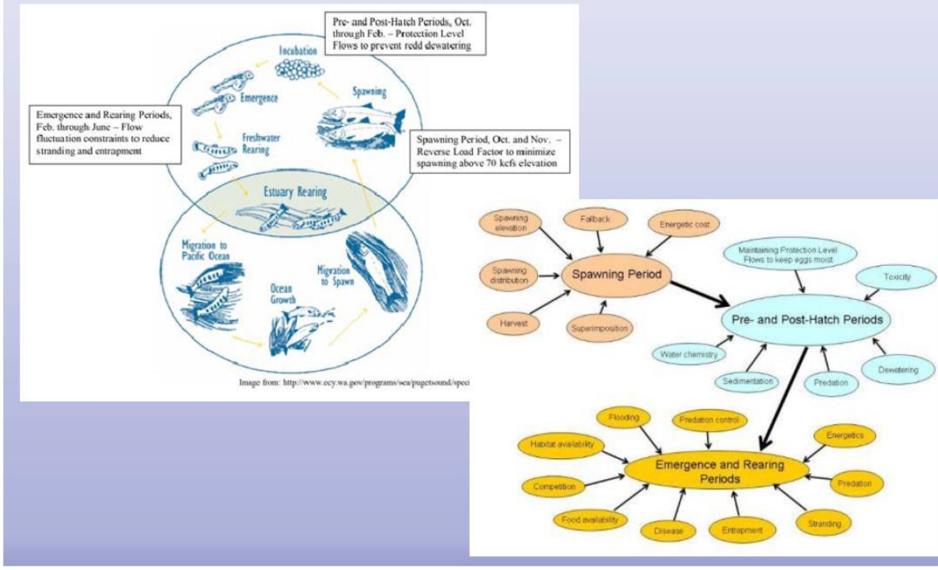
b) Current Protections and Mitigation

c) The HRFCPPA and Phased Study Approach



# 2. **Conceptual Framework for Study Plan**

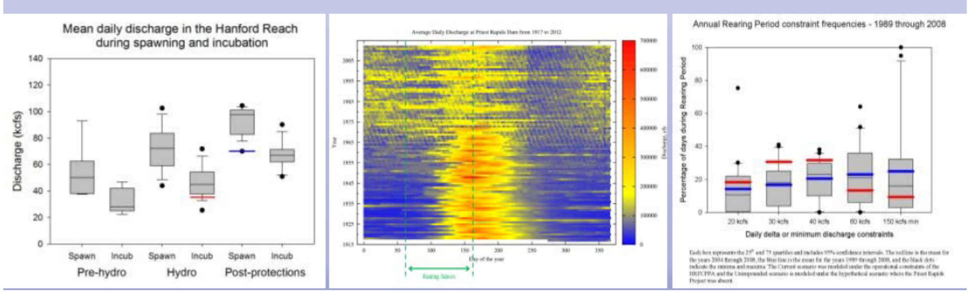
## a) Life-cycle Driven




# 3. Flow Conditions in the Hanford Reach

a) Grant PUD's contribution to flow fluctuations in the Hanford Reach

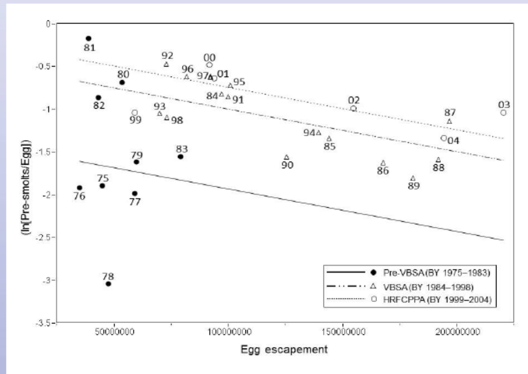
b) Hydrodynamic model synthesis for habitat and hydrologic evaluations

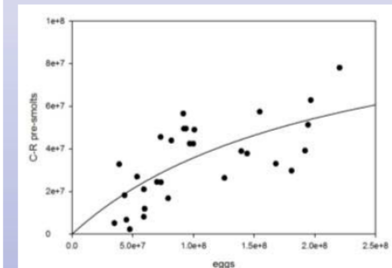


# 4. Productivity Assessment

a) Significant difference pre- and post-VBSA

b) Flow variables correlated with productivity

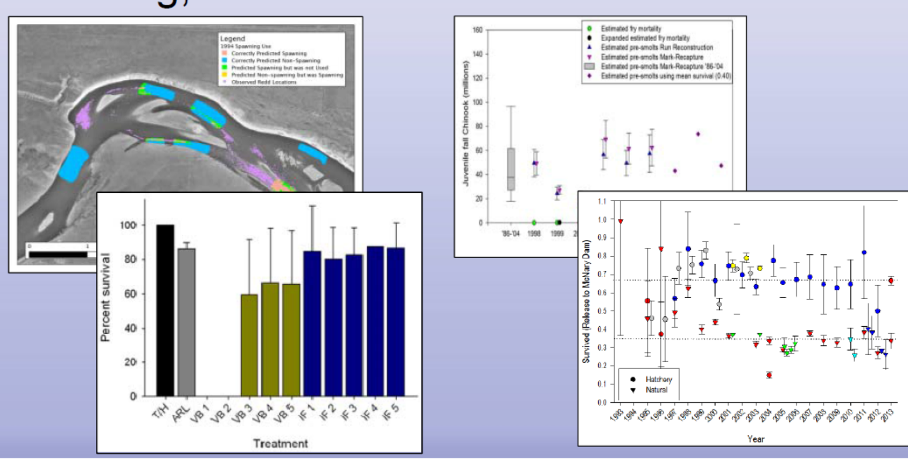



# 5. Annotated Bibliography and Life-Stage Studies

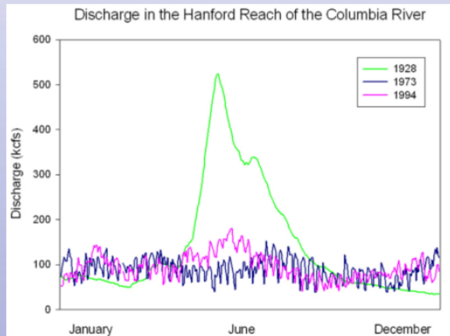
a) Annotated Bibliography

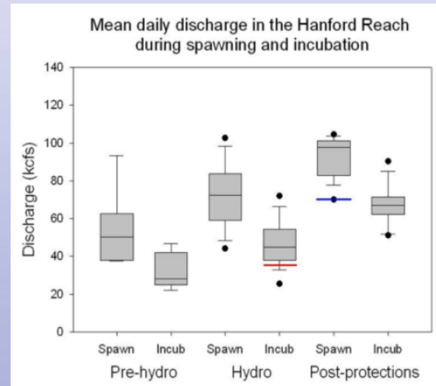
b) Spawning, incubation, survival, emergence, rearing, etc.



## 6. Synthesis of mechanisms for high productivity

a) Extreme events, food availability, intergravel conditions, predation, etc.




## 7. Adaptive management, future monitoring, and the HRFCPPA

a) Current mitigation

b) Adaptive management process

c) Current and future monitoring

d) Priest Rapids Hatchery monitoring

e) HRFCPPA annual monitoring and reporting

# Timeline

| Month | Report Review and Discussion Topic |
|---|---|
| August | • Outline of Final Report and IFS/IFP |
| September | • Density dependence review |
| October | • Stranding and entrapment summary |
| November | • Fall Chinook monitoring and evaluation plan<br>• **Draft Final Report and IFS/IFP to FCWG**<br>  • **90 day review** |
| December-January | • Targeted discussion on report topics, TBD. |
| February 2015 | • **Comments due** |
| March 2015 | • Report revisions, response to comments |
| April 2015 | • **Final Report and IFS/IFP due to Washington DOE and FERC** |

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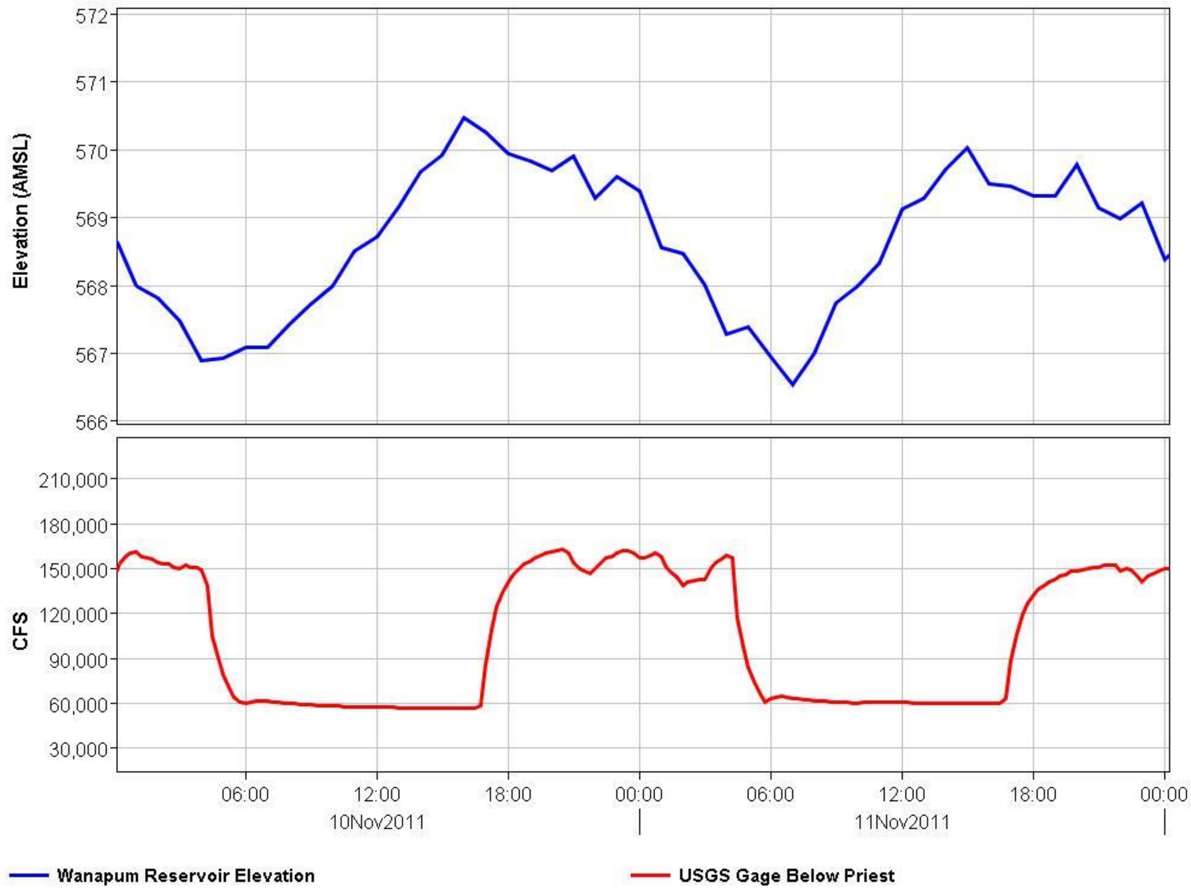
# Attachment 2

## Time series of Wanapum Reservoir elevations and discharges downstream from Priest Rapids Dam.



# Attachment 3

## Proposed Density Dependence Studies

**Research Summary 1** – 07/22/2014 – Ryan Harnish, Battelle

**Title:** Enumeration of egg loss caused by redd superimposition

**Management Purpose:** Identify the level to which spawning escapement contributes to egg loss caused by redd superimposition for Hanford Reach fall Chinook salmon.

**Background:** Recent stock-recruit analyses conducted for the Hanford Reach fall Chinook salmon population have revealed density dependence. However, the mechanism(s) driving this relationship are not well understood. Potential causes of density dependence include superimposition of redds, use of lower-quality habitat by later-arriving females, and/or competition among juveniles for food or space (Hilborn and Walters 1992). The benefits to productivity associated with constraints on flow fluctuations from Priest Rapids Dam may not be realized at high escapements due to density-dependent mortality associated that may result from redd superimposition. The current 2014 forecast for the Columbia River Upriver Bright return (minus Snake River wild URB) is estimated at 858,000 adults (WDFW), which far exceeds the $S_{MSY}$ estimate of ~34,400 adults and the spawning escapement at which density dependence is observed ($S$ = 42,000 adults; Harnish et al. 2012). Because the total number of eggs successfully deposited in a spawning area approaches carrying capacity of the area as the number of spawners increases, we would expect a higher rate of superimposition and a larger number of eggs on the substrate during years of high escapement. Thus, there is a substantial risk for redd superimposition and density dependent mortality from egg loss in 2014.

**Objective:**

1. Enumerate egg loss caused by superimposition in study transects of the Hanford Reach of the Columbia River during the 2015 fall Chinook salmon spawning season – to be compared across a range of spawner (or redd) abundances.

**Approach:** Survey transects will be established in one or two major spawning areas of the Hanford Reach (e.g., Vernita Bar, Locke Island) prior to the 2014 fall Chinook salmon spawning season. Once spawning commences, transects will be surveyed from a research boat using previously described methodology that utilizes a high-sensitivity remote camera (Sartek SDC-MAL) attached to a weighted platform (Groves and Garcia 1998; Dauble et al. 1999; Mueller and Duberstein 2005). An integrated video/tow cable attached to a manual winch with 12 channel slip ring mechanism is used to raise and lower the platform to the desired depth. Two parallel mounted underwater lasers (C-Map Systems Model HL6312G) will provide a reference scale for estimating coverage area.

Based on previous surveys in the Hanford Reach, the platform will be lowered to a depth about 1.6 m from the substrate, which will provide a coverage area of about 3.8 $m^2$ (McMichael et al. 2004). The boat will be maneuvered slowly along the transect while filming and recording the substrate. An on-board, real-time differential global positioning system (Trimble GPS Pathfinder Pro XR) will be used to collect positional data and to navigate transects. Two on board high-resolution monitors will be used for real-time viewing and recordings will be made using an 8-mm digital recorder (Sony Model GV-HD700/1). Recorded video will be analyzed using Image Pro Plus software (Media Cybernetics), which allows for the automated enumeration of items that meet a predetermined set of criteria (size, color, etc.). This software will allow for the efficient enumeration of all eggs captured on video.

Transects will be surveyed weekly to enumerate eggs. The abundance of "lost" eggs observed on the substrate will be compared against redd counts. Redds will be counted on the same dates that eggs are enumerated from digital photographs obtained from a fixed-wing aircraft, unmanned aerial vehicle (AUV), or fixed camera mounted at a location that overlooks the spawning area. If the timing of redd counts does not coincide with egg enumeration events, logistic regression will be used to estimate the abundance of redds at the time of egg enumeration surveys – in a manner similar to that described by Hayes et al. (2013). The relationship between the number of eggs lost and redd abundance will be explored from the data collected in 2014. Ideally, this study would be repeated over a number of years with varying levels of fall Chinook salmon escapement to the Hanford Reach.

**Anticipated Results:** The proposed research will provide quantitative data that will provide a better understanding of 1) the relationship between escapement levels and the number of eggs lost due to superimposition and 2) the escapement level at which the area approaches carrying capacity for the number of eggs that can be successfully deposited.

**Schedule:** This work would need to be initiated (funded) by October 1, 2014 so that surveys could begin around the start of fall Chinook salmon spawning in the Hanford Reach. If the UAV approach is implemented, lead times would be longer to allow for equipment acquisition or subcontracting. The full study plan would be developed in coordination with the Fall Chinook Working Group. Data collection would occur weekly between the initiation and termination of spawning. A draft report would be provided to the FCWG by April 30, 2015 and a final report and submitted publication would be completed by June 30, 2015.

**Notes:** This study will make use of aerial redd counts and thus will require collaboration between PNNL and those conducting aerial redd counts.

**References:**

Dauble D.D., R.P. Mueller, R.L. Johnson, W.H. Mavros, and C.S. Abernethy. 1999. *Surveys of Fall Chinook Salmon Spawning Areas Downstream of Lower Snake River Hydroelectric Projects*. Summary Report for 1993–1998. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

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Harnish, R.A., R. Sharma, G.A. McMichael, R.B. Langshaw, T.N. Pearsons, and D.A. Bernard. 2012. Effect of Priest Rapids Dam operations on Hanford Reach fall Chinook salmon productivity and estimation of maximum sustainable yield, 1975–2004. PNWD-4339, Battelle, Pacific Northwest Division, Richland, WA.

Hayes, D., B.J. Bellgraph, B.M. Roth, D.D. Dauble, and R.P. Mueller. 2013. Timing of redd construction by fall Chinook salmon in the Hanford Reach of the Columbia River. River Research and Applications. doi:10.1002/rra.2719.

Hilborn, R., and C.J. Walters. 1992. Quantitative fisheries stock assessment. Chapman and Hall, New York.

McMichael, G.A., R.P. Mueller, and J.A. Vucelick. 2004. Chinook salmon escapement and spawning in the Priest Rapids Project. Report prepared for the Public Utility District No. 2 of Grant County. Technical Report PNWD-3380, Battelle – Pacific Northwest Division, Richland, WA.

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WDFW, Washington Department of Fish and Wildlife. 2013 Columbia River adult fish returns and 2014 forecasts. Available: http://wdfw.wa.gov/fishing/forecasts/columbia_river/2013_columbia_river_adult_fish_returns_and_2014_forecasts.pdf (Accessed: July 2014).

**Research Summary 2** – 07/16/2014 – Geoff McMichael, Cascade Aquatics

**Title:** Qualitative assessment of egg loss resulting from redd superimposition

**Management Purpose:** Determine how extensive egg loss resulting from egg pocket disturbance is in a high escapement year for Hanford Reach fall Chinook salmon.

**Background:** Productivity analyses of the Hanford Reach fall Chinook salmon population have indicated that production of pre-smolts is lower from brood years with high escapement (Harnish et al. 2014). One suspected source of this reduced production resulting from high escapements is that spawning habitat is limiting and that redd superimposition may negatively influence gamete survival. Past redd surveys have shown that high density spawning areas frequently are disturbed to the point that the substrate surface looks 'all white', indicating that individual redd boundaries overlap extensively. However, it is not known to what extent the egg pockets in redds are disturbed to the point of dislodging fertilized eggs when redd margins overlap. Past snorkeling surveys in the Vernita Bar area of the Hanford Reach revealed that large numbers of salmon eggs were visible on the surface of the substrate. In addition, eggs of a variety of developmental stages were also collected in drift nets within the spawning area (Oldenburg et al. 2014). Some of the eggs may have been dislodged from redds by subsequent spawning activity, while some may have not been buried by spawning females. If redds constructed early in the season are lost to production through disturbance of later spawning females, then overall production is reduced and emergence timing of juveniles may be shifted later the following spring.
If production of the Hanford Reach fall Chinook salmon is reduced as a result of redd superimposition during years of high escapement, management actions could be taken to optimize harvest to enhance productivity. The following objectives would marginally increase the understanding regarding this aspect of potential carrying capacity in spawning areas of the Hanford Reach fall Chinook salmon population.

**Objectives:**

1. Determine the relationship between the number of fall Chinook salmon eggs visible on the substrate and the number of redds (or total disturbed substrate area).
2. Determine the detection probability of dislodged eggs in fall Chinook salmon spawning areas.

**Approach:** Standardized snorkel drifts would be conducted at various times in fixed locations within known spawning areas of fall Chinook salmon within the Hanford Reach. Underwater videography and still photographs would be collected in known spatial locations and the redd density (or disturbed substrate area) would be estimated in these areas on the same dates. An alternative approach would be the use of an unmanned aerial vehicle (AUV) to record digital photographs at pre-determined points early, in the middle, and late in the spawning season in areas with low, medium, and high densities of redds. To determine the relative detection probability of dislodged eggs, known numbers of fertilized eggs would be released near the substrate in areas of similar depth, velocity, and substrate composition to spawning areas. Within 10 minutes following the release of eggs, visual, videographic, and photographic data would be collected. Subsequent analyses would be conducted to estimate the proportion of eggs detected using the various methods. Correction factors based on these data would be applied to field data.

**Anticipated Results:** The proposed research will provide increased qualitative understanding of the spatial and temporal extents of redd superimposition that results in substrate disturbance to egg pocket depth. These data as well as previously reported data on egg-to-fry survival and productivity will be useful for providing a qualitative assessment of the influence of high escapement on overall egg-to-fry survival.

**Schedule:** This work would need to be initiated (funded) by September 15, 2014 in order to acquire the necessary supplies and equipment and permits to conduct the work. If the UAV approach is implemented, lead times would be longer to allow for equipment acquisition or subcontracting. The full study plan would be developed in coordination with the Fall Chinook Working Group and fieldwork would be coordinated with Grant PUD and WDFW staff. Data collection would take place on Sundays between November 2 and 30, 2014. Analyses would take place between January and March 2015. A draft report would be provided to the FCWG by April 30, 2015 and a final report and submitted publication would be completed by June 30, 2015.

**Notes:** We propose that Cascade Aquatics and PNNL collaborate to conduct this project along with coordination with Grant PUD and WDFW.

**References:**

Harnish, R.A., R. Sharma, G.A. McMichael, R.B. Langshaw, and T.N. Pearsons. 2014. Effect of hydroelectric dam operations on the freshwater productivity of a Columbia River fall Chinook salmon population. Canadian Journal of Fisheries and Aquatic Sciences 71:1-14. doi:10.1139/cjfas-2013-0276.

Oldenburg, E.W., B.J. Goodman, G.A. McMichael, and R.B. Langshaw. 2012. Forms of production loss during the early life history of fall Chinook salmon. Battelle–Pacific Northwest Division Report prepared for Public Utility District No. 2 of Grant County, PNWD-4314, Richland, Washington.

**Research Summary 3** – 07/16/2014 – Geoff McMichael, Cascade Aquatics

**Title:** Empirical measurement of redd superimposition

**Management Purpose:** Determine when and where substrate spawning areas are disturbed to egg pocket depth by subsequent digging activity to better quantify the extent of redd superimposition during a high escapement year of fall Chinook salmon to the Hanford Reach.

**Background:** Productivity analyses of the Hanford Reach fall Chinook salmon population have indicated that production of pre-smolts is lower from brood years with high escapement (Harnish et al. 2014). One suspected source of this reduced production resulting from high escapements is that spawning habitat is limiting and that redd superimposition may negatively influence gamete survival. Past redd surveys have shown that high density spawning areas frequently are disturbed to the point that the substrate surface looks 'all white', indicating that individual redd boundaries overlap extensively. However, it is not known to what extent the egg pockets in redds are disturbed to the point of dislodging fertilized eggs when redd margins overlap. If redds constructed early in the season are lost to production through disturbance of later spawning females, then overall production is reduced and emergence timing of juveniles may be shifted later the following spring. If production of the Hanford Reach fall Chinook salmon is reduced as a result of redd superimposition during years of high escapement, management actions could be taken to optimize harvest to enhance productivity. The following objectives would address this aspect of potential carrying capacity in spawning areas of the Hanford Reach fall Chinook salmon population.

**Objectives:**

1. Determine the timing of substrate disturbance resulting from fall Chinook salmon spawning activity
2. Determine the spatial extent of substrate disturbance resulting from fall Chinook salmon spawning activity
3. Estimate the proportion of fall Chinook salmon redds in low, medium, and high density spawning areas in which substrate is disturbed to egg pocket depth following natural spawning.

**Approach:** Small (e.g., 0.2 g) acoustic transmitters incased in a near-neutrally buoyant material would be seeded in spawning areas before/during spawning season to determine the area and timing of substrate disturbance to egg pocket depth. An injection method will be developed with a probe and pumped water to place the transmitters into known spawning areas prior to the onset of spawning activity and then at regular periods during the spawning season into redds that are judged to be complete (spent female defending). Acoustic telemetry receivers would be deployed downstream of the areas with injected transmitters to determine the timing of disturbance. Velocity measurements and the spatial location of dislodged transmitters will be used to determine the spatial and temporal substrate disturbance patterns.

**Anticipated Results:** The proposed research will provide increased understanding of the spatial and temporal extents of redd superimposition that results in substrate disturbance to egg pocket depth. These data as well as previously reported data on egg-to-fry survival and productivity will be useful for estimating the quantitative influence of high escapement on overall egg-to-fry survival. By using the tiered approach (low, medium, and high density), we will be able to develop estimates for a range of escapement numbers to develop a model that relates the escapement numbers to the productivity of this population. This model may be useful for refining escapement targets and for informing managers of the need for early and effective management decision making when high escapements of Hanford Reach fall Chinook salmon are expected.

**Schedule:** This work would need to be initiated (funded) by September 1, 2014 in order to acquire the necessary equipment and permits to conduct the work. The full study plan would be developed in coordination with the Fall Chinook Working Group and fieldwork would be coordinated with Grant PUD and WDFW staff. The first seeding of transmitters would take place prior to October 15, 2014. Subsequent spawning season seedings would take place on Sundays between November 2 and 30, 2014. Data collection in the field would continue through December 30, 2014. Analyses would take place between January and March 2015. A draft report would be provided to the FCWG by April 30, 2015 and a final report and submitted publication would be completed by June 30, 2015.

**Notes:** 'Loaner' equipment may be available to support this research and we propose that Cascade Aquatics and PNNL collaborate to conduct this project along with coordination with Grant PUD and WDFW.

**Reference:**

Harnish, R.A., R. Sharma, G.A. McMichael, R.B. Langshaw, and T.N. Pearsons. 2014. Effect of hydroelectric dam operations on the freshwater productivity of a Columbia River fall Chinook salmon population. Canadian Journal of Fisheries and Aquatic Sciences 71:1-14.

**Research Summary 4** – 07/22/2014 – Ryan Harnish, Battelle

**Title:** Physical characteristics of Hanford Reach fall Chinook salmon juveniles

**Management Purpose:** Identify whether or not competition among fall Chinook salmon juveniles may be causing the density-dependent relationship observed for the Hanford Reach fall Chinook salmon population.

**Background:** Recent stock-recruit analyses conducted for the Hanford Reach fall Chinook salmon population have revealed density dependence. However, the mechanism(s) driving this relationship are not well understood. Potential causes of density dependence include superimposition of redds, use of lower-quality habitat by later-arriving females, and/or competition among juveniles for food or space (Hilborn and Walters 1992). The benefits to productivity associated with constraints on flow fluctuations from Priest Rapids Dam may not be realized at high spawning escapements due to density-dependent mortality caused by competition among juveniles for food and/or space, reduced juvenile fitness, and ultimately reduced juvenile survival. The current 2014 forecast for the Columbia River Upriver Bright return (minus Snake River wild URB) is estimated at 858,000 adults (WDFW), which far exceeds the $S_{MSY}$ estimate of ~34,400 adults and the spawning escapement at which density dependence has been observed for the population ($S$ = 42,000 adults; Harnish et al. 2012). If the availability and/or quality of spawning habitat is not limiting, it is possible the density-dependent relationship is driven by competition among juveniles for food and/or space.

**Objective:**

1. Characterize the physical characteristics (e.g., length, weight, relative condition factor, length-at-age, fat content, etc.) of Hanford Reach fall Chinook salmon juveniles from post-emergent fry through smolt stages – to be compared across a range of escapements.

**Approach:** Each year, the Columbia River Inter-Tribal Fish Commission (CRITFC) seines natural-origin fall Chinook salmon from the Hanford Reach with the goal of implanting 200,000 juveniles with coded-wire tags. We propose to use this large-scale effort to evaluate the relationship between spawner abundance and the physical characteristics of the resulting juvenile cohort. Juveniles will be subsampled from each seine pull (or a subsample of seine pulls) to obtain physical characteristic data, such as length and weight (from which relative condition factor [$K_n$] can be calculated). A smaller subsample could be collected and euthanized to obtain otoliths to look at daily growth increments, develop length-at-age relationships, and to obtain fat content. A power analysis would be conducted prior to the tagging season to identify the sample size required to detect a meaningful difference in $K_n$, growth, length-at-age, and fat content between years. This study would be repeated over a number of years with varying levels of fall Chinook salmon escapement to the Hanford Reach to better understand the relationship between escapement levels and the physical condition of juveniles.

**Schedule:** This work would need to be initiated (funded) by May 15, 2015 so that juvenile sampling could begin at the start of the CRITFC seining effort. The full study plan would be developed in coordination with the Fall Chinook Working Group. Samples would be collected daily throughout the period of CRITFC seining, which occurs in June. Samples would be processed in July and August and data would be analyzed in September and October. A draft report would be provided to the FCWG by January 15, 2015 and a final report and submitted publication would be completed by February 28, 2016.

**Notes:** We propose that Cascade Aquatics and Battelle collaborate to conduct this project in coordination with CRITFC.

**References:**

Harnish, R.A., R. Sharma, G.A. McMichael, R.B. Langshaw, T.N. Pearsons, and D.A. Bernard. 2012. Effect of Priest Rapids Dam operations on Hanford Reach fall Chinook salmon productivity and estimation of maximum sustainable yield, 1975–2004. PNWD-4339, Battelle, Pacific Northwest Division, Richland, WA.

Hilborn, R., and C.J. Walters. 1992. Quantitative fisheries stock assessment. Chapman and Hall, New York.

WDFW, Washington Department of Fish and Wildlife. 2013 Columbia River adult fish returns and 2014 forecasts. Available: http://wdfw.wa.gov/fishing/forecasts/columbia_river/2013_columbia_river_adult_fish_returns_and_2014_forecasts.pdf (Accessed: July 2014).

**Research Summary** 5 – 07/22/2014 – Ryan Harnish, Battelle

**Title:** Historic effect of escapement on fish size

**Management Purpose:** Identify whether or not competition among fall Chinook salmon juveniles may have caused the density-dependent relationship observed for the Hanford Reach fall Chinook salmon population.

**Background:** Recent stock-recruit analyses conducted for the Hanford Reach fall Chinook salmon population have revealed density dependence. However, the mechanism(s) driving this relationship are not well understood. Potential causes of density dependence include superimposition of redds, use of lower-quality habitat by later-arriving females, and/or competition among juveniles for food or space (Hilborn and Walters 1992). The benefits to productivity associated with constraints on flow fluctuations from Priest Rapids Dam may not be realized at high spawning escapements due to density-dependent mortality caused by competition among juveniles for food and/or space, reduced juvenile fitness, and ultimately reduced juvenile survival. The current 2014 forecast for the Columbia River Upriver Bright return (minus Snake River wild URB) is estimated at 858,000 adults (WDFW), which far exceeds the $S_{MSY}$ estimate of ~34,400 adults and the spawning escapement at which density dependence has been observed for the population ($S$ = 42,000 adults; Harnish et al. 2012). If the availability and/or quality of spawning habitat is not limiting, it is possible the density-dependent relationship is driven by competition among juveniles for food and/or space.

**Objective:**

1. Explore the historic relationship between Hanford Reach fall Chinook salmon escapement and smolt size through the development of a model that incorporates multiple predictor variables that may affect growth of Hanford Reach fall Chinook salmon juveniles (e.g., escapement of URBs to the Hanford Reach and Snake River, river temperature, numbers of hatchery fish released, etc.).

**Approach:** Subsamples of smolts are collected annually from the juvenile bypass system at McNary Dam (MCN) throughout the smolt migration period and measured for length as part of the Smolt Monitoring Program (SMP). These data will be obtained from Fish Passage Center or SMP staff for each year they are available. Mean fork length (FL) will be calculated from lengths of unclipped subyearling Chinook salmon measured at MCN during June and July (the period of Hanford Reach fall Chinook salmon juvenile passage at MCN). A regression model will be developed to examine the relationship between Hanford Reach fall Chinook salmon escapement and FL of unclipped subyearling Chinook salmon sampled as part of the SMP. Additional variables may also affect the size of unclipped subyearling fall Chinook salmon sampled at MCN and need to be incorporated into the model to account for these other sources of variability. In addition to Hanford Reach fall Chinook salmon escapement, other predictor variables that may affect the size of subyearling Chinook salmon sampled at MCN include: Snake River fall Chinook salmon escapement, temperature of the Snake and Columbia rivers, and numbers of hatchery fall Chinook salmon released in the Snake and Columbia rivers. Snake River escapement will be estimated as the ladder count at Ice Harbor Dam, the first dam on the Snake River upstream from the mouth; these data will be obtained from the Columbia River DART website. Average June and July river temperatures will be calculated for the Snake and Columbia rivers from river environment data obtained from the Columbia River DART website. Annual numbers of hatchery subyearling fall Chinook salmon released into the Snake and Columbia rivers (upstream of MCN) will be obtained from the FPC website. Multiple approaches, including general additive modeling, multiple linear regression, and non-parametric multiplicative regression, will be used to identify the model that best describes the relationship between Hanford Reach fall Chinook salmon escapement and FL of subyearling Chinook salmon at MCN.

**Schedule:** This work could be initiated (funded) as late as July 2015, following the collection of subyearling fall Chinook salmon FL data by the SMP at MCN. Waiting until the summer of 2015 would allow for the inclusion of the juvenile cohort produced from the high fall Chinook salmon escapement of 2014. Data would be collected during August and September and analyzed from October through November. A draft report would be provided to the FCWG by February 1, 2016 and a final report and submitted publication would be completed by March 1, 2016.

**References:**

Harnish, R.A., R. Sharma, G.A. McMichael, R.B. Langshaw, T.N. Pearsons, and D.A. Bernard. 2012. Effect of Priest Rapids Dam operations on Hanford Reach fall Chinook salmon productivity and estimation of maximum sustainable yield, 1975–2004. PNWD-4339, Battelle, Pacific Northwest Division, Richland, WA.

Hilborn, R., and C.J. Walters. 1992. Quantitative fisheries stock assessment. Chapman and Hall, New York.

WDFW, Washington Department of Fish and Wildlife. 2013 Columbia River adult fish returns and 2014 forecasts. Available: http://wdfw.wa.gov/fishing/forecasts/columbia_river/2013_columbia_river_adult_fish_returns_and_2014_forecasts.pdf (Accessed: July 2014).