Appendix A

FERC Settlement Agreement and License Articles

APPENDIX A FERC SETTLEMENT AGREEMENT AND LICENSE ARTICLES

The Settlement Agreement and License Articles for the Cowlitz Project can be found online at:

http://www.mytpu.org/tacomapower/power-system/hydro-power/licensing/cowlitz-river-project/Default.htm

Appendix B

2006 Cowlitz FHMP

APPENDIX B 2006 COWLITZ FHMP

The 2006 FHMP and other FHMP documents can be found online at:

http://www.cowlitzfish.net/FHMP/Plan.html

Appendix C

ESA Documents

APPENDIX C ESA DOCUMENTS

The 2010 Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan, approved June 6, 2010, can be found online at:

http://www.lcfrb.gen.wa.us/Recovery%20Plans/March%202010%20review%20draft%20RP/RP%20Frontpage.htm

Appendix D

WDFW Policies

APPENDIX D WDFW POLICIES

The Washington Department of Fish and Wildlife (WDFW) policies regarding hatcheries can be found online at:

http://wdfw.wa.gov/hatcheries/

Appendix E

HSRG Recommendations

APPENDIX E HSRG RECOMMENDATIONS

The Hatchery Scientific Review Group (HSRG) has reviewed all state, tribal and federal hatchery programs in the Columbia River Basin. Individual population reports were completed for Chinook, Coho, and steelhead populations in the Cowlitz Basin. The report can be found online at:

http://www.hatcheryreform.us/

Appendix F

Record of Public Involvement

Cowlitz River Project
Fish Hatchery Management Plan
Record of Public Involvement

Public Review Meeting
August 22, 2011

Location: St. Mary's Academy, Toledo, Washington
Time: 4:30 – 6:30 PM

Participants:
Stan Bartle
Tony Crocco
Rick Lovell
John Serl
Dave Becker
James Chin
Shannon Wills
Buddy Rose
Mike Sexton
Rob Nowowiejski
Nic Norbeck
Scott Attridge
Chuck Wicken
Eugene Smith
Bob Kintzer
Bill Meyer
Pat Frazier
Sara LaBorde
Debbie Young
Keith Underwood
Andy Appleby
Tom Santee
Michelle Day
Ken Marsula
Stephanie Marsula

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1 Comment: Chuck Wicken, Mike Sexton

Don't cut back the fall Chinook production or the sport fishing industry on the Cowlitz River will cease. Production should remain at 4 million. Cuts should be made from the summer run or other production programs rather than all from the fall Chinook.

Response: The Settlement Agreement (SA) specifically places emphasis on recovery of natural populations in the Cowlitz basin: *"The emphasis of this agreement is ecosystem integrity and the restoration and recovery of wild, indigenous salmonid runs, including ESA-listed and unlisted stocks to harvestable levels"* (Section 6; 6.1.1 of the Cowlitz River Hydroelectric Project Settlement Agreement, August 2000).

The FTC adopted conservation goals as outlined in the Lower Columbia River Salmon Recovery Plan (LCRSRP) (Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan, approved June 6, 2010, (http://www.lcfrb.gen.wa.us).

In addition, the FTC also agreed to use the Hatchery Scientific Review Group's (HSRG) standards for the allowable level of hatchery influence to determine compliance with the LCRSRP. (http://www.hatcheryreform.us/)

Based on these standards, conservation constraints limit the fall Chinook production to a maximum of 2.4 million smolts. Any increase from the currently proposed 1.5 to the maximum level of 2.4 million would require a reduction in production of other species by an equivalent poundage (11,250 lbs at 80 fish per pound) to stay within the 650,000 production limit specified in the SA (Article 5) (approximately 56,000 summer steelhead, or 56,000 winter steelhead or 56,000 spring Chinook at 5 fish per pound be need to be eliminated).

Through the WDFW Cowlitz Ad Hoc Advisory Committee process, a priority was placed on spring Chinook and both summer and winter steelhead for production to benefit fisheries. WDFW will continue to work with the Ad Hoc Advisory Group to ameliorate any negative impacts cause by the decrease in fall Chinook production.

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2 Comment: Tony Crocco

Production that benefits upper Cowlitz reaches should not be reduced.

Response: Comment noted. Currently, the FTC is not considering any changes in programs that benefit the upper river fisheries.

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3 Comment: Rick Lovell

He supports maintaining current levels of fall Chinook production, but would like to understand the effects this would have on production of other species.

Response: The Settlement Agreement (SA) specifically places emphasis on recovery of natural populations in the Cowlitz basin: *"The emphasis of this agreement is ecosystem integrity and the restoration and recovery of wild, indigenous salmonid runs, including ESA-listed and unlisted stocks to harvestable levels"* (Section 6; 6.1.1 of Cowlitz River Hydroelectric Project Settlement Agreement, August 2000).

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Through the WDFW Cowlitz Ad hoc Advisory Committee process, a priority was placed on spring Chinook and both summer and winter steelhead for production to benefit fisheries. WDFW will continue to work with the Ad Hoc Advisory Group to ameliorate any negative impacts cause by the decrease in fall Chinook production.

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4 Comment: Chuck Wicken and others

Fall Chinook production is critical to sustaining fishing guiding businesses. The economic benefit to local communities is significant in the early fall.

Response: The Settlement Agreement (SA) specifically places emphasis on recovery of natural populations in the Cowlitz basin: *"The emphasis of this agreement is ecosystem integrity and the restoration and recovery of wild, indigenous salmonid runs, including ESA-listed and unlisted stocks to harvestable levels"* (Section 6; 6.1.1 of Cowlitz River Hydroelectric Project Settlement Agreement, August 2000).

The FTC adopted conservation goals as outlined in the Lower Columbia River Salmon Recovery Plan (LCRSRP) (Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan, approved June 6, 2010, (http://www.lcfrb.gen.wa.us).

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Through the WDFW Cowlitz Ad hoc Advisory Committee process, a priority was placed on spring Chinook and both summer and winter steelhead for production to benefit fisheries. WDFW will continue to work with the Ad Hoc Advisory Group to ameliorate any negative impacts cause by the decrease in fall Chinook production.

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5 Comment:

Under the FHMP, increased returns of wild fish accrue as credits against production, but because wild fish cannot be retained, catch opportunity goes down. Explain how this is going to sustain harvest opportunities.

Response: Harvest objectives are clearly defined in the new FHMP (Section 2.2.2). In addition, the Settlement Agreement (SA) recognizes the importance of sustainable fisheries (Section 6.1.6) and also identifies (Section 6.1.2) that hatchery production will be required to maintain fisheries.

Credits are accumulated based on natural-origin juveniles successfully migrating down the Cowlitz River. Credits are not accrued by adult returns of natural-origin adults in the Cowlitz River. Due to the conservation constraints and standards adopted by the FTC, the number of natural origin adult returns will limit the level of hatchery production for that population.

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6 Comment: Stan Bartle

The FTC and Cowlitz Ad Hoc committee attempted to address the concerns of all affected interest groups in developing this FHMP. It wasn't possible to meet everyone's objectives; everyone has to give up something.

Response: Comment noted.

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7 Comment:

The economies of the Toledo and Castle Rock areas depend upon the sport fishery. Many industries will be harmed by reduced production (motels, restaurants, tackle shops, etc.). Has this impact been analyzed?

Response: The economic impact of a reduction in fall Chinook to the Toledo and Castle Rock areas was not specifically analyzed. However, the increased production of summer steelhead and spring Chinook (both high value species) are thought to help mitigate this impact.

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8 Comment:

Production of late-winter run Chinook should be expanded (meaning the hatchery should take eggs from a broad run timing (for all stocks), as there is really no "late-winter run" Chinook identified specific to the Cowlitz River).

Response: The Washington Department of Fish and Wildlife, operators of the Cowlitz hatcheries, already follow a rigorous adult collection and spawning schedule designed to take eggs for the broadest possible run timing for each hatchery population of Cowlitz-origin salmonids. This schedule for fall Chinook includes later returning fall Chinook adults in the Cowlitz River. In addition, incorporating more natural origin fish into the broodstock (integrated programs) should help expand the run timing (of both the earlier and later segments) of the fall Chinook run.

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9 Comment:

The steelhead fishery has been poor for the last ten years. Attraction water releases from the hatchery and at Barrier Dam have changed fish presence (and increased speed of upstream migration). Steelhead no longer stop at traditional fishing areas like Blue Creek.

Response: Changes in water discharge operations at Cowlitz Trout Hatchery are warranted and WDFW has agreed to modify the schedule described in the draft FHMP Update to the following: 100% of the water is discharged down Blue Creek beginning February 15th and until August 10th. From August 11th to February 14th, water will be discharged approximately 50% to Blue Creek and 50% to the Cowlitz River outfall. In addition, WDFW proposes to investigate changes in the speed of upstream migration of adults for all species to determine the level of change and develop alternative methods of achieving the goal of returning to historical upstream migration speed if this proposed new strategy is not sufficient.

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10 Comment:

Data was requested on the number of wild fish in the Cowlitz River. It appeared to several participants that larger harvests are allowed at the mouth of the river than what is allowed upstream. Gillnetters are taking so many fish that it affects the river guide businesses.

Response: Comment noted. Allocation between user groups is not under the preview of the FHMP update. Allocation issues are determined by an annual process with representatives of WDFW (North of Falcon) and in-season changes are addressed through the Columbia River Compact (WA and OR). Both of these processes have opportunity for public participation. Information on these processes is available at http://wdfw.wa.gov/.

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11 Comment:

Habitat for fall spawning fish is very limited downstream of Castle Rock. The amount of lower river spawning gravel should be analyzed.

Response: The quantity and quality of habitat for fall Chinook in the Cowlitz River is an important assumption in setting the levels of hatchery production. In addition, there is uncertainty about the assumed values used for this analysis. The Monitoring and Evaluation Plan has action items directed at determining the number of natural-origin adults and juveniles the system is actually producing. These data will allow for an assessment of the amount and productivity of available habitat. Future production programs will be modified to reflect the actual productivity of the watershed.

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12 Comment:

The amount of lower river spawning gravel (balance of comment not recorded)

Response: See Comment 11 response for detail on spawning gravel.

13 Comment:

Nutrient enhancement should target the lower Cowlitz as well as the upper Cowlitz.

Response: WDFW has developed a protocol for the design, implementation, monitoring, and reporting of the distribution of carcasses to restore nutrient levels in streams. Currently nutrients are being delivered by natural-origin fish, allowable levels of hatchery-origin fish on the spawning grounds, adults placed in upper watershed areas for re-colonization and hatchery fish placed in streams to achieve harvest goals. Direct placement of carcasses can be used to increase the nutrient level following established WDFW protocols.

Additional nutrient enhancement for the lower river is not being considered until more precise estimates of the number of fish spawning naturally have been determined. Until that time, any additional nutrient enhancement should be focused on the upper Cowlitz first, using live adult spring and fall Chinook (for better distribution and limited impact to conservation objectives), then, if necessary, by placing carcasses regardless of species (excluding steelhead). However, WDFW will continue to evaluate this strategy and consider the lower river in future nutrient enhancement programs as they are developed.

14 Comment:

One of the biggest problems affecting fish in the Cowlitz system is smolt collection at Cowlitz Falls.

Response: Comment noted. Smolt collection at Cowlitz Falls Dam is not under the preview of the FHMP Update. A separate article in the SA (Article 1), does deal with this issue in detail (http://cowlitzfish.net/).

15 Comment: Dave Becker

Need to do something for conservation of sea-run cutthroat trout.

Response: For the purposes of this FHMP, cutthroat are being treated as a stabilizing population. Currently cutthroat trout cannot be harvested in the upper basin to allow for protection. All upper Cowlitz River basin cutthroat encountered at the CSH will be transported to the upper river basins. WDFW should established conservation goals for this species as part of the FHMP process. The USFWS did not list sea-run cutthroat trout and thus the lack of recovery goals to guide the FTC.

16 Comment: Shannon Willis

Think about expanding run timing of steelhead.

Response: This issue has been debated extensively on the Cowlitz River. The best historical database of run timing prior to “significant” hatchery fish impacts on the Cowlitz River is the number of adults passed over Mayfield Dam from 1961-1968. This data shows that adult steelhead were present and migrating in the Cowlitz River in the early winter time period; however, the late winter steelhead run comprised the majority of the total run in the river.

WDFW and Tacoma Power are committed to a broodstock collection schedule for the integrated programs planned for the future that will encompass the entire run timing. For Cowlitz River steelhead that would include collecting fish from the early, mid and late-winter time periods, this is expected to restore the historic run timing of the native Cowlitz steelhead.

Regarding funding of the steelhead recycling study, due to a lack of FTC consensus on the need to do recycling or study its impacts, WDFW agreed to seek funding for this activity.

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17 Comment: Dave Becker

When production is lost due to mortality one year, it should be made up in future years by increased smolt production.

Response: Smolt production is limited based on conservation objectives. It is not possible to increase production in future years due to unexpected losses in past years.

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18 Comment: Dave Becker

Expand our thinking about strays and how they may be valuable in re-colonization; they may be good.

Response: Introduction of non-native stocks/species is not consistent with ESA or stated recovery goals.

Comments received by US Mail or email

Comments letters were received by US Mail or email during a public comment period from August 22 to September 12, 2011. Individual comments within multiple-comment letters have been numbered for responses.

19 Comment: Randall Sharp Email

Throughout the development of the FHMP plan, "Recycling" of Spring Chinook Salmon on the Lower Cowlitz River was discussed and seriously considered. "Recycling" of any of the salmon runs on the Cowlitz River is simply for the benefit of the salmon guides of the Lower Cowlitz Basin at the expense of the Upper Basin fisheries. It is driven by greed. It is not recycling! It is reshocking, reseparating, and retrucking! The result is the continued degeneration of the fish, less for food banks, and an inferior fishery for the Upper Cowlitz Basin which would have a negative impact on Upper Basin economics as well. If "Recycling" is allowed with one salmon run, it may likely open the door to do the same for other runs. **PLEASE!** **Do Not** open the door to any "Recycling" of salmon runs on the Cowlitz River. It is not good for fish, and not good for anyone other than the Lower Cowlitz Basin salmon fisheries, specifically the guides. Instead, we should pursue bringing as many salmon as possible into the Upper Cowlitz Basin as it once was before the dams were in place! Note: Find attached a Letter sent to Jim Scott on April 18, 1011. Please enter this letter into official public comment on the FHMP plan as well. Thanks,

Randall R. Sharp

PO Box 396,

Randle, WA. 98377

360-497-3124

2sharp@dishmail.net

Retired Teacher and

Resident of the Upper Cowlitz River

Basin for 40 years

Response: Comment noted. The proposed FHMP does not include recycling of any salmon species (including spring Chinook). However, a very limited evaluation of the effectiveness of recycling of summer steelhead to increase harvest (a species that cannot be transported to the upper river) has been proposed. Data will be collected regarding the increased harvest and ultimate destination (hatchery or natural spawning) of recycled fish to evaluate the impact on natural origin winter steelhead.

20 Comment: Michael Genson Email

From: mike.genson40@gmail.com [mailto:mike.genson40@gmail.com] **On Behalf Of** Mike Genson
Sent: Monday, September 12, 2011 6:35 PM
To: Cowlitz River Public Feedback
Subject: Cowlitz Fisheries Management Proposal

Regarding the Cowlitz Fisheries Management Plan, there are two areas that are of great concern. The EXTREME reduction in hatchery fall chinook smolt, and the EXTREME reduction in hatchery coho smolt will remove completely two of the most popular fish runs in the Cowlitz. If this part of the plan is included as you have proposed, it will destroy fall guided fishing on the Cowlitz. I am not a fishing guide. My concern is the negative economic impact this will have on Lewis and Cowlitz Counties! Taking the present number of hatchery coho and fall chinook out of the river system will have a negative impact on down stream fisheries all the way to Bouy 10 to some degree. Fishers who presently travel to Lewis and Cowlitz Counties will go to other areas. Only Tacoma Power will benefit from this part of the plan. One of the Washington's premium fall fisheries will be not be listed as endangered, it will be Extinct!!!

Michael K. Genson

880 Spencer Road

Toledo, WA 98591

360-520-4896

mikegenson@toledotel.com

Response: The Settlement Agreement (SA) specifically places emphasis on recovery of natural populations in the Cowlitz basin: *"The emphasis of this agreement is ecosystem integrity and the restoration and recovery of wild, indigenous salmonid runs, including ESA-listed and unlisted stocks to harvestable levels"* (Section 6; 6.1.1 of Cowlitz River Hydroelectric Project Settlement Agreement, August 2000).

The FTC adopted conservation goals as outlined in the Lower Columbia River Salmon Recovery Plan (LCRSRP) (Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan, approved June 6, 2010, (http://www.lcfrb.gen.wa.us).

In addition, the FTC also agreed to use the Hatchery Scientific Review Group's (HSRG) standards for the allowable level of hatchery influence to determine compliance with the LCRSRP (http://www.hatcheryreform.us/).

Based on these standards, conservation constraints limit the fall Chinook production to a maximum of 2.4 million smolts and coho to 3.4 million smolts (before crediting is applied) (see Table 3-16 of FHMP). Any increase from the currently proposed levels (1.5 million fall

Chinook and 2.2 million coho) would require a reduction in production of other species by an equivalent poundage to stay within the 650,000 production limit specified in the SA (Article 5).

Through the WDFW Cowlitz Ad Hoc Advisory Committee process, a priority was placed on spring Chinook and both summer and winter steelhead for production to benefit fisheries. WDFW will continue to work with the Ad Hoc Advisory Group to ameliorate any negative impacts cause by the decrease in fall Chinook and coho production.

State of Washington
Department of Fish and Wildlife
2108 Grand Blvd. Vancouver WA 98661 (360) 906-6700

September 12, 2011

Mark LaRiviere
Natural Resources Manager
Tacoma Power
P.O. Box 11007
Tacoma, Washington 98411

Dear Mr. LaRiviere,

As you are aware Washington Department of Fish and Wildlife (WDFW) has been hosting an Ad Hoc Advisory Group during the last year to assist WDFW in providing input regarding the Fishery and Hatchery Management Plan (FHMP) Update. This Ad Hoc group has been extremely valuable in helping guide WDFW's engagement in the development of the draft FHMP Update. Input from this Advisory Group has helped WDFW, the Cowlitz Fisheries Technical Committee (FTC), in producing an FHMP update that recognizes the priorities of angling and conservation interests in the Cowlitz Basin. The draft of the FHMP Update distributed for public comments effectively addresses the majority of the issues discussed by WDFW's Ad Hoc Advisory Group. The Advisory Group met on Tuesday August 30, 2011 to provide comments regarding the Cowlitz River FHMP Update. Comments from WDFW's Ad Hoc Advisory Group are included in the remainder of this letter.

The Ad Hoc Advisory Group was concerned about the lack of public involvement in the Annual Decision Making Process, specifically "Section 2.1 Annual Decision Making Process (Adaptive Management)". WDFW and the Ad Hoc Advisory Group are concerned that this section does not identify any involvement from interested public. WDFW and our Ad Hoc Advisory Group are recommending that the annual review process be expanded to include a workshop that allows interested public to be provided with the information being used to develop the Action Plan for the upcoming years and an opportunity to provide input to the Cowlitz FTC regarding the proposed Action Plan. WDFW and the Advisory Group believe that this would increase the transparency of this process and increase public understanding of the needs for certain fishery and hatchery management actions to be enacted in the Cowlitz River Basin. Additionally, a public workshop included in the annual review process would disseminate information to key stakeholders in the basin to ensure that there are no surprises in future management actions.

WDFW 1

With respect to hatchery production levels the primary concern expressed by the Ad Hoc Advisory Group was the significant reduction proposed for fall Chinook – annual smolt releases drop from 5,000,000 to 1,500,000 – which will result in a significant negative impact to fall fisheries in the Cowlitz River downstream of the Barrier Dam. This action will have a very negative effect on the fall fishery, and the local communities in the lower Cowlitz River (downstream of the Barrier Dam) because this fishery is largely driven by the opportunity to harvest fall Chinook. While the Ad Hoc Advisory Group understood the necessity of these actions – due to the 650,000 pound production cap for the Cowlitz Complex the is required by the Cowlitz River Hydroelectric Project Settlement Agreement – they were very concerned about the negative impact to local communities, businesses and the angling public in general. WDFW will continue to work with the Ad Hoc Advisory Group to ameliorate these negative impacts. While the Ad Hoc Advisory Group did not provide any recommendations to changes in the 2012 Action Plan, they did continue to express reservations in the severe reduction in fall Chinook production.

WDFW 2

Prior to the August 30 Ad Hoc Advisory Group meeting a member provided some input regarding Section 5.5 Hatchery Operations, and this input was discussed at the meeting on August 30. The Ad Hoc Advisory Group was in support of continuing implement actions that could help slow migration of hatchery fish – especially summer steelhead, spring Chinook and winter steelhead – through the lower Cowlitz River to increase fishing opportunities downstream of the Barrier Dam. Below are the recommendations that were supported by the Advisory Group:

Hatchery Operations

5.5.1: This is a good strategy. Migration into the trap should be monitored when water flow is modified to determine the effects on fish migration.

WDFW 3

5.5.2 This is a good start but we need more specificity to ensure the success of this alteration.

We propose the following language:

Hatchery Operations for Summer Steelhead from June 1 through August 10
Discharge will be directed on alternating weeks: in the first week, 50% to Blue Creek and 50% through the new outfall; in the next 6 weeks, 100% will be released to Blue Creek. In the 8th week return to 50% to Blue Creek and 50% after August 10 to initiate final migration to Barrier Dam.

The only exception will be during the smolt release period when all water will be directed down Blue Creek as required for hatchery operations. WDFW will attempt to evaluate any changes to the fishery that this operational change creates. Future modifications to this schedule will be determined based on this evaluation.

Additionally, it is recommended that 100,000 summer steelhead smolts be imprinted with Blue Creek source water.

Hatchery Operations for Late Winter Steelhead from February 15 to April 15

Discharge will be directed on alternating weeks: in the first 2 week, 50% to Blue Creek and 50% through the new outfall; in the next 3 weeks, 100% will be released to Blue Creek. In the 5th week return to alternating weeks 50% to Blue Creek and 50% to initiate final migration to Barrier Dam.

Reporting of numbers for fish transported upstream was another issue that was discussed at our Ad Hoc Advisory Group Meeting on August 30, 2011. The concern presented focused largely and an inability for the public to track the disposition of fish over time. The concern expressed was that while the Tacoma Power web site does a good job of providing weekly transportation of adult returns to various release sites in the basin, the web site does not provide a cumulative running total for the year of adults transported to different locations in the basin. Additionally, the Tacoma Power web site does not include other kinds of disposition (e.g. nutrient enhancement and food banks). While this is not directly related to the FHMP, WDFW wanted to bring this forward for discussion by the FTC because it does relate to fish management activities called for in the FHMP. At a minimum, WDFW and our Ad Hoc Advisory Group recommend modifying the data presented in the Tacoma Power web site to include yearly running cumulative totals of fish transported, by species/race, to allow the public to observe how the FHMP is being implemented. An example of a table for FTC consideration is attached (Attachment 1). WDFW 4

The FHMP Update depends on modeling results to guide fishery management decisions in the Cowlitz Basin. Improvements in the amount and precision of data collected will be necessary to implement the Annual Decision Making Process. The Monitoring and Evaluation Plan – as described in Section 4 and Appendix J – provide data that is critical to evaluating whether fishery management actions proposed in this FHMP Update are effectively achieving the intended conservation and angling benefits. To that end there needs to be a full funding commitment to ensure that the Monitoring and Evaluation Plan is implemented as proposed. WDFW 5

WDFW staff has also reviewed this document and have few additional comments. These comments have been compiled in the attached document (Attachment 2). The section with a comment is highlighted in yellow and the comment is in a bubble below the yellow highlighted section. The comments are on pages 23, 31, 41, 47, 50, 53, 54, 61, 62, 66, 67, 78 & 89.

Thank you for providing us with the opportunity to comment on the FHMP Update. We also appreciate your consideration of recommendations from the Ad Hoc Advisory Committee during the process of developing this FHMP Update. If you have any questions please feel free to contact me.

Patrick Frazier
Region 5 Fish Program Manager

Attachments – Attachment 1
Attachment 2

Cc: Debbie Young (Tacoma Power)
Jim Scott (WDFW)
Sara LaBorde (WDFW)
Wolf Dammers (WDFW)
Mark Johnson (WDFW)
WDFW Ad Hoc Advisory Group

WDFW Attachment 1

Hatchery Adult Fall Chinook

Week Ending	Total Returns	Brood-Stock	Upstream Transportation Tilton River	Lake Scanewa	Cowlitz @ Packwood	Cispus River	Food Bank	Nutrient Enhancement	Other
Season to date	***1,000***	***20***	***325***	***0***	***325***	***300***	***25***	***0***	***5***
Season to date %	*100%*	*2%*	*33%*	*0%*	*33%*	*30%*	*3%*	*0%*	*1%*
2-Sep	50	.	10	0	20	5	10	0	0
9-Sep	300	15	80	0	65	40	100	0	0

Hatchery Jack Fall Chinook

Week Ending	Total Returns	Brood-Stock	Upstream Transportation Tilton River	Lake Scanewa	Cowlitz @ Packwood	Cispus River	Food Bank	Nutrient Enhancement	Other
Season to date	***1,000***	***20***	***325***	***0***	***325***	***300***	***25***	***0***	***5***
Season to date %	*100%*	*2%*	*33%*	*0%*	*33%*	*30%*	*3%*	*0%*	*1%*
2-Sep	50	.	10	0	20	5	10	0	0
9-Sep	300	15	80	0	65	40	100	0	0

5) In the event that the application of credits (and commensurate reduction in hatchery programs) impacts the ability to achieve major objectives of the FHMP (conservation and sustainable fisheries), adjustments in the application of credits maybe altered by the FTC (i.e., forego credit, apply credits across populations).

6) A minimum (floor) of hatchery production may be established by the FTC on a population-by-population basis. Note that the floor applies only to crediting. Hatchery production may be reduced below this floor to meet conservation and or the 650,000 poundage standard.

7) Because the number of natural-origin out-migrants is converted to pounds of production for crediting, base production from which credits are subtracted (by species) is established as numbers of smolts of a specified "base size" at release. If the size at release changes or varies, the base production remains the poundage associated with base production numbers at "base size". For example, spring Chinook historically have been reared to 5 fish per pound (fpp) (base size) and 972,000 smolts have been released. Total poundage then is 194,400 pounds (base production). Many more spring Chinook could be released if the fish per pound at release was reduced, but the base production would remain at 194,400 and credits would be subtracted from the poundage number, rather than the number of smolts.)

Table 2-14 identifies how natural production credits will be assigned to each hatchery program. The credit mechanism will be calculated as follows:

1) For every yearling wild/natural juvenile produced from the upper Cowlitz and Tilton rivers, hatchery yearling production will be reduced by two fish (2:1 ratio), on a species-specific basis.

2) For every subyearling wild/natural juvenile produced from the Upper Cowlitz and Tilton rivers, hatchery yearling production will be reduced by 0.5 fish (0.5:1 ratio), on a species-specific basis. If the hatchery releases only subyearlings, hatchery subyearling production would be reduced at a 2:1 ratio.

The 2:1 or 0.5:1 credit ratio began in year 1 of the FHMP and is applied to a reduction in the Cowlitz Hatchery Complex production obligation beginning with the next brood year for each species. For example, if the most recent five-year rolling average for coho natural-origin juveniles was 200,000 (data available in the late spring), the credit would be assigned to the following brood year egg collection. This will ensure that hatchery managers will have sufficient time to plan and implement future broodstock needs.

The calculated credit ratio will remain in force until smolt-to-adult survival rate (SAR) data are complete for each brood year and then updated. When possible, SARs will be calculated for both the hatchery and wild component and the credit ratio calculated as follows:

- Credit Ratio = Wild SAR/ Hatchery SAR

Summary of Comments on Correspondence to Mark LaRiviere - WDFW and Ad Hoc Advisory Committee Comments to FHMP Update - Attachment 2.pdf

Page: 34

Author: johnsmjj Subject: Highlight Date: 8/30/2011 3:16:00 PM

Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 3:17:12 PM
The base program, prior to credits, for spring Chinook since 2002 has been 967,000 smolts.

WDFW 6

Table 3-1. 2012 Lower Cowlitz fall Chinook hatchery program.

2013 Smolt Release Number[1] Prior to Credit Adjustment	1,500,000
Release Size (fish/lb)	80
Credit Adjustment (number)	29,292
Credit Adjustment (lbs)	366
Adjustment for Pound Limit, if any	879,505
Net Smolt Release Target for 2013 (number)	1,500,000
Net Smolt Release Target for 2013 (lbs)	52,500
Adults Transported Above Mayfield for Harvest	1,600

[1] Target smolt number to be released from to 2011 brood, i.e. smolts will be released in 2012.

3.2 LOWER COWLITZ SPRING CHINOOK

There are no natural production goals for Lower Cowlitz spring Chinook. This is a segregated harvest program. The original broodstock source was the native spring Chinook from the Upper Cowlitz basin. The program therefore also serves as a temporary gene bank for the planned reintroduction of spring Chinook into the Upper Cowlitz/Cispus and Tilton basins.

3.2.1 Management Targets

No changes to the assumptions or management targets are expected over the period covered by this FHMP. The goals are to maintain population viability and to maximize harvest within the Cowlitz River, subject to the limitations associated with the operational constraints and priorities of the Cowlitz Salmon Hatchery.

The genetic identity and diversity of the population will continued to be maintained by employing BMPs in the hatchery (collecting eggs over the entire return timing, 1:1 mating schemes, etc.) in order for the population to be an effective source for re-colonization of the upper watershed. Otherwise, no significant conservation constraints have been identified.

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Author: johnsmjj Subject: Highlight Date: 8/30/2011 3:34:58 PM

Author: johnsmjj Subject: Highlight Date: 8/30/2011 3:34:54 PM

Author: johnsmjj Subject: Highlight Date: 8/30/2011 3:35:03 PM

Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 3:34:39 PM
Not sure how the 52,500 pound figure was arrived at. 1.5 million at 80 fpp would be 18,750 pounds

WDFW 7

Author: johnsmjj Subject: Highlight Date: 8/30/2011 3:33:32 PM

Author: johnsmjj Subject: Highlight Date: 8/30/2011 3:32:08 PM

Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 3:32:56 PM
This note is not consistent with the table.

WDFW 8

steelhead? The study will use a combination of radio tags, floy tags and other identification methods as needed to determine the fate of recycled summer steelhead. WDFW proposes that the study be conducted by USGS. While previous studies have determined how many recycled fish returned to the separator at the Cowlitz Salmon Hatchery, these studies have not accurately determined the fate of fish that did not arrive at the separator. This study will ensure that data on the fate of recycled summer steelhead are collected and will be used to guide future management decisions about recycling summer steelhead in the Cowlitz basin.

The study proposes to recycle up to 500 summer-run steelhead one time, using a combination of radio tags, floy tags and opercula punches to allow for evaluation. Returns to hatchery facilities, lower river weirs and harvest rates will be enumerated. The study will begin when WDFW secures funding. The impact of recycling (presumed to be increased pHOS) will require reducing the currently proposed program from 650,000 to 625,892 summer steelhead.

3.4.4 Actions for 2012

Assuming an NOR return of 506 late winter steelhead, the Decision Rules indicate a release of 482,389 late winter steelhead smolts along with 650,000 summer steelhead smolts. The Upper Cowlitz and Tilton programs are assumed to be no greater than 118,000 and 48,500 late winter steelhead, respectively (see Figure 3-7).

Table 3-4. 2012 Lower Cowlitz late winter steelhead hatchery program.

2013 Smolt Release Number[1] Prior to Credit Adjustment	482,389
Release Size (fish/lb)	5.5
Credit Adjustment (number)	8,092
Credit Adjustment (lbs)	1,471 lbs
Adjustment for Pound Limit, if any	0
Net Smolt Release Target for 2013 (number)	**473,297**
Net Smolt Release Target for 2013 (lbs)	**86,054 lbs**

[1] Target smolt number to be released from the 2011 brood, i.e., smolts will be released in 2013.

Table 3-5. 2012 Lower Cowlitz summer steelhead hatchery program.

2013 Smolt Release Number[1] Prior to credit adjustment	650,000
Release Size (fish/lb)	5.5
Adjustment for Pound Limit, if any	0
Net Smolt Release Target for 2013 (number)	**650,000**
Net Smolt Release Target for 2013 (lbs)	**118,182**

[1] Target smolt number to be released from the 2011 brood, i.e., smolts will be released in 2013.

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Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 4:00:53 PM
This fall & winter (2011) and January 2012 will represent the 2012 brood for steelhead and cutthroat.

WDFW 9

Author: johnsmjj Subject: Highlight Date: 8/30/2011 3:58:55 PM

Author: johnsmjj Subject: Highlight Date: 8/30/2011 4:01:25 PM

Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 4:04:41 PM
Same comment as above.

WDFW 10

Management Precision—performance evaluation to improve run forecasting and harvest over time to more effectively implement the Decision Rules. In other words, this monitors the effectiveness of the application of the Decision Rules.

A methodology for estimating NOR returns of Upper Cowlitz fall Chinook adults in-season should be developed. This methodology should include a strategy to identify and transport all NORs and the appropriate number of HORs to selected locations in the upper river for harvest and natural spawning. These values will be collected during monitoring for Lower Cowlitz fall Chinook, Upper River spring Chinook and Upper River coho. No further monitoring is identified.

3.5.4 Actions for 2012

Table 3-5. 2012 Upper Cowlitz Fall Chinook Program.

2013 Smolt Release Number[1] Prior to Credit Adjustment	0
Number of Adults Transported and Released above Cowlitz Falls	≤ 7,000

[1] Target smolt number to be released from the 2011 brood, i.e., smolts will be released in 2013.

3.6 UPPER COWLITZ SPRING CHINOOK

The Upper Cowlitz spring Chinook population is designated as Primary. There are currently few natural spawners in the Upper Cowlitz/Cispus Rivers. The Lower Cowlitz hatchery population is derived from the native spring Chinook from this area and will be used to reintroduce natural production.

3.6.1 Management Targets

Figure 3-10 describes three views of the future for the population and the fisheries it supports (Scenarios A, B, and C). It identifies the conditions under which harvest and conservation goals will be reached in the future. The figure also captures the current conditions, showing where we are now and where we expect to be in the future. Section 3.6.2, Decision Rules, describe how we intend to get from the current condition to the long-term target (Scenarios A, B, or C). Until substantial improvements in FPS have been made, this analysis suggests that it is unlikely that natural production can be sustained above Cowlitz Falls (Figure 3-10).

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Author: johnsmjj Subject: Highlight Date: 8/30/2011 4:36:03 PM

Author: johnsmjj Subject: Highlight Date: 8/30/2011 4:07:27 PM

Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 4:36:01 PM
If there were smolts to be released it should say 2012 brood not the 2011 brood released in 2014.

WDFW 11

3.6.4 Actions for 2012

Table 3-6. 2012 Upper Cowlitz spring Chinook hatchery program.

2014 Smolt Release Number[1] Prior to Credit Adjustment	0
Number of Adults Transported and Released Above Cowlitz Falls	8,000

[1] Target smolt number to be released from the 2011 brood, i.e., smolts will be released in 2013.

3.7 UPPER COWLITZ COHO

Coho have been reintroduced into the upper Cowlitz from the lower Cowlitz hatchery program. This evolving Upper Cowlitz population has been designated as Primary in the LCSRP, with a minimum abundance target of 4,000 natural-origin spawners (Figure 3-11). This population has the potential to play a key role in the recovery of the Lower Columbia coho ESU. Upper Cowlitz coho contribute to pre-terminal fisheries as well as fisheries in the lower and upper Cowlitz basins.

3.7.1 Management Targets

The factors that inhibit progress toward conservation goals for this population are fish passage survival at Cowlitz Falls and strays from adult HORs transported upstream for harvest purposes. Only HORs that are positively identified as Upper Cowlitz coho (i.e., hatchery fish with 100% NOR parents), will be transported to the Upper Cowlitz. No Lower Cowlitz coho will be transported above Cowlitz Falls.

The current hatchery program is integrated with a pNOB of 100%. These fish are reared and released from the Cowlitz Salmon Hatchery to avoid the loss due to low fish passage survival at Cowlitz Falls Dam. The challenge for this population is to provide fishing opportunity in the upper Cowlitz without exceeding a pHOS of 30% effective HOR spawners. The pHOS target can be met by a combination of increased FPS, increased harvest rate on HORs, and/or by limiting the number of adult HORs that are transported to the upper Cowlitz.

Another potential means to improve homing and harvest rates for HORs that are transported above Cowlitz Falls would be to acclimate and release smolts from satellite ponds in the Upper Cowlitz. These acclimation ponds would be located where harvest opportunities would be greater and/or the likelihood would be significantly reduced that unharvested HORs end up mingling with NOR spawners. Unless transported below the Barrier Dam, a consequence of releasing hatchery fish in the upper basin would be reduced smolt to adult survival due to the limited fish passage survival. Smolts released from the acclimation ponds would have to be uniquely identified in order to be distinguished from those released directly from the hatchery.

The credit mechanism (Section 2.5.3) for Upper Cowlitz coho would reduce this hatchery program by two smolts for every natural-origin smolt captured at Cowlitz Falls and released in the lower river. The hatchery program, however, would not be reduced due to crediting below a minimum level defined by the maximum number of adult HORs that could be transported in a high survival year for NORs. For this population, this number

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Author: johnsmjj Subject: Highlight Date: 8/30/2011 4:14:25 PM

Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 4:35:30 PM
Same as previous note, should be 2012 brood released in 2014.

WDFW 12

Management Precision—performance evaluation to improve, for example, run forecasting over time to more effectively implement the decision rules. In other words, this monitors the effectiveness of applying the Decision Rules.

A methodology for estimating NOR return of Upper Cowlitz coho adults in-season must be developed before the fish passage survival trigger is met. This methodology should include a strategy to identify and transport the appropriate number of HORs to selected locations in the upper river for harvest while assuring that a 30% pHOS is met, once the trigger is met.

Appendix G contains tables identifying the critical parameters that are uncertain, affect decisions and should be monitored.

Chapter 4 identifies the variables, parameters estimated, frequency of sampling and data collected that will be used to effectively address the needs for all populations in a comprehensive monitoring plan.

3.7.4 Actions for 2012

Table 3-7 summarizes the planned actions for 2011, consistent with the Decision Rules for Upper Cowlitz/Cispus coho. Note that broodstock collected in 2012 will produce smolts to be released in 2014. The release numbers in 2011 are from brood collected in 2009.

Table 3-7. 2012Upper Cowlitz/Cispus coho program.

2013 Smolt Release Number[1] Prior to Credit Adjustment	978,000
Release Size (fish/lb)	15
Credit Adjustment (number)—See Section 3.13.1	0
Credit Adjustment (lbs)	0
Adjustment for Pound Limit, if any	0
Net Smolt Release Target for 2014 (number)	978,000
Net Smolt Release Target for 2014 (lbs)	65,200
All NOR returns not needed for brood will be transported above Cowlitz Falls.	
Number of HOR Adults from Upper Cowlitz Integrated Program Transported above Cowlitz Falls	≤25,000

[1] Target smolt number to be released from the 2011 brood, i.e., smolts will be released in 2013.

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Author: johnsmjj Subject: Highlight Date: 8/30/2011 4:34:44 PM

Author: johnsmjj Subject: Highlight Date: 8/30/2011 4:32:29 PM

Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 4:34:41 PM
Should be 2012 brood released in 2014?

WDFW 13

3.8.3 Monitoring Priorities

Key Assumptions—parameters estimated from the accumulation of data over time. Accuracy and precision will improve from year to year.

The most critical assumption for Upper Cowlitz steelhead is fish passage survival. See Appendix H and J and Chapter 4 for more details on overall monitoring. Stock identification marks for this population can be found in Table 2-10.

Annual Status and Trends—tracks annual outcomes in terms of variable annual biological targets. These targets are revised each year according to Decision Rules and by taking run forecasts into account. Viewed over time (the trends part), this information will track progress towards conservation and harvest goals.

Management Precision—performance evaluation to improve, for example, run forecasting over time to more effectively implement the Decision Rules. In other words, this monitors the effectiveness of the application of the Decision Rules.

Appendix H contains tables identifying the critical parameters that are uncertain and affect decisions and should be monitored.

Chapter 4 identifies the variables, parameters estimated, frequency of sampling and data collected that will be used to effectively address the needs for all populations in a comprehensive monitoring plan.

3.8.4 Actions for 2012

Table 3-8. 2012 Upper Cowlitz steelhead hatchery program.

2013 Smolt Release Number[1]	118,000

[1] Target smolt number to be released from the 2011 brood, i.e., smolts will be released in 2013. All smolts will be released from the hatchery below Mayfield.

Kelt Reconditioning Study – A study will be implemented using a limited number of winter steelhead kelts to determine if kelt reconditioning can benefit recovery of listed winter steelhead in the upper Cowlitz River. The study duration will not exceed four years and the total number of kelts reconditioned will not exceed 20 fish annually. Selected NOR kelts will be collected at Cowlitz Falls Dam and transported to the Cowlitz Trout Hatchery for inclusion in the study. Females will be rated as good or fair condition (see below) and only those males that are rated as good condition will be used in this study, consistent with the following priority: 1) good females, 2) fair females, and 3) good males. Because of the small number of fish included in this study, it is likely that only "good" females will be used. At the end of the study data will be summarized and analyzed, and presented to the FTC to determine if kelt reconditioning should occur in future years, and if so, at what level.

Wild late winter-run steelhead kelts will be collected at the Cowlitz Falls Fish Facility between April and July where abundance historically has averaged about 200 wild (unmarked) kelts per year (range 86 to 373). Tacoma Power will transport the kelts to the

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Author: johnsmjj Subject: Sticky Note Date: 8/30/2011 4:39:10 PM
The 2013 smolt release will be from the 2012 brood taken as eggs in the spring of 2012.

WDFW 14

Author: johnsmjj Subject: Highlight Date: 8/30/2011 4:38:07 PM

Cowlitz Trout Hatchery (CTH) where adults will be held in the adult holding ponds. Kelts will be sequestered by arrival week and reconditioning will be modeled after the Yakama Nation kelt "short-term" reconditioning program at Prosser.

Specific details need to be developed, but generally reconditioning involves a one-time injection with antibiotics (Oxytetracycline), regular treatment with formalin to prevent fungal infection and introduction of feed using freeze-dried krill. Steelhead kelts will be held 3 to 5 weeks depending on the re-initiation of feeding. They will then be transported to a pre-determined release location (e.g., Castle Rock, below much of the in-river sport fishery, or some other location acceptable to the FTC). The release could be conducted by hatchery staff.

While at CTH, the steelhead will be held under conditions that are more conservative than normal adult brood holding (i.e., given 2 to 3 times more water and space). Shade cloth covers will be installed to reduce stress during holding. The water supply will be re-used from the juvenile ponds but there is a long history of successful long-term adult broodstock holding at CTH during summer months under higher loading conditions.

It is recommended that the screening criteria used by the Yakama Nation be adopted for this study. This involves selecting kelts in "good" or "fair" condition that are most likely to survive the reconditioning process. These fish are identified by the following criteria:

- Good: Lack of any wounds or descaling
- Fair: Lack of any major wounds and/or descaling

In addition, marking and evaluation will be undertaken. Cost effective evaluation method(s) will be explored (e.g., PIT tags, radio, acoustic, CWT, or elastomer).

Biological parameters to be included in the study include, but are not limited to the following:

- Measurements of weight gain and other phenotypic traits of reconditioned kelts deemed appropriate during the study compared to non-reconditioned kelts
- Speed of post-release downstream migration of reconditioned vs. non-reconditioned kelts
- Amounts of feed used during reconditioning
- Survival rate of kelts during reconditioning
- Return rate of reconditioned kelts compared to non-reconditioned kelts

Study results will be provided via Cowlitz Trout Hatchery Annual reports.

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Author: johnsmjj Subject: Highlight Date: 9/2/2011 8:03:06 AM

Author: johnsmjj Subject: Sticky Note Date: 9/2/2011 8:03:51 AM
Recommend injecting at Cowlitz Falls to avoid double handling at CTH

WDFW 15

Management Precision—performance evaluation to improve, for example, run forecasting over time to more effectively implement the Decision Rules. In other words, this monitors the effectiveness of the application of the Decision Rules.

Appendix H contains tables identifying the critical parameters that are uncertain, affect decisions and should be monitored.

Chapter 4 identifies the variables, parameters estimated, frequency of sampling and data collected that will be used to effectively address the needs for all populations in a comprehensive monitoring plan.

3.11.4 Actions for 2012

Table 3-10. Tilton steelhead program 2012 actions.

Steelhead Reared to 20 fish/lb at Cowlitz Hatchery and Transferred to Tilton Acclimation Ponds	51,000
Released from Acclimation Ponds at 5.5 fish/lb 2014.[1]	50,000

[1] Capitol and operating costs of acclimation will be a WDFW responsibility.

3.12 LOWER COWLITZ CUTTHROAT

Hatchery production of cutthroat is based on harvest goals and constrained by total Cowlitz Hatchery Complex production limits (Section 2.5.2) and by potential for adverse ecological interactions with, indigenous salmon and steelhead populations. The number of fish released should be smallest number possible to meet harvest objectives.

3.12.1 Management Targets

The harvest benefits in terms of numbers of fish caught are largely unknown. The potential ecological interaction risks associated with the program are also unknown. Harvest rates in the past have ranged from 26 - 46% (average 34%) (Tipping and Blankenship 1993).

3.12.2 Decision Rules

Conservation adjustments to the size of the cutthroat program will be based on an assessment of harvest benefits versus ecological risks. The program will be sized to assure that harvest benefits outweigh conservation concerns associated with ecological interactions with indigenous salmonids.

3.12.3 Monitoring Priorities

Key Assumptions—parameters estimated from the accumulation of data over time. Accuracy and precision will improve from year to year.

The most critical assumptions for Lower Cowlitz cutthroat are the predation rate on NOR juveniles of other species (see Lower Cowlitz fall Chinook) and contribution to harvest.

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Author: johnsmjj Subject: Highlight Date: 9/1/2011 10:47:33 AM

Author: johnsmjj Subject: Sticky Note Date: 9/1/2011 10:47:48 AM
I thought TP was taking this on???

WDFW 16

Annual Status and Trends—tracks annual outcomes in terms of variable annual biological targets. These targets are revised each year according to Decision Rules and take into account the run forecasts. Viewed over time (the trends part), this information will track progress towards conservation and harvest goals.

For Lower Cowlitz cutthroat, annual estimates of terminal harvest rates are critical to assessing achievement of harvest goals. Monitoring of Lower Cowlitz fall Chinook, coho and steelhead will include values for this program.

Management Precision—performance evaluation to improve run forecasting and harvest over time to more effectively implement the Decision Rules. In other words, this monitors the effectiveness of the application of the Decision Rules.

A goal for harvest and a methodology for estimating HOR contribution to terminal fisheries should be developed. This methodology should include a strategy to identify the specific contribution by Lower River cutthroat to harvest and angler days. Values for harvest could be collected during monitoring for Lower River fall Chinook, coho and steelhead, but developing harvest goes for this species will require a separate effort.

3.12.4 Actions for 2012

The production target for brood year 2012 is 101,247 smolts at 4 fish per pound, including off-station releases.

An action plan for altering the release (later) and/or location (transporting downstream) of searun cutthroat should be developed and implemented to address predation if juvenile monitoring shows predation by this species is a concern.

3.13 SUMMARY OF HATCHERY PRODUCTION, ESCAPEMENT AND HARVEST TARGETS FOR 2011/2012

This section brings together the conservation rules from Sections 3.1 through 3.12 with the crediting rules and the hatchery poundage limits to arrive at a production plan for 2011/2012. More of the data and calculations used to develop the final hatchery production numbers and other management targets for 2011/2012 are available in Appendix I. The rules for crediting and poundage limits were presented in Section 2.5.

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Author: johnsmjj Subject: Highlight Date: 9/1/2011 10:49:05 AM

Author: johnsmjj Subject: Sticky Note Date: 9/1/2011 10:49:23 AM
goals?

WDFW 17

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Author: johnsmjj Subject: Highlight Date: 9/1/2011 11:05:57 AM

Author: johnsmjj Subject: Sticky Note Date: 9/1/2011 11:06:18 AM
2012?

Author: johnsmjj Subject: Highlight Date: 9/1/2011 11:07:05 AM

Author: johnsmjj Subject: Sticky Note Date: 9/1/2011 11:08:32 AM
All of these release years need to be advanced one year.

WDFW 18

3.13.2 Adjustments to Meet Total Production Limits (650 lb) in 2011

Table 3-16. 2012 adjustments to hatchery production for total pounds of production following conservation and credit adjustments.

Program	Release Size (Fish/lb)	WDFW Target[1] Production (# of smolts)	Conservation Adjustment[1]	NOR Run Associated with Base Production[1]	Credit Adjustment	650,000 lb Adjustment	NOR Run Associated with Adjusted Production	Release Year
LC Fall Chinook	80	4,200,000	2,400,000	NOR > 1,172	2,393,809	1,500,000	NOR >732	2012
LC Spring Chinook	5	500,000	500,000		497,115	497,115		2013
LC Spring Chinook	8	800,000	800,000		800,000	800,000		2013
LC Spring Chinook	16	500,000	500,000		500,000	500,000		2013
UC Spring Chinook	--	0	0		0	0		2013
LC Coho	15	2,400,000	2,400,000	NOR > 1,577	2,275,373	1,200,000	NOR> 1,018	2013
UC Coho [2]	15	978,000	978,000		978,000	978,000		2013
LC LW Steelhead	5.5	599,224	481,389	NOR > 506	478,122	478,122	NOR > 498	2013
UC LW Steelhead[3]	5.5	175,000	118,000[4]		118,000	118,000		2013
LC Summer Steelhead	5.5	650,000	650,000		650,000	650,000		2013
Tilton LW Steelhead[5]	20	50,000	51,000		51,000	51,000		2013
LC Cutthroat[6]	4	160,000	102,401		101,841	101,841		2013
Total lbs of production		**810,400**	**741,762**		**731,815**	**648,951**		

[1] Base Production represents the conservation limit to hatchery production, when the affected natural run meets the condition indicated in the table.
[2] Credit for Upper Cowlitz natural production applied to Lower Cowlitz hatchery program.
[3] Conservation adjustment is applied to both Lower and Upper Cowlitz steelhead production.
[4] Upper Cowlitz steelhead production is limited to 118,000 due to the expected NOR run size for the Lower Cowlitz population (about 500); see Decision Rule in Figure 3-7.
[5]Tilton steelhead will be reared to 20 fish/lb at the hatchery and then transferred to acclimation ponds.
[6] Cutthroat program adjusted to reduce ecological interaction risks to listed species.

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Author: johnsmjj Subject: Sticky Note Date: 9/1/2011 11:14:00 AM
The numbers for the fall chinook in 2012 are going to change based on our conversation, 4,500,000.

WDFW 19

Author: johnsmjj Subject: Highlight Date: 9/1/2011 11:11:08 AM

3.13.3 Hatchery Production Targets for All Programs in 2012

Table 3-17. Summary of hatchery production by release year from 2011 through 2013 for all Cowlitz Programs.

Program	Release Size (fish/lb)	Release Year 2011[1]			Release Year 2012 [2,3]			Release Year 2013 [4]		
		BY	Number	Lbs	BY	Number	Lbs	BY	Number	Lbs
LC-Fall Chin	80	2010	4,779,500	59,744	**2011**	**1,500,000**	**18,750**	2012	TBD	TBD
LC-Spring Chin	5	2009	905,226	181,045	2010	906,369	181,274	**2011**	**497,115**	**99,423**
LC-Spring Chin	8	2009			2010			**2011**	**800,000**	**100,000**
LC-Spring Chin	16	2009	55,000[8]	4,583	2010	55,000[5]	4,583	**2011**	**500,000**	**31,250**
LC-Coho	15	2009	1,804,746	120,316	2010	842,716	56,181	**2011**	**1,200,000**	**80,000**
UC-Coho	15	2009	1,000,000	66,667	2010	1,000,000	66,667	**2011**	**978,000**	**65,200**
LC-LW Sthd	5.5	2010	361,757	65,774	2011	362,855	65,974	**2012**	**478,122**	**86,931**
UC-LW Sthd	5.5	2010	0		2011	0	0	**2012**	**118,000**	**21,455**
LC-Sum Sthd	5.5	2010	450,000	81,818	2011	450,000	81,818	**2012**	**650,000**	**118,182**
LC-Sum Sthd	6	2010	100,000	16,667	2011	100,000	16,667			
LC-EW Sthd	5.5	2010	300,000	54,545	2011	300,000	54,545			
Tilton LW Stlhd[6]	20							**2012**	**51,000**	**2,550**
LC-Cutthroat	4	2010	147,596	36,899	2011	147,599	36,900	**2012**	**100,841**	**25,210**
LC-Cutthroat	5.5	2010	10,000[9]	1,818	2011	10,000	1,818			
	Total			**689,876**			**585,177**			**630,201**[7]

Note: Cells shaded yellow are the production plan for BYs 2011 and 2012 (i.e. the 2011 FBD) Cells shaded blue are the production plan for BY 2010 and 2011 (2010 FBD).
[1] This production is from brood year 2010 and earlier.
[2] Except for fall Chinook, this production is already in the hatchery.
[3] The BY 2010 production numbers do not include the off-station production which amounts to about 22,000 lbs of Cowlitz Hatchery production.
[4] The BY 2011 production number incorporate off-station programs. They must be accommodated within these limits (see Section 5.3).
[5] Released at 12 fish/lb.
[6] Tilton steelhead will be reared to 20 fish/lb at the hatchery and then transferred to acclimation ponds and released at 5.5 fish/lb.
[7] This total does not include the fall Chinook program. Size of this program will be determined in 2012.
[8] Transferred at 12 fpp.
[9] Transferred to FOC at 5.5 fpp.

5.5.2 Cowlitz Trout Hatchery

Prior to 2006, drain water from the Cowlitz Trout Hatchery was discharged into the lower portion of Blue Creek, downstream of the outlets to the five-acre steelhead and cutthroat trout rearing ponds. When the adults returned to the vicinity of the hatchery, a large portion of the fish held in the Cowlitz River downstream of the mouth of Blue Creek, leading to a concentrated fishery in a limited area of river.

Tacoma Power constructed a new outlet into the Cowlitz River downstream of the Blue Creek boat launch as part of the Cowlitz Hatchery Complex remodel project. The existing outfall into Blue Creek was maintained in an operational status. By routing the hatchery discharge directly into the Cowlitz River, this reduced the attraction of fish to Blue Creek and promoted their tendency to stray within the river system upstream to the Cowlitz Salmon Hatchery ladder and trap. This process was partially done to eliminate adult returns to the Cowlitz Trout Hatchery where they were not needed since all steelhead and cutthroat trout broodstock can be taken at the Cowlitz Salmon Hatchery separation facility. Another reason for the new hatchery outfall was to accommodate requests of the angling public and WDFW to spread out the fishery in the Cowlitz River upstream of the mouth of Blue Creek.

Since February 2007, WDFW has operated the outfall distribution of the Cowlitz Trout Hatchery water at an approximately 50:50 level except for the six week period in the spring when juvenile steelhead and cutthroat trout are being released from the five-acre ponds. During that time, 100% of the hatchery discharge is routed into Blue Creek.

***Proposed change**:* Discharge will be directed on alternating weeks: in the first week, 50% to Blue Creek and 50% through the new outfall; in the next week, 100% will be released to Blue Creek. The only exception will be during the smolt release period when all water will be directed down Blue Creek as required for hatchery operations. WDFW will attempt to evaluate any changes to the fishery that this operational change creates. Future modifications to this schedule will be determined based on this evaluation.

5.6 RESIDENT FISH

Article 5.b) of the SA states that:

> *"Through 2004, the Licensee will provide funding for 50,000 pounds of trout production. Subsequent to 2004, future trout production will be based upon a review by the FTC of the success or failure of the program and any impacts on listed stocks."*

Trout provided by Tacoma Power will be released into the Cowlitz basin, consistent with the tenets of the "Washington Department of Fish and Wildlife Statewide Steelhead Management Plan: Statewide Policies, Strategies, and Actions", completed by WDFW in February of 2008. This document states the following:

> *1) Protect wild steelhead stocks from potential interactions with hatchery-origin rainbow trout:*

Page: 91

Author: johnsmjj Subject: Highlight Date: 9/2/2011 8:08:38 AM

Author: johnsmjj Subject: Sticky Note Date: 9/2/2011 8:12:08 AM
Clint pointed out that the discharge was formerly at the base of the ladder which is actually physically upstream of the outlet of the 5 ac rearing lakes for most of the year. It would only be discharged downstream during smolt release. Don't know if this detail needs to be inserted or not...

WDFW 20

21 Comment: WDFW 1

Response: The FTC agrees and, as part of our annual decision making process, will conduct a pre-season workshop, open to the public, followed by a public input period.

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22 Comment: WDFW 2

Response: The Settlement Agreement (SA) specifically places emphasis on recovery of natural populations in the Cowlitz basin: *"The emphasis of this agreement is ecosystem integrity and the restoration and recovery of wild, indigenous salmonid runs, including ESA-listed and unlisted stocks to harvestable levels"* (Section 6; 6.1.1 of Cowlitz River Hydroelectric Project Settlement Agreement, August 2000).

The FTC adopted conservation goals as outlined in the Lower Columbia River Salmon Recovery Plan (LCRSRP) (Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan, approved June 6, 2010, (http://www.lcfrb.gen.wa.us).

In addition, the FTC also agreed to use the Hatchery Scientific Review Group's (HSRG) standards for the allowable level of hatchery influence to determine compliance with the LCRSRP (http://www.hatcheryreform.us/).

Based on these standards, conservation constraints limit the fall Chinook production to a maximum of 2.4 million smolts. Any increase from the currently proposed 1.5 to the maximum level of 2.4 million would require a reduction in production of other species by an equivalent poundage (11,250 lbs at 80 fish per pound) to stay within the 650,000 production limit specified in the SA (Article 5). (Approximately 56,000 summer steelhead, or 56,000 winter steelhead or 56,000 spring Chinook at 5 fish per pound be need to be eliminated).

Through the WDFW Cowlitz Ad Hoc Advisory Committee process, a priority was placed on spring Chinook and both summer and winter steelhead for production to benefit fisheries. WDFW will continue to work with the Ad Hoc Advisory Group to ameliorate any negative impacts cause by the decrease in fall Chinook production.

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23 Comment: WDFW 3

Response: See response to Comment 9.

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24 Comment: WDFW 4

Response: We agree that more detailed reporting (including cumulative) is appropriate. Tacoma Power has agreed to provide weekly reports that include the previous week's and cumulative total distributions of adult by species, origin (hatchery vs. natural) and planting locations. WDFW will continue to report total adults and jacks trapped and fish held on station and other data via the weekly escapement report, available at http://wdfw.wa.gov/. WDFW will report on fish for nutrient enhancement, food bank or other distribution annually as is done currently.

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25 Comment: WDFW 5

Response: We agree that the proposed Monitoring and Evaluation is critical to achieving success of this new FHMP. To that end, funding for the work described is very important. WDFW and Tacoma Power have agreed on most, if not all, the proposed work elements described in Appendix J, and who is responsible for funding those work elements (see "Deliverables" within MA and AM in Appendix J). In the near future, Tacoma Power will formalize an agreement on contractual work needed to move forward.

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26 Comment: WDFW 6

Response: Comment noted. The document will be corrected.

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27 Comment: WDFW 7

Response: Comment noted. The document will be corrected.

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28 Comment: WDFW 8

Response: Comment noted. The document will be corrected.

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29 Comment: WDFW 9

Response: Comment noted. The document will be corrected.

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30 Comment: WDFW 10

Response: Comment noted. The document will be corrected.

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31 Comment: WDFW 11

Response: Comment noted. The document will be corrected.

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32 Comment: WDFW 12

Response: Comment noted. The document will be corrected.

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33 Comment: WDFW 13

Response: Comment noted. The document will be corrected.

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34 Comment: WDFW 14

Response: Comment noted. The document will be corrected.

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35 Comment: WDFW 15

Response: Comment noted. The document will be corrected.

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36 Comment: WDFW 16

Response: Comment noted, it is Tacoma's responsibility to provide capital and operating cost.

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37 Comment: WDFW 17

Response: Comment noted. The document will be corrected.

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38 Comment: WDFW 18

Response: Comment noted. The document will be corrected.

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39 Comment: WDFW 19

Response: Production by year as identified will require adjustment to reflect final agreement and submission to FERC of the FHMP.

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40 Comment: WDFW 20

Response: Comment noted. The document will be corrected.

LaRiviere, Mark

From: Bob Reid [cpr-fish@toledotel.com]
Sent: Saturday, September 17, 2011 10:15 AM
To: LaRiviere, Mark
Cc: Lonnie Goble, LCFD 10; Scott, Jim B (DFW); Frazier, Patrick A (DFW); Michelle Day; Erich Gaedeke; contact@cowlitzfish.net; Don Glaser; Dale Scott; Anthony Crocco; Sean Orr; Terry Turner; Carl Burke; Shannon Wills; Stan Bartle; Jim
Subject: Comments on Draft FHMP
Attachments: FHMP comments for 2011 Draft.doc

Mark I have attacked my written comments to this email in a "word" format attachment.

Sorry that my comments are coming in a little late, but as you know, heath reasons had prevented me from getting them back to you by the 12th. I still think that the public needs more time to read and digest your Draft FHMP before they can make there comments on it. I appreciate that you had called and granted me a comment extension deadline to Monday, September 19.

Don't worry very much about any spelling or grammar errors (i am sure there are lots of them), as I was really rushed to getting them back to you as requested so that you could address them in the FHMP. Feel free to call me if you have any further questions about my comments.

Regards,

Bob Reid,
CPR-Fish

Mark

My comments to the Draft FHMP are written in Blue. I have posted the FHMP issue in black and have highlighted the main issue that my comments apply to in red.

First off, the new FHMP leaves the past readers of the original July 2, 2004 FHMP scratching there heads at best! The two plans are not linked or tied together. License Article 6 requires the FHMP to be "updated" every 6 years and not to be completely rewritten! There are Phases and objectives that have not been carried over into the new Draft of the FHMP and its almost impossible for the read or the public to see if the original objectives and Phases of the first FHMP have been met. Instead, the Draft FHMP takes a leap into an all new FHMP with no explanation of the success or failures of the first FHMP.

REID 1

The current Draft FHMP has major changes from the first FHMP but it doesn't explain how or why these changes have been made. The new FHMP needs to show in detail why these changes have been made, it needs to show the reason or science for why the changes have been made in the new updated version of Tacoma's FHMP.

2.1.1 Process (p.5)

The annual decision making process centers around a pre-season workshop, held under the FTC auspices, where status and trends, key assumptions, and previously agreed upon decision rules are reviewed and translated into an Annual Action Plan (Section 3). Prior to this workshop, Washington Department of Fish and Wildlife (WDFW) and Tacoma Power will update key assumptions and status and trends based on monitoring results from the most recent season. That information is captured in the In-Season Implementation Tool (ISIT), a database and calculator described in Appendix I. Decision rules will be reviewed each year, but are expected to change less frequently. Barring extraordinary circumstances, the decision rules should only be updated every six years, as the FHMP is updated. In other words, decisions will change each year due to new information, but the rules for making those decisions should remain the same. The decision rules are described below for each Cowlitz population in Section 3.

The agenda for the pre-season workshop is driven by the outline of the Status and Trends and Key Assumptions sections, where the new information brought in through the M&E program will be highlighted. The Status and Trends portion of the agenda will cover natural production (e.g., most recent spawning escapement abundance and composition), harvest, and hatchery production by species and hatchery program. *The Key Assumptions part of the agenda will include, for each population: habitat and natural production parameters, smolt to adult survival parameters (e.g., most recent estimates of average fish passage survival at Cowlitz Falls, harvest parameters (e.g., pre-terminal exploitation rates), and hatchery production parameters (e.g., updated in-hatchery survival projections).*

It has not yet been established that Cowlitz Falls will be the only fish collection facilities to measure and estimate the total upper Cowlitz fish passage survival rates. In fact, other collections facilities have been proposed below Cowlitz Falls and extend miles into the lower section of Riffe Lake. (See Draft DFPT recommendations conceptual design 90%).

REID 2

2.1.2 Roles and Responsibilities

The process described here is not intended to in any way alter the legal and policy mandates and responsibilities of the management entities involved in the fishery management process in the Cowlitz Basin. Instead it is meant to provide a structure within which those responsibilities can be carried out in a manner that is consistent with the Settlement Agreement. The role of the FTC will be to review information brought forward at the annual workshop, apply decision rules and approve the action plan for the coming year. The FTC may also convene to review progress during the year at selected milestones identified in the annual work plan. *In agreeing to this FHMP, the managers (WDFW and NOAA) and Tacoma Power commit to provide the data and information required to complete the action plan at the end of the workshop.*

This is an extremely misleading statement! Only WDFW and NOAA are the fishery "managers" of the states fisheries. It's being implied that Tacoma Power is also a manager of our fisheries. It should say "*In agreeing to this FHMP, WDFW and NOAA (the fishery managers) along with Tacoma Power commit to provide the data and information required to complete the action plan at the end of the workshop*"

REID 3

2.2.3 Harvest (P-14)

" [1] Note that the FTC has no influence on current or future harvest in pre-terminal fisheries. In-river fishery goals are set by the managers, in this case primarily WDFW, consistent with state policies and federal ESA requirements. Realized in-river harvest opportunities will be affected by FTC decisions.

This inconsistent of what is stated in the Settlement Agreement under 12.5; 12.6; and 12.7
The FTC can only make "recommendations" to Tacoma and the agencies. It is the WDFW's responsibility to either except the FTC recommendations or to refuse them as only they and NOAA are the legal parties that have been authorized to affect our in-river harvest opportunities.

REID 4

Table 2-8. Expected harvest rates by fishery within the six year period of this FHMP. (P-14)

Charts and table fails to show the projected amount of harvestable expected fish that are being harvested by the state and processed or sold to food banks and fish processors. Often the amount harvested by the state far out weights the amount that is harvested by the sport fisheries. Coho and summer run steel are perfect examples. The tables and charts do not reflect this data. The charts should be updated to reflect the true amounts of fish that are being harvested by all parties and not just the ocean, Columbia and **Terminal (Sport) Fisheries**

REID 5

Table 2-10. Stock identification marks of salmonid population groups found in the Cowlitz River.

There appears to be a major problem and conflict with how coho are being marked! The FHMP shows that all NOR's coho that are produced in the Lower Cowlitz will not be marked. The FHMP also states that there will be no marking on NOR's that are produced from the Tilton River. Yet under the terms of the Settlement Agreement (Article 3) it clearly states: " B) as determined based on the above-described tables with respect to: (i) the number of pre-spawners arriving at the Barrier Dam, in at least 3 of 5 consecutive brood years measured, and based on the 5-year rolling average, exceeds an abundance level ***which indicates natural recruitment above Mayfield Dam has achieved*** self-sustaining levels, as determined by the National Marine Fisheries Service in consultation with the FTC or agencies; (ii) the productivity level in 3 of 5 years and the 5-year rolling average, as measured at the Barrier Dam or other Cowlitz River fish counting facilities by the recruit/pre-spawner ratio, exceeds 1.0."

Coho are one of the species that fall under this license requirement and if the Tilton coho NOR's have *no defining marks* to separate those from the Lower River NORs coho, there is no way to see if this recruit/pre-spawner ratio requirement can be meant! It's appears that Tacoma would have to amend its License if there are no marking differences between the two.

REID 6

2.4.2 Recent Harvest by Fishery and Population

Table 2-12. Recent 5-year average catch estimates by fishery and stock. (P-18 and 19)

Again, charts fail to show true total harvest rates: The charts should be updated to reflect the true amounts of fish that are being harvested by *all parties* including the hatchery and states take/sales, and not just the ocean, Columbia and **Terminal (Sport) Fisheries harvest.**

Page 23 talks about "credits" for wild fish production and what the credit rates will be, but there is no mention or discussion of what the "deductions" numbers will be from the lost of any wild fish that are lost in handling or marking. Whenever smolts are handled, especially during smolting, there will be lost! THE FHMP should identify such lost and adjust the crediting formulas.

REID 7

3.1.1 Management Targets (P-28)

"There is uncertainty about whether the effects of *C. shasta* disease are fully accounted for in the productivity parameter for the current condition. Fall Chinook will not be used for nutrient enhancement in the lower river because of disease concerns

This makes no sense at all! What does C-Shasta have to do with nutrient enhancement in the lower river? Why would it be ok to use fall chinook for nutrient enhancement in the upper Cowlitz or the Tilton River but you can't use them in the lower river? What's the difference between letting fall chinook adult spawn and contribute to the nutrients naturally in the upper river but you can't use them in the lower river for nutrient enhancement?

Why would it be biological sound to allow these same fish that may be infectious into the upper reaches of the Cowlitz and not into the lower reaches where they spawn naturally in large numbers below the dams because of C-Shasta?

REID 8

Page 29
3.2
States: Each year, 1,600 of the adult returns from this program will be transported above Mayfield to provide harvest and assist in achieving nutrient enhancement targets in the Tilton. There is no distinct fall Chinook population identified in the recovery plan for the Tilton. Fall Chinook transferred to the Tilton are considered part of the Lower Cowlitz fall Chinook population.

Again, this makes no sense! How can the HRSG justify using this stock for nutrient enhancement above Mayfield but not in the lower river? It would appear that WDFW wants to sell these excess fall chinook instead of using them for nutrient enhancement in the lower river. REID 9

3.2 LOWER COWLITZ SPRING CHINOOK (P-31)

There are no natural production goals for Lower Cowlitz spring Chinook. This is a segregated harvest program. The original broodstock source was the native spring Chinook from the Upper Cowlitz basin. The program therefore also serves as a temporary gene bank for the planned reintroduction of spring Chinook into the Upper Cowlitz/Cispus and Tilton basins.

This is a very misleading statement. WDFW hatchery records and inter hatchery transfers show that there was approximately 525,000 Willamette River run spring chinook smolts transferred into the Cowlitz Salmon Hatchery for its brood stock needs back in the mid to late 60's due to a complete lost of water supply into the Cowlitz Salmon Hatchery. All of the Cowlitz brood stock was killed for both the spring and fall Cowlitz Hatchery chinook runs that year. So in fact, a large percentage of the Cowlitz gene pool for its fall and spring chinook stocks was heavily genetically influenced with Willamette River gene stock. This transfer has pretty much been kept a secret, and possibly may be a major factor why the Cowlitz Spring and Fall chinook runs have failed to adapt in successful numbers in the Cowlitz basin. At the very least, the FHMP should note these huge transfers of chinook that had taken place when the hatchery started its production up in the late 60's. It would be a biologically dishonest action to keep this information hidden as it's been done in the past. REID 10

It's hard for WDFW and others to make the biological argument that our early winter stocks of steelhead must be discontinued because they carry some small traces of genetic Chamber Ck. steelhead genes and are then considered to be genetically inferior and unfit to use as a locally adapted winter run brood stock, yet it perfectly "OK" for WDFW to use a known polluted gene stock from the Willamette River because WDFW hasn't told anyone that the entire brood stock run for a certain year was replaced and polluted by a non native Cowlitz stock of chinook.

3.4 LOWER COWLITZ STEELHEAD (p-37)

The Lower Cowlitz indigenous late winter steelhead population is designated as Contributing. The HSRG standards for hatchery influence have not been met in recent years. The proportion of hatchery fish effectively spawning with the indigenous late winter steelhead population exceeds the 10% limit. In addition, the census number of strays from the segregated summer steelhead program exceeds the 30% limit associated with ecological risk. Even though the abundance of natural-origin spawners exceeds the 400 fish recovery target, a large proportion of these fish are likely offspring of hatchery fish spawning in the wild with low fitness.

There have been no known studies to support such an assertion that any offspring of these Cowlitz Hatchery/wild fish are of "low fitness" and until this assertion can be supported by such studies on the Cowlitz, this statement should be removed from this FHMP. It is not supported by any facts that this condition exists on the Cowlitz or its tributaries. In fact, it's inconsistent of the results that were found in the recent lower Cowlitz River steelhead genetic study.

REID 11

3.4.3 Monitoring Priorities (p-40)

To determine the fate of recycled summer steelhead, a study will be implemented to evaluate the assumed harvest, stray rates, and weir removal rates used in the FHMP modeling. For summer steelhead, there are some data on steelhead recycling from past studies in the lower Cowlitz River (trucking returning adults downstream to provide additional harvest opportunity); however, these studies left some important questions unanswered. Specifically, what are the stray and harvest rates of recycled summer steelhead? The study will use a combination of radio tags, floy tags and other identification methods as needed to determine the fate of recycled summer steelhead. WDFW proposes that the study be conducted by USGS. While previous studies have determined how many recycled fish returned to the separator at the Cowlitz Salmon Hatchery, these studies have not accurately determined the fate of fish that did not arrive at the separator. This study will ensure that data on the fate of recycled summer steelhead are collected and will be used to guide future management decisions about recycling summer steelhead in the Cowlitz basin.

The study proposes to recycle up to 500 summer-run steelhead one time, using a combination of radio tags, floy tags and opercula punches to allow for evaluation. Returns to hatchery facilities, lower river weirs and harvest rates will be enumerated. The study will begin when WDFW secures funding. The impact of recycling (presumed to be increased pHOS) will require reducing the currently proposed program from 650,000 to 625,892 summer steelhead.

First off, there appears to be a lot of misinformation about the real run timing of the Cowlitz native steelhead stocks. Much of this FHMP is being manipulated around misclassifying the true Cowlitz early run native stock steelhead as being the "introduced" and non native Chamber Creek stock. Numerous historical data, studies and reports (Smith, 1947, 1948; Kray 1957; Thompson and Routhfus 1969; Tipping 1984) all show that the Cowlitz had an "early timed run" that started in mid November and peaked in December and January. That early run timing represented just about half of the entire Cowlitz native wither steelhead run.

It is Tacoma's responsibility to mitigate for the lost of these fish and there natural run timing under recovery efforts associated with being listed (ESA). The first plants of hatchery fish (steelhead) were made in 1938 (3700) @ 3.5/lb. numerous none native stocks from other basins were used during those plants. Hatchery plants became consistent starting in 1951 where Chamber Creek stock were introduced and continued annually until 1967. The average number of plated Chambers was only 41,661 fish @ 2.5-13/lb.

REID 12

From 1967 onward, ***only Cowlitz steelhead stocks were used for brood stock*** and there were no more transfers of Chamber Creek steelhead into the Cowlitz or its hatcheries or gene pool (Tipping 1984).

3.4.3 states: " The study will begin when WDFW secures funding."
Tacoma should be required to fund this study because these fish are part of Tacoma's legal mitigation requirements under its operating license.

For Lower Cowlitz steelhead, annual estimates of spawner abundance and composition (pHOS) and NOR and HOR catch in terminal fisheries are important for tracking progress toward goals over time. Five-year running averages of pHOS, NOS and catch should be reported every year.

Management Precision—performance evaluation to improve run forecasting and harvest over time to more effectively implement the Decision Rules. In other words, this monitors the effectiveness of the application of the Decision Rules.

A methodology for estimating HOR and NOR returns and harvest of Lower Cowlitz steelhead adults should be developed to allow more accurate estimates of these values.

Not really sure why this statement is even mentioned in Tacoma's FHMP. You can't keep unmarked steelhead in the lower Cowlitz River and Tacoma doesn't fun any creel checks to see if anglers hooked and released any wild steelhead in the first place. Secondly, if they were to do so, the angler wouldn't have the slightest idea if the unmarked fish that he had caught and released was a stray from who knows where!

This reminds us of Tacoma's last FHMP! It's unacceptable for the public to assume that anything will be done simply because it's mentioned in the Draft FHMP. Perfect example can be read in numerous statements in Tacoma last FHMP such as "Phase 2 Objectives. Phase 2 objectives would depend on the results of Phase 1 strategies, and therefore cannot be described in detail at this time. " REID 13

Tacoma's Draft FHMP does not refer back to its own "strategies" that are noted in Phase 1 of it own FHMP. Much of these new changes are not part of Tacoma's original FHMP that was sold to the public. During Tacoma's Public meetings to discuss their FHMP, never once did they refer back to the original FHMP and how their new changes compared to there Phase 1 and Phase 2 objectives. In Tacoma's old FHMP under 5.3.2 (goals and Objectives) Tacoma states that Conservation goals are presented in terms of biological significance of the stock and its viability. Habitat goals are expressed with respect to the quality of the environment to produce late winter steelhead.

What the hell has happen to the past "objectives" and how have they been implemented as proposed in your last FHMP? Surely, you can't try to tell the readers of this Draft that it's "adaptive management" as you have during the past 7 years to the pubic in this newest version of the FHMP. If you did use adaptive management, the new plan should state exactly what the changes were and why they were made and who made them.

3.5 UPPER COWLITZ FALL CHINOOK (p-42)

The upper Cowlitz fall Chinook population is designated as a Stabilizing population. Recovery goals for this population have not been quantified.

At a minimum, the FHMP should reflect the best data available on what the upper Cowlitz chinook adult returns actually were. That information is readily available in historic documents such as the 1990 Cowlitz River Sub basin Plan for Salmon and Steelhead which estimated that the area above Cowlitz Falls could produce 4,254,000 smolts. Also other documents such as the Draft Cowlitz River Subbasin Summary (May 17, 2002) states that fall chinook distribution was no less then 14,000 adults above Mayfield and that the Cispus had 8,100 adult escapements. There should be no reason why the FHMP can't reflect the actual historical past documented numbers as a baseline number for what the upper Cowlitz would consider to be a Stabilizing number. Also NOAA –Fisheries listed "Chinook" as threaten and they didn't separate them from being spring chinook or fall chinook in there listing. So recovery goals for this population still must be shown and this seems to be a major oversight by the agencies.

REID 14

3.5.2 Decision Rules (p-42)

There are no plans to release juvenile fall Chinook in the Upper Cowlitz/Cispus Rivers. Depending on availability, up to 7,000 adult fall Chinook from the Lower Cowlitz hatchery program will be transported and released above Cowlitz Falls for harvest and nutrient enhancement purposes. The number (7,000) is based on watershed carrying capacity, consistent with the nutrient enhancement rules (Section 5.1).

Again, historic data and the above information show that the number should be increased to 8,100 adult fall chinook for above Cowlitz Falls into the Cispus River alone. The area around Randle and up could easy handle another 2-3 thousand fall chinook adults. The FHMP should reflect all known historic numbers that spawned above Cowlitz Falls on each specie.

Where is the logic? Fall chinook is the last native indigenous stock of salmonids to be reintroduced back into the Upper Cowlitz. Just like the spring chinook introduction, there were only hatchery fish available to use for their reintroduction efforts. The FHMP really needs to explain what science justifies not allowing plants of fall chinook to help jump start recovery of these fish in the Upper Cowlitz. Why was it biologically sound to plant millions of spring chinook to start the recovery in the Upper Cowlitz for spring chinook, but now its no biologically sound to do the same with fall chinook? The FHMP really needs to explain the reasoning why fall chinook fry are being held back now when they could help jump start recovery of Upper Cowlitz fall chinook as was done with spring chinook.

REID 15

3.6 UPPER COWLITZ SPRING CHINOOK

The Upper Cowlitz spring Chinook population is designated as Primary. There are currently few natural spawners in the Upper Cowlitz/Cispus Rivers. The Lower Cowlitz hatchery population is derived from the native spring Chinook from this area and will be used to reintroduce natural production.

This would be a true statement except for the fact that the Cowlitz Spring chinook are not really "derived from the native stock"! As stated earlier, the Cowlitz lost its entire spring chinook brood back in the late 60's and depended 100% on the transfer of brood stock from the Willamette River when some 525,000 Willamette River run spring chinook stock were transferred from out of basin into the Cowlitz Salmon Hatchery. The FHMP should reflect and note this stock transfer. It's simply amazing that WDFW and others who know differently keep turning there heads to this fact! The FHMP should state what the Cowlitz Subbasin plan stated which was; "Brood stock for the subbasin has been Cowlitz stock except for some Willamette brood stock in 1967". REID 16

3.10 TILTON COHO (P-56)

This is a Stabilizing population with some natural production and high degree of hatchery influence (high pHOS) (Figure 3-10).

How are the Tilton NOR's coho going to be identified separately from that of the lower Cowlitz NOR's? REID 17

3.10.1 Management Targets

Figure 3-15 captures the current conditions of the population, showing where we are now and where we expect to be in the future. Section 3.10.2, Decision Rules, describes how we intend to get from the current condition to the long-term target. No quantitative conservation targets have been identified for this population. It is expected to provide harvest benefits and nutrient enhancement.

Tilton coho are being used as a "trigger" requirement for triggering volitional upstream fish passage at Mayfield (read Article 3 of the Settlement Agreement). In addition, the license requires Tacoma to test to see if any of three adult indigenous species of coho, chinook or steelhead can self sort themselves; " A) adult fish in Mayfield Lake are able to choose their tributary of origin and survive Mayfield Lake transit at rates determined by NMFS and USFWS, in consultation with the FTC or agencies, to be sufficient to achieve effective upstream passage through volitional facilities; and B) as determined based on the above-described tables with respect to: (i) the number of pre-spawners arriving at the Barrier Dam, in at least 3 of 5 consecutive brood years measured, and based on the 5-year rolling average, exceeds an abundance level which indicates natural recruitment above Mayfield Dam has achieved self-sustaining levels, as determined by the National Marine Fisheries Service in consultation with the FTC or agencies; (ii) the productivity level in 3 of 5 years and the 5-year rolling average, as measured at the Barrier Dam or other Cowlitz River fish counting facilities by the recruit/pre-spawner ratio, exceeds 1.0; and (iii) the disease management plan required by Article 8 has been implemented." REID 18

The Draft FHMP completely ignores this requirement of Tacoma's Operating License and doesn't address the issues of how this FHMP will address or deal with it. If in fact this requirement is dropped, Tacoma must amend its license to reflect so. But as it stands at this time, the FHMP must address this issue with all three species until Tacoma's license has been amended and must be addressed in every one of its Decision Rules, Monitoring Priorities, and Management Targets.

It ain't Bugger King, and you can't order it anyway that you want to!

3.10.3 Monitoring Priorities (P-57)

Key Assumptions—parameters estimated from the accumulation of data over time. Accuracy and precision will improve from year to year.

The most critical assumptions for Tilton coho are fish passage survival and productivity and capacity of the habitat. Current actions that place adult coho into the area are aimed at colonizing available habitat and providing harvest. Monitoring of Lower Cowlitz coho, Upper Cowlitz coho and Tilton steelhead will include values for this program. No further monitoring is identified.

This is inconsistent with the terms and conditions of the Settlement Agreement under Article 3. (see my comments above on Table 2-10. Stock identification marks of salmonid population groups found in the Cowlitz River.)

REID 19

For Tilton coho, annual estimates of NOR returns (counted at the Cowlitz Salmon Hatchery), pre-spawning mortality of HORs and NORs (including fishery induced mortality), and enumeration of smolt out-migrants from the Tilton River are most important to track progress toward goals over time. Monitoring of Lower Cowlitz coho, Upper Cowlitz coho and Tilton steelhead will include values for this program. No further monitoring is identified.
Again, if Tilton NORs coho are to be unmarked as stated in Table 2-10 in the FHMP, there is no way to tell if the NOR fish that are being counted monitored at the Cowlitz Salmon Hatchery are Tilton NOR's or Lower Cowlitz NORs recruits. They must be marked to see if the NOR Tilton coho meet upstream fish passage trigger requirements

REID 20

3.12 LOWER COWLITZ CUTTHROAT (P-61)

Hatchery production of cutthroat is based on harvest goals and constrained by total Cowlitz Hatchery Complex production limits (Section 2.5.2) and by potential for adverse ecological interactions with, indigenous salmon and steelhead populations. The number of fish released should be smallest number possible to meet harvest objectives.

The Draft FHMP doesn't address any issues whatsoever on the Upper Cowlitz River cutthroat. There is nothing in the new Draft FHMP to address the recovery or management of these species. The FHMP must address this specie, especially when it addresses the lower river cutthroat. This is another perfect example of how this plan doesn't follow through with your last FHMP! The old July 2, 2004 FHMP describes the plan for Sea Run Cutthroat (5.19) it has Phase 1, and Phase 2, plus Objectives and strategies. The Draft FHMP now turns a blind eye to the management, production, and previous Phases and objectives of the original FHMP with no explanation for doing so. And you wonder why Tacoma isn't getting very many written comments to its plan? There is no continuity from FHMP 1 to FHMP 2

REID 21

5.1 NUTRIENT ENHANCEMENT RULES (P-72)

For a more complete discussion of Nutrient Enhancement in the Cowlitz Basin, see page 16 of the Final FHMP completed in 2006 (Appendix B).

How many different versions of the original FHMP does Tacoma have? The FHMP that I and the public have been reading was published in July of 2004 and not 2006. Hopefully it's just a typo on Tacoma's part. REID 22

5.1.1 History

Prior to the initiation of extractive fisheries in mid-to late-19th century, the Cowlitz River watershed received an annual influx of marine derived nutrients (MDN) that fueled the entire watershed ecosystem. Initiation of extractive fisheries and subsequent construction of dams led to the dramatic reduction in the amount of MDN delivered to the Cowlitz River basin (Stockner and Ashley 2003). There is little doubt now that MDN are an important component of Pacific Northwest anadromous salmonid ecosystems (Stockner 2003). The productivity and capacity of watersheds within the Cowlitz River Basin are directly tied to the level (ultimately) of spawner-delivered MDN. This could also mean that models with density-dependent parameters estimated from MDN-poor systems would underestimate the productive capacity of the stream/watershed.

This wording needs to be reversed! It was Tacoma's Cowlitz Dams that stopped the mass majority in the reduction of MDN that were being delivered to the Cowlitz River basin and not the initiation of extractive fisheries. Here are a few quotes from your own legal briefing to acquire your original operating license. "Anadromous fish are those that spawn in fresh water, migrate to the ocean for two to four years, according to their life cycle, and then return to fresh water to spawn, and in most instances to die. On the Cowlitz River three species of salmon, the fall chinook, spring chinook and the silver, and tow species of trout, the steelhead and cutthroat, are found (Exhibit 25, page 8; Exhibit 28, page 7). It is not the City's position that some losses of some fish may or will not result from its project; but it has at all times been and stands ready and willing now to provide the best known means at any reasonable cost for fish protection and conservation (Tr. 879-880), and it and its engineers and biologists are of the opinion that ultimate net losses of fish, if any, from the project will be small (Exhibit 14, pages 6-7)." REID 23

Anyone who's ever read Tacoma's "BRIEF OF APPLICANT CITY OF TACOMA dated March 24, 1951 wouldn't be saying that the "Initiation of extractive fisheries and subsequent construction of dams led to the dramatic reduction in the amount of MDN delivered to the Cowlitz River basin"! That simply isn't the way that that history or the records tell it. You really do need to rewrite your statement to reflect the actual facts.

5.3 OFF-STATION PROGRAMS (P-77)

The use of in-basin net pens, where hatchery-origin juveniles are reared (usually until smolted) and then released into the natural environment to continue their outmigration, produce returning adults that are imprinted to a location different than normal hatchery reared and released smolts. As such, these adults do not return to the hatchery with the same level of homing fidelity (they have a higher stray rate). These adults pose a genetic risk by breeding with naturally produced adults (domestication). Due to the higher stray rates of adults produced from net pen-reared juveniles, they generate more hatchery fish on the spawning grounds (pHOS) per fish released than direct hatchery plants, which needs to be accounted for in estimating total pHOS.

The HSRG made the following observations regarding the use of net pens and the practice of outplanting salmonid juveniles (HSRG 2004):

> "*Tagging and genetic studies have shown that outplanting and net pen programs promote stray rates that far exceed natural levels (Candy and Beacham 2000; Mackey et al. 2001).*"

The HSRG further noted that:

> "*…Outplanting and net pen releases from segregated hatchery programs* (summer steelhead in the Cowlitz is an example from Table 5.3) *are especially problematic because of the potentially high level of genetic divergence between the hatchery stock and natural populations where straying and natural spawning may occur. Although the natural spawning success of hatchery-origin fish may be less than that of natural-origin fish when they occur in the same stream, those same data indicate that significant numbers of hatchery-origin fish from nonnative or long-standing "domesticated" populations do indeed spawn successfully and can contribute significant numbers of progeny to naturally spawning populations (Chilcote et al. 1986;Campton et al. 1991; Mackey et al. 2001; Kostow et al. 2003; McLean et al. 2003).*"

Actually, the above information doesn't really hold true to the net pin projects on the Lower Cowlitz. Over 100,000 summer runs had been specially marked before there release so that WDFW could check and see where these fish were being caught, or where they ended up at. Before making such a broad reaching conclusion about the net pen fish on the Cowlitz, the results of such studies by WDFW should be shown in the FHMP. Since there are no historic records that show that there was any major natural spawning by native Cowlitz steelhead in the lower Cowlitz mainstem, straying rates by net pen summer runs into lower river are no greater then that of the hatchery fish (summer runs) from the Cowlitz Hatcheries. Also all the major tributaries that still have any natural spawning of steelhead in the lower Cowlitz tributaries, now have weirs on them to prevent strays from spawning with any native stocks. REID 24

Also, there are no records that I am aware of that show that net pin reared Cowlitz Spring chinook stray. There is no native spring chinook spawning in the Lower Cowlitz or any of its tributaries, so the above statement can't apply to the Cowlitz net pen reared fish. The entire above statement needs to be rewritten to reflect the true facts about Cowlitz.

Moreover, the above statement "*less than that of natural-origin fish when they occur in the same stream, those same data indicate that significant numbers of hatchery-origin fish from nonnative or long-standing "domesticated" populations do indeed spawn successfully and can contribute significant numbers of progeny to naturally spawning populations (Chilcote et al. 1986;Campton et al. 1991; Mackey et al. 2001; Kostow et al. 2003; McLean et al. 2003). ", i*s not only misleading, it's flat out wrong when its applied to the Cowlitz Basin! During the

Cowlitz genetic study on steelhead, it was shown that WDFW had actually "planted" 10's of thousands of “domesticated” hatchery smolts (both Chambers and mixed Chambers stock) into the Lower Cowlitz tributaries. In addition to the smolt plants, there were 100's of thousands of egg plants from these same fish planted into the different lower tributaries. I know this for a fact, because in 1987-1988 was a volunteer who participated in many of these egg plants in the tributaries of the Cowlitz. This information was supplied to WDFW during the Cowlitz Advisory Group meetings, and should be made available for the public to read before such unfounded statements are finalized in your FHMP and should have been included in the recent Cowlitz steelhead genetic study.

"The existing in-basin smolt acclimation net-pen programs are not included in the proposed future hatchery program (Table 3-17). If smolt acclimation net-pen programs are proposed, then a reduction in the on-station program that accounts for increased stray rates will be required to maintain consistency with HSRG standards.

This statement can't possibly apply to the spring chinook net pen projects in the Lower Cowlitz because there are no natural stocks spawning in the lower Cowlitz or its tributaries. Your above statement is way too broad reaching and needs to be rewritten to reflect fact.

5.4 PRODUCTIVITY TESTING

As part of the development of this Draft FHMP, the FTC has chosen to suspend productivity testing.

This is a huge issue that has major long lasting effects to the entire FHMP. The public needs far more information on why this was done by the FTC and how it affects the rest of Tacoma's FHMP. The license requires productivity testing and now this FHMP suspends it with no explanation of why it's been suspended. Again, in Phase 2 of the original FHMP (5.62.1.) under Stock Reintroduction and Recovery; it states "TO Achieve this goal, the FHMP calls for the establishment of self-sustaining coho populations in both the Tilton River and the Upper Cowlitz River, and eventually the Integration of the hatchery and natural components of the run if it can be shown that natural production can be sustainable over time" REID 25

The Draft FHMP doesn't show how or why Phase 2 has now been changed nor does it show how this new proposed change effects the actual legal requirements of Article 3.

5.5.2 Cowlitz Trout Hatchery

Prior to 2006, drain water from the Cowlitz Trout Hatchery was discharged into the lower portion of Blue Creek, downstream of the outlets to the five-acre steelhead and cutthroat trout rearing ponds. When the adults returned to the vicinity of the hatchery, a large portion of the fish held in the Cowlitz River downstream of the mouth of Blue Creek, leading to a concentrated fishery in a limited area of river.

Tacoma Power constructed a new outlet into the Cowlitz River downstream of the Blue Creek boat launch as part of the Cowlitz Hatchery Complex remodel project. The existing outfall into Blue Creek was maintained in an operational status. By routing the hatchery discharge directly into the Cowlitz River, this reduced the attraction of fish to Blue Creek and promoted their tendency to stray within the river system upstream to the Cowlitz Salmon Hatchery ladder and trap. This process was partially done to eliminate adult returns to the Cowlitz Trout Hatchery where they were not needed since all steelhead and cutthroat trout broodstock can be taken at the Cowlitz Salmon Hatchery separation facility. Another reason for the new hatchery outfall was to accommodate requests of the angling public and WDFW to spread out the fishery in the Cowlitz River upstream of the mouth of Blue Creek.

Since February 2007, WDFW has operated the outfall distribution of the Cowlitz Trout Hatchery water at an approximately 50:50 level except for the six week period in the spring when juvenile steelhead and cutthroat trout are being released from the five-acre ponds. During that time, 100% of the hatchery discharge is routed into Blue Creek.

Proposed change: Discharge will be directed on alternating weeks: in the first week, 50% to Blue Creek and 50% through the new outfall; in the next week, 100% will be released to Blue Creek. The only exception will be during the smolt release period when all water will be directed down Blue Creek as required for hatchery operations. WDFW will attempt to evaluate any changes to the fishery that this operational change creates. Future modifications to this schedule will be determined based on this evaluation.

My comments are reflected in the same comments that WDFW had sent to you on September 12 from the Cowlitz River Advisory Group. REID 26

5.6 RESIDENT FISH

Article 5.b) of the SA states that:

> *"Through 2004, the Licensee will provide funding for 50,000 pounds of trout production. Subsequent to 2004, future trout production will be based upon a review by the FTC of the success or failure of the program and any impacts on listed stocks."*

Trout provided by Tacoma Power will be released into the Cowlitz basin, consistent with the tenets of the "Washington Department of Fish and Wildlife Statewide Steelhead Management Plan: Statewide Policies, Strategies, and Actions", completed by WDFW in February of 2008. This document states the following:

> *1) Protect wild steelhead stocks from potential interactions with hatchery-origin rainbow trout:*

a) Hatchery-origin rainbow trout shall not be released in anadromous waters.

b) Hatchery-origin rainbow trout shall not be released in lakes if the release would result in significant negative impact to wild steelhead.

2) Protect wild steelhead stocks from importation, dissemination, and amplification of pathogens by adhering to the "Salmonid Disease Control Policy of the Co-managers of Washington State".

WDFW's Statewide Steelhead Management Plan limits hatchery releases into anadromous waters; therefore, WDFW will investigate and/or develop new release sites to benefit local communities in the Tilton and upper Cowlitz basins. Establishing new release sites will require time for WDFW to collaborate with the angling public, local communities, and other management entities to for the purpose of identifying and developing new locations. For the 2013 release year, WDFW will develop a new release strategy, including new release locations, that is consistent with the aforementioned key tenets of WDFW's Statewide Steelhead Management Plan.

The Settlement Agreement requires Tacoma to develop 3 different Satellite rearing locations in the **Upper Basin**. The Tilton River is not considered to be the "upper Cowlitz Basin", so none of the 3 rearing locations can be used for rearing or acclimation ponds in the Tilton River. To do so would be a direction violation of the FERC order that was issued on page 29 of its April 2006 order. REID 27

41 Comment: REID 1

Response: The draft FHMP Update includes a long-term vision for Cowlitz River fisheries resources. This update follows the requirements of the Settlement Agreement (SA) and recognizes that other viewpoints exist. The FHMP Update describes a plan and annual implementation process that is consistent with the broader long term vision for salmon recovery in the basin and meets the obligation as describe in the SA. The Update identifies actions that are consistent with other plans that have the same goals for the Cowlitz basin fisheries resources.

In 2008, the Cowlitz Fisheries Technical Team (FTC) members agreed to design and evaluate Cowlitz River fisheries and hatchery programs in the FHMP update based on their alignment and consistency with:

- The goals and objectives described in the SA and the Lower Columbia River Salmon Recovery Plan including salmon recovery goals (population designations, and viability goals, including abundance),
- Hatchery Scientific and Review Guidelines (HSRG) standards based on population designations hatchery influence on natural spawning (pHOS, PNI, and pNOB), and
- WDFW's Conservation and Sustainable Fishery Plan.

FTC members agreed that a single updated document would replace the original FHMP and that the original FHMP would remain as a stand-alone document. The FHMP update refers to the original FHMP in some cases, however, the FTC wanted to improve the format and address the five items (see Section 1.1) required to be included in the FHMP per the SA.

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42 Comment: REID 2

Response: Tacoma Power's 90% conceptual design report for Downstream Fish Passage at Cowlitz Falls Dam has recently been reviewed by the FTC. While most of the collection facility investment is planned for the Cowlitz Falls Dam area it is possible that additional collection facilities will be operated.

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43 Comment: REID 3

Response: Agreed. WDFW and NMFS are the fishery managers. The FHMP Update has been edited to more accurately reflect those roles

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44 Comment: REID 4

Response: Correct. The FTC is a recommending body to Tacoma Power and as such does not have management authority. The footnote has been corrected by eliminating the last sentence.

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45 Comment: REID 5

Response: Table 2-8 is intended to show the expected harvest rates during the life of this FHMP. WDFW attempts to maximize harvest opportunities subject to conservation constraints. These constraints can result in a large number of fish returning to the facility. Table 2-13 will be modified to account for the total number of adults arriving at the facilities and their final disposition.

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46 Comment: REID 6

Response: The productivity test currently in place in the upper Cowlitz River basin is recommended to be suspended in this draft FHMP Update. As a result (in Table 2-10) the juvenile coho marking protocols were changed to accommodate the mix of natural- and hatchery-origin adults returning to the CSH separator, and their origins in the Cowlitz River basin. This change will allow adults to be returned to their basin of origin.

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47 Comment: REID 7

Response: See response to Comment 45. Regarding crediting for natural fish production, credit is based on the number of fish released from the stress relief ponds, not for the number originally collected. This results in handling mortality being accounted for and not included in the total released numbers used in credit calculations.

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48 Comment: REID 8

Response: The FTC has consulted with the foremost expert in *Ceratomyxa shasta* (Dr. J. Bartholmew) in developing this protocol for use of fall Chinook carcasses. The habitat conditions in the upper watershed are not conducive to amplification of the host organism that harbors *C. shasta* however, the lower river habitat is known to harbor the host organism.

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49 Comment: REID 9

Response: See response to Comment 48.

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50 Comment: REID 10

Response: While the records do show large losses of spring Chinook adults during the 1960's and other brood sources were used to supplement the remaining brood, there is no evidence or record that the entire Chinook broodstock during any year was lost. Willamette River spring Chinook juveniles were released at the Cowlitz Salmon Hatchery for two years, but was not continued. Managers do not believe, based on the genetic evidence, that this brief importation significantly compromised the genetic integrity of the Cowlitz Chinook stocks. The policy for the last several decades in the Cowlitz basin has been to not allow importation of broodstock from outside the watershed. The spring Chinook stock currently in Cowlitz hatchery has been shown to be genetically distinct from all other spring Chinook stocks, including the Willamette. See additional response regarding steelhead in the Response to Comment 51.

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51 Comment: REID 11

Response: Early Chambers steelhead are not native to the basin. There are a number of studies that demonstrate that hatchery steelhead have an adverse impact on natural steelhead populations. In addition, genetic work done on the Cowlitz (2008, 2009) demonstrated the inter breeding of early Chambers steelhead with the native steelhead population. One of the guiding principals of the Settlement Agreement is to prioritize the recovery of native populations within the Cowlitz basin. For these reasons the FTC has recommended the termination of the early Chambers stock steelhead program.

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52 Comment: REID 12

Response: This issue has been debated extensively on the Cowlitz River. The best historical database of run timing prior to “significant” hatchery fish impacts on the Cowlitz River is the number of adults passed over Mayfield Dam from 1961-1968. This data shows that adult steelhead were present and migrating in the Cowlitz River in the early winter time period; however, the late winter steelhead run comprised the majority of the total run in the river.

WDFW and Tacoma Power are committed to a broodstock collection schedule for the integrated programs planned for the future that will encompass the entire run timing. For Cowlitz River steelhead that would include collecting fish from the early, mid and late-winter time periods, this is expected to restore the historic run timing of the native Cowlitz steelhead.

Regarding funding of the steelhead recycling study, due to a lack of FTC consensus on the need to do recycling or study its impacts, WDFW agreed to seek funding for this activity.

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53 Comment: REID 13

Response: The Cowlitz FHMP Update is a new approach to the issues on the Cowlitz River. The FTC acknowledges that the original FHMP did not function as intended and it was recommended to be replaced with the new approach in the FHMP Update.

The Objectives from the FHMP have been replaced with conservation and harvest goals more in keeping with intent of the FHMP license article.

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54 Comment: REID 14

Response: The Cowlitz FHMP Update document and process adapted the population status and recovery goals listed in the Lower Columbia River Fish Recovery Board Recovery Plan. There are established target escapement goals (see Table 2-1). There is uncertainty about past escapement estimates of Chinook populations in the upper Cowlitz River basins, and this plan focuses on meeting the conservation goals and the recovery actions.

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55 Comment: REID 15

Response: Under current collection efficiencies (20-30%), releases of juveniles in the upper river produce no benefit to harvest or conservation. Chinook juveniles have been planted in the upper basin to determine collection efficiencies. The FTC is recommending the priority for upper basin spring and fall Chinook should be harvest and nutrient enhancement. This can only be accomplished by adult releases.

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56 Comment: REID 16

Response: See response to Comment 50.

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57 Comment: REID 17

Response: Any unmarked fish arriving at the CSH separator is assumed to be of Tilton origin. Any unmarked fish encountered below the separator may be either lower river or Tilton origin. The stray rate of lower Cowlitz River NOR coho is assumed to be small or minimal.

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58 Comment: REID 18

Response: The FTC is recommending the productivity test be suspended. The comment is accurate; the FTC recommendation must be filed with FERC by Tacoma Power for approval.

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59 Comment: REID 19

Response: See response to Comment 46. Since productivity testing is recommended for suspension, the need to accurately identify Tilton origin coho is no longer critical. The origin of all juveniles out migrating from the Tilton River system, and the subsequent adult returns, will be ascertained by their lack of tags or marks. All will be NOR fish. The stray rates of NOR fish from lower Cowlitz River populations is assumed to be small.

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60 Comment: REID 20

Response: See response to Comment 59. The productivity testing has been recommended to be suspended, thus the need for distinguishing Tilton River origin fish is ended.

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61 Comment: REID 21

Response: For the purposes of this FHMP cutthroat are being treated as a stabilizing population. Currently cutthroat trout cannot be harvested in the upper basin to allow for protection. All upper Cowlitz River basin cutthroat encountered at the CSH will be transported to the upper river basins. WDFW should established conservation goals for this species as part of the FHMP process. The USFWS did not list sea-run cutthroat trout and thus the lack of recovery goals to guide the FTC.

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62 Comment: REID 22

Response: The original FHMP was published in 2004; however, it was not approved by FERC until 2006. The Update document will be changed to be consistent.

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63 Comment: REID 23

Response: The FTC assumes that both actions contributed to the loss of MDN to the upper watershed. It was not our intent to describe the order in which these losses occurred. To provide more clarity, the wording has been change in this section.

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64 Comment: REID 24

Response: WDFW has not completed studies on either steelhead or spring Chinook smolt net pen releases in the lower Cowlitz River. The effects of net pen rearing have been conducted in other locations and have consistently shown a higher stray rate for fish released from them. These data were cited in the body of the FHMP. We acknowledge that past hatchery practices of planting fish throughout the basin were inconsistent with the current understanding of “Best Management Practices” and these practices have been discontinued with steelhead.

However, the conservation issues associated with net pen release in the lower Cowlitz for spring Chinook are not the same as those for summer steelhead and the use of nets pens to rear spring Chinook could be considered in the future as long as they are consistent with the conservation objectives for other populations and limits to hatchery production.

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65 Comment: REID 25

Response: The FTC and Tacoma Power will continue to pursue the steps necessary to suspend productivity testing as required in the SA. This requires sound justification when filing a plan with FERC under a separate process. This information will be available to the public at that time.

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67 Comment: REID 26

Response: See Response to Comment 9.

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68 Comment: REID 27

Response: The Section being commented on is about the resident trout program and changes that may occur in the future rather than acclimation facilities. Acclimation facilities have never been considered for the trout program.

Appendix G

Credit Mechanism

APPENDIX G CREDIT MECHANISM

Credit Mechanism tables were used to develop recommendations on how to manage salmonids in the Cowlitz Basin. These tables can be found online at:

http://www.mytpu.org/tacomapower/power-system/hydro-power/licensing/cowlitz-river-project/license-documents/fisheries-committee.htm

Appendix H

APPENDIX H

This appendix includes tables (by species) that describe critical parameters, i.e. those that are uncertain and affect fish management decisions. Tables have been developed for Chinook, coho and steelhead populations designated as Primary or Contributing (Table H-1). In this appendix, Upper Cowlitz and Cispus populations are combined under the Upper Cowlitz heading.

Table H-1. Population designations of salmonids in the Cowlitz Basin.

Species	Population	Recovery Priority
Below Mayfield Dam		
Fall Chinook	L. Cowlitz	Contributing
Chum (Fall)	L. Cowlitz	Contributing
Chum (Summer)	L. Cowlitz	Contributing
Winter Steelhead	L. Cowlitz	Contributing
Coho	L. Cowlitz	Primary
Above Mayfield Dam		
Fall Chinook	U. Cowlitz	Stabilizing
Spring Chinook	U. Cowlitz	Primary
Winter Steelhead	U. Cowlitz	Primary
Coho	U. Cowlitz	Primary
Spring Chinook	Cispus	Primary
Winter Steelhead	Cispus	Primary
Coho	Cispus	Primary
Spring Chinook	Tilton	Stabilizing
Winter Steelhead	Tilton	Contributing
Coho	Tilton	Stabilizing

The tables that follow identify the parameters, the affected decisions, and the variables that need to be sampled to estimate the parameters or their indicators.

Rows highlighted in green indicate monitoring priorities (see Section 4 of the 2011 FHMP Update). Parameters, Indicators, and Variables Measured should be equal to Precision Standards presented in *NOAA Guidance for Monitoring Recovery of Salmon and Steelhead: 2011*.

Parameters have been designated as Natural (N), Hatchery (H), Status Natural (SN), Status Hatchery (SH) and Management (MP).

Table H-2. Key Assumptions for Lower Cowlitz Fall Chinook (Found in AHA data set)

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	N1	Habitat Productivity	Size of hatchery program	$Prod_{FCH}$>300 smolts/spawner	Recruits per spawner	NOR Catch, Escapement, Smolt abundance
3	N2	Habitat Capacity	Size of hatchery program	Cap_{FCH}>600,000 smolts	Abundance	NOR Catch, Escapement, Smolt abundance
2	N3	Current Relative Fitness	Size of hatchery program	<=0.5	Recruits per spawner, PNI	NOR Catch, Escapement, Smolt abundance
3	N4	SAR	Size of hatchery program	0.8 - 1 %	Recruits/Smolt	NOR Catch, Escapement, Smolt abundance
3	N5	Pre-terminal Exploitation Rates	Size of hatchery program	Historically 50% Will be reduced to below 40%	Catch/Recruitment	NOR Catch, Escapement
3	N6	Terminal/Incidental mortality Rate	Size of hatchery program	2%	Total NOR mortality/Total NOR handled	Encounter rates of NORs, mortality
3	N7	Predation Rate by HORs (from Segregated programs)	Size of hatchery program /species composition /size at release/ style of release	in-significant	NORs consumed per HORs	Monitor HOR juvenile stomach contents post release

Table H-2. Key Assumptions for Lower Cowlitz Fall Chinook (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
1	N8	Competition Factor of HORs	Size of hatchery program /species composition/size at release/style of release	in-significant	Overlap in time and space of juvenile HORs and NORs	Migration speed, timing of HOR juveniles post release, temporal and spatial distribution of NOR juveniles
1	N9	Disease	Size of hatchery program /species composition/size at release/style of release, Hatchery operations, rearing methods.	in-significant	Disease incidence in NOR juveniles, adults	Occurrence of pathogens in NOR juveniles
	*N10	Max % of NORs available for broodstock	Size of hatchery program	30%	Policy or practical constraint	NOR Broodstocking Harvest Rate
N/A	N11	Fish Collection Efficiency (if applicable to population)	Success of reintroduction efforts	N/A	Policy or practical constraint	Smolt collection, Percentage collected of index groups.

*Not part of this Monitoring and Evaluation Plan. This number is determined by NOAA.

Table H-3. Key Assumptions for Lower Cowlitz Fall Chinook Hatchery Population/Programs						
In-Hatchery Parameters						**(Found in AHA data set)**
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H1	Pre-spawning survival	Number of brood needed	90%	Total fish spawned/total fish collected for brood	Number of fish spawned, Number of fish held for brood
3	H2	Percent Females	Number of brood needed	50%	Total females collected for brood/Total fish collected for brood	Females collected for brood, total fish collected for brood
3	H3	egg to smolt survival	Number of brood needed	87%	Smolts released/Eggs collected	Eggs collected, smolts released

Table H-3 cont.						
Out-of-Hatchery Parameters						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H4	SAR	Hatchery operations, rearing methods.	0.16%	HOR recruitment/Smolts release	Combined HOR Escapement and harvest, smolts released
3	H5	Recruits/Spawner	Hatchery operations, rearing methods.	3.6	Total HOR recruits/Number of fish spawned	Total HOR runsize by Brood year, Numbers spawned by brood year, Recoveries from other hatcheries at Cowlitz by age and brood year
3	H6	Pre-terminal Exploitation Rates	Level of terminal fishing opportunity, Size of hatchery program	50%	HOR recoveries in pre-terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fisheries
3	H7	Terminal harvest Rate	Size of hatchery program	2%	HOR recoveries in terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fishery

Table H-3 cont.

Effects on Conservation and the Environment

Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H8	Stray Rate	Size of hatchery program	25%	HORS spawning naturally/Total HORs return	HOS, HOR returns to hatchery
2	H9	Relative Reproductive Success of HORs	Allowable level of census pHOS	80%	HOS smolts /spawner vs NOR smolts /spawner	Pedigree analysis (genetic marker) of naturally spawning fish

Table H-4. Annual Status and Trend Information (Lower Cowlitz Fall Chinook)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SN1	Runsize (recruitment)	Broodstock and natural escapement Management. Size of hatchery program.	Annual runsize prediction	NOR catch +NOS	NOR catch, NOS
3	SN2	Spawner Abundance	Size of hatchery program	Based on Decision rules and annual runsize predictions	NOS + HOS	NOS, HOS
3	SN3	pHOS	Size of hatchery program	same	HOS/(HOS+NOS)	HOS, NOS
3	SN4	PNI	Size of hatchery program	same	pNOB/(pNOB+pHOS)	HOB, NOB, NOS, HOS
3	SN5	Recruits per Spawner	No effect on annual basis but does affect estimate of Key Assumptions	same	Returns to natural spawning areas match estimates	NOS, NOR catch, by age

Table H-4. Annual Status and Trend Information (Lower Cowlitz Fall Chinook)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
			long-term.			
3	SN6	Pre-terminal catch	Impacts runsize prediction. Level of terminal fishing opportunity.	same	NOR recoveries in pre-terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fisheries
3	SN7	Terminal Catch	Impacts runsize prediction. Size of hatchery program (available pNOB)	same	NOR recoveries in terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fishery

Rating	Parameter Designation	Natural Production Outcomes	Decisions affected by Parameter	Population Specific Pre-season Target	Indicator	Variables Measured
3	SH1	Runsize	Level of terminal fishing opportunity. Broodstock and natural escapement Management. Hatchery program size.	Based on Decision rules and annual runsize predictions	HOR catch + HOR escapement	HOR catch, Hatchery rack returns, HOS
3	SH2	Broodstock Collected	Size of hatchery program	Based on Decision rules and annual runsize predictions	HOB + NOB	HOB, NOB
3	SH3	pNOB	Size of hatchery program. Broodstock and natural escapement Management.	same	NOB/(NOB +HOB)	NOB,HOB
	SH4	Hatchery Surplus	Size of hatchery program. Terminal fish opportunity.	same	Hatchery Rack returns-HOB-HORs upstream- NE(HORs)	Hatchery Rack returns, Hatchery fish released upstream, HOB, Hatchery fish used for NE
3	SH5	Number released	Pre-terminal,	same	Eggs taken- loss during rearing	Survival at all life

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
			terminal fishing opportunity. Future runsize predictions.			stages in hatchery
3	SH6	Pre-terminal catch	Level of terminal fishing opportunity, Broodstock and natural escapement Management.	same	HOR recoveries in pre-terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fisheries
3	SH7	Terminal Catch	Size of hatchery program (available HOB). Broodstock and natural escapement Management.	same	HOR recoveries in terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fishery

Table H-5. Management Targets for Lower Cowlitz Fall Chinook						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	MP1	Pre-terminal catch by species and fishery	Level of terminal fishing opportunity. Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in pre-terminal catch	Total HOR recoveries and sampling rates in fisheries
3	MP2	Terminal Catch by Species and Fishery	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in terminal catch	Total HOR recoveries and sampling rates in fishery
3	MP3	Terminal Catch by Month (all species)	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in monthly terminal catch	Total catch by month
3	MP4	Terminal Effort by Month	Future runsize and harvest predictions and methodology.	Policy or practical constraint	Number of anglers x days	Anglers days

Table H-6. Key Assumptions for Lower Cowlitz Coho (Found in AHA data set)

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	N1	Habitat Productivity	Size of hatchery program	$Prod_{LC}$>20 smolts/spawner	Recruits per spawner	NOR Catch, Escapement, Smolt abundance
3	N2	Habitat Capacity	Size of hatchery program	Cap_{LC}>30,000 smolts	Abundance	NOR Catch, Escapement, Smolt abundance
2	N3	Current Relative Fitness	Size of hatchery program	0.72	Recruits per spawner, PNI	NOR Catch, Escapement, Smolt abundance
3	N4	SAR	Size of hatchery program	13 %	Recruits/Smolt	NOR Catch, Escapement, Smolt abundance
3	N5	Pre-terminal Exploitation Rates	Size of hatchery program	<25%	Catch/Recruitment	NOR Catch, Escapement
3	N6	Terminal/Incidental mortality Rate	Size of hatchery program	2%	Total NOR mortality/Total NOR handled	Encounter rates of NORs, mortality
3	N7	Predation Rate by HORs (from Segregated programs)	Size of hatchery program /species composition /size at release/ style of release	in-significant	NORs consumed per HORs	Monitor HOR juvenile stomach contents post release

Table H-6. Key Assumptions for Lower Cowlitz Coho (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
1	N8	Competition Factor of HORs	Size of hatchery program /species composition/size at release/style of release	in-significant	Overlap in time and space of juvenile HORs and NORs	Migration speed, timing of HOR juveniles post release, temporal and spatial distribution of NOR juveniles
1	N9	Disease	Size of hatchery program /species composition/size at release/style of release, Hatchery operations, rearing methods.	in-significant	Disease incidence in NOR juveniles, adults	Occurrence of pathogens in NOR juveniles
	N10	Max % of NORs available for broodstock	Size of hatchery program	0%	Policy or practical constraint	NOR Broodstocking Harvest Rate
N/A	N11	Fish Collection Efficiency (if applicable to population)	Success of reintroduction efforts	N/A	Policy or practical constraint	Smolt collection, Percentage collected of index groups.

Table H-7. Key Assumptions for Lower Cowlitz Coho Hatchery Population/Programs						
In-Hatchery Parameters						**(Found in AHA data set)**
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H1	Pre-spawning survival	Number of brood needed	90%	Total fish spawned/total fish collected for brood	Number of fish spawned, Number of fish held for brood
3	H2	Percent Females	Number of brood needed	50%	Total females collected for brood/Total fish collected for brood	Females collected for brood, total fish collected for brood
3	H3	egg to smolt survival	Number of brood needed	87%	Smolts released/Eggs collected	Eggs collected, smolts released

Table H-7 cont.						
Out-of-Hatchery Parameters						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H4	SAR	Hatchery operations, rearing methods.	2.7%	HOR recruitment/Smolts release	Combined HOR Escapement and harvest, smolts released
3	H5	Recruits/Spawner	Hatchery operations, rearing methods.	28	Total HOR recruits/Number of fish spawned	Total HOR runsize by Brood year, Numbers spawned by brood year, Recoveries from other hatcheries at Cowlitz by age and brood year
3	H6	Pre-terminal Exploitation Rates	Level of terminal fishing opportunity, Size of hatchery program	50%	HOR recoveries in pre-terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fisheries
3	H7	Terminal harvest Rate	Size of hatchery program	15%	HOR recoveries in terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fishery

Table H-7 cont. *Effects on Conservation and the Environment*						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H8	Stray Rate	Size of hatchery program	0.3%	HORS spawning naturally/Total HORs return	HOS, HOR returns to hatchery
2	H9	Relative Reproductive Success of HORs	Allowable level of census pHOS	80%	HOS smolts /spawner vs NOR smolts /spawner	Pedigree analysis (genetic marker) of naturally spawning fish

Table H-8. Annual Status and Trend Information (Lower Cowlitz Coho)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SN1	Runsize (recruitment)	Broodstock and natural escapement Management. Size of hatchery program.	Annual runsize prediction	NOR catch +NOS	NOR catch, NOS
3	SN2	Spawner Abundance	Size of hatchery program	Based on Decision rules and annual runsize predictions	NOS + HOS	NOS, HOS
3	SN3	pHOS	Size of hatchery program	same	HOS/(HOS+NOS)	HOS, NOS
3	SN4	PNI	Size of hatchery program	same	pNOB/(pNOB+pHOS)	HOB, NOB, NOS, HOS
3	SN5	Recruits per Spawner	No effect on annual basis but does affect estimate of Key Assumptions	same	Returns to natural spawning areas match estimates	NOS, NOR catch, by age

Table H-8. Annual Status and Trend Information (Lower Cowlitz Coho)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
			long-term.			
3	SN6	Pre-terminal catch	Impacts runsize prediction. Level of terminal fishing opportunity.	same	NOR recoveries in pre-terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fisheries
3	SN7	Terminal Catch	Impacts runsize prediction. Size of hatchery program (available pNOB)	same	NOR recoveries in terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fishery

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
3	SH1	Runsize	Level of terminal fishing opportunity. Broodstock and natural escapement Management. Hatchery program size.	Based on Decision rules and annual runsize predictions	HOR catch + HOR escapement	HOR catch, Hatchery rack returns, HOS
3	SH2	Broodstock Collected	Size of hatchery program	Based on Decision rules and annual runsize predictions	HOB + NOB	HOB, NOB
3	SH3	pNOB	Size of hatchery program. Broodstock and natural escapement Management.	same	NOB/(NOB +HOB)	NOB,HOB
	SH4	Hatchery Surplus	Size of hatchery program. Terminal fish opportunity.	same	Hatchery Rack returns-HOB-HORs upstream- NE(HORs)	Hatchery Rack returns, Hatchery fish released upstream, HOB, Hatchery fish used for NE
3	SH5	Number released	Pre-terminal,	same	Eggs taken- loss during rearing	Survival at all life

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
			terminal fishing opportunity. Future runsize predictions.			stages in hatchery
3	SH6	Pre-terminal catch	Level of terminal fishing opportunity, Broodstock and natural escapement Management.	same	HOR recoveries in pre-terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fisheries
3	SH7	Terminal Catch	Size of hatchery program (available HOB). Broodstock and natural escapement Management.	same	HOR recoveries in terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fishery

Table H-9. Management Targets						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	MP1	Pre-terminal catch by species and fishery	Level of terminal fishing opportunity. Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in pre-terminal catch	Total HOR recoveries and sampling rates in fisheries
3	MP2	Terminal Catch by Species and Fishery	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in terminal catch	Total HOR recoveries and sampling rates in fishery
3	MP3	Terminal Catch by Month (all species)	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in monthly terminal catch	Total catch by month
3	MP4	Terminal Effort by Month	Future runsize and harvest predictions and methodology.	Policy or practical constraint	Number of anglers x days	Angler days

Table H-10. Key Assumptions for Lower Cowlitz Late Winter Steelhead (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	N1	Habitat Productivity	Size of hatchery program	$Prod_{LWS}$ >23 smolts/spawner	Recruits per spawner	NOR Catch, Escapement, Smolt abundance
3	N2	Habitat Capacity	Size of hatchery program	Cap_{LWS} 7300 smolts	Abundance	NOR Catch, Escapement, Smolt abundance
2	N3	Current Relative Fitness	Size of hatchery program	<=0.5	Recruits per spawner, PNI	NOR Catch, Escapement, Smolt abundance
3	N4	SAR	Size of hatchery program	>10.0%	Recruits/Smolt	NOR Catch, Escapement, Smolt abundance
3	N5	Pre-terminal Exploitation Rates	Size of hatchery program	<5%	Catch/Recruitment	NOR Catch, Escapement
3	N6	Terminal/Incidental mortality Rate	Size of hatchery program	<2%	Total NOR mortality/Total NOR handled	Encounter rates of NORs, mortality
3	N7	Predation Rate by HORs (from Segregated programs)	Size of hatchery program /species composition /size at release/ style of release	in-significant	NORs consumed per HORs	Monitor HOR juvenile stomach contents post release

Table H-10. Key Assumptions for Lower Cowlitz Late Winter Steelhead (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
1	N8	Competition Factor of HORs	Size of hatchery program /species composition/size at release/style of release	in-significant	Overlap in time and space of juvenile HORs and NORs	Migration speed, timing of HOR juveniles post release, temporal and spatial distribution of NOR juveniles
1	N9	Disease	Size of hatchery program /species composition/size at release/style of release, Hatchery operations, rearing methods.	in-significant	Disease incidence in NOR juveniles, adults	Occurrence of pathogens in NOR juveniles
	N10	Max % of NORs available for broodstock	Size of hatchery program	30%	Policy or practical constraint	NOR Broodstocking Harvest Rate
N/A	N11	Fish Collection Efficiency (if applicable to population)	Success of reintroduction efforts	N/A	Policy or practical constraint	Smolt collection, Percentage collected of index groups.

Table H-11. Key Assumptions for Lower Cowlitz Later Winter Steelhead Hatchery Population/Programs

In-Hatchery Parameters **(Found in AHA data set)**

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	H1	Pre-spawning survival	Number of brood needed	90%	Total fish spawned/total fish collected for brood	Number of fish spawned, Number of fish held for brood
3	H2	Percent Females	Number of brood needed	50%	Total females collected for brood/Total fish collected for brood	Females collected for brood, total fish collected for brood
3	H3	egg to smolt survival	Number of brood needed	87%	Smolts released/Eggs collected	Eggs collected, smolts released

Table H-11 cont.						
Out-of-Hatchery Parameters						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H4	SAR	Hatchery operations, rearing methods.	1.0%	HOR recruitment/Smolts release	Combined HOR Escapement and harvest, smolts released
3	H5	Recruits/Spawner	Hatchery operations, rearing methods.	20	Total HOR recruits/Number of fish spawned	Total HOR runsize by Brood year, Numbers spawned by brood year, Recoveries from other hatcheries at Cowlitz by age and brood year
3	H6	Pre-terminal Exploitation Rates	Level of terminal fishing opportunity, Size of hatchery program	<5%	HOR recoveries in pre-terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fisheries
3	H7	Terminal harvest Rate	Size of hatchery program	>50%	HOR recoveries in terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fishery

Table H-11 cont.

Effects on Conservation and the Environment

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	H8	Stray Rate	Size of hatchery program	10%	HORS spawning naturally/Total HORs return	HOS, HOR returns to hatchery
2	H9	Relative Reproductive Success of HORs	Allowable level of census pHOS	80%	HOS smolts /spawner vs NOR smolts /spawner	Pedigree analysis (genetic marker) of naturally spawning fish

Table H-12. Annual Status and Trend Information (Lower Cowlitz Steelhead)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SN1	Runsize (recruitment)	Broodstock and natural escapement Management. Size of hatchery program.	Annual runsize prediction	NOR catch +NOS	NOR catch, NOS
3	SN2	Spawner Abundance	Size of hatchery program	Based on Decision rules and annual runsize predictions	NOS + HOS	NOS, HOS
3	SN3	pHOS	Size of hatchery program	same	HOS/(HOS+NOS)	HOS, NOS
3	SN4	PNI	Size of hatchery program	same	pNOB/(pNOB+pHOS)	HOB, NOB, NOS, HOS
3	SN5	Recruits per Spawner	No effect on annual basis but does affect estimate of Key Assumptions	same	Returns to natural spawning areas match estimates	NOS, NOR catch, by age

Table H-12. Annual Status and Trend Information (Lower Cowlitz Steelhead)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
			long-term.			
3	SN6	Pre-terminal catch	Impacts runsize prediction. Level of terminal fishing opportunity.	same	NOR recoveries in pre-terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fisheries
3	SN7	Terminal Catch	Impacts runsize prediction. Size of hatchery program (available pNOB)	same	NOR recoveries in terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fishery

Rating	Parameter Designation	Natural Production Outcomes	Decisions affected by Parameter	Population Specific Pre-season Target	Indicator	Variables Measured
3	SH1	Runsize	Level of terminal fishing opportunity. Broodstock and natural escapement Management. Hatchery program size.	Based on Decision rules and annual runsize predictions	HOR catch + HOR escapement	HOR catch, Hatchery rack returns, HOS
3	SH2	Broodstock Collected	Size of hatchery program	Based on Decision rules and annual runsize predictions	HOB + NOB	HOB, NOB
3	SH3	pNOB	Size of hatchery program. Broodstock and natural escapement Management.	same	NOB/(NOB +HOB)	NOB,HOB
	SH4	Hatchery Surplus	Size of hatchery program. Terminal fish opportunity.	same	Hatchery Rack returns-HOB-HORs upstream- NE(HORs)	Hatchery Rack returns, Hatchery fish released upstream, HOB, Hatchery fish used for NE
3	SH5	Number released	Pre-terminal,	same	Eggs taken- loss during rearing	Survival at all life

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
			terminal fishing opportunity. Future runsize predictions.			stages in hatchery
3	SH6	Pre-terminal catch	Level of terminal fishing opportunity, Broodstock and natural escapement Management.	same	HOR recoveries in pre-terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fisheries
3	SH7	Terminal Catch	Size of hatchery program (available HOB). Broodstock and natural escapement Management.	same	HOR recoveries in terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fishery

Table H-13. Management Targets for Lower Cowlitz Steelhead						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	MP1	Pre-terminal catch by species and fishery	Level of terminal fishing opportunity. Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in pre-terminal catch	Total HOR recoveries and sampling rates in fisheries
3	MP2	Terminal Catch by Species and Fishery	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in terminal catch	Total HOR recoveries and sampling rates in fishery
3	MP3	Terminal Catch by Month (all species)	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in monthly terminal catch	Total catch by month
3	MP4	Terminal Effort by Month	Future runsize and harvest predictions and methodology.	Policy or practical constraint	Number of anglers x days	Angler days

Table H-14. Key Assumptions for Upper Cowlitz Spring Chinook (Includes Cispus) (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	N1	Habitat Productivity	If and when recovery is achieved.	$Prod_{USC}$ >35 smolts/spawner	Recruits per spawner	NOR Catch, Escapement, Smolt abundance
3	N2	Habitat Capacity	If and when recovery is achieved.	Cap_{USC} >99,000 smolts	Abundance	NOR Catch, Escapement, Smolt abundance
2	N3	Current Relative Fitness	Number of hatchery fish transported upstream.	<=0.5	Recruits per spawner, PNI	NOR Catch, Escapement, Smolt abundance
3	N4	SAR	If and when recovery is achieved	1.1%	Recruits/Smolt	NOR Catch, Escapement, Smolt abundance
3	N5	Pre-terminal Exploitation Rates	If and when recovery is achieved.	<10%	Catch/Recruitment	NOR Catch, Escapement
3	N6	Terminal/Incidental mortality Rate	If and when recovery is achieved.	1%	Total NOR mortality/Total NOR handled	Encounter rates of NORs, mortality
3	N7	Predation Rate by HORs (from Segregated programs)	Size of hatchery program /species composition /size at release/ style of release	in-significant	NORs consumed per HORs	Monitor HOR juvenile stomach contents post release

Table H-14. Key Assumptions for Upper Cowlitz Spring Chinook (Includes Cispus) (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
1	N8	Competition Factor of HORs	Size of hatchery program /species composition/size at release/style of release	in-significant	Overlap in time and space of juvenile HORs and NORs	Migration speed, timing of HOR juveniles post release, temporal and spatial distribution of NOR juveniles
1	N9	Disease	Size of hatchery program /species composition/size at release/style of release, Hatchery operations, rearing methods.	in-significant	Disease incidence in NOR juveniles, adults	Occurrence of pathogens in NOR juveniles
	*N10	Max % of NORs available for broodstock	Size of hatchery program	0%	Policy or practical constraint	NOR Broodstocking Harvest Rate
3	N11	Fish Collection Efficiency (if applicable to population)	If and when recovery is achieved. When Decision rule triggers engage.	20%	Policy or practical constraint	Smolt collection, Percentage collected of index groups.

*Not part of this Monitoring and Evaluation Plan. This number is determined by NOAA.

Table H-15. Key Assumptions for Upper Cowlitz Spring Chinook Hatchery Population/Programs						
In-Hatchery Parameters						**(Found in AHA data set)**
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H1	Pre-spawning survival	Number of brood needed	N/A	Total fish spawned/total fish collected for brood	Number of fish spawned, Number of fish held for brood
3	H2	Percent Females	Number of brood needed	N/A	Total females collected for brood/Total fish collected for brood	Females collected for brood, total fish collected for brood
3	H3	egg to smolt survival	Number of brood needed	N/A	Smolts released/Eggs collected	Eggs collected, smolts released

Table H-15 cont.						
Out-of-Hatchery Parameters						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H4	SAR	Hatchery operations, rearing methods.	N/A	HOR recruitment/Smolts release	Combined HOR Escapement and harvest, smolts released
3	H5	Recruits/Spawner	Hatchery operations, rearing methods.	N/A	Total HOR recruits/Number of fish spawned	Total HOR runsize by Brood year, Numbers spawned by brood year, Recoveries from other hatcheries at Cowlitz by age and brood year
3	H6	Pre-terminal Exploitation Rates	Level of terminal fishing opportunity, Size of hatchery program	N/A	HOR recoveries in pre-terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fisheries
3	H7	Terminal harvest Rate	Number of adults transported upstream	N/A	HOR recoveries in terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fishery

Table H-15 cont.

Effects on Conservation and the Environment

Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H8	Stray Rate	Size of hatchery program	N/A	HORS spawning naturally/Total HORs return	HOS, HOR returns to hatchery
2	H9	Relative Reproductive Success of HORs	Allowable level of census pHOS	N/A	HOS smolts /spawner vs NOR smolts /spawner	Pedigree analysis (genetic marker) of naturally spawning fish

Table H-16. Annual Status and Trend Information (Upper Cowlitz Spring Chinook)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SN1	Runsize (recruitment)	Broodstock and natural escapement management. Size of hatchery program.	Annual runsize prediction	NOR catch +NOS	NOR catch, NOS
3	SN2	Spawner Abundance	Size of hatchery program	Based on Decision rules and annual runsize predictions	NOS + HOS	NOS, HOS
3	SN3	pHOS	Size of hatchery program	same	HOS/(HOS+NOS)	HOS, NOS
3	SN4	PNI	Size of hatchery program	same	pNOB/(pNOB+pHOS)	HOB, NOB, NOS, HOS
3	SN5	Recruits per Spawner	No effect on annual basis but does affect estimate of Key Assumptions	same	Returns to natural spawning areas match estimates	NOS, NOR catch, by age

Table H-16. Annual Status and Trend Information (Upper Cowlitz Spring Chinook)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
			long-term.			
3	SN6	Pre-terminal catch	Impacts runsize prediction. Level of terminal fishing opportunity.	same	NOR recoveries in pre-terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fisheries
3	SN7	Terminal Catch	Impacts runsize prediction. Size of hatchery program (available pNOB)	same	NOR recoveries in terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fishery

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
3	SH1	Runsize	Level of terminal fishing opportunity. Broodstock and natural escapement Management. Hatchery program size.	Based on Decision rules and annual runsize predictions	HOR catch + HOR escapement	HOR catch, Hatchery rack returns, HOS
3	SH3	pNOB	Size of hatchery program. Broodstock and natural escapement Management.	same	NOB/(NOB +HOB)	NOB,HOB
	SH4	Hatchery Surplus	Size of hatchery program. Terminal fish opportunity.	same	Hatchery Rack returns-HOB-HORs upstream- NE(HORs)	Hatchery Rack returns, Hatchery fish released upstream, HOB, Hatchery fish used for NE
3	SH5	Number released	Pre-terminal, terminal fishing opportunity. Future runsize predictions.	same	Eggs taken- loss during rearing	Survival at all life stages in hatchery

Rating	Parameter Designation	Natural Production Outcomes	Decisions affected by Parameter	Population Specific Pre-season Target	Indicator	Variables Measured
3	SH6	Pre-terminal catch	Level of terminal fishing opportunity, Broodstock and natural escapement Management.	same	HOR recoveries in pre-terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fisheries
3	SH7	Terminal Catch	Size of hatchery program (available HOB). Broodstock and natural escapement Management.	same	HOR recoveries in terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fishery

Table H-17. Management Targets for Upper Cowlitz Spring Chinook						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	MP1	Pre-terminal catch by species and fishery	Level of terminal fishing opportunity. Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in pre-terminal catch	Total HOR recoveries and sampling rates in fisheries
3	MP2	Terminal Catch by Species and Fishery	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in terminal catch	Total HOR recoveries and sampling rates in fishery
3	MP3	Terminal Catch by Month (all species)	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in monthly terminal catch	Total catch by month
3	MP4	Terminal Effort by Month	Future runsize and harvest predictions and methodology.	Policy or practical constraint	Number of anglers x days	Angler days

Table H-18. Key Assumptions for Upper Cowlitz Coho (Includes Cispus) (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	N1	Habitat Productivity	Size of hatchery program	$Prod_{UCC}$>20 smolts/spawner	Recruits per spawner	NOR Catch, Escapement, Smolt abundance
3	N2	Habitat Capacity	Size of hatchery program	Cap_{UCC}>196,900 smolts	Abundance	NOR Catch, Escapement, Smolt abundance
2	N3	Current Relative Fitness	Size of hatchery program	<=0.5	Recruits per spawner, PNI	NOR Catch, Escapement, Smolt abundance
3	N4	SAR	Size of hatchery program	2.4%	Recruits/Smolt	NOR Catch, Escapement, Smolt abundance
3	N5	Pre-terminal Exploitation Rates	Size of hatchery program	<20%	Catch/Recruitment	NOR Catch, Escapement
3	N6	Terminal/Incidental mortality Rate	Size of hatchery program/number of HORs transported upstream.	2%	Total NOR mortality/Total NOR handled	Encounter rates of NORs, mortality
3	N7	Predation Rate by HORs (from Segregated programs)	Size of hatchery program /species composition /size at release/ style of release	in-significant	NORs consumed per HORs	Monitor HOR juvenile stomach contents post release

Table H-18. Key Assumptions for Upper Cowlitz Coho (Includes Cispus) (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
1	N8	Competition Factor of HORs	Size of hatchery program /species composition/size at release/style of release	in-significant	Overlap in time and space of juvenile HORs and NORs	Migration speed, timing of HOR juveniles post release, temporal and spatial distribution of NOR juveniles
1	N9	Disease	Size of hatchery program /species composition/size at release/style of release, Hatchery operations, rearing methods.	in-significant	Disease incidence in NOR juveniles, adults	Occurrence of pathogens in NOR juveniles
	*N10	Max % of NORs available for broodstock	Size of hatchery program	30%@ FCE above 30%, below FCE 30%, no limit	Policy or practical constraint	NOR Broodstocking Harvest Rate
	N11	Fish Collection Efficiency (if applicable to population)	Success of reintroduction efforts	40%	Policy or practical constraint	Smolt collection, Percentage collected of index groups.

*Not part of this Monitoring and Evaluation Plan. This number is determined by NOAA.

Table H-19. Key Assumptions for Upper Cowlitz Coho Hatchery Population/Programs

In-Hatchery Parameters **(Found in AHA data set)**

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	H1	Pre-spawning survival	Number of brood needed	90%	Total fish spawned/total fish collected for brood	Number of fish spawned, Number of fish held for brood
3	H2	Percent Females	Number of brood needed	50%	Total females collected for brood/Total fish collected for brood	Females collected for brood, total fish collected for brood
3	H3	egg to smolt survival	Number of brood needed	76%	Smolts released/Eggs collected	Eggs collected, smolts released

Table H-19 cont.

Out-of-Hatchery Parameters

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	H4	SAR	Hatchery operations, rearing methods.	2.65%	HOR recruitment/Smolts release	Combined HOR Escapement and harvest, smolts released
3	H5	Recruits/Spawner	Hatchery operations, rearing methods.	31.0	Total HOR recruits/Number of fish spawned	Total HOR runsize by Brood year, Numbers spawned by brood year, Recoveries from other hatcheries at Cowlitz by age and brood year
3	H6	Pre-terminal Exploitation Rates	Level of terminal fishing opportunity, Size of hatchery program	>30%	HOR recoveries in pre-terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fisheries
3	H7	Terminal harvest Rate	Size of hatchery program/number of HORs transported upstream.	>15%	HOR recoveries in terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fishery

Table H-19 cont.

Effects on Conservation and the Environment

Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H8	Stray Rate	Size of hatchery program	0.3%	HORS spawning naturally/Total HORs return	HOS, HOR returns to hatchery
2	H9	Relative Reproductive Success of HORs	Allowable level of census pHOS	80%	HOS smolts /spawner vs NOR smolts /spawner	Pedigree analysis (genetic marker) of naturally spawning fish

Table H-20. Annual Status and Trend Information (Upper Cowlitz Coho)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SN1	Runsize (recruitment)	Broodstock and natural escapement Management. Size of hatchery program.	Annual runsize prediction	NOR catch +NOS	NOR catch, NOS
3	SN2	Spawner Abundance	Size of hatchery program	Based on Decision rules and annual runsize predictions	NOS + HOS	NOS, HOS
3	SN3	pHOS	Size of hatchery program/number of HORs transported upstream	same	HOS/(HOS+NOS)	HOS, NOS
3	SN4	PNI	Size of hatchery program	same	pNOB/(pNOB+pHOS)	HOB, NOB, NOS, HOS
3	SN5	Recruits per Spawner	No effect on annual basis but does affect estimate of Key Assumptions long-term.	same	Returns to natural spawning areas match estimates	NOS, NOR catch, by age
3	SN6	Pre-terminal catch	Impacts runsize	same	NOR recoveries in pre-terminal	Total NOR recoveries

Table H-20. Annual Status and Trend Information (Upper Cowlitz Coho)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
			prediction. Level of terminal fishing opportunity.		catch/total NOR runsize	and sampling rates in fisheries
3	SN7	Terminal Catch	Impacts runsize prediction. Size of hatchery program (available pNOB), number of HORs transported upstream.	same	NOR recoveries in terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fishery

Rating	Parameter Designation	Natural Production Outcomes	Decisions affected by Parameter	Population Specific Pre-season Target	Indicator	Variables Measured
3	SH1	Runsize	Level of terminal fishing opportunity. Broodstock and natural escapement Management. Hatchery program size.	Based on Decision rules and annual runsize predictions	HOR catch + HOR escapement	HOR catch, Hatchery rack returns, HOS
3	SH2	Broodstock Collected	Size of hatchery program	Based on Decision rules and annual runsize predictions	HOB + NOB	HOB, NOB
3	SH3	pNOB	Size of hatchery program. Broodstock and natural escapement Management.	same	NOB/(NOB +HOB)	NOB,HOB
	SH4	Hatchery Surplus	Size of hatchery program. Terminal fish opportunity.	same	Hatchery Rack returns-HOB-HORs upstream- NE(HORs)	Hatchery Rack returns, Hatchery fish released upstream, HOB, Hatchery fish used for NE
3	SH5	Number released	Pre-terminal,	same	Eggs taken- loss during rearing	Survival at all life

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
			terminal fishing opportunity. Future runsize predictions.			stages in hatchery
3	SH6	Pre-terminal catch	Level of terminal fishing opportunity, Broodstock and natural escapement Management.	same	HOR recoveries in pre-terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fisheries
3	SH7	Terminal Catch	Size of hatchery program (available HOB). Broodstock and natural escapement Management. Number of HORs transported upstream.	same	HOR recoveries in terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fishery

Table H-21. Management Targets for Upper Cowlitz Coho

Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	MP1	Pre-terminal catch by species and fishery	Level of terminal fishing opportunity. Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in pre-terminal catch	Total HOR recoveries and sampling rates in fisheries
3	MP2	Terminal Catch by Species and Fishery	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in terminal catch	Total HOR recoveries and sampling rates in fishery
3	MP3	Terminal Catch by Month (all species)	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in monthly terminal catch	Total catch by month
3	MP4	Terminal Effort by Month	Future runsize and harvest predictions and methodology.	Policy or practical constraint	Number of anglers x days	Angler days

Table H-22. Key Assumptions for Upper Cowlitz Steelhead (Includes Cispus) (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	N1	Habitat Productivity	Volitional upstream passage	$Prod_{UCSH}$>19 smolts/spawner	Recruits per spawner	NOR Catch, Escapement, Smolt abundance
3	N2	Habitat Capacity	Volitional upstream passage	Cap_{UCSH}>12,000 smolts	Abundance	NOR Catch, Escapement, Smolt abundance
2	N3	Current Relative Fitness	Size of hatchery program	<=0.5	Recruits per spawner, PNI	NOR Catch, Escapement, Smolt abundance
3	N4	SAR	Volitional upstream passage	4.72%	Recruits/Smolt	NOR Catch, Escapement, Smolt abundance
3	N5	Pre-terminal Exploitation Rates	Size of hatchery program	<5%	Catch/Recruitment	NOR Catch, Escapement
3	N6	Terminal/Incidental mortality Rate	Volitional upstream passage	3%	Total NOR mortality/Total NOR handled	Encounter rates of NORs, mortality
3	N7	Predation Rate by HORs (from Segregated programs)	Size of hatchery program /species composition /size at release/ style of release	in-significant	NORs consumed per HORs	Monitor HOR juvenile stomach contents post release

Table H-22. Key Assumptions for Upper Cowlitz Steelhead (Includes Cispus) (Found in AHA data set)

Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
1	N8	Competition Factor of HORs	Size of hatchery program /species composition/size at release/style of release	in-significant	Overlap in time and space of juvenile HORs and NORs	Migration speed, timing of HOR juveniles post release, temporal and spatial distribution of NOR juveniles
1	N9	Disease	Size of hatchery program /species composition/size at release/style of release, Hatchery operations, rearing methods.	in-significant	Disease incidence in NOR juveniles, adults	Occurrence of pathogens in NOR juveniles
	*N10	Max % of NORs available for broodstock	Size of hatchery program	30%@ FCE above 30%, below FCE 30%, no limit	Policy or practical constraint	NOR Broodstocking Harvest Rate
	N11	Fish Collection Efficiency (if applicable to population)	Success of reintroduction efforts	40%	Policy or practical constraint	Smolt collection, Percentage collected of index groups.

*Not part of this Monitoring and Evaluation Plan. This number is determined by NOAA.

Table H-23. Key Assumptions for Upper Cowlitz Coho Hatchery Population/Programs						
In-Hatchery Parameters						**(Found in AHA data set)**
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H1	Pre-spawning survival	Number of brood needed	90%	Total fish spawned/total fish collected for brood	Number of fish spawned, Number of fish held for brood
3	H2	Percent Females	Number of brood needed	50%	Total females collected for brood/Total fish collected for brood	Females collected for brood, total fish collected for brood
3	H3	egg to smolt survival	Number of brood needed	76%	Smolts released/Eggs collected	Eggs collected, smolts released

Table H-23 cont.

Out-of-Hatchery Parameters

Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H4	SAR	Hatchery operations, rearing methods.	2.65%	HOR recruitment/Smolts release	Combined HOR Escapement and harvest, smolts released
3	H5	Recruits/Spawner	Hatchery operations, rearing methods.	31.0	Total HOR recruits/Number of fish spawned	Total HOR runsize by Brood year, Numbers spawned by brood year, Recoveries from other hatcheries at Cowlitz by age and brood year
3	H6	Pre-terminal Exploitation Rates	Level of terminal fishing opportunity, Size of hatchery program	>30%	HOR recoveries in pre-terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fisheries
3	H7	Terminal harvest Rate	Size of hatchery program	>15%	HOR recoveries in terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fishery

Table H-23 cont.

Effects on Conservation and the Environment

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	H8	Stray Rate	Size of hatchery program	0.3%	HORS spawning naturally/Total HORs return	HOS, HOR returns to hatchery
2	H9	Relative Reproductive Success of HORs	Allowable level of census pHOS	80%	HOS smolts /spawner vs NOR smolts /spawner	Pedigree analysis (genetic marker) of naturally spawning fish

Table H-24. Annual Status and Trend Information (Upper Cowlitz Steelhead)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SN1	Runsize (recruitment)	Broodstock and natural escapement Management. Size of hatchery program.	Annual runsize prediction	NOR catch +NOS	NOR catch, NOS
3	SN2	Spawner Abundance	Size of hatchery program	Based on Decision rules and annual runsize predictions	NOS + HOS	NOS, HOS
3	SN3	pHOS	Size of hatchery program	same	HOS/(HOS+NOS)	HOS, NOS
3	SN4	PNI	Size of hatchery program	same	pNOB/(pNOB+pHOS)	HOB, NOB, NOS, HOS
3	SN5	Recruits per Spawner	No effect on annual basis but does affect estimate of Key Assumptions	same	Returns to natural spawning areas match estimates	NOS, NOR catch, by age

Table H-24. Annual Status and Trend Information (Upper Cowlitz Steelhead)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
			long-term.			
3	SN6	Pre-terminal catch	Impacts runsize prediction. Level of terminal fishing opportunity.	same	NOR recoveries in pre-terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fisheries
3	SN7	Terminal Catch	Impacts runsize prediction. Size of hatchery program (available pNOB)	same	NOR recoveries in terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fishery

Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SH1	Runsize	Level of terminal fishing opportunity. Broodstock and natural escapement Management. Hatchery program size.	Based on Decision rules and annual runsize predictions	HOR catch + HOR escapement	HOR catch, Hatchery rack returns, HOS
3	SH2	Broodstock Collected	Size of hatchery program	Based on Decision rules and annual runsize predictions	HOB + NOB	HOB, NOB
3	SH3	pNOB	Size of hatchery program. Broodstock and natural escapement Management.	same	NOB/(NOB +HOB)	NOB,HOB
	SH4	Hatchery Surplus	Size of hatchery program. Terminal fish opportunity.	same	Hatchery Rack returns-HOB-HORs upstream- NE(HORs)	Hatchery Rack returns, Hatchery fish released upstream, HOB, Hatchery fish used for NE
3	SH5	Number released	Pre-terminal,	same	Eggs taken- loss during rearing	Survival at all life

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
			terminal fishing opportunity. Future runsize predictions.			stages in hatchery
3	SH6	Pre-terminal catch	Level of terminal fishing opportunity, Broodstock and natural escapement Management.	same	HOR recoveries in pre-terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fisheries
3	SH7	Terminal Catch	Size of hatchery program (available HOB). Broodstock and natural escapement Management.	same	HOR recoveries in terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fishery

Table H-25. Management Targets for Upper Cowlitz Steelhead

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
3	MP1	Pre-terminal catch by species and fishery	Level of terminal fishing opportunity. Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in pre-terminal catch	Total HOR recoveries and sampling rates in fisheries
3	MP2	Terminal Catch by Species and Fishery	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in terminal catch	Total HOR recoveries and sampling rates in fishery
3	MP3	Terminal Catch by Month (all species)	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in monthly terminal catch	Total catch by month
3	MP4	Terminal Effort by Month	Future runsize and harvest predictions and methodology.	Policy or practical constraint	Number of anglers x days	Angler days

Table H-26. Key Assumptions for Tilton River Winter Steelhead (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	N1	Habitat Productivity	Volitional upstream passage	$Prod_{TWS}$>10 smolts/spawner	Recruits per spawner	NOR Catch, Escapement, Smolt abundance
3	N2	Habitat Capacity	Volitional upstream passage	Cap_{TWS}>1660 smolts	Abundance	NOR Catch, Escapement, Smolt abundance
2	N3	Current Relative Fitness	Size of hatchery program	<=0.5	Recruits per spawner, PNI	NOR Catch, Escapement, Smolt abundance
3	N4	SAR	Volitional upstream passage	7.91%	Recruits/Smolt	NOR Catch, Escapement, Smolt abundance
3	N5	Pre-terminal Exploitation Rates	Size of hatchery program	<5%	Catch/Recruitment	NOR Catch, Escapement
3	N6	Terminal/Incidental mortality Rate	Volitional upstream passage	2%	Total NOR mortality/Total NOR handled	Encounter rates of NORs, mortality
3	N7	Predation Rate by HORs (from Segregated programs)	Size of hatchery program /species composition /size at release/ style of release	in-significant	NORs consumed per HORs	Monitor HOR juvenile stomach contents post release

Table H-26. Key Assumptions for Tilton River Winter Steelhead (Found in AHA data set)						
Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
1	N8	Competition Factor of HORs	Size of hatchery program /species composition/size at release/style of release	in-significant	Overlap in time and space of juvenile HORs and NORs	Migration speed, timing of HOR juveniles post release, temporal and spatial distribution of NOR juveniles
1	N9	Disease	Size of hatchery program /species composition/size at release/style of release, Hatchery operations, rearing methods.	in-significant	Disease incidence in NOR juveniles, adults	Occurrence of pathogens in NOR juveniles
	*N10	Max % of NORs available for broodstock	Size of hatchery program	0%	Policy or practical constraint	NOR Broodstocking Harvest Rate
3	N11	Fish Collection Efficiency (if applicable to population)	Volitional upstream passage	67%	Policy or practical constraint	Smolt collection, Percentage collected of index groups.

*Not part of this Monitoring and Evaluation Plan. This number is determined by NOAA.

Table H-27. Key Assumptions for Tilton River Winter Steelhead Hatchery Population/Programs

In-Hatchery Parameters **(Found in AHA data set)**

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	H1	Pre-spawning survival	Number of brood needed	N/A	Total fish spawned/total fish collected for brood	Number of fish spawned, Number of fish held for brood
3	H2	Percent Females	Number of brood needed	N/A	Total females collected for brood/Total fish collected for brood	Females collected for brood, total fish collected for brood
3	H3	egg to smolt survival	Number of brood needed	N/A	Smolts released/Eggs collected	Eggs collected, smolts released

Table H-27 cont.

Out-of-Hatchery Parameters

Rating	*Parameter Designation*	*Parameters*	*Decisions affected by Parameter*	*Hypotheses (Population Specific)*	*Indicator*	*Variables Measured*
3	H4	SAR	Hatchery operations, rearing methods.	N/A	HOR recruitment/Smolts release	Combined HOR Escapement and harvest, smolts released
3	H5	Recruits/Spawner	Hatchery operations, rearing methods.	N/A	Total HOR recruits/Number of fish spawned	Total HOR runsize by Brood year, Numbers spawned by brood year, Recoveries from other hatcheries at Cowlitz by age and brood year
3	H6	Pre-terminal Exploitation Rates	Level of terminal fishing opportunity, Size of hatchery program	N/A	HOR recoveries in pre-terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fisheries
3	H7	Terminal harvest Rate	Size of hatchery program	N/A	HOR recoveries in terminal catch/total HOR recoveries	Total HOR recoveries and sampling rates in fishery

Table H-27 cont.

Effects on Conservation and the Environment

Rating	***Parameter Designation***	***Parameters***	***Decisions affected by Parameter***	***Hypotheses (Population Specific)***	***Indicator***	***Variables Measured***
3	H8	Stray Rate	Size of hatchery program	N/A	HORS spawning naturally/Total HORs return	HOS, HOR returns to hatchery
2	H9	Relative Reproductive Success of HORs	Allowable level of census pHOS	N/A	HOS smolts /spawner vs NOR smolts /spawner	Pedigree analysis (genetic marker) of naturally spawning fish

Table H-28. Annual Status and Trend Information (Tilton Winter Steelhead)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	SN1	Runsize (recruitment)	Broodstock and natural escapement Management. Size of hatchery program.	Annual runsize prediction	NOR catch +NOS	NOR catch, NOS
3	SN2	Spawner Abundance	Size of hatchery program	Based on Decision rules and annual runsize predictions	NOS + HOS	NOS, HOS
3	SN3	pHOS	Size of hatchery program	same	HOS/(HOS+NOS)	HOS, NOS
3	SN4	PNI	Size of hatchery program	same	pNOB/(pNOB+pHOS)	HOB, NOB, NOS, HOS
3	SN5	Recruits per Spawner	No effect on annual basis but does affect estimate of Key Assumptions	same	Returns to natural spawning areas match estimates	NOS, NOR catch, by age

Table H-28. Annual Status and Trend Information (Tilton Winter Steelhead)						
Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
			long-term.			
3	SN6	Pre-terminal catch	Impacts runsize prediction. Level of terminal fishing opportunity.	same	NOR recoveries in pre-terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fisheries
3	SN7	Terminal Catch	Impacts runsize prediction. Size of hatchery program (available pNOB)	same	NOR recoveries in terminal catch/total NOR runsize	Total NOR recoveries and sampling rates in fishery

Rating	*Parameter Designation*	*Natural Production Outcomes*	*Decisions affected by Parameter*	*Population Specific Pre-season Target*	*Indicator*	*Variables Measured*
3	SH1	Runsize	Level of terminal fishing opportunity. Broodstock and natural escapement Management. Hatchery program size.	Based on Decision rules and annual runsize predictions	HOR catch + HOR escapement	HOR catch, Hatchery rack returns, HOS
3	SH2	Broodstock Collected	Size of hatchery program	Based on Decision rules and annual runsize predictions	HOB + NOB	HOB, NOB
3	SH3	pNOB	Size of hatchery program. Broodstock and natural escapement Management.	same	NOB/(NOB +HOB)	NOB,HOB
	SH4	Hatchery Surplus	Size of hatchery program. Terminal fish opportunity.	same	Hatchery Rack returns-HOB-HORs upstream- NE(HORs)	Hatchery Rack returns, Hatchery fish released upstream, HOB, Hatchery fish used for NE
3	SH5	Number released	Pre-terminal,	same	Eggs taken- loss during rearing	Survival at all life

Rating	Parameter Designation	Natural Production Outcomes	Decisions affected by Parameter	Population Specific Pre-season Target	Indicator	Variables Measured
			terminal fishing opportunity. Future runsize predictions.			stages in hatchery
3	SH6	Pre-terminal catch	Level of terminal fishing opportunity, Broodstock and natural escapement Management.	same	HOR recoveries in pre-terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fisheries
3	SH7	Terminal Catch	Size of hatchery program (available HOB). Broodstock and natural escapement Management.	same	HOR recoveries in terminal catch/total HOR runsize	Total HOR recoveries and sampling rates in fishery

Table H-29. Management Targets for Tilton Winter Steelhead

Rating	***Parameter Designation***	***Natural Production Outcomes***	***Decisions affected by Parameter***	***Population Specific Pre-season Target***	***Indicator***	***Variables Measured***
3	MP1	Pre-terminal catch by species and fishery	Level of terminal fishing opportunity. Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in pre-terminal catch	Total HOR recoveries and sampling rates in fisheries
3	MP2	Terminal Catch by Species and Fishery	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in terminal catch	Total HOR recoveries and sampling rates in fishery
3	MP3	Terminal Catch by Month (all species)	Future runsize and harvest predictions and methodology.	Policy or practical constraint	HOR recoveries in monthly terminal catch	Total catch by month
3	MP4	Terminal Effort by Month	Future runsize and harvest predictions and methodology.	Policy or practical constraint	Number of anglers x days	Angler days

Appendix I

Population Specific Assumptions and Data (ISIT)

APPENDIX I POPULATION SPECIFIC ASSUMPTIONS AND DATA (ISIT)

The AHA Tool was used to create population specific assumptions and data (ISIT) used for recommendations on how to manage salmonids in the Cowlitz Basin. These ISIT tables can be found online at:

http://www.mytpu.org/tacomapower/power-system/hydro-power/licensing/cowlitz-river-project/license-documents/fisheries-committee.htm

Appendix J

Monitoring and Evaluation Plan: Analytical Methods and Monitoring Activities

APPENDIX J MONITORING AND EVALUATION PLAN: ANALYTICAL METHODS AND MONITORING ACTIVITIES

The purpose of the Monitoring and Evaluation (M&E) Plan is to:

- Evaluate performance relative to goals and expectations and adjust conduct of hatchery and harvest management operations according to decision rules. Indicators of program success include abundance, productivity, distribution, and composition for naturally produced populations, and benefits to fisheries;

- Test key assumptions and adjust the Decision Rules accordingly.

The steps in the M&E process that lead from field observations to decisions are illustrated below. The information (indicators) needed to support decision making is identified in Appendix H. These information requirements, combined with the NOAA standards for accuracy and precision (NOAA Guidance for Monitoring Recovery of Salmon and Steelhead: 2011), drive the analysis and monitoring needs (blue arrows in diagram). This Appendix (J) describes the Monitoring Activities (MAs) that produce the data (measures) needed for the Analytical Methods (AMs) that will be used to estimate the indicators that support decision making (black arrows).

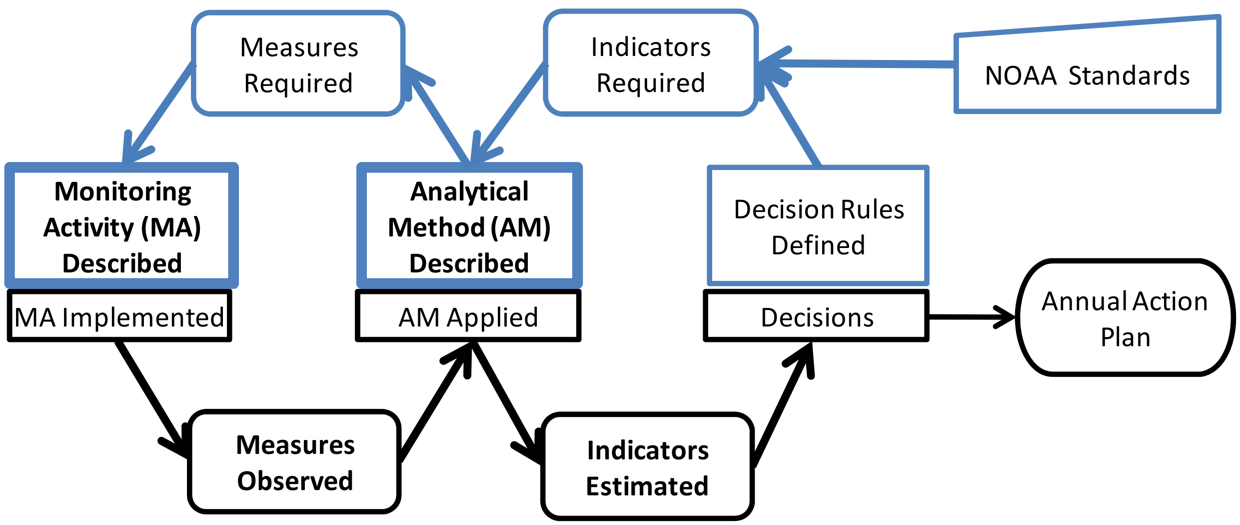

Figure J-1. Steps in the M&E process that go into making an Annual Action Plan.

Several of the analytical and monitoring methods described below have not previously been implemented in the Cowlitz basin. In particular, genetic mark-recapture methods have the potential to significantly improve estimates of spawner abundance among other indicators; however, there remains significant uncertainty about how to collect the data required to meet standards for accuracy and precision of the indicators used in the decision making process. Therefore, the effort in the initial years of this M&E plan should focus on refining monitoring methods and testing analytical assumptions. Different sampling methods should be explored in a systematic way to assure:

a) That future estimates of indicators will meet accuracy and precision standards in a cost effective manner, and

b) That sufficient data are collected and preserved from the initial years to allow indicators to be back calculated in the future (i.e., there should be no opportunity loss).

In particular, alternative methods for collecting tissue samples from adults and juveniles should be tested. These methods include trapping, seining, and electro-fishing for juveniles, and trapping and carcass collection for adults. Sufficient numbers of fish should be sampled to meet theoretical precision standards as calculated from the power analysis shown in the sections below. Once the critical assumptions have been tested and the optimal sampling method identified, subsamples of the tissues will be genotyped and used in the genetic mark-recovery estimation of abundance and composition of the natural spawning populations for Lower Cowlitz (LC) fall Chinook and/or LC coho, and/or LC steelhead.

By January 1, 2012, WDFW will present for FTC approval, a detailed monitoring “efficacy testing” plan designed to (a) test the assumptions of the genetic mark-recapture method (see MA-A and AM-1 below), and (b) identify the most effective methods for collecting the data (juvenile and adult tissue samples) needed to implement the genetic-mark recapture method for fall Chinook, coho and steelhead in the lower Cowlitz. This “efficacy testing” plan will be initiated during 2012 and the results will be reported to the FTC and used to refine the genetic mark-recapture monitoring plan (MA-A) and analysis (AM 1) for LC fall Chinook, coho, and steelhead over time through the adaptive management process described in the FHMP Update. The results of the “efficacy test” will refine the protocols for the monitoring activities needed to estimate spawner abundance and a set of related indicators (e.g., smolt migration speed and timing).

Descriptions of Monitoring Activities (MA)

Table J-1 links the monitoring activities to the analytical methods that produce the indicator estimates needed for the annual decision making process. The links to decisions are captured in Appendix H.

Table J-1. Monitoring activities that will provide the data (measure) that support the analysis for one or more of the populations in the project area.

Code	Name/Description	Analytical Methods Supported	Application (Populations)
MA-A	Carcass/Redd Surveys	AM-1, AM-2	LC: FCH, COH, STHD
MA-B	Juvenile Trapping	AM-1, AM-9, AM-10, AM-14	LC: FCH, COH, STHD, CUT
MA-C	Creel Survey	AM-4, AM-5	All Populations
MA-D	Catch Record Cards	AM-3, AM-4, AM-5, AM-11	LC: FCH, COH, STHD, SPC
MA-E	Hatchery Brood Bio-sampling	AM-6	LC: FCH, COH, STHD, SPC UC: COH, SPC
MA-F	In-hatchery Monitoring	AM-7	All hatchery programs
MA-G	Juveniles at Cowlitz Falls	AM-12	UC: COH, STHD, SPC, FCH
MA-H	Juveniles at Mayfield	AM-13	TIL: COH, STHD, SPC
MA-I	Adults at Separator	AM-11	UC: COH, STHD, SPC, FCH TIL: COH, STHD, SPC
MA-J	Weir Operation	AM-1b	LC: COH, STHD

MA-A. Carcass and redd surveys and sampling of natural spawners.

Applies to:

Estimation of natural spawner abundance, composition and distribution of:

- Lower Cowlitz fall Chinook
- Lower Cowlitz coho
- Lower Cowlitz steelhead

The purpose of adult monitoring is to provide status and trend information as required by the Settlement Agreement (SA) and the Fish Hatchery Management Plan (FHMP), and to provide empirical estimates of key parameters that drive Cowlitz FHMP decisions. For natural production status and trend monitoring, indicators to be estimated include spawner abundance, age structure, origin, sex, distribution, and the number of coded wire-tag (CWT) salmon spawning in the Lower Cowlitz River and tributaries (excluding the Toutle and Coweeman rivers). These Viable Salmonid Population (VSP) indicators will be estimated using the proposed analytical methods described in Section AM-1. In addition, other high priority parameters that scale hatchery programs identified in Table J-1 should be empirically estimated including: juvenile productivity, juvenile capacity, relative reproductive success (RRS), smolt to adult survival rate (SAR), pre-terminal exploitation rates, terminal/incidental mortality rate, and predation rates from HOR fish. Lower priority parameters such as competition factors for HOR fish and disease also need to be estimated. The monitoring activities to estimate these key parameters include adult spawning ground surveys, juvenile outmigrant trapping, and a CWT program for hatchery releases, which possibly transition into a wild stock CWT program.

Lower Cowlitz Fall Chinook

This section focuses on the natural production monitoring for adult Chinook salmon. The collection of data will be consistent with American Fisheries Society salmonid monitoring protocols (Johnson et al. 2007). In addition, all data will be stored in the WDFW databases, including: the spawning ground survey (SGS), juvenile migrant (JMX), age and scales (A&S), trap/adult mark-recapture (TMR), and genetic (G) databases. Redd location data collection will follow the protocols developed by Rawding and VanderPloeg (2009), with data stored in the redd locations portion of SGS. In addition, WDFW is developing a unique biological identification number to cross-reference or link biological, genetic, and CWT data stored in multiple databases.

Genetic Mark-Recapture. The recommended method for estimating fall Chinook salmon abundance in the Lower Cowlitz River is parental genetic mark-recapture. This method is considered cost-effective because it relies on carcass sampling, which is required for other VSP diversity metrics including origin and age structure. Carcass sampling is also required for the recovery of CWTs. The CWT program is used to determine the origin of hatchery strays and to estimate harvest rates for Cowlitz Hatchery fall Chinook salmon. In addition, the genetic based estimator takes advantage of juvenile outmigrant trapping required to estimate speed of downstream migration, and natural smolt abundance as described in Table J-1 of Appendix H of the FHMP Update.

Genetic tagging approaches designed to estimate abundance are varied (Palsbøll 1999), and may be structured to directly recapture the same individual (Palsbøll et al. 1997, Taberlet et al. 1997) or recover an individual’s genotype through parentage analysis (Jones and Avise 1997; Pearse et al. 2001). In the latter technique, the multi-locus genotypes from sampled adult carcasses will define the “mark” sample, and smolts surveyed the following year coupled with parentage analysis will define the “capture” and “recapture” samples. This proposed genetic mark-recapture method, while analogous in many ways to traditional mark-recapture techniques, is a novel application to salmon (Blankenship et al 2010). Recent reviews of genetic abundance methods and estimators can be found in Pettit and Valiere (2006) and Lukas and Burnham (2005a). The genetic mark-recapture method for salmon was first proposed by Blankenship et al. (2010), and is currently being used to estimate abundance for seven Chinook salmon populations in Washington. It requires genetic sampling of carcasses and sampling of outmigrants proportional to their abundance migrating past the screw trap.

The genetic mark-recapture abundance estimate is for the spawners above the smolt trap. A single redd count of the entire spawning distribution near the peak in spawning activity (the recommended method to determine the distribution indicator) is used to expand the genetic mark-recapture estimate to account for the proportion of spawners below the trap. Spawning distribution is best captured through the use of Global Positioning Satellites (GPS) to determine redd locations, since salmon carcasses are known to be recovered distant to spawning sites (Murdoch et al. 2009). One method currently used by WDFW includes a complete survey of the spawning distribution near peak redd abundance, with every redd located by GPS. Application of the genetic abundance method also provides auxiliary information, including the relative reproductive success of hatchery spawners compared to natural-origin spawners, an estimate of the number of effective breeders, and the effective population size. The last two indictors may better reflect population persistence than the traditional spawner abundance estimates.

Sampling Design. The design to estimate abundance and biological attributes, such as age, pHOS, sex, or other measures, requires representative sampling of adults and juveniles. For this method, adult sampling options include a simple random sample (SRS) or possibly a general randomized tessellation stratified (GRTS) sample (Courbois et al. 2008). The following is a hypothetical example for the collection of biological data for fall Chinook salmon in the Cowlitz River. The first step in the process is to define the sample frame or spawning distribution. In this example, the distribution for Tule fall Chinook spawning in the Cowlitz River was estimated through a model that used field data on the upper most spawning locations from various rivers and creeks for LCR Tules and GIS attributes such as drainage area and gradient (Fransen et al. 2006, Rawding et al. 2010). As shown in Figure J-2, two SRS were drawn for the spawning area above (red) and below (green) a proposed smolt trap location on the Cowlitz River below Olequa Creek. There may be differences in the biological metrics, especially origin, in these areas and separate spawner abundance estimates are computed for the area above and below trap. Each point, which is typically expanded to a mile long reach, is surveyed weekly for carcasses. All visible carcasses are collected by wading, walking stream banks, and/or gaffing from a boat. Surveys are initiated from the onset to the completion of spawning. Juvenile Chinook salmon outmigrants are collected proportional to their abundance. Smolt trap monitoring activities (Volkhardt et al. 2007) and analytical methods are described in MA-B and AM-1a respectively.

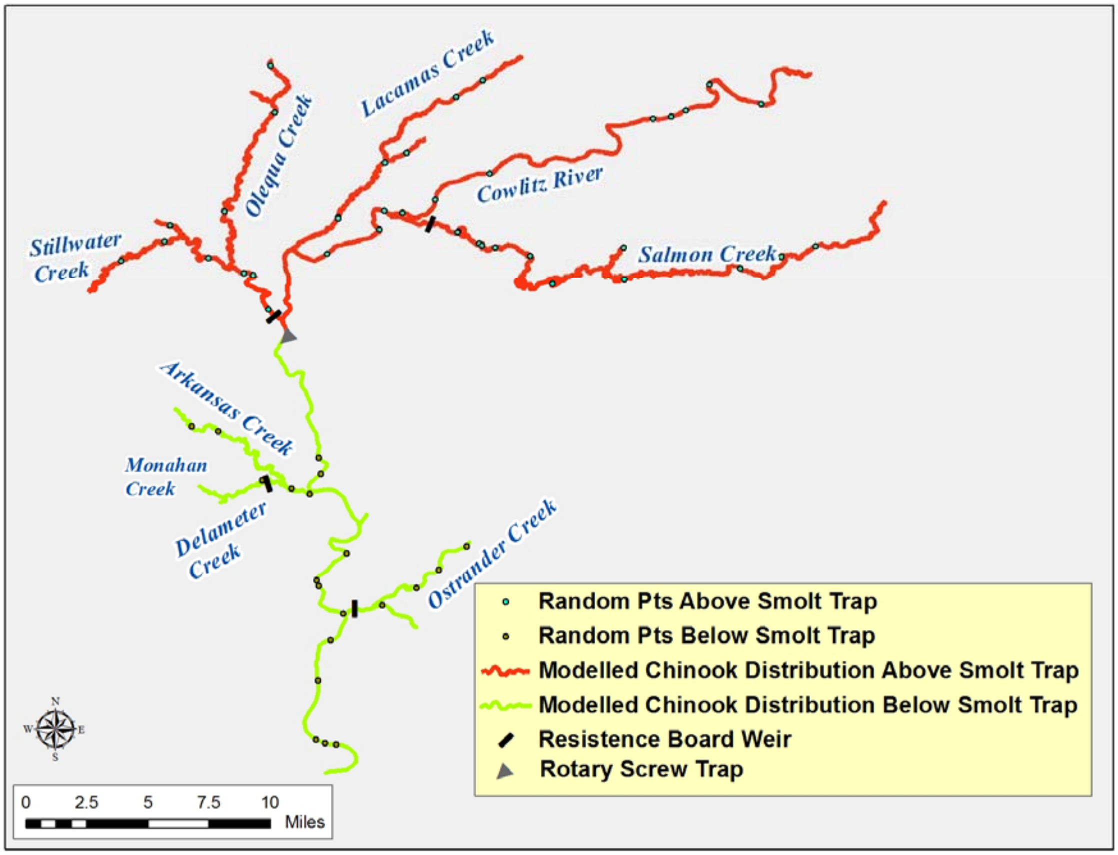

Figure J-2. Hypothetical random design for the collection of biological data to estimate fall Chinook abundance and other adult indicators. This example assumes a suitable smolt trap location near the railroad bridge below Olequa Creek.

Adult Data Collection. Carcasses in the water are typically gaffed up using a 10 foot steel conduit pipe with two double 10/0 barbless hooks attached on one end with a bolt and a hose clamp (Hawkins et al. 2004). A longer 16 foot gaff is used for retrieving the carcasses from the deepest water. Carcasses in the smaller tributaries are usually collected with a smaller 6 f00t gaff. Carcass sampling protocols are similar to those recommended by the American Fisheries Society (Crawford et al. 2007). All carcasses are identified to species based on physical characteristics unique to each species. For Chinook salmon, fish are enumerated by the following categories: unmarked, marked, and unknown. Unmarked fish are Chinook with intact adipose fins and snout; marked fish have their snout but are missing their adipose fin; and unknown Chinook are salmon with either a missing caudal peduncle or snout.

All unmarked and marked fish are sampled for CWTs following standard protocols (NWMT 2001). The surface of the CWT wand with radiating arrows are placed in contact with the snout and moved from the right to the left eye, and then up and over the snout area. The wand is also inserted into the mouth with the radiating arrows rubbed against the roof of the mouth in vertical strokes. If a CWT is detected, the red LED will light up and a beep is emitted from the wand. When a CWT is detected, the snout is severed by cutting across the head straight down behind the eyes (Crawford et al. 2007). The snout is placed in a plastic bag with a tag number linking the snout to biological data (length, sex, fin clips, spawning success for females, and scale sample number) recorded on the scale card, stream survey card, or other datasheet. Snouts are stored in a freezer and periodically delivered to the WDFW CWT lab in Olympia.

A systematic sampling rate is developed to meet sampling goals for genetic samples and biological data including length, sex, spawning success for females, and scales. For bio-sampled fish, a fork length is taken by running the tape measure from the tip of the snout to the fork in the tail. Sex is determined based on morphometric differences between males and females, and confirmed when checked for spawn success. The abdominal cavity is cut open to confirm sex and determine spawning success. Spawning success categories range from 100% to a pre-spawning mortality and are approximated based on visual inspection.

Scale samples are collected on the spawning grounds or at hatchery/weir sites by selecting scales from the preferred area as described in Crawford et al. (2007). Preferred scales are samples in an area about 1-6 scale rows above and about 15 scale rows wide in the lateral line in a diagonal between the posterior insertion of the dorsal fin and anterior insertion of the anal fin. Scale samples are removed with forceps with special care to select samples that are of good quality (round shape, non-regenerated) and not adjacent to one another (to minimize the effects of regeneration) as described in a WDFW technical report (Cooper et al. 2011). Scales are placed on the gummed portion of WDFW scale cards with their exterior surfaces facing up. The scale card number, position number, date, and location create a unique code in the A&S database.

Tissue samples are collected from carcasses for genetic analysis. A small portion of tissue is excised from a fin in good condition and placed in a labeled vial with 100% ethanol. A DNA identification code and sample number are recorded on the modified scale card. After sampling is completed, tails are removed from carcasses to prevent re-sampling the carcasses in future weeks.

Other mark-recapture methods were considered for Cowlitz River fall Chinook salmon including a stratified Petersen (Hahn et al. 2003), and Jolly-Seber method using carcass tagging (Sykes and Botsford 1986, Rawding et al. 2006). Major concerns with the stratified Petersen method were capturing sufficient numbers of live fish, implementation of a statistically valid creel survey to censor the marked fish removed from the population by anglers (harvest), catch and release mortality of tagged fish, and censoring returns to the hatcheries and Barrier dam. The major concern with the carcass tagging method was the assumption that each carcass has the same probability of being caught, given that it is in the population. Some research has suggested that in larger rivers, carcasses that float into deep stagnant pools violate this assumption (Boydstun 1994, Conrad 2000), and some biologists have noted that these conditions may occur at certain locations in the Cowlitz River. If the carcass tagging option is pursued, commercial divers should be used to capture and tag fish weekly in these deep pools to assess this assumption (Hawkins et al. 2003). Weir operation on the mainstem Cowlitz was not pursued because it has a low chance of success in this very large river. The sonar option (Maxwell 2007) was also considered, but the wide river and overlapping runs of coho and chum salmon along with steelhead make it difficult to identify and distinguish the different species without a test fishing program.

A key assumption for the genetic mark-recapture method to yield unbiased estimates is to collect juveniles proportional to outmigration. As mentioned above, outmigrant trapping is needed to estimate travel time and natural abundance in order to estimate productivity and capacity. However, if outmigrant trapping does not occur, juveniles may be collected through other methods such as seining, electrofishing, or baited minnow traps (Hahn et al. 2007, Temple and Pearsons 2007, and Bryant 2000). These approaches work in theory, but the large basin size and presumed outmigration of fry commencing in February and continuing through August or later would make successful field application of these methods challenging. First, the catchability of juvenile Chinook is likely to vary based on flow, turbidity, and fish size. Without developing an understanding of gear efficiency and selectivity, representative juvenile sampling will be difficult to demonstrate. Second, there is a tendency for a portion of the LCR juvenile Tule Chinook salmon population to rear before migration (Rawding 2010). Smolt trapping adjusts catchability to the fry stage using the Von Bertalanffy Growth and Beverton-Holt instantaneous mortality equations. It is unclear how catches from other methods adjust for fish moving through the system at unknown rates. If these other methods are to be pursued to representatively collect juveniles, then concurrent smolt trapping may be used to test the hypothesis that there is no difference in spawner abundance estimates between the alternate collection methods and the smolt trap method.

WDFW is pursuing the use of genetic mark-recapture using returning adults on the Coweeman River (adult to adult), but given that some fall Chinook do not mature until age 6, there will be a significant delay in estimating escapement. Results from this study will not be available until 2015. There are some unique challenges in application of this method to the Cowlitz River based on the possible homing of adults and meeting the mark-recapture assumptions, especially those concerned with equal catchability. First, if the degree of homing to individual spawning sites (specific riffles or tailouts) is high, the methods to collect carcasses as proposed for parental genetic mark-recapture, which is a spatial random sample of a number of one-mile sites, may need to be modified. This modification may lead to sampling the entire spawning distribution for carcasses, and then collecting a random sample from all carcasses to achieve the requirement of equal catchability in the first or second sample. Another issue is the adult to adult genetic mark-recapture estimate will be biased high depending on the natural stray rate. For example, natural-origin North Fork Lewis Chinook that are coded-wire tagged as juveniles, are recovered as adult carcasses on the Cowlitz River, based on CWT recoveries (WDFW and RMIS databases). Estimation of stray rates from other Oregon and Washington wild fall Chinook populations without genetic sampling or CWT juvenile programs will be difficult to estimate. While the parental genetic mark-recapture method has proven successful, development of adult to adult mark-recapture programs could be pursued in conjunction with an expanded Cowlitz River adult sampling program along with genetic sampling and/or juvenile CWT tagging programs for all fall Chinook populations within the LCR ESU.

Lower Cowlitz Coho

The purpose of adult coho monitoring activities is status and trend monitoring as required by the SA and the FHMP, and to provide empirical estimates of key parameters that drive Cowlitz FHMP decisions. For natural production status and trend monitoring, indicators to be estimated include spawner abundance, age structure, origin, sex, and distribution. These Viable Salmonid Population (VSP) indicators will be estimated using the proposed analytical methods described in the next section. In addition, other high priority parameters that scale hatchery programs (identified in Table J-1) should be empirically estimated, including: juvenile productivity, juvenile capacity, RRS, SAR, pre-terminal exploitation rates, terminal/incidental mortality rate, and predation rates from HOR fish. Lower priority parameters, such as competition factors for

HOR fish and disease, also need to be estimated. The monitoring activities to estimate these key parameters include adult spawning ground surveys and juvenile outmigrant trapping.

This chapter focuses on the natural production monitoring for adult coho and relies on Appendix J in the FHMP Update to address the monitoring issues associated with hatcheries and harvest. The collection of data will be consistent with American Fisheries Society salmonid monitoring protocols (Johnson et al. 2007). In addition, all data will be stored in the WDFW databases, including: the spawning ground survey (SGS), juvenile migrant (JMX), Age and Scales (A&S), Trap/Adult Mark-Recapture (TMR), and Genetic (G) databases. Redd location data collection will follow the protocols developed by Rawding and VanderPloeg (2009), with data stored in the redd locations portion of SGS. In addition, WDFW is developing a unique biological identification number to cross-reference or link biological, genetic, and CWT data stored in multiple databases.

Mark-Recapture and AUC surveys. Due to the diverse life history strategies including freshwater rearing, a higher percentage of adult spawning in tributaries, and entry and spawning time in higher turbidity water conditions (Sandercock 1991), alternate monitoring strategies were considered for coho salmon compared to other adult salmonids. In addition, the challenges associated with adult coho monitoring during difficult environmental periods require flexibility and redundancy to be successful.

The primary recommended method for estimating coho abundance in the Lower Cowlitz River is a mark-recapture. This method was considered cost-effective because it relied on weirs that were in place for hatchery management goals such as controlling pHOS. Weirs also allow the collection of other VSP diversity metrics including origin and age structure, which may be difficult to obtain from carcass surveys since recovery rates for this species can be low. Although the final number and location of weir sites has not been determined, weirs are currently operating near the mouth of Olequa and Delameter Creeks with possible weirs added at locations near the mouth of Salmon and Ostrander Creeks.

In traditional salmon mark-recapture estimates, adults are captured via traps in fish ladders or weirs, or using tangle nets or seines (Labelle 1994, Jacobs 2002, Crawford et al. 2007). After capture, fish are marked and released. The recovery event often consists of sampling the spawning grounds for marked and unmarked carcasses although other approaches using upstream traps may be used (Jacobs 2002). However, two modified mark-recaptures for coho salmon are recommended (Korman et al. 2002, and Zserlong and Rundio 2007). These are recommended because they provided concurrent mark recapture estimate with estimates of observer efficiency and stream life, which can vary substantially between years and locations (Hetrick and Nemeth 2003, Holt and Cox 2008). Other approaches to estimate stream life require electroshocking (Sollazi 1984, Irvine et al. 1992), which may be more difficult to obtain NOAA permits due to concerns about electroshocking injuries. In addition, both methods also estimate survey life but the modification of the Korman method in Appendix 1 provides a more robust estimate of survey life.

The first approach outlined by Korman et al (2002) for steelhead was described above and adapted for salmon (Appendix 1). In appendix 1, steelhead will be radio and spaghetti tagged throughout the run. Radio tag antennae will be placed below the estimated point of entry into the population to determine the date radio tagged fish move into the survey area. On the day of a snorkel survey, a raft or helicopter will be used to radio track fish to determine if they are alive and present in the survey area. Fish classified in this manner are called tags. The spawning ground survey will be used to estimate the observer efficiency based on observed spaghetti tags with active radio tags. The abundance estimate is all observed fish divided by the observer efficiency. Assuming binomial sampling, each snorkel survey provides an independent estimate of population abundance. The Area-Under-the-Curve (AUC) in fish days can be estimated by interpolation between the survey estimates of abundance. In addition, if timer radio tags are used (Shardlow et al. 2007) instead of normal radio tags the survey life (sl) can be estimated. Timer radio tags have two tilt switches and a timer set to record death of the fish if the tag angle is between 45 and 315 degrees for longer than 3 minutes. These tags have been accurate in estimating survey life in the hatchery and for one wild population. Trapezoidal approximation is used to estimate the AUC (English et al. 1992), which is an interpolation of the daily fish abundance estimators (Korman et al. 2002) based on the time of counts and the population abundance from the mark-recapture. Timer tags provide an independent estimate of the mean and standard deviation of survey life. Different equations or distributions could be used to estimate survey life, which is often assumed to be constant or declining (Su et al. 2001, Korman et al. 2002). Escapement is estimated as the AUC divided by the survey life (Hilborn et al. 1999).

Zserlong and Rundio 2007 released different colored tagged fish during different portions of the run. Observer efficiency was estimated with 24 hours after release by survey the entire spawning distribution. Survey life was estimated using the recovery of tagged carcasses. The mid-point between the last survey and the recovery date was used to minimize bias in survey life.

The proposed mark-recapture abundance estimate is for the spawners above the tributary weirs. However, since the weirs were not chosen randomly, extrapolation of this data to other tributaries may lead to biased estimates. Methods must be developed to estimate abundance in unsurveyed tributaries. AUC and redd based estimates are common for coho salmon (English et al. 1992, Gallagher and Gallagher 2005). AUC based abundance estimates include a calculation of the number of fish days expanded by estimated observer efficiency and stream life which is the longevity of coho salmon in tributaries (English et al. 1992). In contrast, redd based abundance estimates assume redd detection, that redds can be accurately classified between species, and require an estimate of females per redd and sex ratio to calculate escapement (Gallagher and Gallagher 2005). The Department of Fisheries and Ocean (DFO) using variations of random designs (English et al. 1992), and Oregon Department of fish and Wildlife (ODFW) tend to use AUC to estimate coho escapements using GTRS designs (Diaz-Ramos et al. 1996, Firman and Jacobs 2004, Stevgens 2002, Suring et al. 2006) while WDFW in Puget Sound tends to use redd surveys. Recently WDFW is exploring both redd and AUC methods to estimate adult coho salmon abundance in the LCR. It is unclear which method will be more effective on the Cowlitz River for coho salmon and it is recommended that both redd and fish count information be collected concurrent with the mark-recapture study design.

Since the mark-recapture method only provides abundance estimates above weirs, the first proposed method to estimate abundance in unsurveyed tributaries is to use redd surveys. This is the same method as used for steelhead and is not repeated here. Rather than just relying on redd surveys, concurrent counts of live fish occur as well and AUC for each reach is estimated using the methods from Bue et al. (1998).

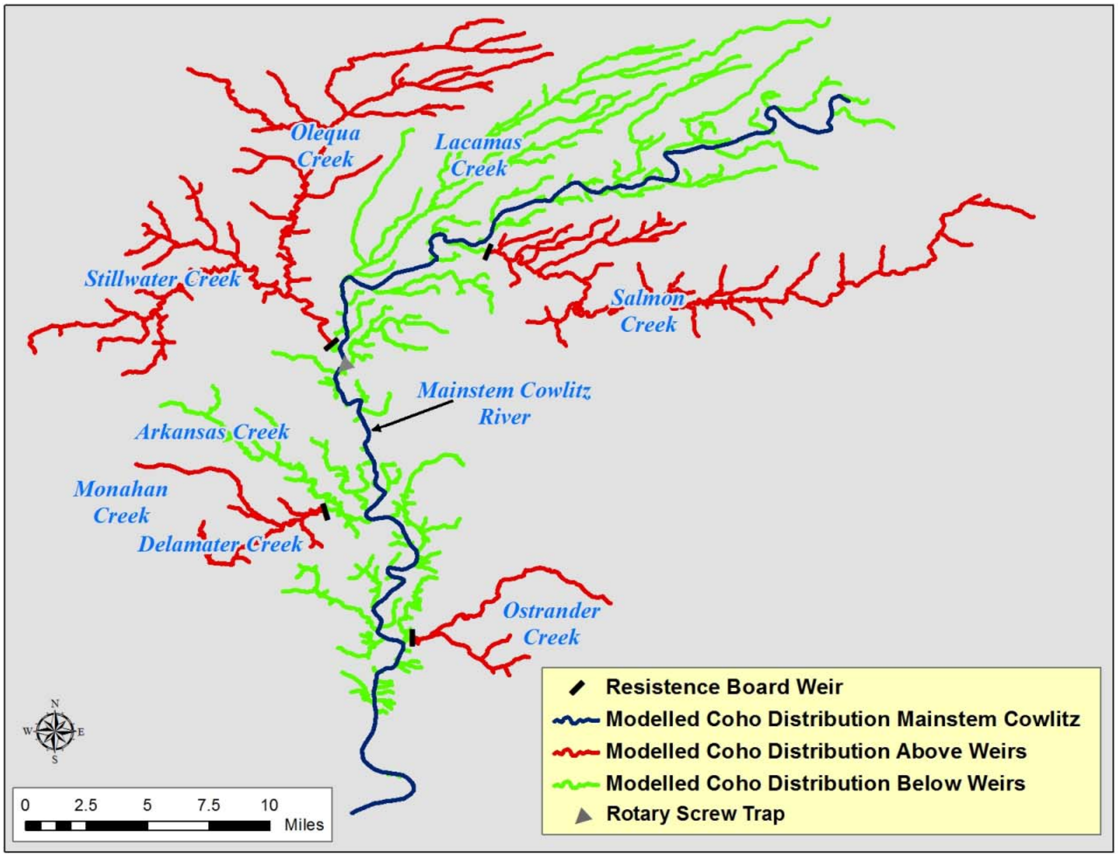

Figure J-3. Hypothetical random design for the collection of biological data to estimate coho abundance and other adult indicators. This example assumes suitable weir locations near the mouth of Delameter, Olequa, Salmon, and Ostrander Creeks, and random sampling of steelhead redds in other tributaries.

The proposed mark-recapture and redd/AUC surveys provide an estimate of tributary escapement, but coho spawning in the mainstem is not addressed. WDFW has observed mainstem spawning in the Lower Columbia River tributaries. Therefore, it is expected that some mainstem spawning occurs in the Cowlitz River. During the Chinook spawning period from September through November, mainstem Cowlitz River flows below Mayfield Dam were generally less than 5000 cfs (Figure J-5), which provides for good visibility to view redds (Julie Henning, WDFW, pres. comm.). In contrast, flows during coho spawning season from October through February, ranged from over 5,000 to 19,000 cfs (Figure J-5) making redd, fish or carcass detection difficult to impossible. Given the turbidity from the Toutle River (RM 20) it is unlikely that redds or fish could be detected below this point.

Estimating mainstem spawning abundance will be challenging. The mainstem could be surveyed at times when environmental conditions allow between October and February. Assuming spawning time in the tributaries is similar to the mainstem, estimates could be developed based on the proportion of the total redds or fish present in tributaries on the same date as the mainstem redd survey. If a year in which environmental conditions allow complete AUC or redd estimates in the mainstem, the proportion of mainstem spawners could be estimated and this could be used in years without mainstem counts, assuming the proportion of redds in the mainstem is constant between years.

Another issue for mainstem spawning ground surveys is the proportion of hatchery spawners, which can be determined from carcass surveys. However, since carcass recovery rates in the mainstem are likely to be low there is no easy solution for determining the origin of mainstem spawners. Regardless, funding should be invested into estimating coho spawners in the mainstem and pursuing other options for estimating mainstem abundance including the possible use of genetic mark-recapture as detailed in redundant approaches.

Data Collection. Adults will be collected in traps operated at the weirs. Since it is unlikely that weirs will be 100% effective in routing fish passage into traps, the area directly above and below traps will be surveyed daily and, when possible, observed fish will be seined. Weir sampling protocols are similar to those recommended by the American Fisheries Society (Zimmerman and Zabkar 2007). Sampling at the weirs for biological attributes, such as age, pHOS, sex, or other measures, will occur.

All fish will be identified to species based on physical characteristics unique to each species. All adult coho will be sampled for genetic material and biological data including length, sex, and scales. All unmarked coho will be anesthetized, bio-sampled, double Floy (FD 68BC T-bar Anchor tags Floy Tag & Mfg., Inc Seattle, WA) tagged and released upstream. For bio-sampled fish, a fork length will be taken by running the tape measure from the tip of the snout to the fork in the tail. Fish will be enumerated by the following categories: unmarked, marked, and unknown. Unmarked fish are those with intact adipose fins and marked fish are missing their adipose fin. Sex is determined based on morphometric differences between males and females. All unmarked and marked steelhead will be sampled for CWTs following standard protocols (NWMT 2001) as described in the Chinook section of this document.

Scale samples will be collected at the weir sites by selecting six scales from the preferred area as described in Crawford et al. (2007) as described in the Chinook section of this document. The scale card number, position number, date, and location create a unique code in the A&S database. Tissue samples for genetic analysis will be collected from adults. A small portion of tissue will be excised from a fin or the opercle in good condition and placed in a labeled vial with 100% ethanol. A DNA identification code and sample number will be recorded on the modified scale card.

Redd and AUC Data Collection. The distribution for coho spawning in the Cowlitz River was estimated through a model that used field data on the uppermost spawning locations from various rivers and creeks for LCR winter steelhead and GIS attributes, such as drainage area and gradient (Fransen et al. 2006, Rawding et al. 2010). Every two weeks redd surveys will be conducted. All identifiable redds will be flagged, and their location (latitudinal and longitudinal coordinates) will be recorded. Redd locations will be captured using recreational grade Garmin units set in WGS 83. Prior to recording redd locations, GPS units will be allowed to acquire satellite locations until accuracies from 5 to 50 feet are achieved. In subsequent surveys, previously flagged redds will be inspected to determine if they should be classified as “still visible” or “not visible”. A redd is classified as “still visible” if it would have been observed and identified without the flagging present, and was recorded as “not visible” if it did not meet this criteria. Surveys will occur at all possible spawning locations above the weirs and random locations in tributaries without weirs. Redd counts are assumed to be a complete census of steelhead above weirs.

Weekly counts of live salmon will be conducted to develop an AUC escapement estimate by reach (English et al. 1992). Counts of adult salmon should commence prior to tributary entry and continue until spawning is completed. Counts of live coho salmon will be recorded separately for each survey reach. All coho carcasses recovered on stream surveys will be examined and sampled as per protocol identified for coho weir sampling described above.

Contingency Plans for Abundance Estimates. It is possible that in some years, environmental conditions may limit mark-recapture estimates due to assumption violations. In this case, redd surveys will still provide an estimate based on number of females per redd and sex ratios from other years.

However, it may be difficult to operate a traditional coho mark-recapture study design to estimate coho abundance due to small population size and challenging environmental conditions during the weir operation period throughout the adult steelhead migration. Therefore, we are proposing contingency plans if precision and bias goals are not met using the approach described above.

The second approach is the fall Chinook genetic mark-recapture approach modified for coho salmon. Since fall Chinook emigrate as fry and subyearlings, the rearing time is variable from a few days to months, so it was recommended that smolt trapping be used to collect fall Chinook juveniles in proportion to the outmigration to meet the equal catchability assumption. However, coho juveniles rear from less than one to two years before emigrating as smolts to the ocean (Sandercock 1991). This residency suggests that there is an opportunity to collect juveniles through other methods, such as seining, electrofishing, or baited minnow traps (Hahn et al. 2007, Temple and Pearsons 2007, and Bryant 2000) before emigration. May is likely an optimal time for collection of fry because all fry should have emerged and a length at age key can be used to classify age zero coho salmon juveniles.

Juveniles would be collected using a simple random design over the observed spawning distribution based on redd surveys above the weirs. Key assumptions in this method are: emigration of juvenile coho salmon from the spawning area is negligible before sampling, the gear type and sampling design provide for equal catchability of juvenile coho, and genotyped fry are correctly assigned to the sampled or unsampled parents. This genetic mark-recapture method for coho is likely to be the most robust because it is reasonable to assume the above assumptions can be met. As with steelhead, it may be likely to combine likelihoods, bootstraps, or posterior probability results from independent methods to improve the precision of the estimate.

A third approach considered is a variation of the genetic mark-recapture approach for coho, instead using smolt traps operated near the weir sites rather than fry collections. In this study design, coho outmigrants are aged and assigned to a brood or spawning year. Genotyped smolts from the correct year class are compared to adult samples to estimate abundance. Key assumptions with this method include: emigration from the spawning zone is random or negligible before smolting, all smolts have equal catchability and survival, and genotyped juveniles are correctly assigned to the sampled or unsampled parents. The largest concern with this method is the assumption that emigration before smolting is negligible or random, and the survival of smolts from less than age 1 to age 2 can be estimated so all smolt samples have equal catchability.

A fourth approach is the use of the mainstem smolt trap to capture coho juveniles. Adults are collected at tributary weirs above the mainstem smolt trap site and juveniles are collected at the mainstem smolt trap site. This approach is identical to the fall Chinook approach proposed earlier. It has similar issues as the third approach, but it may be difficult to catch sufficient smolts for a reliable estimate due to poor trap efficiencies in the large mainstem rivers (Kinsel et al. 2008). However, trap efficiencies are likely to be higher for coho than steelhead smolts.

Other Sampling Approaches. Weir operation on the mainstem Cowlitz was not pursued because it has a low chance of success in this very large river. The sonar option (Maxwell 2007) was also considered but the wide river and overlapping runs of steelhead and fall Chinook salmon along with coho make it difficult to identify and distinguish the different species without a test fishing program. WDFW is pursuing the use of genetic mark-recapture using returning Chinook salmon adults on the Coweeman River (adult to adult), but given that some fall Chinook do not mature until age 6, there will be a significant delay in estimating escapement. Results from this study will not be available until 2015. There are some unique challenges in application of this method to Cowlitz River coho salmon based on the possible homing of adults and meeting the mark-recapture assumptions, especially those concerned with equal catchability. First, if the degree of homing to individual tributaries is very high (>99%), the methods for collection of adults at weirs is appropriate for parental genetic mark-recapture. However, if straying occurs into tributaries without weirs or the mainstem, abundance estimates are likely to be biased high. Stray rates from other Oregon and Washington wild steelhead populations without genetic sampling or CWT juvenile programs will be difficult to estimate and bias the abundance estimate. For the time being these other sampling approaches are not recommended.

Lower Cowlitz Steelhead

As with fall Chinook salmon, the purpose of adult steelhead monitoring activities is status and trend monitoring as required by the SA and FHMP, and to provide empirical estimates of key parameters that drive Cowlitz FHMP decisions. For natural production status and trend monitoring, indicators to be estimated include spawner abundance, age structure, origin, sex, and distribution. These Viable Salmonid Population (VSP) indicators will be estimated using the proposed analytical methods described in the next section. In addition, other high priority parameters that scale hatchery programs (identified in Table J-1) should be empirically estimated, including: juvenile productivity, juvenile capacity, RRS, SAR, pre-terminal exploitation rates, terminal/incidental mortality rate, and predation rates from HOR fish. Lower priority parameters, such as competition factors for HOR fish and disease, also need to be estimated. The monitoring activities to estimate these key parameters include adult spawning ground surveys, and juvenile outmigrant trapping.

This chapter focuses on the natural production monitoring for adult steelhead and relies on Appendix J in the FHMP Update to address the monitoring issues associated with hatcheries and harvest. As with fall Chinook salmon, the collection of data will be consistent with American Fisheries Society salmonid monitoring protocols (Johnson et al. 2007). In addition, all data will be stored in the WDFW databases, including: the spawning ground survey (SGS), juvenile migrant (JMX), Age and Scales (A&S), Trap/Adult Mark-Recapture (TMR), and Genetic (G) databases. Redd location data collection will follow the protocols developed by Rawding and

VanderPloeg (2009), with data stored in the redd locations portion of SGS. In addition, WDFW is developing a unique biological identification number to cross-reference or link biological, genetic, and CWT data stored in multiple databases.

Mark-Recapture and Redd Surveys. Due to the diverse life history strategies of steelhead, including freshwater rearing and iteroparity (Leider et al. 1986), a higher percentage of adults spawning in Cowlitz River tributaries (Bryce Glaser, WDFW pers. comm.), environmental conditions in the Cowlitz mainstem that limit the success of spawning ground surveys (Chris Glezies, WDFW pers. comm.), the possible production of smolts from resident rainbow trout (Ararki et al. 2007), and entry and spawning time in higher turbid water conditions (Busby et al. 1996), alternate monitoring strategies were considered for steelhead compared to fall Chinook. In addition, the challenges associated with adult steelhead monitoring during difficult environmental periods require flexibility and redundancy to be successful.

The primary recommended method for estimating steelhead abundance in the Lower Cowlitz River is traditional steelhead mark-recapture. This method is considered cost-effective because it relies on weirs that are in place for hatchery management goals of controlling pHOS and collection of broodstock. Weirs also allow the collection of other VSP diversity metrics including origin and age structure, which cannot be obtained by carcass surveys since steelhead are iteroparous. Although the final number and location of weir sites has not been determined, weirs are currently operating near the mouth of Olequa and Delameter Creeks with possible weirs to be added at locations near the mouth of Salmon and Ostrander Creeks.

In traditional salmon mark-recapture estimates, adults are captured via traps in fish ladders or weirs, or using tangle nets, seines, or angling. After capture, fish are marked and released. The recovery event often consists of sampling the spawning grounds for marked and unmarked carcasses, although other approaches using upstream traps may be used (Labelle 1994, McPheason et al. 1999, Parken et al, 2003, Crawford et al. 2007, Underwood et al. 2007, Zserlong and Rundio 2007). However, for steelhead the recovery event is typically the trapping of steelhead as adults further upstream (Rawding and Cochran 2005) or as kelts at the same trap. Kelts are classified as spawned out steelhead emigrating back toward the ocean (Begich 1993, Mayer et al. 2005).

The proposed mark-recapture abundance estimate is for the spawners above the tributary weirs. However, since the weirs were not chosen randomly extrapolation of this data to other tributaries may lead to biased estimates. Methods must be developed to estimate abundance for areas below weirs and for tributaries without weirs. Concurrent to the mark-recapture study design, a census of redds above the weirs should be conducted via stream surveying. This allows the number of females per redd above the weirs to be estimated, which can be applied to estimate the number of females from redd surveys in tributaries without weirs. Females may be expanded to adults based on the sex ratio documented at the weirs.

Since the mark-recapture method only provides abundance estimates above the weirs, the proposed method to estimate abundance in areas below weirs and tributaries without weirs is to use redd surveys. Redd surveys provide counts of all redds in the sampling unit (reach) throughout the season and reaches represent a sample of the possible spawning habitat. Spatial sampling designs for redd surveys typically include a simple random sample (SRS) or a general randomized tessellation stratified (GRTS) sample (Courbois et al. 2008). Estimation of redds using SRS can be considered finite population sampling (Williams et al. 2002). The assumptions and sources of error with this approach are addressed later in the analytical methods assumptions and indicator sections.

The following is a hypothetical example for the collection of redd data for steelhead in tributaries to the Cowlitz River without weirs. The first step in the process is to define the sample frame or spawning distribution in all tributaries. In this example, the distribution for steelhead spawning in the Cowlitz River was estimated through a model that used field data on the upper most spawning locations from various rivers and creeks for LCR winter steelhead and GIS attributes, such as drainage area and gradient (Fransen et al. 2006, Rawding et al. 2010). As shown in Figure J-4, a SRS was drawn for the spawning area in tributaries without weirs (green). Each point, which is typically expanded to a mile long reach, is surveyed weekly for redds. All visible redds are identified and enumerated by walking or boating reaches every two weeks. Surveys are initiated from the onset to the completion of spawning.

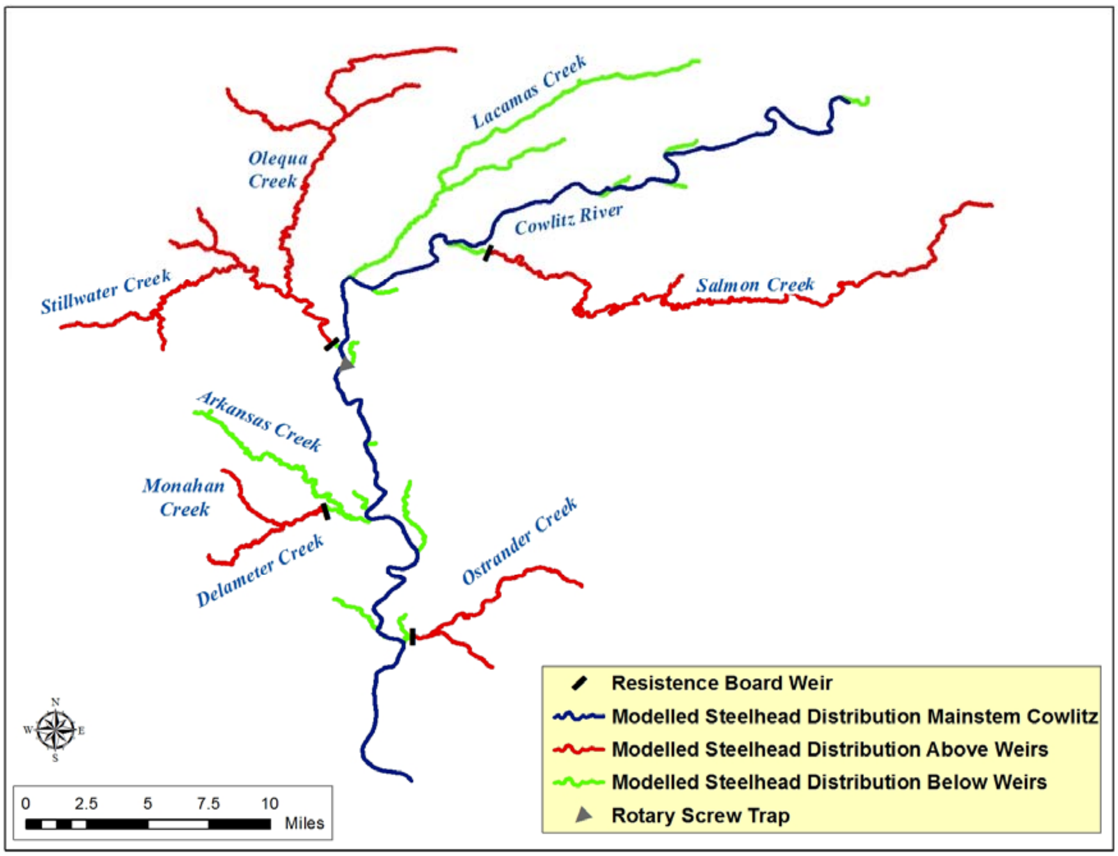

Figure J-4. Hypothetical random design for the collection of biological data to estimate steelhead abundance and other adult indicators. This example assumes suitable weir locations near the mouth of Delameter, Olequa, Salmon, and Ostrander Creeks, and random sampling of steelhead redds in other tributaries.

The proposed mark-recapture and redd surveys provide an estimate of tributary escapement, but steelhead spawning in the mainstem Cowlitz River is not addressed. WDFW has observed mainstem spawning in all other Lower Columbia River tributaries. Therefore, it is expected that mainstem spawning occurs in the Cowlitz River. During the Chinook spawning period from September through November, mainstem Cowlitz River flows below Mayfield Dam were generally less than 5000 cfs (Figure J-5), which provides for good visibility to view redds (Julie Henning, WDFW, pers. comm.). In contrast, flows during steelhead spawning season from February through June ranged from over 5,000 to 15,000 cfs (Figure J-5) making redd detections difficult to impossible. Given the turbidity from the Toutle River (RM 20) it is unlikely that redds could be detected below this point.

Estimating mainstem spawning abundance will be challenging. The mainstem could be surveyed for redds at times when environmental conditions allow between late March and June. Assuming spawning time in the tributaries is similar to the mainstem, mainstem estimates could be developed based on the proportion of the total redds present in tributaries on the same date as the mainstem redd survey. In a year in which environmental conditions allow complete redd estimates in the mainstem, the proportion of mainstem redds could be estimated, and this could be used in years without complete mainstem redd counts, assuming the proportion of redds in the mainstem is constant between years.

Another issue for mainstem redds is the proportion of hatchery spawners, which cannot be determined from redd surveys. In tributaries, we propose to use the weirs to estimate proportions, but there is no easy solution for the mainstem. Regardless, funding should be invested into estimating redds in the mainstem and pursuing other options for estimating mainstem abundance, including the possible use of genetic mark-recapture as detailed in redundant approaches.

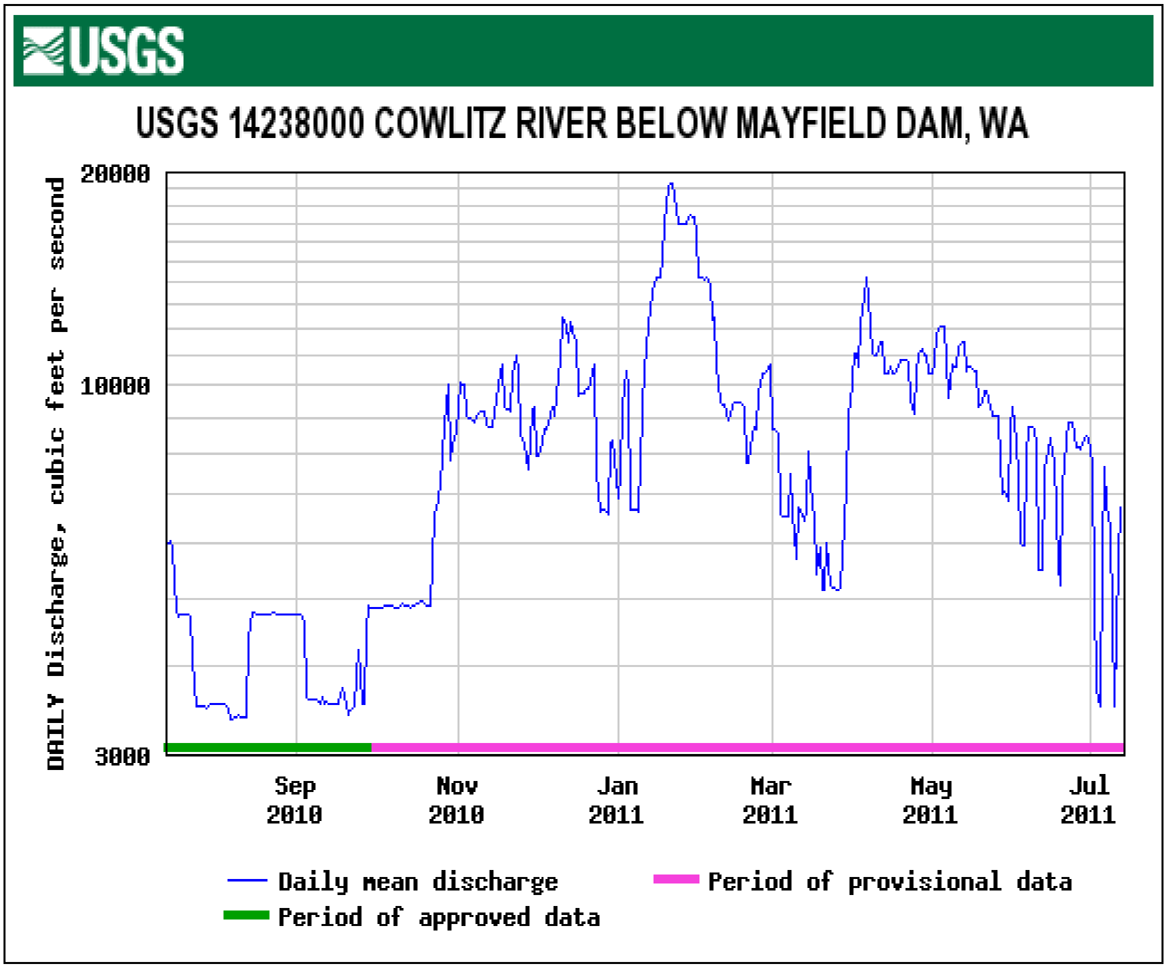

Figure J-5. Estimated Cowlitz River flow from the USGS Mayfield gauge for 2010-11.

Data Collection. Adults will be collected in traps operated at the weirs. Since it is unlikely that weirs will be 100% effective in routing fish passage into traps, the area directly above and below traps will be surveyed daily and when possible, observed fish will be seined. Weir sampling protocols are similar to those recommended by the American Fisheries Society (Zimmerman and Zabkar 2007). Sampling at the weirs for biological attributes, such as age, pHOS, sex, or other measures will occur.

All fish will be identified to species based on physical characteristics unique to each species. All adult steelhead will be sampled for genetic material and biological data including length, sex, and scales. All unmarked steelhead will be anesthetized, bio-sampled, double Floy (FD 68BC T-bar Anchor tags Floy Tag & Mfg., Inc Seattle, WA) tagged and released upstream. For bio-sampled fish, a fork length will be taken by running the tape measure from the tip of the snout to the fork in the tail. Fish will be enumerated by the following categories: unmarked, marked, and unknown. Unmarked fish are those with intact adipose fins and marked fish are missing their adipose fin. Sex is determined based on morphometric differences between males and females. All unmarked and marked steelhead will be sampled for CWT following standard protocols (NWMT 2001) as described in the Chinook section of this document.

Scale samples will be collected at the weir sites by selecting six scales from the preferred area as described in Crawford et al. (2007) as described in the Chinook section of this document. The scale card number, position number, date, and location create a unique code in the A&S database. Tissue samples for genetic analysis will be collected from adults. A small portion of tissue is excised from a fin or the opercle in good condition and placed in a labeled vial with 100% ethanol. A DNA identification code and sample number are recorded on the modified scale card.

Redd Data Collection. The distribution for steelhead spawning in the Cowlitz River was estimated through a model that used field data on the upper most spawning locations from various rivers and creeks for LCR winter steelhead and GIS attributes, such as drainage area and gradient (Fransen et al. 2006, Rawding et al. 2010). Every two weeks redd surveys will be conducted. All identifiable redds will be flagged, and their location (latitudinal and longitudinal coordinates) will be recorded. Redd locations will be captured using recreational grade Garmin units set in WGS 83. Prior to recording redd locations, GPS units will be allowed to acquire satellite locations until accuracies from 5 to 50 feet are achieved. In subsequent surveys, previously flagged redds will be inspected to determine if they should be classified as "still visible" or "not visible". A redd is classified as "still visible" if it would have been observed and identified without the flagging present, and was recorded as "not visible" if it did not meet this criteria. Surveys will occur at all possible spawning locations above the weirs and random locations in tributaries without weirs. Redd counts are assumed to be a complete census of steelhead above weirs.

Contingency Plans for Abundance Estimates. It is possible that in some years, environmental conditions may limit mark-recapture estimates due to assumption violations. In this case redd surveys will still provide an estimate based on data of females per redd and sex ratios from other years.

However, it may be difficult to operate a traditional steelhead mark-recapture study design to estimate steelhead abundance due to small population size and challenging environmental condition during the weir operation period throughout the adult steelhead migration. Therefore, we are proposing contingency plans if precision and bias goals are not met using the approach described above. In the first approach, adult steelhead should be double Floy and PIT tagged. It is possible to calculate a Petersen estimate based on the number of tags released, and the sample of tagged and untagged repeat spawners in subsequent years. These repeats may be added directly to the recaptures and unmarked fish for a single estimate of abundance or combined through likelihoods, bootstraps, or posterior probabilities. The key assumptions in this method are no tagging effects and complete mixing of adults between the time of tagging and return as repeat spawners, which are both likely to be met.

The second approach is the fall Chinook genetic mark-recapture approach modified for steelhead. Since fall Chinook emigrate as fry and subyearlings, the rearing time is variable from a few days to months, so it was recommended that smolt trapping be used to collect fall Chinook juveniles in proportion to the outmigration to meet the equal catchability assumption. However, steelhead juveniles rear for one to four years before emigrating as smolts to the ocean (Leider et al. 1986). This residency suggests that there is an opportunity to collect juveniles through other methods, such as seining, electrofishing, or baited minnow traps (Hahn et al. 2007, Temple and Pearsons 2007, and Bryant 2000) before emigration. Late July is likely an optimal time for collection of fry because all fry should have emerged and a length at age key can be used to classify age zero O. mykiss.

Juveniles would be collected using a simple random design over the observed spawning distribution based on redd surveys above the weirs. In addition, if NOAA approval can be obtained, sacrificing fry and the use of otolith microchemistry could be used to identify if the fry were from anadromous mothers (Zimmerman and Reeves 2000) and an abundance estimate for steelhead females could be obtained using the genetic mark-recapture method. Key assumptions in this method are: otolith microchemistry is reliable for differentiating anadromous and non-anadromous parents, visual characteristics or genetic marks can be used to differentiate cutthroat from steelhead fry, emigration of juvenile steelhead from the spawning area is negligible before sampling, the gear type and sampling design provide for equal catchability of juvenile steelhead, and genotyped fry are correctly assigned to the sampled or unsampled parents. This genetic mark-recapture method for steelhead is likely to be the most robust because it is reasonable to assume the above assumptions can be met. As with repeat spawners, it may be likely to combine likelihoods, bootstraps, or posterior probabilities results from independent methods to improve the precision of the estimate. If otolith microchemistry is not used, the abundance estimate from the genetic mark-recapture will include all O. mykiss contributing to off-spring, which includes rainbow trout.

A third approach considered is a variation of the genetic mark-recapture approach for steelhead, instead using smolt traps operated near the weir sites rather than fry collections. In this study design, steelhead smolts are aged and assigned to a brood or spawning year. Genotyped smolts from the correct year class are compared to adult samples to estimate abundance. This estimate is the sum of the anadromous estimate and the resident rainbow trout that produce smolts. Key assumptions with this method include: emigration from the spawning zone is random or negligible before smolting, all smolts have equal catchability and survival, and genotyped juveniles are correctly assigned to the sampled or unsampled parents. The largest concern with this method is the assumption that emigration before smolting is negligible or random, and the survival of smolts from age 1 to 4 can be estimated so all smolt samples have equal catchability.

A fourth approach is the use of the mainstem smolt trap to capture steelhead juveniles. Adults are collected at tributary weirs above the mainstem smolt trap site and juveniles are collected at the mainstem smolt trap site. This approach is identical to the fall Chinook approach proposed earlier. It has similar issues as the third approach, but it may be difficult to catch sufficient smolts for a reliable estimate due to poor trap efficiencies in the large mainstem rivers (Kinsel et al. 2008).

Other Sampling Approaches. Weir operation on the mainstem Cowlitz was not pursued because it has a low chance of success in this very large river. The sonar option (Maxwell 2007) was also considered but the wide river and overlapping runs of coho and spring Chinook salmon, along with steelhead make it difficult to identify and distinguish the different species without a test fishing program. WDFW is pursuing the use of genetic mark-recapture using returning Chinook salmon adults on the Coweeman River (adult to adult), but given that some fall Chinook do not mature until age 6, there will be a significant delay in estimating escapement. Results from this study will not be available until 2015. There are some unique challenges in application of this method to Cowlitz River steelhead based on the possible homing of adults and meeting the mark-recapture assumptions, especially those concerned with equal catchability. First, if the degree of homing to individual tributaries is very high (>99%), the methods for collection of adults at weirs is appropriate for parental genetic mark-recapture. However, if straying occurs into tributaries without weirs or the mainstem, abundance estimates are likely to be biased high. Stray rates from other Oregon and Washington wild steelhead populations without genetic sampling or CWT juvenile programs will be difficult to estimate and bias the abundance estimate. For the time being these other sampling approaches are not recommended.

The final approach considered is that from Korman et al (2002) and Korman et al. (2007), in which he proposed a method to radio and spaghetti tag steelhead throughout the run. Radio tag antennae are placed below the estimated point of entry into the population to determine the date radio tagged fish move into the survey area. On the day of a snorkel survey, a raft or helicopter is used to radio track fish to determine if they are alive and present in the survey area. Fish classified in this manner are called tags. The snorkel survey is used to estimate the observer efficiency based on observed spaghetti tags with active radio tags. The abundance estimate is all observed fish divided by the observer efficiency. Assuming binomial sampling, each snorkel survey provides an independent estimate of population abundance. The Area-Under-the-Curve (AUC) in fish days can be estimated by interpolation between the survey estimates of abundance. In addition, if timer radio tags are used (Shardlow et al. 2007) instead of normal radio tags the survey life (sl) can be estimated. Timer radio tags have two tilt switches and a timer set to record death of the fish if the tag angle is between 45 and 315 degrees for longer than 3 minutes. These tags have been accurate in estimating survey life in the hatchery and for one wild population. Trapezoidal approximation is used to estimate the AUC (English et al. 1992), which is an interpolation of the daily fish abundance estimators (Korman et al. 2002) based on the time of counts and the population abundance from the mark-recapture. Timer tags provide an independent estimate of the mean and sd of survey life. Different equations or distributions could be used to estimate survey life, which is often assumed to be constant or declining (Su et al. 2001, Korman et al. 2002). Escapement is estimated as the AUC divided by the survey life (Hilborn et al. 1999).

The Korman approach is a viable approach for estimating steelhead populations in Cowlitz River tributaries using weirs to tag fish, radio tagging fish to estimate residence time and observer efficiency, developing the daily abundance estimate using snorkeling, and the annual abundance estimate using AUC. However, application of this approach is very labor intensive and should be pursued if other methods are unsuccessful.

MA-A Deliverables

Fall Chinook	
What	1. Representative sample of tissue from adults/carcasses and juveniles of sufficient size to meet the precision standards. 2. Representative sample of biological data (length, sex, origin, scales) from adults/carcasses of sufficient size to meet the precision standards. 3. Representative sample of biological data (length, sex, origin, scales) from juvenile outmigrants of sufficient size to meet the precision standards. 4. Entry of data into genetic, age and scales, juvenile migrant, and spawning ground survey databases for future analysis 5. Operation and maintenance of genetic, age and scales, juvenile

	migrant, and spawning ground survey databases
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power to fund Items 1-4; WDFW to fund Item 5

Coho	
What	6. Capture-mark-recapture sufficient coho adults to meet the precision standards and estimate survey life and observer efficiency. 7. Collect genetic and biological data (length, sex, origin, scales) from all adults to meet the precision standards. 8. Conduct AUC and redd surveys as described and record individual redd locations. 9. Entry of data into trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases for future analysis. 10. Operation and maintenance of trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power to fund Items 6-9; WDFW to fund Item 10

Steelhead	
What	11. Capture-mark-recapture sufficient steelhead adults to meet the precision standards. 12. Collect genetic and biological data (length, sex, origin, scales) from all adults to meet the precision standards. 13. Conduct redd surveys as described and record individual locations. 14. Entry of data into trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases for future analysis. 15. Operation and maintenance of trap, genetic, age and scales, juvenile migrant, and spawning ground survey databases.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power to fund Items 11-14; WDFW to fund Item 15

MA-B. Juvenile Trapping and Sampling

Applies to:

Estimation of natural spawner abundance (re-capture of juveniles for genetic abundance estimation), smolt migration timing and speed, and cutthroat predation assessment. Affected populations are:

- Lower Cowlitz fall Chinook
- Lower Cowlitz coho
- Lower Cowlitz steelhead
- Lower Cowlitz cutthroat

Juvenile trapping would occur for the purpose of collecting genetic samples for use in the genetic mark-recapture analysis (AM-1a) to produce NOS and HOS estimates for Lower Cowlitz fall Chinook. In addition, data will be collected to estimate abundance and downstream migration speed of outmigrating juvenile fall Chinook.

Unless results of the efficacy test (see introduction) indicate otherwise, a rotary screw trap will be operated in the lower Cowlitz River from February through September annually. A random sub-sample of the juvenile salmonids captured will be examined for species, origin (HOR vs NOR), length and weight. The trap will be operated according to protocols developed as a part of the efficacy testing in the initial year(s) of this plan.

A smolt trap will be located in the mainstem Cowlitz River upstream of the confluence with the Toutle River to ensure that fish collected originated from only the Cowlitz River. Including migrants from the Toutle River would violate the key assumption that we are sampling a closed system. The trap will be located as near to the confluence with the Toutle River as possible and in a location that promotes higher than average trap efficiencies. The trap will be operated for the duration of the juvenile fall Chinook migration period—typically February through August. For the genetic mark recapture analysis, the juvenile salmon outmigrants must be collected in proportion to their abundance.

The following technique, even with its biases, offers a relatively low cost approach to estimate trap FCE. Smolts are tagged using the elastomer format visible implant tag (VIE) developed by Northwest Marine Technology. Four colors of elastomer are implanted in the left and right adipose eye tissue and FCE is calculated for each group based on the number of marked fish that were recaptured, divided by the total number released for each group. One group each of steelhead, coho and Chinook juveniles are marked and released upstream per week during peak migration periods. Only fish that appear healthy and within the normal smolt size range would be marked. Marked fish would be allowed to recover, transferred to a transport tank supplied with a continuous flow of river water, held overnight and released into Cowlitz River within one mile above the smolt trap the next day.

Hatchery cutthroat trout will be captured in the mainstem Cowlitz River downstream of the Barrier Dam using beach seines. Stomach contents will be collected from hatchery and naturally produced cutthroat trout to determine prey species in diet. Sampling of hatchery cutthroat trout will occur in the fall time spring time frame after juvenile hatchery cutthroat have been released from the hatchery and had some time to rear in the river.

MA-B Fall Chinook Deliverables

What	1. Genetic samples from trapped juvenile fall Chinook for use in the genetic mark-recapture method (AM-1). 2. Data for estimating abundance and downstream migration speed of juvenile fall Chinook. 3. Number of salmonids found in the stomachs of cutthroat trout by species, and the number of trout sampled.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power to fund Items 1-3

MA-C. Creel Surveys

Applies to:

Estimation of kept and released catch in ocean, mainstem Columbia and Cowlitz river fisheries by population for:

- All Cowlitz Chinook, coho and steelhead populations. Cowlitz River fisheries estimates for spring Chinook are not required as there is currently no natural population.

Ocean Fisheries. A stratified statistical creel program will provide effort estimates and stock specific catch estimates. Ocean fisheries are partitioned into catch areas based on port of landing. Effort levels are estimated by counting the number of boats that leave a given port on a given day. Subsequent sampling of anglers upon their return provides an average number of anglers per boat that is applied to the number of boats to provide an estimate of total anglers per day. Anglers are randomly contacted to collect data regarding fishing effort (number of anglers and duration of trip) and success (number of fish kept and released). Catch data from angler surveys is applied to effort estimates to provide daily catch estimates. Daily effort and species specific catch estimates are aggregated for each catch area from the northern Canadian border to Southern California to provide total effort and catch estimates. Landed catch is sampled for biological data and to recover CWTs. CWT recovery data is used to further apportion the species specific catch estimates to produced stock specific catch estimates for each catch area. Stock specific catch estimates by catch area are then aggregated to produce stock specific catch estimates for ocean fisheries in their entirety.

CWT marking programs are in place for salmon production from the Cowlitz River. Recoveries of CWT marked fish released from the Cowlitz River provide data necessary to estimate catch of

Cowlitz salmon in ocean fisheries. CWT marks are applied only to hatchery fish; therefore, catch estimates are for hatchery fish only. For mark selective fisheries, natural-origin fish released will be estimated using marked to unmarked ratios of fish handled in each catch area. This catch ratio will be applied to estimates of kept hatchery fish to estimate the number of natural-origin fish released. Released fish will then be apportioned by stock using the stock composition of hatchery fish landed in the same catch area. Stock specific estimates of natural fish handled will be estimated for each catch area and then aggregated to provide ocean wide estimates.

Additional details regarding sampling methodology and annual catch estimates can be found in (Lai et al. 1991).

Mainstem Columbia River. Daily effort and species specific catch estimates are aggregated for each catch area from the northern Canadian border to Southern California to provide total effort and catch estimates. Landed catch is sampled for biological data and to recover CWTs. CWT recovery data is used to further apportion the species specific catch estimates in order to produce stock specific catch estimates for each catch area. Stock specific catch estimates by catch area are then aggregated to produce stock specific catch estimates for ocean fisheries in their entirety.

The stratified statistical creel program will provide effort estimates and stock specific catch estimates. The lower Columbia River (downstream of Bonneville Dam) is partitioned into 10 catch areas. Effort levels are estimated by conducting twice-a-week aerial surveys to provide and instantaneously count the number of boats and bank anglers. For boat fisheries, subsequent sampling of anglers at boat ramp provides an estimate of number of anglers per boat that is applied to the number of boats to provide an estimate of total number of anglers. Effort estimates from twice-a-week aerial counts are expanded to estimate total effort by month. Anglers are randomly contacted to collect data regarding fishing effort (number of anglers and duration of trip) and success (number of fish kept and released). Catch data from angler surveys is applied to effort estimates to prove monthly catch estimates. Effort and catch estimates are stratified by angling method (boat or bank) and days (weekends or weekdays) and subsequently aggregated to produce monthly effort and species specific catch estimates for each catch area in the lower Columbia River. Landed catch is sampled for biological data and to recover CWTs. CWT recovery data is used to further apportion the species specific catch estimates to produce monthly stock specific catch estimates for each catch area in lower Columbia River.

CWT marking programs are in place for Cowlitz River salmon production. Recoveries of CWT-marked fish released from the Cowlitz River provide data needed to estimate catch of Cowlitz salmon in lower Columbia River fisheries. CWT marks are applied only to hatchery production; therefore, catch estimates are for hatchery fish only. For mark selective fisheries, natural-origin fish released will be estimated using marked to unmarked ratios of fish handled in each catch area. This catch ratio will be applied to estimates of kept hatchery fish to estimate the number of natural-origin fish released. Released fish will then be apportioned by stock using the stock composition of hatchery fish landed in the same catch area. Stock specific estimates of natural fish handled will be estimated for each catch area and then aggregated to provide estimates for the lower Columbia River.

Additional details regarding sampling methodology and annual catch estimates can be found in (U.S. v Oregon TAC 2008).

Cowlitz River. Creel surveys require varying levels of effort depending on the design and precision of catch estimates required. For all species in the Cowlitz River downstream of the Barrier Dam, a creel survey could be used for two primary purposes: 1) to improve catch estimates of NOR and HOR fall Chinook or 2) to determine the ratio of hatchery fish kept and natural fish released.

Collecting data necessary to achieve the first purpose could be achieved using statistical creel surveys similar to those described above for ocean and lower Columbia River fisheries. A statistical creel survey requires independent estimates of effort levels and success rates. The fishery may be stratified by time, area and/or fishing method. Ground or aerial surveys will be required to estimate the number of anglers participating in the fishery. Random surveys of anglers would need to be conducted to determine the number of hatchery fish kept and natural fish released. Catch data would be applied to effort estimates to provide catch estimates. Sampling of catch to recovered CWTs would be needed to determine the number of fish landed in the Cowlitz River that were not Cowlitz-origin fish. Catch will be estimated using Catch Record Cards (see Section MA-D).

A creel census intended to achieve the second purpose would likely not require implementation of a randomized statistical creel program. Surveys to estimate effort levels would not be necessary. Catch estimates would be provided via Catch Record Cards, as currently occurs. Random surveys of anglers (one to two days per week, typically August through May) would be conducted to determine numbers of hatchery fish kept and natural fish released. These data would be used to develop a ratio of natural fish released per hatchery fish kept. This ratio would be applied to the estimate of hatchery fish kept in order to estimate the number of natural fish released. This estimate is then used to determine mortality of NORs due to handling (see AM-5 below).

Commercial Fisheries. All landed catch from commercial fisheries in the ocean and lower Columbia River must be recorded on fish tickets and submitted to the state in which those fish are landed. Fish tickets include the poundage of fish landed by species, but not the number. Fish landed at processing plants are randomly sampled to determine the average weight of fish landed by species, which can be applied to the weight reported on the fish tickets to determine the number of fish landed by species. Landed catch is also sampled to collect biological data and recover CWTs. CWT recovery data is applied to catch estimates to produce a stock specific estimate of the number of fish landed. CWT marking programs are in place for salmon production from the Cowlitz River. Recoveries of CWT-marked fish released from the Cowlitz River provide data needed to estimate catch of Cowlitz salmon in ocean and Columbia River commercial fisheries (U.S. v Oregon TAC 2008).

Precision Levels. Accurate harvest rates in fisheries are necessary to calculate several key metrics in the AHA model used to evaluate various production program options, including NOS and HOS abundance estimates. Statistical creel programs in place for lower Columbia River and ocean sport fisheries, plus sampling programs in place for commercial fisheries, all provide accurate species specific catch estimates. In contrast, catch estimates within the Cowlitz River have a much lower level of accuracy. Over the next 3 to 5 years, data collected through improved abundance estimation methodology should be used to determine if increased precision in catch estimates is needed to achieve the precision goal (CV = 15%) for NOS and HOS abundance estimates.

Creel Survey Work Elements

- For Sport Fisheries
  - Conduct fishing effort counts
  - Sample anglers for effort and success
  - Sample catch for biological data and to recover CWTs
  - Summarize and analyze data to produce stock specific catch estimates
- For Commercial Fisheries
  - Summarize fish ticket data
  - Sample catch for biological data and to recover CWTs
  - Summarize and analyze data to produce stock specific catch estimates

MA-C Deliverables

What	1. For Columbia River and ocean sport fisheries (statistical creel): number of angler days, kept and released catch (NORs and HORs) by stock and recoveries of CWTs. 2. For Columbia River and ocean commercial fisheries (statistical sampling program): kept and released catch (NORs and HORs) by stock and recoveries of CWTs. 3. For Cowlitz River fisheries (random angler survey): kept and released catch (NORs and HORs).
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	WDFW to fund Items 1 and 2 (information for catch outside of Washington to be provided by PSMFC). Tacoma Power to fund item 3

MA-D. Catch Record Cards

Applies to:

Estimating in-river (Cowlitz) catches by population for:

- All Cowlitz Chinook, coho and steelhead populations

Catch Record Cards (CRCs) are used to produce species specific kept-catch estimates for the Cowlitz River. The CRC system depends primarily on voluntary participation and compliance by anglers. In order to fish for salmon and steelhead, an angler is required to purchase a CRC. When an angler catches and lands a salmon or steelhead, they are required to record that catch on their CRC card. CRC are valid for a one year time frame (April-March). At the end of the year, the angler is to return their CRC to the WDFW. Anglers holding in-sample cards are sent reminders to return their CRC to WDFW.

CRCs require the angler to enter the location where they caught and landed their fish. For the Cowlitz River, there are several different locations that can be recorded: (561 Cowlitz River below Mayfield; 563 Cowlitz River between Mayfield Dam and Cowlitz Falls Dam; 559 Cowlitz

River above Cowlitz Falls Dam and Lake Scanewa; and 555 Cispus River). Data recorded on CRCs is then summarized to determine the total number of fish recorded by species and fishing location (harvest summary), which is expanded to estimate total annual catch by species and fishing location. A bias adjustment factor is applied for some species and in some areas to account for successful anglers returning cards at a higher rate than unsuccessfully anglers.

Precision Levels. Accurate harvest rates in fisheries are needed to calculate several key metrics in the AHA model used to evaluate various production program options, including NOS and HOS abundance estimates. In general, estimates based on CRCs have a low level of accuracy as compared to statistical creel programs. Over the next 3 to 5 years, data collected through an improved abundance estimation methodology should be used to determine if increased precision in catch estimates is needed to achieve the precision goal (CV = 15%) for NOS and HOS abundance estimates.

Work Elements

- Summarize recorded catch by species and location
- Expand recorded catch to estimate total annual catch by species and location

MA-D Deliverables

What	1. The number of hatchery fish kept by species and location as determined by catch record cards.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	WDFW

MA-E. Hatchery Broodstock Biological Sampling

Applies to:

Estimation of sex, length, age and origin (NOR vs. HOR) of hatchery broodstock for

- All hatchery programs

Cowlitz hatchery broodstock will be sampled annually by collecting age, length, sex, and coded wire-tags. After spawning, the fish are held in totes in the spawning room and then all fish are sampled for origin (HOR versus NOR). A random sample is collected for the other metrics. Scales are removed and place on scale cards. Broodstock fish are wanded for coded wire-tags and heads are removed if a tag is found. Individual fish measurements are collected. All data collected will be entered into the WDFW Region 5 biological database.

MA-E Deliverables

What	1. Scales, sex and lengths of fish spawned at the Cowlitz Salmon Hatchery. 2. CWT data.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

MA-F. In-Hatchery Monitoring/ Record Keeping

Applies to:

Estimation of in-hatchery survival by life stage and release numbers (and sizes), monitoring of disease and hatchery operations for:

- All hatchery programs

WDFW collects data on all aspects of hatchery operations including egg survival, fry survival, fingerling survival, release numbers and pathological testing results. Quarterly reports and a final annual report are generated from these data as part of the operations contract with Tacoma Power. All data collected are entered into "Fish Books", a database maintained by WDFW. The data are then checked by WDFW and, after quality control, included in the WDFW Region 5 biological database.

MA-F Deliverables

What	1. Pre-spawn survival, egg survival, egg to smolt survival, 2. Number of fish released; 3. Incidence of disease.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

MA-G. Juveniles from Upper Cowlitz

Applies to:

Marking of and estimation of smolt outmigration abundance and mark-recapture collection efficiency for:

- Upper Cowlitz spring Chinook,
- Upper Cowlitz fall Chinook
- Upper Cowlitz coho
- Upper Cowlitz steelhead

The Cowlitz Falls Fish Facility (CFFF) is operated throughout the spring-summer smolt migration in the upper Cowlitz River basin. Seasonal operations begin April 16 and extend to August 31. The CFFF is staffed at all times while operating and staff operations include inspections, monitoring and adjusting flow across the separator, and debris removal. Staff also monitor flap gate operation and fish condition in the holding tanks. Smolts collected are carefully handled, examined and transported to the stress-relief ponds at the Cowlitz Salmon Hatchery prior to their release into the adjacent Cowlitz River to continue their migration. Parr, fry, and rainbow trout are released back into the reservoir above Cowlitz Falls Hydroelectric Project. Non-salmonids are released below the project.

MA-G Deliverables

What	1. Numbers by species, 2. Marks (if present), 3. Subsample of lengths of juvenile salmonid outmigrants collected at the CFFF, 4. Mark-recapture estimation of FCE 5. Marking all out-migrants according to Table 2-10 (FHMP Update).
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Items 1-4 are funded by BPA. Providing data is the responsibility of Tacoma Power. Tacoma Power is working with BPA to share the cost for item 5. Tacoma will fund item 5 until sharing responsibilities are resolved.

MA-H. Juveniles at Mayfield

Applies to:
Estimation of smolt outmigration abundance and mark-recapture collection efficiency for: • Tilton spring Chinook, • Tilton coho • Tilton steelhead

The juvenile salmonid bypass system is operated year-round at Mayfield Dam. The secondary separator pumps are turned off during the winter, however, the bypass system continues to operate in a passive mode. While in passive mode all fish are bypassed directly into the downstream transport pipeline. Beginning April 1st, the secondary separator pumps are turned on and the fish are routed into holding raceways at the Mayfield counting facility. The raceways are checked for accumulated fish up to six days/week from April through December. All juvenile salmonids are examined for visual marks and clips. Adult salmonids and non-salmonid fish are not examined for marks. All salmonids (except rainbow trout, Atlantic salmon, tiger musky, and Arctic char) are released downstream with or without tagging. Fish not released below Mayfield Dam are returned alive to Mayfield Lake or sacrificed after recording.

MA-H Deliverables

What	1. Numbers by species, 2. Marks (if present) 3. Subsample of lengths of juvenile salmonid outmigrants collected at the Mayfield Dam downstream collection facility.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

MA-I. Adults at Cowlitz Salmon Hatchery Separator

Applies to:
Estimation of the number, origin, and disposition of adults returning to the hatchery for • All populations

Tacoma Power handles all adult salmonids that enter the ladder and separator facility at the Cowlitz Salmon Hatchery. The facility operates year-round and data is collected on the origin of all fish handled. The disposition of all fish (hatchery broodstock, upstream, surplus or downstream), by origin, is recorded into an Access database. The data is reviewed weekly and provided to the WDFW. It is then checked by WDFW and, after quality control, included in the Cowlitz Complex annual report.

MA-I Deliverables

What	Weekly summary of the number, timing, origin and disposition of adult salmonids handled at the Cowlitz Salmon Hatchery adult fish separator.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

MA-J. Weir Operation and Lower Cowlitz Adult Capture

Applies to:

Estimation of natural spawner abundance, controlling pHOS, and collection of natural origin broodstock for:

- Lower Cowlitz coho
- Lower Cowlitz steelhead
- Lower Cowlitz fall Chinook

Operation of weir on selected tributaries of the lower Cowlitz River would achieve three key objectives: 1) control number of hatchery fish on spawning grounds, 2) collect naturally produced winter steelhead for use in an integrated hatchery broodstock program and 3) provide data to assist in producing abundance estimates for naturally produced winter steelhead and coho. The need to collect natural-origin fall Chinook for use in an integrated broodstock program will require the development of methods to capture adults in the mainstem Cowlitz upstream of the confluence with the Toutle River.

Weirs

Floating Resistance Board weirs will be operated in three selected tributaries of the lower Cowlitz River: Olequa Creek, Salmon Creek and Ostrander Creek. Weirs will be operated year round. A single crew will rotate between all four weirs with the goal of checking traps every 1 to 2 days.

Weirs will be operated to prevent all summer steelhead from entering the area upstream of the weirs. All summer steelhead captured by these weirs will either be returned to the stream below the weir or will be removed from the system completely. Hatchery fish would only be returned to the Cowlitz River during the summer months prior to the fall freshets (September) when the sport fishing effort levels are high. All fish returned to the river would be documented and marked to determine their fate after release. No additional data or information will be collected from summer steelhead.

For winter steelhead, weirs will be operated to control number of hatchery fish escaping to natural spawning areas, to collect naturally produced fish to develop an integrated broodstock, and to provide data that assists in producing annual abundance estimates.

During the early period of winter steelhead returns (November through February), all hatchery steelhead (winters and summer stock) that are collected at the weir will be removed from the river. During this time, hatchery winter steelhead entering these tributaries are predominantly summer steelhead or Chambers Creek stock winter steelhead, both of which have a negative impact on natural production. For the duration of this FHMP Update, no hatchery steelhead collected during the November to February time frame will be used for broodstock purposes; however, as time goes on and the Chambers Creek stock is eliminated from the system, naturally produced fish returning during this time frame could be used to expand the return timing of integrated hatchery program winter steelhead.

During the late period of winter steelhead returns (March through early June), weirs will be operated for all of the aforementioned purposes. Access by hatchery steelhead to natural spawning areas will be controlled. Some hatchery fish may be passed into natural spawning areas where abundance of naturally produced fish is critically low. Hatchery fish not passed upstream will be removed from the system completely. Some naturally produced fish will be retained for use in developing an integrated broodstock. Naturally produced fish not used for broodstock purposes will be marked prior to passing upstream above the weir for use in a mark-recovery study to estimate abundance of naturally produced winter steelhead in these select tributaries. Data collected in these mark-recapture studies will assist in estimating overall abundance of naturally produced winter steelhead in the lower Cowlitz basin (see Section AM-1).

During the coho migration (late September through January), weirs will be operated to control hatchery coho on spawning grounds and provide data to assist in producing abundance estimates for naturally produced coho. All hatchery coho returning to these tributaries will be removed from the system. Naturally produced coho will be marked prior to passing upstream above the weir for use in a mark-recovery study to estimate abundance of naturally produced winter steelhead in these select tributaries. Data collected in these mark-recapture studies will help estimate overall abundance of naturally produced coho in the lower Cowlitz basin (See Section AM-1).

Weirs are expected to function properly for summer steelhead, but weather conditions may pose a challenge during periods of extreme flows for winter steelhead and coho.

Collection of Fall Chinook (NOR) Broodstock

A method of collection will be installed in the Cowlitz River downstream of the Barrier Dam and upstream of the confluence with the Toutle River for the primary purpose of collecting naturally produced fall Chinook to develop an integrated broodstock. Collection site will be near to the confluence with the Toutle River as possible to maximize the number of naturally produced fall Chinook captured. The fish collector will be operated daily to collect unmarked fish for transport to Cowlitz Salmon Hatchery. The number of naturally produced fall Chinook transported to hatchery for spawning purposes will depend on program size identified in the FHMP Update, Section 3.1.

The fish collector could also be used to control the number hatchery fall Chinook returning to natural spawning locations upstream of the Toutle River. The collector will provide the capability to remove hatchery fall Chinook from the Cowlitz River to achieve the pHOS goal set forth in Section 3.1. Achieving pHOS will need to be tempered by the demographic risks associated with reduced spawning abundances. Removal of hatchery fall Chinook will be determined by program size and natural spawning abundance goals described in the FHMP Update, Section 3.1. All other species, regardless of origin, would be passed upstream to continue their migration.

Weir Work Elements

- Install weir
- Maintain and repair weir as needed
- Check weir to handle fish
- Summarize number of fish handled by species, origin and disposition

Mainstem Collection Work Elements

- Test alternative gear
- Select, operate and maintain gear
- Summarize number of fish handled by species, origin and disposition

MA-J Deliverables

What	From tributary collection: 1. Number of hatchery summer steelhead returned to the Cowlitz River 2. Number of hatchery summer steelhead, winter steelhead and coho removed from the Cowlitz basin 3. Number of naturally produced winter steelhead collected for broodstock purposes 4. Number of hatchery and naturally produced winter steelhead and coho passed upstream of weirs 5. Number of marked naturally produced winter steelhead and coho passed upstream of weirs From mainstem collection: 1. Number of naturally produced fall Chinook collected for broodstock purposes
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	From tributary collection-Items 1-5: • WDFW/Tacoma Power to split operational and maintenance costs of weirs. • WDFW to provide capital outlay to purchase and install weirs. • Cost of operation and maintenance will be based on months of

	operation: WDFW: May-November; Tacoma Power: December-April. From mainstem collection - Item 1 • Tacoma Power will fund pending completion of study design.

ANALYTICAL METHODS (AM) USED TO ANALYZE DATA

Table J-2 associates analytical methods with indicators estimated, data needed and populations affected. The use of indicators in the annual decision making process is provided in Appendix H.

Table J-2. Indicators estimated for each analytical method, monitoring activities needed, and populations affected. All variables are estimated annually.

Analytical Method (Code)	Variables Estimated (Indicators)	Data/Observations Needed for the Analysis (Measures)	How will Data be Collected? (Monitoring Activities)	Application (Populations)
AM-1a	Spawner abundance and composition for Lower Cowlitz fall Chinook (NOS+HOS, pHOS)	Genotyped adult tissue samples, juvenile genotype samples, redd count, number of mass marked carcasses, and number of carcasses sampled	MA-A, MA-B	LC: FCH
AM-1b	Spawner abundance and composition for Lower Cowlitz coho (NOS+HOS, pHOS)	Genotyped adult tissue samples, juvenile genotype samples, redd count, number of mass marked spawners, and number of spawners sampled	MA-J, MA-A	LC: COH
AM-1c	Spawner abundance and composition for Lower Cowlitz steelhead (NOS+HOS, pHOS)	Genotyped adult tissue samples, juvenile genotype samples, redd count, number of mass marked spawners, and number of spawners sampled	MA-J, MA-A	LC: STHD
AM-2	Spawner distribution	Redd counts by stream reach	MA-A, MA-K	LC: FCH, COH, and STHD
AM-3	Pre-terminal exploitation rates	CWT data	MA-D	LC: FCH, COH, STHD. UC: COH.
AM-4	Terminal catch of HORs	Catch, effort, and mark sampling data	MA-D, MA-C	LC: FCH, COH, STHD, SPC, CUT UC: FCH, COH, STHD, SPC TIL: COH, STHD
AM-5	NOR mortality in terminal fisheries	Catch, effort, and mark sampling data	MA-D, MA-C	LC: FCH, COH, and STHD
AM-6	HOB, NOB, pNOB	Counts of marked and unmarked returns to the hatchery, counts of HORs and NORs spawned	MA-E	LC: FCH, COH, and STHD
AM-7	Hatchery recruits per spawner ratio (and SAR)	Pre-spawn mortality, egg mortality, egg to smolt mortality, catch, and escapement	MA-F	LC: FCH, COH, and STHD

Analytical Method (Code)	Variables Estimated (Indicators)	Data/Observations Needed for the Analysis (Measures)	How will Data be Collected? (Monitoring Activities)	Application (Populations)
AM-8	PNI	pNOB (AM-6) and pHOS (AM-11 and 15) estimates	none	LC: FCH, and STHD UC: COH, SPC, STHD
AM-9	Smolt abundance using stratified-Peterson (Darroch) mark-recapture method	Mark-recapture data	MA-B	LC: FCH, COH, STHD
AM-10	Smolt migration speed and timing	Mark-recapture data	MA-B	LC: FCH, COH, STHD
AM-11	Natural spawning escapement abundance (NOS) and pHOS at adult separator	Number of HORs, NORs by destination, mark sampling, catch sampling	MA-I, MA-D	UC: COH, SPC, STHD TIL: STHD
AM-12	Smolt yield, timing and FPS at Cowlitz Falls	Smolt counts and mark-recapture for collection efficiency	MA-G	UC: COH, SPC, STHD
AM-13	Smolt yield, timing and FPS at Mayfield	Smolt counts and mark-recapture for collection efficiency	MA-H	TIL: STHS, COH, SPC
AM-14	Predation rate of cutthroat on salmonids	Stomach contents	MA-B	LC: CUT

AM-1a. Method for Estimating Natural Spawner Abundance and Composition for Fall Chinook

Applies to:

Estimation of natural spawner abundance and composition for:

- Lower Cowlitz fall Chinook

The purpose of the Analysis Methods section is to document the methodology used to develop point estimates and confidence intervals for various fall Chinook salmon indicators. It provides an explicit data flow from the collection of data in the Monitoring Activities section to the estimation of indicators. The Analysis Methods include laboratory methods for genetic, scale, and CWT data; sample size requirements for various indicators to ensure that precision goals can be achieved; the key assumptions for the indictors; and explicit statistical analysis of field and laboratory data used to estimate the indicators. In addition, there are sections to estimate calibration factors and a contingency plan to estimate abundance if the genetic mark-recapture estimate fails in some years. However, it is likely that the abundance estimates from the contingency plan will not met NOAA guidance for precision but should be unbiased.

Molecular Genetics Lab Analysis. PSC/GAPS standardized microsatellite markers are used for parentage/sibship analysis. SNP loci are not used for this project, despite their likely succession to microsatellite markers, because the efficacy of SNPs for pedigree reconstruction is currently being evaluated. They may be used in the future. The laboratory procedures and analytical methods are well-established for the microsatellite GAPS loci (Seeb et al. 2007). Microsatellites are highly variable and have been the preferred marker for pedigree reconstruction (Jones and Arden 2003) because there are many alleles per locus (typically 35 to 40). The total number of possible allelic combinations for the 13 microsatellite markers is approximately 4013 = 6.7 x 1020.

Polymerase chain reaction (PCR) amplification is used on each fish sample using the 13 fluorescently end-labeled microsatellite marker loci standardized as part of the GAPS project (Seeb et al. 2007). Loci are amplified as part of multiplexed sets using either a PTC200 thermal cycler (MJ Research) or GeneAmp 9700 (Applied Biosystems). PCR products are visualized by electrophoresis on an ABI 3730xl automated capillary analyzer (Applied Biosystems), and fragment analysis is completed using GeneMapper 3.7 (Applied Biosystems). Standardization of genetic data to GAPS allele standards is conducted following Seeb et al. (2007).

There are two broad categories for parentage inference: 1) exclusion and 2) maximum likelihood methods. Exclusion is conceptually the simplest method, whereby Mendelian inheritance rules are used to determine incompatibilities between a candidate parent-offspring pair. If all but two parents are excluded as possible parents (given all parents are sampled), then by definition, parentage has been assigned. Yet, this method is extremely sensitive to sampling issues and the reality of genotyping errors (e.g., process error, null alleles, allele drop-out, or mutation) that may contribute to false exclusion (Wang 2004; Kalinowski et al. 2007). In contrast, maximum likelihood approaches take the form of log-likelihood ratios and determine the most likely parent-offspring relationship from a pool of non-excluded parents. These data are used to formulate a likelihood for alternative hypothesized relationships of multiple genotypes. The methods explicitly account for genotyping error and have been shown to be robust in the presence of error and more accurate than exclusion (Marshall et al. 1998; Wang 2004; Kalinowski et al. 2007).

The maximum likelihood methods can be further subdivided into pairwise (Kalinowski et al. 2007; Riester et al. 2009) and group approaches (Wang 2004; Wang and Santure 2009). Pairwise methods estimate the relationship between two individuals, ignoring any other relationships present in the data. Pairwise methods are well established and have been shown to be statistically powerful (Jones and Arden 2003; Kalinowski et al. 2007). We will be using pairwise methods following the forms developed by Kalinowski et al. (2007) (i.e., CERVUS 3) and Riester et al. (2009) (i.e., FRANz) for parentage analysis. While few methods exist for simultaneously estimating parentage (or sibships) among any number of individuals, enormous power gains of group methods have been shown, because (1) assignment errors may be nullified and (2) reductions of statistical power caused by background relationships in the data are counteracted by inferring relationships among multiple individuals (Wang 2004; Wang 2007). Preliminary analysis from brood year 2009 for Coweeman fall Chinook suggests that both pairwise and group methods accurately infer parentage (data not shown). Yet, it appears the group method developed by Wang and Santure (2009) is superior because in addition to producing the “recapture” parameter, it also recovers total unique adults sampled, a critical piece of information required for mark-recapture applications using a Hypergeometric estimator for spawner abundance or the estimation of breeders using accumulation curves of unique genotypes compared to all genotypes.

An important topic to consider is the precision of genotyping efforts and the reliability of inferred relationships. For the purposes of this analysis, genotyping accuracy pertains to determination of “marks” and genetic error pertains to the correct determination of “recapture”. Regarding the determination of “marks”, carcass samples will be genotyped in duplicate to effectively eliminate the inaccurate recording of the parental genotype. Smolt samples will be analyzed independently by two people to reduce the occurrence of process errors. Regarding the determination of recaptures (i.e., parentage) or sibships, many factors affect accuracy, from number of genetic markers used to relationships of individuals in the dataset. Wang (2004) found that for simulated data with known relationships, 10 microsatellite loci or 160 SNP loci were sufficiently powerful to almost perfectly reconstruct various sibling and parentage-offspring configurations under weak family structure (i.e., dataset composed of 0.75% full-sibs, 4% half-sibs, and 95.25 non-sib dyads). For datasets with stronger family structure, fewer loci were required to correctly infer relationships. Anderson and Garza (2006) reported a similar finding, with an estimate of < 2 of 1000 offspring incorrectly assigned to their parents using 100 SNP loci. Wang (2004) showed that relatedness among parents does affect assignment accuracy, but the reduction is modest. For example, full sib matings lead to a decrease in assignment accuracy of 1% and 4% for parentage and sibships, respectively, when compared to matings between unrelated parents. Yet, the small decrease in accuracy can be compensated by increasing the number of loci used for analysis. Wang (2004) also analyzed empirical datasets containing known pedigrees, and reported that when age and sex was known, only five microsatellite loci were required to perfectly reconstruct both parent-offspring and sibling relationships. If age and sex were unknown, 10 microsatellite loci recovered 100% of full-sib relationships and 97.5% of the parent offspring relationships. In this study, we are using 13 microsatellite loci; therefore, published literature suggests there is sufficient power to reliably reconstruct the necessary pedigree information.

Fish Aging Lab Analysis. Acetate impressions are made of the scale samples by a scale card press. Where samples are covered with clear acetate (0.5mm thickness) and pressed under 1200-1300 PSI @ 100° C for 30 seconds to 1 minute. Acetate impressions are then slightly cooled and removed from the scale card. Acetate impressions of scale samples are aged using a modified Gilbert/Rich ageing notation (Groot and Margolis 1991), where annuli are counted along with the scale edge to produce a total age in years. Annuli are defined as an area of narrowly spaced circuli that represent winter/early spring growth. Age is recorded as the total age in years followed by the year at outmigration. For example; 41 is noting a total age of 4 while the juvenile salmon left its natal freshwater habitat within its first year of life (subyearling). A 42 would note a total age of 4 while the juvenile salmon left its fresh water rearing habitat in its second year of life (yearling).

CWT Lab Analysis. The recovery of CWT tags at the WDFW lab follows the procedures outlined in tag recovery chapter (Blankenship and Hiezer 1978) of the Pacific Coast Coded Wire Tag Manual and is briefly repeated here. Each snout is passed through a magnetic detector to determine tagged and untagged snouts. Untagged snouts are set aside and rechecked after magnetizing the tag. To ensure the tag is magnetized, the length of the tag must pass through the horseshoe magnet in a plane parallel with a straight line collecting the poles. If the tag angle is off more than 40 degrees the tag may not be magnetized. Therefore, the head is passed through the magnet in three positions corresponding to the X, Y, and Z axes and then through the detector.

Large heads are often dissected to maximize tag detections. Snouts with no tags are saved and an x-ray machine is periodically used determine tag presence in these “no tagged” snouts. After determining a tag is present, the snout is dissected, and the tag is located by process of elimination. After recovering the tag, the binary code is determined by careful observation under a microscope. CWT data is then entered into WDFW CWT access database, and provided to managers as needed and uploaded into the Regional Mark Information System (RMIS).

Sample Size for Abundance. The purpose of this section is to ensure the adult monitoring program sample sizes are large enough to meet the NOAA and FHMP precision goals. Traditional mark-recapture sampling requirements for different precision levels have been estimated by Seber 1982 (pages 65-68). However, in genetic mark-recapture analysis, this is not a straightforward process due to study design differences, including the percentage of unsuccessful spawners, incubation survival, offspring per spawner, number of times a male successfully mates, schooling of juveniles, and two genotypes per juvenile.

Adult Chinook escapement estimates in the Cowlitz River have ranged from ~1000 to over 14,000 during the last 11 years and averaged ~4000 fish (WDFW 2011). Carcass sampling occurs from the I-205 Bridge upstream to the Barrier Dam during the die off period at a frequency of 1 to 2 times per week. Samplers annually inspect from ~500 to ~5000 fish for CWTs. The total varies between less than 20% to over 40% of the run, depending on resources and environmental conditions (Chris Gleizes, WDFW, personal communication). Therefore, if this sampling scheme is followed, a minimum of 200 tissue samples could be collected from adults. Approximately 75% of the carcass samples in the Coweeman were successfully genotyped; the remaining 25% could not be genotyped because the tissue was too degraded. This would result in 150 genotyped carcasses for the Cowlitz Chinook population in the lowest abundance year with a low carcass recovery rate.

Incubation survival averaged approximately 17% to the fry stage in LCR streams (not accounting for density dependence) (Rawding et al. 2010). Trap efficiency in the Skagit River, a similar large system, range from 1% to 9% for Chinook salmon (Kinsel et al. 2008). Assuming an average escapement of 4,000 adults in the Cowlitz with a 1:1 sex ratio, the yield would be 2,000 females. Assuming average fecundity of 5,000 eggs yields an average deposition of 10,000,000 eggs, with a 10% survival rate, this equates to 1,000,000 migrants. Using the lower end of the Skagit efficiency (1%) yields a minimum trap catch of 10,000 outmigrants in a year with average escapement and incubation survival. The minimum catch would be reduced to 8,000 to because approximately 20% of the Chinook spawn below the proposed location of the smolt trap.

Since this technique is new, there is little information on the variability of the unique aspects mentioned above. Rather than speculate on the range of these values, a Binomial Distribution and idealized population was used to estimate the Coefficient of Variation (CV), with roughly equal offspring for successful spawners, males spawning with one female, and ~20% unsuccessful spawners (an estimate from the Coweeman). These constraints probably yield a lower CV than would be observed but provide an exploration of the relationship between marks, captures, and CV for populations between 1,000 and 8,000 adults (Figure J-6). Bailey’s approximation of variance for abundance using the Binomial distribution was used to estimate the CV and may provide slightly more precise estimates than exact estimates based on the Binomial sampling and actual data. The only example using this method on the Coweeman produced a preliminary CV of approximately 7% based on 201 carcasses and 1991 juveniles.

This CV was about 3% higher than the Binomial approximation. Given the minimum carcass recoveries of 200 spawners and a smolt trap catch of 8,000 juveniles, it is reasonable to expect the CV of less than 10% to be achieved.

More specific guidance on juvenile and adult sampling can be achieved with the continued application of this method, especially regarding the balance between adult and juveniles samples and their effect on genotyping error rates. It should be noted that these sample sizes do not account for additional sources of uncertainty including the percentage of redds below the trap, unclipped hatchery fish, and genotyping error rates.

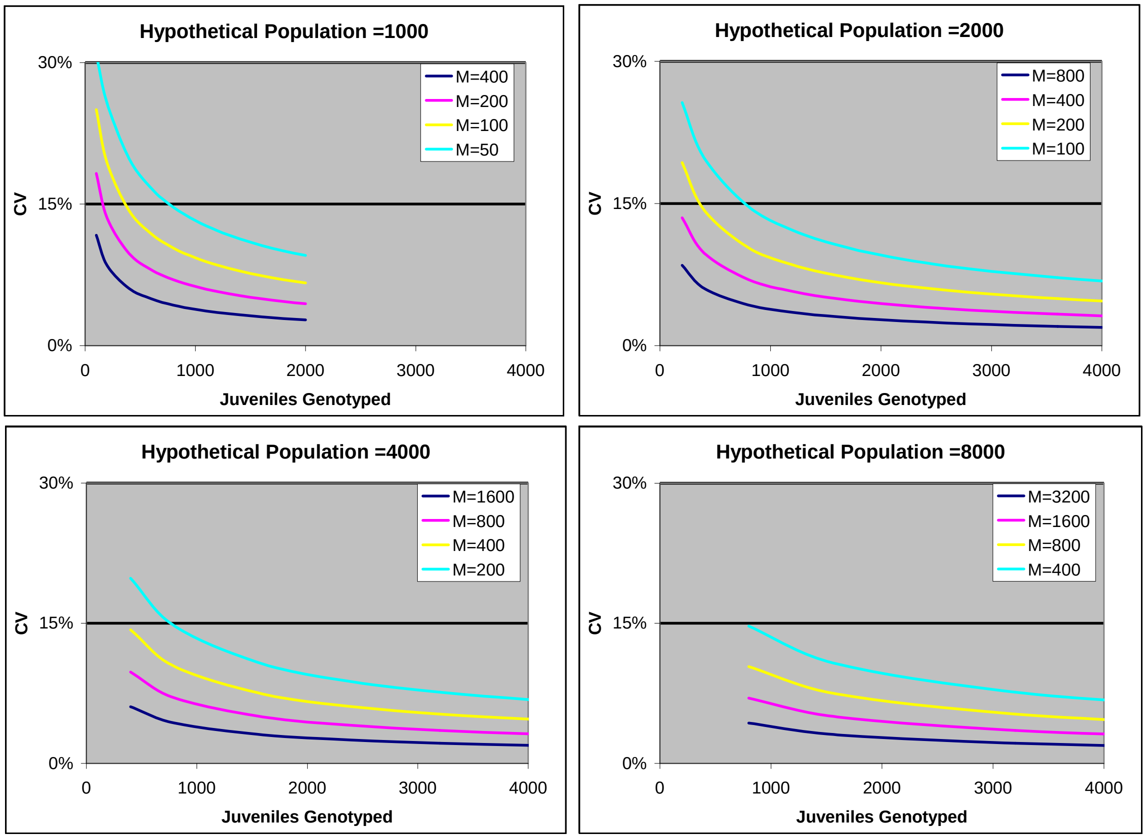

Figure J-6. Estimated CV for abundance using Bailey's approximation of the Binomial Distribution for hypothetical population sizes, number of genotyped carcasses (marks=M), and number of genotyped juveniles (captures=C). Under the lowest hypothetical population only 2,000 juveniles may be sampled.

Sampling Size for Juvenile Mass Mark. One of the assumptions in the genetic mark-recapture is that all natural-origin fish can be identified correctly. However, this occurs only if 100% of the hatchery production is mass marked or if natural-origin and hatchery-origin fish are phenotypically different. Also, the use of the mass marking provides an alternate method of estimating pHOS. Therefore, for adult and juvenile purposes, accurate estimates of the proportion of hatchery fish that are clipped is important. This explores the sample size needed to accurately identify the proportion of hatchery fish that are unclipped (pH). The normal approximation to the Binomial distribution was used to estimate the standard deviation of the pH and the 95% confidence width interval (CWI) was obtained by multiplying the standard deviation times 1.96.

The 95% CWI for the expected range of pH (95% to 99.5%) are plotted against the sample size in Figure J-7. As expected, when the pH is lower, CWI is lower. The CWI also decreases with sample size. For the higher pH (98% to 99.5%), which is near the goal of 99%, there are little precision gains after 3,000 samples (Figure J-7). Assuming the tagging crew met their goal, a sample size of 3,000 would yield an estimate with a 95% CI of 99% + 0.36% (i.e. 98.64% to 99.36%). No specific guidelines have been developed for pH, but assuming the CWI should be less than 0.5%, a sample size of 3,000 is adequate, unless the pH is less than 98% in which case it may be necessary to increase sample size to 5,000.

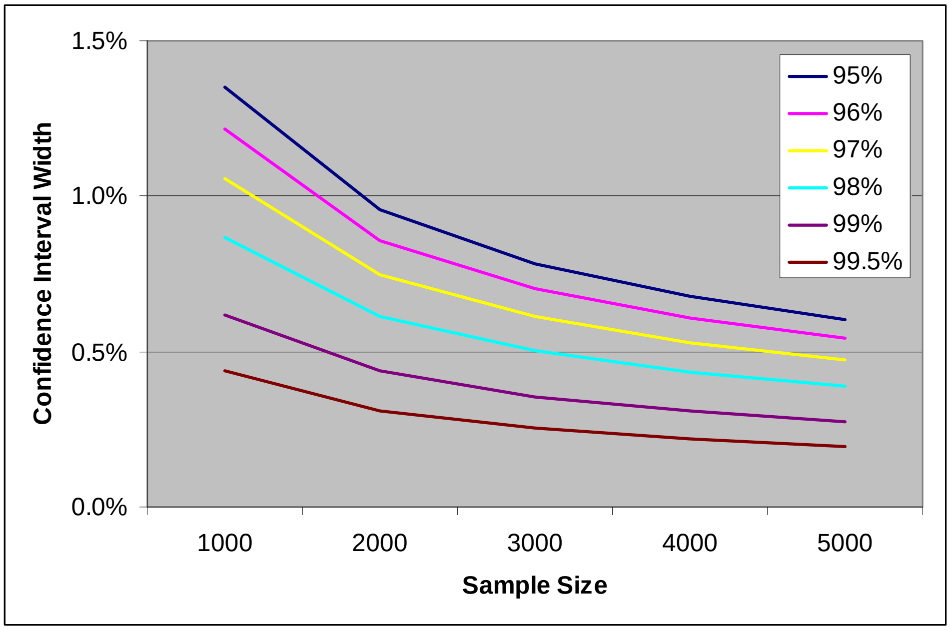

Figure J-7. Sample size for precision, as measured by the confidence interval width, for different mark rates and sample sizes for adipose clipped Chinook salmon.

Sample Size for CWT, Age and Sex. A consideration not addressed is the sample rate for CWT from the spawning grounds. For fisheries monitoring, a sample rate of 20% of the total catch is recommended (Hankin et al. 2005). In part, this sample rate tries to account for the variance in estimating harvest from creel surveys. Since the CVs for escapement estimates are likely to be more precise than fisheries sampling, it is possible that a sampling rate of < 20% may be acceptable for spawning ground surveys. The Coded Wire Tag Implementation Team (CWTIT) is addressing this question and is likely to provide guidance by 2012.

Specific precision for age composition goals were not addressed in the NOAA monitoring guidance. However, since NOAA adopted the Chinook Technical Committee (CTC) goal for the abundance precision standard, the CTC age standard is probably a reasonable starting point. This uses the estimates of adult age composition that are within +/- 5% of the true value 95% of the time. It should be noted that the standard applies to adults and not jacks due to the difficulty in capturing sufficient jacks to obtain the required precision and size selectivity in sampling jack (Zhou 2002, Murdoch et al. 2009).

The age with the most individuals and those percentages close to 50% are the most sensitive to meeting the CTC guidance. For Cowlitz River Chinook salmon between 2004 and 2009, the mean percentage of age 4 fish was 55%; therefore, this group was used in a sensitivity analysis in meeting the CTC standard (Figure J-8). For each group that is required to meet the age standard, approximately 400 readable scales must be collected. If there are requirements for sex and origin, this may equate to 1,600 scales. At a minimum, 400 readable scales should be collected but scales are required from each fish when tissue samples are collected for genetic analysis for mark-recapture assumption testing.

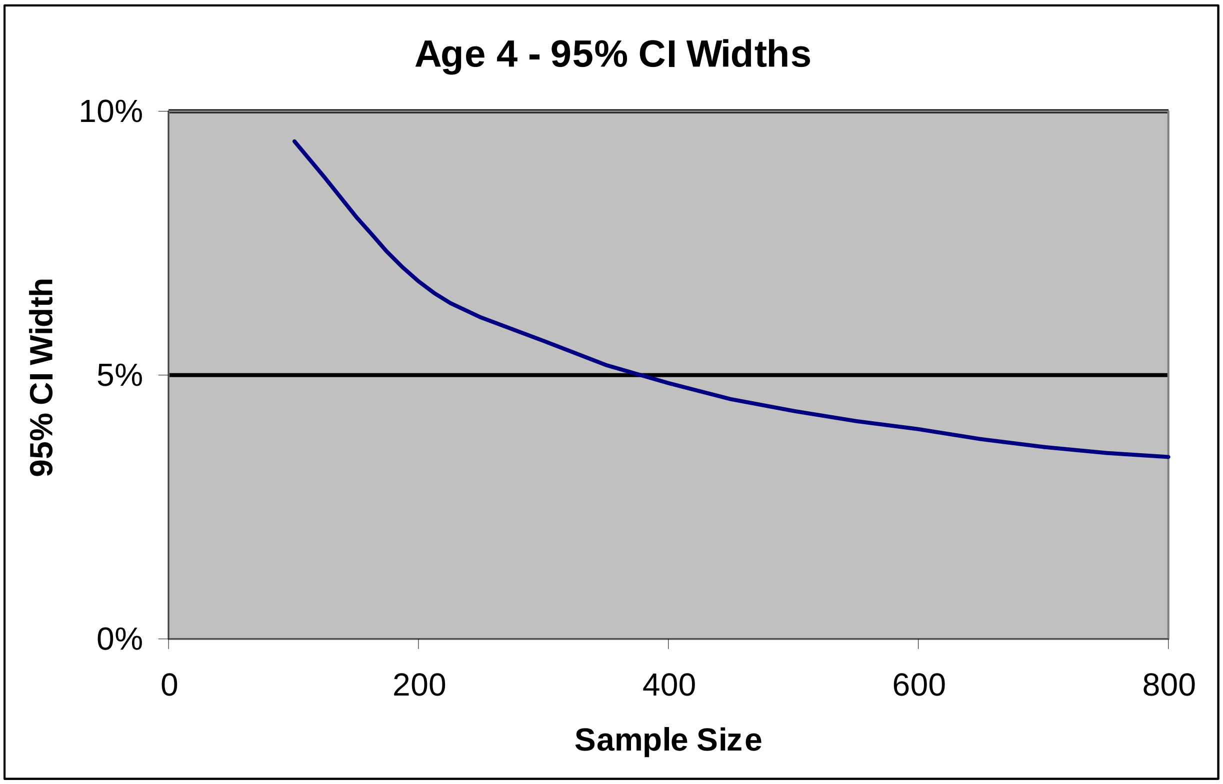

Figure J-8. Sample size requirements for CTC precision goals, expressed as 95% CI width, for age 4 Chinook salmon.

Abundance Assumptions. The conditions necessary for appropriate use of the parental genetic Petersen estimator are: 1) all fish have an equal probability of being marked in the first event (1a), or all fish have an equal probability of being inspected for marks in the second event (1b); or marked fish are mixed completely with unmarked fish between sampling events (1c); 2) there is no recruitment or emigration between sample events; 3) there is no tag-induced mortality; 4) fish do not lose their marks between events; and 5) all marked and unmarked fish are recognizable and reported.

Luckas and Burnham (2005a) reviewed these assumptions for genetic-based abundance estimators. We propose to meet assumption (1b) by collecting juveniles in proportion to their weekly outmigration abundance, which assures that all fish have the same probability of being captured in the second event. Further, the weekly outmigration estimates will be scaled to the fry stage by estimating the Brody growth coefficient and asymptotic length from the von Bertalanffy growth equation using mean weekly lengths. The asymptotic length, growth coefficient, and critical length (40mm) are used to estimate the instantaneous mortality (z) from the Beverton-Holt mortality equation.

The closure assumption is that the population size remains constant during the experiment. For salmon mark-recapture studies, this assumption may be relaxed so that the closure assumption is met if marking and recovery occur over the entire run (Arnason et al. 1996). However, we have some spawners that contribute no offspring, which may be considered mortality. The number of carcasses still yields a valid estimate at the time of tagging even with this “mortality” as long as genotyped and not genotyped carcasses have the same percentage of unsuccessful parents (Williams et al 2002). There is no mark loss (assumption 3) because genetic marks are permanent. Assumption (4), that genetic marks do not affect survival or catchability of the offspring from the sampled adult salmon is met because genetic marks were obtained from carcasses.

The greatest concern in this proposal is being able to test assumption (5) that all “recaptures” are correctly identified and reported, where a true parent of an offspring is identified as the parent and a non-parent of a juvenile is correctly identified as unrelated. Traditional mark-recapture studies developed a correction for missed or incomplete reporting of marks. Rajwani and Schwarz (1997) recommended re-sampling previously sampled fish for missed tags from the first sample. Seber (1982) offered another solution, which applies to the non-reporting of marks by volunteers or potentially inexperienced samplers by contrasting this to an assumed 100% reporting rate. Yet, the above designs focus on missed physical marks.

An alternative means of verifying the accuracy of pedigree reconstruction using simulations is described. Multiple sets of individuals are created of known relationships by resampling actual genetic data obtained from recovered carcasses. Multiple sets of smolts are created from simulated parents using the rules of Mendelian segregation. Following the generation of these new simulated datasets, the accuracy of pedigree reconstruction can be measured at the dyad, family, or entire sample level. The measured accuracy by the statistic P (a | b), the frequency of dyads assigned the relationship a when the actual relationship is b (Wang 2004). For sibship inference among smolt offspring, accuracy is measured by P(FS|FS), P(HS|HS), and P(UR|UR), where FS, HS, and UR are full-sib, half-sib, and unrelated, respectively. For parentage inference, accuracy is measured by the frequencies that parentage is correctly assigned, P(PO | PO), or correctly unassigned, P(XO | XO), when the actual parent is included in and excluded from the candidate pool, respectively. By evaluating the accuracy of pedigree reconstruction in the simulations, we can identify the level and causes of inaccuracy. The abundance estimator could be extended by including the uncertainty in the genetic assignment rate (Lucas and Burnham 2005b, Link and Barker 2010, page 227).

Additional assumptions are required to expand the genetic mark-recapture estimate to the spawners below the smolt trap. These assumptions are: 1) the spawning time and redd detectability above and below the trap site are equal, and 2) juveniles from spawners below the trap do not move upstream after emergence. Both are reasonable, especially if the flight date can be chosen when the Toutle River is running clear.

Indicators. A data analysis flow diagram (DAFD) is used to provide a visual representation of how the indicators were estimated from the measurements. These are field observation and the metrics that are a derived estimate based on measurements. There are many different populations and methods used to estimate indicators, so each population is likely to have a separate DAFD for the population indicators.

WDFW uses directed acyclic graphs (DAG), which are a specific form of a DAFD. A DAG is a graphical representation of a statistical model that facilities the understanding of the model structure. A DAG has three elements nodes, plates, and edges. The node can be 1) a constant, such as data or a prior parameter value in a Bayesian analysis, 2) a stochastic sampling distribution such as normal, binomial, beta distributions, or 3) a logical expression (such as a regression equation $y = a + bx$). In our DAGs, shaded rectangles represent constants, shaded ellipse nodes are observed probabilistic nodes, and open ellipses are unobserved probabilistic nodes. The conditional dependencies between nodes are expressed as arrows called edges. Solid lines depict deterministic or probabilistic dependencies and hollow or broken lines represent logical relationships or dependencies. The repeated part of the graph is represented by a frame or plate.

All quantities are depicted as nodes in the DAG, in which arrows run into nodes from their direct influences (parents). The model represents the assumption that, given its parent nodes pa[v], each node v is independent of all other nodes in the graph except descendants of v, where a descendant is defined. The conditional independence assumptions represented by the graph mean that the full joint distribution of all quantities V has a simple factorization in terms of the conditional distribution p(v | parents[v]) of each node given its parents, so that

$$p(V) = \prod p(v \mid \text{parents}[v]) \qquad v \text{ in } V$$

A crucial concept is that the parent-child distributions are all that is needed to fully specify the model. Using the BUGS software (Spiegelhalter et al. 2003) sorts out the necessary sampling methods directly from the expressed graphical structure. More importantly, constructing the DAG in BUGS, which is sometimes referred to as a Doodle, provides the BUGS code for statistical analysis for the indicator, which provides both a point estimate and Bayesian confidence interval. In addition, for those wanting to analyze the data outside of the above software, an option in OpenBUGS allows the code to be exported into LaTex, which provides a standard statistical expression for the code. Therefore, the use of the DAG in the specified manner provides a transparent, graphical, and statistical depiction of the model on multiple levels that facilitates the development of point and variance estimates for the measurements and indicators.

An illustrative DAG (Figure J-9) with the underlying statistical framework (Table J-3) are presented for parental genetic mark-recapture combined with redd surveys to estimate abundance, pHOS, pNOS, along with NOS and HOS by age for Lower Cowlitz fall Chinook salmon. This DAG makes simple assumptions, including pHOS is equal above and below the juvenile trap, all hatchery fish are mass marked, redd enumeration and detection are equal above and below the trap, Chinook in the upper and lower river have similar spawning time, and there is no error in genetic assignments. If these assumptions are not met, the illustrative DAG can be modified. For example, if pHOS is different above and below the trap, HOS and NOS will be calculated separately for each area and summed.

Table J-3 defines the data to be collected, parameters to be estimated and their expected values, as well as the sampling and prior distributions to capture the uncertainty in the estimates using a Bayesian approach. This same framework could be used for estimation using maximum likelihood, bootstrapping, or normal approximation using the delta method.

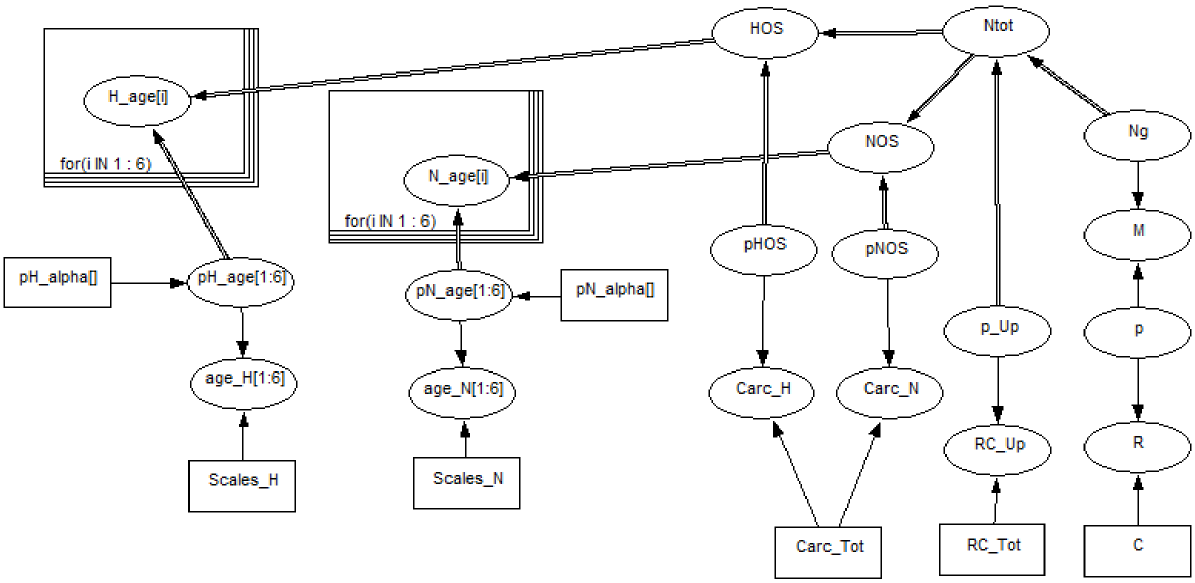

Figure J-9. This is a directed acyclic graph (DAG) for fall Chinook salmon indicator estimates using parental genetic mark-recapture, single redd basinwide redd survey, carcass recoveries for parental genotyping, pHOS, and aging, and juvenile outmigrant trapping to collect juvenile samples proportional to the outmigration to estimate recaptures through genotyping.

Table J-3. Definitions of variables used for a pooled Petersen genetic mark recapture estimate for Chinook Salmon and the sampling and prior distributions for the uncertainty in the parameter estimates. This is the statistical framework for the DAG (Figure J-9).

Data	
M	Marks-genotypes from adult tissue samples
R	Recaptures- genotyped juveniles (assigned to a previously sampled adult)
C	Captures- all genotyped juveniles assigned to a unique parent
RC_Up	Redd count above the smolt trap site
RC_Tot	Total redd count
Carc_H	Number of carcasses that were mass marked

Carc_N	Number of carcasses that were unmarked
Carc_Tot	Number of carcasses examined
Age_H	Number of hatchery origin fish by age
age_N	Number of natural origin fish by age
Parameter Estimates	
P	Proportion of captured fish that are marked
Ng	Spawner abundance based on genetic mark-recapture for area > smolt trap site
p_Up	Proportion of redds above the smolt trap site
Ntot	Spawners abundance estimate for the entire river
pHOS	Proportion of hatchery spawners
pNOS	Proportion of natural origin spawners
HOS	Number of hatchery origin spawners
NOS	Number of natural origin spawners
p_H_age[i]	Proportion of hatchery origin spawners by age
p_N_age[i]	Proportion of natural origin spawners by age
Expected Values	
(1.1)	Ng = M *C/R
(1.2)	p_Up = RC_Up/RC_Tot
(1.3)	Ntot = Ng / p_Up
(1.4)	pHOS = Carc_H/ Carc_Tot
(1.5)	pNOS= Carc_H/ Carc_Tot
(1.6)	HOS = pHOS * Ntot
(1.7)	NOS = pNOS * Ntot
(1.8)	pH_age[i] = H_age[i] / Σ H_age[i]
(1.9)	pN_age[i] = N_age[i] / Σ N_age[i]
(1.10)	H_age[i] = HOS * pH_age[i]
(1.11)	N_age[i] = NOS * pN_age[i]
Sampling Distributions	
(2.1)	R ~Binomial (C,p)
(2.2)	M ~Binomial (Mg,p)
(2.3)	RC_Up ~ Binomial(RC_Tot,p_Up)
(2.4)	Carc_H ~ Binomial(Carc_Tot, pHOS)
(2.5)	age_H[i] ~ Multinomial(pH_Age[i],Σ H_age[i])
(2.6)	Age_N[i] ~ Multinomial(pN_Age[i],Σ N_age[i])
Prior Distribution	
(3.1)	Ng ~ Uniform(C, 10000)
(3.2)	p ~Beta(0.5,0.5)
(3.3)	p_Up ~Beta(0.5,0.5)

(3.4)	p_HOS ~Beta(0.5,0.5)
(3.5)	pH_alpha[i] ~Dirichlet (age2…6 = 0.5)
(3.6)	pN_alpha[i] ~Dirichlet (age2…6 = 0.5)

Calibrated Methods. Redd surveys conducted concurrently with the genetic mark-recapture method would allow historic standardization of the historic abundance series. Therefore, this approach is recommended so as to not lose this valuable information. Although redd surveys are the most popular method to estimate Chinook salmon escapement in Washington State, the Cowlitz River is the only population in the Lower Columbia River where redd surveys are used. All other Lower Columbia River basins use weirs, mark-recapture, AUC, and PCE. The PCE in other Lower Columbia River tributaries is likely to be phased out since single surveys are not consistent with representative biological sampling requirements. The redd count method was applied in the Cowlitz River because the first surveys were conducted by Washington Department of Fisheries Olympia staff, who were familiar with redd surveys in Puget Sound. For other fall Chinook populations in the Lower Columbia River, redd surveys are not conducted for several reasons: because historically high hatchery releases and a robust population on the Lewis River led to problems in redd identification due to superimposition, mis-identification due to overlap in spawning time with other species (Gallagher and Gallagher 2005), potential for more than one redd per female (Kuligowski et al. 2005), the presence of test digs and variation in redd characteristics (Crisp and Carling 1989), and counting errors due to experience, training, and other factors (Dunham et al. 2001; Muhlfeld et al. 2006). Therefore it is prudent to pursue other approaches for calibration, including as the PCE and AUC for spawning Chinook salmon.

For future work, three methods are likely candidates: AUC for spawning fish; PCE for lives, deads, lives and deads, or redds; and a total estimate of redds. Parken et al. (2003) compared the PCE for lives and dead to the AUC method based on counts of fish identified as spawners based on aerial surveys. A single flight at the peak would be used to develop the PCE factor (escapement/peak count). However, this method is likely to have the lower correlation due to variability in the spawning time, not conducting the survey on the peak, and the difficulty in developing a correction factor to account for poor visibility from a single flight (Parken et al. 2004, Holt and Cox 2008). This PCE had a mean expansion factor of 1.96 with CV=6%, but had annual biases in escapement (-14% to +21%) for Nicola River Chinook (Parken et al. 2003). In contrast, Parken et al. (2003) found the apparent residence time (AUC spawners/ escapement) had a mean estimate of residence time of 5.86 days with a CV =5%. However the annual biases using the AUC method were 50% less than PCE and ranged from –8% top +5%. This study indicates AUC estimates are slightly more precise but less biased than PCE estimates, but are likely to be two times more expensive since 5 to 7 flights are needed vs. three flights needed to determine the peak.

Assuming an appropriate spatial and temporal sampling design is developed for these calibrated methods, the precision of the calibration factors will be related to the frequency of the surveys and the percentage of spawning habitat surveyed. For example, if 80% or more of the Chinook salmon in the Cowlitz River spawn between the I-5 Bridge and the Barrier Dam, a total of 7 aerial surveys in these 25 miles would likely yield a more precise estimate of apparent residence time than 7 boat surveys in 10 sections (one mile each).

Contingency Plan for Abundance Estimates. It is possible that in some years, environmental conditions may limit carcass or juvenile sampling, which may lead to problems in developing parental genetic mark-recapture estimates due to assumption violations. A single redd flight is recommended to determine the spawning distribution. Therefore, a peak helicopter redd expansion factor will be developed in years when the genetic mark-recapture estimate is available. Also, carcass surveys should include counts of live Chinook classified as spawners in the randomly selected reaches. By expanding for the unsampled reaches, the total fish days or AUC can be estimated. The apparent residence time is calculated by dividing the genetic mark-recapture estimate into the AUC estimate. Therefore, these live counts made during the carcasses surveys provide an alternate method to estimate escapement if the parental genetic mark-recapture estimate is not possible. There has been poor correlation between boat and aerial redd surveys on the Cowlitz due to the depth of redds, wide and shallow spawning riffles, and two boats not being able to see the spawning area (Chris Gleizes, WDFW pers. comm.). Therefore, it is likely the redd-based estimate will be less precise and more biased for an individual year than the AUC estimate. Unlike the calibration estimates, estimates developed using contingencies are not likely to have the spatial and temporal coverage to meet NOAA precision guidance, yet should yield unbiased estimates.

The analysis method deliverables must be documented in an annual report. This report will use standard scientific format including introduction, study site, field data collection, laboratory data methods, statistical methods, results for the annual indicator estimates, results for the calibration (if needed), and discussion. The annual parameters, variables, and indicators reported are from the Lower Cowlitz fall Chinook tables in Appendix H. The discussion will include the time series of indictors and recommendation to modify the monitoring program to meet goals. In addition to the report, specific deliverables from field sampling and laboratory processing are listed below.

Data Collection. Representative biological samples and measurements needed to estimate Chinook salmon indicators.

Genetic Lab. The deliverables from this lab include the number of carcasses genotyped (Marks=M), the number of juveniles genotyped (Captures=C), and the number of juveniles assigned to a genotyped carcass (Recaptures =R). In addition, an estimate of the error rate in marks and unmarked fish will also be provided.

Fish Aging Lab. There is urgency to provide age estimates for pre-season Chinook salmon forecasts. The age for each readable scale is recorded on the scale cards, usually by January. This is the deliverable from the Fish Aging Lab. Ages from the scale card are entered into the Vancouver A&S database, which contains sample information and other biological data.

CWT Lab. As with age data, there is an urgency to provide preliminary CWT data for fishery management and the preseason forecast. This information is made available to WDFW Vancouver staff as needed. The final deliverable from the CWT Lab is the uploading of all CWT codes data into RMIS, which is scheduled to occur later in the calendar year.

AM-1a Deliverables

What	1. The analysis method deliverables must be documented in an annual report.

	2. Number of carcasses genotyped (Marks=M), the number of juveniles genotyped (Captures=C), and the number of juveniles assigned to a genotyped carcass (Recaptures =R). 3. Estimate the error rate in marked and unmarked fish 4. Mean and variance estimates for natural spawner abundance 5. The age of each readable scale 6. Preliminary CWT data for fishery management and preseason forecast.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power will fund Items 1, 2 and 3. WDFW will fund Items 4, 5 and 6.

Acknowledgments. Scott Blankenship (Molecular Genetics Lab) provided the details on genetic tissue collection, genetic analysis, and background information for genetic abundance estimates. Lynne Anderson (Coded Wire Tag Lab) provided assistance with the sections on CWT collection and analysis, and Lance Campbell (Fish Aging Lab) provided a draft of the scale sample collection and aging analysis. Mara Zimmerman (Wild Salmonid Production Unit) provided insights into successful juvenile trapping operations in large basins. Danny Warren provided the DAG and Databases/DAG/Indicator diagrams. Pat Frazier and Bryce Glaser reviewed an earlier draft of the document. The Cowlitz Fisheries Technical Committee – FHMP Update Work Group provided basin specific information for monitoring sites and activities that assisted with the development of this framework.

AM-1b. Method for Estimating Natural Spawner Abundance and Composition for Lower Cowlitz Coho

Applies to

Spawner abundance estimation for

- Lower Cowlitz coho

The purpose of the Analysis Methods section is to document the methodology used to develop point estimates and confidence intervals for various coho salmon indicators. It provides an explicit data flow from the collection of data in the Monitoring Activities section to the estimation of indicators. The Analysis Methods include laboratory methods for genetic, scale, and CWT data, sample size requirements for various indicators to ensure that precision goals can be achieved, the key assumptions for the indictors, and explicit statistical analysis of field and laboratory data used to estimate the indicators. In addition, there are sections to estimate calibration factors and a contingency plan to estimate abundance if the genetic mark-recapture estimate fails in some years. However, it is likely that the abundance estimates from the contingency plan will not met NOAA guidance for precision, but should be unbiased.

Sample Size for Abundance. The purpose of this section is to ensure the adult monitoring program sample sizes are large enough to meet the NOAA and FHMP precision goals. Traditional mark-recapture sampling requirements for different precision levels for the Petersen estimator have been estimated by Seber 1982 (pages 65-68). The current population of steelhead above the weirs is unknown and some estimate is needed to evaluate mark-recapture sample sizes. Liermann et al. (2010) demonstrated the equilibrium Chinook abundance is related to drainage area. However, since 2010 was the first year of adult coho monitoring and the data has not been analyzed it is difficult to use the drainage area approach for coho salmon. However, making the assumptions that abundance in Lower Cowlitz tributaries is likely higher for coho than steelhead, it may be reasonable to assume that coho populations above weirs are two times greater than steelhead and are likely to range from 200 to over 1000 fish.

The steelhead graphs in Figure J-10 suggest that when abundance is high (400 adults) and the weir can be effectively operated, it is possible that supplemental juvenile collections may not be needed. One condition that satisfies the precision target is capturing and marking 50% of the adults and a carcass recovery rate of 5%. However, it should be noted the CV are based on the assumption that all fish have an equal probability of being marked in the first event, or all fish have an equal probability of being inspected for marks in the second event, or marked fish mix completely with unmarked fish between sampling events. If none of these assumptions are met, a stratified Petersen or Darroch estimator is required for an unbiased estimate. This stratification will decrease the precision. See the juvenile abundance section for a discussion of this estimator.

More specific guidance on juvenile and adult sampling can be achieved with the application of this method on the Cowlitz River, especially regarding the balance between adult and juveniles samples. It should be noted that these sample sizes do not account for additional sources of uncertainty, especially the redd or AUC estimates in tributaries without weirs.

Using Korman's method it is difficult to estimate sample sizes through traditional methods. Therefore simulations were used to estimate the effect of tagging and recovery rates, survey life, residence time, and population size for a small population of Chinook salmon. These results are applicable for coho salmon as well. The method is very robust. See Appendix 1 for more details.

Sample Size for CWT, Age, and Sex. CWT sampling on spawning grounds is not a priority for coho but they are not likely to be recovered in high numbers. Specific precision goals for age composition were not addressed in the NOAA monitoring guidance. However, since NOAA adopted the CTC goal for the abundance precision standard, the CTC age standard is probably a reasonable starting point, which is estimates of adult age composition that are within +/- 5% of the true value 95% of the time. It should be noted that the standard applies to adults and not jacks due to the difficulty in capturing sufficient jacks to obtain the required precision and size selectivity in sampling jacks (Zhou 2002, Murdoch et al. 2009). In the Chinook section, an analysis suggested that 400 scales would be needed to meet the CTC standard. However, no standard has been developed for coho. From a practical perspective, it is recommended a total of 400 scales be collected from the traps with an additional 400 scales from carcass recoveries. In addition, all captured coho should be sampled for CWT, and sex.

In the Chinook Section, we described Molecular Genetics, Fish Aging, and CWT analysis. These analyses are the same for coho salmon and not repeated here. The sample size analysis for mass mark is as described for Chinook Salmon, but the coho distribution uses probalistic sampling rather than a redd census near peak to report on occupancy rates or changes in distribution.

Abundance Assumptions. The conditions necessary for the parental genetic Petersen estimator have already been discussed in the Chinook section and the traditional Petersen estimator in the steelhead section. Korman's period abundance estimator uses the Peterson estimator. Schwarz and Taylor (1998) indicated that this estimator is consistent when the following assumptions are met: 1) the population is closed, 2) all fish in the population have the same probability of being tagged (2a) or all fish have the same probability of being captured in the second sample (2b); or tagged fish mix uniformly with untagged fish (2c), 3) there is no tag loss, 4) tagging does not affect catchability, and 5) all tagged and untagged fish are properly assigned and reported.

The closure assumption for the daily estimates requires no fish immigrate or emigrate during the time of the survey. Radio tracking at the same time as the observation survey, documents the exact number of marked animals alive in the survey area. If the observation survey is nearly instantaneous (i.e. snorkels conducted by multiple crews in a short period of time) this assumption can be met. Immigration and emigration to and from the survey area can be monitored through the use of radio tags detected at the lower and or upper river fixed antennae sites.

Assumption two can be met if the first or second samples are random, which is very difficult to achieve. It may also be met if tagging occurs proportional to the run, or the entire distribution is surveyed and snorkel efficiencies are similar in all reaches, or if the entire distribution is surveyed and tagged and untagged fish completely mix. Diagnostic chi-square tests (Seber 1982, Arnason et al. 1996, Schwarz and Taylor 1998) are used to test these assumptions for spatial stratification as there is no need to test for temporal stratification since radio tracking and snorkeling are almost simultaneous. The pooled Petersen estimator is consistent if p-values from either test are greater than the type 1 error. If not, separate abundance estimates should be calculated by spatial stratum. The Petersen estimator is only consistent for homogeneous groups. It is unclear if observation capture and recapture probabilities may be influenced by sex and size. However, these covariates would be difficult to observe while surveying.

The third assumption is no tag loss or failure, which applies to both radio and spaghetti tags. The number of Chinook salmon alive in the survey area (mi) should be determined at the same time as the snorkel survey with concurrent radio tracking. Therefore, standard protocols must be established to determine radio tag loss (regurgitated) or failure (not transmitting) (Bendock and Alexandersdottir 1993). A double tagging experiment should be developed to assess tag loss (spaghetti with secondary mark). See Seber (1982, page 94) for equations used to estimate tag loss and retention. Since all fish are radio and spaghetti tagged, tag loss must be determined for the spaghetti tags. In Lower Columbia fall Chinook tagged with Floy tags and recovered carcasses the probability of losing a single tag is ~ 30% for male salmon, and 10% for female salmon. In these double Floy tagging experiments assuming independent tag loss, the probability of retaining at least one Floy tag is 91% for males and 99% for females. Other tag types have been used successfully for Chinook mark-recapture studies including Petersen discs specialized Floy tag. The Kurl-lock tags placed on the opercle have good retention and are fine for mark-recapture experiments, but are very difficult to observe when surveying because tags need to be placed on the dorsal surface for consistent detections.

The fourth assumption is that tagging does not affect catchability. This has two important considerations. First, since radio tags are used to identify survey life, tagging cannot reduce survival. Ramstad and Woody (2003) monitored sockeye salmon control and treatment groups (radio tags) placed in net pens from up to 33 days and found a single mortality in each group, resulting in 3% mortality for the control and 2% for the radio tag. This suggests that with proper handling and tagging techniques this assumption can be met. As mentioned above, a rule set should be developed to determine mortality and these fish could be censored. A second consideration is that tagged fish behave similar to untagged fish. Radio tagged fish may drop downstream and after tagging and sulk. However, if tagging occurs below the fixed antennae sites, by the time a fish moves upstream its behavior should be similar to untagged fish.

The final assumption is that all marked and unmarked fish are identified and reported correctly. This may be further clarified that all fish (tagged or untagged) during the snorkel survey have an equal probability of being detected (observed). For this a couple of possibilities exist including: 1) observers miss observing the untagged fish because bright tags on tagged fish are more easily detected because snorkelers are attracted to the bright color, or 2) in inverse, the tags are neutrally colored and tagged fish are missed because the tag blends in with the background of the fish and is not detected. In Lower Columbia tributaries with clear water (visibility over 8m) using fluorescent 2.5 inch Floy tags or 1 inch Petersen Discs, the fish are observed before the tag. However, in more turbid water (visibility < 3m) the fish are still observed first, but need to be more closely examined to determine fluorescent tag presence. Development and implementation of standard protocols including the number of observers based on visibility and river width, spacing, and viewing window can improve observer efficiencies and consistency of the estimates (Thurow 1994).

In a traditional approach to detect missed marks a secondary crew would resample fish (Rajwani and Schwarz 1997). A binomial distribution would be used to estimate missed marks. This assumption is difficult in snorkeling because the exact same fish cannot be re-sampled, but independent observer teams could resurvey the same stretch. The hypothesis that there was no difference between the tagged and untagged fish between surveys could be tested. Acceptance of the null hypothesis infers that there is no difference between the two surveys in the marked ratio between surveys, but if both surveys were equally biased in a higher or lower detection of tagged fish you could get the same results. Steps to properly identify tags and to carefully examine individual fish to ensure proper classification should be implemented.

Conditions for the appropriate use of the Petersen estimator are: 1) all fish have an equal probability of being marked in the first event (1a), or all fish have an equal probability of being inspected for marks in the second event (1b); or marked fish mixed completely with unmarked fish between sampling events (1c); 2) there is no recruitment or emigration between sample events; 3) there is no tag-induced mortality; 4) fish do not lose their marks between events; and 5) all marked and unmarked fish are recognizable and reported.

Assumption 1, often termed the equal catchability assumption, is satisfied if one of the above three conditions (1a, b, c) is met. This assumption is considered the “Achilles heel” of the Petersen Estimator (Arnason et al. 1996) because catchability can be influenced by many factors. Diagnostic chi-square tests are used to test these assumptions (Darroch 1961, Arnason et al. 1996, Schwarz and Taylor 1998). Assumption 1b, recapture probabilities are constant across all recovery strata, is determined by the equal proportions test. Assumption 1c, capture probabilities are constant across all tagging strata, is determined by the complete mixing test. The pooled Petersen estimator is consistent if p-values from either test are greater than the type 1 error. If p-values are less than the type 1 error rate, then a Darroch/Stratified Petersen estimator should be used (Schwarz and Taylor 1998). See the juvenile monitoring section for a more detailed description of the Darroch estimator. The Petersen estimator is only consistent for homogeneous groups. Since capture and recapture probabilities may be influenced by sex and size, diagnostic chi-square or Kolmogorov-Smirnov tests should be conducted to determine if stratification by either of these factors is required for unbiased estimates.

The closure assumption is that the population size remains constant during the experiment. For salmon mark-recapture studies this assumption may be relaxed so that the closure assumption is met if marking and recovery occur over the entire run (Arnason et al. 1996). However, some adults will not survive to emigrate as kelts, which may be considered mortality. The number of adults still yields a valid estimate at the time of tagging even with this “mortality” as long as tagged and untagged parents survive equally to the kelt stage (Williams et al 2002). There is no mark loss (assumption 3) will be assessed through double tagging methods. The assumption (4) that marks do not effect survival or catchability will not be directly assessed in the study, but in a separate study at Skamania Hatchery the 21 day survival for tagged (treatment group) and untagged steelhead (control group) was over 99% for each group and not statistically different (Charlie Cochran, WDFW unpublished data).

Assumption (5) is that all fish are correctly identified and reported. This will occur as there will be few fish handled and each fish will be carefully examined. If there is a need to better quantify this assumption, Rajwani and Schwarz (1997) recommended re-sampling previously sampled fish for missed tags from the first sample. If any of the above violations occur, the abundance estimator could be extended by including the uncertainty closure, tag loss, tag survival, and missed tag rates (Thedinga et al. 1994, and Carlson et al. 1998).

Under certain conditions redd surveys are likely to remain an important method of estimating coho abundance. The major assumptions for using redd surveys in tributaries without weirs are: 1) the females per redd from streams with weirs is the same as streams without weirs (similar type of habitat and density), and 2) the same protocols are used on redd surveys in stream with and without weirs. Using the same protocols for redd identification may standardize challenges with redd counts including: 1) redd identification due to superimposition, 2) misidentification due to overlap in spawning time with other species (Gallagher and Gallagher 2005), 3) the presence of test digs and variation in redd characteristics (Crisp and Carling 1989), and 4) counting errors due to experience, training, and other factors (Dunham et al. 2001; Muhlfeld et al. 2006).

Indicator Estimates. WDFW uses directed acyclic graphs (DAG), which are a specific form of a DAFD. A DAG is a graphical representation of a statistical model that facilities the understanding of the model structure. The DAG was explained in the Chinook section. An illustrative DAG (Figure J-10) with the underlying statistical framework (Table J-4) is presented for mark-recapture combined with AUC surveys to estimate abundance, pHOS, pNOS, along with NOS and HOS by age for Lower Cowlitz coho salmon. Table J-4 defines the data to be collected, parameters to be estimated and their expected values, and the sampling and prior distributions to capture the uncertainty in the estimates using a Bayesian approach. This same framework could be used for estimation using maximum likelihood, bootstrapping, or normal approximation using the delta method.

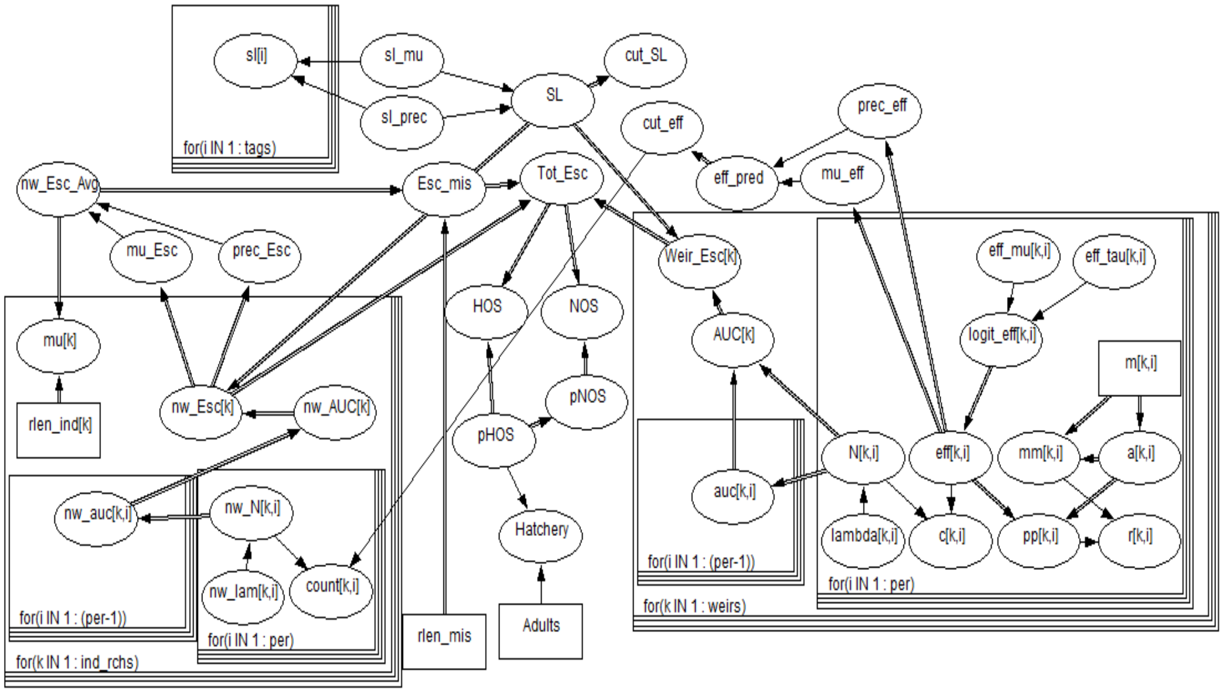

Figure J-10. This is a directed acyclic graph (DAG) for coho indicator estimates using mark-recapture estimates in tributaries with weirs and redd survey in tributaries without weirs. Age, sex, and pHOS data is similar at the weirs and can be summed.

Table J-4. Definitions of variables used for a pooled Petersen mark recapture estimate for coho salmon and AUC surveys in weirs without tributaries and the sampling and prior distributions for the uncertainty in the parameter estimates. This is the statistical framework for the DAG (Figure J-11).

Variable	Variable Description
Data	
M	Marks
R	Recaptures
C	Captures
H_age	Number of hatchery-origin fish by age
N_age	Number of natural-origin fish by age
redd_census	Cumulative number of redds above the weir site
Adults	Cumulative number of adults trapped at all weirs
Females	Cumulative number of females trapped at all weirs
rlen_ind	Length of each surveyed reach
rlen_mis	Cumulative length of all unsurveyed reaches
obs_redds	Cumulative number of redds in each surveyed reach
Scales_H	Number of carcasses that were unmarked

Scales_M	Number of carcasses that were mass marked
females	Females trapped at each weir
adults	Adults trapped at each weir
Sl	Survey life for individual radio tagged fish
Count	Observed live fish on each survey in each reach
Parameter Estimates	
N	Spawner abundance based on genetic mark-recapture for area above the weir site
eff	Trap efficiency
logit_eff	Logit of trap efficiency
eff_mu	Mean of the logit of trap efficiency
eff_tau	Precision of the logit of trap efficiency
mu_eff	Mean of trap efficiency
prec_eff	Precision of trap efficiency
eff_pred	Average trap efficiency assuming normal distribution
Ntot	Spawners abundance estimate for the entire river
pHOS	Proportion of hatchery origin spawners
pNOS	Proportion of natural origin spawners
HOS	Number of hatchery origin spawners
NOS	Number of natural origin spawners
pH_age[i]	Proportion of hatchery origin spawners by age
pN_age[i]	Proportion of natural origin spawners by age
p_H_age[i]	Proportion of hatchery origin spawners by age
p_N_age[i]	Proportion of natural origin spawners by age
sum_N	Sum of spawner abundance above weirs
prop_F	Proprtion of females handled at traps
Avg_FpR	Average females per redd
Redd_Tot	Total redds in tributaries without weirs
Redd_spawners	Total spawners based on redd surveys in tributaries without weirs
sum_mredds	Total number of redds from reaches not surveyed
SL	Average survey life assuming normal distribution
sl_mu	Mean survey life
sl_prec	Precision of survey life
AUC	Total fish days measured as the area under the curve above weir
Weir_Esc	Escapement above weir
nw_AUC	Total fish days measured as the area under the curve for surveyed reach
nw_Esc	Escapement for all surveyed reaches
nw_Esc_Avg	Average escapement for all surveyed reaches

	assumes normal distribution
mu_Esc	Mean escapement of all surveyed reaches
prec_Esc	Precision of escapement for all surveyed reaches
Expected Values	
a[k,i] = equals(m[k,i])	
pp[k,i] = (1-a[k,i])*eff[k,i]	
mm[k,i]= m[k,i]*a[k,i]	
N[k,i] = C[k,i]/eff[k,i]	
eff[i] = logit_eff[k,i]	
$auc[k,i] = \sum_{i=2}^{n} (t_i - t_{i-1}) \frac{(N_i + N_{i+1})}{2}$	
AUC[k,i] = nw_auc[k,i] + N[k,1]*SL/2 +N[k,last]*SL/2	
Weir_Esc[k] = AUC[k]/SL	
$nw\_auc[k,i] = \sum_{i=2}^{n} (t_i - t_{i-1}) \frac{(nw\_N_i + nw\_N_{i+1})}{2}$	
nw_AUC[k,i] = auc[k,i] + nw_N[k,1]*SL/2	
nw_N[k,last]*SL/2	
nw_Esc[k] = AUC[k]/SL	
mu_eff = mean(eff[,])	
prec_eff = 1/(sd(eff[,])*sd(eff[,]))	
mu_Esc = mean(nw_Esc[ ])	
prec_Esc = 1/(sd(nw_Esc[])*sd(nw_Esc[ ]))	
Tot_Esc = ∑Weir_esc[k] +Esc_mis + ∑nw_Esc[k]	
pHOS = Hatchery/Adults	
pNOS= 1- pHOS	
HOS = pHOS * Tot_Esc	
NOS = pNOS * Tot_Esc	
mu[i] = rlen_ind[i] * lambda	
Esc_mis = nw_Esc_Avg * rlen_mis	
Sampling Distribution	
mm[k,i] ~Binomial (r[k,i], pp[k,i])	
c[k,i] ~Binomial (N[k,i], eff[k,i])	
logit_eff[i] ~Normal(eff_mu, eff_tau)	
SL ~ Normal(sl_mu,sl_tau)	
count[k,i] ~Binomial (nw_N[k,i], eff_pred[k,i])	
eff_pred ~Normal(mu_eff, prec_eff)	
nw_Esc_Avg ~ Normal(mu_Esc,prec_Esc)	
nw_N[k,i] ~Poisson(nw_lam[k,i])	
N[k,i] ~Poisson(lambda[k,i])	

Hatchery ~ Binomial(Adults, pHOS)
Prior Distribution
pHOS ~ Beta(0.5,0.5)
sl_mu ~Normal(0.0.0001)
sl_prec ~ Gamma(0.001,0.001)
Lambda[k,i] ~ Gamma(0.01,0.01)
nw_lam[k,i] ~ Gamma(0.01,0.01)
eff_mu[k,i] ~ Normal(0,0.01)
tau_eff[k,i] ~ Gamma(0.01,0.01)

Calibrated Methods. Unlike Chinook salmon, redd and AUC surveys are recommended to be conducted concurrently with mark-recapture estimates above weirs. This is needed to estimate abundance in other tributaries without weirs. Therefore, the result of these redd surveys is an estimate of females per redd above each weir for each year. At the end of the FHMP Update period, policy makers should decide if continued concurrent surveys are needed above weirs.

The analysis method deliverables must be documented in an annual report. This report will use standard scientific format, including: introduction, study site, field data collection, laboratory data methods, statistical methods, results for the annual indicator estimates, results for the calibration (if needed), and discussion. The annual parameters, variables, and indicators reported on are from the Lower Cowlitz coho salmon tables in Appendix H and can be found in Tables J-1 & J-2 in this document. The discussion will include the time series of indictors and recommendation to modify the monitoring program to meet goals. In addition to the report, specific deliverables from field sampling and laboratory processing are similar to the Chinook Salmon deliverables listed above.

AM-1b Deliverables

What	1. The analysis method deliverables must be documented in an annual report. 2. Number of adults genotyped (Marks=M), the number of juveniles genotyped (Captures=C), and the number of juveniles assigned to a genotyped carcass (Recaptures =R). 3. Estimate the error rate in marked and unmarked fish. 4. Mean and variance estimates for natural spawner abundance. 5. The age of each readable scale. 6. Preliminary CWT data for fishery management and preseason forecast.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power will fund Items 1, 2 and 3. WDFW will fund Items 4, 5 and 6.

AM-1c. Method for Estimating Natural Spawner Abundance and Composition for Lower Cowlitz Steelhead

Applies to
Spawner abundance estimation for • Lower Cowlitz steelhead

The purpose of the Analysis Methods section is to document the methodology used to develop point estimates and confidence intervals for various steelhead indicators. It provides an explicit data flow from the collection of data in the Monitoring Activities section to the estimation of indicators. The Analysis Methods include laboratory methods for genetic, scale, and CWT data, sample size requirements for various indicators to ensure that precision goals can be achieved, the key assumptions for the indictors, and explicit statistical analysis of field and laboratory data used to estimate the indicators. In addition, there are sections to estimate calibration factors and a contingency plan to estimate abundance if the genetic mark-recapture estimate fails in some years. However, it is likely that the abundance estimates from the contingency plan will not met NOAA guidance for precision, but should be unbiased.

Sampling Size for Abundance. The purpose of this section is to ensure the adult monitoring program sample sizes are large enough to meet the NOAA and FHMP precision goals. Traditional mark-recapture sampling requirements for different precision levels for the Petersen estimator have been estimated by Seber 1982 (pages 65-68). The current population of steelhead above the weirs is unknown and some estimate is needed to evaluate mark-recapture sample sizes. Liermann et al. (2010) demonstrated the equilibrium Chinook abundance is related to drainage area. Making the same assumption for steelhead we can estimate a range of likely abundances for Cowlitz tributaries using population abundance from adjacent areas.

The tributary drainage areas for proposed weirs include 100 square miles for Olequa Creek, 80 square miles for salmon Creek, 44 square miles for Arkansas Creek, and 26 square miles for Ostrander Creek. The ten year average wild steelhead escapement in the Coweeman River is slightly less than 500 adults and its drainage area is 125 square miles. Olequa Creek drains approximately 100 square miles, which is 80% of the Coweeman drainage area. Therefore a reasonable starting point is the Olequa may support near 400 adult steelhead. Ostrander Creek drains the smallest area, approximately 25 square miles, which is similar in drainage area to Abernathy, Mill, and Germany Creeks. Abundance estimates in these creeks has ranged from 22 to over 300. Based on this information we estimated the CV for population sizes of 50, 100, 200, and 400 adults (Figure J-11). Further we assumed marking rates at the weir from 80% to 5% with various adult to kelt survival and recapture probabilities.

The graphs in Figure J-11 suggest that when population are low (50 adults), optimal weir operations are needed to meet the precision target of a CV of less than 15%. One condition that satisfies the precision target is capturing and marking 80% of the adults, having an adult to kelt survival of 50%, and kelt trap efficiency of 50%. This may be an unrealistic expectation for some years and, in cases like this, it is likely that supplemental collection of juveniles and the use of the genetic mark recapture method will be required to meet the precision goals. When abundance is high (400 adults) and the weir can be effectively operated, it is possible that supplemental juvenile collections may not be needed. One condition that satisfies the precision target is capturing and marking 40% of the adults, having an adult to kelt survival of 50%, and kelt trap efficiency of 80%, which is reasonable. However, it should be noted the CV are based on the assumption that all fish have an equal probability of being marked in the first event, or all fish have an equal probability of being inspected for marks in the second event, or marked fish mixed completely with unmarked fish between sampling events. If none of these assumptions are met a stratified Petersen or Darroch estimator is required for an unbiased estimate. The stratification will decrease the precision. See the juvenile abundance section for a discussion of this estimator.

More specific guidance on juvenile and adult sampling can be achieved with the application of this method on the Cowlitz River, especially regarding the balance between adult and juveniles samples. It should be noted that these sample sizes do not account for additional sources of uncertainty, especially the redd estimates in tributaries without weirs.

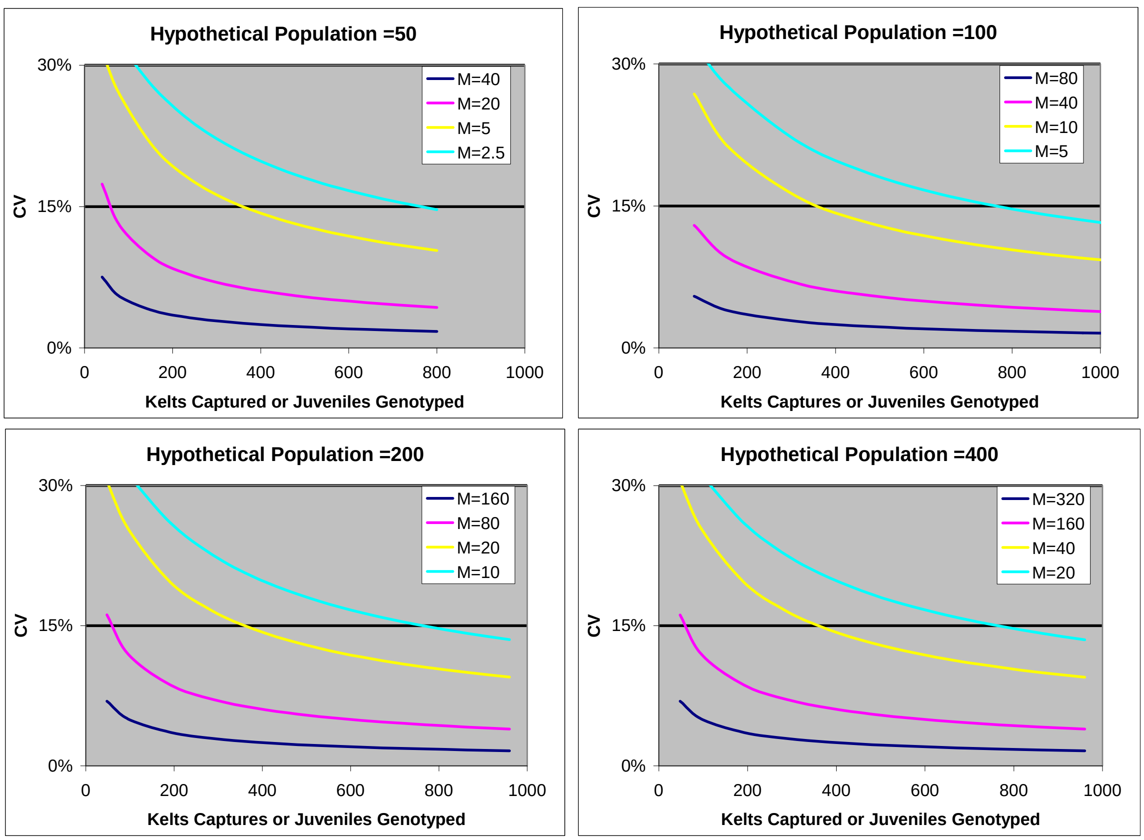

Figure J-11. Estimated CV for abundance using Bailey's approximation of the Binomial Distribution for hypothetical population sizes, number of genotyped carcasses (marks=M), and number of genotyped juveniles (captures=C).

Sample Size for CWT, Age, and Sex. CWT sampling on spawning grounds is not a priority for steelhead since they cannot be recovered in high numbers and their use for developing exploitation and maturation rates is a low priority since ocean harvest rates are believed to be low. Specific precision goals for age composition were not addressed in the NOAA monitoring guidance. However, since NOAA adopted the CTC goal for the abundance precision standard, the CTC age standard is probably a reasonable starting point, which is estimates of adult age composition that are within +/- 5% of the true value 95% of the time. It should be noted that the standard applies to adults and not jacks due to the difficulty in capturing sufficient jacks to obtain the required precision and size selectivity in sampling jacks (Zhou 2002, Murdoch et al. 2009). In the Chinook section, an analysis suggested that 400 scales would be needed to meet the CTC standard. However, no standard has been developed for steelhead. From a practical perspective, steelhead have the most diverse life histories of any salmonid. Some of these are very rare, so it is recommended that all captured steelhead should be sampled for CWT, age, and sex.

In the Chinook Section, we described Molecular Genetics, Fish Aging, and CWT analysis. These analyses are the same for steelhead and not repeated here. The exception is that steelhead will be aged according to the European notation (Groot and Margolis 1991). In this system, age is recorded as the winters identified in freshwater after hatching and the winters identified in the marine environment. For example a typical winter steelhead age is 2.1+, which indicates two winters in freshwater plus one winter and part of another winter in the ocean. The European system is the preferred notation for steelhead due to the complex ages from repeat spawning. The sample size analysis for mass mark is as described for Chinook Salmon, but the steelhead distribution uses probalistic sampling rather than a redd census near peak to report on occupancy rates or changes in distribution.

Abundance Assumptions. The conditions necessary for the parental genetic Petersen estimator have already been discussed in the Chinook section. Conditions for the appropriate use of the Petersen estimator are: 1) all fish have an equal probability of being marked in the first event (1a), or all fish have an equal probability of being inspected for marks in the second event (1b); or marked fish mixed completely with unmarked fish between sampling events (1c); 2) there is no recruitment or emigration between sample events; 3) there is no tag-induced mortality; 4) fish do not lose their marks between events; and 5) all marked and unmarked fish are recognizable and reported. These have been identified and discussed in Rawding (2009) and are repeated here.

Assumption 1, often termed the equal catchability assumption, is satisfied if one of the above three conditions (1a, b, c) is met. This assumption is considered the "Achilles heel" of the Petersen Estimator (Arnason et al. 1996) because catchability can be influenced by many factors. Diagnostic chi-square tests are used to test these assumptions (Darroch 1961, Arnason et al. 1996, Schwarz and Taylor 1998). Assumption 1b, recapture probabilities are constant across all recovery strata, is determined by the equal proportions test. Assumption 1c, capture probabilities are constant across all tagging strata, is determined by the complete mixing test. The pooled Petersen estimator is consistent if p-values from either test are greater than the type 1 error. If p-values are less than the type 1 error rate, then a Darroch/Stratified Petersen estimator should be used (Schwarz and Taylor 1998). See the juvenile monitoring section for a more detailed description of the Darroch estimator. The Petersen estimator is only consistent for homogeneous groups. Since capture and recapture probabilities may be influenced by sex and size, diagnostic chi-square or Kolmogorov-Smirnov tests should be conducted to determine if stratification by either of these factors is required for unbiased estimates.

The closure assumption is that the population size remains constant during the experiment. For salmon mark-recapture studies this assumption may be relaxed so that the closure assumption is met if marking and recovery occur over the entire run (Arnason et al. 1996). However, some adults will not survive to emigrate as kelts, which may be considered mortality. The number of adults still yields a valid estimate at the time of tagging even with this “mortality” as long as tagged and untagged parents survive equally to the kelt stage (Williams et al 2002). There is no mark loss (assumption 3) will be assessed through double tagging methods. The assumption (4) that marks do not effect survival or catchability will not be directly assessed in the study, but in a separate study at Skamania Hatchery the 21 day survival for tagged (treatment group) and untagged steelhead (control group) was over 99% for each group and not statistically different (Charlie Cochran, WDFW unpublished data).

Assumption (5) is that all fish are correctly identified and reported. This will occur as there will be few fish handled and each fish will be carefully examined. If there is a need to better quantify this assumption, Rajwani and Schwarz (1997) recommended re-sampling previously sampled fish for missed tags from the first sample. If any of the above violations occur, the abundance estimator could be extended by including the uncertainty closure, tag loss, tag survival, and missed tag rates (Thedinga et al. 1994, and Carlson et al. 1998).

Due to the inability to observe spawning or holding steelhead and the lack of steelhead carcasses, redd surveys are likely to remain an important method of estimating steelhead abundance. The major assumptions for using redd surveys in tributaries without weirs are: 1) the females per redd from streams with weirs is the same as streams without weirs (similar type of habitat and density), and 2) the same protocols are used on redd surveys in stream with and without weirs. Using the same protocols for redd identification may standardize challenges with redd counts including: 1) redd identification due to superimposition, 2) misidentification due to overlap in spawning time with other species (Gallagher and Gallagher 2005), 3) the presence of test digs and variation in redd characteristics (Crisp and Carling 1989), and 4) counting errors due to experience, training, and other factors (Dunham et al. 2001; Muhlfeld et al. 2006).

Indicator Estimates. WDFW uses directed acyclic graphs (DAG), which are a specific form of a DAFD. A DAG is a graphical representation of a statistical model that facilities the understanding of the model structure. The DAG was explained in the Chinook section. An illustrative DAG (Figure J-12) with the underlying statistical framework (Table J-5) is presented for mark-recapture combined with redd surveys to estimate abundance, pHOS, pNOS, along with NOS and HOS by age for Lower Cowlitz steelhead. This DAG makes simple assumptions, including pHOS is the same in tributaries with and without weirs, mark-recapture assumptions are met, and hatchery and wild along with male and female steelhead recovery rates are the same in the mark-recapture experiment. If these assumptions are not, met the illustrative DAG can be modified. Table J-5 defines the data to be collected, parameters to be estimated and their expected values, and the sampling and prior distributions to capture the uncertainty in the estimates using a Bayesian approach. This same framework could be used for estimation using maximum likelihood, bootstrapping, or normal approximation using the delta method.

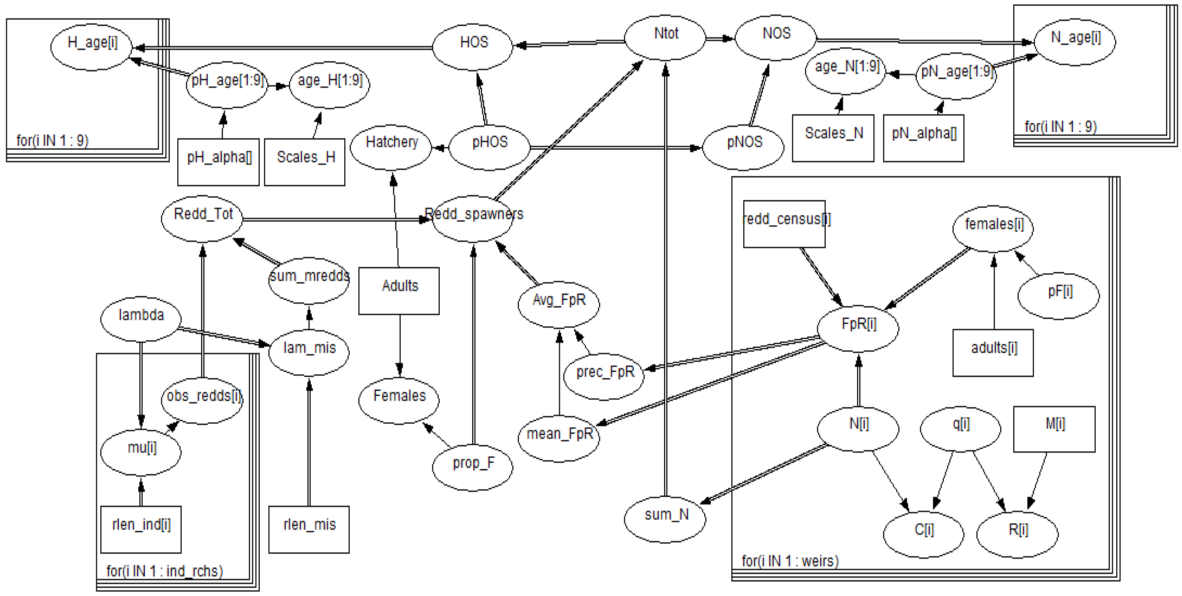

Figure J-12. This is a directed acyclic graph (DAG) for steelhead indicator estimates using mark-recapture estimates in tributaries with weirs and redd survey in tributaries without weirs. Age, sex, and pHOS data is similar at the weirs and can be summed.

Table J-5. Definitions of variables used for a pooled Petersen mark recapture estimate for steelhead and redd surveys in weirs without tributaries and the sampling and prior distributions for the uncertainty in the parameter estimates. This is the statistical framework for the DAG (Figure J-12).

Variable	Variable Description
Data	
M	Marks
R	Recaptures
C	Captures
H_age	Number of hatchery-origin fish by age
N_age	Number of natural-origin fish by age
redd_census	Cumulative number of redds above the weir site
Adults	Cumulative number of adults trapped at all weirs
Females	Cumulative number of females trapped at all weirs
rlen_ind	Length of each surveyed reach
rlen_mis	Cumulative length of all unsurveyed reaches
obs_redds	Cumulative number of redds in each surveyed reach
Scales_H	Number of carcasses that were unmarked
Scales_M	Number of carcasses that were mass marked
females	Females trapped at each weir

adults	Adults trapped at each weir
Parameter Estimates	
N	Spawner abundance based on genetic mark-recapture for area above the weir site
q	Recapture efficiency
Ntot	Spawners abundance estimate for the entire river
pHOS	Proportion of hatchery origin spawners
pNOS	Proportion of natural origin spawners
HOS	Number of hatchery origin spawners
NOS	Number of natural origin spawners
pH_age[i]	Proportion of hatchery origin spawners by age
pN_age[i]	Proportion of natural origin spawners by age
p_H_age[i]	Proportion of hatchery origin spawners by age
p_N_age[i]	Proportion of natural origin spawners by age
sum_N	Sum of spawner abundance above weirs
prop_F	Proprtion of females handled at traps
Avg_FpR	Average females per redd
Redd_Tot	Total redds in tributaries without weirs
Redd_spawners	Total spawners based on redd surveys in tributaries without weirs
sum_mredds	Total number of redds from reaches not surveyed
Expected Values	
(1.1)	N = C/q
(1.2)	q= R/C
(1.3)	Ntot = redd spawners + sum_N
(1.4)	pHOS = Hatchery/Adults
(1.5)	pNOS= 1- pHOS
(1.6)	HOS = pHOS * Ntot
(1.12)	NOS = pNOS * Ntot
(1.13)	pH_age[i] = H_age[i] / Σ H_age[i]
(1.14)	pN_age[i] = N_age[i] / Σ N_age[i]
(1.15)	mu[i] = rlen_ind[i] * lambda
(1.16)	lam_mis = lambda * rlen_mis
(1.17)	Redd_Tot = sum_mredds + ∑obs_redds[i]
(1.18)	Prop_F = Females/Adults
(1.19)	pF=females[i]/adults[i]
(1.20)	FpR=females[i]/redd_census[i]
(1.21)	mean_FpR= mean(FpR[])
(1.22)	prec_FpR = 1/var(FpR[])
(1.23)	redd_spawners = Redd_Tot*Avg_FpR/prop_F
(1.24)	sum_N=∑N[i]

Sampling Distribution	
(2.7)	R ~Binomial (C,q)
(2.8)	M ~Binomial (M,q)
(2.9)	Hatchery ~ Binomial(Adults, pHOS)
(2.10)	H_age[i] ~ Multinomial(pH_Age[i],Σ H_age[i])
(2.11)	N_age[i] ~ Multinomial(pN_Age[i],Σ N_age[i])
(2.12)	Avg_FpR ~Normal(mean_FpR,prec_FpR)
(2.13)	sum_mredds ~ Poisson(lam_mis)
(2.14)	obs_redds[i] ~ Poisson(lambda)
Prior Distribution	
(3.7)	N ~ Uniform(C, 500)
(3.8)	q ~Beta(0.5,0.5)
(3.9)	p_HOS ~Beta(0.5,0.5)
(3.10)	pH_alpha[i] ~Dirichlet (age2…10 = 0.5)
(3.11)	pN_alpha[i] ~Dirichlet (age2…10 = 0.5)
(3.12)	lambda ~ Gamma(0.01,0.01)
(3.13)	prop_F ~ Beta(0.5.0.5)
(3.14)	pF ~ Beta(0.5,0.5)

Calibrated Methods. Unlike Chinook salmon, redd surveys are recommended to be conducted concurrently with mark-recapture estimates above weirs. This is needed to estimate abundance in other tributaries without weirs. Therefore, the result of these redd surveys is an estimate of females per redd above each weir for each year. At the end of the FHMP Update period, policy makers should decide if continued concurrent surveys are needed above weirs.

The analysis method deliverables must be documented in an annual report. This report will use standard scientific format, including: introduction, study site, field data collection, laboratory data methods, statistical methods, results for the annual indicator estimates, results for the calibration (if needed), and discussion. The annual parameters, variables, and indicators reported on are from the Lower Cowlitz steelhead tables in Appendix H and can be found in Tables J-1 & J-2 in this document. The discussion will include the time series of indictors and recommendation to modify the monitoring program to meet goals. In addition to the report, specific deliverables from field sampling and laboratory processing are similar to the Chinook Salmon deliverables listed above except for timelines and deliverables from the Otolith Lab. If otolith microchemistry is used to determine anadromy, then this lab would be responsible for reporting on the methods used for this determination and providing this data for the genetic database.

AM-1c Deliverables

What	1. The analysis method deliverables must be documented in an annual report, 2. Number of adults genotyped (Marks=M), the number of juveniles genotyped (Captures=C), and the number of juveniles assigned to a genotyped carcass (Recaptures =R),

	3. Estimate the error rate in marked and unmarked fish, 4. Mean and variance estimates for natural spawner abundance, 5. The age of each readable scale, 6. Preliminary CWT data for fishery management and preseason forecast.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power will fund Items 1, 2 and 3. WDFW will fund Items 4, 5 and 6.

AM-2. Method for Analyzing Spawner Distribution

Applies to

Spawner distribution of:

- Lower Cowlitz fall Chinook
- Lower Cowlitz coho
- Lower Cowlitz steelhead

For spatial structure, NOAA identified two key issues: 1) determine the percent of occupied habitat at the time of listing, and 2) determine if there is a change in the distribution over time. Guidelines for collection of this data are limited. There are no guidelines for statistical analysis of the data and since this data has not been collected on the Cowlitz, it is difficult to conduct a power analysis to determine a + 15% change in distribution with 80% power. Therefore, methods to monitor and report on this indicator should remain flexible.

As described in Section AM-1a (the method for estimating natural spawner abundance and composition for fall Chinook), the genetic mark-recapture abundance estimate is for the spawners above the smolt trap. A single redd count of the entire spawning distribution near the peak in spawning activity is used to expand the genetic mark-recapture estimate to account for the proportion of spawners below the trap. Therefore, we a proposing a census of redds near peak salmon spawning abundance, which can be used for both the abundance estimate and to meet the requirement for analyzing spawner distribution. This is a modification of NOAA's method 1 for determining spatial structure.

In other basins, during the peak redd survey of spawning distribution, WDFW staff identified and counted every individual redd. In addition, its location is geo-referenced through the use of Global Positioning Satellites (GPS). Since salmon carcasses are known to be recovered distant to spawning sites (Murdoch et al. 2009), redds or live counts of spawning fish are the preferred method to determine spawner distribution.

Due to the lack of specific analytical guidelines, the following approaches are proposed based on the collection of peak count redd location data. The first is to determine the occupancy rate of the spawner distribution. This is the percentage of all surveyed reaches within the spawner distribution in which one or more redd was observed. Confidence intervals will be estimates using the Binomial or normal approximation to the Binomial distribution. To examine patterns of change, statistical analyses of the year-to-year re-occupation of redd sites will be done with Chi-square test, creating a contingency table comparing and contrasting occupation by reach.

We expect there to be changes in the spawner distribution based on modifications to hatchery programs, variations in rainfall that alter spawner access to small tributaries, and other factors. As NOAA and others better define analyses to detect biologically significant changes to spawner distribution, the raw redd location data collected by this project will be available to be re-analyzed with alternate statistical approaches. NOAA guidelines recommend "probabilistic sampling" to "determine if spawner densities and distribution have shifted or increased" (Method 3). The proposed method is intended to be consistent with NOAA's Method 3.

Data management include: downloading of redd locations data, checking redd locations for accuracy, and adding redd locations data to the WDWF Spawning Ground Survey (SGS) database. Other deliverables include providing map(s) of redd locations and a table of redd counts by reach by year. In addition, appropriate statistical analysis will be conducted (occupancy rate, Chi-square, and trend analyses).

AM-2 Deliverables

What	1. Chi-square contingency table showing redd distribution by reach and by year 2. Map of individual redd locations and/or density of redds for the Chinook spawning distribution
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power and WDFW will jointly fund the analysis for all species.

AM-3. Method for Estimating Pre-Terminal Exploitation Rates

Applies to

Estimation of pre-terminal (ocean and mainstem Columbia) exploitation rates for:

- Lower Cowlitz fall Chinook
- Lower Cowlitz coho
- Lower Cowlitz steelhead
- Upper Cowlitz coho

Fishery related mortality estimates are produced annually for pre-terminal fisheries occurring in the Pacific Ocean and the mainstem Columbia River. Mortalities can occur in two forms: catch kept and release mortalities. Pre-terminal fisheries include sport and commercial fisheries in the lower mainstem Columbia River, the sport fishery in the Columbia estuary (Buoy 10), and sport and commercial fisheries in the ocean. Mortality estimates are produced using different methodologies depending on the location (Columbia River, Buoy 10 or ocean) and type (sport or commercial) of each fishery (Pacific Management Council 2008, 2011; Joint Columbia River Management Staff 2010, 2011).

Total pre-terminal abundance (number of fish entering ocean fisheries) must be calculated to estimate pre-terminal exploitation rate. Pre-terminal abundance can be estimated by summing the number of fish entering the Cowlitz River and the number of mortalities occurring in pre-terminal fisheries. The exploitation rate is determined using the following formula:

Total Exploitation Rate = Total pre-terminal fishery related mortalities/Number of fish entering ocean fisheries

The pre-terminal exploitation rate can be calculated as either a ratio or a percentage. Separate exploitation rates will be developed for hatchery produced fish (HOR) vs. naturally produced fish (NOR) to account for the implementation of mark selective fisheries.

AM-3 Deliverables

What	1. Pre-terminal exploitation rates by population for ocean and mainstem Columbia fisheries
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power and WDFW will jointly fund the estimation of Cowlitz specific exploitation rates for all species.

AM-4. Method for Estimating Terminal Catch of HORs

Applies to

Estimation of terminal (Cowlitz River) catch of HORs for:

- Lower Cowlitz spring Chinook
- Lower Cowlitz fall Chinook
- Lower Cowlitz coho
- Lower Cowlitz steelhead
- Upper Cowlitz spring Chinook
- Upper Cowlitz fall Chinook
- Upper Cowlitz coho
- Upper Cowlitz steelhead
- Tilton coho
- Tilton steelhead

Catch in terminal fisheries is defined as the number of fish caught and kept in sport fisheries that occur in areas upstream and downstream of Mayfield Dam. Fisheries occurring downstream of Mayfield Dam include the mainstem Cowlitz River and tributaries that enter the Cowlitz downstream of the Barrier Dam. Fisheries occurring upstream of Mayfield Dam include the Tilton River and the Cowlitz basin upstream of Cowlitz Falls Dam. Estimation methodology can vary by species, the fishery it is targeting, and the location of fishery.

Methodology employed can include angler-produced punch cards or the application of harvest rates. Punch cards provide a specific annual catch estimate by species and stream or river section (e.g., Cowlitz River downstream of Mayfield Dam). Punch cards are used in the area downstream of Mayfield Dam, with catches in tributaries added to mainstem catches to estimate harvest in this location.

Harvest rates can be calculated using past creel survey data or information from other similar fisheries. This method currently is used for the Tilton and upper Cowlitz basins. For coho fisheries, the harvest rate used is based on data collected from creel surveys conducted during the most recent ten-year period. For other species, harvest rates are based on information from other similar fisheries. The harvest rate is applied to the number of HORs transported to the Tilton and upper Cowlitz basins to estimate the number of HORs caught and kept in each basin per the formula below:

Number of fish harvested = Number of fish transported upstream X Harvest rate

Requirements to Meet NOAA Accuracy and Precision Guidelines: NOAA guidelines do not address harvest estimates; however, the accuracy of these estimates has a direct impact on the accuracy and precision of abundance estimates for HORs. HOR returns to the Cowlitz River are calculated based on the formula below:

Return to river mouth = return to hatchery + escapement to spawning grounds + harvest in Cowlitz River fisheries

Methodology currently used to estimate harvest of HORs in the Cowlitz River will need to be evaluated to determine the impact of these estimates on the precision of annual HOR abundance estimates (see Section AM-1). Over the next 3 to 5 years, data collected through improved abundance estimation methodology should be used to determine if increased precision in catch estimates is necessary to achieve the precision goal (CV = 15%) for NOS and HOS abundance estimates.

Work Elements

- Below Mayfield Dam
  - Summarize Catch Record Cards (CRC) returned by species
  - Compile catch for Cowlitz basin based on CRCs returned by species
  - Expand recorded catch from CRC to estimate total harvest for various sections of the Cowlitz basin by species
- Above Mayfield Dam
  - Summarize number of HORs released into upper Cowlitz and Tilton basins by species
  - Apply predetermined harvest rates to the number of HORs transported upstream to determine number of HORs kept in fisheries by species
  - Apply predetermined mortality to rates to the number of NORs handled in fisheries to determine the number of fishery related mortalities by species

AM-4 Deliverables

What	1. Number of HOR fall Chinook, coho, winter steelhead and coho landed in the Cowlitz basin downstream of Mayfield Dam, Tilton River basin, and the Cowlitz basin upstream of Cowlitz Falls Dam. 2. Level of precision of catch record card methodology for estimating terminal catch (meeting NOAA precision standards).
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	WDFW to provide funding.

AM-5. Method for Estimating NOR Mortality in Terminal Fisheries

Applies to Estimation of incidental NOR mortality in terminal fisheries • All Cowlitz populations

NOR mortalities are estimated through a two step process: 1) estimate the number of NORs handled per HORs kept, and 2) application of a post-release mortality rate to the number of NORs handled. In the first step, the ratio of NORs handled per HORs kept will be applied to the estimate of the number of HORs kept (see AM-4), according to the formula below:

NORs handled = (NORs handled / HORs Kept) * HORs kept

The ratio of NORs handled per HORs kept can be calculated using several different methods. The most common method used in the Cowlitz basin will be to estimate the number of NORs and HORs entering the fishery. These data are used to calculate the ratio of NORs entering the fishery per HORs entering the fishery, which replaces the NORs handled/HORs kept ratio in the formula above.

Requirements to meet NOAA Accuracy and Precision Guidelines: NOAA guidelines do not address fishery-related release mortality estimates; however, the accuracy of these estimates has a direct impact on the accuracy and precision of abundance estimates for NORs. NOR returns to the Cowlitz River are calculated based on the formula below:

Return to river mouth = return to natural spawning areas + release mortalities in Cowlitz River fisheries

The methodology currently used to estimate harvest of NORs in the Cowlitz River will need to be evaluated to determine the impact of these estimates on the precision of estimates of annual NOR abundance (see Section AM-1). Over the next 3 to 5 years, data collected through improved abundance estimation methodology should be used to determine if increased precision in catch estimates is necessary to achieve the precision goal (CV = 15%) for NOS and HOS abundance estimates.

The most statistically accurate method of determining the ratio of NORs handled/HORs kept would be to implement a random statistical creel census that directly estimates the number of NORs handled and HORs kept in a given fishery. Another alternative would be to perform spot check surveys that randomly sample anglers to estimate the number of NORs handled and HORs kept in a given fishery. Data collected by either of these sampling strategies can be used to estimate the NORs handled/HORs kept ratio used in the formula above.

Work Elements

- Below Mayfield Dam
    - Determine ratio of NORs to HORs entering fishery by species

- Apply NOR:HOR ratio to HOR catch to determine number of NORs handled in fishery by species
- Apply predetermined mortality rate to the number of NORs handled in fishery to determine number of fishery related mortalities occurring in the lower Cowlitz River by species

- Above Mayfield Dam
  - Summarize the number of NORs released into upper Cowlitz and Tilton basins by species
  - Apply predetermined harvest rates to number of NORs transported upstream to determine number of NORs handled in fisheries by species
  - Apply predetermined mortality to rate to the number of NORs handled in fisheries to determine number of fishery related mortalities by species

AM-5 Deliverables

What	1. Number of NOR mortalities, by species, occurring due to handle in fisheries in the Cowlitz basin downstream of Mayfield Dam, Tilton River basin, and the Cowlitz basin upstream of Cowlitz Falls Dam. 2. Level of precision estimating NOR mortalities (meeting NOAA precision standards).
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Funding will be provided by WDFW.

AM-6. Method for Estimating/Enumerating HOB, NOB and pNOB

Applies to

Estimation of hatchery broodstock by origin (HOB, NOB and pNOB)

- All hatchery programs

All broodstock will be sampled for origin (HOR versus NOR) and a random sample will be sampled for other metrics (see MA-E). The proportion of natural-origin brood (pNOB) will be calculated with the following equation: pNOB = NOB / (NOB + HOB).

The population differentiation will made using scale data from all broodstock. All data collected will be entered into the WDFW Region 5 biological database.

AM-6 Deliverables

What	1. Estimates of hatchery- and natural-origin broodstock for all hatchery

	programs 2. Estimate of pNOB for each program
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Funding will be provided by Tacoma Power

AM-7. Method for Estimating Hatchery Recruit per Spawner Ratio (and SAR)

> Applies to
>
> Estimation of survival of hatchery fish from broodstock collected to recruitment and spawning
>
> - All hatchery programs

The hatchery recruit per spawner ratio is intended to depict the average number of hatchery fish that were produced per fish spawned. A spawner is defined as a fish spawned in the hatchery whose eggs or sperm were used to produce smolts for subsequent release. A recruit is defined as a fish that survived to enter the first ocean fishery that it could encounter. An estimate of the number of spawners is derived by a simple accounting of the number of fish spawned at the hatchery. Recruits are calculated by combining the number of fish returning to the hatchery with the terminal harvest and the pre-terminal mortality as per the formula below:

Number of recruits = Total returns to hatchery + Catch in terminal fisheries + Mortalities in non-terminal fisheries

Methodology for estimating catch in terminal fisheries and mortalities in non-terminal fisheries is described in items AM-3 and AM-4 above.

AM-7 Deliverables

What	1. Estimates of R/S and SAR for each hatchery program
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

AM-8. Method for Estimating PNI

Applies to:
Calculation of PNI from pNOB and pHOS • Lower Cowlitz fall Chinook • Lower Cowlitz coho • Lower Cowlitz steelhead • Upper Cowlitz coho

PNI (Proportion of Natural Influence) is a reflection of the gene flow rate between the natural environment and the hatchery environment. It is estimated using the following formula:

PNI = pNOB / (pNOB / pHOS)

Where
pNOB is the proportion of broodstock consisting of natural-origin fish (Number of natural origin fish in hatchery broodstock / Total number of fish in hatchery broodstock) and pHOS is the proportion of fish spawning naturally consisting of hatchery-origin fish (Number of hatchery origin fish spawning in the wild / Total number of fish spawning in the wild).

AM-8 Deliverables

What	1. Estimate of PNI for all integrated hatchery programs
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

AM-9. Method for Stratified-Peterson (Darroch) Mark-Recapture Estimate

Applies to:
Smolt abundance estimation for • Lower Cowlitz fall Chinook • Lower Cowlitz coho • Lower Cowlitz steelhead

Juvenile mark-recapture estimation for the Cowlitz River should be designed based on a stratified Petersen or Darroch estimator or their alternatives (Seber 1982, Dempson and Stansbury 1991, Arnason et al. 1996, Thedinga et al. 1994, Carlson et al. 1998, Volkhardt et al. 2007). This framework will be used to develop estimates of trap efficiency for homogeneous periods by species and life stage. In addition, it has the flexibility to include the use of covariates such as flow, turbidity, and temperature to improve the precision of the estimates and to account for days when trapping was missed. To ensure the estimates are unbiased, standard mark-recapture assumptions should be tested and marks or recaptures adjusted based on tagging effects (Thedinga et al. 1994, Carlson et al. 1998). In addition, abundance estimates should be made for the different hatchery and upriver release groups using lower river trap efficiency trials. If the trap estimates are unbiased and there is limited mortality or residualization, then there should be no statistical difference between the releases and estimated trap abundance.

NOAA recommends simultaneously estimating adult and juvenile abundance for at least one population in each MPG, consistent with a 15% CV standard. This will be achieved for the Upper Cowlitz coho and steelhead populations (see below).

Juvenile abundance information aimed at the 15% CV standard will not be the focus for the lower river coho and steelhead populations. Juvenile abundance data will be collected, but the CV standard may not necessarily be met.

AM-9 Deliverables

What	1. Smolt abundance estimate for Lower Cowlitz fall Chinook, coho and steelhead
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

AM-10. Method for Estimating Smolt Migration Speed and Timing

Applies to:

Estimation of smolt migration speed and timing for:

- Lower Cowlitz fall Chinook
- Lower Cowlitz coho
- Lower Cowlitz steelhead

Unless results of the efficacy test (see introduction) indicate otherwise, a rotary screw trap will be operated in the lower Cowlitz River from February through September annually (see MA-B above). A random sub-sample of the juvenile salmonids captured will be examined for species, origin (HOR vs. NOR), length and weight. The trap will be operated according to protocols developed as a part of the efficacy testing in the initial year(s) of this plan.

Smolt migration time for a hatchery fish is defined as the time from release at the hatchery to recovery at a downstream site. The smolt migration speed is simply the smolt migration time divided by the distance between the release and recovery sites. If all hatchery releases from a single species are released within a 24 hour period, the hatchery release will be considered instantaneous. The migration time and speed for each individual fish is calculated as above. Descriptions of travel time or speed may include the mean, median, and mode and its spread or variability as described by the variance. It is unclear what the distribution of individual travel times will be. The above statistics can be estimated using bootstrapping, the normal distribution assuming the sample size is large enough (Central Limit Theorem), or using goodness of fit tests to identify appropriate distribution. If there is an interest to describe the difference in timing between hatchery summer and winter steelhead migration time and speed differential marking program should be considered.

If hatchery fish are volitionally released, it is recommended that different daily release groups are marked or tagged as fish leave the hatchery. Options for marking and tagging include visual batch marks (elastomer, panjet, or other marks), or individual tags (visual implant, PIT, or other tags) to estimate travel times from daily release groups. If marks are used, there needs to be a sufficient number of marks and locations to identify individual release groups. If PIT tags are used for the yearling releases, additional information will be obtained from the NOAA PIT tag trawl operated in the lower Columbia River near Cathlamet, WA. If marks or tags are used, a power analysis should be conducted to determine the appropriate mark or tag rates given recovery efficiencies. This is suggested after a recovery site is identified and gear efficiency is estimated.

Timing is defined as the daily or weekly catch or estimate of juvenile abundance passing a recovery site. This is typically a graphical display, although the same descriptive statistics and methods described for migration time and speed can be used for timing.

All data collected will be entered into the WDFW statewide juvenile migrant (JMX) database.

AM-10 Deliverables

What	1. Dates of 10%, 50%, and 90% completion of smolt migration for each Lower Cowlitz population 2. Summary of travel speed as a function of date
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

AM-11. Method for Estimating Natural Spawning Escapement at Adult Separator

Applies to:

Estimation of natural spawning escapement abundance (NOS) and pHOS at adult separator

- Upper Cowlitz spring Chinook
- Upper Cowlitz coho
- Upper Cowlitz steelhead
- Tilton steelhead

Tacoma Power determines the origin of all adult salmonids that enter the separator facility at the Cowlitz Salmon Hatchery. The data is centered into an Access database that tracks the origin of all fish handled. The origin and disposition of all fish (hatchery broodstock, upstream, surplus or downstream) is calculated from the database. The data is reviewed weekly and provided to the WDFW. It is then checked by WDFW and, after quality control, included in the Cowlitz Complex annual report.

AM-11 Deliverables

What	1. Number of NOR adult salmonids handled at the Cowlitz Salmon Hatchery adult fish separator facility
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

AM-12. Method for Estimating Smolt Yield, Timing and Fish Passage Survival at Cowlitz Falls

Applies to

Estimation of smolt yield, timing and fish passage survival at Cowlitz Falls

- Upper Cowlitz spring Chinook
- Upper Cowlitz coho
- Upper Cowlitz steelhead

The CFFF uses estimates of fish collection efficiency based on mark-recapture data and smolts collected to estimate smolt yields from either releases of spring Chinook fry, or from natural production in the upper Cowlitz River basin. The total collection by population is divided by the average mark recapture fish collection efficiency estimate for the season to estimate the total number of smolts that migrated during the spring-summer season. It is not possible to identify the proportion of steelhead and coho smolts produced from NOR or HOR adults that spawned in the upper watershed.

AM-12 Deliverables

What	1. Number of smolts by population, and the juvenile salmonid yield of the upper Cowlitz River basin 2. Fish passage survival by species
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Funded by BPA, data provided to Tacoma Power. Providing data for the annual workshop is the responsibility of Tacoma Power.

AM-13. Method for Estimating Smolt Yield, Timing and Fish Passage Survival at Mayfield

Applies to

Estimation of smolt yield, timing and fish passage survival at Mayfield

- Tilton spring Chinook
- Tilton coho
- Tilton steelhead

Tacoma Power uses the data collected by the WDFW and reported in the annual Cowlitz Evaluations report to calculate the fish passage survival by species. The model uses the current fish guidance efficiency, turbine survival estimates, and spill volume and turbine usage to calculate an annual fish passage survival rate as defined in the Cowlitz Hydroelectric Project Settlement Agreement.

AM-13 Deliverables

What	1. Annual fish passage survival (FPS) of juvenile salmonids by species
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

AM-14. Method for Estimating Predation Rate of Hatchery Origin Juveniles on Natural Origin Salmonids

Applies to:
Estimation of predation rate of hatchery origin juveniles on salmonids as it affects: • All salmonids

Hatchery origin juvenile diets in the lower Cowlitz River will be examined to determine the impact of the hatchery programs on the wild fall Chinook juvenile population. Hatchery origin juveniles will be captured in the mainstem Cowlitz River downstream of the Barrier Dam using smolt traps. Stomach contents will be collected from hatchery and naturally juveniles to determine prey species in their diet. Sampling of hatchery juveniles will occur in spring after juvenile hatchery fish t have been released from the hatchery and they have had some time to rear in the river. Stomach contents will be examined to identify any salmonids consumed, specifically juvenile fall Chinook. Consumption of salmonids by hatchery origin juveniles will be compared to hatchery releases to determine if there is a correlation between predation and hatchery releases to assist in determining predation rate on naturally produced salmonids. If adequate samples are collected, diet composition of hatchery origin juveniles will be compared to diet composition of naturally produced fish of the same species.

Work Elements

- Collect hatchery origin juveniles using beach seines/juvenile traps
- Collect stomach samples from hatchery origin fish
- Identify the number of salmonids, by species and origin if possible, consumed by individual hatchery origin fish by species.
- Summarize predation numbers and rates of hatchery fish on salmonids, by species and origin if possible, including the range of predation rates between individuals

AM-14 Deliverables

What	Predation rate by HOR juveniles of juvenile salmonids on an individual fish basis, including range of predation rates.
When	Prior to the annual pre-season workshop (FHMP Update Chapter 2.1)
Funding Responsibility	Tacoma Power

APPENDIX J CITATIONS

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