Addendum to *Analyses to support a review of an ESA jeopardy consultation on fisheries impacting Lower Columbia River tule Chinook salmon, October 5, 2007.*

Lower Columbia tule Chinook working group[1]

February 7, 2008

Introduction

In October of 2007, NOAA-Fisheries, with assistance from a NMFS/WDFW/ODFW working group, released a report describing the predicted effects of alternative exploitation rates on the viability of Lower Columbia River (LCR) tule populations (Ford et al. 2007). This addendum to the October report provides some additional analyses and results for NOAA-Fisheries and others to consider prior to developing guidance for the 2008 fisheries. In particular, the addendum addresses several important issues that were raised, but not fully resolved, in the October report. These issues include:

* Relationship of the estimated annual or brood year exploitation rates (ERs) and recovery exploitation rates (RERs) in the October report to those generated by the FRAM model and used for fishery management.

The ERs and RERs developed in the October report were derived from run reconstructions of three naturally spawning tule populations (Coweeman, Grays, Lewis). The method used the escapement data (spawning abundance and age structure) of the natural populations combined with age specific harvest rates estimated from CWT recoveries of LCR tule hatchery stocks to estimate natural recuits/spawner and adult equivalent exploitation rates for each of the three focal natural tule populations. This method of estimating exploitation rates differs from the methodology used in the FRAM model, which focuses exclusively on CWT indicator stocks and does not use data on natural escapements. Because the ER's estimated by the two methods appeared to differ (see Table 11 and Figure 17 of the October report), it was not clear how to apply the RERs developed in the October report to a management regime based on the FRAM model. In addition, the PFMC recently approved the use of a new set of indicator stocks for LCR tules (Attachment 1), so it appeared important to reconsider the indicator stocks used for the RER and viability analyses as well.

* Comparison of the RER methodology used in the October report with that used for 2002 biological opinion that formed the basis of the previous consultation standard.

Simmons (2001) conducted an analysis to develop an RER for the Coweeman population that guided the consultation standard from 2002 – 2006 (NMFS 2002). The Simmons (2001) methodology differed from the October report in that Simmons used ERs and age structure estimated from the Cowlitz Hatchery indicator stock, instead of natural escapement data, to generate a Coweeman River run reconstruction. Although the work group concluded that the methodology used in the October report is more appropriate

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because it focuses more directly on the populations of interest, it determined that it would be useful to make a direct comparison of the RERs estimated using the alternative methods.

* Sensitivity of results to errors in the estimated age structure of natural spawners.

The October report used naturally spawning age structure estimates for each of the three focal natural populations, but did not take into account the sample sizes associated with these estimates. Since some of these sample sizes were very small, the workgroup determined that it would be useful to test the sensitivity of the RERs to uncertainty in the age structure data. The viability curve analyses reported in the October report already took into account uncertainty in age structure.

Summary of results

* Updated RERs developed using a new composite (seven stock) harvest indicator did not differ very much from the RERs that were reported in the October report. In particular, the 'best fit' updated RERs were 34-58% for the Coweeman (compared to 48-58% in the October report); 44-52% for the Lewis (compared to 44-46% in the October report); and 0-20% for the Grays (compared to 0 in the October report).

* In contrast to the other two populations, the RER for the Grays population is very sensitive to model assumptions. However, the best fitting models that included all available data produced consistently low RERs – 0 to 8%, depending on the choice of the lower escapement threshold. The workgroup was unable to recommend an appropriate lower threshold for the Grays population, due to uncertainty about the amount of available habitat in the watershed. The NWFSC, in collaboration with ODFW and WDFW, is updating the watershed size categories for all of the Lower Columbia Chinook populations, but the updated sizes were not available in time for this addendum.

* Lavoy (2007; Attachment 2) directly compared the FRAM-based annual ER estimates using the new four-stock PFMC 'natural tule' indicator stock to the annualized ER generated using the natural population run reconstructions and a seven-stock composite hatchery indictor stock developed for this addendum. Although the annual estimates varied somewhat between the two methodologies, overall the estimates were very similar and suggest that there is no need for a 'conversion factor' to translate between RERs generated on the basis of natural population run reconstructions and those generated by the FRAM model.

* Comparing RERs generated by the hatchery cohort reconstruction method used by Simmons (2001) with the natural cohort reconstruction method used in the October report is complicated by the many differences between the two methods. However, in general the two methods appear to produce similar results, especially when marine survival is included as a co-variate in the analysis.

* Key points:
    - The RERs and viability results reported in October remain basically unchanged.

- The estimates of past exploitation rates remain basically unchanged for the Lewis and Grays. The updated estimates for Coweeman are lower than were reported in October due to use of a different set of harvest rate indicator stocks.
- It appears appropriate to use the RERs directly to develop a consultation standard, without any need for an RER/FRAM ‘conversion factor’.

Results

New indicator stocks

The PFMC recently adopted a new composite set of CWT indicator stocks designed to represent LCR natural tule Chinook populations (Attachment 1). The new PFMC indicator is based on composite data from four hatcheries: Cowlitz, Washougal, Kalama, and Big Creek. To maximize recovery sample sizes and representation of LCR tule populations, the workgroup decided to use an even broader composite drawn from seven LCR tule hatcheries: Cowlitz, Washougal, Kalama Falls, Fallert Crk, Toutle, Elochoman, and Big Creek. Although the workgroup discussed several possible options for developing individual indicator stocks for each natural tule population, in the end the group decided that using a single composite indicator stock was appropriate in order to maximize sample sizes and minimize random variation in harvest rate estimates. Tag groups that were subject to extreme terminal fisheries that focused exclusively on hatchery produced fish were eliminated from the analysis. A description of the new composite indicator is provided in Appendix AA.

The use of the new composite indicator stock resulted in some fairly substantial differences in estimated exploitation rates compared to those in the October report, particularly for the Coweeman population (Figure 1A; Table 1). Differences between the new estimates and the October report estimates were less substantial for the Grays and Lewis populations (Figure 1 B and C; Table 1). The differential changes from the October estimates among populations resulted from the different indicator stocks used in the October report. In particular, the October estimates for the Coweeman used the Cowlitz Hatchery stock alone as an indicator, whereas the Grays and Lewis estimates were made using a composite indicator consisting of releases from the Cowlitz, Washougal and Grays Hatcheries.

Lavoy (2007; Attachment 2) directly compared the FRAM-based annual ER estimates using the new four-stock PFMC ‘natural tule’ indicator stock to the annualized estimates we generated using the natural population run reconstructions and the seven-stock composite hatchery indictor stock. Although the annual estimates varied somewhat between the two methodologies, overall the estimates were very similar and suggest that there is no need for a ‘conversion factor’ to translate between RERs generated on the basis of natural population run reconstructions and those generated by the FRAM model.

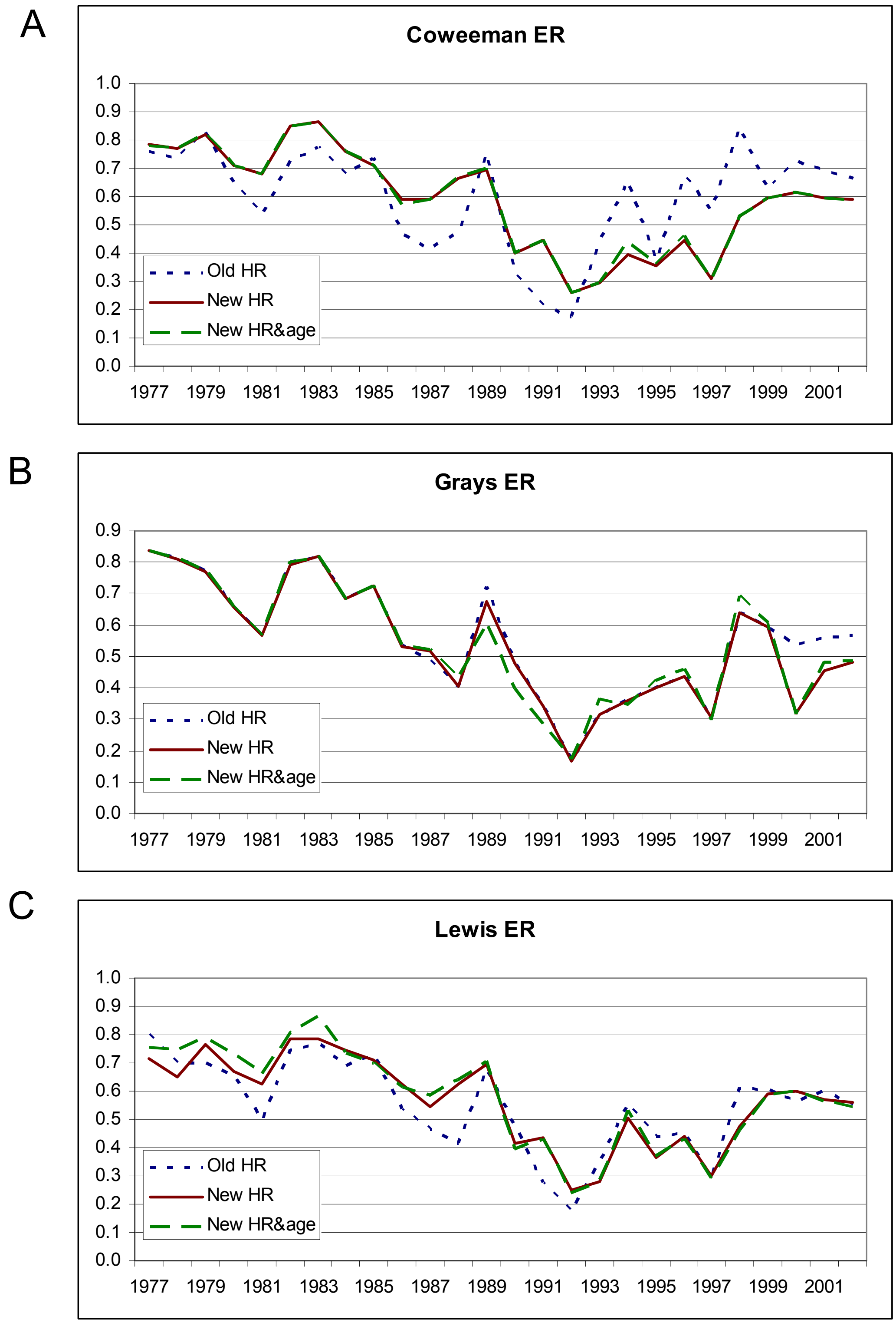

Figure 1 -- Comparison of estimated adult equivalent broodyear exploitation rates using alternative hatchery indicator stocks. Old HR = estimate from the October 2007 report. New HR = estimate made with the new seven population composite indicator stock. New HR & age = estimates made with the new composite indicator stock and eliminating annual age data with sample sizes <40. A) Coweeman, B) Grays, C) Lewis.

Table 1 –Comparison of estimated adult equivalent broodyear exploitation rates using alternative hatchery indicator stocks. Old HR = estimate from the October 2007 report. New HR = estimate made with the new seven population composite indicator stock. New HR & age = estimates made with the new composite indicator stock and eliminating annual age data with sample sizes <40.

Year	Coweeman			Grays			Lewis		
	Old HR	New HR	New HR&age	Old HR	New HR	New HR&age	Old HR	New HR	New HR&age
1977	0.758	0.783	0.781	0.839	0.837	0.839	0.799	0.715	0.757
1978	0.736	0.772	0.772	0.815	0.811	0.815	0.698	0.652	0.745
1979	0.832	0.822	0.824	0.774	0.768	0.774	0.702	0.767	0.788
1980	0.646	0.712	0.712	0.657	0.656	0.657	0.654	0.669	0.735
1981	0.534	0.682	0.680	0.567	0.565	0.567	0.497	0.625	0.658
1982	0.723	0.850	0.851	0.801	0.794	0.801	0.743	0.785	0.806
1983	0.775	0.865	0.862	0.820	0.818	0.820	0.771	0.786	0.864
1984	0.680	0.758	0.758	0.685	0.684	0.685	0.688	0.746	0.734
1985	0.737	0.709	0.709	0.726	0.724	0.726	0.731	0.712	0.699
1986	0.467	0.588	0.571	0.536	0.532	0.536	0.537	0.627	0.613
1987	0.417	0.588	0.590	0.488	0.518	0.520	0.464	0.543	0.585
1988	0.471	0.667	0.668	0.405	0.403	0.428	0.415	0.625	0.639
1989	0.754	0.697	0.698	0.722	0.677	0.607	0.681	0.697	0.706
1990	0.331	0.401	0.401	0.483	0.477	0.394	0.476	0.413	0.393
1991	0.214	0.444	0.444	0.343	0.343	0.285	0.274	0.437	0.430
1992	0.176	0.258	0.258	0.169	0.169	0.171	0.173	0.250	0.242
1993	0.439	0.296	0.293	0.317	0.317	0.364	0.349	0.281	0.281
1994	0.656	0.394	0.438	0.360	0.360	0.347	0.555	0.506	0.529
1995	0.375	0.353	0.362	0.399	0.399	0.422	0.441	0.364	0.371
1996	0.673	0.445	0.460	0.436	0.436	0.458	0.448	0.440	0.428
1997	0.549	0.312	0.303	0.307	0.307	0.295	0.294	0.298	0.292
1998	0.843	0.532	0.529	0.638	0.638	0.692	0.610	0.477	0.461
1999	0.627	0.596	0.596	0.596	0.596	0.607	0.604	0.590	0.590
2000	0.727	0.616	0.616	0.537	0.318	0.315	0.564	0.600	0.600
2001	0.697	0.594	0.593	0.557	0.454	0.482	0.600	0.571	0.565
2002	0.663	0.590	0.591	0.567	0.481	0.485	0.553	0.562	0.545

Updates to age structure data

Attachment 3 (Dec 10, 2007 memo from D. Rawding) describes the process for estimating age structure and hatchery fractions for the natural spawners in the three focal populations. Note that these data have not changed from the October report; the attachment merely provides greater detail in how the estimates were derived.

In order to test the sensitivity of the RERs to uncertainty in the age structure data, RERs were redeveloped in two ways: 1) using the annual age structure estimates regardless of sample size, and 2) using only annual age structure estimates with sample sizes >40 combined with using the 'age engine' method (see Appendix B of the October report) to estimate the age structure of the missing years. In both cases, the age engine was used to generate age structure estimates for years with no age data for the natural escapement. These analyses used the new 7-hatchery composite indicator stock described above.

In general, although the age estimates for some individual years varied substantially depending on whether small age samples sizes were included or excluded (Appendix BB), the estimated spawner recruit functions were not very sensitive to exclusion of age data based on small sample sizes (Table 2).

Updated RERs

Updated RERs for the three focal populations are reported in Table 3, along with the RERs from the October report. Only results from models that included the marine survival co-variate are reported because these models fit the data (based on AIC – see October report) much better than models that did not include marine survival (Table 2). A table of all RERs calculated, including those for models without the marine survival co-variate, is included as Appendix CC.

With the exception of the Grays populations, the RERs for the three populations were not sensitive to the decision of whether to include each annual age composition estimate, or to only include those estimates with sample sizes > 40 (Table 3). The one exception was the Grays population when a lower escapement level (LEL) of 51 was used. In that case, the RERs more than doubled when samples sizes < 40 were estimated using the age engine instead of the observed data. It is not surprising that the Grays population would be sensitive to exclusion of age data, however, because this population had only 3 years of age data with sample size > 40 (Appendix BB). Because the n=40 sample size cutoff results in throwing out most of the age data for the Grays population, we believe the RERs generated using all of the available data are likely to be more appropriate. In the future, a method to combine the age engine estimates with the annual estimates from the data in a weighted fashion may be worth exploring.

The Coweeman RERs using the Ricker or Beverton-Holt models dropped somewhat compared to the October report (Table 3). The cause of the drop, however, may be that estimated S_{msy} increased for this population under these models compared to the value associated with using the Cowlitz indicator stock. Since our rule for setting the upper escapement level (UEL) was to use the higher of average natural origin escapement or S_{msy}, this resulted in a higher UEL compared to that used in the October report (Table 3).

Table 2 – Parameter estimates derived using harvest rate information from the new (seven stock) composite indicator stock. "Old age" = estimates using the annual age composition regardless of samples size, "new age" = estimates made after dropping annual age estimates with samples sizes < 40. Compare to Table 8 of the October report. Shading of Δ AIC indicates model with equivalent support.

Population	Parameter		No covariates				Marine survival covariate		
S-R function			**Ric**	**Bev**	**Hoc**		**Ric**	**Bev**	**Hoc**
Coweeman	a		16.8	na	16.0		8.1	9.5	6.7
old age	b		440	1,764	1,764		1,413	6,087	3,613
	c						0.94	0.96	0.91
	MSY sp		380	10	110		1020	1250	540
	MSE (rec)		1.65	1.19	1.19		1.04	1.04	1.03
	Autocorrel		0.038	0.000	0.000		-0.040	-0.041	-0.024
	F statistic	F(1,27)	0.32	0.06	0.00	F(2,26)	3.31	3.33	3.46
	P(rec)		58%	81%	100%		6%	6%	5%
model	MSE (esc)		0.38	0.50	0.50		0.25	0.25	0.25
selection	F statistic	F(1,21)	18.5	9.7	9.7	F(2,20)	19.9	20.0	20.4
	P(esc)		0.0%	0.5%	0.5%		0.0%	0.0%	0.0%
	Δ AIC		8.9	15.1	15.1	.	1.1	1.2	0.7
Coweeman	a		16.9	na	16.1		7.9	9.2	6.7
new age	b		434	1,758	1,758		1,475	6,306	3,591
	c						0.94	0.96	0.90
	MSY sp		370	10	110		1060	1310	540
	MSE (rec)		1.59	1.16	1.16		1.02	1.03	1.02
	Autocorrel		0.050	-0.011	-0.011		-0.040	-0.041	-0.021
	F statistic	F(1,27)	0.57	0.00	0.00	F(2,26)	3.28	3.15	3.34
	P(rec)		46%	100%	100%		6%	6%	6%
model	MSE (esc)		0.37	0.48	0.48		0.24	0.24	0.24
selection	F statistic	F(1,21)	19.3	10.6	10.6	F(2,20)	21.0	21.3	21.4
	P(esc)		0.0%	0.4%	0.4%		0.0%	0.0%	0.0%
	Δ AIC		8.3	14.2	14.2	.	0.3	0.2	0.0
Grays	a		3.0	5.8	2.2		8.5	na	71.4
old age	b		465	477	454		266	615	614
	c						0.89	1.17	1.17
	MSY sp		220	120	210		180	10	10
	MSE (rec)		2.14	1.92	2.09		2.52	1.48	1.48
	Autocorrel		0.294	0.356	0.234		0.163	0.293	0.293
	F statistic	F(1,27)	1.72	2.22	2.60	F(2,26)	2.20	6.58	6.58
	P(rec)		0.20	0.15	0.12		14%	14%	14%
model	MSE (esc)		1.60	1.60	1.60		1.11	1.11	1.11
selection	F statistic	F(1,21)	3.2	3.2	3.2	F(2,20)	6.8	6.8	6.8
	P(esc)		8.8%	8.8%	8.8%		0.6%	0.6%	0.6%
	Δ AIC		19.6	17.8	18.3	.	13.0	4.0	3.9

Grays new age	a		3.2	0.3	3.2		4.9	na	47.8
	b		11	10	0		359	426	426
	c						1.08	1.26	1.26
	MSY sp		280	180	250		220	10	10
	MSE (rec)		2.66	2.59	2.64		2.67	1.89	1.89
	Autocorrel		0.345	0.361	0.327		0.059	0.099	0.099
	F statistic	F(1,27)	3.21	0.00	3.19	F(2,26)	3.95	6.98	6.98
	P(rec)		0.09	0.10	0.09		4%	4%	4%
model selection	MSE (esc)		1.41	1.41	1.41		0.79	0.79	0.79
	F statistic	F(1,21)	5.1	5.1	5.1	F(2,20)	13.2	13.2	13.2
	P(esc)		3.5%	3.5%	3.5%		0.0%	0.0%	0.0%
	Δ AIC		16.8	16.0	14.8	.	5.1	0.0	0.0

Lewis old age	a		3.2	3.7	2.4		5.5	7.7	4.5
	b		2,188	4,011	2,526		1122	3063	1996
	c						0.76	0.76	0.77
	MSY sp		1070	1000	1040		690	640	450
	MSE (rec)		0.75	0.73	0.82		0.20	0.18	0.22
	Autocorrel		-0.049	-0.037	-0.071		-0.102	-0.030	-0.109
	F statistic	F(1,27)	1.57	1.58	1.67	F(2,26)	35.45	41.39	31.47
	P(rec)		0.22	0.22	0.21		0%	0%	0%
model selection	MSE (esc)		0.45	0.45	0.45		0.07	0.07	0.07
	F statistic	F(1,21)	1.6	1.6	1.6	F(2,20)	43.3	43.3	43.3
	P(esc)		21.9%	21.9%	21.9%		0.0%	0.0%	0.0%
	Δ AIC		42.4	42.2	42.9	.	2.3	0.0	6.1

Lewis new age	a		2.9	3.2	2.5		5.3	7.0	3.8
	b		3,256	6,155	2,813		1309	3539	2521
	c						0.73	0.74	0.73
	MSY sp		1500	1520	1140		790	740	670
	MSE (rec)		1.43	1.40	1.52		0.99	0.94	1.08
	Autocorrel		-0.128	-0.123	-0.144		-0.051	-0.035	-0.079
	F statistic	F(1,27)	0.06	0.06	0.05	F(2,26)	4.38	4.97	3.61
	P(rec)		0.81	0.81	0.83		3%	3%	3%
model selection	MSE (esc)		0.43	0.43	0.43		0.12	0.12	0.12
	F statistic	F(1,21)	1.9	1.9	1.9	F(2,20)	22.9	22.9	22.9
	P(esc)		18.7%	18.7%	18.7%		0.0%	0.0%	0.0%
	Δ AIC		41.5	41.5	41.8	.	13.3	11.8	16.9

Table 3 – Updated RERs for the Coweeman, Grays and EF Lewis populations. Only spawner/recruit parameters estimated with the marine survival co-variate are reported. LEL = lower escapement level, UEL = upper escapement level. "Old age" = estimates using the annual age composition regardless of samples size, "new age" = estimates made after dropping annual age estimates with samples sizes < 40.

Coweeman

	October Report values			Updated with new indicator stock and age information					
LEL=51	S_{MSY}	UEL	RER	S_{MSY}	UEL	RER - old age	RER - new age	S_{MSY}	UEL
Ricker	790	790	0.48	1020	1020	0.34	0.38	1060	1060
Bev-Holt	1070			1250	1250	0.52	0.52	1310	1310
Hockey	510	750	0.58	540	750	0.58	0.58	540	750
LEL=151									
Ricker	790	790	0.46	1020	1020	0.34	0.38	1060	1060
Bev-Holt	1070	1070	0.54	1250	1250	0.52	0.52	1310	1310
Hockey	510	750	0.58	540	750	0.58	0.58	540	750

Grays

RER	October Report values			Updated with new indicator stock and age information					
LEL=51	S_{MSY}	UEL	RER	S_{MSY}	UEL	RER - old age	RER - new age	S_{MSY}	UEL
Ricker	180			200				220	
Bev-Holt	na	221	0	na	221	0.08	0.18	na	221
Hockey	na	221	0	na	221	0.06	0.20	na	221
LEL=151									
Ricker	180			200				220	
Bev-Holt	na	221	0	na	221	0	0	na	221
Hockey	na	221	0	na	221	0	0	na	221

Lewis

RER	October Report values			Updated with new indicator stock and age information					
LEL=51	S_{MSY}	UEL	RER	S_{MSY}	UEL	RER - old age	RER - new age	S_{MSY}	UEL
Ricker	550			690	690		0.44	790	790
Bev-Holt	440	645	0.46	640	645	0.50	0.52	740	740
Hockey	310	645	0.44	450				670	
LEL=151									
Ricker	550			690	690		0.44	790	790
Bev-Holt	440	645	0.46	640	645	0.50	0.52	740	740
Hockey	310	645	0.44	450				670	

Comparison of RERs estimated using the natural cohort analysis method (A&P Tables and the Dynamic Model) versus using the hatchery cohort analysis method (Simmons 2001)

One of the issues identified in the October report was that exploitation rate estimates differed considerably depending on which data were used in their estimation. Of particular concern was the potential problem of developing RERs using one set of data and assumptions, and then applying these RERs to a management framework developed under a different set of data and assumptions.

In addition to the question of whether the RERs estimated in the October report are in the same 'currency' as the FRAM ERs (see above, and attachment 2), another question is the sensitivity to of RERs to the method of run reconstruction. In particular, to support the 2002-2006 biological opinion, Simmons (2001) developed an RER for the Coweeman population that involved using estimates of exploitation rates and productivity derived from the hatchery CWT indicator stock instead of the natural run reconstruction approach used in the October report. Simmons (2001) also used a method of estimating spawner/recruit parameters that involved mean square minimization of "observed" and predicted *recruits*. In contrast, the October report used a method which involved mean square minimization of "observed" versus predicted *escapement*. In order to compare RERs generated from these alternative methods, we applied Simmons (2001) method to the Coweeman population using the updated harvest indicator stocks and several alternative methods for developing natural recruits from the indicator stock cohort analysis, and then reestimated the spawner/recruit parameters from the natural cohort run reconstructions by fitting the recruit data instead of the escapement data.

In order to use the hatchery cohort analysis as a method of estimating natural recruitment, it is necessary to assign natural recruits to natural broodyears. It is not entirely clear how to do this. Simmons (2001) used the natural origin escapement age structure to split the annual escapements into brood year escapements and applied the AEQ ERs estimated from the hatchery cohort analysis to the brood year escapement to get brood year recruits. This method does not seem ideal, since the ER is based on a different age composition than the spawning escapements. In addition to Simmon's method, we therefore also tried two alternative methods: we used the age composition of the hatchery indicator stock escapements, either as an average calculated over all years (average hatchery age) or by broodyear (annual hatchery age). Simmons (2001) did not use marine survival as a co-variate, but in the comparisons we estimated parameters both with and without this co-variate.

The results of these comparisons are shown in Table 4. When the marine survival co-variate is included in the model, the results differed little among the various methods and models. In contrast, when the marine survival co-variate was not included, the resulting RERs differ considerably depending on which method was used to generate them (only the Ricker model was used). In particular, when the natural cohort reconstruction method was used and parameters were estimated by minimizing escapement error, the resulting RER was 0. In contrast, the RERs generated by the hatchery cohort method ranged from 16% to 48%, depending on the method used to assign recruits to brood years.

Some of the difference between the two methods appears to be due to the method of parameter estimation rather than cohort reconstruction *per se*, because the RER generated by the natural cohort method combined with parameter estimation based on minimizing error in recruitment was 46%, similar to the hatchery cohort method. Fitting the models based on recruit data results in a lower MSE for recruits than fitting based on escapement. Since the MSE is used in the forward simulations, a lower MSE will result in a less variable population and therefore a higher RER. In general, however, we believe fitting the models using escapement data is more appropriate than using recruit data, because the escapement data are somewhat closer to being 'observations' than are the recruit data.

Other differences between the two methods can occur because of differing estimates of capacity. For example, when the marine survival co-variate is included, the hatchery cohort method produces higher estimates of capacity than the natural cohort method. Under our rule set of using the higher of either S_{msy} or average natural origin escapement, this can result in using different UELs for the two methods (Table 4).

Table 4 -- Comparison of natural run reconstruction (A&P Tables/Dynamic Model) method of generating RERs with the hatchery exploitation rate method used by Simmons (2001).

	Natural run reconstruction method				Hatchery stock run reconstruction method (Simmons 2001)				
RER	S_{MSY}	UEL			S_{MSY}	UEL			
LEL=151			Min rec	Min esc			NOR age	Ave Hat Age	Ann Hat Age
No covariate									
Ricker	540	750	0.46	0	370	750	0.16	0.48	0.48
Bev-Holt	50	750			10	750			
Hockey	150	750			110	750			
Marine Survival									
Ricker	790	790	0.46	0.38	1060	1060			0.50
Bev-Holt	570	750	0.52	0.52	1310	1310			0.42
Hockey	490	750	0.54	0.58	540	750			
Note: all RERs triggered by UEL									

Updated viable curves

Viability curve analysis using spawner/recruit data derived using the new composite indicator stock are reported in Table 5 and Figure 2, and remain largely unchanged from the values in the October report.

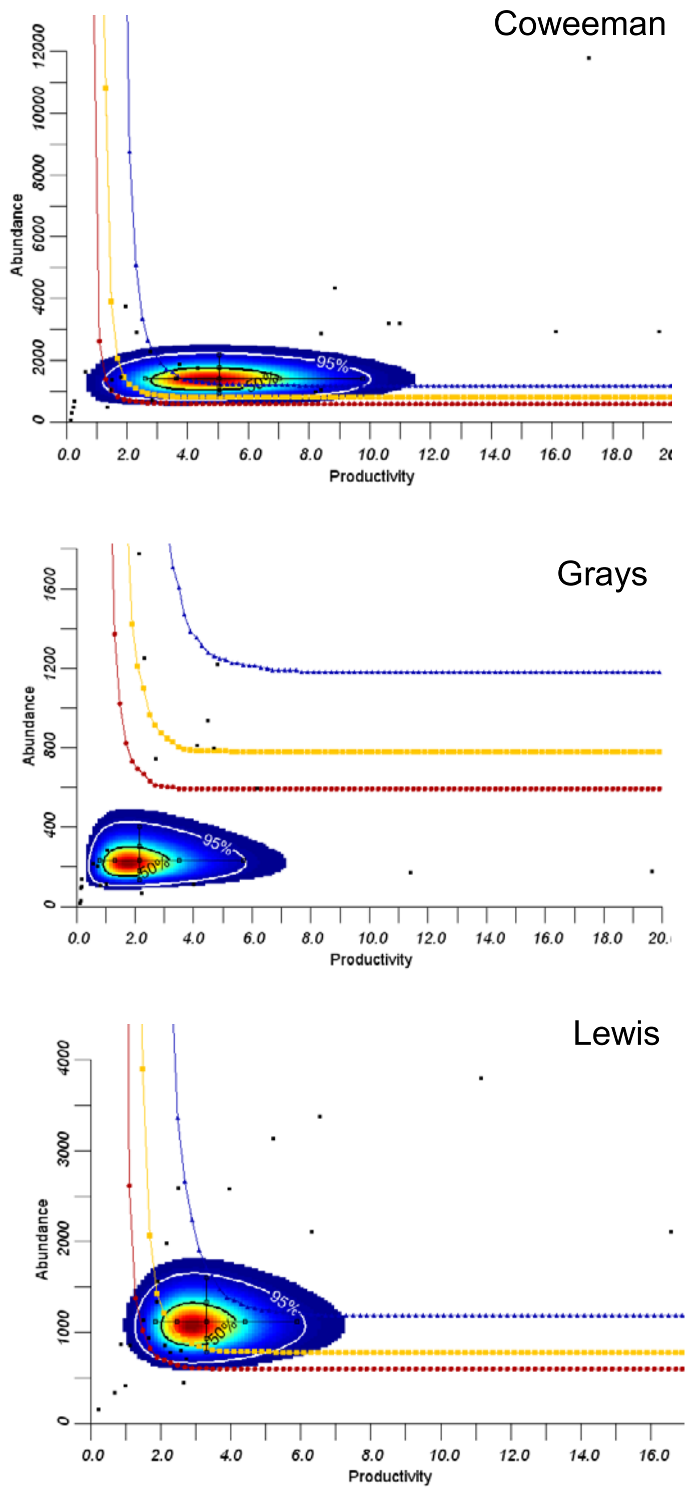

Figure 2-- Abundance and productivity status of the Coweeman, Grays and Lewis populations relative to three viability curves: 0% AEQ exploitation rate (bottom curve), 25% AEQ exploitation rate (middle curve), and 50% AEQ exploitation rate (top curve). Quasi-extinction level set to 150/year for four years. The risk curves describe a 5% probability of declining to the QET in 100 years. Updated from Figure 16 in the October report using spawner/recruit data derived from the new composite indicator stock.

Table 5 -- Probabilities of meeting viability criteria for abundance and productivity under alternative future exploitation rates for category 1 populations and assuming current habitat and environmental conditions.

Strata	State	Populations	Probability of meeting viability criteria					
			QET = 50			QET = 150		
			0 harvest	25% harvest	50% harvest	0 harvest	25% harvest	50% harvest
October report values								
Coast Fall	WA	Grays	54%	16%	0%	0%	0%	0%
Cascade Fall	WA	Coweeman	100%	99%	93%	99%	95%	53%
	WA	Lewis	100%	98%	71%	98%	78%	5%
Updates based on new indicator stock								
Coast Fall	WA	Grays	43%	10%	0%	0%	0%	0%
Cascade Fall	WA	Coweeman	100%	99%	95%	99%	95%	56%
	WA	Lewis	100%	99%	80%	99%	80%	5%

References

Ford, M., N. Sands, P. McElhany, R. Kope, D. Simmons, and P. Dygert. 2007. Analyses to support a review of an ESA jeopardy consultation on fisheries impacting Lower Columbia River tule Chinook salmon. National Marine Fisheries Service Northwest Fisheries Science Center and Northwest Regional Office, Seattle, WA. October 5, 2007.

NMFS. 2002. Letter from D Robert Lohn and Rod McInnis to Hans Radtke.

Simmons, D. 2001. Memo from Dell Simmons to ARA, Sustainable Fisheries Division. Subject: Revised RER for Coweeman River Natural Tule fall Chinook. November 12, 2001.

Appendix AA. Columbia River natural fall tule composite indicator stock.

Cowlitz hatchery fall fingerling releases have been used in the Pacific Salmon Commission's Chinook model and in the Fishery Regulation Assessment Model (FRAM) to represent Washington hatchery tule fall Chinook. Because the distribution of ocean fishery CWT recoveries from this stock differs from that of other lower river tule hatchery stocks, there was concern that the Cowlitz hatchery fall stock does not adequately represent other components of the lower river wild tule stock, especially components originating from Oregon tributaries. In some years, there were also very limited recoveries of CWTs in both fisheries and in the spawning escapement. To address these concerns, a composite hatchery indicator stock was developed that included CWTs from six different individual tule stocks from the lower Columbia River. These six stocks included: Cowlitz, Elochoman, Toutle, Kalama (Kalama Falls and Fallert Creek hatcheries), Washougal, and Bonneville (Bonneville and Big Creek hatcheries). Exploitation rate analysis of the individual stocks and the aggregate stock were performed using the Pacific Salmon Commission, Joint Chinook Technical Committee's procedures and software. The tags codes used to represent each stock are listed below.

	Stock					
Brood year	Cowlitz	Elochoman	Toutle	Kalama	Washougal	Bonneville
1976		631604	631640	631639	631641	091609 091610
1977	631802	631744	631763 631801	631746 631747 631742	631803	071704 071705
1978	631942 631951	631856 631956	631854 631941	631957	631938 631946	071844
1979	632154 632159 632137	632005		632105 632006	632153	072160
1980	632156 632255	632234 632317		632036 632254	632148 632251	072331 072333 072334
1981	632032 632450 632462 632603	632242 632260		632460 632463	632461	072410
1982	632503 632610				632238 632239 632259	
1983	632327 632328 633019 633020 633124 633125				633116 633117 633118 633119	
1984	633235 633236 633237 633238 633448 633449 633450 633451				633334 633335 633407 633408 633414 633415 633416 633428	

					633431 633432 633433 633434	
1985	634108	633458 633459 633819 633820			633320 633827 633828 633829 633830 633831 633832 634113	
1986	634126				634150	073319 073813 073814 073815 073816 073817
1987	635231		633316		635228	074559 074560 074561 074562 074563 074601
1988	635250	630735 630737 630738		630741 630742 630744		074335 074336 074337 074521 075009 075010
1989	630452		631349		635904	074255 074256 074259 074261
1990	634056		634019 634020 634236		635621	074262 074401 075519 075520
1991	634526	634534 634624	633115		634616	074944 074947 075757 075758 075759 075760
1992	635015	635036 635039	634934	634939 634936	635040 635043	076021 076022 076023 076024
1993	635539	635051 635053	635048	635054 635160	635158 635159	070547 070548
1994	635523 635620	635723 635724	635206	635205 635203	635512 635515	070952 076141 076144
1995	635851 636005	636008	636110	635630 635634	636108 636109	070550 071142
1996	630224 630227	636348 636349	630234	635630 635634	636350 636351	071251
1997	630311	630239 630240	630245	630458 630243	630415 630457	092121 092448

1998	631031	631036	631038	631039 631037	630501 630502	
1999	631330	630504	631040	630190 630191	630194	093005
2000	630673	630196	630879	630279 630280	630877	093250
2001	631379	630881	631408	631406 631407	631415 631417	093452
2002	631782	631410	631869	631554 631556	631543 631544	093751
2003	632573		632276	631873 632275	631567 631996	094122

Appendix BB – Alternative annual age estimates

Age samples

The tables below give the age distributions used for the 3 populations. When sample sizes are given these are the years of data provided. The first set of data is that we used before for the October report and in the recent analyses as the original data. In the columns to the right, new age distributions, only the rows in bold (i.e., sample sizes >40) were used as is and the other years were generated from the age engine.

Coweeman

		Using given age distribution					Using age distributions for sample size > 40				
Year	Sample size	2	3	4	5	6	2	3	4	5	6
1977		4%	11%	45%	39%	0%	5%	11%	46%	38%	0%
1978		1%	34%	40%	24%	1%	2%	31%	43%	23%	1%
1979		1%	6%	79%	13%	0%	1%	7%	78%	14%	0%
1980		3%	14%	31%	52%	0%	3%	11%	34%	50%	0%
1981		0%	25%	57%	17%	1%	0%	26%	53%	20%	1%
1982		13%	1%	65%	21%	0%	14%	1%	68%	17%	0%
1983		4%	70%	3%	23%	0%	5%	67%	3%	25%	0%
1984		2%	11%	86%	1%	0%	3%	10%	86%	1%	0%
1985		1%	19%	39%	42%	0%	1%	17%	40%	42%	0%
1986		10%	5%	65%	19%	1%	11%	5%	64%	18%	1%
1987		3%	60%	13%	24%	0%	4%	56%	16%	24%	0%
1988	**62**	7%	15%	73%	4%	0%	7%	15%	73%	4%	0%
1989	**188**	3%	8%	33%	56%	0%	3%	8%	33%	56%	0%
1990	**70**	10%	26%	37%	23%	4%	10%	26%	37%	23%	4%
1991	39	0%	32%	38%	30%	0%	2%	26%	53%	19%	0%
1992	**94**	2%	7%	74%	16%	1%	2%	7%	74%	16%	1%
1993	**125**	7%	31%	35%	27%	0%	7%	31%	35%	27%	0%
1994	**108**	6%	31%	56%	7%	0%	6%	31%	56%	7%	0%
1995	**160**	3%	30%	52%	16%	0%	3%	30%	52%	16%	0%
1996	**170**	0%	15%	66%	18%	0%	0%	15%	66%	18%	0%
1997	**91**	0%	1%	62%	37%	0%	0%	1%	62%	37%	0%
1998	12	1%	8%	49%	41%	0%	1%	12%	52%	33%	1%
1999	32	3%	35%	46%	16%	0%	6%	11%	54%	28%	1%
2000	28	2%	17%	74%	7%	0%	6%	34%	36%	22%	0%
2001	**135**	2%	20%	68%	9%	0%	2%	20%	68%	9%	0%
2002	**196**	1%	26%	55%	18%	0%	1%	26%	55%	18%	0%
2003	**238**	1%	8%	66%	25%	0%	1%	8%	66%	25%	0%
2004	**206**	3%	8%	62%	28%	0%	3%	8%	62%	28%	0%
2005	**100**	1%	17%	48%	34%	0%	1%	17%	48%	34%	0%

Grays											
		Using given age distribution					Using age distributions for sample size > 40				
Year	Sample size	2	3	4	5	6	2	3	4	5	6
1977		2%	30%	56%	12%	0%	2%	32%	51%	14%	0%
1978		1%	11%	75%	13%	0%	1%	9%	74%	16%	0%
1979		3%	6%	54%	37%	0%	4%	6%	43%	47%	0%
1980		3%	35%	33%	29%	0%	3%	37%	29%	30%	0%
1981		11%	13%	70%	6%	0%	15%	10%	68%	7%	0%
1982		1%	51%	32%	16%	0%	0%	57%	23%	20%	0%
1983		4%	2%	88%	5%	0%	6%	1%	89%	5%	0%
1984		3%	42%	12%	42%	0%	3%	44%	3%	50%	0%
1985		4%	12%	81%	2%	0%	5%	9%	85%	1%	0%
1986		5%	27%	41%	27%	0%	6%	29%	29%	36%	0%
1987		4%	23%	63%	9%	0%	6%	22%	64%	8%	0%
1988		1%	22%	60%	16%	0%	1%	24%	54%	21%	0%
1989		1%	9%	72%	19%	0%	1%	8%	70%	21%	0%
1990		3%	10%	48%	38%	0%	5%	11%	38%	46%	0%
1991	**64**	6%	36%	36%	22%	0%	6%	36%	36%	22%	0%
1992	0	1%	13%	75%	11%	0%	1%	4%	81%	14%	0%
1993	2	7%	37%	53%	2%	0%	2%	9%	23%	66%	0%
1994	4	0%	0%	26%	74%	0%	46%	11%	32%	11%	0%
1995	4	0%	0%	52%	48%	0%	1%	83%	12%	4%	0%
1996	25	4%	35%	58%	4%	0%	3%	2%	93%	2%	0%
1997	7	14%	14%	71%	0%	0%	7%	25%	9%	60%	0%
1998	27	0%	40%	43%	17%	0%	6%	31%	60%	3%	0%
1999	**106**	0%	36%	59%	5%	0%	0%	36%	59%	5%	0%
2000	24	8%	4%	76%	11%	0%	5%	31%	46%	18%	0%
2001	21	4%	50%	46%	0%	0%	5%	18%	64%	13%	0%
2002	6	5%	32%	48%	16%	0%	9%	21%	47%	23%	0%
2003	28	4%	11%	68%	18%	0%	3%	36%	47%	14%	0%
2004	**84**	3%	14%	74%	10%	0%	3%	14%	74%	10%	0%
2005	36	18%	34%	32%	17%	0%	10%	16%	41%	32%	0%

Lewis											
		Using given age distribution					Using age distributions for sample size > 40				
Year	Sample size	2	3	4	5	6	2	3	4	5	6
1977		6%	38%	47%	9%	0%	14%	24%	50%	12%	0%
1978		29%	19%	45%	7%	0%	9%	21%	53%	16%	0%
1979		12%	30%	45%	13%	0%	10%	16%	54%	19%	1%
1980		41%	13%	39%	7%	0%	12%	19%	46%	22%	1%
1981		9%	9%	69%	13%	0%	11%	22%	50%	17%	1%
1982		31%	32%	36%	1%	0%	0%	20%	60%	19%	1%
1983		9%	10%	70%	10%	0%	26%	0%	52%	21%	1%
1984		7%	9%	77%	7%	0%	14%	59%	1%	24%	1%
1985		17%	21%	46%	15%	0%	2%	14%	84%	0%	1%
1986		13%	39%	41%	7%	0%	21%	4%	41%	35%	0%
1987		14%	24%	44%	18%	0%	15%	50%	14%	20%	2%
1988	**89**	**10%**	**14%**	**58%**	**17%**	**0%**	**10%**	**14%**	**58%**	**17%**	**0%**
1989	**69**	**4%**	**14%**	**38%**	**43%**	**0%**	**4%**	**14%**	**38%**	**43%**	**0%**
1990	14	4%	16%	26%	21%	32%	8%	22%	52%	16%	1%
1991	26	8%	32%	32%	24%	4%	4%	16%	60%	20%	1%
1992	22	6%	16%	69%	9%	0%	18%	8%	48%	26%	1%
1993	22	7%	24%	49%	20%	0%	10%	40%	26%	22%	2%
1994	**48**	**25%**	**6%**	**52%**	**17%**	**0%**	**25%**	**6%**	**52%**	**17%**	**0%**
1995	35	10%	16%	26%	48%	0%	12%	35%	29%	23%	0%
1996	**95**	**1%**	**19%**	**70%**	**10%**	**0%**	**1%**	**19%**	**70%**	**10%**	**0%**
1997	**60**	**0%**	**2%**	**62%**	**36%**	**0%**	**0%**	**2%**	**62%**	**36%**	**0%**
1998	33	5%	49%	24%	22%	0%	25%	24%	15%	34%	3%
1999	**40**	**3%**	**45%**	**42%**	**10%**	**0%**	**3%**	**45%**	**42%**	**10%**	**0%**
2000	39	6%	15%	65%	15%	0%	23%	22%	46%	9%	0%
2001	**89**	**1%**	**40%**	**57%**	**3%**	**0%**	**1%**	**40%**	**57%**	**3%**	**0%**
2002	**244**	**5%**	**20%**	**67%**	**8%**	**0%**	**5%**	**20%**	**67%**	**8%**	**0%**
2003	**246**	**2%**	**16%**	**61%**	**20%**	**0%**	**2%**	**16%**	**61%**	**20%**	**0%**
2004	**259**	**3%**	**6%**	**71%**	**19%**	**1%**	**3%**	**6%**	**71%**	**19%**	**1%**
2005	**224**	**1%**	**13%**	**41%**	**43%**	**1%**	**1%**	**13%**	**41%**	**43%**	**1%**

Appendix CC – Complete list of RERs calculated

Coweeman									
Delta AIC	old harvest estimates			new harvest estimates					
			old age			old age	new age		
No covariate									
Ricker			6.23			8.16	8.32		
Bev-Holt			12.71			14.39	14.18		
Hockey			12.61			14.39	14.18		
Marine Survival									
Ricker			1.65			0.36	0.31		
Bev-Holt			3.22			0.46	0.24		
Hockey			0			0	0		
RER	old harvest			new harvest					
LEL=51	S_{MSY}	UEL	RER - old age	S_{MSY}	UEL	RER - old age	RER - new age	S_{MSY}	UEL
No covariate									
Ricker	440	750	0	380	750	0	0	370	750
Bev-Holt	120			10	750			10	750
Hockey	130	750	0.42	110	750			110	750
Marine Survival									
Ricker	790	790	0.48	1020	1020	0.34	0.38	1060	1060
Bev-Holt	1070			1250	1250	0.52	0.52	1310	1310
Hockey	510	750	0.58	540	750	0.58	0.58	540	750
LEL=116									
No covariate									
Ricker	440	750	0	380	750	0	0	370	750
Bev-Holt	120			10	750			10	750
Hockey	130	750	0.44	110	750			110	750
Marine Survival									
Ricker	790	790	0.46	1020	1020	0.34	0.38	1060	1060
Bev-Holt	1070			1250	1250	0.52	0.52	1310	1310
Hockey	510	750	0.56	540	750	0.58	0.58	540	750
LEL=151									
No covariate									
Ricker	440	450	0.52						
Ricker	440	750	0	380	750	0	0	370	750
Bev-Holt	120	750	0.42	10	750			10	750
Hockey	130	750	0.42	110	750			110	750
Marine Survival									
Ricker	790	790	0.46	1020	1020	0.34	0.38	1060	1060
Bev-Holt	1070	1070	0.54	1250	1250	0.52	0.52	1310	1310
Hockey	510	750	0.58	540	750	0.58	0.58	540	750

Grays

Delta AIC			old harvest			new harvest			
			old age			old age	new age		
No covariate									
Ricker			15.66			15.66	16.80		
Bev-Holt			13.85			13.85	16.01		
Hockey			14.42			14.42	14.77		
Marine Survival									
Ricker			9.10			9.10	5.09		
Bev-Holt			0.08			0	0		
Hockey			0			0	0		
RER			**old harvest**			**new harvest**			
LEL=51	S_{MSY}	UEL	RER - old age	S_{MSY}	UEL	RER - old age	RER - new age	S_{MSY}	UEL
No covariate									
Ricker	220			240	240	0.46	0.34	280	280
Bev-Holt	120	221	0.42	120	221	0.42	0.42	180	221
Hockey	210	221	0.46	210	221	0.44	0.34	250	250
Marine Survival									
Ricker	180			200				220	
Bev-Holt	na	221	0	na	221	0.08	0.18	na	221
Hockey	na	221	0	na	221	0.06	0.20	na	221
LEL=151									
No covariate									
Ricker	220	240		240	240	0.38	0.20	280	280
Bev-Holt	120	221	0.30	120	221	0.30	0.28	180	221
Hockey	210	221	0.32	210	221	0.30	0.10	250	250
Marine Survival									
Ricker	180			200				220	
Bev-Holt	na	221	0	na	221	0	0	na	221
Hockey	na	221	0	na	221	0	0	na	221

Lewis

Delta AIC			old harvest			new harvest			
			old age			old age	new age		
No covariate									
Ricker			35.77			42.37	29.71		
Bev-Holt			35.30			42.20	29.62		
Hockey			36.70			42.93	30.01		
Marine Survival									
Ricker			5.10			2.32	1.43		
Bev-Holt			0			0	0		
Hockey			2.08			6.06	5.09		
RER			old harvest			new harvest			
LEL=51	S_{MSY}	UEL	RER -old age	S_{MSY}	UEL	RER - old age	RER- new age	S_{MSY}	UEL
No covariate									
Ricker	760			1070	1070	0.34	0.28	1500	1500
Bev-Holt	590	645	0.42	1000	1000	0.40	0.32	1520	1520
Hockey	320	645	0.40	1040		0.36	0.32	1140	
Marine Survival									
Ricker	550			690	690		0.44	790	790
Bev-Holt	440	645	0.46	640	645	0.50	0.52	740	740
Hockey	310	645	0.44	450				670	
LEL=127									
No covariate									
Ricker	760			1070	1070	0.34	0.28	1500	1500
Bev-Holt	590	645	0.44	1000	1000	0.40	0.32	1520	1520
Hockey	320	645	0.40	1040		0.36	0.32	1140	
Marine Survival									
Ricker	550			690	690		0.44	790	790
Bev-Holt	440	645	0.44	640	645	0.50	0.52	740	740
Hockey	310	645	0.44	450				670	
LEL=151									
No covariate									
Ricker	760			1070	1070	0.34	0.28	1500	1500
Bev-Holt	590	645	0.44	1000	1000	0.40	0.32	1520	1520
Hockey	320	645	0.40	1040	1040	0.36	0.32	1140	1140
Marine Survival									
Ricker	550			690	690		0.44	790	790
Bev-Holt	440	645	0.46	640	645	0.50	0.52	740	740
Hockey	310	645	0.44	450				670	

Attachments

Attachment 1:

Washington Department of FISH and WILDLIFE

INTERGOVERNMENTAL RESOURCE MANAGEMENT

November 8, 2007

TO: Jim Scott

FROM: Larrie LaVoy

SUBJECT: **UPDATES TO FRAM AND MODELING OF LOWER COLUMBIA NATURAL TULE CHINOOK FOR ESA COMPLIANCE**

The Model Evaluation Workgroup (MEW) of Pacific Fishery Management Council (PFMC) has recently completed a revision to the Fishery Regulation Assessment Model (FRAM) that added five Chinook stocks to the existing suite of west coast production groups. The use of this new data set in FRAM is being reviewed by the PFMC this week and is expected to get approval for 2008 management.

Chinook FRAM has three stocks representing fall run Chinook produced in the lower Columbia River: Oregon Hatchery Tule, Washington Hatchery Tule, and Lower Columbia Wild (Bright). Until this recent revision where a Lower Columbia Natural Tule stock was added to FRAM, there has not been a specific natural/wild stock in FRAM that represented natural production of "Tule" type Chinook (not bright; early spawning). Since the ESA listing of the Lower Columbia Chinook ESU, compliance with the ESA regarding salmon fishery impacts has been assessed using the Washington Hatchery Tule stock in FRAM. FRAM estimates of ocean fishery impacts on Washington Hatchery Tules were combined with river fishery impacts to produce an "all-fishery" exploitation rate that is measured against the ESA exploitation rate ceiling. The ESA jeopardy standard for Lower Columbia Tule Chinook was based on a Rebuilding Exploitation Rate (RER) derived from stock recruitment analysis on natural Chinook in the Coweeman River, a tributary to the Cowlitz River. A review of this analysis was presented by National Marine Fisheries Service (NMFS) at the PFMC Salmon Methodology Review in October.

The recoveries of coded-wire-tags (CWT) in fisheries and escapement areas during a common model 'base period' provide the basis for FRAM fishery assessment. Representative CWT groups are selected for each FRAM stock and via cohort reconstruction of the fishery and escapement recoveries a profile of abundance and exploitation rates by time, area, and age can be derived. Washington Hatchery Tule stock in FRAM uses recoveries from Cowlitz Hatchery CWT release groups (1977-79 brood years), even though other Washington hatcheries in the lower Columbia River release CWT groups, as well. There are no wild Tule Chinook tagged in the lower Columbia, although wild “Bright” Chinook are CWT’d in the North Lewis River. Tule Chinook have a different ocean distribution than Bright-type Chinook in the Columbia River so the use of Bright-type CWT groups for wild Tules is not appropriate. Since the Coweeman River is within the Cowlitz watershed, the usage of the Washington Hatchery Tule stock in FRAM was a logical surrogate for assessing ocean fishery impacts on the Coweeman natural population. Other natural Tule Chinook populations in the Lower Columbia may be more closely associated with production from other tributaries and the hatcheries within those basins. Vulnerability to main stem Columbia River fisheries will differ for those fish produced both downstream and upstream of the Coweeman/Cowlitz watershed. Therefore, in order to provide a more representative picture of fishing impacts on all lower Columbia Tule Chinook, CWTs from a blend of Lower Columbia production areas is warranted. In addition, adding CWT groups from a broader mix of production areas (hatcheries in this case) will help mitigate against unusual “events” and/or low recoveries which can create problems when tracking single-source tag groups during “in-season” management or in post-season ER assessment. Adding more populations and/or broadening the RER coverage for Lower Columbia Tule Chinook is the intent of the NMFS RER analysis.

CWT groups from one Oregon hatchery (Big Creek) and three Washington hatcheries (Cowlitz, Kalama Falls, Washougal) were selected to represent Lower Columbia Natural Tule Chinook in FRAM (Table 1). The use of CWT groups from one Oregon hatchery and three Washington hatcheries was chosen to reflect broad geographic representation in the lower, middle, and upper sections of the Lower Columbia and the higher natural production potential in Washington (although no formal analysis was conducted on this aspect). Also, with the exception of Kalama Falls in the 1980’s, tagging of Tule Chinook has been nearly continuous at these facilities, lending themselves to a good time-series data set for post season ER calculations (Table 2). This time-series of CWT recoveries could be used in NMFS stock recruitment analysis to derive brood year ER estimates for post season assessment or additional RER analysis. Using all available CWT groups each year, as is done in Columbia in-river run reconstruction, would entail significantly more data compilation and analysis. Brood year ERs from the CWT recoveries can be compared--after some numeric conversion--to FRAM fishing-year based estimates which are derived from base period tag recovery data matched with year specific catch and abundance information.

The Information Report prepared for PFMC review on adding five Chinook stocks to FRAM contained catch distribution and ER estimates for Washington Tule Chinook and Lower Columbia Natural Tule Chinook. Catch distribution during the model base period (approximately 1979-82 fishing years) was similar between the two Tule stocks (Table 3). The Information Report also contained a comparison of AEQ mortality and ERs for preseason and postseason FRAM runs for 2003-05 between the two FRAM Tule stocks (Table 4).

TABLE 1. CHINOOK CWT GROUPS USED IN 2007 FRAM CALIBRATION

FRAM	NAME	RUN	Code	BYR	AGE	DAT1	DAT2	Type	TAGGED	ADS	UNMARK	TOTL	AGY	STOCK	HATCHERY
20	Wash Tule	FALL CHIN	631802	77	1	780619	780619	P	146001	7523	503262	656786	WDFW	COWLITZ R 26.0002	COWLITZ SALMON HAT
20	Wash Tule	FALL CHIN	631942	78	1	790627	791016	I	143568	2326	4157781	4303675	WDFW	COWLITZ R 26.0002	COWLITZ SALMON HAT
20	Wash Tule	FALL CHIN	632154	79	1	800603	800711	I	244267	9915	5671774	5925956	WDFW	COWLITZ R 26.0002	COWLITZ SALMON HAT
34	LwrColNat	FALL CHIN	631802	77	1	780619	780619	P	146001	7523	503262	656786	WDFW	COWLITZ R 26.0002	COWLITZ SALMON HATCH
34	LwrColNat	FALL CHIN	631942	78	1	790627	791016	I	143568	2326	4157781	4303675	WDFW	COWLITZ R 26.0002	COWLITZ SALMON HATCH
34	LwrColNat	FALL CHIN	632154	79	1	800603	800711	I	244267	9915	5671774	5925956	WDFW	COWLITZ R 26.0002	COWLITZ SALMON HATCH
34	LwrColNat	FALL CHIN	071704	77	1		19780512	E	105207	7314		112521	ODFW	BIG CR HATCHERY	BIG CR HATCHERY
34	LwrColNat	FALL CHIN	071705	77	1		19780512	E	106424	8630		115054	ODFW	BIG CR HATCHERY	BIG CR HATCHERY
34	LwrColNat	FALL CHIN	071844	78	1		19790521	P	224859	0	5022367	5247226	ODFW	BIG CR HATCHERY	BIG CR HATCHERY
34	LwrColNat	FALL CHIN	072160	79	1		19800513	P	143385	2480	6287594	6433459	ODFW	TANNER CR (BNVILLE)	BIG CR HATCHERY
34	LwrColNat	FALL CHIN	631746	77	1	19780712	19780712	P	150517	4591	947340	1102448	WDFW	KALAMA R 27.0002	KALAMA FALLS HATCH
34	LwrColNat	FALL CHIN	631747	77	1	19780915	19780915	B	140899	4368		145267	WDFW	KALAMA R 27.0002	KALAMA FALLS HATCH
34	LwrColNat	FALL CHIN	631957	78	1	19790622	19790713	I	214503	3262	5176553	5394318	WDFW	KALAMA R 27.0002	KALAMA FALLS HATCH
34	LwrColNat	FALL CHIN	632105	79	1	19800613	19800624	I	100355	1528	2299061	2400944	WDFW	KALAMA R 27.0002	KALAMA FALLS HATCH
34	LwrColNat	FALL CHIN	631803	77	1	19780627	19780627	P	151399	1135		152534	WDFW	WASHOUGAL R 28.0159	WASHOUGAL HATCH
34	LwrColNat	FALL CHIN	631938	78	1	19790614	19790902	I	97417	213	1967350	2064980	WDFW	WASHOUGAL + TOUTLE	WASHOUGAL HATCH
34	LwrColNat	FALL CHIN	631946	78	1	19790614	19790902	I	154477	8113	3114577	3277167	WDFW	WASHOUGAL + TOUTLE	WASHOUGAL HATCH
34	LwrColNat	FALL CHIN	632153	79	1	19800630	19800630	I	314605	7501	5800092	6122198	WDFW	COWLITZ MIXED STOCKS	WASHOUGAL HATCH

Table 2 . Tag codes for Big Creek, Cowlitz, Kalama Falls, Washougal hatchery Tule Chinook, 1980-2005 broods.

Big Creek Tule Tag Codes (implied 0 on left 72331=072331): Brd YR

1980	72331	72333	72334												
1981	72410														
1982	72857	72858													
1983	73133	73140													
1984	73224	73225	73226	73227	73228	73229	73230	73231	73232	73233					
1985	73347	73348	73349	73350	73351	73434	73435	73436	73437	73438	73439	73440	73441	73442	73443
1986	73319	73453	73454	73455	73456	73457	73458	73459	73460	73461	73462	73463	73501	73502	73503
	73504	73813	73814	73815	73816	73817									
1987	73535	73536	73537	73538	73539	74136	74137	74138	74139	74140	74141	74142	74143	74144	74145
	74559	74560	74561	74562	74563	74601									

1988	73346	73540	74159	74160	74161	74162	74163	74201	74202	74203	74204	74205	74206	74207	74208
	74335	74336	74337	74521	75009	75010									
1989	74255	74256	74259	74261	74338	74339	74340	74341	74342	74343	74344	74345	74346	74511	74512
	74513	74514	74515	74516											
1990	74262	74401	75519	75520	75650	75651	75652	75759	75760						
1991	74944	74947	75653	75716	75717	75757	75758								
1992	70232	75737	76021	76022	76023	76024									
1993	70547	70548	70755	70756											
1994	70540	70541	70542	70543	70952	76141	76144								
1995	70550	71142	71352	71353											
1996	71251														
1997	92121	92448													
1998															
1999	93005	93048	93049												
2000	93250														
2001	93452	93532	93533												
2002	93751	93817	93818												
2003	93959	93960	94122												
2004	90546	92101	94021												
2005	94423														

Cowlitz Tule Tag Codes:

Brd Yr								
1980	632156	632255						
1981	632032	632450	632462	632603				
1982	632503	632610						
1983	632327	632328	633019	633020	633124	633125		633451
1984	633235	633236	633237	633238	633448	633449	633450	
1985	634108							
1986	634126							
1987	635231							
1988	635250							
1989	630452							

1990	634056		
1991	634526		
1992	635015		
1993	635539		
1994	635523	635620	
1995	635851	636005	
1996	630224	630227	
1997	630311		
1998	631031		
1999	631330		
2000	630673		
2001	631379		
2002	631782		
2003	632573		
2004	632989	633075	
2005	633287		

Kalama Falls Tag Codes:
Brd Yr

1980	632036		
1981	632460		
1982			
1983			
1984			
1985			
1986			
1987			
1988	630741	630742	630744
1989			
1990			
1991			
1992	634939		
1993	635054		

1994	635205											
1995	635630											
1996	636352											
1997	630458											
1998	631039											
1999	630191											
2000	630279											
2001	631406											
2002	631554											
2003	631873											
2004	632477											
2005	632886											

Washougal Tag Codes:

Brd Yr												
1980	632251											
1981	632461											
1982	632238	632239	632259									
1983	633116	633117	633118	633119								
1984	633334	633335	633407	633408	633414	633415	633416	633428	633431	633432	633433	633434
1985	633320	633827	633828	633829	633830	633831	633832					
1986	634150											
1987	635228											
1988												
1989	635904											
1990	635621											
1991	634616											
1992	635040	635043										
1993	635158	635159										
1994	635512	635515										
1995	636108	636109										
1996	636350	636351										
1997	630415	630457										

1998	630501	630502
1999	630194	
2000	630877	
2001	631415	631417
2002	631543	631544
2003	631567	631996
2004	632475	
2005	632883	

Table 3. Proportion AEQ mortality and escapement for WA Tule and Lower Col Natural Tule Chinook during FRAM base period.

Fishery	WA Hat. Tule	Lower Col Nat Tule
Alaska-Canada	0.306	0.396
WA Ocean	0.237	0.171
OR/CA Ocean	0.039	0.020
Puget Sound	0.009	0.026
Freshwater	0.146	0.131
Escapement	0.263	0.256

Table 4. AEQ mortality and ER for Washington Hatchery Tule and Lower Col Natural Tule from 2003-05 FRAM runs

		WA Hatchery Tule (Coweeman)					Lower Col Natural Tule				
FRAM Run	Measure	Alaska	Canada	WA-CA Marine	Col R	Total	Alaska	Canada	WA-CA Marine	Col R	Total
2003 Postsn	AEQ Mort	4766	24589	17274	10135	56764	704	3998	1949	1642	8293
	ER	0.039	0.201	0.141	0.083	0.464	0.037	0.212	0.103	0.087	0.439
2003 Presn New FRAM	AEQ Mort	9932	11988	27641	11715	61276	1223	1718	2693	1710	7344
	ER	0.073	0.088	0.202	0.086	0.447	0.066	0.093	0.146	0.093	0.399
2004 Postsn	AEQ Mort	4005	22644	12135	8266	47050	637	3761	1313	1399	7110
	ER	0.043	0.241	0.129	0.088	0.501	0.042	0.250	0.087	0.093	0.473
2004 Presn New FRAM	AEQ Mort	5218	10094	11086	7417	33815	1037	2001	1499	1491	6028
	ER	0.069	0.133	0.146	0.098	0.446	0.072	0.138	0.104	0.103	0.416
2005 Postsn	AEQ Mort	3072	19820	11795	5116	39803	471	3372	1333	878	6054
	ER	0.041	0.268	0.159	0.069	0.538	0.039	0.283	0.112	0.074	0.508
2005 Presn New FRAM	AEQ Mort	3853	14251	17386	8764	44254	421	1386	1251	1051	4109
	ER	0.037	0.138	0.169	0.085	0.430	0.038	0.124	0.112	0.094	0.369

Attachment 2:

INTERGOVERNMENTAL RESOURCE MANAGEMENT

January 11, 2008

TO: Pat Pattillo

FROM: Larrie LaVoy

SUBJECT: **Comparison of exploitation rates for Lower Columbia Tule Chinook between the new recalibrated FRAM and "A&P Tables" CWT analysis used for RER derivation.**

FRAM was recalibrated this year and new stocks were added to the model including Central Valley California and Lower Columbia Natural Tule Chinook. For PFMC management and ESA assessment beginning in 2002, Lower Columbia Tule exploitation rates were derived from using the Washington Tule stock in FRAM as a surrogate for Coweeman natural tule Chinook. The Washington Tule stock is based on CWT recovery data from Cowlitz Hatchery. The new Lower Columbia Natural Tule stock is represented by CWT data from four lower Columbia hatcheries: Cowlitz, Washougal, Kalama, and Big Creek (Oregon). This new version of FRAM with the new stocks have been approved for use in 2008 by PFMC.

A review of the ESA jeopardy standard on Lower Columbia natural tule stock was initiated last year by NOAA's National Marine Fisheries Service. In this analysis, the Rebuilding Exploitation Rate (RER) governing ESA jeopardy limits are being redone using additional CWT recovery data and other new information. Whereas the previous RER level were based only on Cowlitz CWT data for the Coweeman stock (like FRAM's WA Tule), this new analysis is being applied to run reconstructions for three populations (Grays, Lewis, Coweeman) and uses CWT recoveries from seven lower Columbia hatcheries (Cowlitz, Washougal, Kalama Falls, Fallert Crk, Toutle, Elochoman, and Big Creek). The end product in this phase of the review will be exploitation rate profiles for the three populations in the Abundance and Productivity tables (A&P)and potentially one or more new RERs for Lower Columbia natural tules. The stock recruitment and risk assessment analysis that produces the new RERs incorporates management system error and other uncertainties/variables in its derivation.

I compared FRAM based exploitation rate estimates to those rates used in the RER analysis. If the FRAM based estimates were consistently skewed high or low relative to those in the RER analysis then adjustment is probably warranted to convert any RER ceiling to an "equivalent" rate using FRAM. Total and marine-only AEQ exploitation rates were estimated for 1983-2006 fishing years from post-season FRAM runs. I used the same system of FRAM output and spreadsheet workup ("CoweemanXXX.xls") that is used for preseason exploitation rate assessment. These FRAM based exploitation rates were compared in the table below to the corresponding annual rates derived in the A&P tables from Norma Jean Sands (NOAA Science Center).

For the years where there were estimates for FRAM and A&P (1983-2004), there were no significant differences in the mean exploitation rates. For the entire period, mean exploitation rates for the two data sets were remarkably similar. There were differences on an annual basis but not in a consistent manner that could be used to derive an "equivalency" adjustment. The incorporation of management error and other uncertainties in the RER risk assessment analysis buffers against some of these differences. Therefore I conclude that no adjustment to an RER (or the FRAM generated exploitation rate) is warranted in order to achieve equivalency between FRAM and the RER data systems and that the Lower Columbia Natural Tule stock in FRAM is suitable for estimating exploitation rates for Lower Columbia natural tule populations.

Fishing Yr		FRAM Post-Season: WA Tule Total ER	FRAM Post-Season: WA Tule Marine	FRAM Post-Season: Lower Col Nat. Total ER	FRAM Post-Season: Lower Col Nat. Marine	A&P-CWT Analysis: Grays Total ER	A&P-CWT Analysis: Grays Marine	A&P-CWT Analysis: Lewis Total ER	A&P-CWT Analysis: Lewis Marine	A&P-CWT Analysis: Coweeman Total ER	A&P-CWT Analysis: Coweeman Marine
1983		0.64	0.56	0.68	0.61	0.66	0.60	0.65	0.51	0.88	0.85
1984		0.63	0.43	0.70	0.54	0.79	0.57	0.78	0.61	0.68	0.50
1985		0.64	0.54	0.66	0.58	0.55	0.46	0.61	0.47	0.67	0.52
1986		0.81	0.56	0.83	0.60	0.80	0.56	0.75	0.48	0.84	0.63
1987		0.80	0.54	0.80	0.54	0.80	0.48	0.87	0.59	0.89	0.63
1988		0.81	0.51	0.79	0.45	0.74	0.36	0.80	0.47	0.81	0.49
1989		0.56	0.39	0.56	0.36	0.61	0.44	0.62	0.43	0.58	0.37
1990		0.64	0.60	0.57	0.51	0.57	0.51	0.59	0.48	0.60	0.49
1991		0.59	0.47	0.62	0.50	0.55	0.46	0.61	0.46	0.82	0.76
1992		0.68	0.60	0.65	0.58	0.27	0.25	0.59	0.51	0.59	0.53
1993		0.61	0.52	0.61	0.51	0.49	0.42	0.70	0.55	0.64	0.46
1994		0.35	0.32	0.36	0.33	0.25	0.25	0.26	0.25	0.31	0.31
1995		0.40	0.35	0.38	0.33	0.65	0.63	0.31	0.26	0.38	0.34
1996		0.27	0.19	0.25	0.16	0.13	0.08	0.25	0.18	0.25	0.19
1997		0.38	0.27	0.37	0.25	0.55	0.43	0.35	0.29	0.38	0.32
1998		0.31	0.20	0.35	0.24	0.35	0.32	0.38	0.23	0.25	0.17
1999		0.41	0.27	0.41	0.27	0.42	0.29	0.45	0.36	0.49	0.44
2000		0.47	0.37	0.45	0.35	0.51	0.40	0.38	0.30	0.47	0.41
2001		0.48	0.42	0.50	0.44	0.38	0.33	0.38	0.30	0.39	0.32
2002		0.48	0.40	0.50	0.41	0.74	0.70	0.56	0.44	0.63	0.53
2003		0.43	0.38	0.40	0.35	0.54	0.47	0.65	0.58	0.62	0.55
2004		0.47	0.41	0.44	0.38	0.31	0.25	0.53	0.47	0.55	0.50
2005		0.54	0.47	0.51	0.43						
2006		0.51	0.44	0.51	0.44						
Average	**1983-04**	**0.54**	***0.42***	**0.54**	***0.42***	**0.53**	***0.42***	**0.55**	***0.42***	**0.58**	***0.47***
	1995-04	0.41	0.33	0.41	0.32	0.46	0.39	0.42	0.34	0.44	0.38
	2000-04	0.47	0.40	0.46	0.39	0.50	0.43	0.50	0.42	0.53	0.46
1983-04	**geomean**	0.52	0.40	0.52	0.40	0.49	0.39	0.52	0.40	0.54	0.44
	median	0.52	0.42	0.53	0.43	0.55	0.43	0.59	0.46	0.60	0.49
	var	0.0253	0.0152	0.0268	0.0169	0.0366	0.0220	0.0325	0.0159	0.0383	0.0269
	stdev	0.16	0.12	0.16	0.13	0.19	0.15	0.18	0.13	0.20	0.16
	CV	30%	29%	30%	31%	36%	35%	33%	30%	34%	35%
	95% C.I.+-	0.33	0.26	0.34	0.27	0.40	0.31	0.38	0.26	0.41	0.34

A&P Table Spreadsheets: A&PCoweemanV91newcomposite40age.xls; A&PLewisV90newcomposite40age.xls; A&PGrayV90newcomposite40age.xls

Attachment 3:

December 10, 2007
To: Tule Work Group
From: Dan Rawding
Subject: Age Structure and Hatchery Fraction

The purpose of this memo is to summarize the age structure and hatchery fraction for use in determining recovery exploitation rates. Historic WDFW/PCMFC reports from 1977 were examined to obtain age data and the source. Age structure is available from the 1960's onward for fall Chinook salmon. However, age structure can be divided into two periods. The first is the pre-1988 period. Although age structure is available it was not obtained through the scale analysis of tributary Chinook salmon. Previous biologists used a variety of sources including hatchery, the Cowlitz terminal gill net fishery, and the lower Columbia River gill net fishery. The terminal fishery was used during one year (1981). The biologists preferred hatchery data and when that was unavailable, they used gill net data from the lower Columbia River fall fishery. From 1988 to the present, tributary scales were collected and aged. Therefore, age data from 1988 onward is representative of the river except when few sample were collected, then hatchery ages were used again.

I am not sure if hatchery age structure is representative of wild age structure. To the extent that both groups successfully reach the ocean and co-mingle, then this may be acceptable. With a hatchery or wild population, brood year failure is possible. In the hatchery, this may be due to disease while in the wild it may be due to flooding.

The age structure for fall Chinook salmon is a combination of aged scales and visual observations. During spawning ground surveys live Chinook salmon are classified as adults or jacks based on size cut off of 57 cm. Therefore, if 3 jacks are observed during a peak count of 100 and no jacks are collected from scales, the percentage of jacks is 3% and the adult age composition for the remaining 97% of adults are based on the 100 aged scales. If the same observation 3 jacks and 97 adults are made but 100 scales are collected with 4 jacks and the rest adults, the scale age is used for all salmon ages. In other words the jack composition is represented by the highest percentage based on observations or scales.

Age calculation steps are found in the enclosed spreadsheet for the Coweeman worksheet. The number by age (cells 53-57) is calculated from the age structure in cells (cells 47-51) * scales samples for that year, which are found in the PSMFC/WDFW reports. This is not exactly how it was calculated above but can be used to provide a quick assessment of uncertainty in age structure. So cells (53-7) are the estimated age structure for total escapement, while cells (9-13) are the percentage of fish by age group. Next the total escapement (hatchery and wild) is the percentage (cells 9-13) * the estimate of escapement (cell 6). The estimate of hatchery spawners is based on CWT as described below (cells 20-24). These cells (20-24) are subtracted from the escapement (cells 9-13) to yield estimates of wild escapement by age.

The second task was to summarize the hatchery fraction. The following steps were taken. First, RMIS was queried to obtain all records of recovered tags in the tributaries. Only those records with a CWT number were used. In some years adipose clipped Chinook salmon were recovered; however these were not used in the analysis because it is unclear if they were wild fish with missing adipose fins, or if they were hatchery fish that lost their tag. For hatchery fish that lost their tag, it is unclear which tag code they should be associated with.

RMIS was queried to obtain all hatchery releases associated with that tag code. In general, CWT groups are release in June but may extend from May through July. CWT released during this time period were assumed to represent hatchery production. If hatchery releases occurred between January and March, they were usually not tagged. Due to their small size and presumably lower survival they were not linked to any tag code. Disregarding winter releases had little influence of the hatchery proportion in the Coweeman and Lewis because so few CWT were recovered but this assumption may lead to different results in other basins. Juvenile tag rate for each CWT code was the CWT released by the total release.

Next historic PCMGC/WDFW reports from 1977 were examined to obtain the mark sample size, which is the number of carcasses examined for a missing adipose fin. The mark sample rate is the carcasses divided by the population estimate. The expanded number of CWT was estimated by dividing the number of CWT by age by the mark sample rate. The estimate hatchery spawners by age was the expanded CWT estimate divided by the juvenile tag rate. The estimated number of hatchery fish was constrained so that the number of hatchery fish by age could not exceed the total (all fish by age). The hatchery fraction was then the estimated number of hatchery fish divided by the total escapement.

Using the juvenile tag rate instead of the adult tag rate decreased the estimated hatchery fraction. However, the annual hatchery fraction can only be estimated when representative hatchery groups are tagged and sufficient number of carcasses are recovered. For example, of the seven CWT recoveries in the Coweeman River 6 have been from Kalama Hatchery programs and 1 from the Elochoman River. If straying is related to distance from the hatchery, then it makes sense that hatchery fish from the Kalama have a higher probability of straying then those from the Elochoman. It is interesting to note the fall Chinook from the Cowlitz Hatchery have not been recovered in the Coweeman. For Brood Years 1982 – 1991 only one CWT group was released from the Kalama River in 1988. In addition, sample sizes were small (30 or less prior to 1988). Therefore, it is not possible to accurately determine hatchery fractions for this period. It should be noted that 1 only CWT was recovered prior to 2001; this occurred in 1985 and this expands to 330 adults and a hatchery fraction of 0.67.