MEMORANDUM

Department of Fish and Wildlife
Intra Departmental

Date: December 10, 2007
To: Files, HQ
From: Chris Kern
Subject: 2008 Willamette Spring Chinook Forecast

The 2007 Willamette spring Chinook run garnered significant public attention in 2007. Declining runs in 2005-2007, following the record returns of 2002-2004 have led to the perception that the Willamette run is crashing. In reality, total returns in the mid-1990s were as low or lower than the last few years returns. The 2007 return is preliminarily estimated at 40,500 fish to the Columbia River mouth. An estimated 10,000 of those were naturally-produced fish.

The 2007 return was below the mean projected value, but was greater than the lower bounds of the estimate (Table 1). However, due to the large percentage of naturally-produced fish in the return, the number of returning hatchery fish (approximately 30,500) was well below the projected 46,800 expected return, and was below the lower bounds of 34,100 fish (lower bound estimate times 10% wild).

The projection for 2007 utilized the same 10% wild composition estimate that has been used in past years, but the actual return was comprised of nearly 25% wild fish. At this time, methods to effectively project returns of naturally-produced fish have not been developed. Staff would like to begin internal review of available methods and data to develop these projections for future years.

As has been noted in past years, there is a strong tendency for the models used in projecting Willamette returns to underestimate the total return in years in which the run is increasing, and to overestimate the return in years in which the run is decreasing. This can be seen in the lag between projected and actual returns in Figure 1, as well as in the relationship shown in Figure 2. Projection errors are magnified by increasing or declining run size effects. Adjusting for this error source is difficult, but substantial modifications were made for the 2008 projection to attempt to do so.

Table 1. 2007 projected and actual return.

	Columbia River Returns				
	Age 3	Age 4	Age 5	Age 6	Total
2007 Forecast	1,600	7,500	42,500	300	52,000
Lower	500	3,600	33,500	290	37,900
Upper	2,100	15,200	54,000	900	72,200
Actual 2007 Return	**525**	**14,192**	**24,702**	**1,011**	**40,468**

Table 2. Preliminary summary of the 2007 Willamette River spring Chinook return.

Catch	Age 3	Age 4	Age 5	Age 6	Total
LCR Commercial (Gillnet)	0	109	750	16	875
LCR Commercial (Gillnet-rel. mortality)	0	7	68	2	77
SAF Commercial[1]	0	83	234	0	317
LCR Sport (kept catch)	8	413	1,122	19	1,562
LCR Sport (release mortality)	0	13	34	1	48
L. Will. Sport Fishery (kept catch)	57	1,689	3,505	188	5,439
L. Will. Sport Fishery (rel. mortality)[2]	3	76	157	8	244
Falls Indian Fishery	0	0	0	0	0
Lower Clackamas Sport (kept catch)	10	50	151	0	211
Lower Clackamas Sport (rel. mortality)[2]	0	2	5	0	7
	78	2,442	6,026	234	8,780
Escapement					
Willamette Falls Count[3,11]	280	9,188	12,891	739	23,098
Mortality Below Falls[9]	0	11	22	1	34
Clackamas Hatchery Return[3,4,12]	111	1,813	4,130	52	6,106
Eagle Creek Hatchery Return[3,5,12]	1	1	2	0	4
North Fork Dam, Passed Upstream[3,6]	42	502	1,144	14	1,702
North Fork Dam, Recycled Downstream[3,7]	10	168	381	5	564
Natural Spawn Bel. N.F. Dam	1	15	34	0	50
Sea Lion Predation[8]	2	52	72	4	130
	447	11,750	18,676	815	31,688
Run Entering Columbia	**525**	**14,192**	**24,702**	**1,049**	**40,468**
Percent	1.3%	35.1%	61.0%	2.6%	
Run Entering Willamette	517	13,567	22,494	1,011	37,589
Percent	1.4%	36.1%	59.8%	2.7%	
Run Entering Clackamas	175	2,551	5,847	71	8,644
Percent	2.0%	29.5%	67.6%	0.8%	

[1] Includes 274 fish from Youngs Bay and 43 fish from Blind Slough.

[2] Release mortality rate from Lindsey et. al. (12.2% of released fish).

[3] Uses actual counts for jacks.

[4] Includes 2,307 hatchery fish returned to Clackamas Hatchery from N. Fork Dam trap.

[5] USFWS estimate of fish returning to Eagle Creek Hatchery. Fish do not enter hatchery.

[6] Includes 12 mortalities from wild fish collected at N. Fork Dam trap.

[7] Includes 15 mortalities from hatchery fish collected at N. Fork Dam trap.

[8] Average of most recent five year period.

[9] Age composition based on scale analysis of Willamette River sport catch.

[10] Age composition based on scale analysis of Clackamas River sport catch.

[11] Age composition based on scale analysis of hatcheries above Willamette Falls.

[12] Age composition based on scale analysis of Clackamas Hatchery returns.

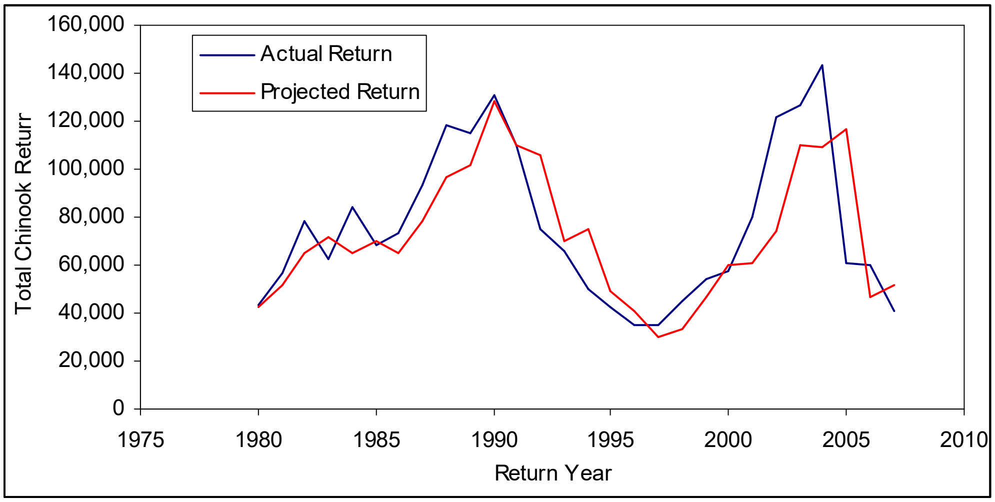

Figure 1. Actual and projected returns of Willamette River spring Chinook, 1975-2007.

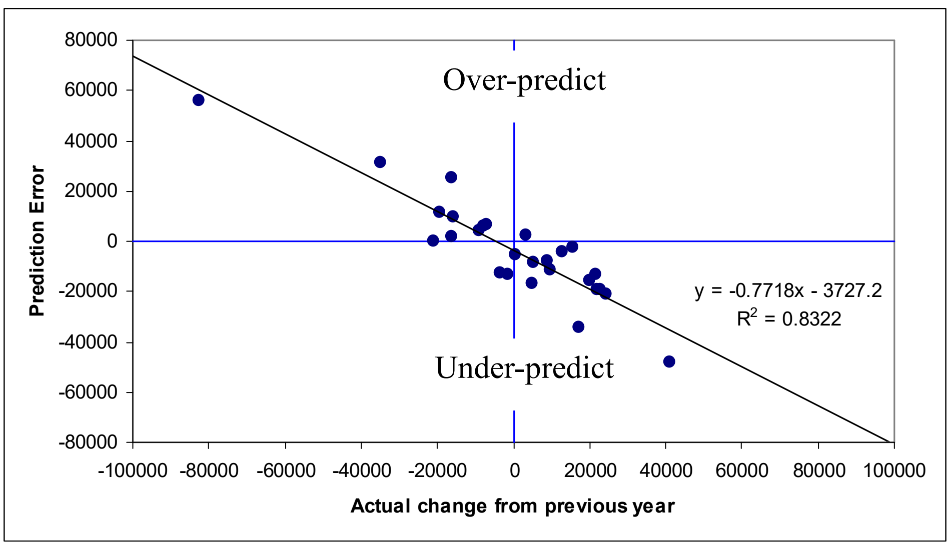

Figure 2. Errors in projections associated with declining or increasing run size effects.

Projections for Age 3 fish returning in 2008

In past years, either a simple cohort ratio of Age 2 (mini-jack) returns in year y-1 versus Age 3 returns in year y was used to estimate Age 3 returns based Age 2 returns, or the recent 5-year average Age 3 return was used. Both methods utilize the number of fish counted at Willamette Falls. The cohort ratios used are typically the recent 5-yr or 10-yr average (Figure 3.1). For the 2008 projection, the 5-yr average Age 3 return produces an estimate of 1,400 Age 3 fish; the 10-yr average cohort ratio produces an estimate of 3,200. There is a positive regression relationship between the counts of Age 2 and Age 3 fish that can also be used to estimate Age 3 returns (Figure 3.2). However, this relationship is weakest at Age 2 counts below 10,000 fish. The 2007 count was 3,100 Age 2 fish. If a non-linear regression is applied to the data and used to estimate the 2008 return, the result is an estimate of 2,000 Age 3 fish ($r^2 = 0.384$).

For the composite estimate of returns for 2008, the 5-yr average Age 3 return will be used as the point estimate for Age 3 fish (1,400), the non-linear regression estimate (2,000) will be used as the upper bounds, and the average lowest return of Age 3s for similar returns of Age 2s (775) will be used as the lower bounds.

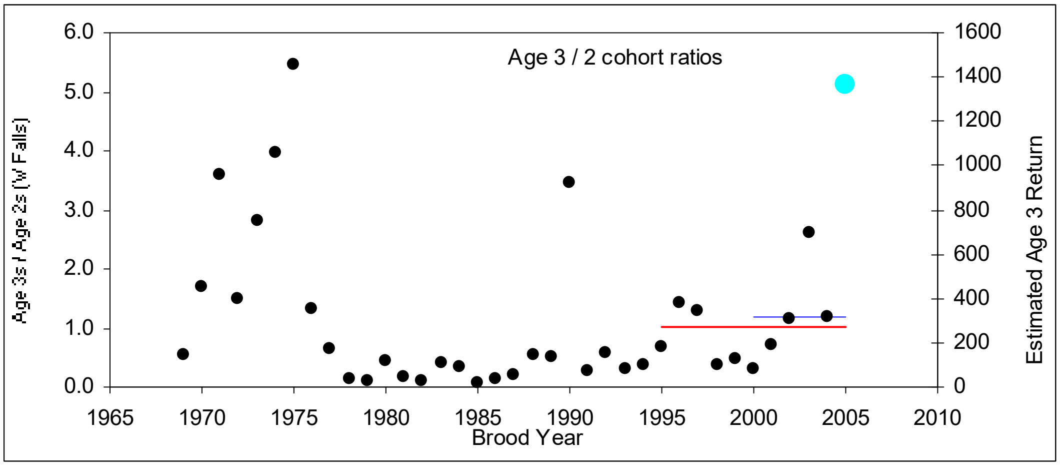

Fig. 3.1. Age 2 and Age 3 cohort ratios, 1969-2004 brood years. Red and blue lines indicate 10-yr and 5-yr cohort ratio averages. Light blue point = 2008 estimate (5-yr average Age 3 return; 1,400).

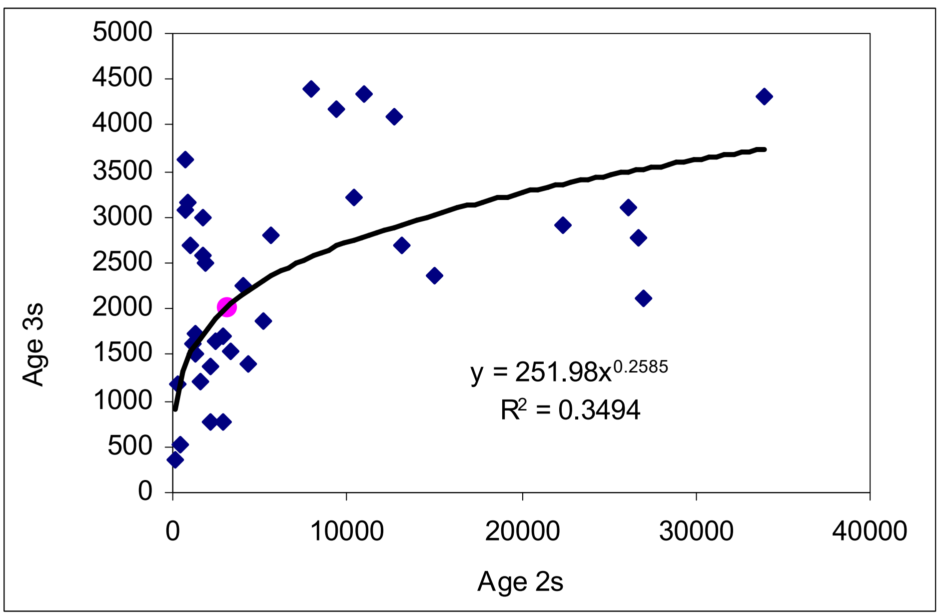

Fig. 3.2. Non-linear regression of Age 2 and Age 3 counts at Willamette Falls, brood years 1969-2004. Pink point is the 2008 estimate (2,000).

Projections for Age 4 fish returning in 2008

Estimates for Age 4 fish have typically been derived from regression estimates of Age 3 and Age 4 returns. Various combinations of Age 4 and 5 counts from Willamette Falls, Columbia River returns, and ocean abundance estimates have been used. The data from Willamette Falls is useful because it represents the most complete count – the only estimation procedure involved in calculating the returns by age class is the sampling design of the collection of aging samples. The Columbia River and ocean abundance estimates require the addition of other estimation procedures to account for harvest and mortality to these points. In the case of ocean abundance, assumptions regarding ocean harvest and mortality are applied to the point estimates. These procedures can introduce outside variances to the estimates, but at times do prove to be useful in describing the patterns of fish returns. Several of these methods were evaluated in the 2008 projection process.

As mentioned in the introduction, there is a definite tendency for over-prediction when run sizes are declining. To adjust for this, several changes were made to the past protocols for the projections. One method was to create a set of dummy variables for use in the regressions. The dummy values were either 1 or -1. A -1 was assigned to each year in which the Age 3 return was less than the preceding years' return, and a 1 was assigned to each year in which it was greater. The dummy values were used in a multiple linear regression to estimate the Age 4 return. The fit of this relationship was poor ($r^2 = 0.200$), and was only marginally improved when a second variable for ocean upwelling conditions was added ($r^2 = 0.210$). Next, the brood years with dummy values of -1 were used to calculate a regression that would only apply to brood years where the Age 3 return was less than the preceding year. This relationship was better ($r^2 = 0.580$), but the sample size is relatively small (n=16). When the ocean upwelling variable was added, the fit was improved ($r^2 = 0.610$). Other similar regressions were also utilized based on whether or not the Age 3 return was below the average Age 3 return, or whether the Age 3 return was below a minimum number (1000 or 2000 fish). These regressions typically provided a better fit than past methods, but with lower sample sizes. However, the estimates generated by these regressions were substantially lower than more standard models, which may help reduce the tendency to over-predict returns in declining runs. Cohort ratios for Age 3 and Age 4 fish were also used to project 2008 Age 4 return.

One sampling issue was found in the 2007 return of Age 4 fish. No age samples are collected from adult fish passing Willamette Falls (Age 3 fish can be identified reliably by size). In most years, the age distribution for these fish is assumed to be the same as the age distribution from the lower Willamette River sport fishery. However, in 2007, a higher-than-average composition of Age 5 fish in the fishery and in returns to Clackamas Hatchery led to concerns that the sport fishery age distribution might be biased by a higher return of Clackamas Age 5 fish. Therefore, staff utilized age distributions from upriver hatchery returns to estimate the age distribution of adult fish at Willamette Falls. Unfortunately, CWT data is not available to verify the scale readings for this data yet. To evaluate the importance of this change, the regressions for adult fish were re-run using the assumption that the age distribution at Willamette Falls was the same as the lower Willamette sport fishery. There was little impact on the Age 4 prediction under this change; the only effect was a slight decline in regression slopes due to the inclusion of a lower number of Age 4 fish from 2007 (about 12,000 fish instead of 14,000). Age 5 effects will be discussed in the Age 5 section. For the 2008 projection, the above adjustment is not used in the final run projection, but it should be considered when weighing sources of potential error in the estimate.

For the composite estimate of returns for 2008, the approximate median Age 4 value for the most powerful regression models (14,800) will be used as the point estimate, the lower median value (8,600) will be used as the lower bounds, and the highest point estimate (17,300) will be used for the upper bounds.

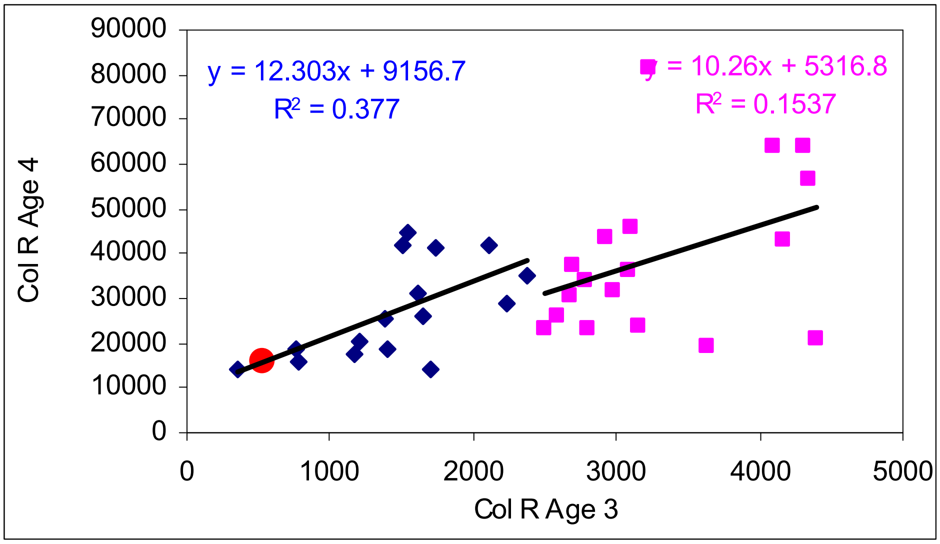

Fig. 4.1. Regressions of Columbia River Age 3 versus Columbia River Age 4 returns when Age 3 returns were below (blue) or above (pink) the average value for Age 3 returns. Red point = 2008 estimate (15,600).

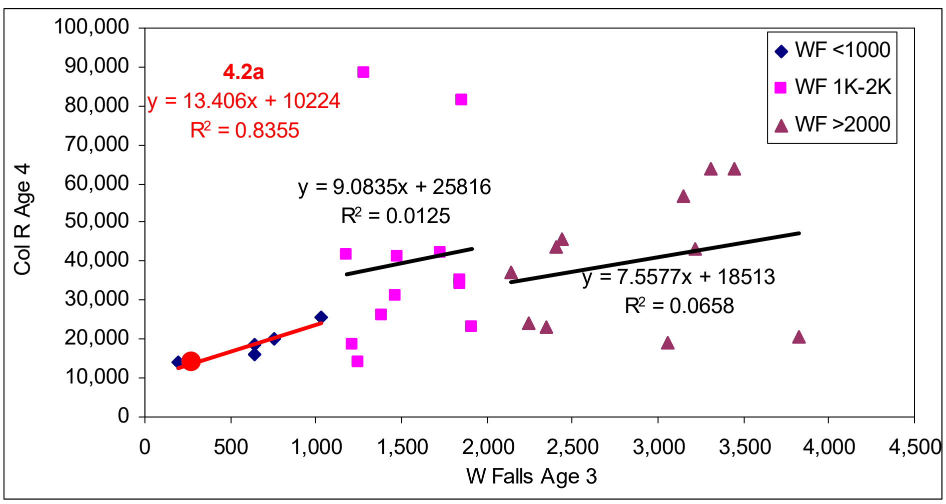

Fig. 4.2a. Regressions of Columbia River Age 4 and Willamette Falls Age 3 returns in years with Age 3 returns of <1,000 fish (blue points), 1,000-2,000 fish (pink points), and >2,000 fish (maroon points). Red point = 2008 estimate (14,000).

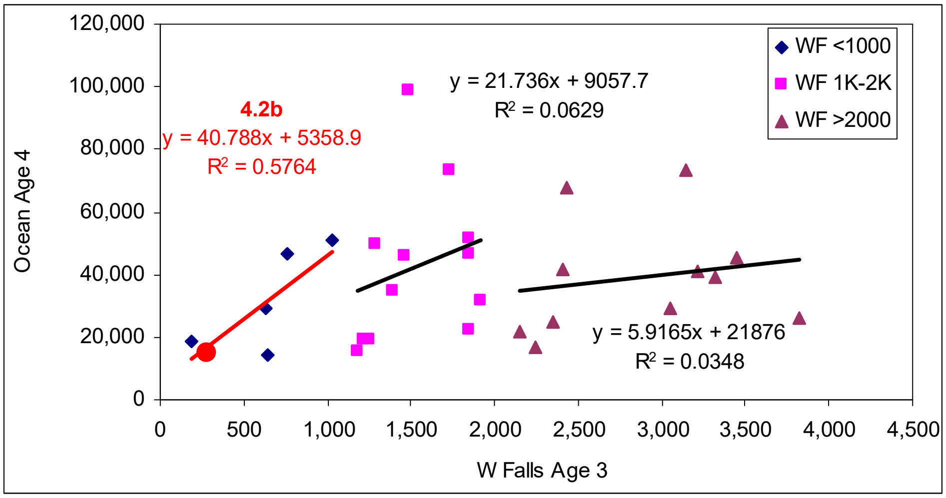

Fig. 4.2b. Regressions of Ocean Age 4 and Willamette Falls Age 3 returns in years with Age 3 returns of <1,000 fish (blue points and red line), 1,000-2,000 fish (pink points), and >2,000 fish (yellow points). To calculate Columbia River projections, estimated Ocean Age 4 abundance is multiplied by 0.104 assumed ocean harvest of Age 4 fish. Red point = 2008 estimate (15,000).

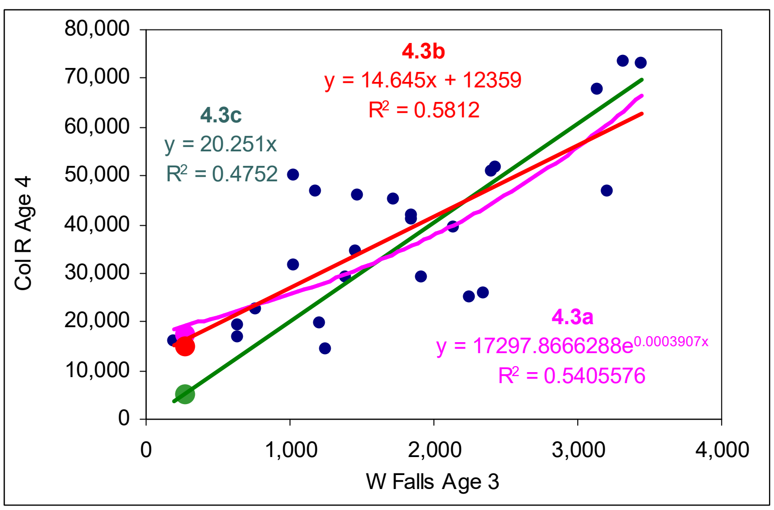

Fig. 4.3a-c. Regressions of Willamette Falls Age 3 fish and Ocean abundance of Age 4 fish. To calculate Columbia River projections, estimated Ocean Age 4 abundance is multiplied by 0.104 assumed ocean harvest of Age 4 fish. Three regressions are included: 4.3a – non-linear regression (pink; estimate = 17,300), 4.3b – linear regression with y-intercept calculated (red; estimate = 14,700), and 4.3c – linear regression with y-intercept forced to 0 (green; estimate = 5,000).

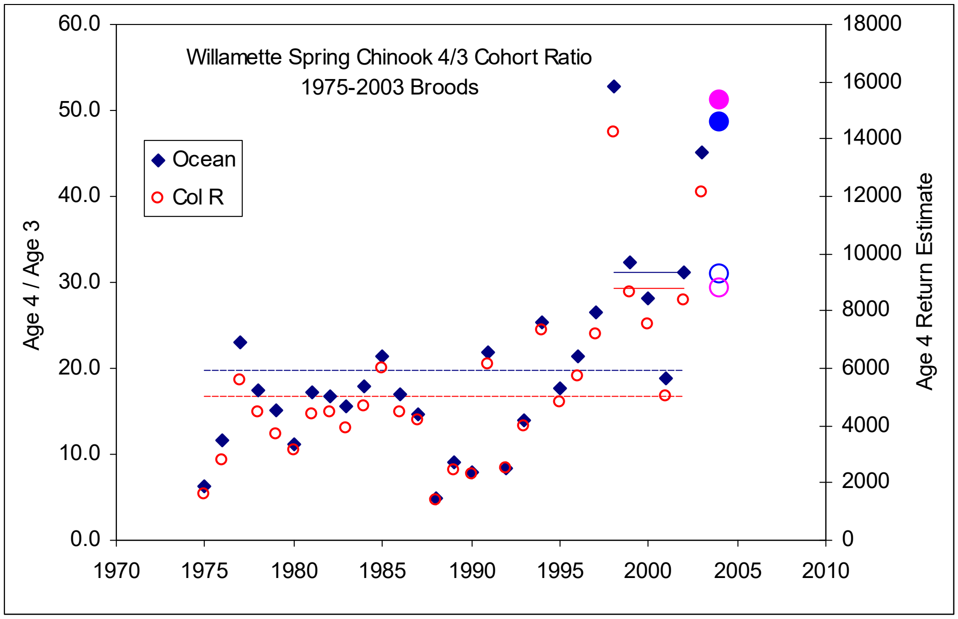

Fig. 4.4a-d. Cohort ratios for Ocean abundance (4.4a and b) and Columbia River (4.4c and d) Age 4 and Age 3 returns. Blue points and lines are based on ocean abundances, and red points and lines are based on Columbia River abundances. Dotted lines indicate all-year average ratio, solid lines indicate recent 5-year average ratio. (Note secondary y-axis for point estimates. Solid light blue point = 5-yr 2008 Col R from Ocean estimate (14,600), open light blue point = all-yr 2008 Col R from Ocean estimate (9,300). Solid pink point = 5-yr 2008 Col R estimate (15,300), open pink point = all-yr 2008 Col R estimate (8,800).)

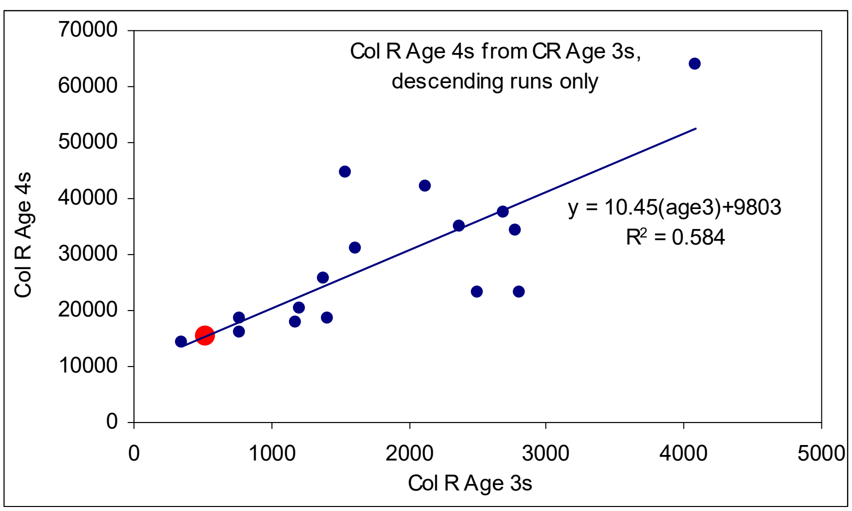

Fig. 4.5a. Regression of Columbia River Age 3 and Age 4 returns where Age 3 returns are less than previous years' Age 3 return. Red point = 2008 estimate (15,300).

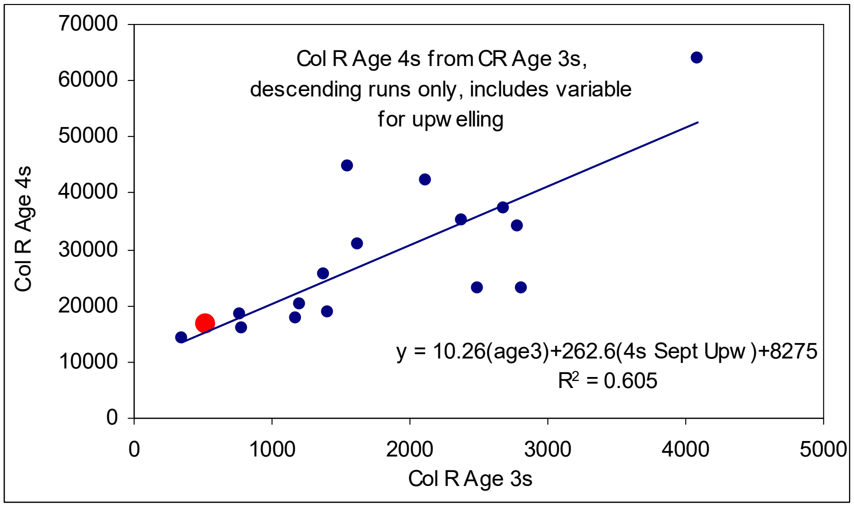

Fig. 4.5b. Regression of Columbia River Age 3 and Age 4 returns where Age 3 returns are less than previous years' Age 3 return. Regression includes an ocean upwelling variable (September mean upwelling at Neah Bay in the first year of Age 4 ocean residence). Red point = 2008 estimate (16,800).

Projections of Age 5 fish returning in 2008

Projections for Age 5 fish have historically been estimated with methods similar to those for Age 4s. Similar issues exist regarding tendencies to over- or under-predict in decreasing or increasing run years. Similar adjustments were made for Age 5 projections, as discussed in the Age 4 section. Figures 5.1-5.5 demonstrate the regressions used for the 2008 projection of Age 5s. The use of lower Willamette sport fishery age data to calculate age classes for the Willamette Falls counts of adults altered the projected number of Age 5 fish. If the Age 4 return in 2007 is reduced by this method to 12,000 fish (instead of 14,000 fish), the projected Age 5 return drops by 300 – 1,900 fish, depending on the model used. These reductions are not counteracted by equal increases in Age 6 fish due to the lower conversion of Age 5 to Age 6, compared to the conversion of Age 4 to Age 5. This has the effect of decreasing the total estimate (all ages) by around 500 – 2,000 fish overall due to effects on the Age 4 and Age 5 predictions. For the 2008 projection, the above adjustment is not used in the final run projection, but it should be considered when weighing sources of potential error in the estimate.

For the composite estimate of returns for 2008, the approximate median Age 5 value for the most powerful regression models (17,200) will be used as the point estimate, the lower median value (12,500) will be used as the lower bounds, and the highest point estimate (23,200) will be used for the upper bounds.

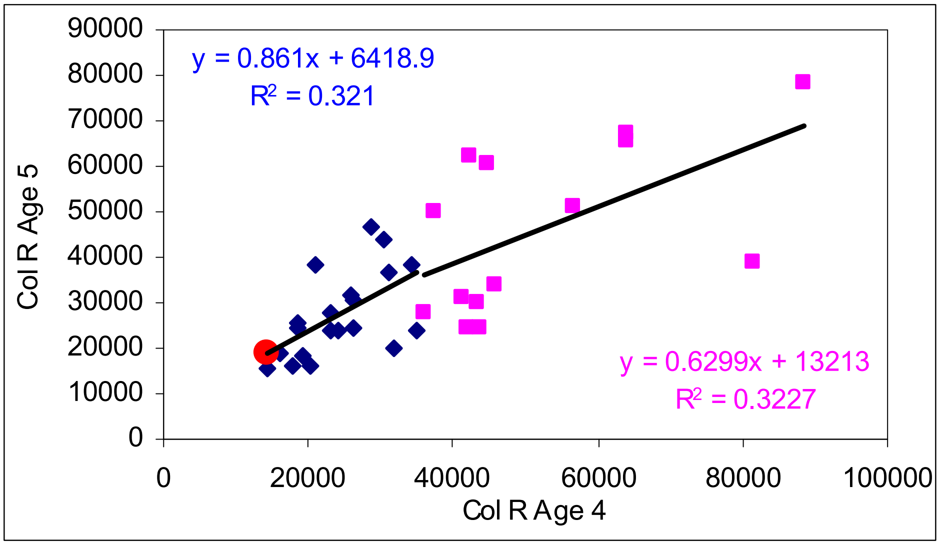

Fig. 5.1. Regressions of Columbia River Age 4 and Age 5 fish for years when Age 4 returns are below (blue) and above (pink) average return. Red point = 2008 estimate (18,600).

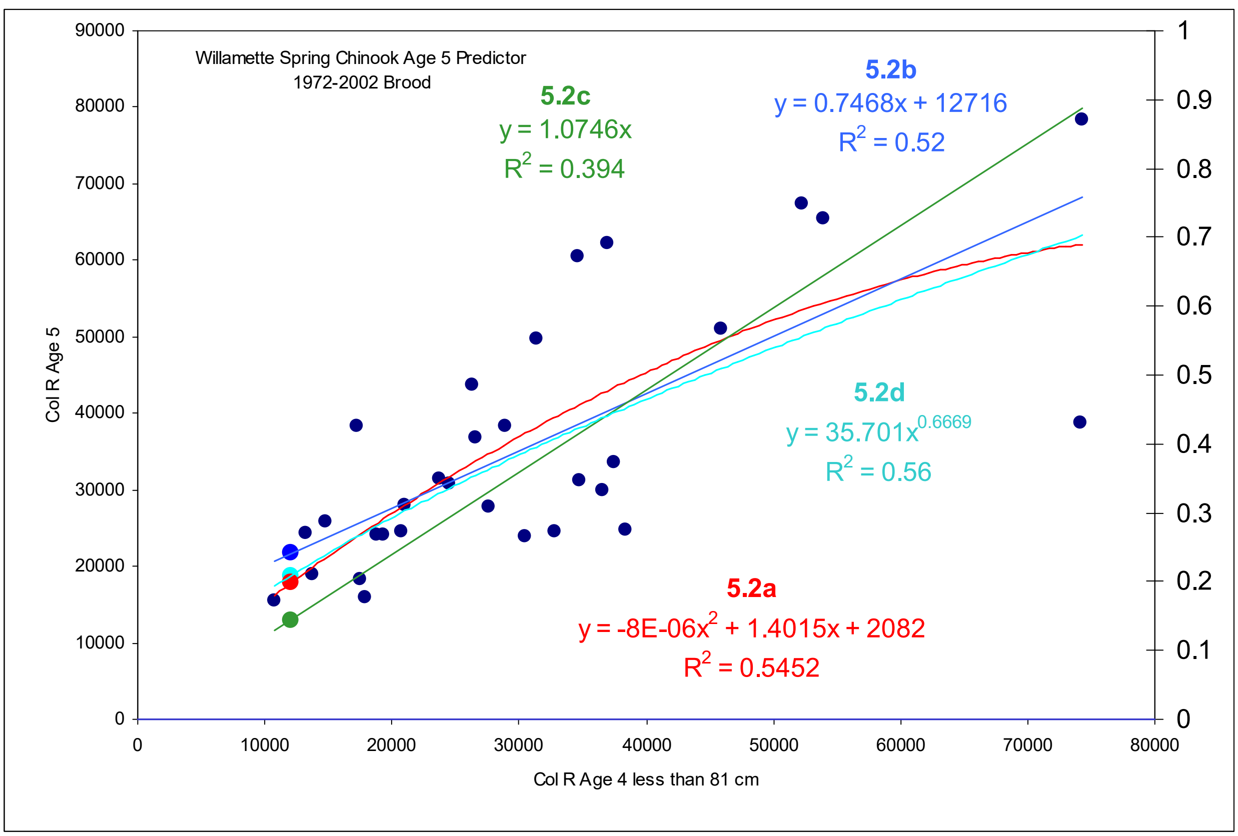

Fig. 5.2a-d. Regressions of Columbia River Age 4 (<81cm fork length) and Age 5 returns. Four regressions are included: 5.2a – polynomial regression (red; estimate = 17,800), 5.2b – linear regression with y-intercept calculated (blue; estimate = 21,700), 5.2c – linear regression with y-intercept forced to 0 (green; estimate = 13,000), and 5.2d – non-linear (power) regression (light blue; estimate = 18,800).

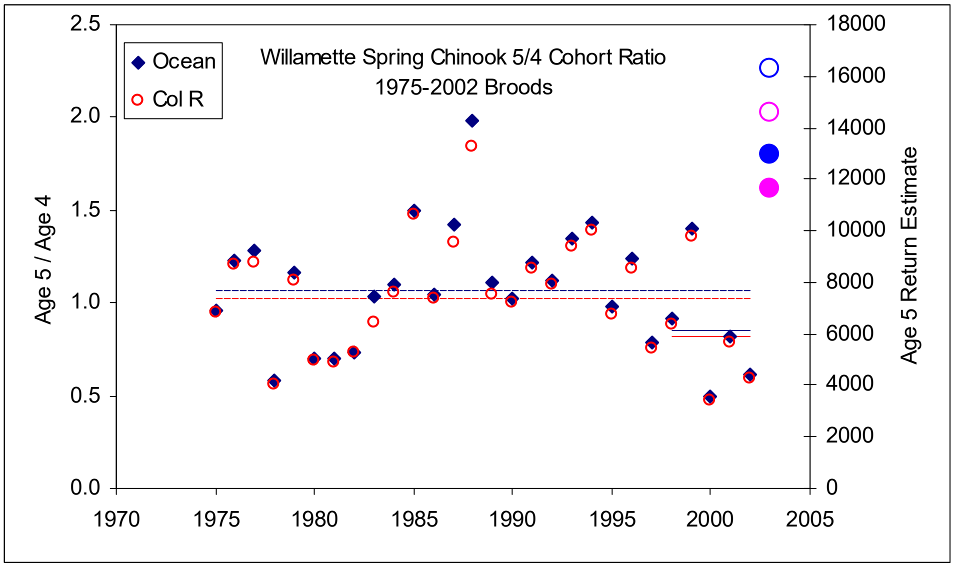

Fig. 5.3a-d. Cohort ratios for Ocean abundance (5.3 a and b) and Columbia River (5.3c and d) Age 5 and Age 4 returns. Blue points and lines are based on ocean abundances, and red points and lines are based on Columbia River abundances. Dotted lines indicate all-year average ratio, solid lines indicate recent 5-year average ratio. (Note the secondary y-axis for point estimates. Solid light blue point = 5-yr 2008 Col R from Ocean estimate (13,000), open light blue point = all-yr 2008 Col R from Ocean estimate (16,300). Solid pink point = 5-yr 2008 Col R estimate (11,600), open pink point = all-yr 2008 Col R estimate (14,600).)

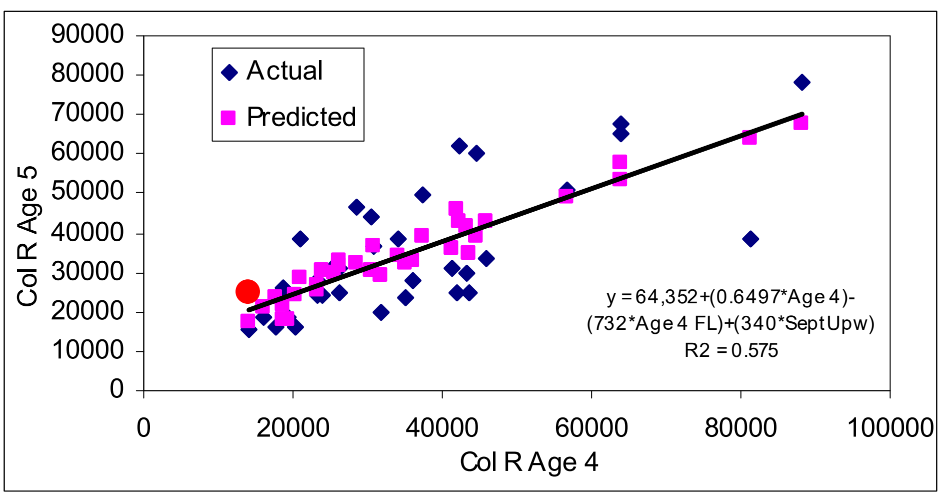

Fig. 5.4. Age 5 regression model based upon Age 4 returns, Age 4 mean fork length, and September mean upwelling for first year of ocean residence for Age 5 fish. Red point = 2008 estimate (24,965).

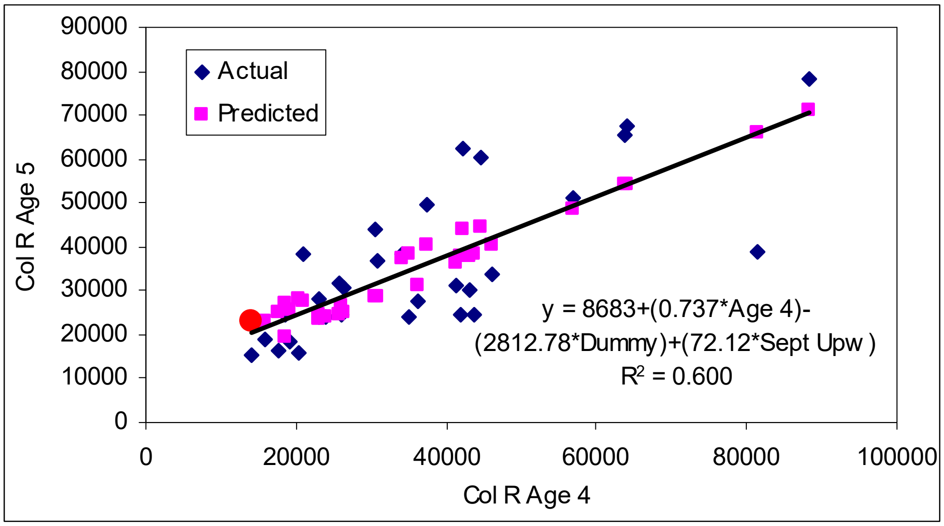

Fig. 5.5. Age 5 regression model based upon Age 4 returns, dummy variable (less than or greater than preceding year), and September mean upwelling for first year of ocean residence for Age 5 fish. Red point = 2008 estimate (28,222).

Projections for Age 6 fish returning in 2008

Projections for Age 6 fish have typically been estimated using either cohort ratios between Age 5 and Age 6 fish from the same brood year, or average Age 6 returns over 5- or 10-year periods. Methods are similar to those described for Age 3 projections. A regression model (r^2 = 0.388) was also used to project Age 6 returns in 2008 from Age 5 returns in 2007.

For the composite estimate of returns for 2008, the Age 6 estimate from the linear regression model (650) will be used as the point estimate, the 10-yr average cohort ratio estimate (600) will be used as the lower bounds, and the 5-yr average Age 6 return value (950) will be used for the upper bounds.

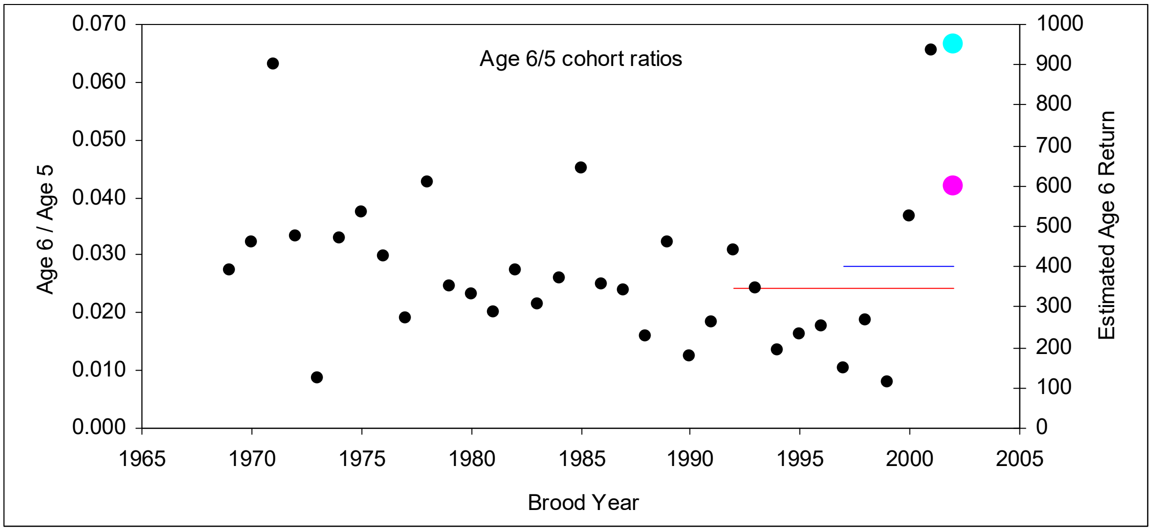

Fig. 6.1. Age 6 and Age 5 cohort ratios, 1969-2004 brood years. Red and blue lines indicate 10-yr and 5-yr average cohort ratios. Blue point = 5-yr average return of Age 6s 2008 estimate (950); pink point = 10-yr average cohort ratio 2008 estimate (600).

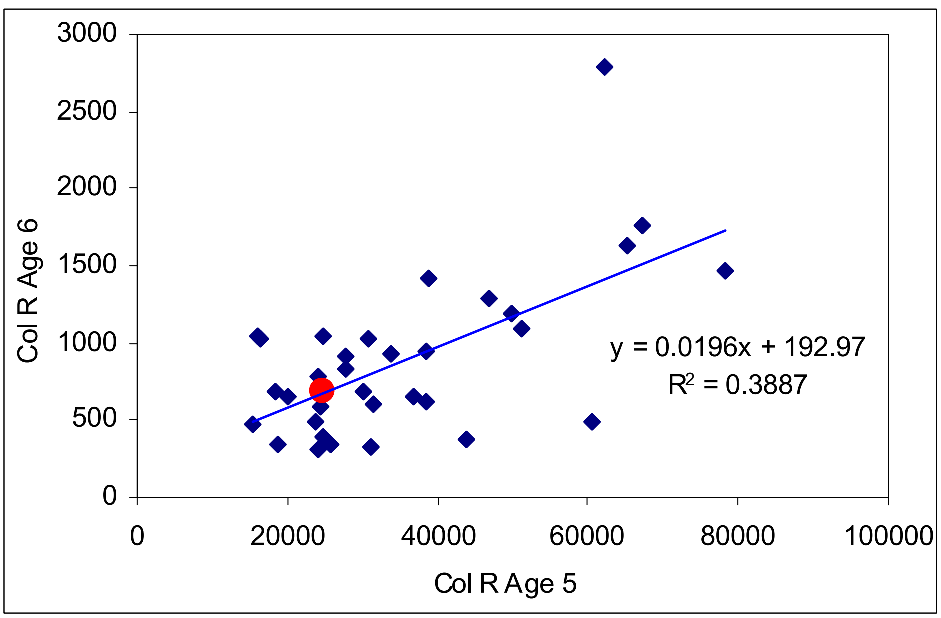

Fig. 6.2. Regression of Columbia River Age 5 and Age 6 returns. Red point = 2008 estimate (650).

Table 3. 2008 Projected Willamette spring Chinook return.

	Columbia River Returns				
	Age 3	Age 4	Age 5	Age 6	Total
2008 Forecast	**1,400**	**14,800**	**17,200**	**650**	**34,050**
Lower	775	8,600	12,500	600	22,475
Upper	2,000	17,300	23,200	950	43,450

Assuming a wild return of 15% for 2008, the number of returning hatchery fish would be 28,900 fish. The 2007 return had a stronger wild component than expected, at nearly 25% of the total return. The 2007 Clackamas River hatchery returns also made up a higher portion of the run than usual, comprising 16% of the total return. If either? of these conditions are repeated in 2008, and the forecast is accurate, the total return to areas above Willamette Falls may be below the 20,000 fish needed to maintain broodstock needs.

Table 4 shows the lowest five and highest five values for runs of each age class since 1972. The 2007 Age 3 and Age 4 runs were both the second lowest return for those age classes since 1972. The 2006 return of 321 fish was the lowest Age 3 return, and the 1996 return of 14,164 fish was the lowest Age 4 return. The 2006 Age 3 return was followed by a return of 14,192 Age 4s in 2007, and the 1996 Age 4 return was followed by a return of 15,493 Age 5s in 1997. Table 4 also contains a summary of returns in year y+1 for cohorts showing similar run sizes to those comprising the 2007 run. If the lowest subsequent year values for years with similar run sizes were representative of the 2008 return, the following distribution would be expected: Age 3 = 776 fish, Age 4 = 14,192 fish, Age 5 = 15,493 fish, and Age 6 = 302 fish. This would equate to a total run size of 30,763 fish, which is greater than the sum of the minimum estimates shown in Table 3.

Table 4. Range of historic returns, and returns for runs following counts similar to 2007 counts.

Age Class	Lowest 5	Highest 5	2007 Value
Age 3	321 - 873	3,054 - 4,399	525 (2nd lowest since 1972, average 1,900)
Age 4	14,164 - 17,690	56,752 - 88,338	14,192 (2nd lowest since 1972, average 35,000)
Age 5	15,493 - 18,892	60448 - 78,333	24,702 (average 35,000)
Age 6	235 - 381	1,424 - 2,886	1,049 (average 1,000)

Age 3s from Age 2s

Age 2 in y	Age 3 in y+1
2007 = 3,129	2008 ≈ 1,400
2,918	776
2,906	1,710
4,395	1,407
5,162	1,864
3,313	1,547

Age 4s from Age 3s

Age 3 in y	Age 4 in y+1
2007 = 525	2008 ≈ 14,800
351	14,192
764	18,629
776	15,962
873	17,690

Age 5s from Age 4s

Age 4 in y	Age 5 in y+1
2007 = 14,192	2008 ≈ 17,200
17,635	38,541
17,690	16,289
15,962	18,892
14,164	15,493

Age 6s from Age 5s

Age 5 in y	Age 6 in y+1
2007 = 24,702	2008 ≈ 650
24,637	1,047
23,842	481
24,139	776
24,116	302
24,392	593
25,816	346
24,617	399

As shown in Figure 7, the modifications to the projection methods used in 2008 seem to have reduced, but not eliminated, the tendency to over-predict returns when run sizes are declining. When the 2008 methods were applied to past years with declining trends, the results indicate a lower amount of over-prediction. However, the trend still exists, and implies that there is still some likelihood that the 2008 projection will be over-predicted. The 2008 run is currently projected to be about 6,000 fish less than the 2007 return, which might indicate a potential over-prediction of around 1,500 fish.

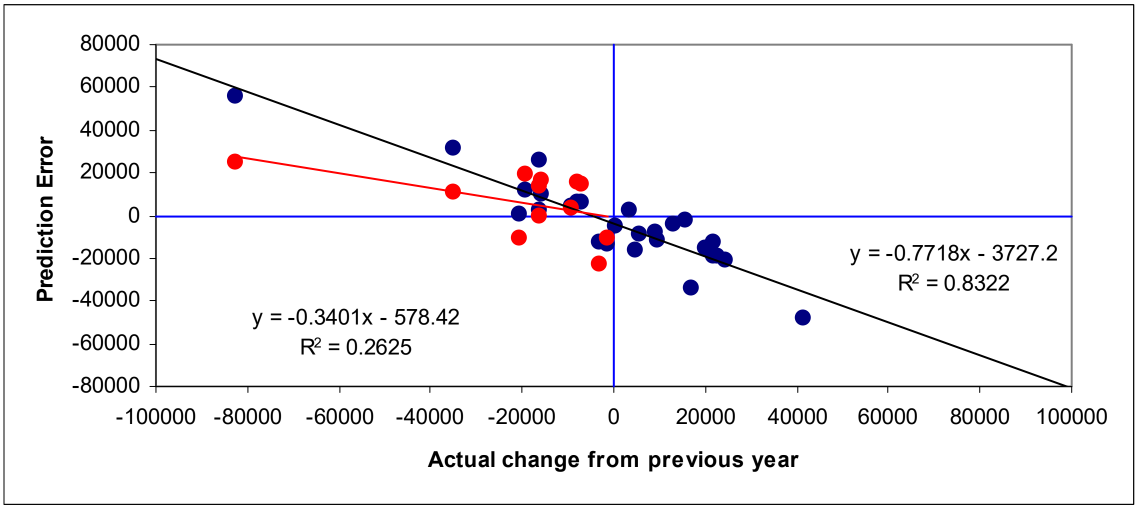

Fig. 7. Change in tendencies to under-predict on a declining run year using modifications added to the 2008 projection methods.

Because the evaluation of tendencies for over- or under-predictions utilizes actual returns as a dependent variable, they are useful for accounting for errors after a run year is over, but not for forecasting errors in current projections. In an effort to create a method that would allow for adjustments to projections, the changes between predicted values (rather than actual values) between years were evaluated in a similar fashion. This was only done for years with descending run sizes, but could also be done for years with increasing run sizes.

The result is a method for adjusting the run prediction downward for years when lower runs are expected than were seen in the previous year (Figure 8). If this adjustment is accurate, then the 2008 projection, even with method adjustments to prevent it, may over-predict the actual return by up to 8,000 fish. This potential error, combined with uncertainty in the percentages of wild fish and Clackamas River fish in the 2008 return, could dramatically impact the anticipated number of returning hatchery fish in 2008, which in turn drive fisheries and broodstock expectations for Willamette River hatcheries.

As shown in Table 5, the assumptions used for wild fish returns and Clackamas River turn-off can drastically alter the expected return of hatchery fish to areas above Willamette Falls. Table 6 shows the potential combined impacts of a lower Willamette River sport fishery (using 10-yr low, average, and high hatchery harvest rates), assumptions of 10%, 15%, and 20% wild composition, and assumptions of 10%, 15%, and 20% Clackamas River hatchery fish composition. Of the 81 values shown for broodstock escapement over Willamette Falls, 31 of them describe scenarios in which the number of broodstock is less than the 20,000 goal. Twenty-seven of these are based on scenarios in which 0 fishing was allowed on Willamette stocks in the Willamette and mainstem Columbia.

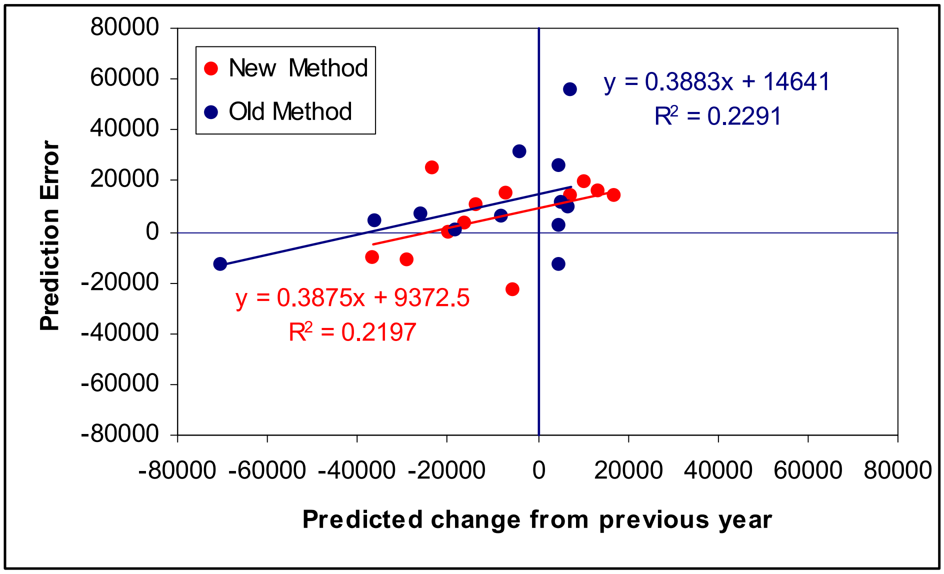

Figure 8. Projected errors in predictions when the projected run in year y+1 is less than the projected run in year y.

Table 5. Projected run sizes for 2008 and resulting Willamette Falls hatchery fish escapement under various wild fish and Clackamas hatchery fish return assumptions. Willamette Falls escapement goal is 20,000 fish.

Total Run Size	Assumptions	Falls Hatchery Escapement
22,475	10% wild, 10% Clackamas hatchery	18,205
22,475	15% wild, 15% Clackamas hatchery	16,238
22,475	20% wild, 20% Clackamas hatchery	14,384
34,050	10% wild, 10% Clackamas hatchery	27,581
34,050	15% wild, 15% Clackamas hatchery	24,601
34,050	20% wild, 20% Clackamas hatchery	21,792
43,400	10% wild, 10% Clackamas hatchery	35,154
43,400	15% wild, 15% Clackamas hatchery	31,357
43,400	20% wild, 20% Clackamas hatchery	27,776

Table 6. Effects of varying estimates for wild fish and Clackamas River hatchery fish returns. Hatchery runs are total run (Table 3) minus wild component (10%, 15%, 20% of total). Willamette Falls escapements are hatchery run minus Clackamas hatchery fish turn-off minus lower river fishery removals at three hatchery harvest rates (6%, 12%, and 18%) for the Willamette River sport fishery. Fishery impacts for the three lowest hatchery run values are assumed to be 0% (no fishing). Mainstem harvest of Willamette fish is 0 in all cases.

	Willamette Falls Escapements								
	Low Hatchery HR (6%)			Average Hatchery HR (12%)			High Hatchery HR (18%)		
Hatchery Run	10% Clack	15% Clack	20% Clack	10% Clack	15% Clack	20% Clack	10% Clack	15% Clack	20% Clack
18,000	16,200	15,300	14,400	16,200	15,300	14,400	16,200	15,300	14,400
19,100	17,200	16,200	15,300	17,200	16,200	15,300	17,200	16,200	15,300
20,200	18,200	17,200	16,200	18,200	17,200	16,200	18,200	17,200	16,200
27,200	23,000	21,800	20,500	21,600	20,400	19,200	20,100	19,000	17,900
28,900	24,500	23,100	21,800	22,900	21,600	20,400	21,400	20,200	19,000
30,600	25,900	24,500	23,000	24,300	22,900	21,600	22,600	21,400	20,100
34,700	29,400	27,700	26,100	27,500	26,000	24,400	25,600	24,200	22,800
36,900	31,200	29,500	27,700	29,200	27,600	26,000	27,200	25,700	24,200
39,100	33,000	31,200	29,400	30,900	29,200	27,500	28,800	27,200	25,600

Appendix Table 1. Historic run reconstruction data utilized in 2008 projection analyses.

Brood Year	Col R Mouth Age 5	Col R Mouth Pred Age 5	Col R Mouth Age 4 Col Total	Col R Mouth Age 4 Col <81cm	Col R Mouth Pred Age 4	Age 4 Will Mean Length	Age 4 Will % > 81cm	Age 3 Col Total	Willamette Falls Count Age 3	Willamette Falls Count Age 2	ocean harv rate age 4	ocean harv rate age 5	Upwelling at Neah Bay Age 3 Fish Apr	May	Jun	Jul	Aug	Sep	Age 4 Fish Apr	May	Jun	Jul	Aug	Sep	Age 5 Fish Apr	May	Jun	Jul	Aug	Sep
1969	46724		28674	26417		73.17	7.87	2242	1381	4113			-14	42	6	39	15	1	-5	11	27	15	27	8	23	9	11	32	54	0
1970	20066		31947	24912		76.05	22.02	2986	2483	1750			-5	11	27	15	27	8	23	9	11	32	54	0	-3	12	38	19	37	4
1971	16289		17690	15594		73.53	11.85	1179	746	328			23	9	11	32	54	0	-3	12	38	19	37	4	17	15	59	45	14	10
1972	30790		26266	24493		72.33	6.75	2590	2093	1734			-3	12	38	19	37	4	17	15	59	45	14	10	-3	6	31	5	9	1
1973	43810		30546	26328		74.19	13.81	2686	1903	957			17	15	59	45	14	10	-3	6	31	5	9	1	-2	9	39	42	24	2
1974	27810		36090	27598		75.83	23.53	3077	2547	773			-3	6	31	5	9	1	-2	9	39	42	24	2	-3	17	28	58	3	-16
1975	18336	20500	19298	17523		72.69	9.20	3626	3053	663	0.143	0.011	-2	9	39	42	24	2	-3	17	28	58	3	-16	10	24	83	25	35	-2
1976	27920	21000	23126	21005	20000	72.94	9.17	2495	1917	1884	0.209	0.015	-3	17	28	58	3	-16	10	24	83	25	35	-2	-15	41	32	63	68	5
1977	31464	30000	25730	23769	30000	72.58	7.62	1378	1032	2174	0.187	0.044	10	24	83	25	35	-2	-15	41	32	63	68	5	-1	8	5	80	24	-6
1978	24637	30000	43647	32849	33000	76.33	24.74	2918	2402	22433	0.139	0.026	-15	41	32	63	68	5	-1	8	5	80	24	-6	0	59	74	36	38	7
1979	38330	30000	34158	28908	40000	74.64	15.37	2779	1844	26679	0.182	0.035	-1	8	5	80	24	-6	0	59	74	36	38	7	5	45	24	18	26	12
1980	29996	35000	43244	36593	33000	75.32	15.38	4172	3215	9438	0.075	0.014	0	59	74	36	38	7	5	45	24	18	26	12	-14	-1	33	72	27	0
1981	23842	30000	35050	30486	33000	74.98	13.02	2376	1846	14999	0.147	0.028	5	45	24	18	26	12	-14	-1	33	72	27	0	7	20	49	79	39	12
1982	33684	35000	45964	37497	33000	75.68	18.42	3095	2437	26174	0.108	0.003	-14	-1	33	72	27	0	7	20	49	79	39	12	6	2	26	57	84	9
1983	51028	45000	56752	45895	41000	75.62	19.13	4343	3144	10939	0.162	0.129	7	20	49	79	39	12	6	2	26	57	84	9	-6	22	37	39	68	9
1984	67353	51000	64042	52194	50000	75.62	18.50	4090	3449	12639	0.124	0.045	6	2	26	57	84	9	-6	22	37	39	68	9	1	-6	12	54	55	15
1985	62270	46000	42168	36897	48000	74.10	12.50	2118	1728	27010	0.069	0.014	-6	22	37	39	68	9	1	-6	12	54	55	15	0	34	31	31	48	21
1986	65363	55000	63872	53908	78000	75.30	15.60	4316	3314	34000	0.129	0.023	1	-6	12	54	55	15	0	34	31	31	48	21	7	14	12	61	15	16
1987	49734	31000	37372	31355	50000	75.20	16.10	2688	2145	13154	0.051	0.065	0	34	31	31	48	21	7	14	12	61	15	16	2	27	31	27	9	17
1988	38423	18000	20840	17235	69000	75.60	17.30	4399	3820	7904	0.05	0.072	7	14	12	61	15	16	2	27	31	27	9	17	-8	30	42	52	28	8
1989	24139	31000	23163	18739	47000	76.00	19.10	2810	2347	5623	0.102	0.064	2	27	31	27	9	17	-8	30	42	52	28	8	-55	-4	23	38	26	20
1990	24116	31000	24050	19312	39000	76.60	19.70	3156	2245	913	0.039	0.02	-8	30	42	52	28	8	-55	-4	23	38	26	20	-1	7	11	58	10	3
1991	18892	16300	15962	13791	16000	75.00	13.60	776	642	2918	0.059	0.03	-55	-2	23	38	26	20	-1	7	11	58	10	3	-2	29	9	37	12	0
1992	15493	3200	14164	10749	21700	76.51	24.11	1710	1249	2906	0.014	0.028	-1	7	11	58	10	3	-2	29	9	37	12	0	-61	14	18	63	26	8
1993	24392	18600	18701	13278	23700	78.17	29.00	1407	1211	4395	0.043	0.03	-2	29	9	37	12	0	-61	14	18	63	26	8	-4	0	1	25	3	-6
1994	25816	23400	18629	14760	13800	76.65	20.77	764	637	2095	0.039	0.033	-61	14	18	63	26	8	-4	0	1	25	3	-6	3	15	60	24	41	23
1995	24617	31100	26175	20689	22000	76.91	20.96	1642	1388	2397	0.104	0.036	-4	0	1	25	3	-6	3	15	60	24	41	23	7	18	11	44	20	22
1996	36860	29600	30958	26571	26700	75.39	14.17	1618	1462	1146	0.104	0.036	3	15	60	24	41	23	7	18	11	44	20	22	-5	3	23	25	33	1
1997	31168	45600	41243	34764	29400	75.67	15.71	1729	1479	1336	0.104	0.036	7	18	11	44	20	22	-5	3	23	25	33	1	-2	16	25	68	2	3
1998	78333	89200	88338	74248	25900	75.52	15.95	1864	1288	5162	0.104	0.036	-5	3	23	25	33	1	-2	16	25	68	2	3	9	10	18	48	40	4
1999	60448	41200	44696	34595	18400	75.99	22.60	1547	1025	3313	0.104	0.036	-2	16	25	68	2	3	9	10	18	48	40	4	-14	8	37	30	29	3
2000	38704	87500	81321	74132	64800	74.01	8.84	3228	1851	10376	0.104	0.036	9	10	18	48	40	4	-14	8	37	30	29	3	0	15	18	30	10	3
2001	15975	21656	20285	17841	26300	73.99	12.05	1206	757	1659	0.104	0.036	-14	8	37	30	29	3	0	15	18	30	10	3	-13	-4	16	30	41	24
2002	24702	46531	41912	38400	22,244	73.79	8.38	1505	1180	1289	0.104	0.036	0	15	18	30	10	3	-13	-4	16	30	41	24	0	16	34	54	77	18
2003	0	0	14192	12086	3,611	74.76	14.84	351	190	135	0.104	0.036	-13	-4	16	30	41	24	0	16	34	54	77	18	-7	32	7	12	18	12
2004			0		5,062			525	279	443	0.104	0.036	0	16	34	54	77	18	-7	32	7	12	18	12						
2005										3129	0.104	0.036	-7	32	7	12	18	12												

Age 5 and Age 4 SPRING CHINOOK RETURNS - Number of fish Entering the Columbia River.

Age 4 COLUMBIA SPRING CHINOOK RETURNS :

- Number of 4's less than 81 cm in length = Total number of 4's x (percent 4's less than 81 cm in length / 100).
- Mean length of 4's and percent 4's less than 81cm in length are determined from data collected in the Willamette River Sport Sampling Program.

Age 3 WILLAMETTE FALLS COUNTS :

- For 1969-85 broods, Willamette Falls count = actual count / 0.59.
- for 1986-Present broods, Willamette Falls count = actual count.

Age 3 Columbia River Returns

- For 1969-85 broods, adjusted to reflect corrected Willamette Falls count

Appendix Table 2. Summary of regressions and projection analyses for 2008 estimates.

Age	Figure Num	Estimate	Description	N	r^2	Comments
3	3.1	1363	Cohort ratio	10	na	Recent 5-yr average cohort ratio.
3	3.1	3195	Cohort ratio	10	na	Recent 10-yr average cohort ratio.
3	3.2	2018	WF 2s v Col R 3s	36	0.349	Non-linear regression of WF 2s and Col R 3s. b= calc. Not used in past, very little correlation at 2 count <10,000.
4	4.1	15616	Above or below average	16	0.377	Based on regressions of Col R 3s vs Col R 4s where the 3s of same brood year are below or above average value for age3 returns.
4	4.2a	13,964	Wfalls age3s <= 1000	5	0.836	Regression of Col R 4s from W Falls 3s in years with <=1000 3s.
4	4.2b	14,998	Wfalls age3s <= 1000	5	0.576	Regression of Col R 4s from W Falls 3s in years with <=1000 3s.
4	4.3a	17,284	W Falls 3 v Ocean 4s	27	0.54	Non-linear regression of WF 3s vs Ocean 4s, then multiplied by avg ocean HR of 0.896 to get to Col R 4s (r^2 is for the 3s v Oc 4s only)
4	4.3b	14,735	W Falls 3 v Ocean 4s	27	0.581	Linear regression of WF 3s vs Ocean 4s with b=calc, then multiplied by avg ocean HR of 0.896 to get to Col R 4s (r^2 is for the 3s v Oc 4s only)
4	4.3c	5,062	W Falls 3 v Ocean 4s	27	0.475	Linear, forced through b=0, of WF 3s vs Ocean 4s, then multiplied by avg ocean HR of 0.896 to get to Col R 4s (r^2 is for the 3s v Oc 4s only)
4	4.4a	14609	Col R 3/4 Cohort ratio, ocean	35	na	Cohort ratio of Col R 3s to Ocean 4s, then multiplied by Ocean HR (0.896) to get Col R 4s, uses 5 yr average ratios
4	4.4b	9254	Col R 3/4 Cohort ratio, ocean	35	na	Cohort ratio of Col R 3s to Ocean 4s, then multiplied by Ocean HR (0.896) to get Col R 4s, uses all yr average ratios
4	4.4c	15345	Col R 3/4 Cohort ratio, Col R	35	na	Cohort ratio of Col R 3s to Col R 4s, uses 5 yr average ratios
4	4.4d	8813	Col R 3/4 Cohort ratio, Col R	35	na	Cohort ratio of Col R 3s to Col R 4s, uses all yr average ratios
4	4.5a	15288	Col R 3 v Col R 4, descending years	16	0.583	3s v 4s Subset only includes years which had an Age 3 count lower than previous year.
4	4.5b	16814	Col R 3 v Col R 4, with Ocean, descending years	16	0.605	3s v 4s with a variable added for Neah Sept upwelling for 4s in first year at sea. Subset only includes years which had an Age 3 count lower than previous year.
5	5.1	18638	Above or below average	20	0.321	Based on regressions of Col R 4s vs Col R 5s where the 4s of same brood year are below or above average value for age4 returns.
5	5.2a	17810	Col R 4 <81cm v Col R 5	31	0.545	Polynomial regression of Col R 4s <81 cm vs Col R 5s.
5	5.2b	21742	Col R 4 <81cm v Col R 5	31	0.52	Linear, b=calc regression of Col R 4s <81 cm vs Col R 5s.
5	5.2c	12988	Col R 4 <81cm v Col R 5	31	0.394	Linear, b=0 regression of Col R 4s <81 cm vs Col R 5s.
5	5.2d	18836	Col R 4 <81cm v Col R 5	31	0.56	Non-Linear regression of Col R 4s <81 cm vs Col R 5s.
5	5.3a	12963	Col R 4/5 Cohort ratio, ocean	34	na	Cohort ratio of Ocean 4s to Ocean 5s, then multiplied by Ocean HR (0.964) to get Col R 5s, uses 5 yr average ratios
5	5.3b	16319	Col R 4/5 Cohort ratio, ocean	34	na	Cohort ratio of Ocean 4s to Ocean 5s, then multiplied by Ocean HR (0.964) to get Col R 5s, uses all year average ratios
5	5.3c	11615	Col R 4/5 Cohort ratio, Col R	34	na	Cohort ratio of Col R 4s to Col R 5s, uses 5 yr average ratios
5	5.3d	14593	Col R 4/5 Cohort ratio, Col R	34	na	Cohort ratio of Ocean 4s to Ocean 5s, uses all year average ratios
5	5.4	24965	Col R 4 v Col R 5, with addn variables	34	0.575	Multiple linear regression of Col R 5s from Col R 4s using variables Age 4, mean Age 4 FL, Sept 5s Upwelling.
5	5.5	22822	Col R 4 v Col R 5, with addn variables	34	0.6	Multiple linear regression of Col R 5s from Col R 4s using variables Age 4, dummy (< or > than previous), Sept 5s Upwelling.
6	6.1	950	Cohort ratio	10	na	Recent 5-yr average cohort ratio.
6	6.1	598	Cohort ratio	10	na	Recent 10-yr average cohort ratio.
6	6.2	677	WF 2s v Col R 3s	33	0.389	Linear regression of Col R 5s and Col R 6s. b= calc