Columbia River Upriver Spring Chinook –

2005 Forecast and Return

Draft Report of the *U.S. v. Oregon* Technical Advisory Committee

November 14, 2005

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Introduction

The pre-season 2005 upriver spring Chinook (including Snake River summer Chinook) forecast was 254,100 at the Columbia River mouth. The run came in substantially less than forecast at approximately 106,000 at the river mouth. This is still the 8th largest run since 1980. Because of the significant effects of modifying planned fisheries in-season on the treaty and non-treaty fishing communities, the *U.S. v. Oregon* parties asked the Technical Advisory Committee (TAC) to analyze the spring Chinook run and try to determine the likely causes for the shortfall. This report attempts to show the various factors that may in part be responsible. This report is also in part, a follow-up to a May 26, 2005 memorandum from Usha Varanasi to Robert Lohn concerning the same subject (NMFS 2005)

In general all Columbia River stocks returned at very high levels between the years 2000 and 2004. The 2001 upriver spring Chinook return was a record high since 1938. Most stocks have declined from their peak returns in the past two to three years, but many are still at high levels.

Columbia River Intertribal Fish Commission (CRITFC) staff sample spring Chinook at Bonneville Dam each year. Scales are collected and aged. Columbia upriver spring Chinook and Snake River spring/summer Chinook are primarily yearling type fish. A very small proportion of the 2005 return was from subyearling type fish. Generally, these fish spend a full year in fresh water prior to migrating to the ocean. The 2005 return was comprised of jacks from brood year (BY) 2002 and adults from BY 2001, 2000, and 1999. Only about 1% of the return was from BY 1999. The vast majority of the 2005 return was comprised of adults from BY 2001 and 2000. The 2005 adult return would have primarily outmigrated in 2003 and 2002.

In this report, the TAC reviewed a number of possible scenarios that may have contributed to the run not returning as predicted. There are two separate but related questions. One is what factors may be responsible for the return being lower than the past couple years. Another is why did the forecast not predict this decline.

Forecast Techniques

The TAC uses an aged based regression technique to forecast spring Chinook. This technique has been used for a number of years. The data and forecast are prepared by WDFW staff and reviewed by TAC. The jack counts used in these forecasts are an index of jack returns based on a combination of certain hatchery jack returns and upriver dam counts. The jack index used has changed over time. The age-4 and age-5 returns are based on fishery data and the Bonneville Dam sampling data. Figures 1 and 2 show the relationship between the jack index and age- 4 fish and the relationship between the age-4 and age-5 fish. Regressions for age-3 index jacks and age-4 year returns have a good statistical correlation (r-squared value = 0.88). The age-4 return is typically about 73% of the adult return. The correlation between the age-4 return and the age-5 return is not as strong (r-squared value = 0.38), but since the age-5 return is a smaller component of the run, this relationship does not produce a major part of the error with the forecast. In 2004, the jack index value was over 7,000 fish, which was the third highest in the dataset.

Table 1 and Figure 3 show historic TAC preseason forecasts from 1980 to present compared to actual returns. There has been significant variation between the forecast and actual returns with returns in many years substantially above or below forecast. TAC has over-predicted the run size in nine out of 26 years between 1980 and 2005. In only three years was the error greater than 25%. The three years with the largest percent error were 1994, 2004, and 2005. In 1994, the percent forecast error was almost as great as 2005, but because both the forecast and actual run were extremely small in 1994, the affect on fishery management was less significant than in 2005. In 17 out of 26 years, the returns were under-predicted. In nine of those years, the under-prediction was greater than 25%. In four years out of 26, TAC did not predict the change in the direction of the return. In 1982 and 1993, TAC predicted the run would decrease when it actually increased. In 2004 and 2005, TAC predicted the run would increase and it decreased.

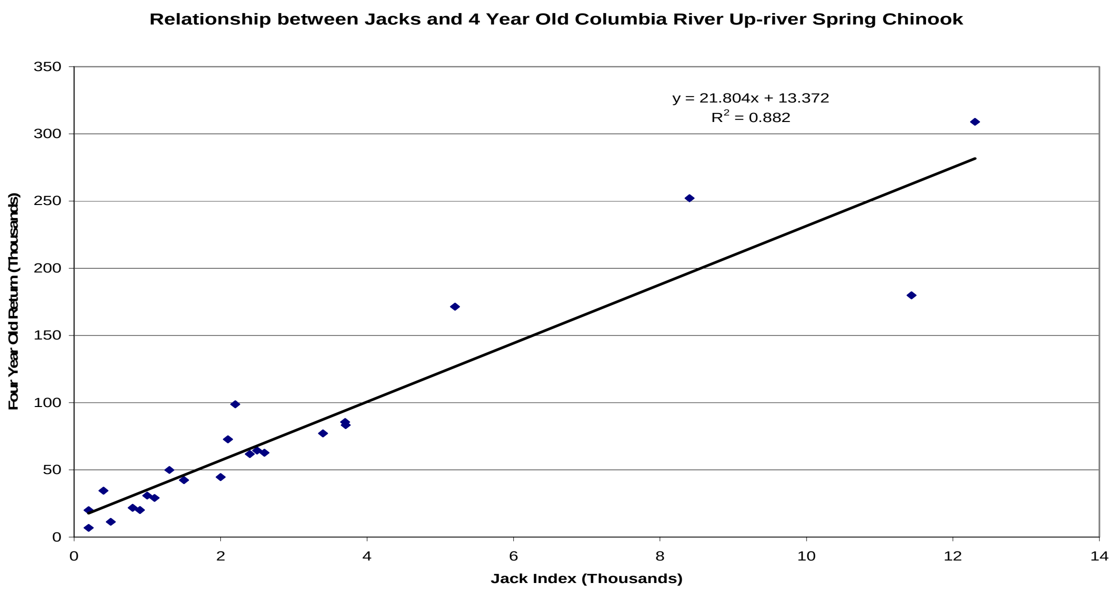

Figure 1. Relationship between Jack Index and Age-4 Spring Chinook Return 1982-2004
(Dataset for season ending May 31)

From 1980 through 1999 the run sizes were generally very low and fisheries were extremely constrained. Therefore errors in forecast had smaller direct fishery management implications. In 2004 and 2005, because the actual run sizes did allow for moderate fisheries, the error in forecasts caused more significant in-season management difficulties.

The index jacks that are used in the forecast are a subset of the total jacks counted at Bonneville Dam. Historically, the index jacks have been a smaller percent of the jacks counted at Bonneville than they were in 2003 and 2004. TAC will be examining the length frequencies of hatchery returns to determine if the jack index needs to be adjusted or modified prior to making the 2006 forecast. When TAC completes the 2005 run reconstructions, other factors may become apparent that TAC will need to review further.

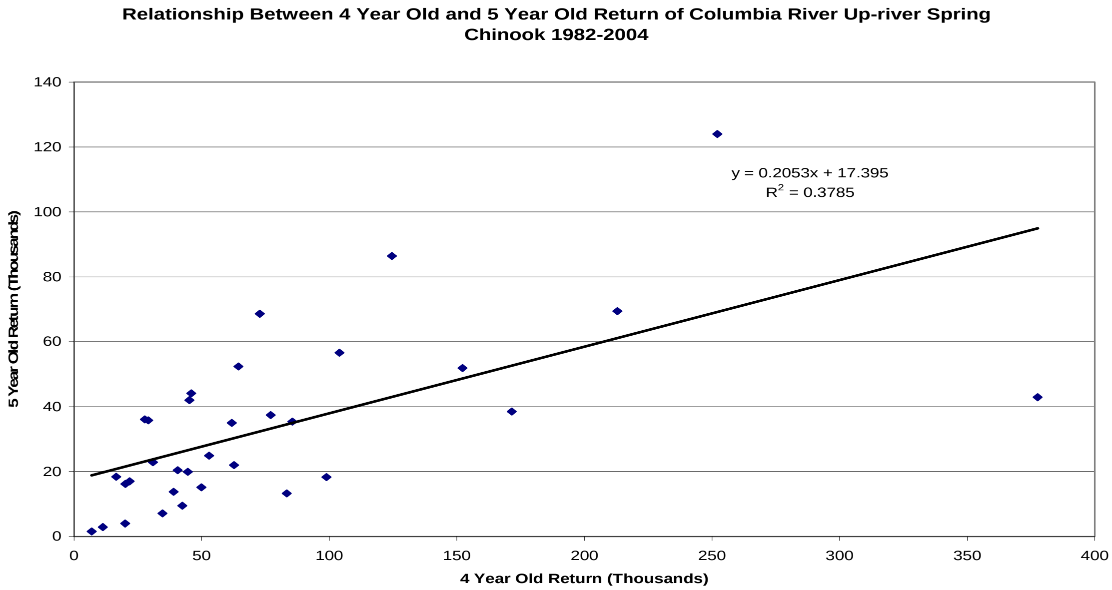

Figure 2. Relationship Between Age-4 Return and Age-5 Spring Chinook Return.
(Dataset for season ending May 31)

For comparison, alternate forecasts prepared by CRITFC fish science department staff are shown in Table 2.   They also show significant differences between the forecast and the actual return (Miranda et. al. 2005). These forecasts predict Bonneville Dam return and therefore may be influenced by fisheries downstream of Bonneville Dam that differ from historic patterns. The CRITFC forecast also did not perform well in 2004 or 2005 and shows many of the same types of error rates as the TAC forecasts. The functional differences in these two forecast methods are not great (both rely on age based regressions), but the level of error in the past two years was different. This also may point to some anomaly with the jack index data for the Snake River.

There are some indications that changes in jack index numbers in the past couple years may have contributed to the forecast error. But the jack index data does not appear to explain all of the forecast error. TAC is recently accounting for a higher proportion of the total jack index in the Snake River counts.   This could possibly be at least partly explained in some sort of change in maturation rate of Snake River fish. This does not explain why the Snake River counts are a higher proportion of the Bonneville jack counts.

Another example of an independent test of forecast methodology was done by NMFS in 2005.   The NMFS Science Center staff did a regression based forecast using Snake River dam counts and sampling data and determined that this method also produced an over-prediction for 2005.

Table 1. Comparison of Pre-Season Forecasts Versus Actual Run Size

10/18/2005

TAC Spring Chinook Forecasts for Uprvier Spring Chinook

Year	Pre-Season	Actual Return	Error	Percent of Actual
2005	254,100	106,000	148,100	140%
2004	360,700	193,377	167,323	87%
2003	145,400	208,850	-63,450	-30%
2002	333,700	295,111	38,589	13%
2001	364,600	416,468	-51,868	-12%
2000	134,000	178,659	-44,659	-25%
1999	24,600	38,700	-14,100	-36%
1998	36,200	38,376	-2,176	-6%
1997	67,800	114,124	-46,324	-41%
1996	37,200	51,530	-14,330	-28%
1995	12,000	10,197	1,803	18%
1994	49,000	21,075	27,925	133%
1993	76,200	111,758	-35,558	-32%
1992	71,400	89,969	-18,569	-21%
1991	61,900	59,883	2,017	3%
1990	120,800	99,486	21,314	21%
1989	92,700	83,402	9,298	11%
1988	64,500	97,237	-32,737	-34%
1987	79,700	100,164	-20,464	-20%
1986	115,000	120,627	-5,627	-5%
1985	52,600	86,498	-33,898	-39%
1984	44,200	48,658	-4,458	-9%
1983	51,800	57,826	-6,026	-10%
1982	48,700	71,252	-22,552	-32%
1981	64,900	63,766	1,134	2%
1980	25,600	53,207	-27,607	-52%
Average Bias				-0.2%
Average Error				33%

2005 includes Snake River Summer Chinook.

Most tributary returns for Columbia River spring chinook were less than predicted. Many tributaries have forecasts made by regional state staff and/or tribal staff. Tributary forecasts are made with independent data sets and are not necessarily related to the TAC methods for total run forecasts. The Wind River prediction was 8,300. The preliminary actual return was 3,200. From 1988-2004, the Wind River returns have been over-predicted by 34%. For the Little White Salmon River, the 2005 prediction was 7,600 and the preliminary actual return was 3,400. The Little White salmon percent error for forecasts is 52%. For the Klickitat River, the 2005 prediction was 5,100, and the preliminary actual return was 1,400. The 2005 Yakima forecast was 14,500, and the actual return was 6,700.

Table 2. Alternate Pre-Season Forecasts for Bonneville Run Size

CRITFC Spring Chinook Forecasts

	Bonneville Counts			
Year	Predicted	Actual	Error	Percent
2005	157,000	97,816	59,184	61%
2004	216,900	170,320	46,580	27%
2003	90,500	195,671	-105,171	-54%
2002	220,400	269,428	-49,028	-18%
2001	379,300	392,351	-13,051	-3%
2000	107,800	178,522	-70,722	-40%
1999	32,900	38,705	-5,805	-15%
Average Bias				-6%
Average Error				31%

2005 is through June 15.

From 1997-2004, the average forecast error was 32%. The wild return based on redd counts for the John Day river in 2005 was about half of the 2004 return. Because so many different forecasts in the Columbia River basin were over forecasts in 2005, it appears that the likely cause of the 2005 return being so much less than anticipated is not entirely due to forecast imprecision.

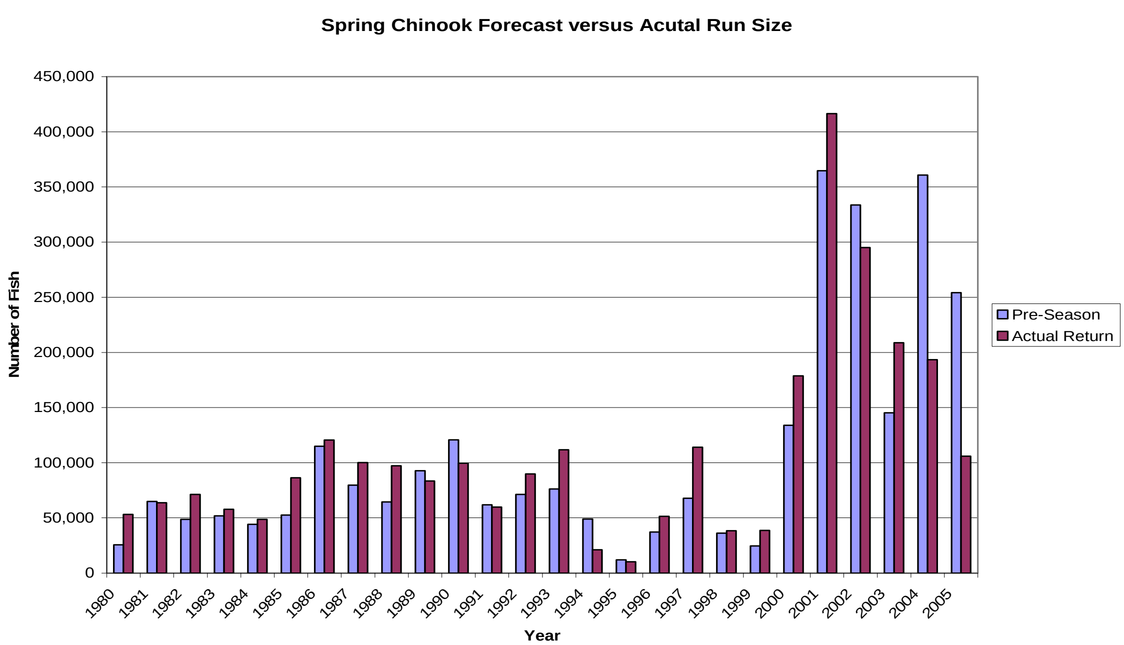

Figure 3. Comparison of Preseason and Actual Spring Chinook Run Sizes

2005 Spring In-River Fisheries

Mainstem in-river fisheries in 2005 were managed according to the harvest rate schedule in the 2005-2007 Interim Management Agreement. Under this agreement, the non-treaty harvest rate was limited to 2% of the wild river mouth run size of upriver spring Chinook. The allowed treaty harvest rate was variable with different in-season run size estimates, but was 7% of the entire run based on the final actual run size. Mainstem non-treaty fisheries (which occur primarily below Bonneville) stayed within the allowed 2% wild impact rate. Due to uncertainties in in-season run updating, non-treaty fisheries were temporarily restricted because they were estimated to possibly be exceeding the run-size estimate in use at that time. As the in-season predictions increased, the estimated harvest rates decreased. Lower river fisheries were monitored according to standard methodology and catches and release mortality estimates were updated on a regular basis. Lower river harvest estimates and release mortality estimates of upriver stock fish are used to add to Bonneville Dam counts to estimate the river mouth run size. It is not possible for the lower river fisheries therefore to be "responsible" for any shortfall in the river mouth return estimate unless there were some significant error in the catch estimation procedures. There is no evidence to suggest any problem such as this.

Likely Sources of Mortality

Tributary Rearing Survival

Most up-river spring Chinook are yearling type fish. They rear in fresh water for a full year before migrating to the ocean. This means they are subjected to a variety of potential sources of mortality in their freshwater rearing stage. Water conditions, food supply, competition, and predation vary throughout the basin. TAC does not have any directly comparable methods of establishing what the survival through freshwater rearing was for specific groups of fish.

It may be assumed that flow is a key factor affecting rearing survival. As a surrogate measure for likely rearing survival, TAC looked at flow measurements. Appendix 1 contains a set of water year run-off data for water years 2000-2003. The spring Chinook in question would have been rearing in water years' 2002 and 2003. These data show that stream flow relative to long term averages was variable in different months, basins, and years. Typically flows were less in 2002-2003 than in 2000-2001. This suggests that rearing conditions may have been worse in 2002-2003.

If rearing mortality due to low flows was higher than normal, this should have been demonstrated in low jack returns as well as low adult returns. The relatively high jack returns and lower adult returns are not necessarily consistent with this theory.

Juvenile Passage Survival

Passage through the hydropower system is a significant source of mortality for juvenile salmonids. The total mortality is affected by the time of migration, flows, spill, and the level of barging. Total passage mortality can vary significantly between stocks and between years.

The Fish Passage Center provides data on juvenile fish passage as well as other data (www.fpc.org). The Fish Passage Center estimated that outmigrant survival of PIT tagged fish in 2002 was similar to levels observed prior to 2001 (FPC 2003). In 2003, they estimated lower than average survival in the Snake River, but average survival from McNary to Bonneville. It appears that while migration conditions were not excellent in either year, they were not out of the range of typical conditions. Migration conditions were generally regarded to be worse in 2001 before these fish migrated. Presuming spring Chinook passage mortality was somewhat greater than average in 2002 and 2003, the jack return should have indicated this. As discussed above, the high jack returns are not necessarily consistent with the assumption of higher than average passage mortality.

Marine Survival

Marine survival undoubtedly has a large influence on returning adult spring Chinook abundance. Like all salmon, spring Chinook are subject to a variety of complex predator/prey relationships, temperature and upwelling regimes, and changing current patterns during their years spent in the ocean.

There are no definitive tools that can be used to correlate any particular environmental factor in the ocean to survival of any particular salmon stock. Given the sparse Coded-wire tag (CWT) recoveries in ocean fisheries, it is challenging to determine where the bulk of any particular spring Chinook stock is in the ocean at any particular time. So while definite changes were noted in the ocean environment from southern British Columbia to California beginning in 2004, it is difficult to gauge to what degree these changes may have impacted spring Chinook survival.

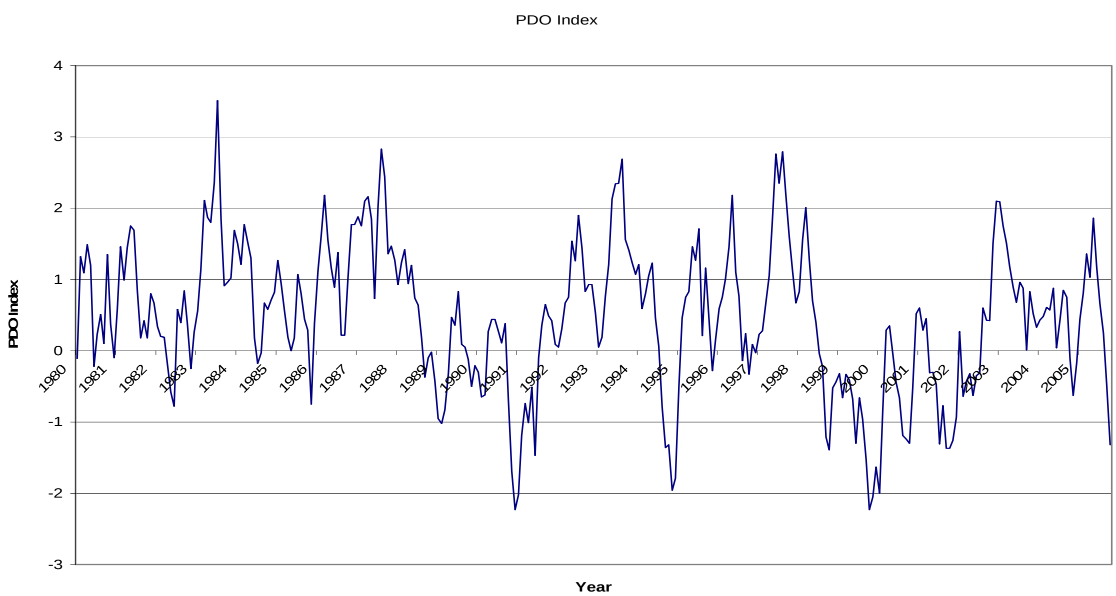

Figure 4. The Pacific Decadal Oscillation (PDO) **(Data from: http://www.jisao.washington.edu/pdo/)**

Some of the commonly available data on ocean conditions include data on the Pacific Decadal Oscillation (PDO) (Figure 4). The PDO is a long-term pattern of sea temperature variability in the North Pacific. Other data include a similar but shorter term measurement of El Nino. The National Oceanic and Atmospheric Administration (NOAA) and other agencies collect numerous data of sea surface temperature, wind patterns and other oceanographic data. There are also data collected on coastal upwelling. Upwelling brings colder nutrient rich water to the surface which stimulates primary production and provides food throughout the food web. There were changes noted in the ocean environment in late 2004 and early 2005 such as lack of upwelling and temperatures that are typically associated with El Nino conditions even though there was not an El Nino at the time. These changes support theory but do not prove that there could have been some change in the ocean environment that affected the survival of spring Chinook.

Several other spring Chinook stocks on the West Coast did not return as predicted. These include: Willamette spring Chinook, Klamath spring Chinook, and Rogue River spring Chinook. The Washington coastal tribes reported that in general, returns of Washington coastal spring/summer Chinook stocks were "low" in 2005 (Zeiner 2005). Exact information on returns relative to forecasts are not available yet. The spring and summer Chinook return to the Fraser River were about the lowest on record in 2005 according to the effort based index calculated in the Albion Chinook test fishery (Brown 2005). To date, spawning counts are also very low. There are no forecasts done for Fraser spring/summer Chinook. There is also no forecast done for Umpqua spring Chinook but the return was also very low relative to recent years. Most of these stocks appear to have had relatively high returns within the past five years but now seem to have declined. The information relative to other spring/summer Chinook returns is consistent with the theory that there may have been some change in ocean survival for these stocks.

Canadian/Ocean Fisheries

It is generally assumed that Columbia River upriver spring Chinook and Snake River spring/summer Chinook are harvested at only very low levels in ocean fisheries. This assumption is based on the small number of CWT's from these groups that are recovered in ocean fisheries (Alaskan, Canadian, or southern U.S.)

As an example, for brood year 1997 Imnaha spring/summer Chinook, a total of 597 CWTs were recovered from 1999 to 2001. Of these, 7 were recovered in the Oregon coastal commercial troll fishery (1.2%) and 4 were recovered in the groundfish fishery (probably whiting fishery) in either California, Oregon or Washington (0.7%). The numbers, locations, and fisheries that recover spring Chinook CWTs is quite variable, but the general low numbers is a common trend for any particular upriver spring Chinook stock. The rest of the recoveries were from in-river fisheries, terminal area fisheries, and hatchery recoveries.

By comparison for Brood Year 2000 and 2001 Imnaha spring summer Chinook, 317 CWTs are reported as recovered in the CWT database. Of these, 3 were reported from Canadian troll fisheries, 3 from the Washington ocean troll fishery and 3 from the treaty ocean troll fishery. These are the only ocean recoveries shown and are only 2.8% of the total recoveries.

For Brood Year 2000 and 2001 Dworshak and Kooskia Spring Chinook, 338 tags have been reported as recovered in the CWT database. Of these, 8 or 2.3% were recovered in Canadian troll fisheries and none in other ocean fisheries. Coded-wire tag data is probably not fully recorded in the PSMFC database from 2004 ocean fisheries yet so these percentages could change as data are finalized.

There is some salmon bycatch in various groundfish fisheries such as the West Coast whiting fishery. NMFS reported to the Pacific Fishery Management Council that in 2004 the total bycatch of all stocks of Chinook in the West Coast whiting fishery was 8,802. CWTs are collected from bycatch sampling for the whiting fishery. TAC has not examined the CWT data, but given the total impact estimate, even if a high proportion was Columbia River spring Chinook it would not account for the discrepancy between the pre-season forecast and actual run size.

In 2004, the Bering Sea Pollock fishery reported a substantial increase in salmon bycatch, but TAC has not been able to determine the magnitude of this impact or how many if any of these fish could have been Columbia River spring Chinook.

In the Makah tribal winter troll fishery that occurred in the Strait of Juan de Fuca in late 2004 and early 2005, the Chinook catch greatly exceeded the pre-season expectations. This fishery was not managed as a quota fishery, but rather with “season management”. The total harvest was just over 20,000 Chinook. Coded-wire tags from the Makah treaty troll fishery from 2004-2005 season showed no CWTs from Columbia River upriver spring Chinook.

West Coast Vancouver Island Troll Fishery

Some people have speculated that recent changes in the West Coast Vancouver Island troll fishery have increased impacts to Columbia River spring Chinook stocks. Figure 1 shows total Chinook catch from all stocks in the WCVI troll fishery from 1980 to 2004. Total harvest has increased each year since 2001 in response to generally increasing trends in Chinook abundance coast wide.

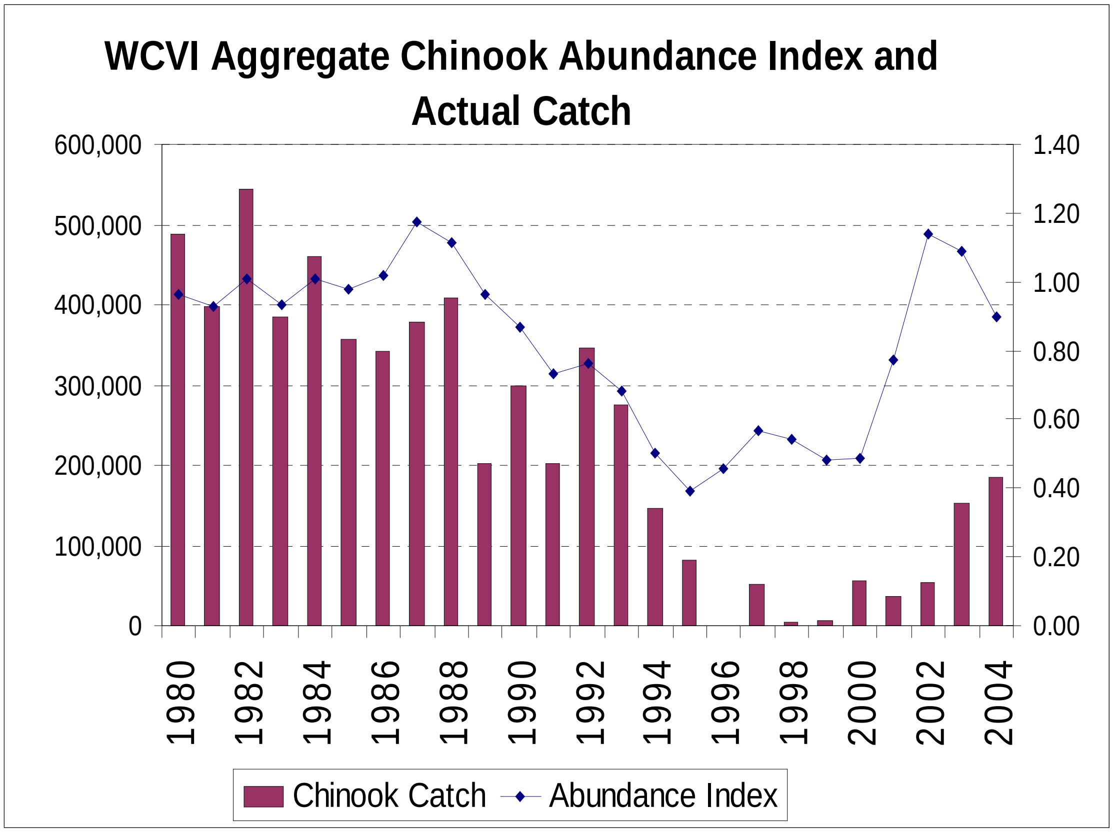

Figure 5. WCVI Chinook Harvest (source M. McClure, CRITFC)

During 1999-2004, an estimated 53 upriver spring Chinook CWTs were recovered from the Northwest Vancouver Island troll fishery out of a total of 17,314 and an estimated 32 upriver spring Chinook CWTs were recovered from the Southwest Vancouver Island troll fishery out of a total of 29,032 total tags.

The proportion of the total WCVI catch comprised of upriver spring Chinook is usually quite small. Even though preliminary estimates of the proportion of the harvest comprised of Columbia River spring Chinook where somewhat higher than previous years, the proportion remained relatively small. Based on this preliminary work, the harvest in the WCVI fishery does not account for the difference between the forecast and actual runsize in 2005.

Marine Mammals

California sea lion and harbor seal populations on the West Coast have been increasing since the passage of the Marine Mammal Protection Act (MMPA) in 1972. These populations have grown at an annual rate of 5%-7%, tripling their numbers since 1970. Harbor Seals are present in the Columbia River year-round, with peak numbers exceeding 3,000 from mid-December through mid-March. California Sea lions are also present (300-500) during the fall, winter and spring (NOAA 1997). Sea Lions and Harbor Seals (pinnipeds) feed on salmonids as well as other fish. In the spring, marine mammals enter the Columbia River presumably following the early smelt and spring Chinook migrations. Pinnipeds tend to leave the river by early June. Numerous sources have indicated a generally increasing trend of pinniped populations in the Columbia in the spring months. Pinnipeds, primarily sea lions, prey on both spring Chinook and steelhead throughout the lower Columbia River. They hunt for salmonids on their own and prey on fish caught in commercial gillnets and fish that are caught on hook and line gear. The abundance of these animals in the Columbia River also appears to have increased.

Numerous sources have indicated a generally increasing trend of pinniped populations in the Columbia in the late winter and spring months (February through April).

In most cases where pinnipeds and salmonid smolts co-occur, it is also assumed that the pinnepeds are feeding on smolts. However, because the smolts are consumed under water, it is difficult to determine the extent of the exploitation (NOAA 1997).

In the past decade, California Sea lions have occurred seasonally with increasing frequency further upstream in the lower Columbia River (below Bonneville Dam). The Corps of Engineers has monitored pinnipeds in the area immediately downstream from Bonneville Dam (Stansell. 2005). Table 3 shows the summary of their observations beginning in 2002.

Table 3. Summary of Pinniped Presence and Predation Below Bonneville Dam.

Year	Number of Days	Average Number per Day	Estimated Salmonid Consumption	Percent of Run Size at Bonneville
2002	58	4.7	1,010	0.4%
2003	71	6.4	2,329	1.1%
2004	97	7.5	3,533	1.9%
2005	101+	8.4	2,920+	3.4%

These data are only reflective of the situation from approximately Tanner Creek to the Dam. TAC is not aware of any reliable estimates for total predation in the lower Columbia River.

Bonneville Dam sampling in 2004 indicated approximately 12% of the spring Chinook run had been marked and or injured from encounters with pinnipeds. This percentage does not inform about how many spring Chinook were killed. Information on direct mortality (i.e. how many pinnipeds are feeding on how many salmonids) is unknown; however, data on scarring and marks from pinnipeds does serve as an indicator of trends of exposure. The Corps of Engineers has not finalized estimates for 2005, but preliminary estimates are likely in the range of 2004 (Lorz 2005). 2005 sampling data show that approximately 22% of the spring Chinook sampled at Bonneville showed some sign (bites, scrapes, claw marks) of encounters with pinnipeds, an increase of 83% over that observed in 2004.

California Sea Lions and harbor seals have always been present in the Columbia River when salmonids are migrating, both in and out of the system, and there has always been some background level of predation. TAC assumes that the background predation may have been relatively constant and we have not attempted to account for it. There is considerable evidence that pinniped numbers have increased in recent years along with probable increases in predation. While we have not attempted to manage or account for these losses, it may be prudent to attempt to due so if it were possible to accurately quantify the level of predation. If you assume that pinnipeds prey on salmon and steelhead at equal rates, the estimated predation in the Bonneville tailrace only accounts for a small fraction of the missing fish in either 2004 or 2005.

Summary

TAC has not been able to make a definitive conclusion regarding why there was such a significant difference between the pre-season forecast and the actual spring Chinook return in 2005. TAC believes that the reason is most likely due to a combination of factors working together. While it is clear that some sources of mortality have increased relative to recent years, the available data suggests that no single source (i.e.: Canadian fisheries or sea lions) can be blamed alone. TAC believes that the most important factor may be an adverse change in marine conditions that reduced survival and which likely increased the level of inherent uncertainty in our ability to forecast the return.

TAC will further review the spring Chinook forecast methodology and dataset in an effort to ensure future forecasts are as accurate as possible. When detailed run reconstruction is completed, more information will be available for specific tributary returns. The 2005 run points to the desirability to work toward a better understanding of spring Chinook survival in the ocean, but given our limited knowledge of where spring Chinook are at various times in their ocean migration, this will be a difficult problem to address. The TAC will continue to update the *U.S. v Oregon* Policy Group as more information becomes available.

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Appendix 1. Tributary Flow Data 2000-2003

WY 2000 RUNOFF DATA

MID-COLUMBIA

OKANOGAN R. at TONASKET	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	76	170	130	99	87	59	213	441	435	213	65	77
30 YR. AVG.	69	74	71	69	71	88	139	480	615	233	92	65
PCT. AVG.	**110**	**228**	**183**	**143**	**123**	**67**	**153**	**92**	**71**	**91**	**71**	**118**

METHOW R. at PATEROS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	35.7	77.3	55.3	41.8	31.1	35.7	155.3	230.6	252.3	104.5	32	18.4
30 YR. AVG.	28.7	29.1	27.6	26.3	23.8	36.3	87.2	299.5	359	127.1	42	26.7
PCT. AVG.	**124**	**266**	**200**	**159**	**130**	**98**	**178**	**77**	**70**	**82**	**76**	**69.1**

WENATCHEE R. AT PESHASTIN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	65	256	183	88	56	73	286	416	509	263	88	48
30 YR. AVG.	61	95	110	103	94	121	207	455	542	280	99	52
PCT. AVG.	**106**	**271**	**166**	**86**	**59**	**61**	**138**	**92**	**94**	**94**	**89**	**91**

LOWER SNAKE

IMNAHA R. at IMNAHA	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	9.8	14.9	11.1	10.5	9.8	21.5	70.2	76.2	59.5	25.2	12.3	10.7
30 YR. AVG.	10.4	12.1	12.9	13.8	15.2	27.6	53.5	95.2	83.6	37.1	13	9.5
PCT. AVG.	**95**	**123**	**86**	**76**	**64**	**78**	**131**	**80**	**71**	**68**	**95**	**113**

SALMON R. AT WHITEBIRD	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	280	303	277	271	267	346	915	1799	1291	413	219	221
30 YR. AVG.	320	317	296	285	278	366	672	1901	2478	905	357	289
PCT. AVG.	**87**	**96**	**93**	**95**	**96**	**94**	**136**	**95**	**52**	**46**	**61**	**77**

CLEARWATER R. at OROFINO	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	97	180	232	168	299	500	1151	1585	1021	248	86	102
30 YR. AVG.	140	186	237	258	298	466	888	1770	1616	445	138	120
PCT. AVG.	**69**	**97**	**98**	**65**	**100**	**107**	**130**	**90**	**63**	**56**	**62**	**85**

GRANDE RONDE R. at TROY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	48.6	85.1	128.5	93.5	215.1	322.8	455.2	339.4	254.1	105.7	41.2	49.4
30 YR. AVG.	52	69.7	114.1	137.5	172.2	256.8	342	406.3	334.1	131.5	51.8	46.6
PCT. AVG.	**94**	**122**	**113**	**68**	**125**	**126**	**133**	**84**	**76**	**80**	**80**	**106**

Source: NOAA-NWS-Northwest River Forecast Center   October 13, 2005   CRITFC Hydro Program

WY 2000 RUNOFF DATA

LOWER COLUMBIA

S.F. WALLA WALLA near MILTON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	2.9	6	14.4	10.1	15.7	19.7	26.5	14.4	11.1	3.4	1.9	2.3
30 YR. AVG.	6.7	8	10.4	11.8	11.4	13.3	15.8	17.9	11.8	7.6	6.8	6.4
PCT. AVG.	**43**	**76**	**138**	**85**	**138**	**148**	**168**	**81**	**95**	**44**	**28**	**36**

UMATILLA R. at PENDLETON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	3.7	11.3	40.6	30.1	74.8	96.5	82.7	30.7	24.4	4.9	2.5	3.6
30 YR. AVG.	4.2	12.8	34.2	45.3	50.8	62.7	70.3	48.8	17.2	4.4	2.6	2.9
PCT. AVG.	**87**	**89**	**119**	**67**	**147**	**154**	**118**	**63**	**142**	**112**	**94**	**124**

JOHN DAY R. at SERVICE CREEK	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	23.4	31.5	40	51.6	136.3	279.7	390.3	152.8	68.4	18.4	3.7	8.9
30 YR. AVG.	22.5	40	82.7	128.7	148.2	242.7	298	304	154.2	38.7	12.5	13.1
PCT. AVG.	**104**	**79**	**48**	**40**	**92**	**115**	**131**	**50**	**44**	**48**	**30**	**68**

DESCHUTES R. at BIGGS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	341.2	394.5	419.3	402.1	481.4	536.1	535.5	364.6	325.5	299.4	282.8	282
30 YR. AVG.	290	323.9	403.2	438.6	415.5	445.4	399.1	363.2	315.2	285.5	272.2	266.6
PCT. AVG.	**118**	**122**	**104**	**92**	**116**	**120**	**134**	**100**	**103**	**105**	**104**	**106**

Source: NOAA-NWS-Northwest River Forecast Center   October 13, 2005   CRITFC Hydro Program

WY 2001 RUNOFF DATA

MID-COLUMBIA

OKANOGAN R. at TONASKET	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	65	61	49	42	32	38	59	260	211	81	36	28
30 YR. AVG.	69	74	71	69	71	88	139	480	615	233	92	65
PCT. AVG.	**94**	**82**	**69**	**61**	**45**	**44**	**42**	**54**	**34**	**35**	**40**	**43**

METHOW R. at PATEROS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	20.9	19	19.1	17.2	15.5	17.8	18.4	115.6	91.6	39.3	18.4	13.7
30 YR. AVG.	28.7	29.1	27.6	26.3	23.8	36.3	87.2	299.5	359	127.1	42	26.7
PCT. AVG.	**73**	**66**	**69**	**65**	**65**	**49**	**21**	**39**	**26**	**31**	**44**	**51.3**

WENATCHEE R. AT PESHASTIN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	62	45	36	36	27	56	114	356	217	107	45	27
30 YR. AVG.	61	95	110	103	94	121	207	455	542	280	99	52
PCT. AVG.	**102**	**47**	**33**	**35**	**29**	**46**	**55**	**78**	**40**	**38**	**46**	**51**

LOWER SNAKE

IMNAHA R. at IMNAHA	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	12.3	9.5	8.6	7.4	7.2	15.4	27.4	46.7	22.6	11.1	6.8	5.9
30 YR. AVG.	10.4	12.1	12.9	13.8	15.2	27.6	53.5	95.2	83.6	37.1	13	9.5
PCT. AVG.	**118**	**79**	**67**	**54**	**48**	**56**	**51**	**49**	**27**	**30**	**52**	**63**

SALMON R. AT WHITEBIRD	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	302	253	227	209	192	283	398	1244	697	298	182	165
30 YR. AVG.	320	317	296	285	278	366	672	1901	2478	905	357	289
PCT. AVG.	**94**	**80**	**77**	**73**	**69**	**77**	**59**	**65**	**28**	**33**	**51**	**57**

CLEARWATER R. at OROFINO	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	261	152	125	116	136	392	643	1519	773	227	104	63
30 YR. AVG.	140	186	237	258	298	466	888	1770	1616	445	138	120
PCT. AVG.	**186**	**82**	**53**	**45**	**46**	**84**	**72**	**86**	**48**	**51**	**75**	**53**

GRANDE RONDE R. at TROY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	60.3	58.3	52.9	52.9	50.5	143.3	208.8	316	110.7	51	33.8	28
30 YR. AVG.	52	69.7	114.1	137.5	172.2	256.8	342	406.3	334.1	131.5	51.8	46.6
PCT. AVG.	**116**	**84**	**46**	**39**	**29**	**56**	**61**	**78**	**33**	**39**	**65**	**60**

Source: NOAA-NWS-Northwest River Forecast Center October 13, 2005 CRITFC Hydro Program

WY 2001 RUNOFF DATA

LOWER COLUMBIA

S.F. WALLA WALLA near MILTON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	3.8	4.6	5.8	5.3	6.5	15.8	22.7	15.8	4.2	2.4	2.4	2.3
30 YR. AVG.	6.7	8	10.4	11.8	11.4	13.3	15.8	17.9	11.8	7.6	6.8	6.4
PCT. AVG.	**57**	**58**	**55**	**45**	**57**	**119**	**144**	**89**	**36**	**32**	**35**	**36**

UMATILLA R. at PENDLETON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	7.1	11.3	16	16	21.1	51.6	66.6	33.8	7.1	3.7	2.5	2.4
30 YR. AVG.	4.2	12.8	34.2	45.3	50.8	62.7	70.3	48.8	17.2	4.4	2.6	2.9
PCT. AVG.	**167**	**89**	**47**	**35**	**42**	**82**	**95**	**69**	**41**	**84**	**94**	**83**

JOHN DAY R. at SERVICE CREEK	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	24.6	25	28.3	28.9	33.3	111.3	173.1	155.5	38.7	11.1	4.3	4.8
30 YR. AVG.	22.5	40	82.7	128.7	148.2	242.7	298	304	154.2	38.7	12.5	13.1
PCT. AVG.	**109**	**63**	**34**	**22**	**23**	**46**	**58**	**51**	**25**	**29**	**34**	**36**

DESCHUTES R. at BIGGS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	320.9	323.7	332	320.3	290.4	317.2	289.8	307.4	271.9	272.4	263.8	257
30 YR. AVG.	290	323.9	403.2	438.6	415.5	445.4	399.1	363.2	315.2	285.5	272.2	266.6
PCT. AVG.	**111**	**100**	**82**	**73**	**70**	**71**	**73**	**85**	**86**	**95**	**97**	**96**

Source: NOAA-NWS-Northwest River Forecast Center October 13, 2005 CRITFC Hydro Program

WY 2002 RUNOFF DATA

MID-COLUMBIA

OKANOGAN R. at TONASKET	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	47	65	58	81	53	66	161	545	800	259	74	55
30 YR. AVG.	68	85	79	73	78	103	177	542	597	265	113	74
PCT. AVG.	**68**	**77**	**74**	**111**	**69**	**64**	**91**	**101**	**134**	**98**	**66**	**74**

METHOW R. at PATEROS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	17.2	18.4	24	23.4	20.5	28.9	85.7	265.6	419.5	148.2	39.3	23.2
30 YR. AVG.	28.1	32	29.9	26.4	23.7	38.7	102.6	320.4	344.7	142.9	46.8	27.3
PCT. AVG.	**61**	**58**	**80**	**89**	**87**	**75**	**84**	**83**	**122**	**104**	**84**	**85**

WENATCHEE R. AT PESHASTIN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	40	140	80	139	90	107	256	446	691	354	87	39
30 YR. AVG.	60	123	118	99	101	133	228	470	498	285	103	51
PCT. AVG.	**67**	**114**	**68**	**141**	**89**	**80**	**113**	**95**	**139**	**124**	**85**	**76**

LOWER SNAKE

IMNAHA R. at IMNAHA	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	7.4	8.9	9.2	9.2	7.8	12.9	57.7	75	67.2	24	9.8	7.1
30 YR. AVG.	9.6	11.7	13.2	15.2	14.9	30.9	55.5	96.3	79.2	39.1	13.7	9.6
PCT. AVG.	**77**	**76**	**70**	**61**	**52**	**42**	**104**	**78**	**85**	**61**	**72**	**75**

SALMON R. AT WHITEBIRD	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	217	255	218	173	190	255	735	1550	1854	546	243	200
30 YR. AVG.	301	310	297	288	272	394	704	1924	2331	892	356	275
PCT. AVG.	**72**	**82**	**73**	**60**	**70**	**65**	**104**	**81**	**80**	**61**	**68**	**73**

CLEARWATER R. at OROFINO	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	126	177	135	210	178	329	996	1594	1822	458	109	68
30 YR. AVG.	128	196	252	249	313	512	912	1766	1504	464	144	111
PCT. AVG.	**98**	**90**	**53**	**84**	**57**	**64**	**109**	**90**	**121**	**99**	**76**	**61**

GRANDE RONDE R. at TROY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	41.2	56.5	63.9	95.3	83.9	204.1	492.1	372	330.8	92.2	32.6	28.6
30 YR. AVG.	50.7	74.7	123.7	143.3	195.8	304	365.9	439.6	330.2	138.6	52.2	45.3
PCT. AVG.	**81**	**76**	**52**	**67**	**43**	**67**	**135**	**85**	**100**	**67**	**62**	**63**

Source: NOAA-NWS-Northwest River Forecast Center October 13, 2005 CRITFC Hydro Program

WY 2002 RUNOFF DATA

LOWER COLUMBIA

S.F. WALLA WALLA near MILTON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	2.7	4.3	7.2	10.8	11.4	15.7	32.6	18.4	4.8	1.3	0.9	0.9
30 YR. AVG.	6.7	8	10.4	11.8	11.4	13.3	15.8	17.9	11.8	7.6	6.8	6.4
PCT. AVG.	**40**	**54**	**69**	**91**	**100**	**118**	**206**	**103**	**41**	**18**	**13**	**14**

UMATILLA R. at PENDLETON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	3.7	8.9	20.3	33.2	36.7	58.4	97	40.6	11.9	3.7	1.8	2.4
30 YR. AVG.	4.1	15.1	36.9	43.7	54	71.5	70.2	53.6	17.8	4.7	2.8	2.9
PCT. AVG.	**90**	**59**	**55**	**76**	**68**	**82**	**138**	**76**	**67**	**78**	**65**	**82**

JOHN DAY R. at SERVICE CREEK	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	16.6	24.4	40.6	78.7	62.8	125.4	326.6	162.9	72.6	11.7	4.3	5.4
30 YR. AVG.	23.4	41	83.2	116.6	156.7	287.8	316.4	324.9	154.1	42.3	13.9	13.7
PCT. AVG.	**71**	**60**	**49**	**68**	**40**	**44**	**103**	**50**	**47**	**28**	**31**	**39**

DESCHUTES R. at BIGGS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	285.3	301.1	341.8	376.9	294.3	321.5	360.6	329.5	330.2	284	263.1	256.4
30 YR. AVG.	297.4	331.9	405.2	449.4	437.4	475.1	417.1	370.9	319.3	288.9	275.3	269.2
PCT. AVG.	**96**	**91**	**84**	**84**	**67**	**68**	**86**	**89**	**103**	**98**	**96**	**95**

Source: NOAA-NWS-Northwest River Forecast Center   October 13, 2005   CRITFC Hydro Program

WY 2003 RUNOFF DATA

MID-COLUMBIA

OKANOGAN R. at TONASKET	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	44	50	48	45	41	42	114	285	327	69	23	29
30 YR. AVG.	68	85	79	73	78	103	177	542	597	265	113	74
PCT. AVG.	**65**	**58**	**60**	**62**	**52**	**41**	**64**	**53**	**55**	**26**	**21**	**40**

METHOW R. at PATEROS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	20.3	17.3	19.1	17.8	15.5	21.5	77.9	209.7	289.2	62.7	20.3	14.3
30 YR. AVG.	28.1	32	29.9	26.4	23.7	38.7	102.6	320.4	344.7	142.9	46.8	27.3
PCT. AVG.	**72**	**54**	**64**	**68**	**66**	**56**	**76**	**65**	**84**	**44**	**43**	**52.3**

WENATCHEE R. AT PESHASTIN	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	28	40	41	73	112	146	225	372	446	144	48	27
30 YR. AVG.	60	123	118	99	101	133	228	470	498	285	103	51
PCT. AVG.	**46**	**33**	**35**	**74**	**111**	**110**	**99**	**79**	**90**	**50**	**47**	**54**

LOWER SNAKE

IMNAHA R. at IMNAHA	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	7.4	6.5	9.2	14.1	15.5	32.6	53	81.2	72	22.1	3.1	1.8
30 YR. AVG.	9.6	11.7	13.2	15.2	14.9	30.9	55.5	96.3	79.2	39.1	13.7	9.6
PCT. AVG.	**77**	**56**	**70**	**93**	**104**	**106**	**96**	**84**	**91**	**57**	**22**	**19**

SALMON R. AT WHITEBIRD	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	210	216	211	245	265	387	724	1855	2024	479	251	204
30 YR. AVG.	301	310	297	288	272	394	704	1924	2331	892	356	275
PCT. AVG.	**70**	**70**	**71**	**85**	**97**	**98**	**103**	**96**	**87**	**54**	**71**	**74**

CLEARWATER R. at OROFINO	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	64	96	91	251	426	711	1125	1736	1257	264	100	72
30 YR. AVG.	128	196	252	249	313	512	912	1766	1504	464	144	111
PCT. AVG.	**50**	**49**	**36**	**101**	**136**	**139**	**123**	**98**	**84**	**57**	**69**	**65**

GRANDE RONDE R. at TROY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	40	42.2	42.4	92.8	161.6	377.5	345.7	364	263	59.6	32	30.3
30 YR. AVG.	50.7	74.7	123.7	143.3	195.8	304	365.9	439.6	330.2	138.6	52.2	45.3
PCT. AVG.	**79**	**57**	**34**	**65**	**83**	**124**	**95**	**83**	**80**	**43**	**61**	**67**

Source: NOAA-NWS-Northwest River Forecast Center October 13, 2005 CRITFC Hydro Program

WY 2003 RUNOFF DATA

LOWER COLUMBIA

S.F. WALLA WALLA near MILTON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	1.3	2.6	3.1	15.3	19.1	35.9	26.1	16.6	3.9	1.8	1.8	1.7
30 YR. AVG.	6.7	8	10.4	11.8	11.4	13.3	15.8	17.9	11.8	7.6	6.8	6.4
PCT. AVG.	**20**	**33**	**30**	**129**	**168**	**271**	**165**	**93**	**33**	**24**	**26**	**27**

UMATILLA R. at PENDLETON	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	3.7	4.2	4.9	43.7	55.5	95.3	64.9	36.3	7.1	2.5	1.8	2.4
30 YR. AVG.	4.1	15.1	36.9	43.7	54	71.5	70.2	53.6	17.8	4.7	2.8	2.9
PCT. AVG.	**90**	**28**	**13**	**100**	**103**	**133**	**92**	**68**	**40**	**52**	**65**	**82**

JOHN DAY R. at SERVICE CREEK	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	15.4	17.3	22.1	63.9	118.8	205.3	270.1	250.2	92.2	12.9	4.3	6.5
30 YR. AVG.	23.4	41	83.2	116.6	156.7	287.8	316.4	324.9	154.1	42.3	13.9	13.7
PCT. AVG.	**66**	**42**	**27**	**55**	**76**	**71**	**85**	**77**	**60**	**31**	**31**	**48**

DESCHUTES R. at BIGGS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Obs. Volume (KaF)	282.2	280.2	305.6	354.1	356	362.1	340.3	293.3	277.3	268.1	267.4	256.4
30 YR. AVG.	297.4	331.9	405.2	449.4	437.4	475.1	417.1	370.9	319.3	288.9	275.3	269.2
PCT. AVG.	**95**	**84**	**75**	**79**	**81**	**76**	**82**	**79**	**87**	**93**	**97**	**95**

Source: NOAA-NWS-Northwest River Forecast Center — October 13, 2005 — CRITFC Hydro Program