

Submission 9

Estimate of SARs of Snake River Spring Chinook Salmon

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Our SAR analyses for the composite wild Snake River spring chinook salmon population required an annual estimate of the number of wild spring chinook salmon smolts in the outmigration, the annual wild catch plus escapement of returning spring chinook salmon to the Snake River Basin above Ice Harbor Dam, and an estimate of the age composition of the adults that returned each year. The SAR was based on the combined catch plus escapement of natural 1-, 2-, and 3-ocean Snake River adults that returned from each year's smolt outmigration divided by the estimated number of natural smolts in the outmigration. No smolt abundance estimates were available for the upper Columbia or John Day Rivers so SARs for these two areas were not available.

We estimated the annual natural adult run (catch plus escapement) to the Snake River Basin from Beamesderfer et al. 1997 (Table B2., unpublished manuscript¹.) From the Beamesderfer et al. manuscript we also computed the natural run (catch plus escapement) for wild spring chinook salmon to the Methow River (from Table G.4.) in the upper Columbia River Basin and to the John Day River (from Table J.4.) in the middle Columbia River Basin to use as comparisons to the Snake River stocks.

We estimated the total number of spring chinook salmon redds in the Snake River Basin from 1964 to 1995 by combining the annual indexed redds for the Salmon River and Middle Fork Salmon River from Matthews and Waples (1991) with the best total indexed redds estimate for streams in the Imnaha and Grand Ronde River as detailed in the Beamesderfer et al. manuscript. To estimate missing redd counts from 1991 to 1995 in the Salmon River, we averaged the percentage of Salmon River redds to the total number of spring chinook salmon redds for the period 1986 to 1990 and applied this value to the annual total number of redds in the other 3 basins for the missing years.

Estimates of natural smolts for the period from 1964 to 1993 were based on Raymond's (1988) estimates for the period from 1964 to 1984 and an estimate of natural smolts for 1985 to 1995. The smolt estimates for the latter period were derived from an index of natural smolts from 1976 to 1984 compared with the annual detailed redd count information from the Middle Fork Salmon, Imnaha, and Grand Ronde Rivers. The average number of smolts per redd was 973 for the period 1976 to 1984; 1,030 for the period 1978 to 1984; and 1,047 for the period 1980 to 1984. We averaged the three averages to develop a smolt per redd index of 1,017 and applied this to the number of total redds estimated between 1983 and 1995.

We then used the age-class distributions on the spawning grounds and weighted them by the percentage of redds in the indexed areas to the entire number of indexed redds. We used the same age class-distribution for Salmon River redds as those in the Middle Fork Salmon River as age-distribution data for the period 1960 to 1981 between the two areas was very similar (unpublished data from IDFG, Charlie Petrosky, personal communication).

¹Beamesderfer, R. C. P., H. A. Schaller, M. P. Zimmerman, C. E. Petrosky, O. P. Langness, and L. LaVoy. 1997. Spawner - recruit data for spring and summer chinook salmon populations in Idaho, Oregon, and Washington. In D.R. Marmorek and C. N. Peters (eds.) Plan for Analyzing and Testing Hypotheses (PATH): Retrospective and prospective analyses of spring/summer chinook reviewed in FY1997. Available from ESSA Technologies Ltd., Vancouver, B.C.

RESULTS OF SAR ANALYSIS

The estimated total indexed spring chinook salmon redds in the Snake River Basin ranged from a low of 144 in 1995 to a high of 7,434 in 1967 (Table 1.) The combined catch plus escapement of natural spring chinook salmon to the Snake River Basin from smolt outmigrations from 1964 through 1993 ranged from approximately 600 to 90,900 fish (Figure 1.) Prior to 1979, catches ranged from approximately 35 to 55% of the escapement; whereas, since 1979, the return to the Snake River Basin was comprised of almost entirely escapement. For comparison, the combined catch plus escapement of natural spring chinook salmon to the Methow River in the upper Columbia River Basin and the John Day River in the middle Columbia River ranged from approximately 420 to 15,165 (Figure 2) and 1,130 to 10,930 fish (Figure 3), respectively. The SAR of natural spring chinook salmon to the Snake River Basin from the 1964 through 1993 smolt migrations ranged from 0.1 to 7.0 % (Figure 4.)

ANALYSIS OF THE EVIDENCE

The SARs for natural Snake River wild spring chinook salmon provide the basis on which we analyze the evidence about what were the primary and secondary factors that led toward the depletion of the natural Snake River spring chinook salmon stocks and the hypotheses about which factors presently appear to have the largest influence on stock performance. We argue that any hypotheses or combination of hypotheses about past and present stock performance must have compatibility with the observed patterns in the SARs. From our SAR derivation (Figure 4), we identify four general periods (based on the year of the juvenile smolt migration) to which hypotheses must match: 1964 to 1970, 1971 to 1981, 1982 to 1985, and 1986 to present (Figure 5.)

As hydropower is generally identified as the major contributing factor that depleted the Snake River stocks and continues to keep them depressed, we first discuss the SARs in the four periods and provide observations about the hydropower conditions that existed in each of the periods.

Period I. The SARs from 1964 to 1970, with the exception of the 1967 outmigration, averaged about 4%. From 1964 to 1967, Snake River Basin smolts migrated through only Ice Harbor, McNary, The Dalles, and Bonneville Dams. The lowest SAR of the period occurred in 1968, the year John Day Dam was completed, although power was not generated at the dam until July of that year. The 1969 SAR was above the average and the 1970 SAR nearly average, the respective years when Lower Monumental and Little Goose Dams were completed. Average flows during the outmigrations ranged from 86 to 175 kcfs (Figure 6.) The estimated juvenile chinook salmon survival from Ice Harbor Dam to The Dalles Dam averaged 63% from 1966 to 1968 Raymond (1979.) In 1969, juvenile survival from Lower Monumental Dam to The Dalles Dam dropped approximately 10% to 56%. The estimated juvenile survival from Little Goose Dam to The Dalles Dam dropped to 22% in 1970. Despite wide ranges in flows, nearly twice as many dams in the hydropower system through which smolts migrated at the end of the period compared to the beginning, and estimated large changes in smolt survival, SARs over the period were relatively unchanged.

Period II. The SARs in this period dropped considerably from Period I, with the exception of the 1975 outmigration year. The SAR in 1975 was nearly the average of the previous period, even though it was the year that Lower Granite Dam was completed and smolts migrated through eight dams for the first time. The direct impact of dams on the juvenile downstream migrants, as measured with marked fish, was detailed from 1971 to 1975 by Raymond (1979.) Juvenile chinook salmon survivals ranged from a low of 2-5 % in the low-flow years of 1973 and 1977, and ranged from 20-30% in other years. The lowest SAR was a product of the 1976 smolt migration even though the lowest survival of migrants were observed

during the 1973 and 1977 low-flow years. Further, the SAR in 1976 was approximately 10 times lower than in 1975 although flows and spill within the hydropower system were nearly identical in both years. Transportation of smolts from the upper dams on the Snake River became operational for the general smolt population beginning in 1977. The estimated percentage of smolts in the outmigration transported between 1977 and 1981 ranged from 46-68%. With the exception of the 1975 outmigration, with widely varying levels of transportation and flow, SARs were relatively, uniformly low.

Period III. A trash boom was installed in front of the powerhouse at Lower Granite Dam and it substantially decreased debris associated with the bypass system compared to previous years (Williams and Matthews 1995.) All SARs in this period were higher than most of the SARs in Period II and the 1982 and 1985 SARs were nearly as high as those in Period I. Flows and spill were generally high from 1982 to 1984 and, thus, the percentage of fish transported in those years (range 26 to 28%) was lower than in previous period. However, in 1985, flows were again lower and an estimated 51% of the smolts were transported.

Period IV. All SARs in this period were uniformly low although flows, the amount of spill, and percentage of fish transported varied considerably between years.

Table 1. Estimate of total spring chinook salmon redds in the Snake River Basin, 1964 to 1995.

Year	Grand	Middle Fk. Ronde	Salmon	Salmon	Imnaha Total
1964	1254	1813	3479	496	7042
1965	989	968	1835	391	4183
1966	1565	1947	3269	561	7342
1967	1401	1970	3616	447	7434
1968	1178	2005	3043	507	6733
1969	1871	1395	1571	556	5393
1970	1512	1408	1922	474	5316
1971	1514	759	2108	738	5119
1972	1022	986	2755	626	5389
1973	1412	1545	2385	909	6251
1974	660	550	1416	464	3090
1975	396	755	1695	281	3127
1976	529	233	876	280	1918
1977	430	330	1742	241	2743
1978	792	879	4389	715	6775
1979	161	216	536	85	998
1980	334	39	128	66	567
1981	185	170	722	162	1239
1982	368	98	304	225	995
1983	327	154	533	178	1192
1984	246	142	188	206	782
1985	458	304	318	245	1325
1986	547	451	494	207	1699
1987	672	438	678	156	1944
1988	868	1164	607	208	2847
1989	288	118	325	74	805
1990	265	256	273	54	848
1991	164	260	*246	99	769
1992	294	173	*293	118	878
1993	528	655	*784	384	2351
1994	169	23	*114	36	342
1995	53	11	*48	32	144

* estimated

Figure 1. Estimated adult wild spring chinook salmon returns (catch + escapement) to the Snake River Basin above Ice Harbor Dam.

Figure 2. Estimated adult wild spring chinook salmon returns (catch + escapement) to the Methow River.

Figure 3. Estimated adult wild spring chinook salmon returns (catch + escapement) to the John Day River.

Figure 4. Wild Snake River spring chinook salmon smolt to adult return (catch + escapement) rates to the upper dam on the Snake River. (Estimates of wild smolts from 1964 to 1984 from Raymond [1988]. Estimates of smolts from 1985 to 1995 based on an index of smolts compared to indexed redds from 1976 to 1984.)

Figure 5. Wild Snake River spring chinook salmon smolt to adult return (catch + escapement) rates to the upper dam on the Snake River broken out by periods. (Estimates of wild smolts from 1964 to 1984 from Raymond [1988]. Estimates of smolts from 1985 to 1995 based on an index of smolts compared to indexed redds from 1976 to 1984.)

Figure 6. Average Snake River flows during the spring smolt outmigration.