FISH PASSAGE CENTER

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MEMORANDUM

TO: Rod Sando

FROM: Michele DeHart

DATE: June 18, 2014

RE: Data Request

You requested that we characterize the in-river juvenile migration conditions that result in high smolt-to-adult return rates (SARs). In response to that request we are providing the following information.

The Comparative Survival Study (CSS) began in 1996 with the objective of establishing a long-term dataset of annual estimates of the survival rate of generations of salmon from their outmigration as smolts to their return to freshwater as adults to spawn. Since then, CSS PIT-tag monitoring efforts have generated useful time series of data on juvenile passage metrics, juvenile survival rates, and smolt-to-adult return rates. These data have provided an important monitoring tool for tracking population trends. To date, CSS analyses have resulted in new understandings of the relationships between the freshwater passage experience of smolts and their subsequent survival at later life stages, including first year ocean survival and smolt-to-adult return rates.

Using PIT-tag data generated through the CSS, Haeseker et al. (2012) developed models for Snake River spring/summer Chinook and steelhead that characterized the variation in overall life-cycle mortality rates. Using these models they concluded that increases in spill levels and reductions in water transit times increase smolt-to-adult survival rates. The models considered a range of ocean conditions and the authors concluded that their study highlights the importance of considering river management options in the face of variable ocean conditions for Snake River Chinook salmon. Similarly, using spawner-to-recruit data Petrosky and Schaller (2010) and Schaller et al. (2014) suggest that hydrosystem-related direct and delayed mortality may be reduced substantially through actions (e.g., spill, surface passage, increases in water velocity through drawdown, or dam removal) that reduce the number of powerhouse passages, speed water velocity and juvenile migrations, as well as reduce the reliance on juvenile collection and transportation.

So, the CSS reports, as well as all the papers generated from the CSS data, contain the analyses that answer your question. However, in an attempt to simplify the concepts we have tried to present a summary of the factors that have been identified by the CSS as being significant in determining the SARs. We used wild Snake River spring/summer Chinook, the data set for which the CSS has the longest time series of information, to identify recent years with the highest and lowest estimated SARs. We looked at the five highest SARs measured through the CSS and the six years with the lowest SARs. We then went back and quantified the annual juvenile migration conditions that affect the variables identified as significant: some measure of spill capturing the avoidance of powerhouse passage, and flow or water transit time. In this case spill is used to incorporate the effect of decreasing fish migration time and avoidance of powerhouse passage.

The juvenile migration conditions for each year were illustrated using runoff volume (January through July) in the Snake and Middle Columbia rivers and its rank in the historic record (1929–2012), average flow over the Biological Opinion (BiOp) spring flow period, and the total amount of spill (Ksfd) that occurred over the eight dams in the Federal Columbia River Power System (FCRPS) during the spring period. (The BiOp spring period is defined as April 3 to June 20 in the Snake and April 10 to June 30 in the Upper and Middle Columbia). The runoff volume for a given year provides insight into the amount of water available and helps to provide an understanding as to whether the conditions that occurred were voluntary or involuntary. The average flow is used to illustrate the relative transit time of fish in the riverine system; the higher the average flow, the faster the fish travel time. The total spill as the sum of Ksfd across all FRCPS projects for the spring BiOp period is used to illustrate the relative provision of non-powerhouse passage routes, and the magnitude of the reduction in fish delay as they approach a powerhouse.

The variability in ocean conditions is presented using the index for the May Pacific Decadal Oscillation (PDO) for each year. A negative PDO suggests good ocean conditions characterized by cooler ocean temperatures in the eastern Pacific and a positive PDO suggests negative ocean conditions characterized by warmer ocean conditions in the eastern Pacific. Values for PDO closer to zero suggest more neutral ocean conditions.

The river and ocean conditions were then given a relative rank to demonstrate the variability in the parameters. The relative ranking of river conditions was assessed as "+", "++", "0", "-". A positive value was given if river conditions exceeded BiOp targets, 0 if they were close to BIOP targets, and a negative value if less than BiOp targets. The 1997 river conditions were designated "++" since this extremely high water year resulted in conditions that were nearly double the BiOp targets. The ocean conditions received a rank of "+" if the May PDO was 0 to -1; a "++" if less than -1; a "-" if 0 to 1; and a "- -" if greater than 1. An overall ranking of river and ocean variables is provided based on the individual values and the resulting SAR is reported.

Table 1. Characterization of juvenile conditions and resulting SARs for the five highest years and the six lowest years for juvenile migration years between 1994 and 2011.

Juvenile Migration Year	Runoff Volume				Spring Period Flow			∑ Daily Spill (Kcfs) *1000	PDO	Relative Ranking			SAR
	LGR	Rank	TDA	Rank	LGR	PRD	MCN			River	Ocean	Overall	
1997	50	1	159	1	163	262	441	121	1.83	+ +	- -	+	1.78
1999	36	18	124	13	117	170	304	75	-0.68	+	+	+	2.55
2000	25	50	98	47	85	158	243	55	-0.05	**0**	+	+	1.72
2008	28	39	99	46	99	168	287	78	-1.37	+	+ +	+	3.24
2009	29	30	90	59	110	141	268	66	-0.88	+	+	+	1.61
1994	16	79	75	73	61	124	191	20	1.23	-	- -	-	0.47
1995	29	34	104	41	101	131	253	46	1.46	+	- -	-	0.35
1996	42	8	140	6	138	217	358	88	2.18	+	- -	-	0.43
2003	24	55	88	63	90	141	231	49	0.89	**0**	-	-	0.34
2004	21	63	83	66	70	127	203	42	0.88	-	-	-	0.54
2005	18	74	81	69	66	123	196	50	1.86	-	- -	-	0.24

Notes:

1. Runoff Volume (January to July) and rank among 83 water years (1929 –2011).
2. Spring Flow Period equals April 3 to June 20 in the Snake and April 10 to June 30 in the Upper and Middle Columbia.
3. ∑ Daily spill equals total Kcfs by day summed across the spring period for each project, then totaled across all projects in the FCRPS.
4. PDO index for May obtained from http://jisao.washington.edu/pdo/PDO.latest .
5. SARs from Table 4.1 CSS 2013 Annual Report.

From Table 1, the importance of juvenile migration conditions in determining SARs is apparent. Only those years with in-river conditions, where river flow and spill volumes met, or more often exceeded the BiOp targets, yielded the higher SARs. In order for the high SAR to occur, the juvenile migration conditions were usually associated with positive ocean conditions, except for one instance. In 1997 the juvenile migration conditions far exceeded any observed in other years and in spite of the poor ocean conditions, the fish returned at a relatively higher SAR. The years with the lowest SARs also illustrate a few conditions. Years with flow and spill less than, or near, the BiOp flow targets yield low adult returns. If fish don't survive the juvenile river migration, or through the early ocean period due to delayed hydrosystem mortality, (Petrosky and Schaller 2010; Schaller et al., 2014) they cannot return as adults. Even in years where river conditions are deemed good, low SARs can result just by the fact that ocean conditions can be variable, and a good river condition can be paired with bad ocean conditions. However, based on the result from the 1997 juvenile migration year, the impact of the bad ocean may be minimized by having in-river migration conditions that far exceed those provided by the BiOp.

In summary, the table above only illustrates the same concepts that were presented at the 2014 Annual CSS Meeting on April 23, 2014. The presentations are located on the web at http://www.fpc.org/documents/CSS/Presentations%20from%20the%202014%20CSS%20Annual%20Meeting.pdf . For example, the following figure was part of the presentations from the 2014

CSS meeting. In the following figure the range of possible SARs that could occur over the range of possible ocean conditions is shown under the BiOp spill program and the 125% TDG spill levels. This figure demonstrates that even for the higher spill levels (125% TDG) there are some instances when the projected SARs will be low due to the variability in ocean conditions. However, increasing the juvenile survival, and decreasing delayed mortality due to improved river conditions, maximizes the probability that higher SARs will occur.

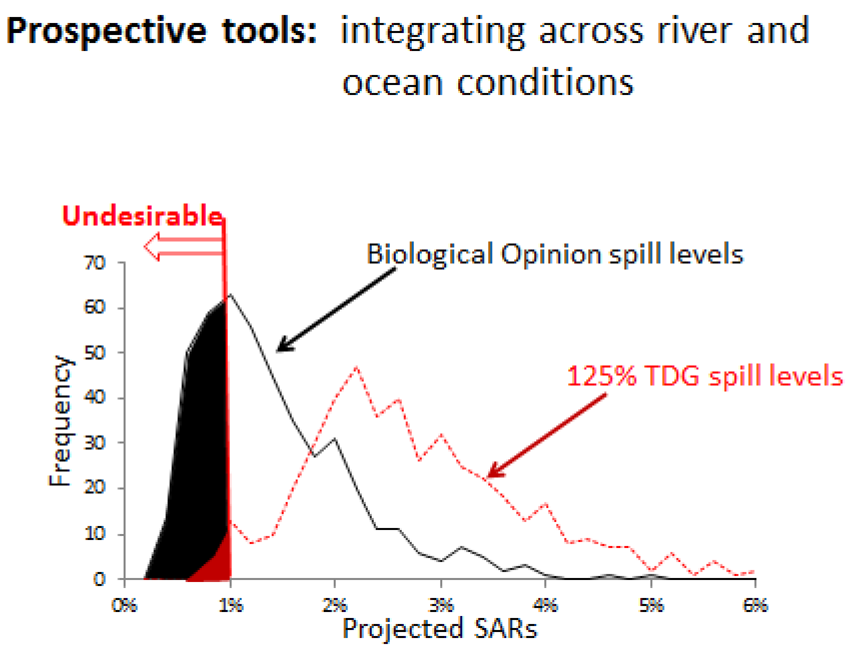

Figure 1. Predicted SARs that will result from juveniles migrating under BiOp spill levels and 125% TDG spill levels, over a range of ocean conditions.

In conclusion, the hydrosystem variables that affect the direct and delayed mortality of juvenile salmonids and translate to higher adult SARs include: spill, surface passage structures, increased flows, reservoir drawdowns, and dam removal. The variables presented are focused on reducing the number of powerhouse passages and increasing the speed of juvenile migration through the hydrosystem.

References

Haeseker, S.L., J.M. McCann, J.E. Tuomikoski, and B. Chockley. 2012. Assessing freshwater and marine environmental influences on life-stage-specific survival rates of Snake River spring/summer Chinook salmon and steelhead. Transactions of the American Fisheries Society, 141:1, 121–138.

Petrosky, C.E., and H.A. Schaller. 2010. Influence of river conditions during seaward migration and ocean conditions on survival rates of Snake River Chinook salmon and steelhead. Ecology of Freshwater Fish 19(4): 520–536.

Schaller, H.A., C.E. Petrosky and E.S. Tinus. 2014. Evaluating river management during seaward migration to recover Columbia River stream-type Chinook salmon considering the variation in marine conditions. Canadian Journal of Fisheries and Aquatic Sciences 71: 259–271.