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MEMORANDUM

TO: FPAC

Michele DeHart

FROM: Michele DeHart

DATE: October 27, 2000

RE: Comments on “Review of Survival, Flow, Temperature, and Migration Data for Hatchery-Raised Sub-Yearling Fall Chinook Salmon above Lower Granite Dam, 1995-1998 by Dreher et al.

In response to your request we have reviewed the subject document and offer the following comments for your consideration. On the basis of the Dreher analysis we have concluded that:

- **The protection measures established by NMFS are inadequate for listed fall Chinook.**
- **NMFS should have established a higher flow target for fall Chinook juvenile migrants.**
- **Based on the positive correlation with water temperature, NMFS should have established a water temperature criterion of 17 degrees centigrade for the juvenile fall Chinook migration in the Snake River.**

General Comments

The authors recognize that there is a significant correlation between flow and juvenile fall Chinook survival. They however question the effect of flow on survival on the basis that correlation is not causality and that other factors also correlate with survival. We agree there is a positive correlation between juvenile survival and flow, and there is also a positive correlation between release date and decreasing water temperature and survival. The authors argue that correlation does not establish causality (a long held statistical analyses principal) and therefore the fact that a correlation exists cannot be used to support the establishment of a flow requirement to increase survival of ESA listed fall Chinook. This is an interesting argument since it is exactly the argument proffered by statisticians employed by tobacco companies in the past. They recognized that a correlation existed between smoking and lung cancer, but they did argue that this did not establish causality. Good principals can be used to buttress bad arguments. History has shown us that in circumstances such as smoking and lung cancer, where survival is at stake, it may be most prudent to take protective actions on the basis of the correlation. In the case of protection of an ESA listed fall Chinook where survival is at stake protection on the basis of a documented correlation is the only judicious action available.

The Dreher study does not successfully establish that NMFS was mistaken in establishing a flow target to protect listed fall Chinook. The Dreher analysis, however, does establish a strong argument that NMFS should have included in their draft Biological Opinion for 2000, a water temperature target as well as a flow target for the summer months in the Snake River. The establishment of a summer flow target by NMFS is the only prudent alternative action available to NMFS in light of the fact that the fall Chinook stocks in the Snake River have declined to near extinction. The facts that, flow, water temperature, turbidity, and release date are all co-dependent variables in the data set do not diminish the importance of the flow survival relationship or the basis for establishing a flow target. In fact, the question should be raised to NMFS regarding the establishment of a water temperature criteria, on the basis of this data particularly in regard to the upper Snake River.

Specific Comments

A clear flow and smolt to adult return relationship exists for fall listed fall Chinook.

On page 47 the Dreher et al. report states, “Adult returns are the best, and only complete, way to assess whether increased flow improves fish survival.” They further discuss that the NMFS juvenile fall chinook survival studies in reservoir reaches do not fully address the mortality factors affecting fish. They base their statement on personal communications and unpublished data that suggest late migrating fall chinook with low in-river survival did not necessarily translate to low adult returns. The case of late migrating fall chinook is a special case that must be discussed in context. The particular fish referred to in Dreher et al. include those late migrating fish that over-winter rather than migrate that year. These fish migrate as yearlings the following spring and have a relatively good adult survival. This phenomenon is likely a survival strategy of fall chinook, which is advantageous to late-migrating fish, but is not likely the best strategy for the whole population. Delaying migration is a strategy employed due to low flows late in the migrating season. It was observed in 1995, when flows were high during the late fall, that fall chinook continued to migrate (and did not over-winter) as evidenced by the recovery of PIT tags at McNary Dam. The over-wintering yearling fall chinook migrants were not observed the following spring (1996).

An analysis conducted by Fish Passage Center staff (see attached memo from Jerry McCann to Michele DeHart dated October 17, 2000) addresses the relation between adult returns and juvenile migration flows. Here it is concluded that spawner-recruit data “reveals that flow is important in the productivity of Snake River fall chinook salmon and that the relationship appears robust to assumptions, both in calculating the number of recruits as well as the number of spawners.”

Dreher maintains that there is no flow travel time relationship for fall Chinook.

- Because of the extended time of subyearling chinook spent rearing above Lower Granite Dam, we would not expect that the regression of flow against travel time would show a significant relation. PIT tag data on wild subyearling chinook from 1991-1997 showed median travel time of approximately 40 days from the projected date of reaching a minimum size of 85 mm to arriving at Lower Granite Dam. These same years showed a median travel time of less than 25 days to migrate from Lower Granite Dam to McNary Dam for wild subyearling chinook. **A significant relation between travel time and flow is shown in Figure 1 for wild subyearling chinook between Lower Granite Dam and McNary Dam** as the smolts have become more active migrants by the time they entered this reach of river. By the time the composite of wild and hatchery subyearling chinook originating above Lower Granite Dam in years 1997-1999 were passing between McNary and Bonneville dams, they were migrating at speed closer to that of yearling chinook, traversing this lower Columbia reach in 5-10 days on average (Figure 2). Subyearling chinook appear to respond to flow once they reach the state of maturation where they are active migrants, as seen by their increasing migration rates as they move down through the hydrosystem. This clearly shows that higher flow targets would further decrease fall Chinook travel time in their downstream migration

Figure 1

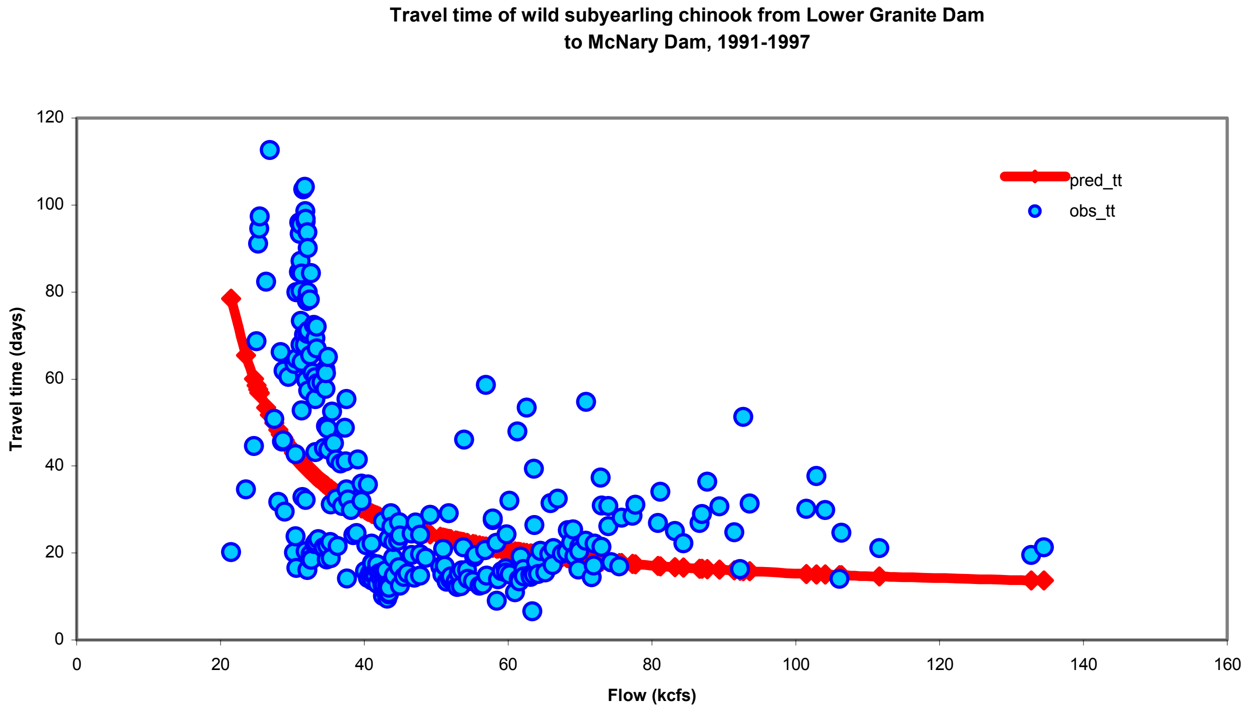
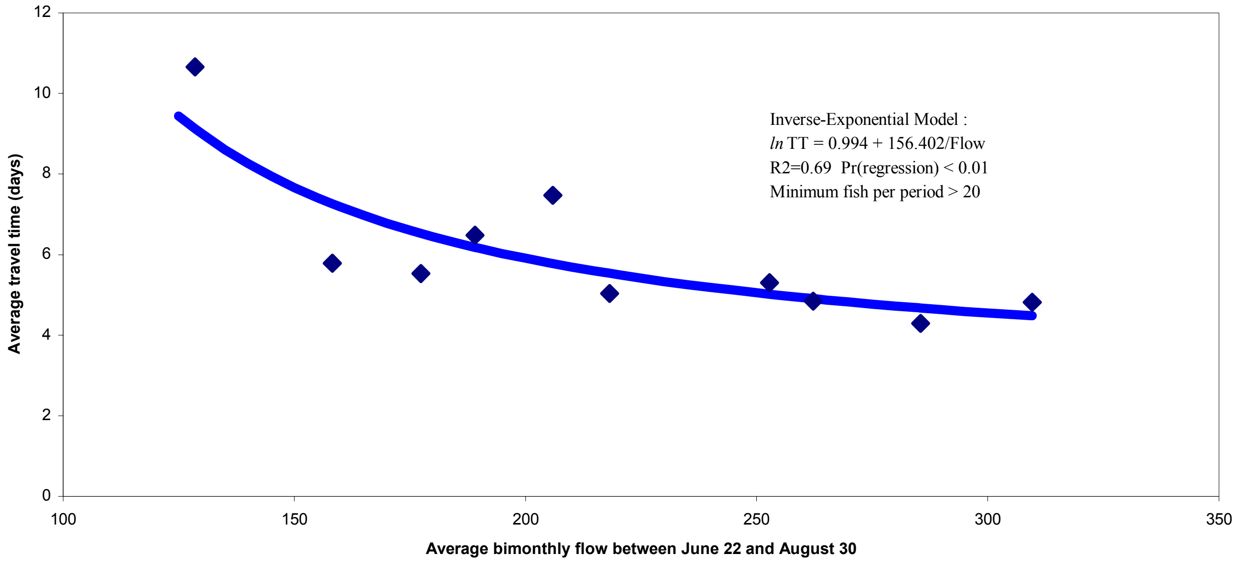


Figure 2



Bimonthly average travel time (TT) versus flow for subyearling chinook of Snake River origin between McNary and Bonneville dams (1997-99)

The Dreher analysis is limited to hatchery release groups that do not represent the normal hatchery or wild migration of fall Chinook. The Dreher analysis is limited to groups of fall Chinook marked at Lyons Ferry in the morning and trucked to release sites above Lower Granite Dam and released the same afternoon. The data and plots presented clearly show a flow travel time relationship for fall Chinook. The attached memorandum (Tom Berggren) also displays a flow survival relationship for juvenile fall Chinook.

The Dreher analysis fails to recognize the complexity of interdependent variables

- The series of bivariate regression runs fail to capture the complexity of the relations among these predictor variables. The inter-dependence of these factors needs to be modeled through the inclusion of interaction terms. For example, river temperature at Lower Granite Dam is a function of seasonal date and river flow, that itself is a mixture of cooler water from the Clearwater River drainage and warmer water from the mainstem Snake River above Hells Canyon Dam. Turbidity is a function of river flow, and migration timing is a function of river temperature and river flow. The form of these functional relations need not be linear either. Given this potentially more complex inter-relation among the predictor variables, it is inappropriate to rule out that flow as an important component for fall chinook smolt survival.

Averaging flow as is done in this analysis has the effect of repressing a flow survival relationship. This makes the existing correlation between flow and survival more significant from a management standpoint.

- Averaging the flow and temperature data over the dates from release to 5% passage is inappropriate when comparisons to survival are being made. The FPC has looked at the subyearling fall chinook PIT tagged at Lyons Ferry Hatchery and trucked and released at various sites in the Snake River from early June through early July. Our analysis shows substantially lower survival estimates to Lower Granite Dam when average flows during the period of middle 60% passage at Lower Granite Dam drops below 50 kcfs. Flows in 2000 during the summer were lower than in 1999, and estimated survival to Lower Granite Dam remained lower for each weekly release group. The results here reflect the year-to-year difference for those fall chinook that outmigrated as subyearlings.

	Year 1999 Pittsburg Landing AP (KM 346)			Year 2000 Pittsburg Landing AP (KM 346)		
Release date	Survival to LGR	Mid-60% Passage	Avg. Flow (kcfs)	Survival to LGR	Mid-60% Passage	Avg. Flow (kcfs)
June 1	0.479	6/20-8/2	71.0	0.152	6/25-7/4	39.0
June 8	0.463	6/28-8/11	54.3	0.040	7/1-7/30	38.1
June 15	0.277	7/24-8/19	42.7	0.086	7/9-8/17	33.8
June 22	0.325	7/28-8/31	38.6	0.022	7/17-8/26	30.2
June 29	0.122	8/7-9/27	29.1	0.029	8/7-9/7	23.8
July 6	0.088	8/11-10/13	27.2	0.010	8/7-9/17*	23.6

* For July 6, 2000, release assume 80% date 10 days later than that of June 29 release.

	Year 1999 Asotin (KM 234)			Year 2000 Above Captain John Rapid AP (KM 266)		
Release date	Survival to LGR	Mid-60% Passage	Avg. Flow (kcfs)	Survival to LGR	Mid-60% Passage	Avg. Flow (kcfs)
June 1	0.404	6/9-8/2	83.1	0.359	6/28-7/9	38.1
June 8	0.386	6/24-8/16	57.4	0.188	6/30-7/22	39.6
June 15	0.315	7/5-8/20	47.3	0.148	7/4-8/11	35.2
June 22	0.277	7/30-9/1	38.0	0.093	7/18-9/3	28.0
June 29	0.193	8/4-9/28	29.8	0.051	8/10-9/20	23.6
July 6	0.134	8/11-10/15	27.2	0.022	8/19-9/30*	22.4

*For July 6, 2000, release assume 80% date 10 days later than that of June 29 release.

In summary, Dreher et al. conclude that "existing correlations between survival of hatchery raised, subyearling fall Chinook salmon with flow rates and water temperatures do not support the postulation that augmenting mainstem Snake River flows improves subyearling survival" on the basis of elementary statistical tenets. This is precisely the same approach that led to twenty years of delay and thousands of lives in the tobacco and lung cancer correlation. The overwhelming body of evidence clearly shows that flow and water temperature affect fall Chinook survival. A stock, which is threatened with extinction, cannot afford the superfluous arguments over correlations and causative effects in the face of the overwhelming body of evidence supporting the provision of flows and lower water temperatures. This is particularly true in the light of mounting evidence that the lack of a water temperature criterion and that the established flow protection measures are not adequate to provide protection to fall Chinook.

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MEMORANDUM

TO: FPAC

FROM: Tom Berggren

DATE: October 12, 2000

RE: Subyearling chinook survival to Lower Granite Dam vs flow

We reviewed the survival of subyearling fall chinook from point of release to Lower Granite Dam tailrace for 1999 and 2000. The following table and attached graph illustrate a significant flow/survival relationship for these groups of summer migrants.

Subyearling fall chinook PIT tagged at Lyons Ferry Hatchery and trucked and released at various sites in the Snake River from early June through early July show substantially lower survival estimates to Lower Granite Dam when average flows during the period of middle 60% passage at Lower Granite Dam drops below 50 kcfs. Flows in 2000 during the summer were lower than in 1999, and estimated survival to Lower Granite Dam remained lower for each weekly release group. The results here reflect the year-to-year difference for those fall chinook that outmigrated as subyearlings.

	Year 1999 Pittsburg Landing AP (KM 346)			**Year 2000 Pittsburg Landing AP (KM 346)**		
Release date	**Survival to LGR**	**Mid-60% Passage**	**Avg. Flow (kcfs)**	**Survival to LGR**	**Mid-60% Passage**	**Avg. Flow (kcfs)**
June 1	0.479	6/20-8/2	71.0	0.152	6/25-7/4	39.0
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* For July 6, 2000, release assume 80% date 10 days later than that of June 29 release.

	Year 1999 Asotin (KM 234)			Year 2000 Above Captain John Rapid AP (KM 266)		
Release date	**Survival to LGR**	**Mid-60% Passage**	**Avg. Flow (kcfs)**	**Survival to LGR**	**Mid-60% Passage**	**Avg. Flow (kcfs)**
June 1	0.404	6/9-8/2	83.1	0.359	6/28-7/9	38.1
June 8	0.386	6/24-8/16	57.4	0.188	6/30-7/22	39.6
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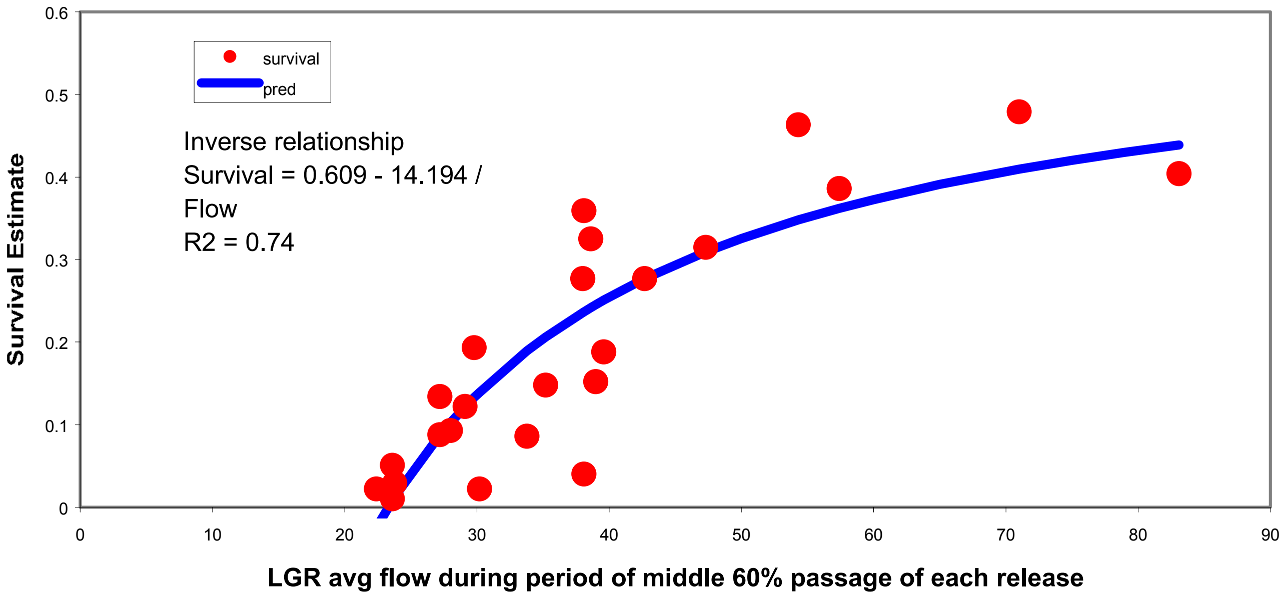
Subyearling chinook survival from sites above pool to Lower Granite Dam tailrace, 1999 and 2000



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MEMORANDUM

TO: Michele DeHart

FROM: Jerry McCann

DATE: October 17, 2000

RE: Review of Spawner Recruit Analysis in Anderson, Hinrichsen Holmes

Anderson et. al., argued that augmentation flow is not important for fall chinook salmon. They used as they called it an "ecological and mechanistic framework" to analyze impacts of flow on survival. As part of their analysis they considered recruit spawner relationships in Snake River fall chinook. They explored whether there was "a statistically significant relationship between flow and life-cycle survival…" for adult chinook salmon. Anderson et. al., used PATH spawner-recruit data and chose to use the "natural spawner" totals when calculating recruits per spawner. I used that same data source and two others for Snake River fall chinook (see Tables 1 through 3 below). In all cases I found a significant relationship between recruits per spawner and flow.

Anderson et. al., ran regression analysis and included a spawner variable according to the Ricker (1975) productivity equation

$$R = Se^{(a-bS),} \qquad \text{Eq(1)}$$

where R = recruits, S = spawners, a = average productivity rate and b is the density dependent factor. From this we derive the ln(R/S) as shown in equation 2. Anderson et. al., used this model

$$\ln(S_i/R_i) = a-bS_i + \varepsilon_{i,} \qquad \text{Eq(2)}$$

to develop their regression equations. But their regressions results showed that the spawner term ($a-bS_i$) was not significant and the overall model, which included a flow parameter for the error term, was not significant either. However, the flow terms, in each case $\varepsilon_{i,}$ were significant. One interpretation of a non-significant spawner parameter might be that spawner density is too low to be near equilibrium and thus not as important in determining recruits/spawner as other factors, such as river conditions or ocean conditions might be. In other words, the term a-bS_i is small enough in relation to the error term that removing it from the model has little effect on the relationship. Therefore, we regressed ln(R/S) against a flow parameter. We used the June through July average daily flow as an index of flow conditions as did Anderson et al. We also removed the years prior to 1977. I did this because those years prior to 1977 migrant fish would have encountered greatly different conditions in the Snake River than the present configuration of the hydrosystem (see Petrosky 1991 for a description).

In each case I found a significant relationship between ln(R/S) and flow. In every case I found the inverse flow parameter a better fit to the data than flow, the resulting line when plotted with R/S and flow results in a sigmoidal curve. This type of curve makes the most sense biologically and provides the best fit to the data.

I conclude that a more thorough analysis of the spawner-recruit data reveals that flow is important in the productivity of Snake River fall chinook salmon and that the relationship appears robust to assumptions, both in calculating the number of recruits as well as the number of spawners.

Methods

I chose to use the PATH derived adult recruit per spawner data set for Snake River Basin (SRB) fall chinook and carry out a similar analysis as Anderson et. al. I used Anderson's Ice Harbor flow index (average daily flow for June and July at Ice Harbor as an index of flows as Anderson et al did in their analysis). For Snake River Basin spawner recruit data I used data from NMFS Draft Biological Opinion 2000 spreadsheet entitled "Falls_sep7Update.xls" available as supporting documentation for the NMFS 2000BiOp at http://www.nwr.noaa.gov/1hydrop/hydroweb/docs/2000/2000Biop.htm. In this spread sheet NMFS summarized PATH run reconstructions for the Snake River and calculated their own recruit per spawner data. NMFS reconstruction uses recruits to spawning grounds. These two data sets represent extremes in calculations of recruits but both data sets begin with identical spawners by brood year (Tables 2-3). I also used the same data set as Anderson et al but I removed the years prior to 1977 to analyze flow as the hydrosystem is currently configured. Note spawner numbers in Tables 1 and 2 are total spawners from Peters (1999) while Table 3 uses natural spawner values from Peters (1999). And that recruit numbers are identical in Table 1 and 3 representing all recruits including fish removed in adult ocean fishery, mortality in hydrosystem, river fishery as well as brood stock removals. NMFS calculated recruits to above Lower Granite Dam (Table 2). Thus each data set analyzed encompasses different assumptions about the calculation of spawners and recruits. Which is a robust way of analyzing assumptions of the productivity flow relationship for this stock.

Results

In each case the ln (R/S) regression with S resulted in a model that was insignificant and shape of residual plot suggest a term was missing from the model (Draper 1980). While regression of ln(R/S) with F (flow) resulted in a model that was significant for the 'Peters' (Table 1) and NMFS (Table 2) data set, while the Anderson data set (Table 3) was not significant ($P = 0.15$). But in all cases regression of ln(R/S) with 1/F (inverse flow) lead to improved fit (r square) and improved significance. See figures 1- 3 for regression equations, r square and p values.

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Figure 1. Plot of Peters 1999 data set (Table 1), using total spawners (includes hatchery strays) with predicted line from regression. R square 0.43 p = 0.008

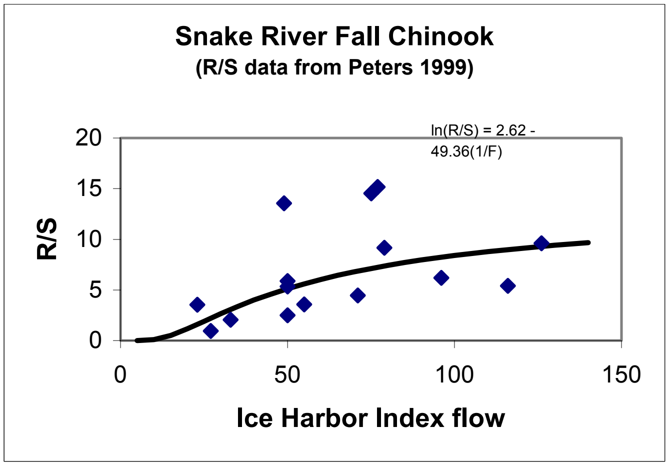

Figure 2. Plot of NMFS 2000 data set (Table 2), using total spawners (includes hatchery strays) and recruits above LGR with predicted line from regression. R square 0.55 p = 0.006

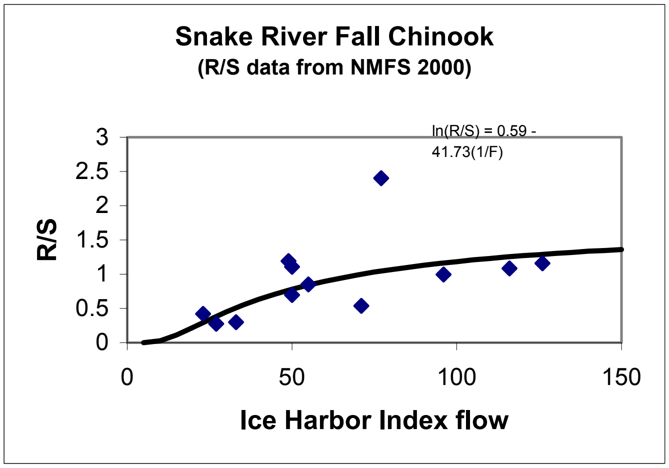

Figure 3. Plot of Anderson et al data set (Table 3 using natural spawners and total recruits) wi th predicted line from regression. R square 0.31 p = 0.03

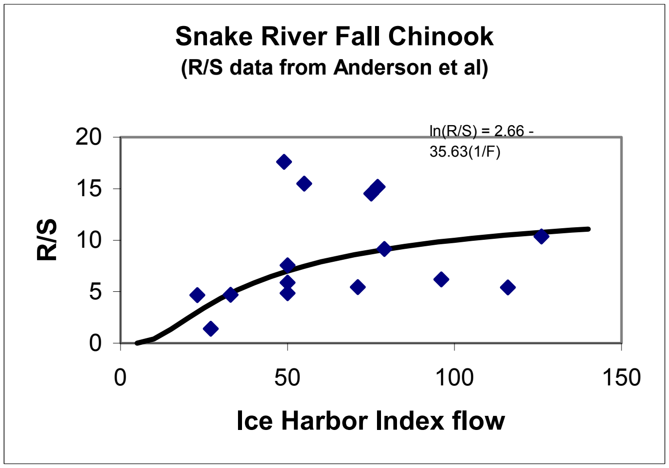

Table 1. Data from Peters 1999 using total spawners.

Brood Year	Spawners	Recruits	Ln(R/S)
1977	1011	9259	2.215
1978	841	4946	1.771
1979	802	11657	2.676
1980	515	7817	2.72
1981	878	4746	1.687
1982	1209	7500	1.825
1983	909	8723	2.261
1984	717	9721	2.607
1985	1080	4821	1.496
1986	1403	4971	1.265
1987	1064	2171	0.713
1988	702	3748	1.675
1989	815	2031	0.913
1990	273	975	1.273
1991	767	717	-0.066

Table 2. Data set from NMFS 2000 BiOp With recruits to Snake River Basin

Brood		NMFS 2000	NMFS 2000
Year	Spawner	Recruit	ln(R/S)
1980	515	1236	0.8756
1981	878	951	0.080192
1982	1209	1201	-0.00682
1983	909	1054	0.147843
1984	717	856	0.177021
1985	1080	581	-0.62025
1986	1403	593	-0.86116
1987	1064	318	-1.20877
1988	702	778	0.103055
1989	815	568	-0.36034
1990	273	233	-0.15975
1991	767	211	-1.28844

Table 3. Data set used by Anderson et al. from Peters 1999 using “natural spawners”.

Brood Year	Spawners	Recruits	Ln(R/Sn)
1977	1011	9259	2.214656
1978	841	4946	1.771743
1979	802	11657	2.676554
1980	515	7817	2.719889
1981	878	4746	1.687411
1982	1209	7500	1.825109
1983	842	8723	2.337938
1984	552	9721	2.868496
1985	885	4821	1.695149
1986	1067	4971	1.53877
1987	462	2171	1.547378
1988	495	3748	2.02442
1989	418	2031	1.580802
1990	63	975	2.739303
1991	509	717	0.342628

References

Draper, N.R. and H. Smith 1980. Applied Regression Analysis. John Wiley & Sons Inc., 709 pp. USA

Peters, C.N., D.R. Marmorek, and I. Parnell (eds.) 1999. PATH Decision Analysis Report for Snake River Fall Chinook. Prepared by ESSA Technologies Ltd., Vancouver, BC, 332 pp.

Petrosky, C.E. 1991. Influence of Smolt Migration Flows on Recruitment and Return Rates of Idaho Spring Chinook, Idaho Department of Fish and Game Report 23 pages + tables and figures.

Ricker, W.S. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada. Bulletin 191: 382 pp. Ottawa, ON.

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