Northwest Power and Conservation Council

November 8, 2004

MEMORANDUM

TO: Fish and Wildlife Committee

FROM: Bruce Suzumoto

SUBJECT: Reservoir operations and flow-survival symposium

Staff will discuss the result of the November 9- 10 reservoir operations and flow-survival symposium jointly sponsored by the Council and NOAA Fisheries. They will also speak about summarizing the symposium findings and how the findings may be used to frame implementation discussions. Attached is a copy of the symposium agenda and the briefing document that was written to focus symposium discussion.

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Reservoir Operations / Flow Survival Symposium
November 9th - 10th, 2004

Northwest Power & Conservation Council
851 S.W. Sixth Ave., Suite 1100
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Tuesday, November 9, 2004

10 - 10:10 a.m. **Welcome - Chip McConnaha, Facilitator**
Symposium format and ground rules

10:10 - 10:30 a.m. **Introduction by Bob Lohn, NOAA Fisheries**
July 19, 2004 Letter and Symposium Purpose

1.	**10:30 -11:15 a.m.**	**Describe alternative/goals** 1. Amendment description and upriver biological effects – Jim Litchfield, State of Montana; Brian Marotz, Montana Fish Wildlife and Parks.
	11:15 -11:30 a.m.	Questions and Clarification
	11:30 -12:00 p.m.	2. Description of overall water changes resulting from proposed operation- John Fazio, Northwest Power & Conservation Council; Roger Schiewe, Bonneville Power Administration. • Quantity, velocity, and timing of water • How will water change be passed downriver
2.		**Translating changes in flow to changes in velocity temperature**
	1:00 - 1:15 p.m.	• Water velocity - depict change in velocity, key reaches - John Fazio, Northwest Power & Conservation Council.
	1:15 - 1:45 p.m.	• Temperature modeling- models available and ability to estimate change - Ben Cope, U.S. Environmental Protection Agency; Jim Adams, U.S. Army Corps of Engineers.
	1:45 - 2 p.m.	Questions and Clarification
3.a	**2:00 - 2:45 p.m.**	**Status and presence of affected anadromous stocks** • Stock status- Snake River fall chinook, Upper Columbia, Lower Columbia, summer and fall chinook - John Stein, NOAA Fisheries. • Fish present in river at key index sites- Margaret Filardo and Tom Berggren, Fish Passage Center.

	2:45 – 3:00	**Break**
		Biological responses to river conditions and flow augmentation • Downstream migration and juvenile survival as related to river conditions
	3:00 - 3:25 p.m.	o Snake River fall Chinook salmon upstream of Lower Granite Dam - Billy Connor, U.S. Fish & Wildlife Service.
	3:25 - 3:50 p.m.	o Columbia River subyearling Chinook salmon upstream of McNary Dam - Margaret Filardo and Tom Berggren, Fish Passage Center.
	3:50 - 4:15 p.m.	o Snake River fall Chinook salmon between Lower Granite Dam and McNary Dam and subyearling Chinook salmon downstream of McNary Dam – Steve Smith, NOAA Fisheries
	4:15 – 4:40 p.m.	• Reservoir-type fall Chinook salmon: an exception to the rules - Billy Connor, U.S. Fish & Wildlife Service.
	4:40 – 5:00 p.m.	Questions and Clarification

Wednesday, November 10, 2004

3.b	**8:00 - 8:30 a.m.**	• Delayed effects on outmigrants- Jim Congleton, University of Idaho.
		• Adult Passage
	8:30 - 9 a.m.	o Behavior passage - Chris Peery, University of Idaho.
	9 - 9:30 a.m.	o Temperature - Summer- Bioenergetics- Dave Geist, Battelle.
	9:30 - 9:45 a.m.	**Break**
		• Predicting change in fish responses 1. Status of models and application to this assessment
	9:45 -10:15 a.m.	CRISP ----------------------Chris Van Holmes, University of Washington.
	10:15 -10:45 a.m.	SIMPAS---------------------Jim Ruff, NOAA Fisheries.
		2. Other considerations
	10:45 -11:15 a.m.	NRC Report- Al Giorgi, BioAnalysts.
	11:15 - 11:30p.m.	Questions and Clarification
4.		**Research and anadromous needs- discussion of research needs and experimental feasibility**
	1:00 - 2 p.m.	• Panel- Steve Smith, Mike Langeslay, U.S. Army Corps of Engineers; Al Giorgi, BioAnalysts; Chuck Peven, Chelan PUD; and Billy Connor, U.S. Fish & Wildlife Service.
	2 - 2:15 p.m.	Question and Clarification
5.		**Wrap Up**
	2:15 - 2:45 p.m.	• ISAB Panel – ISAB members
	2:45 - 3 p.m.	• Next steps - Chip McConnaha

Northwest Power and Conservation Council

October 21, 2004

Anadromous Fish Issues Regarding the Proposed Council Summer Flow Initiative: A Briefing Paper

The Columbia River System consists of a complex network of storage reservoirs and run-of-river dams. Water management is complicated by balancing needs of various uses. Flow augmentation (FA) is one such use, which involves strategically timed release of water from storage reservoirs for the purpose of improving migratory conditions at run-of-river projects for juvenile salmonids, and in some instances adult life stages. The NW Power and Conservation Council's (Council) mainstem amendments proposes to alter summer FA operations at storage reservoirs in Montana from the current strategy to one involving a reduction in flow and water releases shifted more into September. The goal of the alternative action is to improve conditions for resident fish species in the vicinity of Libby and Hungry Horse dams, while minimizing risk to anadromous fish stocks downstream.

The timing and duration of FA is meant to coincide with the migratory periods of smolts during their journey seaward. The purpose is to increase migration speed and survival by increasing water velocity through reservoirs and/or decreasing water temperature. The rationale for flow augmentation is founded on two premises:

1. Increased river discharge results in higher water velocity through reservoirs that in turn increases the migration speed of smolts through the impoundments of the Lower Snake and Columbia rivers, ultimately resulting in increased smolt survival through this migratory corridor. Furthermore, swifter migration may result in improved survival at seawater entry.
2. Increased river discharge can lower water temperature in the mainstem, improving migratory and rearing conditions for both juvenile and adult salmonids, particularly during the summer.

The strength of these premises has been debated for nearly four decades. Numerous investigations have been conducted to evaluate the merits and deficiencies of the premises as pertaining to different species. Since the proposed action would alter summer-flows emanating

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from the upper Columbia River Basin, juvenile life stages of species dominating the migration during that period will be emphasized herein.

During the summer, juvenile ocean-type Chinook salmon are the dominant juvenile life history stage rearing and migrating in the Columbia River from the mouth of the Okanogan River through the estuary. As such, discussions will focus on data available for those fish (Upper Columbia fall/summer Chinook, Lower and Mid-Columbia fall Chinook, and Snake River fall Chinook). The overall status of those populations in terms of abundance and productivity are important considerations when evaluating the importance of various management actions.

This briefing paper is intended to provide general background information for an upcoming symposium that will be sponsored by NOAA and the Council. That symposium will examine the consequences of implementing the alternative Council plan for managing summer-FA from Montana Reservoirs. This briefing document is a general survey of key information describing the relationships between key smolt responses to water velocity and temperature. Most information describing the migratory behavior of juvenile ocean-type Chinook has been obtained for fall Chinook in the Snake River. Relatively little information is available within the upper and lower arms of the Columbia River, the primary zones of interest for the proposed water management action. In some cases a summary of information for spring migrants is provided for context.

FA Effects on Physical Conditions

Drafting water from storage reservoirs (FA) changes the physical properties of the mainstem Columbia River and the chain of tributaries connected to the storage reservoirs. In the mainstem, water velocity through reservoirs increases and changes in water temperature or turbidity may occur. It is not clear how the proposed action will alter these river characteristics relative to the current base case. This needs to be addressed and preferably demonstrated during the symposium. Apart from the expected direct effects on anadromous fish, broader ecosystem function may be altered throughout the affected network of tributaries and the mainstem. Would the expected changes be more normative? Should this be a goal of the action? These issues also deserve discussion.

Timing of Water and Fish

The proposed action shifts the timing of water released from Hungry Horse and Libby Reservoirs. To realize the same timing at Chief Joseph Dam requires coordination of reservoir drafting through Canada and at Grand Coulee and Chief Joseph dams. Thus, the quantity and quality of water the anadromous fish will encounter is reliant on water discharged at Chief Joseph.

The extent to which FA water coincides with the migration timing of ocean-type Chinook ESUs will be an important element in the decision making process. The migration timing of ESUs at index sites (RI, MCN and BON) in the upper and lower Columbia should be described in the symposium. By way of example some graphs produced by the FPC (2003) provide a general guide describing migration timing at McNary Dam for all subyearling ocean-type Chinook, in recent years. Overall it appears that few fish remain inriver to migrate seaward during

September (Appendix 1). This might suggest that shifting water later may not provide an obvious advantage.

Conversely, Williams et al. (2004) noted that late-migrating (September and later) Snake River fall Chinook exhibit high adult return rates, and appear to contribute substantially to the population of returning adults. Recent analyses by USFWS staff indicate there are likely two primary life history patterns for Snake River fall Chinook, one component that migrates from the system during the summer and another that moves slowly seaward rearing in reservoirs throughout the fall and winter. It is unclear whether shifting flows later would offer some benefit to this late-migrating segment of the population, but this is a possibility. This population segment has received little management attention thus far. This topic could be a pivotal element during the upcoming symposium.

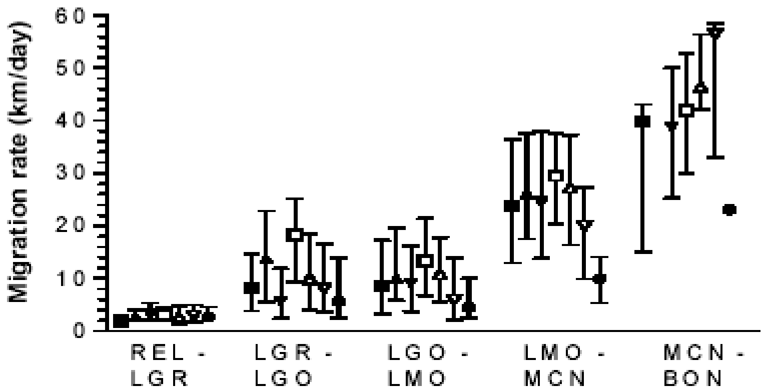
Flow effects on smolt migration speed

For most spring-migrating stocks the collective evidence indicates that increased flow (water velocity) contributes to swifter migration speed. Several recent survey papers support this observation (Williams et al. 2004, Giorgi et al. 2002, and State, Federal and Tribal Anadromous Fish Managers 2003). According to the synthesis provided by Giorgi et al. (2002), river discharge appears to be the most influential variable affecting migration speed of steelhead and sockeye salmon in the Snake and Upper Columbia rivers. Two factors, flow and the degree of smolt physiological development, have explained most of the observed variation in the migration rate of yearling Chinook salmon.

Ocean-type Chinook- At least four variables have been implicated as influencing the migration speed of summer-migrating sub-yearling (fall or summer/fall) chinook; flow (velocity), water temperature, turbidity and fish size. Through the upper Columbia (Rock Island to McNary Dam) Giorgi et al. (1997) found that the size of sub-yearling chinook was the best predictor of migration speed between Rock Island and McNary Dams. In contrast, through reaches of the Snake River, flow, water temperature, and turbidity have been correlated with migration speed (Muir et al. 1999). However, the predictor variables were correlated among themselves. Through the summer migration period, river discharge decreased, temperature increased, and turbidity decrease. Thus, it was not possible to analytically demonstrate effects attributable to a particular environmental agent.

One of the more extensive and recent analyses of smolt travel time in the context of environmental variables was published by SFTAFM (2003). They analyzed several years of PIT tag data obtained by the USFWS and NOAA. They reported that the best predictors of fish travel time from release sites to Lower Granite Dam included water temperature, fish size, and distance to the dam (Appendix 2). They went on to report that the next best regression model for describing the observed variability in smolt travel time also included flow indices. It seems reasonable to conclude that within the uppermost reach of the Snake River (above Lower Granite Dam); temperature, fish size and flow are implicated as important variables influencing migration speed. But it is not possible to identify the most influential of those variables with the data at hand.

NOAA investigators monitored the migration of those PIT-tagged fish through the rest of the FCRPS. Williams et al. (2004) found that the migration speed of Snake River Fall Chinook increased dramatically as they moved downstream. By the time they were moving through the MCN-BON reach, they were migrating at nearly ten times the rate observed upstream from lower Granite Dam.



This suggests that responses to environmental variables that were observed from the release location to Lower Granite Dam may differ when those fish reach the lower Columbia (MCN-BON).

River Conditions and Smolt Survival

Investigations that examine the relationship between smolt survival and prevailing river conditions have not been conducted for ocean-type Chinook (or any species) migrating through the upper and lower arms of the Columbia River. In large part, the absence of PIT tag detection systems restrict the ability to perform robust evaluations, like those conducted in the Snake River.

Survival estimates are available for the Snake River. NOAA investigators recently compiled all information available that describes the survival of Snake River fall Chinook juveniles in the Snake River (Williams et al. 2004). They found that survival to Lower granite Dam was correlated with water temperature flow, and turbidity. Cooler turbid water that is associated with early summer and higher flows result in higher survival. No similar information was presented for summer-migrating fish as they traversed the remaining portion of the Lower Snake River (LGR-MCN or LOMO). Also, they had no survival estimates for fish migrating later during the fall and winter (Appendix 3). This may be a critical information gap, since this late-migrating component appears to contribute substantially to the population of returning adults.

Similar results were reported by Connor et al. (1998) in the Snake River. Using PIT-tagged juvenile fall chinook that reared upstream from Lower Granite Dam, they regressed tag detection rates at the dam (survival index), against flow and temperature separately. They found that over four years, the detection rate was positively correlated to mean summer flow (r-squared = 0.993, P = 0.003) and negatively correlated with maximum water temperature (r-squared = 0.984, P = 0.008). They acknowledged that the predictor variables were highly correlated, limiting specific inferences regarding the effects of the individual variables.

In an attempt to analytically clarify the effects of water velocity from temperature on survival, Anderson and Van Holmes (September draft 2004) conducted a passage model based analysis. They characterized their overall findings using the CRiSP model as:

"Our study indicates flow is not significant while the other studies indicate it is. Our study indicates temperature is important while other studies ignore temperature or underestimate its significance. These differences are particularly important when considering the impacts of water augmentation and withdrawals on survival. The impact of flow augmentation, unlike the between-year changes in flow, is essentially immeasurable and must be assessed with models. Our analysis indicates that the impacts of flow augmentation and water withdrawal on water velocity are insignificant. "

Clearly there is some disagreement and uncertainty within the scientific community with regard to which environmental variables have the most influence on survival of ocean-type chinook the most. Nevertheless, flow (water velocity) and temperature are both considered key agents. Determining which is the most influential can be important. For example, if cooler water is the chief beneficial agent, then FA should facilitate cooling. If it does not, then the water management strategy may be ineffective.

Furthermore, it is necessary to quantify the magnitude of response expected under different discharge or temperature profiles. This is rarely done, but recently, SFTAFM (2003) presented such an assessment. An example from their report is presented in Appendix 4. Using relationships of flow/temperature and survival they compared expected survival under the two scenarios (with and without summer FA). They predicted that FA improved survival to LGR by about 10-20 percentage points, over the years they examined. This approach provides a useful method for demonstrating how to translate the expected changes in river conditions into predicted smolt responses associated with implementing the NPCC flow alternative.

Delayed Effects

Not all biological responses may be expressed while smolts are still in fresh-water. As noted by the NRC (2004), it is plausible that if migration rate is too slow, smolts may be physiologically compromised. This could potentially affect survival at seawater entry and beyond. Recent research suggests that concerns regarding such delayed may be well-founded, and exacerbated by low instream flows and associated slower migration. Congleton et al. (2002) studied changes in condition of spring-migrating yearling chinook salmon from Lower Granite Dam to Bonneville Dam, for the years 1998-2002. In all years body lipid and protein mass decreased significantly and with increasing travel time. The implication is that slower migration forces the juveniles to tap reserves beyond normal levels. It is possible that such a tax on body reserves could compromise smolt performance at seawater. It is not known whether these same physiological patterns apply to ocean-type Chinook. In the context of the NPCC proposal, if the migration speed of ocean-type Chinook shifts appreciably from the base condition, then the potential for delayed effects is a concern.

Research and Analytical Needs

Is it practical or even possible to empirically measure the change in survival associated with the proposed action? It appears unlikely. PIT tags are the tool of choice for estimating survival over extended reaches. Unfortunately, PIT detection systems are lacking in the upper Columbia. This limited sampling ability compromises the quality and utility of survival estimates. Furthermore, the expected change in survival would be so small that vast numbers of PIT tagged fish would be required to provide any reasonable sensitivity. This difficulty remains for any evaluation contemplated for the lower Columbia (MCN-BON), even though PIT sampling capability exists there. Also, it is probably not practical to isolate or detect effects attending the proposed action because, 1) any change in survival would likely be very small, and 2) many other competing actions or conditions could mask any effect.

No doubt models will need to be employed to characterize the change in survival expected under the proposed action. Candidate models include SIMPAS, CRiSP, and the approach SFTAFM (2003) recently presented. In recent years these models have been updated, but not adequately reviewed by any regional process. Thus, their output may be suspect. The symposium should explore the strengths and limitations associated with these models or any other analytical approaches that analysts may offer. In the symposium, presentations should include descriptions of the general structure and function of the model, calibration data, key assumptions and outstanding uncertainties, and the status of updating input parameters.

Other Considerations

It may be inappropriate to view this, or any, proposed water management action as an isolated event. The course of the Columbia reflects a complex set of water-related activities, which in concert dictate the quantity and quality of water at any location and point in time. Recently the National Research Council published a book discussing issues regarding the management of water use in the Columbia River (NRC 2004). They discussed several issues that are relevant here. Their study area was centered in the lower Columbia. Water withdrawals from the Columbia (the focus of that study) are concentrated during the summer months and are largely governed by irrigation demands. This suggests that increasing the volume withdrawn during the summer (July and August) poses some unquantifiable risk to salmonid stocks. The risk associated with reducing flows and perhaps increasing water temperature may degrade river conditions. They further noted that broad-scale climate change has resulted in the increased regional water temperatures in recent decades, and the trend is expected to continue well into the future. During periods in the summer water temperature levels in the lower Columbia River already reach critical biological thresholds (> 20 degrees C) that put salmonids at risk. Actions that exacerbate this condition may be maladaptive.

Furthermore, mainstem water withdrawals directly compete with actions like flow augmentation, and may offset some of the perceived benefits associated with increasing instream flows. Without a regional water-use plan, competing actions may result in unexpected consequences. FA water may be extracted before it reaches its intended destination, or water quality may be compromised by irrigation or municipal/industrial return flows.

Summary

NOAA posed four issues that they felt were important in deciding the benefits or risks associated with the proposed action:

1. What is the state of the science describing flows and juvenile survival? Where is there consensus and where is there disagreement?
2. Which attributes are most important in making hydro decisions? What kind of research would be needed to resolve them?
3. Is there an experimental design practical and feasible to detect flow-survival effects attending the proposed changes in reservoir operations? If so, how would the experiment be structured?
4. In modeling projected effects of flow on listed and non-listed fish, what are the relative strength and weaknesses of the available models? Is there credible scientific information that certain models and assumptions are likely to be more reliable than others?

This brief summary characterizes the general situation regarding these issues:

- The timing of the water delivery and fish migration period needs clarification. There appear to be few late-migrating subyearling Chinook that would encounter the shift of water into September. However, those late migrants may be a critical population component, since they contribute substantially to adult returns.
- Based on data obtained for Snake River fall Chinook, flow and temperature are implicated as important variables affecting smolt migration speed and survival in the upper Snake River (above LGR), during the summer.
- No survival information is available for the late-migrating segment of the Snake River fall Chinook. This constitutes an important information gap.
- It has not been demonstrated that survival relationships described for summer migrants in the upper Snake hold for other summer-migrating ocean-type Chinook inhabiting other river segments. Data obtained from other river segments describe different migratory dynamics that may influence survival. For example, the Snake River fish dramatically increase their migration rate in the lower Columbia (MCN-BON).
- It will be difficult, if not impossible, to conduct field studies that can detect survival changes attributable to the proposed action.
- Evaluation of the effects of the proposed action on smolt migration and survival will involve model analyses. The current configuration of recently updated passage models is not commonly understood, nor have strengths and limitations been aired. More than one modeling approach will be required to properly characterize the uncertainty.

Literature Cited

Anderson, J., and C. Van Holmes. In review. Effects of flow and other covariates on juvenile salmon and steelhead survival through the Columbia and Snake rivers. CJFAS.

Congleton, J., T. Wagner, J. Evavold, D. Fryer, and B. Sun. 2002. Evaluation of physiological changes in migrating juvenile salmonids and effects on performance and survival. Annual report to USACE.

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Muir, W. D., S. G. Smith, E. E. Hockersmith, M. B. Eppard, W. P. Connor, T. Anderson, and B. D. Arnsberg. 1999. Fall chinook salmon survival and supplementation studies in the Snake River and lower Snake River reservoirs, 1997. Annual report (DOE/BP-10891-8)

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SFTAFM. 2003. State, Federal, and Tribal Anadromous Fish Managers comments on the Northwest Power Planning Council Draft Mainstem Amendments as they Relate to Flow/Survival Relationships for Salmon and Steelhead.

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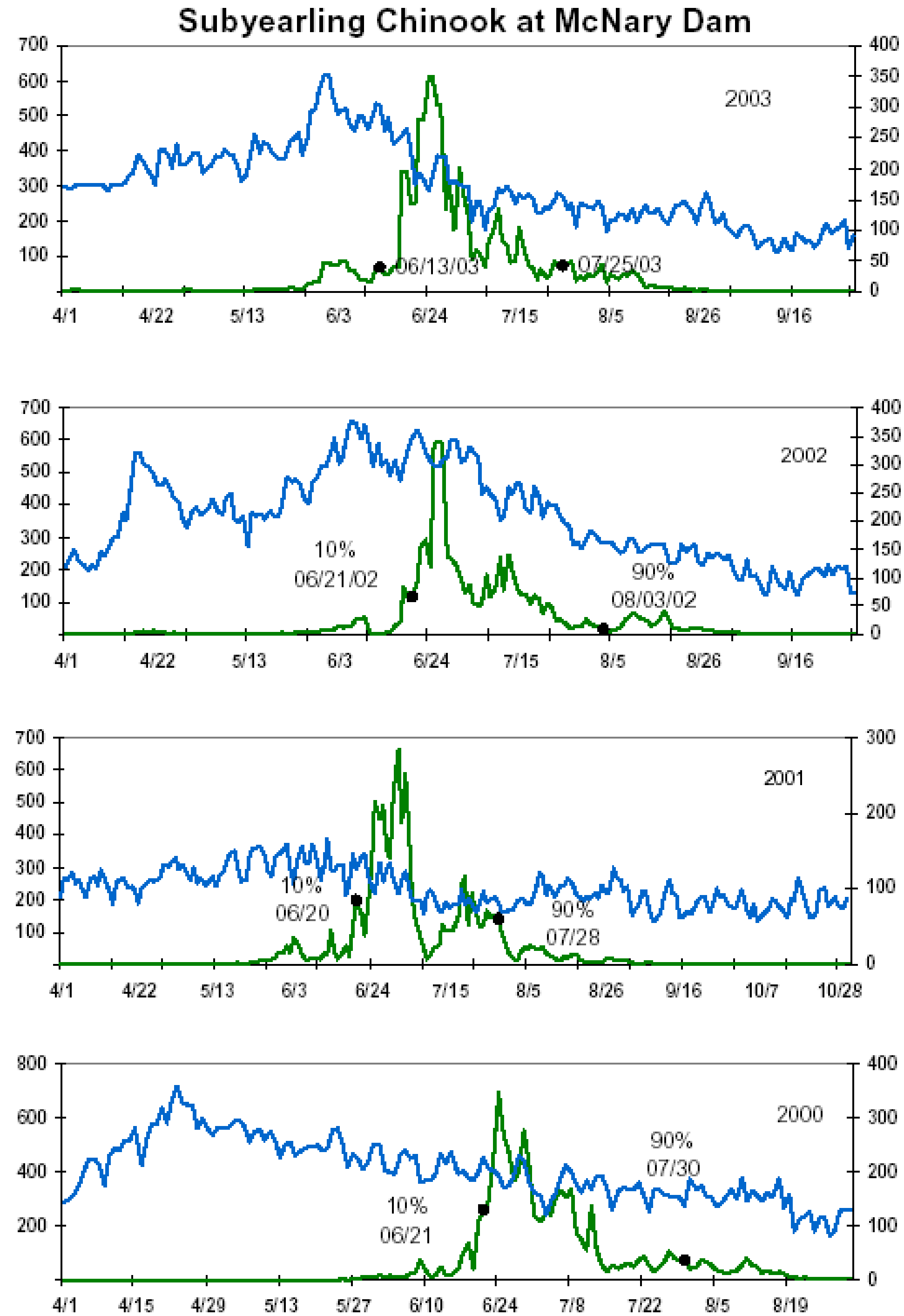
Appendix 1. Figure from FPC 2003 Annual Report.

Figure 4. Subyearling Chinook Timing at McNary Dam 2000 to 2003.



Appendix 2. Excerpt from SFTAFM (2003).

Fall Chinook Rate of Seaward Movement Results

A total of 2,808 observations were available (years 1992-2001) to describe the factors affecting rate of seaward movement of PIT-tagged fall chinook salmon from initial tagging to detection at Lower Granite Dam. After pooling the data across reaches and running every possible regression model, the slope coefficient for flow changed from being positive to negative when flow and temperature were entered into the same regression models. The correlation coefficient for the relation between flow and temperature was $r = -0.77$ ($P < 0.0001$). The slope coefficient for tagging date changed from being negative to positive when tagging date and temperature were entered in the same regression models. The correlation coefficient for the relation between tagging date and temperature was $r = 0.60$ ($P < 0.0001$). All models containing both flow and temperature, and tagging date and temperature, were removed from the analysis because of problematic multicollinearity.

The regression model with the best fit included the predictor variables temperature, fork length and riverine distance (Table 18). The slope coefficients for each of the three factors differed significantly from zero, and together the three factors explained 73% of the variability observed in natural-log-transformed rate of seaward movement (Table 18). Natural-log-transformed rate of seaward movement generally decreased as temperature increased, and increased as fork length and riverine distance increased, as shown by the sign and *P* values of the slope coefficients (Table 18). The slope in the residual plot indicates that rate of seaward movement decreased as temperature increased throughout the range of 9 to 21°C (Figure 15).

Appendix 3. Excerpt from Williams et al (2004, June 4 draft).

The survival of both wild and hatchery fish to Lower Granite Dam varied widely among years and within years with survival declining as the migration season progressed, flows decreased, and water clarity and temperature increased (Connor et al. 2003a; Smith et al. 2003). Certainly, a need exists for an estimated average survival through the Lower Granite Dam reservoir, but with data collected to date, we could not partition what portion of the mortality occurred within the hydropower system, as measures of survival (and travel time) represented both rearing and migration.

Estimating survival for subyearling chinook salmon below Lower Granite Dam has also been difficult. Because of lower detection efficiencies (because of lower fish guidance efficiencies for fall chinook), fewer PIT-tagged fish, poor survival to Lower Granite Dam, and fish dispersed over a wide time period, survival for Snake River fall chinook was only estimated as far as the tailrace of Lower Monumental Dam through 2001, and only for fish of hatchery origin (Smith et al. 2002; Smith et al. 2003). Survival between the tailrace of Lower Granite Dam and the tailrace of Lower Monumental Dam has been highly variable, with a general decline in mid to late-August, and much lower overall than for spring migrating yearling chinook salmon (Fig. 24). We did not make a survival estimate over this reach in 2002. Due to larger releases f fish in 2003, we estimated survival between the tailraces of Lower Granite and McNary Dams. Survival ranged from 75% for fish leaving Lower Granite Dam the second week in June to 22% for fish leaving the second week in July.

We have no survival estimates for juvenile fish that migrated in September and October,

Appendix 4. Excerpt from SFTAFM 2003.

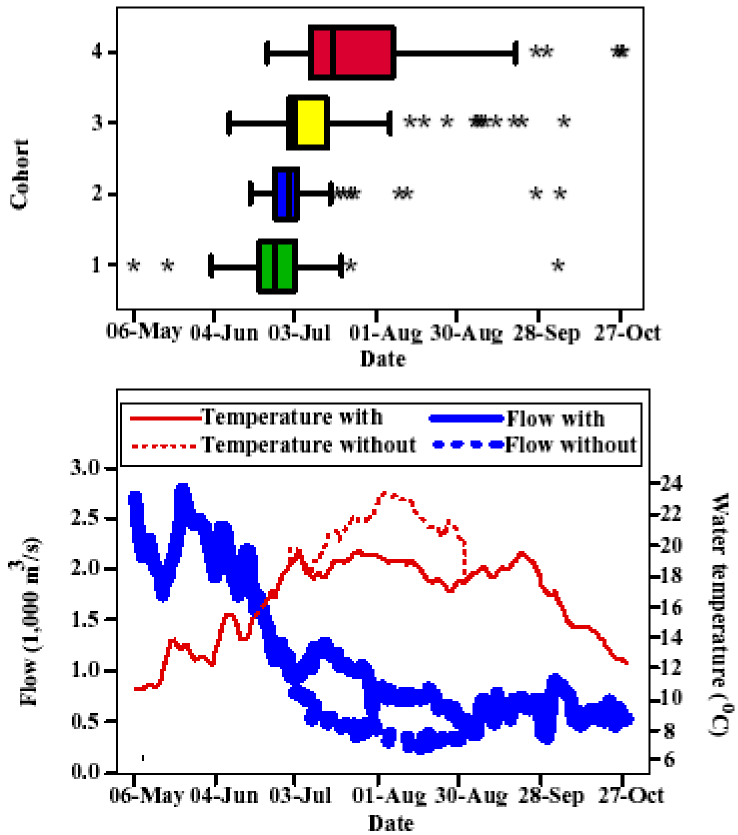


Figure 19. Box plots showing passage timing at Lower Granite Dam for PIT-tagged wild subyearling fall chinook salmon from each of four cohorts in 2000 (top), and the mean daily flows and water temperatures observed in Lower Granite Reservoir when flow was augmented (with) compared to those that may have occurred if flows had not been augmented (without; bottom).

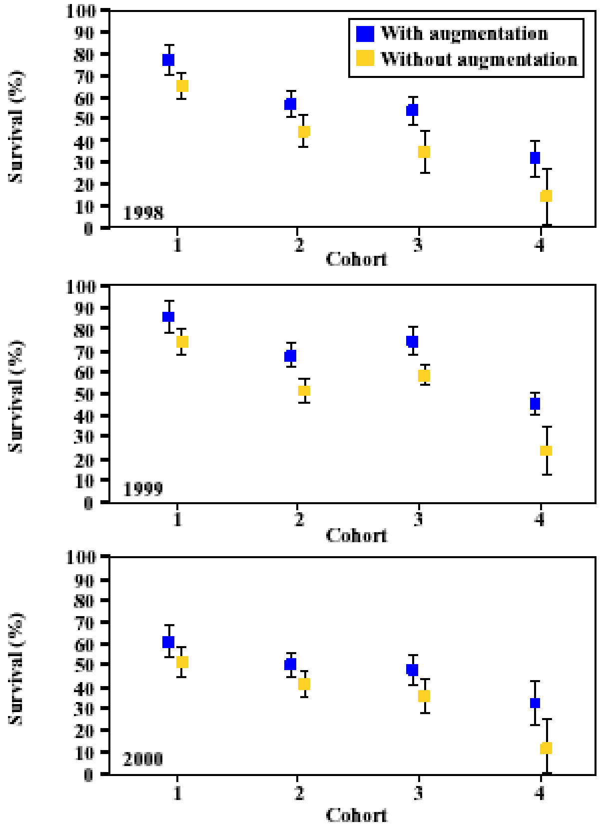


Figure 20. Survival (+95% C.I.) to the tailrace of Lower Granite Dam for PIT-tagged wild subyearling fall chinook salmon (1998 top; 1999 middle; 2000 bottom) predicted from observed mean flow and water temperatures (from Table 1), and from mean flows and water temperatures recalculated to represent those that would have occurred if flow were not augmented (from Table 3). The equation Cohort survival = 140.82753 + 0.02648 Flow -7.14437 Temperature was used to make both sets of predictions.

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