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MEMORANDUM

TO: FPAC

FROM: Michele DeHart

DATE: January 20, 2008

RE: Surrogate fall Chinook experimental groups

We summarized the available data and compared subyearling fall Chinook surrogates and wild/natural PIT tagged fish to respond to your questions. The questions and answers are summarized below and followed by a detailed discussion of our review.

- **Do surrogate fall Chinook groups provide a reliable basis for fish passage management decisions regarding smolt transportation, spill for fish passage and flow management?**

Our review indicates that there are differences between surrogate groups and wild natural groups and that those differences may vary year to year, indicating that extreme caution should be used in applying surrogate group results to fish passage management decisions.

- **Do surrogate fall Chinook group provide smolt-to-adult return data that is representative of wild/natural and or production groups of fall Chinook?**

Adult return data is not complete and it is premature to draw conclusions regarding adult return rates of surrogate fish versus natural wild fish. Although, early information indicates there may be some differences.

Background

During 2005 and 2006, surrogate fish were released as a proxy for the wild/natural fish because of the low numbers of fish available for tagging and research. Surrogates are genetically the same as production fish but reared under specially managed conditions at Dworshak Hatchery to produce a smaller sized fish similar to the wild/natural marked fish. The targeted size is

based on sizes of wild fish captured during PIT tag operations in the Snake and Clearwater rivers.

Emigration timing of the surrogate groups is determined by the release schedules. The release schedules are designed to imitate the wild/natural passage emigration timing. The wild/natural timing is in turn estimated by sampling of marked wild/natural fish in the same year. Ostensibly wild fall Chinook populations were captured and marked with PIT tags in the Snake River and Clearwater River over 58-92 day periods in 2005 and 2006 (Table 1). Surrogate fish were released over much shorter periods (11-20 days). The surrogate releases are timed to match the peak marking periods for wild/natural fish to best mimic the wild/natural marked fish.

Table 1. Start and end release/marketing dates for surrogates and wild/natural fish.

		Start date	End date	No. days
		Snake River		
2005	Surrogates	05/16	05/27	11
	Wild/natural	04/14	07/05	82
2006	Surrogates	05/15	06/03	19
	Wild/natural	05/02	06/29	58
		Clearwater River		
2005	Surrogates	06/21	07/08	17
	Wild/natural	05/03	08/03	92
2006	Surrogates	06/19	07/09	20
	Wild/natural	06/02	08/03	62

Do surrogate fall Chinook groups provide a reliable basis for fish passage management decisions regarding smolt transportation, spill for fish passage and flow management?

We considered several different aspects of surrogate fish characteristics to determine how well they imitated wild/natural fish during outmigration in 2005 and 2006. We compared surrogates to natural fish in terms of their length at marking, condition factor, outmigration timing, travel time and survival.

Length, weight and condition

We compared length and weight data between surrogates and wild/natural fish that were marked or released at similar times. The mean fork length of the surrogates has usually been 4-10 mm (5-15%) larger than their wild/natural counterparts in the same year. Fork length and weight data were collected on the same day as PIT tagging and release for wild/natural and surrogate fish. Wild fish were marked over several months every spring while surrogates were released into the Snake and Clearwater rivers over a few weeks. To summarize these data, we compared lengths by month for each group. The mean length of surrogates (by month) was 4 to 10 mm larger than that measured for wild/natural fish in 5 of 7 possible comparisons (Figure 1). On one occasion, surrogates were 4 mm smaller than wild/natural fish and once were similar in size.

The smallest Chinook that can be feasibly marked with PIT tags are about 60 mm in fork length. So, the marking of wild/natural fish is usually protracted over several months as, smaller fish in the ostensibly wild population grow to a size accessible for marking. Temporally, surrogate fish were only available to mimic wild/natural fish over a short window of time and may not represent the whole population as accurately as the wild/natural marking program. This is particularly true for the Snake River where surrogate releases were not released during the early and late months of the wild/natural marking program in both years (Figure 1).

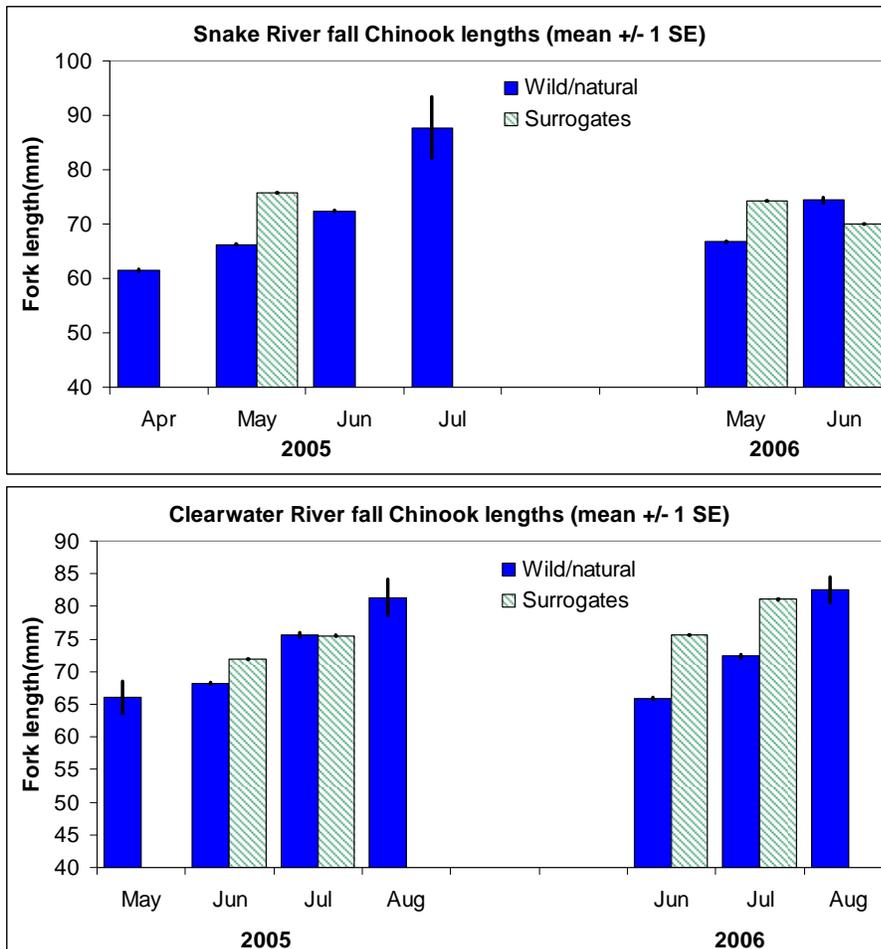


Figure 1. Fork length for surrogate and wild/natural marked fish. The top and bottom panels are for the Snake and Clearwater rivers respectively.

Condition factor allows for a measure of the “plumpness” of fish by incorporating length and weight measurements in one index. As its name implies, this index is often used as a general indication of the well being of the fish. This was calculated as: $\text{length}^3 \text{ (mm)} \div \text{weight (grams)} * 10^5$ (Anderson 1996). To ascertain the degree to which surrogates were leaner than wild/natural fish an analysis was performed to compare weights of surrogates and wild/natural fish where lengths overlapped. Fish were pooled into 10 mm length bins (e.g. 60 mm bin was 60-69 mm)

and weights were compared between surrogates and wild/natural fish. This resulted in 5 comparisons in the 60, 70, 80, 90, and 100 mm bins. Surrogates were significantly “leaner” than wild/natural fish tagged the same month (or when comparing with wild/natural fish of any month; Figure 2). All tests were significant (p -value < 0.05). The mean weight for the wild/natural fish was always larger 0.1 to 1.7 grams (3 to 34%) than the surrogate fish of similar length.

It is possible that the reduced condition factor for surrogates was a result of the rearing process. Surrogate fish are of the same genetic stock as production fish, but are much smaller in size. This is probably the result of hatchery operations purposely suppressing growth in an attempt to produce a “similar” sized fish as wild/natural marked fish. A side effect of suppressing growth may have been the production of a much thinner fish than their wild/natural marked counterparts. This reduced condition, might have affected performance relative to wild/natural fish.

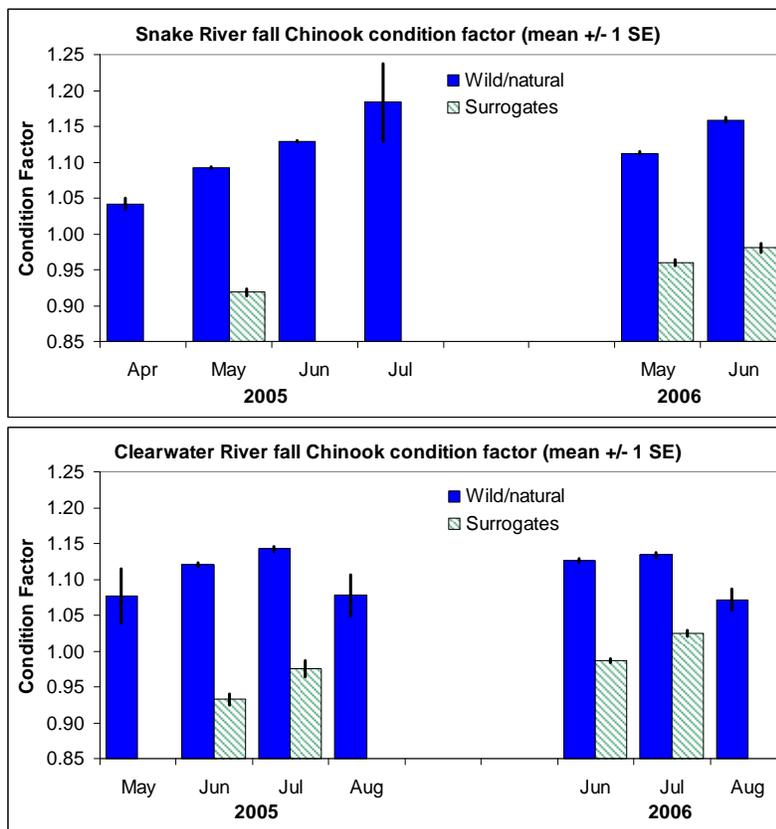


Figure 2. Condition factor for surrogate and wild/natural marked fish. The top and bottom panels are for the Snake and Clearwater rivers respectively.

Emigration Timing

The dates on which PIT tags are detected at particular dams describes migration timing for detected fish. Groups with similar detection dates would likely be exposed to similar emigration conditions. We summarized detection dates at the first three dams in the hydrosystem along with fish travel time through a particular reach. A median value of detection dates (the date where

50% of the detected PIT tagged fish had passed), allows for a simple comparative measure of detection timing. We compared the median date for the upper three dams in the hydrosystem. Nonparametric bootstrapped (1000 iterations) median detection dates were shown for all groups in figure 3; the 25th and 975th bootstrap estimates were used as confidence intervals for the median (“the percentile method”; Williams et al. 2002). In cases with less than 9 measurements, the median of the data is shown without confidence intervals.

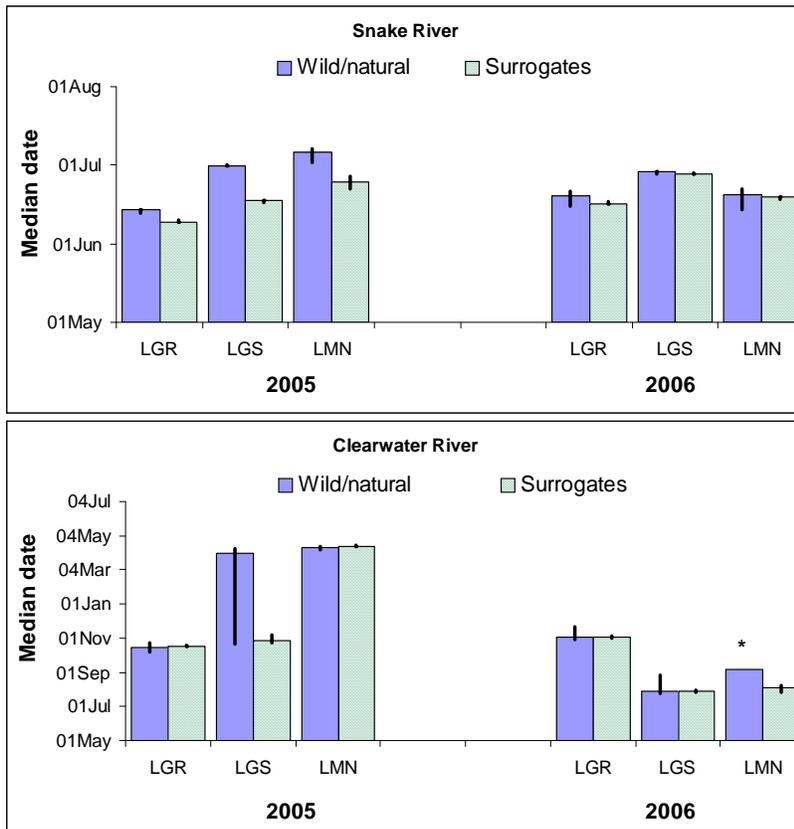


Figure 3. The median date of detections (95% CI) at LGR, LGS, and LMN. Wild/natural and surrogates are shown for the Snake and Clearwater Rivers (top and bottom panel respectively). “*” = no confidence interval. Note that in the bottom panel, the y-axis spans 1 year; this is due to the holdover fish being detected the following year.

For Snake River fish surrogates, the median detection dates were 4-13 days earlier for than wild/natural fish in 2005. In 2006, surrogates and wild/natural fish were similar. Clearwater River median detection dates were generally later than for the Snake River because of later summer passage and holdover behavior. Holdover fish were sometimes detected 11 or 12 months after tagging (note the y-axis range in the lower panel). In the Clearwater River, surrogates and wild/natural were similar.

The comparisons we made can only indicate how well the release schedules actually caused passage timing to match the wild/natural timing, since surrogate timing is largely a reflection of the release schedule. These differences in measurements of timing may be an effect of the poor

temporal overlap between surrogate releases and the wild/natural marking during 2005 in the Snake River (see length figure by month). Surrogates only overlap with a portion of the wild/natural marked fish in all cases. However, during 2005 in the Snake River, there were the fewest number of overlapping days (13%; period of surrogate releases period of wild/natural tagging). These data suggest that surrogate timing can not be used as a basis for passage management decisions, because the timing is a function of the release schedule and the surrogate timing does not always reflect the wild/natural timing.

Fish Travel Time

Fish travel time (FTT) is descriptive of the use of a particular reach and is usually expressed as a median value. Median fish travel time was calculated for release to LGR, LGR to LGS, and LGS to LMN. The nonparametric bootstrapped (1000 iterations) median fish travel time is shown for all groups in figure 4; the 25th and 975th bootstrap estimates were used as confidence intervals for the median (“the percentile method”; Williams et al. 2002). In cases with less than 9 measurements, the median of the data is shown without confidence intervals. The first estimate (release to LGR) probably includes some rearing time in addition to travel time to LGR.

In general, production fish had a shorter FTT than other groups although once in the hydrosystem, this difference was diminished. Wild/natural fish took about 5 days longer to travel from release to LGR during 2006 than surrogate fish. The median value appeared to hold this trend through the first two reaches of the hydrosystem that year but the differences were not statistically different. Other than 2005 in the Snake River, wild/natural and surrogate FTT's were similar.

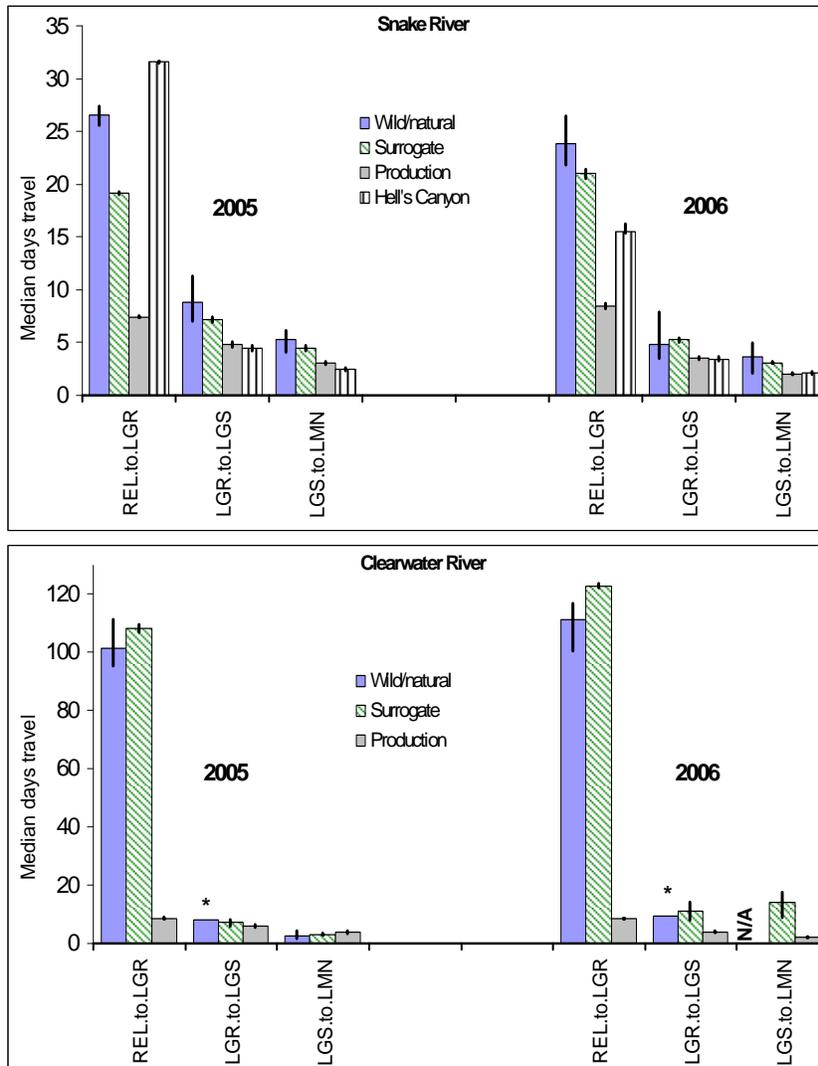


Figure 4. Median fish travel times (95% CI) from release to LGR, and through the first two reaches of the hydrosystem. All groups are shown for the Snake and Clearwater River (top and bottom panel respectively). “*” = no confidence interval, N/A = no measurement.

Survival

Annual survival was estimated for Snake River fish but not for Clearwater River fish because of the confounding effects of Clearwater River holdovers. We included only fish that were detected at LGR or LGS and not transported. The estimated survival through the first 2 reaches of the hydrosystem for Snake River wild/natural fish was always higher than for surrogate fish (summarized in figure 5 as LGR to LMN). However, these differences were not statistically significant because of low sample sizes for wild/natural fish. As compared to the production fish, surrogate survival estimates were significantly lower. So, of the fish entering the hydrosystem, the trend was lower survival for surrogate fish than for either production or wild/natural fish.

Also, surrogates have similar timing to wild/natural fish, but dissimilar from production fish. This may suggest that Snake River surrogates may be less fit for emigration during similar dates as the wild/natural fish. Keeping in mind that timing of surrogate fish is largely determined by the release schedule.

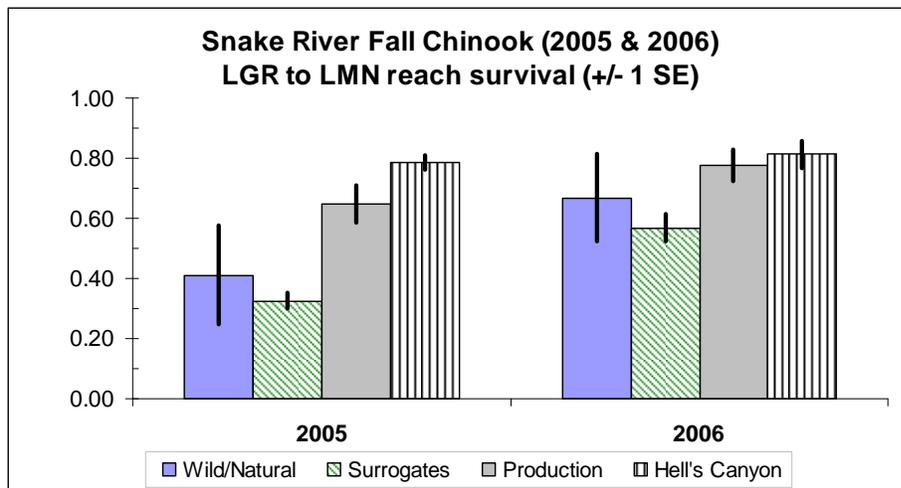


Figure 5. Snake River reach survival estimates from LGR to LMN for each fish group and both years.

Annual survival estimates were produced for each group of fall Chinook from the Snake River. Groups were composed of fish that were detected at LGR in early summer (mid June to early July) and not transported. To improve the precision of survival estimates unique detects at LGS (not detected at LGR) were added as a LGS release (see Fish Passage Center Technical Report 2007-1 for details on this technique). This approach improves samples sizes and is consistent with CJS methodology. Survival estimates were not calculated for Clearwater River fall Chinook because these fish have a protracted outmigration period and are known to exhibit holdover behavior that would confound survival estimates.

If surrogates are to be used as a proxy to determine wild/natural fish responses to environmental conditions, they have to respond as wild/natural fish in all conditions. Survival during the juvenile emigration through the hydrosystem is an important life history aspect for these fish. The LGR to LMN survival estimates are shown in Figure 6 (reach survival estimates beyond LMN could not consistently be calculated due to low sample sizes). The estimated survival through the first 2 reaches of the hydrosystem for Snake River wild/natural fish was always higher than for surrogate fish. However, these differences were not statistically significant. As compared to the production fish, surrogate survival estimates were significantly lower. So, of the fish entering the hydrosystem, the trend was lower survival for surrogate fish than for either production or wild/natural fish.

Do surrogate fall Chinook group provide smolt-to-adult return data that is representative of wild/natural and or production groups of fall Chinook?

Adult returns

Adult returns can be thought of as the end product of the fall Chinook life cycle. For both years, the adult return is currently incomplete. The maximum aged adults from the 2005 and 2006 migration years are 2-salts and jack's respectively. Figure 5 shows the adult returns to Lower Granite (LGR), Ice Harbor (IHR), McNary (MCN), or Bonneville (BON) dams for each group of fish. For each category, the numbers of returns are shown as a proportion of those fish tagged above LGR (Figure 6).

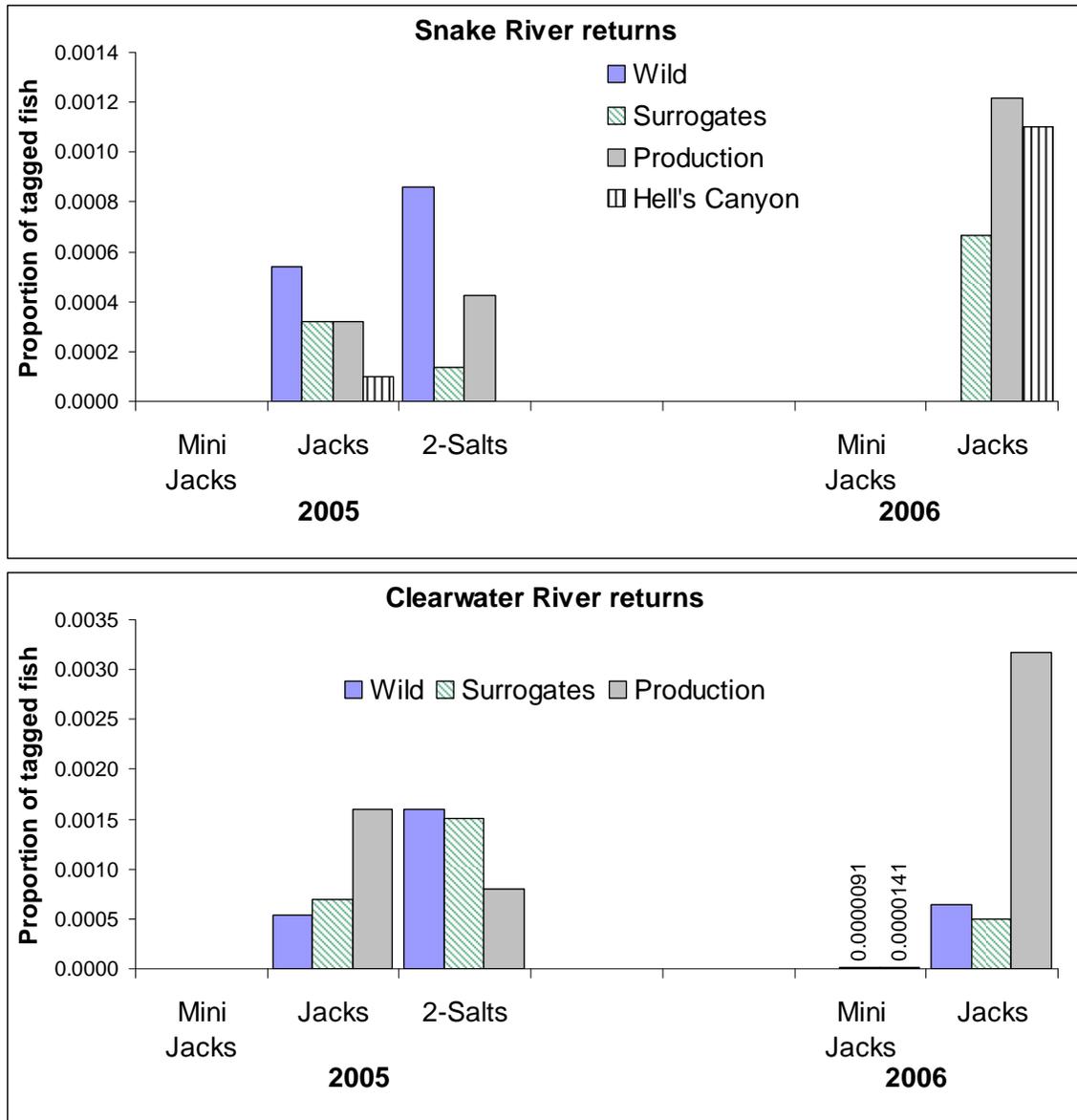


Figure 6. Adult returns for all groups. Each bar is the proportion of tagged fish above LGR that returned as adults (as of ~ 31 Nov 2007). The top and bottom panels are for the Snake and Clearwater rivers respectively.

Although incomplete, there are some observations worth noting from these data. In the Snake River surrogate returns appear to be dissimilar from production and wild/natural fish (except for production jack returns in 2005). The wild/natural fish appeared to produce markedly more returns than surrogates or production fish in the Snake River during 2005. The 2006 wild/natural marked fish have not produced returns yet from the Snake River.

In the Clearwater River, the wild/natural and surrogates groups appear more similar than the production group. However, the wild/natural fish have not produced any detected mini-jack's in any category. The only group to produce any min-jack's are the 2006 Clearwater surrogates and production fish.

It is premature to draw any conclusion regarding adult returns of surrogate and wild/natural fall Chinook because adult returns are not complete. Early return data is displayed in the attached figures indicating that in some cases differences in adult returns occur. These may be due to the surrogates themselves, condition factors, or poor temporal overlap between the wild/natural marking program and surrogate releases or juvenile migration experience.

Conclusions

Matching surrogate fish with their wild/natural counterparts exactly in size, timing, and condition has uncertain results that can vary from year to year. Our review suggests that the two are not always similar. Although surrogate fish represent a tool that allows research to take place, caution should be exercised in applying results and passage characteristics of surrogate fish groups to the run-at-large or to natural/wild production. Passage management decisions based upon surrogate fish groups could be misapplied to wild/natural and production groups. Before surrogate data can be used for management decisions, their similarity with wild/natural fish needs to be evaluated by river and year. Future adult return data may shed more light on similarities and differences between the two. In addition, caution should be used before surrogate survival estimates are used in place of wild/natural marked fish.

References

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. *Fisheries Techniques* 2:447-482.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. *Analysis and management of animal populations*. Academic Press San Diego.

FPC 2006. *Fish Passage Center, annual report 2006*. DOE/BP-1994-330-00, Bonneville Power Administration, Portland, OR (US). Appendix A: Subyearling Chinook Survival in

Lower Granite Dam to McNary Dam reach in 2006 compared to years 1998 to 2005;
Preliminary analysis.