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MEMORANDUM

TO: Brian Lipscomb, CBFWA
Bill Tweit, WDFW

FROM: Michele DeHart

DATE: November 13, 2008

RE: Review, "Survival of migrating salmon smolts in large rivers with and without dams", Welch et al. PLOS Biology 2008

The Fish Passage Center received two requests for review of the Welch et al paper. Brian Lipscomb, Columbia Basin Fish and Wildlife Authority (CBFWA) requested responses to the following specific questions. Bill Tweit, Washington Department of Fish and Wildlife requested a review of the paper specifically addressing tag effects, and recommended that we rely on Canadian scientists at the Department of Fisheries and Ocean for an assessment of the Fraser River survival estimates generated by Welch et al. We have requested data from the Canada Department of Fisheries and Ocean and have requested their assessment of the Fraser River survival estimates, but we have not yet received a response. We have answered the specific questions directly based upon our review. We follow with detailed discussion of our concerns as a result of our review. **Our overall conclusions are:**

- **Acoustic tags of the size range and tag burden used in the Welch study are likely to affect fish behavior and survival.**
- **The acoustic tag/POST array is of questionable utility and application for monitoring juvenile salmon and steelhead migration characteristics including survival.**
- **The Welch et al analysis and conclusions are questionable because they rely on a wide range of disparate data sets over different time periods, different tag types and require implicit assumptions that are not identified by Welch et al.**

- **The validity of the comparison Columbia/Snake Pit tags to acoustic tags is questionable. The conclusion that acoustic tag data and PIT tag data result in indistinguishable results is highly questionable. The Snake/Columbia acoustic tag group does not represent the juvenile Chinook run at large.**

CBFWA Questions

Is this a valid comparison of survival rates of spring Chinook and steelhead in these two river systems?

No, this is not a valid comparison of survival rates of spring Chinook and steelhead in these two river systems. Our review raised significant questions as to the validity of the acoustic survival estimates in each river, and whether or not they are representative of the wild and hatchery Chinook and steelhead populations in the Fraser and Columbia Rivers. We question the validity of this study because several important, implicit assumptions were not mentioned in the Welch paper, and must be addressed before we could accept the comparison as valid. One major assumption is that the acoustic tags utilized did not reduce survival rates of tagged fish. We identified several lines of evidence suggesting that this assumption was violated. The ratio of tag weight to fish weight in the Welch study far exceeded recommended guidelines. Welch's Fraser River results indicate that mortality rates measured in the Fraser were several times higher than has ever been observed in the Columbia, with mortality rates far exceeding the worst migration year on record, 2001. The validity of the Welch et al. conclusions precariously hinge on the major assumption that acoustic tag and PIT tag methodologies produce the same survival results. The Welch et al. comparison of one PIT tag group and one group of double marked PIT/acoustic tag fish is unconvincing and appears to have been confounded by significant differences in the release size, location, and timing of those groups. Furthermore, Welch et al. combined several different tag types, collected from different years, to generate a generic estimate of whole river survival to compare the two river systems. This miscellany approach of combining disparate sources of data raises further questions about the validity of the study and its comparisons.

What are the strengths of this study; what are the weaknesses of this study?

Weaknesses in this study include: the lack of a study design, no hypothesis is identified, assumptions are not clearly stated, implicit assumptions were poorly evaluated, methodologies are opaque and unclear, and critical data are not provided. Welch et al. do not discuss some important issues in their study data, such as the apparent tag effects on mortality rates among the Fraser River groups analyzed. The authors did not present basic information such as sample sizes or size at release, nor did they discuss the effects of their extremely small sample sizes or their major assumptions regarding detection probabilities. For example, we found that the Fraser River survival estimates for 2004 were based upon only two fish detected in the POST array. Potential sources of error and bias that were not addressed in Welch's study include: apparent tagging effects of the acoustic tags, differential tagging effects between tag types, poor-precision survival estimates based upon very small sample sizes, the questionable approach of combining tag groups from various populations, comparing groups released at different time periods and locations, comparing groups that were handled differently, and the effects of tag shedding and tag mortality. These factors and the potential biases they introduce are all important considerations in a good experimental design. Because these issues were not adequately addressed, we find the experimental design and study conclusions to be very weak. Furthermore, the fish selected for acoustic tagging and used to compare river systems appear to have been unrepresentative members of the overall hatchery or wild populations in either river.

This study does raise questions regarding the impacts that acoustic tags have on fish survival.

Is the conclusion that "overall migratory survival of salmon smolts in the Columbia and Fraser systems is now similar" supported by the data presented?

No, this conclusion is not supported by the data presented. There is no data presented in the paper that properly addresses overall migratory survival for either river system. The Columbia/Snake estimate, with the exception of 2006 where Dworshak Hatchery fish were released from Kooskia, overall migratory survival is a miscellany combination of years, populations, migration experiences and mark types. The 2006 “overall” migration survival estimate based upon 400 acoustic tagged group from Kooskia is problematic in its representation of the Chinook population and in the calculation of the survival estimate itself. There is no basis presented to assume that the mark groups represent the hatchery juvenile Chinook population at large, nor is there a basis presented to assume that the mark groups represent the wild populations of Chinook and steelhead in the Snake/Columbia or Fraser Rivers. For the Fraser groups there is no basis provided for concluding that the acoustic mark groups represent the run-at-large in the Fraser River in terms of their size at release, time of release, or their passage distribution. Welch et al. base their analysis of overall migratory survival of Snake/Columbia spring Chinook on their large assumption that there was no survival difference between PIT tagged juveniles and acoustic tagged juveniles. The authors attempt to justify this assumption by comparing one group of acoustic and PIT tagged fish (double tagged) with one group of PIT tagged spring summer Chinook released from Dworshak Hatchery with PIT tags. However, upon careful examination this comparison appears to be flawed and deeply confounded by several potential sources of bias and error such as, the releases took place a month apart, with the PIT tags released the last week of March and the acoustic tags released in May, the groups were released from different locations, Kooskia and Dworshak, which are 60 km apart, and the passage distributions of these two groups at Lower Granite Dam, the first PIT tag detection site, were not similar.

Is there any evidence that if the survival rates were the same for these two river systems, that this demonstrates that the dams are not a major limiting factor for Columbia River fish populations?

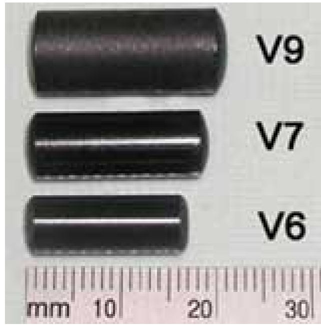
No. For the reasons listed above, we are concerned that Welch's estimates of Fraser River survival rates are doubtful, and we believe that those estimates indicate that their acoustic tags are causing significant mortality. However, if we were to assume that those survival rates were valid and similar to the PIT-tag survival rates observed in the Columbia, then the Welch study strongly indicates that dams are a major limiting factor for Columbia River fish populations. In the unimpounded Thompson-Fraser, Welch's data indicate that Chinook migrated at an average rate of 54 km/day while steelhead migrated at an average rate of 62 km/day. In the impounded Snake-Columbia, Welch's data indicate that Chinook migrated at an average rate of 22 km/day and steelhead migrated at 28 km/day. These rates strongly indicate that dams and their associated reservoirs have reduced migration speeds by more than half. Applying the Thompson-Fraser migration speeds to the Snake-Columbia, Chinook would arrive to below Bonneville 9 to 31 days earlier and steelhead would arrive 5 to 24 days earlier without the low-velocity reservoirs and concrete passage difficulties caused by the dams. In addition to migration delays, there is substantial evidence that passage through the dams results in delayed mortality that is expressed after juveniles migrate past Bonneville Dam. These two factors, migration delays and delayed mortality, demonstrate that dams are a major limiting factor for Columbia River fish populations, even if we were to assume that survival rates were the same for these two river systems.

Fish Passage Center Specific Review Comments

Acoustic tags affect fish survival and behavior

Tagging studies are used to make inferences about a population. To make valid inferences applicable to the entire population, tagging studies should make attempts to representatively tag all members of the population in terms of their size, distribution, and migration timing. In addition, the tag used to mark fish should have minimal effect on the animal's behavior, such that the behavior of the tagged fish mimics the behavior of untagged members of the studied population. When the tags themselves alter animal behavior or survival, study results are rendered invalid for making inferences about a population, and only represent effects on the tagged individuals.

In Welch's study, we have major concerns about the large size and heavy weight of the acoustic tags that were utilized. Welch used the V9 acoustic tag exclusively in the Columbia River, while both the V7 and V9 acoustic tags were used in the Frasier River study. The V9 tag measures 9 mm by 20 mm and weighs 3.1g, while the V7 tag measures 7mm by 22 mm and weighs between 0.7 and 1.0 g.



Typically the effect of a tag is assumed to be relative to the ratio of the tag weight to overall weight of the organism (tag burden). There is some variability in the accepted range of tag burden used in different studies. Winter (1983, 1996 and 2000) recommends that the ratio of tag weight to body weight (in air) should be less than 2%. This recommendation was a widely accepted guideline in place for several years. However, studies such as Zale et al. (2005), used transmitters as large as approaching 4% of body weight without substantial decreases in laboratory fish performance. Others studies (Adams et al, 1998) suggest that surgical implants representing 2.2 to 5.6% of the fish's body weight in fish greater than 120 mm, are acceptable given that laboratory swimming performance of juvenile Chinook was compromised relative to the controls when the tag ratio exceeded 5%. Lacroix et al. (2004) suggested that in long term studies tag weights of less than 8% of body weight for juvenile Atlantic salmon could be used since laboratory fish swimming performance recovered after several days.

Several studies were reviewed by a group of Columbia Basin experts and a series of guidelines were established for study protocols. An intermediate tag ratio 5 to 6.5% was recommended by Peven et al. (2005) in the "Guidelines and recommended protocols for conducting, analyzing and reporting juvenile salmonid survival in the Columbia River Basin."

The studies conducted by Welch et al. (2008) in the Columbia River used a tag weighing 3.1 g and implanted in yearling Chinook fish exceeding 140 mm in length. Based on the weights at time of tagging for his study groups in 2006, this represents an average (+/- 95% CI) tag burden of 9.3% (+/- 0.14%) that ranged up to 11.5%. Thus, Welch's tagging of Dworshak spring Chinook exceed the recommended guidelines for tag burdens based on laboratory studies. Because laboratory settings are much more benign than migration through the Columbia, it is likely that excessive tag burden may have affected the behavior and survival rates measured in the Columbia. Welch et al. provided no data on the length or weight of the steelhead or Chinook released into the Thompson-Fraser, therefore we could not determine the tag burden for the Fraser studies. It seems likely that given the size of the tags used in the Thompson-Fraser would also exceed the recommended guidelines for laboratory studies and could have affected the results obtained during the challenges of river migration after release.

Welch et al.'s claim that the survival of their acoustic tagged fish is the same as PIT tagged fish is inconsistent with other studies. A joint study, presently being implemented by NOAA Fisheries, Batelle Northwest and the US Army Corps of Engineers (AFEP Research Review December 2007), using yearling Chinook with surgically implanted acoustic tags with an average body burden of 3% by weight showed a significantly lower relative survival for study fish migrating from Lower Granite to McNary Dam, which was consistent with laboratory studies they conducted at the same time. Other studies conducted by this same group of researches using subyearling Chinook found that tag burdens approaching 5% showed negative effects on the performance and behavior of the subyearling salmon after two weeks.

In summary, based on the laboratory and field studies that have been conducted to date, it seems likely that acoustic tags in the size range and tag burden used in the Welch study would affect fish behavior and survival. If this is the case, then the study results would be rendered invalid for making inferences about untagged populations, and would only represent effects on the tagged individuals themselves.

Welch et al. did not address potential bias from tag shedding or tagging mortality

Survival estimates in the Fraser River exclusively used acoustic tags, but the Welch study made no attempt to correct survival estimates for tag shedding or tagging mortality. A previous study by Welch found that tag shedding rates multiplied by tag mortality rates for steelhead of 140-160mm in length can range from ~15–25% (Welch et al. 2007, Figure 2). The Welch et al. (2007) laboratory study tested dummy tags more similar to the V9 tags than the V7 tags. Even if one assumed that no adjustment is needed for the V7 tag, correcting the V9 survival estimates with these tag mortality and tag shedding rates would increase geometric mean survival (standardized to 100km) from 67% to 70% or 72% for Fraser steelhead. Perhaps more importantly, the additional uncertainty associated with tag shedding/mortality would increase the already large variance estimates associated with these survival estimates, raising significant questions about the accuracy and precision of the results presented in Welch et al. (2008).

Welch et al. comparison of acoustically-tagged and PIT-tagged Snake River spring/summer Chinook:

The Welch et al. (2008) analysis and conclusions comparing the Fraser and Snake/Columbia is dependent on the assumption that survival estimates of PIT-tagged and acoustically tagged smolts are the same, and therefore can both be used to make comparisons between the two river systems. To demonstrate that these two tags are comparable in the Snake River, Welch et al (2008) provides a comparison of reach survivals between PIT-tagged and acoustic/PIT-tagged yearling hatchery Chinook through the impounded region of the Snake and Lower Columbia rivers. Based on this comparison, Welch et al. (2008) concludes that PIT and acoustic tag methodologies provide similar survival estimates for freely migrating smolts through these portions of the Snake and Lower Columbia rivers, therefore justifying the combination of PIT tag and acoustic tag estimates. Further Welch et al. expand their results to the run at large. The Welch et al. conclusion and subsequent comparison are questionable.

Welch et al. attempt to categorize the survival of all Snake River wild and hatchery yearling Chinook populations based on a comparison of just one group of 400 acoustically tagged hatchery smolts that were released at Kooskia to one group of PIT-tagged smolts released from Dworshak. This is problematic; the Welch mark group is not representative of the run at large. The hatchery yearling Chinook released from Dworshak National Fish Hatchery (DWOR) in migration year 2006 only represented about 10% of all the overall release of hatchery yearling spring Chinook above Lower Granite Dam. The 400 acoustic tagged fish from Kooskia did not represent <u>any</u> hatchery spring Chinook releases relative to size at release, time of release or size at tagging. In addition, Welch et al. did not present any data indicating that their mark group represented wild Snake River yearling spring Chinook or their survival rates through the hydrosystem.

Conclusions about the comparison of the results of acoustic and PIT mark groups being indistinguishable from each other are not valid because other significant differences between the mark groups that could affect survival were not addressed. The acoustic tag group had different migration distribution and timing, release date, and size at tagging.

To assess whether PIT-tagged smolts survive at similar rates as acoustically tagged smolts it is imperative that other confounding factors are addressed. For example, release size, time of release, rearing conditions, and release site must all be the same for both groups being compared so that the only differing variable is the type of tag. This is important because as all of these other variables can also affect juvenile survival. However, these basic scientific principles were not followed for the comparative analysis presented in Welch et al. (2008).

First, the PIT-tagged smolts and acoustically tagged smolts presented in this comparative analysis were very different in their sizes at tagging. The PIT-tagged smolts presented in Figure 2 of Welch et al (2008) were based on 97,291 yearling spring Chinook smolts that were PIT-tagged and released from Dworshak hatchery (Faulkner, 2007). At the time of tagging, these

PIT-tagged smolts were 111.3 ± 0.06 mm FL (Mean ± 95% CI). However, the acoustically tagged smolts were tagged with a V9 acoustic tag, which has a minimum tagging size of approximately 140 mm FL. At the time of their tagging, these smolts were 146.2 ± 0.82 mm FL (Mean ± 95% CI). Figure 1 below illustrates the difference in the size frequency distribution of the yearling spring Chinook that were PIT-tagged versus those that were acoustically tagged.

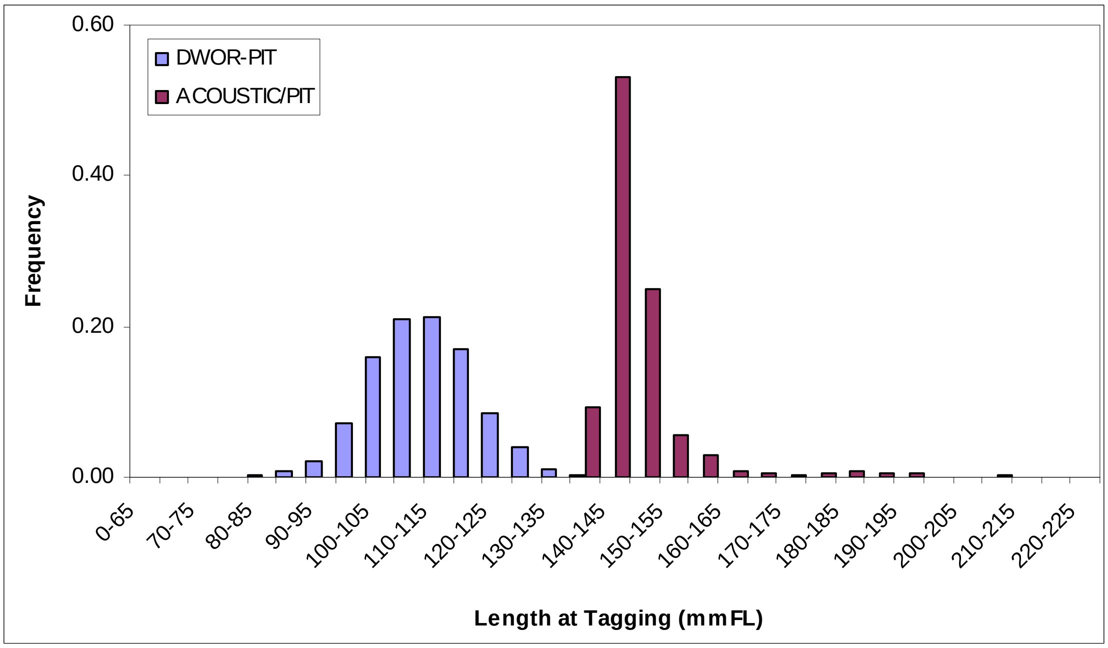


Figure 1. Size frequency distribution of length at tagging for Snake River yearling spring Chinook that were PIT-tagged (DWOR-PIT) versus acoustic/PIT-tagged (ACOUSTIC/PIT) in migration year 2006.

Furthermore, the PIT-tagged smolts were reared at DWOR, tagged from January 4 to February 10, 2006, and held at DWOR for 46 to 82 days (geometric mean: 65.4 days) until their direct release from the hatchery. The acoustically tagged smolts were transferred to Kooskia in March 2006 where they were reared to the minimum size for tagging (140mm FL). These smolts were then tagged from April 11 to April 28, 2006 and held for 3 to 27 days (geometric mean: 14.3 days) until their release into Clear Creek. Clear Creek is approximately 60 km upstream from Dworshak, where the PIT-tagged smolts were released.

Finally, The PIT-tagged juveniles were released from Dworshak on March 27 and March 29, 2008, whereas the acoustically tagged smolts were released at Clear Creek much later in the migration season (May 1 and May 8, 2008). As is demonstrated in Figure 2, the difference in passage timing for these two groups at Lower Granite Dam is substantial. The acoustically tagged smolts had a much later arrival timing to LGR than did the PIT-tagged smolts. In fact, by the time any of the acoustically tagged smolts arrive at LGR, over 50% of the PIT-tagged smolts had already passed LGR. This same pattern was true when compared to the LGR timing of the yearling Chinook run-at-large (Figure 2). In addition to the later passage timing, the acoustically tagged smolts seemed to have a more compressed timing at LGR when compared to that of the PIT-tagged smolts or to the run-at-large.

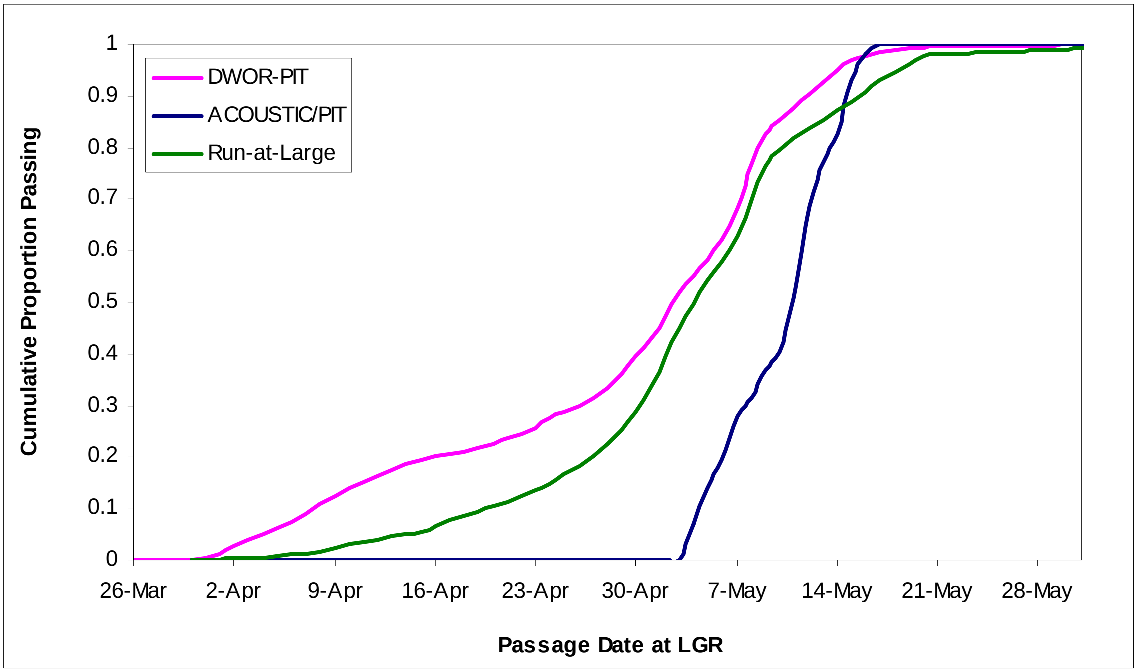


Figure 2. Cumulative proportion of PIT-tagged yearling Chinook released from DWOR (DWOR-PIT) and acoustically tagged yearling Chinook released from Clear Creek (ACOUSTIC/PIT) passing Lower Granite Dam. The passage timing of the run-at-large is based on yearling Chinook passage data collected for the Smolt Monitoring Program at Lower Granite Dam in 2006.

The survival estimates for Snake River acoustic tag fish are questionable because of assumptions regarding detection probabilities

The acoustic tag survival estimates developed by Welch et al are largely the results of estimated or assumed detection probabilities of the POST array. The 2006 Snake River acoustic tag survival estimates reported in Welch et al. (2008) were generated in a pilot study funded by the Bonneville Power Administration (BPA). Review of the Kintama Research Corporation report to the Bonneville Power Administration, Contract No. 2003-114-00, Grant No. 00021107 January 11, 2007, the authors (Welch et al.) reported survival estimates were "…*adjusted for lost gear using the global average method…*". The "*global average method"* averages the number of tag detections per (operating) receiver and then expands that number to those that were inoperable. At the Willapa array 11 of 40 receivers were not operating during the period when tagged fish passed; detections were expanded 1.3 times. This is not a standard Cormack, Jolly, Seber (CJS) method for estimating detection probability. In fact the survivals represent an adjusted minimum survival, since the survivals presented were based on release numbers divided by total detections or in this case adjusted total detections.

Combining disparate data sets and estimates to compare river systems and implicit but unidentified assumptions

Welch et al. attempted to compare Fraser River and Columbia River smolt survival estimates for out-migrating steelhead and Chinook. Survival was measured in the Fraser River from release to near the river mouth with acoustic tags. To facilitate comparable whole river estimates for the Columbia River, PIT tag survival estimates were combined with acoustic tag estimates. Survival estimates were then combined within and across years to generate a generic estimate of whole river survival to compare the two river systems. Welch's approach requires acceptance of several unproven and questionable assumptions such as:

- Survival is homogenous across years in the Columbia River and in the Fraser River.
- Survival is homogeneous across stocks within a species (Columbia or Fraser)
- Survivals from the Kooskia NFH to the Willapa line detection site are interchangeable with survivals from Lower Granite Dam to the Astoria Bridge.
- Tag shedding and tagging mortality is zero for both V9 and V7 tags
- Therefore, tag shedding and mortality of V9/V7 acoustic tags are similar to and can be combined with PIT tag survival estimates.

A summary of the origin of the data sets combined by Welch et al. are shown in Table 1.

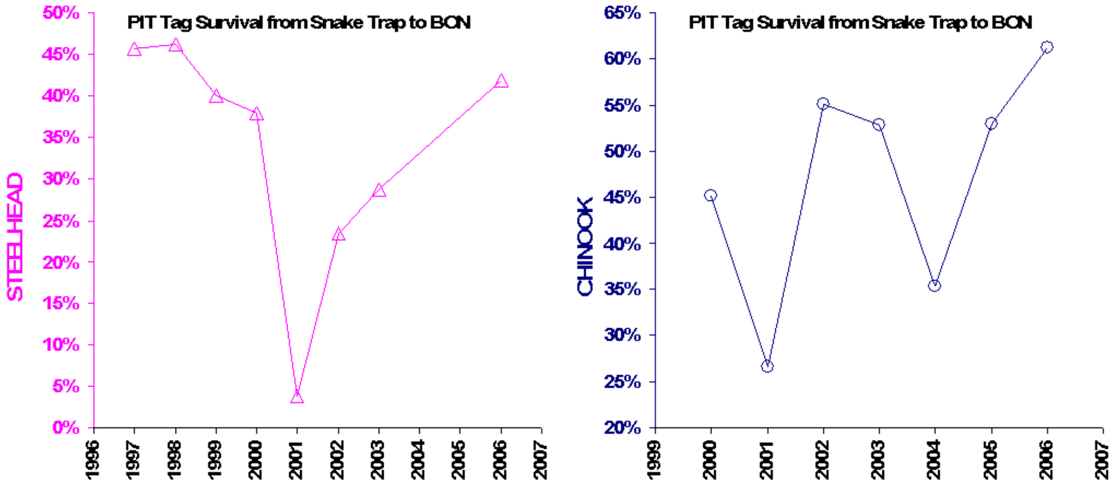
Table 1. Years and reaches where survival estimates were reported in Welch et al. 2008. PIT tag estimates are labeled PIT while acoustic tag estimates are labeled V9 or V7. The case where survival is estimated for the same species in both river systems is highlighted in yellow.

CHINOOK				
Year	**Thomp./Fraser to Mouth**	**SKTRP to BON**	**BON to Astoria Bridge**	**Kooskia to Willapa**
1997				
1998				
1999		PIT		
2000		PIT		
2001		PIT		
2002		PIT		
2003		PIT		
2004	V9	PIT	V9	
2005	V7, V7, V9	PIT		
2006	V7, V7	PIT		V9
STEELHEAD				
Year	**Thomp./Fraser to Mouth**	**SKTRP to BON**	**BON to Astoria Bridge**	**Kooskia to Willapa**
1997		PIT		
1998		PIT		
1999		PIT		
2000		PIT		
2001		PIT		
2002		PIT	V9	
2003		PIT	V9	
2004	V9			
2005	V9, V9			
2006	V7, V7, V9, V9	PIT		

To generate an overall estimate of survival for each species in the Thompson-Fraser, it appears that the author averaged across all estimates for a species. This would weight the overall estimate more towards years with more estimates (e.g. for steelhead, this approach give more weight to year such as 2006, with 4 survival estimates). A Monte Carlo procedure was then used to calculate a variance around this point estimate.

For the Columbia River, the Kooskia to Willapa estimate was included for Columbia River Chinook (see "Whole-River Survival", Table 1, Welch et al 2008). It should be noted that the Kooskia to Willapa estimate includes 192 km of smolt emigration corridors that are not included in any other Columbia River survival estimate. These additional smolt migration routes include ~ 68 km from the Astoria Bridge to the Willapa detection site in the ocean and ~ 124 km upriver of all other Columbia River survival estimates shown here. Despite this mismatch, this is included as a companion to an estimate from the Snake River Trap to the Astoria Bridge (i.e. note two separate estimates for the entire Columbia River in Figure 1, Welch et al. 2008). Even when adjusting by km or time, it seems inappropriate to assume that the mortality rate would be constant across such disparate areas.

Figure 3. PIT tag survival point estimates reported in Welch et al, 2008 for the Snake Trap to Bonneville dam reach.



There is only one case in this study where the same species is measured in the same year and only measured within the river system (i.e. no ocean mortality as in the Kooskia to Willapa line survival). This is in 2004 for Chinook. The author notes that "there is a paucity of data concerning interannual variation in smolt survival in either system we studied." However, the PIT tag survival values in Table 1 in the article run counter to this argument. PIT tag survival for Chinook ranged from 26.6% to 61.2% and steelhead survivals ranged from 3.8% to 46.2% (see Figure 3. above; values taken from Table 1 in Welch et al, 2008). Even with this obvious interannual variation, PIT tag survivals across more than eight years in the Columbia are presented as being comparable with estimates across 3 years (sometimes different years) in the Thompson-Fraser River.

Lower Columbia River survival from Bonneville Dam to Astoria Bridge are based on few years with limited overlap with years of Thompson-Fraser data.

- There is overlap of only one year for Chinook (2004) and no years for steelhead (2002-2003 in lower Columbia and 2004-2006 in the Thompson Fraser).
- Given the uncertainty about the validity of the 2004 survival estimate for Chinook with the V6 tag in the Thompson-Fraser data, there may be effectively no years in common between the lower Columbia River and Thompson-Fraser River data.

Too few years of lower Columbia River (Bonneville to Astoria Bridge) survival rates are available for both Chinook and steelhead to adequately match the 8-yr data set for the Snake-Columbia hydrosystem (Lewiston to Bonneville Dam).

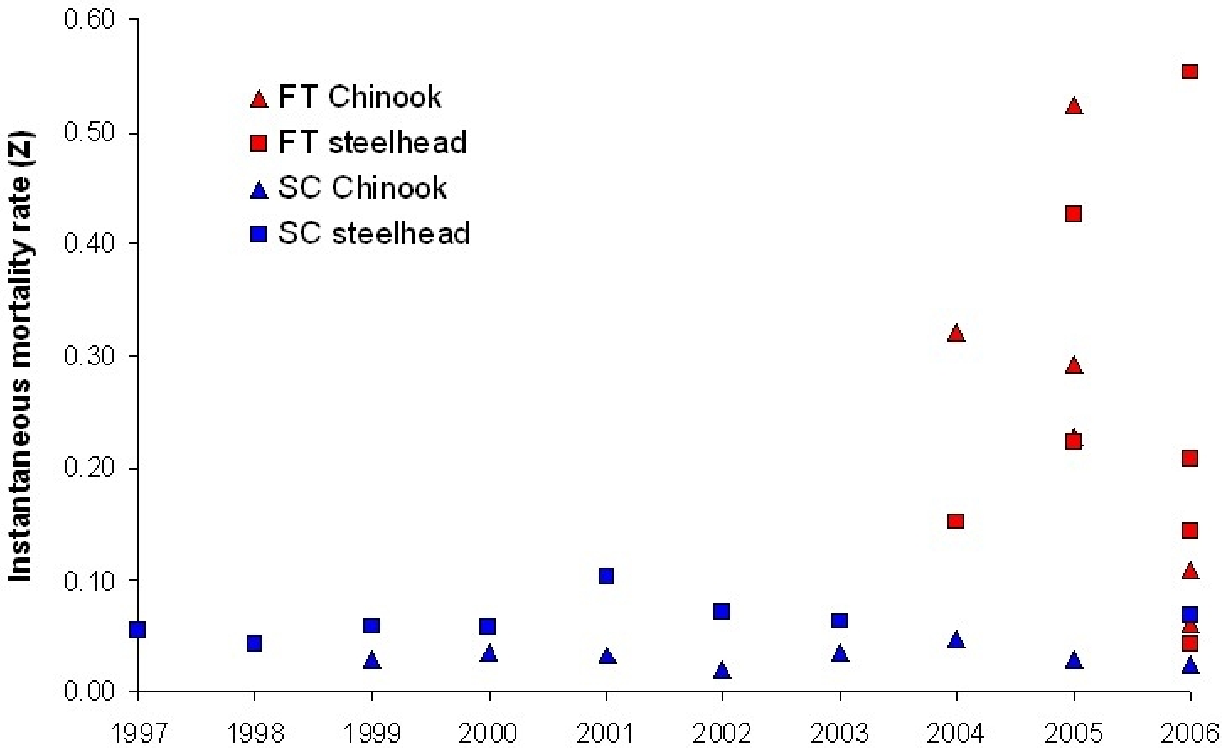
- Only a one year (2004) survival rate is available in the lower Columbia River to relate with the 8-yr period (1999-2006) of hydrosystem survival rates.
- Only two years (2002-2003) of survival rates are available in the lower Columbia River to relate with the 8-yr period (1997-2003 and 2006) of hydrosystem survival rates.
- The available lower Columbia River survival rate estimates occur in years of relatively low hydrosystem estimated survival for both Chinook and steelhead. While higher than 2001, the hydrosystem survival rates in the respective 8-yr periods for each species were lower (<37%) in matching years compared to the remaining non-matching years (>37%).
- The 2003 lower Columbia River estimate for steelhead is a weighted average of ROR (mixed population including non-Snake River stocks) and BARGED (Snake River stocks only) even though researchers reported a statistical significantly higher survival with the BARGED fish.
- Since only BARGED fish were available for Chinook, so it is unclear why researchers didn't limit the 2002 and 2003 steelhead to BARGED fish in order to guarantee that only Snake River stocks were utilized.

Instantaneous mortality rates in the Columbia/Snake relative to the Fraser

The Comparative Survival Study Ten-Year Retrospective Analysis Report (Schaller et al. 2007) conducted a comprehensive analysis of instantaneous mortality rates for spring/summer Chinook and steelhead in the Snake Columbia Rivers. Using the equation describing the exponential law of population decline, Schaller et al. (2007) calculated the total instantaneous mortality rate (Z) as

$$\text{Total instantaneous mortality} = Z = \frac{-\log(survival)}{median.FTT},$$

where *median.FTT* is the median fish travel time of the release cohort. In their application, instantaneous mortality rates measure the proportion of the juvenile population that die during each day of the migration, with typical values ranging between 3% to 6% . However, when instantaneous mortality rates are calculated using the same method for the Fraser-Thompson (FT) acoustic tag groups, the resulting instantaneous mortality rates for the Fraser-Thompson fish are incredibly high. These acoustic-derived instantaneous mortality rates were 8 times higher than the PIT-derived estimates for Snake-Columbia (SC) Chinook and 4 times higher than the PIT-derived estimates for Snake-Columbia steelhead (see figure below). In terms of daily percent mortality, Welch's data indicate that 42% of the tagged Deadman stock steelhead died each day spent migrating (a 2.9 d migration) through the Fraser-Thompson in 2006, resulting in an estimated survival rate of only 20%. If Welch's acoustic-derived estimates of survival are accurate, these levels of mortality raise serious questions about the future persistence of the Fraser-Thompson Chinook and steelhead populations. In contrast, the PIT-derived data indicate that on average 6% of the steelhead and 3% of the Chinook died per day of migration through the Snake-Columbia, and in years with good flow and spill conditions, only 3% of the steelhead and 2% of the Chinook died per day. Nearly all of Welch's acoustically-tagged groups have instantaneous mortality rates that are several times higher than the worst migration year in the Columbia, 2001 where spill was terminated and flows were very low. The fact that instantaneous mortality rates are several times higher in the Fraser-Thompson compared to the Snake-Columbia in nearly all cases suggests that either acoustic tags themselves are causing significant mortality, or other factors in the Fraser-Thompson are causing major, catastrophic losses of juvenile Chinook and steelhead.



Welch et al. illustrate the impacts of the hydrosystem on salmon and steelhead migration

The Welch paper actually illustrates how much the hydrosystem has reduced migration speeds relative to the unimpounded Thompson-Fraser. Welch et al. provide acoustic-derived data indicating that Chinook migration rates averaged 54 km/d, while steelhead migration rates averaged 62 km/d in the Thompson-Fraser. These rates stand in stark contrast to the Welch's PIT-derived data for the Columbia River hydrosystem. Through the Snake-Columbia, Chinook migration rates averaged 22 km/d, while steelhead migration rates averaged 28 km/d. Based on the Welch et al. data, Thompson-Fraser Chinook and steelhead migration speeds were more than double those observed for the Snake-Columbia system. It is interesting to note that after fish passed Bonneville Dam, through the unimpounded section of the lower Columbia River, the Welch et al. data indicate that Chinook traveled at a rate of 62 km/d and steelhead averaged 78 km/d, rates similar to those observed in the unimpounded Thompson/Fraser. These data strongly demonstrate the degree that the hydrosystem has resulted in significant reductions in migration speeds (and therefore delayed entry into the ocean) compared to unimpounded systems like the Thompson-Fraser and the unimpounded Columbia River below Bonneville Dam. Welch et al. however neglect to discuss these migration rate differences.

Tag effects are apparent in the Fraser-Thompson Data

The Welch et al. paper illustrates but does not discuss the rather large disparities between the V7 and V9 tag survival estimates within individual years for both species. For Thompson-Fraser Chinook in 2005, the V7 tag survival rate was nearly double (1.8 times higher than) the V9 tag survival rate. For Thompson-Fraser steelhead in 2006, the V9 tag survival rate was more than triple (3.1 times higher than) the V7 tag survival rate for the Coldwater stock and nearly double (1.7 times higher than) the V7 tag survival rate for the Deadman stock. This large, within-year, within-stock disparities between tag types for both Chinook and steelhead suggest that tagging effects may have influenced the reliability of the results. Similarly, there were large variations in median travel time, such as 10.4 d for the V7 tag compared to 2.9 d for the V9 tag for Deadman stock steelhead released in 2006 and traveling the same distance. It is hard to conceive of a logical reason why one tag type would have triple the travel time as another tag type released in the same year and at the same location.

Thompson-Fraser survival estimates appear biased low for Chinook when using the larger V9 tags, which may have impacted survival due to tag size.

- Researchers used only V9 in 2004 with very dismal survival estimated.
- In 2005, paired releases of V7 and V9 were made on the Coldwater stock release (both migrating same distance), and the V9 tagged fish survived 44% less than there V7 counterpart.
- In 2006, researchers switched to only using V7 tags on Chinook
- The 2005 -2006 survival estimates with V7 tags ranged 23-32%, making one question whether the V9 tag estimates were biased low (only 2% in 2004 and 16.9% in 2005).

Thompson-Fraser survival estimates for steelhead show inconsistencies in 2006 between the smaller V7 and larger V9 tags, which make it difficult to accept either estimate as valid for that year.

- The larger V9 tag had detection efficiencies of >70% for Chinook/steelhead in both the Thompson-Fraser and Columbia rivers, except in 2006 for steelhead in the Thompson-Fraser River.
- The manufacturer of the V9 and V7 tags shows a higher detection range for the stronger V9 tag.
- The 2006 steelhead had a 41% lower detection efficiency reported the V9 tag than V7 tag, which seems biased low, and therefore, the resulting survival rate reported for the V9 tag may be biased high. Alternatively, the V7 tag survival estimates may have been biased low.

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