



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, WA 98112-2097

October 2, 2007

MEMORANDUM FOR: F/NWR5 - Bruce Suzumoto

FROM: F/NWC3 - John W. Ferguson

SUBJECT: Preliminary survival estimates among large west coast rivers

As part of our NOAA Fisheries FCRPS Biological Opinion Implementation funding, I convened a mini-workshop on 16-18 July 2007 to discuss the current approaches and methods used to assess and estimate juvenile salmonid survival among large, west coast rivers. The workshop was attended by Bruce McFarlane and Steve Lindley (SFWSC, Santa Cruz Laboratory), David Welch and several staff from Kintama Research (Nanaimo, British Columbia), and several NWFSC scientists from the Fish Ecology Division. The goal of the workshop was to share information, develop common approaches, and hopefully reach agreement about how to make comparative assessments of survival among the rivers in the future and report results in peer-reviewed journals. The following preliminary estimates of survival among the rivers were discussed or are otherwise currently available. The acoustic estimates of survival are preliminary and it is not appropriate to imply their meaning regarding policy issues at this time. Further analyses, review, and replication will be needed before the utility of these data becomes clear. However, these are the best estimates currently available, and they are being provided in this context.

- Estimated survival based on PIT tags of yearling Chinook salmon and steelhead from the Snake River trap to the tailrace of Bonneville Dam: Preliminary estimated survival for 2007 and comparisons to final estimates for the 2001-2006 are reported in a Memorandum to you from me dated 31 August 2007. Mean estimated survival was 56.0% for yearling Chinook salmon traveling through the entire hydropower system (all 8 reservoirs and dams) in 2007, which was second only to 2006 in our series. Estimated survival of steelhead traveling through the same reach was 39.2% in 2007.
- At the workshop, David Welch provided powerpoint slides showing estimated survival of yearling Chinook salmon that were acoustically tagged and released from Kooskia National Fish Hatchery in the Snake River in 2006 ($n = 396$; FL >140 mm). Estimated survival of acoustically-tagged fish and PIT-tagged fish appeared similar from the point-of-release to the extent of our estimates based on PIT tags, or approximately 500 km below the release point in the Columbia River. No statistical analyses were performed,

but the regressions for both sets of data showed similar patterns in survival versus distance through the hydropower system ($S_{PIT} = e^{-0.0015x}$ and $S_{acoustic} = e^{-0.0014x}$).

- At the workshop, David Welch provided estimates on the survival of yearling Chinook salmon that were acoustically tagged and released into the Coldwater, Nicola or Soius Rivers of the Thompson-Fraser watershed in 2006. Survival of these fish was estimated to detection arrays in the lower Fraser River near its mouth; however, the exact distance over which the estimates were made was not provided. David also released acoustically tagged yearling Chinook salmon from Kooskia National Fish Hatchery in the Snake River, and measured survival to the McGowen channel below Bonneville Dam in 2006. He then compared to the survival of yearling Chinook released into the Thompson River tributaries and measured to the 'mouth,' to the survival of fish released into the Snake River to below Bonneville Dam, and reported that the survival of fish in both groups was similar (not significantly different); the 95% CI for Thompson-Fraser salmon appeared to range from approximately 14-34%.
- At the workshop, David also compared the survival of steelhead released into the Snake-Columbia River to steelhead acoustically tagged and released into the Thompson-Fraser system in 2006. I do not know the total sample sizes, fish lengths, source, rearing history, or whether the fish released into the Snake-Columbia River were tagged with PIT or acoustic tags. My notes indicate that the Thompson River steelhead were of wild origin. The survival of fish in both tag groups was similar (not significantly different) when survival through the Thompson-Fraser was compared to the 'impounded' Snake-Columbia; the 95% CI for Thompson-Fraser salmon appeared to range from approximately 21-39%. These estimates are from a verbal presentation of data. We do not have a document on this study at this time.
- Steve Lindley presented results of the studies conducted in the Sacramento River. Late-fall yearling Chinook salmon (mean FL=160 mm) and steelhead (mean FL=180 mm) from the Coleman National Fish Hatchery located on Battle Creek below Shasta Dam were acoustically tagged and released at the beginning of 2007. Estimated survival to the mouth (Golden Gate Bridge) was approximately 5% for steelhead and 2% for the yearling Chinook salmon. It was an extremely low flow year in California in 2007, and they felt the resultant environmental conditions influenced the results. I asked whether warm water temperatures were of concern, and they said no, these fish migrate during February and March on the outflow of the spring snowmelt off the west slope of the northern Sierra Nevada mountains. They have analyzed their data and detections to some degree, and believe at this time that most of the mortality occurred in the freshwater component of the river.
- In 2006, NOAA Fisheries, USGS, and PNNL initiated a study to compare the survival of acoustically- and PIT-tagged fish through the FCRPS. The survivals of hatchery yearling Chinook salmon released at the tailrace of Lower Granite Dam were not statistically different among tag types to downstream sites (Little Goose, Lower Monumental, McNary, John Day, and Bonneville dams) except for the Lower Granite to Little Goose reach, where survival of acoustically tagged fish was higher than that of PIT-tagged fish. Mean estimated survival to Bonneville Dam was 0.48 (SE = 0.03) and 0.54 (SE = 0.09) for acoustically and PIT-tagged fish, respectively (Hockersmith et al. In review).

- Since 2001, we have been working with our partners (PNNL and USACE) to downsize acoustic transmitters for implantation into subyearling Chinook salmon and develop concomitant detection equipment. In 2006, we evaluated survival for acoustically-tagged, run-of-the-river yearling and subyearling Chinook salmon from below Bonneville Dam through the lower Columbia River and estuary and the mouth of the river (235 river kilometers) using the Cormack-Jolly-Seber (CJS) single-release survival model (McMichael et al. 2007). Four groups of yearling Chinook salmon were obtained from the daily smolt monitoring sample at the Bonneville Dam Second Powerhouse, tagged, and released into the juvenile bypass system. Preliminary survival estimates for groups of fish released on May 2, 11, 19, and 27 were 0.66 (SE = 0.035), 0.57 (SE = 0.036), 0.84 (SE = 0.038), and 0.62 (SE = 0.040), respectively. Eight groups of subyearling Chinook salmon were tagged and released at 5-d intervals from 17 June through 22 July. Preliminary survival estimates for the first four release groups ranged from 0.84 (SE = 0.038) to 1.01 (SE = 0.046). However, estimated survival for the remaining groups ranged from 0.67 (SE = 0.040) for the fifth group to 0.18 (SE = 0.041) for the final group. Mean estimated survival from Bonneville Dam to the mouth of the Columbia River was 0.68 (SE = 0.038) and 0.66 (SE = 0.036) for spring and summer releases, respectively. Results from studies conducted in 2005 showed similar magnitudes and temporal trends in estimated survival. Mean estimated survival during spring and summer 2005 was 0.69 (SE = 0.061) and 0.50 (SE = 0.037), respectively.

In summary, studies of comparative survival between tag types or among large west coast rivers are just beginning, but we have some estimates of survival through the impounded and regulated Columbia River, the regulated Sacramento, and the unimpounded and unregulated Fraser River. Other than the estimates of survival through the FCRPS based on PIT tags, estimates of survival through these rivers and the Columbia River below Bonneville Dam are preliminary and are still being reviewed, analyzed, and reported. When using the CJS method to estimate survival, the results presented as survival actually include the joint probability of survival and the tendency to migrate to the downstream site. For yearling (stream-type) juvenile Chinook salmon, data and observations over years of study suggest that smolts have a directed migration to the ocean and do not linger or residualize. Thus, the “survival” estimates appear robust. For subyearling (ocean-type) Chinook salmon in the Snake River, recent evidence shows that not all fish have a directed migration (Connor et al. 2005). Thus, estimates of “survival” to downstream detection arrays for this life-history type represent a minimum estimate. Tagged smolts that delay migration for weeks to months, but survive and migrate past downstream detection arrays after batteries in tags have died or the detection arrays have been removed for the winter, are not included in the standard CJS survival estimates provided here.

Each tag type has its strengths and weaknesses; we are most comfortable with PIT-tag based estimates at this time because we have 20 years of experience with this tagging methodology. However, use of PIT tags to estimate survival requires a high level of infrastructure that is typically not available in large river systems. Thus, we are discussing how to use and apply common acoustic-based methods among the studies of survival in large river systems to standardize the methods as much as possible. Results of our discussions at the mini-survival workshop were positive and promising for achieving our goal of standardizing the source fish,

and the tagging, release, and analysis protocols. All three research groups are very cognizant of potential tagging and tag effects (Chittenden et al., Submitted; Hockersmith et al. In review; Welch et al. Submitted). Survival studies in all three rivers are scheduled to be replicated through 2009 to incorporate inter-annual variability, and we hope to develop a joint manuscript after the 2008 or 2009 field seasons. David Welch has developed a draft manuscript comparing survival in the Fraser River to the Columbia River, and once the manuscript has been submitted to a journal, we will have a chance to review it and better understand the river reaches studied, source fish, analytical methods used, and the point estimates of survival reported.

References

- Chittenden, C., K.G. Butterworth, K. Fiona Cubitt, Melinda C. Jacobs, Adrian Ladouceur, David W. Welch & R. Scott McKinley (Submitted) Growth, survival, tag retention, swimming performance and condition of coho salmon (*O. kisutch*) psmolts surgically implanted with 6, 7 and 9mm acoustic tags. *Environmental Biology of Fishes*
- Connor, W. P., J. G. Sneva, K. F. Tiffan, R. K. Steinhorst, D. Ross. 2005. Two alternative Juvenile life history types for fall Chinook salmon in the Snake River Basin. *Transactions of the American Fisheries Society* 134:291-304.
- Hockersmith, E., R. Brown, T. Liedtke. In review. Comparative performance of acoustic-tagged and PIT-tagged juvenile salmonids. Report of research to the U.S. Army Corps of Engineers, Portland District Contract W66QKZ60441152 (the report is being reviewed internally and will be released to the USACE shortly).
- McMichael, G. A., J. A. Vucelick, B. J. Bellgraph, T. J. Carlson, R. L. McComas, L. Gilbreath, S. G. Smith, B. Sandford, G. Matthews, and J. W. Ferguson. 2007. A study to estimate salmonid survival through the Columbia River Estuary using acoustic tags, 2005 and 2006 synthesis report. Report of research to the U.S. Army Corps of Engineers, Portland District. PNNL-A-54927.
- Welch, D.W., Batten, S.D., and Ward, B.R. (2007) "Growth, Survival, and Rates of Tag Retention for Surgically Implanted Acoustic Tags in Steelhead Trout (*O. mykiss*)". *Hydrobiologia* 582:289–299 DOI 10.1007/s10750-006-0553-x Available at: <http://dx.doi.org/10.1007/s10750-006-0553-x>

CF:

F/NWC3 – John Williams
F/NWC3 – Eric Hockersmith
F/NWC3 – Lynn McComas
F/NWC – John Stein