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MEMORANDUM

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FROM: Michele DeHart

DATE: May 22, 2013

SUBJECT: Review of "Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean" by Rechisky, Welch, et al. April 23, 2013

The Comparative Survival Study Oversight Committee, comprised of technical representatives of the state, federal and tribal fishery management agencies reviewed the subject article. The article was published in the April 2013 edition of the Proceedings of the National Academy of Science (PNAS).

The Oversight Committee review found significant flaws with the methods and assumptions used in this study. Results indicate significant confounding due to tagging and handling effects. Critical assumptions regarding offshore ocean migration patterns and array detection efficiency are inconsistent with the available data. Because of these issues, the conclusions regarding hydrosystem-related delayed mortality are overreaching and unsupportable. In addition, the Rechisky study was conducted for only three years and had little contrast in ocean and river conditions as compared to long term studies (9–60 years) that provide evidence of significant hydrosystem delayed mortality (Deriso et al. 2001, Schaller & Petrosky 2007, Petrosky and Schaller 2010, and Haeseker et al. 2012). As part of the scientific, peer-review process, the Oversight Committee determined that it was necessary to submit a Letter to the Editor of the

PNAS describing our technical concerns with the methods, assumptions, and conclusions of the article. The PNAS criteria for Letters to the Editor limit the response to 500 words and 5 references. PNAS at times publishes longer commentaries but those are "by invitation only." A brief Letter to the Editor was submitted to PNAS. Below is the complete version of the CSS Oversight Committee review of the Rechisky/Welch journal article.

Comments on "Influence of multiple dam passage on survival of juvenile Chinook salmon in the Columbia River estuary and coastal ocean" by Rechisky et al. (2013)

Introduction

As a test for the hydrosystem-related delayed mortality hypothesis (Budy et al. 2002), Rechisky et al. (2013) conducted a mark-recapture study using acoustic telemetry that compared the estimated survival rates of a group of hatchery-origin spring Chinook salmon that migrated through four dams to a group of hatchery-origin spring Chinook salmon that migrated through eight dams in the Columbia River basin. They report that their estimates of river, estuary and early-ocean survival rates were similar between the two groups. Because their estimates did not provide evidence that hydrosystem-related delayed mortality occurred in the estuary or the first month in the coastal ocean, they suggest that hydrosystem mitigation efforts may be ineffective. However, our examination of their methods, assumptions, and results indicate that their results are confounded by significant tagging effects and that their assumptions are inconsistent with the available data. In addition, this study was conducted for only three years and had little contrast in ocean and river conditions as compared to long term studies (9–60 years) that provide evidence of significant hydrosystem delayed mortality (Deriso et al. 2001, Schaller & Petrosky 2007, Petrosky and Schaller 2010, and Haeseker et al. 2012). For these reasons, their conclusions regarding hydrosystem-related delayed mortality are overreaching and unsupportable.

Non-Representative Tagging and Tagging Effects

A key requirement of tagging studies is that tagged individuals should be representative of the untagged population of interest. If significant differences exist between the tagged and untagged populations, then inferences can become limited to the tagged individuals themselves and may not be applicable to the untagged population of interest due to confounding. Rechisky et al. (2013) fail in numerous ways to meet this basic requirement for the design and implementation of tagging studies, which results in a highly confounded study.

Hatchery spring Chinook salmon from Cle Elum National Fish Hatchery (NFH) in the Yakima River exhibit smolt-to-adult return rates (SARs) that are substantially higher than SARs of Dworshak NFH (Tuomikoski et al. 2012). For spring Chinook salmon from Cle Elum NFH and

Dworshak NFH to be used as populations for inference, fish selected for tagging should have been representative of the releases that have exhibited the differential survival rates reported in Tuomikoski et al. (2012). However, the fish that were selected for tagging differ from these groups selected for inference in several important ways. Fish with acoustic tags were 10–20 mm longer, were released 21–83 days later, and were released 59–249 rkm further downriver than their corresponding hatchery populations of inference. Length at tagging (Zabel and Achord 2004), timing of release (Haeseker et al. 2012, Scheuerell et al. 2009), and migration distance (Faulkner et al. 2012) have all been shown to influence survival rates of Chinook salmon at multiple life stages. Any of these factors alone confound comparisons with the populations of inference, let alone the combination of all three. In addition, hydrosystem conditions in terms of water velocity and spill percentages experienced by out-migrating juvenile Chinook salmon can vary substantially within and among years (Haeseker et al. 2012). Thus, the hydrosystem conditions experienced by groups released 21–83 days apart were most likely different. In summary, highly confounded differences in length at tagging, timing of release, location of release, and probable differences in hydrosystem conditions following release most likely invalidate any comparisons between the Cle Elum and Dworshak hatchery stocks that were tagged with passive integrated transponder (PIT) tags and the acoustic-tagged individuals that were examined in Rechisky et al. (2013). Any differences or similarities between the groups could have been attributable to any number or combination of the above confounding factors. Therefore, the claim that the acoustic-tagged groups are representative of the Cle Elum and Dworshak hatchery stocks is unsupportable due to these confounding factors caused by the study implementation.

In addition to the substantial differences in length at tagging, timing of release, and location of release between study fish and their corresponding hatchery populations of inference, Rechisky et al. (2013) compare acoustic-tagged Cle Elum and Dworshak hatchery Chinook salmon that were significantly different with regard to their length at tagging. Cle Elum hatchery Chinook salmon were significantly longer in 2006 (two-tailed t-test assuming unequal variances; P = 6E-52), but were significantly shorter in 2008 (P = 8E-28) and 2009 (P = 0.005). The data on length at tagging contradict the authors' claim that the Cle Elum and Dworshak hatchery groups were "size-matched" and add an additional layer of confounding to the results.

If one assumes that the large differences between the acoustic-tagged individuals and the Cle Elum and Dworshak hatchery populations are unimportant and not influential to study results, then those populations can therefore be used to assess differential handling and tagging effects of the acoustic tags used in this study versus conventional PIT-tag-based estimates. The Chinook salmon studied in Rechisky et al. (2013) were dual-tagged with both an acoustic tag and a PIT-tag, allowing for comparable survival calculations using the PIT-tag detection systems that are installed at the hydrosystem dams (Tuomikoski et al. 2012). The PIT-tag system technology also allows for calculation of SARs for PIT-tagged Chinook salmon, a key metric that could not be measured by solely relying on the acoustic tags employed in Rechisky et al. (2013).

Using the methods and results described in Tuomikoski et al. (2012), we calculated SARs from the point of hydrosystem entry (i.e., McNary Dam for Yakima River releases and Lower Granite Dam for Clearwater River releases) until adult return 1–3 years later at Bonneville Dam. This allowed for comparisons of SARs between the acoustic-tagged groups and the PIT-tag-only Cle Elum and Dworshak hatchery groups (Figure 1). Results show that for the acoustic-tagged fish, there were zero adult returns from the Yakima River releases in 2006, from the Clearwater River releases in 2006 and from the Yakima River releases in 2009. In four of the six stock-years evaluated, the SARs for the acoustic-tagged groups were substantially lower than SARs for the PIT-only hatchery groups, indicating that tagging and handling effects likely compromised the SAR estimates.

The SAR estimates also indicate that the magnitude of the tagging and handling effect appears to be different between the Yakima River releases and the Clearwater River releases. Across-years, the PIT-tag-only SARs were nearly equivalent to the acoustic-tag SARs for the Clearwater River releases, but were 11.9 times higher than the acoustic-tag SARs for the Yakima River releases. This observation of differential tagging effects between the two release locations is sufficient to explain the failure to detect differential delayed mortality.

The effects of the excessive tag burdens used in this study have been previously reviewed numerous times (FPC memos: March 13, 2009, November 13, 2008). Those reviews showed significant reductions in survival for acoustic-tagged fish relative to comparable PIT-tagged fish that were released in similar locations and at similar times. The detrimental effects of tagging and handling were particularly severe from releases in 2007 (Porter et al. 2009). Those data and results were not reported or even mentioned in Rechisky et al. (2013). In 2007, acoustic-tagged fish from Dworshak hatchery stock showed an estimated 92% mortality from release to below Bonneville Dam. Similarly, acoustic-tagged fish from Cle Elum hatchery stock showed an estimated 89% mortality from release to below Bonneville Dam. As a “proof-of-concept” study (Rechisky et al. 2013), we believe that it is somewhat misleading to withhold results from study implementation during one year of a four-year study.

Recent studies on the effects of excessive tag burden raise additional concern about the methods used by Rechisky et al. (2013). Field studies have been conducted on yearling spring Chinook salmon comparing the survival and migration rates of PIT-tagged and acoustic-tagged groups that were well controlled in terms of similar length at release, location of release, and timing of release (Wargo-Rub 2009, 2011). These studies found significant differences in survival, which increased as fish moved downriver. Significant differences in survival were observed for acoustic-tagged Chinook salmon with average tag burdens of 2.3%, well less than Rechisky et al. (2013) burdens of 4.4–9.4%.

Detection Arrays

The two ocean acoustic detection subarrays used to estimate the marine survival rates for the first month at sea for this study were located off shore of Willapa Bay, Washington, and Lippy Point, Vancouver Island. These two subarrays considerably differed in the number of receivers and the extent of their distance off shore. The Willapa Bay subarray had 40–45 receivers extending up to 36 km off shore, whereas the Lippy Point subarray had 24 receivers extending only 19 km off shore. The authors assumed that salmon migration was confined to the coastal zone spanned by these subarrays. However, for yearling Chinook salmon, Peterson et al. (2006) found yearling Chinook in trawl catches beyond 36 km off the Washington coast during June. Therefore, it appears sampling at the Willapa Bay and Lippy Point arrays are not equivalent, which would confound survival estimates made between these two locations.

The authors identified that estimation of detection probabilities for the Lippy Point subarray was not possible because of too few detections of tagged smolts at the distant Alaska subarray. This inability to estimate detection probabilities at Lippy Point puts into question the survival estimates used to draw conclusions concerning delayed mortality. In our view, the sensitivity analysis used to explore the effects of alternative assumptions is far too narrow given the true uncertainty about the actual detection probability of the Lippy Point subarray.

Emigration from Study Area

Rechisky et al. (2013) assume that all fish migrated north on the continental shelf at depths shallower than 200 m and through the Lippy Point subarray. If this assumption is not valid, the survival estimates will be biased low. The recent study by McMichael et al. (2011) comprehensively measured the direction and speed of acoustic-tagged yearling Chinook salmon as they entered the Columbia River plume with a 15 by 20 km "box" centered on the mouth of the Columbia River and extending to the 100 m depth contour (Figure 2). A total of 638 yearling Chinook salmon were detected on their array and only ~23% of the Chinook salmon were detected on the north boundary of the array. The majority of the detections (~58%) occurred on the western terminal array directly off the mouth of the Columbia River, and a substantial portion of the detections (~19%) occurred on the south boundary of the array. The median rate of emigration from leaving the mouth of the Columbia River until detection on the plume arrays was 47 km per day. At this rate of emigration, spring Chinook salmon migrating in a westerly direction would be expected to remain on the continental shelf for a little over a day. A study by Schreck et al. (2005) that deployed short arrays off the northern and southern jetties at the Columbia River mouth detected 12% of the tagged Chinook salmon on the southern jetty array. Further, Rechisky et al. (2012) detected two yearling Chinook on an array positioned 131 km south of the Columbia River mouth. This array was in place during 2009 only. Combined, these results suggest that some yearling Chinook salmon, and perhaps even a majority, may have migrated off the continental shelf and emigrated from the study area monitored by the subarrays.

As a result, the estimates reported in Rechisky et al. (2013) are likely biased low, although the degree of this bias is unknown.

Effects of Hydrosystem Development and Operations on Freshwater and Ocean Survival

In-river survival is not always 50% as reported. It varies between 25% and 83% and is influenced by hydrosystem conditions (Haeseker et al. 2012). Similarly, ocean survival rates, SARs, and overall life-cycle survival rates are influenced by hydrosystem conditions (Schaller and Petrosky 2007, Petrosky and Schaller 2010, Haeseker et al. 2012). In addition, this study was conducted for only three years and provided limited contrast in ocean and river conditions as compared to the studies that found support for considerable level of hydrosystem delayed mortality. Therefore, the conclusion that hydrosystem mitigation efforts may be ineffective is neither justified nor supportable. These studies spanned 9–60 years and analyzed over 600,000 PIT-tagged individuals.

Conclusions

During the first month's migration through the estuary and coastal ocean, Rechisky et al. (2013) found no evidence that Snake River hatchery Chinook smolts experienced lower survival rates than hatchery Chinook from the Yakima River (mid-Columbia River) that migrated through fewer dams. However, the authors acknowledge these estimates represented tagged groups whose size, holding, and timing of release had been manipulated to accommodate acoustic tags that were large relative to fish size. As a result, tagged fish were not representative of the hatchery populations of inference, confounding comparisons between the acoustic-tagged fish and the hatchery populations. Similarly, the size distribution of the hatchery study fish was larger than all but a small fraction of the wild individuals, concurrent with differences in migration timing between study fish and wild fish. The study was short term (three years), and the migration conditions that study fish experienced were different than migration conditions experienced by most wild and hatchery fish. Because there were very few numbers of fish detected at the northern ocean arrays, the detection efficiency of the Lippy Point array is unknown and the assumption about the extent of the distance of offshore migration is unsupportable by data, the survival estimates for the first month at sea are highly questionable. Thus, their conclusions that "hydrosystem mitigation efforts may be ineffective if differential mortality rates for wild or hatchery fish develop in the ocean for reasons unrelated to dam passage" is unsupportable.

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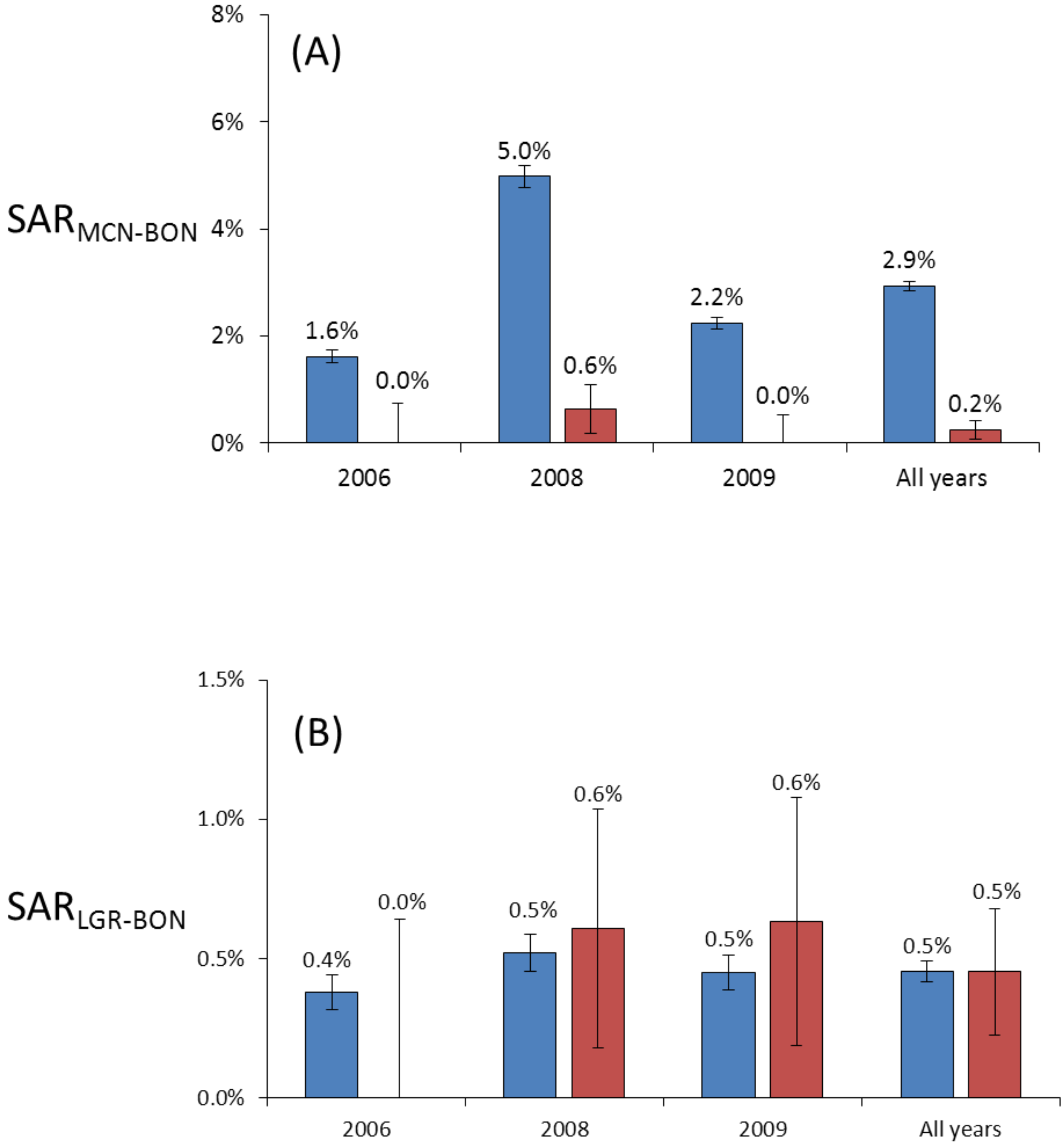

Figure 1. (A) Estimates of smolt-to-adult return (SAR) rates measured from McNary Dam to Bonneville Dam for Cle Elum hatchery Chinook salmon tagged using PIT-tags-only (blue bars) and tagged with both acoustic- and PIT-tags (red bars) during 2006, 2008, 2009, and across all years. (B) Estimates of smolt-to-adult return (SAR) rates measured from Lower Granite Dam to Bonneville Dam for in-river-migrating (C0) Dworshak hatchery Chinook salmon tagged using PIT-tags-only (blue bars) and tagged with both acoustic- and PIT-tags (red bars) during 2006, 2008, 2009, and across all years. For both panels, error bars represent one standard error and the SAR estimate is printed above the error bar.

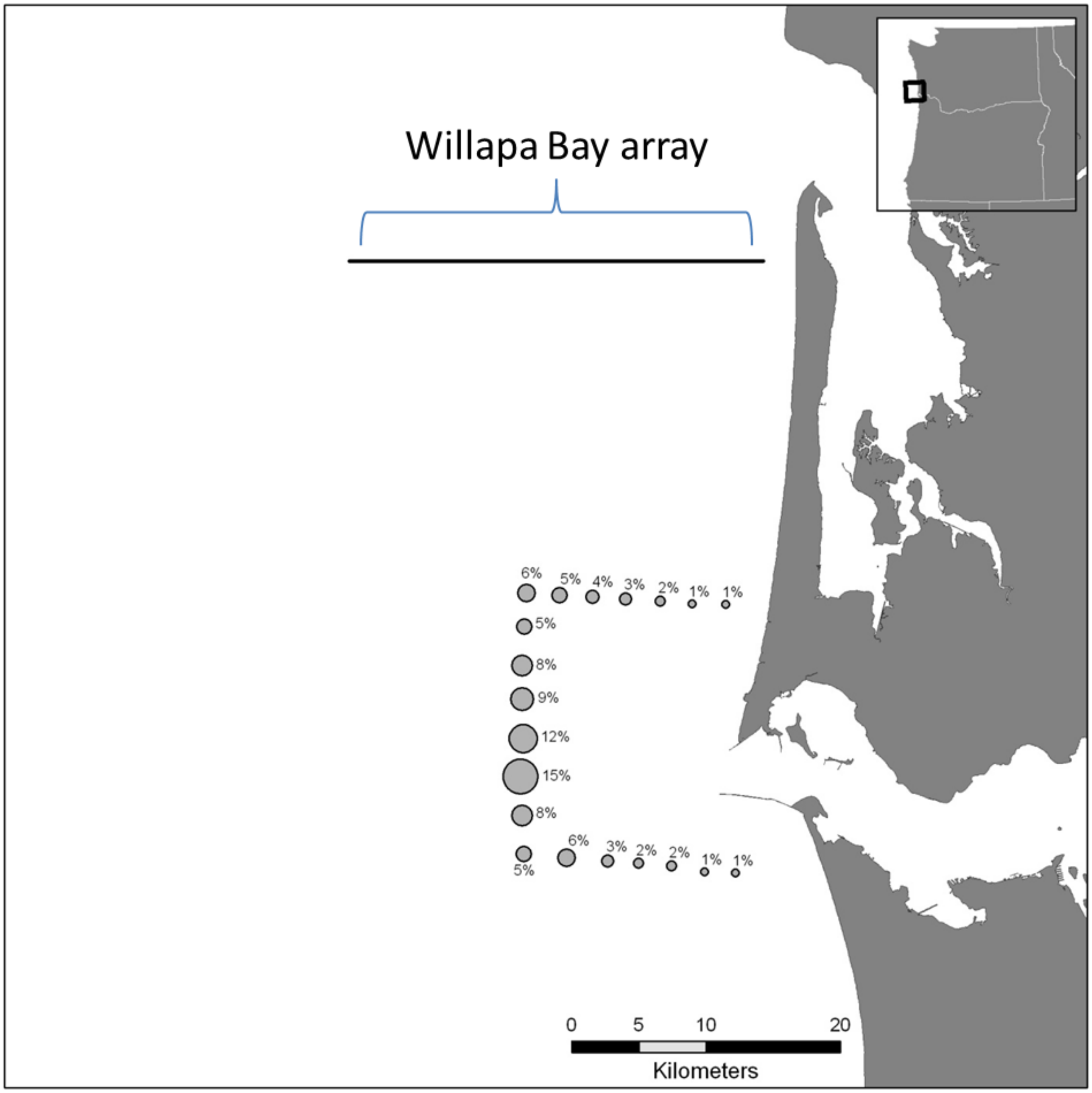

Figure 2. Position of the Willapa Bay receiver array used by Rechisky et al. (2013) and the Columbia River plume network of arrays used by McMichael et al. (2011). The circles represent receiver positions and their diameters are scaled according to the percentage of detections that were recorded at each receiver. These percentages are printed next to each circle.