

To: Co-PI of ESRP Learning Project # 13-1508P, Estimating density-dependent rearing limitations

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Subject: Juvenile Chinook response to Nisqually Estuary Restoration: comments on recent paper by David et al. (2014)

Our ESRP Learning Objective project integrates and analyzes possible factors influencing juvenile Chinook density, residence, and growth in natal estuaries of Puget Sound. Through a collaborative effort, we are examining data from four different estuaries with varying habitat types & amounts, connectivity, and juvenile Chinook outmigration population abundance and structure (e.g., life history diversity and hatchery/wild composition). The estuaries are the Skagit and Snohomish, with the hopes of including the Nooksack and Nisqually. The recent paper on foraging and growth of juvenile Chinook in the Nisqually estuary (David et al. 2014) was received with great interest. It is a useful and timely paper. Kudos to those involved.

A couple of things I noticed in David et al. was: a) the abstract statement that juvenile Chinook densities were lower in the restored channels than in the reference channels, and b) mention in the paper's discussion that landscape position might be part of the reason why densities were lower.

The paper's discussion says the reference sites are closer to the river than the restored sites, observations easily seen by looking at the paper's Figure 1. I was curious and did a quick quantification of landscape position of the Nisqually sites based on methods used in the Skagit Chinook Recovery Plan (after Beamer et al. 2005, Beamer and Wolf 2011). Results for landscape position of the four Nisqually sites are shown below in Figures 1 and 2. I also eyeballed the juvenile Chinook densities shown in David et al.'s Figure 2 to plot against connectivity. These results are shown in Figure 3 below. In all three years, landscape connectivity positively correlates with observed seasonal juvenile Chinook density (i.e., fishdays). Sites with higher landscape connectivity are closer to the source of the fish – the river – and have higher Chinook densities. However, there are some differences in the years; namely, 2012 has lower variability in seasonal Chinook densities between all four sites.

The David et al. paper includes no discussion regarding the potential influence of varying juvenile Chinook outmigration population sizes on Chinook densities in the estuary. Some of the year-to-year differences in Figure 3 might be due to varying numbers of fish capable of using estuary habitat in the Nisqually.

I recently learned from Joe Anderson that WDFW operates a mainstem trap in the Nisqually River and produced outmigration population estimates for the same years as those in the David et

al. paper. The Nisqually River smolt trap estimates for subyearling Chinook were similar to each other in 2010 (128,000) and 2011 (116,000) but higher in 2012 (246,000). I plotted juvenile Chinook densities in the Nisqually estuary by the WDFW Chinook outmigration estimates (Figure 4). Interestingly, juvenile Chinook seasonal density at three of the four estuary sites in the Nisqually positively correlated with outmigration size. The site that did not follow the positive correlation with outmigration size was the site with the highest landscape connectivity (Nisqually Reference). Also, the year with the highest outmigration size (2012) had the most uniform fish densities within the estuary. Obtaining more years of data and parsing the outmigration data into migrating parr and fry population estimates may be informative for understanding the influence of outmigration population size on the density of juvenile Chinook in the Nisqually estuary. Annual and seasonal variability in the a) number of juvenile Chinook salmon produced in habitat areas downstream of the WDFW trap (and therefore not included in the outmigration estimates); b) hatchery Chinook release size, timing, marking (or not), and fish size; and c) timing and magnitude of freshets could also influence when and how many juvenile Chinook used estuary habitat in the Nisqually. It would be wise to include all these factors in a comprehensive analysis.

Regardless of the confusing/confounding/incomplete results of juvenile Chinook outmigration population size, landscape connectivity is a significant covariate (ANOVA: $p=0.025$ without including outmigration and $p=0.027$ including outmigration) explaining differences in juvenile Chinook seasonal density within the Nisqually estuary. This result is detected using only 4 sites over 3 years.

The David et al. paper concludes that some – but not all – of the ecosystem attributes important for juvenile salmon can recover rapidly after large scale estuary restoration. This is an important finding. However, I think David et al. may be understating their conclusions because the reference and restored sites ideally would not be compared directly if their landscape position (connectivity) is so different. I suspect the differing results on water temperature – and therefore fish growth conclusions – are also influenced by not explicitly incorporating connectivity.

References:

Beamer, EM, A McBride, C Greene, R Henderson, G Hood, K Wolf, K Larsen, C Rice, and K Fresh. 2005. Delta and nearshore restoration for the recovery of wild Skagit River Chinook salmon: linking estuary restoration to wild Chinook salmon populations. Appendix to the Skagit Chinook Recovery Plan. Available at www.skagitcoop.org/.

Beamer, E., and K. Wolf. 2011. Measurements of landscape connectivity for blind tidal channel networks and selected pocket estuary outlets within the Skagit tidal delta and bay. Skagit River System Cooperative, LaConner, WA.

David, A, CS Ellings, I Woo, CA Simenstad, JY Takekawa, KL Turner, AL Smith and JE Takekawa. 2014. Foraging and growth potential of juvenile Chinook salmon after tidal restoration of a large river delta. Trans. Amer. Fish. Society 143:1515-1529.

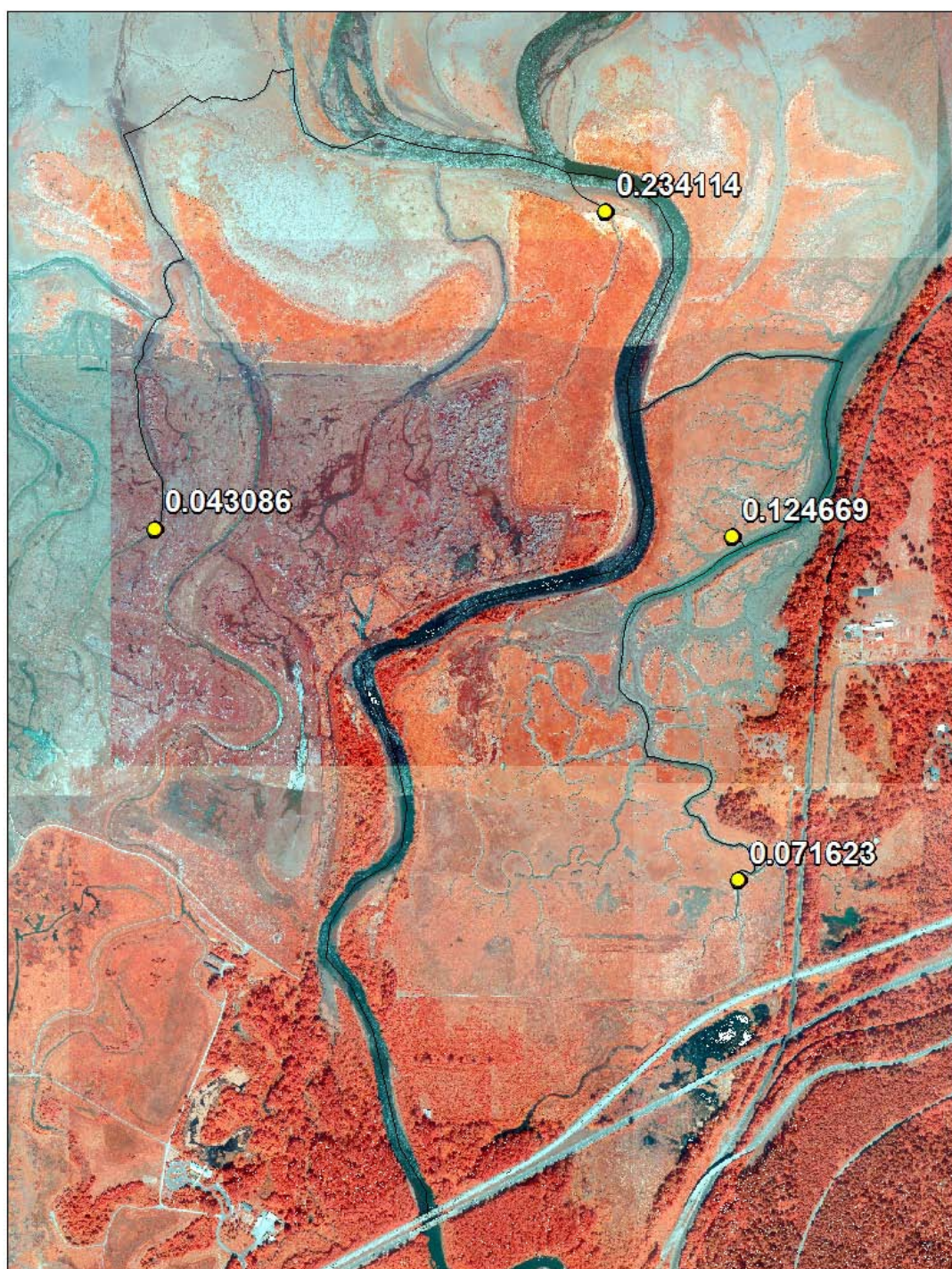


Figure 1. Landscape connectivity values based on Skagit Chinook Plan landscape connectivity methods (after Beamer et al. 2005, Beamer and Wolf 2011).

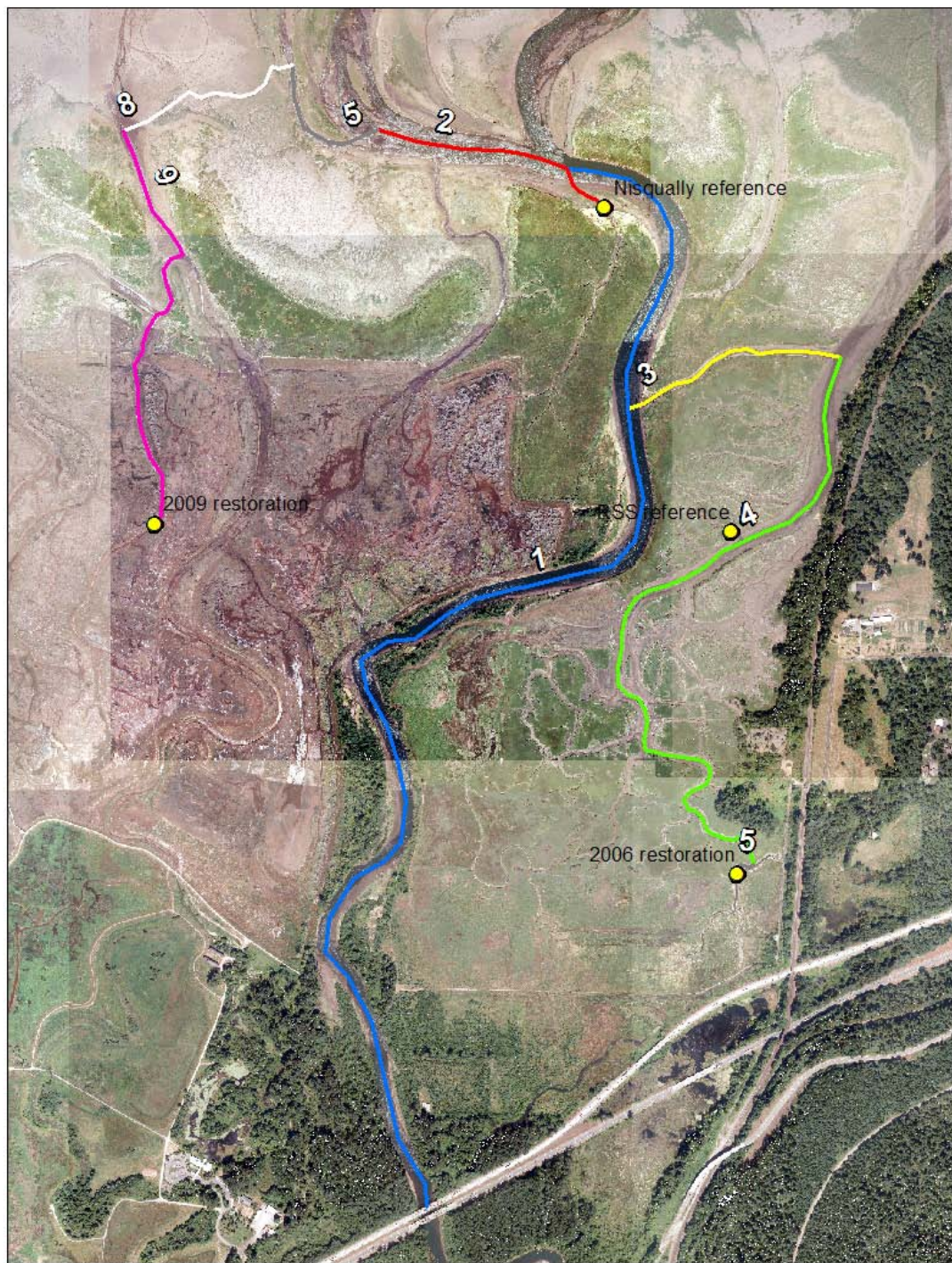


Figure 2. Hypothesized fish migration pathways and their associated channel order used to calculate landscape connectivity (after Beamer et al. 2005, Beamer and Wolf 2011).

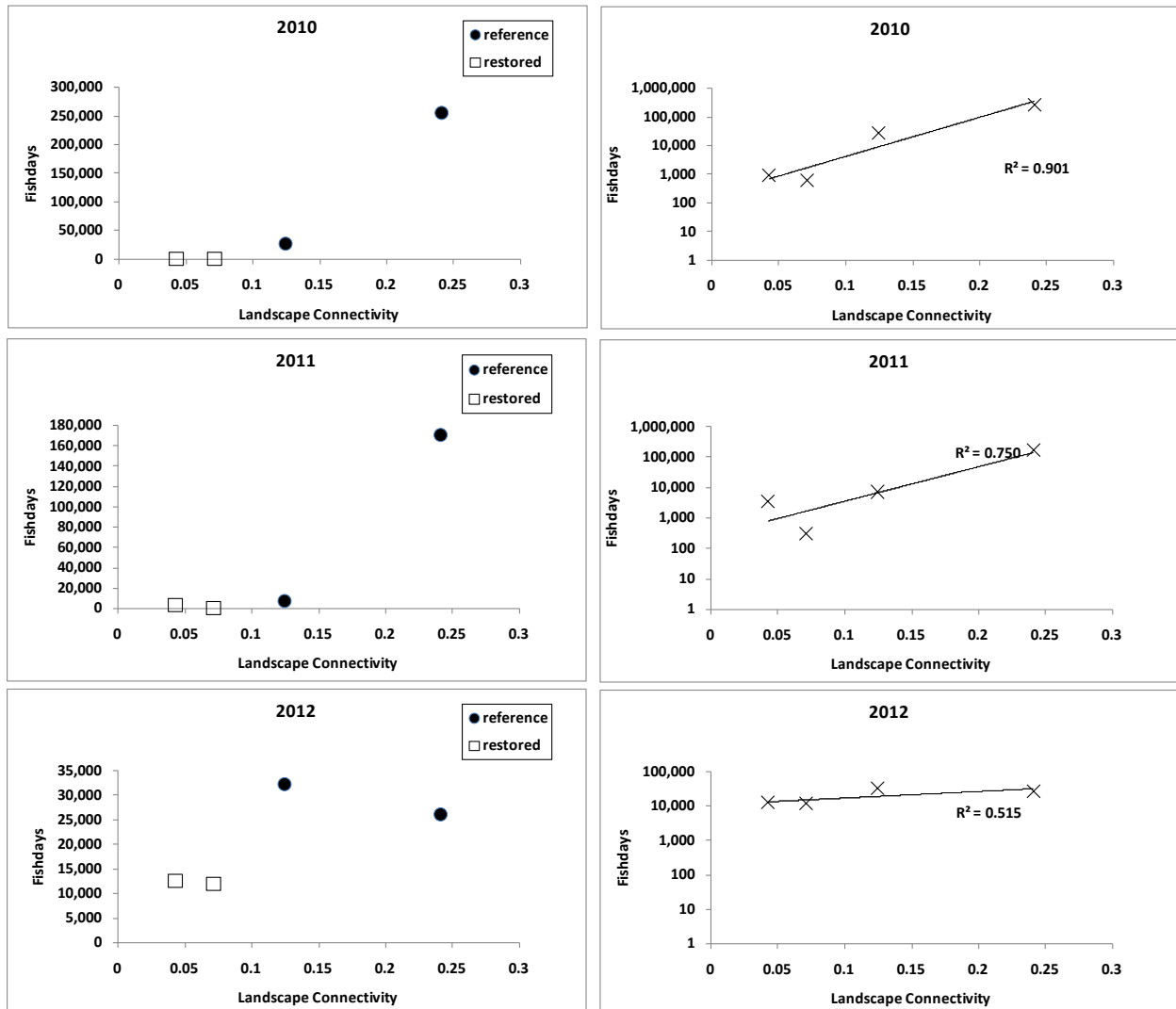


Figure 3. Relationship between landscape connectivity and juvenile Chinook seasonal density (fishdays). Juvenile Chinook density data were calculated from David et al. (2014), Figure 2.

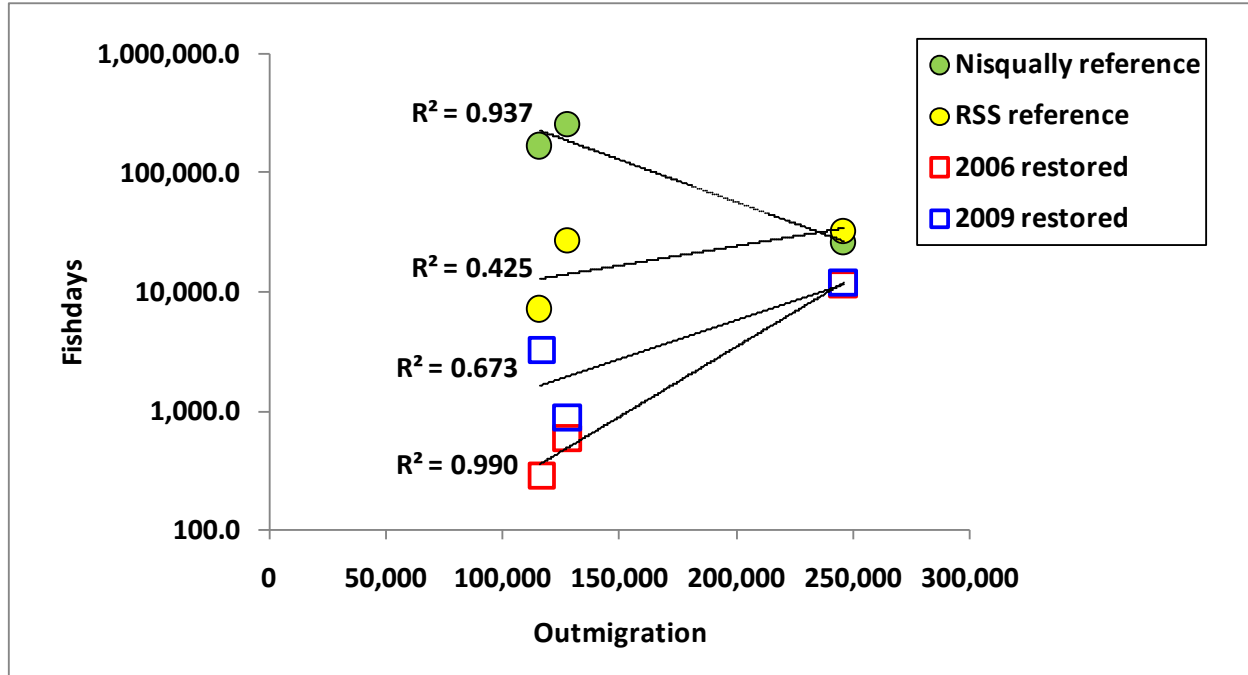


Figure 4. Relationship between Nisqually River subyearling unmarked Chinook outmigration population size and juvenile Chinook seasonal density (fishdays). Outmigration data are from Joe Anderson (WDFW). Juvenile Chinook density data were calculated from David et al. (2014), Figure 2.