Input to the WRC Annual Loss Independent Review Panel

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Broadly, the Panel is being asked to recommend tools/analyses that can inform management of winter-run Chinook entrainment at the South Delta export facilities. The Winter-run Chinook Salmon Machine Learning (WRCML) model is one tool identified in the materials provided to the review panel. I participated in the stakeholder sub-group that advised CDFW's development of the WRCML Model, and would like to draw your attention to several key issues.

- The original intent of the modeling effort was to apply sophisticated statistical analyses (i.e. machine learning XGB-DART) to Delta monitoring data (physical and biological) to improve short-term prediction of winter-run entrainment events. The model documentation provided to the Panel states that "89 ecological variables" were considered in the development of the model (the inset figure was provided to stakeholder sub-group during early development of the WRCML to depict the breadth of monitoring data being analyzed). However, the documentation does not identify or describe those variables. Since the Panel is being asked to identify indicators that might improve entrainment forecasting, detailed information about ALL the variables considered is highly relevant-- variables that aided prediction are just as relevant to Panel's charge as variables that did not. The Panel should request that CDFW provide detailed information on the "89 ecological variables" considered.

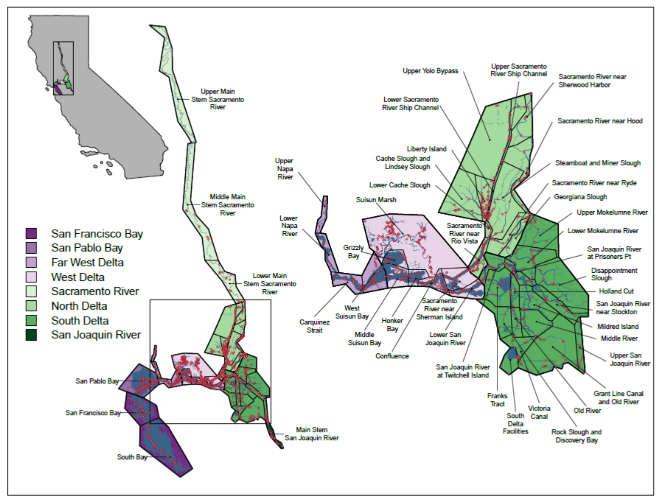

Figure 3: Map of the San Francisco Estuary and the Sacramento River with regions denoted by thick bordered and colored polygons, sub-regions denoted by thin bordered polygons, and sampling stations included in our compiled database denoted by red bordered yellow points. NOTE: Enhanced Delta Smelt Monitoring stations are not included for map clarity. The inset map illustrates the study region relative to the state of California.

- The WRCML Model documentation provides a list of 12 "model features" (Table 1) used in the final model. However, the relative importance of each of the model features is not reported. Importantly, **none** of the model features found to be important via model selection represent conditions within the Delta (Sherwood Harbor is West Sacramento). This is particularly relevant because the modeling effort invested tremendous effort evaluating in-Delta data sources—particularly in-Delta fisheries monitoring program data. Model results shared with the stakeholder subgroup showed that model features representing seasonality/time of year (water temperature at Sherwood Harbor; Brood DOY) and early life-stage abundance of winter-run (juvenile production at the Red Bluff Diversion Dam) were the most important predictors of salvage. Exports, San Joaquin River inflow, and Delta Cross Channel (DCC) position fell below the model selection importance threshold, but were included in the final model because of management relevance. Other analyses based on the most reliable data (as described below, tagged juvenile winter-run) show that exports are a key predictor of salvage.
- The WRCML model was developed using salvage observations of length-at-date (LAD) identified winter-run, not genetically confirmed fish. Because the LAD-based identification (particularly at the

salvage facilities) exhibits a high false positive rate, the model will tend to under-predict "absence" and over-predict "presence".

- Predicted loss numbers (i.e. expanded salvage) used to classify "absence", "low presence" and "high presence" in the WRCML model were based on the 50th percentile of a 7-day moving average of observed loss (4.29 fish). While appealing in its simplicity, decades of coded-wire-tagged releases show that proportional entrainment loss of winter-run Chinook is very low (mean 0.25% with exports as high as ~11,750 cfs; Zeug & Cavallo 2014). A moving daily average greater than 4.29 fish per day may be higher than the median, but no available analysis suggests this value represents a meaningful threshold for impacts winter-run survival or viability. It should be incumbent on the regulatory agencies to attempt to define meaningful, non-arbitrary thresholds.
- The categories "absence", "low presence" and "high presence" suggest the WRCML model is predicting the risk of winter-run reaching the South Delta. Thus, WRCML model predictions of "absence" or "low presence" resulting from less negative OMR values might be interpreted as providing more protection. In fact, tagging studies suggest some fraction of winter-run may reach the South Delta independent of OMR flows—exports appear to influence if fish that have already approached the South Delta are salvaged. Despite fifteen years of intensive acoustic tagging studies, no analysis or data supports OMR management (to less negative -5,000) provides routing or survival benefit to juvenile winter-run.

Several other review questions allude to alternative approaches to this issue. Briefly, two points that should be considered. First, an independent workshop panel convened by the Delta Science Program in 2011 recommended development of salmon life cycle models as a means to provide rigorous assessment of issues like OMR management (Rose et al. 2011). Several such models have since been developed, but NMFS and CDFW have not used these models to evaluate or improve effectiveness of their OMR management strategies. Second, the most reliable and longest-term data source on winter-run loss rates and factors influencing loss is provided by coded-wire-tagged hatchery winter-run Chinook salmon. Releases have been made annually since 1993. Zeug and Cavallo (2014) and Cavallo (2016) analyzed releases through 2007, but releases have continued through 2025. This data (paired with acoustic tagging-based survival estimates) have been used to estimate proportional entrainment loss of winter-run from proposed operations, but the data has not been used by fisheries agencies to evaluate the effectiveness of OMR management strategies.

Cavallo, B. 2016. Sacramento River Winter-run Chinook Entrainment Risk Evaluation. Technical Memorandum provided to DOSS. Available: https://www.researchgate.net/publication/332798497_Sacramento_River_Winter-run_Chinook_entrainment_risk_evaluation

Rose, K, J. Anderson, M. McClure, and G. Ruggerone. 2011 Salmonid Integrated Life Cycle Models Workshop. Report of the Independent Workshop Panel to the Delta Science Program. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/cmnt091412/sldmwa/rose_et_al_2011.pdf

Zeug, S. & B. Cavallo. 2014. Controls on the Entrainment of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) into Large Water Diversions and Estimates of Population-Level Loss. PLOS One 9(7):e101479. DOI: 10.1371/journal.pone.0101479