

# Appendix O Interactive Object-Oriented Salmon Simulation (IOS) Winter-Run Life Cycle Results

## Summary of IOS Model Results (Model Run by Cramer Fish Sciences)

We observed an increasing trend in winter-run escapement through time for all four water operation scenarios. Although trends in escapement were similar for all studies, by the end of the 80-year model run escapement was higher for studies 7.0 and 6.0 than studies 7.1 and 8.0. It should be noted that escapement trends are sensitive to factors external to OCAP related environmental conditions. For example, increased harvest rate or loss of winter run hatchery contribution could easily lead to a different population trajectory. In evaluating effects of the proposed actions, differences between the four studies rather than absolute trends should be examined.

We found that study 6.0 produced on average 87,000 more smolts entering the ocean annually than study 7.0. Increased smolt production led to an average annual escapement increase of approximately 1,800 adult winter-run Chinook in years 1923-2002 for study 6.0. While studies 7.1 and 8.0 annually produced on average 300,000 and 176,000 fewer smolts than study 7.0, respectively. For studies 7.1 and 8.0, reduced smolt production led to an average annual escapement reduction of approximately 6,200 and 3,600 adult spawners, respectively.

Study 6.0 survival proportions across all life stages and spatial locations were almost identical to those observed in study 7.0. Increased abundance of smolts and spawning adults in Study 6.0 apparently results from slightly improved in-river juvenile survival. Unlike studies 7.1 and 8.0 (discussed below), water year type doesn't appear to be driving the differences in survival between study 6.0 and 7.0.

Differences between study 7.0, and studies 7.1 and 8.0 appears to be driven largely by decreased in-river survival among juveniles during critically dry water years. The year with the largest difference in juvenile in-river survival between 7.0 and studies 7.1 and 8.0 was 1977. Adult escapement in 1980, 3 years later, exhibits the largest difference in adult abundance between study 7.0 and studies 7.1 and 8.0. 1977 is the most critically dry water year during the 80-year period of 1923-2002 (Table of Water Year Type). Our results suggest that winter-run abundance may exhibit a greater sensitivity to critically dry water years under water studies 7.1 and 8.0 relative to 7.0.

## Conclusion

The IOS model was designed to serve as a quantitative framework for estimating the long-term response of Sacramento River Chinook populations to changing environmental conditions (e.g. river discharge, temperature, habitat quality at a reach scale). Life cycle models are well-suited for such evaluations because they integrate survival changes at various life stages, across multiple habitats, and through many years.

In applying the IOS winter run Chinook model to predicted environmental conditions under four alternative operational scenarios, we found that escapement increased for all four studies. Escapement for study 6.0 was similar to study 7.0 throughout the 80-year model run, with average annual escapement slightly higher for study 6.0 (Figure 3). However, escapement for studies 7.1 and 8.0 was typically lower than study 7.0 by approximately 15 percent (Figure 3). Winter-run Chinook salmon abundance demonstrated considerable sensitivity to critically dry water years for studies 7.1 and 8.0 relative to study 7.0. The primary mechanism for this observed difference appears to have been reduced survival of juvenile winter-run during critically dry water years for studies 7.1 and 8.0.

While differences in survival between operational scenarios were seemingly minimal, (e.g. see Table 1), the IOS model effectively integrates these incremental effects over many salmon generations. This long-term, life cycle approach indicates that episodic reduction in juvenile survival (particularly in critically dry years) leads to an average annual reduction of 6,200 adult spawners for 7.1 and 3,600 for 8.0 (relative to study 7.0). The effect of this reduced escapement through an 80-year period of simulation is sensitive to effects external to the proposed action. For example, increased harvest rate or loss of winter run hatchery supplementation would exacerbate the effects reported here.

In evaluating effects of the proposed actions, differences between the four studies should be favored over analysis of absolute trends. It should also be noted that IOS model results reported here do not include confidence intervals or other measures of uncertainty. As such, quantitative results should be interpreted cautiously, with preference given to general trends rather than specific, numeric values.