Estimated survival of juvenile salmonids through the lower Columbia River and estuary, and mortality due to avian predation

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Data from three studies will be reported. First, since 2001 we have been working with our partners (PNNL and USACE) to downsize acoustic transmitters for implantation into subyearling Chinook salmon *O. tshawytscha* 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 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 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.

Second, we have been detecting passive integrated transponder (PIT) tags on piscivorous bird colonies in the Columbia River Basin since 1998 (Ryan et al. 2001, 2003). Efforts in 2006 yielded > 66,000 juvenile salmonid *Oncorhynchus* spp. tags not previously detected, which accounted for 2.6% of all PIT-tagged salmonids released into the Columbia River Basin that year. The majority of these tags were detected on Caspian tern *Sterna caspia* and double-crested cormorant *Phalacrocorax auritas* colonies in the Columbia River estuary. Of the steelhead *O. mykiss* that migrated in-river and were detected at Bonneville Dam or were transported and released downstream from the dam, an average of 7.8, 10.4 and 13.1% of fish from the Snake, Upper Columbia, and Mid-Columbia River basins were detected on the East Sand Island tern colony, respectively. In comparison, approximately 1% of the subyearling Chinook salmon and < 2% of the yearling Chinook salmon detected at or released downstream from Bonneville Dam were detected on the same colony. These estimates appear conservative based on a detection efficiency of 64% for PIT tags placed on the island colony by us prior to the nesting season. There is also a large colony of cormorants on East Sand Island. The number of PIT tags deposited on this colony was estimated in collaboration with Oregon State University (OSU) and Real Time Research (RTR). Detection efficiency was estimated for only a subset of the colony area which was then extrapolated to the entire colony based on PIT tags recovered per nesting pair (CBR 2006). Using this approach, we estimate that of the PIT tagged salmonids detected at

Bonneville Dam, 9.7% of the tags in fish from the Snake River, 7.2% from the Upper Columbia River, and 9.2% from the Mid-Columbia River were deposited on the colony. In summary, steelhead from throughout the Columbia River Basin were significantly more vulnerable to avian predators in the estuary than were other salmonids. This pattern is consistent among previous years (e.g., Ryan et al. 2003). The one exception is that subyearling fall Chinook salmon that were PIT tagged and released from four lower Columbia River hatcheries were detected on the islands in considerably higher proportions (mean = 16%) than were fall Chinook salmon detected at or released directly downstream from Bonneville Dam (approximately 1%). In addition, we also estimated that significant losses to juvenile salmon occurred due to the cormorant colony on East Sand Island.

Third, during spring 2006 we conducted a study to test the hypothesis that releasing transported juvenile salmonids to the lower Columbia River estuary at river kilometer (rkm)10 (Astoria) would produce higher smolt-to-adult return rates (SARs) than releasing them just below Bonneville Dam at rkm 225 (Skamania Landing). Run-of-the-river yearling Chinook salmon and steelhead were collected at Lower Granite Dam and PIT-tagged, held one day, and loaded on barges for transport. A total of 16,100 wild and hatchery yearling Chinook salmon were tagged and released at rkm 10, while 23,700 wild and hatchery yearling Chinook salmon were tagged and released at rkm 225. In addition, we released 29,100 wild and hatchery steelhead at rkm 10 and 41,600 wild and hatchery steelhead at rkm 225. Based on detections of PIT tags on bird colonies, the new release protocol and location affected the vulnerability of transported fish to avian predators: mean avian predation rates were 3.0% for yearling Chinook salmon released at rkm 225, but only 0.4% for those released at rkm 10. Avian predation rates were 13.8% for steelhead released at rkm 225, but only 1.7% for cohorts released at Astoria. In summary, releasing transported fish farther downstream, at night, and on an outgoing tide resulted in approximately a seven-fold reduction in losses to avian predators. Adult returns over several years will be required to determine the true efficacy of releasing transported salmonids at rkm 10 compared to the traditional release site at rkm 225 as measured by SARs, such that additional factors such as ocean entry timing and conditions are included in the assessment.

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