

Relative Vulnerability of PIT-Tagged Subyearling Fall Chinook Salmon to Avian Predation in the Columbia River Estuary

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Thousands of subyearling Chinook salmon (*Oncorhynchus tshawytscha*) migrate annually through the lower Columbia River (LCR) and are predated by Caspian terns (*Hydroprogne caspia*) and double-crested cormorants (*Phalacrocorax auritus*) nesting on artificially-created dredge spoil islands in the Columbia River estuary. Electronic recovery of PIT tags on avian colonies during 2002-2009 revealed that the LCR Chinook salmon evolutionary significant unit is the most vulnerable to avian predation from a single source in the Columbia River basin. We compared the two predominant PIT-tagged subyearling stocks, tule and upriver bright (URB), generally originating on the west and east sides of the Cascade Mountains, respectively. Stock type and migration distance were critical determinants of relative vulnerability to avian predation because Chinook salmon exhibit a wide range of migration behaviors. We found significantly different ($P < 0.001$) avian predation rates of LCR-released tule (33.4%) and URB fish detected at Bonneville Dam (4.2%). Predation rates of LCR-released fish exceeded 50% during some years. The proportions of LCR-released fish consumed by double-crested cormorants (85%) and Caspian terns (15%) differed significantly ($P < 0.001$) from the proportions of Bonneville Dam-detected fish consumed by double-crested cormorants (51%) and Caspian terns (49%). We hypothesize that stock type and release location of fish influence vulnerability to avian predators by affecting smoltification, migration rate, duration of estuary residency, and estuary habitat use of subyearling Chinook salmon. Specifically, we hypothesize these factors contribute to higher predation rates of LCR-released tule stock because these fish rear in the estuary for prolonged periods in habitats where avian predators, particularly double-crested cormorants, have greater foraging success. We estimate Caspian terns and double-crested cormorants nesting on East Sand Island consume greater than eight million tule subyearling Chinook salmon released into the LCR annually.