Red Bluff Technical Report Abstract

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Borthwick, S.M., and R.R. Corwin, 2001. Wild Fish Entrainment by Archimedes Lifts and an Internal Helical Pump at the Red Bluff Research Pumping Plant, Upper Sacramento River, California: February 1997 - May 2000, Red Bluff Research Pumping Plant Report Series, Volume 13, United States Department of the Interior, Bureau of Reclamation, Red Bluff, California. 79 pp.

The overall goal of the Red Bluff Research Pumping Plant (RPP) biological evaluation program was to determine whether Archimedes lifts and internal helical pumps could be used to deliver water to the Tehama-Colusa canal without harming fisheries resources in the Sacramento River, with emphasis on chinook salmon. From February 1997 through May 2000, 133 trials were conducted to evaluate species, numbers, and characteristics of fish entrained from the river into the RPP. Trials lasted 24 hours and were segmented into diurnal and nocturnal periods. After passing through a lift or pump, fish were captured in downstream holding tanks, identified, measured (length), and assessed for mortality and injury. The specific objectives addressed in this study were: 1) determine diel and seasonal patterns of entrainment, 2) compare mortality and injury to fish passed through Archimedes lifts and the internal helical pump, 3) estimate the number of chinook salmon entrained annually, and 4) estimate the fraction of juvenile chinook salmon passing Red Bluff Diversion Dam that were entrained into the RPP.

Twenty-eight species of fish were captured during entrainment trials. Juvenile chinook salmon were most frequently entrained followed by prickly sculpin, lamprey, Sacramento sucker, Sacramento pikerninnow, and riffle sculpin. These six species comprised 94 percent of the 26,220 fish captured. Ninety-four percent of entrained fish were <100 mm in length. Nocturnal entrainment of chinook salmon exceeded diurnal entrainment in 33 of 35 months. Other fish species were also entrained more frequently at night. Seasonal patterns of chinook salmon entrainnient followed patterns of abundance in the river, peaking in winter as fall-run juvenile chinook salmon outmigrated.

Mortalities and injuries of fish were compared among pumps during eighty 24-h trials and fifteen 2 to 3-h trials when all three pumps operated simultaneously. In the short-duration trials fish were removed from the tanks every 10- 15 minutes. The objective of the short-duration trials was to minimize mortality due to confinement in holding tanks. In both 24-h and short-duration trials, mortalities and injuries were not due solely to pump passage. On their way to the holding tanks, fish traveled past screens with motorized brushes and into concrete channels where dewatering ramps were used to adjust the amount of flow into the tanks. Once in the holding tanks, fish were subject to turbulence and debris. Also, condition of the fish prior to entrainment was unknown. Therefore, frequency of mortality and sub-lethal injury obtained in this study for wild entrained fish are assumed to be overestimates of that due to pump passage alone.

Mean percent mortality of chinook salmon in the short-duration trials was 0.9, 0.6, and 1.2 for Archimedes 1, Archimedes 2, and the internal helical pump, respectively, compared to 2.8, 2.9, and 4.9 in the 24-h trials. Mortality did not differ significantly among the three pumps for the short-duration or the 24-h trials. Percent frequency of chinook salmon with sub-lethal injuries was < 0.3 percent for each of the three pumps during short-duration trials and <1.8 percent in the 24-h trials.

The total number of chinook salmon entrained during trials was consistently less than 5,000 each year. The estimated number entrained was calculated weekly for each pump as the product of the number entrained per hour during trials and the hours the pump operated. The estimated total number of chinook salmon entrained was consistently less than 10,000 each year. During this study the RPP was operated for biological evaluations during all seasons. Therefore, the number of fish entrained was higher than would occur if the plant was used solely to meet water needs of the Tehama-Colusa and Corning canals. Forty-nine percent of chinook salmon entrained were collected during trials conducted in December and January, months that the plant typically would not be operated to supply water to the canals.

During this study, 24-h trials were conducted simultaneously with the U. S. Fish and Wildlife Service's rotary screw trap sampling in the Sacramento River to determine the fraction of chinook salmon in the river entrained into the RPP during different seasons of the year. The screw trap sampling provided daily estimates of the total number of juvenile chinook salmon passing Red Bluff Diversion Dam (RBDD). The fraction of fish passing RBDD that were entrained into the RPP was consistently less than the fraction of river discharge diverted. During 84 trials, the fraction of daily passage entrained ranged from 0.00007 to 0.0138 and averaged 0.0022 (0.22 percent). The highest fraction entrained occurred during the winter outmigration of fall chinook salmon. The fraction of winter chinook salmon entrained averaged 0.0017 and ranged from 0.00008 to 0.0066. The small fraction of salmon entrained likely was due to the position of the pump intakes near the bottom of the river whereas the majority of outmigrating chinook salmon inhabited the upper water column. The small fraction of chinook salmon entrained into the RPP, combined with the low frequency of mortality and sub-lethal injury to all fish passed through the pumps, supports the conclusion that the RPP can be operated with little harm to fishery resources, including chinook salmon, in the Sacramento River at Red Bluff.