**U.S. Army Corps of Engineers, Portland District**

**Willamette Action Team for Ecosystem Restoration (WATER)**

**RM&E Concept Paper**

**STUDY CODE:** JPL-XX-21-DET

**TITLE:** ***Juvenile Chinook Salmon Behavior, Passage, and Survival During Detroit Dam Interim Downstream Fish Passage Operations: Interim Measure #5 & #7.***

**BIOLOGICAL OPINION ACTION:** RPA 4.3, 4.8, 4.11.

**MANAGEMENT PURPOSE:** Provide information to support the evaluation of interim operations to determine if interim operations provide a benefit to downstream-migrating juvenile Chinook salmon compared to existing operations. Study results will be used by the Action Agencies, WATER, and WATER subcommittees through the decision-making process to determine if and how interim operations should be modified to optimize operational downstream passage strategies at Detroit and Big Cliff Dams. Inform decisions regarding safe and efficient downstream passage and associated operations at Detroit and Big Cliff Dams.

**FUNDING SOURCE:** CRFM

**BACKGROUND:** Passage timing and distribution, fish behavior in the forebay, and survival need to be evaluated to determine if interim operations #5 and #7 are providing a benefit to juvenile Chinook salmon passage and survival at Detroit and Big Cliff Dams.

A rotary screw trap was placed below Detroit Dam in 2011, 2012, 2013, and 2014 to estimate weekly abundance of subyearling and yearling Chinook. From 2011-2014, water levels at this site were highly variable, making trap operation difficult. For example, due to the dynamic reservoir elevations at the site, the trap only operated 67% (181/272) of the days that were available for fishing in 2011 and 63 days in 2014 (trap removed March 6), resulting in limited catch information. Due to safety modifications and inadequate flow to operate the trap, fish were not collected from approx. mid-January to early May and late June to late Aug. 2012. Yearling Chinook passed in January and passed starting in May with the start of spring spill operation while subyearling Chinook passed in late spring and fall/winter (Romer, 2013). Khan, Royer, and others (2012), using fixed location hydroacoustics, evaluated passage timing of smolt sized targets over the yearlong study period. Run timing peaked in the winter months. Fish passed the turbines and ROs during all hours of the day. Turbine passage rates were highest during late fall, winter, and early spring months with passage lowest during the summer months. Daily passage was low at the spillway during June through August and increased in September. Diel distribution at the spillway showed a distinct peak in passage between mid-morning and mid-afternoon and low passage at night. In the spring and summer when the spillway is available, downstream passage occurs primarily through the spillway (Khan, Royer, and others 2012, Beeman, Hansel and others, 2014a). Beeman and Adams (2015) evaluated hourly passage. The daily timing of passage events varied primarily by season. Most dam passage of fish with known passage routes was at night during the spring study period. There was a greater predominance of night passage during the fall study period compared to the spring period, with 95.1 percent of the Chinook salmon passing the dam at night during this period. **These studies have identified challenges in rotary screw trap operations resulting in interrupted fish collection as well as different results in diel passage patterns using other evaluation methods.**

Comparisons of direct survival (48hrs) of juvenile salmon passing through the spillway, turbine, and RO were conducted in 2009 with sensor and live fish tests. Comparisons were made at the spillway with 1.5 and 3.5 ft gate opening. Comparison at the RO were with 1 ft and 5 ft gates opening. Sensor fish comparisons indicate that passing the RO through the 5-foot gate opening was the least deleterious route for fish passage at Detroit Dam and turbine passage was the most deleterious passage route (Duncan, 2009). These data are supported by the survival and malady estimates obtained from live-fish testing. Injury rates were highest for turbine and spillway passage through the 3.5-foot gate opening. Live rainbow trout used in direct injury and survival studies showed high mortality through the spillways (16% to 40% with about 50% injury) and the turbines (46% with about 50% injury; Normandeau Associates, Inc., 2011). At the RO, survival was high through the upper RO with the 5 ft gate opening (ca. 94% survival). **These cursory survival rates do not include juvenile Chinook, indirect mortality or barotraumas and therefore are underestimates of total losses.**

USGS acoustic telemetry studies in 2012 and 2013 provided information on median forebay residence times with some fish spending almost 3 months in the forebay prior to passing (fig. 12; table 8; Beeman, Hansel, and others, 2014a; Beeman and Adams, 2015). Acoustic telemetry tag life is a limitation in longer term evaluations. **Data gaps exist in understanding; overwintering rates and behavior; impacts of copepods and predators; and the resulting effects on survival and dam passage.**

Beeman and Adams (2015) reported that dam passage rates of fish within 25 m of the dam were affected by several measured factors, but the largest effects were seasonal conditions and diel period. Fish densities were most concentrated near the dam during the spring when the spillway was operating and least concentrated near the dam in the fall when the spillway was not operating. Most of the passage events of tagged fish occurred during the spill only condition, followed by the spillway plus powerhouse and powerhouse only conditions. Khan, Royer, and others (2012) reported that approximately 86.5% of the fish passed through the turbines during the yearlong study period. When spillway Bay 5 was operated simultaneously with the turbines – 72% of the fish passing the dam used the spillway, and 28% used the turbines. **There will need to be new information collected to understand the links between seasonal, diel, and interim operations on behavior and route-specific passage during evaluations over the study period.**

Kock, Beeman, others (2015) conducted an evaluation to estimate dam passage survival during a period of spill in 2014 with a paired release recapture study design. Double-tagged fish (acoustic and PIT) were released upstream (997) and downstream (625) of Detroit Dam. A total of 43 fish (6.8%) of the upstream release group passed Detroit. Of these, 54.8% passed the RO, 31.0% passed the spillway, and 14.4% passed the turbines. **Dam passage survival estimates were not presented as they would have been highly uncertain due to the low numbers of fish that passed during the study period.** When Chinook salmon were directly captured in downstream screw traps, mortality varied by year. Mortality of unmarked juvenile Chinook salmon was 60% in 2011, 29% in 2012, and 11% in 2013 with most of the Chinook collected Aug-Dec (Romer and others 2012, 2013, 2014). **As mentioned above, rotary screw trapping below Detroit Dam is difficult and more rigorous estimates of dam survival would be beneficial for evaluating interim operations.**

Beeman and Adams (2015) estimated survival was lower in the 11 km between Detroit Dam and Minto Dam (a reach including Big Cliff Reservoir and Dam) than in the remaining 241 km from Minto Dam to Portland. Estimating survival was not a primary objective of the study, so USGS used a single-release design rather than a multiple-release design commonly used to estimate survival over short distances such as passage at a dam. In the spring study period, this reach accounted for 59.1 percent of cumulative Chinook salmon mortality between Detroit Dam and Portland and 63.1 percent of the cumulative steelhead mortality in that reach. In the fall study period, the first 11 km accounted for 80.0 percent of the cumulative mortality of Chinook salmon between Detroit Dam and Portland. Kock and others (2015) estimated cumulative survival from the Minto tailrace to Portland was 23 percent, which was lower than previously observed. Beeman and others (2015) found that survival of juvenile Chinook salmon and steelhead ranged from 39 to 65 percent in this reach during 2013 and 2014. **The discrepancy in survival rates between tagged fish in Kock and others (2015) and tagged fish from previous studies provides evidence to support earlier observations that factors such as release timing or fish source may have influenced observations in this study.** Oligher and Donaldson (1966) conducted Big Cliff Kaplan turbine unit tests to determine what effect various operating conditions would have on survival of fish passing through this type of turbine. There were two series during 13-25 Oct. 1964, 2-14 May 1966 with three head tests of 91, 81, and 71 ft. Test fish were hatchery reared Chinook between three to four inches in length in Oct. 1964 and four inches in May 1966. Procedures included a mark recapture study with test fish introduced through a four-inch diameter pipe into the center of the penstock. 120 ft long recovery nets with live boxes at the downstream end were attached to both draft tube openings. Control fish were introduced into the forward end of the nets. After testing, test and control fish were removed and transported by truck to Marion Forks hatchery for holding where mortality and injuries were recorded. Average survival from all tests in Oct. 1964 was 91.1 percent at 91 ft. head, 94.5 percent at 81 ft. head, and 89.7 percent at 71 ft. head. Average survival from all tests in May 1966 was 92.2 percent at 91 ft. head, 89.8 percent at 81 ft. head, and 90.6 percent at 71 ft. head. Survivals of approximately 95 percent were achieved at best turbine efficiency for all three heads. Test problems were identified during the study and included: debris in first test series 1964, reversal of smoltification in May 1966 and non-active feeding of test fish during the first test series, overcrowding in the planting hose contributing heavily to mortality, problems with holding fish in preparation for testing, considerable portions of uncaptured fish “no doubt” had moved into and were holding in the draft tube during the net removal procedure. **Big Cliff Dam information regarding passage timing and distribution, fish behavior in the forebay, and dam survival is limited. Collecting additional passage and survival data would benefit the understanding of the Interim Measures biological performance and the potential uplift in passage and survival that could be achieved if operations were to be modified in the future in an effort to optimize operational downstream passage strategies at Detroit and Big Cliff Dams.**

**OBJECTIVES:**  Evaluation of downstream fish passage at Detroit Dam under the two Interim Measures (#5 and #7), fall drawdown with RO operations and summer temperature operations using the spillway. The primary objectives are to evaluate the relative improvement of interim dam operations on passage and survival of juvenile Chinook salmon. The following should be evaluated for juvenile Chinook relative to typical and interim operations:

1. Monitor seasonal (monthly, weekly, etc…) and diel passage timing and rates of subyearling and yearling Chinook salmon during the study period at Detroit and Big Cliff Dams.
2. Detail operations and environmental conditions at Detroit and Big Cliff Dams i.e., flow route, timing, volume, forebay elevation, temperature, etc…
3. Determine passage distribution of juvenile Chinook salmon between the spillway and turbine(s) spring/summer (approx. June 1 – Oct. 31) and the DET RO and turbines in the fall/winter (approx. Nov. 1 – Feb. 1.) at Detroit and Big Cliff Dams.
4. Compare passage proportions by route.
5. Estimate efficiency (percent of total fish approaching that enter and appear to pass through each route) and passage effectiveness (ratio of fish through a given route to percent of total flow through that route) for each species during interim operations.
6. Forebay residence time
7. Overwintering rate and subsequent dam passage vs. non passage.
8. Assess fish behavior in the Detroit Dam forebay and near dam outlets during interim operations.
9. Forebay distribution.
10. Estimate vertical and horizontal distribution of fish in the forebay and near the face of the dam.
11. Estimate forebay and reservoir directional movement.
12. Estimate survival during interim operations.
13. Detroit Dam passage.
14. Downstream of Detroit Dam. Reach specific survival estimates: DET - BC, BC - Minto, Minto – The confluence of the Santiam R. and Willamette R.

**SCHEDULE:** 2022-2024. An approximate two-year study will be conducted to account for overwintering objectives as well as variability in environmental and operational conditions.

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