Appendix B

Annotated Bibliography

Appendix B

Annotated Bibliography

This annotated bibliography includes citations with hyperlinks to portable document files on this digital video disk (DVD) and brief abstracts describing original juvenile salmonid passage and survival studies at Bonneville Dam from 1939 through 2005. The intent of the abstract is to elaborate slightly on the title so that readers less familiar with the research can determine whether they want to open the portable document file (PDF). For convenience, citations with more than two authors are arranged by first author, year, and an assigned alphabetic letter within years, because that is how they were called out in the synthesis report (e.g., Evans et al. 2006b). Code numbers refer to links that appear in the DVD accompanying the print version of this report.

Adams, N. S., R. E. Reagan, S. D. Evans, M. J. Farley, L. S. Wright, and D. W. Rondorf. 2006. Movement, Distribution, and Passage Behavior of Radio-Tagged Juvenile Chinook Salmon and Steelhead at Bonneville Dam, 2005. Draft Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 2005, the authors used radio telemetry to examine the movements and behavior of yearling and sub-yearling Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* in the forebay of Bonneville Dam. There are actually two reports under this cover and they have different authors. The first (Page 1) is on yearling Chinook salmon and steelhead, and the second (Page 54) is on subyearling Chinook salmon, and the two reports have different authors. The objectives of this research were to: 1) determine the behavior, distribution, and approach patterns of fish in the forebay areas of Bonneville Dam, 2) determine the timing and route of dam passage of fish, 3) estimate fish passage efficiency for the entire Bonneville Dam complex, fish guidance efficiency for powerhouses I and II, and efficiency and effectiveness for the spillway and corner collector, and 4) provide data to estimate survival of radio tagged fish released above Bonneville Dam. This report includes the study of yearling Chinook salmon and steelhead trout during spring, 2005, and the study of subyearling Chinook salmon during summer, 2005. BS176

Bell, M. C. 1971. Ecological impact of pool and tailwater regulations at Bonneville Dam (fish and wildlife). U. S. Army Corps of Engineers, Portland, Oregon.

This paper assessed the impact of extreme operational conditions on fish and wildlife resources in the lower Columbia River. The author summarized effects of extreme operations on the following: 1) embayments; 2) spawning grounds for shad, smelt, and sturgeon; 3) Waukeena Pond; 4) hatcheries located in the Bonneville Pool area; 5) Hood River spawning grounds; 6) nitrogen exposure; 7) fishway facilities constructed in tributary streams entering Bonneville Pool; 8) temperature; 9) passage of adult salmon at Bonneville; 10) waterfowl and wildlife; 11) rate of movement of downstream migrants in the Bonneville Pool areas; and 12) potential stranding areas. BS112

Bickford, S.H. and J.R. Skalski. 2000. Re-Analysis and Interpretation of 25 Years of Snake-Columbia River Juvenile Salmonid Survival Studies. North American Journal of Fisheries Management. 20:53-68.

This is a meta-analysis study that examines trends and variability in estimates of the survival of juvenile salmonids between 1971 and 1995 in the Snake-Columbia Basin, where tagging studies to estimate salmonid smolt survival have been done for decades. There is a short review of the history of the Federal Hydropower System and of survival studies in the Columbia-Snake system. Experimental (paired release, balloon tag, PIT tag, etc.) and analytical methods are discussed. Fifty-three smolt survival investigations from 1971 to 1996 were reexamined to identify general patterns for survival of smolts through turbines, spill bays, and river reaches. Of these, 33 met the authors' criteria (which are presented in an appendix) for meta-analysis. The assumptions of the studies were reevaluated whenever possible and those results are presented in an appendix. Although the project, its operations, fish species, size, condition, head, and other factors may confound comparisons among studies, generally consistent results were found among projects, species, and head levels. BS022 PDF reproduced with permission of www.fisheries.org.

BioAnalysts, ENSR, and INCA. 2001. Bonneville 2nd Powerhouse Corner Collector site selection study. Report Prepared for U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

This study identified, evaluated, and recommended a location and a preliminary design for a high flow outfall as part of a corner collector surface flow bypass system, formed by modifying the existing ice and trash sluiceway at B2. The B2 Corner Collector (B2CC) project would enlarge and deepen the old sluiceway entrance, create a conveyance channel to the west (down stream) end of Cascades Island, and create a high-flow outfall there in the spillway tailrace. At a normal forebay elevation of 74.5 ft, the B2CC would discharge just over five kcfs.

This is a very complete project analysis including rationale, computational and physical modeling reports, site selection for both ends of the B2CC, tailrace egress, a decision-making analysis, costs, a high-flow outfall survival study, and a review of studies of juvenile salmonid passage survival with special attention to northern pikeminnow predation. BS007

BioSonics Inc. 1998. Hydroacoustic evaluation and studies at Bonneville Dam, spring/summer 1997 volume 1 and 2. Contract Report to the U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

In 1997 BioSonics, Inc. conducted this hydroacoustic study of fish distribution upstream of and passage through the southern end of B2. The study had two main tasks. The first, using data obtained from fixed-aspect hydroacoustics, they estimated fish passage through and effects on Unit 11 passage of the sluice at the south end of the powerhouse. The second, using mobile hydroacoustic data, they described the spatial and temporal aspects of fish distribution in the Bonneville Dam powerhouse forebays in general and upstream of the south end of B2 as a function of sluice operation. There was also an effort to evaluate the efficacy of three different transducer mounts for sampling spillway passage.

The fixed-aspect study was carried on using single beam hydroacoustics, a 6-degree and a 12-degree transducer, each aimed upward from below the upstream side of the sluice entrance to sample sluiceway passage and an opposed pair of single-beam 6-degree transducers sampling above and below the tip of the Intake 11A STS to sample fish passage above and below the STS there. Sluiceway operation was set according to a randomized block experimental design. The sluice was operated in three ways: closed, open down to Elevation (EL) 61 ft above mean sea level (MSL) producing a discharge of about 3.3 kcfs, and open down to EL 68 MSL, which passed about 1.1 kcfs. Response variables were estimates of fish passage through the sluiceway and Intake 11A and fish guidance efficiency at Intake 11A. The 1997 passage season was a very high water season.

Sluiceway operation at both elevations was found to have "a substantial impact" on fish passage through Intake 11A in spring with total Unit 11 passage being "much lower" with the sluice open, the difference being "significant" for guided passage. Estimates of sluiceway passage were "much lower" with the weir at EL 61 than at EL 68, which the authors attribute to low fish detectability with the higher velocities and turbulence inherent in the lower elevation. At the shallower EL 68 weir level the sluiceway passed an estimated 3,000 fish per day in both spring and summer. In summer sluiceway operation made little difference in fish passage estimates at Intake 11A. BS024

Counihan, T. D., K. J. Felton, G. Holmberg, and J. H. Peterson. 2002. Survival Estimates of Migrant Juvenile Salmonids in the Columbia River through Bonneville Dam Using Radio-Telemetry, 2001. Final Report of Research by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

The objectives of this work were to provide estimates of relative survival of yearling and sub-yearling Chinook salmon passing via all routes at Bonneville Dam in 2001 and to provide relative survival estimates of fish passing through the juvenile bypass system at Powerhouse 2. Based on a paired release strategy above and below the dam, relative survival probabilities ranged from 0.85 to 1.05 for yearling Chinook salmon and 0.73 to 1.08 for sub-yearling Chinook. Survival through the JBS ranged from 0.78 to 1.1 for yearling and from 0.62 to 1.28 for sub-yearling Chinook. Relative survival ranged from 0.83 to 1.07 for turbine-passed yearling Chinook salmon and from 0.82 to 1.03 for non-turbine passed yearling Chinook salmon. No significant differences between the survival of yearling Chinook salmon passing all routes at Bonneville Dam during spill and no-spill operations were detected. Significant differences were detected when separating yearling passage through turbine and non-turbine routes during spill and no-spill conditions: survival of turbine-passed fish was greater during periods of no spill and survival of non-turbine-passed fish was greater during periods of spill. BS139

Counihan, T.D., G.S. Holmberg, and J.H. Petersen. 2003. Survival Estimates of Migrant Juvenile Salmonids through Bonneville Dam using Radio-Telemetry, 2002. Final Report of Research by the U. S. Geological Survey, Columbia River Research Laboratory for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

This study evaluated the survival of radio-tagged yearling Chinook salmon through a Minimum Gap Runner (MGR) turbine unit and the downstream migration (DSM) channel at Bonneville Dam's first powerhouse and route specific survival. Using releases of radio-tagged yearling Chinook salmon released as part of the survival study at The Dalles Dam and releases made below the outfall of the 2nd powerhouse JBS, the authors were able to evaluate survival through the spillway (including by spill deflector type) and the two powerhouses, including turbines, the JBS, and the B2 Corner Collector. Survival estimates ranged from 0.90 to 1.33 for fish released through the John Day Dam JBS and 0.90 to 1.13 for fish released into the MGR at powerhouse 1. Survival estimates for fish released in the DSM ranged from 0.60 to 1.05. Survival of fish was estimated to be 0.98 through the spillway, 0.90 through powerhouse 1, 0.99 through powerhouse 2. Overall survival through the dam was estimated to be 0.98. BS136

Counihan, T. D., J. Hardiman, C. Walker, A. Puls, and G. Holmberg. 2006a. Survival estimates of migrant juvenile salmonids through Bonneville Dam using radio telemetry, 2004. Final Report of Research by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

During 2004, the USGS evaluated the survival of radio-tagged yearling and subyearling Chinook salmon and steelhead trout through the ice and trash sluiceway and the minimum gap runner (MGR) turbine unit at Bonneville Dam's powerhouse 1. In addition, releases of radio-tagged yearling Chinook salmon, steelhead trout, and subyearling Chinook salmon at The Dalles Dam and below the outfall of the 2nd powerhouse JBS were used to estimate survival through the spillway and the two powerhouses. Spillway survival was by spill condition and the type of spill-bay deflector, and estimates were also made for the turbines, juvenile bypass systems, and sluiceways, including the B2 Corner Collector. BS172

Counihan, T. D., J. Hardiman, C. Walker, A. Puls, and G. Holmberg. 2006b. Survival estimates of migrant juvenile salmonids through Bonneville Dam using radio telemetry, 2005. Final Report of Research by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

During 2005, the USGS evaluated the survival of radio-tagged yearling and subyearling Chinook salmon and steelhead trout through the Bonneville Dam spillway, powerhouses 1 and 2, the B2 Corner Collector, the juvenile bypass system (JBS) at powerhouse 2, and through all routes collectively using the route-specific survival model. Radio-tagged fish were released at The Dalles Dam and in the tailrace of Bonneville Dam and were interrogated at Bonneville Dam and three radio-telemetry arrays below Bonneville Dam. The USGS also evaluated the survival of radio-tagged yearling and subyearling Chinook salmon and steelhead trout using paired releases through the ice and trash sluiceway at Bonneville Dam's powerhouse 1. Site-specific releases were made directly into the ice and trash sluiceway and in the tailrace of Bonneville Dam below the outfall of Powerhouse 2 JBS. BS173

Dawley, E. M., L. G. Gilbreath, and R. D. Ledgerwood. 1988. Evaluation of juvenile salmonid survival through the second powerhouse turbines and downstream migrant bypass system at Bonneville Dam, 1987. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

Fish guidance efficiency (FGE) testing at the Bonneville Dam Second Powerhouse since 1983 has shown poor guidance of downstream migrant salmonids from turbine intakes equipped with submersible traveling screens (STS) (Krcma et al. 1984; Gessel et al. 1987). Pending resolution of FGE problems, operation of the Second Powerhouse during juvenile migration periods has been curtailed at night and restricted in daytime. During these periods, downstream migrants pass Bonneville Dam via the First Powerhouse turbines and bypass system and over the spillway between the two powerhouses. While it is generally agreed that operation in this manner will maximize survival of migrants passing Bonneville Dam, the rationale for this procedure is based on studies of passage mortality at Bonneville Dam First Powerhouse (Holmes 1952) and at other hydroelectric projects with different operating conditions (Schoeneman 1961). Since survival studies have not been conducted at the Bonneville Dam Second Powerhouse, information specific to this location is needed.

In 1987, the National Marine Fisheries Service (NMFS), in cooperation with the U.S. Army Corps of Engineers (COE), began a multi-year study to evaluate survival of subyearling fall Chinook salmon passing through the Bonneville Dam Second Powerhouse turbines and bypass system and through the spillway. Research conducted in 1987 had the following objectives: (1) Determine short-term comparative survival of juvenile salmon released at upper and lower locations in a Second Powerhouse turbine intake; in the Second Powerhouse bypass system; and below Bonneville Dam at Hamilton Island, Columbia River kilometer (Rkm) 232. Estimates are to be obtained from brand recoveries in the estuary at Jones Beach (Rkm75). (2) Determine the long-term survival (to adults) of marked subyearling

Chinook salmon released at the locations listed in (1) above. Estimates are to be obtained from tag and grand recoveries in various fisheries, at the Bonneville Dam fish trap, and at hatcheries. BS090

Dawley, E. M., L. G. Gilbreath, R. D. Ledgerwood , P. J. Bently, B. P. Sanford, and H. H. Schiewe. 1989. Survival of subyearling Chinook salmon which have passed through the turbines, bypass system, and tailrace basin of Bonneville Dam Second Powerhouse, 1988. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Research at the Columbia River's Bonneville Dam Second Powerhouse has shown that subyearling Chinook salmon (*Oncorhynchus tshawytscha*) migrating in summer, mostly fall Chinook salmon, are not effectively guided into the bypass system from turbines equipped with submersible traveling screens (STS; Gessel et al. 1988). Consequently, most pass downstream through the turbines. To minimize turbine passage losses pending resolution of this guidance problem, operation of the Second Powerhouse has been curtailed at night; daytime operation has been restricted to periods necessary to limit spill to less than 2,124 m^8/sec (75,000 ft^8/sec) or to meet firm energy demands if energy is unavailable elsewhere in the power system. As a result downstream migrants usually pass Bonneville Dam via the turbines and bypass system of the First Powerhouse and, when flow conditions allow, over the spillway between the two powerhouses.

The rationale for this operating procedure was based on studies of passage mortality at the Bonneville Dam First Powerhouse (Holmes 1952) and at other hydroelectric projects (Schoeneman et al. 1961) with different physical features and turbine operating characteristics (elevation of blade in relation to tailwater, dimension of blades, and hydraulic head). Hence, the adequacy of this procedure as the best means of protecting downstream migrant salmonids at the Second Powerhouse had not been rigorously documented. Moreover, the Kaplan turbines installed at the Second Powerhouse are of a more efficient design (less cavitation) than those previously studied at Bonneville First Powerhouse, and passage mortality is thought to be inversely related to turbine efficiency (Bell et al. 1981). Highly sensitive survival studies have not been conducted at Bonneville Dam since construction of spillway flow deflectors or the Second Powerhouse; therefore, information specific to this project was needed for management of fish passage in relation to power production.

Accordingly, in 1987, the National Marine Fisheries Service (NMFS), in cooperation with the U.S. Army Corps of Engineers (COE), began a multi-year study to evaluate relative survival of subyearling fall Chinook salmon that have passed through the Bonneville Second Powerhouse turbines and bypass and through the spillway. Estimates of long- and short-term survival of marked Chinook salmon using various passage routes were compared to similar estimates for control groups released in the tailrace and in the river 2.5 km downstream. Long-term relative survival was based on returns of tagged and branded adult fish to ocean fisheries, Columbia River fisheries, the Bonneville Dam Second Powerhouse fish trap, and Columbia River hatcheries. Short-term relative survival was based on recoveries of branded fish 157 km downstream from the dam at the head of the estuary at Jones Beach, river kilometer (Rkm) 75. Secondary objectives of the estuarine sampling were to evaluate the success of the release strategies, condition of test fish (descaling, injuries, size, and gill Na^+-K^+ATPase), and migration behavior.

During the second year of this study, in 1988, as in 1987, the spillway releases were cancelled due to insufficient river flow in this drought year. In 1988, fish planned for release in the spillway were instead released into the front roll of the turbine discharge. Also in 1988, the downstream control release site was changed from the shoreline location used in 1987 to a mid-river site. The bypass and turbine release sites were the same as used in 1987 (Dawley et al. 1988). BS088

Dawley, E. M., R. D. Ledgerwood, L. G. Gilbreath , and P. J. Bentley. 1991. Survival of juvenile

salmon studied at Bonneville Dam. National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center Quarterly Report. July-August-September 1991:1-5.

This is a Northwest Fisheries Science Center Coastal Zone and Estuarine Studies Division quarterly report that summarizes different approaches towards improving survival of downstream migrants. The paper emphasizes the juvenile fish transportation program and bypass system technology. The authors contend the most striking finding of the "Bonneville Survival Study" is that differences in estuarine recoveries of juvenile salmon from turbine and bypass groups suggested little survival benefit associated with the bypass system. Data to date clearly suggest that bypass passage has not substantially improved survival over turbine passage for summer-migrating juvenile Chinook salmon at Bonneville Dam. BS133

Dawley, E. M., R. D. Ledgerwood, L. G. Gilbreath, B. P. Sandford, P. J. Bentley, M. H. Schiewe, and S. J. Grabowski. 1992. Survival of Juvenile Salmon Passing through Bonneville Dam and Tailrace. Pages 145-156 in Passage and Survival of Juvenile Chinook Salmon Migrating from the Snake River Basin. Proceedings of a technical workshop held February 26-28, 1992, University of Idaho.

Authors used a trap net to assess survival of juvenile salmonids passing through Bonneville Dam from 1987-1990. Trends observed in the juvenile recovery data suggest that bypass passage has not substantially improved survival as compared to turbine passage for summer-migrating juvenile Chinook salmon at Bonneville Dam. Authors concluded that 1) bypass passage appears to cause significant stress, loss of scales, and some direct mortality; 2) survival of fish leaving the bypass system appears to be diminished by northern squawfish predation; 3) conditions that appear to increase survival of downstream-released fish over bypass-released fish include high water velocity, long distance to predator habitat, current direction parallel to shoreline, low level of stress for migrants at river entry, lack of predator attraction from continuous availability of juvenile salmon, and nighttime release of fish to limit avian predation, and 4) conditions thought to decrease survival of outmigrants at Bonneville Dam second powerhouse bypass system may be important at other dams, and should be investigated. BS129

Dawley, E. M., L. G. Gilbreath, R. D. Ledgerwood, P. J. Bentley, and S. J. Grabowski. 1993a. Direct Measure of Stress, Descaling, Injury and Mortality for Juvenile Salmonids Passing through the Bypass System of the Bonneville Dam First Powerhouse. Report for the U.S. Army Corps of Engineers – North Pacific Division, by the National Oceanic Atmospheric Administration National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division, Seattle, Washington.

Juvenile salmon fish condition was assessed using a triangular-shaped net deployed to trap fish as they moved from the bypass system discharge conduit in winter of 1992-93. Turbine operations were reduced to provide calm water for net deployment. Trap net recovery estimates ranged from 52% to 99%. High recovery percentages of fish killed immediately prior to release suggested that test fish, which suffered injuries and were moribund or incapacitated upon entry to the net, were recovered at a higher rate than unaffected fish. These results suggested that the observed effects represent a liberal estimate of impacts of bypass passage. Yearling and subyearling Chinook salmon were the primary test fish used in the assessment. Descaling and mortality observed after passage were insignificant for hatchery-reared spring Chinook salmon. Effects observed among the test fish generally increased with distance traveled through the bypass collection channel and discharge conduit. Releases directly into the net showed little or no effects, with descaling and mortality 0.3% or less for yearlings and about 1% for subyearlings. Scale loss and mortality percentages for yearling Chinook salmon averaged 4.5% and 0.9%, respectively, for fish released into the downwell; 12.4% and 7.7%, respectively, for those released about half way down the collection channel; and 3.1% and 1.2%, respectively, for those released at the south end of the channel. Scale loss and mortality for subyearling Chinook salmon averaged 9.5 and 1.0 %, respectively, for fish released into the downwell; and 7.8% and 1.2%, respectively, for fish released into the middle of the channel. Fish passing through the tailrace release hose experienced similar scale loss and mortality. BS130

Dawley, E. M., R. D. Ledgerwood, L. G. Galbreath, P. J. Bently, and S. J. Grabowski. 1993b. "Do bypass systems protect salmonids at dams?" in Proceeding of the Fish Passage Policy and Technology Symposium, pp 161-168. September 1993, Portland, Oregon. American Fisheries Society.

Bypass systems at dams on the Columbia and Snake Rivers divert large numbers of juvenile salmonids away from turbine intakes and downstream into tailrace areas. However, few rigorous assessments of comparative survival have been made between bypassed fish and those passing through turbines. A study was initiated at Bonneville Dam in 1987 to provide definitive information regarding passage survival. Results to date show bypassed fish had lower survival than fish passing the dam through turbines or spillways. Fish exiting the bypass system had elevated plasma concentrations of cortisol (an index of stress), but physical injuries were not apparent. One likely cause for decreased survival of bypassed fish was predation by northern squawfish on fish exiting the bypass outlet. Study results indicate that bypass operational procedures, as well as location and physical conditions at the bypass outlet, favor high predation. Factors contributing to high predation include 1) river-water velocity of less than 1.2 m/s at the bypass exit; 2) proximity of the bypass exit to predator sanctuary areas; 3) location of the bypass exit at a curved reach of river where flow was directed toward shorelines; 4) poor dispersal of released fish, resulting in increased juvenile salmon density in the migration route; 5) disorientation of juvenile salmonids upon exiting the bypass outlet; and 6) continuous release at one site. (This is the original abstract). BS102 PDF reproduced with permission of www.fisheries.org.

Dawley, E. M., L .G. Gilbreath, R. D. Ledgerwood, P. J. Bentley, and B. P. Sandford. 1998. Effects of Bypass System Passage at Bonneville Dam Second Powerhouse on Downstream Migrant Salmon and Steelhead; Direct Capture Assessment, 1990-1992. Final Report for the U.S. Army Corps of Engineers, by the National Oceanic Atmospheric Administration National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division, Seattle, Washington.

The general objective of this work was to isolate water flow conditions and sections of the second powerhouse bypass system that may cause physical trauma to juvenile salmonids during passage. The authors concluded that injury and mortality of test fish was not occurring during passage through the bypass system at the 2nd powerhouse. However, they did state that passage through the bypass system likely caused stress and fatigue in juvenile migrants and could contribute to diminished predator avoidance. They also noted that northern pikeminnow predation is particularly intense at the outlet of the bypass system. The authors offered the following conclusions: 1) the point source release from the bypass discharge conduit allows for increased predation; 2) migration through the low-velocity tailrace basin results in increased predation; and 3) the location of the bypass outlet on the north side of the tailrace in conjunction with the southward bend in the river tends to direct outmigrants shoreward toward rip-rap areas that are prime habitat for northern pikeminnow. BS114

Evans, S. D., J. M. Plumb, A. C. Braatz, K. S. Gates, N. S. Adams, and D. W. Rondorf. 2001a. Passage behavior of radio-tagged yearling chinook salmon and steelhead at Bonneville Dam associated with the surface bypass program, 2000. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 2000, the B1 prototype surface collector (PSC) was extended to include turbines 1-6. Each vertical-slot entrance was 20 ft wide. This spring study used radio telemetry to examine the movements of Chinook salmon (this time yearlings) as they approached and passed the dam. The objectives were to 1) determine the behavior, distribution, and approach patterns of yearling salmonids in the forebay areas of Bonneville Dam; 2) determine the time and route of dam passage; 3) determine movement patterns and behavior in the vicinity of the PSC; and 4) assess the efficiency and effectiveness of the PSC. B1 had generation priority.

Nearly half (49%) of steelhead passed at B1 and 34% passed the spillway. Of the steelhead that passed at B1, 44% passed into the sluiceway, 33% were guided into the downstream migration channel by screens, and 23% passed through the turbines (B1 FPE = 77%). Forty-four percent of Chinook salmon passed through the spillway. Of the Chinook salmon that passed at B1, 29% passed into the sluiceway, 36% were guided into the bypass, and 35% were unguided and passed directly through the turbines. Of the fish that passed at B2, 55% of steelhead and 39% of Chinook salmon were guided into the bypass by the STS and 45% of steelhead and 60% of Chinook salmon passed through the turbines. Passage rates were highest for both species during the day at the spillway and B1 whereas passage rates were highest for both species during the night at B2.

The PSC was quite efficient at collecting fish. The collection efficiency (number entering the PSC/the total number passing units 1-6) was 83% for steelhead and 78% for Chinook salmon (80% combined). The PSC was also relatively effective compared to water passing into the turbines and the spillway. When compared to spillway effectiveness (1.0 for steelhead and 1.3 for Chinook salmon), PSC effectiveness was about twice as high. BS014

Evans, S. D., N. S. Adams, and D. W. Rondorf. 2001b. Passage behavior of radio-tagged subyearling Chinook salmon at Bonneville Dam associated with the surface bypass program, 2000. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

This summer study used radio telemetry to examine the movements and behavior of sub-yearling Chinook salmon in the forebay of Bonneville Dam during the 2000 passage season when the prototype surface collector (PSC) was in place over the 18 intakes of units 1-6. The objectives were to 1) determine the behavior, distribution, and approach patterns of sub-yearling Chinook salmon in the forebay areas of Bonneville Dam; 2) determine the time and route of dam passage of yearling Chinook salmon; 3) determine movement patterns and behavior of yearling Chinook salmon in the vicinity of the PSC; and 4) assess the efficiency and effectiveness of the PSC. B1 had generation priority.

Median travel rate from release to Bonneville Dam was 2.3 km/h for fish released from both The Dalles Dam and Hood River Bridge, resulting in travel times of 34.6 h and 18.2 h, respectively. Median forebay residence time was shortest at the spillway (7.2 min) compared to 1.8 h and 2.1 h at B1 and B2, respectively. The spillway passed the most fish (69.5%), followed by B1 (30%) and B2 (0.5%). Of the fish that passed at B1, 68% passed into the sluiceway, 23% passed directly through the turbines, and 9% were guided into the bypass via the turbine intake screens. At the spillway and B2, a higher proportion of fish passed during night compared to day. In contrast, at B1 a lower proportion of fish passed during night compared to day.

Of the fish that entered the B1 forebay, 72% were detected within 20 ft of the PSC and were therefore considered to have discovered the PSC. Of those fish, 67% entered the PSC. However, of the fish that entered the PSC, only 41% (59 of 143) entered via the entrance they were first detected at without moving to one or more other entrances. In relation to units 1-6, the PSC was quite efficient at collecting fish. Of the fish that passed at units 1-6 (guided, unguided, and sluiceway), 81% entered the PSC. The PSC was also relatively effective compared to water passing into the turbines and the spillway.

An effectiveness of 2.5 indicated that the percentage of fish that entered the PSC out of total passage at units 1-6 was 2.5 times the percentage of water that entered the PSC. When compared to spillway effectiveness (1.2), PSC effectiveness was over twice as high. Since fish that entered the PSC could pass through other routes, the PSC was not considered an actual passage route for purposes of calculating passage metrics such as FPE. However, if the PSC had been an actual passage route, FPE would have increased from 91% to 94%. BS013

Evans, S. D., C. D. Smith, N. S. Adams, and D. W. Rondorf. 2001c. Passage behavior of radio-tagged yearling chinook salmon at Bonneville Dam, 2001. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

This is the spring 2001 radio telemetry study at Bonneville Dam. From 1 May to 2 June, 1,211 yearling Chinook salmon were tagged and release near Hood River, OR, about 20 mi upstream. This was a severe drought year and mean river discharge at Bonneville Dam during the study period was only 134.9 kcfs, with 72% of flow through B2, 22% at the spillway, and 6% at B1. From May 1-15 and during three 5-h blocks on May 24-25, 1.2 kcfs of spill was discharged through each of spill bays 1 and 18 and represented 1.7% of total discharge (hereafter referred to as 2% spill). From May 16 to June 9, a mean 50 kcfs was discharged through 10 spill bays and represented 37% of total discharge (hereafter referred to as 37% spill).

Of the 1,211 tagged fish released at Hood River, 1,117 (97%) were detected at Bonneville Dam. Median travel rate to the dam was 1.8 km/h, resulting in a median travel time of 22.1 h. Median forebay residence time was shortest at B2 (0.2 h) compared to 2.7 h at B1 and 0.3 h at the spillway. Passage routes were determined for 98% of fish detected at Bonneville Dam. B2 passed the most fish (80%), followed by the spillway (16%) and B1 (4%). Of the fish that passed at B1, 76% passed into the sluiceway, 13% passed through the turbines (unguided), and 11% were diverted into the turbine bypass system by turbine intake screens (guided). Since the B2 sluiceway did not operate in 2001, all fish that passed at B2 entered the turbine intakes; 54% were unguided and 46% were guided. At all dam areas, a higher proportion of fish passed during night compared to day.

Estimated fish passage efficiency (Project FPE) in spring 2001 was 56%. During hours of 37% spill, estimated FPE was 64%, and during hours of 2% spill, FPE was 47%. At B1, FPE was 87% overall, 100% during 37% spill, and 86% during 2% spill. At B2, FPE was 46% overall, 49% during 37% spill, and 43% during 2% spill. Spillway efficiency was 16% overall, 30% during 37% spill, and 1% during 2% spill. Spillway effectiveness was 0.70 overall, 0.86 during 37% spill, and 0.53 during 2% spill.

The proportion of discharge allocated at B1, B2, and the spillway affected which dam area fish entered and passed, as well as the time spent in the forebay before passing. All passage metrics except FGE at B2 were lower in 2001 than 2000, largely due to low river flows in 2001. All passage metrics were higher during periods of 37% spill than during periods of 2% spill. The results indicate that, during a low flow year, the current intake screen guidance systems at B1 and B2 do not divert sufficient numbers of yearling Chinook salmon to meet the project FPE goal of 80%. BS006

Evans, S. D., C. D. Smith, N. S. Adams, and D. W. Rondorf. 2001d. Passage behavior of radio-tagged subyearling Chinook salmon at Bonneville Dam, 2001. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

This was the summer 2001 radio-telemetry study at Bonneville Dam. It involved 647 subyearling Chinook salmon smolts that were tagged and released at Hood River (about 20 miles upstream from

Bonneville dam) from July 1 through July 19 of 2001. This was a very low-water year and the mean Bonneville Dam discharge during the study was only 81 kcfs, most (94%) of which went through B2, while only 3.4% at passed B1 and 2.4% was spilled. Fish passage very roughly correlated with discharge. Of the 90% (582) of the tagged fish for which passage rates were determined, 92% passed at B2, 6% passed at B1, and only 2% passed the spillway. Median travel time from Hood River to the dam was just over one day (26.8 h).

Median forebay residence time was shortest at B2 (0.7 h) compared to 2.4 h at B1 and 1.5 h at the spillway. Of the 49 fish that passed B1, 34 (70%) went through the sluiceway, six (13%) were guided by screens, five (10%) passed through turbines, and three (7%) went through the Bradford Island fishway. Since B2's sluice was not operated in 2001, all fish that passed at B2 entered the turbine intakes; 65% were unguided and 35% were guided. At all dam areas, a higher proportion of fish passed during night compared to day.

Project FPE was 40% overall, 89% at B1 and 35% at B2. FGE was higher at B1 (57%) than B2 (35%). However, the sample size was small at B1 (n = 7 fish). Spillway efficiency was 2%. Spillway effectiveness was 0.8.

The proportion of discharge allocated at B1, B2, and the spillway affected which dam area fish entered and passed, as well as the time spent in the forebay before passing. All passage metrics except FGE (at B1 and B2) were lower in 2001 than in 2000, largely due to low river flows in 2001. Although low discharge lowered passage metrics in general, at B1, it was likely responsible for fewer fish becoming entrained in turbine flow, thereby increasing the number of fish available to the surface-oriented sluiceway. Our results indicate that, during a low flow year, the current intake screen guidance systems at B1 and B2 do not divert sufficient numbers of yearling Chinook salmon to meet the project FPE goal of 80%. BS005

Evans, S. D., L. S. Wright, C. D. Smith, R. E. Wardell, N. S. Adams, and D. W. Rondorf. 2003a. Passage behavior of radio-tagged yearling Chinook salmon and steelhead at Bonneville Dam, 2002. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 2002, the USGS used radio telemetry to examine the movements and behavior of yearling Chinook salmon *Oncorhynchus tshawytscha* and steelhead *Oncorhynchus mykiss*, in the forebay of Bonneville Dam. The objectives of this research were to 1) determine the behavior, distribution, and approach patterns of fish in the forebay areas of Bonneville Dam; 2) determine the timing and route of dam passage of fish; 3) estimate fish passage efficiency for the entire Bonneville Dam complex, fish guidance efficiency for powerhouses I and II, and spillway efficiency and effectiveness; and 4) provide data to estimate survival of radio-tagged fish released above Bonneville Dam.

As in previous years, the proportion of discharge allocated at B1, B2, and the spillway affected which dam area fish entered and passed, as well as the time fish spent in the forebay before passing. Overall, greater than half of both species passed through the spillway and of the three spill treatments, TDG Day spill was the most efficient, passing 63% of Chinook salmon and 70% of steelhead relative to all other passage routes. Passage metrics for yearling Chinook salmon were higher in 2002 than in 2001. All passage metrics, except FPEB1 and FGEB2 (and therefore FPEB2), were very similar to passage metrics in 2000. Spillway efficiency and FPE were lower in 2001, largely because of low river flows. Very little water was available for spill in 2001 and that resulted in minimal spill and very low spill efficiency and, therefore, low FPE. Fish passage efficiency at B1 in 2001 was 18-22% greater than in 2002 and 2000, respectively. Fish passage efficiency at B1 was higher in 2001 because a large proportion of smolts entered the sluiceway. The authors believe the cause of high sluiceway passage in 2001 was due to very low turbine operation at B1, which entrained less fish and made them available to the surface-oriented sluiceway. No steelhead were tagged in 2001 so no comparisons could be drawn for this species and year. However, a comparison of passage metrics for steelhead between 2002 and 2000 shows that, unlike for Chinook salmon, most efficiencies were greater in 2002. In general, this may be attributable to the natural tendency of steelhead to migrate shallower in the water column than Chinook salmon, enabling steelhead to utilize shallower, non-turbine passage routes to a greater extent than Chinook salmon. Our results indicate that, although the current intake screen guidance systems at B1 and B2 have relatively poor guidance efficiency, the project FPE goal of 80% can be attained if sufficient numbers of fish are passed via a combination of non-turbine routes (spill, sluice, and turbine guidance systems). BS037

Evans, S. D., L. S. Wright, R. E. Wardell, N. S. Adams, and D. W. Rondorf. 2003b. Passage behavior of radio-tagged subyearling Chinook salmon at Bonneville Dam, 2002: Revised for Corrected Spill. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

The objectives to this 2002 study were to: 1) determine the behavior, distribution, and approach patterns of fish in the forebay areas of Bonneville Dam, 2) determine the timing and route of dam passage, 3) estimate fish passage efficiency for the entire Bonneville Dam, fish guidance efficiency for powerhouses I and II, and spillway efficiency and effectiveness, and 4) provide data to estimate survival of radio-tagged fish released above Bonneville Dam. Median travel rates to the dam were 2.1 km/h and 2.5 km/h for fish released from Rock Creek and from both John Day and The Dalles dams, respectively. Travel times from the release site to the dam were 64.4 h (Rock Creek), 45.6 h (John Day), and 29.1 h (The Dalles). Of 3,357 fish released, 78% were detected at Bonneville. Most fish passed the spillway followed by B2 and B1. Of the fish passing B1, the majority passed into the sluiceway, followed by turbine passage, screen guidance, and the navigation lock. Slightly more than half the fish passing B2 were unguided into the turbine units, with the remainder guided by screens. Overall, a higher proportion of fish passed the project during the day than at night. Fish passage efficiency was 82% overall, 72% at B1, and 47% at B2. Fish guidance efficiency was higher at B2 than at B1. Spillway efficiency and effectiveness were 58% and 1.2, respectively. Sluiceway efficiency at B1 was 48% and sluiceway effectiveness was 27.9. BS137

Evans, S. D., L. S. Wright, C. D. Smith, R. E. Wardell, N. S. Adams, and D. W. Rondorf. 2006a. Passage behavior of radio-tagged yearling Chinook salmon and steelhead at Bonneville Dam, 2002: Revised for Corrected Spill. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 2002, the authors used radio telemetry to examine the movements and behavior of yearling Chinook salmon *Oncorhynchus tshawytscha* and steelhead *Oncorhynchus mykiss,* in the forebay of Bonneville Dam. The objectives of this research were to: 1) determine the behavior, distribution, and approach patterns of fish in the forebay areas of Bonneville Dam, 2) determine the timing and route of dam passage of fish, 3) estimate fish passage efficiency for the entire Bonneville Dam complex, fish guidance efficiency for powerhouses I and II, and spillway efficiency and effectiveness, and 4) provide data to estimate survival of radio tagged fish released above Bonneville Dam. BS177

Evans, S. D., L. S. Wright, R. E. Wardell, N. S. Adams, and D. W. Rondorf. 2006b. Passage behavior of radio-tagged subyearling Chinook salmon at Bonneville Dam, 2002: Revised for Corrected Spill. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 2002, the authors used radio telemetry to examine the movements and behavior of subyearling Chinook salmon, *Oncorhynchus tshawytscha,* in the forebay of Bonneville Dam. The objectives of this research were to: 1) determine the behavior, distribution, and approach patterns of fish in the forebay areas of Bonneville Dam, 2) determine the timing and route of dam passage of fish, 3) estimate fish passage efficiency for the entire Bonneville Dam complex, fish guidance efficiency for powerhouses I and II, and spillway efficiency and effectiveness, and 4) provide data to estimate survival of radio tagged fish released above Bonneville Dam. This report covers the study of subyearling Chinook salmon during the summer of 2002. Study activities on yearling Chinook salmon and steelhead conducted in spring 2002 were reported by Evans et al. (2002). BS178

Evans, S. D., L. S. Wright, R. E. Reagan, N. S. Adams, and D. W. Rondorf. 2006c. Passage behavior of radio-tagged subyearling Chinook salmon at Bonneville Dam, 2004: Revised for Corrected Spill. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

The behavior, passage efficiency, and survival of subyearling Chinook salmon were investigated in 2004 at Bonneville Dam using radio telemetry. Over 11,000 tagged fish were release for the investigation and 75% of those fish were detected at Bonneville Dam. Median travel times were 55.9 hours and 38.5 hours from the release sites at John Day Dam and The Dalles Dam, respectively. Bonneville Powerhouse 2 (B2) passed 60% of the fish detected while the spillway passed 35% of fish detected and Powerhouse 1 (B1) passed 5% of fish detected. Fish passage efficiency was 68% for the project. Passage efficiency was also calculated for each passage route available to fish. Surface passage routes were more efficient at than other areas of the dam when spill discharge was higher. Passage metrics were generally lower in 2004 than 2002, but the 68% passage efficiency for the project was achievable because of the effectiveness of the B2 corner collector (5.9) which passed 14 times less water than the spillway with an effectiveness of 0.9. BS180

Faber, D.M., M.A. Weiland, R.A. Moursund, and T.J. Carlson. 2001. Evaluation of the Fish Passage Effectiveness of the Bonneville I Prototype Surface Collector using Three-Dimensional Ultrasonic Fish Tracking, PNNL-13526 Prepared for U.S. Army Corps of Engineer District, Portland, Oregon by Pacific Northwest National Laboratory, Richland, Washington.

This report describes tests conducted at Bonneville Dam on the Columbia River in the spring of 2000. The studies used three-dimensional (3D) acoustic telemetry and computational fluid dynamics (CFD) hydraulic modeling techniques to evaluate the response of outmigrating juvenile steelhead (*Oncorhynchus mykiss*) and yearling Chinook salmon (*O. tshawytscha*) to the Prototype Surface Collector (PSC) installed at Powerhouse I of Bonneville Dam in 1998 to test the concept of using a deep-slot surface bypass collector to divert downstream migrating salmon from turbines. The study was conducted by Pacific Northwest National Laboratory (PNNL), the Waterways Experiment Station of the U.S. Army Corp of Engineers (COE), Asci Corporation, and the U.S. Geological Survey (USGS), and was sponsored by COE's Portland District. The goal of the study was to observe the three-dimensional behavior of tagged fish (fish bearing ultrasonic micro-transmitters) within 100 meters (m) of the surface flow bypass structure to test hypotheses about the response of migrants to flow stimuli generated by the presence of the surface flow bypass prototype and its operation. Research was done in parallel with radio telemetry studies conducted by USGS and hydroacoustic studies conducted by WES & Asci to evaluate the prototype surface collector. BS141

Ferguson, J. 1993. Relative Survival of Juvenile Chinook Salmon through Bonneville Dam on the Columbia River. Pages 58-65 in Proceedings of the Workshop on Fish Passage at Hydroelectric Developments, March 26-28, 1991, St. John's, Newfoundland. Canadian Technical Report of Fisheries and Aquatic Sciences, No. 1905, Department of Fisheries and Oceans, St. John's Newfoundland.

Juvenile Chinook salmon that passed through the Bonneville second powerhouse juvenile bypass system, during the summer, had significantly lower survival rates than upper and lower turbine, spillway, and downstream control groups. Predation by northern squawfish (*Ptychocheilus oregonensis*) was suspected to have been the cause of high mortalities among bypassed fish. No significant difference existed between survival rates of upper and lower turbine groups. Estimates of long-term survival using adult returns are incomplete at this time. (This is the original abstract). BS087 PDF reproduced with permission of the NRC Research Press. http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_desc_e?cjfas

Ferguson, J. W., G. M. Matthews, R. L. McComas, R. F. Absolon, D. A. Brege, M. H. Gessel, and L. G. Gilbreath. 2005. Passage of Adult and Juvenile Salmon Through Federal Columbia River Power System Dams. NOAA Technical Memorandum, Fish Ecology Division, Northwest Fisheries Science Center, Seattle, WA, USA.

This technical memorandum focuses primarily on passage data associated with the dams as they have been configured recently, and not on effects on salmon that might accrue from major changes such as dam removal. The effects of the FCRPS on evolutionarily significant units of salmon listed under the Endangered Species Act and potential benefits to these populations from actions undertaken in the hydropower system are being addressed elsewhere, such as through deliberations of the Technical Recovery Teams, which establish biologically based recovery goals, and Biological Opinions. The authors present a synthesis of the most recent and current information and summary conclusions on the following topics: 1) juvenile salmonid passage through spillways, 2) juvenile passage through mechanical screen bypass systems, 3) juvenile passage through turbines, 4) juvenile passage through sluiceways and surface bypass systems, 5) juvenile diel passage and timing past dams, and 6) adult salmonid passage past dams and through the eight-dam reach. BS183 PDF reproduced with permission of the NRC Research Press. http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_desc_e?cjfas

Fisheries Engineering Research Program. 1957. Effect of Structures at Main Columbia River and Certain Other Dams on Downstream Migration of Fingerling Salmon. U.S. Army Engineer Division, North Pacific.

This work was initiated to determine under prototype conditions the rate of survival or mortality of fingerling salmon passing through the turbines, spillways, and stilling basins of main-stem Columbia River dams. Some of the work was conducted at dams in other watersheds to test methods and techniques and to compare results. The primary objective was to obtain information needed in the design and operation of different features at dams. The following are some of the conclusions offered: 1) there was little or no significant mortality in passing pressure accommodated and non-pressurized fingerling salmon through the Bonneville and McNary turbines; 2) spillway mortality data from Bonneville and McNary are not conclusive; 3) more controlled testing is necessary to learn the effect of the gossamer bags on survival of fish under prototype conditions; 4) spillway split gate experiments at McNary gave indication of little or no significant mortality; 5) air and mechanical agitation tests conducted under laboratory conditions caused mortality to fingerling salmon in gossamer bags but did not injure free-swimming fingerlings; 6) no significant mortality resulted during the performance of laboratory tests wherein large numbers of fingerling salmon were caused to pass through a venturi where pressure ranged as low as 0.5 pounds psi;

and 7) impact at 45.6 fps velocity in an 8-inch jet of water against a solid steel plate set both at 45-degree and 90-degree angles caused no significant mortality to fingerling salmon. BS107

Gauley, J. E., R. E. Anas, and L. C. Schlotterbeck. 1958. Downstream Movement of Salmonids at Bonneville Dam. Special Scientific Report #236, U. S. Fish and Wildlife Service, Washington, DC.

This study assessed movement of outmigrant salmonids based on trap catches in fishways at Bonneville Dam. Results indicated most outmigrants were caught during hours of darkness during the years 1946, 1949, 1950, and 1953. In 1952, the majority were day migrants. Hourly fishing in 1952 and 1953 indicated that maximum movement of Chinook salmon and steelhead trout tends to occur at dawn and dusk. The authors conclude that the percentage of Chinook salmon that migrate at night appears to be more highly correlated with turbidity than with days elapsed from start of sampling. BS122

Gessel, M. H., R. F. Krcma, W. D. Muir, C. S. McCutcheon, L. G. Gilbreath, and B. H. Monk. 1985. Evaluation of the juvenile collection and bypass systems at Bonneville Dam - 1984. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

Initial studies to evaluate the efficiency of the fingerling collection and bypass system at the Bonneville Dam Second Powerhouse began in 1983. These studies showed a very low fish guiding efficiency (FGE) of less than 30% for the submersible traveling screens (STS) (Krcma et al. 1984). Vertical distribution tests, conducted during the same period, indicated two problem areas in developing acceptable (>70%) FGE. First, a large percentage of the smolts were passing through the intakes at a depth below the STS. Second, significant avoidance or rejection of guidance was occurring because FGE was approximately half of the potential indicated by vertical distribution studies. An extensive model study program was initiated to investigate ways of improving the distribution of fish entering the turbine intakes and reducing or eliminating the avoidance/rejection problem, thereby improving the guiding capabilities of the STS. A series of methods for improving FGE was developed.

During the 1984 smolt migration, the National Marine Fisheries Service (NMFS) under contract to the U.S. Army Corps of Engineers (COE) evaluated various methods that were intended to improve the fingerling collection and bypass efficiency at the Bonneville Dam Second Powerhouse. Studies were also conducted to evaluate the operation of the newly completed fingerling bypass and indexing facility at the First Powerhouse and to identify problem areas and make recommendations if necessary for improved operation.

The 1984 research had the following primary objectives: (1) Evaluate the various modifications/additions developed during model studies to improve FGE at the Second Powerhouse. (2) Continue monitoring the downstream migrant system (DSM) and smolt indexing facilities at the Second Powerhouse. (3) Evaluate the operation of the smolt indexing system facilities at the First Powerhouse. (4) Determine fish quality and stress through the juvenile bypass and indexing system at the First Powerhouse. (5) Measure orifice passage efficiency (OPE) of the fingerling bypass orifices at both powerhouses. BS032

Gessel, M. H., L. G. Gilbreath, W. D. Muir, and R. F. Krcma. 1986a. Evaluation of the juvenile collection and bypass systems at Bonneville Dam - 1985. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

The National Marine Fisheries Service (NMFS) under contract to the U.S. Army Corps of Engineers (COE) began studies in 1983 to evaluate the fingerling collection and bypass system at the Bonneville Dam Second Powerhouse. These studies have concentrated primarily on improving the fish guiding efficiency (FGE) of the submersible traveling screens (STS). Studies in 1983 showed very low FGEs of less than 30% for the STS (Krcma et al. 1984). Vertical distribution tests conducted during the same period indicated two problem areas: (1) a large percentage of the juvenile salmonids were passing through the turbine intake below the STS and (2) avoidance and/or deflection was also occurring because FGE was approximately half of the theoretical potential FGE (based on vertical distribution tests). An extensive model study was initiated to determine potential methods of increasing FGE.

Studies during the 1984 field season implemented several of the recommended modifications/additions to the STS and trashracks (Gessel et al. 1985). FGE, however, remained at an unacceptable level, plus fish condition deteriorated as indicated by increased descaling and mortality. Vertical distribution tests reinforced the indication of an avoidance/deflection problem since potential FGEs greater than 70% were indicated, but FGEs of only 30%-50% were attained. Several possible reasons were suspected for the avoidance/deflection problem: (1) a flow restriction causing a "zone of resistance" that fish detect and avoid, (2) increasing velocity below the STS that attracts smolts, (3) a flow deflection that diverts a percentage of the intercepted fish below the STS, and (4) a combination of all three.

During the 1985 smolt migration, NMFS evaluated various methods intended to improve the fingerling collection and bypass system efficiency at the Bonneville Dam Second Powerhouse. Studies were also conducted to evaluate the fingerling bypass and sampling facilities at the First Powerhouse. Research for 1985 had the following primary objectives: (1) Evaluate modifications to improve FGE at the Second Powerhouse. (2) Continue monitoring the Second Powerhouse downstream migrant system (DSM) sampling facilities. (3) Evaluate the First Powerhouse juvenile bypass and sampling system. (4) Determine fish quality and stress through the First Powerhouse juvenile bypass and indexing system. (5) Continue orifice passage efficiency (OPE) studies at the First Powerhouse. (6) Determine diel passage of juvenile migrants at the First Powerhouse. (7) Continue temporal smolt passage studies at Bonneville Dam. This report provides pertinent findings of the research conducted in 1985. BS031

Gessel, M. H., L. G. Gilbreath, W. D. Muir, and R. F. Krcma. 1986b. Continuing studies to improve and evaluate the fingerling collection and bypass system at Bonneville Dam. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

The objectives of this work were to 1) continue FGE and vertical distribution test to evaluate a variety of modifications or additions to improve the effectiveness of the submerged traveling screens, and 2) operate the first and second powerhouse collection facilities to obtain data related to FGE research and to continue to evaluate the collection and indexing site at the first powerhouse. BS131

Gessel, M. H., L. G. Gilbreath, W. D. Muir, B. H. Monk, and R. F. Krcma. 1987. Evaluation of the juvenile salmonid collection and bypass systems at Bonneville Dam - 1986. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

This NMFS netting report is the immediate predecessor to Gessel et al. 1988 and reports on some of the work contributing to Gessel et al. 1991 involving modifications to improve FGE at B2. It also discusses an evaluation of both powerhouse downstream migrant (DSM) systems.

Turbine Intake Modifications - Prior to 1985 FGE at selected test B2 intakes, assayed by netting, had been incrementally raised from about 25% to about 40%. This effort used netting to evaluate FGE and vertical distribution with and without

a. lowering the STS 27 in.
b. raising the hydraulic "operating gate"
c. streamlining the top three trash racks on the top half of the intake
d. a "false" gap
e. internal deflectors
f. intake ceiling extensions (later called "turbine intake extensions" or "TIES").

FGE tests were conducted in intakes 12A and 12B and vertical distribution tests were conducted in Intake 13A for the spring (yearling) migration and in Intake 13B for the summer (subyearling) migration. Test unit loading was generally about 18 kcfs in spring and 17 kcfs in summer, but powerhouse loading was variable.

The authors concluded the following:

1. FGE of almost 70% was attained on the experimental intake in spring (yearling fish) with the intake modifications and TIES.
2. Streamlined trash racks improved guidance.
3. Modifications, including trash racks and TIES, did not raise sub-adult FGE over that of the previous year.
4. Descaling at B2 was worse than in the previous year.

Other matters, including the B2 dry separator and sampling methods, were discussed. BS029

Gessel, M. H., B. H. Monk, and J. G. Williams. 1988. Evaluation of the juvenile fish collection and bypass systems at Bonneville Dam - 1987. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

This report evaluates improvements to the Bonneville Dam B2 submerged traveling screens (STSs) and their intakes, the downstream migrant (DSM) collection and handling facilities, and the temporal distribution of smolt passage as well as assaying fish condition ("quality"). Some of the work reported (the part about turbine intake modifications) here is also discussed in the North American Journal of Fisheries Management paper Gessel et al 1991.

Turbine Intake Modifications - The 1987 season involved testing variations on the best passage configuration from the previous year. There were three main lines of investigation. The first compared FGE with lowered STSs, streamlined trash racks, and intake ceiling extensions on six adjacent intakes (11C-13B) to FGEs with lowered STSs and streamlined trash racks on those same intakes but with the intake ceiling extensions removed from every other intake. Two powerhouse operational regimes were tested; four units running vs. six or seven units running. The second line of investigation on Intake 12B tested the efficacy of an array of 40 250-W mercury vapor lights, deployed on the ceiling intake, ceiling extension, and trash rack to attract fish to shallower depth for better screen guidance. The third intake alteration tested was a small external (upstream side) deflector on the trash rack. Removal of the top three trash racks was also tested with an "internal deflector" closing the gap left by the top trash rack and the STS. That test was done because the distance from the trash rack to the screen at B2 is less than half the 6-m distance at B1 and other projects.

These investigations produced the following results:

1) At full operations (six or seven units), spring Chinook salmon FGE of greater than 70% was attained at Intake 12A (no ceiling extension) and 60% was attained at Intake 12B (with ceiling extension). In summer, Chinook salmon FGE averaged only 16% and none of the modifications seemed to improve that.
2) Mercury vapor lights showed some promise for raising FGE.
3) The small external deflector did not raise FGE.
4) Removing the top three trash racks did not raise FGE.

Smolt Collection Systems - This part of the report addresses the B1 and B2 Downstream Migrant (DSM) facilities, which were operated to determine fish "quality" (condition) relative to the FGE studies as well as to generally evaluate the systems. The systems were found to be operable "as is" but recommendations were made to improve the ease and quality of fish and water handling, especially in full operations, with fluctuating pool levels, and debris loading. Descaling and mortality were found to be very low except for yearling Chinook salmon and especially for sockeye salmon.

Utility of DSM Systems to Sample the Run at Large - In general the authors conclude that sampling of the two DSM systems as is currently conducted is inadequate to estimate the multi-species run at large. Even with more extensive sampling, the facts that different species and runs guide at different rates and that both turbine and spillway passage would remain unsampled means that the DSM system will not be satisfactory indices of the run at large. BS028

Gessel, M. H., B. H. Monk, D. A. Brege, and J. G. Williams. 1989. Fish guidance efficiency studies at Bonneville Dam First and Second Powerhouse - 1988. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

At Bonneville Dam First Powerhouse, fish guidance efficiency (FGE) testing with submersible traveling screens (STS) was initially conducted during the early and late portions of the 1981 spring outmigration. Guidance in excess of 70% was observed for all species (Krcma et al. 1982). These results were considered adequate; however, since these tests, further FGE studies at other projects have indicated that FGEs varied considerably from year to year as well as within each field season. Additionally, average FGE measurements on summer migrating subyearling Chinook salmon have been less than 50% at McNary Dam (Brege et al. 1988) and John Day Dam (Krcma et al. 1986). Thus, measurements of subyearling Chinook salmon FGE during the summer migration were made to provide baseline information prior to completion of the new navigational lock at Bonneville First Powerhouse.

Evaluation of the juvenile bypass and collection system at Bonneville Dam Second Powerhouse began in 1983. The initial FGE estimate of traveling screens was less than 30% for yearling Chinook lowered STS increased FGE to > 40%. In 1986, the addition of turbine intake extensions (TIE) improved FGE to over 70% for some tests. In 1987, results from guidance tests indicated that underwater mercury vapor lights could alter the movement of juvenile migrants into and within a turbine intake. Studies in 1988 continued light tests, and initial tests were conducted on the feasibility of using bar screens instead of STSs to improve FGEs.

During the 1988 juvenile salmonid outmigration, the National Marine Fisheries Service (NMFS) in conjunction with the U.S. Army Corps of Engineers (COE) conducted studies at both Bonneville powerhouses with the following objectives: (1) Continue the FGE and vertical distribution testing program Bonneville Second Powerhouse to evaluate the following modifications/additions for improving FGE and STS effectiveness: (a) Turbine intake extensions (b) Higher porosity guiding device (bar screen) (c) Internal trashrack deflector (d) Illuminated trashracks and intake ceiling. (2) Conduct standard

FGE and vertical distribution measurements at Bonneville First Powerhouse to provide data comparable to 1981 research and baseline data for late summer subyearling Chinook salmon migrants.

In addition to these investigations, a complementary physiological study was conducted to determine if relationships existed between the physiological status of the migrant population and the prevailing FGE estimates. Results from that study will be reported in a separate document. BS089

Gessel, M. H., D. A. Brege, B. H. Monk, and J. G. Williams. 1990. Continued studies to evaluate the juvenile bypass systems at Bonneville Dam, 1989. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Research at Bonneville Dam Second Powerhouse (Bonneville II) began in 1983 with the evaluation of the fingerling collection and bypass system. In these studies, fish guiding efficiency (FGE) was between 20% and 25% for yearling Chinook salmon, far less than the 70% or greater at Bonneville Dam First Powerhouse (Bonneville I), and much below the 70% guidance standard considered by the Columbia Basin Fish and Wildlife Authority as the minimum level needed for adequate fish passage. Research in 1985 indicated that streamlined trashracks and lowered submersible traveling screens (STSs) could increase FGE to >40% for yearling Chinook salmon. Research in 1986 and 1987 resulted in some FGE estimates >70% when using turbine intake extensions (TIEs) combined with earlier modifications. Tests in 1988 with submerged bar screens (SBSs) resulted in increased FGE; however, descaling of juvenile salmonids during testing was unacceptable. Also in 1988, mercury vapor lights attached to the intake ceiling and STS frame increased FGE, but results were inconsistent.

Initial studies of FGE with prototype STSs at Bonneville I were conducted during the early and late portions of the 1981 juvenile salmonid spring outmigration. Guidance estimates >70% were observed for all species tested (Krcma et al. 1982). Based on these results and information obtained at similar projects, a full complement of STSs was installed at the powerhouse in 1984. Subsequent research on summer migration subyearling Chinook salmon at John Day Dam (Krcma et al. 1986; Brege et al. 1987) and McNary Dam (Brege et al. 1988) indicated guidance ranged from 25% to 45%, varying both during the season and from year to year. Because of these poor results, FGE was measured for the first time during the 1988 summer outmigration at Bonneville I to determine baseline guidance levels prior to installation of a floating guide wall for the new Bonneville Dam navigation lock. Fish guidance was <12% (Gessel et al. 1989), which was much lower than the 70% average for subyearling Chinook salmon measured during May 1981 (Krcma et al. 1982).

During the 1989 juvenile salmonid outmigration, the National Marine Fisheries Service (NMFS) conducted studies at both Bonneville Dam powerhouses with the following objectives: (1) Continue FGE and vertical distribution testing at Bonneville II to evaluate the following modifications or additions for improving FGE and STS effectiveness in conjunction with TIEs: (a) raised operating gate (b) bar screens (c) perforated plate with bar screens to reduce descaling, and(d) illuminated guiding device. (2) Continue FGE and vertical distribution testing at Bonneville I to more accurately assess FGE and STS effectiveness over the spring and summer juvenile salmonid outmigration prior to construction of the navigation lock guide wall. BS086

Gessel, M. H., J. G. Williams, D. A. Brege, R. F. Krcma, and D. R. Chambers. 1991. Juvenile salmonid guidance at the Bonneville Dam Second Powerhouse, Columbia River, 1983-1989. North American Journal of Fisheries Management. 11:400-412.

This North American Journal of Fisheries Management paper begins with a short history of the development of turbine intake screening systems in the Columbia-Snake River System, which began at

Ice Harbor Dam in 1970, but concentrates on NMFS netting and gatewell dipping studies at B2 from 1983 to 1989. Initial expectations of fish guidance efficiency (FGE, the proportion of fish that passed a turbine intake or unit that passes above a screen) of over 70% for all species were not realized. Rather, FGEs of less than 25% were recorded for subyearling Chinook salmon and coho salmon and about 33% for steelhead were estimated.

Modeling and empirical studies, some of which are described, led in 1984 to modification of trash racks (changing the pitch on shallower ones and blocking deeper ones), effectively extending the screen to the trash racks with wedge wire, closing gaps at the sides of the STS, and other structural modifications as well as reducing turbine loading and installing attracting lights over intakes. This increased FGE slightly (to about 30%) but also increased descaling and mortality and the louvered and blocked trash racks were removed for summer.

In 1985, one STS was incrementally lowered to increase the gap between the top of the STS and the intake ceiling, and streamlined trash racks were installed upstream of the test intake. Lowering the screen 1.2 m, along with the streamlined trash racks, produced a Chinook salmon FGE of 33% and lowering it just 0.7 m resulted in FGE of 40%. In all cases the gap net catch was below 1% although the actual gap and flow through it had been substantially increased. Mean steelhead FGE remained below 39% and subyearling Chinook salmon FGE ranged from 28% down to 20%. In 1985 modeling studies suggested that the installation of turbine intake extensions (TIEs) might reduce the eddies and provide more uniform vertical flows into the intakes. In 1985 FGEs remained lower than about 40% for both Chinook salmon and steelhead.

In 1986 TIES were found to improve guidance under restricted operations but a substantial cross current still formed under full powerhouse loading and that reduced guidance efficiencies. Summer guidance was especially low (18-24%). Modeling indicated that TIEs placed on every other (alternating) intake might further disrupt the current and improve guidance. In 1987 the two possible schemes of alternating intakes were tested and found not to differ substantially, but guidance was improved in both spring and summer and was not dependent on powerhouse operations. Tests with mercury vapor lights as attractants were promising. In 1988 experiments were conducted with a high-porosity bar screen that did not improve guidance for most of the season and substantially increased descaling. The mercury vapor lights did not improve guidance in 1988. In 1989 the bar screen porosity was reduced from 45% to 33% and this reduced descaling to the level of the STSs while contributing to higher guidance in spring (to 78% in mid May).

The authors discuss their methods and application of those methods for other water projects. They acknowledge that the sensory and behavioral mechanisms that influence guidance and passage are ill understood, that the short passage season severely limits testing and replication, and that project operations are important determinants. Results are also very species-specific and life stage-specific. They concluded that higher-porosity bar screen, although it sometimes improved guidance, was too apt to foul and injure fish. The final configurations, with lowered STS, streamlined trash racks, and TIEs on alternate intakes would result in the highest possible guidance and survival. BS025

Gessel. M. H., B. P. Sandford, B. H. Monk, and D. A. Brege. 1994. Population estimates of northern squawfish, Ptychocheilus oregonensis, at Bonneville Dam First Powerhouse, Columbia River. NOAA technical memorandum NMFS-NWFSC-18, Northwest Fisheries Science Center, Seattle, Washington.

Northern squawfish are well-known predators of juvenile salmonids in the Pacific Northwest rivers and may substantially deplete the number of subyearling Chinook salmon passing Bonneville Dam. To assess predation impacts and evaluate management decisions, population estimates of northern squawfish are needed. Angling was used to derive a population estimate of northern squawfish in the Bonneville

Dam first powerhouse forebay pool during summer 1989. A crew of three to six fished from the forebay deck of the powerhouse with light sport-tackle and artificial lures. Between 5 and 19 July, a total of 2,464 adult northern squawfish were captured and 2,399 tagged. Tagged fish were recovered as early as the day after tagging; a total of 35 were recovered. The catch per unit effort for the marking period averaged approximately 19 northern squawfish per hour. Nine additional tagged fish were recovered from 226 squawfish captured on 4 August. Three different statistical methods were applied to the catch data to provide population estimates of northern squawfish ranging from 54,480 to 61, 828. (This is the original abstract). BS118

Gilbreath, L. G., E. M. Dawley, R. D. Ledgerwood, P. J. Bently, and S. J. Grabowski. 1993. Relative Survival of Subyearling Chinook Salmon that have Passed Bonneville Dam Via the Spillway or Second Powerhouse Turbines or Bypass System: Adult Recoveries through 1991. Prepared for U.S. Army Corps of Engineers by the National Oceanic Atmospheric Administration National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division, Seattle, Washington.

Objectives were 1) compare relative survival among marked treatment groups of subyearling Chinook salmon released simultaneously through a turbine and the bypass system at Bonneville Dam powerhouse 2 and 2) from coded-wire tag recovery data for immature and adult Chinook salmon, estimate long-term relative survival of treatment groups.

Juvenile fall Chinook salmon with distinguishable marks were released simultaneously through a turbine and the bypass system at Bonneville Dam second powerhouse during the summers of 1987-1990 and recovered with seines near the upper boundary of the Columbia River estuary at Jones Beach to estimate short-term comparative passage survival relative to passage routes through the dam. Additional releases were made into the tailrace. Recovery of bypass released fish was significantly lower than recovery of fish released into the turbine at powerhouse 2 over the four years of the study and recovery of both turbine- and bypass-released fish was lower than fish released into the tailrace.

Data from the adult portion of this study was incomplete at the time of this report since a majority of the tagged juveniles were not returning to spawn as adults yet. The data set for 1987 was nearly complete and suggested no significant difference in survival between turbine- and bypass-released fish. BS081

Giorgi, A. E. and J. R. Stevenson. 1995. A Review of Biological Investigations Describing Smolt Passage Behavior at Portland District Corps of Engineer Projects: Implications in Surface Collection Systems. Prepared by Don Chapman Consultants, Inc., Boise, Idaho, for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

The objective was to provide a review of the available information on smolt passage studies at Bonneville, The Dalles, and John Day dams and to discuss the relevance of research findings to the design of surface collector and bypass devices.

This report summarizes the available information on smolt passage studies at Bonneville, The Dalles, and John Day dams for research efforts using radio telemetry, hydroacoustics, netting, and smolt monitoring. Studies of diel passage patterns, vertical distribution, horizontal distribution, forebay approach patterns, and specific passage strategies are reviewed and summarized. Recommendations were made using the available data for design and placement of surface collector and bypass devices. BS075

Hanks, M. E. and G. R. Ploskey. 2000. Experimental hydroacoustic deployments to improve estimates of fish guidance efficiency. Technical Report ERDC/EL TR-00-8 prepared by the USACE Engineer Research and Development Center, Vicksburg, MS for the USACE Portland District, Portland, Oregon.

This study tested transducer locations and orientations in order to improve the hydroacoustic detectability of fish and to identify important sampling considerations to increase the accuracy, reliability, and comparability of hydroacoustic estimates of fish passage and FGE. The work involved two split-beam and six single-beam transducers in several configurations in Intake 8B of BI to assess the effects of transducer location and orientation on FGE estimates.

Through the sampling season the single beam transducers were deployed in four different ways while the two split-beam transducer deployments remained constant for comparison with the other four.

Split-beam Deployment Standard for Comparison, One Up Looker for Guided, One Down Looker for Unguided - One split beam transducer, mounted near the bottom of Trash Rack 5 and aimed 53 degrees above the horizontal, sampled guided (above the STS screen) passage. The other, mounted near the top of Trash Rack 1 and aimed 77 degrees below the horizontal, sampled unguided (below the STS tip) passage. Both were set about a half meter from the Oregon (south) side of the screen and were aimed about 11 degrees towards Washington (north) of vertical so that the beams sampled a large proportion of the intake's width, albeit at different elevations. The transducers were slow multiplexed at 2-sec intervals with a ping rate of 15 pings per second for 5 out of every 20 min.

The single-beam transducers were deployed in four different sampling configurations throughout the sampling season and the passage and FGE estimates of each were compared with the unchanged split-beam deployment. Intake 8B was divided into thirds and each was sampled with a pair of single-beam transducers arrayed in different ways. The deployments were:

Detectability modeling for all deployment resulted in effective beam angles very similar to the nominal values. The "Discussion and Recommendations" section includes rationales for different deployments and sampling (ping rate vs. volume reverberation, target time in-beam, beam diameter and range, fish aspect, etc.). There is considerable discussion of the sampling requirements needed to capture the lateral variability of passage within an intake. Transducer rotators and beam steering are discussed as possible strategies for getting intake-wide variability in a relatively short time, such as within a passage season. BS020

Hansel, H. C., R. S. Shively, J. E. Hensleigh, B. D. Liedtke, R. E. Wardell, R. H. Wertheimer, and T. P. Poe. 1999. Movement, distribution, and behavior of radio-tagged juvenile chinook salmon and steelhead in the forebay of Bonneville Dam, 1998. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 1994 the U.S. Army Corps of Engineers (COE) initiated a program to develop and evaluate surface-oriented juvenile salmonid bypass systems at hydroelectric dams on the Columbia and Snake rivers. The goal of the program was to develop juvenile bypass systems that would significantly improve the passage efficiency and survival of juvenile salmonids as they migrate downstream.

From 1995 to 1997 the COE has contracted the Biological Resources Division (BRD) of the U.S. Geological Survey to evaluate the efficiency of prototype surface collector and bypass systems by examining the behavior of juvenile steelhead and yearling and subyearling Chinook salmon using radio telemetry in the forebays of John Day Dam (JDA), The Dalles Dam (TDA), and Bonneville Dam (BON).

In 1998, BRD again used radio telemetry to examine the movements and behavior of radio-tagged juvenile steelhead and yearling and subyearling Chinook salmon in the forebay of BON. The objectives of this research were to determine 1) the general behavior, distribution, and approach patterns of juvenile salmonids in the near-dam forebay areas of BON; 2) the time and route of dam passage; and 3) the behavior of fish associated with tests of surface bypass concepts and prototype surface bypass structures. BS038

Hawkes, L. A., R. C. Johnsen, W. W. Smith, R. D. Martinson, W. A. Hevlin, and R. F. Absolon. 1991. Monitoring of downstream salmon and steelhead at federal hydroelectric facilities. Annual Report 1990 by the U.S. Department Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, ETSD, to the U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon.

This old NMFS smolt monitoring study involved sampling smolts passing three dams, John Day, The Dalles, and Bonneville in 1990. Smolts were collected by three different methods (a "funnel airlift pump system" at John Day Dam, gatewell dipping at The Dalles Dam until July 4 when a system similar to that at John Day Dam was installed, and smolt traps in the bypasses of both Bonneville Dam powerhouses.

Sampled animals were anaesthetized and examined for species and condition with subsamples measured for length. The John Day passage season involved several shutdowns of the sampled unit (Unit 5) including an 11-day period (May 29 – June 9) when the parts of the powerhouse were shut down due to a fire. The fire at John Day Dam also affected juvenile passage at the other two dams because of pool maintenance and because two smolt transport barges had to discharge cargo in the upper John Day Dam pool. For these reasons and others (the differences in sampling schedules, locations, and methods from dam to dam and from year to year, operational effects, etc.), comparisons with data from other years is problematic.

Injury and descaling data are presented, along with river discharge, spillway discharge, and unit discharge where appropriate. Sockeye salmon were found to be especially fragile to descaling and handling stress. BS023

Hensleigh, J. E., R. S. Shively, H. C. Hansel, J. M. Hardiman, G. S. Holmberg, B. D. Liedtke, T. L. Martinelli, R. E. Wardell, R. H. Wertheimer, and T. P. Poe. 1999. Movement, distribution and behavior of radio-tagged juvenile chinook salmon and steelhead in John Day, The Dalles and Bonneville Dam forebays, 1997. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 1994 the U.S. Army Corps of Engineers (COE) initiated a program to develop and evaluate surface-oriented juvenile salmonid bypass systems at hydroelectric dams on the Columbia and Snake rivers. The goal of the program was to develop juvenile bypass systems that would significantly improve the passage efficiency and survival of juvenile salmonids as they migrate downstream.

n 1995 and 1996 the COE contracted the Biological Resources Division (BRD) of the U.S. Geological Survey (formerly National Biological Service) to evaluate the efficiency of prototype surface collector and bypass systems by examining the behavior of yearling and subyearling Chinook salmon using radio telemetry in the forebays of John Day Dam (JDA), The Dalles Dam (TDA), and Bonneville Dam (BON).

In 1997, BRD again used radio telemetry to examine the movements and behavior of radio-tagged yearling Chinook salmon, subyearling Chinook salmon, and juvenile steelhead in the forebays of JDA, TDA, and BON. The objectives of this research were to determine: (1) the general behavior, distribution, and approach patterns of juvenile salmonids upriver and in the forebay areas of JDA, TDA, and BON; (2) the behavior of fish once inside the near-dam forebay area; (3) the time and route of dam passage; and (4) the changes in behavior of fish associated with tests of surface bypass concepts and prototype surface bypass structures. BS035

Holmberg, G. S., R. S. Shively, H. C. Hansel, T. L. Martinelli, M. B. Sheer, J. M. Hardiman, B. D. Liedtke, L. S. Blythe, and T. P. Poe. 1996. Movement, distribution, and behavior of radio-tagged juvenile chinook salmon in John Day, The Dalles, and Bonneville Dam forebays, 1996. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 1994 the U.S. Army Corps of Engineers (Portland District) initiated a program to develop and evaluate surface-oriented juvenile salmonid bypass systems at lower Columbia River hydroelectric dams with the goal of significantly improving the passage efficiency and survival of juvenile salmonids. The following studies were conducted as part of the biological evaluation of surface bypass concepts and prototypes.

In 1995 the National Biological Service (now the USGS, Biological Resources Division) and the Oregon Cooperative Fishery Research Unit examined the movements and behavior of radio-tagged juvenile yearling and subyearling Chinook salmon in the forebays of John Day and The Dalles dams. Information collected on fish behavior included approach to the dams, residence time and fish location in the forebay, and time and route of passage.

In 1996, the Geological Resources Division continued similar research efforts at John Day and The Dalles dams and initiated research efforts at Bonneville Dam. The main objectives of the study were to describe (1) the general behavior, distribution, and approach patterns of juvenile salmonids upriver and into the forebay areas of the dams; (2) the behavior of fish once inside the near-dam forebay areas in relation to dam operating conditions; and (3) the time and route of dam passage. BS036

Holmberg, G. S., R. E. Wardell, M. G. Mesa, N. S. Adams, and D. W. Rondorf. 2001a. Evaluation of the Bonneville Dam Second Powerhouse new juvenile bypass system, 1999. Annual Report by U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

This study evaluates the 2.7 km conveyance pipe and outfall that take screened smolts from B2 past known foraging habitat for northern pikeminnow. The main objectives of the study were to determine

1. the physiological effects on smolts of traveling through the conveyance pipe,
2. the effects of passage through the conveyance pipe on tailrace egress, and
3. the influence of tailrace water velocities on fish movements.

Physiological effects were assayed by comparing blood cortisol and lactate levels from PIT-tagged hatchery Chinook salmon (162 sub-yearling and 168 yearling) and 336 steelhead smolts as well as run-of-river smolts sampled before and after passage through the system. Plasma cortisol and lactate concentrations increased between entrance to the conveyance pipe and after passage, especially in the hatchery fish, which also had tagging stress. When fish were allowed to recover in tanks, lactate levels increased then returned to pre-passage levels within 6 h. Cortisol showed more protracted increases followed by a decrease, but did not return to pre-entrance levels. There were no differences in cortisol and lactate concentrations between night and day. Some PIT-tagged steelhead delayed in the pipe, possibly due to factors including hatchery steelhead not being disposed to migrate and initial operations of the facility. As water temperatures increased and operations of the facility were adjusted, delay decreased.

Radio-tagged smolts were released upriver from the dam and directly into the JBS. Fish movements were monitored from the forebay through the JBS to the outfall area, and to an exit site 8 km downriver of the dam. The influence of tailrace hydraulic conditions was evaluated by comparing the movements of radio-tagged fish to a passive drift buoy, or drogue, equipped with a global positioning system (GPS), and by measuring water velocities using an acoustic Doppler current profiler.

Travel time and movement data were obtained for 454 yearling Chinook, 361 steelhead, and 100 sub-yearling Chinook salmon released from upriver studies and 134 yearling Chinook salmon, 135 steelhead, and 148 sub-yearling Chinook salmon placed into the upstream end of the bypass. Overall, fish moved quickly through the conveyance pipe with no evidence of direct mortality. Travel time between the forebay and the outfall area was longer than travel time through non-JBS passage routes. This was a result of the longer distance of the pipe compared to the spillway and BI tailrace areas. Yearling Chinook salmon took 79 min and steelhead took 74 min to travel between the forebay and the outfall area through the JBS. The majority of this time was spent in the conveyance pipe. Yearling Chinook salmon and steelhead that passed the dam through the spillway and BI took between 24 and 30 min to travel from the forebay to the outfall area. Median travel time between the outfall and the downriver exit site was 36 min for yearling Chinook, 33 min for steelhead, and 34 min for sub-yearling Chinook. Travel time through the tailrace was similar for fish that passed through the JBS and non-JBS routes. Less than 5% of the fish monitored took more than 90 min to travel between the outfall area and the exit site. BS016

Holmberg, G. S., R. E. Wardell, M. G. Mesa, N. S. Adams, and D. W. Rondorf. 2001b. Evaluation of the Bonneville Dam Second Powerhouse juvenile bypass system, 2000. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 1999 the new B2 juvenile bypass and 2.7 km conveyance pipe were completed. This study evaluated the effects of travel through the modified bypass system in 2000. The main objectives of the study were to determine: 1) the physiological effects of passing down the pipe on smolts, 2) the effects of passage through the conveyance pipe on tailrace egress behavior, and 3) the influence of tailrace water velocities on fish movements.

The physiological evaluation assayed blood plasma cortisol and lactate concentrations in down migrating smolts before entering and after passage through the conveyance pipe. Based on these assays the stress response from passage through the conveyance pipe was minimal.

Radio telemetry was used to evaluate dam passage and tailrace egress. Median travel time from the forebay to the outfall area through the JBS was longer than median travel time through non-JBS routes. Delay of Chinook salmon may have been caused by fish holding in the collection channel upstream of the conveyance pipe. For steelhead, the majority of this time was spent in the conveyance pipe. Yearling Chinook salmon and steelhead that passed the dam through the spillway and BI had a median travel time of approximately 30 minutes between the forebay and the outfall. Overall, fish moved quickly through the conveyance pipe. There was no evidence of direct mortality caused by the pipe.

Median travel time and behavior through the tailrace area below the outfall was similar for upriver fish that passed through JBS and through other routes. No significant differences were detected in median travel times to the downriver exit stations for either yearling or sub-yearling Chinook salmon released into the JBS compared to stressed and unstressed fish released near the outfall. However, stressed steelhead took longer to reach the downriver exit stations compared to steelhead released into the JBS and unstressed steelhead released near the outfall. Less than 4% of the fish the authors released into the JBS and obtained travel times for took more than 90 min to travel between the outfall area and the first exit station 8 km downriver. Mobile tracking contacted 28 (18%) of the fish the authors released into the upstream end of the conveyance pipe. Of these, none were believed to be consumed by predators. One delayed before moving downriver, and none used the side channel behind Ives Island. The authors also contacted 86 fish that were released upriver. Of these, 2% were believed to be consumed by predators, 7% delayed before moving downriver, and 3% used the side channel behind Ives Island. Of the yearling Chinook salmon that were detected by fixed site antennas behind Ives Island, 14% had passed through the JBS, and 15% of the steelhead detected there had passed through the JBS. BS008

Holmes, H. B. 1952. Loss of fingerlings in passing Bonneville Dam as determined by marking experiments. U.S. Fish and Wildlife Service, Portland, Oregon.

This work involved a series of marking experiments designed to assess the magnitude of loss of fingerlings passing Bonneville Dam. A total of 1.5 million fingerlings were marked and 4,197 adult marked fish were recovered. The major findings of the study were as follows: 1) individual experiments should be looked upon as independent measures of differing conditions as to loss in passing the dam; 2) losses of fingerlings in a hose used for liberating the fingerlings may have added bias to the results; 3) by assigning varying weights to the individual observations, average losses of 11% to 15% were obtained; and 4) results indicated a somewhat greater loss of fingerlings as a result of passage through the turbines as compared with passage through the spillway. BS103

Jensen, A. L. 1987. Bonneville Dam Second Powerhouse Fish Guidance Research: Velocity Mapping Studies. Prepared for the U.S. Army Corps of Engineers, by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Coastal Zone and Estuarine Studies Division, Northwest and Alaska Fisheries Center, Seattle, Washington.

Studies to evaluate the efficiency of the fingerling collection and bypass system at the Bonneville Dam 2nd Powerhouse indicated that hydraulic conditions in and around the turbine intakes might be a factor in the low fish guiding efficiencies (FGE) measured (Krcma et al. 1984; Gessel et al. 1985, 1986). The study reported here was undertaken to obtain measurements of the velocities occurring near the trashracks and within the intakes of Turbines 12 and 15 at the Bonneville 2nd Powerhouse. Earlier studies showed good FGE at the Bonneville 1st Powerhouse and the McNary Powerhouse, so similar measurements were made at these sites for comparison. BS092

Johnsen, R. C. and E. M. Dawley. 1974. The effect of spillway flow deflectors at Bonneville Dam on total gas supersaturation and survival of juvenile salmon. Final Report by the National Marine Fisheries Service for the U. S. Army Engineer District, Portland, Oregon.

In the late 1960's supersaturation of dissolved gases caused by spillway discharges was noted in the waters of the Lower Columbia River. Prototype flow deflectors were installed at Bonneville Dam in 1971 and tested to determine if dissolved gas levels would be reduced. These tests indicated a substantial reduction in the amount of supersaturation produced when compared to standard spillbays. In 1974 three additional deflectors were added at Bonneville to ascertain effects of multiple flow deflectors of dissolved gas content and anadromous fish passage through and around the spill discharge.

Five flow volumes were tested at four different elevations and water samples were collected to determine amount of gas supersaturation. Gas concentrations of water passing over the spillway deflectors were 6 to 12% less than those in water passing through the control bays. At saturation levels over 120% this is a significant difference. However, when 431,453 juvenile fall Chinook salmon were released in three treatments (control, modified spillway, standard spillway), no significant differences in survival were found. Therefore, the spillway deflectors are not considered to be detrimental to juvenile fall Chinook salmon passing through the spillway. BS171

Johnson, G. E., A. E. Giorgi, and M. W. Erho. 1997. Critical Assessment of Surface Flow Bypass Development in the Lower Columbia and Snake Rivers, Completion Report. Prepared for the U.S. Army Corps of Engineers, Walla Walla and Portland Districts, Portland, Oregon, by BioAnalysts, Inc., Vancouver, Washington.

The overall objectives of this study was to critically assess surface flow bypass (SFB) development in the Columbia Basin, especially as it pertains to mainstem Columbia and Snake River dams operated by the Corps of Engineers. This report describes the basic premises of SFB development in the Columbia and Snake Rivers and evaluates SFB development strategies relative to the basic SFB premises. It discusses research and evaluation efforts and lessons learned at SFB prototype development sites, assesses the direction and plans for future SFB development at Corps dams, and identifies major information deficiencies. The report ends with recommendations and conclusions on the Corps' SFB program. (This is the original abstract). BS128

Johnson, G. E. and A. E. Giorgi. 1999. Development of surface flow bypasses at Bonneville Dam: A synthesis of data from 1995 to 1998 and a draft M&E plan for 2000. Annual Report, prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by BioAnalysts, Inc. Vancouver, Washington.

This study was undertaken as part of the Portland District's surface bypass program at Bonneville Dam. It begins with a thorough history of surface bypass work in the Basin. It includes reviews of both hydrology and fish passage studies going back over 30 years at Bonneville Dam and follows the development of surface passage at both B1 (the "prototype surface collector") and B2 (the prototype corner collector). It discusses hydrology, bathymetry, project operations, juvenile migration timing and pathways, forebay delay, smolt injury and survival, tailrace passage, and predation. Tests of modifications to Bonneville Dam that are discussed include trash rack blockages at B1, the effects of turbine intake extensions (TIES) at B2, and operations of sluiceways at both powerhouses, the several steps of developing the B1 prototype, and the high-flow outfall study. Near the end there is a large table with unresolved questions about surface collection at Bonneville Dam and how they might be resolved, as well as flow charts with suggested strategies and time lines for implementation. This is a very well organized and useful analysis of the development of surface collection for Bonneville Dam prior to 2000. BS015

Johnson, G. E. and T. J. Carlson. 2001. Monitoring and Evaluation of the Prototype Surface Collector at Bonneville First Powerhouse: Synthesis of Results. PNNL-13516, Prepared for the U.S. Army Corps of Engineers by Pacific Northwest National Laboratory, Richland, Washington.

The purpose of this report was to consolidate results from surface bypass studies at Bonneville Powerhouse 1 in 2000. Specific objectives were to 1) review results from the 2000 PSC studies; 2) relate 2000 results to previous findings (1998 and 1999); and 3) make conclusions about PSC performance (its potential to collect fish) on a species-specific basis and for the run at large. Primary conclusions were 1) monitoring and evaluation of the PSC in 2000 allowed for a thorough evaluation of its performance; 2) the surface bypass concept was found to be an efficient way to collect smolts and minimize turbine passage; 3) PSC collection efficiency estimates from independent methods comported reasonably well; 4) the best available data for collection efficiency are from the 2000 evaluation; 5) collection efficiency was similar between spring and summer (did not decrease in summer but stayed largely unchanged while the run composition changed); 6) Collection efficiency for the B1 PSC was higher than that for the SBC at Lower Granite Dam and was comparable to that for the Wells Dam surface bypass; 7) extending the PSC to units 1 and 2 was worthwhile because the surface bypass entrances at units 1 and 3 passed a substantial proportion of total PSC fish passage; 8) the PSC was twice as effective as spill at passing fish at Bonneville Dam in 2000; and 9) there are uncertainties with development of a permanent surface bypass at B1, but is likely they can be satisfactorily resolved with additional research and development. BS125

Johnson, R. L. 1970. Tests of fingerling passage at Bonneville Dam. Summary. Report No. 18. U.S. Army Corps of Engineers, North Pacific Division, Fisheries-Engineering Research Program, August 1970.

The purpose of this work was to compare the effectiveness of the ice and trash sluice with the power units for passing fingerling fish downstream from the powerhouse into the downstream flow of the tailrace. Buoyant grapefruits were used as fish surrogates. Variable river discharges were tested to observe the effect of differing tailwater depth. The first test group results indicated that about two-thirds of the grapefruit went directly downstream with low tailwater conditions. A maximum of 72% of the fruit went downstream with high sluice discharge while normal and low sluice discharge passed 60% and 68%, respectively. The second group of tests with higher river discharge resulted in 19%, 22%, and 33% of downstream passage of grapefruit associated with the low, normal, and high sluice discharges, respectively. BS098

Johnson, R. L., R. A. Moursund, and M. A. Simmons. 1999. Fish Behavior in Front of the Prototype Surface Collector at Bonneville Dam in 1998. Final Report, prepared for U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by Pacific Northwest National Laboratory, Richland, Washington.

This document is the third in a series of reports that describe the results of the fixed-location hydroacoustic evaluation of the prototype surface collector (PSC) at Bonneville Dam in the spring and summer of 1998. The smolt behavior evaluation was planned and executed in conjunction with the fish passage evaluation of the first powerhouse by the U.S. Army Engineer Waterways Experiment Station (CEWES). The overall aim of the behavioral component was to evaluate the fine-scale fish behavior in front of the PSC. This was accomplished by remotely and non-intrusively sensing precise travel routes, mean swimming directions, and velocities, and reconciling observed fish movements with flow vectors to obtain the swimming effort vector. Specific objectives for this first year of PSC evaluation were to examine the potential fish behavioral differences based on slot configuration and to build a basis of understanding about the approach dynamics of smolts related to the PSC structure. The first objective focused on determining the optimal slot width, velocity, and flow for attracting smolts in the near-field zone (0 to 3 m). The second, and perhaps most crucial, objective focused on understanding fish behavior from the face of the PSC through the intermediate zone (3 to 15 m) to provide design insight for functional installation and operation of a permanent structure. BS030

Johnson, R. L., M. A. Simmons, C. S. Simmons, K. D. Hand, and J. Thomas. 2000. Evaluation of Fish Behavior in Front of the Prototype Surface Collector at Bonneville Dam, 1999. (Hydroacoustic) Final Report Prepared for the U.S. Army Corps of Engineers, Portland District, by Pacific Northwest National Laboratory, Richland, Washington.

In the spring and summer of 1999 Battelle (led by R. L. Johnson) conducted split-beam hydroacoustics and multibeam sonar studies of fish trajectories just upstream of the Unit 3 slot entrance of the B1 Prototype Surface Collector (PSC). The B1 PSC was a temporary structure with variable width entrances designed to test surface bypass concepts. It was configured to test two different entrance slot widths, 5 ft and 20 ft. The SimRad multibeam system was used to evaluate fish trajectories through a composite beam aimed from a barge tethered about 18m upstream of the face of the PSC's Unit 5 entrance slot and six PAS split-beam transducers, arranged above and below the slot in three opposed pairs, one up-looking and one down-looking. The barge-mounted multibeam system captured fish approach trajectories and the smaller (six degree) split-beam systems sampled very near-field trajectories. The multibeam system sampled 9,372 fish tracks and the split-beam system sampled 34,599 fish tracks.

The narrower (5-ft) slot configuration was associated with a notable downward movement as fish came within the 60-ft range of the multibeam system. Nearer the collector, they scattered both upward and downward. Fish approaching the wider (20-ft) configuration remained at a relatively constant depth during their approach until very near the structure where they moved downward several meters. Lateral, southerly movement was not apparent for the 5-ft configuration until fish were within about 15 feet of the opening. For the 20-ft configuration there was more movement of fish to the south approximately 25 ft from the face of the collector. BS027

Johnson, R.L. C.S. Simmons, S.L. Thornsten, M.A. Chamness, M.A. Simmons, C.A. McKinstry and K.D. Hand. 2001. Hydroacoustic Evaluation of Fish Behavior at Bonneville Dam First Powerhouse: 2000 Prototype Surface Flow Bypass. Final report prepared for U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by Battelle, Pacific Northwest Division, Richland, Washington.

The purpose of this study was to evaluate fish behavior in front of the PSC at turbine Unit 3 of the first powerhouse at Bonneville Dam. The objectives were to describe fish behavior within 18 m of the collector with respect to direction of movement and water flow, and to compare the behavior of fish in front of the opening with those along the side of the opening. Fish were sampled using multibeam and split-beam sonar systems. Major findings were 1) the percentage of milling fish was the highest within 5 m of the collector. Based on a comparison of displacement versus swimming speed, milling fish expend more energy than directed fish; 2) half the fish detected along the sides of the collector were milling; 3) more fish were present in front of the collector during the day; and 4) in spring, the fish were distributed higher in the water column than in summer. Based on these results the authors recommend that, for future fish bypass design efforts, the mechanisms that cause milling in front of an unobstructed collector opening be modeled. Improved mitigation technologies may become apparent by understanding these delay mechanisms. BS124

Jones, S. T., G. M. Starke, and R. J. Stansell. 1996. Predation by birds and effectiveness of predation control measures at Bonneville, The Dalles and John Day Dams in 1995. CENPP-CO-SRF, US Army Corps of Engineers, Cascade Locks, Oregon.

This study assessed avian predation at Bonneville, The Dalles and John Day dams in 1995. The authors estimated a minimum of 52,773 juvenile fish were taken by gulls at Bonneville Dam and 64,787 were juveniles taken by gulls at The Dalles Dam in 1995. Observations of avian predation at John Day Dam were too infrequent to estimate the total number of taken fish. At Bonneville, predation primarily occurred in the tailwaters of both powerhouses and the spillway. At The Dalles, predation was almost exclusive to the spillway tailrace. At John Day, most predation occurred at the powerhouse forebay and at the JBS outfall. Predation was heaviest in April and June at Bonneville, April through July at The Dalles, and in April and early June at John Day. At Bonneville, predation success for gulls ranged from 35% to 43% by location, for ospreys from 69 to 80% and for great blue herons 73% to 100%. Gull predation success ranged from 20% to 42% at The Dalles and 25% to 56% at John Day Dam. Predation abatement lines appeared effective at times and ineffective at other times. On many occasions birds showed no response to propane canons used at The Dalles Dam. BS108

Jones, S. T., G. M. Starke, and R. J. Stansell. 1997. Predation by gulls and effectiveness of predation control measures at Bonneville, The Dalles and John Day Dams in 1996. CENWP-CO-SRF, USACE, US Army Corps of Engineers, Cascade Locks, Oregon.

Estimates of feeding gull numbers, of juvenile fish consumed by gulls, and of gull predation control methods were examined at Bonneville, The Dalles, and John Day dams in 1996. Feeding activity occurred primarily in the spillway tailwaters at Bonneville, in the area of The Dalles Bridge at The Dalles Project, and near the JBS outfall at John Day. Gull predation success rates were 43% at Bonneville, and 52% at John Day. On the basis of average daily numbers of gulls present, the new line array at The Dalles Dam appeared to deter over 95% of gulls from feeding. The line arrays at Bonneville were not installed until gull numbers had dropped for the season, and the hydrocannon installation was not complete or functional during the 1996 evaluation. BS105

Jones, S. T., G. M. Starke, and R. J. Stansell. 1999. Predation by gulls and effectiveness of predation control measures at Bonneville, The Dalles and John Day Dams. CENWP-OP-SRF, US Army Corps of Engineers, Cascade Locks, Oregon.

This study assessed the effectiveness of avian deterrent methods and determined gull numbers, feeding locations, and seasonal distributions and estimated minimum numbers of juvenile fish consumed by gulls at Bonneville, The Dalles, and John Day dams. Stainless steel avian line arrays were observed to be 100% effective in preventing gulls from feeding within the area of their coverage. The hydrocannon installed on the John Day Dam JBS outfall was also observed to be effective at deterring gulls. Significant feeding locations were the middle and lower spillway channel at Bonneville, just upstream of The Dalles Bridge at The Dalles Project, and the JBS outfall and the area adjacent to the lower navigation lock wall at John Day dam. At all three projects, the greatest number of feeding gulls were present during the month of May. Estimated minimum numbers of juvenile fish taken by gulls were 35,966 at Bonneville and 94,176 at John Day. No estimate was calculated for The Dalles because shoreline viewing distances to feeding gulls were too great. BS106

Krcma, R. F., C. W. Long, and C. S. Thompson. 1978. Research on the development of a fingerling protection system for low head dams - 1977. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

The research goals for this work were to 1) evaluate the prototype bar screen and 2) complete studies on the design and operating criteria for submerged orifices. Primary research findings were 1) significant descaling of fingerlings occurred when fish were detained in gatewells equipped with vertical barrier screens, especially of the design for the Bonneville 2nd powerhouse; 2) to provide fish timely egress from the gatewells, an orifice system with at least a 75% FPE is needed; 3) one 12-inch-diameter lighted orifice in a darkened gatewell provides acceptable (>75%) FPE through the entire range of submergence (3 to 10 feet); fish showed no preference for either the north or the south orifice; and 4) a significant percentage of the total debris entering gatewells can be expected to pass out through 12-inch-diameter orifices. BS095

Krcma, R. F., D. DeHart, M. Gessel, C. Long, and C. W. Sims. 1982. Evaluation of submersible traveling screens, passage of juvenile salmonids through the ice-trash sluiceway, and cycling of gatewell-orifice operations at the Bonneville First Powerhouse, 1981. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

The U.S. Army Corps of Engineers (COE) is proceeding with the design and implementation of the fingerling bypass for the Bonneville First Powerhouse. The final configuration could either be a conventional submersible traveling screen (STS) system (similar to McNary and Lower Granite Dam), a bypass for fish directly from the forebay through the existing ice and trash sluiceway to the tailrace, or some combination of the above. To obtain the necessary data for determining the final configuration, the COE funded a cooperative study with the National Marine Fisheries Service (NMFS) and the Oregon Department of Fish and Wildlife (ODFW).

The study had the following primary objectives: (1) evaluate the effectiveness of the STS for guiding juvenile salmonids, (2) evaluate the feasibility of cycling the operation of the submerged orifices providing egress for juvenile salmonids from the gatewells, and (3) evaluate the use of the ice and trash sluiceway as a means of bypassing juveniles directly from the forebay to the tailrace. A secondary objective was to evaluate a balance flow vertical barrier screen (BFVBS) in a model and test a prototype screen if time permitted.

NMFS was responsible for the STS and orifice cycling studies and also monitored fish entering intake gatewells as part of the evaluation of the effectiveness of the ice and trash sluice. ODFW was responsible for the operation and evaluation of the ice and trash sluice for bypassing fingerling salmonids directly from the forebay to the tailrace. This report covers the NMFS portion of the research. A separate report covering the ODFW segment of the research was prepared by ODFW and is attached as Appendix B. BS039

Krcma, R. F., M. H. Gessel, W. D. Muir, C. S. McCutcheon, L. G. Gilbreath, and B. H. Monk. 1984. Evaluation of the juvenile collection and bypass system at Bonneville Dam - 1983. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

The fingerling collection and bypass system for the Bonneville Second Powerhouse was completed in 1982 and was in full-scale operation during the 1983 smolt migration. The National Marine Fisheries Service (NMFS), under contract to the U.S. Army Corps of Engineers (COE), conducted a research program during the 1983 smolt migration to evaluate this bypass system, attempt to identify problem areas, and make recommendations if necessary. In addition, a study was conducted to determine the potential of a screen cycling operation for submersible traveling screens (STS) at both the 1st and 2nd Powerhouses.

The primary objectives of the research at Bonneville Dam during the 1983 smolt migration were as follows: (1) Evaluate the efficiency of the STS and the gatewell orifice bypass system (2nd Powerhouse). (2) Monitor fish quality and stress through the collection and bypass systems (both powerhouses). (3) Evaluate the smolt collection system and its potential for indexing smolt migration (2nd Powerhouse). (4) Evaluate the potential of screen cycling (both powerhouses). (5) Determine the feasibility of using the downwell release site in the observation room at the 2nd Powerhouse as a release site for transported fingerlings. This report provides the final analysis of the results by objectives of the 1983 research program. BS033

Ledgerwood, R. D., E. M. Dawley, L. G. Gilbreath , P. J. Bently, B. P. Sanford, and M. H. Schiewe. 1990. Relative survival of subyearling chinook salmon which have passed Bonneville Dam via the spillway or the Second Powerhouse turbines or bypass system in 1989, with comparisons to 1987 and 1988. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Objectives were to 1) compare relative survival among marked treatment groups of subyearling Chinook salmon released simultaneously through a turbine and the bypass system at Bonneville Dam Powerhouse 2, 2) compare relative survival of subyearling Chinook salmon released into the bypass system to fish released at the bypass outfall to estimate bypass mortality, and 3) estimate long-term relative survival of treatment groups from coded-wire tag recovery data for immature and adult Chinook salmon.

Juvenile fall Chinook salmon with distinguishable marks were released simultaneously through a turbine, into the bypass system, and at the bypass outfall at Bonneville Dam second powerhouse from 30 June to 3 August and recovered with seines near the upper boundary of the Columbia River estuary at Jones Beach to estimate short-term comparative passage survival relative to passage route through the dam. There were no significant differences in relative survival of subyearling Chinook salmon released into the bypass system, the turbines, or at the bypass outfall. The authors speculate that difference in survival in previous years may have been due to predation by northern squawfish at the bypass outlet and that the increase in tailwater elevation due to increased turbine operation may have reduced predatory effectiveness at the bypass outlet.

Adult recovery data for the 1987 released fish showed a poor return rate. Of the groups released in 1987 only fish release at the Hamilton Island shoreline showed significantly different survival. Lower survival was also documented for these fish as subyearlings in 1987. The authors suspect this lower survival was due to predation in the near shore area. BS085

Ledgerwood, R. D., E. M. Dawley, L. G. Gilbreath , P. T. Bently, B. P. Sanford, and M. H. Schiewe. 1991. Relative survival of subyearling chinook salmon that have passed through the turbines and bypass system of Bonneville Dam Second Powerhouse, 1990. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

In 1990, based on 10 releases, there were no significant differences in relative survival of subyearling Chinook salmon released into the bypass system, the turbines, or at the bypass egress at Bonneville Dam Second Powerhouse. The failure of the turbine release hose severely compromised the study by reducing from 21 to 10 the number of data blocks available for analysis of turbine to bypass passage survival differences.

The following conclusions were based on 4 years of estuarine recoveries of juvenile salmonids released at Bonneville Dam. It cannot be over-emphasized that these conclusions are valid only for the species and size of fish tested (subyearling chinook salmon) and the dam passage conditions and river environment during testing. Other fish species or other sizes of chinook salmon passing through the dam at other times of the year may have substantially different survival levels. Moreover, these conclusions are preliminary pending assessment of treatment group differences among adults recovered over the next 5 years.

1) In 1990, based on 10 releases and much reduced statistical power, there were no significant differences in relative survival of subyearling chinook salmon released into the bypass system, the turbines, or at the bypass egress at Bonneville Dam Second Powerhouse.
2) The failure of the turbine release hose compromised the study by reducing from 21 to 10 the number of data blocks available for analysis of turbine to bypass passage survival differences.
3) Estuarine sampling of juveniles provided recovery data to make statistical comparisons among treatment groups that are as sensitive as comparisons from expected adult recovery data; the lack of differences in catch distributions through time among treatment groups suggests uniform sampling of all treatment groups.

4) Analyses of differences in recoveries of bypass- and egress-released fish using 21 release blocks suggest that in past years of study (1988 and 1989) the front-roll release was not a good control for the bypass system. The authors speculate that predation by northern squawfish in the locality of the bypass outlet structure may have caused the diminished survival.
5) The authors speculate that increased turbine operation (from four to eight units) may have diminished abundance and predatory effectiveness of northern squawfish near the bypass outlet. The reduced statistical power compromised this assessment.
6) Tailwater elevation may be an important factor in explaining differences in turbine versus bypass passage survival; generally, the relative survival of bypass fish increased with increased tailwater surface elevation.
7) Few descaled fish (less than 1% of the total) were captured at Jones Beach, and, except for the lower turbine groups released through a torn hose early in the study, there was no apparent relationship with the treatments tested.
8) The conditions tested did not necessarily represent environmental conditions in the tailrace after long-term operation of the Second Powerhouse, but provided observations useful for evaluating the reasons for and the seriousness of decreased survival associated with bypass passage.
9) Adult recovery data for the 1987 releases are essentially complete, but detection power was low (15.5%) due to poor return rate. Except for the lower survival of Hamilton Island (shoreline) release groups, all differences were insignificant (P = 0.05). BS083

Ledgerwood, R. D., E. M. Dawley, L. G. Gilbreath , L. T. Parker, B. P. Sanford, and S. J. Grabowski. 1994. Relative survival of subyearling Chinook salmon after passage through the bypass system at the First Powerhouse or a turbine at the First or Second Powerhouse and the tailrace basins at Bonneville Dam, 1992. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

The objective was to compare relative survival among marked groups of subyearling Chinook salmon released into the bypass system of Bonneville Dam first powerhouse, the turbines at the first and second powerhouses, and at a site in swift water about 2.5 km downstream from the dam.

Fish were marked with coded wire tags and cold branded. These fish were released in groups into the bypass channels at the first powerhouse, the turbine at the first powerhouse, the turbine at the second powerhouse, and at a mid-channel 2.5 km downstream of the dam. Tagged fish were recovered near the upper boundary of the Columbia River estuary at Jones Beach to estimate short-term survival. Results showed lower survival rates for fish released into the bypass system at the first powerhouse compared to fish released into the turbines at the first powerhouse. Fish passing through the second powerhouse turbines and tailrace had lower survival than fish passing through the first powerhouse turbines and tailrace. BS079

Long, C. W. 1976. Final report on vertical distribution of fingerling salmonids in turbine intakes of the Bonneville First Powerhouse. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

This study estimated the vertical distribution of out-migrant steelhead trout, coho, sockeye, and both spring and fall Chinook salmon in turbine intakes 3B and 5B of Bonneville first powerhouse during the spring of 1975. Fyke nets were used to capture fish in the gatewells. Results indicated that for steelhead, coho, and spring Chinook, the percentage caught in the top two nets did not differ between units 3 and 5 at full turbine load. However, significantly fewer sockeye and fall Chinook were caught in the top two nets when the load on Unit 3 was reduced to two-thirds capacity. Data indicated that all species are more highly concentrated in the upper 29% of the intake flows at Bonneville as compared to The Dalles or McNary Dam (data from The Dalles and McNary were collected in a previous study in 1960 and 1961). BS097

Long, C. W. and R. F. Krcma. 1977. Development of a system for protecting juvenile salmonids at the Second Powerhouse at Bonneville Dam - progress 1976. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

This work addressed the problem of increasing the FPE of submerged orifices by developing better orifice design and operating criteria. The premise was that if passage efficiencies of 90% or more could be achieved in spite of increased flows and turbulence within the gatewells, delay of fish within the gatewells would be reduced. The tests were conducted in gatewell 9B at Bonneville Dam first powerhouse. Initial tests showed that 8-inch orifices were inadequate and that 18-inch orifices were over-adequate. Two 12-inch orifices were found to be superior to two 10-inch orifices. Based on diel passage of smolts through the collection system, it was determined that maintenance work on the system would have the least impact on fish passage if done between 1200 and 1600 hrs. Descaling of smolts was not a serious problem as long as a high FPE was maintained. BS096

Magne, R. A. 1984. Hydroacoustic Survey of the Bonneville Second Powerhouse Forebay to Determine the Spatial Distribution of Outmigrant Juvenile Salmonids. U.S. Army Corps of Engineers, Portland District, NPPOP-RM-FFU, Fisheries Office, Bonneville Lock and Dam, Cascade Locks, Oregon.

The primary objectives of this study were to define lateral and vertical distributions of downstream migrant salmonids in three areas upstream of the second powerhouse. The secondary objectives were to assess vertical distributions of fish at individual turbine intakes and to identify behavior of smolts inside the turbine intake above the traveling screens. The major findings were as follows: 1) horizontal distribution of smolts in the near forebay at night was not evenly distributed but was more in line with expected flows into the active turbines at the north and south extremes of the dam; 2) vertical distribution of smolts passing into turbine units 11 and 12 during full and reduced loading showed the smolts to be interceptable by the screen; and 3) 85% of the fish distribution was within 10 meters of the surface, indicating that smolts following modeled flow lines would be directed below the traveling screens. BS110

Magne, R. A. 1987a. Bonneville II Hydroacoustic Monitoring Memorandum for the Record, #1, 27 May 1987.

The purpose of this work was to describe temporal and spatial distributions of fish passage through the main turbine units, fish turbine and sluiceway, and to estimate FGE for turbine passage. Limited results in this memorandum indicated individual daily estimates of FGE between NMFS netting efforts and hydroacoustic techniques were poorly correlated. Large numbers of fish passed through the sluice, and passage was observed to occur during both day and night time periods. Temporal peaks in passage were observed at the sluiceway between 0600 and 1000 hrs and between 1600 and 2000 hrs, with the fewest fish passing between 0000 and 0600 hrs. No obvious behavioral differences were noted associated with fish at intake slots with and without intake extensions. BS094

Magne, R. A. 1987b. Hydroacoustic Monitoring at the Bonneville Dam Project in 1988, Proposal plus 1987 data. U.S. Army Corps of Engineers, Portland District, Bonneville Lock and Dam, Cascade Locks, Oregon.

Operation of the second powerhouse at Bonneville Dam has been severely restricted because of the ineffectiveness of the juvenile bypass collection system. The expected guidance of at least 70% of the juvenile downstream migrants into this system has not been realized. Revenue losses have been substantial and will continue with restrictions that are in place now. Structural improvements to the turbine intakes (lowered STS, streamlined trash racks, and roof extensions) have improved fish guiding efficiency (FGE) for yearlings; however, it is unknown if similar improvements can be expected.

Proposals to operate the second powerhouse based solely on hydroacoustic estimates of passage there have not been acceptable. Instead there has been considerable interest in a distribution of passage study for the entire Bonneville project (powerhouse 1, powerhouse 2 and the spillway). Hydroacoustic monitoring, radio telemetry tracking, and mark recapture techniques are all being considered for this work. All have deficiencies regarding providing the necessary information on distribution of passage at the project.

Preliminary analysis of spring hydroacoustic monitoring data at the second powerhouse in 1987 showed that the ice and trash sluiceway at the south end of the powerhouse passed a large proportion of the downstream migrants between 0600 h and 2000 h. The Corps proposes operation of some or all of the turbines at powerhouse 2 and that an independent, mutually acceptable, technique could verify those results, then operation of the powerhouse would be warranted. Operation of the second powerhouse to determine the proportion of subyearling downstream migrants passing through the bypass facilities and main turbines would also be investigated. Objectives of the program would be as follows: (1) Determine bypass effectiveness (the proportion of downstream migrants that pass through the bypass system and sluiceway out of total second powerhouse passage) during both the spring and summer outmigrations. (2) Determine the accuracy of hydroacoustic estimates of passage into main turbine unit intakes and the sluiceway. (3) Determine the extent of residualism in the forebay and tailrace area after shut down of the powerhouse in the evening. (4) Determine ways to effectively make hydroacoustic estimates at the first powerhouse main turbine unit intakes, sluiceway intakes and spillway. (5) Determine the percent mortality of downstream migrants caused by passage through the ice and trash sluiceway at the second powerhouse. BS043

Magne, R. A. 1987c. Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at Bonneville Dam, 1987. U.S. Army Corp of Engineers, Portland District, Operations Division, Fisheries Field Unit, Bonneville Lock and Dam, Cascade Locks, Oregon.

The sluiceway at Bonneville Dam second powerhouse was evaluated for effectiveness in passing juvenile salmonids under various powerhouse loading conditions. Also evaluated were transducers located inside a turbine intake, and the difference in fish abundance or behavior in slots between turbine intake extensions and slots with turbine intake extensions.

Fish passage at the sluiceway averaged 81% of the total passing the 2nd powerhouse during the hours of 0600 and 2000. Between 2000 and 2100 h fish passage averaged about 30% through the sluiceway with two, three, four, or five turbine units operating. In general the more turbines operating, the fewer fish passed the sluiceway. Tight groups of fish were observed passing the sluiceway, which could result in underestimated counts. The technique of hydroacoustic monitoring at the 2nd powerhouse sluiceway should be evaluated for accuracy.

The sonar estimate of FGE using transducers oriented inside the turbine intake at Unit 12 was 36% while the NMFS estimate was 45%. Daily comparisons showed poor correlation, possibly due to small sample sizes. Seasonal estimates were more favorable. Transducers installed inside turbine intakes seemed to perform well.

No obvious difference was noted in fish behavior or counts between slots with a turbine intake extension and slots without a turbine intake extension. (This is the original abstract). BS109

Magne, R. A., D. J. Rawding, and W. T. Nagy. 1986. Hydroacoustic Monitoring at the Bonneville Dam Second Powerhouse during 1986 Fish Guiding Efficiency Tests. Fishery Field Unit, U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

The Portland District Fisheries Field Unit conducted a second year of hydroacoustic studies at the Bonneville Dam Second Powerhouse in 1986. This study took place in conjunction with efforts by the National Marine Fisheries Service (NMFS) to evaluate the effect of modifications to turbine intakes to improve fish guiding efficiency (FGE) at that site. The work was initiated by the Corps to improve the unacceptably low FGE of submersible traveling screens (STSs) documented by the NMFS after the powerhouse came on line in 1982 (Krcma et al. 1984; Gessel et al. 1985; Gessel et al. 1986a, b). Sonar monitoring of juvenile salmonids (*Oncorhynchus app., Salmo gairdneri*) passing into turbines at the second powerhouse was intended to provide insight into the effect of the roof extensions on the distribution of fish just upstream of the trash racks. Differences in the depth distributions of passage at turbines with and without the extensions and differences in these distributions between 1985 and 1986 were expected to provide clues to the reasons for the results obtained and to furnish guidance for further development of structural modifications to improve survival of salmonids passing the project.

Improved FGE was obtained for yearling Chinook salmon (*Oncorhynchus tshawytscha*) with various modifications tested by the NMFS during this year's outmigration; the roof extensions did not provide any improvement in FGE over 1985 (no roof extensions) for subyearlings according to a preliminary report by Gessel et al. (1986b).

This report addresses the hydroacoustic findings on fish behavior at the second powerhouse observed during the 1986 spring and summer outmigrations of juvenile salmonids and refers back to 1985 results to identify differences in vertical distributions between the two years. The objectives of the study at the second powerhouse during the FGE test were to (1) Determine the vertical distribution of juvenile salmonids entering each monitored turbine intake and the relationship these distributions have with FGE test results. (2) Determine the horizontal distribution of juvenile salmonids entering monitored turbine intakes across the powerhouse. (3) Determine estimates of passage into the ice and trash sluiceway. BS042

Magne, R. A., R. J. Stansell, and W. T. Nagy. 1989. A Summary of Hydroacoustic Monitoring at the Bonneville Dam Second Powerhouse in 1988. Fishery Field Unit, U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

Efforts to improve guidance of migrating, juvenile salmonids into the bypass systems at the Bonneville Dam Second Powerhouse continued in 1988. The Corps has been directly involved in the hydroacoustic assessment of fish behavior and in estimating the numbers of fish passing into the turbine intakes and ice and trash sluiceway. In the course of the monitoring in 1987, it became evident, both visually and hydroacoustically, that large numbers of juveniles were passing into the sluiceway. For this reason, a determination of the proportion of passage into the sluiceway compared to passage into the turbine intakes became an object of particular interest. Objectives for the 1988 work were as follows: (1) Determine the relationship between acoustic estimates of passage into a turbine and estimates of passage into that turbine based on fish guidance efficiency (FGE) tests conducted concurrently by the National Marine Fisheries Service (NMFS). (2) Determine target strengths of juveniles inside a turbine intake and at the sluiceway using dual-beam techniques. (3) Determine if a low-light, silicon-intensified target (SIT) video camera can provide reliable estimates of juvenile passage and behavior at the second powerhouse sluiceway intake. BS044

Martinson, R. D., R. J. Graves, R. B. Mills, and J. W. Kamps. 1997. Monitoring of Downstream Salmon and Steelhead at Federal Hydroelectric Facilities - 1996. Prepared for Bonneville Power Administration, Environment, Fish and Wildlife, Portland, Oregon, by NOAA Environmental and Technical Services Division Northwest Region, Portland, Oregon.

This paper summarizes the NMFS Smolt Monitoring Project for 1996 and discusses the smolt monitoring facilities at John Day and Bonneville Dams. Data generated from monitoring the smolt passage facilities include 1) species-specific hourly and daily sample totals; 2) brands and fin clips; 3) descaling and mortality; 4) species-specific length and condition data; 5) river, powerhouse, turbine, and spill flow data; and 6) PIT tag detection and recapture conditions. A total of 70,559 fish were handled at John Day and 58,128 fish at Bonneville in 1996. BS116

McConnell, R. J. and W. D. Muir. 1982. Preliminary evaluation of the Bonneville juvenile bypass system - Second Powerhouse. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest and Alaska Fisheries Science Center, Seattle, Washington.

The objective of this study was to identify potential problems with the DSM prior to a comprehensive evaluation scheduled for the spring of 1983. Marked fish were released into gatewells and into a portion of the DSM. No statistical difference was observed in recoveries of DSM- and tailrace-released fish, indicating that fish who entered the downwell in the DSM gallery and were transported downstream from the 2nd powerhouse survived as well as those released directly into the tailrace. The 10% sampler was exceptionally accurate as it recovered 9.9% of 2,230 marked fish released into a gatewell. Subyearling fall Chinook salmon smolts were captured most frequently and had the least descaling, whereas sockeye smolts were captured less frequently but suffered a higher rate of descaling. BS104

Michimoto, R. T. and L. Korn. 1969. A Study to Determine the Value of Using the Ice-Trash Sluiceway for Passing Downstream-Migrant Salmonids at Bonneville Dam. Final report Prepared for the U. S. Army Corps of Engineers, North Pacific Division, Fisheries-Engineering Research Program, Portland, Oregon, by the Fish Commission of Oregon, Research Division, Portland, Oregon.

The purpose of this work was to determine the value of using the sluiceway at Bonneville Dam to pass out-migrant fish. The specific objectives of the project were to 1) estimate the number of downstream migrants entering the sluiceway at Bonneville Dam during part-time use; 2) of the fish migrating through the powerhouse side of the forebay at Bonneville Dam determine the proportion entering the sluiceway; and 3) determine if fish survive best when passing through the sluiceway or turbines at Bonneville Dam. The authors estimated that 41,992 steelhead, 101,750 coho and 75,555 Chinook salmon passed the sluiceway during the six weekends of sampling. Small proportions of the first two release groups and 15% of the third release group entered the sluiceway. Sluiceway mortality testing results were inconclusive. BS099

Michimoto, R. T. 1971. Bonneville and The Dalles Dams Ice-Trash Sluiceway Studies, 1971. Report #20, Prepared for the U. S. Army Corps of Engineers, North Pacific Division, Fisheries-Engineering Research Program, Portland, Oregon, by the Fish Commission of Oregon, Research Division, Portland, Oregon.

In the spring of 1969, the Fish Commission of Oregon, with funds supplied by the U.S. Army Corps of Engineers, studied the feasibility of using the ice-trash sluiceway at Bonneville Dam to pass downstream-migrant salmonids. The study was an attempt to pass migrants via the sluiceway rather than through the turbines where, as established in previous studies, significant mortalities occur (Schoeneman, Pressey, and Junge, 1961). The authors found that fish entered the sluiceway mainly during the day and that they suffered negligible mortality.

At the conclusion of the study, the authors recommended full-time operation of the Bonneville ice-trash sluiceway during the spring of each year to pass downstream migrants. The authors also recommended that the Fisheries-Engineering Technical Advisory Committee consider the value of operating sluiceways at other main-stem dams for passing juvenile fish.

The U.S. Army Corps of Engineers agreed to operate the ice-trash sluiceways at Bonneville and The Dalles dams for fish passage beginning in the spring of 1971 and financed a study by the Fish Commission of Oregon to evaluate the operation of the sluiceways. At Bonneville Dam the authors compared the entry of fish into the sluiceway using overflow and submerged-orifice entrances, and determined if submerged mercury-vapor lights increased collection of fish at night. At The Dalles Dam the authors determined if there were operational problems associated with using the sluiceway to pass downstream migrants. BS091

Monk, B. H., G. E. Varney, and S. J. Grabowski. 1992. Continuing studies to evaluate and improve submersible traveling screens for fish guidance at Bonneville Dam First Powerhouse, 1991. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Objectives were to 1) determine if FGE is similar in various turbine intakes across the face of the powerhouse and 2) evaluate the effects of a raised operating gate on FGE.

Fish guidance efficiency was calculated from gatewell dip-net catches (guided fish estimate) and gap and fyke nets attached to the STS (unguided fish estimate). There was not a significant difference in FGE in paired tests between units 3 and 8. Unit 5 had significantly lower FGE than unit 8 during paired tests. The authors suggest that this difference may be due to the small sample size. FGE was significantly increased by raising the operating gate.

BS082

Monk, B. H., J. A. Ross, B. P. Sanford, and D. B. Dey. 1993. Continuing studies to measure and improve fish guidance efficiency of submersible traveling screens at Bonneville Dam First Powerhouse, 1992. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Objectives were to compare fish guidance efficiency 1) using a standard elevation submerged traveling screen with a stored operating gate, 2) using a standard elevation submerged traveling screen with a raised operating gate, and 3) using a lowered submerged traveling screen with a raised operating gate.

Fish guidance efficiency was calculated from gatewell dip-net catches (guided fish estimate) and gap and fyke nets attached to the STS (unguided fish estimate). Results showed that lowering the STS did not improve FGE. Raising the operating gate did not significantly improve FGE for yearling Chinook salmon. However, FGE was significantly increased for subyearling Chinook salmon, coho salmon, and steelhead.

BS080

Monk, B. H., B. P. Sandford, and D. B. Dey. 1994. Evaluation of the fish guidance efficiency of submersible traveling screens and other modifications at Bonneville Dam Second Powerhouse, 1993. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Bonneville Dam Second Powerhouse was completed in 1982 and National Marine Fisheries Service (NMFS) researchers began evaluating fish guidance efficiency (FGE) at this facility in 1983. Initial measurements of FGE with standard-length submersible traveling screens (STSs) were less than 24% for yearling Chinook (*Oncorhynchus tshawytsca*) and coho salmon (*O. kisutch*), and approximately 33% for steelhead (*O. mykiss*). These results were lower than the expected design level of greater than 70% for all species (Krcma et al. 1984). As a result, the NMFS study objective changed from evaluating FGE to determining means to improve FGE.

Research at Bonneville Dam Second Powerhouse from 1983 to 1989 indicated that modifications to increase flows above the STS and smooth flows into and within the turbine intake could substantially increase juvenile salmonid guidance during the spring outmigration (Gessel et al. 1991). At that time, lowering the STS by 0.8 m using streamlined trashracks, and installing alternating TIEs appeared to be the best way to accomplish this. Therefore, even though most FGE testing was done at the south end of the powerhouse (Unit 12), the authors recommended lowering all STSs at Bonneville Dam Second Powerhouse 0.8 m, and installing streamlined trashracks and alternating TIEs across the entire width of the powerhouse. Tests in 1987 showed that, with these modifications in place, FGE in Unit 12 was higher with seven turbine units in operation than with four turbine units in operation (Gessel et al. 1988). However, tests were not conducted in other units across the powerhouse.

Our research objective during the 1993 spring and summer outmigrations was to evaluate the effects of these modifications (alternating TIEs, lowered STSs, and streamlined trashracks) on FGE in south, middle, and north turbine units, under full and partial powerhouse operation.

BS055

Monk, B. H., B. P. Sandford, and D. B. Dey. 1995. Evaluation of the fish guidance efficiency of submersible traveling screens and other modifications at Bonneville Dam Second Powerhouse, 1994. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

The Bonneville Dam Second Powerhouse was completed in 1982 and the National Marine Fisheries Service (NMFS) began evaluating fish guidance efficiency (FGE) at this facility in 1983. Initial measurements of FGE with standard-length submersible traveling screens (STSs) were less than 25% for yearling Chinook (*Oncorhynchus tshawytsca*) and coho salmon (*O. kisutch*), and approximately 33% for steelhead (*O. mykiss*). These guidance levels were considerably lower than the expected design level of greater than 70% for all species (Krcma et al. 1984).

From 1984 to 1989, the U.S. Army Corps of Engineers and NMFS tested various design modifications to improve FGE at Bonneville Dam Second Powerhouse. The results of this research indicated that modifications to increase flows above the STS and smooth flows into and within the turbine intake could substantially increase FGE for yearling Chinook salmon during the spring outmigration (Gessel et al. 1991). This was accomplished by lowering the STSs 0.8 m (30 in) and installing streamlined trashracks and turbine intake extensions (TIEs). From 1987 to 1989, FGE tests were conducted with these modifications installed in Units 11, 12, and 13. Mean FGE in Unit 12 (for 4- to 5-day test series) ranged from 51% to 74%. Although this FGE testing was done at the south end of the powerhouse, with only partial powerhouse operation, NMFS recommended the installation of these modifications across the entire powerhouse.

In 1993, studies were conducted during the spring and summer juvenile salmonid outmigrations to evaluate FGE after the full installation of TIEs (in alternate slots), lowered STSs, and streamlined trashracks at the second powerhouse.

Because of the need to establish and confirm accurate FGE values at this dam, a short series of FGE tests were conducted during the 1994 spring outmigration to evaluate how representative or anomalous the 1993 FGE results were. These tests were also conducted in Turbine Units 12, 15, and 17, but only in the non-TIE slots (1993 tests had been conducted in adjacent TIE and non-TIE slots). Since the 1993 results did not indicate large differences between 4- and 6-unit operation, 4-unit tests were not conducted in 1994 and comparisons were made between 6- and 8-unit operation only. BS056

Monk, B. H., B. P. Sandford, and D. B. Dey. 1999a. Evaluation of extended-length submersible bar screens at Bonneville Dam First Powerhouse, 1998. Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

In 1998, NMFS conducted in-turbine netting and gatewell dipping to estimate fish guidance efficiency (FGE), 24-hour orifice passage efficiency (OPE), and levels of descaling and injury for three extended-length submersible bar screens (ESBSs) installed in Unit 8 at B1. To further improve FGE by increasing flows into the gatewell, operating gates were raised in the A and C slot of Turbine Unit 8, and the gate was removed in the B slot to accommodate a fyke-net frame for FGE testing.

Research objectives were as follows:

1) Evaluate the FGE of a prototype ESBS during spring and summer juvenile salmonid out migration.
2) Evaluate 24-hr orifice passage efficiency (OPE) of juvenile fish bypass orifices with the ESBSs during spring and summer out migration.
3) Evaluate the effects of the ESBSs and associated guidance devices (including the vertical barrier screen) on juvenile salmonids and lamprey. BS018

Monk, B. H., M. H. Gessel, and J. W. Ferguson. 1999b. An evaluation of the biological database for improving fish guidance efficiency at Bonneville Dam Second Powerhouse. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the

National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Biological and hydraulic data collected between 1983 and 1998 are reviewed and discussed. The biological data were collected using a variety of methods, including direct capture fyke netting and gatewell dipping, hydroacoustics, and radio telemetry. Hydraulic data were collected by both field measurements and model techniques. Results of the experimental period from 1983 to 1989, and the post-construction evaluation period from 1993 to 1998, are described.

BS054

Monk, B. H. and B. P. Sandford. 2001. Evaluation of extended-length submersible bar screens at Bonneville Dam First Powerhouse, 2000. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

In hopes of increasing FGE over that achieved by conventional, 20-ft long submersible traveling screens (STSs), 40-ft-long extended-length bar screens (ESBSs) were installed in Unit 8 at B1 and tested in 1998. These screens have been successful at increasing FGE at middle Columbia and Snake River dams. To further improve FGE by increasing flows into the gatewell, operating gates were also raised in the A and C slots and the gate was removed in the B slot to accommodate a fyke-net frame used for FGE testing.

In 2000, FGE netting tests with ESBSs and raised operating gates were repeated. As in 1998, orifice passage efficiency (OPE) tests with the ESBSs installed were also conducted. OPE is the percentage of guided fish that leave the gatewell via the orifice in a proscribed time (17 hours in 2000). Fish sampled from both the FGE and OPE tests were also examined for descaling and injury. For statistical comparisons, OPE and descaling-injury rates were also acquired at Unit 9, in which STSs were installed with the operating gate in the stored position. Average FGE for the spring migration in 2000 ranged from 4% to 9% lower for all species than in 1998. However, average FGE for the two years combined was 70% or greater for yearling Chinook, coho, and steelhead during the spring migration. For all three species, this indicated a potential increase in FGE of 23% to 34% with the extended screens.

In June and early July, FGE for yearling Chinook salmon averaged 47% in both 1998 and 2000. In the later part of July 1998, average FGE for yearling Chinook salmon decreased to 23% (tests were not conducted in 2000 because insufficient numbers of fish were available for meaningful analysis). Compared to tests also conducted in the later part of July 1988 and 1989 with STSs, this indicated a potential increase in FGE for yearling Chinook salmon with ESBSs of approximately 13% during the later part of the summer migration.

Combined average OPE for 1998 and 2000 was over 75% for yearling Chinook salmon and over 90% for sub-yearling Chinook salmon (in both the STS and ESBS units). In 2000, passage times for both yearling and sub-yearling Chinook salmon from the gatewell to the passive integrated transponder (PIT)-tag detector at the downstream monitoring facility was approximately 3 hours for the STS and 4 hours for the ESBS. These differences in OPE and passage time were not significant, indicating that fish passage from the gatewell to the bypass channel was not changed by the ESBS.

Instances of significantly higher descaling were measured once for yearling Chinook salmon in the ESBSs in 1998 and once in 2000 but these differences ranged from only 1.5% to 2%. For all other species in both years, there was no difference in descaling rates between the two screens. Hemorrhaged eyes and torn or bent opercula were the only other injuries found in 1998 or 2000 with either screen. In both years, the injury rate was 1% or less for all species during both spring and summer testing, with no significant differences between the two screens. BS009

Monk, B. H., R. Absolon, B. P. Sandford, and J. W. Ferguson. 2002. Evaluation of intake modifications at Bonneville Dam Second Powerhouse, 2001. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

In an effort to improve fish guidance at Bonneville Second Powerhouse, the Portland District made structural changes to smooth and increase flow up the gatewells of some turbine intakes. Those changes, made in the spring of 2001 to intakes B and C of Unit 15 were as follows:

1) Extending the vertical barrier screen (VBS) downward by removing part of the concrete beam below it,
2) Installing a turning vane below the submerged traveling screen (STS) picking beam to direct more flow upward and into the gatewell, and
3) Installing a "gap closure device" to narrow the gap between the top of the STS and the intake ceiling through which some flow, and possibly some fish, may pass back to the turbine.

In Intake 15A the concrete beam was reduced, the VBS was extended downward, and a turning vane was installed but there was no gap closure device.

Spring testing produced FGE estimates of 71% for yearling Chinook salmon and over 80% for steelhead and coho, the highest estimated values ever for B2 (15%-33% higher than equivalent estimates made in 1994). In summer the estimated FGE for yearling Chinook salmon averaged 57%, or 17% higher than previously estimated.

Concurrent OPE estimates found that 94% of yearling Chinook salmon in spring and 99% of yearling Chinook salmon in summer left the gatewell within 17 hours. For each species there were no significant differences in either OPE or passage times between Gatewells 15B and 16B (an unmodified turbine intake). Descaling rates were low (2%-3% in spring and <2% in summer) for both the modified (Intake 15B) and unmodified (Intake 16B) intakes as well as for modified Intake 15A, which had no gap closure device. The authors deem these results encouraging and recommend similar modifications for the entire powerhouse. The passage time to the Smolt Monitoring Facility for the PIT-tagged OPE test fish averaged 1.6 hours for yearling and 0.8 hour for subyearling Chinook.

Results from salmonid parr and juvenile lamprey were also tabulated. BS003

Monk, B. H., B. P. Sandford, D. A. Brege, and J. W. Ferguson. 2004. Evaluation of turbine intake modifications at the Bonneville Dam Second Powerhouse, 2002. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

In 2000, the U.S. Army Corps of Engineers conducted hydraulic model studies to evaluate flow in the second powerhouse intakes at Bonneville Dam. As a result of these evaluations, three modifications were proposed to increase upward flow toward the intake gatewells:

1. Increase the size of the vertical barrier screen (VBS) by removing a portion of the concrete beam below it.
2. Install a turning vane below the picking beam on the submersible traveling screen (STS).

3. Install a gap-closure device on the intake ceiling downstream from the top edge of the STS.

In addition, to meet new design criteria for salmonid fry established by NOAA Fisheries, screen mesh openings on the new VBS were decreased to reduce impingement of fry.

In 2001, with all three of these modifications installed in the B and C gatewells of unit 15, the authors measured fish guidance efficiency (FGE), orifice passage efficiency (OPE), and fish condition. Mean FGE was 71% for yearling Chinook salmon and over 80% for steelhead and coho, the highest values measured at the second powerhouse since testing began in the early 1980s. Improvements in FGE were similar for subyearling Chinook salmon. OPE was high for yearling Chinook salmon in the spring (94%) and for subyearling Chinook salmon in the summer (99%). All fish in the 2001 OPE tests were PIT-tagged, so passage times from release in the gatewell to the detectors at the downstream smolt-monitoring facility could be measured. Median passage time for the 10 replicate tests averaged 1.6 and 0.8 h for yearling and subyearling Chinook salmon, respectively. For each species, there was no significant difference between unit 15 and an unmodified unit for either OPE or passage time. During FGE and OPE tests, descaling and injury rates were low for all species, with no significant differences between the modified and unmodified units.

Because of these promising results, the same three intake modifications were installed in turbine unit 17 to determine if the results obtained in the middle of the powerhouse (unit 15) could also be achieved along the northern shoreline, where eddies and cross currents in the forebay were thought to reduce FGE. For all species tested during spring 2002, FGE was higher in gatewell 17B, with no turbine intake extension (TIE), than in either gatewell with a TIE (17A and 17C). Differences were significant (P=0.05) for yearling Chinook salmon among all three gatewells. Respective mean FGEs for yearling Chinook, steelhead, and coho were 66%, 54%, and 71% in gatewell 17B (with no TIE), and 47%, 49%, and 51% in gatewell 17A (with TIE). Although values were not as high as those obtained in unit 15 in 2001, they were higher than those observed in unit 17 in 1994.

Mean FGE during spring 2002 was higher than in 1994 for all yearling species and for both test gatewells. For gatewell 17B, the differences between 2002 and 1994 were 14%, 20%, and 21% for yearling Chinook salmon, coho salmon, and steelhead, respectively. For 17A the differences between 2002 and 1994 were 8%, 1%, and 17% for yearling Chinook salmon, coho salmon, and steelhead, respectively. The higher FGEs observed for all species in 2002 in the gatewell with no TIE (17B) were similar to results observed for the entire second powerhouse in 1993 and 1994. During summer testing, mean FGE for subyearling Chinook salmon was 57% in gatewell 17B (identical to that found in 2001 in gatewell unit 5B) and 47% in 17A. Summer FGE studies were not conducted in 1994.

During spring 2002, OPE was not as high for yearling Chinook salmon (87%) as it was the previous year (94%). Structural problems with the redesigned VBSs interrupted testing and thus reduced the number of replicates. During FGE and OPE tests, descaling and injury rates were low for all species, with no significant differences between the modified and unmodified unit. Release and recovery of fry-sized coho salmon in the bypass pipe and to gatewell slot 15B during the last two weeks of March indicated minimal impingement or injury. BS142

Muir, W. D., A. E. Giorgi, W. S. Zaugg, and B. R. Beckman. 1989. An assessment of the relationship between smolt development and fish guidance efficiency at Bonneville Dam. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Research conducted by the National Marine Fisheries Service (NMFS) in cooperation with the U.S. Army Corps of Engineers (COE) has demonstrated that fish guidance efficiency (FGE) not only changes from year to year and among dams, but can also change during the course of any year's outmigration and even within a day. Data acquired at Lower Granite and Little Goose Dams from 1985 to 1987 suggest that intraseasonal changes in FGE are associated with the changing physiological status of the smolt population. NMFS researchers have presented evidence, which indicates that yearling Chinook salmon, *Oncorhynchus tshawytscha*, that are fully smolted within the population are more susceptible to guidance by traveling screens (Giorgi et al. 1988; Muir et al. 1988). The authors hypothesize that over the course of the outmigration the proportion of fully smolted fish in the population increases, which in turn explains intraseasonal increases in FGE observed at Lower Granite Dam. The purpose of this study is to determine if seasonal changes in the physiological status of the migrant population are evident at Bonneville Dam, and assess whether those changes are related to concurrent FGE estimates. BS045

Muir, W. D., S. G. Smith, J. G. Williams, E. E. Hockersmith, and J. R. Skalski. 2001. Survival estimates for migrant yearling chinook salmon and steelhead tagged with passive integrated transponders in the lower Snake and lower Columbia Rivers, 1993-1998. North American Journal of Fisheries Management. 21:269-282.

Precise, up-to-date survival estimates for salmonids that migrate through reservoirs, hydroelectric dams, and free-flowing sections of the Snake and Columbia rivers are essential to develop effective strategies for recovering depressed stocks. To provide this information, survival was estimated for yearling Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* that were tagged with passive integrated transponder (PIT) tags and released to migrate through Snake River dams and reservoirs during the study years 1993 through 1998. A multiple-recapture model for single release groups was used to estimate survival from detections of PIT-tagged fish at dams. The stretch of river over which survival was estimated varied between years, depending on the release site, the number of dams with the capability to detect and re-release PIT-tagged fish back to the river, the total number of fish marked, and the efficiency of detecting PIT-tagged fish at each dam.

Precision of survival estimates varied with the number of fish PIT-tagged and released and the amount of spill at dams with PIT-tag detectors. When spill levels were high, detection probabilities were lower, as was precision. Mortality at bypass outfall sites was not significant at any Snake River dam investigated. Estimated annual average per-project (combined reservoir and dam passage) survival ranged from 86% to 94% for yearling Chinook salmon and from 88% to 92% for steelhead. Survival estimates were higher for both species in years when spill was used specifically to pass fish through nonturbine routes. Over the same stretches of river in years with similar flow conditions from 1970 through 1975, per-project survival estimates typically averaged 57%–71% for yearling Chinook salmon and 77%–90% for steelhead. From 1993 to 1998, survival estimates for fish released from Snake River basin hatcheries to the Lower Granite Dam tailrace indicated that substantial smolt mortality occurred before fish entered the hydropower system. For each hatchery, estimated survival varied each year, and estimates from different hatcheries to Lower Granite Dam varied inversely with the distance fish traveled. (This is the original abstract). BS067 PDF reproduced with permission of www.fisheries.org.

Muir, W. D., S. G. Smith, R. W. Zabel, D. M. Marsh, and J. G. Williams. 2003. Survival estimates for the passage of spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs, 2002. Annual Report of Research for the U.S. Army Corps of Engineer District, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

Objectives were 1) estimate reach and project survival and travel time in the Snake and Columbia Rivers throughout the migration period of yearling Chinook salmon and steelhead; 2) evaluate relationships between survival estimates and migration conditions; and 3) evaluate the survival-estimation models under prevailing conditions.

This report provides reach survival and travel time estimates for PIT-tagged yearling Chinook salmon (hatchery and wild), hatchery sockeye salmon, hatchery coho salmon, and steelhead (hatchery and wild) in the Snake and Columbia Rivers in 2002. PIT-tagged smolts were detected at interrogation facilities at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams and in the PIT-tag detector trawl operated in the Columbia River estuary. Survival estimates were calculated using a statistical model for tag-recapture data from single release groups (the "Single-Release Model").

Estimated survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.949 for yearling Chinook salmon and 0.882 for steelhead. Respective average survival estimates for yearling chinook salmon and steelhead were 0.980 and 0.882 from Little Goose Dam tailrace to Lower Monumental Dam tailrace; 0.837 and 0.652 from Lower Monumental Dam tailrace to McNary Dam tailrace (including passage through Ice Harbor Dam); 0.907 and 0.844 from McNary Dam tailrace to John Day Dam tailrace; and 0.840 and 0.612 from John Day Dam tailrace to Bonneville Dam tailrace (including passage through The Dalles Dam). Combining average estimates from the Snake River smolt trap to Lower Granite Dam, from Lower Granite Dam to McNary Dam, and from McNary Dam to Bonneville Dam, estimated annual average survival through the entire hydropower system from the head of Lower Granite reservoir to the tailrace of Bonneville Dam (eight projects) was 0.551 (SE = 0.057) for Snake River yearling chinook salmon and 0.234 (SE = 0.045) for Snake River steelhead. For yearling spring chinook salmon released in the Upper Columbia River, estimated survival from point of release to McNary Dam tailrace was 0.573 (SE 0.005) for fish released from Leavenworth Hatchery, 0.533 (SE = 0.009) for fish released from Entiat Hatchery, and 0.505 (SE = 0.021) for those from Winthrop Hatchery. The results are reported primarily in tables and figures with minimal explanation of methodology. Methodology and statistical models used in the analyses were the same as in previous study years, and details are provided in previous annual reports cited in the text. BS074

Nagy, W. T. and R. A. Magne. 1986. Hydroacoustic Study of Juvenile Fish Passage at the Bonneville Second Powerhouse in 1985. U.S. Army Corps of Engineers, Portland, NPPOP-P-NR-FFU, Fisheries Office, Bonneville Lock and Dam, Cascade Locks, Oregon, 17 April 1986.

The objectives of this work were to 1) determine the vertical distribution of juvenile salmonids entering Unit 12 during testing of modified trash racks and guidance structures within the intake; 2) determine if juvenile salmonids within the intake above the STS are rejecting guidance into the gatewell; and 3) determine if there is lateral movement of juvenile salmonids near the intakes of units 11 and 12. Results indicated that generally fish further away from the trash racks were more evenly distributed than fish immediately upstream of the trash racks. Detected fish exhibited no obvious signs of rejecting guidance by the submerged traveling screen. The majority of fish detected in front of Unit 12 showed movement in a southward direction. BS093

Nagy, W. T. 1997. Final Report on the Search to Find a Non-Lethal Method for Measuring Fish Guiding Efficiency within Turbine Intakes. U.S. Army Corps of Engineers, Portland District, Fish Field Unit, Bonneville Lock and Dam, Cascade Locks, Oregon.

The objective was, through a literature review, to develop a non-lethal technique that is as non-obtrusive as possible for determining fish guiding efficiency within turbine intakes.

From the literature review, four types of remote sensing technologies were applicable: 1) light imaging including range-gated video, synchronous-scan video, separation of light, and camera and polarization techniques, 2) sound imaging, including acoustic camera, acoustic holography, and high-resolution sonar, 3) acoustic screen methods, including electronic within-pulse scanning, quasi-ideal beam, two-element split-beam sonar, and moving target indication sonar and 4) scanned laser radar. Advantages and disadvantages of each technology are provided in the report. BS078

Normandeau Associates Inc., J. R. Skalski, and Mid Columbia Consulting Inc. 1996. Potential Effects of Spillway Flow Deflectors on Fish Condition and Survival at the Bonneville Dam, Columbia River. Prepared for US Army Corps of Engineers, Portland District, by Normandeau Associates, Inc. Drumore, Pennsylvania.

This study assessed fish condition and survival of hatchery-reared Chinook salmon that passed over the Bonneville spillway with and without flow deflectors, as well as those passing through the sluiceways at both powerhouses. The authors observed that a small proportion of fish suffered injuries (1.3%), were descaled (0.5%), or lost equilibrium (0.5%) associated with spillway passage. Primary injuries were hemorrhaging, bruises, and bulging eyes, and the cause of the injuries was attributed to contacts with hard surfaces of the spill bay and tainter gate. The small size of injured fish precluded determining whether injury types were significantly different for the "with" and "without flow" deflector conditions. Injury rate was 1.1% at both sluiceways. BS126

Normandeau Associates Inc., J.R. Skalski, and Mid Columbia Consulting, Inc. 2000. Direct Survival and Condition of Juvenile Chinook Salmon Passed through an Existing and New Minimum Gap Runner Turbines at Bonneville Dam First Powerhouse, Columbia River. Prepared for US Army Corps of Engineers, Portland District, by Normandeau Associates, Inc. Drumore, Pennsylvania.

Objectives were to 1) test the hypothesis of whether the passage survival through a newly installed minimum gap runner turbine (unit 6) equals or exceeds that of the existing Kaplan turbine (unit 5); 2) determine whether peak turbine operating efficiency is correlated with turbine passage survival; 3) determine the effectiveness of gap minimization; and 4) identify injury mechanisms and in-turbine areas where fish injuries occur.

Hatchery Chinook salmon with balloon tags and radio transmitters were released into a standard Kaplan turbine and a MGR turbine through a specially designed induction system to evaluate passage survival of the two turbine types. The study design was a two-by-three-by-four factorial (two turbines x three release locations x four power levels). Induction pipes released fish at the stay vanes at three vertical release points so fish would pass near the blade tip, mid-blade, or hub region. The turbines were operated at four power levels from the lower 1% operating limit to the upper 1% operating limit. Overall results showed fish passage survival through the MGR was equal to or better than through an existing turbine.

BS077

Normandeau Associates Inc., J. R. Skalski, and Mid-Columbia Consulting Inc. 2001. Passage Survival Investigation of Juvenile Chinook Salmon through Bonneville Powerhouse II Bypass Sluice at Two Tailwater Conditions Columbia River, Washington. Final report. Prepared for US Army Corps of Engineers, Portland District, by Normandeau Associates, Inc. Drumore, Pennsylvania.

The specific objective of this study was to estimate absolute survival and condition of yearling Chinook salmon at two different outfall flows (1 and 2.5 kcfs) and two tailrace levels (high and low). This study was conducted to assess only the direct effects of juvenile fish passing at a surrogate high flow outfall sluice chute at B2. Incidence of injury, scale loss, or loss of equilibrium was low at both discharge rates during both the high and low tailwater tests. Less than 1% of recaptured treatment fish displayed any visible injuries. The authors concluded that, based on their results, the periphery region of the B2 outfall sluice chute, with estimated entry velocities of 31 to 48 ft/sec, inflicts minimal mortality and injury to entrained juvenile salmon. The field tests indicated that a high outfall with entry velocities <48 ft/sec should provide safe fish passage, provided other factors such as sufficient tailrace depth, no predator haven, and minimal outfall jet recirculation are also present. BS123

Normandeau Associates Inc., Mid Columbia Consulting Inc., and J. R. Skalski. 2003. Juvenile Salmonid Survival and Condition in Passage through Modified Spillbays at Bonneville Dam, Columbia River. Prepared for US Army Corps of Engineers, Portland District, by Normandeau Associates, Inc. Drumore, Pennsylvania.

This is a tag-recapture study in which hatchery Chinook salmon were balloon and radio tagged and passed through two Bonneville Dam spill bays. Recovered fish were assessed for injury and death and then held 48 hours for final tabulation. Spill Bay 14 had a flow deflector at the standard depth of 14 ft above mean sea level (MSL) whereas Spill Bay 14 was lower, at seven ft above MSL to reduce total dissolved gas levels induced by spillway discharge and the present study investigated the possible effects of the lowered flow deflector on injury and survival rates. Fish releases through both spill bays were done in spring at relatively high and cool tailwater conditions (18.4-25.4 MSL, 12.3-14.2 ^{o}C); in summer tailwater conditions were relatively low and warm (11.0-13.6 MSL, 19.5-20.5 ^{o}C). Two spillway discharge rates were tested, 75 kcfs and the dissolved gas cap, although Spill Bay 16 was up to 2 kcfs higher at a given setting than was that from Spill Bay 14. Control fish were released downstream of Spill Bay 17. In all there were eight experimental treatments:

Bay 14 (14 ft MSL flow deflector) 75 kcfs spillway discharge, spring (high tailwater)
Bay 16 (7 ft MSL flow deflector) 75 kcfs spillway discharge, spring (high tailwater)
Bay 14 (14 ft MSL flow deflector) Gas Cap spillway discharge, spring (high tailwater)
Bay 16 (7 ft MSL flow deflector) Gas Cap spillway discharge, spring (high tailwater)
Bay 14 (14 ft MSL flow deflector) 75 kcfs spillway discharge, summer (low tailwater)
Bay 16 (7 ft MSL flow deflector) 75 kcfs spillway discharge, summer (low tailwater)
Bay 14 (14 ft MSL flow deflector) Gas Cap spillway discharge, summer (low tailwater)
Bay 16 (7 ft MSL flow deflector) Gas Cap spillway discharge, summer (low tailwater).

Two primary response variables were reported, probability of surviving and proportion of clean ("without evident injury, scale loss, or loss of equilibrium") fish. Probabilities of survival were very similar between the two spill bays under similar discharge and tailwater conditions and the authors found the effect of the flow deflector on probability of surviving "difficult to isolate." Statistical hypothesis tests to evaluate differences between the two flow deflector configurations tests are not presented. "Clean Fish" probabilities also were similar among treatments and statistical tests are presented. The authors point out that the 95% confidence intervals computed for each treatment type overlap except for the 75 kcfs treatments in summer (low tailwater) at both spill bays where the probabilities were lower. Both probability of surviving and probability of being "clean" were always higher in the gas cap spillway discharge than at the 75 kcfs spillway discharge although again statistical tests to evaluate the significance of those differences are not presented. BS002

Northwest Fisheries Science Center. 2000. Salmonid travel time and survival related to flow in the Columbia River Basin. White Paper of the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

The purpose of this white paper is to provide a synthesis of scientific information regarding the effects of river flow through the hydropower system, as it is presently configured and operated, on anadromous salmonids. Other white papers are available that address the effects of predation and dam passage on salmonids. A fourth white paper provides a synthesis of scientific information on the effects of transporting juvenile salmonids around dams to mitigate for losses of juvenile migrants that would otherwise migrate downstream through the dams on the lower Snake and Columbia rivers.

The white papers do not address the possible effects on salmonids that might accrue from major changes to the present configuration of the hydropower system (e.g., draw down or dam removal); nor do they speculate about potential indirect effects (e.g., delayed mortality) that might occur as a result of hydropower system passage. Empirical data on these subjects are scarce. Other forums, such as the Plan for Analyzing and Testing Hypotheses (PATH) and the Cumulative Risk Initiative (CRI), are addressing these issues. Nonetheless, it is recognized that many of the impacts of dams on migrant fish, as identified in the white papers, would decrease with removal of dams. Most analyses conducted to date indicate that removal of dams would lead to higher direct survival of migrant fish. Such findings are not inconsistent with anything presented in this white paper.

Following regional review beginning in October 1999, this white paper has been modified to reflect comments and information provided by numerous reviewers and resource agencies including Idaho Water Users Association, Inc., IDACORP, Inc., Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, Idaho Department of Fish and Game, Columbia Basin Fish and Wildlife Authority, Washington Department of Fish and Wildlife, Columbia River Inter-Tribal Fish Commission Center, and Fish Passage Center. BS069 White papers like this one are available on the Northwest Fisheries Science Center home page (www.nwfsc.noaa.gov/pubs/nwfscpubs.html).

Petersen, J. H., D. M. Gadomski, and T. P. Poe. 1994. "Differential predation by northern squawfish (Ptychocheilus oregonensis) on live and dead juvenile salmonids in the Bonneville Dam tailrace (Columbia River)." Can. J. Fish. Aquat. Sci. 51:1197-1204.

Juvenile salmonids (*Oncorhynchus spp*.) that have been killed or injured during dam passage may be highly vulnerable or preferred prey of predators that aggregate below dams. Salmonid loss due to predation will be overestimated using gut content analysis if some prey were dead or moribund when consumed. To examine this issue, field experiments were conducted in the Bonneville Dam tailrace to compare rates of capture of live and dead juvenile salmonids by northern squawfish. Known numbers of coded-wire tagged live and dead Chinook salmon were released into the tailrace on six nights. Northern squawfish were collected after each release and their gut contents were examined for tags. When 50% of salmon released were dead, northern squawfish consumed 62% dead salmon. When 10% of salmon released were dead, comparable with dam passage mortality, 22% of the tags found in northern squawfish digestive tracts were from dead salmon. These results indicate that predator feeding behavior and prey condition are important considerations when estimating the impact of predation on a prey population. (This is the original abstract). BS132 PDF reproduced with permission of the NRC Research Press. http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_desc_e?cjfas

Ploskey, G. R., L. R. Lawrence, P. N. Johnson, W. T. Nagy, and M. G. Burczinski. 1998. Hydroacoustic evaluation of juvenile salmonid passage at Bonneville Dam including surface collection simulations. Technical Report EL-98-4, Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by US Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

This Technical Report describes results of studies conducted by the U.S. Army Engineer District, Portland (CENPP) and the U.S. Army Engineer Waterways Experiment Station (CEWES) to resolve critical uncertainties in the implementation of smolt-collector technologies and estimation of fish passage efficiency (FPE) for the Bonneville Project. Available biological information is inadequate to design and locate surface collector prototypes at Bonneville Dam (Giorgi and Stevenson 1995). Information on the vertical and lateral distributions of smolts in forebay areas of both powerhouses and the spillway was limited, no mobile surveys had been conducted, and no manipulative testing had been done to determine likely responses of smolts to surface openings.

The goals of this study were to (1) provide the biological information necessary to facilitate the design and placement of a surface-collector prototype and (2) make progress toward the estimation of FPE for the entire Bonneville Project. Objectives were as follows: (1) use mobile hydroacoustics to measure the vertical and horizontal distribution of salmon smolts in forebay areas of both powerhouses and to characterize the day and night variation in distributions in spring and summer; (2) estimate smolt passage into two turbines and into the center sluice gate above each turbine, as well as the FPE ratio for pared sluiceway/turbine openings under two test conditions (blocked versus unblocked trash racks and open versus closed sluice gates) in spring and summer at Powerhouse 1; (3) evaluate smolt swimming direction in the area immediately upstream of two test units at Powerhouse 1, particularly at the zone of separation between flows entering turbines and flows entering sluice gates; (4) estimate guided and unguided smolt passage into eight turbine intakes of Powerhouse 2 and identify effects of an open or closed sluice chute on the fish guidance efficiency (FGE) of adjacent turbine units. BS040

Ploskey, G. R., P. N. Johnson, and T. J. Carlson. 2000. Evaluation of a low-frequency, sound-pressure system for guiding juvenile salmon away from turbines at Bonneville Dam, Columbia River." North American Journal of Fisheries Management. 20:951-967.

This paper presents two different but related studies, the first conducted at Bonneville Dam and the second in net pens in Ballard, WA. In June of 1995 the effectiveness of a 122-m-long array of 25 low-frequency transducers for guiding juvenile salmon away from turbine units 9 and 10 at B1 was tested using fixed-aspect hydroacoustics to assay. Test sounds were dominated by 300- and 400-Hz frequencies and transmitted as 2-s crescendos with repeated amplitude ramps from 0 to about 160 dB referenced to 1 μPa at 1 m every 2 s. No significant differences in the mean number of fish passing north or south across the upstream end of the transducer array, where the angle of incidence of flow was only about 5 degrees, were found during sound-on and sound-off treatments. The power of these one-tailed t-tests ($\alpha = 0.05$) for detecting 50% differences in means was 82% for fish passing north across the array and 99% for fish passing to the south. Sampling in front of four turbine intakes using fixed-aspect hydroacoustics found no significant differences in the mean number of smolts upstream of intakes during 4-h sound-on and sound-off treatments. The statistical power of the 4-h tests was at least 98% for detecting differences in means as small as 20% at $\alpha = 0.05$ in a two-tailed analysis of variance and a one-tailed t-test.

In 1997, net-pen tests were done to corroborate and interpret the negative results from the 1995 field experiment. Captive schools of sub-yearling Chinook salmon and coho and yearling sockeye salmon were exposed to the same 300 - 400 Hz signal as was used in the Bonneville Dam study but in a net pen in Ballard (Seattle) WA. Fish were videotaped using underwater visible light cameras. No startle reactions were observed and the frequency of avoidance of the signal was less than or equal to the frequency of coincidental avoidance during control trials without sound. After exposure to the 300- and 400-Hz signal, one school of sub-yearling Chinook salmon exhibited non-directional startle responses to 150- or 180-Hz sound, indicating that those fish could respond. The authors concluded that the 300- and 400-Hz signal did not influence the behavior or distribution of juvenile salmon in either study. BS021 PDF reproduced with permission of www.fisheries.org.

Ploskey, G. R., W. T. Nagy, L. R. Lawrence, D. S. Patterson, C. R. Schilt, P. N. Johnson, and J. R. Skalski. 2001a. Hydroacoustic Evaluation of Juvenile Salmonid Passage through Experimental Routes at Bonneville Dam in 1998. ERDC/EL TR-01-2, Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by US Army Engineer Research and Development Center, Vicksburg, Mississippi.

This study dealt with surface collection both at the PSC on B1 and the sluice chute that would become the B2 corner collector. It used fixed-aspect hydroacoustics to evaluate passage and the efficiency and effectiveness of several experimental passage routes. Routes at B1 included the PSC on units 3-6 (units 4 and 6 were off line), units adjacent to the PSC with STSs, and Intake 8B with an ESBS. The widths of the 40-ft-deep PSC entrance slots were alternated between 5 and 20 ft wide to provide stratified random treatments lasting two days each at intakes 3B and 5B in spring and summer to determine if slot width altered fish-passage indices at the PSC. At B2, routes included the sluice chute, units 11-13 adjacent to the sluice, and the JBS. B2 tests consisted of 24-hr opened and closed sluice treatments on fish passage. The overall goal was to inform the implementation of surface collection for juvenile salmon passage at Bonneville Dam. BS019

Ploskey, G. R., P. N. Johnson, W. T. Nagy, C. R. Schilt, L. R. Lawrence, D. S. Patterson, and J. R. Skalski. 2001b. Hydroacoustic Evaluation of the Bonneville Dam Prototype Surface Collector in 1999. ERDC/EL TR-01-1, Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by US Army Engineer Research and Development Center, Vicksburg, Mississippi.

This study, which was conducted in spring and summer 1999, evaluated the efficiency and effectiveness of one unit of a prototype surface collector (PSC) for collected juvenile salmon at Powerhouse 1, Bonneville Dam. The 50-ft-deep slots in Intake 5b were configured to have 5- or 20-ft-wide openings that were changed according to a blocked experimental design for evaluating effects on fish passage, efficiency, and effectiveness. The PSC, located in front of units 3 through 6, extends 20 ft upstream into the forebay and 50 ft below the surface at maximum pool elevation. It was not intended to be a fish bypass structure but a test facility. As it exists, fish entering the PSC pass through the structure and into the turbine, as opposed to being deposited into a bypass channel in a full-scale collector.

The original goals for 1999 research were as follows: (1) Test hydroacoustic-sampling methods proposed for the year-2000 evaluation of the prototype surface collector (PSC) and identify any potential problems or biases. (2) Evaluate a split-beam deployment upstream of a PSC slot and determine whether it provides estimates of fish passage that can be correlated to estimates from in-turbine transducers. (3) Estimate the efficiency and effectiveness of two adjacent PSC units and determine whether 1998 results hold for adjacent units creating greater downward flow than a single operating unit. Goal number three could not be realized in 1999 since Unit 6 remained inoperable throughout the sampling seasons. Nevertheless, the authors did evaluate the performance of a single PSC unit relative to its performance in the previous year. BS048

Ploskey, G. R., C. R. Schilt, M. E. Hanks, J. R. Skalski, W. T. Nagy, P. N. Johnson, D. S. Patterson, J. Kim, and L. R. Lawrence. 2002a. Hydroacoustic Evaluation of Fish Passage through Bonneville Dam in 2000. ERDC/EL TR-02-8, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

This report summarizes the first of three consecutive years of full-project hydroacoustic passage estimation (project and powerhouse FPEs, turbine FGEs, spill efficiency and effectiveness, temporal and spatial trends) at Bonneville Dam. It differed from the subsequent two years in two important respects.

There was generation priority at B1 and a prototype surface collector (PSC) was in place over the eighteen intakes of units 1-6.

Eight of the 18 spill bays were sampled, as were one of each turbine intakes at units 7-10 (B1) and 11-18 (B2). At the B1 PSC, sampling was done by opposed pairs of split beams at the 20-ft-wide entrance slots in front of units 1, 2, 4, 5, and 6. The entrance slot in front of Unit 3 was sampled with a barge-mounted multibeam system (see BS124) and the volume just upstream of the Unit 8 trash racks was sampled by two fixed and one traversing split beam transducers (see BS 115). BS011

Ploskey, G. R., C. R. Schilt, M. E. Hanks, J. R. Skalski, W. T. Nagy, P. N. Johnson, D. S. Patterson, J. Kim, and L. R. Lawrence. 2002b. Hydroacoustic Evaluation of a Prototype Surface Collector and In-Turbine Screens at Bonneville Dam Powerhouse 1 in 2000. ERDC/EL TR-02-15, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

The year 2000 was the first of three consecutive years of full-project hydroacoustic passage estimation. It was unique among the three in that it involved the testing of a full-scale (over all 18 intakes of units 1-6) deep-slot prototype surface collector (PSC) and because B1 had generation priority. In the same year as the full-project hydroacoustic sampling effort (Ploskey et al. 2002), U.S. Geological Survey radio-telemetry studies of yearling Chinook salmon and yearling Chinook salmon and steelhead passage (Evans et al. 2001), National Marine Fisheries Service conducted in-turbine netting at Unit 8 (Simmons et al. 2001) and the Pacific Northwest National Laboratory evaluated approach behavior and fish distributions at Unit 8 using fixed and traversing split beam sonar and at the PSC entrance in front of Unit 3 using multi-beam and split beam sonar (Johnson et al. 2001). A joint effort by PNNL and USGS investigated behavior of acoustic tagged yearling Chinook salmon as they approached the project.

Based upon results from 1998 and 1999, the PSC slot configuration for 2000 had 20-ft-wide slot widths for all six PSC units. The primary effects evaluated in 2000 were weekly changes throughout spring and summer in a variety of fish passage measures, including numbers passing into and under the PSC, and efficiency, effectiveness, diel patterns, and horizontal and vertical patterns of distribution. Beyond the PSC there was interest in testing the guidance efficiency of extended-length submersible bar screens (ESBSs) at Unit 8. BS012

Ploskey, G. R., C. R. Schilt, M. E. Hanks, P. N. Johnson, J. Kim, J. S. Skalski, D. S. Patterson, W. T. Nagy, and L. R. Lawrence. 2002c. Hydroacoustic evaluation of fish-passage efficiency at Bonneville Dam in 2001. PNNL-14047, Prepared for U.S. Army Corps of Engineers by Pacific Northwest National Laboratory, Richland, Washington.

This is the second of three consecutive years of full-project fixed-aspect hydroacoustic studies at Bonneville Dam. The 2001 passage season occurred during a severe drought and with unusually high demand for electricity; therefore, spillway discharge was curtailed such that the project spilled roughly half of what had been spilled in the previous year.

Project FPE was estimated at 63% in spring and 53% in summer. In the previous year it was estimated at 79% in both seasons and the large difference was attributed to the much lower spill discharge in 2001 as well as the loss of the guidance contribution of the prototype surface collector that covered the upper portions if the 18 intakes of units 1-6 at B1 in 2000. In 2001 the FPE estimates at the two powerhouses was also low (49% in spring and 40% in summer for B1, 57% in spring and 42% in summer for B2). Project FPE was 15% and 35% higher during 50 kcfs spill periods in spring and summer, respectively, than it was during non-spill periods.

Overall (in both spill and no spill periods) spill efficiency estimates in spring (14%) and summer (20%) 2001 were significantly lower than were estimates made in 2000, undoubtedly because of reduced volume and duration of spill during the drought in 2001. For periods of spill, spill efficiency was 33% in spring and 58% in summer. Overall spill effectiveness was 0.84 in spring and 1.83 in summer. For periods of spill, spill effectiveness was 0.93 in spring and 1.6 in summer. Spill effectiveness also was about 38% lower in spring 2001 than it was the previous spring. In 2000, spill was continuous at about 75,000 cfs during the day and 120,000 cfs at night, but lack of water in 2001 limited spill to about 50,000 cfs for about 21 of 45 days in spring and 10 of 40 days in summer.

There were positive relations between the number of hours of spill per day and FPE and spill-efficiency metrics, with significantly higher fish passage through the spillway at night than during the day, even though the amount of spill was the same during each period. In a typical water year, nighttime spill discharge is often set to the gas cap whereas daytime spill is lower to reduce adult fallback. In 2001 the spill discharge was about 50 kcfs day and night and this study found much higher estimated spillway passage at night, suggesting that fish behavior as well as discharge is involved. Both spill efficiency and Project FPE increased linearly with the number of spill hours per day in spring. At spill durations of 0 to 10 h/day, average FPE was about 54% whereas at spill durations of 11 to 24 h/day average FPE was about 71%. The authors recommend that, under low-water conditions, spillway operation be at least for 11 hr/day and that nighttime spill predominate when full-time spill is impossible. BS004

Ploskey, G. R., C. R. Schilt, J. Kim, C. W. Escher, and J. R. Skalski. 2003. Hydroacoustic Evaluation of Fish Passage through Bonneville Dam in 2002. PNNL-14356, Prepared for the U.S. Army Corps of Engineers by Pacific Northwest National Laboratory, Richland, Washington.

This report summarizes the results of two different studies. The first study was the third consecutive year of Bonneville Dam full-project juvenile passage estimates based on fixed-aspect hydroacoustics. Sampling was done in the intakes of all operating turbines and spill bays, and in the two operating sluiceway entrances at B1. Estimated passage metrics included turbine guidance efficiency (FGE), FPE (79% in spring and 74% in summer), spill efficiency (52% in spring and 42% in summer), spill effectiveness (108% in spring and 96% in summer), sluiceway efficiency (6% in spring and 11% in summer), and sluiceway effectiveness (21.9% in spring and 47.9% in summer). Powerhouse FPEs were 58% in spring and 61% in summer for B1 and 53% in spring and 46% in summer for the Second Powerhouse (B2). Sluiceway efficiency and effectiveness relative just to B1 (efficiency 33% in spring and 29% in summer; effectiveness 13.5% in spring and 26.9% in summer) were also calculated. Seasonal and diel trends are reported. Comparisons of major passage metrics for the three study years (2000-2002) and recommendations for future project operations, especially powerhouse and turbine unit priorities and the effects of spill discharge on other passage metrics, were made.

The second study reported was an evaluation of the effects on fish guidance of structural modifications that had been made to the intakes of two B2 turbine units as compared to that at the other six at B2. Hydroacoustic sampling found estimated FGE at the modified intakes of units 15 and 17 to be significantly higher than those at the unmodified intakes. Besides the fixed-aspect hydroacoustic sampling in the turbine intakes, a Dual-frequency IDentification SONAR (DIDSON) unit was deployed for two days in each passage season to estimate the proportions of fish that were lost back to the turbine by passing through the gap. Gap loss was estimated to be as high as 14.7% of the total passage (guided + unguided) through unmodified intake 18A and as low as 2.7% at modified intake 17B in spring. In summer, estimated gap loss was similar (between 12% and 13%) at unmodified intake 13B and modified intake 17C. The DIDSON was also deployed from the downstream side of a trash rack on one spring night to determine its efficacy for estimating fish passage around the sides of an STS. The deployment that was tested was deemed unable to image a large enough fraction of the side gap to permit gap-passage estimation. BS001

Ploskey, G.R., M.A. Weiland, C. R. Schilt. 2004. Evaluation of Fish Losses through Screen Gaps at Modified and Unmodified Intakes of Bonneville Dam Second Powerhouse in 2003, PNNL-14539 Prepared for the U.S. Army Corps of Engineers, Portland District, Portland, Oregon, by PNNL Richland WA.

In a 2003 study by Pacific Northwest National Laboratory (PNNL) for the U.S. Army Corps of Energy, the authors sampled nine gatewell slots at Bonneville Dam Second Powerhouse (B2) with a Dual-frequency Identification Sonar (DIDSON) acoustic imaging device to estimate the gap loss of juvenile salmonids. Gap loss is the number of fish guided by screens but lost to turbine passage through the gaps between the tops of submerged traveling screens (STSs) and the intake ceilings. Six of the intakes (Units 15 and 17) had been modified to improve fish guidance efficiency (FGE, the proportion of fish passing above intake screens) while the three unmodified intakes at Unit 13 served as controls. All three units had similar configurations of turbine intake extensions (TIES). Intake modifications included removal of concrete between the gatewell and bulkhead slots to increase the area of the vertical barrier screen and installation of a turning vane and gap-closure device to direct more flow up into the gatewell slot.

This study was to determine if those modifications, which did increase FGE, had the added benefit of reducing gap loss. In the unmodified intakes of Unit 13, the authors also sampled with infrared optical cameras to evaluate the proportions of fish and non-fish objects passing through the STS gaps and found that fish composed just 28.6% of all objects in spring and 12.9% in summer. Experiments in a laboratory tank confirmed that the DIDSON detects echoes from the surfaces of waterlogged sticks, macrophytes, and other debris as well as from fish. The authors developed filters based on target size, motion, range at first appearance, and the number of frames in which a target was seen to discriminate between fish and non-fish images. Filtered data produced estimates within 6% of those obtained by multiplying unfiltered DIDSON counts by the fish fraction estimated from optical-camera data. BS140

Ploskey G. R., M. A. Weiland, C. R. Schilt, P. N. Johnson, M. E. Hanks, D. S. Patterson, J. R. Skalski, and J. Hedgepeth. 2005. Hydroacoustic Evaluation of Fish Passage through Bonneville Dam in 2004. PNNL-15249, Pacific Northwest National Laboratory, Richland, WA, for the U. S. Army Corps of Engineers, Portland District, Portland, Oregon.

The Portland District of the U.S. Army Corps of Engineers requested that the Pacific Northwest National Laboratory (PNNL) conduct fish-passage studies at Bonneville Dam in 2004. These studies support the Portland District's goal of maximizing fish-passage efficiency (FPE) and obtaining 95% survival for juvenile salmon passing Bonneville Dam. Major passage routes include 10 turbines and a sluiceway at Powerhouse 1 (B1), an 18-bay spillway, and eight turbines and a sluiceway at Powerhouse 2 (B2).

In this report, the authors present results of four studies related to juvenile salmonid passage at Bonneville Dam. The studies were conducted between April 15 and July 15, 2004, encompassing most of the spring and summer migrations. Studies included evaluations of 1) project fish passage efficiency and other major passage metrics, 2) B2 fish guidance efficiency and gap loss, 3) smolt approach and fate at the B2 Corner Collector (B2CC), and 4) B2 vertical barrier screen head differential. BS174

Ploskey, G. R., G. E. Johnson, M. A. Weiland, F. Khan, R. P. Mueller, J. A. Serkowski, C. L. Rakowski, J. B. Hedgepeth, J. R. Skalski, B. D. Ebberts, and B. A. Klatte. 2006a. Acoustic camera evaluation of juvenile salmonid approach and fate at surface flow outlets of two hydropower dams. HydroVision 2006 Conference held in Portland, Oregon. HCI Publications, Kansas City Missouri, USA.

The objective of this study was to estimate and compare fate probabilities for juvenile salmon approaching two surface flow outlets (SFOs) to identify effective design characteristics. The SFOs differed principally in forebay location, depth, discharge, and water velocity over a sharp-crested weir. Both outlets were about 20 ft wide. The 22-ft deep Bonneville Powerhouse 2 Corner Collector (B2CC) was located in the southwest corner of the forebay and passed 5,000 ft^3/s of water at normal-pool elevation. In contrast, The Dalles Dam ice and trash sluiceway outlet above Main Unit 1-3 (TDITC) was not located in a forebay corner, was only 8-ft deep, and discharged about 933 ft/s at normal-pool elevation. The linear velocity of water over the weir was about 15 ft/s at the B2CC and 5 ft/s at the TDITC. The authors used a Dual-Frequency Identification Sonar (DIDSON) to record movements of fish within about 65 ft of the B2CC and within 35 ft of the TDITC. Fish were actively tracked fish by manually adjusting pan and tilt rotator angles to keep targets in view. The probability of fish entering each SFO was estimated by a Markov chain analysis, which did not require complete fish tracks. There are two important components to designing SFOs, the location within the forebay to take advantage of forebay circulation and specific entrance characteristics such as discharge and depth which affect the size and shape of the entrainment zone and high entrance probability zone. Providing SFOs with an entrainment zone extending upstream of structure could reduce entrance rejection, decrease forebay residence time and risk of predation, and increase passage of schools of smolts. BS181 PDF reproduced with permission of HCI Publications. http://www.hcipub.com/

Ploskey, G. R., J. Kim, M. A. Weiland, J. S. Hughes, and E. S. Fischer. 2006b. Reanalysis of hydroacoustic fish-passage data from Bonneville Dam after spill-discharge corrections. Draft Report by the Pacific Northwest National Laboratory, Richland, WA, for the U. S. Army Corps of Engineers, Portland District, Portland, Oregon.

This report presents a reanalysis of four years (2000, 2001, 2002, and 2004) of fish passage estimates at Bonneville Dam after spill discharge was reevaluated for those years. Data was collected using fixed-aspect hydroacoustics. Results from the 2005 fixed-aspect hydroacoustics study at Bonneville dam are also included. Metrics include passage efficiencies for all passage routes at Bonneville Dam: spill, Powerhouse 1 (B1) turbines, Powerhouse 2 (B2) turbines, B1 sluiceway, B2 corner collector (B2CC), and non-turbine routes. Comparisons between passage routes (i.e. spill vs. sluiceway) are also reevaluated in this report. This reanalysis showed an increase in spill effectiveness that was significantly higher than previous estimates. Increased spill effectiveness still shows a trend that the B2CC and the B1 sluiceway are much more efficient at passing fish at low water discharge. Recommendations, based on the data collected and the resulting trends, are to maximize surface-collection and reduce dependency on spill as a method of fish passage. BS182

Ploskey, G. R., M. A. Weiland, S. A. Zimmerman, J. S. Hughes, K. Bouchard, E. S. Fischer, C. R. Schilt, M. E. Hanks, J. Kim, J. R. Skalski, J. Hedgepeth, and W. T. Nagy. 2006c. Hydroacoustic Evaluation of Fish Passage through Bonneville Dam in 2005. PNNL-15944, Pacific Northwest National Laboratory, Richland, WA, for the U. S. Army Corps of Engineers, Portland District, Portland, Oregon.

The Portland District of the U.S. Army Corps of Engineers requested that the Pacific Northwest National Laboratory (PNNL) conduct fish-passage studies at Bonneville Dam in 2005. In this report, the authors present results of two juvenile salmonid passage studies conducted at Bonneville Dam during the spring and summer migrations between April 16 and July 15, 2005: 1) a hydroacoustic evaluation of project fish passage efficiency and other major passage metrics, and (2) a DIDSON evaluation of smolt approach and fate at the B1 Sluiceway Outlet 3C from the B1 forebay. BS175

Plumb, J. M., M. S. Novick, B. D. Liedtke, and N. S. Adams. 2001. Passage behavior of radio-tagged yearling chinook salmon and steelhead at Bonneville Dam associated with the surface bypass program, 1999. Annual Report by the U. S. Geological Survey, Columbia River Research Laboratory, Cook, Washington for the U. S. Army Engineer District, Portland, Oregon.

In 1999, the USGS used radio telemetry to examine the movements and behavior of juvenile hatchery steelhead and yearling spring Chinook salmon in the forebay of Bonneville Dam. In 1999 the PSC covered units 3-5 but only Unit 5 was operating. The deep-slot entrance was alternated between 5 ft and 20 ft wide.

The objectives were to determine

1. the general behavior, distribution, and approach patterns of juvenile salmonids upriver and in the forebay areas of Bonneville Dam
2. the time and route of dam passage
3. fish behavior associated with tests of surface bypass concepts and prototype surface bypass structures;
4. and to compare these results to those observed during 1998.

BS017

Portland District Corps of Engineers. 2002. Bonneville decision document: juvenile fish passage recommendation. System Configuration Team, U.S. Army Engineer District, Portland, Oregon.

This is a decision document to address various proposed structural alternatives for fishery improvements at Bonneville Dam. Throughout the development of the document, a model called SIMPAS developed by NMFS was used to evaluate the various combinations of alternatives and the assumptions made by the authors where risk and uncertainty of the survival data had to be assigned and used as input to the model. The following recommendations will be forwarded to the System Configuration Team for yearly regional prioritization and implementation funding: 1) B2 will be the priority powerhouse; 2) implement the B2 Corner Collector as soon as possible; 3) continue to evaluate methods to improve B2 FGE and implement if results are favorable; 4) defer decision on B1 until critical information is available (B1 sluiceway efficiency and survival, B1 DSM Spring survival and adult fallback with high spill); and 5) defer the performance standard for B1 as laid out in the December 2000 BIOP due to deferral of the B1 decision. BS134

Reagan, R. E., S. D. Evans, L. S. Wright, M. J. Farley, N. S. Adams, and D. W. Rondorf. 2006. Passage Behavior of Radio-Tagged Yearling Chinook Salmon and Steelhead at Bonneville Dam, 2004: Revised for Corrected Spill. Final Report of Research by the U. S. Geological Survey, Columbia River Research Lab for the U. S. Army Corps of Engineers District, Portland, Oregon.

The behavior, passage efficiency, and survival of yearling Chinook salmon and steelhead were investigated in 2004 at Bonneville Dam using radio telemetry. Over 11,000 tagged fish were release for the investigation and approximately 90% of those fish were detected at Bonneville Dam. Median travel times were from 29.6 to 41.5 hours from the release sites at John Day Dam and The Dalles Dam. Bonneville Powerhouse 2 (B2) passed 59% of the Chinook salmon detected and 66% of the steelhead detected while the spillway passed 33% of yearling Chinook salmon detected and 25.5% of steelhead detected and Powerhouse 1 (B1) passed the remainder of fish detected. Fish passage efficiency was 71%

for yearling Chinook salmon and 86% steelhead for the project. Passage efficiency was also calculated for each passage route available to fish. Surface passage routes were more efficient at than other areas of the dam when spill discharge was higher. Passage metrics were generally lower in 2004 than 2002, but the passage efficiencies for the project was achievable because of the effectiveness of the B2 corner collector (8.4 for yearling Chinook salmon and 19.1 for steelhead) which passed 17 times less water than the spillway which had an effectiveness of 0.9 for yearling Chinook salmon and 0.7 for steelhead. BS179

Shrank, B. P., E. M. Dawley, and B. Ryan. 1997. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish and Invertebrates in Priest Rapids Reservoir and Downstream from Bonneville and Ice Harbor Dams, 1995. Coastal Zone and Estuarine Studies Division, Seattle, Washington.

The objective of this study was to assess some of the impacts of ambient levels of gas-supersaturated water on aquatic organisms residing in the Columbia and Snake Rivers. Visual examinations were made of fish and invertebrates using 2.5- to 5-power magnification lenses to assess external signs of GBD (subcutaneous emphysema on fins, head, eyes, and body surface). The authors examined 84 salmonid fishes, 7,272 non-salmonid fishes, and 1,303 invertebrates for signs of GBD. Few signs of GBD among invertebrates were observed. Signs of GBD in fish were prevalent downstream from Ice Harbor Dam but were rare in the other river reaches sampled. Dissolved gas supersaturation (DGS) was extremely high downstream from Ice Harbor between 8 May and 20 June as a result of turbine outages at the dam. When DGS reached 138% and 130% of saturation, signs of GBD were observed in 20% of resident fish, with nearly half of these fish displaying severe signs. Upstream from Priest Rapids Dam, substantive signs of GBD were observed in only one sampling period. Downstream from Bonneville Dam, signs of GBD were observed in five species of fish, but the highest prevalence of GBD signs did not exceed 3% at any time. BS119

Simmons, M. A., C. S. Simmons, S. L. Thorsten, M. A. Chamness, R. L. Johnson, C. A. McKinstry, and K. D. Hand. 2001. Splitbeam Evaluation of Near-Field Fish Behavior at Bonneville Dam First Powerhouse, Unit 8. Prepared for the U.S. Army Corps of Engineers, by Pacific Northwest National Laboratory, Richland, Washington.

The purpose of this study was to evaluate fish behavior in front of Unit 8 of the first powerhouse at Bonneville Dam and to determine if this behavior could be attributed to the presence of a modified extended-length submersible bar screen (ESBS) installed in 2000. Juvenile migrant behavior was characterized using split-beam hydroacoustics at the B slot of Unit 8. Based on their results, the authors concluded that 1) because the fish population immediately upstream of the trash racks was high in the water column, the majority of fish would not have been entrained under the tip of the ESBS from the sample region; 2) there was a substantial degree of milling upstream of the trash racks; 3) only one region was identified that potentially could contribute to fish entrainment, but that occurred at night, when relatively few fish were detected (at that time fish were still relatively high in the water column away from the tip of the ESBS); and 4) the majority of tracked fish were located in the center region of the slot opening with lower numbers to the north and south. Based on these conclusions, the authors recommended that 1) for future fish bypass design efforts, the mechanisms that cause milling in front of an unobstructed turbine intake be modeled; and 2) further research be conducted to establish the validity of their finding that the majority of tracked fish were located in the center region of the slot opening with lower numbers to the north and south sides. BS115

Skalski, J. R., D. Mathur, and P. G. Heisey. 2002. Effects of Turbine Operating Efficiency on Smolt Passage Survival. North American Journal of Fisheries Management 22:1193–1200.

The authors conducted a retrospective analysis of data on the relationship between operating efficiency of Kaplan turbines and direct passage survival of salmonid smolts. A review of a key report instrumental in establishing 61% turbine efficiency rule for operating Snake and Columbia river hydroelectric stations found a weak association ($r^2 = 0.112$) but also found misspecification of the turbine efficiency data. At four Snake and Columbia river dams, manipulative studies were performed to investigate the relationship between turbine performance and smolt passage survival, as estimated with balloon-tag releases and recoveries. At all sites, peak passage survival did not coincide with the observed turbine operating efficiency peak. The difference between maximum survival and survival at peak turbine efficiency was as much as 3.2%. However, at three sites, maximum survival was within the 61% peak efficiency operating rule. A meta-analysis that used balloon-tag survival results from 11 different hydropower projects also found no association between relative turbine efficiency at a site and smolt passage survival ($r^2 = 0.0311$, $P = 0.2640$). For the benefit of smolt survival during passage, the authors recommend managing turbine operations to achieve maximum passage survival rather than focusing solely on peak operating efficiency of Kaplan turbines. BS170 PDF reproduced with permission of www.fisheries.org.

Smith, S. G., W. D. Muir, S. Achord, E. E. Hockersmith, B. P. Sandford, J. G. Williams, and J. R. Skalski. 2000a. Survival Estimates for the Passage of Juvenile Salmonids through Snake & Columbia River Dams & Reservoirs, 1998. Annual Report Prepared for by the Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington.

In 1998, the National Marine Fisheries Service and the University of Washington completed the sixth year of a study to estimate survival of juvenile salmonids passing through dams and reservoirs on the Snake and Columbia Rivers. Actively migrating steelhead smolts (Oncorhynchus mykiss) were collected at Lower Granite Dam, tagged with passive integrated transponder (PIT) tags, and released to continue their downstream migration. Steelhead (hatchery and wild) were PIT tagged and released in proportion to the number arriving at the dam. The authors did not PIT tag any yearling chinook salmon (O. tshawytscha) in 1998 because sufficient numbers for survival estimation were PIT-tagged and released from Lower Granite Dam for the Transportation Evaluation Study and from Snake River Basin hatcheries. PIT-tagged smolts were detected at interrogation facilities at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams. PIT-tagged smolts were also detected using the PIT-tag trawl operated in the Columbia River estuary, and PIT tags were recovered from bird colonies in the Columbia River estuary. Survival estimates were calculated using the Single-Release (SR) Model. At McNary Dam, the authors evaluated post-detection bypass survival for yearling Chinook salmon (a test of a SR Model assumption).

Research objectives in 1998 were 1) to estimate reach and project survival in the Snake River throughout the steelhead and yearling Chinook salmon migrations, 2) to evaluate the survival-estimation models under prevailing operational and environmental conditions in the Snake River, and 3) to estimate post-detection bypass survival for yearling chinook salmon at McNary Dam.

This report provides reach survival and travel time estimates for PIT-tagged hatchery and wild juvenile steelhead and yearling Chinook salmon in the Snake and Columbia Rivers during 1998. Estimates of post-detection bypass survival for yearling Chinook salmon at McNary Dam are also reported. Results are reported primarily in the form of data tables and figures with minimal description of methods and analysis. Detailed information on the methodology and statistical models used for this report is provided in five previous annual reports on this study, which are cited here. BS064

Smith, S. G., W. D. Muir, G. A. Axel, R. W. Zabel, J. G. Williams, and J. R. Skalski. 2000b. Survival Estimates for the Passage of Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 1999. Prepared for the Bonneville Power Administration, by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Coastal Zone and Estuarine Studies Division, Northwest and Alaska Fisheries Center, Seattle, Washington.

Objectives were 1) to estimate reach and project survival in the Snake and Columbia Rivers throughout the yearling Chinook salmon and steelhead migrations, 2) to evaluate the survival-estimation models under prevailing operational and environmental conditions, 3) to estimate post-detection bypass survival for subyearling fall Chinook salmon at McNary Dam, and 4) to estimate reach survival for subyearling fall Chinook salmon from the McNary Dam tailrace to the tailrace of John Day Dam.

For the transportation study, PIT-tagged smolts were recorded at detection facilities at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams. PIT-tagged smolts were also detected using the PIT-tag detector trawl operated in the Columbia River estuary and additional PIT tags were recovered from bird colonies in the Columbia River estuary. Survival estimates were calculated using a statistical model for single-release, multiple capture data. Post-detection bypass survival was estimated for river-run subyearling fall Chinook salmon at McNary Dam during the summer migration (test of a single-release model assumption) and reach survival for subyearling fall Chinook salmon from McNary Dam tailrace to the tailrace of John Day Dam.

Estimated survival probabilities from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.949 for yearling Chinook salmon and 0.926 for steelhead. For individual reaches, average estimated survival probabilities were as follows for yearling Chinook salmon and steelhead respectively: from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 0.925 and 0.915; from Lower Monumental Dam tailrace to McNary Dam tailrace, 0.904 and 0.833; from McNary Dam tailrace to John Day Dam tailrace, 0.853 and 0.920; and from John Day Dam tailrace to Bonneville Dam tailrace, 0.814 and 0.682. The average overall estimates of survival probabilities for yearling Chinook salmon and steelhead from Lower Granite Dam tailrace to Bonneville Dam tailrace were 0.557 and 0.440 respectively. At McNary Dam, average post-detection bypass survival probability for subyearling fall Chinook salmon was 0.988 (SE = 0.027), and survival from the tailrace of McNary Dam to the tailrace of John Day Dam was 0.775 (SE = 0.019). The results are reported primarily in tables and figures with minimal explanation of methodology. Methodology and statistical models used in the analyses were the same as in previous study years, and details are provided in previous annual reports cited in the text. BS073

Snelling, J. C. and S. A. Mattson. 1996. Movement and Behavior of Juvenile Salmonids at Three Lower Columbia River Dams. Year-end report for 1996. Oregon Cooperative Fishery Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon.

The primary objectives of this work were to 1) determine the optimum outfall locations to exit juvenile salmonids from the Bonneville tailrace, thereby reducing vulnerability to predation, and 2) determine the migration behavior of radio-tagged juvenile Chinook salmon from their passage at John Day to a point about 18 km below The Dalles Dam, thereby providing an estimate of migratory success. The major findings of the study were as follows: 1) juvenile Chinook salmon released from the Bonneville first and second powerhouse outfalls or at the proposed outfall location followed the shipping channel; up to 10% of fish released from Powerhouse II and the proposed outfall location used the side channels around Pierce and Ives Islands, which nearly doubled their travel time in the 8 km study area; 2) 3% to 4% of the fish held for more than 30 min within the same 400 m, apparently unrelated to where they were released; 3) about 25% of the subyearlings released from existing outfalls were immediate mortalities, probably eaten by northern squawfish; 4) yearling Chinook salmon released at the proposed outfall traveled more rapidly than did those released from either powerhouse; the benefit to subyearlings only accrued from comparisons with the 2nd powerhouse; 5) juvenile Chinook salmon released above Bonneville Dam by USGS and electronically intercepted by receivers used in this study below behaved similarly to those released above the dam; 6) yearlings moved through The Dalles pool directly, following the shipping channel; subyearlings spent more time at the river margins; 7) the more direct route through the north Miller Island channel was not a chosen route; 8) the authors documented 65% of yearling and 39% of subyearling Chinook salmon released above John Day Dam as migrating past Lyle Point below The Dalles Dam; 6% of both age classes succumbed to predation, with California Gulls in The Dalles tailrace being the dominant predator; and 9) results represent fish behavior under exceptionally high flow conditions; thus results may be quite different in another year with a different hydrograph. BS127

Stansell, R. J., R. A. Magne, W. T. Nagy, and L. M. Beck. 1990. Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at Bonneville Dam, 1989. Prepared by the U.S. Army Corps of Engineers, Portland District, Fisheries Field Unit, Bonneville Lock and Dam, Cascades Locks, Oregon.

During hydroacoustic monitoring in 1986, 1987, and 1988 it became evident that the ice and trash chute (ITC) at Bonneville Dam second powerhouse was passing large numbers of juvenile salmonids (Magne et al. 1986, 1987, 1989). Dual-beam target strength estimates in 1988 indicated that fish entering the ITC averaged eight decibels (dB) higher than fish entering the turbine units (Magne et al. 1989). This could have been caused by differences in fish orientation, multiple fish passing through the hydroacoustic beam at the same time at the same range, or because the dual-beam method may not work when ranges between the transducer and target are short. In order to determine the behavior and orientation of fish entering the beam, underwater video cameras, situated in a manner to view the area ensonified by the acoustic beam, were deployed.

The results of the 1988 Bonneville study comparing the National Marine Fisheries Service (NMFS) Fish Guiding Efficiency (FGE) and hydroacoustic Theoretical Fish Guiding Efficiency (TFGE, those fish detected at an elevation greater than that of the bottom of the Submerged Traveling Screen and assumed to have been guided into the gatewell, divided by the total number of fish detected in the slot) at turbine slots 13A and 17B were promising, and showed a good correlation over the entire spring period, but varied greatly day to day (Magne 1989). This day-to-day variation was thought to be due to small sample sizes resulting from short sampling periods. Comparison with a sampling technique that collects data over a longer period of time should show better day-to-day correlation. The Portland District Corps of Engineers Fisheries Field Unit proposed a study to address these concerns in 1989. BS050

Thorne, R. E. and E. S. Kuehl. 1989. Evaluation of Hydroacoustics Techniques for Assessment of Juvenile Fish Passage at Bonneville Powerhouse I. Final Report Prepared for U.S. Army Corps of Engineers, Portland District, by BioSonics, Inc., Seattle, Washington.

The COE contracted BioSonics, Inc. to determine how a hydroacoustic system can be deployed and operated so that a routine monitoring program can be conducted at Bonneville Powerhouse I. The eventual goal will be to estimate total juvenile salmonid passage at the powerhouse and the relative distribution of these fish among the various passage routes. This information will then be used to evaluate fish bypass systems at the powerhouse.

Hydroacoustic data were collected at Turbine 3 of Bonneville Powerhouse I from June 28 to July 27, 1988, using two in-turbine transducers mounted to the trash racks. Sampling was concurrent with fish guiding efficiency (FGE) studies at Turbine 3 conducted by the National Marine Fisheries Service

(NMFS) using fyke nets and gatewell dip nets. Turbine 3 was operated only during FGE sampling, which was generally 2000 h to 2245 h. After successful application at Turbine 3, additional transducers were deployed in a similar fashion at Turbine 7, which is a noisier location because of turbulence associated with an adjacent wing wall. Sampling took place during both daytime and nighttime periods at Turbine 7 from July 20 to 27, 1988. The objective was to evaluate whether the deployment and sampling techniques used at Turbine 3 could be applied to other, noisier sites at the powerhouse.

This study focused on the relationship between acoustic target strength and system noise thresholds, since that is the most critical factor for successful operation of acoustic systems in this noisy environment. BS047

Thorne, R. E. and G. E. Johnson. 1993. "A Review of Hydroacoustic Studies for Estimation of Salmonid Downriver Migration Past Hydroelectric Facilities on the Columbia and Snake Rivers in the 1980s." Reviews in Fisheries Science. 1 (1):27-56.

Hydroelectric development on the Columbia and Snake Rivers substantially impacted salmonid populations. The 1980 Pacific Northwest Electric Power Planning and Conservation Act mandated development of a program to mitigate these impacts. Hydroacoustics was one of the techniques that were applied to study the temporal and spatial characteristics of the downstream salmonid migration. Over 60 hydroacoustic studies were conducted at the various hydroelectric facilities on the Columbia and Snake Rivers during the 1980s. The primary objectives were measurement of run timing, vertical distribution, horizontal distribution, diel distribution, spill efficiency, and bypass efficiency. The techniques provided a cost-effective, non-lethal, and accurate means to study passage rates, migration paths, and efficiencies of various operational and bypass mechanisms. In at least one case, the techniques were instrumental in the development of a successful bypass procedure. The development of hydroacoustic techniques for the Columbia and Snake Rivers contributed to successful applications of these techniques throughout the world, although more widespread application is hindered by the complexity and lack of understanding of the techniques. (This is the original abstract). Permission was not granted by the publisher (Taylor and Francis Group) for us to provide a PDF of this copyrighted article.

Toner, M. A. and E. M. Dawley. 1995. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish and Invertebrates Downstream from Bonneville Dam, 1993. Annual Report of Research for the U.S. Army Corps of Engineer Division, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

During the period of high spring flow in the Columbia River in 1993, the occurrence of gas bubble disease (GBD) in migrating juvenile salmonids and other aquatic biota residing in the Columbia River downstream from Bonneville Dam was monitored. Fishes and invertebrates were collected with a 50-m beach seine, a 7.5-m seine, and a Ponar bottom sampler at 18 locations from Columbia Rkm 228 to 62. Dissolved gas saturation values at the U.S. Army Corps of Engineers' Warrendale, OR, monitoring station (Rkm 226) reached 128% on four days, with daily mean values above 120% on nine days. However, the dissolved gas concentrations measured at the sampling locations from 27 April through 14 June averaged 112%, with a range from 103% to 122%; concentrations above 120% occurred upstream from Rkm 179 from 11 May through 21 May. External signs of GBD were infrequent. A low prevalence of GBD occurred in 6 of the 20 species that were examined. Mild signs of GBD (small blisters between fin rays) were observed in less than 1% of the juvenile Chinook salmon (n=1,648) and peamouth (n=238), in 3% of the juvenile coho salmon (n=711), and in 2% of the juvenile steelhead (n=50) examined. Moderate to severe signs of GBD (large blisters on the body and exophthalmia) were observed in less than 1% of the sticklebacks (n=906) and prickly sculpins (n=174) examined. No evidence of GBD was observed in invertebrates collected from monitoring sites. (This is the original abstract). BS121

Toner, M. A., B. Ryan, and E. M. Dawley. 1995. Evaluation of the Effects of Dissolved Gas Supersaturation on Fish and Invertebrates Downstream from Bonneville, Ice Harbor and Priest Rapids Dams, 1994. Annual Report of Research for the U.S. Army Corps of Engineer Division, Portland, Oregon by the National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center, Seattle, Washington.

This study involved monitoring the prevalence of gas bubble disease (GBD) in resident fish and invertebrates in four river reaches: downstream from Bonneville and Ice Harbor Dams, and upstream and downstream from Priest Rapids Dam, during the period of high spill in 1994. Visual examinations were made of fish and invertebrates using 2.5- to 5-power magnification lenses to assess external signs of GBD (subcutaneous emphysema on fins, head, eyes, and body surface). Authors examined 2,082 salmonid fishes, 11,976 non-salmonid fishes, and 4,133 invertebrates for signs of GBD. Signs of GBD were prevalent downstream from Ice Harbor Dam, but were rare in the other river reaches sampled. Downstream from Ice Harbor in early May, TDG levels reached 136% for of saturation for three days and were higher than 130% for 7 to 11 hours each day. Signs of GBD were observed in 5% to 10% of resident fish captured during the month of May. Half of the 22 species captured displayed signs of GBD. When TDG levels at the sampling sites dropped to a daily average of 110% of saturation with peaks no higher than 115%, GBD signs among fish disappeared. Signs of GBD among invertebrates were few. BS120

Uremovich, B. L., S. P. Cramer, C. F. Willis, and C. O. Junge. 1980. Passage of Juvenile Salmonids through the Ice-Trash Sluiceway and Squawfish Predation at Bonneville Dam, 1980. Annual Progress Report, Prepared for the U.S. Army Engineer, Portland District, by the Oregon Department of Fish and Wildlife Portland, Oregon.

The goal of studies in 1980 was to determine operating criteria for passing the maximum number of juvenile salmonids possible through the ice-trash sluiceway. The three objectives under this goal were to (1) Determine the sluiceway bypass efficiency for yearling salmonids when sluice-gates 4A, B, C, 5A were fully opened, (2) determine the horizontal distribution and abundance of juvenile salmonids passing through penstocks with the sluiceway operating at optimum criteria, and (3) determine the best sluice-gate openings or passage of subyearling Chinook salmon (*Oncorhynchus tshawytsca*) through the sluiceway after July 1. BS051

Ward, D. L., J. H. Petersen, and J. J. Loch. 1995. "Index of Predation on Juvenile Salmonids by Northern Squawfish in the Lower and Middle Columbia River and in the Lower Snake River." American Fisheries Society. 124:321-334.

The authors developed a predation index to describe the relative magnitude of predation on juvenile salmonids by northern squawfish (NS) throughout the lower and middle Columbia River and lower Snake River. The predation index was the product of an abundance index and a consumption index. The authors evaluated various catch indices and found that catch per unit effort best reflected differences among NS abundances. NS abundance was higher in the lower Columbia River than in the middle Columbia or Snake rivers and was highest in Bonneville reservoir and the Columbia River downstream from Bonneville Dam. The consumption index was based on the concept of meal turnover time for a sample of NS. Variables needed to calculate the consumption index (CI) were water temperature (T), mean weight of the NS (W), mean number of salmonids in each gut (S), and mean weight of the gut contents (GW): CI = 0.0209T1.60W0.27(SGW-0.61). Generally, NS consumption of juvenile salmonids was highest in tailraces downstream from dams and higher in the Columbia River than in the Snake River. Predation on juvenile salmonids was much higher in the lower Columbia River than in the middle Columbia or lower Snake River and usually was higher in summer than in spring. Predation was highest in the Columbia River downstream from Bonneville Dam and in John Day Reservoir. The predation index identified areas where predator control efforts can be most effective. Angling for NS at dams should be concentrated in tailraces. Removal efforts concentrated in the lower Columbia River would have the greatest effect on predation. BS135 PDF reproduced with permission of www.fisheries.org.

Willis, C. F. and B. L. Uremovich. 1981. Evaluation of the Ice and Trash Sluiceway at Bonneville Dam as a Bypass System for Juvenile Salmonids, 1981. Annual Progress Report, Fish Research Project, Oregon, Prepared for the National Marine Fisheries Service, by the Oregon Department of Fish and Wildlife, Portland, Oregon.

The Columbia River Fisheries Council (1981) has established a goal that bypass systems should pass at least 70% of the available juvenile salmonids. Submersible traveling screens (STS) are being installed in the second powerhouse to bypass juvenile salmonids. The study reported here was designed to determine the best system for bypassing juvenile salmonids around the first powerhouse.

In 1981, tests were conducted to determine if STSs or the ice-trash sluiceway should be used to bypass juvenile salmonids around the first powerhouse. The National Marine Fisheries Service (NMFS) evaluated the guidance efficiency (proportion of juveniles collected in gatewells) of the STS system and the Oregon Department of Fish and Wildlife (ODFW) evaluated the bypass efficiency of the ice-trash sluiceway (proportion of juveniles passing through the sluiceway). This report describes the finding from the ice-trash sluiceway evaluation. The goal of our 1981 study was to develop final criteria for operating the sluiceway at Bonneville first powerhouse as a means of bypassing juvenile salmonids and to evaluate the bypass efficiency of the sluiceway when operated according to optimum criteria. To achieve this goal, the authors had three objectives: (1) Determine the best sluice-gate openings for attracting maximum numbers of juvenile salmonids. (2) Determine the efficiency of the sluiceway, when operated under optimum conditions, for bypassing juvenile salmonids. (3) Determine the factors other than the location of gate openings and flow per gate, that influence the effectiveness of the sluiceway for bypassing juvenile salmonids. BS062

Zabel, R. W., S. G. Smith, W. D. Muir, D. M. Marsh, J. G. Williams, and J. R. Skalski. 2001. Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs. 2000 Annual Report, DOE/BP-10891-10, Prepared for Bonneville Power administration, by the Fish Ecology Division, National Marine Fisheries Service, Seattle, Washington.

Objectives were 1) to estimate reach and project survival in the Snake and Columbia Rivers throughout the yearling Chinook salmon and steelhead migrations, and 2) to evaluate the performance of the survival-estimation models under prevailing operational and environmental conditions.

The Single-Release (SR) Model was used to estimate survival for releases of PIT-tagged yearling Chinook salmon, sockeye salmon, and steelhead from Snake River Basin hatcheries and traps and from Lower Granite Dam in 2000. Hatchery steelhead were tagged with PIT tags and released at Lower Granite Dam, and yearling chinook salmon PIT tagged by other studies, were used for reach survival and travel time estimation. PIT-tagged smolts were detected at interrogation facilities at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams. Smolts were also detected in the PIT-tag detector trawl operated in the Columbia River estuary.

Estimated survival from the tailrace of Lower Granite Dam to the tailrace of Little Goose Dam averaged 0.938 for yearling Chinook salmon and 0.901 for steelhead. From Little Goose Dam tailrace to Lower Monumental Dam tailrace, estimated survival averaged 0.887 and 0.904; from Lower Monumental Dam tailrace to McNary Dam tailrace (including passage through Ice Harbor Dam), estimated survival averaged 0.928 and 0.842; from McNary Dam tailrace to John Day Dam tailrace, estimated survival averaged 0.898 and 0.851; and from John Day Dam tailrace to Bonneville Dam tailrace (including passage through The Dalles Dam), estimated survival averaged 0.684 and 0.754 for yearling chinook salmon and steelhead, respectively. The overall estimates of yearling Chinook salmon and steelhead survival from Lower Granite Dam tailrace to Bonneville Dam tailrace (7 projects) were 0.486 and 0.393 respectively. Results are reported primarily in the form of tables and figures. BS072

Zimmerman, M. P. and D. L. Ward. 1999. "Index of predation on juvenile salmonids by northern pikeminnow in the lower Columbia River Basin, 1994-1996." Transactions of the American Fisheries Society. 128:995-1007.

The authors estimated relative abundance of northern pikeminnow *Ptychocheilus oregonensis* and relative consumption of juvenile salmonids *Oncorhynchus spp*. by northern pikeminnow at standardized sites in the lower Columbia and lower Snake rivers from 1994 to 1996. Indexes of abundance and consumption were compared with indexes measured from 1990 to 1993 to evaluate changes in predation concurrent with a predator control program in the lower Columbia basin. Reductions in indexes of northern pikeminnow abundance, consumption, or both resulted in mean 1994–1996 predation index values that were 44%–91% lower than mean 1990–1993 values through-out the lower Columbia basin. Consumption of juvenile salmonids by surviving northern pike-minnow has not decreased in response to predator control efforts. Spatial patterns were consistent among years, being greatest downstream from Bonneville Dam, intermediate in lower Columbia River reservoirs, and lowest at Snake River sites. Reductions in relative predation were consistent with changes in northern pikeminnow population structure associated with harvest, although annual variation in river flow, dam spill, and juvenile salmonid passage may have magnified reductions in predation. (This is the original abstract). BS066 PDF reproduced with permission of www.fisheries.org.