EVALUATION OF EXTENDED-LENGTH SUBMERSIBLE BAR SCREENS AT JOHN DAY DAM, 2002

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EXECUTIVE SUMMARY

The juvenile fish collection and bypass system at John Day Dam was installed between 1984 and 1986. The fish-collection portion of the system utilized a standard-length submersible traveling screen (STS), which diverts fish from the turbine intakes toward a collection channel. Estimates by NMFS in 1985-1986 showed that fish guidance efficiencies (FGE) of the STSs were more than 70% for yearling chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss*, but only 21-35% for subyearling chinook salmon.

Encouraging results from tests of an extended-length submersible bar screen (ESBS) at other dams during the early 1990s suggested that FGE at John Day Dam might be improved using the ESBS. In 1996, NMFS evaluated the ESBS at the dam and found FGEs of 79% or higher for all species. Between 1996 and 1999, the perforated-plate panels and associated mounting hardware on the back of the ESBS were modified extensively to reduce harmonic vibration, which had previously resulted in failure of the perforated-plate attachment structures.

In 1999, tests were conducted at John Day Dam to evaluate FGE, orifice passage efficiency (OPE), and fish condition using the ESBS with its modified perforated plate and an inlet flow vane. For yearling chinook salmon, FGE was 80%, and OPE was 97.1% using the ESBS (OPE was 39.8% in the STS slot). However, when ESBS unit was operated at 155 MW, descaling and mortality increased.

Based on these increases, the U.S. Army Corps of Engineers redesigned the vertical barrier screen (VBS) and designed an outlet flow-control device (OFC) to reduce gatewell flows and create a more benign hydraulic environment in the gatewell. Research goals at John Day Dam in 2002 were to evaluate FGE, OPE, and the effects on fish condition of the ESBS with a modified VBSs and the OFC device. OPE and fish condition were compared between the modified gatewell fitted with an ESBS (Slot 7B) and a standard gatewell fitted with an STS (Slot 6B).

Delays in installation of the modified equipment precluded the extensive test schedule originally proposed, and also eliminated our ability to test impingement of salmonid fry on the ESBS. Spring testing began in late May, and only five FGE/OPE tests were completed. Mean FGEs (with 95% confidence interval) for the modified unit were 80.0% (±9.4) for yearling chinook salmon and 72.2% (±13.2) for sockeye salmon *O. nerka*.

Coho salmon *O. kisutch* and steelhead were not present in sufficient numbers during the abbreviated spring test season for meaningful statistical calculations.

Mean OPE for yearling chinook salmon was 98.8% (SE = 0.7) for the modified unit and 87.6% (SE = 3.1) for the standard unit. The 11.2% difference in OPE between the two units was significant ($t = 3.65$, $P = 0.022$).

Median and 90% passage travel times for yearling chinook salmon were shorter for fish exiting the modified unit than those exiting the standard unit. The difference in median travel time of 7.94 h was not significant ($t = 2.52$, $P = 0.065$), but the difference in the 90th percentile passage time of 18.50 h ($t = 6.46$, $P = 0.003$) was significant. Mortality of PIT-tagged yearling chinook released during FGE and OPE tests was low, at 0.1, 0.2, and 0.3% for the ESBS slot, STS slot, and the collection channel, respectively. Mean yearling chinook salmon descaling was 4% for the ESBS and 6% for the STS during the FGE tests.

Summer testing began on 17 June for subyearling chinook salmon and continued through 9 July, when turbine problems curtailed the evaluation. Mean FGE (with 95% confidence interval) was 63.8% (±5.8) for subyearling chinook salmon for the 14 tests. Other salmonid species were not present in large enough numbers for statistical evaluations. Mean OPE for subyearling chinook salmon was 96.5% (SE = 1.1) with the modified unit and 88.1% (SE = 3.2) with the standard unit. The 8.4% difference in OPE between the two units was significant ($t = 2.55$, $P = 0.027$).

Median passage times for subyearling chinook salmon were 0.32 h for fish released to the ESBS slot (7B), 1.58 h for fish released to the STS slot (6B), and 0.1 h for fish released to the collection channel. Between the ESBS and STS slots, the 1.26-h difference in median passage time was not significant ($t = 1.82$, $P = 0.099$), but the 7.0-h difference in the 90th percentile passage time was ($t = 2.65$, $P = 0.024$). During OPE tests, mortality of released PIT-tagged subyearling chinook salmon was also low, at 0.1, 0, and 0.5% for the ESBS slot, STS slot, and collection channel, respectively. Mean subyearling chinook salmon descaling was 1% for the ESBS and 2% for the STS.

We did not see the increase in descaling and mortality at the Smolt Monitoring Facility that we observed in 1999 during operation of the modified unit. We concluded that modifications to the gatewell at John Day Dam produced favorable hydraulic conditions while maintaining high FGE and OPE.

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INTRODUCTION

John Day Dam, located at Columbia River Kilometer 347 (River Mile 216), is operated by the U.S. Army Corps of Engineers (USACE) and is the third hydroelectric project upstream from the mouth. Completed in 1968, John Day Dam is equipped with 16 turbine units, 20 spillways, and a navigation lock (Fig. 1).

The juvenile fish collection and bypass system at John Day Dam was installed between 1984 and 1986. The fish-collection portion of the system consists of standard-length submersible traveling screens (STSs), which divert fish from the turbine intakes and guide them up into the gatewell slots. The system includes a single 35-cm-diameter (14 in) orifice leading from each gatewell to an enclosed gallery. A transportation channel carries fish from the gallery to a tailrace release area approximately 0.4 km downstream from the dam. A state-of-the-art bypass and sampling facility was completed in 1999 and evaluated by Absolon et al. (2000).

In 1985, the National Marine Fisheries Service (NMFS), in cooperation with the USACE, began a series of studies to evaluate the partially finished fish-passage system and sampling facilities (Krcma et al. 1986). The fish guidance efficiency (FGE) of the STSs was estimated for all salmonid species *Oncorhynchus* spp. and found to be more than 70% for yearling chinook salmon *O. tshawytscha* and steelhead *O. mykiss*, but much lower (21%) for subyearling chinook salmon. In 1985, orifice passage efficiency (OPE) for all juvenile salmonids was greater than 70%. However, with the bypass system connected to only 9 turbine units, orifice head was 1.7 m, considerably higher than the 1.1 m expected when the bypass system was connected to all 16 turbine units. Thus, because a reduction in orifice head may reduce OPE, and the fish sampling facilities located on the transportation channel were incomplete at the time, only preliminary evaluations were possible in 1985.

Prior to the 1986 smolt migration, the collection and bypass system for Turbine Units 10, 11, and 12 was completed. The remaining bypass orifices (Units 13, 14, 15, and 16) would be completed during 1986. Numerous modifications had also been made to the temporary juvenile fish sampling and handling facilities. With a completed bypass system in 12 units, orifice head was reduced to about 1.2 m (very close to the expected normal operating head of 1.1 m).

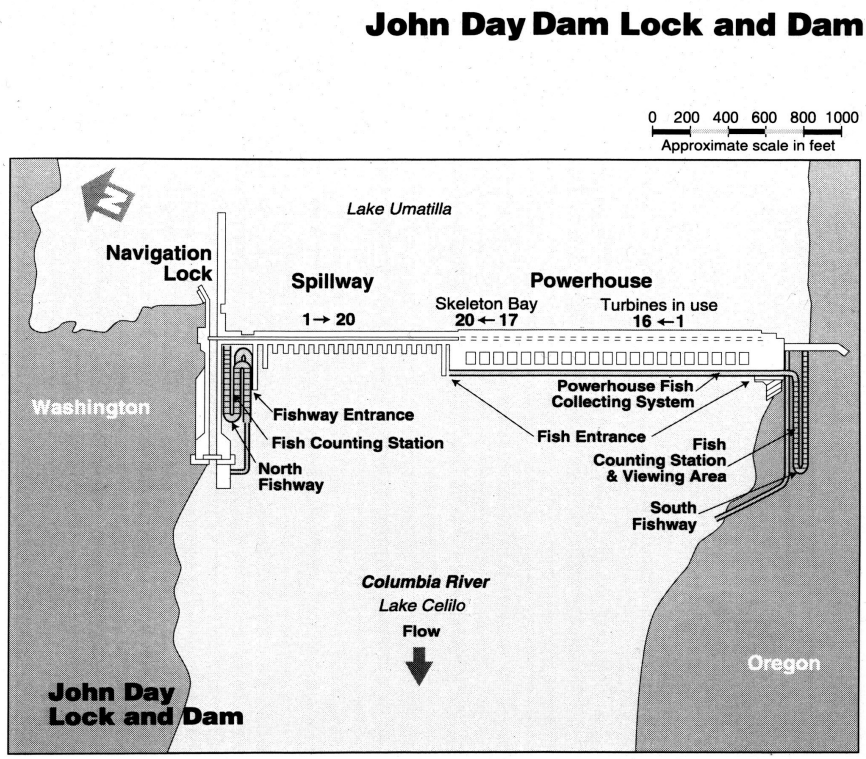


Figure 1. Overview of John Day Dam on the Columbia River showing numbering sequence of turbine units and spillway.

In 1986, FGE tests conducted with subyearling chinook salmon averaged only 35% (Brege et al. 1987). This was higher than in 1985, but still considerably lower than target levels (70%). Seasonal average OPEs were 69 and 66% for yearling and subyearling chinook salmon, respectively. There were no significant differences in seasonal average OPE between the 1985 and 1986 seasons despite the reduction in orifice head.

Encouraging results from tests with extended-length screens at McNary Dam in 1991, 1992, and 1993 (Brege et al. 1992; McComas et al. 1993, 1994) and at The Dalles Dam in 1993 and 1994 (Brege et al. 1994; Absolon et al. 1995) suggested that FGE for both yearling and subyearling chinook salmon at John Day Dam might be improved with longer screens.

In 1996, we conducted tests at John Day Dam to evaluate the FGE of an extended-length submersible bar screen (ESBS) used with an inlet flow vane and the effects of these guidance devices on descaling of juvenile salmonids. In addition, we

evaluated the effects of enlarged orifices, from 30 to 35 cm diameter (12 to 14 in), and increased gatewell flow produced by the ESBS, from 200 to 700 cfs, on OPE. Fish guidance efficiencies in 1996 were 84, 94, 95, 79, and 60% for yearling chinook salmon, steelhead, coho salmon *O. kisutch*, sockeye salmon *O. nerka*, and subyearling chinook salmon, respectively (Brege et al. 1997). Yearling chinook salmon OPE was consistently higher in the ESBS slot than in the STS slot, with a statistically significant difference in mean OPEs of 99 and 80% for the ESBS and STS, respectively. Mean OPE for subyearling chinook salmon was 97% for both the ESBS and STS.

Between 1996 and 1999, the perforated-plate panels and associated mounting hardware on the back of the ESBS were modified extensively to reduce harmonic vibration, which had previously resulted in failure of the perforated-plate attachment structures. Because of mechanical durability problems with the ESBS first tested at John Day Dam in 1996, the USACE also modified the structural design of the ESBS.

In 1999, tests were conducted at John Day Dam to evaluate the FGE, OPE, and fish condition of an ESBS with modified perforated plates and an inlet flow vane. Yearling chinook salmon FGE was 80% for the ESBS, similar to 1996 results. However, the difference in OPE was even higher, 97.1 and 39.8%, respectively, for the ESBS and the STS. In addition, when the test unit containing the ESBS was operated at 155 MW over a 20-hour period, both descaling of fish recovered from the gate slot and overall mortality at the fingerling bypass evaluation facility increased (Brege et al. 2001).

Based on the 1999 results, the USACE redesigned the vertical barrier screen with a bar screen surface and a more open perforated plate configuration. In the event that the new VBS did not perform as expected, an outlet flow control device (OFC) was added to further reduce flows.

The goals of research at John Day Dam in 2002 were to evaluate FGE, OPE, and the effects on fish condition of ESBSs with the modified VBS and OFC deployed in a turbine unit. In addition, OPE and fish condition with the ESBSs, modified VBSs, and OFC device were compared to results of concurrent tests with an STS and unmodified gate slot. The 2002 research objectives were:

1) Prior to the main juvenile migration period, determine whether the gatewell environment created by the ESBS, modified VBS, and OFC is harmful to juvenile salmonids, including swim-up fry.

2) Determine the FGE using an ESBSs with a modified VBSs and OFC in turbine units at John Day Dam during the spring and summer juvenile salmonid migrations.

3) Determine the OPE and passage time through a juvenile fish bypass orifice with the ESBSs used in conjunction with modified VBSs and OFC, and compare them to OPE and passage times in a standard gatewell slot (STS).

4) Evaluate the effects of the ESBS and associated guidance devices on juvenile salmonid descaling, and compare to descaling associated with STSs. Monitor and record any impingement of swim-up fry and juvenile lamprey *Lampetra tridentata*.

OBJECTIVE 1: Determine whether the gatewell environment created by the ESBS, modified VBS, and OFC is harmful to juvenile salmonids

Approach

An injury/mortality test series was scheduled prior to FGE/OPE testing due to the twenty-fold increase in mortality of test fish subjected to the high flows of the ESBS test slot, which was observed in 1999 (Brege et al. 2001). The original proposal called for groups of 100 hatchery-reared juvenile salmonids to be PIT tagged, held 1 h for short-term mortality, and released either to the fingerling bypass channel, an ESBS gatewell with the modified VBS and OFC, or an STS-equipped (standard) gatewell.

Six replicates were to be conducted using a total of 1,800 fish, and this sample size would provide statistical precision sufficient to discern a difference of 3% between the test and control gate slots ($\alpha = 0.05$, $\beta = 0.2$), assuming a 98% detection rate of marked fish. Forty replicates would be necessary to discern a difference of 1%. To test for detectable differences between the three treatments, we used a two-factor ANOVA with treatment as a fixed factor and daily block as a random factor. Fish condition and mortality would be monitored by diverting 100% of the fish into the Smolt Monitoring Facility (SMF).

To determine the effects of the gatewell environment on swim-up fry, hatchery reared fish would be marked using the Bismark brown dye technique (Krcma et al. 1986), released in the gatewell, allowed to exit via the orifice, and recaptured at the SMF. Five groups of 200 fish each were to be released in the test gatewell slot. The releases were to be made with a 240-L cylindrical aluminum canister lowered 7 m below the orifice (Absolon and Brege 2003). Every effort would be made to use fish approximating those passing John Day Dam (less than 60 mm in length). These tests would be similar to those conducted at John Day Dam by Absolon et al. (2000). In order to recover all the fry, the sample rate at the SMF would be set at 100%. These tests were scheduled during early April to minimize the collection of non-target fish.

Results and Discussion

Numerous delays in the schedule of the installation of the VBS and ESBS precluded the extensive tests originally proposed. Tests to determine the effects of the gatewell environment on swim-up fry were canceled because these fish were no longer available by the start of testing.

Fish condition tests were conducted on 8 and 9 May when releases of 50 PIT-tagged river-run yearling chinook salmon were made into the collection channel at Turbine Unit 8. Fish were recovered by the separation by code (SbyC) diversion at the SMF. The purpose of these releases was to determine if our release hose through the air vent would injure juvenile salmonids. No descaling or mortality was observed in the recovered fish (Appendix Table A2).

On 21 May, installation of the VBS and ESBS was complete, and between 22 and 24 May, three releases of 100 PIT-tagged river-run yearling chinook salmon were made in Slot 7B of the test unit. Test fish were pre-selected, and only fish in good condition (i.e., not descaled) were marked. Again, fish were recovered by SbyC diversion at the SMF. No mortality of marked fish was observed, and descaling averaged only 3% (Appendix Table A2). Following a reassessment of the release technique, changes were made to further reduce any descaling due to handling. Since the test equipment in Unit 7 was not causing any serious damage to juvenile salmonids, testing for FGE was scheduled to begin the following week. The OFC would not be deployed during the following FGE/OPE tests because fish condition was acceptable.

OBJECTIVE 2: Determine Fish Guidance Efficiency for the ESBS using a Modified VBS and OFC

Approach

Methods for determining FGE were similar to those used in previous evaluations of extended-length screens (Brege et al. 1992; McComas et al. 1993). Gatewell dip-net catches provided estimates of the number of guided fish (Swan et al. 1979); fyke-net catches provided estimates of the number of unguided fish (Fig. 2). Fish guidance efficiency for each species was calculated as gatewell catch (guided fish) divided by the total number of fish by species (guided and unguided), passing through the turbine intake during the test period:

$$FGE = \frac{GW}{GW + FN} \times 100\%$$

$$GW = gatewell\ catch$$
$$FN = fyke\text{-}net\ catch$$

Guided fish were confined to the bulkhead slot by a vertical barrier screen (VBS) that separated the bulkhead slot from the operating-gate slot (Fig. 2). The VBS in the standard slot extends from the turbine intake ceiling beam to the bottom of the intake deck beam. This VBS consists of 10 panels, each 2.6-m high, which extend across the full width of the gate slot. The front of each panel is covered with monofilament mesh, and the back is either perforated steel plate to control flow or a solid plate to block flow through the screen section (Fig. 3). The VBS used with the STS consists of three solid and seven open (14% porosity) panels.

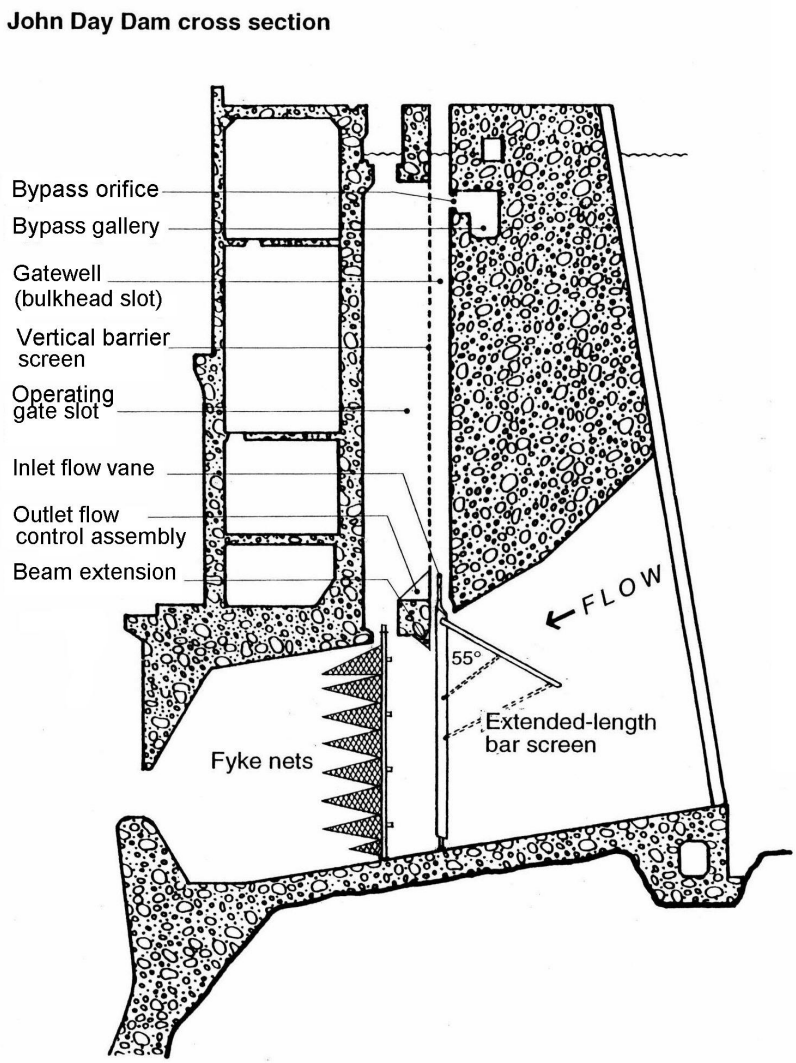


Figure 2. Cross section of a turbine unit at John Day Dam with extended-length submersible bar screen (ESBS) and inlet flow vane in place.

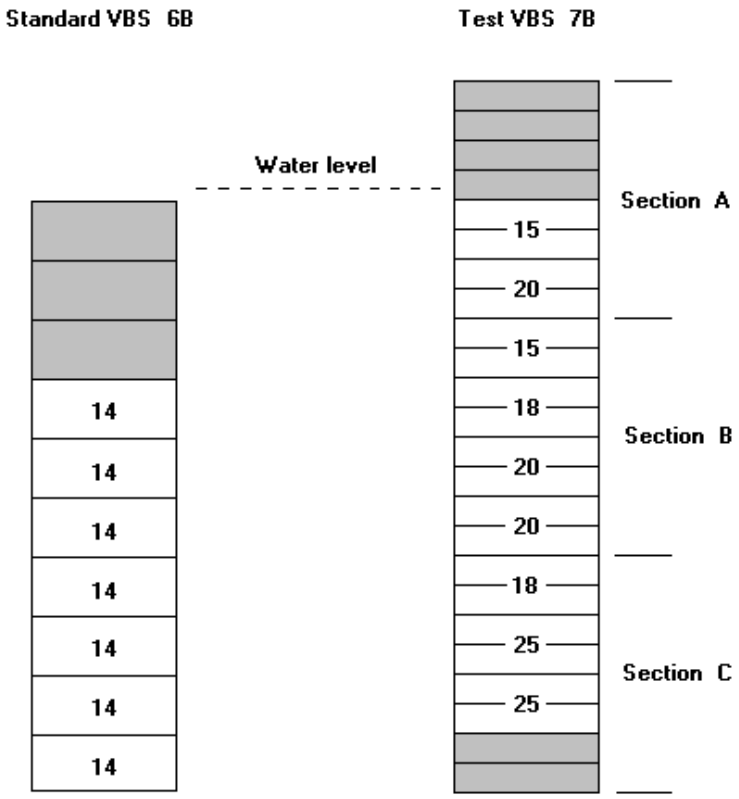


Figure 3. Vertical barrier screen configurations used with extended submersible bar screens (ESBSs) and standard-length submersible traveling screens (STSs) at John Day Dam. Numbers at the center of individual screen panels indicate the percentage of perforation (open area) on the plate situated on the back of the panel. Shaded areas indicate panels backed with solid plate.

The configuration of the VBSs in Unit 7 was different from that in Unit 6 (and the rest of the units on the powerhouse) due to the higher flows into the gatewell generated by the ESBS and inlet flow vane. The VBSs in Unit 7 consisted of three removable sections (10.4-m-high) labeled A, B, and C from top to bottom, with each section consisting of 8, 1.3-m-high bar-screen panels (Fig. 3). A finely spaced (1.75 mm) bar screen on the panels was oriented perpendicular to flow (rather than parallel to flow as found on the ESBSs). The back of each bar screen panel is covered with either perforated or solid steel plate. The VBS for the test slots extends upward from the turbine intake ceiling beam to the intake deck.

The top four panels of the experimental VBS (section A in Fig. 3) are backed by solid plate, the next two panels with 15% porosity perforated plate, and the two panels following with 20% perforated plate. The top half of the first section is above water level (el. 265 ft) and sits in front of the concrete divider beam between the upstream and downstream gate slots (Fig. 2). The center of the VBS (section B in Fig. 3) has panels 1-2, 3-4, and 5-8 backed with 15, 18, and 20% perforated plate, respectively. The bottom section ©) has panels 1-2 backed with an 18% perforated plate, panels 3-6 backed with a 25% perforated plate, and panels 7-8 backed with solid plate.

Extended-length bar screens with inlet flow vanes similar to those tested during FGE tests in 1993 and 1994 at The Dalles Dam (Brege et al. 1994; Absolon et al. 1995) and in 1999 at John Day Dam (Brege et al. 2001) were used in the test slots. Unit 7, the test unit, had an ESBS with 25% porosity perforated plate, while the STS in Unit 6 had 48% porosity, the standard condition for the STS at John Day Dam. The bar screen surfaces of ESBSs for the 2002 tests at John Day Dam differed from earlier versions. They had been refitted with a finer spaced (1.75 mm) bar-screen surface prior to the test season in an effort to reduce impingement of fry and juvenile Pacific lamprey *Lampetra tridentata*.

Each FGE test lasted a minimum of 1 h, and typically began at 2000 (dusk), when fish lingering in the forebay are most likely to begin movement through the powerhouse (Brege et al. 1996). The FGE tests ended between 2100 and 2300, when it was estimated by gatewell dipnetting that the target number of fish (200 total) had been collected in the gatewell and fyke nets. Total numbers of fish collected were monitored by dipnetting the gatewells at 10- to 15-minute intervals during the test.

Past FGE studies have utilized fyke nets attached to a frame beneath the STS to collect unguided fish. With the ESBS, this is not possible because the screen framework fills the entire bulkhead slot of the turbine intake (Fig. 2). Therefore, a frame with fyke nets was installed in the downstream gate slot to collect unguided fish. Similar to studies at The Dalles Dam in 1993 and 1994, streamlined fyke-net frames and increased mesh opening on the fyke nets were used to reduce the effect of the frame on flow through the test unit.

Fyke nets were arranged in three columns (designated as left, middle, and right, as viewed from downstream) and eight levels (numbered from top to bottom) with the ESBSs (Fig. 2). The smaller nets at Level 8 are approximately one-third the size of nets at other levels and catch very few fish (Brege et al. 1994; Absolon et al. 1995; Appendix Table A1); therefore, the catch from Net-Level 8 was added to that of Net-Level 7 for comparisons to previous FGE studies, since most other studies cited seven net levels. Because the proportion of total fyke-net catch for each column cannot be reliably predicted with the ESBS, cod ends were placed on all 24 fyke nets used in FGE tests with these screens. The leading edge of the ESBS intercepts flow at approximately the same elevation as the bottom of Net Level 4 (Fig. 2).

Fish guidance efficiency tests with an ESBS were conducted in the center gate slot of Unit 7 during the spring and summer juvenile salmonid migration. As in 1999, there were no FGE tests conducted with an STS at John Day Dam in 2002. Thus fish guidance efficiency was measured only for the ESBS treatment, and confidence intervals for mean FGE were expressed as

$$\pm t_{0.025,\, n-1} \times \mathrm{SE}$$

where t corresponds to /2 = 0.05, df = number of tests in a series (n) minus one, and SE = SD/ $\overline{n}$. We examined normal probability plots to assess the adequacy of using the t statistic.

Test Unit 7 and adjacent units were operated at 155 MW, with an approximate discharge of 21,000 cfs during the test period. River flows were near normal during our test season. Hourly spill patterns at John Day Dam during May were determined by the experimental design of an ongoing hydroacoustic study to estimate fish passage through the spillway and powerhouse (Moursund et al. 2002). The study design called for spill regimes of 0% during the day (0600-1859) and 60% at night (1900-0559) or 30% day and 30% night arranged in two-day blocks. Total average river flows were 250 to 350 kcfs with spills of 60-130 kcfs during the 6 weeks of testing.

Results and Discussion

Testing for FGE began 28 May and ended 9 July, when the test unit (Unit 7) was disabled with mechanical problems (Appendix Table A1). Due to the late start of the FGE tests, we conducted only five tests on yearling migrants at the end of May. During the spring FGE tests, we handled 10 subyearling chinook salmon, 842 yearling chinook salmon, 149 steelhead, 34 coho salmon, and 470 sockeye salmon, for a total of 1,505 juvenile salmonids handled. Juvenile lamprey were captured incidentally during FGE tests. A summary of the lamprey catch is furnished in Appendix B.

Mean FGEs (with 95% confidence intervals) were 80.0% (±9.3) for yearling chinook salmon and 72.2% (±13.2) for sockeye salmon for the five spring tests. Coho salmon and steelhead were not present in sufficient numbers during the abbreviated test season for meaningful statistical calculations. Daily FGE for yearling chinook and sockeye salmon is shown in Figure 4. Yearling chinook salmon FGE was nearly identical to the 80.3% found in 1999 (Brege et al. 2001) and compared favorably with FGEs of 78 and 80% obtained with the ESBS at McNary Dam in 1991 and 1992 (Brege et al. 1992; McComas et al. 1993). These FGEs were higher than those measured at The Dalles Dam in 1993 (73%) and 1994 (69%) using ESBSs (Brege et al. 1994; Absolon et al. 1995).

Mean FGE for yearling chinook salmon was 80%, similar to the 84% measured at John Day Dam in 1996 and somewhat higher than the 72% estimated in 1985 using STSs with fyke nets deployed directly below the screens (Krcma et al. 1986). Daily sockeye salmon FGEs were similar to yearling chinook salmon throughout the test period.

FGE and percent catch by net level for all species are shown in Figure 5. For yearling chinook salmon, the largest catch was in Net-Level 5 (7.2%), followed by Net-Levels 2 and 4 (4.5% each). These results are similar to those seen in 1999, when the largest catch of yearling chinook salmon was in Net-Level 5 (5.1%), followed by Net-Levels 4 and 6 (3.5 and 3.3%, respectively). For sockeye salmon, the net-level catches were somewhat higher, but similar, for both 1999 and 2002. Coho salmon and steelhead catches were not included in Figure 5 due to low numbers. Overall, catches by net level for the 2002 season were similar to those found in 1996 and 1999.

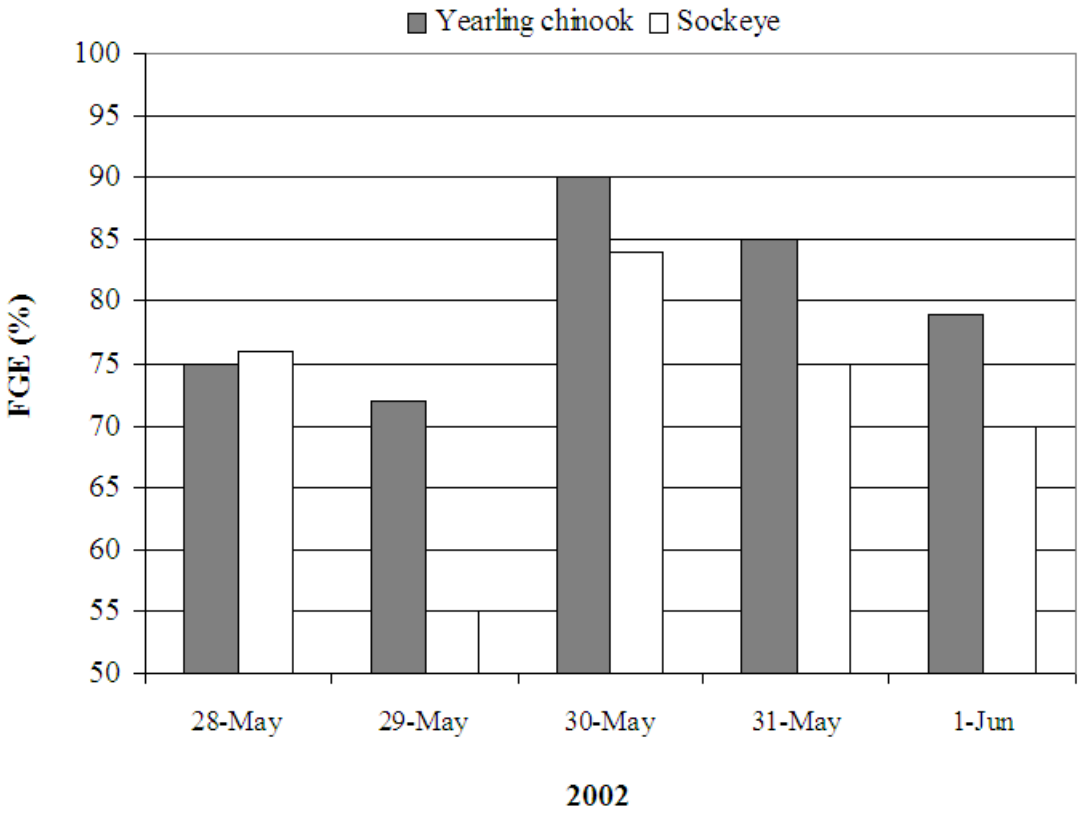
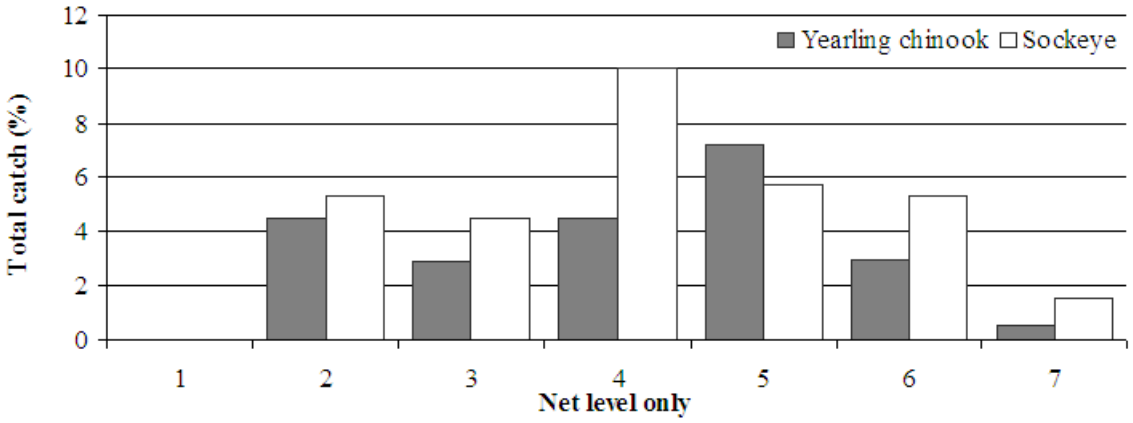


Figure 4. Daily fish guidance efficiency (FGE) for yearling chinook and sockeye salmon at John Day Dam, 2002.



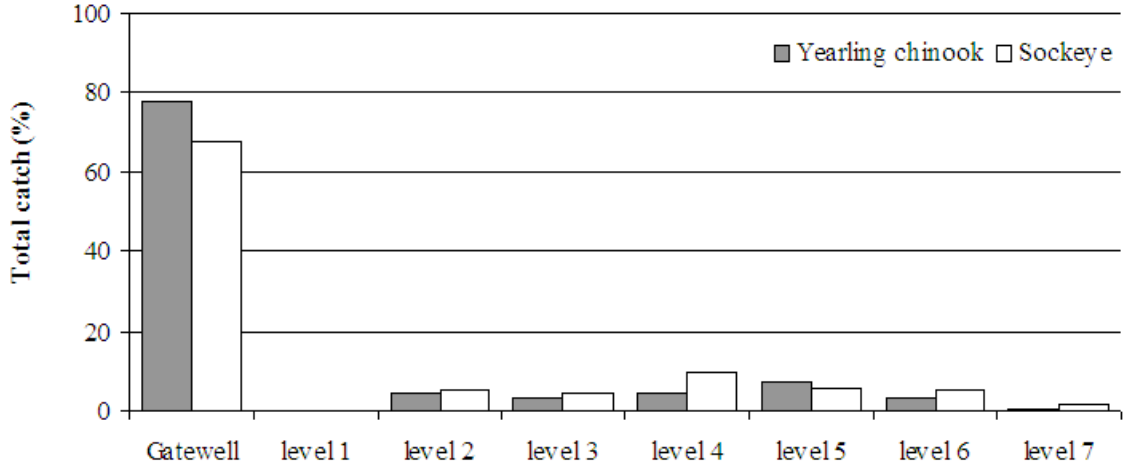


Figure 5. Seasonal catch by net level and by net level compared to gatewell catch during fish guidance efficiency tests for yearling chinook and sockeye salmon at John Day Dam, 2002. Gatewell indicates gatewell dipnet catch, Levels 1-7 indicate fyke-net catches (Level 1 is at the top and Level 7 at the bottom of the turbine intake).

Testing for FGE resumed on 17 June and targeted subyearling chinook salmon. Fourteen tests were completed by 9 July, when the series was discontinued due to mechanical problems with the turbine unit. During the summer FGE tests, we handled 4,638 subyearling chinook salmon, 57 yearling chinook salmon, 21 steelhead, 35 coho salmon, and 44 sockeye salmon, for a total of 4,795 juvenile salmonids.

Mean FGE (with 95% confidence intervals) was 63.7% (±5.8) for subyearling chinook salmon for the 14 tests. Other salmonid species were not present in adequate numbers for statistical evaluations. Daily FGE for subyearling chinook salmon is shown in Figure 6. Mean FGE for the ESBS in 2002 was slightly higher than the 60% found in 1996 (Brege et al. 1997). It was also comparable to the FGE of 64% at McNary Dam for the ESBS in 1991 (Brege et al. 1992) and 59% at The Dalles Dam in 1993 (Brege et al. 1994). The mean subyearling chinook salmon FGE of 63.7% was well above the FGE of 35% found in 1986 using the STS (Brege et al. 1987).

Percent catch by net level and FGE is shown in Figure 7. Similar to 1996, Net-Level 5 contained the largest catch; however, this net level contained a smaller percentage of the catch (9.9 vs. 13.9%) this season than in the earlier study. Larger catches of subyearling chinook salmon in the nets indicate that these fish pass through the turbine intakes at greater depths than yearling chinook salmon in the spring.

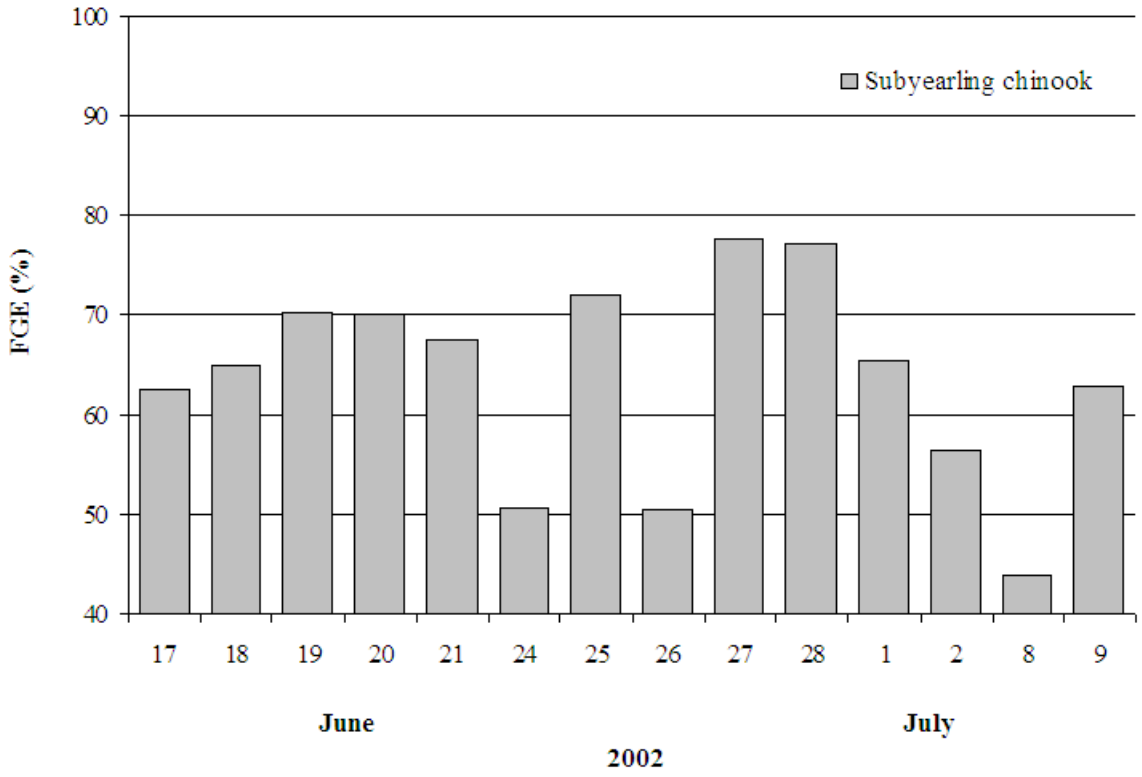


Figure 6. Daily fish guidance efficiency (FGE) for subyearling chinook salmon at John Day Dam, 2002.

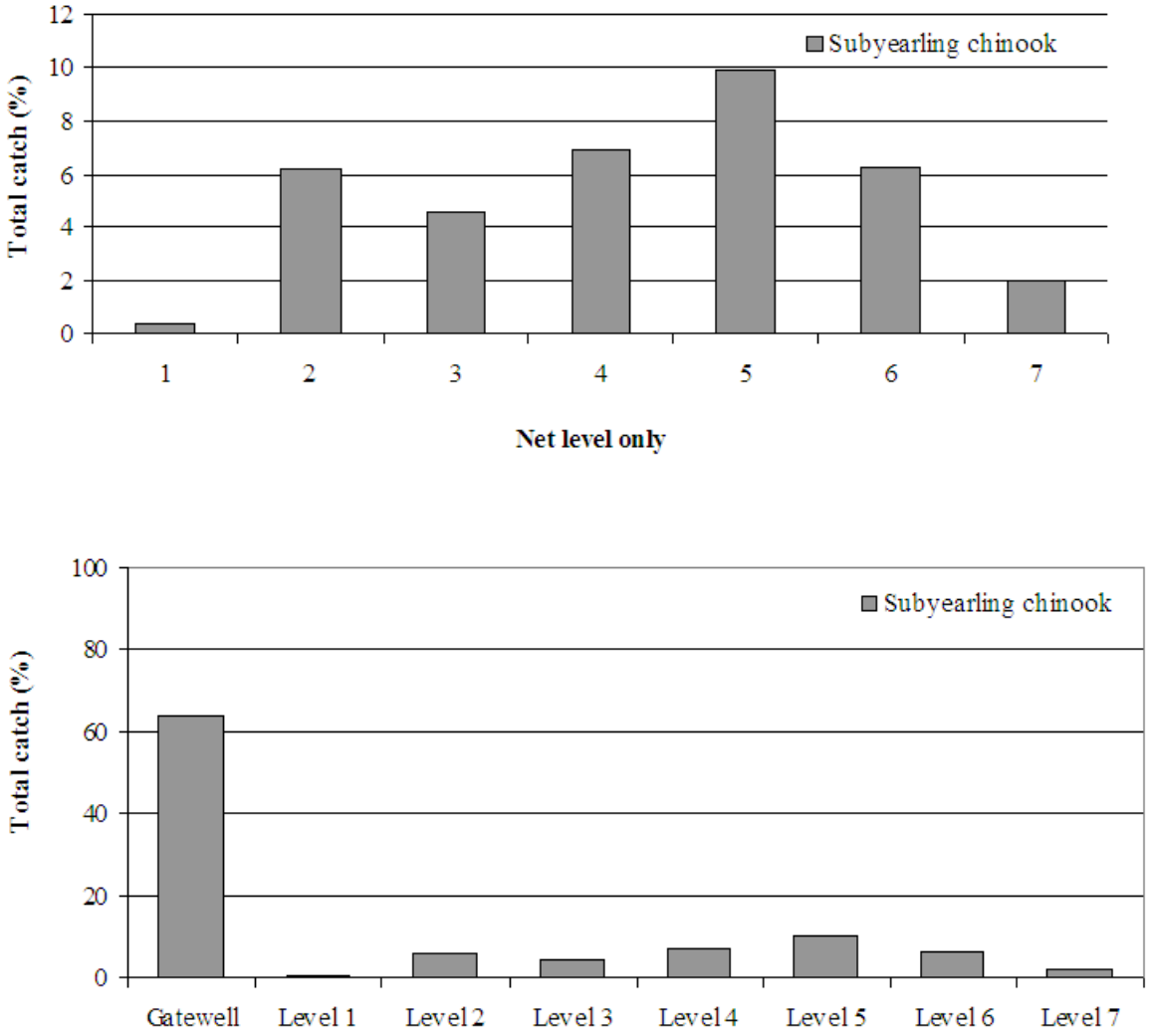


Figure 7. Seasonal catch by net level and by net level compared to gatewell catch during fish guidance efficiency (FGE) tests for subyearling chinook salmon at John Day Dam, 2002. Gatewell indicates gatewell dipnet catch, Level 1 through 7 indicate fyke net catches (Level 1 is at the top and Level 7 at the bottom of the turbine intake).

OBJECTIVE 3: Evaluate Orifice Passage Efficiency with an ESBS, Inlet Flow Vane, Modified VBS, and OFC

Approach

In 1994, the diameter of the orifice inserts at John Day Dam were increased from 30 to 35 cm (12 to 14 in). The orifices are located 1.1 m (3 ft 6 in) on center from the north end of each gate slot at elevation 76.4 m (250.5 ft) mean sea level. Normal operating pool for the reservoir is elevation 265.0 ft mean sea level. Depending on the resulting drawdown of the gatewell surface due to turbine operation, submergence of the juvenile fish bypass orifices is about 4.2 m (14 ft), which is deeper than at other Columbia and Snake River dams. The head differential between water in the juvenile fish bypass conduit and the forebay level was maintained at 1.4 m (4.5 ft). With a normal drawdown in the gatewell surface of 15 cm (0.5 ft) during turbine operation, the head differential between the gatewell and juvenile fish bypass channel is 1.2 m (4.0 ft).

A variety of methods have been used to measure OPE at John Day Dam. In 1999, we used an indirect method similar to that used in previous OPE studies with traveling screens at John Day Dam (Krcma et al. 1986, Brege et al. 1987). In 2002, we estimated OPE using PIT-tagged fish. Each day test slots (6B, 7B) were dipnetted, collected fish were anesthetized with tricaine methanesulfonate (MS-222) and examined for injury, and 100 juvenile salmonids per OPE replicate were PIT tagged.

Test fish were held in the release canister for 3 to 4 h to monitor short-term mortality. Fish that were obviously injured (descaled, torn fins, etc.) were not marked. Test fish were released in the center of the test gatewells, 30 ft (9.1 m) below the surface and allowed to exit the gatewells through the juvenile fish bypass orifice. The releases were made with a 240-L (63 gal.) cylindrical aluminum canister lowered in a steel frame as described by Absolon and Brege (2003).

In addition, for each OPE test, 50 PIT-tagged fish were released into the fingerling bypass channel to measure length of time for fish movement through the system. Detection of PIT-tagged fish at the SMF provided both OPE and passage times from release through the bypass system to the facility. In addition, PIT-tagged fish were sorted, diverted into a holding tank at the SMF to be examined for injury.

In 2002, FGE and OPE tests were conducted in the test units on the same days. At a specified time each test day, all fish were dipnetted from the gatewells (Swan et al. 1979). Turbine Unit 6 was operated continuously during the spring test period, while Turbine Unit 7 was operated from 2300 until 1800 h the next day for OPE tests, shut down from 1800 to 2000 h to lower the fyke-net frame into place, run from 2000 to 2130 h for the FGE test, shut down to raise the fyke-net frame and remove the catch, and restarted about 2300 h for the OPE test.

Since OPE tests were being conducted in the same slot as the FGE tests, OPE tests could not begin until FGE tests and associated short-term descaling tests in Slot 6B had concluded for the day. The time interval for OPE tests in the STS-equipped unit corresponded to the time interval for tests conducted in ESBS-equipped units, approximately 18 h. The median time needed to pass 10, 50, and 90% of the test fish that exited the gatewell was calculated. Differences in OPE and travel time statistics were analyzed using paired *t*-tests where pairs were the two treatments each day. We examined normality plots of the paired differences to assess whether the assumption of normality was reasonable for these sets of daily proportions.

Results and Discussion

Testing for OPE began 28 May and ended 8 July. Equipment installation delays limited us to only 5 OPE tests in the spring, and turbine unit failure decreased the summer effort to 12 tests. In 2002, using the PIT-tag method, we handled fewer fish on the intake deck than in previous years, since all fish recovered from the gatewells did not require anaesthetization to be physically examined. When enough fish had been recruited for tagging purposes, the remainder of the dip-netted fish were released into the collection channel. As they passed through a 4-in hose, PIT-tagged fish were detected via a detection ring surrounding the hose.

We handled 7,067 subyearling and 4,773 yearling chinook salmon, 282 steelhead, 127 coho salmon, and 2,202 sockeye salmon for a total of 14,451 juvenile salmonids (Appendix Table A4). We marked and released 3,397 subyearling and 1,753 yearling chinook salmon (included in the above count) during these tests. While examining PIT-tagged juveniles at the SMF, a total of 17,442 subyearling and 3,044 yearling chinook salmon, 760 steelhead, 202 coho salmon, and 1,294 sockeye salmon (22,742 total) were examined as bycatch (Appendix Table A3).

Mean OPE for yearling chinook salmon was 98.8% (SE = 0.7) with the ESBS (Slot 7B) and 87.6% (SE = 3.1) with the STS (Slot 6B). The difference in OPE between the two units, 11.2%, was significant ($t = 3.65$, $P = 0.022$). Daily OPE was consistently higher in the ESBS slot than in the STS slot (Fig. 8). The 2002 test results with the ESBS were similar to the 1999 yearling chinook salmon OPE of 97% (Brege et al. 2001), but were higher than that found at McNary Dam in 1995 when yearling chinook salmon OPEs were 79 and 78% for north and south orifices, respectively (McComas et al. 1997).

These OPEs are also higher than those observed at The Dalles Dam in 1995, when OPEs for west and east orifices using ESBSs were 80 and 68%, respectively (Brege et al. 1997). The mean OPE of 87.6% with STS for yearling chinook salmon was somewhat higher than the 72% recorded in 1985 (Krcma et al. 1986) and considerably higher than the 39.5% found in 1999 at John Day Dam (Brege et al. 2001).

Mean OPE for subyearling chinook salmon with the ESBS (Slot 7B) and the STS (Slot 6B) was 96.5% (SE = 1.1) and 88.1% (SE = 3.2), respectively. The difference in OPE between the two units, 8.4%, was significant ($t = 2.55$, $P = 0.027$). Daily OPE was consistently higher in the ESBS slot than in the STS slot from the beginning of the sample period through 26 June, but about the same for the remainder of the tests (Fig. 9).

Travel times for yearling and subyearling chinook salmon release groups are shown in Figures 10 and 11. Table 1 shows the 10th percentile, median, and 90th percentile passage times (in hours) for both species. Differences between the STS (6B) and ESBS gate slot (7B) are shown along with their statistical significance. Median and 90th percentile passage times were significantly shorter for juveniles exiting the gate slot fitted with the ESBS than the slot with the STS.

Table 1. Tenth percentile, median, and 90th percentile passage times for yearling and subyearling chinook salmon released to gate slots equipped with an STS (6B) and ESBS (7B). Shaded cells indicate significant difference ($P < 0.05$) in passage time between the STS and ESBS.

	Passage time (h)		
	10%	Median	90%
	Yearling chinook salmon		
Collection channel	0.09	0.18	0.55
ESBS (Slot 7B)	0.11	1.6	2.88
STS (Slot 6B)	0.17	9.54	21.38
Difference 6B/7B	0.06	7.94	18.50
t	1.37	2.52	6.46
P	0.242	0.065	0.003
	Subyearling chinook salmon		
Collection channel	0.07	0.10	0.30
ESBS (Slot 7B)	0.19	0.32	7.23
STS (Slot 6B)	0.09	1.58	14.22
Difference 6B/7B	-0.10	1.26	6.99
t	2.30	1.82	2.65
P	0.044	0.099	0.024

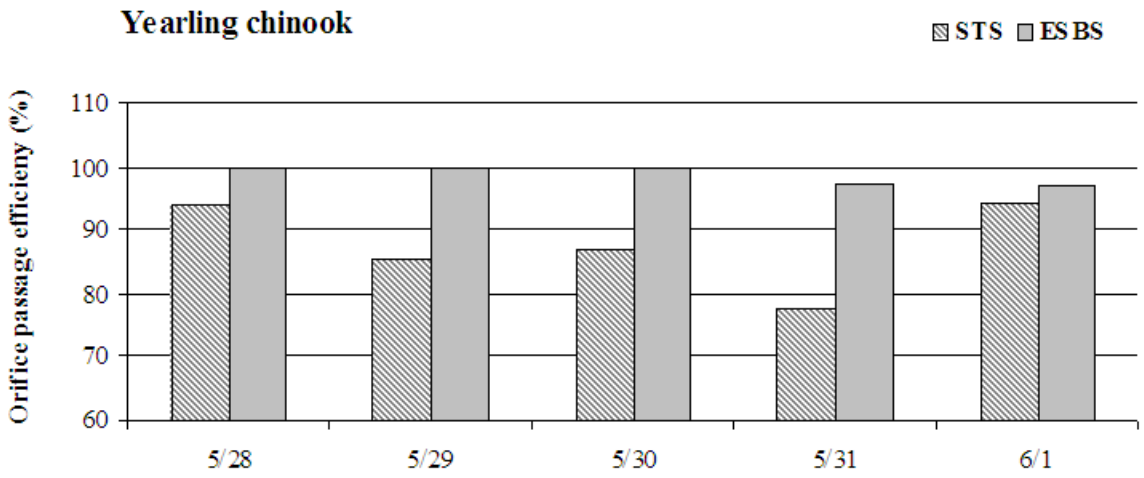


Figure 8. Daily orifice passage efficiency (OPE) for yearling chinook salmon at John Day Dam, 2002.

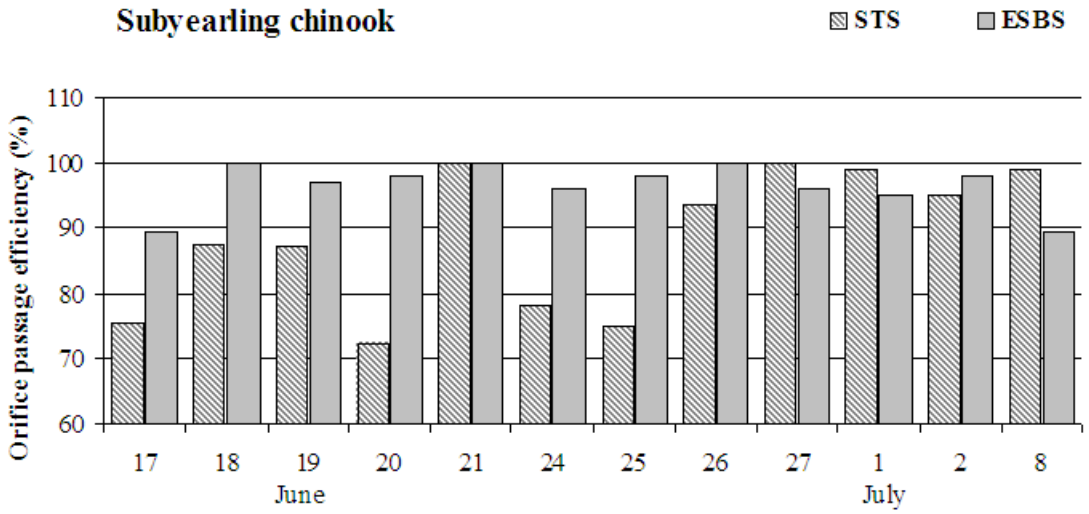


Figure 9. Daily orifice passage efficiency (OPE) for subyearling chinook salmon at John Day Dam, 2002.

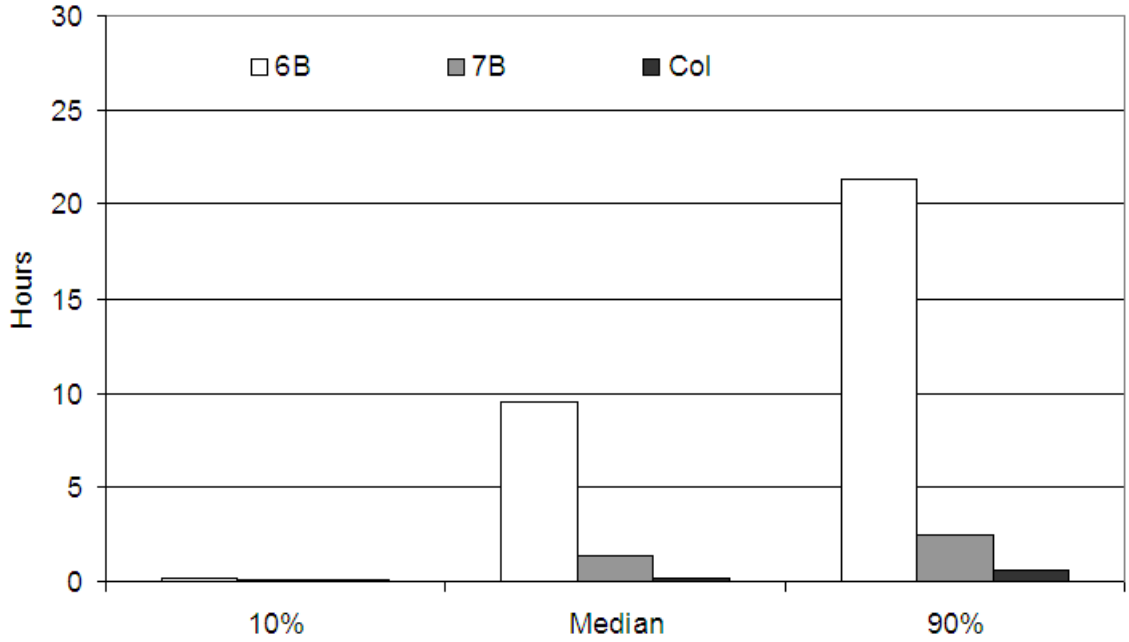


Figure 10. Mean fish passage times for yearling chinook salmon through gate slots with an STS (6B), an ESBS (7B), and the collection channel (COL) at John Day Dam, 2002.

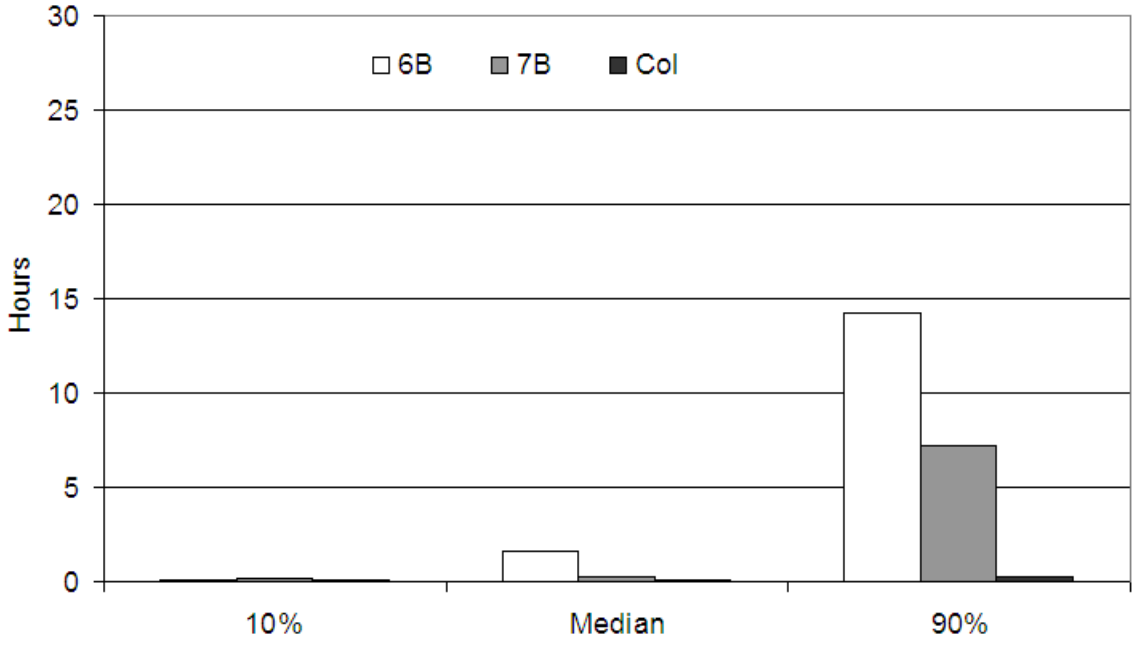


Figure 11. Mean fish passage times for subyearling chinook salmon through gate slots with an STS (6B), an ESBS (7B), and the collection channel (COL) at John Day Dam, 2002.

OBJECTIVE 4: Evaluate the Effects of an ESBS used with an Inlet Flow Vane, Modified VBS, and OFC on Juvenile Salmonid Descaling

Approach

Fish condition during FGE and OPE tests was monitored using standard Fish Transportation Oversight Team descaling criteria (Ceballos et al. 1993). Fish condition in the STS slot (6B) was compared to fish condition during the FGE test in the ESBS slot (7B) during the same time period. In addition, fish condition was evaluated for PIT-tagged fish that left the gatewell via the bypass orifice during OPE tests and were collected at the SMF. Captured fish were anesthetized with MS-222, identified by species, examined, and enumerated. Mortalities and head injuries such as folded operculums and eye injuries were also recorded.

Results and Discussion

Fish condition was acceptable and low for fish dipnetted from the ESBS and STS gate slots during FGE tests. Mean descaling of yearling chinook salmon in spring was 4% for the ESBS and 6% for the STS; mean descaling of subyearling chinook salmon in the summer was 1% for the ESBS and 2% for the STS. Detailed descaling data for fish captured during FGE tests is shown in Appendix Table A1.

Fish condition was very good for marked fish recovered at the SMF during the OPE studies. For yearling chinook salmon, descaling was 0% for all three release groups: the ESBS slot, the STS slot, and the collection channel (Appendix Table A2). For subyearling chinook salmon, descaling was 0.6, 0.9, and 0.3% for the ESBS slot, STS slot, and collection channel, respectively. As previously mentioned, these fish were preselected for condition (i.e., not descaled) prior to tagging and release.

Mortality of PIT-tagged yearling chinook salmon was low at 0.1, 0.2, and 0.3% for the ESBS slot, STS slot, and collection channel, respectively. Mortality of PIT-tagged subyearling chinook salmon was also low at 0.1, 0, and 0.5%, respectively (Appendix Table A2). Descaling and mortality did not increase at the SMF as was observed in 1999, indicating that the new VBS improved hydraulic conditions in the gatewell. The outlet flow control device was not deployed during the FGE/OPE tests because descaling and mortality were low during initial fish condition tests and remained low throughout the remaining test series.

CONCLUSIONS

Yearling Chinook Salmon

1) Mean FGE for yearling chinook salmon was 80.0% (±9.3) using the ESBS (Slot 7B) with a modified perforated plate, a bar screen with 1.75-mm bar spacing, an inlet flow vane, and the redesigned VBS, which was also equipped with bar screen with 1.75-mm spacing.

2) Mean OPE for yearling chinook salmon was 98.8% (SE = 0.7) in the gate slot equipped with an ESBS (7B) and the associated guidance devices described above. Mean OPE was 87.6% (SE = 3.1) in the STS gate slot (6B). The 11.2% difference in OPE between the two units was significant ($t = 3.65$, $P = 0.022$).

3) Mean yearling chinook salmon descaling was 4% using the ESBS (Slot 7B) and associated guidance devices and 6% using the STS (Slot 6B) during FGE tests.

4) Mortality of PIT-tagged yearling chinook salmon released during OPE tests was low, at 0.1, 0.2, and 0.3% for the ESBS slot, STS slot, and the collection channel, respectively.

5) Median and 90th percentile passage times for yearling chinook salmon were shorter for fish exiting the gate slot fitted with an ESBS (7B) than those exiting the slot fitted with an STS (6B). The 7.94-h difference in median travel time was not significant ($t = 2.52$, $P = 0.065$), but the 18.50-h difference in the 90th percentile passage time was significant ($t = 6.46$, $P = 0.003$).

Subyearling Chinook Salmon

1) Mean FGE for subyearling chinook salmon was 63.8% (±5.8) using the ESBS (Slot 7B) with a modified perforated plate, a bar screen with 1.75-mm bar spacing, an inlet flow vane, and the redesigned VBS, which was also equipped with bar screen with 1.75-mm spacing.

2) Mean OPE for subyearling chinook salmon was 96.5 (SE = 1.1) using the ESBS (Slot 7B) and associated guidance equipment described above and 88.1% (SE = 3.2) using the STS (Slot 6B). The 8.4% difference in OPE between the two units was significant ($t = 2.55$, $P = 0.027$).

3) Mean subyearling chinook salmon descaling was 1% with the ESBS (Slot 7B) and associated guidance devices and 2% with the STS (Slot 6B) during FGE tests.

4) Mortality of PIT-tagged subyearling chinook salmon released during OPE tests was also low, at 0.1, 0, and 0.5% for the ESBS slot, STS slot, and the collection channel, respectively.

5) Median and 90th percentile passage times were shorter for subyearling chinook salmon exiting Slot 7B (ESBS) than Slot 6B (STS). The 1.26-h difference in median travel time was not significant ($t = 1.82$, $P = 0.099$), but the 6.99-h difference in 90th percentile passage time was significant ($t = 2.65$, $P = 0.024$).

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APPENDIX A

Data Tables

Appendix Table A1. Numbers of fish caught, by species, and fyke-net catch distribution for individual replicates of fish guidance efficiency (FGE) tests at John Day Dam, 2002. L, M, and R indicate the left, middle, and right column of the fyke net; T indicates total catch for net levels.

	Subyearling chinook				Yearling chinook				Steelhead				Coho				Sockeye			
Location	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T
28 May																				
Level 1																				
Level 2					2	7		9	2	2		4					8	1		9
Level 3					4	3	3	10	1			1						2	4	6
Level 4					3	2	5	10	1			1					4	4	4	12
Level 5					8	6	6	20	1			1							2	2
Level 6					4	2	2	8	2			2						1		1
Level 7							1	1									1			1
Level 8																				
Net total					21	20	17	58	7	2		9					5	4	3	12
Gatewell								171				82				5				101
Total								229				91				5				132
FGE (%)								74.7				90.1				100				76.5
Des (%)								5.3				14.6				20				38.6
29 May																				
Level 1											1	1								
Level 2					6	4	7	17	1			1					5	4	1	10
Level 3					3	3	3	9	1		1	2					4		6	10
Level 4					9	6	7	22									8	10	10	28
Level 5					4	4	9	17									2	8	7	17
Level 6	1			1	4	4	3	11			1	1					5	8	6	19
Level 7																	1		4	5
Level 8																				
Net total	1			1	26	21	29	76	2	0	3	5					25	30	34	89
Gatewell				2				192				21				11				110
Total				3				268				26				11				199
FGE (%)				66.7				71.6				80.8				100				55.3
Des (%)								5.2				9.5				0				16.4
30 May																				
Level 1																				
Level 2					1	2	1	4	1	2	1	4					1	1	1	3
Level 3																	3			3
Level 4																	1		2	3
Level 5					2		2	4									1			1
Level 6																				
Level 7							2	2												
Level 8																				
Net total					3	2	5	10	1	2	1	4					6	1	3	10
Gatewell							7	91			3	7				3				52
Total								101				11				3				62
FGE (%)								90				63.6				100				83.9
Des (%)								2.2				0				0				26.9

Appendix Table A1. Continued.

	Subyearling chinook				Yearling chinook				Steelhead				Coho				Sockeye			
Location	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T
31 May																				
Level 1																				
Level 2					2	1		3	1			1								
Level 3						1		1												
Level 4					2			2												
Level 5	1		1	2	3		2	5									1	1		2
Level 6					1	2		3									1	1		2
Level 7																	1			1
Level 8																				
Net total	1		1	2	8	4	2	14	1			1					3	2		5
Gatewell				1				80				4				1				15
Total				3				94				5				1				20
FGE (%)				33.3				85.1				80				100				75
Des (%)								3.8												13.3
1 June																				
Level 1										1		1								
Level 2					2	1	2	5		1	1	2					1		2	3
Level 3					1		3	4										1	1	2
Level 4					2	1	1	4									3		1	4
Level 5					5	3	7	15							1	1	3	1	1	5
Level 6						1	2	3						1		1	2	1		3
Level 7							1	1			1	1								
Level 8																				
Net total					10	6	16	32		2	2	4		1	1	2	9	3	5	17
Gatewell				4				118				12				12				40
Total				4				150				16				14				57
FGE (%)				100				78.7				75				85.7				70.2
Des (%)				25				5.1												7.5
17 June																				
Level 1			1	1																
Level 2	6	1		7													1			1
Level 3	7	2	2	11	1			1	1			1						1		1
Level 4	3	5	2	10		1	1	2									1			1
Level 5	3	2	3	8	3			3									1			1
Level 6	1	5	2	8	2			2												
Level 7	1		1	2																
Level 8	1			1													1			1
Net total	22	15	11	48	6	1	1	8	1			1					4	1		5
Gatewell				80				22								5				4
Total				128				30				1				5				9
FGE (%)				62.5				73.3								100				44.4
Des (%)								4.55								20				

Appendix Table A1. Continued.

	Subyearling chinook				Yearling chinook				Steelhead				Coho				Sockeye			
Location	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T
18 June																				
Level 1																				
Level 2	2	4		6													1			1
Level 3	5	4	2	11														1		1
Level 4	8	8	8	24																
Level 5	6	13	8	27	1			1												
Level 6	3	10	4	17	2			2									1	1	1	3
Level 7		2	2	4	1			1							1	1				
Level 8			1	1																
Net total	24	41	25	90	4			4							1	1	2	2	1	5
Gatewell				167				7				3				2				6
Total				257				11				3				3				11
FGE (%)				65				63.6				100				66.7				54.5
Des (%)																				33.3
19 June																				
Level 1	1		2	3																
Level 2	6	9	5	20										1		1	1			1
Level 3	4	2		6														1		1
Level 4	7	8	9	24																
Level 5	12	9	4	25														1		1
Level 6	12	9	4	25																
Level 7	2		5	7																
Level 8	1			1																
Net total	45	37	29	111										1		1	1	2		3
Gatewell				262				8				5				11				6
Total				373				8				5				12				9
FGE (%)				70.2				100				100				91.7				66.7
Des (%)																9.09				
20 June																				
Level 1																				
Level 2	12	13		25							1	1								
Level 3	8	1	6	15					1			1								
Level 4	7	6	10	23																
Level 5	5	10	6	21																
Level 6	2	6	2	10																
Level 7		1		1																
Level 8																				
Net total	34	37	24	95					1		1	2								
Gatewell				223				3				5				1				3
Total				318				3				7				1				3
FGE (%)				70.1				100				71.4				100				100
Des (%)				0.45																

Appendix Table A1. Continued.

	Subyearling chinook				Yearling chinook				Steelhead				Coho				Sockeye			
Location	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T
21 June																				
Level 1	1			1																
Level 2	11	7	2	20					1			1	1			1				
Level 3	8	3	5	16																
Level 4	5	8	6	19																
Level 5	15	4	4	23																
Level 6	5	5	1	11						1		1		1		1				
Level 7	3			3																
Level 8		1	1	2																
Net total	48	28	19	95					1	1		2	1	1		2				
Gatewell				196				1				1				4				1
Total				291				1				3				6				1
FGE (%)				67				100				33.3				66.7				100
Des (%)				1.02																
24 June																				
Level 1	1		1	2																
Level 2	14	14	3	31																
Level 3	8	4	11	23																
Level 4	11	11	9	31											1	1				
Level 5	17	13	15	45																
Level 6	12	14	8	34																
Level 7	5	2	1	8																
Level 8		1		1																
Net total	68	59	48	175											1	1				
Gatewell				180				1				2				2				3
Total				355				1				2				3				3
FGE (%)				50.7				100				100				66.7				100
Des (%)																				
25 June																				
Level 1	1	1		2																
Level 2	8	7	1	16																
Level 3	9	3	11	23																
Level 4	13	15	14	42																
Level 5	11	18	15	44																
Level 6	9	7		16																
Level 7	1	2	1	4																
Level 8		1		1																
Net total	52	54	42	148																
Gatewell				382																
Total				530																
FGE (%)				72.1																
Des (%)				1.8																

Appendix Table A1. Continued.

	Subyearling chinook				Yearling chinook				Steelhead				Coho				Sockeye			
Location	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T
26 June																				
Level 1																				
Level 2	17	11	103																	
			8																	
Level 3	10	9	10	29																
Level 4	16	10	19	45																
Level 5	23	48	19	90																
Level 6	22	20		42																
Level 7	6	7	4	17																
Level 8	1	1	1	3																
Net total	95	106	63	264																
Gatewell				269				2												1
Total				533				2												2
FGE (%)				50.5				100												100
Des (%)				0.4																
27 June																				
Level 1			5	5																
Level 2	21	13	10	44																
Level 3	6	2	1	9																
Level 4	3	3	3	9																
Level 5	2	5	7	14																
Level 6	3	3	2	8																
Level 7		2	2	4																
Level 8		2		2																
Net total	35	30	30	95																
Gatewell				333																
Total				428																
FGE (%)				78																
Des (%)				1.2																
28 June																				
Level 1	1	1		2																
Level 2	9	7		16																
Level 3	4	1	5	10																
Level 4	7	1	4	12																
Level 5	3	7	6	16																
Level 6	2	4	2	8																
Level 7																				
Level 8		1		1																
Net total	26	22	17	65																
Gatewell				218																1
Total				283																1
FGE (%)				77.0																100
Des (%)																				

Appendix Table A1. Continued.

	Subyearling chinook				Yearling chinook				Steelhead				Coho				Sockeye			
Location	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T
01 July																				
Level 1	1			1																
Level 2	11	9	1	21																
Level 3	10	5	7	22																
Level 4	11	5	7	23																
Level 5	12	15	13	40																
Level 6	9	12	5	26																
Level 7	2	4	1	7																
Level 8			3	3																
Net total				143																
Gatewell				272																
Total				415																
FGE (%)				66																
Des (%)				0.74																
2 July																				
Level 1																				
Level 2	8	5	2	15																
Level 3	4	1	5	10																
Level 4	4	6	8	18																
Level 5	3	9	6	18																
Level 6	11	4	2	17																
Level 7	3	1	2	6																
Level 8																				
Net total	33	26	25	84																
Gatewell				109																
Total				193																
FGE (%)				56.5																
Des (%)																				
8 July																				
Level 1																				
Level 2	9	8	7	24																
Level 3	6	10	5	21																
Level 4	6	15	12	33																
Level 5	20	19	25	64																
Level 6	14	20	17	51																
Level 7	6		5	11																
Level 8	2	1		3																
Net total	63	73	71	207																
Gatewell				162				1								5				2
Total				369				1								5				4
FGE (%)				43.9				100								100				50
Des (%)				0.62				100												50

Appendix Table A1. Continued.

	Subyearling chinook				Yearling chinook				Steelhead				Coho				Sockeye			
Location	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T	L	M	R	T
									9 July											
Level 1																				
Level 2	1	1	2	4																
Level 3	3	2	3	8															1	1
Level 4		2	3	5																
Level 5	11	5	6	22																
Level 6	11	7	2	20																
Level 7	1			1																
Level 8		1		1																
Net total	27	18	16	61																1
Gatewell				104																1
Total				165																2
FGE (%)				63																50
Des (%)				.96																

Appendix Table A2. Numbers of fish caught and condition for individual replicates of orifice passage efficiency (OPE) tests at John Day Dam, 2002.

Date	File[a] name	Temp. (°C)	Release time	No. tagged	No. morts	No. re-leased	Smolt Monitoring Facility Recaps	Morts	Desc	Desc (%)	Gate-well recaps	OPE (%)
5/8	128.COL	11.0	14:58	50	0	50	33	0	0	0	na[b]	na
5/9	129.COL	12.0	14:59	50	0	50	48	0	0	0	na	na
5/28	148.COL	15.1	23:39	52	0	52	46	0	0	0	na	na
5/29	149.COL	14.9	23:12	52	0	52	52	1	0	0	na	na
5/30	150.COL	15.1	22:45	56	1	55	55	0	0	0	na	na
5/31	151.COL	15.1	22:53	54	0	54	51	0	0	0	na	na
6/1	152.COL	15.8	23:08	58	3	55	52	0	0	0	na	na
5/28	148.6B	15.1	23:10	100	0	100	86	0	0	0	6	94.0
5/29	149.6B	14.9	23:42	110	0	110	86	1	0	0	16	85.5
5/30	150.6B	15.1	22:17	106	1	105	84	0	0	0	14	86.7
5/31	151.6B	15.1	22:25	108	1	107	79	0	0	0	24	77.6
6/1	152.6B	15.8	23:54	109	1	108	84	0	0	0	6	94.4
5/22	142.7B	13.0	20:12	106	0	106	102	0	3	2.9	0	100
5/23	143.7B	14.0	19:02	105	6	99	92	0	1	1.1	0	100
5/24	144.7B	14.5	19:04	106	0	106	98	0	5	5.1	0	100
5/28	148.7B	15.1	23:23	109	0	109	92	1	0	0	0	100
5/29	149.7B	14.9	22:55	110	0	110	97	0	0	0	0	100
5/30	150.7B	15.1	22:28	100	0	100	96	0	0	0	0	100
5/31	151.7B	15.1	22:26	105	0	105	99	0	0	0	3	97.1
6/1	152.7B	15.8	23:04	107	9	98	93	0	0	0	3	96.9
6/17	168.COL	16.1	01:50	55	0	55	44	0	0	0	na	na
6/18	169.COL	16.0	23:05	56	0	56	55	0	0	0	na	na
6/19	170.COL	17.0	21:36	52	0	52	50	2	0	0	na	na
6/20	171.COL	16.8	22:36	49	0	49	46	0	1	2.2	na	na
6/21	172.COL	17.1	22:29	50	0	50	48	0	0	0	na	na
6/24	175.COL	17.0	23:41	50	0	50	48	0	0	0	na	na
6/25	176.COL	17.0	23:07	51	0	51	50	0	0	0	na	na
6/26	177.COL	17.8	23:47	54	0	54	54	0	0	0	na	na
6/27	178.COL	17.8	22:56	51	0	51	50	0	0	0	na	na
6/28	179.COL	18.0	22:49	50	0	50	45	1	1	2.2	na	na
7/1	182.COL	18.2	23:49	53	0	53	47	0	0	0	na	na
7/2	183.COL	18.6	21:36	52	0	52	52	0	0	0	na	na
7/8	189.COL	17.8	00:21	53	0	53	47	0	0	0	na	na
6/17	168.6B	16.1	01:15	110	0	110	77	0	0	0	27	75.5
6/18	169.6B	16.0	22:35	104	0	104	87	0	0	0	13	87.5
6/19	170.6B	17.0	21:26	105	0	105	81	0	0	0	19	81.9
6/20	171.6B	16.8	22:07	105	0	105	74	0	0	0	29	72.4
6/21	172.6B	17.1	22:08	105	0	105	95	0	7	7.4	0	100
6/24	175.6B	17.0	22:12	105	0	105	74	0	0	0	23	78.1
6/25	176.6B	17.0	21:42	104	0	104	65	0	3	4.6	26	75.0
6/26	177.6B	17.8	22:22	106	0	106	92	0	0	0	7	93.4

Appendix Table A2. Continued.

Date	File[a] name	Temp. (°C)	Release time	No. tagged	No. morts	No. re-leased	Smolt Monitoring Facility Recaps	Morts	Desc	Desc (%)	Gate-well recaps	OPE (%)
6/27	178.6B	17.8	22:32	103	0	103	83	0	0	0	0	100
6/28	179.6B	18.0	22:25	105	0	105	61	0	0	0	---	---
7/1	182.6B	18.2	23:22	102	0	102	93	0	0	0	1	99.0
7/2	183.6B	18.6	23:13	105	0	105	100	0	0	0	5	95.2
7/8	189.6B	17.8	23:58	105	0	105	75	0	0	0	1	99.0
6/17	168.7B	16.1	01:31	105	0	105	80	0	0	0	11	89.5
6/18	169.7B	16.0	22:43	106	0	106	86	0	0	0	0	100
6/19	170.7B	17.0	21:26	105	0	105	72	0	0	0	3	97.1
6/20	171.7B	16.8	22:15	105	0	105	85	0	0	0	2	98.1
6/21	172.7B	17.1	22:17	105	0	105	95	0	5	5.3	0	100
6/24	175.7B	17.0	23:24	105	0	105	63	0	0	0	4	96.2
6/25	176.7B	17.0	22:52	102	0	102	86	0	0	0	2	98.0
6/26	177.7B	17.8	23:31	105	0	105	93	0	0	0	0	100
6/27	178.7B	17.8	22:40	105	0	105	88	1	2	2.3	4	96.2
6/28	179.7B	18.0	22:33	105	0	105	63	0	0	0	---	---
7/1	182.7B	18.2	23:32	102	1	101	89	0	0	0	5	95.0
7/2	183.7B	18.6	23:22	103	0	103	80	0	0	0	2	98.1
7/8	189.7B	17.8	00:06	104	0	104	80	0	1	1.2	11	89.4

a File name consists of the Julian date followed by the release site, either COL for collection channel, 6B for Slot 6B (STS), or 7B for Slot 7B (ESBS).

b na indicates not applicable since test fish were released into the collection channel, ie. there are no gatewell recaptures or OPE calculations.

Appendix Table A3. Numbers of fish caught, by species, during separation by code operations at the smolt monitoring facility at John Day Dam, 2002.

Date	Tank (E or W)	Tagged recaptures	Yearling chinook	Chinook fry	Subyearling Chinook	Coho	Steelhead	Sockeye
5/8	W	32	24	0	0	1	1	2
5/8	E	3	41	0	0	1	2	4
5/8	W	22	13	0	0	0	1	2
5/8	E	1	24	0	0	1	2	4
5/8	W	7	7	0	0	0	0	0
5/8	E	2	17	0	0	0	0	0
5/8	W	3	4	0	0	1	0	0
5/9	W	53	77	0	0	1	7	6
5/9	E	2	31	0	0	0	4	3
5/9	W	1	2	0	0	0	0	0
5/22	E	1	13	0	0	9	2	27
5/22	W	110	82	0	0	1	7	180
5/22	E	8	55	0	0	0	12	178
5/22	W	0	0	0	0	0	1	0
5/23	W	62	40	0	0	0	4	22
5/23	E	11	53	0	0	0	4	28
5/23	W	39	47	0	0	1	11	118
5/23	E	5	40	0	0	0	2	92
5/23	W	3	3	0	0	0	1	2
5/23	E	0	4	0	0	0	0	3
5/24	W	50	52	0	0	0	6	14
5/24	E	3	36	0	0	0	4	27
5/24	W	55	52	0	0	0	6	14
5/24	E	13	36	0	0	0	6	52
5/25	E	0	5	0	0	0	0	3
5/25	W	5	1	0	0	0	0	1
5/28	W	161	135	0	0	2	158	14
5/28	E	10	87	0	0	1	78	25
5/28	W	0	7	0	0	0	0	2
5/28	E	2	9	0	0	0	13	0
5/28	W	89	117	0	0	0	32	19
5/28	E	20	103	0	0	1	31	10
5/29	W	186	121	1	0	0	30	60

Appendix Table A3. Continued.

Date	Tank (E or W)	Tagged recaptures	Yearling chinook	Chinook fry	Subyearling Chinook	Coho	Steelhead	Sockeye
5/29	E	10	91	0	0	1	18	22
5/29	W	0	3	0	0	0	1	1
5/29	E	0	2	0	0	0	0	0
5/29	W	35	39	0	0	1	4	10
5/29	E	4	26	0	0	0	5	5
5/30	W	22	35	0	0	0	2	20
5/30	E	0	25	0	0	0	4	12
5/30	W	250	269	0	0	3	34	62
5/30	E	16	166	0	0	6	27	43
5/30	W	26	109	0	0	0	5	4
5/30	E	7	91	0	0	6	1	5
5/30	W	10	20	0	0	0	0	1
5/30	E	5	21	0	0	3	1	2
5/31	W	141	109	0	0	5	12	17
5/31	E	1	89	0	0	4	12	12
5/31	W	3	50	0	0	0	0	0
5/31	W	83	37	0	0	1	13	4
5/31	E	5	22	0	0	5	6	6
5/31	W	38	55	0	0	1	3	18
5/31	E	3	5	0	0	3	2	6
5/31	W	1	1	0	0	0	0	1
6/1	W	228	233	0	0	33	48	35
6/1	E	12	97	0	0	89	29	13
6/1	W	2	1	0	0	0	0	0
6/1	W	27	39	0	0	4	3	1
6/1	E	3	34	0	0	3	4	7
6/1	W	25	23	0	0	1	4	8
6/1	E	0	14	0	0	10	3	4
Spring Totals		1,916	3,044	1	0	199	666	1,231

Appendix Table A3. Continued.

Date	Tank (E or W)	Tagged recaptures	Yearling chinook	Chinook fry	Subyearling Chinook	Coho	Steelhead	Sockeye
6/17	W	132	0	0	97	0	4	1
6/17	E	1	0	1	56	0	1	1
6/17	W	14	0	0	13	0	1	0
6/17	E	0	0	0	2	0	0	0
6/17	W	48	0	0	8	0	0	0
6/17	W	34	0	0	40	0	2	1
6/17	E	0	0	0	28	0	1	1
6/18	W	208	0	0	356	0	12	5
6/18	W	17	0	0	22	0	2	1
6/18	W	21	0	0	202	0	2	4
6/19	W	177	0	0	490	0	14	9
6/19	E	0	0	0	25	0	0	0
6/19	W	23	0	0	31	0	2	0
6/19	W	27	0	0	183	0	1	2
6/19	E	1	0	0	104	0	0	0
6/20	W	168	0	0	458	0	19	7
6/20	W	63	0	0	230	0	2	4
6/20	W	6	0	0	20	1	0	0
6/20	E	0	0	0	21	0	2	0
6/21	W	204	0	0	468	0	7	4
6/21	E	0	0	0	229	0	0	5
6/21	W	2	0	0	5	0	0	0
6/21	W	33	0	0	157	1	1	0
6/24	W	141	0	0	324	0	2	2
6/24	E	1	0	0	171	0	1	0
6/24	W	12	0	0	29	0	0	0
6/24	E	0	0	0	21	0	0	0
6/25	W	57	0	0	286	0	1	0
6/25	E	0	0	2	179	0	0	0
6/25	W	149	0	0	423	0	3	0
6/25	E	1	0	0	224	0	3	0
6/25	W	3	0	0	1	0	0	0
6/25	E	0	0	0	6	0	0	0
6/26	W	74	0	0	339	0	2	0
6/26	E	0	0	0	188	0	0	0

Appendix Table A3. Continued.

Date	Tank (E or W)	Tagged recaptures	Yearling chinook	Chinook fry	Subyearling Chinook	Coho	Steelhead	Sockeye
6/26	W	195	0	3	1,332	0	1	3
6/26	E	2	0	0	667	0	0	0
6/27	W	56	0	0	889	0	3	0
6/27	E	1	0	0	643	0	1	0
6/27	W	200	0	0	2,279	0	0	0
6/27	E	2	0	0	1161	0	0	0
6/27	W	3	0	0	27	0	0	1
6/28	W	31	0	0	137	0	0	0
6/28	E	0	0	0	152	0	0	0
6/28	W	163	0	0	886	0	1	1
6/28	E	1	0	0	485	0	0	1
6/28	W	11	0	0	19	0	0	0
6/28	E	0	0	0	17	0	0	0
7/1	W	60	0	0	121	0	0	0
7/1	E	2	0	0	188	0	0	0
7/1	W	160	0	0	672	0	0	0
7/1	E	1	0	0	358	0	0	0
7/1	W	7	0	0	17	0	0	0
7/1	E	0	0	0	8	0	0	0
7/2	W	66	0	0	161	0	0	0
7/2	E	0	0	0	116	0	2	0
7/2	W	179	0	0	490	0	1	1
7/2	E	2	0	0	228	0	0	0
7/3	W	59	0	0	105	0	0	0
7/3	E	0	0	0	100	0	0	0
7/8	W	137	0	0	142	0	0	0
7/8	E	2	0	0	124	0	0	0
7/8	W	9	0	0	13	0	0	0
7/8	E	0	0	0	6	0	0	0
7/9	W	71	0	0	113	0	0	0
7/9	E	0	0	0	100	1	0	0
7/9	W	213	0	0	203	0	0	0
7/9	E	1	0	0	43	0	0	0
7/10	W	8	0	0	2	0	0	0
7/10	E	0	0	0	2	0	0	0
Summer Totals		3,259	0	6	17,442	3	94	53

Appendix Table A4. Numbers of fish caught, by species, during gatewell cleanout and recruitment dipnetting for OPE at John Day Dam, 2002.

Date	Gatewell dipped	Activity[a]	Yearling chinook	Chinook fry	Subyearling Chinook	Coho	Steelhead	Sockeye
5/8	8B	CC Rel	145	0	0	2	25	48
5/9	8B	CC Rel	90	0	0	5	16	21
5/22	8B	FC7B	121	0	0	0	43	1,036
5/23	8B	FC7B	305	0	0	3	0	34
5/24	8B	FC7B	229	0	0	4	7	92
5/28	8B	RecM	460	0	1	8	33	166
	6B	Desc	98	0	0	2	17	34
5/29	6B	OPE	657	0	2	3	29	58
	6B	Desc	80	0	1	2	5	13
	7B	OPE	85	0	0	1	10	10
5/30	6B	OPE	351	0	5	1	3	78
	6B	Desc	113	0	0	0	2	20
	7B	OPE	338	0	6	5	11	20
5/31	6B	OPE	218	0	5	4	9	191
	6B	Desc	161	0	0	0	1	26
	7B	OPE	340	0	6	2	7	47
5/30	6B	OPE	406	0	0	14	24	198
	6B	Desc	156	0	3	4	6	10
	7B	OPE	208	0	0	14	3	7
6/17	8B	RecM	70	0	367	11	11	56
	6B	Desc	18	0	79	12	6	5
6/18	6B	OPE	14	0	236	0	0	2
	6B	Desc	13	0	92	2	1	4
	7B	OPE	3	0	142	1	2	0
6/19	6B	OPE	0	0	0	0	0	0
	6B	Desc	3	0	136	4	5	0
	7B	OPE	37	0	440	0	0	0
6/20	6B	OPE	0	0	0	0	0	0
	6B	Desc	1	0	93	1	1	0
	7B	OPE	7	0	395	9	1	4
6/21	6B	OPE	0	0	0	0	0	0
	6B	Desc	0	0	77	1	2	0
	7B	OPE	4	0	454	6	0	5
6/24	6B	OPE	1	0	85	0	0	0
	6B	Desc	0	0	44	0	0	0
	7B	OPE	1	0	307	0	1	1

Appendix Table A4. Continued.

Date	Gatewell dipped	Activity[a]	Yearling chinook	Chinook fry	Subyearling Chinook	Coho	Steelhead	Sockeye
6/25	6B	OPE	0	0	0	0	0	0
	6B	Desc	0	0	150	1	0	1
	7B	OPE	2	0	483	0	0	0
6/26	6B	OPE	0	0	0	0	0	0
	6B	Desc	0	0	181	0	0	0
	7B	OPE	1	0	373	1	0	0
6/27	6B	OPE	0	0	0	0	0	0
	6B	Desc	0	0	17	1	0	0
	7B	OPE	0	0	373	0	0	0
6/28	6B	OPE	0	0	0	0	0	0
	6B	Desc	1	0	167	0	0	0
	7B	OPE	1	0	401	1	0	0
7/1	6B	OPE	0	0	0	0	0	0
	6B	Desc	0	0	176	0	0	0
	7B	OPE	7	0	463	0	0	0
7/2	6B	OPE	0	0	0	0	0	0
	6B	Desc	0	0	125	0	0	0
	7B	OPE	10	0	365	0	0	0
7/8	6B	OPE	1	0	367	1	1	13
	6B	Desc	0	0	36	0	0	0
7/9	7B	OPE	17	0	414	1	0	2
Total Catch			4,773	0	7,067	127	282	2,202

a Activities were CC Rel = collection channel release, FC 7B = fish condition tests in Slot 7B, RecM = recruitment for marking, Desc = descaling tests, OPE = orifice passage efficiency tests

Appendix Table A5. Travel times of yearling and subyearling chinook salmon during OPE and fish condition tests at John Day Dam, 2002. Abbreviations: 6B = STS slot, 7B = ESBS slot, COL = collection channel release.

Release location	Release date	Release time	Travel time passage percentile (days)			Number of fish
			10th	median	90th	
		Yearling chinook salmon				
6B	5/28	23:10	0.015	0.251	0.897	100
6B	5/29	22:39	0.006	0.815	1.010	105
6B	5/30	22:15	0.004	0.258	1.039	102
6B	5/31	22:22	0.006	0.631	1.015	104
6B	6/01	22:51	0.004	0.033	0.493	97
		Mean(d)	0.007	0.398	0.891	102
		Mean(h)	0.17	9.54	21.38	
7B	5/23	19:02	0.007	0.021	0.058	96
7B	5/24	19:04	0.009	0.041	0.071	103
7B	5/28	23:23	0.006	0.008	0.014	97
7B	5/29	22:53	0.004	0.009	0.025	103
7B	5/30	22:25	0.004	0.007	0.021	97
7B	5/31	22:33	0.004	0.284	0.504	98
7B	6/01	23:02	0.005	0.025	0.035	98
		Mean(d)	0.006	0.056	0.104	99
		Mean(h)	0.13	1.35	2.50	
COL	5/08	15:58	0.004	0.005	0.032	50
COL	5/09	15:59	0.005	0.005	0.007	50
COL	5/22	19:11	0.005	0.031	0.073	104
COL	5/28	23:38	0.003	0.004	0.028	52
COL	5/29	23:11	0.003	0.004	0.008	52
COL	5/30	22:43	0.003	0.004	0.016	54
COL	5/31	22:50	0.003	0.004	0.009	50
COL	6/01	23:26	0.003	0.004	0.010	55
		Mean(d)	0.004	0.008	0.023	58
		Mean(h)	0.09	0.18	0.55	

Appendix Table A5. Continued.

Release location	Release date	Release time	Travel time passage percentile (days)			Number of fish
			10th	median	90th	
		Subyearling chinook salmon				
6B	6/18	01:14	0.004	0.018	0.601	85
6B	6/18	22:32	0.003	0.010	0.842	91
6B	6/19	22:16	0.003	0.009	0.521	86
6B	6/20	22:06	0.003	0.225	0.804	104
6B	6/24	22:10	0.004	0.044	0.837	80
6B	6/25	21:39	0.004	0.259	0.860	80
6B	6/26	22:20	0.003	0.008	0.788	99
6B	6/27	21:29	0.004	0.005	0.282	86
6B	7/01	22:20	0.004	0.007	0.271	98
6B	7/02	22:12	0.003	0.023	0.318	99
6B	7/08	22:55	0.004	0.114	0.393	91
		Mean(d)	0.004	0.066	0.592	91
		Mean(h)	0.09	1.58	14.22	
7B	6/18	01:29	0.003	0.010	0.365	92
7B	6/18	22:40	0.013	0.016	0.038	92
7B	6/19	22:24	0.023	0.029	0.484	76
7B	6/20	22:15	0.012	0.013	0.552	93
7B	6/24	22:23	0.006	0.008	0.118	90
7B	6/25	21:51	0.006	0.008	0.072	96
7B	6/26	22:29	0.003	0.006	0.323	103
7B	6/27	21:38	0.004	0.008	0.360	93
7B	7/01	22:30	0.006	0.031	0.443	90
7B	7/02	22:21	0.006	0.007	0.028	86
7B	7/08	23:04	0.005	0.010	0.529	83
		Mean(d)	0.008	0.013	0.301	90
		Mean(h)	0.19	0.32	7.23	

Appendix Table A5. Continued.

Release location	Release date	Release time	Travel time passage percentile (days)			Number of fish
			10th	median	90th	
		Subyearling chinook salmon (continued)				
COL	6/18	01:49	0.003	0.004	0.010	55
COL	6/18	23:02	0.003	0.004	0.007	55
COL	6/19	22:35	0.003	0.004	0.016	51
COL	6/20	22:35	0.003	0.004	0.015	48
COL	6/21	22:28	0.003	0.004	0.017	50
COL	6/24	22:40	0.003	0.003	0.009	49
COL	6/25	22:06	0.003	0.004	0.011	51
COL	6/26	22:45	0.003	0.004	0.005	54
COL	6/27	21:54	0.004	0.004	0.006	51
COL	6/28	21:48	0.003	0.004	0.017	50
COL	7/01	22:47	0.003	0.004	0.012	53
COL	7/02	22:35	0.003	0.004	0.013	52
COL	7/08	23:19	0.003	0.005	0.022	53
		Mean(d)	0.003	0.004	0.012	52
		Mean(h)	0.07	0.10	0.30	

APPENDIX B

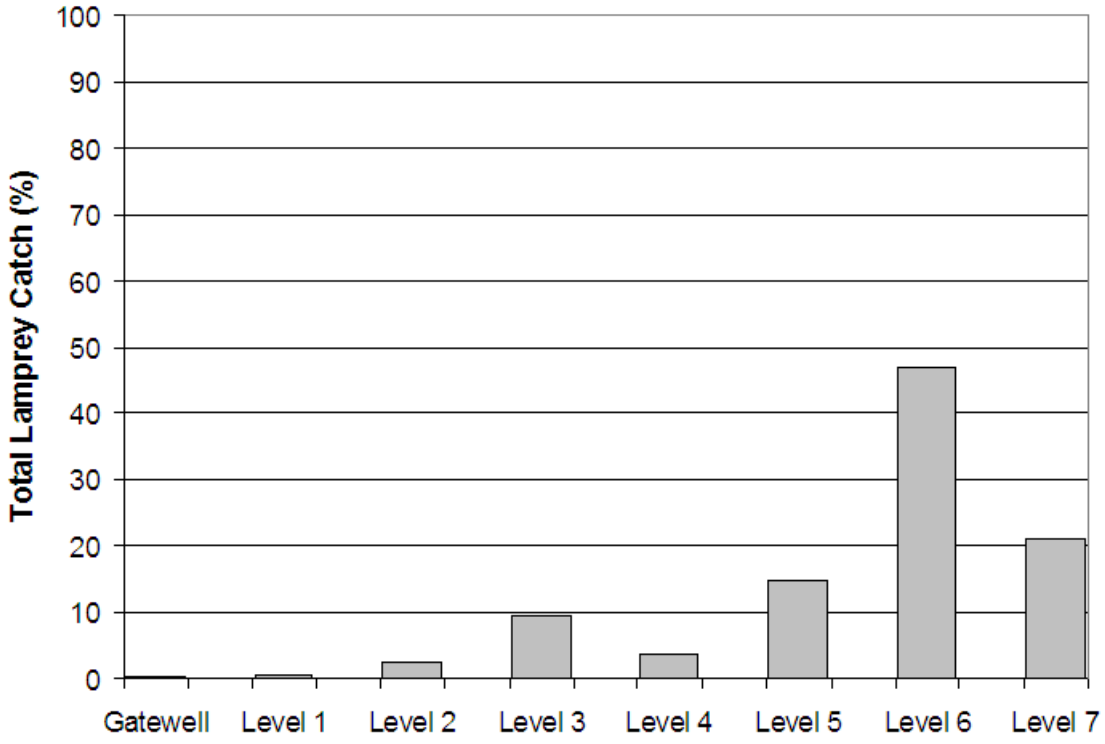
Juvenile Pacific Lamprey Fyke-Net Catch

The following information on juvenile Pacific lamprey *Lampetra tridentata* is being provided at the request of fishery agencies present at the USACE annual AFEP review of research held in Portland, Oregon, in November, 2002. During the presentation of results of this FGE study, a figure showing seasonal juvenile lamprey catch by net level, similar to Appendix Figure B, was presented, and the vertical distribution of juvenile lamprey at John Day Dam was discussed.

Seasonal FGE and percent catch by net level for juvenile lamprey are shown in Appendix Figure B and enumerated in Appendix Table B. For juvenile lamprey FGE was only 0.3% with 99.7% of the lamprey catch occurring in the nets. The largest catch was in Net-Level 6 (47.2%), followed by the bottom net-levels (7 and 8) and Net-Level 5 (21.0 and 15.0%, respectively). The vertical distribution of juvenile lamprey appears to be opposite to that of juvenile salmonids outmigrating during the same time period. For yearling chinook salmon, FGE was 80% and the largest net catch was in Level 5 (7.2%), followed by Levels 2 and 4 (4.5% each).

Appendix Table B. Juvenile lamprey catch by net level during fish guidance efficiency (FGE) tests at John Day Dam, 2002.

		Fyke net level								Totals
Date	Gatewell1	2	3	4	5	6	7	8		by date
28 May	0	0	0	4	1	6	14	9	0	34
29 May	0	0	2	2	0	2	9	5	2	22
30 May	0	0	0	2	2	6	17	0	1	28
31 May	0	0	1	2	4	11	11	1	0	30
1 June	0	0	2	5	2	3	23	5	0	40
17 June	2	0	3	11	31		41	12	0	111
18 June	0	2	5	4	1	12	43	7	2	76
19 June	1	0	6	5	4	17	26	10	0	69
20 June	0	0	1	9	0	13	62	30	1	116
21 June	0	1	3	16	6	14	78	26	4	148
24 June	0	1	0	2	1	9	43	29	1	86
25 June	0	0	0	1	2	8	26	13	0	50
26 June	0	1	1	5	4	17	41	22	3	94
27 June	0	1	0	3	0	0	10	2	3	19
28 June	0	1	1	10	4	9	28	6	1	60
1 July	0	0	1	4	3	8	18	14	0	48
2 July	0	1	5	11	4	8	45	9	6	89
8 July	0	0	4	19	1	17	43	32	2	118
9 July	1	0	0	8	0	5	37	14	2	67
Total	4	8	35	123	50	196	617	246	28	1,307
Percent	0.3	0.6	2.7	9.4	3.8	15.0	47.2	18.8	2.2	



Appendix Figure B. Seasonal catch by net level during fish guidance efficiency (FGE) tests for juvenile Pacific sea lamprey at John Day Dam, 2002. Gatewell = gatewell dipnet catch, Level 1 through 7 = fyke net Catches (Level 1 is at the top, Level 7 at the bottom of the turbine intake). Total catch was 1,307 juvenile lamprey.