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Use of Predation Detection Acoustic Tags to Estimate Juvenile Chinook Salmon Salvage Efficiency and Loss

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14. ABSTRACT
According to the 2009 National Marine Fisheries Service Biological Opinion on the Coordinated Long-Term Operations of the Central Valley Project and State Water Project (NMFS 2009), the Bureau of Reclamation shall improve salvage efficiency at the Tracy Fish Collection Facility (TFCF) so that overall survival is greater than 75.0%. To determine if the TFCF is meeting this requirement, as well as ascertain where fish loss is occurring, juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) with surgically implanted Predation Detection Acoustic Tags (PDATs) were released and tracked at the TFCF during varying pumping operations at the C.W. "Bill" Jones Pumping Plant (JPP). Results suggest facility components (i.e., primary channel louvers and secondary channel screens) are effective enough to meet the NMFS (2009) efficiency requirement. Salvage efficiency at the TFCF appears to be heavily impacted by predation, and elimination of this source of loss could result in efficiencies that meet or exceed the NMFS (2009) mandate. In addition, higher pumping rates at the JPP appeared to result in increased TFCF salvage efficiencies for juvenile Chinook Salmon. To verify these trends, additional efficiency testing is recommended at the TFCF using PDATs, as well as a more extensive hydrophone array and/or mobile tracking technology.

15. SUBJECT TERMS
Whole facility efficiency, fish passage, fish survival, predation, anadromous fish, acoustic telemetry, hydroacoustic, biotelemetry, Sacramento-San Joaquin River Delta, Tracy Fish Collection Facility

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Tracy Fish Facility Improvement Program
California-Great Basin · Interior Region 10

prepared by

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Tracy Fish Facility Improvement Program

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Disclaimer

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Executive Summary

The Tracy Fish Collection Facility (TFCF; Byron, California) was constructed in the mid-1950s by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), to divert and salvage fish from water destined for export by the C.W. "Bill" Jones Pumping plant (JPP). According to Action IV.4.1 of the 2009 National Marine Fisheries Service Biological Opinion on the Coordinated Long-Term Operations of the Central Valley Project and State Water Project (NMFS 2009), Reclamation shall undertake actions to improve TFCF salvage efficiency (i.e., whole facility efficiency) for Chinook Salmon (*Oncorhynchus tshawytscha*) and other fish species so survival throughout the entire facility is greater than 75.0%. During this experiment, juvenile Chinook Salmon with surgically implanted Predation Detection Acoustic Tags (PDATs; Model 900-PD; HTI-Vemco USA, Inc., Seattle, Washington) were released and tracked at the TFCF during varying pumping operations (i.e., 1, 2, 3, 4, and 5 pump operation) at the C.W. "Bill" Jones Pumping Plant (JPP; increased pumping at the JPP is associated with higher TFCF primary channel water flow and velocity) to estimate salvage efficiency, participation, primary channel louver efficiency, secondary channel screen efficiency, passage time of salvaged experimental Chinook Salmon, total predation loss, pre-facility predation, predation in the primary channel, and predation in the secondary channel during each operational condition.

Juvenile Chinook Salmon salvage efficiency and participation significantly increased with increased pumping at the JPP. Primary channel louver efficiency averaged 72.2–100% and was not significantly influenced by the number of pumps in operation at the JPP. Secondary channel screen efficiency was 100% throughout the experiment. Passage time of salvaged Chinook Salmon and pre-facility predation estimates significantly decreased with increased pumping at the JPP, while total predation loss estimates potentially decreased significantly with increased pumping. Predation in the primary channel and predation in the secondary channel were not significantly influenced by the number of JPP pumps in operation. Predation in the secondary channel was minimal during all JPP pump operations.

Results suggest facility components (i.e., primary channel louvers and secondary channel screens) are effective enough for juvenile Chinook Salmon to meet the 75.0% salvage efficiency mandated by the NMFS (2009). Salvage efficiency at the TFCF for juvenile Chinook Salmon appears to be heavily impacted by predation, and elimination of this source of loss could result in efficiencies that meet or exceed the NMFS (2009) mandate. In addition, higher pumping rates at the JPP appeared to result in increased TFCF salvage efficiencies for juvenile Chinook Salmon.

To verify the trends described during this experiment, it is recommended that additional efficiency testing be completed at the TFCF using PDATs, as well as a more extensive hydrophone array and/or mobile tracking technology. To obtain greater sample sizes and higher test power, it may be prudent to release externally marked fish along with PDAT-tagged fish during future research efforts to investigate salvage efficiency at the TFCF.

Introduction

The Tracy Fish Collection Facility (TFCF; Byron, California; operated by the U.S. Department of the Interior, Bureau of Reclamation [Reclamation]) was constructed in the mid-1950s to divert and salvage fish from Sacramento-San Joaquin River Delta (Delta) water destined for export by the C.W. "Bill" Jones Pumping plant (JPP) for primarily agricultural use in the southern San Joaquin Valley (Reyes et al. 2018). Water flow and velocity in the primary channel at the TFCF are dependent on the number of pumps in operation at the JPP, with increased pumping at the JPP associated with higher TFCF primary channel water flow and velocity. The TFCF uses a behavioral louver-bypass guidance system in the primary channel (consisting of 36 individual 2.6-m wide louver panels with 2.5-cm spaced vertical slats [Reclamation 1956, Reyes et al. 2018]) to guide entrained fish from the primary channel into a secondary channel, and vertically rotating traveling screens (Hydrolox™, Elmwood, Louisiana; consisting of 4 screens [in series] with 1.8-mm wide x 50.0-mm long openings and 32.0% open area [Reclamation 2012]) in the secondary channel to guide entrained fish from the secondary channel into a holding tank. Fish that are not successfully guided by the primary channel louvers or secondary channel traveling screens are lost downstream to the JPP (Bates and Vinsonhaler 1957, Bates et al. 1960). Likewise, fish preyed upon in front of or within the TFCF are also considered to be lost as they are not successfully collected in a TFCF holding tank (i.e., salvaged). Loss of listed fish species, including winter-run and spring-run Chinook Salmon (*Oncorhynchus tshawytscha*), is computed using loss formulas developed in consultation with the California Department of Fish and Wildlife (CDFW) and the U.S. Fish and Wildlife Service (USFWS) and approved by National Marine Fisheries Service (NMFS; NMFS 2009). Certain loss rates, such as predation in the primary channel (between the TFCF trashrack and primary louver array) and pre-facility predation (upstream of the TFCF trashrack), have previously been largely unknown at the TFCF and necessitated the use of a placeholder value when using loss formulas (Jahn 2011).

The 2019 NMFS Biological Opinion on Long-Term Operations of the Central Valley Project (CVP) and State Water Project (SWP; NMFS 2019) states that Reclamation shall minimize the impact of the amount or extent of incidental take of listed species during operations, although it does not provide specific efficiency requirements. Despite this, Action IV.4.1 of the 2009 NMFS Biological Opinion on the Coordinated Long-Term Operations of the CVP and SWP (NMFS 2009), states that Reclamation shall undertake actions to improve TFCF salvage efficiency (i.e., whole facility efficiency) for Chinook Salmon and other species so that overall survival is greater than 75.0%. Efforts to estimate salvage efficiency at the TFCF using acoustic telemetry have been completed previously by Karp et al. (2017), although data was only collected during 1, 3 and 5 pump operation at the JPP (1, 2, 3, 4, and 5 pump operation is possible at the JPP) and acoustic tags without predation detection technology were used, which made it difficult to definitively determine if predation had occurred. In addition, Karp et al. (2017) completed testing before the secondary channel louvers were replaced with traveling screens in 2014 (Reyes et al. 2018).

To obtain more accurate estimates of salvage efficiency, as well as efficiency of individual facility components (i.e., primary channel louvers and secondary channel screens), it is necessary to determine the location and extent of predation loss at the TFCF. Therefore, a proof-of-concept experiment was completed at the TFCF with varying pumping operations (i.e., 1, 2, 3, 4, and 5 pump operation) at the JPP using juvenile Chinook Salmon with surgically implanted acoustic tags capable of detecting predation events (i.e., Predation Detection Acoustic Tags [PDATs]).

Methods

Experimental Design

A release-recapture experiment was completed between March 2017 and October 2019 using juvenile Chinook Salmon with surgically implanted PDATs (Model 900-PD; 307 kHz frequency; 1.0 g in air; 6.0-mm diameter x 25.0-mm long; HTI-Vemco USA, Inc., Seattle, Washington]), which contain a fuse of digestible material (polysaccharide and gelatin) that dissolves when the tag encounters digestive fluids in a predator's stomach, creating an open circuit that alters the tag signal and indicates that a predation event has occurred (Schultz et al. 2017; Figure 1). Experimental Chinook Salmon were released and tracked at the TFCF during varying pumping operations (i.e., 1, 2, 3, 4, and 5 pump operation) at the JPP to estimate salvage efficiency (the percentage of experimental Chinook Salmon collected in a TFCF holding tank after removing non-participants [i.e., fish that did not partake in the experiment] from the release group), participation (the percentage of experimental Chinook Salmon that passed the TFCF trashrack in a downstream direction and entered the primary channel), primary channel louver efficiency (the percentage of experimental Chinook Salmon effectively guided from the primary channel to the secondary channel by the primary channel louvers), secondary channel screen efficiency (the percentage of experimental Chinook Salmon effectively guided from the secondary channel to the holding tanks by the secondary channel traveling screen), passage time of salvaged experimental Chinook Salmon (from the trash boom to the holding tanks), total predation loss, pre-facility predation (predation occurring upstream of the TFCF trashrack), predation in the primary channel (predation occurring between the TFCF trashrack and primary louver array), and predation in the secondary channel (predation occurring between the downstream end of the bypass pipes and the secondary channel traveling screens) during each operational condition.

Three replicates were completed during 1, 3, 4, and 5 pump operation at the JPP, while 4 replicates were completed during 2 pump operation at the JPP. An additional replicate was completed during 2 pump operation at the JPP because extra fish and PDATs were available for testing when the JPP was operating at this pumping level. During each replicate, 10–11 experimental Chinook Salmon (mean fork length [FL] = 133.4 mm [range = 103.0–212.0 mm]) were released. Testing was conducted during normal day-to-day operations (i.e., louver and trashrack cleaning, tidal changes, monthly predator removals in the bypass pipes and secondary channel, etc. [Reyes et al. 2018]) and the facility was operated according to criteria for Chinook Salmon specified by NMFS (2009; i.e., secondary channel water velocity of approximately 0.9 m/s) and SWRCB (1978; i.e., primary channel and secondary channel bypass ratios equal to, or greater than 1.0) to the greatest extent possible, although it is not possible to meet all criteria during certain tidal conditions (Sutphin and Bridges 2008).

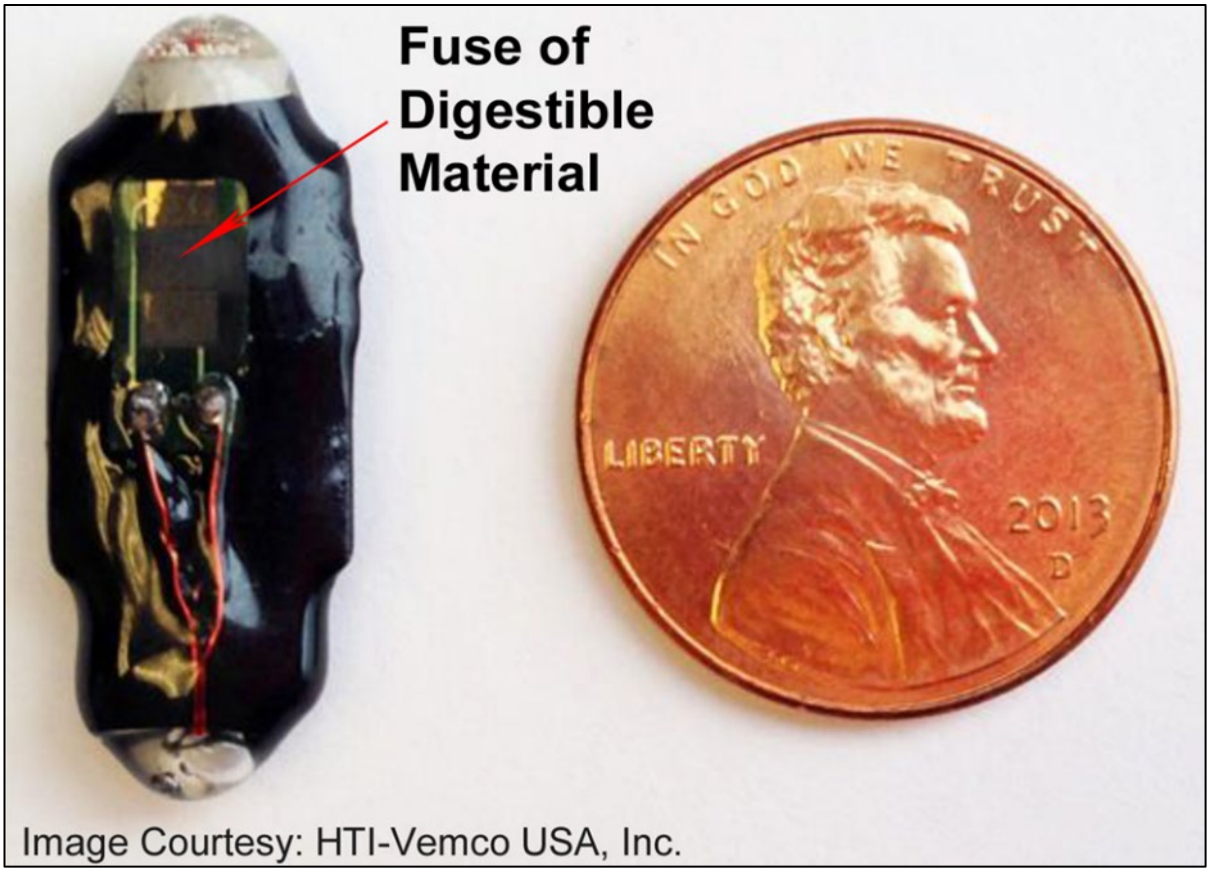

Figure 1.—Predation Detection Acoustic Tag (Model 900-PD; 307 kHz frequency; 1.0 g in air; 6.0-mm diameter x 25.0-mm long; HTI-Vemco USA, Inc., Seattle, Washington]) with fuse of digestible material (polysaccharide and gelatin; image courtesy of HTI-Vemco USA, Inc.).

Twenty-three fixed acoustic telemetry hydrophones (Model 590; HTI-Vemco USA, Inc., Seattle, Washington) and three acoustic tag receivers (Model 290; HTI-Vemco USA, Inc., Seattle, Washington) were installed throughout the TFCF (Figure 2). Hydrophones installed upstream of the facility, in the primary channel, in the secondary channel, and in holding tanks were affixed to facility infrastructure using stainless steel pipes (5.1-cm inside diameter), hose clamps or custom mounts, and various hardware. Hydrophones installed downstream of the facility were deployed using anchors (13.6–29.5 kg) with rope (9.5-mm diameter twisted polypropylene) and surface floats (25.4-cm diameter). Hydrophones were connected to acoustic tag receivers using hydrophone cables (Model 690; HTI-Vemco USA, Inc., Seattle, Washington). In conjunction, this equipment was used to track fish movements upstream of (range = approximately 100 m upstream of the TFCF trash boom), within (in the primary channel, secondary channel, and holding tanks), and downstream of the TFCF (range = approximately 100 m downstream of the end of the primary louver deck), although there was no detection capability in the bypass pipes (i.e., pipes connecting the primary channel to the secondary channel) or holding tank conduit (i.e., conduit connecting the secondary channel to the holding tanks).

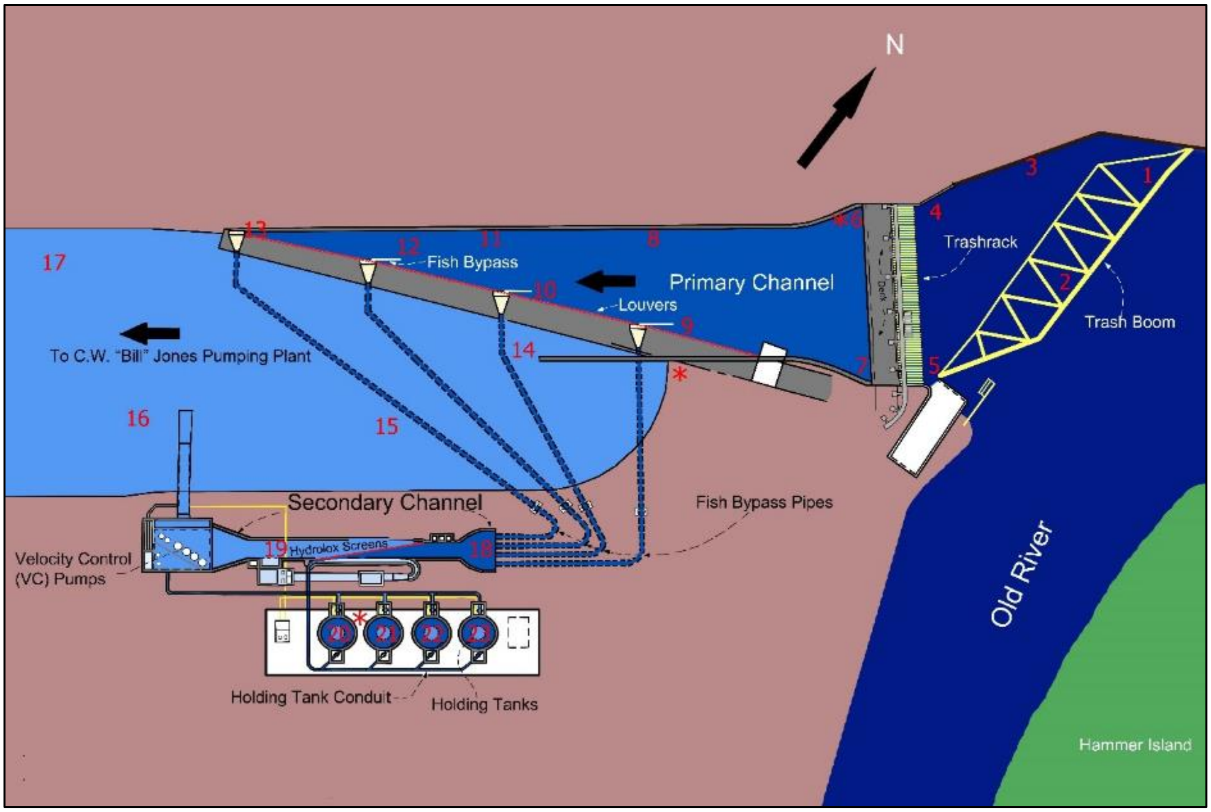

Figure 2.—Diagram of the Tracy Fish Collection Facility (Bureau of Reclamation, Byron, California) showing major facility components, locations of the 23 acoustic telemetry hydrophones used during this experiment (red numbers), and locations of acoustic tag receivers (red asterisks).

In addition to the hydrophones, hydrophone cables, and acoustic tag receivers installed at the TFCF, hydrophones (Model 590), hydrophone cables (Model 690), and data loggers (Model 395; HTI-Vemco USA, Inc., Seattle Washington) deployed by California Department of Water Resources (DWR) in Old River and Grant Line Canal (Figure 3) were used to possibly detect fish that swam out of detection range of the hydrophone array deployed upstream of the TFCF trashrack and potentially determine if predation events occurred upstream of the facility (i.e., pre-facility). The use of DWR data loggers and hydrophones was based on the recommendation by Karp et al. (2017) to perform acoustic facility efficiency studies with the installation of additional acoustic tag receivers and hydrophones upstream of the TFCF trash boom to potentially reduce the proportion of unknown fates.

Experimental Chinook Salmon were released from the midpoint of the TFCF trash boom and tracked to determine fate. Fish were tracked for up to 140 h after the end of the operational period during which they were released or until all fates could be determined. This was done to adequately detect predation events since Schultz et al. (2017) reported a maximum trigger time of 140 h for Model 900-PD PDATs, which are the same PDAT used during this experiment. Acoustic telemetry data at the TFCF was recorded into hourly files and downloaded daily, while the acoustic telemetry systems were verified to be operational throughout the experimental period. Hydraulic data (water temperature, primary channel depth, primary channel flow, primary channel velocity, secondary channel depth, secondary channel flow, secondary channel velocity, primary channel and secondary channel bypass ratios [ratio of bypass entrance velocity to channel velocity], holding tank flow, and the number of secondary channel velocity control pumps and holding tank pumps in operation) was recorded every 30 mins for 2 h, after which hydraulic data was recorded every 2 h until there was a change in pump operation at the JPP. Researchers did not have control of the number of pumps in operation at the JPP and unexpected changes in pumping conditions occurred during this experiment. Due to this, experimental periods varied in duration (approximately 14.6–685.7 h [approximately 0.6–28.6 d]) and were based on fish release date and time, as well as the date and time of the change in JPP pump operation.

Figure 3.—Locations of data loggers and hydrophones deployed by the California Department of Water Resources (yellow dots) in Old River (OR) and Grant Line Canal (GLC) in relation to the Tracy Fish Collection Facility (TFCF; red dot).

Fish Source and Care

Juvenile Chinook Salmon were obtained from Coleman National Fish Hatchery (Anderson, California) and Mokelumne River Hatchery (Clements, California) and transported to either the DWR Fish Science Building (FSB; Byron, California) or the Reclamation Tracy Aquaculture Facility (TAF; Byron, California) using 1,135.6-L (300.0-gal) or 1,703.4-L (450.0-gal) rectangular insulated fish transport tanks containing oxygenated treated (ozonated) Sacramento River (Coleman National Fish Hatchery) or Mokelumne River (Mokelumne River Hatchery) water. Upon arrival at the FSB or TAF, fish were held in 1,362.8-L (360.0-gal) circular tanks or 1,514.2-L (400.0-gal) circular tanks, respectively, and provided recirculated, temperature controlled (approximately 12.5 °C), aerated, treated (treatment at FSB = filtered and ultraviolet [UV] sterilized; treatment at TAF = ozonated, settled, filtered, and UV sterilized) Delta water. Fish were fed floating 1.5-mm classic fry pellets (Skretting, Tooele, Utah) or floating 2.0-mm pellets (Bio-Oregon, Longview, Washington, and Skretting, Tooele, Utah) at approximately 2.5% body weight per day. Feed was withheld for at least 24 h prior to surgical implantation of PDATs.

Fish Processing and Release

The target length of juvenile Chinook Salmon used for this experiment was approximately 120 mm fork length (FL). This approximate length was desired because it is within the range of Chinook Salmon lengths typically salvaged at the TFCF (CDFW 2020) and surgical implantation of Model 900-PD PDATs was possible using this size of juvenile Chinook Salmon without introducing excessive (> 6.7% [Brown et al. 2010]) tag burden (i.e., the weight of a transmitter relative to the weight of a fish [Brown et al. 2010, Liedtke et al. 2012]).

Surgical implantation of Model 900-PD PDATs in juvenile Chinook Salmon was performed at either the FSB or the TAF and guidelines in Liedtke et al. (2012) were generally followed. Surgical tools were decontaminated in a 3.0% Chlorohexadine acetate solution (Nolvasan®; Zoetis United States, Parsippany, New Jersey) or with 70.0% isopropyl alcohol (Cumberland Swan, Smyrna, Tennessee) and were thoroughly rinsed with distilled water prior to use. Predation Detection Acoustic Tags were activated and programmed using an acoustic tag programmer (Model 490 LP; HTI-Vemco USA, Inc., Seattle, Washington). After activation and programming, PDATs were decontaminated using a tabletop UV sterilizer (Salon Sundry M-2009, Sunrise Florida) with 40 min UV exposure time (20 mins on each side).

Fish were captured from 1,362.8-L (360.0-gal; at the FSB) or 1,514.2-L (400.0-gal; at the TAF) circular tanks using monorail nets with 6.4-mm knotless nylon mesh (45.0-cm x 45.0-cm frame, 15.0-cm depth, 1.0-m handle; Pentair Aquatic Ecosystems, Inc., Apopka, Florida) and placed in a 10.0-L (2.6-gal) anesthetic bath containing either a 40.0 mg/L dose of AQUI-S 20E® liquid anesthetic (AQUI-S, Lower Hutt, New Zealand) and 2.5 mL of Stress Coat® water conditioner (API Fish Care, Chalfont, Pennsylvania) or a 100.0 mg/L concentration of Tricaine Methanesulfonate (MS-222; Argent Chemical Laboratories, Redmond, Washington), along with a 100.0 mg/L concentration of sodium bicarbonate (Arm and Hammer™; Church & Dwight Co., Inc., Ewing, New Jersey) and 5.0 mL of Prime® water conditioner (Seachem Laboratories, Inc., Madison, Georgia). After the desired extent of anesthesia was obtained (Stage III, surgical anesthesia; total loss of equilibrium and no reaction to touch stimuli [Coyle et al. 2004]), fish were removed from the anesthetic bath, measured (FL), and weighed (g). Fish were then moved to a surgery station and an anesthetic mixture containing 20.0 mg/L AQUI-S 20E® and 2.5 mL of Stress Coat® water conditioner or 75.0–100.0 mg/L MS-222, 75.0-100.0 mg/L sodium bicarbonate, and 5.0 mL of Prime® water conditioner, was dispensed into the fish's mouth using 6.4-mm diameter aquarium tubing.

Incisions were made parallel and lateral to the ventral midline of the juvenile Chinook Salmon using 3.0–5.0-mm-deep microsurgical blades with a 15.0-degree blade angle (Surgical Specialties Puerto Rico, Inc., Rincon, Puerto Rico). Individual PDATs were then inserted into the body cavity of the fish. As was done by Karp et al. (2017) and recommended by Liedtke et al. (2012), incisions were closed with two independent sutures (2 x 3 knot) in an interrupted pattern using 4/0 Ethicon, taper point, RB-1, 17.0-mm, ½ circle, 68.6-cm, violet, coated VICRYL Plus sutures and Mayo-Hegar needle holders. A modified surgeon's knot was used to secure each suture and sutures were trimmed using stainless steel operating scissors. Following closure of incisions, 10.0% povidone-iodine (Betadine; Purdue Products L.P., Stamford, Connecticut) was applied to incision sites and fish were temporarily placed in perforated 18.9-L (5.0-gal) black buckets containing approximately 7.6 L (2.0-gal) of oxygenated treated (ozonated, settled, and filtered) Delta water. Time to complete surgical implantation of acoustic tags was noted. For the first 10 fish, time until recovery from anesthesia was also recorded.

Following surgical implantation of PDATs at the TAF, fish were placed in 170.3-L (45.0-gal) circular tanks containing flow-through, aerated, treated (ozonated, settled, and filtered) Delta water at ambient Delta water temperature (9.8–23.3 °C) and held for at least 24 h before release. For surgical implantations that took place at the FSB, fish were placed in 1,362.8-L (360.0-gal) tanks after completion of surgical activity. These tanks contained recirculated, aerated, treated (filtered and UV sterilized) Delta water at ambient Delta water temperature. Fish were held in these conditions at the FSB for approximately 11 d until they were transported to the TAF where they were held (for at least 24 h) in 170.3-L (45.0-gal) tanks and provided flow-through, aerated, treated (ozonated, settled, and filtered) Delta water at ambient Delta water temperature. Fish maintained in tanks for more than 24 h after the surgical process were fed as previously described, although feed was withheld at least 24 h prior to release. Post-surgery mortalities were immediately replaced (i.e., a different PDAT was activated, programmed, and surgically implanted in another juvenile Chinook Salmon using the procedures previously described) and held for at least 24 h before release.

Prior to release, fish were netted from the 170.3-L (45.0-gal) tanks within the TAF and transferred to perforated 18.9-L (5.0-gal) black buckets with lids (at a density of 2–5 fish per bucket) containing approximately 7.6 L (2.0-gal) of oxygenated treated (ozonated, settled, and filtered) Delta water at ambient Delta water temperature. Each bucket was then transported to the TFCF trash boom and floated in raw Delta water for final acclimation (1 h; Figure 4). After the 1-h acclimation period, fish were released downstream of the TFCF trash boom via water-to-water transfer (Figure 5).

Figure 4.—Acclimation of acoustically tagged juvenile Chinook Salmon prior to release at the Tracy Fish Collection Facility trash boom.

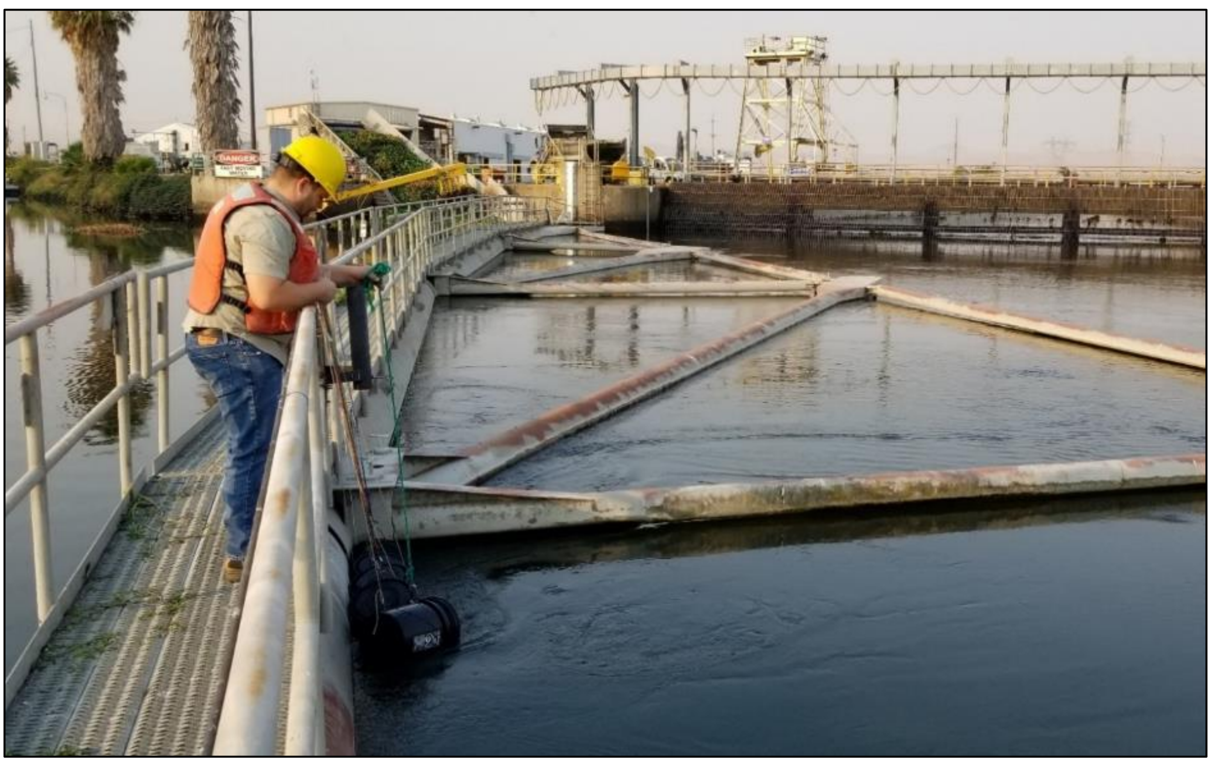

Figure 5.—Release of acoustically tagged juvenile Chinook Salmon downstream of the Tracy Fish Collection Facility trash boom via water-to-water transfer.

Data Analyses

Chinook Salmon length and weight data for this experiment was not normally distributed (P = < 0.050 for both length and weight; Shapiro-Wilk test; Minitab 19; Minitab, State College, Pennsylvania); therefore, non-parametric statistics were used for all length and weight comparisons. A Kruskal-Wallis one-way ANOVA on rank transformed data (Minitab 19; Minitab, State College, Pennsylvania) was used to determine if there were significant differences in lengths and weights of Chinook Salmon released at each pumping rate during this experiment, while a Dunn's test (Minitab 19; Minitab, State College, Pennsylvania) was used to identify pumping rates during which experimental Chinook Salmon lengths and/or weights significantly differed from the others.

Acoustic tag detections were used to determine fish fate and identify where loss occurred. The dichotomous key developed by Karp et al. (2017) was modified and employed to assign fates (Appendix A, Table A-1). When assigning fates, it was assumed that acoustic tags detected in the TFCF primary channel were still in live experimental Chinook Salmon upon trashrack passage (i.e., experimental Chinook Salmon were not preyed upon prior to entering the primary channel) and acoustic tags detected downstream of the primary channel louvers were still in live experimental Chinook Salmon upon primary channel louver passage (i.e., experimental Chinook Salmon were not preyed upon prior to passing downstream of the primary channel louvers). Likewise, it was assumed all acoustic tags detected in the secondary channel were still in live experimental Chinook Salmon upon entry. If possible, all fish salvaged in TFCF holding tanks during the experimental period were processed to ensure all salvaged experimental Chinook Salmon were accounted for and to verify PDATs were not untriggered in a predatory fish. If it was not possible to process all salvaged fish during the experimental period, it was assumed acoustic tags detected in the holding tanks were still in live experimental Chinook Salmon upon entry (i.e., experimental Chinook Salmon were not preyed upon prior to entering holding tanks; this was only assumed for 3 fish). Since PDATs were used during this experiment to determine predation events, it was not necessary to develop rules (i.e., cease of tag movement) to assign predation events as was done by Karp et al. (2017). Despite this, it was necessary to establish PDAT trigger time thresholds to assess if a predation event occurred during the hydraulic period in which the fish was released. The maximum PDAT trigger time of 140 h reported by Schultz et al. (2017) was applied and PDATs that triggered more than 140 h after the end of the hydraulic period during which they were released were considered to have been preyed upon after the hydraulic change at the JPP.

Equations provided by Karp et al. (2017) were used to calculate passage time (for salvaged acoustically tagged Chinook Salmon only), salvage efficiency, participation, primary channel louver efficiency, secondary channel screen efficiency, total predation loss, and pre-facility predation (Appendix B). In addition, equations were developed to calculate predation in the primary channel and predation in the secondary channel (Appendix B). For salvage efficiency, a low estimate (all fish of unknown fate were assumed to be predation loss) and a high estimate (all fish of unknown fate were assumed to be non-participants) are provided. Likewise, a low estimate (all fish of unknown fate were assumed to be non-participants) and a high estimate (all fish of unknown fate were assumed to be predation loss) are provided for total predation loss, pre-facility predation, and predation in the primary channel.

Scatterplots with best-fit trendlines were generated for each fate (i.e., salvage, non-participation, primary louver loss, secondary screen loss, predation, and unknown; Figures 6 through 11), as well as salvage efficiency, participation, primary channel louver efficiency, secondary channel screen efficiency, passage time, total predation loss, pre-facility predation, predation in the primary channel, and predation in the secondary channel during varying (i.e., 1, 2, 3, 4, and 5) pump operation at the JPP (Figures 12 through 20; Excel 365; Microsoft Corporation, Redmond, Washington). Regression analysis (linear and/or polynomial; Minitab 20; Minitab, State College, Pennsylvania) was used to determine if primary channel hydraulics (i.e., primary channel flow, primary channel velocity, and primary channel bypass ratio), fate assignments (i.e., salvage, non-participation, primary louver loss, secondary screen loss, predation, and unknown), efficiency (i.e., salvage efficiency, primary channel louver efficiency, and secondary channel screen efficiency), participation, passage time, and predation estimates (i.e., total predation loss, pre-facility predation, predation in the primary channel, and predation in the secondary channel) were significantly influenced by the number of pumps in operation at the JPP.

Results and Discussion

Experimental Fish

Chinook Salmon used during this experiment (n = 161) had a mean FL of 133.4 mm (range = 103.0–212.0 mm) and a mean weight of 29.0 g (range = 12.6–121.0 g; Appendix C, Table C-1). There were several significant differences in the lengths and weights of juvenile Chinook Salmon among treatment groups in this experiment ($P = < 0.001$ for both length and weight; Kruskal-Wallis one-way ANOVA). Specifically, there were significant differences in the lengths and weights of Chinook Salmon released during 4 JPP pump replicates versus those released during 1 ($P = < 0.001$ for both length and weight; Dunn's test), 3 ($P = <0.001$ for both length and weight; Dunn's test), and 5 JPP pump operation ($P = 0.008$ and $P = 0.004$ for length and weight, respectively; Dunn's test), with Chinook Salmon released at 4 JPP conditions being significantly longer and heavier. It is assumed differences in Chinook Salmon length and weight between treatment groups did not influence results of this experiment, especially since all Chinook Salmon used during this experiment were within the size range typically salvaged at the TFCF (CDFW 2020). Tag burden during this experiment ranged from 0.8–7.9% and averaged 4.2%. Anesthesia time during surgical implantation of acoustic tags ranged from 0.7–4.5 mins and averaged 2.3 mins, while surgery time ranged from 2.2–5.5 mins and averaged 3.6 mins. Time until recovery from anesthesia ranged from 1.4–6.6 mins and averaged 3.0 mins, although this was only determined for the first 10 fish that underwent surgery. Post-surgery survival of experimental fish was 98.2% (161/164).

Hydraulic Conditions

Average primary channel flow, primary channel velocity, primary channel bypass ratio, secondary channel flow, secondary channel velocity, secondary channel bypass ratio, and temperature at the TFCF during replicates performed at 1, 2, 3, 4, and 5 JPP pump operation are reported in Appendix D (Tables D-1 through D-5) and summarized in Table 1. Primary channel flow and primary channel velocity at the TFCF significantly increased with increasing number of pumps in operation at the JPP ($P = < 0.001$ for both primary channel flow and primary channel velocity; linear regression analysis). Primary bypass ratio significantly decreased as the number of pumps in operation at the JPP increased ($P = < 0.001$; linear regression analysis) and average primary channel bypass ratio remained above 1.0 for all JPP pumping rates (Table 1). Average secondary channel flow, secondary channel velocity, and secondary channel bypass ratio were comparable regardless of the number of pumps in operation at the JPP (Table 1), which was expected because hydraulics in the secondary channel are largely determined by the combination of secondary channel Velocity Control pumps in operation and not the number of pumps operating at the JPP. Average water temperature during testing was 14.0 °C (range = 9.4–24.2 °C).

The information in Table 1 demonstrates there was some degree of overlap in primary channel hydraulic conditions among successive pumping operations at the JPP. This was expected since primary channel hydraulics depend somewhat on water depth, and therefore hydraulics at different pumping rates could be the same depending on tidal action.

Table 1.—Average (Avg.; minimum–maximum) primary channel flow (m^3/s), primary channel velocity (m/s), primary channel bypass ratio, secondary channel flow (m^3/s), secondary channel velocity (m/s), secondary channel bypass ratio, and temperature (°C) during replicates performed at 1, 2, 3, 4, and 5 pump operation at the C.W. "Bill' Jones Pumping Plant (JPP).

	1 JPP	2 JPP	3 JPP	4 JPP	5 JPP
Avg. Primary Channel Flow (Minimum–Maximum; m^3/s)	23.6 (8.7–45.1)	48.1 (18.5–82.9)	70.4 (44.1–93.7)	106.7 (81.4–144.5)	112.1 (87.5–142.0)
Avg. Primary Channel Velocity (Minimum–Maximum; m/s)	0.2 (0.1–0.3)	0.3 (0.1–0.5)	0.5 (0.4–0.7)	0.7 (0.5–0.9)	0.7 (0.5–1.0)
Avg. Primary Channel Bypass Ratio (Minimum–Maximum)	6.5 (1.7–18.5)	3.3 (1.3–6.3)	2.4 (1.8–3.8)	1.7 (1.2–2.6)	1.4 (0.7–2.3)
Avg. Secondary Channel Flow (Minimum–Maximum; m^3/s)	3.2 (1.6–4.7)	3.7 (1.9–5.1)	3.9 (3.5–4.5)	4.3 (3.5–5.0)	3.8 (2.0–5.3)
Avg. Secondary Channel Velocity (Minimum–Maximum; m/s)	0.6 (0.2–1.1)	0.8 (0.3–1.1)	0.8 (0.6–1.1)	0.8 (0.6–1.3)	0.8 (0.3–1.1)
Avg. Secondary Channel Bypass Ratio (Minimum–Maximum)	1.6 (0.8–3.0)	1.3 (0.8–2.4)	1.1 (0.7–1.4)	1.2 (0.7–1.6)	1.4 (0.9–2.6)
Avg. Temperature (Minimum–Maximum; °C)	14.3 (11.1–19.1)	15.0 (11.3–24.2)	15.8 (12.1–18.6)	14.2 (10.7–16.3)	12.5 (9.4–21.9)

Fate Determination

Salvaged

The percentage of experimental Chinook Salmon salvaged (i.e., collected in a TFCF holding tank) significantly increased as pumping increased at the JPP ($P = 0.008$; polynomial regression analysis), although data was variable during all JPP pump operations and R^2 value of the best-fit trendline was moderate (Chin 1998; $R^2 = 0.52$; Figure 6). On average (minimum–maximum), 16.7% (0–50.0%), 5.0% (0–10.0%), 30.0% (10.0%–40.0%), 33.3% (10.0–50.0%), and 66.7% (30.0–90.0%) of acoustically tagged Chinook Salmon were salvaged during 1, 2, 3, 4, and 5 pump operation at the JPP, respectively (Appendix E, Table E-1). These results suggest the salvage of juvenile Chinook Salmon at the TFCF is generally greater at higher JPP pumping rates. The lower percentage of experimental Chinook Salmon salvaged during 2 JPP pump operation than 1 JPP pump operation was likely due to overlap in certain primary channel hydraulic conditions among these pumping levels.

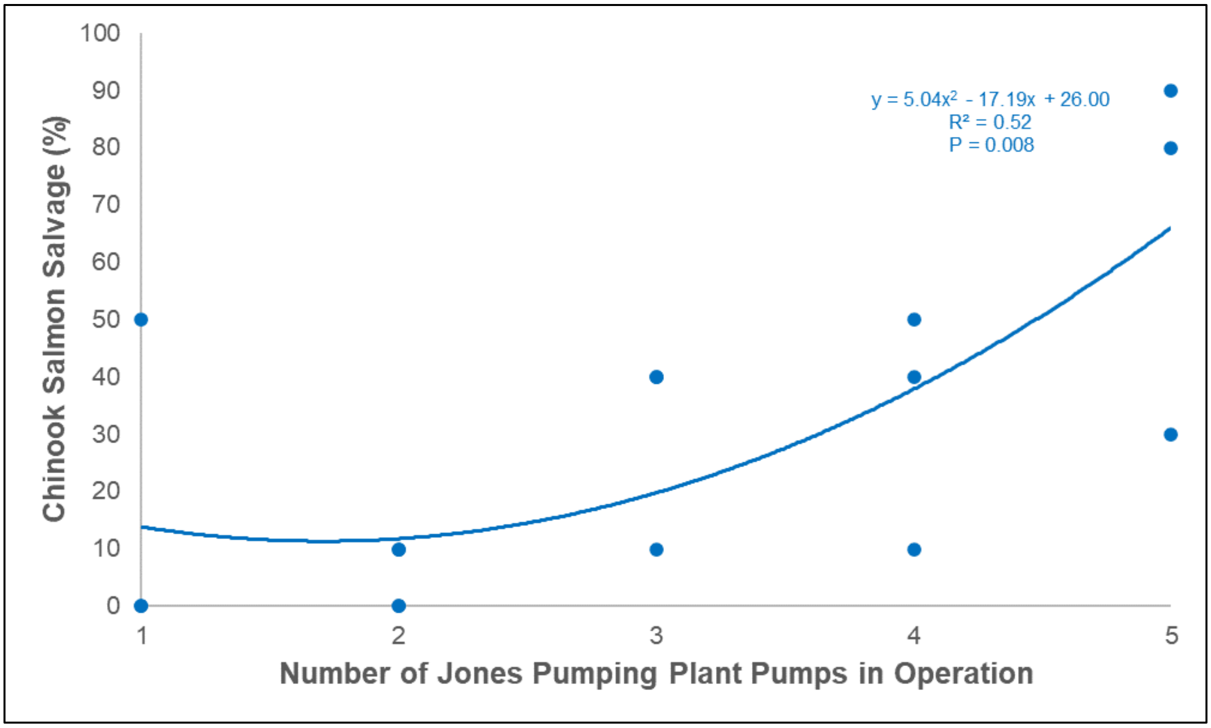

Figure 6.—Percentage of experimental Chinook Salmon salvaged (i.e., collected in a holding tank) at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Non-Participation

A fate of non-participation was assigned to acoustically tagged Chinook Salmon that did not partake in the experiment. These fish were 1) recovered in holding tanks after the end of the hydraulic period during which they were released, 2) lost through the primary channel louvers after the end of the hydraulic period during which they were released, or 3) detected within or upstream of the TFCF 140 h after the end of the hydraulic period during which they were released without a triggered PDAT. In all cases, experimental Chinook Salmon assigned a fate of non-participation remained upstream of the TFCF trashrack until there was a change in JPP pump operation. There was not a significant relationship between the assignment of non-participation fates and the number of pumps in operation at the JPP ($P = 0.234$; polynomial regression analysis). On average (minimum–maximum), non-participation was 0%, 10.0% (0–20.0%), 16.7% (0–50.0%), 6.7% (0–20.0%) and 0% during replicates performed at 1, 2, 3, 4, and 5 JPP pump operation, respectively (Appendix E, Table E-1). From the best-fit trendline, it appeared non-participation was highest at mid-pumping levels at the JPP (i.e., when there was 2, 3 and 4 JPP pumps in operation), although data was variable during 2, 3, and 4 pump operation and R^2 value of the trendline was weak (Chin 1998; $R^2 = 0.20$; Figure 7).

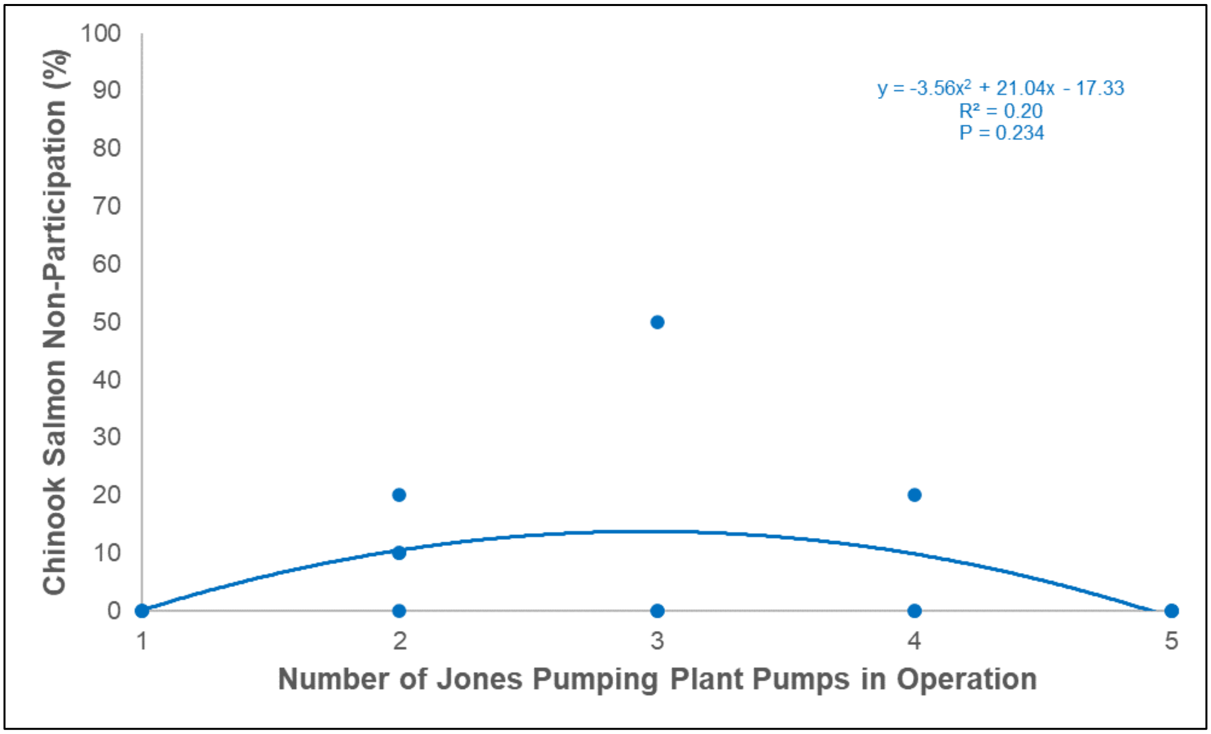

Figure 7.—Percentage of experimental Chinook Salmon assigned the fate of non-participation (i.e., fish that did not partake in the experiment) at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Primary Channel Louver Loss

Loss of experimental Chinook Salmon through the TFCF primary channel louvers was low (averaged ≤ 10.0% of fish released) during all operational conditions at the JPP and was not significantly influenced by the number of pumps in operation (P = 0.919; polynomial regression analysis). In addition, data was variable during 1, 3, and 5 pump operation at the JPP and R^2 value of the trendline was weak (Chin 1998; R^2 = 0.01; Figure 8). During 1, 3, and 5 pump operation at the JPP, average (minimum–maximum) primary channel louver loss was 3.3% (0–10.0%), 10.0% (0–20.0%), and 3.3% (0–10.0%), respectively, while 0% of experimental Chinook Salmon were lost through the primary channel louvers during 2 and 4 JPP pump operation (Appendix E, Table E-1).

Based on the time each experimental Chinook Salmon was detected downstream of the primary channel louvers, as well as facility records of primary channel louver cleaning events, it was determined that 20.0% (1/5) of the experimental Chinook Salmon lost through the primary channel louvers (i.e., 0.6% [1/161] of all experimental Chinook Salmon and 1.9% [1/52] of experimental Chinook Salmon that encountered the primary channel louvers) were lost while cleaning of the louvers was occurring. This demonstrates that a portion of fish lost through the primary channel louvers may potentially be passing through the 2.6-m wide (Reclamation 1956, Reyes et al. 2018) void in the primary channel louver array that is created when each of the 36 louver panels is individually lifted for cleaning, although it appears the majority of primary channel louver loss occurs through the 2.5-cm spaced vertical slats of the primary louvers during non-cleaning periods. This makes sense because the primary channel louver panels are only cleaned for a portion of each day (108–144 mins [i.e., 7.5–10.0% of a day] to clean all 36 primary channel louver panels with a cleaning frequency of 1–6 cleanings per day depending on debris load [Reyes et al. 2018]) and the extent of fish loss through the void in the primary channel louver array during cleaning is likely dependent on the proportion of time the primary channel louvers are cleaned.

Overall, results suggest there is minimal loss of juvenile Chinook Salmon through the TFCF primary channel louvers, including when the primary channel louver panels are being lifted for cleaning. In addition, it appears primary channel louver loss is not strongly dependent on the number of pumps in operation at the JPP.

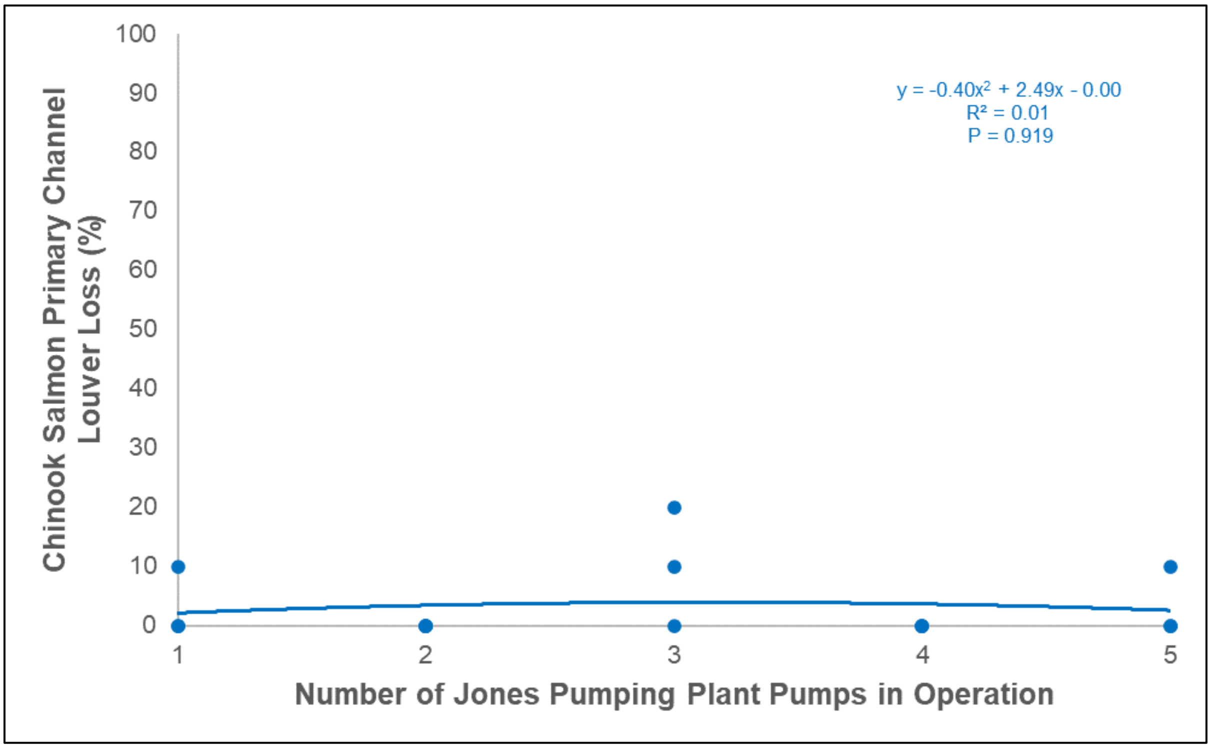

Figure 8.—Percentage of experimental Chinook Salmon lost through the primary channel louvers at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Secondary Channel Screen Loss

No experimental Chinook Salmon were lost through the secondary channel traveling screens during this experiment (Figure 9; (Appendix E, Table E-1)). This suggests the TFCF secondary channel traveling screens are 100% efficient for juvenile Chinook Salmon, and that 1.8-mm wide x 50.0-mm long screen openings are an appropriate size for the effective guidance and salvage of this species and life stage of fish.

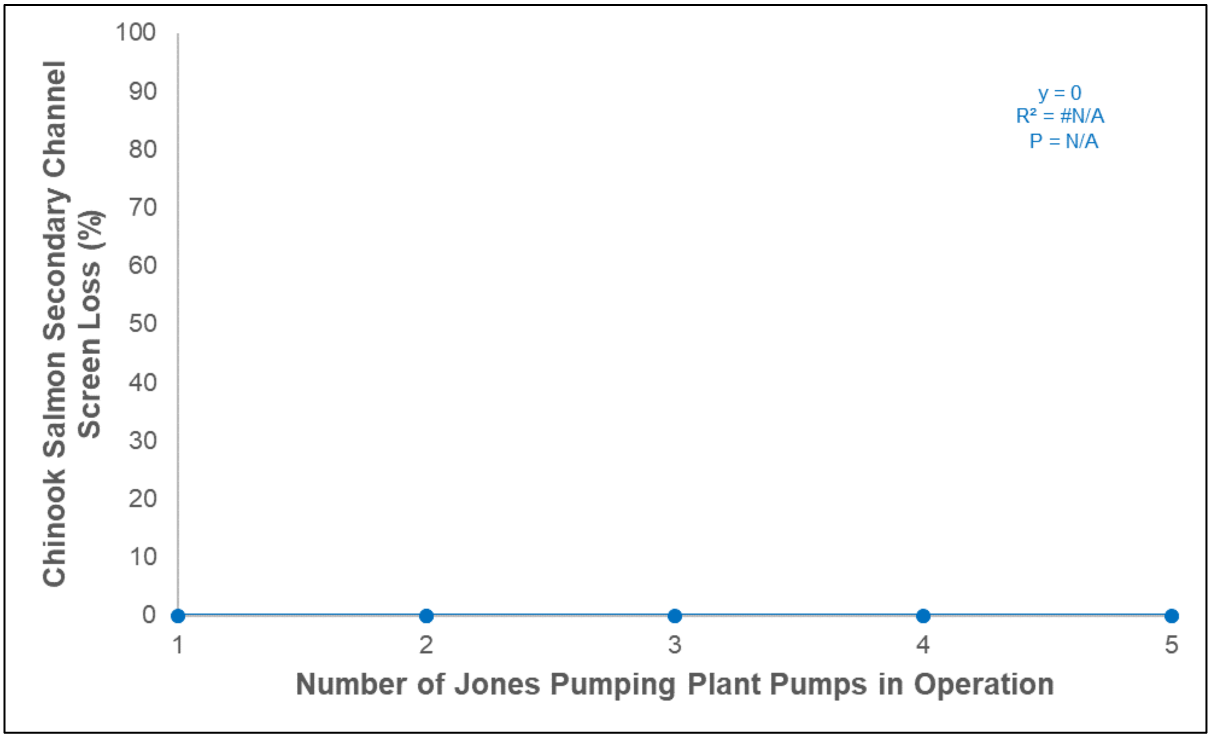

Figure 9.—Percentage of experimental Chinook Salmon lost through the secondary channel traveling screens at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Predation Loss

The percentage of experimental Chinook Salmon lost to predation was not significantly influenced by the number of pumps in operation at the JPP (P = 0.368; linear regression analysis), which suggests predation at the TFCF is influenced by factors other than primary channel flow and velocity (i.e., predator abundance, predatory species assemblage, predator activity and behavior, extent of fish and/or debris entrainment, water turbidity, etc.). On average (minimum–maximum), 47.6% (20.0–72.7%), 45.0% (10.0–90.0%), 33.3% (10.0–60.0%), 43.3% (10.0–80.0%), and 26.7% (10.0–50.0%) of experimental Chinook Salmon were determined to be lost to predation via a triggered PDAT during 1, 2, 3, 4, and 5 pump operation at the JPP, respectively (Appendix E, Table E-1). These results suggest predation on juvenile Chinook Salmon is a significant source of loss at the TFCF. The best-fit trendline suggests predation may be lower during maximum JPP pump operation (i.e., when there is 5 JPP pumps in operation), although data was highly variable during all JPP pump operations and R^2 value of the trendline was weak (Chin 1998; $R^2 = 0.06$; Figure 10). Since PDATs were conservatively allowed up to 140 h after the end of the operational period during which they were released to trigger (based on maximum PDAT trigger time reported by Schultz et al. 2017), it is possible that some predation events may have occurred after the end of the hydraulic period during which the fish was released, resulting in predation estimates that may be biased high.

The mean trigger time of PDATs after release was 62.3 h (2.6 d; range = 6.6–301.7 h [0.3–12.6 d]; Appendix C, Table C-1). Only PDATs with a definitive trigger time were used to calculate this estimate. Mean PDAT trigger time during this experiment was higher than mean acoustic tag defecation times reported by Schultz et al. (2015; 43.2 h [1.8 d] from consumption to defecation using Model 800 acoustic tags [307 kHz frequency; 0.5 g in air; 6.1-mm diameter x 13.5-mm long; HTI-Vemco USA, Inc., Seattle, Washington]) and Karp et al. (2017; 41.3 h [1.7 d] from release to defecation using Model 800 acoustic tags), as well as mean PDAT trigger times reported by Schultz et al. (2017; 59.2 h [2.5 d] after consumption using Model 900-PD PDATs [i.e., the same PDAT used during this experiment]). This was expected since trigger times from this experiment are potentially biased high because the exact time of predation events could not be determined, and it is assumed that all triggered PDATs were consumed immediately after release. Differences in trigger time/defecation time estimates may also be due to the use of different models of acoustic tags (i.e., differences in acoustic tag size and characteristics), variability in environmental conditions, experimental Chinook Salmon size, predatory fish species, predatory fish size, and predatory fish gut fullness.

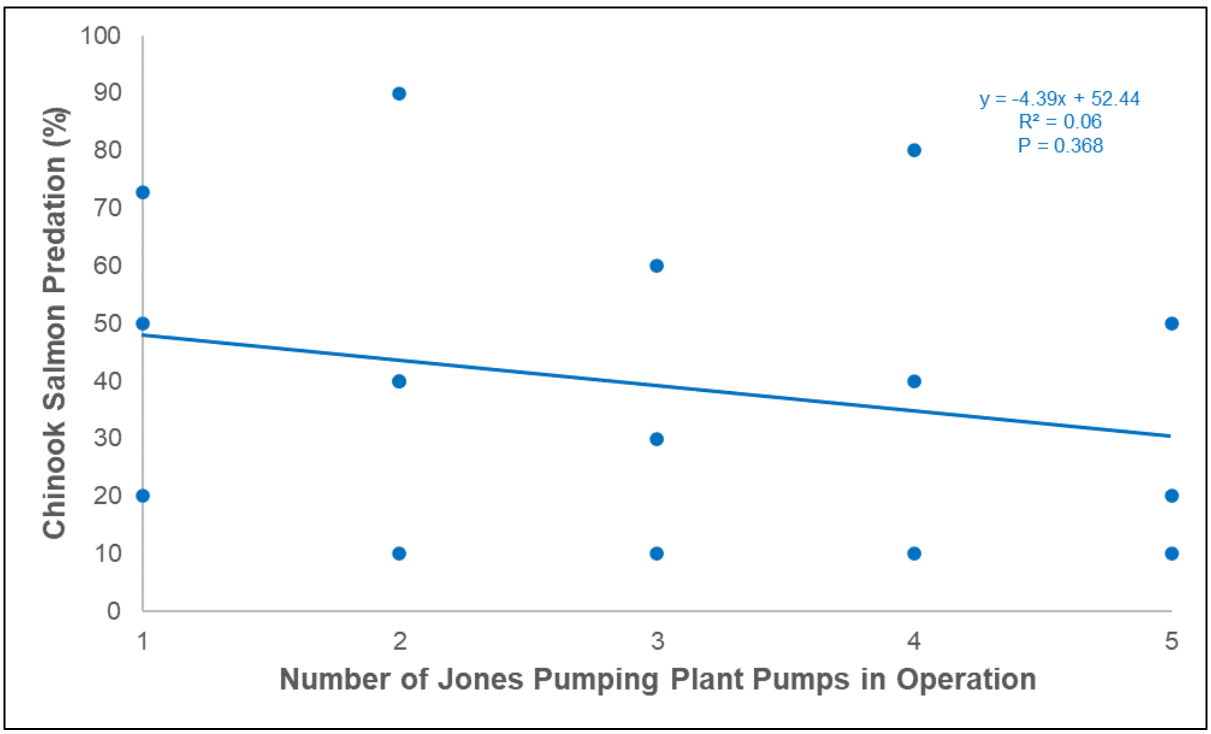

Figure 10.—Percentage of experimental Chinook Salmon lost to predation at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. “Bill” Jones Pumping Plant.

Unknown Fate

There was a significant negative linear association between the percentage of experimental Chinook Salmon assigned an unknown fate and the number of pumps in operation at the JPP

(P = 0.009; linear regression analysis), although data was variable during all JPP pump operations and R^2 value of the trendline was moderate (Chin 1998; R^2 = 0.40; Figure 11). On average (minimum–maximum), 32.4% (20.0–50.0%), 40.0% (10.0–60.0%), 10.0% (0–20.0%), 16.7% (10.0–30.0%), and 3.3% (0–10.0%) of experimental Chinook Salmon were classified as having unknown fates during 1, 2, 3, 4, and 5 pump operation at the JPP, respectively (Appendix E, Table E-1). Most of these fish were assigned an unknown fate because they were determined to have exited the TFCF hydrophone array in an upstream direction without a triggered PDAT. After exiting the array, these tags were not detected again at the TFCF or by any of the hydrophones deployed by DWR in Old River or Grant Line Canal. Due to the lack of detections, it was not possible to verify if the PDAT had triggered; therefore, it was not possible to determine if these fish exited the facility as a Chinook Salmon (non-participation) or in the stomach of a predator (loss to predation) and an unknown fate was assigned. A few fish were assigned this fate after disappearing from the primary channel without detection upstream of the facility, downstream of the facility, in the secondary channel, or in the holding tanks. In this situation, it was likely that fish either experienced tag failure or held in the bypass pipes (either as a Chinook Salmon or in a predator) where there was no acoustic detection capability.

None of the experimental Chinook Salmon that exited the TFCF hydrophone array in an upstream direction without a triggered PDAT were detected by hydrophones deployed by DWR in Old River or Grant Line Canal during this experiment (i.e., within 140 h after the end of the operational period during which fish were released). This suggests experimental Chinook Salmon that exited the upstream TFCF hydrophone array either 1) maintained their position between the TFCF and Old River or Grant Line Canal, 2) were preyed upon with trigger of PDAT and subsequent tag defecation occurring in the unmonitored area between the TFCF and Old River or Grant Line Canal, or 3) moved to other locations in the Delta that were not monitored during this experiment (i.e., Clifton Court Forebay [SWP] or downstream reaches of Old River). The lack of detections by the DWR hydrophones in Old River or Grant Line Canal was likely due to the large amount of unmonitored area between these stations and the upstream TFCF hydrophone array, as well as the existence of numerous unmonitored routes that could have been utilized by experimental Chinook Salmon. Considering this, it appears the only reasonable way to potentially reduce the number of unknown fate assignments upstream of the TFCF is by obtaining more thorough detection capability upstream of the facility by installing an expanded hydrophone array and/or using mobile tracking technology.

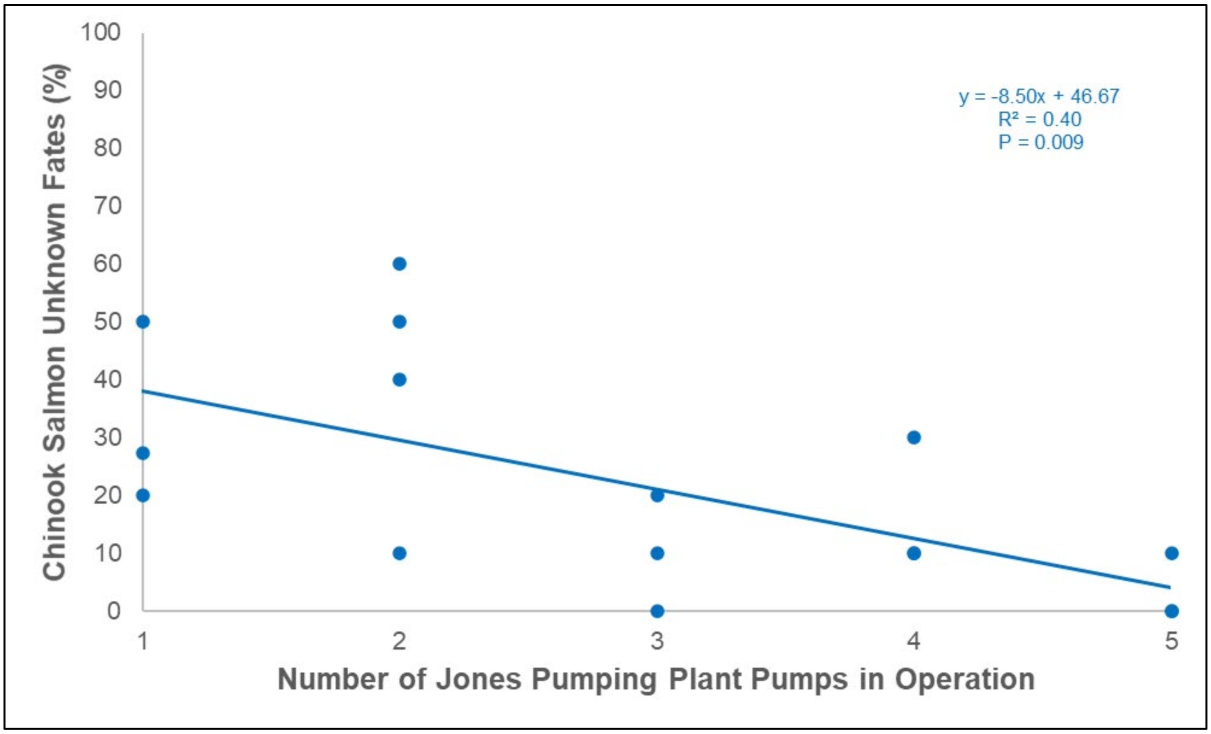

Figure 11.—Percentage of experimental Chinook Salmon with an unknown fate assignment at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Salvage Efficiency

Low and high estimates of juvenile Chinook Salmon salvage efficiency significantly increased with increasing number of pumps in operation at the JPP (P = 0.004 and 0.015, respectively; linear regression analysis), although data was variable at all JPP pump operations and R^2 values of trendlines were moderate (Chin 1998; R^2 = 0.46 [low estimate] and 0.36 [high estimate]; Figure 12). On average (minimum–maximum), low estimates of salvage efficiency during 1, 2, 3, 4, and 5 pump operation at the JPP were 16.7% (0–50.0%), 5.9% (0–12.5%), 33.3% (20.0–40.0%), 36.7% (10.9–50.0%), and 66.7% (30.0–90.0%), respectively, while high estimates of salvage efficiency during 1, 2, 3, 4, and 5 pump operation at the JPP were 20.8% (0–62.5%), 17.5% (0–50.0%), 39.2% (33.0–44.4%), 48.9% (11.0–80.0%), and 67.8% (33.3–90.0%), respectively (Appendix F, Table F-1). Data from this experiment suggests Reclamation is likely not meeting the 75.0% salvage efficiency at the TFCF for juvenile Chinook Salmon that is mandated by Action IV.4.1 of NMFS (2009) and implies higher pumping rates at the JPP likely benefit overall salvage of juvenile Chinook Salmon at the TFCF.

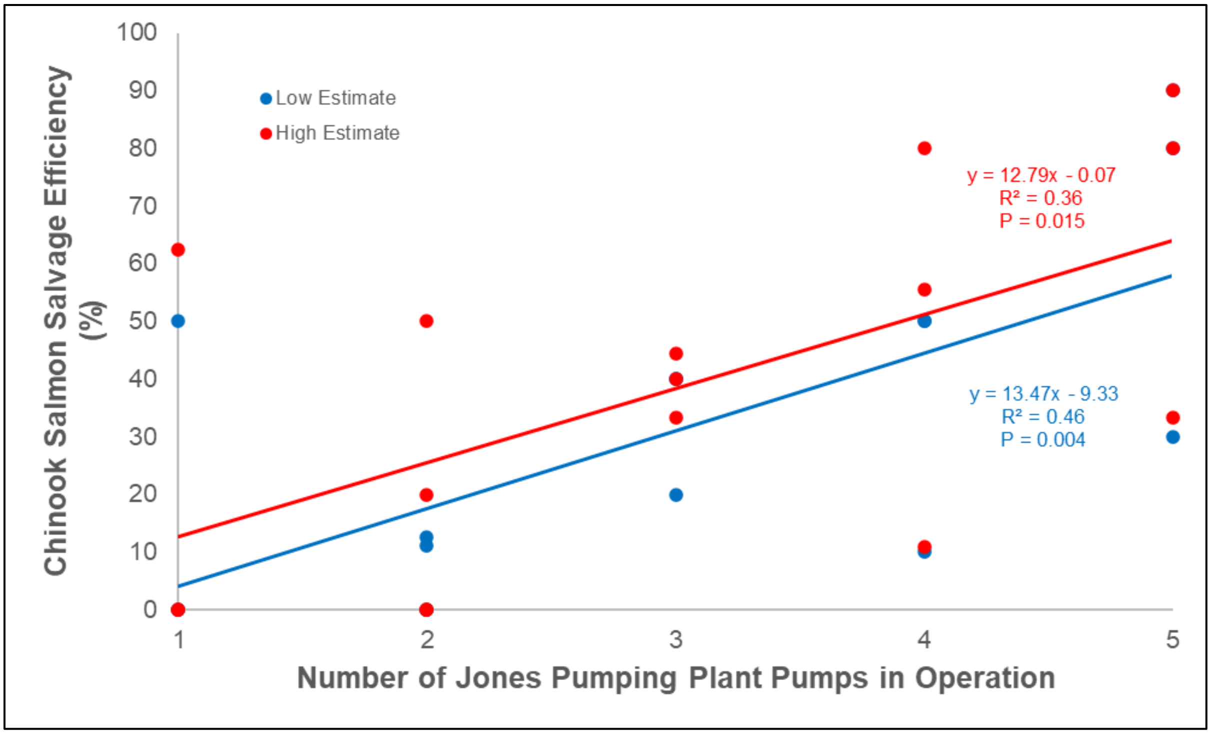

Figure 12.—High and low estimates of juvenile Chinook Salmon salvage efficiency at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Participation

Estimates of participation significantly increased as the number of pumps in operation at the JPP increased (P = 0.002; linear regression analysis), although data was variable and R^2 value of the trendline was moderate (Chin 1998; R^2 = 0.51; Figure 13). On average (minimum–maximum), participation of experimental Chinook Salmon during 1, 2, 3, 4, and 5 pump operation at the JPP was 35.5% (0–70.0%), 7.5% (0–10.0%), 56.7% (20.0–80.0%), 76.7% (50.0–90.0%), and 90.0% (70.0–100%), respectively (Appendix F, Table F-1). These results suggest juvenile Chinook Salmon are more likely to enter the TFCF at higher pumping rates, which implies that higher pumping rates likely benefit overall salvage of juvenile Chinook Salmon at the TFCF assuming loss to predation within the facility is not a factor.

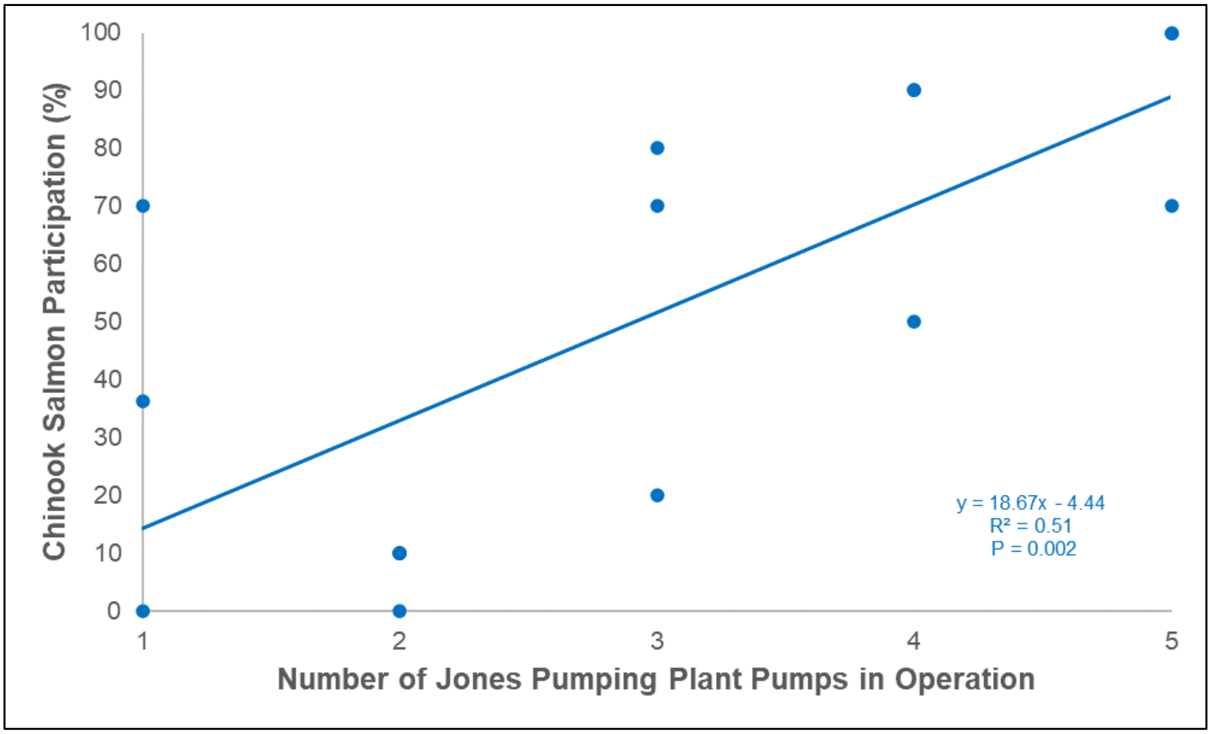

Figure 13.—Juvenile Chinook Salmon participation (percentage of fish that passed the trashrack and entered the Tracy Fish Collection Facility primary channel) during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Primary Channel Louver Efficiency

Estimates of primary channel louver efficiency were not significantly influenced by the number of pumps in operation at the JPP ($P = 0.787$; linear regression analysis). On average (minimum–maximum), primary channel louver efficiency during 1, 2, 3, 4, and 5 pump operation at the JPP was 83.3% (83.3–83.3%), 100%, 72.2% (50.0–100%), 100%, and 91.7% (75.0–100%), respectively (Appendix F, Table F-1). While best-fit trendlines appeared to demonstrate a slight increase in primary channel louver efficiency with increased pumping at the JPP, data was highly variable and R^2 value of the trendline was weak (Chin 1998; $R^2 = 0.01$), further indicating primary channel louver efficiency at the TFCF is not strongly dependent on the number of pumps in operation at the JPP (Figure 14). This suggests that juvenile Chinook Salmon primary channel louver efficiency may be influenced by primary channel bypass ratio, which was generally greater than 1.0 (i.e., bypass entrance water velocity was greater than channel water velocity) throughout this experiment (Table 1 and Appendix D [Tables D-1 through D-5]). Despite this, it was apparent from the data that acoustically tagged Chinook Salmon were more likely to interact with or encounter the TFCF primary channel louvers when the JPP was pumping at higher capacities (Figure 13), which implies that higher pumping rates may benefit overall salvage of juvenile Chinook Salmon at the TFCF. In addition, this suggests primary channel louver efficiency estimates developed during this experiment for higher JPP pumping rates are likely more representative than estimates developed for lower pumping rates as the proportion of fish that encountered the primary louvers was likely greater.

Ultimately, results from this experiment suggest primary channel louver loss of juvenile Chinook Salmon at the TFCF is a minor source of loss and primary channel louver performance is adequate to meet or exceed the 75.0% mandated by Action IV.4.1 of NMFS (2009). It appears that solely eliminating primary channel louver loss would not be enough to obtain TFCF salvage efficiencies that consistently meet the NMFS (2009) mandate and it would still be necessary for Reclamation to address other sources of loss (i.e., predation) to meet this regulatory requirement.

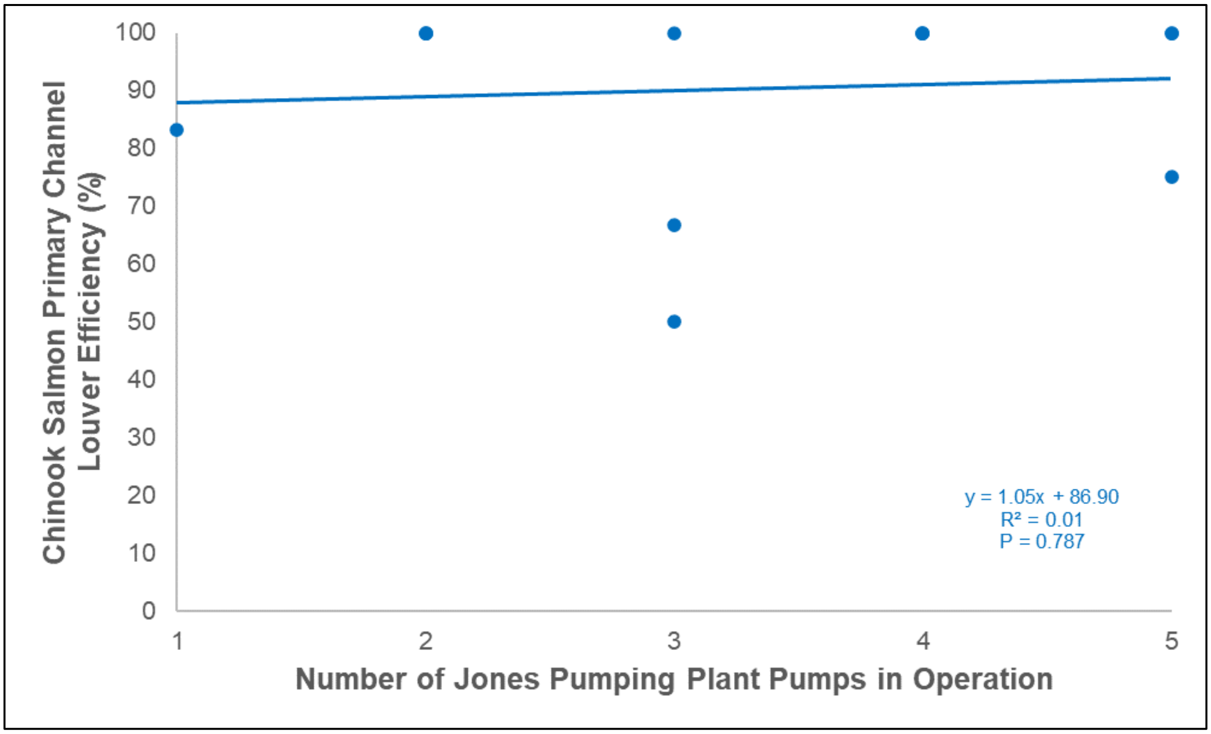

Figure 14.—Juvenile Chinook Salmon primary channel louver efficiency at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. “Bill” Jones Pumping Plant.

Secondary Channel Screen Efficiency

Secondary channel screen efficiency was 100% throughout this experiment (Figure 15; Appendix F, Table F-1). This suggests replacement of the secondary channel louvers with vertical traveling screens at the TFCF eliminated loss of juvenile Chinook Salmon through the guidance system in the secondary channel and indicates secondary channel screen performance is adequate to meet the NMFS (2009) efficiency mandate for juvenile Chinook Salmon. This result was expected as the vertical traveling screen has much smaller openings (1.8-mm) than the secondary channel louvers that were historically used at the TFCF (2.5-cm).

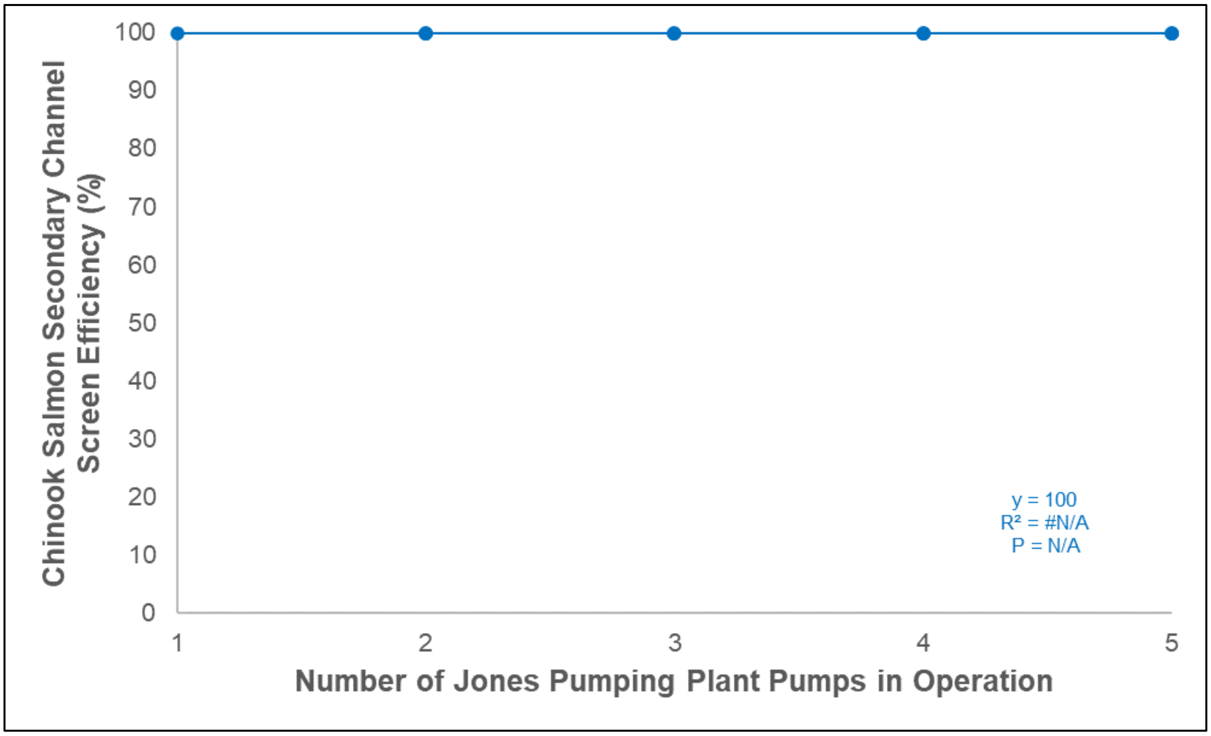

Figure 15.—Juvenile Chinook Salmon secondary channel screen efficiency at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Passage Time

Passage time of juvenile Chinook Salmon was significantly influenced by the number of pumps in operation at the JPP ($P = < 0.001$; polynomial regression analysis), with decreased passage time associated with increased JPP pumping. Passage time of salvaged experimental Chinook Salmon through the TFCF during 1, 2, 3, 4, and 5 pump operation at the JPP (based on release date and time, as well as the date and time the fish was detected in a TFCF holding tank) averaged 49.5 h (minimum–maximum = 21.3–89.7 h), 5.6 h (minimum–maximum = 1.0–10.1 h), 6.9 h (minimum–maximum = 0.1–11.4 h), 4.9 h (minimum–maximum = 0.6–9.3 h), and 0.4 h (minimum–maximum = 0.1–1.9 h), respectively (Appendix C, Table C-1; Appendix F, Table F-1). Despite high variability in passage times during 1 JPP pump operation, R^2 value of the trendline was substantial (Chin 1998; $R^2 = 0.68$; Figure 16). Reduced passage time through the TFCF with increased pumping at the JPP was expected since primary channel flow and velocity significantly increased with increased pumping at the JPP, which would theoretically promote quicker passage of juvenile Chinook Salmon through the facility. The reduced passage time with increased JPP pumping potentially influenced predation within and/or upstream of the facility and was likely a contributing factor to the overall increase in salvage efficiency at higher JPP pumping rates.

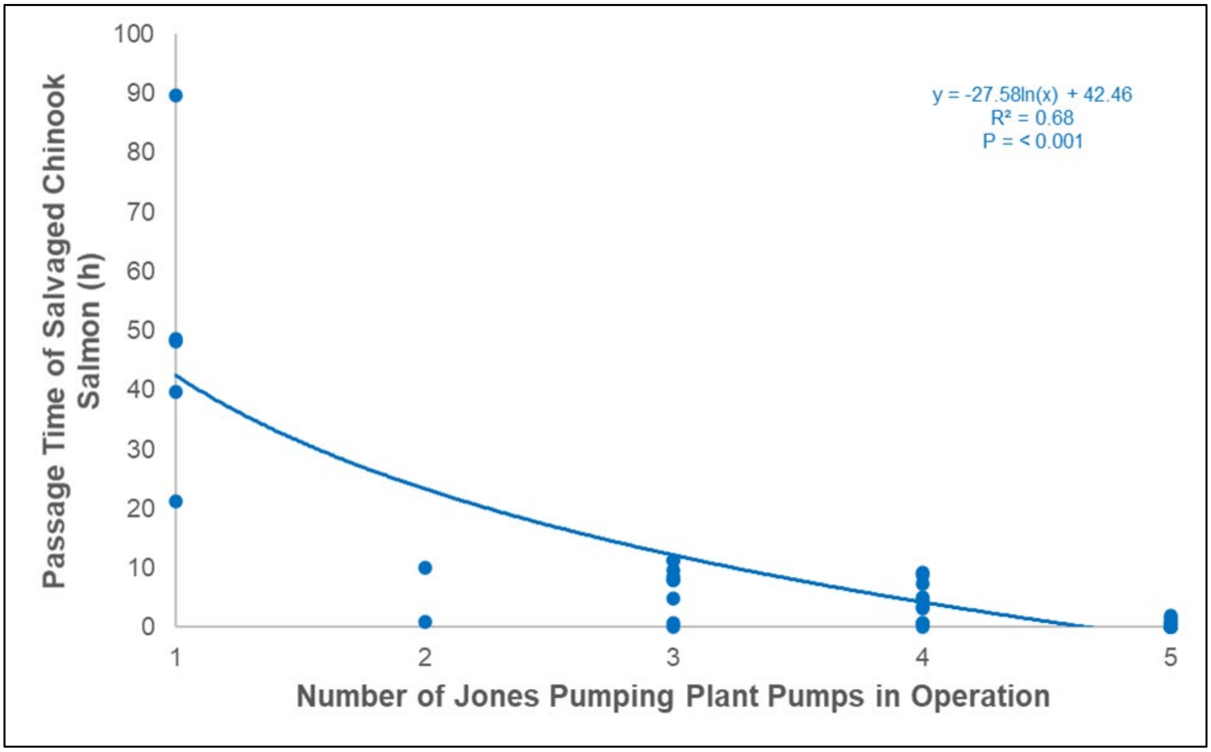

Figure 16.—Passage time of juvenile Chinook Salmon released at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Total Predation Loss

Low estimates of total predation loss were not significantly influenced by the number of pumps in operation at the JPP (P = 0.368; linear regression analysis), although high estimates of total predation loss were significantly influenced by JPP pumping rate (P = 0.010; linear regression analysis). On average (minimum–maximum), low estimates of total predation loss during 1, 2, 3, 4, and 5 pump operation at the JPP were 47.6% (20.0–72.7%), 45.0% (10.0–90.0%), 33.3% (10.0–60.0%), 43.3% (10.0–80.0%), and 26.7% (10.0–50.0%), respectively, while high estimates of total predation loss during 1, 2, 3, 4, and 5 pump operation at the JPP were 80.0% (40.0–100%), 85.0% (70.0–100%), 43.3% (30.0–60.0%), 60.0% (40.0–90.0%), and 30.0% (10.0–60.0%), respectively (Appendix F, Table F-1). Best-fit trendlines appeared to demonstrate total predation loss decreased with increased pumping at the JPP, although estimates were variable at all JPP pump operations and R^2 values of trendlines were weak to moderate (Chin 1998; $R^2 = 0.06$ [low estimate] and 0.38 [high estimate]; Figure 17). High variability in total predation loss estimates was expected based on results of previously published reports (i.e., Karp et al. 2017 and Bridges et al. 2019) and may be due to seasonal and yearly differences in overall predator abundance and predatory species assemblage within and upstream of the TFCF (predatory fish species at the TFCF include Striped Bass [*Morone saxatilis*], White Catfish [*Ameiurus catus*], Channel Catfish [*Ictalurus punctatus*], Largemouth Bass [*Micropterus salmoides*], Bluegill [*Lepomis macrochirus*], and Redear Sunfish [*Lepomis microlophus*];

Sutphin et al. 2014, Wu and Bridges 2014), differences in predator activity and behavior (due to differences in water temperature, light levels, time of day, etc.), differences in wild fish and/or debris entrainment, and differences in water turbidity.

Ultimately, results suggest predation is the main source of loss for juvenile Chinook Salmon at the TFCF and elimination of predation loss could result in TFCF salvage efficiencies that meet or exceed the 75.0% mandated by Action IV.4.1 of NMFS (2009). In addition, the significant reduction in high estimates of total predation loss at the TFCF with increased pumping at the JPP supports that higher pumping rates may benefit overall salvage of juvenile Chinook Salmon at the TFCF.

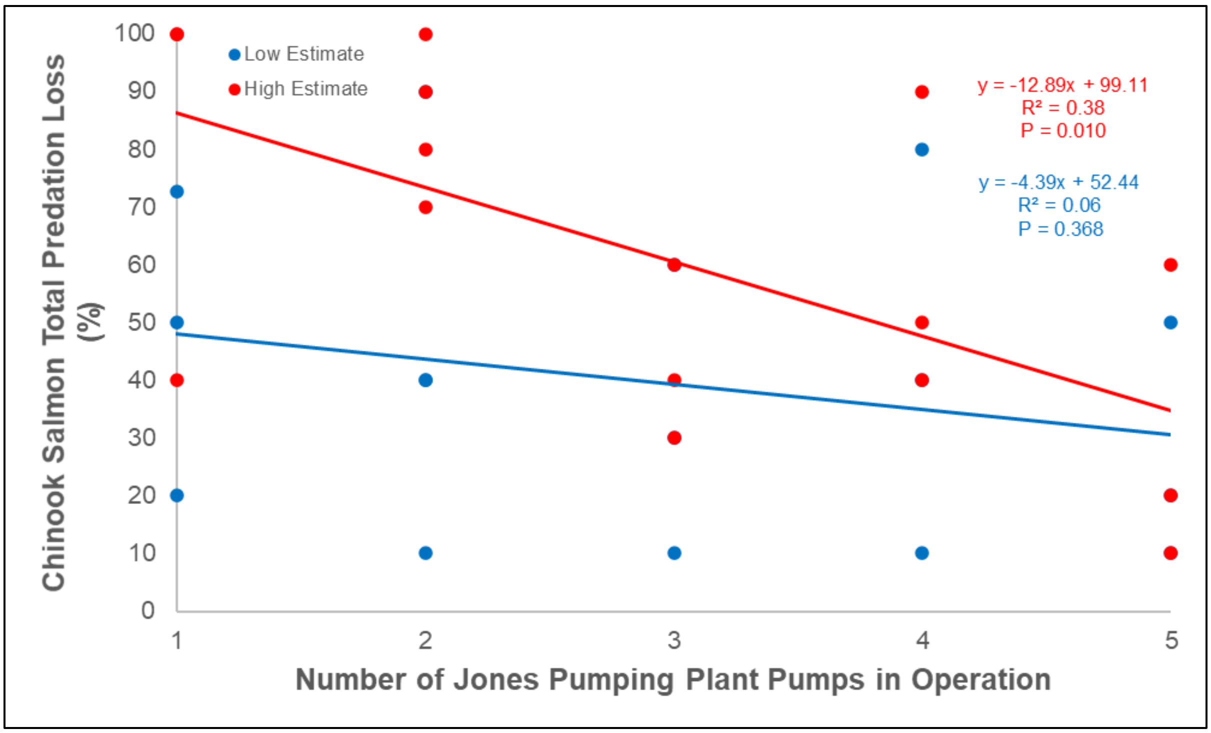

Figure 17.—High and low estimates of juvenile Chinook Salmon total predation loss at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Pre-Facility Predation

Low and high estimates of pre-facility predation significantly decreased as the number of pumps in operation at the JPP increased (P = 0.039 [linear regression analysis] and 0.003 [polynomial regression analysis], respectively), although data was highly variable at 1 and 2 JPP pump operation and R^2 values of trendlines were moderate (Chin 1998; R^2 = 0.27 [low estimate] and 0.59 [high estimate]; Figure 18). On average (minimum–maximum), low estimates of pre-facility predation during 1, 2, 3, 4, and 5 pump operation at the JPP were 32.1% (10.0–50.0%), 42.5% (10.0–90.0%), 16.7% (10.0–30.0%), 3.3% (0–10.0%), and 10.0% (0–30.0%), respectively, while high estimates of pre-facility predation during 1, 2, 3, 4, and 5 pump operation at the JPP were 64.5% (30.0–100%), 82.5% (70.0–100%), 26.7% (20.0–30.0%), 16.7% (10.0–30.0%), and 10.0% (0–30.0%), respectively (Appendix F, Table F-1). These results suggest the majority of juvenile Chinook Salmon predation at the TFCF is likely occurring upstream of the TFCF trashrack during lower JPP pump operations (i.e., when 1–3 pumps are in operation at the JPP). This was expected since experimental Chinook Salmon were more likely to remain upstream of the TFCF trashrack and be preyed upon during reduced pump operations at the JPP. In addition, the inundation of predators due to increased entrainment of wild fish and/or debris at the TFCF during higher JPP pumping rates (CDFW 2020) may have reduced predation risks for experimental Chinook Salmon under these circumstances (Furey et al. 2016, Furey et al. 2020). The high extent of variability in pre-facility predation estimates observed during lower JPP pumping rates may have also been due to natural variation in predator abundance, predatory species assemblage, predator feeding behavior, and/or water turbidity upstream of the TFCF.

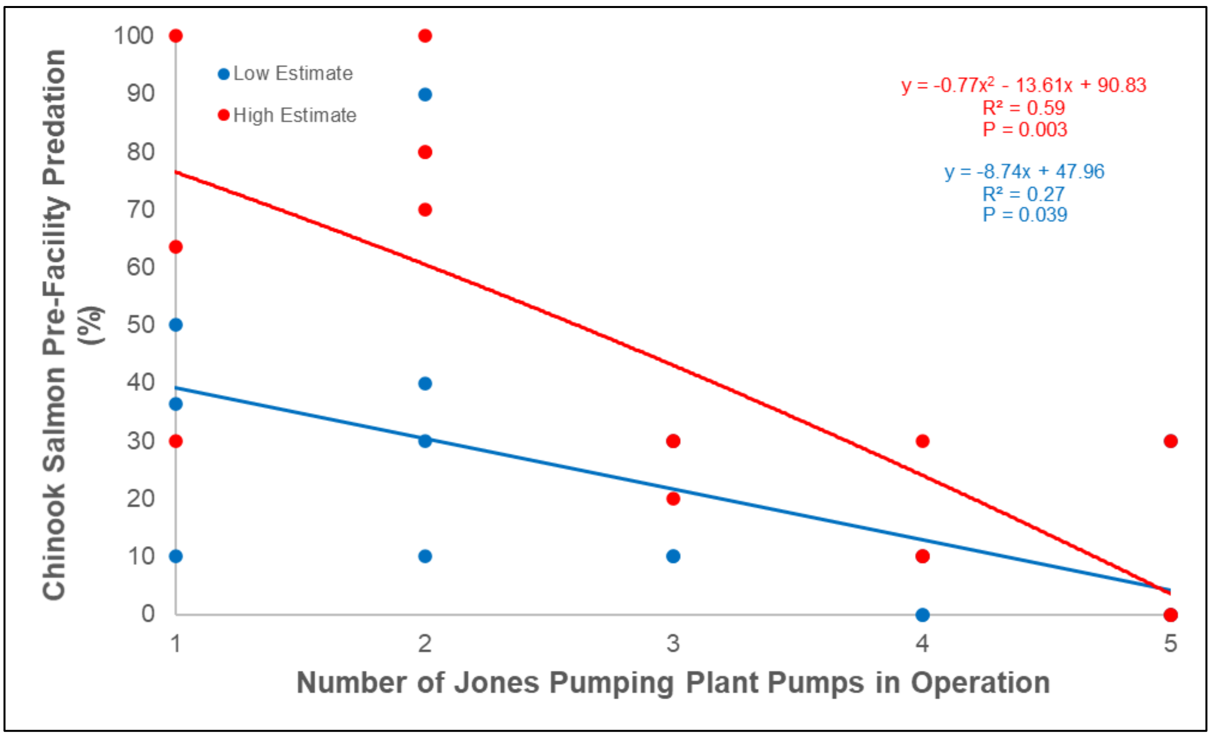

Figure 18.—High and low estimates of juvenile Chinook Salmon pre-facility predation (upstream of the Tracy Fish Collection Facility trashrack) during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Predation in the Primary Channel

Low and high estimates of predation in the primary channel were not significantly influenced by the number of pumps in operation at the JPP (P = 0.459 and 0.601, respectively; linear regression analysis). On average (minimum–maximum), low estimates of predation in the primary channel during 1, 2, 3, 4, and 5 JPP pump operation were 57.2% (14.3–100%), 33.3% (0–100%), 19.1% (0–28.6%), 47.4% (20.0–77.8%), and 19.5% (10.0–28.6%), respectively, while high estimates of predation in the primary channel during 1, 2, 3, 4, and 5 pump operation at the JPP were 57.2% (14.3–100%), 33.3% (0–100%), 19.1% (0–28.6%), 51.1% (20.0–88.9%), and 24.3% (10.0–42.9%), respectively (Appendix F, Table F-1). Best-fit trendlines appeared to show slightly decreased predation in the primary channel with increased pumping at the JPP, although data was highly variable during all JPP pump operations and R^2 values of trendlines were weak (Chin 1998; R^2 = 0.05 [low estimate] and 0.02 [high estimate]; Figure 19). Results from this experiment suggest the extent of predation in the TFCF primary channel is influenced by factors other than primary channel flow and velocity (i.e., predator abundance, predatory species assemblage, predator activity and behavior, extent of fish and/or debris entrainment, water turbidity, etc.).

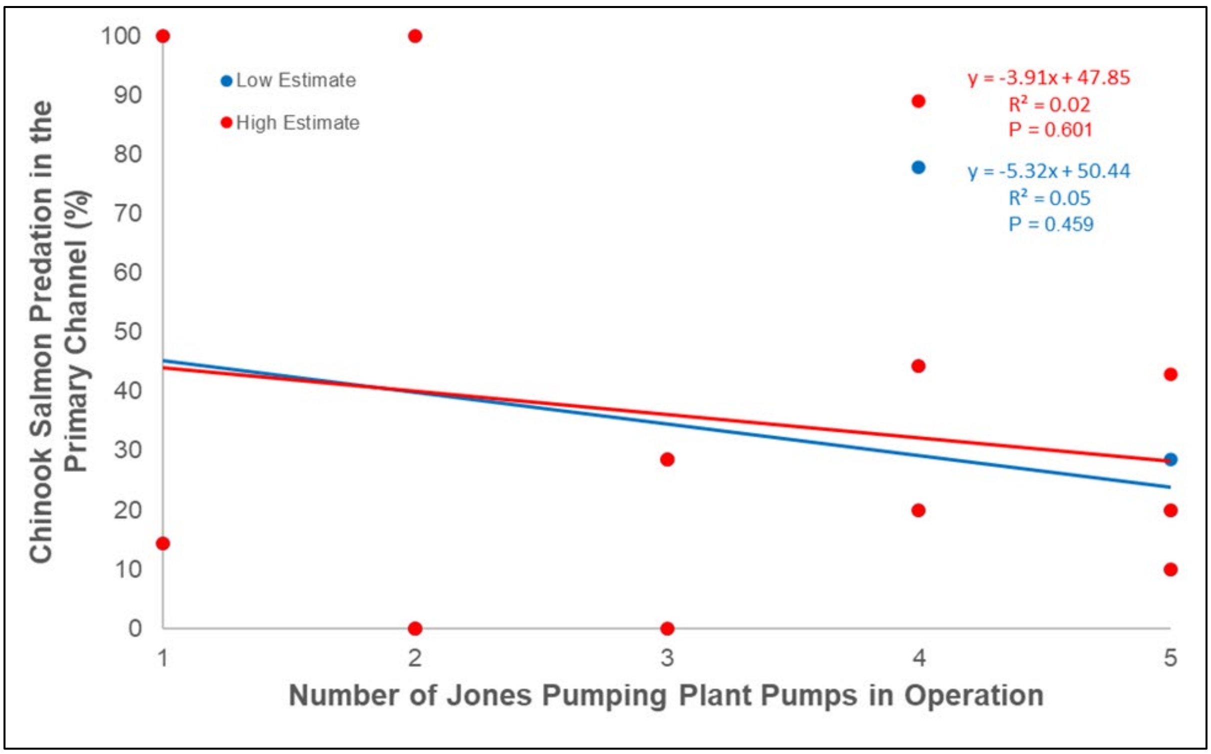

Figure 19.—High and low estimates of juvenile Chinook Salmon predation in the primary channel (between the Tracy Fish Collection Facility trashrack and primary louver array) during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Predation in the Secondary Channel

Estimates of predation in the secondary channel were not significantly influenced by the number of pumps in operation at the JPP (P = 0.528; polynomial regression analysis). On average (minimum–maximum), predation in the TFCF secondary channel during 1, 2, 3, 4, and 5 pump operation at the

JPP was 0%, 0%, 6.7% (0–20.0%), 0%, and 0%, respectively (Appendix F, Table F-1). The extent of predation that occurred in the secondary channel represented 0.6% (1/161) of all experimental fish and 1.6% (1/64) of all predation events during this experiment. Results suggest loss to predation within this portion of the TFCF is minimal during all JPP pump operations (Figure 20). The low predation rate in the secondary channel implies that predator abundance at this location is likely lower than other areas within or near the TFCF, which may be due to predator removal efforts that are completed within the bypass pipes and secondary channel on a monthly basis (Reyes et al. 2018).

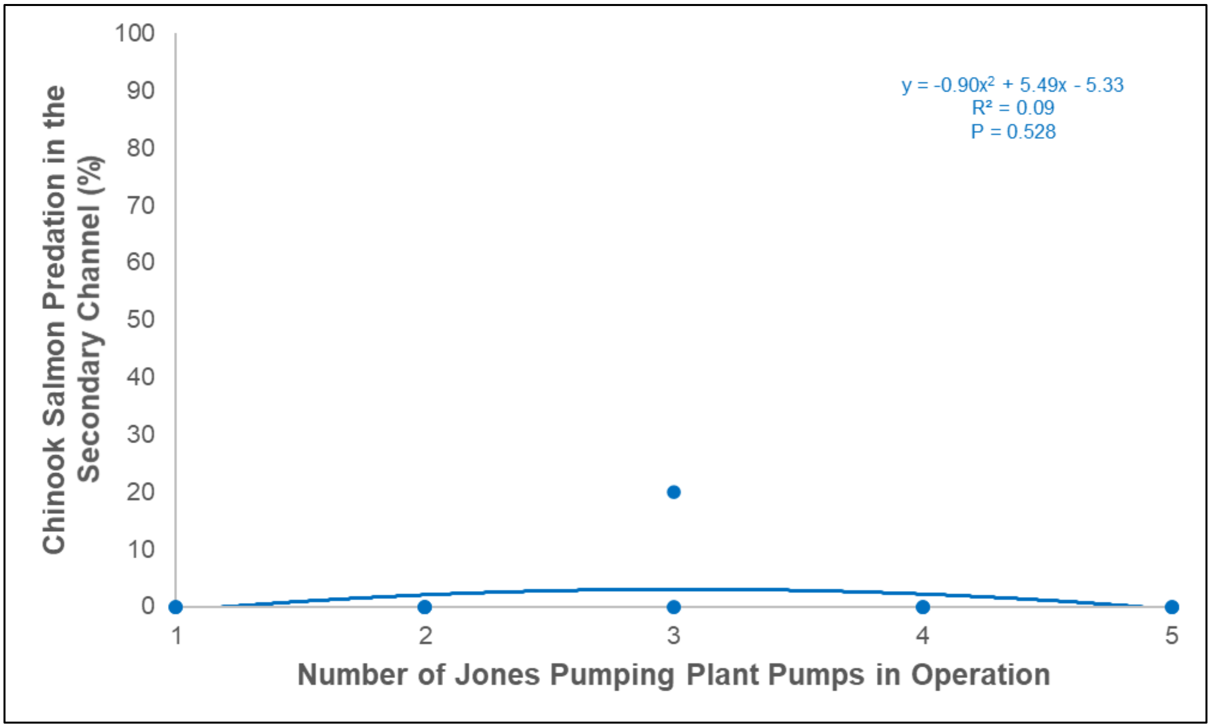

Figure 20.—Juvenile Chinook Salmon predation in the secondary channel at the Tracy Fish Collection Facility during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill" Jones Pumping Plant.

Pre-Screen Loss

In the past, the term "pre-screen loss" has been vaguely described and defined in various manners because there is no logical delineation between direct effects within the fish screening facilities and predation effects within and near them (Jahn 2011). According to Jahn (2011), pre-screen loss is defined as mortality due to predation before fish encounter the salvage facility. Likewise, Karp et al. (2017) defines pre-screen loss as loss to predation upstream of the TFCF trashrack. According to these definitions, pre-screen loss would be equivalent to pre-facility predation loss estimates (predation upstream of the TFCF trashrack) developed during this experiment (i.e., average [minimum–maximum] low estimates of pre-screen loss during 1, 2, 3, 4, and 5 pump operation at the JPP would be 32.1% [10.0–50.0%], 42.5% [10.0–90.0%], 16.7% [10.0–30.0%], 3.3% [0–10.0%], and 10.0% [0–30.0%], respectively, while average [minimum–maximum] high estimates of pre-screen loss during 1, 2, 3, 4, and 5 pump operation at the JPP would be 64.5% [30.0–100%], 82.5% [70.0–100%], 26.7% [20.0–30.0%], 16.7% [10.0–30.0%], and 10.0% [0–30.0%], respectively [Appendix F, Table F-1]). Despite this, pre-screen loss has also been defined as predation leading up to the TFCF primary channel louver array (Anonymous 2013) as well as predation between the TFCF primary channel louvers and the TFCF trashrack (CDFW 2013 and Reyes et al. 2018). According to the definition provided by Anonymous (2013), pre-screen loss would be equivalent to the sum of pre-facility predation and predation in the primary channel loss estimates provided by this experiment (or total predation loss minus predation in the secondary channel; i.e., average [minimum–maximum] low estimates of pre-screen loss during 1, 2, 3, 4, and 5 JPP pump operation would be 47.6% [20.0–72.7%], 45.0% [10.0–90.0%], 30.0% [10.0–50.0%], 43.3% [10.0–80.0%] and 26.7% [10.0–50.0%], respectively, while average [minimum–maximum] high estimates of pre-screen loss during 1, 2, 3, 4, and 5 pump operation at the JPP would be 80.0% [40.0–100%], 85.0% [70.0–100%], 40.0% [30.0–50.0%], 60.0% [40.0–90.0%] and 30.0% [10.0–60.0%], respectively [Appendix F, Table F-1]), while according to the definition provided by CDFW (2013) and Reyes et al. (2018), pre-screen loss would equal estimates of predation in the primary channel developed during this experiment (i.e., average [minimum–maximum] low estimates of pre-screen loss during 1, 2, 3, 4, and 5 JPP pump operation would be 57.2% [14.3–100%], 33.3% [0–100%], 19.1% [0–28.6%], 47.4% [20.0–77.8%] and 19.5% [10.0–28.6%], respectively, while average [minimum–maximum] high estimates of pre-screen loss during 1, 2, 3, 4, and 5 pump operation at the JPP would be 57.2% [14.3–100%], 33.3% [0–100%], 19.1% [0–28.6%], 51.1% [20.0–88.9%], and 24.3% [10.0–42.9%], respectively [Appendix F, Table F-1]).

Due to differing and somewhat vague definitions of "pre-screen loss" used in the past, this term was intentionally avoided during this experiment. Instead, estimates for total predation loss, pre-facility predation, predation in the primary channel, and predation in the secondary channel have been provided so that future researchers may choose which loss estimate(s) to use as "pre-screen loss." Regardless of the definition of pre-screen loss used, estimates of overall pre-screen loss (i.e., pre-screen loss during all JPP pump operations combined) obtained during this experiment (22.4–42.9% [Jahn 2011 and Karp et al. 2017], 39.1–60.9% [Anonymous 2013], and 33.8–36.3% [CDFW 2013 and Reyes et al. 2018]) were greater than the placeholder value for pre-screen loss currently applied in facility salmonid loss equations (15.0%; Jahn 2011, Reyes et al. 2018), suggesting the current placeholder value may be low. Since the extent and locality of predation events appeared to vary depending on water flow and velocity within or near the TFCF, the use of different placeholder values for each potential JPP pumping condition (i.e., 1, 2, 3, 4, and 5 JPP pumps in operation) may be prudent when using formulas to compute winter-run and spring-run Chinook Salmon loss associated with TFCF operations.

Conclusions and Recommendations

The use of PDATs during this experiment appeared to reduce the number of unknown fates assigned to juvenile Chinook Salmon released and tracked at the TFCF by allowing for the distinction between predation events and non-participation. The reduction in unknown fates ultimately allowed for the development of more accurate and precise estimates of salvage efficiency, as well as efficiency of individual facility components (i.e., primary channel louvers and secondary channel screens), and increased ability to determine how operations (i.e., the number of pumps in operation at the JPP) influences salvage efficiency at the TFCF for juvenile Chinook Salmon. Despite the fact that inclusion of monitoring stations in Old River and Grant Line Canal did not yield any detections or result in the reassignment of any unknown fates during this experiment, the only reasonable way to potentially reduce the number of unknown fate assignments is by obtaining more thorough detection coverage upstream of the TFCF by installing an expanded hydrophone array and/or using mobile tracking technology.

Results of this experiment suggest Reclamation is not consistently meeting the 75.0% salvage efficiency at the TFCF for juvenile Chinook Salmon that is mandated by Action IV.4.1 of NMFS (2009). While performance of the primary channel louvers and secondary channel traveling screens at the TFCF is adequate to meet or exceed the NMFS (2009) efficiency mandate, it appears salvage efficiency is heavily impacted by predation loss (especially in the primary channel and upstream of the trashrack [i.e., pre-facility]) to an extent that elimination of this source of loss could result in TFCF salvage efficiencies that meet or exceed the requirement specified by NMFS (2009).

The small data set collected during this experiment, as well as the high variability in predation estimates observed, made it difficult to definitively determine if facility operations significantly influence salvage efficiency, as well as the efficiency of individual facility components (i.e., primary channel louvers and secondary channel traveling screen). While additional data collection is necessary for support, there was evidence suggesting that higher pumping rates at the JPP result in a net increase in TFCF salvage efficiency for juvenile Chinook Salmon. It appeared that as pumping at the JPP increased (i.e., as primary channel water flow and velocity increased at the TFCF), participation significantly increased, passage time through the facility significantly decreased, total predation loss potentially decreased significantly, and salvage efficiency significantly increased. As pumping increased at the JPP, pre-facility predation significantly decreased, while predation in the primary channel and secondary channel were not significantly influenced. The extent of decrease in pre-facility predation with increased pumping at the JPP resulted in potentially significant reduction in total predation loss, which was likely the driving force behind the significant increase in juvenile Chinook Salmon salvage efficiency at the TFCF with increased pumping at the JPP.

Since there were limited replicates completed at each JPP pumping condition during this experiment, it is recommended that Reclamation perform additional efficiency evaluations at the TFCF to expand upon results of this study and verify apparent trends. It is suggested that future evaluations incorporate PDATs, as well as a more extensive hydrophone array upstream of the TFCF and/or mobile tracking technology. To obtain greater sample sizes and higher test power, it may be prudent to release externally marked fish along with PDAT-tagged fish during future research efforts at the TFCF to investigate salvage efficiency.

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Appendix A—Dichotomous Key Used to Assign Fates to Acoustically Tagged Chinook Salmon During Facility Efficiency Replicates Performed at the Tracy Fish Collection Facility

Table A-1.—Dichotomous key used during facility efficiency replicates at the Tracy Fish Collection Facility to assign fates to juvenile Chinook Salmon with surgically implanted Predation Detection Acoustic Tags (HTI-Vemco USA, Inc., Seattle, Washington).

Step	Observation	Action/Fate Assignment
1a	Fish dead	Delete
1b	Fish alive	Go to 2
2a	Tag dead	Delete
2b	Tag alive	Go to 3
3a	Tag remained in upstream array	Go to 4
3b	Tag left upstream array	Go to 5
4a	Predation Detection Acoustic Tag not triggered in upstream array for more than 140 h after end of hydraulic period	Non-Participation
4b	Predation Detection Acoustic Tag triggered in upstream array	Go to 6
5a	Tag moved upstream and left array	Unknown (Upstream of Facility)[1]
5b	Tag moved downstream through trashrack into primary channel during hydraulic period	Go to 7
6a	Predation Detection Acoustic Tag triggered in upstream array within 140 h after end of hydraulic period	Pre-Facility Predation
6b	Predation Detection Acoustic Tag triggered in upstream array after 140 h after end of hydraulic period	Non-Participation
7a	Predation Detection Acoustic Tag triggered in primary channel	Go to 8
7b	Predation Detection Acoustic Tag not triggered in primary channel	Go to 9
8a	Predation Detection Acoustic Tag triggered in primary channel within 140 h after end of hydraulic period	Predation in Primary Channel
8b	Predation Detection Acoustic Tag triggered in primary channel after 140 h after end of hydraulic period	Non-Participation
9a	Tag remained in primary channel for over 140 h after end of hydraulic period	Non-Participation
9b	Tag left primary channel	Go to 10
10a	Tag moved downstream through primary channel louvers into intake channel to the Delta-Mendota Canal	Go to 11
10b	Tag did not move into intake channel to the Delta-Mendota Canal	Go to 12
11a	Tag moved downstream through primary channel louvers into intake channel to the Delta-Mendota Canal during hydraulic period	Primary Channel Louver Loss

Step	Observation	Action/Fate Assignment
11b	Tag moved downstream through primary channel louvers into intake channel to the Delta-Mendota Canal after hydraulic period	Non-Participation
12a	Tag moved upstream through trashrack	Go to 13
12b	Tag moved into primary channel bypass pipes	Go to 14
13a	Tag left upstream array	Unknown (Upstream of Facility)[1]
13b	Tag remained in upstream array	Go to 15
14a	Tag remained in bypass pipes or was not detected again	Unknown (Primary Channel)[1]
14b	Tag detected in secondary channel	Go to 16
15a	Predation Detection Acoustic Tag not triggered in upstream array for more than 140 h after end of hydraulic period	Non-Participation
15b	Predation Detection Acoustic Tag triggered in upstream array	Go to 17
16a	Tag detected downstream of secondary channel screen	Secondary Channel Screen Loss
16b	Tag not detected downstream of secondary channel screen	Go to 18
17a	Predation Detection Acoustic Tag triggered in upstream array within 140 h after end of hydraulic period	Pre-Facility Predation
17b	Predation Detection Acoustic Tag triggered in upstream array after 140 h after end of hydraulic period	Non-Participation
18a	Predation Detection Acoustic Tag triggered in secondary channel	Go to 19
18b	Predation Detection Acoustic Tag not triggered in secondary channel	Go to 20
19a	Predation Detection Acoustic Tag triggered in secondary channel within 140 h after end of hydraulic period	Predation in Secondary Channel
19b	Predation Detection Acoustic Tag triggered in secondary channel after 140 h after end of hydraulic period	Non-Participation
20a	Tag remained in secondary channel for over 140 h after end of hydraulic period	Non-Participation
20b	Tag left secondary channel	Go to 21
21a	Tag moved upstream into bypass pipes and was not detected again	Unknown (Secondary Channel)[1]
21b	Tag detected in holding tank	Go to 22
22a	Fish/tag collected in holding tank during hydraulic period	Salvaged
22b	Fish/tag collected in holding tank outside of hydraulic period	Non-participation

[1] **Unknown = Chinook Salmon whose fates could not be assigned with any certainty.**

Appendix B—Equations Used During Facility Efficiency Replicates Performed at the Tracy Fish Collection Facility With Acoustically Tagged Chinook Salmon

Passage Time = Time from release to collection in holding tank.

Participation = # of fish that moved downstream through the trashrack and entered the primary channel/# of fish released.

Salvage Efficiency
Low Estimate = # of fish salvaged/(# of fish released – # of known non-participants); assumes all fish with an unknown fate are losses to predation.

High Estimate = # of fish salvaged/(# of fish released – # of known non-participants – # of fish with unknown fate); assumes all fish with an unknown fate are non-participants.

Primary Channel Louver Efficiency = (# of fish salvaged + # of fish lost through secondary channel screens)/(# of fish salvaged + # of fish lost through secondary channel screens + # of fish lost through primary channel louvers).

Secondary Channel Screen Efficiency = # of fish salvaged/(# of fish salvaged + # of fish lost through secondary channel screens).

Total Predation Loss
Low Estimate = # of fish with triggered Predation Detection Acoustic Tag/# of fish released; assumes all fish with an unknown fate are non-participants.

High Estimate = (# of fish with triggered Predation Detection Acoustic Tag + # of fish with unknown fate)/# of fish released; assumes all fish with unknown fate are losses to predation.

Pre-Facility Predation
Low Estimate = # of fish with triggered Predation Detection Acoustic Tag upstream of the trashrack/# of fish released; assumes all fish with an unknown fate are non-participants.

High Estimate = (# of fish with triggered Predation Detection Acoustic upstream of the trashrack + # of fish with an unknown fate that did not enter the primary channel)/# of fish released; assumes all fish with an unknown fate are losses to predation.

Predation in the Primary Channel

Low Estimate = # of fish with triggered Predation Detection Acoustic Tag in primary channel/(# of fish released - # of fish that did not enter primary channel); assumes all fish with unknown fate in the primary channel are non-participants.

High Estimate = (# of fish with triggered Predation Detection Acoustic Tag in primary channel + # of fish with unknown fate in primary channel)/(# of fish released - # of fish that did not enter primary channel); assumes all fish with unknown fate in the primary channel are losses to predation.

Predation in the Secondary Channel = # of fish with triggered Predation Detection Acoustic Tag in secondary channel/(# of fish released - # of fish that did not enter secondary channel).

Appendix C—Predation Detection Acoustic Tag, Operational, Morphometric, and Other Information for Facility Efficiency Replicates Performed at the Tracy Fish Collection Facility with Acoustically Tagged Chinook Salmon

Table C-1.—Predation Detection Acoustic Tag (PDAT; Model 900-PD; HTI-Vemco USA, Inc., Seattle, Washington) period, PDAT subcode, the number of pumps in operation at the C.W. "Bill" Jones Pumping Plant (JPP), fork length (mm), weight (g), passage time (h; from the trash boom to the holding tanks), PDAT trigger time after release (h), and fate for acoustically tagged Chinook Salmon used during this experiment (n = 161).

Fish No.	Period	PDAT Subcode	Number of Pumps On at JPP (1–5)	Fork Length (mm)	Weight (g)	Passage Time (h)	PDAT Trigger Time After Release (h)	Fate
1	5781	23	4	184	75.8	9.3	—	Salvaged
2	5004	23	4	174	68.4	—	—	Unknown (Upstream of Facility)
3	5655	23	4	212	121	—	25.3	Predation in Primary Channel
4	3387	23	4	176	70.5	—	50.1	Predation in Primary Channel
5	4626	23	4	185	80.6	3.1	—	Salvaged
6	6159	23	4	180	71.9	3.1	—	Salvaged
7	5403	23	4	170	64.4	0.6	—	Salvaged
8	4815	23	4	171	59.6	—	39.9	Predation in Primary Channel
9	5130	23	4	172	58.9	0.7	—	Salvaged
10	5529	23	4	181	74.9	—	25.5	Predation in Primary Channel
11	5907	2	4	148	35.4	—	37.5	Predation in Primary Channel
12	5802	2	4	153	39	—	—	Non-Participation (Upstream of Facility)
13	7167	2	4	143	33.4	4.6	—	Salvaged
14	6936	2	4	164	49.4	—	—	Unknown (Upstream of Facility)
15	7461	2	4	161	43.3	7.2	—	Salvaged
16	3912	2	4	158	42.3	—	—	Unknown (Upstream of Facility)
17	3660	2	4	148	35.9	8.9	—	Salvaged

Fish No.	Period	PDAT Subcode	Number of Pumps On at JPP (1–5)	Fork Length (mm)	Weight (g)	Passage Time (h)	PDAT Trigger Time After Release (h)	Fate
18	5676	2	4	145	33.6	—	—	Non-Participation (Upstream of Facility)
19	5151	2	4	154	38.5	4.9	—	Salvaged
20	4500	2	4	163	43.9	—	—	Unknown (Upstream of Facility)
21	6537	2	3	132	20.8	—	—	Non-Participation (Upstream of Facility)
22	7482	2	3	157	42.9	—	—	Unknown (Upstream of Facility)
23	4626	2	3	162	45.8	—	—	Unknown (Upstream of Facility)
24	5004	2	3	157	44.4	—	—	Non-Participation (Upstream of Facility)
25	4668	2	3	154	39.1	7.9	—	Salvaged
26	3618	2	3	154	38	—	301.7	Non-Participation (Upstream of Facility)
27	6180	2	3	165	46.1	—	—	Non-Participation (Upstream of Facility)
28	7062	2	3	155	40	—	—	Non-Participation (Upstream of Facility)
29	7041	2	3	153	39.5	—	—	Primary Channel Louver Loss
30	7188	2	3	168	52.4	—	64.6	Pre-Facility Predation
31	6411	2	2	167	50.5	—	—	Unknown (Upstream of Facility)
32	6054	2	2	174	50.9	—	—	Unknown (Upstream of Facility)
33	5655	2	2	175	54.2	—	—	Unknown (Upstream of Facility)
34	3198	2	2	170	49.9	—	—	Non-Participation (Upstream of Facility)
35	3786	2	2	155	36.9	10.1	—	Salvaged
36	5403	2	2	175	57.7	—	—	Unknown (Upstream of Facility)
37	6432	2	2	171	47.5	—	—	Unknown (Upstream of Facility)
38	6285	2	2	161	42.8	—	—	Non-Participation (Upstream of Facility)
39	6306	2	2	152	38.7	—	64.4	Pre-Facility Predation
40	6810	2	2	174	55.4	—	—	Unknown (Upstream of Facility)
41	7293	2	2	135	26.3	—	67.0	Pre-Facility Predation
42	5781	2	2	134	25.4	—	—	Unknown (Upstream of Facility)
43	6789	2	2	143	32.1	—	—	Unknown (Upstream of Facility)
44	3408	2	2	126	22.4	—	—	Unknown (Upstream of Facility)

Fish No.	Period	PDAT Subcode	Number of Pumps On at JPP (1–5)	Fork Length (mm)	Weight (g)	Passage Time (h)	PDAT Trigger Time After Release (h)	Fate
45	6159	2	2	124	22.1	—	—	Unknown (Upstream of Facility)
46	5130	2	2	148	41.6	—	—	Non-Participation (Upstream of Facility)
47	4290	2	2	125	22.7	—	23.9-24.7	Pre-Facility Predation
48	6033	2	2	120	21.6	—	—	Unknown (Upstream of Facility)
49	6915	2	2	121	21	—	69.9-70.6	Pre-Facility Predation
50	4038	2	2	125	23	—	16.8	Predation in Primary Channel
51	7314	2	4	124	19.8	—	116.4-127.8	Pre-Facility Predation
52	5277	2	4	118	18.3	—	36.5	Predation in Primary Channel
53	4836	2	4	122	21.6	—	34.6	Predation in Primary Channel
54	5928	2	4	131	26.1	—	—	Unknown (Primary Channel)
55	4080	2	4	122	21.5	—	66.1	Predation in Primary Channel
56	4248	2	4	113	16.8	7.0	—	Salvaged
57	5025	2	4	120	21	—	95.9	Predation in Primary Channel
58	6684	2	4	124	21.8	—	16.2	Predation in Primary Channel
59	5529	2	4	125	22.4	—	167.0	Predation in Primary Channel
60	5550	2	4	124	22.2	—	25.9	Predation in Primary Channel
61	3371	23	5	143	35.2	—	114.8	Predation in Primary Channel
62	3733	23	5	139	32.4	1.5	—	Salvaged
63	4363	23	5	114	18	0.4	—	Salvaged
64	4813	23	5	118	20.9	0.1	—	Salvaged
65	5167	23	5	120	21.5	0.9	—	Salvaged
66	5591	23	5	118	18.7	0.1	—	Salvaged
67	5953	23	5	132	25	0.3	—	Salvaged
68	6547	23	5	141	34.7	—	30.1	Predation in Primary Channel
69	6971	23	5	130	25.6	0.2	—	Salvaged
70	7027	23	5	129	24.9	0.1	—	Salvaged
71	3733	23	5	139	32.4	0.5	—	Salvaged
72	4363	23	5	114	18	0.1	—	Salvaged
73	4813	23	5	118	20.9	—	39.2	Predation in Primary Channel
74	5167	23	5	120	21.5	0.1	—	Salvaged
75	5591	23	5	118	18.7	0.4	—	Salvaged
76	5953	23	5	132	25	0.7	—	Salvaged
77	6971	23	5	130	25.6	0.2	—	Salvaged
78	7027	23	5	129	24.9	0.1	—	Salvaged

Fish No.	Period	PDAT Subcode	Number of Pumps On at JPP (1–5)	Fork Length (mm)	Weight (g)	Passage Time (h)	PDAT Trigger Time After Release (h)	Fate
79	3313	23	5	106	14.2	0.1	—	Salvaged
80	3701	23	5	127	24.4	1.9	—	Salvaged
81	3433	23	1	122	22.1	—	33.3	Predation in Primary Channel
82	3719	23	1	120	18.5	48.2	—	Salvaged
83	4243	23	1	110	15.3	—	—	Primary Channel Louver Loss
84	4987	23	1	115	13.8	48.5	—	Salvaged
85	5261	23	1	110	13.6	—	—	Unknown (Upstream of Facility)
86	5581	23	1	120	20.8	89.7	—	Salvaged
87	5879	23	1	107	13.6	39.7	—	Salvaged
88	6211	23	1	113	17.8	—	—	Unknown (Upstream of Facility)
89	6823	23	1	126	22.2	21.3	—	Salvaged
90	7177	23	1	112	16.3	—	11.2-179.4	Pre-Facility Predation
91	3607	23	2	124	20.6	1.0	—	Salvaged
92	3823	23	2	106	20.1	—	57.3	Pre-Facility Predation
93	4513	23	2	108	14.9	—	—	Unknown (Upstream of Facility)
94	4673	23	2	131	26.3	—	—	Non-Participation (Upstream of Facility)
95	5227	23	2	126	22.6	—	27.2-27.8	Pre-Facility Predation
96	5639	23	2	136	28.8	—	—	Unknown (Upstream of Facility)
97	5849	23	2	129	23.8	—	—	Unknown (Upstream of Facility)
98	6389	23	2	114	17.3	—	37.9	Pre-Facility Predation
99	6719	23	2	135	27.2	—	—	Unknown (Upstream of Facility)
100	7499	23	2	129	22.7	—	82.7	Pre-Facility Predation
101	3511	23	3	131	26.1	—	42.0	Pre-Facility Predation
102	4013	23	3	118	20	9.5	—	Salvaged
103	4349	23	3	127	23.9	0.6	—	Salvaged
104	4903	23	3	134	25	—	30.5	Predation in Primary Channel
105	5039	23	3	126	21.2	—	24.2	Predation in Primary Channel
106	5791	23	3	116	18.4	—	143.7-365.1	Predation in Secondary Channel
107	6089	23	3	138	31	—	57.9	Pre-Facility Predation
108	6469	23	3	122	20	0.1	—	Salvaged
109	6701	23	3	130	25.6	4.9	—	Salvaged
110	7477	23	3	140	31.5	—	72.9	Pre-Facility Predation
111	3461	23	3	114	17.5	8.6	—	Salvaged
112	3671	23	3	107	14.6	—	59.3	Predation in Primary Channel

Fish No.	Period	PDAT Subcode	Number of Pumps On at JPP (1–5)	Fork Length (mm)	Weight (g)	Passage Time (h)	PDAT Trigger Time After Release (h)	Fate
113	4327	23	3	110	14.8	11.4	—	Salvaged
114	4861	23	3	106	12.6	7.9	—	Salvaged
115	5431	23	3	116	17.1	—	—	Primary Channel Louver Loss
116	6029	23	3	110	14.8	11.4	—	Salvaged
117	6379	23	3	103	13.1	—	10.5	Predation in Primary Channel
118	6733	23	3	106	13.2	—	—	Unknown (Upstream of Facility)
119	7243	23	3	111	15.2	—	28.5	Pre-Facility Predation
120	4229	23	3	108	12.7	—	—	Primary Channel Louver Loss
121	3571	23	1	115	19.4	—	—	Unknown (Upstream of Facility)
122	4111	23	1	117	20.1	—	—	Unknown (Upstream of Facility)
123	4523	23	1	120	20.7	—	—	Unknown (Upstream of Facility)
124	4691	23	1	117	18.2	—	61.4-62.7	Pre-Facility Predation
125	5417	23	1	122	21.7	—	43.9	Pre-Facility Predation
126	5711	23	1	118	19.3	—	46.1	Pre-Facility Predation
127	6173	23	1	115	17.9	—	—	Unknown (Upstream of Facility)
128	6421	23	1	120	20.1	—	54.9	Pre-Facility Predation
129	6869	23	1	121	20.5	—	—	Unknown (Upstream of Facility)
130	7103	23	1	129	24.7	—	53.7	Pre-Facility Predation
131	4889	23	5	112	14.4	—	—	Primary Channel Louver Loss
132	5113	23	5	110	15.6	—	27.7	Pre-Facility Predation
133	5531	23	5	113	16.5	—	12.8	Pre-Facility Predation
134	6163	23	5	126	23.4	—	50.7	Predation in Primary Channel
135	6337	23	5	113	17.6	—	26.3	Predation in Primary Channel
136	6983	23	5	124	23.5	0.1	—	Salvaged
137	7349	23	5	134	31.4	—	—	Unknown (Primary Channel)
138	3323	23	5	126	24.3	—	30.3	Pre-Facility Predation
139	4139	23	5	124	20.9	0.1	—	Salvaged
140	4457	23	5	119	18.3	0.1	—	Salvaged
141	5237	23	2	120	21.8	—	101.9	Pre-Facility Predation
142	5557	23	2	118	19.7	—	6.6	Pre-Facility Predation
143	6101	23	2	125	21.6	—	14.9	Pre-Facility Predation
144	6521	23	2	130	25.4	—	22.2-23.2	Pre-Facility Predation
145	6653	23	2	110	15.1	—	26.9	Pre-Facility Predation
146	7079	23	2	116	17.1	—	40.2	Pre-Facility Predation
147	3217	23	2	122	21.9	—	—	Unknown (Upstream of Facility)

Fish No.	Period	PDAT Subcode	Number of Pumps On at JPP (1–5)	Fork Length (mm)	Weight (g)	Passage Time (h)	PDAT Trigger Time After Release (h)	Fate
148	3907	23	2	123	19.2	—	29.4	Pre-Facility Predation
149	4481	23	2	117	19.1	—	28.5	Pre-Facility Predation
150	4877	23	2	118	18.8	—	21.0	Pre-Facility Predation
151	3581	23	1	132	24.3	—	257.2	Pre-Facility Predation
152	3929	23	1	138	26.5	—	—	Unknown (Upstream of Facility)
153	4271	23	1	139	24.6	—	27.1	Pre-Facility Predation
154	4919	23	1	132	25.6	—	207.6	Predation in Primary Channel
155	5051	23	1	140	28.4	—	—	Unknown (Upstream of Facility)
156	5441	23	1	143	32.2	—	—	Unknown (Upstream of Facility)
157	6113	23	1	132	20.6	—	53.1	Predation in Primary Channel
158	6599	23	1	136	27.8	—	31.1-45.9	Pre-Facility Predation
159	6791	23	1	145	36.6	—	278.2	Predation in Primary Channel
160	7121	23	1	135	24.3	—	52.1	Pre-Facility Predation
161	6761	23	1	135	21.5	—	144.1	Predation in Primary Channel
AVG	**—**	**—**	**—**	**133.4**	**29.0**	**8.7**	**62.3**	**—**

Appendix D—Hydraulic and Temperature Data During Facility Efficiency Replicates Performed at the Tracy Fish Collection Facility with Acoustically Tagged Chinook Salmon

Table D-1.—Hydraulic and temperature data for Chinook Salmon facility efficiency replicates performed during 1 pump operation at the C.W. “Bill” Jones Pumping Plant.

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/12/2019	1034	30.2	0.2	5.2	3.7	0.6	1.3	11.4
3/12/2019	1104	30.7	0.2	5.2	3.8	0.6	1.3	11.4
3/12/2019	1134	31.0	0.2	5.2	3.8	0.6	1.3	11.5
3/12/2019	1204	25.8	0.2	6.2	3.8	0.6	1.3	11.6
3/12/2019	1400	19.6	0.1	8.6	4.0	0.7	1.2	11.8
3/12/2019	1600	23.6	0.2	7	3.9	0.7	1.3	12.3
3/12/2019	1800	28.0	0.2	5.9	3.9	0.8	1.3	12.5
3/12/2019	2000	27.6	0.2	5.9	3.9	0.8	1.4	12.4
3/12/2019	2200	33.3	0.2	4.9	3.9	0.7	1.3	12.3
3/12/2019	2400	29.4	0.2	5.3	3.7	0.6	1.4	12.1
3/13/2019	0200	23.9	0.2	6.6	3.8	0.7	1.3	11.9
3/13/2019	0400	23.3	0.2	6.6	3.7	0.7	1.4	11.9
3/13/2019	0600	23.1	0.2	6.6	3.7	0.7	1.4	11.7
3/13/2019	0800	32.6	0.2	4.7	3.7	0.7	1.4	11.5
3/13/2019	1000	34.5	0.2	4.8	3.9	0.7	1.3	11.4
3/13/2019	1200	25.5	0.2	6.7	4.1	0.6	1.3	11.2
3/13/2019	1400	24.0	0.2	6.7	3.8	0.7	1.3	11.6
3/13/2019	1600	9.6	0.1	17.5	4.0	0.7	1.3	12.0
3/13/2019	1800	13.8	0.1	11.9	3.9	0.8	1.3	12.2
3/13/2019	2000	17.9	0.1	9.1	3.9	0.9	1.3	12.1
3/13/2019	2200	22.0	0.2	7.3	3.8	0.9	1.3	12.0

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/13/2019	2400	36.5	0.2	4.3	3.7	0.8	1.4	11.9
3/14/2019	0200	32.6	0.2	4.7	3.7	0.7	1.4	11.7
3/14/2019	0400	23.1	0.2	6.7	3.7	0.7	1.4	11.7
3/14/2019	0600	22.4	0.2	6.7	3.6	0.8	1.4	11.6
3/14/2019	0800	40.7	0.3	4	3.9	0.8	1.4	11.4
3/14/2019	1000	32.3	0.2	5.1	3.9	0.8	1.3	11.4
3/14/2019	1200	39.6	0.2	4.3	4.1	0.7	1.2	11.1
3/14/2019	1400	14.7	0.1	11.4	4.0	0.7	1.3	11.2
3/14/2019	1600	33.5	0.2	9.9	3.9	0.7	1.3	11.7
3/14/2019	1800	13.8	0.1	11.9	3.9	0.8	1.3	12.2
3/14/2019	2000	17.7	0.1	9.1	3.8	0.9	1.3	12.2
3/14/2019	2200	21.6	0.2	7.1	3.7	0.9	1.4	12.1
3/14/2019	2400	30.5	0.2	5	3.6	0.9	1.5	12.1
3/15/2019	0200	27.4	0.2	5.8	3.8	0.8	1.4	12.0
3/15/2019	0400	32.5	0.2	4.9	3.8	0.7	1.4	11.6
3/15/2019	0600	32.6	0.2	5	3.9	0.7	1.3	11.9
3/15/2019	0800	22.7	0.2	7.2	3.9	0.8	1.2	11.7
3/15/2019	1000	22.8	0.2	7	3.8	0.8	1.3	11.7
3/15/2019	1200	33.1	0.2	4.9	3.8	0.7	1.3	11.7
3/15/2019	1400	25.3	0.2	6.7	4.1	0.6	1.3	11.5
3/15/2019	1600	14.8	0.1	11.1	3.9	0.6	1.3	11.7
3/15/2019	1800	14.4	0.1	11.4	3.9	0.7	1.2	12.2
3/15/2019	2000	13.8	0.1	12	3.9	0.8	1.3	12.5
3/15/2019	2200	13.3	0.1	11.8	3.7	0.8	1.4	12.6
3/15/2019	2400	30.6	0.2	5.1	3.7	0.9	1.4	12.3
3/16/2019	0200	35.6	0.2	4.4	3.7	0.8	1.5	12.3
3/16/2019	0400	27.8	0.2	5.8	3.8	0.7	1.4	12.0
3/16/2019	0600	18.7	0.1	8.6	3.8	0.7	1.4	11.6
3/16/2019	0800	23.0	0.2	7	3.8	0.8	1.3	11.8
3/16/2019	1000	22.8	0.2	7.2	3.9	0.8	1.3	12.0
3/16/2019	1200	28.3	0.2	5.7	3.9	0.8	1.3	12.1
3/16/2019	1400	29.7	0.2	6.2	4.4	0.7	1.1	11.9
3/16/2019	1600	20.4	0.1	8	3.9	0.6	1.3	12.0
3/16/2019	1800	9.7	0.1	17	3.9	0.7	1.2	12.3

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/16/2019	2000	13.9	0.1	11.6	3.8	0.8	1.2	12.8
3/16/2019	2200	13.5	0.1	11.3	3.6	0.8	1.4	13.1
3/16/2019	2400	17.3	0.1	8.8	3.6	0.9	1.4	12.9
3/17/2019	0200	30.6	0.2	5.1	3.7	0.9	1.4	12.8
3/17/2019	0400	32.0	0.2	5	3.8	0.8	1.4	12.7
3/17/2019	0600	28.3	0.2	5.2	3.5	0.6	1.5	12.1
3/17/2019	0800	14.0	0.1	12	4.0	0.8	1.2	11.9
3/17/2019	1000	18.1	0.1	8.8	3.8	0.8	1.3	12.3
3/17/2019	1200	31.8	0.2	5	3.8	0.8	1.3	12.6
3/17/2019	1400	33.6	0.2	4.4	3.6	0.6	1.4	12.6
3/17/2019	1600	30.7	0.2	5.7	4.2	0.6	1.2	12.4
3/17/2019	1800	24.7	0.2	6.6	3.9	0.6	1.2	12.6
3/17/2019	2000	33.8	0.2	4.8	3.8	0.7	1.2	12.8
3/17/2019	2200	23.7	0.2	6.9	3.9	0.7	1.2	13.1
3/17/2019	2400	17.5	0.1	8.8	3.7	0.9	1.4	13.3
3/18/2019	0200	21.6	0.2	7	3.6	0.9	1.4	13.2
3/18/2019	0400	27.0	0.2	5.8	3.7	0.8	1.4	13.0
3/18/2019	0600	32.8	0.2	4.8	3.8	0.7	1.4	12.5
3/18/2019	0800	19.0	0.1	8.6	3.9	0.7	1.3	12.2
3/18/2019	1000	13.8	0.1	11.9	3.9	0.8	1.3	12.5
3/18/2019	1200	18.0	0.1	8.7	3.7	0.8	1.4	12.9
3/18/2019	1400	32.6	0.2	5.1	4.0	0.8	1.2	13.2
3/18/2019	1600	24.9	0.2	6.7	4.0	0.6	1.3	12.9
3/18/2019	1800	25.9	0.2	6.5	4.0	0.6	1.3	12.9
3/18/2019	2000	24.6	0.2	6.7	3.9	0.7	1.2	13.2
3/18/2019	2200	24.4	0.2	6.7	3.9	0.7	1.2	13.3
3/18/2019	2400	13.8	0.1	11.4	3.7	0.7	1.4	13.7
3/19/2019	0200	17.8	0.1	8.7	3.7	0.8	1.4	13.9
3/19/2019	0400	18.2	0.1	8.6	3.7	0.8	1.4	13.8
3/19/2019	0600	28.3	0.2	5.7	3.8	0.7	1.4	13.6
3/19/2019	0800	24.2	0.2	6.7	3.9	0.7	1.2	12.7
3/19/2019	1000	18.8	0.1	8.5	3.8	0.7	1.2	12.8
3/19/2019	1200	18.1	0.1	9.4	4.1	0.9	1.2	13.6
3/19/2019	1400	31.5	0.2	4.9	3.6	0.8	1.3	13.7

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/19/2019	1600	31.7	0.2	5.3	4.0	0.7	1.2	13.3
3/19/2019	1800	31.0	0.2	5.5	4.1	0.6	1.1	13.2
3/19/2019	2000	15.4	0.1	11.1	4.1	0.6	1	13.6
3/19/2019	2200	14.6	0.1	11.3	3.9	0.7	1.1	13.6
3/19/2019	2400	14.1	0.1	10.9	3.7	0.7	1.1	13.6
5/29/2019	1058	13.3	0.1	11.2	3.6	0.8	1.2	16.9
5/29/2019	1128	17.5	0.1	8.5	3.5	0.8	1.2	17.4
5/29/2019	1158	17.4	0.1	8.6	3.5	0.8	1.3	17.6
5/29/2019	1228	30.6	0.2	4.9	3.6	0.8	1.2	17.6
5/30/2019	1400	26.0	0.2	6.1	3.8	0.9	1.2	18.0
5/30/2019	1600	36.2	0.2	4.7	4.1	0.9	1.1	18.3
5/30/2019	1800	27.8	0.2	6.1	4.0	0.8	1.1	17.4
5/30/2019	2000	18.7	0.1	9	4.0	0.8	1.1	17.6
5/30/2019	2200	17.9	0.1	9.3	4.0	0.9	1.1	18.6
5/30/2019	2400	22.1	0.2	6.9	3.7	0.9	1.2	18.7
5/31/2019	0200	31.6	0.2	4.9	3.7	0.8	1.2	18.4
5/31/2019	0400	23.8	0.2	6.5	3.7	0.7	1.2	17.5
5/31/2019	0600	30.2	0.2	5.2	3.7	0.6	1.2	17.3
5/31/2019	0800	33.8	0.2	5	4.0	0.8	1.1	17.3
5/31/2019	1000	18.0	0.1	8.9	3.8	0.8	1.1	17.4
5/31/2019	1200	17.7	0.1	8.7	3.7	0.9	1.2	18.1
5/31/2019	1400	21.5	0.2	7	3.6	1.0	1.1	18.7
5/31/2019	1600	31.6	0.2	5.2	3.9	0.8	1.1	19.1
5/31/2019	1800	28.7	0.2	6	4.1	0.8	1	18.3
5/31/2019	2000	19.2	0.1	8.8	4.0	0.7	1.1	18.4
5/31/2019	2200	13.8	0.1	12.2	4.0	0.8	1.1	18.7
5/31/2019	2400	17.9	0.1	8.7	3.7	0.8	1.2	19.1
10/24/2019	0951	12.5	0.1	8.3	2.5	0.6	1.8	17.1
10/24/2019	1021	16.4	0.1	6.3	2.4	0.6	1.9	17.1
10/24/2019	1051	16.2	0.1	6.2	2.4	0.6	1.9	17.1
10/24/2019	1121	16.0	0.1	6.4	2.4	0.7	1.9	17.2
10/24/2019	1200	16.0	0.1	6.4	2.4	0.7	1.9	17.2
10/24/2019	1400	34.4	0.2	3	2.5	0.5	1.6	17.1
10/24/2019	1600	32.1	0.2	2.6	2.0	0.3	2.2	17.1

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
10/24/2019	1800	28.4	0.2	3	2.0	0.3	2.2	17.2
10/24/2019	2000	13.6	0.1	5.8	1.9	0.3	2.6	17.2
10/24/2019	2200	12.9	0.1	6.1	1.9	0.4	2.5	17.3
10/24/2019	2400	20.7	0.2	4	1.9	0.5	2	17.7
10/25/2019	0200	35.2	0.2	3.2	2.7	0.5	1.8	17.2
10/25/2019	0400	28.5	0.2	3.9	2.7	0.5	1.8	17.2
10/25/2019	0600	14.3	0.1	7.8	2.7	0.5	1.8	17.1
10/25/2019	0800	22.4	0.2	4.9	2.6	0.5	1.9	17.1
10/25/2019	1000	21.2	0.2	3.5	1.8	0.4	2.4	17.0
10/25/2019	1200	16.1	0.1	4.9	1.9	0.5	1.4	17.3
10/25/2019	1400	41.6	0.3	1.7	1.7	0.4	1.4	17.4
10/25/2019	1600	36.4	0.2	2.1	1.8	0.3	2.4	17.2
10/25/2019	1800	28.7	0.2	2.9	2.0	0.3	2.4	17.3
10/25/2019	2000	9.3	0.1	8.5	1.9	0.3	2.6	17.4
10/25/2019	2200	13.1	0.1	5.9	1.9	0.4	2.6	17.4
10/25/2019	2400	12.6	0.1	6.5	2.0	0.4	2.5	17.7
10/26/2019	0200	39.2	0.3	2.8	2.6	0.5	0.9	17.4
10/26/2019	0400	33.1	0.2	3.4	2.7	0.5	1.8	17.3
10/26/2019	0600	45.1	0.2	2.5	2.7	0.4	1.8	17.2
10/26/2019	0800	9.3	0.1	8.8	2.0	0.3	2.2	17.2
10/26/2019	1000	8.7	0.1	9.2	1.9	0.4	2.5	17.1
10/26/2019	1200	12.5	0.1	6.3	1.9	0.4	2.5	17.3
10/26/2019	1400	37.7	0.3	2	1.8	0.4	2	17.7
10/26/2019	1600	32.0	0.2	2.6	1.9	0.3	2.1	17.3
10/26/2019	1800	29.0	0.2	3	2.1	0.3	2.3	17.4
10/26/2019	2000	14.6	0.1	6	2.1	0.3	2.3	17.5
10/26/2019	2200	13.7	0.1	6	2.0	0.3	2.4	17.5
10/26/2019	2400	17.4	0.1	4.7	2.0	0.4	2.5	17.6
10/27/2019	0200	33.5	0.2	2.4	1.9	0.5	2.4	17.5
10/27/2019	0400	40.0	0.3	2.1	2.0	0.4	2.4	17.3
10/27/2019	0600	28.7	0.2	3	2.0	0.3	2.4	17.1
10/27/2019	0800	14.8	0.1	5.5	2.0	0.3	2.5	16.8
10/27/2019	1000	32.8	0.2	2.6	2.0	0.3	2.3	16.7
10/27/2019	1200	13.6	0.1	6	1.9	0.4	2.5	16.3

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
10/27/2019	1400	30.8	0.2	2.7	2.0	0.5	2.2	16.3
10/27/2019	1600	37.5	0.2	3	2.7	0.5	1.8	16.5
10/27/2019	1800	23.9	0.2	4.7	2.7	1.0	1.8	16.1
10/27/2019	2000	14.3	0.1	7.8	2.7	0.4	1.8	16.1
10/27/2019	2200	13.9	0.1	8	2.6	0.5	1.8	16.0
10/27/2019	2400	13.1	0.1	6.5	2.0	0.4	2.4	15.7
10/28/2019	0200	13.2	0.1	6.2	2.0	0.4	2.5	15.7
10/28/2019	0400	28.6	0.2	2.8	1.9	0.5	1.6	15.4
10/28/2019	0600	27.3	0.2	5.9	1.9	0.3	1.6	15.1
10/28/2019	0800	24.0	0.2	4.1	2.3	0.4	2.1	15.0
10/28/2019	1000	9.3	0.1	10.6	2.3	0.4	2.1	15.0
10/28/2019	1200	17.2	0.1	5.6	2.3	0.5	2.1	14.9
10/28/2019	1400	16.7	0.1	5.9	2.4	0.6	2	15.3
10/28/2019	1600	40.0	0.3	2.4	2.3	0.5	2	15.6
10/28/2019	1800	33.1	0.2	3	2.4	0.4	2	14.9
10/28/2019	2000	23.8	0.2	4.1	2.3	0.3	2	15.0
10/28/2019	2200	14.4	0.1	6.7	2.3	0.4	2.1	15.2
10/28/2019	2400	13.6	0.1	6.3	2.0	0.4	2.4	15.1
10/29/2019	0200	12.9	0.1	6.6	2.0	0.4	2.4	14.9
10/29/2019	0400	20.6	0.2	3.9	1.9	0.5	1.5	14.8
10/29/2019	0600	30.6	0.2	2.7	2.0	0.4	2.4	14.7
10/29/2019	0800	32.8	0.2	2.4	1.9	0.3	2.5	14.6
10/29/2019	1000	14.3	0.1	4.8	1.6	0.2	3	14.5
10/29/2019	1200	9.0	0.1	9.9	2.1	0.4	2.2	14.6
10/29/2019	1400	21.4	0.2	4	2.1	0.4	2.2	14.6
10/29/2019	1600	35.0	0.2	2.7	2.3	0.5	1.8	14.6
10/29/2019	1800	33.0	0.2	2.8	2.2	0.4	2.2	14.6
10/29/2019	2000	29.5	0.2	3.3	2.3	0.3	2	14.6
10/29/2019	2200	9.9	0.1	10.2	2.4	0.4	1.8	14.7
10/29/2019	2400	13.8	0.1	7	2.3	0.4	2.1	14.8
10/30/2019	0200	13.1	0.1	7.4	2.3	0.5	2.1	14.3
10/30/2019	0400	16.4	0.1	6.2	2.4	0.6	1.5	13.9
10/30/2019	0600	37.5	0.3	2.6	2.4	0.5	2	13.6
10/30/2019	0800	31.8	0.2	3.2	2.4	0.5	2	13.6

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
10/30/2019	1000	28.4	0.2	3.6	2.4	0.4	1.8	13.6
10/30/2019	1200	13.8	0.1	7.2	2.4	0.4	1.9	13.6
10/30/2019	1400	21.8	0.2	4.2	2.2	0.5	2.2	13.8
10/30/2019	1600	25.4	0.2	3.8	2.3	0.5	2	13.8
10/30/2019	1800	36.7	0.2	2.8	2.4	0.4	2	13.8
10/30/2019	2000	33.8	0.2	2.9	2.3	0.4	2	13.8
10/30/2019	2200	19.7	0.1	5.1	2.4	0.4	1.9	14.0
10/30/2019	2400	13.8	0.1	7.1	2.3	0.4	2	14.1
10/31/2019	0200	13.1	0.1	7.5	2.3	0.5	2.1	13.8
10/31/2019	0400	12.4	0.1	6.2	1.8	0.4	1.7	13.4
10/31/2019	0600	20.0	0.2	3.3	1.6	0.4	2	13.1
10/31/2019	0800	34.8	0.2	2	1.7	0.3	2.8	12.9
10/31/2019	1000	27.7	0.2	2.7	1.8	0.3	2.1	13.1
10/31/2019	1200	18.7	0.1	5	2.2	0.4	2.1	13.3
10/31/2019	1400	8.9	0.1	10	2.1	0.4	1.9	13.4
10/31/2019	1600	17.0	0.1	4.9	2.0	0.4	2.4	13.6
10/31/2019	1800	36.0	0.2	2.6	2.2	0.4	2.1	13.5
10/31/2019	2000	33.1	0.2	2.9	2.3	0.4	2	13.6
10/31/2019	2200	29.5	0.2	3.3	2.3	0.3	2	13.7
10/31/2019	2400	14.5	0.1	6.7	2.3	0.4	2.1	13.7
11/1/2019	0200	21.6	0.2	6.9	3.6	0.9	1.3	13.7
11/1/2019	0400	16.8	0.1	8.6	3.5	0.9	1.3	13.1
11/1/2019	0600	16.2	0.1	8.3	3.2	1.0	0.9	12.8
11/1/2019	0800	16.7	0.1	8.8	3.5	0.9	1.3	12.6
11/1/2019	1000	25.8	0.2	5.7	3.5	0.9	1.3	12.6
11/1/2019	1200	36.5	0.2	4.4	3.9	0.8	1.1	12.9
11/1/2019	1400	9.3	0.1	17.7	3.9	0.8	1.1	13.8
11/1/2019	1600	8.8	0.1	18.5	3.9	0.9	1.1	14.2
11/1/2019	1800	39.8	0.3	4.1	3.9	0.9	1.1	13.5
11/1/2019	2000	32.8	0.2	5	3.9	0.8	1.2	13.7
11/1/2019	2200	29.5	0.2	5.6	3.9	0.7	1.2	14.2
11/1/2019	2400	19.8	0.1	8.5	4.0	0.7	1.1	14.3
11/2/2019	0200	18.1	0.1	8.4	3.6	0.8	1.2	14.2
11/2/2019	0400	21.4	0.2	7.1	3.6	0.9	1.2	13.7

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
11/2/2019	0600	20.7	0.2	7.5	3.7	1.0	0.8	12.9
11/2/2019	0800	36.4	0.3	3.7	3.2	0.9	0.8	12.4
11/2/2019	1000	26.0	0.2	5.9	3.7	0.9	1.3	12.5
11/2/2019	1200	23.1	0.2	6.9	3.8	0.8	1.2	12.8
11/2/2019	1400	23.4	0.2	6.8	3.8	0.7	1.1	14.1
11/2/2019	1600	13.7	0.1	12	3.9	0.8	1	14.3
11/2/2019	1800	22.1	0.2	7.5	3.9	0.9	1.1	14.0
11/2/2019	2000	36.7	0.2	4.7	4.1	0.9	1.1	13.4
11/2/2019	2200	33.6	0.2	5.6	4.5	0.8	1	13.7
11/2/2019	2400	29.5	0.2	5.7	4.0	0.7	1	14.0
11/3/2019	0200	27.6	0.2	5.8	3.8	0.8	1.2	13.8
11/3/2019	0400	17.5	0.2	9.2	3.8	0.9	1.2	13.7
11/3/2019	0600	16.5	0.1	9.7	3.8	1.1	0.8	13.7
11/3/2019	0800	32.5	0.2	4.2	3.2	0.9	0.8	12.4
11/3/2019	1000	31.0	0.2	5.1	3.8	0.9	1.3	12.7
11/3/2019	1200	13.8	0.1	11.6	3.8	0.8	1.2	12.9
11/3/2019	1400	28.5	0.2	5.6	3.8	0.7	1.1	13.2
11/3/2019	1600	14.0	0.1	11.8	3.9	0.8	1.1	13.4
11/3/2019	1800	17.9	0.1	9	3.8	0.9	1.2	13.6
11/3/2019	2000	32.0	0.2	6.1	4.7	1.0	1	13.4
11/3/2019	2200	28.8	0.2	5.7	3.9	0.8	1.1	13.4
11/3/2019	2400	24.4	0.2	7	4.0	0.7	1.1	13.6
AVG	**—**	**23.6**	**0.2**	**6.5**	**3.2**	**0.6**	**1.6**	**14.3**

Table D-2.—Hydraulic and temperature data for Chinook Salmon facility efficiency replicates performed during 2 pump operation at the C.W. “Bill” Jones Pumping Plant.

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/14/2018	0910	50.0	0.3	3.7	4.4	0.9	1.1	11.9
2/14/2018	0940	44.7	0.3	4.1	4.3	1.0	1.1	11.9
2/14/2018	1010	39.8	0.3	4.5	4.2	1.0	1.1	11.9
2/14/2018	1040	39.4	0.3	4.6	4.3	1.0	1.1	11.9
2/14/2018	1200	42.8	0.3	3.9	4.0	1.0	1.1	12.1
2/14/2018	1400	65.3	0.5	2.8	4.3	1.0	1.1	12.1
2/14/2018	1600	55.4	0.4	3.3	4.4	0.9	1.1	12.2
2/14/2018	1800	53.4	0.3	3.5	4.4	0.8	1.1	12.2
2/14/2018	2000	38.3	0.2	4.8	4.4	0.8	1.1	12.2
2/14/2018	2200	40.7	0.3	4.4	4.3	0.9	1.3	12.0
2/14/2018	2400	39.2	0.3	4.3	4.0	1.0	1.2	11.9
2/15/2018	0200	41.1	0.3	3.8	3.7	1.0	1.0	11.9
2/15/2018	0400	58.6	0.4	2.8	4.0	1.0	1.3	11.8
2/15/2018	0600	55.7	0.4	3.3	4.3	1.0	1.1	11.7
2/15/2018	0800	55.1	0.4	3.4	4.4	0.9	1.1	11.6
2/15/2018	1000	45.0	0.3	4.0	4.3	0.9	1.3	11.7
2/15/2018	1200	43.3	0.3	4.0	4.1	1.0	1.1	11.7
2/15/2018	1400	55.0	0.4	3.1	4.1	1.0	1.3	11.8
2/15/2018	1600	49.4	0.3	3.7	4.4	1.0	1.1	11.7
2/15/2018	1800	56.8	0.4	3.3	4.4	0.8	1.1	11.8
2/15/2018	2000	33.0	0.2	5.6	4.4	0.8	1.1	11.9
2/15/2018	2200	40.7	0.3	4.5	4.3	0.9	1.1	11.7
2/15/2018	2400	39.0	0.3	4.4	4.1	1.0	1.2	11.7
2/16/2018	0200	41.1	0.3	3.8	3.8	1.0	1.0	11.7
2/16/2018	0400	60.7	0.5	2.6	3.7	1.0	1.0	11.7
2/16/2018	0600	56.6	0.4	3.1	4.2	1.0	1.1	11.4
2/16/2018	0800	54.8	0.4	3.4	4.5	0.9	1.1	11.3
2/16/2018	1000	36.2	0.2	5.0	4.3	0.9	1.1	11.4
2/16/2018	1200	37.9	0.3	4.6	4.1	1.1	1.1	11.5
2/16/2018	1400	52.9	0.4	2.8	3.6	1.0	1.0	11.7
2/16/2018	1600	56.3	0.4	3.0	4.0	0.9	1.3	11.6

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/16/2018	1800	55.4	0.4	3.3	4.4	0.9	1.1	11.9
2/16/2018	2000	42.8	0.3	4.2	4.3	0.8	1.1	11.9
2/16/2018	2200	36.0	0.2	4.9	4.2	0.9	1.1	11.8
2/16/2018	2400	42.6	0.3	3.9	3.9	1.0	1.2	11.7
2/17/2018	0200	45.0	0.3	3.3	3.5	1.0	1.0	11.6
2/17/2018	0400	65.5	0.5	2.4	3.7	1.0	1.0	11.5
2/17/2018	0600	60.3	0.4	2.7	3.9	0.9	1.3	11.3
2/17/2018	0800	58.8	0.4	3.0	4.2	0.9	1.2	11.4
2/17/2018	1000	79.3	0.5	2.3	4.3	0.8	1.1	11.6
2/17/2018	1200	34.4	0.2	4.9	4.0	1.0	1.2	11.8
2/17/2018	1400	45.5	0.3	3.6	3.9	1.0	0.8	11.8
2/17/2018	1600	60.6	0.4	2.7	4.0	0.9	1.4	11.8
2/17/2018	1800	54.8	0.4	3.3	4.3	0.9	1.2	12.0
2/17/2018	2000	47.3	0.3	3.9	4.4	0.8	1.1	12.1
2/17/2018	2200	41.7	0.3	4.4	4.3	0.9	1.1	12.1
2/17/2018	2400	40.2	0.3	4.2	4.0	0.9	1.2	12.0
2/18/2018	0200	53.2	0.4	2.9	3.6	1.0	1.0	11.9
2/18/2018	0400	60.7	0.5	2.8	4.0	1.1	0.9	11.8
2/18/2018	0600	59.9	0.4	2.8	4.0	1.0	1.2	11.7
2/18/2018	0800	53.9	0.4	3.5	4.5	0.9	1.0	11.7
2/18/2018	1000	51.3	0.3	3.9	4.7	0.9	1.0	11.8
2/18/2018	1200	36.2	0.2	5.1	4.4	0.9	1.0	11.9
2/18/2018	1400	47.9	0.3	3.6	4.1	0.9	1.1	12.3
2/18/2018	1600	55.7	0.4	3.1	4.0	1.0	1.2	12.4
2/18/2018	1800	58.4	0.4	3.0	4.1	0.9	1.1	12.1
2/18/2018	2000	61.5	0.4	2.9	4.3	0.8	1.1	12.1
2/18/2018	2200	43.7	0.3	4.1	4.2	0.7	1.1	12.1
2/18/2018	2400	36.5	0.2	4.8	4.2	0.9	1.2	11.8
11/27/2018	0900	57.8	0.4	2.7	3.8	0.9	1.4	13.1
11/27/2018	1000	57.8	0.4	2.7	3.7	0.8	1.5	13.1
11/27/2018	1200	61.2	0.4	2.6	3.8	0.7	1.4	13.1
11/27/2018	1400	41.3	0.3	3.8	3.8	0.8	1.4	13.1
11/27/2018	1600	44.0	0.3	3.5	3.7	0.9	1.4	13.1
11/27/2018	1800	68.9	0.5	2.4	3.9	0.8	1.3	13.2

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
11/27/2018	2000	62.5	0.4	2.6	3.9	0.7	1.4	13.1
11/27/2018	2200	49.7	0.3	3.2	3.8	0.6	1.4	13.1
11/27/2018	2400	38.8	0.2	4.2	3.9	0.7	1.3	13.1
11/28/2018	0200	36.0	0.2	4.4	3.8	0.8	1.4	13.1
11/28/2018	0400	38.5	0.3	3.9	3.6	0.9	1.4	13.1
11/28/2018	0600	37.0	0.3	3.7	3.3	0.9	1.1	12.7
11/28/2018	0800	54.1	0.4	2.7	3.5	0.9	1.0	12.8
11/28/2018	1000	40.5	0.3	4.1	3.9	0.8	1.3	13.4
11/28/2018	1200	42.4	0.3	3.6	3.7	0.7	1.4	13.3
11/28/2018	1400	33.3	0.2	4.8	3.8	0.7	1.4	13.2
11/28/2018	1600	36.0	0.2	4.4	3.8	0.8	1.4	13.3
11/28/2018	1800	53.4	0.4	2.9	3.7	0.8	1.4	13.4
11/28/2018	2000	53.4	0.4	3.0	3.8	0.7	1.3	13.5
11/28/2018	2200	57.7	0.4	2.8	3.9	0.7	1.4	13.3
11/28/2018	2400	44.3	0.3	3.7	3.9	0.7	1.4	13.2
3/28/2019	0948	50.8	0.3	3.0	3.6	0.7	1.1	12.9
3/28/2019	1018	51.3	0.3	2.9	3.5	0.7	1.3	13.0
3/28/2019	1048	51.8	0.3	2.9	3.6	0.7	1.2	12.8
3/28/2019	1118	52.1	0.3	2.9	3.5	0.6	1.2	12.8
3/28/2019	1200	52.1	0.3	2.9	3.5	0.6	1.2	12.8
3/28/2019	1400	40.0	0.2	3.9	3.7	0.6	0.9	13.0
3/28/2019	1600	43.2	0.3	3.9	4.0	0.7	1.1	13.3
3/28/2019	1800	42.2	0.3	3.9	3.9	0.8	1.1	13.8
3/28/2019	2000	45.7	0.3	3.8	4.1	0.9	1.0	14.0
3/28/2019	2200	47.9	0.3	3.8	4.3	1.0	1.0	13.8
3/28/2019	2400	61.3	0.4	2.6	3.8	0.9	1.1	13.7
3/29/2019	0200	58.8	0.4	2.7	3.8	0.8	1.1	13.3
3/29/2019	0400	56.2	0.4	2.9	3.8	0.7	1.1	12.9
3/29/2019	0600	51.8	0.3	3.0	3.7	0.7	1.2	12.8
3/29/2019	0800	45.7	0.3	3.5	3.8	0.8	1.2	13.2
3/29/2019	1000	49.7	0.3	3.2	3.8	0.8	1.2	13.2
3/29/2019	1200	56.0	0.4	3.1	4.1	0.8	1.1	13.1
3/29/2019	1400	82.9	0.5	2.1	4.1	0.7	1.1	13.1
3/29/2019	1600	29.3	0.2	6.3	4.4	0.8	1.0	13.3

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/29/2019	1800	42.2	0.3	4.2	4.3	0.8	1.0	13.9
3/29/2019	2000	45.7	0.3	3.9	4.2	0.9	1.0	14.3
3/29/2019	2200	43.8	0.3	3.8	4.0	0.9	1.1	14.4
3/29/2019	2400	51.4	0.4	3.2	3.9	1.0	1.0	14.2
3/30/2019	0200	57.2	0.4	2.9	4.0	0.9	1.1	14.2
3/30/2019	0400	55.4	0.4	3.3	4.4	0.9	1.0	13.0
3/30/2019	0600	51.8	0.3	4.1	5.1	0.9	1.0	12.9
3/30/2019	0800	46.2	0.3	3.6	4.0	0.8	1.1	13.2
3/30/2019	1000	44.7	0.3	3.5	3.7	0.8	1.1	13.6
3/30/2019	1200	53.9	0.4	3.2	4.1	0.9	1.0	13.7
3/30/2019	1400	60.6	0.4	2.8	4.0	0.8	1.0	13.7
3/30/2019	1600	59.1	0.4	3.0	4.2	0.7	1.0	13.4
3/30/2019	1800	43.2	0.3	4.3	4.4	0.8	1.0	13.8
3/30/2019	2000	37.3	0.2	4.6	4.1	0.8	1.0	14.4
3/30/2019	2200	40.2	0.3	4.4	4.2	0.9	1.0	14.8
3/30/2019	2400	43.0	0.3	3.5	3.6	0.9	1.2	14.6
3/31/2019	0200	58.1	0.4	2.8	3.9	0.9	1.1	14.6
3/31/2019	0400	54.5	0.4	3.2	4.2	0.8	1.1	13.8
3/31/2019	0600	51.8	0.3	3.4	4.2	0.8	1.0	13.1
3/31/2019	0800	41.7	0.3	3.8	3.7	0.7	1.1	13.1
3/31/2019	1000	41.3	0.3	4.0	3.9	0.8	1.1	13.9
3/31/2019	1200	49.2	0.3	3.4	4.0	0.9	1.0	14.1
3/31/2019	1400	55.7	0.4	3.0	4.0	0.8	1.0	13.6
3/31/2019	1600	63.4	0.4	2.5	3.8	0.6	1.2	13.8
3/31/2019	1800	43.9	0.3	3.6	3.8	0.6	1.2	14.1
3/31/2019	2000	42.4	0.3	3.9	3.9	0.7	1.2	14.4
3/31/2019	2200	45.2	0.3	3.5	3.8	0.8	1.2	14.9
3/31/2019	2400	43.5	0.3	3.6	3.7	0.9	1.2	15.2
6/18/2019	1052	24.2	0.2	6.3	3.6	0.6	1.2	24.2
6/18/2019	1122	42.8	0.3	3.6	3.7	0.7	1.2	23.6
6/18/2019	1152	33.0	0.2	4.7	3.7	0.7	1.3	22.8
6/18/2019	1222	32.5	0.2	4.7	3.6	0.7	1.3	22.6
6/18/2019	1400	31.1	0.2	3.5	2.6	0.5	1.6	22.9
6/18/2019	1600	34.3	0.2	3.0	2.5	0.5	1.6	23.4

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
6/18/2019	1800	35.2	0.2	3.0	2.5	0.5	1.9	23.0
6/18/2019	2000	41.1	0.3	2.5	2.5	0.5	1.9	21.6
6/18/2019	2200	52.1	0.3	2.2	2.7	0.5	1.6	21.4
6/18/2019	2400	39.0	0.2	2.3	2.1	0.3	2.1	22.8
6/19/2019	0200	18.5	0.1	5.7	2.5	0.4	1.8	23.6
6/19/2019	0400	46.4	0.3	2.3	2.6	0.5	1.7	21.9
6/19/2019	0600	52.9	0.3	2.0	2.5	0.4	1.8	21.1
6/19/2019	0800	66.5	0.4	1.4	2.2	0.3	2.1	22.4
6/19/2019	1000	35.6	0.2	2.5	2.1	0.3	2.0	24.1
6/19/2019	1200	33.8	0.2	3.1	2.5	0.4	1.7	24.0
6/19/2019	1400	36.5	0.2	3.0	2.6	0.5	1.8	22.8
6/19/2019	1600	48.4	0.3	1.7	2.0	0.4	2.3	23.7
6/19/2019	1800	34.6	0.2	2.4	2.0	0.4	2.3	24.0
6/19/2019	2000	45.0	0.3	1.9	2.0	0.4	2.3	22.5
6/19/2019	2200	47.8	0.3	1.8	2.1	0.3	2.3	21.6
6/19/2019	2400	39.0	0.2	2.7	2.5	0.4	1.8	22.2
6/20/2019	0200	33.0	0.2	3.2	2.5	0.4	1.9	22.7
6/20/2019	0400	42.2	0.3	2.5	2.5	0.4	1.8	21.6
6/20/2019	0600	42.6	0.3	2.5	2.5	0.4	1.8	21.6
6/20/2019	0800	80.7	0.5	1.3	2.6	0.4	1.8	20.9
6/20/2019	1000	57.0	0.3	1.9	2.6	0.4	1.6	23.8
6/20/2019	1200	33.9	0.2	3.0	2.5	0.4	1.9	23.9
6/20/2019	1400	41.3	0.3	2.6	2.5	0.5	1.8	22.6
6/20/2019	1600	48.7	0.3	1.9	2.3	0.5	2.0	23.4
6/20/2019	1800	43.0	0.3	1.9	2.0	0.4	2.4	23.6
6/20/2019	2000	62.9	0.4	1.3	1.9	0.4	2.4	22.1
6/20/2019	2200	66.3	0.4	1.5	2.3	0.4	2.0	21.6
6/20/2019	2400	58.5	0.4	1.8	2.5	0.4	1.8	21.7
6/21/2019	0200	48.1	0.3	2.2	2.5	0.4	1.8	22.2
6/21/2019	0400	45.7	0.3	2.3	2.5	0.5	1.8	21.3
6/21/2019	0600	55.7	0.4	1.9	2.5	0.5	1.8	21.4
6/21/2019	0800	52.8	0.3	2.0	2.6	0.4	1.8	21.0
AVG	**—**	**48.1**	**0.3**	**3.3**	**3.7**	**0.8**	**1.3**	**15.0**

Table D-3.—Hydraulic and temperature data for Chinook Salmon facility efficiency replicates performed during 3 pump operation at the C.W. "Bill" Jones Pumping Plant.

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/12/2018	0955	70.4	0.5	2.6	4.3	1.0	1.2	12.1
2/12/2018	1025	73.6	0.5	2.5	4.3	1.1	1.3	12.1
2/12/2018	1055	68.5	0.5	2.6	4.3	1.1	1.2	12.1
2/12/2018	1125	77.1	0.5	2.3	4.2	1.0	1.1	12.4
2/12/2018	1200	68.5	0.5	2.6	4.3	1.1	1.2	12.1
2/12/2018	1400	82.6	0.5	2.3	4.5	0.9	1.1	12.9
2/12/2018	1600	85.6	0.5	2.2	4.5	0.8	1.1	12.5
2/12/2018	1800	78.0	0.5	2.4	4.5	0.8	1.2	12.5
2/12/2018	2000	56.0	0.4	3.3	4.4	0.9	1.2	12.4
2/12/2018	2200	64.9	0.5	2.7	4.2	0.9	1.3	12.7
2/12/2018	2400	66.6	0.5	2.4	3.8	1.0	1.4	12.7
5/15/2019	0927	60.0	0.4	2.6	3.7	0.8	1.2	16.8
5/15/2019	0957	54.5	0.4	2.8	3.7	0.8	1.3	16.8
5/15/2019	1027	58.4	0.4	2.7	3.7	0.8	1.1	16.8
5/15/2019	1057	66.7	0.5	2.3	3.6	0.8	1.2	16.9
5/15/2019	1200	56.3	0.4	2.7	3.6	0.9	1.1	17.4
5/15/2019	1400	73.2	0.5	2.1	3.6	0.9	1.2	17.3
5/15/2019	1600	83.5	0.5	2.0	3.9	0.8	1.1	16.3
5/15/2019	1800	72.4	0.5	2.2	3.8	0.7	1.1	16.6
5/15/2019	2000	65.3	0.4	2.6	4.0	0.8	1.0	16.5
5/15/2019	2200	57.8	0.4	2.7	3.7	0.8	1.2	16.7
5/15/2019	2400	59.9	0.4	2.5	3.6	0.9	1.2	17.3
5/16/2019	0200	85.0	0.6	1.9	3.9	0.8	1.2	16.2
5/16/2019	0400	86.1	0.5	1.9	4.0	0.7	1.0	16.1
5/16/2019	0600	80.7	0.5	2.1	4.0	0.6	1.0	16.1
5/16/2019	0800	59.9	0.4	2.7	3.9	0.6	1.1	16.1
5/16/2019	1000	61.4	0.4	2.6	3.9	0.7	1.1	16.1
5/16/2019	1200	58.4	0.4	2.7	3.8	0.8	1.1	16.4
5/16/2019	1400	60.6	0.4	2.5	3.6	0.9	1.2	17.1
5/16/2019	1600	82.6	0.5	2.1	4.2	0.9	1.1	15.6
5/16/2019	1800	77.2	0.5	2.3	4.2	0.7	1.1	15.5

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
5/16/2019	2000	68.9	0.4	2.5	4.1	0.7	1.1	15.6
5/16/2019	2200	56.2	0.4	3.1	4.1	0.8	1.0	15.6
5/16/2019	2400	58.8	0.4	2.7	3.8	0.8	1.1	16.1
5/17/2019	0200	79.6	0.5	2.0	3.8	0.9	1.1	16.3
5/17/2019	0400	77.2	0.5	2.1	4.0	0.7	1.0	15.0
5/17/2019	0600	80.3	0.5	2.1	4.0	0.6	0.9	15.1
5/17/2019	0800	60.5	0.4	2.7	3.9	0.6	1.0	15.1
5/17/2019	1000	57.7	0.4	2.9	3.9	0.7	1.0	15.1
5/17/2019	1200	55.1	0.4	3.0	3.9	0.8	1.0	15.4
5/17/2019	1400	56.3	0.4	2.7	3.7	0.9	1.0	16.3
5/17/2019	1600	78.4	0.5	2.1	4.0	0.9	1.0	16.2
5/17/2019	1800	83.1	0.5	2.1	4.1	0.9	1.0	15.6
5/17/2019	2000	82.5	0.5	2.1	4.2	0.7	1.1	14.8
5/17/2019	2200	61.2	0.4	2.8	4.1	0.8	1.1	14.8
5/17/2019	2400	64.6	0.4	2.4	3.7	0.8	1.2	14.8
5/23/2019	0933	85.3	0.5	2.0	4.0	0.6	1.1	14.6
5/23/2019	1003	76.0	0.5	2.2	4.0	0.6	1.2	14.6
5/23/2019	1033	70.9	0.4	2.3	4.0	0.6	1.1	14.6
5/23/2019	1103	65.6	0.4	2.5	4.0	0.6	1.1	14.6
5/23/2019	1200	63.4	0.4	2.7	4.0	0.7	1.1	14.9
5/23/2019	1400	61.2	0.4	2.7	3.9	0.7	1.0	15.9
5/23/2019	1600	58.8	0.4	2.8	3.9	0.9	1.1	16.6
5/23/2019	1800	64.2	0.5	2.4	3.6	0.9	1.2	17.1
5/23/2019	2000	71.6	0.5	2.1	3.6	0.9	1.2	17.1
5/23/2019	2200	78.4	0.5	2.1	3.9	0.8	1.1	15.7
5/23/2019	2400	86.5	0.5	1.9	4.0	0.7	1.2	15.7
5/24/2019	0200	73.1	0.5	2.3	3.9	0.7	1.2	15.6
5/24/2019	0400	65.9	0.4	2.5	3.9	0.7	1.1	15.5
5/24/2019	0600	64.9	0.4	2.5	3.9	0.8	1.1	15.7
5/24/2019	0800	76.1	0.5	2.2	4.1	0.7	1.1	15.2
5/24/2019	1000	79.2	0.5	2.1	3.9	0.6	1.1	15.1
5/24/2019	1200	63.7	0.4	2.6	4.0	0.7	1.1	15.3
5/24/2019	1400	66.3	0.4	2.5	4.0	0.8	1.2	16.3
5/24/2019	1600	59.4	0.4	2.9	4.1	0.9	1.0	16.9

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
5/24/2019	1800	64.9	0.5	2.6	4.0	1.0	1.0	17.8
5/24/2019	2000	67.0	0.5	2.4	3.9	1.0	1.1	17.9
5/24/2019	2200	91.9	0.6	1.9	4.1	0.9	1.0	16.7
5/24/2019	2400	79.3	0.5	2.1	3.9	0.8	1.1	16.3
5/25/2019	0200	76.9	0.5	2.1	3.8	0.7	1.1	16.1
5/25/2019	0400	67.6	0.4	2.4	3.9	0.7	1.1	15.9
5/25/2019	0600	64.9	0.4	2.5	3.9	0.8	1.2	15.9
5/25/2019	0800	68.9	0.5	2.5	4.1	0.8	1.1	16.2
5/25/2019	1000	90.4	0.6	1.8	3.9	0.7	1.1	15.4
5/25/2019	1200	78.0	0.5	2.1	3.9	0.7	1.2	15.5
5/25/2019	1400	65.9	0.4	2.5	3.9	0.7	1.1	16.4
5/25/2019	1600	63.9	0.4	2.7	4.1	0.9	1.1	17.4
5/25/2019	1800	44.1	0.5	3.8	4.0	1.0	1.1	17.9
5/25/2019	2000	67.7	0.5	2.4	3.9	1.0	1.0	18.3
5/25/2019	2200	80.0	0.6	2.1	3.9	1.0	1.1	17.4
5/25/2019	2400	89.0	0.6	1.8	3.8	0.9	1.1	16.7
5/26/2019	0200	79.7	0.5	2.0	3.8	0.7	1.1	16.5
5/26/2019	0400	71.4	0.5	2.2	3.8	0.7	1.0	16.3
5/26/2019	0600	67.3	0.4	2.3	3.8	0.7	0.8	16.2
5/26/2019	0800	69.6	0.5	2.2	3.7	0.7	1.1	16.1
5/26/2019	1000	75.0	0.5	2.2	3.9	0.8	1.1	15.7
5/26/2019	1200	77.6	0.5	2.1	3.9	0.7	1.1	15.6
5/26/2019	1400	68.3	0.4	2.4	4.0	0.7	1.1	15.8
5/26/2019	1600	65.3	0.4	2.5	3.9	0.8	1.2	16.9
5/26/2019	1800	67.4	0.5	2.4	3.8	0.8	1.2	17.3
5/26/2019	2000	64.6	0.5	2.5	3.9	0.9	1.1	18.6
5/26/2019	2200	80.4	0.6	1.9	3.7	0.9	1.2	16.7
5/26/2019	2400	92.4	0.6	1.8	4.0	0.9	1.0	16.5
5/27/2019	0200	74.6	0.5	2.2	3.9	0.8	1.2	16.2
5/27/2019	0400	73.1	0.5	2.2	3.9	0.7	1.2	16.2
5/27/2019	0600	62.5	0.4	2.6	3.8	0.7	1.1	16.1
5/27/2019	0800	59.4	0.4	2.8	3.9	0.8	1.1	16.1
5/27/2019	1000	66.4	0.5	2.3	3.6	0.8	1.2	16.2
5/27/2019	1200	80.5	0.5	2.0	3.8	0.8	1.2	15.9

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
5/27/2019	1400	74.2	0.5	2.2	3.9	0.8	1.2	15.9
5/27/2019	1600	63.3	0.4	2.7	4.0	0.9	1.1	16.3
5/27/2019	1800	65.6	0.5	2.4	3.8	0.9	1.2	17.0
5/27/2019	2000	63.1	0.5	2.4	3.6	0.9	1.2	17.4
5/27/2019	2200	69.9	0.5	2.1	3.5	1.0	0.7	17.2
5/27/2019	2400	93.7	0.7	1.8	4.0	1.0	0.7	16.2
AVG	**—**	**70.4**	**0.5**	**2.4**	**3.9**	**0.8**	**1.1**	**15.8**

Table D-4.—Hydraulic and temperature data for Chinook Salmon facility efficiency replicates performed during 4 pump operation at the C.W. “Bill” Jones Pumping Plant.

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/22/2017	1020	100.9	0.6	1.8	4.3	0.8	1.2	14.7
3/22/2017	1050	110.5	0.7	1.7	4.4	0.8	1.1	14.7
3/22/2017	1120	116.5	0.7	1.6	4.3	0.8	1.1	14.7
3/22/2017	1150	117.6	0.7	1.6	4.4	0.8	1.1	14.7
3/22/2017	1200	116.5	0.7	1.6	4.3	0.8	1.1	14.7
3/22/2017	1400	116.5	0.7	1.5	4.4	0.7	1.1	14.9
3/22/2017	1600	106.4	0.6	2.1	4.0	0.7	1.3	14.9
3/22/2017	1800	98.5	0.6	1.8	4.3	0.7	1.2	15.1
3/22/2017	2000	100.4	0.6	1.8	4.3	0.8	1.1	15.1
3/22/2017	2200	102.1	0.7	1.8	4.3	0.9	1.2	14.9
3/22/2017	2400	105.0	0.7	1.7	4.3	0.9	1.2	14.8
3/23/2017	0200	117.1	0.8	1.6	4.3	0.8	1.2	14.7
3/23/2017	0400	118.7	0.7	1.6	4.4	0.7	1.2	14.2
3/23/2017	0600	105.9	0.6	1.7	4.4	0.7	1.2	14.1
3/23/2017	0800	103.4	0.6	1.7	4.4	0.7	1.1	13.9
3/23/2017	1000	100.4	0.6	1.8	4.3	0.8	1.1	13.8
3/23/2017	1200	123.1	0.8	1.5	4.4	0.8	1.1	14.0
3/23/2017	1400	84.8	0.7	2.2	4.5	0.7	1.2	14.2
3/23/2017	1600	116.5	0.7	1.6	4.4	0.7	1.1	14.4
3/23/2017	1800	105.4	0.6	1.7	4.3	0.7	1.2	14.6
3/23/2017	2000	102.4	0.6	1.8	4.3	0.8	1.2	14.7
3/23/2017	2200	98.4	0.6	1.8	4.3	0.8	1.2	14.7
3/23/2017	2400	95.9	0.6	1.9	4.3	0.9	1.2	14.6
3/24/2017	0200	107.9	0.7	1.7	4.3	0.9	1.2	14.5
3/24/2017	0400	123.7	0.8	1.5	4.4	0.7	1.2	13.9
3/24/2017	0600	120.5	0.7	1.5	4.3	0.7	1.2	13.9
3/24/2017	0800	104.4	0.6	1.7	4.3	0.7	1.2	14.1
3/24/2017	1000	106.2	0.7	1.7	4.4	0.8	1.0	14.0
3/24/2017	1200	107.8	0.7	1.7	4.4	0.9	1.1	13.9
3/24/2017	1400	129.1	0.8	1.5	4.5	0.8	1.1	13.9
3/24/2017	1600	120.5	0.7	1.5	4.3	0.7	1.3	13.9

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/24/2017	1800	108.4	0.6	1.7	4.4	0.7	1.2	13.9
3/24/2017	2000	100.4	0.6	1.9	4.5	0.7	1.1	13.9
3/24/2017	2200	97.5	0.6	1.8	4.3	0.7	1.3	13.8
3/24/2017	2400	98.4	0.6	1.9	4.3	0.8	1.2	13.8
3/25/2017	0200	105.6	0.7	1.7	4.3	0.9	1.3	13.7
3/25/2017	0400	118.9	0.8	1.5	4.3	0.9	1.2	13.6
3/25/2017	0600	121.0	0.7	1.5	4.4	0.7	1.2	13.4
3/25/2017	0800	96.2	0.6	1.8	4.3	0.7	1.2	13.4
3/25/2017	1000	93.1	0.6	2.0	4.4	0.8	1.2	13.4
3/25/2017	1200	99.9	0.6	1.8	4.3	0.8	1.3	13.5
3/25/2017	1400	107.8	0.7	1.6	4.3	1.1	1.1	13.7
3/25/2017	1600	124.9	0.8	1.4	4.3	0.7	1.2	13.7
3/25/2017	1800	108.9	0.6	1.7	4.4	0.6	1.2	13.8
3/25/2017	2000	101.3	0.6	1.8	4.4	0.7	1.1	14.1
3/25/2017	2200	98.5	0.6	1.9	4.4	0.7	1.2	14.1
3/25/2017	2400	105.2	0.7	1.8	4.4	0.9	1.0	14.0
3/26/2017	0200	107.2	0.7	1.7	4.3	0.9	1.1	13.9
3/26/2017	0400	116.0	0.8	1.6	4.3	0.7	1.2	13.9
3/26/2017	0600	126.1	0.8	1.5	4.5	0.7	1.0	13.4
3/26/2017	0800	102.8	0.6	1.8	4.4	0.7	1.2	13.3
3/26/2017	1000	104.9	0.6	1.7	4.4	0.7	1.2	13.4
3/26/2017	1200	97.0	0.6	1.8	4.3	0.7	1.2	13.5
3/26/2017	1400	108.3	0.7	1.7	4.3	0.8	1.2	13.7
3/26/2017	1600	125.6	0.8	1.4	4.3	0.8	1.2	13.9
3/26/2017	1800	122.7	0.7	1.5	4.4	0.7	1.2	14.0
3/26/2017	2000	104.2	0.6	1.7	4.3	0.6	1.2	14.1
3/26/2017	2200	100.4	0.6	1.8	4.3	0.7	1.2	14.2
3/26/2017	2400	101.9	0.6	1.8	4.3	0.8	1.1	14.2
3/27/2017	0200	98.9	0.6	1.8	4.3	0.8	1.2	14.1
3/27/2017	0400	122.4	0.8	1.5	4.4	0.9	1.2	14.1
3/27/2017	0600	126.7	0.8	1.5	4.6	0.7	1.2	13.7
3/27/2017	0800	104.2	0.6	1.8	4.5	0.7	1.1	13.6
3/27/2017	1000	101.3	0.6	1.8	4.3	0.7	1.2	13.6
3/27/2017	1200	103.9	0.6	1.8	4.4	0.7	1.2	13.7

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/27/2017	1400	108.9	0.7	1.6	4.3	0.8	1.1	14.1
3/27/2017	1600	114.2	0.7	1.6	4.3	0.8	1.1	14.3
3/27/2017	1800	117.6	0.7	1.6	4.4	0.7	1.2	14.4
3/27/2017	2000	99.0	0.6	1.8	4.4	0.6	1.2	14.3
3/27/2017	2200	96.2	0.6	1.9	4.4	0.7	1.2	14.4
3/27/2017	2400	98.5	0.6	1.9	4.4	0.8	1.2	14.4
3/28/2019	0200	104.1	0.7	1.8	4.3	0.8	1.2	14.4
3/28/2019	0400	111.3	0.7	1.6	4.3	0.9	1.2	14.3
3/28/2019	0600	128.0	0.8	1.5	4.4	0.7	1.2	13.9
3/28/2019	0800	108.9	0.6	1.6	4.3	0.6	1.2	13.7
3/28/2019	1000	101.8	0.6	1.7	4.3	0.7	1.2	13.8
3/28/2019	1200	98.5	0.6	1.8	4.3	0.7	1.3	13.8
3/28/2019	1400	100.4	0.6	1.7	4.3	0.8	1.0	14.1
3/28/2019	1600	98.4	0.6	1.9	4.4	0.9	1.1	14.4
3/28/2019	1800	113.2	0.7	1.6	4.4	0.7	1.2	14.6
3/28/2019	2000	108.4	0.6	1.7	4.4	0.7	1. 2	14.5
3/28/2019	2200	96.7	0.6	1.9	4.4	0.7	1.1	14.7
3/28/2019	2400	98.9	0.6	1.8	4.3	0.7	1.2	14.7
3/29/2019	0200	99.9	0.6	1.8	4.2	0.8	1.2	14.7
3/29/2019	0400	106.1	0.7	1.7	4.3	0.9	1.2	14.6
3/29/2019	0600	124.9	0.8	1.5	4.4	0.8	1.2	14.5
3/29/2019	0800	118.7	0.7	1.6	4.4	0.7	1.2	14.0
3/29/2019	1000	103.2	0.6	1.8	4.4	0.7	1.1	14.1
3/29/2019	1200	99.9	0.6	1.8	4.3	0.7	1.2	14.3
3/29/2019	1400	96.1	0.6	1.8	4.2	0.8	1.6	14.6
3/29/2019	1600	101.0	0.7	1.7	4.2	0.8	1.2	14.9
3/29/2019	1800	125.2	0.8	1.4	4.3	0.8	1.1	15.3
3/29/2019	2000	124.3	0.8	1.5	4.3	0.7	1.2	15.1
3/29/2019	2200	107.4	0.6	1.7	4.4	0.7	1.1	15.0
3/29/2019	2400	100.4	0.6	1.8	4.3	0.7	1.2	15.2
3/30/2017	0200	101.4	0.6	1.8	4.3	0.8	1.2	15.1
3/30/2017	0400	103.1	0.7	1.7	4.2	0.8	1.2	15.1
3/30/2017	0600	129.7	0.8	1.4	4.4	0.8	1.2	15.0
3/30/2017	0800	125.0	0.7	1.4	4.4	0.6	1.1	14.4

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/30/2017	1000	106.1	0.6	1.7	4.4	0.6	1.2	14.4
3/30/2017	1200	144.5	0.9	1.2	4.4	0.6	1.2	14.7
3/30/2017	1400	95.3	0.6	1.8	4.3	0.7	1.1	14.8
3/30/2017	1600	98.0	0.6	1.8	4.3	0.7	1.2	15.0
3/30/2017	1800	98.4	0.6	1.8	4.2	0.8	1.2	15.3
3/30/2017	2000	105.2	0.7	1.7	4.3	0.8	1.2	15.2
3/30/2017	2200	117.1	0.7	1.6	4.4	0.7	1.2	14.9
3/30/2017	2400	106.9	0.6	1.7	4.4	0.7	1.2	14.9
3/31/2017	0200	104.9	0.6	1.7	4.4	0.7	1.2	14.9
3/31/2017	0400	118.3	0.8	1.5	4.4	0.7	1.2	14.7
3/31/2017	0600	103.1	0.7	1.8	4.3	0.9	1.2	14.4
3/31/2017	0800	116.0	0.7	1.6	4.4	0.7	1.1	13.9
3/31/2017	1000	105.1	0.6	1.7	4.3	0.6	1.1	13.8
3/31/2017	1200	98.5	0.6	1.8	4.4	0.6	1.1	13.8
3/31/2017	1400	96.2	0.6	1.9	4.4	0.7	1.2	14.0
3/31/2017	1600	98.0	0.6	1.8	4.3	0.7	1.2	14.1
3/31/2017	1800	93.7	0.6	1.9	4.2	0.8	1.2	14.6
3/31/2017	2000	100.0	0.7	1.8	4.3	0.9	1.2	14.7
3/31/2017	2200	120.7	0.8	1.5	4.3	0.8	1.2	14.4
3/31/2017	2400	104.4	0.6	1.7	4.3	0.7	1.2	14.3
4/1/2017	0200	101.9	0.6	1.8	4.3	0.8	1.2	14.3
4/1/2017	0400	97.4	0.6	1.9	4.4	0.9	1.2	14.3
4/1/2017	0600	101.0	0.7	1.8	4.3	0.9	1.2	14.2
4/1/2017	0800	116.5	0.7	1.6	4.4	0.8	1.2	13.8
4/1/2017	1000	113.0	0.7	1.7	4.5	0.7	1.2	13.7
4/1/2017	1200	98.1	0.6	1.8	4.2	0.6	1.2	13.7
4/1/2017	1400	95.4	0.6	2.0	4.5	0.8	1.2	14.1
4/1/2017	1600	95.6	0.6	1.9	4.3	0.8	1.2	14.6
4/1/2017	1800	95.9	0.6	1.9	4.3	0.9	1.2	14.7
4/1/2017	2000	97.9	0.7	1.8	4.1	0.9	1.1	15.1
4/1/2017	2200	120.6	0.8	1.5	4.3	0.9	1.2	14.7
4/1/2017	2400	113.8	0.7	1.6	4.4	0.7	1.1	14.4
4/2/2017	0200	109.4	0.7	1.7	4.3	0.7	1.2	14.4
4/2/2017	0400	104.1	0.7	1.7	4.3	0.8	1.2	14.6

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
4/2/2017	0600	98.4	0.6	1.8	4.3	0.8	1.2	14.6
4/2/2017	0800	123.1	0.8	1.5	4.3	0.8	1.2	14.3
4/2/2017	1000	120.5	0.7	1.6	4.5	0.7	1.1	14.1
4/2/2017	1200	109.4	0.6	1.7	4.4	0.6	1.1	14.3
4/2/2017	1400	101.3	0.6	1.7	4.3	0.7	1.1	14.7
4/2/2017	1600	101.9	0.6	1.8	4.4	0.8	1.1	15.2
4/2/2017	1800	93.7	0.6	1.8	4.2	0.8	1.2	15.2
4/2/2017	2000	106.8	0.7	1.6	4.1	0.9	1.3	15.7
4/2/2017	2200	129.7	0.9	1.4	4.2	0.9	1.2	15.4
4/2/2017	2400	124.9	0.8	1.5	4.4	0.8	1.2	15.1
4/3/2017	0200	118.7	0.7	1.5	4.4	0.7	1.1	14.9
4/3/2017	0400	105.7	0.7	1.7	4.3	0.8	1.1	15.1
4/3/2017	0600	100.4	0.6	1.8	4.3	0.8	1.1	15.1
4/3/2017	0800	102.6	0.7	1.8	4.4	0.9	1.2	14.8
4/3/2017	1000	121.9	0.8	1.5	4.4	0.8	1.0	14.6
4/3/2017	1200	113.0	0.7	1.6	4.4	0.6	1.1	14.7
4/3/2017	1400	102.8	0.6	1.8	4.4	0.7	1.2	14.9
4/3/2017	1600	102.9	0.6	1.8	4.4	0.8	1.1	15.3
4/3/2017	1800	98.9	0.6	1.8	4.3	0.8	1.2	15.7
4/3/2017	2000	95.4	0.6	1.8	4.1	0.9	1.2	15.8
4/3/2017	2200	105.6	0.7	1.6	4.1	0.9	1.3	15.8
4/3/2017	2400	127.2	0.9	1.4	4.4	0.9	1.2	15.6
4/4/2017	0200	121.9	0.8	1.5	4.4	0.8	1.2	15.1
4/4/2017	0400	101.9	0.6	1.8	4.3	0.8	1.2	15.1
4/4/2017	0600	101.4	0.6	1.8	4.3	0.8	1.2	15.1
4/4/2017	0800	103.1	0.7	1.8	4.4	0.9	1.0	15.0
4/4/2017	1000	111.3	0.7	1.6	4.3	0.8	1.1	14.8
4/4/2017	1200	122.5	0.8	1.5	4.4	0.7	1.2	15.0
4/4/2017	1400	106.9	0.6	1.7	4.3	0.7	1.2	15.3
4/4/2017	1600	99.4	0.6	1.9	4.4	0.7	1.1	15.6
4/4/2017	1800	100.4	0.6	1.8	4.3	0.8	1.1	15.9
4/4/2017	2000	100.5	0.7	1.8	4.3	0.9	1.1	16.1
4/4/2017	2200	101.2	0.7	1.7	4.1	0.9	1.2	16.1
4/4/2017	2400	113.8	0.8	1.6	4.2	1.0	1.2	16.0

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
4/5/2017	0200	127.8	0.8	1.4	4.3	0.8	1.2	15.3
4/5/2017	0400	113.8	0.7	1.6	4.4	0.7	1.2	15.2
4/5/2017	0600	102.9	0.6	1.8	4.3	0.7	1.2	15.3
4/5/2017	0800	103.6	0.7	1.8	4.4	0.8	1.2	15.4
4/5/2017	1000	101.5	0.7	1.7	4.3	0.9	1.1	15.3
4/5/2017	1200	121.2	0.8	1.5	4.3	0.8	1.2	15.2
4/5/2017	1400	119.3	0.7	1.5	4.3	0.8	1.0	15.7
4/5/2017	1600	104.9	0.6	1.7	4.3	0.7	1.1	16.0
4/5/2017	1800	104.4	0.6	1.7	4.3	0.8	1.1	16.2
4/5/2017	2000	97.4	0.6	1.8	4.1	0.8	1.3	16.3
4/5/2017	2200	97.9	0.7	1.8	4.2	0.9	1.2	16.3
4/5/2017	2400	108.2	0.8	1.6	4.0	0.9	1.3	16.3
4/6/2017	0200	129.9	0.9	1.4	4.3	0.9	1.2	15.6
4/6/2017	0400	122.5	0.8	1.5	4.4	0.8	1.2	15.4
4/6/2017	0600	109.9	0.7	1.7	4.3	0.7	1.2	15.3
4/6/2017	0800	102.4	0.6	1.7	4.4	0.8	1.1	15.6
4/6/2017	1000	98.4	0.6	1.8	4.3	0.8	1.2	15.6
4/6/2017	1200	109.6	0.7	1.6	4.3	0.9	1.2	15.4
4/6/2017	1400	124.9	0.8	1.5	4.4	0.8	1.2	15.2
4/6/2017	1600	116.0	0.7	1.6	4.4	0.7	1.2	15.2
4/6/2017	1800	99.9	0.6	1.8	4.3	0.7	1.2	15.3
4/6/2017	2000	96.6	0.6	1.9	4.3	0.8	1.2	15.2
4/6/2017	2200	101.5	0.7	1.8	4.3	0.9	1.2	15.2
4/6/2017	2400	97.9	0.7	1.8	4.2	0.9	1.3	15.1
4/7/2017	0200	132.4	0.9	1.4	4.3	0.9	1.2	14.8
4/7/2017	0400	128.6	0.8	1.4	4.3	0.7	1.2	14.5
4/7/2017	0600	114.1	0.7	1.6	4.4	0.6	1.2	14.4
4/7/2017	0800	101.8	0.6	1.8	4.4	0.7	1.1	14.5
4/7/2017	1000	102.9	0.6	1.8	4.3	0.7	1.2	14.6
4/7/2017	1200	99.4	0.6	1.8	4.3	0.8	1.2	14.4
4/7/2017	1400	111.9	0.7	1.6	4.4	0.9	1.2	14.4
4/7/2017	1600	129.9	0.8	1.5	4.5	0.7	1.1	14.2
4/7/2017	1800	113.0	0.7	1.6	4.3	0.6	1.2	14.2
4/7/2017	2000	104.9	0.6	1.7	4.3	0.7	1.2	14.6

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
4/7/2017	2200	100.4	0.6	1.8	4.3	0.8	1.2	14.5
4/7/2017	2400	101.0	0.7	1.8	4.2	0.9	1.3	14.4
4/8/2017	0200	102.8	0.7	1.7	4.1	0.9	1.3	14.3
4/8/2017	0400	120.1	0.8	1.5	4.4	0.8	1.2	13.7
4/8/2017	0600	122.7	0.7	1.5	4.4	0.7	1.2	13.6
4/8/2017	0800	102.3	0.6	1.8	4.4	0.7	1.2	13.6
4/8/2017	1000	102.9	0.6	1.8	4.4	0.8	1.1	13.8
4/8/2017	1200	99.4	0.6	1.8	4.3	0.8	1.2	13.7
4/8/2017	1400	105.6	0.7	1.8	4.5	0.9	1.1	13.8
4/8/2017	1600	124.3	0.8	1.4	4.2	0.7	1.2	13.8
4/8/2017	1800	121.6	0.7	1.5	4.3	0.7	1.2	13.9
4/8/2017	2000	100.9	0.6	1.8	4.3	0.7	1.2	14.1
4/8/2017	2200	101.4	0.6	1.8	4.3	0.8	1.2	14.2
4/8/2017	2400	97.9	0.6	1.8	4.2	0.8	1.2	14.1
4/9/2017	0200	102.3	0.7	1.7	4.1	0.9	1.1	13.8
4/9/2017	0400	127.9	0.9	1.3	4.3	0.9	1.2	13.4
4/9/2017	0600	123.7	0.8	1.5	4.5	0.7	1.1	13.0
4/9/2017	0800	106.9	0.6	1.7	4.4	0.7	1.2	12.9
4/9/2017	1000	97.5	0.6	1.9	4.4	0.8	1.2	13.2
4/9/2017	1200	98.4	0.6	1.8	4.2	0.8	1.2	13.4
4/9/2017	1400	98.4	0.7	1.9	4.4	1.0	1.1	13.7
4/9/2017	1600	116.3	0.8	1.5	4.2	0.9	1.2	13.8
4/9/2017	1800	121.3	0.8	1.5	4.3	0.7	1.2	14.0
4/9/2017	2000	104.9	0.6	1.7	4.3	0.7	1.2	14.0
4/9/2017	2200	101.9	0.6	1.8	4.3	0.8	1.2	14.2
4/9/2017	2400	97.9	0.6	1.8	4.2	0.8	1.2	14.1
4/10/2017	0200	102.8	0.7	1.7	4.1	0.9	1.2	14.1
4/10/2017	0400	110.6	0.8	1.5	4.2	0.9	1.2	13.7
4/10/2017	0600	121.9	0.8	1.5	4.5	0.8	1.2	13.1
4/10/2017	0800	105.9	0.6	1.8	4.5	0.7	1.1	13.0
4/10/2017	1000	96.1	0.6	1.8	4.3	0.7	1.1	13.4
4/10/2017	1200	97.9	0.6	1.8	4.3	0.8	1.2	13.6
4/10/2017	1400	98.4	0.7	1.8	4.2	0.9	1.2	13.9
4/10/2017	1600	120.7	0.8	1.5	4.2	0.9	1.2	13.7

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
4/10/2017	1800	120.7	0.8	1.5	4.3	0.8	1.2	14.4
4/10/2017	2000	105.4	0.6	1.7	4.3	0.7	1.2	14.3
4/10/2017	2200	97.0	0.6	1.9	4.3	0.8	1.2	14.5
4/10/2017	2400	98.9	0.6	1.8	4.3	0.8	1.2	14.6
4/11/2017	0200	102.8	0.7	1.7	4.1	0.9	1.2	14.6
4/11/2017	0400	122.0	0.8	1.5	4.3	0.9	1.2	14.1
4/11/2017	0600	125.6	0.8	1.5	4.4	0.8	1.2	13.6
4/11/2017	0800	117.6	0.7	1.6	4.4	0.7	1.2	13.6
4/11/2017	1000	102.9	0.6	1.7	4.3	0.7	1.1	14.1
4/11/2017	1200	96.1	0.6	1.8	4.3	0.9	1.1	14.2
4/11/2017	1400	96.9	0.6	1.8	4.2	0.9	1.2	14.3
4/11/2017	1600	101.8	0.7	2.0	3.7	0.9	1.3	14.3
4/11/2017	1800	122.4	0.8	1.5	4.3	0.8	1.2	14.4
4/11/2017	2000	114.9	0.7	1.6	4.4	0.7	1.1	14.4
4/11/2017	2200	99.4	0.6	1.8	4.3	0.7	1.2	14.4
4/11/2017	2400	96.6	0.6	1.9	4.3	0.8	1.2	14.5
4/12/2017	0200	102.6	0.7	1.7	4.2	0.8	1.2	14.5
4/12/2017	0400	109.0	0.7	1.6	4.2	0.9	1.2	14.4
4/12/2017	0600	130.4	0.8	1.4	4.4	0.8	1.2	13.8
4/12/2017	0800	117.6	0.7	1.6	4.4	0.7	1.2	13.7
4/12/2017	1000	100.8	0.6	1.8	4.4	0.7	1.2	13.9
4/12/2017	1200	95.6	0.6	1.9	4.2	0.7	1.1	14.4
4/12/2017	1400	97.9	0.6	1.8	4.2	0.9	1.2	14.6
4/12/2017	1600	96.8	0.7	1.7	4.1	0.9	1.2	14.9
4/12/2017	1800	123.9	0.9	1.4	4.2	0.9	1.1	14.8
4/12/2017	2000	125.6	0.8	1.4	4.3	0.7	1.2	14.7
4/12/2017	2200	105.9	0.6	1.7	4.3	0.7	1.2	14.6
4/12/2017	2400	102.4	0.6	1.8	4.3	0.8	1.2	14.9
4/13/2017	0200	104.1	0.7	1.7	4.3	0.8	1.3	14.8
4/13/2017	0400	106.1	0.7	1.7	4.3	0.9	1.2	14.7
4/13/2017	0600	138.6	0.9	1.3	4.3	0.8	1.2	14.2
4/13/2017	0800	118.2	0.7	1.6	4.5	0.7	1.2	14.1
4/13/2017	1000	97.6	0.6	1.9	4.5	0.7	1.0	14.1
4/13/2017	1200	97.5	0.6	1.8	4.2	0.7	1.1	14.7

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
4/13/2017	1400	99.4	0.6	1.8	4.3	0.8	1.1	14.8
4/13/2017	1600	98.9	0.7	1.8	4.2	0.9	1.2	15.0
4/13/2017	1800	117.5	0.8	1.5	4.3	0.9	1.2	14.9
4/13/2017	2000	122.5	0.8	1.5	4.3	0.7	1.2	15.0
4/13/2017	2200	116.0	0.7	1.5	4.3	0.7	1.2	14.8
4/13/2017	2400	103.9	0.6	1.8	4.3	0.7	1.2	14.8
4/14/2017	0200	105.2	0.7	1.7	4.2	0.8	1.2	14.8
4/14/2017	0400	106.1	0.7	1.7	4.2	0.8	1.2	14.6
4/14/2017	0600	117.1	0.8	1.6	4.4	0.9	1.2	14.3
4/14/2017	0800	119.3	0.7	1.5	4.3	0.7	1.2	14.1
4/14/2017	1000	106.9	0.6	1.7	4.4	0.7	1.2	14.1
4/14/2017	1200	98.9	0.6	1.8	4.3	0.7	1.2	14.3
4/14/2017	1400	99.9	0.6	1.8	4.3	1.0	1.0	14.7
4/14/2017	1600	101.0	0.7	1.8	4.3	1.0	1.2	14.9
4/14/2017	1800	105.0	0.7	1.7	4.2	1.0	1.2	15.2
4/14/2017	2000	121.4	0.8	1.5	4.2	0.9	1.2	15.1
4/14/2017	2200	120.1	0.8	1.5	4.3	0.8	1.2	14.8
4/14/2017	2400	106.8	0.7	1.7	4.4	0.8	1.1	14.6
4/15/2017	0200	103.1	0.7	1.7	4.3	0.8	1.2	14.8
4/15/2017	0400	104.5	0.7	1.7	4.3	0.9	1.1	14.7
4/15/2017	0600	116.6	0.8	1.6	4.3	0.8	1.2	14.1
4/15/2017	0800	124.9	0.8	1.5	4.4	0.8	1.2	13.9
4/15/2017	1000	110.4	0.7	1.6	4.3	0.7	1.2	13.8
4/15/2017	1200	102.9	0.6	1.8	4.3	0.7	1.2	14.3
4/15/2017	1400	95.1	0.6	1.9	4.3	0.8	1.1	14.4
4/15/2017	1600	96.4	0.6	1.8	4.2	0.9	1.2	14.8
4/15/2017	1800	101.8	0.7	1.7	4.2	1.0	1.2	15.1
4/15/2017	2000	113.2	0.8	1.6	4.2	1.0	1.2	15.0
4/15/2017	2200	121.8	0.8	1.5	4.3	0.8	1.2	14.6
4/15/2017	2400	116.5	0.7	1.5	4.3	0.8	1.2	14.4
4/16/2017	0200	105.2	0.7	1.8	4.4	0.8	1.2	14.7
4/16/2017	0400	102.1	0.7	1.8	4.3	0.9	1.2	14.7
4/16/2017	0600	105.6	0.7	1.7	4.4	0.9	1.2	14.6
4/16/2017	0800	124.9	0.8	1.5	4.3	0.8	1.2	14.1

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
4/16/2017	1000	115.4	0.7	1.6	4.4	0.7	1.2	14.1
4/16/2017	1200	99.4	0.6	1.8	4.3	0.7	1.2	14.3
4/16/2017	1400	96.6	0.6	1.9	4.5	0.8	1.1	14.4
4/16/2017	1600	93.2	0.6	1.9	4.2	0.8	1.2	14.3
4/16/2017	1800	94.4	0.6	1.8	4.2	0.9	1.2	14.3
4/16/2017	2000	100.6	0.7	1.7	4.1	0.9	1.2	14.4
4/16/2017	2200	119.4	0.8	1.5	4.4	0.9	1.1	14.3
4/16/2017	2400	116.5	0.7	1.6	4.4	0.8	1.2	14.2
4/17/2017	0200	102.4	0.6	1.8	4.4	0.8	1.2	14.1
4/17/2017	0400	103.6	0.7	1.8	4.4	0.9	1.2	14.2
4/17/2017	0600	102.1	0.7	1.8	4.3	0.9	1.2	14.2
4/17/2017	0800	118.9	0.8	1.5	4.4	0.8	1.2	13.8
4/17/2017	1000	124.9	0.8	1.5	4.4	0.7	1.2	13.7
4/17/2017	1200	94.0	0.6	1.9	4.3	0.7	1.2	13.9
4/17/2017	1400	100.9	0.6	1.8	4.3	0.8	1.2	14.2
4/17/2017	1600	101.5	0.7	1.8	4.4	0.9	1.2	14.3
4/17/2017	1800	98.4	0.7	1.8	4.2	0.9	1.2	14.3
4/17/2017	2000	105.0	0.7	1.7	4.1	1.0	1.2	14.3
4/17/2017	2200	120.7	0.8	1.5	4.2	0.9	1.2	13.9
4/17/2017	2400	118.9	0.8	1.5	4.3	0.8	1.2	13.8
4/18/2017	0200	112.2	0.7	1.7	4.5	0.8	1.2	13.8
4/18/2017	0400	100.4	0.6	1.9	4.4	0.8	1.2	13.9
4/18/2017	0600	103.1	0.7	1.8	4.3	0.9	1.2	13.9
4/18/2017	1400	99.9	0.6	1.8	4.3	0.8	1.3	14.1
4/18/2017	1600	102.6	0.7	2.1	3.8	0.8	1.3	14.3
4/18/2017	1800	103.4	0.7	1.7	4.1	0.9	1.3	14.6
4/18/2017	2000	103.9	0.7	1.6	3.8	0.9	1.4	14.7
4/18/2017	2200	118.2	0.8	1.4	3.9	0.9	1.3	14.4
4/18/2017	2400	123.9	0.8	1.4	4.2	0.8	1.2	14.0
4/19/2017	0200	116.5	0.7	1.5	4.3	0.7	1.2	13.9
4/19/2017	0400	101.9	0.6	1.8	4.3	0.8	1.2	13.8
4/19/2017	0600	104.1	0.7	1.7	4.2	0.8	1.3	14.0
4/19/2017	0800	101.5	0.7	1.6	4.0	0.8	1.3	13.9
4/19/2017	1600	102.6	0.7	1.7	4.2	0.8	1.2	14.8

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
4/19/2017	1800	102.8	0.7	1.7	4.2	0.9	1.2	15.2
4/19/2017	2000	99.0	0.7	1.7	4.0	1.0	1.2	15.4
4/19/2017	2200	107.0	0.8	1.6	4.1	1.0	1.2	15.3
4/19/2017	2400	119.5	0.8	1.5	4.2	0.9	1.2	14.7
1/30/2018	0915	86.1	0.6	1.8	3.7	0.9	1.4	10.7
1/30/2018	0945	94.2	0.7	1.7	3.8	1.0	1.4	10.7
1/30/2018	1015	93.7	0.7	1.7	3.8	1.0	1.4	10.8
1/30/2018	1045	92.6	0.7	1.7	3.8	1.0	1.4	11.0
1/30/2018	1200	99.3	0.7	1.5	3.6	0.9	1.0	11.2
1/30/2018	1400	109.4	0.8	1.6	4.2	0.9	1.2	11.1
1/30/2018	1600	105.6	0.7	1.8	4.6	1.0	1.2	10.9
1/30/2018	1800	115.3	0.7	1.6	4.7	0.9	1.0	10.9
1/30/2018	2000	95.6	0.6	1.9	4.5	0.8	1.1	10.9
1/30/2018	2200	94.9	0.6	1.9	4.3	0.9	1.2	10.8
1/30/2018	2400	93.1	0.7	1.8	4.1	0.9	1.3	11.0
11/29/2018	0824	103.2	0.7	1.5	3.7	0.9	1.3	13.6
11/29/2018	0854	96.8	0.7	1.6	3.8	0.9	1.3	13.6
11/29/2018	1000	96.8	0.7	1.6	3.8	0.9	1.3	13.6
11/29/2018	1200	97.4	0.6	1.7	3.8	0.8	1.4	13.2
11/29/2018	1400	102.4	0.6	1.6	3.9	0.7	1.3	13.2
11/29/2018	1600	83.3	0.5	2.0	4.1	0.7	1.3	13.2
11/29/2018	1800	88.1	0.6	1.8	3.8	0.8	1.4	13.2
11/29/2018	2000	106.7	0.7	1.6	3.9	0.8	1.3	13.3
11/29/2018	2200	106.2	0.7	1.6	4.0	0.7	1.3	13.1
11/29/2018	2400	98.9	0.6	1.7	4.1	0.7	1.2	13.1
11/30/2018	0200	82.5	0.5	2.1	4.1	0.7	1.3	13.1
11/30/2018	0400	86.3	0.6	2.0	4.1	0.8	1.3	13.0
11/30/2018	0600	83.2	0.6	1.9	3.8	0.9	1.4	13.1
11/30/2018	0800	94.6	0.7	1.7	3.7	1.0	1.0	13.1
11/30/2018	1000	103.3	0.7	1.4	3.5	0.9	1.1	13.2
11/30/2018	1200	82.6	0.5	1.8	3.6	0.8	0.9	13.2
11/30/2018	1400	100.4	0.6	1.5	3.6	0.7	1.0	13.1
11/30/2018	1600	90.4	0.6	1.8	4.0	0.7	1.0	13.1
11/30/2018	1800	99.4	0.7	1.7	4.0	0.9	0.8	13.1

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
11/30/2018	2000	99.6	0.7	2.0	4.8	1.2	0.7	13.3
11/30/2018	2200	101.8	0.7	1.7	4.0	0.9	0.9	13.3
11/30/2018	2400	107.3	0.7	1.6	4.0	0.9	1.3	13.3
12/1/2018	0200	92.8	0.6	1.8	3.9	0.8	1.3	12.9
12/1/2018	0400	87.5	0.6	1.9	3.9	0.9	1.3	12.9
12/1/2018	0600	86.9	0.6	1.8	3.8	1.0	1.0	12.9
12/1/2018	0800	86.9	0.7	1.7	3.5	1.1	0.9	12.9
12/1/2018	1000	109.2	0.8	1.4	3.7	1.1	0.9	13.0
12/1/2018	1200	114.3	0.8	1.4	3.9	1.0	1.3	12.9
12/1/2018	1400	96.8	0.7	1.7	3.8	0.9	0.9	12.8
12/1/2018	1600	103.4	0.7	1.7	4.2	0.9	0.9	12.8
12/1/2018	1800	86.8	0.6	2.0	4.2	0.9	1.0	12.8
12/1/2018	2000	81.4	0.6	2.6	5.0	1.3	0.7	12.7
12/1/2018	2200	91.6	0.7	1.8	3.9	1.1	0.9	12.9
12/1/2018	2400	113.0	0.8	1.4	3.8	1.0	1.4	12.9
AVG	**—**	**106.7**	**0.7**	**1.7**	**4.3**	**0.8**	**1.2**	**14.2**

Table D-5.—Hydraulic and temperature data for Chinook Salmon facility efficiency replicates performed during 5 pump operation at the C.W. “Bill” Jones Pumping Plant.

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/13/2019	1147	124.9	0.8	1.4	4.2	0.8	1.2	9.8
2/13/2019	1217	126.8	0.8	1.4	4.2	0.7	1.3	9.8
2/13/2019	1247	113.2	0.7	1.5	4.1	0.7	1.2	9.9
2/13/2019	1317	113.8	0.7	1.5	4.2	0.7	1.3	9.9
2/13/2019	1400	113.8	0.7	1.5	4.1	0.7	1.2	9.9
2/13/2019	1600	108.3	0.7	2.0	3.8	0.8	1.4	10.0
2/13/2019	1800	104.0	0.7	1.6	4.0	0.9	1.3	10.0
2/13/2019	2000	100.7	0.7	1.7	4.0	0.9	1.4	10.0
2/13/2019	2200	103.3	0.7	1.6	3.9	1.0	1.3	10.0
2/13/2019	2400	113.6	0.8	1.5	4.0	0.9	1.3	10.1
2/14/2019	200	120.0	0.8	1.4	4.0	0.8	1.3	10.1
2/14/2019	400	115.4	0.8	1.5	4.1	0.8	1.3	10.2
2/14/2019	600	114.8	0.8	1.5	4.2	0.9	1.3	10.2
2/14/2019	800	116.0	0.8	1.4	4.0	0.9	1.3	10.2
2/14/2019	1000	124.3	0.8	1.4	4.1	0.7	1.2	10.4
2/14/2019	1200	116.0	0.7	1.4	4.1	0.6	1.3	10.4
2/14/2019	1400	123.1	0.7	1.5	4.3	0.6	1.2	10.5
2/14/2019	1600	94.6	0.5	2.3	3.9	0.6	1.3	10.6
2/14/2019	1800	99.9	0.6	1.8	4.2	0.7	1.2	10.7
2/14/2019	2000	95.6	0.6	1.8	4.2	0.8	1.2	10.7
2/14/2019	2200	99.4	0.7	1.7	4.1	0.9	1.4	10.7
2/14/2019	2400	98.4	0.7	1.7	4.0	0.9	1.3	10.6
2/15/2019	200	105.0	0.7	1.6	4.1	0.9	1.3	10.7
2/15/2019	400	117.1	0.8	1.5	4.2	0.8	1.2	10.6
2/15/2019	600	108.3	0.7	1.6	4.1	0.8	1.2	10.6
2/15/2019	800	107.2	0.7	1.6	4.0	0.8	1.3	10.5
2/15/2019	1000	110.7	0.7	1.5	4.0	0.8	1.2	10.5
2/15/2019	1200	119.5	0.8	1.5	4.2	0.8	1.3	10.6
2/15/2019	1400	126.1	0.8	1.4	4.3	0.7	1.2	10.6
2/15/2019	1600	102.8	0.6	1.7	4.2	0.6	1.2	10.7
2/15/2019	1800	94.5	0.6	1.9	4.3	0.7	1.2	10.7

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/15/2019	2000	99.4	0.6	1.7	4.1	0.8	1.3	10.7
2/15/2019	2200	100.0	0.7	1.7	4.1	0.9	1.3	10.8
2/15/2019	2400	91.4	0.6	1.8	3.9	0.9	1.3	10.7
2/16/2019	200	124.5	0.9	1.3	4.0	0.9	1.3	10.7
2/16/2019	400	113.0	0.8	1.5	4.1	0.9	1.3	10.7
2/16/2019	600	106.1	0.7	1.6	4.1	0.8	1.3	10.6
2/16/2019	800	100.5	0.7	1.7	4.1	0.9	1.3	10.6
2/16/2019	1000	102.8	0.7	1.7	4.1	0.9	1.3	10.6
2/16/2019	1200	116.0	0.8	1.5	4.0	0.8	1.4	10.8
2/16/2019	1400	132.9	0.8	1.3	4.2	0.8	1.2	10.4
2/16/2019	1600	113.0	0.7	1.6	4.3	0.6	1.2	10.4
2/16/2019	1800	95.4	0.6	1.8	4.0	0.6	1.3	10.4
2/16/2019	2000	96.1	0.6	1.8	4.2	0.8	1.2	10.5
2/16/2019	2200	91.8	0.6	1.9	4.1	0.9	1.3	10.8
2/16/2019	2400	87.5	0.6	1.9	3.9	0.9	1.3	10.7
2/17/2019	200	116.9	0.8	1.4	3.9	0.9	1.4	10.8
2/17/2019	400	111.8	0.8	1.5	3.9	0.9	1.4	10.9
2/17/2019	600	109.6	0.7	1.5	3.9	0.8	1.3	10.8
2/17/2019	800	105.6	0.7	1.6	4.1	0.8	1.4	10.8
2/17/2019	1000	107.9	0.7	1.4	3.8	0.8	1.4	10.8
2/17/2019	1200	107.9	0.7	1.5	3.9	0.9	1.4	11.0
2/17/2019	1400	132.5	0.9	1.4	4.3	0.8	1.1	11.2
2/17/2019	1600	120.5	0.7	1.5	4.4	0.7	1.2	10.4
2/17/2019	1800	108.9	0.6	1.7	4.5	0.7	1.2	10.4
2/17/2019	2000	104.4	0.6	1.7	4.4	0.7	1.2	10.4
2/17/2019	2200	94.7	0.6	1.9	4.2	0.8	1.3	10.7
2/17/2019	2400	93.9	0.6	1.8	4.0	0.9	1.3	10.9
2/18/2019	200	103.3	0.7	1.6	4.0	0.9	1.4	10.9
2/18/2019	400	111.2	0.8	1.5	4.0	0.9	1.3	10.7
2/18/2019	600	113.6	0.8	1.4	3.9	0.8	1.4	10.7
2/18/2019	800	106.7	0.7	1.5	3.9	0.8	1.3	10.4
2/18/2019	1000	104.0	0.7	1.6	4.1	0.9	1.4	10.4
2/18/2019	1200	105.6	0.7	1.5	3.8	0.9	1.3	10.4
2/18/2019	1400	109.6	0.7	1.5	4.0	0.8	1.4	10.7

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/18/2019	1600	140.7	0.9	1.3	4.3	0.8	1.2	10.6
2/18/2019	1800	113.0	0.7	1.6	4.4	0.7	1.2	10.2
2/18/2019	2000	95.6	0.6	1.9	4.3	0.7	1.3	10.1
2/18/2019	2200	94.7	0.6	1.9	4.2	0.7	1.1	10.1
2/18/2019	2400	91.8	0.6	1.9	4.0	0.8	1.3	10.4
2/19/2019	200	99.6	0.7	1.7	4.0	0.9	1.3	10.4
2/19/2019	400	104.5	0.7	1.6	4.0	0.9	1.3	10.2
2/19/2019	600	112.4	0.8	1.5	4.1	0.9	1.3	10.0
2/19/2019	800	110.7	0.7	1.6	4.2	0.9	1.3	9.9
2/19/2019	1000	95.4	0.6	1.8	4.1	0.9	1.3	9.8
2/19/2019	1200	101.8	0.7	1.5	3.7	0.9	1.4	9.9
2/19/2019	1400	113.8	0.8	1.4	3.8	0.9	1.4	10.1
2/19/2019	1600	123.3	0.8	1.4	4.1	0.9	1.3	10.3
2/19/2019	1800	113.8	0.7	1.8	4.9	0.8	1.1	10.1
2/19/2019	2000	98.5	0.6	2.2	5.1	0.9	1.0	10.0
2/19/2019	2200	100.4	0.6	2.0	5.0	0.9	1.1	10.1
2/19/2019	2400	90.4	0.6	2.1	4.5	0.9	1.1	10.1
2/20/2019	200	94.7	0.7	1.7	3.9	0.9	1.3	10.4
2/20/2019	400	122.6	0.9	1.5	4.3	0.9	1.2	10.4
2/20/2019	600	115.6	0.8	1.6	4.3	0.9	1.3	10.4
2/20/2019	800	110.7	0.7	1.6	4.2	0.8	1.5	9.8
2/20/2019	1000	102.1	0.7	1.7	4.2	0.8	1.3	9.8
2/20/2019	1200	101.7	0.7	1.7	4.0	0.9	1.3	9.9
2/20/2019	1400	108.2	0.8	1.5	3.9	0.9	1.2	10.1
2/20/2019	1600	134.2	0.9	1.3	4.0	1.0	1.4	10.3
2/20/2019	1800	142.0	0.9	1.3	4.5	0.9	1.2	10.3
2/20/2019	2000	110.9	0.7	2.0	5.3	0.8	1.0	10.1
2/20/2019	2200	111.6	0.7	2.0	5.2	0.9	1.0	10.1
2/20/2019	2400	108.3	0.7	1.6	4.1	1.0	1.3	10.2
2/21/2019	200	100.1	0.7	1.6	3.9	0.9	1.4	10.3
2/21/2019	400	103.3	0.7	1.6	3.8	0.9	1.2	9.9
2/21/2019	600	106.2	0.7	1.5	3.8	0.8	1.4	9.8
2/21/2019	800	117.5	0.8	1.5	4.2	0.9	1.3	9.7
2/21/2019	948	116.6	0.8	1.5	4.0	0.8	1.3	9.8

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/21/2019	1000	116.6	0.8	1.5	4.0	0.8	1.3	9.8
2/21/2019	1018	111.9	0.7	1.5	4.1	0.8	1.3	9.8
2/21/2019	1048	111.3	0.7	1.5	4.1	0.8	1.3	9.8
2/21/2019	1118	110.2	0.7	1.6	4.1	0.8	1.3	9.8
2/21/2019	1200	110.2	0.7	1.6	4.1	0.8	1.3	9.8
2/21/2019	1400	100.7	0.7	1.7	4.1	1.0	1.3	10.0
2/21/2019	1600	113.8	0.8	1.5	4.0	0.9	1.3	10.2
2/21/2019	1800	131.2	0.9	1.3	4.2	0.8	1.3	10.2
2/21/2019	2000	118.2	0.7	1.5	4.2	0.7	1.3	10.1
2/21/2019	2200	101.9	0.6	1.7	4.1	0.7	1.3	10.1
2/21/2019	2400	98.9	0.6	1.8	4.1	0.8	1.3	10.0
2/22/2019	200	100.7	0.7	1.7	4.0	0.9	1.4	9.9
2/22/2019	400	106.4	0.8	1.5	3.8	1.0	1.4	9.7
2/22/2019	600	123.9	0.9	1.4	4.0	0.9	1.4	9.6
2/22/2019	800	116.3	0.8	1.4	4.0	0.9	1.2	9.5
2/22/2019	1000	121.2	0.8	1.4	4.1	0.8	1.3	9.5
2/22/2019	1200	110.2	0.7	1.5	4.0	0.8	1.3	9.6
2/22/2019	1400	105.6	0.7	1.6	4.0	0.9	1.3	9.6
2/22/2019	1600	114.3	0.8	1.4	3.9	1.0	1.3	10.2
2/22/2019	1800	118.2	0.8	1.4	4.1	0.9	1.3	10.2
2/22/2019	2000	122.4	0.8	1.4	4.1	0.8	1.3	10.1
2/22/2019	2200	115.9	0.7	1.5	4.1	0.7	1.2	9.8
2/22/2019	2400	96.9	0.6	1.8	4.0	0.8	1.3	9.9
2/23/2019	200	99.6	0.7	1.6	3.9	0.9	1.4	9.9
2/23/2019	400	103.5	0.8	1.6	3.9	1.0	1.0	9.7
2/23/2019	600	113.0	0.8	1.5	4.0	1.0	1.3	9.6
2/23/2019	800	108.8	0.8	1.6	4.1	0.9	1.3	9.5
2/23/2019	1000	119.4	0.8	1.3	3.9	0.8	1.2	9.4
2/23/2019	1200	115.4	0.8	1.5	4.1	0.8	1.2	9.5
2/23/2019	1400	106.2	0.7	1.6	4.0	0.9	1.3	9.8
2/23/2019	1600	105.3	0.8	1.5	3.8	1.0	1.3	9.9
2/23/2019	1800	121.4	0.9	1.4	3.9	1.0	1.4	10.0
2/23/2019	2000	115.0	0.8	1.5	4.1	0.9	1.3	10.0
2/23/2019	2200	119.4	0.8	1.5	4.3	0.9	1.2	9.9

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/23/2019	2400	106.7	0.7	1.6	4.1	0.8	1.3	9.9
2/24/2019	200	99.0	0.7	1.6	3.8	0.9	1.4	9.9
2/24/2019	400	102.3	0.8	1.5	3.6	1.0	1.0	9.8
2/24/2019	600	101.1	0.8	1.4	3.4	1.0	1.1	9.7
2/24/2019	800	136.3	1.0	1.0	3.1	1.0	1.2	9.6
2/24/2019	1000	131.9	0.9	1.3	4.1	0.8	1.3	9.7
2/24/2019	1200	113.0	0.7	1.5	4.1	0.8	1.3	9.8
2/24/2019	1400	106.2	0.7	1.6	4.0	0.7	1.3	9.8
2/24/2019	1600	93.1	0.7	1.7	3.8	1.0	1.3	9.9
2/24/2019	1800	103.5	0.8	1.5	3.7	1.0	0.9	10.0
2/24/2019	2000	108.8	0.8	1.5	4.0	0.9	1.3	10.0
2/24/2019	2200	110.0	0.8	1.5	4.0	0.9	1.4	10.0
2/24/2019	2400	111.2	0.8	1.5	4.1	0.9	1.3	10.0
2/25/2019	200	110.0	0.8	1.5	4.0	0.9	1.4	9.9
2/25/2019	400	104.7	0.8	1.6	4.0	1.0	1.3	9.7
2/25/2019	600	102.9	0.8	1.5	3.6	1.0	1.2	9.7
2/25/2019	800	108.8	0.8	1.5	3.8	0.9	1.4	9.6
2/25/2019	1000	116.6	0.8	1.4	4.0	0.8	1.4	9.8
2/25/2019	1200	121.9	0.8	1.4	4.1	0.7	1.3	10.1
2/25/2019	1400	101.5	0.7	1.6	3.9	0.8	1.4	10.2
2/25/2019	1600	100.7	0.7	1.6	3.7	0.9	1.2	10.3
2/25/2019	1800	109.5	0.8	1.4	3.8	1.0	1.1	10.3
2/25/2019	2000	123.5	0.9	1.3	3.8	0.9	1.0	10.5
2/25/2019	2200	113.8	0.8	1.5	4.0	0.9	1.4	10.6
2/25/2019	2400	106.2	0.7	1.6	4.1	0.9	1.3	10.6
2/26/2019	200	118.7	0.8	1.4	3.8	0.8	1.4	10.6
2/26/2019	400	112.4	0.8	1.4	3.8	0.8	1.4	10.6
2/26/2019	600	109.4	0.8	1.5	3.8	0.9	1.4	10.6
2/26/2019	800	125.2	0.9	1.3	4.0	0.9	1.4	10.5
2/26/2019	1000	125.2	0.8	1.3	4.0	0.8	1.3	10.4
2/26/2019	1200	124.9	0.8	1.4	4.2	0.7	1.3	10.2
2/26/2019	1400	103.4	0.6	1.7	4.2	0.7	1.3	10.3
2/26/2019	1600	98.9	0.6	2.0	4.8	0.9	1.1	10.4
2/26/2019	1800	107.3	0.7	1.6	4.2	0.9	1.3	10.5

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
2/26/2019	2000	107.0	0.8	1.5	3.8	0.9	1.3	10.6
2/26/2019	2200	107.0	0.8	1.5	3.8	0.9	1.3	10.6
2/26/2019	2400	123.3	0.8	1.4	4.0	0.8	1.3	10.7
2/27/2019	200	116.6	0.8	1.5	4.0	0.8	1.3	10.7
2/27/2019	400	116.6	0.8	1.5	4.0	0.8	1.3	10.7
2/27/2019	600	109.6	0.7	1.5	4.0	0.8	1.3	10.7
2/27/2019	800	122.0	0.8	1.4	4.2	0.9	1.3	10.6
2/27/2019	1000	128.4	0.8	1.4	4.2	0.8	1.3	10.6
2/27/2019	1200	125.5	0.8	1.3	4.1	0.6	1.2	10.4
2/27/2019	1400	117.6	0.7	1.5	4.3	0.7	1.3	10.7
2/27/2019	1600	114.3	0.7	1.9	4.0	0.7	1.3	11.0
2/27/2019	1800	108.3	0.7	1.6	4.2	0.8	1.2	11.3
2/27/2019	2000	100.5	0.7	1.7	4.1	0.9	1.3	11.4
2/27/2019	2200	110.6	0.8	1.5	4.0	0.9	1.4	11.3
2/27/2019	2400	118.2	0.8	1.4	4.0	0.9	1.4	11.3
2/28/2019	200	118.2	0.8	1.4	4.0	0.9	1.4	11.3
2/28/2019	400	123.1	0.8	1.4	4.1	0.8	1.3	11.2
2/28/2019	600	107.2	0.7	1.6	4.0	0.8	1.4	11.2
2/28/2019	800	106.8	0.7	1.8	3.5	0.8	1.6	11.2
2/28/2019	1000	122.7	0.8	1.4	4.1	0.9	1.3	11.2
2/28/2019	1200	133.9	0.9	1.2	4.1	0.7	1.3	11.2
2/28/2019	1400	125.5	0.8	1.4	4.2	0.7	1.3	11.1
2/28/2019	1600	108.8	0.7	1.6	4.2	0.7	1.2	11.4
2/28/2019	1800	107.8	0.7	1.6	4.2	0.8	1.3	11.7
2/28/2019	2000	107.9	0.7	1.6	4.0	0.9	1.4	11.7
2/28/2019	2200	112.6	0.8	1.4	3.9	0.9	1.5	11.6
2/28/2019	2400	110.1	0.8	1.5	3.9	1.0	1.3	11.5
3/1/2019	200	128.3	0.9	1.3	4.0	0.9	1.3	11.3
3/1/2019	400	125.2	0.8	1.4	4.1	0.8	1.3	11.3
3/1/2019	600	118.3	0.8	1.5	4.2	0.8	1.3	11.3
3/1/2019	800	113.6	0.8	1.8	3.6	0.8	1.4	11.2
3/1/2019	1000	112.4	0.8	1.5	4.0	0.9	1.4	11.2
3/1/2019	1200	139.9	0.9	1.2	4.1	0.8	1.3	11.2
3/1/2019	1400	132.3	0.8	1.3	4.2	0.7	1.2	11.4

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/1/2019	1600	121.6	0.7	1.5	4.2	0.7	1.1	11.4
3/1/2019	1800	111.6	0.7	1.5	4.1	0.7	1.4	11.6
3/1/2019	2000	108.3	0.7	1.6	4.0	0.8	1.3	11.7
3/1/2019	2200	109.0	0.7	1.6	4.1	0.9	1.3	11.7
3/1/2019	2400	103.3	0.7	1.7	4.1	0.9	1.3	11.7
3/2/2019	200	131.3	0.9	1.3	4.0	0.9	1.3	11.6
3/2/2019	400	125.2	0.8	1.3	4.0	0.8	1.4	11.5
3/2/2019	600	118.9	0.8	1.4	4.1	0.7	1.3	11.5
3/2/2019	800	117.1	0.8	1.5	4.2	0.8	1.3	11.4
3/2/2019	1000	109.6	0.7	1.5	3.9	0.8	1.4	11.4
3/2/2019	1200	124.6	0.8	1.4	4.1	0.8	1.4	11.4
3/2/2019	1400	132.9	0.8	1.3	4.2	0.7	1.3	11.4
3/2/2019	1600	127.9	0.8	1.6	3.7	0.6	1.4	11.4
3/2/2019	1800	106.4	0.6	1.6	4.1	0.6	1.3	11.5
3/2/2019	2000	111.6	0.7	1.5	4.1	0.7	1.3	11.6
3/2/2019	2200	111.9	0.7	1.5	4.1	0.8	1.2	11.7
3/2/2019	2400	102.8	0.7	1.6	4.0	0.9	1.4	11.7
3/3/2019	200	118.2	0.8	1.4	3.9	0.9	1.4	11.6
3/3/2019	400	129.2	0.9	1.3	4.1	0.8	1.3	11.4
3/3/2019	600	129.7	0.8	1.3	4.1	0.7	1.3	11.4
3/3/2019	800	106.2	0.7	1.6	4.0	0.7	1.4	11.3
3/3/2019	1000	111.9	0.7	1.5	4.1	0.8	1.3	11.5
3/3/2019	1200	109.4	0.8	1.5	3.9	0.9	1.3	11.6
3/3/2019	1400	124.6	0.8	1.4	4.2	0.9	1.3	11.4
3/3/2019	1600	130.5	0.8	1.3	4.2	0.7	1.3	11.7
3/3/2019	1800	113.0	0.7	1.5	4.2	0.6	1.3	11.8
3/3/2019	2000	109.4	0.7	1.6	4.1	0.7	1.3	11.8
3/3/2019	2200	104.7	0.7	1.6	4.0	0.7	1.4	11.9
3/3/2019	2400	109.6	0.7	1.5	4.0	0.8	1.3	12.0
3/4/2019	200	110.0	0.8	1.5	4.0	0.9	1.3	11.9
3/4/2019	400	117.5	0.8	1.4	4.0	0.8	1.3	11.7
3/4/2019	600	126.5	0.8	1.4	4.1	0.8	1.3	11.7
3/4/2019	800	120.1	0.8	1.4	4.1	0.7	1.2	11.7
3/4/2019	1000	111.9	0.7	1.5	4.0	0.8	1.3	11.8

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/4/2019	1200	113.0	0.8	1.5	4.0	0.9	1.3	11.9
3/4/2019	1400	129.9	0.9	1.8	4.2	0.9	1.3	12.1
3/4/2019	1600	128.0	0.8	1.3	4.1	0.7	1.2	12.1
3/4/2019	1800	118.2	0.7	1.5	4.2	0.6	1.3	12.0
3/4/2019	2000	108.8	0.7	1.6	4.0	0.7	1.3	12.3
3/4/2019	2200	104.7	0.7	1.6	4.0	0.7	1.3	12.4
3/4/2019	2400	108.5	0.7	1.6	4.0	0.9	1.3	12.4
3/5/2019	200	109.4	0.8	1.5	3.9	0.9	1.3	12.4
3/5/2019	400	133.1	0.9	1.3	4.0	0.8	1.3	12.4
3/5/2019	600	126.6	0.8	1.3	4.0	0.8	1.3	12.4
3/5/2019	800	115.9	0.7	1.5	4.2	0.7	1.3	12.4
3/5/2019	1000	110.7	0.7	1.5	3.9	0.8	1.3	12.4
3/5/2019	1200	108.5	0.7	1.5	3.9	0.9	1.3	12.4
3/5/2019	1400	120.7	0.8	1.4	4.1	0.9	1.3	12.5
3/5/2019	1600	133.2	0.9	1.5	4.7	0.9	1.0	12.6
3/5/2019	1800	126.7	0.8	1.3	4.0	0.9	0.9	12.3
3/5/2019	2000	108.8	0.7	1.6	4.1	0.9	1.1	12.6
3/5/2019	2200	105.2	0.7	1.6	3.9	1.1	0.9	12.6
3/5/2019	2400	109.6	0.7	1.5	3.9	0.8	1.3	12.5
3/6/2019	200	101.2	0.7	1.6	3.9	0.9	1.4	12.4
3/6/2019	400	127.9	0.9	1.3	3.9	0.8	1.3	12.2
3/6/2019	600	117.1	0.8	1.4	3.9	0.7	1.4	12.1
3/6/2019	800	121.9	0.8	1.5	4.3	0.7	1.3	12.1
3/6/2019	1000	117.0	0.7	1.4	4.0	0.7	1.2	12.1
3/6/2019	1200	107.8	0.7	1.6	4.1	0.8	1.3	12.3
3/6/2019	1400	112.5	0.7	1.6	4.2	0.8	1.3	12.4
3/6/2019	1600	126.2	0.8	1.4	4.3	0.8	1.2	12.5
3/6/2019	1800	125.0	0.7	1.5	4.4	0.6	1.2	12.4
3/6/2019	2000	94.2	0.5	1.8	4.0	0.9	1.4	12.4
3/6/2019	2200	99.4	0.6	1.6	3.8	0.6	1.4	12.6
3/6/2019	2400	101.9	0.6	1.7	4.1	0.7	1.2	12.7
3/7/2019	200	96.9	0.6	1.7	3.9	0.8	1.3	12.7
3/7/2019	400	120.6	0.8	1.4	4.0	0.8	1.3	12.3
3/7/2019	600	113.6	0.7	1.4	3.9	0.7	1.3	12.2

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
3/7/2019	800	112.7	0.7	1.5	4.0	0.7	1.3	12.2
3/7/2019	1000	106.8	0.7	1.6	4.0	0.7	1.3	12.3
3/7/2019	1200	102.1	0.7	1.6	3.9	0.8	1.3	12.4
3/7/2019	1400	98.9	0.7	1.7	3.9	0.8	1.3	12.4
3/7/2019	1600	120.6	0.8	1.4	4.0	0.8	1.3	12.4
3/7/2019	1800	119.3	0.7	1.4	4.1	0.7	1.3	12.4
3/7/2019	2000	113.0	0.7	1.6	4.2	0.6	1.3	12.3
3/7/2019	2200	103.4	0.6	1.7	4.1	0.7	1.3	12.3
3/7/2019	2400	105.2	0.7	1.5	3.8	0.7	1.4	12.3
3/8/2019	200	93.9	0.6	1.7	3.8	0.8	1.4	12.2
3/8/2019	400	107.3	0.7	1.6	4.0	0.9	1.3	11.9
3/8/2019	600	110.7	0.7	1.5	4.1	0.8	1.3	11.8
6/6/2019	934	117.1	0.7	1.4	3.8	0.6	1.2	21.8
6/6/2019	1004	100.9	0.6	1.9	4.7	0.9	0.9	21.6
6/6/2019	1034	99.4	0.6	1.6	3.8	0.6	1.1	21.8
6/6/2019	1104	97.5	0.6	1.6	3.8	0.7	1.2	21.9
6/6/2019	1200	100.9	0.6	1.6	3.8	0.7	1.1	21.2
6/6/2019	1400	94.9	0.6	1.7	3.9	0.9	1.1	21.4
6/6/2019	1600	99.6	0.7	1.6	3.9	1.0	1.1	21.7
6/6/2019	1800	120.7	0.9	1.4	4.0	1.1	1.1	21.3
6/6/2019	2000	127.0	0.9	1.2	3.7	0.9	1.3	21.2
6/6/2019	2200	114.4	0.8	1.4	3.8	0.9	1.2	20.8
6/6/2019	2400	114.7	0.7	1.0	2.7	0.4	1.7	21.2
6/7/2019	200	96.9	0.6	1.0	2.4	0.4	1.9	20.9
6/7/2019	400	97.9	0.7	1.0	2.3	0.4	2.1	19.8
6/7/2019	600	111.2	0.8	0.9	2.4	0.5	1.9	19.3
6/7/2019	800	116.6	0.8	0.9	2.4	0.4	2.0	19.2
6/7/2019	1000	104.9	0.6	1.0	2.4	0.3	2.0	20.7
6/7/2019	1200	106.8	0.7	0.9	2.2	0.3	2.1	20.6
6/7/2019	1400	105.0	0.7	0.9	2.2	0.4	2.3	19.8
6/7/2019	1600	100.7	0.7	0.9	2.2	0.4	2.1	20.2
6/7/2019	1800	106.4	0.8	0.9	2.2	0.5	2.1	20.6
6/7/2019	2000	116.6	0.9	0.8	2.1	0.5	2.2	20.7
6/7/2019	2200	124.2	0.9	0.8	2.2	0.5	2.2	21.1

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
6/7/2019	2400	131.2	0.9	0.7	2.3	0.4	2.0	20.4
6/8/2019	200	103.6	0.7	0.9	2.1	0.3	2.1	20.2
6/8/2019	400	104.0	0.7	1.0	2.4	0.5	2.2	19.7
6/8/2019	600	113.8	0.8	0.9	2.3	0.5	2.1	19.3
6/8/2019	800	120.7	0.8	0.8	2.2	0.4	2.1	19.1
6/8/2019	1000	137.3	0.9	0.9	2.2	0.4	2.2	19.6
6/8/2019	1200	116.5	0.7	0.8	2.1	0.3	2.2	20.2
6/8/2019	1400	98.9	0.7	0.9	2.1	0.4	2.3	19.8
6/8/2019	1600	105.6	0.7	0.9	2.2	0.4	2.3	19.9
6/8/2019	1800	113.7	0.8	0.7	2.0	0.5	2.6	20.4
6/8/2019	2000	105.1	0.8	0.8	2.1	0.5	1.5	20.4
6/8/2019	2200	124.2	0.9	0.7	2.1	0.5	1.5	20.1
6/8/2019	2400	136.3	0.9	0.8	2.5	0.5	2.1	19.8
6/9/2019	200	114.2	0.8	0.9	2.3	0.4	2.0	19.4
6/9/2019	400	101.8	0.7	1.0	2.3	0.5	1.6	19.3
6/9/2019	600	104.5	0.7	0.9	2.3	0.5	2.1	19.2
6/9/2019	800	128.3	0.9	0.8	2.3	0.5	2.0	18.7
6/9/2019	1000	120.7	0.8	0.8	2.3	0.5	2.0	18.6
6/9/2019	1200	128.6	0.8	0.8	2.4	0.4	1.9	19.7
6/9/2019	1400	114.8	0.8	0.9	2.4	0.4	1.9	20.1
6/9/2019	1600	107.6	0.8	0.9	2.4	0.5	1.9	20.6
6/9/2019	1800	99.9	0.7	1.3	3.2	0.8	1.4	21.1
6/9/2019	2000	99.9	0.8	1.0	2.3	0.6	1.1	20.6
6/9/2019	2200	128.3	0.9	0.8	2.3	0.5	1.0	20.0
6/9/2019	2400	123.5	0.9	0.8	2.4	0.5	0.9	19.7
6/10/2019	200	122.0	0.8	0.8	2.3	0.4	0.9	19.7
6/10/2019	400	114.2	0.8	0.8	2.3	0.4	0.9	19.2
6/10/2019	600	107.3	0.7	0.9	2.3	0.4	0.9	19.2
6/10/2019	800	111.3	0.8	0.8	2.1	0.4	2.2	19.2
6/10/2019	1000	116.2	0.8	0.8	2.3	0.5	2.0	18.9
6/10/2019	1200	129.0	0.9	0.8	2.3	0.4	2.0	19.1
6/10/2019	1400	127.8	0.8	0.7	2.3	0.4	2.0	20.3
6/10/2019	1600	105.6	0.7	0.9	2.3	0.5	2.0	20.6
6/10/2019	1800	114.3	0.8	0.8	2.3	0.5	2.0	20.8

Date	Time	Primary Channel Flow (m^3/s)	Primary Channel Velocity (m/s)	Primary Channel Bypass Ratio	Secondary Channel Flow (m^3/s)	Secondary Channel Velocity (m/s)	Secondary Channel Bypass Ratio	Water Temperature (°C)
6/10/2019	2000	105.1	0.8	0.9	2.3	0.6	1.1	21.0
6/10/2019	2200	122.0	0.9	1.9	2.3	0.6	1.9	20.4
6/10/2019	2400	115.0	0.8	0.9	2.5	0.5	1.8	20.2
AVG	**—**	**112.1**	**0.7**	**1.4**	**3.8**	**0.8**	**1.4**	**12.5**

Appendix E—Summary Table for Juvenile Chinook Salmon Fate Assignments

Table E-1.—Average (Avg.; minimum–maximum) salvage (%), non-participation (%), primary channel louver loss (%), secondary channel screen loss (%), predation loss (%), and unknown fate assignments (%) for replicates performed with acoustically tagged Chinook Salmon during 1 (average flow = 23.6 m^3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m^3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m^3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m^3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m^3/s, average velocity = 0.7 m/s) at the C.W. "Bill' Jones Pumping Plant (JPP).

	1 JPP	2 JPP	3 JPP	4 JPP	5 JPP
Avg. Salvage (Minimum–Maximum; %)	16.7 (0–50.0)	5.0 (0–10.0)	30.0 (10.0–40.0)	33.3 (10.0–50.0)	66.7 (30.0–90.0)
Avg. Non-Participation (Minimum–Maximum; %)	0 (0–0)	10.0 (0–20.0)	16.7 (0–50.0)	6.7 (0–20.0)	0 (0–0)
Avg. Primary Channel Louver Loss (Minimum–Maximum; %)	3.3 (0–10.0)	0 (0–0)	10.0 (0–20.0)	0 (0-0)	3.3 (0–10.0)
Avg. Secondary Channel Screen Loss (Minimum–Maximum; %)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Avg. Predation Loss (Minimum–Maximum; %)	47.6 (20.0–72.7)	45.0 (10.0–90.0)	33.3 (10.0–60.0)	43.3 (10.0–80.0)	26.7 (10.0–50.0)
Avg. Unknown Fate (Minimum–Maximum; %)	32.4 (20.0–50.0)	40.0 (10.0–60.0)	10.0 (0–20.0)	16.7 (10.0–30.0)	3.3 (0–10.0)

Appendix F—Summary Table for Juvenile Chinook Salmon Efficiency, Participation, Passage Time, and Predation Estimates

Table F-1.—Average (Avg.; minimum–maximum) salvage efficiency (%), participation (%), primary channel louver efficiency (%), secondary channel screen efficiency (%), passage time (h), total predation loss (%), pre-facility predation (%), predation in the primary channel (%), predation in the secondary channel (%), pre-screen loss (upstream of trashrack; %), pre-screen loss (upstream of primary channel louvers; %), and pre-screen loss (between the primary channel louvers and trashrack; %) for replicates performed with acoustically tagged Chinook Salmon during 1 (average flow = 23.6 m3/s, average velocity = 0.2 m/s), 2 (average flow = 48.1 m3/s, average velocity = 0.3 m/s), 3 (average flow = 70.4 m3/s, average velocity = 0.5 m/s), 4 (average flow = 106.7 m3/s, average velocity = 0.7 m/s), and 5 pump operation (average flow = 112.1 m3/s, average velocity = 0.7 m/s) at the C.W. "Bill' Jones Pumping Plant (JPP).

	1 JPP	2 JPP	3 JPP	4 JPP	5 JPP
Avg. Salvage Efficiency (Minimum–Maximum; %)	Low = 16.7 (0–50.0) High = 20.8 (0–62.5)	Low = 5.9 (0–12.5) High = 17.5 (0–50.0)	Low = 33.3 (20.0–40.0) High = 39.2 (33.0–44.4)	Low = 36.7 (10.9–50.0) High = 48.9 (11.0–80.0)	Low = 66.7 (30.0–90.0) High = 67.8 (33.3–90.0)
Avg. Participation (Minimum–Maximum; %)	35.5 (0–70.0)	7.5 (0–10.0)	56.7 (20.0–80.0)	76.7 (50.0–90.0)	90.0 (70.0–100)
Avg. Primary Channel Louver Efficiency (Minimum–Maximum; %)	83.3 (83.3–83.3)	100 (100–100)	72.2 (50.0–100)	100 (100–100)	91.7 (75.0–100)
Avg. Secondary Channel Screen Efficiency (Minimum–Maximum; %)	100 (100–100)	100 (100–100)	100 (100–100)	100 (100–100)	100 (100–100)
Avg. Passage Time (Minimum–Maximum; h)	49.5 (21.3–89.7)	5.6 (1.0–10.1)	6.9 (0.1–11.4)	4.9 (0.6–9.3)	0.4 (0.1–1.9)
Avg. Total Predation Loss (Minimum–Maximum; %)	Low = 47.6 (20.0–72.7) High = 80.0 (40.0–100)	Low = 45.0 (10.0–90.0) High = 85.0 (70.0–100)	Low = 33.3 (10.0–60.0) High = 43.3 (30.0–60.0)	Low = 43.3 (10.0–80.0) High = 60.0 (40.0–90.0)	Low = 26.7 (10.0–50.0) High = 30.0 (10.0–60.0)
Avg. Pre-Facility Predation (Minimum–Maximum; %)	Low = 32.1 (10.0–50.0) High = 64.5 (30.0–100)	Low = 42.5 (10.0–90.0) High = 82.5 (70.0–100)	Low = 16.7 (10.0–30.0) High = 26.7 (20.0–30.0)	Low = 3.3 (0–10.0) High = 16.7 (10.0–30.0)	Low = 10.0 (0–30.0) High = 10.0 (0–30.0)

	1 JPP	2 JPP	3 JPP	4 JPP	5 JPP
Avg. Predation in Primary Channel (Minimum–Maximum; %)	Low = 57.2 (14.3–100) High = 57.2 (14.3–100)	Low = 33.3 (0–100) High = 33.3 (0–100)	Low = 19.1 (0–28.6) High = 19.1 (0–28.6)	Low = 47.4 (20.0–77.8) High = 51.1 (20.0–88.9)	Low = 19.5 (10.0–28.6) High = 24.3 (10.0–42.9)
Avg. Predation in Secondary Channel (Minimum–Maximum; %)	0 (0–0)	0 (0–0)	6.7 (0–20.0)	0 (0–0)	0 (0–0)
Avg. Pre-Screen Loss—Upstream of Trashrack***** (Minimum–Maximum; %)	Low = 32.1 (10.0–50.0) High = 64.5 (30.0–100)	Low = 42.5 (10.0–90.0) High = 82.5 (70.0–100)	Low = 16.7 (10.0–30.0) High = 26.7 (20.0–30.0)	Low = 3.3 (0–10.0) High = 16.7 (10.0–30.0)	Low = 10.0 (0–30.0) High = 10.0 (0–30.0)
Avg. Pre-Screen Loss—Upstream of Primary Channel Louvers****** (Minimum–Maximum; %)	Low = 47.6 (20.0–72.7) High = 80.0 (40.0–100)	Low = 45.0 (10.0–90.0) High = 85.0 (70.0–100)	Low = 30.0 (10.0–50.0) High = 40.0 (30.0–50.0)	Low = 43.3 (10.0–80.0) High = 60.0 (40.0–90.0)	Low = 26.7 (10.0–50.0) High = 30.0 (10.0–60.0)
Avg. Pre-Screen Loss—Between Primary Channel Louvers and Trashrack******* (Minimum–Maximum; %)	Low = 57.2 (14.3–100) High = 57.2 (14.3–100)	Low = 33.3 (0–100) High = 33.3 (0–100)	Low = 19.1 (0–28.6) High = 19.1 (0–28.6)	Low = 47.4 (20.0–77.8) High = 51.1 (20.0–88.9)	Low = 19.5 (10.0–28.6) High = 24.3 (10.0–42.9)

*** Jahn (2011), Karp et al. (2017)**

**** Anonymous (2013)**

***** CDFW (2013), Reyes et al. (2018)**