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2010 Spring Chinook Escapement to the Upper Basin of the Klickitat River Based on DIDSON Sonar Counts

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January 5, 2011

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EXECUTIVE SUMMARY

A Dual-Frequency Identification Sonar (DIDSON) sonar was deployed to observe fish passage through the Castile Falls Fishway on the Klickitat River, and to obtain an estimate of 2010 spring Chinook *Oncorhynchus tshawytscha* escapement to the upper basin. The DIDSON continuously recorded sequential 1-hour files from mid May until September 2010, except for occasional interruptions due to technical problems. "Echograms" were processed from the original DIDSON video files, and upstream passage events observed in the echograms of large fish deemed to be spring Chinook were noted. The resulting data were analyzed to account for a period when DIDSON files were unavailable, producing an estimate for total spring Chinook escapement to the upper basin of 26 to 27 fish (95% confidence interval). This estimate bears witness to a substantial level of escapement of spring Chinook which was not detected through spawning surveys conducted in 2010, during which only a single redd was counted. Based on a 3 fish per redd expansion factor, the expected redd count for the DIDSON-based escapement estimate would have been approximately 9 redds.

INTRODUCTION

The Yakama Nation (YN) is actively involved in efforts to rebuild the spring Chinook *Oncorhynchus tshawytscha* population in the Klickitat River (YN 2008, and see www.ykfp.org/klickitat/). These efforts have included projects to renovate the Castile Falls Fishway Complex to facilitate repopulation of the upper basin. Castile Falls (rkm 103) is a series of 11 natural falls with a total vertical drop of 33 m over 1.0 km, located in the Klickitat River Gorge immediately upstream of the confluence with the West Fork of the Klickitat River – all within the boundaries of the YN reservation. Upstream of Castile Falls, the Klickitat and its tributary streams comprise 72 rkm, much of which would make for prime spawning and juvenile rearing habitat for spring Chinook (YN 2008). Castile Falls, however, created a near-total barrier to upstream migration of spring Chinook (and steelhead) into the upper basin of the Klickitat River (Figure 1).

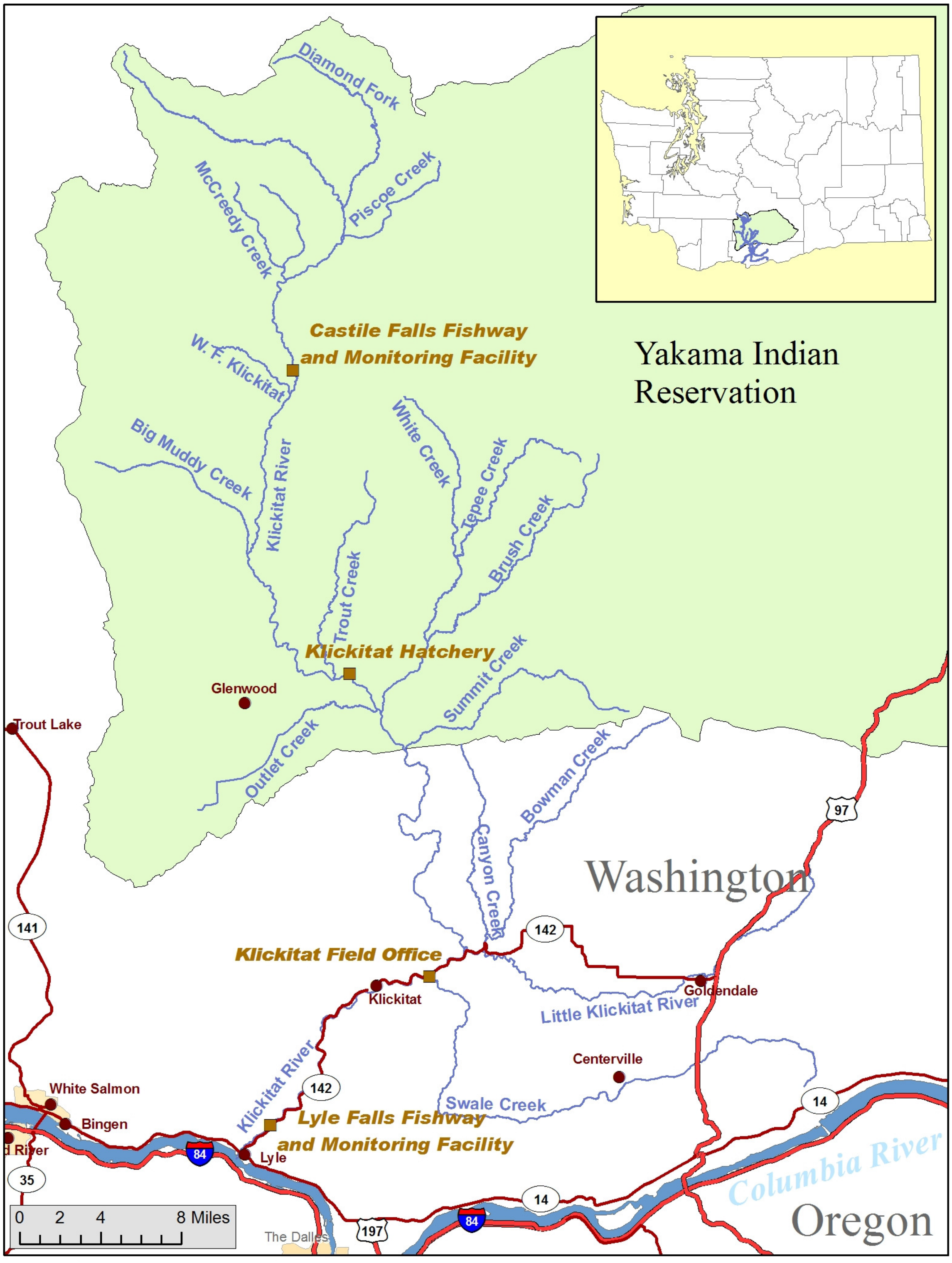

Figure 1. Location of Yakama Nation facilities for the Klickitat River Anadromous Fisheries Project (Figure 1-2, YN 2008).

In the early 1950s, the Washington Department of Fish and Wildlife (WDFW) signed a Memorandum of Agreement with the Yakama Nation (YN), the Bureau of Indian Affairs, and the US Fish and Wildlife Service to use Mitchell Act funds to finance a construction project to improve access for anadromous fish (spring Chinook and steelhead) to the upper Klickitat basin (YN 2008). Construycted between 1960 and 1962, the Fishway Complex consists of two tunnels - one 61 m in length which by-passes Falls #4 and #5, and a second 260 m in length which by-passes Falls #10 and #11 (the uppermost barrier). At the upstream end of the second Fishway, a 3-4 m high concrete dam was constructed to divert flow into the tunnel (Figure 2A and 2B). Additionally, blasting of Falls #1, #8 and #9 was performed to facilitate fish passage. The smaller Falls #2, #3 and #6 were not modified as they were not considered to be barriers. Unfortunately, the design of the Fishway tunnels did not sufficiently preclude entry of rock and debris which is mobilized by the heavy flows that the river experiences each spring, and maintenance of the tunnels was inadequate. As a result, the tunnels became completely blocked within a few years of operation; and with the upstream dam creating an additional blockage for migration via the natural river channel, the upper basin became virtually inaccessible to spring Chinook (YN 2008).

YN projects to renovate the Fishway Complex began in 2002. Flow into the two tunnels was blocked, and the accumulated debris removed. The concrete stair-step fish ladder structure within each was demolished and replaced with a vertical slot design that would accumulate debris less readily, maintain suitable entrance velocities and depth, as well as head differences between pools and maximum velocities at the weir slots. Trash racks were modified and a fore bay sluice gate installed in both tunnels to better preclude entry of debris into the tunnels, and to facilitate its removal. In summer of 2005, renovation was complete and water flow reestablished through the Fishway. Later that same year, spring Chinook redds were observed during walking surveys of the river in the upper basin.

For many years, the Washington Department of Fish and Wildlife operated a segregated spring Chinook program at the Klickitat Hatchery (rkm 68; Figure 1). Returns of fish from this program to the lower basin supported sport and tribal harvest, but the naturally spawning population has remained depressed. In December 2005, management of the hatchery was transferred to the YN, and operations are transitioning from a segregated to an integrated program, with the additional objective to supplement and rebuild the natural population (YN 2008). At present, the juvenile acclimation and release locations for the supplementation program will remain at locations in the river below Castile Falls. The YN decided to wait for up to a nine year period to see if spring Chinook would naturally (re)colonize the newly accessible upper basin and build up an abundant naturally-spawning population, similar to their decision regarding steelhead (YN 2008). If monitoring data indicates that fish are not finding and populating the new habitat, the YN will proceed with adult and/or juvenile out-planting. Accurate measures of annual escapement during this interim period will be essential to informing this management decision.

Figure 2. A) Dam and upstream outlet of Castile Falls upper Fishway at high water (May 2010). B) At low water (August 2009). C) Fishway outlet showing weirs, job site storage boxes and installation of DIDSON. D) DIDSON on stand. E) DIDSON deployed. F) Field computer and external hard drive.

Since reopening the Fishway, spawning escapement of spring Chinook to the upper basin has been estimated indirectly by expansion of an annual redd count. The YN performs three successive redd surveys during the spawning season each year (mid-August through late-September), spaced approximately 14 days apart. The surveys are presumed to cover essentially the totality of the known spawning area within the basin above Castile Falls. The total number of redds observed during these surveys is then multiplied by the expansion factor of 3 fish per redd (Zendt and Bosch 2009) to obtain an estimate of total escapement. While the method of estimating spawning abundance by expansion of annual redd counts is recognized to have substantial uncertainty (e.g., Mosey and Truscott 1999, Murdoch and Miller 1999, Dunham et al. 2001, Faurot and Kucera 2005, Gallagher et al. 2007), it has been the only method feasible for use in the upper basin. However, that fish migrating to the upper basin must pass through the Fishway presents an opportunity to make direct counts. The recently completed Klickitat River Anadromous Fisheries Master Plan (YN 2008) includes a proposal to construct a fish monitoring facility within the upstream Fishway, that will include an optical video fish counting system, as well as radio and PIT tag antennae and recording instruments, and satellite data transmission equipment. Construction of this facility began in the summer of 2010, with hopes of having the system operational for the 2011 migration season. While awaiting completion of the monitoring facility, we proposed use of an alternative technology for direct counting of fish passing through the Fishway - a Dual-Frequency Identification Sonar (DIDSON™; Sound Metrics Corporation, Seattle, Washington, www.soundmetrics.com).

A DIDSON is a multi-beam underwater acoustic video camera. It repetitively emits sets of sound beams and uses its unique patented lens to resolve the reflections of objects passing within its field of view into two-dimensional images. The standard model of the DIDSON emits an array of 96 beams at high frequency (HF; 1.8 MHz), or 48 beams at low frequency (LF; 1.1 MHz). The DIDSON has a functional range of 10-12 m when operated at HF, and a range of 24+ m when operated at LF - though with reduced resolution of the images relative to those obtained using the HF transducer. Placed in a body of water and oriented to transmit horizontally through the water column, it produces a top-down ("bird's-eye") view of the conically-shaped ensonified field. Unlike optical cameras, the camera is able to "see" objects irrespective of light intensity, and in water with up to moderate levels of turbidity. Additionally, field testing for fisheries applications, including salmon escapement estimation in rivers, has shown that the DIDSON has some significant advantages relative to other sonar systems (Moursund et al. 2003, Johnson et al. 2004, Maxwell and Gove 2004, Faurot and Kucera 2005, Galbreath and Barber 2005, Xie et al. 2005, Kucera and Orme 2006, Burwen et al. 2007, Maxwell 2007, Faulkner and Maxwell 2008, Melegari and Osborne 2008).

In 2009, we deployed a DIDSON at the upstream outlet of the Castile Falls upper Fishway, and operated the sonar over the summer. Recordings were reviewed, and an estimate of spring Chinook escapement was calculated based on the counts of fish passage events (Galbreath et al. 2010). In 2010, we again operated the DIDSON, following a design that was slightly modified from that used in 2009. We report here results of the 2010 study.

METHODS

In May 2010, preparations were made to deploy a standard model DIDSON at the upstream outlet of the Castile Falls Fishway. The outlet canal of the Fishway consists of six 3.2 m long openings. Each opening is faced with a heavy metal trash rack. The 15 cm spacing between the vertical bars of the trash rack grates permits exit of upstream migrating salmon and steelhead from within the Fishway to the upper basin of the Klickitat River, but blocks entry of most large woody debris. To the outside face of five of the six trash rack openings (the upper two and the lower three) we attached sections of picket weir fencing, so as to restrict passage of fish out of the Fishway to the single unobstructed opening (Figure 2C). Each section of weir fencing consisted of a 3.1 m x 0.8 m aluminum frame, with holes drilled along the lengths at 7 cm intervals, through which the pickets were passed. The pickets consisted of lengths (1.8 m for the downstream frames, and 1.2 m for the upstream frames) of 1.6 cm diameter aluminum conduit. This set-up contrasts slightly from that used in 2009, when we left two openings unobstructed. By limiting exit of the fish from the Fishway to a single opening in 2010, we were able to diminish the needed operating range of the DIDSON, providing somewhat improved resolution of the resulting images.

On May 14, the DIDSON was placed within a silt exclusion box (not pictured) and attached to an H-frame stand (Figure 2D). Use of the silt exclusion box was a recommendation made in the report of the previous year's study (Galbreath et al 2010). The box was later removed - on July 27 – after water flow and turbidity had diminished considerably (Figure 3). The DIDSON was placed in the water immediately outside of the Fishway, 5.5 m upstream of the unblocked section. Sandbags were placed on the legs of the stand to stabilize the sonar against the force of the flowing water. The DIDSON was oriented in a downstream direction parallel to the Fishway, and was readjusted over the course of the study to keep the lens at a depth of 20 to 40 cm below the water surface (Figure 2E).

A 1900 l propane tank, transported to the site in 2009, was refilled and used to fuel a Global Thermoelectric (Calgary, Alberta, Canada) Model 5120™ thermoelectric generator (TEG), which produces a continuous 24 volts DC current of approximately 108 watts. The DIDSON was powered directly from the TEG, whereas power to the field computer was first passed through a 24 to 12 v DC transformer. Two heavy duty job site storage boxes were installed on top of the Fishway outlet – one to house the electronic equipment - field computer, external hard drive, transformer, etc. – and the other for storage of tools and miscellaneous equipment (Figure 2F).

The DIDSON was programmed with a 4.6 m Start Length and a 5 m Window Length (Sound Metrics Corporation 2009), such that the entire water column outside the unblocked section, through which upstream migrating salmon were obliged to pass, was within the field of view of the sonar (Figure 2C). The DIDSON was programmed to record sequential 1-hour files, at high frequency (1.8 MHz) and 11 frames per second, on a continual basis from May 14 to September 01, 2010. While the previous year's results indicated that spring Chinook did not migrate through the Fishway until mid-July, we began recording earlier to see if we could detect passage of steelhead, which we suspect migrate through the Fishway primarily in the months of

May and June. The 2009 data also indicated that spring Chinook migration ended by mid to late August, and redd surveys in previous years indicate spawning activity has begun already before the end of August, so we ceased DIDSON operation the first of September. The site was visited weekly to confirm proper operation of the sonar, to remove the 500 GB external portable hard drive to which the previous week's files had been stored, and to replace the hard drive with a new one. The recorded files were later copied to a pair of larger (2 GB) office-based hard drives – one drive used for processing and file reading, and the other as a back-up.

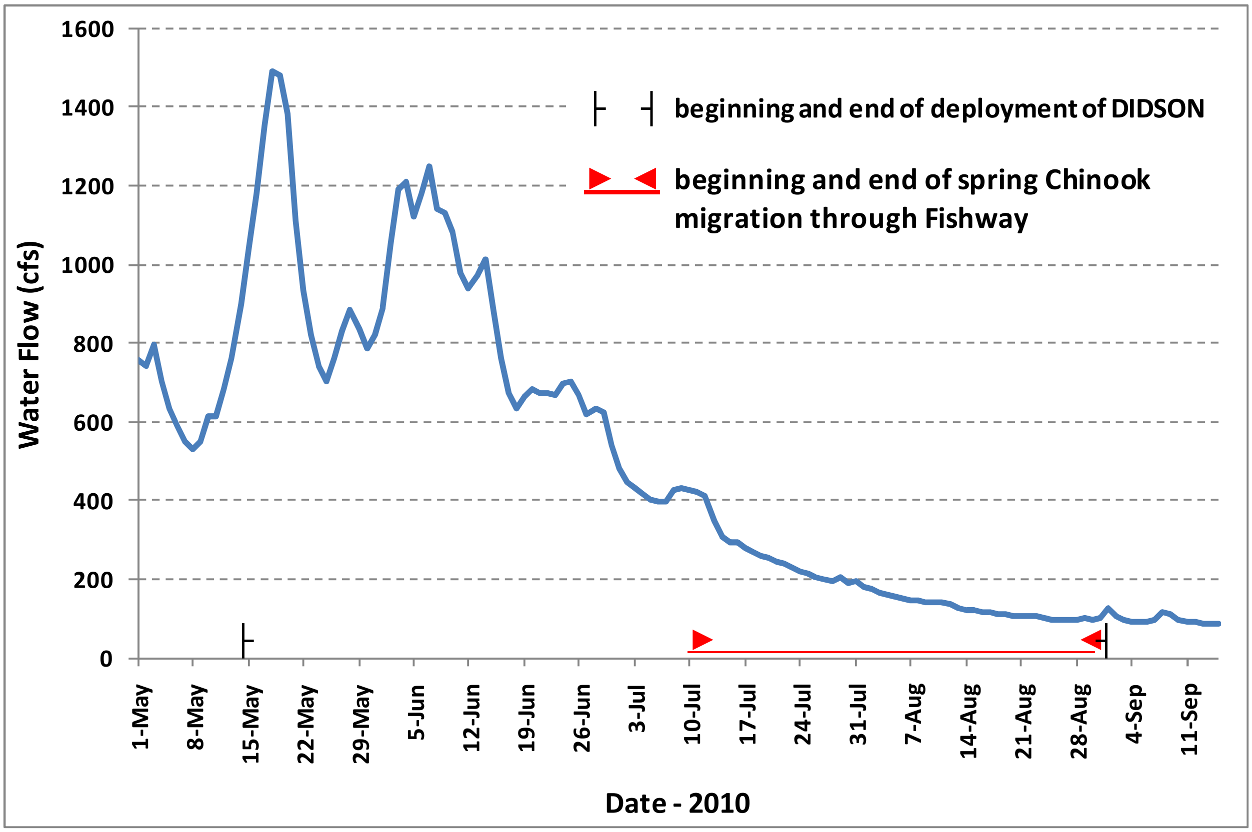

Figure 3. Water flow (cfs) recorded at the USGS stream flow gauge number 14107000 (Klickitat River above West Fork near Glenwood, WA), located 1 km upstream of the Castile Falls Fishway Complex (rkm 103). (http://waterdata.usgs.gov/nwis/dv?cb_00060=on&cb_00065=on&format=html&begin_date=2010-05-01&end_date=2010-09-15&site_no=14107000&referred_module=sw)

Processing and reading of the DIDSON video files began in August and finished in December 2010. Initially, an echogram was created for each DIDSON file. Processing parameters for the echograms included: Minimum Track Size = 12, Minimum cluster Area = 200 cm^2, and Maximum Cluster Area = 10,000 cm^2. Minimum Threshold parameter was set at 3.5, 3.9 or 4.2 dB, in accordance with the amount of background "noise" created by turbulence (entrained air bubbles) in the water at the time the file was recorded (Sound Metrics Corporation 2009).

The echograms were reviewed by a single reader (Barber). When "tracks" in the echograms occurred (indicative of possible fish passage events), a rectangle around the track was drawn to

create a “tape loop” of the raw video. When the image in the video loop appeared to represent passage of a fish of medium to large size (suspected to be a salmon - as opposed to movement of a smaller sized fish, of floating debris, or of a cloud of air bubbles, etc.), a note was made of the frame number and time, and of the relative size and direction of movement of the fish. After, all files were read, each noted passage event was re-reviewed in the presence of two additional readers (Frederiksen and Galbreath). Together, the readers reached a consensus as to which images were indeed those of upstream migrating spring Chinook, and the hour and date of the confirmed counts were recorded in a spreadsheet (Appendix).

The data set was then analyzed to assess temporal trends – both within days (diurnal) and across dates – then an estimate was derived of the number of upstream passage events that had occurred for a period during the migration when DIDSON files were missing. The total number of observed salmon was expanded by this estimated number of unobserved fish, to obtain an estimate of total spring Chinook escapement for the year. This estimate was then compared to that based on an expansion of the total redd count recorded for 2010.

RESULTS

Escapement Estimation

A total of 24 salmon passage events were observed, the first on July 10 and the last on August 31 (Figure 3, Appendix). Similar to observations made in 2009, the fish passage events were relatively evenly distributed across the migration period, providing no evidence for a trend in returns across days. In contrast to the previous year’s data, however, there was a diurnal pattern to fish passage in the 2010 data, e.g., 14 of the 24 observations (58%) occurred in the 4 hour period between 2 PM and 7 PM (of which 6 were made between 5 and 6 PM).

The sonar ceased operation for approximately 4 days (104 hours) between July 30 and August 3 during the middle of the migration through the Fishway (Appendix). It was therefore necessary to estimate the number of fish that may have passed unobserved during this period. Without evidence for a daily trend to returns across the migration period, we modeled migration as a Poisson process with a common average daily count. To estimate this value (μ_d), we used information only from days for which a full set of 24 files were available. The likelihood for μ_d is given by: $P(X|\mu_d) = \Pi_i \, \mu_d^{x_i} e^{-\mu d} (x_i!)^{-1}$. We minimized the negative log-likelihood of the Poisson distribution to obtain the maximum likelihood estimate of the daily return rate μ_d, which was estimated to be 0.5, as illustrated in Figure 4.

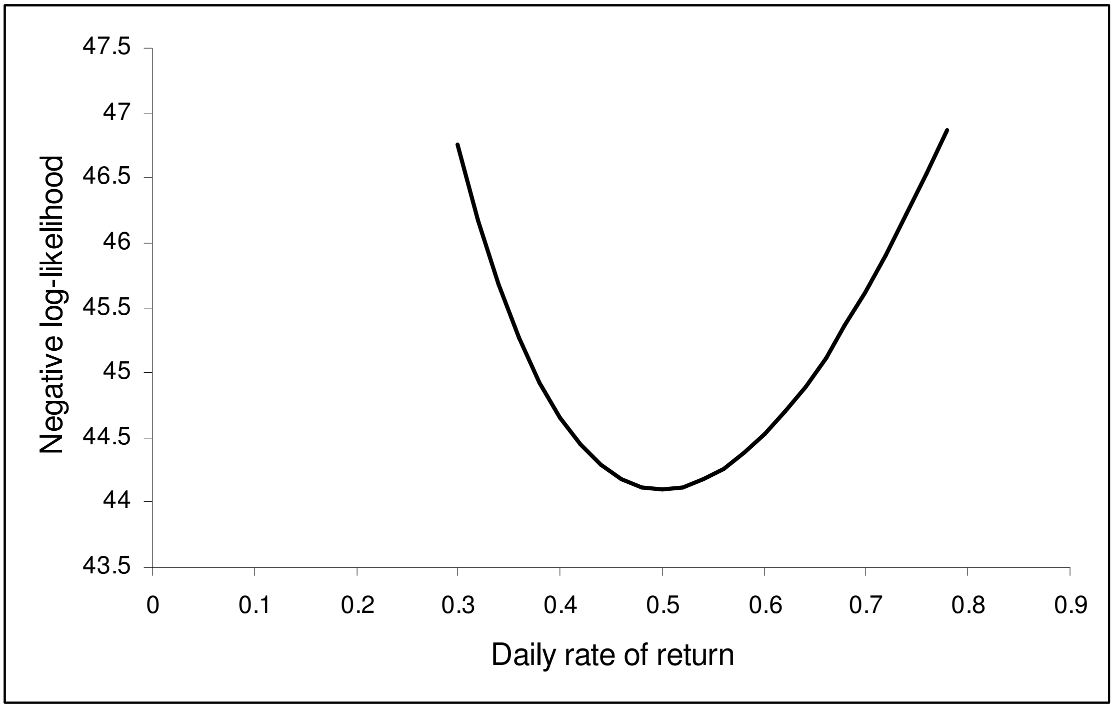

Figure 4: Profile of the maximum likelihood estimation of mean daily return rate.

To account for the observed diurnal trend in returns, a model with a Gaussian distribution $N(\mu_h,\sigma_h)$ was used, where μ_h is the mean run hour and σ_h is the standard deviation in hours. To better parameterize the diurnal run timing, we combined the hourly counts from 2009 with those from 2010, and treated these data as a sample from the hourly run timing distribution. We assumed a single mode across a 24 hour continuous distribution and estimated the mean run hour (μ_h) and the standard deviation (σ_h). The fit of the hourly run timing data is shown in Figure 5. We then used the cumulative distribution $F(h_j) = \Pr(h<=h_j)$ to estimate what portion of the daily run would be predicted over a period (h_i, h_j) using the formula:

$$X_{d,est} = \mu_d\ (\ F(h_j)\text{-}F(h_i)\ ) \qquad (1)$$

where d is a day with at least one unobserved hour. The estimated total unobserved number of fish for the season is the sum of the $X_{d,est}$'s for all days without full observation coverage. For example, if the sonar was not in operation between 8 am and 4 pm, the cumulative area under the curve in Figure 5 would be the portion of μ_d fish estimated to have been unobserved. Therefore our estimate of the total number of unobserved fish is the sum of all daily products using Equation (1).

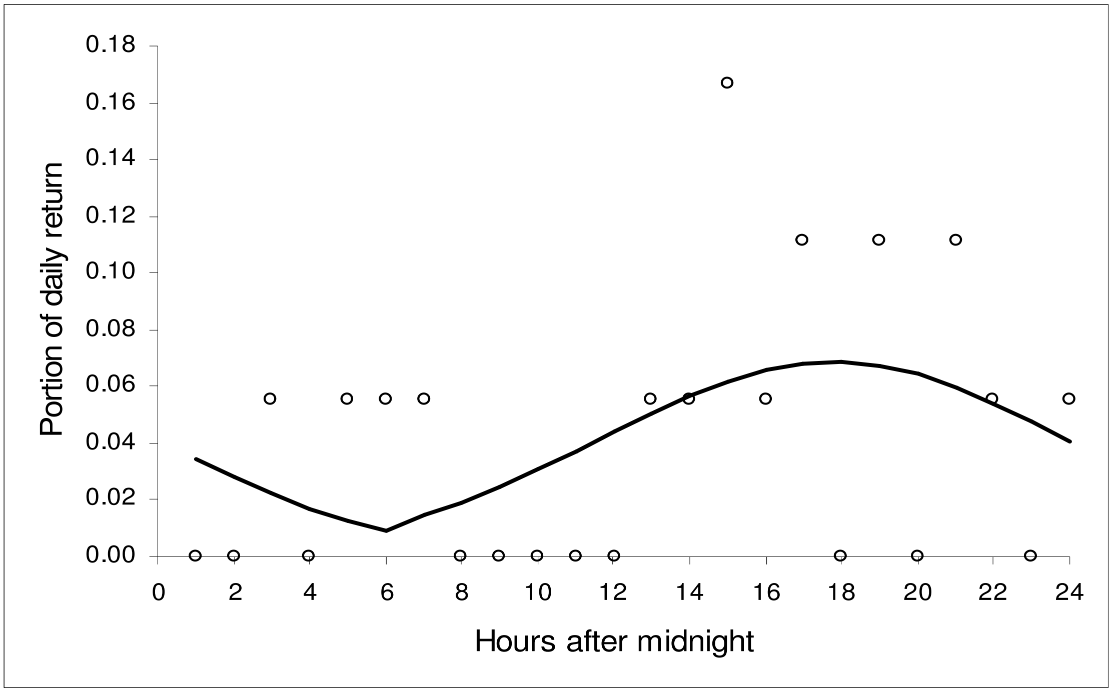

Figure 5. Statistical fit of the hourly run timing of fish passing the fishway. Open points are the normalized combined counts at mid-point of each hour of the day after midnight. Line is the fit of the Gaussian distribution.

We estimate that the sum of all $X_{d,est}$ is 2.35, meaning that we estimate at least 2 fish were unaccounted for during the period July 30 to Aug 3 period when the sonar was inoperative. For comparison, we also estimated the unaccounted fish assuming no trend in hourly run timing (i.e., uniform probabilities across all hours, as in the 2009 analysis), and obtained 2.33 fish - which is intuitive if you consider that the missing data were not heavily weighted to any particular hour. The 95% confidence interval for $X_{d,est}$ is (0.44,0.74). Therefore, we estimate a 95% confidence interval of between 2 and 3.5 fish unobserved (values rounded to the nearest whole number), which added to the direct count of 24 yields an estimate for the 2010 escapement between 26 and 27 fish.

DIDSON Operation

Silt Exclusion Box - Flow in the Klickitat River (Figure 3) peaks in late spring, and is accompanied by high suspended sediment levels. During the 2009 study there was a progressive accumulation of silt within the sonar lens, and a progressive degradation in resolution of the recordings – to the point that files in early June 2009 were unreadable. In 2010, therefore, we initially deployed the DIDSON within a silt exclusion box, which successfully kept the sonar lens unobstructed. The exclusion box was later removed (July 27, 2010), after flow and turbidity levels had dramatically decreased.

Power Source - The TEG operated extremely well – providing a quiet reliable power source, in significant contrast to the 1000 W propane-converted internal combustion generator we used in 2009 (see Galbreath et al. 2010). Propane consumption of the TEG was approximately 2.5 gallons per day.

Recording Interruptions - Over the study period, the DIDSON unexpectedly ceased recording on five occasions, resulting in multi-day gaps within the data set each time. The first three stoppages occurred in the months of May and June. Two, and possibly all three, of these stoppages were the result of the power line from the TEG having been accidentally cut or disconnected during construction activities on the Fishway. Fortunately, these stoppages occurred prior to the beginning of the spring Chinook migration through the Fishway, and thus did not affect the escapement estimate. Electronic or software "glitches" of unknown nature were apparently the cause(s) of other stoppages. The fourth stoppage occurred at the end of July, resulting in loss of four days worth of files during the period when spring Chinook were actively migrating up through the Fishway. The last stoppage occurred on September 1. Data from the previous year indicated that migration had likely ceased by the end of August, so on September 3, when the problem was observed, the DIDSON and associated equipment were removed and packed up.

DISCUSSION

The estimate derived from the DIDSON recordings for the 2010 escapement of spring Chinook to the upper basin of the Klickitat River was 26-27 fish – similar to the estimate of 24 ± 4 fish for the 2009 escapement. We feel the 2010 estimate to be conservative. Counts were noted only for images of obviously large fish, leaving the possibility that smaller jack-size adult fish may have gone uncounted. It is also possible that we did not observe a few additional late arriving fish. On September 3, we discovered that the DIDSON had ceased operation on September 1. As the last count made in the 2009 study was on August 22, which is also the approximate the time spawning surveys from 2009 and prior years indicate that reproduction of spring Chinook had already begun, we presumed there was no need to restart the sonar for additional recordings in September. To our surprise, however, four fish were observed in the last 3 days' files (August 29-31). We therefore do not know whether additional fish migrated through Castile Falls in September 2010. However, if there were, it is also possible that they arrived too late to participate in spawning with the main population.

A further reason to consider our escapement estimate as conservative is that we were told that on a day in August, one of the construction workers working on renovation of the upper Fishway, observed two fish successfully jumping upstream over the dam. This apparently occurred at the small notch (approx. 1m long and 10-15 cm deep) in the upper edge of the dam located towards the opposite shore from the Fishway (Figure 2B), and shortly after YN personnel had cleared some woody debris previously lodged there. While we have no reason to doubt the veracity of this observation, we do believe it to represent a very rare event. Two

to three workers were present at the Fishway all through the summer, and no other incidents of this nature were related to us; not even of fish attempting to jump the dam.

The 2010 spring Chinook escapement estimate of 26 to 27 was obviously greater than that based on redd counts. Only a single redd was observed during the 2010 YN spawning surveys in the upper basin (1 redd x 3 fish-per-redd = 3 fish). Dividing our DIDSON-based escapement estimate by the 3 fish-per-redd expansion factor, yields an expected redd count of 9. It seems unlikely that pre-spawn mortality could account for more than a small portion of the discrepancy between estimates. The adults arrive within a few weeks prior to the spawning period, leaving little time for disease and/or predation to dramatically diminish their number. Despite tribal regulations which prohibit harvest of spring Chinook above Castile Falls, poaching has occurred in past years. However, no evidence of illegal fishing was observed in 2010, and although poaching cannot be ruled out entirely as a source of pre-spawn mortality, if it occurred it was likely very limited. Instead, the discrepancy appears more likely to an underestimate of the redd count. It is possible some redds were unobserved (e.g., redds created beneath woody debris or cut banks, or redds which had "faded" due to time periods between surveys that extended to greater than 14 days for some sections. It is also possible that spawning is occurring in locations outside the known surveyed spawning areas (e.g., far upper reaches of the Klickitat River).

We began operation of the DIDSON on May 14, with the thought that early on we might record counts of fish migration into the upper basin that could be attributable to steelhead. Turbulence and turbidity were high during this period, which reduced the resolution of the recordings. Also, there were three multi-day stoppages of the sonar between then and July 1. Nonetheless, we read approximately 25 days worth of recorded files, and observed no fish passage events. If steelhead were migrating into the upper basin during this mid-May to July 1 period, they were likely very few in number.

Construction activities began in 2010 to install new monitoring equipment in the upper Castile Falls Fishway, with completion anticipated in spring 2011. This will include a video camera and recording system which will be used to count fish passage events in a manner similar to that used for escapement estimation with the DIDSON. If, however, there is a delay in operability of this equipment, the DIDSON will be redeployed to assist in obtaining a 2011 escapement estimate.

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Appendix – Hourly counts of upstream spring Chinook passage through the Castile Falls Fishway as observed in 2010 DIDSON recordings. (“na” - file was unavailable or unreadable)

	May																	
Hour	14	15	16	17	18	19	2	21	22	23	24	25	26	27	28	29	30	31
0	na								na	na	na	na	na					
1	na								na	na	na	na	na					
2	na								na	na	na	na	na					
3	na								na	na	na	na	na					
4	na								na	na	na	na	na					
5	na								na	na	na	na	na					
6	na								na	na	na	na	na					
7	na					na			na	na	na	na	na					
8	na					na			na	na	na	na	na					
9	na								na	na	na	na	na					
1	na				na				na	na	na	na	na					
11	na								na	na	na	na	na					na
12	na						na	na	na	na	na	na	na					
13	na							na	na	na	na	na						
14	na							na	na	na	na	na						
15	na					na		na	na	na	na	na						
16								na	na	na	na	na						
17				na	na			na	na	na	na	na						
18				na				na	na	na	na	na						
19								na	na	na	na	na						
2						na		na	na	na	na	na						
21								na	na	na	na	na						
22								na	na	na	na	na						
23								na	na	na	na	na						
Day Σ																		

	June																													
Hour	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	16	17	18	19	2	21	22	23	24	25	26	27	28	29	30
0		na	na	na	na	na	na	na															na	na	na	na	na	na	na	
1	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
2	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
3	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
4	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
5	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
6	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
7	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
8	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
9	na	na	na	na	na	na	na	na															na	na	na	na	na	na	na	
1	na	na	na	na	na	na	na	na															na	na	na	na	na	na		
11	na	na	na	na	na	na	na	na															na	na	na	na	na	na		
12	na	na	na	na	na	na	na																na	na	na	na	na	na		
13	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
14	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
15	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
16	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
17	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
18	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
19	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
2	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
21	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
22	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
23	na	na	na	na	na	na	na															na	na	na	na	na	na	na		
Day Σ																														

	July								
Hour	1	2	3	4	5	6	7	8	9
0									
1									
2									
3									
4									
5									
6									
7									
8									
9									
1									
11									
12									
13									
14									
15									
16									
17									
18									
19									
2									
21									
22									
23									
Day Σ									

Hour	July																						August																															Sept.	Hour
	1	11	12	13	14	15	16	17	18	19	2	21	22	23	24	25	26	27	28	29	3	31	1	2	3	4	5	6	7	8	9	1	11	12	13	14	15	16	17	18	19	2	21	22	23	24	25	26	27	28	29	3	31	1	Σ
0																						na	na	na	na																														
1																						na	na	na	na																														
2								1														na	na	na	na														1																		2
3																						na	na	na	na																														
4																						na	na	na	na																		1														1
5																						na	na	na	na																														
6	1																					na	na	na	na																													na	1
7																						na	na	na	na																													na	
8				1																		na	na	na	na																													na	1
9																						na	na	na	na																													na	
1																						na	na	na	na														1				1													na	2
11																						na	na	na																														na	
12																						na	na	na																														na	
13		1																			na	na	na	na																														na	1
14																					na	na	na	na																														na	
15																				1	na	na	na	na																														na	1
16										1			1								na	na	na	na			1									1																		na	4
17												1									na	na	na	na				1			2									1											1			na	6
18		1																			na	na	na	na																														na	1
19																					na	na	na	na																												1	2	na	3
2																					na	na	na	na																														na	
21																					na	na	na	na																														na	
22																					na	na	na	na																														na	
23																1					na	na	na	na																														na	1
Day Σ	1	2		1				1		1		1	1			1				1							1	1			2					1	2			1	2										1	1	2		24