Lewis River Bull Trout (*Salvelinus confluentus*)
Annual Operations Report

Cougar Creek - 2016

North Fork Lewis River – 2016

Merwin	*FERC No. 935*
Yale	*FERC No. 2071*
Swift No. 1	*FERC No. 2111*
Swift No. 2	*FERC No. 2213*

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April 2017

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1.0 INTRODUCTION

PacifiCorp and the Public Utility District No. 1 of Cowlitz County, Washington (Cowlitz PUD) (collectively the Utilities) are involved in various bull trout (*Salvelinus confluentus*) and salmonid monitoring programs on the North Fork Lewis River in southwest Washington. These monitoring programs and this report are designed to meet requirements pursuant to Article 402 in the Utilities' Federal Energy Regulatory Commission (FERC) operating licenses for the Merwin, Yale, Swift No. 1 and Swift No. 2 hydroelectric projects as well as requirements pursuant to sections 4.9, 9.6 and 14.2.6 of the Lewis River Settlement Agreement (SA). This Report and listed monitoring programs also serve to meet requirements contained in the 2006 Biological Opinion issued to PacifiCorp and Cowlitz PUD by the U.S. Fish and Wildlife Service (USFWS).

All activities are developed in consultation with the USFWS. This Report provides results from programs that are either ongoing or have been completed in 2016. For methods and general descriptions of all programs please refer to the Bull Trout Annual Operating Plan for the North Fork Lewis River 2016 that was submitted to the USFWS, members of the Lewis River Aquatic Coordination Committee (ACC) and FERC within the ACC/TCC Annual Report in April 2016.

2.0 STUDY AREA

Bull trout monitoring activities are performed on the North Fork Lewis River and its tributaries upstream of Merwin Dam commencing at river mile (RM) 19.5 and ending at Lower Falls, a complete anadromous and resident fish barrier at RM 72.5. The North Fork Lewis River above Merwin Dam is influenced by three reservoirs created by the hydroelectric facilities; 4,000 acre Merwin Reservoir, 3,800 acre Yale Reservoir, and the largest and furthest upstream 4,600 acre Swift Reservoir. From Lower Falls downstream, the North Fork Lewis is free-flowing for approximately 12 miles until the river reaches the head of Swift Reservoir at RM 60. A map of the study area for all programs is shown in Figure 2.0-1.

Bull trout are found in all three reservoirs as well as the Swift No. 2 Power Canal, with the bulk of the population residing in Swift Reservoir. Only three known bull trout spawning streams are found in the study area; Rush and Pine Creeks, tributaries to the North Fork Lewis River upstream of Swift Reservoir, and Cougar Creek a tributary to Yale Reservoir. Recent genetic analysis performed in 2011 identified three distinct local populations residing within the basin; Rush, Pine, and Cougar Creek bull trout (Dehaan and Adams 2011).

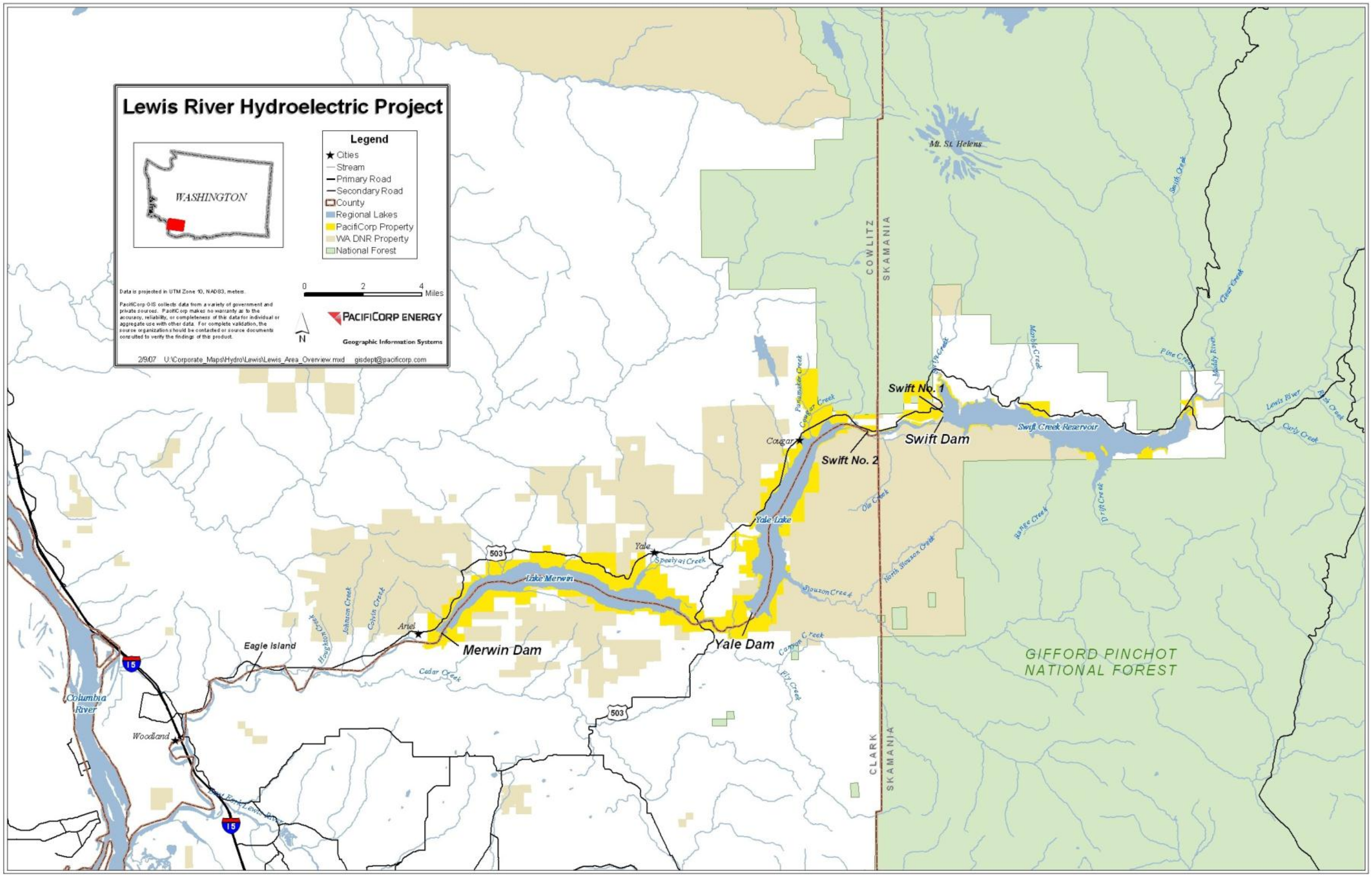

Figure 2.0-1. Map of North Fork Lewis River study area.

3.0 METHODS AND RESULTS

During 2016 the Utilities participated in, funded, or initiated eight monitoring programs.

1. Swift Reservoir adult migration, Survival (S), and Genetic Estimation of Breeder Population (Nb) estimates
2. Fin ray ageing of Eagle Cliff and Swift Bypass Reach handled bull trout
3. Half-duplex Passive Integrated Transponder (PIT) tag antenna arrays in Cougar, Pine, P8, Drift, and Rush Creeks
4. Yale tailrace collection and transport
5. Swift bypass reach collection and transport
6. Bull trout redd surveys of Cougar Creek
7. Bull trout redd surveys of Pine and Rush Creeks and Pine Creek tributary P8
8. Bull trout Condition Factor (k) assessment

3.1 FERC PROJECT LICENSE ARTICLE 402(B) AND LEWIS RIVER SETTLEMENT AGREEMENT SECTION 9.6 – SWIFT RESERVOIR BULL TROUT POPULATION EVALUATION

3.1.1 ESTIMATE OF THE NUMBER OF STAGING BULL TROUT THAT MIGRATED UP THE NORTH FORK LEWIS RIVER FROM THE HEAD OF SWIFT RESERVOIR

EAGLE CLIFFS BULL TROUT COLLECTION (MARK):

Tangle net collection activities at the upper end of Swift Reservoir began on May 11, 2016 and continued through June 30, 2016 (Appendix A). Nine netting days were completed during the period. Netting activities ceased after the June 30 event due to low water and high in-season recapture rate. A total of 103 bull trout were captured in the Eagle Cliffs area of Swift Reservoir. Of these, 62 were tagged with two green colored three inch Floy® T-bar anchor tags between the last two posterior dorsal fin-rays. Of the remaining 41 captures, 12 did not meet minimum fork length tagging requirements (>450mm), and 29 were current year recaptures (Appendix A).

Of the 74 maiden bull trout captures in 2016, 30 had Floy® or PIT (Passive Integrated Transponder) tags from previous years bringing the total capture rate of previously handled fish to 41 percent (30 fish of a total of 74).

To catch Swift Reservoir staging bull trout, tangle nets are typically drifted along the stream bottom by means of a power boat or allowed to passively soak for up to ten minutes in slow-water areas of high bull trout concentration. Tangle nets consist of dyed green 6# monofilament, with depths of approximately 2 meters (m), varying lengths of 25 – 40 m, and varying mesh sizes of 2.5 – 7.5 centimeter (cm) stretch. 2015 was a unique year in terms of typical catch methods experienced historically.

Keeping with previously established methods, all Floy® tagged bull trout captures received a second same colored tag on the opposite side of the fish. It is anticipated that double-tagging bull trout captures will refine tag-loss estimates and assumptions within the annual migration estimate. Tag retention was evaluated by snorkelers during the recapture surveys performed of the confluence areas of Muddy River and Rush and Pine Creeks. Surveyors paid careful attention to the number of green tags observed in tagged bull trout in order to determine the proportion of bull trout missing a green tag.

All newly captured bull trout received Floy® (if larger than 450mm) and half-duplex (HDX) PIT tags (if greater than 250mm dorsal sinus PIT tag location, if less than 250mm but greater than 120mm, these fish received a full-duplex (FDX) PIT tag).

The preferred tagging location for the 23mm HDX tag was the dorsal sinus. A small incision was made with a scalpel just anterior to the dorsal sinus and the tag was then gently pushed toward the caudal peduncle into the sinus (Tranquilli et. al 2003). If a bull trout was recaptured containing a Full Duplex (FDX) PIT tag, these fish were double-tagged with an HDX PIT tag as well. Research conducted by the United States Geological Survey (USGS) in 2007 identified that, when the copper coils of an FDX tag came within 1 centimeter (cm) of the copper coils within an HDX tag, the FDX tag interfered with the HDX tag signal and the HDX tag was not detected by the tag reader (Compton 2007). To alleviate the problem of tag interference between the two tag types in double-tagged bull trout, HDX tags were inserted in the dorsal sinus on the opposite side of the original FDX tagging location. Since 2010, this location has been incorporated with no known interference.

Along with tagging activities, all captured bull trout (minus same year recaptures) were measured to their caudal fork and, when feasible, weighed to the nearest gram. Recording bull trout weights is a data collection activity that was first implemented in 2008 and, along with fork lengths, will be used to assess the condition factor (K-factor) of bull trout residing in Swift Reservoir (Fulton 1902). When available, this biological information will be recorded with each fish captured and individual metrics will be compared with each recapture to evaluate trends in reservoir productivity and how this pertains to bull trout behavior. In order to not skew K-factors, bull trout that had recently fed on large fish (evidenced by a caudal fin protruding from the jaw) were not weighed. All true maiden captures were also sampled for genetic material with the intent of genetic analysis being performed at a later date.

SNORKEL SURVEYS OF THE CONFLUENCE AREAS OF MUDDY RIVER, PINE, AND RUSH CREEKS WITH THE NORTH FORK LEWIS RIVER (RECAPTURE):

Snorkel surveys of the three confluence areas occurred weekly from August 17 to October 4 for a total of eight weeks (Table 3.1-1).

Snorkel surveys of the Muddy, Pine, and Rush confluence areas began upstream of each confluence in the North Fork Lewis and continued downstream until bull trout were no longer observed, usually a distance of approximately 100m. Given the short distance between the mouth of Pine Creek and the Muddy River, this area was also surveyed for bull trout during each confluence survey day (Figure 3.1-2).

Table 3.1-1. 2016 bull trout snorkel survey results for the Muddy River, Rush and Pine Creeks confluence areas with the North Fork Lewis River (recapture).

Date	Location	# marked	# Unmarked	Total	% of total with mark	Single tags observed	Tag loss %
17-Aug	Pine, Rush, Muddy confluence areas	4	37	41	11%	1	25%
23-Aug	Pine, Rush, Muddy confluence areas	5	37	42	14%	0	0%
31-Aug	Pine, Rush, Muddy confluence areas	4	41	45	10%	0	0%
6-Sep	Pine, Rush, Muddy, confluence areas	3	35	38	8%	0	0%
15-Sep	Pine, Rush, Muddy, confluence areas	2	28	30	7%	0	0%
22-Sep	Pine, Rush, Muddy confluence areas	1	33	34	3%	0	0%
29-Sep	Pine, Rush, Muddy confluence areas	0	32	32	0%	0	0%
4-Oct	Pine, Rush, Muddy confluence areas	3	37	40	8%	0	0%
TOTAL	**Pine, Rush, Muddy confluence areas**	**22**	**280**	**302**	**7%**		

During each snorkel survey all bull trout were enumerated (Tables 3.1-1). Care was taken to determine the presence of any green Floy® tagged bull trout, and due to the current Floy® tag retention study, biologists also recorded any green Floy® tag loss (i.e. a bull trout with only one green tag as opposed to two). During the eight confluence snorkel surveys, bull trout missing green Floy® tags were rarely observed. Given individual tagged fish cannot be distinguished during each snorkel survey, cumulatively counting tag-loss during subsequent surveys would be erroneous. The only way to accurately express tag-loss without the chance of double-counting is to record the percentage of fish with only one tag for each survey (Table 3.1-1). The only tag-loss (25 percent) was observed on August 17 when one bull trout was observed with only one green Floy® tag.

The Swift Reservoir bull trout migration data was analyzed and a migration estimate obtained using program NOREMARK®. NOREMARK® computes an estimate of population size for a closed population with a known number of marked animals and one or more re-sighting events (White 1996). Program NOREMARK® utilizes four mark-resight estimators of population abundance; for all four estimators, the marked fish are assumed to have been drawn randomly from the population. That is, the marked fish are a representative sample of the population (White 1996).

For 2016, utilizing data collected during Muddy River, Rush, and Pine Creek confluence snorkels, the estimate of adult bull trout that migrated upstream from Eagle Cliffs is 753 (95% CL 525-1,153) (Table 3.1-2 and Figure 3.1-1).

A key assumption within the NOREMARK® mark/recapture estimate is that each tagged individual has an equal probability of being "recaptured" and counted during recapture activities (closed population). Being iteroparous, bull trout have the ability to migrate and spawn one year and not the next and as such, captured individuals tagged in the Eagle Cliffs area of the reservoir may not migrate upstream to the recapture survey areas after release.

Currently, the rate associated with tagged non-migrating bull trout in Swift Reservoir is unknown. It is assumed that the rate of non-migration fluctuates from one year to the next and is most likely closely related to size of fish and reservoir productivity. Thus, care should be taken during evaluation of this migration estimate, as this variable non-migration rate may positively bias migration abundance estimates. An un-validated ten percent in-season Floy® tag loss is assumed within the current estimate. At this time, an in-season mortality rate is unknown and therefore unaccounted for.

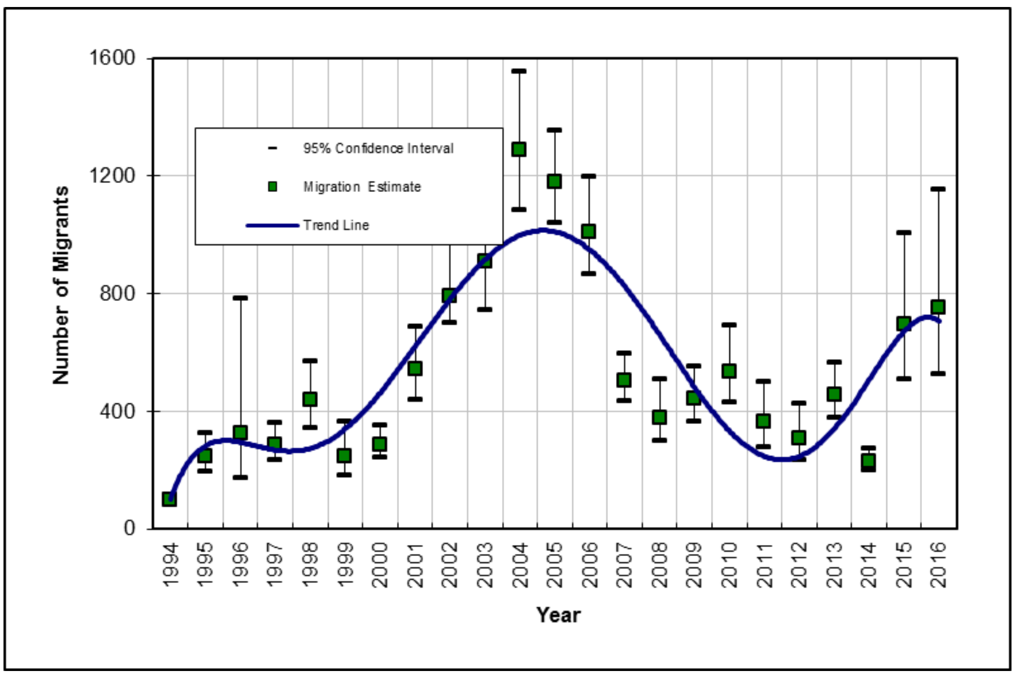

Figure 3.1-1. Estimates of bull trout that migrated from Swift Reservoir up the North Fork Lewis River for the years 1994 through 2016. (1994-2000 Peterson Estimator, 2001- 2016 Program NOREMARK®, Smith 1996)

Table 3.1-2. Tabular data of Swift Reservoir bull trout mark-recapture migration estimates for 1994 - 2016. (1994-2000 Peterson Estimator, 2001-2016 Program NOREMARK®, Smith 1996)

Year	Lower Bound (95% CL)	Upper Bound (95% CL)	Migration Estimate
1994	85	118	101
1995	193	326	246
1996	173	782	325
1997	235	361	287
1998	345	571	437
1999	181	365	248
2000	242	352	288
2001	439	689	542
2002	701	1092	792
2003	745	1140	911
2004	1084	1556	1287
2005	1042	1354	1181
2006	865	1198	1011
2007	436	596	505
2008	298	507	380
2009	367	554	445
2010	430	690	536
2011 (tribs.)	278	502	364
2011 (confluences)	362	539	436
2011 (tribs. and confl. combined)	354	493	414
2012 (tribs.)	235	425	308
2012 (confluences)	279	381	323
2012 (tribs. and confl. combined)	277	364	316
2013	377	564	455
2014	198	274	230
2015	509	1,006	697
2016	525	1,153	753

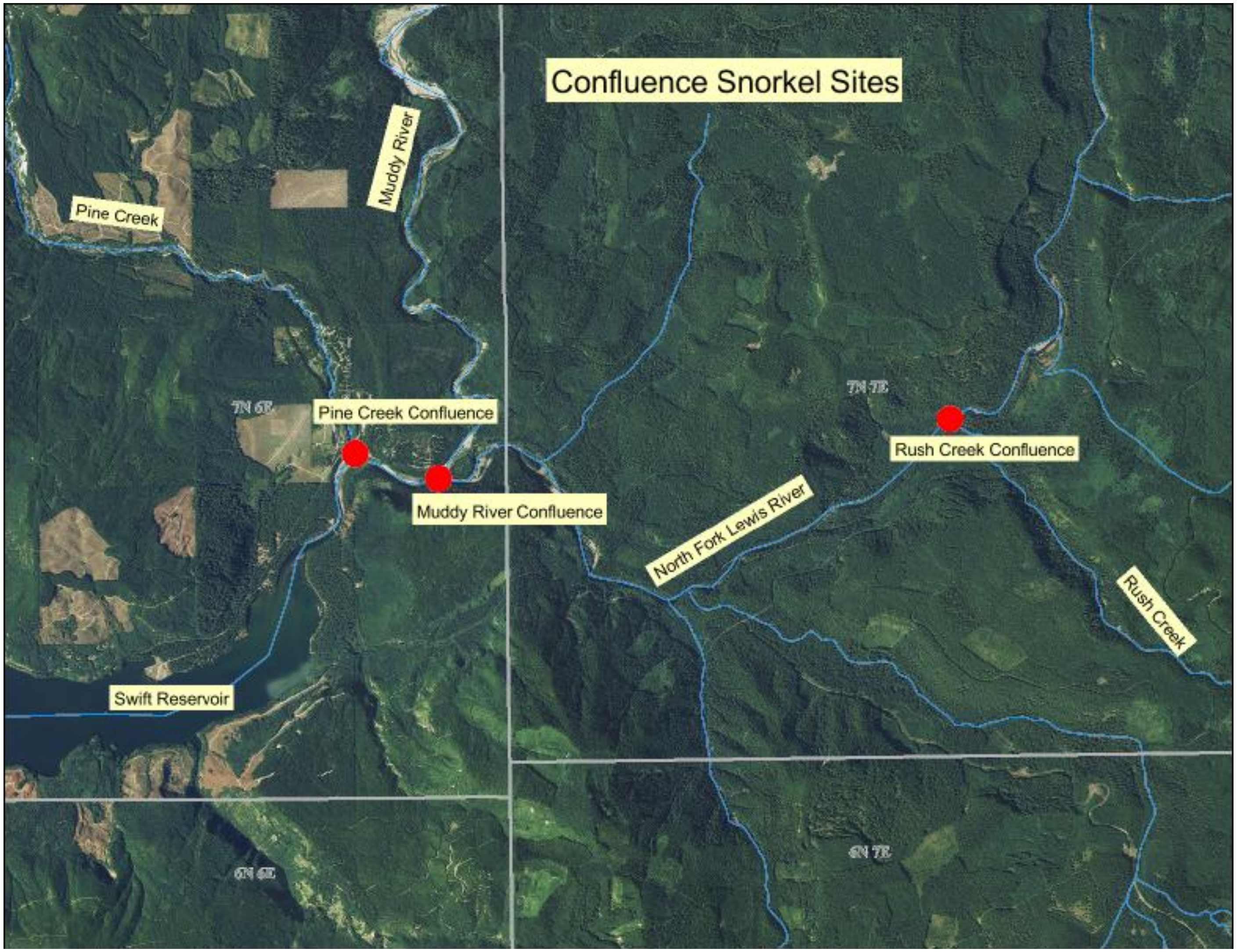

Figure 3.1-2. Snorkel sites (for recapture) associated with the Swift Reservoir bull trout migration estimate.

Age Structure

New in 2016 in order to assess age at migration and age at length, was collection of fin ray material from bull trout captures during Eagle Cliff collection activities. Fin rays were used as a means to specifically age captured fish and followed methods as first described in "Age Structure, Growth, and Factors Affecting Relative Abundance of Life-History Forms of Bull Trout in the Clark Fork River Drainage, Montana and Idaho "(Zymonas 2006). Similar to otoliths and scales, fin rays within bony fishes develop rings, or annuli, as the fish ages. These rings can be counted to get an accurate age of the specimen in question. Per methods identified in Zymonas 2006, fin ray material was collected in the field from the first three rays of one pectoral fin, excising the ray as close to the body as possible. Excised rays were then placed in a scale envelope, allowed to dry and sent to the United States Geographic Services (USGS) lab at the University of Montana for analysis.

At this time samples are still in analysis at the ageing lab. Results will be reported as soon as practicable, but may be reported within the 2017 Lewis River Bull Trout Annual Report.

3.1.2 EVALUATION OF SURVIVAL (S) OF SWIFT AND YALE RESERVOIR BULL TROUT POPULATIONS THROUGH THE USE OF PIT TAG DETECTIONS

For more detailed Results, Analysis, Methods and Equations, please see the technical memorandum "Bull Trout Monitoring Methods in the NF Lewis" from Dr. Robert Al-Chokhachy of the United States Geological Survey located in Appendix C of this Report.

3.1.3 EVALUATION OF THE SWIFT RESERVOIR BULL TROUT EFFECTIVE POPULATION (NE)

Activities pursuant to the eventual annual assessment of an Effective Population (N_e) size of bull trout within Swift Reservoir were performed in 2016. N_e is performed as part of the bull trout demographic characteristics evaluation objective within Section 17 of the Monitoring and Evaluation Plan.

Estimation of effective population size can provide information on the level of genetic variation within a population and how fast genetic variation may be lost through genetic drift (Luikart et al. 2010). The effective population size represents the size of an ideal population that would have the same rate of loss of genetic variation as the observed population (Wright 1931). Although general guidelines for minimum effective population sizes have been suggested (e.g., the 50/500 rule; Franklin 1980), evaluating temporal trends in estimates of N_e are often more useful than determining whether a population meets some minimum threshold number. For example, a population that shows a large decrease in N_e over the course of one or two generations could be experiencing a genetic bottleneck or decline in abundance. Alternatively, an increase in effective size following implementation of new management actions could be one indication that the population is responding positively (Pers. Comm. Pat DeHaan, USFWS).

To evaluate N_e, genetic tissue from juvenile bull trout from the same cohort (presumably age 0) was attained from utilized spawning tributaries (Rush, Pine, and Cougar Creeks, Figures 3.1.3-1 to 3.1.3-3). In order to get maximum genetic representation, fish captures were spatially balanced as much as practical along the length of usable habitat within each stream. Surveys were timed such to ensure capture of prior year's brood fish, with less than 70 mm fork length the cut-off used to determine age 0 bull trout (Fraley/Shepard 1989).

Areas within Rush Creek were sampled with a backpack electrofishing unit on July 13, July 14, and July 20 (Figure 3.1.3-1). In all, 18 juvenile bull trout were captured and sampled for genetic tissue. 17 of the captures were less than 70 mm fork length and assumed to be of 2015 brood year origin and so were included within the N_e analysis. The length range of the bull trout used within the analysis was 42 mm – 57 mm, with an average fork length of 49 mm.

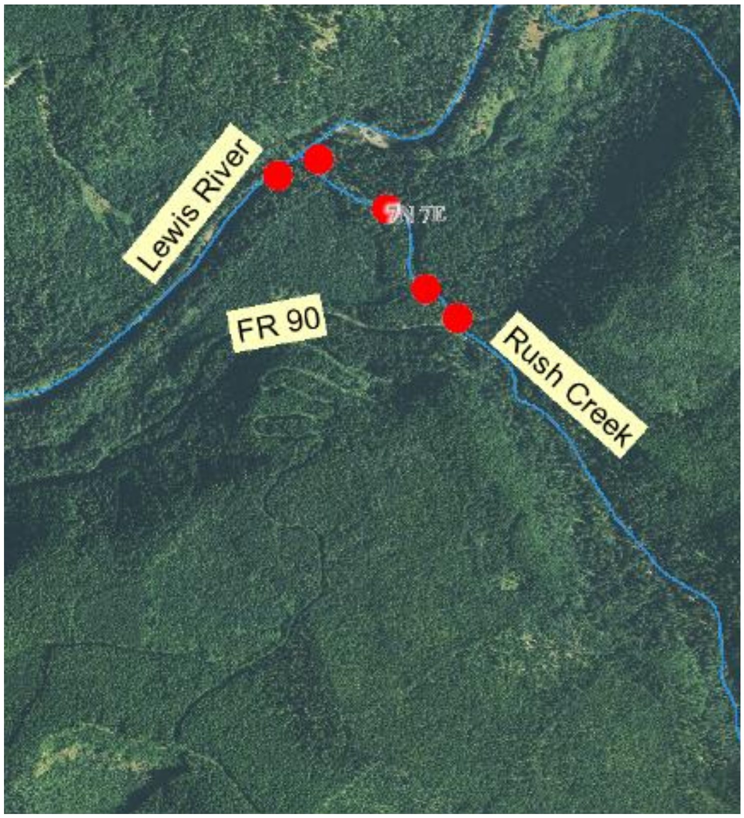

Figure 3.1.3-1. Electrofishing sites within Rush Creek during 2016 juvenile bull trout collection.

Areas within Pine Creek and tributary P8 were sampled for juvenile bull trout with a backpack electrofisher on June 21, June 24, and July 5 (Figure 3.1.3-2). In all, 52 juvenile bull trout were captured from within P8 with all captures meeting the fork length criteria of less than 70 mm. Five juvenile bull trout were captured from within areas of Pine Creek, with all captures meeting the fork length criteria used for the N_e analysis. The lengths of the 57 assumed 2015 brood year bull trout captured in the Pine system ranged from 43 mm – 70 mm with an average fork length of 57 mm.

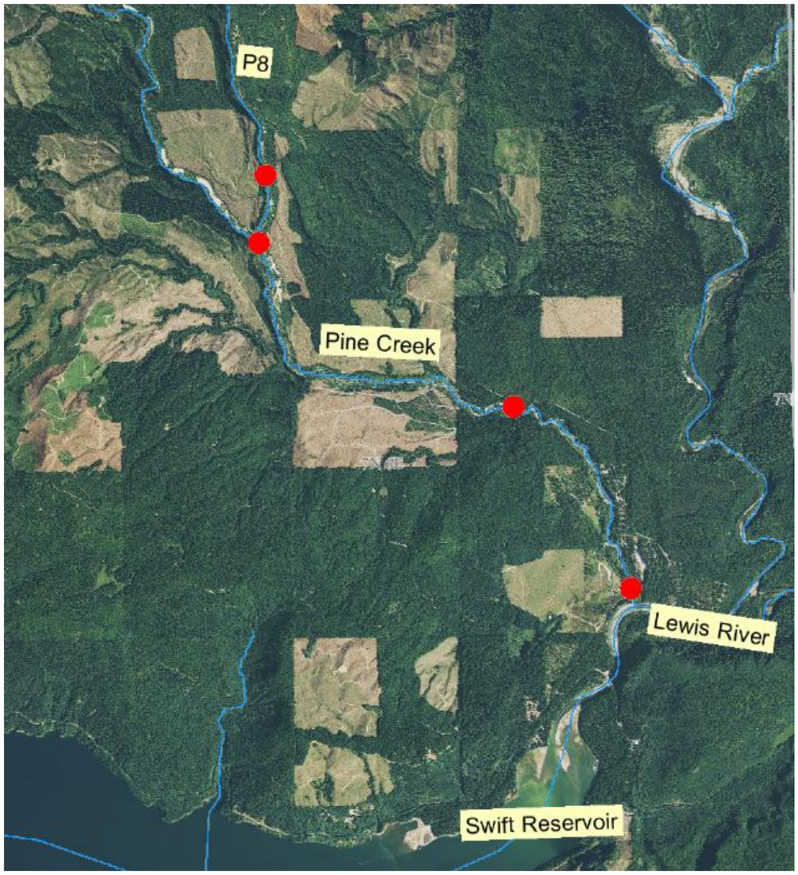

Figure 3.1.3-2. Electrofishing sites within the Pine Creek system during 2016 juvenile bull trout collection.

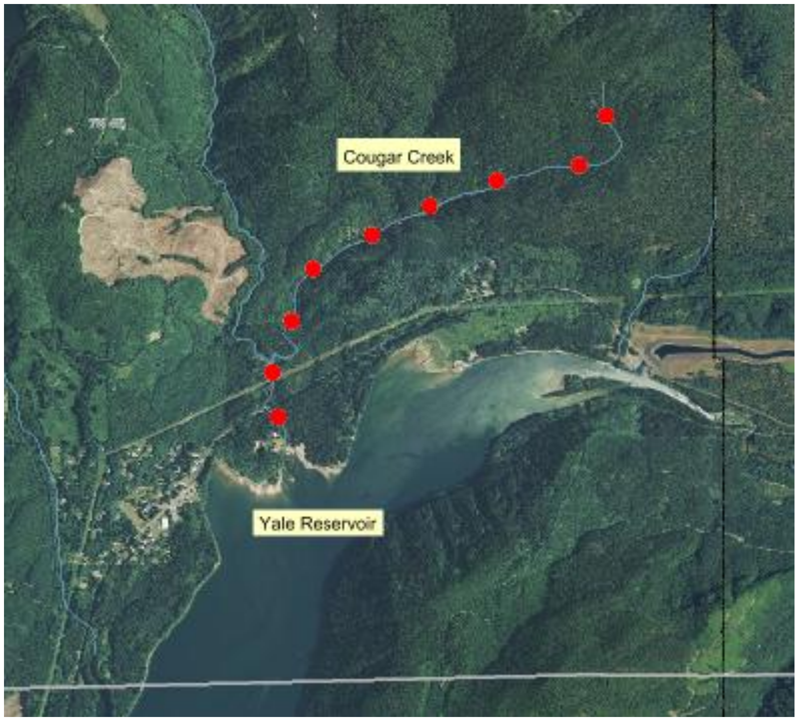

Figure 3.1.3-3. Electrofishing sites within the Cougar Creek system during 2016 juvenile bull trout collection.

Areas within Cougar Creek were sampled with a backpack electrofishing unit on June 28 and June 29 (Figure 3.1.3-3). In all, 60 juvenile bull trout were captured and sampled for genetic tissue. Of these, 57 were less than 70 mm fork length and assumed to be of 2015 brood year origin and so were included within the N_e analysis. The length range of bull trout utilized within the analysis was 41 mm – 70 mm, with an average fork length of 55 mm.

Analysis of Nb for 2016 by the Abernathy Lab as well as material and methods for all genetic analysis performed within the Lewis River basin in 2016 can be found in Appendix D of this Report.

Juvenile bull trout/coho interactions

Numerous young of the year (YOY) coho were also found to be occupying the same habitat as YOY bull trout in the Cougar and Pine creek systems in Yale and Swift reservoirs and as such were inadvertently captured during electrofishing surveys. These coho were quantified and measured to their caudal fork as part of activities pursuant to Objective 18 within the M&E Plan, evaluation of resident/anadromous fish interactions.

Juvenile coho captured within the Pine Creek drainage were progeny of adults released above Swift Reservoir as part of the continued anadromous reintroduction program. Juvenile coho encountered within Cougar Creek were a surprise in 2016, as no concerted anadromous reintroduction efforts have to date taken place within this reservoir. A high water event within the Lewis River basin that occurred during the third week of December 2015 caused a large volume of water to be spilled over all three hydroelectric facilities. With the additional planting of later spawning late stock coho into Swift Reservoir in late 2015, an unknown amount of fecund adults are assumed to have migrated downstream during this high water spill event and then ultimately spawned within Cougar Creek.

Coho YOY dominated the catch in both Pine/P8 and Cougar creeks, totaling 424 and 300 captured respectively. This corresponds to a YOY bull trout catch of 57 and 57, a difference in overall collected of 87 percent more YOY coho captures in Pine/P8 creeks and 81 percent more in Cougar Creek. A marked contrast was observed in Rush Creek, where no coho YOY were encountered (Figure 3.1.3-4).

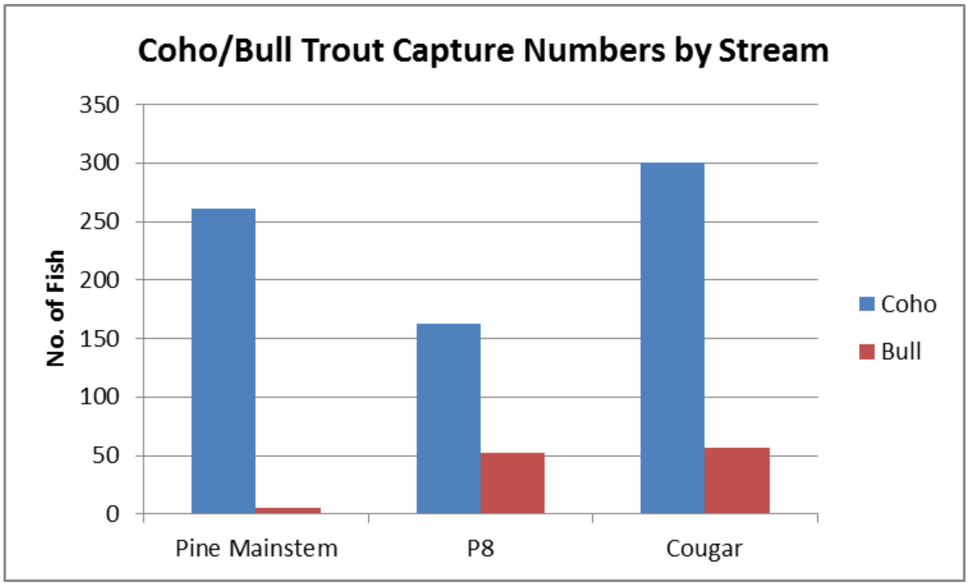

Figure 3.1.3-4

Size of coho YOY in terms of average fork length was also assessed and compared to that of YOY bull trout occupying the same habitat within the Pine and Cougar creek systems. Across the board coho YOY were marginally smaller than bull trout YOY, with the biggest discrepancy occurring within Pine Creek mainstem and P8 where coho YOY were 37 and 32 percent smaller and had average fork lengths of 42 and 39mm compared to that of bull trout YOY at 66 and 57mm. The sizes observed within Cougar Creek were more similar to one another, with coho YOY fork lengths 13 percent smaller than that of observed bull trout YOY fork lengths. Average observed coho YOY fork lengths in Cougar Creek were 48mm as compared to 55mm for bull trout (Figure 3.1.3-5).

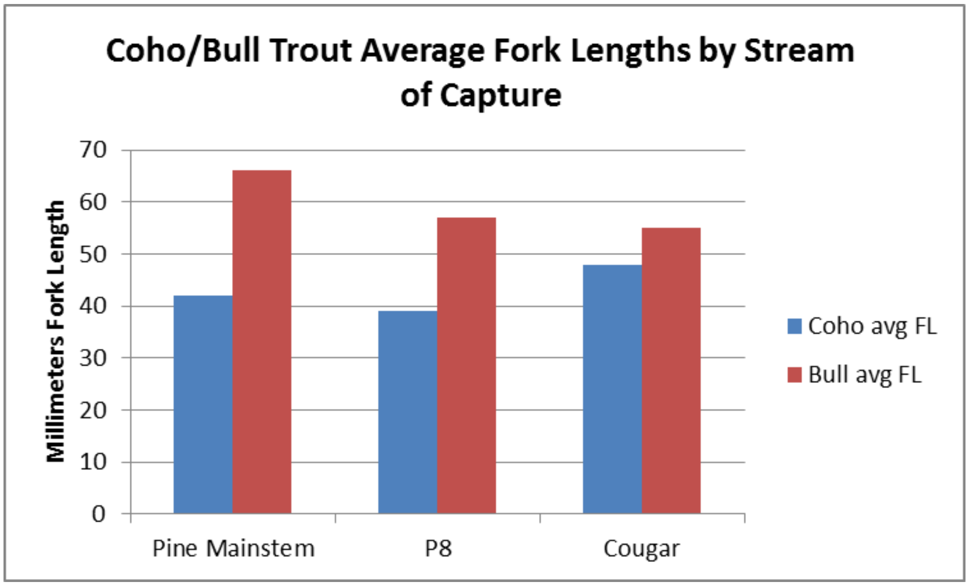

Figure 3.1.3-5

This is in marked contrast to what was observed during 2015 electrofishing activities where all encountered coho were larger than their bull trout counterparts. This likely was an additional function of the newly reintroduced later spawning late stock coho whose progeny emerge after that of the typically stocked early coho and thus do not have as much time for growth prior to when the surveys are performed in the early summer. Conversely, bull trout YOY during this time have emerged sooner than late stock coho and have had more opportunity for growth, as the data reflects.

The December 2015 high water event referenced above brought near record high flows to the upper Lewis River basin. These high flows occurred immediately after the 2015 bull trout spawn and it is assumed they may have led to scouring of newly dug bull trout redds. 2016 electrofishing catch of 2015 bull trout brood within Pine Creek mainstem and Rush Creek seems to back up the assumption of the December 2015 flood being a scouring event, as the catch per unit effort (CPUE) dropped on average by 86 percent within Pine mainstem in 2016 and 68 percent within Rush Creek (Figure 3.1.3-6). Interesting to note that both P8 and Cougar creeks seem to be spawning refugia, and data suggests they offer better protection during high water events as CPUE in 2016 within these two streams remained similar to catch observed in 2015. Cougar Creek was not surveyed for bull trout juveniles in 2014 (Figure 3.1.3-6).

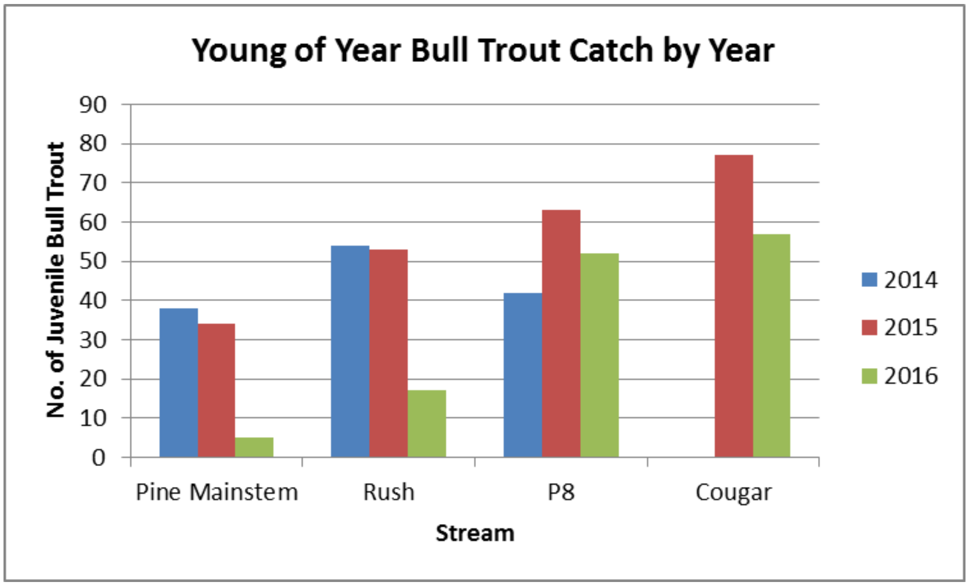

Figure 3.1.3-6. Trend bull trout juvenile catch during stream electrofishing surveys. Cougar Creek was not surveyed in 2014.

3.2 Lewis River Passive Integrated Transponder Tag Antenna Arrays

3.2.1 Evaluation of Swift and Yale Reservoir Bull Trout through the use of Stream-Width Half-Duplex Passive Integrated Transponder Antennas in Rush, P8, Pine and Cougar Creeks

Stream-width half-duplex PIT tag antennas were placed in Pine, P8, Rush, Cougar and Drift Creeks in the late summer through fall time period (Figures 3.2.1-1 and 3.2.1-2). The remote PIT antenna array in Pine Creek was stream-spanning and located in a shallow riffle approximately 300 m upstream from the confluence with the North Fork Lewis River. The Rush Creek antenna array was located in a narrow shoot approximately 100 m upstream from the confluence with the North Fork Lewis River. The array in P8 was stream-spanning and located approximately 150 m upstream from the confluence with Pine Creek. The array on Drift Creek was also stream-spanning and was located approximately 100 m upstream from its confluence with Swift Reservoir. The array in Cougar Creek was also stream spanning and located approximately 200 m upstream from its confluence with Yale Reservoir.

Each half-duplex antenna site consisted of two antennas (for directionality) that were multiplexed (synchronized) and spaced approximately two meters apart. Antennas consisted of 10-gauge copper wire looped along the stream bottom starting from one stream bank, spanning the entire wetted-width of the stream along the stream bottom to the opposite bank, and then along the stream surface back to the original starting point creating a large swim thru rectangle shape. Each antenna wire or cable was connected to an Oregon RFID RI-Acc-008B antenna tuner unit. Copper twinax was then run from each tuner unit to an Oregon RFID RI-RFM-008 reader board and data logger. The antenna reader board and data logger were located in secure Joboxes near the stream bank and were powered by two large 12 volt deep-cycle marine batteries run in parallel. Batteries were charged via 120w solar panels hooked to a charge controller.

Figure 3.2.1-1. Half-duplex stream-width PIT tag antenna locations in the Upper Lewis River Basin – 2016.

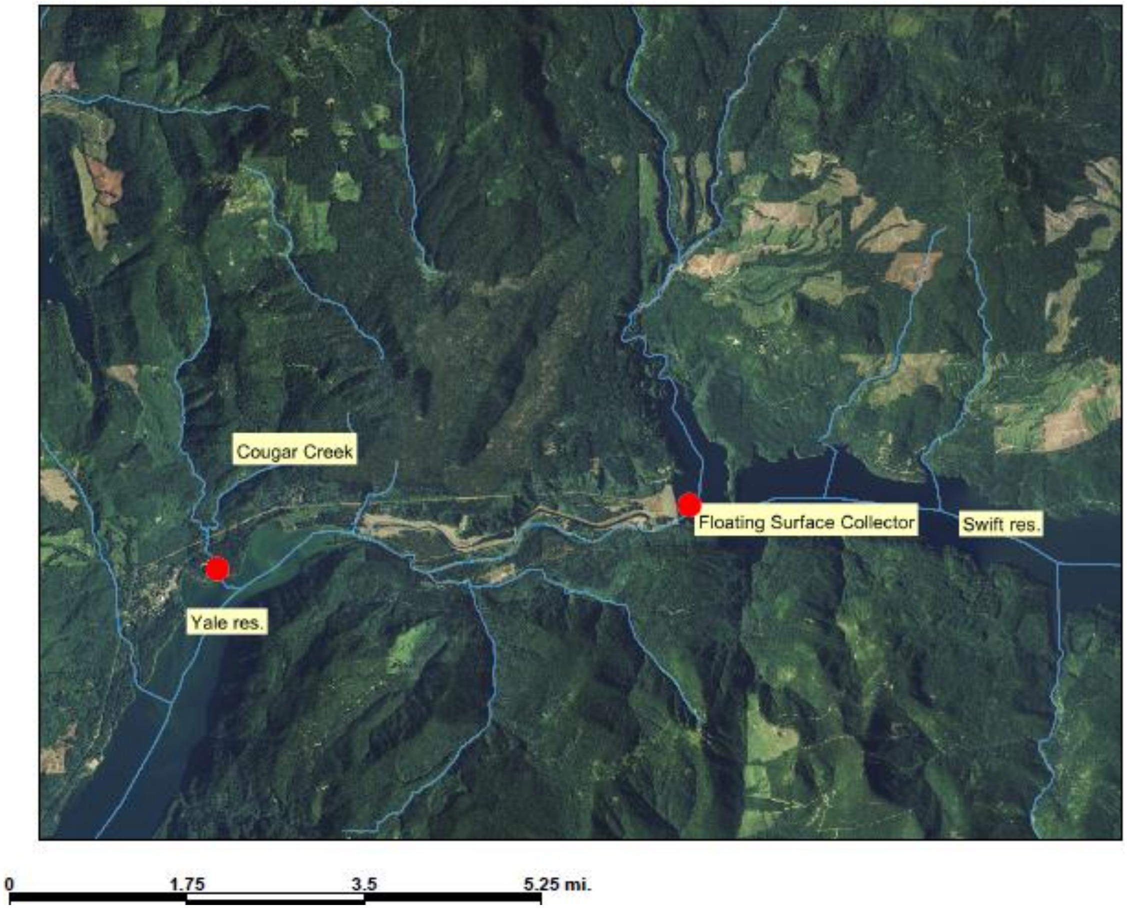

Figure 3.2.1-2. Half-duplex stream-width PIT tag antenna locations in the Yale Reservoir Basin – 2016.

In 2016 there were 66 unique PIT tag detections at stationary antennae in tributaries to Yale and Swift reservoirs. The breakdown of detections by stream, as well as timing and spawning frequency is as follows:

Cougar Creek

The PIT antenna at the mouth of Cougar Creek was in operation from August 8 – October 13, at which time the antenna loop was destroyed by a high water event. Continuous operation was experienced during this sampling timeframe with no loss of power. During the migration period 118 detections occurred at the antenna resulting in 26 unique bull trout. All of the 118 upstream and downstream movement events occurred during the crepuscular period. Peak migration was observed on October 5 with a total of eight individual bull trout moving past the antenna site (Figure 3.2.1-3).

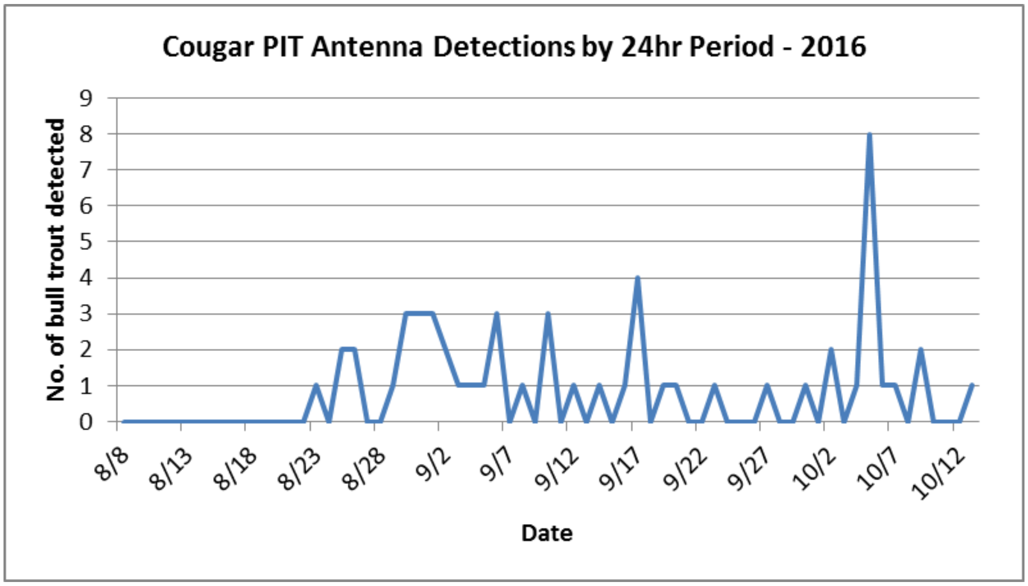

Figure 3.2.1-3

The number of unique bull trout detections in 2016 as compared to historical detections is expressed in Figure 3.2.1-4. Of the 26 bull trout that migrated upstream, fourteen (54 percent) were consecutive spawners with one fish being detected for the last five consecutive years. Twelve bull trout migrants (46 percent) were maiden detections in 2016.

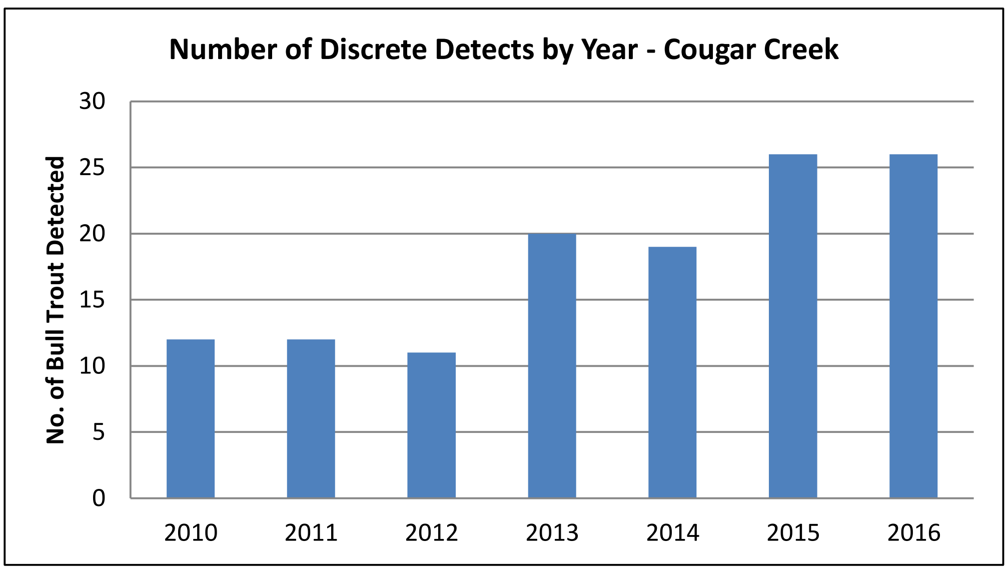

Figure 3.2.1-4

Pine Creek

The PIT antenna at the mouth of Pine Creek was in operation from July 26 to October 8, no power loss was experienced during the survey period. 546 detections were experienced during the period of operation resulting in 30 discrete bull trout tags. 96 percent of detections at this site occurred during the crepuscular period. Peak migration past this antenna was observed on August 23 when five bull trout volitionally swam past (Figure 3.2.1-5).

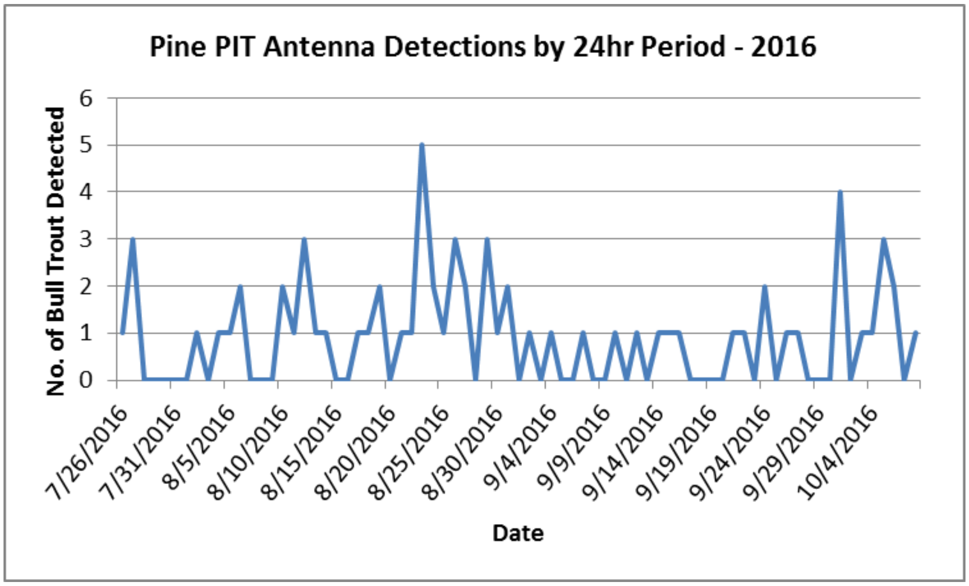

Figure 3.2.1-5

The number of discrete detects at this site dropped significantly from the previous year (Figure 3.2.1-6). This in part was due to the truncated collection timeframe as a high water event during the first week of October destroyed the antenna loop prohibiting detection of post-spawn out-migrating bull trout. Of the 30 bull trout that migrated upstream past this antenna, 54 percent showed evidence of consecutive year migrations (2, 3, 4 or 5 year consecutive), 33 percent were maiden detections, 10 percent showed evidence of biennial migrations, and 3 percent were transported from out of basin during 2016 (one bull trout from the Swift Bypass Reach).

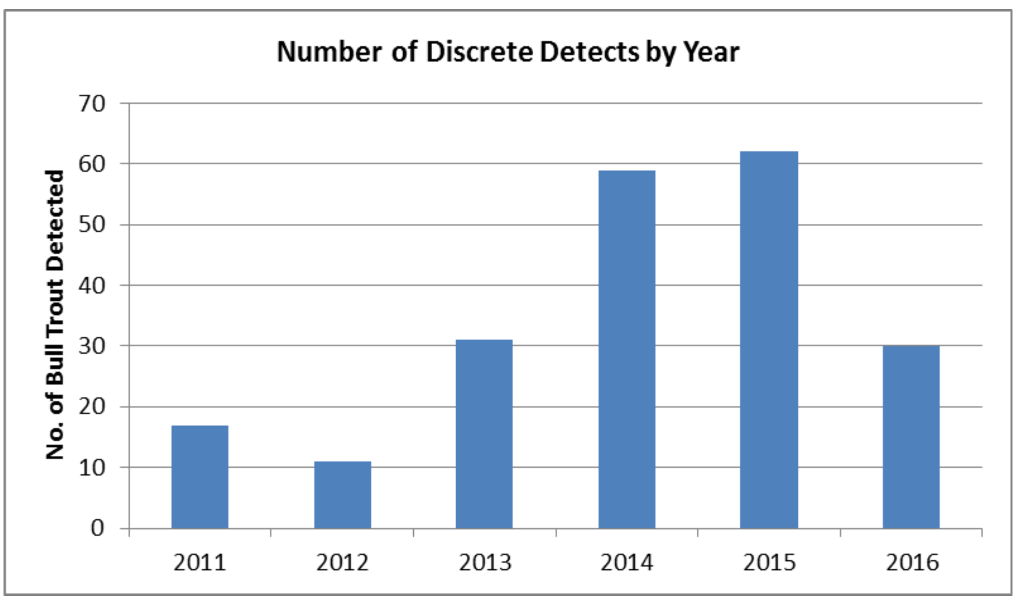

Figure 3.2.1-6

Pine Creek Tributary P8

The PIT antenna at the mouth of Pine Creek tributary P8 was in operation from August 11 to October 11. Power loss was experienced for 23 of the 62 days of operation, from September 4 – 11 and September 18 – October 2 due to a faulty battery and problems associated with the charge controller attached to the solar panel. 2,277 detections were recorded during the period of operation resulting in 10 discrete bull trout tags. Movement passed this site in terms of time during the day was random, with no favoring of crepuscular hours over diurnal. Peak migration was observed on October 5 when five bull trout volitionally swam past this antenna (Figure 3.2.1-7).

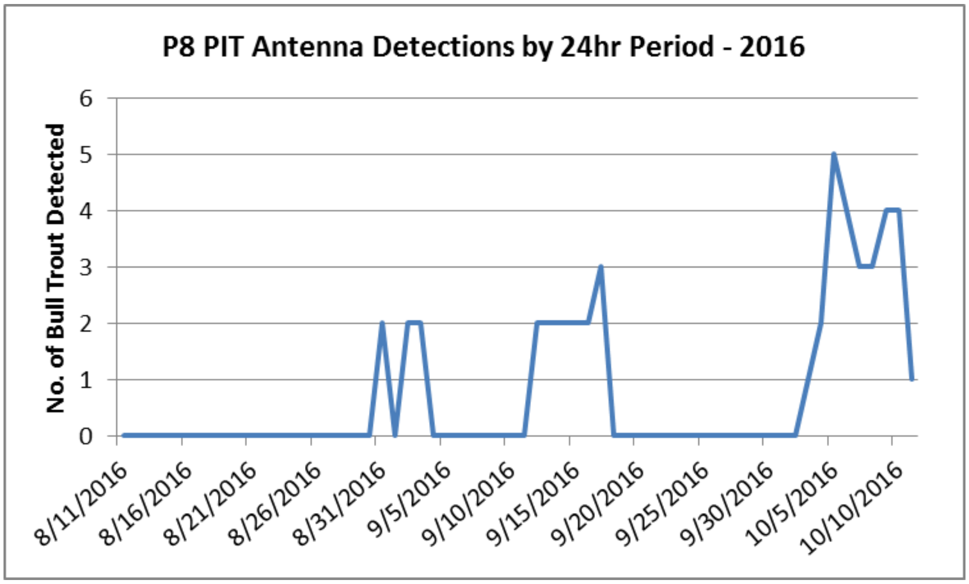

Figure 3.2.1-7

Discrete detections at this site dropped drastically from the previous two years (Figure 3.2.1-8). This was due in part to logistical complications experienced with the antenna systems power supply during the survey period. Of the ten bull trout detected at this antenna in 2016, forty percent showed evidence of consecutive year migrations, while sixty percent were maiden detections.

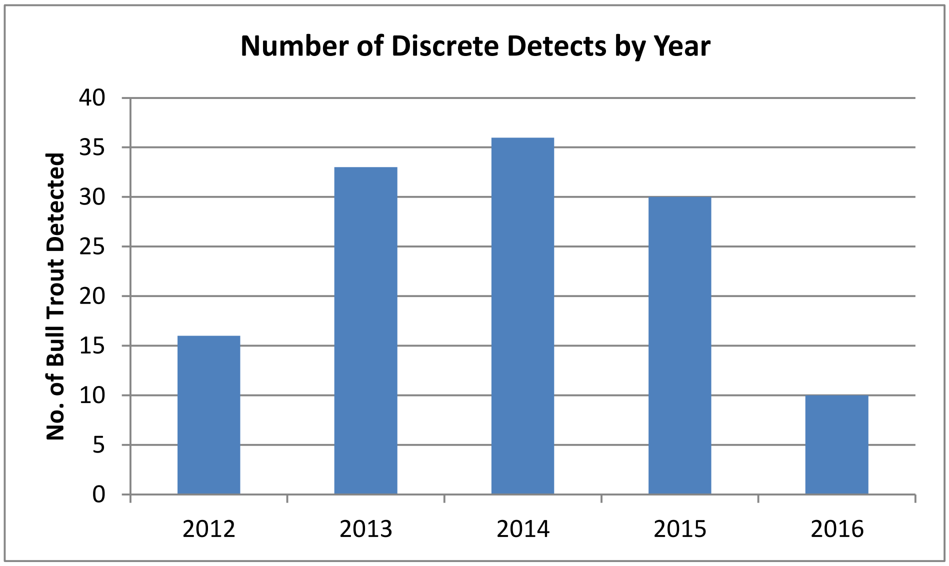

Figure 3.2.1-8

Rush Creek

Due to unforeseen and unfortunate logistical complications that continued to occur at the Rush antenna site with the antenna operating system as well as power source, no PIT tag interrogation data was collected at this site in 2016. The antenna was powered up and put into operation on August 29 but no usable data was collected.

Drift Creek

The PIT antenna at the mouth of Drift Creek was in operation from August 4 to October 8. Loss of power occurred from August 30 – September 16. No bull trout tags were interrogated moving passed this site during times of reader power up.

3.3 Lewis River Bull Trout Capture and Transport Activities

3.3.1 FERC Project License Article 402(a) and Lewis River Settlement Agreement Sections 4.9.1 & 4.9.2 - Swift Bypass Reach Capture and Transport Activities

The Swift Bypass Reach is the former Lewis River channel between the Swift No. 1 and Swift No. 2 hydroelectric projects. Since 2010, a minimum flow of 65 cubic feet per second (cfs) has flowed in the Bypass Reach through what the SA termed the “Upper Release Point” and the “Canal Drain”. The Upper Release Point flows from the Swift No. 2 Power Canal directly upstream from the Swift No. 1 spill plunge pool and provides 51 – 76 cfs of water depending on the time of year. The Canal Drain flows from the Swift No. 2 Power Canal into an approximately 350 m long reach (termed the Constructed Channel) that is relatively unaffected by Swift No. 1 spill events and provides a continual 14 cfs of water flow. This Constructed Channel then joins the main channel Bypass Reach. Along with Ole Creek, these two water release points provide most of the flow into the Bypass Reach.

In 1999, The Utilities began netting the Swift No. 2 powerhouse tailrace as part of requirements contained in amendments to Article 51 of the former Merwin license. The tailrace was not netted from 2001 to 2005 because of the Swift No. 2 canal failure in 2001 and subsequent reconstruction. Capture efforts were then restarted in 2006 pursuant to sections 4.9.1 and 4.9.2 of the Lewis River Settlement Agreement and in 2008 pursuant to Article 402(a) of the new FERC licenses for Swift No. 1 and No. 2.

At the 2007 annual bull trout coordination meeting (attended by USFWS, WDFW, and PacifiCorp), the Utilities proposed to discontinue netting the Swift No. 2 tailrace (since only two fish had been captured since 1999) and move the collection site to an area near the International Paper (IP) Bridge within the Swift Bypass Reach (Figure 3.3.2-1). As noticed in past Swift Bypass Reach snorkel surveys, this area was found to contain adult bull trout between the months of June thru October. The USFWS and those in attendance at the 2007 coordination meeting approved this recommendation (see Utilities 2007 Annual Bull Trout Monitoring Plan for meeting notes http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Hydro/Hydro_Licensing/Lewis_River/Annual_Bull_Trout_Monitoring_Plan_2007.pdf).

Figure 3.3.1-1. Map showing bull trout sampling areas between Swift No.1 and Swift No. 2 powerhouse's.

2016 collection activities typically focused on capturing bull trout from the agreed-upon sampling area of the bypass reach below the International Paper Bridge and from the confluence of the bypass reach with Yale Reservoir (Figure 3.3.1-1). Angling was the primary method of capture in this area early in the season (when bull trout are aggressive and still actively feeding) due to its effectiveness and low rate of incidental catch of other species present in the survey area.

As the season progressed and bull trout became increasingly indifferent to fishing lures, the method of capture switched to utilizing passively set tangle nets. Nets similar in length, depth and mesh size to those used at Eagle Cliffs and the Yale powerhouse tailrace were used for the Swift Bypass efforts. Unlike other collection areas within the Lewis River basin where nets are allowed to passively "soak" unattended, bull trout captured in the bypass reach are corralled by biologists in snorkel gear into set nets and as such, are constantly checked. When a bull trout became entangled, the net was immediately pulled in and the bull trout freed and placed in a holding container (aerated cooler or live box in the stream).

The Swift Bypass Reach was sampled eight times from May 23 to July 25, 2016. During this sampling time-frame, 24 bull trout were captured. Of these, 17 were maiden captures, seven were past year recaptures, and two expired while being held in the Merwin Hatchery holding tanks awaiting results from rapid response genetic analysis (Appendix B). Maiden captures were tagged with a uniquely coded HDX PIT tag, sampled for genetic tissue and fin ray material, weighed, and measured to their caudal fork. Recaptured bull trout from this area were simply interrogated for their PIT code, measured, sampled for fin ray material for ageing and weighed.

In past collection activities, Swift Bypass Reach captured bull trout, after tagging and biologically sampling, were simply released back to the point of capture. With the completion of the Lewis River bull trout genetic baseline in 2011, all new bypass reach bull trout captures have been transported to Speelyai or Merwin Hatchery and held while rapid response genetic analysis of each individual fish is performed at the Abernathy Lab. The intent of the rapid response genetic analysis is to identify any Swift origin bull trout residing in Yale Reservoir that are prevented from returning to their natal stream to spawn, and to transport them back upstream into Swift Reservoir. It is commonly accepted that bull trout are highly migratory and, over time, a portion of the Swift bull trout population has migrated downstream of Swift No. 1 dam either by passing through spill gates during spill events or passing through the turbine units in the powerhouse.

The 17 maiden bull trout captures in 2016 were transported to Merwin Hatchery and held in one of three circular tanks while awaiting results from the genetics lab. Circular tanks were approximately 2.5 meters in diameter and 2 meters in height, water was filled to within half a meter of the top of each tank. Circular tanks were fed with constantly moving water; and water temperature never exceeded 12° Celsius for the duration of the collection period. Only like-sized bull trout were held in the same tank. ¾ inch plywood was placed over the top of each circular tank to prevent bull trout from jumping out of the tank. The longest a bull trout was held while awaiting genetic analysis during 2016 activities was approximately 48 hours.

It was agreed during 2016 planning meetings to continue to err on the side of caution when deciding which captured bull trout would be transported upstream for release into Swift Reservoir after Rapid Response genetic analysis. Therefore, only bull trout found to be genetically endemic to Rush Creek, Pine Creek, or a combination thereof at a Greatest Likelihood of Origin score of ≥.99 were transported upstream to Swift Reservoir in 2016. In contrast, bull trout with a likelihood score of less than 0.99 to Rush Creek, Pine Creek, a combination of the two, or with a Greatest Likelihood of Origin score greater than 0.02 to Cougar Creek were released back into Yale Reservoir. A sheet detailing genetic analysis of all previously captured bull trout that were simply sampled and released during prior years was on-site so as to determine real-time origin of any recaptured fish. If origin of recaptured fish was known, that fish was not held at a hatchery, but instead taken to one of the release points described above as determined by its greatest likelihood of origin score. For a description of Materials and Methods used by the lab for Rapid Response genetic analysis of Lewis River bull trout in 2016 please refer to the report titled "Rapid Response Genetic Analysis of Bull Trout Collected in the Lewis River, WA 2011 Annual Report" (DeHaan and Adams 2011).

Of the 24 bull trout captured in the Swift Bypass Reach in 2016, eight were found to be of Pine Creek origin, and of these five were transported upstream to Swift Reservoir. The three Pine Creek origin fish that were not transported upstream were either released at the capture location due to extenuating circumstances (2), or expired while being held at Merwin Hatchery (1). The remaining sixteen captures either did not score high enough to be assigned to Rush or Pine, or scored a high likelihood to the Cougar Creek population and as such were returned to Yale Reservoir.

Figures 3.3.1-2 and 3.3.1-3 illustrate the size distribution of 2016 Swift Bypass Reach captures by area of final disposition, and historical total capture and transport numbers.

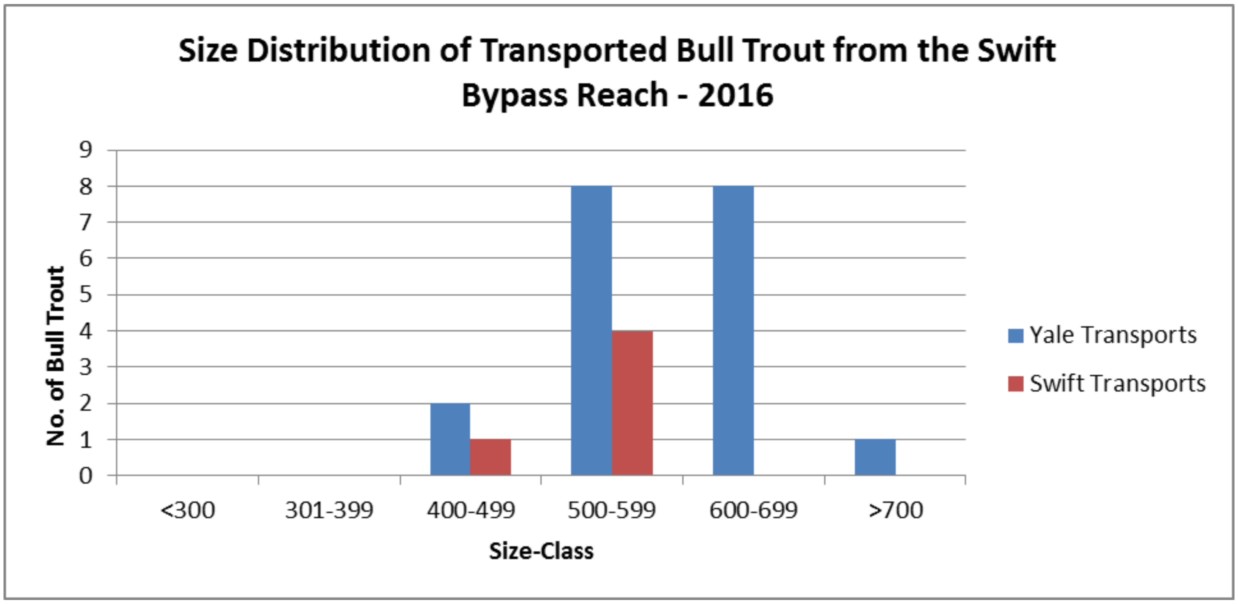

Figure 3.3.1-2. Size distribution of transported bull trout from the Swift Bypass Reach in 2016.

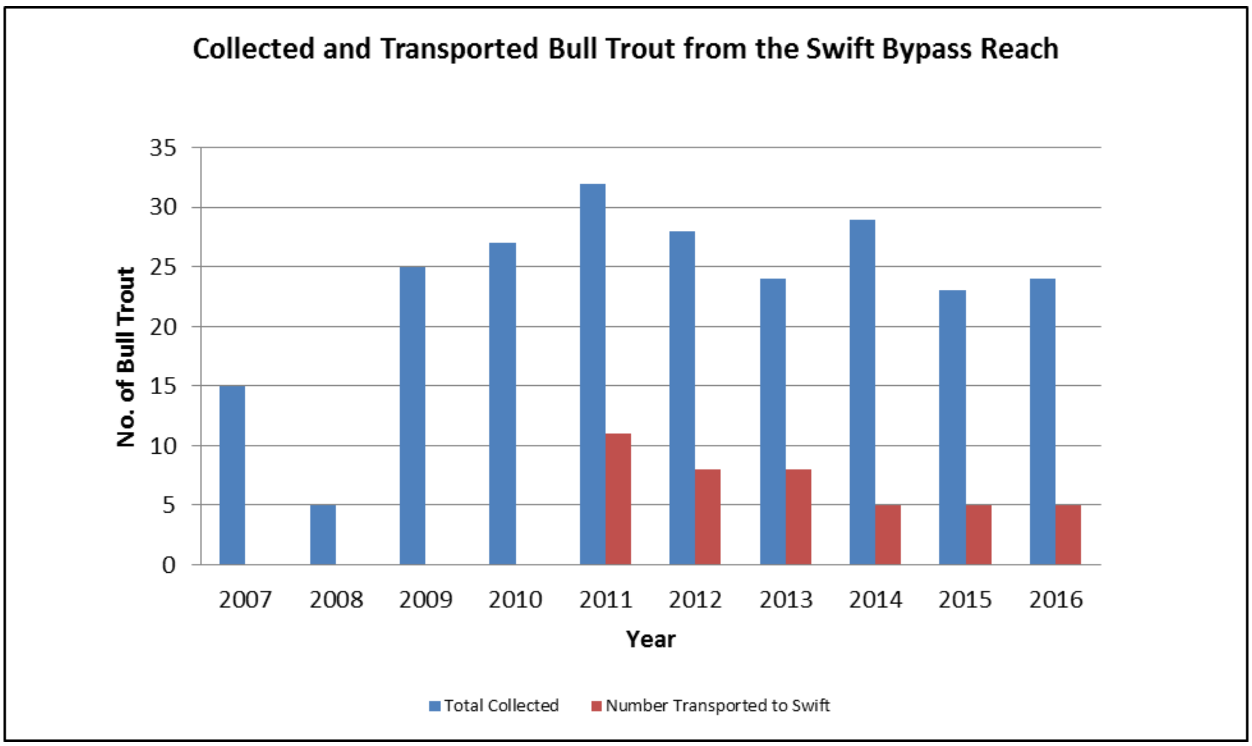

Figure 3.3.1-2. Historical Swift Bypass Reach capture and transport numbers.

Table 3.3.2-1. Number of bull trout collected from the Swift Bypass Reach (Yale Reservoir) and transferred to Swift Reservoir: 2007 – 2016.

YEAR	No. captured at the Swift Bypass Reach	No. transferred to Swift Reservoir	No. released back into Yale Reservoir	MORTALITIES
2007	15	0	15	0
2008	6	0	6	0
2009	25	0	25	0
2010	27	0	27	0
2011	32	15	17	0
2012	29	8	20	1
2013	24	8	16	0
2014	30	5	25	0
2015	21	5	15	1
2016	24	5	17	2
TOTAL	**233**	**46**	**184**	**4**

3.3.2 FERC Project License Article 402(a) and Lewis River Settlement Agreement Sections 4.9.1 & 4.9.2 - Yale Tailrace Capture and Transport Activities

Per Article 402(a) in the FERC licenses and the Lewis River SA section 4.9.1, PacifiCorp annually captures bull trout from the Yale powerhouse tailrace (upper Merwin Reservoir). All bull trout captures are transported to and held at Merwin Hatchery while rapid response genetic analysis is performed following methods outlined in Section 3.3.2 of this Report. Depending on the outcome of the analysis, bull trout are either transported for release into Yale or Swift reservoirs. A total of 159 bull trout have been captured from the Yale tailrace since the program began in 1995.

To capture bull trout from the Yale tailwaters, monofilament mesh tangle nets are used (typically 40 m long, 2 m deep, and consisting of 6.5 cm stretch mesh). Depending on catch rates, netting occurs for the most part on a weekly basis beginning in June and ending mid-August. Netting usually occurs between the hours of 0900 and 1200. During this time, the powerhouse generators are taken off-line to facilitate deployment and handling of the nets. Nets are tied to the powerhouse wall and then stretched across the tailrace area using a powerboat. The nets are then allowed to sink to the bottom. Depending on conditions or capture rate, the nets are either held by hand on one end or allowed to fish unattended. The maximum time nets are allowed to fish is 10 minutes.

Upon capture of a bull trout, it is immediately freed of the net (usually by cutting the net material) and placed in a live well. Captured fish are measured to their caudal fork, weighed with a hand-held scale to the nearest gram, fin ray sample taken for ageing, and then inserted with a uniquely coded HDX or FDX PIT tag (size dependent). All fish are scanned with a hand-held PIT tag detector to check for previous tags prior to inserting a PIT tag. Along with fork length information, the weights of captured bull trout will be used to assess the condition factor (K-factor) of fish residing in Lake Merwin, and excised fin rays will be utilized to age all captures.

Use of Alternative Capture Methods

PacifiCorp continues to consider more effective and less intrusive methods to collect bull trout from the Yale tailrace. Past alternative methods investigated include; beach seines, purse seines, drifting tangle nets when the powerhouse is online, and angling.

In 2016, tangle nets and angling were the only methods used. To date, tangle nets remain the most effective. PacifiCorp continues research on possible alternative methods of effective capture and transport. However, upon investigation of each concept or pilot test conducted at other Northwestern dams, PacifiCorp has not been successful in finding a better alternative than the current method.

Yale Netting Results

At the Yale powerhouse tailrace, three capture attempts were completed; June 15, July 15, and August 15 yielding eight bull trout. Of these eight captures, two were recaptures from Yale Reservoir capture activities as evidenced by PIT tags, and one individual expired during the capture and handling process. All captured bull trout after genetic lab analysis were found to be of Cougar Creek ancenstry and as such were transported and released into Yale Reservoir. Procedures concerning Reporting a bull trout mortality and Handling of the bull trout carcass per the USFWS Biological Opinion for the Lewis River were followed and adhered to.

Table 3.3.2-1. Number of bull trout collected from Yale tailrace (Merwin Reservoir) and transferred to the mouth of Cougar Creek (Yale tributary) or Swift Reservoir: 1995 – 2016.

YEAR	No. captured at the Yale tailrace	No. transferred to mouth of Cougar Creek	No. transferred to Swift Reservoir	No. released back into Merwin Reservoir	MORTALITIES
1995	15	9	0	6	0
1996	15	13	0	2	0
1997	10	10	0	0	0
1998	6	6	0	0	0
1999	6	0	0	6	0
2000	7	7	0	0	0
2001	0	0	0	0	0
2002	6	5	0	1	0
2003	19	8	0	1	10^
2004	8	3	0	5	0
2005	5	5	0	0	0
2006	5	5	0	0	0
2007	13	13	0	0	0
2008	15	15	0	0	0
2009	5	5	0	0	0
2010	1	0	0	0	1
2011	6	5	0	0	1
2012	3	3	0	0	0
2013	6	4	2	0	0
2014	0	0	0	0	0
2015	1	0	0	0	1
2016	8	7	0	0	1
TOTAL	**159**	**119**	**2**	**21**	**14**

^Please refer to the 2003 PacifiCorp Threatened and Endangered Species Monitoring Report for a description of mortalities

3.4 LEWIS RIVER BULL TROUT SPAWNING SURVEYS

3.4.1 FERC PROJECT LICENSE ARTICLE 402(B) AND LEWIS RIVER SETTLEMENT AGREEMENT SECTION 9.6 - COUGAR CREEK SPAWNING ESTIMATE

Since 1979, PacifiCorp biologists, along with various state and federal agencies, have conducted annual surveys to estimate spawning escapement of kokanee in Cougar Creek. Along with the kokanee, surveyors also count the number of bull trout and bull trout redds observed within the creek. In 2016, the Utilities conducted six Cougar Creek bull trout redd surveys from September 10 to October 29. Surveys begin at the mouth of the creek and end at the creek's spring source, a distance of approximately 2100 m.

Figure 3.4.1-1. GPS locations of bull trout redds in Cougar Creek in 2016. Each red dot represents an individual bull trout redd (n=12).

Due to the wide range use of redd counts to quantify bull trout spawner abundance, multiple research studies have been performed in an effort to gauge the precision of this methodology and also to question the efficacy of redd counts as a population estimator (Dunham et al. 2001, Muhlfeld et al. 2006). Most often, redd surveys are conducted in large river systems with multiple different observers. The large systems necessitate the need for index areas mainly due to time and logistical constraints. The use of indices has been questioned based on their reliance of fish coming back to the same area at the same time every year to spawn. In addition, the use of multiple observer teams and a variety of observers on the same project, is considered to cause inaccuracies based on the variability between observers' experience with identifying redds.

The redd count methodology employed within Cougar Creek differs from most large-scale redd surveys in that the stream is small enough to feasibly cover the entire length during each survey, and currently is the only known bull trout spawning stream in Yale Reservoir. Cougar Creek also lends itself nicely to these types of surveys in that the water is extremely clear and has stable flow for most of the survey period. Also, redd life, the amount of time a redd remains visible, has an exceptionally long duration. Most, if not all, observed redds remain visible during the entire time-frame of the surveys.

In 2016, biologists walked the entire 2100 m of Cougar Creek during each redd survey. Surveys are typically completed over an extended period of time to address potential error associated with spawn-timing, but due to a high water event that occurred on October 12 the stream became un-surveyable for the remainder of the spawning season leading to the latter half of the spawning curve not being captured. To alleviate inter-observer variability, all surveys in 2016 were performed by the same experienced biologists. Dunham et al. (2001) specified that a sampling effort should not rely on indices and should use the same surveyors as effective ways of improving the reliability of bull trout redd counts.

The real challenge of using bull trout redds to quantify the bull trout spawning population size lies in determining the relationship between redd counts and actual numbers of fish (Budy et al. 2003). Much past and present research has been conducted that attempts to correlate the number of spawning adult bull trout per redd. These numbers range widely by basin (1.2 to 4.3 fish per redd) and it seems the number of bull trout per redd is most likely basin or watershed specific. At this time, given that the exact number of bull trout that ascended Cougar Creek in 2016 to spawn is unknown, there is no reliable way to get an approximate number of fish per redd.

During each 2016 redd survey, new redds were flagged and identified by Global Positioning Satellite (GPS) coordinates. The date, location of redd in relation to the flag, and GPS coordinates were all written on the flagging (Figure 3.4.1-1). Subsequent surveys inspected each redd to see if they were still visible. If a redd was still visible, that information was written on the flagging with the date, until the redd was no longer visible, at which time this was noted on the flagging. Biologists also counted any bull trout observed within the vicinity of each redd.

12 individual bull trout redds were observed in Cougar Creek in 2016. Due to the high water event referenced above the survey period was truncated and surveys were only completed on two occasions, September 20 and October 11. These flood conditions persisted from October 12 through to the end of the spawning season making for unsafe redd survey conditions. Due to the shortened survey season, the 2016 dataset is considered incomplete and the 12 redds observed are the minimum number of redds created within the stream.

As in past years, all bull trout redds were observed in the upper half of the creek upstream of a log jam that in most years is impassable to kokanee (Figure 3.4.1-1).

A recent concern in Cougar Creek, first observed in 2008, are bull trout redds found to be superimposed over one another. During redd counts in 2016, no bull trout redds were observed superimposed over a previously excavated bull trout redd.

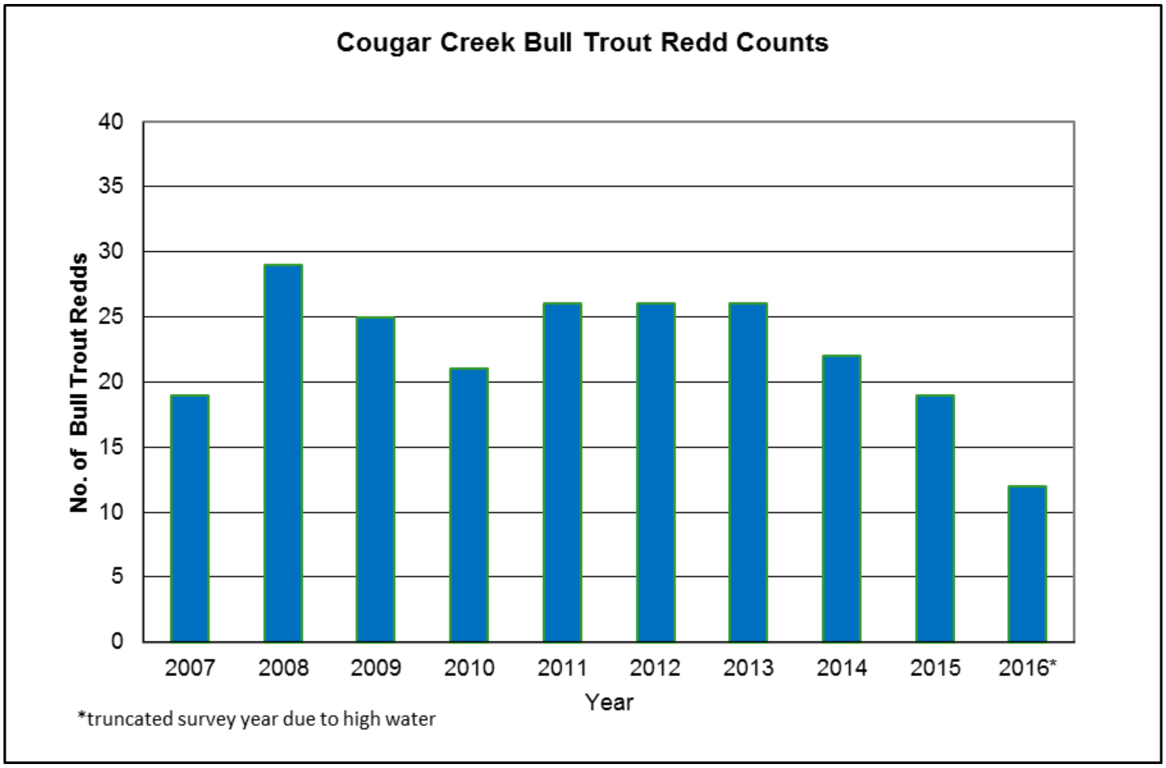

Figure 3.4.1-2. Annual Cougar Creek bull trout cumulative redd counts, 2007-2016.

3.4.2 Bull Trout Redd Surveys of Pine Creek, Pine Creek Tributary P8, and Rush Creek

P8

Tributaries to Pine Creek are counted from the mouth of Pine Creek upstream. P8 (Figure 3.4.2-1) is the eighth and largest of these tributaries. Based on surveys performed in 1999 and 2000 to document the extent of available anadromous fish habitat within the North Fork Lewis River basin, P8 contains approximately 6400 m of accessible anadromous fish habitat and has relatively low gradient for the first 1600 m. P8 is a relatively small stream, with an average wetted width of 3.5 m, but it contains abundant annual flow and cold water (PacifiCorp and Cowlitz PUD 2004).

Redd surveys (consistent with methodology utilized on Cougar Creek) were performed on Pine Creek tributary P8 twice during the 2016 bull trout spawning season, September 16 and October 3. Due to the same high water event referenced above in the Cougar Creek Redd Survey Section that occurred on October 12, surveys of the latter half of the spawning curve were not completed. In all, GPS coordinates were collected from 20 bull trout redds during the truncated survey period. Redds were observed and counted from the mouth of P8 to 2100 m upstream (Figure 3.4.2-1 and 3.4.2-3).

For the past two seasons spawning coho have been observed within P8 during bull trout spawning surveys. No coho or coho redds were observed within P8 in 2016. This likely was a function of the truncated survey season, as very few coho had been transported and released into

Swift Reservoir prior to the high water event on October 12 that ceased all subsequently planned surveys.

Pine Creek

Redd surveys on a 10-day rotation of all available spawning habitat within Pine Creek were planned for 2016. Due to the earlier referenced high water event that occurred on October 12, surveys encompassing the entire spawn timeframe were not completed. Prior to surveys being cancelled, the entire available spawning habitat was surveyed from September 19 – October 3, nine bull trout redds were marked by flagging and GPS during this time (Figure 3.4.2-1).

Rush Creek

It was also planned prior to the season to perform bull trout redd surveys within Rush Creek on the same 10-day rotation similar to Pine, P8, and Cougar creeks, but again and similar to those watersheds surveys became unsafe to perform after the October 12 high water event and remained as such through the rest of the bull trout spawn timeframe. Prior to the high water event Rush Creek was surveyed on September 21 and October 12, thirteen redds were observed and marked by flagging and GPS (Figure 3.4.2-2). Redd surveys were completed from the stream mouth upstream to the Forest Road 90 bridge, a distance of approximately 1,600 m.

Figure 3.4.2-1. GPS locations of bull trout redds in Pine and P8 creeks in 2016. Each red dot represents an individual bull trout redd (n=29).

Figure 3.4.2-2. GPS locations of bull trout redds in Rush Creek in 2016. Each red dot represents an individual bull trout redd (n=13).

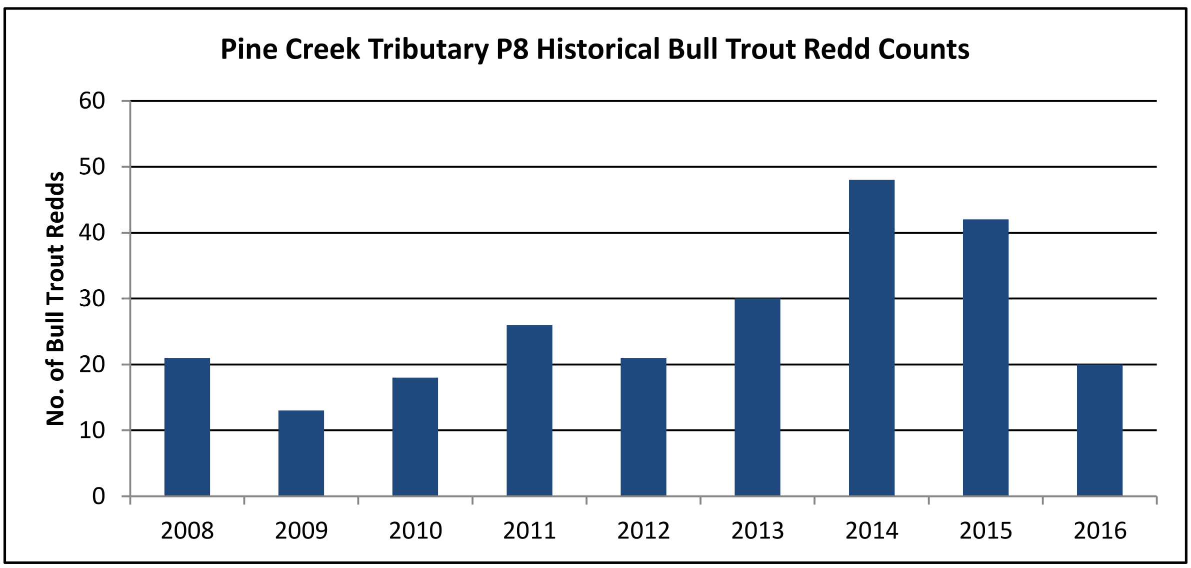

Figure 3.4.2-3. Pine Creek tributary P8 historical bull trout redd counts (2008 and 2009 data courtesy of WDFW).

3.5 BULL TROUT CONDITION FACTOR (K)

Since 2008, most captured bull trout encountered in the Lewis River basin have been weighed to the nearest gram (Map 2.0-1). The goal of gathering this additional biological information is to quantify the condition factor of bull trout in Merwin, Yale, and Swift reservoirs. This standardized information can then be utilized to compare the condition of reservoir bull trout populations from year to year. K-factor data may also offer insights into reservoir productivity and its potential influence on bull trout spawning migration frequency.

Condition factor is a simple weight-length relation that is generally thought to be one of several indices of healthy fish (Nielson and Johnson 1983). Fulton (1902) established the weight-length relation equation that was used to estimate K-factors in this study.

The Fulton-type equation used is as follows;

$K = (W/L^3)*X$

Where;

K = metric condition factor
W = weight in grams
L = length in millimeters
X = Arbitrary scaling constant (for our purposes 10^5 was used)

A hand-held scale was used to weigh fish during Lewis River basin netting activities. To weigh bull trout, a landing net or water-filled bucket was attached to the hand-held scale, the scale was allowed to tare to zero, a bull trout was placed in the landing net or water-filled bucket, and the weight was recorded to the nearest gram. The entire time bull trout were out of water if weighed with a landing net was normally under 10 seconds. When feasible, bull trout were weighed on land. While in a boat, calm coves were sought out but a measure of inaccuracy was unavoidable due to the pitch and roll of the boat in response to wave action. Biologists felt this inaccuracy was acceptable if it alleviated any added undue stress to the captured bull trout due to over-handling or length of holding time.

A total of 101 bull trout were weighed from Merwin, Yale and Swift reservoirs in 2016. Of those fish, 70 were from Swift Reservoir, 24 from Yale Reservoir, and seven from Merwin Reservoir (not all captured bull trout were weighed in 2016 due to the occasional lack of available equipment).

For salmonids, K-factor values usually fall between 0.8 and 2.0 (Nielson and Johnson 1983). A K-factor scale was used to filter the data and to help analyze the values for comparison. The scale is based on direct visual observations of all weighed bull trout within the North Fork Lewis River basin to date, and may adaptively change in the future with the input of additional data. The scale used is as follows:

- less than 0.99 = Poor
- 1.00 – 1.19 = Fair
- 1.20 – 1.39 = Healthy
- greater than 1.40 = Exceptional

Figure 3.5-1 represents the percent distribution of weighed bull trout occurrences in the above mentioned K-factor scale. Bars in the graph are divided to represent bull trout from each sampling area. Figure 3.5-2 represents condition factors and their correlation to the corresponding fork length for all measured fish (n=101). The regression line indicates a slight statistical correlation existed in 2016 between fish length and condition factor; though not on the magnitude that was expected or observed in prior years, the larger size-class bull trout exhibited a slightly higher condition factor than the smaller size-class fish (Figure 3.5-2).

Median condition factor values were 1.25 for fish sampled in Yale Reservoir, and 1.11 for fish sampled in Swift Reservoir. When comparing numeric fish condition factors, care needs to be taken to only compare fish of like fork lengths (Anderson and Gutreuter 1983). Figure 3.5-3 compares bull trout lengths to weights recorded and the corresponding curve established by this relationship.

To quantify variation within the 2016 condition factor data-set, the coefficient of variation (%CV) was computed and represented in percent format. Coefficient of variation is the standard deviation of a sample divided by the arithmetic mean; this number is then multiplied by 100 to convert to percent CV. The coefficient of variation from the entire bull trout condition factor sample in 2016 was 13.9 percent. Figures 3.5-4 and 3.5-5 are historical comparisons of collected Condition Factor data grouped by reservoir.

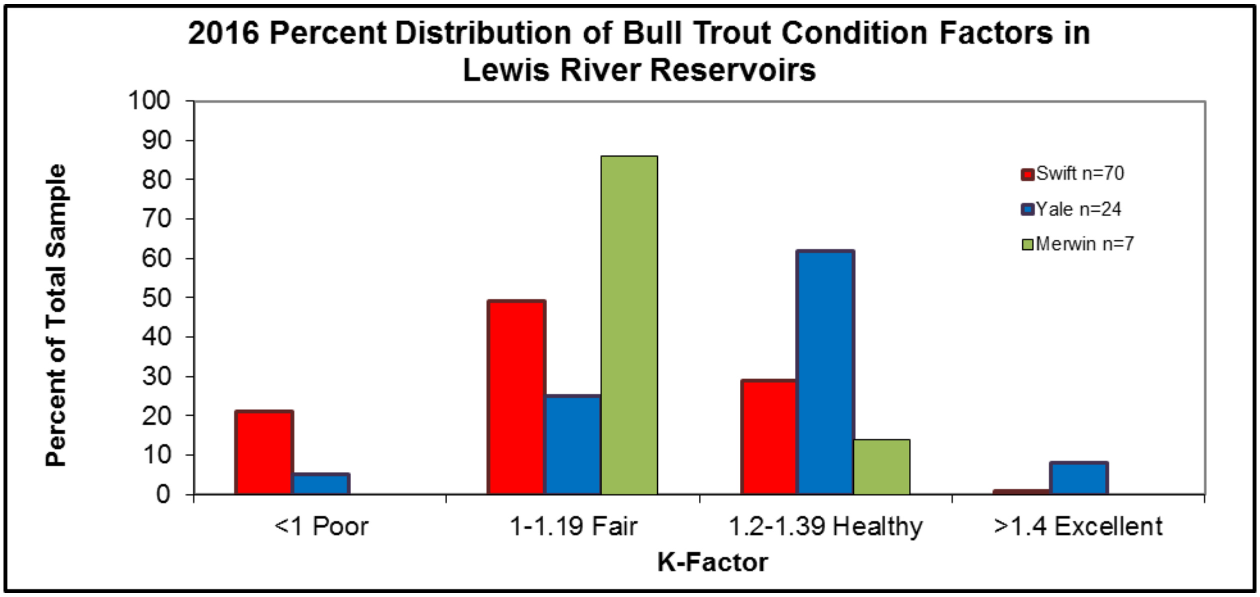

Figure 3.5-1. Percent distribution of all weighed bull trout in 2016 over established Lewis River condition factor scale.

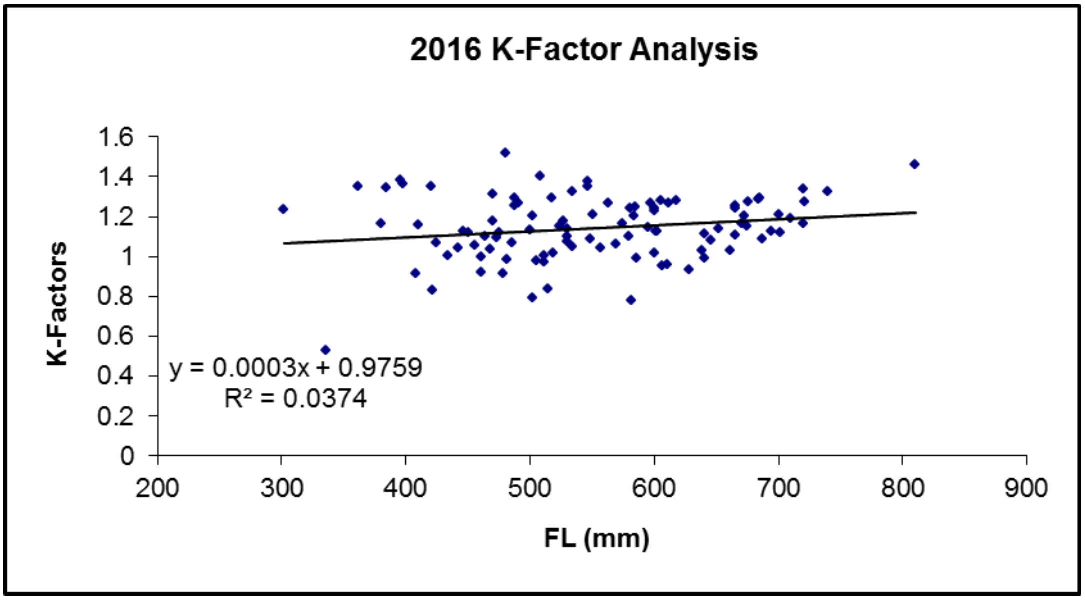

Figure 3.5-2. Individual bull trout condition factors in relation to corresponding fork lengths for entire sample from all sample areas combined in 2016.

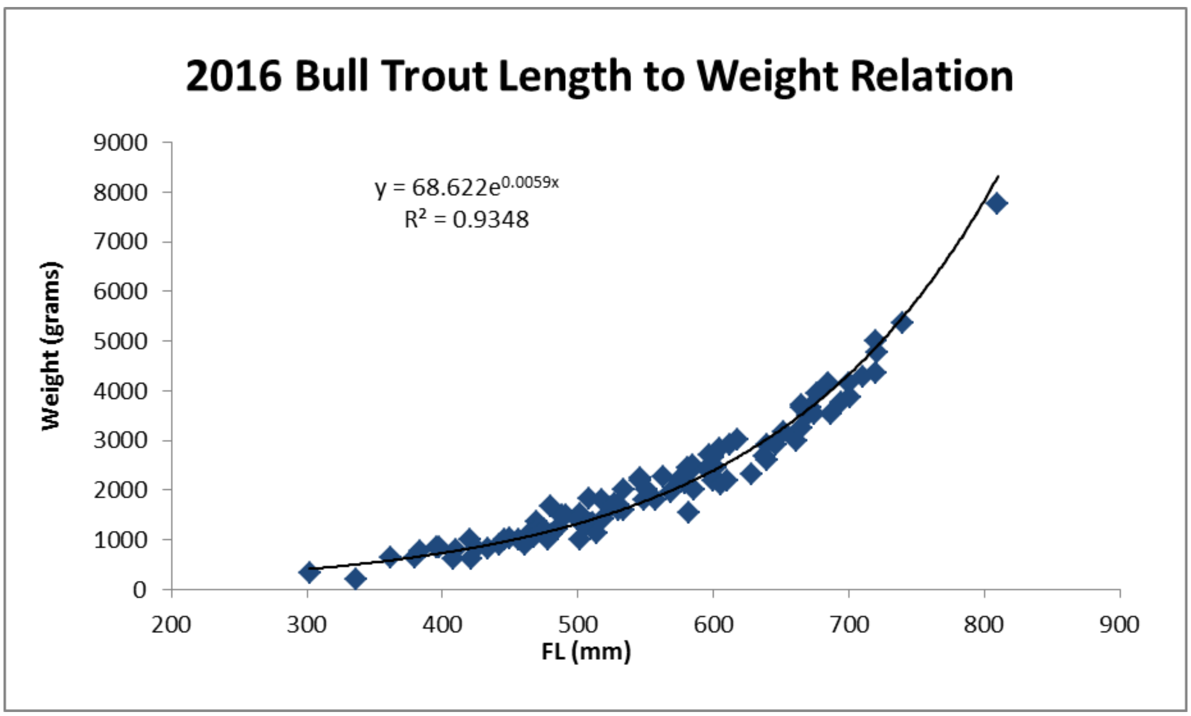

Figure 3.5-3. Bull trout length to weight relation curve observed in 2016. Each dot represents an individual fish (n=101).

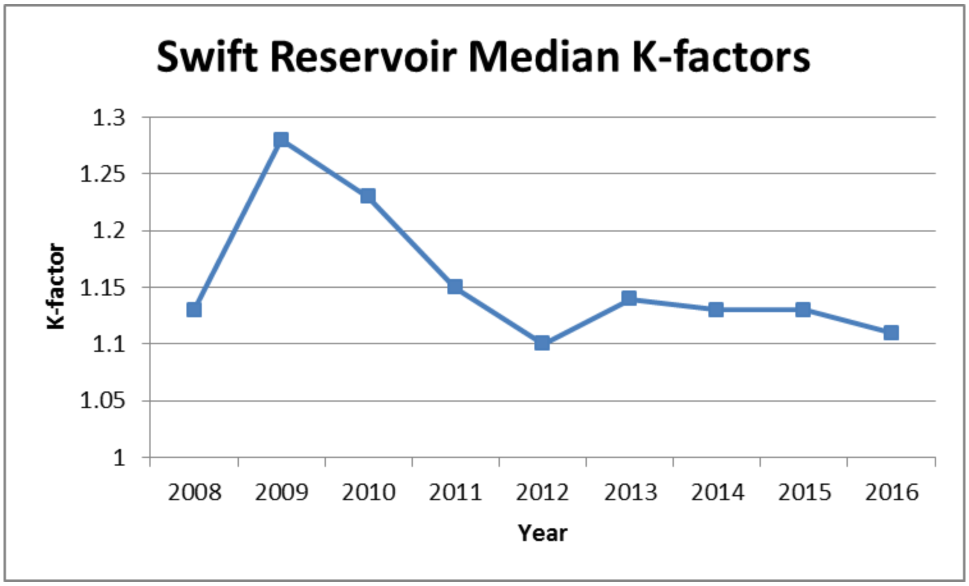

Figure 3.5-4. Historical median K-factors observed from bull trout within Swift Reservoir.

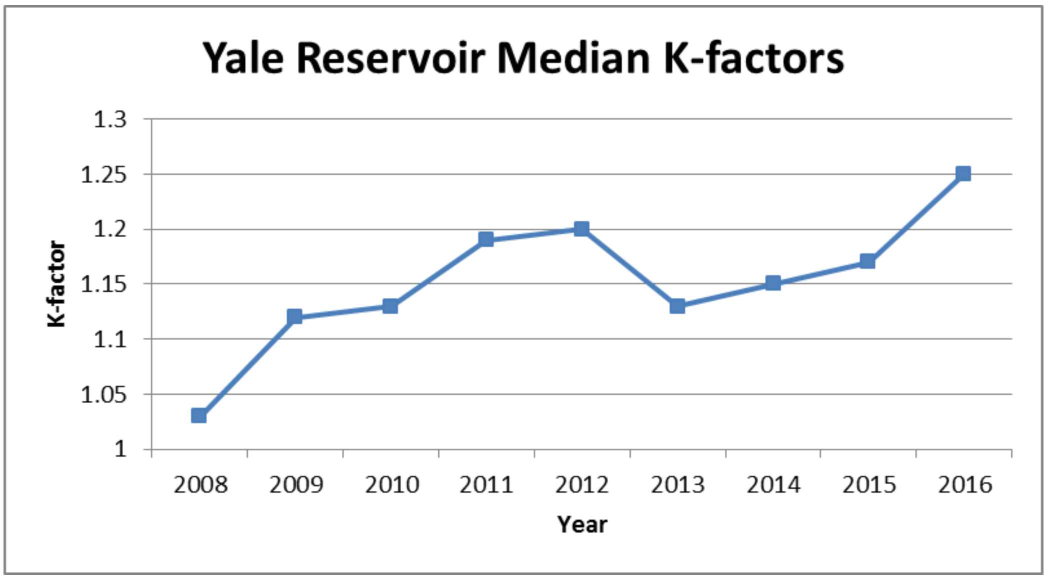

Figure 3.5-5. Historical median K-factors observed from bull trout within Yale Reservoir.

4.0 DISCUSSION

As directed in Article 402 of the Federal Energy Regulatory Commission issued operating licenses for Merwin, Yale, Swift No.1, and Swift No.2 hydroelectric projects (issued June 26, 2008) and pursuant to Section 9.6 and 4.9 of the Lewis River Settlement Agreement, and Objective 17 of the Monitoring and Evaluation Plan the Utilities are to monitor bull trout populations in Swift Reservoir and Yale Reservoir annually as well as annually capture and transport bull trout from the Yale powerhouse and Swift No.2 tailrace areas. The Utilities collected the data contained in this Report to accomplish these mandated monitoring objectives.

The estimated number of bull trout that staged in the Eagle Cliffs area at the head of Swift Reservoir in the spring/summer and then migrated upstream the North Fork Lewis River in the summer/fall increased over the previous year in 2016. This number is likely grossly over-estimated and given the breadth within the upper bound 95 percent confidence interval (almost +/-400 of 753), caution should be taken when evaluating. The uncertainty surrounding the migration estimate in 2016 stems from the lack of marked individuals observed during re-sight surveys. Though 62 bull trout were marked with double green Floy® tags at Eagle Cliffs in the early summer, it seems very few of these fish actually left the marking area and ventured upstream in the late summer/early fall as evidenced by the high mark to no-mark ratio observed during snorkeling surveys (average of 1 mark to 13 no marks, or seven percent of total observed sample marked). High observer error during snorkeling surveys was no longer considered an issue after review of 2016 PIT antenna detections revealed that only 17 percent (11 of 62) of bull trout Floy® tagged during 2016 activities actually migrated past an antenna located at either Pine, P8, or Drift during the sampling period (August – October. Due to rampant equipment malfunction, the Rush Creek PIT antenna captured no data in 2016 and thus the 11 in year migrants is considered a minimum).

At this time the specific reason for lack of 2016 Floy® marked bull trout to the re-sight area or spawning tributary's is unknown. Based off of this same lack of migration of in-season tagged fish observed in 2015, changes were made to the tagging program in 2016 to only incorporate larger sized bull trout, 450 mm in fork length or greater. It was hoped that by not Floy® tagging bull trout less than 450 mm that this would exclude sexually immature fish that may have had no intention of migrating to the spawning grounds. It appears that the greater tagging size did not help as intended. According to PIT antenna detections in 2016, only 17 percent of tagged fish from Eagle Cliff this year actually migrated to the spawning grounds, this is very similar to the observed 19 percent in-season tagged migration in 2015. The 17 percent in-year tagged migration is likely skewed low as it only incorporates antenna detections from Pine, P8, and Drift and not Rush Creek.

To further investigate the issue of non-migrating large bull trout tagged during Eagle Cliff sampling, Dr. Robert Al-Chokhachy from the United States Geological Survey analyzed all historic PIT antenna detections and the fishes corresponding Eagle Cliff capture information. What he found was that handling seemed to play a significant role in tagged bull trout's migration patterns from one year to the next, especially with fish handled multiple times during the same season. Data strongly suggested in-year recaptures, of which there were 13 in 2015 and 29 in 2016, delayed their spawning migration by one or more years from the time of handling when compared to fish handled only once during Eagle Cliff sampling. From this analysis it appears over-handling of bull trout at Eagle Cliff in the spring and early summer does indeed play a role and influence the rate at which they migrate later in the fall. For additional analysis of migration rates of Eagle Cliff tagged bull trout as well as methods please see “Bull Trout Monitoring Studies in the NF Lewis” (Al-Chokhachy, 2017) located in Appendix C of this Report.

Data for a genetic estimation of the Effective Number of Breeders (Nb) was again collected in 2016, and the 2016 USFWS Lewis River Genetic Annual Report detailing methods, materials, and analysis of collected juvenile bull trout fin-clips can be found in Appendix D of this Report.

PIT antenna detection data in 2016 was analyzed for bull trout Survival (S), migration timing, and stream utilization. Unfortunately, due to pervasive equipment malfunction, no data was gathered from the passive PIT antenna deployed within Rush Creek in 2016. The interrogation season was cut short at all other deployed antennas as well in 2016 due to a high water event that occurred the first week of October that wiped out all in-stream wire loops, no detections were recorded after this event. This fact made it difficult in 2016 to assess and compare spawning stream usage between Pine and Rush creeks and also lead to one of the lowest detection years on record in terms of individual fish interrogated. A more detailed analysis of PIT antenna detections as they correlate to an estimate of Survival (S) from one year to the next, as well as the probability that an individual fish will make a spawning excursion can be found in “Bull Trout Monitoring Studies in the NF Lewis” (Al-Chokhachy, 2017) located in Appendix C of this Report.

Bull trout captures in the Yale powerhouse tailrace increased significantly in 2016 (8) over 2015 (1). Capture methods (tangle nets) were similar to past collection years, but total effort days in 2016 (3) tapered off from typical historical effort days (5) . New methodologies to capture these fish continue to be investigated, though at this time tangle nets remain the most effective and efficient. With the construction in late 2009 of the Yale Entrainment Reduction Net, and the Yale Spillway Entrainment Reduction Net in 2013, pursuant to section 4.9.3 of the Lewis River Settlement Agreement, capture numbers of bull trout in the Yale powerhouse tailrace are anticipated to continue to remain low. It is assumed though that a portion of fish will continue to volitionally migrate downstream during spill events. Two of the 2016 Yale tailrace captures were recaptures from activities upstream in Yale Reservoir and likely moved downstream during the large spill event that occurred in December 2015. The Yale Spillway Entrainment Reduction Net is only effective up to 5,000 cubic feet per second spill, any spill greater than 5,000 cubic feet per second triggers the net to be lowered. The spill in December 2015 reached a maximum of 21,000 cubic feet per second.

Collection and tagging methods within the Swift Bypass Reach continued relatively unchanged in 2016. Unless of known genetic origin from a previous capture, all captured Swift Bypass Reach bull trout in 2016 were held in circular tanks at Merwin Hatchery while rapid response genetic analysis was performed. Bull trout that scored high enough in a Likelihood of Origin Analysis (greater than 99 percent) to a Swift Reservoir population (or combination thereof) were transported upstream and released into Swift, while bull trout that did not meet the scoring criteria were released back into Yale Reservoir. Capture numbers in 2016 (24) were consistent with what has been encountered in recent years. 5 of the 24 Swift Bypass Reach bull trout captures, after analysis, were found to be endemic to a Swift Reservoir local population (all five scored highly to Pine Creek) and were transported and released into Swift Reservoir. The remaining nineteen captures were either endemic to the Cougar Creek local population, or did not score high enough in the Likelihood of Origin analysis to Rush or Pine Creek and were released back to Yale Reservoir.

Comprehensive bull trout redd counts were planned in 2016 for Cougar, P8, Pine, and Rush creeks. Surveys were to occur on a 10-day rotation and encompass the entire spawn timeframe. Most surveys began in mid-September and continued until early October when early fall storms brought record rainfall to the area for an extended period of time. The record rainfall led to extremely high run-off and rivers that remained at or near flood stage through the entire month of October and into November. The high water led to unsafe redd survey conditions and all surveys ceased on October 12. The latter half of the bull trout spawn curve was not surveyed in 2016 and as such the 2016 bull trout redd dataset is unfortunately incomplete.

Weights of most handled bull trout were again collected in 2016. Individual weights were then compared to corresponding fork lengths and fish condition factors were assigned. Due to the low catch numbers encountered this spring and summer during Eagle Cliffs netting, the number of weights recorded in Swift Reservoir in 2016 (70) remained low and comparable to 2015 (64). The number of weights recorded in Yale Reservoir in 2016 (24) was also comparable to that recorded in 2015 (22). An uptick in catch at the Yale tailrace allowed condition factors to be gathered from bull trout residing within Merwin Reservoir for the first time in three years, where a total of seven bull trout lengths and weights were taken. When the calculated condition factors of like-sized individuals were compared, the year 2016 showed a slight increase in overall bull trout condition factor in Yale; while Swift exhibited a slight decrease in overall median condition. Median values observed in Swift Reservoir in 2016 (1.11) dipped slightly to what was observed in 2015 (1.13); while Yale for the third year in a row showed an increase over the previous year with fish handled in 2016 exhibiting a median condition factor of 1.25 compared to 1.17 in 2015. Bull trout handled from Merwin Reservoir during 2016 activities had median condition factors of 1.16. It is anticipated that condition factor information may offer insight into reservoir productivity as it relates to bull trout, and the overall health of individual bull trout. This information can then be related to how fish condition may affect bull trout behavior especially in terms of reproduction and year-to-year spawning behavior.

5.0 ACKNOWLEDGEMENTS

The Utilities would like to thank Dr. Robert Al-Chokhachy from USGS for his analysis of bull trout PIT tag data and subsequent Survival and abundance estimates. As well as Jim Byrne from WDFW for his assistance in the Swift Reservoir migration estimate data analysis.

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APPENDIX A

2016 EAGLE CLIFF CAPTURE RAW DATA

Floy tagged Capture #	DATE	LENGTH (mm)	FLOY COLOR	FLOY No.	PIT	REMARKS	Weight (grams)	Genetic Vial #	Fin ray Card #	Capture Method
1	5/5/2016	534	Green	1/2	3DD003BC96B48	no HDX tags on boat	1600	TN 15-082	1	Angling
2	5/5/2016	602	Green	3/4	3DD003BC96B5E	h2o 9.5	2460	TN 15-083	2	Angling
3	5/11/2016	600	Green	5/6	AC7766A	h2o 7.7	2200	TN 15-084	3	Angling
4	5/11/2016	488	Green	7/8	AC7766B		1500	TN 15-086	4	Angling
4	5/11/2016	418	too small		AC7766C			TN 15-087	5	Angling
4	5/11/2016	442	too small		AC7766D		900	TN 15-088	6	Angling
5	5/11/2016	605	Green	9/10	A89AF2F	RECAP Chartreuse 33	2840		7	Angling
6	5/11/2016	740	Green	11/12	AC7766E		5360	TN 15-089	8	Drift net
7	5/11/2016	672	Green	13/14	AC7766F		3660	TN 15-090	9	Drift net
8	5/24/2016	491	Green	15/16	AC77629	RECAP Pink 9/10	1500		10	Drift net
9	5/24/2016	597	Green	17/18	AC77524	RECAP Pink 97/98	2700		11	Drift net
10	5/24/2016	618	Green	19/20	AC7765B	RECAP Pink 111/112	3020		12	Drift net
11	5/24/2016	646	Green	21/22	AC77604	RECAP Yellow 71/72. Large sucker in throat			13	Drift net
12	5/24/2016	549	Green	23/24	AC775A8	RECAP	1800		14	Drift net
13	5/24/2016	810	Green	25/26	AC3562A	RECAP Yellow 9/10	7760		15	Drift net
14	5/24/2016	710	Green	27/28	AC775F1	RECAP Pink 23/24	4270		16	Drift net
15	5/24/2016	470	Green	29/30	AC77672		1360	TN 15-091	17	Drift net
16	5/24/2016	502	Green	31/32	AC77674		1520	TN 15-092	18	Drift net
16	5/24/2016	396	too small		AC77673		860	TN 15-093	19	Drift net
16	5/24/2016	362	too small		AC77675		640	TN 15-094	20	Drift net
16	5/24/2016	398	too small		AC77676		860	TN 15-095	21	Angling
17	5/24/2016	470	Green	33/34	AC77677		1220	TN 15-096	22	Drift net
17	5/24/2016	384	too small		AC77678		760	TN 15-097	23	Drift net
17	5/24/2016	420	too small		AC77679		1000	TN 15-098	24	Drift net
17	5/31/2016					RECAP this year Green 9/10				Drift net
18	5/31/2016	453	Green	35/36	AC7767E	h2o 11.3		TN 15-099	25	Drift net
19	5/31/2016	664	Green	37/38	AC7758B	RECAP			26	Drift net
20	5/31/2016	720	Green	39/40	AC77680		5000	TN 15-100	27	Drift net
21	5/31/2016	670	Green	41/42	A0F6576	RECAP Pink 65	3500		28	Drift net
22	5/31/2016	557	Green	43/44	AC7760A	RECAP Yellow 83	1800		29	Drift net
23	5/31/2016	582	Green	45/46	AC7767D	Blind in one eye	1540	TN 15-101	30	Drift net
24	5/31/2016	579	Green	47/48	AC7753D	RECAP Yellow 45/46	2140		31	Drift net

25	5/31/2016	665	Green	49/50	AC775CC	RECAP Yellow 101	3700		32	
26	5/31/2016	551	Green	51/52	AC77601	RECAP Yellow 55/56	2020		33	
26	5/31/2016	302	too small		AC7767B		340	TN 15-102	34	
26	5/31/2016	282	too small		3DD000BC96B62					
26	5/31/2016	348	too small		AC7767A			TN 15-103	35	
27	5/31/2016	481	Green	53/54	3DD0003BC96830 & AC7767F	RECAP Pink 31/32. Double PIT	1100		36	
28	5/31/2016	475	Green	55/56	AC7767C		1200	TN 15-104	37	
29	5/31/2016	473	Green	57/58	AC77681		1160	TN 15-105	38	
30	5/31/2016	500	Green	59/60	AC77682		1420	TN 15-106	39	
31	5/31/2016	640	Green	61/62	AC35633	RECAP Orange 117/118	2600		40	
32	5/31/2016	612	Green	63/64	AC775B4	RECAP Yellow 36. Sucker in throat			41	
33	5/31/2016	586	Green	65/66	AC77648	RECAP Pink 77	2000		42	
34	6/2/2016	511	Green	67/68	3DD0003BC9685 C & AC77687	RECAP Pink 29/30. Double PIT	1300		43	Angling
34	6/2/2016		Green			RECAP this year Green 7/8				Drift net
35	6/2/2016	638	Green	69/70	AC35668	RECAP	2680		44	Drift net
36	6/2/2016	694	Green	71/72	AC77688	h2o 10.5	3760	TN 15-107	45	Drift net
37	6/2/2016	485	Green	73/74	AC77689		1220	TN 15-108	46	Drift net
38	6/2/2016	461	Green	75/76	AC77631	RECAP Pink 33/34	980		47	Drift net
38	6/2/2016	434	too small		AC7768A		820	TN 15-109	48	Drift net
39	6/2/2016	464	Green	77/78	AC77637	RECAP Pink 43	1100		49	Drift net
39	6/8/2016		Green			RECAP this year Green 31/32				
39	6/8/2016		Green			RECAP this year Green 9/10				
39	6/8/2016		Green			RECAP this year Green				
39	6/8/2016		Green			RECAP this year Green				
39	6/8/2016		Green			RECAP this year Green				
39	6/8/2016	408	too small		AC7768E		620	3140-100	50	
40	6/8/2016	569	Green	79/80	AC7768F		1960	3140-099	51	
41	6/8/2016	601	Green	81/82	AC7768D		2440	3140-098	52	
42	6/8/2016	640	Green	83/84	A0F6557	RECAP. Fins few and far between, no fin ray sample taken	2920			
43	6/8/2016	530	Green	85/86	AC7768B		1700	3140-097	53	
44	6/8/2016	534	Green	87/88	AC77620	RECAP Yellow 93/94	2020		54	
44	6/17/2016		Green			RECAP this year Green 43/44				
44	6/17/2016		Green			RECAP this year Green 83/84				
44	6/17/2016		Green			RECAP this year Green 51/52				

44	6/17/2016		Green			RECAP this year Green 73/74				
44	6/17/2016		Green			RECAP this year Green 77/78				
44	6/17/2016	336	too small		AC7768C	h2o 9.1	200	TN 15-110	55	
44	6/17/2016	425	too small		AC77693		820	TN 15-111	56	
45	6/17/2016	519	Green	89/90	AC77694		1420	TN 15-112	57	
46	6/17/2016	461	Green	91/92	AC77695		900	TN 15-113	58	
47	6/17/2016	508	Green	93/94	AC77696					
48	6/17/2016	511	Green	95/96	AC77697		1340	TN 15-114	59	
49	6/17/2016	628	Green	97/98	A0F6575	RECAP White 87	2320		60	
49	6/17/2016	421	too small		AC77698		620	TN 15-115	61	
50	6/17/2016	606	Green	99/100	AC77699		2120	TN 15-116	62	
51	6/17/2016	646	Green	101/102	AC7769A		2920	TN 15-117	63	
52	6/17/2016	502	Green	103/104	AC35630	RECAP Pink 6	1000		64	
53	6/17/2016	610	Green	105/106	AC775C7	RECAP Pink 7	2180		65	
53	6/17/2016		Green			RECAP this year Green 85/86				
53	6/17/2016		Green			RECAP this year Green 63/64				
54	6/17/2016	450	Green	107/108	AC77647	RECAP Pink 75/76	1020		66	
55	6/17/2016	446	Green	109/110	AC7769B		1000	TN 15-118	67	
56	6/17/2016	524	Green	111/112	AC7769C		1660	TN 15-119	68	
56	6/23/2016		Green			RECAP this year Green 91/92				
56	6/23/2016		Green			RECAP this year Green 83/84				
56	6/23/2016		Green			RECAP this year Green 63/64				
56	6/23/2016		Green			RECAP this year Green 93/94				
56	6/23/2016		Green			RECAP this year Green 73/74				
56	6/23/2016		Green			RECAP this year Green 78, missing 79, added 200				
57	6/23/2016	478	Green	113/114	AC7769F	h2o 11.2	1000	TN 15-119	69	
58	6/23/2016	505	Green	115/116	AC77656	RECAP	1260	TN 15-120	70	
59	6/23/2016	468	Green	117/118	AC776A0		1060	TN 15-121	71	
60	6/23/2016	530	Green	119/120	AC776A1		1640	TN 15-122	72	
61	6/23/2016	687	Green	121/122	A89AF7E	RECAP Pink 113/114	3520		73	
61	6/30/2016		Green			RECAP this year Green 51/52				Angling
61	6/30/2016		Green			RECAP this year Green 33/34				Angling

61	6/30/2016		Green			RECAP this year Green 79/80				Angling
61	6/30/2016		Green			RECAP this year Green 121/122				Angling
61	6/30/2016		Green			RECAP this year Green 19, missing 20, added 123				Angling
61	6/30/2016	410	too small		AC776A8		800	TN 15-124		Angling
62	6/30/2016	600	Green		AC776A7		2680	TN 15-123		Angling

APPENDIX B

2016 SWIFT BYPASS REACH RAW DATA

Date	F.L. mm	NEW PIT #	Recap PIT #	Genetic Vial #	Weight (grams)	Comments	Transported?	Fin ray card	Genotypic Sex	Local Pop.
5/23/2016	684		AC35639		4120	RECAP, Yale origin, released. Set net	Yale	Y1		Cougar
5/23/2016	585	AC77671		TN 15-162	2500	Set net	Yale	Y2	Male	Cougar
5/23/2016	685		AC7764A		4160	RECAP, Yale origin, released. Set net	Yale	Y3		Cougar
5/23/2016	508		AC77622		1840	RECAP, Yale origin, released. Set net	Yale	Y4		Cougar
6/1/2016	514	AC77683		3140-001	1140	Angling. MORT, jumped out of holding tank at hatchery	MORT	Y5	Female	Pine
6/1/2016	584	AC77684		3140-002	2400	Angling	Swift	Y6	Female	Pine
6/1/2016	480	AC77686		3140-003	1680	Angling	Swift	Y7	Female	Pine
6/6/2016						No bull trout captures. Found carcass of PIT # A89AF3D				
6/13/2016	676		AC7764C		3940	RECAP, Yale origin, released. Set net	Yale	Y8		Cougar
6/13/2016	546	AC77690		3140-004	2240	Set net	Yale	Y9	Male	Cougar
6/13/2016	530	AC77691		3140-005	1600	Set net	Yale	Y10	Male	Cougar
6/20/2016	721	AC7769D		3140-007	4780	Set net. Fish stressed, released.	Yale	Y11	Male	Pine
6/20/2016	665		AC77611		3260	RECAP, Yale origin, released. Angling	Yale	Y12		Cougar
6/20/2016	581	AC7769E		3140-008	2440	Angling	Swift	Y13	Female	Pine
6/27/2016	518	AC776A2		3140-009	1800	Angling. MORT, died in hatchery holding tank	MORT	Y14	Male	Cougar
6/27/2016	488	AC776A3		3140-010	1460	Set net	Yale	Y15	Female	Cougar
6/27/2016	600	AC776A4		3140-011	2660	Set net	Swift	Y16	Male	Pine
6/27/2016	595	AC776A5		3140-012	2420	Angling	Swift	Y17	Female	Pine
6/27/2016	456	AC776A6		3140-013	1000	Angling	Swift	Y18	Male	Pine
7/11/2016	612		AC7764D		2900	Net at confluence	Yale	AC7764D		Cougar
7/11/2016	652		AC7765A		3160	Net at confluence	Yale	AC7765A		Cougar
7/11/2016	546	AC776A9		3140-014	2200	Net at confluence	Yale	AC776A9	Female	Cougar
7/25/2016	665	AC777AD		3140-018	3660		Yale	AC776AD	Female	Cougar
7/25/2016	527	AC776AE		3140-019	1720		Yale	AC776AE	Female	Cougar
7/25/2016	563	AC776AF		3140-020	2260		Yale	AC776AF	Female	Cougar

APPENDIX C

MEMO: "BULL TROUT MONITORING STUDIES IN THE NF LEWIS"
DR. ROBERT AL-CHOKHACHY, UNITED STATES GEOLOGICAL SURVEY

Bull trout monitoring studies in the NF Lewis

Robert Al-Chokhachy (USGS), Jeremiah Doyle (PacifiCorp), Jim Byrne (DFW)

USGS
science for a changing world

Objectives

- Utilize existing mark-recapture data to estimate survival, movement patterns, abundance
- Evaluate monitoring approach-means for improvement, effects on bull trout, etc.

Approach

- Movement
  - Marking data at Eagle Cliff
    - Drift gill nets and angling
  - Antenna data
    - Pine/P8, Rush

- Proportion of populations spawning in different tributaries
- Age at migration for inference of sexual maturity
- Are movement patterns influenced by handling at Eagle Cliff?

Approach

- Survival analyses
  - Separate analyses (Yale and Swift)
  - Swift
    - Used only tagging information
      - Floy tags and PIT-tags (1997-2016)
      - Cormack Jolly Seber (CJS) model
    - Marking and antenna data (Pine, P8, Muddy, Rush)
      - Barker model (Al-Chokhachy et al. 2008; Bowerman et al. 2013)
        - » Are animals detected alive in between annual marking events
          - Collector, antenna data, etc.
      - 2011 - 2016

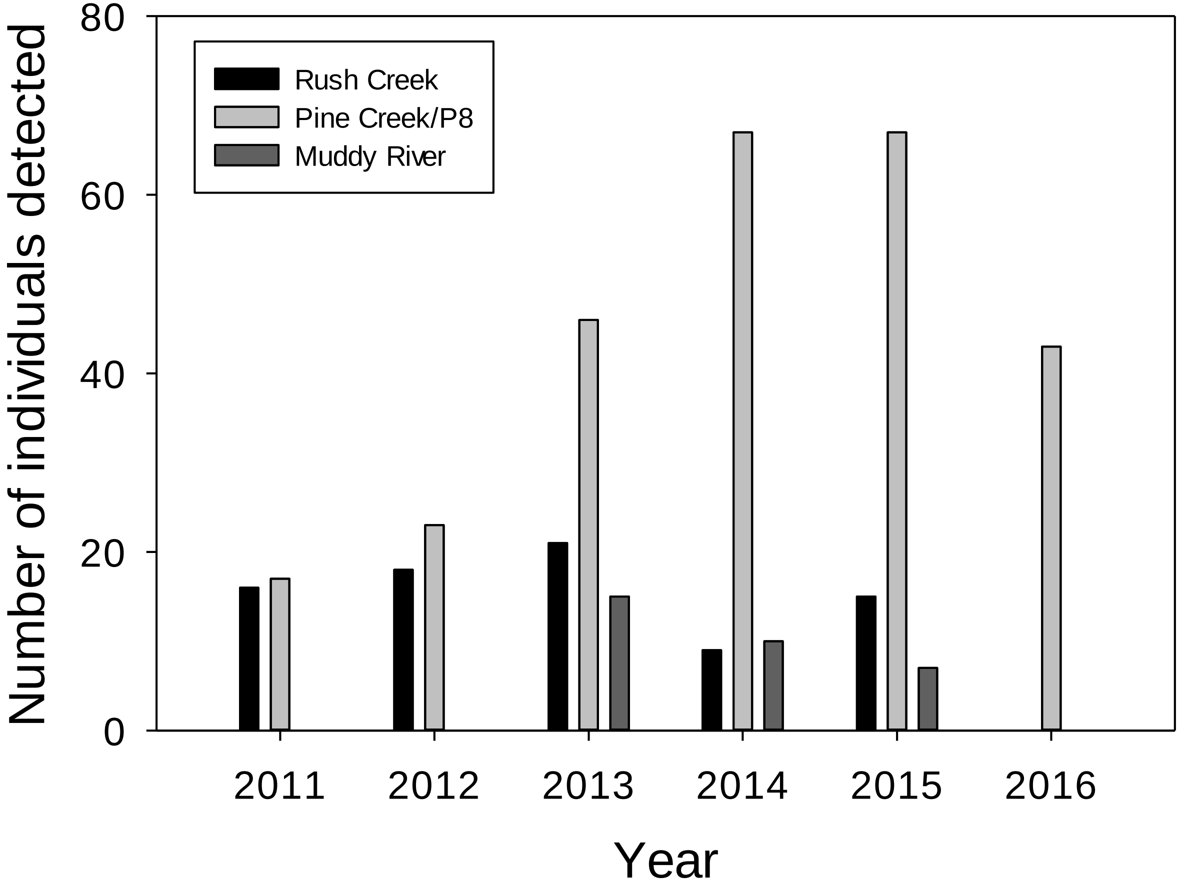
Approach

- Survival analyses
  - CJS
    - Estimates of apparent survival only (phi)
      - Does not include emigration
      - Fish is undetected (capture probability or mortality)
      - Estimates biased low
  - Barker model
    - Estimates of “true” survival (S)
      - Emigration is estimated
    - Higher estimates than CJS

Abundance

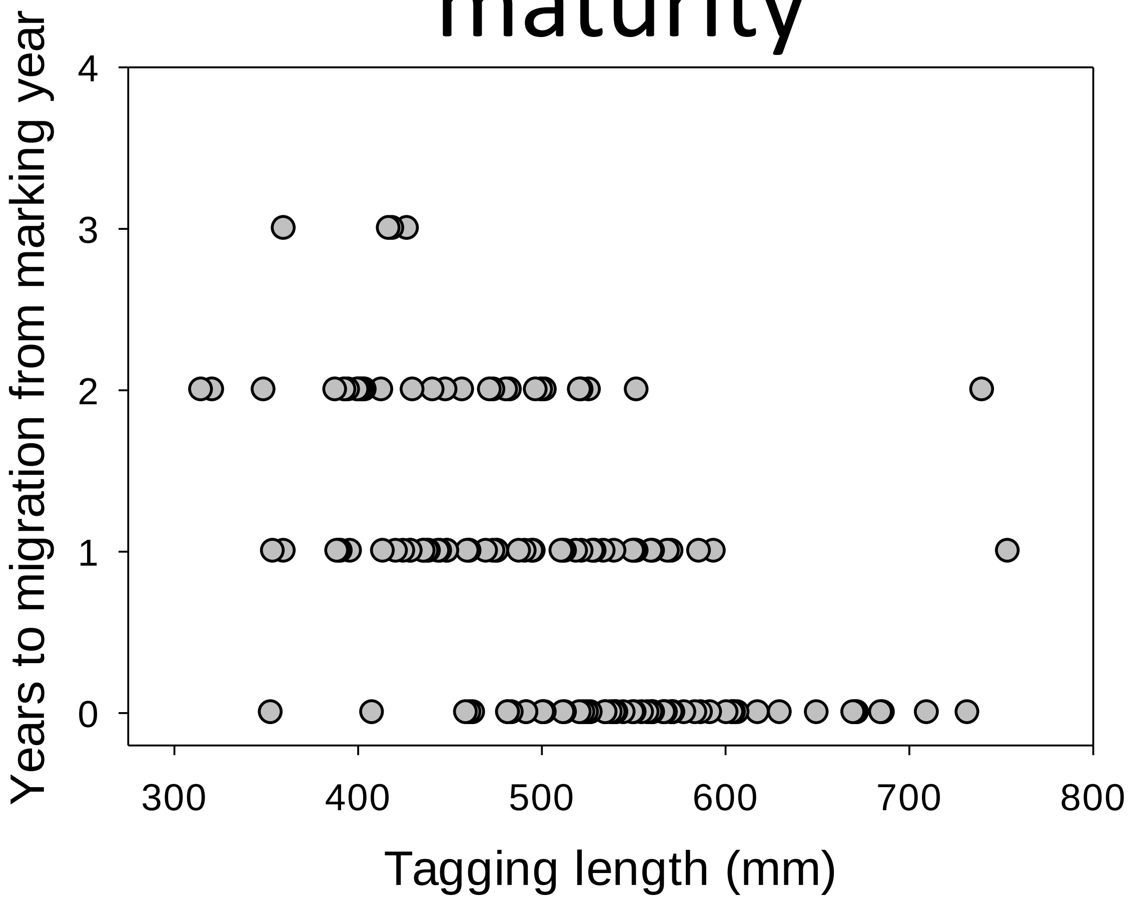
- Survival analyses
  - Separate analyses (Yale and Swift)
  - Swift
    - CJS
    - Barker
  - Yale
    - Bypass sampling, Cougar antenna, etc.
    - Barker only (2010 – 2016)

Results: movement



- Spatial distribution
  - Equal proportion during 2011, 2012
  - Since 2012, majority of population (marked) are spawning in Pine/P8 (~80% of individuals detected at antennas)

Results: movement and age of maturity



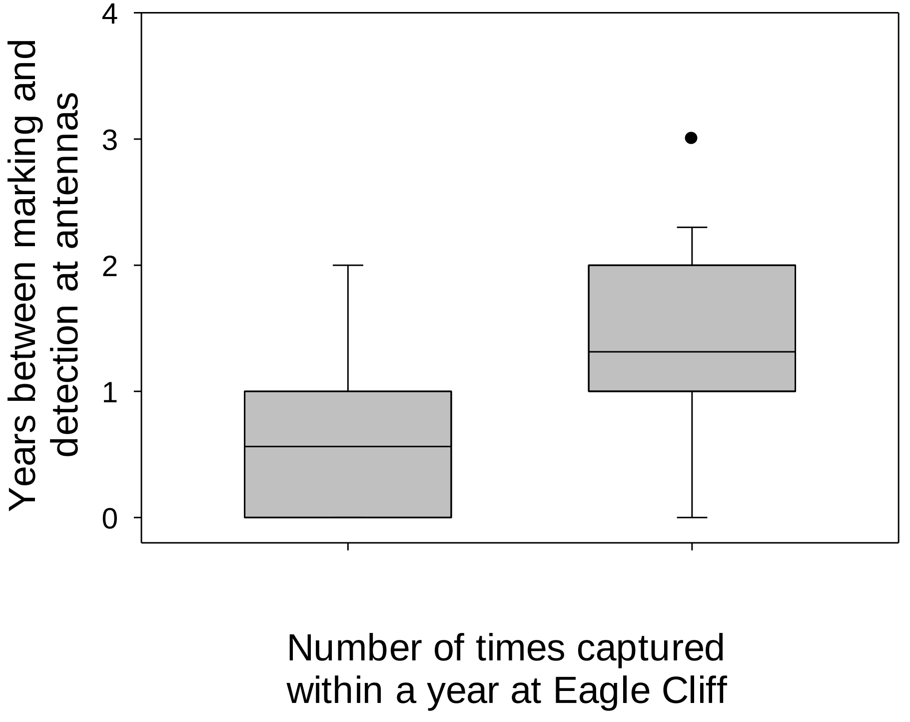
- Movement and inference of sexual maturity
  - Fish emigrating during year of marking most typically were fish >450 mm
  - Consistent with information from marked smaller fish
  - Estimates of abundance-over estimating population size?

Results: movement and handling

Date captured	ID
5/23/2007	1BF13BB1FA
5/29/2007	1BF13BB1FA
6/27/2007	1BF13BB1FA
6/16/2010	100053FF487
6/23/2010	100053FF487
6/30/2010	100053FF4D0
7/7/2010	100053FF4D0
6/6/2007	1BF23CA05F
6/27/2007	1BF23CA05F
6/27/2007	1BF23CA05F

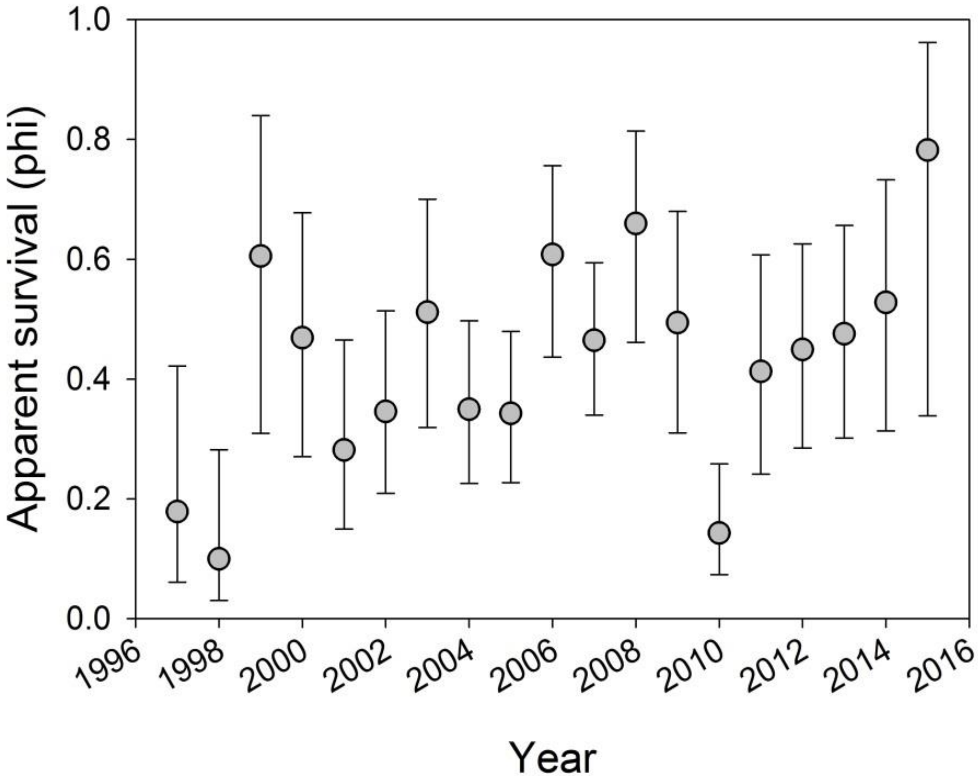
- Data indicate numerous fish handled multiple times a year
- Effects?

Results: movement and handling



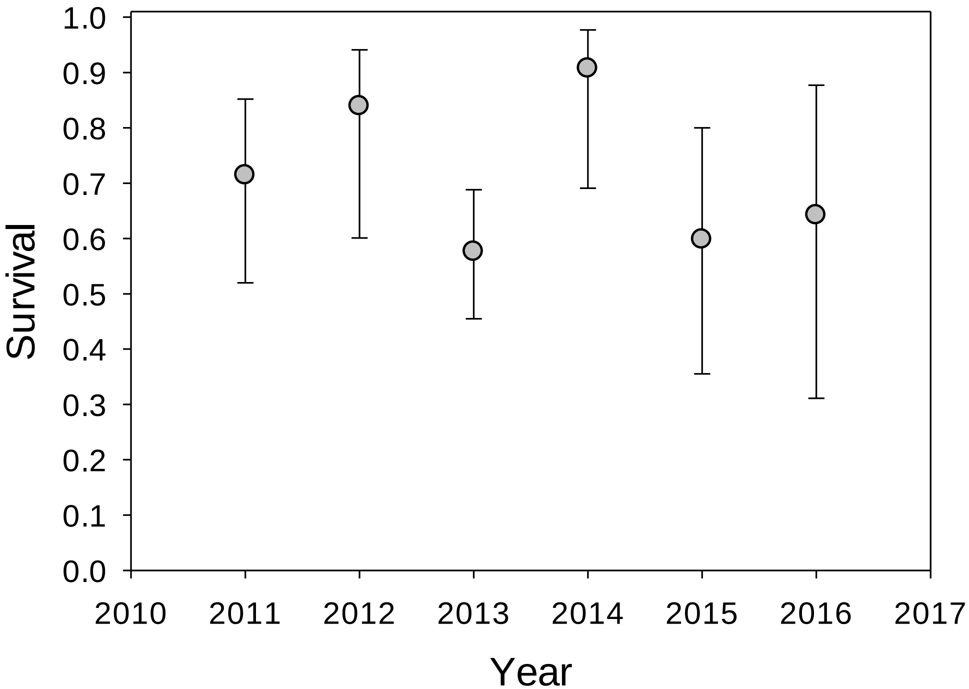
- Fish handled multiple times within a year delay spawning
  - $P<0.001$
- Loss of reproduction

Results: Swift survival



- Survival analyses
  - CJS
- Size
  - Decreasing survival with size
  - Most fecund fish
  - Management or senescence?
- Obvious response from the ESA listing
- High interannual variability
  - Why
  - Stability of adfluvial populations

Results: Swift survival



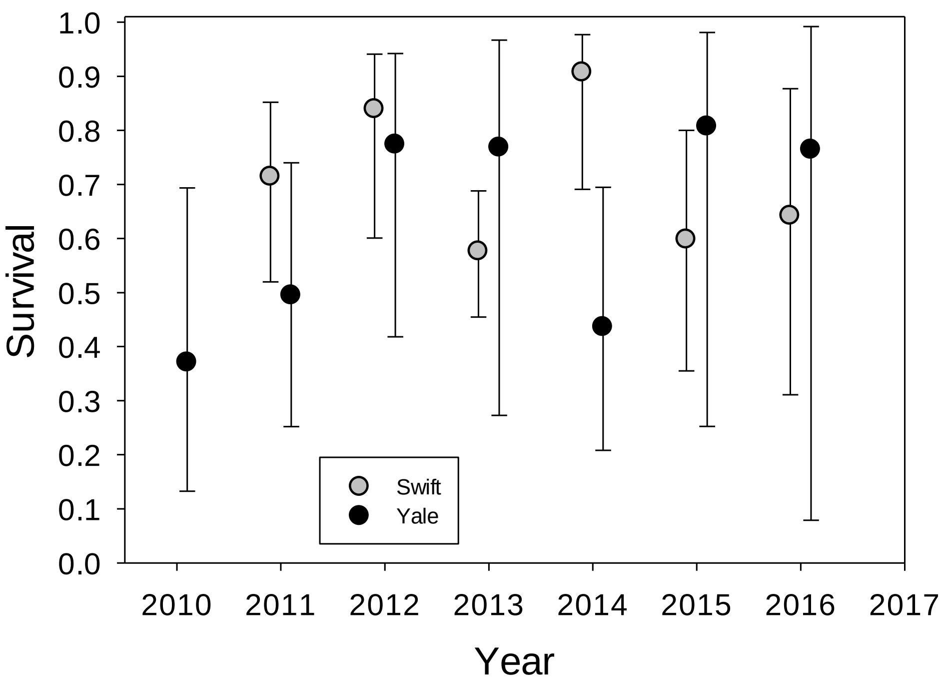
Survival analyses
- CJS average = 0.47 (SD = 0.15)

Barker estimates
- Significantly higher
    - Average = 0.72, SD = 0.13
    - Considerably lower than found in literature (Johnston et al. 2007)
    - Supported by repeat spawner information

Size
- Decreasing survival with size

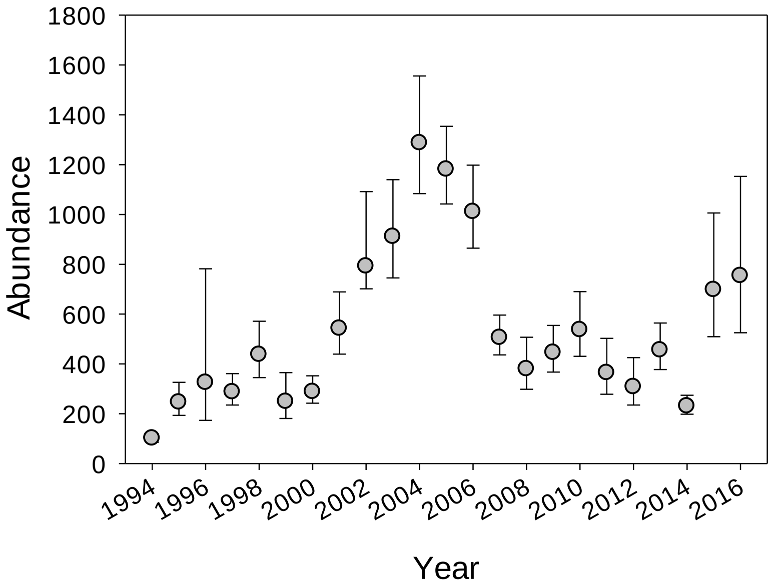
High interannual variability
- Wide CIs?

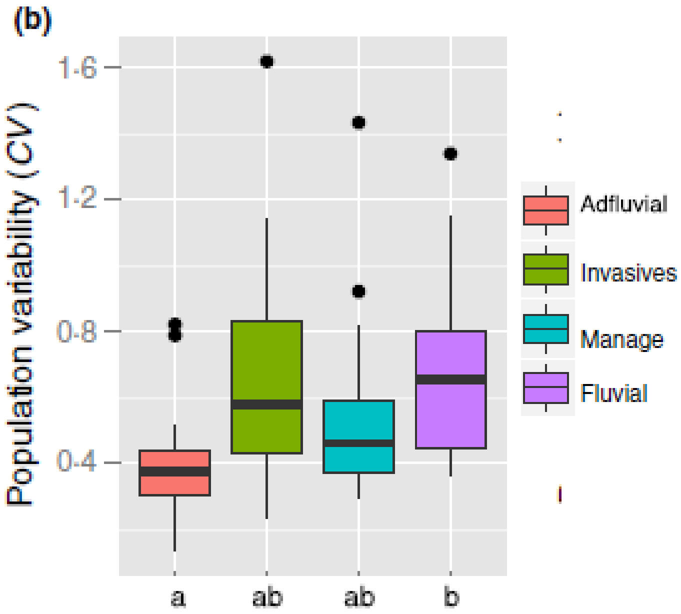
Results: Yale and Swift survival



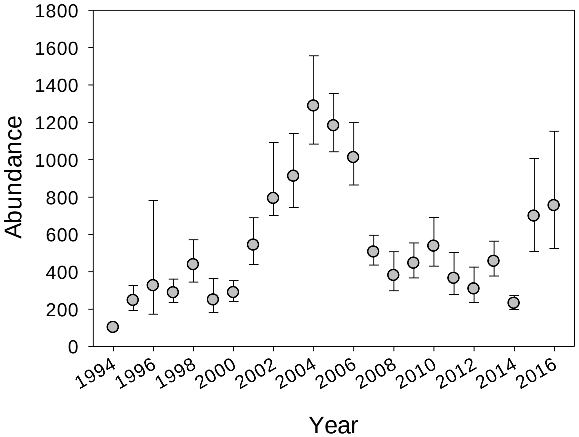
- Barker estimates
- Populations do not appear to track each other
- Yale
  - Much more variability
  - Lower recapture rate
  - Smaller dataset
  - Unable to estimate survival with CJS

Results: Abundance Swift





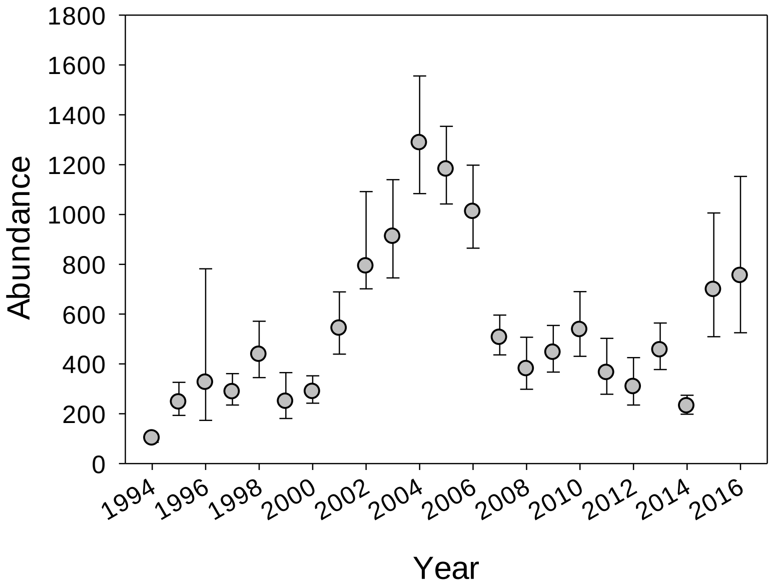
- Estimates from mark-recapture
  - Noremark
  - Need to alter to look at likely adults
- Response since ESA
  - Similar to survival results
- Since 2001 high interannual variability for an adfluvial population
  - CV = 0.51
  - Why?



Monitoring abundance Swift

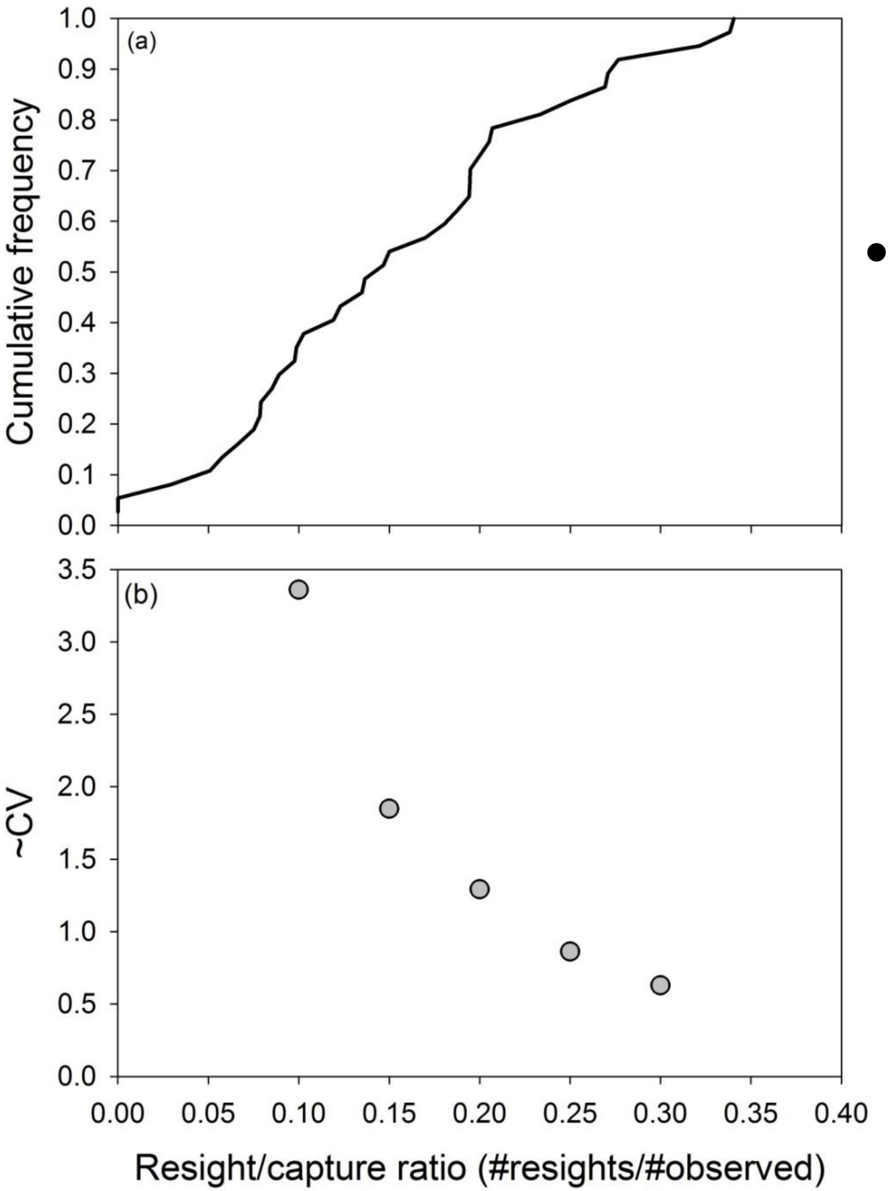
- Abundance estimates
  - Different sources of data
    - Redd counts
    - Survival data
    - Movement data
    - Abundance estimates
- Questions->how to iteratively improve monitoring

Results: Abundance Swift



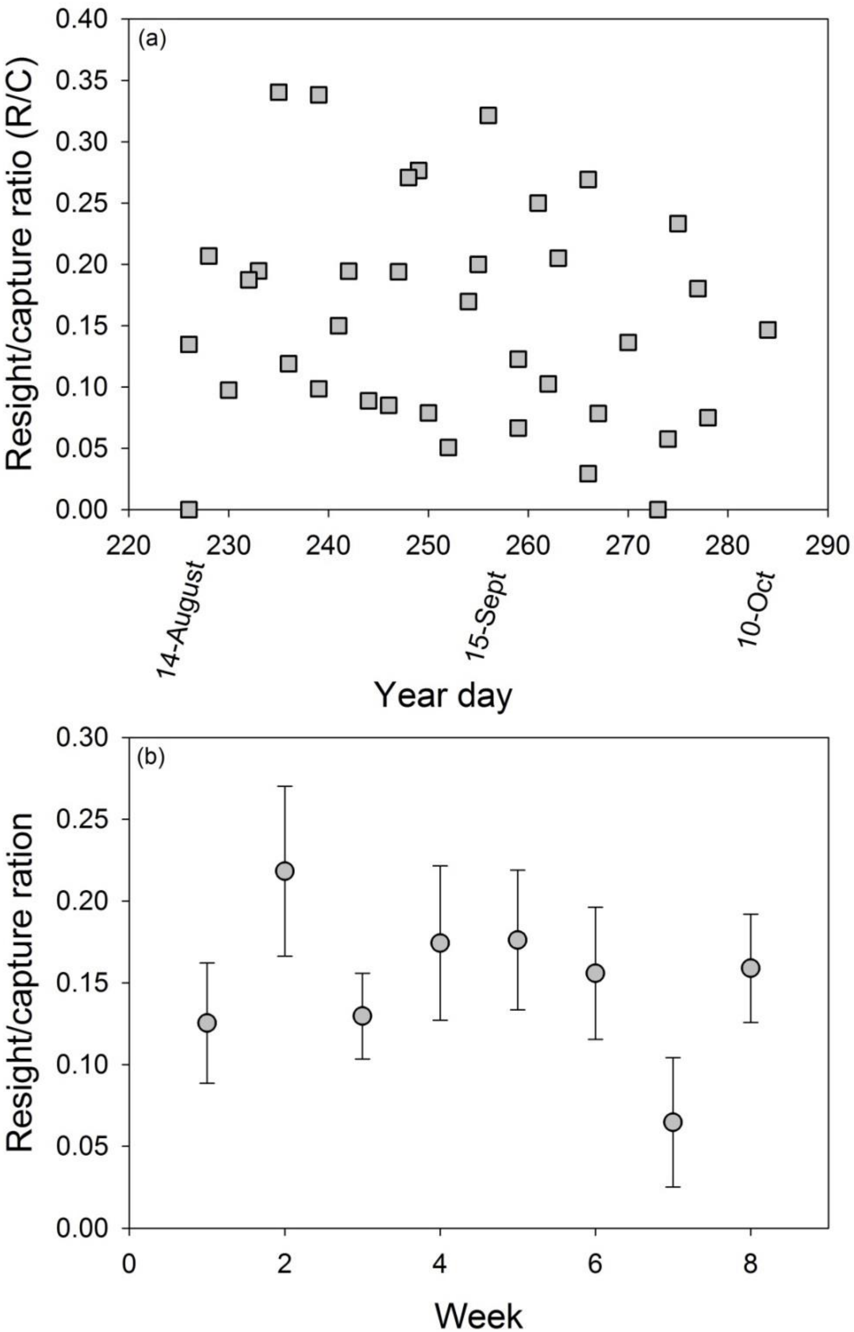
- Estimates from mark-recapture
  - Noremark
- Goal of monitoring?
- Precision of estimates
  - Typically +/- 24% of abundance estimate
  - 2015-2016
- Can refine methods to improve?

Monitoring abundance Swift

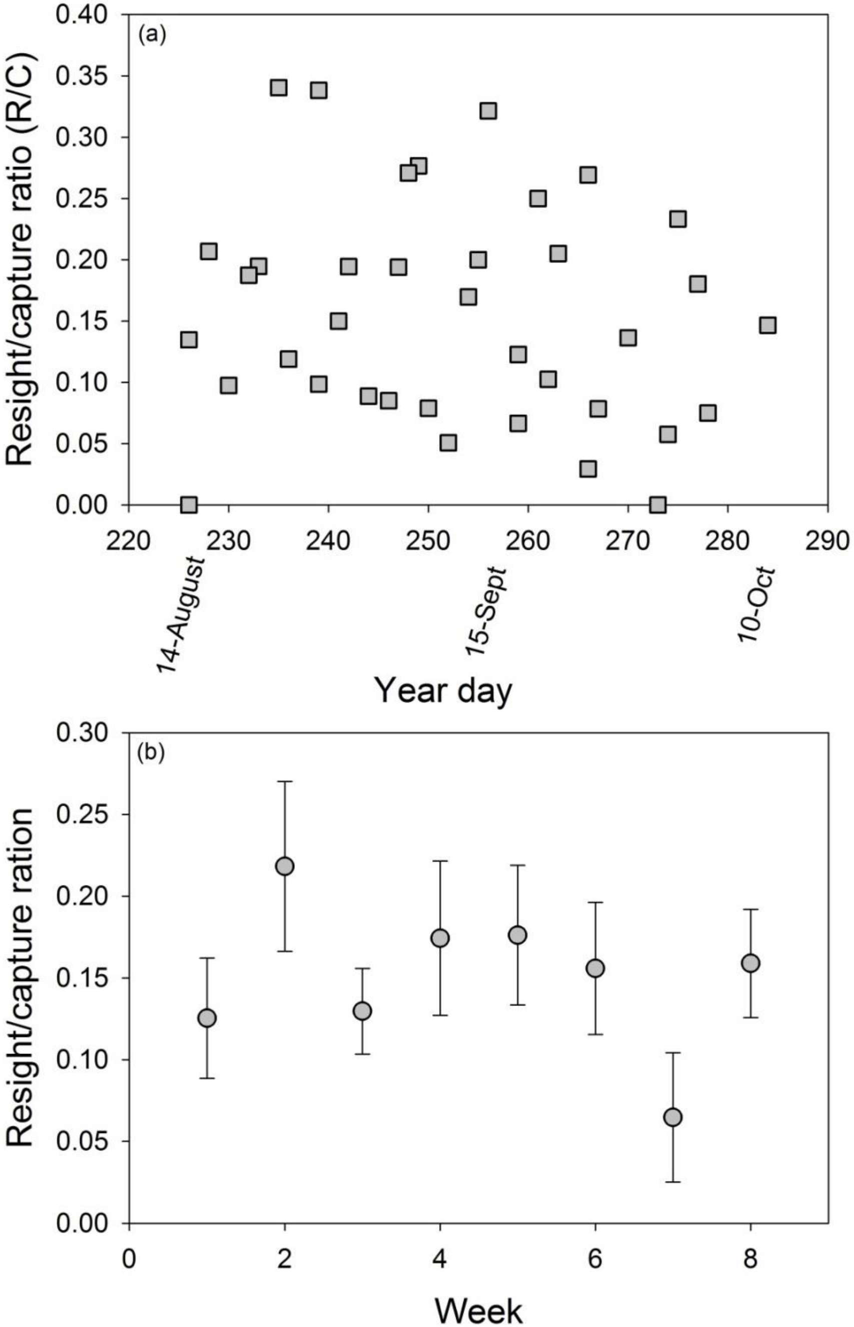


- Noremark
  - Uses resight/capture (total observed during snorkeling) ratio across all sampling events to estimate N, CI
  - R/C ratios are highly variable
  - Majority of R/C values are low
  - Obtaining robust estimates of abundance will require R/C >0.20
    - Al-Chokhachy et al. 2009

Monitoring abundance Swift

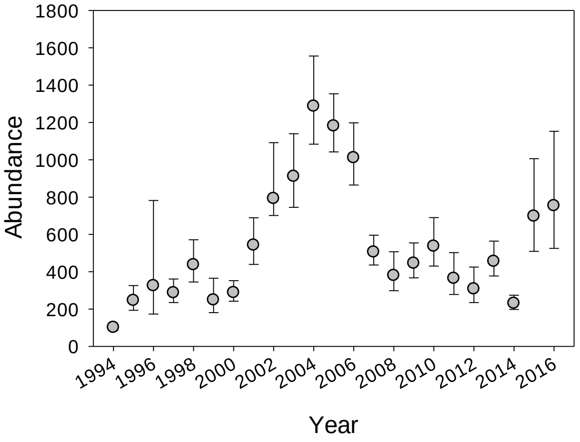


- Noremark
  - Uses resight/capture ratio across all sampling events to estimate N, CI
  - R/C ratios are highly variable
  - Lowest values occur early and late
    - With no individual resighting, if goal is to continue estimating abundance can effort be truncated?



Monitoring abundance Swift

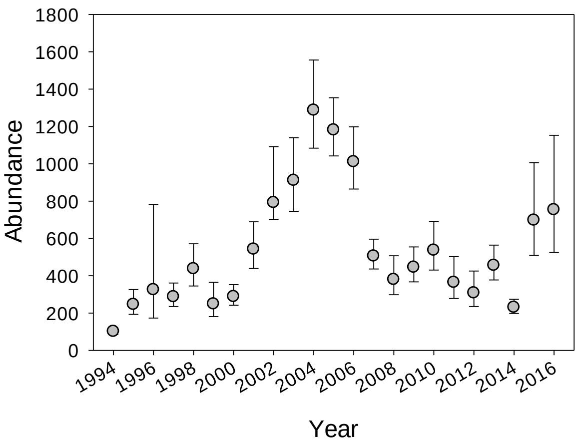
- Noremark
  - Uses resight/capture ratio across all sampling events to estimate N, CI
  - R/C ratios are highly variable
  - Lowest values occur early and late
    - With no individual resighting, if goal is to continue estimating abundance can effort be truncated?



Monitoring abundance Swift

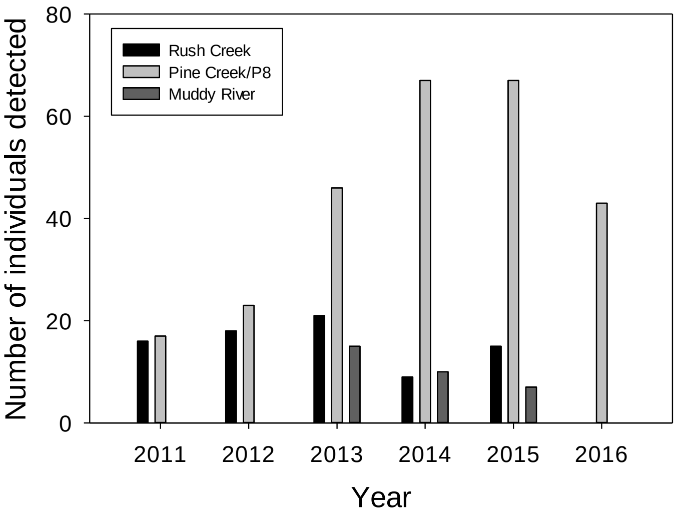
- Abundance estimates and monitoring data
  - Different sources of data
    - Redd counts
    - Survival data
    - Movement data
    - Abundance estimates
- Questions->how to iteratively improve monitoring?

Improving monitoring in the Upper Lewis

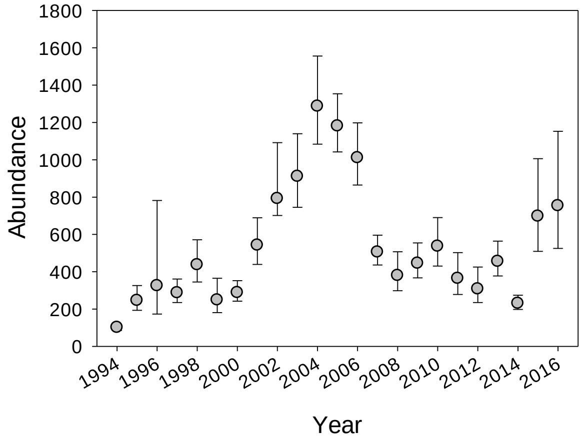


- Questions->how to iteratively improve monitoring
  - Why don't redd count data align with estimates of abundance and movement?

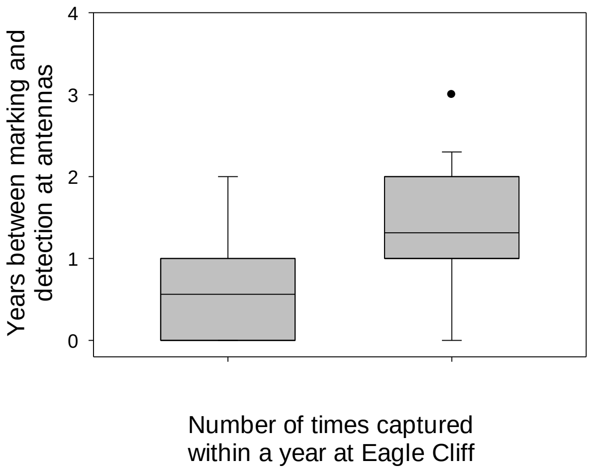
Year	Rush redds
2015	1
2014	1
2013	0
2012	0
2011	0
2010	4
2009	13
2008	6
2007	14



Improving monitoring in the Upper Lewis



- Questions->how to iteratively improve monitoring
  - Is the current monitoring approach negatively affecting bull trout in this landscape?

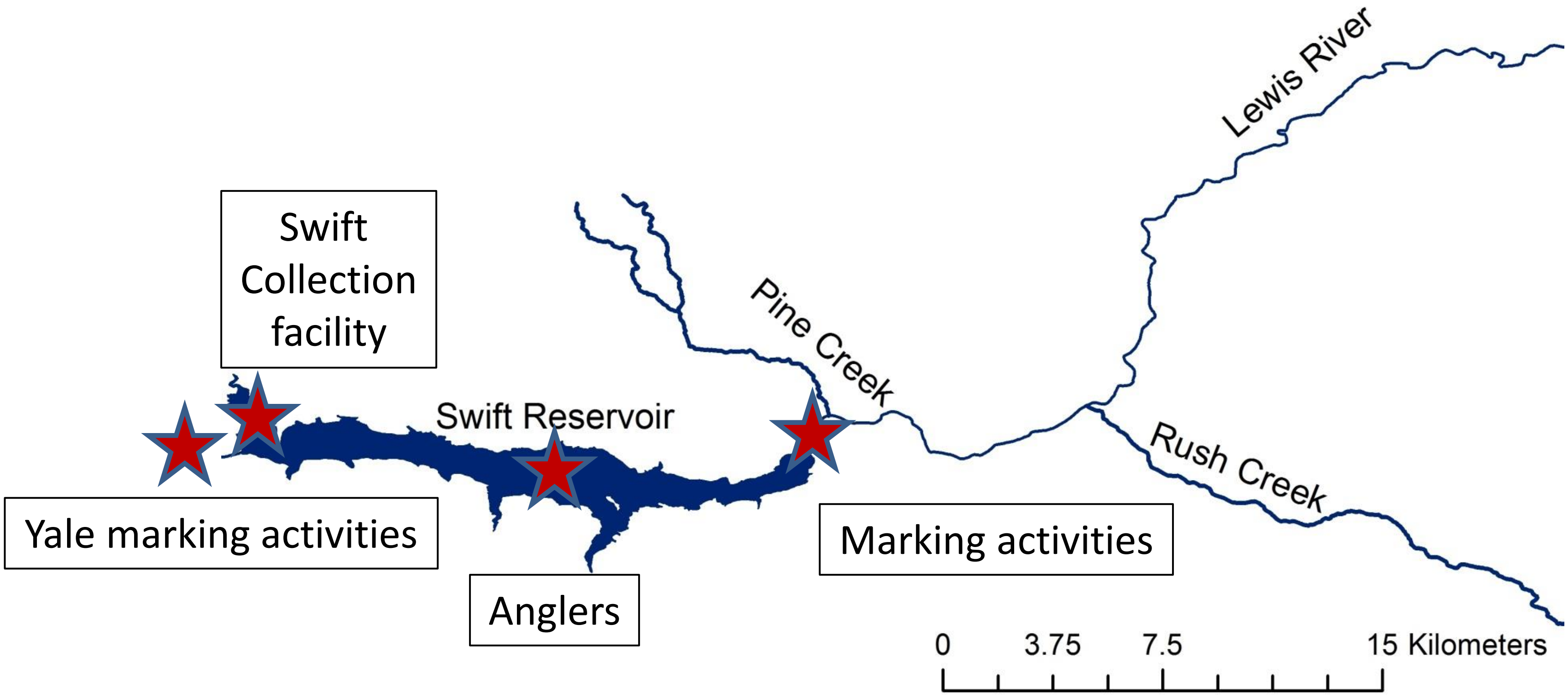


Improving monitoring in the Upper Lewis

- Questions->how to iteratively improve monitoring
  - Is the current monitoring approach negatively affecting bull trout in this landscape?
  - Part of the reason survival is low?

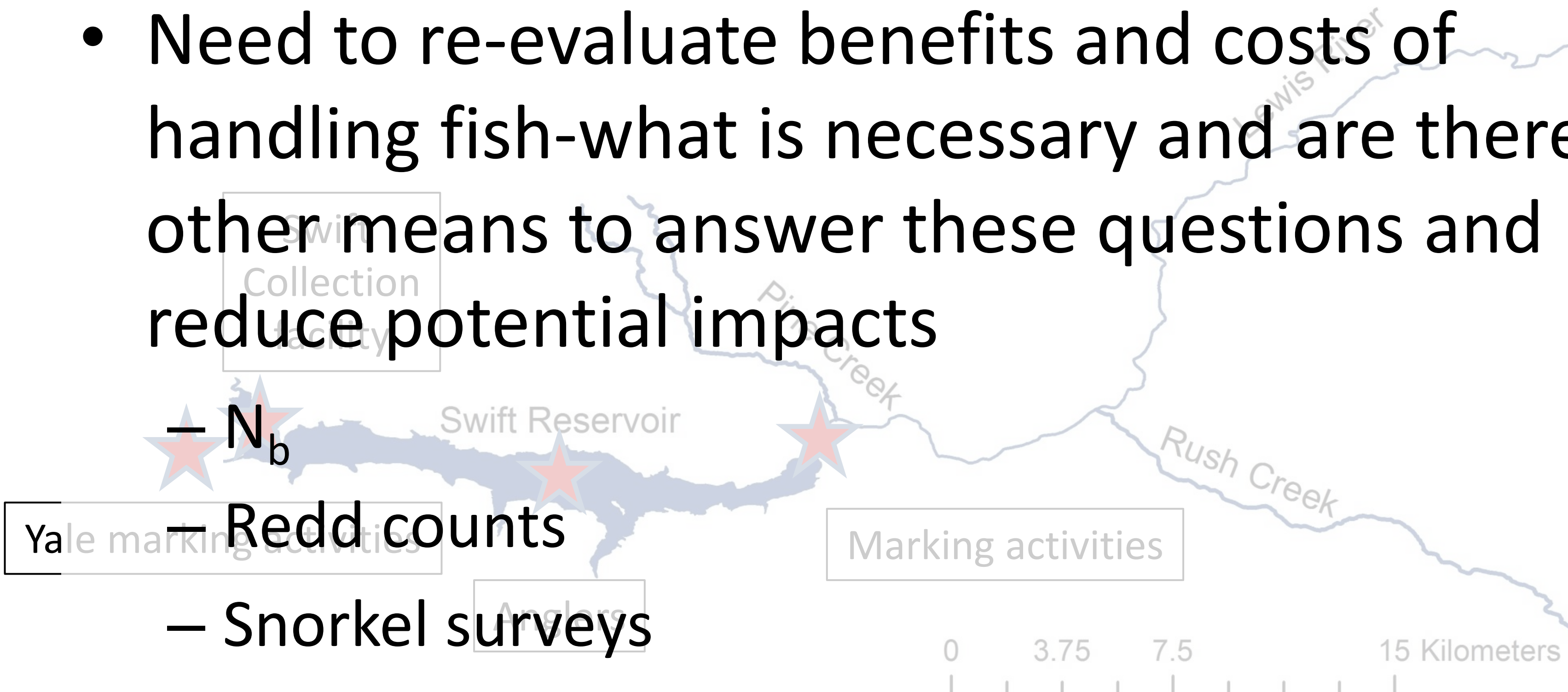
Comments
Hook in throat
Hook in gut
Jaw tore up
Unhealthy fish
Hook and line in mouth
Fishing line out vent
Fishing line out mouth
Swallowed hook
Mort, hook in gullet
Line wrapped
Ingested fishing line

Potential for high amounts of handling

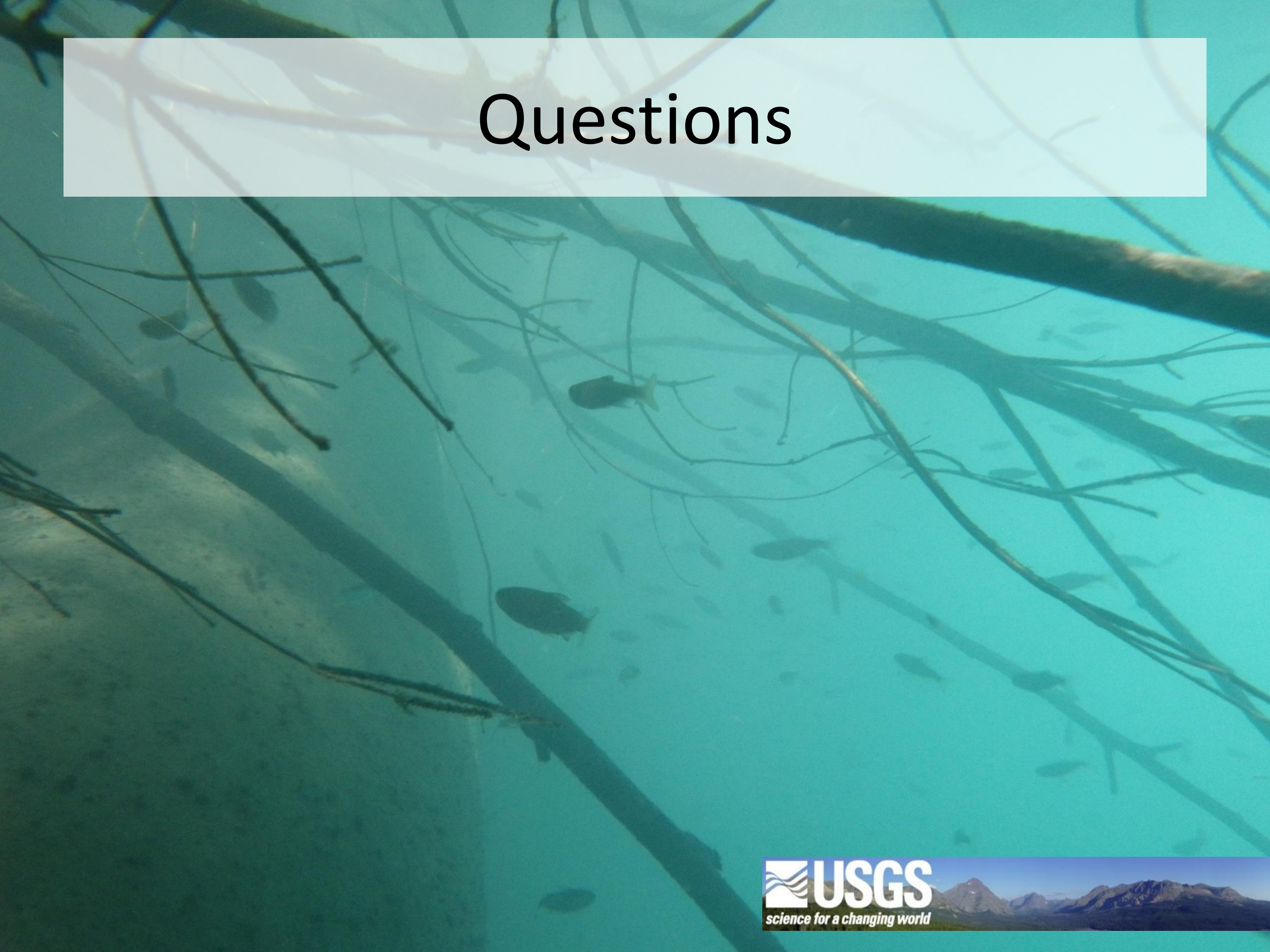


Potential for high amounts of handling

- Need to re-evaluate benefits and costs of handling fish-what is necessary and are there other means to answer these questions and reduce potential impacts
  - N_b
  - Redd counts
  - Snorkel surveys
    - Biased, but can be stronger at detecting trends



Questions



APPENDIX D

2016 USFWS LEWIS RIVER BULL TROUT GENETICS ANNUAL REPORT

Rapid Response Genetic Analysis and Genetic Estimation of Spawner Abundance of Bull Trout Collected in the Lewis River, WA

2016 Annual Report

Final Report Submitted

03/09/2017

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Background

The maintenance of migratory corridors and migratory life history type individuals has been recognized as an important factor for conserving bull trout populations (Rieman and Dunham 2000; Rieman and Allendorf 2001). Migratory individuals provide a means for recolonization of extirpated populations and gene flow among small populations, enabling persistence in dynamic landscapes and counteracting the loss of fitness caused by inbreeding (Northcote 1997; Reiman and Allendorf 2001). Migratory corridors utilized by bull trout have been extensively fragmented by the construction of dams that lack adequate fish passage facilities, and fragmentation of migratory corridors has been recognized as a threat to the persistence of many bull trout populations throughout the species range (Rieman et al. 1997; U.S. Fish and Wildlife Service [USFWS] 2002). Previous studies examining the effects of migratory barriers on bull trout populations have documented reduced genetic variation in populations isolated above barriers (Whiteley et al. 2006; DeHaan et al. 2011a) and entrainment of bull trout through dams (Neraas and Spruell 2001; Whiteley et al. 2006; DeHaan et al. 2011b).

The Lewis River is a Columbia River tributary in Washington which contains one of two bull trout populations in the USFWS Lower Columbia Critical Habitat Unit (USFWS 2010). Bull trout spawning has been documented in three main tributaries within the Lewis River system: Cougar Creek, Pine Creek, and Rush Creek (Figure 1). Four dams constructed on the mainstem Lewis River fragment bull trout habitat and prevent fish that migrate downstream through the dams from returning to spawning habitats. Cougar Creek is located above Yale Dam and is separated from Pine and Rush creeks by two dams; Swift No.1 and No. 2 (Figure 1). Each year bull trout are collected in the tailrace of Yale Dam and in the Swift Bypass Reach (the historic Lewis River channel) below Swift No. 1 Dam. The origins of these individuals are unknown but it is presumed that fish below Yale Dam originate in tributaries above the dam since spawning has not been observed below the dam, and it is presumed that some portion of the fish collected in the Swift Bypass Reach originate in Pine and Rush creeks. Re-establishing migratory connectivity in the system is important for allowing highly fecund migratory fish to contribute to numerically depressed spawning populations and for maintaining gene flow among spawning populations and adequate effective population sizes.

Upstream transport of bull trout collected below Lewis River dams was suggested as a means to re-establish migratory connectivity in the system; however, there were concerns with simply passing all fish collected below the dams upstream. Cougar Creek is a relatively small population and passing fish from the Swift Bypass Reach to the area above Swift No. 1 Dam may result in the transport of fish from Cougar Creek away from their natal spawning habitat. Additionally, fish collected below Yale Dam could have originated above Yale Dam in Cougar Creek or in tributaries above Swift No. 1 Dam (Pine and Rush creeks). It was recognized that information on the tributary of origin for fish collected below the dams would be helpful for guiding fish transport decisions. To help address this issue, the USFWS Abernathy Fish Technology Center (AFTC) conducted a genetic analysis of bull trout collected from Cougar, Pine, and Rush creeks as well as fish collected below Yale Dam and in the Swift Bypass Reach. Results of this analysis showed that genetically distinct local spawning populations exist in each of the three tributaries and that genetic population assignments could be used to identify the most likely local spawning population of origin for unknown individuals (DeHaan and Adams 2011).

Based on the results of these analyses, in 2011 PacifiCorp initiated an effort to transport bull trout collected below the Lewis River dams upstream. The goal of this program was to use real-time genetic assignment analysis (i.e. "rapid response") to determine the local spawning population of origin for bull trout collected below the dams and to use this information to help inform upstream transport decisions.

The number of bull trout spawning in the Swift Reservoir tributaries of Pine and Rush creeks each year is not well understood. These estimates of spawner abundance are important in developing effective conservation and management plans for Lewis River bull trout. Beginning in 1996 PacifiCorp and various state and federal partners (Doyle 2014) initiated annual surveys to track upstream passage of adult bull trout into Pine and Rush Creeks. They expanded this by adding annual bull trout redd surveys within P8, a tributary to Pine Creek, in 2010. In 2014 PacifiCorp contacted AFTC to provide a complementary genetic estimate of spawner abundance to current in-stream methods. Genetic monitoring to estimate spawner contribution can be a more effective way to look at the true reproductive contribution of individuals to a population of concern (Schwartz et al. 2007). This report summarizes this analysis of effective number of breeders (N_b) for bull trout in Cougar, Pine and Rush Creeks, as well as the fourth year of the rapid response genetic analysis conducted by AFTC, and the analysis of additional bull trout added to the population assignment baseline.

Materials and Methods

2016 Rapid Response Analysis

For rapid response analysis, PacifiCorp biologists collected adult bull trout below Yale Dam and in the Swift Bypass Reach on one or two days per week from May 23 through July 25,

2016. A small (approximately 1cm^2) tissue sample was taken from all previously un-sampled bull trout captured, and delivered to AFTC personnel, typically within 24 hours. Adult bull trout were held at the Washington Department of Fish and Wildlife's Merwin Fish Hatchery below Merwin Dam pending genetic results.

As soon as fin clips from adult bull trout captured below the Lewis River dams were delivered to AFTC, DNA was extracted using a modified Chelex extraction protocol (Miller and Kapuscinski 1996). All individuals were genotyped at the following 16 microsatellite loci: *Omm1128, Omm1130* (Rexroad et al. 2001), *Sco102, Sco105, Sco106, Sco107, Sco109,* (Washington Dept. of Fish and Wildlife *unpublished*), *Sco200, Sco202, Sco212, Sco215, Sco216, Sco218, Sco220* (DeHaan and Ardren 2005), *Sfo18* (Angers et al. 1995) and *Smm22* (Crane et al. 2004). Polymerase chain reactions (PCR) were conducted in 10µL volumes containing 2µL of template DNA, 5µL of 2X Qiagen multiplex PCR master mix (final concentration of 3mM $MgCl_2$), and 0.2µL of oligonucleotide PCR primer mix. PCR conditions were as follows: initial denaturation at 95°C for 15 minutes, then 29 cycles of 95°C for 30 seconds, 90 seconds at the multiplex specific annealing temperature, and 60 seconds primer extension at 72°C, followed by a final extension at 60°C for 20 minutes. Following PCR, capillary electrophoresis was conducted on an ABI 3130xl Genetic Analyzer (Applied Biosystems Inc., Foster City, CA) following the manufacturer's protocols. All fish collected for rapid response analysis were genotyped two times to ensure consistency of results.

The baseline dataset used for genetic assignments consisted of fish from Cougar (n = 69), Pine (n=105), and Rush (n=72) creeks. The program ONCOR (Kalinowski et al. 2008) was used to assign unknown origin individuals collected below Lewis River Dams to their most likely population of origin. Each unknown origin individual was assigned to its first and second most likely local spawning population of origin and the probability of observing the individual's genotype in each local population were also reported. A description of the methods used for the probability calculations can be found in Kalinowski et al. (2008). Once genetic assignments were calculated, a report documenting the date and time samples were received at AFTC, the date and time results were sent, and for each individual, the individual's PIT (passive integrated transponder) tag number, collection location, first and second most likely local population of origin, the probability value for each genetic assignment, and transport suggestions (Yale or Swift reservoir) were e-mailed to PacifiCorp biologists. An example report can be found in Appendix 1. Once PacifiCorp biologists received the genetic assignment data, this information was used to inform fish transport decisions. Bull trout that assigned to either the Rush or Pine creek local population with a probability greater than 0.990, or with a combined probability for Pine and Rush creeks greater than 0.990, were transported upstream for release into Swift Reservoir. Bull trout that did not meet these criteria were transported and released into Yale Reservoir.

Baseline Analysis

Fin clips from age-0 bull trout were collected by PacifiCorp staff in 2016 from Cougar Creek (n=53), Pine Creek (n=5), P8 (a Pine Creek tributary, n=52), and Rush Creek (n=17) in order to estimate the effective number of breeders within those systems. Samples were genotyped using the methods described above except that DNA was extracted from fin clips using Qiagen DNeasy96 extraction kits (Qiagen Inc., Valencia, CA). Age-0 bull trout from Pine Creek and P8 genotyped in 2016 were combined for all analyses (DeHaan and Adams 2011). All local spawning populations were then tested for departures from Hardy-Weinberg equilibrium (HWE) expectations using exact tests implemented in the program GENEPOP v4.0.7 (Raymond and Rousset 1995). GENEPOP was also used to test populations for evidence of linkage disequilibrium (LD: non-random association among alleles). Populations were examined for number of full sibling families and number of individuals in each full sibling family using COLONY v2.0 (Wang 2004). Following protocols established in DeHaan and Adams (2011), we retained up to three full siblings from each family and removed all other siblings. Once full siblings had been removed, we conducted HWE and LD tests on the revised dataset.

We used the program NeEstimator v2 (Do et al. 2014) to estimate the effective population size (N_e) for age-0 samples from Cougar, Pine and Rush Creeks based on linkage disequilibrium (Waples 2006). When this estimate is applied to individuals collected in a single cohort it allows us to estimate the effective number of breeders that produced the cohort (N_b; Waples and Teel 1990). To minimize the effect of rare alleles on our estimates we selected P_{crit}=0.02 (Waples and Do 2010). Upper and lower 95% confidence intervals were estimated using the jackknife re-sampling method. To assess the role that large family groups within the dataset had on calculating N_b we made estimates with the original data set (including all age-0 fish) and with the reduced family data (removing all but three individuals assigned to a family group). Estimates of N_b were also obtained during the process of assigning individuals to family groups in COLONY v2.0.

Genetic data from age-0 bull trout from Cougar, Pine and Rush creeks were combined with previously genotyped samples from Cougar, Pine and Rush creeks and added to the baseline dataset. We conducted leave-one-out assignment tests to examine the accuracy of the updated baseline for assigning unknown origin fish to their most likely local population of origin. Each baseline individual was removed from the population it was collected from and treated as an unknown, the allele frequencies for all populations were then re-calculated, and the unknown fish was assigned to its most likely population. The number of individuals assigned to the local population they were collected from (presumably their natal tributary) provides a measure of assignment accuracy. Leave-one-out tests were conducted using ONCOR and we determined the likelihood for each population assignment and the probability of observing that individual's genotype in the assigned population.

Results and Discussion

2016 Rapid Response Analysis

During 2016, 21 bull trout were collected for rapid response genetic analysis; 17 were collected in the Swift Bypass Reach and 4 were collected in the Yale Tailrace. All samples were processed within 24 hours of receipt at AFTC. Of the 21 samples processed, 12 of them assigned to Cougar Creek as their most likely population of origin (Table 1). The remaining nine samples, eight assigned to Pine Creek as their most likely population of origin and one assigned to Rush Creek as its most likely population of origin. Probability values for population assignments ranged from 0.966 to 1.000 and probability scores for regional assignments ranged from 0.966 to 1.000 (Table 1). Genotypes for all 21 rapid response bull trout analyzed in 2016 can be found in Appendix 2.

Previous genetic studies have documented entrainment of adult bull trout through mainstem dams (Neraas and Spruell 2001; DeHaan et al. 2011b) and data from this study show that entrainment of adult bull trout occurs at the Lewis River dams as well. Large migratory bull trout are highly fecund (Fraley and Shepard 1989; Al-Chokhachy and Budy 2008) and these fish can contribute significant numbers of offspring to demographically depressed populations. Prior to 2011, bull trout that migrated downstream through the Lewis River dams were lost from their natal spawning populations. Upstream transport of fish collected below the Lewis River dams greatly benefits populations above the dams by helping to maintain the number of spawning adults in these populations which in turn results in greater numbers of offspring produced.

All of the fish collected in 2016 were collected in either the Swift Bypass Reach or the Yale Tailrace and genetic assignments showed that individuals originated from both above and below the two Swift dams. Simply passing all of these fish above Swift No. 1 Dam may have resulted in several fish from Cougar Creek potentially losing access to their natal spawning habitat. Cougar Creek is considered to be a relatively small local spawning population, and the loss of several spawning adults from Cougar Creek could have a negative effect on the long term persistence of this local population. Clearly the use of genetic data to guide fish transport decisions benefits not only the Pine Creek and Rush Creek local populations upstream of the dams that have lost migratory adults due to entrainment, but also benefits the local spawning population in Cougar Creek by helping to maintain the number of spawning adults.

Identification of full sibling groups - COLONY Analysis

Two loci, *Sco 215* and *Sfo18*, were fixed for a single allele in all Cougar, Pine, and Rush Creek age-0 bull trout; in addition, *Sco 109* was fixed for a single allele in Pine Creek. Cougar and Pine Creek samples deviated from Hardy-Weinberg equilibrium at *Sco212*; in addition Cougar Creek deviated at *Sco 102* and *Sco 106*, while Pine Creek deviated at *Sco 105* and *Sco202*. Four pairs of loci (out of 91 total) exhibited evidence of linkage in Cougar Creek and twenty seven pairs of loci showed evidence in Pine Creek. Results of the linkage disequilibrium tests were consistent with collections of closely related individuals (i.e., full siblings). Results of the COLONY analysis indicated a large number of related individuals in the age-0 samples collected from Cougar and Pine creeks (Appendix 3). In Cougar Creek, there was one full-sibling family with seven individuals, one full-sibling families with six individuals and two smaller families with three individuals. In Pine Creek there was one large full-sibling family with nineteen individuals, one full-sibling family with twelve individuals, two full-sibling families with six individuals. In Rush Creek there was one large full-sibling family detected with six individuals. As indicated above, we removed all but three individuals from each full-sibling family prior to adding these individuals to the baseline dataset. After full-siblings were removed from the dataset, three pairs of loci (out of 91 total) exhibited linkage in Cougar Creek and three pairs of loci showed evidence in Pine Creek.

Effective number of breeders - N_b

Estimates of effective number of breeders were greatest in Rush Creek (N_b=18.2; 95% C.I.=6.8-Inf using the N_b estimator with reduced families), lower in Cougar Creek (N_b=16.8; 95% C.I.=13.2-21.6), and lowest in Pine Creek (N_b=7.4; 95% C.I.=3.9-12.4). Overlap in 95% C.I. indicated that these observed differences were not significant. Estimated values of N_b varied with estimation method and number of individuals used per family (Table 2), although they consistently estimated a smaller N_b for Pine Creek when compared to Cougar and Rush creeks. These estimates provide a baseline to track how estimates of N_b fluctuate on an annual basis and can provide an indicator for the health of bull trout populations with long term monitoring (Luikart et al 2010). In addition these data can provide a comparison with how redd counts and counts of spawning adults in these two tributaries relate to estimates of N_b. It is important to note that since these estimates of the effective number of breeders were generated using a single cohort of individuals, they are presumably lower than the true N_e (Luikart et al. 2010; Waples and Do 2010). General guidelines have been suggested for minimum viable levels of N_e with a minimum of 50 individuals suggested as necessary to avoid the short term effects of inbreeding and N_e of 500 to help ensure long-term population persistence (Franklin 1980). Although these are just general guidelines and true minimum N_e values vary among species and populations, the relatively low estimates observed for the two Lewis River bull trout populations suggest that these small populations may face increased risks from inbreeding and genetic drift in the short-term.

Baseline Analysis

Two loci, *Sco215* and *Sfo18*, were fixed for a single allele in all three baseline populations. These two loci were primarily included in genotyping efforts to identify hybrid individuals (no hybrid fish were observed in this study) and to facilitate comparisons with other studies. Cougar Creek and Rush Creek deviated from Hardy-Weinberg equilibrium expectations at the locus *Sco109* due to a deficiency of heterozygotes. All other loci conformed to Hardy-Weinberg equilibrium expectations in all three populations. Six pairs of loci (out of 91 total) exhibited evidence of linkage in Cougar Creek, five pairs of loci showed evidence of linkage in Pine Creek, and four pairs of loci showed evidence of linkage in Rush Creek. Nearly all (98.5%) of the baseline fish were assigned to the local spawning population that they were collected from in the leave-one-out assignment tests. The exceptions were five fish collected in Cougar Creek, two of which assigned to Pine Creek and three of which assigned to Rush Creek; and two fish that were collected in Pine Creek, one of which assigned to Cougar Creek and one that assigned to Rush Creek. Probability values for correctly assigned fish to population of origin were 0.964, 0.990 and 1.000 for Cougar, Pine and Rush Creeks respectively (Figure 2). Probability values for correctly assigned fish to region of origin were 0.964 and 0.997 for Swift and Yale Reservoirs respectively (Figure 2).

Data Management Plan

Raw (genotype) data generated in the course of the work described here have been archived in the U.S. Fish and Wildlife Service Abernathy Fish Technology Center Progeny Database.

Acknowledgements

Funding for this project and all of the genetic samples analyzed under this contract were provided by PacifiCorp. Christian Smith and XX provided comments on an earlier version of this report. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the U. S. Fish and Wildlife Service.

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Table 1. Collection information and genetic population assignments for 21 adult bull trout collected below Lewis River dams in 2016.

PIT Tag #	Genetic ID	Date Sampled	Date Received	Collection Location	Genotypic Sex	Most Likely Population #1	Probability	Most Likely Population #2	Probability	Transport Suggestions
AC77671	TN15-162	5/23/2016	5/23/2016	Swift Bypass Reach	Male	Cougar Creek	1.000			Yale
AC77683	3140-001	6/1/2016	6/1/2016	Swift Bypass Reach	Female	Pine Creek	1.000			Swift
AC77684	3140-002	6/1/2016	6/1/2016	Swift Bypass Reach	Female	Pine Creek	1.000			Swift
AC77686	3140-003	6/1/2016	6/1/2016	Swift Bypass Reach	Female	Pine Creek	1.000			Swift
AC77690	3140-004	6/13/2016	6/13/2016	Swift Bypass Reach	Male	Cougar Creek	1.000			Yale
AC77691	3140-005	6/13/2016	6/13/2016	Swift Bypass Reach	Male	Cougar Creek	1.000			Yale
AC77692	3140-006	6/15/2016	6/21/2016	Yale Tailrace	Male	Cougar Creek	1.000			Yale
AC7769D	3140-007	6/20/2016	6/21/2016	Swift Bypass Reach	Male	Pine Creek	1.000			Swift
AC7769E	3140-008	6/20/2016	6/21/2016	Swift Bypass Reach	Female	Pine Creek	1.000			Swift
AC776A2	3140-009	6/27/2016	6/27/2016	Swift Bypass Reach	Male	Cougar Creek	1.000			Yale
AC776A3	3140-010	6/27/2016	6/27/2016	Swift Bypass Reach	Female	Cougar Creek	1.000			Yale
AC776A4	3140-011	6/27/2016	6/27/2016	Swift Bypass Reach	Male	Pine Creek	1.000			Swift
AC776A5	3140-012	6/27/2016	6/27/2016	Swift Bypass Reach	Female	Pine Creek	1.000			Swift
AC776A6	3140-013	6/27/2016	6/27/2016	Swift Bypass Reach	Male	Pine Creek	1.000			Swift
AC776A9	3140-014	7/11/2016	7/11/2016	Swift Bypass Reach	Female	Cougar Creek	1.000			Yale
	3140-015		7/25/2016	Yale Tailrace	Female	Cougar Creek	1.000			Yale
	3140-016		7/25/2016	Yale Tailrace	Female	Rush Creek	0.966	Cougar Creek	0.034	Yale
	3140-017		7/25/2016	Yale Tailrace	Female	Cougar Creek	1.000			Yale
AC776AD	3140-018	7/25/2016	7/25/2016	Swift Bypass Reach	Female	Cougar Creek	1.000			Yale
AC776AE	3140-019	7/25/2016	7/25/2016	Swift Bypass Reach	Female	Cougar Creek	1.000			Yale
AC776AF	3140-020	7/25/2016	7/25/2016	Swift Bypass Reach	Female	Cougar Creek	1.000			Yale

Table 2. Estimates of effective number of breeders (N_b; 95% CI) in three Lewis River tributaries for multiple N_b estimators in 2016 (minimum allele frequencies of 0.02).

Tributary	N_b Estimator All Individuals	N_b Estimator Reduced Families	Colony
Cougar Creek	11.1 (8.9-13.7)	16.8 (13.2-21.6)	19.0 (11.0-37.0)
Pine Creek	3.1 (2.6-3.7)	7.4 (3.9-12.4)	9.0 (4.5-24.0)
Rush Creek	9.1 (4.1-20.0)	18.2 (6.8-Inf)	8.0 (4.0-25.0)

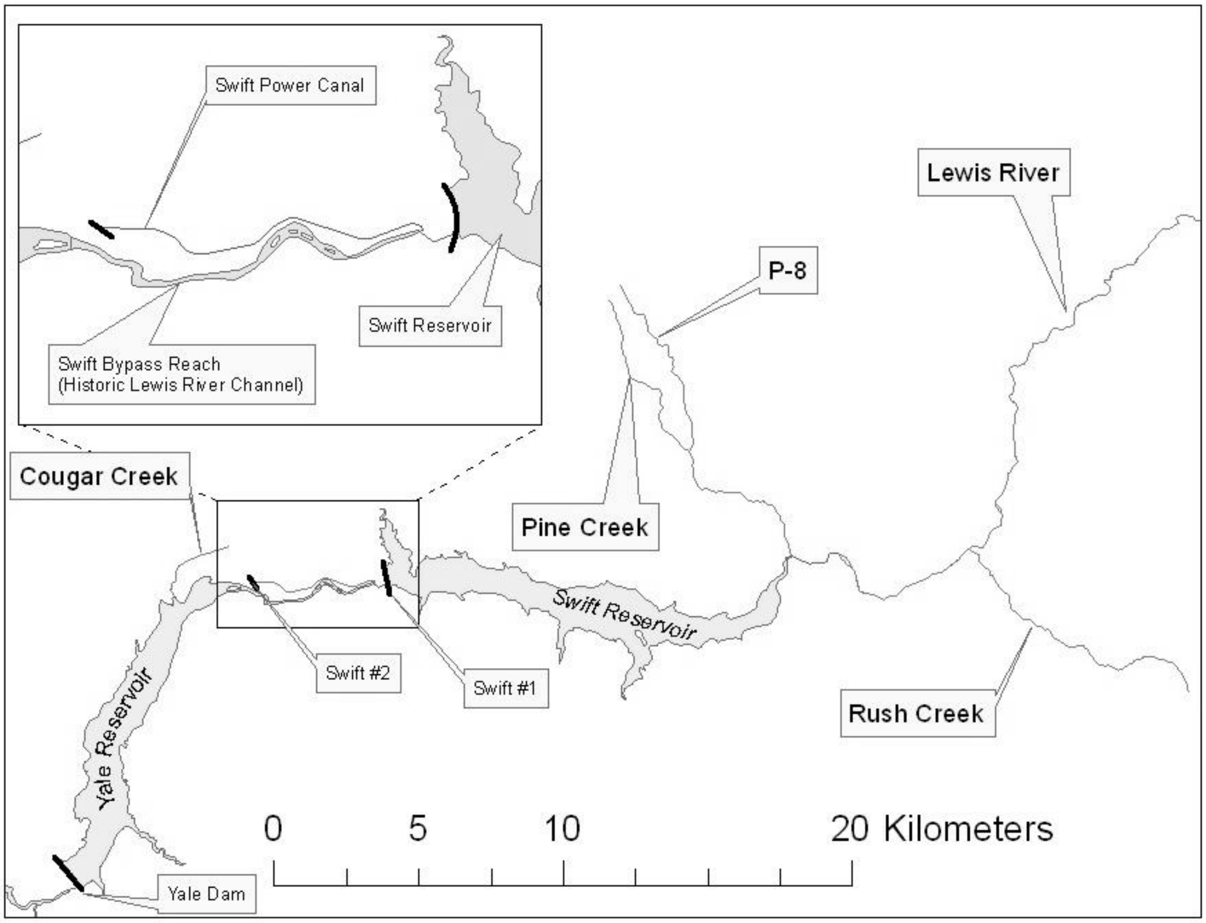

Figure 1. Lewis River system in Washington. Cougar, Pine, and Rush creeks are the primary bull trout spawning tributaries and are the three populations in the baseline dataset. Bull trout for rapid response analysis were collected below Yale Dam and in the Swift Bypass Reach.

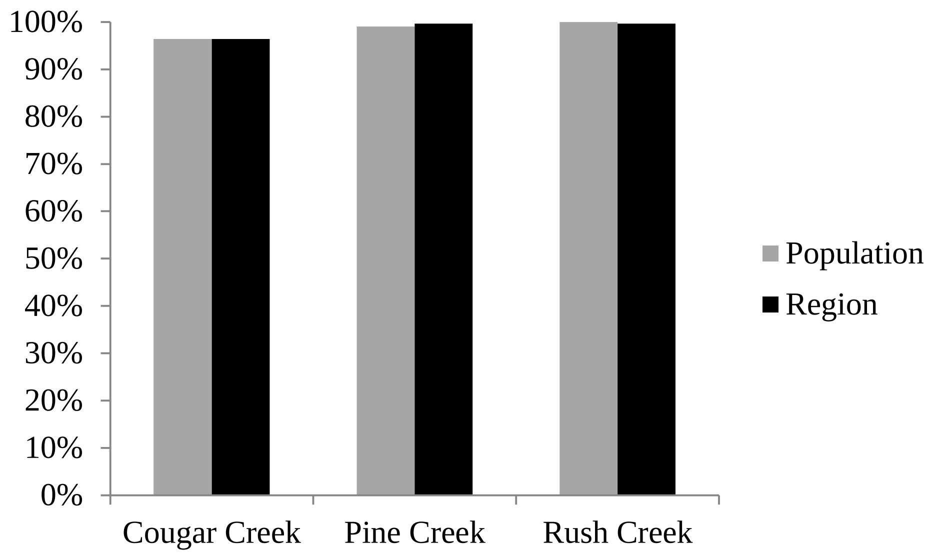

Figure 2.Percentages of baseline individuals correctly assigned to their population of origin (Cougar, Pine and Rush creeks; Grey bars) and to their region of origin (Yale and Swift reservoirs; Black bars) of Lewis River bull trout during leave-one-out assignment tests.

Appendix 1. Sample rapid response report sent by AFTC to PacifiCorp biologists.

United States Department of the Interior
FISH AND WILDLIFE SERVICE

Abernathy Fish Technology Center
Conservation Genetics Program
1440 Abernathy Creek Road, Longview, WA 98632
Phone: (360) 425-6072, Fax: (360) 636-1855

2016 Lewis River Bull Trout Rapid Response Genetic Population ID

Date: June 2, 2016

To: Jeremiah Doyle
PacifiCorps Energy
105 Merwin Village Ct.
Ariel, WA 98603
360-225-4448 (office)
360-608-2410 (cell)
Jeremiah.Doyle@PacifiCorp.com

From: Michaela Brinkmeyer and Brice Adams
michaela_brinkmeyer@fws.gov; brice_adams@fws.gov

cc: Christian Smith, Jennifer Von Bargen

Date and Time Samples Received: 6/1/2016 13:00 **Date and Time Results Sent:** 6/2/16 1:40 PM

Sample ID	Collection Location	Genotypic Sex	Most Likely Population of Origin	Probability	Most Likely Region of Origin	Probability	2nd Most Likely Population of Origin	Probability	2nd Most Likely Region of Origin	Probability	Suggestions for Transport
AC77683	Swift Bypass Reach	Female	Pine Creek	1.000	Swift	1.000					Swift
AC77684	Swift Bypass Reach	Female	Pine Creek	1.000	Swift	1.000					Swift
AC77686	Swift Bypass Reach	Female	Pine Creek	1.000	Swift	1.000					Swift

Appendix 2. Genotypes at 16 microsatellite loci and the genetic sex identification markers for 21 bull trout collected below Lewis River Dams in 2016. Question marks represent genotypes that could not be determined due to failed PCR amplification.

PIT Tag Number	BT_SexID		Omm1128		Omm1130		Sco102		Sco105		Sco106		Sco107		Sco109		Sco200	
AC77671	67	102	331	351	298	302	166	166	154	154	180	208	297	297	360	360	142	142
AC77683	67	67	331	351	298	332	169	173	154	190	152	180	285	285	?	?	142	155
AC77684	67	67	331	351	298	298	169	169	190	194	152	208	293	297	296	296	142	142
AC77686	67	67	331	351	290	298	169	173	154	154	152	180	293	297	296	296	155	155
AC77690	67	102	281	351	298	302	166	166	166	194	180	180	297	362	360	360	142	142
AC77691	67	102	331	351	298	298	166	166	190	190	208	208	293	293	296	360	142	142
AC77692	67	102	281	281	302	302	166	169	190	202	180	208	285	285	296	296	142	142
AC7769D	67	102	331	331	298	298	169	173	194	202	152	180	285	297	296	296	155	155
AC7769E	67	67	331	331	298	298	169	169	154	194	152	180	285	297	296	296	142	142
AC776A2	67	102	281	281	298	298	166	173	190	194	208	208	293	293	360	360	142	142
AC776A3	67	67	281	351	298	302	166	169	154	154	152	180	297	297	360	360	142	142
AC776A4	67	102	331	331	298	298	169	169	154	194	152	180	285	297	296	296	142	155
AC776A5	67	67	331	351	298	298	169	173	154	190	180	180	285	297	296	296	130	142
AC776A6	67	102	331	351	298	302	169	173	190	194	152	180	285	293	296	296	142	142
AC776A9	67	67	281	331	298	298	166	169	190	190	180	208	297	297	?	?	142	142
3140-015	67	67	281	331	298	298	169	169	154	194	208	208	289	297	296	296	142	142
3140-016	67	67	327	327	298	298	166	169	158	190	208	208	306	306	360	360	142	142
3140-017	67	67	281	351	298	302	166	173	194	194	180	208	285	285	296	296	142	142
AC776AD	67	67	281	331	298	298	169	169	166	202	152	208	293	293	296	296	142	155
AC776AE	67	67	331	351	298	302	166	166	154	190	208	212	293	293	360	360	142	142
AC776AF	67	67	351	351	290	302	169	169	190	190	208	208	285	293	360	360	142	142

Appendix 2. *Continued*

PIT Tag Number	Sco202		Sco212		Sco215		Sco216		Sco218		Sco220		Sfo18		Smm22	
AC77671	122	122	273	277	289	289	209	213	209	209	342	342	151	151	210	246
AC77683	122	126	230	273	289	289	213	213	209	209	294	342	151	151	218	222
AC77684	122	130	273	300	289	289	213	221	197	213	294	294	151	151	222	222
AC77686	130	130	273	300	289	289	213	213	209	209	342	342	151	151	226	226
AC77690	130	130	273	273	289	289	213	213	197	209	294	310	151	151	226	246
AC77691	122	130	273	273	289	289	213	269	209	209	294	294	151	151	210	226
AC77692	122	122	273	277	289	289	209	213	209	213	294	394	151	151	218	246
AC7769D	126	126	230	300	289	289	213	213	209	233	294	394	151	151	226	242
AC7769E	126	130	300	300	289	289	213	213	197	197	294	342	151	151	218	226
AC776A2	130	130	273	273	289	289	213	213	209	213	294	294	151	151	226	234
AC776A3	122	130	273	273	289	289	213	213	209	233	342	342	151	151	222	246
AC776A4	126	130	300	300	289	289	213	213	213	233	294	342	151	151	?	?
AC776A5	126	130	300	300	289	289	221	221	209	233	294	342	151	151	226	226
AC776A6	126	130	230	300	289	289	221	221	197	209	294	294	151	151	226	242
AC776A9	122	122	273	273	289	289	213	213	209	229	294	294	151	151	210	226
3140-015	122	130	273	273	289	289	213	213	209	209	294	342	151	151	210	222
3140-016	122	130	273	273	289	289	213	213	209	209	294	371	151	151	222	242
3140-017	122	122	273	300	289	289	213	213	213	233	294	294	151	151	210	222
AC776AD	122	126	273	300	289	289	213	213	209	209	310	394	151	151	?	?
AC776AE	122	122	273	277	289	289	209	213	209	209	294	342	151	151	210	246
AC776AF	122	130	273	273	289	289	213	213	209	209	294	294	151	151	210	246

Appendix 3. Results of COLONY analysis for age-0 bull trout collected from Cougar, Pine and Rush Creeks. Individuals assigned to each full sibling family are listed in the rows of the table.

Tributary	Full Sib Family #	Prob(Inc.)	Member-1	Member-2	Member-3	Member-4	Member-5	Member-6	Member-7	Member-8	Member-9	Member-10
Cougar	1	1.000	3142-055									
Cougar	2	1.000	3142-056	3142-062	3142-065	3142-068	3142-080	3142-082				
Cougar	3	1.000	3142-057									
Cougar	4	1.000	3142-058	3142-059	3142-074							
Cougar	5	0.849	3142-060	3142-085								
Cougar	6	1.000	3142-061									
Cougar	7	0.984	3142-063	3142-070								
Cougar	8	1.000	3142-064									
Cougar	9	1.000	3142-066									
Cougar	10	1.000	3142-067									
Cougar	11	1.000	3142-069									
Cougar	12	1.000	3142-071									
Cougar	13	1.000	3142-072									
Cougar	14	1.000	3142-073									
Cougar	15	1.000	3142-075									
Cougar	16	1.000	3142-076									
Cougar	17	1.000	3142-077									
Cougar	18	1.000	3142-078									
Cougar	19	1.000	3142-079									
Cougar	20	1.000	3142-081									
Cougar	21	1.000	3142-083									
Cougar	22	1.000	3142-084									
Cougar	23	1.000	3142-086									
Cougar	24	1.000	3142-087	3142-090	3142-091	3142-092	3142-094	3142-095	3143-095			
Cougar	25	1.000	3142-088									
Cougar	26	1.000	3142-089	3142-093	3143-099							
Cougar	27	1.000	3142-096									
Cougar	28	1.000	3142-097									
Cougar	29	1.000	3142-098									
Cougar	30	1.000	3143-091									
Cougar	31	1.000	3143-092									

Tributary	Full Sib Family #	Prob(Inc.)	Member-1	Member-2	Member-3	Member-4	Member-5	Member-6	Member-7	Member-8	Member-9	Member-10
Cougar	32	1.000	3143-093									
Cougar	33	1.000	3143-094									
Cougar	34	1.000	3143-096									
Cougar	35	1.000	3143-097									
Cougar	36	1.000	3143-098									
Pine	1	1.000	3141-001									
Pine	2	0.833	3141-002	3141-003								
Pine	3	1.000	3141-004									
Pine	4	1.000	3142-001	3142-002	3142-028	3142-038	3142-010	3142-011	3142-013	3142-015	3142-018	3142-021
Pine	5	1.000	3142-003									
Pine	6	0.882	3142-004	3142-007	3142-012	3142-016	3142-041	3142-053				
Pine	7	1.000	3142-005	3142-008	3142-009	3142-052	3142-017	3142-020	3142-043	3142-045	3142-046	3142-048
Pine	8	1.000	3142-006	3142-022	3142-030	3142-031	3142-037	3142-047				
Pine	9	1.000	3142-014									
Pine	10	1.000	3142-019									
Pine	11	1.000	3142-023									
Pine	12	1.000	3142-026									
Pine	13	1.000	3142-027									
Pine	14	1.000	3142-029									
Pine	15	1.000	3142-032									
Pine	16	1.000	3142-036									
Pine	17	1.000	3142-042									
Rush	1	1.000	3143-001									
Rush	2	1.000	3143-002	3143-003	3143-007	3143-008	3143-009	3143-012				
Rush	3	1.000	3143-004									
Rush	4	1.000	3143-005									
Rush	5	1.000	3143-006									
Rush	6	1.000	3143-010									
Rush	7	1.000	3143-011									
Rush	8	1.000	3143-013									
Rush	9	1.000	3143-014									
Rush	10	1.000	3143-015									

Tributary	Full Sib Family #	Member-11	Member-12	Member-13	Member-14	Member-15	Member-16	Member-17	Member-18	Member-19
Pine	4	3142-024	3142-025	3142-033	3142-034	3142-035	3142-039	3142-040	3142-044	3142-051
Pine	5									
Pine	6									
Pine	7	3142-049	3142-050							