Englishman River Adult Coho 2013

A pilot study using PIT tags as an alternative enumeration method

Report Prepared for:

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Introduction

The Englishman River originates at Jewel Lake on the Beaufort Range and drains eastward for approximately 38 km to the Strait of Georgia at the City of Parksville. The Englishman River originates near Shelton Lake and joins the mainstem about 8.5 km from the ocean while the upstream limit for anadromous salmonids is Englishman River Falls (river km 15). A constructed side channel (Clay Young Channel, 2006/07) is provided with water from an engineered intake about one kilometer upstream of the South Englishman confluence and returns the water at a point nearly 4.5 km downstream.

The majority of the 3.8 km long side channel flows through Englishman River Regional Park. An extensive network of trails run along sections of the channel making it ideal for visually enumerating spawning salmon. Students from the VIU RMOT program have conducted a series of stream walks since 2009 to document use by adult Coho and other salmonids.

BC Conservation Foundation (BCCF) fisheries staff have conducted many snorkel surveys in the watershed to enumerate adult Steelhead and salmon over the last 17 years. In particular, counts of adult Coho are met with variable success due to high water conditions typical of the fall on Vancouver Island. A pilot study was undertaken in the fall of 2013 to determine the viability of channel counts as an alternative for estimating adult Coho abundance. A combination of PIT tags (Passive Integrated Transponders) and visual tags ("spaghetti tags") were applied to adult Coho in the mainstem below the side channel in an attempt to correct channel counts for observer efficiency and to document the proportion of the population using the channel. The project was run on a pilot scale to see if the technique was feasible such that proper funding for a full scale study could be sought in the future. The goal was to collect enough data to design and plan a full scale study as well as to better understand Coho behavior/production within the channel.

Methods

Stream Walks

Enumeration of Coho adults in the side channel began on October 24, 2013 and continued through January 25, 2014. The Clay Young Channel was divided into three sections from the bottom to the top (Figure 1). Section one extended from the mainstem Englishman upstream to a point 500 m above the first road crossing, section 2 from this point to the bottom of the spawning riffle, and section 3 from the riffle to the intake in the mainstem. Live and dead fish of all species were enumerated during weekly visits.

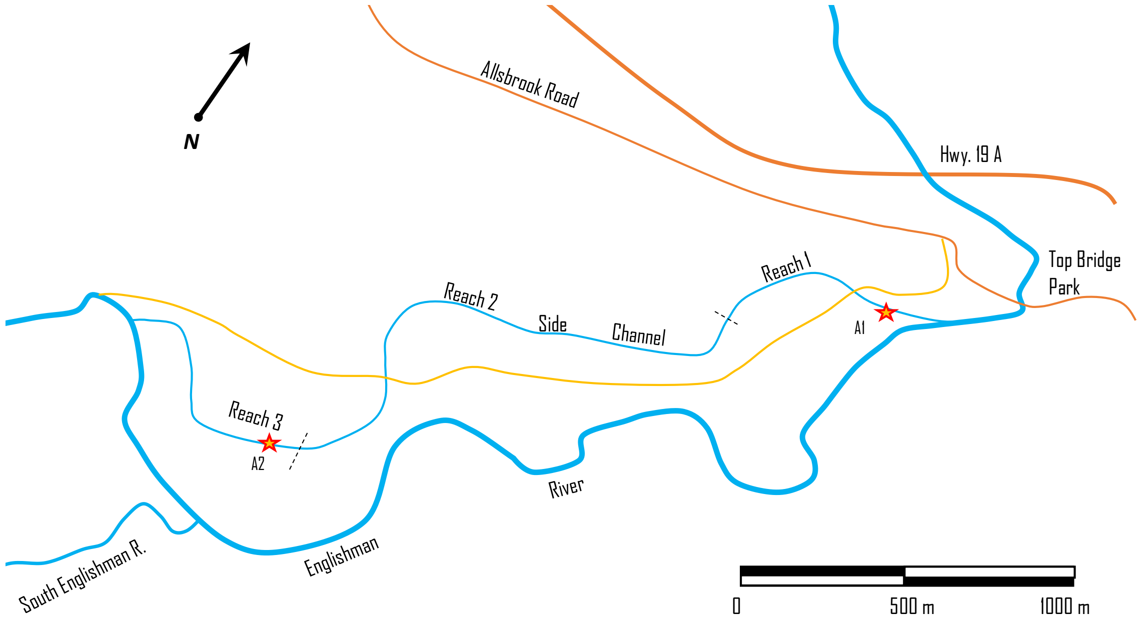

Figure 1. Map of the Clay Young Channel including reach breaks for adult counts (dotted lines) and PIT detection arrays (red stars). The direction of flow is from west to east.

Fish Capture and Tagging

Adult Coho were captured using a variety of techniques including angling, tangle netting and seine netting. Due to concerns over a high number of non-Englishman origin fish staging in the portion of the lower river near Plummer Road in Parksville, the majority of tagging activities occurred above the Highway 19 Bridge ("Orange Bridge"). All tagging activities occurred below the side channel entrance to ensure each fish had an equal probability of entering the channel. Only wild origin (adipose present) fish were tagged despite the presence of hatchery origin (adipose fin clip, AFC) fish in the system which were certainly from other watersheds as there is no hatchery Coho production on the Englishman.

Tagging activities began with the first bump of fish on October 2 and continued through December 29. Upon capture, the fork length (mm), sex and condition[1] of each fish was recorded. A visual "Spaghetti" tag was inserted through the back under the dorsal fin and secured using a double overhand knot. The point of tag insertion was about three fin rays forward from the tail and 5-8 mm below where the dorsal fin meets the body (Figure 2). A PIT tag was also inserted using a 6 gauge needle on the ventral side between the pelvic fins. The tag was placed under the skin but not in the body cavity to limit tag loss (tags can be expelled from the body cavity during later stages of maturation). Tags were able to be inserted into the body as risk of consumption by humans was low. No fisheries for wild Coho were open in areas 14 and 17 during the fall of 2013 so there was no targeted harvest. Hatchery Coho were open for harvest in marine waters and could be intercepted if they left the river which further supported the decision not to tag AFC fish. PIT tags were pre-scanned and the unique ID (tag number) was written on a piece of waterproof paper taped to each tag. Both the spaghetti tag and PIT tag numbers were recorded prior to release as well as the date, time and location of capture.

[1] 1- bright, 2- moderate, 3- mid-spawn, 4-post spawn

Figure 2. Typical application of a Spaghetti tag to an adult Coho on the Englishman River, fall 2013.

The portion of the river where tagging was conducted was open for catch and release angling during the study (closed upstream from Top Bridge December 1-May 30 to protect wild Steelhead). Fish were captured by volunteer anglers in accordance with angling regulations (no natural bait, single barbless hooks) and the majority were on spoons, spinners or jigs. A 15 m x 2 m sinking tangle net (10 cm web) was deployed in holding locations by at least one snorkeler in a dry suit. Only 1-5 fish were captured per set to ensure all fish could be removed quickly after capture and placed in a 50 L plastic tub prior to tagging. A 30 m x 8 m seine net (5 cm stretch mesh) was deployed from an inflatable boat with a small outboard engine in deep holding pools and retrieved with a crew of 4-6 people. If more than 10 fish were captured in a set the net was left pursed in the water as to create a holding pen while fish were dip netted out and processed in 50 L plastic totes before being released back into the river.

PIT Array Installation

Half-Duplex (HDX) 32 mm PIT tags were selected for this study due to relatively easy antenna construction, large read range and low power consumption. Tags and electronics were sourced from Oregon RFID[2]. PIT tag detection arrays were installed at two locations in the side channel. Each array consisted of two antennas such that direction and efficiency could be determined based on the sequence of detections. Each antenna consisted of 2-3 turns of 12 gauge stranded wire inside of ¾" PVC conduit to form a rectangular loop. The dimensions of each loop varied with the site but were approximately 1.5-2.0 m x 1 m. Tags were able to be read up to 50 cm from either side of the loop when in a pass-through orientation (Figure 3). Antennas were connected to a tuning box then to the reader using a section of 24 AWG shielded twinax cable. The reader and 12 V batteries (two to three in parallel) were located inside of a locked steel job box approximately 5-15 m from the antennas. The scan rate (read/listen or duty cycle) was set high enough to ensure each tag was detected multiple times at each antenna but not so high that power consumption was excessive. The optimal setting for each site was approximately 12 scans per second split between the two antennas (6/sec each).

Battery banks at each monitoring site required weekly changes. The readers were downloaded regularly to ensure the equipment was functioning properly. All detection records were logged on the reader's internal memory and partitioned into upload events whereby only detections since the last download were immediately displayed. Any past download event could also be accessed to ensure data were not lost. The internal memory was able to store far more data than was collected during the study (approximately one million detections).

[2] http://www.oregonrfid.com/

Figure 3. PIT tag detection array at Site 2 consisting of two pass-through antennas as well as a steel job box to house the reader and batteries (right).

Snorkel Surveys

The mainstem Englishman River was swum by BCCF and DFO crews to enumerate adult salmon. Each crew consisted of two observers moving downstream in parallel while maintaining even spacing between themselves and each bank to maximize coverage. The standard index section was from the side channel intake pool to the bottom of the Plummer Road run (8.0 km) and encompassed the entire tagging area. Observations of tagged Coho were recorded on each survey in addition to species specific counts. A total of seven surveys were completed between September 12 and December 17, 2013. Swim data were recorded on standardized DFO Stream Inspection Logs (SILs) and submitted to Stock Assessment staff.

Population Estimates

Area under the curve methodology was used to derive an estimate of adult Coho abundance based on both stream walks and snorkel survey results. Before conducting the AUC estimate, an expanded population estimate based on tag observations was calculated for each survey date. The Chapman modified Peterson mark recapture equation below (Lockwood *et al*. 2000) was used to calculate population estimates for each survey based on the number of tags observed.

$N= ((M+1)(C+1))/(R+1)$

Where;

N = population estimate,

M = number of tagged fish present in survey reach,

C = total number of fish observed in survey reach

R = number of tags observed

For snorkel surveys, an estimate of the number of live tags available for observation on each survey (M) was required as fish were susceptible to dying or moving out of the survey reach. The probability of mainstem residence (in the snorkel survey reach) by day after tagging was calculated separately for fish tagged in condition 1, 2 and 3 (Figure 4). This was accomplished by looking at the time between tagging and channel entry for fish which were detected on the lower array. From this data, frequency distributions for the number of fish remaining in the mainstem relative to days after tagging were plotted to derive tag depletion curves.

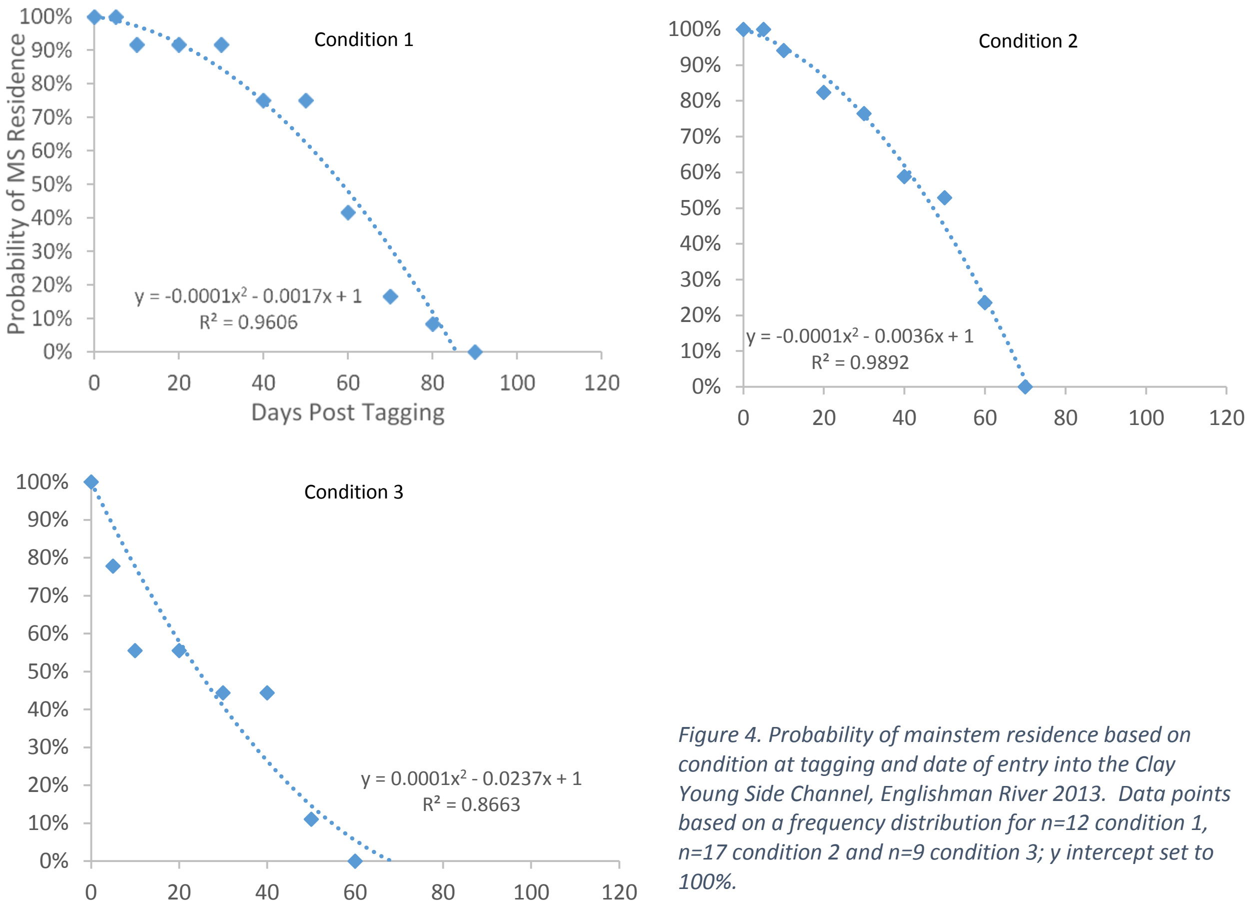

Figure 4. Probability of mainstem residence based on condition at tagging and date of entry into the Clay Young Side Channel, Englishman River 2013. Data points based on a frequency distribution for n=12 condition 1, n=17 condition 2 and n=9 condition 3; y intercept set to 100%.

Depletion curves were applied to each and every fish tagged during the study period based on the condition at tagging to derive an estimate of live tags in the survey reach. For example, a condition 1 fish tagged on October 2 would have a 99.3% chance of still being in the mainstem on October 4 but only an 83.9 % chance by November 4. If 100 condition 1 fish were tagged on October 2, we would expect that approximately 84 would still be in the survey reach on November 4. As new fish were tagged throughout the study, the cumulative sum of all probabilities were updated daily such that a total number of potential tags in the swim section was able to be estimated (Figure 5). The number of observed tags in each survey (R) was then compared to the estimated number available (M) to calculate observer efficiency.

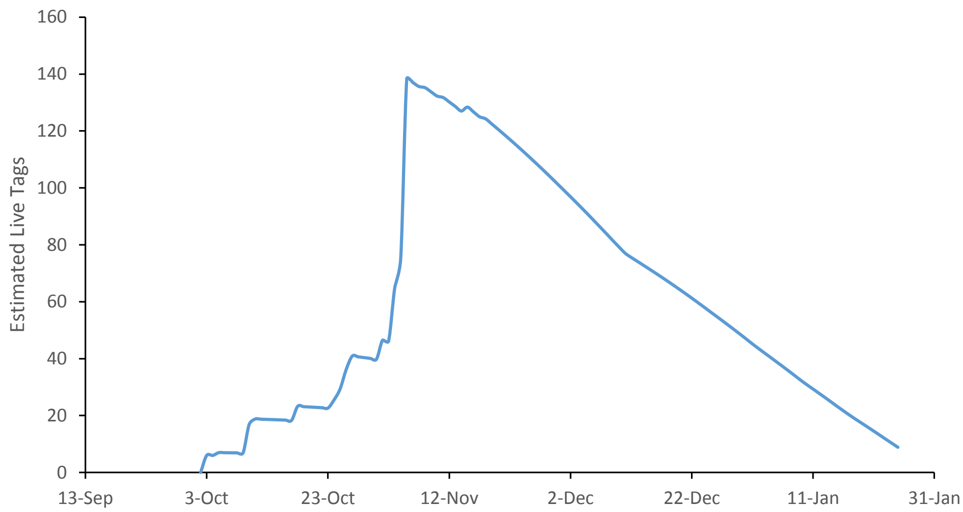

Figure 5. Estimated live tags available for observation in the mainstem snorkel survey index based on the cumulative probability for 154 tagged Coho, Englishman River 2013. Note: individual probabilities based on tagging date and specific residence time by condition from Figure 4.

Similar to the mainstem, the Chapman modified Peterson mark recapture equation was used to estimate weekly Coho abundance in the Clay Young Channel. An estimate of the number of live tags available for observation was made based on the linear relationship between channel entry date and residence time (days to post-spawn) from Figure 6. This calculation was made for each and every tagged fish which entered the side channel. The probability that each tag was alive on any given day was calculated by dividing the number of days since entry by the estimated residence time. For example, a fish entering the channel on November 15 would have an estimated residence time of 54.9 days. The probability of that fish being alive in the channel on December 1 (16 days later) would then be 1 – (16/54.9) or 70.8%. The resulting total number of live tags per day (taking into account fish moving in and out of the channel) is displayed below in Figure 7.

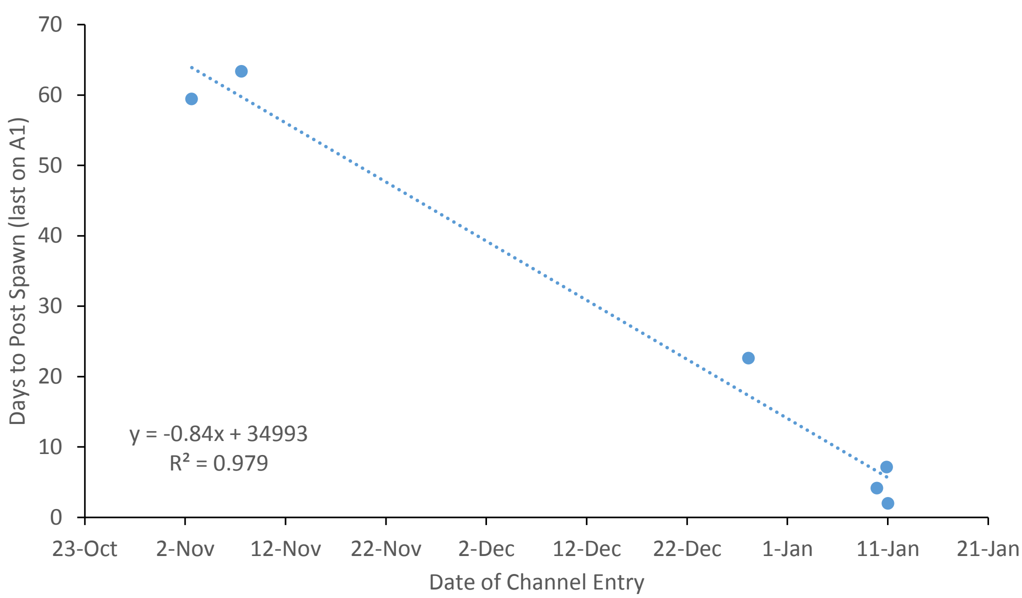

Figure 6. Behavior of six tagged fish which were detected entering the side channel, moving into the spawning area in reach 3 then back downstream after spawning presumably to die shortly after. Clay Young Side Channel - Englishman River, fall 2013.

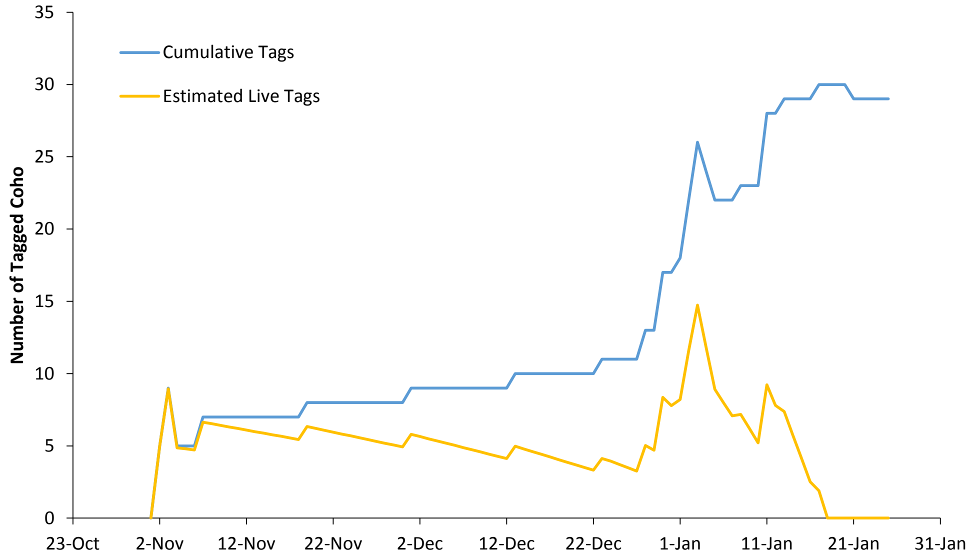

Figure 7. Cumulative number of tagged Coho in the side channel and estimated live tags available for observation during stream walks based on channel entry date and residence time predicted by Figure 6.

Results

Fish Capture

A total of 166 adult Coho were tagged during the study period; 154 fish were captured in the mainstem and 12 in the side channel. Of the three capture methods, angling accounted for the vast majority of effort and produced 81 fish (Figure 8). A seine net was used on two occasions (Oct 9 and Nov 4) but was only effective on the later event after switching locations. A total of 63 fish were captured by seining and tagged at Parry's Pool following a snorkel survey on November 4. Ten fish were also captured by tangle netting in Allsbrook Canyon on October 9 following a failed seining attempt.

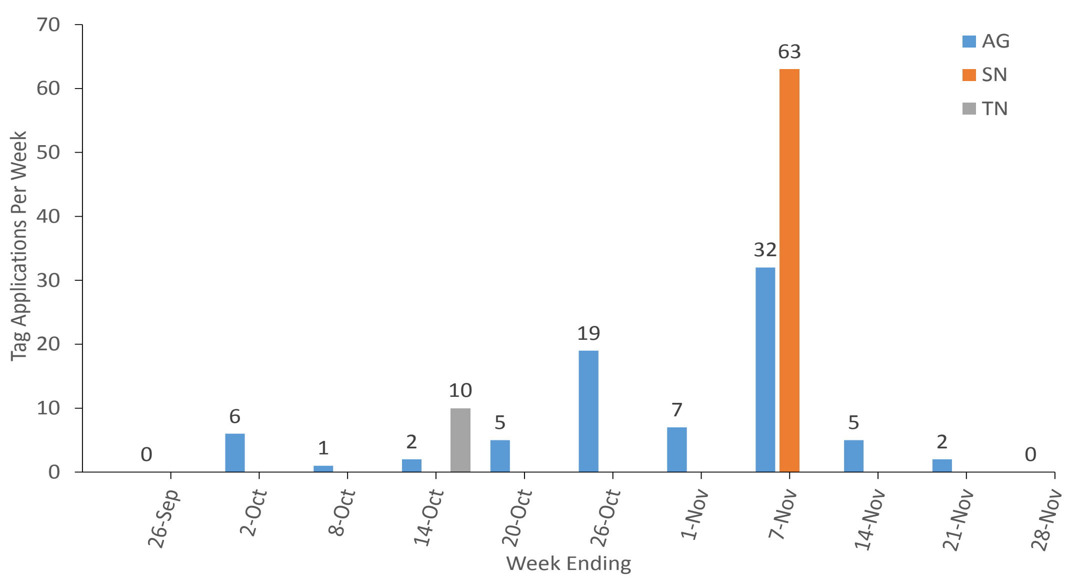

Figure 8. Summary of tag applications by week and capture method (AG – angling, SN –seine Net, TN – tangle net), Englishman River adult Coho, fall 2013. (Not shown: 2 fish were also captured by angling on Dec 29 and 12 fish within the side channel on Nov 14/21)

As a result of the successful seining operation on November 4 and a high number of captures by angling, the number of fish tagged peaked at 95 in the week of November 7.

A total of 98 males and 68 females were captured throughout the study period. Males averaged 653.3 mm +/- 12.3 while females were significantly smaller at 617.8 mm +/- 13.2 (95% C.I.). When looking at the distribution of sizes (Figure 9), both sexes occupied a similar range but there was a noticeable contingent of larger males beyond 650 mm. This may be in part due to sexual dimorphism as males adapted their jaws in preparation for fighting on the spawning grounds. Conversely, females maintained their appearance resulting in a very “normal” distribution of sizes throughout the study.

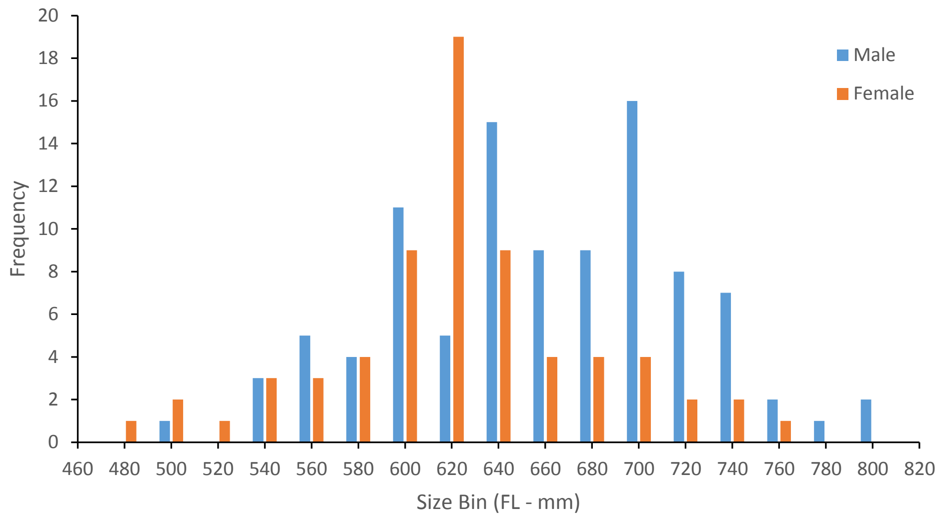

Figure 9. Length frequency distribution for male and female adult Coho captured in the Englishman River, fall 2013.

The average condition of fish increased from bright/moderate (1-2) to mid/post-spawn (3-4) throughout the study period. As fish were expected to die shortly after reaching condition 4 (post spawn) a rough estimate for the end of the run was set at January 25 based on the official zero count in the Clay Young Channel. When plotted by week (Figure 10), the trend including all points was quite linear (R^2= 0.89) suggesting that the majority of fish were maturing throughout the capture period.

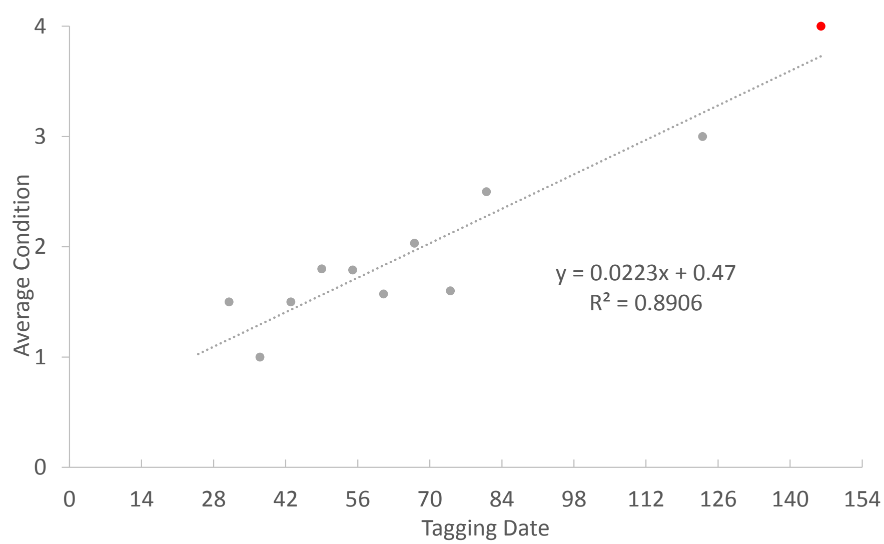

Figure 10. Average condition of fish captured and tagged in the mainstem throughout the study by week. Note: condition ranged from 1 (bright) to 4 (post spawn), Day 0 = September 1, Day 146 = Jan 25 (red dot) and was arbitrarily set to condition 4.

Channel Counts

The side channel was regularly surveyed beginning October 24, 2013 through January 25, 2014 (Table 1). Observations of fish were limited until November 7 and peaked on November 28. Coho were routinely observed through January 18 and a zero count was recorded on January 25 which signaled the end of the study. Observations of tagged fish were low at a total of 14 throughout the study. Of these, 6 were observed on November 21. A total of twelve fish were captured and tagged within the channel in the preceding two weeks. Unfortunately, these were marked with the same colour tags as the rest of the study so they were unable to be distinguished later. It is suspected that the majority of tag observations on the November 21 survey were of these fish.

Table 1. Summary of adult Coho observations in the Clay Young side channel by reach, October 24, 2013 – January 25, 2014. Note: counts in reach 1 are broken into sections above and below the lower PIT array.

	FISH					TAGS				
Survey	**R1**		**R2**	**R3**	**TOTAL**	**R1**		**R2**	**R3**	**TOTAL**
Date	**Below**	**Above**				**Below**	**Above**			
24-Oct-13	0	0	2	0	2	0	0	0	0	0
31-Oct-13	0	0	0	0	0	0	0	0	0	0
7-Nov-13	11	0	12	38	61	0	0	0	1	1
14-Nov-13	13	11	39	72	135	0	0	1	0	1
21-Nov-13	0	32	19	25	76	0	5	1	0	6
28-Nov-13	18	68	7	30	123	0	2	0	1	3
8-Dec-13	20	3	2	1	26	1	0	0	1	2
18-Dec-13	16	15	5	12	48	0	0	1	0	1
28-Dec-13	75				75	1				1
30-Dec-13	34	16	0	28	78	0	0	0	0	0
8-Jan-14	3	5	0	41	49	0	0	0	0	0
14-Jan-14				50	50				0	0
18-Jan-14	0	0	2	19	21	0	0	0	0	0
25-Jan-14	0	0	0	0	0	0	0	0	0	0

Snorkel Counts

Snorkel surveys were conducted in the 8.0 km index section of the mainstem Englishman River from September 13 to December 17, 2013. Counts peaked on October 22 at 5,329 adults while the greatest number of tags were observed on November 21 at 59 (Figure 11). The distribution of adults during the peak count (October 22) was heavily skewed towards the lower end with 2,665 fish observed in the Plummer Road run alone.

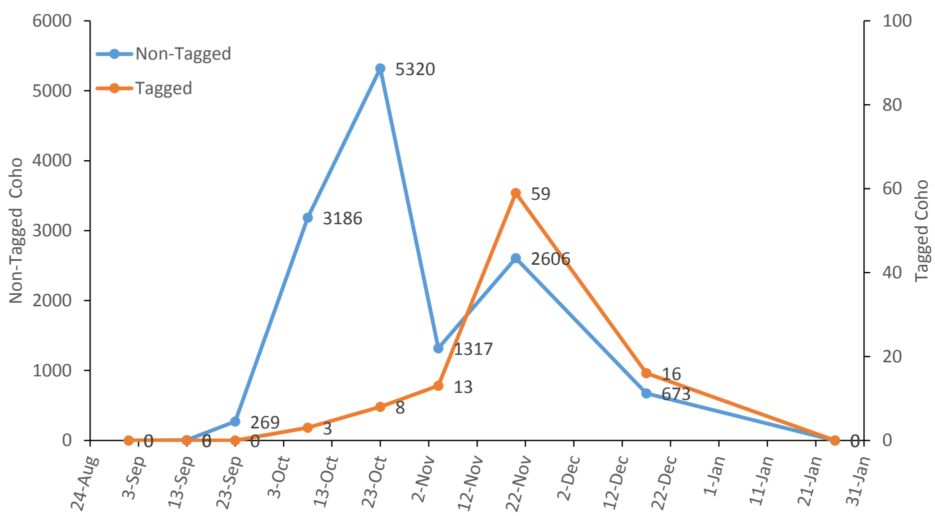

Figure 11. Observations of adult Coho in the 8.0 km index section from the side channel intake pool to the end of Plummer Road, Englishman River, fall 2013.

Few fish were present in mid-September and there was a noticeable bump of fish that entered the river between September 22 and October 7, likely coinciding with a high water event on September 30 (Figure 12). Outside of a small amount of rain in early November, the fall of 2013 was abnormally dry resulting in below normal flows. This provided ample opportunity for mainstem swims which is not typical of this system. Following the September 30 event, the next big rainfall event did not occur until January 12th.

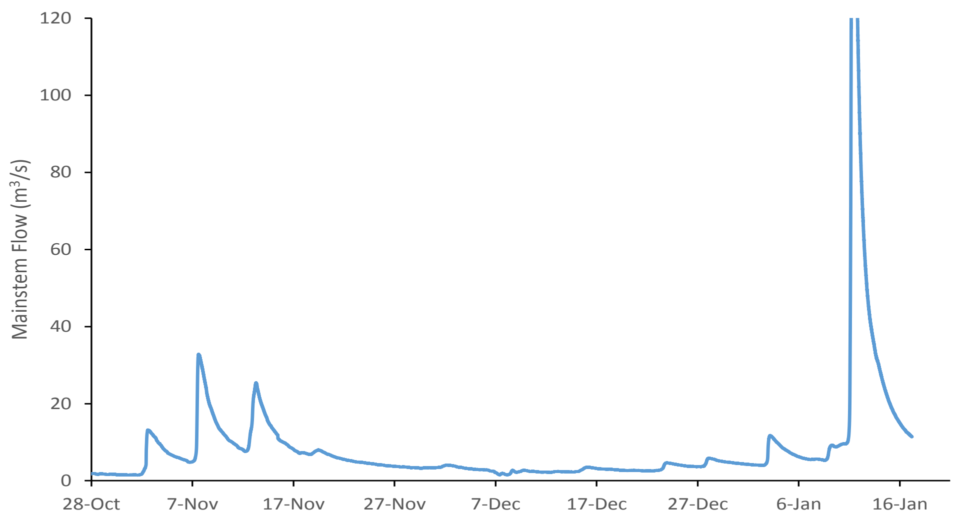

Figure 12. Discharge measured at WSC station 08HB002 – Englishman River near Parksville – September 1, 2013- January 31, 2014.

PIT Tag Detections

A total of 39 unique PIT tags were detected entering the side channel of the 154 tags that were applied in the mainstem. This suggests that approximately 25% of the adult Coho in the Englishman River entered the side channel in 2013/14. Of the 39 tagged fish, six backed out and later re-entered, four fish entered three times and one fish on six occasions. In addition, six left within 48 hours and were never detected again suggesting about 21% (33/154) of all Coho spawned in the channel in 2013.

The timing of channel entry was sporadic until mid-December, likely due to below normal flows. The first pulse of tagged fish entered the week ending November 7 resulting in 16 detections (Figure 13). Few detections were noted through to the week of December 12 and then became regular through January 23rd. Time of day was also an important factor influencing detections with the majority of activity occurring in hours of darkness (Figure 14). No fish were detected at the lower antenna between 5 am and 1 pm while the first few hours after sunset generally produced the most activity.

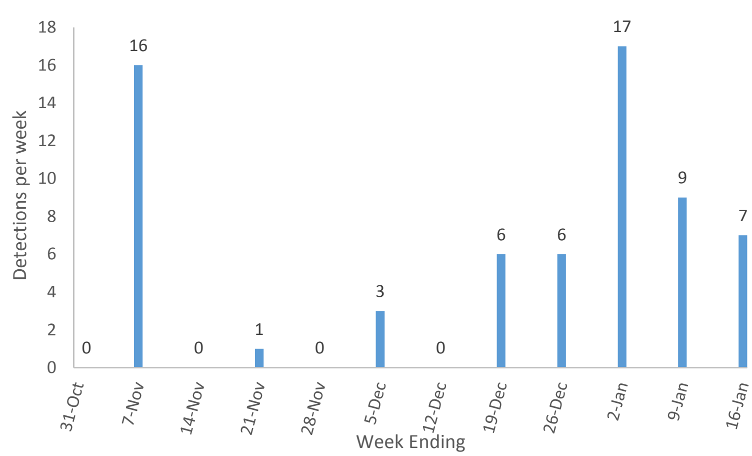

Figure 13. Summary of the number of PIT tag detections at the lower array in the side channel by week, October 18, 2013-January 25, 2014. Note: the total number of detections is shown with some fish entering multiple times over the study period.

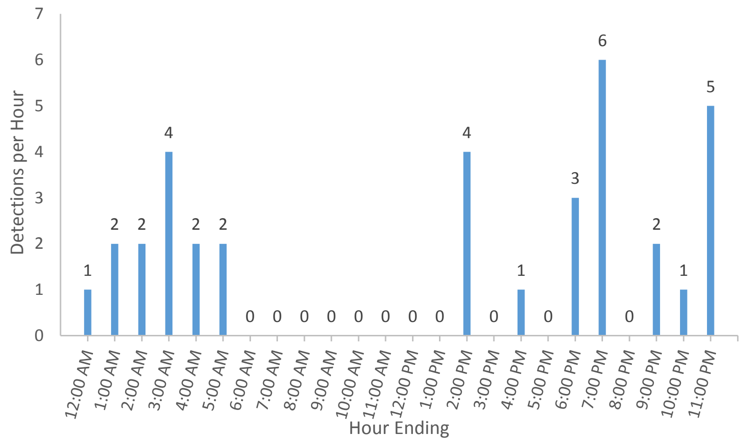

Figure 14. Summary of the number of PIT tag detections at the lower array in the side channel by hour, October 18, 2013-January 25, 2014.

The state of maturation (condition) that was recorded for each fish during tagging was compared to the time each fish took to enter the channel. Despite the range in condition over the tagging period, fish tagged at a later stage of maturation (condition 3) took significantly less time to enter the side channel compared to bright fish (Figure 15; 25.7 days vs. 56.7 days) while those tagged at condition 2 took 43.8 days on average. This suggests that behavior may be strongly influenced by the state of maturation in addition to environmental conditions.

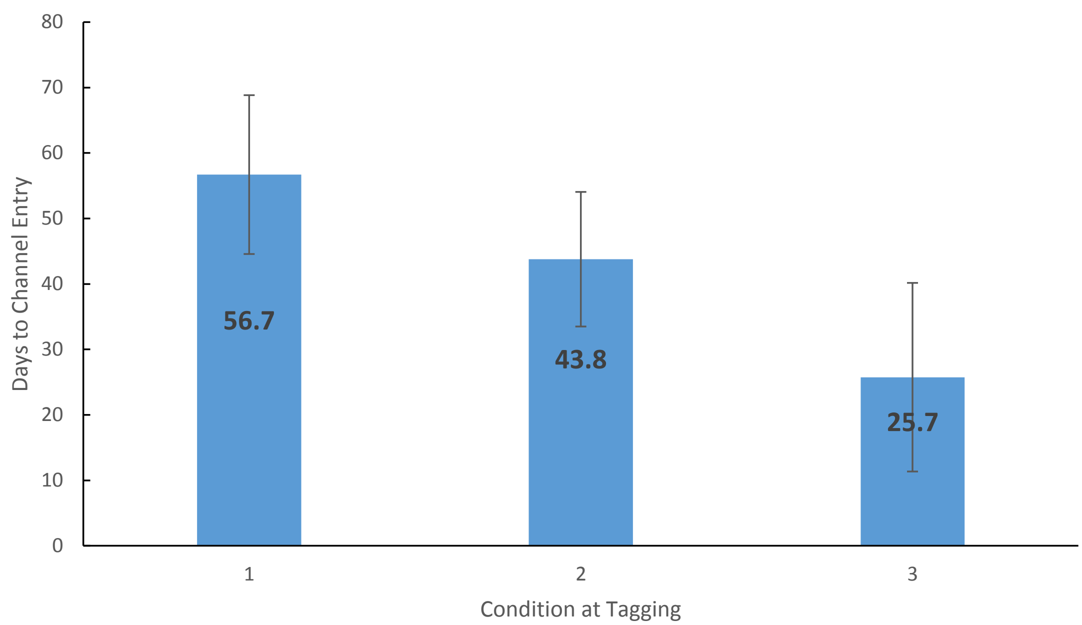

Figure 15. Average number of days between tagging in the mainstem and detection in the side channel by condition at tagging, Englishman River Coho, fall 2013. Note: Condition was recorded as 1- Bright, 2 – Pre-Spawn, 3 Mid-Spawn; error bars represent 95% confidence intervals around the means.

The main purpose of the upper array was to evaluate residence time within the side channel. A key spawning area (highly suitable depth/velocity and substrate) was located just upstream of the reach 2/3 divide. The array was positioned to document the movement of fish onto the spawning grounds in reach 3 then presumably back downstream to reach 2 just prior to death. Of the 39 tagged fish that entered the side channel, nine were detected at the upper array. Six of the nine fish were able to be tracked back downstream after spawning to reveal the residence time from entry to post-spawn.

Despite a small number of fish that were tracked leaving reach 3 after spawning, channel entry occurred over a wide range in dates that allowed for a comparison of early and late groups. Fish that entered in early November had a significantly longer residence time than those which entered in mid-January (Figure 6, above). The difference was extreme at an average of 61.4 days compared to 4.4 days. One fish which entered the channel on December 28 displayed a residence time of 22.6 days which fit well with the linear trend that links early and late migrants (R^2= 0.98). Despite not knowing the time that the other three fish left the spawning grounds, the time between channel entry and first detection at the upper array followed a very similar trend with the early migrant taking 70.7 days and the latest only 0.9 days. The shortest transit time between the lower array in reach 1 and the upper array in reach 3 was 0.7 days or 16.6 hours.

This suggests that residence time within the side channel was continuously variable depending on the date of channel entry. A rough estimate for the end of the run can be found by setting the "days to post spawn" to zero. Using the best fit line for residence time, spawning was estimated to be finished on Julian day 41658.3 or January 19, 2014. Assuming fish die shortly after spawning, the end of the run likely occurred in the third week of January. This estimate is also supported by actual channel counts which reached zero on January 25th (third week) as well as the general trend of condition over time (Figure 10). Snorkel counts suggest the run began about September 15 (6 fish counted on Sept 13) so from start to finish the Coho run spanned approximately 130 days in 2013. In-river abundance peaked sharply on about October 1 which suggests the majority of the run occurred over approximately 115 days.

Population Estimates

Snorkel Survey

An area under the curve (AUC) estimate was conducted using observations of tagged and non-tagged Coho in the mainstem snorkel surveys. The primary challenges with this calculation for the Englishman River in 2013 were:

1) The snorkel index only included a section of the anadromous habitat in the mainstem requiring separate estimates for survey life (time in index) and residence time (time in river)
2) Coho tend to prefer spawning in tributaries which were not swum
3) There was no containment of tags in the bottom end of the river (fish could leave undetected)
4) Residence time/survey life was poorly understood

These issues were resolved in the following manner:

1) Fish were assumed to move out of the snorkel reach into either tributaries or upper mainstem habitats at the same rate as those entering the Clay Young Channel.
2) Tagging activities were focused upstream of the Highway 19 A bridge ("orange bridge") to limit the interception of transient fish. No AFC fish were tagged as they were clearly not from the Englishman watershed and they were available for harvest in other areas. (A full stream pass over antenna was tested but did not provide satisfactory detection range to function as containment)
3) PIT tag detection data was used to calculate the time each fish was at large between tagging and detection in the side channel (survey life). The time each fish spent in the side channel was also monitored with two detection arrays with the uppermost near the key spawning reach. The combined observations allowed for an estimate of total residence time (river entry to death).

A mark-recapture estimate was derived for each snorkel survey in order to estimate the instantaneous live adult Coho population in the watershed. One of the key assumptions to this type of estimate is that there is equal mixing of tags within the population. This assumption was violated on the October 22 survey when half of the snorkel count came from the last run adjacent to Plummer Road. No tags were applied in this section as the risk of encountering mixed stocks (e.g. French Creek) was believed to be high. As a result, the number of tags observed to the Highway 19 A bridge was compared only to the count excluding Plummer Road (2,664 fish). As a result, the expanded count of adult Coho on October 22 above Plummer Road (7,106 fish) was added to the Plummer Road count (2,656) to produce a peak abundance estimate of 9,762 (Figure 16).

In order to complete the AUC population estimate, an estimate of survey life was required to convert fish days to number of adults. Given that the majority of adults likely arrived in-river as condition 1, their survey life was assumed to be similar to the average duration of time bright fish spent in the mainstem before entering the side channel. Using data for condition 1 fish from Figure 15 (above), we used a survey life of 56.7 +/-12.1 days to complete the AUC estimate. The cumulative number of "fish-days", or area under the curve for the expanded estimate in Figure 16, was calculated at 542,229 (Table 2). The end of run day was set at January 25 based on observations from Figures 9 and 15 as well as the zero count in the Clay Young channel on January 25. When divided by a residence time of 56.7 days, the total adult escapement to the Englishman River watershed in 2013 was estimated at 9,564 (range based on variation in residence time only 7,882-12,159).

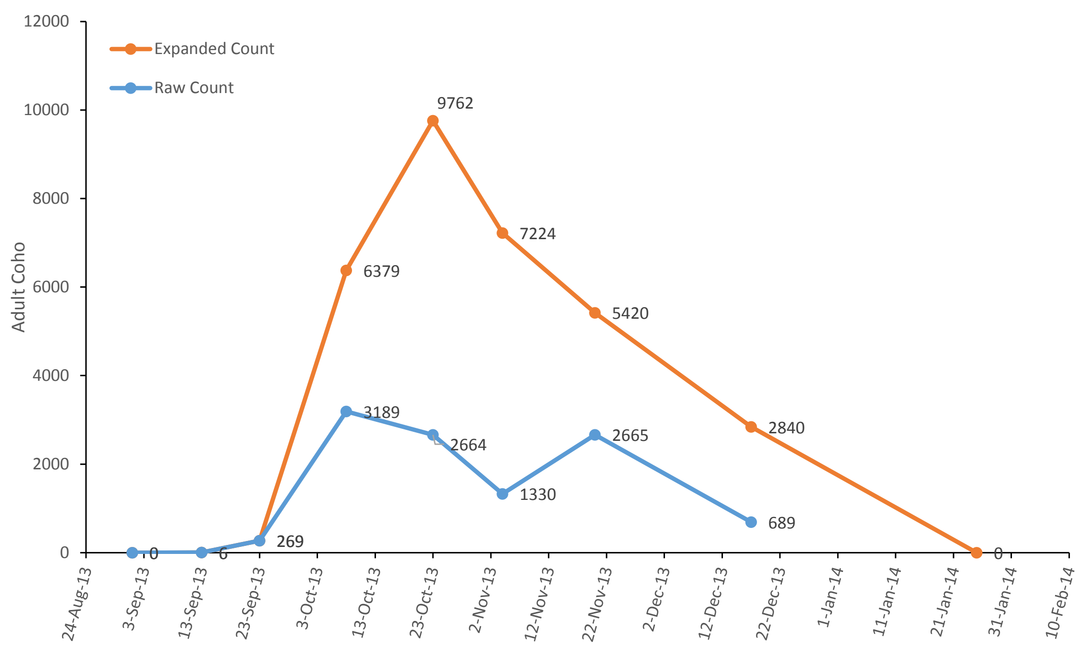

Figure 16. A comparison of the raw snorkel survey count of adult Coho in the index section of the Englishman River compared to the estimated number of live fish in the system using the Peterson mark recapture formula. Note; Oct 22 peak count is a sum of the mark-recapture estimate upstream of Plummer Road (7,106) and the Plummer Road count (2,656)

The estimate of 9,564 does not agree with the peak count of 9,762 on October 23 as the total should exceed the peak count. It is more than likely that a considerable number of fish in the Plummer Road run enumerated on October 22 did not stay in the Englishman River. This theory is supported by tagging studies in 2001 were Coho captured/tagged on the Englishman were later recovered during brood stock collection at French Creek and comprised approximately 10% of the catch (Baillie and Young 2002). Hatchery (AFC) Coho were regularly encountered throughout the study period by tagging crews in 2013 providing further evidence that the Englishman River, in particular the lower end, is a staging area for

Coho stocks in adjacent watersheds. If we assume that approximately 1,000 fish enumerated on the October 22 snorkel survey left the Englishman River prior to spawning, the peak count would be reduced to 8,762 and the AUC adjusted to 9,326 adults. Although this is an approximation, consideration for this anomaly should be given while interpreting results.

Table 2. Summary of parameters used to derive a Peterson population estimate for each snorkel survey event as well as the final AUC estimate, Englishman River, fall 2013. Note- yellow highlight on October 22 indicates Plummer Road count excluded from mark-recapture due to unequal mixing of tags but raw count added to total.

			M		C		R	
Survey Date	**AUC Fish Days**	**Total Tags In River**	**Live Tags in Survey**	**Observer Efficiency**	**Total Captures**	**Total No Mark**	**Total Marked**	**Petersen Population**
1-Sep-13	0	0	0		0	0	0	0
13-Sep-13	**36**	**0**	**0**		6	6	0	6
23-Sep-13	**1375**	**0**	**0**		269	269	0	269
8-Oct-13	**49860**	**7**	**7**	42.9%	3189	3186	3	6379
23-Oct-13	**121058**	**24**	**23**	34.8%	2664	2656	8	9762
4-Nov-13	**101919**	**80**	**75**	17.3%	1330	1317	13	7224
20-Nov-13	**101154**	**154**	**121**	48.8%	2665	2606	59	5420
17-Dec-13	**111511**	**154**	**69**	23.2%	689	673	16	2840
25-Jan-14	**55383**	**154**	**0**			0	0	0
Fish Days	***542295.5***							
Estimate	***9564.3***							
High	12159.1							
Low	7882.2							

Figure 17 (below) suggests that fish which entered the side channel at progressively later dates had spent more time in the mainstem after tagging. Figure 6 (above) shows an inverse relationship where fish which entered the side channel at an earlier date had a significantly longer residence time than those which entered later. When the time between tagging and first detection for 29 condition 1 and 2 fish was added to the estimated channel residence time from Figure 6 (based on entry date) a watershed residence time estimate was derived. This can be thought of as the total amount of time between river entry (assumed that tags applied shortly after) and death (post-spawn). The estimated watershed residence times were remarkably similar and ranged between 70.9 and 103.5 days. The average was calculated at 79.2 +/- 3.3 days (95% C.I.). The longest time between tagging and last detection in the channel was 90.6 days (October 2 to January 1).

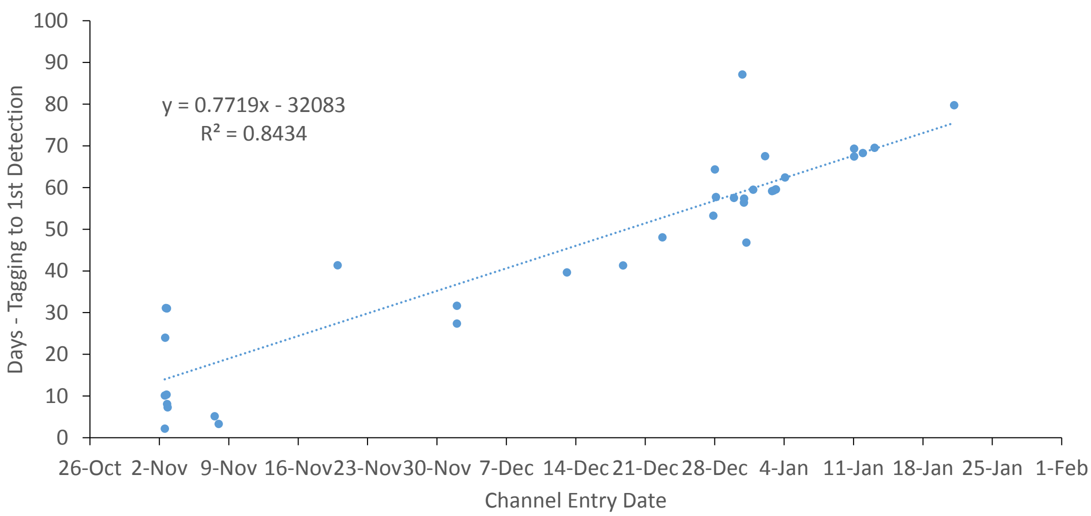

Figure 17. Data comparing the time between tagging and entry in the Clay Young channel based on date of entry for 38 PIT tagged adult Coho, Englishman River, fall 2013.

Side Channel

Channel walks were completed by RMOT students and staff weekly starting on October 24, 2013 through January 25, 2014. The largest number of fish observed was 135 on November 14 and a smaller bi-modal peak on December 30 at 78. Counts were expended based on water clarity (Figure 18, Table 3) which suggested each peak actually represented 193 and 111 fish, respectively. The total area under the curve was calculated at 7,549.6 fish days and using a residence time of 14 days yielded a channel escapement estimate of 539 adult Coho (Table 3) which was less than the previous 4 year average of 1,046 (Table 4). After expansion by the proportion of Coho known to use the channel in 2013 (21.4%), a watershed escapement estimate of 2,518 was produced.

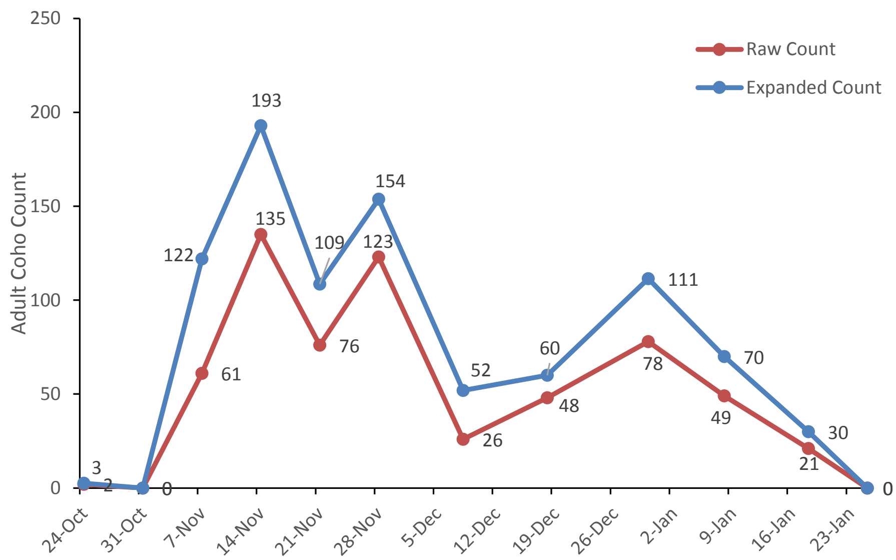

Figure 18. Raw and expanded counts of adult Coho in the Clay Young Channel based on standard methodology used by RMOT staff/students. Englishman River watershed, fall 2013.

Table 3. Parameters used for the RMOT AUC estimate of Coho abundance in the Clay Young Channel, fall 2013. Data courtesy of John Morgan, VIU.

Date	Day of Survey	No of fish	Water Vis	Obs Eff	Corrected No.	Area (Corr.)
24-Oct	0	2	E	80%	2.5	8.8
31-Oct	7	0	E	80%	0.0	427.0
7-Nov	14	61	F	50%	122.0	1102.0
14-Nov	21	135	G	70%	192.9	1055.0
21-Nov	28	76	G	70%	108.6	918.1
28-Nov	35	123	E	80%	153.8	1028.8
8-Dec	45	26	F	50%	52.0	560.0
18-Dec	55	48	E	80%	60.0	1028.6
30-Dec	67	78	G	70%	111.4	816.4
8-Jan	76	49	G	70%	70.0	500.0
18-Jan	86	21	G	70%	30.0	105.0
25-Jan	93	0	G	70%	0.0	
		Obs Eff	(from DFO)			
		E	80%		**Fish Days**	**7549.6**
		G	70%		**Residence Time**	**14**
		F	50%		**AUC Estimate**	**539**
		P	35%			
		VP	20%			

Table 4. Summary of RMOT AUC estimates of Coho escapement into the Clay Young Channel, 2009-2013.

Year	Coho (N)
2009	396
2010	2581
2011	577
2012	629
2013	539

The channel counts were also subjected to a different method of calculating observer efficiency based on the number of PIT/spaghetti tagged Coho observed. As the lower tag detection array was located upstream of at least one holding pool, counts had to be restricted to the area above only. Both the raw and expanded counts peaked on November 14 at 122 and 423 respectively (Figure 19). A second large peak occurred between December 30 and January 8 which was also marked by an influx of tags in early January (Figures 6 and 12, above). However, the number of fish observed throughout December and January was relatively stable at 21-46.

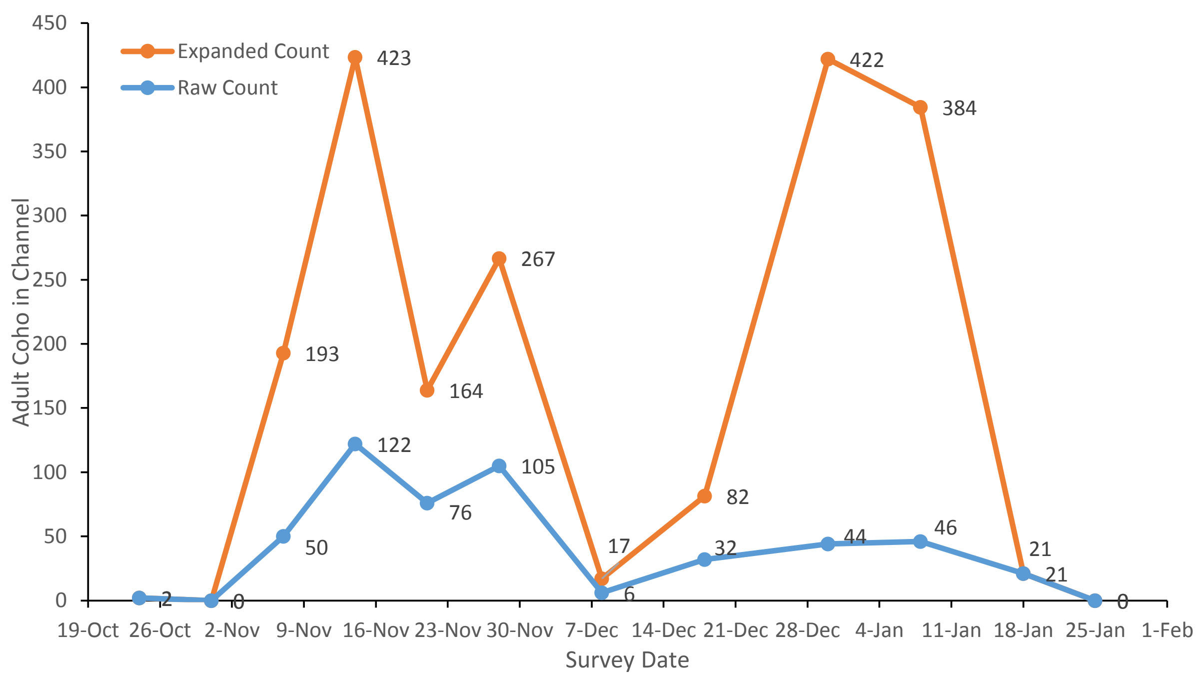

Figure 19. Raw and expanded counts of adult Coho in the Clay Young Side Channel, October 2013-January 2014.

The AUC estimate for Coho escapement in the side channel was difficult to derive from the PIT data for a number of reasons. First, the number of observed tags was low at a total of 14 over 10 surveys including six on November 21. Secondly, residence time appears to vary with channel entry date so arriving at a single estimate was challenging (14 days was adopted following Simpson *et al.* 2000 and RMOT calculations). And lastly, 12 fish were tagged in the channel (seven on Nov 14 and five on Nov 21) which were unable to be distinguished from "mainstem" tags which introduced uncertainty into the number of tags available for observation. However, an estimate was produced while keeping the above issues in mind.

A total of 17,069 fish-days were calculated based on the expanded counts throughout the study period (Table 5). This was then divided by an average residence time of 14 days to produce a channel escapement estimate of 1,219 Coho. In order to produce a watershed escapement estimate, the channel escapement was expanded by the 33 of 154 tags (21.4 %) which spent more than one day in the side channel yielding 5,697 adult Coho.

Table 5. Summary of parameters used in the AUC estimate of Coho escapement into the Clay Young Side Channel, fall 2013. The side channel count was expanded by the proportion of mainstem tags (21.4 %) that resided in the channel for more than one day.

				M		C		R	N
Survey Date	**AUC Fish Days**	**#Tags Detected in Channel**	**Total Tags in Channel**	**Tags remaining in channel**	**Observer Efficiency**	**Total Captures**	**No Mark**	**Marked**	**Petersen Population**
17-Oct-13	0	0	0	0		0	0	0	0
24-Oct-13	7	0	0	0		2	2	0	2
31-Oct-13	7	0	0	0		0	0	0	0
7-Nov-13	675	7	7	7	15.2%	50	49	1	193
14-Nov-13	2157	7	14	6	16.9%	122	121	1	423
21-Nov-13	2056	8	20	14	42.9%	76	70	6	164
28-Nov-13	1507	8	20	9	33.0%	105	102	3	267
8-Dec-13	1418	9	21	7	29.9%	6	4	2	17
18-Dec-13	492	10	22	4	25.0%	32	31	1	82
30-Dec-13	3021	17	29	8	0.0%	44	44	0	422
8-Jan-14	3629	23	35	7	0.0%	46	46	0	384
18-Jan-14	2027	30	42	0	0.0%	21	21	0	21
25-Jan-14	74	29	41	0	0.0%	0	0	0	0
									0
Fish Days	17069.0								
Survey life	14								
Channel Escapement	1219.2								
Expansion (21.4%)	5697.3								

Comparison to previous Coho stock assessment methods/results

DFO and contractors have been collecting stock assessment data for all five species of Pacific salmon in the Englishman River as far back as 1953 (DFO NuSEDS database). Escapement estimates over the last 10 years (2003-2013) have varied from a low of 490 in 2006 to a high of 17,238 in 2013 (Figure 20, Table 6). DFO AUC estimates suggest that 2013 was an anomalously high escapement relative to all data on file going back to 1953. The estimated number of adult Coho in the Clay Young Channel based on RMOT stream walks appears to be anomalously low in 2013 at 539 relative to the exceptional mainstem escapement. PIT tag results indicate about 21% of the total escapement in 2013 utilized the Clay Young Channel for spawning. If this is accurate, the AUC estimate of 17,238 suggests that about 3,688 adult Coho utilized the side channel for spawning which does not agree with the RMOT estimate of 539 or the PIT based AUC channel estimate of 1,219 from Table 5.

Table 6. Summary of parameters used for the Englishman River adult Coho AUC estimate conducted by DFO. Data courtesy DFO Stock Assessment, Nanaimo, BC.

Englishman													
Date	**Live Coho**	**Dead Coho**	**Obs. Eff. Coho**	**Expanded Live Coho**	**Survey Distance**	**Total Accessable**	**% Coverage Coho**	**Number of Days**	**Coho System Est.**	**Coho Sum**	**Comments**	**Raw Live+Dead Coho**	**Expanded Live+Dead Coho**
6-Sep-13	0	0	100%	0					0	0		0	0
13-Sep-13	6	0	79.00%	8	8300	8300	100%	7	8	27		6	8
23-Sep-13	269	1	73.30%	367	8300	8300	100%	10	367	1873		270	368
8-Oct-13	3186	0	73.40%	4,340	8300	8300	100%	15	4340	35302		3186	4340
23-Oct-13	5321	14	84.70%	6,281	8300	8300	94%	15	6682	82668		5335	6295
4-Nov-13	1317	7	37.20%	3,537	8300	8300	91%				Low OE not used	1324	3544
20-Nov-13	2606	0	70.00%	3,723	8300	8300	85%	28	4380	154880		2606	3723
17-Dec-13	689	9	80.00%	861	8300	8300	75%	27	1148	74635		698	870
24-Dec-13	0		100.00%	0	1	1	100%	7	0	4018		0	0
	Raw Peak Live + Dead:		**5335**										
	Expanded Peak Live + Dead:		**6295**										
	Survey Life:		**20.5**										
	AUC Estimate:		**17238**										

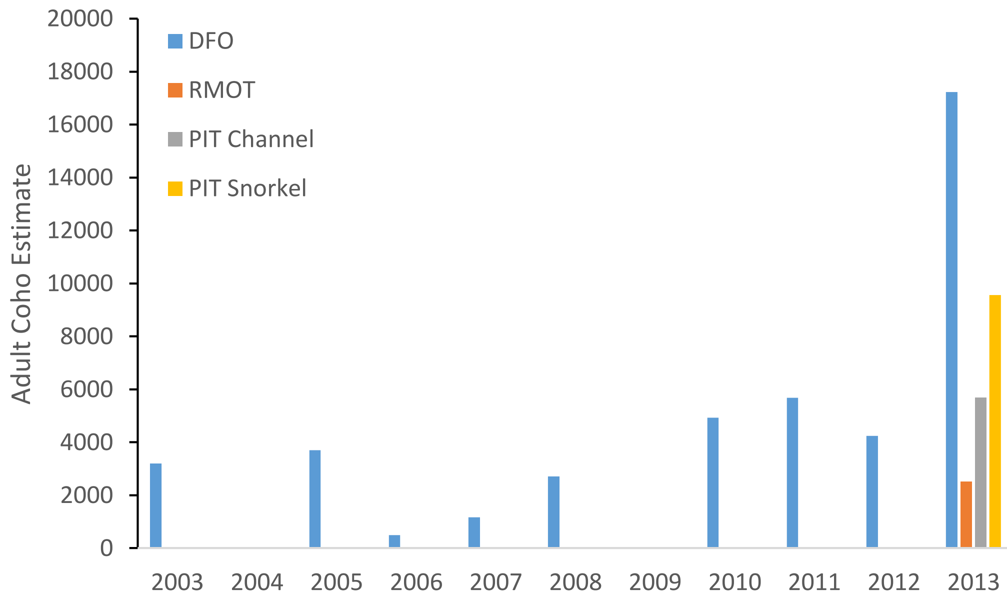

Figure 20. Estimates of adult Coho escapement in to the Englishman River based on DFO, RMOT and PIT tag data 2003-2013. Note: adults were present in the mainstem 2004 and 2009 but no surveys were completed; all estimates are based on AUC with the exception of 2007. RMOT AUC count expanded by 21.4% of all tagged Coho which used the Clay Young Channel in 2013.

Discussion

Mainstem Counts

The primary intent of the study was to investigate alternative methods of estimating Coho escapement compared to traditional mainstem snorkel counts. The main reason for this is that snorkel surveys become challenging later in the fall as rainfall increases discharge and reduces visibility. Side channel counts were identified as a potential way to maintain Coho enumeration throughout a much wider portion of each season. Snorkel surveys were conducted throughout the majority of the Coho run in 2013 due to below average flows and generally good observation conditions. This was not expected at the outset of the study but provided additional data to calibrate channel counts.

The number of visible tags deployed in the mainstem as part of the side channel PIT tag study provided an opportunity to refine snorkel counts further by using daily estimates of observer efficiency. Estimating the number of live tags in the survey reach for each swim was challenging because tag colour did not vary by week. Instead, PIT tag data collected from the Clay Young Side Channel was used to estimate how many tagged fish were still in the survey reach. This method required the assumption that all fish remained in the mainstem a similar amount of time as those entering the Clay Young Channel before migrating into tributaries (South Englishman, Center Creek, Morrison Creek) or into the upper reaches of the mainstem above the survey reach (upstream of the side channel intake pool). We could not validate this assumption in 2013 but this should be investigated if PIT tags are deployed in future years.

Channel counts

The fall of 2013 was marked by below normal flow conditions in the Englishman River and above average Coho escapement. Side channel counts conducted by VIU RMOT students and staff were expected to end in late November (marked by a zero count) but instead continued through January, ending January 25th. A sufficient number of tags (33 or 21.4%) were determined to have used the channel for spawning following application in the mainstem. This number was valuable in estimating the proportion of the population which used the channel and was considered reliable. Low numbers of tags were observed, particularly in the latter half of the season, to derive robust estimates of observer efficiency. The estimates by week ranged between 0% and 42% with a pooled estimate of 23% for the season. This was far lower than the estimated 70% average over 12 surveys used for the RMOT AUC estimate. It is possible that tag loss rates were high and contributed to decreased observer efficiency. A tag loss estimation method should be incorporated into future study designs due to this large discrepancy.

As with all AUC estimates, survey life was found to significantly influence the resulting number of adults. Several estimates of survey life for adult Coho exist including 13-17 days (Irvine *et al*. 1992) and 14 days (Simpson *et al.* 2000). While Baillie and Young (2001) used 30 days, DFO has chosen 20.5 days for the 2013 AUC calculation. PIT tag data collected during the fall of 2013 suggest survey life for Englishman River Coho was much longer, at least for a portion of the population. The average number of days 38 fish were at large (presumably in the mainstem) between tagging and detection in the side channel was found to be 43.6 +/- 7.6 days. As fish were tagged throughout the season, the estimate was able to be further refined by condition with bright fish taking significantly longer than mature fish (56.7 +/- 12.1 days vs. 25.7 +/- 14.4 days). Baillie and Young (2001) attempted to calculate survey life for Englishman Coho by creating depletion curves for different colour tags applied at weekly intervals. They were unsuccessful because the number of tags did not decrease over a five week period which suggests survey life may have been much longer than anticipated in 2001 which supports the PIT tag data.

Excerpt from Baillie and Young (2001)

"The method of calculating SL using the observed number of tags present in the system requires counts through time until all of the tagged fish have died. For Coho, the data from the first group of tags (orange) was confusing. The number of tags observed in the main stem for the ensuing 5 weeks is between 53% and 87% of the number applied, and then the main stem counts are discontinued due to flood conditions. With no apparent decrease in the number of tags present, and no zero count the data cannot be used to calculate a survey life for Coho. We chose to assume a survey life of 30 days, based on the long period with no measured decrease in live tagged Coho."

Once in the side channel, the amount of time fish resided prior to spawning was found to vary with the date of channel entry. Fish which entered near the beginning of the season (early November) were detected over 60 days later leaving the upper spawning area while fish which entered in mid-January were detected leaving the same spawning area only 1-3 days later. When looking at both the time between mainstem tagging and channel entry (calculated) and the estimated channel residence time based on entry date (extrapolated), Coho that used the Clay Young Side Channel in 2013 displayed an estimated time between tagging and death of 79.2 days. The longest recorded time between mainstem tagging and detection at the upper side channel array was 90.6 days.

Although we used a survey life equivalent to the average mainstem residence time for condition 1 fish, it is unclear if this is representative of the entire population. We can assume it is appropriate for approximately 21% of the total population based on the proportion of tags that entered the Clay Young channel. However, the PIT tag data suggests that survey life in 2013 was likely much longer than previous estimates, possibly due to abnormally low flows conditions, and therefore caution should be exercised when interpreting AUC estimates based on standard residence times.

Excerpt from Simpson et al. 2000

"One difficulty with comparing the data between studies is that methods used to calculate survey life vary. Also, in some cases, survey life is equivalent to stream residence time whereas in others survey life is only a portion of stream residence time. This inconsistency occurs when the survey area is limited to a portion of the stream. Clearly, more estimates are needed, especially on larger systems to see if the suspected positive correlation between system size and survey life is accurate. There are also potential regional differences in survey lives – e.g. between interior and coastal fish (R. Bailey, DFO, Kamloops, pers. comm.). If so, ascribing survey lives according to system size and regional variation may address some of the inaccuracies in AUC estimates without the prohibitive job of estimating survey life yearly on every system. Indicator streams, where fences are already in place, could be used to calibrate estimates on a year to year basis if need be. In summary, with more data, we may be able to refine SL assumptions to make AUC estimates more accurate. We also need more annual replications to further define the confidence limits for these SL's."

The pattern of PIT tag detections in the Clay Young Channel also suggests that a significant number of fish entered the channel in January. Of the 32 fish (entry time for one fish was unknown) which spent more than one day in the channel, 21 or 66% entered after Christmas Day. Given the strong relationship between channel residence (entry to death) and entry date we can assume these later fish were alive for a much shorter time than fish enumerated in November. If the tagged fish are representative of the non-tagged population, 2/3 of the side channel count should be attributed to the period between December 25 and January 25. Interestingly, no tagged fish were observed in the channel after December 18. An efficiency of 0% was used for the mark-recapture calculations which resulted in a dramatic peak in expanded counts relative to the number of fish observed. The accuracy of the channel estimate is therefore believed to be low as a result.

In hindsight, the frequency of channel counts should have increased continuously throughout the season as channel residence time decreased. It remains unclear if using an AUC calculation is appropriate when survey life appears to be dependent on the date of the survey (i.e. continuously variable). The process of PIT tagging adult Coho in the mainstem Englishman River and subsequent detection in the Clay Young Channel was found to be viable. Tagged fish were also observed, albeit in low numbers, during regular stream walks. Simply increasing the number of tags applied in the mainstem to approximately 500 should overcome difficulties calculating observer efficiency. No additional external tagging activates should be conducted in the channel unless the tags are of a different colour or style. Internally implanted PIT tags could also be used to further examine survey life within the side channel without confounding observer efficiency estimates.

Comparison to DFO AUC Estimate

The DFO AUC estimate based on snorkel surveys was much higher (17,238) compared to either the PIT tag AUC snorkel estimate (9,564) or the PIT tag AUC channel count estimate (5,697). The difference between the PIT based and non-PIT based snorkel estimates can be attributed to different values for survey life and observer efficiency. The DFO method estimates observer efficiency from SILs at 70-85% with the exception of the November 4 survey where 37% was indicated and was removed from the analysis. The PIT method used the number of tags observed on each survey compared to the number of estimated tags in the survey reach. When calculated in this manner, observer efficiency varied between a low of 17% on November 4 and a high of 49% on November 20. Survey life for the PIT based method was calculated based on the average number of days a bright fish (one that just entered the river) was at large before entering the Clay Young Channel (56.7 days). Survey life for the DFO estimate was based on observations in many other watersheds and was much closer to published values at 20.5 days.

This discrepancy in survey life is a good example in how sensitive AUC estimates are to parameters used in the calculation. In this case, a lower survey life (20.5 days) would nearly triple an estimate based on 56.7 days. However because of differing values in observer efficiency, the PIT based estimate was just under half of the DFO estimate.

The channel derived AUC estimate is displayed with low confidence. An insufficient number of tags were re-sighted to assign a reliable observer efficiency to most of the counts (a minimum of 3-5 observations per survey is suggested). This is particularly evident in the December/January counts when the majority of tagged (and presumably non-tagged) fish entered the channel. An observer efficiency of zero was recorded for the December 30 and January 8 counts when collectively there were 15 tags available for observation. In order for this method to be viable in the future, more tags would need to be deployed in the mainstem (min. ~500) to ensure a robust estimate of observer efficiency is derived.

The estimate of a 14 day survey life used in the channel AUC calculation also requires refinement. More tags in the channel would increase the amount of behavioral monitoring (i.e. live/dead) if paired with additional arrays near key spawning reaches. However, the estimate of 14 days is suggested by Simpson *et al.* (2000) for nearby watersheds where Coho behavior in smaller streams may be similar to that observed in the Clay Young Channel. PIT data confirmed a very broad range of survey lives ranging between a few days to over two months. The PIT based channel estimate attempted to reconcile this difference by using a continuously variable survey life for tags which entered the channel on different days. It remains unclear at this time how to incorporate such a wide variation in survey life into a traditional AUC estimate.

Program Expansion

Within the Englishman Watershed

Initial work conducted in 2013 was on a pilot scale and limited by the number of monitoring sites (two – both in the Clay Young Channel) as well as numbers of tagged fish (~150). The resolution of side channel counts could be improved with more tags deployed in the mainstem (assuming 500 were tagged, approximately 100 tags would enter the channel). However, the behavior of Coho in the channel also suggests that the frequency of counts may have to increase over time to capture the later component of the run. Survey life for the latest spawners (mid-January 2014) in the pilot study was estimated at only a few days based on PIT tag detections. This suggests that the live population within the channel could have been completely replaced several times in the last few weeks of the study which would require a significant expansion factor for raw counts.

It is suggested if the project is repeated within the Clay Young Channel that:

- At least 500 tags be deployed in the mainstem
- The frequency of channel counts is increased, particularly later in the season (Dec 15- Jan 31)
- A third array is deployed in the channel near the culvert crossing to monitor fish movement and survey life
- Incorporate a method to estimate tag loss (double tagging etc.)

In order to compare channel estimates to a baseline, AUC snorkel survey estimates are required. However, the results from this study suggest that observer efficiency and survey life estimates should be revisited for snorkel data. These parameters can be difficult/expensive to calculate and are known to vary between years. If conducted properly, a PIT tag based project could provide automated monitoring for a significant number of fish. Active radio telemetry ("radio tags") have been used to track the movements of fish on other projects but the method becomes prohibitively expensive with large tag groups at a cost of ~$250 per tag (500 tags would cost over $125,000). By comparison, 500 PIT tags would cost $1,250.

BCCF/FLNRO piloted a full stream (~40 m) width PIT tag detection antenna in the Englishman River for tracking the movements of adult Steelhead in the winter of 2014/15. The antenna, located at the lower end of the Plummer Road Run, was operational throughout a range of flows up to 65 cms and did not sustain any damage. It consisted of a single loop of wire with the upper run suspended approximately 0.5 m above the lower wire which ran along the stream bed. A high performance manufactured full stream antenna system is available[3] but comes at a significantly higher cost (~ $1000/m vs. $20/m).

Although it would be a considerable undertaking, it is theoretically possible to contain PIT tags applied in the snorkel survey index section. Arrays (two antennas in series to determine direction) would be required in the mainstem at Plummer Road as well as at the Side Channel intake pool. Additional arrays would also be required in tributaries (south fork Englishman, Center Creek, Clay Young Channel). This approach would provide significant data on survey life/stream residence time as well as refine observer efficiency estimates. A lower array would also shed light on the "transient" portion of the population that is suspected to enter the Englishman for a period of time before ascending local streams such as French Creek.

The primary limitation to this approach would be the ability to maintain arrays during high flows and the potential for reduced detection efficiency during those times. However, the potential benefit of automated data collection for refining survey life/residence time and observer efficiency estimates should not be overlooked. These parameters are repeatedly cited as weaknesses in most studies using AUC methodology.

A more practical expansion of the channel count method would be to include an additional tributary such as Center Creek. A single array could be constructed and maintained at most flows near the confluence with the South Englishman River. This would serve as containment such that a known number of tags are present in the channel. The channel is narrow enough such that counts of tagged and non-tagged Coho could be conducted in a similar manner to the Clay Young Channel although access is not as good.

Although there are a variety of options identified above, it is strongly recommended that future studies using PIT tags be designed to primarily refine estimates of survey life and secondarily observer efficiency. It is within these two parameters that a more accurate population assessment can be calculated. It is also recommended that alternative assessment methods (non-AUC) be investigated which do not rely on these parameters as heavily but can incorporate new pieces of data derived from PIT tag recoveries.

[3] http://www.biomark.com/catalog/antennas

Another piece of information that PIT tags can be helpful for estimating is marine survival. One suggested approach would be to apply smaller 12 mm PIT tags to smolts captured in the mainstem using a rotary screw trap (RST). This would ensure a mix of smolts from all areas of the watershed were captured and not just one tributary. Then, monitoring arrays could be constructed in side channel/tributary habitats where the probability of detection (smaller antennas) and ability to maintain an array (lower flows) is highest. A sufficient number of returning adults would have to be captured and tagged in the lower mainstem in order to estimate the contribution of each side channel/tributary to the total adult escapement. The number of returning adults with PIT tags applied as smolts could then be expanded by the proportion of the total run which was scanned. For example, 1000 PIT tags are applied to smolts and 100 to adults. Of the 100 tags applied to adults, 20 end up in the Clay Young Channel and 10 in Center Creek. We then know 30% of the adult population was scanned. We also detect 45 PIT tags from fish tagged as smolts. If these 45 tags represent 30% of the population then we know 150 PIT tagged smolts returned as adults yielding a marine survival estimate of 15%. Taking it one step further, if an accurate smolt estimate can be derived from the same RST used for tagging (say 85,000 +/- 10,000) then we can estimate the adult escapement at 12,750 +/- 1,500 without conducting any actual adult enumeration. Sources of uncertainty using this method include long term tag loss from the smolt group, emigration of adults tagged in-river and the uncertainty associated with the RST smolt estimate.

Outside of the Englishman River watershed

The potential to use PIT tag technology on other watersheds with Coho populations is significant. The primary features of the technology that should be exploited are:

1) Large numbers of tags can be applied at low cost

2) Detections are automated which allows for long study durations

3) Antennas can be easily constructed and maintained in smaller habitats (channel width <10 m, preferably 5 m)

4) Tag life is indefinite – no limits on time.

One suggested watershed where the technology could be thoroughly tested would be Black Creek. The advantages of this location are:

1) Presence of smolt and adult fence

2) Long term data set

3) Small channel width

4) Significant Coho production

A wide range of metrics, from survey life to marine survival, could be compared and contrasted with data from the counting fence such that any potential biases are identified. Following that, the potential to expand the use of the technology to other species/watersheds could be better evaluated.

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Appendix A

Coho Tagging Record

Fall 2013 Englishman Coho Bio/tagging Data

	Date		Location	Time	Sex	FL (mm)	Condition	PIT	Full PIT	Spaghetti #	Tag Color	Notes
1	2-Oct-13	10/2/13 1:10 PM	Allsbrook Canyon	13:10	m	691	2	8820	0000_0000000179008820	2308	Orange	
2	2-Oct-13	10/2/13 1:45 PM	Allsbrook Canyon	13:45	m	708	1	8822	0000_0000000179008822	2322	Orange	
3	2-Oct-13	10/2/13 5:15 PM	Allsbrook Canyon	17:15	f	552	1	8811	0000_0000000179008811	2307	Orange	hook damage to eye
4	2-Oct-13	10/2/13 5:17 PM	Allsbrook Canyon	17:17	m	627	2	8819	0000_0000000179008819	2310	Orange	
5	2-Oct-13	10/2/13 5:30 PM	Allsbrook Canyon	17:30	m	658	2	8821	0000_0000000179008821	2337	Orange	
6	2-Oct-13	10/2/13 5:40 PM	Allsbrook Canyon	17:40	f	704	1	8823	0000_0000000179008823	2320	Orange	
7	4-Oct-13	10/4/13 4:30 PM	Despard Ave.	16:30	f	630	1	8762	0000_0000000179008762	2323	Orange	
8	9-Oct-13	10/9/13 1:40 PM	Allsbrook Canyon	13:40	m	585	2	8768	0000_0000000179008768	2318	Orange	
9	9-Oct-13	10/9/13 1:50 PM	Allsbrook Canyon	13:50	m	675	1	8793	0000_0000000179008793	2313	Orange	
10	9-Oct-13	10/9/13 2:00 PM	Allsbrook Canyon	14:00	f	690	1	8812	0000_0000000179008812	2306	Orange	
11	9-Oct-13	10/9/13 2:05 PM	Allsbrook Canyon	14:05	m	740	2	8858	0000_0000000179008858	2315	Orange	
12	9-Oct-13	10/9/13 2:20 PM	Allsbrook Canyon	14:20	m	685	2	8816	0000_0000000179008816	2340	Orange	
13	9-Oct-13	10/9/13 2:22 PM	Allsbrook Canyon	14:22	f	498	2	8817	0000_0000000179008817	2327	Orange	
14	9-Oct-13	10/9/13 2:26 PM	Allsbrook Canyon	14:26	f	583	2	8818	0000_0000000179008818	2319	Orange	
15	9-Oct-13	10/9/13 2:30 PM	Allsbrook Canyon	14:30	m	600	2	8815	0000_0000000179008815	2328	Orange	
16	9-Oct-13	10/9/13 2:35 PM	Allsbrook Canyon	14:35	f	580	1	8849	0000_0000000179008849	2316	Orange	
17	9-Oct-13	10/9/13 2:50 PM	Allsbrook Canyon	14:50	f	580	1	8814	0000_0000000179008814	2332	Orange	
18	10-Oct-13	10/10/13 9:21 AM	Allsbrook Canyon	9:21	f	620	1	8826	0000_0000000179008826	2309	Orange	
19	10-Oct-13	10/10/13 12:55 PM	Scout Run	12:55	f	600	1	8825	0000_0000000179008825	2339	Orange	
20	17-Oct-13	10/17/13 9:30 AM	Allsbrook Canyon	9:30	f	610	1	8830	0000_0000000179008830	2343	Orange	
21	17-Oct-13	10/17/13 9:45 AM	Allsbrook Canyon	9:45	m	700	2	8838	0000_0000000179008838	2311	Orange	
22	17-Oct-13	10/17/13 11:55 AM	Parrys	11:55	m	650	2	8824	0000_0000000179008824	2341	Orange	
23	17-Oct-13	10/17/13 12:24 PM	Parrys	12:24	m	710	2	8833	0000_0000000179008833	2304	Orange	
24	17-Oct-13	10/17/13 12:41 PM	Parrys	12:41	f	500	2	8828	0000_0000000179008828	2317	Orange	
25	23-Oct-13	10/23/13 8:55 AM	Allsbrook Canyon	8:55	f	620	2	8831	0000_0000000179008831	2333	Orange	
26	23-Oct-13	10/23/13 9:15 AM	Allsbrook Canyon	9:15	f	630	2	8836	0000_0000000179008836	2336	Orange	
27	23-Oct-13	10/23/13 10:25 AM	Allsbrook Canyon	10:25	m	570	2	8827	0000_0000000179008827	2043	Orange	
28	24-Oct-13	10/24/13 3:20 PM	Plummer Road	15:20	f	615	2	8843	0000_0000000179008843	88	Orange	Bleeding from mouth
29	24-Oct-13	10/24/13 4:15 PM	Plummer Road	16:15	m	695	3	8853	0000_0000000179008853	693	Orange	
30	24-Oct-13	10/24/13 5:00 PM	Plummer Road	17:00	m	600	1	8767	0000_0000000179008767	87	Orange	
31	24-Oct-13	10/24/13 5:05 PM	Plummer Road	17:05	f	625	2	8770	0000_0000000179008770	78	Orange	
32	25-Oct-13	10/25/13 2:56 PM	Plummer Road	14:56	m	560	2	8779	0000_0000000179008779	97	Orange	
33	25-Oct-13	10/25/13 3:13 PM	Plummer Road	15:13	f	610	1	8774	0000_0000000179008774	2314	Orange	Recap in Millstone
34	25-Oct-13	10/25/13 4:06 PM	Parrys	16:06	f	570	2	8776	0000_0000000179008776	2338	Orange	
35	25-Oct-13	10/25/13 4:41 PM	Parrys	16:41	f	640	1	8775	0000_0000000179008775	2325	Orange	
36	25-Oct-13	10/25/13 3:00 PM	Plummer Road	15:00	m	635	2	8857	0000_0000000179008857	96	Orange	
37	25-Oct-13	10/25/13 3:30 PM	Plummer Road	15:30	m	648	2	8850	0000_0000000179008850	86	Orange	
38	25-Oct-13	10/25/13 4:00 PM	Plummer Road	16:00	m	615	3	8851	0000_0000000179008851	2324	Orange	
39	26-Oct-13	10/26/13 11:29 AM	Plummer Road	11:29	m	670	1	8784	0000_0000000179008784	2300	Orange	
40	26-Oct-13	10/26/13 11:52 AM	Plummer Road	11:52	m	710	2	8796	0000_0000000179008796	2329	Orange	
41	26-Oct-13	10/26/13 12:24 PM	Plummer Road	12:24	m	600	1	8791	0000_0000000179008791	2326	Orange	
42	26-Oct-13	10/26/13 2:02 PM	Parrys	14:02	f	590	2	8789	0000_0000000179008789	2335	Orange	
43	26-Oct-13	10/26/13 3:41 PM	Plummer Road	15:41	f	620	1	8773	0000_0000000179008773	2321	Orange	
44	31-Oct-13	10/31/13 8:00 AM	Plummer Road	8:00	m	660	3	8792	0000_0000000179008792	2330	Orange	
45	31-Oct-13	10/31/13 8:05 AM	Plummer Road	8:05	f	550	2	8780	0000_0000000179008780	2331	Orange	
46	31-Oct-13	10/31/13 8:32 AM	Plummer Road	8:32	f	590	1	8788	0000_0000000179008788	2334	Orange	
47	31-Oct-13	10/31/13 8:52 AM	Plummer Road	8:52	f	610	1	8787	0000_0000000179008787	2342	Orange	
48	31-Oct-13	10/31/13 9:04 AM	Plummer Road	9:04	f	620	1	8783	0000_0000000179008783	191	yellow	
49	31-Oct-13	10/31/13 10:01 AM	Plummer Road	10:01	m	590	1	8798	0000_0000000179008798	185	yellow	
50	31-Oct-13	10/31/13 10:07 AM	Plummer Road	10:07	f	540	2	8781	0000_0000000179008781	187	yellow	
51	2-Nov-13	11/2/13 9:20 AM	Plummer Road	9:20	f	540	1	8790	0000_0000000179008790	181	yellow	
52	2-Nov-13	11/2/13 9:25 AM	Plummer Road	9:25	f	590	2	8778	0000_0000000179008778	182	yellow	
53	2-Nov-13	11/2/13 9:30 AM	Plummer Road	9:30	m	690	1	8765	0000_0000000179008765	199	yellow	
54	2-Nov-13	11/2/13 10:02 AM	Plummer Road	10:02	m	610	3	8844	0000_0000000179008844	180	yellow	
55	2-Nov-13	11/2/13 10:15 AM	Plummer Road	10:15	m	730	1	8804	0000_0000000179008804	11	yellow	
56	2-Nov-13	11/2/13 10:24 AM	Plummer Road	10:24	m	600	2	8859	0000_0000000179008859	177	yellow	
57	2-Nov-13	11/2/13 10:35 AM	Plummer Road	10:35	f	640	1	8807	0000_0000000179008807	198	yellow	
58	2-Nov-13	11/2/13 10:40 AM	Plummer Road	10:40	f	680	1	8855	0000_0000000179008855	176	yellow	
59	2-Nov-13	11/2/13 10:51 AM	Plummer Road	10:51	m	640	2	8806	0000_0000000179008806	192	yellow	
60	2-Nov-13	11/2/13 11:00 AM	Plummer Road	11:00	m	690	3	8810	0000_0000000179008810	186	yellow	
61	2-Nov-13	11/2/13 11:10 AM	Plummer Road	11:10	f	620	2	8805	0000_0000000179008805	196	yellow	
62	2-Nov-13	11/2/13 4:07 PM	Despard Ave.	16:07	f	650	3	8808	0000_0000000179008808	924	Green	
63	2-Nov-13	11/2/13 4:22 PM	Despard Ave.	16:22	m	740	2	8809	0000_0000000179008809	917	Green	
64	2-Nov-13	11/2/13 5:00 PM	Parrys	17:00	m	680	2	8813	0000_0000000179008813	920	Green	
65	2-Nov-13	11/2/13 5:11 PM	Parrys	17:11	f	640	2	8690	0000_0000000179008690	926	Green	
66	2-Nov-13	11/2/13 5:31 PM	Parrys	17:31	f	610	1	8695	0000_0000000179008695	919	Green	
67	2-Nov-13	11/2/13 5:43 PM	Parrys	17:43	f	600	1	8688	0000_0000000179008688	925	Green	
68	2-Nov-13	11/2/13 9:02 AM	Plummer Road	9:02	m	580	2	8777	0000_0000000179008777	178	yellow	
69	2-Nov-13	11/2/13 9:10 AM	Plummer Road	9:10	m	610	1	8782	0000_0000000179008782	190	yellow	
70	3-Nov-13	11/3/13 12:35 PM	Plummer Road	12:35	m	750	1	8699	0000_0000000179008699	926	Green	
71	3-Nov-13	11/3/13 1:19 PM	Plummer Road	13:19	m	720	2	8700	0000_0000000179008700	916	Green	
72	3-Nov-13	11/3/13 3:03 PM	Parrys	15:03	m	710	3	8696	0000_0000000179008696	918	Green	
73	3-Nov-13	11/3/13 3:12 PM	Parrys	15:12	m	640	2	8697	0000_0000000179008697	913	Green	
74	3-Nov-13	11/3/13 3:25 PM	Parrys	15:25	m	680	2	8689	0000_0000000179008689	908	Green	
75	3-Nov-13	11/3/13 10:53 AM	Plummer Road	10:53	m	730	1	8694	0000_0000000179008694	927	Green	

76	3-Nov-13	11/3/13 11:00 AM	Plummer Road	11:00	f	620	1	8693	0000_0000000179008693	905	Green	
77	3-Nov-13	11/3/13 11:18 AM	Plummer Road	11:18	m	700	1	8687	0000_0000000179008687	923	Green	
78	3-Nov-13	11/3/13 11:22 AM	Plummer Road	11:22	m	720	3	8691	0000_0000000179008691	928	Green	
79	3-Nov-13	11/3/13 12:00 PM	Plummer Road	12:00	f	480	1	8692	0000_0000000179008692	922	Green	
80	3-Nov-13	11/3/13 12:15 PM	Plummer Road	12:15	m	730	2	8698	0000_0000000179008698	926	Green	
81	4-Nov-13	11/4/13 2:00 PM	Parrys	14:00	m	635	2	8752	0000_0000000179008752	882	Green	
82	4-Nov-13	11/4/13 2:02 PM	Parrys	14:02	f	670	1	8761	0000_0000000179008761	872	Green	
83	4-Nov-13	11/4/13 2:04 PM	Parrys	14:04	m	725	3	8747	0000_0000000179008747	875	Green	
84	4-Nov-13	11/4/13 2:06 PM	Parrys	14:06	f	585	1	8754	0000_0000000179008754	874	Green	Punctured Eye
85	4-Nov-13	11/4/13 2:08 PM	Parrys	14:08	m	600	3	8750	0000_0000000179008750	879	Green	
86	4-Nov-13	11/4/13 2:10 PM	Parrys	14:10	f	730	1	8760	0000_0000000179008760	880	Green	
87	4-Nov-13	11/4/13 2:12 PM	Parrys	14:12	f	760	1	8749	0000_0000000179008749	871	Green	
88	4-Nov-13	11/4/13 2:14 PM	Parrys	14:14	f	575	1	8759	0000_0000000179008759	878	Green	
89	4-Nov-13	11/4/13 2:16 PM	Parrys	14:16	f	620	1	8751	0000_0000000179008751	873	Green	
90	4-Nov-13	11/4/13 2:18 PM	Parrys	14:18	m	685	2	8753	0000_0000000179008753	883	Green	
91	4-Nov-13	11/4/13 2:20 PM	Parrys	14:20	m	545	3	8758	0000_0000000179008758	884	Green	
92	4-Nov-13	11/4/13 2:22 PM	Parrys	14:22	m	645	3	8756	0000_0000000179008756	881	Green	
93	4-Nov-13	11/4/13 2:24 PM	Parrys	14:24	m	795	3	8757	0000_0000000179008757	877	Green	
94	4-Nov-13	11/4/13 2:26 PM	Parrys	14:26	m	555	2	8755	0000_0000000179008755	885	Green	
95	4-Nov-13	11/4/13 2:28 PM	Parrys	14:28	m	590	3	8748	0000_0000000179008748	888	Green	
96	4-Nov-13	11/4/13 2:30 PM	Parrys	14:30	m	655	3	8662	0000_0000000179008662	893	Green	
97	4-Nov-13	11/4/13 2:32 PM	Parrys	14:32	m	625	3	8670	0000_0000000179008670	894	Green	
98	4-Nov-13	11/4/13 2:34 PM	Parrys	14:34	m	700	2	8671	0000_0000000179008671	896	Green	
99	4-Nov-13	11/4/13 2:36 PM	Parrys	14:36	f	695	2	8664	0000_0000000179008664	887	Green	
100	4-Nov-13	11/4/13 2:38 PM	Parrys	14:38	f	705	1	8665	0000_0000000179008665	889	Green	
101	4-Nov-13	11/4/13 2:40 PM	Parrys	14:40	m	640	1	8666	0000_0000000179008666	897	Green	
102	4-Nov-13	11/4/13 2:42 PM	Parrys	14:42	m	540	1	8668	0000_0000000179008668	895	Green	
103	4-Nov-13	11/4/13 2:44 PM	Parrys	14:44	m	610	3	8669	0000_0000000179008669	898	Green	
104	4-Nov-13	11/4/13 2:46 PM	Parrys	14:46	m	700	2	8667	0000_0000000179008667	899	Green	
105	4-Nov-13	11/4/13 2:48 PM	Parrys	14:48	m	760	2	8663	0000_0000000179008663	886	Green	
106	4-Nov-13	11/4/13 2:50 PM	Parrys	14:50	m	560	3	8744	0000_0000000179008744	900	Green	
107	4-Nov-13	11/4/13 2:52 PM	Parrys	14:52	m	635	1	8741	0000_0000000179008741	890	Green	
108	4-Nov-13	11/4/13 2:54 PM	Parrys	14:54	m	620	3	8733	0000_0000000179008733	891	Green	
109	4-Nov-13	11/4/13 2:56 PM	Parrys	14:56	f	685	2	8734	0000_0000000179008734	892	Green	
110	4-Nov-13	11/4/13 2:58 PM	Parrys	14:58	m	590	2	8736	0000_0000000179008736	963	Green	
111	4-Nov-13	11/4/13 3:00 PM	Parrys	15:00	m	670	3	8740	0000_0000000179008740	966	Green	
112	4-Nov-13	11/4/13 3:02 PM	Parrys	15:02	m	700	3	8732	0000_0000000179008732	8??	Green	
113	4-Nov-13	11/4/13 3:04 PM	Parrys	15:04	m	645	3	8738	0000_0000000179008738	965	Green	
114	4-Nov-13	11/4/13 3:06 PM	Parrys	15:06	f	615	1	8737	0000_0000000179008737	932	Green	
115	4-Nov-13	11/4/13 3:08 PM	Parrys	15:08	f	675	2	8746	0000_0000000179008746	960	Green	
116	4-Nov-13	11/4/13 3:10 PM	Parrys	15:10	m	705	1	8735	0000_0000000179008735	958	Green	
117	4-Nov-13	11/4/13 3:12 PM	Parrys	15:12	m	680	2	8739	0000_0000000179008739	961	Green	
118	4-Nov-13	11/4/13 3:14 PM	Parrys	15:14	m	630	2	8743	0000_0000000179008743	959	Green	
119	4-Nov-13	11/4/13 3:16 PM	Parrys	15:16	m	695	3	8706	0000_0000000179008706	962	Green	
120	4-Nov-13	11/4/13 3:18 PM	Parrys	15:18	m	700	3	8742	0000_0000000179008742	964	Green	
121	4-Nov-13	11/4/13 3:20 PM	Parrys	15:20	m	665	3	8745	0000_0000000179008745	951	Green	
122	4-Nov-13	11/4/13 3:22 PM	Parrys	15:22	m	705	1	8713	0000_0000000179008713	852	Green	
123	4-Nov-13	11/4/13 3:24 PM	Parrys	15:24	m	695	3	8711	0000_0000000179008711	945	Green	
124	4-Nov-13	11/4/13 3:26 PM	Parrys	15:26	m	635	1	8707	0000_0000000179008707	956	Green	
125	4-Nov-13	11/4/13 3:28 PM	Parrys	15:28	m	800	3	8703	0000_0000000179008703	944	Green	
126	4-Nov-13	11/4/13 3:30 PM	Parrys	15:30	f	660	3	8705	0000_0000000179008705	953	Green	
127	4-Nov-13	11/4/13 3:32 PM	Parrys	15:32	m	695	3	8704	0000_0000000179008704	948	Green	
128	4-Nov-13	11/4/13 3:34 PM	Parrys	15:34	f	640	1	8712	0000_0000000179008712	9??	Green	
129	4-Nov-13	11/4/13 3:36 PM	Parrys	15:36	f	690	2	8715	0000_0000000179008715	957	Green	
130	4-Nov-13	11/4/13 3:38 PM	Parrys	15:38	f	560	1	8714	0000_0000000179008714	950	Green	
131	4-Nov-13	11/4/13 3:40 PM	Parrys	15:40	f	640	3	8716	0000_0000000179008716	954	Green	
132	4-Nov-13	11/4/13 3:42 PM	Parrys	15:42	m	675	2	8708	0000_0000000179008708	949	Green	
133	4-Nov-13	11/4/13 3:44 PM	Parrys	15:44	f	590	1	8710	0000_0000000179008710	955	Green	
134	4-Nov-13	11/4/13 3:46 PM	Parrys	15:46	m	660	3	8709	0000_0000000179008709	946	Green	
135	4-Nov-13	11/4/13 3:48 PM	Parrys	15:48	m	545	3	8722	0000_0000000179008722	931	Green	
136	4-Nov-13	11/4/13 3:50 PM	Parrys	15:50	f	605	2	8721	0000_0000000179008721	947	Green	
137	4-Nov-13	11/4/13 3:52 PM	Parrys	15:52	m	590	2	8723	0000_0000000179008723	939	Green	
138	4-Nov-13	11/4/13 3:54 PM	Parrys	15:54	m	640	3	8718	0000_0000000179008718	936	Green	
139	4-Nov-13	11/4/13 3:56 PM	Parrys	15:56	f	600	3	8720	0000_0000000179008720	943	Green	
140	4-Nov-13	11/4/13 3:58 PM	Parrys	15:58	m	530	3	8724	0000_0000000179008724	930	Green	
141	4-Nov-13	11/4/13 4:00 PM	Parrys	16:00	m	570	3	8719	0000_0000000179008719	940	Green	
142	4-Nov-13	11/4/13 4:02 PM	Parrys	16:02	m	580	2	8725	0000_0000000179008725	933	Green	
143	4-Nov-13	11/4/13 4:04 PM	Parrys	16:04	f	610	2	8730	0000_0000000179008730	938	Green	
144	4-Nov-13	11/4/13 11:07 AM	Plummer Road	11:07	f	660	1	8701	0000_0000000179008701	921	Green	
145	7-Nov-13	11/7/13 10:44 AM	Parrys	10:44	m	640	3	8683	0000_0000000179008683	906	Green	
146	10-Nov-13	11/10/13 3:40 PM	Double Log	15:40	f	635	1	8729	0000_0000000179008729	929	Green	
147	14-Nov-13	11/14/13 3:05 PM	Reach 3	15:05	m	765	4	8854	0000_0000000179008854	76	Orange	
148	14-Nov-13	11/14/13 3:08 PM	Reach 3	15:08	m	586	4	8801	0000_0000000179008801	81	Orange	
149	14-Nov-13	11/14/13 3:11 PM	Reach 3	15:11	f	610	4	8847	0000_0000000179008847	82	Orange	
150	14-Nov-13	11/14/13 3:14 PM	Reach 3	15:14	f	510	4	8837	0000_0000000179008837	77	Orange	MORT Nov 22 Reach 3
151	14-Nov-13	11/14/13 3:17 PM	Reach 3	15:17	m	535	4	8856	0000_0000000179008856	84	Orange	
152	14-Nov-13	11/14/13 3:46 PM	Reach 2	15:46	m	490	4	8848	0000_0000000179008848	83	Orange	
153	14-Nov-13	11/14/13 3:53 PM	Reach 2	15:53	m	625	4	8841	0000_0000000179008841	90	Orange	
154	14-Nov-13	11/14/13 10:00 AM	Parrys	10:00	f	660	1	8680	0000_0000000179008680	909	Green	
155	14-Nov-13	11/14/13 10:03 AM	Parrys	10:03	m	670	3	8672	0000_0000000179008672	903	Green	
156	14-Nov-13	11/14/13 11:20 AM	Allsbrook Canyon	11:20	m	640	2	8686	0000_0000000179008686	912	Green	
157	14-Nov-13	11/14/13 12:36 PM	Slough Hole	12:36	f	610	1	8674	0000_0000000179008674	902	Green	
158	17-Nov-13	11/17/13 2:20 PM	Rick's Run	14:20	m	655	3	8726	0000_0000000179008726	937	Green	
159	17-Nov-13	11/17/13 3:35 PM	Slough Hole	15:35	f	735	2	8832	0000_0000000179008832	934	Green	
160	21-Nov-13	11/21/13 10:00 AM	Reach 1	10:00	f	610	3	8797	0000_0000000179008797	91	orange	Brush Pile pool
161	21-Nov-13	11/21/13 10:10 AM	Reach 1	10:10	f	610	2	8446	0000_0000000179008446	89	orange	Brush Pile pool
162	21-Nov-13	11/21/13 10:20 AM	Reach 1	10:20	f	540	3	8771	0000_0000000179008771	94	orange	Brush Pile pool
163	21-Nov-13	11/21/13 10:30 AM	Reach 1	10:30	m	700	2	8839	0000_0000000179008839	98	orange	Brush Pile pool
164	21-Nov-13	11/21/13 10:40 AM	Reach 1	10:40	m	625	3	8840	0000_0000000179008840	80	orange	Brush Pile pool
165	29-Dec-13	12/29/13 2:30 PM	Grassy Bank	14:30	f	670	3	8829	0000_0000000179008829	1941	Green	
166	29-Dec-13	12/29/13 2:45 PM	Grassy Bank	14:45	m	740	3	8799	0000_0000000179008799	3025	Orange	

Appendix B

PIT Tag Detection Records

LOWER ARRAY			
Date/Time	PIT Tag ID	Read Count	Antenna #
11/2/13 13:04	0000_0000000179008792	1	A1
11/2/13 13:05	0000_0000000179008792	17	A2
11/2/13 13:52	0000_0000000179008817	1	A1
11/2/13 13:53	0000_0000000179008817	27	A2
11/2/13 15:48	0000_0000000179008820	1	A1
11/2/13 15:49	0000_0000000179008820	14	A2
11/2/13 17:34	0000_0000000179008831	1	A1
11/2/13 17:35	0000_0000000179008831	13	A2
11/2/13 17:45	0000_0000000179008819	1	A1
11/2/13 17:46	0000_0000000179008819	13	A2
11/2/13 17:53	0000_0000000179008819	1	A1
11/2/13 18:02	0000_0000000179008819	1	A1
11/2/13 18:09	0000_0000000179008811	1	A1
11/2/13 18:10	0000_0000000179008811	25	A2
11/2/13 18:16	0000_0000000179008819	1	A1
11/2/13 18:16	0000_0000000179008819	14	A2
11/2/13 18:52	0000_0000000179008776	1	A1
11/2/13 18:53	0000_0000000179008776	36	A2
11/2/13 20:04	0000_0000000179008791	1	A1
11/2/13 20:05	0000_0000000179008791	31	A2
11/3/13 0:39	0000_0000000179008836	11	A2
11/3/13 0:40	0000_0000000179008836	1	A1
11/3/13 22:40	0000_0000000179008831	11	A2
11/3/13 22:41	0000_0000000179008831	1	A1
11/4/13 2:28	0000_0000000179008836	47	A2
11/4/13 2:29	0000_0000000179008836	1	A1
11/4/13 2:47	0000_0000000179008819	1	A2
11/4/13 2:49	0000_0000000179008819	1	A1
11/4/13 6:36	0000_0000000179008791	11	A2
11/4/13 6:37	0000_0000000179008791	1	A1
11/7/13 13:32	0000_0000000179008831	1	A1
11/7/13 13:34	0000_0000000179008831	9	A2
11/7/13 13:53	0000_0000000179008844	1	A1
11/7/13 15:46	0000_0000000179008844	1	A1
11/7/13 15:46	0000_0000000179008844	8	A2
11/7/13 23:28	0000_0000000179008722	1	A1
11/7/13 23:29	0000_0000000179008722	18	A2
11/19/13 23:16	0000_0000000179008816	8	A1
11/19/13 23:17	0000_0000000179008816	9	A2
12/1/13 23:59	0000_0000000179008780	1	A1
12/2/13 0:02	0000_0000000179008780	22	A2
12/2/13 0:15	0000_0000000179008732	1	A1
12/2/13 0:19	0000_0000000179008732	2	A2
12/2/13 6:51	0000_0000000179008732	4	A2
12/2/13 6:52	0000_0000000179008732	1	A1
12/13/13 2:13	0000_0000000179008694	1	A1
12/13/13 2:15	0000_0000000179008694	12	A2
12/13/13 2:27	0000_0000000179008694	5	A2
12/13/13 2:28	0000_0000000179008694	1	A1
12/13/13 2:36	0000_0000000179008694	1	A1
12/13/13 2:39	0000_0000000179008694	8	A2
12/13/13 3:26	0000_0000000179008694	155	A2
12/13/13 3:36	0000_0000000179008694	1	A1
12/13/13 17:09	0000_0000000179008694	1	A1
12/13/13 17:24	0000_0000000179008694	40	A2
12/13/13 17:33	0000_0000000179008694	1	A1
12/13/13 17:50	0000_0000000179008694	1	A1
12/13/13 17:55	0000_0000000179008694	1	A1
12/13/13 17:56	0000_0000000179008694	11	A2
12/15/13 6:28	0000_0000000179008732	1	A1
12/15/13 6:31	0000_0000000179008732	13	A2
12/15/13 6:36	0000_0000000179008732	42	A2
12/15/13 6:42	0000_0000000179008732	1	A1
12/18/13 18:16	0000_0000000179008683	127	A1
12/18/13 18:18	0000_0000000179008683	16	A2
12/19/13 5:57	0000_0000000179008683	7	A2
12/19/13 5:57	0000_0000000179008683	12	A1
12/21/13 20:47	0000_0000000179008732	1	A1
12/21/13 20:58	0000_0000000179008732	1	A1
12/21/13 21:16	0000_0000000179008732	41	A2
12/21/13 21:27	0000_0000000179008732	6	A2
12/21/13 21:33	0000_0000000179008732	1	A1
12/22/13 0:28	0000_0000000179008732	1	A1
12/22/13 0:36	0000_0000000179008732	1	A1
12/22/13 17:41	0000_0000000179008718	1	A1
12/22/13 17:44	0000_0000000179008718	89	A2
12/22/13 18:03	0000_0000000179008718	1	A1
12/22/13 18:09	0000_0000000179008718	10	A2
12/22/13 20:05	0000_0000000179008718	7	A2
12/22/13 20:07	0000_0000000179008718	1	A1
12/22/13 21:54	0000_0000000179008732	1	A1
12/23/13 17:51	0000_0000000179008718	1	A1
12/23/13 17:57	0000_0000000179008718	12	A2
12/23/13 18:09	0000_0000000179008718	8	A2
12/23/13 21:11	0000_0000000179008718	79	A2
12/23/13 21:16	0000_0000000179008718	1	A1
12/23/13 21:57	0000_0000000179008732	1	A1
12/23/13 21:58	0000_0000000179008732	36	A2
12/23/13 22:03	0000_0000000179008732	11	A2
12/24/13 7:06	0000_0000000179008732	5	A2
12/24/13 7:06	0000_0000000179008732	1	A1
12/27/13 20:38	0000_0000000179008738	1	A1
12/27/13 20:44	0000_0000000179008738	12	A2
12/28/13 0:35	0000_0000000179008767	1	A1
12/28/13 0:38	0000_0000000179008767	7	A2
12/28/13 1:07	0000_0000000179008732	1	A1
12/28/13 1:11	0000_0000000179008732	8	A2
12/28/13 1:46	0000_0000000179008767	6	A2
12/28/13 1:58	0000_0000000179008767	1	A1
12/28/13 2:24	0000_0000000179008767	1	A1
12/28/13 2:59	0000_0000000179008767	31	A2
12/28/13 3:12	0000_0000000179008781	1	A1
12/28/13 3:14	0000_0000000179008781	8	A2
12/28/13 3:19	0000_0000000179008781	9	A2
12/28/13 6:02	0000_0000000179008781	7	A2
12/28/13 6:04	0000_0000000179008781	1	A1
12/29/13 22:40	0000_0000000179008859	1	A1
12/29/13 22:47	0000_0000000179008859	9	A2
12/30/13 18:44	0000_0000000179008762	1	A1
12/30/13 18:49	0000_0000000179008762	16	A2
12/30/13 19:39	0000_0000000179008762	8	A2
12/30/13 22:56	0000_0000000179008752	1	A1
12/30/13 22:58	0000_0000000179008697	1	A1
12/30/13 23:00	0000_0000000179008752	8	A2
12/30/13 23:01	0000_0000000179008697	12	A2
12/30/13 23:05	0000_0000000179008752	10	A2
12/31/13 4:50	0000_0000000179008672	1	A1
12/31/13 4:53	0000_0000000179008672	14	A2
12/31/13 21:05	0000_0000000179008782	1	A1
12/31/13 21:07	0000_0000000179008782	33	A2
1/2/14 2:05	0000_0000000179008789	1	A1
1/2/14 2:06	0000_0000000179008789	15	A2
1/2/14 18:51	0000_0000000179008710	1	A1
1/2/14 18:52	0000_0000000179008710	19	A2
1/2/14 18:53	0000_0000000179008829	1	A1
1/2/14 18:54	0000_0000000179008781	1	A1
1/2/14 18:56	0000_0000000179008829	13	A2
1/2/14 18:56	0000_0000000179008781	12	A2
1/2/14 19:37	0000_0000000179008791	1	A1
1/2/14 19:38	0000_0000000179008791	3	A2
1/2/14 22:46	0000_0000000179008725	1	A1
1/2/14 22:48	0000_0000000179008725	12	A2
1/3/14 3:18	0000_0000000179008741	1	A1
1/3/14 3:20	0000_0000000179008741	31	A2
1/3/14 4:15	0000_0000000179008737	1	A1
1/3/14 4:16	0000_0000000179008737	7	A2
1/3/14 7:58	0000_0000000179008737	3	A2
1/3/14 8:14	0000_0000000179008737	1	A2
1/4/14 0:52	0000_0000000179008737	67	A2
1/4/14 1:06	0000_0000000179008737	6	A2
1/4/14 1:12	0000_0000000179008725	9	A2
1/4/14 1:12	0000_0000000179008737	19	A2
1/4/14 1:13	0000_0000000179008725	1	A1
1/4/14 1:15	0000_0000000179008737	1	A1
1/4/14 2:23	0000_0000000179008813	1	A1
1/4/14 2:32	0000_0000000179008813	16	A2
1/4/14 2:36	0000_0000000179008813	1	A1
1/4/14 4:18	0000_0000000179008725	1	A1

1/4/14 4:26	0000_0000000179008725	1	A1
1/4/14 4:28	0000_0000000179008725	3	A2
1/4/14 4:29	0000_0000000179008791	8	A2
1/4/14 4:29	0000_0000000179008791	1	A1
1/4/14 4:34	0000_0000000179008725	9	A2
1/4/14 4:36	0000_0000000179008725	1	A1
1/4/14 4:41	0000_0000000179008813	1	A1
1/4/14 4:41	0000_0000000179008725	1	A1
1/4/14 4:42	0000_0000000179008725	23	A2
1/4/14 4:47	0000_0000000179008813	1	A1
1/4/14 4:47	0000_0000000179008725	1	A1
1/4/14 4:53	0000_0000000179008813	1	A1
1/4/14 4:54	0000_0000000179008813	40	A2
1/4/14 21:25	0000_0000000179008813	1	A1
1/4/14 21:39	0000_0000000179008813	72	A2
1/4/14 21:57	0000_0000000179008813	12	A2
1/4/14 22:13	0000_0000000179008813	11	A2
1/4/14 22:17	0000_0000000179008813	1	A1
1/4/14 22:51	0000_0000000179008813	1	A1
1/4/14 23:10	0000_0000000179008813	20	A2
1/4/14 23:35	0000_0000000179008813	16	A2
1/4/14 23:47	0000_0000000179008813	1	A1
1/4/14 23:53	0000_0000000179008813	17	A2
1/4/14 23:59	0000_0000000179008813	9	A2
1/5/14 0:09	0000_0000000179008813	196	A2
1/5/14 0:17	0000_0000000179008813	14	A2
1/5/14 0:23	0000_0000000179008813	13	A2
1/5/14 0:31	0000_0000000179008813	1	A2
1/5/14 0:40	0000_0000000179008813	5	A2
1/5/14 0:45	0000_0000000179008813	77	A2
1/5/14 0:56	0000_0000000179008813	46	A2
1/5/14 1:03	0000_000000017900883	1	A1
1/5/14 1:12	0000_0000000179008813	6	A2
1/5/14 1:42	0000_0000000179008813	1	A1
1/5/14 1:43	0000_0000000179008813	98	A2
1/5/14 1:51	0000_0000000179008813	24	A2
1/5/14 1:59	0000_0000000179008813	12	A2
1/5/14 2:01	0000_0000000179008813	1	A1
1/5/14 2:13	0000_0000000179008781	7	A2
1/5/14 2:14	0000_0000000179008781	1	A1
1/5/14 2:34	0000_0000000179008813	1	A1
1/5/14 2:35	0000_0000000179008813	48	A2
1/5/14 2:41	0000_0000000179008813	12	A2
1/5/14 2:53	0000_0000000179008813	1	A1
1/5/14 3:49	0000_0000000179008813	1	A1
1/5/14 3:53	0000_0000000179008813	3	A2
1/5/14 4:04	0000_0000000179008725	1	A1
1/5/14 4:24	0000_0000000179008813	1	A1
1/5/14 4:28	0000_0000000179008813	28	A2
1/5/14 4:34	0000_0000000179008813	1	A1
1/5/14 5:26	0000_0000000179008813	1	A1
1/5/14 5:30	0000_0000000179008813	1	A1
1/5/14 5:33	0000_0000000179008813	104	A2
1/5/14 6:45	0000_0000000179008813	1	A1
1/5/14 6:49	0000_0000000179008813	9	A2
1/5/14 6:52	0000_0000000179008813	1	A1
1/5/14 7:05	0000_0000000179008813	32	A2
1/5/14 17:30	0000_0000000179008813	1	A1
1/5/14 17:31	0000_0000000179008813	62	A2
1/5/14 19:09	0000_0000000179008813	1	A1
1/5/14 19:13	0000_0000000179008813	32	A2
1/5/14 19:18	0000_0000000179008813	13	A2
1/5/14 19:25	0000_0000000179008813	1	A1
1/8/14 17:35	0000_0000000179008725	85	A1
1/8/14 17:41	0000_0000000179008725	40	A2
1/9/14 22:02	0000_0000000179008710	14	A1
1/9/14 22:04	0000_0000000179008710	20	A2
1/10/14 19:35	0000_0000000179008781	22	A1
1/10/14 19:43	0000_0000000179008781	162	A2
1/10/14 21:30	0000_0000000179008791	18	A1
1/10/14 21:34	0000_0000000179008791	34	A2
1/11/14 0:40	0000_0000000179008741	24	A1
1/11/14 0:41	0000_0000000179008741	18	A2
1/11/14 1:03	0000_0000000179008737	479	A1
1/11/14 1:07	0000_0000000179008737	17	A2
1/11/14 1:35	0000_0000000179008688	31	A1
1/11/14 1:36	0000_0000000179008707	23	A1
1/11/14 1:37	0000_0000000179008707	12	A2
1/11/14 1:39	0000_0000000179008688	37	A2
1/11/14 17:19	0000_0000000179008707	10	A2
1/11/14 17:19	0000_0000000179008707	1	A1
1/11/14 22:24	0000_0000000179008723	14	A1
1/11/14 22:25	0000_0000000179008723	30	A2
1/11/14 22:33	0000_0000000179008723	1	A2
1/11/14 22:42	0000_0000000179008723	7	A1
1/11/14 23:11	0000_0000000179008723	10	A1
1/11/14 23:12	0000_0000000179008723	15	A2
1/13/14 3:00	0000_0000000179008755	7	A1
1/13/14 3:01	0000_0000000179008755	14	A2
1/14/14 2:07	0000_0000000179008741	9	A2
1/14/14 2:10	0000_0000000179008741	5	A1
1/17/14 19:58	0000_0000000179008741	8	A1
1/17/14 19:59	0000_0000000179008741	16	A2
1/17/14 23:13	0000_0000000179008804	20	A1
1/17/14 23:27	0000_0000000179008804	84	A2
1/17/14 23:58	0000_0000000179008804	7	A2
1/18/14 0:07	0000_0000000179008804	5	A1
1/18/14 0:18	0000_0000000179008804	20	A2
1/18/14 0:24	0000_0000000179008804	5	A1
1/18/14 0:50	0000_0000000179008804	14	A1
1/18/14 0:52	0000_0000000179008804	15	A2
1/18/14 0:59	0000_0000000179008804	8	A2
1/18/14 1:10	0000_0000000179008804	20	A1
1/18/14 1:30	0000_0000000179008804	14	A1
1/18/14 1:32	0000_0000000179008804	40	A2
1/18/14 1:45	0000_0000000179008804	18	A1
1/18/14 4:05	0000_0000000179008804	13	A1
1/18/14 4:28	0000_0000000179008804	47	A2
1/18/14 4:35	0000_0000000179008804	6	A1
1/18/14 4:57	0000_0000000179008804	24	A1
1/18/14 5:04	0000_0000000179008804	6	A1
1/18/14 7:15	0000_0000000179008804	8	A1
1/18/14 7:25	0000_0000000179008804	83	A1
1/18/14 9:47	0000_0000000179008804	3	A1
1/18/14 11:53	0000_0000000179008804	2	A1
1/18/14 17:17	0000_0000000179008804	23	A1
1/18/14 17:24	0000_0000000179008804	26	A1
1/18/14 17:47	0000_0000000179008804	10	A1
1/18/14 17:51	0000_0000000179008804	18	A2
1/18/14 17:57	0000_0000000179008804	9	A2
1/18/14 18:05	0000_0000000179008804	28	A1
1/18/14 18:44	0000_0000000179008804	17	A1
1/18/14 18:52	0000_0000000179008804	44	A2
1/18/14 18:57	0000_0000000179008804	16	A1
1/18/14 19:03	0000_0000000179008804	46	A2
1/18/14 19:07	0000_0000000179008804	6	A1
1/18/14 19:31	0000_0000000179008804	18	A1
1/18/14 19:36	0000_0000000179008804	110	A2
1/18/14 20:02	0000_0000000179008804	9	A2
1/18/14 20:04	0000_0000000179008804	32	A1
1/18/14 22:53	0000_0000000179008804	11	A1
1/18/14 22:55	0000_0000000179008804	24	A2
1/18/14 23:11	0000_0000000179008804	35	A2
1/18/14 23:14	0000_0000000179008804	7	A1
1/21/14 3:31	0000_0000000179008741	7	A2
1/21/14 3:33	0000_0000000179008741	4	A1
1/21/14 20:30	0000_0000000179008781	8	A2
1/21/14 20:31	0000_0000000179008781	5	A1

UPPER ARRAY			
Date Time	PIT Tag ID	Read Count	Antenna #
11/14/13 3:02 PM	0000_0000000179008854	16	A2
11/14/13 3:03 PM	0000_0000000179008854	33	A2
11/14/13 3:03 PM	0000_0000000179008854	23	A1
11/14/13 3:21 PM	0000_0000000179008854	15	A1
11/14/13 3:21 PM	0000_0000000179008854	13	A2
11/14/13 3:22 PM	0000_0000000179008854	15	A2
11/14/13 3:22 PM	0000_0000000179008854	3	A1
11/14/13 3:32 PM	0000_0000000179008854	6	A1
11/14/13 3:32 PM	0000_0000000179008854	5	A2
11/14/13 4:53 PM	0000_0000000179008856	8	A2
11/14/13 4:53 PM	0000_0000000179008856	3	A1
11/14/13 5:43 PM	0000_0000000179008856	3	A1
11/14/13 5:43 PM	0000_0000000179008856	28	A1
11/14/13 5:44 PM	0000_0000000179008856	17	A2
11/14/13 6:27 PM	0000_0000000179008854	3	A2
11/14/13 6:27 PM	0000_0000000179008854	4	A1
11/14/13 6:27 PM	0000_0000000179008856	9	A2
11/14/13 6:27 PM	0000_0000000179008856	3	A1
11/14/13 6:28 PM	0000_0000000179008847	1	A2
11/14/13 6:28 PM	0000_0000000179008847	3	A1
11/14/13 7:17 PM	0000_0000000179008856	26	A1
11/14/13 7:18 PM	0000_0000000179008856	37	A2
11/14/13 7:22 PM	0000_0000000179008856	5	A2
11/14/13 7:22 PM	0000_0000000179008856	11	A1
11/14/13 7:30 PM	0000_0000000179008856	17	A1
11/14/13 7:31 PM	0000_0000000179008856	6	A2
11/14/13 7:40 PM	0000_0000000179008854	7	A1
11/14/13 7:40 PM	0000_0000000179008854	4	A2
11/14/13 8:03 PM	0000_0000000179008847	10	A1
11/14/13 8:06 PM	0000_0000000179008847	6	A2
11/14/13 8:06 PM	0000_0000000179008847	2	A2
11/14/13 8:07 PM	0000_0000000179008847	10	A2
11/14/13 8:40 PM	0000_0000000179008856	6	A2
11/14/13 8:41 PM	0000_0000000179008856	16	A1
11/14/13 9:01 PM	0000_0000000179008854	10	A2
11/14/13 9:01 PM	0000_0000000179008854	10	A1
11/14/13 9:32 PM	0000_0000000179008854	6	A1
11/14/13 9:32 PM	0000_0000000179008854	5	A2
11/14/13 9:46 PM	0000_0000000179008856	27	A1
11/14/13 9:47 PM	0000_0000000179008856	29	A2
11/14/13 11:10 PM	0000_0000000179008854	3	A2
11/14/13 11:10 PM	0000_0000000179008854	3	A1
11/15/13 1:22 AM	0000_0000000179008854	6	A1
11/15/13 1:27 AM	0000_0000000179008854	5	A1
11/15/13 1:41 AM	0000_0000000179008854	7	A1
11/15/13 1:41 AM	0000_0000000179008854	4	A2
11/15/13 3:17 AM	0000_0000000179008854	19	A2
11/15/13 3:17 AM	0000_0000000179008854	8	A1
11/15/13 4:08 AM	0000_0000000179008854	14	A1
11/15/13 4:08 AM	0000_0000000179008854	6	A2
11/15/13 4:54 AM	0000_0000000179008854	3	A2
11/15/13 4:54 AM	0000_0000000179008854	4	A1
11/15/13 5:15 AM	0000_0000000179008854	5	A1
11/15/13 5:15 AM	0000_0000000179008854	3	A2
11/15/13 6:00 AM	0000_0000000179008854	3	A2
11/15/13 6:00 AM	0000_0000000179008854	4	A1
11/15/13 6:16 AM	0000_0000000179008847	1	A2
11/15/13 6:16 AM	0000_0000000179008847	4	A1
11/15/13 6:46 AM	0000_0000000179008854	4	A1
11/15/13 6:46 AM	0000_0000000179008854	3	A2
11/15/13 7:55 AM	0000_0000000179008847	1	A1
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11/15/13 8:25 PM	0000_0000000179008854	9	A1
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11/16/13 1:30 AM	0000_0000000179008854	7	A1
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11/16/13 3:26 AM	0000_0000000179008854	8	A1
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1/17/14 1:12 AM	0000_0000000179008781	9	A2
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1/19/14 6:47 PM	0000_0000000179008781	4	A1

Appendix C

Photographic Record

Photo 1. Tagged adult Coho in reach 3 of the Clay Young Channel, November 22, 2013.

Photo 2 Large male Coho (condition 2) captured in the lower Englishman River, fall 2013.

Photo 3. Carcass of a tagged Coho on the bank of the mainstem Englishman River, December 29, 2014.