Annual Report For The Cheakamus River Bull Trout Radiotelemetry and Enumeration Program, 2008

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Summary

This report details the annual results of the second of a three year study examining bull trout population size and behavior in the Cheakamus River near Squamish, B.C. In 2008, we continued to observe the movements and locations of bull trout that were tagged during the spring of 2007, and beginning in February of 2008 we surgically implanted radio tags in an additional 31 bull trout in the Cheakamus River. These new fish and the 39 bull trout tagged in 2007 were tracked throughout 2008 utilizing a combination of fixed telemetry stations and mobile tracking. Radiotelemetry data revealed that the 2007 tag group migrated into the Cheakamus River in the autumn where they remained for on average 213±16 (SD) days before migrating out of the river in late spring/early summer.

During 14 diver enumeration surveys, bull trout were counted and observer efficiency data was collected. An average of 87 bull trout was counted across all surveys with the maximum count being 136. The population estimate for bull trout in the Cheakamus River during the winter-spring period in 2008 was 176 fish. The estimates of abundance between 1996 and 2008 averaged 174 fish.

In an expansion of the original study design we also tracked bull trout migration in the Squamish River during the autumn of 2008. This data indicated the majority of tagged bull trout migrated over 50 km upstream from the Cheakamus River confluence to an area of the upper Squamish River. This is the first information obtained in the Squamish River watershed providing evidence of seasonal migration patterns and it suggests a limited extent of spawning locations for these fish. The study will continue in 2009 to corroborate residence data obtained for the Cheakamus River and to evaluate current and historic bull trout abundance. Several additional radio tags will also be implanted in bull trout to increase the quantity of behavioral data collected.

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Introduction

Project Background

On August 5, 2005 an estimated 45,000 litres of sodium hydroxide entered the Cheakamus River as the result of a train derailment (McCubbing et al. 2006). A number of juvenile and adult char were recorded as mortalities in the Cheakamus River due to the spill. Genetic analyses funded by CN on fish recovered from the spill determined that the char in the Cheakamus River are bull trout (*Salvelinus confluentus*) and not Dolly Varden (*Salvelinus malma*). The impact of this mortality on the size and distribution of the bull trout population in the Cheakamus River is currently unknown. In 2007 this study was initiated to develop a better understanding of the historical abundance of adult bull trout and their seasonal utilization of habitat.

The number of adult bull trout in the Cheakamus River from the confluence of the Cheekeye River to the anadromous boundary, approximately 14 km, upstream has been enumerated annually by snorkel survey since 1996. These counts are auxiliary data collected as part of a snorkel program to estimate steelhead escapement for BC Hydro. An average of nine swims have been conducted per year between February and May and these surveys provide a source of information on the distribution of bull trout over the 14 km survey area as well as relative abundance. The data are therefore potentially useful to evaluate the impact of the CN spill, and provide defensible background information to measure recovery. Abundance and distribution of bull trout from nine pre-spill years can be compared to similar data in 2006 and 2007-2009 to evaluate bull trout abundance. Future data collection from BC Hydro steelhead enumeration surveys after 2009 would allow for a continued assessment of recovery if any impact did occur, but is not included in this study plan.

Unlike the Cheakamus River steelhead escapement program, no radio telemetry information was available for bull trout prior to this study. Radio telemetry is required to determine the proportion of fish seen by divers and the survey life, or residence time, of fish in the survey area. These data are required to translate counts of fish across multiple surveys within a year into a defensible annual abundance estimate. Variation in survey life, the number of days a fish spends in the survey area and/or diver efficiency across years that is not accounted for in the estimation procedure can lead to spurious conclusions about inter-annual trends in abundance. Differences in diver observer efficiency in the upper and lower portions of the river (Korman et al. 2005 and 2002) may also influence the assessment of distribution for different parts of the bull trout population that may have been differentially impacted by the spill.

The data in this interim report should be considered provisional. Only a portion of bull trout in the system were radio tagged and tracked, and only one cycle of radio tagged fish have been tracked for a full year. We are currently in the process of tracking the second tag group to corroborate information obtained in Year 1 about residence times. Abundance analyses will be further refined using these data, and assessments of bull trout migration patterns, while suggestive, are preliminary at this time.

Study Area

The Cheakamus River watershed is a major tributary of the Squamish River and drains an area of 1010 km^2 (upstream of Brackendale gauging station) of the Coastal Mountain range in south-western BC. Discharge is affected by BC Hydro through operation of Daisy Reservoir and the Cheakamus generating plant, a 155 MW storage and diversion project. The generation project, completed in 1957, consists of a 28 m high, 680 m long dam that impounds Daisy Reservoir. From this reservoir, a portion of the river flow is diverted through an 11-km long tunnel to a powerhouse on the Squamish River. The Cheakamus River, downstream of the reservoir, extends 26 km to its confluence with the Squamish River. Only the lower seventeen kilometers of this river are accessible to anadromous salmon, and bull trout as a number of natural barriers preclude further upstream migration.

The study area for the Cheakamus River Bull Trout Radio Telemetry and Enumeration Program can generally be separated into three areas: the snorkel survey area, the Cheakamus River radio tracking area and the Squamish watershed radio tracking area (Fig. 1). The snorkel survey area encompasses the portion of the Cheakamus River between the confluence of the Cheekye River (river km 3.5) and the anadromous barrier (river km 17.5). The Cheakamus River radio tracking area encompasses the Cheakamus River from the confluence with the Squamish River (river km 0) to the anadromous barrier. Information was collected in this area from mobile tracking during snorkel surveys, and from three fixed stations. In addition, numerous opportunistic mobile tracking surveys were conducted in the Squamish River downstream of the Cheakamus River confluence (Fig. 1). The Squamish watershed tracking area includes a fixed station operated in the fall of 2007 and 2008 near Pillchuck Creek and a broad mobile tracking area. Mobile tracking (by air, by vehicle, and through ground truthing) conducted in 2008 encompassed portions the Squamish, Elaho, and Mamquam rivers as well as Ashlu Creek (Fig. 1).

Methods

River Data

Hourly water temperatures in 2008 were recorded with an Onset Tidbit temperature logger (courtesy of BC Hydro) placed at the North Vancouver Outdoor School (~ river km 5). Mean daily discharge (Q) over the survey period obtained from the Water Survey of Canada (WSC) hourly discharge record for the Cheakamus River at Brackendale (WSC 08GA043) (Lynne Campo, Environment Canada. 2009, pers. comm., January 13).

Radio Telemetry

Adult bull trout in the Cheakamus River were implanted with Lotek NTC-6-2 NanoTag series radio transmitters (Lotek Wireless Inc., Newmarket, Ontario). The radio tag dimensions are 30.1 mm long by 9.1 mm diameter and they weigh 4.5 grams in air. Tags were set at a staggered burst rate of 10 seconds with an estimated operational life of 678 days (warranty to 542 days).

Adult bull trout were captured by angling in the Cheakamus River between February 21 and May 13, 2008. Captured fish were held in a fish tube for a short period of time and then placed in a large tote and anesthetized using a clove oil solution. Fish length and weight were recorded; tissue and fin samples were collected and archived for future genetic and age sampling. A brightly colored external floy tag was attached posterior to the dorsal fin prior to surgery for visual identification during snorkel surveys. When the bull trout had reached level 4 anesthesia (total loss of equilibrium or swimming motion, and weak opercular motion) they were placed dorsally on a neoprene-lined, V-shaped surgical table (Fig. 2). From this point until the completion of surgery, the head and gills were gently bathed in anesthetic solution.

To implant the radio tags a small (approx. 3 cm) incision was made in the belly just off the mid-line and between the pectoral and pelvic girdles. A curved needle attached to the radio tag antenna was inserted through the incision and exiting the body wall several centimeters posterior to the incision. The antenna was then pulled through the body wall and the radio tag carefully inserted into the body cavity. The incision was then sutured with 2 or 3 surgical knots and the fish was placed in a holding tube located in slow moving water within the river. Bull trout were not released until they exhibited orientation to the current and strong swimming movements.

Post–surgery observations and mobile tracking did not indicate any mortalities occurring from surgical procedures (e.g. within the first 24-48 hours). Opportunistic mobile tracking also indicated tagged bull trout remained in close proximity to their point of capture and release after tagging.

Snorkel Surveys

Fourteen snorkel surveys were conducted between January 23 and May 8, 2008, and 18 surveys were conducted between January 29 and May 23, 2007. Procedures during each snorkel survey followed those outlined in Korman et al. (2005) for adult steelhead enumeration. On each survey, a team of three divers floated the 13.5 km survey area from river km (rkm) 17 to km 3.5 in 4-6 hours. The survey area was divided into 34 sections averaging 380 m in length (Korman et al. 2005). The number of tagged and untagged char observed in each section on each survey was recorded. Diver efficiency, or the proportion of char observed on each swim, was estimated based on the number of tagged fish observed by all three divers (based on the presence of an external colored tag) to the total number of tags known to be present in the survey area based on telemetry data. Because of an unknown rate of external tag loss from the 2007 tag group, only fish tagged in 2008 were used for the 2008 diver observation efficiency evaluation. Horizontal visibility (HV) was estimated by measuring the maximum distance from which a diver could detect a dark object held underwater at 1 m depth. Horizontal visibility was measured in sections 4 (rkm=14.5) and 21 (rkm=7.5) to index conditions in the upper and lower survey areas, respectively. A technician in a small raft floated 50-100 m behind the swim crew and determined the number of tagged bull trout in each river section using a Lotek SRX 400 version 4.01/W5 mobile receiver outfitted with a 3-element Yagi antenna (model F-3FB). These data, in conjunction with data from fixed-location receivers, were used to determine the number of tagged fish (by year of tagging) present in the snorkel survey area on each survey.

Abundance Estimation

Estimates of the total number of char present in the survey area on each swim survey *i* (N_i) depend on the number of fish that are counted (n_i) and the proportion of fish present in the survey area that are observed ($pCap_i$, or diver efficiency),

(1) $$N_i = \frac{n_i}{pCap_i}$$

The total run size for char over the winter-spring period when swims are conducted (*N*), depends on survey-specific estimates of abundance (N_i), as well as the proportion of the total run that is present during each survey ($pRun_i$). Assuming all fish have arrived in the survey area prior to the first swim survey each year (typically late January), $pRun_i$ represents the proportion of fish remaining in the survey area by each survey date. In this case, a population estimate for the total abundance over the winter-spring survey period (*N*) can be determined from,

(2) $$N = \frac{\frac{\sum_{i=1}^{k} N_i}{k}}{pRun_k}$$

where, *k* is the total number of surveys up to and including survey number *k*, and $pRun_k$ represents the proportion of the run remaining by survey *k*. The nominator of eqn. 2 is simply the average of expanded counts across surveys 1 through *k*. Note that in the situation where all fish have arrived prior to the first swim survey, and no fish have left prior to the last survey, $pRun_i$=1 for all surveys, and the total run size can be estimated as an average of survey-specific population estimates across all swims. Eqn. 2 represents a slightly more complex alternative where, N_i's are averaged over a period when the majority of the run is present (e.g. prior to May 1st), and that average is then expanded by the proportion of the run that is present prior to the cut-off date.

A key objective of this project is to reconstruct the historical time series of char abundance in the survey area over the winter-spring period to determine if the caustic soda spill in the Cheakamus River in 2005 has reduced the abundance of char relative to years before the spill. The number of char observed on each swim survey has been recorded as part of the BC Hydro-funded adult steelhead enumeration program since its inception in 1996. However, as both the number of swim surveys conducted each year and the river conditions on those surveys has varied, trends in count data across years may not reflect trends in actual abundance. Diver efficiency for steelhead was correlated with river conditions (Korman et al. 2007), with efficiency being higher when discharge is low and water clarity is high. We used the same logistic model as in Korman et al. (2007) to model diver efficiency for char,

(3) $$qP_i = \frac{\frac{HV}{Q}^{\rho_s}}{\rho_h^{\rho_s} + \frac{HV}{Q}^{\rho_s}}$$

where, qP_i is the physically-based prediction of diver efficiency on survey *i*, *HV/Q* is the ratio of horizontal visibility in the lower river (section 24) to discharge, ρ_h is the *HV/Q* ratio at which observer efficiency is 0.5, and ρ_s is the slope of the relationship. We estimated parameters of the qP-HV/Q model using maximum likelihood under the assumption that error in the total number of tagged char observed on each swim survey follows a Poisson distribution,

(4) $$r_i \sim Poisson(qP_i * M_i)$$

where, r_i is the number of tags observed on each survey, and M_i is the total number of tags present, as determined by mobile telemetry surveys and fixed-telemetry station data. The product of qP_i and M_i represents the expected number of tags observed on each survey. Model parameters were estimated by minimizing the negative sum of the log likelihoods across surveys returned from the Poisson model using the Solver non-linear search routine in Excel. Parameters were estimated independently for each study year (2007 and 2008) and also estimated based on data combined across years.

In years with telemetry data, $pCap_i$ for each survey can be estimated based on survey-specific tagging data only ($pCap_i=r_i/M_i$), or from the qP-HV/Q relationship (eqn. 3). The latter estimate is likely more robust because sampling error of efficiency estimates based on r_i/M_i can be large when the number of tags observed is low. The qP-HV/Q relationship reduces this error because it essentially averages efficiency estimates across surveys with similar river conditions. The qP-HV/Q relationship is also essential to estimate char abundance in the majority of survey years when char telemetry data are not available (1996-2006).

We hypothesize that the Cheakamus River likely supports or supported a group of char with a more resident life history strategy than what is apparent from the telemetry data collected to date (Ladell et al. 2009). The collection of 9 juvenile and 20 adult dead char immediately after the spill (see Table 2 from McCubbing et al. 2006) indicates that char spawn in the mainstem Cheakamus or its tributaries, and that both adult and juvenile char can remain in the Cheakamus over the summer period. Electrofishing and juvenile snorkel surveys conducted in the March 2008 showed that juvenile char in the mainstem Cheakamus River are rare (n=13 of 4565 juveniles captured across 16 sites) and are generally found within a distance of 1.5 km downstream of Culliton Creek (Korman 2008). Inspection of counts of adult char from swim surveys since 1996 reveals a spatially bi-modal distribution of fish during the winter-spring period, with a low-abundance group located approximately between the anadromous barrier (Section 0, rkm=17.0) to just downstream of the confluence with Culliton Creek (ca. Section 8, rkm =13.5), and a larger-abundance group located approximately between the Bailey Bridge (Section 21, rkm=7.5) and the Cheekeye River confluence (Section 34, rkm=3.5). Given these observations, we speculate that the upstream group of adult char has a more resident life history strategy than the downstream group. If these assumptions hold, the relative abundance of the upstream group should have been more severely impacted by the caustic soda spill, since a higher fraction would have been present in August relative to the downstream, more migratory group. To evaluate this hypothesis, we computed the proportion of total counts of char upstream of the Bailey Bridge (rkm = 7.5) to the total over the entire survey area for each year, and compared the ratios in years before and after the spill. Note that the absolute value of the ratio in any year inherently assumes that diver efficiency is similar for upper and lower populations. This is likely not the case, as diver efficiency for steelhead is approximately 2-fold greater below the Bailey Bridge than above (Korman et al. 2005) due to differences in channel morphology. Potential differences in observer efficiency for char cannot be evaluated from this study because very few of the tagged char in 2007 or 2008 were located above the Bailey Bridge. However, the assumption of equal diver efficiency for the upper and lower char groups is not critical to the analysis, since evaluation of the hypothesis depends on the relative changes in upper-to-total count ratios across years, and not the absolute value of the ratios.

Residence/Spawning 2008

Additional tracking of radio tagged bull trout outside of the Cheakamus River watershed was undertaken in the autumn of 2008. The intention was to determine, if possible, the movements of bull trout after leaving the Cheakamus River and also to obtain information on the location of spawning areas. Two fixed receiver stations were installed on the bank of the Squamish River on July 4, 2008. One station was located approximately 1 km downstream of the Cheakamus River confluence and the second was located approximately 8 km upstream (Fig. 1). A fixed wing aircraft was used in September 2008 to mobile track (Fig. 3) the entire Squamish River watershed including the Ashlu River, Elaho River, Shovelnose Creek and the Mamquam River (Fig. 1). Additional manual tracking during October 2008 was accomplished from a vehicle moving along the eastern side of the Squamish River from approximately river km 60 to Squamish River Estuary.

Results

River Data

Discharge in the Cheakamus River over 2008 was typical of a managed river with high inflows. When possible the river discharge is held at the Water Use Plan (WUP) determined flow regime, however, rain and snow melt events still cause variability in discharge (Figure 4). Water Use Planning is a process involving BC Hydro and participating stakeholders to explore ways to find a better balance among water use interests, such as fisheries, wildlife, recreation, heritage conservation, flood control, and the need to generate power.

Water temperature increased steadily between mid-February and mid-May when the majority of snorkel surveys were conducted. The water temperature regime increased to its maximum level by mid-August with a high daily temperature of 15.9 ºC (Fig. 5).

Radio Telemetry

2007 Radio Tags

The majority (83%, n=33) of the 40 bull trout radio tagged between January and May of 2007 migrated downstream out of the Cheakamus River (Table 1, Fig. 6; see also Fig. 7 for a representative pattern) in the late spring/early summer of that same year (Ladell et al 2007). This post-surgery migration may in part be a reaction to handling induced stress and as such may represent a modified movement pattern compared with untagged individuals. Seventeen of the radio tagged fish were never reacquired in any of the subsequent tracking surveys and were lost to further analysis. Over an average period of 479 days post surgery, there was a total of 10 fish (26%) which appear to have died or shed their tag within the Cheakamus River at some point showing a pattern of no migration over an extended period of time (Fig. 8).

After the post-surgery emigration from the Cheakamus River in the late spring/early summer of 2007, fourteen tagged bull trout were observed returning to the Cheakamus River in the late autumn of 2007 (Table 1). Eleven of the 40 (28%) bull trout with tags implanted in 2007 exhibited a migration pattern into and out of the Cheakamus River between fall 2007 and summer 2008. These tagged char remained for an average of 213±16 (SD) days in the Cheakamus River; providing valuable data on the 'residence time' in the swim survey area which is required in abundance analysis modeling. All of the bull trout tagged in 2007, and still considered alive, naturally (i.e. the behavior was not affected by post tagging stress) emigrated out of the river in the late spring of 2008 (see Figure 9 for representative pattern). The majority (9 of 13) returned to the Cheakamus River where they were tracked as of December 2008. As the battery life of these radio tags is expected to expire within in the first two months of 2009, these tagged fish are not expected to be available for evaluation in subsequent surveys.

Bull trout tagged in 2007 that returned to the Cheakamus River in 2008 appeared to show considerable habitat fidelity. Tagged fish often migrated to the same reach as the one in which they had been tagged where they remained for most of the winter.

2008 Radio Tags

A total of 32 radio tags were implanted in bull trout in the Cheakamus River between 13 February and 13 May, 2008 (Table 1). The first radio tag (Code 53, Floy 52) was improperly activated reducing the total number of active radio tags implanted since 2007 to 71. The average length of bull trout tagged in 2008 was 603 mm (range = 455 – 765 mm) which is slightly larger than the mean length of fish tagged in 2007 (563 mm) (Ladell et. al. 2007). A total of 28 bull trout were weighed with a mean weight of 3.0 kg (range = 1.1 to 6.6 kg).

The sex of individual bull trout was determined by examination of external marking, coloration and body shape. In 2008, out of a total of 28 fish for which a sexual determination was made, 14 appeared to be males suggesting a sex ratio of 1:1 male:female amongst the fish angled and tagged for this survey. When the sex ratio of bull trout is combined with data from 2007 the overall distribution is 1:1.2 males:females.

Bull trout which were radio tagged in the spring of 2008 showed a similar pattern of movement to fish tagged in 2007. A total of 26 of 31 (84%) fish migrated out of the Cheakamus River between late March and early July. Only two of the tagged fish (6%) remained in the Cheakamus River over the summer; one in the lower river (Code 69) and one in the upper river

(Code 79). The majority of tagged bull trout (62%) that migrated out of the Cheakamus River in the late spring of 2008 had not returned by the end of the calendar year. One of these fish (Code 87) was killed, and its tag recovered in the Squamish River. A total of 12 tagged bull trout (41% of the emigrants) moved back into the Cheakamus River in the autumn. The timing of the return migration from the Squamish River (12 October – 17 November) was similar to that seen for the 2007 tag group (Figure 6). Further data collection (spring 2009) is required to evaluate migration patterns of the 2008 tag group.

Residence/Spawning 2008

Aerial radio tracking was conducted on September 2, 16 and October 9, 2008. Vehicle radio tracking took place on October 16, 29 and December 12, 2008. Taken in concert, the use of fixed stations in the Squamish River, aerial telemetry and mobile telemetry have given us picture of bull trout movements outside of the Cheakamus River. The pattern of movement seen in the majority of fish was to leave the Cheakamus River and enter the Squamish River during the period between 15 May and July 15. Due to the width and depth of the Squamish River at the confluence the fixed station at this location was unable to determine the direction of movement for fish that left the Cheakamus River. Opportunistic mobile tracking surveys in spring 2007 and 2008 did confirm at least some fish migrated downstream, but it is not clear how many fish moved downstream or if any fish entered the estuary. Fixed station tracking in 2007 indicated tagged bull trout subsequently moved upstream in the Squamish River primarily in the first half of July (Table 3), and mobile tracking (air and ground) subsequently identified the putative spawning area for the majority of the bull trout. We tracked 25 individual bull trout to a small (<1 km lineal) area in the upper Squamish River. Bull trout were in this area on September 2, the date of our first aerial overflight, and downstream migrations began October 12 and continued through the end of November (Table 3).

Snorkel Surveys and Abundance Estimate

The average number of char counted (tagged and untagged) across 18 and 14 surveys in 2007 and 2008 was 110 and 87, respectively (Table 4). Maximum counts across surveys in 2007 and 2008 were 180 and 136, respectively. Average diver efficiency across surveys, computed as the ratio of tags observed (r_i) to tags present (M_i), was 0.60 in both years. There was a moderately strong relationship between the ratio of horizontal visibility to discharge (HV/Q) and diver efficiency (r/M) in both 2007 and 2008 (Fig. 10). The best-fit qP-HV/Q models explained 64 and 68% of the variation in observer efficiency in 2007 and 2008, respectively. The relationships were very consistent among years, and a single relationship based on data combined across years explained 65% of the variation in diver efficiency. Aside from river conditions, observer efficiency is likely affected by factors that effect fish behaviour and distribution, such as water temperature and the availability of chum fry, a major prey species. If these latter factors are important, a seasonal trend in residuals from the qP-HV/Q relationship should be apparent. There was no trend in residuals across survey dates with the exception of a consistent under-prediction of efficiency on the earliest three surveys in 2008 (Fig. 11). Efficiency estimates during these surveys were very uncertain and not very representative, as they were based on a total of only 1-4 tagged char that held in only two of 34 river sections over the three surveys.

Trends in char abundance across surveys in 2007 and 2008 (expanded counts) based on the qP-HV/Q relationship or the survey-specific ratios of tags observed to tags present (r_i/M_i) were relatively consistent (Fig. 12). There was greater temporal variation in expanded counts based on survey-specific efficiency estimates, which was likely driven by greater sampling error due to the limited number of tags. There was no consistent seasonal trend in char abundance among years (Fig. 13). Some years showed relatively constant abundance through time (e.g. 2008), while others showed increasing (e.g. 2007) or declining (e.g., 2006) seasonal trends. It is likely that apparent seasonal trends in abundance are dominantly driven by sampling error, as the telemetry data indicate that very few fish arrive or depart from the survey area over the period when the majority of swim surveys are conducted (Table 2), and there was no seasonal trend in residuals from the qP-HV/Q relationship.

A total of 74 downstream departure dates from the survey area have been recorded at the fixed station at the Cheekeye River confluence to date (Table 2). This number includes departure dates in the year of tagging for fish tagged in 2007 and 2008, as well as departure dates in 2008 for fish tagged in 2007. The cumulative proportions of fish departing before April 1st, May 1st, and June 1st were 0.08 (n=6), 0.18 (n=13), and 0.55 (n=41), respectively. Since the programs inception in 1996, 75% of the surveys each year have been conducted prior to May 1st, and estimates of abundance from swims conducted in May are generally highly uncertain because diver efficiency is low at that time due to high discharge and reduced visibility. Thus, to develop preliminary population estimates for char in the Cheakamus River during the winter-spring period, we averaged the expanded counts across all surveys conducted before May 1st using the best fit qP-HV/Q relationship, and expanded these averages using a *pRun* estimate of 0.82 (=1-0.18, eqn. 2).

The population estimates for char in the Cheakamus River during the winter-spring period in 2007 and 2008, were 210 and 176 fish, respectively. Using the same methodology, historical estimates of abundance between 1996 and 2008 averaged 174 fish (Fig. 14). We observe from this data that char abundance increased over four-fold between the late 1990's and 2004/2005 from an average of 75 fish to over 300 fish. The average abundance since the spill (2006-2008) was calculated as 193 fish. This average is approximately 60% of the peak abundance that occurred in 2004-2005, but above the average abundance across all pre-spill years (1996-2005) of 168 fish.

The ratio of fish counted upstream of the Bailey Bridge (section 21, rkm=7.5) to the total count has varied considerably across years, ranging from a low of 0.06 in 2006, the first year after the spill, to a high of 0.38 in 1996 (Fig. 15). The average ratio across all post-spill years was 0.10, which was considerably lower than the average from pre-spill years of 0.18. However, a decline in the abundance of char upstream of the Bailey Bridge was apparent two years before the spill (2004 and 2005), and the most recent ratio (2008, 0.14) is similar to the pre-spill historical average.

Future Work

Preliminary estimates of the population size for char utilizing the Cheakamus River over the winter-spring survey period presented in this report are based on the assumption that no fish enter the survey area between late January and the end of April. This assumption is supported by the telemetry data analyzed to date, but considerably more information will be available to evaluate this assumption when the arrival timing of fish tagged in 2008 is determined through analysis of the 2009 fixed station data. In addition, our preliminary estimates of abundance do not include estimates of uncertainty. This requires implementation of a more complex version of the model presented here that accounts for uncertainty in survey-specific population estimates due to sampling error, uncertainty in parameters defined the qP-HV/Q relationship, and uncertainty in the proportion of the run that remains by May 1st (*pRun*). Estimates from the more complex model will be provided in the final report.

Eight unused radio tags are still available from activities in 2007 and 2008. These tags will be implanted in bull trout in the spring of 2009. The information from these tagged fish will assist in evaluating migration patterns and spawning areas and may also provide additional observer efficiency data during swims. If feasible, a portion of the available tags will be implanted in bull trout from the upper Cheakamus River to assist in clarifying theories about resident life histories. We also suggest that the molecular analysis should be undertaken in 2009 to potentially clarify the population structure of bull trout in the Cheakamus River (Costello et al 2003, Taylor and Costello 2006).

The three Cheakamus River fixed stations will remain in place until the 2008 tag group of bull trout has left the river to provide an additional residence time date set for use in the abundance model. Following the spring outmigration the two fixed stations in the Squamish River will be installed and operated until December 2009. In addition mobile tracking surveys will be conducted in the Squamish River watershed to corroborate information about adult bull trout movements outside of the Cheakamus River collected in 2008.

Table 1. Cheakamus River migration timing and residence data for radio tagged bull trout for which clear movement patterns and residence time can be evaluated. Note: 2008 entry/exit data and residence will be collected for 2008 tag group in 2009.

Code (Tag Year)	Tagging Date	1st Cheakamus R. exit date	1st Cheakamus R. re-entry date	2nd Cheakamus R. exit date	Cheakamus R. Residence time (days)	2nd Cheakamus R. re-entry date	Date of tag loss/fish death
(2007)							
21	15-Jan-07	31-Oct-07					
22	15-Jan-07						02-Aug-07
23	17-Jan-07	28-Mar-07					
24	24-Jan-07						02-Aug-07
25	30-Jan-07	26-May-07	02-Nov-07	22-May-08	202	31-Oct-08	
30	3-Feb-07	16-May-07					?
26	6-Feb-07	07-Jul-07	10-Nov-07	18-Jun-08	221	04-Nov-08	
29	12-Feb-07						?
27	19-Feb-07	12-Jun-07	18-Nov-07	03-Jun-08	198	23-Nov-08	
20	22-Feb-07	14-May-07					
16	22-Feb-07	28-Nov-07					?
28	27-Feb-07	05-Jul-07	19-Nov-07	06-Jun-08	200	15-Nov-08	
19	1-Mar-07	16-Apr-07					
18	1-Mar-07	17-Apr-07					
17	1-Mar-07	23-Jun-07	23-Oct-07	19-Jun-08	240	30-Oct-08	
14	7-Mar-07	02-Jun-07					14-Mar-08
13	7-Mar-07	15-Jun-07	26-Oct-07	06-Jun-08	224	03-Nov-08	
15	7-Mar-07	21-Jun-07					
12	7-Mar-07						?
11	8-Mar-07	11-Mar-07					
40	8-Mar-07	27-Jun-07	22-Oct-07	22-Apr-08	183		
39	10-Mar-07	11-Mar-07	11-Nov-07	22-Jun-08	224	25-Oct-08	
37	15-Mar-07	25-May-07					
38	15-Mar-07	19-Mar-07	22-Oct-07	09-Dec-07	49		
31	19-Mar-07	01-Aug-07	10-Apr-08				
32	27-Mar-07	12-May-07					
33	27-Mar-07	11-May-07					
34	29-Mar-07	24-Apr-07					02-Jun-07
35	5-Apr-07						?
36	7-Apr-07	21-Jun-07	22-Oct-07	06-Jun-08	228	21-Oct-08	
46	7-Apr-07	17-Apr-07					
44	7-Apr-07	03-May-07	15-Oct-07	15-May-08	213		
41	7-Apr-07	21-May-07	17-Oct-07	24-May-08	220		
42	7-Apr-07	17-Apr-07					
43	20-Apr-07	11-Jun-07					
45	20-Apr-07	13-Jun-07					
47	20-Apr-07	21-May-07	03-Nov-07	25-May-08	204	31-Oct-08	
48	9-May-07						?
49	18-May-07	26-May-07	29-Oct-07				
50	23-May-07	30-May-07					
(2008)							
54	21-Feb-08	15-May-08					
55	21-Feb-08	23-May-08					
58	27-Feb-08	23-May-08					

Code (Tag Year)	Tagging Date	1st Cheakamus R. exit date	1st Cheakamus R. re-entry date	2nd Cheakamus R. exit date	Cheakamus R. Residence time (days)	2nd Cheakamus R. re-entry date	Date of tag loss/fish death
(2008)							
62	9-Mar-08	27-Mar-08					
57	15-Mar-08	31-Mar-08					
63	19-Mar-08	01-Apr-08					
64	23-Mar-08	03-July-08	04-Nov-08				
59	30-Mar-08	02-Jun-08	04-Nov-08				
52	3-Apr-08	17-May-08	13-Oct-08				
56	3-Apr-08	18-May-08	19-Oct-08				
75	3-Apr-08	11-Jun-08					
74	4-Apr-08	16-Jun-08	25-Oct-08				
73	4-Apr-08	26-May-08					
61	4-Apr-08						
68	4-Apr-08	07-May-08					
69	12-Apr-08						
72	22-Apr-08	26-May-08					
70	22-Apr-08	03-Jun-08					
85	22-Apr-08						
66	22-Apr-08	06-May-08					
67	22-Apr-08	30-May-08					
88	22-Apr-08	01-May-08	18-Oct-08				
77	23-Apr-08	26-Jun-08					
76	23-Apr-08	29-Jun-08	15-Nov-08				
65	23-Apr-08	29-Jun-08	17-Oct-08				
71	23-Apr-08	12-May-08					
90	23-Apr-08	17-May-08	17-Nov-08				
87	28-Apr-08	11-Sept-08					21-Oct-08
78	1-May-08	24-May-08	13-Oct-08				
86	6-May-08	08-May-08					
79	13-May-08						

Table 2. Catch data and biological information for bull trout radio tagged during 2008

Code	Frequency	Floy #	Tagging date	Length (cm)	Weight (g)	Sex	Capture location	River km
54	149.360	53	21-Feb-08	51	2600	F	Gauge Pool	5.4
55	149.360	54	21-Feb-08	53	1550	M	Gauge Pool	5.4
58	149.360	57	27-Feb-08	63	2700	M	Gauge Pool	5.4
62	151.320	60	9-Mar-08	67		M	Frogs Pond	3.2
57	149.360	56	15-Mar-08	57	1700		NVOS Pool	5.7
63	151.320	61	19-Mar-08	73.5	5100		NVOS Pool	5.7
64	151.320	62	23-Mar-08	55	1800	M	Moodys	3.8
59	149.360	58	30-Mar-08	67	4000	M	Moodys	3.8
52	149.360	51	3-Apr-08	63		M	Moodys	3.8
56	149.360	55	3-Apr-08	56		F	Moodys	3.8
75	151.320	73	3-Apr-08	62		F	Moodys	3.8
74	151.320	72	4-Apr-08	54.5	1600	F	Moodys	3.8
73	151.320	71	4-Apr-08	53	1700	F	Moodys	3.8
61	151.320	59	4-Apr-08	52.5	1200	F	Moodys	3.8
68	151.320	66	4-Apr-08	65.5	4500	M	Moodys	3.8
69	151.320	67	12-Apr-08	55	1700		d/s of Stables	1.2
72	151.320	70	22-Apr-08	68	5500	M	Woodpool	4.7
70	151.320	68	22-Apr-08	71.5	6200	F	Woodpool	4.7
85	151.320	83	22-Apr-08	68.5	4500	M	Woodpool	4.7
66	151.320	64	22-Apr-08	60	2300	F	Woodpool	4.7
67	151.320	65	22-Apr-08	55	2000	F	u/s Moody's	4.0
88	151.320	86	22-Apr-08	69.5	5600	F	u/s Moodys	4.0
77	151.320	75	23-Apr-08	61.5	2500	M	Gauge Pool	5.4
76	151.320	74	23-Apr-08	51	1600	F	Gauge Pool	5.4
65	151.320	63	23-Apr-08	63	2300	F	Gauge Pool	5.4
71	151.320	69	23-Apr-08	58	2200	M	Gauge Pool	5.4
90	151.320	88	23-Apr-08	64	2700	F	Gauge Pool	5.4
87	151.320	85	28-Apr-08	45.5	1500	M	Moody's	3.8
78	151.320	76	1-May-08	76.5	6600	M	Gauge Pool	5.4
86	151.320	84	6-May-08	46.5	1100	M	Gauge Pool	5.4
79	151.320	77	13-May-08	62.5	4000	F	NVOS Pool	5.7

Table 3. Squamish River migration timing and residence data for selected radio tagged bull trout for which clear movement patterns and residence time can be evaluated.

Code (Year)	Upstream Squamish R Date	Downstream Squamish R Date	Upper Squamish R. residence time
(2007)			
36	12-July-08	20-Oct-08	100
39		24-Oct-08	
13		01-Nov-08	
17		28-Oct-08	
25		29-Oct-08	
26		03-Nov-08	
28		12-Nov-08	
27		21-Nov-08	
(2008)			
64	15-July-08	03-Nov-08	111
65	09-July-08	14-Oct-08	97
70	07-July-08		
74	15-July-08	23-Oct-08	100
76	06-July-08	12-Nov-08	129
79	01-July-08		
55	08-Sept-08		
87	12-Sept-08	25-Sept-08	13
52		12-Oct-08	
56		17-Oct-08	
78		12-Oct-08	
88		17-Oct-08	
47		30-Oct-08	
59		02-Nov-08	
90		16-Nov-08	

Table 4. Counts of total tagged and untagged char in the Cheakamus River survey area in 2008. Cumulative radio tags placed in the entire river and numbers of tagged char remaining in the survey reach are listed.

Survey Date	Discharge (Q in m^3/sec)	Visibility (HV in m)	HV/Q	Observed Untagged	Observed Tagged (r)	Total Tags Present (M)	Diver Efficiency (r/M)
29-Jan-07	18	11.5	0.64	176	4	4	1.00
6-Feb-07	15	9.7	0.66	151	5	6	0.83
15-Feb-07	21	3.4	0.16	19	1	8	0.13
28-Feb-07	16	7.4	0.45	132	9	9	1.00
6-Mar-07	18	7	0.39	91	8	11	0.73
15-Mar-07	19	5.2	0.27	46	4	18	0.22
22-Mar-07	22	5.7	0.26	81	11	16	0.69
29-Mar-07	20	5.9	0.30	112	12	17	0.71
3-Apr-07	24	5.4	0.23	103	12	17	0.71
5-Apr-07	23	5.7	0.25	95	12	17	0.71
10-Apr-07	25	6.15	0.25	92	16	23	0.70
17-Apr-07	22	6.5	0.30	128	14	21	0.67
24-Apr-07	26	5.4	0.21	80	8	24	0.33
30-Apr-07	22	6.1	0.27	134	17	23	0.74
4-May-07	26	5.3	0.21	81	8	24	0.33
10-May-07	24	5.8	0.24	117	12	23	0.52
15-May-07	26	5.3	0.21	94	10	21	0.48
23-May-07	32	4.7	0.15	69	7	19	0.37
23-Jan-08	17	9.6	0.57	118	0	0	
13-Feb-08	23	7.7	0.34	115	1	1	1.00
27-Feb-08	18	7.3	0.41	118	3	3	1.00
13-Mar-08	23	7.4	0.33	91	4	4	1.00
19-Mar-08	17	6.8	0.40	132	4	6	0.67
26-Mar-08	18	6.7	0.37	107	6	7	0.86
3-Apr-08	22	6	0.27	76	3	8	0.38
10-Apr-08	22	5.4	0.25	90	8	12	0.67
16-Apr-08	23	5.5	0.24	62	6	12	0.50
23-Apr-08	24	4.1	0.17	35	5	18	0.28
1-May-08	24	4.6	0.19	38	4	23	0.17
5-May-08	30	4.2	0.14	36	8	23	0.35
6-May-08	28	4.7	0.17	53	10	23	0.43
8-May-08	25	5.4	0.22	69	10	22	0.45

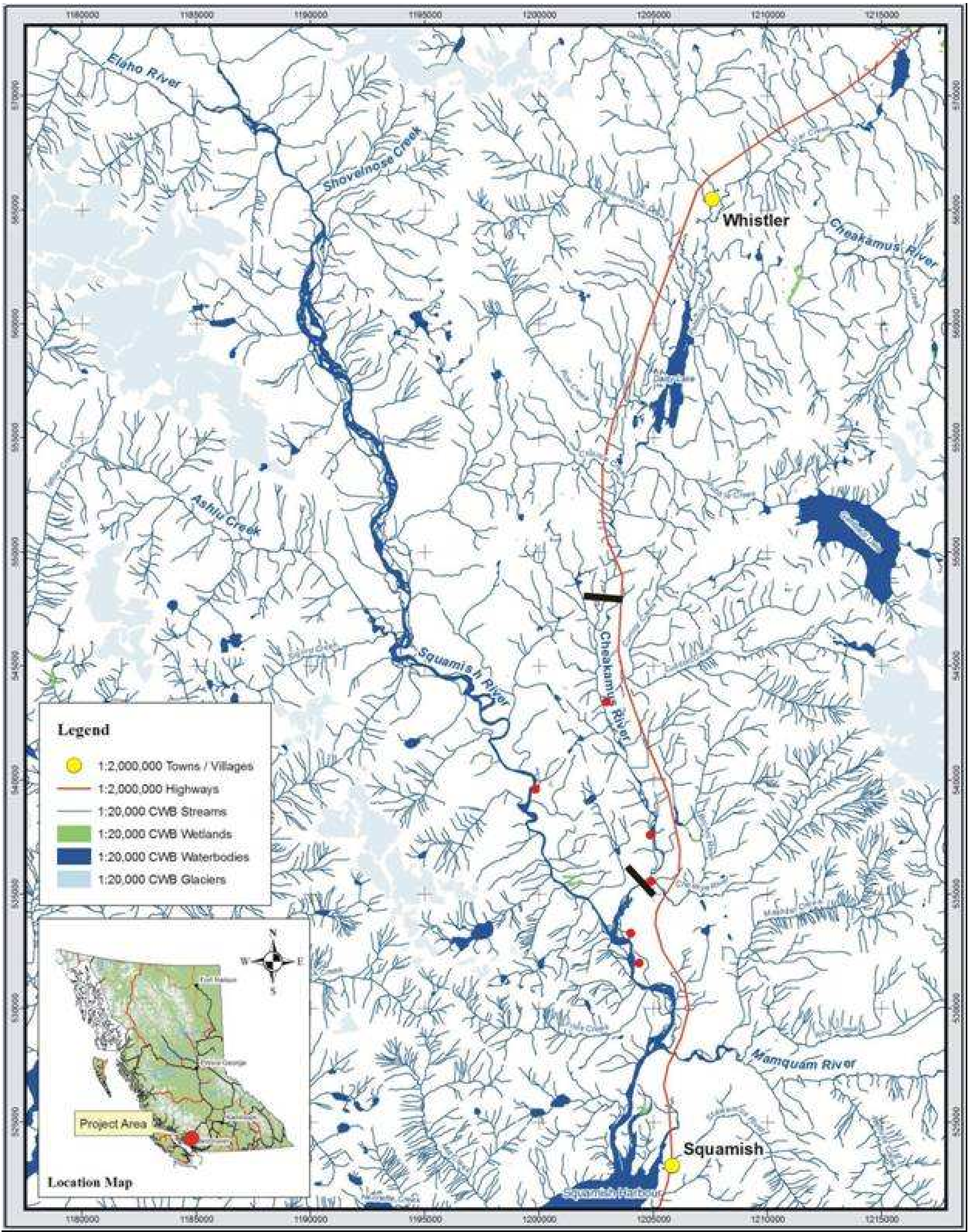


Figure 1. The Cheakamus River and Squamish River. Fixed telemetry stations are indicated by red dots and the snorkel survey area is bounded by black bars

Figure 2. Suturing the incision on a Cheakamus River bull trout after insertion of radio tag into body cavity – March, 2007.

Figure 3. Aerial tracking char over the Squamish River from a Cessna 206 fixed wing aircraft – September, 2008.

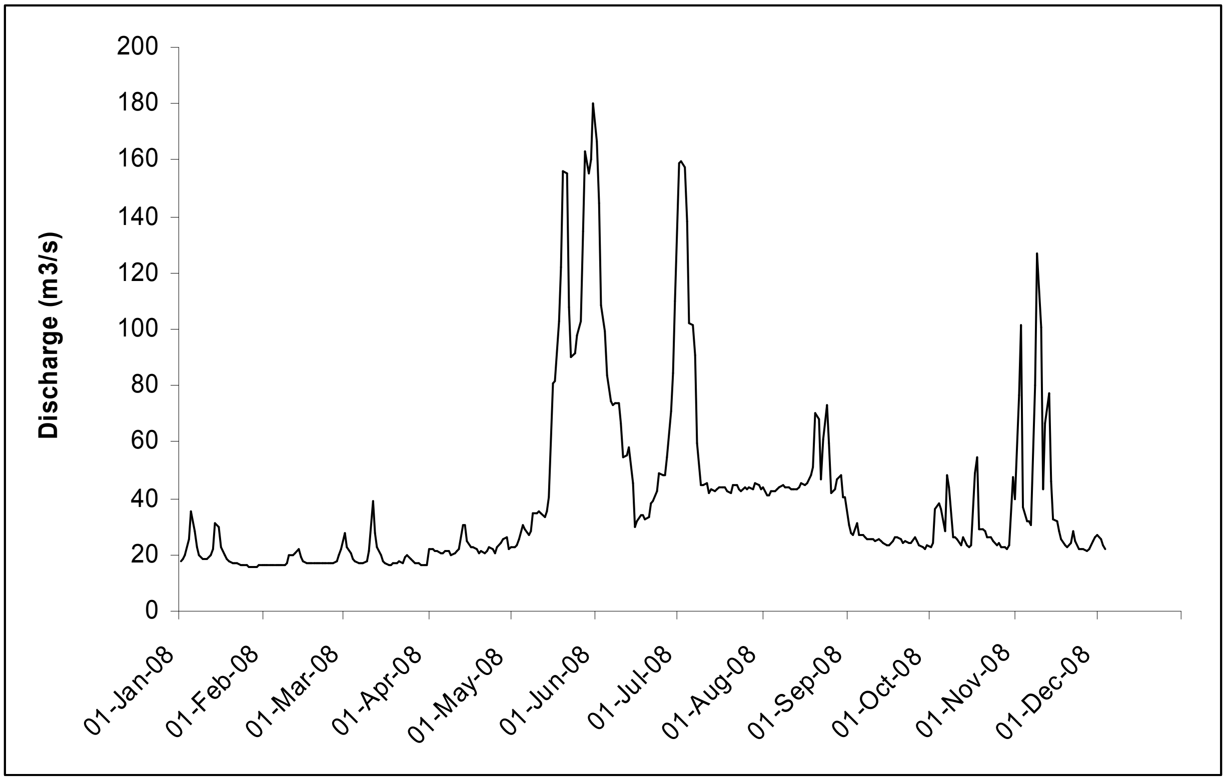


Figure 4. Discharge profile of the Cheakamus River measured at the Water Survey of Canada gauging station 08GA043 (Brackendale), 2008.

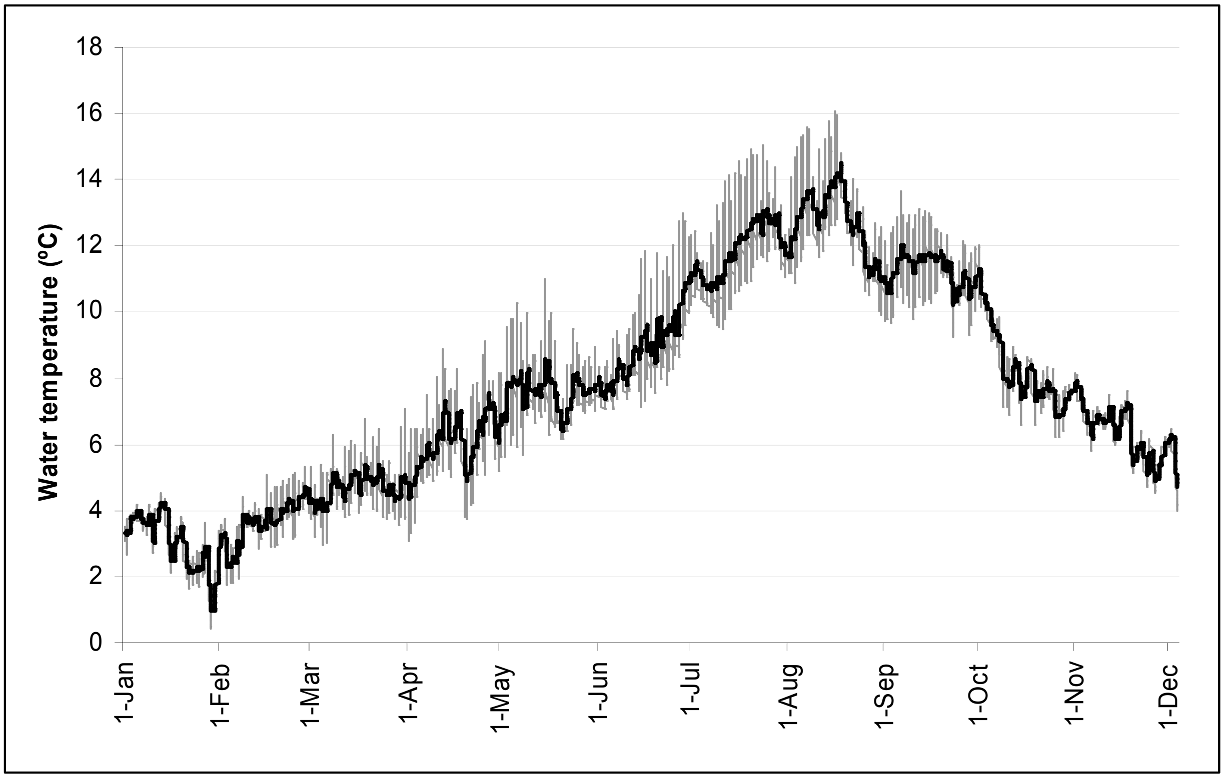


Figure 5. Annual profile of water temperature in the Cheakamus River at the North Vancouver Outdoor School (river km 5) for 2008. Black line indicates daily average with daily maximum and minimum temperature shown by gray bars.

	2007												2008											
Code	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
21	h	h	d	h	u	h	h	u	h	d														
22	h	h	h	h	h	h	h	d	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	
23	h	h	d																					
24		h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	
25		h	h	h	d						u	h	h	h	h	h	d						u	h
30		h	h	h	d																			
26		h	h	h	d						h	h	h	u	h	h	h	d						
29		h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h
27		h	h	d h	h	d					u	h	h	h	d	h	d							h
20			h	h	d																			
16			h	h	d						h	h							h	h	h	h	h	h
28			h	h	h	d					u	h	h	h	h	h	d							
19			h	h	h																			h
18			h	d																				
17			h	h	h	d					h	h	h	h	h	d	h	d					u	h
14			d	h	h						h	h	h	u	h	h	h	h	h	h	h	h	h	h
13			h	h	h	h					h	h	h	h	h	h	d						h	h
15			h	h	h	h																		
12			h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	
11																								
40			h	h	h	d					h	h	h	h	h	d								
39												h	h	h	h	h	h	d						
37			h	h	u d																**			
38			h	d																				
31			h	h	h	h	d																	
32				d																				
33				h	d																			
34				h	h	h	h											h	h	h	h	h	h	h
35				h																				
36				h	h	d					u	h	h	h	h	h	h	d					h	
46				h	d																			
44											h	h	h	h	h	h	d							
41				h	d						h	h	h	h	h	h	d							
42				d																				
43				h	h	d																		
45				h	h	d																		

	2007												2008											
Code	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
47				h	h	d					h	h	h	h	h	h	d							
48					h																			
49											h	h	h	h	h	h	h	h	h	h	h	h	h	h
50						d																		
54															h	h	d							
55															h	h	d							
58															h	h	d							
62															h									
57																								
63																								
64																h	h	d						
59																d	d						u	h
52																h	d						h	h
56																h	d						h	h
75																h	h	d						
74																h	d						h	h
73																h	d							
61																h	h	h	h	h	h	h	h	h
68																h	d	h	h	h	h	h		
69																				h	h	h	h	h
72																	d							
70																	d							
85																	u	d		u	h	h	h	h
66																d								
67																	d							
88																							h	h
77																	h	d						
76																	h	d						h
65																	h	d				u	d	u
71																								
90																								h
87																		h	h	h	d	Fish killed		
78																		d					h	h
86																		d						
79																		h	h	u	d	h	h	h
**		Mamquam R.																						

Figure 6. Annual movement patterns of radio tagged bull trout in the Squamish River watershed. Grey areas indicate residence within the Cheakamus River, grid patterned areas illustrate residence outside of the Cheakamus River and red grid patterns show bull trout located in the upper Squamish River. Letters indicate any migration within that month: h=hold, u=upstream, d=downstream.

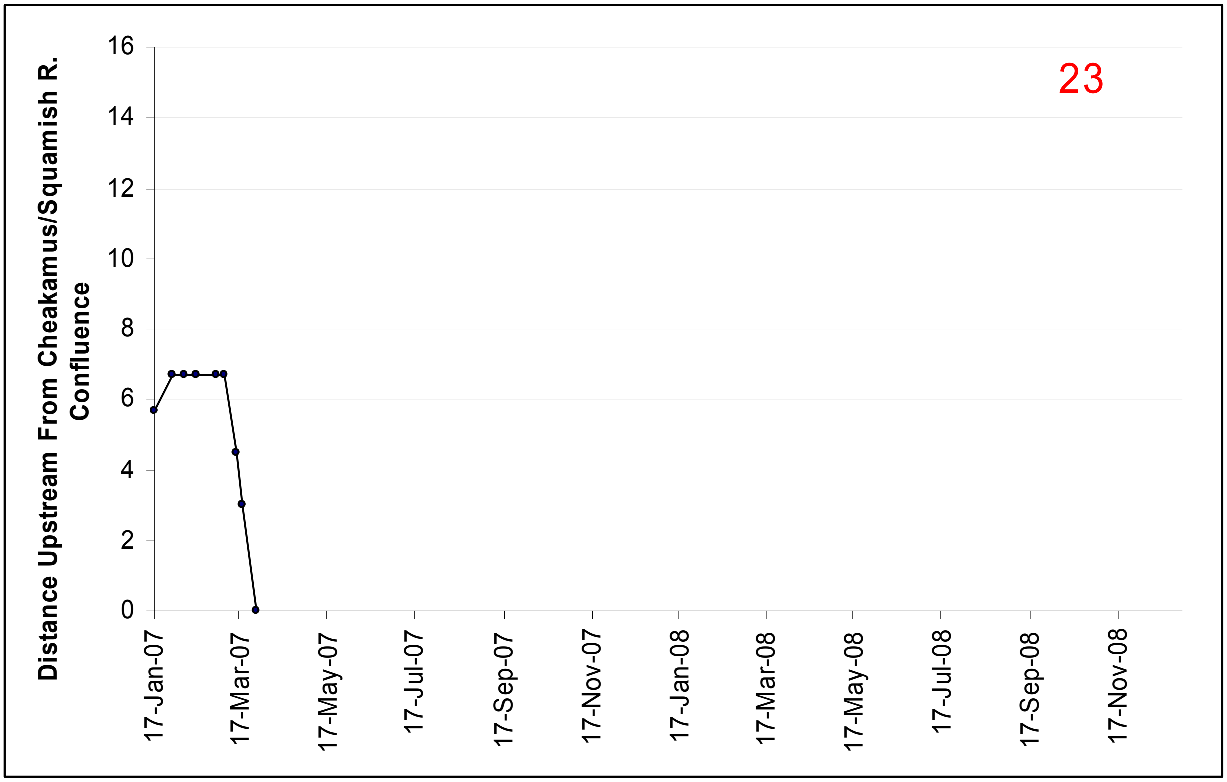


Figure 7. Movements of a 2007 radio tagged bull trout (Code 23) within the Cheakamus River. Migration pattern is representative of a fish which was tagged in of 2007 and outmigrated to the Squamish River. This bull trout was not tracked in the Cheakamus or Squamish River after April 2007.

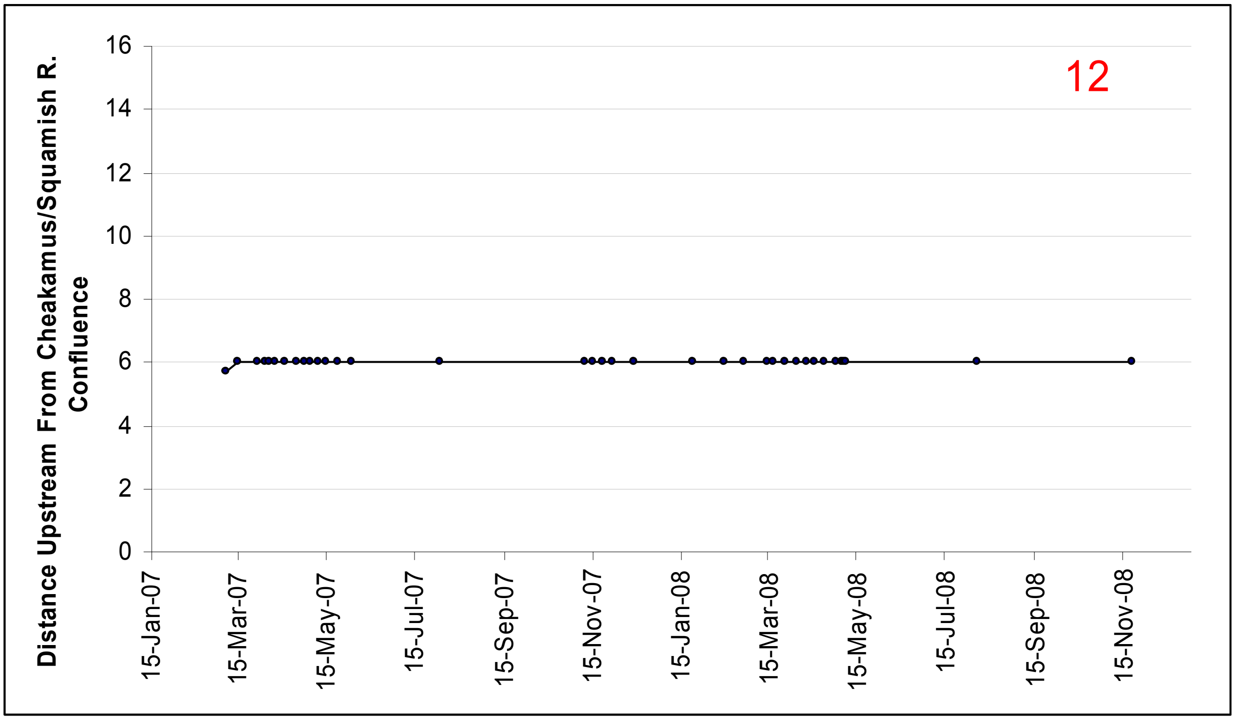


Figure 8. Movements of a 2007 radio tagged bull trout (Code 23) within the Cheakamus River. Migration pattern is representative of a fish which was tagged in the spring of 2007 and is believed to have either died or shed its tag in the river.

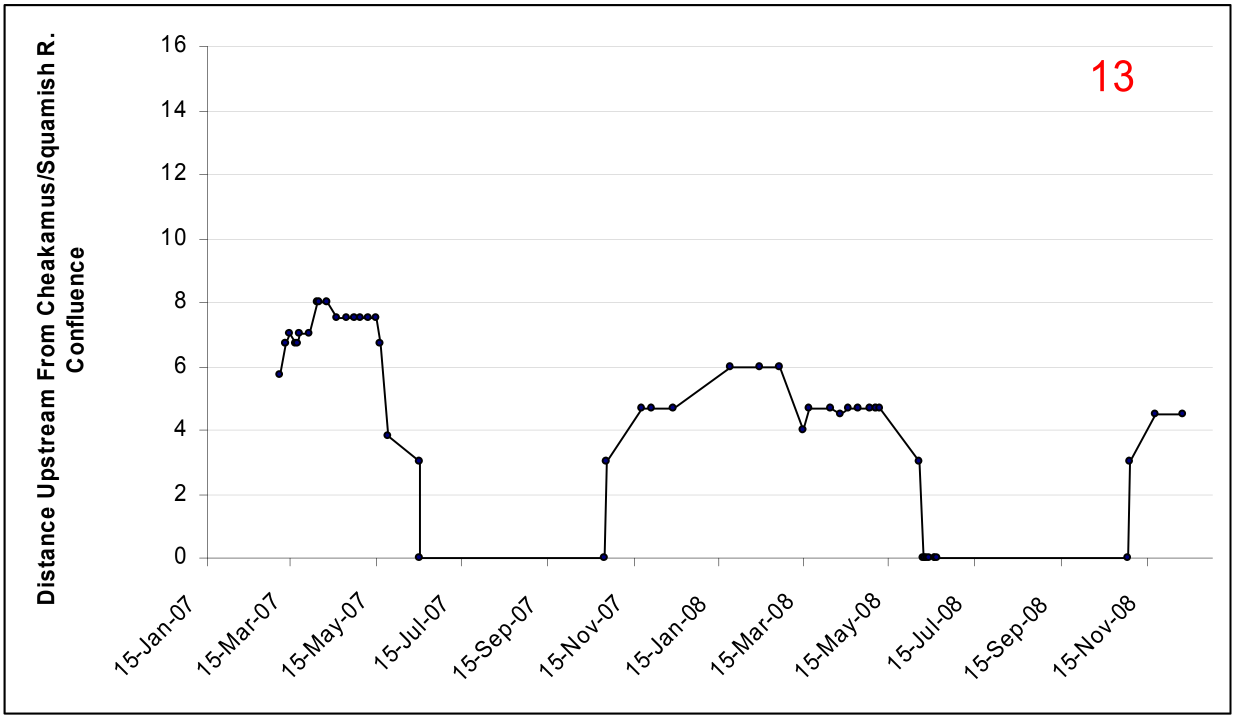


Figure 9. Movements of a 2007 radio tagged bull trout (Code 13) within the Cheakamus River. Migration pattern is representative of a fish which was tagged in of 2007, outmigrated to the Squamish River (twice) and, returned to the Cheakamus River (twice).

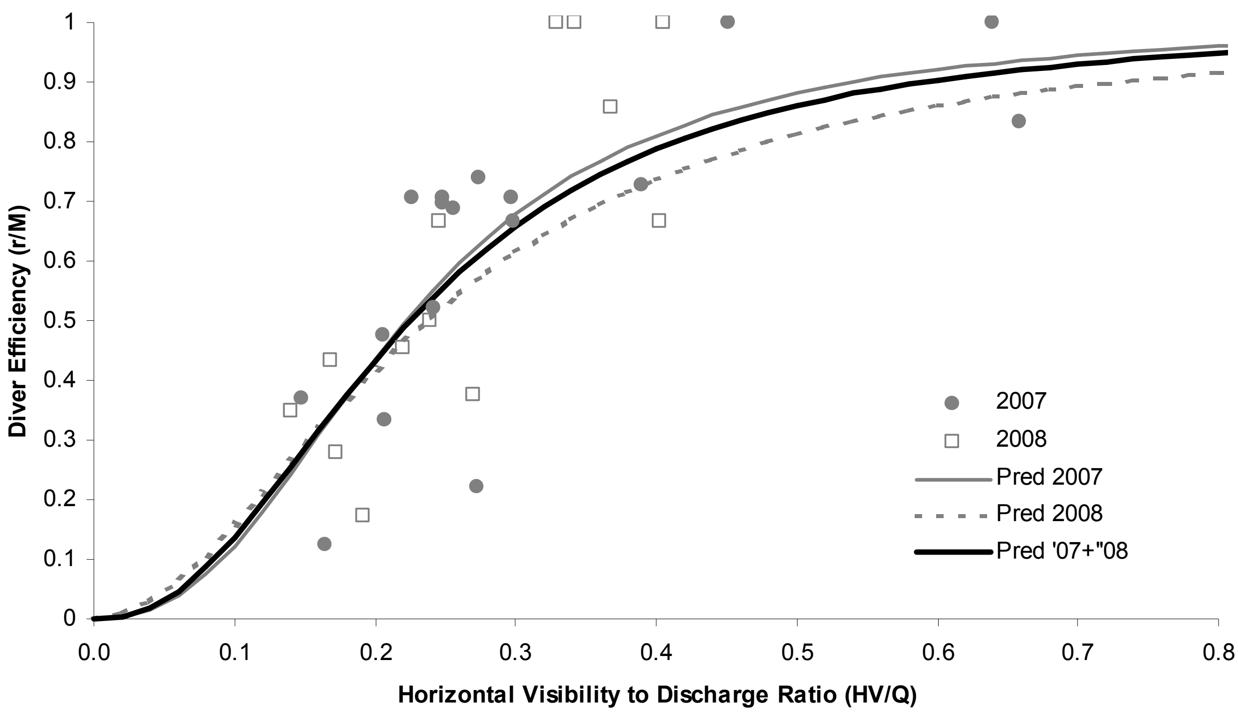


Figure 10. The relationship between the proportion of tagged char that are observed in the Cheakamus River survey area (diver efficiency or r/M) and the ratio of horizontal visibility (at section 21) to discharge. Gray filled circles and open squares represent observations from 2007 and 2008, respectively. Gray solid and dashed lines represent best-fit relationships to the 2007 and 2008 data, respectively. The solid black line represents the best-fit relationship using data combined across years

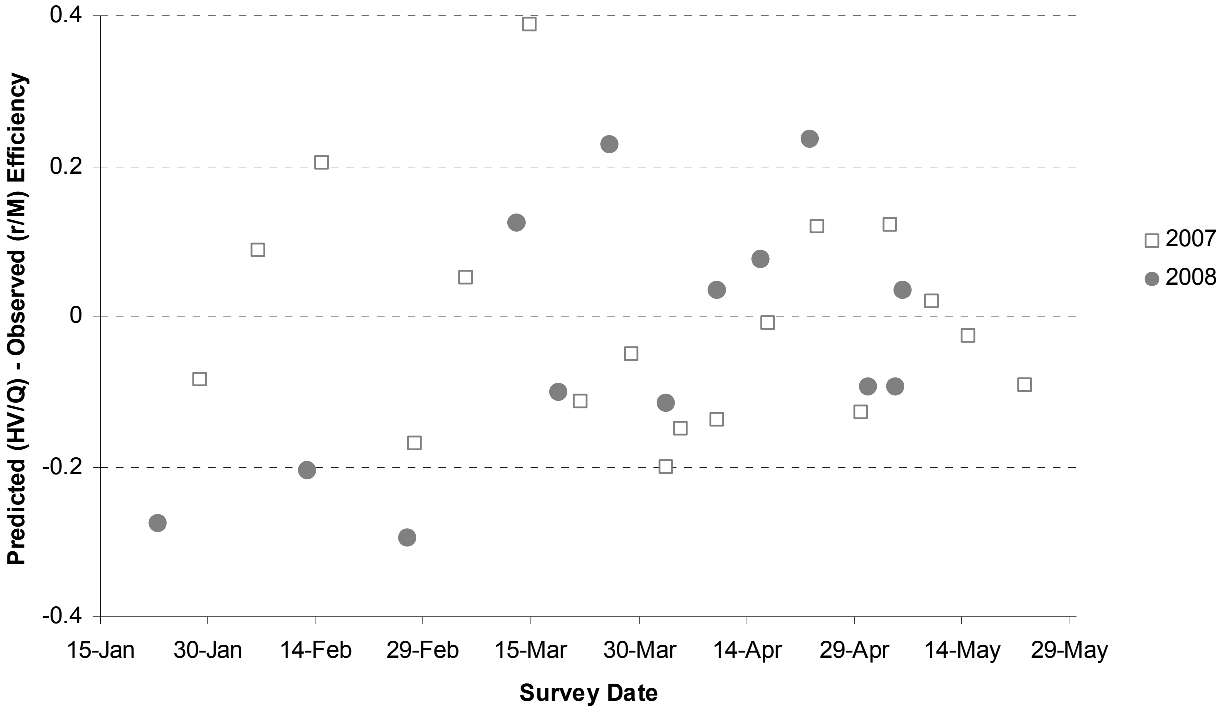


Figure 11. Residuals from the best-fit combined-year qP-HV/Q model (solid black line in Fig. 10) as a function of survey date. Gray filled circles and open squares represent residuals from 2007 and 2008, respectively.

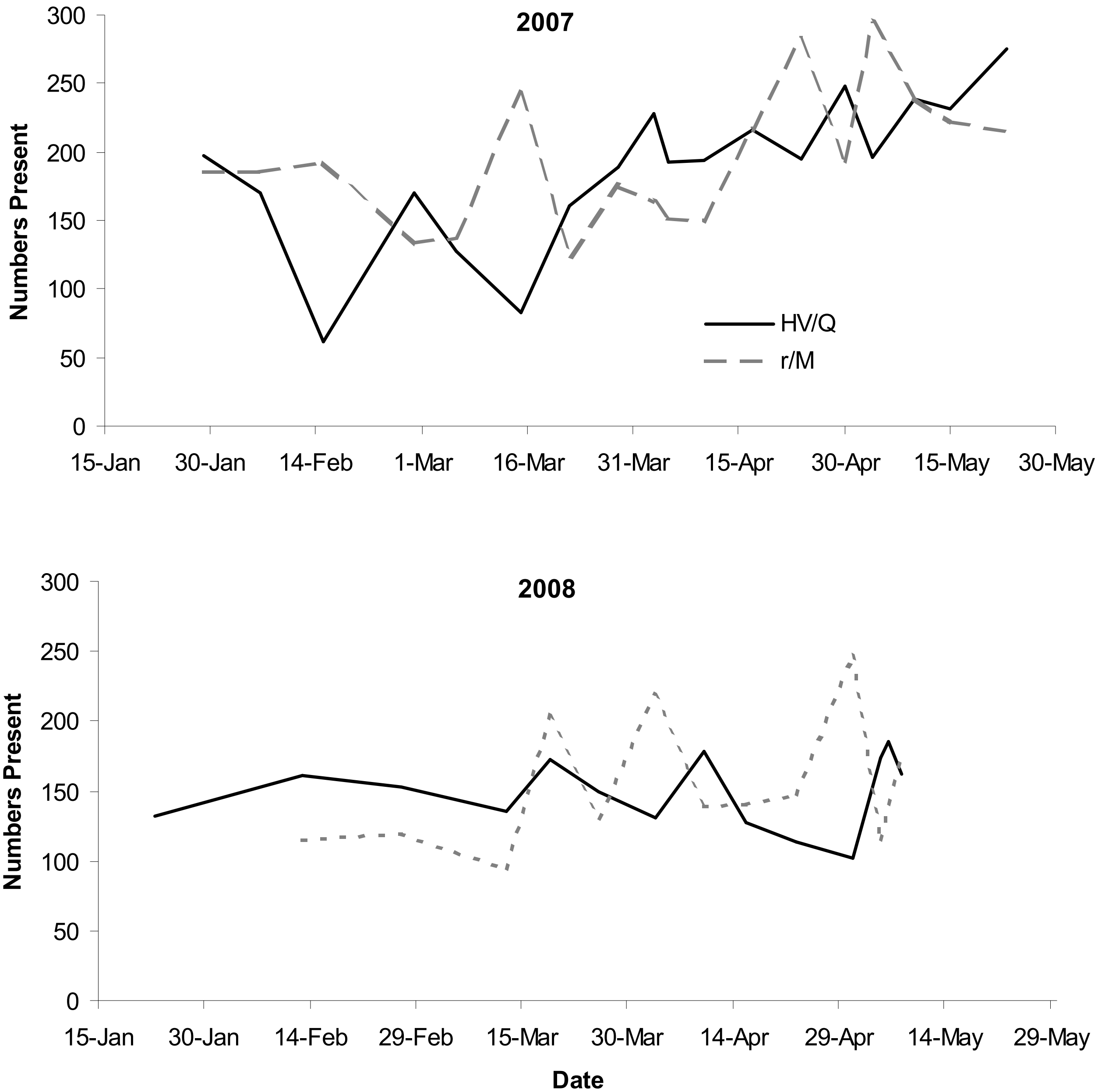


Figure 12. Estimates of the number of adult char present in the survey area in 2007 (top) and 2008 (bottom) by survey date determined by expanding counts by the ratio of tags observed to tags present (*r/M*, dashed gray line) or the best-fit combined-year model that predicts diver efficiency as a function of river conditions (qP-HV/Q, solid black line).

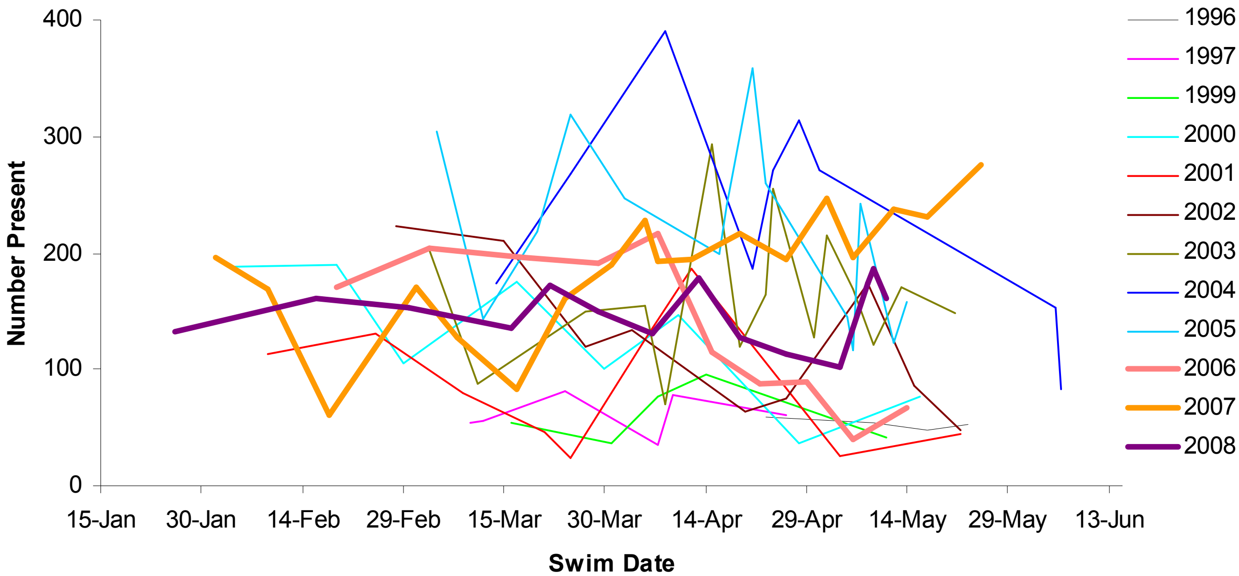


Figure 13. Estimates of the number of char present in the survey area by survey date from 1996 through 2008 (no survey conducted in 1998) based on the best-fit combined-year qP-HV/Q model. Thick lines denote seasonal abundance trends in years following the caustic soda spill.

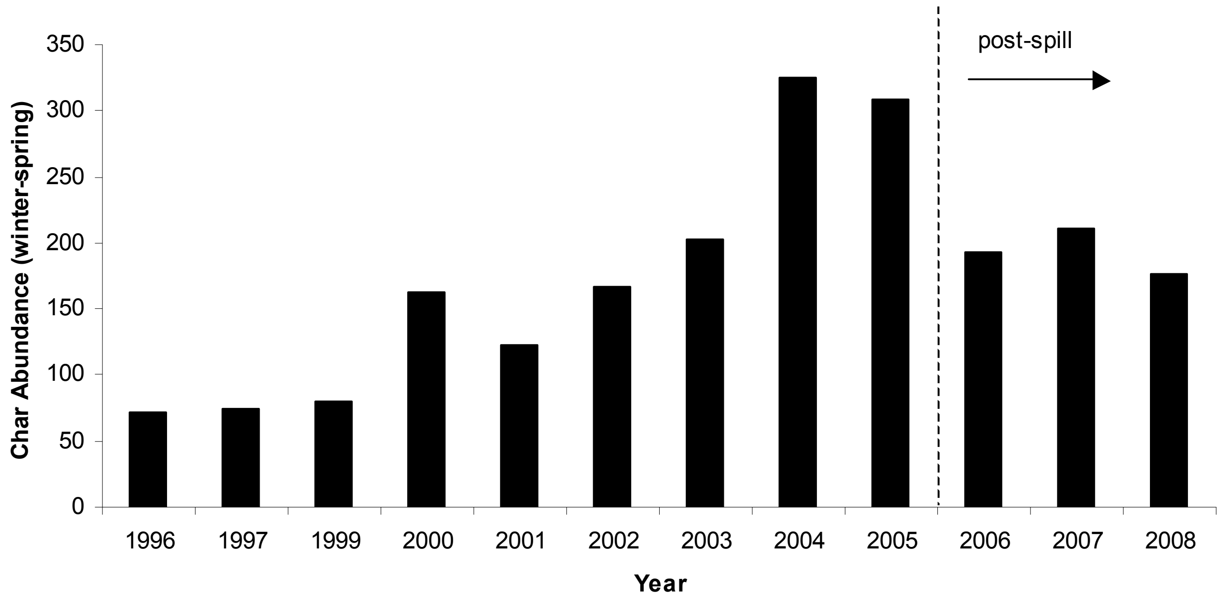


Figure 14. Preliminary estimates of total char abundance in the Cheakamus River survey area during the winter-spring period from 1996 through 2008 (no surveys conducted in 1998).

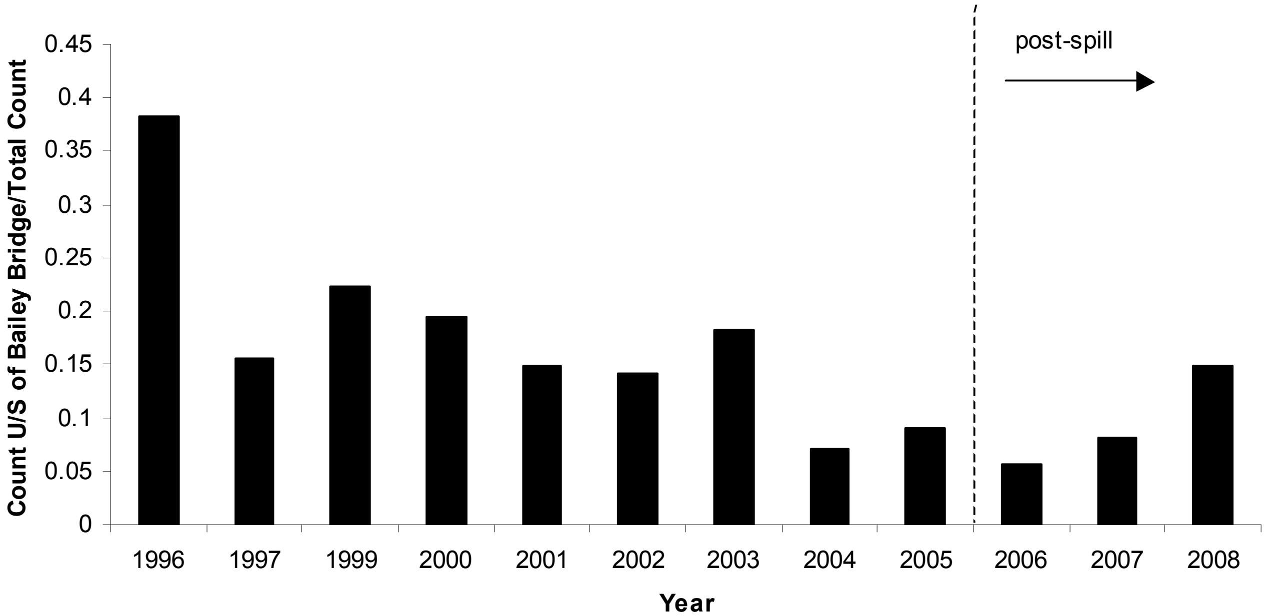


Figure 15. The ratio of total char counts (summed across surveys) upstream of the Bailey Bridge on the Cheakamus River (section 21 or rkm=7.5) to total counts for the entire survey area by year (no surveys were conducted in 1998). Temporal variation in the ratio potentially represents changes in the abundance of an upper-river more resident component of the Cheakamus char population relative to the total population.

References

Costello, A.B., T. Down, S. Pollard, C.J. Pacas, and E.B. Taylor. 2003. The influence of history and contemporary stream hydrology on the evolution of genetic diversity within species: an examination of microsatellite DNA variation in bull trout, Salvelinus confluentus (Pisces: Salmonidae). Evolution 57: 328-344.

Korman, J., Ahrens, R.N.M., Higgins, P.S., and Walters, C.J. 2002. Effects of observer efficiency, arrival timing, and survey life on estimates of escapement for steelhead trout (Oncorhynchus mykiss) derived from repeat mark-recapture experiments. Can. J. Fish. Aquat. Sci. 59: 1116-1131.

Korman, J., P. Higgins, and C. Melville. 2005. Incorporating the effects of migratory behaviour and river conditions into estimates of steelhead escapement, BC Hydro Power Authority and BC Habitat Conservation Trust Fund. 56p.

Korman, J. and D. McCubbing. 2007. 2007 Steelhead Escapement to the Cheakamus River. Report prepared for B.C. Hydro Power Authority.

Korman, J., C. C. Melville and P. S. Higgins. 2007. Integrating multiple sources of data on migratory timing and catchability to estimate escapement for steelhead trout (*Oncorhynchus mykiss*). Can. J. Fish. Aquat. Sci. 64: 1101-1115.

Korman, J. 2008. Cheakamus River steelhead adult abundance, and juvenile habitat use and abundance monitoring 2007-2008. Final Report. 99 pp. Prepared by Ecometric Research Inc. for BC Hydro. Available at http://www.bchydro.com/etc/medialib/internet/documents/environment/pdf/wup_-_cheakamus_cmsmon-03.Par.0001.File.CMSMON_03_Cheakamus_Steelhead_Adult_Abundance_2007.pdf

Ladell, J, J. Korman and C. Melville. 2007. Interim Report for Cheakamus River Char Radio Telemetry and Enumeration Program (2007). Report submitted to CN Environment, Surrey, BC. 19 p.

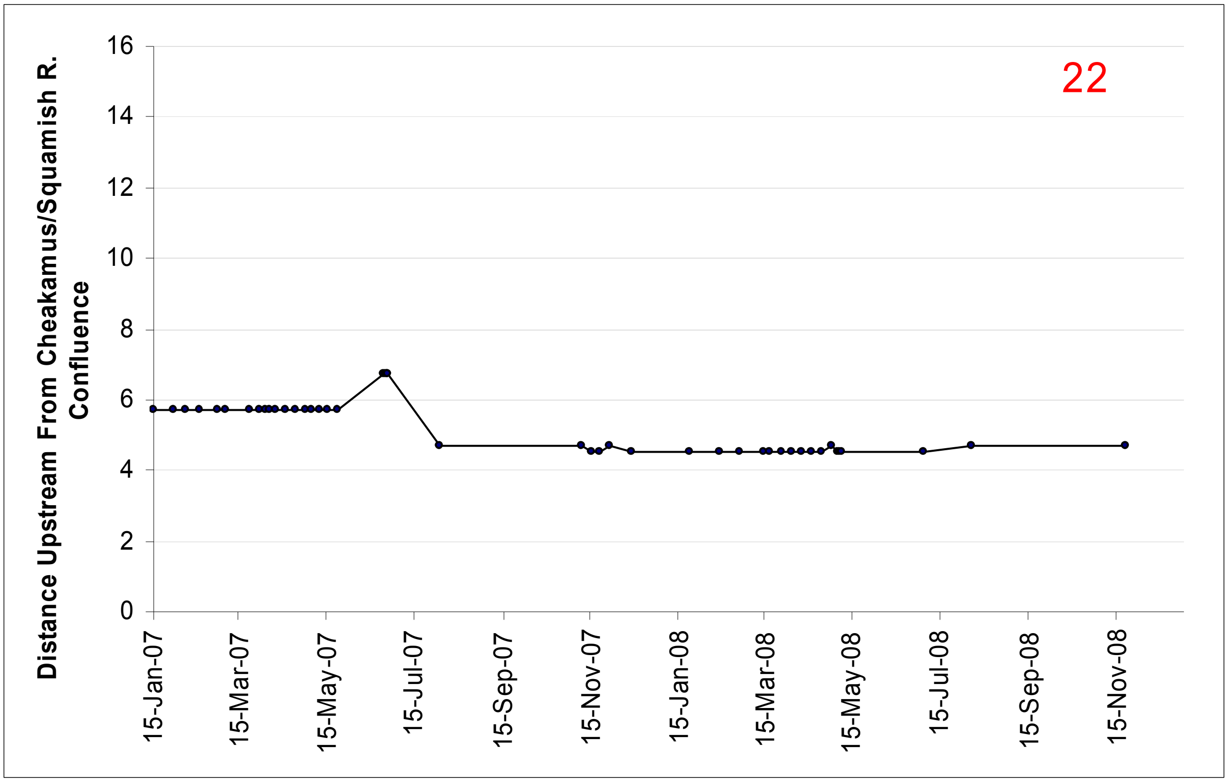
McCubbing, D.J.F., C.C. Melville, G. Wilson and M. Foy. 2006. Assessment of the CN sodium hydroxide spill August 5th, 2005 on the fish populations of the Cheakamus River. Report for Ministry of Environment and Cheakamus Ecological Recovery Technical Committee. 131p.

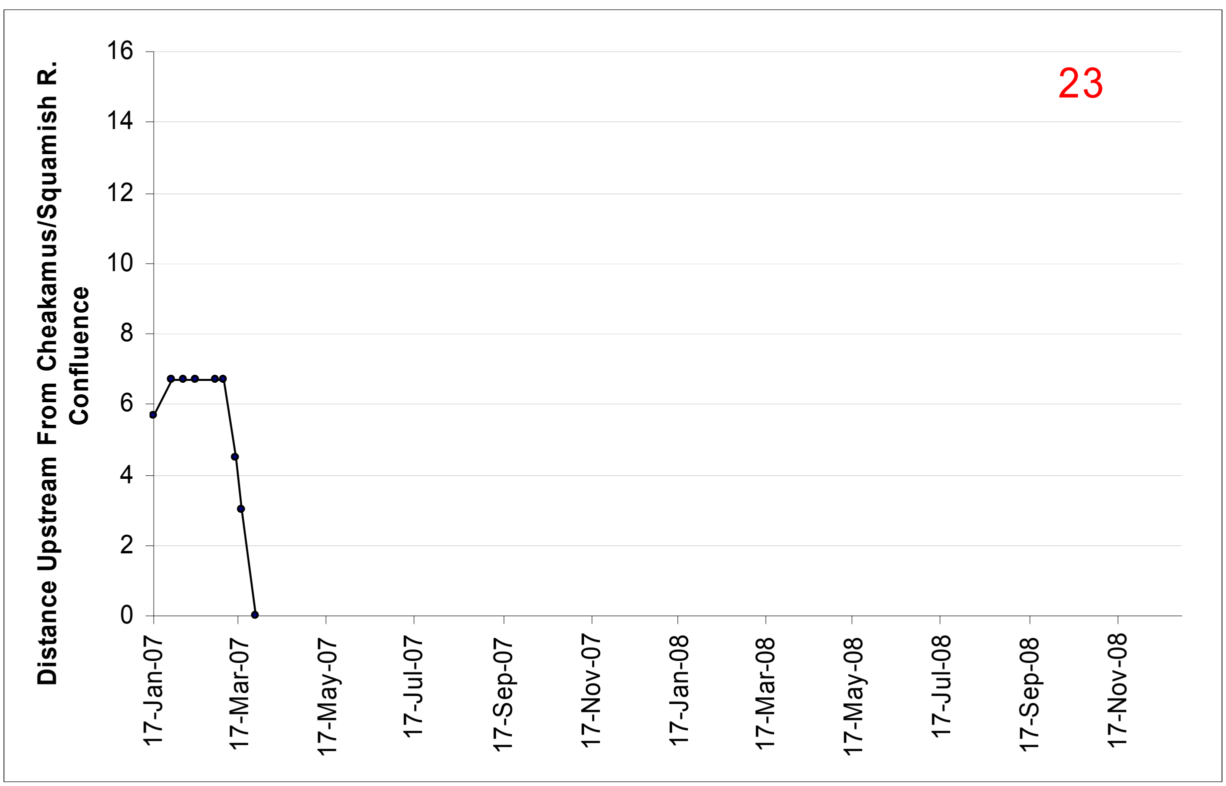
Melville C. and McCubbing D. November 2006. Use of radio telemetry to calibrate observer efficiency and monitor recovery of Cheakamus River char (Salvelinus sp.) using pre and post spill snorkel surveys, FINAL DRAFT. Prepared for Canadian National Railway

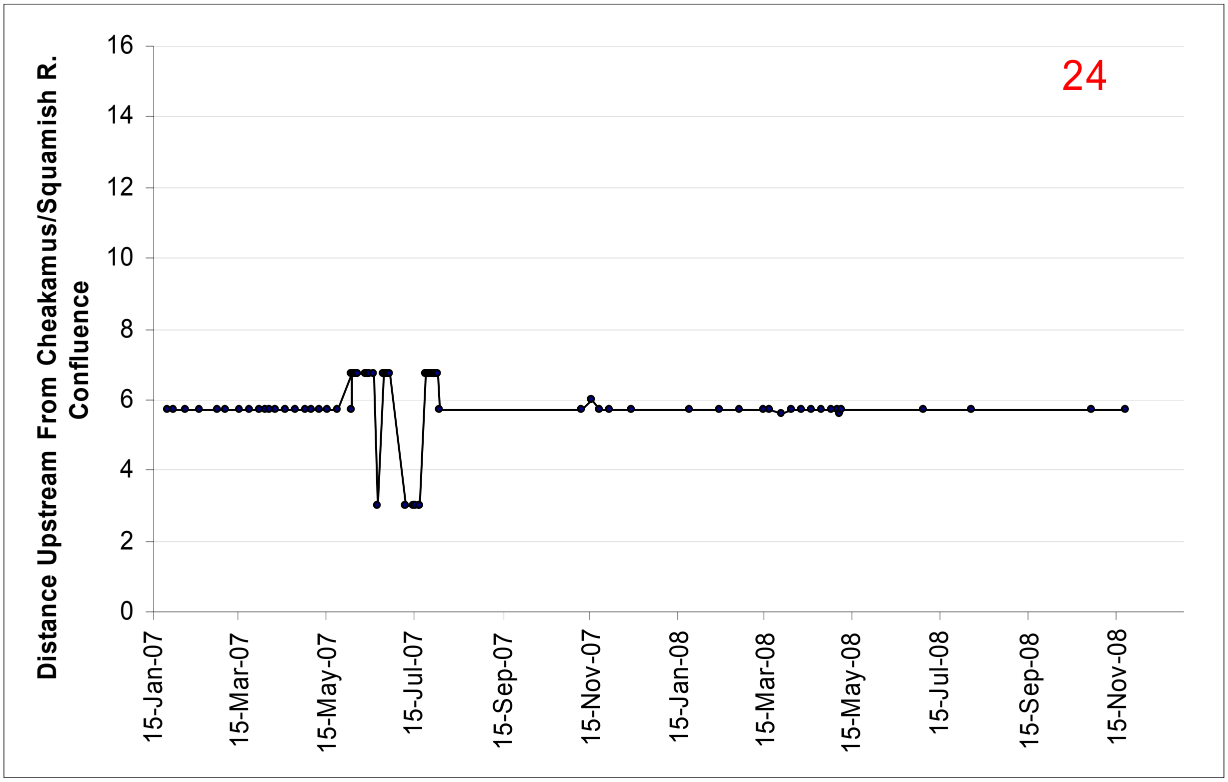
Taylor, E.B. and A.B. Costello. 2006. Microsatellite DNA analysis of coastal populations of bull trout (Salvelinus confluentus) in British Columbia: zoogeographic implications and its application to recreational fishery management. Can. J. Fish. Aquat. Sci. 63: 1157–1171.

Triton Environmental Consultants, Ltd. 2006. Cheakamus Ecosystem Recovery Plan, 2006. Final Report, November 2006. Prepared for Canadian National Railway Company, in Cooperation with Cheakamus Ecosystem Restoration Technical Committee.

Appendix A. 2007 Radio Tagged Bull trout Migration Patterns in the Cheakamus River



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Distance Upstream From Cheakamus/Squamish R. Confluence
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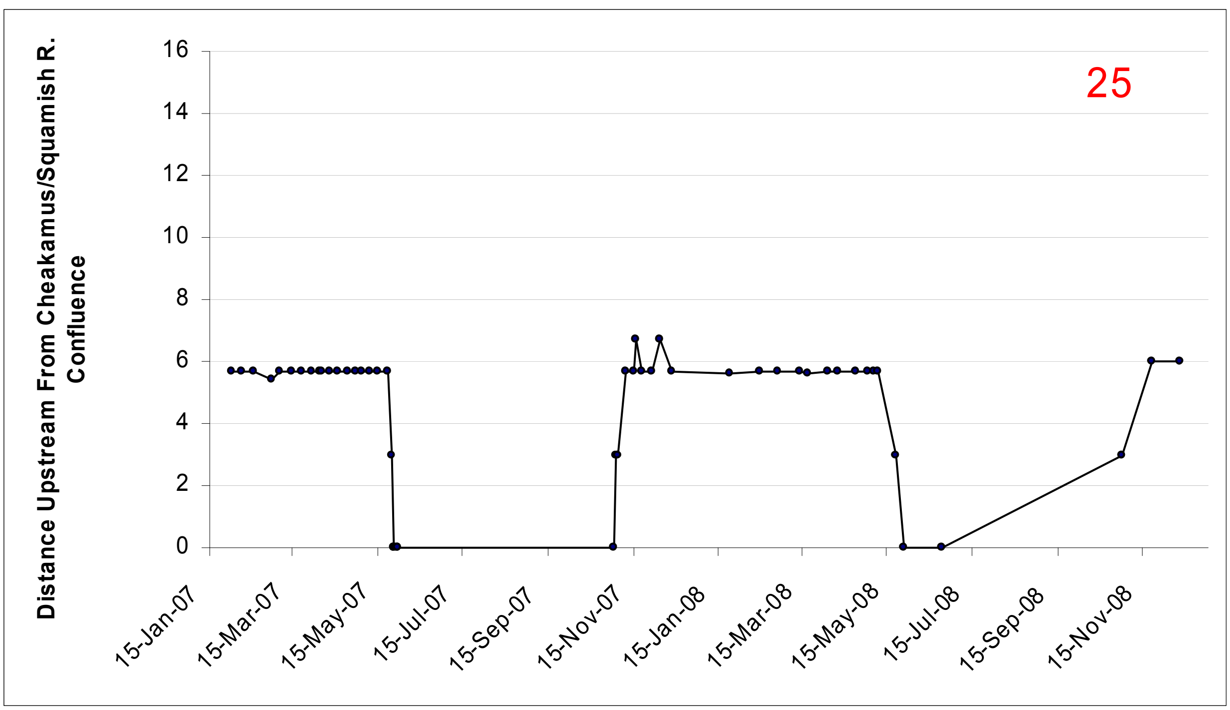
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Distance Upstream From Cheakamus/Squamish R. Confluence
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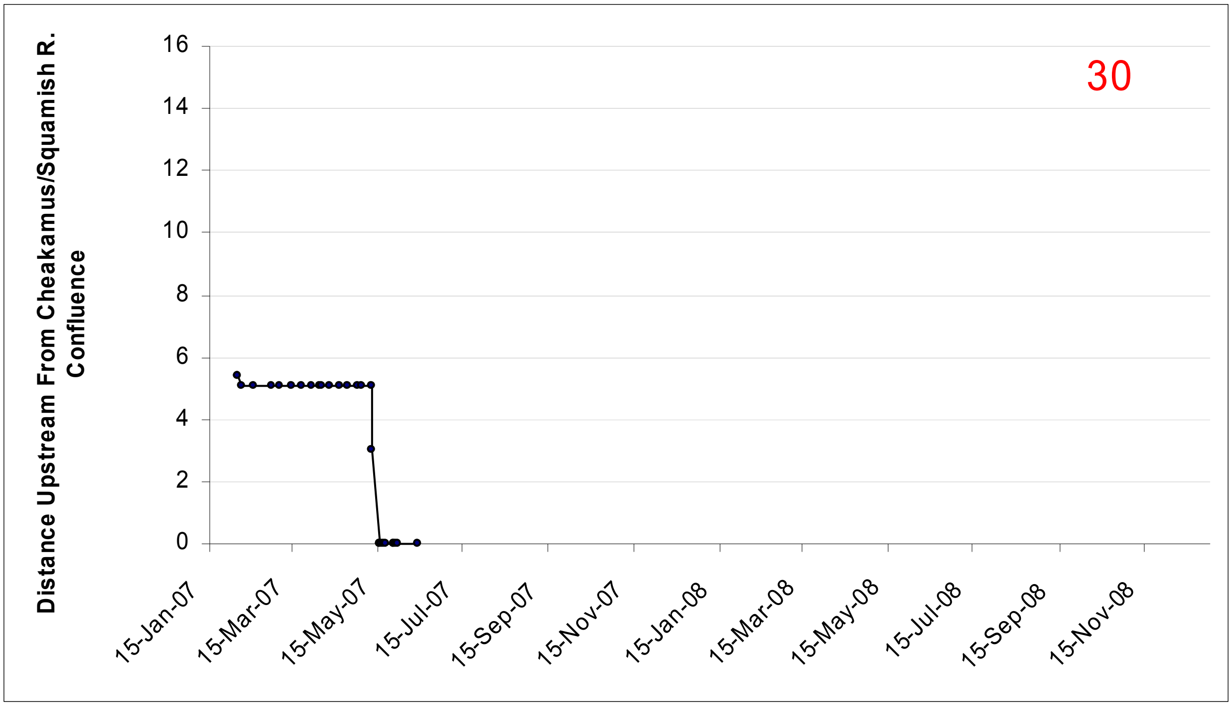
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Distance Upstream From Cheakamus/Squamish R. Confluence
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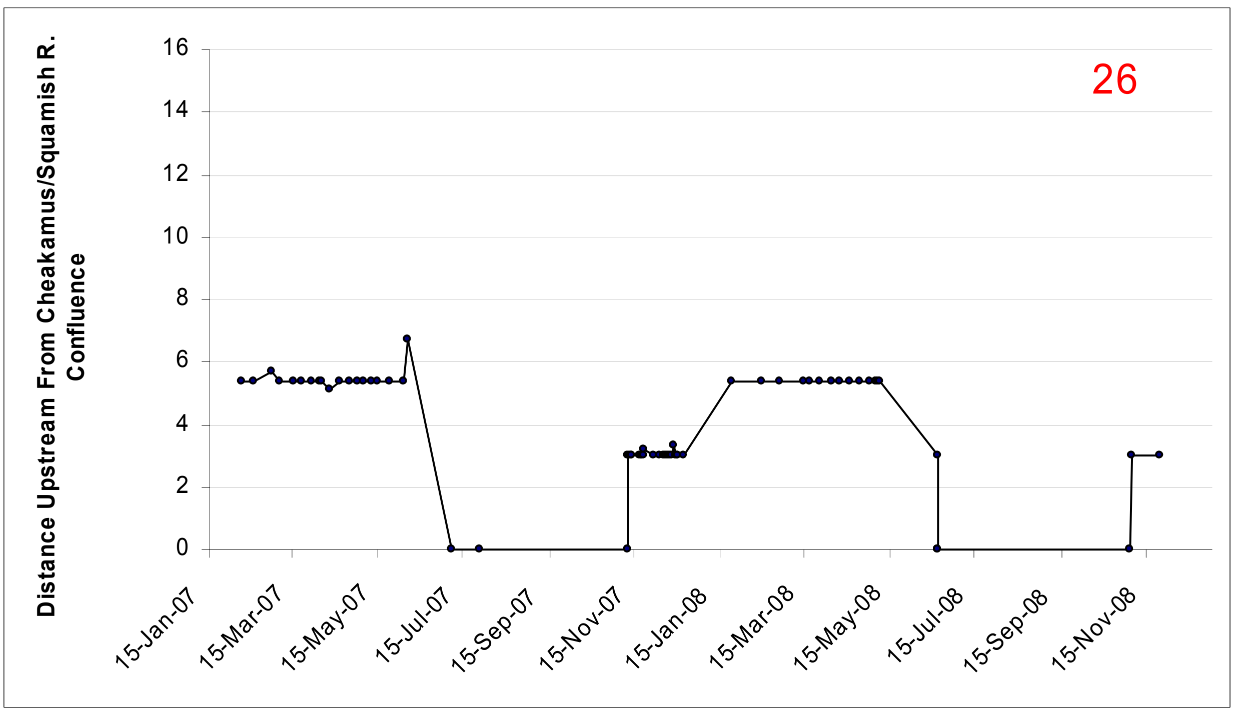
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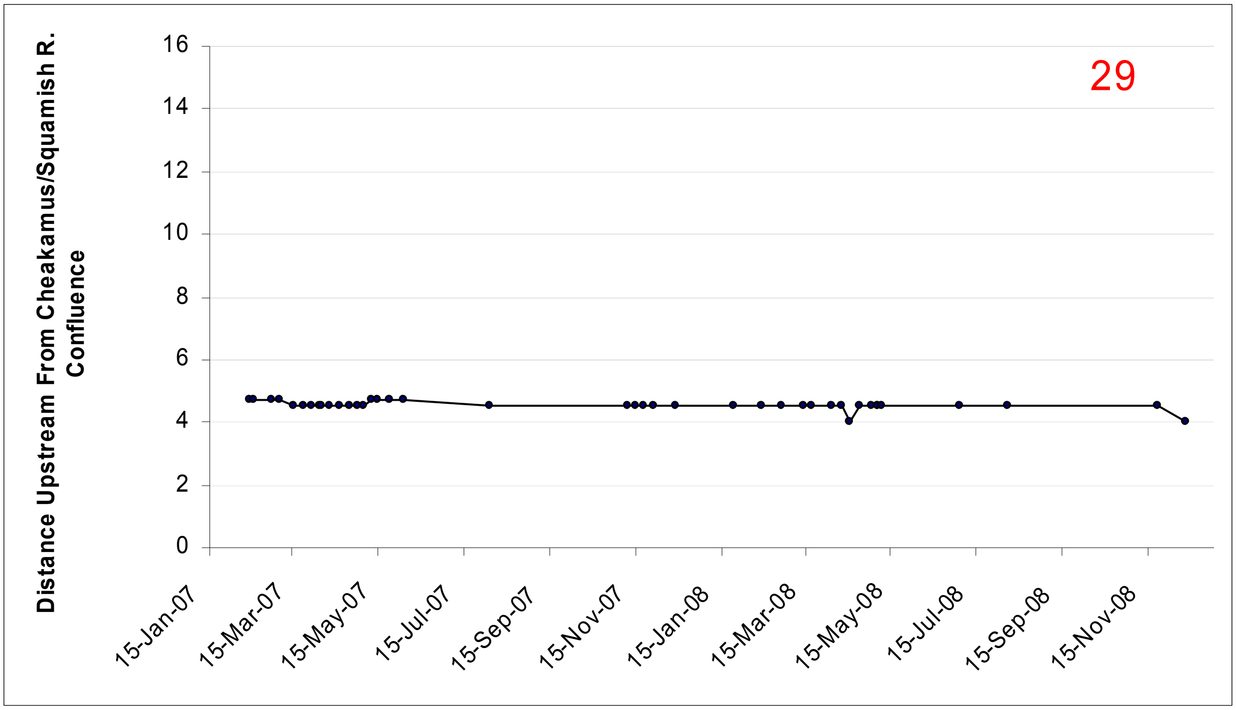
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Distance Upstream From Cheakamus/Squamish R. Confluence
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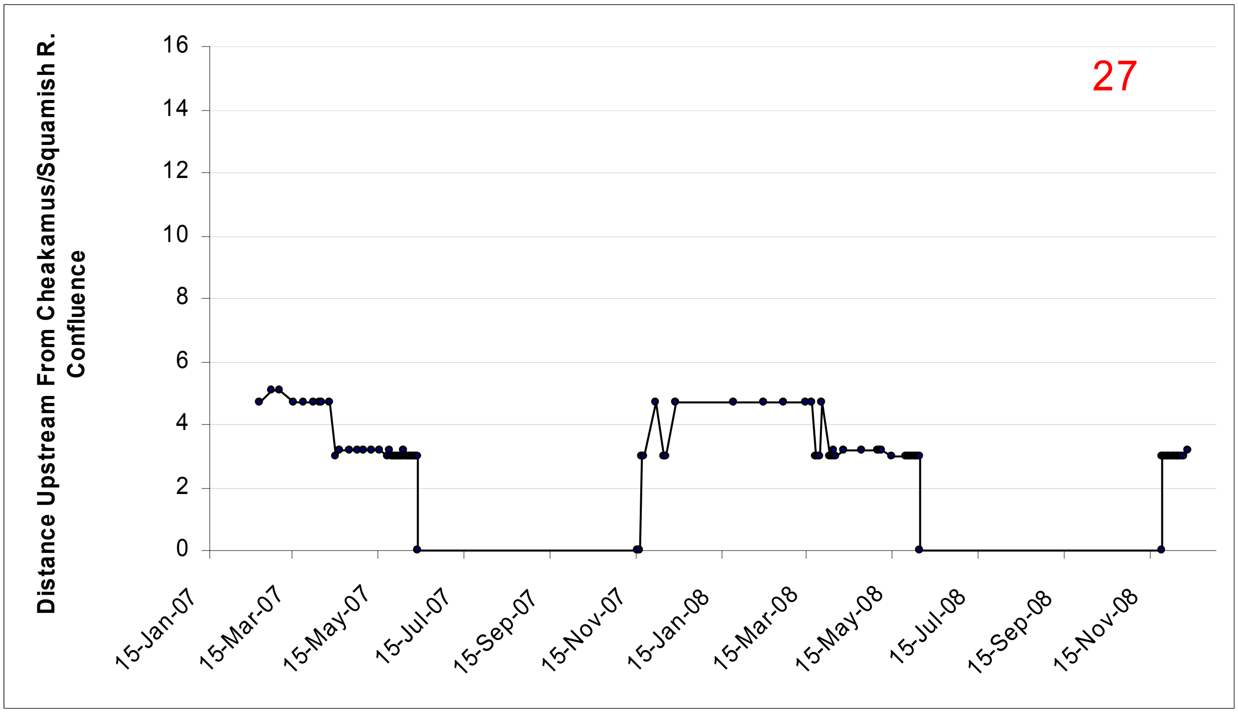
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Distance Upstream From Cheakamus/Squamish R. Confluence
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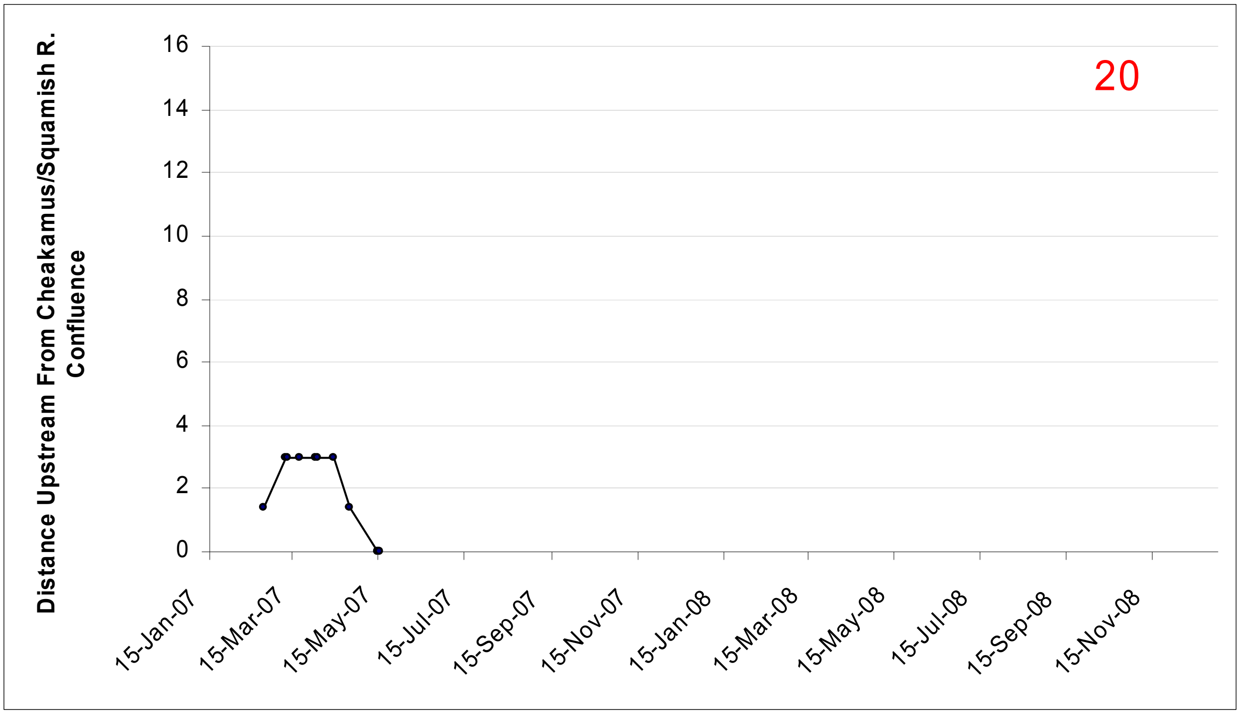
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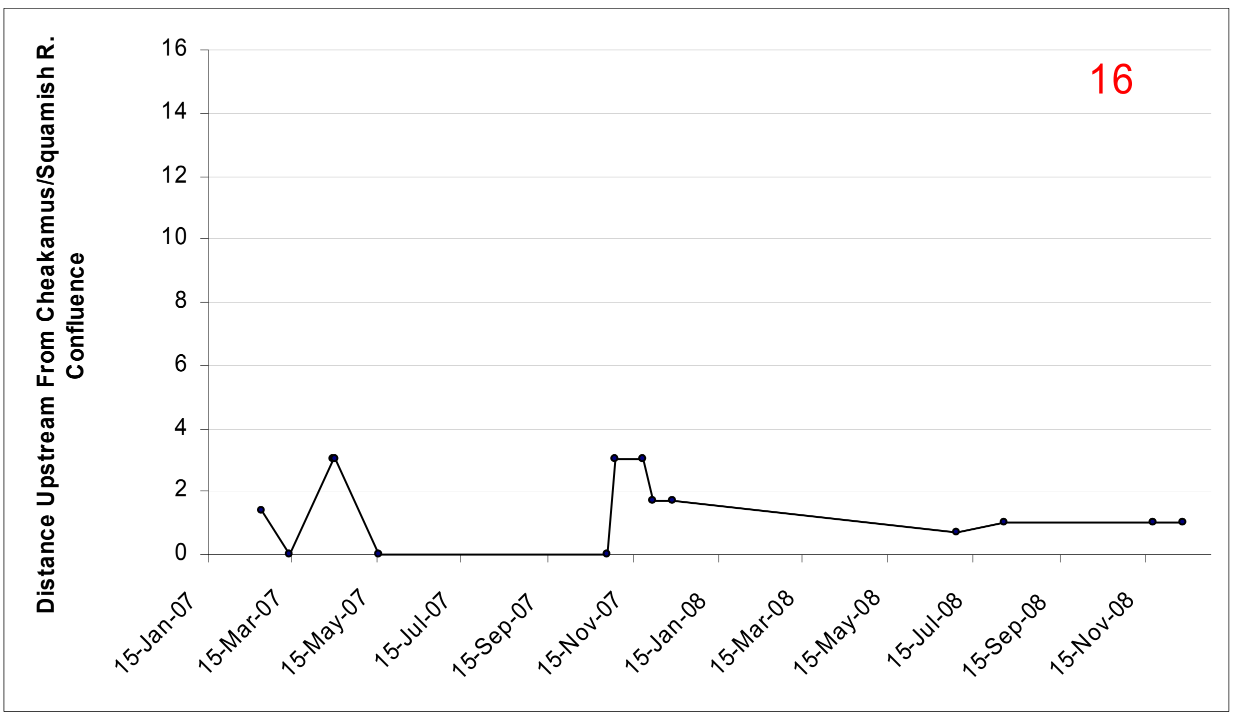
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Distance Upstream From Cheakamus/Squamish R. Confluence
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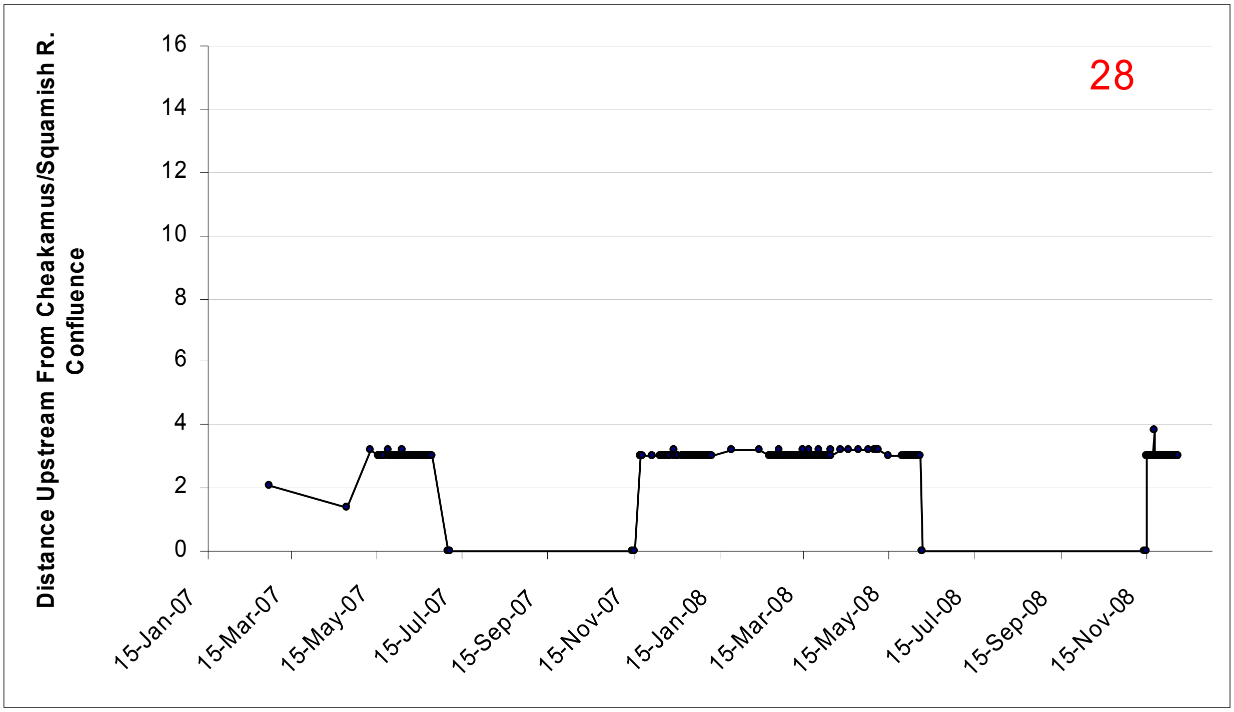
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Distance Upstream From Cheakamus/Squamish R. Confluence
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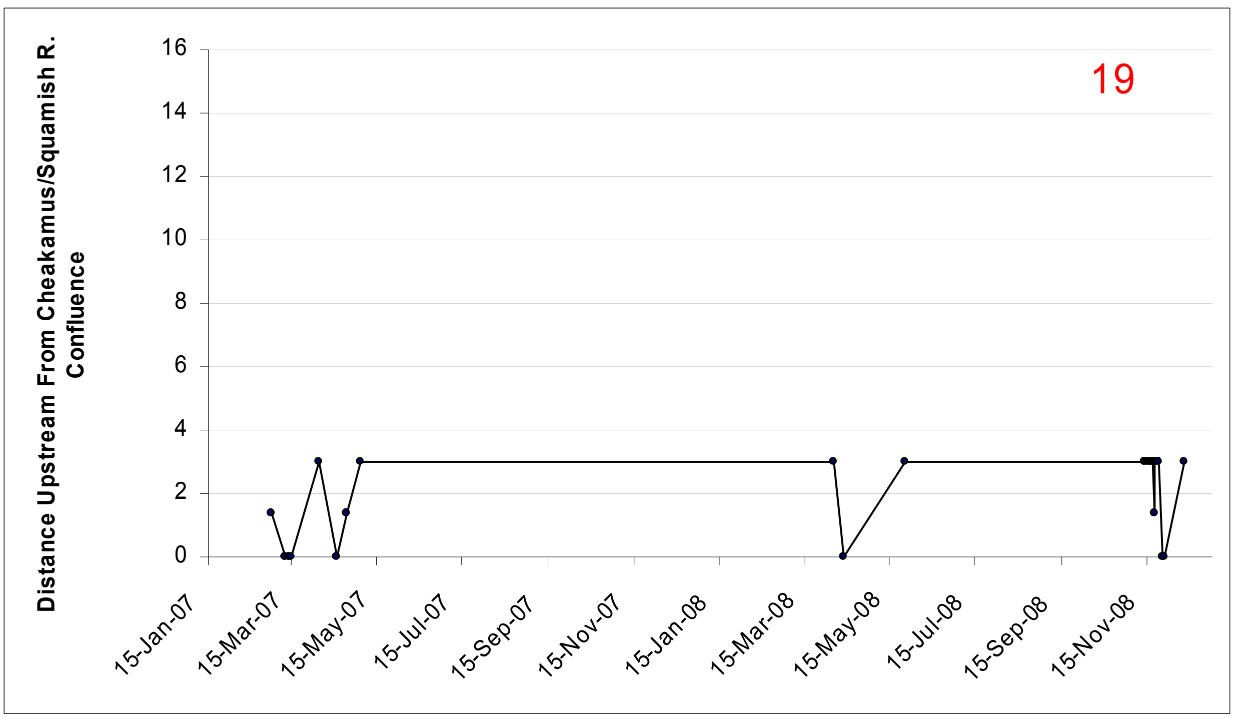
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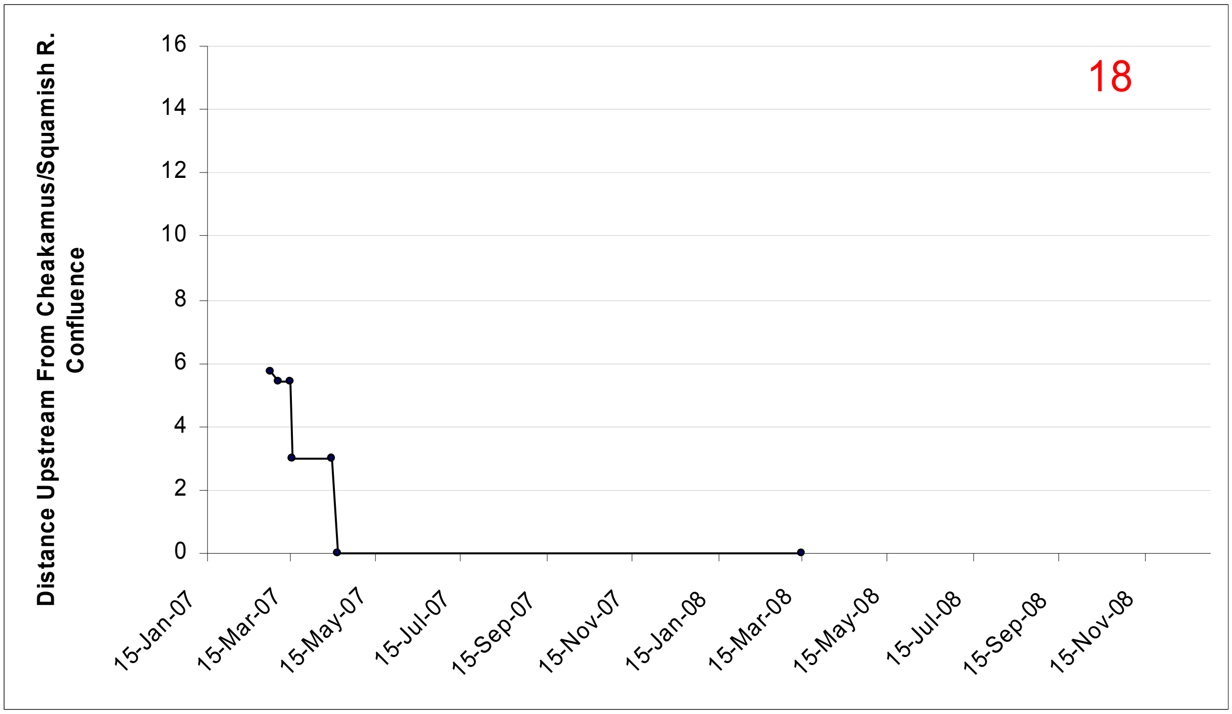
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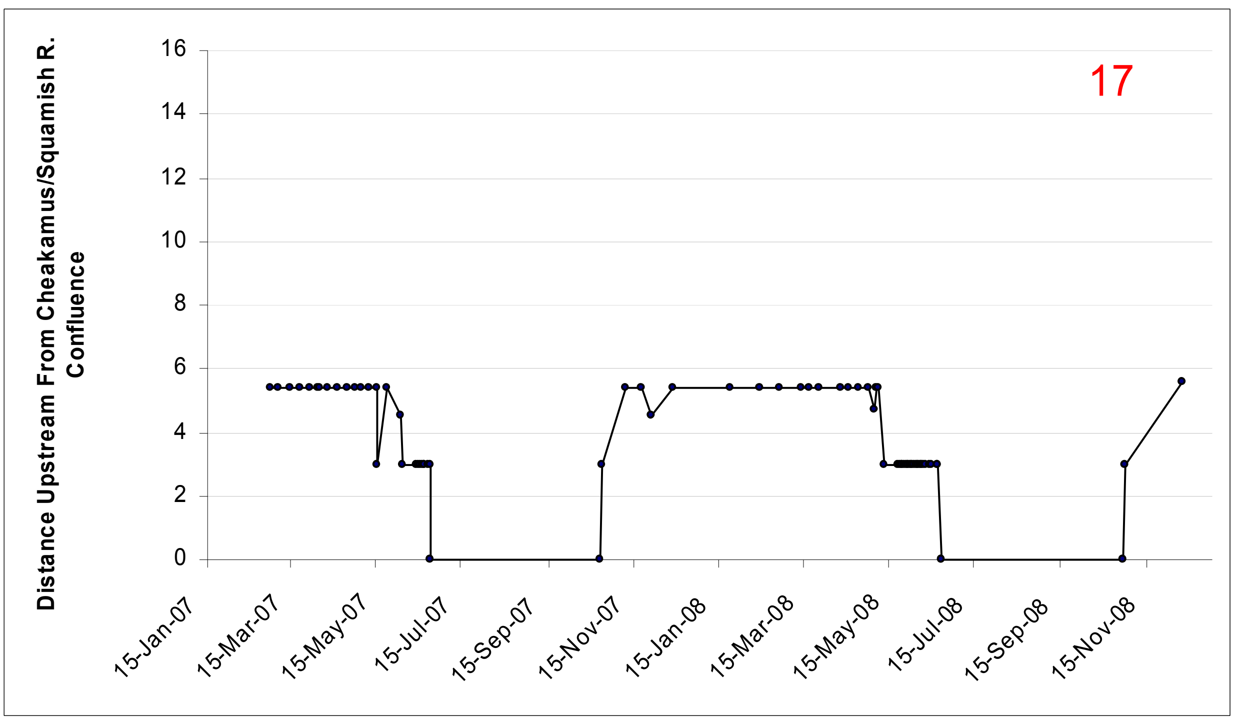
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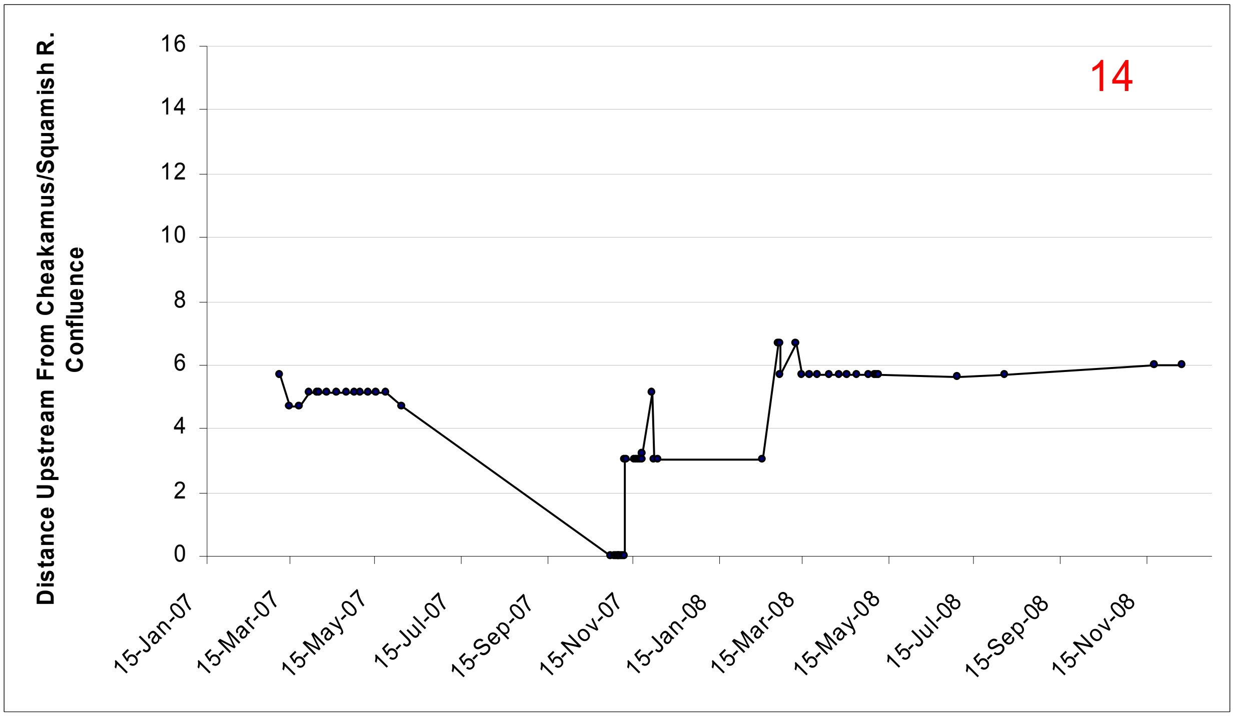
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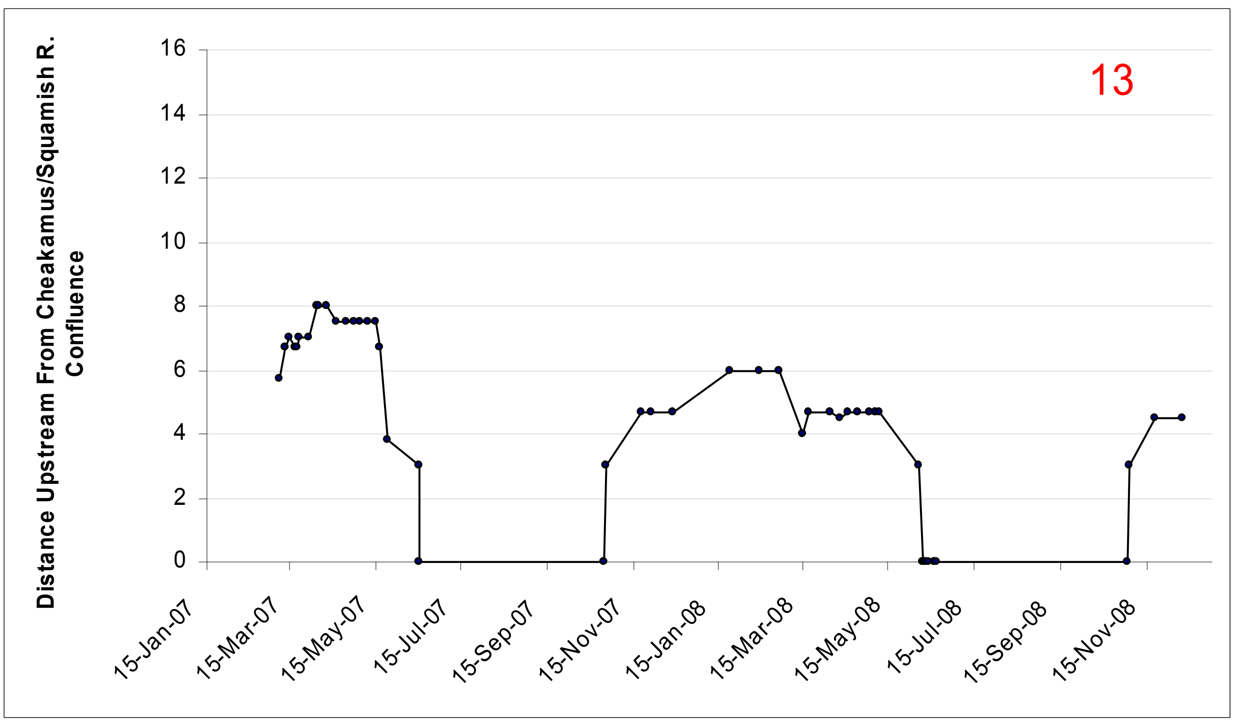
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Distance Upstream From Cheakamus/Squamish R. Confluence
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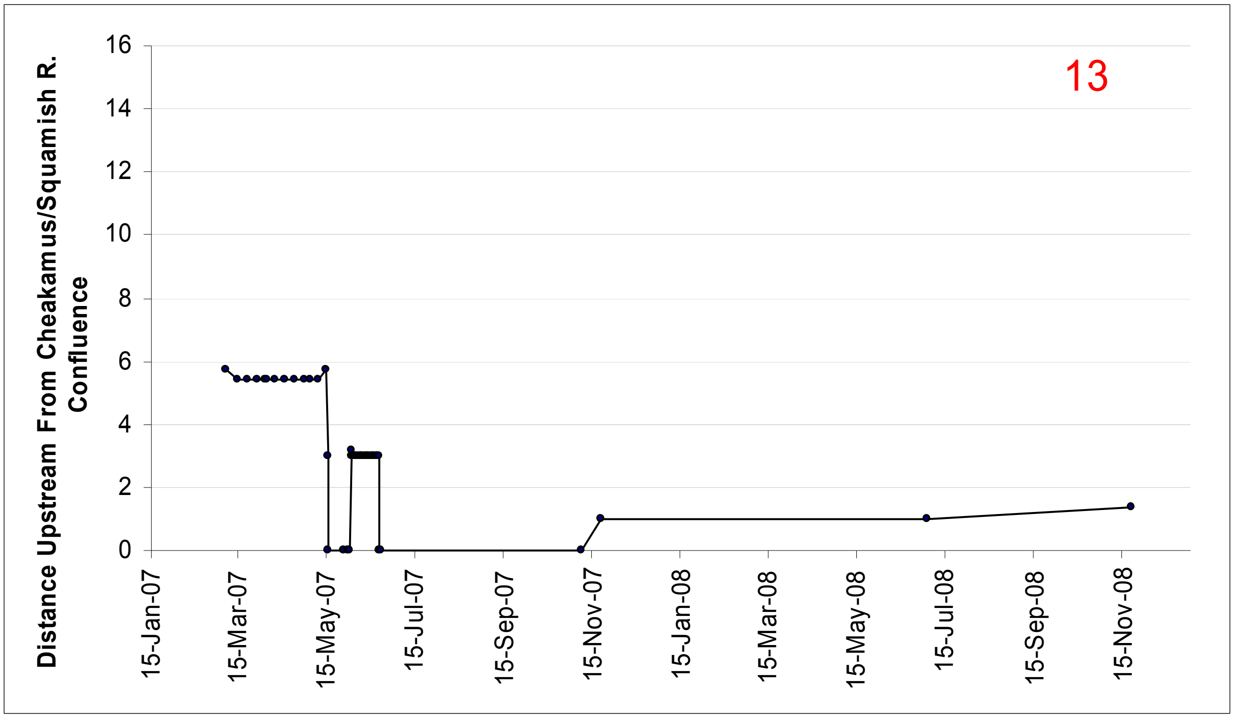
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Distance Upstream From Cheakamus/Squamish R. Confluence
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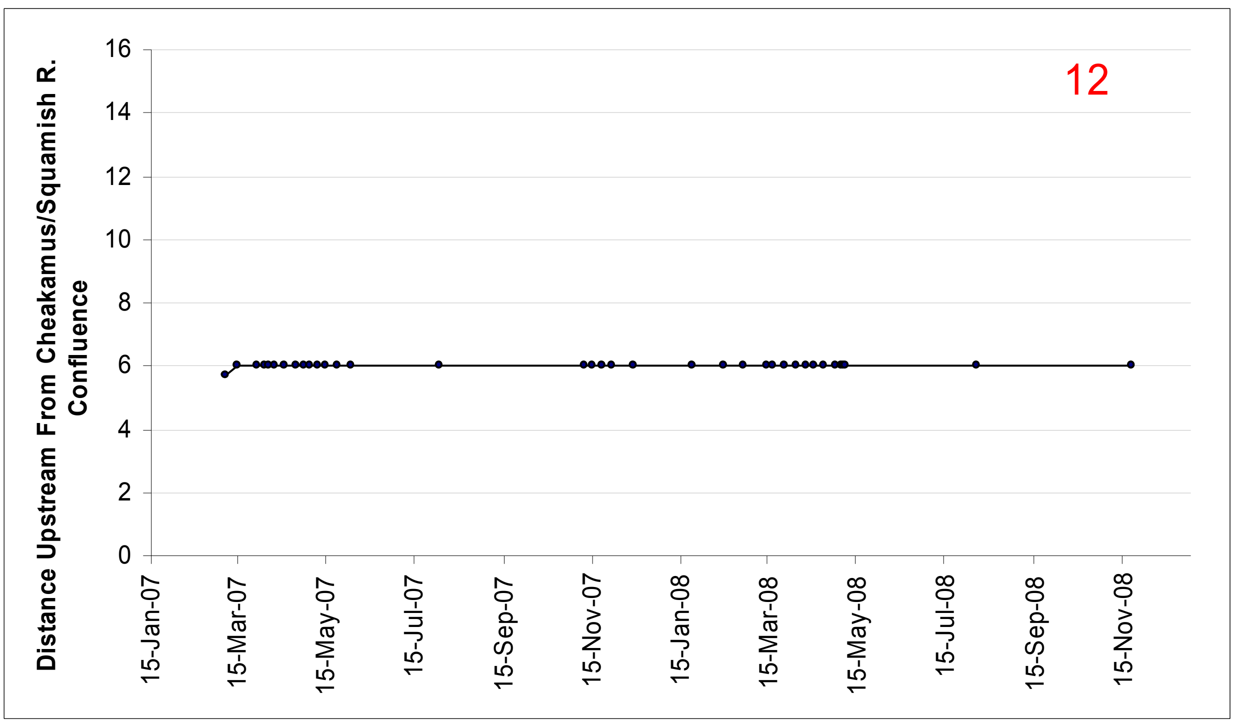
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Distance Upstream From Cheakamus/Squamish R. Confluence
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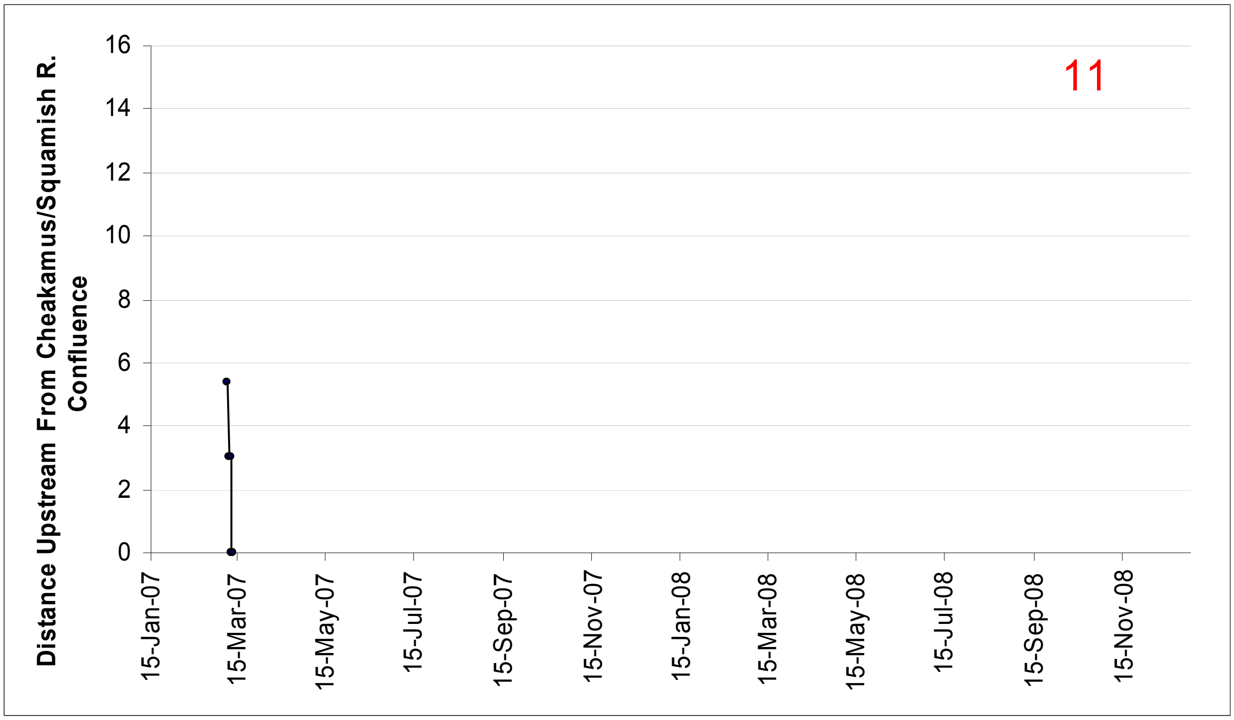
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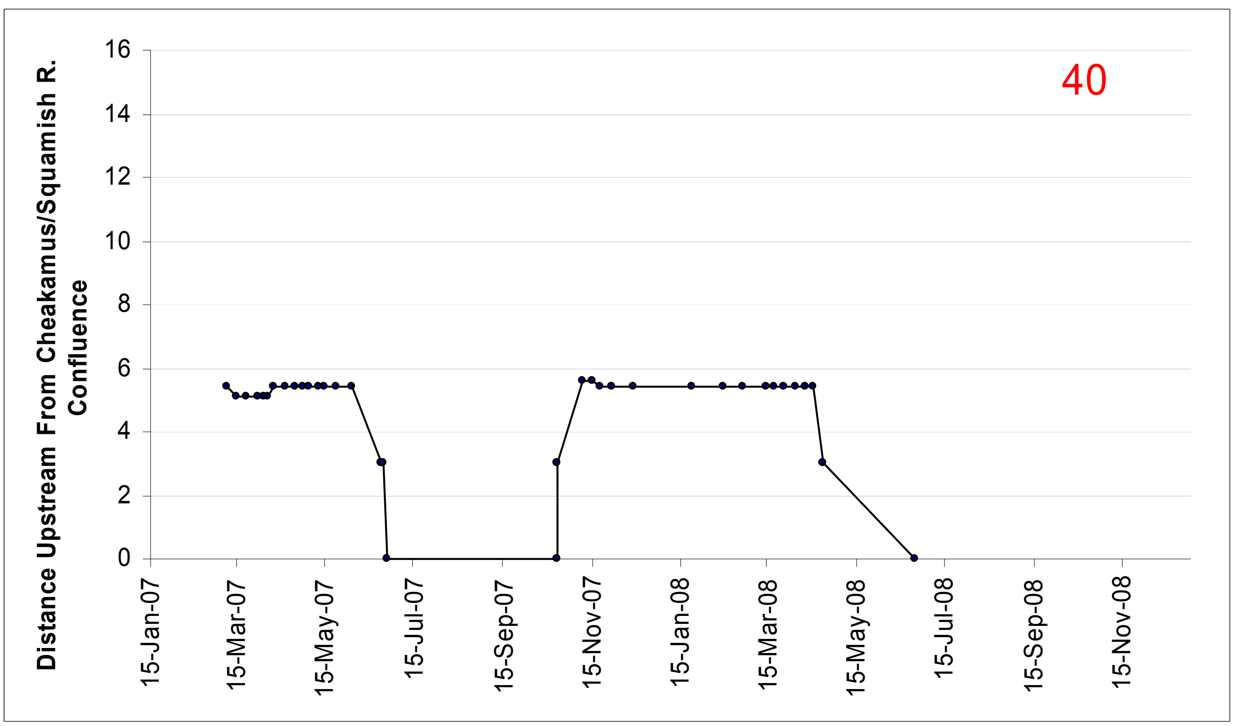
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Distance Upstream From Cheakamus/Squamish R. Confluence
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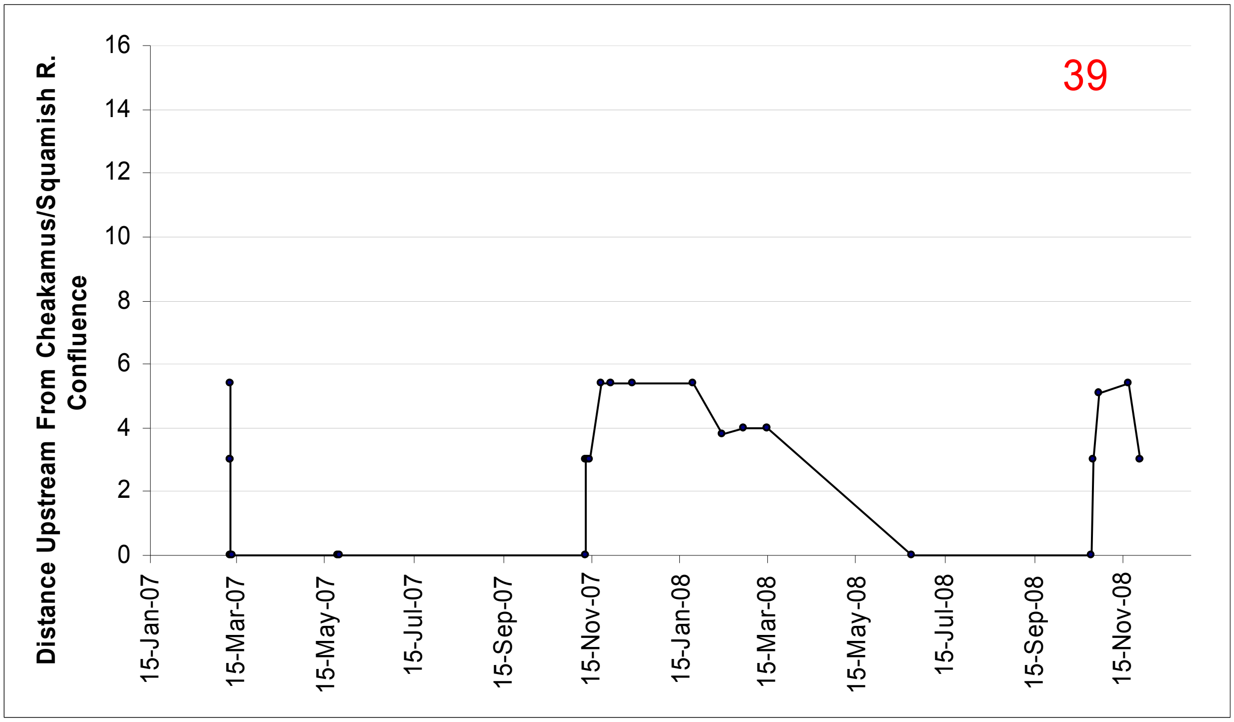
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Distance Upstream From Cheakamus/Squamish R. Confluence
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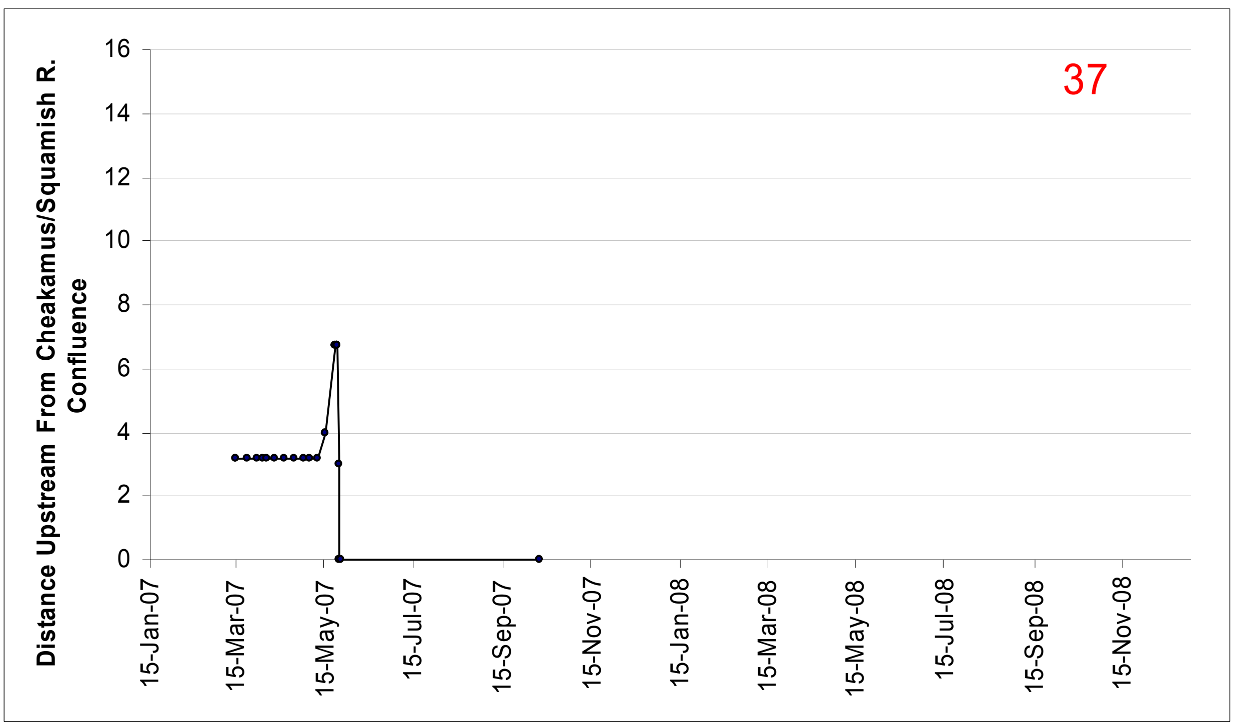
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Distance Upstream From Cheakamus/Squamish R. Confluence
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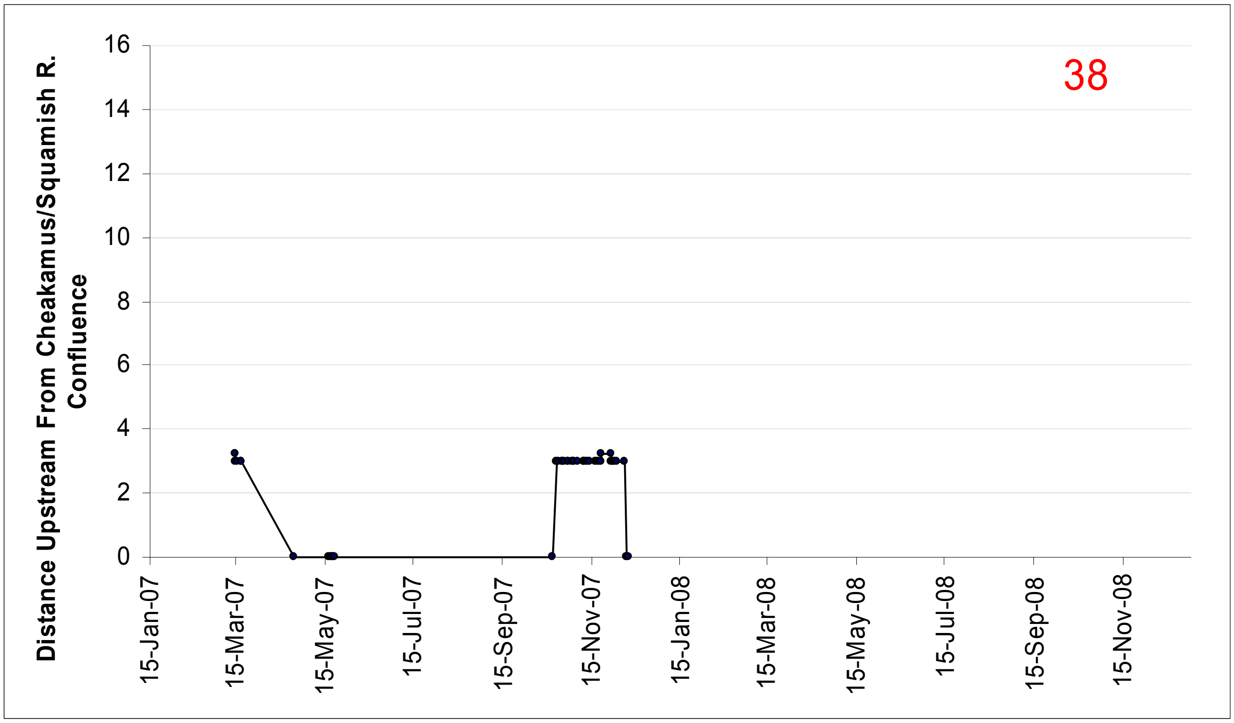
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Distance Upstream From Cheakamus/Squamish R. Confluence
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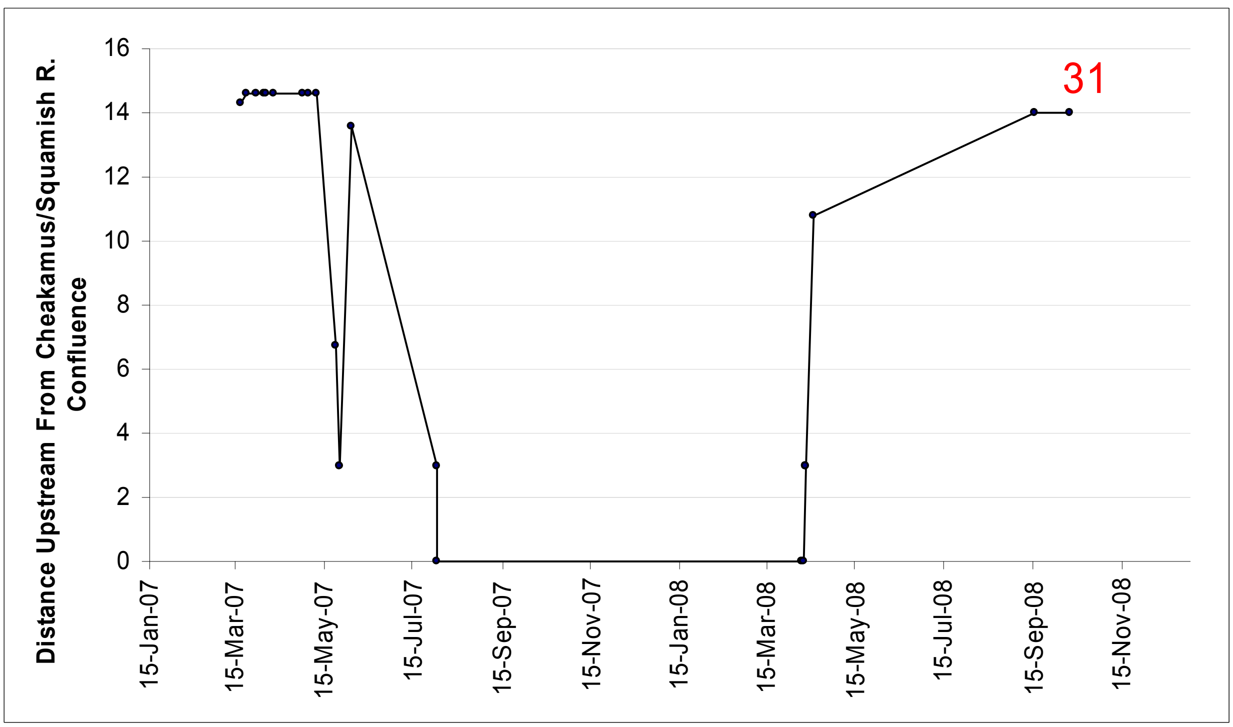
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Distance Upstream From Cheakamus/Squamish R. Confluence
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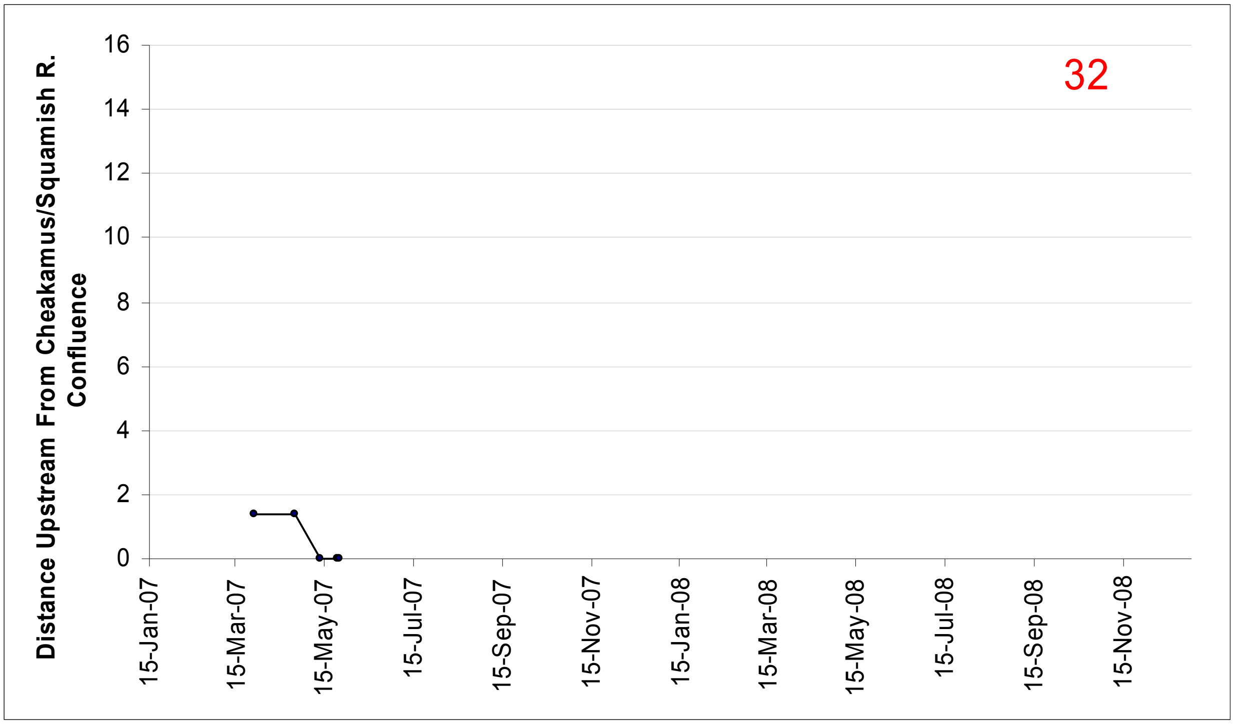
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Distance Upstream From Cheakamus/Squamish R. Confluence
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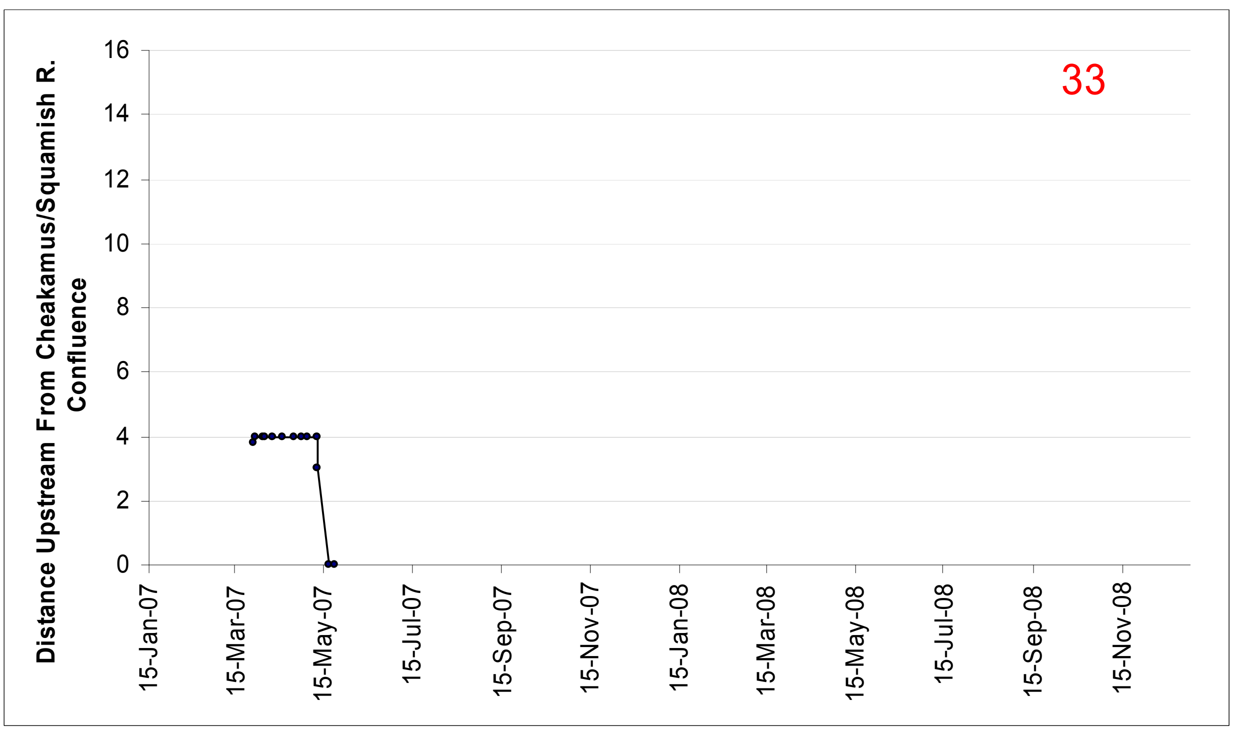
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Distance Upstream From Cheakamus/Squamish R. Confluence
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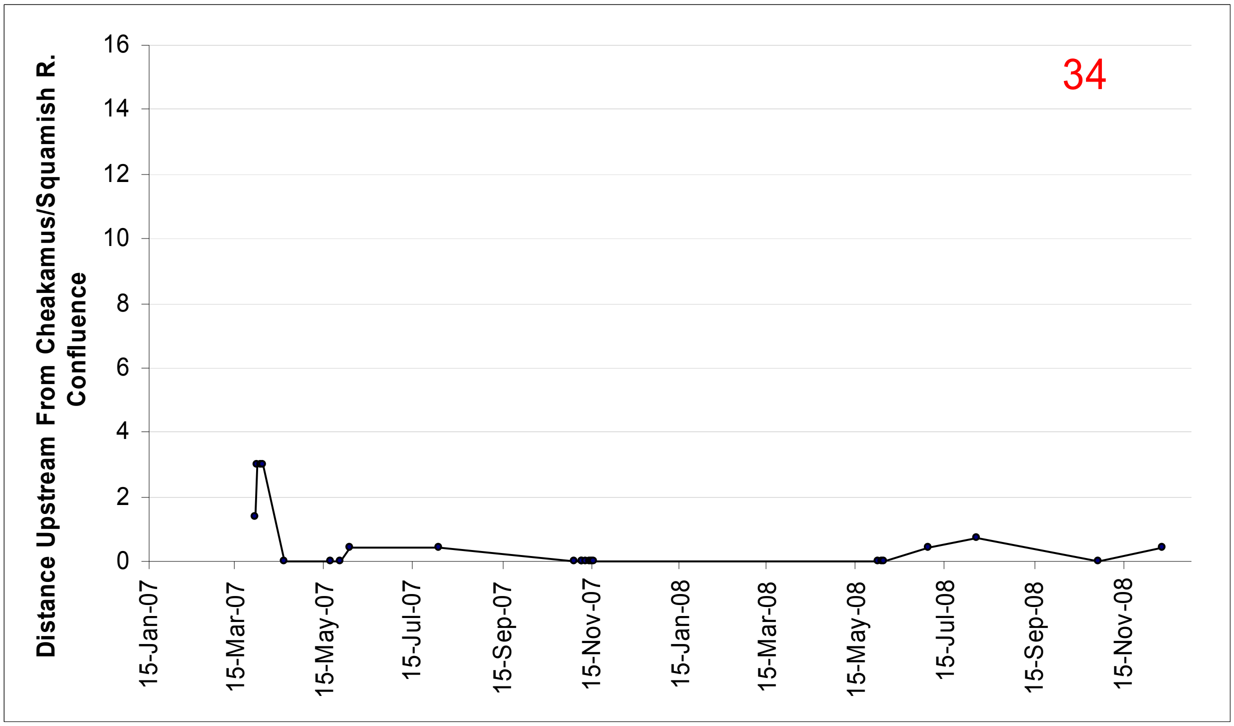
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Distance Upstream From Cheakamus/Squamish R. Confluence
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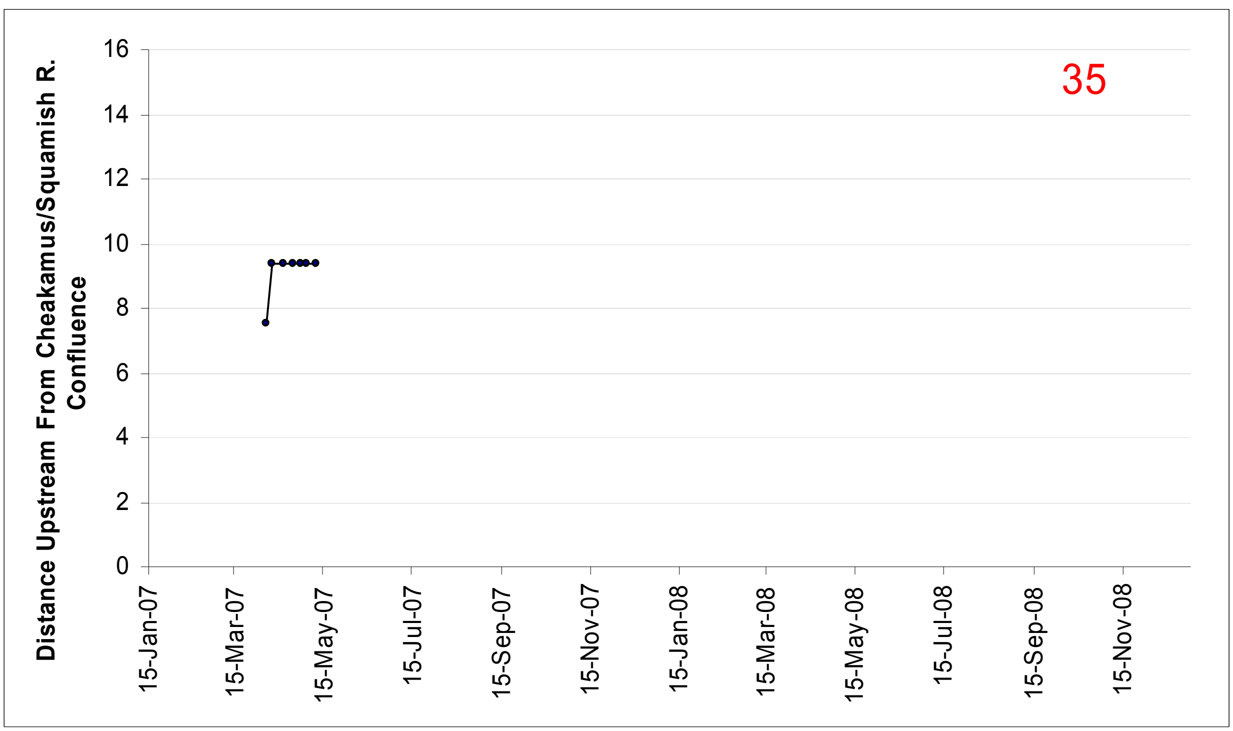
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Distance Upstream From Cheakamus/Squamish R. Confluence
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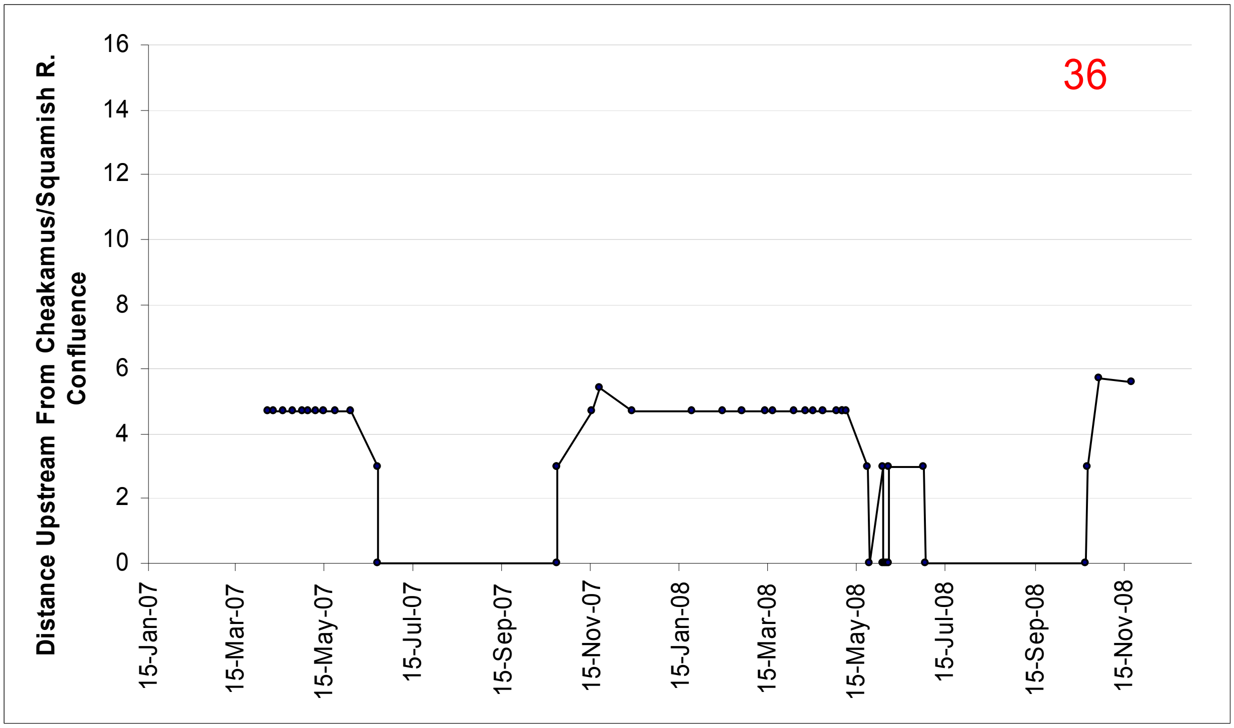
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Distance Upstream From Cheakamus/Squamish R. Confluence
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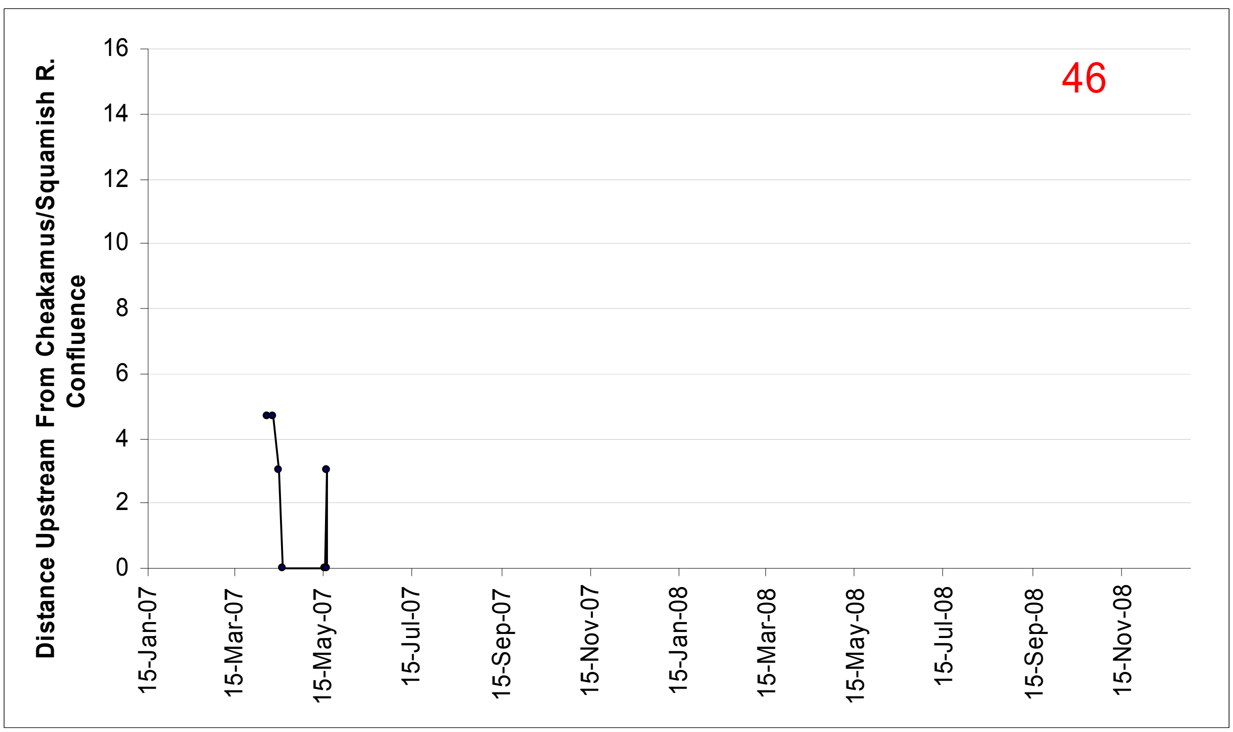
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Distance Upstream From Cheakamus/Squamish R. Confluence
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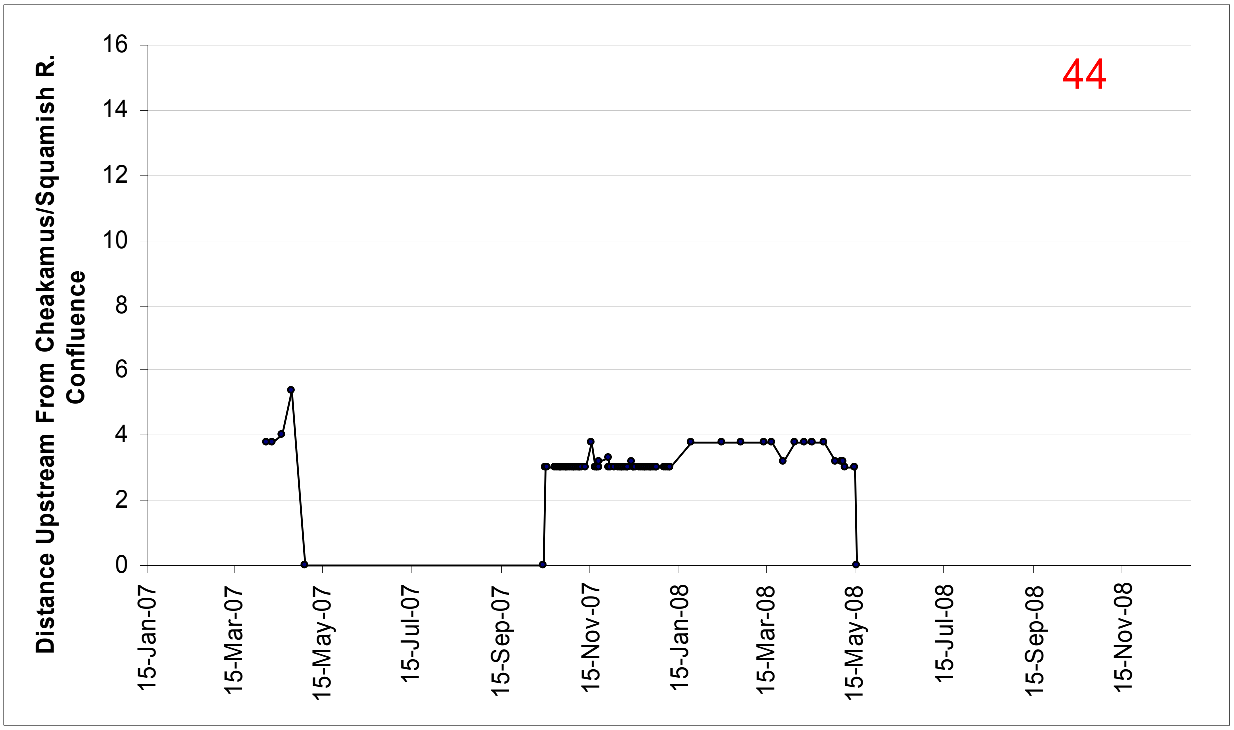
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Distance Upstream From Cheakamus/Squamish R. Confluence
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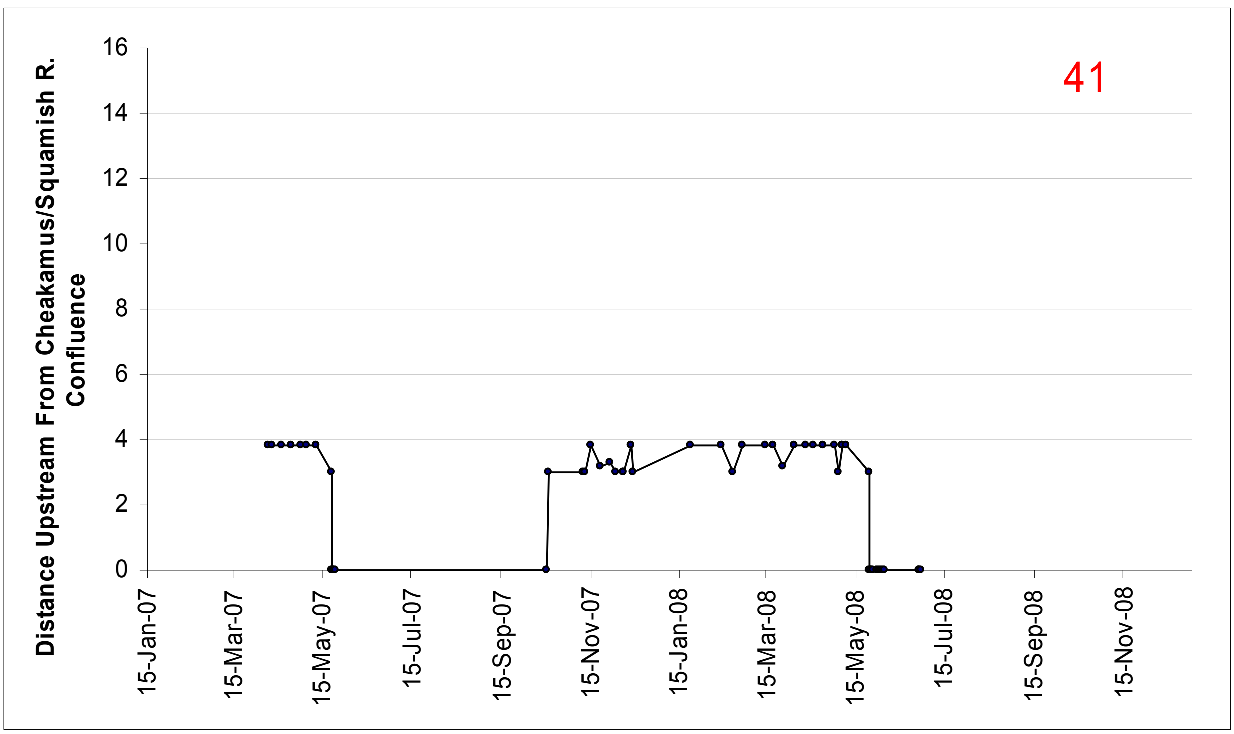
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Distance Upstream From Cheakamus/Squamish R. Confluence
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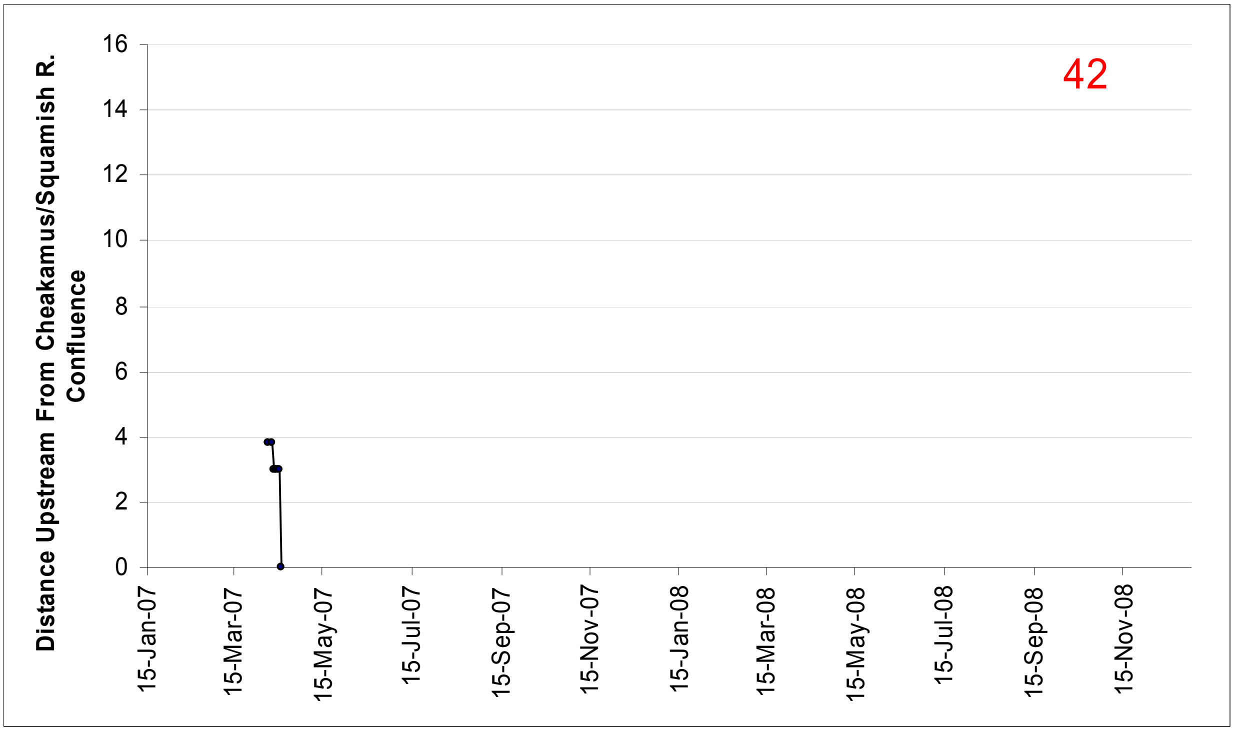
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Distance Upstream From Cheakamus/Squamish R. Confluence
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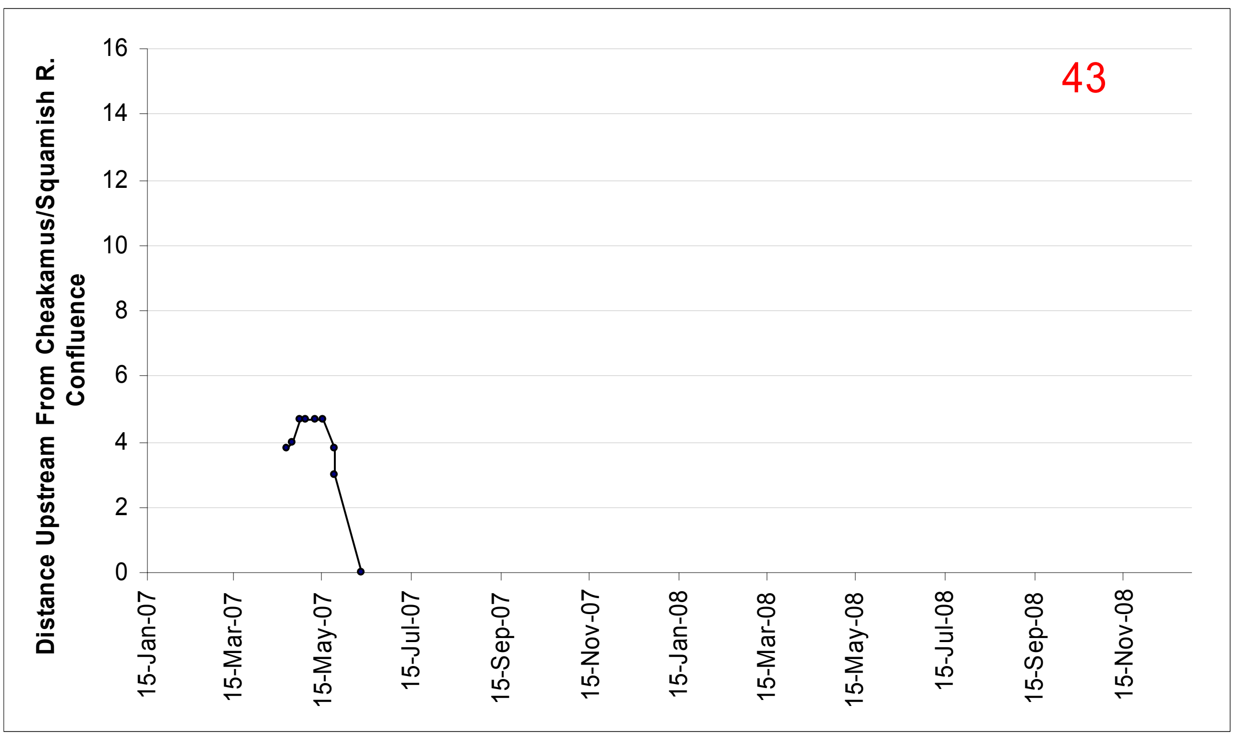
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Distance Upstream From Cheakamus/Squamish R. Confluence
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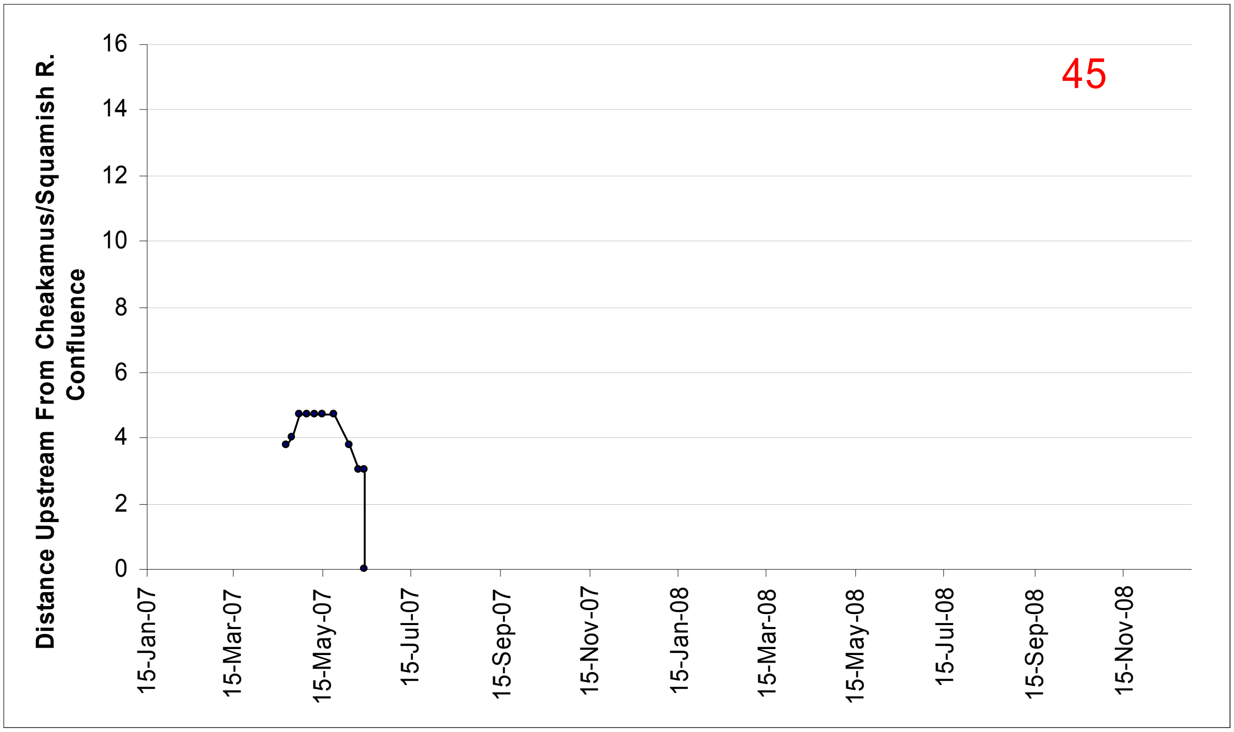

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Distance Upstream From Cheakamus/Squamish R. Confluence
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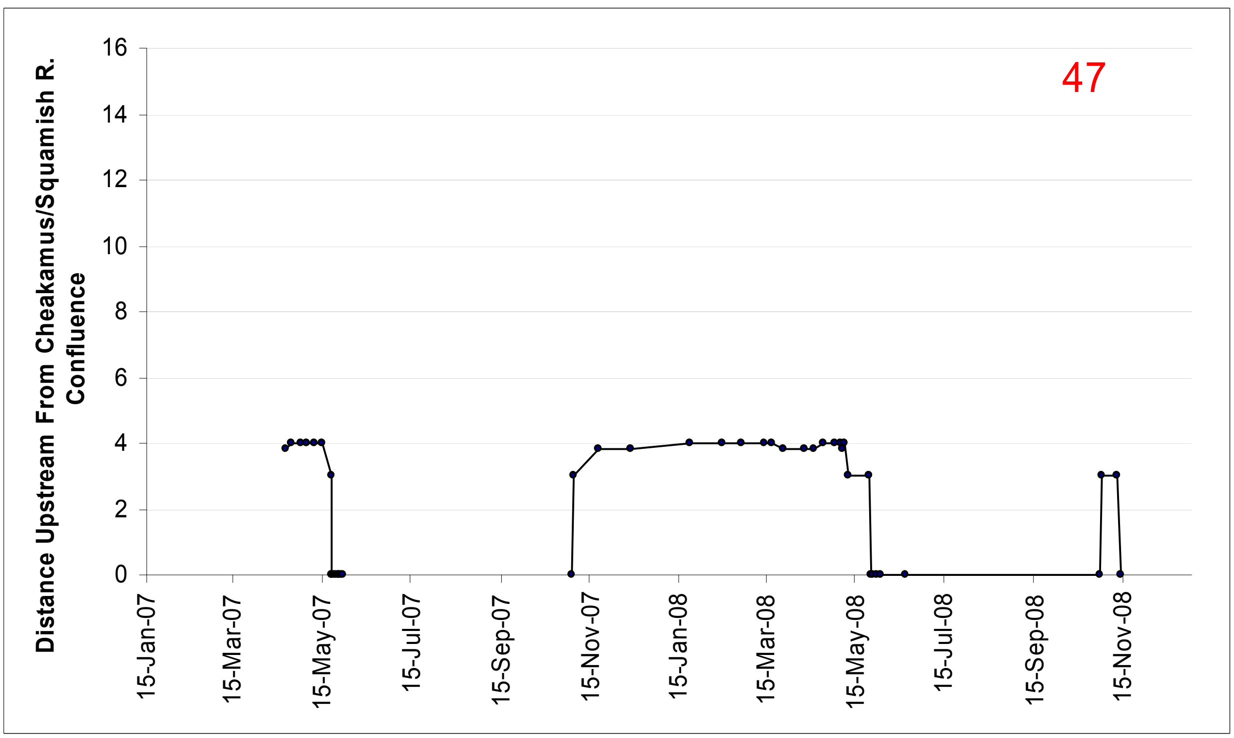

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Distance Upstream From Cheakamus/Squamish R. Confluence
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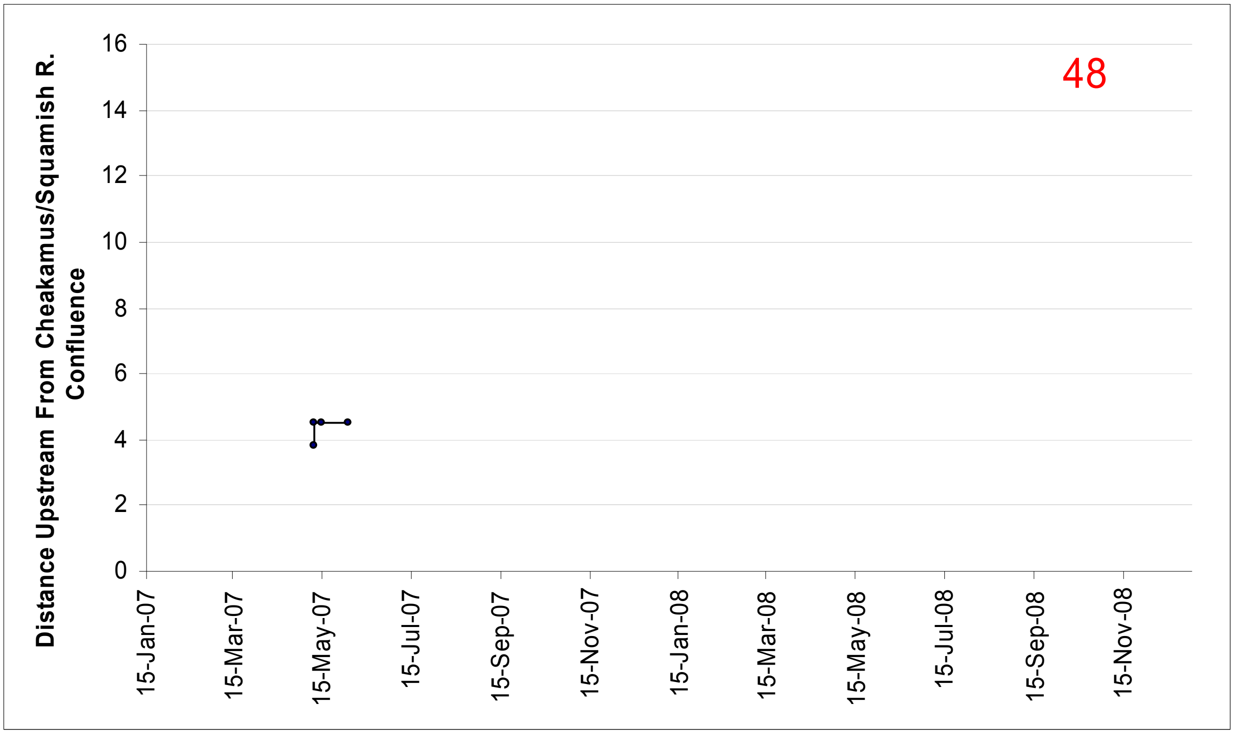
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Distance Upstream From Cheakamus/Squamish R. Confluence
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15-Nov-07
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15-Mar-08
15-May-08
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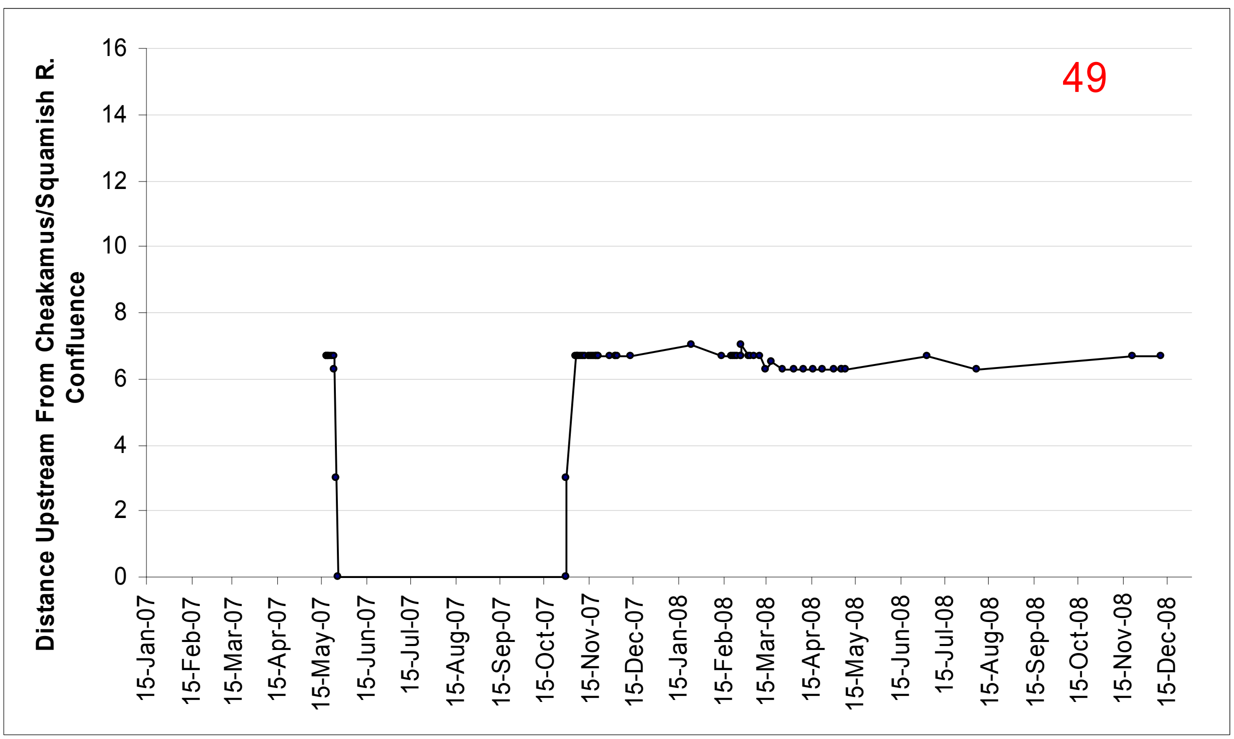
15-Sep-08
15-Nov-08


49
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
15-Jan-07
15-Feb-07
15-Mar-07
15-Apr-07
15-May-07
15-Jun-07
15-Jul-07
15-Aug-07
15-Sep-07
15-Oct-07
15-Nov-07
15-Dec-07
15-Jan-08
15-Feb-08
15-Mar-08
15-Apr-08
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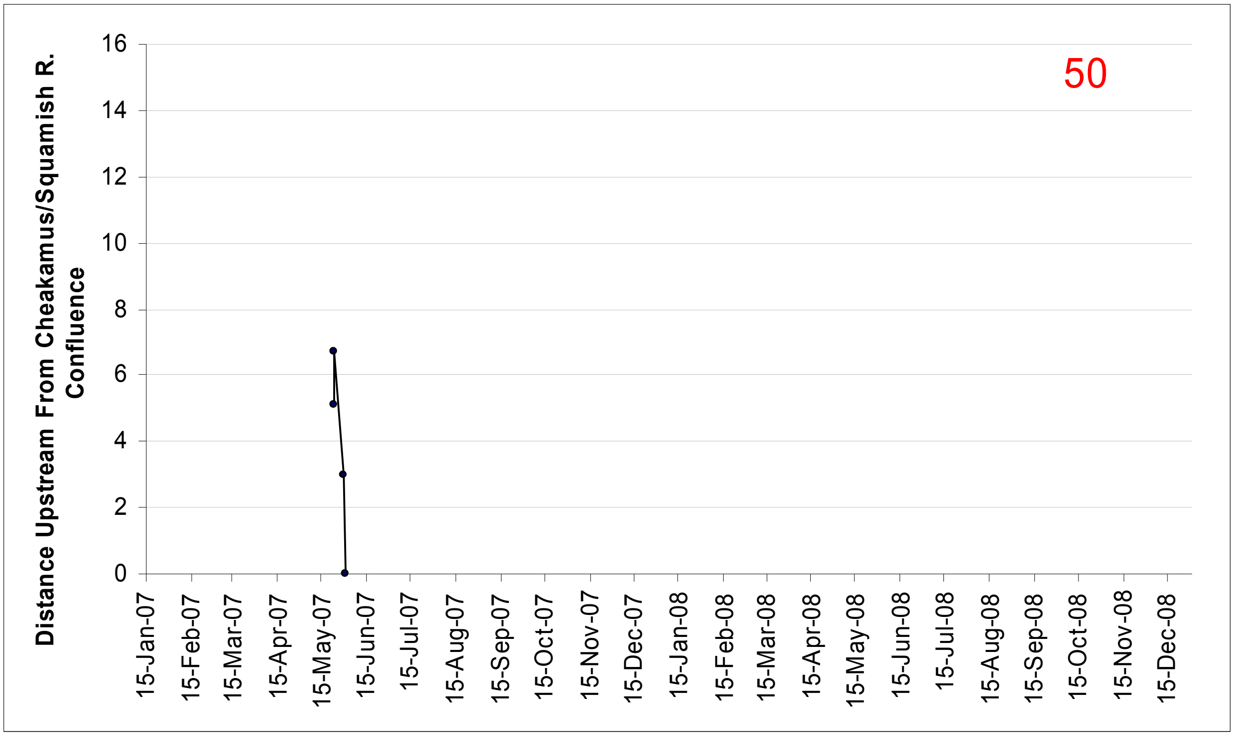
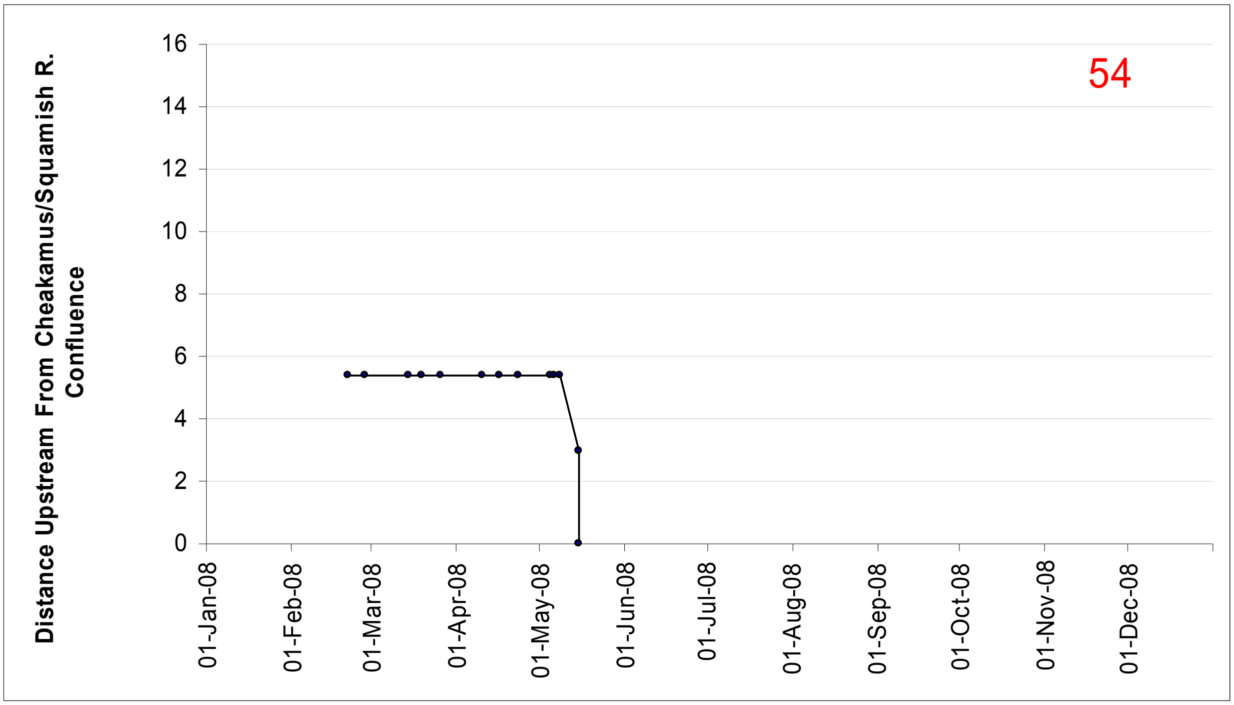
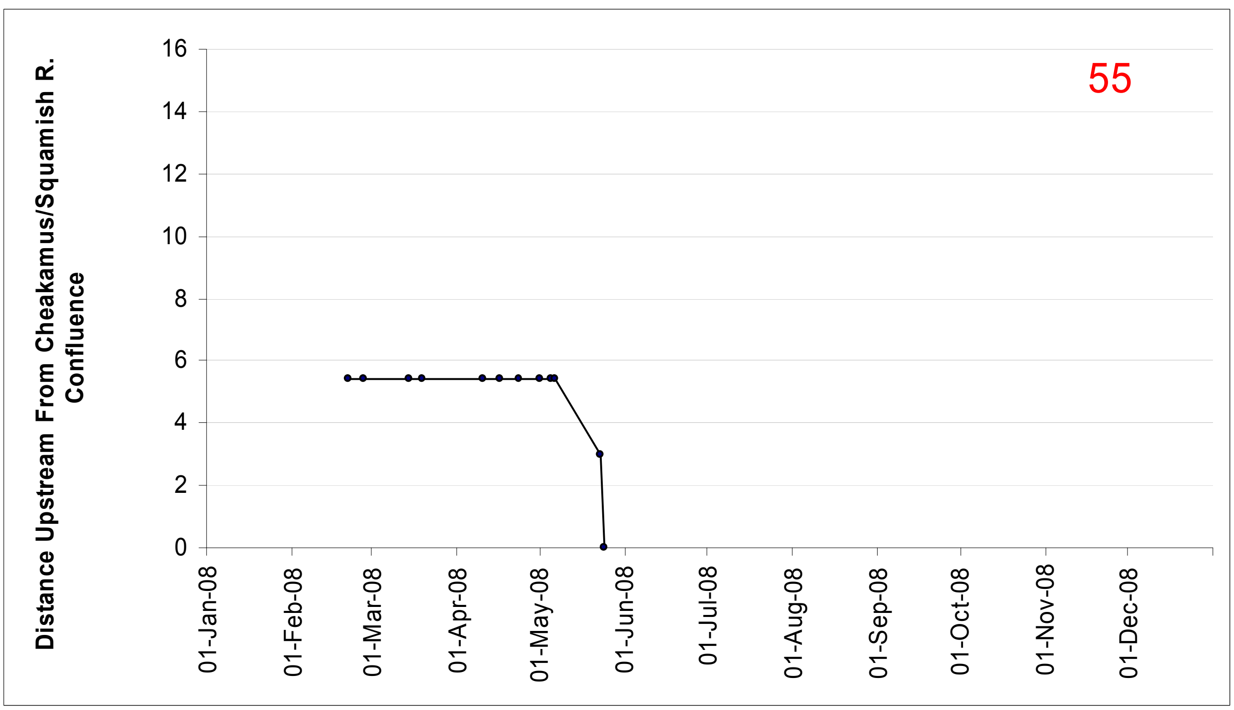
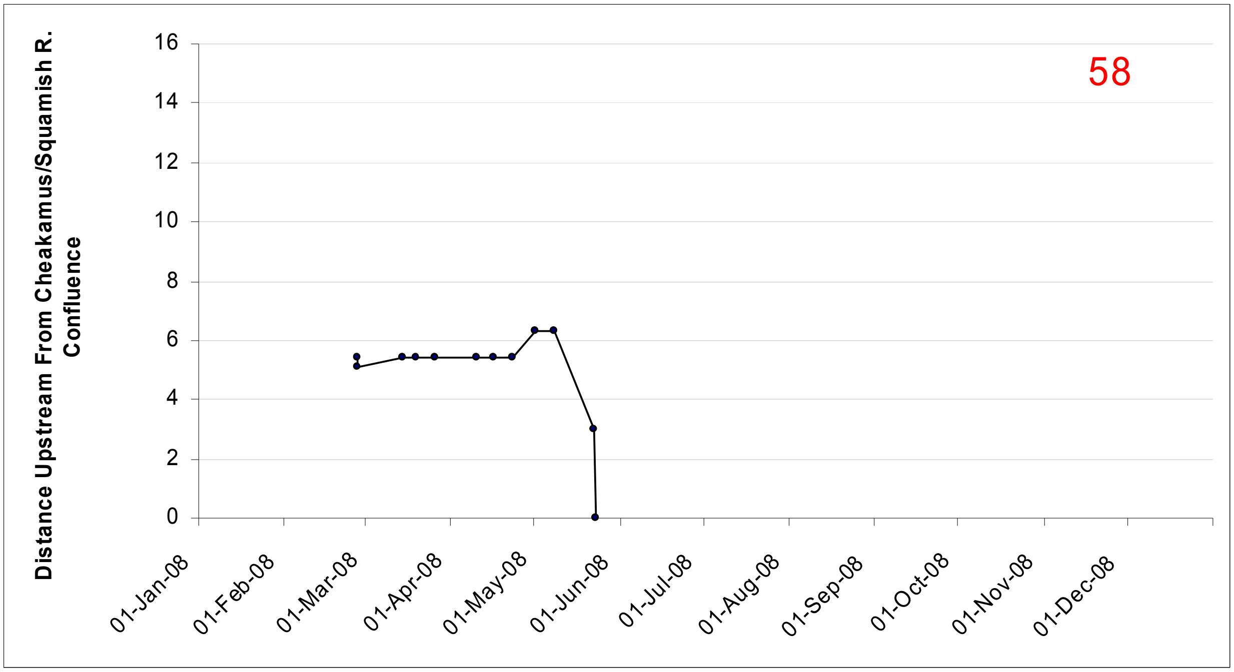
15-Oct-08
15-Nov-08
15-Dec-08


50
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
15-Jan-07
15-Feb-07
15-Mar-07
15-Apr-07
15-May-07
15-Jun-07
15-Jul-07
15-Aug-07
15-Sep-07
15-Oct-07
15-Nov-07
15-Dec-07
15-Jan-08
15-Feb-08
15-Mar-08
15-Apr-08
15-May-08
15-Jun-08
15-Jul-08
15-Aug-08
15-Sep-08
15-Oct-08
15-Nov-08
15-Dec-08

Appendix B. 2008 Radio Tagged Bull trout Migration Patterns in the Cheakamus River






58
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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01-Jul-08
01-Aug-08
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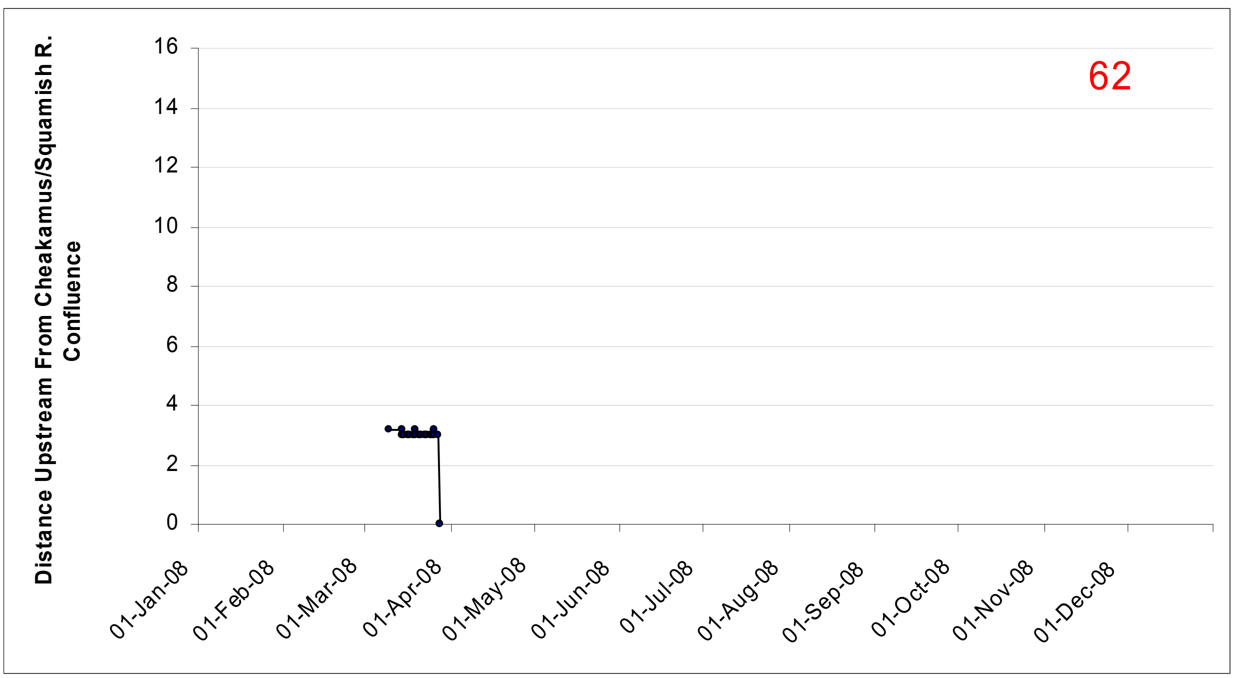
01-Oct-08
01-Nov-08
01-Dec-08


62
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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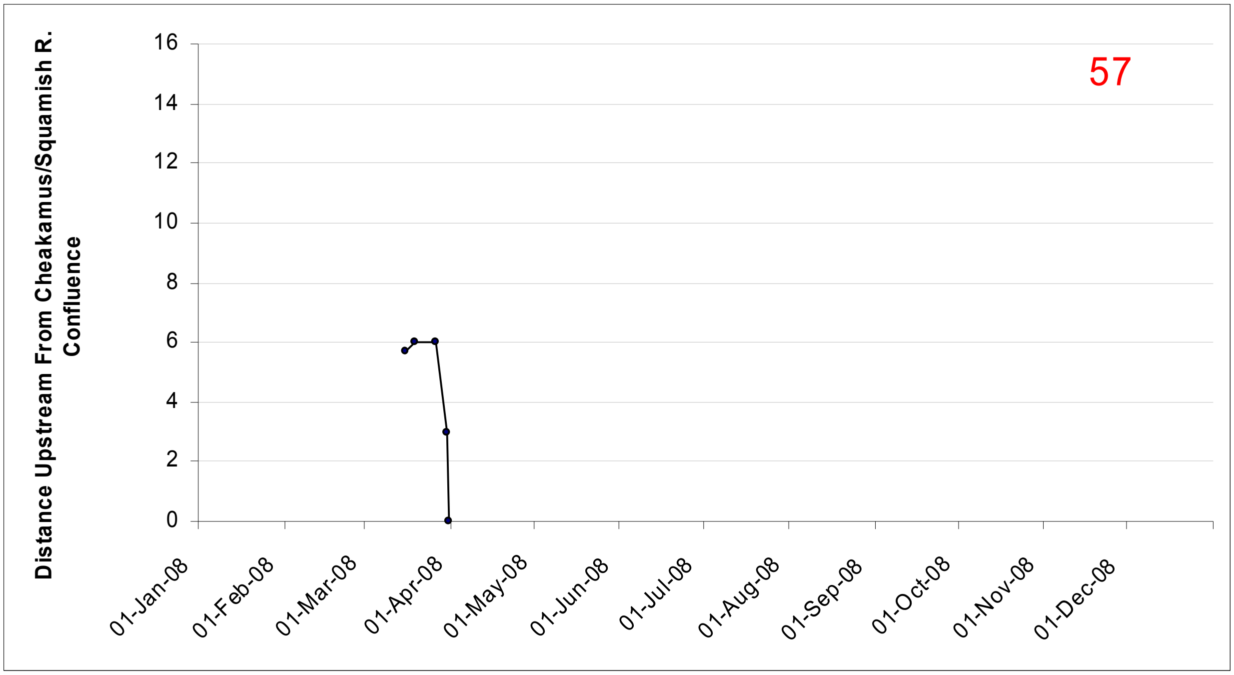
01-Nov-08
01-Dec-08


57
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
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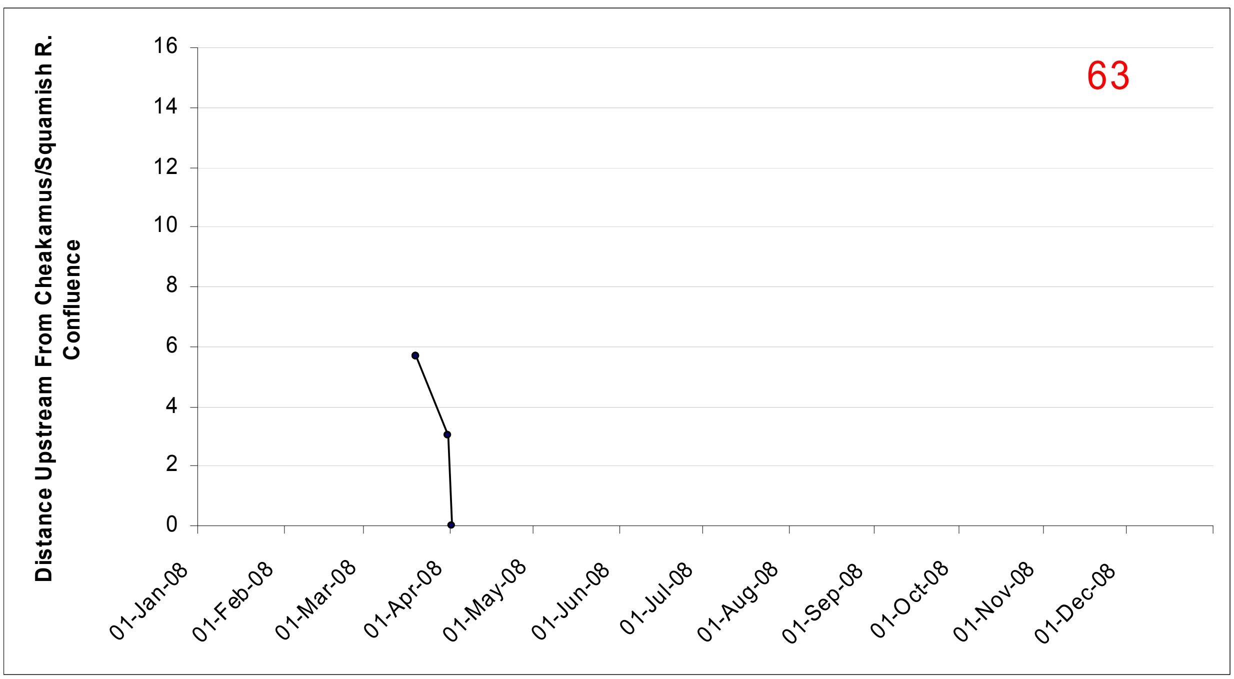
01-Nov-08
01-Dec-08


63
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
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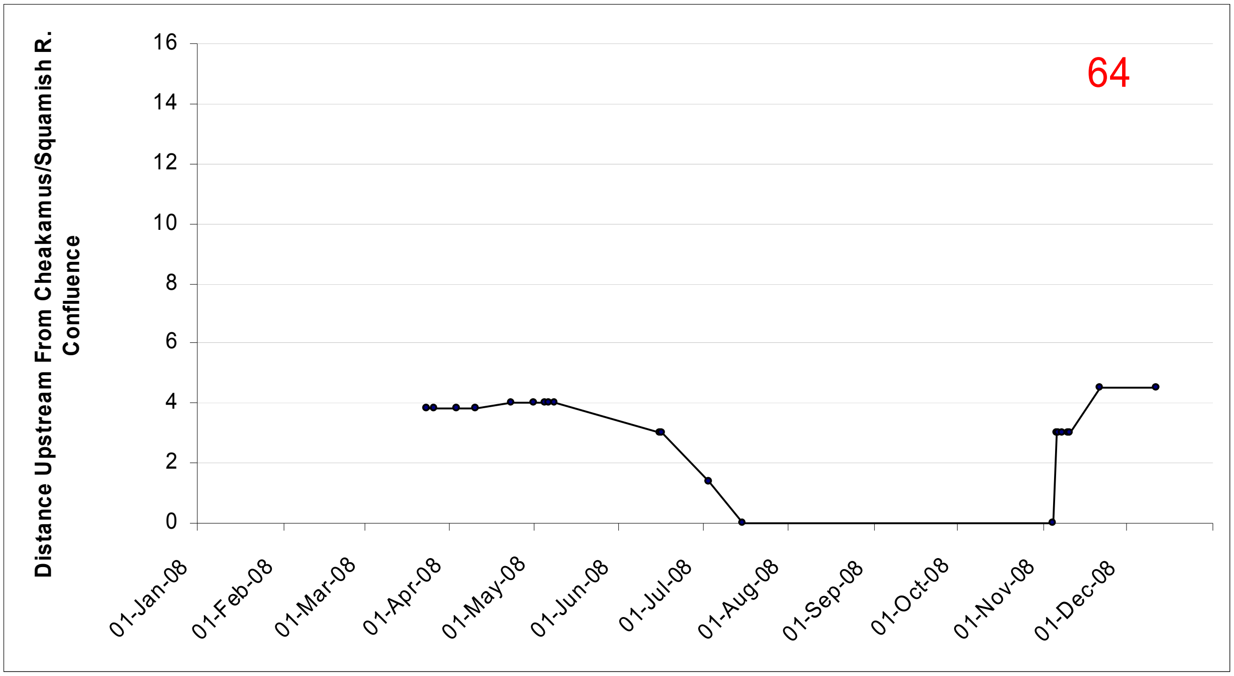
01-Nov-08
01-Dec-08


64
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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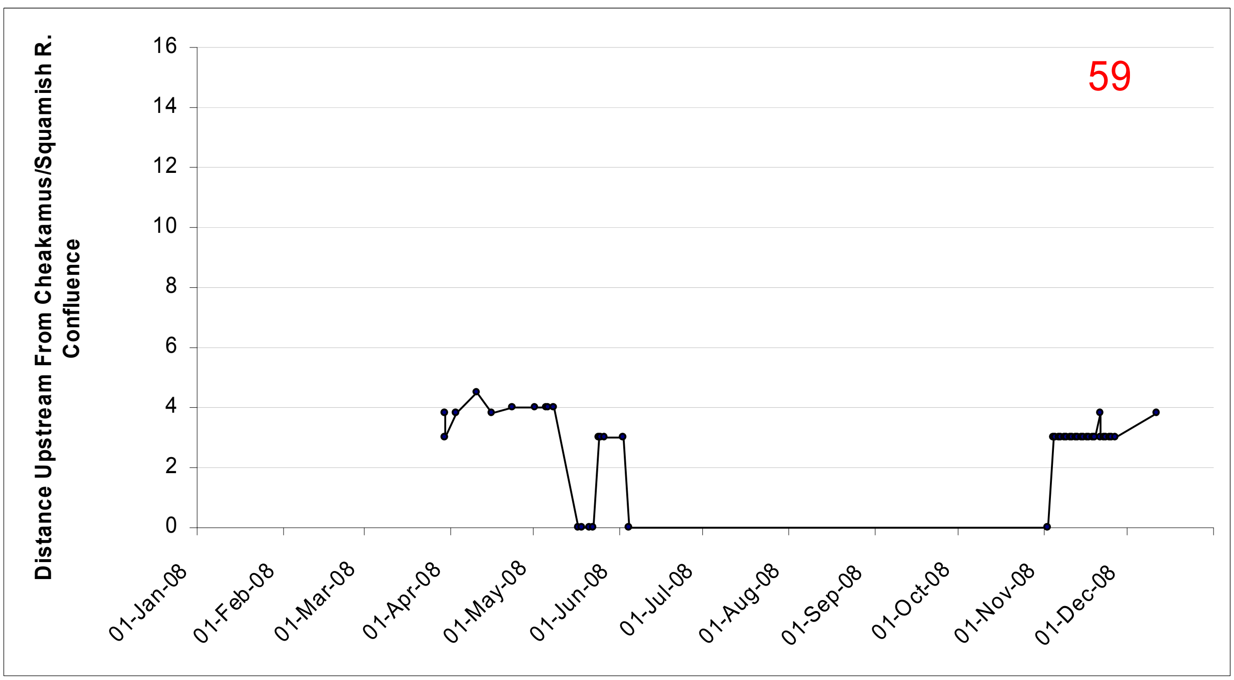
01-Nov-08
01-Dec-08


59
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
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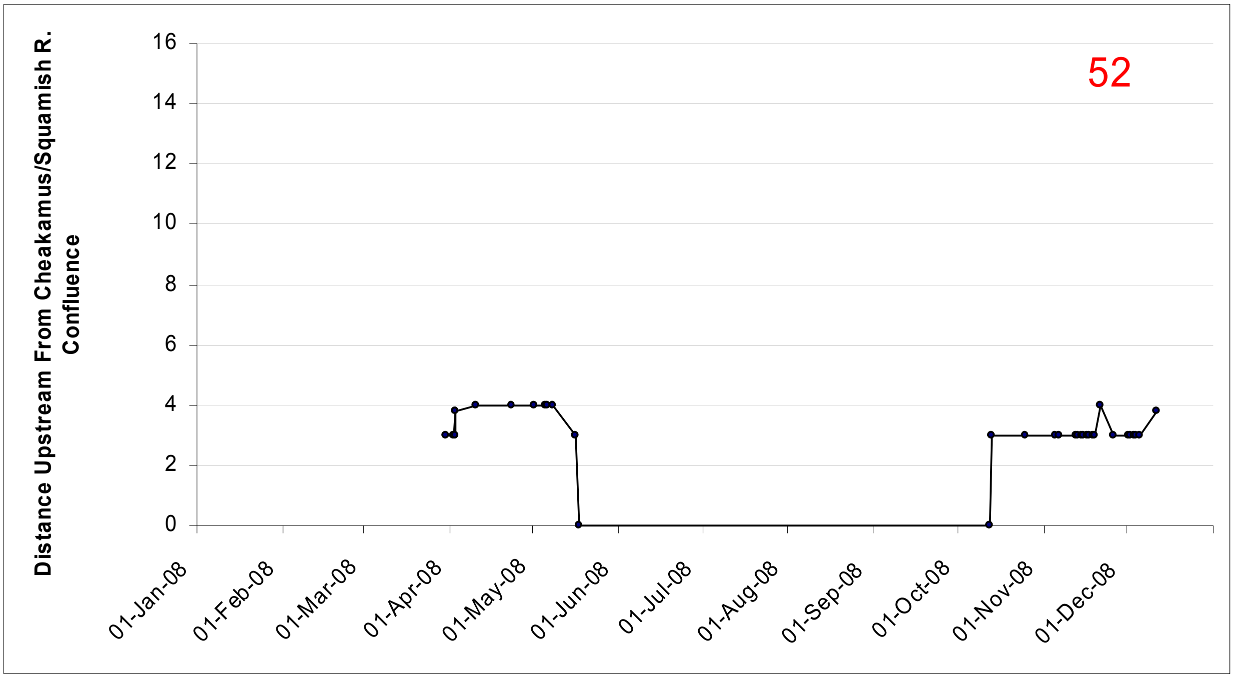
01-Nov-08
01-Dec-08


52
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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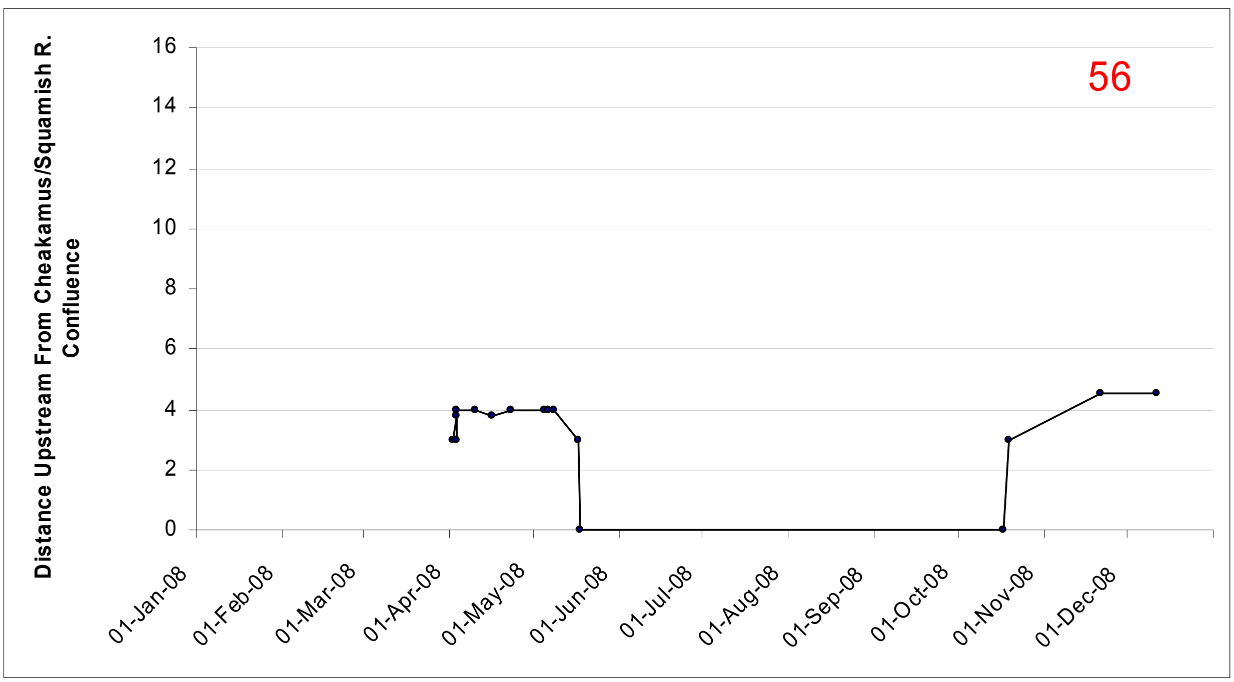
01-Nov-08
01-Dec-08


56
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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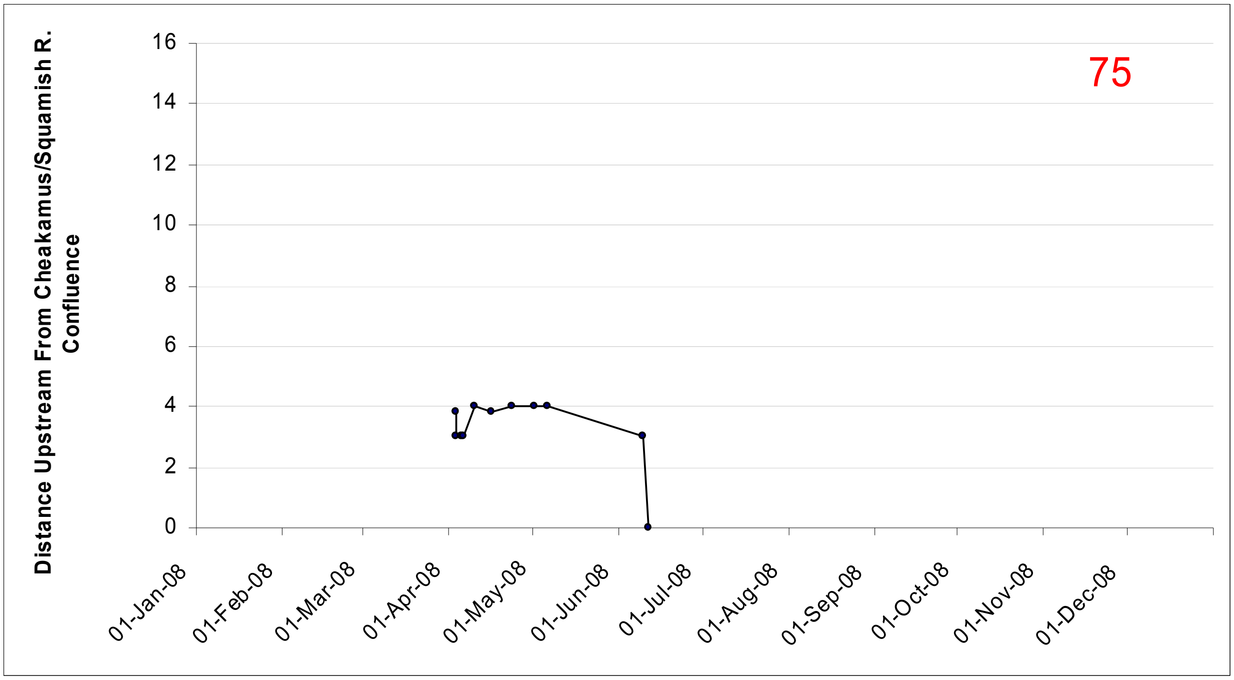
01-Nov-08
01-Dec-08


75
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
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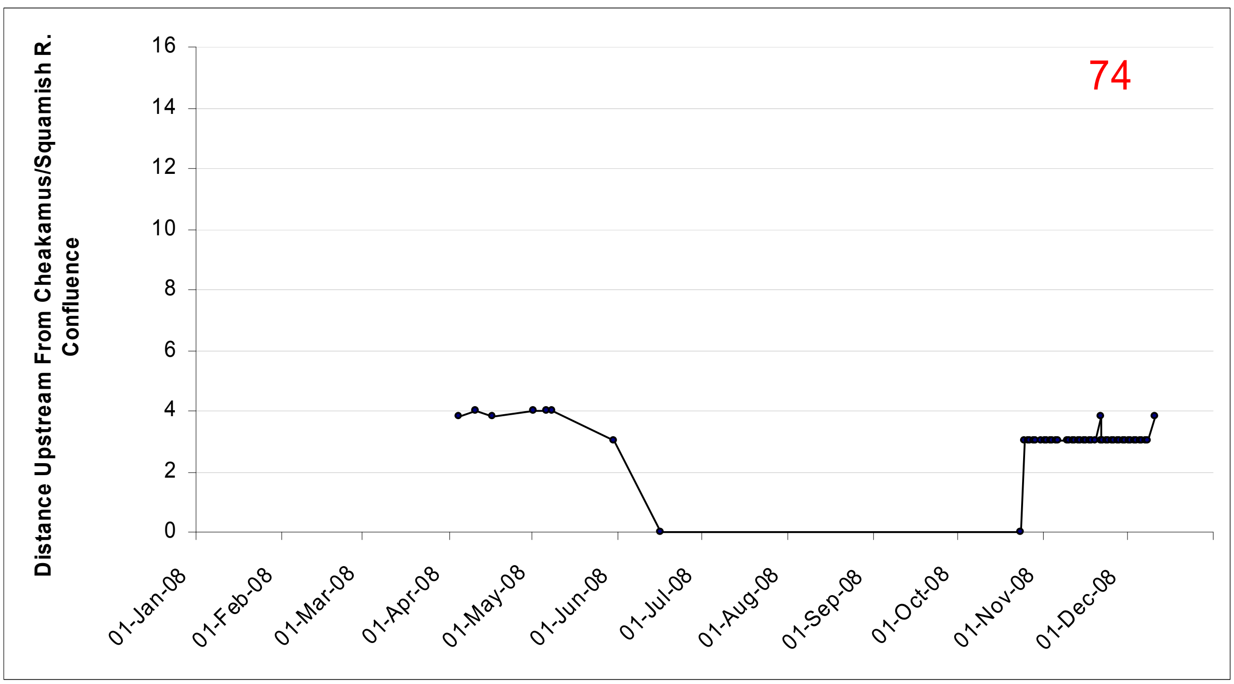
01-Nov-08
01-Dec-08


74
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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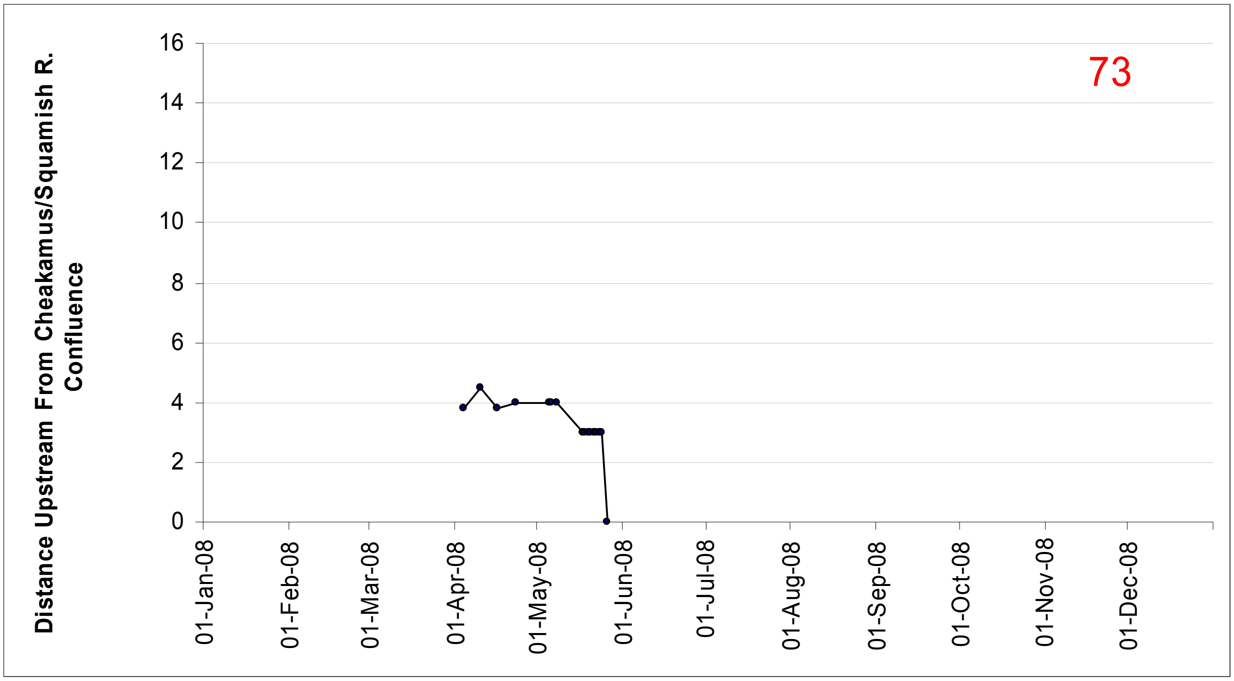
01-Nov-08
01-Dec-08


73
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
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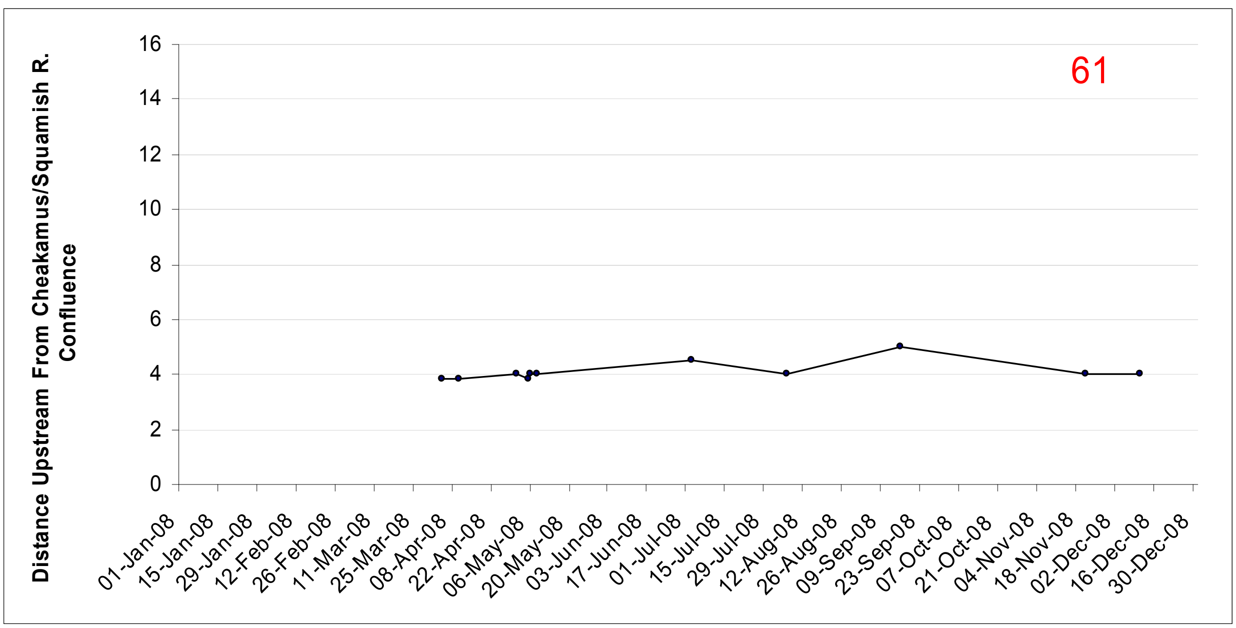
01-Nov-08
01-Dec-08


61
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
15-Jan-08
29-Jan-08
12-Feb-08
26-Feb-08
11-Mar-08
25-Mar-08
08-Apr-08
22-Apr-08
06-May-08
20-May-08
03-Jun-08
17-Jun-08
01-Jul-08
15-Jul-08
29-Jul-08
12-Aug-08
26-Aug-08
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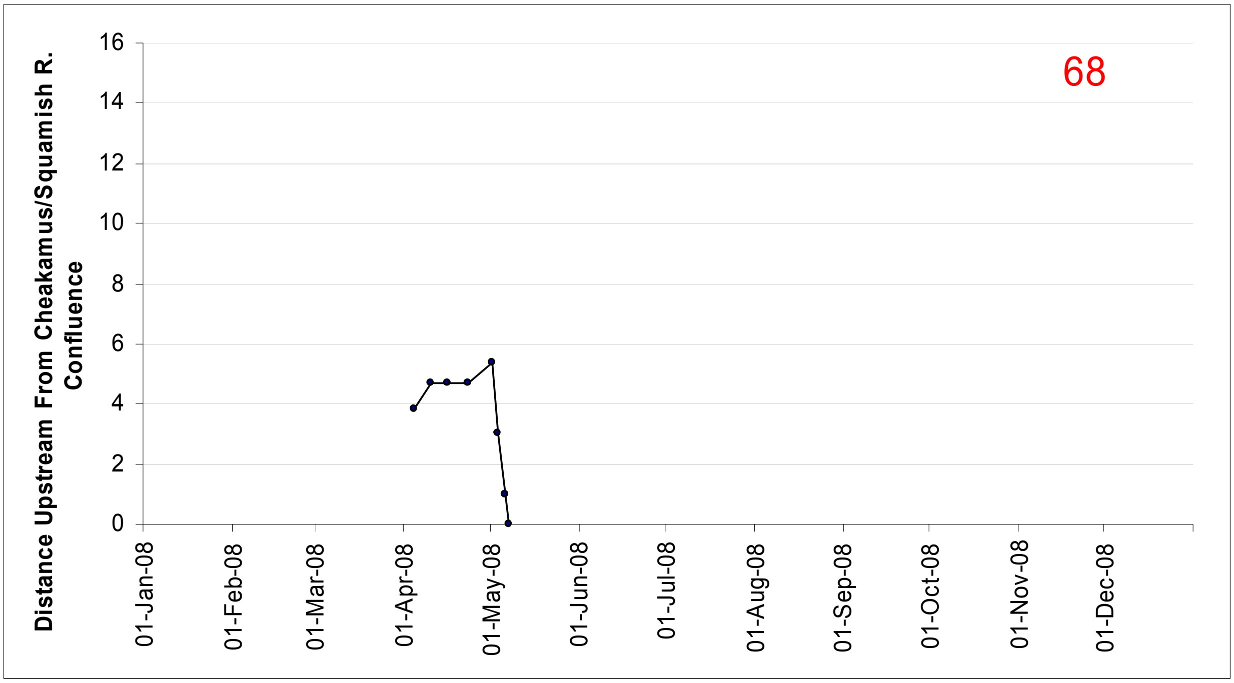
02-Dec-08
16-Dec-08
30-Dec-08


68
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
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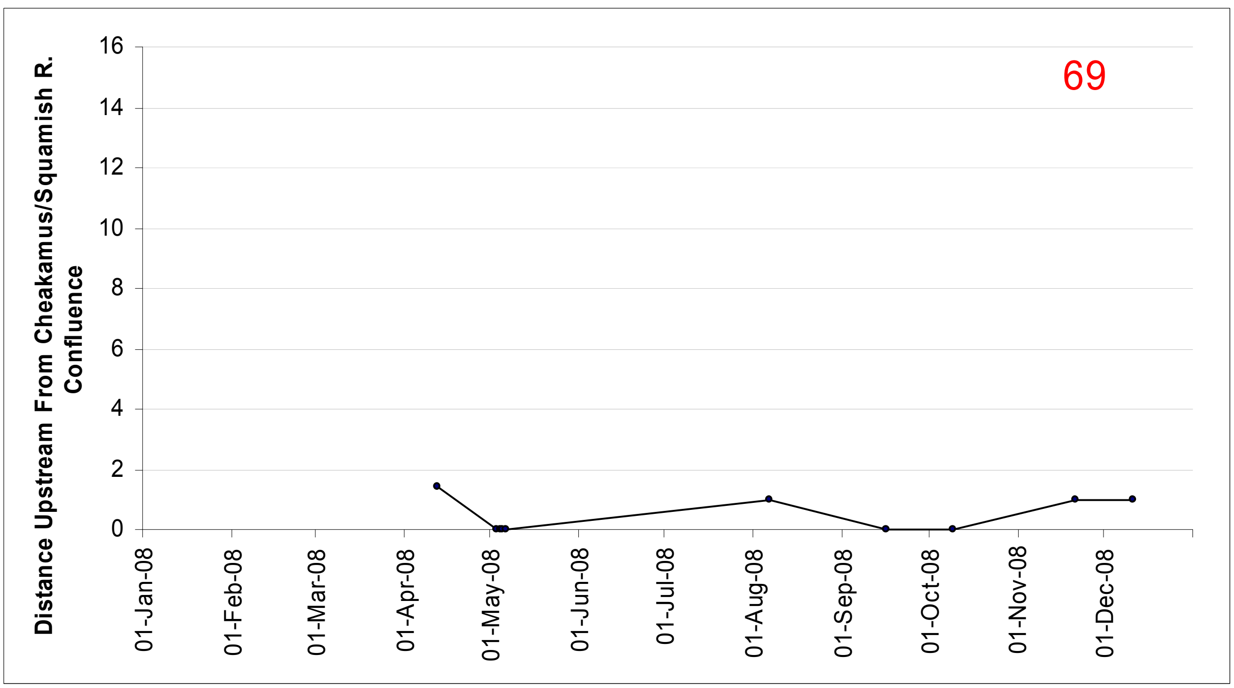
01-Nov-08
01-Dec-08


69
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
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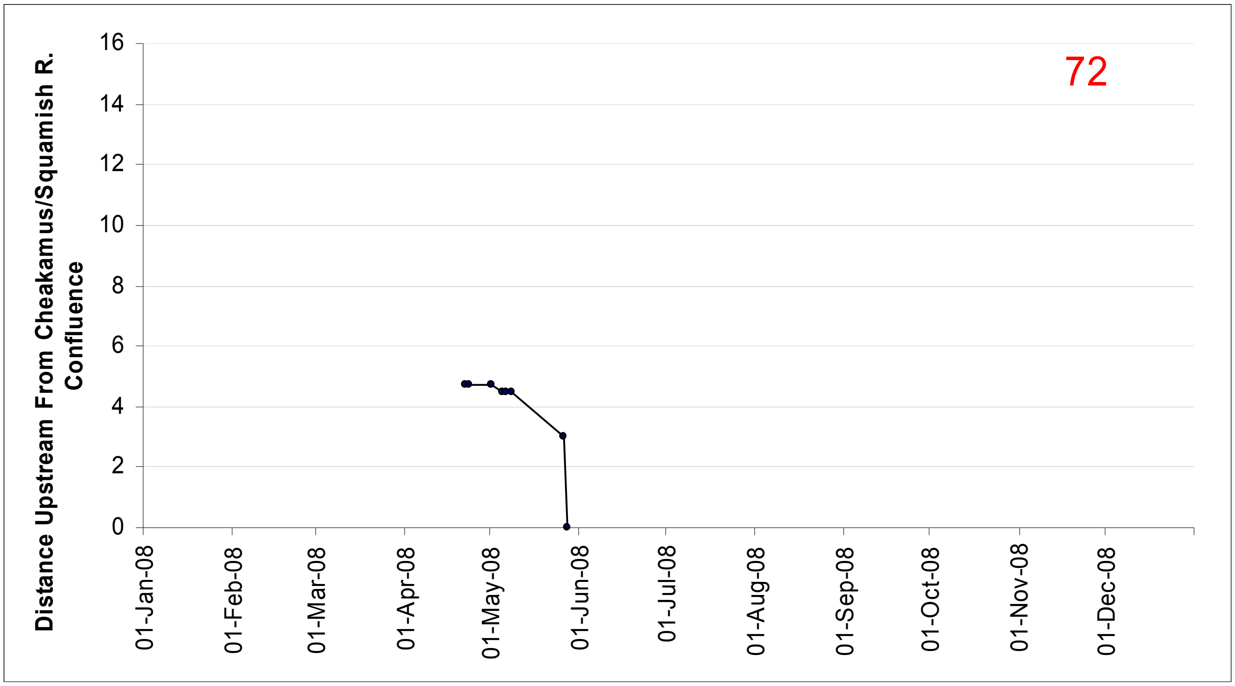
01-Nov-08
01-Dec-08


72
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
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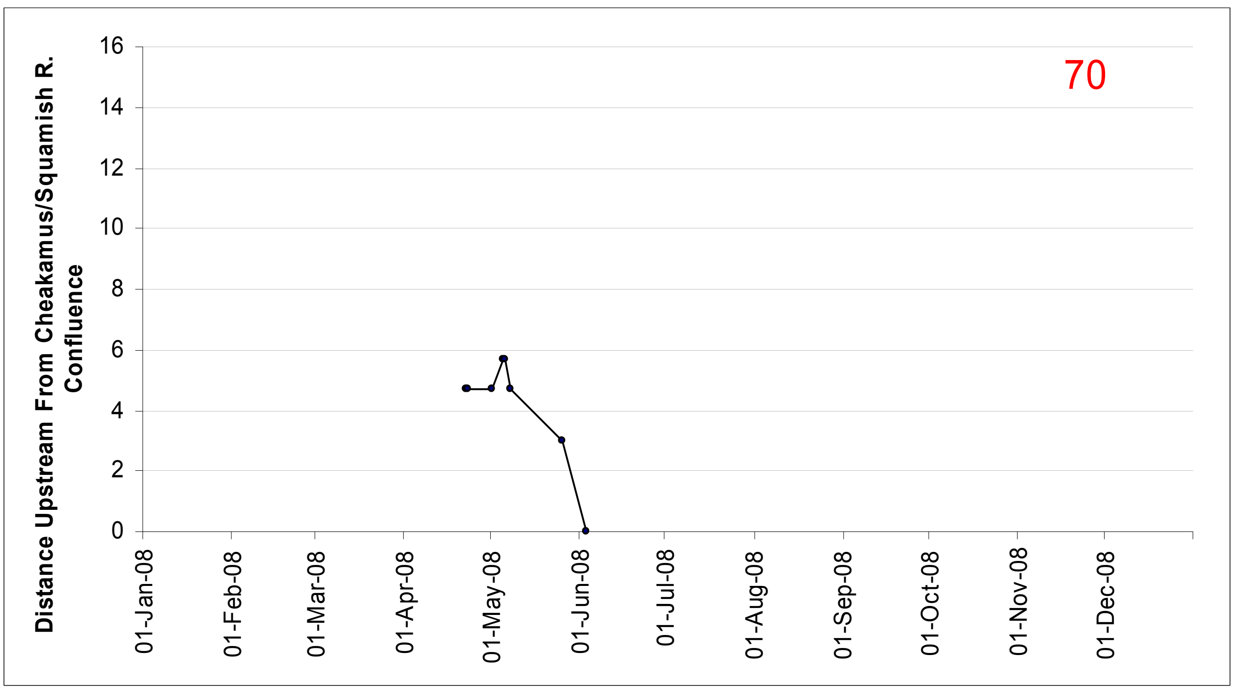
01-Nov-08
01-Dec-08


70
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
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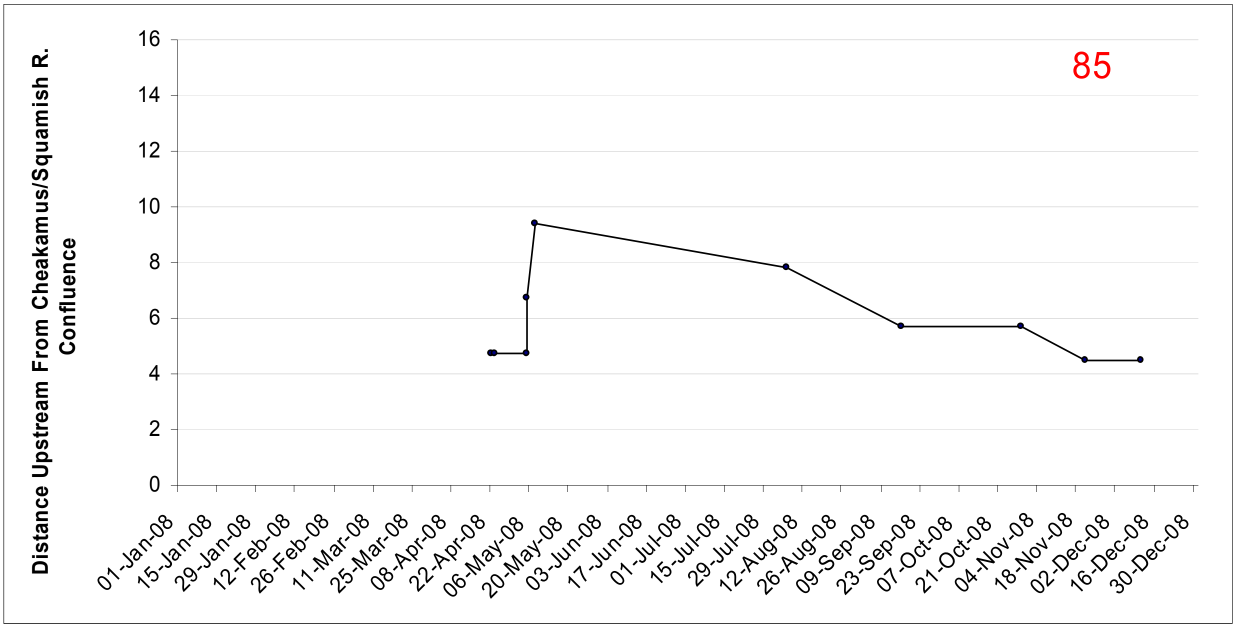
01-Nov-08
01-Dec-08


85
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
15-Jan-08
29-Jan-08
12-Feb-08
26-Feb-08
11-Mar-08
25-Mar-08
08-Apr-08
22-Apr-08
06-May-08
20-May-08
03-Jun-08
17-Jun-08
01-Jul-08
15-Jul-08
29-Jul-08
12-Aug-08
26-Aug-08
09-Sep-08
23-Sep-08
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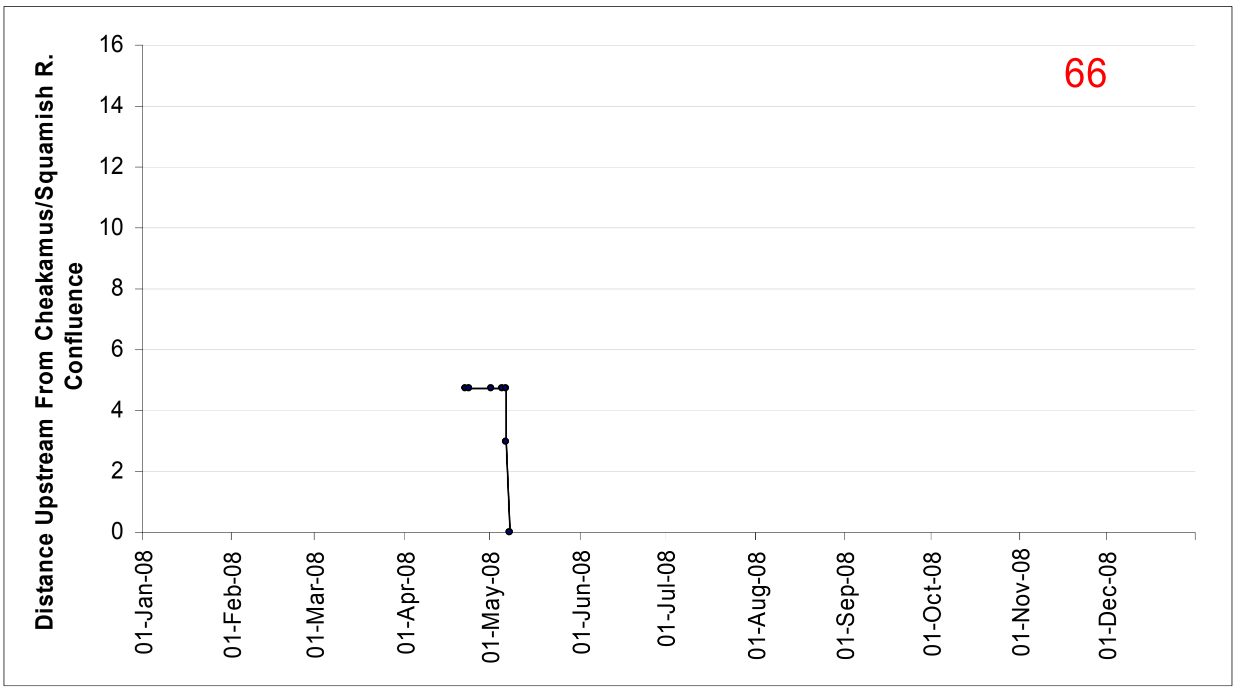
04-Nov-08
18-Nov-08
02-Dec-08
16-Dec-08
30-Dec-08


66
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
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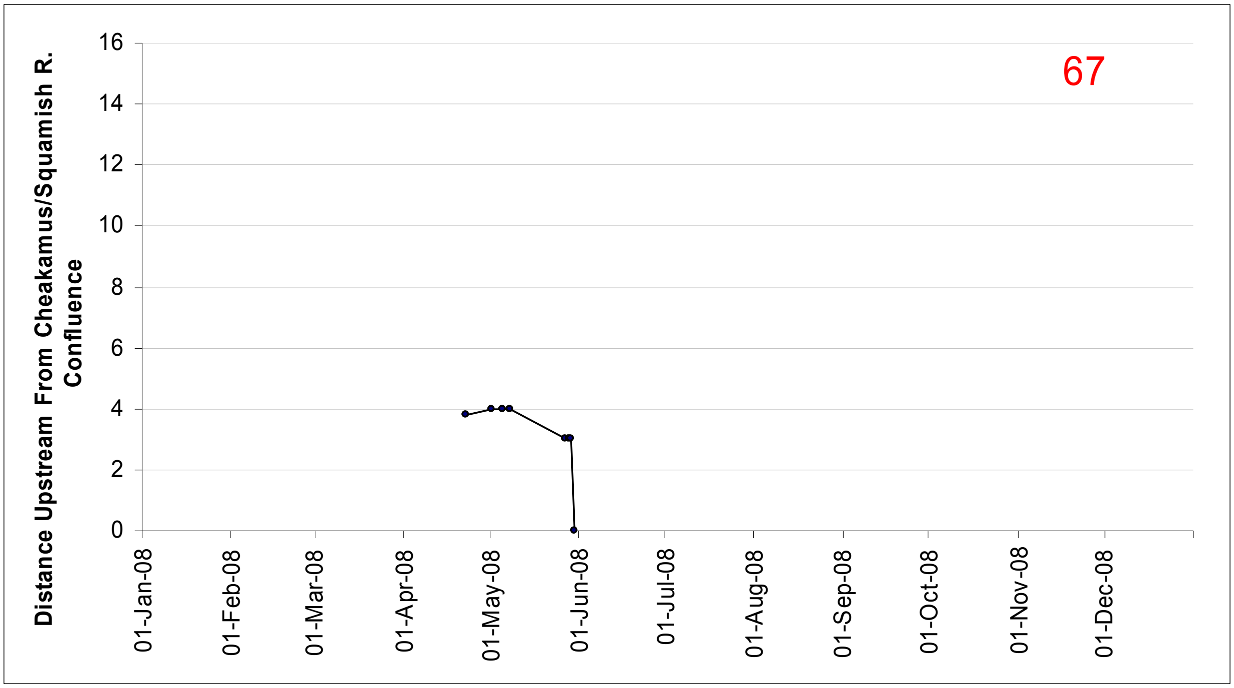
01-Nov-08
01-Dec-08


67
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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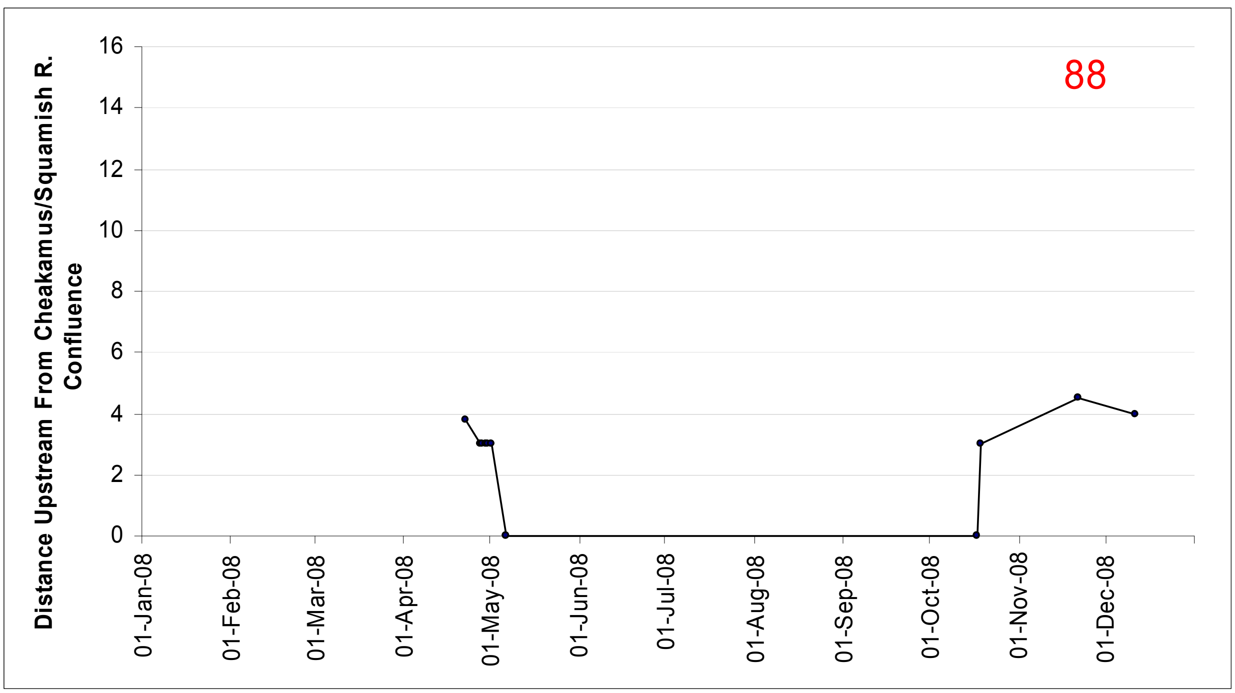
01-Nov-08
01-Dec-08


88
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
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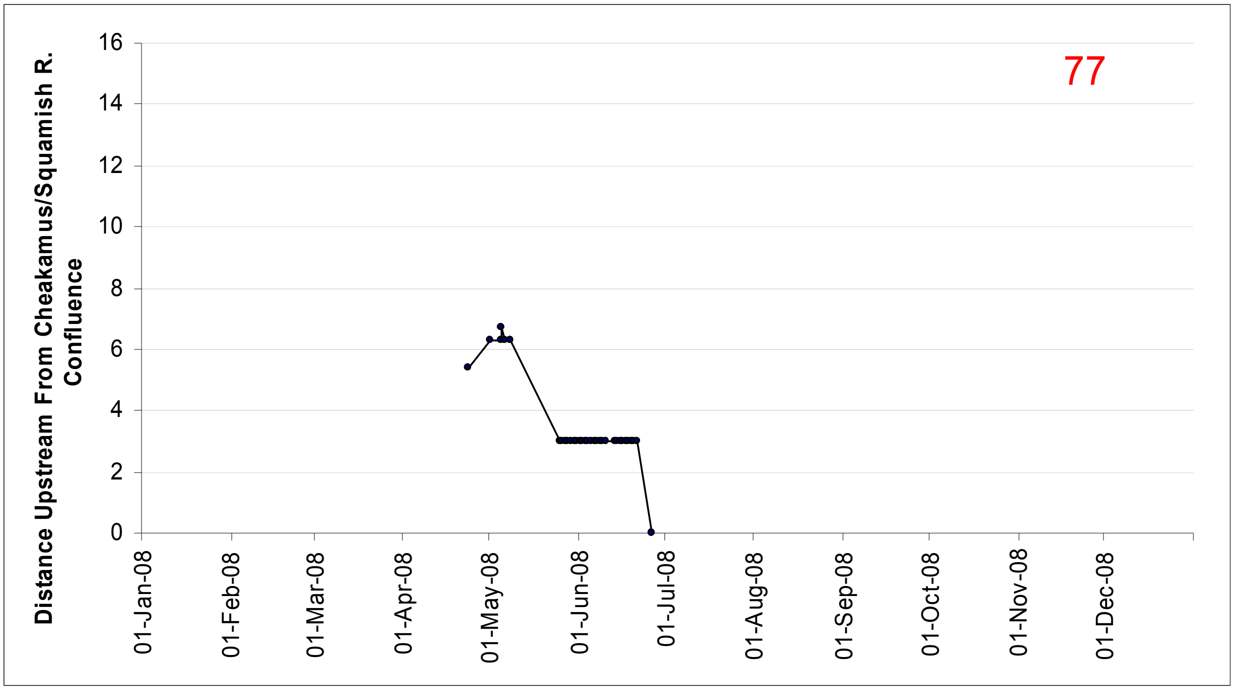
01-Nov-08
01-Dec-08


77
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
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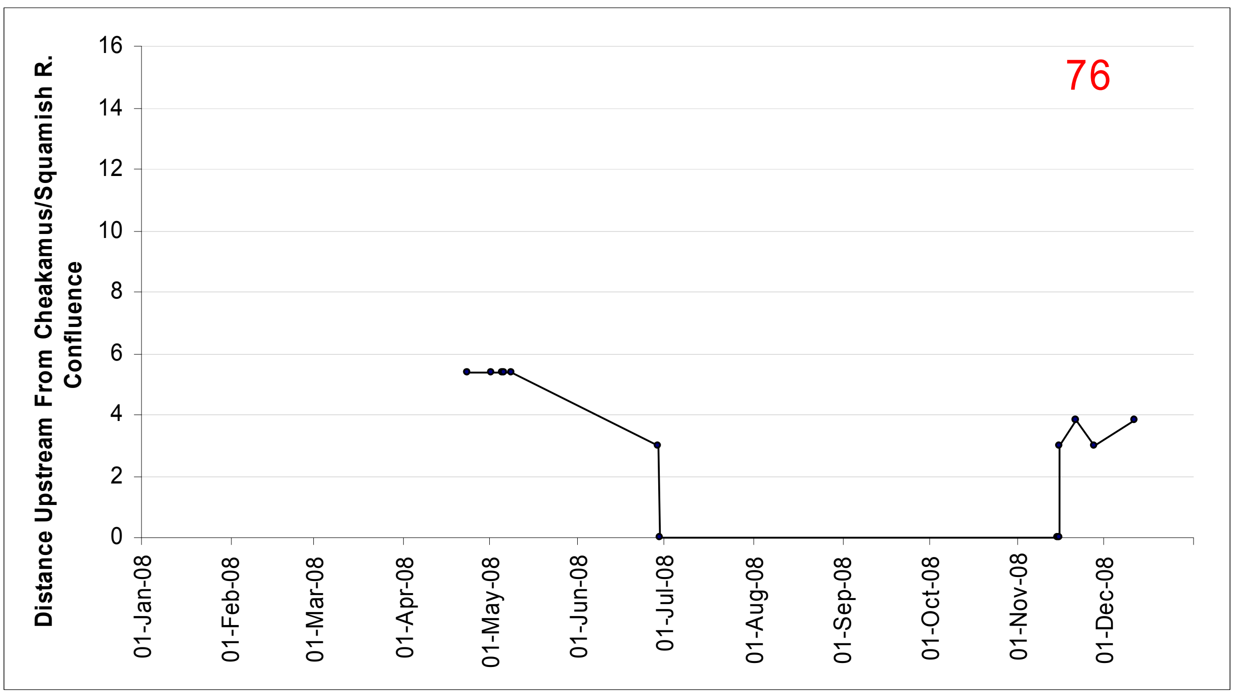
01-Nov-08
01-Dec-08


76
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
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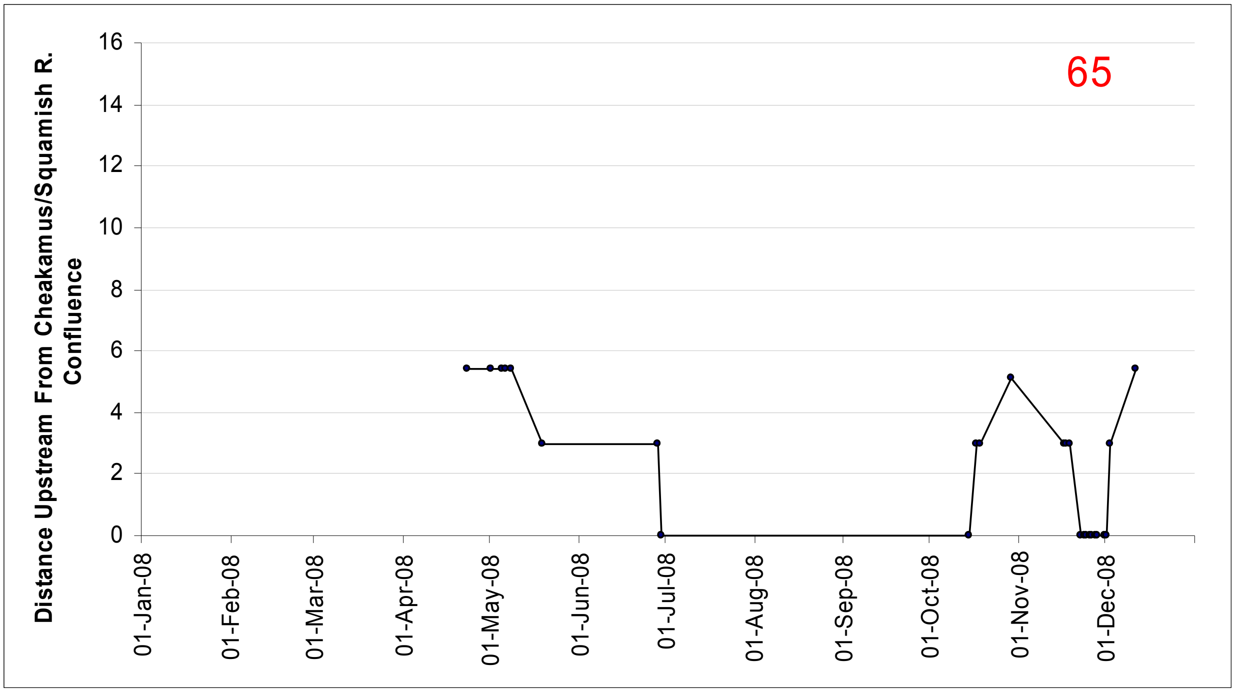
01-Nov-08
01-Dec-08



65
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
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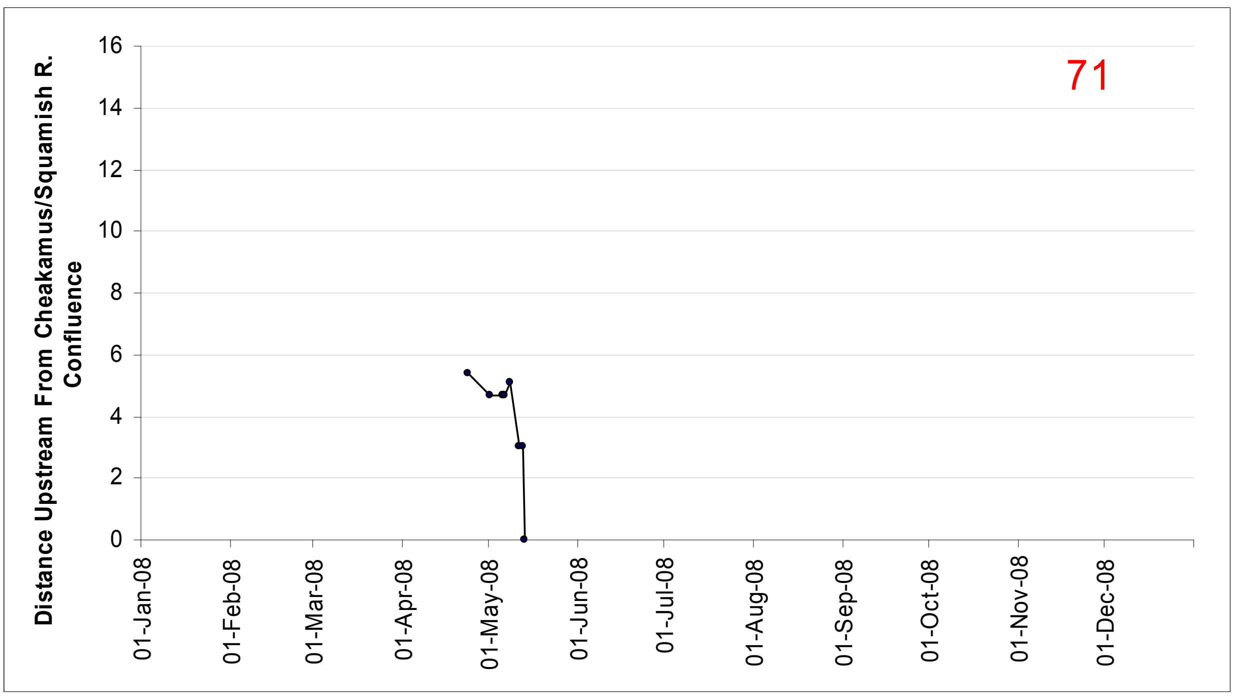
01-Nov-08
01-Dec-08



71
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
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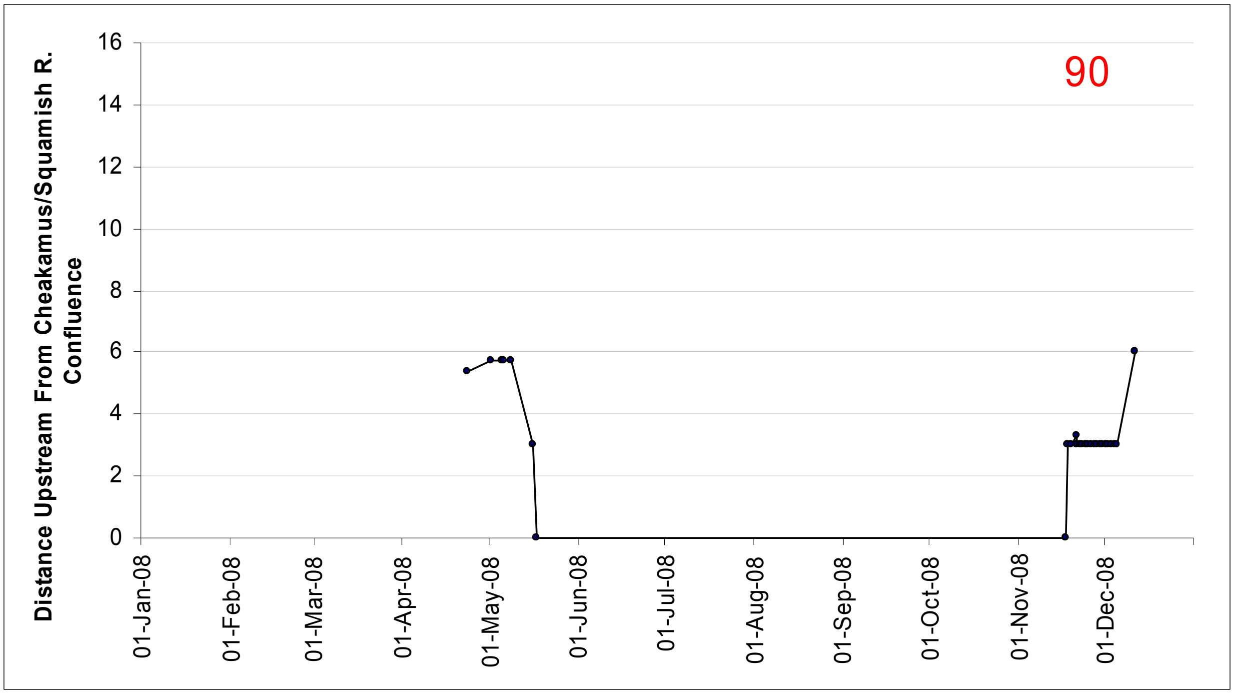
01-Nov-08
01-Dec-08


90
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
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01-May-08
01-Jun-08
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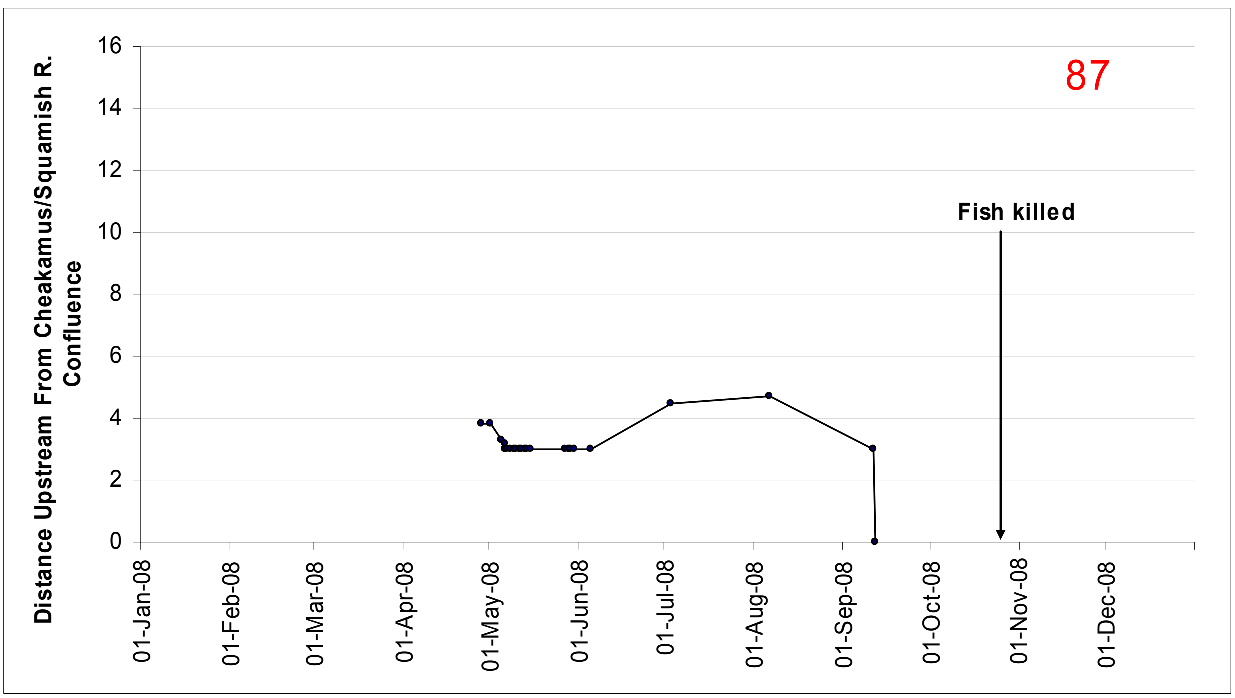
01-Nov-08
01-Dec-08


87
Fish killed
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
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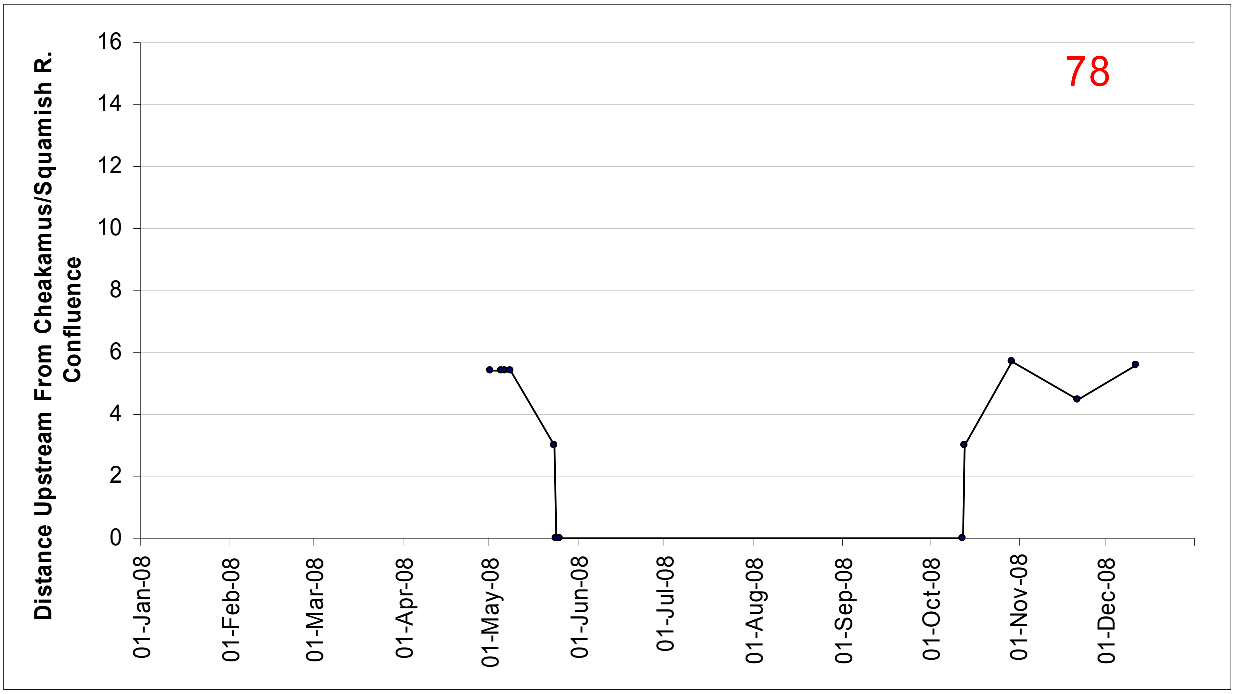
01-Nov-08
01-Dec-08


78
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
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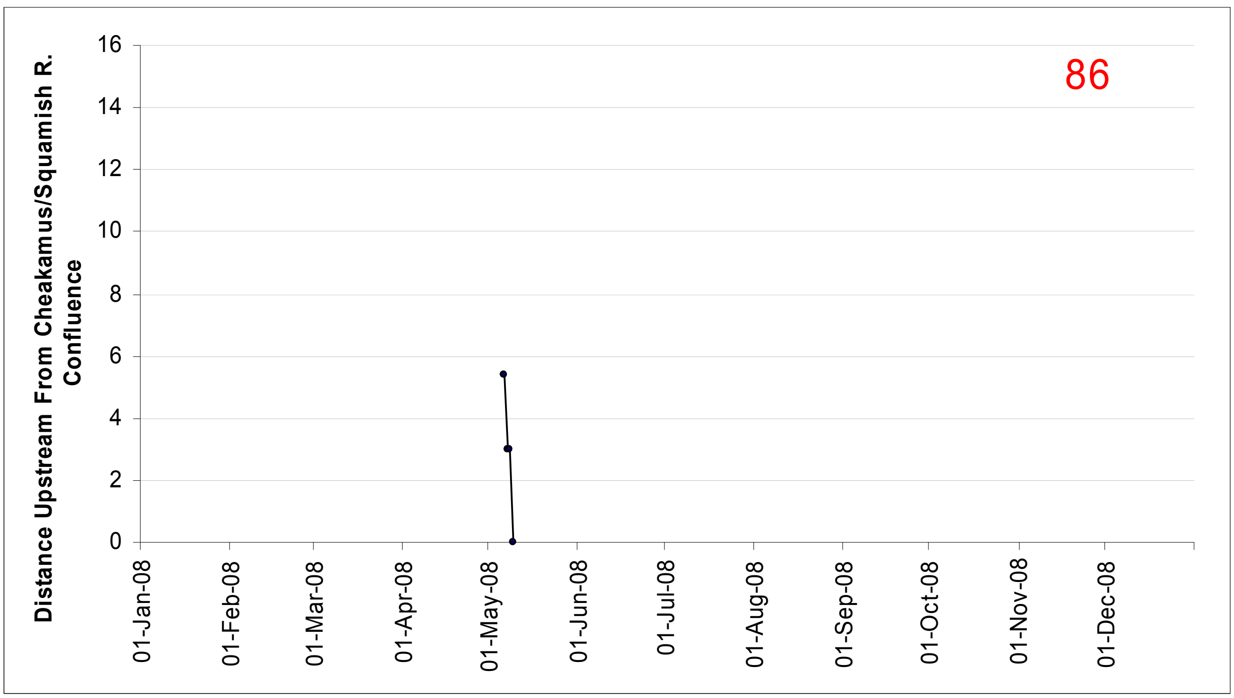
01-Nov-08
01-Dec-08


86
Distance Upstream From Cheakamus/Squamish R. Confluence
16
14
12
10
8
6
4
2
0
01-Jan-08
01-Feb-08
01-Mar-08
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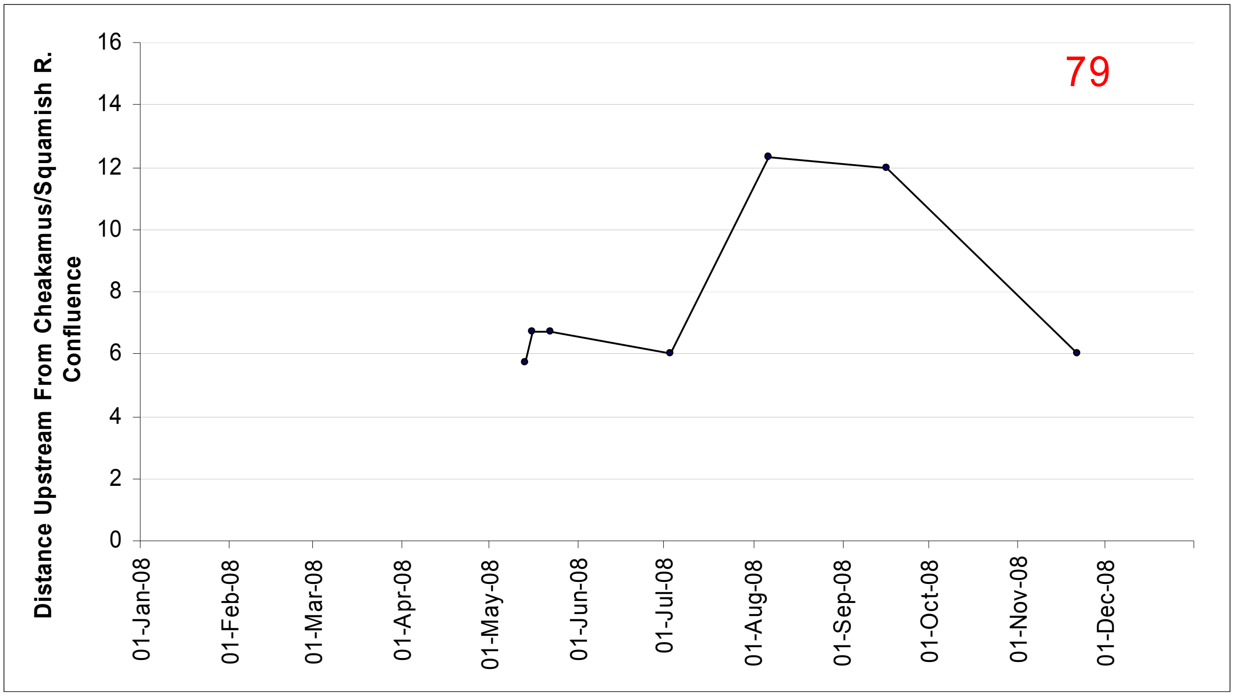
01-Nov-08
01-Dec-08


79
Distance Upstream From Cheakamus/Squamish R. Confluence
0
2
4
6
8
10
12
14
16
01-Jan-08
01-Feb-08
01-Mar-08
01-Apr-08
01-May-08
01-Jun-08
01-Jul-08
01-Aug-08
01-Sep-08
01-Oct-08
01-Nov-08
01-Dec-08