



2007 Creel Survey of the Squamish River Watershed Recreational Fishery

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Summary

As part of the Squamish River Watershed Recovery Plan (Pacific Salmon Foundation, 2005) a need was identified to assess the impact of the recreational fishery in this watershed on its populations of Chinook, pink, chum, and coho salmon. To address this need, a study was conducted between July 27 and December 31, 2007 to determine and investigate the attributes of this fishery that are important for an optimum survey design, and to estimate angler effort and catch with some utility for stock assessment and management. A total of 103 roving survey and 186 access point survey shifts were completed over the course of this study resulting in 2,157 angler interviews representing 6,772 hours of angler effort. A roving-access point survey was identified as the best survey design to estimate angler effort and catch for this fishery. Analysis based on this design estimated angler effort to be 30,450 angler-hours (equivalent to 10,811 angler trips), 15 Chinook salmon released, 42 and 9,203 pink salmon harvested and released respectively, 332 and 1,604 chum salmon harvested and released respectively, and 374 coho salmon released.

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1.0 Stock and Watershed Profile

The Squamish River and its tributaries drain a watershed of about 3,200 square kilometers into the head of Howe Sound in southern Georgia Strait. This watershed supports several species of Pacific Salmon, the most abundant of which are Chinook, pink, chum, and coho along with late-run steelhead. All of these species are targeted by recreational anglers who are drawn to the area by a wide range of quality angling opportunities with relatively easy access.

Through a Salmon Assessment Framework (Pacific Salmon Foundation, 2006), as part of a Squamish River Watershed Recovery Plan (Pacific Salmon Foundation, 2005), a Technical Review Committee representing a broad range of responsible and interested parties, along with the Canadian National Railway Company as an important stakeholder in the area, identified the need to assess the effects of the recreational fishery in this watershed on its populations of Chinook, pink, chum and coho. The most recent assessment of this fishery was conducted in 1998 (Palermo and Thompson, 2000) which focused only on the lower Squamish River, below and including its confluence with the Cheakamus River in October and November. The terms of reference identified above were significantly broader than this, therefore a study was proposed with primary objectives to determine and investigate the attributes of this fishery that are important for an optimum survey design, and to estimate angler effort and catch with some utility for stock assessment and fishery management. Other objectives were identified to gather data on harvest of non-target species, fishing methods and gear, biological attributes of the catch, and some angler characteristics.

2.0 Methods

2.1 Study Design

A number of survey designs have been developed to provide for unbiased estimates of effort and catch in recreational fisheries each with different sets of assumptions and efficiencies. Following generally accepted notation, where the first and second terms denote the methods used to estimate effort and catch rate respectively, four commonly-used potential on-site survey designs were identified for this study including roving-roving, roving-access, and access-access designs described by Pollock (1994), and a roving*access-access design (also referred to as a hybrid design) described by Schubert (1995). A decision framework was constructed to determine the optimum design for this fishery which considered the nature of its attributes relating to angler access to the fishery, the stability of catch rates for target species, and daily angler activity (Figure_2).

A preliminary on-site reconnaissance of recreational fishing locations in this fishery was conducted prior to the beginning of this study, which found a number of easily accessed locations with both diffused and focused access, as well as high- and low-volume angler use. The Squamish River

Road and Squamish Main (Squamish Valley Road) run parallel to the Squamish River mainstem along its entire length providing easy access to multiple fishing locations. Roads on both sides of the Mamquam River afford easy access to fishing locations up to Ring Creek. An all-weather road and trail network provides extensive access to fishing locations along the Ashlu River to the first bridge crossing. A potential for focused access was found at shoreline trail exits on the Cheakamus River between the Bailey Bridge and Sunwolf, however diffused access was found downstream from there to its confluence with the Squamish River. These findings indicated limited practicality and efficiency for estimating angler effort using an access-access design so this was not considered as a general option pending further investigation during the study. Palermo and Thompson (2000) reported stable catch rates for chum and coho in a 1998 survey of the lower Squamish River recreational fishery during October and November, however no work had been done to determine whether recreational catch rates are stable for other species outside of these boundaries. Similarly, daily angler activity profiles were reported to be relatively flat and low suggesting that a roving*access-access method would be inefficient and result in low precision estimates, however no structured information was available for angler activity profiles outside of that survey.

Concurrent access point and roving surveys were implemented to investigate these attributes. The distribution of angler access to this fishery and angler activity profiles were investigated using complete-trip data collected through the access point survey. The stability of catch rates were investigated by testing for differences in catch rates estimated with incomplete-trip data collected through the roving survey with complete-trip data collected through the access point survey. These surveys were also structured to provide data with utility to estimate angler effort and catch with either roving-roving, roving-access, or roving*access-access designs, albeit not necessarily with high precision given the need to satisfy multiple objectives.

Comprehensive spatio-temporal survey frames were identified so that all of the fishing activity of interest was included and fishery regulations were considered (Appendix_1). The recreational target species identified in the terms of reference for this study defined its provisional boundaries as the mainstem of the Squamish River from its confluence with the Elaho River to a lower boundary at $49^{\circ} 43.775' N$ x $123^{\circ} 09.648' W$, the Mamquam River up to its confluence with Ring Creek, the Cheakamus River up to a suspension bridge crossing below Cheakamus Canyon, and the Ashlu River up to the first bridge crossing below Ashlu Canyon (Figure_1). Similarly, the temporal boundaries were defined as from the beginning of the Chinook fishery which, given large snow packs that had accumulated in the watershed over previous months, was anticipated to begin in mid-July, through to the end of December, covering most of the subsequent pink, chum and coho fisheries.

Survey time frames were stratified into twelve period strata, each covering about two weeks to provide for in-season, bi-weekly survey reviews and adjustments. Each of these were further stratified by day type (weekday and weekend) and shift (early and late). Shift times divided average daylight hours (Figure_3) in each survey period into 2 equal time periods with no overlap (these are shown at the bottom of survey schedules presented in Appendix_2). Survey effort was allocated to temporal strata based on 1) an approximately equal allocation over survey periods, 2) 40% and 60% allocated to weekend and weekday day types respectively given that weekend angler effort is typically higher in recreational fisheries, and 3) an equal allocation to each shift type (Table_2). In total, 5 roving and 14 access point shifts were allocated to July, between 20 and 24 roving shifts

and 40 to 48 access point shifts were allocated to each month between August and November, and 12 roving shifts were allocated to December. Within each period, primary sampling units (calendar dates) were selected according to random sampling without replacement for both access point and roving surveys (Appendix_2).

Spatial strata for these surveys were defined as a set of confluences between the Squamish River and its tributaries which support a significant abundance of target species. Five spatial strata were initially defined for the survey area (Figure_1, Table_1) as 1) Zone 1 on the Squamish River mainstem between the lower survey boundary marked by a outfall conduit at 49° 43.775' N x 123° 09.648' W and a powerline crossing 1.6 kms upstream from the confluence of the Squamish and Cheakamus Rivers, 2) Zone 2 on the Cheakamus River from its confluence with the Squamish River to a suspension bridge crossing below Cheakamus Canyon, 3) Zone 3 on the Squamish River from the upper boundary of Zone 1 to its confluence with the Ashlu River, 4) Zone 4 on the Ashlu River from its confluence with the Squamish River to the first bridge crossing below Ashlu Canyon, and 5) Zone 5 on the Squamish River between its confluences with the Ashlu and Elaho Rivers. Zone 1 was further divided into three strata from October to December in order to isolate Mamquam River effort and catch, and to harmonize spatial strata with those defined for the 1998 survey of the lower Squamish River. These were defined as 1) Zone 1.1 on the Squamish River extending from the lower boundary of Zone 1 to its confluence with the Mamquam River, 2) Zone 1.2 covering the Mamquam River up to Ring Creek, and 3) Zone 1.3 on the Squamish River from its confluence with the Mamquam River to the upper boundary of Zone 1 at the powerline crossing. The allocation of survey effort to spatial strata was based on a bi-weekly assessment of the distribution of angler counts across zones collected through the roving survey. After calendar date (the primary sampling unit), secondary sampling units were defined only for the access point survey as a fishing location and were selected with probabilities according to the bi-weekly assessments of angler distribution (Table_2). Of 30 fishing locations that were catalogued, 5 were given a sampling probability of 0 where very little angler activity was observed or anticipated (less than an average of one angler per day), with the remaining locations given sampling probabilities between 0.03 and 1.0.

2.2 Operational Procedures

2.2.1 Roving Survey

A clerk transited most of the survey area by car according to 1 of 6 route plans selected according to random sampling with equal probability for each roving shift (Appendix_3). Clerks accessed fishing locations on the Squamish River between Lower Boundary and its confluence with the Cheakamus River from secondary roads leading off Government Road through Squamish, Brackendale, and with permission, Squamish First Nations Reserve lands. Fishing locations on the Squamish River between its confluence with the Cheakamus River and Powerhouse Channel were accessed from the Squamish Valley Road, and on the Ashlu River along a secondary road leading from the Squamish Valley Road approximately 2 kms downstream from Powerhouse Channel. Mamquam River fishing locations were accessed along secondary roads up to the Garibaldi Park Road on the north side of the river and a commercial gravel pit operation on its south side. The

Cheakamus River downstream from the Highway 99 crossing was accessed either at Sunwolf or the Stables, and by foot above the Highway 99 crossing to the Bailey Bridge along a trail on its eastern shoreline when water levels allowed. The Cheakamus River above the Bailey Bridge was accessed along the Paradise Valley Road as far the Suspension Bridge. Active anglers were intercepted and interviewed for catch, effort, and other information, including whether or not they were being guided, residence, gear used, species targeted, and biological data from harvested catch, while a concurrent progressive angler count was also conducted by the same clerk (Appendix_4). To minimize the shadow effect during each progressive count, which is a cumulative reduction in the probability of encountering anglers subsequent to each interview (Wade et al, 1991), the clerk was required to reach an established check point at least half-way through the progressive count, pre-determined as the approximate geographic mid-point of the route. If intensive fishing activity was encountered during a progressive count the clerk implemented sequential subsampling of active anglers in order to arrive at the appropriate check point on time. Mean times through each zone and period were examined for randomness using a runs test (Bradley, 1968). These showed order independence ($p > 0.05$) for all cases.

2.2.2 Access Point Survey

All anglers exiting from the fishery at selected access points were counted, intercepted, and interviewed for information relating to effort, catch, and other information including whether or not they were guided, their residence, gear used, and species targeted (Appendix_4).

2.2.3 Aerial Survey

A limited aerial survey was implemented to 1) determine the utility of this method to count anglers in the survey area, and 2) to determine if the sampling frame was covering all of the active fishery. Flights were conducted using a Cessna Skyhawk on wheels from the Squamish Municipal Airport, starting at the confluence of the Squamish the Cheakamus Rivers, then up to Swift on the Cheakamus River before turning west down the Pilchuck River, then up the Squamish River provisionally to furthest extent of anticipated significant angling effort (at least to High Falls Creek) before turning back down the Squamish River to the Ashlu River, then to the lower survey boundary at $49^{\circ} 43.775' N$ x $123^{\circ} 09.648' W$. Where possible, flights were done at an altitude of 500 ft. AGL with a pilot and one observer. Flight times were set to begin at 1200 hours and adjusted if needed to occur at times of relatively high levels of angler activity as determined through the access point survey. The observer on these flights counted active anglers (rods) in the survey area noting the time, location, and mode (bank or boat) of each count on a flight record chart.

2.3 Data Analysis

Data collected through both roving and access point surveys were analyzed to 1) investigate the distribution of angler access 2) test for stable catch rates, and 3) investigate angler activity profiles.

Effort and catch estimates were subsequently calculated on the basis of the best survey design determined by this analysis.

2.3.1 Angler Access

The distribution of angler access determines, in part, the appropriate method(s) both to estimate angler effort and catch rate. Where angler access is focused at a few points, an access-access design is an efficient method both to estimate effort and an unbiased catch rate. Where angler access occurs at multiple points and/or is diffused, other design options must be considered including roving-roving, roving*access-access, and roving-access designs. Further, where catch rates are estimated using complete-trip data through access points, such as for roving*access-access and roving-access designs, some relatively high-use access points through which catch rates are representative of the area need to be present. The distribution of angler access was initially investigated through a preliminary reconnaissance which found multiple access points along the Squamish, Ashlu, and Mamquam Rivers, diffused access to the Cheakamus River downstream of the Highway 99 crossing, and a potential for focused access to the Cheakamus River above this point to the Bailey Bridge (see 2.1 above). This was investigated further where, using access point survey data, angler effort flow through each of 6 access points on the Squamish and Mamquam Rivers that were selected with relatively high probabilities was estimated using the direct expansion method described by Pollock (1994) and compared with effort estimated using roving survey data. This showed that a substantial proportion of angler effort (83%) estimated for the Squamish, Mamquam, and Ashlu Rivers used these access points. It was also found that almost all of the angler access to the Cheakamus River upstream of the Highway 99 occurred at the Bailey Bridge and Sunwolf both of which were sampled with a high probability. Most sites on the Squamish, Mamquam, and Ashlu Rivers within a zone were associated with a continuous section of river and were defined for practical purposes, where a survey clerk could view and intercept all of the anglers exiting from that site, rather than for unique attributes, so negligible differences between sites within the same zone were expected. These findings indicated high-volume access points in each zone, through which angler catch rates were similar to those in other parts of the zone, which could support both roving*access-access and roving-access designs.

2.3.2 Catch Rate Estimators

Stability of the catch rate through an average fishing trip was assessed to determine the appropriate method for calculating an unbiased estimator. Where there are multiple angler access points or where angler access is diffused, the roving method can be used to collect angler catch rate data efficiently provided that catch rates are stable, however because anglers are intercepted part way through their trip in a roving survey, this method will produce bias estimators if catch rates are unstable (Hoenig, 1997) in which event catch rate estimators must be calculated from complete-trip data collected through an access point. To determine whether catch rates were stable, the hypothesis was tested that catch rates based on incomplete- and complete-trip data, collected through the roving and access point surveys respectively, were not significantly different. Typically, catch rates in recreational fisheries are not normally distributed so a Shapiro-Wilk W statistics and corresponding p-values (Royston, 1995) were calculated for 32 sets of data by

period, zone, species, and catch rate (harvest or release rate) to test for normality. These showed that catch rates for this fishery were not normally distributed, a key assumption for parametric testing. Following MacKenzie (1991), an alternative distribution-free test using the Mann-Whitney U statistic was calculated for each set of data. The power-efficiency for this test is at least 86% of comparable parametric tests for normally distributed data, and is greater for distributions that are not normally distributed (Wilcoxon, 1964). A relatively high value for α ($\alpha=0.20$) was set to minimize the chance of a type II error that could lead to the erroneous conclusion that catch rate estimators were equivalent when they were not. Results for 14 of 32 sets of data tested (Table_3, Appendix_5) showed significant differences ($P<0.20$) between incomplete- and complete-trip catch rates indicating they were unstable, therefore catch rates needed to be calculated from complete-trip data collected through access points.

2.3.3 Angler Activity Profiles

English (1986) found that the co-efficient of variation (CV) of an effort estimate, calculated for a roving*access-access survey as an average effort count adjusted for a proportion of daily effort active at any given time (angler activity profile), denoted as P , can increase rapidly for values of P that are less than 20% where, assuming a binomial distribution for P , variance of P is calculated as $(P(1-P))/N$ and its CV can be estimated as $\sqrt{(1/P-1)/N}$. For this study, angler activity profiles were calculated generally according to DPA Consulting (1982) using access point survey data related to the times at which each angler trip started and finished, so that individual trips active in each one-hour block at a fishing location were given a value of one divided by a probability π of selecting that location, then summed and divided by the total value for all trips across all locations within day type and zone strata by month with sufficient data (Appendix_6). Angler profiles for most strata showed low peaks in activity usually occurring in mid- to late-morning. Peak values were greater than 20% in only 4 of 16 profiles with only one profile that was greater (marginally) than 25%. This indicated that while a roving*access-access survey may provide for an unbiased catch and effort estimates, there could also be a significant variance component associated with P that is added to these estimates.

2.3.4 Effort and Catch Estimation

Based on the decision framework described in Section 2.1 above, a roving-access survey design was determined to be the best single method for making precise and unbiased effort and catch estimates for this fishery where multiple angler access points, unstable catch rates, and relatively low and flat angler activity profiles were found. Therefore, angler effort was estimated using angler count data collected through the roving survey, and catch rates were estimated using complete-trip data collected through the access point survey. Effort was estimated as the product of the mean effort estimate by shift type and the number of days by day type within a period and zone; catch rate (harvest or release per angler-hour) was calculated as a ratio-of-means estimator. This is the appropriate estimator when catch rate data are taken from completed fishing trips (Hoenig, 1997). Catch (harvest or release) was estimated as the product of the catch rate and effort estimate by shift type and day type within a period and zone. These estimates were summed over day type and period then reported by month.

Generally following notation used by Bernard (1998), angler effort in units of angler-hours was estimated as follows:

$$\bar{E}_{ihj} = T_j * \left(\sum_{t=1}^r x_{iht} / r \right) \quad (1)$$

where \bar{E}_{ihj} is the mean number of angler-hours over shift type i for day type h in biweekly period j , T_j is the shift duration for period j which is the time between mid-day and either sunrise or sunset (Figure 3), t is an individual progressive roving angler count, r is the number of progressive roving counts conducted over shift type i , and x is an angler count.

Estimated total monthly effort \hat{E}_l was calculated for month l as:

$$\hat{E}_l = \sum_j \sum_h \sum_i D_{hj} * \bar{E}_{ihj} \quad (2)$$

where D_{hj} is the total number of day type h days in period j .

Variance of the effort estimate over shift type i for day type h in period j , $v(\hat{E}_{ihj})$, was calculated as:

$$v(\hat{E}_{ihj}) = \sum_{t=1}^r (\bar{E}_{ihj} - (T_j * x_{it}))^2 / r - 1 \quad (3)$$

The variance of the effort estimate for month l , $v(\hat{E}_l)$ was calculated as;

$$v(\hat{E}_l) = \sum_j \sum_h \sum_i v(\hat{E}_{ihj}) \quad (4)$$

The standard error of the effort estimate for month l , $SE(\hat{E}_l)$, is;

$$SE(\hat{E}_l) = \sqrt{v(\hat{E}_l)} \quad (5)$$

Catch rates, estimated for the harvest and release of each species separately, were calculated as a ratio-of-mean harvest and mean effort following Schubert (1995) and Hoenig (1997) as follows;

$$\overline{cpue}_{ihj} = \sum_p \sum_{k=1}^{m_i} c_{kihjp} / \pi_{pj} \bigg/ \sum_p \sum_{k=1}^{m_i} e_{kihjp} / \pi_{pj} \quad (6)$$

where \overline{cpue}_{ihj} is the estimated mean catch rate, as a general case for harvest or release rate estimators, over shift type i for day type h in period j , k is an individual fisher, m is the number of anglers interviewed over shift type i , c is a number of fish caught reported by angler k , e is a

number of angling*hours reported by fisher k , π_{pj} is the probability of selecting site p in period j (Table_2). Note that since all anglers exiting access points were intercepted for an interview, weighting factors to account for varying proportions of anglers intercepted for an interview between sites were not included in equation (6).

Following Thompson (1992), variance for catch rate estimators, $v(\overline{cpue}_{ihj})$, over shift type i for day type h in period j , were calculated as:

$$v(\overline{cpue}_{ihj}) = \sum_{k=1}^{m_i} (c_{kihj} - e_{kihj} \overline{cpue}_{kihj})^2 / \overline{e}_{ihj}^2 * m_{ihj} * (m_{ihj} - 1), \quad (7)$$

Catch, as a general case for harvest or release, was calculated as the product of effort and catch rate as;

$$\hat{C}_{ihj} = (D_{ih} * \overline{E}_{ihj}) * \overline{cpue}_{ihj} \quad (8)$$

where \hat{C}_{ihj} is the catch estimated for shift type i for day type h in period j .

Variance of the estimated catch was calculated as;

$$v(\hat{C}_{ihj}) = \hat{E}_{ihj}^2 * v(\overline{cpue}_{ihj}) + \overline{cpue}_{ihj}^2 * v(\hat{E}_{ihj}) - v(\overline{cpue}_{ihj}) * v(\hat{E}_{ihj}) \quad (9)$$

where $v(\hat{C}_{ihj})$ is the variance of the catch estimated over shift type i for day type h in period j following Goodman (1960) for the variance of products of two independent variates for which variance components are estimated, and \hat{E}_{ihj} is the estimated effort over shift type i for day type h in period j calculated as the term $D_{ih} * \overline{E}_{ihj}$ shown in equation (8) above.

Variance of the catch estimate for month l , $v(\hat{C}_l)$ was calculated as;

$$v(\hat{C}_l) = \sum_j \sum_h \sum_i v(\hat{C}_{ihj}) \quad (10)$$

The standard error of the catch estimate for month l , $SE(\hat{C}_l)$, is;

$$SE(\hat{C}_l) = \sqrt{v(\hat{C}_l)} \quad (11)$$

3.0 Results

3.1 Operational Results

Snow pack levels were measured at 1,463 mm (water equivalent) on the upper Squamish River (Station 3A25P) by the Water Stewardship Division of the British Columbia Ministry of the Environment on June 15, 2007 which is 1.8 times greater than the sixteen-year normal level for this date (820 mm). This resulted in prolonging high flow on the Squamish River and its tributaries by almost one month so that most fishing locations on the river were not exposed until late July. Survey operations were held on standby from mid-June until late July when both roving and access point surveys were implemented (July 27). Both surveys were conducted continuously to the end of November, then the roving survey was extended through December. The roving survey covered Zones 1 to 5 (up to High Falls Creek) from late July to November. This was reduced to Zones 1 and 2 through December when snow covered the Squamish Valley Road past the Cheakamus River limiting access to upper Squamish River survey zones. Similarly, the access point survey covered Zones 1, 2, and 5 from late July to September, then Zones 1 and 2 for October and November. Zones 3 and 4 were not covered through the access point survey on the basis of bi-weekly reviews of roving angler counts and the aerial survey indicating very limited or no angling activity in those areas. Similarly, Zone 5 was provisionally not covered after the end of September, contingent on continued nil roving angler counts through the zone, given that no anglers had been observed there from late July to September through either the roving or access point survey. Those survey resources were reallocated to provide for additional spatial strata on the lower Squamish and Mamquam Rivers. A total of 185 access point survey shifts were completed resulting in 712 angler interviews (Table_4). Similarly, 105 roving shifts were completed resulting in a total of 1,445 angler interviews of 1586 anglers counted (Table_5).

The aerial survey was limited to two weekend-day flights: one flight in August and one in September. These covered all expected fishing locations on the Cheakamus River from its confluence with the Squamish River to Swift, and on the Squamish River from the lower survey boundary to High Falls Creek. These flights were found to be useful in observing parts of the survey area not easily accessible from the ground, particularly in Zone 3, and provided a means to identify all fishing activity in much of the survey area including most of the Squamish, Mamquam, and Ashlu Rivers. However, aerial surveys of the Powerhouse Channel on the Squamish River, on the Cheakamus River between Sunwolf and the North Vancouver Outdoor School property, and at the Suspension Bridge on the Cheakamus River were less effective where the forest canopy overhangs several shoreline fishing locations.

3.2 Angler Effort and Catch

Total angling effort on the Squamish River Watershed from July 23 to December 31 was estimated to be 30,450 angler-hours (SE=406) which is equivalent to an estimated 10,811 angler trips based on access point survey interview data where the mean completed trip length was calculated to be 2.8 hours (Table_6). Effort generally peaked over two periods during the study, first coinciding with migrating pink in August and early September, then with migrating chum and coho in October and

November (Figure_4). Discharge rates on the Squamish, Cheakamus, and Mamquam Rivers had a dampening effect on effort, particularly in October and November when volume on the Squamish River reached 500 m³/sec and over on three occasions. Over 50% of total angler effort occurred during August and early September in Zone 1 where anglers targeted migrating pink primarily along the extended bar on the Squamish River adjoining and downstream of its confluence with the Mamquam River. A further 28% of total angler effort occurred in October. While still fishing on the Squamish River, primarily at Fisherman's Park and at its confluence with the Cheakamus River, anglers expanded into Zone 2 on the Cheakamus River in October targeting first chum then coho after chum non-retention came into effect on November 2. Almost 15% of total angler effort occurred in November, evenly divided between the Squamish River at Fisherman's Park and its confluence with the Cheakamus River, and the Cheakamus River primarily at and adjacent to Sunwolf. Negligible angler effort occurred in December when significant snowfall combined with high flows on the Squamish River (up to 800 m³/sec) limited access and opportunity to the fishery during much of the month. Almost no angler effort was observed in Zones 3 to 5 through either the roving, access point, or aerial surveys. Few recreational locations are available to the public in Zone 3, and although it was anticipated that anglers would access this zone by jet or drift boats, none were observed through these surveys. Very limited effort was observed in Zone 4, the Ashlu River, where for much of the study at least two grizzly bears took up residence in this area deterring anglers from fishing normally productive pools on the lower part of this river. Typically a location where Chinook are targeted in June, July, and August, no anglers were observed at the Powerhouse Channel in Zone 5 during the survey.

Estimates of angler catch rates (harvest and release) and catch were made for 4 species of salmon including Chinook, pink, chum, and coho by month and zone (Table_6, Figure_5). Other species were observed or reported including char, cutthroat trout, and rainbow trout. Total catch of Chinook is estimated to be 15 fish (SE=11), all taken on the Cheakamus River and reported as released. One harvested female Chinook (>55 mm) was observed through the access point survey. It is believed that the prohibition on harvest of Chinook over 55 mm was well understood by anglers in this fishery so this event was considered to be an anomaly therefore not included in the catch analysis. Pink were the most numerous species caught in this fishery, almost all of which were released. A total of 9,203 pink (SE=1318) were estimated to have been caught and released almost exclusively during August and September in Zone 1. A estimated harvest of 42 pink (SE=41) was based on the observation of 3 individual fish through the access point survey. Although the retention of pink in this fishery was prohibited throughout the study period, some confusion was noted among anglers about this regulation so these data were included in the catch analysis as representing the angling population. The chum catch was estimated to be 332 (SE=124) harvested and 1,604 (SE=218) released. No chum harvest was reported or observed after November 2 when chum non-retention came into effect. Chum were caught exclusively during October and November mostly in Zone 1.3 on the Squamish River and Zone 2 on the Cheakamus River. An estimated 374 coho (SE=94) were caught and released from September to November. About 68% of this catch occurred in October and was evenly divided between the Lower Squamish River and the Cheakamus River. Char, cutthroat trout, and rainbow trout were also reported or observed through both the roving and access point surveys. Nine char and 2 rainbow trout released on the Cheakamus River were reported in the roving survey for October and November. The release of 4 cutthroat trout on the Cheakamus River and 1 cutthroat trout on the lower Squamish River were observed or reported in the access point survey in August and September.

Similarly, 1 char on the lower Squamish River, and 2 char on the Cheakamus River were observed or reported in the access point survey in October.

3.3 Angler Characteristics

Data for angler characteristics relating to target species, attractors, angler residence, and guided trips were collected through both the roving and access point surveys as part of the interview process. Note that given potential avidity bias, where more avid anglers have a higher probability of being interviewed, these data do not necessarily indicate the proportion of total individual anglers in each category, rather they indicate relative effort in each category.

Target species changed with salmon migration timing and regulation. Between 80% and 99% of the angling effort was observed targeting pink between July and September as they migrated into the Squamish River watershed where, during odd years, they dominate the species composition at that time (Table_7). In October, as chum and pink began to migrate into the watershed, targeted species switched to chum (50%), coho (16%), and combined chum_coho (27%). As a result of regulation changes on November 2, when chum retention was no longer permitted, target species switched to coho (51%) and combined chum_coho (18%). Coho was reported to be the exclusive target species in December.

The composition of attractors favoured by anglers changed with target species. Between 64% and 70% of anglers targeting pink used flies (Table_8); consequently, 78% of pink were caught on a fly (Table_9). As target species shifted to chum and coho in October and November, the percentage of fly use declined to 42% while the use of lures and wool increased to 56%; correspondingly, 75% of chum were caught either with a lure or wool, and 78% of coho were caught on a lure. Three Chinook observed in the access point survey were caught either with a lure or wool, 88% and 13% of char were caught with a lure or fly respectively, and cutthroat were caught either with a fly (13%), lure (50%), or bait (38%).

Most of the angling effort in this fishery originated either from local communities in Squamish and Brackendale (34%) or from the surrounding region in Whistler and Vancouver (54%) (Table_10). Another 8% of the angler effort came from the U.S., most of which occurred in July and August. The remaining 4% of anglers interviewed originated from other British Columbia communities, other parts of Canada, or outside of North America. Most trips were unguided (94% of angler interviews); guided trips generally occurred on the lower Squamish River targeting pink with flies. Most guided angler effort was from the U.S., and about 60% of the angler effort from there was guided.

3.4 Biological Samples

Very limited opportunities were available to collect biological samples from the catch. Data were collected from only 8 chum, all harvested in late October in Zone 1.3 (Appendix_7). This sample was comprised of 2 females and 6 males caught between October 20 and October 28 for which a mean fork length was calculated at 721 mm (SE=23).

4.0 Discussion

The primary objectives of the current study, to investigate the attributes of this fishery important to a survey design, and to develop and implement an appropriate survey to estimate angler effort and catch, were largely addressed. Multiple access points and diffused angler access, unstable catch rates, and relatively low and flat angler activity profiles were found in this study. Therefore, a roving-access survey design was determined to be the best method to estimate angler effort and catch. An equivalent roving*access-access survey design may also provide for unbiased estimates however potentially with lower precision. The precision with which effort and catch were estimated in this study provide high utility for assessment and management purposes for total effort (CV=1.3%), and total release of the main target species including pink (CV=14.3%), chum (CV=13.6%), and coho (CV=25.0%). Harvest rates for these species showed higher variance resulting in lower confidence for harvest estimates, however harvest opportunities and events in this fishery were very limited by regulation. Chinook catch reported in the access point survey was a very rare event, where only three individual fish were documented, resulting in low precision on the estimate (CV=75.2%). In the context of the current fishery, it is doubtful whether any survey design short of approaching a census could provide an estimate for Chinook catch with the precision that is possible for main target species.

Survey results for Zones 1.1 and 1.3 can be compared to results from the 1998 survey of the lower Squamish River recreational fishery for October and November. These show that while effort in October was roughly the same over these years (7,165 angler-hours in 1998 compared to 6,537 angler-hours in 2007) November effort in 2007 (2,456 angler-hours) was only 32% of that estimated in 1998 (7,571 angler-hours). Mean trip length changed by 18% over these years from 3.7 hours in 1998 to 3.0 hours in 2007. Chum catch rate was 85% lower in 2007 than in 1998 estimated at 0.099 and 0.67 chum/angler-hour respectively. Similarly, the coho catch rate in 2007 (0.00725 coho/angler-hour) was 62% of that estimated in 1998 (0.0117 coho/angler-hour).

5.0 Recommendations

In relation to the primary objectives of the current survey, it has been shown that, as a general approach, a roving-access design can provide unbiased estimates with relatively high precision for effort and target species catch for this fishery. This design can be refined and re-focused to provide for fishery estimates with greater efficiency and more definition with the following recommendations:

- Incorporate three-stage sampling where days are sub-sampled (shifts). Citing potential length-of-stay bias, Bernard (1998) cautioned against sub-sampling days where fisheries are based on highly migratory species exhibiting short-term abundance for which restrictive bag limits have been imposed. However, there is no apparent mechanism that might lead to this kind of problem for the current Squamish River Watershed recreational fishery, where either much of the fishery is catch and release, or aggregate bag limits are high relative to potential harvest. Should a mechanism develop which triggers anglers to exit the fishery, such as a restrictive bag limit, sampling may need to be scheduled to cover the entire fishing day.

- Incorporate non-uniform probability sampling for access point sites within spatial strata to optimize sample size and minimize variance on a Horvitz-Thompson catch rate estimator (Cochran, 1977). Assuming a similar fishery regime, sampling probabilities can be provisionally based on a function of roving counts observed by fishing location and estimated variance of the catch rate estimators in the current survey.
- Implement an operational protocol where both roving and access point data are collected during a sampled period (shift) for a zone by the same clerk. This protocol would require the clerk to transit the zone at least twice during each shift to conduct an instantaneous angler count and spend the remaining time at a selected access point interviewing exiting anglers. This will provide for daily estimates of effort, catch rate, and catch where variance can be calculated between days.
- Consider an access-access survey design for the Cheakamus River between Sunwolf and the Bailey Bridge. A review of angler access to this part of the Cheakamus River, where most of the angling effort was found, indicated that anglers access this part of the fishery almost completely through either Sunwolf or the Bailey Bridge. This design would provide for unbiased estimates of catch and effort, and relatively more anglers could be intercepted with this design compared to a roving-access design for which the clerk would need to spend a considerable part of each shift in transit conducting instantaneous counts.
- Implement Zone 1.1, 1.2, and 1.3 strata (2007) for all survey periods. This will provide for estimates specific to the Mamquam River and better precision for estimates of effort and catch on the lower Squamish River (below the upper boundary of Zone 1).
- Implement bi-weekly temporal strata that were established for the current study so that survey effort can be adaptively allocated according to significant changes in the fishery regime as a result of factors including regulation and stock abundance.
- Conduct aerial surveys of Zones 3 to 5 on the last weekend of each survey period to monitor for significant angling activity that would require an extension of the survey frame.
- Provisionally focus roving-access survey effort exclusively on the lower Squamish, Mamquam, and Cheakamus Rivers (Zones 1.1, 1.2, 1.3, and 2) contingent on periodic aerial survey observations through Zones 3 to 5.
- Set a minimum of between 40 and 44 shifts per month needed to survey 4 zones over 2 periods each month. The optimum distribution of these shifts between zones over months would depend on spatial-temporal survey frame as a function of survey objectives. These objectives can be mostly easily defined as species targets given the sequential manner over which these occur. Extensions of the spatial survey frame into Zones 3, 4, and 5 would require at least another 8 shifts per month for each zone that is added.

Acknowledgements

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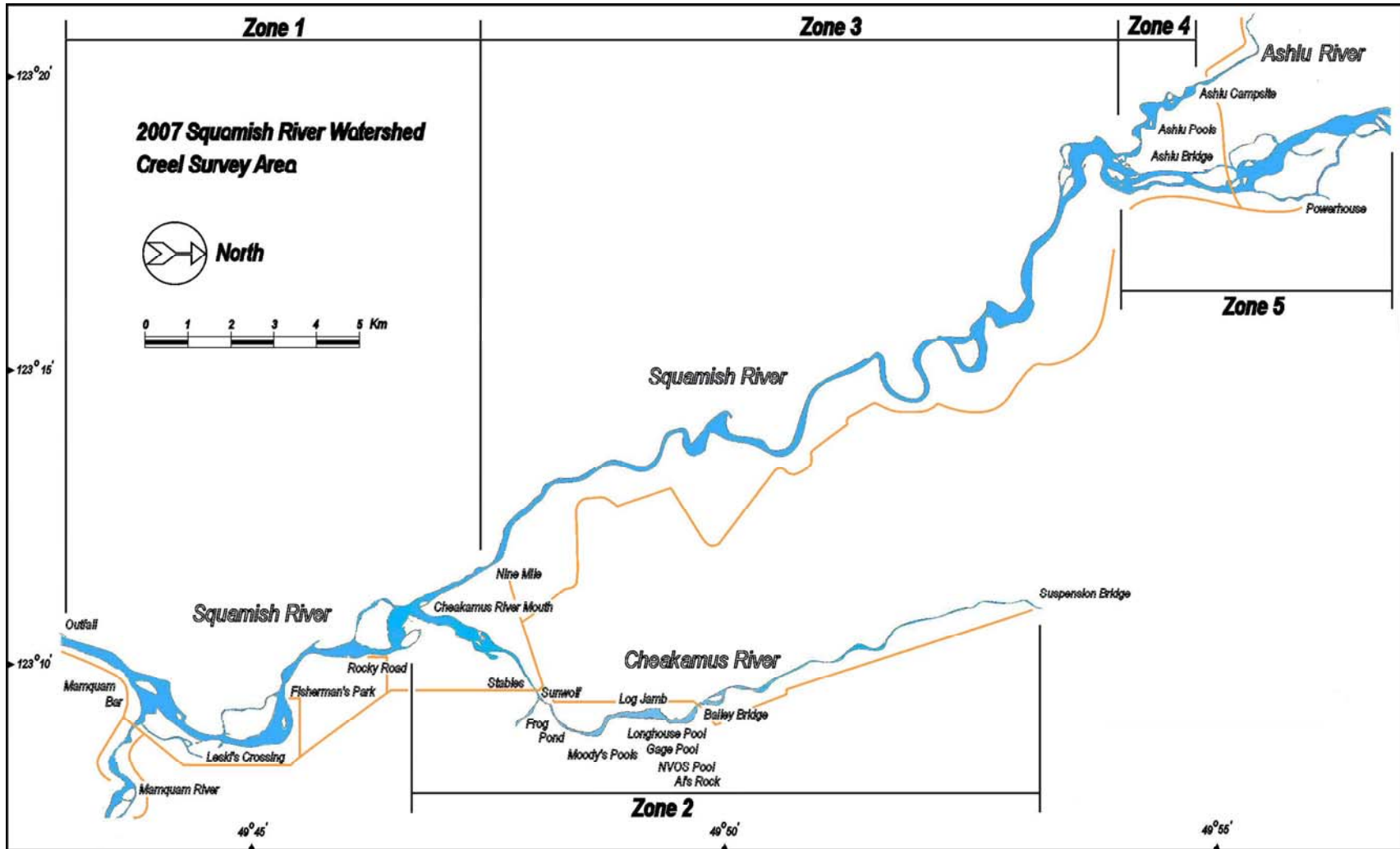
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Figures and Tables



Figure_1. Map of the 2007 Squamish River Watershed Recreational Fishery Survey area, fishing locations, and zones. Main roads are shown as burnt orange.

FISHERY ATTRIBUTES

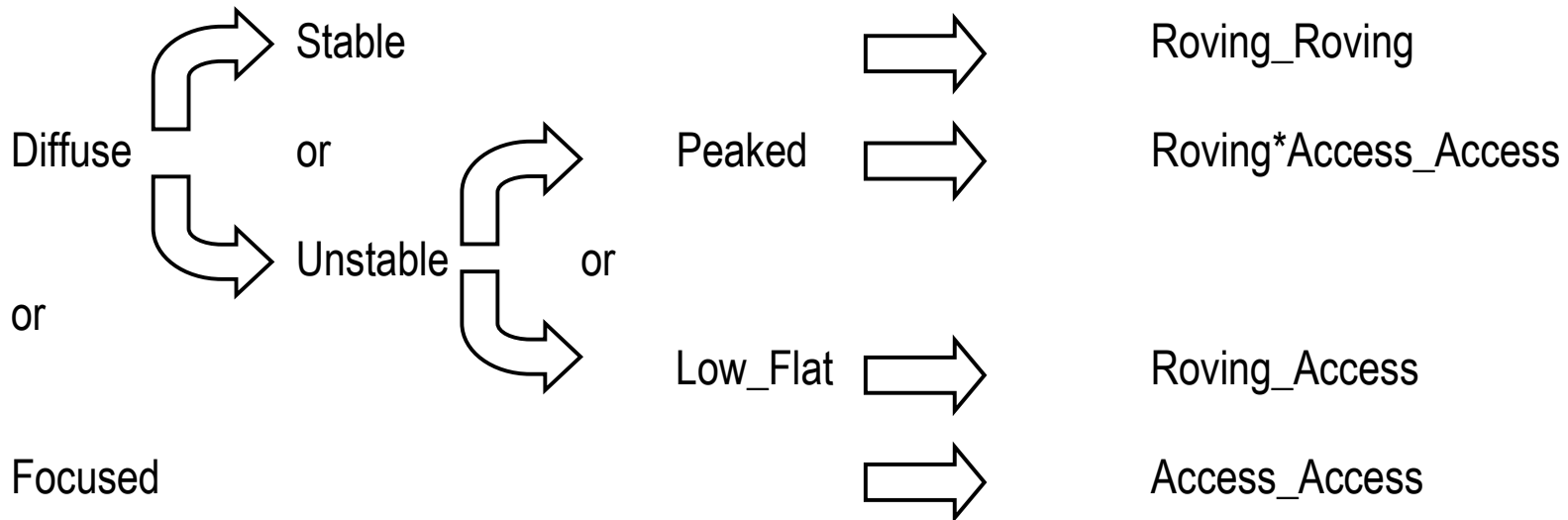
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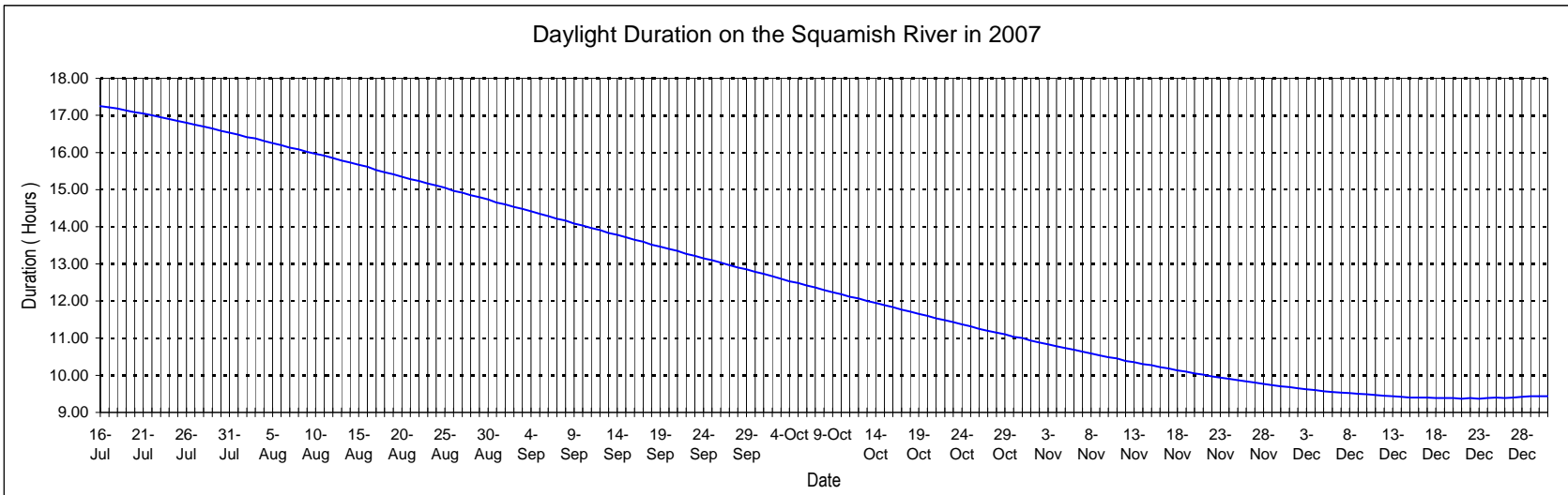
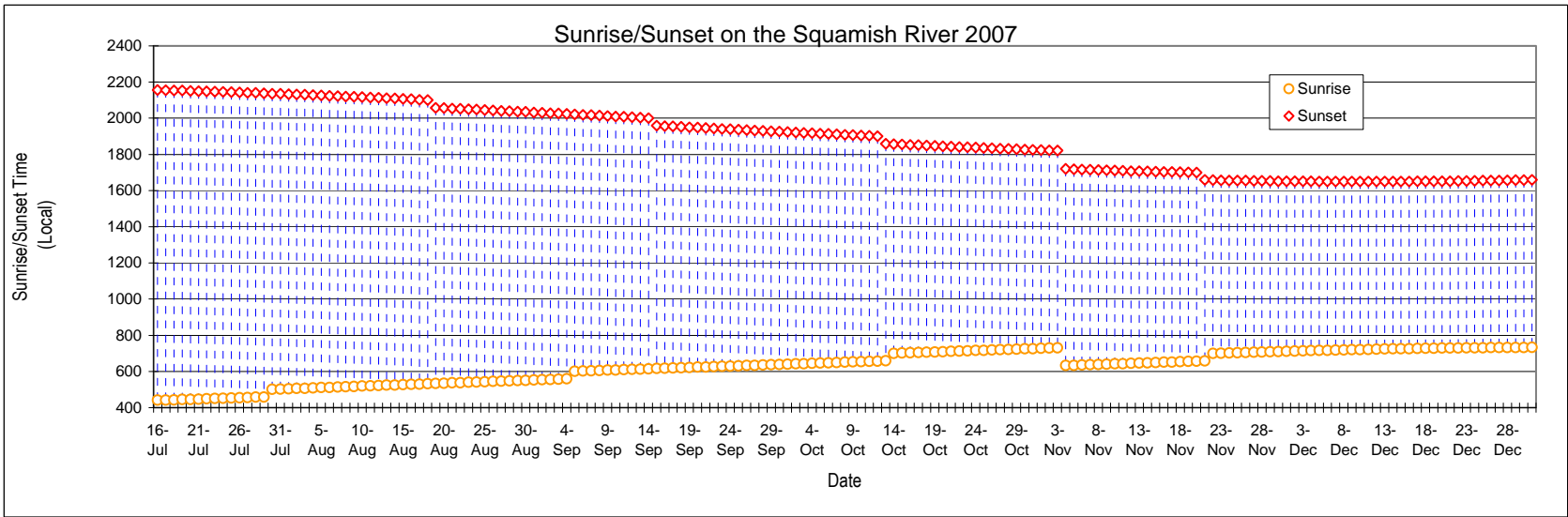
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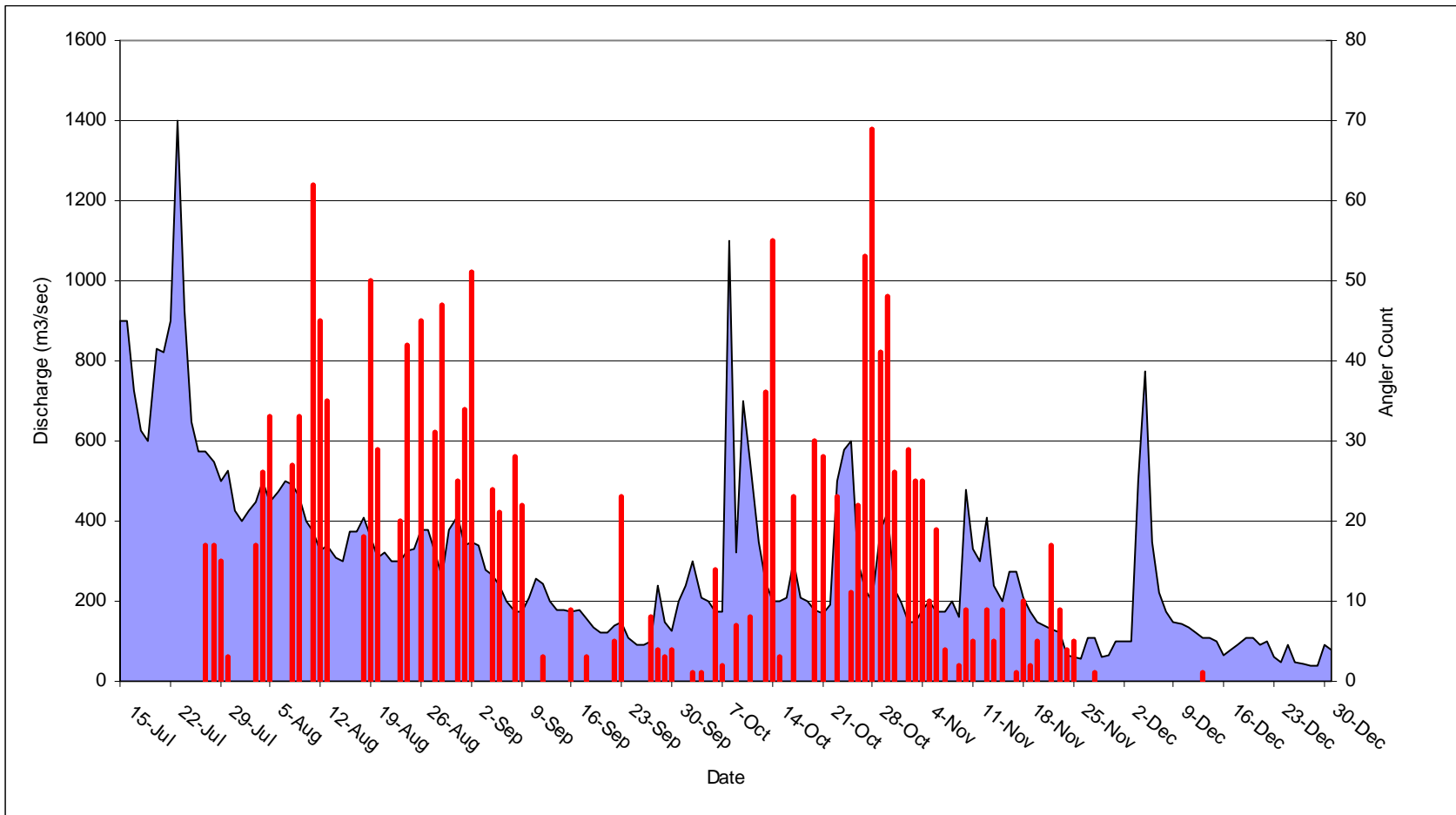
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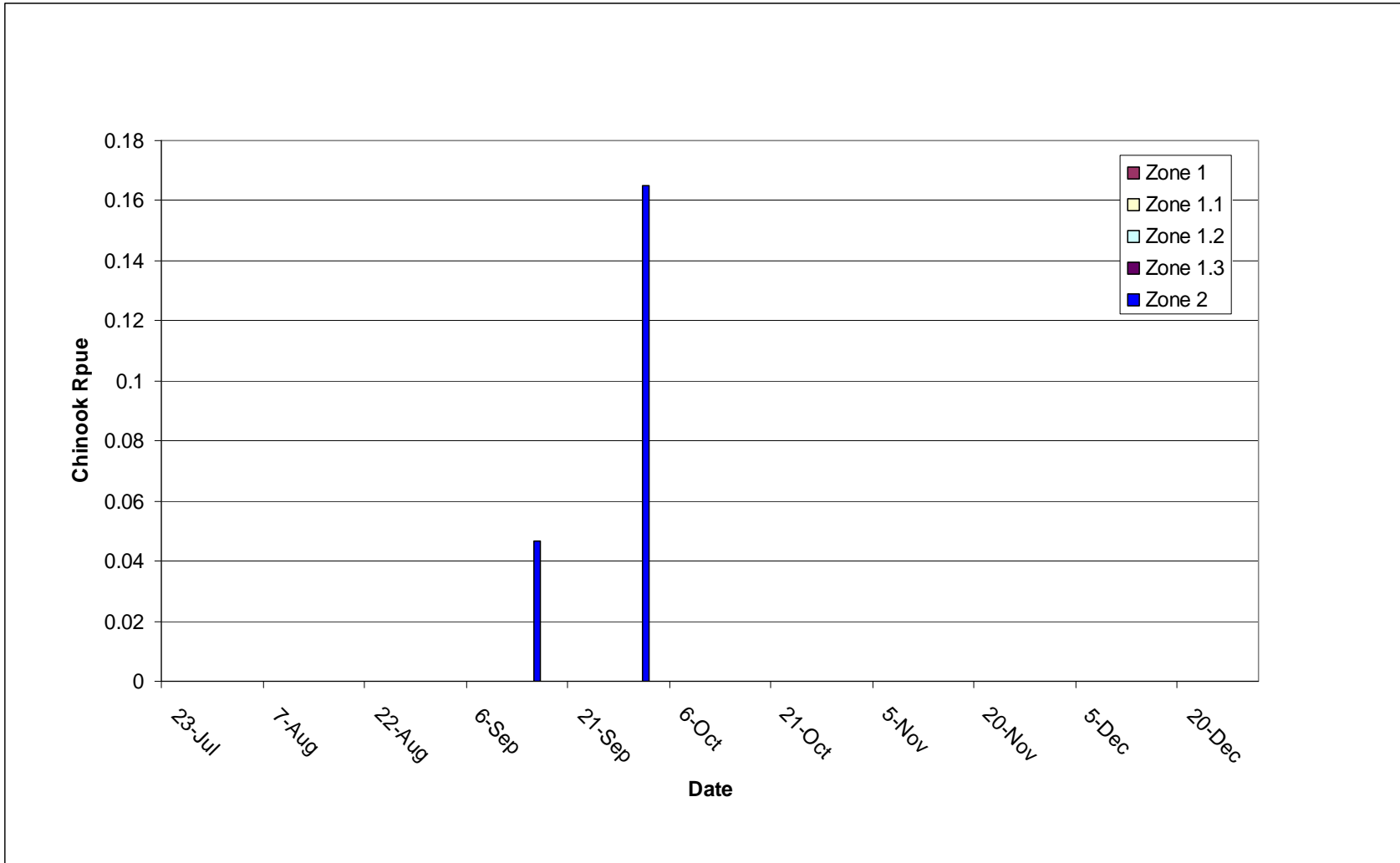
Figure_2. Decision framework to determine an optimum survey design for the 2007 Squamish River Watershed recreational fishery.



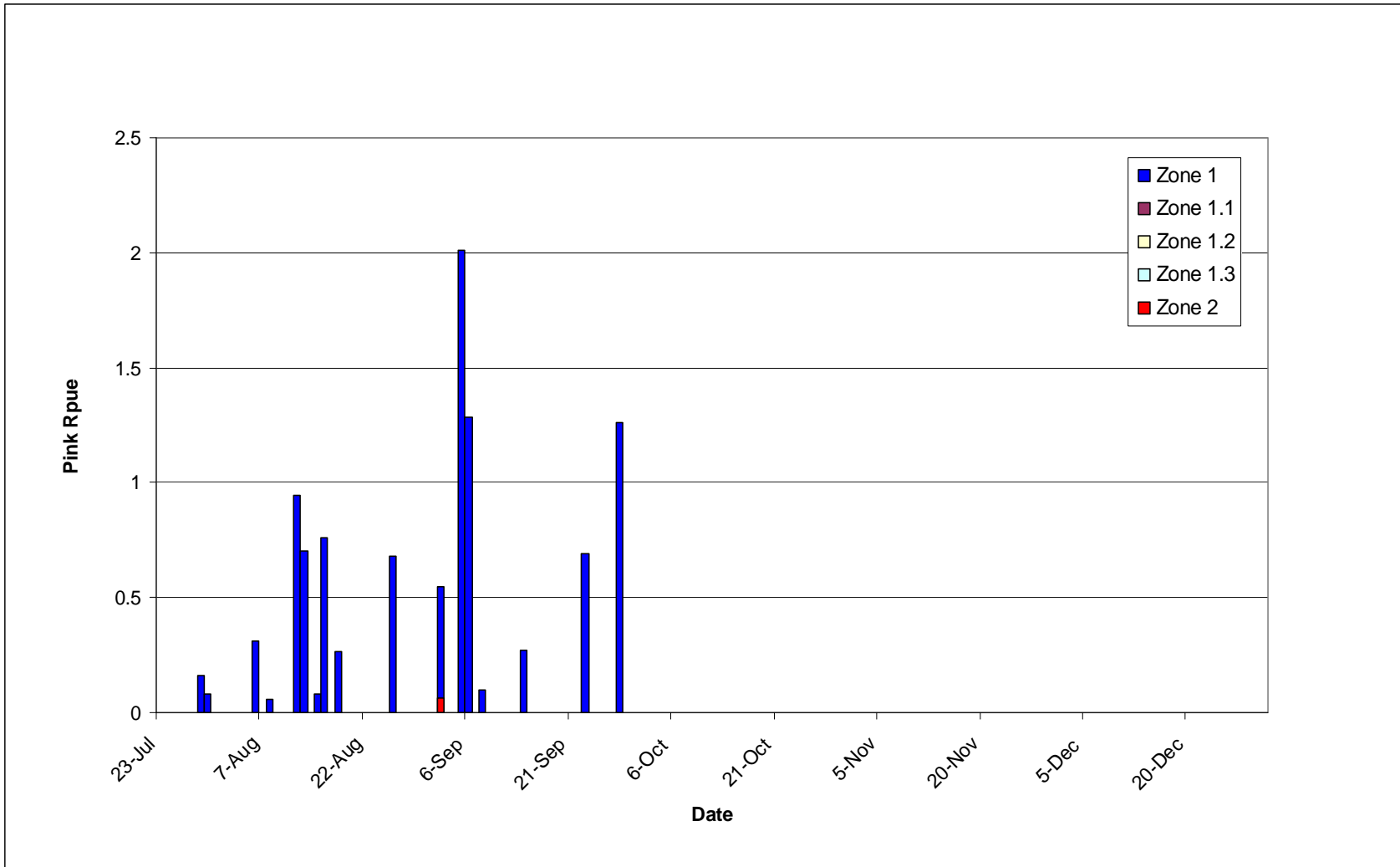
Figure_3. Sunrise and sunset times and daylight hours for the 2007 Squamish River Watershed recreational fishery (at Squamish, B.C.)



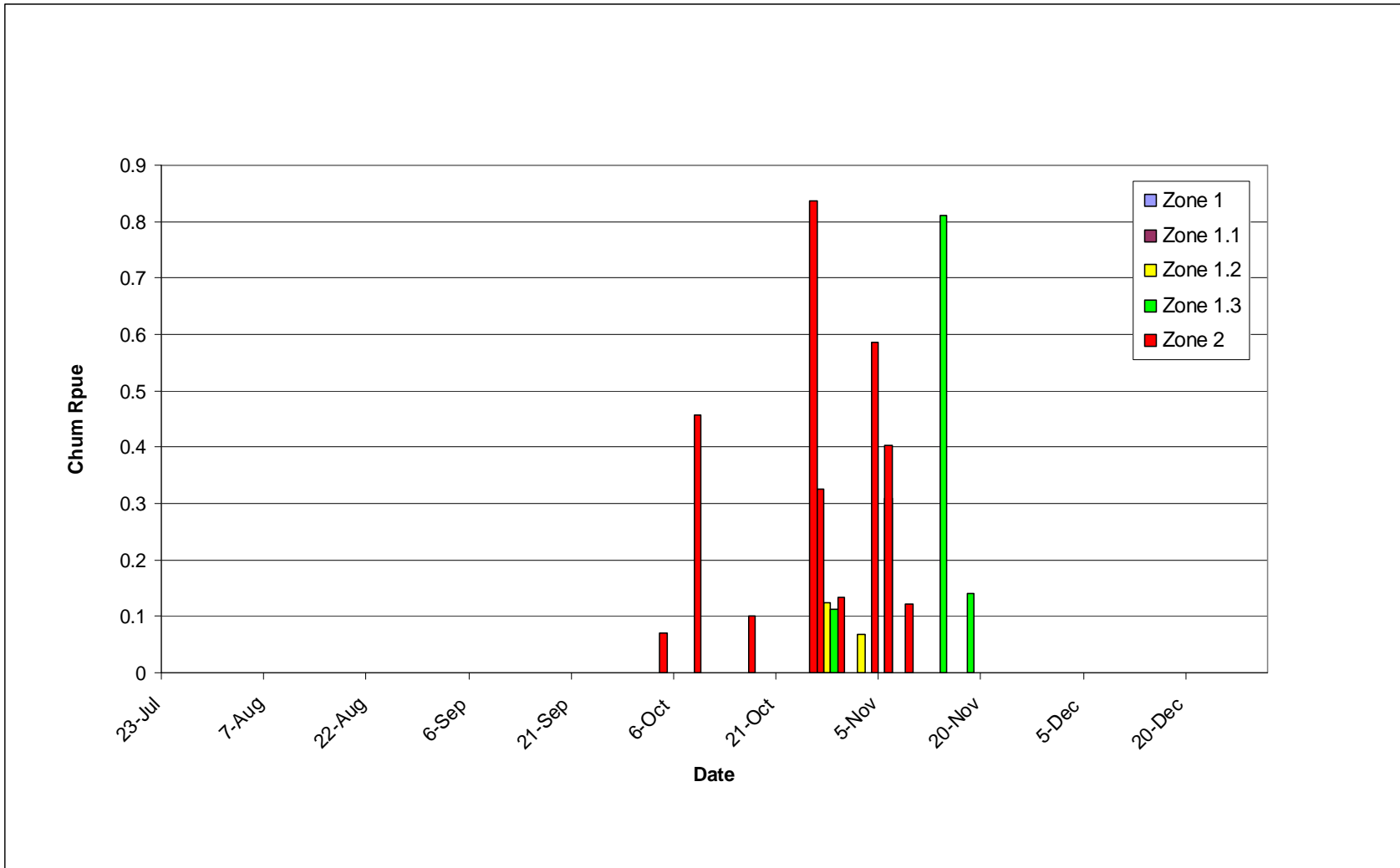
Figure_4. Discharge rates (m³/sec) on the Squamish River near Brackendale, B.C., and roving survey angler counts in the Squamish River Watershed recreational fishery between July 15 and December 31, 2007.



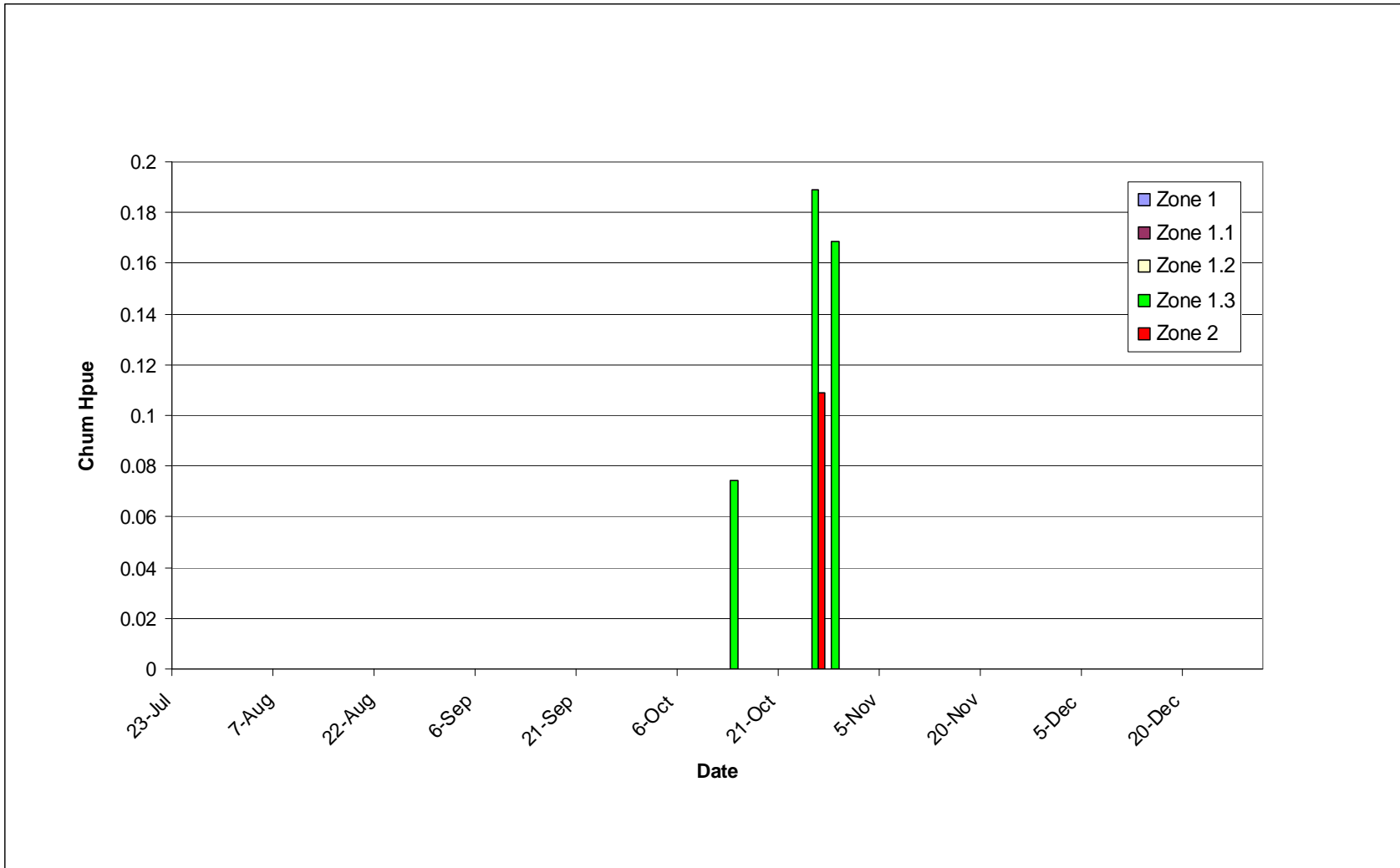
Figure_5. Chinook salmon release rates (fish/angler*hour) measured in the 2007 Squamish River Watershed recreational fishery by zone, and date.



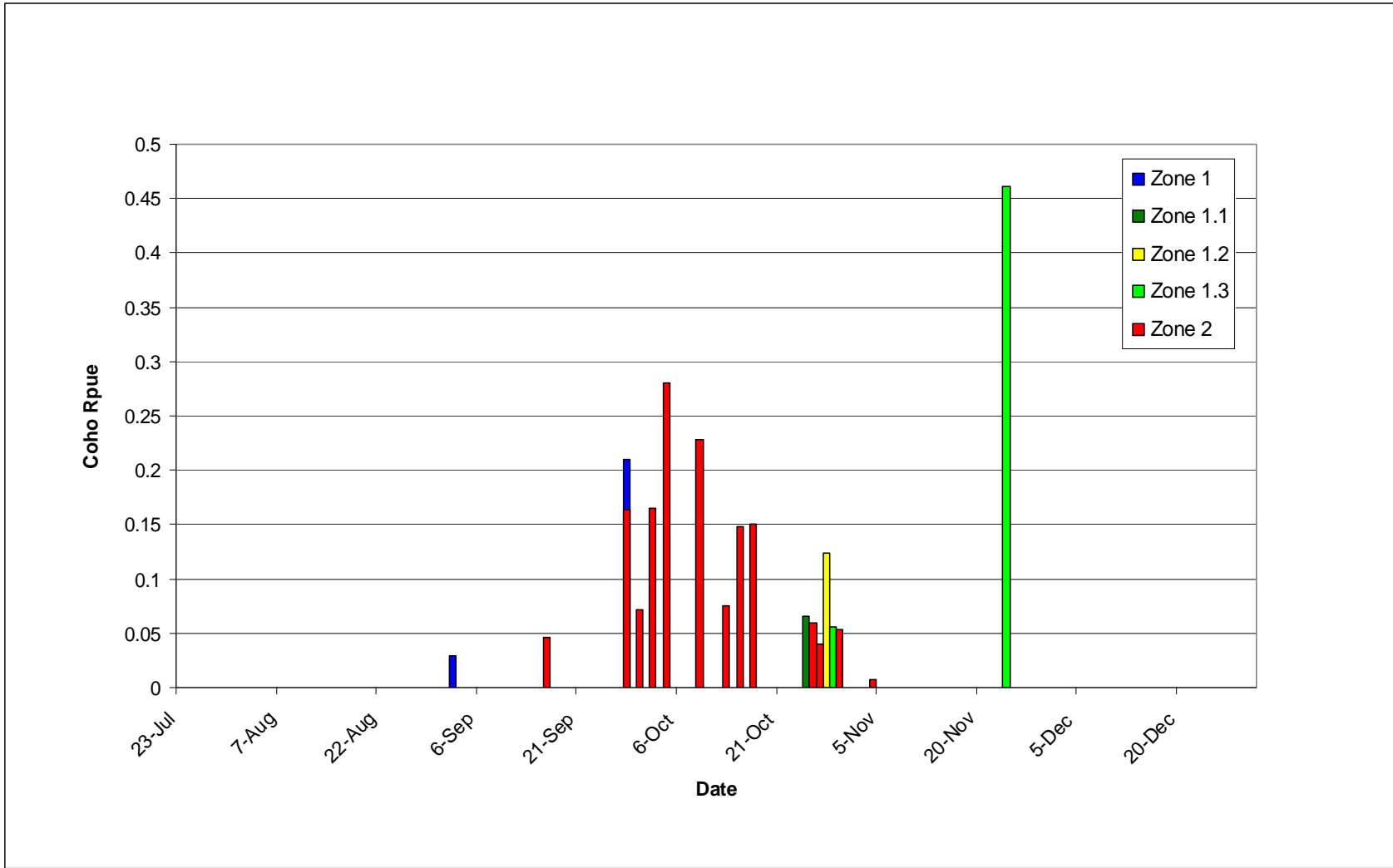
Figure_6. Pink salmon release rates (fish/angler*hour) measured in the 2007 Squamish River Watershed recreational fishery by zone, and date.



Figure_7. Chum salmon release rates (fish/angler*hour) measured in the 2007 Squamish River Watershed recreational fishery by zone, and date.



Figure_8. Chum salmon harvest rates (fish/angler*hour) measured in the 2007 Squamish River Watershed recreational fishery by zone, and date.



Figure_9. Coho salmon harvest rates (fish/angler*hour) measured in the 2007 Squamish River Watershed recreational fishery by zone, and date.

Table_1. Zones, sections and sites defined for the 2007 Squamish River Watershed Creel Survey.

Zone	Section	Site	Code	System	
1 (Lower Boundary - Powerlines)	1 (Lower Boundary to Upper Mamquam Bar) (Sub-Zone 1.1 October - December)	Outfall	OUT	SQM	
		Lower Mamquam Bar	LMB	SQM	
		Mid Mamquam Bar	MMB	SQM	
		Upper Mamquam Bar	UMB	SQM	
		Zone 1 Section 1	Z1S1	SQM	
	2 (Mamquam Mouth to Train Bridge)(Sub Zone 1.2 October - December extended to Ring Creek)	Mamquam River (to Train Bridge)	MQR(LTB)	MAM	
		Train Bridge to Hwy Bridge	MQR(UTB)	MAM	
		Hwy Bridge to Golf Course	MQR(HW)	MAM	
		Above Golf Course	MQR(GF)	MAM	
		Zone 1 Section 2	Z1S2	MAM	
	3 (Upper Mamquam Bar to Powerlines)(Sub-Zone 1.3 October - December)	Leski's Crossing	LCR	SQM	
		Fisherman's Park	FSP	SQM	
		Rocky Road	RRD	SQM	
		Downstream Cheakamus Mouth	DCKM	SQM	
		Upstream Cheakamus Mouth	UCKM	SQM	
		Zone 1 Section 3	Z1S3	SQM	
	2 (Cheakamus Mouth - Suspension Bridge)	1 (Cheakamus Mouth to Cheekye Bridge)	Stables	STB	CHK
			Sunwolf	SNW	CHK
Zone 2 Section 1			Z2S1	CHK	
2 (Cheekye Bridge to Bailey Bridge)		Frog Pond	FGP	CHK	
		Moody's 1	MOD1	CHK	
		Moody's 2	MOD2	CHK	
		Log Jamb	LJM	CHK	
		Longhouse Pool	LHP	CHK	
		Gage Pool	GGP	CHK	
		NVOS Pool	NVP	CHK	
		Al's Rock	ALR	CHK	
		Bailey Bridge	BLB	CHK	
		Zone 2 Section 2	Z2S2	CHK	
3 (Bailey Bridge to Suspension Bridge)		Suspension Bridge	SSB	CHK	
		Zone 2 Section 3	Z2S3	CHK	
3 (Powerlines - Ashlu Confluence)		1 (Powerlines to Pilchuck)	9 Mile	NML	SQM
			Zone 3 Section 1	Z3S1	SQM
		2 (Pilchuck to Ashlu Confluence)	Zone 3 Section 2	Z3S2	SQM
4 (Ashlu Confluence - Ashlu Campsite)		1 (Ashlu Confluence to Ashlu Campsite)	Ashlu Campsite	ASC	ASH
			Lower Ashlu Pools	LAP	ASH
	Zone 4 Section 1		Z4S1	ASH	
5 (Ashlu Confluence - Elaho Bridge)	1 (Ashlu Confluence to Power House Channel)	Ashlu Bridge	ASB	SQM	
		Power House Channel	PHC	SQM	
		Zone 5 Section 1	Z5S1	SQM	
	2 (Power House Channel to Elaho Bridge)	Zone 5 Section 2	Z5S2	SQM	

Table_2. Allocation of survey effort (*n* shifts) and site sampling probabilities (π) for the 2007 Squamish River Watershed Creel Survey.

Survey	Zone	Site	Month_Period										Zone	Site	Month_Period													
			July		August				September						October		November				December							
			P1.2		P2.1		P2.2		P3.1		P3.2				P4.1		P4.2		P5.1		P5.2		P6.1		P6.2			
			π	<i>n</i>	π	<i>n</i>	π	<i>n</i>	π	<i>n</i>	π	<i>n</i>			π	<i>n</i>	π	<i>n</i>	π	<i>n</i>	π	<i>n</i>	π	<i>n</i>	π	<i>n</i>		
Roving	1-5		na	5	na	10	na	10	na	10	na	10			na	10	na	12	na	12	na	12	na	6	na	6		
Access Point	1	Outfall	0.00	0.03	0.03	0.00	0.00	0.00	1.1	Outfall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
		Lower Mamquam Bar	0.00	0.13	0.13	0.19	0.19	1.1	Lower Mamquam Bar	0.50	0.50	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Mid Mamquam Bar	0.50	0.13	0.13	0.19	0.19	1.1	Mid Mamquam Bar	0.50	0.50	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Upper Mamquam Bar	0.00	0.13	0.13	0.19	0.19	1.1	Upper Mamquam Bar	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Sub Total		4	6	6	6	6	0	0																		
		Mamquam River	0.00	0.11	0.11	0.19	0.19	1.2	Mamquam River	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Sub Total		4	4	4	4	4	0	0																		
		Leski's Crossing	0.50	0.03	0.03	0.00	0.00	1.3	Leski's Crossing	0.25	0.00	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Fisherman's Park	0.00	0.20	0.20	0.08	0.08	1.3	Fisherman's Park	0.25	0.50	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		Rocky Road	0.00	0.13	0.13	0.08	0.08	1.3	Rocky Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Downstream Cheakamus	0.00	0.08	0.08	0.08	0.08	1.3	Downstream Cheakamus	0.50	0.50	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Upstream Cheakamus	0.00	0.03	0.03	0.00	0.00	1.3	Upstream Cheakamus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Sub Total		5	8	8	8	8	0	0																			
	2	Stables	0.00	0.12	0.12	0.00	0.00	2	Stables	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Sunwolf	0.50	0.24	0.24	0.00	0.14	2	Sunwolf	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Frog Pond	0.00	0.04	0.04	0.00	0.00	2	Frog Pond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Moody's 1	0.00	0.04	0.04	0.00	0.00	2	Moody's 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Moody's 2	0.00	0.04	0.04	0.00	0.00	2	Moody's 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Log Jamb	0.00	0.12	0.12	0.25	0.14	2	Log Jamb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	Longhouse Pool	0.00	0.12	0.12	0.00	0.00	2	Longhouse Pool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Gage Pool	0.00	0.04	0.04	0.00	0.00	2	Gage Pool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
NVOS Pool	0.00	0.04	0.04	0.25	0.14	2	NVOS Pool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Al's Rock	0.00	0.04	0.04	0.00	0.00	2	Al's Rock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Bailey Bridge	0.50	0.12	0.12	0.50	0.57	2	Bailey Bridge	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50			
Suspension Bridge	0.00	0.04	0.04	0.00	0.00	2	Suspension Bridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Sub Total		5	8	8	8	8	0	0																				
3	9 Mile	0.00	0.00	0.00	0.00	0.00	3	9 Mile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Sub Total		0	0	0	0	0	0	0																				
4	Ashlu Campsite	0.00	0.00	0.00	0.00	0.00	4	Ashlu Campsite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Lower Ashlu Pools	0.00	0.00	0.00	0.00	0.00	4	Lower Ashlu Pools	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Sub Total		0	0	0	0	0	0	0																				
5	Ashlu Bridge	0.00	0.00	0.00	0.00	0.50	5	Ashlu Bridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
Power House Channel	1.00	1.00	1.00	1.00	0.50	5	Power House Channel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Sub Total		4	4	4	4	4	0	0																				
Total			14	20	20	20	20	20			20	24	24	24	24	0	0	0	0									
Grand Total			19	30	30	30	30	30			30	36	36	36	36	6	6	6	6									

Table_3. P-values for complete vs. incomplete angler trip catch rates (harvest or release per angler-hour) by species.

Month	Period	Zone	Chinook		Pink		Coho		Chum	
			Hpue	Rpue	Hpue	Rpue	Hpue	Rpue	Hpue	Rpue
July	1.2	1								
		2								
		5								
August	2.1	1								
		2								
		5								
	2.2	1				0.1081				
		2								
		5								
September	3.1	1				0.0008		0.7155		
		2								
		5								
	3.2	1				0.2859		0.8233		
		2		0.1613				0.0813		
		5								
October	4.1	1.1								
		1.2								
		1.3						0.3723	0.0365	
		2		0.2439				0.1646		0.3393
	4.2	1.1						0.0307		0.5347
		1.2						0.7956		0.4414
		1.3						0.9566	0.6577	0.0275
		2					0.0850	0.1080	0.0132	0.2177
November	5.1	1.1								
		1.2								0.5383
		1.3					0.07115	0.7115	0.7115	0.4422
		2						0.0587		0.0287
	5.2	1.1								
		1.2								
		1.3								
		2						0.5613		0.1328

Table_4. Shifts and angler interviews completed by zone, fishing site, and month through the access point survey of the 2007 Squamish River Watershed recreational fishery.

Zone	Location		July	August	September	October	November	Grand Total	
1	OF	Shifts	0	1	0	0	0	1	
		Interviews	0	0	0	0	0	0	
	DCKM	Shifts	0	5	0	0	0	5	
		Interviews	0	5	0	0	0	5	
	FSP	Shifts	3	3	3	0	0	9	
		Interviews	2	0	3	0	0	5	
	FSP	Shifts	0	1	0	0	0	1	
		Interviews	0	0	0	0	0	0	
	LMB	Shifts	0	3	3	0	0	6	
		Interviews	0	60	8	0	0	68	
	MMB	Shifts	2	4	4	0	0	10	
		Interviews	59	66	12	0	0	137	
	MQRL	Shifts	0	0	2	0	0	2	
		Interviews	0	0	14	0	0	14	
	MQRR	Shifts	0	0	4	0	0	4	
		Interviews	0	0	33	0	0	33	
	UMB	Shifts	0	1	1	0	0	2	
		Interviews	0	24	0	0	0	24	
	Total	Shifts	5	18	17	0	0	40	
		Interviews	61	155	70	0	0	286	
1.1	LMB	Shifts	0	0	0	5	4	9	
		Interviews	0	0	0	32	1	33	
	MMB	Shifts	0	0	0	5	4	9	
		Interviews	0	0	0	16	2	18	
	UMB	Shifts	0	0	0	0	2	2	
		Interviews	0	0	0	0	0	0	
	Total	Shifts	0	0	0	10	10	20	
		Interviews	0	0	0	48	3	51	
	1.2	MQRL	Shifts	0	0	0	4	3	7
			Interviews	0	0	0	18	5	23
MQRR		Shifts	0	0	0	4	5	9	
		Interviews	0	0	0	26	12	38	
Total		Shifts	0	0	0	8	8	16	
		Interviews	0	0	0	44	17	61	
1.3	DCKM	Shifts	0	0	0	5	6	11	
		Interviews	0	0	0	40	14	54	
	FSP	Shifts	0	0	0	4	5	9	
		Interviews	0	0	0	28	14	42	
	LCR	Shifts	0	0	0	1	1	2	
		Interviews	0	0	0	0	0	0	
	Total	Shifts	0	0	0	10	12	22	
		Interviews	0	0	0	68	28	96	

Table_4 continued. Shifts and angler interviews completed by zone, fishing site, and month through the access point survey of the 2007 Squamish River Watershed recreational fishery.

Zone	Location		July	August	September	October	November	Grand Total
2	BLB	Shifts	0	4	12	8	8	32
		Interviews	0	14	49	35	9	107
	LHP	Shifts	0	3	0	0	0	3
		Interviews	0	3	0	0	0	3
	LJM	Shifts	0	1	1	1	0	3
		Interviews	0	1	0	4	0	5
	MOD2	Shifts	0	1	0	0	0	1
		Interviews	0	0	0	0	0	0
	NVP	Shifts	3	0	1	0	0	4
		Interviews	4	0	0	0	0	4
	SNW	Shifts	2	4	1	7	8	22
		Interviews	0	2	3	49	45	99
	SSB	Shifts	0	1	0	0	0	1
		Interviews	0	0	0	0	0	0
	STB	Shifts	0	2	0	0	0	2
		Interviews	0	0	0	0	0	0
	Total	Shifts	5	16	15	16	16	68
		Interviews	4	20	52	88	54	218
5	ASB	Shifts	0	0	6	0	0	6
		Interviews	0	0	0	0	0	0
	PHC	Shifts	3	8	2	0	0	13
		Interviews	0	0	0	0	0	0
	Total	Shifts	3	8	8	0	0	19
		Interviews	0	0	0	0	0	0
Grand Total Shifts			13	42	40	44	46	185
Grand Total Interviews			65	175	122	248	102	712

Table_5. Angler counts and interviews completed by zone and month through the roving survey of the 2007 Squamish River Watershed recreational fishery.

Zone		July	August	September	October	November	December	Grand Total
1	Counts	5	22	21	0	0	0	48
	Interviews	36	493	225	0	0	0	754
1.1	Counts	0	0	0	22	19	12	53
	Interviews	0	0	0	88	5	0	93
1.2	Counts	0	0	0	22	20	12	54
	Interviews	0	0	0	68	6	0	74
1.3	Counts	0	0	0	22	20	12	54
	Interviews	0	0	0	201	109	0	310
2	Counts	5	22	21	22	20	12	102
	Interviews	0	10	27	105	71	1	214
3	Counts	5	22	21	4	9	0	61
	Interviews	0	0	0	0	0	0	0
4	Counts	5	22	21	7	9	0	64
	Interviews	0	0	0	0	0	0	0
5	Counts	5	22	21	7	9	0	64
	Interviews	0	0	0	0	0	0	0
Total	Counts	25	110	105	106	106	48	500
	Interviews	36	503	252	462	191	1	1445

Table_6. Effort and catch (harvest and release) estimates by species, month, and zone for the Squamish River Watershed recreational fishery between July 23 and December 31, 2007.

Month	Zn	Effort (Angler*H rs)	SE Effort	Cn Har	SE Cn Har	Cn Rel	SE Cn Rel	Pk Har	SE Pk Har	Pk Rel	SE Pk Rel	Cm Har	SE Cm Har	Cm Rel	SE Cm Rel	Co Har	SE Co Har	Co Rel	SE Co Rel	Mean Angler*H ours per Trip	Est. Angler Trips
July	1	1,228	102	0	0	0	0	2	2	55	14	0	0	0	0	0	0	0	0		
(23-31)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total		1,228	102	0	0	0	0	2	2	55	14	0	0	0	0	0	0	0	0	2.58	476
Aug.	1	11,723	277	0	0	0	0	40	41	6397	1217	0	0	0	0	0	0	0	0		
	2	216	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total		11,939	278	0	0	0	0	40	41	6397	1217	0	0	0	0	0	0	0	0	3.29	3629
Sept.	1	3,768	197	0	0	0	0	0	0	2745	507	0	0	0	0	0	0	50	37		
	2	361	24	0	0	5	3	0	0	6	4	0	0	0	0	0	0	6	5		
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	4	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total		4,141	199	0	0	5	3	0	0	2751	507	0	0	0	0	0	0	56	37	2.54	1630

Table_6 continued. Effort and catch (harvest and release) estimates by species, month, and zone for the Squamish River Watershed recreational fishery between July 23 and December 31, 2007.

Month	Zn	Effort (Angler *Hrs)	SE Effort	Cn Har	SE Cn Har	Cn Rel	SE Cn Rel	Pk Har	SE Pk Har	Pk Rel	SE Pk Rel	Cm Har	SE Cm Har	Cm Rel	SE Cm Rel	Co Har	SE Co Har	Co Rel	SE Co Rel	Mean Angler *Hours perTrip	Est. Angler Trips
Oct.	1.1	1,581	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	27		
	1.2	1,302	58	0	0	0	0	0	0	0	0	0	0	20	20	0	0	20	19		
	1.3	3,654	147	0	0	0	0	0	0	0	0	303	123	89	64	0	0	44	45		
	2	2,024	55	0	0	10	11	0	0	0	0	28	10	276	84	0	0	161	52		
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total		8,561	177	0	0	10	11	0	0	0	0	332	124	385	107	0	0	253	76	2.92	2932
Nov.	1.1	82	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	1.2	106	7	0	0	0	0	0	0	0	0	0	0	5	7	0	0	0	0		
	1.3	2,268	75	0	0	0	0	0	0	0	0	0	0	365	139	0	0	55	38		
	2	2,102	25	0	0	0	0	0	0	0	0	0	0	849	129	0	0	10	10		
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total		4,558	80	0	0	0	0	0	0	0	0	0	0	1219	189	0	0	65	39	3.14	1452
Dec.	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2	24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total		24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	na	
Grand Total		30,450	406	0	0	15	11	42	41	9203	1318	332	124	1604	218	0	0	374	94	2.82	10118

Table_7. Proportions of interviews for target species by month in the 2007 Squamish River Watershed recreational fishery measured through the roving survey.

Target Species	July	August	September	October	November	December	Grand Total
Char	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Chinook	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Chum	0.00	0.00	0.04	0.50	0.14	0.00	0.18
CmCo	0.00	0.00	0.01	0.27	0.18	0.00	0.11
CnCo	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Coho	0.00	0.00	0.05	0.16	0.51	1.00	0.13
Cutthroat	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Pink	0.97	0.99	0.80	0.00	0.00	0.00	0.51
PnkCo	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Unspecified	0.03	0.01	0.06	0.06	0.16	0.00	0.06

Table_8. Proportions of interviews for attractors by month in the 2007 Squamish River Watershed recreational fishery measured through the roving survey.

Attractor	July	August	September	October	November	December	Grand Total
Bait	0.00	0.00	0.02	0.01	0.01	0.00	0.01
Fly	0.64	0.70	0.64	0.47	0.42	0.00	0.58
Lure	0.11	0.19	0.18	0.20	0.18	1.00	0.19
Spin n Glow	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Spinner	0.06	0.00	0.01	0.04	0.13	0.00	0.03
Spoon	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unspecified	0.00	0.00	0.02	0.00	0.01	0.00	0.01
Wool	0.17	0.10	0.13	0.28	0.25	0.00	0.18

Table_9. Proportions of access point survey interviews for catch of each species by attractor in the 2007 Squamish River Watershed recreational fishery.

Attractor	Char	Chinook	Chum	Coho	Cutthroat	Pink	Total
Fly	0.13	0.00	0.21	0.17	0.13	0.78	321
Unspecified	0.00	0.00	0.00	0.00	0.00	0.00	1
Lure	0.88	0.67	0.38	0.78	0.50	0.13	159
Wool	0.00	0.33	0.37	0.03	0.00	0.09	102
Bait	0.00	0.00	0.00	0.00	0.38	0.00	3
Spoon	0.00	0.00	0.01	0.03	0.00	0.00	3
Spinner	0.00	0.00	0.03	0.00	0.00	0.00	5
Total Observed	8	3	185	36	8	354	594

Table_10. Proportions of angler interviews by residence measured through the roving survey of the 2007 Squamish River Watershed recreational fishery.

Residence	July	August	September	October	November	December	Grand Total
Canada	0.03	0.01	0.03	0.01	0.02	0.00	0.01
Local	0.44	0.24	0.28	0.43	0.48	1.00	0.34
Offshore	0.00	0.01	0.02	0.00	0.02	0.00	0.01
Province	0.03	0.01	0.00	0.00	0.00	0.00	0.01
Region	0.28	0.57	0.58	0.55	0.47	0.00	0.54
US	0.22	0.15	0.09	0.00	0.02	0.00	0.08
Unspecified	0.00	0.01	0.00	0.00	0.00	0.00	0.00

Appendix 1: Fishery Regulations

Regulations relevant to this study relating to the Squamish River watershed recreational fishery to December 31, included the following:

General

- Recreational fishing prohibited on all Squamish River tributaries except for the Mamquam River, Ashlu River, Powerhouse Channel, and Elaho River.
- The aggregate daily limit for all species of salmon from tidal and non-tidal waters combined was four.

Pink Salmon

- No retention of pink salmon on the Squamish River and its tributaries.

Chinook Salmon

- Chinook retention (2 per day) allowed for fish <55cm on the Squamish River below the powerlines.
- Chinook retention (2 per day) allowed for fish <55cm on the Squamish River above the powerlines to September 15.
- Non-retention for all Chinook salmon on the Cheakamus River (after August 1).
- Chinook retention (2 per day) allowed for fish <55cm on the Mamquam River above the CN Rail bridge to September 15.
- Chinook retention (2 per day) allowed for fish <55cm on the Mamquam River below the CN Rail bridge.

Coho Salmon

- Hatchery coho retention (1 per day) allowed on the Squamish River below the powerlines after September 15.
- Hatchery coho retention (1 per day) allowed on the Cheakamus River after September 15.
- Hatchery coho retention (1 per day) allowed on the Mamquam River after September 15.

Chum Salmon

- Chum retention (2 per day) allowed on the Squamish River below the powerlines between September 15 and November 2.
- Chum retention (2 per day) allowed on the Cheakamus River between September 15 and November 2.
- Chum retention (2 per day) allowed on the Mamquam River below the CN rail bridge between September 15 and November 2.

Appendix 2: Survey Schedules

2007 Squamish River Watershed Creel Survey Provisional Schedule																																	
MONTH >		JULY																															
PERIOD >		*PERIOD 1.1															*PERIOD 1.2																
DAY >		S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	
DATE >		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
ROVING, ROVING SURVEY	ZONE	SHIFT																															
	ZONE 1	Early																															
	Outfall >Powerlines	Late																															
	ZONE 2	Early																															
	Cheakamus River	Late																															
	ZONE 3	Early																															
	Powerlines>Ashlu River	Late																															
	ZONE 4	Early																															
	Ashlu River	Late																															
	ZONE 5	Early																															
Ashlu>Elaho	Late																																
ACCESS POINT_DIRECT OBSERVATIONS SURVEY	ZONE 1	Early																															
	Outfall	Late																															
	ZONE 1	Early																															
	Lower Mamquam Bar	Late																															
	ZONE 1	Early																															
	Mid Mamquam Bar	Late																															
	ZONE 1	Early																															
	Upper Mamquam Bar	Late																															
	ZONE 1	Early																															
	Mamquam River	Late																															
	ZONE 1	Early																															
	Leski's Crossing	Late																															
	ZONE 1	Early																															
	Fisherman's Park	Late																															
	ZONE 1	Early																															
	Rocky Road	Late																															
	ZONE 1	Early																															
	Dwn Cheakamus Mouth	Late																															
	ZONE 2	Early																															
	Stables	Late																															
	ZONE 2	Early																															
	Sunwolf	Late																															
	ZONE 2	Early																															
	Log Jamb	Late																															
	ZONE 2	Early																															
	Bighouse Pool	Late																															
	ZONE 2	Early																															
	Gage Pool	Late																															
ZONE 2	Early																																
NVOS Pool	Late																																
ZONE 2	Early																																
Bailey Bridge	Late																																
ZONE 2	Early																																
Suspension Bridge	Late																																
ZONE 5	Early																																
Ashlu Bridge	Late																																
ZONE 5	Early																																
Powerhouse	Late																																

Roving Shift Times:
 Period 1.2
 (1) Early = 0500-1330
 (2) Mid = NA
 (3) Late = 1330-2200

Access Point Shift Times:
 Period 1.2
 (1) Early = 0500-1330
 (2) Late = 1330-2200

2007 Squamish River Watershed Creel Survey Provisional Schedule																																						
MONTH >		AUGUST																																				
PERIOD >		PERIOD 2.1															PERIOD 2.2																					
DAY >		W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F						
DATE >		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31						
SURVEY	ZONE	SHIFT																																				
	ROVING, ROVING SURVEY	ZONE 1	Early			1	1	1						1			1			1						1				1	1	1			1			
Outfall >Powerlines		Late				1			1	1			1	1					1		1							1		1	1	1	1					
ZONE 2		Early			^	^	^					^			^			^		^				^	^	^				^	^	^						
Cheakamus River		Late				^			^	^			^	^					^		^				^	^			^	^	^	^						
ZONE 3		Early			^	^	^					^			^			^		^				^	^	^				^	^	^						
Powerlines>Ashlu River		Late				^			^	^			^	^					^		^				^	^			^	^	^	^						
ZONE 4		Early			^	^	^					^			^			^		^				^	^	^				^	^	^						
Ashlu River		Late				^			^	^			^	^					^		^				^	^			^	^	^	^						
ZONE 5		Early			^	^	^					^			^			^		^				^	^	^				^	^	^						
Ashlu>Elaho		Late				^			^	^			^	^					^		^				^	^			^	^	^	^						
ACCESS POINT_DIRECT OBSERVATIONS SURVEY	ZONE 1	Early																																				
	Outfall	Late																																				
	ZONE 1	Early						1																												1		
	Lower Mamquam Bar	Late												1																								
	ZONE 1	Early																																				
	Mid Mamquam Bar	Late								1																											1	
	ZONE 1	Early																																				
	Upper Mamquam Bar	Late																																				
	ZONE 1	Early																																				
	Mamquam River	Late																																				
	ZONE 1	Early																																				
	Leski's Crossing	Late																																				
	ZONE 1	Early				1								1																								
	Fisherman's Park	Late																																			1	
	ZONE 1	Early																																				
	Rocky Road	Late																																				
	ZONE 1	Early					1																															
	Dwn Cheakamus Mouth	Late													1														1								1	
	ZONE 2	Early				1	1																															
	Stables	Late																																				
	ZONE 2	Early																																				
	Sunwolf	Late																																				
	ZONE 2	Early																																				
	Log Jamb	Late					1								1																							
ZONE 2	Early																																					
Bighouse Pool	Late																																					
ZONE 2	Early																																					
Gage Pool	Late																																					1
ZONE 2	Early																																					
NVOS Pool	Late																																					
ZONE 2	Early																																					
Bailey Bridge	Late																																				1	
ZONE 2	Early																																					
Suspension Bridge	Late																																				1	
ZONE 5	Early																																					
Ashlu Bridge	Late																																					
ZONE 5	Early																																					
Powerhouse	Late																																					

Roving Shift Times:
 Period 2.1
 (1) Early = 0500-1300
 (2) Mid = NA
 (3) Late = 1300-2100

Access Point Shift Times:
 Period 2.1
 (1) Early = 0500-1300
 (2) Late = 1300-2100

Roving Shift Times:
 Period 2.2
 (1) Early = 0530-1300
 (2) Mid = NA
 (3) Late = 1300-2030

Access Point Shift Times:
 Period 2.2
 (1) Early = 0530-1300
 (2) Late = 1300-2030

2007 Squamish River Watershed Creel Survey Provisional Schedule																															
MONTH >		SEPTEMBER																													
PERIOD >		PERIOD 3.1														PERIOD 3.2															
DAY >		S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
DATE >		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
SURVEY	ZONE	SHIFT																													
	ROVING SURVEY	ZONE 1	Early		1			1		1	1				1		1						1			1				1	1
Outfall > Powerlines		Late	1				1		1				1		1		1		1				1		1			1	1		
ZONE 2		Early		^			^		^	^				^		^					^		^		^		^		^	^	
Cheakamus River		Late	^				^		^		^			^		^		^			^		^		^		^		^	^	
ZONE 3		Early		^			^		^	^				^		^					^		^		^		^		^	^	
Powerlines > Ashlu River		Late	^				^		^		^			^		^		^			^		^		^		^		^	^	
ZONE 4		Early		^			^		^	^				^		^					^		^		^		^		^	^	
Ashlu River		Late	^				^		^		^			^		^		^			^		^		^		^		^	^	
ZONE 5		Early		^			^		^	^				^		^					^		^		^		^		^	^	
Ashlu > Elaho		Late	^				^		^		^			^		^		^			^		^		^		^		^	^	
ACCESS POINT DIRECT OBSERVATIONS SURVEY	ZONE 1	Early																													
	Outfall	Late																													
	ZONE 1	Early								1														1							
	Lower Mamquam Bar	Late																									1				
	ZONE 1	Early	1							1																	1				
	Mid Mamquam Bar	Late																													
	ZONE 1	Early													1																
	Upper Mamquam Bar	Late																													
	ZONE 1	Early					1																							1	
	Mamquam River	Late						1																				1			
	ZONE 1	Early																													
	Leski's Crossing	Late																													
	ZONE 1	Early																													
	Fisherman's Park	Late			1											1															
	ZONE 1	Early																												1	
	Rocky Road	Late																													
	ZONE 1	Early																													
	Dwn Cheakamus Mouth	Late																													
	ZONE 2	Early																													
	Stables	Late																													
	ZONE 2	Early																													
	Sunwolf	Late																													
	ZONE 2	Early																													
	Log Jamb	Late	1																												
	ZONE 2	Early																													
	Bighouse Pool	Late																													
	ZONE 2	Early																													
	Gage Pool	Late																													
ZONE 2	Early																														
NVOS Pool	Late																														
ZONE 2	Early		1			1																									
Bailey Bridge	Late						1																								
ZONE 2	Early																														
Suspension Bridge	Late																														
ZONE 5	Early																														
Ashlu Bridge	Late																														
ZONE 5	Early																														
Powerhouse	Late																														

Roving Shift Times: Period 3.1 (1) Early = 0600-1300 (2) Mid = NA (3) Late = 1300-2000	Access Point Shift Times: Period 3.1 (1) Early = 0600-1300 (2) Late = 1300-2000	Roving Shift Times: Period 3.2 (1) Early = 0630-1300 (2) Mid = NA (3) Late = 1300-1930	Access Point Shift Times: Period 3.2 (1) Early = 0630-1300 (2) Late = 1300-1930
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2007 Squamish River Watershed Creel Survey Provisional Schedule																																
MONTH >		OCTOBER																														
PERIOD >		PERIOD 4.1															PERIOD 4.2															
DAY >		M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W
DATE >		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SURVEY	ZONE	SHIFT																														
ROVING SURVEY	ZONE 1.1 > 1.3	Early			1			1			1			1	1			1			1			1	1			1			1	
	Outfall >Powerlines	Late		1		1			1				1				1			1			1			1			1	1	1	
	ZONE 2	Early						^				^			^				^			^			^	^			^		^	
	Cheakamus River	Late		^	^	^		^			^			^			^			^			^			^			^	^	^	
	ZONE 3	Early													^					^										^		
	Powerlines>Ashlu River	Late		^	^	^		^							^					^					^				^		^	
	ZONE 4	Early														^				^										^		
	Ashlu River	Late		^	^	^		^								^				^					^				^		^	
	ZONE 5	Early														^				^										^		
	Ashlu>Elaho	Late		^	^	^		^								^				^					^				^		^	
ACCESS POINT DIRECT OBSERVATIONS SURVEY	ZONE 1.1	Early																														
	Outfall	Late																														
	ZONE 1.1	Early			1										1												1					
	Lower Mamquam Bar	Late																								1					1	
	ZONE 1.1	Early																										1			1	
	Mid Mamquam Bar	Late		1				1																								
	ZONE 1.1	Early																														
	Upper Mamquam Bar	Late																														
	ZONE 1.2	Early						1							1															1		
	Mamquam River	Late							1					1													1			1		
	ZONE 1.3	Early																														
	Lesk's Crossing	Late					1																									
	ZONE 1.3	Early																														
	Fisherman's Park	Late																												1		
	ZONE 1.3	Early																														
	Rocky Road	Late																														
	ZONE 1.3	Early														1																
	Dwn Cheakamus Mouth	Late					1																					1			1	
	ZONE 2	Early																														
	Stables	Late																														
	ZONE 2	Early			1																								1			1
	Sunwolf	Late									1				1						1								1			
	ZONE 2	Early																														
	Log Jamb	Late		1																												
	ZONE 2	Early																														
	Bighouse Pool	Late																														
	ZONE 2	Early																														
	Gage Pool	Late																														
	ZONE 2	Early																														
	NVOS Pool	Late																														
ZONE 2	Early							1			1				1												1			1		
Bailey Bridge	Late					1																					1			1		
ZONE 2	Early																															
Suspension Bridge	Late																															
ZONE 5	Early																															
Ashlu Bridge	Late																															
ZONE 5	Early																															
Powerhouse	Late																															

Roving Shift Times: Period 4.1 (1) Early = 0700-1300 (2) Mid = NA (3) Late = 1300-1900	Access Point Shift Times: Period 4.1 (1) Early = 0700-1300 (2) Late = 1300-1900	Roving Shift Times: Period 4.2 (1) Early = 0700-1300 (2) Mid = NA (3) Late = 1300-1900	Access Point Shift Times: Period 4.2 (1) Early = 0700-1300 (2) Late = 1300-1900
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Appendix 3: Roving Survey Route Plans

Site	Sys	Route Plan_1	Route Plan_2	Route Plan_3	Route Plan_4	Route Plan_5	Route Plan_6
Outfall	SQM						
Lower Mamquam Bar	SQM						
Mid Mamquam Bar	SQM						
Upper Mamquam Bar	SQM						
Mamquam River	MAM						
Leski's Crossing	SQM						
Fisherman's Park	SQM						
Rocky Road	SQM						
Downstream Cheakamus Mouth	SQM						
Upstream Cheakamus Mouth	SQM						
Stables	CHK						
Sunwolf	CHK						
Frog Pond	CHK						
Moody's 1	CHK						
Moody's 2	CHK						
Log Jamb	CHK						
Longhouse Pool	CHK						
Gage Pool	CHK						
NVOS Pool	CHK						
Al's Rock	CHK						
Bailey Bridge	CHK						
Suspension Bridge	CHK						
9 Mile	SQM						
Ashlu Bridge	SQM						
Ashlu Campsite	ASH						
Lower Ashlu Pools	ASH						
Power House Channel	SQM						

Appendix 4: Survey Forms

Appendix 5: Wilcoxon Rank Sum Test Results

Chinook Rpue Zone 2, Period 3.2

Variable	Rank	Sum	N	U Stat	Mean Rank
Complete	715		26	364	27.5
Incomplete	663		26	312	25.5
Total	1378		52		
Normal Approximation with Corrections for Continuity and Ties 1.401					
Two-tailed P-value for Normal Approximation 0.1613					
Maximum difference allowed between ties 0.00001					
Cases Included 52 Missing Cases 0					

Chinook Rpue Zone 2, Period 4.1

Variable	Rank	Sum	N	U Stat	Mean Rank
Complete	986		28	580	35.2
Incomplete	1360		40	540	34
Total	2346		68		
Normal Approximation with Corrections for Continuity and Ties 1.165					
Two-tailed P-value for Normal Approximation 0.2439					
Total number of values that were tied 67					
Maximum difference allowed between ties 0.00001					
Cases Included 68 Missing Cases 12					

Pink Rpue Zone 1, Period 2.2

Variable	Rank	Sum	N	U Stat	Mean Rank
Complete	7484	65		5339	115.1
Incomplete	24901	189		6946	131.8
Total	32385	254			
Normal Approximation with Corrections for Continuity and Ties 1.607					
Two-tailed P-value for Normal Approximation 0.1081					
Maximum difference allowed between ties 0.00001					
Cases Included 254 Missing Cases 124					

Pink Rpue Zone 1, Period 3.1

Variable	Rank	Sum	N	U Stat	Mean Rank
Complete	3161.5	39		2381.5	81.1
Incomplete	22039	185		4833.5	119.1
Total	25200	224			
Normal Approximation with Corrections for Continuity and Ties 3.358					
Two-tailed P-value for Normal Approximation 0.0008					
Total number of values that were tied 88					
Maximum difference allowed between ties 0.00001					
Cases Included 224 Missing Cases 146					

Pink Rpue Zone 1, Period 3.2

Variable	Rank	Sum	N	U Stat	Mean Rank
Complete	1192	30		727	39.7
Incomplete	1509	43		563	35.1
Total	2701	73			
Normal Approximation with Corrections for Continuity and Ties 1.067					
Two-tailed P-value for Normal Approximation 0.2859					
Total number of values that were tied 51					
Maximum difference allowed between ties 0.00001					
Cases Included 73 Missing Cases 13					

Coho Rpue Zone 1, Period 3.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	4360	39	3580	111.8
Incomplete	20171	182	3518	110.8
Total	24531	221		
Normal Approximation with Corrections for Continuity and Ties 0.364				
Two-tailed P-value for Normal Approximation 0.7155				
Total number of values that were tied 217				
Maximum difference allowed between ties 0.00001				
Cases Included 221 Missing Cases 149				

Coho Rpue Zone 1, Period 3.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	1086	30	621	36.2
Incomplete	1470	41	609	35.9
Total	2556	71		
Normal Approximation with Corrections for Continuity and Ties 0.223				
Two-tailed P-value for Normal Approximation 0.8233				
Total number of values that were tied 69				
Maximum difference allowed between ties 0.00001				
Cases Included 71 Missing Cases 11				

Coho Rpue Zone 1, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	455	12	377	37.9
Incomplete	2030	58	319	35
Total	2485	70		
Normal Approximation with Corrections for Continuity and Ties 2.161				
Two-tailed P-value for Normal Approximation 0.0307				
Total number of values that were tied 69				
Maximum difference allowed between ties 0.00001				
Cases Included 70 Missing Cases 46				

Coho Rpue Zone 1.2, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	805	22	552	36.6
Incomplete	1896	51	570	37.2
Total	2701	73		
Normal Approximation with Corrections for Continuity and Ties 0.259				
Two-tailed P-value for Normal Approximation 0.7956				
Total number of values that were tied 69				
Maximum difference allowed between ties 0.00001				
Cases Included 73 Missing Cases 31				

Coho Rpue Zone 1.3, Period 4.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	745.5	21	514.5	35.5
Incomplete	1882.5	51	556.5	36.9
Total	2628	72		
Normal Approximation with Corrections for Continuity and Ties 0.892				
Two-tailed P-value for Normal Approximation 0.3723				
Total number of values that were tied 70				
Maximum difference allowed between ties 0.00001				
Cases Included 72 Missing Cases 30				

Coho Rpue Zone 1.3, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	4611	47	3483	98.1
Incomplete	14499	148	3473	98
Total	19110	195		
Normal Approximation with Corrections for Continuity and Ties 0.054				
Two-tailed P-value for Normal Approximation 0.9566				
Total number of values that were tied 191				
Maximum difference allowed between ties 0.00001				
Cases Included 195 Missing Cases 103				

Coho Hpue Zone 1.3, Period 5.1

Variable	Rank	Sum N	U Stat	Mean Rank
Complete	611	13	520	47
Incomplete	3854	81	533	47.6
Total	4465	94		
Normal Approximation with Corrections for Continuity and Ties 0.370				
Two-tailed P-value for Normal Approximation				0.7115
Total number of values that were tied				93
Maximum difference allowed between ties 0.00001				
Cases Included 94 Missing Cases 70				

Coho Rpue Zone 1.3, Period 5.1

Variable	Rank	Sum N	U Stat	Mean Rank
Complete	611	13	520	47
Incomplete	3854	81	533	47.6
Total	4465	94		
Normal Approximation with Corrections for Continuity and Ties 0.370				
Two-tailed P-value for Normal Approximation				0.7115
Total number of values that were tied				93
Maximum difference allowed between ties 0.00001				
Cases Included 94 Missing Cases 70				

Coho Rpue Zone 2, Period 3.2

Variable	Rank	Sum N	U Stat	Mean Rank
Complete	728	26	377	28
Incomplete	650	26	299	25
Total	1378	52		
Normal Approximation with Corrections for Continuity and Ties 1.743				
Two-tailed P-value for Normal Approximation				0.0813
Total number of values that were tied				49
Maximum difference allowed between ties 0.00001				
Cases Included 52 Missing Cases 0				

Coho Rpue Zone 2, Period 4.1

Variable	Rank	Sum N	U Stat	Mean Rank
Complete	1098	29	663	37.9
Incomplete	1317	40	497	32.9
Total	2415	69		
Normal Approximation with Corrections for Continuity and Ties 1.390				
Two-tailed P-value for Normal Approximation				0.1646
Total number of values that were tied				54
Maximum difference allowed between ties 0.00001				
Cases Included 69 Missing Cases 17				

Coho Hpue Zone 2, Period 4.2

Variable	Rank	Sum N	U Stat	Mean Rank
Complete	3570	60	1740	59.5
Incomplete	3811	61	1920	62.5
Total	7381	121		
Normal Approximation with Corrections for Continuity and Ties 1.723				
Two-tailed P-value for Normal Approximation				0.0850
Total number of values that were tied				120
Maximum difference allowed between ties 0.00001				
Cases Included 121 Missing Cases 7				

Coho Rpue Zone 2, Period 4.2

Variable	Rank	Sum N	U Stat	Mean Rank
Complete	3451	60	1621	57.5
Incomplete	3930	61	2039	64.4
Total	7381	121		
Normal Approximation with Corrections for Continuity and Ties 1.607				
Two-tailed P-value for Normal Approximation				0.1080
Total number of values that were tied				101
Maximum difference allowed between ties 0.00001				
Cases Included 121 Missing Cases 7				

Coho Rpue Zone 2, Period 5.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	1913.5	44	923.5	43.5
Incomplete	2272.5	47	1144.5	48.4
Total	4186	91		

Normal Approximation with Corrections for Continuity and Ties 1.89

Two-tailed P-value for Normal Approximation 0.0587

Total number of values that were tied 84

Maximum difference allowed between ties 0.00001

Cases Included 91 Missing Cases 5

Coho Rpue Zone 2, Period 5.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	170	10	115	17
Incomplete	425	24	125	17.7
Total	595	34		

Normal Approximation with Corrections for Continuity and Ties 0.58

Two-tailed P-value for Normal Approximation 0.5613

Total number of values that were tied 33

Maximum difference allowed between ties 0.00001

Cases Included 34 Missing Cases 16

Chum Rpue Zone 1.1, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	414	12	336	34.5
Incomplete	2071	58	360	35.7
Total	2485	70		

Normal Approximation with Corrections for Continuity and Ties 0.621
Two-tailed P-value for Normal Approximation 0.5347
Total number of values that were tied 68
Maximum difference allowed between ties 0.00001
Cases Included 70 Missing Cases 46

Chum Rpue Zone 1.2, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	783	22	530	35.6
Incomplete	1918	51	592	37.6
Total	2701	73		

Normal Approximation with Corrections for Continuity and Ties 0.770
Two-tailed P-value for Normal Approximation 0.4414
Total number of values that were tied 67
Maximum difference allowed between ties 0.00001
Cases Included 73 Missing Cases 31

Chum Rpue Zone 1.2, Period 5.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	102	11	36	9.3
Incomplete	51	6	30	8.5
Total	153	17		

Exact Permutation Test Two-tailed P-value 1.0000
Normal Approximation with Corrections for Continuity and Ties 0.615
Two-tailed P-value for Normal Approximation 0.5383
Total number of values that were tied 16
Maximum difference allowed between ties 0.00001

Chum Hpue Zone 1.3, Period 4.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	834	21	603	39.7
Incomplete	1794	51	468	35.2
Total	2628	72		

Normal Approximation with Corrections for Continuity and Ties 2.091
Two-tailed P-value for Normal Approximation 0.0365
Total number of values that were tied 68
Maximum difference allowed between ties 0.00001
Cases Included 72 Missing Cases 30

Chum Hpue Zone 1.3, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	4681.5	47	3553.5	99.6
Incomplete	14429	148	3402.5	97.5
Total	19110	195		

Normal Approximation with Corrections for Continuity and Ties 0.443
Two-tailed P-value for Normal Approximation 0.6577
Total number of values that were tied 183
Maximum difference allowed between ties 0.00001
Cases Included 195 Missing Cases 103

Chum Rpue Zone 1.3, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	4152.5	47	3024.5	88.4
Incomplete	14958	148	3931.5	101.1
Total	19110	195		

Normal Approximation with Corrections for Continuity and Ties 2.204
Two-tailed P-value for Normal Approximation 0.0275
Total number of values that were tied 169
Maximum difference allowed between ties 0.00001
Cases Included 195 Missing Cases 103

Chum Hpue Zone 1.3, Period 5.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	611	13	520	47
Incomplete	3854	81	533	47.6
Total	4465	94		
Normal Approximation with Corrections for Continuity and Ties 0.370				
Two-tailed P-value for Normal Approximation				0.7115
Total number of values that were tied			93	
Maximum difference allowed between ties 0.00001				
Cases Included 94 Missing Cases 70				

Chum Rpue Zone 1.3, Period 5.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	552	13	461	42.5
Incomplete	3913	81	592	48.3
Total	4465	94		
Normal Approximation with Corrections for Continuity and Ties 0.768				
Two-tailed P-value for Normal Approximation				0.4422
Total number of values that were tied			59	
Maximum difference allowed between ties 0.00001				
Cases Included 94 Missing Cases 70				

Chum Rpue Zone 2, Period 4.1

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	253.5	13	162.5	19.5
Incomplete	566.5	27	188.5	21
Total	820	40		
Normal Approximation with Corrections for Continuity and Ties 0.956				
Two-tailed P-value for Normal Approximation				0.3393
Total number of values that were tied			38	
Maximum difference allowed between ties 0.00001				
Cases Included 40 Missing Cases 16				

Chum Hpue Zone 2, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	3878	60	2048	64.6
Incomplete	3503	61	1612	57.4
Total	7381	121		
Normal Approximation with Corrections for Continuity and Ties 2.479				
Two-tailed P-value for Normal Approximation				0.0132
Total number of values that were tied			117	
Maximum difference allowed between ties 0.00001				
Cases Included 121 Missing Cases 9				

Chum Rpue Zone 2, Period 4.2

Variable	Rank Sum	N	U Stat	Mean Rank
Complete	3861	60	2031	64.4
Incomplete	3520	61	1629	57.7
Total	7381	121		
Normal Approximation with Corrections for Continuity and Ties 1.233				
Two-tailed P-value for Normal Approximation				0.2177
Total number of values that were tied			94	
Maximum difference allowed between ties 0.00001				
Cases Included 121 Missing Cases 9				

Chum Rpue Zone 2, Period 5.1

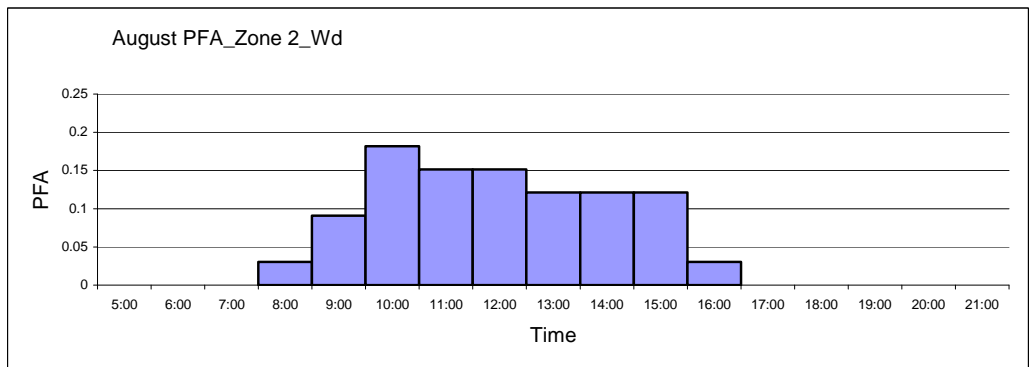
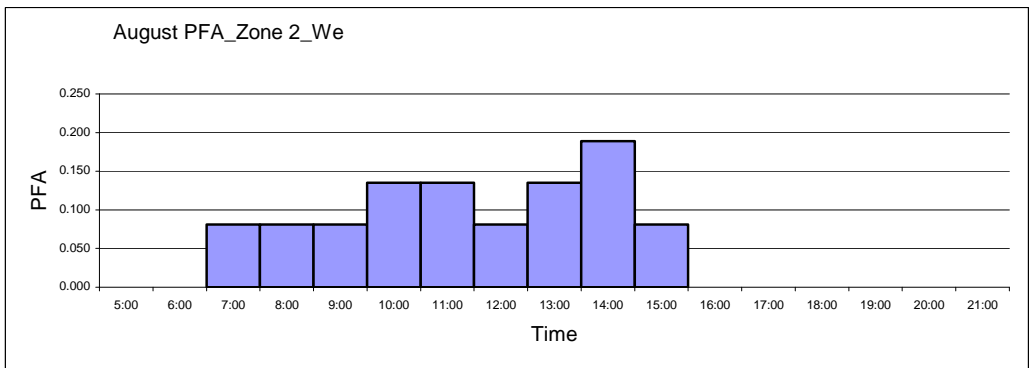
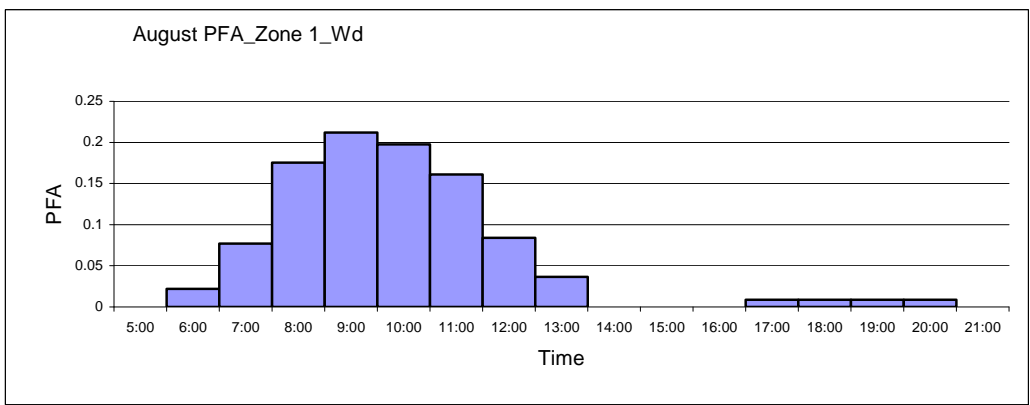
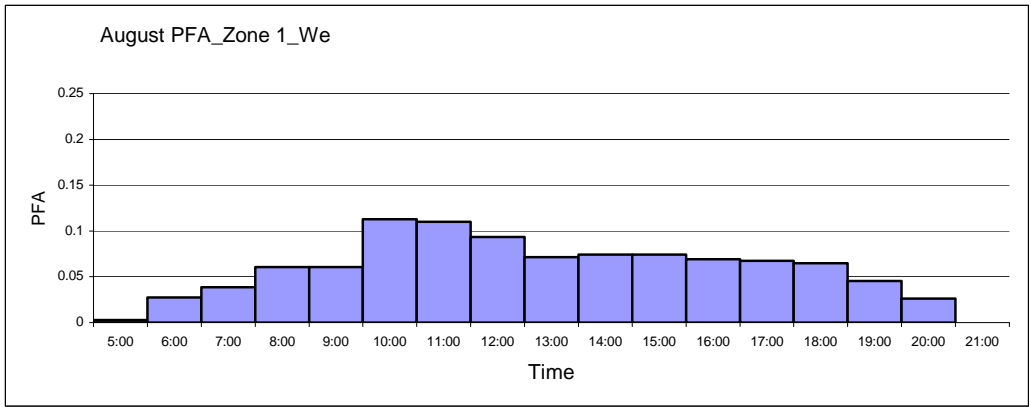
Variable	Rank Sum	N	U Stat	Mean Rank
Complete	2287	44	1297	52
Incomplete	1899	47	771	40.4
Total	4186	91		
Normal Approximation with Corrections for Continuity and Ties 2.187				
Two-tailed P-value for Normal Approximation				0.0287
Total number of values that were tied			60	
Maximum difference allowed between ties 0.00001				
Cases Included 91 Missing Cases 5				

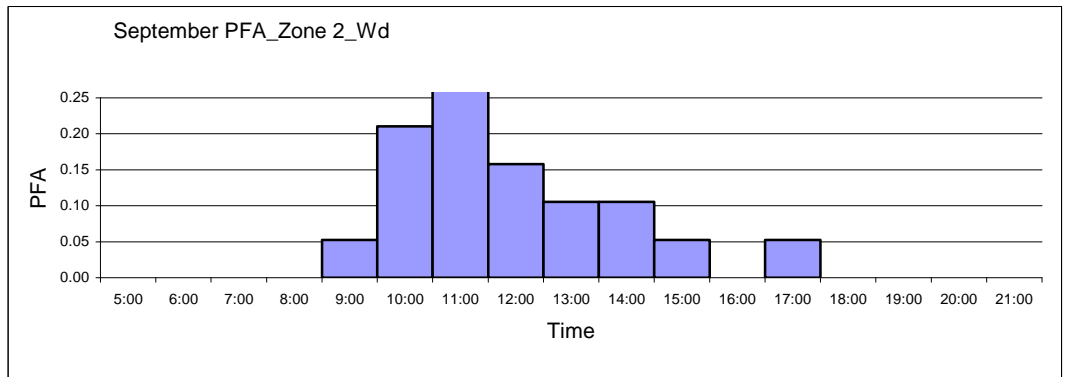
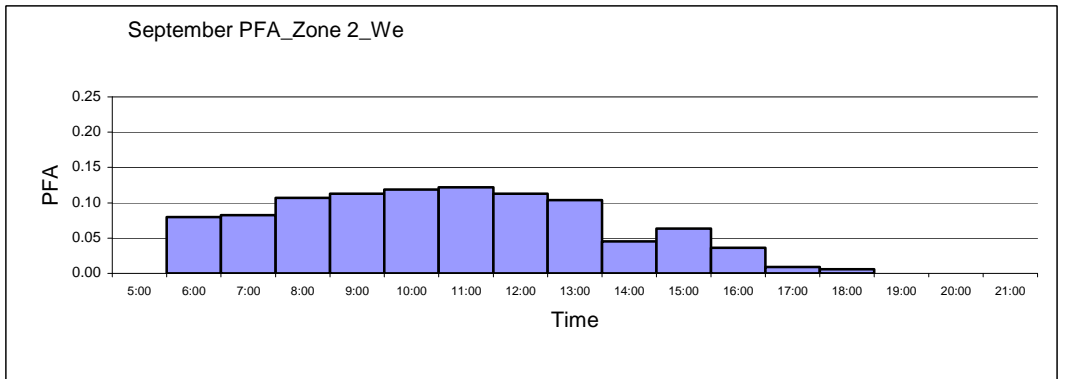
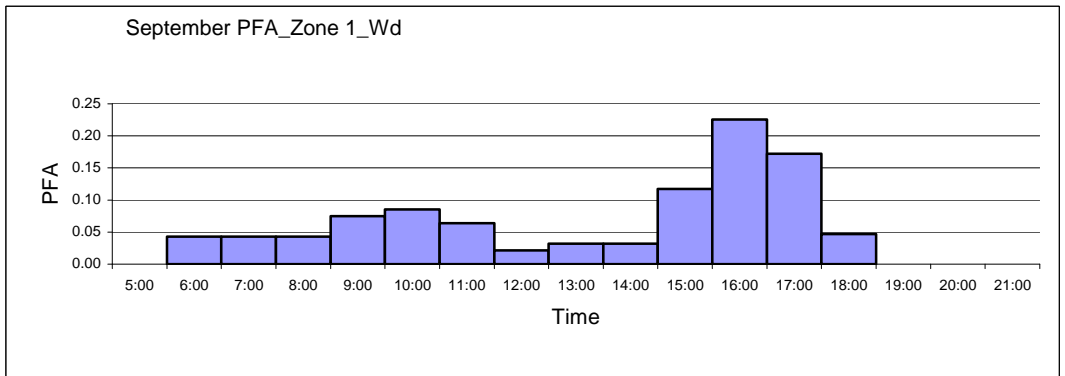
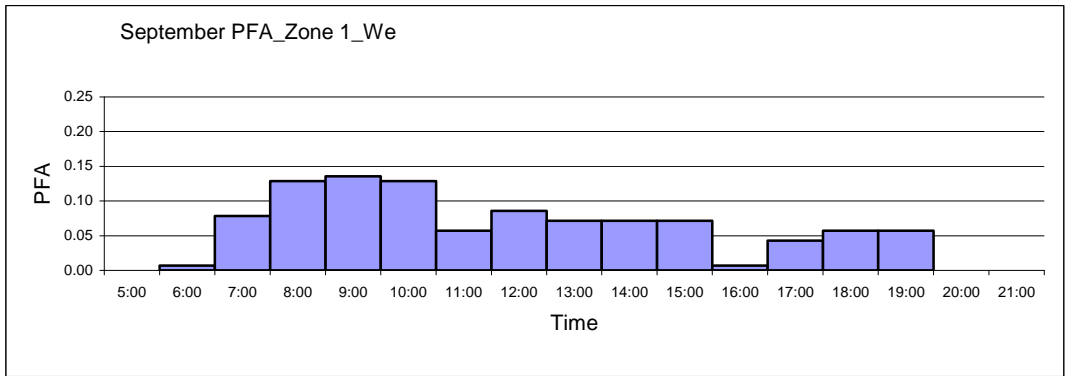
Chum Rpuue Zone 2, Period 5.2

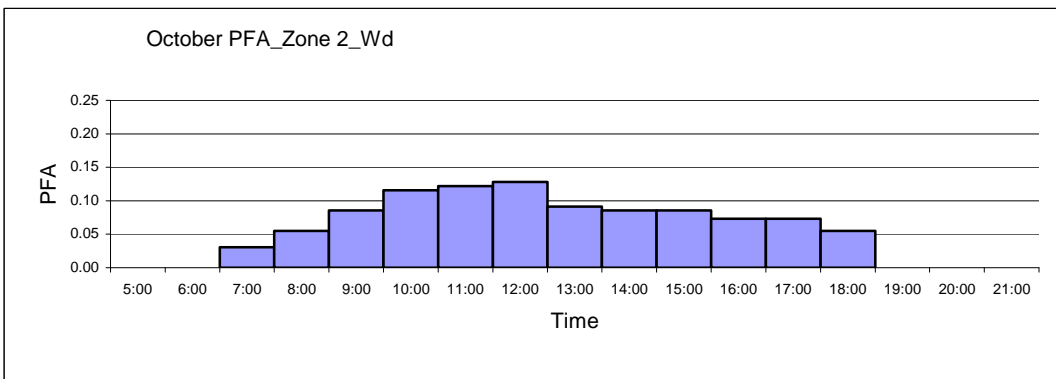
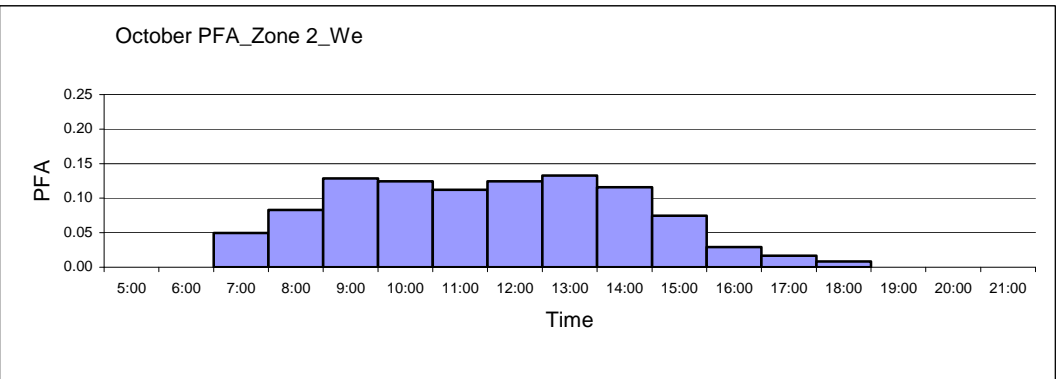
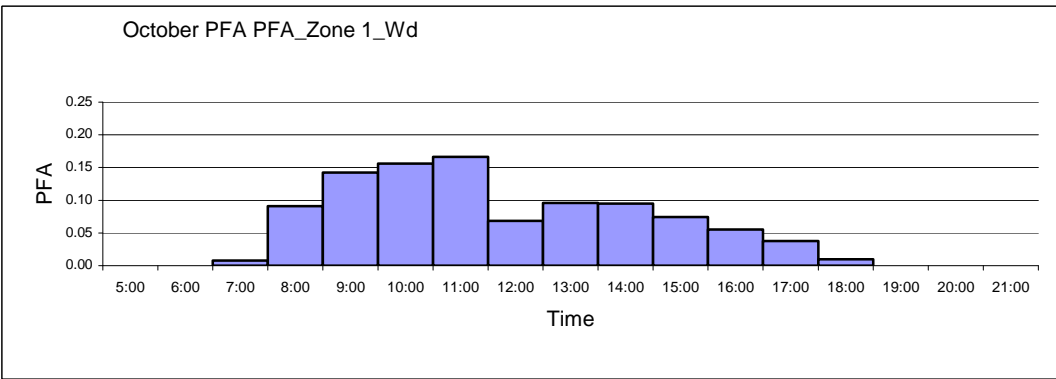
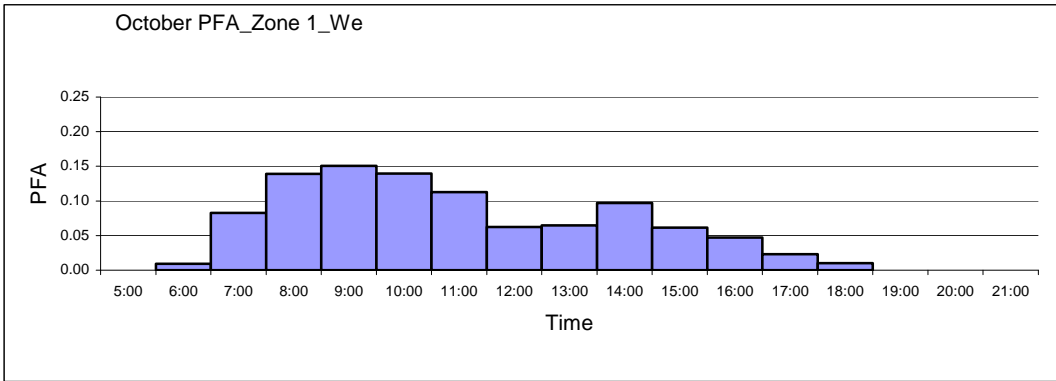
Variable	Rank Sum	N	U Stat	Mean Rank
Complete	150	10	95	15
Incomplete	445	24	145	18.5
Total	595	34		

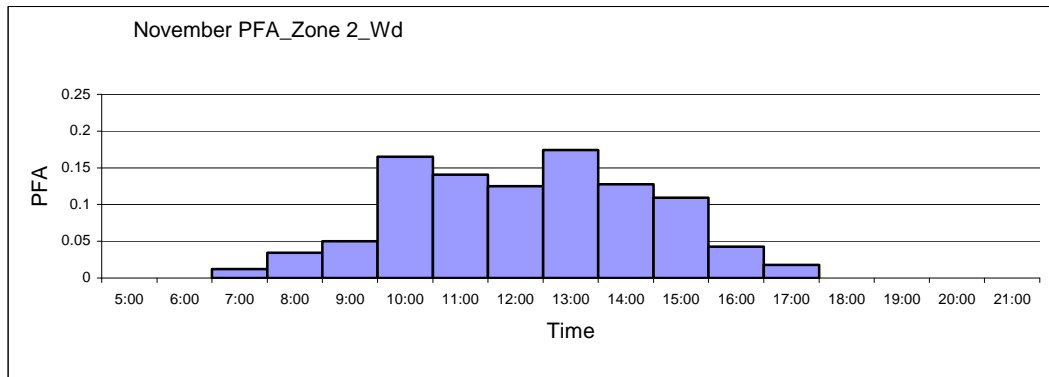
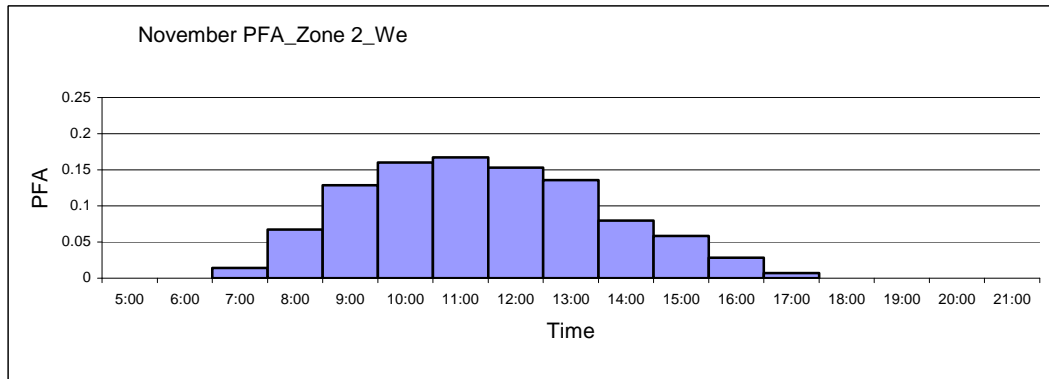
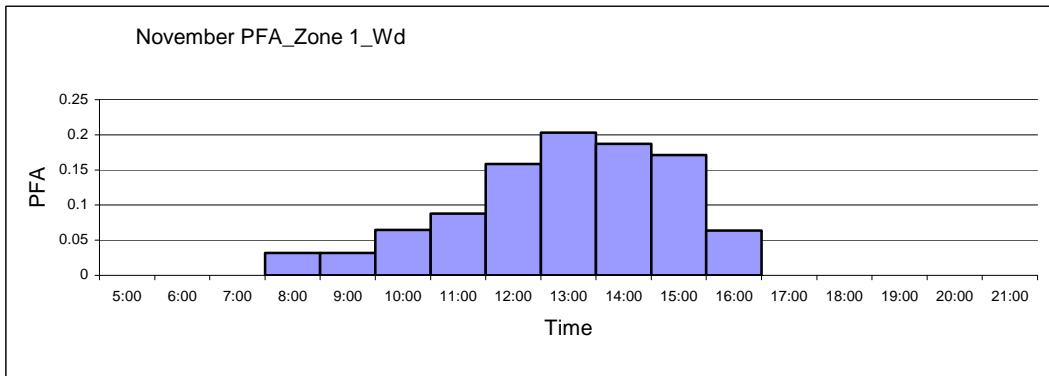
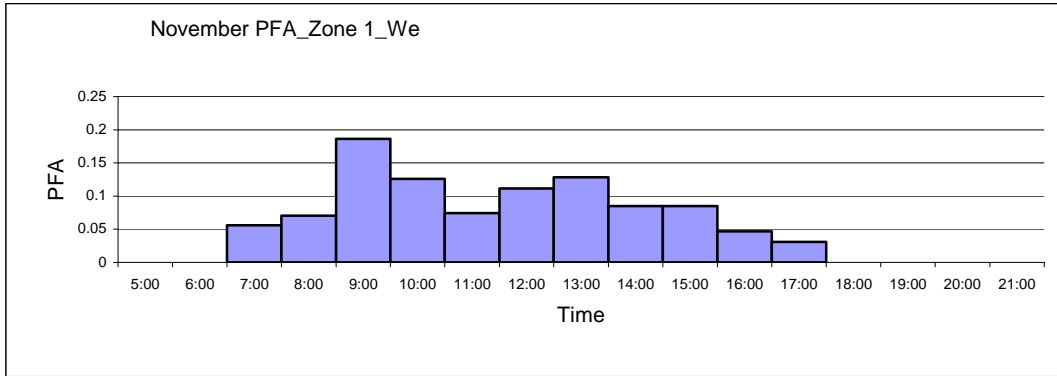
Normal Approximation with Corrections for Continuity and Ties 1.500
Two-tailed P-value for Normal Approximation 0.1328
Total number of values that were tied 31
Maximum difference allowed between ties 0.00001
Cases Included 34 Missing Cases 16

Appendix 6: Angler Activity Profiles









Appendix 7: Biological Data

Date	Location	Species	Fork Length (mm)	Sex	Maturity	Scale Book	Scale	Adipose Clip	E Signal	Head Label No.	Head Taken
20-Oct	FSP	Chum	778	M	M	na	na	na	na	na	na
20-Oct	DCKM	Chum	736	M	M	na	na	na	na	na	na
26-Oct	DCKM	Chum	736	M	M	na	na	na	na	na	na
26-Oct	DCKM	Chum	718	F	M	na	na	na	na	na	na
27-Oct	LSC	Chum	642	M	M	na	na	na	na	na	na
27-Oct	FSP	Chum	671	M	M	na	na	na	na	na	na
28-Oct	FSP	Chum	656	M	M	na	na	na	na	na	na
28-Oct	FSP	Chum	831	F	M	na	na	na	na	na	na