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Abundance and Run Timing of Adult Salmon in Clear Creek, Hogatza River, Alaska, 2000-2005

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ON THE COVER
Photo: Spawning chum salmon in Clear Creek.
Photograph by: D. Esse, Bureau of Land Management

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Abundance and Run Timing of Adult Salmon in Clear Creek, Hogatza River, Alaska, 2000-2005

David A. Esse and Carl F. Kretsinger

I. Abstract

Adult salmon abundance and run timing were monitored on Clear Creek, a tributary to the Hogatza River, using a counting tower in 2000 and standard picket style weir with trap from 2001-2005. The six-year average abundance of summer chum salmon from 2000 to 2005 was 14,073, ranging from 3,674 in 2001 to 26,420 in 2005. Chinook salmon abundance averaged 10, ranging from 0 in 2001 to 30 in 2004. Sockeye salmon abundance averaged 6, ranging from 0 in 2000 and 2001 to 18 in 2005. The average median date of summer chum salmon passage was July 11, with the middle 50% of the run passing the counting site, on average, over a 10 day period. Female summer chum salmon comprised on average 43.7% of the run and ranged from 39.7% in 2003 to 52.8% in 2002. The age composition of summer chum salmon was comprised almost entirely of age 0.3 and 0.4 fish with 0.3 dominating in 2003, 2004, and 2005 and age 0.4 in 2000, 2001, and 2002. Mid-eye to fork-of-tail length (MEL) for male summer chum salmon ranged from 470 mm to 705 mm. MEL for female summer chum salmon ranged from 440 mm to 635 mm. Mean length increased with age for both male and female chum salmon and male chum salmon mean length at age was greater than females at the same age.

II. Introduction

Clear Creek is a tributary to the Hogatza River located in central Alaska about 170 km north of Galena. The Clear Creek drainage supports one of the most productive summer chum salmon (*Oncorhynchus keta*) spawning populations in the Koyukuk River drainage. It provides important spawning and rearing habitat for chum, Chinook (*O. tshawytscha*), sockeye (*O. nerka*), and coho (*O. kisutch*) salmon along with resident fish species. With mine development occurring within the watershed, the Bureau of Land

Management (BLM) is responsible for balancing the protection of these fish populations and habitat required by these fish with resource development.

The BLM's administration of land within the Clear Creek drainage is accomplished through legislative mandates and several management plans. One of these plans is the Hogatza Area of Critical Environmental Concern (ACEC) Aquatic Habitat management Plan (Kretsinger et al. 1994). The ACEC identification, designation, and management process is an integral part of the BLM's multiple-use planning and management process. Through the ACEC process, BLM has a mandate to both provide special management attention that will protect important environmental resources, and do this without unnecessarily or unreasonably restricting users of these lands from uses that are compatible with that protection. As part of the Hogatza ACEC designation, BLM in cooperation with the State of Alaska, identified six management objectives which, among other items, called for the maintenance of aquatic and riparian habitat, water quality, and stream flows necessary to protect the salmon spawning and rearing habitat within Clear Creek.

Land status within the Hogatza ACEC is a patchwork of federal, state, native corporation, and private land. Approximately 1,440 acres along Clear, Aloha, and Bear Creek are covered by unpatented mining claims and 2,617 acres along Clear, Aloha, and Bear Creek are privately owned (Kretsinger et al. 1994). On those portions of Clear and Caribou Creek that are administered by BLM and that are not under claim, 300 foot mineral withdrawals extending along both sides of the stream were approved (subject to prior existing claims) in the Record of Decision for the Central Yukon Resource Management Plan (BLM 1986).

Mining has been conducted in the Clear Creek drainage since the early 1900's. Most of the early mining was exploratory in nature and little observable evidence of this work remains today. Starting in 1958, Alaska Gold began mining on Bear Creek within the Caribou Creek drainage, eventually mining over 500 acres. In the 1990's Taiga Mining Company, Inc. continued mining upper Bear and Ida creeks in the Caribou Creek watershed. Currently placer mining is taking place on private land along Clear Creek and its principal tributary Aloha Creek.

Extraction of placer deposits often requires direct disturbance of aquatic and riparian habitat. The adverse effects of this type of disturbance on fish and other aquatic organisms are well documented in the literature (Reynolds et al. 1989; Buhl and Hamiltion 1990; Hicks et al. 1991; Nelson et al. 1991; Milner and Piorkowski 2004). The combination of active mine development occurring in the Clear Creek watershed, the potential for adverse impacts related to mine development, and the paucity of knowledge concerning the existing conditions and trend of aquatic resources within the area led to heightened concern as to whether or not the Bureau would be in a position to determine if its management obligations regarding the protection of salmon spawning habitat within the Hogatza ACEC are being met.

In order to monitor and assure the continued health of the Clear Creek chum salmon population it was necessary to establish a baseline from which future comparisons may be made. From 1995 – 2007, as part of an overall effort to characterized fishery resources within the Hogatza ACEC the BLM assisted with or operated a salmon abundance project on Clear Creek. Initially, enumeration was undertaken to provide managers with data on the order of magnitude of abundance of spawners in the Clear Creek watershed. From 2002 to 2005, abundance data was also a necessary component for a smolt survival study which focused on quantifying and mapping chum salmon spawning habitat and estimating survival rates of incubating eggs and alevins. Data on egg to smolt survival rates provided BLM with baseline information with which to evaluate the impact of mining on chum salmon habitat and manage the salmon resources according to the plans outlined above. This paper summarizes the results for years 2000-2005.

The objectives of the project were to: 1) Count the daily adult salmon passage through the weir; 2) Describe the run-timing characteristics of adult summer chum salmon by date of quartile passage, period of time required to pass mid-50% of run, and proportion of daily to cumulative passage; 3) estimate the age and sex composition of the weekly passage of adult chum salmon such that simultaneous 90% confidence intervals have maximum widths of 0.20; and 4) estimate the mean length of summer-run chum salmon by sex and age.

III. Study Area

Clear Creek is a sinuous clear water stream located within a portion of the Hogatza River watershed (Figure 1) in northwestern Alaska. The 193 km^2 watershed drains the eastern slopes of the Zane Hills and flows 39 km in a northeasterly direction to its confluence with the Hogatza River. Aloha Creek and Comeback Creek are tributaries to Clear Creek and flow east to southeast to their confluences with the north bank of Clear Creek. Lowlands and poorly drained sites within the study area consist predominately of black spruce (*Picea mariana)*. Well drained areas consist of a mixture of white spruce (*P. glauca*), paperbirch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), willows (*Salix ssp.*), and balsam poplar (*P. balsamifera*).

Aquatic habitat within the Clear Creek upstream of Aloha Creek is in a nearly pristine state and functioning at its full biological potential. Downstream of Aloha Creek Clear Creek has been exposed to additional sediment inputs resulting from mine related watershed and stream channel disturbance occurring within the Aloha Creek watershed.

With the exception of occasional periods of elevated turbidity in lower Clear Creek due to mining activity taking place in the Aloha Creek watershed, water quality within Clear Creek is representative of natural conditions. The water has a near neutral pH (6.7 – 7.1), low conductivity (29 - 54 umhos), low total dissolved solids (≤ 24 mg/L), low nitrate (0.32 mg/L), low turbidity (< 3.0 NTU), and low total phosphate (< 0.04 mg/L). Within the 16 km reach used by salmon for spawning, Clear Creek upstream of Aloha Creek is characterized as a Rosgen (1996) B4 stream channel type with 43 % pool; 43 % riffle, and 14% glide. Downstream of Aloha Creek, Clear Creek is a C4 stream type consisting of 83 % pool; 8 % riffle; and 9 % glide habitat. The stream gradient through the 16 km reach ranges between 0.2 and 0.6 %. Stream banks are 97 % stable and riparian habitat is classified as 100% proper functioning condition. Large woody debris through this reach plays only a minor role in defining the streams morphology but is responsible for providing some instream cover. The surface substrate through the reach is predominantly a mix of fine and coarse gravel (2-64 mm). Snow data collected during the month of March (2002-2008) near the mouth of Clear Creek had an average depth of 115.3 cm with a 26.4 cm SWE. Average monthly discharge in Clear Creek ranges from a low of 13 m^3/s in April to a high of 304 m^3/s in June, with an annual average of 95 m^3/s (Table 1).

Fish species found in Clear Creek include summer chum salmon, Chinook salmon, sockeye salmon, coho salmon, arctic grayling (*Thymallus arcticus),* northern pike *(Esox lucius)*, longnose sucker (*Catostomus catostomus*), slimy sculpin (*Cottus cognatus*), burbot (*Lota lota),* Dolly Varden (*Salvelinus malma),* Alaska blackfish (*Dallia pectoralis),* Arctic lamprey (*Lampetra japonica*) round (*Prosopium cylindraceum*), and broad whitefish (*Coregonus nasus)*). Chum salmon spawning is concentrated in the lower 16 km of Clear Creek and has been observed in Aloha Creek and Comeback Creek (Figure 2).

The weir site was located approximately 1.0 rkm upstream of the confluence of Clear Creek and the Hogatza River. With the exception of spring ice-out flows, this site is above the backwater influence of the Hogatza River, and below most of the chum salmon spawning. The site was selected for its position in the drainage, its uniform cross section, and shallow water depth. The stream channel has a gradual sloping cross section as it runs from a gravel bar to cut bank providing a good even substrate on which to construct and anchor the weir.

IV. Methods

Tower/Weir operation

2000

A 5.0 m high counting tower was erected on the south side of the stream adjacent to a shallow riffle. The tower was constructed out of 10 cm x 10 cm treated lumber and 2 cm plywood. Tower height and angle of observation permitted excellent visual observation at this location. Originating on the north bank, a 15 m standard picket weir was installed partially across the river to divert fish to the south side of the stream to assist observers in the counting tower. The pickets (3 m long with a 1.3 cm diameter) were joined together by horizontally run stringers and five A-frames constructed of 15.2 cm wide, 5 cm thick, treated wood.   Between each A-Frame, three aluminum angle stringers (3.8 m long x 7.6 cm wide x 0.64 cm thick with 2.5 cm holes on 5 cm centers) each supported approximately 75 pieces of conduit when in place. The A-Frames were anchored into the substrate by tying off to #68 Duckbill Earth Anchors upstream of the weir. Vexar fencing was attached to the northernmost A-Frame and run 2.0 m up the north bank in order to prevent undocumented fish passage.

A contrast panel was made of white vinyl and measured 9 m long and 0.9 m wide. The panel was initially anchored to the substrate using 0.3 m spikes of 8 mm round stock. The spikes failed in high velocity sections and were replaced with #68 duckbill anchors. The panel extended out from the south bank and slightly overlapped the south end of the picket weir thus forcing the fish over the panel. Both the weir and contrast panel were cleaned daily of accumulated debris.

2001-2005

A standard picket style weir and aluminum and polyvinyl chloride (PVC) live trap were installed upon arrival in mid-June each year. The standard picket style partial weir was assembled across the stream with the trap located along the south bank. Aside from two additional A-frames, weir materials and construction were identical to those used in

2000. A pre-constructed trap (Mackey Lake Co.) was incorporated into the weir on the upstream side. The trap, measuring 3.0 m long, 2.0 m wide, and 1.8 m high, was constructed of an aluminum frame with panels of aluminum angle and PVC pickets and anchored using four #68 duckbill anchors. White plastic sandbags were placed under and around the base of the trap to seal and stabilize the trap. Visual inspections for holes and structural problems were conducted daily. Fish carcasses and debris were cleaned from the weir as they accumulated, often several times a day.

Abundance Estimation

2000

Counting tower operations were conducted 7 days per week, 24 hours per day, with each observer counting for a six hour period per day. The observer conducted the counts from an elevated position on the counting tower and wore polarized sunglasses as necessary to reduce glare from the water surface and facilitate observation of the fish. Counting began at the top of each hour and continued for a minimum of 20 minutes. Seasonal estimates of escapement based on hourly counts of >20 minutes have 90-95% accuracy of escapement estimates based on full hour counts (Lean 1987, VanHatten 2000). Bromaghin and Bruden (1999) found that sampling designs in which a fixed number of minutes are counted each hour consistently produce superior estimates to those of two-stage or rotating sampling designs. Fish passage by species and direction was recorded on tally counters, and transcribed onto data forms immediately after the 20-minute counting session. The actual count was then multiplied by an expansion factor to compensate for the portion of the hour when the observer was not counting and to obtain the estimate of hourly passage. The equation to estimate hourly passage is:

$N = n \times EF$

where:

N = estimated salmon passage (by species) in that hour

n = actual count (upstream movement of $species_1$ - downstream movement by $species_1$)

EF = (60/number of minutes counted)

The expanded hourly escapement estimates for each species were summed to achieve a daily escapement estimate (0000 - 2359). Run timing characteristics (e.g. quartile days, peak date of passage etc...) were determined after completion of the project. To compensate for missed counting periods we followed the methods as stated in Sandone (1995):

1. A single hourly count that was missed would be estimated by averaging the hourly count before and after missing the count.
2. If hourly counts were missed for a portion of the day, the expanded daily count for that day would be estimated by dividing the expanded partial daily count by the mean proportion of the expanded counts for the corresponding hours for the first day before and after having a full 24 hours count.
3. If a full daily count was missed, the estimate for that day would be calculated as the mean salmon passage for the day before and after missed counts.
4. If counting was not conducted for two or more days, the estimate for those days would be determined by extrapolating the last full day of counts and first full day of counts after resumption of counting.

2001-2005

Adult salmon passing through the trap were counted and identified to species**.** The schedule for counting was 24 hours/day, 7 days/week with one observer for each 6 hour period. The counts were recorded on tally counters and then transcribed to data forms immediately after the counting shift was over. Hourly counts were then summed to give a daily count. Fish were allowed to pass through the weir during high migration periods. A single picket was lifted at the top of each hour and fish passing through the weir were then enumerated from atop the weir using tally counters. Interpolation for missed counts were made using the same methods as in 2000. Median date of passage, peak of run and quartile days of chum salmon passage were determined by calculating the proportion of daily to cumulative passage.

Each third week of July, two individuals walked downstream from the weir to the mouth. Salmon observed spawning in the stream section below the weir were enumerated along with carcasses.

Age-Sex-Length

2000

A 30 m long by 1.8 m deep net with 2.5 cm stretch mesh was used to block the stream above the weir while a 15 m long by 1.2 m deep with 0.9 cm stretch mesh net was used to capture fish for age-sex-length sampling. Age-sex-length (ASL) were determined from a weekly sample of 163 chum/week. Samples were taken uniformly through the week (25 chum/day) with the strata beginning on Sunday. Chum salmon captured for age, sex, and length information were identified by sex and measured to the nearest five millimeters from mid-eye to fork-of tail (MEL). Morphological maturation characteristics were used to determine sex (Groot and Margolis 1991). One scale was removed from the area being two rows above the lateral line and on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin on the left side of the fish. Fish were then given a fin clip on the upper lobe of the caudal fin to prevent repeat sampling. Scales were sent to ADF&G's Commercial Fisheries Division in Anchorage for processing, where acetate impressions of the scales were made and aged. All ages are reported in European notation (Foerster 1968).

2001-2005

Chum salmon were captured and sampled as they entered the aluminum-PVC trap. Captured salmon were placed in a submerged aluminum cradle and sampled using the same methods as in 2000. Sampling strata, processing, ageing, and run timing determination used were also identical to those used in 2000.

Data Analysis

Data was analyzed using a temporally stratified random sampling design (Cochran 1977) with statistical weeks defining strata. The sample size of 163 fish/week provided the number of fish needed to estimate the weekly age and sex composition of the population having three age classes so that 90% confidence intervals have maximum widths of 0.20 while allowing for up to 15% unreadable scales (Bromaghin 1993). Strata with small numbers of sampled fish were combined in order to obtain a sample size large enough for analysis.

Statistical Method

Within a given stratum m, the proportion of species i passing the weir that are of sex j and age k (p_{ijkm}) is estimated as

$$P_{ijkm} = n_{ijkm} \; / \; n_{i++m}$$

where n_{ijkm} denotes the number of fish of species i, sex j, and age k sampled during stratum m and a subscript of "+" represents summation over all possible values of the corresponding variable, e.g., n_{i++m} denotes the total number of fish of species i sampled in stratum m. The variance of P_{ijkm} is estimated as

$$v(P_{ijkm}) = (1 - n_{i++m} \; / \, N_{i++m}) \, (P_{ijkm} \, (1 - P_{ijkm}) \, / \, n_{i++m} - 1),$$

where N_{i++m} denotes the total number of species i fish passing the weir in stratum m. The estimated number of fish of species i, sex j, age k passing the weir in stratum m (N_{ijkm}) is

$$N_{ijkm} = N_{i++m} \, P_{ijkm} \, ,$$

with estimated variance

$$v(N_{ijkm}) = N^2_{i++m} \, v(P_{ijkm})$$

Estimates of proportions for the entire period of weir operation are computed as weighted sums of the stratum estimates, i.e.,

$$P_{ijk} = \sum_{m} (N_{i++m} / N_{i+++}) P_{ijkm}$$

and

$$v(P_{ijk}) = \sum_{m} (N_{i++m} / N_{i+++})^2 v(P_{ijkm})$$

The total number of fish in a species, sex, and age category passing the weir during the entire period of operation is estimated as

$$N_{ijk} = \sum_{m} N_{ijkm} ,$$

with estimated variance

$$v(N_{ijk}) = \sum_{m} v(N_{ijkm})$$

Water conditions

Stream elevation (cm), turbidity (NTU), water temperature (°C), precipitation (cm), and stream velocity (m^3/s) were recorded at 1200 daily. Water level was measured to the nearest centimeter on a surveyed stream gauge. Turbidity was measured using a Hach model 2100P portable turbidimeter using the standard procedures as outlined for the instrument. Water temperature was taken directly upstream of the weir on a thermometer submerged 30 cm beneath the surface. Precipitation was measured for the previous twenty four hours with a rain gage. Stream discharge was measured whenever the water level varied by more than 3 cm from the season's initial measurement in order to define the stage-discharge relationship. Discharge was recorded using a Price AA current meter, top setting rod, and tag line using the six-tenths depth method (Rantz et al. 1982). A water elevation versus discharge rating was developed by combining the direct discharge measurement and computer simulated peak discharges using log-log regression analysis (Rantz et al. 1982).

V. Results

Tower/Weir operation

The date of tower/weir installation was determined by runoff conditions in June. The starting date for counts ranged from June 21 in 2002 to June 25 in 2000. Removal of the tower/weir was completed after three consecutive days of counts of less than one percent of the total cumulative. This date varied from July 25, 2000 to August 2 in 2001, 2002, and 2003.

Throughout the duration of the project the weir was operational except for brief periods in 2003, 2004, and 2005. In 2003 two rain events brought enough precipitation to suspend counting operations. During these periods (June 26-27, July 1-4) high flows required the removal of pickets from the two stringer sections located within the thalweg. At that time chum salmon were observed migrating through these removed sections however high turbidity prevented an accurate count of these fish. In 2004 and 2005 the trap was left open during two crew change events where fish migrated uncounted for a period of eight hours. A high water event, similar to those in 2003, prevented counting for two hours on July 11 and all day on July 12, 2005.

Abundance and Run Timing

The average annual recorded abundance for summer chum salmon for the six year period was 14,073. Abundance estimates were 19,376 (2000), 3,674 (2001), 13,150 (2002), 6,159 (2003), 15,661 (2004), and 26,420 (2005) (Table 2). Not included in weir abundance estimates were spawning summer chum salmon observed below the weir during foot surveys. Counts below the weir were 150 (2000), 474 (2001), 755 (2002), 498 (2003), 270 (2004), and 685 (2005). Run timing varied from year to year with salmon initially passing through the weir as early as June 21 in 2004 and as late as July 7 in 2001.

Average median date of passage from 2000 to 2005 was July 11 with dates ranging from July 8 in 2002 to July 13 in 2000 and 2001. The middle 50 % of the run passed in an average of 10 days (Table 2). Chinook and sockeye salmon abundance was small in all years ranging from 0 – 30 and 0 – 18 (Tables 3 and 4).

Age-Sex-Length

Summer chum salmon were represented by four age classes with age class 0.3 comprising the majority of fish in 2003 (90 %), 2004 (63 %), and 2005 (86 %), and age 0.4 comprising the majority in 2000 (77 %), 2001 (60%), and 2002 (73 %) (Table 5). The dominant age class was the same for males and females for all years. Female chum salmon composition ranged from 39.7 % to 52.8 % with estimated abundance varying from 1,489 to 11,921 (Table 6). Mean length increased with age for both male and female chum salmon. Male chum salmon length ranged from 470 to 705 mm and females 440 to 635 mm. On average, male chum salmon were longer than females at the same age (Table 7).

Water conditions

Over the course of the study, water temperatures remained within the limits acceptable to salmon and ranged from 5 to 15° C with an average noon-time temperature of 8.4 over the six seasons of study. Precipitation ranged from 3.2 cm in 2005 to 12.8 cm in 2003 with a seasonal average of 5.7 cm. Turbidity (NTU) ranged from 0.7 to 27.9 with an average noon-time reading of 2.4. Stream discharge measurements ranged from 1.4 to 30.4 m^3/s with the high discharge corresponding to the timing of snow melt and large precipitation events during most years.

VI. Discussion

Weir/Tower Operation

Counting using the tower and flash panel in 2000 was effective once the contrast panel was adequately anchored. In all years the weir and trap performed well and were effective in allowing for accurate counts and collection of biological indices of migrating salmon. High water events suspended counting for brief periods in 2003 and 2005 but the weir remained intact. Picket spacing was adequate to prevent adult salmon from passing between the pickets. Smaller-sized resident species may have passed through the weir undetected.

Abundance and Run Timing

Prior to this study a counting tower located at the mouth of Clear Creek was operated from 1995 to 1999. Participants include the Tanana Chiefs Conference (TCC) in 1995, USFWS and BLM in 1996, and TCC, BLM and Bering Sea Fisherman's Association from 1997 to 1999. With ten years of complete data and one incomplete count in 1998 from the Clear Creek tower and weir, short-term trends can be analyzed and compared to other tributaries within the Koyukuk drainage and the Yukon River watershed. In the mid-1990's, abundance of summer chum salmon in Clear Creek peaked at 116,735, but then suffered a series of run failures in 1999, and 2001 (Figure 9) (Headlee 1996; G. VanHatten pers. comm.). This low abundance of summer chum salmon closely followed the Yukon River summer chum stocks as a whole (Figure 10) (U.S. and Canada JTC 2008). The cause of this decline is presently unknown but a combination of oceanic and freshwater conditions could be at fault (Beachem and Starr 1982, Kruse 1998). With the exception of 2001, Clear Creek's summer chum salmon pattern of escapement has mirrored that of Henshaw Creek and the Gisasa River for the years 2000 to 2005 (VanHatten and Voight 2005: O'brien and Berkbilger 2005b; Berkbilger and Elkin 2006, Wiswar 2001; VanHatten 2002; VanHatten 2003; VanHatten 2004, O'brien and Berkbilger 2005a, Obrien 2006). In 2001 the Gisasa River and Henshaw Creek saw increases of 57% (N=17,936) and 42% (N=34,777) respectively while Clear Creek decreased by 81% (N=3,674) (VanHatten 2002, VanHatten 2005). Also, in 2005, Clear Creek did not have as pronounced abundance estimate compared to these same two escapement projects. While the Gisasa River and Henshaw Creek projects counted 172,259 and 148,935 summer chum salmon respectively, Clear Creek had a return of only 26,420 fish (O'Brien 2006, Berkbigler and Elkin 2006). This may be a product of the significantly lower escapement and low proportion of females spawning in 2001, having only 1,489 females. With 86% of the returning salmon being from the low abundance 2001 brood year, lower 2005 abundance would be expected. However 2005 had the largest summer chum salmon abundance of years 2000 to 2005.

Run timing also varied between years with summer chum salmon arriving as early as June 21st in 2004 and as late as July 7th in 2001. The late arrival of fish in 2001 was also documented in the Gisasa River and Henshaw Creek (VanHatten 2002). The Yukon and Koyukuk Rivers had later ice-out conditions in 2001 which is most likely the cause of the late arrival of salmon to their spawning grounds.

Age

Summer chum salmon populations are generally comprised of 3 (0.2), 4 (0.3), and 5 (0.4) year old fish with northern latitude stocks having a larger proportion of 4 and 5 year old fish (Groot and Margolis, 1998). This northern latitude trend was exhibited in Clear Creek with 4 and 5 year old fish comprising 96.4% of the run for all years with 99.8 % of the 2005 run being of these two age classes. In Clear Creek, between 2000 and 2005, no single age class was consistently more abundant. Of sampled fish, age 5 fish were more abundant from 2000 to 2002 while age 4 fish dominated from 2003 through 2005. The age at maturity and subsequent return to spawning areas of adult salmon is effected by many factors including but not limited to growth in the second year of marine life and the abundance of the brood (Helle 1979, Beachem and Starr 1982). The negative correlation between the age at maturity and abundance of the brood is evident when looking at the Clear Creek population from 2000 through 2005. The high abundance years of 1995 to 1997 produced older age 5 fish for 2000 through 2002 while the lower abundance years of 1999 through 2001 produced predominately age 4 fish in 2003 through 2005. In fact the two highest percentages of any age class fish occurred with age 4 fish in both 2003 (90.3%) and 2005 (85.6%). These fish were produced from the 1999 and 2001 returns which contained some of the lowest abundances for any brood group.

Sex Composition

Sex ratios of salmon abundances are indicative of the general health of the run. A large abundance does not necessarily mean that the run is healthy unless the stock has a good representation of females. From 2000 to 2005 the proportion of female chum salmon remained above 39%, averaging 43.7 % indicating a healthy sex composition (Table 6). Generally, during a salmon spawning period, there are a higher proportion of males during the early stages of the run while females dominate the later stages (Beachum and Starr 1992). This was true for all years at Clear Creek with the exception being the 2000 run.

VII. Conclusions

Clear Creek supports one of the largest spawning populations of summer chum salmon within the Koyukuk River watershed. Past data collection (1995 – 1999) combined with the results from this study indicate that a great deal of inter-annual variability in spawner abundance occurs. This variability is due to many factors that result in less than optimal marine and freshwater habitat conditions. These conditions that are caused by large scale climatic changes (e.g. decadal oscillation) or more localized weather phenomenon which influence local river conditions (e.g. floods, drought, and winter freeze-down) are often the primary controlling factors when considering overall salmon productivity. However, outside the realm of natural influence, BLM does have a role in the protection of freshwater habitat. In the case of Clear Creek, ongoing mining development within the drainage continues to threaten high value salmon spawning habitat that is administered by BLM. In order for BLM to ensure that it is meeting its commitment to protect this habitat it will be necessary to periodically monitor salmon escapement in conjunction with the monitoring of smolt survival rates and document overall trends in habitat condition.

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X. Appendix A: Tables

Table 1. Average monthly discharge (2000 – 2006) for Clear Creek 1.3 km upstream from it's confluence with the Hogatza River, Alaska; (from Kretsinger and Kostohrys 2008).

Month	Avg. Monthly flow (cfs)
Jan	32
Feb	25
Mar	20
Apr	17
May	228
Jun	398
Jul	169
Aug	163
Sep	212
Oct	110
Nov	67
Dec	47
Average	124

Table 2. Daily and cumulative counts for summer chum salmon, Clear Creek, Alaska 2000-2005.

	2000		2001		2002		2003		2004		2005	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
6/21					0	0			43	43		
6/22					0	0	1	1	30	73	0	0
6/23					1	1	3	4	88	161	0	0
6/24			0	0	4	5	2	6	23	184	0	0
6/25	0	0	0	0	20	25	5	11	83	267	3	3
6/26	0	0	0	0	339	364	**12**	23	235	502	0	0
6/27	0	0	0	0	117	481	**10**	33	144	646	1	4
6/28	0	0	0	0	46	527	20	53	84	730	10	14
6/29	0	0	0	0	50	577	5	58	136	866	24	38
6/30	8	8	0	0	98	675	43	101	376	1242	75	113
7/1	32	40	0	0	301	976	**125**	226	604	1846	66	179
7/2	61	101	0	0	299	1275	**207**	433	253	2099	165	344
7/3	346	447	0	0	1016	2291	**289**	722	1385	3484	516	860
7/4	782	1229	0	0	747	3038	**371**	1093	408	3892	709	1569
7/5	505	1734	0	0	1363	4401	454	1547	1042	4934	1633	3202
7/6	326	2060	0	0	886	5287	392	1939	1404	6338	833	4035
7/7	392	2452	9	9	1015	6302	435	2374	350	6688	1441	5476
7/8	504	2956	111	120	641	6943	563	2937	933	7621	740	6216
7/9	1872	4828	294	414	542	7485	175	3112	476	8097	1355	7571
7/10	2289	7117	415	829	613	8098	122	3234	793	8890	2676	10247
7/11	1635	8752	285	1114	564	8662	175	3409	961	9851	**2031**	12278
7/12	909	9661	542	1656	822	9484	99	3508	963	10814	**2113**	14391
7/13	1106	10767	181	1837	693	10177	150	3658	746	11560	2195	16586
7/14	531	11298	110	1947	556	10733	219	3877	**498**	12058	**1381**	17967
7/15	1398	12696	167	2114	475	11208	112	3989	1010	13068	1095	19062
7/16	975	13671	185	2299	447	11655	320	4309	556	13624	1116	20178
7/17	968	14639	322	2621	364	12019	296	4605	325	13949	1059	21237
7/18	1181	15820	399	3020	176	12195	332	4937	227	14176	551	21788
7/19	964	16784	265	3285	142	12337	256	5193	165	14341	607	22395
7/20	924	17708	178	3463	79	12416	120	5313	168	14509	609	23004
7/21	766	18474	39	3502	81	12497	79	5392	**188**	14697	**475**	23479
7/22	440	18914	32	3534	78	12575	45	5437	182	14879	415	23894
7/23	180	19094	22	3556	98	12673	77	5514	65	14944	386	24280
7/24	230	19324	14	3570	80	12753	43	5557	113	15057	397	24677
7/25	52	19376	13	3583	40	12793	67	5624	144	15201	294	24971
7/26			17	3600	35	12828	179	5803	104	15305	226	25197
7/27			9	3609	52	12880	70	5873	72	15377	256	25453
7/28			14	3623	76	12956	80	5953	67	15444	254	25707
7/29			10	3633	35	12991	54	6007	85	15529	231	25938
7/30			6	3639	57	13048	46	6053	78	15607	157	26095
7/31			10	3649	52	13100	24	6077	54	15661	195	26290
8/1			18	3667	34	13134	67	6144			130	26420
8/2			7	3674	16	13150	15	6159				
Total	19376		3674		13150		6159		15661		26420	

Boxed areas=quartiles(25,50, and 75%)

Cum=cumulative

Bold=interpolated counts

Table 3. Daily and cumulative counts for Chinook, Clear Creek, Alaska 2000-2005.

	2000		2001		2002		2003		2004		2005	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
6/21					0	0			0	0		
6/22					0	0	0	0	0	0	0	0
6/23					0	0	0	0	0	0	0	0
6/24			0	0	0	0	0	0	0	0	0	0
6/25	0	0	0	0	0	0	0	0	0	0	0	0
6/26	0	0	0	0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	0	0	0	0	0	0	0
6/29	0	0	0	0	0	0	0	0	0	0	0	0
6/30	0	0	0	0	0	0	0	0	0	0	0	0
7/1	0	0	0	0	0	0	0	0	0	0	0	0
7/2	0	0	0	0	0	0	0	0	0	0	0	0
7/3	0	0	0	0	0	0	0	0	0	0	0	0
7/4	0	0	0	0	0	0	0	0	0	0	0	0
7/5	0	0	0	0	0	0	0	0	0	0	0	0
7/6	0	0	0	0	0	0	0	0	0	0	0	0
7/7	0	0	0	0	0	0	0	0	0	0	0	0
7/8	0	0	0	0	0	0	0	0	0	0	0	0
7/9	0	0	0	0	0	0	1	1	0	0	0	0
7/10	0	0	0	0	0	0	0	1	0	0	0	0
7/11	0	0	0	0	0	0	0	1	0	0	0	0
7/12	0	0	0	0	0	0	1	2	0	0	0	0
7/13	1	1	0	0	0	0	0	2	2	2	0	0
7/14	0	1	0	0	0	0	0	2	0	2	0	0
7/15	1	2	0	0	1	1	0	2	0	2	0	0
7/16	0	2	0	0	2	3	0	2	3	5	0	0
7/17	0	2	0	0	1	4	0	2	3	8	1	1
7/18	0	2	0	0	0	4	0	2	4	12	0	1
7/19	0	2	0	0	0	4	0	2	0	12	0	1
7/20	0	2	0	0	1	5	0	2	0	12	0	1
7/21	0	2	0	0	3	8	0	2	2	14	0	1
7/22	0	2	0	0	1	9	0	2	6	20	0	1
7/23	0	2	0	0	2	11	1	3	1	21	0	1
7/24	0	2	0	0	2	13	0	3	2	23	1	2
7/25	0	2	0	0	0	13	1	4	4	27	2	4
7/26			0	0	0	13	1	5	0	27	0	4
7/27			0	0	1	14	0	5	0	27	1	5
7/28			0	0	0	14	0	5	1	28	3	8
7/29			0	0	0	14	0	5	1	29	1	9
7/30			0	0	0	14	0	5	1	30	0	9
7/31			0	0	0	14	0	5	0	30	0	9
8/1			0	0	0	14	0	5			0	9
8/2			0	0	1	15	0	5				
Total	2		0		15		5		30		9	

Cum=cumulative

Table 4. Daily and cumulative counts for sockeye, Clear Creek, Alaska 2000-2005.

	2000		2001		2002		2003		2004		2005	
Date	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
6/21					0	0			0	0		
6/22					0	0	0	0	0	0	0	0
6/23					0	0	0	0	0	0	0	0
6/24			0	0	0	0	0	0	0	0	0	0
6/25	0	0	0	0	0	0	0	0	0	0	0	0
6/26	0	0	0	0	0	0	0	0	0	0	0	0
6/27	0	0	0	0	0	0	0	0	0	0	0	0
6/28	0	0	0	0	0	0	0	0	0	0	0	0
6/29	0	0	0	0	0	0	0	0	0	0	0	0
6/30	0	0	0	0	0	0	0	0	0	0	0	0
7/1	0	0	0	0	0	0	0	0	0	0	0	0
7/2	0	0	0	0	0	0	0	0	0	0	0	0
7/3	0	0	0	0	0	0	0	0	0	0	0	0
7/4	0	0	0	0	0	0	0	0	0	0	0	0
7/5	0	0	0	0	0	0	0	0	0	0	0	0
7/6	0	0	0	0	0	0	0	0	0	0	0	0
7/7	0	0	0	0	0	0	0	0	0	0	0	0
7/8	0	0	0	0	0	0	0	0	0	0	0	0
7/9	0	0	0	0	0	0	0	0	1	1	0	0
7/10	0	0	0	0	0	0	0	0	0	1	0	0
7/11	0	0	0	0	0	0	0	0	0	1	0	0
7/12	0	0	0	0	0	0	0	0	0	1	0	0
7/13	0	0	0	0	0	0	0	0	0	1	0	0
7/14	0	0	0	0	0	0	0	0	0	1	0	0
7/15	0	0	0	0	0	0	0	0	0	1	0	0
7/16	0	0	0	0	0	0	0	0	0	1	1	1
7/17	0	0	0	0	1	1	0	0	0	1	0	1
7/18	0	0	0	0	1	2	0	0	0	1	0	1
7/19	0	0	0	0	0	2	0	0	0	1	0	1
7/20	0	0	0	0	1	3	0	0	0	1	1	2
7/21	0	0	0	0	1	4	1	1	0	1	2	4
7/22	0	0	0	0	1	5	0	1	0	1	0	4
7/23	0	0	0	0	1	6	1	2	0	1	0	4
7/24	0	0	0	0	0	6	0	2	0	1	0	4
7/25	0	0	0	0	0	6	0	2	0	1	1	5
7/26			0	0	0	6	0	2	0	1	1	6
7/27			0	0	0	6	0	2	0	1	4	10
7/28			0	0	0	6	0	2	0	1	3	13
7/29			0	0	0	6	1	3	0	1	0	13
7/30			0	0	1	7	0	3	0	1	0	13
7/31			0	0	1	8	0	3	2	3	4	17
8/1			0	0	0	8	3	6			1	18
8/2			0	0	2	10	0	6				
Total	0		0		10		6		3		18	

Cum = Cumulative

Table 5. Age and sex ratio by stratum for summer chum salmon sampled at Clear Creek, Alaska 2000-2005.

2000

				Brood year and age			
				1997	1996	1995	1994
Strata	Run Size (N)	Sample size (n)	Percent Female	0.2	0.3	0.4	0.5
7/2-7/8	2956	120	55.8	0	10 (2.8)	87.5 (3.0)	2.5 (1.4)
7/9-7/15	9740	231	41.1	0	21.6 (2.7)	77.5 (2.8)	0.9 (0.6)
7/16-7/29	6680	122	36.1	0	29.4 (4.1)	67.2 (4.3)	3.3 (1.6)
Total	19376	473	41.7	0	20.8 (3.5)	77.4 (3.6)	1.9 (1.3)
Male	11311	267		0	18.3 (3.8)	78.3 (4.5)	3.4 (3.0)
Female	8065	206		0	23.8 (5.6)	76.2 (5.6)	0

2001

				Brood year and age			
				1998	1997	1996	1995
Strata	Run Size (N)	Sample size (n)	Percent Female	0.2	0.3	0.4	0.5
7/1-7/14	1947	93	39.8	0	21.5 (4.3)	68.8 (4.8)	9.7 (3.1)
7/15-7/21	1555	101	44.6	0	38.6 (4.9)	58.4 (4.9)	3.0 (1.7)
7/22-8/3	172	107	12.1	0	41.1 (4.8)	54.2 (4.8)	4.7 (2.1)
Total	3674	301	40.5	0	34.3 (4.5)	60.2 (4.8)	5.6 (2.6)
Male	2185	206		0	35.4 (5.5)	58.3 (5.9)	6.3 (3.4)
Female	1489	95		0	31.6 (10.4)	64.2 (10.7)	4.2 (3.3)

2002

				Brood year and age			
				1999	1998	1997	1996
Strata	Run Size (N)	Sample size (n)	Percent Female	0.2	0.3	0.4	0.5
6/23-6/29	577	94	33	0	6.4 (2.5)	89.3 (3.2)	4.2 (2.1)
6/30-7/6	4710	208	55.8	0	11.0 (2.2)	86.1 (2.4)	2.9 (1.7)
7/7-7/13	4890	191	55	0.5 (0.5)	17.3 (2.7)	79.1 (3.0)	3.1 (1.3)
7/14-7/20	2239	178	45.5	1.1 (0.8)	26.4 (3.3)	66.9 (3.5)	5.6 (1.7)
7/21-7/27	464	156	50.6	2.6 (1.0)	34.6 (3.3)	62.2 (3.6)	0.6 (0.5)
7/28-8/3	270	108	65.7	2.8 (0.9)	51.8 (3.3)	44.4 (3.1)	0.9 (0.5)
Total	13150	935	52.8	1.1 (1.0)	23.4 (3.8)	72.5 (4.1)	2.9 (1.4)
Male	6213	452		1.1 (1.4)	18.6 (5.1)	75.7 (5.7)	4.6 (2.7)
Female	6937	483		1.0 (1.3)	30.0 (5.6)	69.6 (5.7)	1.4 (1.5)

Table 5 (cont.). Age and sex ratio by stratum for summer chum salmon sampled at Clear Creek, Alaska 2000-2005.

2003

				Brood year and age			
				2000	1999	1998	1997
Strata	Run Size (N)	Sample size (n)	Percent Female	0.2	0.3	0.4	0.5
6/22-7/5	1547	57	33.3	0	68.4 (6.2)	22.8 (5.6)	8.8 (3.8)
7/6-7/12	1961	166	34.3	0	89.7 (2.4)	8.4 (2.2)	1.8 (1.0)
7/13-7/19	1685	167	48.5	0.6 (0.6)	92.8 (2.0)	5.4 (1.8)	1.2 (0.8)
7/20-7/26	610	157	46.5	0	91.7 (2.2)	8.2 (2.2)	0
7/27-8/2	356	132	43.2	1.5 (0.8)	95.4 (3.3)	3.1 (1.2)	0
Total	6159	679	39.7	0.4 (0.5)	90.3 (4.0)	7.8 (3.3)	1.5 (2.0)
Male	3715	392		0	88.6 (5.2)	9.2 (4.4)	9 (2.2)
Female	2444	287		1.1 (1.1)	92.7 (5.8)	5.9 (5.1)	0.3 (0.6)

2004

				Brood year and age			
				2001	2000	1999	1998
Strata	Run Size (N)	Sample size (n)	Percent Female	0.2	0.3	0.4	0.5
6/21-6/26	502	114	42.1	0.9 (0.9)	28.9 (4.3)	69.3 (4.3)	0.9 (0.9)
6/27-7/3	2982	181	45.9	1.1 (0.8)	47.5 (3.7)	50.8 (3.7)	0.6 (0.6)
7/4-7/10	5406	180	46.7	1.1 (0.8)	67.8 (3.5)	30.5 (3.4)	0.6 (0.6)
7/11-7/17	5059	175	44	2.9 (1.2)	76.0 (3.2)	21.1 (3.1)	0
7/18-7/24	1108	177	39.5	5.7 (1.7)	74.0 (3.3)	20.3 (3.0)	0
7/25-7/31	604	116	40.5	7.8 (1.6)	79.3 (3.7)	12.9 (2.1)	0
Total	15661	943	44.8	3.1 (1.7)	63.3 (4.4)	33.3 (3.9)	0.3 (0.4)
Male	8651	534		2.3 (2.0)	64.0 (5.9)	33.3 (5.5)	0.4 (0.8)
Female	7010	409		4.2 (2.8)	62.3 (6.6)	33.3 (5.4)	0.2 (0.4)

2005

				Brood year and age			
				2002	2001	2000	1999
Strata	Run Size (N)	Sample size (n)	Percent Female	0.2	0.3	0.4	0.5
6/30-7/9	7571	245	30.2	0	75.5 (2.8)	24.5 (2.8)	0
7/10-7/16	12607	193	54.4	0	83.4 (2.7)	16.1 (2.6)	0.5 (0.5)
7/17-7/23	4102	192	47.4	0	93.8 (1.8)	6.2 (1.8)	0
7/24-8/1	2140	175	38.9	0	93.1 (1.9)	6.3 (1.8)	0.6 (0.6)
Total	26420	805	42.7	0	85.6 (2.5)	14.2 (2.5)	0.2 (0.4)
Male	14562	467		0	83.1 (3.6)	16.7 (3.6)	0.2 (0.8)
Female	11828	338		0	89.1 (3.6)	10.6 (3.6)	0.3 (0.4)

Standard errors are in parenthesis. Beginning and ending strata were combined in order to obtain adequate sample size.

Table 6. Proportion and estimated number of female summer chum salmon Clear Creek, Alaska, 2000-2005.

Year	Run Size (N)	Sample Size (n)	Percent Female	Estimated number of females
2000	19376	473	41.7 (2.3)	8065
2001	3674	301	40.5 (3.4)	1489
2002	13150	935	52.8 (2.0)	6937
2003	6159	679	39.7 (2.3)	2444
2004	15661	943	44.8 (1.9)	7010
2005	26420	805	42.7 (2.0)	11921

Table 7. Summer chum mid-eye to fork length (mm) by age and sex, Clear Creek, Alaska, 2000-2005.

		Male					Female		
Age	N	Mean	SE	Range	Age	N	Mean	SE	Range
				2000					
0.3	49	572	3	515-640	0.3	49	549	3	500-600
0.4	209	600	2	535-700	0.4	157	572	2	515-635
0.5	9	587	5	560-625	0.5	0			
				2001					
0.3	68	571	3	520-630	0.3	30	529	5	490-620
0.4	117	608	3	525-705	0.4	61	564	4	490-630
0.5	13	611	6	555-635	0.5	4	560	4	550-565
				2002					
0.2	5	526	4	515-535	0.2	5	509	10	485-540
0.3	84	564	3	500-635	0.3	134	541	2	475-590
0.4	342	588	1	520-670	0.4	336	558	1	475-630
0.5	21	605	5	555-645	0.5	7	574	3	560-590
				2003					
0.2	0				0.2	3	498	13	490-515
0.3	347	554	1	480-630	0.3	266	532	2	440-630
0.4	36	595	5	540-650	0.4	17	577	6	520-620
0.5	9	605	8	560-640	0.5	1	580		580
				2004					
0.2	12	525	10	475-595	0.2	17	501	6	465-560
0.3	342	554	1	475-635	0.3	255	530	2	465-595
0.4	178	584	2	530-655	0.4	136	555	2	495-605
0.5	2	588	3	585-590	0.5	1	590		590
				2005					
0.3	388	564	1	470-645	0.3	301	541	2	470-620
0.4	78	586	3	530-655	0.4	36	563	5	495-610
0.5	1	595		595	0.5	1	545		545

XI. Appendix B: Figures

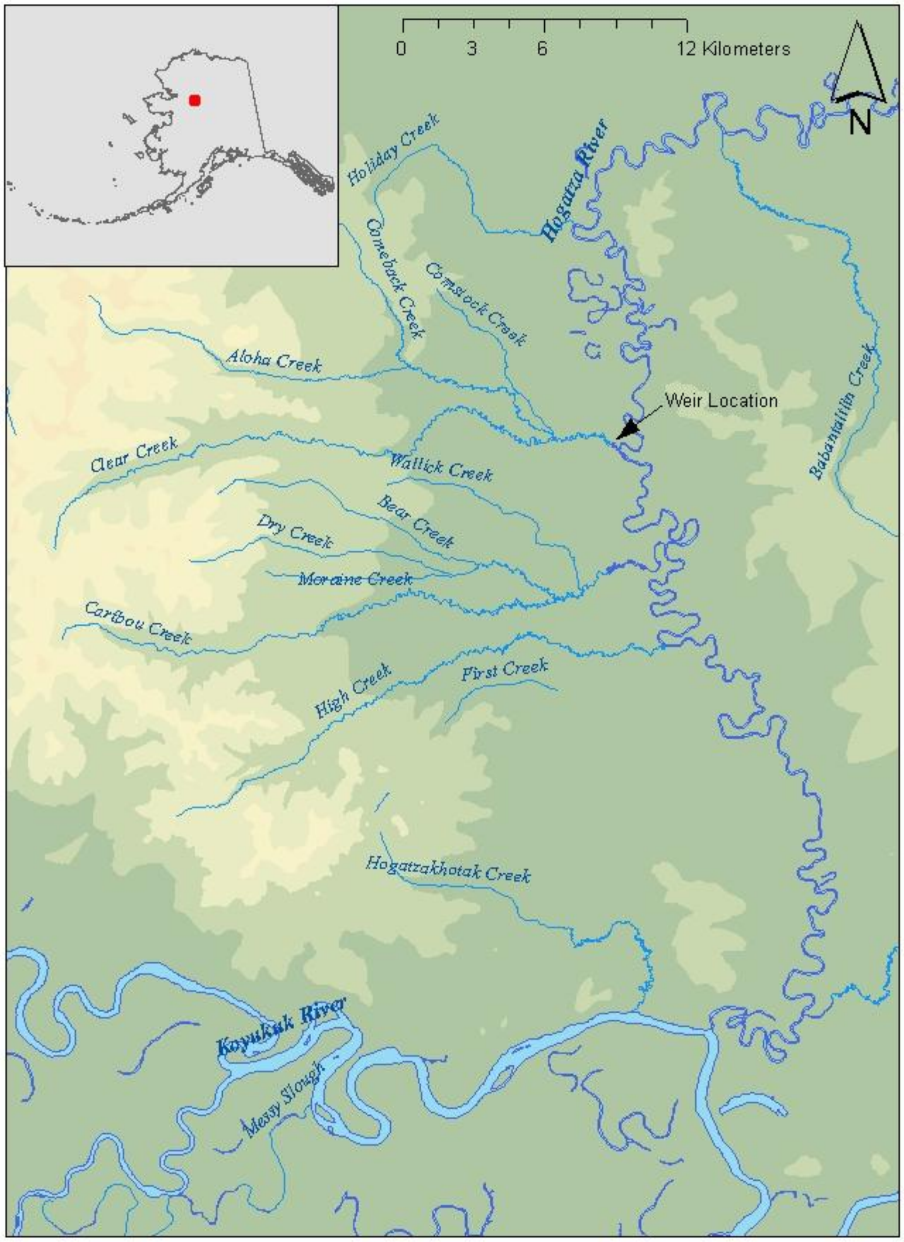

Figure 1. Location of the tower / weir (2000 – 2005) on Clear Creek (Hogatza River), Alaska.

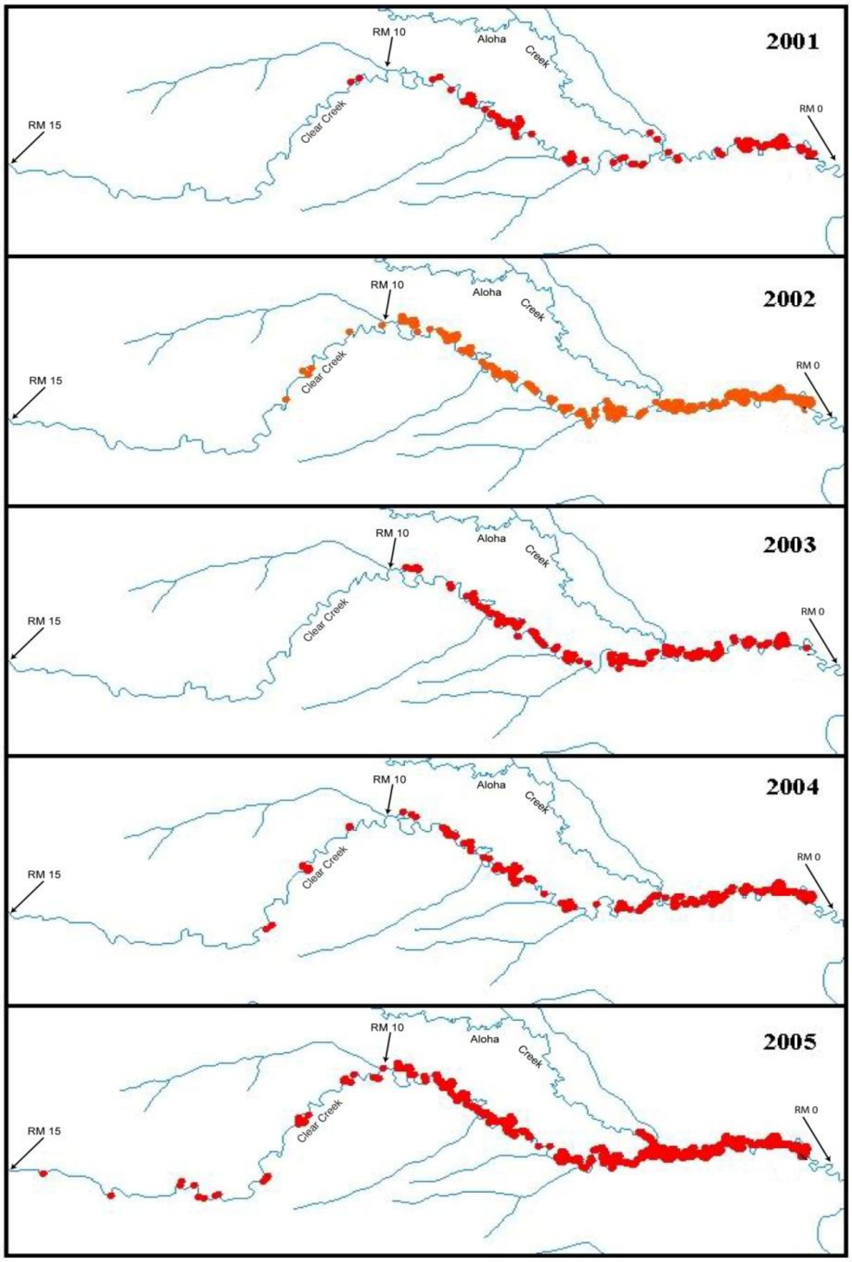

Figure 2. Location of chum salmon redds (nests; depicted as dots) within Clear Creek (Hogatza River) Alaska, 2001-2005. RM denotes river mile

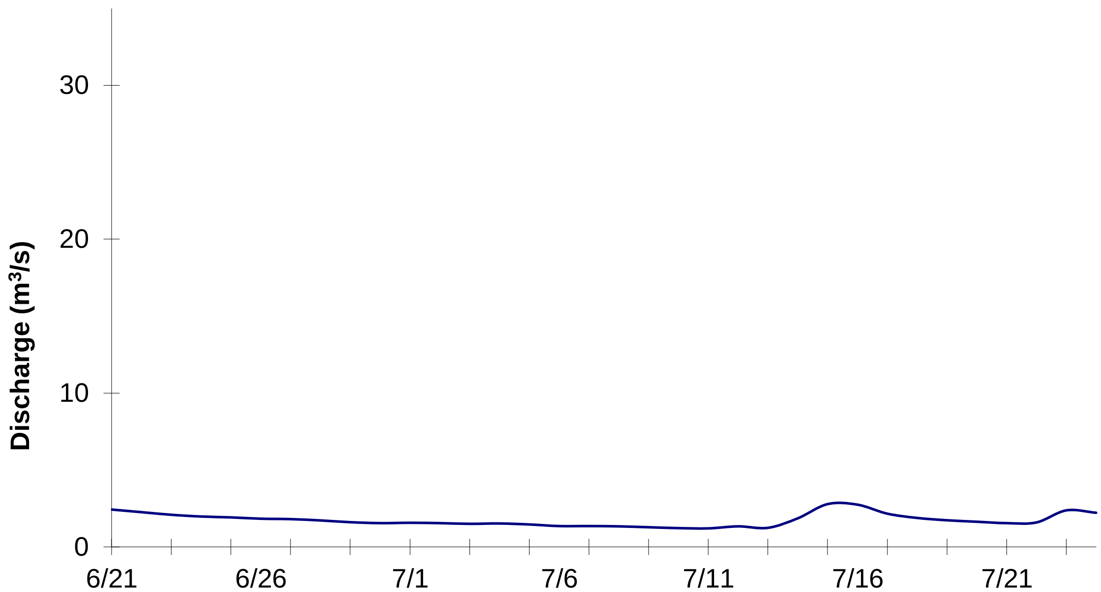

Figure 3. Daily discharge (m^3/s) for the period 22 June – 25 July 2000, Clear Creek, Alaska.

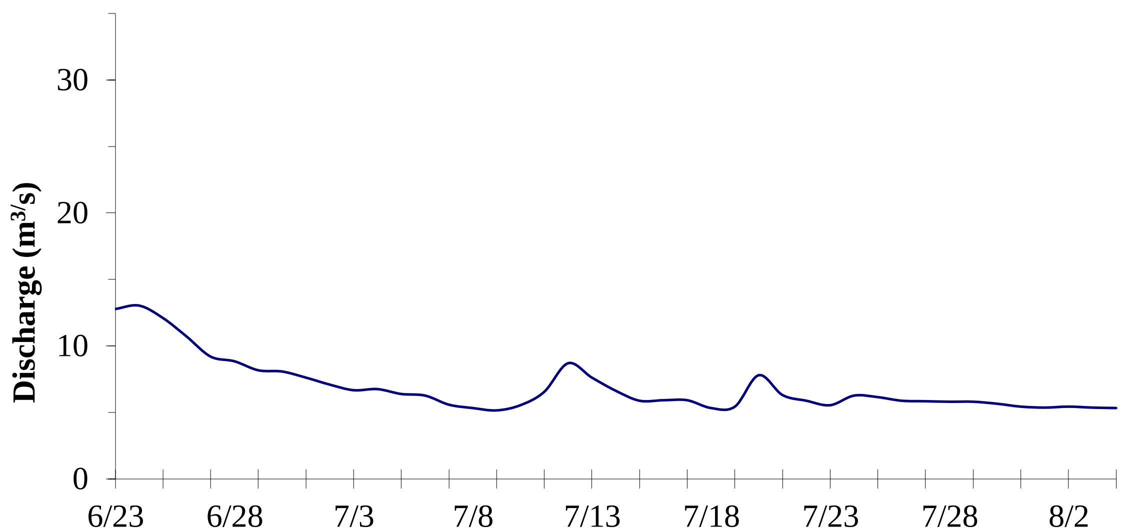

Figure 4. Daily discharge (m^3/s) for the period 23 June – 3 August 2001, Clear Creek, Alaska.

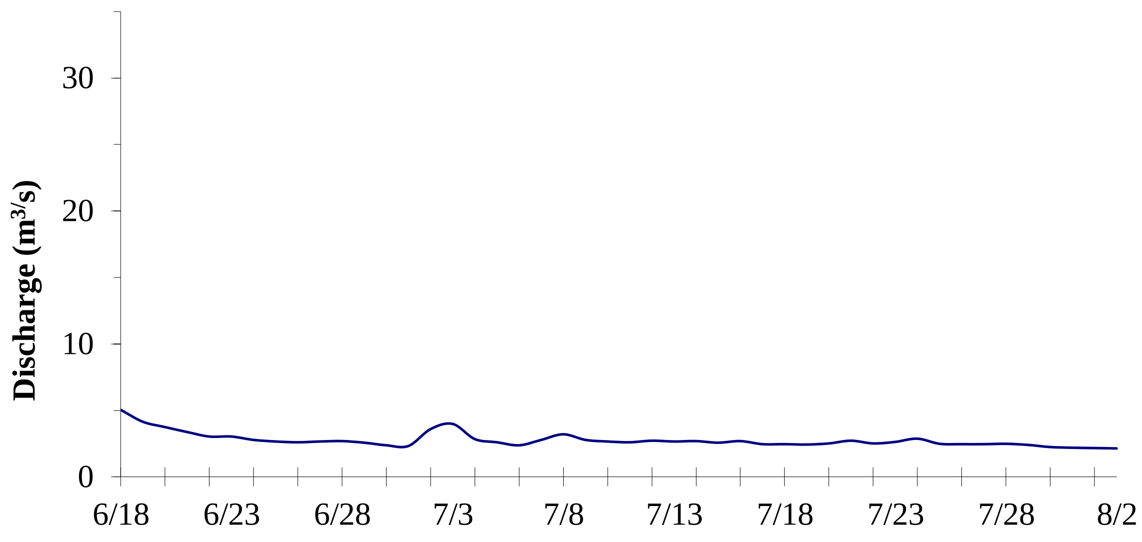

Figure 5. Daily discharge (m^3/s) for the period 18 June – 2 August 2002, Clear Creek, Alaska.

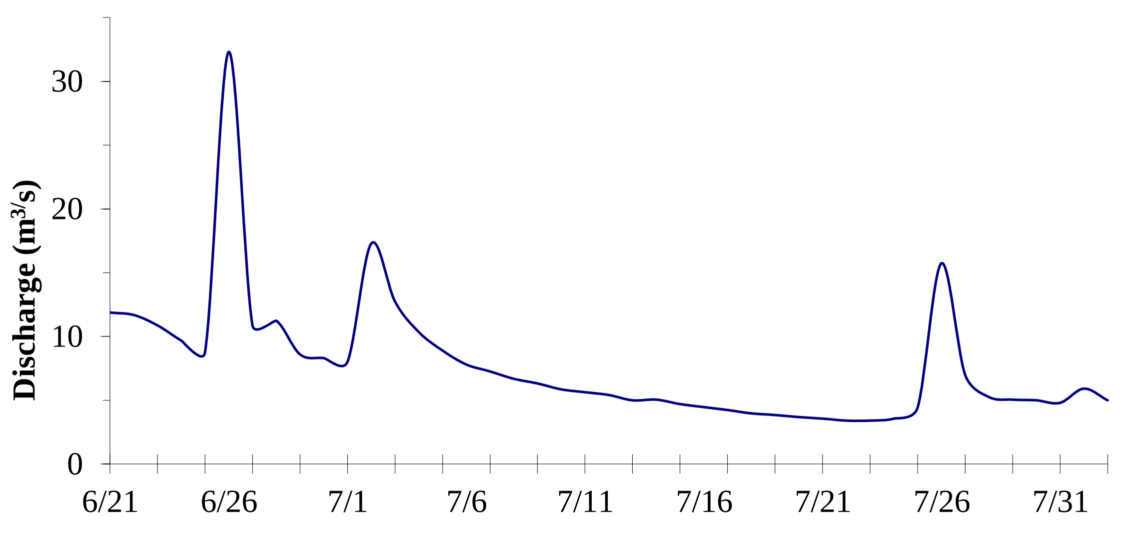

Figure 6. Daily discharge (m^3/s) for the period 21 June – 2 August 2003, Clear Creek, Alaska.

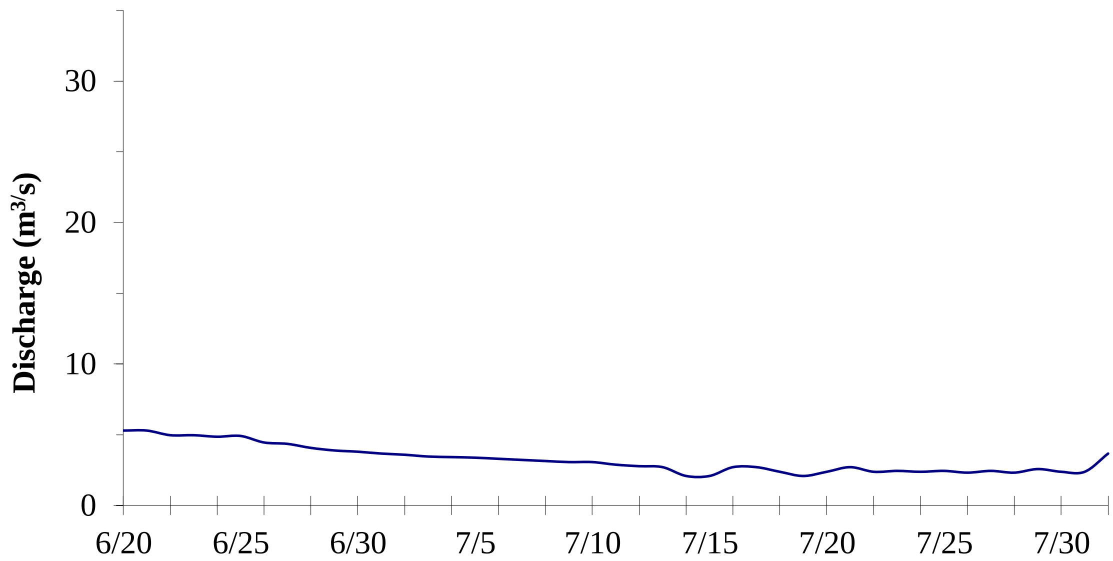

Figure 7. Daily discharge (m^3/s) for the period 20 June – 1 August 2004, Clear Creek, Alaska.

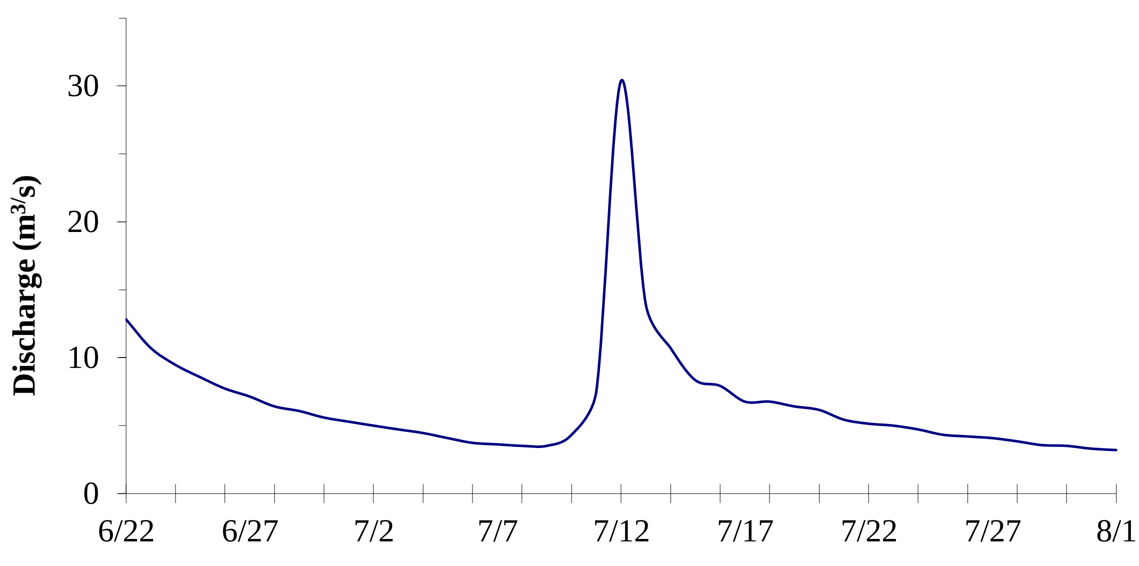

Figure 8. Daily discharge (m^3/s) for the period 22 June – 1 August 2005, Clear Creek, Alaska

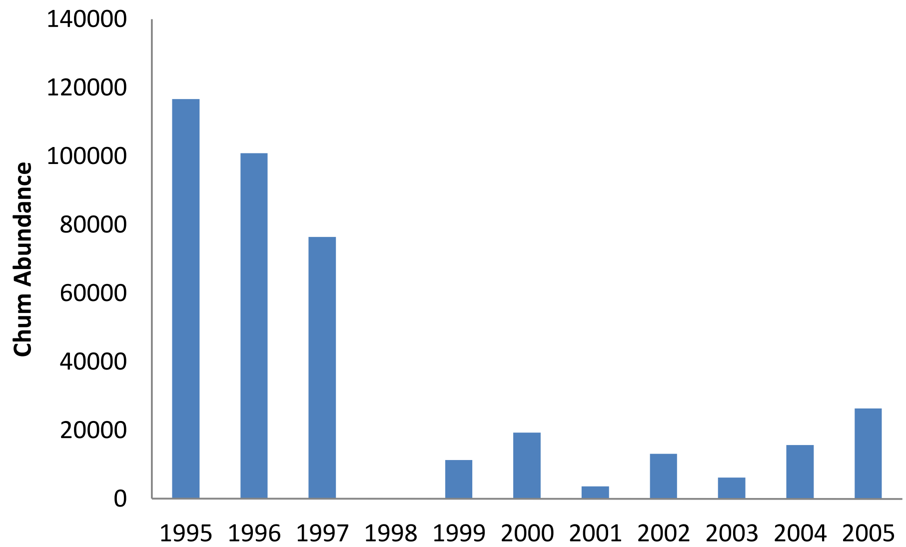

Figure 9. Summer chum abundance in Clear Creek, Alaska, 1995 – 2005.

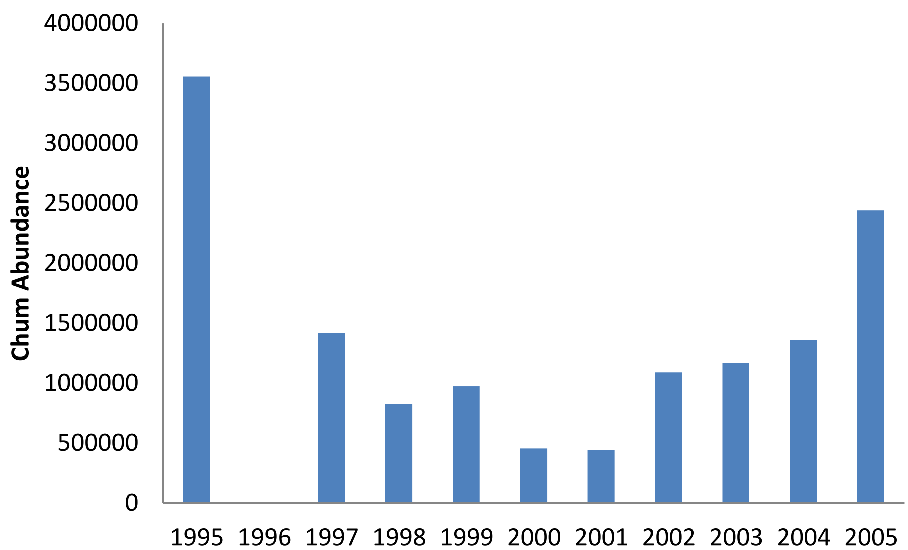

Figure 10. Summer chum abundance, Yukon River, Pilot Station Sonar, Alaska, 1995 – 2005

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