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ENVIRONMENTAL CONSERVATION PROGRAM

EAGLE RIVER ADULT SALMON MONITORING

Final Report

March 2013

U .S. ARMY ENGINEER DISTRICT, ALASKA

Final Report for Study

Monitor Eagle River Prey Species JBER AK
Contract W911KB-10-D-0011 Task Order 0007

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Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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ABSTRACT

During May through September of 2012 a salmon enumeration study was completed in Eagle River for the first time. A Dual Frequency Identification Sonar (DIDSON) was used to estimate salmon escapement and a fish wheel was used to document species run timing and apportion daily sonar counts by species. The data collection lasted 125 days with the DIDSON operation beginning on May 14 and ending on September 15. The study duration was sufficient to encompass the majority of the run timing for all five species of Pacific salmon (*Oncorhynchus* sp.) native to Alaska, and all five species were found to be present in Eagle River. Daily escapement was estimated for all salmon species; however, significant data gaps exist for periods when high flow events suspended the DIDSON operation. A data gap in July appears to have coincided with peak passage for several species, and since no historical run timing and abundance information is available to interpolate run strength during this period, a minimum estimate is provided. The total minimum run strength for all species was estimated to be 3,316 salmon. It was assumed that the fish wheel sampling was not selective for species; however, fish wheel bias in species apportionment has been previously documented in other similar studies. Each salmon species was apportioned by both the daily fish wheel catch and by the overall season's total catch. The daily apportionment numbers are useful to describe the run time and relative run strength of each species, but the season total is more likely representative of the actual minimum escapement. The Chinook salmon (O. *tshawytscha*) daily seasonal apportioned escapement is believed to be the most accurate of the species specific estimates because very little overlap with run timing of other species occurred. Passage estimates for sockeye salmon (O. *nerka*), pink salmon (O. *gorbuscha*), and chum salmon (O. *keta*) were incomplete because of the removal of the sonar during high flow periods. Overlap in run timing for these species also adds uncertainty to the species specific escapement estimates. The estimate for coho salmon (O. *kisutch*) may have been truncated since the study ended early because of the flooding in mid-September.

1.0 INTRODUCTION

This project was initiated to begin the process of establishing escapement baselines and run timeframe for salmon species within Eagle River and evaluate the association of beluga whale presence at or near the mouth of Eagle River with the salmon species presence and abundance in Eagle River. Beluga whales are opportunistic feeders and known to prey on salmon. Four species of Pacific salmon, Chinook *(Oncorhynchus tshawytscha),* sockeye *(Oncorhynchus nerka),* chum *(Oncorhynchus keta),* and coho *(Oncorhynchus kisutch),* are considered a primary constituent element (PCE) necessary for endangered Cook Inlet Beluga whale recovery. All four of these Pacific salmon species are known to spawn in Eagle River, and their combined run timing begins in May and lasts well into fall.

The Cook Inlet Beluga Whale (CIBW) was listed (50 CFR Part 224; Federal Register Vol. 73, No. 205, Oct 22, 2008) by the National Oceanic and Atmospheric Association-National Marine Fisheries Service (NOAA-NMFS) as "endangered" under authority of the Endangered Species Act effective 21 December 2008. In April of 2011, NOAA-NMFS identified critical habitat for CIBW (ESA, Sec. 4(a)(3)). While Joint Base Elmendorf-Richardson (JBER) property lies above the mean-high-tide line of Knik Arm, the CIBW critical habitat includes portions of anadromous stream systems that feed into Knik Arm and upper Cook Inlet including Eagle River.

Anadromous streams are the spawning and rearing sites for salmon, an essential biological component of the CIBW critical habitat. The 2004 Department of Defense Authorization Act (Section 4(a)(3) of Public Law 108-136) specifies that military lands may be exempted from critical habitat designations if the installation's integrated natural resources management plan (INRMP) (Sec 101 of Sikes Act (16 U.S.C. 670a) outlines actions to monitor and enhance species and their habitat and is approved by the Secretary of Commerce (for endangered marine mammals). JBER's INRMP has identified monitoring fish in waterways designated as Essential Fish Habitat (EFH) as part of JBER's conservation plan. The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established a requirement to describe and identify 'Essential Fish Habitat' (EFH). Eagle River is one of several JBER waterways classified as EFH for Pacific salmon by NMFS and the Alaska Department of Fish and Game (ADF&G). Thus, monitoring fish species in Eagle River is an inherent responsibility of JBER.

1.1 Project Area

Little is known about Pacific salmon productivity in the Eagle River. The Alaska Department of Fish and Game (ADF&G) reports that Eagle River is relatively unproductive, but lists five species of Pacific salmon: Chinook salmon, sockeye salmon, coho salmon, chum salmon, and pink salmon, as well as Arctic grayling (*Thymallus arcticus)*, Dolly Varden char (*Salvelinus malma)*, and rainbow trout (*Oncorhynchus mykiss)*, as present in the river system (Miller 2007).

Eagle River is approximately 15 miles north of Anchorage, Alaska with the lower nine river miles flowing within JBER property. The first four river miles are located within the Eagle River Flats Impact Area (Figure 1). Eagle River was closed to Chinook salmon fishing from 1964 to 1991; however, the proximity of the river to the urban population of Alaska promoted it as a candidate for supplementation efforts to produce a salmon fishery. Beginning in 1990, Eagle River was stocked with approximately 100,000 Chinook salmon smolts from neighboring Ship Creek per year, and in 1992 a limited sport fishery opened. Due to poor smolt to adult returns, stocking of Chinook salmon was discontinued in 1995. As part of the Anchorage Urban Coho Program, Eagle River was also stocked with 105,000 coho salmon smolts in 1994 (Miller 2007).

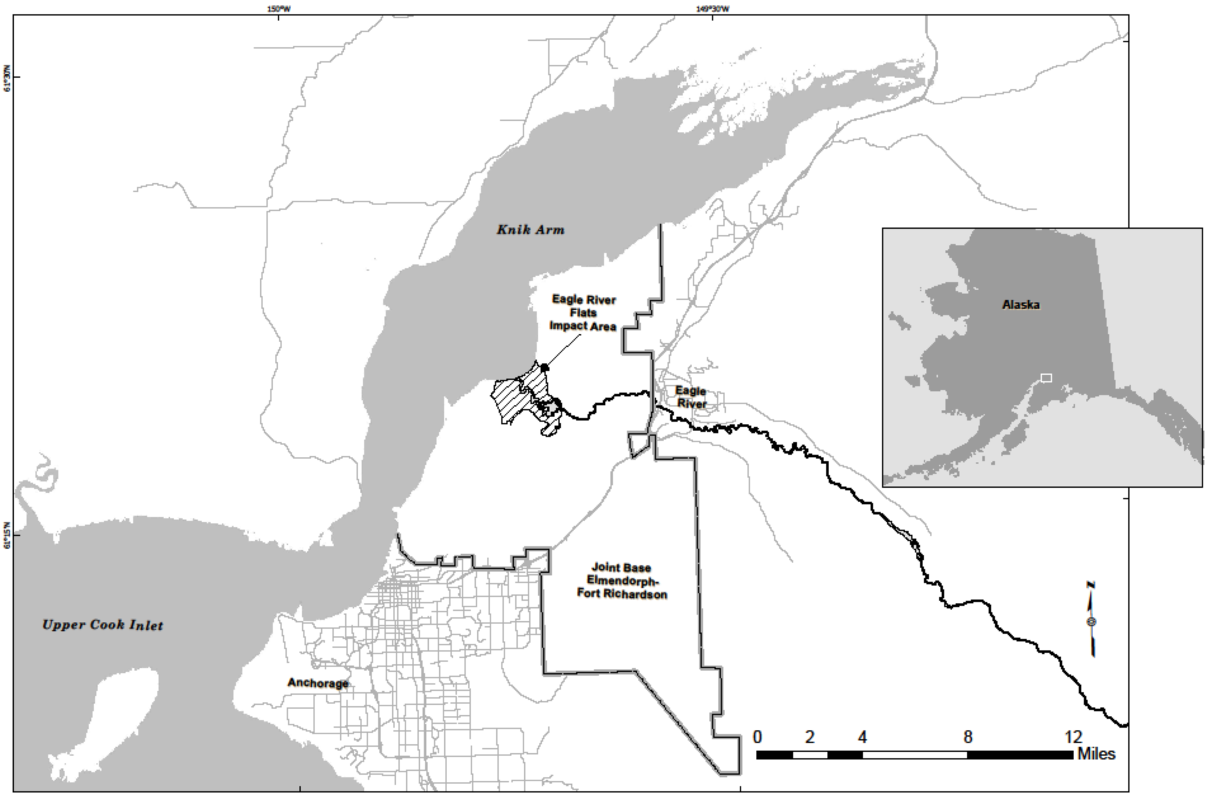

Figure 1. Location of Eagle River and JBER relative to Anchorage, AK, and Knik Arm.

Recreational fisheries targeting Eagle River salmon are limited to the run of wild Chinook salmon, which is known to return to the Eagle River drainage from late May through early July. This short duration fishery typically opens for four three-day weekends bracketing Memorial Day (Miller 2007). Because of the relatively low abundance of Chinook salmon and difficult fishing conditions, participation and harvest rates have declined. The peak of recreational harvest occurred in 1996 when the Chinook salmon catch was estimated at 586 and harvest was estimated at 309 fish. During 2009, zero Chinook salmon were estimated to have been caught.

Alaska State Department of Fish and Wildlife, Division of Sport Fish management currently focuses on maintaining the Chinook salmon fishery opportunity in balance with natural production. Salmon abundance data collected by ADF&G has been limited to spawning ground surveys in the clear water South Fork and Meadow Creek tributaries, due in part to the difficulty in enumerating salmon in the glacial waters of Eagle River. Foot surveys for Chinook salmon escapement conducted in the South Fork Eagle River from 1994 to 2003 reported an average of 233 fish with a range of 27 to 447. A sustainable escapement goal of 50 to 300 Chinook salmon was established for the South Fork Eagle River based on historic foot surveys. There is currently no management escapement goal set for Eagle River Chinook salmon. Escapement has not been estimated for other salmon species and no other specific ADF&G research projects are planned (Miller 2007).

1.2 Site Description

Site selection for this project had multiple limiting criteria, including both stream geometry characteristics needed for the equipment to operate properly, plus access and land use restrictions. It was desirable to be as far downstream as possible while remaining upstream of tidal influence with access from the existing road system and access to electrical utilities. The study site was also required to stay outside of the Eagle River Flats Impact Area, which contains the first four river miles, and downstream of the recreational boat take-out. These criteria limited the potential sites to a 600 meter section of the lower river, at approximately river mile four, between the Route Bravo Bridge and the boat take-out parking lot.

The Dual Frequency Identification Sonar (DIDSON) system was deployed at a site on the left bank approximately 500 meters upstream of the Impact Area boundary and immediately downstream of the boat take-out. This location was selected because it fulfilled a number of prerequisites for the successful acoustic enumeration of migrating salmon: 1) single channel; 2) wedge-shaped river cross-section that matches the shape of the sonar beam; 3) uniform slope without deep depressions or boulders that can create blind spots; 4) relatively laminar flow (turbulence introduces noise); 5) ease of access; and 6) located within a reasonable distance of a site suitable for the operation of a fish wheel. The DIDSON system does not allow for the accurate differentiation of species. Consequently, this information was provided by a fish wheel operating concurrently with the DIDSON sampling. The fish wheel was approximately 100 meters downstream from the DIDSON, also on the left bank (Figure 2).

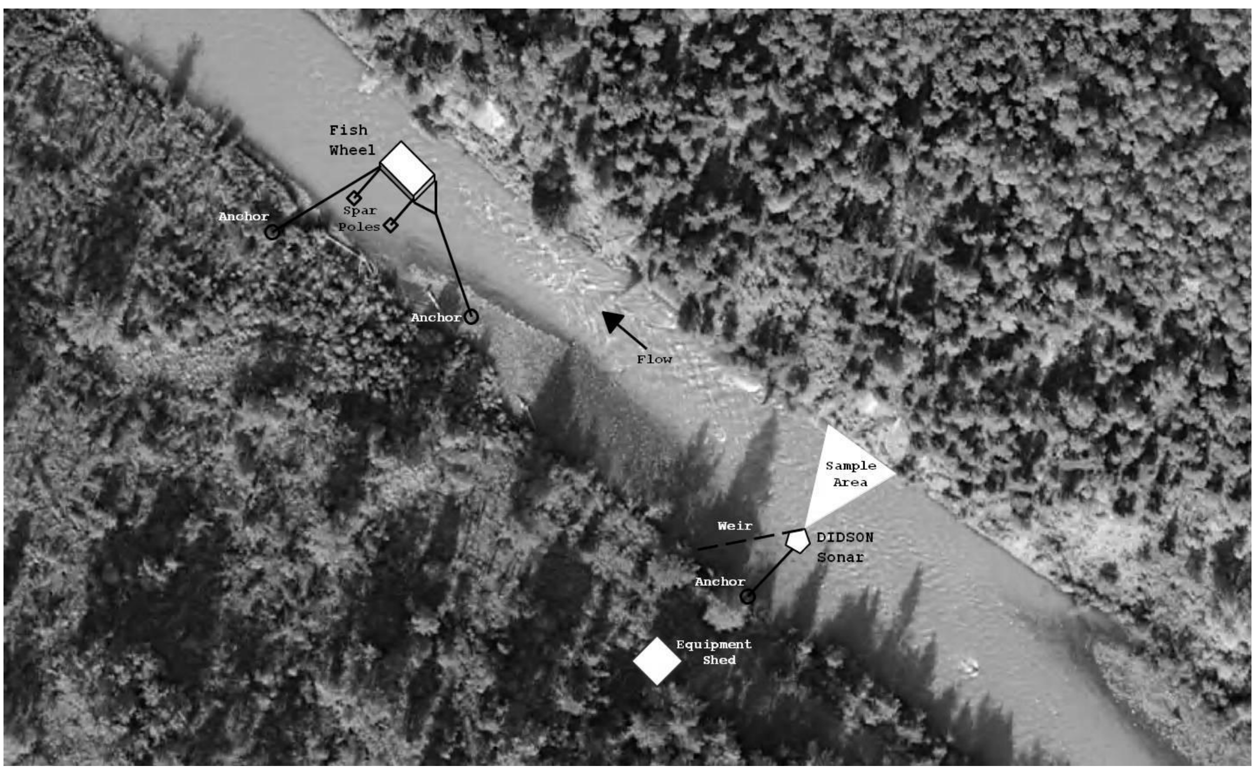

Figure 2. Relative location of the 2012 Eagle River adult salmon monitoring system components.

2.0 OBJECTIVE

The goal of this project is to provide a baseline enumeration of adult salmon returning to Eagle River. The objective during 2011was to select a site and acquire and test the equipment then, in 2012, describe Pacific salmon species composition, run timing, and relative run strength. Additional project objectives included creation of an operations manual and assessing if videography was a viable means of identifying the species of fish caught by the fish wheel.

3.0 METHODS

The Eagle River adult salmon monitoring system combines passive hydroacoustics and physical capture to estimate the migration timing and relative abundance of salmon. The sonar provides a count of all salmon-sized fish moving past a fixed location, and a fish wheel equipped with an event triggered video system apportions the fish species. Hydroacoustic methods are typically used to assess abundance in migrating fish populations when other methods are not feasible (i.e., the river is too wide or swift for weirs or too turbid for observation towers). While hydroacoustics can provide continuous counts of fish passage, fish can usually not be identified to species and therefore require apportionment by other means. Common species apportionment techniques for salmon include the use of fish wheels for test fishing (Westerman and Willette 2011).

Dual-frequency identification sonar is a high-resolution imagining sonar that has been widely used in fisheries applications and has been especially successful in the enumeration of adult salmon (Belcher et al. 2001, Burwen et al. 2007, Burwen et al. 2010, Cronkite et al. 2006, Galbreath et al. 2011, Holmes et al. 2006, Maxwell and Gove 2007). This sonar is commonly used throughout Alaska and has worked well for enumerating fish at high passage rates (Maxwell and Gove 2007). Dual-frequency identification sonar was first used in the Upper Cook Inlet by ADF&G on the Kenai River in 2005 and since then has also been used on the Yentna and Kasilof rivers (Burwen et al. 2007, Burwen et al. 2010, Maxwell and Gove 2007). Fish wheels have been used by ADF&G to physically capture fish at Kenai river mile 19, Kasilof, and Yentna rivers sonar sites in order to apportion the fish counts by species. The Yentna River fish wheel apportionment program was discontinued after it was found to produce poor sockeye salmon abundance estimates, especially in years of high pink salmon abundance (Fair et al. 2009, Suzanne Maxwell personal communication). The sonar site, located on the Kenai River, at river mile 8.6, is tasked with estimating Chinook salmon escapement. At this site, ADF&G is assessing their ability to identify species using the fish lengths obtained from the DIDSON data (Burwen et al. 2007, Burwen et al. 2010).

3.1 Project Components

Project equipment acquisition began in June 2011, and the adult salmon monitoring system was installed and tested in the Eagle River during September 2011. Formal data collection was scheduled to begin by May 20, 2012.

3.1.1 DIDSON Sonar and Supporting Equipment

A long range model 300 DIDSON was used to monitor fish passage in the river. The hydroacoustic system was deployed in a fixed location with a shore-based transducer aimed perpendicular to the water flow. Because of seasonal river stage fluctuations, the DIDSON sonar transducer was mounted approximately 20 m from the shoreline. Fish migrating close to shore were directed offshore with the use of a weir to insure they pass through the sonar transducer beam at a range where the beam width was large enough to detect the fish; therefore, the weir extended out 1 m past the DIDSON. A modular A-frame type picket weir was constructed of tubular steel. As the river stage increased, weir sections were installed to prevent fish from getting behind the sonar. During periods of high flow, when the DIDSON was removed from the water, the weir was deconstructed to avoid being damaged by floating debris.

The transducer was mounted in its standard orientation, with the beam array nearly horizontal. In this configuration the radial array of 48 beams creates a pie-shaped field of view that covers 29° horizontally. The geometry of the field of view works out such that the cross-range dimension of the image equals approximately half the range. For example, at 10 m range the image is 5 m wide.

The resolution of the acoustic image is different for its two dimensions. The cross-range resolution (upstream/downstream in this case) is determined by the 0.6° spacing of the 48 beams, which translates into roughly 1/50th of the range (e.g., at 10 m the cross-range resolution is 20 centimeters). The down-range resolution depends only on the user selected window length. For a 10 m range window it is approximately 2 cm. The overall image resolution is limited by the cross-range resolution, which decreases with range.

A 3°concentrator lens, which compresses the vertical dimension of the beam, was used to fit the beam to the river cross-section. To optimize coverage and image quality, the transducer was deployed in approximately 0.5 m water depth, with the lens compartment approximately 20 cm above the river bottom, tilted 2° down from horizontal. This resulted in the bottom of the beam grazing the slope of the river bottom.

The sonar system was operated with a laptop computer running DIDSON Viewer software Version 5.23. Data was written through an external serial advanced technology attachment (eSATA) connection to a redundant array of independent disks (RAID) external drive configured to write two mirrored copies of the data, with a capacity of 2 terabytes for each copy.

The study site was equipped with a storage building wired to the electrical grid. This set-up provided security and a reliable power supply for the DIDSON sonar and supporting electronics and allowed for the DIDSON data to be reviewed daily on-site.

The sonar system consisted of the following specific components:

- DIDSON LR300 unit with compass module (attitude sensor)
- Silt exclusion box
- Concentrator lens (3°)
- Data transmission cable (200 feet)
- DIDSON top side controller box with power and data connections
- Data capture computer with DIDSON Control and Display software
- External storage device (Buffalo 8 terabyte drive configured Raid 10)
- Data review computer with DIDSON Viewer software
- Transducer stream mount with manual pan and tilt adjusters
- Fish exclusion weir

3.1.2 Test Fishing

In turbid rivers, fish wheels are often used as a live-capture technique for monitoring migratory fish runs. After capture in the wheel's rotating baskets, fish are lifted out of the water, slid down a chute, collected in a live-box, and then sampled. To eliminate the handling and holding of fish associated with fish wheel live-boxes, an event-triggered video system was developed so that fish were recorded during capture and then immediately released back into the river. The advantages of the event-triggered video system over traditional fish wheels with live-boxes are reduced handling and holding time for captured fish; potentially improved counting accuracy; and potentially lower labor costs (Daum 2005). There are some disadvantages as well because the electronics involved increased equipment cost, required personnel knowledge for set up and maintenance, and increased potential for misidentified species over physical handling of fish.

Fish wheel site selection was restricted to a very limited area and access was only possible on one river bank. The fish wheel site did not have sufficiently strong trees near to the river bank to attach the anchor cable and ropes; therefore, a rock gabion measuring 1.2 m by 1.2 m was constructed on a gravel bar upstream of the fishing site as the primary anchor (Figure 2). The site did offer a protected back eddy which helped make personnel access to the wheel easier and safer and was used to shelter the wheel during flood events. Water resistance against the baskets is the force driving the rotation of the wheel, and thus the fish wheel had to operate near the middle of the river along the velocity break between the eddy and the thalweg. In so doing, the bank oriented salmon were not sampled. This location was the only feasible site because of the shallow river depth upstream and downstream.

The fish wheel and event-triggered video system consisted of the following components (Figure 3):

- Fish wheel (aluminum pontoons, baskets, axle and sprocket assembly, and railings)
- Video chute (wood and rubber fish delivery system)
- Event-triggered video system (camera, motion sensing digital video recorder, and batteries)
- Electronics enclosure
- Live box
- Deployment system (spar poles, rebar, cables, ropes, and hardware)

Figure 3. Photograph of the fish wheel equipped with the event-triggered video system operating in the Eagle River during 2012.

3.1.3 River Temperature and Stage

A hydrology monitoring station consisting of a staff gage and a stilling well with in-water and atmospheric pressure recording transducers was established at the data collection site. The pressure transducers recorded water level fluctuations at 15-minute intervals. The staff gage was surveyed for elevation in relation to a temporary bench mark and river stage was manually recorded daily.

The National Oceanic and Atmospheric Association's Advanced Hydrologic Prediction Service provides real time river stage data and predicted stage trends at the Glenn Highway Bridge approximately 5 river miles upstream of the data collection site.

3.2 Data Collection

3.2.1 DIDSON Sonar Operation

The sonar data was collected with the DIDSON Viewer Software Version 5.23, provided by the manufacturer, Sound Metrics Corporation. During the initial set-up procedure the range of data collection (window length), frame rate, file duration, and storage location was defined. The DIDSON was set to record 15-minute files in a stratified sampling scheme alternating between two 10-m range windows 24 hours per day. Early in the season the first stratum sampled from 0.4 to 10.4 m; the second stratum sampled from 3.3 to 13.3 m. On May 25, to cover a wider river at higher water level, the second stratum was changed to image from 9.6 to 19.6 m. All data was collected in high-frequency mode (1.2 MHz). The average sustained frame rate was eight frames per second, the maximum rate supported by the computer. All data was permanently stored on an external hard drive for future analysis.

The heavy silt load of the river necessitated regular cleaning of the DIDSON, since the image quality noticeably deteriorated from silt accumulating in the lens compartment. To maintain image clarity, the transducer was removed from the river and its lens compartment flushed an average of once every three weeks.

As the water level changed through the season, the transducer was moved further offshore to keep it submerged at the desired depth when the water level was dropping, or closer to shore to allow personnel to safely access it when the water level was rising. A daily log was maintained to document changes made to the DIDSON transducer position or data collection software settings. The transducer was repositioned 12 times during the 2012 data collection. Under all conditions the second stratum reached the opposite shore.

3.2.2 Fish Wheel Operation

In order to sample as many fish as possible, the fish wheel was scheduled to operate every day; sub-sampling did not occur. For the purposes of evaluating the event-triggered video system, the live holding box was authorized to be used continuously for first two weeks. Thereafter, the use of the live box was limited in an attempt to reduce fish handling. Between July 1 and July 30, the live box was operated for two days per week. From July 30 to the end of the season, the live box was used only when personnel were present at the site, which was generally from 9 a.m. to 4 p.m. seven days per week. The fish wheel remained in one position throughout the season, although it was moved laterally as flow fluctuated to maintain adequate depth and current to rotate the baskets.

Personnel visited the site at least once per day to clear the live holding box of fish and download the video from the event-triggered video system. Equipment maintenance and repositioning of the wheel was completed as needed throughout the season.

3.3 DIDSON Sonar Data Processing and Analysis

The raw DIDSON data files were batch processed with the Convolved Samples Over Threshold (CSOT) function of the DIDSON Viewer software. This function writes a second set of files that retain only the frames of the original file showing moving objects. This is accomplished by subtracting the static image background (in our case reflections from the river bottom), followed by an image smoothing step and cluster detection. The cluster detection algorithm looks for clusters of contiguous image samples (“pixels”) that are brighter and greater in total cluster size than user-specified values. In addition, the user can specify the number of frames that are retained before (prequel) and after (sequel) each frame where motion has been detected. This provides an extra buffer for frames where the fish image is truncated and would thus not meet the size threshold. The goal is to choose a set of parameter values that retain all frames of interest while removing the maximum number of frames that show no moving objects or only objects that are smaller than the fish of interest. The secondary files that are generated from this process are referred to as CSOT files. At the beginning of the project CSOT parameters were set deliberately conservative (conserving a higher number of frames than necessary) to make sure no fish were missed. As the season progressed and more fish images became available for testing, the CSOT parameters were set more restrictively. The settings that were found to be most effective were a brightness threshold of 6.7 dB in combination with a minimum cluster area of

500 cm^2 and a pre- and sequel of four frames. For a subset of the files the CSOT results were compared with the original files. No fish were missed in the CSOT process in any of these test files.

All CSOT files were then reviewed in video-mode with the intensity and threshold display settings adjusted for optimum contrast of the fish images. Files were reviewed with background subtraction (default dynamic) on and transmission loss correction off. Each fish that was seen was marked and manually measured by clicking a series of points (no more than three or four) along the perceived “mid-line” of the fish. This process generates Fish Count files with information on each fish, including date, time, range, length, and direction of travel (upstream or downstream).

The Fish Count files were merged into one Microsoft Excel worksheet, where redundant headers and other unused information were removed. Each fish was assigned a count of 1, if it was moving upstream, or -1, if it was moving downstream. The stratification scheme used during data collection had some overlap between the two 10-m range windows (see section 3.2.1 above). The overlapping area was sampled 100% of the time, while the remaining area was sampled only 50% of the time. Counts of fish that were seen within the strata overlap were not expanded, while counts of fish that were seen outside the overlap were multiplied by two to compensate for the fact that these areas were sampled only half of the time. The results of this extrapolation produced what we refer to as expanded counts. Expanded counts were summarized by date and compared to fish wheel catch data and river discharge. Passage rates were examined for patterns in range, time of day and tidal cycles. Tide information was obtained from Tides & Currents Pro Version 2.5, which provides NOAA data from the harmonic station Anchorage, Knik Arm.

As part of the quality control process, hydroacoustics experts at Aquacoustics, Inc. reviewed all DIDSON data from May 14 through June 19, and a subset of four hours per day (two 15-minute files per stratum) for all remaining files.

3.4 Species Proportion Estimates

Apportioning species to the expanded net upstream DIDSON fish counts were calculated using both the daily and total seasonal fish wheel catch proportions. The daily apportionment is valuable to identify the run timing and relative run strength, but because of the limited capture success of the fish wheel, there could be significant discrepancies on days when large numbers of fish passed the sonar station but very few were sampled by the fish wheel. For example, on August 1, 228 salmon were estimated to have passed the sonar station but only one fish, a pink salmon, was caught by the wheel even though sockeye and chum salmon were caught in higher proportions than pink salmon in the days previous and following. Applying an overall seasonal proportion to the total DIDSON fish count is likely a more accurate representation of the total escapement of each salmon species. For the purposes of species apportionment it must be assumed that fish wheel species selectivity did not exist because no selectivity information is available for the sample site.

The total daily escapement for each species (T_d) was estimated by multiplying the total daily sonar count for all species (N_d) by the daily proportion of each species of salmon caught in the wheel on the same day (P_d) using the following equation:

$$T_d = P_d \ (N_d)$$

Where P_d is the total number of each salmon species caught by the wheel on that day (s_d) divided by the total number of salmon caught by the wheel on that day (n_d).

$$P_d = \frac{s_d}{n_d}$$

On days when no fish were captured in the fish wheel the daily species proportion (P_d) was interpolated by averaging the nearest one day previous (d_1) and one day following (d_2).

$$P_d = \frac{(\ d_1 + d_2)}{2}$$

On days when the DIDSON was not operating the actual fish wheel catch (T_d) was considered as the daily passage (these days were greatly underestimated because the fish wheel typically caught only 5% of the salmon counted by the DIDSON).

The total season's escapement for each species (*Ts*) was estimated by multiplying the total sonar season's count for all species (*Ns*) by the total season's proportion of each species of salmon caught in the wheel (*Ps*) using the following equation:

$$Ts = Ps\ (N)$$

Where *Ps* is the total number of each salmon species caught by the wheel (s_s) divided by the total number of salmon caught by the wheel during the entire season (n_s).

$$P_s = \frac{s_s}{n_s}$$

4.0 RESULTS

The DIDSON fish monitoring operation was conducted over 125 days from May 14 to September 15. On three occasions data collection was disrupted for more than one day. The sonar was taken out of the water twice to avoid equipment damage during flooding on June 20 through 29 and again July 18 through 31. The third disruption occurred September 4 through 7 when data collection was down because of a power outage. The sonar operation ended September 15 when an impending flood forced removal of all sonar equipment for the final time. In total, 96 days or 77% of the study period was sampled with DIDSON.

4.1 Fish Passage

The first salmon was recorded on May 17. Salmon passage remained low throughout May, averaging only one fish per day, and peaked at six fish on May 30. During the month of June the passage rate increased to an average of 19 fish per day with a peak daily passage of 46 fish on June 18; however, the DIDSON was not operated during ten days from June 20 through June 29 because of a high water event. The month of July had by far the highest overall passage rate, averaging 180 fish per day and reaching a peak of 341 on July 31. Because of another high water event, the DIDSON did not operate for 12 continuous days from July 19 through July 30. Salmon passage continued to be high during the first half of August, averaging 116 fish per day with a peak of 191 fish on August 4. On August 15 the passage rate dropped significantly and the average for the second half of the month was down to 23 fish per day. Passage rate continued to decline in September and averaged only four fish per day up until September 15 when the DIDSON was removed for the season because of another high water event. A total of 1,646 salmon were recorded by the DIDSON during 2012, only nine of which were observed moving downstream. Figure 4 shows the expanded DIDSON fish counts for the entire season.

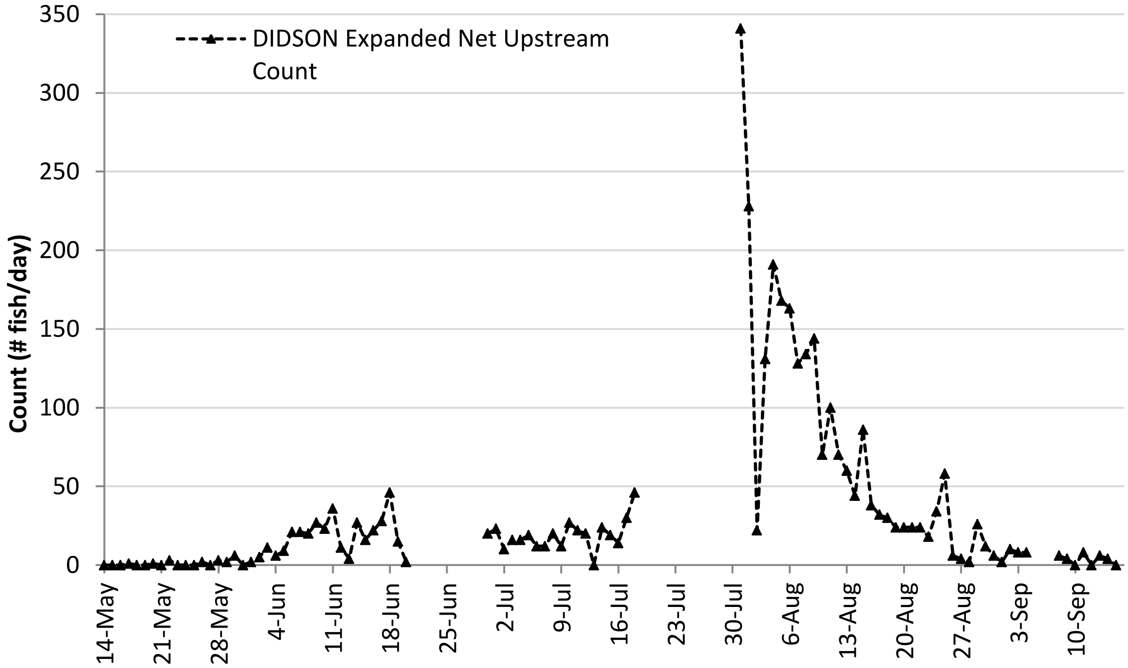

Figure 4. Eagle River DIDSON 2012 expanded net upstream count.

Between the period of May 14 and July 20 only 25% of the salmon had migrated past the sonar station. On August 4 approximately 50 % of the salmon had passed, and by August 18 a total of 90 % of the 2012 salmon run was completed. Peak daily salmon passage occurred on July 31 at 341 salmon, even though this was the first day of sampling after the flood and data collection did not start until noon. Figure 5 shows the cumulative expanded DIDSON fish counts and percent total run passage for 2012. Appendix A contains a table of the DIDSON sonar daily observed and expanded fish counts.

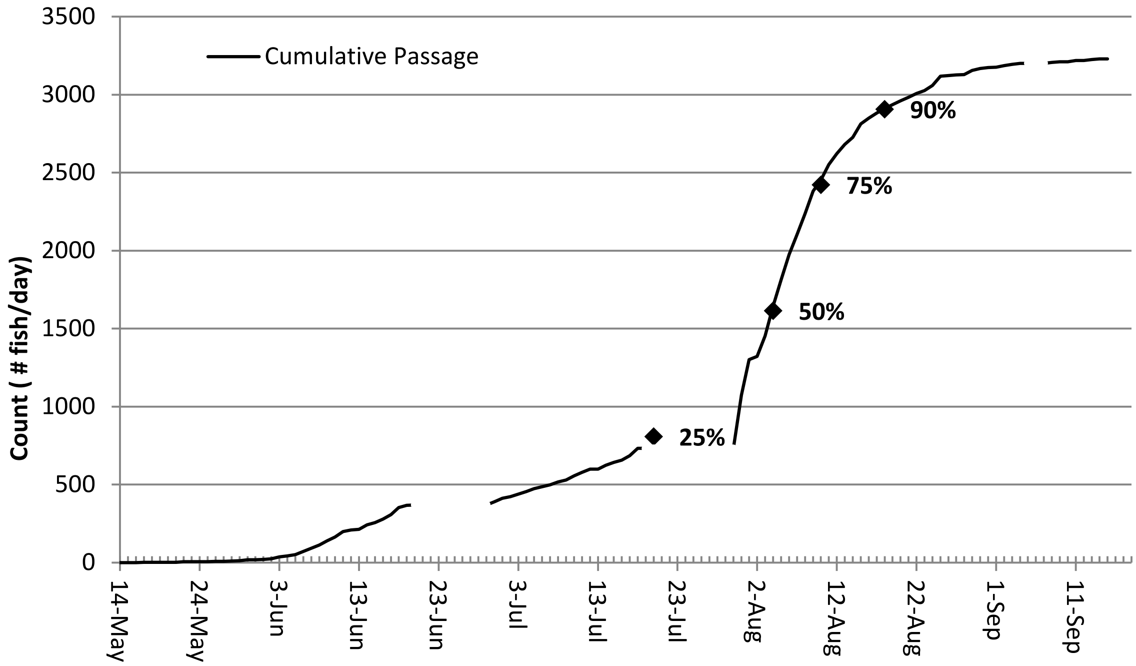

Figure 5. Cumulative daily salmon passage showing run complete percentiles for all fish recorded by the Eagle River DIDSON during 2012.

4.1.1 Diurnal Patterns

Fish passage rates (sum of expanded fish count per hour) for diurnal and tidal patterns were examined. Plotting the time of the entire DIDSON dataset shows a trend of passage rates being lowest in the early morning hours, 3 a.m. to 10 a.m., and then gradually increasing until late evening, and gradually decreasing at night (Figure 6). Because the temporal patterns in the complete dataset may be biased by the data gaps when the DIDSON was not operating, a subset of the data (June 30 to July 18) where DIDSON data was collected continuously was also examined. The subset (Figure 7) shows more variation, but otherwise a similar general trend of high passage rates in the afternoon and evening. The subset data does however, show higher passage after midnight than in the afternoon and evening.

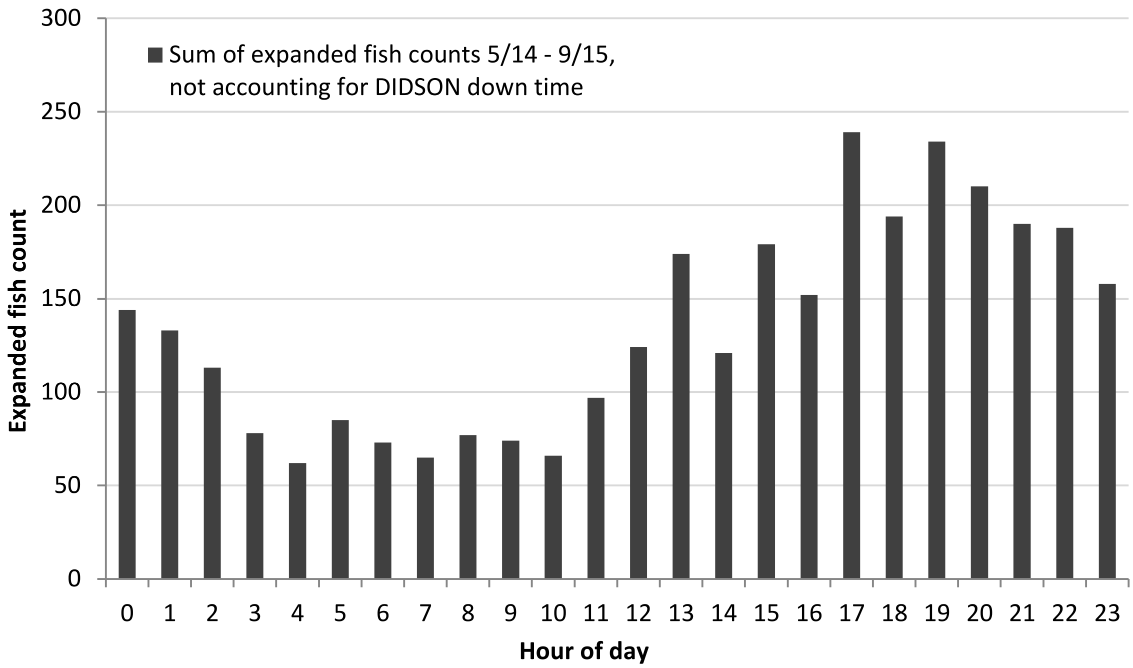

Figure 6. Diurnal pattern of fish passage by hour of day using the sum of expanded fish counts during the entire Eagle River data collection season (5/14 – 9/15) and not accounting for DIDSON down time.

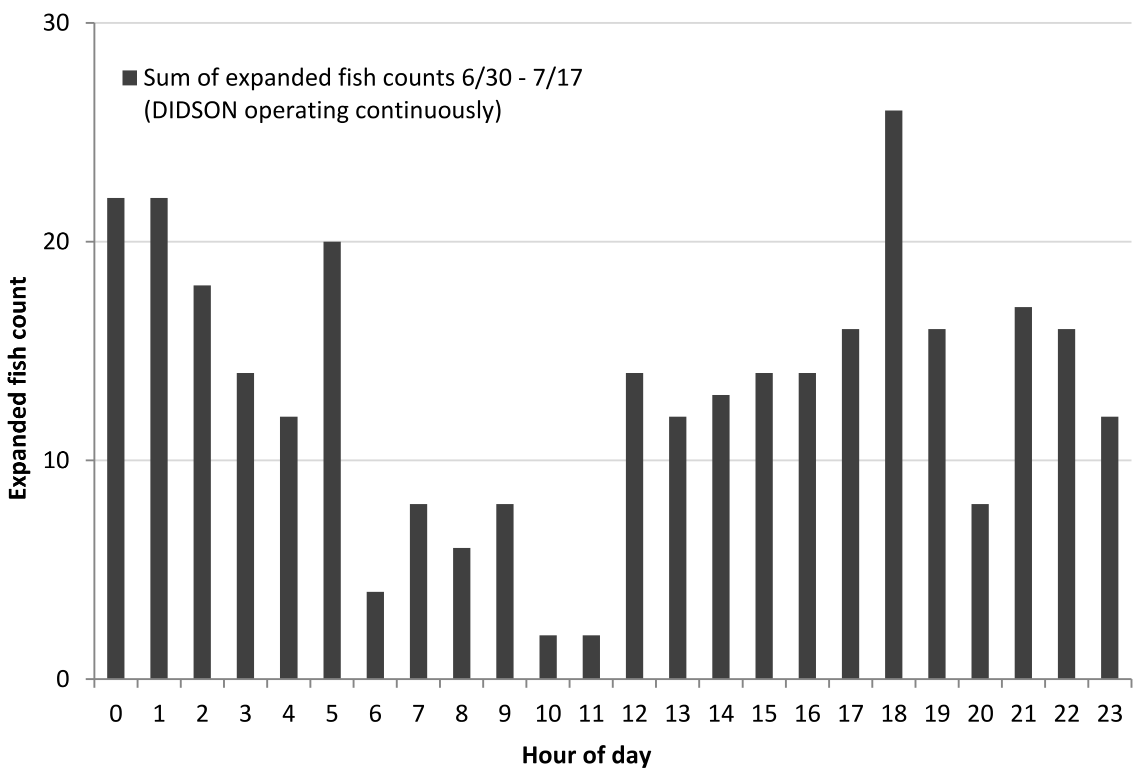

Figure 7. Diurnal pattern of fish passage by hour of day using the sum of expanded fish counts during the period when the Eagle River DIDSON was operating continuously (6/30 – 7/17).

The relationship between fish movement and tidal stage was also examined for the full DIDSON dataset as well as a subset of continuous data coinciding with a series of strong tides (June 30 to July 9). Neither a time series plot, nor plotting the expanded fish count by the number of hours within high or low tide (NOAA Anchorage, Knik Arm harmonic station) revealed noticeable tide-related patterns in fish passage (data not shown).

4.1.2 Cross Channel Distribution

The range (i.e., distance from the transducer) distribution of all fish recorded on the DIDSON images varied over time (Figure 8). In May and through the first week in June, the majority of the fish passed offshore, at a range of 10 m or more. Through the remainder of June fish were seen relatively uniformly distributed within the first 10 m. During July and August fish passage was heavily concentrated between the 2 to 3 m range. Towards late August and for the remainder of the season fish were more concentrated within the first 5 m of range. Most of these changes, notably the shift towards shore, appeared to coincide with the arrival of different species more than the increase in river stage, suggesting that the larger Chinook and chum salmon in particular tended to travel further offshore while sockeye and pink salmon were oriented to the left river bank because it was more shallow and lower velocity than the right bank.

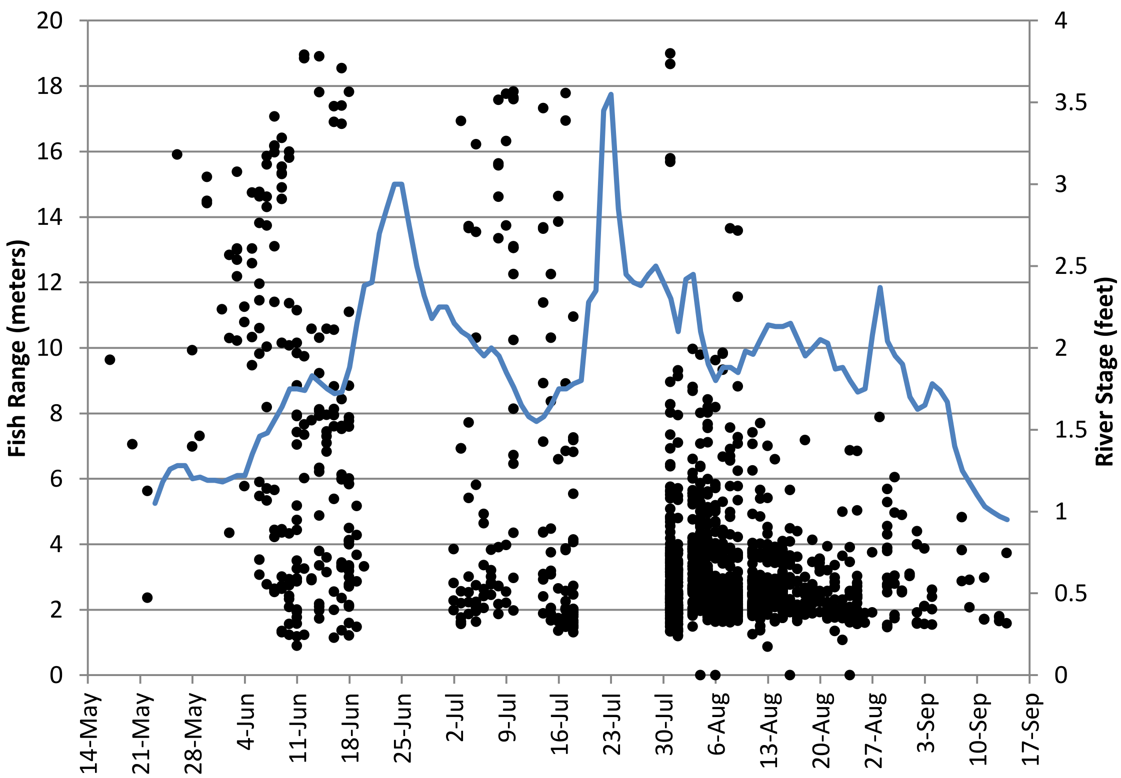

Figure 8. Range distribution over time of all fish recorded by the Eagle River DIDSON and river stage at the site during 2012.

4.1.3 Fish Length

The length frequency distribution of all fish recorded on the DIDSON images is unimodal and nearly symmetrical, with the mode occurring at 80 cm (Figure 9). Considering the mix of species caught in the fish wheel, with sockeye salmon being the most abundant, it is unlikely that the histogram of the DIDSON fish lengths reflects their true length distribution. The fish range distribution, which shows fish heavily concentrated between 2 and 3 m (Figure 8), points towards the depth of field (i.e., the range window over which the image appears in focus) as a likely source of error.

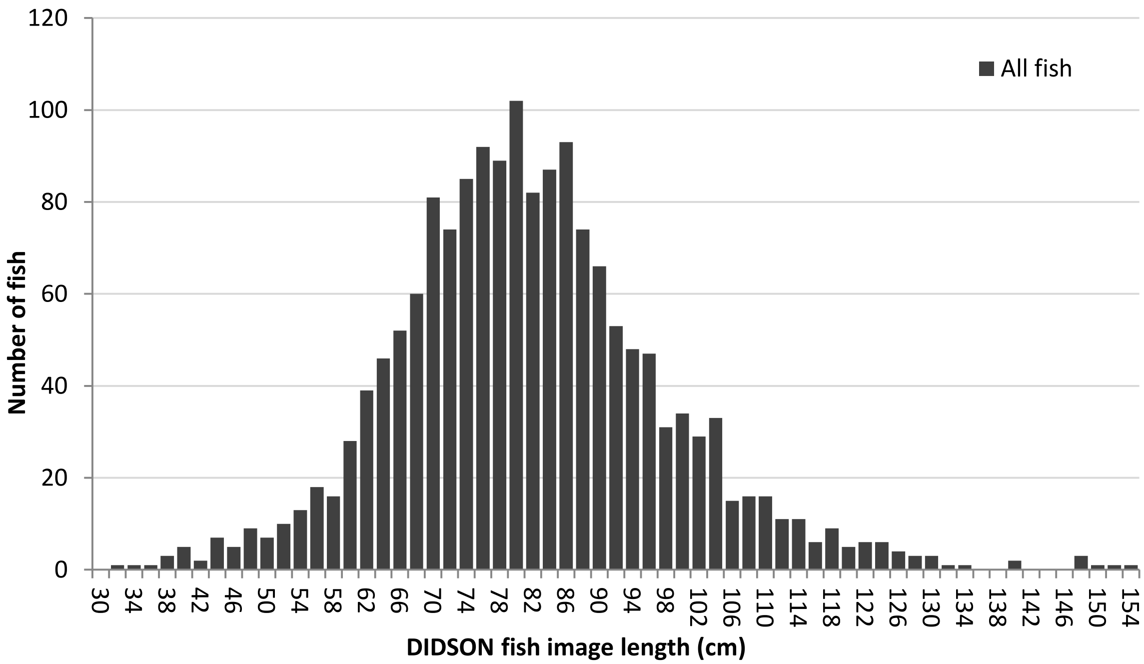

Figure 9. Histogram of all fish lengths measured from Eagle River DIDSON images during 2012 (*n* = 1,646).

Coinciding with the arrival of sockeye salmon an increasing proportion of fish is seen at less than 3 m range. To examine this further we selected a subset of the data (July 31 to August 11) and compared the length histogram of fish seen at a range of 3 m or less (Figure 10) with that of fish seen at a range of more than 3 m (Figure 11). The length mode of the close range fish lies at 86 cm, while that of fish seen further out is 74 cm, i.e. considerably smaller. However, it is widely believed that larger salmon species, mainly Chinook salmon, tend to migrate further offshore than smaller salmon (e.g. pink or sockeye salmon). Therefore the lengths of fish farther offshore would be expected to be greater than those detected closer to shore. The DIDSON data in this case indicates the opposite and further calls into question the accuracy of the DIDSON length estimates we obtained with this dataset. Close examination of the DIDSON images collected in this study revealed that fish at a range of 3 m or less are noticeably blurrier, which likely biased their length measurements high.

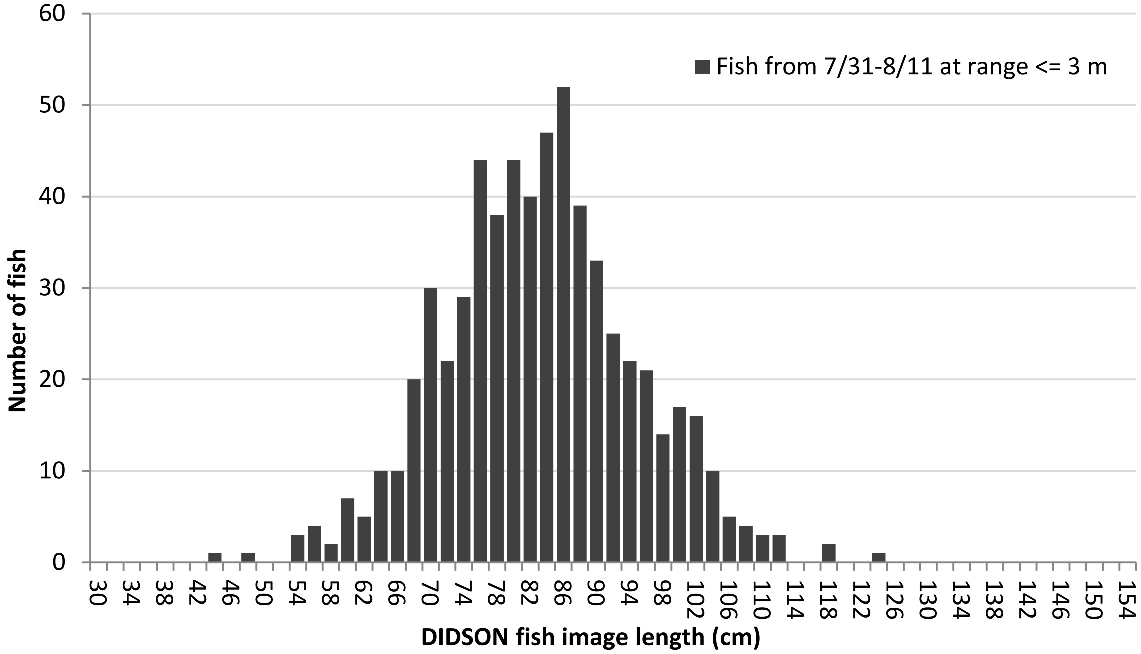

Figure 10. Histogram of the Eagle River 2012 DIDSON image length of fish recorded in the period of July 31 to August 11 at a range equal to or less than 3 m (*n* = 624).

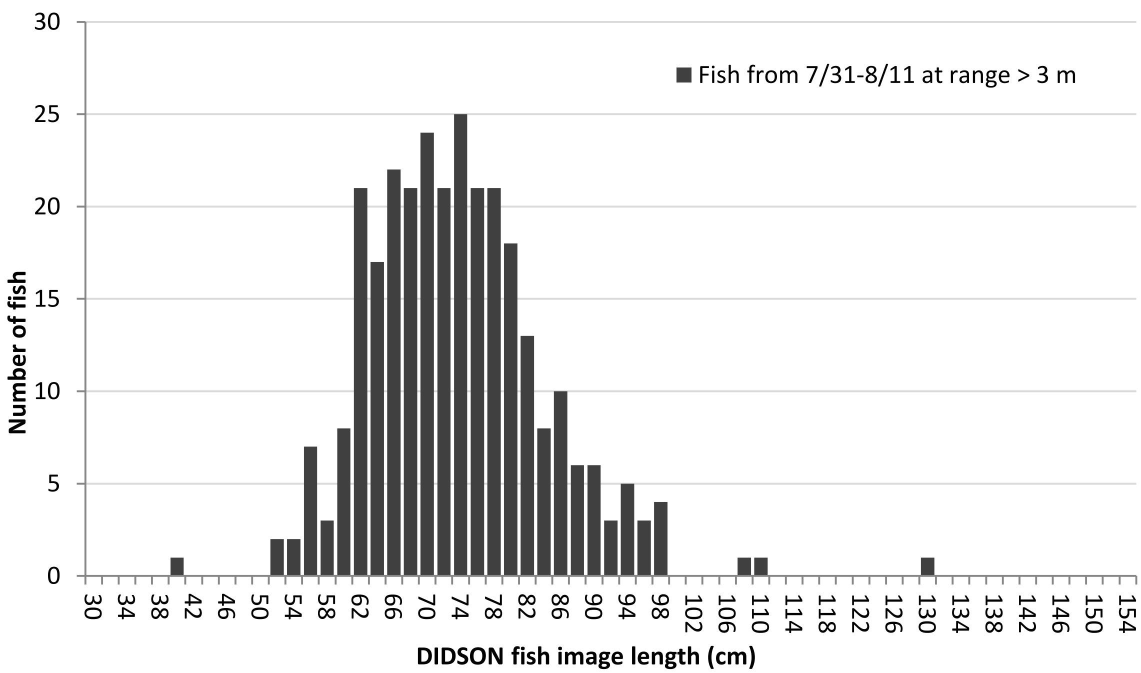

Figure 11. Histogram of the Eagle River 2012 DIDSON image length of fish recorded in the period of July 31 to August 11 at a range greater than 3 m (*n* = 295).

4.2 Species Abundance and Run Timing

The fish wheel began operating June 13, and the last day of operation was September 11. During this 91-day period the fish wheel operated 68 full days, 19 partial days, and there were 4 days when the wheel did not operate. Partial operating days were due mainly to the wheel being stopped at night by debris (five instances) and river stage dropping causing the wheel to hit the streambed (six instances). Mechanical issues and maintenance also rendered the fish wheel inoperable for partial days on occasion (five instances). There were three days when access to the site was restricted because of military operations and one day when mechanical issues prevented operation. An extreme high water event beginning September 16 and lasting through September 30 made working on the wheel unsafe and also damaged the fish wheel anchor system. This precluded further data collection during 2012.

The only species of fish captured in the fish wheel were Pacific salmon. A total of 173 salmon (5% of the total 2012 salmon run estimated by DIDSON) were captured during the 87 days when the wheel was operating. Of these, 42% (72 fish) were captured exclusively in the holding box, 40 % (69 fish) were identified exclusively with the event-triggered video system, and 18 % (32 fish) were recorded on video and also captured in the holding box. Sockeye salmon was the most abundant species captured in the fish wheel, comprising 48 % of the total catch (83 fish). Chum salmon was the next most abundant fish species caught at 22 % (39 fish) and Chinook salmon was 15 % (26 fish) of the total catch. Pink salmon made up 7 % (12 fish) and Coho 5 % (8 fish) of the total catch, while 3 % (5 fish) of the fish wheel catch was not identifiable to species. Table 1 summarizes the number of each species captured by the fish wheel and the method used to identify the species. Figure 12 shows the daily fish wheel catch by species related to the DIDSON daily expanded fish count. Appendix B contains all daily and cumulative fish wheel catch data apportioned to species.

Table 1. Number of fish captured in the fish wheel and the method used to identify the species.

Species Captured	Count per Identification Method			Total	
	Live Box	Video	Live Box and Video		
Chinook	20	4	2	26	15%
Sockeye	30	33	20	83	48%
Pink	4	3	5	12	7%
Chum	18	17	4	39	22%
Coho	0	7	1	8	5%
Unidentified	0	5	0	5	3%
Total	72	69	32	173	
	42%	40%	18%		

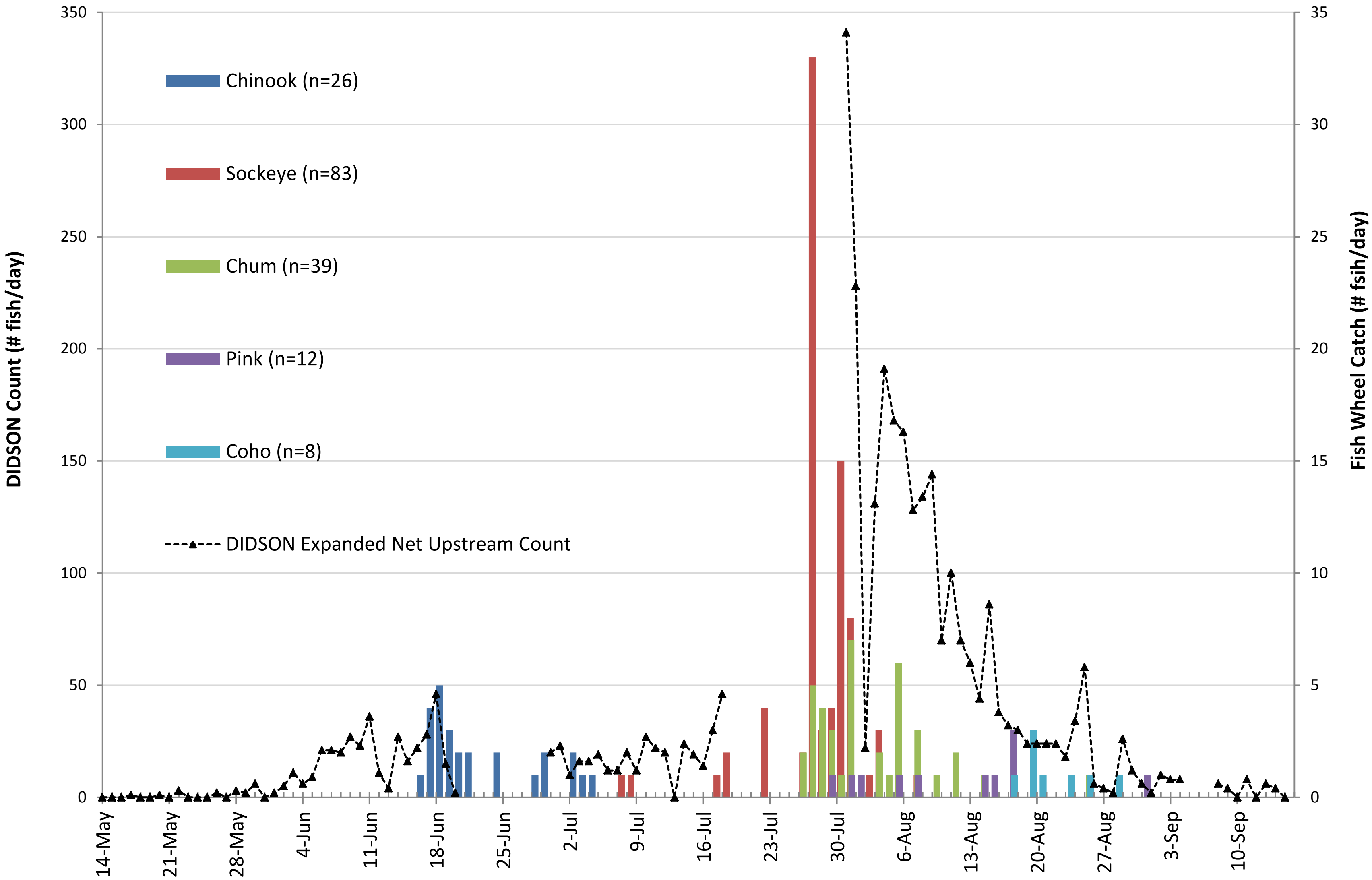

Figure 12. Daily Eagle River 2012 DIDSON expanded net upstream count and fish wheel catch by species.

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4.2.1 Chinook salmon

The number of Chinook salmon passing through JBER during 2012 is estimated to be a minimum of 487 fish (14.7% of the total estimated salmon run) using the daily apportioned method (Appendix B) and 497 (15.0% of the total salmon) using the seasonal apportioned method (Table 1). The first fish was observed by the DIDSON on May 17 and the first fish captured by the fish wheel was a Chinook salmon on June 16 (June 13 was the first day of fish wheel operation). Chinook salmon were consistently captured by the fish wheel at a rate of one to four fish per day from June 16 through July 2. A total of 26 Chinook salmon (15.0% of the total fish wheel catch) where captured and during this period no other salmon species were captured by the fish wheel indicating a strong likelihood that all the fish counted by the DIDSON were Chinook salmon during this time.

The Chinook salmon run in Eagle River is estimated to have occurred from May 17 through July 6. The midpoint (50^{th} percentile) of the Chinook salmon run was on June 16, and by June 30 80 % of the run had passed the sonar site. Figure 13 shows the Chinook salmon daily sonar count plotted with the daily fish wheel catch rate.

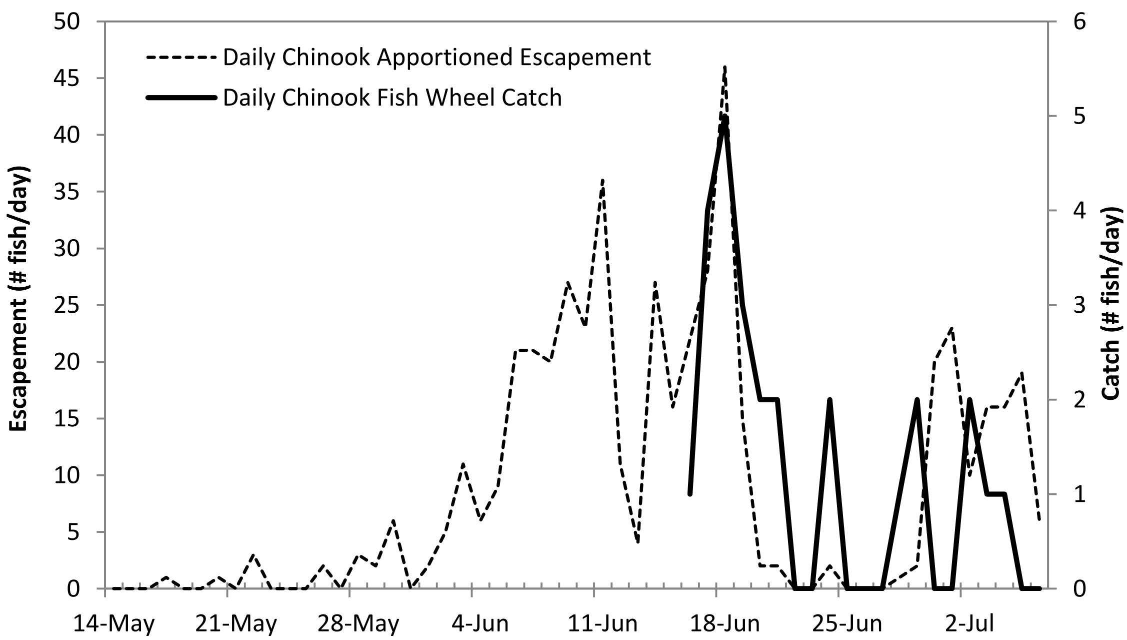

Figure 13. Chinook salmon daily sonar passage estimate and fish wheel catch rate for Eagle River during 2012.

Note that DIDSON sonar was not operating from June 21 to June 29.

4.2.2 Sockeye salmon

The number of sockeye salmon passing through JBER during 2012 is estimated to be a minimum of 711 fish (21.4% of the total estimated salmon run) using the daily apportioned method (Appendix B) and 1,592 (48.0% of the total salmon) using the seasonal apportioned method (Table 1). The first sockeye was captured by the fish wheel on July 7, but sockeye catch remained low at one or two fish per day until July 27 when the peak catch was 33 fish in the wheel. The DIDSON sonar was not operating because of a high water event during the period of peak sockeye salmon migration and therefore the actual run strength is likely greatly underestimated. A total of 83 sockeye salmon (48.0% of the total fish wheel catch) were captured. However, during the later half of the sockeye migration period chum and pink salmon were also migrating and the overlap in run timing increases the possibilities of species misclassification because of fish wheel bias.

The sockeye salmon run in Eagle River is estimated to have occurred from July 6 through August 8. The midpoint (50th percentile) of the sockeye run was on July 31, and by August 5 80% of the run had passed the sonar site. Figure 14 shows the sockeye salmon daily sonar count plotted with the daily fish wheel catch rate.

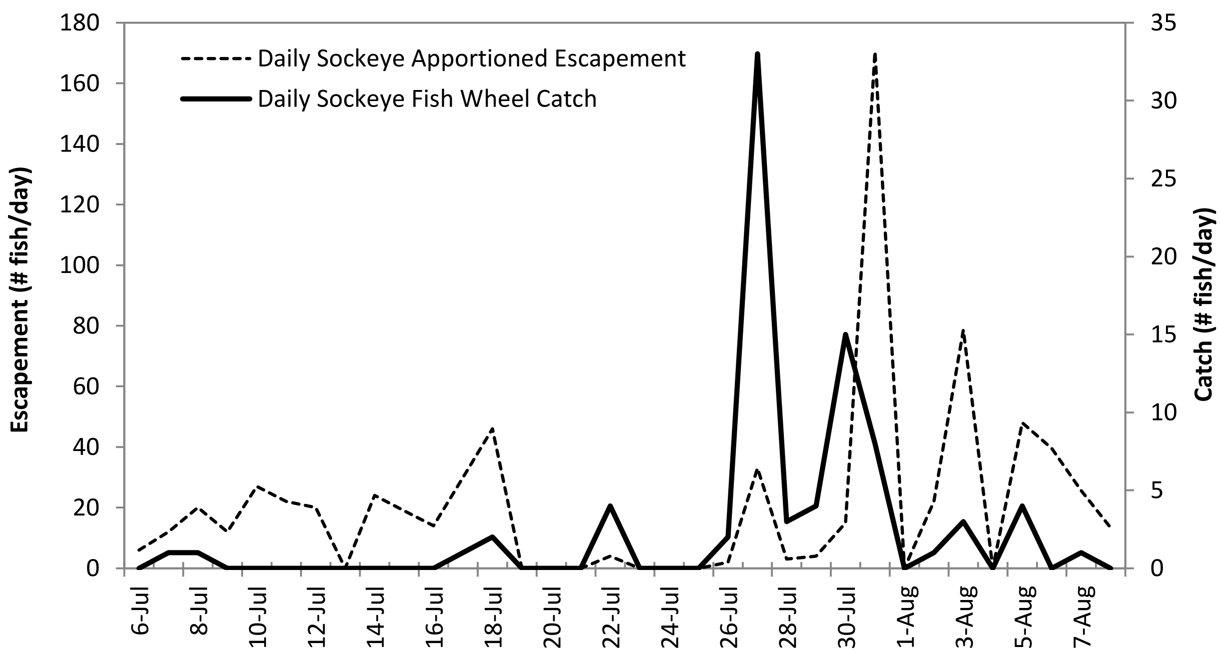

Figure 14. Sockeye salmon daily sonar passage estimate and fish wheel catch rate for the Eagle River during 2012.

Note that DIDSON sonar was not operating from July 19 to July 30.

4.2.3 Chum Salmon

The number of chum salmon passing through JBER during 2012 is estimated to be a minimum of 1,226 fish (37.0% of the total estimated salmon) using the daily apportioned method (Appendix B) and 730 (22.5% of the total salmon) using the seasonal apportioned method (Table 1). The first chum was captured by the fish wheel on July 26 and the peak catch was seven fish on July 31. A total of 39 chum salmon (22.5% of the total fish wheel catch) were captured by the fish wheel. However, sockeye and pink salmon had very similar run timing and the overlap increases the possibilities of species misclassification because of fish wheel bias. Also, the DIDSON sonar was not operating because of a high water event during the period leading up to the peak chum salmon migration and therefore there are five days when chum salmon may be greatly underestimated.

The chum salmon run in Eagle River is estimated to have occurred from July 26 through August 27. The midpoint (50th percentile) of the chum run was on August 8, and by August 11 80% of the run had passed the sonar site. Figure 15 shows the chum salmon daily sonar count plotted with the daily fish wheel catch rate.

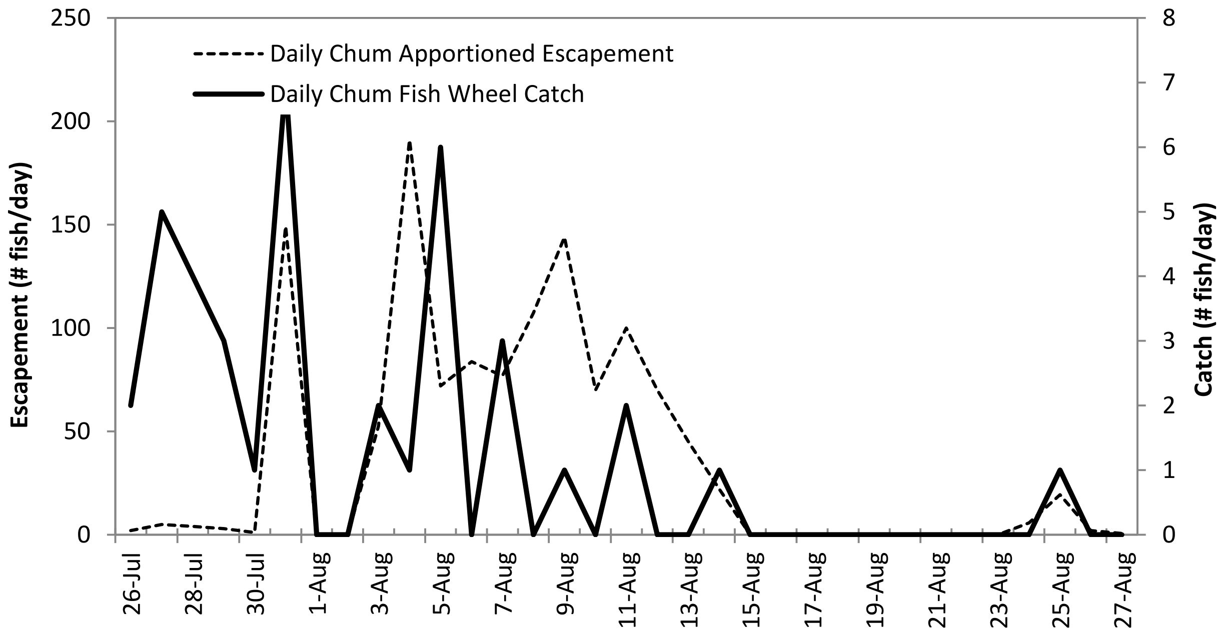

Figure 15. Chum salmon daily sonar passage estimate and fish wheel catch rate for Eagle River during 2012. Note that DIDSON sonar was not operating from July 19 to July 30.

4.2.4 Pink Salmon

The number of pink salmon passing through JBER during 2012 is estimated to be a minimum of 555 fish (16.7% of the total estimated salmon run) using the daily apportioned method (Appendix B) and 232 (7.0% of the total salmon) using the seasonal apportioned method (Table 1). The first pink salmon was captured by the fish wheel on July 29 and the peak catch was three fish on August 17. A total of 12 pink salmon (7.0% of the total fish wheel catch) were captured by the fish wheel. However, sockeye and chum salmon had similar run timing and the overlap increases the possibilities of species misclassification because of fish wheel bias. The DIDSON was operational throughout the majority of the pink salmon run.

The pink salmon run in Eagle River is estimated to have occurred from July 29 through August 31. The midpoint (50th percentile) of the pink salmon run was on August 6 and by August 15 80% of the run had passed the sonar site. Figure 16 shows the pink salmon daily sonar count plotted with the daily fish wheel catch rate.

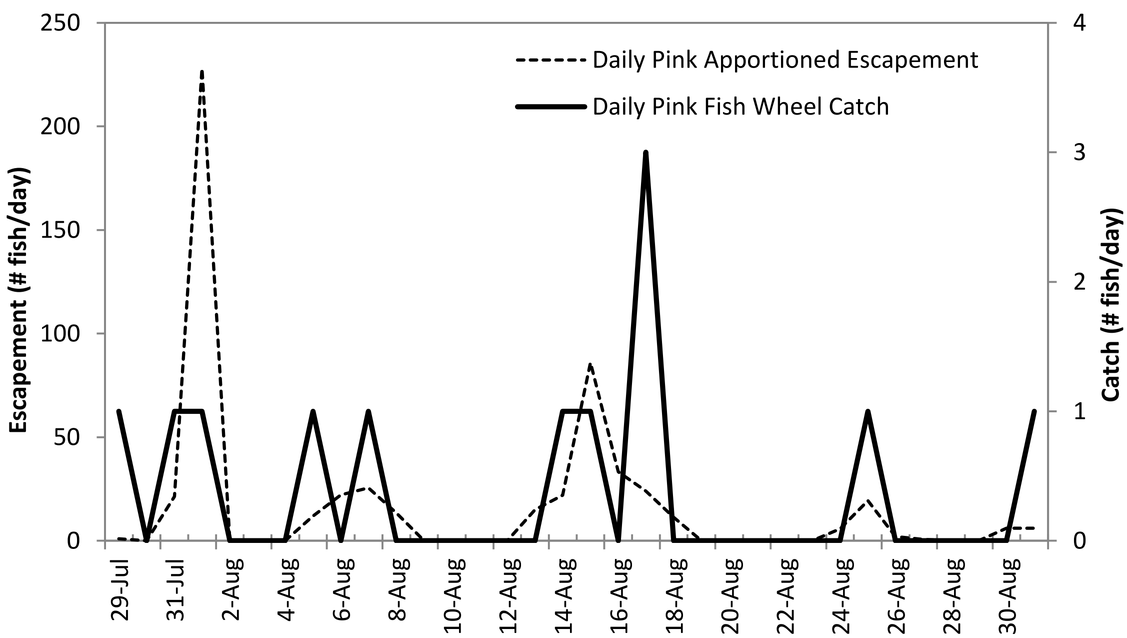

Figure 16. Pink salmon daily sonar passage estimate and fish wheel catch rate for Eagle River during 2012. Note that DIDSON sonar was not operating from July 19 to July 30.

4.2.5 Coho Salmon

The number of coho salmon passing through JBER during 2012 is estimated to be a minimum of 282 fish (8.5% of the total estimated salmon run) using the daily apportioned method (Appendix B) and 166 (4.6% of the total salmon) using the seasonal apportioned method (Table 1). The first coho salmon was captured by the fish wheel on August 17 and the peak catch was three fish on August 19. A total of eight coho salmon (4.6% of the total fish wheel catch) were captured by the fish wheel. However, there was some overlap with the pink and chum salmon run time, increasing possibilities of species misclassification because of fish wheel bias. Data collection ended September 15. During the week prior to the end of data collection the DIDSON sonar was still observing salmon migrating upstream at an average rate of four fish per day. All these fish were likely coho salmon and therefore the total escapement estimate is low because an unknown number of fish migrated after the study ended.

The coho salmon run in Eagle River is estimated to have begun August 16. No information is available to estimate the duration of the coho run. Figure 17 shows the coho salmon daily sonar count plotted with the daily fish wheel catch rate.

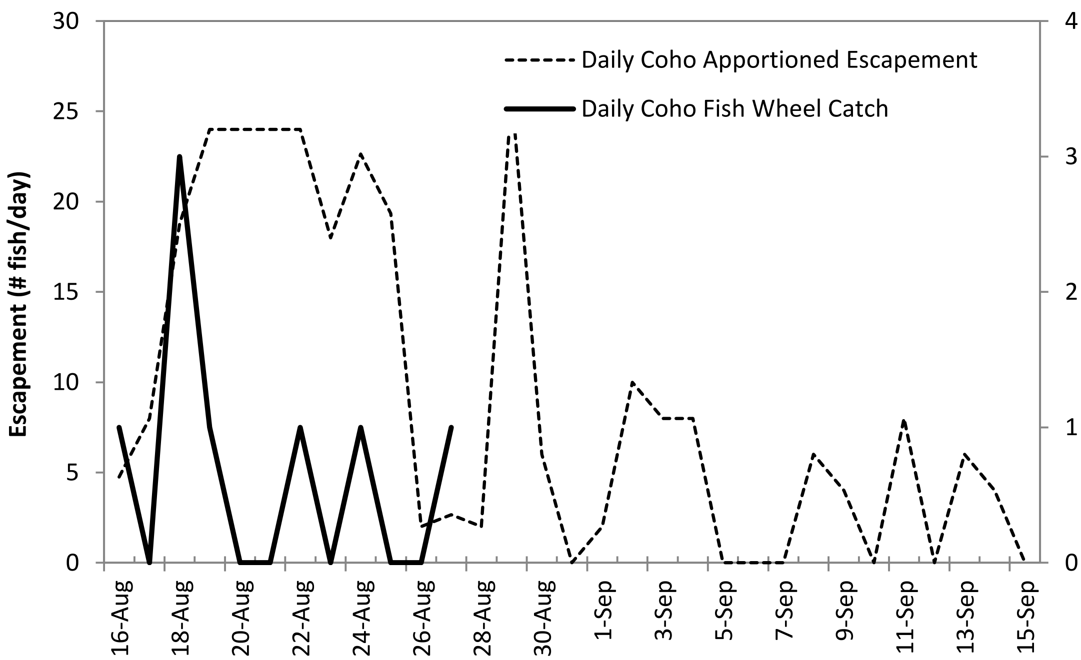

Figure 17. Coho salmon daily sonar passage estimate and fish wheel catch rate for Eagle River during 2012. Note that data collection ended on September 15 when salmon were still in the river.

5.0 DISCUSSION

Adult salmon enumeration in riverine sampling conditions is challenging and requires specialized in-river equipment and the proper selection of acoustic sampling techniques. Deployment of equipment is difficult in rivers having high current velocities and substantial fluctuations in water levels as was the case in this study on the Eagle River. Site selection and equipment placement was critical to the successful use of the DIDSON and fish wheel. Establishment of the site, support equipment including mounts, weirs to direct fish away from the shoreline, enclosures for the equipment, and power supply should be well established during low water conditions.

5.1 DIDSON Based Abundance Estimates

The DIDSON system, as it was used in 2012, proved to be an effective tool for enumerating adult salmon escapement in the Eagle River during low to moderately high flow conditions. The image quality was sufficient to confidently count the number of adult salmon-sized fish. Automatic motion detection reduced the data that had to be reviewed manually to a manageable amount. On average staff spent approximately two hours to process one day’s worth of data.

Based on the DIDSON data collected, it is estimated that a minimum of 3,230 adult salmon passed upstream while the DIDSON was operating (an additional 86 fish were captured by the fish wheel during periods when the DIDSON was not operating). However, even though the system performed well most of the time, this is probably a considerable underestimate of the true number of salmon that moved upstream because the sonar had to be removed on several occasions to avoid equipment damage or loss during moderate to high flood events. The most significant interruption lasted for 12 consecutive days towards the end of July (July 19 to 30). The fish wheel catch suggests that a large number of sockeye and chum salmon passed during this period.

The main limitation to 2012 DIDSON data is the data gaps during periods when the transducer was removed from the river because of high stream flow. Eagle River discharge is driven by high elevation snow and ice melt and/or periods of heavy rain. Spring runoff is typically moderate and does not produce flooding. During 19 of the last 23 years of record, at least one high flow event has occurred. The most common period of high flow occurs from summer melt in late July through early August and typically last one week or longer in duration. Large damaging floods typically occur during the fall rainy season, such as in 2012, which had the fourth largest flood on record (NOAA 2012). Table 2 summarizes the yearly peak high flow event frequency and relative size.

Table 2. Eagle River high flow event frequency by month from 1990 to 2012.

Month	Peak Yearly High Flow Frequency 1990 and 2012		
	High Flow[1]	**Moderate Flood[2]**	**Large Flood[3]**
June	1	0	0
July	3	0	1
August	7	0	3
Sept	0	0	2
Oct	0	1	0
Nov	0	1	0
Total	**11**	**2**	**6**

[1]NOAA Advanced Hydrologic Prediction Service considers a discharge of approximately 2,500 cfs at the Glenn Highway Bridge to be the high flow action stage.

[2]NOAA Advanced Hydrologic Prediction Service considers a discharge of approximately 3,500 cfs at the Glenn Highway Bridge to be the flood stage.

[3]For this summary a large flood is considered to be a discharge of greater than 4,500 cfs at the Glenn Highway Bridge.

During 2012, the DIDSON and weir were removed from the river during three high flow events. The DIDSON data collection was suspended at approximately 1,500 cfs with the floods reaching peak discharge of between 2,000 and 3,000 cfs (excluding the extreme flood event that truncated the data collection in mid-September). Given that a stream discharge exceeding 1,500 cfs is likely to occur during most years for extended durations, increasing the DIDSON's high water operational threshold should be investigated. During 2012, if the DIDSON was operated up to a stream discharge of 2,000 cfs the data gaps would have been significantly reduced. A cage type transducer mount, similar to one used by the ADF&G at their Copper River site, could help protect the DIDSON underwater unit from debris impact and would thus allow the operation to continue through moderate high water events. However, in addition to such a cage, other modifications to the transducer mount and weir, such as an elevated walkway, would be required to provide access and retrieval of the equipment prior to a flood stage, since even at moderated flows personnel access to the DIDSON is challenging. Figure 18 shows the expanded DIDSON fish counts for the entire season and mean daily river discharge collected by NOAA upstream of the study site indicating at what flow the sonar was removed.

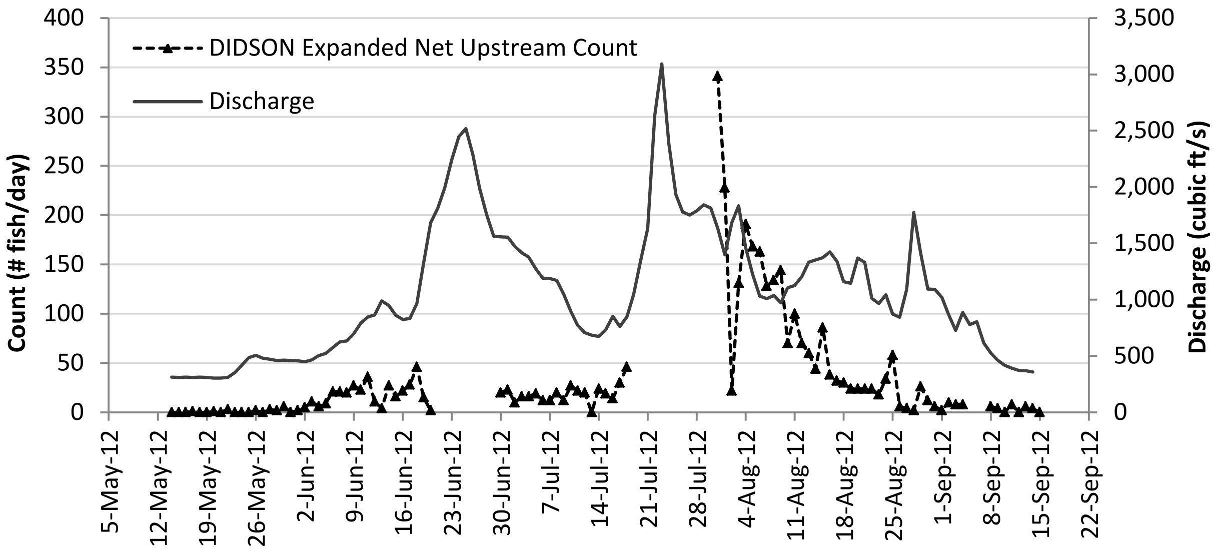

Figure 18. DIDSON expanded net upstream count and stream discharge for Eagle River, 2012.

5.2 Species Apportionment Using Fish Wheels

Species apportionment to total sonar counts is known to be problematic when the run timing of several species overlaps. Typically with sonar counts researchers only attempt to apportion the species that are the focus of a particular management objective. This study, however, required the abundance and run timing for all five species of salmon present in the river. Because of uncertainty in the use of fish wheels to apportion species, ADF&G in 2009 initiated a four-year fish wheel selectivity study (Westerman and Willette 2011) at its Yentna River sonar site to gather information on fish wheel catch bias. Currently the Yentna River escapement estimates are apportioned with species specific selectivity coefficients based on the mark recapture probabilities developed at other fish wheel sites in the 1950s and 1980s. These selectivity coefficients are specific to each river type and would not likely be appropriate to apply to the Eagle River, which is very dissimilar to the Yentna River. Sometimes the ADF&G also reports species specific escapement estimates under the assumption that no fish wheel selectivity exists as was done in this study. It is unlikely that a fish wheel selectivity study would be completed specifically for Eagle River, and therefore the most important thing to be done to increase the confidence in the escapement estimates would be to increase the sample size by improving the catch per unit effort of the fish wheel. This could be accomplished by installing a weir from the river bank out to the fish wheel and also by adding smaller picket weir leads onto the fish wheel pontoons to guide fish into the baskets.

Salmon generally migrate near the river bottom and along shorelines where stream velocities are lower. Fish wheels must be positioned where the fish are migrating and the baskets must remain as close to the stream substrate as possible in order to efficiently catch salmon. Because of ice cover during the project planning phase and high velocity and glacial turbidity during the fish wheel construction phase, the fish wheel site's stream channel depth was unknown at the time. In order to insure that the baskets would reach the river bottom a standard 6-ft by 6-ft basket was constructed. However, after deployment of the fish wheel, it was found that the maximum depth of the river at the fish wheel site was only about 3 feet and many boulders further limited the basket's fishing depth. The inability to submerge the fish wheel baskets to the desired 4- to 6-feet depth created several problems: 1) the wheel had to be operated near the middle of the river to find adequate depth, which limited the catch efficiency of bank oriented salmon; 2) with only 2- to 3-ft of the baskets in the water the force of the current which powers the baskets rotation was not sufficient to lift the largest of the salmon and deliver them to the event-triggered video system and/or live holding box; and 3) with the baskets so far out of the water the salmon had to be lifted approximately 6 feet high to be deposited into the collection system. This may have created handling stress on the fish.

The problems caused by the limited fishing depth at the site were mitigated during the 2012 season by adding paddles to create more surface area and thus increase the rotational power of the baskets. Rubber slings and baffles were also used to control the fish delivery. It would be preferable in the future to find a deeper location that is close to the stream bank. This would solve many problems experienced in 2012 and potentially intercept more salmon and increase confidence in the species apportionment estimates. If a better suited site cannot be used, then modifying the baskets by shortening the length from 6 feet down to 4 feet is suggested.

5.3 Apportioning Fish Counts with DIDSON Data

Although DIDSON images show the approximate physical size and the general shape of the fish and thus provide more clues to identify fish species than traditional single-beam and split-beam sonars, species identification still remains one of the biggest challenges (Mueller et al. 2008, Mueller et al. 2010). Only in a few special cases have DIDSON based fish length estimates been successfully used to apportion fish counts of mixed salmon species (Burwen et al. 2010). Burwen et al. (ADF&G) use DIDSON fish lengths to estimate the proportion of Chinook salmon in a mix of Chinook and sockeye salmon in the Kenai River. While Burwen et al. are facing the difficult challenge of estimating one species in the presence of another that is an order of magnitude more abundant, they are dealing with two salmon species that differ considerably in physical size. For improved size estimates they are using a high-resolution lens that doubles the cross-range resolution (at the expense of total beam size). Our results suggest that Chinook salmon in the Eagle River are sufficiently separated temporally that they can be apportioned based solely on run-timing.

The species that do overlap in time also overlap substantially in size. While length of Eagle River salmon were not collected from the fish wheel catch in 2012, discussing the situation with other researchers who monitor mixed salmon runs re-affirms that DIDSON lengths cannot be used to apportion species in a mix of pink, sockeye, coho and chum salmon. In a personal communication, Suzanne Maxwell (ADF&G) indicated that Yentna River sockeye, coho and chum have too much overlap in their physical size distribution to attempt a DIDSON length based separation. The Yentna River pink salmon even and odd-year runs differ in size, with one being small enough in physical size to be a potential candidate for size-based apportionment, while the larger one is too similar in size to be distinguished from the other species.

Without any physical length data on Eagle River fish it is unclear whether it is worth pursuing DIDSON length measurements as a potential means of apportioning even just pink salmon. If it is to be pursued, two modifications would be desirable: an ARIS model would be preferable over the Long Range Model used this year. This would provide double the cross-range resolution, which is critical for the accuracy of length estimates. Secondly, fish at close range (< 5 m) should be sampled with a shorter range window, which would somewhat reduce the problem of fish being out of focus at close range, an issue that probably lead to the DIDSON fish length estimates obtained this year overestimating the true size of the fish.

The Alaska Department of Fish and Game has been examining DIDSON data for salmon tail-beat frequencies as a potentially useful tool for species identification (Mueller et. al. 2010). JBER did not employ this technique during 2012 but intends to coordinate with ADF&G to evaluate all species differentiation methods in 2013.

5.4 Vicinity Trends

Salmon escapement research is generally limited to individual species in streams with popular sport fisheries or those streams that produce large amounts of salmon and are therefore important to supplying commercial fisheries. The Alaska State Board of Fisheries assigns escapement goals, generally based on ADF&G research data, in an attempt to sustainably manage these fisheries. Escapement estimates are derived in many ways from weir counts, helicopter or foot surveys, creel census, harvest reporting, and sonar projects similar to this study in the Eagle River. In general, for Chinook, sockeye, and coho salmon it can be assumed that streams where sport fisheries are permitted have healthy populations of the target species and where the fisheries do not exist salmon are not considered abundant. While escapement trends may be similar throughout some Knik Arm streams, the Eagle River is unique in the area since most other salmon producing tributaries in Knik Arm are smaller, lower elevation watersheds.

Salmon populations within the Northern Cook Inlet region have been declining since 2007. Chinook and coho salmon in particular have not returned in the abundance forecasted. As a result, some Chinook and coho fisheries in the Northern Cook Inlet District, including within the Knik Arm Management Unit, were closed by emergency order during 2012. Because of their relatively low sport and commercial value, little information exists for pink and chum salmon abundance in the area. The declining trend in salmon abundance appears likely to continue for all five Pacific salmon species.

The Alaska Department of Fish and Game's Chinook Salmon Research Team has published its Chinook Salmon Stock Assessment and Research Plan to address recent downturns in Chinook salmon stock productivity and abundance throughout Alaska (ADF&G 2013). The proposed studies include enumeration of adult escapement, estimates of juvenile abundance during smolt stage, nearshore marine surveys, and a suite of local and traditional knowledge studies within 12 rivers including the Susitna and Kenai Rivers in Cook Inlet. Chinook salmon are socially and economically important to Alaska and Governor Sean Parnell's budget for the 2014 fiscal year included $10 million for Chinook salmon research in addition to the $14.6 million ADF&G typically spends each year on Chinook salmon related research and management. Representative Bob Herron, Democrat in Bethel, also has a bill in the legislature that could fund Chinook salmon studies in the future (Dischner 2013).

The following streams in vicinity to Knik Arm have predominantly wild stocks and some form of adult salmon monitoring for one or more species that may be relevant for comparison with Eagle River salmon production and regional trends:

- Little Susitna River- ADF&G index surveys to estimate Chinook salmon and counting weir to estimate artificially supplemented coho and sockeye salmon
- Fish Creek- ADF&G counting weir to estimate coho and sockeye salmon
- Cottonwood Creek- ADF&G counting weir and index surveys to estimate coho salmon

- Wasilla Creek- ADF&G index survey to estimate coho salmon
- Jim Creek- ADF&G index survey to estimate coho salmon
- Sixmile Creek- JBER counting weir to estimate sockeye salmon

Chinook salmon

The nearest stream to Eagle River with a wild stock Chinook salmon escapement estimate is the Little Susitna River, which enters Upper Cook Inlet west of Anchorage. Chinook salmon return to the Little Susitna River from late May through early July with the peak immigration approximately mid-June (Oslund 2010). The Little Susitna River is not nearly as glacially influenced as Eagle River and it is the only stream in the Knik Arm Management Unit other than Eagle River and the Eklutna tailrace open to Chinook salmon harvest. As such, a sustainable escapement goal (SEG) was established in 2002 with lower and upper bounds of 900 and 1,800 fish (Ivey et. al. 2009). The ADF&G has estimated Little Susitna Chinook salmon escapement annually with peak aerial index surveys since 1979 and occasionally by using a counting weir. Aerial counts between 2003 and 2010 ranged from 2,095 in 2005 to 589 in 2010, well below the lower SEG bound (Table 3) (Oslund et. al. 2010). The historical peak of Little Susitna River Chinook salmon appears to have occurred in 1988 when the weir count was 7,374 and the aerial count was 3,197 (Oslund et al. 2010). The one-time peak aerial fish counts represent only a minimum number and for the Little Susitna are always significantly lower than escapement estimates from weir counts.

Escapement estimates for 2012 have not been published but Chinook salmon abundance within the Little Susitna River has followed the regional downward trend. Based on the SEGs and harvest records, it appears that the Little Susitna River may produce 5 to 10 times the number of Chinook salmon as the Eagle River. Differences in spawning, rearing, and overwinter habitat are likely reasons. However, based on the first Eagle River escapement estimate it appears that Eagle River had a relatively strong Chinook salmon run in 2012 compared to the Little Susitna 2010 data (Table 3).

Besides the Little Susitna River, Moose Creek is the only other stream where adult Chinook salmon abundance is monitored. Moose Creek is a relatively small fast flowing non-glacial stream that does not have a direct connection to salt water but is a tributary to the Matanuska River. Historically, Moose Creek was significantly altered by channelization from a railroad which created barriers to fish migration. Work began in 2005 to restore fish passage. Aerial counts of Chinook salmon spawning grounds have been completed almost every year since 1983 and are used to index year to year trends. The peak was in 1988 when 1,072 were observed. The average from 1983 to 2008 was 522 Chinook salmon while the average from 2001 to 2010 was down to 278 with the low in 2012 at 142 (Oslund et. al 2010).

Like the Little Susitna River, Moose Creek has had a significant downward trend in Chinook salmon abundance. Eagle River appears to have similarly abundant Chinook salmon population as Moose Creek had in the 1980s and 90s. With Eagle River having about 500 Chinook salmon returning to spawn in 2012, which is known to be a year of low abundance in other Chinook salmon systems, it likely had a much greater number of spawners in the past.

Coho salmon

The Little Susitna River supports the largest coho salmon fishery of the Knik Arm streams. Coho salmon harvest in the Little Susitna River is second only to the Kenai River which supports the largest coho salmon harvest in Alaska. However, the Little Susitna was supplemented with hatchery reared coho smolts from 1982 to 1995 (Oslund et al. 2010). Coho salmon escapement has been counted annually at a weir since 1988. Coho escapement in the Little Susitna River has been highly variable. The 10-year average from 2000 to 2010 was 21,670, with two years having more than 40,000 fish. The peak coho escapement was 47,938 in 2002 but in 2010 the weir count was down to a low of 9,214 fish (Table 3) (Oslund et al. 2010).

Jim Creek, a tributary to the Knik River, currently supports another large coho sport fishery. Historically, coho were stocked in many Knik Arm tributaries, including Fish Creek, Jim Creek, Eklutna Tailrace, and Cottonwood and Wasilla creeks. Escapement data is available for Fish and Jim creeks; however, all these estimates are completed upstream of major fisheries. Unlike the 2012 Eagle River data, the ADF&G escapement estimates do not represent the total number of salmon returning to the river, this could be derived by summing the escapement and harvest data for these streams.

All the Knik arm streams with coho escapement estimates show a downward trend over the past decade with a steep decline over the past few years. While the Eagle River coho salmon data collection was truncated by a flood event, the early season counts were very low which may not be surprising given that even the largest coho producing streams including Little Susitna River, Fish Creek, and Jim Creek were closed to fishing by emergency order during 2012 because of the low adult returns.

Table 3. Salmon escapement estimates for select Knik Arm tributaries, 2000 to 2010.

Year	Little Susitna River		Fish Creek		Jim Creek
	Chinook[a]	Coho[b]	Coho[b]	Sockeye[b]	Coho[c]
2000	1,094	15,436	5,218	19,533[e]	3,218
2001	1,238	30,587	9,247	43,498[e]	1,594
2002	1,660	47,938	14,651	90,482[e]	4,103
2003	1,114	10,877	1,231	91,952[e]	1,814
2004	1,694	40,199	1,415	22,157[e]	5,697
2005	2,095	16,839[d]	3,011	14,215[e]	3,347
2006	1,855	8,786[d]	4,967	32,562[e]	4,139
2007	1,731	17,573	6,868	27,948[e]	1,875
2008	1,297	18,485	4,868	19,339[e]	2,919
2009	1,028	9,523	8,214	83,480[e]	2,524
2010	589	9,214	6,977	126,836[e]	662

[a]Aerial index count

[b]Weir count

[c]Foot survey index count

[d]Partial count due to weir submersion

[e]Hatchery reared sockeye salmon contributed to the Fish Creek escapement

Source Oslund 2010

6.0 SUMMARY

Adult salmon enumeration in Eagle River had not been conducted prior to this study. While the estimated total salmon passage of 3,316 fish may be significantly lower than the actual number of fish that returned to Eagle River in 2012, the combination of DIDSON sonar to enumerate all salmon passing through JBER and a fish wheel to apportion the species to the sonar counts was proven to be a feasible and successful method to address the project goal and objectives. The major challenges to the study are the rapidly fluctuating water level and frequency of high flow events, which suspended data collection during periods of peak salmon migration and the accuracy of the species specific estimates apportioned by fish wheel catch data. Addressing lessons learned in 2012 to develop modifications to equipment and operational procedures in future years will increase the overall accuracy of the salmon passage estimates.

7.0 ACKNOWLEDGEMENTS

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9.0 APPENDICES

Appendix A

DIDSON Daily Observed and Expanded Fish Counts

Appendix A. DIDSON daily observed and expanded fish counts, Eagle River 2012.

Date	Range Stratum R1 (Near)		Range Stratum R2 (Far)		R1 + R2	
	Fish Observed	Expanded Net Count	Fish Observed	Expanded Net Count	Total Fish Observed	Total Expanded Net Count
05/22/12	1	2	1	1	2	3
05/28/12	1	2	1	1	2	3
05/29/12	1	2	1	1	2	3
06/02/12	1	2	1	2	2	4
06/04/12	1	2	1	1	2	3
06/05/12	1	2	3	6	4	8
06/06/12	4	8	1	2	5	10
06/07/12	5	10	2	3	7	13
06/08/12	6	12	6	11	12	23
06/09/12	7	14	2	4	9	18
06/10/12	9	17	4	7	13	24
06/11/12	19	33	7	13	26	46
06/12/12	5	6	6	11	11	17
06/13/12	3	2	6	8	9	10
06/14/12	13	22	7	13	20	35
06/15/12	7	14	3	6	10	20
06/16/12	8	16	2	3	10	19
06/17/12	13	22	3	5	16	27
06/18/12	21	42	1	2	22	44
06/19/12	8	15	3	5	11	20
06/20/12	1	2	1	2	2	4
06/30/12	8	16	3	6	11	22
07/01/12	9	18	3	6	12	24
07/02/12	5	10	2	4	7	14
07/03/12	7	14	2	4	9	18
07/04/12	6	12	3	5	9	17
07/05/12	7	14	1	2	8	16
07/06/12	6	12	2	4	8	16
07/07/12	6	12	3	5	9	17
07/08/12	5	10	5	10	10	20
07/09/12	3	6	3	6	6	12
07/10/12	8	16	6	11	14	27
07/11/12	6	12	5	10	11	22
07/12/12	8	16	2	4	10	20
07/14/12	10	20	2	4	12	24
07/15/12	10	19	3	5	13	24

-continued-

Appendix A. DIDSON daily observed and expanded fish counts, Eagle River 2012.

Date	Range Stratum R1 (Near)		Range Stratum R2 (Far)		R1 + R2	
	Fish Observed	Expanded Net Count	Fish Observed	Expanded Net Count	Total Fish Observed	Total Expanded Net Count
07/16/12	7	14	2	4	9	18
07/17/12	15	30	1	2	16	32
07/18/12	23	46	1	2	24	44
07/31/12	168	336	0	0	168	336
08/01/12	112	224	0	0	112	224
08/02/12	10	20	0	0	10	20
08/03/12	66	131	0	0	66	131
08/04/12	99	193	0	0	99	193
08/05/12	86	168	0	0	86	168
08/06/12	82	163	0	0	82	163
08/07/12	65	128	0	0	65	128
08/08/12	67	134	0	0	67	134
08/09/12	72	144	0	0	72	144
08/10/12	35	70	0	0	35	70
08/11/12	50	100	0	0	50	100
08/12/12	35	70	0	0	35	70
08/13/12	30	60	0	0	30	60
08/14/12	22	44	0	0	22	44
08/15/12	43	86	0	0	43	86
08/16/12	19	38	0	0	19	38
08/17/12	16	32	0	0	16	32
08/18/12	15	30	0	0	15	30
08/19/12	12	24	0	0	12	24
08/20/12	12	24	0	0	12	24
08/21/12	12	24	0	0	12	24
08/22/12	12	24	0	0	12	24
08/23/12	9	18	0	0	9	18
08/24/12	17	34	0	0	17	34
08/25/12	29	58	0	0	29	58
08/26/12	3	6	0	0	3	6
08/27/12	2	4	0	0	2	4
08/28/12	1	2	0	0	1	2
08/29/12	13	26	0	0	13	26
08/30/12	6	12	0	0	6	12
08/31/12	3	6	0	0	3	6
09/01/12	1	2	0	0	1	2

-continued-

Appendix A. DIDSON daily observed and expanded fish counts, Eagle River 2012.

Date	Range Stratum R1 (Near)		Range Stratum R2 (Far)		R1 + R2	
	Fish Observed	Expanded Net Count	Fish Observed	Expanded Net Count	Total Fish Observed	Total Expanded Net Count
09/02/12	5	10	0	0	5	10
09/03/12	4	8	0	0	4	8
09/04/12	4	8	0	0	4	8
09/08/12	3	6	0	0	3	6
09/09/12	2	4	0	0	2	4
09/11/12	4	8	0	0	4	8
09/13/12	3	6	0	0	3	6
09/14/12	2	4	0	0	2	4
Totals	**1535**	**3033**	**111**	**201**	**1646**	**3230**

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Appendix B

Fish Wheel Daily Catch and Species Apportionment

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Appendix B. Fish Wheel daily catch and expanded and cumulative species apportionment, Eagle River 2012.

Date	Chinook			Sockeye			Chum			Pink			Coho		
	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum
14-May		0	0	0	0		0	0		0	0		0	0	
15-May		0	0	0	0		0	0		0	0		0	0	
16-May		0	0	0	0		0	0		0	0		0	0	
17-May		1	1	0	0		0	0		0	0		0	0	
18-May		0	1	0	0		0	0		0	0		0	0	
19-May		0	1	0	0		0	0		0	0		0	0	
20-May		1	2	0	0		0	0		0	0		0	0	
21-May		0	2	0	0		0	0		0	0		0	0	
22-May		3	5	0	0		0	0		0	0		0	0	
23-May		0	5	0	0		0	0		0	0		0	0	
24-May		0	5	0	0		0	0		0	0		0	0	
25-May		0	5	0	0		0	0		0	0		0	0	
26-May		2	7	0	0		0	0		0	0		0	0	
27-May		0	7	0	0		0	0		0	0		0	0	
28-May		3	10	0	0		0	0		0	0		0	0	
29-May		2	12	0	0		0	0		0	0		0	0	
30-May		6	18	0	0		0	0		0	0		0	0	
31-May		0	18	0	0		0	0		0	0		0	0	
1-Jun		2	20	0	0		0	0		0	0		0	0	
2-Jun		5	25	0	0		0	0		0	0		0	0	
3-Jun		11	36	0	0		0	0		0	0		0	0	
4-Jun		6	42	0	0		0	0		0	0		0	0	
5-Jun		9	51	0	0		0	0		0	0		0	0	
6-Jun		21	72	0	0		0	0		0	0		0	0	
7-Jun		21	93	0	0		0	0		0	0		0	0	

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Appendix B. Fish Wheel daily catch and expanded and cumulative species apportionment, Eagle River 2012.

Date	Chinook			Sockeye			Chum			Pink			Coho		
	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum
8-Jun		20	113	0	0		0	0		0	0		0	0	
9-Jun		27	140	0	0		0	0		0	0		0	0	
10-Jun		23	163	0	0		0	0		0	0		0	0	
11-Jun		36	199	0	0		0	0		0	0		0	0	
12-Jun		11	210	0	0		0	0		0	0		0	0	
13-Jun		4	214	0	0		0	0		0	0		0	0	
14-Jun		27	241	0	0		0	0		0	0		0	0	
15-Jun		16	257	0	0		0	0		0	0		0	0	
16-Jun	1	22	279	0	0		0	0		0	0		0	0	
17-Jun	4	28	307	0	0		0	0		0	0		0	0	
18-Jun	5	46	353	0	0		0	0		0	0		0	0	
19-Jun	3	15	368	0	0		0	0		0	0		0	0	
20-Jun	2	2	370	0	0		0	0		0	0		0	0	
21-Jun	2	2	372	0	0		0	0		0	0		0	0	
22-Jun	0	0	372	0	0		0	0		0	0		0	0	
23-Jun	0	0	372	0	0		0	0		0	0		0	0	
24-Jun	2	2	374	0	0		0	0		0	0		0	0	
25-Jun	0	0	374	0	0		0	0		0	0		0	0	
26-Jun	0	0	374	0	0		0	0		0	0		0	0	
27-Jun	0	0	374	0	0		0	0		0	0		0	0	
28-Jun	1	1	375	0	0		0	0		0	0		0	0	
29-Jun	2	2	377	0	0		0	0		0	0		0	0	
30-Jun	0	20	397	0	0		0	0		0	0		0	0	
1-Jul	0	23	420	0	0		0	0		0	0		0	0	
2-Jul	2	10	430	0	0		0	0		0	0		0	0	

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Appendix B. Fish Wheel daily catch and expanded and cumulative species apportionment, Eagle River 2012.

Date	Chinook			Sockeye			Chum			Pink			Coho		
	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum
3-Jul	1	16	446	0	0		0	0		0	0		0	0	
4-Jul	1	16	462	0	0		0	0		0	0		0	0	
5-Jul	0	19	481	0	0		0	0		0	0		0	0	
6-Jul	0	6	487	0	6	6	0	0		0	0		0	0	
7-Jul	0	0		1	12	18	0	0		0	0		0	0	
8-Jul	0	0		1	20	38	0	0		0	0		0	0	
9-Jul	0	0		0	12	50	0	0		0	0		0	0	
10-Jul	0	0		0	27	77	0	0		0	0		0	0	
11-Jul	0	0		0	22	99	0	0		0	0		0	0	
12-Jul	0	0		0	20	119	0	0		0	0		0	0	
13-Jul	0	0		0	0	119	0	0		0	0		0	0	
14-Jul	0	0		0	24	143	0	0		0	0		0	0	
15-Jul	0	0		0	19	162	0	0		0	0		0	0	
16-Jul	0	0		0	14	176	0	0		0	0		0	0	
17-Jul	0	0		1	30	206	0	0		0	0		0	0	
18-Jul	0	0		2	46	252	0	0		0	0		0	0	
19-Jul	0	0		0	0	252	0	0		0	0		0	0	
20-Jul	0	0		0	0	252	0	0		0	0		0	0	
21-Jul	0	0		0	0	252	0	0		0	0		0	0	
22-Jul	0	0		4	4	256	0	0		0	0		0	0	
23-Jul	0	0		0	0	256	0	0		0	0		0	0	
24-Jul	0	0		0	0	256	0	0		0	0		0	0	
25-Jul	0	0		0	0	256	0	0		0	0		0	0	
26-Jul	0	0		2	2	258	2	2	2	0	0		0	0	
27-Jul	0	0		33	33	291	5	5	7	0	0		0	0	

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Appendix B. Fish Wheel daily catch and expanded and cumulative species apportionment, Eagle River 2012.

Date	Chinook			Sockeye			Chum			Pink			Coho		
	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum	Catch	App. Total	Cum
28-Jul	0	0		3	3	294	4	4	11	0	0		0	0	
29-Jul	0	0		4	4	298	3	3	14	1	1	1	0	0	
30-Jul	0	0		15	15	313	1	1	15	0	0	1	0	0	
31-Jul	0	0		8	171	484	7	149	164	1	21	22	0	0	
1-Aug	0	0		0	0	484	0	0	164	1	228	250	0	0	
2-Aug	0	0		1	22	506	0	0	164	0	0	250	0	0	
3-Aug	0	0		3	79	584	2	52	217	0	0	250	0	0	
4-Aug	0	0		0	0	584	1	191	408	0	0	250	0	0	
5-Aug	0	0		4	48	632	6	72	480	1	12	262	0	0	
6-Aug	0	0		0	40	672	0	84	563	0	22	284	0	0	
7-Aug	0	0		1	26	697	3	77	640	1	26	310	0	0	
8-Aug	0	0		0	13	711	0	107	747	0	13	323	0	0	
9-Aug	0	0		0	0		1	144	891	0	0	323	0	0	
10-Aug	0	0		0	0		0	70	961	0	0	323	0	0	
11-Aug	0	0		0	0		2	100	1061	0	0	323	0	0	
12-Aug	0	0		0	0		0	70	1131	0	0	323	0	0	
13-Aug	0	0		0	0		0	45	1176	0	15	338	0	0	
14-Aug	0	0		0	0		1	22	1198	1	22	360	0	0	
15-Aug	0	0		0	0		0	0	1198	1	86	446	0	0	
16-Aug	0	0		0	0		0	0	1198	0	33	480	0	5	5
17-Aug	0	0		0	0		0	0	1198	3	24	504	1	8	13
18-Aug	0	0		0	0		0	0	1198	0	11	515	0	19	32
19-Aug	0	0		0	0		0	0	1198	0	0	515	3	24	56
20-Aug	0	0		0	0		0	0	1198	0	0	515	1	24	80
21-Aug	0	0		0	0		0	0	1198	0	0	515	0	24	104

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Appendix B. Fish Wheel daily catch and expanded and cumulative species apportionment, Eagle River 2012.

Date	Chinook			Sockeye			Chum			Pink			Coho		
	Catch	App. Total	Cum	Catch	App. Total		Catch	App. Total	Cum	Catch	App. Total		Catch	App. Total	Cum
22-Aug	0	0		0	0		0	0	1198	0	0	515	0	24	128
23-Aug	0	0		0	0		0	0	1198	0	0	515	1	18	146
24-Aug	0	0		0	0		0	6	1204	0	6	521	0	23	168
25-Aug	0	0		0	0		1	19	1223	1	19	540	1	19	187
26-Aug	0	0		0	0		0	2	1225	0	2	542	0	2	189
27-Aug	0	0		0	0		0	1	1226	0	1	543	0	3	192
28-Aug	0	0		0	0		0	0		0	0	543	1	2	194
29-Aug	0	0		0	0		0	0		0	0	543	0	26	220
30-Aug	0	0		0	0		0	0		0	6	549	0	6	226
31-Aug	0	0		0	0		0	0		1	6	555	0	0	226
1-Sep	0	0		0	0		0	0		0	0		0	2	228
2-Sep	0	0		0	0		0	0		0	0		0	10	238
3-Sep	0	0		0	0		0	0		0	0		0	8	246
4-Sep	0	0		0	0		0	0		0	0		0	8	254
5-Sep	0	0		0	0		0	0		0	0		0	0	254
6-Sep	0	0		0	0		0	0		0	0		0	0	254
7-Sep	0	0		0	0		0	0		0	0		0	0	254
8-Sep	0	0		0	0		0	0		0	0		0	6	260
9-Sep	0	0		0	0		0	0		0	0		0	4	264
10-Sep	0	0		0	0		0	0		0	0		0	0	264
11-Sep	0	0		0	0		0	0		0	0		0	8	272
12-Sep	0	0		0	0		0	0		0	0		0	0	272
13-Sep	0	0		0	0		0	0		0	0		0	6	278
14-Sep	0	0		0	0		0	0		0	0		0	4	282
Totals	**26**	**487**		**83**	**711**		**39**	**1226**		**12**	**555**		**8**	**282**	

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Appendix C

Mean Daily River Stage and Temperature

Appendix C. Mean daily river stage and temperature, Eagle River 2012.

Date	Mean Daily Sensor Depth, ft	Mean Daily Temp, °F
5/17/2012	0.35	50.6
5/18/2012	0.44	47.4
5/19/2012	0.50	46.5
5/20/2012	0.53	46.1
5/21/2012	0.54	47.5
5/22/2012	0.62	48.5
5/23/2012	0.75	48.8
5/24/2012	0.86	46.1
5/25/2012	0.79	45.1
5/26/2012	0.65	45.8
5/27/2012	0.62	45.3
5/28/2012	0.63	45.7
5/29/2012	0.69	47.4
5/30/2012	0.64	45.0
5/31/2012	0.66	44.8
6/1/2012	0.61	46.6
6/2/2012	0.63	47.3
6/3/2012	0.75	47.2
6/4/2012	0.72	44.8
6/5/2012	0.80	47.8
6/6/2012	0.85	47.9
6/7/2012	0.81	45.9
6/8/2012	0.91	46.3
6/9/2012	0.95	45.5
6/10/2012	1.08	45.8
6/11/2012	1.14	45.7
6/12/2012	1.09	44.0
6/13/2012	1.14	43.7
6/14/2012	1.13	45.5
6/15/2012	1.13	45.9
6/16/2012	1.06	46.9
6/17/2012	1.11	47.8
6/18/2012	1.22	49.8
6/19/2012	1.27	49.3
6/20/2012	1.45	47.6
6/21/2012	1.46	45.9
6/22/2012	1.71	48.3
6/23/2012	1.81	48.3
6/24/2012	1.95	46.1
6/25/2012	2.06	44.7
6/26/2012	1.88	44.4
6/27/2012	1.40	44.3
6/28/2012	1.05	44.0
6/29/2012	1.03	45.3

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Appendix C. Mean daily river stage and temperature, Eagle River 2012.

Date	Mean Daily Sensor Depth, ft	Mean Daily Temp, °F
6/30/2012	0.96	46.8
7/1/2012	0.92	46.0
7/2/2012	0.74	43.8
7/3/2012	0.58	44.5
7/4/2012	0.52	44.4
7/5/2012	0.59	45.1
7/6/2012	0.54	45.9
7/7/2012	0.53	45.4
7/8/2012	0.49	45.7
7/9/2012	0.36	45.6
7/10/2012	0.23	45.7
7/11/2012	0.21	45.7
7/12/2012	0.44	44.7
7/13/2012	0.61	45.1
7/14/2012	0.55	46.8
7/15/2012	0.45	47.0
7/16/2012	0.48	46.2
7/17/2012	0.45	47.6
7/18/2012	0.45	49.3
7/19/2012	0.52	50.1
7/20/2012	0.65	49.0
7/21/2012	0.76	47.2
7/22/2012	1.39	45.0
7/23/2012	2.51	43.0
7/24/2012	2.40	42.8
7/25/2012	2.16	45.0
7/26/2012	2.10	46.7
7/27/2012	2.08	47.1
7/28/2012	2.12	46.8
7/29/2012	2.13	47.2
7/30/2012	2.11	45.2
7/31/2012	1.94	44.8
8/1/2012	1.84	45.0
8/2/2012	2.10	43.7
8/3/2012	2.08	43.3
8/4/2012	1.84	43.9
8/5/2012	1.69	44.2
8/6/2012	1.57	45.1
8/7/2012	1.59	46.0
8/8/2012	1.58	45.8
8/9/2012	1.56	46.5
8/10/2012	1.69	46.8
8/11/2012	1.67	47.1
8/12/2012	1.73	48.2
8/13/2012	1.79	47.5

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Appendix C. Mean daily river stage and temperature, Eagle River 2012.

Date	Mean Daily Sensor Depth, ft	Mean Daily Temp, °F
8/14/2012	1.81	46.0
8/15/2012	1.84	45.8
8/16/2012	1.85	45.7
8/17/2012	1.75	45.3
8/18/2012	1.63	44.0
8/19/2012	1.72	44.6
8/20/2012	1.80	44.2
8/21/2012	1.73	44.4
8/22/2012	1.56	46.0
8/23/2012	1.61	46.1
8/24/2012	1.54	44.1
8/25/2012	1.47	45.7
8/26/2012	1.44	44.8
8/27/2012	1.81	46.6
8/28/2012	2.08	44.0
8/29/2012	1.76	43.3
8/30/2012	1.63	44.6
8/31/2012	1.59	44.0
9/1/2012	1.55	43.8
9/2/2012	1.40	43.4
9/3/2012	1.37	44.5
9/4/2012	1.44	43.1
9/5/2012	1.40	42.9
9/6/2012	1.36	42.5
9/7/2012	1.12	43.3
9/8/2012	0.98	42.3
9/9/2012	0.87	42.1
9/10/2012	0.80	41.4
9/11/2012	0.73	40.7
9/12/2012	0.70	42.4
9/13/2012	0.68	43.4
9/14/2012	0.67	44.0
9/15/2012	0.74	43.8
9/16/2012	1.53	43.5
9/17/2012	2.09	42.3
9/18/2012	1.55	42.5
9/19/2012	1.50	42.9
9/20/2012	2.34	43.8
9/21/2012	2.70	42.5
9/22/2012	2.77	43.8