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EAGLE RIVER ADULT SALMON MONITORING ON JOINT BASE ELMENDORF-RICHARDSON, ALASKA, 2015

FINAL

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Eagle River Adult Salmon Monitoring on Joint Base Elmendorf-Richardson, Alaska, 2015

Prepared for:
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LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

°	degrees (angular)
°F	degrees Fahrenheit
%	percent
ADF&G	Alaska Department of Fish and Game
Ah	Amp Hours
CSOT	Convolved Samples Over Threshold
DIDSON	dual-frequency identification sonar
DVR	digital video recorder
ESA	Endangered Species Act
ft	feet
fps	frames per second
GB	gigabyte
INRMP	Integrated Natural Resources Management Plan
JBER	Joint Base Elmendorf - Richardson
LED	light emitting diode
m	meter
mbps	megabyte per second
n =	number
NOAA	National Oceanic & Atmospheric Administration
N_d	DIDSON count for all species of salmon recorded daily
N_s	DIDSON total seasonal count for all species of salmon
NMFS	National Marine Fisheries Service
PCEs	Primary Constituent Elements
P_d	daily proportion of salmon species caught in fish wheel
P_s	seasonal proportion of salmon species caught in fish wheel
SD	secure digital
S_d	daily number of salmon species caught by the fish wheel
S_s	total season's number of salmon species caught by the fish wheel
T_d	total daily escapement of all salmon species
T_s	total season's escapement for each species

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ABSTRACT

The Eagle River salmon enumeration study, located on Joint Base Elmendorf-Richardson (JBER), began in 2012 and completed its fourth season in 2015. The 2015 study was conducted from May 12 to September 16, lasting 128 days in total. The entire span of the study was successful at estimating the run timing, relative abundance, and species composition of all Pacific salmon (*Onchorhyncus* spp.) native to Eagle River, Alaska. In total 12,755 salmon were estimated to have passed two long range, 300-m dual-frequency identification sonars (DIDSON) in 2015. This was the pilot year for using two synced DIDSON sonars to have a continuous view of the width of the river. Both daily and seasonal apportionment methods were used to describe the species abundance based on catch-apportioned fish caught in a fish wheel equipped with a digital video recording (DVR) camera system and a live box. In total, 217 salmon were captured in the fish wheel from its installation on June 18 to its removal on September 12. The seasonal apportionment method is likely more representative of the actual abundance of all species counted in Eagle River versus the daily apportionment method. Chinook salmon (*O. tshawytscha*) abundance using the daily apportioned method was 621 and the seasonal apportionment was 976. Sockeye salmon (*O. nerka*), abundance using the daily apportioned method was 1,606 and the seasonal apportionment was 1,882. Chum (*O. keta*) abundance using the daily apportioned method was 3,227 and the seasonal apportionment was 3,833. Pink salmon (*O. gorbuscha*) abundance using the daily apportioned method was 2,902 and the seasonal apportionment was 3,276. Coho salmon (*O. kisutch*) abundance from the daily apportioned method was 1,905 and the seasonal apportionment was 2,858. Chum were found to be the most prolific salmon in Eagle River. However, due to low end-of-season river flow and height, the fish wheel was unable to catch fish consistently throughout the day, and so the end-of-season run timing (mid-August through September) is incomplete for the 2015 season.

INTRODUCTION

Establishing a baseline for salmon escapement and run timing in Eagle River is an important component to understanding the presence and abundance of beluga whales (*Delphinapterus leucas)* at the mouth of Eagle River. In 2008, National Marine Fisheries Service (NMFS) listed the Cook Inlet beluga whale as endangered (NMFS 2008). Beluga whales are predatory in nature and follow eulachon (*Thaleichtys pacificus)* into the Upper Cook Inlet during the spring, then switch to consuming salmon (*Oncorhynchus* spp.) as the eulachon numbers decline (NMFS 2009). When the Cook Inlet beluga whale was listed as endangered, four out of the five species of Pacific salmon – Chinook (*Oncorhynchus tshawytscha*), sockeye (*Oncorhynchus nerka*), chum (*Oncorhynchus keta*), and coho (*Oncorhynchus kisutch*) – were considered as primary constituent elements (PCEs) (U.S. Army Corps of Engineers, Alaska District [USACE] 2013). As PCEs, these fish are considered necessary for the recovery of the Cook Inlet beluga whale (USACE 2013).

On April 11, 2011, the final ruling to designate critical habitat for the Cook Inlet beluga whale was announced (NMFS 2011), with all of the upper Cook Inlet, including the Knik Arm, designated as critical habitat. Joint Base Elmendorf-Richardson (JBER) property is adjacent to the Knik Arm, but no portion of JBER property is listed as critical habitat. The Endangered Species Act (ESA) Section 4(a)(3)(B)(i) states "*…Secretary shall not designate as critical habitat any lands or other geographical areas owned or controlled by the Department of Defense, or designated for its use, that are subject to an integrated natural resources management plan prepared under section 670a of this title…*". JBER's Integrated Natural Resources Management Plan (INRMP) outlines monitoring of anadromous waterways on JBER.

In 2011, HDR Inc. was awarded a contract to design and implement a salmon monitoring project in Eagle River (USACE 2013). The pilot season was conducted during the summer of 2012 when dual-frequency identification sonar (DIDSON) and a fish wheel with videography were deployed in Eagle River. In 2013, the DIDSON and fish wheel were operated by JBER personnel. In 2014 and 2015, the DIDSON and fish wheel was deployed with the help of MWH Americas Inc, Anchorage, AK office.

In 2015, two DIDSON sonars were implemented simultaneously by means of syncing them via DIDSON top-side software to achieve a continuous view of the sampling area. This methodology allowed for a more complete enumeration of the fish travelling upstream within the Eagle River.

OBJECTIVE

The primary goal of this project is to establish a baseline enumeration of adult salmon returning to Eagle River and describe Pacific salmon species composition, run timing, and relative run strength using DIDSON sonars and a fish wheel. A secondary goal of this project is to determine if there is a correlation between the timing of the Cook Inlet belugas in Eagle Bay and salmon entering Eagle River.

STUDY SITE

Eagle River is a glacially fed river approximately 15 miles north of Anchorage, Alaska, where the lower nine river miles flow through JBER property. The last four river miles are located within the Eagle River Flats Impact Area (Figure 1). The fish wheel and DIDSON locations are approximately four river miles up from the mouth of Eagle River (Figure 2).

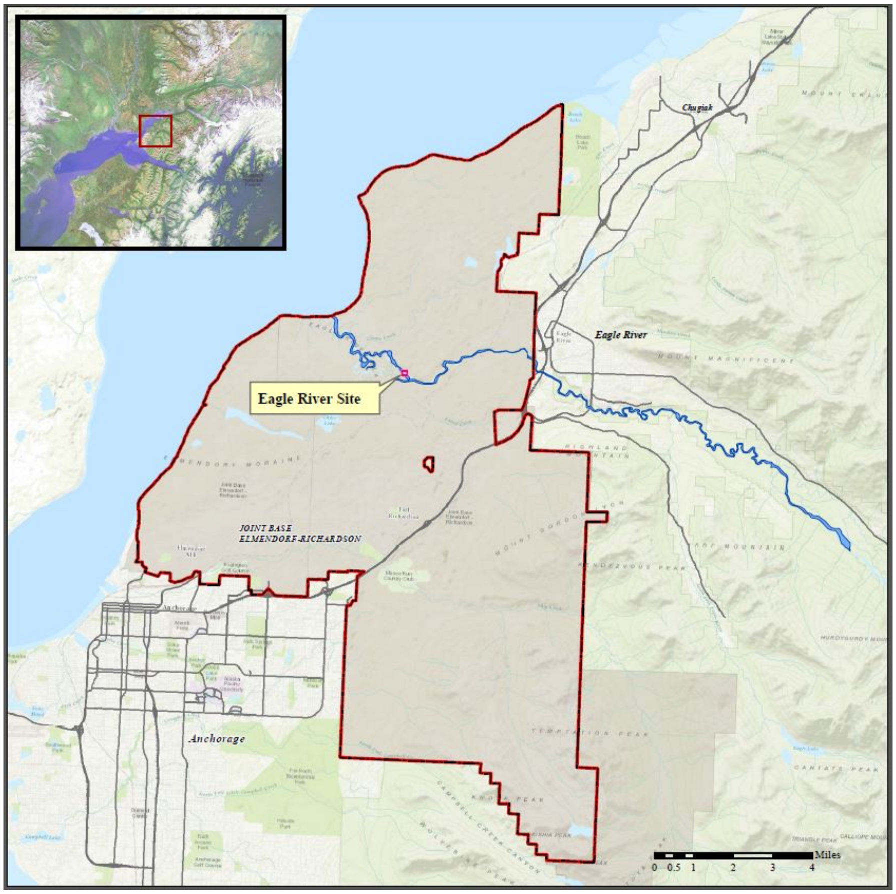

Figure 1. Location of Eagle River and JBER relative to Anchorage, AK, and Knik Arm.

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

The DIDSON system was deployed from the left river bank, approximately 500 m upstream of the Eagle River Flats Impact Area boundary and immediately downstream of the boat take-out. This site was selected because it has a single channel, wedged-shaped river cross section that matched the shape of the sonar beam, had a uniform slope without deep depressions or boulders that can create blind spots, has ease of access, and is within a reasonable distance of the suitable site for the operation of the fish wheel (USACE 2013). The DIDSON system does not allow for accurate differentiation of species alone; therefore, a fish wheel operating concurrently was deployed to associate species and run timing with the DIDSON data collection. The fish wheel was deployed approximately 100 m downstream from the DIDSON, also on the left bank (Figure 2).

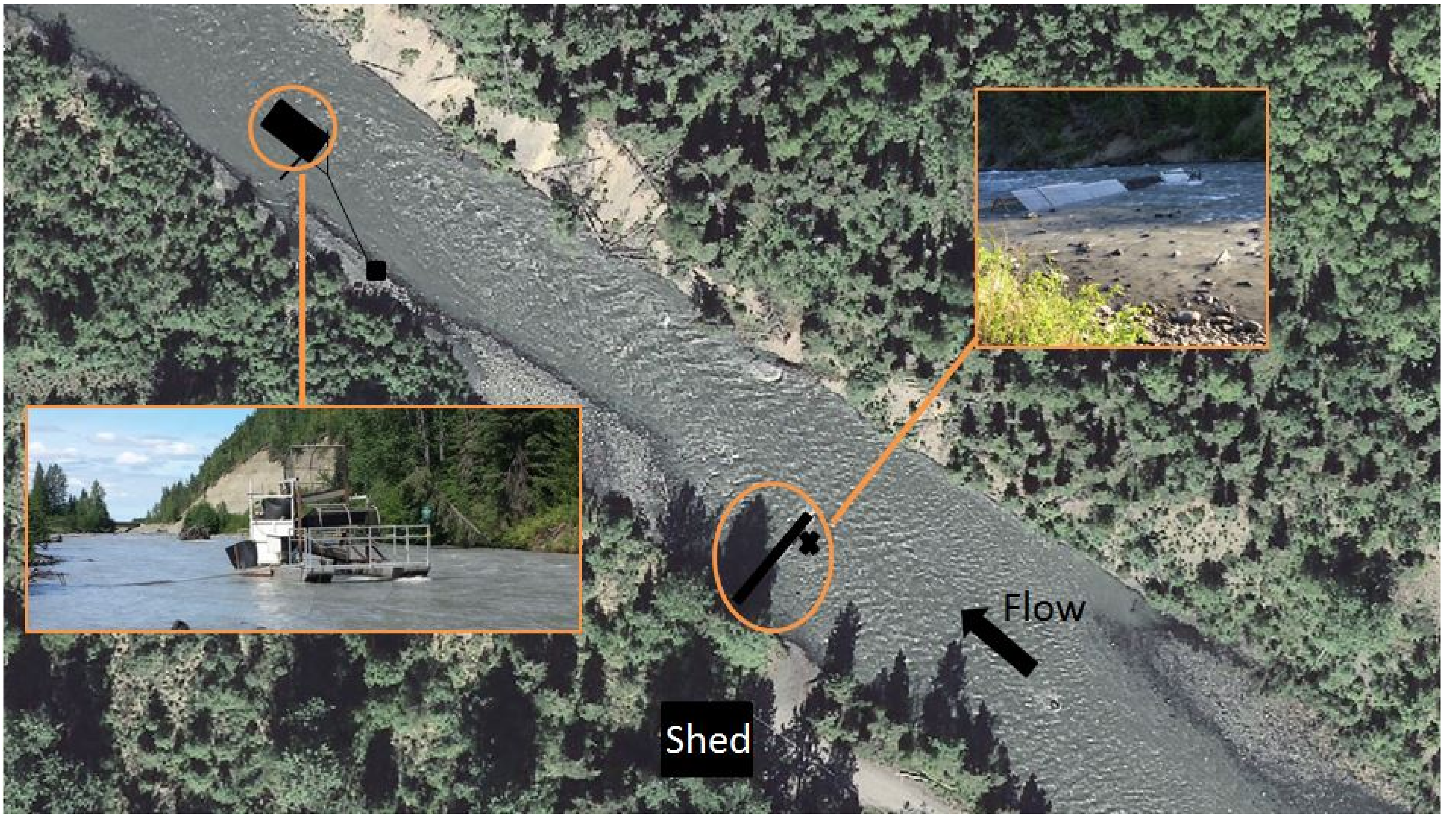

Figure 2. Location of the 2015 Eagle River adult salmon monitoring equipment.

METHODS

DIDSON Deployment

Two long range, model 300 DIDSON sonars were used to passively sample moving salmon. A DIDSON is an acoustic sonar that uses a transducer that emits 48 acoustic beams in a wedge-shaped array forming a field of view 29° wide by 14° tall that can reach 60 m (Sound Metrics Corp 2008).

The first DIDSON was installed on May 12, 2015, at 1415 aimed toward the right bank perpendicular to the river current, measuring 10 m. A modular A-frame type picket weir was installed approximately one meter downriver and extended approximately one meter past the DIDSON toward the right bank to ensure that fish passed through the ensonified area and were detectable. On June 6, 2015, at 1200, the second DIDSON was installed and the two sonars were synced to view a total of 30 m (one sonar viewing 0-20 m and the other 20-30 m) and created 15 minute increment files. Once the water levels began to rise, the sonars were moved closer to river bank left to ensure quick and safe removal of equipment when needed.

The DIDSONs were placed in silt exclusion boxes mounted to a metal-framed tripod placed perpendicular to the river flow. The tripod frame allowed for manual adjustments in the horizontal and vertical angle of the DIDSONs' "view". The DIDSONs' aim was adjusted so that the river bottom and surface could be seen in the display. The sonars were attached to the tripod via a stainless steel plate with two threaded rods attached to it. The sonars then had their own stainless steel plates attached to the tops of the silt boxes that had attachments in which the threaded rods could be placed through and tightened with hex nuts (Figure 3). Both sonars were attached to the same tilt adjustment plate, which caused both sonars to have the same viewing angle or tilt. A 3° concentrator lens was used to help optimize the DIDSON transducer to the river's profile (USACE 2013).

Figure 3. (a) Plate and rod system used for installing the two sonars to the tripod arm. (b) The sonars attached to the tripod arm via the plate and rod system. (1) Where the base of the arm attaches. (2) Where sonar one silt box is attached using 4 bolts. (3) Where sonar two silt box is attached using 4 bolts. (4) Threaded rod with hex nuts for sonars to hang from. Also allows for lateral motion of the sonars if needed for view or to minimize interference.

Specific components required for the DIDSON operation include the following:

- 2 DIDSON LR 300 units
- 2 silt exclusion boxes
- 2 concentrator lenses (3°)
- Data transmission cable (60 and 150 m)
- Tripod with dual sonar customized plate
- 2 DIDSON top side controller boxes with power and data connections
- Netgear 4 Port 10 Base 10-T 10 megabyte per second (mbps) Ethernet Hub
- 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

DIDSON Site Setup

On site, a wooden shed housed two computers and an eight terabyte external hard drive. The DIDSON viewer software (version 5.26) was installed on the first computer and was used solely to manipulate the DIDSONs' window lengths, frame rates, file durations, recording, and it sent the data to the external eight terabyte solid state hard drive. After the hardware was set up top-side and the sonars were placed in the water, they could be synced using the methods set forth by Sound Metrics Corp (see 'Sonar Syncing'). Once this was completed, the sonars would begin to record on a 15-minute increment within the hour. Every 15 minutes, each DIDSON would then create a new file, allowing for more manageable review.

Sonar Syncing

In order to record data from two sonars in close proximity to one another, they must be synced to minimize interference. Not only was interference minimized, but both sonars' data could be recorded to a single computer. The synced sonars were designated as a "controller" sonar (Sync Out) and a "follower" sonar (Sync In), making recording simultaneously with the same frame rate a seamless action. The use of a 60-m data transmission cable on one sonar and a 150-m data transmission cable on the second sonar, and their connection to one computer, necessitated the use of a 10-mbps Ethernet hub. This allowed the data transmission for both sonars on separate cables to connect to a single computer simultaneously and forced both transmissions to travel at 10 mbps (which was the necessary speed for the 150-m data transmission cable). Before the sonars could be synced, they needed to be designated as Sync Out and Sync In. The Sync Out sonar's top-side software was able to control the Sync In sonar's recording initiation and recording settings. It was also important to calculate the best frame rate for both sonars to keep interference at a minimum. Using too high of a frame rate can cause increased interference. Different settings are necessary due to the maximum frame rate for each sonar needing to be half of the achievable maximum frame rate for an equivalent single sonar of the longest range (Sound Metrics Corp, 2011). Therefore, if one sonar with a range of 30 m has a maximum frame rate of 4 frames per second (fps), then two sonars with a combined range of 30 m must split the 4 fps between the two of them, making each frame rate 2 fps. However, if one sonar is set to high frequency and the other sonar is set to low frequency, its maximum frame rate almost doubles. This allows for a faster frame rate for both of the sonars, although at the expense of half of the cross-range resolution of the low frequency sonar (Sound Metrics Corp 2011). For the purpose of this project, one sonar, the Sync Out sonar, was set at high frequency and the Sync In sonar was set to low frequency. This allowed them to both be able to record at 4 fps with minimal interference. Once the sonars were synced according to Sound Metrics Corp's (2011) methods for syncing sonars to a single computer, the view on each sonar was decided. The Sync Out sonar recorded from 0.48 to 20 m or the near view. The Sync In sonar recorded from 20 to 30 m or the far view.

DIDSON Data Analysis

A second computer was equipped with DIDSON viewer software (version 5.26) and was used to process and review the raw data files into Convolved Samples Over Threshold (CSOT) format. The raw files were copied from the Buffalo hard drive to an external hard drive and then put onto the second computer for CSOT processing. The CSOT program used the raw data files and wrote a new file that contained only files that showed motion (USACE 2013).

All files were reviewed in video mode, and each observed fish was marked and manually measured using the software. Upstream and downstream moving fish were counted while holding fish and those that moved horizontally through the river profile were not counted. Upstream fish were defined as those that travelled visibly upstream and did so before the end of the DIDSON file. Holding fish were carefully observed between files and subsequently counted only if they travelled upstream or downstream. By marking and measuring fish, a Fish Count file was generated with information such as date, time, range, length, and direction of travel (upstream or downstream). Once the file reviewing was completed, the Fish Count file was merged into a Microsoft Excel worksheet with the redundant header removed (USACE 2013). Direction of travel of each fish was noted in the Excel worksheet; "+1" designating a fish traveling upstream and "-1" for fish traveling downstream.

As part of the quality control process, dates with the greatest fish passage (200+ fish) were reviewed for a second time by staff. The quality-controlled counts were then compared to the original counts. Any difference between the two counts were reviewed for a third time and then added to the final count for the corresponding day.

2015 Fish Wheel Deployment

DIDSONs are unable to differentiate fish species; therefore, a fish wheel is used in conjunction with the DIDSON to understand the species apportionment. Fish wheels are another passive sampling techniques that captures fish by scooping the fish out of the water and sliding them into a live box (Hubert et al. 2012). The fish wheel operated using the force of the river against the fish baskets, which caused the wheel to rotate, capturing fish by scooping them out of the water. Fish slid into either a live box or a video-recorded chute that allowed the fish to return to the river without being handled. The fish wheel was located approximately 110-m downriver from the DIDSON on the river bank left. The site does not have any trees that could be used to secure the fish wheel, so a 4 feet (ft) by 4 ft gabion was constructed, filled with local river rock, and placed above the ordinary high water mark.

The fish wheel consisted of the following components (Figure 4):

- Fish wheel (2 aluminum pontoons, 3 baskets (6 ft by 6 ft), pulley-mounted vertically adjustable axle and sprocket assembly, and railings)
- Video chute (wood and rubber fish delivery system)
- Recording digital video system (GoPro Hero 3+, 128 gigabyte (GB) secure digital (SD) cards, GoPro battery eliminators with DC battery attachments, pelican case to house GoPro and prevent moisture buildup, security camera, digital video recorder (DVR), light-emitting diode (LED) Light, Inverter, and two deep-cycle 100 ampere hour CAh) batteries)
- Electronics enclosure
- Wooden live box
- Deployment system (spar poles, rebar, cables, ropes, and hardware)

The attached live box was operated only while personnel were on site. The digital video recorder and cameras were used to reduce unnecessary handling and holding of fish. Video was recorded of the fish as it slid through the primary chute prior to it being redirected to the river through the secondary chute, which consisted of ¼ inch-thick rubber sheeting, allowing the fish to bypass the live box.

2015 Fish Wheel Data Collection and Analysis

The fish wheel remained in one position throughout the 2015 season, although it was moved laterally as flow fluctuated to maintain adequate depth and current to rotate the baskets. The live box was operated during the day when technicians were present, typically between 9 a.m. and 4 p.m., and was checked at minimum twice daily for fish. Fish were identified by species and an axillary fin clip (n=100 per species) was collected for genetic analysis by the Alaska Department of Fish and Game (ADF&G). The fish were then released promptly back into the river. During the evenings, the secondary rubber chute was put in place, the GoPro and digital video recorder were set to record, a timer was set for the LED light to be turned on during dark hours and any fish caught in the fish wheel were released immediately back into the river.

Personnel reviewed the video recording daily to identify fish that were captured and released while personnel were not on site. Due to the large size of the GoPro videos and the many hours of video to examine each day, the DVR recordings were reviewed first at four times the normal speed to observe evidence of fish. The DVR image was not sharp enough to identify fish species, so when a fish was observed, the time was noted and personnel would find the fish at the noted time on the GoPro video. The GoPro image was much sharper and allowed for easier identification of the passing fish. Fish that were easily identifiable were recorded by species and fish less easily distinguished were recorded as unknown. The unknown fish from the GoPro and video recorder were omitted from the seasonal apportionment method.

Figure 4. Photograph of the fish wheel equipped with the digital video system operating in the Eagle River.

2015 Species Proportion Estimates

The techniques for species apportionment were developed from the data collected during the 2012 season (USACE 2013). The 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 it is limited because of low capture success of the fish wheel. Fish wheels are known to be biased in selecting different fish species and the size of the fish (Meehan 1961, ADF&G 1983, and Willette et al. 2015[1]). 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 this sample site.

The total daily escapement for each species (T_d) was estimated by multiplying the total daily DIDSON 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.

$$\boldsymbol{T_d = P_d\ (N_d)}$$

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).

$$\boldsymbol{P_d = S_d\ /\ N_d}$$

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).

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

[1] Currently in draft.

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 ≤ 5% of the salmon counted by the DIDSON).

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

$$T_s = P_s (N_s)$$

Where P_s 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).

$$P_s = S_s/N_s$$

Fish Wheel Catch Comparisons

The 2015 field season will be the final season for fish wheel deployment, under advisement from ADF&G. The deployment of the fish wheel will remain suspended until further evidence is compiled verifying that fish wheels are effective tools for apportionment. A comparative assessment of fish catch, by species, for all fish wheel seasons was compiled and graphed.

RESULTS

The DIDSON fish monitoring operation was conducted over 128 days from May 12 to September 16. The DIDSONs were deployed for a total of 110 days over the study period, an 87% deployment rate. From May 12 until May 20, the river stage was low enough to be 10 m from the right bank. Only one sonar was deployed during this time and 10 m were viewed on the sonar. On May 20, the range of view was altered to 2.5 m to 12.5 m from the sonar. This change was made in order to create a better view of the right bank and thus the deeper channel. This did not include the first 2.5 m in front of the sonar lens. On May 24, the sonar needed to be placed closer to the left bank due to rising water levels and swifter currents. It was placed 20 m from the right bank and was recording the 0-20 m range. The image was not optimal; however, fish were still visible for counting (18 fish were counted during this time). After the first high water event which began on May 31 and ended on June 6, the second sonar was deployed with the first one. From June 6 until June 16, various ranges were used during the initial deployment of the two sonars in order to achieve the best view and record the entire width of the river. On June 16, the sonars were 30 m from the right bank and recorded 0-20 m and 20-30 m.

There were two occasions of high water events, May 31 through June 6 and August 19 through August 20. These two events totaled to 171.3 hours, or 7.1 days, of un-sampled time. The first high water event had a peak river height of 2.1 ft at the Eagle River on-site staff gauge (Figure 5). The second high water event reached a peak river height of 2.9 ft (Figure 5). There were other disruptions to sampling time such as software issues (73 hours), power outages (16.6 hours), technical troubleshooting (9.4 hours), and sonar maintenance (4.2 hours). These disruptions usually consisted of the sonars being powered down for only short periods of time during the day, and they were usually left in the water during the disruption (except during sonar maintenance). DIDSON software issues made up the majority of the disruptions (8 separate occurrences). Syncing the two sonars caused more data to be running on the single computer. Any pop-up windows or extra data usage caused the DIDSON software to malfunction. Other software malfunctions were brought to Sound Metrics Corp.'s attention for troubleshooting and possible future repairs. The DIDSON operations ended on September 16, 2015, when the number of observed fish declined dramatically and access to the site was not feasible due to military training.

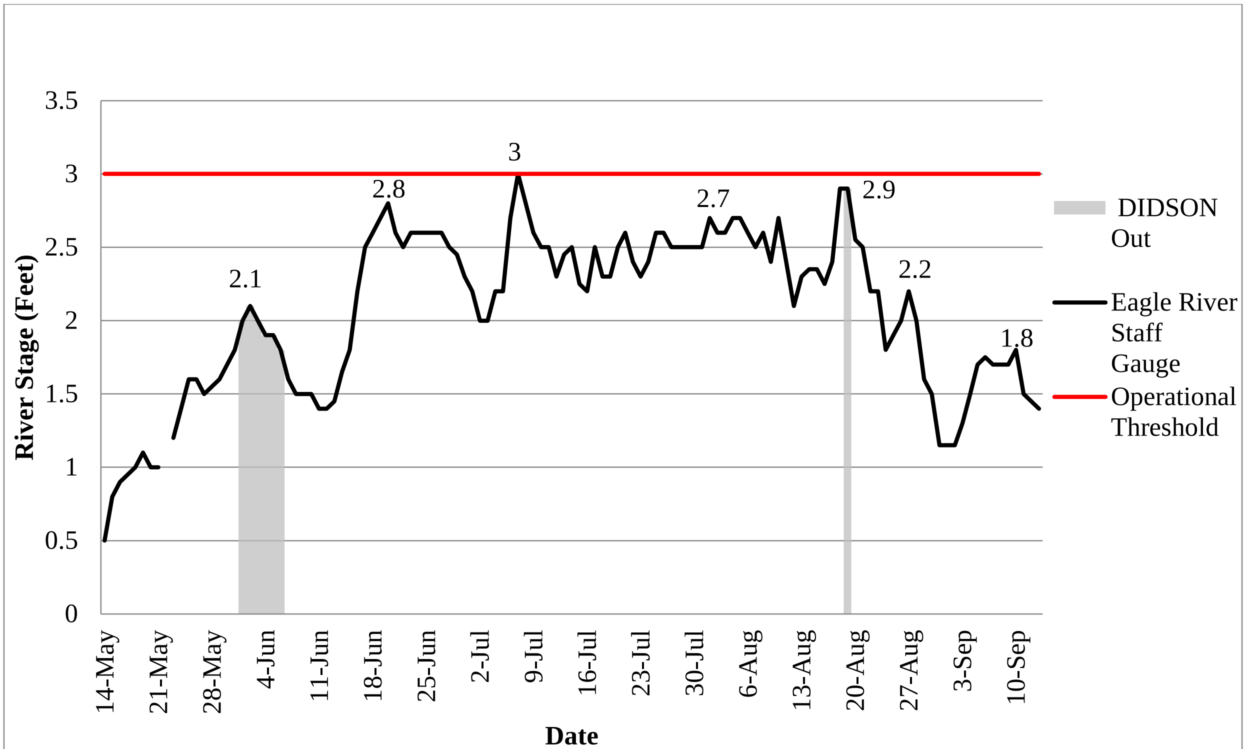

Figure 5. Daily staff gauge river height at the Eagle River site and operational threshold. Grey bars show when the DIDSON was removed due to high water events. (The NOAA hydrograph was skewed due to highway construction creating deeper pools). Also, a red line at 3.0 ft shows the operation threshold for safety.

CSOT processing was utilized for data review beginning on May 12. However, beginning on June 17, CSOT processing was no longer completed due to a sensitivity issue with the interference. Many fish were not being formatted into new CSOT files. Complete raw data for both sonars was reviewed from this point forward.

Starting May 12 to May 31, 25 fish passed the sonar during the time it was recording only the furthest 10-20 m. From June 6 until the end of the season, when both sonars were returned to the water, 96% of the fish (12,222) travelled in the near field (0 to 20 m from sonar) and 4% of the fish (508) travelled in the far field (20-30 m from the sonar). The use of two sonars with a continuous view, along with reviewing the raw data, produced a high level of confidence in the fish totals for the season.

Fish Passage

On May 19, 2015, the DIDSON recorded the first salmon. During the month of May, only 25 fish were recorded by the DIDSON, with an average of 1.25 per day and a peak number of fish seen in any one day was 7 fish on May 30. June saw a comparative increase as 498 fish passed the DIDSON, with a daily average of 16.6 fish per day and a peak occurring on June 17 with 54 fish. The average daily passage rate for July was 173.23 fish per day, with a total of 5,370 fish passing the DIDSON during the month. A peak occurred on July 31 with 563 fish passing the DIDSON. The large push of fish began on July 23 with 414 fish passing the sonar and steadily increased into the first half of August. The month of August saw the largest number of salmon pass the DIDSON, with a total of 6,491 fish for the month, an average of 209.39 per day and a peak occurring on August 2 with 598 fish passing in a single day. The month of September, which was only sampled for 16 days, saw a decline in fish passage, with a total of only 371 fish, a daily average of 23.19 fish and the peak occurring on the 1st with 40 fish. A total of 12,755 salmon were recorded by the DIDSON during 2015, with another 367 observed travelling downstream. Figure 6 shows the upstream DIDSON fish counts for the entire season.

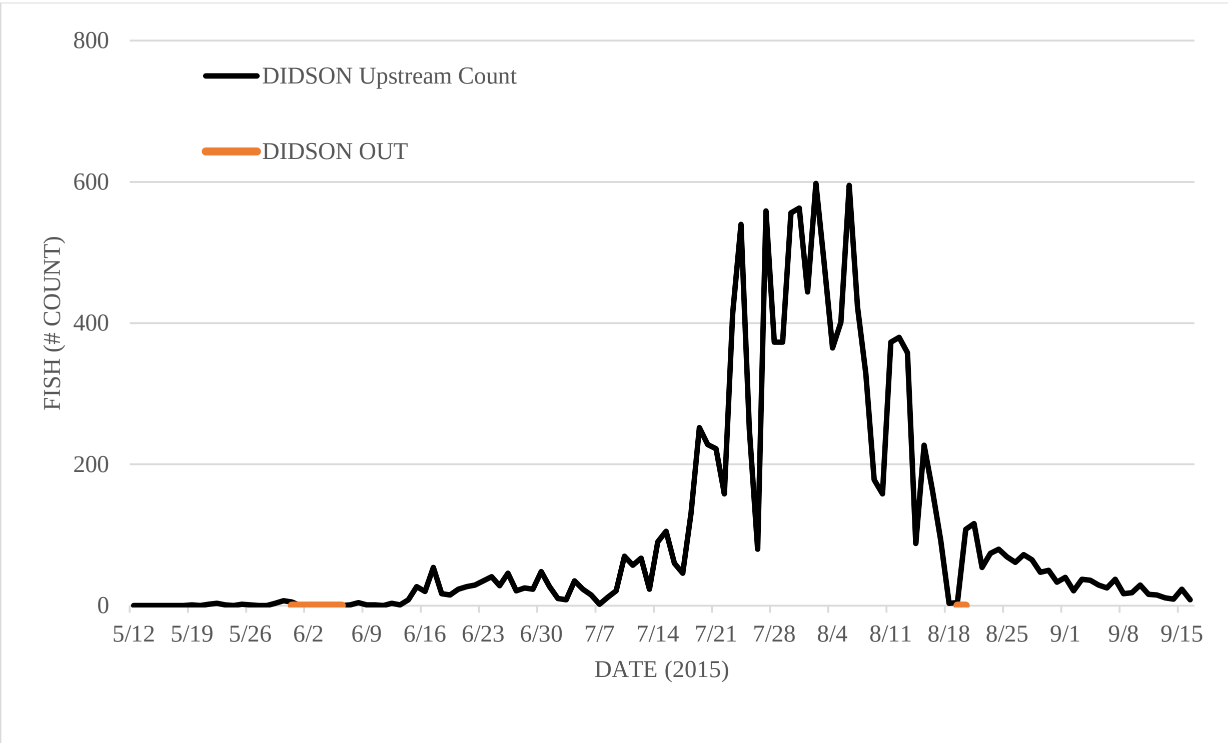

Figure 6. Eagle River DIDSON 2015 upstream count.

Between the period of May 12 and July 24, only 25% of the salmon had migrated past the DIDSON. On August 1, approximately 50% of the salmon had passed, and by August 16, a total of 90% of the 2015 salmon run was completed (Figure 7). Peak daily salmon passage occurred on August 2 at 598 salmon. Appendix A contains a table of the DIDSON sonar daily observed fish counts.

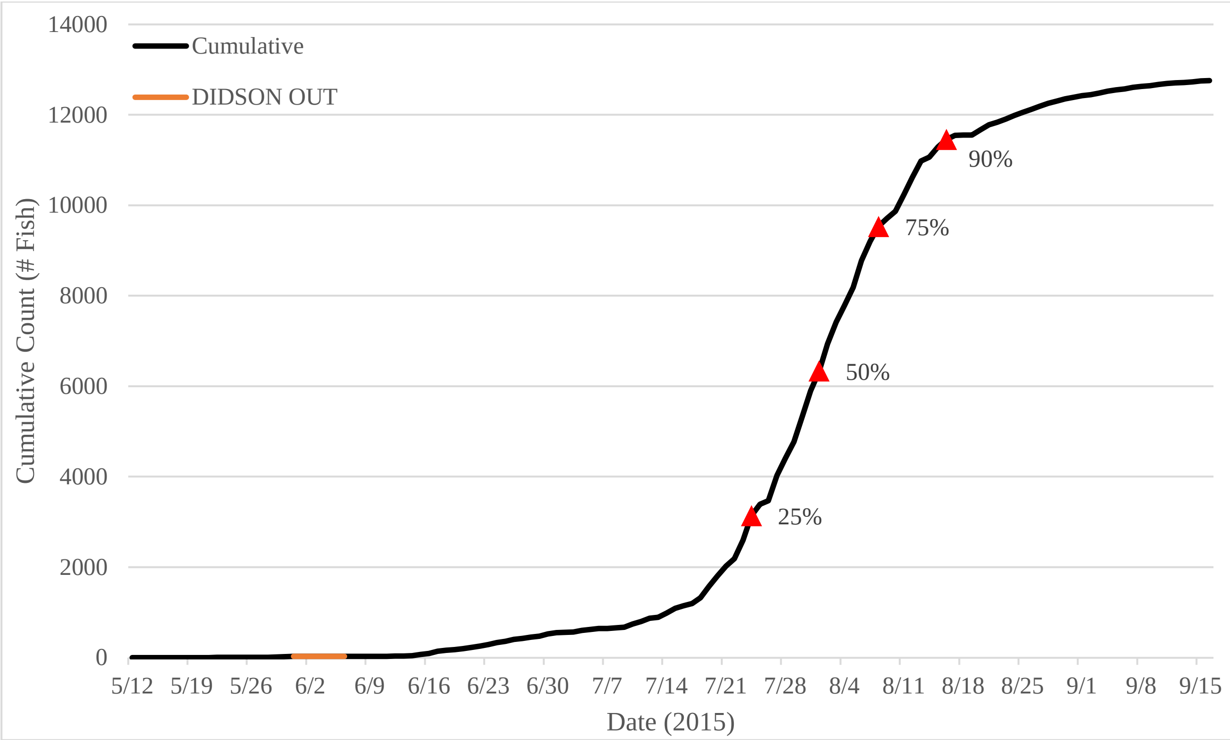

Figure 7. Cumulative daily salmon passage showing run complete percentiles for all fish recorded by the Eagle River DIDSON during 2015.

Diurnal Patterns

Diurnal movements of fish passage, the sums of observed fish count per hour, were examined in 2015. The entire DIDSON dataset was plotted against the 24 hours found in a day. As seen in Figure 8, 4 a.m. to 9 a.m. had the lowest passage rates. The highest passage rates occurred from 3 p.m. to 6 p.m., then decreased during the onset of morning.

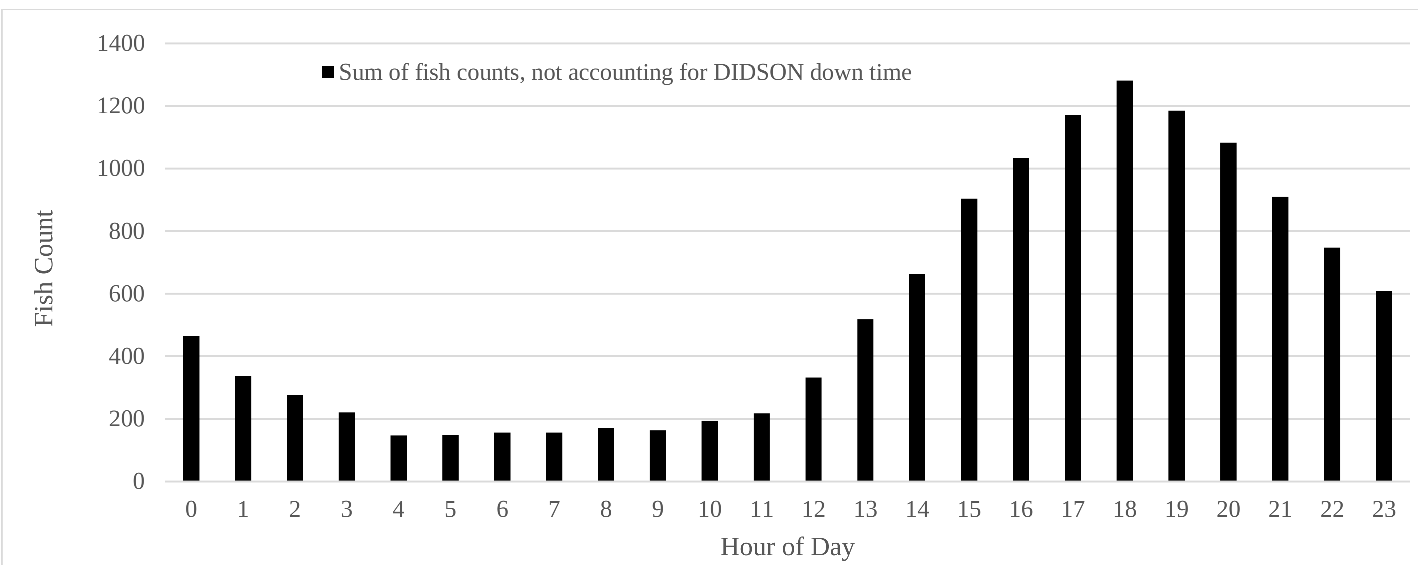

Figure 8. Diurnal pattern of fish passage by hour of day using the sum of expanded fish counts during the entire Eagle River data collection season (5/12 – 9/16) and not accounting for DIDSON down time.

Cross Channel Distribution

Figure 9 shows the range of distribution of fish as they moved up river. In the figure the first fish of the season, May 12 through May 24, appear to be in the "near" section. However, this is misleading because the water level was so low the DIDSON was placed in the middle of the river. That section is usually considered the "far" section of the river and equates to the 20-30 m range measured after June 6 of this season. On May 12 until May 20, 0-10 m from the sonar was measured. This equates to the 20-30 m range when compared to the dual sonar ranges (Figure 9, red). From May 20 until May 24, 2.5-12.5 m was measured as a way to be able to have a better view of the far bank, which equated to the 22.5-32.5 m range on the dual sonars (Figure 9, green). From May 24 until May 31, 0-20 m was measured, which equated to the 10-30 m range on the dual sonars (Figure 9, yellow). This change was made due to rising water and the need to move the sonar and weir closer to the left bank. On June 6, the two sonars were placed in the river measuring the entire 30 m in front of the sonar. Once both sonars were utilized, the near range (0-20 m from the sonar) indicated that more fish passed on river left than river right throughout the season. The distribution of the fish observed on dual sonar within the river averaged in the 0-3 m range (Figure 9). When the first 25 fish (measured with only one sonar) are removed from the total near count, 12,222 fish, or 96%, travelled in the 0-20 m (near) range and 508 fish, or 4%, travelled in the 20-30 m (far) range during dual sonar deployment. However, if the 25 fish from May 12th until May 31st during single sonar use were counted as far fish, the percentage remained at 4%.

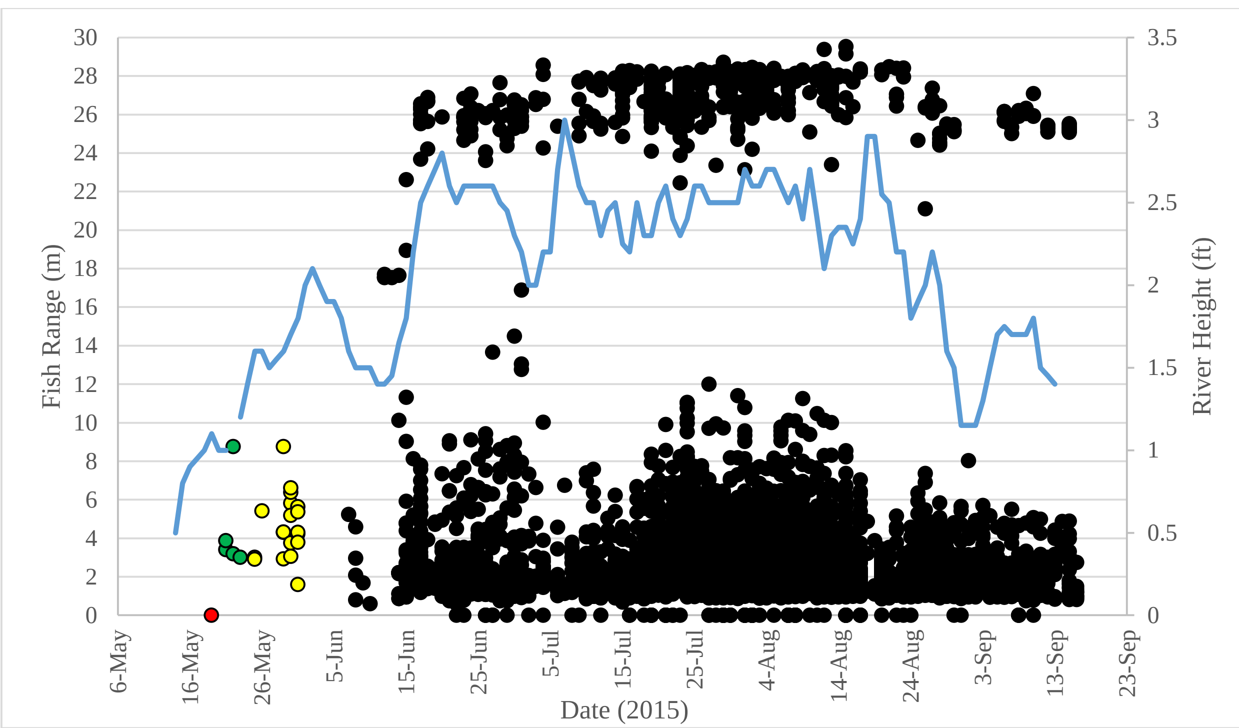

Figure 9. Range distribution over time of all fish recorded by the Eagle River DIDSON and river stage at the site during 2015.Red= measuring 0-10 m range from May 12 to May 20. Green=2.5-12.5 m range from May 20 to May 24. Yellow= measuring 0-20 m range from May 24 to May 31. Black = measuring 0-30 m range from June6 to September 16.

Species Abundance and Run Timing

The fish wheel began operating June 18, 2015, with the last day of operation September 12, 2015. During this 86-day period, the fish wheel operated and sampled 69.2 days with an 81% sampling rate. 16.6 days went un-sampled which was due to dropping river stage (216.4 hours), technical issues with the cameras or LED light

(166.7 hours), debris build-up (5 hours), and fish wheel maintenance (2 hours). The issue that most affected fish wheel sampling was low river stage. This low water level caused the current to slow and thus did not give the wheel enough momentum to spin the baskets. The technical issues were the second largest cause of non-sampled time. This was due to the new camera system and probable user error in the beginning. The cameras also would overheat at times and the SD cards would reach capacity before they could be changed.

A total of 217 salmon or 1.7% of the total 2015 salmon run estimated by DIDSON was captured by the fish wheel when it was operating. Of these, 26.0% (57 fish) were captured exclusively in the holding box, 74.0% (160 fish) were identified exclusively with the digital video system. Chum salmon was the most abundant species captured in the fish wheel, comprising 25.3% (55 fish) of the total catch. Pinks were the next abundant fish with 21.7% (47 fish) caught in the fish wheel. Coho salmon made up 18.9% (41 fish). While sockeye, made up only 12.4% (27 fish) of the fish caught in the fish wheel and Chinook made up 6.5% (14 fish) of the total catch. Finally, 15.2%, (33 fish) of the total fish caught in the fish wheel were not identifiable to species. These unidentifiable, unknown fish were omitted during seasonal apportionment and from the daily apportionment (unknown fish were used to calculate daily apportionment, but their apportionment was not documented). Table 1 summarizes the number of each species captured by the fish wheel and the method used to identify the species. Figure 10 shows the daily fish wheel catch by species related to the DIDSON daily upstream fish count. Table 2 shows abundance by species estimated for both daily apportioned and seasonal apportioned salmon. 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		
Chinook	5	9	14	6.5%
Sockeye	8	19	27	12.4%
Pink	21	26	47	21.7%
Chum	12	43	55	25.3%
Coho	11	30	41	18.9%
Unknown	0	33	33	15.2%
	57	160	217	
Total	26%	74%		

Table 2. 2015 Daily and Seasonal Apportionments

Species	Daily Apportionment		Seasonal Apportionment	
Chinook	621	5.1%	976	7.7%
Sockeye	1606	13.2%	1882	14.8%
Chum	3227	26.6%	3833	30.1%
Pink	2902	23.9%	3276	25.7%
Coho	1905	15.7%	2858	22.4%
Unknown[2]	1890	15.6%		

[2] Unknown counts for daily apportionment were included to demonstrate how daily apportionments accounted for unknown and unidentifiable fish. The total does not equate to 12,755 (total fish observed on sonar) due to times when no fish were caught in the fish wheel for more than 2 days. Unknown fish were excluded from seasonal apportionment, however.

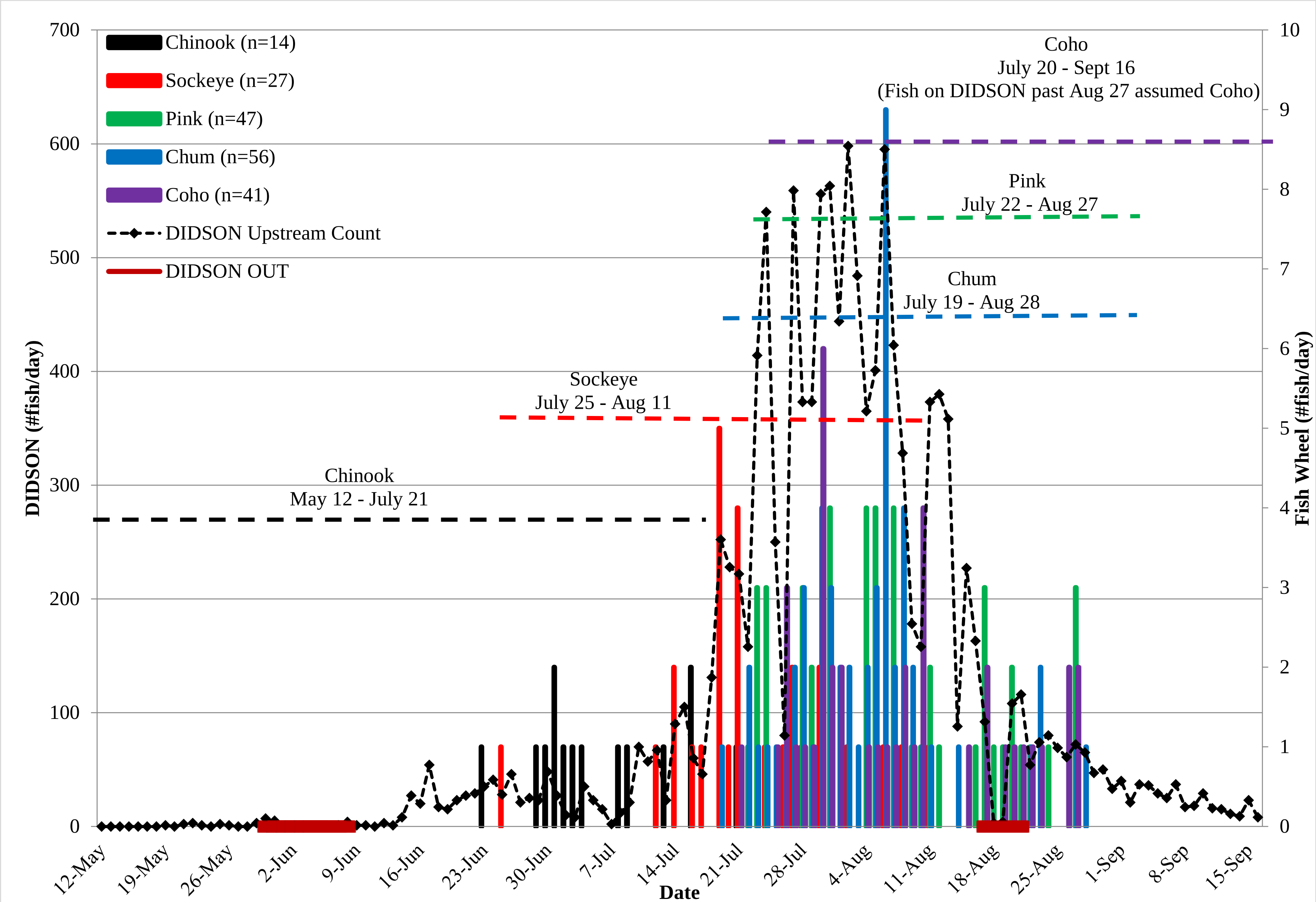

Figure 10. Daily DIDSON upstream count (n=12,755) and fish wheel catch (n=184) by species (Unknown species not included). Sonar was completely removed for a total of 7 days.

Chinook salmon

With the use of the DIDSON and the fish wheel, a daily apportionment estimate of 621 Chinook or 5.1% of the daily apportioned salmon (4.9% of the total DIDSON salmon run count) run occurred in 2015. When the seasonal apportionment method was applied, an estimate of 976 or 7.7% of the total salmon (excluding unknowns) run were Chinook (Table 2). The first Chinook observed on the DIDSON was on May 19, while the first Chinook was caught in the fish wheel on June 23. The fish wheel was not operating from May 12 to June 17 to reduce the stress on the Chinook. It can be inferred from previous years' data and knowledge that the only species of salmon in Eagle River during this time are Chinook salmon, that the fish observed on DIDSON during this time were assumed Chinook and apportioned as such. The DIDSON was not operating from May 31 to June 6 due to a high water event, therefore, the run timing may not be estimated correctly due to the lack of data during those six days. Chinook salmon were consistently captured by the fish wheel from June 23 through July 21. Out of the 217 salmon caught in the fish wheel, 14 of them were Chinook or 6.5% of the total fish wheel catch (Table 1). Figure 11 shows the Chinook salmon daily DIDSON count plotted with the daily fish wheel catch rate.

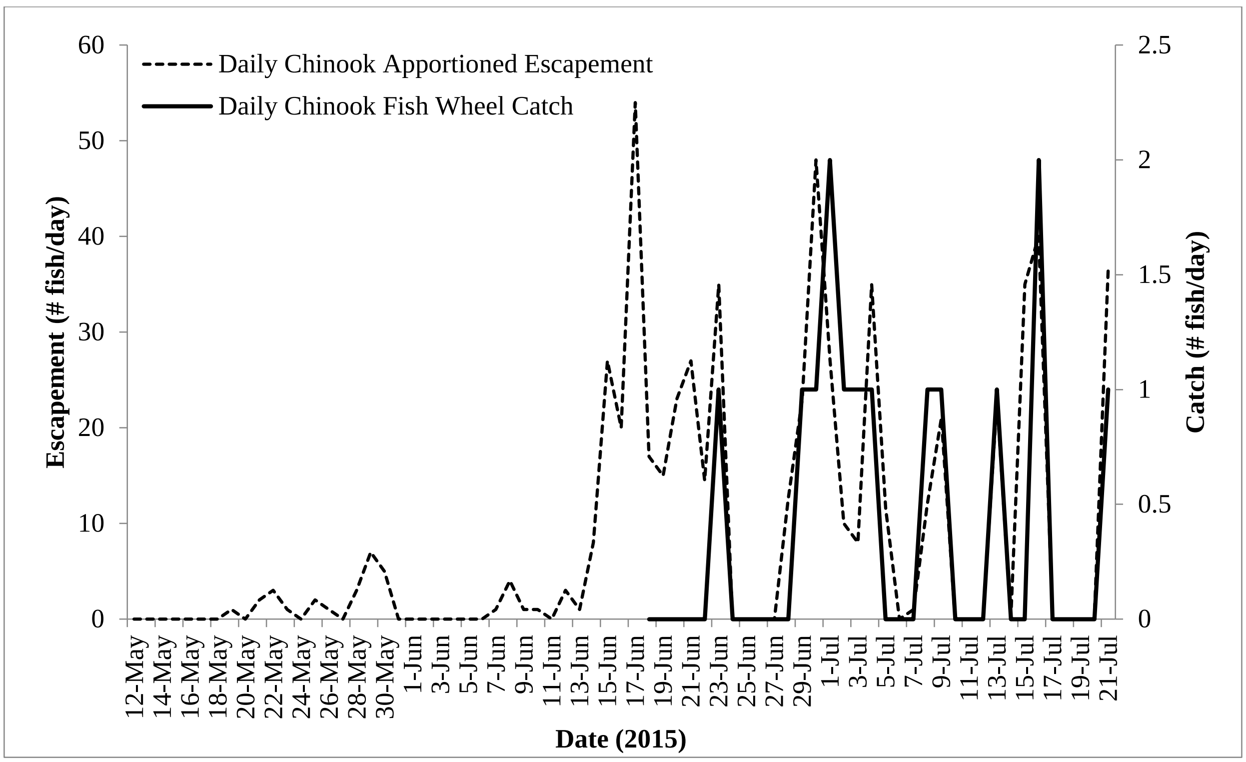

Figure 11. Chinook daily DIDSON passage estimate and fish wheel catch rate.

Sockeye salmon

With the use of the DIDSON and the fish wheel, a daily apportionment estimate of 1,606 sockeye or 13.2% of the total daily apportioned salmon run occurred in 2015. When the seasonal apportionment method was applied, an estimate of 1,882 or 14.8% of the total salmon run were sockeye (Table 2). The first sockeye was caught in the fish wheel on June 25 and the second was not caught until July 12. Sockeye salmon were then consistently captured by the fish wheel from July 12 through August 11. Out of the 217 salmon caught in the fish wheel, 27 of them were sockeye or 25.7% of the total fish wheel catch (Table 1). Figure 12 shows the sockeye salmon daily DIDSON count plotted with the daily fish wheel catch rate.

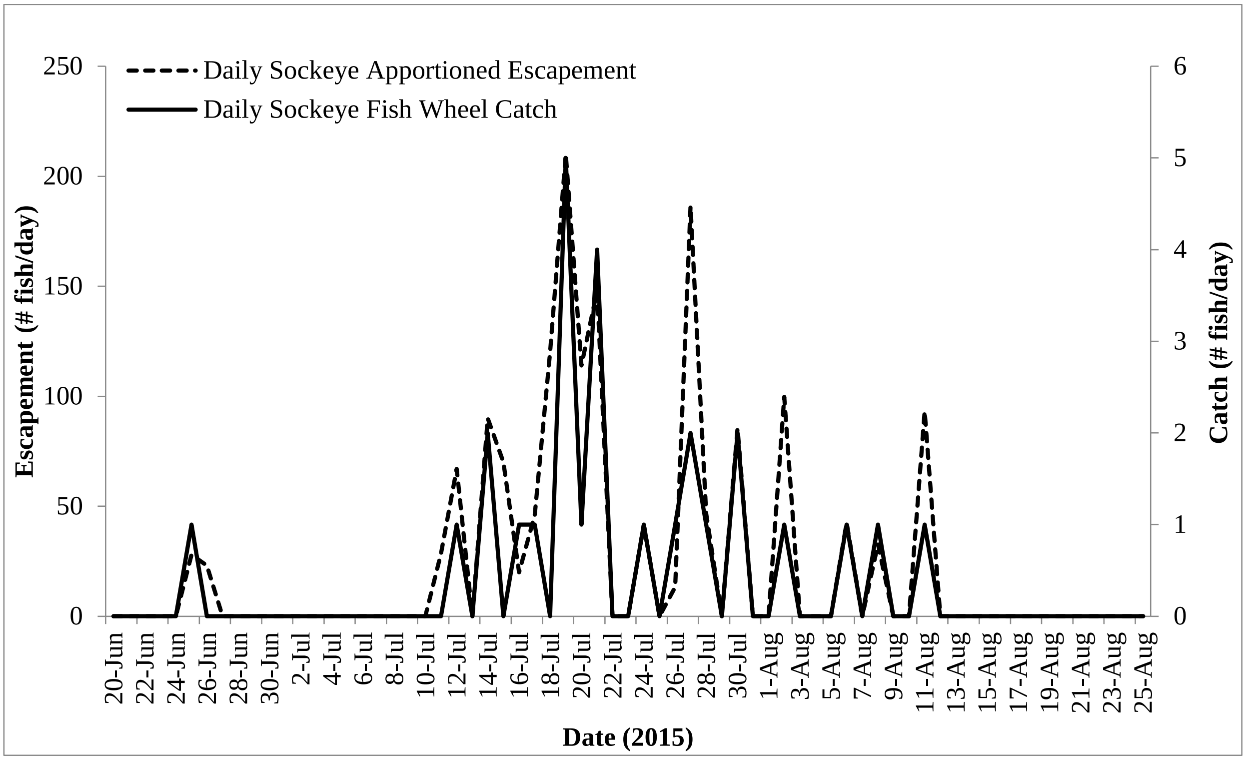

Figure 12. Sockeye daily DIDSON passage estimate and fish wheel catch rate.

Chum Salmon

With the use of the DIDSON and the fish wheel, a daily apportionment estimate of 3,227 chum or 26.6% of the total daily apportioned salmon run occurred in 2015. When the seasonal apportionment method was applied, an estimate of 3,833 or 30.1% of the total salmon run were chum (Table 2). The first chum was caught in the fish wheel on July 19. The DIDSON was not operating for 1.1 days from August 19 to August 20, which may have caused a slight underestimation of chum salmon during the decline of their run. Chum salmon were consistently captured by the fish wheel from July 19 through August 28. They were the last species of fish to be caught in the fish wheel. Out of the 217 salmon caught in the fish wheel, 55 of them were chum or 25.3% of the total fish wheel catch (Table 1). Figure 13 shows the chum salmon daily DIDSON count plotted with the daily fish wheel catch rate.

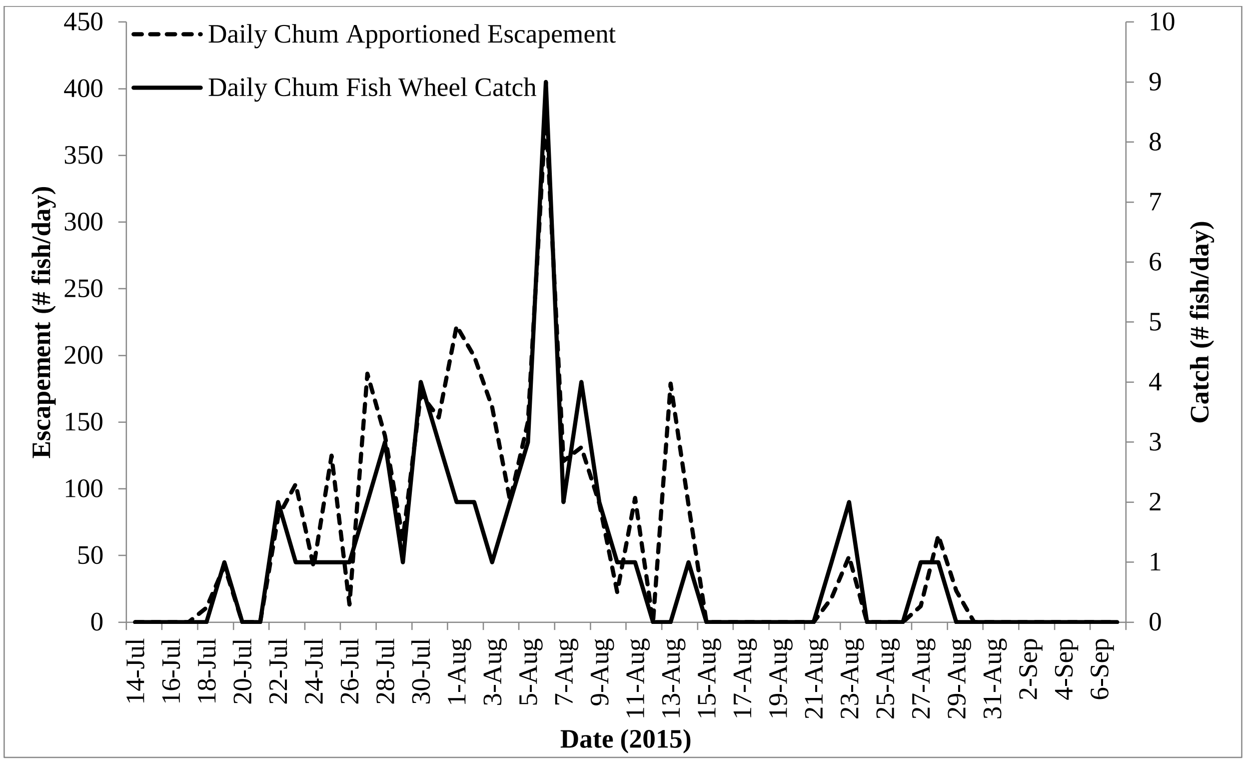

Figure 13. Chum daily DIDSON passage estimate and fish wheel catch rate.

Pink Salmon

With the use of the DIDSON and the fish wheel a daily apportionment estimate of 2,902 pink or 23.9% of the total daily apportioned salmon run occurred in 2015. When the seasonal apportionment method was applied, an estimate of 3,276 or 23.7% of the total salmon run were pink (Table 2). The first pink was caught in the fish wheel on July 22. The DIDSON was not operating for 1.1 days from August 19 to August 20 which may have caused a slight underestimation of pink salmon during the end of their run. Pink salmon were consistently captured by the fish wheel from July 22 through August 27. Out of the 217 salmon caught in the fish wheel, 47 of them were pink or 21.7% of the total fish wheel catch (Table 1). Figure 14 shows the pink salmon daily DIDSON count plotted with the daily fish wheel catch rate.

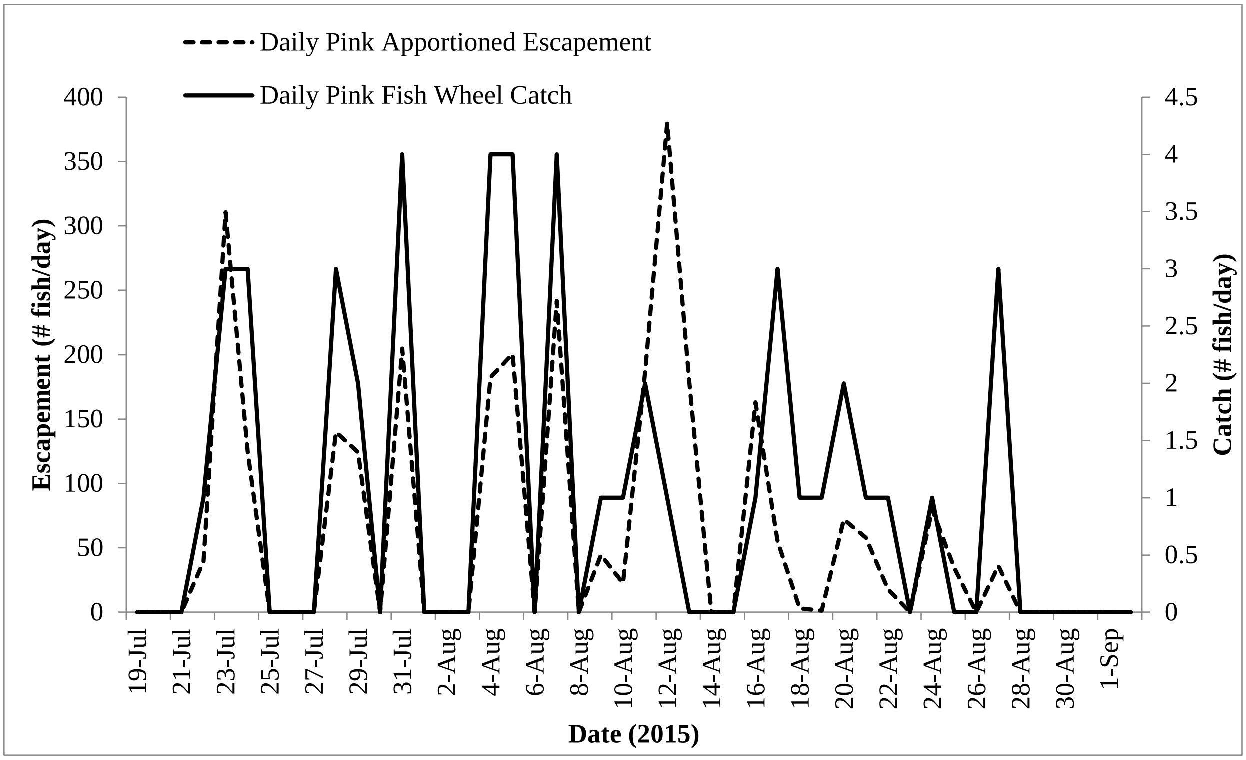

Figure 14. Pink daily DIDSON passage estimate and fish wheel catch rate.

Coho Salmon

With the use of the DIDSON and the fish wheel, a daily apportionment estimate of 1,905 coho or 15.7% of the total salmon run occurred in 2015. When the seasonal apportionment method was applied, an estimate of 2,858 or 22.4% of the total salmon run were coho (Table 2). This is probably underestimated because salmon were still being captured on the DIDSON moving up river on the last day of operation. The first coho was caught in the fish wheel on July 21. Coho salmon were consistently captured by the fish wheel from July 21 through August 27. Out of the 217 salmon caught in the fish wheel, 48 of them were coho or 35.8% of the total fish wheel catch (Table 1). Figure 15 shows the coho salmon daily DIDSON count plotted with the daily fish wheel catch rate.

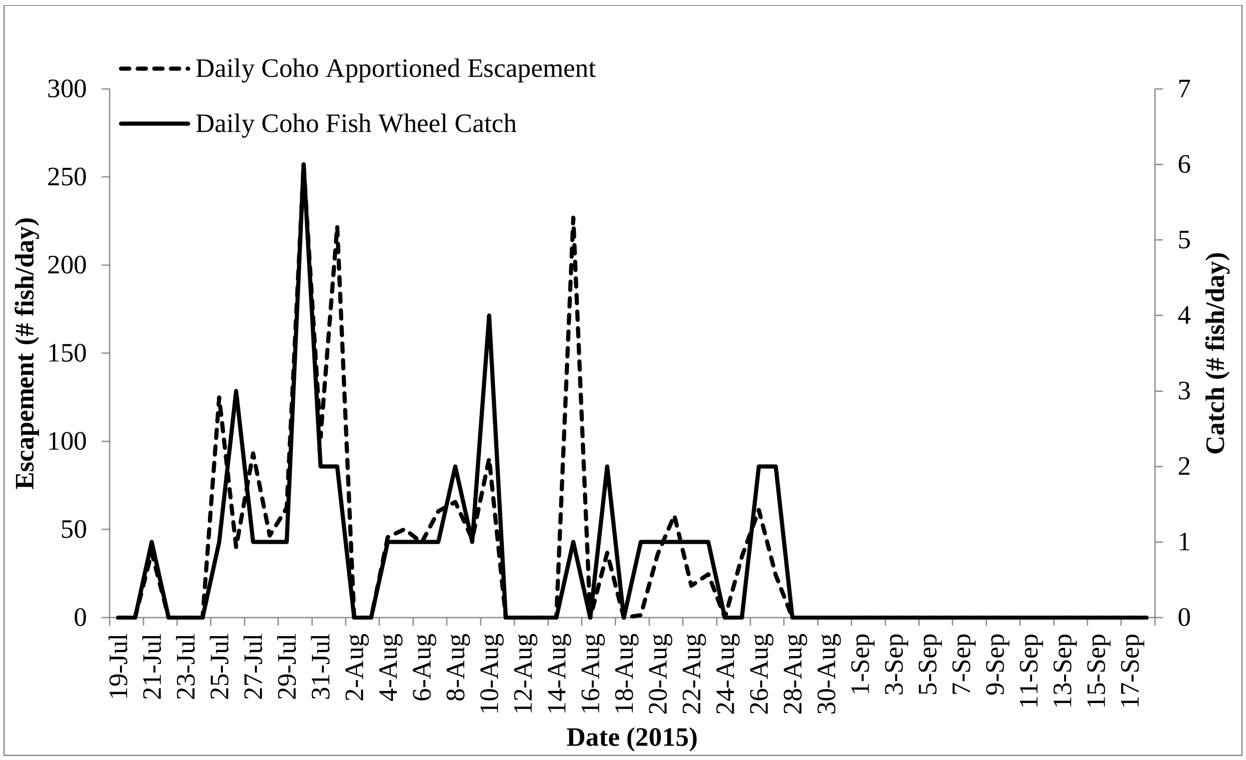

Figure 15. Coho daily DIDSON passage estimate and fish wheel catch rate.

DISCUSSION

Adult salmon enumeration in Eagle River is challenging and requires specialized in-river equipment and the proper selection of acoustic sampling techniques. Deployment of equipment is difficult because of high water velocities and substantial fluctuations in water levels. 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 were well established at the site. Coordination between military training and sampling was communicated daily, and all military training activities took precedence over fisheries sampling. There were only a few instances where the training took place during the day when field crews could not access the site. However, the site could be accessed in the early morning and late evening hours, before and after training exercises, to record data, conduct any essential maintenance, and shut down the equipment if necessary.

DIDSON Based Abundance Estimates

During the 2015 field season, the dual DIDSON setup was effective at enumerating adult salmon escapement in Eagle River. With the use of the DIDSON sonars, an estimate of 12,755 adult salmon passed upstream, which is the highest estimate currently recorded for this site. This estimation is considered to be fairly accurate due to an 87% deployment rate and the use of dual sonars in order to have a complete and constant view of the river. The use of the dual sonar system increased the fish totals because the counts were based on actual fish recorded instead of calculated assumptions, as completed in previous years.

The main limitations to the 2015 DIDSON data were the data gaps due to sonar removal and technical issues. The more common of the two were technical issues due to it being the pilot year of the dual sonar system and having to troubleshoot often. The most prevalent technical issue occurred when the top-side software stopped recording on both sonars due to anti-virus pop-ups on the main computer. Once the anti-virus program was removed, the software issue ceased. Regardless of the 13% of un-sampled periods, it is believed that the fish totals presented serve as a reasonable enumeration of the total salmon passing along this reach of Eagle River.

The largest sonar disruption, causing the sonar to be completely removed from the river due to high water, lasted for 6 days from May 31 to June 6. From previous years' data, it is thought that a portion of the beginning of the Chinook run was partially missed due to this disruption. It is unknown if any other species were travelling upstream during this time because the fish wheel was not deployed until June 18. The interruption was likely not long enough for a significant decrease in the Chinook count and the interruption also did not occur during the peak of the Chinook run. The dual sonar system did not begin until June 6, when both sonars had their silt boxes available for deployment. From May 12 until May 31, during the Chinook run, various ranges were recorded (as listed in the methods section). Once the dual sonars were deployed, 30 m of the river were continuously recorded. The end of the Chinook run and the entire sockeye, chum, pink and coho runs were assumed to have been completely observed using the dual sonar system.

The majority of the fish traveled in the 0-3 m range, which was close to the sonars. It is believed that due to the consistent high water threshold (Figure 16), these fish were concentrating in the shallowest, slowest moving water possible (USACE 2013), which was in the area at the end of the weir, right in front of the sonars.

The previously used NOAA hydrograph at the Glenn Highway Bridge, which was upstream approximately 7.75 km from the sample site, was altered due to construction of the new Eagle River Bridge at the site of the gauge and was thus unavailable for correlation to the on-site staff gauge or to estimate the possibility of high water events. However, a new NOAA gauge was installed by NOAA technicians on June 30 on Bravo Bridge. Bravo Bridge is located on JBER and is 0.58 km downstream from the sample site. The use of the Bravo Bridge gauge allowed for a correlation of the on-site staff gauge to the Bravo Bridge gauge (Figure 16). The data for the NOAA Bravo Bridge gauge is considered preliminary and could include errors due to malfunctions. It is also important to note that the NOAA Bravo Bridge gauge is tidally influenced.

Eagle River discharge is driven by high elevation snow and ice melt and/or periods of heavy rain. The trend throughout the summer months is an increasing river height caused by increasing ambient temperatures and ice melt as shown in Figure 5. The first steep increase can be seen at the end of May (Figure 16), which caused a six day disruption in data collection. On August 19, the NOAA Bravo Bridge gauge reached its peak of 6.26 ft while the site staff gauge read 2.9 ft on the same day. Figure 16 shows this increase in river height, and high amounts of large debris caused a one day disruption in data collection. The site staff gauge reached its highest measured point on July 7 with a reading of 3.0 ft. The NOAA Bravo Bridge gauge read 6.01 on the same day (Figure 16). The sonars were left in the river during this time with no disruptions to data collection.

It would be beneficial to continue to compare the site gauge reading to the NOAA Bravo Bridge gauge readings to be more informed about the conditions of the sonar site and to be able to make decisions if the sonars should be left in the river or removed.

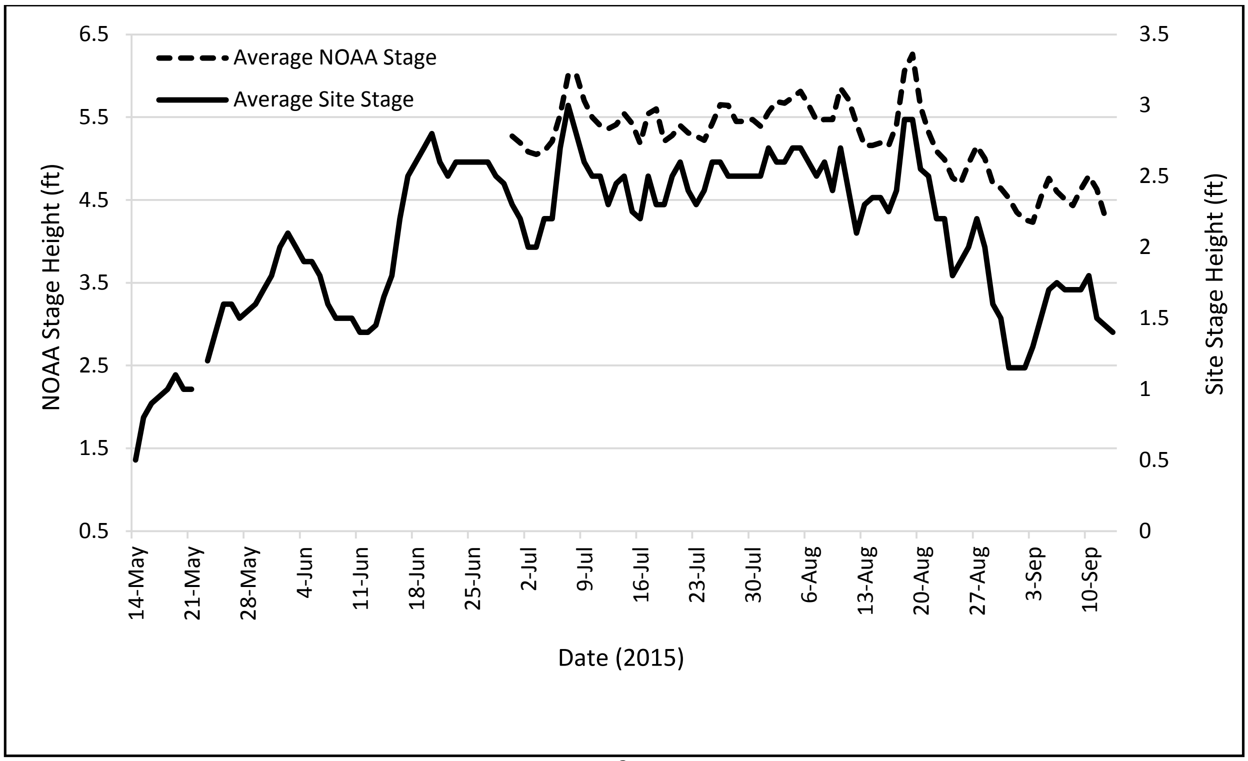

Figure 16. Comparison of Eagle River on-site staff gauge[3] and NOAA's Bravo Bridge staff.

Fish Wheel Based Abundance Estimates

Typically, the fish wheel is assembled in June with additional paddles attached to create more surface area to assist in spinning the baskets with a stronger effort. They are useful in allowing the baskets to spin even when a 30 pound fish enters a basket. In the 2015 field season, the fish wheel

[3] Sample location staff gauge readings were taken once a day in the morning at varying times and therefore are not daily averages.

was assembled and deployed on June 18 without these additional paddles. They were not used due to insufficient materials and also due to swifter river conditions. The baskets without the paddles were spinning at a satisfactory speed. Cables connecting the baskets were installed, which allowed each basket to pull the proceeding basket along.

The video image quality for overnight fish wheel operations was markedly better this field season compared to previous field seasons due to higher resolution cameras. However, the lack of motion detect capabilities made data review arduous. The GoPro cameras did overheat during military training exercise periods (when the camera was used constantly without the use of the live box) and switched itself off early in the day. During these times, the backup camera, which had lower resolution and thus low quality images, was utilized to review fish wheel catch. These videos made up a majority of the unknown fish numbers (23 of the 33 unknown fish). An LED light setup on a timer was used for the darker hours of the season. The light was bright and in six instances caused a glare on the fish's scales, making identification difficult. The light was moved to shine indirectly onto the chute which aided in some instances, but the glare still caused identification issues. A filter or a light with decreased lumens may be necessary in the future. There were two instances when fish were not identifiable due to an incomplete pass through the chute. These two fish were caught by the baskets but were released toward the chute and fell through a gap between the chute and the end of the basket opening. This issue was resolved by adding extra rubber backing to the chute itself creating a taller slide and thus closing the gap. Lastly, the last two unknown fish were unidentifiable due to their speed descending through the chute or their motion within the chute concealing their identifiable traits.

Of the 14 Chinook caught, there was one mortality that occurred and this was due to low flow and the fish wheel baskets being unable to spin continuously due to variable times when it would get stuck on the bottom. Additionally, there was one mortality of a sockeye salmon caught in the fish wheel, due to a gap between the fish wheel basket and the opening of the chute. Three pink salmon also died as a result of the gap between the basket and the chute. There was only one coho mortality, which occurred due to low flow and the baskets not having enough momentum to spin.

In mid to late August, after the final high water event on August 19, water levels were on a general decrease. The lowering water levels caused the fish wheel to consistently hit bottom and get stuck on the river bed. Every effort was made to get the wheel to spin; however, flow in the area of the wheel was extremely slow. Fish were no longer caught after August 28 when a chum passed through the chute at night during higher water levels. These conditions did not allow for the coho run timing to be fully observed, skewing the data. For the run timing graph (Figure 10), it is assumed that the fish seen on sonar in mid-September were coho, although no coho were actually caught in the fish wheel to allow for this apportionment.

Significant discrepancies can occur on days when large numbers of fish pass the sonar station but very few or none at all are sampled by the fish wheel. For example, during the 2015 field season on August 12, 380 salmon were estimated to have passed the DIDSONs (Appendix A), but only one fish, a pink salmon, was caught by the wheel (Appendix B) even though sockeye, chum, and pink salmon were caught in higher proportions than the pink salmon in the days previous and following. Another example occurred on August 13, when 358 salmon were estimated to have passed the DIDSONs (Appendix A), yet no fish were caught by the fish wheel. When no fish were caught in the wheel for more than 2 days, no apportionment could be calculated and fish observed on sonar could not be included in the daily apportionment totals. This occurred twice at the beginning of the season (June-July) and from August 29 until the end of the season on September 12 due to zero fish catch. Applying an overall seasonal apportion to the total DIDSON fish count would likely be a more accurate representation of the total escapement of each salmon species.

Stream morphology, current velocity, and water height all play a part in fish wheel selectivity (ADF&G 1983). One method to reduce the selectivity of fish wheels used to apportion DIDSON counts is to conduct a mark-recapture study and develop a model for the fish not caught. The earliest mark-recapture study to identify fish wheel selectivity in Alaska was conducted on the Taku River between 1956 and 1959 (Meehan 1961). Meehan (1961) found that the fish wheel was selecting for smaller Chinook salmon, and, after Chinook and coho salmon had been captured, they were less likely to be recaptured while pink salmon were easily recaptured. At the end of Meehan's (1961) study, he felt that many rivers operating fish wheels would have some sort of selectivity or bias between and within species. However, Meehan (1961) still believed that fish wheels were a good tool when paired with other capture techniques to estimate escapement.

In 1982, the ADF&G also conducted a study to test if the fish wheels in the Susitna River, specifically at the Talkeetna and Curry stations, were also selective. In ADF&G's (1983) report, it found that at both sites, Chinook and chum salmon were under-caught while pink salmon were over-caught and sockeye and coho salmon were neither under-caught nor over-caught. The report also suggested that when fish species overlap in run timing, the selectivity of the fish wheel severely impacts the daily sonar counts.

In a 2015 report by Willette et al., the Yenta fish wheels were found to be selective, and sonar abundance estimates were biased in high water years. Using a variety of tagging methods, along with statistics, Willette et al. (2015) were able to develop a model to that would apportion fish that the sonar counted correctly. This model would not be usable on JBER as every site is different. In order for JBER to reduce selectivity, a study incorporating methods from Meehan (1961), ADF&G (1983) and Willette et al. (2015) could be conducted.

Fish Wheel Historical Data

The total number of fish caught in the fish wheel in 2015 was higher than any other year. The pink, chum, and unknown species catches were also the highest in 2015. The 2015 fish wheel season caught 14 Chinook, only 4 more than the previous year's catch and 12 less than the 2012 season (Figure 17). The 2012 fish wheel season caught more sockeye than any other year with 83 (Figure 17), which is also the highest number of fish caught for any one species. The 2014 fish wheel season catch for coho was the highest among all the field seasons. The year 2013 had the lowest catch of unknown species at zero unknowns counted. Overall, during the four seasons of fish wheel deployment, 624 fish were caught for the purposes of species apportionment.

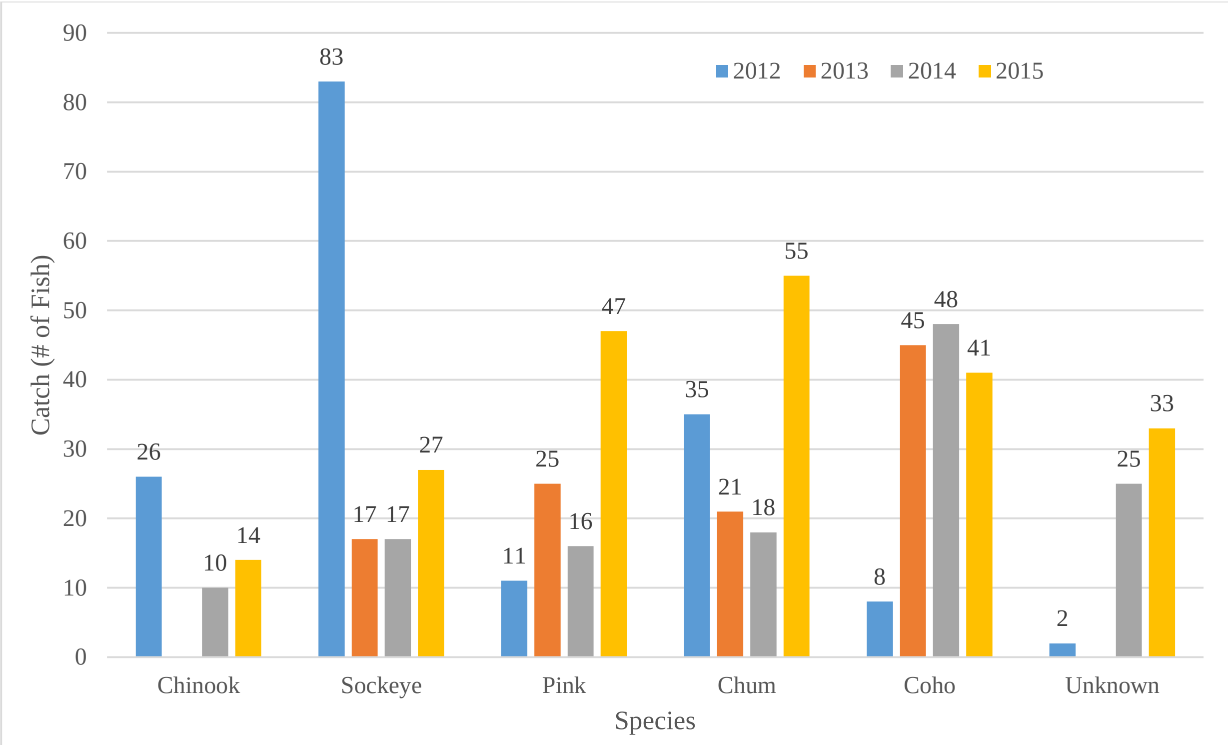

Figure 17. Comparison of each species and unknown fish caught in the fish wheel each season deployed.[4]

SUMMARY

The adult salmon enumeration project in Eagle River on JBER concluded its fourth field season in 2015. An estimated 12,755 salmon were enumerated using the DIDSONs in 2015. This is thought to be an accurate estimation for the number of salmon that returned to Eagle River this field season. The single largest challenge that this project faced was the rapid water fluctuations and high water events during the peak salmon migrations. This season was a success when it came to utilizing two synced sonars to sample the entire river continuously, providing an accurate representation of the number of salmon travelling upstream of the sample site. The 2015 field season, was also the final year for the utilization of the fish wheel for apportionment. It successfully caught 217 fish during the 2015 season, with a total of 624 fish during all of its deployments at Eagle River.

RECOMMENDATIONS

1. One of the biggest challenges that this project faced was rapid fluctuating water depths and high flow events. It is suggested to continue to increase the DIDSON’s high water operation as suggested in U.S. Army Corps of Engineers, Alaska District (USACE) 2013 report.
2. Water temperature plays a key role in the migration of the salmon. It is suggested that water temperature continue to be monitored on Eagle River to see if that is the case with salmon utilizing Eagle River.

[4] The 2013 report only recorded two Chinook caught in the fish wheel catch. However, these Chinooks had already spawned.

3. It was observed during the 2015 season that 83% of fish travelled within 3 meters of the sonar, and it is therefore concluded that they preferred the near shore section of the river. It is recommended that the weir consistently block the entire area behind the sonar so fish are forced in front of the sonar for sampling.
4. A continuous view of the ensonified area of the river is key in being able to accurately enumerate salmon within the river. It is recommended that a dual sonar system continue to be used in the future.
5. Complete a study to determine the fish wheel selectivity at this location.

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APPENDICES

Appendix A: DIDSON Daily Observed Fish Counts

Date	Range Stratum R1 (Near) Fish Observed	Range Stratum R2 (Far) Fish Observed	R1+R2 Total Fish Observed	Cumulative
May-12	0	0	0	0
May-13	0	0	0	0
May-14	0	0	0	0
May-15	0	0	0	0
May-16	0	0	0	0
May-17	0	0	0	0
May-18	0	0	0	0
May-19	1	0	1	1
May-20	0	0	0	1
May-21	2	0	2	3
May-22	3	0	3	6
May-23	1	0	1	7
May-24	0	0	0	7
May-25	2	0	2	9
May-26	1	0	1	10
May-27	0	0	0	10
May-28	0	0	0	10
May-29	3	0	3	13
May-30	7	0	7	20
May-31	5	0	5	25
Jun-1	0	0	0	25
Jun-2	0	0	0	25
Jun-3	0	0	0	25
Jun-4	0	0	0	25
Jun-5	0	0	0	25
Jun-6	0	0	0	25
Jun-7	1	0	1	26
Jun-8	4	0	4	30
Jun-9	1	0	1	31
Jun-10	1	0	1	32
Jun-11	0	0	0	32
Jun-12	0	3	3	35
Jun-13	0	1	1	36
Jun-14	6	2	8	44
Jun-15	25	2	27	71
Jun-16	20	0	20	91
Jun-17	47	7	54	145
Jun-18	12	5	17	162

Date	Range Stratum R1 (Near)	Range Stratum R2 (Far)	R1+R2	Cumulative
	Fish Observed	Fish Observed	Total Fish Observed	
Jun-19	15	0	15	177
Jun-20	22	1	23	200
Jun-21	27	0	27	227
Jun-22	29	0	29	256
Jun-23	28	7	35	291
Jun-24	34	7	41	332
Jun-25	27	1	28	360
Jun-26	43	3	46	406
Jun-27	18	3	21	427
Jun-28	22	3	25	452
Jun-29	20	3	23	475
Jun-30	41	7	48	523
Jul-1	18	9	27	550
Jul-2	10	0	10	560
Jul-3	6	2	8	568
Jul-4	32	3	35	603
Jul-5	23	0	23	626
Jul-6	14	1	15	641
Jul-7	2	0	2	643
Jul-8	12	0	12	655
Jul-9	15	6	21	676
Jul-10	69	1	70	746
Jul-11	54	3	57	803
Jul-12	60	7	67	870
Jul-13	23	0	23	893
Jul-14	86	4	90	983
Jul-15	91	14	105	1088
Jul-16	58	2	60	1148
Jul-17	44	2	46	1194
Jul-18	129	2	131	1325
Jul-19	216	36	252	1577
Jul-20	220	8	228	1805
Jul-21	215	7	222	2027
Jul-22	156	2	158	2185
Jul-23	368	46	414	2599
Jul-24	497	43	540	3139
Jul-25	243	7	250	3389
Jul-26	72	8	80	3469
Jul-27	547	12	559	4028
Jul-28	367	6	373	4401
Jul-29	366	7	373	4774

Date	Range Stratum R1 (Near) Fish Observed	Range Stratum R2 (Far) Fish Observed	R1+R2 Total Fish Observed	Cumulative
Jul-30	547	9	556	5330
Jul-31	551	12	563	5893
Aug-1	433	11	444	6337
Aug-2	579	19	598	6935
Aug-3	477	7	484	7419
Aug-4	351	14	365	7784
Aug-5	390	11	401	8185
Aug-6	593	2	595	8780
Aug-7	412	11	423	9203
Aug-8	322	6	328	9531
Aug-9	175	3	178	9709
Aug-10	155	3	158	9867
Aug-11	366	7	373	10240
Aug-12	372	8	380	10620
Aug-13	346	12	358	10978
Aug-14	86	2	88	11066
Aug-15	222	5	227	11293
Aug-16	161	2	163	11456
Aug-17	87	5	92	11548
Aug-18	3	0	3	11551
Aug-19	4	0	4	11555
Aug-20	106	2	108	11663
Aug-21	115	1	116	11779
Aug-22	50	4	54	11833
Aug-23	72	2	74	11907
Aug-24	80	0	80	11987
Aug-25	68	1	69	12056
Aug-26	58	3	61	12117
Aug-27	67	5	72	12189
Aug-28	59	6	65	12254
Aug-29	46	1	47	12301
Aug-30	47	3	50	12351
Aug-31	33	0	33	12384
Sep-1	40	0	40	12424
Sep-2	21	0	21	12445
Sep-3	37	0	37	12482
Sep-4	36	0	36	12518
Sep-5	29	0	29	12547
Sep-6	19	6	25	12572
Sep-7	35	2	37	12609
Sep-8	13	4	17	12626

Date	Range Stratum R1 (Near) Fish Observed	Range Stratum R2 (Far) Fish Observed	R1+R2 Total Fish Observed	Cumulative
Sep-9	11	7	18	12644
Sep-10	26	3	29	12673
Sep-11	14	2	16	12689
Sep-12	12	3	15	12704
Sep-13	11	0	11	12715
Sep-14	9	0	9	12724
Sep-15	12	11	23	12747
Sep-16	8	0	8	12755
TOTAL:	**12,247**	**508**	**12,755**	**12,755**

Appendix B: Fish Wheel Daily Catch by Species

	Chinook		Sockeye		Chum		Pink		Coho		Unknown (Unk)			
Date	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Total w/o Unk	Total with Unk
Jun-18	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-19	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-20	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-21	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-22	0	50.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-23	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jun-24	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	1
Jun-25	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jun-26	0	0.00%	0	50.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-27	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-28	0	50.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jun-29	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jun-30	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-1	2	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	2	2
Jul-2	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-3	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-4	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-5	0	50.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jul-6	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jul-7	0	50.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jul-8	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-9	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-10	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	1

	Chinook		Sockeye		Chum		Pink		Coho		Unknown (Unk)			
Date	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Total w/o Unk	Total with Unk
Jul-11	0	0.00%	0	50.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jul-12	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-13	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-14	0	0.00%	2	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	2	2
Jul-15	0	33.00%	0	66.67%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Jul-16	2	66.67%	1	33.33%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	3	3
Jul-17	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Jul-18	0	0.00%	0	91.67%	0	8.33%	0	0.00%	0	0.00%	0	0.00%	0	0
Jul-19	0	0.00%	5	83.33%	1	16.67%	0	0.00%	0	0.00%	0	0.00%	6	6
Jul-20	0	0.00%	1	50.00%	0	0.00%	0	0.00%	0	0.00%	1	50.00%	1	2
Jul-21	1	16.67%	4	66.67%	0	0.00%	0	0.00%	1	16.67%	0	0.00%	0	6
Jul-22	0	0.00%	0	0.00%	2	50.00%	1	25.00%	0	0.00%	1	25.00%	3	4
Jul-23	0	0.00%	0	0.00%	1	25.00%	3	75.00%	0	0.00%	0	0.00%	4	4
Jul-24	0	0.00%	1	7.69%	1	7.69%	3	23.08%	0	0.00%	8	61.54%	5	13
Jul-25	0	0.00%	0	0.00%	1	50.00%	0	0.00%	1	50.00%	0	0.00%	2	2
Jul-26	0	0.00%	1	16.67%	1	16.67%	0	0.00%	3	50.00%	1	16.67%	5	6
Jul-27	0	0.00%	2	33.33%	2	33.33%	0	0.00%	1	16.67%	1	16.67%	5	6
Jul-28	0	0.00%	1	12.50%	3	37.50%	3	37.50%	1	12.50%	0	0.00%	8	8
Jul-29	0	0.00%	0	0.00%	1	16.67%	2	33.33%	1	16.67%	2	33.33%	4	6
Jul-30	0	0.00%	2	15.38%	4	30.77%	0	0.00%	6	46.15%	1	7.69%	12	13
Jul-31	0	0.00%	0	0.00%	3	27.27%	4	36.36%	2	18.18%	2	18.18%	9	11
Aug-1	0	0.00%	0	0.00%	2	50.00%	0	0.00%	2	50.00%	0	0.00%	4	4
Aug-2	0	0.00%	1	16.67%	2	33.33%	0	0.00%	0	0.00%	3	50.00%	3	6
Aug-3	0	0.00%	0	0.00%	1	33.33%	0	0.00%	0	0.00%	2	66.67%	1	3
Aug-4	0	0.00%	0	0.00%	2	25.00%	4	50.00%	1	12.50%	1	12.50%	7	8
Aug-5	0	0.00%	0	0.00%	3	37.50%	4	50.00%	1	12.50%	0	0.00%	8	8
Aug-6	0	0.00%	1	7.14%	9	64.29%	0	0.00%	1	7.14%	3	21.43%	11	14

Date	Chinook		Sockeye		Chum		Pink		Coho		Unknown (Unk)			
	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Total w/o Unk	Total with Unk
Aug-7	0	0.00%	0	0.00%	2	28.57%	4	57.14%	1	14.29%	0	0.00%	7	7
Aug-8	0	0.00%	1	10.00%	4	40.00%	0	0.00%	2	20.00%	3	30.00%	7	10
Aug-9	0	0.00%	0	0.00%	2	50.00%	1	25.00%	1	25.00%	0	0.00%	4	4
Aug-10	0	0.00%	0	0.00%	1	14.29%	1	14.29%	4	57.14%	1	14.29%	6	7
Aug-11	0	0.00%	1	25.00%	1	25.00%	2	50.00%	0	0.00%	0	0.00%	4	4
Aug-12	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	1	1
Aug-13	0	0.00%	0	0.00%	0	50.00%	0	50.00%	0	0.00%	0	0.00%	0	0
Aug-14	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Aug-15	0	0.00%	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	0.00%	1	1
Aug-16	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	1	1
Aug-17	0	0.00%	0	0.00%	0	0.00%	3	60.00%	2	40.00%	0	0.00%	5	5
Aug-18	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	1	1
Aug-19	0	0.00%	0	0.00%	0	0.00%	1	33.33%	1	33.33%	1	33.33%	2	3
Aug-20	0	0.00%	0	0.00%	0	0.00%	2	66.67%	1	33.33%	0	0.00%	3	3
Aug-21	0	0.00%	0	0.00%	0	0.00%	1	50.00%	1	50.00%	0	0.00%	2	2
Aug-22	0	0.00%	0	0.00%	1	33.33%	1	33.33%	1	33.33%	0	0.00%	3	3
Aug-23	0	0.00%	0	0.00%	2	66.67%	0	0.00%	1	33.33%	0	0.00%	3	3
Aug-24	0	0.00%	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	1	1
Aug-25	0	0.00%	0	0.00%	0	0.00%	0	50.00%	0	50.00%	0	0.00%	0	0
Aug-26	0	0.00%	0	0.00%	0	0.00%	0	0.00%	2	100.00%	0	0.00%	2	2
Aug-27	0	0.00%	0	0.00%	1	16.67%	3	50.00%	2	33.33%	0	0.00%	6	6
Aug-28	0	0.00%	0	0.00%	1	100.00%	0	0.00%	0	0.00%	0	0.00%	1	1
Aug-29	0	0.00%	0	0.00%	0	50.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Aug-30	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Aug-31	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-1	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-2	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0

	Chinook		Sockeye		Chum		Pink		Coho		Unknown (Unk)			
Date	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Count	% (P_d)	Total w/o Unk	Total with Unk
Sep-3	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-4	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-5	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-6	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-7	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-8	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-9	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-10	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-11	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Sep-12	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0
Total Fish	**14**		**27**		**55**		**47**		**41**		**34**		**183**	**217**

The yellow highlights indicate that no fish were captured in fish wheel and the daily species proportion (P_d) was interpolated by averaging the nearest one day previous and one day following.

Appendix C: Mean Daily Eagle River Height and Temperature, 2015.

Date	NOAA Height[5] (ft)	Sample Site Height (ft)	Temperature (°F)
May-12	-	0.5	-
May-13	-	0.8	-
May-14	-	0.9	55.54
May-15	-	0.95	54.3
May-16	-	1	55.07
May-17	-	1.1	51.35
May-18	-	1	50.6
May-19	-	1	51.63
May-20	-	-	50.95
May-21	-	1.2	55.55
May-22	-	1.4	55.45
May-23	-	1.6	51.09
May-24	-	1.6	52.76
May-25	-	1.5	56.75
May-26	-	1.55	54.7
May-27	-	1.6	54.34
May-28	-	1.7	54.35
May-29	-	1.8	57.63
May-30	-	2	60.1
May-31	-	2.1	61.41
Jun-1	-	2	56.75
Jun-2	-	1.9	51.57
Jun-3	-	1.9	54.35
Jun-4	-	1.8	49.78
Jun-5	-	1.6	52.39
Jun-6	-	1.5	54.07
Jun-7	-	1.5	53.97
Jun-8	-	1.5	55.29
Jun-9	-	1.4	52.43
Jun-10	-	1.4	54.18
Jun-11	-	1.45	55.42
Jun-12	-	1.65	57.66
Jun-13	-	1.8	62.39
Jun-14	-	0.5	65.66
Jun-15	-	0.8	66.68

[5] NOAA gauge at Bravo Bridge used for comparison due to Glenn Highway gauge being incorrectly high due to a temporary construction bridge causing backwater effects.

Date	NOAA Height (ft)	Sample Site Height (ft)	Temperature (°F)
June-16	-	2.2	61.6
Jun-17	-	2.5	61.66
Jun-18	-	2.6	58.69
Jun-19	-	2.7	54.59
Jun-20	-	2.8	52.03
Jun-21	-	2.6	52.41
Jun-22	-	2.5	55.26
Jun-23	-	2.6	55.24
Jun-24	-	2.6	56.96
Jun-25	-	2.6	54.55
Jun-26	-	2.6	54.21
Jun-27	-	2.6	51.82
Jun-28	-	2.5	51.73
Jun-29	-	2.45	53.58
Jun-30	5.27	2.3	55.94
Jul-1	5.19	2.2	55.43
Jul-2	5.08	2	53.79
Jul-3	5.05	2	59.91
Jul-4	5.09	2.2	56.11
Jul-5	5.21	2.2	59.51
Jul-6	5.53	2.7	53.53
Jul-7	6.01	3	47.28
Jul-8	6.02	2.8	48.46
Jul-9	5.7	2.6	50.83
Jul-10	5.5	2.5	54.5
Jul-11	5.4	2.5	56
Jul-12	5.36	2.3	56.4
Jul-13	5.41	2.45	54.13
Jul-14	5.54	2.5	54.01
Jul-15	5.42	2.25	56.4
Jul-16	5.18	2.2	51.97
Jul-17	5.54	2.5	49.45
Jul-18	5.6	2.3	54.44
Jul-19	5.21	2.3	58.31
Jul-20	5.28	2.5	57.95
Jul-21	5.4	2.6	57.47
Jul-22	5.31	2.4	52.06
Jul-23	5.27	2.3	56.89

Date	NOAA Height (ft)	Sample Site Height (ft)	Temperature (°F)
Jul-24	5.22	2.4	59.38
Jul-25	5.42	2.6	54.23
Jul-26	5.65	2.6	48.11
Jul-27	5.64	2.5	51.97
Jul-28	5.45	2.5	52.69
Jul-29	5.45	2.5	52.77
Jul-30	5.47	2.5	55.98
Jul-31	5.39	2.5	56.04
Aug-1	5.56	2.7	56.37
Aug-2	5.69	2.6	56.63
Aug-3	5.67	2.6	56.25
Aug-4	5.74	2.7	54.66
Aug-5	5.81	2.7	55.02
Aug-6	5.65	2.6	55.71
Aug-7	5.46	2.5	57.34
Aug-8	5.47	2.6	52.93
Aug-9	5.47	2.4	50.24
Aug-10	5.85	2.7	47.75
Aug-11	5.71	2.4	49.83
Aug-12	5.42	2.1	51.63
Aug-13	5.16	2.3	52.74
Aug-14	5.16	2.35	56.91
Aug-15	5.19	2.35	48.12
Aug-16	5.15	2.25	49.24
Aug-17	5.41	2.4	47.64
Aug-18	6.06	2.9	44.25
Aug-19	6.26	2.9	46.56
Aug-20	5.63	2.55	50.26
Aug-21	5.32	2.5	48.15
Aug-22	5.09	2.2	50.56
Aug-23	4.99	2.2	51.09
Aug-24	4.77	1.8	50.34
Aug-25	4.7	1.9	53.36
Aug-26	4.94	2	50.31
Aug-27	5.15	2.2	51.71
Aug-28	5	2	47.36
Aug-29	4.7	1.6	43.73
Aug-30	4.64	1.5	45.47

Date	NOAA Height (ft)	Sample Site Height (ft)	Temperature (°F)
Aug-31	4.52	1.15	47.44
Sep-1	4.35	1.15	45.12
Sep-2	4.26	1.15	44.78
Sep-3	4.23	1.3	47.79
Sep-4	4.53	1.5	49.17
Sep-5	4.76	1.7	51.2
Sep-6	4.6	1.75	52.05
Sep-7	4.51	1.7	52.9
Sep-8	4.43	1.7	48.71
Sep-9	4.63	1.7	50.3
Sep-10	4.79	1.8	48.78
Sep-11	4.63	1.5	46.06
Sep-12	4.31	1.45	45.57
Sep-13	4.32	1.4	43.97
Sep-14	4.18	-	47.11
Sep-15	4.16	-	45.85
Sep-16	4.23	-	44.78
Average	**5.22**	**2.06**	**53.06**