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ENVIRONMENTAL CONSERVATION PROGRAM

EAGLE RIVER ADULT SALMON MONITORING ON JOINT BASE ELMENDORF-RICHARDSON, ALASKA, 2016

Final

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EAGLE RIVER ADULT SALMON MONITORING ON JOINT BASE ELMENDORF-RICHARDSON, ALASKA, 2016

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LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

Term/ Unit of Measurement	*Symbol/Abbreviation*
degrees (angular)	°
degrees Fahrenheit	°F
percent	%
Alaska Department of Fish and Game	ADF&G
Amp Hours	Ah
Cook Inlet Beluga Whale	CIBW
Convolved Samples Over Threshold	CSOT
dual-frequency identification sonar	DIDSON
digital video recorder	DVR
feet	ft
frames per second	fps
Integrated Natural Resources Management Plan	INRMP
Joint Base Elmendorf-Richardson	JBER
light emitting diode	LED
meter	m
National Oceanic & Atmospheric Administration	NOAA
DIDSON count for all species of salmon recorded daily	N_d
DIDSON total seasonal count for all species of salmon	N_s
National Marine Fisheries Service	NMFS
Primary Constituent Elements	PCEs

ABSTRACT

The Eagle River Adult Salmon Monitoring on Joint Base Elmendorf-Richardson, Alaska, 2016, began in 2012 and completed its fifth season in 2016. The 2016 study was conducted from June 2 to September 28, for a total of 119 days. The study was successful at estimating the relative abundance of all Pacific salmon (*Onchorhyncus* spp.) native to Eagle River. A total of 5,772 salmon were estimated to have traveled upriver past the two Long Range 300-m dual-frequency identification sonars (DIDSON) in 2016. The run was slow throughout most of June with no days over 100 fish. The run peaked at the end of July through mid-August and then tapered off during the month of September. By August 4th, 50% of the fish had passed the DIDSONs, and, 20 days later on August 24th, over 90% of the fish had passed the DIDSONs. This year was the first year that the fish wheel was not deployed at the request of the Alaska Department of Fish and Game (ADF&G), due to the fact that fish wheels have a bias when catching fish.

INTRODUCTION

Establishing a baseline for salmon escapement and run timing in Eagle River is an important component in understanding the riverine foraging ecology of the Cook Inlet beluga whale (CIBW). In 2008, the National Marine Fisheries Service (NMFS) listed the CIBW 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 CIBW was listed as endangered, four out of the five species of Pacific salmon were listed as primary constituent elements (PCEs): Chinook (*Oncorhynchus tshawytscha*), sockeye (*Oncorhynchus nerka*), chum (*Oncorhynchus keta*), and coho (*Oncorhynchus kisutch*) (U.S. Army Corps of Engineers, Alaska District [USACE] 2013). As PCEs, these fish are considered necessary for the recovery of the CIBW (USACE 2013).

On April 11, 2011, the final ruling to designate critical habitat for the CIBW was announced, with all of the upper Cook Inlet, including the Knik Arm, designated as critical habitat (NMFS 2011). 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. designed and implemented a salmon monitoring project in Eagle River (USACE 2013). The pilot season was conducted during the summer of 2012 in Eagle River with a dual-frequency identification sonar (DIDSON) and a fish wheel with videography.

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 Eagle River.

The 2016 field season was the first year that the fish wheel was not deployed. In previous years, not enough sufficient or beneficial data was collected, and fish caught within the fish wheel were stressed. Replacement methods for fish species apportionment for future data collection are currently under consideration.

GOALS and OBJECTIVES

The primary goal of this project is to enumerate adult salmon returns in Eagle River.

The objectives of the project are as follows:

1) Deploy two DIDSONs in Eagle River for the purpose of enumerating the adult salmon return.
2) Process the data for total abundance, diurnal patterns, and river bank preference.
3) Compare peak run timing to the previous year.

STUDY LOCATION

Eagle River is a glacially fed river approximately 15 miles north of Anchorage, Alaska. The lower nine river miles flow through JBER property (Figure 1), with the last four river miles on JBER located within the Eagle River Flats Impact Area. The study site location of the DIDSONs is approximately four river miles up from the mouth of Eagle River, just upriver of Bravo Bridge.

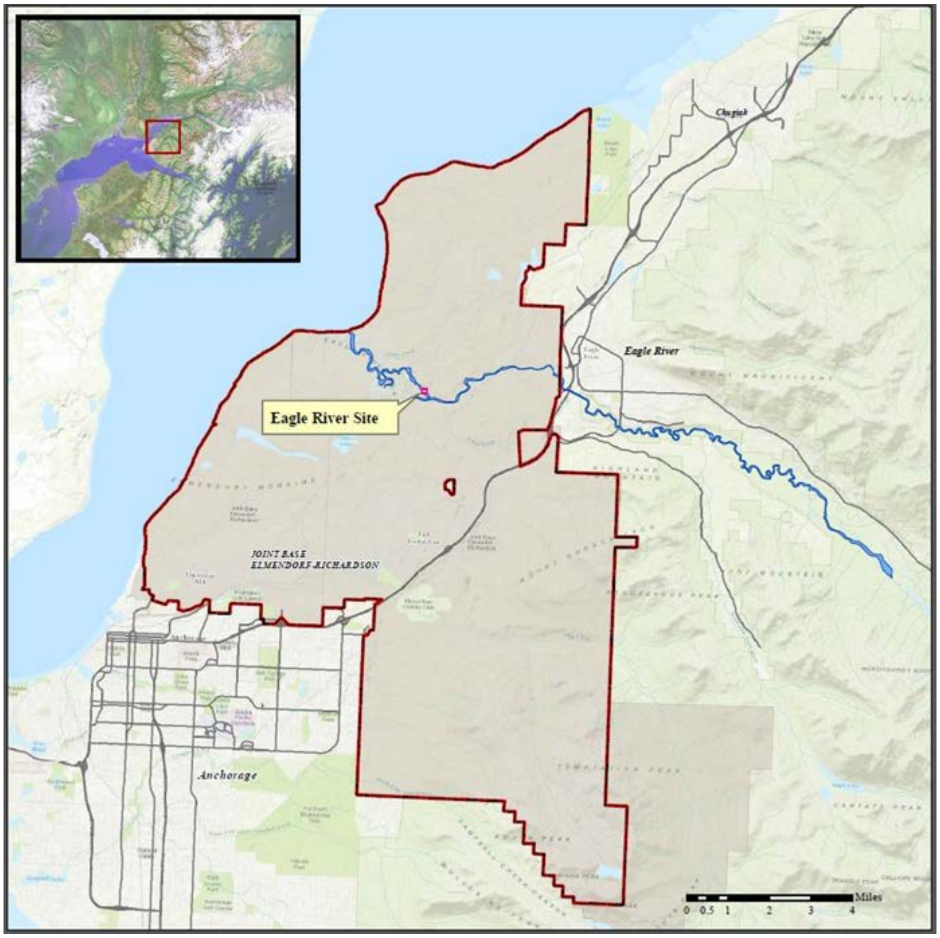

Figure 1. Location of Eagle River and JBER relative to Anchorage, AK, and Knik Arm.

Site selection for this project had multiple limiting criteria, including stream morphology characteristics needed for the DIDSONs 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 required to stay upstream of the Eagle River Flats Impact Area (ERF Impact Area), which contains the last four river miles of Eagle River, and downstream of the recreational boat take-out. These criteria limited the potential sites to a 600 meter (m) section of the lower river, between Route Bravo Bridge and the boat take-out parking lot (USACE 2013).

The DIDSONs were deployed from the river left bank (the terms “river left” and “river right” are defined as the left or right side of the river respectively as the viewer is looking downstream) approximately 500 m upstream of the ERF 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 matches the shape of the sonar beam, a uniform slope without deep depressions or boulders that can create blind spots, and ease of access (USACE 2013). Figure 2 shows the approximate DIDSONs and weir located (circled in orange) on the river left bank.

Figure 2. Location of the 2016 Eagle River adult salmon monitoring equipment (weir and DIDSONs).

METHODS

DIDSON Deployment

Two long-range model 300 DIDSON sonars were used to passively monitor migrating 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 DIDSONs were placed in silt exclusion boxes mounted to a metal-framed tripod placed perpendicular to the river flow. The tripod frame featured an arm that extended out from the frame to allow 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 DIDSONs were attached to the tripod arm via a stainless steel plate with two threaded rods attached to it. The DIDSONs then each had their own stainless steel plates attached to the tops of the silt boxes with attachments in which the threaded rods could be placed through and tightened with hex nuts (Figure 3). Both DIDSONs were attached to the same tilt adjustment plate. A 3° concentrator lens was used to help optimize the DIDSON transducer to the river's profile (USACE 2013). A modular A-frame type picket weir was also installed approximately 1 m downriver and extended approximately 1 m past the DIDSONs toward the river right bank to ensure that fish passed through the ensonified area and were detectable.

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 included the following:

- 2 DIDSON LR300 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

The two DIDSONs were installed on June 2, 2016, at 1215 along the river left bank, aimed perpendicular to the river current towards the river right bank. Once both DIDSONs were synced, they were able to view a total of 40 m (one DIDSON viewing 0-20 m and the other 20-40 m) spanning the river. As water levels in Eagle River fluctuated, the DIDSONs were moved either closer to river left bank or deeper into the river to ensure they were fully submerged. Based on previous seasons, the threshold for operating the DIDSONs safely was at 0.91 m in depth on the site staff gauge (Johnson and Bottom 2016).

DIDSON Site Setup

During the field season at the study site, a wooden shed housed two computers and an eight terabyte external hard drive, with DIDSON viewer software installed on each computer. One computer was used solely to manipulate the DIDSONs' window lengths, frame rates, file durations, recording, and to save the data to the external eight terabyte solid state hard drive. Once the hardware was configured and the DIDSONs were placed in the water, syncing occurred using the methods set forth by Sound Metrics

Corp. (see *How to Sync Multiple DIDSON Sonars* [Sound Metrics Corp 2011] for syncing methods). When this was completed, the DIDSONs were set to collect data continuously, with image files saved in 15 minute intervals. The DIDSONs operated on a 24-hr continual basis between June and September, unless they were required to be removed for periods of maintenance, high water events, military training, and other unforeseeable events, which were documented.

DIDSON Data Analysis

All DIDSON files were reviewed in their entirety. The second computer also had DIDSON viewer software installed and was used to process and review the raw data. The raw files were copied from the eight terabyte hard drive to a smaller external hard drive and then put onto the second computer for review.

The DIDSON view is a pie-shaped wedge within the river that has marks that measure the distance (in meters) that a fish is from the DIDSON. All files were reviewed in video mode, and each fish that was observed was marked and manually measured using the software. Upstream fish were defined as those that travel visibly upstream and did so before the end of the DIDSON file. Downstream fish were defined as those that travel visibly downstream and did so before the end of DIDSON file. Holding fish were defined as those that stay in one position within the DIDSON view and never move upstream or downstream. Horizontally moving fish were defined as those that are seen in the view but they only move closer or further from the DIDSON and move upstream or downstream. All fish viewed migrating upstream or downstream were counted, while holding fish and those that were moving horizontally through the river profile were carefully observed between files and subsequently counted only if they traveled 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 files were merged into a Microsoft Excel worksheet (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 (100+ fish) were reviewed for a second time by staff. The quality controlled counts were then compared to the original counts. Any difference in fish counted was rechecked and verified. When the verification process was completed, the total number of fish counted was corrected in the final count.

RESULTS

Fish Passage

The DIDSONs operated from June 2 until September 28, 2016. The study period (from this point on referred to as 2016 field season) was 117.9 days, of which 77.6 days were sampled and 40.3 day were not sampled. A total of 6,044 fish were observed on the DIDSONs, to include upstream and downstream fish, for the 2016 field season. There were a total of 272 fish observed traveling downstream and the remainder of 5,772 fish were observed traveling upstream.

On June 2, 2016, the first fish was recorded on the DIDSONs. During the month of June, a total of 625 fish were observed. A minimum of 0 fish were observed on the lowest count day and a maximum of 73 fish was observed the highest count day. A total of 28 days out of 30 days were sampled during the month of June.

During the month of July, only 16 out of the 31 days were sampled due to high water events. Despite only sampling half the month, July showed a steady increase in numbers. A total of 1,647 were observed, with a maximum of 366 fish and a minimum of 2 fish being recorded. In the month of August, only 21 out of 31 days were sampled, but August displayed the greatest number of fish for the 2016 field season with a total of 3,081. A maximum of 700 fish traveled upriver on August 16th, while the minimum was 3 fish. It is worth noting that only half of the day was recorded on August 16, meaning all 700 fish were observed within a 12-hour timeframe.

The month of September showed a sharp decline in the number of fish observed. Only 425 fish were observed over 23 days, with an average of 18.5 fish per day. Figure 4 shows the upriver daily passage of fish for the 2016 field season. It is worth noting that a total of 272 fish were observed traveling downriver during the 2016 field season. See Appendix A for more information on the total daily observations.

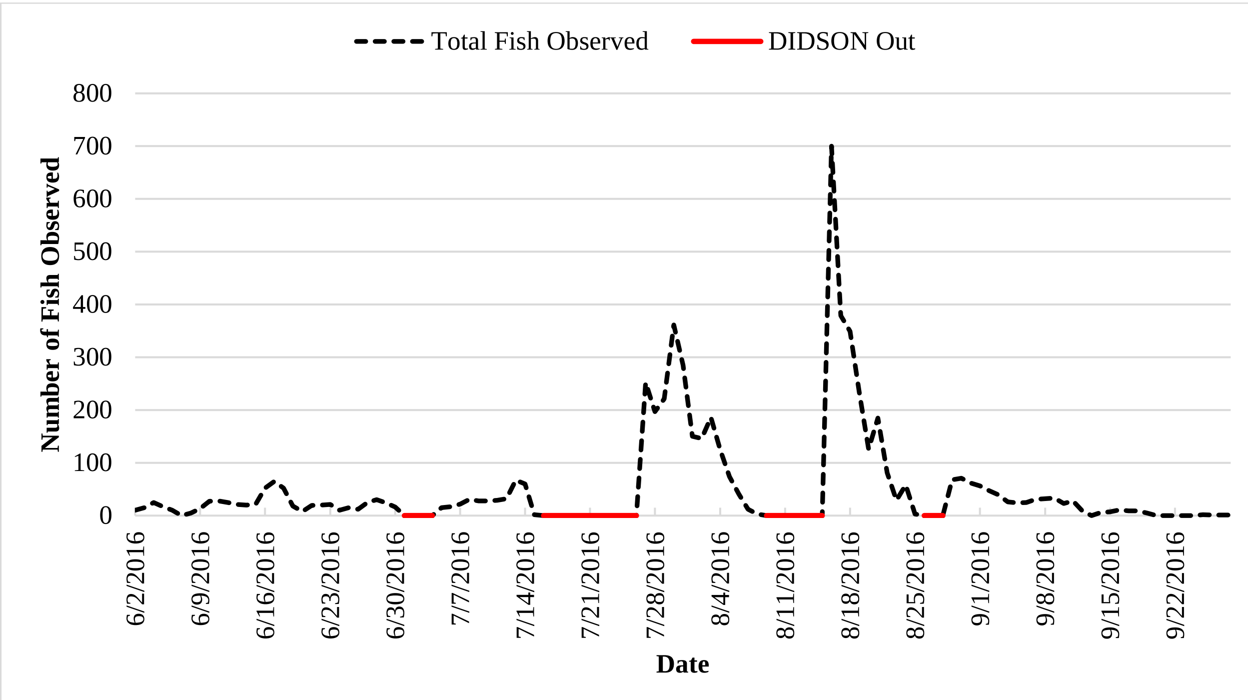

Figure 4. Eagle River DIDSON 2016 upriver daily observations.

By July 28, 25% of the total fish observed on the DIDSONs were documented. Seven days later, on August 4, 50% of the total fish observed on the DIDSONs were reached, and, by August 24, 90% of the total 2016 field season fish observed (Figure 5) were recorded. Figure 5 also indicates when the DIDSONs were not operating due to either high water, military training, or technical difficulties.

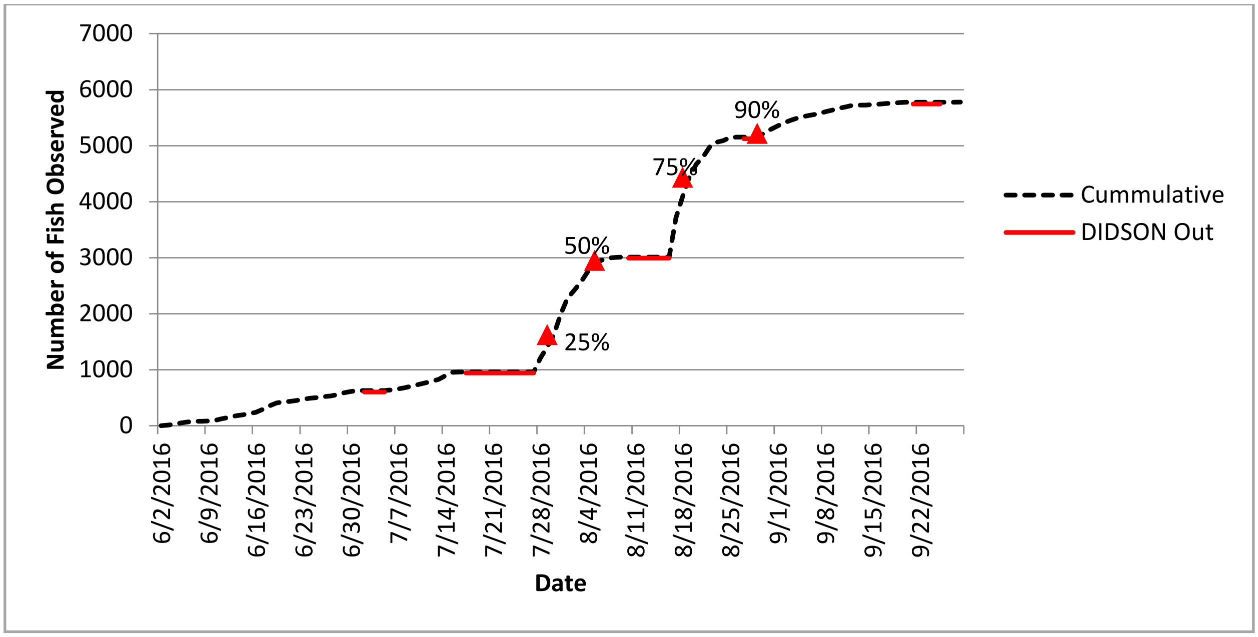

Figure 5. Cumulative daily upriver fish observations for the 2016 field season.

Diurnal Patterns

The diurnal movements of the observed fish were examined for the 2016 field season. All of the DIDSONs data was plotted against a 24-hour day, seen in Figure 6. The highest observations rates occurred between 1400 and 2200, with the lowest observation rates occurring between 0500 and 1000.

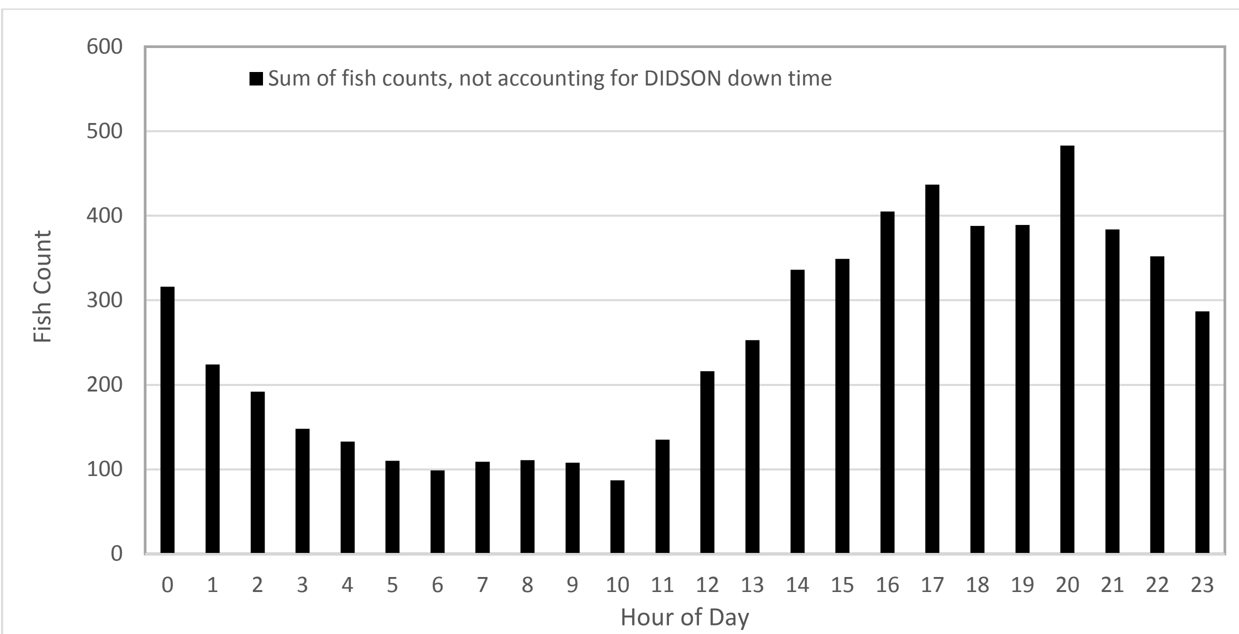

Figure 6.Diurnal pattern of all fish observation by hour of day.

Cross Channel Distribution

Figure 7 shows the range of distribution of both upriver and downriver fish as they passed by the DIDSONs. The first DIDSON recorded the near image, which was set for the first 0-20 m and ranged between the first 10-20 m. The second DIDSON recorded the far image, which was set for 20-40 m and ranged from 10-40 m, depending on the river height. The change in ranges was caused by high or low water events that required adjustment of the DIDSONs' distance from the river left bank. With the implementation of the two DIDSONs, we were able to adjust the viewing ranges to continuously sample the entire span of the river. As seen in the graph below (Figure 7), the majority of the fish traveling upriver and downriver was observed to travel in the near range with a total of 5,755 or 95.2% in the 0-6 m range, 151or 2.5% in the 6-20 m range, and 138 or 2.3% in the 20-30 m range.

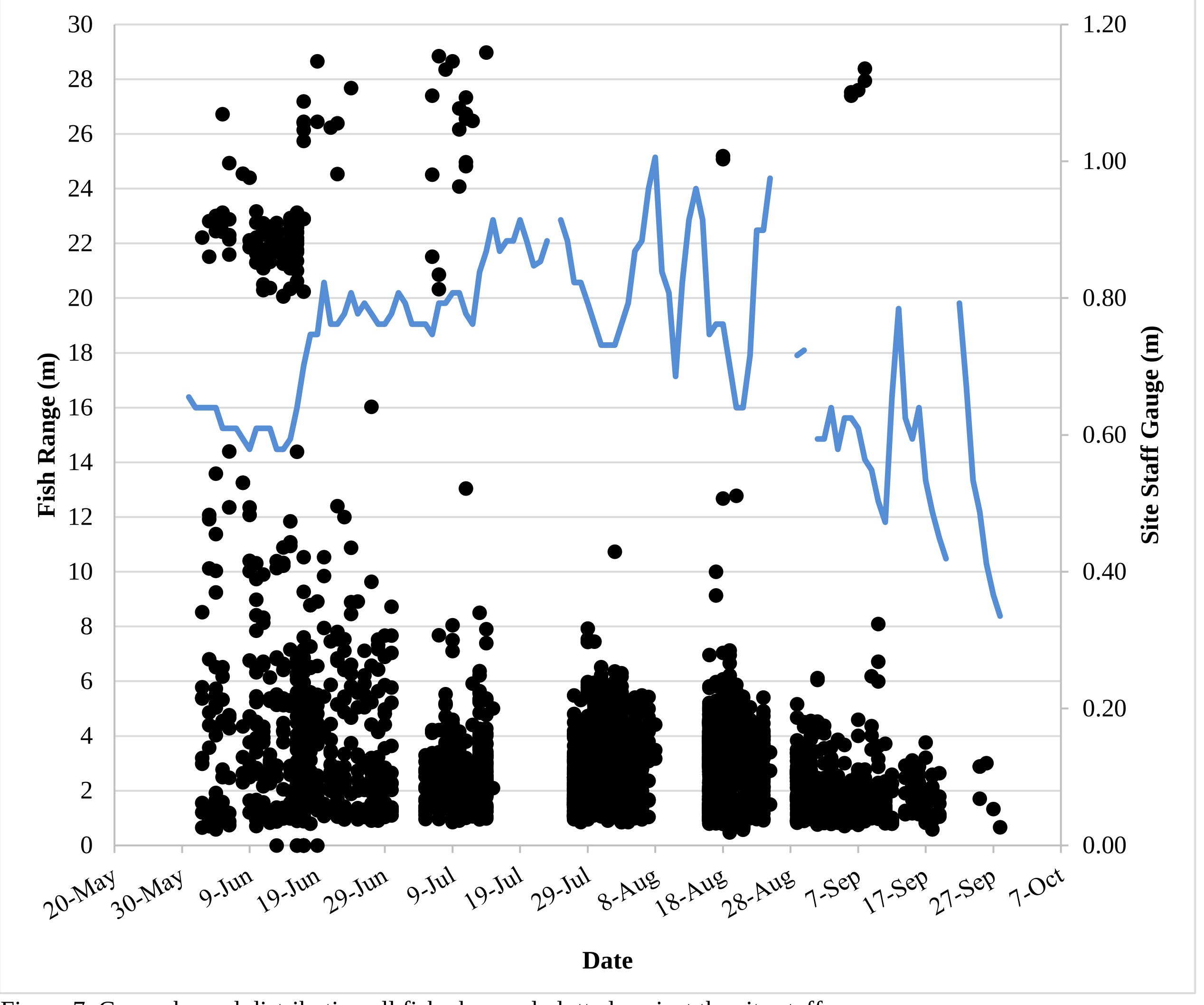

Figure 7. Cross channel distribution all fish observed plotted against the site staff gauge.

Site Staff Gauge

During the 2016 field season, the DIDSONs were removed from the river for a total of 915.4 hours (38 days) due to high water issues. The operational threshold for the DIDSONs is 0.91 m on the site staff gauge. The longest period of time that the DIDSONs were removed from the river due to high water was from July 16th through the 26th.

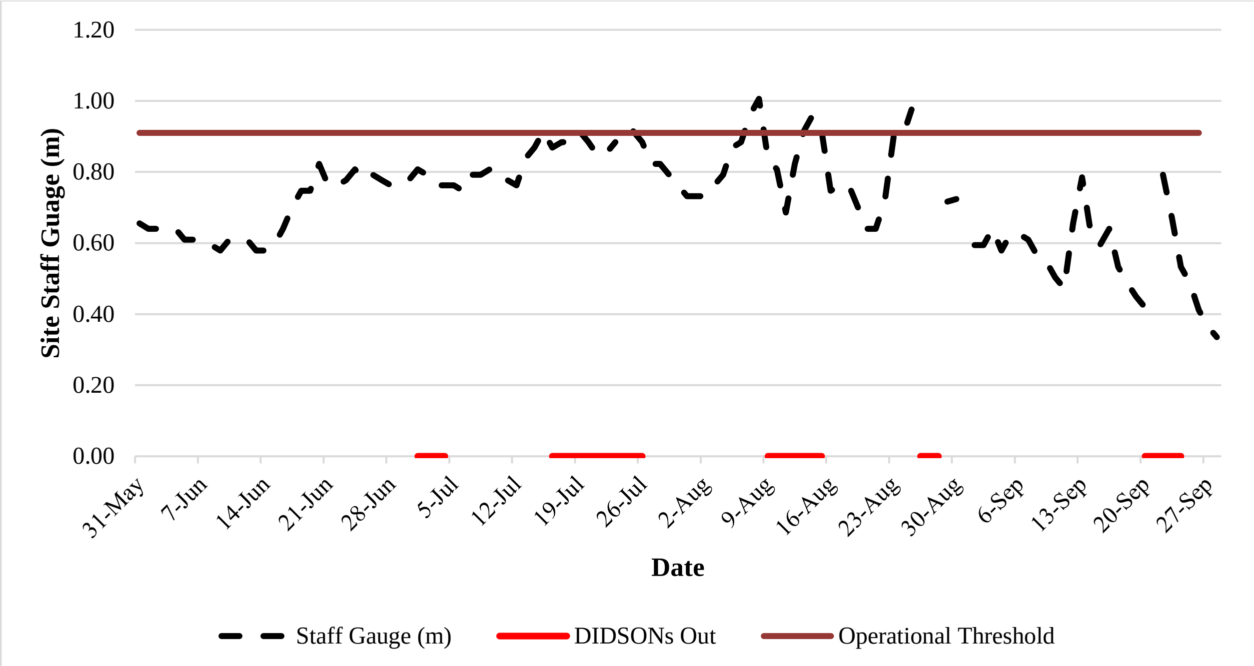

Figure 8. The above graph shows the water (m) height on the site staff gauge, the operational threshold for the DIDSONs, and when the DIDSONs were removed from the water.

DISCUSSION

Adult salmon enumeration in Eagle River is challenging and requires specialized in-river equipment and the proper selection of sampling techniques. Deployment and adjustment of equipment is difficult because of the river's current velocities and substantial fluctuations in water levels. Site selection and equipment placement was critical to the successful use of the DIDSONs. Support equipment including mounts, weirs to direct fish away from the shoreline, enclosures for the equipment, and a power supply were required for a well-established 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 when the training took place during the normal work day when field crews could not access the site. However, the site could be accessed early morning or later in the evening hours, before and after training, to record data or shut down the equipment.

During the 2016 field season, the dual DIDSON setup was effective at enumerating adult salmon escapement in Eagle River. With the use of the DIDSON sonars, an estimated 5,772 adult salmon were observed moving upriver. This enumeration is considered to be low due to a 66% deployment period over the course of the field season and the use of dual DIDSONs in order to have a complete and constant view of the river. The use of the dual DIDSON system is thought to produce more accurate fish totals because the counts were based on actual fish observed instead of calculated assumptions, as completed in previous years. The 2016 field season numbers were estimates because there was no guarantee that all of the fish were counted, and some fish counted could have been large Dolly Varden or rainbow trout.

The main limitation to the 2016 DIDSON data was the amount of time sampled. As in previous years, the sonars had to be removed due to anticipated high water events, including but not limited to flood warnings, storm warnings, extremely hot weather, water height, and large debris. This year's DIDSON study period was 117.9 days, 77.6 of which were sampled, 40.3 of which were not sampled for aforementioned reasons, yielding a sampling percentage of 66%. Although a much higher sampling percentage is ideal, inclement weather presented challenges that required the DIDSONs to be removed from the water at critical times for fish passage and for extended periods of time.

The largest disruption to the DIDSONs and most detrimental to the enumeration of fish was high water, which caused the DIDSONs to be completely removed from the river for 11 days, from July 16th to July 26th. From previous years' data, it is thought that a large portion of the run was missed in that time period.

Eagle River discharge is driven by high elevation snow melt, glacier melt, and/or periods of heavy rain. The trend throughout the summer months is an increasing river height caused by warming ambient air temperatures that melt ice from Eagle Glacier. Combined with spring runoff and periods of heavy rain, these conditions are likely to cause high water or flooding.

During the 2016 field season, it was discovered that the DIDSONs could still be operated above the 0.91 m threshold. This required moving the DIDSONs locations to 7.5 m from river left bank which assisted the field technicians in their ability to reach the DIDSONs during times of high water. Ideally, for DIDSON review, the range of the near would be 0-20 m and the far 20-30 m, meaning there would be a need at least three weirs in the water. If there are only two weirs, the far range has to be set to 20-40 m, which makes reviewing the file for fish very difficult.

The National Oceanic and Atmosphere Administration (NOAA) has a staff gauge on Eagle River located at the Glenn Highway Bridge. Comparing the NOAA staff gauge (Dixson 2017) and the site staff gauge, the two gauges correlated effectively and showed the water peaks occurred at the same time, with an approximate 0.61 m difference between the two gauges (Figure 9). It will be beneficial to continue the observations from the two staff gauges to make informed decisions pertaining to the removal of the DIDSONs from the river.

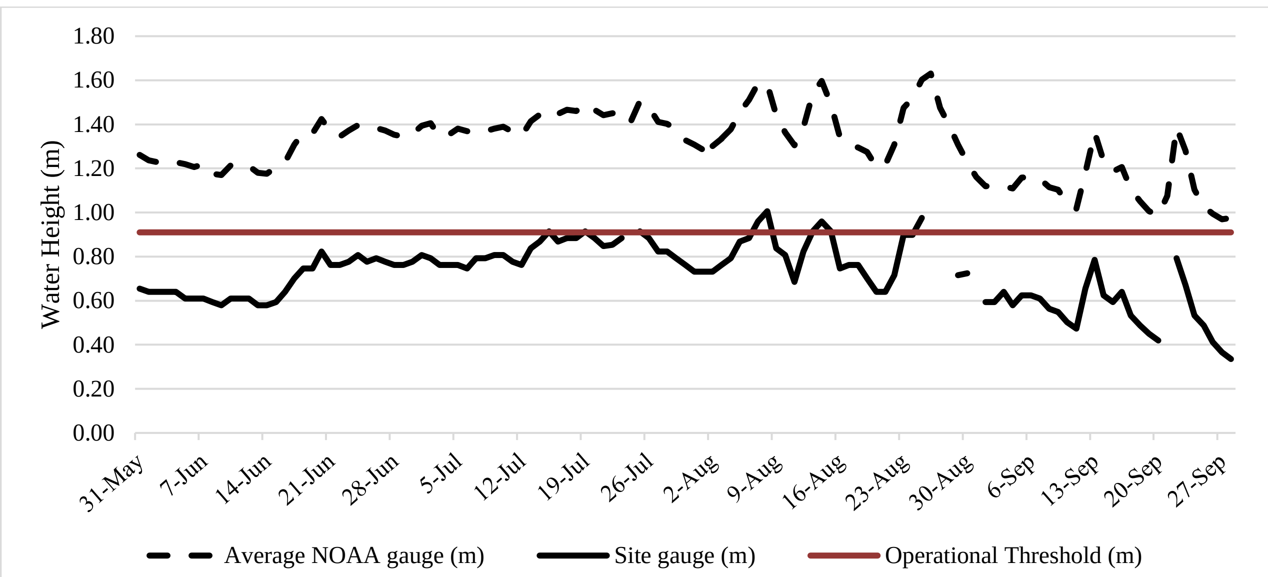

Figure 9. Comparison of Eagle River daily averaged height at Bravo Bridge and on-site location[1] (Dixon 2017).

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

CONCLUSTION

The adult salmon enumeration project in Eagle River on JBER concluded its fifth field season in 2016. A total of 5,772 salmon were observed moving upriver on the DIDSONs in 2016, which was considered a low estimate based on the DIDSONs deployment days during the sampling period. The single largest challenge that this project faced was the rapid water fluctuations and high water events during the peak migrations for the salmon. This season was a success, utilizing two synced DIDSONs to sample the entire river continuously and providing an accurate representation of the number of salmon travelling upstream of the sample site.

RECOMMENDATIONS

1. One of the biggest challenges that this project faced was rapidly fluctuating water depths and high flow events. It is suggested to continue to increase the DIDSON's high water operational threshold as suggested in U.S. Army Corps of Engineers, Alaska District (USACE) 2013 report.
2. Water temperature plays a role in the migration of the salmon (Wilson and Kelly 1984). It is suggested that water temperature be monitored using the HOBO's on Eagle River to see if that is the case with salmon utilizing Eagle River.
3. It was observed during the 2016 season that 95.5% of fish travelled within 6 meters of the near bank DIDSON, 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 DIDSON system continue to be used in the future.

ACKNOWLEDGEMENTS

This study would not have been successful without the efforts of the field technicians: Krystina Bottom, Samuel Satre, and Heather Langendorf. We would like to thank these technicians for their many hours in the cold water maintaining the equipment in challenging conditions, analyzing and organizing data, and many hours of data quality control. We would also like to thank Mr. Bill Hanot at Sound Metrics Corp. for his assistance with the syncing and troubleshooting of the DIDSONs.

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APPENDICES

Appendix A: DIDSON Daily Observed Fish Counts.

All Fish Observed				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
2-Jun	9	1	10	10
3-Jun	11	5	16	26
4-Jun	20	7	27	53
5-Jun	11	7	18	71
6-Jun	7	8	15	86
7-Jun	0	0	0	86
8-Jun	4	2	6	92
9-Jun	11	4	15	107
10-Jun	23	9	32	139
11-Jun	20	11	31	170
12-Jun	14	13	27	197
13-Jun	18	7	25	222
14-Jun	17	6	23	245
15-Jun	14	10	24	269
16-Jun	40	21	61	330
17-Jun	65	8	73	403
18-Jun	58	0	58	461
19-Jun	16	2	18	479
20-Jun	8	0	8	487
21-Jun	18	1	19	506
22-Jun	20	2	22	528
23-Jun	22	0	22	550
24-Jun	10	1	11	561
25-Jun	15	1	16	577

All Fish Observed				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
26-Jun	13	0	13	590
27-Jun	26	0	26	616
28-Jun	30	0	30	646
29-Jun	25	0	25	671
30-Jun	19	0	19	690
1-Jul	0	0	0	690
2-Jul	0	0	0	690
3-Jul	0	0	0	690
4-Jul	0	0	0	690
5-Jul	15	0	15	705
6-Jul	15	3	18	723
7-Jul	21	3	24	747
8-Jul	30	1	31	778
9-Jul	24	1	25	803
10-Jul	30	3	33	836
11-Jul	27	5	32	868
12-Jul	31	1	32	900
13-Jul	67	0	67	967
14-Jul	59	1	60	1027
15-Jul	2	0	2	1029
16-Jul	0	0	0	1029
17-Jul	0	0	0	1029
18-Jul	0	0	0	1029
19-Jul	0	0	0	1029
20-Jul	0	0	0	1029
21-Jul	0	0	0	1029
22-Jul	0	0	0	1029

All Fish Observed				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
23-Jul	0	0	0	1029
24-Jul	0	0	0	1029
25-Jul	0	0	0	1029
26-Jul	0	0	0	1029
27-Jul	259	0	259	1288
28-Jul	201	0	201	1489
29-Jul	224	0	224	1713
30-Jul	366	0	366	2079
31-Jul	295	0	295	2374
1-Aug	165	0	165	2539
2-Aug	149	0	149	2688
3-Aug	195	0	195	2883
4-Aug	133	0	133	3016
5-Aug	77	0	77	3093
6-Aug	44	0	44	3137
7-Aug	13	0	13	3150
8-Aug	3	0	3	3153
9-Aug	0	0	0	3153
10-Aug	0	0	0	3153
11-Aug	0	0	0	3153
12-Aug	0	0	0	3153
13-Aug	0	0	0	3153
14-Aug	0	0	0	3153
15-Aug	0	0	0	3153
16-Aug	716	0	716	3869
17-Aug	392	0	392	4261
18-Aug	355	2	357	4618

All Fish Observed				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
19-Aug	249	0	249	4867
20-Aug	139	0	139	5006
21-Aug	217	0	217	5223
22-Aug	81	0	81	5304
23-Aug	30	0	30	5334
24-Aug	58	0	58	5392
25-Aug	3	0	3	5395
26-Aug	0	0	0	5395
27-Aug	0	0	0	5395
28-Aug	0	0	0	5395
29-Aug	71	0	71	5466
30-Aug	77	0	77	5543
31-Aug	63	0	63	5606
1-Sep	56	0	56	5662
2-Sep	48	0	48	5710
3-Sep	41	0	41	5751
4-Sep	27	0	27	5778
5-Sep	24	0	24	5802
6-Sep	26	2	28	5830
7-Sep	30	1	31	5861
8-Sep	31	2	33	5894
9-Sep	33	0	33	5927
10-Sep	23	0	23	5950
11-Sep	28	0	28	5978
12-Sep	9	0	9	5987
13-Sep	0	0	0	5987
14-Sep	6	0	6	5993

All Fish Observed				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
15-Sep	8	0	8	6001
16-Sep	11	0	11	6012
17-Sep	10	0	10	6022
18-Sep	11	0	11	6033
19-Sep	5	0	5	6038
20-Sep	0	0	0	6038
21-Sep	0	0	0	6038
22-Sep	0	0	0	6038
23-Sep	0	0	0	6038
24-Sep	0	0	0	6038
25-Sep	3	0	3	6041
26-Sep	1	0	1	6042
27-Sep	1	0	1	6043
28-Sep	1	0	1	6044

Appendix B: DIDSON Daily Observed Downstream Fish Counts.

Downstream Fish				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
2-Jun	0	0	0	0
3-Jun	0	1	1	1
4-Jun	0	2	2	3
5-Jun	1	0	1	4
6-Jun	1	4	5	9
7-Jun	0	0	0	9
8-Jun	0	1	1	10
9-Jun	1	1	2	12
10-Jun	3	2	5	17
11-Jun	2	1	3	20
12-Jun	1	1	2	22
13-Jun	2	2	4	26
14-Jun	1	2	3	29
15-Jun	0	2	2	31
16-Jun	8	2	10	41
17-Jun	6	1	7	48
18-Jun	6	0	6	54
19-Jun	0	0	0	54
20-Jun	0	0	0	54
21-Jun	0	0	0	54
22-Jun	2	0	2	56
23-Jun	1	0	1	57
24-Jun	1	0	1	58
25-Jun	0	0	0	58

Downstream Fish				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
26-Jun	1	0	1	59
27-Jun	1	0	1	60
28-Jun	0	0	0	60
29-Jun	1	0	1	61
30-Jun	3	0	3	64
1-Jul	0	0	0	64
2-Jul	0	0	0	64
3-Jul	0	0	0	64
4-Jul	0	0	0	64
5-Jul	0	0	0	64
6-Jul	0	1	1	65
7-Jul	0	2	2	67
8-Jul	0	0	0	67
9-Jul	2	0	2	69
10-Jul	4	1	5	74
11-Jul	1	2	3	77
12-Jul	0	0	0	77
13-Jul	0	0	0	77
14-Jul	0	0	0	77
15-Jul	0	0	0	77
16-Jul	0	0	0	77
17-Jul	0	0	0	77
18-Jul	0	0	0	77
19-Jul	0	0	0	77
20-Jul	0	0	0	77
21-Jul	0	0	0	77
22-Jul	0	0	0	77

Downstream Fish				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
23-Jul	0	0	0	77
24-Jul	0	0	0	77
25-Jul	0	0	0	77
26-Jul	0	0	0	77
27-Jul	7	0	7	84
28-Jul	4	0	4	88
29-Jul	4	0	4	92
30-Jul	5	0	5	97
31-Jul	10	0	10	107
1-Aug	16	0	16	123
2-Aug	3	0	3	126
3-Aug	9	0	9	135
4-Aug	8	0	8	143
5-Aug	3	0	3	146
6-Aug	3	0	3	149
7-Aug	1	0	1	150
8-Aug	0	0	0	150
9-Aug	0	0	0	150
10-Aug	0	0	0	150
11-Aug	0	0	0	150
12-Aug	0	0	0	150
13-Aug	0	0	0	150
14-Aug	0	0	0	150
15-Aug	0	0	0	150
16-Aug	16	0	16	166
17-Aug	13	0	13	179
18-Aug	7	2	9	188

Downstream Fish				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
19-Aug	16	0	16	204
20-Aug	13	0	13	217
21-Aug	32	0	32	249
22-Aug	0	0	0	249
23-Aug	1	0	1	250
24-Aug	0	0	0	250
25-Aug	0	0	0	250
26-Aug	0	0	0	250
27-Aug	0	0	0	250
28-Aug	0	0	0	250
29-Aug	3	0	3	253
30-Aug	6	0	6	259
31-Aug	1	0	1	260
1-Sep	0	0	0	260
2-Sep	1	0	1	261
3-Sep	1	0	1	262
4-Sep	1	0	1	263
5-Sep	0	0	0	263
6-Sep	3	0	3	266
7-Sep	0	0	0	266
8-Sep	1	0	1	267
9-Sep	0	0	0	267
10-Sep	0	0	0	267
11-Sep	0	0	0	267
12-Sep	0	0	0	267
13-Sep	0	0	0	267
14-Sep	0	0	0	267

Downstream Fish				
	Near	**Far**	**Near + Far**	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
15-Sep	1	0	1	268
16-Sep	0	0	0	268
17-Sep	1	0	1	269
18-Sep	2	0	2	271
19-Sep	0	0	0	271
20-Sep	0	0	0	271
21-Sep	0	0	0	271
22-Sep	0	0	0	271
23-Sep	0	0	0	271
24-Sep	0	0	0	271
25-Sep	1	0	1	272
26-Sep	0	0	0	272
27-Sep	0	0	0	272
28-Sep	0	0	0	272

Appendix C: Mean Daily Eagle River Height and Ambient Air Temperature, 2016.

Date	NOAA Height (m)	Sample Site Height (m)	Temperature (°C)
May-31	1.26	0.66	-
Jun-1	1.24	0.64	17.89
Jun-2	1.23	0.64	12.89
Jun-3	1.23	0.64	12.72
Jun-4	1.23	0.64	11.67
Jun-5	1.22	0.61	12.83
Jun-6	1.21	0.61	8.72
Jun-7	1.22	0.61	12.56
Jun-8	1.18	0.59	13.67
Jun-9	1.17	0.58	15.33
Jun-10	1.21	0.61	11.83
Jun-11	1.22	0.61	12.39
Jun-12	1.21	0.61	12.00
Jun-13	1.18	0.58	14.89
Jun-14	1.18	0.58	14.61
Jun-15	1.21	0.59	16.00
Jun-16	1.23	0.64	17.22
Jun-17	1.31	0.70	15.00
Jun-18	1.36	0.75	15.33
Jun-19	1.36	0.75	12.39
Jun-20	1.42	0.82	11.67
Jun-21	1.37	0.76	14.33
Jun-22	1.34	0.76	15.78
Jun-23	1.37	0.78	13.72
Jun-24	1.40	0.81	11.56
Jun-25	1.39	0.78	13.06
Jun-26	1.38	0.79	13.50
Jun-27	1.37	0.78	13.67
Jun-28	1.35	0.76	14.89
Jun-29	1.34	0.76	14.72
Jun-30	1.36	0.78	14.61
Jul-1	1.39	0.81	13.06
Jul-2	1.41	0.79	12.44
Jul-3	1.34	0.76	11.44
Jul-4	1.35	0.76	13.72
Jul-5	1.38	0.76	10.94
Jul-6	1.37	0.75	11.67

Date	NOAA Height (m)	Sample Site Height (m)	Temperature (°C)
Jul-7	1.36	0.79	14.56
Jul-8	1.37	0.79	15.50
Jul-9	1.38	0.81	15.89
Jul-10	1.39	0.81	15.83
Jul-11	1.37	0.78	13.17
Jul-12	1.35	0.76	16.33
Jul-13	1.41	0.84	15.72
Jul-14	1.44	0.87	15.61
Jul-15	1.47	0.91	15.17
Jul-16	1.45	0.87	15.33
Jul-17	1.47	0.88	14.78
Jul-18	1.46	0.88	15.94
Jul-19	1.49	0.91	13.22
Jul-20	1.47	0.88	13.83
Jul-21	1.44	0.85	12.78
Jul-22	1.45	0.85	9.83
Jul-23	1.45	0.88	11.78
Jul-24	1.41	-	9.67
Jul-25	1.51	0.91	7.94
Jul-26	1.48	0.88	9.89
Jul-27	1.41	0.82	10.94
Jul-28	1.40	0.82	12.78
Jul-29	1.38	0.79	12.44
Jul-30	1.33	0.76	13.78
Jul-31	1.31	0.73	12.78
Aug-1	1.28	0.73	10.39
Aug-2	1.30	0.73	12.50
Aug-3	1.34	0.76	14.44
Aug-4	1.38	0.79	10.83
Aug-5	1.45	0.87	10.22
Aug-6	1.51	0.88	9.83
Aug-7	1.58	0.96	7.11
Aug-8	1.58	1.01	7.17
Aug-9	1.44	0.84	9.78
Aug-10	1.36	0.81	11.50
Aug-11	1.30	0.69	10.17
Aug-12	1.39	0.82	9.67
Aug-13	1.54	0.91	7.22

Date	NOAA Height (m)	Sample Site Height (m)	Temperature (°C)
Aug-14	1.60	0.96	6.17
Aug-15	1.49	0.91	9.89
Aug-16	1.34	0.75	12.11
Aug-17	1.31	0.76	10.28
Aug-18	1.30	0.76	13.33
Aug-19	1.27	0.70	11.50
Aug-20	1.21	0.64	12.61
Aug-21	1.22	0.64	11.56
Aug-22	1.31	0.72	9.72
Aug-23	1.48	0.90	9.39
Aug-24	1.52	0.90	9.44
Aug-25	1.60	0.98	6.89
Aug-26	1.63	-	9.89
Aug-27	1.48	0.97	13.22
Aug-28	1.40	-	13.39
Aug-29	1.31	0.72	13.17
Aug-30	1.23	0.72	12.33
Aug-31	1.16	-	11.28
Sep-1	1.12	0.59	11.28
Sep-2	1.12	0.59	11.39
Sep-3	1.12	0.64	10.33
Sep-4	1.11	0.58	11.17
Sep-5	1.16	0.62	9.89
Sep-6	1.16	0.62	10.56
Sep-7	1.15	0.61	9.94
Sep-8	1.12	0.56	10.56
Sep-9	1.10	0.55	10.06
Sep-10	1.04	0.50	8.89
Sep-11	1.02	0.47	9.28
Sep-12	1.18	0.66	13.06
Sep-13	1.36	0.78	11.78
Sep-14	1.23	0.62	5.67
Sep-15	1.19	0.59	8.61
Sep-16	1.21	0.64	8.00
Sep-17	1.11	0.53	7.39
Sep-18	1.05	0.49	11.11
Sep-19	1.01	0.45	7.00
Sep-20	0.99	0.42	10.39

Date	NOAA Height (m)	Sample Site Height (m)	Temperature (°C)
Sep-21	1.08	-	12.00
Sep-22	1.39	0.79	6.61
Sep-23	1.28	0.67	8.33
Sep-24	1.10	0.53	7.56
Sep-25	1.03	0.49	7.00
Sep-26	0.99	0.41	7.61
Sep-27	0.97	0.37	7.06
Sep-28	0.98	0.34	5.17
Average	**4.29**	**0.72**	**11.71**