UNITED STATES AIR FORCE
JOINT BASE ELMENDORF-RICHARDSON
ALASKA

ENVIRONMENTAL CONSERVATION PROGRAM

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

Final

July 2018

Colorado State University
Center for Environmental Management of Military Lands
5-309235

U.S. Army Corps of Engineers
W9128FB-14-2-0001
Task Order 0093
CLIN 8

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

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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
cubic feet per second	CFS
dual-frequency identification sonar	DIDSON
digital video recorder	DVR
Eagle River boat take out	ERBTO
Eagle River Flats	ERF
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

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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 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 salmon and 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, the use of two DIDSON sonars simultaneously was implemented, by means of synchronizing them via DIDSON top-side software, to achieve a continuous view of the entire sampling area. This methodology allowed for a more accurate enumeration of the fish travelling upstream in Eagle River. In 2016, the fish wheel was decommissioned because the data acquired from its operation did not have the resolution necessary to specieate the fish traveling past the DIDSONs. Replacement methods for fish species apportionment for future data collection are currently under consideration.

GOALS and OBJECTIVES

The primary goal of this project is the correlation of upstream movement of CIBW into Eagle River relative to Pacific adult salmon spawning migration.

The objectives for the project are as follows:

1) Deploy two (2) DIDSONs in Eagle River to enumerate the adult salmon return.
2) Process the data for total abundance, diurnal patterns, and riverbank preference.
3) Compare peak run timing to previous years.

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 (ERF Impact Area). The study site location of the DIDSONs is approximately four river miles from the mouth of Eagle River, just upriver of the impact area and Bravo Bridge.

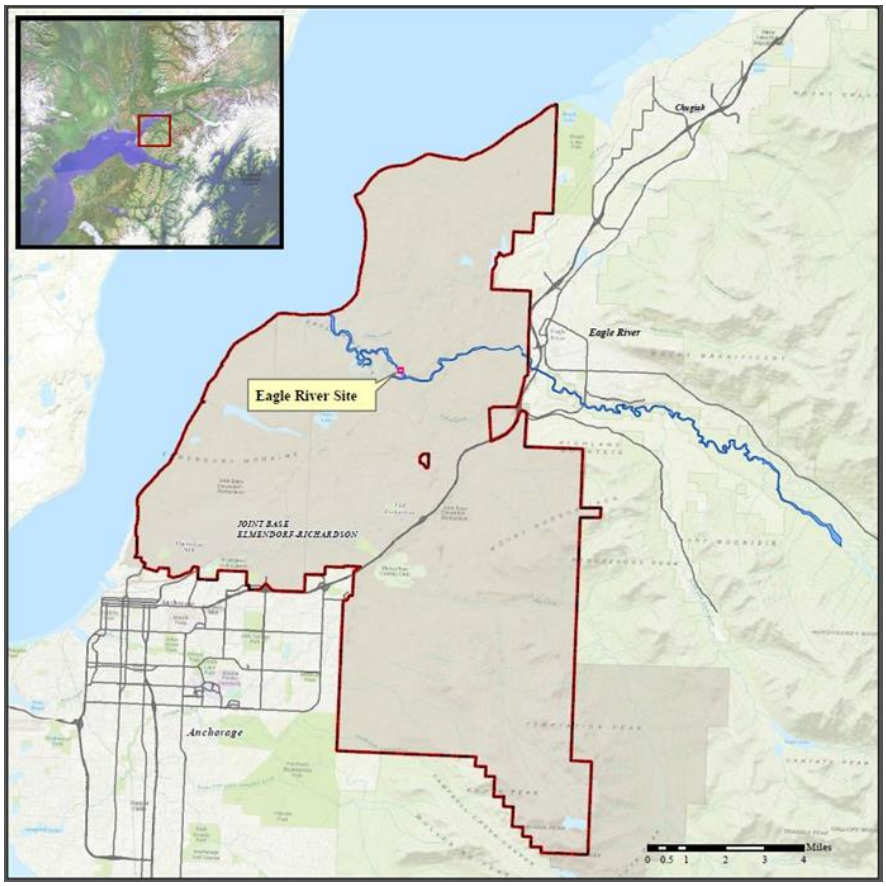

Figure 1. Location of Eagle River and JBER relative to Anchorage, AK, and Knik Arm.

Site selection was conducted by USACE in 2013 to determine the best suitable location for this project, but had multiple limiting criteria, including stream morphology characteristics necessary for DIDSON operation, 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 (USACE 2013). The study site was required to stay upstream of the 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 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 locations (circled in orange) on the river left bank.

Figure 2. Location of the 2017 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 current. 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 were 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 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
- Net-gear 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 (Seagate two terabyte solid-state external hard drive)
- Data review computer with DIDSON Viewer software
- Transducer stream mount with manual pan and tilt adjusters
- Fish exclusion weir

The two DIDSONs were installed 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 between 0-20 m and the other between 10-40 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.

DIDSON Site Setup and Schedule

During the field season, a wooden shed at the study site housed a computer with DIDSON viewer software and a two terabyte external hard drive. The computer was used solely to manipulate the DIDSONs' window lengths, frame rates, file durations, recording, and to save the data to the external two terabyte solid-state hard drive. Once the hardware was configured and the DIDSONs were placed in the water, synchronizing them occurred using the methods set forth by Sound Metrics Corp. (*How to Sync Multiple DIDSON Sonars* [Sound Metrics Corp 2011]). When this was completed, the DIDSONs were set to collect data continuously, with image files saved in 15-minute intervals.

The DIDSONs have previously been deployed in mid-late May and removed in September, however, in the 2017 field season the DIDSONs were deployed for a portion of the month of October to determine whether there is a late run and how far into the fall we could run the DIDSONs. The DIDSONs operated on a continual 24-hour basis from May through October, unless removal for periods of

maintenance, high water events, military training, and other unforeseeable events was required. These out-of-water events were documented.

DIDSON Data Analysis

All DIDSON files were reviewed in their entirety. Other computers with DIDSON viewer software installed were used to process and review the raw data. The raw files were copied from the solid-state hard drive to an external hard drive and transferred to other computers 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 moved 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 do not 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. Direction of travel of each fish was noted in the Excel worksheet by the designations “Dn” for downstream and “Up” for upstream.

RESULTS

The Eagle River Adult Salmon Monitoring project completed its sixth season in 2017, from 22 May to 19 October, for a total of 150 days. Of the 150 day season, 118 days were sampled and 32 days were not sampled for various reasons such as high water events, DIDSON maintenance, or military training exercises. Of the 118 days, some days only partial data was collected because the DIDSONs were removed from the river at some point during those days. For details on specific days that were partially sampled, see appendix D.

The study was successful at estimating the relative abundance of Pacific salmon in Eagle River. A total estimate of 12,824 salmon were documented. Of these, there were 385 fish observed traveling

downstream and the remaining 12,439 fish were observed traveling upstream. The run was slow through May to the end of July with no days over 100 fish until 27 July. The run peaked at the end of July through mid-August and tapered off during the month of September. By 2 August, 25% of the fish had passed the DIDSONs and 23 days later on 24 August over 90% of the fish had passed the DIDSONs.

The last 10 days of May were sampled with a total of 31 fish or 0.2% of the run observed. On 22 May, the first fish was recorded on the DIDSONs. The highest count of eight fish was observed on 24 May, and the lowest count of zero fish on 30 May. The entire month of June was sampled. A total of 645 fish (or 5% of the run) was observed, with the highest count of 51 fish observed on 25 June and the lowest count of zero fish on 10 June. In the month of July, 29 days were sampled. A total of 1,746 fish (or 13.6% of the run) was observed, with the highest count of 354 fish observed on 31 July and the lowest count of five fish on 14 July. In the month of August, 30 days were sampled. August had the greatest number of fish for the 2017 season with a total of 10,010 fish (or 78.1% of the run) observed. The highest count of 798 fish were observed on 4 August and the lowest count of zero fish on 30 August. For six days of the days sampled, the far image of the river was not functioning properly, and were not able to be reviewed (see appendix D). In the month of September, 19 days were sampled. A total of 386 fish (or 3% of the run) were observed, with the highest count of 133 fish observed on 2 September and the lowest count of one fish on three days: the 17th, 18th, and the 29th of September. Eight of the 11 days not sampled were at the beginning of the month (end of peak run time), due to a combination of military training and high water events. September showed a sharp decline in the number of fish observed. During the 2017 field season, the DIDSONs were deployed into the month of October to determine whether there is a late run of adult salmon. In the month of October, 10 days nonconsecutive days were sampled, which included the 2nd – 5th, 11th and 12th, and the 16th-19th. The DIDSONs experienced some technical difficulties recording for five days and were not able to be reviewed. During the 10 days that were recorded, six fish were counted.

Figure 4 shows the upriver daily passage of fish for the 2017 field season. See Appendix A and B for more information on the total daily observations.

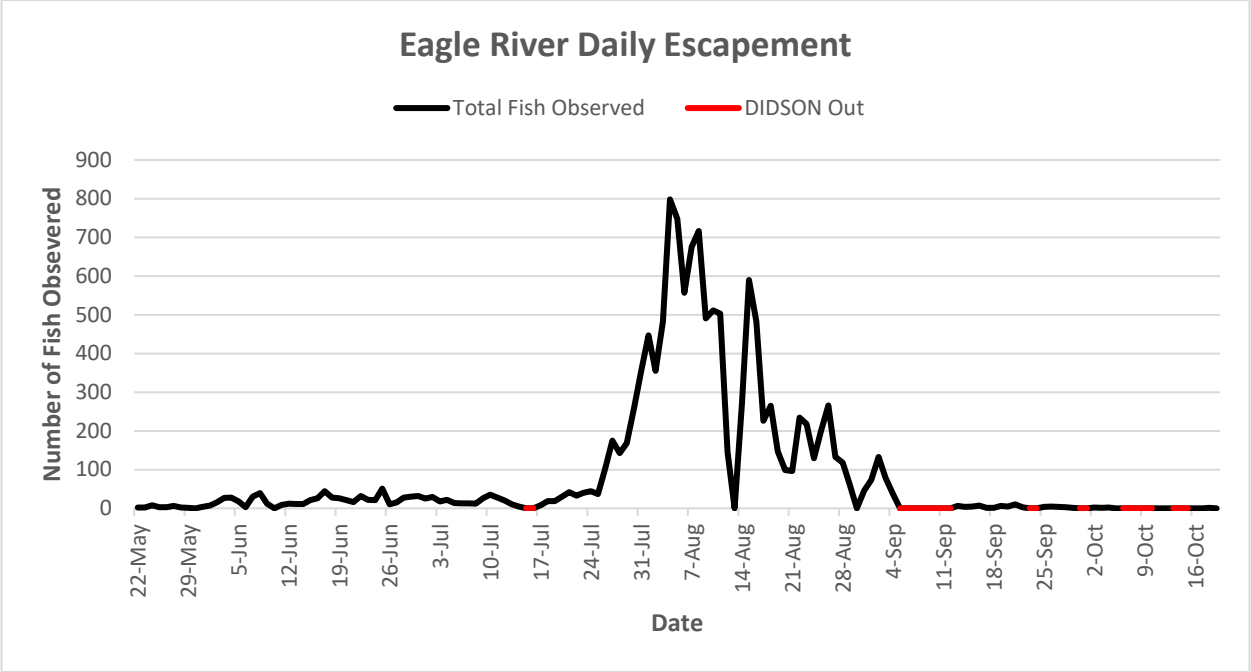

Figure 4. Eagle River DIDSON 2017 daily observations. Note: Eagle River daily escapement includes downriver fish observed.

By 2 August, 25% of the total fish observed on the DIDSONs were documented. Five days later, on 7 August, 50% of the total fish observed on the DIDSONs were reached, and, by August 24, 90% of the total 2017 field season fish observed (Figure 5) were recorded. Figure 5 also indicates when the DIDSONs were not operating due to high water, military training, or technical difficulties.

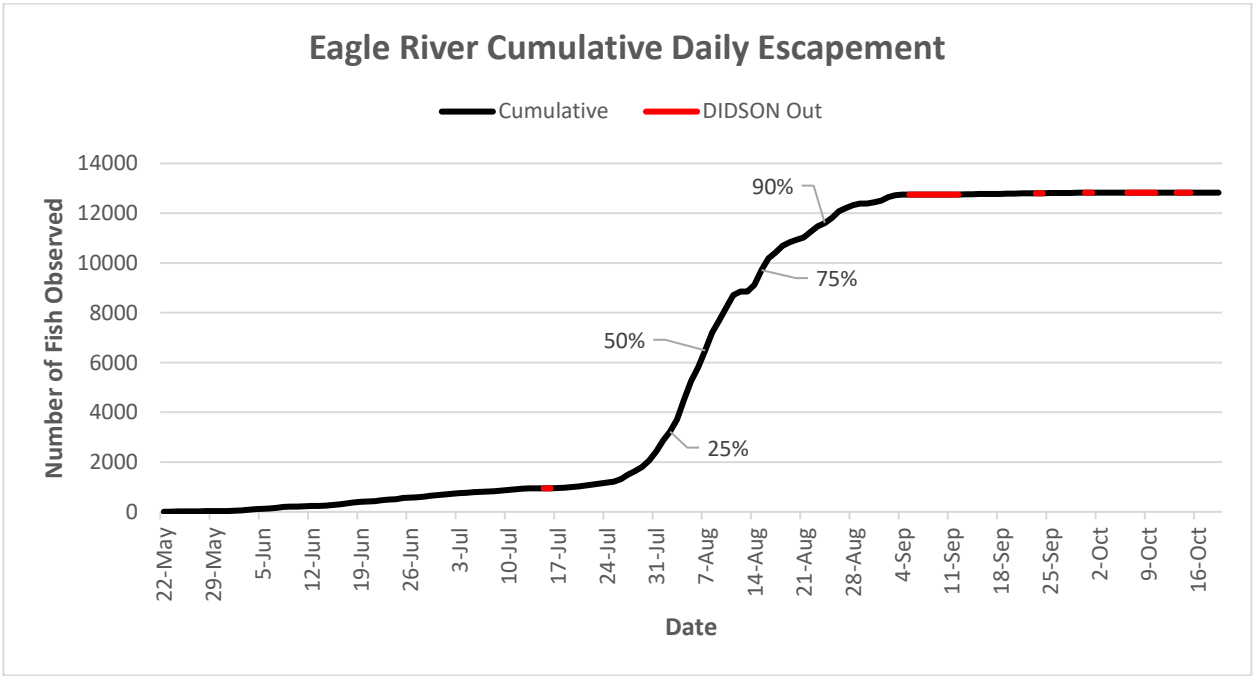

Figure 5. Cumulative daily upriver fish observations for the 2017 field season.

Diurnal Patterns

The diurnal movements of the observed fish were examined for the 2017 field season. All of the DIDSON data was plotted against a 24-hour day, see Figure 6. Higher observed movement rates occurred between 1300 and 0000 with a peak of 984 fish counted at 2000, while the lower observed movement rates occurred between 0100 and 1200 with a low of 198 fish counted at 0500.

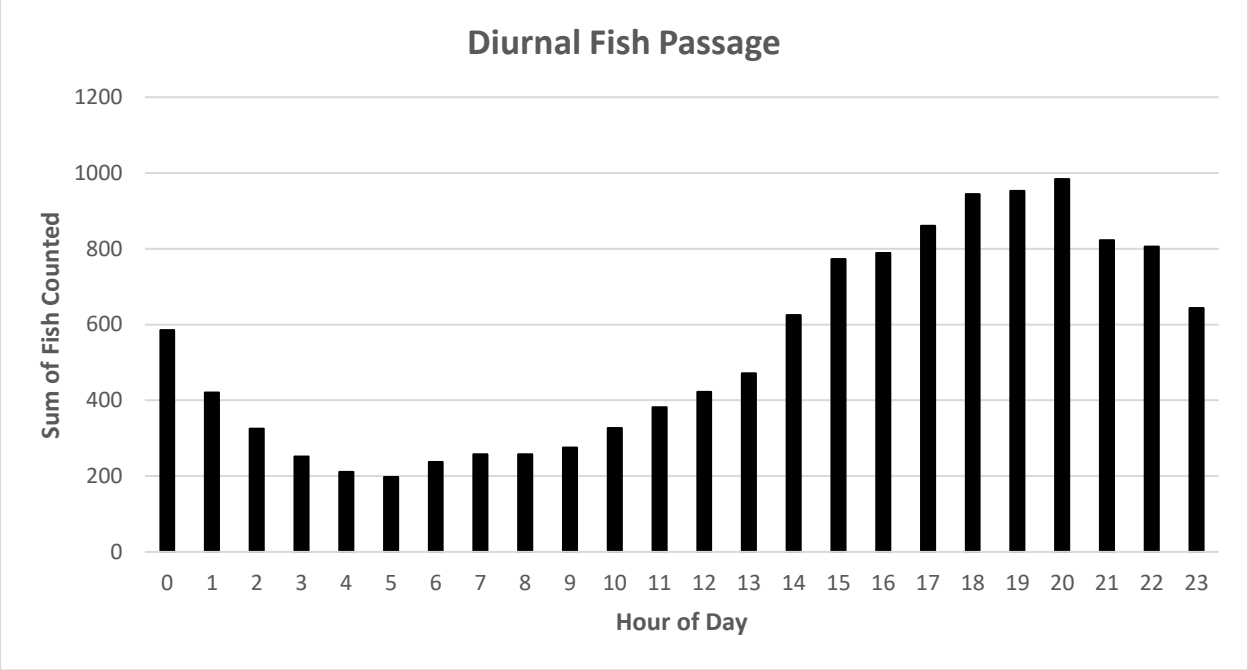

Figure 6. Diurnal pattern of all fish observation by hour of the day for 2017.

Cross Channel Distribution

Figure 7 shows the range of distribution of both upriver and downriver fish as they passed the DIDSONs. The first DIDSON recorded the near image, which was set for the first 0-20 m and the field of view ranged between the first 0-20 m. The second DIDSON recorded the far image, which was set for 20-40 m and the field of view ranged from 10-40 m, depending on the river height. The alteration 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 so that they can 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 were observed to travel in the near range with a total of 11,898 or 92.8%, within the 0-6 m range of the DIDSONs, 786 or 6.1% within the 6-20 m range, and 140 or 1.1% within the 20-40 m range. It is important to note that because the range of the DIDSONs fluctuated with the height of the river, the range does not start at a fixed point from the bank.

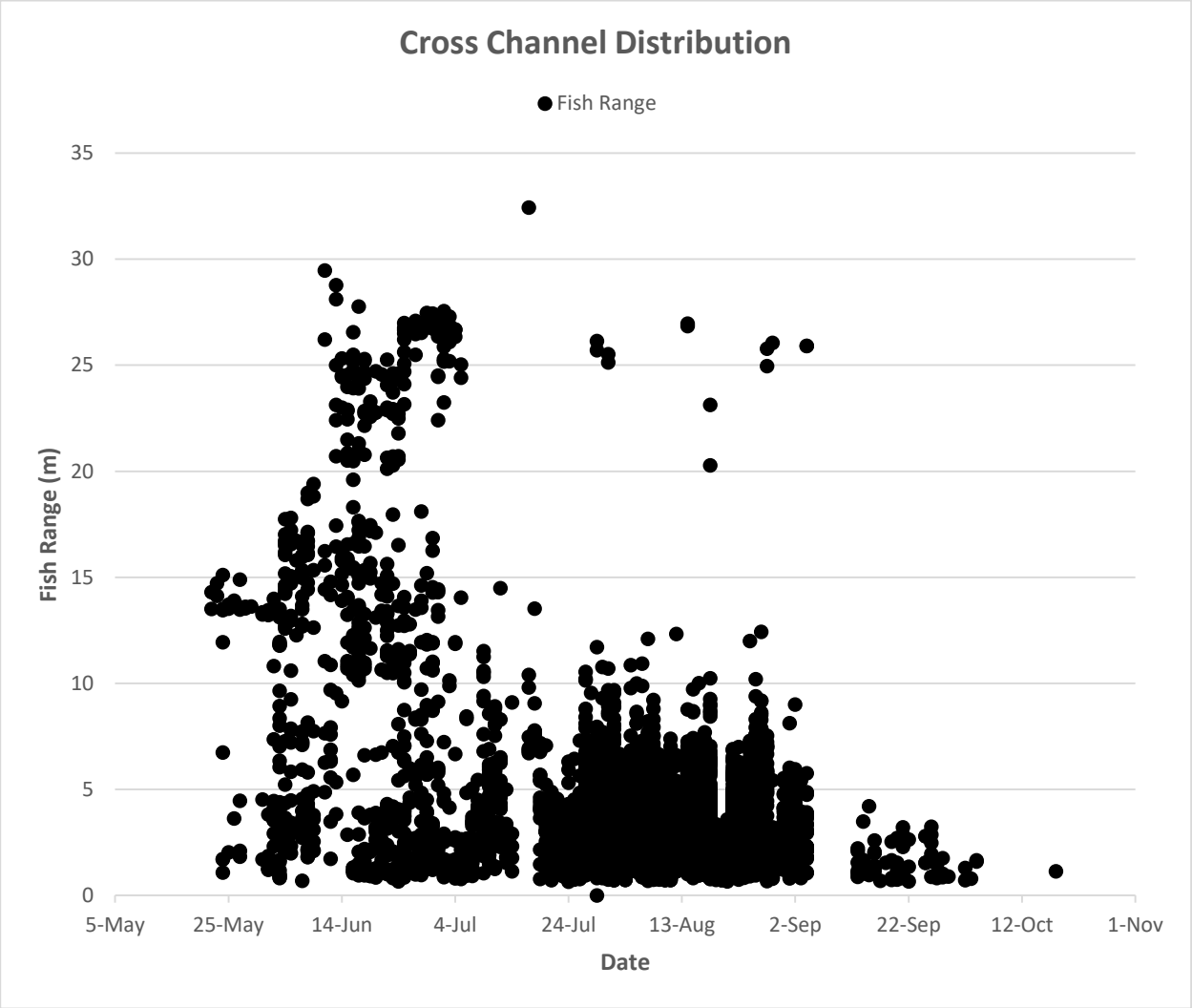

Figure 7. Cross channel distribution all fish observed plotted against the site staff gauge in Eagle River.

Annual Comparative Data

Figure 8 and 9 illustrate the data collected since the introduction of the project in 2012 and continuation through 2017. Both figures display that the adult salmon run begins in May, peaks in July and August, and tapers off throughout September and October. The daily peak of the 2012 season occurred on 31 July with 171 fish. The daily peak for the 2014 season occurred on 6 August with 227 fish. The daily peak of the 2015 season occurred on 2 August with 598 fish. The daily peak of the 2016 season occurred on 16 August with 700 fish. The daily peak of the 2017 season occurred on 4 August with 798 fish. The earliest date a fish was documented occurred on 17 May 2012 and the latest a fish was documented occurred on 18 October 2017.

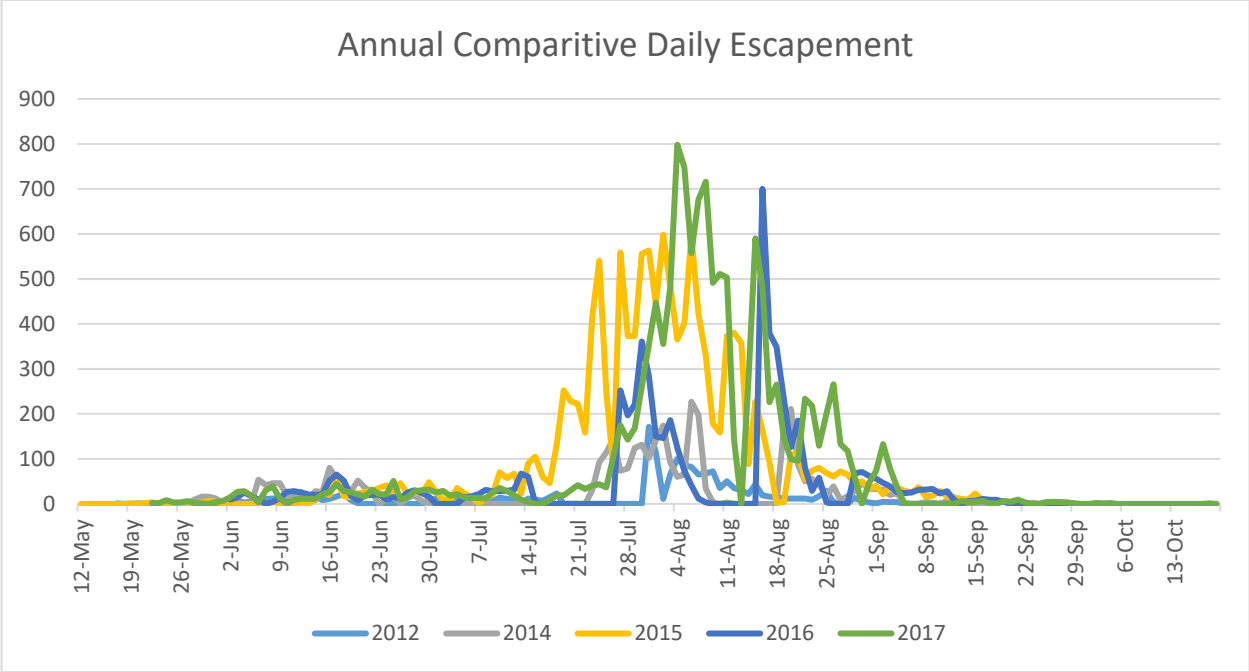

Figure 8. Daily comparison of adult salmon escapement from 2012-2017. [1]

TABLE 1: Season by season cumulative of upstream and downstream fish counted.

YEAR	2012	2013	2014	2015	2016	2017
SEASON TOTAL	1646	No Data	3600	12755	5778	12824

[1] In 2013, the DIDSON equipment was damaged due to flooding and data was not able to be collected for the season.

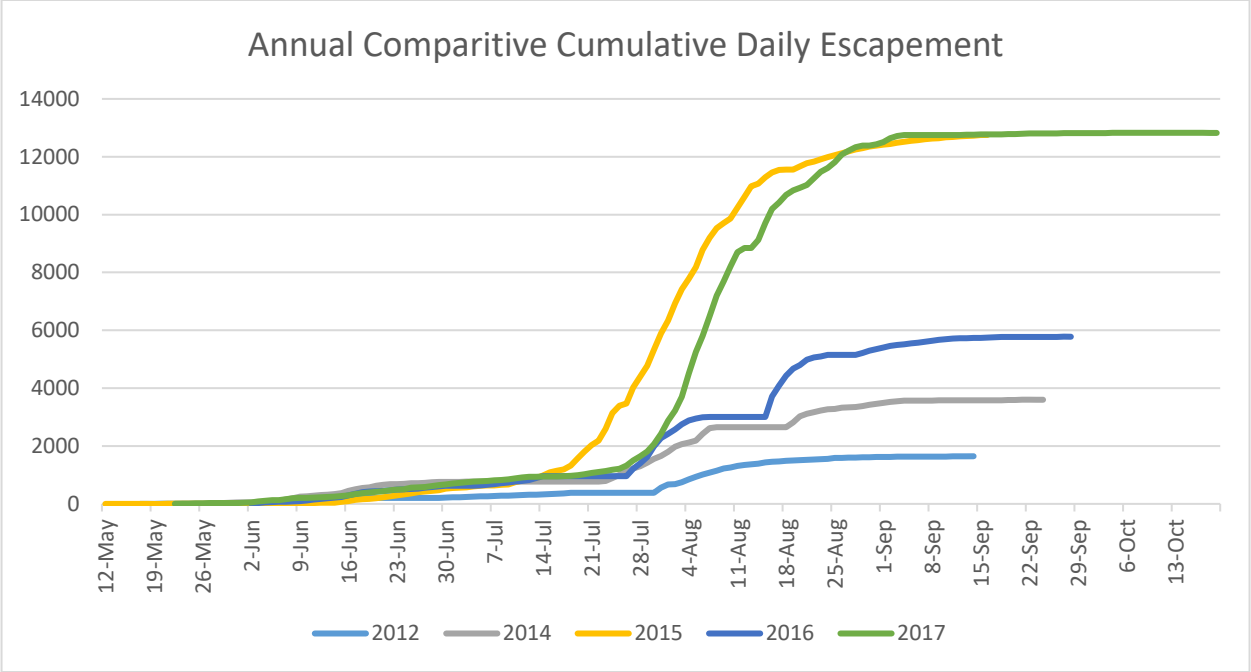

Figure 9. Daily cumulative daily comparison of adult salmon escapement from 2012-2017.[2]

Site Staff Gauge

During the 2017 field season, the DIDSONs were removed from the river for a total of 244.5 hours (10.2 days) due to high water or anticipated high water events. The operational threshold for the DIDSONs has been 0.91 m on the site staff gauge in past years. However, the location where the staff gauge is installed does not remain at a consistent level due to environmental impact (both erosion and/or silt build up). The longest period of time that the DIDSONs were removed from the river due to high water (combined with a military training exercise) was from 4 September through 13 September.

DISCUSSION

Adult salmon enumeration in Eagle River is challenging, requires specialized in-river equipment, and the proper selection of sampling techniques. Deployment and adjustment of equipment is difficult because of the river's high CFS rate and substantial fluctuations in water levels. Site selection and equipment placement is critical to the successful use of the DIDSONs. Support equipment including mounts to hold the DIDSONs, 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 needs to be communicated daily, and all military training activities take precedence over fisheries sampling. There were

[2] In 2013, the DIDSON equipment was damaged due to flooding and data was not able to be collected for the season.

only a few instances when the training took place during the normal workday when field crews could not access the site. However, the site could usually be accessed early morning or during evening hours, before and after training, to record data or shut down the equipment.

There have been changes to the operational protocol for this project and therefore distorts the average of total observed fish over the six-year history of the project (Figure 8 and 9). This was due to multiple reasons. From 2012 until the 2014, a single sonar was utilized in the river. Therefore, the methods for enumerating fish consisted of recording 15-minute intervals in the near and then 15-minute intervals in the far, alternating every 15 minutes in an effort to capture fish passage in the entire span of the river. The methods of reviewing the data files captured by the DIDSONs were completed using a system integrated in the DIDSON software called CSOTs. The CSOTs reviewed each 15-minute file and consolidated what it identified as fish passage into files, and technicians subsequently reviewed those files. At the end of the season, the daily fish data files were multiplied by two to estimate the approximate total fish passage that was unaccounted for with just one sonar. Although the logic applied for lack of equipment, once another DIDSON was installed, the data showed that it was imperative to have two DIDSONs utilized at all times to gather accurate data.

In 2013, the DIDSON and other pieces of equipment experienced some damage due to flooding at the site and was deployed for a brief period before the season ended. In 2015, a second DIDSON was added to the project and two DIDSONs were deployed into the river for the 2015, 2016, and 2017 field seasons. The implementation of the second DIDSON allowed for a comprehensive view (100% when both sonars were deployed, working properly, and have a good field of view) of the river and accurate enumeration of fish passage. Beginning in 2015, the methods for enumerating fish in data files changed. After completing some quality control of previous seasons using the CSOTs, it was discovered that the CSOT program was not identifying all of the fish passage. Eagle River is a glacier-fed river system and has silt flowing through it. Combined with other factors like high turbidity, rapidly changing water depth, and other interference, it makes it very difficult to for the CSOTs to capture all of the movement upstream and downstream. This discovery led to raw data review by technicians for every 15-minute interval recorded. After the switch to a two DIDSON system and raw data review, the total fish numbers increased.

In 2016, the methods remained the same as the previous year and were successful, however, numerous high water events led to the DIDSONs being removed from the river for long periods. These high water events mostly occurred during peak run times in July and August. Because of the low sampling percentage during critical times of the field season, it is estimated that some of the fish passage was not

able to be counted. Removing the DIDSONs out of the river at those times caused detrimental gaps in data and left an incomplete enumeration for the season.

During the 2017 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 12,439 adult salmon were observed moving upriver. The use of the dual DIDSON system is thought to produce more accurate fish totals because the counts are based on actual fish observed instead of calculated assumptions, as completed in previous years. The 2017 field season numbers are considered estimates because there was no guarantee in identification of species of any of the fish that were counted, and some fish counted could have been large Dolly Varden or rainbow trout.

The main limitation to the 2017 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 150 days, 118 of which were sampled, 32 of which were not sampled for aforementioned reasons, yielding a sampling percentage of 78%. Although a 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. 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 8.8 days, from 4 September to 13 September. Although it was not at the peak run time, it caused a gap in data at the tail end of the run.

Eagle River discharge is driven by high elevation snowmelt, glacier melt, and 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 cause high water and flooding.

During the 2017 field season, it was proven 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 (National Weather Service) and the site staff gauge, the two gauges correlated effectively and showed the water peaks occurred at the same time, with an approximate two foot 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.

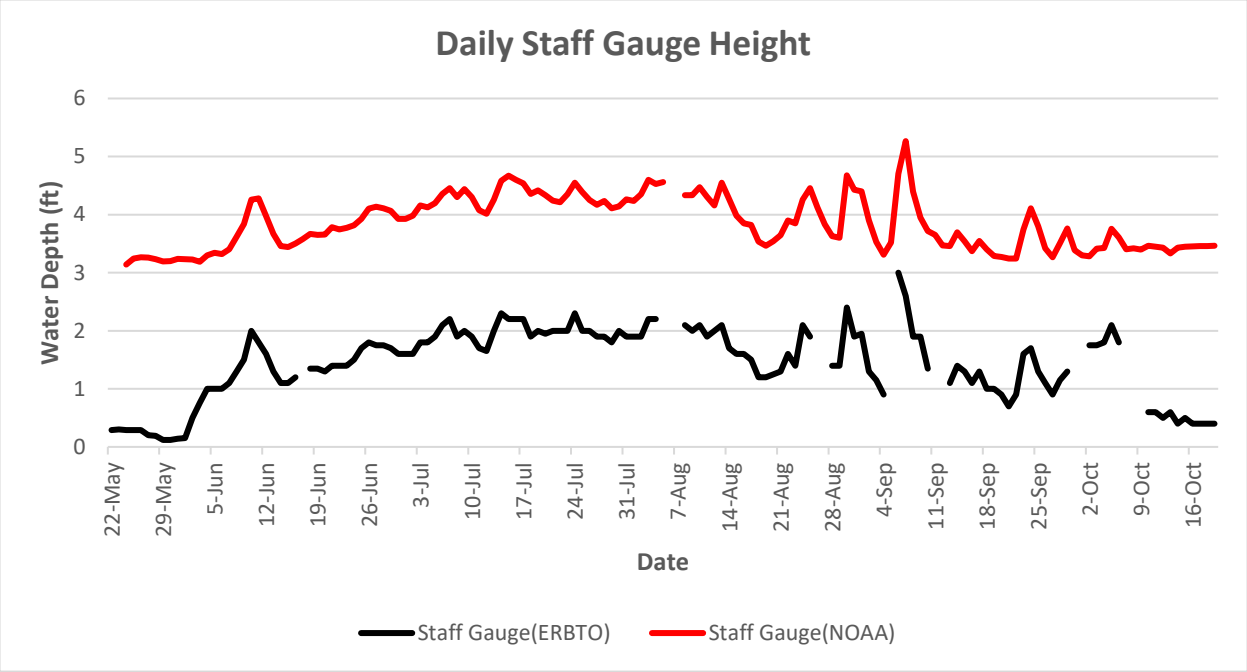

Figure 10. Comparison of Eagle River daily averaged depth at the Glenn Highway Bridge and on-site location[3].

CONCLUSION

The adult salmon enumeration project in Eagle River on JBER concluded its sixth field season in 2017. A total of 12,439 salmon were observed moving upriver on the DIDSONs in 2017, which is considered an average run size 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 throughout 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 traveling upstream of the sample site.

[3] On site location staff gauge readings were taken once a day in the morning at varying times and therefore are not daily averages. NOAA staff gauge depths were averaged from 24 daily measurements on the hour.

RECOMMENDATIONS

1. One of the biggest challenges this project faces is rapidly fluctuating water depths and high flow events. Two suggested options for this challenge are:
    a. Increase the DIDSON's high water operational threshold as suggested in U.S. Army Corps of Engineers, Alaska District (USACE) 2013 report.
    b. Alternatively, adjust the gear in the river according to the weather forecasts and technician comfortability.
2. Water temperature plays a role in the migration of the salmon (Wilson and Kelly 1984). It is suggested that water temperature continue to 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 2017 season that 92.8% of fish travelled within 6 meters of the near bank DIDSON, which suggests a preferred 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 critical to enumerate salmon accurately within the river. It is highly recommended that a dual DIDSON system continue to be used in the future. If only one image can be utilized, prioritize the near, especially 0-10m.
5. Continue start dates in mid-late May and end dates in October to ensure capturing the run of adult salmon in its entirety.
6. There are inconsistencies between years on how gap days are defined due to partial days being recorded. Going forward, using 24 hour increments and Julian dates will make a more accurate assessment of the amount of time sampled.

ACKNOWLEDGEMENTS

This study would not have been successful without the efforts of the field technicians: Samuel Satre, Emily Hughes, Connor Cleary, and Christina Howell. 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 Jessica Johnson, the former Fisheries Biologist, for her efforts in previous years and for part of the season this year. We would also like to thank Mr. Bill Hanot at Sound Metrics Corp. for his assistance with the synchronizing and troubleshooting of the DIDSONs. We would also like to thank the technicians from other programs and their supervisors for their assistance in removal of equipment during high water events.

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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
22-May	2	0	2	2
23-May	0	2	2	4
24-May	4	4	8	12
25-May	1	2	3	15
26-May	1	2	3	18
27-May	3	3	6	24
28-May	0	2	2	26
29-May	0	1	1	27
30-May	0	0	0	27
31-May	2	2	4	31
1-Jun	5	2	7	38
2-Jun	13	2	15	53
3-Jun	21	6	27	80
4-Jun	13	15	28	108
5-Jun	10	8	18	126
6-Jun	0	3	3	129
7-Jun	17	13	30	159
8-Jun	28	11	39	198
9-Jun	8	4	12	210
10-Jun	0	0	0	210
11-Jun	9	0	9	219
12-Jun	12	0	12	231
13-Jun	11	0	11	242
14-Jun	11	0	11	253

All Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
15-Jun	13	8	21	274
16-Jun	6	20	26	300
17-Jun	15	29	44	344
18-Jun	12	16	28	372
19-Jun	13	13	26	398
20-Jun	16	5	21	419
21-Jun	9	7	16	435
22-Jun	10	22	32	467
23-Jun	9	13	22	489
24-Jun	9	12	21	510
25-Jun	35	16	51	561
26-Jun	6	4	10	571
27-Jun	11	4	15	586
28-Jun	21	7	28	614
29-Jun	25	5	30	644
30-Jun	16	16	32	676
1-Jul	14	11	25	701
2-Jul	19	10	29	730
3-Jul	12	6	18	748
4-Jul	17	5	22	770
5-Jul	11	3	14	784
6-Jul	13	0	13	797
7-Jul	13	0	13	810
8-Jul	12	0	12	822
9-Jul	21	5	26	848
10-Jul	35	0	35	883
11-Jul	28	0	28	911

All Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
12-Jul	20	0	20	931
13-Jul	10	0	10	941
14-Jul	5	0	5	946
15-Jul	0	0	0	946
16-Jul	0	0	0	946
17-Jul	7	1	8	954
18-Jul	19	0	19	973
19-Jul	19	0	19	992
20-Jul	30	0	30	1022
21-Jul	42	0	42	1064
22-Jul	33	0	33	1097
23-Jul	40	0	40	1137
24-Jul	44	0	44	1181
25-Jul	37	0	37	1218
26-Jul	104	0	104	1322
27-Jul	175	0	175	1497
28-Jul	143	0	143	1640
29-Jul	166	2	168	1808
30-Jul	260	0	260	2068
31-Jul	352	2	354	2422
1-Aug	447	0	447	2869
2-Aug	355	0	355	3224
3-Aug	482	0	482	3706
4-Aug	798	0	798	4504
5-Aug	748	0	748	5252
6-Aug	557	0	557	5809
7-Aug	676	0	676	6485

All Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
8-Aug	716	0	716	7201
9-Aug	491	0	491	7692
10-Aug	511	0	511	8203
11-Aug	503	0	503	8706
12-Aug	145	0	145	8851
13-Aug	0	0	0	8851
14-Aug	269	2	271	9122
15-Aug	590	0	590	9712
16-Aug	482	0	482	10194
17-Aug	226	0	226	10420
18-Aug	263	2	265	10685
19-Aug	147	0	147	10832
20-Aug	99	0	99	10931
21-Aug	96	0	96	11027
22-Aug	234	0	234	11261
23-Aug	218	0	218	11479
24-Aug	129	0	129	11608
25-Aug	200	0	200	11808
26-Aug	266	0	266	12074
27-Aug	133	0	133	12207
28-Aug	116	2	118	12325
29-Aug	60	1	61	12386
30-Aug	0	0	0	12386
31-Aug	46	0	46	12432
1-Sep	73	0	73	12505
2-Sep	133	0	133	12638
3-Sep	78	0	78	12716

All Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
4-Sep	35	2	37	12753
5-Sep	0	0	0	12753
6-Sep	0	0	0	12753
7-Sep	0	0	0	12753
8-Sep	0	0	0	12753
9-Sep	0	0	0	12753
10-Sep	0	0	0	12753
11-Sep	0	0	0	12753
12-Sep	0	0	0	12753
13-Sep	6	0	6	12759
14-Sep	4	0	4	12763
15-Sep	5	0	5	12768
16-Sep	7	0	7	12775
17-Sep	1	0	1	12776
18-Sep	1	0	1	12777
19-Sep	6	0	6	12783
20-Sep	5	0	5	12788
21-Sep	10	0	10	12798
22-Sep	3	0	3	12801
23-Sep	0	0	0	12801
24-Sep	0	0	0	12801
25-Sep	4	0	4	12805
26-Sep	5	0	5	12810
27-Sep	4	0	4	12814
28-Sep	3	0	3	12817
29-Sep	1	0	1	12818
30-Sep	0	0	0	12818

All Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
1-Oct	0	0	0	12818
2-Oct	2	0	2	12820
3-Oct	1	0	1	12821
4-Oct	2	0	2	12823
5-Oct	0	0	0	12823
6-Oct	0	0	0	12823
7-Oct	0	0	0	12823
8-Oct	0	0	0	12823
9-Oct	0	0	0	12823
10-Oct	0	0	0	12823
11-Oct	0	0	0	12823
12-Oct	0	0	0	12823
13-Oct	0	0	0	12823
14-Oct	0	0	0	12823
15-Oct	0	0	0	12823
16-Oct	0	0	0	12823
17-Oct	0	0	0	12823
18-Oct	1	0	1	12824
19-Oct	0	0	0	12824

Appendix A- Numbers highlighted in red denote that DIDSONS were out of the water or not recording.

Appendix B: DIDSON Daily Observed Downstream Fish Counts.

Downstream Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
22-May	0	0	0	0
23-May	0	0	0	0
24-May	1	0	1	1
25-May	0	0	0	1
26-May	0	0	0	1
27-May	0	0	0	1
28-May	0	0	0	1
29-May	0	0	0	1
30-May	0	0	0	1
31-May	0	0	0	1
1-Jun	0	1	1	2
2-Jun	0	0	0	2
3-Jun	4	0	4	6
4-Jun	1	1	2	8
5-Jun	1	0	1	9
6-Jun	0	3	3	12
7-Jun	0	0	0	12
8-Jun	1	0	1	13
9-Jun	0	0	0	13
10-Jun	0	0	0	13
11-Jun	0	0	0	13
12-Jun	1	0	1	14
13-Jun	2	0	2	16
14-Jun	2	0	2	18

Downstream Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
15-Jun	2	1	3	21
16-Jun	0	4	4	25
17-Jun	1	9	10	35
18-Jun	0	0	0	35
19-Jun	0	2	2	37
20-Jun	0	2	2	39
21-Jun	0	0	0	39
22-Jun	3	1	4	43
23-Jun	1	2	3	46
24-Jun	0	1	1	47
25-Jun	0	1	1	48
26-Jun	0	0	0	48
27-Jun	0	0	0	48
28-Jun	0	1	1	49
29-Jun	0	0	0	49
30-Jun	0	3	3	52
1-Jul	0	0	0	52
2-Jul	0	0	0	52
3-Jul	0	0	0	52
4-Jul	0	0	0	52
5-Jul	0	0	0	52
6-Jul	0	0	0	52
7-Jul	0	0	0	52
8-Jul	0	0	0	52
9-Jul	1	0	1	53
10-Jul	0	0	0	53
11-Jul	0	0	0	53

Downstream Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
12-Jul	0	0	0	53
13-Jul	0	0	0	53
14-Jul	0	0	0	53
15-Jul	0	0	0	53
16-Jul	0	0	0	53
17-Jul	0	0	0	53
18-Jul	0	0	0	53
19-Jul	0	0	0	53
20-Jul	1	0	1	54
21-Jul	1	0	1	55
22-Jul	0	0	0	55
23-Jul	1	0	1	56
24-Jul	0	0	0	56
25-Jul	0	0	0	56
26-Jul	3	0	3	59
27-Jul	14	0	14	73
28-Jul	11	0	11	84
29-Jul	11	0	11	95
30-Jul	28	0	28	123
31-Jul	10	0	10	133
1-Aug	6	0	6	139
2-Aug	17	0	17	156
3-Aug	10	0	10	166
4-Aug	20	0	20	186
5-Aug	36	0	36	222
6-Aug	2	0	2	224
7-Aug	30	0	30	254

Downstream Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
8-Aug	19	0	19	273
9-Aug	9	0	9	282
10-Aug	2	0	2	284
11-Aug	8	0	8	292
12-Aug	4	0	4	296
13-Aug	0	0	0	296
14-Aug	11	0	11	307
15-Aug	15	0	15	322
16-Aug	9	0	9	331
17-Aug	0	0	0	331
18-Aug	18	0	18	349
19-Aug	0	0	0	349
20-Aug	0	0	0	349
21-Aug	1	0	1	350
22-Aug	6	0	6	356
23-Aug	10	0	10	366
24-Aug	1	0	1	367
25-Aug	1	0	1	368
26-Aug	4	0	4	372
27-Aug	3	0	3	375
28-Aug	5	0	5	380
29-Aug	2	0	2	382
30-Aug	0	0	0	382
31-Aug	0	0	0	382
1-Sep	1	0	1	383
2-Sep	2	0	2	385
3-Sep	0	0	0	385

Downstream Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
4-Sep	0	0	0	385
5-Sep	0	0	0	385
6-Sep	0	0	0	385
7-Sep	0	0	0	385
8-Sep	0	0	0	385
9-Sep	0	0	0	385
10-Sep	0	0	0	385
11-Sep	0	0	0	385
12-Sep	0	0	0	385
13-Sep	0	0	0	385
14-Sep	0	0	0	385
15-Sep	0	0	0	385
16-Sep	0	0	0	385
17-Sep	0	0	0	385
18-Sep	0	0	0	385
19-Sep	0	0	0	385
20-Sep	0	0	0	385
21-Sep	0	0	0	385
22-Sep	0	0	0	385
23-Sep	0	0	0	385
24-Sep	0	0	0	385
25-Sep	0	0	0	385
26-Sep	0	0	0	385
27-Sep	0	0	0	385
28-Sep	0	0	0	385
29-Sep	0	0	0	385
30-Sep	0	0	0	385

Downstream Fish Observed				
	Near	Far	Near + Far	
Date	Fish Observed	Fish Observed	Total Fish Observed	Cumulative
1-Oct	0	0	0	385
2-Oct	0	0	0	385
3-Oct	0	0	0	385
4-Oct	0	0	0	385
5-Oct	0	0	0	385
6-Oct	0	0	0	385
7-Oct	0	0	0	385
8-Oct	0	0	0	385
9-Oct	0	0	0	385
10-Oct	0	0	0	385
11-Oct	0	0	0	385
12-Oct	0	0	0	385
13-Oct	0	0	0	385
14-Oct	0	0	0	385
15-Oct	0	0	0	385
16-Oct	0	0	0	385
17-Oct	0	0	0	385
18-Oct	0	0	0	385
19-Oct	0	0	0	385

Appendix B- Numbers highlighted in red denote that DIDSONS were out of the water or not recording.

Appendix C: Mean Daily Eagle River Depth, Ambient Air Temperature, and water temperature.

Date	NOAA Height (ft)	Sample Site Height (ft)	Air Temperature (°C)	Water Temperature (°C)
22-May	0.29			
23-May	0.3			
24-May	0.29	3.14		
25-May	0.29	3.25		
26-May	0.29	3.26		
27-May	0.2	3.26		
28-May	0.19	3.24		
29-May	0.12	3.20		
30-May	0.12	3.20		
31-May	0.14	3.24		
1-Jun	0.15	3.23		
2-Jun	0.5	3.23		
3-Jun	0.76	3.19		
4-Jun	1	3.30		
5-Jun	1	3.34	14.9	8.6
6-Jun	1	3.32	11.7	9.0
7-Jun	1.1	3.40	13.4	9.2
8-Jun	1.3	3.62	14.2	8.7
9-Jun	1.5	3.84	14.9	8.5
10-Jun	2	4.26	11.7	8.4
11-Jun	1.8	4.28	11.8	6.9
12-Jun	1.6	3.98	10.8	7.5
13-Jun	1.3	3.67	11.9	7.4
14-Jun	1.1	3.46	12.7	7.8

Date	NOAA Height (ft)	Sample Site Height (ft)	Air Temperature (°C)	Water Temperature (°C)
15-Jun	1.1	3.44	13.0	8.5
16-Jun	1.2	3.50	14.5	9.4
17-Jun		3.58	13.6	9.2
18-Jun	1.35	3.67	13.1	9.1
19-Jun	1.35	3.65	11.6	8.7
20-Jun	1.3	3.66	11.6	8.1
21-Jun	1.4	3.78	12.2	7.7
22-Jun	1.4	3.74	12.3	8.1
23-Jun	1.4	3.77	12.0	8.0
24-Jun	1.5	3.82	13.9	8.1
25-Jun	1.7	3.93	15.3	9.6
26-Jun	1.8	4.10	12.2	9.3
27-Jun	1.75	4.13	12.3	8.0
28-Jun	1.75	4.11	14.0	8.0
29-Jun	1.7	4.07	11.7	8.2
30-Jun	1.6	3.92	13.7	7.6
1-Jul	1.6	3.92	14.2	8.4
2-Jul	1.6	3.98	11.3	8.0
3-Jul	1.8	4.16	11.3	7.5
4-Jul	1.8	4.12	14.2	7.7
5-Jul	1.9	4.20	15.8	8.7
6-Jul	2.1	4.36	15.0	9.9
7-Jul	2.2	4.45	15.3	9.6
8-Jul	1.9	4.30	11.4	8.3
9-Jul	2	4.44	12.9	7.5
10-Jul	1.9	4.30	11.9	8.3
11-Jul	1.7	4.08	13.4	8.3

Date	NOAA Height (ft)	Sample Site Height (ft)	Air Temperature (°C)	Water Temperature (°C)
12-Jul	1.65	4.02	15.2	8.8
13-Jul	2	4.26	14.9	9.8
14-Jul	2.3	4.58	15.8	9.4
15-Jul	2.2	4.67	15.7	9.2
16-Jul	2.2	4.60	14.5	9.0
17-Jul	2.2	4.54	13.0	8.8
18-Jul	1.9	4.36	11.9	7.6
19-Jul	2	4.42	10.2	7.2
20-Jul	1.95	4.34	13.5	7.2
21-Jul	2	4.24	14.5	8.7
22-Jul	2	4.21	14.6	9.1
23-Jul	2	4.35	15.5	9.3
24-Jul	2.3	4.55	13.4	8.7
25-Jul	2	4.39	11.4	7.5
26-Jul	2	4.25	11.9	7.1
27-Jul	1.9	4.17	14.1	7.8
28-Jul	1.9	4.24	12.4	8.2
29-Jul	1.8	4.11	13.5	7.6
30-Jul	2	4.14	13.4	7.5
31-Jul	1.9	4.26	13.4	8.2
1-Aug	1.9	4.24	12.9	7.9
2-Aug	1.9	4.35	11.6	7.6
3-Aug	2.2	4.60	11.7	7.3
4-Aug	2.2	4.53	14.0	8.0
5-Aug		4.56	14.2	8.3
6-Aug			14.3	8.5
7-Aug			12.8	8.3

Date	NOAA Height (ft)	Sample Site Height (ft)	Air Temperature (°C)	Water Temperature (°C)
8-Aug	2.1	4.34	14.2	8.2
9-Aug	2	4.33	11.4	7.8
10-Aug	2.1	4.47	12.2	7.2
11-Aug	1.9	4.31	10.4	7.0
12-Aug	2	4.16	10.5	6.5
13-Aug	2.1	4.55	10.6	6.4
14-Aug	1.7	4.27	11.1	6.3
15-Aug	1.6	3.98	12.4	7.1
16-Aug	1.6	3.85	9.7	7.2
17-Aug	1.5	3.82	10.3	6.5
18-Aug	1.2	3.53	10.1	7.0
19-Aug	1.2	3.46	11.6	7.1
20-Aug	1.25	3.54	9.7	7.2
21-Aug	1.3	3.65	9.7	6.6
22-Aug	1.6	3.90	12.6	7.2
23-Aug	1.4	3.85	10.1	7.5
24-Aug	2.1	4.26	10.0	6.8
25-Aug	1.9	4.46	10.2	6.4
26-Aug		4.12	11.6	6.7
27-Aug		3.84	10.5	7.0
28-Aug	1.4	3.63	9.9	7.1
29-Aug	1.4	3.60	11.2	7.2
30-Aug	2.4	4.68	9.8	6.2
31-Aug	1.9	4.43	7.8	5.9
1-Sep	1.95	4.40	9.3	5.9
2-Sep	1.3	3.90	8.8	6.1
3-Sep	1.15	3.53	6.7	6.2

Date	NOAA Height (ft)	Sample Site Height (ft)	Air Temperature (°C)	Water Temperature (°C)
4-Sep	0.9	3.31	10.0	6.2
5-Sep		3.52	7.1	6.4
6-Sep	3	4.70	8.2	6.0
7-Sep	2.6	5.27	7.0	5.5
8-Sep	1.9	4.40	8.0	5.4
9-Sep	1.9	3.95	9.4	5.9
10-Sep	1.35	3.72	9.3	6.3
11-Sep		3.65	9.7	6.6
12-Sep		3.47	7.3	6.0
13-Sep	1.1	3.46	12.7	7.0
14-Sep	1.4	3.70	10.1	6.5
15-Sep	1.3	3.54	10.1	6.5
16-Sep	1.1	3.37	8.0	6.6
17-Sep	1.3	3.55	8.5	6.3
18-Sep	1	3.40	8.2	6.4
19-Sep	1	3.29	8.7	6.6
20-Sep	0.9	3.27	5.9	5.9
21-Sep	0.7	3.24	5.8	5.4
22-Sep	0.9	3.24	7.7	6.0
23-Sep	1.6	3.75	7.9	6.1
24-Sep	1.7	4.11	8.3	5.9
25-Sep	1.3	3.80	8.5	6.0
26-Sep	1.1	3.42	5.7	5.2
27-Sep	0.9	3.27	7.9	5.7
28-Sep	1.15	3.51	9.0	6.1
29-Sep	1.3	3.76	8.4	6.0
30-Sep		3.38	5.1	5.8

Date	NOAA Height (ft)	Sample Site Height (ft)	Air Temperature (°C)	Water Temperature (°C)
1-Oct		3.30	1.8	4.3
2-Oct	1.75	3.28	6.2	5.2
3-Oct	1.75	3.41	7.9	6.2
4-Oct	1.8	3.43	8.1	6.0
5-Oct	2.1	3.76	6.7	5.6
6-Oct	1.8	3.61	5.7	4.9
7-Oct		3.40	3.0	4.4
8-Oct		3.42	5.7	4.9
9-Oct		3.40	3.5	4.5
10-Oct	0.6	3.46	6.7	3.8
11-Oct	0.6	3.45	7.3	4.4
12-Oct	0.5	3.43	4.6	4.4
13-Oct	0.6	3.33	5.3	4.8
14-Oct	0.4	3.43	-0.4	3.3
15-Oct	0.5	3.45	-2.0	1.7
16-Oct	0.4	3.46	-3.6	0.7
17-Oct	0.4	3.46	-4.0	-0.2
18-Oct	0.4	3.46	-3.4	-0.3
19-Oct	0.4	3.47	-6.7	-1.7
Average	**1.44**	**3.85**	**10.25**	**6.92**

Appendix C- Any blank cells that were not recorded by either NOAA or the fisheries crew were done for various reasons.

APPENDIX D: DIDSON Sample Times.

				Sampled		Not Sampled	
Date	**Time**	**Action**	**Comment**	**Days**	**Hours**	**Days**	**Hours**
5/22/17	13:15	Start	First day.				0.0
7/14/17	10:45	Stop	High Water Event Caution.	52.9	1269.5		
7/17/17	14:30	Start				3.2	75.8
8/12/17	12:30	Stop	High Water Event Caution.	25.9	622.0		
8/14/17	13:45	Start				2.1	49.2
8/21/17	16:30	Stop	High Water Event Caution.	7.1	170.8		
8/22/17	11:15	Start				0.8	18.8
8/30/17	10:00	Stop	High Water Event. Needed assistance from other crews to remove gear.	7.9	190.7		
8/31/17	10:50	Start				1.0	24.8
9/4/17	15:00	Stop	Not allowed into Eagle River because of military training, and then subsequent high water event.	4.2	100.2		
9/13/17	10:20	Start				8.8	211.3
9/22/17	8:30	Stop	Removed gear in anticipation of heavy rain (high water event).	8.9	214.2		
9/25/17	12:25	Start				3.2	75.9
9/29/17	13:45	Stop	Not enough staff to work weekends.	4.1	97.3		
10/2/17	12:20	Start				2.9	70.6
10/5/17	13:45	Stop	Not enough staff to work weekends/schedule conflict.	3.1	73.4		
10/11/17	15:30	Start				6.1	145.8
10/12/17	9:40	Stop	DIDSON malfunction (not recording).	0.8	18.2		
10/16/17	9:20	Start				4.0	95.7
10/19/17	12:45	Stop	Season end.	3.1	75.4		

TOTAL DIDSON STUDY PERIOD	150 DAYS	3600 HOURS
SAMPLED	118 DAYS	2831.7 HOURS
NOT SAMPLED	32 DAYS	767.8 HOURS
PERCENTAGE SAMPLED	79%	
PERCENTAGE NOT SAMPLED	21%	