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Assessment of the Performance of a DIDSON (Dual Frequency IDentification SONar) to Count Steelhead in Peterson Creek, 2009

by

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and

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August 2012

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

There is a need for a reliable counting method as an alternative to a standard weir to assess steelhead trout *(Oncorhynchus mykiss)* escapement in remote streams in Southeast Alaska. The Alaska Department of Fish and Game tested a Dual Frequency Identification Sonar (DIDSON) in Peterson Creek to count a small stock (*N* approximately 200) of ocean-maturing steelhead in 2009. The DIDSON was operated in an 8-m wide section of stream, and provided near video quality images of steelhead. Detection of steelhead by the DIDSON allowed for enumeration, direction and time of passage, length estimation, and the cross-sectional range of travel from each image. Analysis of the images collected continuously during the field season resulted in detection of 747 steelhead that swam upstream past the DIDSON, and 445 that swam downstream. Daily upstream/downstream behavior (milling/searching) appears to have artificially inflated the count of adult steelhead at the DIDSON site. To account for this behavior, we used a Decision Support Tool developed by the National Marine Fisheries Service Southwest Fisheries Science Center that matched images of adult steelhead moving in opposite directions using elapsed time, length, and group size to determine which steelhead images were likely the same fish. The tool did not work for our purposes. The two major problems were milling and unequal detection of upstream and downstream moving steelhead. The milling behavior of steelhead in Peterson Creek interfered with all aspects of this project. While the DIDSON shows promise for counting iteroparous adult steelhead in small streams in Southeast Alaska, more rigorous protocols must be developed to account for daily migratory behavior of adult steelhead, as well as validation methods.

Key words: Southeast Alaska, steelhead, DIDSON, sonar, milling behavior, Decision Support Tool, Peterson Creek, *Oncorhynchus mykiss*

INTRODUCTION

As part of the ongoing monitoring program for steelhead trout *(Oncorhynchus mykiss)* in Southeast Alaska (SEAK), the Alaska Department of Fish and Game (ADF&G) Division of Sport Fish is continuing to research less intrusive methods than the traditional weir for estimating steelhead escapement.

The need to develop a less intrusive and alternative method to estimate adult steelhead escapement in SEAK streams was identified in the *Southeast Alaska Steelhead Strategic Plan*[1]). The motivation stems from concerns and field observations that standard weirs may delay or impede immigration and emigration. Bain et al. (2003) report that the early installation of the Situk River weir in 1992 delayed the spring immigration based on observations of pooling steelhead downstream of the weir by weir personnel.

Once a less intrusive means of estimating steelhead escapement is developed, the escapement numbers collected may be applied to evaluate snorkel survey index counts (Harding 2009). Such a method would also assist ADF&G to develop a habitat-based carrying capacity model for steelhead in SEAK by providing adult escapement data in 4 systems over the next 10 years (Crupi and Nichols 2011). ADF&G Division of Sport Fish staff are developing this model to predict sustainable steelhead production for systems lacking stock assessment data, but based instead on habitat parameters from 8 SEAK streams that have reliable escapement estimates[1].

ADF&G Division of Sport Fish has been evaluating less intrusive methods at Peterson Creek since 2007. During 2007 and 2008 a flat-panel resistivity counter, that is used widely in the United Kingdom and British Columbia, was tested. This "resistivity weir" was not successful (Coyle and Reed *in prep*), and was replaced with a DIDSON™ (Dual frequency IDentification SONar)[2] acoustic camera in the spring of 2009. ADF&G has used DIDSON to count salmon in larger rivers in Southcentral and Interior Alaska (Kerkvliet et al. 2008; Maxwell and Gove 2004), and most recently at Chilkat Lake in Haines (Heinl et al. 2011).

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[1] Unpublished plan developed by Harding, R. D., A. P. Crupi, and D. J. Reed. *Strategic plan for Southeast Alaska steelhead research and monitoring program*. Alaska Department of Fish and Game. Division of Sport Fish. Available through ADF&G, Douglas Alaska. Hereinafter referred to as the *Steelhead Strategic Plan*.

[2] This and subsequent product names are included for a complete description of the process and do not constitute product endorsement.

DIDSON was originally developed by the University of Washington's Applied Physics Laboratory for naval use, including underwater mine detection (Belcher et al. 2001). The ADF&G sonar program was instrumental in developing its use for estimating abundance of Pacific salmon (Burwen et al. 2007; Carroll et al. 2007; Kerkvliet et al 2008; Maxwell and Gove 2004; Sandall and Pfisterer 2006). This sonar provides video-like images when deployed at close range (under 12 m). However, it does not have the conventional limitations of a video camera as it can provide images in turbid water and the dark.

Although DIDSON has been used to count semelparous salmon in large flowing rivers, its use for counting iteroparous steelhead has been demonstrated in only a few systems. Pipal et al. (2010) used DIDSON to count ESA-listed steelhead in 3 small streams in central California: Big Creek, Scott Creek and the San Lorenzo River. Rand et al. (2010) also used DIDSON to count 10,800 steelhead immigrants into the Utkholok River in Kamchatka, Russia. We evaluated the DIDSON acoustic camera at Peterson Creek in 2009 to count steelhead.

Unlike semelparous salmon, iteroparous steelhead migrate both upstream to spawn, and then migrate downstream to return to the ocean to feed. The implication of this parity for counting steelhead is that the counting method should have an equal probability of counting both upstream and downstream fish.

When possible, any new counting technology should be independently verified with some accepted type of counting method. In this study, the DIDSON was used exclusively for a number of reasons. The standard DIDSON, when used in high frequency mode at ranges less than 12 m with low fish passage rates, was potentially more accurate than validation methods such as weirs, counting towers, Bendix sonar, and various video cameras (Holmes et al. 2006; Kerkvliet et al. 2008; Maxwell and Gove 2004). Because stand-alone DIDSONs have been used repeatedly to count salmon in Alaska (Maxwell and Gove 2004; Kerkvliet et al. 2008), and in California to count steelhead in small streams similar to Peterson Creek (Pipal et al. 2007), and using video would exceed the wattage of our power system, we did not validate the system with video.

OBJECTIVE

Our objective in 2009 was to assess the performance of a DIDSON acoustic camera for estimating upstream passage of steelhead in Peterson Creek. We expected to refine our methods in future years.

STUDY SITE

Peterson Creek (anadromous stream #111-50-10100; Figure 1), located at 25 mile Glacier Highway on the Juneau road system, serves as an index stream for the ADF&G Division of Sport Fish steelhead snorkel survey project (Harding 2009). Low seasonal flows and good access made Peterson Creek a candidate for testing the viability of DIDSON for eventual use in remote streams. Peterson Creek is the most important freshwater sport fishing steelhead stream on the Juneau road system (Schwan 1990), and was designated as a catch-and-release only stream for steelhead by the Alaska Board of Fisheries in April 2009. From 1989 through 1991, ADF&G Division of Sport Fish operated a conventional picket weir on the creek to monitor escapement and run timing, and to collect age, sex, and length data on the steelhead immigration. The adult steelhead immigrant count was 222 in 1989, 179 in 1990, and 215 in 1991, (Harding and Jones 1991, 1992). An incomplete estimate of upstream steelhead passage (while the resistivity counter was operating) in 2007 was 250 (95% CI = 169–364) (Coyle and Reed *in prep*).

Peterson Creek drains Peterson Lake and flows for 8 km before it empties into Amalga Harbor from Salt Lake (Figure 1). A barrier falls is located 4 km downstream from Peterson Lake, and prevents immigrating steelhead from accessing the upper creek or lake. Peterson Creek is a brown-water stream in a watershed that is 53% wetlands. The underlying geology is marine graywacke sandstone. The portion of the creek where the DIDSON was located is classified as a single channel palustrine stream with a moderate-width placid flow channel (ADF&G 2006). The lower portion of the creek has an average gradient of 0.25%, 3.0 m incision depth, and an average channel bed width of 16.0 m (ADF&G 2006).

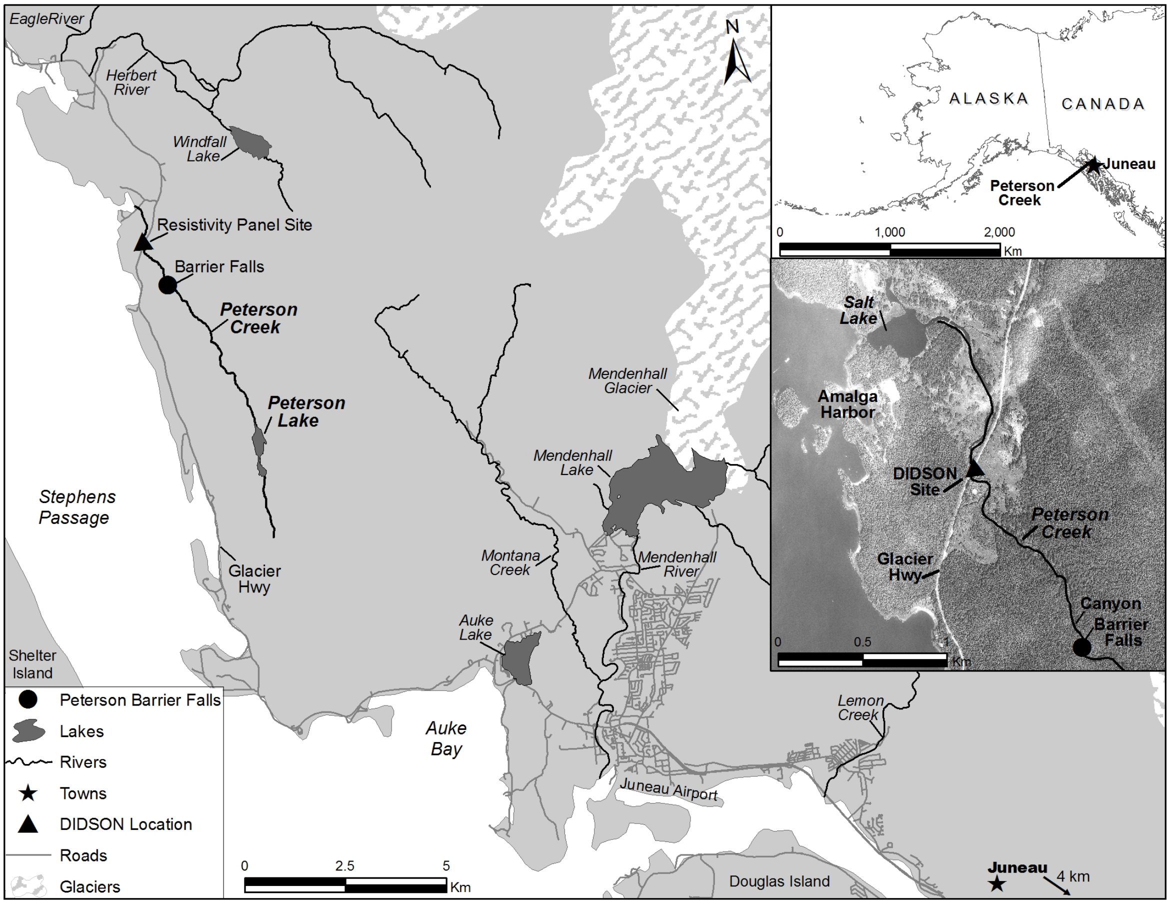


Figure 1.–Location of Peterson Creek DIDSON study site, mile 25 Glacier Highway, Juneau, Alaska, 2009.

Steelhead were stocked in the lake several times from 1941 through 1968, and Peterson Creek was source for egg takes for Snettisham Hatchery from 1983 to 1987 (Harding and Jones 1991). From 1961 through 1989 the creek was managed with the belief that stocked rainbow trout rearing in the lake served as a source of recruitment for Peterson Creek steelhead. However, a study conducted in 1990 and 1991 failed to capture rainbow/steelhead smolt emigrating from above the barrier falls that could contribute to steelhead production (Harding and Jones 1991, 1992). No steelhead have been observed in the winter months, and Peterson Creek steelhead are considered to be ocean-maturing spring run fish. Resident rainbow trout, cutthroat trout, and Dolly Varden have been documented during snorkel surveys in the creek below the barrier falls where steelhead migrate migrate (Harding 2005).

METHODS

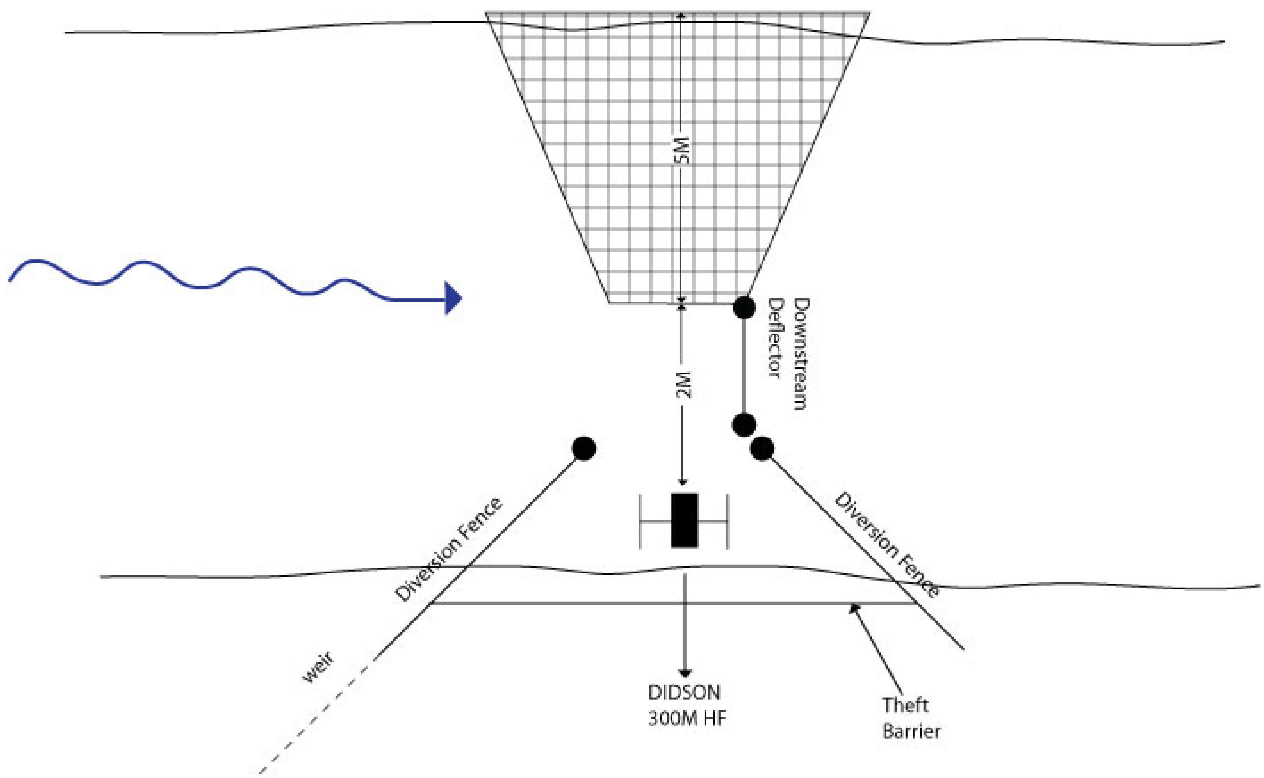
The DIDSON acoustic camera was placed in Peterson Creek approximately 25-m downstream of the Glacier Highway bridge at 58.48731N 134.77740W, and was operated from April 20 through June 5, 2009 (Figure 1). We selected this site because it is in a stream glide with moderate flow, sits above the zone of saltwater incursion, and has a gently sloping bottom on the north side where the transducer was placed. This site is located opposite a cut bank where we thought most of the steelhead would pass, and it was below the spawning grounds. The width of the stream where the DIDSON was placed was approximately 7 m. The water depth here was thought not to drop below 1 m during low flow events, nor rise above 2 m, ensuring the DIDSON would be covered in water, yet not be too deep to miss fish. Peterson Creek downstream of this site was deeper and slower. Upstream of this site beyond the highway bridge is a popular angling spot, which we avoided for 2 reasons: 1) we did not want to interfere with angling; and 2) we did not want anglers spooking the fish back in front of the DIDSON for fear of multiple counts. The dominant substrate at the DIDSON site is organic with a subdominant sand/silt substrate. This relatively soft substrate was expected to decrease potential for any acoustic scattering (Burwen et al. 2007).

The DIDSON was mounted on an H-mount aluminum bracket with an adjustable-height platform that allowed for repositioning in response to changes in water level. The DIDSON was operated at 1.8 MHz (high frequency mode for close ranges up to 15 m), and aimed perpendicular to the current. The insonification window captured the entire stream at depths up to approximately 1.4 m determined via the cosine rule (Sullivan 2004). The initial water depth was 0.29 m at the DIDSON site. Two diversion fences protected the DIDSON from floating debris and helped divert fish into the insonification window (Figure 2). We used a standard DIDSON with an insonification window consisting of 96 beams with a field of view 12˚ vertically and 29˚ horizontally. We used a 5.0 m window length starting at a range from 2.0 m (from the DIDSON) to 7.0 m across the width of the stream. We used a 591 ml plastic bottle filled with gravel as a target to aid in aiming the transducer to ensure that we had coverage across the entire cross-section and depth of the stream where fish were viewed.

The DIDSON downloaded 1-hour files continuously for 42 days using Soundmetrics software version 5.21. We used a frame rate of 8 frames per second (fps) resulting in a 1-hour file with approximately 1 GB of data. Daily files (24 GB) were stored on a 2 TB "La Cie Big 4" Redundant Array of Independent Disks (RAID) drives (with 30% less power consumption than traditional RAID drives) assembled in RAID 10 configuration. This configuration allowed for redundant file storage in the event that one of the drives failed, thus providing a back-up. The 2 TB RAID was sufficient to store all files collected during an entire season. In addition, 2 spare hot-swappable drives were on hand to provide an additional 1-TB storage, or to be used should a drive fail. The files were individually named with date and time using the Soundmetrics data collection software. The DIDSON was supported by a Dell E4200 power-saving laptop. (see Appendix A) All equipment was powered with EFOY 65-W fuel cells. The DIDSON was operated with a single fuel cell, and the laptop and RAID drive with another fuel cell. An additional fuel cell was on hand in the event either of the two being used failed. All equipment was housed inside a locked chain link dog kennel, covered and hidden from sight to protect the equipment from vandals, bears, and weather.

All fish crossing the insonification window (Figure 2) were counted manually by reviewing the DIDSON files as soon as possible using Echotastic version 1 (a software program developed by Carl Pfisterer, Region III ADF&G Division of Commercial Fisheries) that provided simultaneous video viewing with an echogram and fish measuring tool. As many of the files as possible were processed inseason to reduce post-processing delays. When processing data, we used the maximum beam and background subtraction to enhance the images. Downstream counts were summarized daily to keep track of the timing and duration of the kelt emigration. Age or sex determination is not possible with the DIDSON.

Measurements of stream temperature to the nearest 0.5ºC, and depth to the nearest 1.0 cm were recorded daily. Water turbidity and color were measured and recorded daily with a LaMotte TC-3000e Waterproof Turbidity meter. Alkalinity measurements were taken weekly with a Thermo Orion Total Alkalinity test kit to the nearest 0.1 mg $CaCO_3$/L, and pH was taken weekly with a Hannah pH pen. Weather conditions (cloud cover, wind, and precipitation) were recorded using the same codes that are used for steelhead snorkel surveys (Harding 2005). Precipitation was measured with a rain gauge and recorded daily. The area was also scrutinized for signs of beavers, otters, and dogs, and their presence/absence was recorded. Depth measurements for a bottom profile of the stream parallel to the DIDSON were taken at the site on June 5, 2009. Security measures included an extra fence of pickets placed behind the DIDSON, and several battery operated security cameras were mounted around the site.



2009 Peterson Creek DIDSON

Figure 2.–Plan view of DIDSON in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. The creek was approximately 8 m wide. The insonification window of the DIDSON is illustrated by the hatched area. The hatched area was 5.0 m wide, and covered an area 29˚ horizontally x 12˚vertically. A downstream deflector forced the fish into the window, and 2 diversion fences protected the DIDSON from debris and helped divert fish into the insonification window. The creek flows from left to right.Snorkel surveys were conducted in Peterson Creek at the beginning and ending of the project (April 21 and June 4), as well as for the annual snorkel survey index for adult steelhead on May 4, 12 and 19, and June 1 (Harding 2012).

Snorkel surveys were conducted in Peterson Creek at the beginning and ending of the project (April 21 and June 4) as well as for the annual snorkel survey index for adult steelhead on May 4, 12, and 19, and June 1 (Harding *in prep*).

DATA ANALYSIS

Fish Length Verification and Steelhead Identification

We recorded the direction of travel and estimated the length for each fish detected passing the DIDSON. When deploying the DIDSON in streams less than 12 m wide, operating the sonar in high frequency mode results in easily identifiable images that indicate travel direction (Burwen et al. 2007).

Lengths of all fish passing through the insonification area were estimated using the Echotastic measuring feature. Three measurements were taken from each of 3 separate frames of each fish that had an initial image measurement greater than 48 cm. We tried to use frames that had high contrast, minimum cross-talk (Pipal et al. 2010 call this “flare”) and obvious tails on the fish images, but this was not always possible. The length estimate assigned to each fish was the mean of these three measurements.

Steelhead are considered to be those trout migrating upstream that are larger than 56 cm (22 inch per the ADF&G Division of Sport Fish regulatory definition of a steelhead trout (5 AAC 75.220 (A) (B)) in SEAK). To account for measurement and rounding error, any fish migrating upstream with a measured length ≥50 cm was recorded as a steelhead. Fish with mean estimated lengths from 40 to 49 cm were recorded as trout, and only 1 length estimate was recorded for these fish. Fish <40 cm (based on initial estimates) were recorded as trout, but estimated length was not recorded after May 2. Only 2 people were assigned to estimate lengths from the DIDSON images during the field season.

In preparation for another season, we processed all of our raw data files with the Convolved Samples Over Threshold (CSOT) function of the Soundmetrics software. This is a motion-detect feature of the software, which eliminates empty file space, and is a time saving tool. We were able to establish thresholds and cluster sizes for steelhead in Peterson Creek.

The total number of steelhead detected moving upstream and the total number detected moving downstream were recorded on a daily basis. A daily net count was calculated as the number recorded moving upstream minus the number recorded moving downstream. Observations of steelhead thought to be milling that could potentially be counted multiple times were removed using a modified Decision Support Tool (DST) developed by the National Marine Fisheries Service Southwest Fisheries Center. This tool was developed for estimating endangered steelhead in remote California streams with a DIDSON (Pipal et al. 2010), and was used as a filtering method to discriminate between milling fish and emigrating kelts.

To determine whether or not an observed steelhead was a likely repeat, we used 3 criteria (difference in estimated length, elapsed time between the upstream fish and downstream fish observation, and the group size of the fish travelling together) to evaluate all upstream and downstream fish travelling within an hour of each other. Each observation was scored and weighted in the following manner: for the size criteria, paired observations with a less than 5 cm difference were given 3 points, those with a 6 to 10 cm difference were given 2 points, and those with a 10 to 15 cm difference were given 1 point (Table 1). For the elapsed time criteria of upstream/downstream movement (or vice versa), those observations that were less than 5 minutes apart were assigned 4 points, 5 to 10 minutes were assigned 3 points, 11 to 20 minutes were assigned 2 points, and 21 to 60 minutes were assigned 1 point. Observations of similar sized groups seen in both directions were also given 1 point (Table 1).

The decision criteria were implemented using the R programming language (See the R Project for statistical computing. http://www.r-projecct.org/; accessed August 2012). First, all upstream movement times were compared to those for subsequent downstream movements to identify all upstream-downstream pairs that occurred within 60 minutes of each other. Each identified pair was then scored. When movement occurred prior to the peak of upstream migration (described below), each pair of upstream-downstream observations with scores greater than or equal to 6 points were considered to be the same fish milling. Those observations with less than or equal to 5 points were considered to be different fish, and the downstream fish were possible kelts. In the instances when scores of different matches were tied, we chose the match with the closest length. In rare instances when 2 matches had the same score and same length difference, we chose the match with the least amount of elapsed time. In 1 instance of a match with the same score, same length difference, and the same time difference, a coin toss was used to choose the best match.

Table 1.–Modified point assignment from the Decision Support Tool for sorting upstream vs. downstream steelhead images passing within 1 hour of each other. Matched images with cumulative points (scored by length difference, elapsed time, and group size retention) greater than or equal to 6 are considered milling fish. Those with a cumulative of 5 points or less are considered different fish.

Length	Points	Elapsed	Points	Group	Points
≤5 cm	3	≤5 min.	4	Retained	1
6–10 cm	2	6–10 min.	3	Not retained	0
11–15 cm	1	11–20 min.	2		
		21–60 min.	1		

Note: Decision Support Tool (Pipal et al. 2010).

The net count (total daily upstream steelhead minus total daily downstream steelhead) was plotted to determine a peak date of upstream movement. The paired steelhead observations that were assigned to the milling category were subtracted from the number of steelhead counted upstream up to the peak day of the 2009 net count. All downstream steelhead movements observed after the peak day were considered kelts, and no possible pairings with upstream movements were considered.

Observer Error

Two sources of error were evaluated for staff reviewing the DIDSON files. First, we attempted to estimate observer detection error—the failure of readers to detect all fish or mismarks (not fish)—and errors in determining direction of movements. Second, we wanted to estimate the precision (repeatability) of fish length estimates made using 2 different software measuring tools (Echotastic and Soundmetrics). We used 3 observers who had no experience using a DIDSON prior to the 2009 field season.

To estimate observer detection errors, Observer 3 reviewed 11 randomly selected unmarked files for Observer 1, and 9 randomly selected unmarked files for Observer 2. Observer 3 had similar training to Observers 1 and 2, but had more time to review the files postseason.

The proportions of fish not detected by Observer *i* (*i* = 1, 2) relative to Observer 3, were calculated:

$$\hat{p}_{i,3} = n_i / n_{3(i)} \qquad (1)$$

where $n_{3(i)}$ is the number of fish observed and measured by Observer 3, in samples of media viewed in common with Observer *i*, and n_i are those fish in $n_{3(i)}$ that were detected and measured by Observer *i*. Exact 90% binomial confidence limits (CL) were calculated for these proportions (Cochran 1977).

The Mann-Whitney test (Conover 1980) was used to compare the distributions of length measurements for the same fish between 2 observers, and to compare 2 different measurement techniques conducted by the same observer. The Mann-Whitney test is unbiased when testing the two-tailed hypotheses:

H_o: $P(X < Y) = ½$

vs.

H_a: $P(X < Y) \neq ½$

where *X* denotes a randomly chosen value from population 1 and *Y* denotes a randomly chosen value from population 2. Statistical differences were evaluated at the $\alpha = 0.10$ level, as this is the smallest significance level discernable using a two-tailed test for samples of size 3 and 3 with the Mann-Whitney statistic.

Overall comparisons between 2 observers or 2 measurement techniques were made by comparing distributions of differences between means of observations made on each fish. For each fish, the sample mean (Cochran 1977) was calculated for each of 2 samples ($\bar{x}_1$ and $\bar{x}_2$), and then the difference between these two samples was calculated ($d = \bar{x}_1 - \bar{x}_2$).

The Wilcoxon Signed Ranks test (Conover 1980) was used for the two-tailed hypothesis test:

H_o: $d_{50} = 0$

vs.

H_a: $d_{50} \neq 0$

where d_{50} is the median of the "population" of differences from which values of *d* are drawn.

RESULTS

Adult Steelhead Upstream Passage

We attempted to collect DIDSON files continuously from April 20 at 15:38 until June 5 at 10:00, and over 1,930 hours of files were recorded. Only twice did we have equipment failures. The first was on May 5 at 4:42 for 4.8 hours, and the second time on May 11 at 5:30 for 8 hours. The problem appeared to be mice dislodging the cords as mouse droppings were found between the computer and topside box after the second recording disruption. After the construction of a mouse barrier, no disruptions occurred (see Appendix B3). The first fish recorded was an upstream fish at 21:43 on April 20. We conducted a snorkel survey upstream of the DIDSON to just below the canyon in Peterson Creek on April 21 and did not see any adult steelhead (Figure 3). Division of Sport Fish area management staff conducted snorkel surveys on May 4, 12, and 19, and June 1 and counted 2, 15, 22 and 3 steelhead, respectively. We conducted a final snorkel survey on June 4, before removing the DIDSON, and counted 1 steelhead above the DIDSON site.

The total number of adult steelhead (fish ≥50.0 cm) detected moving upstream was 747 fish (Table 2). The maximum count of upstream steelhead was 45 on May 24 (Figure 3). Eighty-eight percent (660) of the upstream moving steelhead moved as single fish, while 6.44% (48) moved upstream as pairs, 2.42% (18) as triples, and 2.82% (21) moved in groups of 4, 5, and 12 fish (Table 3). When all the observations of upstream moving steelhead were pooled across days, steelhead were observed moving upstream at every hour of the day, with more movement during twilight hours and at night (Figure 4). Most of the upstream-moving steelhead migrated in the center of the channel, which was located 4.15.0 m from the DIDSON (Figure 5). This was the second deepest cross-section of the creek, with the section from 5.1 to 6.0 m slightly deeper.

We estimated the lengths of 744 of the 747 adult steelhead images detected moving upstream from the DIDSON files using Echotastic software. The mean length of upstream moving steelhead was 60.2 cm (24 in; SD = 6.6 cm, or 2.6 in), the minimum length was set at 50.0 cm (19.7 in), and the maximum length was 88.8 cm (34.9 in).

The length distribution of the upstream-moving adult steelhead is shown in Figure 6. The median length of upstream-moving steelhead was 59.1 cm, which corresponds to the 55.0–59.9 cm bin containing 29.7% percent of the upstream moving adult steelhead. We also counted and measured 38 upstream-moving fish >40.0 cm and less than <50.0 cm, all of which were considered to be rainbow trout. Eighteen of these steelhead were 40.0–44.9 cm, and 20 were 45.0–49.9 cm (Figure 7).

Table 2.–Historic data from Peterson Creek compared to 2009 data.

Description	1989 (weir)	1990 (weir)	1991 (weir)	2009 (DIDSON)	2010 (weir)
Immigrant	222	189	218	747	115
Emigrant	165	114	165	445	95
Net count	57	75	53	302	20
Post-spawning survival (I/E)	0.74	0.60	0.75	0.60	0.82
Peak escapement	5/14	5/18	5/16	?	5/6
Average temperature	7.3	7.6	4.4	3.2	6.3
First kelt	5/15	5/14	5/24	4/20	5/9
Median water level	27 cm	24 cm	37 cm	42 cm or 236 cm (staff)	55 cm (staff)
First steelhead	5/2	4/13	(before 4/15)	(before 4/20)	4/27
Weir/project dates	4/22–6/4, 1989, but no fish until 5/2	(4/8–6/3, 1990)	(4/15–6/6, 1991)	(4/20–6/5, 2009)	(4/5–5/28)

Source: Data from Harding and Jones (1990–1992; Coyle *in prep*).

Table 3.–Daily summary and group size delineation of individual upstream moving adult steelhead using a DIDSON at Peterson Creek, mile 25 Glacier Highway, Juneau Alaska, 2009.

Date	One fish	Two fish	Three fish	Four fish	Five fish	Twelve fish	Total
4/20	1	ND	ND	ND	ND	ND	1
4/21	4	ND	ND	ND	ND	ND	4
4/22	13	ND	ND	ND	ND	ND	13
4/23	16	ND	ND	ND	ND	ND	16
4/24	4	ND	ND	ND	ND	ND	4
4/25	2	ND	ND	ND	ND	ND	2
4/26	3	ND	ND	ND	ND	ND	3
4/27	5	ND	ND	ND	ND	ND	5
4/28	4	ND	ND	ND	ND	ND	4
4/29	5	ND	ND	ND	ND	ND	5
4/30	3	ND	ND	ND	ND	ND	3
5/1	1	ND	ND	ND	ND	ND	1
5/2	9	ND	ND	ND	ND	ND	8
5/3	32	ND	ND	ND	ND	ND	32
5/4	16	ND	ND	ND	ND	ND	16
5/5	17	ND	ND	ND	ND	ND	17
5/6	25	ND	6	ND	5	ND	36
5/7	5	2	ND	ND	ND	ND	7
5/8	6	2	ND	ND	ND	ND	8
5/9	8	ND	ND	ND	ND	ND	8
5/10	15	ND	ND	ND	ND	12	27
5/11	15	ND	ND	ND	ND	ND	15
5/12	35	ND	ND	ND	ND	ND	35
5/13	23	ND	ND	ND	ND	ND	23
5/14	14	ND	ND	ND	ND	ND	14
5/15	6	2	ND	ND	ND	ND	8
5/16	13	10	ND	ND	ND	ND	23
5/17	5	2	3	ND	ND	ND	10
5/18	9	2	ND	ND	ND	ND	11
5/19	22	2	ND	ND	ND	ND	24
5/20	28	4	ND	4	ND	ND	36
5/21	17	ND	ND	ND	ND	ND	17
5/22	19	ND	ND	ND	ND	ND	19
5/23	22	ND	ND	ND	ND	ND	22
5/24	33	6	6	ND	ND	ND	45
5/25	17	2	ND	ND	ND	ND	19
5/26	34	4	3	ND	ND	ND	40
5/27	23	ND	ND	ND	ND	ND	23
5/28	21	4	ND	ND	ND	ND	25
5/29	28	ND	ND	ND	ND	ND	28
5/30	11	ND	ND	ND	ND	ND	11
5/31	18	ND	ND	ND	ND	ND	18
6/1	14	ND	ND	ND	ND	ND	14
6/2	13	ND	ND	ND	ND	ND	13
6/3	12	4	ND	ND	ND	ND	16
6/4	11	2	ND	ND	ND	ND	13
6/5	3	ND	ND	ND	ND	ND	3
Total	660	48	18	4	5	12	745

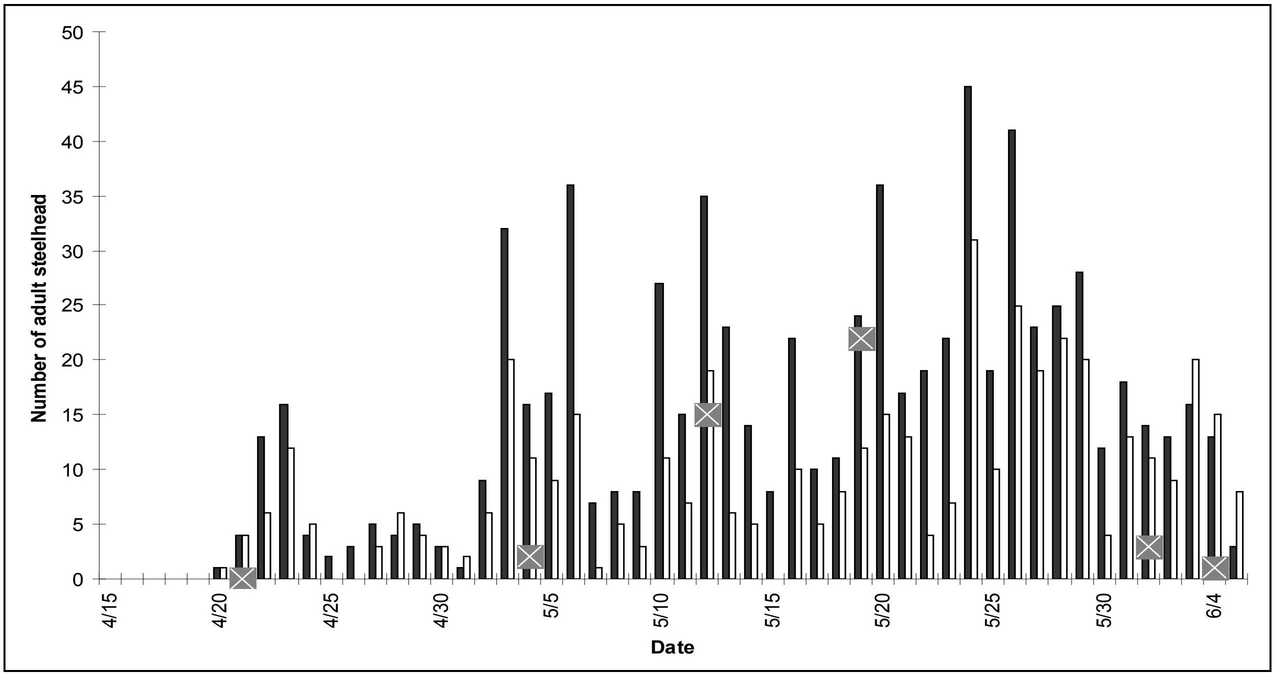


Figure 3.–Daily number of adult steelhead counted moving upstream and downstream in Peterson Creek by the DIDSON. The DIDSON files were continuously recorded in 1-hour increments from April 20 to June 5, 2009 in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska. Snorkel survey counts (0, 2, 15, 22, 3, 1) were made on April 21, May 4, 12, and 19, and June 1 and 4. Solid black bars represent daily upstream migrating steelhead, solid white bars represent daily downstream migrating steelhead, and Xs represent the snorkel survey counts.

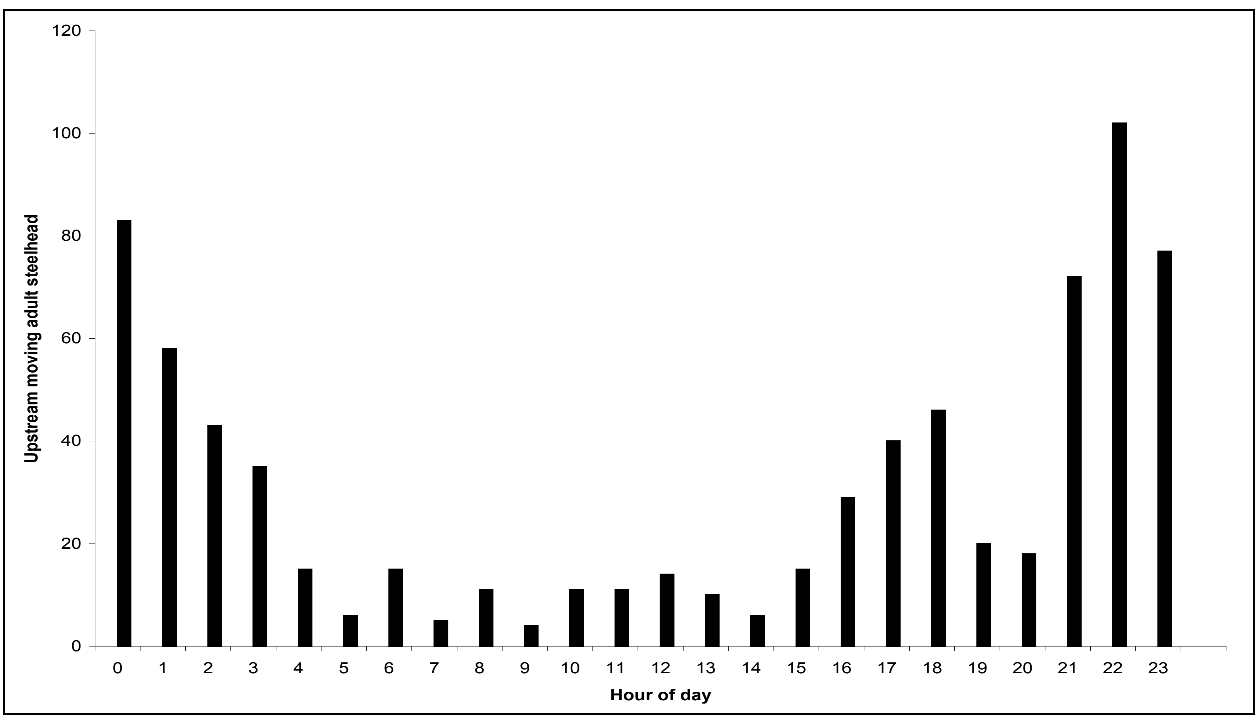


Figure 4.–Number of adult steelhead moving upstream each hour (pooled data, 0 hour is midnight) in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009.

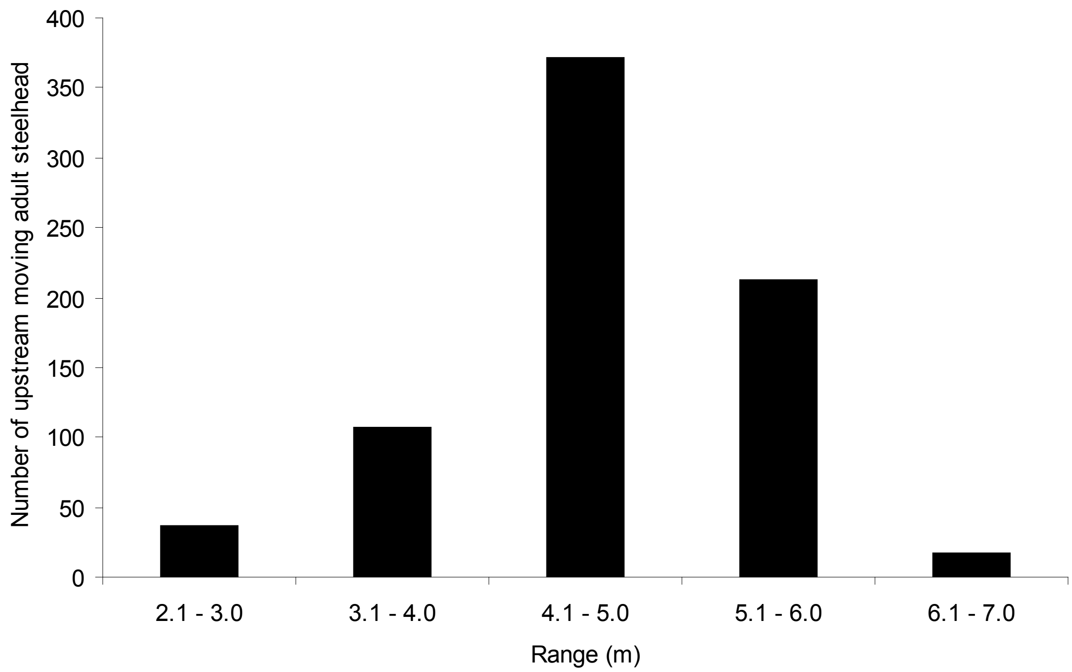


Figure 5.–Number of adult steelhead moving upstream and the range in distance (m) from the DIDSON transducer to the fish as they migrated upstream in Petersen Creek, mile 25 Glacier High way, Juneau, Alaska, 2009.

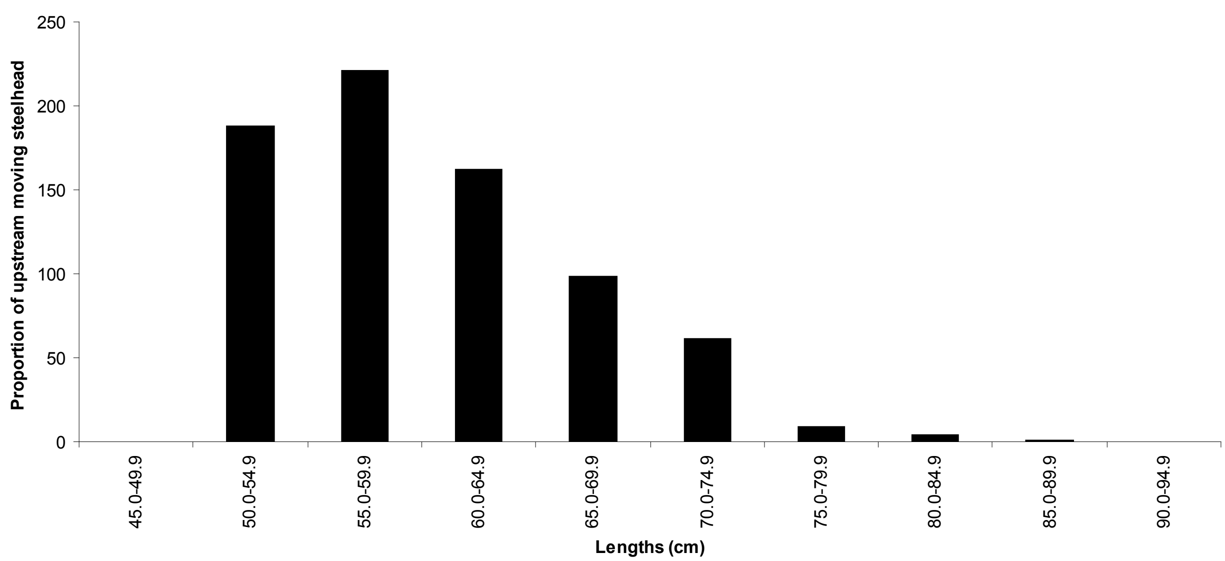


Figure 6.–Length distribution of adult steelhead moving upstream in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. The lengths (cm) were measured as total lengths with a straight line measuring tool using the Echotastic software.

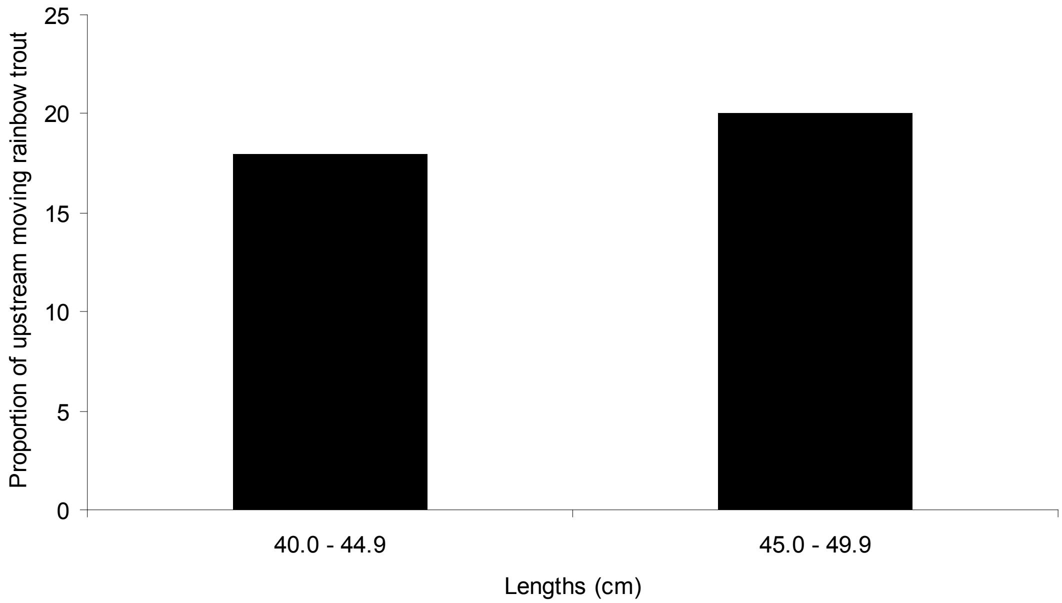


Figure 7.–Length distribution of adult rainbow trout moving upstream each hour in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. The lengths (cm) were measured as total lengths with a straight line measuring tool using the Echotastic software. Rainbow trout are considered to be those fish measuring less than 50.0 cm.

ADULT STEELHEAD DOWNSTREAM PASSAGE

The total number of adult steelhead (fish 50.0 cm and larger) detected moving downstream was 445 fish (Table 2). The maximum count of downstream steelhead was 31 fish on May 24 (Figure 3).

Ninety-two percent (412) of the downstream-moving steelhead moved as single fish, while 3.6% (16) moved downstream as pairs, 2.7% (12) as triples, and 1.1% (5) moved in a group of 5 (Table 4). When all the observations of downstream moving steelhead were pooled, steelhead were observed moving downstream at every hour of the day, with more movement in the twilight hours and at night (Figure 8). As was observed for upstream-migrating fish, most of the downstream-moving steelhead migrated in the center of the channel (Figure 9).

We estimated the lengths of 430 of the 445 adult steelhead images detected moving downstream using Echotastic software. The mean length of downstream moving steelhead was 60.3 cm (23.7 in; SD = 6.2 cm, or 2.4 in), the minimum length was set at 50.0 cm (19.7 in), and the maximum length measured was 78.7 cm (30.9 in). The length distribution of downstream moving adult steelhead is shown in Figure 10. The median length of downstream moving steelhead was 59.3 cm (23.3 in), which corresponds to the 55.0–59.9 cm bin containing 30.7% percent of the downstream-moving adult steelhead. We also counted and measured 75 downstream moving fish images > 40.0 cm <50.0 cm (19.6 in) that were considered to be rainbow trout (Figure 11). Forty of these fish images were 40.0–44.9 cm, and 35 were 45.0–49.9 cm.

NET COUNT

The net daily count of adult steelhead from April 20 to June 5 is plotted in Figure 12. The resulting plot has a multi-modal distribution, with peak counts occurring on May 6 and 20. The maximum number of fish counted on both days was 21. The net count of adult steelhead in Peterson Creek was 302.

REVISED COUNTS WITH DECISION SUPPORT TOOL

Using the method of Pipal et al. (2010), we plotted the total net daily count (Figure 12), and identified a peak to determine a cut-off for milling fish versus kelts. As mentioned above, 2 peaks were identified on May 6 and 20.

Because the method is based on using the peak count to determine which fish are likely kelting, we made 2 revised net counts and 2 escapement estimates. For the May 6 peak, the DST matched 48 pairs of upstream-downstream observations from April 21 to May 6. All of these "milling" fish were subtracted from the final net count of 302 steelhead, for an escapement estimate of 254. For the second peak, the DST matched 91 pairs of upstream-downstream observations from April 21 to May 20. These "milling" fish were subtracted from the final net count of 302 adult steelhead, for an escapement estimate of 211 for the second peak.

Table 4.Daily summary and group size delineation of individual downstream moving adult steelhead using a DIDSON at Peterson Creek, mile 25 Glacier Highway, Juneau Alaska, 2009.

Date	One fish	Two fish	Three fish	Five fish	Daily total
20-Apr	1	ND	ND	ND	1
21-Apr	4	ND	ND	ND	4
22-Apr	5	ND	ND	ND	5
23-Apr	12	ND	ND	ND	12
24-Apr	5	ND	ND	ND	5
27-Apr	3	ND	ND	ND	3
28-Apr	6	ND	ND	ND	6
29-Apr	4	ND	ND	ND	4
30-Apr	3	ND	ND	ND	3
1-May	2	ND	ND	ND	2
2-May	7	ND	ND	ND	7
3-May	20	ND	ND	ND	20
4-May	11	ND	ND	ND	11
5-May	7	2	ND	ND	9
6-May	8	2	ND	5	15
7-May	1	ND	ND	ND	1
8-May	5	ND	ND	ND	5
9-May	3	ND	ND	ND	3
10-May	11	ND	ND	ND	11
11-May	7	ND	ND	ND	7
12-May	19	ND	ND	ND	19
13-May	6	ND	ND	ND	6
14-May	5	ND	ND	ND	5
16-May	8	2	ND	ND	10
17-May	2	ND	3	ND	5
18-May	5	ND	3	ND	8
19-May	12	ND	ND	ND	12
20-May	12	ND	3	ND	15
21-May	13	ND	ND	ND	13
22-May	4	ND	ND	ND	4
23-May	7	ND	ND	ND	7
24-May	28	ND	3	ND	31
25-May	8	2	ND	ND	10
26-May	19	6	ND	ND	25
27-May	18	ND	ND	ND	18
28-May	22	ND	ND	ND	22
29-May	20	ND	ND	ND	20
30-May	5	ND	ND	ND	5
31-May	12	ND	ND	ND	13
1-Jun	11	ND	ND	ND	11
2-Jun	9	ND	ND	ND	9
3-Jun	18	2	ND	ND	20
4-Jun	15	ND	ND	ND	15
5-Jun	8	ND	ND	ND	8
Total	411	16	12	5	445

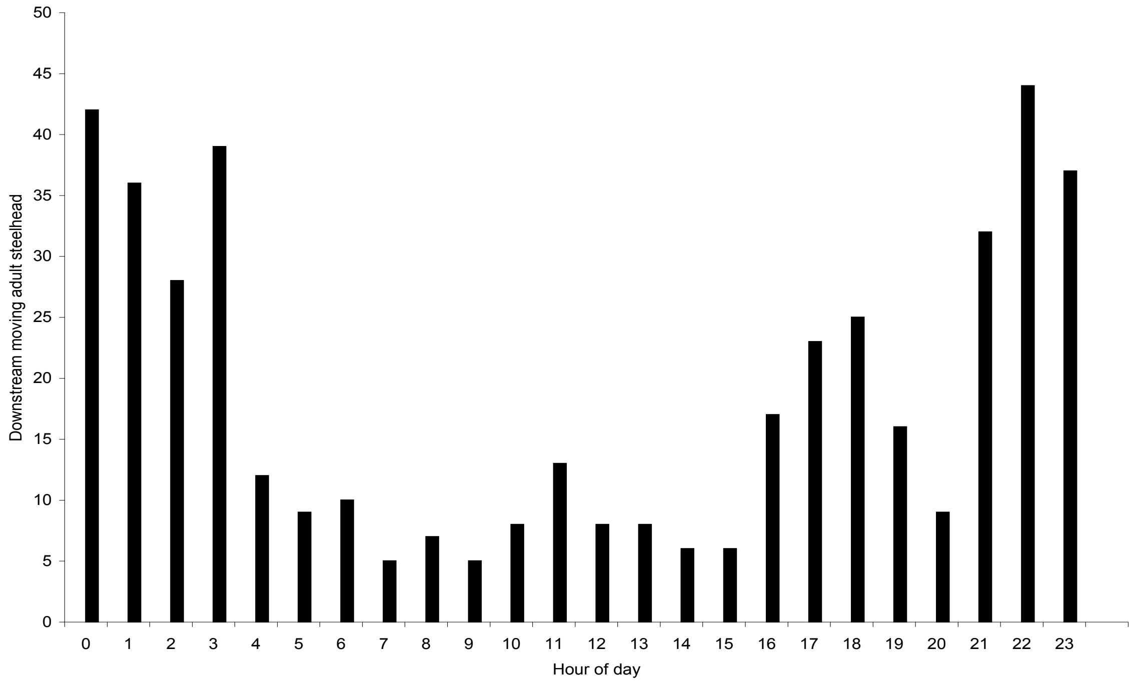


Figure 8.–Number of adult steelhead moving downstream each hour (pooled data, 0 hour is midnight) in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009.

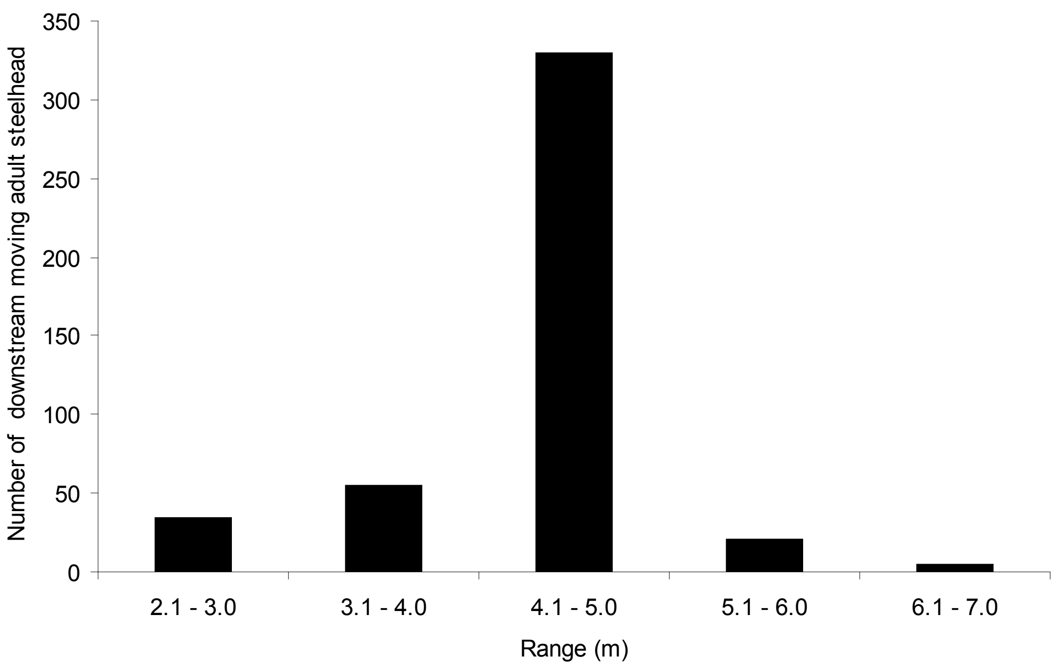


Figure 9.–Number of adult steelhead moving downstream and the range in distance (m) from the DIDSON transducer to the fish as they migrated upstream in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009.

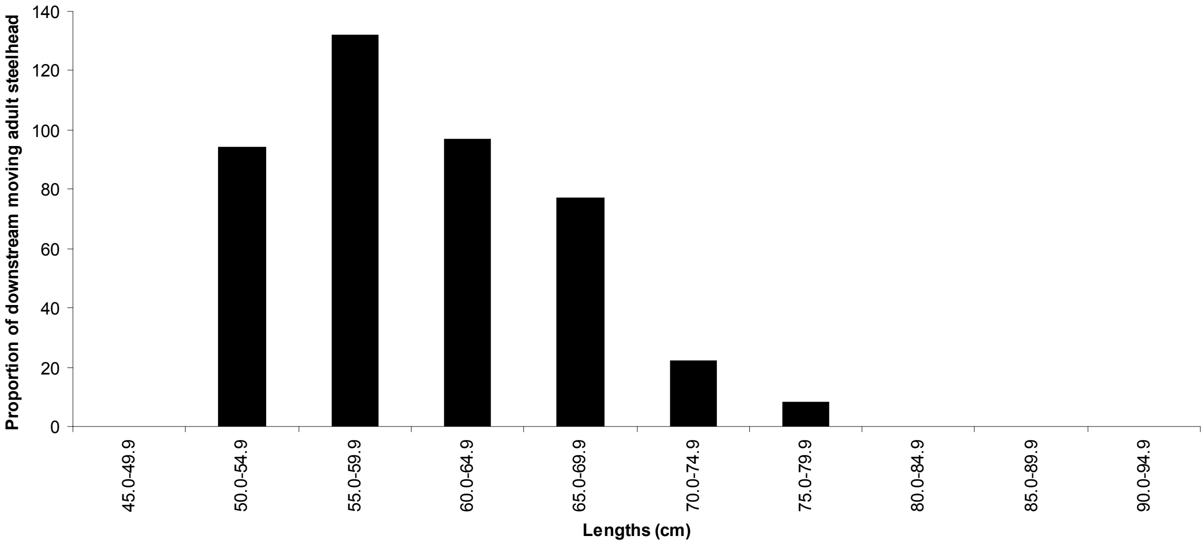


Figure 10.–Length distribution of adult steelhead moving downstream in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. The lengths (cm) were measured as total lengths with a straight line measuring tool using the Echotastic software.

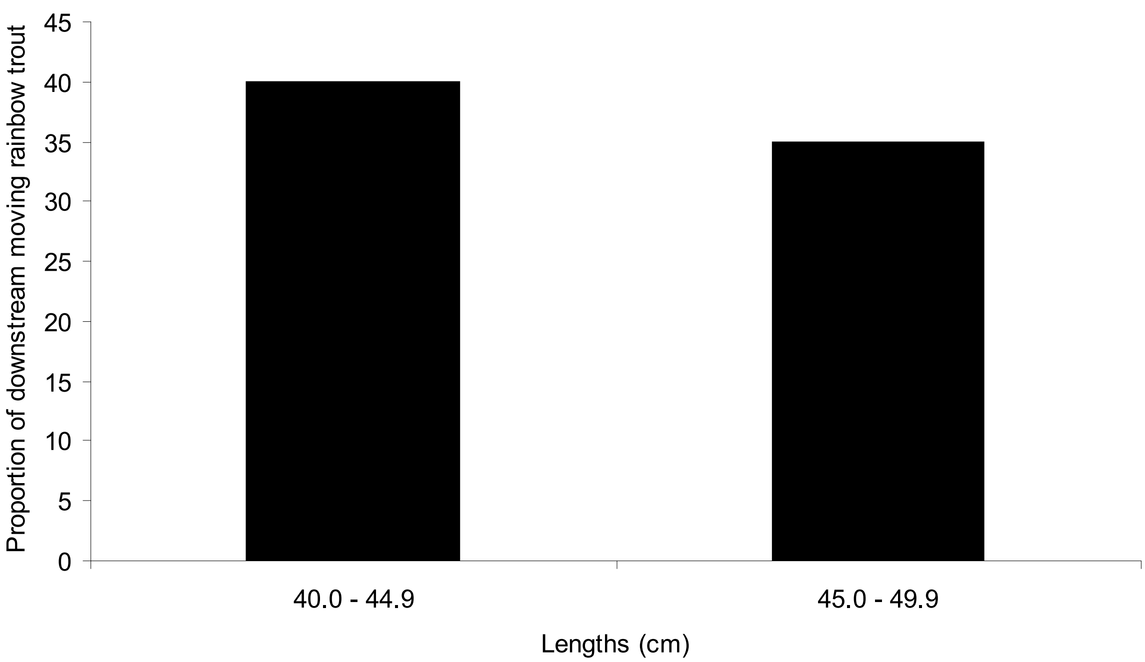


Figure 11.–Length distribution of adult rainbow trout moving downstream in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. The lengths (cm) were measured as total lengths with a straight line measuring tool using the Echotastic software. Rainbow trout are considered to be those fish measuring less than 50.0 cm.

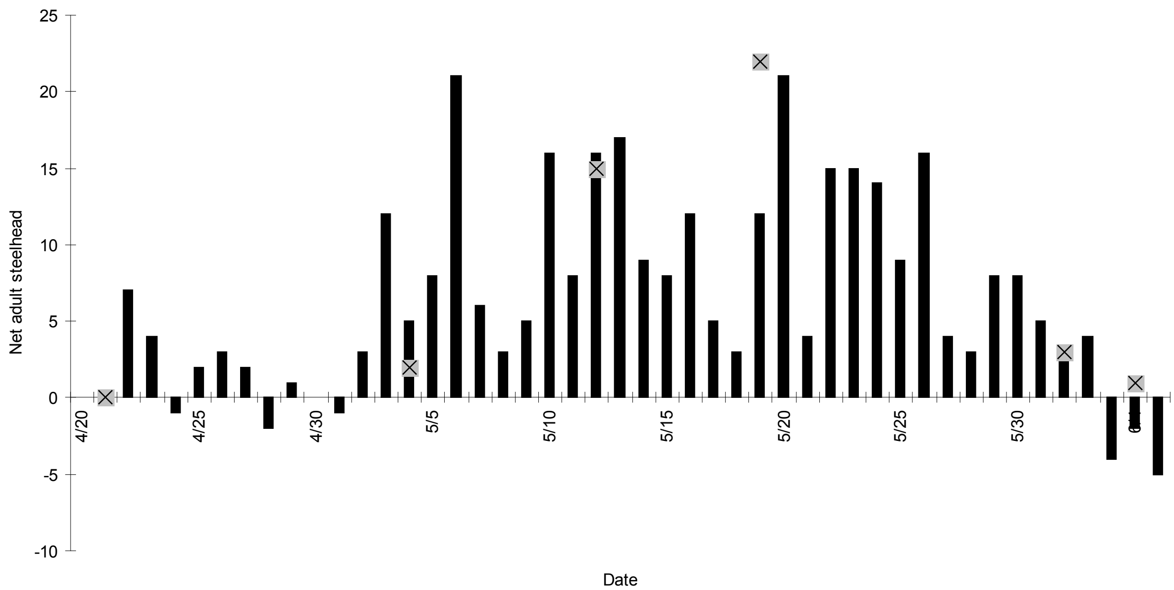


Figure 12.–Net daily count of adult steelhead in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. Xs represent the snorkel survey counts.

POST PROCESSING AND FILE COMPRESSION

We viewed original full length files using Echotastic software, which allowed us to review each file in echogram and video modes simultaneously. We reviewed 1.4 TB of data over a period of approximately 11 weeks utilizing 862 person-hours. We ran all our files through the CSOT function of the Soundmetrics software after first reviewing it manually and unedited in Echostastic. Using a minimum cluster area of 100 cm^2 and a threshold of 4.9 decibels, we were able to compress the files by 93.4%. This could translate into a savings of as much as 1,800 hours, but more importantly it would reduce viewing fatigue. CSOT files could still be viewed through the Echotastic software.

Observer Error: Detection

We determined observer error in detecting steelhead for 2 readers using a third reader after the season. Observers 1 and 2 counted fish both inseason and postseason. Observer 3 independently reviewed a subset of those files and counted fish using the same protocol. Observer 1 missed 2 of the 20 fish detected by Observer 3 in commonly viewed records, resulting in an estimated 90.0% detection rate (90% CL: 71.7%–98.2%). Observer 2 missed 1 of 11 fish detected by Observer 3 and misidentified the direction of 1 of 11 fish in commonly viewed records, resulting in an estimated 81.8 % detection rate (90% CL: 53.0%–96.7%).

Observer Error: Estimating Lengths

We estimated observer error in measuring lengths for 2 readers using a third reader after the season. Observers 1 and 2 measured fish both inseason and postseason. Observer 3 independently reviewed a subset of those files and measured fish using the same protocol. We compared the results using the Soundmetrics software with a 2-vector measuring technique to results using the Echotastic software with a straight line measuring technique (Figures 13 and 14).

For the 15 fish measured by both Observers 1 and 3 using the straight-line method, Observer 3 measurements were significantly longer for 8 fish, and significantly shorter for 3 fish. Observer 3 measurements were more consistent within samples of 3 repeated measurements, with a mean difference of 0.021 m compared to 0.040 m for Observer 1. The median of the differences in mean lengths between observers, 0.043 m, was significantly different from 0.0 m ($P < 0.10$), with Observer 3 measurements being greater (Figure 15). The bimodal histogram for Observer 1 vs. Observer 3 suggests an extreme lack of consistency on the part of one or, possibly, both of the observers (Figure 15).

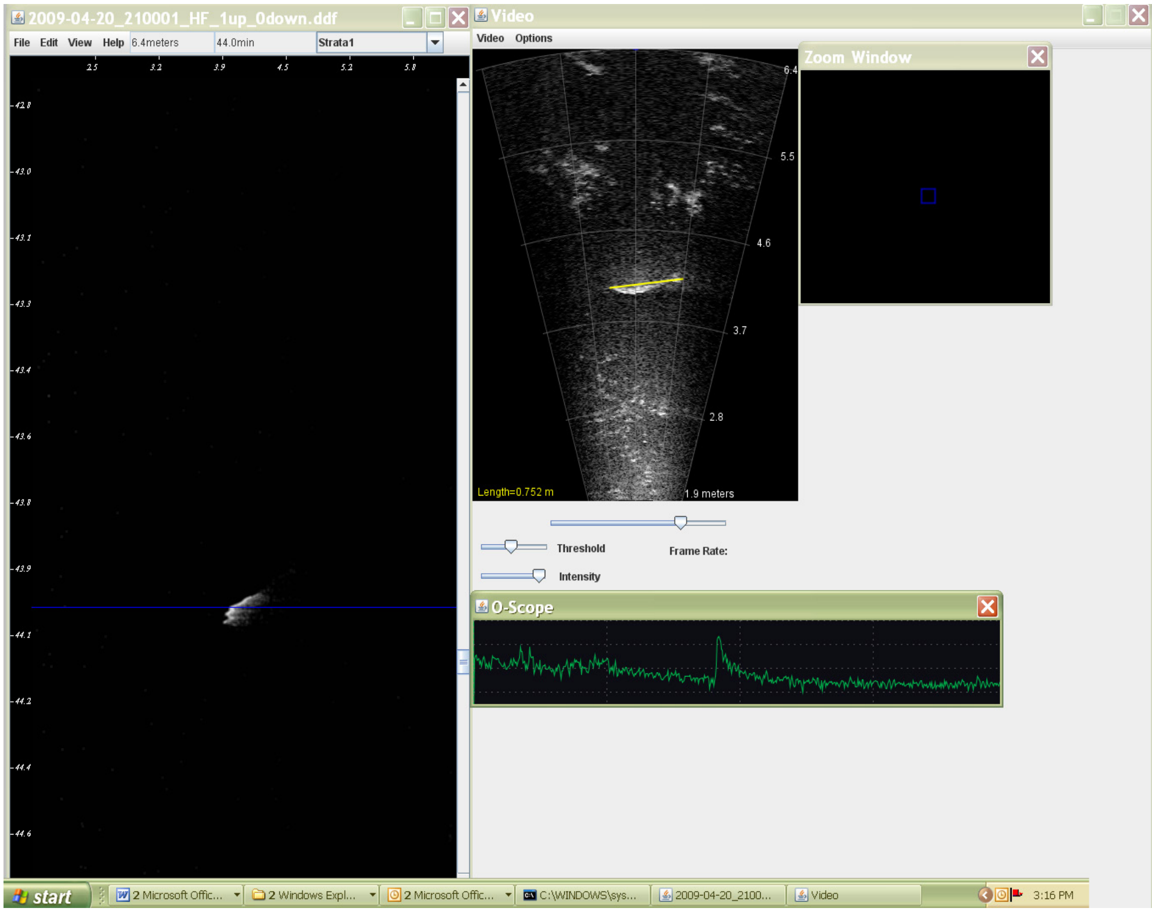


Figure 13.–Straight line measurement using Echotastic software version 1. This steelhead measured 75.4 cm long using this software, and it passed the DIDSON on Peterson Creek at 21:44 on April 20, 2009. The left window is the echogram view, the top center is the video view, the bottom center is the oscilloscope view, and the upper right window is the zoom view. All windows are displayed simultaneously as the video plays. The blue line in the echogram view indicates where the other windows (video, oscilloscope and zoom) are located in time and space Note that the insonification window spans a range from 2.0 m to 7.0 m across Peterson Creek perpendicular to the shore. This is what is called the insonification area. The fish is located 4.4 m from the DIDSON (range). This adult steelhead is oriented upstream in the current.

For the 10 fish measured by both Observers 2 and 3 using the straight-line method, Observer 3 measurements were significantly longer for 6 fish, and significantly shorter for 2 fish. Observer 3 measurements were slightly more consistent within samples of 3 repeated measurements, with a mean range of 0.013 m compared to 0.018 m for Observer 2. The median of the differences in mean lengths between observers, 0.020 m, was not significantly different from 0.0 m ($0.10 < P < 0.20$; (Figure 16).

For the 27 fish measured (by Observer 3) using both the straight-line method and the 2-vector method, 2-vector measurements were significantly longer for 20 fish and significantly shorter for 2 fish. Straight-line measurements were more consistent within samples of 3 repeated measurements, with a mean range of 0.017 m compared to 0.059 m for 2-vector measurements. The median of the differences in mean lengths between methods, 0.108 m, was significantly different from 0.0 m ($P < 0.01$), with 2-vector measurements being greater (Figure 17). The histogram for straight-line vs. 2-vector could be interpreted as being either bimodal or skewed right. The latter interpretation seems more plausible, as the median is captured in the tallest histogram bar (mode).

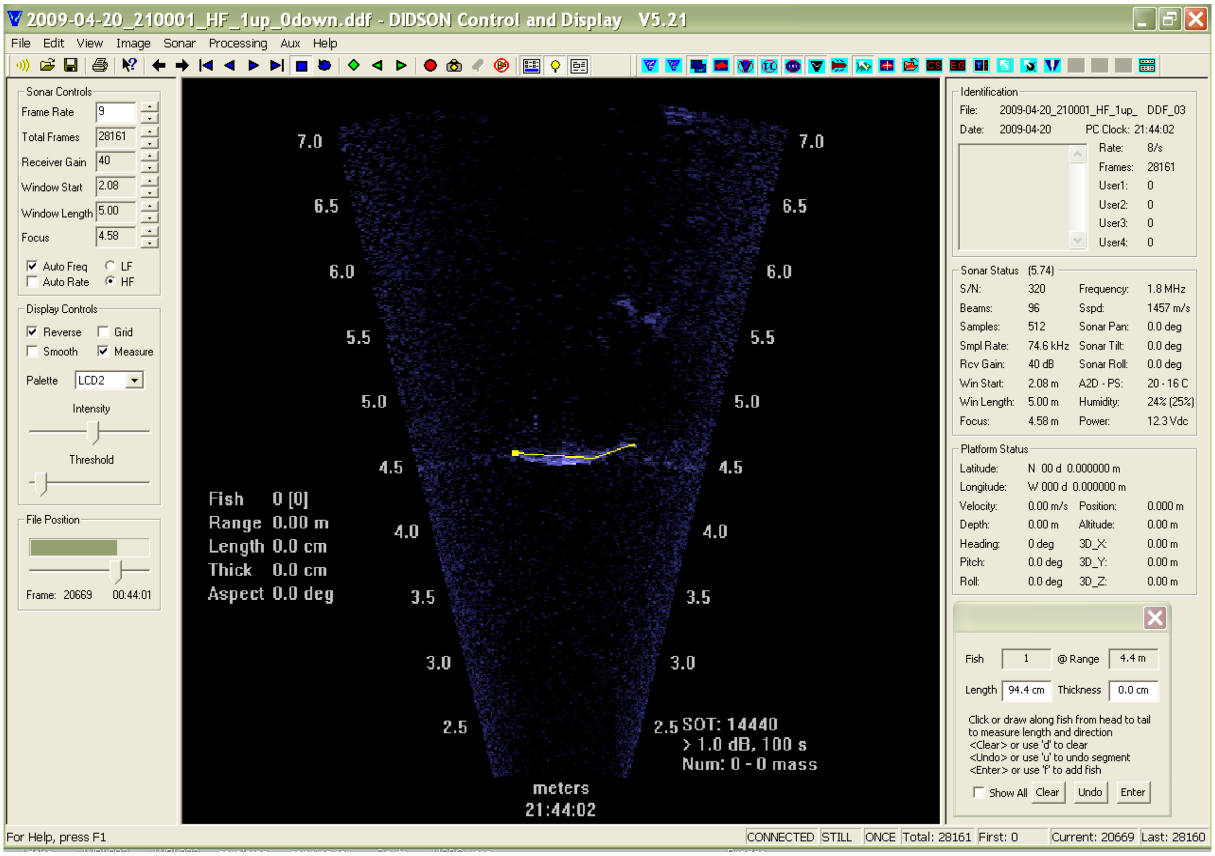


Figure 14.–Two vector measurement using Soundmetrics software version 5.21. This steelhead measured 94.4 cm long using this software (same fish as in Figure 13), and it passed the DIDSON on Peterson Creek at 21:44 on April 20, 2009. Note that the insonification window spans a range from 2.0 m to 7.0 m across Peterson Creek perpendicular to the shore. This is what is called the insonification area. The fish is located 4.4 m from the DIDSON (range). This adult steelhead is oriented upstream in the current.

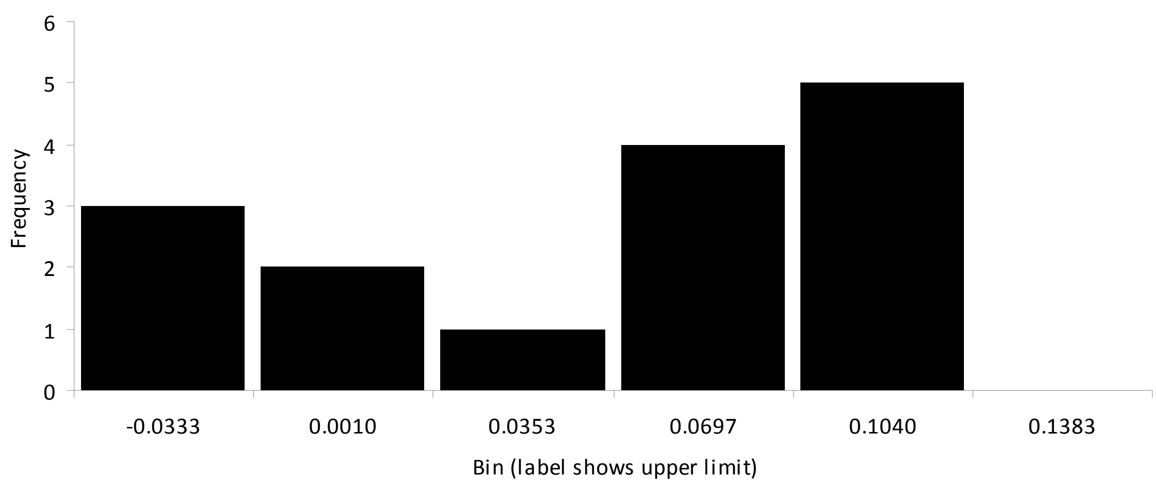


Figure 15.–Frequency versus mean difference of lengths between Observers 1 and 3 using the Echotastic software to measure randomly selected DIDSON records of 20 steelhead moving both upstream and downstream at Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. Observer 1 measured fish both inseason and postseason, whereas Observer 3 measured fish postseason to determine counting and measuring error.

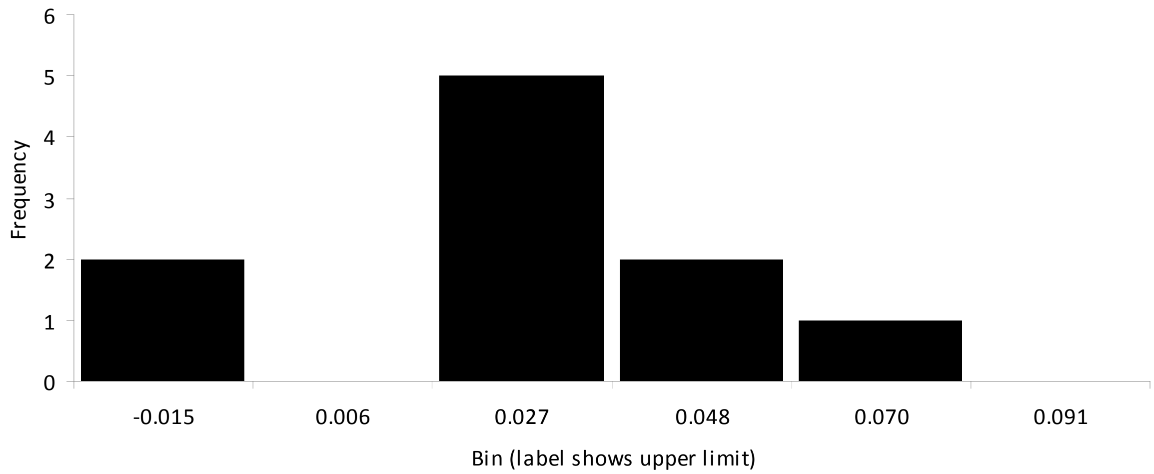


Figure 16.–Frequency versus mean difference of lengths between Observers 2 and 3 using the Echotastic software to measure randomly selected DIDSON files of 11 steelhead moving both upstream and downstream at Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. Observer 2 measured fish both inseason and postseason, whereas Observer 3 measured the fish postseason to determine counting and measuring error.

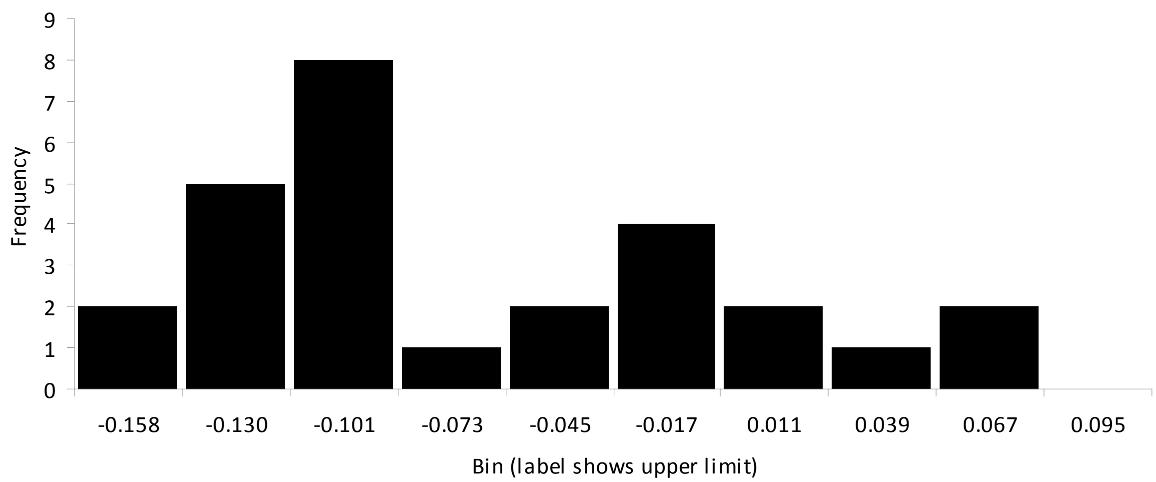


Figure 17.–Frequency versus mean difference of lengths between straight line measurements using Echotastic software and 2 vector measurements using Soundmetrics software. All measurements were made by Observer 3. Measurements are of randomly selected DIDSON files containing 31 steelhead moving both upstream and downstream at Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. Observer 3 measured the fish postseason.

PHYSICAL DATA

Daily water temperatures at the Peterson Creek DIDSON site ranged from 1.0˚C to 11.0˚C from April 20 to June 5 (Figure 18). Daily water turbidity at the site ranged from 0 NTU to 0.69 NTU, and daily water color ranged from 16.7 to 41.3 CU; weekly water pH at the site ranged from 6.6 to 6.8, and water alkalinity was 0 when sampled on April 27, May 7, May 14, May 21, May 28 and June 4; total daily precipitation ranged from 0 to 0.66 cm, with a mean total daily precipitation of 0.13 cm (Appendix D1). Daily water depth at the site ranged from 25.5 to 74.0 cm, and the staff gauge upstream of the site ranged from 0.53 to 1.05 m (Figure 19, Appendix D1). The average daily discharge for Peterson Creek from April 20 to June 5 was 2,415.4 L/s (85.3 ft^3/s). The maximum discharge of 4,488.5 L/s (158.5 $ft^{3/}s$) occurred on May 27, and the minimum discharge of 988.9 L/s (34.9 $ft^{3/}s$) occurred on June 5.

DISCUSSION

Although Southeast Alaska has 309 watersheds known to support annual escapements of steelhead, populations in only 15 streams have been studied or monitored with regularity. Steelhead stocks in Southeast Alaska have been monitored in 11 systems with the use of snorkel surveys since 1997 (Johnson and Jones 2001), and in even fewer systems with weirs (Situk and Karta river, Sitkoh and Peterson creeks) (Johnson and Jones 2001; Harding and Jones 1990–1994; Schmidt 1992; Yanusz 1997; Love and Harding 2008, 2009; Love et al. *in prep*). Snorkel surveys are a low-cost, low-intensity method of indexing abundance, while weirs are high cost and high intensity in terms of staffing. Weirs, however, are often expected to provide a complete enumeration or an estimate of escapement as opposed to an index of escapement.

One long-term objective of our program is to estimate a true abundance-to-snorkel survey correction factor and a measure of precision for snorkel survey counts conducted annually at Peterson Creek. A second long-term objective at Peterson Creek is to use the adult escapement information from both the DIDSON and those enumerated with a traditional weir to build and validate a habitat-based escapement model for steelhead in Southeast Alaska (Crupi and Nichols 2011; *Steelhead Strategic Plan*). Once developed, the steelhead habitat model will be used to predict the minimal escapement necessary to fully seed steelhead streams, based on estimates of rearing capacity.

The need to find alternative methods for counting steelhead in remote systems has become evident. While weirs provide accurate estimates of escapement with well-defined variability, they must be staffed continuously, can fail during high flows if not managed properly, may alter natural fish behavior or deter fish passage, and in some stream systems are not feasible due to flashy flows and channel geomorphology.

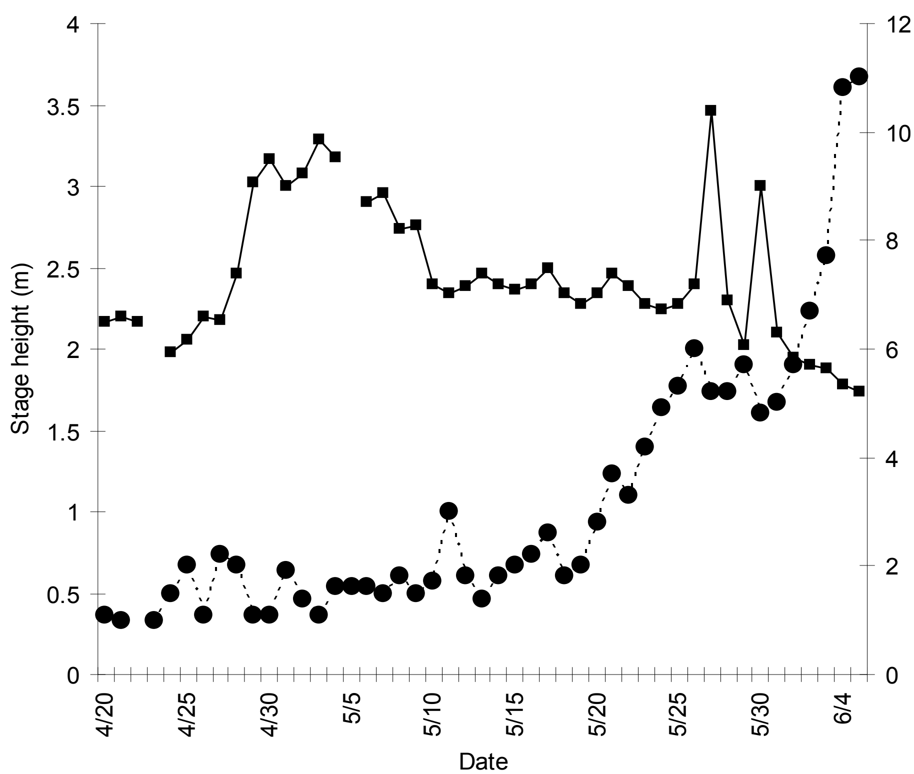


Figure 18.–Temperature (^{o}C) at the DIDSON site vs. the water depth (m) at the staff gauge in Peterson Creek, mile 25 Glacier Highway, Juneau, Alaska, 2009. Stage height depth is represented by solid line with squares, and temperature is represented by dotted line with circles.

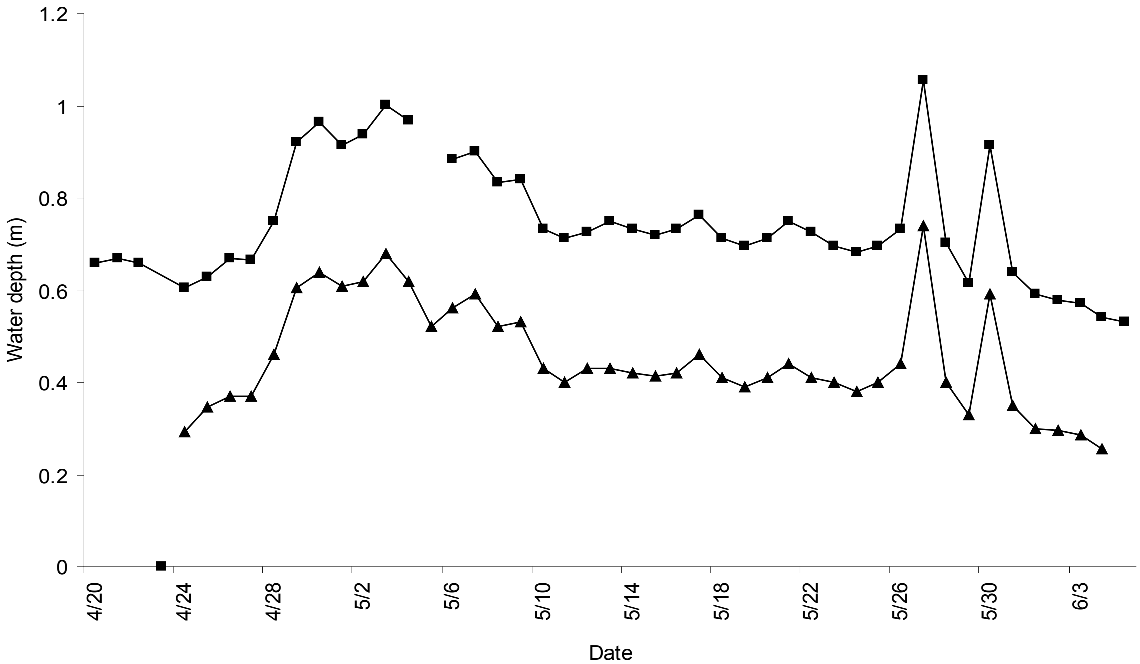


Figure 19.–Water depth (m) at the DIDSON site versus the water depth (m) at the staff gauge in Peterson Creek, mile 25 Glacier Highway, Juneau Alaska, 2009. The depth of the water above the DIDSON is represented by the squares, and the depth of Peterson Creek at the staff gauge is represented by the triangles.

We desired a counting methodology that could provide steelhead escapement estimates with minimal fish handling and less staff that was readily deployable to remote systems in Alaska at a lower cost than traditional weirs. We considered several alternatives to the traditional weir including: a flat panel resistivity counter (McCubbing and Ignace 2000; McCubbing 2005); a mini digital video recorder (DVR) fish video (Van Alen 2008); a resistance board weir with underwater water video (Gates and Palmer 2006 a, b); and a DIDSON. In 2007 in Peterson Creek we tested the least costly alternative, the flat panel resistivity counter, a technology that is used widely in British Columbia and in Europe. The counter underreported the number of steelhead moving across the electrodes, as validated with video, during daylight hours by an estimated 60% (140% efficient) (Coyle and Reed *in prep*). The presumptive cause of the miscount was low conductivity (13.9 µS/cm^2), which is influenced by snowmelt during the steelhead migration. At the suggestion of our contractor, InStream Fisheries, we reduced the spacing of the electrodes in 2008 in an attempt to amplify the signal size. This change did not improve the signal quality, and combined with other malfunctions, we determined that the flat panel resistivity counter was not suitable for our needs (Coyle and Reed *in prep.*).

In 2009, we chose the DIDSON for our next test. DIDSON offered the opportunity to record fish images with a partial weir, thereby not blocking the entire stream, which reduced the staffing requirement. Further, the ADF&G had several staff with extensive experience operating DIDSON that we could rely on for advice and direction. We had the opportunity to borrow a DIDSON from ADF&G Division of Commercial Fisheries, Southeast Region, which saved the $80,000 purchase price. This offered the opportunity to test it without the high start-up cost.

DIDSON has been used with much success to estimate escapement of large numbers of semelparous Pacific salmon in big rivers throughout Alaska where the use of weirs is unrealistic (Carroll et al. 2007; Kerkvliet et al 2008; and Maxwell and Gove 2004). These projects involved some combination of: finding a suitable area in the river to count fish (where the most fish pass); use of a bottom aiming protocol (Faulkner and Maxwell 2009); counting a time-based subsample; and expanding the data with species apportionment from test fishing. Some projects separated fish species with precise length measurements, and/or tail beat characteristics (Burwen et al. 2007; Mueller et al. 2010).

Many attributes of steelhead behavior and life history make them difficult to count. Unlike semelparous salmon, which die on the spawning grounds, steelhead are iteroparous and can return to the ocean after spawning. Therefore steelhead are moving both upstream and downstream. Activity of steelhead can be variable in response to flow and water temperature (Shepard 1972; Nielsen et al. 1994; Workman et al. 2002). Further challenges to enumeration that compound such variable fish behavior include tannic or turbid habitats, high flows from spring snowmelt, the possibility of crepuscular or nocturnal movements, and milling behavior.

In spite of locating the DIDSON in the most desirable glide in Peterson Creek below the spawning grounds, our DIDSON counts were confounded by the milling behavior of the steelhead in the section of Peterson Creek where the DIDSON was deployed. The upstream count of 747 was 4 times the average historical count (Table 2) (Harding and Jones 1990–1992), and 7.5 times the 2010 weir count in Peterson Creek (R. Harding, Fisheries Biologist, ADF&G Division of Sport Fish, Douglas, Alaska, personal communication). The downstream count of 445 steelhead was 3 times the historical average kelt count, and 4.7 times the kelt count at the weir in 2010 (R. Harding, Fisheries Biologist, ADF&G Division of Sport Fish, Douglas, Alaska, personal communication). Further corroboration of milling behavior, rather than an unusually productive year, was provided by the repetitive nature of the upstream-downstream movement, which began on April 20 and ended with the last upstream fish on June 5 (Figure 3).

Milling behavior could be a result of mate searching, resting, avoidance, or some combination thereof. Various studies of rivers on the West Coast document that sex ratios of steelhead runs have more males in the early portion of the season (Gates and Palmer 2006 a, b; Love and Harding 2008, 2009; McMillan et al. 2007). Early spawning males in Peterson Creek could have conceivably found few or no mates on the spawning grounds, and moved downstream to hold in slower, deeper water to conserve their energy and wait. The movement we observed could be similar to the "excursions" that Webb and Hawkins (1989) describe for adult Atlantic salmon in the Ginrock Burn. Radio-tagged males made frequent excursions both upstream and downstream following the females. Early steelhead in Peterson Creek may also have moved upstream, and then were spooked by movement on the highway bridge, or by anglers or predators. Steelhead may also avoid crossing upstream riffles until the energetic cost was worthwhile in terms of spawning success.

For iteroparous steelhead, simple net movement cannot be used to ascertain escapement. Some of the downstream movement is associated with milling, and fish will move once again upstream. Some of the downstream movement is also associated with kelting, and spawned-out steelhead will leave the system. Net movement would therefore underestimate escapement. It is important to then ascertain which fish are milling and which are kelting. Pipal et al. (2010) devised their DST to assist with removing milling steelhead in DIDSON counts in very small populations of endangered steelhead in the San Lorenzo River, Big Creek and Scott Creek in California. When counting fish with DIDSON, it is standard to consider a fish that moves upstream across the insonification window and out of the field of view as a single fish (a count of 1). It is impossible to know if a fish moving the opposite way some time later is the same fish without some kind of individual marker (such as a tag). The DST was developed to help the reader make a standardized objective decision, rather than a guess. We applied the tool with the expectation that it would allow us to make informed and structured subjective decisions for removal of paired observations of possibly milling fish.

Pipal et al. (2010) stated that they developed their point system based on known counts. We applied their method without a known count. The one-hour cutoff was also developed by their readers in a trial and error fashion. Unlike Pipal et al. (2010), we did not assign points for distinctive swimming, as we detected none. An additional complication and source of error to our application of the DST method was that we had a bimodal peak in our daily net count. We suggest the second peak is most likely the true peak, as it corresponds to the peak of the snorkel count (Figure 12). However, our uncertainty in the true peak date resulted in a deviation of 41% (percent difference) in our estimates of escapement, depending on what peak was selected to assign kelt status to the downstream milling fish. Downstream fish after the peak were considered kelts regardless of the point system.

The milling behavior of steelhead observed in Peterson Creek near the DIDSON site was excessive relative to projects where the DST tool has provided reliable results. Pipal et al. (2010) encountered the same problem in Big Creek, and did not continue to use it in that system. In Big Creek, Pipal et al. (2010) observed 990 fish with the DIDSON, but estimated a final escapement of 22–33 steelhead. Similarly, there were 747 upstream steelhead observations for Peterson Creek, where historically there have been 189–218 immigrant steelhead.

Milling behavior could have been exacerbated in Peterson Creek by its gradient, length and proximity to saltwater. Peterson Creek has an average gradient of 0.25%, a 3.0 m incision depth (whereas the depth at the DIDSON was 0.5–1.5 m) and an average channel bed width of 16.0 m (ADF&G 2006). Discharge at Peterson Creek during the spring of 2009 ranged from 988.8 L/s (34.9 ft^3/s) to 4488.6 L/s (158.5 ft^3/s), with an average discharge of 2415.4 L/s (85.3 ft^3/s). The DIDSON was placed approximately 1.5 km from saltwater, and approximately 1.1 km from a salt lagoon at the mouth of the creek. The water below the DIDSON site is slower and deeper, and placing it at the confluence of the creek and the salt lagoon was rejected due to likely milling. Placing it farther upstream was also rejected as the spawning grounds were located there.

Weaver (1963) in his laboratory experiments at the Bonneville Dam reported that adult steelhead swam incrementally faster as water velocities were increased from 2 to 8 ft/s (0.61–2.44 m/s), but slowed at water velocities of 13.4–15.8 ft/s (4.08–4.82 m/s). Bovee (1978) reports the peak probability of use velocity for spawning winter adult steelhead (ocean maturing) ranges from 1 to 3.6 ft/s (0.3 m/s–1.1 m/s), with the peak probability of use at 2 ft/s (0.61 m/s). Velocity measurements back-calculated from discharge at Peterson Creek from April 20 to June 5 ranged from 0.35 m/s to 0.61 m/s (1.2–2.0 ft/s), which is at the very low range of velocity for steelhead acceleration, but at a reasonable velocity for spawning. Perhaps the fish would be less likely to move upstream and down if the velocity was higher, and the energetic cost to do so was greater.

To date DIDSON has been used to count adult steelhead in 4 other systems: Big Creek, Scott Creek, and San Lorenzo River in central California (Pipal et al. 2010), and in the Utkholok River in Kamchatka (Rand et al. 2010). DIDSON counts at Scott Creek, San Lorenzo and Utkholok were considered to be accurate and complete. At Big Creek and Peterson Creek, milling behavior precluded an accurate count. Physical habitat characteristics for these systems are listed in Table 5. This table presents a mosaic of habitat characteristics. Pipal et al. (2010) believe that some aspect of watershed area could influence milling behavior. Reddin et al. (1992) discourage placing automatic fish counters at or close to river mouths, near a confluence, or just downstream of any obstruction where milling is likely to occur. Other variables that could influence milling behavior could be gradient, water velocity/discharge, distance from salt water, temperature regime, and whether or not the stream is clearwater versus brownwater. The steelhead at both Peterson Creek and Big Creek milled excessively. Of the clearwater California streams, Pipal et al. (2010) were unable to count the steelhead in Big Creek due to excessive milling. Big Creek had a slightly higher gradient than the other streams, and the DIDSON was placed the closest to saltwater in that system. Big Creek had the smallest watershed of the California streams, but a larger watershed than Peterson Creek. Utkholok River has a high discharge, but was similar to Peterson Creek as they are both brownwater systems, and both are low gradient. All of the systems other than Peterson Creek (Big

Creek, Scott Creek, San Lorenzo River, Utkholok River) also have stream-maturing steelhead (winter run), whereas the Peterson Creek steelhead are ocean-maturing (spring run). It seems likely that stream-maturing fish would be more likely to move up and down the creek as they reside longer, but this does not appear to be the case.

Unfortunately, we do not have any discharge measurements for Big Creek. Big Creek and Peterson Creek likely have different habitat characteristics that may contribute to the milling behavior of the steelhead. Both creeks had small watersheds, but differed in terms of cross-sectional area (depth x width), gradient, temperature, and distance from saltwater. Peterson Creek is a brownwater system, and Big Creek is a clearwater system. Pipal et al. (2010) suggest that smaller watersheds have fewer fish moving into the system over a longer period of time, which is conducive to higher milling as mate seeking would be more intense. While not evident for the systems in Table 5, water velocity may also play a crucial role in milling behavior. We do recommend that researchers working with DIDSON collect and report these habitat characteristics.

When using a net count, furthermore, upstream and downstream fish must be detected at equal probability. This was not the case at Peterson Creek in 2009. When trying to enumerate both upstream- and downstream-migrating steelhead with the DIDSON, the entire depth of the insonification window should be captured. Observations of steelhead at Peterson Creek indicate that upstream-moving steelhead tended to actively swim along the bottom of the stream, whereas downstream-moving fish sometimes moved passively with the current. It is therefore likely that the downstream-moving steelhead moved higher in the water column than upstream-moving steelhead, which may have affected downstream counts during high water flows. When the DIDSON was turned on its side in an attempt to record the contours of the stream bottom, water depth was so low (20 cm at the DIDSON) that extensive back-scatter prevented it from being useable. We used the cosine rule to determine the maximum depth at which we would feel confident that we were capturing all of the creek that corresponded to the insonification window with the DIDSON (Sullivan 2004). We then verified this by dragging the target at various widths and depths in the creek in front of the DIDSON. Unfortunately, we used the angle of the beam, rather than the angle the DIDSON was tilted at, to calculate this, resulting in failure to insonify the entire depth of the stream at deeper water levels.

During the rising water from April1 29 to May 9, and from May 27 to 30, downstream moving fish high in the water column or close to the DIDSON could have been missed. Downstream movement of steelhead outside the insonification window may account for a large portion of the discrepancy between our upstream and downstream counts. To prevent this uncertainty in the future, modification of Faulkner and Maxwell's (2009) aiming protocol and the use of pan-tilt mechanism may ensure that all of the stream depth is within the ensonfication window at all times.

This was the first time any of our technicians had reviewed DIDSON files, and considerable observer error existed, further compounding the error around our count. The combined observer error indicates that our counts could be underrepresented, and may account for a portion of the disparity between upstream and downstream counts. Three of the 4 steelhead missed by Observers 1 or 2 and detected by Observer 3 were steelhead moving downstream. Steelhead missed moving downstream were either in the center of the field of view (4.3–4.8 m), or near the edge closest to the DIDSON (2.4 m), indicating that missing fish was more likely a result of observer error than a result of the area where the fish were moving. One of the 4 missed fish was on the first day of the project; the remaining missed fish all occurred on the May 25 and 26 when fish activity was high. Reader fatigue and inexperience are the most likely causes of most of the reader error, as over 1,930 hours of data were viewed in our first attempt at using a DIDSON.

Table 5.–Habitat characteristics of DIDSON projects to count steelhead (and 1 Atlantic salmon radio tag study). Data from Big Creek, Scott Creek and San Lorenzo River , Utkholok River, Kamchatka, Russia , and Ginrock Burn, Scotland. Milling behavior was noted by steelhead in Big Creek, California and Peterson Creek, Alaska, and by Atlantic salmon in the Ginrock Burn, Scotland.

	Distance from saltwater (km)	Discharge	Depth (m)	Width (m)	Gradient (%)	Temp range (˚C)	Watershed (km^2)	Stream type	Maturation type
Big Creek	0.3	Not available	2.5	10	1.0	6–12	58	Clearwater	Stream
Scott	1.2	$\bar{x}$ = 75 ft^3/s (30 - 424 ft^3/s)	0.3–1.5	7-15	0.3	8–13	70	Clearwater	Stream
San Lorenzo	12	$\bar{x}$ = 616 ft^3/s (426-1120 ft^3/s)	0.5–1.5	20	0.3	Not available	360	Clearwater	Stream
Peterson	1.1	$\bar{x}$ = 2,415 L/s 85.3 ft^3/s	0.2–1.5	7	0.3	1–11	26	Brownwater	Ocean
Utkholok	25	$\bar{x}$ = 131,897,000L/s 4,657,898 ft^3/s	0.85	32	Not available	9–4	1,371	Brownwater	Stream
Ginrock Burn	Not available	$\bar{x}$ = 0.39 m^3/s (0.29-8.87 m^3/s) 13.8 ft^3/s	Not available	6.6	2.4	~0–6	31	Not available	Atlantic salmon

Source: Data from Big Creek, Scott Creek and San Lorenzo River (Pipal et al. 2010) and unpublished data provided by Kerrie Pipal, NMFS Southwest Fisheries Science Center, Santa Cruz, California. Data from Utkholok River, Kamchatka, Russia (unpublished data, provided by Peter Rand, Wild Salmon Center, Portland, Oregon), and Ginrock Burn, Scotland (Webb and Hawkins 1989).

Running all the files through the CSOT function, along with some check of sampling efficiency, should help reduce observer error in the future. The CSOT function in the Soundmetrics software works in motion-detect mode by detecting clusters of pixels that move synchronously, rather than randomly, through a series of frames that are larger than the threshold set by the individual processing the files (Soundmetrics 2009). In essence, the software detects fish or other objects (sticks, plumes of debris or gravel, etc.), and removes the frames of the files where nothing exists. This is similar to setting a DVR to record in motion detect mode when video recording. Not only does this shorten the file, reducing reader fatigue, but if the threshold and minimum cluster area are set correctly and checked periodically, the software is assisting the reader to detect fish. We began with a minimum cluster area of 100 cm^2 and a threshold of 4.9 decibels, but upon inspection of the CSOT file with the original file, these CSOT settings misclassified some of the clusters resulting in missed fish. With further refinement, we chose settings that did not miss fish (minimum cluster area equal to 100 cm^2 and a threshold of 6 decibels), but after comparison of the original file with the CSOT version, the CSOT version did capture more plumes of gravel. For future work in Peterson Creek we would start with these settings and refine them as the season progressed.

There are many ways to estimate lengths of fish using a DIDSON. Originally, we planned to use the straight-line measuring tool in Echotastic to separate steelhead from rainbow trout. We then planned to use the methods of Burwen et al. (2007) to measure length frequencies, as they concluded that the sinuous measurements of free swimming fish had little bias when used in narrow stream distances such as ours. We originally expected 100–300 measurements, but had over 1,100 images, therefore we curtailed the sinuous measurement (Burwen 2007), and used only the straight-line Echotastic measurements to determine the steelhead lengths. We did compare our straight-line measurements from Echotastic to a more standard measurements (2 vector) made using the Soundmetrics software.

Two-vector measurements in the Soundmetrics software tend to be greater than the straight-line measurements. For a given fish (at least for Observer 3), repeated 2-vector measurements were more variable than straight-line measurements, probably due to a greater number of "decisions" required, which may be hard to replicate. We were unable to expand this comparison to sinuous measurement (Burwen et al. 2007) and the box measurements (Pipal et al. 2010) with the Soundmetrics software due to time and staffing constraints.

It was not feasible to catch and tether or catch and release steelhead of known size past the DIDSON during 2009, but the need to calibrate our DIDSON steelhead measurements with fish of known size is evident. Burwen et al. (2007) found that using the sinuous measuring technique with free-swimming fish at perpendicular distances from the DIDSON less than 12 m in HF mode (1.8MHz) provided length estimates with little measurement bias, and were of sufficient quality to use to discriminate between salmonid species. Future work at Peterson Creek should include comparisons of DIDSON length estimates with steelhead of known size.

We found that we needed to improve our measuring protocol, and to improve cross-training and calibration of observers. For the range of lengths measured by Observers 1 and 2, greater than 70% of the measurements did not overlap the range of lengths measured by Observer 3. The median of the difference in sample means did not vary significantly from 0, only indicating that Observer 2 deviances from Observer 3 averaged out to 0. On a fish-by-fish basis, Observers 1, 2 and 3 were not consistent.

Steelhead are the only large salmonid in Peterson Creek during the steelhead run, and cannot be confused with other species of salmon during the study. Of 17,912 adult steelhead lengths collected from various streams in Southeast Alaska from 1989 to 2006, 24 fish were less than 55 cm (0.13%) (ADF&G unpublished data, Douglas, office network drive:S/Trout/REGIONSH/Master_Reg_Length_Comp.xls, accessed 2009). During the 1989–1991 weir counts at Peterson Creek, none of the steelhead measured were less than 63 cm (Harding and Jones 1990–1992). We have no data on resident trout lengths at Peterson Creek, but the maximum length of resident rainbow trout measured in Sitkoh Creek from 2004 to 2006 was 47 cm (n = 82), suggesting that there should be little overlap between the length frequency distributions of trout and steelhead (D. Love, Fisheries Biologist, ADF&G Division of Sport Fish, Douglas; personal communication). We suspect that our lengths measurements may be biased low, so that some of the 20 upstream-moving and 35 downstream-moving adult steelhead in the 45 cm–50 cm bins (Figures 7 and 11) are steelhead. Again, having known steelhead lengths for comparison would assist with developing a protocol.

Lastly, in spite of the excellent performance of DIDSON to capture fish images in a wide range of circumstances, we should have used it in conjunction with a validating method such as an "index to unbiased estimate comparison" (Rosenberger and Dunham 2005). As we were restricted in terms of power capacity, a weir would also have been a likely choice. The DIDSON and weir would need to be placed far enough apart so as not to affect each other. Holmes et al. (2006) used the DIDSON in concert with a weir. They counted fish through the weir and the DIDSON insonification zone simultaneously. This is different than the system we propose, which would test the DIDSON independently and allow for natural fish behavior.

CONCLUSIONS

The milling behavior of steelhead in Peterson Creek at the sonar site prevented accurate counting with a freestanding DIDSON and partial weir. Failure to detect downstream moving fish at equal probability was equally problematic. The milling behavior of our steelhead affected every aspect of collecting and trying to analyze the data. Not only were we unable to accurately estimate the steelhead escapement in Peterson Creek, the degree of milling overwhelmed the DST rendering it useless, and created many more images for analysis which caused fatigue in our observers.

RECOMMENDATIONS

We recommend initiating a season of collecting information and practicing measurement techniques before embarking on a DIDSON project for steelhead. We suggest moving the DIDSON around in the system of interest and collecting images of moving steelhead: to ascertain if and where they are milling; and to collect data to establish a measuring protocol. While doing so may utilize an entire field season, enough data will be collected to ascertain if further work is warranted, and will also give staff the opportunity for training with measuring and using CSOT before it is critical.

Overall, the diversion weir configuration and powering system worked well. We recommend the improvements depicted in Figure 20 to our 2009 Peterson Creek DIDSON and diversion weir configuration: add a mirror image upstream deflector to help keep fish 1 m in front of DIDSON; add thin netting or similar barrier in front of DIDSON to prevent fish from swimming too close; position the visible ends of both the upstream and downstream deflectors within the insonification window rather than at the edge of the insonfication window; and 4) place a nail for physical reference in the insonification window.

We recommend using a modified aiming protocol based on Faulkner and Maxwell's (2009) river profiling with the DIDSON and a dual axis tilt rotator. The optimal aim for a small stream such as Peterson Creek at depths from 0.2 to 1.5 m should be around -1.0˚ to -1.5˚ (Faulkner and Maxwell 2009). If the stream is very low during the profiling (0.2–0.5 m), we recommend using a lens concentrator. The major modification would be adjusting the beam automatically such that the entire water column is contained in the insonification window (beam). This may mean that the central axis of the beam is not "pushed" into the creek bottom when the water level rises. An alternative would be to use the river bottom aiming, as one would for salmon, but only count immigrant steelhead.

We recommend determination of what measurement techniques/software to use; by practicing with straight-line, 2-vector, box, and sinuous measurements; and determining the precision and time consumption of each. In our study, we could have spent less time with the counting data, and utilized that time more efficiently to develop more rigorous counting, measuring and milling protocols. We recommend training and calibrating observers with images of fish of known length. We recommend utilizing a DIDSON in concert with whatever validation technique is currently in use. If possible, such validation should be with an unbiased estimator that also involves steelhead capture, such as a weir. This would provide steelhead that could be released for accurate length determination.

We concur that the DST should be used only in locations with low milling behavior, and only if necessary. This technique is very time consuming, fails when there is a bimodal peak in net counts, and fails when the milling behavior becomes too prevalent. We also recommend recording and reporting pertinent physical data such as water velocity, watershed area, depth and width at the DIDSON site, discharge, temperature, gradient, distance from saltwater, stream order, and stream type (brownwater, clearwater, glacial, karst). Compilation of such data over a wide range of habitats may help develop physical proxies for 'milling'/'excursion' behavior allowing researchers to avoid such streams or reaches. We recommend purchasing a powerful computer for processing data that has the capability for downloading and processing huge data files, such as the Dell Precision Laptop M4400 with 512 Mb video card, 1900 x 1200 pixel screen, and 4 Gb memory.

An alternative design to enumerate steelhead would be to make a small (less than 0.3 m) opening in the weir to discourage downstream migrating steelhead. Doing so would necessitate that a crew monitor the weir at all times. We felt that in lieu of how time consuming collecting and analyzing the images was, it would be similarly cost effective to operate a weir to pass fish during 2010.

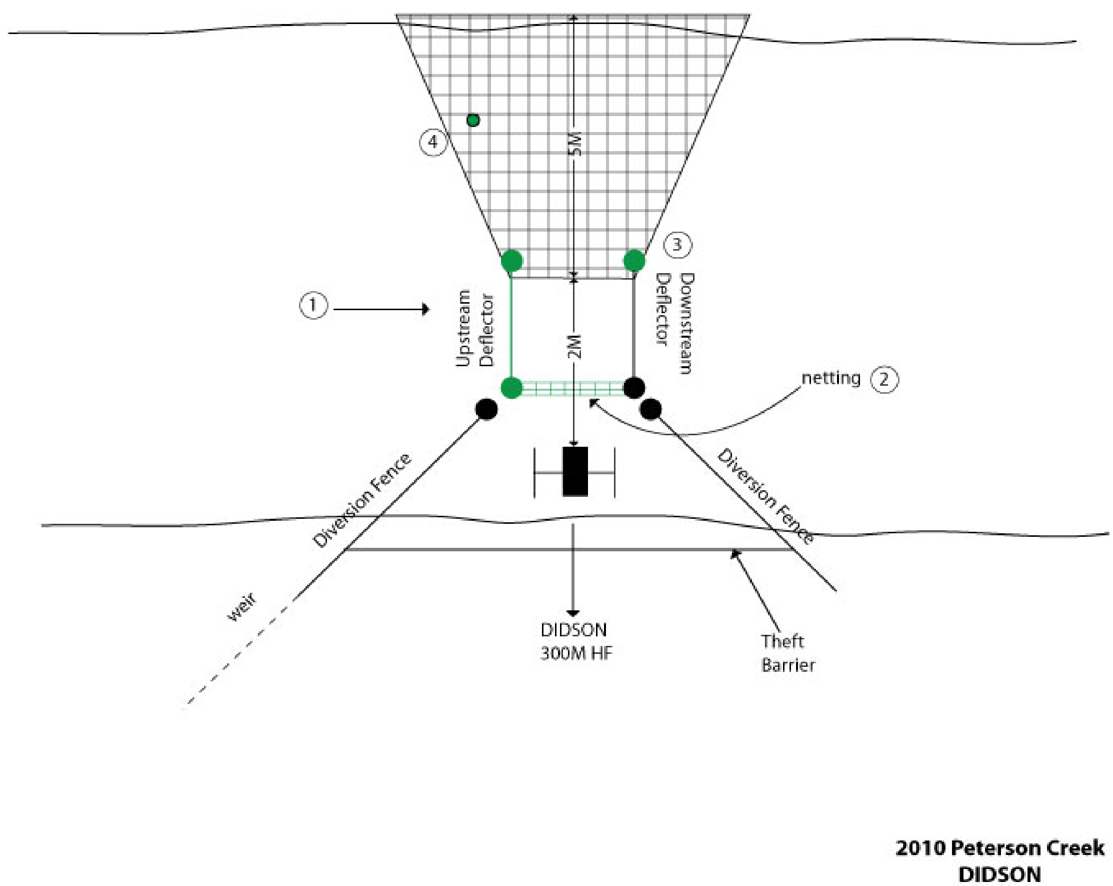


Figure 20.–Proposed changes to Peterson Creek DIDSON and diversion weir configuration: 1) add a mirror image upstream deflector to help keep fish 1 m in front of DIDSON; 2) add thin netting in front of DIDSON to prevent fish from getting too close; 3) position the visible ends of the both the upstream and downstream deflectors within the insonification window rather than at the edge of the insonification window; and 4) place a nail for physical reference in the insonification window.

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APPENDIX A: COMPONENTS AND PRICES FOR DIDSON

Appendix A1.–Components and prices for a DIDSON system run on fuel cells

	Item description	Model no. and supplier	Price each (excluding shipping)
1.	EFOY 1600 fuel cell for 10- L methanol fuel canister. Output = 65 W,12 V (Other models now available for more flexibility: EFOY Pro has 12-24 V and can use either the 10-L jug or 28-L jug) Need 3, 1 to run RAID/laptop 1 to run DIDSON, and 1 back-up	EFOY 1600 Sandpiper Technology http://www.sandpipertech.com/ The Hydrogen Company www.the**hydrogencompany**.com/ IQFuel Company http://www.iqfuelcell.com/	$6,500
2.	10 L EFOY methanol fuel jugs (to power laptop, RAID and DIDSON it took: 20 l methanol per week. Roughly $160/week	10 L EFOY Jugs Sandpiper Technology http://www.sandpipertech.com/ The Hydrogen Company www.the**hydrogencompany**.com/ IQFuel Company http://www.iqfuelcell.com/	$80 for10L
3.	Optima gel battery (marine RV with blue top) 75 amp hour	http://www.optimabatteries.com/home.php Blue Top Group SC31DM	$320
4.	100 A shunt DigitalAmp meter With 5 A inline fuse	M-DIGAMP100 http://www.backwoodssolar.com/	$68
5.	100 A, 100 mV shunt (1 for each amp meter)	SH100 http://www.altestore.com	$24
6.	Cigarette lighter plugs 1 for RAID and 1 for E4200 airport connector	Roadpro RP-203EC 12V 12' extension cord with cigarette lighter plug (comes with both a male and female end). Wire can be cut and outfitted with crimp-on terminal connectors. http://www.amazon.com	$12
7.	12-24 V convertor or switch mode car adapter, regulated, 120 W This steps the voltage to exactly what each appliance may need (for instance, the DIDSON is set at 18 V).The converters have an inline 10A fuse, and there is a button on the back to set the voltage. The convertors have a male cigarette lighter end, and female connectors are available at electronics or auto parts stores. The connectors can be taped with electrical tape to prevent them from coming apart.	CARS000S www.allspectrum.com	$40
8.	Topside box	(comes with DIDSON)	–
9.	TFT Monitor (5.6 in) Good for diagnostics and viewing the start up scripts for the DIDSON. Hook up to DIDSON topside box.	MON5TFT3-KIT www.supercircuits.com Includes battery pack, charger, AC plug and case.	$219
10.	DIDSON 200-ft cable	Ocean Marine Industries http://www.oceanmarineinc.com/	$1,990
11.	DIDSON 300 M with 200 ft cable and topside box. Draws 25 W, approximately 3 A, 14- 32 V. Check serial number, newer models have less draw.	DIDSON 300 M Soundmetrics http://www.soundmetrics.com/ Ocean Marine Industries http://www.oceanmarineinc.com/	$85,000
12.	Dell E4200 airport power brick	Dell PA12 auto air adapter (65 W)	$80

-continued-

Appendix A1.–Page 2 of 2.

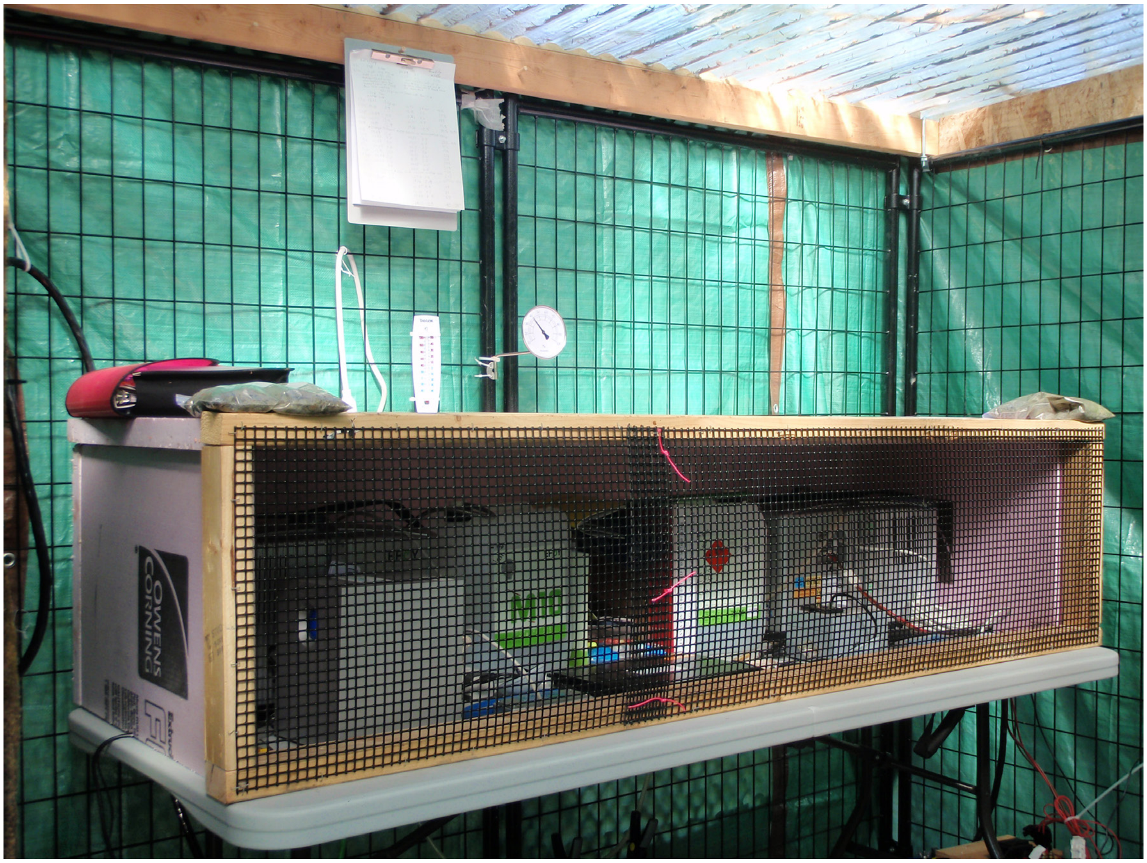
	Item description	Model no. and supplier	Price each (excluding shipping)
13.	Dell E4200 solid state laptop This is a low draw solid state hardrive laptop with an Energy Star rating. System Components include: Intel Core 2 Duo 140 GHz, Windows Operating system (XP), 3.0 GB, DDR3-1066 SDRAM, 1 GB integrated + 2 GB DIMM, internal English backlit keyboard, Mobile Intel Graphics Media Accelerator 4500MHD, 128 GB Mobility Solid State Drive, Dell Wireless 365 Bluetooth, Latitude On Ready, 45 W AC adapter, Wireless Lan 1297 mini card, 6 cell extended battery, and a 6 cell battery slice Draws 1 W in standby mode, 16 W in idle and 25 W in active mode. Amperage is approximately 2.4 (for RAID (33) and laptop (34) together, approximately 55 - 67 W)	http://www.dell.com/us/en/businessnotebooks/laptop_latitude_e4200/	$2,782
14.	RAID Drive (4 TB) 4TB 4big Quadra eSATA/FireWire 800/Firewire 400/USB 2.0 RAID Hard Drive in RAID 10 configuration Holds 2 TB data total, but makes 2 copies and can rebuild the data if something goes wrong with one drive.	LaCie Big 4 Quad 4 TB RAID drive LaCie 301359U http://www.lacie.com/products/product.htm	$750
15	Spare drives for RAID (1 TB each) Should have at least 1 on hand.	LaCie-301364 http://www.lacie.com/products/product.htm	$145
16	Misc.electrical	Shrink tape, butt connectors, wire stripper, solder and soldering gun, terminal connectors	$100

APPENDIX B: DIDSON HARDWARE, WEIR SET-UP, AND ELECTRONICS

Appendix B1.–DIDSON 300 M acoustic camera mounted on an aluminum H-bracket prior to using it in Peterson Creek. The bracket secures the DIDSON in place and is adjustable both horizontally and vertically.

Appendix B2.–Partial weir structure and diversion fence surrounding DIDSON mounted on H-bracket in Peterson Creek. For a top view see Figure 2. The diversion fence protects DIDSON from debris and helps to direct fish into the open channel where they can be recorded by the DIDSON. A security camera is mounted on a pole behind the diversion fence. The partial weir is not connected to the diversion fence so in the event that it collapsed, it would not damage the diversion fence or the DIDSON. The open channel in front of the DIDSON is the insonification area or window and was 4.5 m in length. The insonification window measured 29˚ horizontally by 12˚ vertically. Fish moving through this area were recorded by the DIDSON.

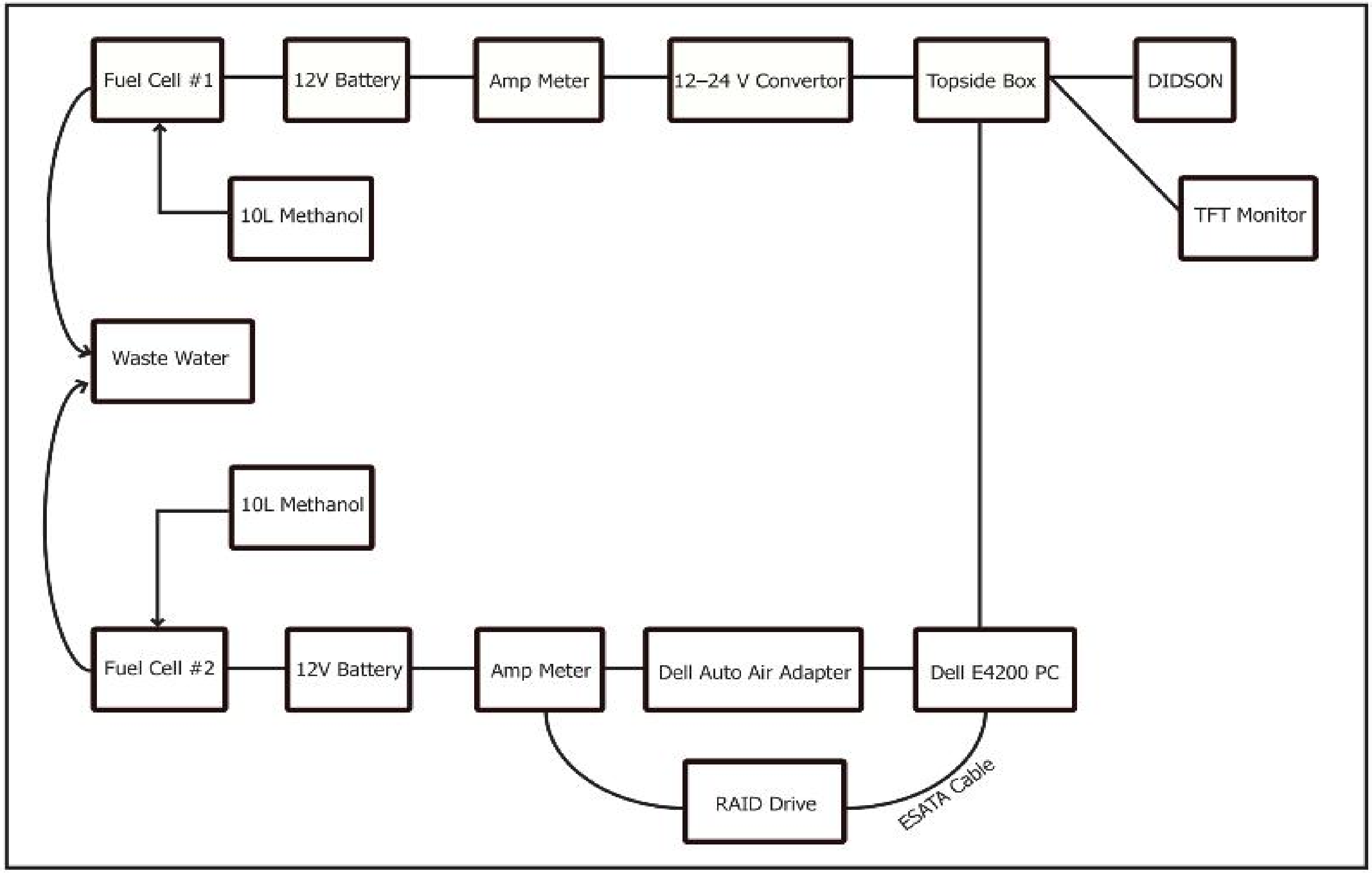
Appendix B3.–The electronic components for the DIDSON at Peterson Creek are housed in a 4 ft x 8 ft dog kennel with a clear fiberglass roof covered with tarps and camouflage netting. The electronics are covered with rigid foam insulation on 3 sides to trap heat, and to control humidity. The screen was a barrier for mice.



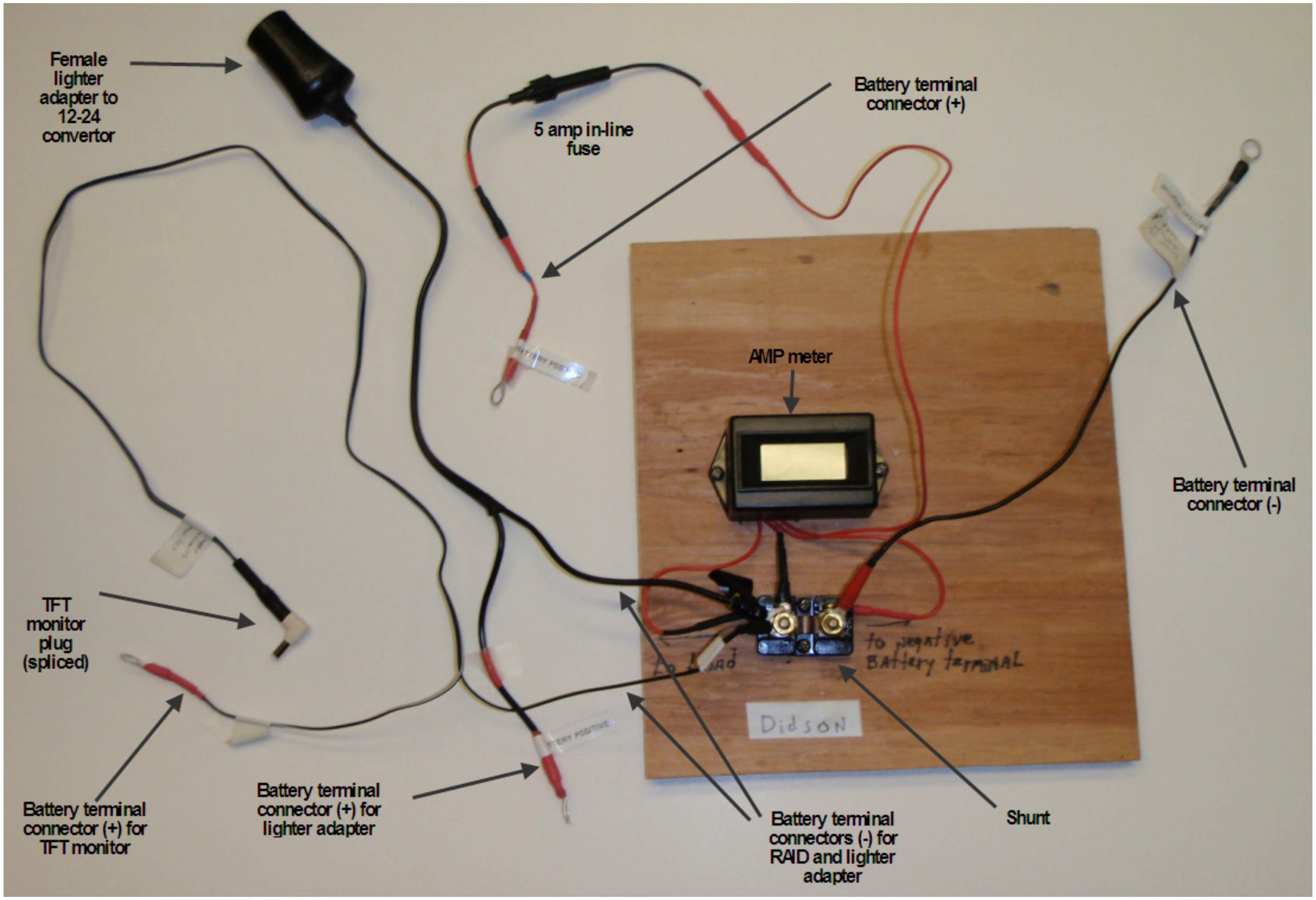
Appendix B4.–Electronic components for the DIDSON at Peterson Creek. The DIDSON and RAID drive were powered by 65 W methanol fuel cells. Wastewater from the fuel cells are collected in the tub beneath the table. Photo by Ken Koolmo. See Appendix C for diagram of electronics.

APPENDIX C: WIRING DIAGRAMS FOR DIDSON, TFT MONITOR, RAID DRIVES, LAPTOP, AND FUEL CELLS

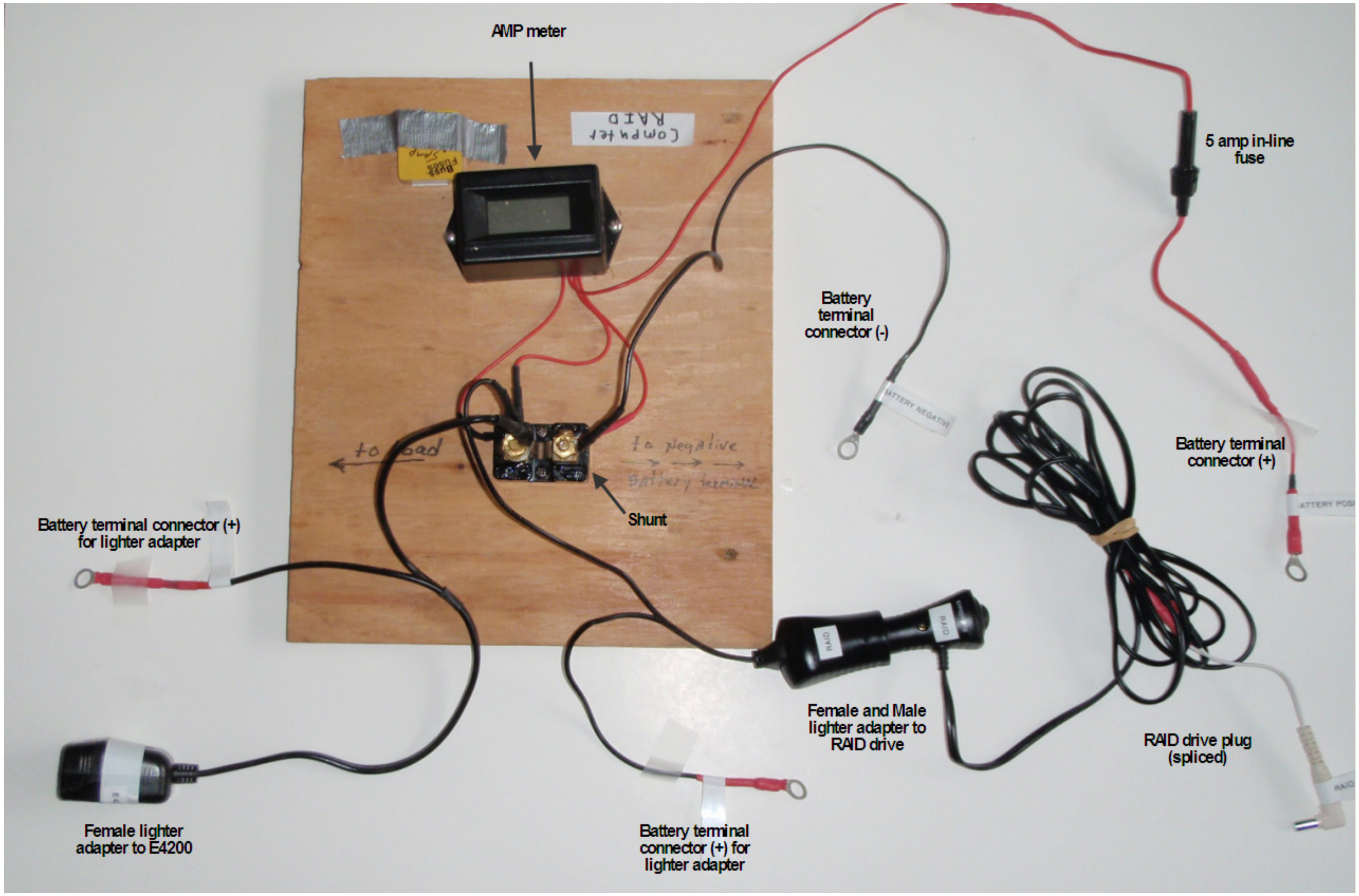
Appendix C1.–Simplified wiring diagram for setting up the DIDSON, TFT monitor, Laptop (PC),and RAID drive with fuel cells. See Appendix A1 for a list of specific components, Appendices C2 and C3 for a detail of the amp meter wiring, and Appendices B3 and B4 for photographs of the components in use at Peterson Creek in 2009.



Appendix C2.–Detail of amp meter for the DIDSON and TFT monitor. Components include: DC amp meter, shunt, female lighter adapter, 12 – 24 V convertor (not shown and is connected to the DIDSON), and battery terminal connectors (for TFT monitor plug, lighter adapter, and amp meter). All components were mounted on a scrap of plywood. The amperage draw was continuously monitored while the DIDSON was operated in Peterson Creek in 2009. See Appendix A for part numbers.



Appendix C3.–Detail of amp meter for the computer and RAID drive. Components include: DC amp meter, shunt, male/female lighter adapters, RAID drive plug (plugs to Dell Auto Air Adapter), and battery terminal connectors (for RAID drive plug, lighter adapter and amp meter). All components were mounted on a scrap of plywood. The amperage draw was continuously monitored while the DIDSON was operated in Peterson Creek in 2009. See Appendix A for part numbers.



APPENDIX D: PHYSICAL DATA FOR PETERSON CREEK 2009

Appendix D1.–Physical data collected during the Peterson Creek DIDSON project, 2009.

Date	Depth[a] (cm)	Stage height[b] (m)	Temperature (˚C)	Alkalinity (mg $CaCO_3$/L)	Turbidity (NTU)	Color (CU)	pH	Precipitation (mm)
4/20/09	ND	0.66	1.1	ND	ND	ND	ND	ND
4/21/09	ND	0.67	1.0	ND	ND	ND	ND	ND
4/22/09	ND	0.66	ND	ND	ND	ND	ND	ND
4/23/09	ND	0.00	1.0	ND	ND	ND	ND	ND
4/24/09	29.1	0.60	1.5	ND	ND	ND	ND	0.00
4/25/09	34.5	0.63	2.0	ND	ND	ND	ND	0.00
4/26/09	37.0	0.67	1.1	ND	ND	ND	ND	0.00
4/27/09	37.0	0.66	2.2	0	ND	ND	6.6	0.00
4/28/09	46.0	0.75	2.0	ND	ND	ND	ND	0.00
4/29/09	60.5	0.92	1.1	ND	ND	ND	ND	0.00
4/30/09	64.0	0.96	1.1	ND	ND	ND	ND	0.00
5/1/09	61.0	0.91	1.9	ND	ND	ND	ND	0.00
5/2/09	62.0	0.94	1.4	ND	ND	ND	ND	0.00
5/3/09	68.0	1.00	1.1	ND	ND	ND	ND	0.00
5/4/09	62.0	0.97	1.6	ND	ND	ND	ND	0.00
5/5/09	52.0	ND-	1.6	ND	ND	ND	ND	0.00
5/6/09	56.0	0.88	1.6	ND	ND	ND	ND	5.08
5/7/09	59.0	0.90	1.5	0	ND	ND	ND	2.54
5/8/09	52.0	0.84	1.8	ND	0.3	ND	ND	0.00
5/9/09	53.0	0.84	1.5	ND	0.2	ND	ND	3.81
5/10/09	43.0	0.73	1.7	ND	ND-	30.5	ND	1.27
5/11/09	40.0	0.71	3.0	ND	0.2	28.5	ND	0.00
5/12/09	43.0	0.73	1.8	ND	0.2	29.9	ND	0.00
5/13/09	43.0	0.75	1.4	ND	0.1	32.9	ND	0.00
5/14/09	42.0	0.73	1.8	0	0.1	30.0	6.7	0.00
5/15/09	41.5	0.72	2.0	ND	0.1	31.2	ND	6.35
5/16/09	42.0	0.73	2.2	ND	0.1	30.2	ND	0.00
5/17/09	46.0	0.76	2.6	ND	0.4	33.9	ND	0.00
5/18/09	41.0	0.71	1.8	ND	0.3	29.8	ND	0.00
5/19/09	39.0	0.69	2.0	ND	0.1	28.0	ND	0.00
5/20/09	41.0	0.71	2.8	ND	0.3	29.9	ND	0.00
5/21/09	44.0	0.75	3.7	0	0.3	29.0	6.8	0.00
5/22/09	41.0	0.73	3.3	ND	0.1	28.0	ND	0.00
5/23/09	40.0	0.69	4.2	ND	0.2	26.6	ND	0.00
5/24/09	38.0	0.68	4.9	ND	0.7	37.1	ND	0.00
5/25/09	40.0	0.69	5.3	ND	0.5	27.8	ND	0.00
5/26/09	44.0	0.73	6.0	ND	0.1	37.1	ND	6.60
5/27/09	74.0	1.05	5.2	ND	ND	16.7	ND	15.24
5/28/09	40.0	0.70	5.2	0	0.3	27.7	6.8	0.00
5/29/09	33.0	0.62	5.7	ND	0.2	33.3	ND	6.60
5/30/09	59.0	0.91	4.8	ND	0.6	41.3	ND	6.60
5/31/09	35.0	0.64	5.0	ND	0.0	19.3	ND	0.00
6/1/09	30.0	0.59	5.7	ND	0.2	28.5	ND	0.00
6/2/09	29.5	0.58	6.7	ND	0.5	ND	ND	0.00
6/3/09	28.5	0.57	7.7	ND	0.3	19.7	ND	0.00
6/4/09	25.5	0.54	10.8	0	0.4	19.8	6.7	0.00
6/5/09	ND	0.53	11.0	ND	0.1	22.9	ND	0.00

[a] This is the depth at the DIDSON.

[b] This is the depth at the staff gauge.

APPENDIX E: FILE DESCRIPTIONS

Appendix E1.–Computer data files used to prepare and generate estimates for "Assessment of the Performance of a DIDSON (Dual Frequency Identification Sonar) to count Steelhead in Peterson Creek, 2009." All files are organized on the Region 1- Douglas Sport Fish Server under S:\Trout\PETERSON\Peterson 2009\FDS Report.

File Name	Description
2009petersoncounts_clc_11.03.09 (version2).xls	All count data, second read data, physical data and graphs
2009 Peterson discharge and velocity.xls	Conversion of discharge data into velocity data
Copy of Carol_Velocity_info.xls	Regressions for discharge and velocity provided by FSL
Peterson09_small_fish.xls	Graphs and length frequencies of images 40-50 cm
Utkholok site characteristics cc (2).doc	Physical data for Utkholok provided by Peter Rand
Physical comparison_Pipal additions(2).doc	Physical data for Big Creek, Scott Creek and San LorenzoRiver provided by Kerrie Pipal
09upoutoriginal.xls	Results of round 1 cuts of DST
09upout2.xls	Results of round 2 cuts of DST
09upsout3.xls	Results of round 3 cuts of DST
09dnout3.xls	Results of round 3 cuts of DST (some downs were missed in up file)
09upout4.xls	Results of round 4 cuts of DST
09dnout4.xls	4 cuts of DST (some downs were missed in up file)
09dnout5.xls	Results of round 5 cuts of DST (last cuts)
Copy of 2nd Reads-color-djr.xls	Observer error file and graphs