Fishery Data Series No. 23-25

Red Lake Remote Video Salmon Escapement Monitoring Project, 2022

by

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and

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Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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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

FISHERY DATA REPORT NO. 23-25

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ABSTRACT

From June 8 through October 13, 2022, Alaska Department of Fish and Game staff operated an autonomous video counting tower (AVCT) immediately below the outlet of Red Lake within the Southern District of the Lower Cook Inlet Management Area (LCIMA). The AVCT was programmed to record high-resolution time-lapse video during daylight hours to provide information on the run-timing and magnitude of Pacific salmon (*Oncorhynchus* spp.) escapements into Red Lake. This project was a component of the Alaska Energy Authority's preliminary assessment of fishery resources in the Martin River drainage, which is under consideration for future hydroelectric power development. Sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), and Dolly Varden (*Salvelinus malma*) were captured on video migrating upstream to Red Lake in 2022. Additionally, juvenile coho salmon were collected from the lake shoreline during a spring sampling trip. The AVCT operated without interruption and documented 681 sockeye salmon with the peak daily count occurring on June 21. Peak run timing for coho salmon occurred on October 10 with a total observed escapement of 48. The AVCT documented 5 pink salmon and 53 Dolly Varden, as well as a variety of wildlife.

Keywords Lower Cook Inlet, Kachemak Bay, Red Lake, Martin River, Pacific salmon, sockeye salmon, coho salmon, pink salmon, Dolly Varden, video, escapement, monitoring, video assessment, salmon escapement, autonomous video counting tower, AVCT

INTRODUCTION

This project was conducted by the Alaska Department of Fish and Game (ADF&G) as a component of the Alaska Energy Authority's (AEA) preliminary assessment of fishery resources in the Martin River drainage, which is under consideration for future hydroelectric power development. The project took place in ADF&G's Lower Cook Inlet Management Area (LCIMA), which includes marine and freshwaters of the Cook Inlet region south of the latitude of Anchor Point including the western shore of Cook Inlet south to Cape Douglas, and the eastern shore of Cook Inlet along the Kenai Peninsula to Cape Fairfield. This area is included in Area H and encompasses all coastal waters and inland drainages entering this area. This project was located within the Southern District of the LCIMA (Figure 1).

The use of aerial surveys to monitor salmon escapement on small clear streams in Alaska began in the 1930s (Eicher 1953) and continues today (Otis and Hollowell 2022). This technique is favored for remote and marginally productive stocks which otherwise may go unassessed due to the high cost of intensive monitoring methods (e.g., weir, sonar) relative to the stream's modest escapement. However, aerial surveys have several drawbacks. Observer experience, water clarity, stream morphology and habitat type, timing and periodicity of survey flights, and stream residency are just a few factors shown to influence the accuracy and precision of aerial survey estimates of salmon escapement (Bevan 1961; Neilson and Geen 1981; Cousens et al. 1982; Shardlow et al. 1987; Perrin and Irvine 1990; Hill 1997; Bue et al. 1998; Jones et al. 2007). Researchers have developed sophisticated statistical approaches for dealing with some of these problems (Hilborn et al. 1999; Adkison and Su 2001; Su et al. 2001), but aerial survey remains an imprecise escapement monitoring tool. At best, it provides consistent indices of in-river escapement among years. It does not provide accurate, reliable estimates of spawner-abundance, particularly when in-river exploitation or predation of salmon is high (Peirce et al. 2011; Peirce et al. 2013) and observer efficiency and stream residency are not precisely known (Perrin and Irvine 1990; Bue et al. 1998; Jones et al. 1998).

Accurate, reliable estimates of spawner abundance are required to assess stock-recruit relationships (Walters and Ludwig 1981), monitor long-term trends in the status of salmon resources (Baker et al. 1996), set appropriate spawning escapement goals for individual streams (Otis et al. 2016), and manage commercial fisheries in season (Hollowell et al. 2019). Because aerial surveys cannot always provide this level of information and more accurate methods are prohibitively expensive for streams with marginal escapements, a niche exists that remote video technology has helped fill. Fishery biologists have long considered the potential for photographic enumeration to eliminate the biases inherent to human derived aerial, ground, and tower counts of salmon escapement. In the late 1940s and early 1950s, researchers experimented with aerial and tower-based photography to count sockeye salmon (*Oncorhynchus nerka*) in the Bristol Bay area (Kelez 1947; Eicher 1953; Mathisen 1962). While these early experiments showed promise, their feasibility was reduced by the state of technology of cameras and recording equipment from that era.

Considerable technological advancement has occurred since that time and recent video and time-lapse recording systems have proven effective in a wide variety of applications. Video has been used successfully to evaluate the use of underwater habitat features (Groves and Chandler 1999; Carlson and Quinn 2005), evaluate the accuracy of side-looking sonar to count outmigrating salmon fry (Mueller et al. 2006), estimate residency on spawning redds (Shardlow 2004), monitor fish wheel catch (Daum 2005), count and measure juvenile salmon in a controlled field situation (Irvine et al. 1991), track fish swimming movements (Hughes and Kelly 1996), and count fish at passageways (Haro and Kynard 1997; Davies et al. 2007). The use of time-lapse video at dam fish passageways along the Columbia River system (Hatch et al. 1994; Hiebert et al. 2000) has advanced to the point where researchers are developing image processing capabilities to increase the efficiency of reviewing video to count fish (Hatch et al. 1998; Shortis and Otis 2014).

Elsewhere in the Pacific Northwest, researchers have been developing underwater video systems associated with partial weirs (Kucera and Faurot 2005; Gates and Palmer 2008; Kerkvliet and Booz 2015). Underwater systems that do not require human operators are not practical for most Alaskan streams because the camera and weir would be vulnerable to high water events, inquisitive bears, and other mammals. To address this, researchers in Alaska have been experimenting with human operated video counting towers (Hetrick et al. 2004) and those that do not require human operators (Otis and Dickson 2002; O'Neal 2007; Otis 2012; Otis 2020). Towers are more practical for remote operation without people present (uncrewed) because there's nothing in the creek to obstruct fish passage or become vulnerable to bears or high-water events. Unlike traditional counting towers, where human observers sample the escapement by counting fish during predefined periods every hour, video counting towers can be programmed to record fish passage continuously. Uncrewed or autonomous video counting towers (AVCT) are well suited for many small clear streams that are otherwise monitored by aerial survey. When deployed at appropriate locations, AVCTs have demonstrated the ability to collect near census quality escapement estimates (Otis et al. 2010) that far surpass the accuracy of aerial survey indices.

The outlet of Red Lake is well suited to monitoring salmon escapement with an AVCT. The outlet stream is narrow, very clear, has shallow laminar flow, and has adequate solar exposure. All these traits are needed for AVCTs to produce high quality video images of migrating salmon. Because salmon escapement was expected to be modest and access to Red Lake is difficult and expensive (i.e., helicopter), an AVCT was determined to be the most effective and economical method for assessing this stock.

OBJECTIVES

1. Operate an autonomous video counting tower (AVCT) at Red Lake to census the daily escapement of adult Pacific salmon during daylight hours from approximately June 8 through October 13.
2. Identify and document other fish and wildlife species (e.g., juvenile salmonids, bears, etc.) captured on video transiting the camera site.

METHODS

STUDY SITE

Red Lake is located approximately 8.8 river km (5.5 mi) upstream of the mouth of the Martin River near the head of Kachemak Bay, in the Southern District of the LCIMA (Figure 1). The Red Lake AVCT was located approximately 100 m below Red Lake along the outlet stream that flows into the Martin River (Figure 2; approximately 59.6966 N, 151.0031 W). This location was selected because it met key criteria for successful AVCT operations (e.g., shallow/clear water, laminar flow, narrow stream width, and adequate southern exposure for generating enough solar power to exceed system requirements).

Components for the video system were mounted to a 3 m (10 ft) section of antenna tower. Approximately 30–60 cm (1–2 ft) of the bottom of the tower were buried in the ground to create a solid base. The top of the tower was stabilized by 3 radially spaced guy lines extending downward to *Duckbill* earth anchors (Model-*88*). A 122 cm (4 ft) length of 6.4 cm diameter (2.5 in) aluminum pipe was secured to the top of the tower for additional height and to provide a place to attach an adjustable video camera housing (Figure 3).

A high-contrast substrate panel was fabricated out of a 4.6 mm ($^{3}/_{16}$ in) mesh beach seine. It was dyed light green because we have found fish are sometimes reluctant to swim across a white panel (E. Otis, *personal observation*). The panel was placed across the bottom of the stream, perpendicular to water flow, to better elucidate fish passing by the AVCT (Figure 3). The upstream edge of the panel was secured to an anchor chain and fastened to the stream bottom using a *Duckbill* earth anchor (Model *DB-68*). The downstream edge was left unencumbered as it was held tight to the stream bed by the current.

Currently, in addition to Red Lake, ADF&G uses AVCTs to monitor escapements for 2 wild salmon stocks in the LCIMA: Mikfik Lake sockeye salmon and Chenik Lake sockeye salmon (Otis 2020). The AVCT at Red Lake was modeled after the design and functionality of those systems.

VIDEO COMPONENTS

The AVCT system was composed of several “off-the-shelf” electronic and video components:

- surveillance camera *(GeoVision Model GV-BX3400)*
- 2 TB hard drive *(Oyen Novus 7200RPM)*
- (4) 85 W solar panels *(Model BP585U)*
- (2) 15 A solar power regulators *(Model AST-15A)*
- (2) 12 V batteries *(Absorbed Glass Mat [AGM], Group 29)*
- 12 V timer switch *(Model JVR 12V)*
- 12 Circuit fuse block *(Blue Sea Systems)*
- Other assorted wires and electrical components

The camera was enclosed in a custom-fabricated, aluminum, weatherproof camera housing attached to the top of the tower where it was adjusted so the view encompassed the entire wetted width of the creek. The other sensitive electronic components were protected inside a commercially available weatherproof aluminum strongbox (Model *UWS-ATV*: 81.3 cm L x 30.5 cm W x 30.5 cm H) set atop a platform secured to the tower approximately 1 m above ground (Figure 3). A 2.5 cm diameter (1 in) flexible conduit protected all cables needed for communication between the camera and strongbox components. Communication cables included: ethernet, 12/2 power, USB, and coaxial. Video from the camera was recorded to a 2 TB external hard drive via a 4.6 m (15 ft) length of USB cable (USB-C to 2.0 mini-B).

The camera (*GeoVision* Model *GV-BX3400*) was a 3 mega-pixel (MP) progressive scan CMOS IP box camera. It was outfitted with a vari-focal (*GeoVision* 3–10.5 mm), auto-iris lens. To balance hard drive capacity with image quality, video was recorded at 3 frames per second (fps) in the MJPEG codec, which compresses video within frames. Other video codecs that compress video across frames, such as H.264, can result in rapid image degradation when recording through a medium of moving water, especially when surface turbulence is present. The camera was powered by a dedicated 12 VDC cable, but it also had power over ethernet (PoE) capability. Setup and review of the camera required a laptop computer running *GeoVision* software (Model *GV-IPCAM H.264*) that was connected to the camera via an ethernet cable. In the field, during setup and periodic maintenance visits, we confirmed the camera was functioning properly using the laptop or a portable monitor connected via coax cable.

Electronic components in this system were powered by two Group 29 12-volt direct current (VDC), 100 ampere hour (Ah) AGM batteries. They were connected in parallel to provide a single 200 Ah capacity battery bank outputting 12 VDC. Four 85W solar panels (e.g., Model *BP585U*), set up as 2 isolated pairs, were used to recharge the battery bank. Wire leads from each pair of solar panels were run through a 15 A fuse block and a 15 A solar power regulator (Model *AST 15*) before going to the battery bank (Figure 4). All sensitive electronic components (e.g., camera, hard drive, monitor) were protected by appropriately sized fuses inside a fuse block, like those used for small boat accessories.

VIDEO INSTALLATION, OPERATION, AND REMOVAL

Given the expense of accessing the site by helicopter, we programmed the camera to maximize storage capacity (up to ~50 days), and coordinated with other researchers to share flights to service our respective field equipment. Hard drives were exchanged on June 15, August 4, and September 22, with final retrieval on October 13.

For more details on the installation, operation, and maintenance of the AVCT, including programming the camera and reviewing video using *GeoVision* software, see Otis and Blackmon (2022) and Appendices A–E in Otis (2020).

VIDEO RECORDING

Time-lapse recording rate was set at 3 fps to optimize hard drive space without compromising the reviewer's ability to track individual fish transiting the video site. Although the camera is capable of recording in the H.264 video compression format, we used the MJPEG format because it yields better quality images and smoother playback for our application. We did not use auxiliary lighting due to power limitations; therefore, there were approximately 4 h each night (00:00–04:00) where it was too dark for the AVCT to see fish in June/July and 6–8 h in August/September. Although disk space required for a day's video varies with the complexity of the images (e.g., varying light conditions, surface turbulence, cloud shadows, etc.), the 2 TB hard drives we used with the camera typically accommodated about 50 days of recorded video, given our programmed settings. Hard drives larger than 2 TB are not compatible with *GeoVision* cameras.

VIDEO REVIEW

Video was reviewed during and after the season to enumerate fish passage (Figure 5). Review of video was easiest when run through the same *GeoVision* camera that was used to record the images, but that was not possible when the camera was still in the field recording fish passage. To overcome this, we installed software (*Ext2Fsd* and *RemoteViewlog*) on select office computers that allowed us to review video files directly from *Linux* formatted external hard drives. *Ext2Fsd* is a free file system driver, written in *C* for *Microsoft* operating systems, that facilitates read/write access to *Linux* formatted drives and files (e.g., ext2, ext3, ext4). *RemoteViewlog* is *GeoVision's* video review software, which provides the reviewer control over a variety of playback features (e.g., screen size, playback speed, brightness, contrast, etc.). For more details on the use of *GeoVision* software for video review, see Appendices D and E in Otis (2020).

Fish counts and other noteworthy observations (e.g., weather, dawn/dusk, video quality; and sightings of bears, moose, or other wildlife captured on video) were recorded in uniform *Microsoft Excel* spreadsheets. Daily fish counts were stratified by species into 6-hour time blocks (e.g., 00:01–06:00, 06:01–12:00, 12:01–18:00, and 18:01–24:00). Staff also recorded periods of video loss or other technical difficulties. See Appendix D in Otis (2020) for further details and an example of this spreadsheet.

RESULTS

ADULT SALMONID ENUMERATION

The AVCT was operated 20 h per day (04:00–24:00) from 12:15 on June 8 until 12:00 on October 13, 2022, resulting in 2,539.5 h of recorded video. Sockeye salmon, coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), and Dolly Varden (*Salvelinus malma*) were observed migrating to Red Lake during 2022 operations. The AVCT operated without interruption and documented a total of 681 sockeye salmon with the peak daily count occurring on June 21 (Table 1, Figure 6). Peak run timing for coho salmon occurred on October 10 with a total observed escapement of 48 (Table 1, Figure 7). The AVCT documented 5 pink salmon and 53 Dolly Varden char (Table 1). The Dolly Varden count was probably underestimated due to the diminutive size and coloration of the fish, which makes them difficult to see when viewed from above.

JUVENILE SALMON

During a brief opportunistic sampling event on June 8, several juvenile salmon observed along the shoreline of Red Lake were caught using a make-shift beach seine. Specimens were collected and transported to our lab in Homer where they were all positively identified as coho salmon.

Other Wildlife Documented

- American dipper *Cinclus mexicanus*
- Bald eagle *Haliaeetus leucocephalus*
- Beaver *Castor canadensis*
- Black bear *Ursus americanus*
- Brown bear *Ursus arctos*
- Common merganser *Mergus merganser*
- Coyote *Canis latrans*
- River otter *Lontra canadensis*
- Harlequin duck *Histrionicus histrionicus*
- Belted kingfisher *Megaceryle alcyon*
- Red squirrel *Tamiasciurus hudsonicus*
- Spotted sandpiper *Actitis macularius*
- Unidentified hawk *Accipiter* sp.

DISCUSSION

Adult Salmon Enumeration

The AVCT performed flawlessly in 2022, enabling accurate assessment of the run timing and magnitude of Pacific salmon returning to Red Lake during daylight hours. No system failures occurred during the 2022 season, and the only downtime was attributed to brief shutdowns to swap hard drives. AVCTs have many advantages over periodic aerial and ground survey counts, some of which are discussed in Otis (2012). The potential limitations of AVCTs include operational integrity of the system and the inability to monitor all 24 hours in a day without adding auxiliary lighting. Hence, there is the potential to underestimate the size of the total run when only counting during daylight hours. On the Anchor River, diurnal timing of local Chinook (*O. tshawytscha*) and coho salmon runs has been monitored for many years. During some years, 30% of the escapement has occurred after 1900 h (Kerkvliet and Booz 2010). Because an exact census of every fish was not a requirement for this pilot study, we did not design the system to accommodate the additional power generation that would have been required for auxiliary lighting. However, it should be noted that approximately 75% of the coho salmon that migrated through a video weir operated by ADF&G on nearby Battle Creek in 2022 did so during hours of darkness (Holly Dickson, ADF&G, Division of Sport Fish, Fishery Biologist, Homer, October 2022, personal communication). Although there is limited coho salmon spawning habitat available above the Red Lake AVCT, it is possible that the coho salmon documented during daylight hours only represented a fraction of the total run. When considering the run timing for Red Lake sockeye and coho salmon and evaluating potential impacts that may derive from future hydroelectric development activities in the drainage, it should be noted that there is an unknown migratory lag time between the date salmon enter the Martin River from Kachemak Bay and the date they are observed at the Red Lake AVCT. An extended study duration (i.e., earlier installation/later removal) may be warranted if this project is continued to ensure the entire sockeye and coho salmon runs are documented. Consideration may also be warranted for adding auxiliary lighting and power generation to the Red Lake AVCT to enable nocturnal video monitoring to better estimate the total run size for all species.

JUVENILE SALMON

Sampling juvenile salmonids was not an objective of this study, but we took advantage of an opportunity to sample fry observed along the shoreline of Red Lake during our Spring 2022 visit to the site. However, that was a cursory effort and the juvenile coho salmon we caught should not be considered representative of all species that may be present. For example, given the number of adult sockeye salmon counted past the AVCT, it would appear Red Lake also provides appropriate rearing habitat for juvenile sockeye salmon. Future survey efforts could determine if juvenile sockeye salmon rear in Red Lake for 1 or 2 years or if they leave the system soon after emerging from the gravel, because they sometimes do in systems lacking sufficient lake resources (Kaeriyama and Ueda 1998). A more thorough and systematic survey involving sampling of different habitats throughout the lake using a variety of capture methods should be used if this becomes a future study objective.

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TABLES AND FIGURES

Table 1.–Daily fish passage at Red Lake autonomous video counting tower (AVCT) by species.

	Sockeye salmon		Pink salmon		Dolly Varden		Coho salmon	
Date	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
8 Jun	1	1	0	0	3	3	0	0
9 Jun	20	21	0	0	13	16	0	0
10 Jun	11	32	0	0	-4	12	0	0
11 Jun	19	51	0	0	8	20	0	0
12 Jun	27	78	0	0	8	28	0	0
13 Jun	35	113	0	0	6	34	0	0
14 Jun	20	133	0	0	3	37	0	0
15 Jun	15	148	0	0	0	37	0	0
16 Jun	40	188	0	0	0	37	0	0
17 Jun	33	221	0	0	1	38	0	0
18 Jun	78	299	0	0	0	38	0	0
19 Jun	90	389	0	0	0	38	0	0
20 Jun	92	481	0	0	0	38	0	0
21 Jun	108	589	0	0	0	38	0	0
22 Jun	10	599	0	0	0	38	0	0
23 Jun	10	609	0	0	0	38	0	0
24 Jun	9	618	0	0	0	38	0	0
25 Jun	13	631	0	0	0	38	0	0
26 Jun	7	638	0	0	0	38	0	0
27 Jun	6	644	0	0	0	38	0	0
28 Jun	9	653	0	0	0	38	0	0
29 Jun	2	655	0	0	0	38	0	0
30 Jun	0	655	0	0	0	38	0	0
1 Jul	6	661	0	0	0	38	0	0
2 Jul	3	664	0	0	0	38	0	0
3 Jul	0	664	0	0	0	38	0	0
4 Jul	0	664	0	0	0	38	0	0
5 Jul	6	670	0	0	0	38	0	0
6 Jul	3	673	0	0	0	38	0	0
7 Jul	1	674	0	0	0	38	0	0
8 Jul	0	674	0	0	0	38	0	0
9 Jul	0	674	0	0	0	38	0	0
10 Jul	0	674	0	0	0	38	0	0
11 Jul	0	674	0	0	0	38	0	0
12 Jul	0	674	0	0	0	38	0	0
13 Jul	0	674	0	0	1	39	0	0
14 Jul	0	674	0	0	1	40	0	0
15 Jul	0	674	0	0	3	43	0	0
16 Jul	0	674	0	0	0	43	0	0
17 Jul	0	674	0	0	0	43	0	0
18 Jul	0	674	0	0	0	43	0	0
19 Jul	1	675	0	0	0	43	0	0
20 Jul	0	675	0	0	0	43	0	0
21 Jul	0	675	0	0	0	43	0	0
22 Jul	0	675	0	0	0	43	0	0
23 Jul	0	675	0	0	0	43	0	0

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Table 1.–Page 2 of 3.

Date	Sockeye salmon		Pink salmon		Dolly Varden		Coho salmon	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
24 Jul	0	675	0	0	0	43	0	0
25 Jul	0	675	0	0	0	43	0	0
26 Jul	0	675	0	0	0	43	0	0
27 Jul	0	675	0	0	0	43	0	0
28 Jul	0	675	0	0	0	43	0	0
29 Jul	0	675	0	0	0	43	0	0
30 Jul	0	675	0	0	0	43	0	0
31 Jul	0	675	0	0	0	43	0	0
1 Aug	0	675	0	0	0	43	0	0
2 Aug	0	675	0	0	0	43	0	0
3 Aug	0	675	0	0	0	43	0	0
4 Aug	0	675	0	0	0	43	0	0
5 Aug	0	675	0	0	0	43	0	0
6 Aug	0	675	2	2	0	43	0	0
7 Aug	0	675	0	2	0	43	0	0
8 Aug	0	675	0	2	0	43	0	0
9 Aug	0	675	1	3	0	43	0	0
10 Aug	0	675	0	3	0	43	0	0
11 Aug	0	675	1	4	0	43	0	0
12 Aug	0	675	0	4	0	43	0	0
13 Aug	0	675	0	4	0	43	0	0
14 Aug	0	675	0	4	0	43	0	0
15 Aug	0	675	0	4	0	43	0	0
16 Aug	0	675	0	4	0	43	0	0
17 Aug	0	675	0	4	0	43	0	0
18 Aug	0	675	0	4	0	43	0	0
19 Aug	0	675	0	4	0	43	0	0
20 Aug	0	675	0	4	0	43	0	0
21 Aug	0	675	0	4	0	43	0	0
22 Aug	0	675	0	4	0	43	0	0
23 Aug	0	675	0	4	0	43	0	0
24 Aug	0	675	0	4	0	43	0	0
25 Aug	0	675	0	4	0	43	0	0
26 Aug	0	675	0	4	0	43	0	0
27 Aug	0	675	0	4	0	43	0	0
28 Aug	0	675	0	4	0	43	0	0
29 Aug	0	675	0	4	0	43	0	0
30 Aug	0	675	0	4	0	43	0	0
31 Aug	0	675	0	4	0	43	0	0
1 Sep	0	675	0	4	0	43	0	0
2 Sep	1	676	0	4	0	43	0	0
3 Sep	1	677	0	4	0	43	0	0
4 Sep	1	678	0	4	0	43	0	0
5 Sep	1	679	0	4	2	45	0	0
6 Sep	0	679	0	4	2	47	0	0
7 Sep	2	681	0	4	3	50	0	0

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Table 1.–Page 3 of 3.

Date	Sockeye salmon		Pink salmon		Dolly Varden		Coho salmon	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
8 Sep	0	681	0	4	0	50	0	0
9 Sep	0	681	0	4	0	50	0	0
10 Sep	0	681	0	4	0	50	0	0
11 Sep	0	681	0	4	0	50	0	0
12 Sep	0	681	0	4	0	50	0	0
13 Sep	0	681	0	4	2	52	0	0
14 Sep	0	681	0	4	0	52	0	0
15 Sep	0	681	1	5	0	52	0	0
16 Sep	0	681	0	5	0	52	0	0
17 Sep	0	681	0	5	0	52	0	0
18 Sep	0	681	0	5	1	53	0	0
19 Sep	0	681	0	5	0	53	0	0
20 Sep	0	681	0	5	0	53	0	0
21 Sep	0	681	0	5	0	53	0	0
22 Sep	0	681	0	5	0	53	0	0
23 Sep	0	681	0	5	0	53	0	0
24 Sep	0	681	0	5	0	53	0	0
25 Sep	0	681	0	5	0	53	0	0
26 Sep	0	681	0	5	0	53	0	0
27 Sep	0	681	0	5	0	53	0	0
28 Sep	0	681	0	5	0	53	0	0
29 Sep	0	681	0	5	0	53	0	0
30 Sep	0	681	0	5	0	53	0	0
1 Oct	0	681	0	5	0	53	2	2
2 Oct	0	681	0	5	0	53	4	6
3 Oct	0	681	0	5	0	53	1	7
4 Oct	0	681	0	5	0	53	3	10
5 Oct	0	681	0	5	0	53	0	10
6 Oct	0	681	0	5	0	53	0	10
7 Oct	0	681	0	5	0	53	4	14
8 Oct	0	681	0	5	0	53	8	22
9 Oct	0	681	0	5	0	53	0	22
10 Oct	0	681	0	5	0	53	15	37
11 Oct	0	681	0	5	0	53	9	46
12 Oct	0	681	0	5	0	53	0	46
13 Oct	0	681	0	5	0	53	2	48

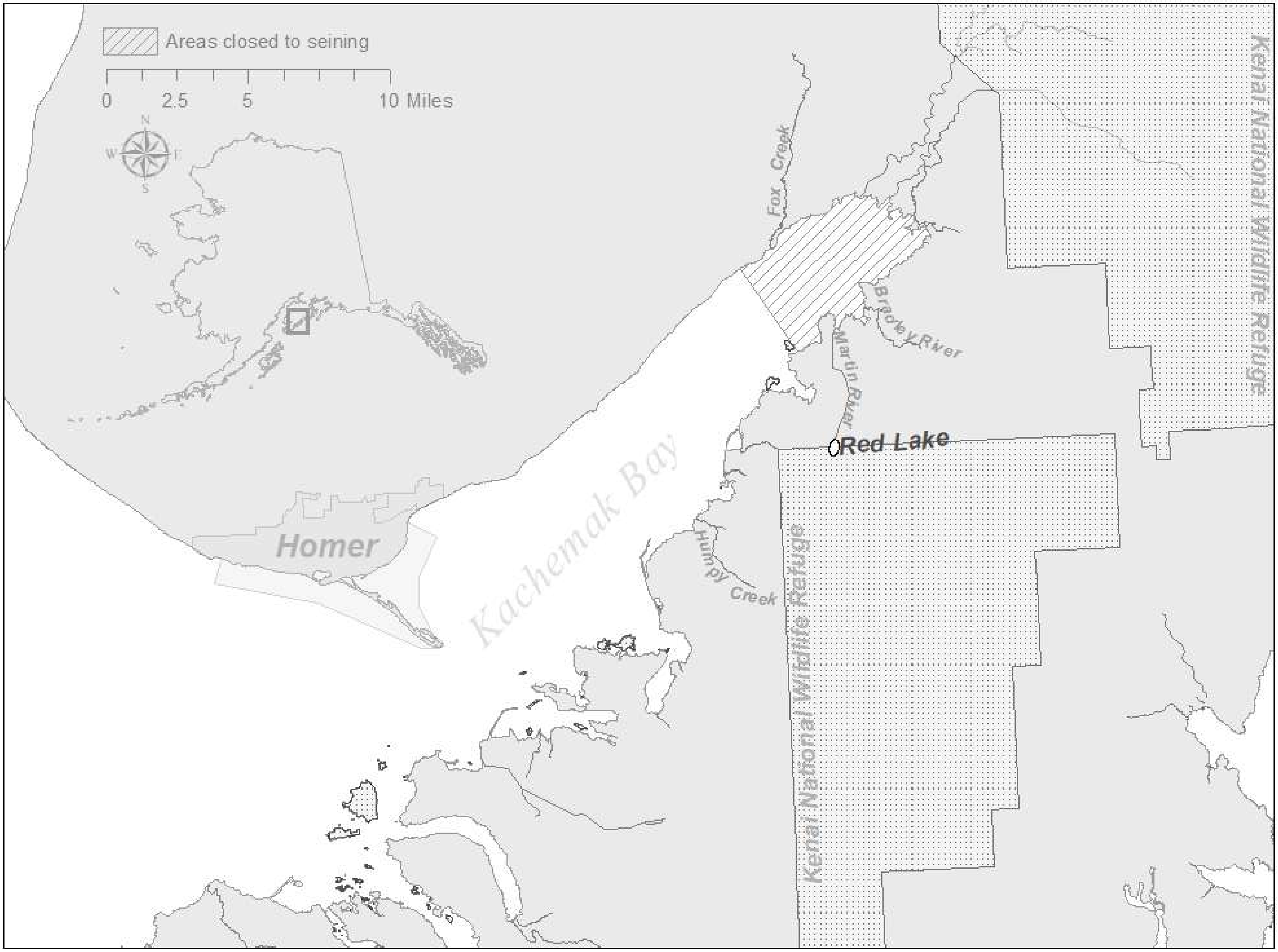

Figure 1.–Map of the Southern District of Lower Cook Inlet showing location of Martin River and Red Lake.

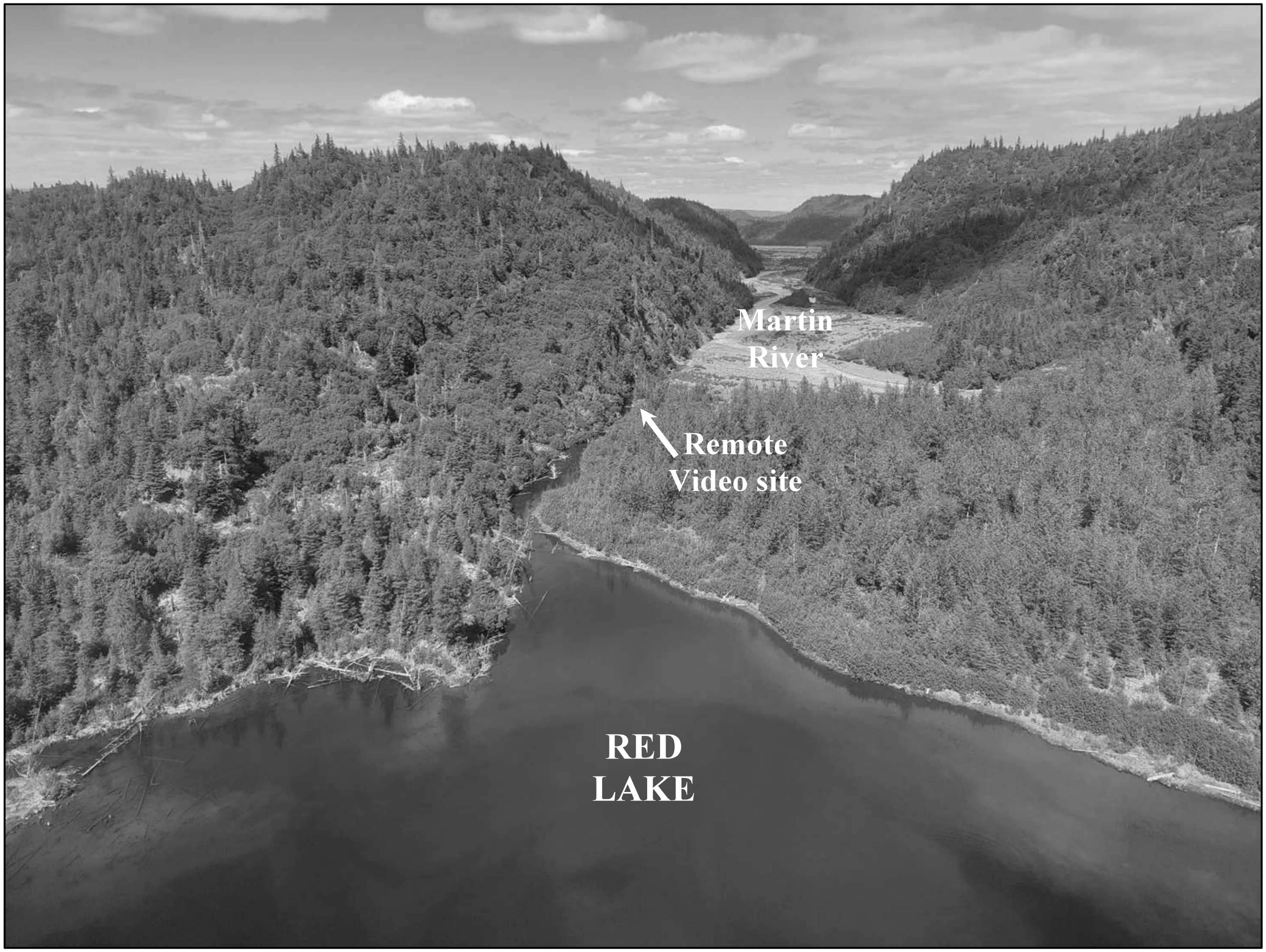

Figure 2.–Photograph illustrating the location of the Red Lake remote video salmon escapement project.

A. B.

Figure 3.–Photographs of autonomous video counting tower (AVCT) system at Red Lake showing (A) the tower, camera, and aluminum strongbox; and (B) the solar panels and high contrast substrate panel across the stream bottom to enhance the contrast of fish swimming past the camera.

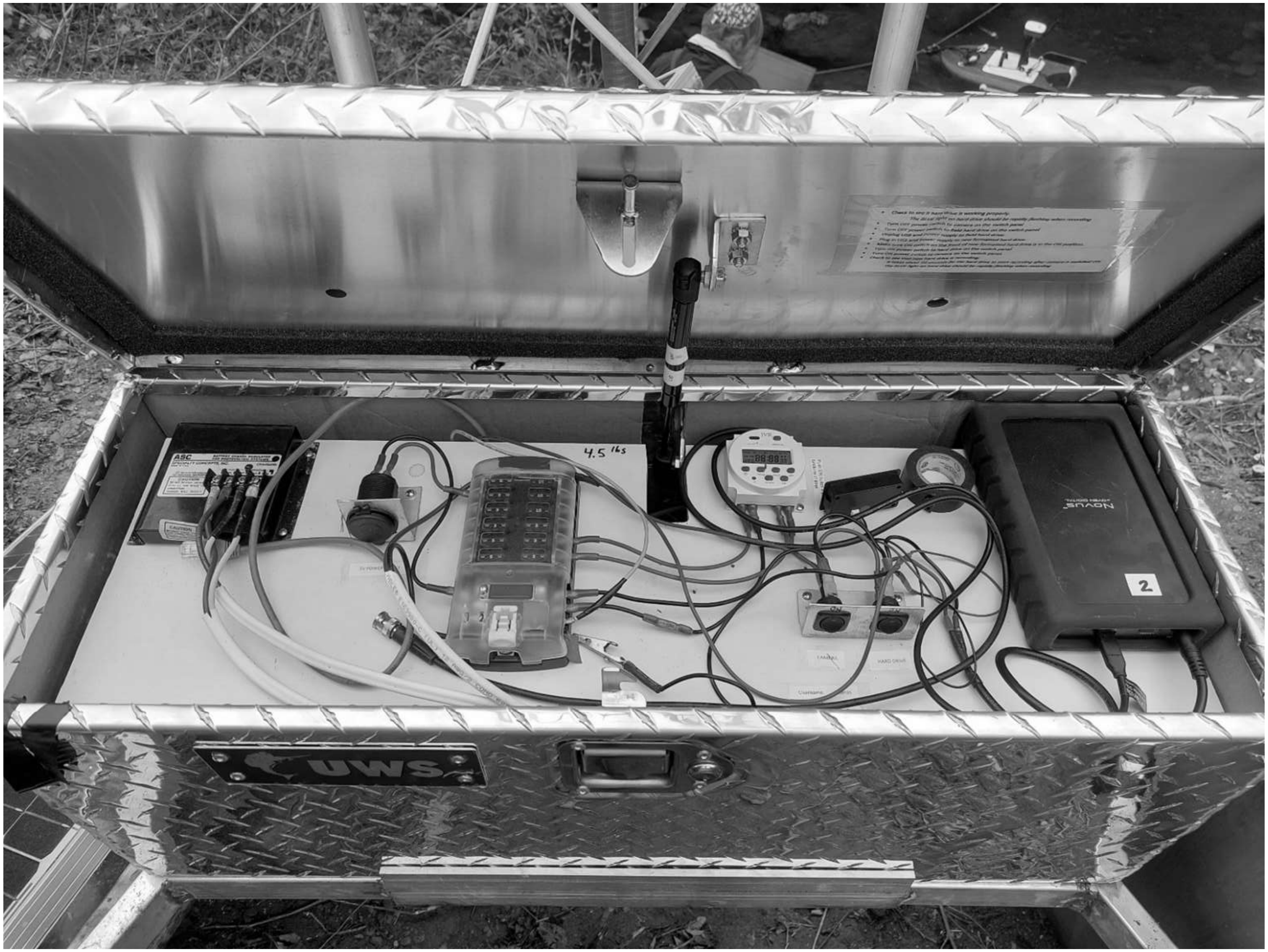

Figure 4.–Picture illustrating the inside of the aluminum strongbox housing various electronic components and two Group 29 12V batteries (underneath the dash panel) that were connected in parallel to make a single 200-amp hour battery bank outputting 12 VDC.

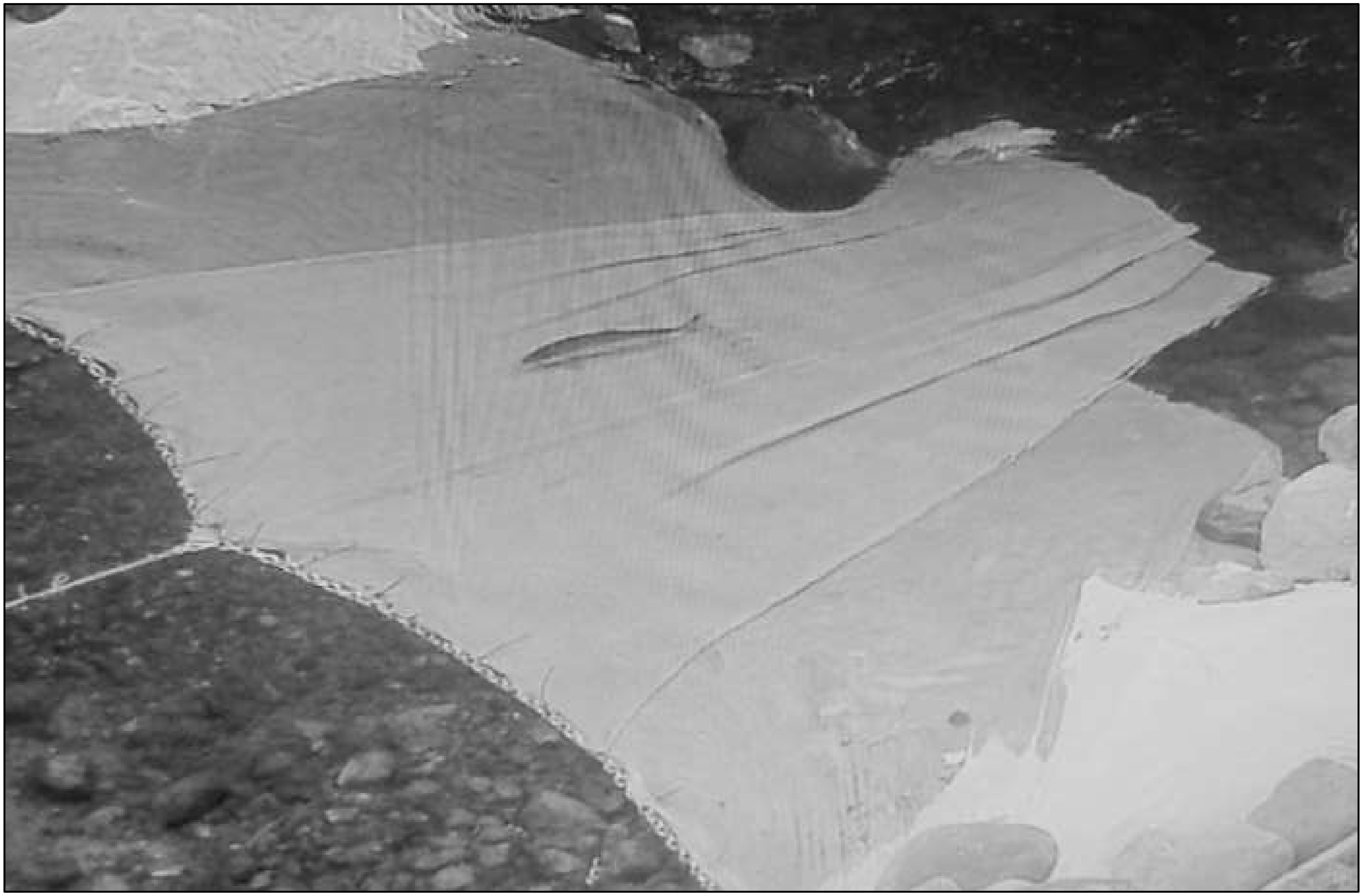

Figure 5.–Screen grab image of adult sockeye salmon migrating upstream, as documented by the autonomous video counting tower (AVCT) system at Red Lake.

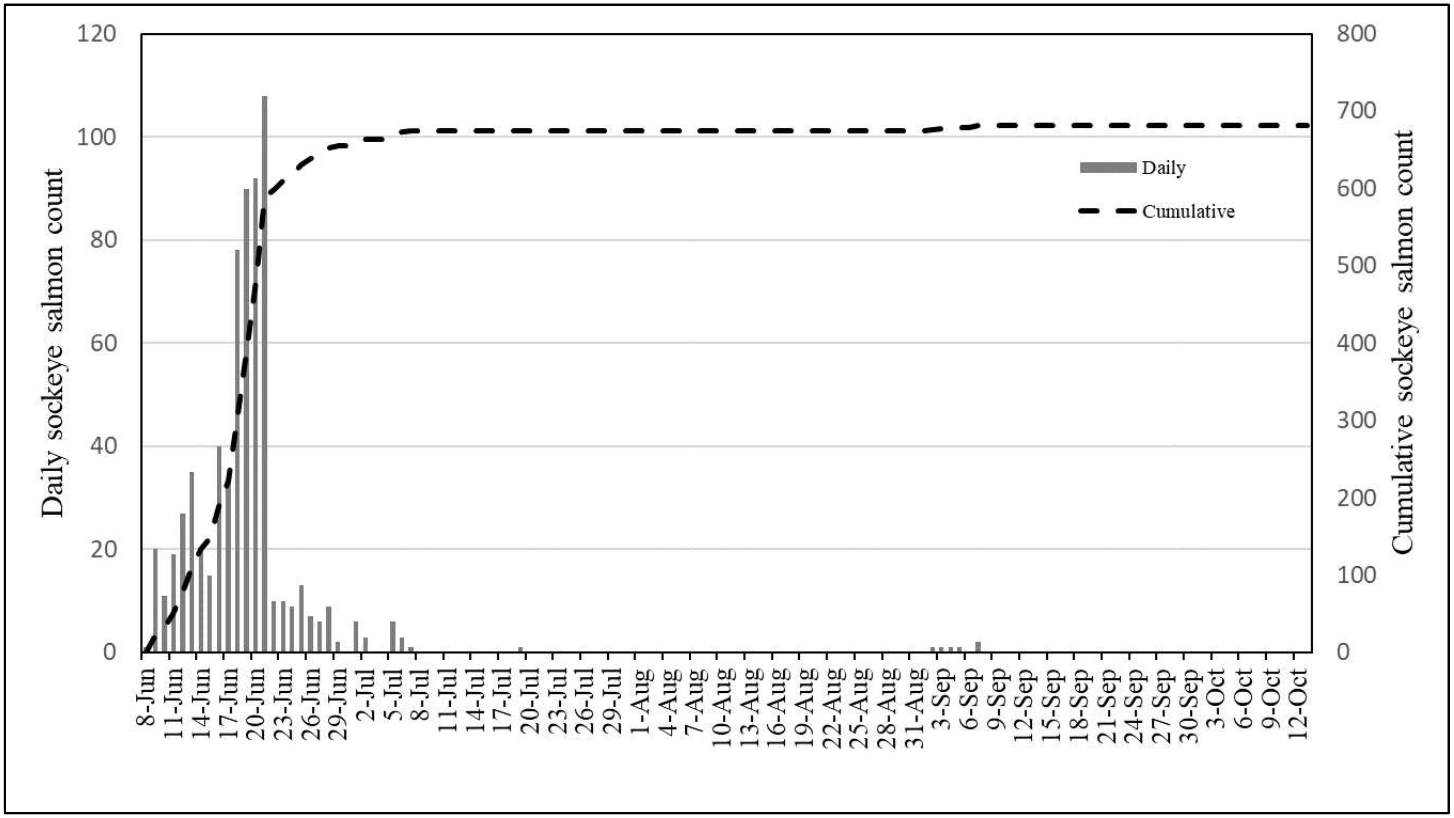

Figure 6.–Chart of daily and cumulative sockeye salmon escapement to Red Lake, 2022.

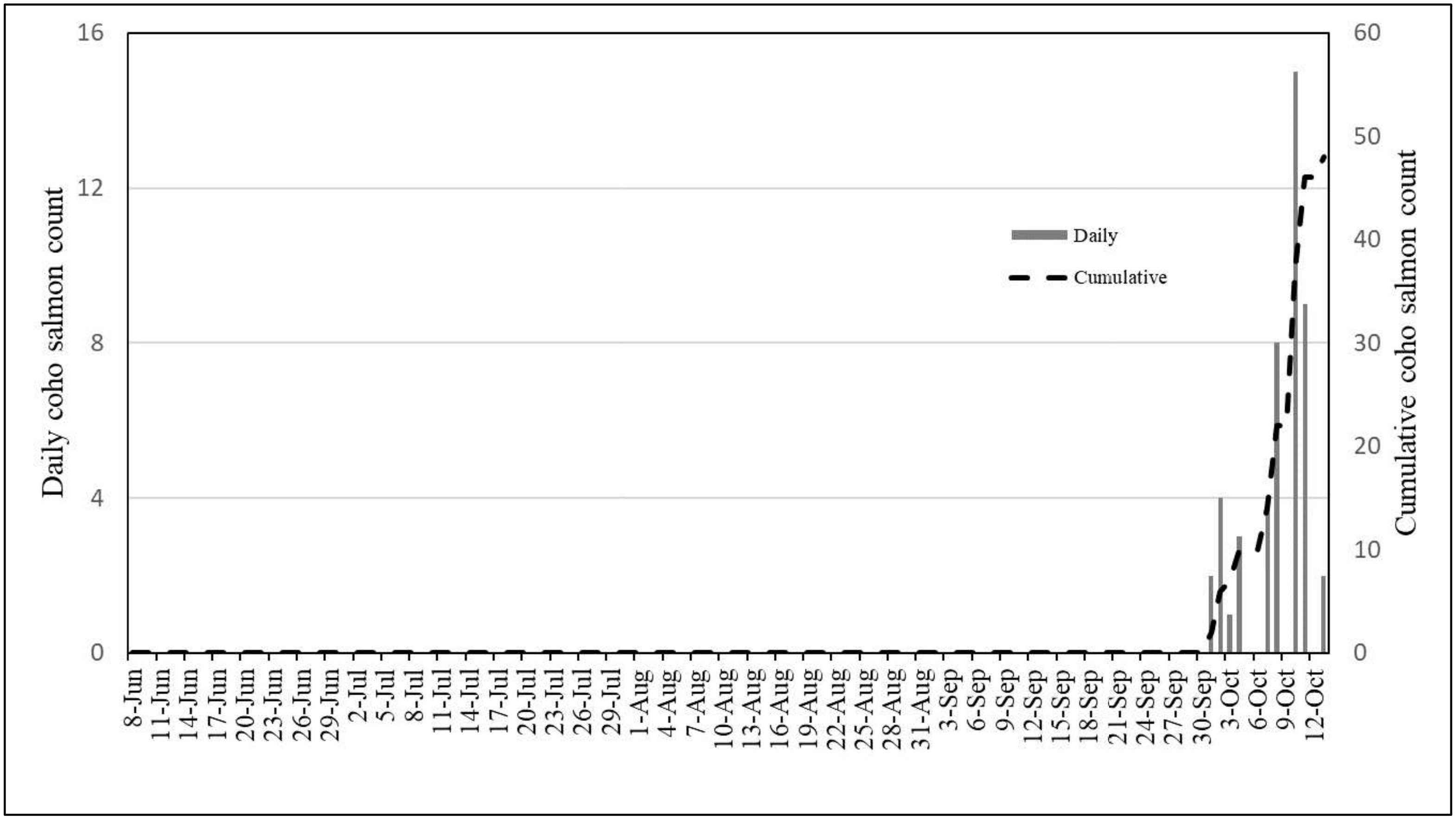

Figure 7.–Chart of daily and cumulative coho salmon escapement to Red Lake.