Fishery Data Series No. 07-55

Test Fish Wheel Project Using Video Monitoring Techniques, Tanana River, 2003

by

Bonnie M. Borba

September 2007

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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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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by
Bonnie M. Borba
Division of Commercial Fisheries, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599
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Bonnie M. Borba
Alaska Department of Fish and Game, Division of Commercial Fisheries,
1300 College Road, Fairbanks, AK 99701, USA

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ABSTRACT

A test fish wheel program located near Nenana, Alaska was used to assess the run timing and relative abundance of Chinook *Oncorhynchus tshawytscha*, chum *O. keta*, and coho *O. kisutch* salmon in the Tanana River. The Nenana test fish wheel project has been operated since 1988, it was operated with a "dead box" (wooden crib to hold the catch on top of the raft) until 1991 and a "live box" (submerged pen attached to the raft that holds the catch for live release) from 1992 to present. Data was collected by a contract fisherman a minimum of 2 times per day. In 2003, feasibility of using video capture data was evaluated for monitoring catch per unit effort data and for identification of tagged fish as part of a mark–recapture project. In the feasibility portion of the study, both video monitoring and manual counts were collected for comparison. The comparisons between the two counting methods was excellent ($r^2 = 0.99$) indicating that the video method can be reliably substituted for the manual method and therefore remove the necessity of holding salmon. The ability of the fish wheel to correlate with trends in other Yukon River drainage test fisheries was evaluated. Based on the first season of feasibility, tags from a mark–recapture project were easily identifiable on the video and were used to produce inseason abundance estimates of fall chum salmon. When both fall chum and coho salmon were present, the operation of video was advantageous to the project since it eliminated having to hold and handle large numbers of fish. Run timing of each salmon species was generated using catch per unit effort data, salmon were sexed both manually and by video, and migration patterns were identified. Subsurface water temperatures were collected at the site. Record numbers of salmon passed through the fish wheel and were enumerated using primarily digital video technology and reported as catch per unit effort resulting in estimated passage of 2,791 Chinook, 396 summer chum, 14,266 fall chum and 28,324 coho salmon.

Key words: Yukon River, Tanana River, Nenana, Chinook, chum, coho, salmon, test fish wheel, catch per unit effort.

INTRODUCTION

The Tanana River test fish wheel program is utilized to assess the run timing and relative abundance of Chinook *Oncorhynchus tshawytscha*, chum *O. keta*, and coho salmon *O. kisutch* salmon. The goal of this project is to obtain pertinent information that fishery managers can use to assess abundance and timing of salmon returning to the Tanana River drainage. The program began with two fish wheels within the Tanana River. One operated near the community of Manley Hot Springs, during the years 1984–1985 and 1988–1994 and was designated the Manley test fish wheel. The second project was located downstream from the community of Nenana and has operated from 1988 to present and was designated the Nenana test fish wheel. The Nenana test fish wheel is the longest continually running fish wheel project in the Yukon River drainage. The data provided by the test fish wheel was used in conjunction with other information to provide salmon run assessment in support of inseason management decisions that were made concerning openings and closures of subsistence, commercial, sport, and personal use fisheries. The chum salmon returns to the Yukon River drainage, of which the Tanana River is a tributary, consist of an early (summer chum) and late (fall chum) salmon run. Salmon enter the Tanana River during two distinct time periods that include a summer season dominated by migration of Chinook and summer chum salmon (July to mid-August) and a fall season dominated by fall chum and coho salmon (mid-August to October). The data collected from this project provides an index of abundance and timing based on catch per unit effort by species. During the fall season the Nenana test fish wheel is also used to provide tag recovery data for a fall chum salmon mark–recapture project which generates abundance estimates for the upper portion of the Tanana River drainage.

The abundance of Chinook, summer chum, and fall chum salmon, returning to the Yukon River drainage have been depressed in recent years (JTC 2004). Infrequent commercial openings and high prices for transportation from remote areas has reduced the availability of Yukon River salmon to markets. These changes prompted the Alaska Department of Fish and Game

(ADF&G) to alter its methods of test fishing with fish wheels, particularly related to the disposition of the catch. From 1988 to 1992 fish were captured by the fish wheel and held in a traditional dead box (wooden crib to hold the catch on top of the raft) and sold commercially to a contracted buyer. Beginning in 1993, test fishing projects within the Yukon River drainage began using live boxes (pens attached to fish wheels used for live releases) to hold the fish until they were enumerated and then released back into the river. In 2003, video monitoring of the Nenana fish wheel catches was tested to eliminate the need to hold fish in the live box based on techniques developed in 1999 (Zuray and Underwood 2000). The project primarily collects relative abundance data for Chinook, summer chum, and coho salmon.

The upper Tanana River mark–recapture project was initiated in 1995 to provide abundance estimates for fall chum salmon. The historical Nenana test fish wheel site became the Tanana River tag recovery fish wheel during the fall season. The test fish wheel was used as a tag recovery site because it was located downstream of the major fishery operated out of the community of Nenana. Fisheries on the Tanana River include subsistence, commercial, sport, and personal use. The fisheries are treated as terminal harvest areas since the stock is of known origin and measurements of management for Chinook and fall chum salmon are based on meeting biological escapement goals on select tributaries. Other mark–recapture and radio telemetry projects on Chinook salmon located down river have also used this site as a recovery location (T. Spencer, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication).

OBJECTIVES

An increasing number of fish wheels are being used within the Yukon River drainage for run assessment projects, raising concerns for holding and handling fish. The application of video methods eliminates the need to hold and handle fish for enumeration purposes. Video technology also provides advancement in the tools utilized for monitoring and assessing fisheries and should be explored and utilized where appropriate.

The objectives for the Nenana test fish wheel were to:

1. Provide daily species composition
2. Provide daily catch per unit effort (CPUE) indices for salmon by species
3. Collect run timing information for each salmon species
4. Test the feasibility of determining gender of salmon by species using video, and
5. Test the feasibility of using video to identify different colored tags to stratify data for a mark–recapture abundance estimate.

STUDY AREA

The Yukon River is the largest river in Alaska, the fifth largest drainage in North America, and drains an area of approximately 855,000 km² or approximately 35% of the State of Alaska. The Yukon River originates in British Columbia, Canada, within 48 km of the Gulf of Alaska, and flows over 3,680 km to its mouths at the Bering Sea. The Tanana River, the largest tributary of the Yukon River, flows northwest through a broad alluvial valley for approximately 800 km to the Yukon River, with a watershed of approximately 115,000 km². The confluence of the Tanana is located approximately 1,100 km upstream from the mouth of the Yukon River. The Nenana test fish wheel project is located approximately 240 km upstream from the mouth of the Tanana River. Commercial salmon fishing is allowed along the entire 1,920 km length of the mainstem Yukon River in Alaska and the lower 360 km of the Tanana River (Figure 1).

The rural resident population of the Yukon Area (excluding the Fairbanks North Star Borough) is approximately 21,000 people (Williams 2004). Most of the people in the Yukon River drainage communities are dependant to varying degrees on fish and game resources for their livelihood, and they participate in the mixed stock subsistence, commercial, and sport fisheries. Of the 43 communities that traditionally participate in the Yukon River drainage fisheries, more than 20 are located along the mainstem Yukon River below the confluence of the Tanana River.

Substantial numbers of Chinook salmon originate in Tanana River tributaries and contribute to the harvests in the mixed stock fishery in areas downstream. The Tanana River is geographically the upper most watershed in which summer chum salmon migrate in the Yukon River drainage. However, Chinook and fall chum salmon continue up into the Canadian portions of the Yukon River drainage. Based on fall chum salmon run reconstruction, the Tanana River component represents on average (1999 to 2003) approximately 37% of the fall chum salmon in the Yukon River drainage.

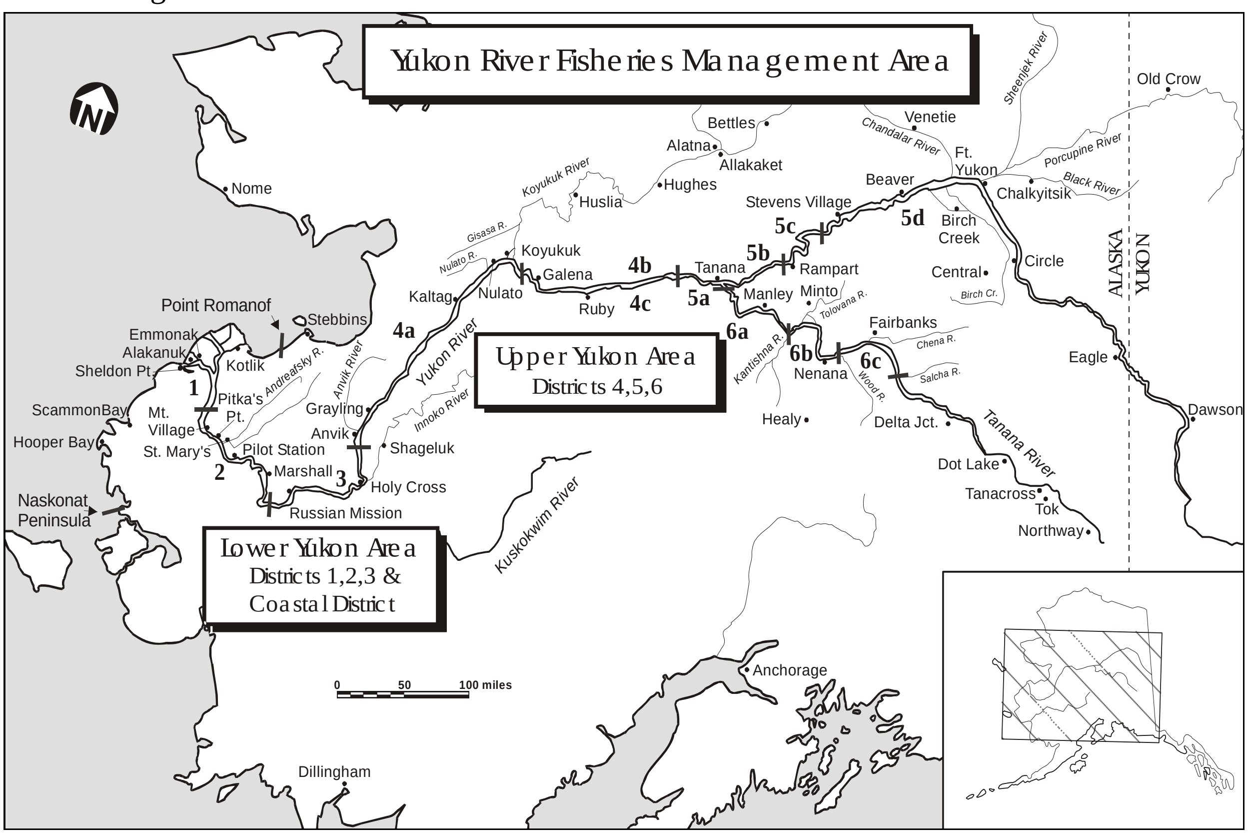

Figure 1.–Fisheries management districts and subdistricts in the Yukon and Tanana River drainages.

METHODS

SITE SELECTION

The Nenana test fish wheel was operated on the right bank of the Tanana River approximately 26 km downstream of the community of Nenana (Figure 2). The Tanana River is known for its heavy silt load and dynamic channeling caused by glacial melt in the summer as well as from seasonal flooding initiated by rain events in smaller tributaries (i.e. Chena, Salcha, and Kantishna rivers). The fish wheel site was chosen based on its relative proximity to the community of Nenana and has always been operated immediately downstream of the majority of the historical areas fished by the local residents. The site was also selected as a tag recovery site in order to satisfy the 'closed population' assumption of a mark–recapture study which tags fish 86 km downstream. The operation of the Nenana test fish wheel has always been contracted to a local fisherman.

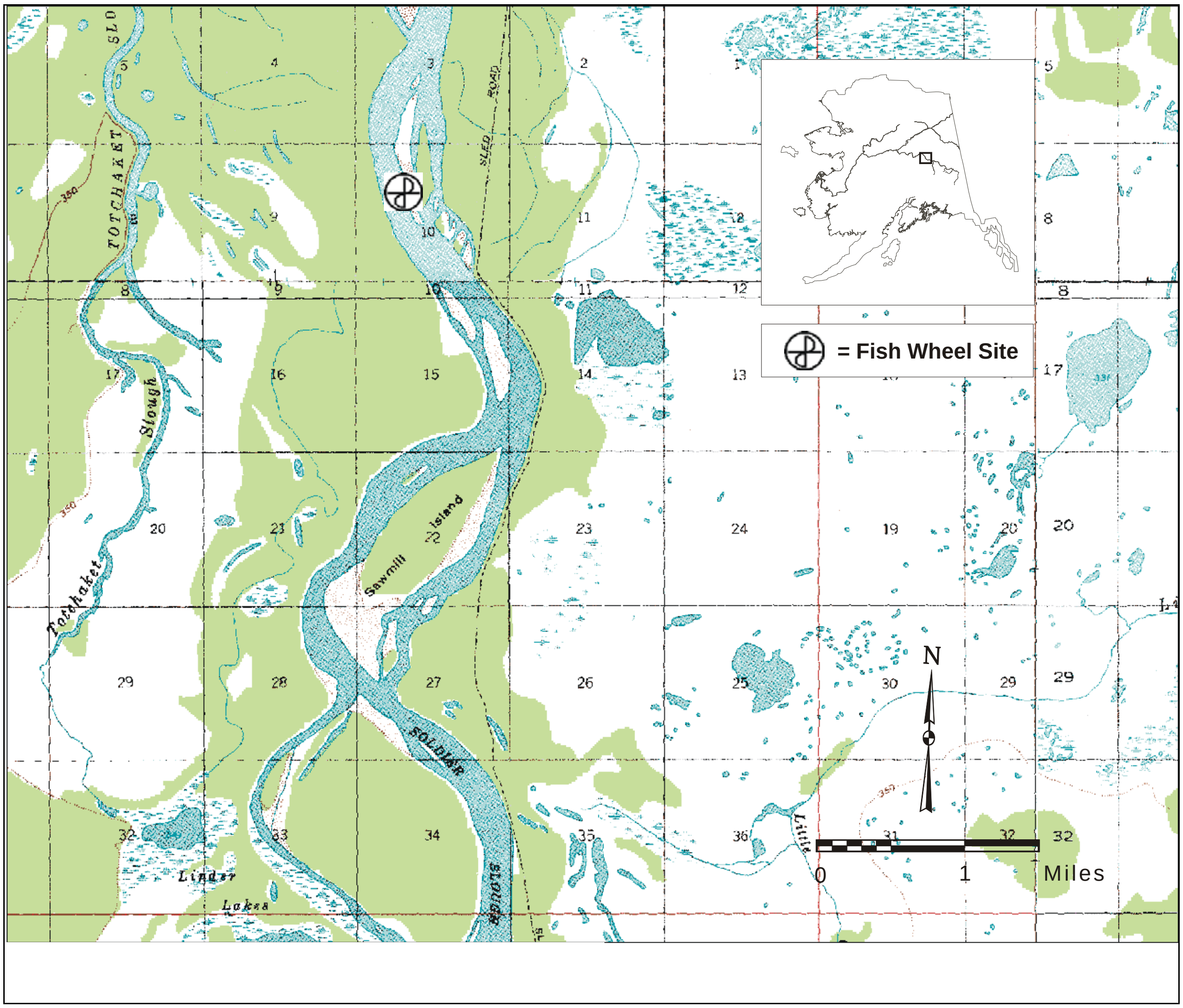

Figure 2.–Location of Nenana test fish wheel, Tanana River drainage, Yukon Area, 2003.

In 2003, the fish wheel was operated by Paul Kleinschmidt who resides in Nenana and who is both knowledgeable in operations of fish wheels as well as in navigation of the Tanana River. The fishing site was obtained through a verbal agreement with the traditionally recognized owner whose family had previously operated the Nenana test fish wheel. Operating the fish wheel below the fishery allows timely collection of data for fishery management. Few adequate locations exist from which to operate a fish wheel as steep cut banks or shallow areas predominate. Additionally sandbars are continually formed in between banks and the braided nature of the river creates numerous side sloughs all of which must be considered during the process of fish wheel site selection. As with the maintenance of any fishing site, during high water events, the contractor secures the electronic equipment, removes leads, pulls the fish wheel into shore, raises the baskets out of the water to prevent catching submerged debris, monitors bank erosion where tie-downs for all equipment are located, and dislodges large amounts of debris from the upstream boom and raft daily.

The local barge companies were informed of the fish wheel's location and asked to steer away and decrease speed in order to reduce the size of their wakes which shake the fish wheel and that would possibly trip the chute door which would allow capturing of blank frames or cause wiring or electronic damage. Smaller river boats would be of less concern since their relatively smaller wakes were not expected to negatively affect operations except for those passing very close to the fish wheel.

SAMPLING

The Nenana fish wheel operated 24 hours a day except when maintenance, repairs, or extreme high water required it to be shut down. Counts were based on an approximate schedule beginning at 0800 hours with the overnight catches added to the previous day. The two basket fish wheel is constructed of spruce poles with square ends for added strength and chain link fencing. The baskets were connected to a log axle which rests on a log raft. The basket chute was made of (1' by 12") wooden planks. The fish would slide down the basket chute and are directed into the video monitoring box (video chute) by a large flap of rubber covering the axle. The fish enter the video chute, consisting of an enclosed space with a white plastic background which is aligned in view of a surveillance camera (12-volt). The fish exit the video chute through a swinging door and are deposited into the live box where they await release. A magnetic switch was triggered each time the chute door was opened. The trigger sends a signal to a 12-volt laptop computer (Panasonic Toughbook[1]) and the software program Salmonsoft FishTick FishCap (version 1.4) captures a preset number of frames from the video camera and stores them on the computer's hard drive (Daum 2005). The digital video files were transferred from the computer to a removable IBM micro-drive for transportation and uploading to a desktop computer for further analysis. For a list of video components refer to Fliris (2003). All video samples were indexed by time stamps. A MS Excel file was emailed to the Fairbanks ADF&G office each day containing the data used to chart relative abundance based on daily and cumulative CPUE counts.

The fish in the live box were removed with a dip net a minimum of 2 times a day, counted, and released back into the river. The contractor dipped fish out of the live box and recorded each species and gender in a field notebook until the live box was emptied. The digital files (avi format) were saved on a micro-drive and transferred to a desk top computer and each video

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

frame was examined. During the review process the Salmonsoft FishTick FishRev software (version 1.3.5) allowed for enumeration by species and gender with an electronic tally. Determination of species and gender were based on visual estimation. Chinook salmon were also categorized by size, large and small, where "small" salmon (those less than 700 mm) were determined by a measurement based on a reference mark applied to the white chute background. All small Chinook salmon were male (Table 1).

The ability to detect tags on salmon was evaluated using the video monitoring system. Based on recommendations from a USFWS (U.S. Fish and Wildlife Service) representative, only certain colors of tags provide good camera resolution. When using stratification methods for developing population estimates several different colors of tags would need to be identified. Acceptable colors included pink, white, dark green, and light green. For the Tanana River mark–recapture project tag colors were proposed to change bi-weekly in the event there was a significant difference in marked proportions at the Nenana test fish wheel. Deployed spaghetti tags were 10 inches in length, however during the season some shorter tags (approximately 5 inches) were deployed. Tags were placed through the skin below the dorsal fin, doubled over, and knotted close to the skin.

Aside from fish harvested for subsistence, the majority of the fish were released alive. Initially during high live box densities some mortality occurred, so capture methods were modified to immediately release the fish by leaving the trap door of the live box open. During periods when the live box was left open only video counts were collected. During video only operations, presence or absence of tags were noted, along with tallies of fish where tag presence could not be determined because of the orientation of the fish traveling through the camera's field of view. During dip netting operations, individual tag numbers were recorded from tagged fish in a field notebook and later compared to the video data. Recovered tag numbers are also used to determine migration rates of tagged fish.

Video Home System (VHS) monitoring was used to provide observations of crowding activity in the closed live box after approximately 7.5 hours of accumulation on August 28–30. This second surveillance camera was set up on the fish wheel aimed at the live box water surface. The fish wheel was emptied during the 0830 hour check and the VHS recording was set to turn on automatically at 1600 hours and record for 2 hours each day. The information on the VHS tapes was also time stamped and could be synchronized with the digital enumeration data. Water temperatures were taken during the majority of the fall season using a HOBO® and StowAway® Data Logger placed approximately 0.5 m underwater along the inshore lead.

Periodic updates were sent to individuals involved in and supporting this project, including to USFWS who provided technical expertise on monitoring fish wheel catches using video techniques. During the fall season mark–recapture portion of the project, fall chum salmon abundance estimates were provided weekly during the Yukon River Drainage Fisheries Association teleconferences.

ANALYSIS

The electronic video counts and the number of fish dipped from the live box during each session were recorded in a log book. Approximate 24-hour counts from either the dip net or video method or a combination were entered into a MS Excel file that calculated daily CPUE for each species (number of fish/24-hours). Daily comparisons were made between dip net and video counts for similar time periods. Comparisons of CPUE were made within season as well as to historical performance. Marked proportion data were used for development of independent abundance estimates. For fall chum salmon on the upper Tanana River, the tagged to untagged proportions were used to calculate daily abundance estimates utilizing the Bailey estimator (Bailey 1951). The information was provided to fisheries managers for inseason run assessment, including projections of abundance of fall chum salmon based on the mark–recapture portion of the study and historical run timing.

ESTIMATION OF PROPORTIONS

Postseason analysis included comparisons of dip net to video counts to evaluate the performance of the video technique. The digital files were reviewed using the Salmonsoft FishTick FishRev software. The hourly assessment was used to develop migration patterns for Chinook, fall chum, and coho salmon. The hourly catch rates (fish/hour) for each species were calculated for all hours in each 24-hour period. The hourly catch rates were expressed as proportions of the daily catch so that high catch periods did not bias the results. Mean hourly catch rates, standard error and 95% confidence intervals were calculated for each hour for all days sampled. To minimize using hours with zero fish captured, only sample sizes of greater than 100 fish passage per day of a particular salmon species were used in this analysis.

Mean proportions were calculated using fish per hour for each counting day:

$$n_{ij} = \sum_i n_j \quad (1)$$

where: n = the number of fish caught,

i = the number of hours per day,

j = the number of days sampled.

RESULTS

SUMMER SEASON

The Nenana test fish wheel contractual period during the summer season was 32 days from June 30 to July 31, 2003. The fish wheel was operational by 1800 hours on June 30. The fish wheel was shut down during the periods 1630 hours July 16 through 1645 hours July 22 and from 1730 hours July 27 through the end of the summer season, July 31, due to extremely high water events that prevented safe operations.

During June and July, the Nenana test fish wheel operated a total of 469 sampling hours out of a possible 540 hours during 22.5 actual operational days. Dip net counts were used to enumerate catches for 68 hours while the video monitoring system was being installed and video comparison counts began on July 3, 2003. Because catch rates were extremely high (>10 fish per hour) at the start of operations, from July 3 through July 10 comparisons between dip net and video counts were conducted during day time periods only. Dip net counts were conducted for a total of 358 hours, whereas video monitoring was conducted for 386 hours during operational periods (Table 1). Problems with debris blocking access of fish entering the video chute area on July 23 resulted in lower counts for the video method.

Table 1.–Daily dip net and video counts for Chinook salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

	Dip Net					Video				
Count Date		Male					Male			
Start Time [a]	Time	Large	Small	Female	Total	Time	Large	Small	Female	Total
6/30 18:00	14.50	23	24	8	55	0.00	ND	ND	ND	-
7/1 8:30	24.00	78	58	30	166	0.00	ND	ND	ND	-
7/2 8:30	24.00	137	79	44	260	0.00	ND	ND	ND	-
7/3 8:30	4.33	35	9	12	56	0.00	ND	ND	ND	-
7/3 16:10	1.00	6	0	2	8	0.00	ND	ND	ND	-
7/3 17:10	0.00	ND	ND	ND	-	14:33	238	41	70	349
7/4 11:40	7.33	41	9	18	68	7.33	43	7	18	68
7/4 8:00	0.50	3	2	1	6	0.00	ND	ND	ND	-
7/4 19:00	0.00	ND	ND	ND	-	13.50	161	42	67	270
7/5 8:30	10.50	55	20	24	99	10.50	58	21	27	106
7/5 19:00	0.00	ND	ND	ND	-	13.50	81	32	43	156
7/6 9:00	10.50	35	19	19	73	10.50	38	19	18	75
7/6 19:30	0.00	ND	ND	ND	-	13.00	54	23	29	106
7/7 8:30	9.50	30	12	6	48	9.50	32	12	6	50
7/7 18:00	0.00	ND	ND	ND	-	14.50	72	30	40	142
7/8 8:30	9.00	25	10	4	39	9.00	21	15	4	40
7/8 17:30	0.00	ND	ND	ND	-	15.00	63	24	24	111
7/9 12:20	5.67	11	4	1	16	5.67	11	4	1	16
7/9 18:00	0.00	ND	ND	ND	-	13.42	53	18	18	89
7/10 12:05	4.00	14	5	2	21	4.00	13	5	3	21
7/10 17:43	0.00	ND	ND	ND	-	14.78	68	13	24	105
7/11 8:30	24.00	45	18	22	85	24.00	44	19	22	85
7/12 8:30	24.00	28	12	15	55	24.00	33	10	14	57
7/13 8:30	24.00	23	11	13	47	24.00	23	11	13	47
7/14 8:30	9.50	4	1	4	9	9.50	4	1	4	9
7/14 23:30	8.00	9	3	3	15	8.00	10	3	3	16
7/15 9:30	8.50	5	5	4	14	8.50	5	5	4	14
7/15 20:00	9.50	6	3	1	10	9.50	5	4	1	10
7/16 8:30	8.00	5	3	0	8	8.00	6	3	0	9
7/17	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/18	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/19	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/20	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/21	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/22 16:45	15.50	1	0	1	2	15.50	ND	ND	ND	-
7/23 8:30	22.50	0	0	2	2	22.50	0	0	0	0
7/24 8:30	23.25	1	0	1	2	23.25	1	0	1	2
7/25 8:30	23.00	0	2	1	3	23.00	0	2	1	3
7/26 8:30	24.00	0	1	2	3	24.00	0	1	1	2
7/27 8:30	9.00	0	0	1	1	9.00	0	0	1	1
7/28	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/29	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/30	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
7/31	0.00	ND	ND	ND	-	0.00	ND	ND	ND	-
8/15–10/1	-	1	3	3	7	-	2	3	4	9
Totals [b]	357.58	620	310	241	1,171	385.78	1,137	365	457	1,959
Sex Ratio [c]		0.79		0.21			0.77		0.23	

[a] Count date may include more than one time frame per day.

[b] Totals do not include 10 Chinook salmon caught during the fall season operations, August 15 to October 1, 2003.

[c] Male sex ratio includes both large and small (<700 mm) fish.

Chinook Salmon

The Nenana test fish wheel captured 1,959 Chinook salmon based on the video monitoring methodology, including 1,137 large (>700 mm) male, 365 small (<700 mm) males, and 457 females (Table 1). During approximately 274 hours both dip net and video methods were in operation simultaneously (Table 2) resulting in 618 and 631 Chinook salmon respectively ($r^2 = 0.9983$). Sex ratio of Chinook salmon was 23% female based on both fish dipped out of the live box and those viewed by video.

Inseason fishery management utilizes comparisons of annual CPUE as indicators of relative run strength and timing. Acceptable counts from both the dip net and video monitoring methods were used to reconstruct the passage of salmon and resulted in a total capture of 2,508 Chinook salmon (not including 10 fish captured after August 15). When only one method was used to enumerate fish that method was used in the calculation of CPUE, however when both systems operated, the video count was most often used for the calculation of CPUE including the numbers of fish captured while making adjustments to the video operations. The cumulative CPUE for the operational period was 2,791 Chinook salmon (Table 3). The midpoint of the Chinook salmon run at the Nenana test fishing site occurred July 4. The peak daily CPUE occurred on July 3 and represents an astounding catch rate of approximately 21 Chinook salmon per hour.

Among the fish captured in the fish wheel were 4 tagged Chinook salmon from the Russian Mission radiotelemetry project including: one male captured on July 3, identified on video using the secondary mark of a yellow spaghetti tag located behind the dorsal fin. In addition one female was captured and dipped from the box on July 6 and two tagged males were identified on July 9, one tag was recovered during the dipping portion of the day and the second tag was identified by the yellow spaghetti tag during the overnight video only operations. Figure 3 illustrates one video frame of several taken as the Chinook salmon slid through the video chute on July 6 showing the radio antenna protruding from the mouth and the spaghetti tag used as a secondary mark visible behind the dorsal fin.

Summer Chum Salmon

The Nenana test fish wheel captured 315 summer chum salmon based on video monitoring (Table 4). Comparisons of dip net and video counts for the same time period resulted in 275 summer chum salmon recorded using the dip net method and 269 summer chum salmon recorded by the video system ($r^2 = 0.9920$). Sex ratios were 43% female summer chum salmon using both methods (Table 5).

Inseason comparisons were made using counts from both the dip net and video monitoring methods to reconstruct the passage of summer chum salmon and resulted in a total capture of 336 with a cumulative CPUE of 396 fish (Table 6). The midpoint of the summer chum salmon run at the Nenana test fishing site occurred July 23. The peak daily CPUE occurred on July 26 with a catch rate of 2.5 summer chum salmon per hour.

Table 2.–Comparisons of dip net and video counts of Chinook salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

		Dip Net				Video			
Count Date	Total	Male				Male			
Start Time [a]	Time (h)	Large	Small	Female	Total	Large	Small	Female	Total
7/4 11:40	7.33	41	9	18	68	43	7	18	68
7/5 8:30	10.50	55	20	24	99	58	21	27	106
7/6 9:00	10.50	35	19	19	73	38	19	18	75
7/7 8:30	9.50	30	12	6	48	32	12	6	50
7/8 8:30	9.00	25	10	4	39	21	15	4	40
7/9 12:20	5.67	11	4	1	16	11	4	1	16
7/10 12:05	4.00	14	5	2	21	13	5	3	21
7/11 8:30	24.00	45	18	22	85	44	19	22	85
7/12 8:30	24.00	28	12	15	55	33	10	14	57
7/13 8:30	24.00	23	11	13	47	23	11	13	47
7/14 8:30	9.50	4	1	4	9	4	1	4	9
7/14 23:30	8.00	9	3	3	15	10	3	3	16
7/15 9:30	8.50	5	5	4	14	5	5	4	14
7/15 20:00	9.50	6	3	1	10	5	4	1	10
7/16 8:30	8.00	5	3	0	8	6	3	0	9
7/23 8:30	22.50	0	0	2	2	0	0	0	0
7/24 8:30	23.25	1	0	1	2	1	0	1	2
7/25 8:30	23.00	0	2	1	3	0	2	1	3
7/26 8:30	24.00	0	1	2	3	0	1	1	2
7/27 8:30	9.00	0	0	1	1	0	0	1	1
Totals	273.75	337	138	143	618	347	142	142	631
Sex Ratio [b]		0.77		0.23		0.77		0.23	

[a] Count date may include more than one time frame per day.

[b] Male sex ratio includes both large and small (< 700 mm) fish.

Table 3.–Catch per unit effort data for Chinook salmon collected from a combination of dip net and video monitoring methods at the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count	Counting		Total	CPUE		Cumulative	
Date	Method	Time(h)	Catch	Per 24 (h)	Per (h)	CPUE	Percent
6/30	Dip net	14.50	55	91	3.79	91	0.03
7/1	Dip net	24.00	166	166	6.92	257	0.09
7/2	Dip net	24.00	260	260	10.83	517	0.19
7/3	Dip net/Video [a]	19.66	413	504	21.00	1,021	0.37
7/4	Video	20.83	338	389	16.23	1,410	0.51
7/5	Video	24.00	262	262	10.92	1,672	0.60
7/6	Video	23.50	181	185	7.70	1,857	0.67
7/7	Video	24.00	192	192	8.00	2,049	0.73
7/8	Video	24.00	151	151	6.29	2,200	0.79
7/9	Video	19.09	105	132	5.50	2,332	0.84
7/10	Video	18.78	126	161	6.71	2,493	0.89
7/11	Video	24.00	85	85	3.54	2,578	0.92
7/12	Video	24.00	57	57	2.38	2,635	0.94
7/13	Video	24.00	47	47	1.96	2,682	0.96
7/14	Video	17.50	25	34	1.43	2,717	0.97
7/15	Video	18.00	24	32	1.33	2,749	0.98
7/16	Video	8.00	9	27	1.13	2,776	0.99
7/17–7/21	ND	0.00	ND	-	-	2,776	0.99
7/22	Dip net	15.50	2	3	0.13	2,779	1.00
7/23	Dip net	22.50	2	2	0.09	2,781	1.00
7/24	Video	23.25	2	2	0.09	2,783	1.00
7/25	Video	23.00	3	3	0.13	2,786	1.00
7/26	Video	24.00	2	2	0.08	2,788	1.00
7/27	Video	9.00	1	3	0.11	2,791	1.00
7/28–7/31	ND	0.00	ND	-	-	-	
8/15–10/1	-	-	10	-	-	-	-
Totals [b]		469.11	2,508	2,791	-	-	-

[a] Includes non-overlapping methods with a dip net count of 64 during 5.33 h and a video count of 349 during 14.33 h.

[b] Totals do not include 10 Chinook salmon caught during the fall season operations, August 15 to October 1, 2003.

Table 4.–Daily dip net and video counts of summer chum salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count Date	Dip Net				Video			
Start Time [a]	Time (h)	Male	Female	Total	Time	Male	Female	Total
6/30 18:00	14.50	1	0	1	0.00	ND	ND	-
7/1 8:30	24.00	0	0	0	0.00	ND	ND	-
7/2 8:30	24.00	1	0	1	0.00	ND	ND	-
7/3 8:30	4.33	0	0	0	0.00	ND	ND	-
7/3 16:10	1.00	0	0	0	0.00	ND	ND	-
7/3 17:10	0.00	ND	ND	-	14.33	0	1	1
7/4 11:40	7.33	0	1	1	7.33	0	1	1
7/4 8:00	0.50	0	0	0	0.00	ND	ND	-
7/4 19:00	0.00	ND	ND	-	13.50	2	1	3
7/5 8:30	10.50	2	1	3	10.50	1	2	3
7/5 19:00	0.00	ND	ND	-	13.50	3	1	4
7/6 9:00	10.50	1	0	1	10.50	1	0	1
7/6 19:30	0.00	ND	ND	-	13.00	5	1	6
7/7 8:30	9.50	5	2	7	9.50	5	2	7
7/7 18:00	0.00	ND	ND	-	14.50	4	4	8
7/8 8:30	9.00	2	1	3	9.00	2	1	3
7/8 17:30	0.00	ND	ND	-	15.00	6	2	8
7/9 12:20	5.67	3	0	3	5.67	3	0	3
7/9 18:00	0.00	ND	ND	-	13.42	5	3	8
7/10 12:05	4.00	3	2	5	4.00	3	2	5
7/10 17:43	0.00	ND	ND	-	14.78	4	4	8
7/11 8:30	24.00	15	8	23	24.00	16	7	23
7/12 8:30	24.00	12	8	20	24.00	12	8	20
7/13 8:30	24.00	13	5	18	24.00	10	8	18
7/14 8:30	9.50	3	1	4	9.50	4	0	4
7/14 23:30	8.00	5	1	6	8.00	5	1	6
7/15 9:30	8.50	1	2	3	8.50	2	0	2
7/15 20:00	9.50	1	2	3	9.50	1	2	3
7/16 8:30	8.00	3	1	4	8.00	3	1	4
7/17	0.00	ND	ND	-	0.00	ND	ND	-
7/18	0.00	ND	ND	-	0.00	ND	ND	-
7/19	0.00	ND	ND	-	0.00	ND	ND	-
7/20	0.00	ND	ND	-	0.00	ND	ND	-
7/21	0.00	ND	ND	-	0.00	ND	ND	-
7/22 16:45	15.50	5	8	13	0.00	ND	ND	-
7/23 8:30	22.50	7	13	20	22.50	6	8	14
7/24 8:30	23.25	16	15	31	23.25	16	16	32
7/25 8:30	23.00	20	26	46	23.00	21	24	45
7/26 8:30	24.00	36	22	58	24.00	33	26	59
7/27 8:30	9.00	10	6	16	9.00	10	6	16
7/28	0.00	ND	ND	-	0.00	ND	ND	-
7/29	0.00	ND	ND	-	0.00	ND	ND	-
7/30	0.00	ND	ND	-	0.00	ND	ND	-
7/31	0.00	ND	ND	-	0.00	ND	ND	-
Totals	357.58	165	125	290	385.78	183	132	315
Sex Ratio		0.57	0.43			0.58	0.42	

[a] Count date may include more than one time frame per day.

Table 5.–Comparisons of dip net and video counts of summer chum salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count Date	Total	Dip Net			Video		
Start Time [a]	Time (h)	Male	Female	Total	Male	Female	Total
7/4 11:40	7.33	0	1	1	0	1	1
7/5 8:30	10.50	2	1	3	1	2	3
7/6 9:00	10.50	1	0	1	1	0	1
7/7 8:30	9.50	5	2	7	5	2	7
7/8 8:30	9.00	2	1	3	2	1	3
7/9 12:20	5.67	3	0	3	3	0	3
7/10 12:05	4.00	3	2	5	3	2	5
7/11 8:30	24.00	15	8	23	16	7	23
7/12 8:30	24.00	12	8	20	12	8	20
7/13 8:30	24.00	13	5	18	10	8	18
7/14 8:30	9.50	3	1	4	4	0	4
7/14 23:30	8.00	5	1	6	5	1	6
7/15 9:30	8.50	1	2	3	2	0	2
7/15 20:00	9.50	1	2	3	1	2	3
7/16 8:30	8.00	3	1	4	3	1	4
7/23 8:30	22.50	7	13	20	6	8	14
7/24 8:30	23.25	16	15	31	16	16	32
7/25 8:30	23.00	20	26	46	21	24	45
7/26 8:30	24.00	36	22	58	33	26	59
7/27 8:30	9.00	10	6	16	10	6	16
Totals	273.75	158	117	275	154	115	269
Sex Ratio		0.57	0.43		0.57	0.43	

[a] Count date may include more than one time frame per day.

Table 6.–Catch per unit effort data for summer chum salmon collected from a combination of dip net and video monitoring methods at the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count	Counting		Total	CPUE		Cumulative	
Date	Method	Time (h)	Catch	Per 24 (h)	Per (h)	CPUE	Percent
6/30	Dip net	14.50	1	2	0.07	2	0.00
7/1	Dip net	24.00	0	0	0.00	2	0.00
7/2	Dip net	24.00	1	1	0.04	3	0.01
7/3	Dip net/Video [a]	19.66	1	1	0.05	4	0.01
7/4	Video	20.83	4	5	0.19	8	0.02
7/5	Video	24.00	7	7	0.29	15	0.04
7/6	Video	23.50	7	7	0.30	23	0.06
7/7	Video	24.00	15	15	0.63	38	0.10
7/8	Video	24.00	11	11	0.46	49	0.12
7/9	Video	19.09	11	14	0.58	62	0.16
7/10	Video	18.78	13	17	0.69	79	0.20
7/11	Video	24.00	23	23	0.96	102	0.26
7/12	Video	24.00	20	20	0.83	122	0.31
7/13	Video	24.00	18	18	0.75	140	0.35
7/14	Video	17.50	10	14	0.57	154	0.39
7/15	Video	18.00	5	7	0.28	160	0.41
7/16	Video	8.00	4	12	0.50	172	0.44
7/17–7/21	ND	0.00	ND	-	-	172	0.44
7/22	Dip net	15.50	13	20	0.84	193	0.49
7/23	Dip net	22.50	20	21	0.89	214	0.54
7/24	Video	23.25	32	33	1.38	247	0.62
7/25	Video	23.00	45	47	1.96	294	0.74
7/26	Video	24.00	59	59	2.46	353	0.89
7/27	Video	9.00	16	43	1.78	396	1.00
7/28–7/31	ND	0.00	ND	-	-	-	-
Totals		469.11	336	396	-	-	-

[a] Includes non-overlapping methods with a dip net count of zero during 5.33 h and a video count of one during 14.33 h.

Figure 3.–Video frame of a Chinook salmon in the Nenana test fish wheel showing net marks from initial capture (arrow), radio antenna protruding from mouth (oval) and secondary mark denoted by yellow spaghetti tag at base of dorsal fin (circle).

Run Timing

The number of Chinook salmon captured by the Nenana test fish wheel in 2003 represented a record catch. However, the summer chum salmon cumulative CPUE was the second lowest catch in 14 years of operation (Table 7). Catch rates and timing were affected by extreme high water conditions in 2003. The fish wheel was completely shut down for two time periods because of record high water levels created by rain events in Interior Alaska (Appendix A1). Adjustments for fish passage were not made for these periods of down time and therefore affect the calculation of run timing. The 2003 midpoint of the Chinook salmon run at the Nenana site was July 4, nearly 9 days earlier than normal. June 30 was the second earliest start date for the project. A test fish project in the lower Yukon River (1,290 km downstream) assessed the Chinook salmon run as only 3 days earlier than normal.

The summer chum salmon midpoint of July 23 was only 2 days earlier than normal (Table 7) but must be reported with the caveat that the fish wheel was not operational for large amounts of time during the major presence of chum salmon.

Table 7.–Chinook and summer chum salmon timing information from the Nenana test fish wheel, Tanana River, Yukon Area, 1988–2003.

		Chinook Salmon		Summer Chum Salmon		Percent
	Operation	Cumulative		Cumulative		Chinook
Year	Period (days)	CPUE	Midpoint	CPUE	Midpoint	Salmon
1988	41	245	13-Jul	1,146	20-Jul	18%
1989	45	235	15-Jul	3,575	28-Jul	6%
1990	52	603	12-Jul	4,046	23-Jul	13%
1991	32	475	17-Jul	5,383	29-Jul	8%
1992	31	549	17-Jul	699	25-Jul	44%
1993	– [a]	-	-	-	-	-
1994	– [b]	-	-	-	-	-
1995	42	683	12-Jul	7,000	29-Jul	9%
1996	44	428	11-Jul	7,464	20-Jul	5%
1997	36	2,143	10-Jul	1,748	20-Jul	55%
1998	46	1,151	14-Jul	1,619	29-Jul	42%
1999	32	661	16-Jul	775	27-Jul	46%
2000	33	184	11-Jul	446	30-Jul	29%
2001	44	904	17-Jul	71	21-Jul	93%
2002	36	1,601	12-Jul	1,074	18-Jul	60%
2003	32	2,791	4-Jul	396	23-Jul	88%
1988–2002						
Median	41	603	13-Jul	1,619	25-Jul	29%

[a] Fish wheel began operations for fall season only on August 18.

[b] Fish wheel began operations August 1 and captured 890 chum salmon through August 15.

FALL SEASON

The Nenana test fish wheel contractual period was 48 days from August 15 to October 1, 2003. Once operations began at 1438 hours on August 15, the fish wheel ran nearly 24 hours per day except for short periods of downtime for maintenance and making minor repairs. Although the water levels rose well above average during early September (Appendix A1) the fish wheel remained operational throughout the season.

During the fall season, the Nenana test fish wheel operated a total of 1,115 sampling hours out of a possible 1,132 hours. Dip net counts were conducted for a total of 453 hours, whereas video monitoring was conducted for 1,098 hours (Table 8). Dip net counts were compared to video counts from August 15 through September 2, and on September 5–6. The video monitoring system was used exclusively for 662 hours because of extremely high catch rates of both fall chum and coho salmon. During most of the video only operations, the trap door of the live box was left open to release salmon immediately after capture to prevent overcrowding, except during times when the contractor harvested fish.

Fall Chum Salmon

The Nenana test fish wheel captured 13,852 fall chum salmon based on video monitoring (Table 8). Approximately 436 hours of dip net and video counts were comparable and resulted in 2,221 fall chum salmon recorded using the dipnet method and 2,229 fall chum salmon recorded

Table 8.–Daily dip net and video counts of fall chum salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count Date	Dip Net				Video			
Start Time [a]	Time (h)	Male	Female	Total	Time (h)	Male	Female	Total
8/15 14:38	17.87	3	3	6	17.87	3	3	6
8/16 8:30	24.00	7	5	12	24.00	7	5	12
8/17 8:30	22.92	6	6	12	22.92	6	6	12
8/18 8:30	24.00	6	4	10	24.00	6	4	10
8/19 8:30	24.00	24	28	52	24.00	24	28	52
8/20 8:30	24.00	54	31	85	24.00	50	37	87
8/21 8:30	24.00	58	54	112	24.00	57	57	114
8/22 9:00	23.50	60	69	129	23.50	61	68	129
8/23 8:30	24.00	59	69	128	24.00	58	70	128
8/24 8:30	24.00	55	37	92	24.00	50	46	96
8/25 8:50	23.67	56	50	106	23.67	53	54	107
8/26 8:30	6.83	15	13	28	6.83	15	12	27
8/26 15:20	17.17	69	32	101	0.00	ND	ND	-
8/27 8:30	24.00	67	75	142	24.00	65	77	142
8/28 8:30	24.00	145	90	235	24.00	135	100	235
8/29 8:30	24.00	152	99	251	24.00	143	106	249
8/30 8:30	23.50	198	84	282	23.50	182	103	285
8/31 8:30	24.00	202	72	274	24.00	192	84	276
9/1 8:30	9.00	69	30	99	9.00	66	33	99
9/1 17:30	0.00	ND	ND	-	15.00	69	49	118
9/2 8:30	10.50	65	23	88	10.50	63	24	87
9/2 19:00	0.00	ND	ND	-	13.50	77	45	122
9/3 8:30	0.00	ND	ND	-	24.00	95	51	146
9/4 8:30	0.00	ND	ND	-	24.00	9	6	15
9/5 8:30	22.75	25	11	36	22.75	27	9	36
9/6 8:30	11.25	26	16	42	11.25	24	16	40
9/6 21:45	0.00	ND	ND	-	10.75	78	58	136
9/7 8:30	0.00	ND	ND	-	24.00	283	221	504
9/8 8:30	0.00	ND	ND	-	24.00	482	396	878
9/9 8:30	0.00	ND	ND	-	24.00	547	468	1,015
9/10 8:30	0.00	ND	ND	-	23.75	592	448	1,040
9/11 8:30	0.00	ND	ND	-	24.00	430	369	799
9/12 8:30	0.00	ND	ND	-	24.00	419	342	761
9/13 8:30	0.00	ND	ND	-	23.50	450	351	801
9/14 8:30	0.00	ND	ND	-	24.00	349	335	684
9/15 8:30	0.00	ND	ND	-	23.75	252	272	524
9/16 8:30	0.00	ND	ND	-	23.25	231	225	456
9/17 8:30	0.00	ND	ND	-	24.00	146	176	322
9/18 8:30	0.00	ND	ND	-	24.00	170	210	380
9/19 8:30	0.00	ND	ND	-	24.00	164	189	353
9/20 8:30	0.00	ND	ND	-	24.00	126	139	265
9/21 8:30	0.00	ND	ND	-	24.00	108	103	211
9/22 8:30	0.00	ND	ND	-	22.25	104	111	215
9/23 8:30	0.00	ND	ND	-	24.00	115	129	244
9/24 8:30	0.00	ND	ND	-	24.00	81	146	227
9/25 8:30	0.00	ND	ND	-	23.33	121	147	268
9/26 8:30	0.00	ND	ND	-	23.67	103	132	235
9/27 8:30	0.00	ND	ND	-	24.00	82	145	227
9/28 8:30	0.00	ND	ND	-	24.00	106	151	257
9/29 8:30	0.00	ND	ND	-	24.00	62	127	189
9/30 8:30	0.00	ND	ND	-	24.00	60	136	196
10/1 8:30	0.00	ND	ND	-	3.50	12	23	35
Totals	452.95	1,421	901	2,322	1,098.03	7,210	6,642	13,852
Sex Ratio		0.61	0.39			0.52	0.48	

[a] Count date may include more than one time frame per day.

by the video system (Table 9). A regression was performed between the two methods resulting in $r^2 = 0.9997$. Sex ratios based on fish dipped out of the live box resulted in 39% female fall chum salmon, whereas viewing by video produced 42% female fall chum salmon.

Inseason comparisons were made using acceptable counts from both dipnet and video monitoring to estimate relative fall chum salmon run strength. Total capture was 13,954 fall chum salmon and the cumulative CPUE was 14,266 fall chum salmon (Table 10). When only one method was used to enumerate fish it was used in the calculation of CPUE, however when both systems operated the video count was most often used for the calculation of CPUE including the numbers of fish captured while making adjustments to the video operations. Data was not adjusted for extremely low passage rates observed on September 4 and 5 most likely an effect of high water on the efficiency of the fish wheel. The midpoint of the fall chum salmon run at the Nenana test fishing site occurred September 11. The peak daily CPUE occurred on September 10 and represented a catch of approximately 44 fall chum salmon per hour.

Observations of the tagged chum salmon that passed through the Nenana test fish wheel indicated that longer tags were more easily detected than shorter tags. Video counts of fall chum salmon during the mark–recapture phase of the project indicated 1% of the fish were "undetermined" which means the observer was unable to tell if a tag was present (by either the primary tag identification or the presence of the secondary mark -an adipose fin clip) due to the orientation of the fish passing through the video camera's line of sight (Appendix A3).

Coho Salmon

The Nenana test fish wheel captured 27,546 coho salmon based on the video monitoring (Table 11). Approximately 437 hours of dip net and video counts were compared resulting in 782 coho salmon recorded using the dip net method and 786 coho salmon recorded by the video system (Table 12). A regression was performed between the two counting methods resulting in $r^2 = 0.9997$ similar to that of the fall chum salmon enumeration. Sex ratios based on fish dipped out of the live box resulted in 33% female coho salmon, whereas viewing by video produced 35% female coho salmon.

Inseason comparisons were made using acceptable counts from both dip net and video monitoring to estimate relative coho salmon run strength. Total capture was 27,564 coho salmon and cumulative CPUE was 28,324 coho salmon (Table 13). When only one method was used to enumerate fish it was used in the calculation of CPUE, however when both systems operated the video count was most often used for the calculation of CPUE including the numbers of fish captured while making adjustments to the video operations. The midpoint of the coho salmon run at the Nenana test fishing site occurred September 18. The peak daily CPUE on September 16 represented a catch of approximately 89 coho salmon an hour. Video monitoring was used exclusively for the remainder of the season, beginning September 7, because of the extremely high catch rates.

Table 9.–Comparisons of dip net and video counts of fall chum salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count Date	Total	Dip Net			Video		
Start Time	Time (h)	Male	Female	Total	Male	Female	Total
8/15 14:38	17.87	3	3	6	3	3	6
8/16 8:30	24.00	7	5	12	7	5	12
8/17 8:30	22.92	6	6	12	6	6	12
8/18 8:30	24.00	6	4	10	6	4	10
8/19 8:30	24.00	24	28	52	24	28	52
8/20 8:30	24.00	54	31	85	50	37	87
8/21 8:30	24.00	58	54	112	57	57	114
8/22 9:00	23.50	60	69	129	61	68	129
8/23 8:30	24.00	59	69	128	58	70	128
8/24 8:30	24.00	55	37	92	50	46	96
8/25 8:50	23.67	56	50	106	53	54	107
8/26 8:30	6.83	15	13	28	15	12	27
8/27 8:30	24.00	67	75	142	65	77	142
8/28 8:30	24.00	145	90	235	135	100	235
8/29 8:30	24.00	152	99	251	143	106	249
8/30 8:30	23.50	198	84	282	182	103	285
8/31 8:30	24.00	202	72	274	192	84	276
9/1 8:30	9.00	69	30	99	66	33	99
9/2 8:30	10.50	65	23	88	63	24	87
9/5 8:30	22.75	25	11	36	27	9	36
9/6 8:30	11.25	26	16	42	24	16	40
Totals	435.78	1,352	869	2,221	1,287	942	2,229
Sex Ratio		0.61	0.39		0.58	0.42	

Table 10.–Catch per unit effort data for fall chum salmon collected from a combination of dip net and video monitoring methods at the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count	Counting		Total	CPUE		Cumulative	
Date	Method	Time (h)	Catch	Per 24 (h)	Per (h)	CPUE	Percent
8/15	Video	17.87	6	8	0.34	8	0.00
8/16	Video	24.00	12	12	0.50	20	0.00
8/17	Video	22.92	12	13	0.52	33	0.00
8/18	Video	24.00	10	10	0.42	43	0.00
8/19	Video	24.00	52	52	2.17	95	0.01
8/20	Video	24.00	87	87	3.63	182	0.01
8/21	Video	24.00	114	114	4.75	296	0.02
8/22	Video	23.50	129	132	5.49	427	0.03
8/23	Video	24.00	128	128	5.33	555	0.04
8/24	Video	24.00	96	96	4.00	651	0.05
8/25	Video	23.67	109	109	4.52	760	0.05
8/26	Dip net	24.00	129	129	5.38	889	0.06
8/27	Video	24.00	142	142	5.92	1,031	0.07
8/28	Video	24.00	235	235	9.79	1,266	0.09
8/29	Video	24.00	249	249	10.38	1,515	0.11
8/30	Video	23.50	285	291	12.13	1,806	0.13
8/31	Video	24.00	276	276	11.50	2,082	0.15
9/1	Video	24.00	217	217	9.04	2,299	0.16
9/2	Video	24.00	209	209	8.71	2,508	0.18
9/3	Video	24.00	146	146	6.08	2,654	0.19
9/4	Video	24.00	15	15	0.63	2,669	0.19
9/5	Video	22.75	36	38	1.58	2,707	0.19
9/6	Video	22.00	176	192	8.00	2,899	0.20
9/7	Video	24.00	504	504	21.00	3,403	0.24
9/8	Video	24.00	878	878	36.58	4,281	0.30
9/9	Video	24.00	1,01	1,015	42.29	5,296	0.37
9/10	Video	23.75	1,04	1,051	43.79	6,347	0.44
9/11	Video	24.00	799	799	33.29	7,146	0.50
9/12	Video	24.00	761	761	31.71	7,907	0.55
9/13	Video	23.50	801	818	34.09	8,725	0.61
9/14	Video	24.00	684	684	28.50	9,409	0.66
9/15	Video	23.75	524	530	22.06	9,938	0.70
9/16	Video	23.25	456	471	19.61	10,409	0.73
9/17	Video	24.00	322	322	13.42	10,731	0.75
9/18	Video	24.00	380	380	15.83	11,111	0.78
9/19	Video	24.00	353	353	14.71	11,464	0.80
9/20	Video	24.00	265	265	11.04	11,729	0.82
9/21	Video	24.00	211	211	8.79	11,940	0.84
9/22	Video	22.25	215	232	9.66	12,172	0.85
9/23	Video	24.00	244	244	10.17	12,416	0.87
9/24	Video	24.00	227	227	9.46	12,643	0.89
9/25	Video	23.33	268	276	11.49	12,919	0.91
9/26	Video	23.67	235	238	9.93	13,157	0.92
9/27	Video	24.00	227	227	9.46	13,384	0.94
9/28	Video	24.00	257	257	10.71	13,641	0.96
9/29	Video	24.00	189	189	7.88	13,830	0.97
9/30	Video	24.00	196	196	8.17	14,026	0.98
10/1	Video	3.50	35	240	10.00	14,266	1.00
Totals		1,115.2	13,9	14,266	-	-	-

Table 11.–Daily dip net and video counts of coho salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count Date	Dip Net				Video			
Start Time [a]	Time (h)	Male	Female	Total	Time (h)	Male	Female	Total
8/15 14:38	17.87	0	0	0	17.87	0	0	0
8/16 8:30	24.00	0	0	0	24.00	0	0	0
8/17 8:30	22.92	0	0	0	22.92	0	0	0
8/18 8:30	24.00	1	0	1	24.00	1	0	1
8/19 8:30	24.00	0	0	0	24.00	0	0	0
8/20 8:30	24.00	5	3	8	24.00	5	3	8
8/21 8:30	24.00	5	2	7	24.00	4	3	7
8/22 9:00	23.50	14	8	22	23.50	14	8	22
8/23 8:30	24.00	6	4	10	24.00	6	4	10
8/24 8:30	24.00	10	5	15	24.00	9	6	15
8/25 8:50	23.67	11	4	15	23.67	11	5	16
8/26 8:30	6.83	6	4	10	6.83	6	4	10
8/26 15:20	17.17	14	4	18	0.00	ND	ND	-
8/27 8:30	24.00	23	13	36	24.00	23	13	36
8/28 8:30	24.00	44	22	66	24.00	44	23	67
8/29 8:30	24.00	57	35	92	24.00	55	36	91
8/30 8:30	23.50	63	25	88	23.50	59	29	88
8/31 8:30	24.00	102	52	154	24.00	101	53	154
9/1 8:30	9.00	54	13	67	9.00	53	14	67
9/1 17:30	0.00	ND	ND	-	15.00	150	80	230
9/2 8:30	10.50	82	39	121	10.50	80	44	124
9/2 19:00	0.00	ND	ND	-	13.50	87	50	137
9/3 8:30	0.00	ND	ND	-	24.00	138	83	221
9/4 8:30	0.00	ND	ND	-	24.00	7	9	16
9/5 8:30	22.75	23	11	34	22.75	24	10	34
9/6 8:30	11.25	20	16	36	11.25	17	19	36
9/6 21:45	0.00	ND	ND	-	10.75	72	41	113
9/7 8:30	0.00	ND	ND	-	24.00	164	87	251
9/8 8:30	0.00	ND	ND	-	24.00	358	147	505
9/9 8:30	0.00	ND	ND	-	24.00	453	221	674
9/10 8:30	0.00	ND	ND	-	23.75	384	153	537
9/11 8:30	0.00	ND	ND	-	24.00	409	169	578
9/12 8:30	0.00	ND	ND	-	24.00	571	242	813
9/13 8:30	0.00	ND	ND	-	23.50	768	353	1,121
9/14 8:30	0.00	ND	ND	-	24.00	853	642	1,495
9/15 8:30	0.00	ND	ND	-	23.75	802	488	1,290
9/16 8:30	0.00	ND	ND	-	23.25	1,260	818	2,078
9/17 8:30	0.00	ND	ND	-	24.00	1,094	768	1,862
9/18 8:30	0.00	ND	ND	-	24.00	1,145	878	2,023
9/19 8:30	0.00	ND	ND	-	24.00	957	742	1,699
9/20 8:30	0.00	ND	ND	-	24.00	768	565	1,333
9/21 8:30	0.00	ND	ND	-	24.00	825	656	1,481
9/22 8:30	0.00	ND	ND	-	22.25	786	619	1,405
9/23 8:30	0.00	ND	ND	-	24.00	680	597	1,277
9/24 8:30	0.00	ND	ND	-	24.00	669	555	1,224
9/25 8:30	0.00	ND	ND	-	23.33	423	414	837
9/26 8:30	0.00	ND	ND	-	23.67	392	401	793
9/27 8:30	0.00	ND	ND	-	24.00	396	411	807
9/28 8:30	0.00	ND	ND	-	24.00	418	387	805
9/29 8:30	0.00	ND	ND	-	24.00	229	292	521
9/30 8:30	0.00	ND	ND	-	24.00	200	351	551
10/1 8:30	0.00	ND	ND	-	3.50	32	51	83
Totals	452.95	540	260	800	1,098.03	16,002	11,544	27,546
Sex Ratio		0.68	0.33			0.58	0.42	

[a] Count date may include more than one time frame per day.

Table 12.–Comparisons of dip net and video counts of coho salmon collected from the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count Date		Dip Net			Video		
Start Time	Time (h)	Male	Female	Total	Male	Female	Total
8/15 14:38	17.87	0	0	0	0	0	0
8/16 8:30	24.00	0	0	0	0	0	0
8/17 8:30	22.92	0	0	0	0	0	0
8/18 8:30	24.00	1	0	1	1	0	1
8/19 8:30	24.00	0	0	0	0	0	0
8/20 8:30	24.00	5	3	8	5	3	8
8/21 8:30	24.00	5	2	7	4	3	7
8/22 9:00	23.50	14	8	22	14	8	22
8/23 8:30	24.00	6	4	10	6	4	10
8/24 8:30	24.00	10	5	15	9	6	15
8/25 8:50	23.67	11	4	15	11	5	16
8/26 8:30	6.83	6	4	10	6	4	10
8/27 8:30	24.00	23	13	36	23	13	36
8/28 8:30	24.00	44	22	66	44	23	67
8/29 8:30	24.00	57	35	92	55	36	91
8/30 8:30	23.50	63	25	88	59	29	88
8/31 8:30	24.00	102	52	154	101	53	154
9/1 8:30	9.00	54	13	67	53	14	67
9/2 8:30	10.50	82	39	121	80	44	124
9/5 8:30	22.75	23	11	34	24	10	34
9/6 8:30	11.25	20	16	36	17	19	36
Totals	436.78	526	256	782	512	274	786
Sex Ratio		0.66	0.33		0.65	0.35	

Table 13.–Catch per unit effort data for coho salmon collected from a combination of dip net and video monitoring methods at the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

Count	Counting		Total	CPUE		Cumulative	
Date	Method	Time (h)	Catch	Per 24 (h)	Per (h)	CPUE	Percent
8/15	Video	17.87	0	0	0.00	0	0.00
8/16	Video	24.00	0	0	0.00	0	0.00
8/17	Video	22.92	0	0	0.00	0	0.00
8/18	Video	24.00	1	1	0.04	1	0.00
8/19	Video	24.00	0	0	0.00	1	0.00
8/20	Video	24.00	8	8	0.33	9	0.00
8/21	Video	24.00	7	7	0.29	16	0.00
8/22	Video	23.50	22	22	0.94	38	0.00
8/23	Video	24.00	10	10	0.42	48	0.00
8/24	Video	24.00	15	15	0.63	63	0.00
8/25	Video	23.67	16	16	0.68	80	0.00
8/26	Dip net	24.00	28	28	1.17	108	0.00
8/27	Video	24.00	36	36	1.50	144	0.01
8/28	Video	24.00	67	67	2.79	211	0.01
8/29	Video	24.00	91	91	3.79	302	0.01
8/30	Video	23.50	88	90	3.74	392	0.01
8/31	Video	24.00	154	154	6.42	546	0.02
9/1	Video	24.00	297	297	12.38	843	0.03
9/2	Video	24.00	261	261	10.88	1,104	0.04
9/3	Video	24.00	221	221	9.21	1,325	0.05
9/4	Video	24.00	16	16	0.67	1,341	0.05
9/5	Video	22.75	34	36	1.49	1,376	0.05
9/6	Video	22.00	149	163	6.77	1,539	0.05
9/7	Video	24.00	251	251	10.46	1,790	0.06
9/8	Video	24.00	505	505	21.04	2,295	0.08
9/9	Video	24.00	674	674	28.08	2,969	0.10
9/10	Video	23.75	537	543	22.61	3,512	0.12
9/11	Video	24.00	578	578	24.08	4,090	0.14
9/12	Video	24.00	813	813	33.88	4,903	0.17
9/13	Video	23.50	1,121	1,145	47.70	6,047	0.21
9/14	Video	24.00	1,495	1,495	62.29	7,542	0.27
9/15	Video	23.75	1,290	1,304	54.32	8,846	0.31
9/16	Video	23.25	2,078	2,145	89.38	10,991	0.39
9/17	Video	24.00	1,862	1,862	77.58	12,853	0.45
9/18	Video	24.00	2,023	2,023	84.29	14,876	0.53
9/19	Video	24.00	1,699	1,699	70.79	16,575	0.59
9/20	Video	24.00	1,333	1,333	55.54	17,908	0.63
9/21	Video	24.00	1,481	1,481	61.71	19,389	0.68
9/22	Video	22.25	1,405	1,516	63.15	20,905	0.74
9/23	Video	24.00	1,277	1,277	53.21	22,182	0.78
9/24	Video	24.00	1,224	1,224	51.00	23,406	0.83
9/25	Video	23.33	837	861	35.87	24,267	0.86
9/26	Video	23.67	793	804	33.51	25,071	0.89
9/27	Video	24.00	807	807	33.63	25,878	0.91
9/28	Video	24.00	805	805	33.54	26,683	0.94
9/29	Video	24.00	521	521	21.71	27,204	0.96
9/30	Video	24.00	551	551	22.96	27,755	0.98
10/1	Video	3.50	83	569	23.71	28,324	1.00
Totals		1,115.20	27,564	28,324	-	-	-

Run Timing

A record number of both fall chum and coho salmon passed through the Nenana test fish wheel in 2003. When compared to the 1988 to 2002 median annual CPUE the fall chum salmon cumulative CPUE was 3.5 times larger and coho salmon cumulative CPUE was 13.8 times larger (Table 14). The fish wheel remained operational through one high water event in early September (Appendix A1). The midpoint of the fall chum salmon run in 2003 appeared 1 day later than the annual median of September 10. Run timing for coho salmon was equal to the annual median date of September 18. The highest daily counts by species included 1,051 fall chum salmon on September 10 and 2,145 coho salmon on September 16. Counts exceeded 1,000 fish per day for fall chum salmon for 2 days (September 9 and 10) and 12 days for coho salmon (September 13–24). For several days in early September, catch rates decreased during a high water event but after September 7, catch rates increased to over 31 salmon per hour. Highest combined catch rates for both fall chum and coho salmon were 109 fish per hour on September 16.

Comparisons of CPUE from two additional fall season projects located downstream of this test fish wheel showed similar patterns of migration in 2003 (Figure 4). The Tanana River tagging fish wheel was located approximately 80 km downstream near the mouth of the Kantishna River and the Subdistrict 5-A fish wheel was located an additional 173 km downstream just below the confluence of the mouth of Tanana and Yukon Rivers (Figure 5). The catch per unit effort of fall chum salmon observed at this site in 2003 represented 7% of the mark–recapture abundance estimate (Figure 6).

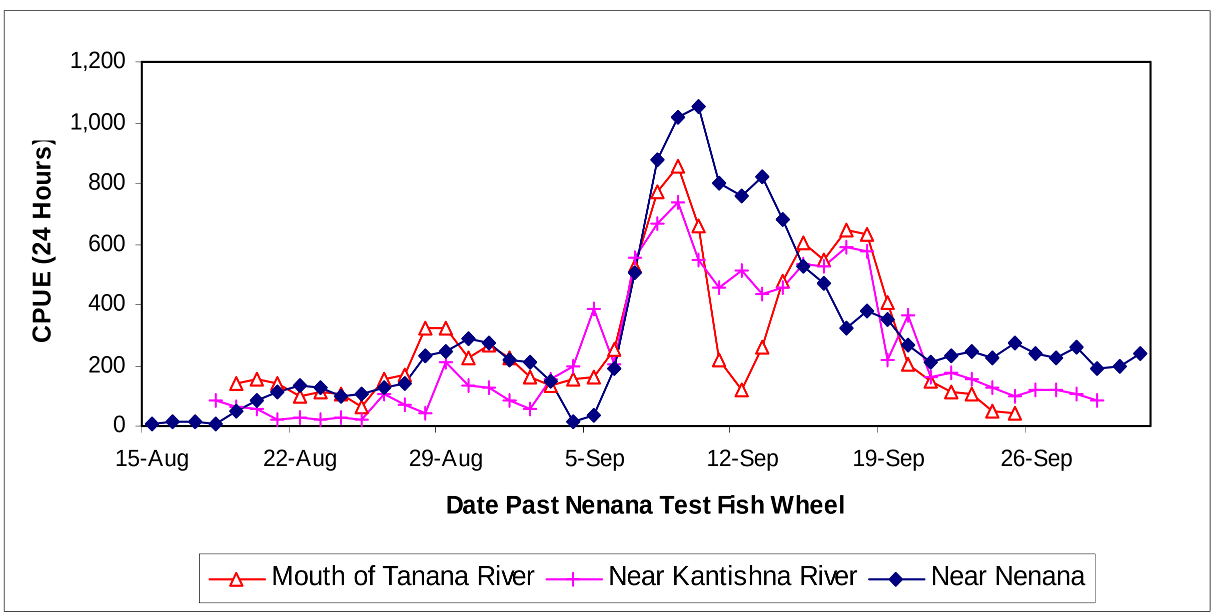

Figure 4.–Comparisons of catch per unit effort data for fall chum salmon from three consecutive test fish wheels monitoring Tanana River stocks, Yukon River drainage, 2003.

Table 14.–Fall chum and coho salmon timing information from the Nenana test fish wheel, Tanana River, Yukon Area, 1988–2003.

Year	Operation Period (days)	Fall Chum Salmon Cumulative CPUE	Fall Chum Salmon Midpoint	Coho Salmon Cumulative CPUE	Coho Salmon Midpoint	Percent Coho Salmon
1988	39	5,114	10-Sep	6,403	16-Sep	56%
1989	44	9,228	12-Sep	4,606	19-Sep	33%
1990	44	4,625	21-Sep	1,347	24-Sep	23%
1991	41	6,082	15-Sep	3,396	17-Sep	36%
1992	32	4,161	10-Sep	4,014	16-Sep	49%
1993	46	4,228	14-Sep	2,553	22-Sep	38%
1994	38	3,831	1-Sep	1,272	14-Sep	25%
1995	47	7,556	12-Sep	2,051	24-Sep	21%
1996	48	3,613	4-Sep	1,628	18-Sep	31%
1997	50	1,619	8-Sep	1,401	18-Sep	46%
1998	52	1,326	13-Sep	980	21-Sep	42%
1999	51	1,269	8-Sep	838	20-Sep	40%
2000	48	1,200	8-Sep	1,735	22-Sep	59%
2001	50	1,853	6-Sep	4,950	14-Sep	73%
2002	52	4,063	14-Sep	7,776	18-Sep	66%
2003	48	14,265	11-Sep	28,324	18-Sep	67%
1988–2002 Median	47	4,063	10-Sep	2,051	18-Sep	40%

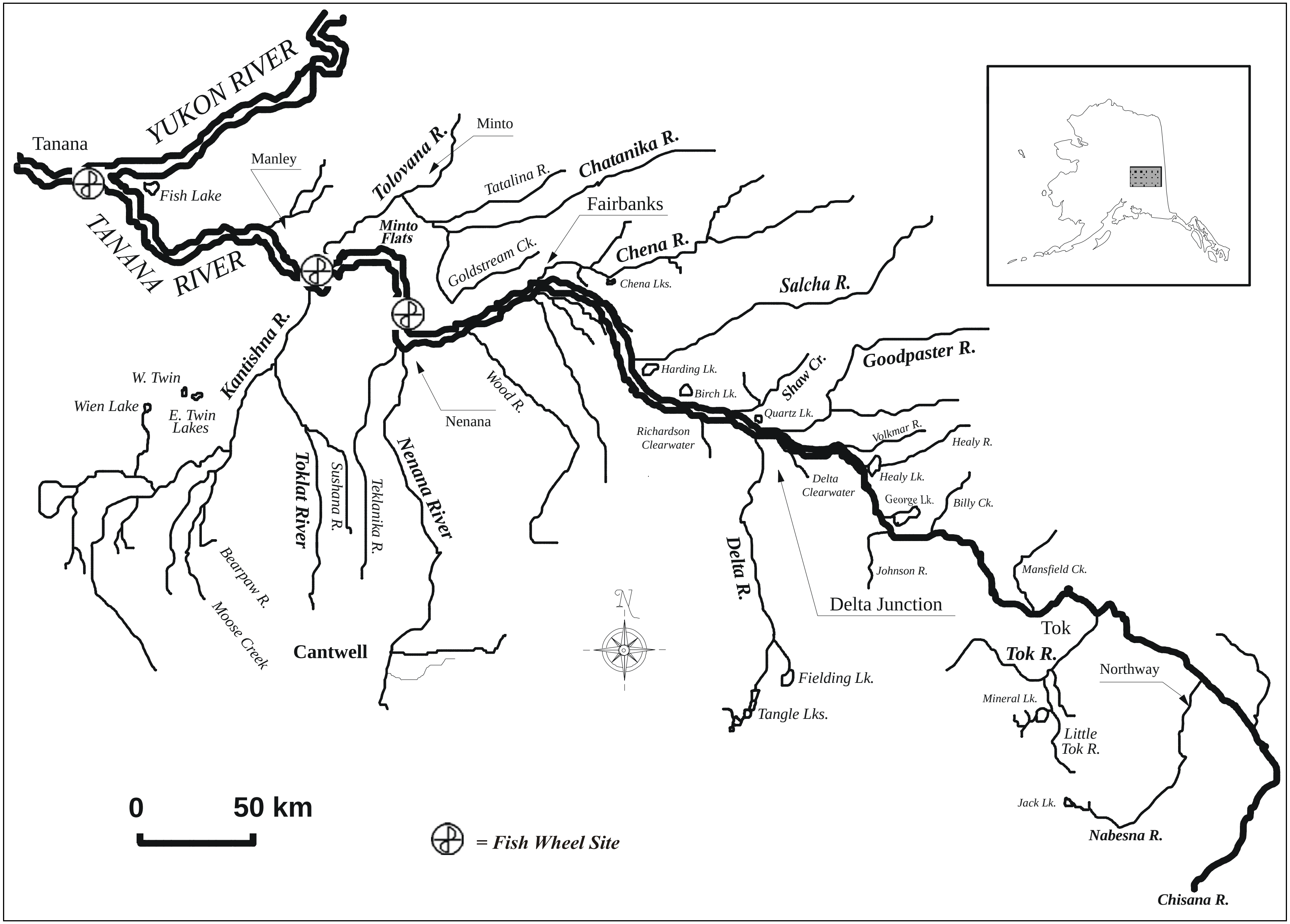

Figure 5.–Locations of Nenana, Tanana tagging and Subdistrict 5-A test fish wheels used to monitor Tanana River salmon stocks, Yukon Area, 2003.

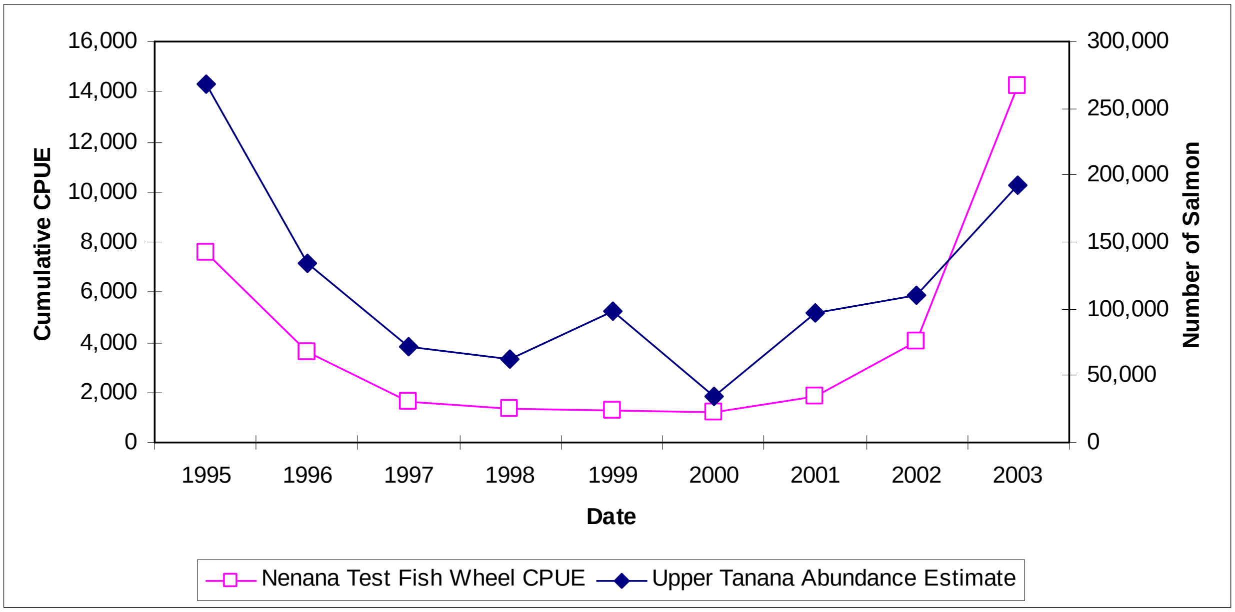

Figure 6.–Relative abundance of fall chum salmon as indicated by comparing cumulative CPUE from the Nenana test fish wheel and the Upper Tanana abundance estimate, Yukon Area, 1995–2003.

Other Harvests

Other non-salmon species captured in the fish wheel, included approximately 508 whitefish *coregonus* spp. and *prosopium* spp.(composed of humpback, broad, and round whitefish, sheefish, least cisco, and a few hybrids), 22 suckers, 4 Northern pike *esox lucius*, and 4 burbot *lota lota*. Less than 1% of the whitefish were captured during the summer season operational period. During the fall season operations, counts were low and sporadic until September 15 and then increased substantially with a peak count of 47 whitefish captured on September 28, 2003. In total 95% of the whitefish were captured after September 15. In a normal live box operation small non-salmon fish typically escape through the ventilation holes however, with the use of video all species of fish captured can be reviewed.

Migration Characteristics

Mean proportions of passage were calculated hourly within a 24 hour counting day (midnight to midnight) to investigate the diel migration patterns for Chinook, fall chum, and coho salmon. Only days where catch rates were greater than 100 fish per day were used for analysis of diel patterns. Sample dates for Chinook salmon were July 5 through July 11 (Appendix A4) and this represents a relatively small sample size (N=7). Chinook salmon passage rates increased between 2400 and 0700 hours, after which passage rates began to drop off during the daytime hours (Figure 7).

Sample dates for fall chum salmon included August 28–31 and September 8–30 (N=36; Appendix A5) for analysis of the diel migration patterns at the Nenana test fish wheel. The diel pattern of fall chum salmon was very different than that of Chinook salmon. Fall chum salmon passage consistently declined twice daily at 0800 and 1800 hours, while peak passage was from 1000 to 1500 hours (Figure 8).

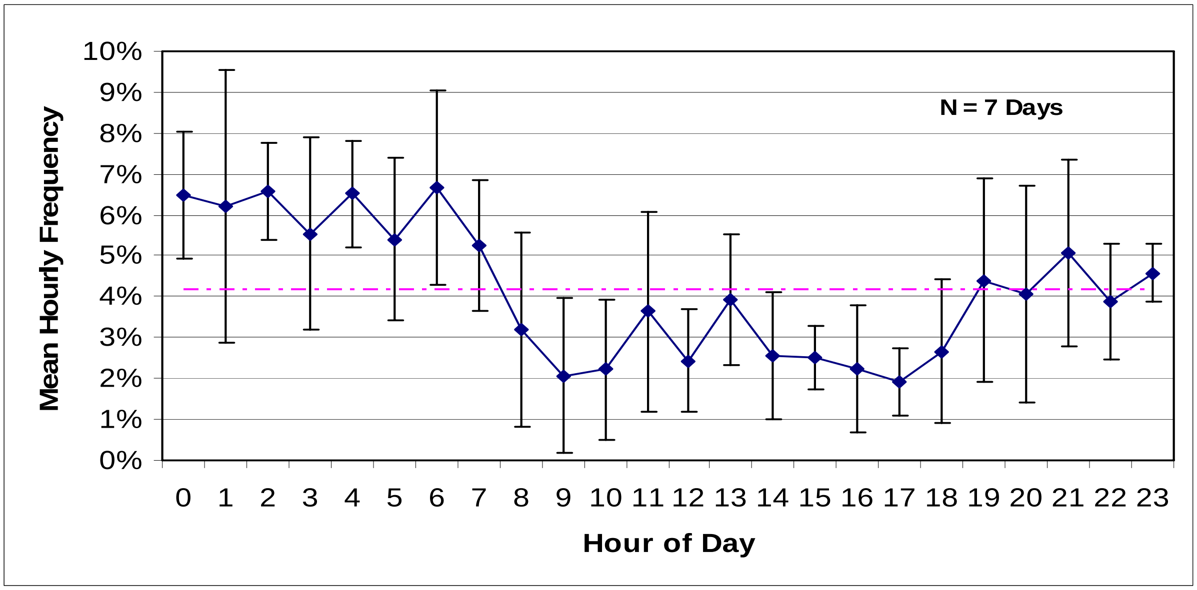

Figure 7.–Mean hourly proportion of Chinook salmon passage at the Nenana test fish wheel and bound confidence intervals (95%), Tanana River, Yukon Area, 2003.

Note: Dashed line represents the average hourly catch (4.17%). Data includes only days with 24 hours of continuous records and a daily capture of over 100 fish.

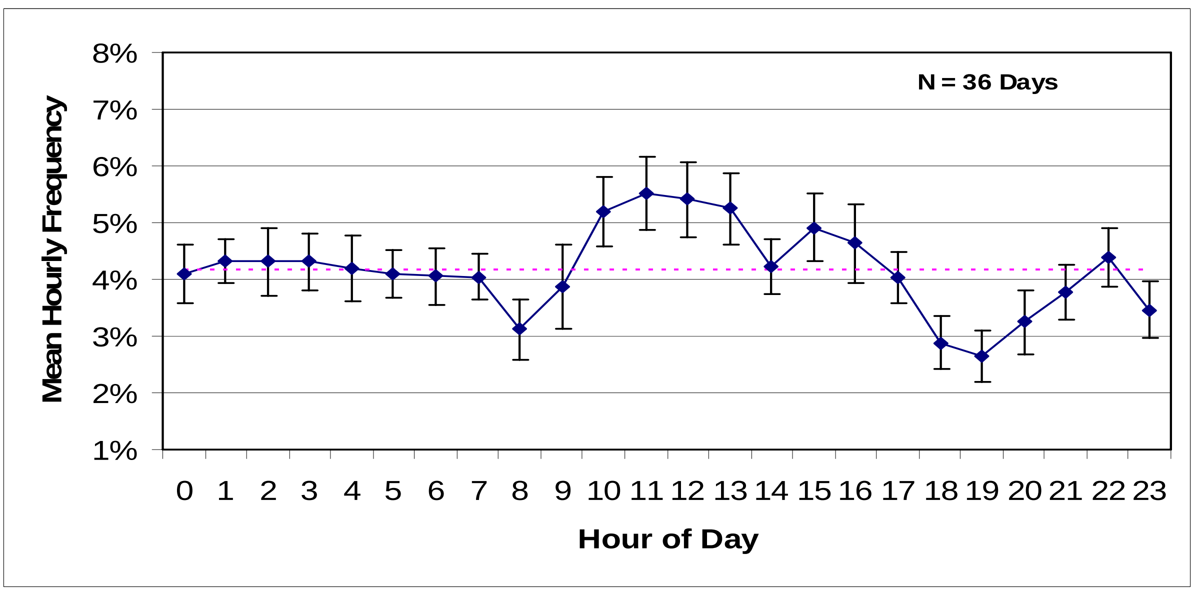

Figure 8.–Mean hourly proportion of fall chum salmon passage at the Nenana test fish wheel and bound confidence intervals (95%), Tanana River, Yukon Area, 2003.

Note: Dashed line represents the average hourly catch (4.17%). Data includes only days with 24 hours of continuous records and a daily capture of over 100 fish.

Coho salmon exhibited a stronger diel pattern than fall chum salmon. The coho salmon diel pattern included a low point observed at 0800 hours and a peak observed at 1400 hours (Figure 9). At the Nenana test fish wheel the sample size (N=28) used for diel migration pattern analysis of coho salmon included sample dates of September 8–30 (Appendix A6). The samples also contained 12 consecutive days (September 13–24) when CPUE was over 1,000 coho salmon per day. Additionally on September 16 and 18, coho salmon passage exceeded 2,000 per day. In 2003, the proportion of coho to fall chum salmon captured in the Nenana test fish wheel was 67% compared to the 1988–2002 median of 40% coho salmon (Table 14).

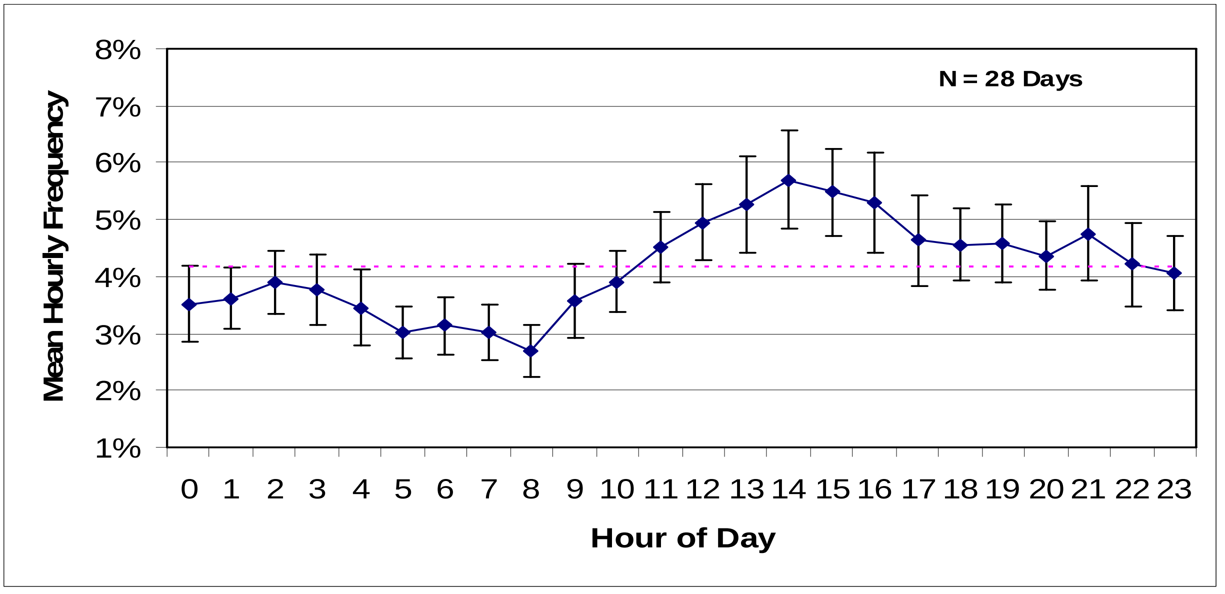

Figure 9.–Mean hourly proportion of coho salmon passage at the Nenana test fish wheel and bound confidence intervals (95%), Tanana River, Yukon Area, 2003.

Note: Dashed line represents the average hourly catch (4.17%). Data includes only days with 24 hours of continuous records and a daily capture of over 100 fish.

The abundance estimates provided by the mainstem sonar at Pilot Station (river mile 123) indicated that the fall chum salmon run in 2003 was 3.4 times that of the coho salmon run (JTC 2004). Based on run reconstruction, the Tanana River contributes greater than 35% to the total fall chum salmon run within the Yukon River drainage. For 2003 that equated to a coho salmon run size to the entire Yukon River drainage only slightly less than the size of the fall chum salmon run to the Tanana River. Overall the coho salmon run in the Tanana River was slightly smaller than the upper Tanana River fall chum salmon abundance but there was an extremely high proportion of coho salmon passing the Nenana test fish wheel which was confirmed by the record escapement in the Delta Clearwater River in the upper portion of the Tanana River drainage.

Temperature data was collected with the data loggers 4 times a day (0200, 0800, 1400, and 2000 hours) from August 16 to October 1, 2003, at the Nenana test fish wheel site. The largest variation in temperature within 1 day during the 4 observation times was 1.56ºC on October 1, and the smallest variation in temperature for one day was 0.15ºC recorded on September 25, 2003 (Figure 10). The average daily temperature was highest on the first day of fall season operations, August 16 at 13.0 ºC, and temperatures dropped to a low of 1.6 ºC on September 24, 2003. On October 1, the large increase in temperature was due to a rapid warming event. Ice accumulations on the fish wheel began occurring on September 13, 2003 around 2200 hours each night and it often took until 1400 hours the following day to melt accumulated ice off of the visible portions of the chute and the swinging door had to be cleaned manually to maintain proper function. The temperature gage was retrieved at 0800 hours on October 2, prior to moving the fish wheel to dry land for winter storage.

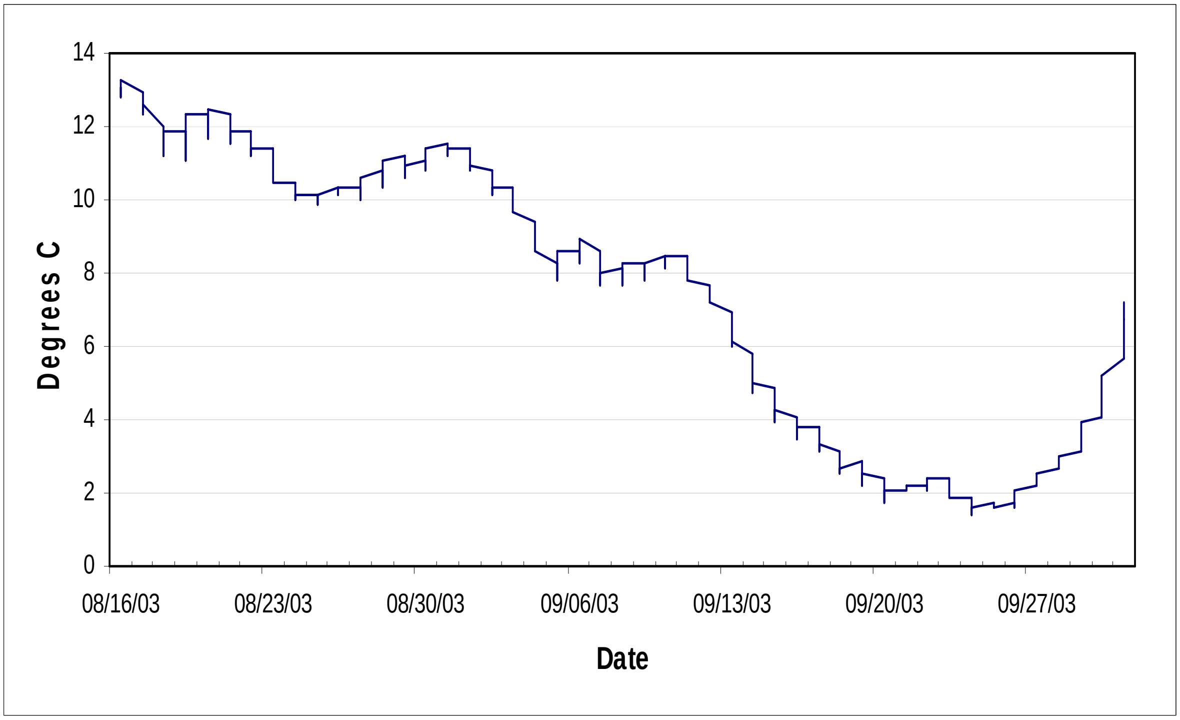

Figure 10.–Water temperature data collected in the Tanana River at the Nenana test fish wheel site from August 16 through October 1, 2003 at 6 hour intervals.

Note: Vertical bars represent high and low temperatures.

There was a cyclic pattern to the daily water temperatures at the fish wheel site. During daily trends of increasing water temperatures, the warmest time of the day occurred at 2000 hours and the coolest occurred at 0800 hours. However during cooling trends the warmest temperatures occurred at 0200 hours and the coolest at 1400 hours. During rapidly warming air temperatures or sustained warmth, the body of heat stored by the water accumulated into the evening. During days with cooling temperatures, the fluctuations within a day resulted in the warmest temperatures being registered in the early morning hours due to the lag time necessary to mix the water heated during the peak of the day into the water column. In the future the temperature data loggers will be deployed at the beginning of the season, approximately July 1 at the Nenana fishing site.

DISCUSSION

The operation of video equipment on fish wheels has been used on fish wheels in the Yukon River since 1999 by USFWS at the Rampart Rapids fall chum salmon mark–recapture project. During video technique development and application on Yukon River drainage fish wheels, several improvements were made to both the hardware and software. Because of the advancements already made at other video sites, very few modifications were necessary to adapt this system to the Nenana test fish wheel. Modifications made to the fish wheel included construction of suitable structures to funnel the fish as they exited from the baskets through the video monitoring chute prior to live release. As the fish wheel operated during the season, modifications were made to fortify the transfer of fish captured in the basket to the chute. Depending on the angle of entry into the video's field of view, adjustments had to be made including number of video frames captured per fish, camera angle, and placement of time stamp in picture frame to facilitate the best image.

VHS monitoring provided a view of how the fish physically enter the live box, behavior in the live box, and attempts to escape from the live box. Although coho salmon appeared to be more active in the live box than fall chum salmon both were observed to leap out of the water and up the sides of the box, raft, and chute door in attempts to continue the migration. During these observations the live box accumulated fish for approximately 11 hours at catch rates between 13 to 16 fall chum and coho salmon combined per hour and resulted in a few mortalities at this level while being confined in the live box. For the remainder of the season video only enumeration was conducted except when the contractor harvested fish.

Comparisons of dipnet to video counts were very accurate since the Nenana fish wheel had a fish tight live box that prevented captured salmon from escaping by leaping out as was observed in other fish wheel projects. Initial modifications were necessary only to direct all the fish into the video chute and not permitting the fish to beach themselves behind the chute structure that was sitting diagonally in the corner of the raft and the live chute. The lower number of Chinook salmon dipped from the live box compared to video counts, was found to be due to local fishermen removing fish from the live box. The contractor was able to contact some of the individuals to remind them that the fish wheel and the fish in it were his property and if they wanted fish they needed to get his approval. The contractor explained to them that the fish must remain in the box until he had completed the tallies. In future operations of the video monitoring system, the live box door will remain open for immediate release of all fish except during periodic comparison checks which will most likely occur when the contract fisherman harvests fish for either subsistence or commercial purposes.

Comparisons of gender using the dip net versus video counts were consistent for Chinook salmon, however for chum and coho salmon both showed a higher bias toward females in the video counts. Bias may have been introduced by conducting dip net counts prior to tallying the fish using the video files. However, more likely it was related to the difficulty of seeing smaller-sized and extremely lively fish passing through the video view. The video capture method created a limited number of frames for the observer to distinguish species, gender, tag color, injuries, etc. An external lighting source was used to facilitate viewing during the nighttime hours and often produced superior views compared to the daytime hours which had a higher incidence of moving shadows and variable lighting. It is unknown to what extent counts by gender were improved by the process of manually dipping the fish out prior to reviewing the video which may keep the observer's eye calibrated.

Fall chum salmon typically enter the mouth of the Yukon River in distinct pulses. As the fish migrate up river they change their rates of migration, turn off into tributaries, and are harvested on their route to the spawning grounds. All of these factors cause changes in the pattern of passage as the fish move upriver. For example two fish wheels located downstream of the Nenana test fish wheel had three strong pulses whereas the up river project had two strong pulses (Figure 5). The second pulse appears to be delayed somewhat and fall chum salmon migrated through the Nenana area in one large pulse on September 6–21. Part of this effect was most likely caused by the high water event in early September compressing the run to some extent.

Similarly, coho salmon had two distinct larger pulses that entered at the mouth of the Tanana River (Appendix A7). However the pulses were more difficult to track into the upper portion of the river possibly because a portion of the run migrates up the Kantishna River, a tributary between the two lower fish wheel projects. The second fish wheel site is located on the mainstem Tanana River upstream of the confluence with the Kantishna River and is used for fall chum salmon tag deployment. This site however is not known to be a good coho salmon run strength indicator. The escapements to the Delta Clearwater River (DCR) substantiated the unprecedented number of coho salmon captured at the upper most fish wheel site near Nenana. The Delta Clearwater River is known to be a major coho salmon producer and is annually monitored within the Tanana River drainage. The 2003 escapement of 103,000 coho salmon to the DCR was 11 times more than the Biological Escapement Goal of 9,000 fish for that system (Vania et al. 2002) and 8 times the 30 year average.

Marked fall chum salmon captured more than once at the tag recovery fish wheel have been low throughout the history of the Tanana River mark–recapture project (1995–2003). For example in 2002, this fish wheel recapture only one tagged fall chum salmon twice out of 72 tags recovered (Cleary and Hamazaki 2003). Because tagged fish are not held when using video there is no method to determine if tagged fish are captures more than once. However, at least two untagged chum salmon were observed to have been captured twice in 2003. These fish had injuries that on one hand made them distinguishable but probably also increased their likelihood of being recaptured. One chum salmon had a missing dorsal fin, another was missing the upper lobe of the caudal fin (Appendix B5; frame 4) and both had fungus growth on the old wounds.

Relative abundance information collected from fish wheels is a function of the effectiveness of the gear with respect to capture of a targeted species in this case salmon, based on the salmon's behavior (bank orientation) and the fisherman's ability to "tune" the fish wheel for optimum performance. Most adjustments made to the fish wheel were in response to constantly changing water levels and effective placement of leads. Relative abundance was compared between projects inseason and between years, however many factors that affect the individual projects must be acknowledged when using this information. For example, Figure 6 illustrates the relative abundance of fall chum salmon between the Nenana test fish wheel using cumulative CPUE compared to the upper Tanana River abundance estimates from 1995 to 2003. The years 1995, 1999 and 2001 are years with the greatest difference between estimates and the highest standard errors (SE > 19,000). The correlation is 0.76 and the $r^2 = 0.57$ between the annual cumulative fall chum salmon CPUE for the Nenana test fish wheel project and the upper Tanana population estimate from the years 1995 to 2003. The average cumulative CPUE for the Nenana test fish wheel represents 3% of the upper Tanana abundance estimate however in 2003 it was 7.4%.

Other factors may affect catch rates and abundance estimates for example at the Nenana test fish wheel site high water levels were extreme in early September in 2003 during the peak fall chum salmon migration and late September in 1995 and 2000, while extremely low water levels may have had an effect in 1996, 1998 and 1999. Also in 2003 the high water event in July had a greater affect on the estimation of run timing of summer chum salmon than Chinook salmon due to the timing of the event with respect to the peak of the individual runs.

It is unknown why passage rates of Chinook salmon decreased after 0700 hours or for the consistent low levels of fall chum salmon passage observed during 0800 hours and 1800 hours which happen to correspond somewhat to the arrival times of the fisherman by boat 2 times each day. However these patterns were very similar to other video monitored fish wheel sites particularly fall chum salmon at Rampart Rapids which is monitored using a wireless video communications system (Zuray 2003). The pattern observed for fall chum salmon at Nenana was different than that observed at the test fish wheel at the mouth of the Tanana River (Fliris and Daum 2003). The fall chum salmon migration pattern observed in the Tanana River, a turbid river, was opposite than what is typically observed in clear water tributaries where peak chum salmon passage occurs at night (Barton 2000).

The diel patterns for both fall chum and coho salmon at the Nenana test fish wheel site were more definite than those observed at the test fish wheel located at the mouth of the Tanana River (Fliris and Daum 2003). The strength of the diel migration patterns up river may be indicative of migratory timing as the salmon near their spawning grounds. Some additional reasons for the pattern observed may include, resting during the daytime hours, moving farther offshore which makes fish less susceptible to shore based fish wheel gear, photoperiod, water temperatures, or densities of fish passage. Fish behavior around an operating fish wheel needs to be further explored possibly through collection of paired Didson sonar offshore counts and hourly video monitoring data. This information would be beneficial to further understanding of fish migration patterns and gear efficiencies.

Although non-salmon species were counted using video monitoring the data was not summarized in any detail in this report. In past operations of the test fish wheel non-salmon species counts were expected to be biased low because many of the smaller species could escape through the drain and baffle holes in the live box and therefore would not be counted in a typical dip net count. By using the video method, each species of fish could be identified. A noted whitefish specialist reviewed the non-salmon catches and observed that some of the whitefish species appeared to be hybridized (R. Brown, Fishery Biologist, USFWS, Fairbanks; personal communication). A problem observed with non-salmon capture was that some of the smaller species took longer to trigger the door that released them into the live box because of their lighter weight and low impact.

The Nenana fish wheel site operates in the main current of the Tanana River and is susceptible to damage by debris either passing or accumulating during high water events. This has resulted in days when operations had to be curtailed. In addition, fish may be migrating through the slough behind the fish wheel site during high water. The Didson sonar could also be used to look at the extent of fish utilization of this slough under different water conditions. Each year a survey of the area and available fishing sites is scrutinized by both ADF&G and the contractor. Currently other suitable sites are not available outside of the area utilized by local fishermen. Although there is a large gap between the test fish wheel site and the next local fisherman’s site upstream, the other qualities that make a good fish wheel site have not been suitable.

Testing of alternate construction materials to replace the chain link fence in the fish wheel baskets has not been investigated in depth. It is the opinion of the contract fisherman that the net mesh would tangle mature salmon, particularly male chum and coho salmon. In addition the seine webbing and high-density plastic webbing materials used to replace the wire on the Yukon River test fish wheels (Zuray 2000) would not withstand the conditions of the fish wheel site on the Tanana River. Both silt loads and debris loads can be substantial on the Tanana River compared to the Yukon River.

Overall, operation of the video monitoring in 2003 on the Nenana test fish wheel was extremely successful in providing comparisons between video and dip net counts, sex ratio, species composition, and determination of presence of tags (radio and spaghetti) and secondary marks. Without the operation of the video monitoring system in 2003 the fish wheel would have had to be shut down when the catch rate exceeded the capacity of the live box to avoid mortalities. Other options include emptying the live box more often however this is cost prohibitive and dangerous during night operations. The length of a spaghetti tag has both lower limits (visibility issues) and upper limits as it is not desirable to allow an excessively long tag to wear on the caudal fin. Of the tags used in 2003 the 10 inch tags appeared optimal. A disadvantage of using video monitoring is that the fish cannot be identified by individual tag numbers therefore creating a loss of migration rate data while more than one mark–recapture study is being conducted on chum salmon within the drainage. Through previous history of the project relatively low numbers of tags (0–2) from the upper Yukon mainstem project (Rampart Rapids above the confluence of the Tanana River) have been captured at the Nenana site annually. Adequate sample sizes for stratification by various tag colors could also be a problem at this site for use in the upper Tanana River abundance estimates unless the fish wheel remains as effective as 2003.

ACKNOWLEDGEMENTS

The author wishes to acknowledge and thank Dave Daum of the USFWS without whom this technological advancement of video monitoring on fish wheels would not have occurred. Mr. Daum provided the list of required equipment, assisted in setting up the equipment and educating ADF&G staff and the contract test fish wheel operator on the use and maintenance of both the hardware and software required for this project. Paul Kleinschmidt is commended for his patience and ingenuity for adaptation of the video equipment to his fish wheel. Pete Cleary is thanked for his assistance throughout the field season with project coordination and logistics without which the department’s involvement in the project would not have been successful. Pat Costello is thanked for her administrative support. Editing of the report was conducted by Pete Cleary, Pat Costello, Dave Daum, Paul Kleinschmidt, Tracy Lingnau and Rick Merizon.

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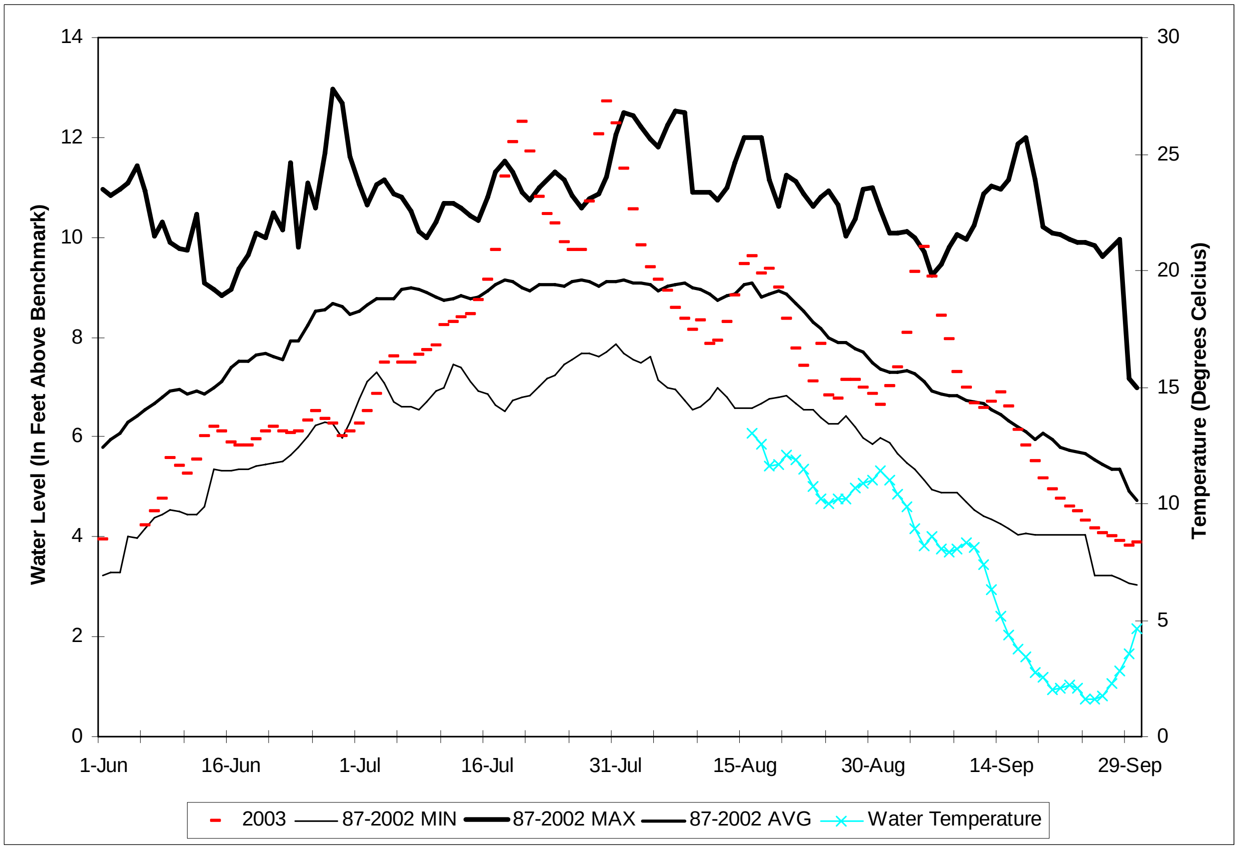
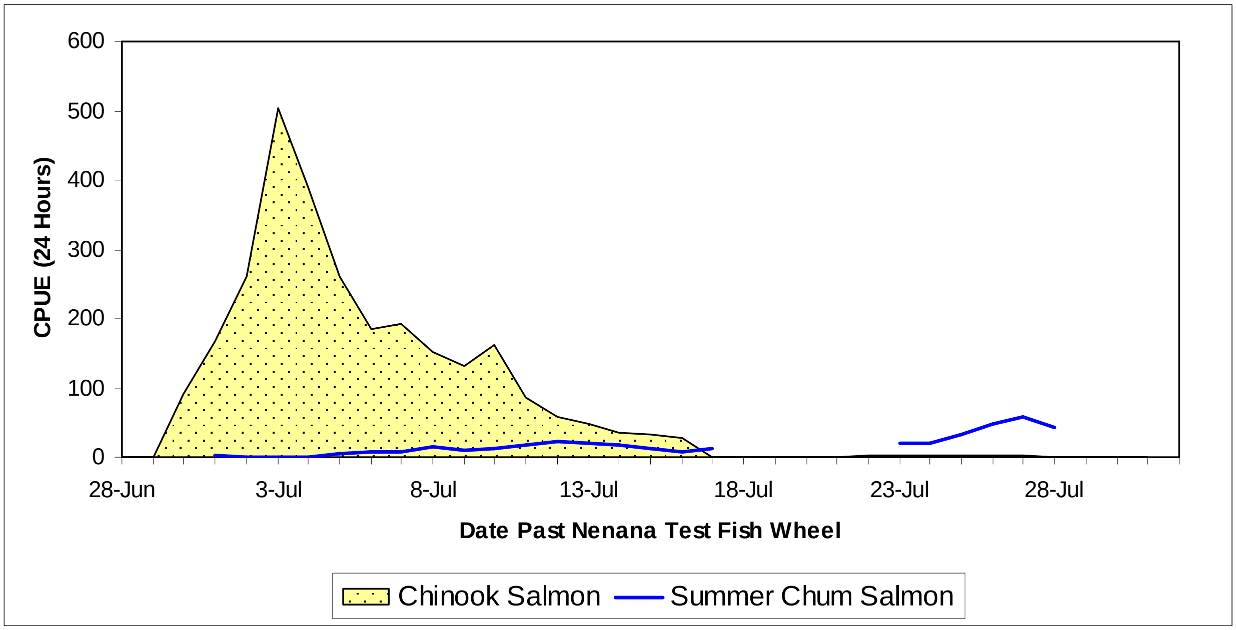
APPENDIX A

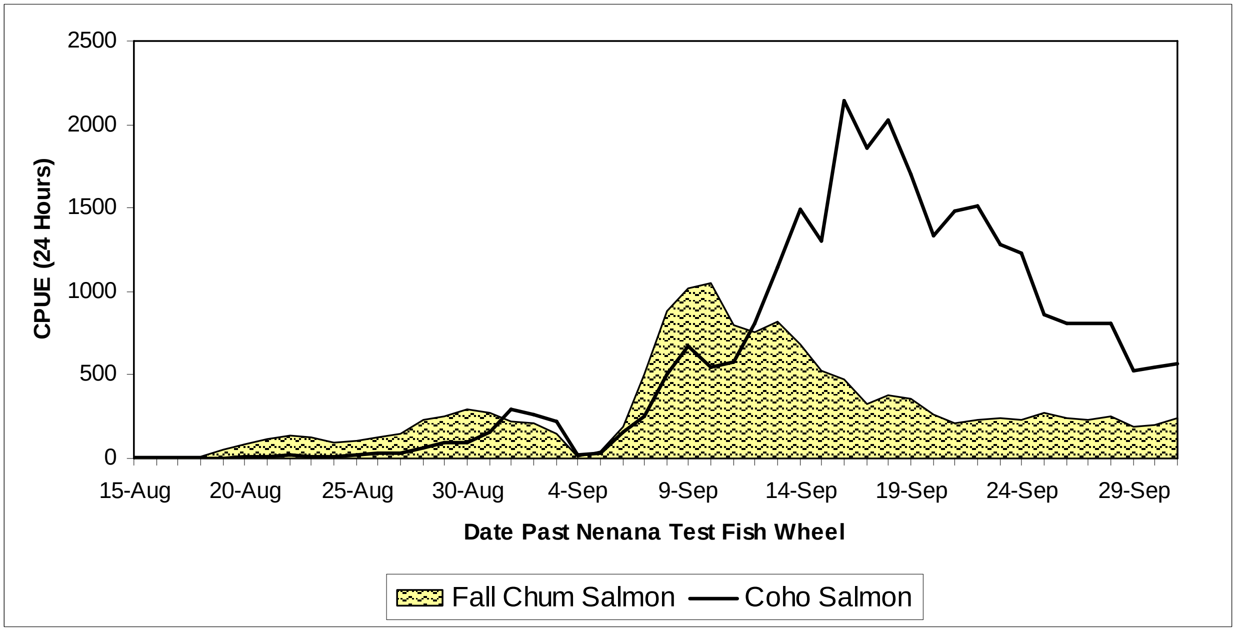
Appendix A1.–Historical Tanana River water levels based on the gage located on the bridge in the community of Nenana, 1987 to 2002 compared to 2003 and subsurface water temperatures taken at the Nenana test fish wheel site in 2003.



Source: NOAA Alaska-Pacific River Forecast Center.

Appendix A2.–Chinook and summer chum salmon (upper panel) and fall chum and coho salmon (lower panel) catch per unit effort collected from a combination of dip net and video monitoring methods at the Nenana test fish wheel site, Tanana River, Yukon Area, 2003.





Appendix A3.–Number of tags recorded by dip net and video methods, including number of fish that were undetermined to possess tags at the Nenana test fish wheel, Tanana River, Yukon Area, 2003.

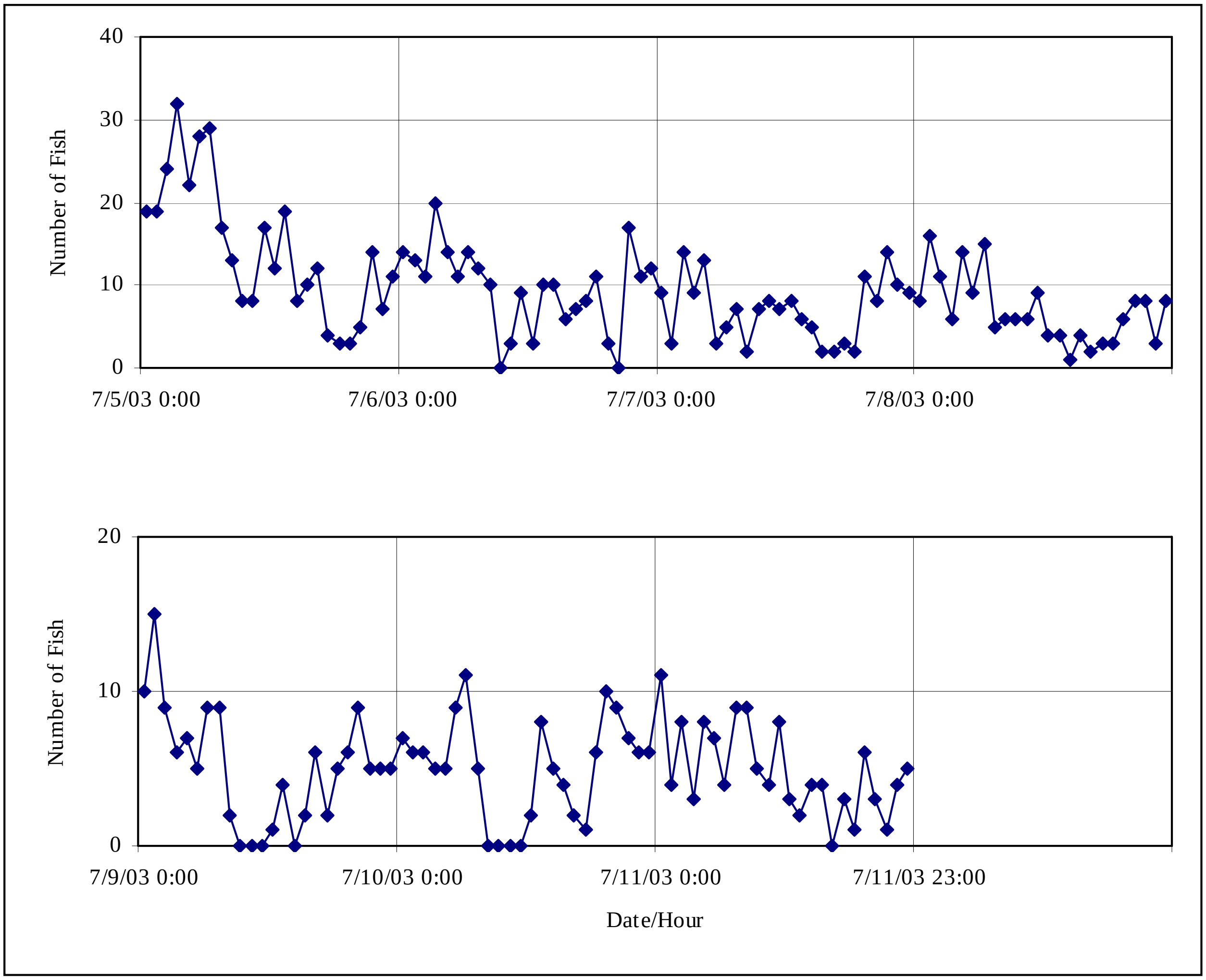
Count Date	Total Tags Recovered	Tag Number Identified	Total Untagged	Undetermined If Tagged	Total Captured
8/15	0	0	6	0	6
8/16	0	0	12	0	12
8/17	0	0	12	0	12
8/18	0	0	10	0	10
8/19	0	0	52	0	52
8/20	3	3	84	0	87
8/21	5	5	107	1	113
8/22	2	2	127	0	129
8/23	1	1	127	0	128
8/24	2	2	94	0	96
8/25	1	1	106	0	107
8/26	0	0	129	0	129
8/27	1	1	141	0	142
8/28	7	7	228	0	235
8/29	5	5	244	0	249
8/30	1	1	284	0	285
8/31	6	6	270	0	276
9/1	3	2 [a]	213	1	217
9/2	5	ND	202	2	209
9/3	4	ND	142	0	146
9/4	0	ND	15	0	15
9/5	0	ND	36	0	36
9/6	2	ND	174	0	176
9/7	13	ND	491	0	504
9/8	43	ND	831	5 [b]	878
9/9	28	ND	983	4	1,015
9/10	31	ND	1004	5	1,040
9/11	19	ND	773	7	799
9/12	19	ND	734	8	761
9/13	11	ND	782	8	801
9/14	7	ND	669	8	684
9/15	3	ND	520	1	524
9/16	10	ND	444	2	456
9/17	5	ND	312	5	322
9/18	11	ND	367	2	380
9/19	11	ND	335	7	353
9/20	5	ND	258	2	265
9/21	6	ND	204	1	211
9/22	14	ND	197	4	215
9/23	11	ND	228	5	244
9/24	8	ND	213	6	227
9/25	15	ND	252	1	268
9/26	9	ND	223	3	235
9/27	5	ND	218	4	227
9/28	16	ND	227	14	257
9/29	12	ND	168	9	189
9/30	6	ND	183	7	196
10/1	0	ND	35	0	35
Totals	366[c]	36	13,466	122	13,954

[a] Remainder of tags were identified using video monitoring techniques, therefore no tag numbers were recovered.

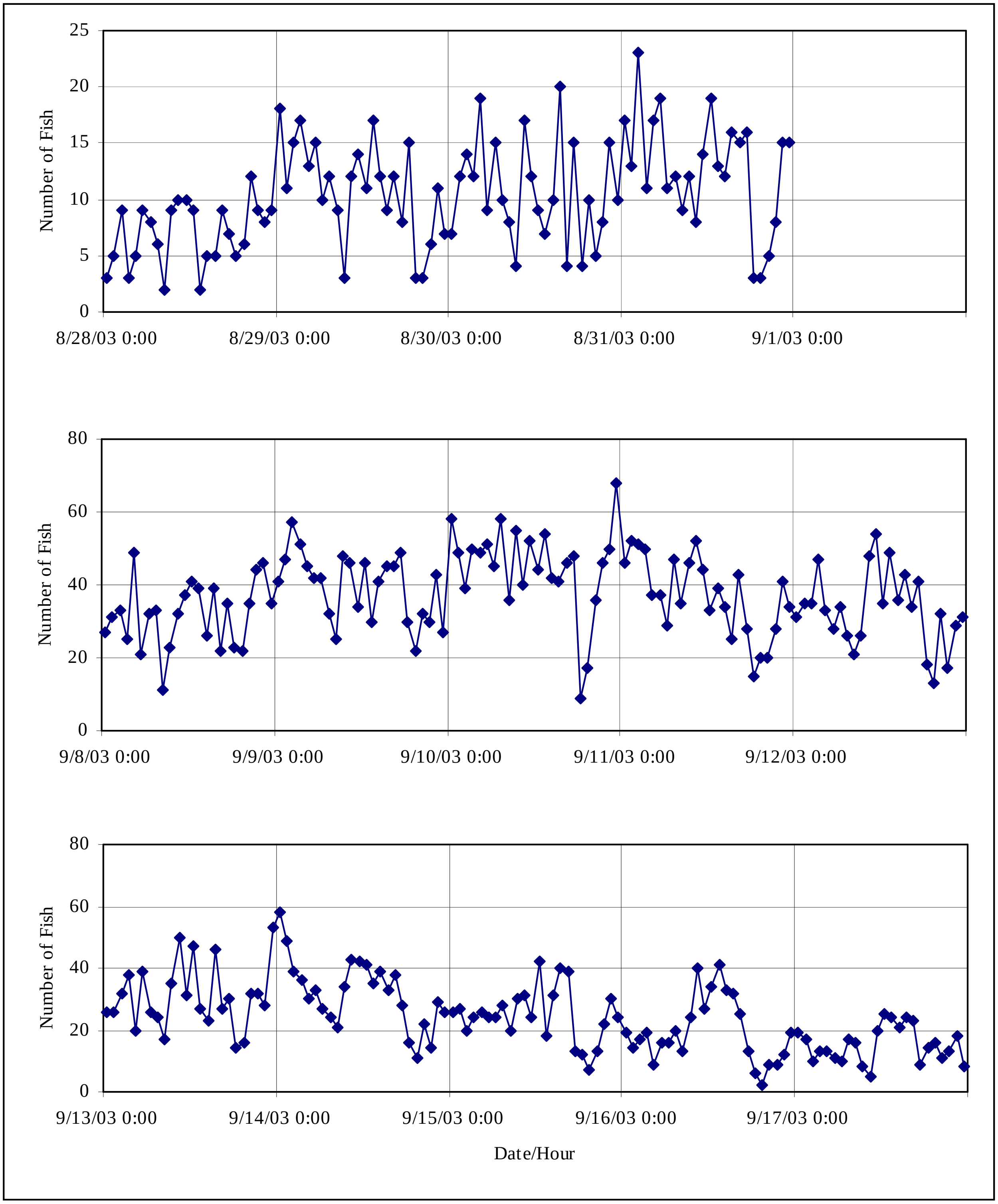
[b] Includes one male salmon reported as a possible tag loss.

[c] Includes two misidentified tag numbers.

Appendix A4.–Hourly catch of Chinook salmon in the Nenana test fish wheel, Tanana River, Yukon Area, 2003.



Appendix A5.–Hourly catch of fall chum salmon in the Nenana test fish wheel, Tanana River, Yukon Area, 2003.



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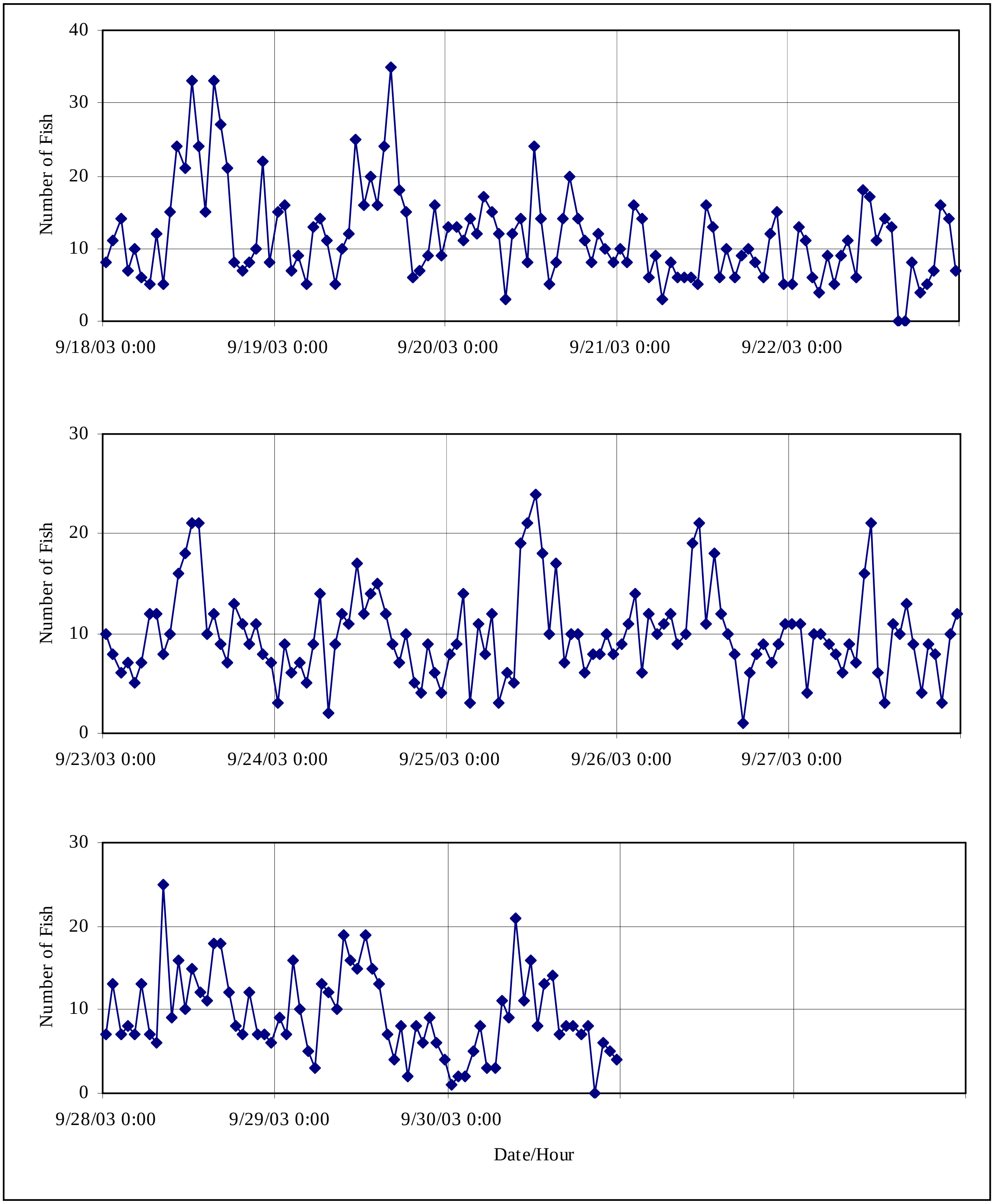
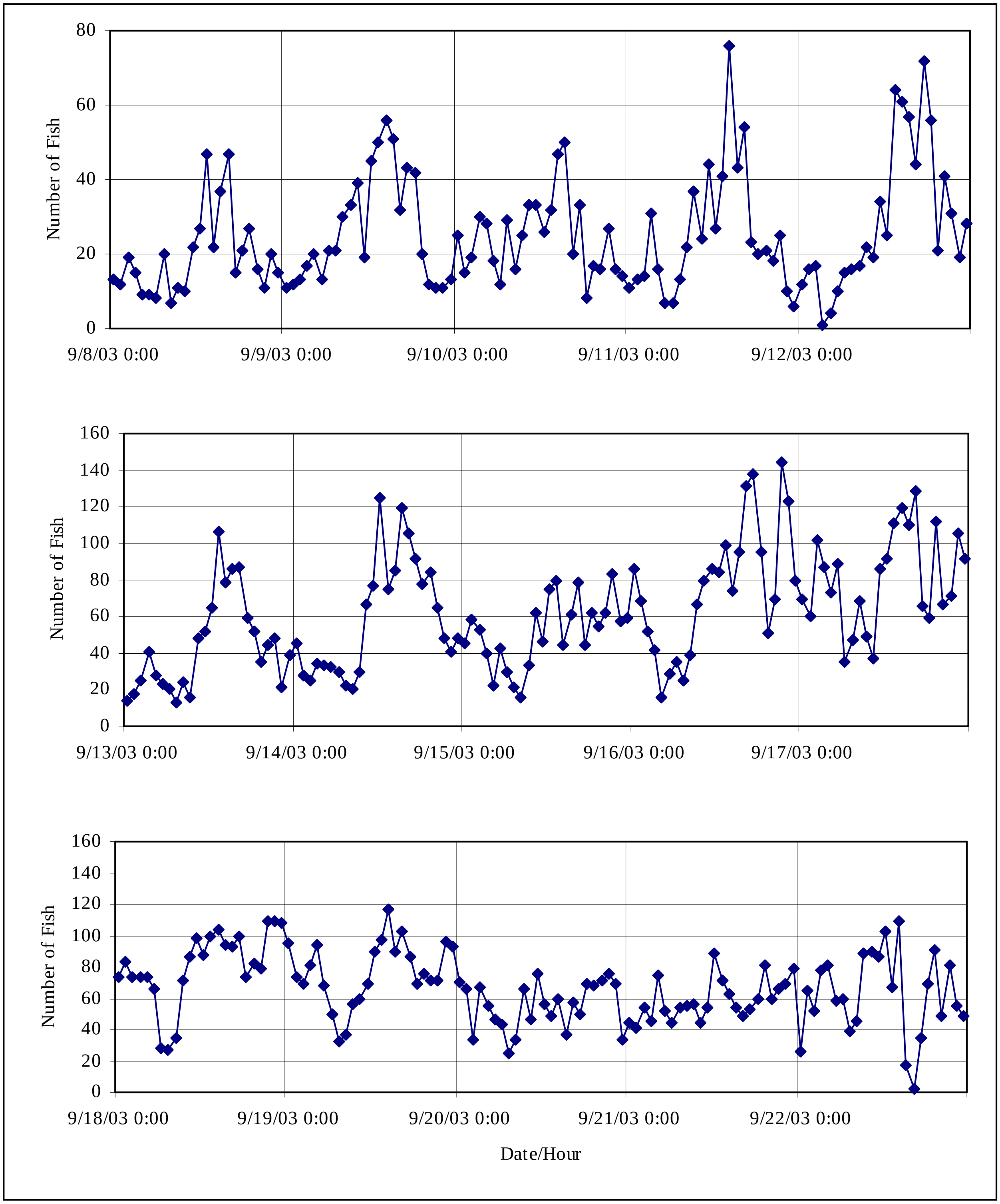
Appendix A5.–Page 2 of 2.



Appendix A6.–Hourly catch of coho salmon in the Nenana test fish wheel, Tanana River, Yukon Area, 2003.



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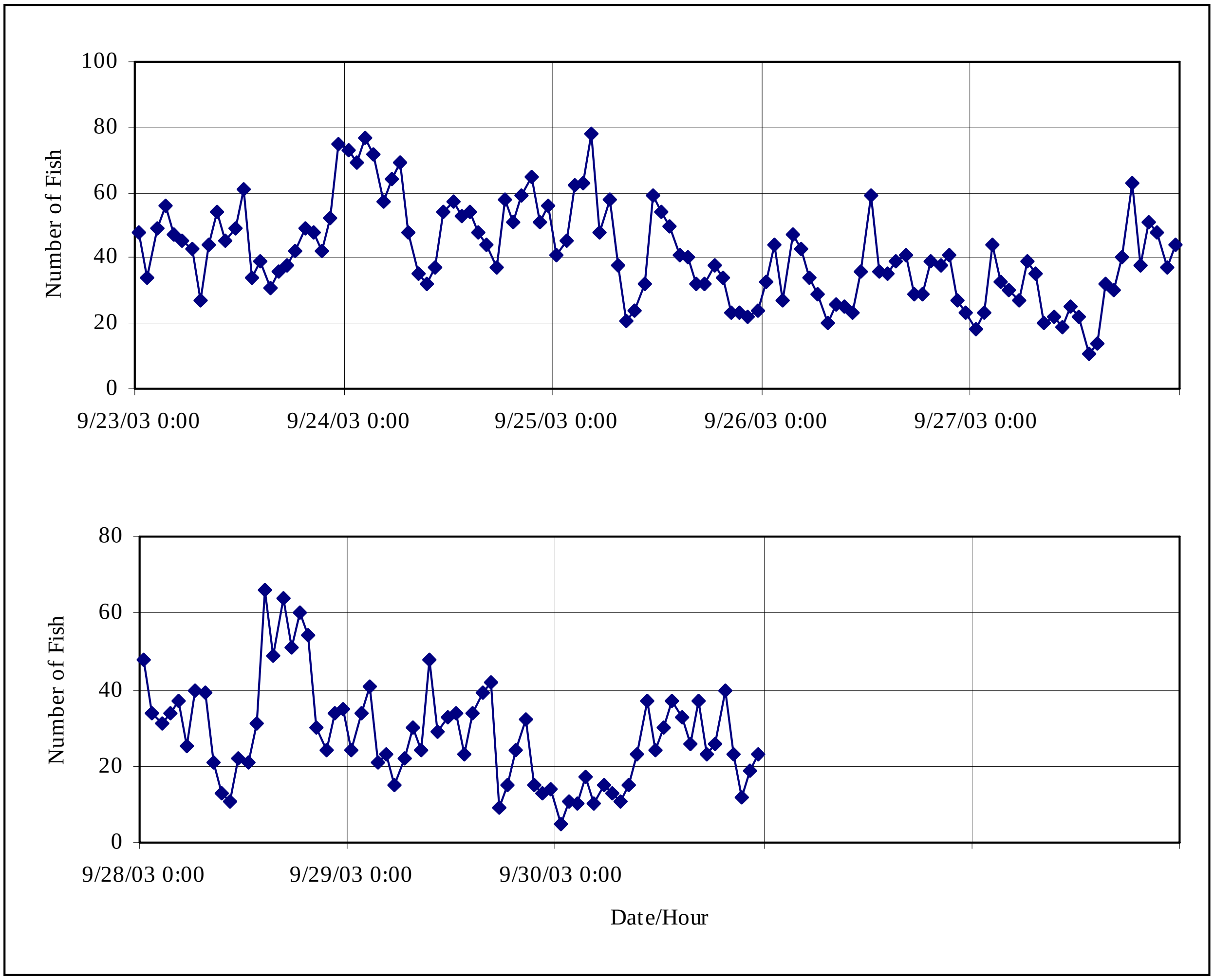
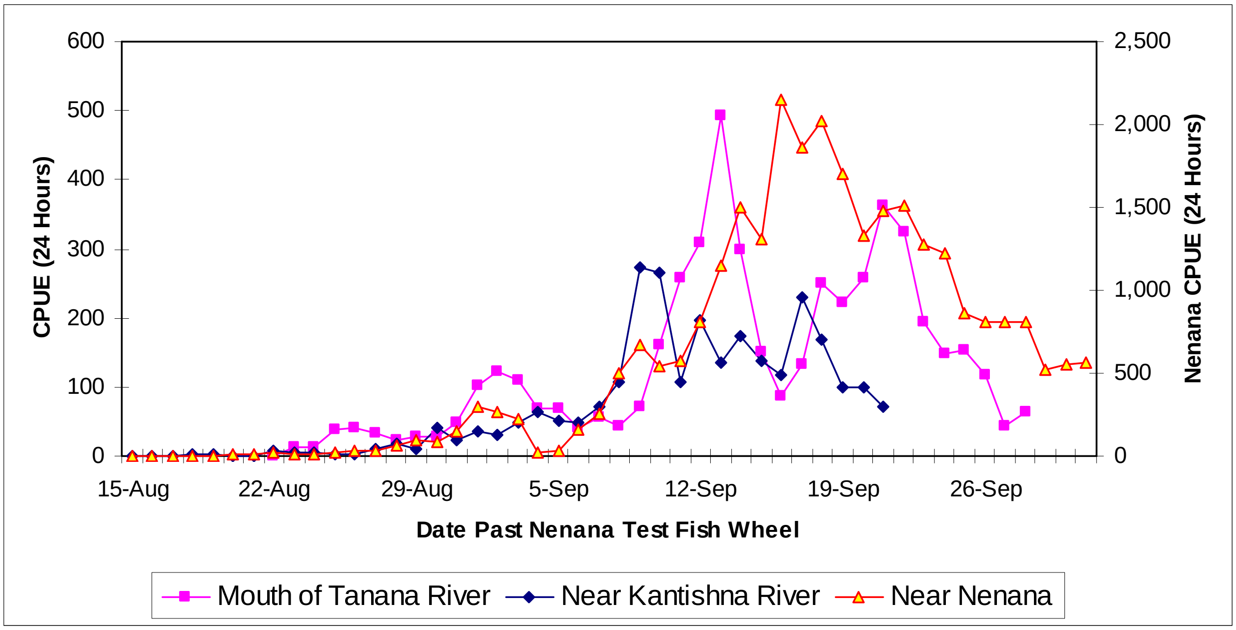
Appendix A6.–Page 2 of 2.



Appendix A7.–Comparisons of catch per unit effort data for coho salmon from three consecutive test fish wheels monitoring Tanana River stocks, Yukon River drainage, 2003.



APPENDIX B

Appendix B1.–Nenana test fish wheel viewed from shore including fish lead.

Source: Photo by Bonnie Borba, ADF&G.

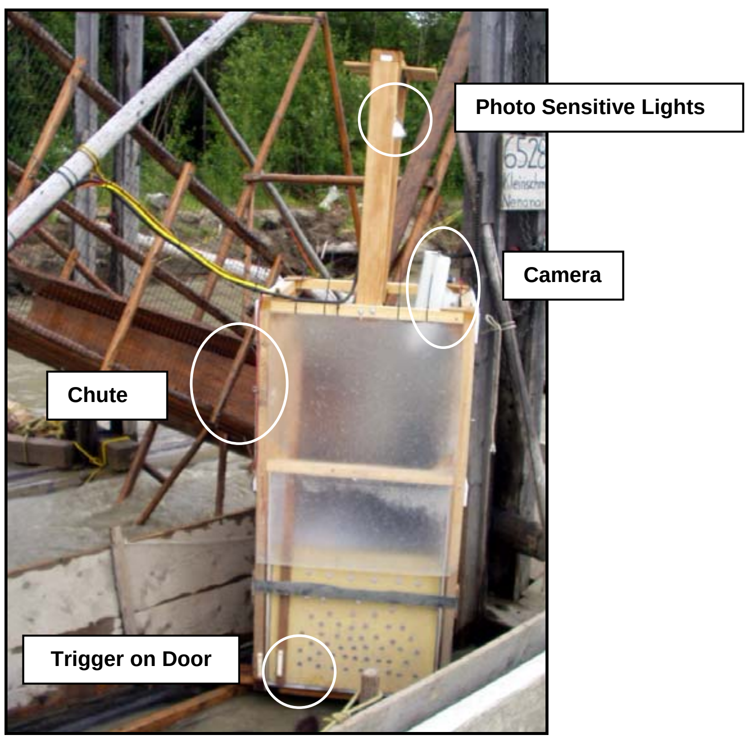
Appendix B2.–Chinook salmon on the edge of the Nenana test fish wheel live box while preparing for installation of video monitoring equipment.

Source: Photo by Bonnie Borba, ADF&G.

Appendix B3.–Laptop operating Salmonsoft FishTick capture program enclosed in several layers of weather proofing.

Source: Photo by Bonnie Borba, ADF&G.

Appendix B4.–Fish pass through an enclosure that provides containment while transferring from fish wheel basket to live box allowing for control of background, camera angle, and lighting.



Source: Photo by Dave Daum, USFWS.

Appendix B5.–Photos of Nenana test fish wheel video monitoring project, Tanana River, Yukon Area, 2003.

Frame 1.–Double catch of Chinook salmon.

Frame 2.**–**Male and female chum salmon.

Frame 3.**–**Tagged fall chum salmon showing adipose clip.

Frame 4.–Male chum salmon that went through the fish wheel 2 times.

Frame 5.**–**Male coho salmon.

Frame 6.–Coho salmon color variations.

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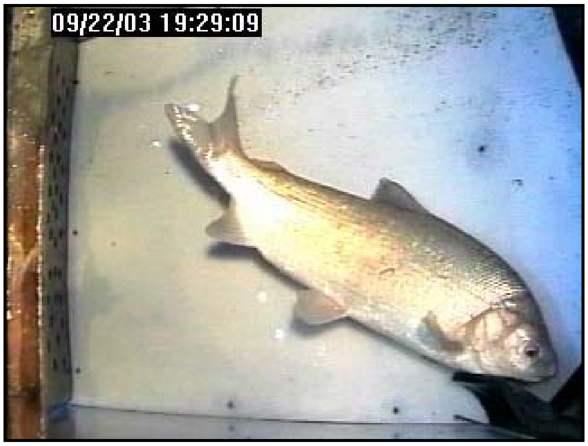
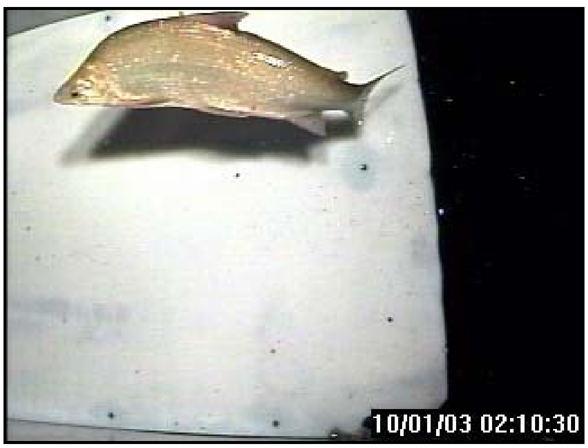
Appendix B5.–Page 2 of 2.



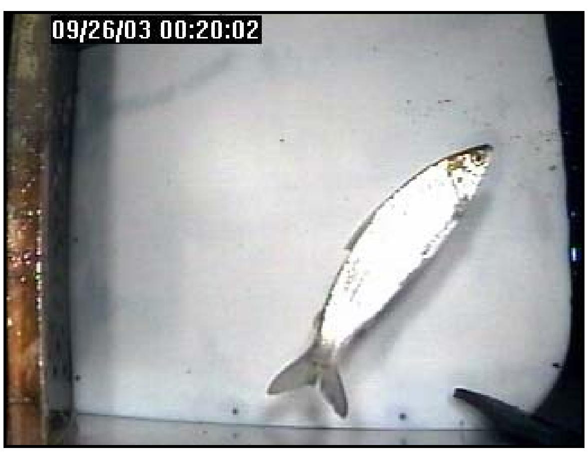
Frame 7.–Broad Whitefish.

Frame 8.–Burbot.

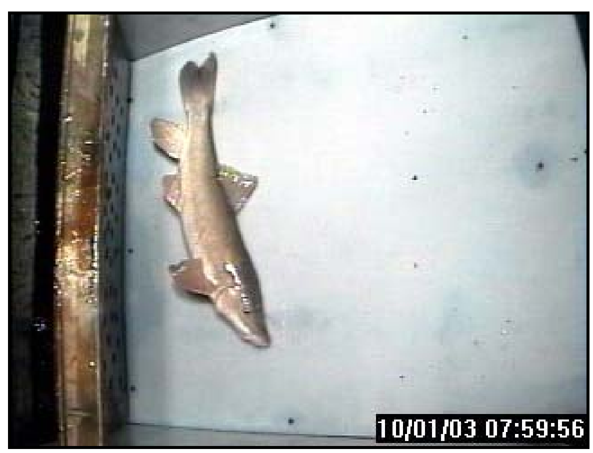


Frame 9.–Humpback Whitefish

Frame 10.–Northern Pike.



Frame 11.–Least Cisco.



Frame 12.–Longnose Sucker.