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Mark–Recapture Abundance Estimates for Yukon River Chinook Salmon in 2000–2004

by

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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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MARK–RECAPTURE ABUNDANCE ESTIMATES FOR YUKON RIVER CHINOOK SALMON IN 2000–2004

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ABSTRACT

Mark–recapture abundance estimates were developed for Yukon River Chinook salmon as part of a basin-wide telemetry study conducted in 2000–2004. Drift gillnets were used to capture the fish. Catch per unit effort (CPUE) for each drift was calculated for fish passing the tagging sites. The tagged fish were recovered at the tagging site, in upriver fisheries, and at various escapement monitoring projects within the basin. Chapman's closed population two-sample, mark–recapture estimator was used to estimate the drainagewide abundance above the tagging sites. The analysis was stratified by length to account for size selectivity of the capture method favoring larger individuals. Bootstrap analysis of the data was used in 2002–2004 to estimate variation. Estimates for large Chinook salmon were: 112,389 fish (SE=18,257) in 2000, 358,098 fish (SE=48,852) in 2001, 125,255 fish (SE=14,429) in 2002, 261,545 fish (SE=18,911) in 2003, and 229,739 fish (SE=16,682) in 2004. Comparisons with drainagewide estimates based on sonar counts at Pilot Station and other indices of abundance are discussed. While these estimates are likely biased due to the technical limitations and logistical difficulties inherent in collecting data in the basin, the information presented provides a point of reference for further research.

Key words: mark–recapture, run abundance, radio tracking, Chinook, salmon, Yukon River, drift gillnet

INTRODUCTION

The Yukon River flows for over 3,000 km originating in Canada, and covering over 855,000 km^2 of interior Alaska and Yukon Territory including many tributaries, the largest being the Koyukuk, Tanana, and Porcupine rivers. Chinook salmon *Oncorhynchus tshawytscha*, is an important species for subsistence, commercial, and sport fisheries. These fisheries are managed to maintain adequate spawning escapements, provide harvest opportunities, and provide adequate passage to the Canadian portion of the drainage. In addition to needing information on run timing, the location of important spawning areas, and stock composition of the return, determining run abundance is extremely important to fishery managers because most fish are harvested in lower reaches of the basin, downstream of important spawning areas. The interim escapement objective for rebuilt Chinook salmon returns that spawn in the Canadian section of the Yukon River is from 33,000 to 43,000 fish (2002 Yukon River Salmon Treaty between the U.S. and Canada). The targeted escapement varies by years and is set by the Yukon River Panel; the target for 2002–2004 was 28,000 fish. A harvest range of 20–26% of the total allowable catch (TAC) is allocated to Canada when the TAC is between 0 and 110,000 Chinook salmon (JTC 2002).

A variety of methods have been used to assess Chinook salmon run abundance in various tributaries since 1961, including counting weirs (Gisasa River, Kateel River, Tozitna River, Henshaw Creek, Blind Creek, and the Whitehorse fishway), test fisheries (Nenana and Dawson City), counting towers (Nulato, Chena, Salcha and Chatanika Rivers) and mark–recapture studies near the U.S.-Canada border. Although these projects estimated or assessed abundance in specific tributaries, the actual size of the entire run is unknown. Tagging studies, using external marks, were conducted on Chinook salmon between 1961–1970 to estimate migration rates, drainagewide abundance, and proportional distribution to major tributaries. However, results from studies conducted in the lower Yukon River near the mouth (1961–1967) were unreliable because of inadequate sampling in braided, lower river channels and extensive commercial harvests that substantially reduced sample sizes. Subsequent studies were moved upriver near Russian Mission (River Kilometer 298–404) to mitigate these problems, but insufficient numbers of fish were tagged resulting in limited information (Geiger 1968; Lebida 1969; Trasky 1973). A lower river test-fishery has operated near the river mouth at Emmonak since 1981, but only records since 1989 were used for drainagewide run timing (JTC 2002). Drainagewide abundance has been indexed with sonar sited at Pilot Station (River Kilometer 196) since 1986. However, newer equipment and data analysis procedures have made these counts more comparable since 1995 (Pfisterer 2002).

Because of the disastrous declines of salmon runs to Western Alaska in 1997 and 1998, the U.S. and Canada conducted cooperative research to determine migratory patterns and population status of Yukon River salmon. As part of this effort, the Alaska Department of Fish and Game (ADF&G) and National Marine Fisheries Service (NMFS) implemented a cooperative radio telemetry study to provide information on the stock composition, spawning distribution, run timing, and migratory characteristics of adult Chinook salmon in the Yukon River (Eiler et al. 2004; 2006a-b). A secondary objective was to develop drainagewide abundance estimates based on a modified mark–recapture experiment using the tagged sample from the study (Spencer et al. 2003; 2005; 2006; 2007). A major challenge for estimating the abundance of Yukon River Chinook salmon is the size and isolated nature of the drainage, and the limited number of sites with accurate counts of salmon that represent significant proportions of the return. Work in 2000–2001 emphasized the development of suitable capture methods, improved telemetry equipment for fish tracking, and the infrastructure necessary for a study of this size and scope. The approach of this study was to use regional areas with several recovery projects as combined recapture sites for calculating the proportion of tagged and untagged fish (Figure 1). These data were used to estimate the abundance of adult salmon passing upstream of Russian Mission. This report is a description of that experiment: the methods used, the results obtained, and the testing of assumptions underlying the experiment.

OBJECTIVES

1. Estimate the stock composition (proportional distribution) of the total Yukon River Chinook salmon escapement among major tributaries.
2. Estimate the stock specific run timing, migration rate, and movement patterns.
3. Estimate the abundance of Chinook salmon in major Yukon River tributaries and the entire Yukon River drainage upriver of Russian Mission with relative precision (coefficient of variation) less than 20%.

METHODS

FIRST SAMPLING EVENT: FISH CAPTURE AND MARKING

Adult Chinook salmon were captured and marked near the villages of Marshall (2000–2002), Russian Mission (2002–2004), and a field camp at Dogfish (2000–2004), 22 km upriver from Russian Mission (Figure 1). Eiler et al. (2004; 2006a) provides additional information on the study area, capture methods, telemetry equipment used, tagging procedures, data collection, and recording techniques. The tagging crews consisted of locally hired contract fishers and project personnel. Project personnel handled and marked the fish, while the contract fishers operated the boat and deployed the net. Fishing started in early June and ended in mid July. Fishing occurred daily during day (0900–1700) and evening (1800–0200); each fishing period was 7.5 hours. Drift gillnets, with 37 m length, 7.6 m depth, and color shade 3, were used. Various net configurations were used in 2000, including nets with Momoi MT-50 or MT-73 14-strand multi-monofilament fiber, hang ratios of 2:1 or 3:1, and three different mesh sizes (16.5 cm, 19.1 cm, and 21.6 cm). Based on results from the first year, gillnets used in 2001 were Momoi MT-73 14-strand multi-monofilament fiber, color shade 3, length 46 m, depth 7.6 m, 21.6 cm mesh size, with a hang ratio of 2:1. In addition, two other net configurations were evaluated in 2001, 21.6cm mesh size gillnets constructed with #21 seine twine and 10.2 cm mesh size gillnets with a hang ratio of 3:1, to compare differences in fish injury and catch rates. The type of gillnet selected for the remainder of the study (2002–2004) was 21.6 cm mesh size constructed with # 21 seine twine (length 46 m, depth 7.6 m, with a hang ratio of 2:1). This net configuration was chosen because of its effectiveness in capturing the target species with minimum injuries, and with less bycatch of other fish species.

Gillnets were fished by drifting parallel to the shore, with the net positioned perpendicular to the bank and suspended from the surface to as near the river bottom as possible. The net was retrieved as soon as a captured fish was detected. The first Chinook salmon encountered in the still immersed net was removed; the net was cut away (if needed) to facilitate quick removal and minimize injury. The captured fish was guided into a dip net constructed of soft, small mesh netting, then hoisted immediately into a holding container of fresh water on the boat. The holding container was equipped with a pump circulating fresh river water. If a second or third Chinook salmon was encountered, they too were placed in the holding tank following the same procedures. Any fish remaining in the gillnet were released. The fish were gently placed in a neoprene-lined tagging cradle submerged in the holding container, and examined by crew members wearing neoprene gloves or with bare hands. If visual inspection showed two of the fish in the holding tank free of serious injury (i.e., only fish with no, minor, or healed injuries were considered suitable), they were selected as test subjects and the third fish released unmarked. If only one fish in the tank appeared free of serious injury, it was selected as the test subject and the other two were released unmarked. If no fish appeared free of serious injury, no test subject was selected from the tank and all fish released unmarked.

Tagging procedures were similar throughout the study, although handling methods differed slightly in 2000–2001 when few radio tags were deployed (Spencer et al. 2003). The fish chosen as test subjects were tagged with a uniquely numbered 35.6 cm long external spaghetti tag (Floy Tag and Manufacturing, Inc., Seattle, WA[1]) attached below the dorsal fin (Wydoski and Emery 1983). The tag was filled with 100 lb monofilament core in 2000 and fine cable (jeweler's line) in 2001–2004. All tagged fish were also marked by removing the axillary process, which was retained for genetic analysis in 2001–2004. These fish were treated as marked individuals in 2000–2001.

Selected fish were tagged with pulse-coded radio transmitters in the 150 MHz frequency range (Advanced Telemetry Systems, Isanti, Minnesota). Most tag dimensions were 2.0 cm in diameter, 5.4 cm in length, and weighed 20 g. The tag was inserted through the mouth and into the stomach using a plastic tube (0.7 cm diameter) until the transmitter was no longer visible. These fish were treated as marked individuals in 2002–2004.

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

The marked fish were sampled to determine their age by removing 3 scales from the preferred area of the body (Welander 1940). The scales were mounted on gummed cards and impressions were made in cellulose acetate. Scale impressions were later projected using a microfiche reader with a 40x lens, and estimated ages were reported in European notation (Moore and Lingnau 2002). Fish were measured from mideye to tail fork (METF) to the nearest 5 mm, and the presence and type of injuries were recorded (none, old minor, new minor, and old major). Mortally injured fish were given to locals for subsistence use. The fish were not anesthetized during the tagging procedure, and were released immediately after processing.

Daily Abundance Estimation

Catch per unit effort (CPUE) for each drift (number of Chinook salmon caught/hour/100-fathom net) was calculated as:

$$\text{CPUE} = \frac{c \cdot 6000}{t \cdot f} \qquad (1)$$

where c is the number of Chinook salmon captured, t is fishing time in minutes (from start time (i.e., initial deployment) until the net was fully retrieved), f is net length in fathoms, and 6000 is a conventional multiplying factor (60 minutes x 100 fathom). Beginning in 2002, the "new" fishing time was calculated as minutes the net was fully deployed + minutes to deploy net/2 + minutes to retrieve net/2 to more accurately quantify fishing time, but for a comparison over the five year period, the "old" t from start time setting the net until fully retrieved was used in the analysis.

To provide an estimate of Chinook salmon passing the tagging sites, an average CPUE for day d was calculated as

$$\text{CPUE}_d = \frac{\sum_{i=1}^{L} c_i \quad 6000}{\sum_{i=1}^{b} t_i \quad f} \qquad (2)$$

Where L is the total number of drifts in day d.

Tracking Procedures

Remote tracking stations (Eiler 1995) were placed on important travel corridors on the Yukon River mainstem and major tributaries (Figure 2). Stations consisted of a computer-controlled receiver (Advanced Telemetry Systems), satellite uplink (Campbell Scientific, Logan, Utah), and self-contained power system (Figure 3). The receiver detected the presence of radio-tagged fish, and recorded the signal strength and activity pattern (active or inactive) of the transmitter, date, time, and location of the fish in relation to the station (i.e., upriver or downriver from the site). Sites selected were on important migration corridors and major tributaries of the drainage. Radio-tagged fish that passed the first set of tracking stations at Paimiut, located approximately

62 km upriver from Russian Mission, were considered to have resumed upriver movements. Fish tracked to terminal reaches of the drainage were classified as distinct spawning stocks. Radio-tagged fish were considered to have passed a tracking station when the recorded data of signal strength indicated the transition from the downriver antenna to the upriver antenna had occurred. Because tracking sites were located in isolated areas, data were transmitted by satellite uplink to a geostationary operational environmental satellite (GOES) system every hour and relayed to a receiving station near Washington D.C. (Eiler 1995). Data were accessed daily via the internet and downloaded into an automated database and GIS mapping program (Eiler and Masters 2000).

Aerial surveys were flown using helicopter and fixed-wing aircraft equipped with a computer-controlled receiver and 4-element Yagi receiving antennas mounted on both sides of the aircraft and oriented forward. Tracking receivers contained an integrated global positioning system to assist in identifying and recording locations. Surveys were conducted on the Yukon River main stem from Marshall to the upper Canadian headwaters and in other selected reaches of the drainage to locate radio-tagged fish that traveled to areas between station sites and upriver of stations on terminal tributaries. Test subjects whose transmitters were detected in villages or fish camps during aerial surveys were considered harvested, even if the fisher did not report recovery of the transmitter.

SECOND (UPSTREAM) SAMPLING EVENT: TAG RECOVERIES

Voluntary returns were important in determining the fate of "unknown" fish for distribution information and several methods were used to recover tagged Chinook salmon. Commercial and subsistence fishers were asked to report any marked fish they captured and several steps were taken to facilitate this voluntary return of the tags (i.e., both external spaghetti tags and radio transmitters). Information about the importance of returning tags was sent to organizations in villages throughout the Yukon River drainage before the field season. A letter of appreciation with information about the fish was sent to each person or agency that returned a tag. A postseason lottery served as added incentive to return tags with both regional (one $200 prize winner from each of five equal-sized regional groupings of recovered tags based on geographical separation), and drainagewide (one $500 prize winner from all people who returned tags) prizes.

Chinook salmon examined for marks as part of the second sampling event in the mark–recapture experiment included those fish observed at weirs on Henshaw Creek, and the Gisasa, Kateel, and Tozitna rivers; and caught with fish wheels located on the Tanana River near Nenana and Yukon River at Rampart Rapids and the Canadian border (Figure 1). Tags were recovered opportunistically from the tagging sites at Marshall and Russian Mission, and during carcass surveys on the Anvik, Chatanika, Chena, Salcha, and Tozitna rivers. Test fisheries at Dawson, Takhini River broodstock sampling and the fishway at Whitehorse also examined fish and recovered tags. Visual counts were conducted from counting towers located on the Chena and Salcha rivers. Subsets of fish from carcass surveys were examined on the Chena and Salcha rivers and ASL data collected. Fish were recorded by remote tracking stations located throughout the drainage, but only data from stations on the Gisasa, Chena, and Salcha rivers, and the Yukon mainstem at the Canadian border were used in the analysis (Figure 2).

DATA ANALYSIS

Mark–Recapture Population Estimation

Chapman's closed population two-sample, mark–recapture estimator (Seber 1982) was employed to estimate the drainagewide population abundance above the tagging sites.

$$\hat{N} = \frac{(\hat{C}+1)(M+1)}{R+1} - 1 \tag{3}$$

where:

- $\hat{N}$ = estimated abundance passing upstream of Russian Mission,
- M = the number marked that successfully went upstream of Russian Mission,
- $\hat{C}$ = estimated number of large fish (generally over 650 mm) inspected during the second event; and
- R = the number of marked fish recaptured among fish inspected upstream at the recovery sites.

Year 2000 and 2001

Variance was estimated as:

$$\hat{V}[\hat{N}] \cong \frac{(M+1)(\hat{C}+1)(M-R)(\hat{C}-R)}{(R+1)^2(R+2)} \tag{4}$$

Year 2002

Variance and statistical bias in $\hat{N}$ were estimated with a parametric bootstrap simulation (as from Efron and Tibshirani 1993). In this study, the simulation was conducted in 4 stages: 1) simulation of the number of marked fish; 2) simulation of numbered recaptured fish; 3) simulation of the number of large fish examined at the recapture sites; and 4) simulation of the abundance of large fish in the Yukon River.

Simulation of the Number of Marked Fish

The number of marked large fish (M') in the simulation was treated as a variate for 2002 because not enough sampling effort was expended to implant all of the 1,000 transmitters available. M' was assumed to have a binomial distribution with $M' \sim B(\hat{N}, \hat{\pi})$ where $\hat{\pi} = M'/\hat{N}$. This was approximated with normal distribution $M' \sim N(M', \sigma)$ where $\sigma^2 = \hat{N}\hat{\pi}(1-\hat{\pi})$.

Simulation of the Number of Recaptured Fish

The marked fish were then assigned to 8 mutually exclusive fates (Table 1) with multinomial distribution $X_i \sim \text{multi}(\pi_i, M')$: 1) disappeared ($\pi_1$); 2) moved upstream to Tanana but not to Chena or Salcha (π_2); 3) moved upstream to remain in a U.S. tributary, but not in the Tanana River (π_3); 4) moved upstream to Canada, but not inspected (π_4), 5) moved upstream through weir on the Gisasa River (R_1) (π_5); 6) moved upstream past towers on the Salcha River (R_2) (π_6); 7) moved upstream over a dam on the Chena River (R_3) (π_8); and 8) were caught in a Canadian subsistence fishery (R_4) (π_9). Probability of each fate was estimated as $\hat{\pi}_i = X_i / M'$ where X_i is the number of large fish in each fate. The simulated number of recaptured fish at 4 streams (R_1^*, R_2^*, R_3^*, and R_4^*) was calculated as $R_i^* = \pi_{i+4}^* \cdot M'^*$. The simulated number of large fish marked and successfully went upstream (M^*) and was calculated as $M^* = M'^* (1 - \pi_1^*)$.

Simulation of the Number of Large Fish Examined at the Recapture Sites

For the third stage of the bootstrap simulation, numbers of fish counted through weirs, past counting towers, and harvested in the Canadian subsistence fishery were fixed to values observed in the experiment. Passage through the weir on the Gisasa River and harvest in the subsistence fishery were each a census. Migrations past the counting tower and over the dam were estimated (JTC 2007), however, they were estimated with little measurement error (CV<5%). The number of large fish inspected at the recapture sites was assumed to come from a binomial distribution $\hat{C}_i \sim \mathrm{B}(C_t, \hat{\pi}_i)$ where C_t is the total number of examined fish, $\hat{\pi}_i$ is an estimated fraction comprised of large salmon ($\hat{\pi}_i = n_{li} / n_i$ where n_{li} is the number of large fish and n_i is a sample size taken of fish at location i,. Simulated estimates $\hat{C}_i^*$ for numbers of large fish "examined" at each upstream location were calculated as $\hat{C}_i^* = C_t \hat{\pi}_i^*$.

Simulation of Abundance of Large Fish in the Yukon River

Given the results from all three stages of simulation, a new estimate of abundance was then calculated for each of the thousand bootstrap samples:

$$N_{(b)}^* = \frac{(M_{(b)}^* + 1)(\hat{C}_{(b)}^* + 1)}{R_{(b)}^*} - 1 \quad (5)$$

where:

$\hat{C}_{(b)}^* = \Sigma \hat{C}_{i(b)}^*$,

$R_{(b)}^* = \Sigma R_{i(b)}^*$, and

b = denotes the simulation.

Estimates for all fish and small fish were calculated for each bootstrap sample in the same fashion with substitution of simulated values into the original equations.

Regardless of whether the estimate is for large, small, or all fish, for fish reaching the Tanana River or into Canada, the estimated variance and estimated relative statistical bias were approximated as:

$$v(\hat{N}) = \frac{\sum_{(b)} (N^*_{(b)} - \overline{N}^*)^2}{B-1} \tag{6}$$

$$\text{Relative Statistical Bias} = \frac{\hat{N} - \overline{N}^*}{\overline{N}^*} \times 100 \tag{7}$$

where:

B = 1,000 and

$\overline{N}^* = (\Sigma N^*_{(b)}) \big/ B$.

Beginning in 2002, passage into the Tanana River and passage into Canada were estimated separately with two methods based on marked fish. If capture at Russian Mission had been proportional to passage at that point, the fraction of test subjects moving upriver into the Tanana River (or into Canada) is the estimated fraction of that passage that reached the Tanana River (or Canada). Given the fates listed in Table 1, estimated abundance of fish moving up the Tanana River ($\hat{N}_{Tan}$) or into Canada ($\hat{N}_{Can}$) were calculated as

$$\hat{N}_{Tan} = \frac{X_2 + X_6 + X_7}{M' - X_1} \hat{N}$$

$$\hat{N}_{Can} = \frac{X_4 + X_8}{M' - X_1} \hat{N} \tag{8}$$

as per Chapman' modification in this "proportional" experiment.

The second method is based on two-event mark–recapture experiments where marked fish from the first event are only those test subjects known to have entered the Tanana River (or Canada) based on remote tracking station (RTS) data and fish inspected during the second event are only taken in samples in the combined Salcha and Chena rivers (or from the Canadian subsistence fishery). Again using fates listed in Table 1:

$$\hat{N}_{Tan} = \frac{(X_2 + X_6 + X_7 + 1)(C_{Sal} + C_{Che} + 1)}{X_6 + X_7 + 1} - 1 \qquad \hat{N}_{Can} = \frac{(X_4 + X_8 + 1)(C_{Can} + 1)}{X_8 + 1} - 1 \tag{9}$$

for this "local" experiment.

Variances and statistical biases in these competing estimates were calculated as part of parametric bootstrap simulations.

Year 2003

The analysis was similar to 2002 except the simulation was conducted in 3 stages: 1) simulation of numbered recaptured fish; 2) simulation of the number of large fish examined at the recapture sites; and 3) simulation of the abundance of large fish in the Yukon River.

Year 2004

The analysis was similar to 2003 except the censoring of few small fish was necessary in 2004 because few small fish were marked, examined, or recaptured so $\hat{C} = C$ in the Chapman estimate.

Tests of Mark–Recapture Assumptions

The Chapman closed population estimator will produce consistent (asymptotically unbiased) estimates of abundance if the following conditions have been met:

a) Recruitment or immigration and emigration or death of unmarked fish does not occur between sampling events;
b) Marking does not affect the fate (mortality, probability of recapture) of a fish;
c) Marked fish do not lose their marks and all marks are recognized, and
d) All fish have an equal probability of capture downstream (first sampling event); or all fish have an equal probability of capture upstream (second sampling event); or marked fish mix completely with unmarked fish between sampling events.

Condition (a) was met; because every fish above Dogfish in the Yukon drainage must have passed Dogfish and tracking information indicated that few fish migrated down river and these were not used in the analysis. Almost all test subjects in 2002–2004 were successfully tracked upstream and exhibited swimming rates suggestive of normal movements (Eiler et al. 2004; 2006a-b), which indicates that condition (b) was met as well. As per condition (c), all transmitters not located moving upstream were censored from the experiment. Because condition (d) relates to space and time, attempts to standardize fishing effort at the tagging sites were designed to catch fish with equal probability throughout the season. Because the typical migratory timing of Chinook salmon populations past a point in large watersheds has upper basin spawners passing earlier and lower basin spawners passing later (Bendock and Alexandersdottir 1993; Burger et al. 1985; Pahlke and Bernard 1996) marked fractions of inspected fish should be similar across sites in the second sampling event if condition (d) has been met. Although lower river fish tended to be more prevalent later in the Yukon River run, upper basin fish were present throughout (Eiler et al. 2004; 2006a), which would lessen the departure from this assumption. Because assumption (d) also relates to size of salmon, lengths of captured and recaptured fish were compared to that of marked fish at the tagging sites.

RESULTS

FIRST SAMPLING EVENT: FISH CAPTURE AND MARKING

Gillnets were fished approximately 200 hours to capture 760 Chinook salmon in 2000, 294 hours to capture 2,313 Chinook salmon in 2001, 506 hours to capture 1,310 Chinook salmon in 2002, 584 hours to capture 2,312 Chinook salmon in 2003, and 690 hours to capture 2,107 Chinook salmon in 2004 (Table 2, Figure 4). Fishing times were calculated using the "old" method so that comparisons could be made for all five years. Fish were marked throughout the run (Figure 5), with higher catches occurring in mid June for 2003–2004 and late June for 2000–2001. Of the 8,802 Chinook salmon captured during the study, 2,988 fish were released unmarked and 152 (1.7%) fish were severely injured or died during capture. A total of 3,068 fish were tagged with radio transmitters and 2,485 fish were marked only with spaghetti tags (Table 2).

CPUE data used for the five years are presented in Figure 5. CPUE was higher in 2000 and 2001 and like catch data, the higher CPUE occurred later in June than in years, 2003–2004. Although there were a few instances in 2001 when drift-fishing times were not available (thus raising CPUE), they did not coincide with the highest CPUE days.

Most fish captured during the study were age-6 (Table 3). Mean lengths of marked fish (n=5,507) were 821 mm (METF) ranging from 395 to 1,075 mm (SD 88) (Table 4).

SECOND (UPSTREAM) SAMPLING EVENT: TAG RECOVERIES

Marked fishes were recaptured 1) at the Marshall, Russian Mission, and Dogfish tagging sites, 2) in upriver escapement monitoring projects, and 3) in U.S. and Canadian fisheries. Relatively few fish were recaptured near the tagging site (Table 5). Tagged individuals were counted or recovered in escapement-monitoring projects including 41 fish in 2000, 102 fish in 2001, 132 fish in 2002, 188 fish in 2003, and 177 fish in 2004. The escapement monitoring projects used to calculate the mark–recapture estimates varied each year due to insufficient recovery numbers, directed tag recovery efforts not associated with numbers of fish, or incomplete information (Table 5).

A significant portion of all marked fish was captured by subsistence fishers, with 123 (18.2%) fish in 2000, 217 (10.8%) fish in 2001, 270 (34.9%) fish in 2002, 271 (24.7%) fish in 2003, and 332 (33.4%) fish in 2004. The Canadian subsistence numbers include the catch from all the Yukon mainstem and tributaries subsistence and test fisheries, excluding the Porcupine River fish. The largest percentage of tags came from Holy Cross and the Rapids/Rampart/Bridge area in the U.S. and from Dawson City in Canada (Table 6).

In 2000 and 2001, few radio transmitters were deployed, so the progress of spaghetti tagged fish could not be verified with tracking stations. Because of this, all tagged fish were considered to have resumed upriver migration, except for 6 fish recaptured and retained at the tagging site in 2000. Therefore, of the fish marked and released, 669 of 675 (99.1%) were considered to have resumed upriver migration in 2000 and 2,010 of 2,010 (100%) in 2001. In 2002, "disproportional" sampling in the marking procedure was introduced by adding and moving tagging crews and to account for this bias, fish tagged by these crews were removed from the analysis, resulting in only 465 of 768 (60.5%) considered to have resumed upriver migration. In 2003, 1,081 of 1,097 (98.5%) and in 2004, 958 of 995 (96.3%) were considered to have resumed upriver migration. Of the 669 fish migrating upriver in 2000, 22 fish (<630 METF) were censured for length, leaving 647 marked fish. Similarly, 43 fish (<640 METF) were censured for 1,967 marked fish in 2001, 46 (<650 METF) censured for 419 fish in 2002, 15 (<650 METF) censured for 1,066 fish in 2003, and 1 (<520 METF) censured for 957 fish in 2004 (Table 7). Tracking stations and recovery projects on spawning tributaries, and aerial surveys were used to determine the final locations for radio-tagged fish during 2002–2004. However, the fate of some fish was not determined. Possible causes include tag malfunction, unreported fishery harvest, and movements to tributaries where aerial surveys were not conducted or recovery projects were not operating. A portion of these fish may have died while in transit to spawning areas further upriver, which could bias estimates.

DATA ANALYSIS

Mark–Recapture Population Estimation

Year 2000

Fishing coincided with the start of the run with no fish caught at the start of fishing. Crews fished between 7 June and 13 July (Appendix A1). The number of Chinook salmon caught closely matched the daily Chinook CPUE except in early July (Figure 5). The use of differing net types complicated CPUE comparisons. Among the six net types used in 2000, those with 16.5 cm and 19.1 cm mesh size nets were dropped because of an unacceptably high bycatch of chum salmon. The 21.6 cm mesh size nets with 2:1 hanging ratio had the highest Chinook to chum salmon catch ratio (Table 8), though no statistical difference was found (ANOVA: $P > 0.05$).

Year 2001

Fishing coincided with the start of the run with no fish caught at the start of fishing. Crews fished between 7 June and 20 July (Appendix A2), and the number of Chinook salmon caught again closely matched the daily Chinook CPUE (Figure 5). Of the three nets used in 2001, the 10.2 cm net was dropped because of an unacceptably high bycatch of chum salmon. Chinook salmon CPUE was higher for multi-monofilament nets (ANOVA: $P<0.05$); however, Chinook salmon to chum salmon ratio was higher for twine nets (Table 9), though no statistical difference (ANOVA: $P > 0.05$) was determined. Injury rate differed significantly between multi-monofilament and twine nets. Rate of new injuries was significantly higher with the twine net (0.53) than that in the multi-monofilament (0.45) (Chi-square 7.2, df=1, $P < 0.007$) (Table 10). However, to minimize handling stress, it is necessary to capture Chinook salmon efficiently and selectively, and reduce handling time. Because seine twine nets were more selective in catching Chinook salmon and easier to use in terms of removing fish than the multi-monofilament nets, we determined that seine twine nets were more suitable for catching Chinook salmon for tagging even with the lower capture rate and higher rate of new, minor injuries.

Year 2002

Fishing took place between 9 June and 13 July, with two crews at Marshall and one at Dogfish (Appendix A3). When tagging began at Marshall, fish were already present and had been passing the site for a week, suggesting that our abundance estimates underestimate the return, especially the upper basin component based on distribution information for the run (Eiler et al. 2004). While the number of Chinook salmon caught closely matched the daily Chinook CPUE, CPUE was significantly less than the previous two years (Figure 5). Also, due to the small number of fish captured and marked at Marshall (even though fishing effort concentrated on the most productive areas), a fourth crew was added at Dogfish from June 20 through July 13. In addition, the second tagging crew at Marshall was moved to Russian Mission from July 5–13. While these changes did enhance our ability to capture fish, the increased effort and the higher probability of catching fish later in the run complicated our mark–recapture calculations. In Figure 6, the timing of marked fish going to recovery projects indicate the probability of catching the different stocks not in proportion to the run could occur. Because of this, we removed the effort of the third and fourth tagging crews. The estimate removed that sampling error from the marking procedure and produced similar marked fractions of inspected fish across recovery sites. Tagging effort was standardized in 2003 and 2004 to address these issues.

Year 2003

Fishing took place between 3 June and 13 July with two crews at Dogfish and two at Russian Mission (Appendix A4). When tagging began at Dogfish and Russian Mission, fish were already present. Similar to 2002, the number of Chinook salmon caught closely matched the daily Chinook CPUE and the CPUE was much lower than 2000–2001 (Figures 4 and 5). Since effort was increased significantly in 2002 to augment the number of fish caught suitable for tagging, it is reflected in a lower CPUE. Similar to 2002, the timing of marked fish going to recovery projects indicate the probability of catching the different stocks not in proportion to the run could occur (Eiler et al. 2004; 2006a-b) (Figure 6). However, since we sampled fish on a consistent basis, that sampling bias was avoided.

Year 2004

In 2004, fishing occurred between 3 June and 19 July with two crews at Dogfish and two at Russian Mission (Appendix A5). Fishing coincided with the start of the run with no fish caught at the start of fishing at Dogfish. Similar to 2002 and 2003, the number of Chinook salmon caught closely matched the daily Chinook CPUE, but CPUE was much lower than in 2000–2001 (Figures 4 and 5), and again the timing of marked fish going to recovery projects was similar (Figure 6).

Tests of Mark–Recapture Assumptions

The length frequency of our tagged sample was not representative of the run due to the selectivity of the gillnets for larger fish. Recaptured fish at recovery projects had essentially the same size distribution as marked fish (Figure 7); however, untagged fish examined upstream were decidedly smaller than those captured downstream for most years. Considering that few small fish were recaptured for the five years, the mark–recapture experiment was used to directly estimate only larger fish. Comparison of captured fish upstream across sampling locations showed these size distributions for fish of all sizes.

Comparison of marked fractions across lower river (upstream of the tagging site), mid-river, and upper river pooled sampling locations indicated that all large fish regardless of their spawning location had an equal chance of being marked at the tagging sites (Table 11). Fractions ranged from an estimated 0.25% at upper river pooled in 2002 to an estimated 1.06% at mid-river pooled in 2000 but the range was not statistically significant in each year (χ^2=1.30, df=3, P=0.552: 2000; χ^2=1.16, df=3, P=0.561: 2001; χ^2=4.76, df=3, P=0.19: 2002; χ^2=3.25, df=3, P=0.35: 2003; χ^2=3.70, df=3, P=0.295: 2004). Fractions of drainagewide pooled samples ranged from 0.33% in 2002 to 0.56% in 2000.

Abundance Estimates

Abundance estimates were calculated for large Chinook salmon passing upstream of Dogfish in 2000–2004. Estimates in 2000 and 2001, when fish were marked primarily with spaghetti tags, were 112,389 fish (SE=18,439) and 358,098 fish (SE=48,877), respectively. In 2002, the estimated abundance was 125,255 fish (SE=14,429) with a statistical bias estimated by bootstrapping of 1.9%. The estimated abundance in 2003 was 261,545 fish (SE=18,911) with a bias of 6.6%. The estimated abundance in 2004 was 229,739 fish (SE=16,682) with a bias of 0.9% (Table 11).

Regional estimates were also calculated for large Chinook salmon in 2002–2004 when fish were marked primarily with radio tags. In 2002, the abundance of Tanana River fish was estimated as 18,235 fish (SE=1,846) for proportional distribution and 14,932 fish (SE=1,312) for the local experiment method, with a statistical bias of 1.1% and 0.9%, respectfully. Estimated abundance of fish passing into the Canadian portion of the Yukon River was 38,264 fish (SE=5,212) for proportional distribution and 51,428 fish (SE=10,880) for the local experiment method, with a bias of 1.4% and 4.9%, respectfully. The estimated abundance of Tanana River fish in 2003 was 45,247 fish (SE=3,061) for the proportional distribution and 48,382 fish (SE=3,268) for local experiment method with a bias of 6.5% and 8.6%, respectively. Estimated abundance of Yukon River fish in Canada was 100,956 fish (SE=8,292) for proportional distribution and 90,037 fish (SE=13,458) for the local experiment method with a bias of 6.6% and 1.7%, respectively. The estimated abundance of Tanana River in 2004 was 46,812 fish (SE=3,254) for the proportional distribution and 50,803 fish (SE=3,602) for local experiment method with a bias of 0.4% and 0.7%, respectfully. Estimated abundance of Yukon River fish in Canada was 68,178 fish (SE=5,872) for proportional distribution and 59,415 fish (SE=7,987) for the local experiment method with a bias of 0.9% and 1.7%, respectfully (Table 12). An abundance estimate for the lower river grouping (i.e. Koyukuk River) was not calculated because of the small number of tags recorded there and incomplete escapement estimates.

An abundance estimate for small Chinook salmon above Dogfish (< 630mm METF) based on frequency distribution of age class was 3,787 (SE=621) obtained from the inspected fish at the recovery projects in 2000. Similarly, the abundance estimate for small salmon (< 640mm METF) was 7,831 fish (SE=1,069) in 2001, 77,423 (SE=8,516) small fish (< 650mm METF) in 2002, and 48,342 (SE=3,727) small fish (< 650 METF) in 2003. The method for classifying small fish used compared length with age class to censure out 2 ocean fish. This resulted in different length criteria for small fish between years. That method could not be done in 2004 when very few small fish were marked, examined, or recaptured upstream and there was no clear division between age classes.

Abundance estimates were developed for the entire basin using information on Andreafsky River escapement, the only major Chinook salmon tributary below the tagging sites, (T. Lingnau, ADF&G, Anchorage, personal communication) and information on Chinook salmon harvests downriver from Dogfish (JTC 2007). The estimate for 2000 was 144,173 fish, developed by including 16,964 fish caught in lower river subsistence fisheries (including Russian Mission), 9,125 fish in commercial fisheries (including test fish and Marshall), and 1,908 fish escapement in the Andreafsky River (Borba and Hamner 2001). This results in a harvest rate of 34.8%. A drainagewide estimate for 2001 was 392,000 fish by including 23,959 fish for subsistence (including Russian Mission) and 2,112 fish escapement for the Andreafsky River (Brase and Hamner 2002). There was no commercial fishing in 2001, resulting in a harvest rate of 16.3%. The drainagewide estimate for 2002 was developed by including 10,173 fish for subsistence, 22,593 fish for commercial fishing (including Marshall), and 7,999 fish escapement for the Andreafsky River (Brase and Hamner 2003). This resulted in a drainagewide estimate of 243,443 fish and a harvest rate of 31.8%. A drainagewide estimate for 2003 was 372,697 fish by including 18,057 fish for subsistence (including Russian Mission), 36,928 fish for commercial fishing, and 7,825 fish escapement for the Andreafsky River (Busher and Hamazaki 2005). This resulted in a harvest rate of 29.1%. A drainagewide estimate for 2004 was 311,377 fish by including 17,542 fish for subsistence (including Russian Mission), 52,565 fish for commercial fishing, and 11,531 fish escapement for the Andreafsky River (Busher and Hamazaki 2005). This resulted in a harvest rate of 39.7% (Table 13, Figure 8).

DISCUSSION

Management of Yukon River Chinook salmon is difficult because of the vast size and isolated nature of the basin, the mixed stock composition of the run, the widespread distribution of the spawning stocks and the relatively compressed timing of the run. This task is further complicated by the international nature of the basin, with scattered fisheries located in both the U.S. and Canada. These fisheries are managed to maintain adequate spawning escapements, allow for passage into the Canadian portion of the drainage, and provide for subsistence (a priority in both countries) and commercial harvests when abundance levels are adequate. Reliable abundance estimates are needed to implement these management objectives and meet international treaty obligations between the two countries. However, in season run assessment is hampered by these factors, as well as the relatively small size of the Chinook salmon run, even in year with strong returns, compared to the large concurrent run of summer chum salmon (*O. keta*) in the lower river which averaged 1,590,124 during 1995–2006 (JTC 2007).

Numerous attempts have been made to obtain accurate basin-wide abundance estimates using a variety of assessment techniques, including sonar counts combined with apportionment sampling and test fishing in the lower river. Assessment projects on principal spawning tributaries attempt to quantify principal components of the return in order to provide insight on the entire run. However, there is generally little confidence in the abundance estimates obtained, due to the technical limitations and logistical difficulties inherent in collecting the data.

Although the basin-wide telemetry study was designed to provide other types of information, the data collected were used to develop mark–recapture abundance estimate of the Chinook salmon return. Work in 2000 primarily dealt with designing suitable capture methods and developing improved telemetry equipment, while 2001 saw the completion of the infrastructure necessary for such a large scale telemetry project. Consequently, the mark–recapture experiment relied on a relatively small number of spaghetti tagged fish, particularly during 2000. To increase the number of marked fish in 2001, all fish (except the most seriously injured) were marked with a spaghetti tag. This change in tagging procedure (i.e., tagging fish in potentially marginal condition) likely biased the abundance estimate high in 2001 due to the likelihood that a disproportionate number of fish may have failed to complete their upriver migration compared to the untagged fish.

Abundance estimates for 2002–2004 were based on the sample of radio tagged fish which resulted in smaller sample sizes, but enhanced our ability to monitor fish status and assess whether the mark–recapture assumptions were met. The primary problem encountered was the lack of recovery projects where adequate numbers of fish representing large proportions of the return could be accurately enumerated, limiting the confidence in the abundance estimates obtained. Ironically, sonar counts on the Yukon River near the U.S.-Canada border were initiated in 2005. The data obtained from this project provides improved estimates on Chinook salmon passage due to good site characteristics for enumeration and the absence of summer chum that confound sonar counts, and would have provided a better basis (i.e., recovery sample) for our abundance estimates.

Size-selective sampling with nets, fish wheels, carcass surveys, weirs, and fishways further complicate mark–recapture calculations. Beginning in 2002, all marked fish were captured with a 21.6 cm mesh gillnet, which likely selected for larger fish, whereas fish examined upstream were captured by various means including fish wheels, carcass surveys, and weirs at recovery sites.

Fish wheels reportedly select for smaller fish (Meehan 1961). Carcass surveys select for larger fish due to the disparity of size and post spawning habits between the sexes (Hubartt and Kissner 1987), while carcass surveys are only a subset of counts. Weirs and fishways presumably do not exhibit size selectivity and likely provide the best indicator of size differences between marked and unmarked samples. However, only a limited number of these types of projects operate in the Yukon River basin with a minimal number of fish enumerated and often with incomplete counts. Also, if different stocks exhibit different relative age or size compositions, the stock passing through the weir represents a biased sample compared to the entire return. Although our tagged samples are likely biased toward large fish, since we did not select marked fish by size, the marked fish are representative of the fish captured at the capture site. The similarity of the marked fractions of tagged fish across the different recovery locations also suggests that our sampling was representative, thus avoiding bias in our estimates of abundance when considering the large-fish component of the run.

Information from radio telemetry work in 2002–2004 (Eiler et. al 2004; 2006a-b) showed that Tanana River and Canadian stocks (excluding Porcupine River fish) comprised approximately 72%, 70%, and 71% of the return respectfully, while our estimates for this collection were 43-56%, 52–57%, and 46–52% respectfully. A similar trend was observed when considering the Tanana and Canadian component separately. While considerably lower, the proportions based on our abundance estimates do not include the effect of fishing on these stocks as they progress upriver. Since stocks traveling farther upriver are exposed to more fishing pressure, it is not surprising that the removal of more upriver tagged fish would affect these percentages. Tanana River and Canadian stock groups exhibited similar run timing patterns between years, with most fish passing through the lower river during the early and middle portion of the run, when fishing pressure was heaviest, and then declining during the latter portion of the run, while lower basin stocks were comprised primarily of late run fish (Eiler et. al 2004; 2006a-b). Although the Tanana River and Canadian stock component of our tagged fish sample was present throughout the run and comprised the largest component, the combination of fishing patterns and our tagging schedule could have affected the abundance estimates.

Chinook salmon passage from the sonar site at Pilot Station (located about 169 km downriver from Dogfish) were consistently less than the mark–recapture estimates from our study. The extent varied by year, with the sonar counts about 35% of mark–recapture estimates for large fish in 2000, 24% in 2001, 74% in 2002, and 94% in 2003 (Figure 9). In 2004, the estimate was about 68%, but the mark–recapture estimate included almost all fish (<520 METF) and the Pilot Station estimate was for all fish. Interestingly, with the exception of 2001, the general abundance trends were similar between the two methods, although relatively greater differences were observed during 2000 and 2004. Our substantially higher estimate in 2001 was likely a result of tagging almost all fish captured instead of tagging a small subsample (i.e. 1–2 of the fish caught) as was done the other four years. The additional time required to process all of the fish likely increased the stress and potential for injury for the individuals tagged last. A number of factors may explain the inconsistencies between the passage point estimate developed from Pilot station sonar and our mark–recapture study. The Pilot Station project is thought to underestimate abundance of Chinook salmon (Pfisterer 2002). Currently its primarily function is to assess chum salmon abundance, and is only used as an index for Chinook salmon returns (T. Lingnau, ADF&G, Anchorage, personal communication). Sonar counts of the bank orientated and shallower swimming chum salmon are likely more accurate than for Chinook salmon that are swimming deeper and farther off shore. Historically, Chinook salmon have comprised only a small percentage of the total salmon run in the Yukon River. For example, Pilot Station estimates were 92,584 for large Chinook salmon and 1,088,463 for summer chum salmon in 2002, and both species exhibit the same general run timing (JTC 2007). Thus, run enumeration and species apportionment using sonar are difficult due to the overlap in timing and size of the two species, the disparity in magnitude of chum vs. Chinook salmon run, gear selectivity to determine species composition, and the behavioral differences (bank orientation and swimming depth).

Run timing patterns developed from sonar counts at Pilot Station show pulses of fish observed in 2000–2004 (Figure 10). Some of those pulses correlated with our CPUE estimates from Russian Mission and certain trends can be discerned. In 2000 and 2001, CPUE and Pilot Station estimates showed a similar trend although Russian Mission showed a late pulse not seen at Pilot Station. A radically different pattern occurred in 2002, with early pulses at Russian Mission trending down later in run while Pilot Station shows several large pulses midway and late in the run. Trends were similar in 2003 but with a greater difference in magnitude, especially later in the run. In 2004, Pilot Station missed an early pulse indicated by Russian Mission and again a greater difference in magnitude later in the run. There is also a question from Pilot Station numbers that such a large proportion of the Chinook salmon run occurred in late June and July in 2002–2004, a pattern not reflected in lower river fisheries, or at upriver escapement projects when evaluated with respect to the movement rates exhibited by migrating Chinook salmon. CPUE values at the tagging sites were higher in 2000 and much higher in 2001 compared to Pilot Station estimates. This situation reversed in 2002–2004, when increased abundance was not reflected in our CPUE (Figure 10). While the use of monofilament nets (and various mesh sizes) the first two years and no commercial fishing in 2001 may have enhanced our catch and CPUE, in 2002 we stopped fishing unproductive areas with low catch rates and added crews to increase the catch to obtain adequate numbers of fish suitable for tagging.

In the absence of reliable abundance estimates, test fisheries have been used by Yukon River managers as an index of abundance for Chinook salmon and other fish species. This information is used to monitor run timing, travel time between fisheries, and to compare run strengths from year to year (JTC 2005). A key consideration with this approach is the selection of the index site. The basic assumption is that the movement of fish past the site is comparable to that of the return. However, the geomorphology of some area, in combination with changing river conditions such as water levels and flow, can impact fish movements and result in variable catch rates that may not reflect the pattern exhibited by the run and provide misleading information. We found this to be a problem at Marshall, where both the catch and CPUE estimates dropped dramatically in 2002 despite increases in Chinook abundance from the previous two years. In addition, the seasonal CPUE pattern did not reflect the overall run pattern, with substantial declines in the later stages of the run even though substantial numbers of fish were still moving through the lower river. While water level and debris conditions in 2002 were different from the two previous years and might partially explain some of the problems experienced, the dramatic change in fishing success at Marshall in 2002 (Figure 11) was not observed at Dogfish (Figure 12) where overall catch rates, CPUE, and seasonal patterns seemed more in line with other indicators of the run. Ultimately, this phenomenon resulted in our abandoning Marshall as a tagging site in 2003, and focusing capture efforts at Russian Mission and Dogfish. These observations illustrate the importance of site selection when establishing test fisheries and other indexes of abundance.

The behavior and movements of Yukon River Chinook salmon are not well understood and could influence abundance estimates. However using radio telemetry does offer some advantages in that we were better able to assess the fates of the marked population. While basin-wide abundance information is critical to effectively manage Chinook salmon fisheries, obtaining reliable data is extremely difficult due to the remote and logistically challenging nature of the basin and the complex characteristics of the runs. A variety of assessment studies, including Pilot Station sonar in the lower Yukon River and a number of projects in terminal reaches, attempt to provide both basin-wide and regional estimates of abundance; however the accuracy of these estimates is uncertain. The estimates developed during our study provide a useful comparison with other information from the basin that will help evaluate existing abundance estimates and potentially assist in developing better methods for obtaining reliable data.

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TABLES AND FIGURES

Table 1.–The 8 mutually exclusive fates assigned to Chinook salmon radio-tagged in the Yukon River in 2002–2004.

	Fate	Number In 2002
1	Disappeared (M' - M)	15
2	Moved upstream to Tanana, but not to Salcha or Chena rivers	18
3	Moved upstream to remain in U.S tributary, but not in Tanana River	227
4	Moved upstream to Canada, but not inspected	105
5	Moved upstream through weir on the Gisasa River (R_1)	3
6	Moved upstream past towers on the Salcha River (R_2)	26
7	Moved upstream over dam on the Chena River (R_3)	17
8	Were caught in Canadian subsistence fishery (R_4)	23

	Fate	Number In 2003
1	Disappeared (M' - M)	16
2	Moved upstream to Tanana, but not to Salcha or Chena rivers	91
3	Moved upstream to remain in U.S tributary, but not in Tanana River	461
4	Moved upstream to Canada, but not inspected	368
5	Moved upstream through weir on the Gisasa River (R_1)	8
6	Moved upstream past towers on the Salcha River (R_2)	56
7	Moved upstream over dam on the Chena River (R_3)	38
8	Were caught in Canadian subsistence fishery (R_4)	44

	Fate	Number In 2004
1	Disappeared (M' - M)	37
2	Moved upstream to Tanana, but not to Salcha or Chena rivers	97
3	Moved upstream to remain in U.S tributary, but not in Tanana River	470
4	Moved upstream to Canada, but not inspected	231
5	Moved upstream through weir on the Gisasa River (R_1)	8
6	Moved upstream past towers on the Salcha River (R_2)	68
7	Moved upstream over dam on the Chena River (R_3)	30
8	Were caught in Canadian subsistence fishery (R_4)	53

Table 2.–Hours fished and number of Chinook salmon captured, marked, fitted with a transmitter, died, released untagged and recaptured in drift gillnets, 2000–2004.

Year	Hours [a]	Captured [a]	Released untagged	Mortalities	Radio Tagged	Spaghetti Tag Only	Recaptured at Tagging Sites
2000	200.1	760	39	34	91 [b]	584	12
2001	294.2	2,313	222	38	117 [b]	1,894	42
2002	505.7	1,310	499	27	768	5	11
2003	583.7	2,312	1,159	33	1,097	2	21
2004	690.2	2,107	1,069	20	995	0	23
Total	2,273.9	8,802	2,988	152	3,068	2,485	109

[a] Includes hours fished and fish captured at Marshall, Russian Mission, and Dogfish locations.

[b] Radio tagged fish considered as spaghetti tagged only.

Table 3.–Relative age composition of Chinook salmon marked in 2000–2004. Percentages of totals are in parentheses.

	Age [a]				
Year	1.2	1.3	1.4	1.5	Sample Size [b]
2000	9 (1.4)	200 (30.3)	400 (60.6)	51 (7.7)	660
2001	22 (1.3)	268 (15.4)	1,330 (76.6)	116 (6.7)	1,736
2002	29 (4.1)	150 (21.2)	445 (62.8)	84 (11.9)	708
2003	4 (0.4)	220 (22.1)	690 (69.3)	82 (8.2) [c]	996
2004	75 (8.4) [d]	163 (18.1)	615 (68.4)	46 (5.1) [c]	899
Total	139 (2.8)	1,001 (20.0)	3,480 (69.6)	379 (7.6)	4,999

[a] Age designation using the European notation.

[b] Includes fish captured at Marshall, Russian Mission, and Dogfish locations.

[c] Includes one 1.6 age fish.

[d] Includes one 1.1 age fish.

Table 4.–Length (METF in mm) composition of Chinook salmon marked in 2000–2004.

Year	Maximum Length	Minimum Length	Mean Length	SD	Sample Size [a]
2000	1,010	470	783	81	675
2001	1,040	440	816	74	1,973
2002	1,060	400	819	95	768
2003	1,075	530	849	83	1,099
2004	1,060	395	825	104	992
Total	1,075	395	821	88	5,507

[a] Includes fish captured at Marshall, Russian Mission, and Dogfish locations.

Table 5.–Recoveries of marked Yukon River Chinook salmon by escapement monitoring projects, 2000–2004. Project numbers used are in box.

Km to Yukon River mouth	Location	Project Type	2000		2001		2002		2003		2004	
			#Tags	# Ex	#Tags	# Ex	#Tags	# Ex	#Tags	# Ex	#Tags	# Ex
274	Marshall	Tagging [a,b]	6	431	25	1,294	2	539	Did not operate		Did not operate	
343	Russian Mission	Tagging [a,b]	Did not operate		Did not operate		1	11	6	715	3	607
365	Dogfish	Tagging [a,b]	6	329	17	1,019	8	760	15	1,597	20	1,500
	Subtotal		12	760	42	2,313	11	1,310	21	2,312	23	2,107
	Projects Upstream of Dogfish [c]											
512	Anvik River	Carcass [a]	0	240	2	383	4	358	3	459	4	NA
779	Nulato River	Tower/Weir [a]	0	916	Did not operate		0	2,696	15	1,716	Did not operate	
912	Gisasa River	Weir [d]	10	2,089	20	3,052	4 [e]	1,931 [e]	11 [e]	1,873 [f]	8 [e]	1,774 [f]
1,570	Henshaw Creek	Weir [d]	1	98	5	1,091	0	649	1	580	2	1,248
	District 4 Subtotal		11	3,343	27	4,526	8	5,634	30	4,628	14	3,022
1,276	Chatanika R.	Carcass [a]	0	37	0	44	1	44	Did not operate		Did not operate	
1,384	Nenana	Fish wheel [a]	1	184	3	870	2	1,527	2	2,377	NA	NA
1,481	Chena River	Carcass/Tower [a,j]	2	516	1	595	30 [e]	6,967 [f]	40 [e]	12,500 [f]	30 [e]	9,645 [f]
1,553	Salcha River	Carcass/Tower [g,j]	0	80	1	308	47 [e]	8,850 [f]	58 [e]	14,600 [f]	68 [e]	15,887 [f]
	Tanana River Subtotal		3	817	5	1,817	80	17,388	100	29,477	98	25,532
1,096	Tozitna River	Weir [h]	Did not operate		Did not operate		5	1,438	5	1,819	8	1,880
1,176	Rampart/Rapids	Fish wheel [d]	2	759	2	2,893	0	838	3	906	NA	NA
	District 5b and 5c Subtotal		2	759	2	2,893	5	2,276	8	2,725	8	1,880
1,981	Border	Fish wheel [i]	9	1,494	14	3,969	1	1,640	4	1,576	1	1,360
2,123	Dawson City	Test fishery [i]	7	761	3	697	3	1,036	0	263	1	167
2,808	Whitehorse	Fishway [i]	0	693	7	988	1	605	1	1,443	2	1,989
	Canadian Subsistence		9	4,829	44	10,139	34	9,257	45	9,616	53	11,088
	Canada Subtotal		25	7,777	68	15,793	39	12,538	50	12,898	57	14,604
	Upstream Sites Total		41	12,696	102	25,029	132	37,836	188	49,728	177	45,038

[a] Recovery project operated by Alaska Department of Fish and Game.
[b] Recovery project operated by National Marine Fisheries Service.
[c] Does not include some projects that operated only one year.
[d] Recovery project operated by U.S. Fish and Wildlife Service.
[e] Number of radio-tagged fish recorded in river.
[f] Estimated escapement.
[g] Recovery project operated by Bering Sea Fishermen's Association.
[h] Recovery project operated by Bureau of Land Management.
[i] Recovery project operated by Canada Department of Oceans and Fisheries.
[j] Does not include carcass surveys in 2002–2004.

Table 6.–Voluntary returns of transmitters from fisheries by nearest community, 2000–2004. Percentage is of total tags returned by community.

Nearest Community	Area	Km from Yukon R. Mouth	Number of Transmitters Returned[a]					
Alaska			2000	2001	2002	2003	2004	%
	Yukon R.	274	3	7	16	0	0	2.1
Russian Mission		343	7	7	7	4	12	3.1
Holy Cross		449	16	28	39	23	32	11.4
Shageluk		528	4	2	0	0	0	0.5
Anvik		510	5	5	9	4	5	2.3
Grayling		541	5	15	10	7	15	4.3
Kaltag		724	3	5	23	6	11	
Nulato		779	8	18	12	17	21	6.3
Koyukuk[b]		808	5	6	6	4	3	2.0
Galena		853	8	2	10	17	26	5.2
Ruby		935	9	3	5	5	10	2.6
Tanana		1,118	18	15	5	13	13	5.3
Manley Hot Springs	Tanana R.	1,231	0	2	1	3	10	1.3
Nenana[c]		1,384	1	5	7	13	5	2.6
Fairbanks		1,481	0	12	4	8	18	3.5
Rapids/Rampart/Bridge	Yukon R.	1,228	7	13	34	54	40	12.2
Stevens Village		1,363	5	13	12	11	14	4.5
Beaver		1,500	2	2	5	11	12	2.6
Fort Yukon[d]		1,613	2	3	15	12	16	4.0
Circle		1,708	1	4	6	7	4	1.8
Eagle		1,952	4	4	9	7	9	2.7
Canada								
Old Crow	Porcupine	2,026	1	2	1	3	3	0.8
Dawson City	Yukon R.	2,123	1	19	16	14	25	6.2
Mayo	Stewart R.	2,446	0	7	1	4	3	1.2
Carmacks[e]	Yukon R.	2,490	8	3	9	9	7	3.0
Pelly Crossing	Pelly R.	2,269	0	9	7	8	8	2.6
Ross River		2,578	0	3	0	0	0	0.2
Whitehorse	Yukon R.	2,808	0	1	1	0	0	0.2
Teslin	Teslin R.	2,865	0	2	0	7	10	1.6
Total Tags Recovered			123	217	270	271	332	100.0

[a] Includes radio-tagged fish recorded in villages or fish camps during aerial tracks.
[b] Includes radio-tagged fish caught in Koyukuk River.
[c] Includes radio-tagged fish caught near Minto.
[d] Includes radio-tagged fish caught in Chandalar River.
[e] Includes radio-tagged fish caught near Minto in Canada.

Table 7.–Number of Chinook salmon marked, 2000–2004.

Year	2000	2001	2002	2003	2004
Initial number marked	675	2,010	768	1,097	995
Censured fish-length [a]	22	43	46	15	1
Removed from total [b]	6 [c]	0	303 [d]	16	37
Number marked	647	1,967	419	1,066	957

[a] For 2000 ≥630 METF, 2001 ≥640 METF, 2002–2003 ≥650 METF, 2004 ≥520 METF.

[b] Unknown fate: died, went to unsurveyed lower tributaries, unreported fishery recovery, tagging error or tag malfunction.

[c] Recaptured and retained at tagging site.

[d] Includes fish censured from two tagging crews.

Table 8.–Drift gillnet CPUE comparison by mesh size and hanging ratio, 2000.

Mesh size / hanging ratio	Chinook CPUE	Chum CPUE	Chinook:Chum Ratio	Number of Drifts
7.5″ / 2:1	22.3	37.4	0.6	213
8.5″ / 2:1	26.0	18.2	1.4	511
8.5″ / 3:1	31.4	39.5	0.8	425

Table 9.–Drift gillnet CPUE comparison by mesh materials used during adjacent time periods, 2001.

Mesh material	Chinook CPUE	Chum CPUE	Chinook:Chum Ratio	Number of Drifts
8.5″ Monofilament	68.2	28.7	2.4	1,047
8.5″#21 Seine Twine	53.0	9.9	5.4	159

Table 10.–Frequency of injury categories between two net types in 2001.

Injury Category	8.5″ Monofilament		8.5″ #21 Seine Twine	
	Number	Percentage	Number	Percentage
No injuries	1,121	43.1	122	42.5
Minor old injures	256	9.8	12	4.2
Major old injuries	114	4.4	6	2.1
Minor new injuries	980	37.6	136	47.4
Major new injuries	133	5.1	11	3.8
Total	2,604	100	287	100

Table 11.–Chinook salmon abundance estimate worksheet for Chinook salmon, 2000–2004.

	Number Examined	Adjusted Number Examined [a]	Number Marked	Adjusted Number Marked [a]	Marked Fraction %	Chapman Estimate [b]	H 95% CI	L 95 % CI	Pilot Station Estimate (90% CI) [c]
2000									
Lower river [d]	2,187	2,103	11	11	0.52				
Mid-river [e]	298	284	3	3	1.06				
Upper river [f]	3,709	3,509	20	19	0.54				
Total [g]	6,194	5,896	34	33	0.56	112,389	148,529	76,249	39,233
2001									
Lower river [d]	4,143	3,333	25	25	0.75				
Mid-river [h]	870	870	3	3	0.34				
Upper river [f]	5,654	5,076	24	22	0.43				
Total [g]	10,667	9,279	52	50	0.54	358,098	453,896	262,299	85,511
2002									
Lower river [d]	1,931	1,091	4	3	0.27				
Mid-river [i]	15,817	10,527	77	43	0.41				
Upper river [f]	9,257	9,257	34	23	0.25				
Total [g]	27,005	20,875	115	69	0.33	125,255	161,353	103,958	92,584
2003									
Lower river [d]	1,873	1,693	11	8					
Mid-river [i]	27,100	24,723	98	94					
Upper river [f]	9,616	9,616	45	44					
Total [g]	38,589	36,032	154	146	0.41	261,545	212,000	284,064	245,037
2004									
Lower river [d]	1,774	1,749	8	8					
Mid-river [i]	25,532	25,532	98	98					
Upper river [f]	11,088	11,088	53	53					
Total [g]	38,394	38,394	159	159	0.41	229,739	266,833	202,195	156,606 [j]

[a] Number of Chinook salmon after censured for length.

[b] For 2000 ≥630 METF, 2001 ≥640 METF, 2002–2003 ≥650 METF, 2004 ≥520 METF.

[c] Estimated passage of large Chinook salmon (Source: JTC 2007).

[d] Koyukuk River weir projects.

[e] Nenana fish wheel and Beaver Creek weir.

[f] Canadian projects including: Subsistence, White Rock and Sheep Rock Fish Wheels, Dawson Test Fishery, Whitehorse Fishway.

[g] Drainagewide pooled.

[h] Nenana fish wheel.

[i] Tanana River projects.

[j] All Chinook salmon.

Table 12.–Estimate of abundance for large fish in the Tanana River and Canada.

	Border Estimate [a]	Estimate	Se	Higher CI	Lower CI	Bias %
Tanana River						
2000		-	-	-	-	-
2001		-	-	-	-	-
2002						
Proportional distribution		18,235	1,846	22,087	14,792	1.1
Local experiment		14,932	1,312	17,985	12,892	0.9
2003						
Proportional distribution		45,247	3,061	48,780	36,841	6.5
Local experiment		48,382	3,268	51,260	38,355	8.6
2004 [b]						
Proportional distribution		46,812	3,254	54,046	41,114	0.4
Local experiment		50,803	3,602	58,634	44,311	0.7
Canada						
2000	16,173	-	-	-	-	-
2001	52,207	-	-	-	-	-
2002	49,214					
Proportional distribution		38,264	5,212	49,429	29,562	1.4
Local experiment		51,428	10,880 9,057	80,249	37,645	4.9
2003	56,929					
Proportional distribution		100,956	8,292	111,840	80,052	6.6
Local experiment		90,037	13,458	122,481	70,566	1.7
2004 [b]	48,111					
Proportional distribution		68,178	5,872	80,462	58,805	0.9
Local experiment		59,415	7,987	78,409	47,044	1.7

[a] Source: JTC 2007.

[b] For 2004 ≥520 METF

Table 13.–Estimate of abundance for fish in the entire Yukon River Basin.

Year	2000	2001	2002	2003	2004
Mark/Recapture Est.	112,389	358,098	125,255	261,545	229,739
Subsistence Harvest	16,964	23,959	10,173	18,057	17,542
Commercial Harvest	9,125	0	22,593	36,928	52,565
Andreafsky River	1,908	2,112	7,999	7,825	11,531
Small Fish [a,b,c,d,e]	3,787	7,831	77,423	48,342	No estimate
Total	144,173	392,000	243,443	372,697	311,377
Harvest Rate [f]	34.8%	16.3%	31.8%	29.1%	39.7%

[a] For 2000 <630mm METF.

[b] For 2001 <640mm METF.

[c] For 2002 <650mm METF.

[d] For 2003 <650mm METF.

[e] For 2004 <520mm METF.

[f] Source: JTC 2007.

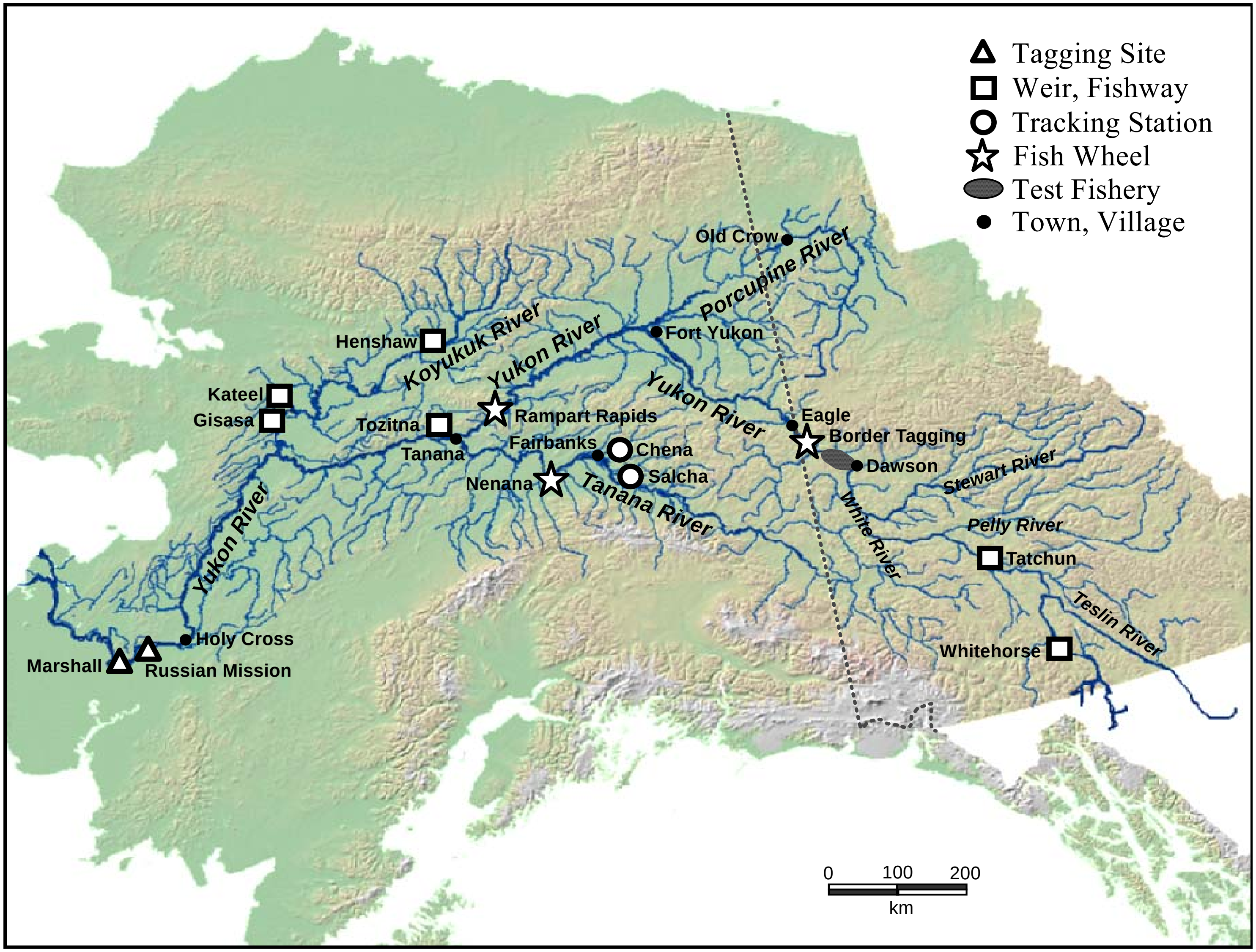


Figure 1.–Yukon River drainage showing the tagging and recovery sites used to develop mark–recapture abundance estimates for Chinook salmon.

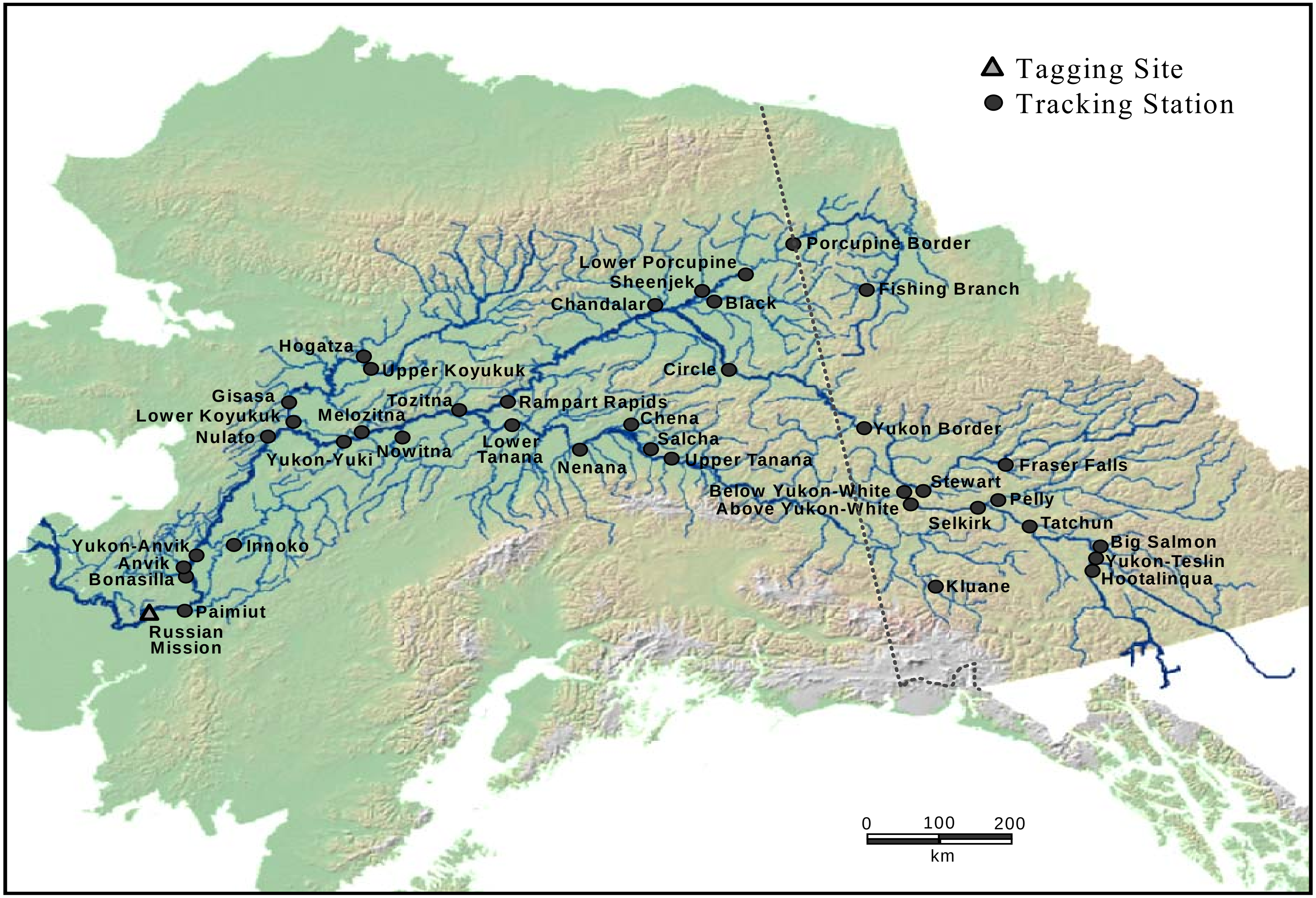


Figure 2.–Yukon River basin showing the location of remote tracking stations used to track the upriver movements of radio-tagged Chinook salmon.

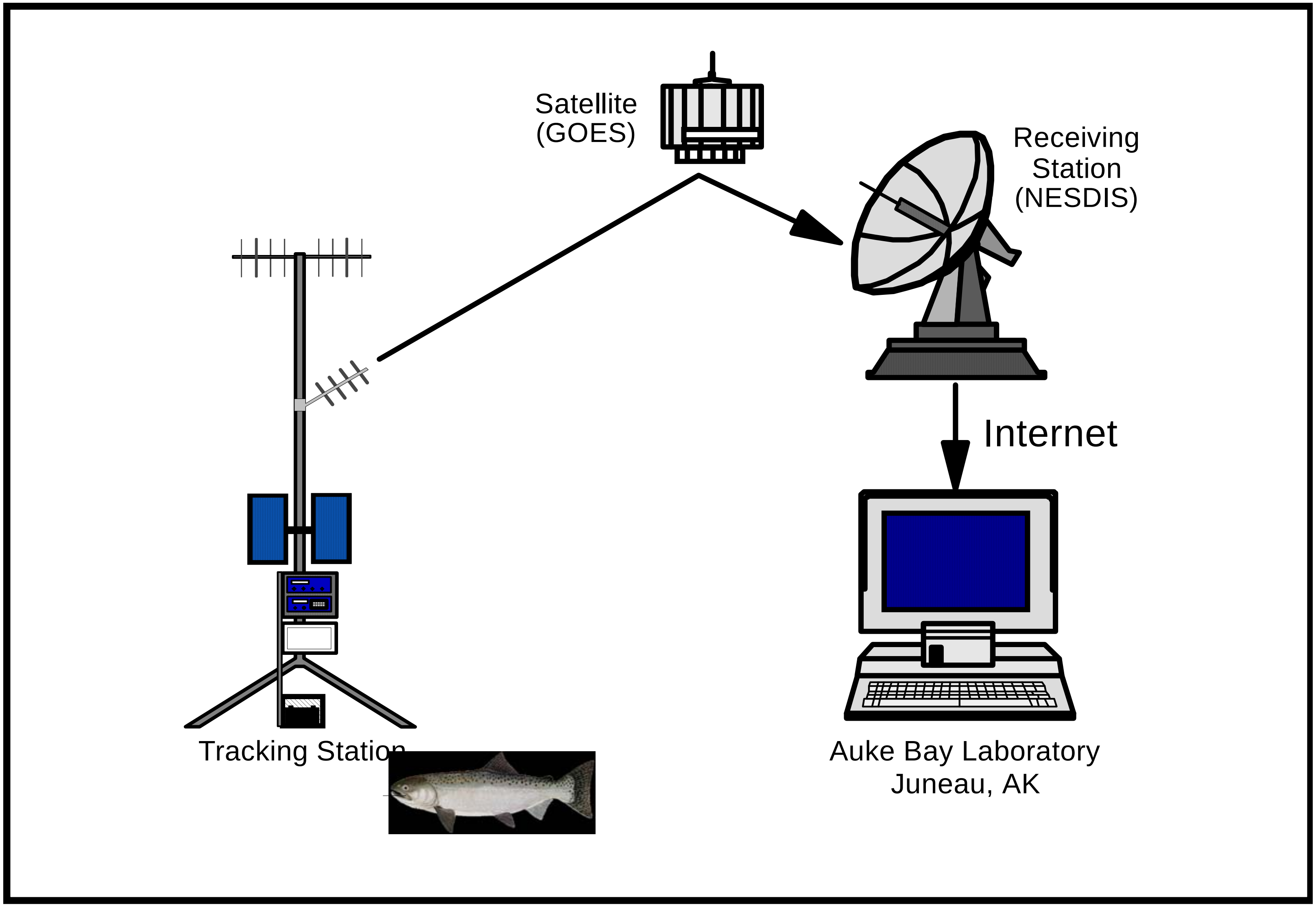


Figure 3.–Remote tracking station and satellite uplink diagram used to collect and access movement information of Chinook salmon in the Yukon River basin.

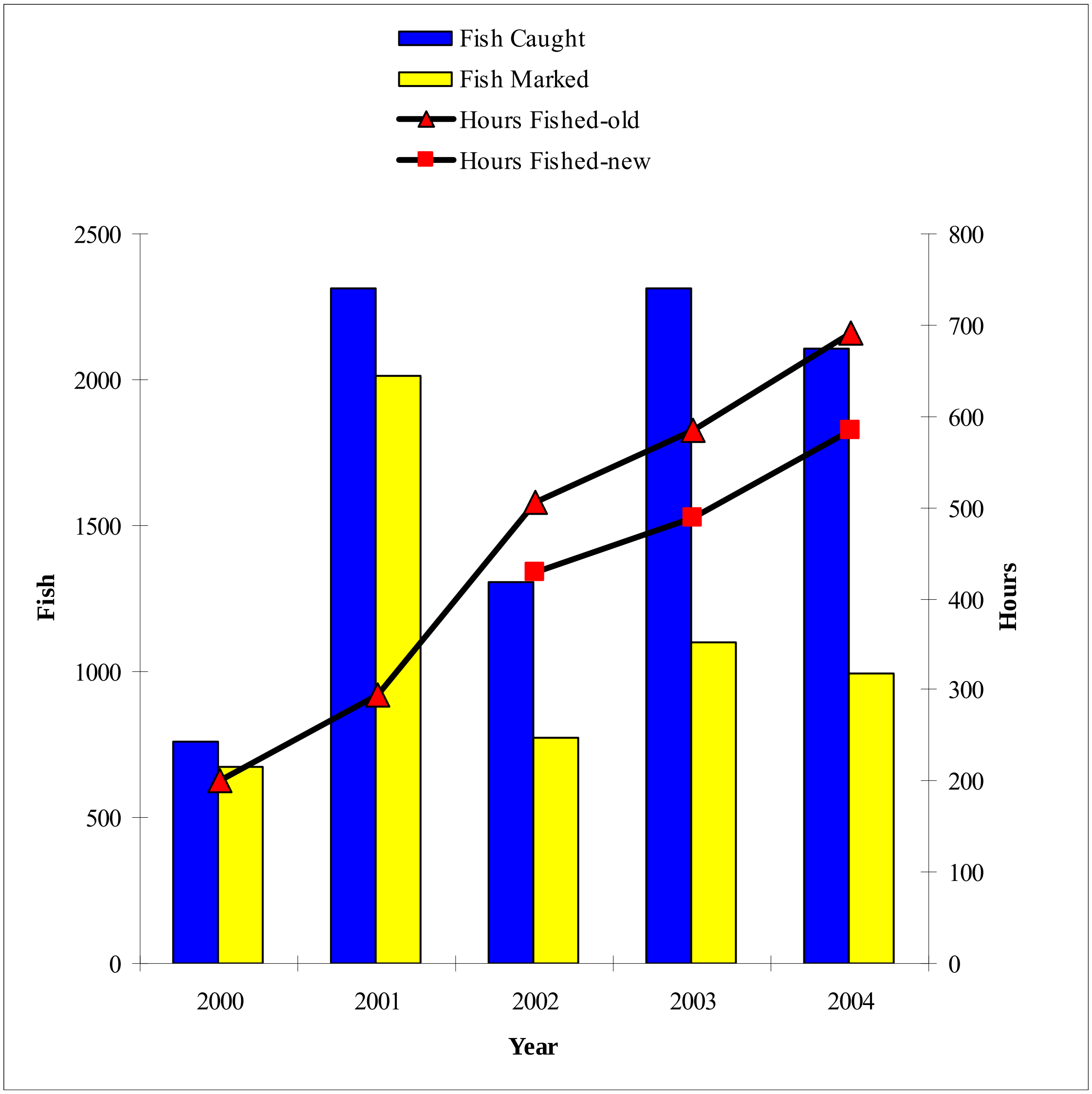


Figure 4.–Numbers of Chinook salmon caught, marked and hours fished, 2000–2004. Hours fished calculated using both "old" and "new" method.

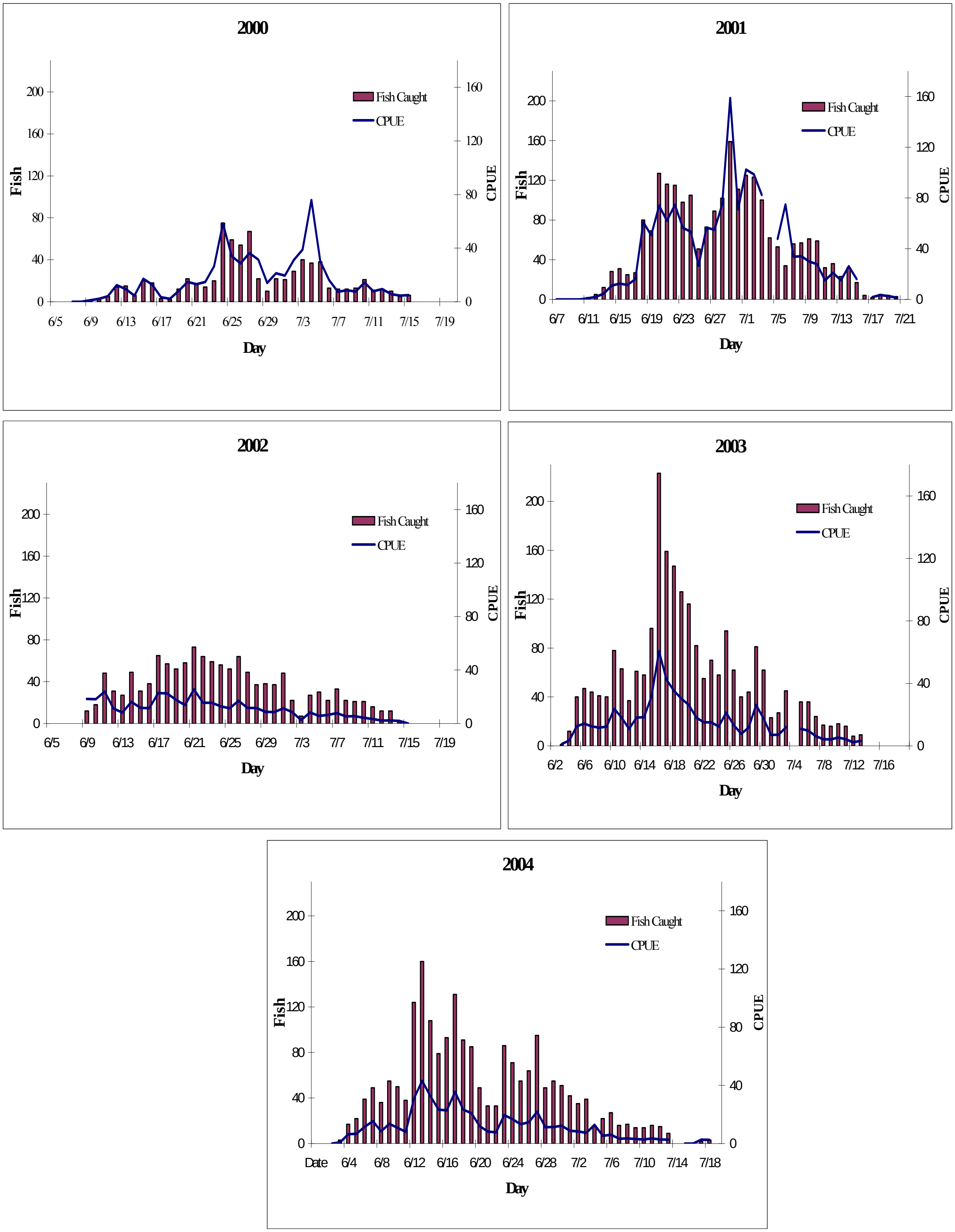
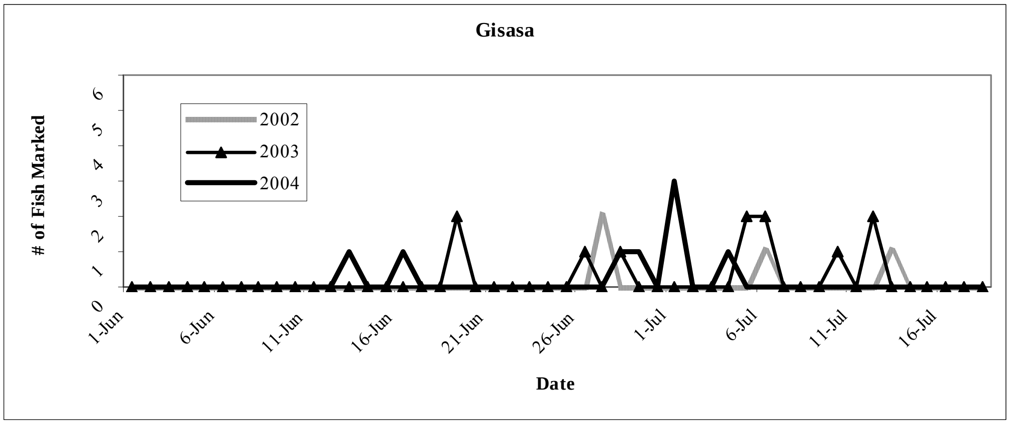
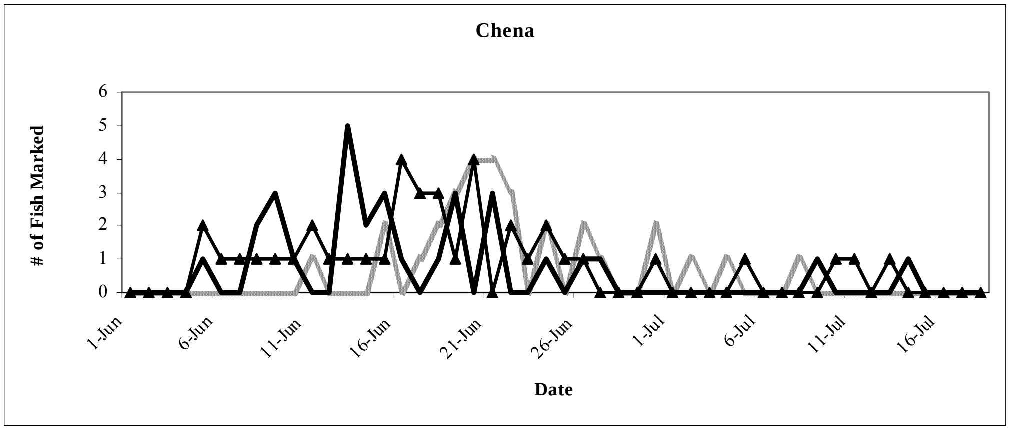
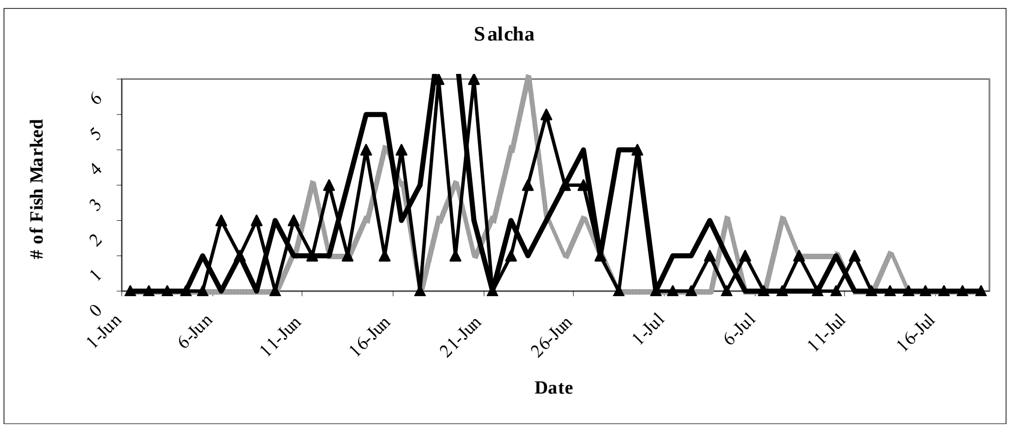


Figure 5.–Daily drift gillnet Chinook salmon CPUE and fish caught, 2000–2004. Marshall site offset by two days.







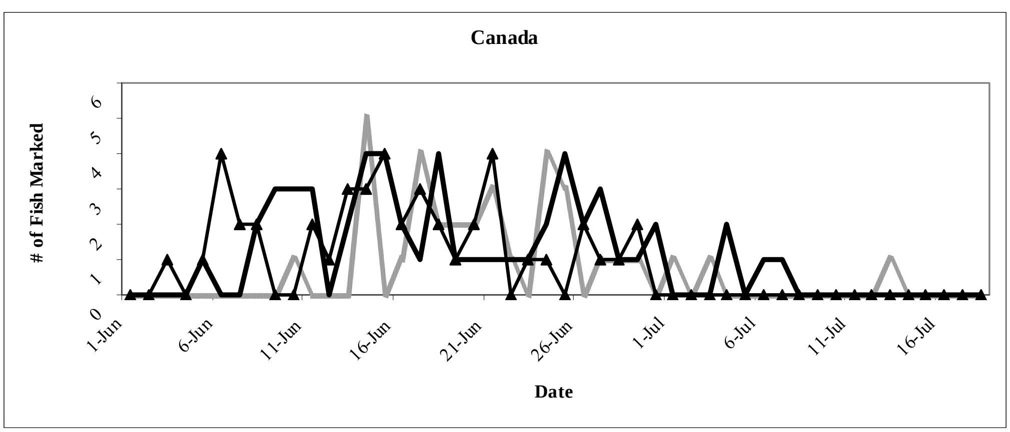


Figure 6.–Timing of marked fish passing Russian Mission destined for recovery projects.

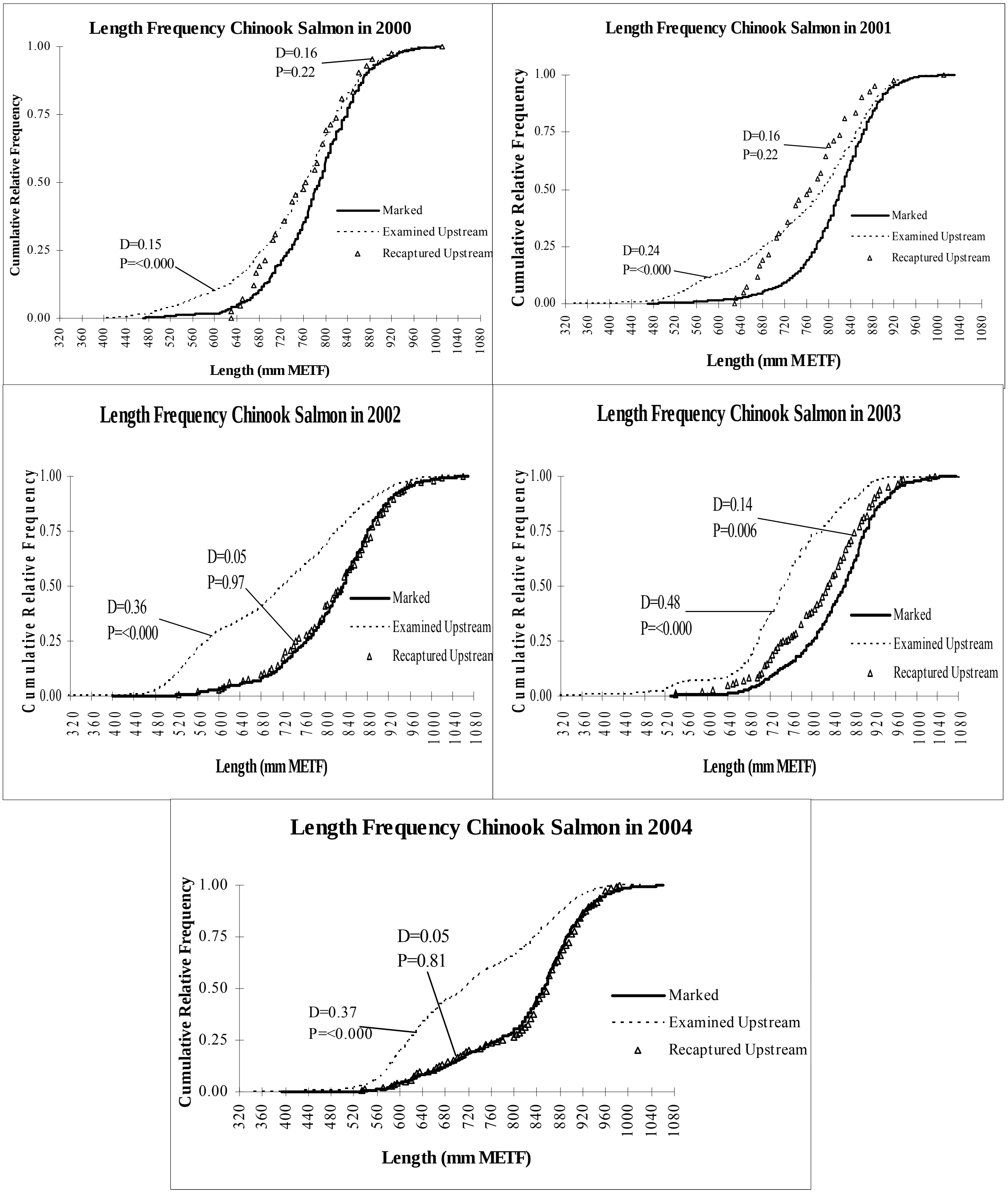


Figure 7.–Cumulative relative length frequencies of Chinook salmon tagged at Russian Mission (marked) and recovered upstream (recaptured), compared with all fish examined at upstream recovery projects (examined).

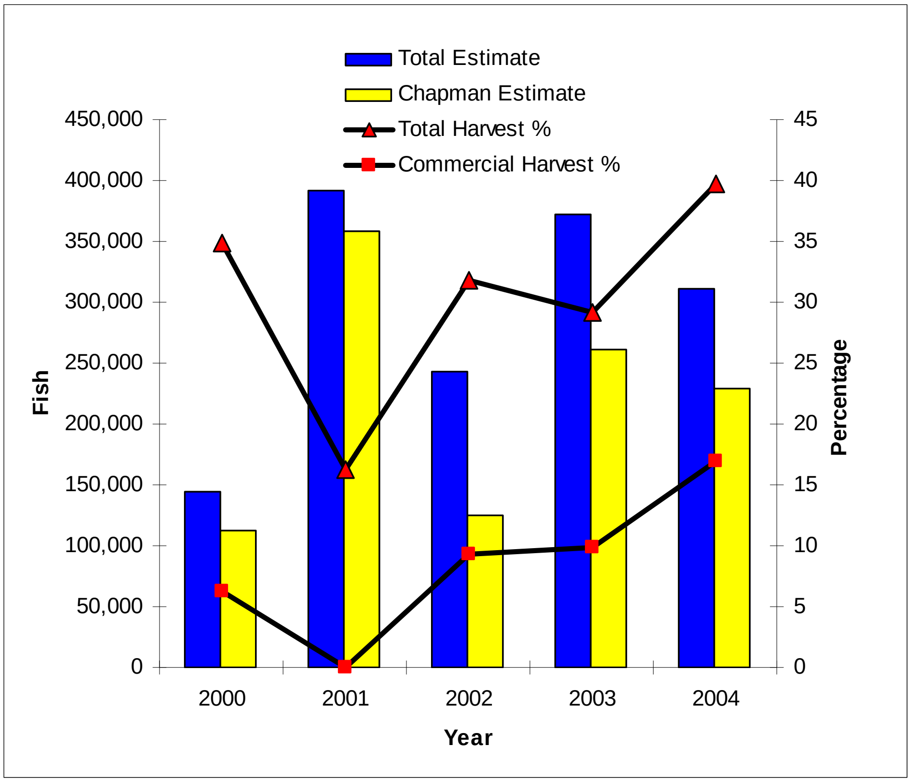


Figure 8.–Abundance estimates and exploitation percentages for Chinook salmon in years 2000–2004.

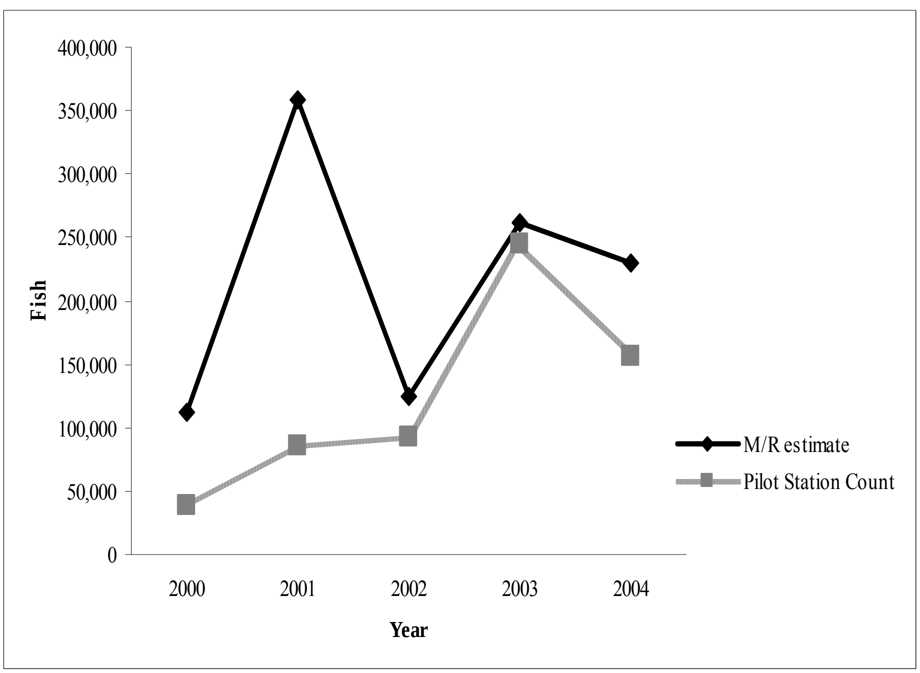
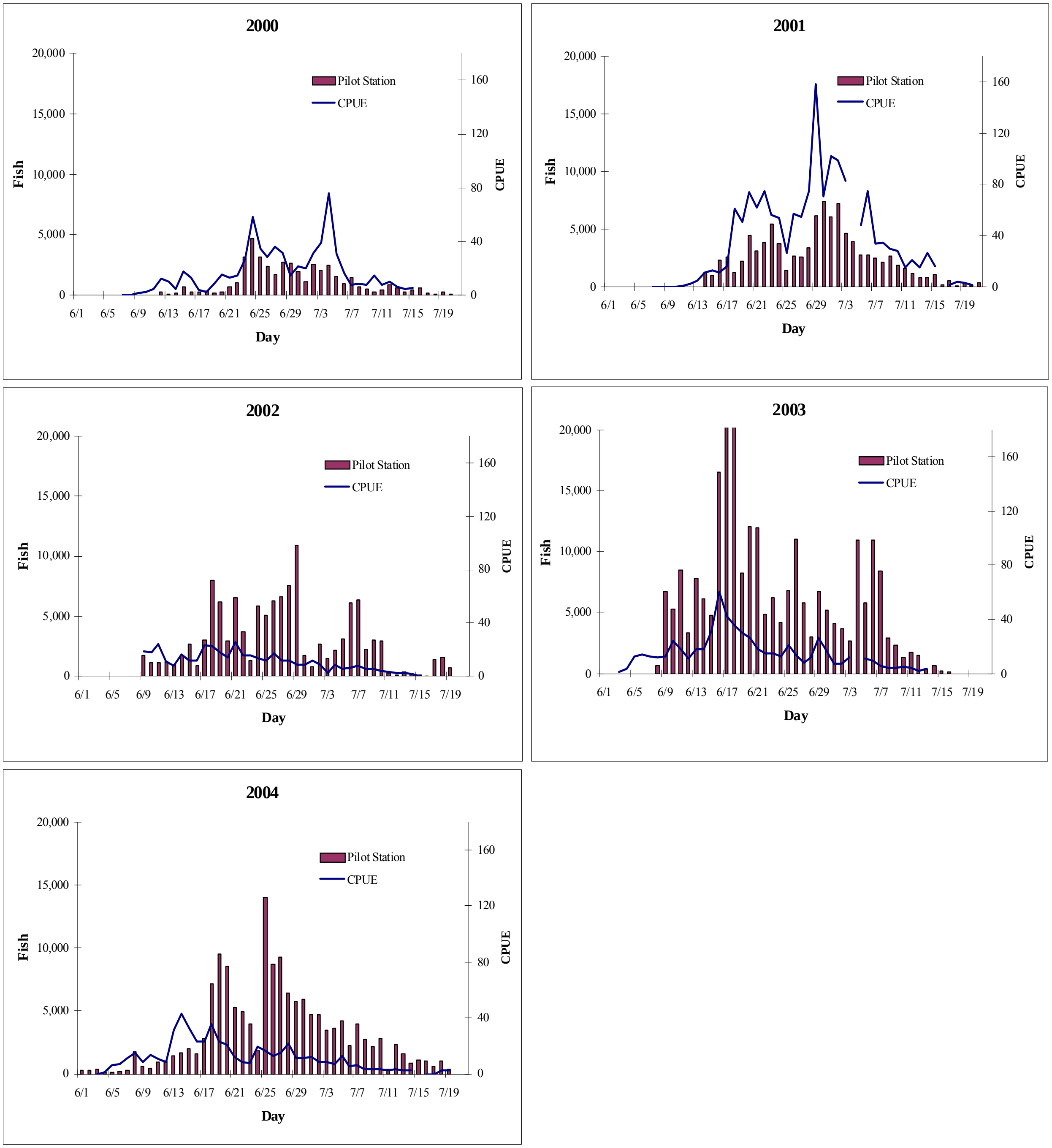


Figure 9.–Comparison of number of Chinook salmon reported at Pilot Station (sonar counts) to mark recapture estimates in 2002–2004 of radio-tagged fish, while 2000–2001 estimates based primarily on recovery of spaghetti tagged fish.



Note: Two Pilot Station values truncated in 2003.

Figure 10.–Daily drift gillnet Chinook salmon CPUE and Pilot Station daily counts, 2000–2004. Pilot Station numbers offset by three days.

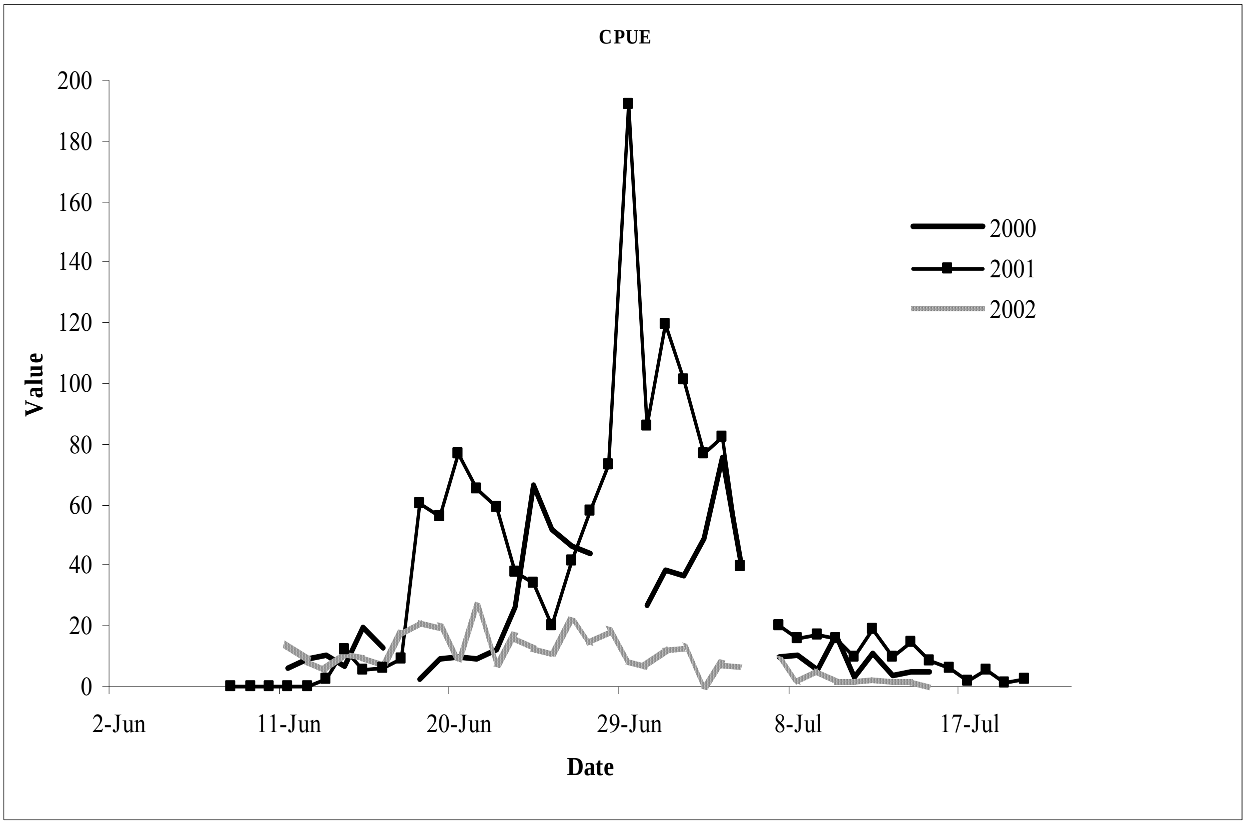
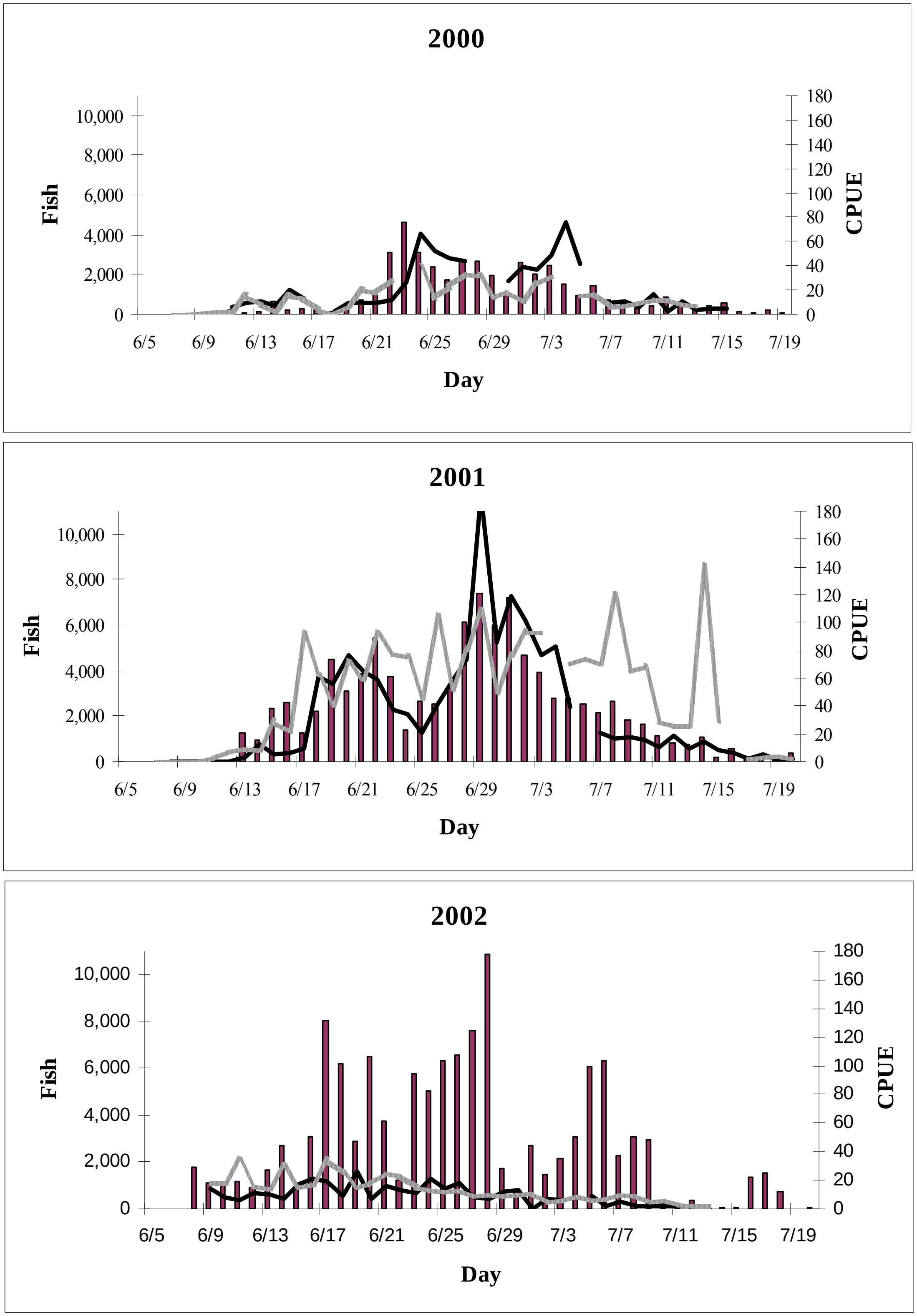


Figure 11.–Marshall daily drift gillnet Chinook salmon CPUE, 2000–2002. Marshall site offset by two days.



Note: One Marshall CPUE value truncated in 2001.

Figure 12.–Comparison of (1) number of Chinook salmon counted at Pilot Station (columns) , (2) CPUE for Chinook salmon captured at the Marshall tagging site (black line), and (3) CPUE for Chinook salmon captured at the Dogfish tagging site (gray line), 2000–2002. Marshall site offset by two days and Pilot Station offset by three days.

APPENDICES

Appendix A1.–Daily catch and tagging summaries from tagging sites in 2000.

	Dogfish										Marshall									
	Chinook salmon										Chinook salmon									
		Tagged		Not tagged								Tagged		Not tagged						
Date	caught	spa-ghetti	radio	recap	morts	released	chum	pink	Other fish	Hours fished	caught	spa-ghetti	radio	recap	morts	released	chum	pink	Other fish	Hours fished
7-Jun	0	0	0	0	0	0	0	0	1	1.5										[a]
8-Jun	0	0	0	0	0	0	0	0	1	3.3										[a]
9-Jun	2	2	0	0	0	0	0	0	1	3.8	3	3	0	0	0	0	0	0	1	2.2
10-Jun	1	1	0	0	0	0	0	0	2	4.2	5	4	0	0	1	0	7	0	1	2.2
11-Jun	5	4	1	0	0	0	0	0	0	2.6	8	8	0	0	0	0	5	0	2	2.8
12-Jun	8	5	2	0	1	0	7	0	0	2.9	4	4	0	0	0	0	7	0	1	2.3
13-Jun	5	3	0	0	2	0	14	0	0	3.4	11	10	0	0	1	0	5	0	0	2.3
14-Jun	5	3	2	0	0	0	8	0	0	3.3	9	9	0	0	0	0	6	0	0	2.8
15-Jun	9	4	3	0	2	0	7	0	0	2.5										[a]
16-Jun	7	2	3	0	2	0	2	0	1	3.1	3	3	0	0	0	0	5	0	0	3.8
17-Jun	2	2	0	0	0	0	6	0	0	3.5	9	7	0	0	1	1	1	0	0	3.4
18-Jun										[a]	7	6	0	0	0	1	1	0	0	3.7
19-Jun	6	4	2	0	0	0	9	0	0	3.3	9	8	0	0	0	1	7	0	1	3.2
20-Jun	15	5	7	1	2	0	2	0	0	2.6	12	10	0	0	0	2	1	0	0	3.3
21-Jun	10	8	1	0	1	0	6	0	0	3.2	25	23	0	0	0	2	4	0	0	2.8
22-Jun										[a]	54	47	4	0	2	1	35	0	0	4.5[b]
23-Jun										[a]	53	39	5	2	4	3	40	0	1	3.9[b]
24-Jun	19	10	6	1	1	1	28	0	0	2.2	19	17	1	0	1	0	23	0	0	2.0
25-Jun	11	5	3	0	3	0	16	0	0	3.2	20	16	2	0	0	2	9	0	0	2.4
26-Jun	34	18	12	1	3	0	22	0	1	5.6[b]										[a]
27-Jun	39	26	11	0	0	2	27	0	0	5.7[b]										[a]
28-Jun	23	16	5	1	1	0	16	0	0	3.0	9	6	2	0	0	1	7	0	0	2.0
29-Jun	8	4	3	0	0	1	9	1	0	3.3	18	14	2	0	0	2	27	0	0	2.0
30-Jun	13	8	3	0	0	2	11	1	0	3.4	20	13	3	1	0	3	23	0	1	2.3
1-Jul	13	13	0	0	0	0	19	0	0	3.5	22	19	3	0	0	0	40	0	0	1.8
2-Jul	4	4	0	0	0	0	18	0	0	1.4	36	27	3	1	0	5	34	0	1	2.1
3-Jul	19	17	0	1	0	1	35	0	1	3.0	22	17	2	1	0	2	21	1	0	2.2
4-Jul										[a]										[a]
5-Jul	11	9	0	0	0	2	29	0	1	3.8	7	6	0	0	0	1	18	2	1	3.4
6-Jul	12	10	0	0	1	1	14	0	1	3.6	7	7	0	0	0	0	11	0	0	2.8
7-Jul	4	3	0	0	1	0	19	1	3	3.1	5	4	0	0	0	1	22	0	1	3.7
8-Jul	9	9	0	0	0	0	18	0	0	3.6	10	8	0	1	1	0	13	0	0	3.2
9-Jul	9	8	0	1	0	0	26	1	1	3.8	5	5	0	0	0	0	25	0	1	2.8
10-Jul	9	9	0	0	0	0	35	1	0	3.4	4	4	0	0	0	0	4	4	4	3.3
11-Jul	7	6	0	0	1	0	17	1	0	3.7	6	5	0	0	0	1	6	1	0	4.5
12-Jul	7	5	0	0	2	0	9	0	0	3.0	3	3	0	0	0	0	12	0	0	4.3
13-Jul	3	3	0	0	0	0	21	2	1	3.4	6	6	0	0	0	0	10	0	0	3.9
Site total	329	226	64[c]	6	23	10	450	8	15	97.2	431	358	27	6	11	29	429	8	16	83.2
Project total	760	584	91	12	34	39	879	16	31	180.4										

Total chinook salmon tagged: 675

Appendix A2.–Daily catch and tagging summaries from tagging sites in 2001.

	Dogfish										Marshall									
	Chinook salmon										Chinook salmon									
		Tagged		Not tagged								Tagged		Not tagged						
Date	Caught	Spa-ghetti	Radio tagged	Recap-tured	Mor-talities	Released alive	Chum salmon	Pink salmon	Other fish	Hours fished	Caught	Spa-ghetti	Radio tagged	Recap-tured	Mort-alities	Released alive	Chum salmon	Pink salmon	Other fish	Hours fished
6-Jun	Did not fish										0	0	0	0	0	0	0	0	0	3.3
7-Jun	0	0	0	0	0	0	0	0	1	3.0	0	0	0	0	0	0	0	0	3	6.1
8-Jun	0	0	0	0	0	0	0	0	3	3.9	0	0	0	0	0	0	0	0	0	7.8
9-Jun	0	0	0	0	0	0	0	0	9	3.1	0	0	0	0	0	0	0	0	0	6.2
10-Jun	0	0	0	0	0	0	0	0	2	3.9	0	0	0	0	0	0	0	0	0	7.2
11-Jun	2	1	0	1	0	0	0	0	4	3.2	5	4	0	0	1	0	0	0	8	7.4
12-Jun	6	5	0	0	0	1	0	0	2	2.6	21	21	0	0	0	0	0	0	1	7.0
13-Jun	7	4	0	0	0	3	0	0	0	2.7	10	10	0	0	0	0	0	0	2	7.1
14-Jun	12	11	0	0	0	1	0	0	1	3.6	8	8	0	0	0	0	1	0	1	5.5
15-Jun	20	18	0	1	0	1	0	0	0	2.8	14	12	0	0	1	1	0	0	1	6.2
16-Jun	13	11	0	1	0	1	0	0	3	3.2	56	52	0	1	3	0	0	0	0	3.7
17-Jun	17	15	0	0	1	1	0	0	0	2.5[a]	50	47	0	0	3	0	2	0	1	3.6
18-Jun	24	17	6	0	1	0	0	0	0	2.0	60	55	0	1	4	0	8	0	0	3.1
19-Jun	21	7	14	0	0	0	1	0	0	1.8	58	57	0	1	0	0	20	0	0	3.6
20-Jun	71	28	23	1	0	19	6	0	0	3.8[b]	48	45	0	2	0	1	12	0	0	3.3
21-Jun	62	40	19	0	3	0	12	0	0	3.6[b]	35	34	0	1	0	0	17	0	0	3.7
22-Jun	63	46	13	0	0	4	15	0	0	3.1[b]	36	35	0	0	0	1	18	0	0	4.2
23-Jun	68	49	14	1	0	4	56	0	0	3.4[b]	29	26	0	0	0	3	18	0	0	5.7
24-Jun	53	23	26	4	0	0	49	0	0	3.6[b]	41	34	0	4	1	2	25	0	0	4.0
25-Jun	28	26	0	0	0	2	34	0	0	1.9	56	45	0	1	1	9	17	0	1	3.9
26-Jun	36	33	0	0	0	3	9	0	0	1.4	67	59	0	0	2	6	22	0	0	3.7
27-Jun	28	25	0	2	0	1	1	0	0	3.1	116	78	0	2	1	35	23	0	0	2.4
28-Jun	40	38	0	0	1	1	5	0	1	1.8	79	62	0	2	2	13	35	0	0	3.7
29-Jun	45	41	0	0	1	3	5	0	0	1.8	90	66	0	0	5	19	28	1	0	3.0
30-Jun	34	29	0	0	0	5	9	0	0	2.6	85	66	0	1	1	17	61	0	1	3.4
1-Jul	32	28	0	0	1	3	15	0	0	2.2	59	51	0	0	1	7	38	0	0	3.1
2-Jul	36	35	0[c]	0	0	1	9	0	0	1.9	62	51	0	3	0	8	52	0	0	3.4
3-Jul	32	25	0	0	0	7	5	0	0	1.7	32	30	0[c]	1	0	1	43	0	2	3.2
4-Jul	Did not fish										Did not fish									
5-Jul	29	23	0	0	1	5	21	0	0	1.5	25	22	2	0	0	1	16	0	1	4.9
6-Jul	33	27	0	0	0	6	13	0	0	1.9	22	21	0	0	0	1	4	0	1	5.7
7-Jul	29	24	0	2	0	3	14	0	0	1.8	26	25	0	0	0	1	19	0	0	6.0
8-Jul	38	29	0	0	0	9	15	0	0	1.2	26	24	0	2	0	0	11	0	1	6.5
9-Jul	38	30	0	3	0	5	9	0	0	2.0	16	15	0	1	0	0	22	0	1	6.4
10-Jul	24	23	0	0	0	1	23	0	0	2.4	20	19	0	1	0	0	24	0	2	5.4
11-Jul	15	12	0	1	1	1	19	0	0	2.6	10	9	0	0	1	0	12	0	0	4.6
12-Jul	18	16	0	0	0	2	9	0	0	2.8	16	16	0	0	0	0	10	0	0	5.5
13-Jul	13	11	0	0	1	1	25	0	0	2.3	6	6	0	0	0	0	5	0	0	3.4
14-Jul	13	12	0	0	0	1	26	0	0	2.7[a]	4	4	0	0	0	0	2	0	0	2.6
15-Jul	11	10	0	0	0	1	8	0	0	2.4	1	1	0	0	0	0	0	0	0	2.6
16-Jul	Did not fish										3	3	0	0	0	0	1	0	0	2.9
17-Jul	1	1	0	0	0	0	12	0	2	3.3	1	1	0	0	0	0	0	0	0	3.7
18-Jul	4	4	0	0	0	0	10	0	4	2.9	1	0	0	1	0	0	2	0	0	2.3
19-Jul	1	1	0	0	0	0	10	0	4	2.9	0	0	0	0	0	0	1	0	0	2.9
20-Jul	2	2	0	0	0	0	17	0	12	2.5	Did not fish							0		
Site total	1,019	780	115	17	11	96	462	0	48	109.1	1,294	1,114	2	25	27	126	569	1	27	193.8
Project total	2,313	1,894	117	42	38	222	1,031	1	75	302.9										

Total chinook salmon tagged: 2,011

[a] Data not available. Hours fished estimated from previous and following two days.

[b] Two crews fished at the Russian Mission site 20 June to 24 June.

[c] Ran out of blue tags. Began using white tags beginning with the evening shift of fishing on 3 July.

Appendix A3.–Daily catch and tagging summaries from tagging sites in 2002.

	Dogfish [a]								Marshall [b]							
	Chinook Salmon								Chinook Salmon							
		Tagged		Not Tagged						Tagged		Not Tagged				
Date	Caught	Radio tagged	Recap.	Mort.	Released Alive	Chum Salmon	Other Fish	Hours Fished	Caught	Radio tagged	Recap.	Mort.	Released Alive	Chum Salmon	Other Fish	Hours Fished
9-Jun	12	7	1	0	3	2	4	2.0	14	5	0	1	8	2	0	3.2
10-Jun	18	10	0	0	7	2	0	3.2	15	6	0	0	9	6	0	5.9
11-Jun	34	16	0	0	17	1	0	3.2	13	6	0	1	7	1	0	8.3
12-Jun	16	10	0	0	4	6	0	3.5	23	12	0	0	8	4	2	7.4
13-Jun	14	12	0	0	3	4	0	3.3	17	16	1	0	3	0	0	5.6
14-Jun	26	16	0	0	10	1	0	2.7	15	5	1	1	8	3	0	7.1
15-Jun	14	10	0	0	5	3	0	3.2	32	14	0	1	16	12	0	6.2
16-Jun	19	10	0	1	6	3	0	4.1	39	22	0	0	14	32	0	5.7
17-Jun	30	16	0	2	14	17	0	2.7	34	20	0	0	14	56	1	5.4
18-Jun	26	15	0	0	11	31	1	2.9	19	5	0	0	14	23	2	7.0
19-Jun	18	9	0	2	5	21	1	3.8	26	12	0	0	14	9	0	3.0
20-Jun	39	23	0	3	14	46	0	6.4	14	5	0	0	8	12	0	6.7
21-Jun	47	26	0	3	16	45	0	6.1	30	12	0	0	19	19	0	6.2
22-Jun	48	29	0	0	19	25	1	6.6	27	16	0	0	10	15	0	7.3
23-Jun	29	23	0	1	7	29	0	7.0	22	14	0	2	8	11	0	6.9
24-Jun	31	21	1	2	7	45	1	8.4	38	18	0	0	22	20	0	5.5
25-Jun	30	17	0	0	14	74	0	8.4	26	17	0	0	8	61	0	5.8
26-Jun	26	18	0	0	8	34	0	6.5	13	7	0	0	6	10	0	2.2
27-Jun	23	17	0	0	6	38	0	8.1	16	10	0	0	6	20	0	6.4
28-Jun	24	17	0	0	6	71	0	8.5	14	5	0	1	8	22	0	6.9
29-Jun	22	16	0	0	6	65	0	8.3	22	8	0	0	14	8	0	6.1
30-Jun	23	13	3	0	7	65	0	7.8	15	10	0	1	4	4	0	4.0
1-Jul	26	20	0	0	6	52	0	8.4	0	0	0	0	0	1	0	6.1
2-Jul	7	7	0	0	0	12	0	5.0	15	6	0	0	9	10	0	7.0
3-Jul	6	3	0	0	4	1	0	3.9	13	6	0	1	5	14	0	7.1
4-Jul	12	10	0	0	2	2	0	4.4	Did not fish							
5-Jul	17	9	0	1	6	21	0	11.5	7	6	0	0	0	3	0	2.7
6-Jul	22	15	0	1	6	28	0	11.9	2	2	0	0	0	5	0	3.8
7-Jul	26	19	1	0	7	39	0	11.7	7	4	0	0	3	9	0	4.4
8-Jul	20	16	1	0	3	10	0	10.6	2	2	0	0	1	0	0	4.0
9-Jul	14	8	0	2	4	10	0	8.8	2	2	0	0	0	1	0	3.4
10-Jul	19	12	1	0	5	12	0	13.2	3	2	0	0	0	1	0	5.3
11-Jul	14	10	0	0	5	5	1	13.0	2	2	0	0	1	2	1	4.0
12-Jul	9	4	1	0	4	5	0	14.8	2	2	0	0	0	5	0	3.8
13-Jul	10	5	0	0	5	7	1	13.3	0	0	0	0	0	1	0	1.0
Site Total	771	489	9	18	252	832	10	247.7	539	279	2	9	247	402	6	181.0
Project Total	1,310	768	11	27	499	1,234	16	428.7								

Note: Mort. = mortalities, Recap. = recaptured.

[a] Two crews fished at the Dogfish site 20 June to 13 July.

[b] One crew fished at the Marshall site 5 July to 13 July.

Appendix A4.–Daily catch and tagging summaries from tagging sites in 2003.

	Russian Mission [a]							Dogfish						
	Chinook salmon							Chinook salmon						
		Tagged		Not tagged					Tagged		Not tagged			
		Radio			Released	Chum	Other		Radio			Released	Chum	Other
Date	Caught	tagged	Recap.	Mort.	alive	salmon	fish	Caught	tagged	Recap.	Mort.	alive	salmon	fish
3-Jun	Did not fish							2	1	0	0	1	1	0
4-Jun	6	2	0	0	4	0	0	10	4	0	0	3	0	0
5-Jun	13	4	0	1	8	0	0	25	16	0	1	9	0	1
6-Jun	12	7	0	0	5	0	0	38	17	1	0	18	0	0
7-Jun	4	1	0	0	3	0	0	42	26	1	0	15	3	0
8-Jun	11	4	0	0	10	7	1	23	18	0	0	9	0	0
9-Jun	10	3	0	0	7	0	0	35	16	0	2	14	0	0
10-Jun	27	6	0	0	21	0	0	49	24	1	1	25	1	0
11-Jun	15	7	0	0	8	2	0	48	14	0	2	31	0	0
12-Jun	15	3	0	1	11	0	0	20	10	1	0	9	0	0
13-Jun	17	8	0	0	9	0	0	49	22	2	0	26	0	0
14-Jun	22	14	0	0	8	0	0	35	19	0	1	12	0	0
15-Jun	39	22	0	1	16	1	0	60	26	0	2	31	0	0
16-Jun	108	32	1	5	63	0	0	133	44	0	1	88	0	0
17-Jun	66	31	0	0	35	3	0	96	41	1	0	51	0	0
18-Jun	41	17	3	0	24	5	0	100	41	1	0	59	6	0
19-Jun	36	14	0	0	21	3	1	82	25	2	0	56	6	0
20-Jun	42	20	0	3	21	2	0	74	36	0	0	39	1	0
21-Jun	26	16	0	1	11	3	0	52	25	0	0	26	23	0
22-Jun	9	5	0	0	5	3	0	41	26	1	0	13	4	1
23-Jun	24	12	0	0	11	2	0	44	27	1	0	20	3	0
24-Jun	26	10	0	0	13	2	0	53	21	0	1	23	7	0
25- Jun	20	16	0	0	8	6	0	52	35	0	0	24	6	1
26- Jun	10	4	0	0	5	2	0	58	31	0	0	22	19	0
27- Jun	6	4	0	0	3	4	0	31	20	0	1	14	14	0
28- Jun	7	5	0	0	2	1	0	33	20	0	0	12	9	0
29- Jun	20	8	1	0	11	2	0	73	36	0	2	30	10	0
30- Jun	7	3	1	0	3	2	0	40	28	1	0	17	5	0
1-Jul	7	2	0	0	5	10	0	19	13	0	2	5	19	0
2-Jul	8	4	0	0	3	3	0	19	12	0	1	6	13	2
3-Jul	15	3	0	0	12	2	0	27	21	0	0	8	23	3
4-Jul [b]	Did not fish													
5-Jul	14	6	0	0	8	1	0	27	12	0	1	12	15	2
6-Jul	11	3	0	0	8	2	0	26	14	1	0	10	13	0
7-Jul	3	3	0	0	0	0	0	16	12	0	0	6	16	0
8-Jul	7	4	0	0	3	4	0	11	3	0	1	6	6	0
9-Jul	3	0	0	1	2	1	0	11	5	0	1	7	15	0
10-Jul	5	1	0	0	4	3	0	16	9	0	0	5	17	0
11-Jul	3	3	0	0	0	3	0	10	7	1	0	4	13	0
12-Jul	0	0	0	0	0	0	0	10	8	0	0	0	4	1
13-Jul	Did not fish							7	5	0	0	4	2	0
14-Jul [b]	Did not fish													
Site total	715	307	6	13	391	79	2	1,597	790	15	20	770	274	11
Project total	**2,312**	**1,097**	**21**	**33**	**1,161**	**3534**	**13**							

Note: Mort. = mortalities, Recap. = recaptured.

[a] Two crews fished at the Russian Mission site 16 June to 21 June and 23 June to 27 June.

[b] One fish radio tagged after midnight.

Appendix A5.–Daily catch and tagging summaries from tagging sites in 2004.

	Russian Mission							**Dogfish**						
	Chinook salmon							Chinook salmon						
		Tagged		Not tagged					Tagged		Not tagged			
Date	Caught	Radio tagged	Recap.	Mort.	Released alive	Chum salmon	Crews fished	Caught	Radio tagged	Recap.	Mort.	Released alive	Chum salmon	Crews fished
3-Jun	Did not fish							0	0	0	0	0	0	1
4-Jun	3	1	0	0	2	1	1	0	0	0	0	0	1	2
5-Jun	5	2	0	0	3	2	1	11	5	1	0	5	1	2
6-Jun	10	9	0	0	1	1	1	13	4	0	0	9	6	2
7-Jun	16	9	0	0	7	0	1	23	11	0	0	12	3	2
8-Jun	19	18	0	0	1	0	2	26	13	0	2	11	3	2
9-Jun	19	13	0	0	6	3	2	21	13	0	0	8	4	2
10-Jun	40	26	0	1	13	0	2	14	6	0	1	7	5	2
11-Jun	24	8	0	0	16	2	2	26	10	2	0	14	5	2
12-Jun	18	11	0	0	7	0	2	21	9	1	0	11	4	2
13-Jun	68	24	0	0	44	2	2	54	20	1	1	32	9	2
14-Jun	63	27	1	1	34	10	2	95	35	0	1	59	11	2
15-Jun	28	16	0	0	12	7	2	84	39	1	0	44	28	2
16-Jun	18	7	0	0	11	30	2	62	30	0	2	30	27	2
17-Jun	30	7	0	0	23	11	2	64	28	1	0	35	16	2
18-Jun	37	10	0	0	27	1	2	90	34	0	0	56	20	2
19-Jun	25	12	0	0	13	10	2	66	30	0	0	36	18	2
20-Jun	22	10	0	0	12	27	2	65	32	1	1	31	35	2
21-Jun	8	3	0	0	5	10	2	40	16	2	0	22	33	2
22-Jun	6	2	0	0	4	4	2	27	16	0	0	11	10	2
23-Jun	4	3	0	0	1	6	2	32	16	0	0	16	18	2
24-Jun	20	4	0	0	16	4	2	57	27	0	2	28	10	2
25-Jun	8	4	0	0	4	4	2	72	38	1	1	32	29	2
26-Jun	9	3	0	0	6	6	2	44	22	0	1	21	44	2
27-Jun	11	7	0	0	4	11	2	45	21	1	1	22	41	2
28-Jun	11	5	0	0	6	15	2	86	39	0	0	47	62	2
29-Jun	13	7	0	0	6	24	2	42	20	1	1	20	75	2
30-Jun	10	2	0	0	8	32	2	44	27	0	0	17	75	2
1-Jul	6	3	0	0	3	15	2	44	25	0	1	18	40	2
2-Jul	10	5	1	0	4	10	1	34	19	0	0	15	31	3
3-Jul	12	5	0	0	7	25	1	23	14	0	0	9	23	3
4-Jul	6	2	1	1	2	9	2	33	18	1	0	14	11	2
5-Jul	Did not fish							15	7	1	0	7	8	1
6-Jul	2	1	0	0	1	0	2	21	9	1	0	11	14	2
7-Jul	1	0	0	0	1	2	2	24	14	0	0	10	22	2
8-Jul	7	5	0	0	2	8	1	10	5	1	0	4	9	3
9-Jul	5	2	0	0	3	4	1	12	7	0	0	5	10	3
10-Jul	2	1	0	0	1	5	2	12	5	0	0	7	23	2
11-Jul	5	4	0	0	1	12	1	9	6	0	0	3	22	3
12-Jul	4	1	0	0	3	15	1	12	4	0	2	6	27	3
13-Jul	1	1	0	0	0	8	2	12	7	2	0	3	30	2
14-Jul	1	1	0	0	0	0	1	10	8	1	0	1	16	2
15-Jul	Did not fish							Did not fish						
16-Jul	Did not fish							0	0	0	0	0	4	1
17-Jul	Did not fish							0	0	0	0	0	3	1
18-Jul	Did not fish							2	2	0	0	0	1	1
19-Jul	Did not fish							3	3	0	0	0	1	1
Site Total	607	281	3	3	320	336		1,500	714	20	17	749	888	
Project Total	**2,107**	**995**	**23**	**20**	**1,069**	**1,224 [a]**								

Note: Mort. = mortalities, Recap. = recaptured.

[a] Includes fish caught with smaller mesh chum nets.

Appendix B1.–CPUE from the tagging sites, 2000–2004. Marshall site offset by two days (not used).

Date	2000			2001			2002			2003			2004		
	Mar	DF	Total	Mar	DF	Total	Mar	DF	Total	RM	DF	Total	RM	DF	Total
June 2															
June 3											1.2	1.2		0.0	0.0
June 4										5.5	2.5	3.4	2.7	0.0	0.9
June 5										10.8	13.6	12.6	4.1	8.5	6.4
June 6										10.3	16.4	14.2	9.6	5.6	6.8
June 7		0.0	0.0		0.0	0.0				3.0	18.2	12.5	13.8	10.7	11.6
June 8		0.0	0.0	0.0	0.0	0.0				9.9	12.5	11.6	16.1	15.2	15.4
June 9		1.0	1.0	0.0	0.0	0.0		18.3	18.3	8.5	14.5	12.3	9.1	7.7	8.3
June 10		2.2	2.2	0.0	0.0	0.0		18.2	18.2	22.9	24.3	23.8	20.6	7.1	13.6
June 11	6.0	2.8	4.1	0.0	2.6	0.9	13.8	34.1	23.9	14.8	19.5	18.2	10.7	10.8	10.8
June 12	9.2	15.1	12.3	0.0	6.9	2.0	8.5	15.7	11.1	14.3	9.3	10.8	8.0	8.2	8.1
June 13	10.5	8.6	9.5	2.7	9.1	4.6	5.6	14.2	8.1	17.7	18.4	18.2	39.7	24.7	31.1
June 14	6.9	2.8	4.7	12.1	8.4	10.9	10.7	30.0	16.3	22.6	16.4	18.3	37.6	48.3	43.1
June 15	19.6	15.3	17.2	5.7	29.1	12.5	10.0	15.0	11.8	54.4	24.7	31.8	17.4	42.9	32.6
June 16	13.0	12.6	12.9	5.8	21.5	11.5	7.5	17.5	11.4	58.6	62.3	60.7	13.6	29.6	23.3
June 17		3.3	3.3	9.0	91.8	15.9	17.1	33.8	22.8	35.5	49.2	42.4	16.0	28.6	22.8
June 18	2.6	0.0	2.2	60.5	61.9	61.0	21.4	25.3	22.5	21.5	49.2	35.2	22.7	46.1	35.7
June 19	8.9	7.0	8.1	56.3	40.0	50.6	19.2	15.4	17.7	20.7	39.8	30.3	14.0	32.8	23.5
June 20	9.9	20.6	14.9	76.6	71.8	74.0	9.2	18.2	13.8	18.9	33.5	26.0	10.9	28.8	20.8
June 21	9.3	17.2	13.0	65.4	59.0	62.0	26.0	25.5	25.7	11.9	24.2	18.1	4.8	16.9	12.0
June 22	12.1	27.9	14.8	59.1	91.9	74.6	7.2	23.1	15.6	9.3	18.3	15.1	3.8	12.0	8.2
June 23	26.5		26.5	37.7	77.9	56.4	16.5	14.7	15.5	10.2	20.2	15.1	1.5	13.0	7.7
June 24	66.7	39.1	58.4	34.3	75.3	53.4	12.8	12.9	12.8	8.7	15.9	12.4	9.1	30.3	19.6
June 25	52.0	12.7	34.1	20.2	45.5	26.6	10.9	11.8	11.4	11.6	31.2	21.3	3.9	28.9	16.8
June 26	46.2	22.7	28.5	41.2	104.3	56.6	21.4	13.1	17.0	3.9	22.8	13.3	4.8	20.1	13.2
June 27	43.6	33.4	36.3	57.9	51.5	55.0	14.5	9.5	11.7	2.6	13.0	7.7	5.8	21.7	14.8
June 28		31.4	31.4	73.4	80.8	74.9	18.4	9.6	11.6	4.9	15.9	11.7	6.7	34.0	21.9
June 29		14.1	14.1	192.0	108.6	158.7	8.4	8.9	8.7	22.7	27.6	26.2	5.9	15.2	11.2
June 30	27.0	19.2	21.3	85.8	49.9	71.0	6.9	9.8	8.5	6.6	22.0	17.5	5.0	16.9	11.4
July 1	38.6	10.8	19.4	119.3	76.4	102.4	12.2	10.7	11.3	6.9	7.0	7.0	3.0	18.2	12.2

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Appendix B1.–Page 2 of 2.

Date	2000			2001			2002			2003			2004		
	Mar	DF	Total	Mar	DF	Total	Mar	DF	Total	RM	DF	Total	RM	DF	Total
July 2	36.3	24.4	31.1	101.5	92.6	98.6	13.0	4.8	8.5	8.2	6.8	7.2	3.9	10.6	8.8
July 3	48.9	31.5	38.8	77.0	93.4	82.4	0.0	6.5	2.5	15.0	10.9	12.0	3.2	9.9	8.4
July 4	75.9		75.9	82.5		82.5	7.5	9.3	8.2				2.4	11.8	7.4
July 5	41.7	15.6	30.2	39.6	70.0	47.8	6.5	5.1 [a]	5.6	15.3	9.2	10.8		12.9	12.9
July 6		16.1	16.1		74.9	74.9		6.4 [a]	6.4	9.9	9.7	9.7	1.1	8.7	5.3
July 7	10.0	5.4	7.4	20.4	70.2	33.6	8.7	7.5 [a]	7.7	2.6	7.7	6.2	0.5	10.4	6.1
July 8	10.6	7.4	8.6	16.1	120.0	34.1	1.8	6.7 [a]	5.4	6.4	3.5	4.3	2.6	3.6	3.3
July 9	5.7	9.0	7.6	17.3	65.1	29.9	5.5	5.5	5.5	2.7	4.7	4.1	0.0	4.1	3.6
July 10	17.1	12.1	14.3	15.9	68.3	27.9	1.8	4.9 [a]	4.2	5.6	5.2	5.3	1.3	4.0	3.1
July 11	2.9	11.9	7.8	10.0	28.6	15.0	2.1	3.7 [a]	3.4	2.7	4.8	4.2	0.7	3.7	2.8
July 12	10.9	7.9	9.4	18.6	25.8	21.1	2.2	2.1 [a]	2.1	0.0	3.2	2.2	2.6	3.7	3.5
July 13	3.9	7.5	5.6	9.5	26.0	15.1	1.8	2.5 [a]	2.3		3.3	3.3	0.4	4.7	2.8
July 14	4.6		4.6	14.5	141.2	26.2	2.0		2.0				0.0	2.9	2.6
July 15	5.0		5.0	8.7	29.5	16.0	0.0		0.0						
July 16				6.1		6.1								0.0	0.0
July 17				1.9	1.9	1.9								0.0	0.0
July 18				5.2	2.7	3.6								2.7	2.7
July 19				1.4	4.1	2.6								2.5	2.5
July 20				2.1	2.6	2.3									

[a] Does not include fishing conducted at Russian Mission.