U.S. Fish and Wildlife Service
Office of Subsistence Management
Fisheries Resource Monitoring Program

Estimating the inriver abundance of Copper River Chinook salmon, 2010 annual report

Annual Report for Study 10-503

The Native Village of Eyak
PO Box 1388
Cordova, AK 99574

LGL Alaska Research Associates, Inc.
1101 E. 76th Avenue, Suite B
Anchorage, AK 99518

March 2011

Estimating the inriver abundance of Copper River Chinook salmon, 2010 annual report

Annual Report for Study 10-503

Keith M. van den Broek, Thomas M. Haluska
Native Village of Eyak
P.O. Box 1388
Cordova, AK 99574

and

Jason J. Smith
LGL Alaska Research Associates, Inc.
1101 E. 76th Ave., Suite B
Anchorage, AK 99518

March 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The purpose of this project was to use fish wheels and two-sample mark-recapture methods for long-term monitoring of Chinook salmon *Oncorhynchus tshawytscha* escapement on the Copper River. This report summarizes results from the 2010 field season, the tenth year since the project's inception. The main objective for 2010 was to estimate the inriver abundance of Chinook salmon returning to the Copper River such that the estimate was within 25% of the true escapement 95% of the time. For the first sample event, up to two live-capture fish wheels were operated at Baird Canyon for a total of 1,865 h from 15 May to 5 July. During this period, 1,745 adult Chinook salmon were marked. For the second sample event, up to two fish wheels were operated at Canyon Creek near the lower end of Wood Canyon for 2,434 h from 18 May to 15 July. A total of 894 Chinook salmon and were examined for marks, of which 69 fish were marked. Using a pooled Petersen estimator, the abundance of Chinook salmon measuring 500 mm FL or greater that migrated upstream of Baird Canyon from 15 May to 5 July was estimated to be 22,323 (SE = 2,492; 95% CI = 17,438-27,207). The median travel time of Chinook salmon marked at Baird Canyon and recaptured at Canyon Creek (91 km upstream) was 9.1 d. Funding for this study by the Fisheries Resource Monitoring Program has been approved through 2013. This highly successful and long-term monitoring program operated by the Native Village of Eyak provides information that has become an integral part of Copper River salmon management.

Citation: van den Broek, K. M., T. M. Haluska, and J. J. Smith. 2011. Estimating the inriver abundance of Copper River Chinook salmon, 2010 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 10-503), Anchorage, Alaska.

INTRODUCTION

The Copper River supports one of the largest Chinook *Oncorhynchus tshawytscha* and sockeye salmon *O. nerka* subsistence fisheries in Alaska. Additionally, this resource is heavily utilized by commercial, sport, and personal use fisheries. Most Copper River Chinook salmon are harvested in an ocean commercial gillnet fishery from mid-May through August in the Copper River District (in and around the mouth of the Copper River). As of 15 September 2010, the estimated commercial harvest was 9,353 Chinook salmon, which was considerably less than the previous 10-year average of 37,300 Chinook salmon and was the smallest harvest in over 40 years. Subsistence and personal use fisheries occur within the Copper River drainage between Haley Creek and the confluence of the Slana River from mid-May through September. From 2004 to 2008, 2,007 and 3,162 Chinook salmon, respectively, were harvested during inriver subsistence and personal use fisheries (Bell, Botz, Brenner, Hollowell, and Moffitt 2010). Rod-and-reel sport fisheries harvest Chinook and sockeye salmon in tributaries of the upper Copper River (mainly the Gulkana, Klutina, and Tonsina rivers); however harvest reporting and analysis for 2010 had not been completed at the time this report was prepared. The sport fishery harvested 4,234 Chinook salmon annually on average from 2000 to 2009 (Somerville 2010b). Because of low 2010 early-season harvest rates in the commercial fishery, and low fish wheel catch rates by our assessment project, Chinook salmon retention was prohibited in the personal use fishery, and reduced from four to two fish in the sport fishery by ADF&G emergency order on 21 June. However, no management changes were made in the inriver State or Federal subsistence fisheries with regards to Chinook salmon retention.

The 2009-2011 Federal Subsistence Fisheries Regulations identify seasons, harvest limits, methods, and means related to taking of fish for subsistence uses as well as Federal public waters and customary and traditional use determinations (Federal Register 2009). There are two main areas in the Copper River drainage where subsistence fisheries take place: 1) Upper Copper River District (Chitina and Glennallen subdistricts), or all Federal public waters of the mainstem Copper River from the mouth of the Slana River downstream to an east-west line crossing the Copper River approximately 200 yards upstream of Haley Creek; and 2) Batzulnetas area, or Federal public waters of the Copper River and Tanada Creek between National Park Service regulatory markers. In the Upper Copper River District, salmon may only be harvested using fish wheels, dip nets and rod and reel. In the Batzulnetas area, salmon may be harvested using fish wheels, dip nets, rod and reel and fyke nets and spears (in Tanada Creek only). The fishing season for both areas typically runs from mid-May to the end of September.

Management of Copper River salmon is complex due to inter-annual variation in the size and timing of stocks, fisheries that target a mixture of stocks, and difficulties in estimating abundance due to the physical characteristics of the drainage. This is further confounded by the interplay of Federal and State government agencies in the management of this gauntlet of fisheries. The Alaska Department of Fish and Game (ADF&G) manages the commercial fishery to achieve an inriver salmon escapement goal, which is monitored at the Miles Lake sonar site, that includes a sustainable escapement goal of 300,000 to 500,000 wild sockeye salmon; a goal of 17,500 other salmon species to account for Chinook and other salmon passing the site; annually determined allocations for inriver subsistence, personal use, and sport harvest based on recent harvest levels; and annually determined allocations for hatchery broodstock and surplus based on forecasted returns. An estimated 924,010 salmon passed the Miles Lake sonar site between 20 May and 31 July 2010, which was 38.3% (256,009 fish) greater than the minimum anticipated count of 668,001 fish (ADF&G 2010).

From 1999-2004, ADF&G conducted radiotelemetry studies to derive the first system-wide estimates of Chinook salmon escapement to the Copper River (Evenson and Wuttig 2000; Wuttig and Evenson 2001; Savereide and Evenson 2002; Savereide 2004). Due to the project's high expense, ADF&G planned to terminate this telemetry-based, escapement-monitoring project after the 2001 season. The possible termination of the radio-tagging project highlighted the need for development of a long-term program to monitor Chinook salmon escapement in the Copper River. In early 2001, the Office of Subsistence Management (OSM) provided funding to the Native Village of Eyak (NVE) to undertake a three-year project with technical assistance from LGL Alaska Research Associates, Inc., and ADF&G. This work showed that accurate estimates of Chinook salmon escapement into the Copper River could be obtained using fish wheels and two-event mark-recapture techniques (Link, Nemeth, and Henrichs 2001; Smith, Link, and Lambert 2003; Smith 2004; Smith, Link, and Cain 2005). Fish wheels and mark-recapture techniques have been successfully used to generate system-wide salmon escapement estimates on numerous large rivers (Meehan 1961; Donaldson and Cramer 1971; Johnson, Marshall, and Elliot 1992; Arnason, Kirby, Schwarz, and Irvine 1996; Link English, and Bocking 1996; Cappiello and Bromaghin 1997; Gordon, Klosiewski, Underwood, and Brown 1998; Link and Nass 1999; Sturhahn and Nagtegaal 1999). Since the initial project, these methods have continued to be used annually on the Copper River (Smith and van den Broek 2005, 2006; Smith, van den Broek, and Wade 2007; van den Broek, Smith, and Wade 2008; van den Broek, Haluska, and Smith 2009, 2010).

This project addresses a priority information need for Federal subsistence fisheries management that was identified in the 2010 Fisheries Resource Monitoring Program (FRMP) request for proposals (OSM 2009). This report is the 2010 annual report to OSM for Fisheries Resource Monitoring Program project 10-503.

Objectives

The objective of this project was:

1. To estimate the annual inriver abundance of Chinook salmon returning to the Copper River from 2010 to 2013 such that the estimates are within 25% of the true value 95% of the time.

Study Area

The Copper River, which drains an area of more than 62,100 km^2 (24,000 mi^2), flows southward through south-central Alaska and enters the Gulf of Alaska near the town of Cordova (Figure 1). Between the ocean and Miles Lake (river km [rkm] 48), the river channel traverses the Copper River Delta, which is a large, highly braided, alluvial flood plain. A relatively high proportion of the Copper River's headwaters are glaciated (18% in 1995), resulting in very high unit discharge (volume per square kilometer of drainage area) and sediment loads (Brabets 1997). From 1988 to 1995, the annual mean discharge on the lower Copper River was 1,625 m^3/s (57,400 ft^3/s), with most flow occurring during the summer months from snowmelt, rainfall and glacier melt

(Brabets 1997). Over the same historical period, peak discharge in June ranged from 3,650 to 4,235 m^3/s while annual peak discharge ranged from 6,681 to 11,750 m^3/s. Water levels in Baird Canyon typically rise sharply from late May through June, level off in July, and then peak in August. Sediment loads make the water very turbid and fill the river with numerous ephemeral sandbars and channel braids for most of its length.

Two major channel constrictions in the lower Copper River between Miles Lake and the mouth of the Chitina River (rkm 172) were selected as marking and recapture sites since they offered the potential of making substantial proportions of the Chinook salmon run available to capture by fish wheels. Baird Canyon is the first major channel constriction on the Copper River upstream of Miles Lake and has been used for operating fish wheels to capture and mark Chinook salmon (Figure 2). The east bank of Baird Canyon is a steep, often sheer, rock wall that rises over 600 m (1,970 ft) above the river. The west bank slopes more moderately to a maximum height of 20 m above the river, is densely wooded, and has a substrate ranging from sand to boulders. The land beyond the west bank is primarily a wetland area that drains the Allen Glacier to the west. The north branch of the Allen River enters on the west bank and is the only major tributary entering Baird Canyon. Wood Canyon is the second major channel constriction on the Copper River upstream of Miles Lake and is located approximately 91 km upstream of Baird Canyon (Figure 3). The lower end of Wood Canyon, below the mouth of Canyon Creek and the lower boundary of the Chitina Subdistrict dip net fishery, was chosen as suitable location for operating fish wheels used to capture and recover marked Chinook salmon. The west bank in this area consists mostly of steep rock walls, whereas the east bank is a mix of sand bars, rock outcroppings, and rock walls.

Chinook and sockeye salmon begin to enter the Copper River in early to mid-May, as rising temperatures and water flush the ice from the river. Nearly all Chinook and sockeye salmon have entered the river by early August (Merritt and Roberson 1986; Evenson and Savereide 1999; Morstad, Sharp, Wilcock, Joyce, and Johnson 1999; Evenson and Wuttig 2000; Sharp, Joyce, Johnson, Moffitt, and Willette 2000). Most of the Chinook salmon run returns to six main tributaries in the upper Copper River, all of which are upstream of Baird and Wood canyons (Evenson and Savereide 1999; Evenson and Wuttig 2000).

METHODS

Project Mobilization

Hiring and Training

Preferred skills of potential candidates for the fisheries technician positions included: prior experience or formal education in either fisheries science or management, experience in salmon fisheries, experience working in a remote field camp, watercraft operation and maintenance or other technical skills, experience working with Alaska Native Tribes, and computer skills or record-keeping abilities. Staff from NVE conducted interviews and screened all the applicants. Six full-time technicians were hired, including four returning technicians, one of whom was a rural Alaskan native involved on the project since 2008. Several other local residents were hired temporarily throughout the season during field camp mobilization, peak sampling periods, and field camp de-mobilization. Preseason training consisted of an overview of the project and NVE policies; first aid/CPR certification; shotgun maintenance and safety training (including bear safety videos); an overview of Copper River salmon fisheries management; swift water rescue; and basic outboard motor maintenance and troubleshooting. Inseason training focused on fish wheel operation and maintenance, boat operation and maintenance, fish sampling and marking procedures, data entry, basic computer skills, communications equipment use, and field camp maintenance.

Permit Requirements

In order to access and operate both field camps and install the fish wheels on the Copper River (including anchoring them to a point on the shore), land-use permits were obtained from the U.S. Forest Service (USFS), Alaska Department of Natural Resources (Division of Mining, Land, and Water), Chugach Alaska Corporation, Eyak Corporation, and Ahtna Incorporated. Fish Resource Permits were also acquired from ADF&G for fish collection and sampling, and Fish Passage Permits from the Habitat Division for fish wheel operation. All permits were obtained prior to the start of the field season.

Fish Wheel Design and Construction

In 2010, two fish wheels (1 and 2) were operated at Baird Canyon (rkm 66) for marking, and two fish wheels (3 and 4) were operated at Canyon Creek (rkm 157) for recovering marks. Fish wheels 1, 2, and 3 were large aluminum models suited for fishing against deep canyon walls. Fish wheels 1 and 2 consisted of two, welded aluminum pontoons (11.6 m long x 0.9 m wide x 0.5 m deep), a 3.7 m long axle, three baskets (3.0 x 3.0 m x 2.1 m), and a tower (6.1 m high) and boom (4.9 m long) assembly that was used to raise and lower the axle. The baskets for fish wheels 1 and 2, used at Baird Canyon, were designed to fish up to about 3 m below the water surface and were lined with knotless nylon mesh (6.4 cm stretch). Fish wheel 3 was similar in design to fish wheels 1 and 2, except that it had shorter baskets (2.5 m deep) so it could be used in shallower depths. An aluminum tank (4.3 m long x 1.5 m deep x 0.6 m wide) for holding captured fish was fitted inside each pontoon. The bottom of each live tank was fitted with windows of extruded aluminum mesh to allow for ample water circulation. Fish wheel 4, at Canyon Creek, consisted of two aluminum pontoons (11.6 m long x 0.6 m wide x 0.5 m deep), four lumber and spruce pole baskets (2.0 m long x 1.8 m wide x 0.8 m deep), and a tower assembly designed to raise and lower the axle. The baskets were lined with knotless nylon mesh (6.4 cm stretch). As with the other fish wheels, each live tank was fitted with windows of extruded aluminum mesh.

In order to reduce the potential for high densities and crowding of fish in the live tanks, escape panels were installed in the live tanks of all project fish wheels. The escape panels consisted of two, adjustable vertical slots in a removable aluminum frame. When installed and opened to the appropriate width (6-7 cm), the escape panels allow smaller fish (e.g., sockeye and by-catch species) to easily swim out of the live tanks, while retaining Chinook salmon. As a result, the escape panels reduce crowding and the potential for sampling mortalities during high catch periods as well as the amount of crew labor for handling fish. Tests in 2004 indicated that the escape panels allowed 69-100% of sockeye salmon to escape from the live tanks, while retaining 100% of the adult Chinook salmon captured (Smith 2004).

Mobilizing the Field Camps

At Baird Canyon, a large main cabin and four small bunkhouse cabins serve as the field camp for crew members. The camp is located on the west bank of the Copper River approximately 2 km upstream from the upper end of Baird Canyon (Figure 2), and is supplied by helicopter, boat or plane from Cordova. The Canyon Creek camp, which is located on the east bank of the Copper River approximately 12 km downstream from Chitina (Figure 3), consists of three cabins, used as a kitchen, office and tool shed, and individual canvas wall tents for crew members. The camp is supplied primarily by boat from Chitina. Mobilization of both camps was timed to ensure that fish wheels could be installed and operated as soon as the river ice cleared and the first salmon began migrating past each location.

Camp Communication

The field crews followed a specific communication protocol to ensure that the camps were operated as safely and efficiently as possible. Each camp was equipped with a base-station VHF, several handheld VHF radios, Iridium satellite telephones, SPOT units, and a Starband satellite internet system (McLean, VA) that provided continuous high-speed internet access. These systems were powered by an array of 6-V batteries (wired to provide 12-V power). These arrays were charged by a combination of solar panels, wind turbines, and a gas-powered generator (for backup only). Each morning at a pre-arranged time, the crew leader from each camp was responsible for contacting the NVE office in Cordova via email to provide information on fish wheel catches, report mark and recovery data, place food and supply orders, arrange flights, and make crew changes. Most camp communications were conducted using the internet. Satellite phones and SPOT units were reserved for emergencies, instances where internet service was temporarily unavailable, or when personnel were away from the base camps for extended time periods. Crews were able to communicate camp needs in a timely and cost-effective manner, receive feedback on project operations from senior managers, and provide daily catch and marking updates needed by state and federal biologists and fishery managers.

Fish Wheel Operation and Catch

Fish Wheel Operation

Suitable fish wheel sites were selected based on water depth, water velocity, accessibility, bankfull width, and protection from floating debris and rock fall. For fish wheels 1 and 2, the two large-basket fish wheels used on this project, water depths greater than 3 m and velocities ranging from 0.5-1.5 m/s were needed to rotate the baskets at optimal speeds. Additionally, narrow, fast-flowing channels were favored for fish wheel placement since these areas tend to concentrate migrating salmon close to shore. Fish wheels 3 and 4 could operate in slower water velocities and shallower depths than the larger fish wheels. Also, the basket assembly of fish wheel 4 could be raised or lowered as water levels changed throughout the season.

Fish wheels 1 and 2 were installed and operated similar to the methods used in previous years. A rock drill was used to set steel anchor pins into the rock walls at the Baird Canyon fish wheel sites. Anchor lines attached to these pins consisted of galvanized wire rope (1.3 cm dia) and polypropylene rope (1.9 cm dia). To hold fish wheels 3 and 4 in place, rigging was attached to trees or other existing structures when available; or a boat anchor was buried 1.5 m deep on the river bank approximately 30 m upstream of the fishing site when no other stable anchorage existed. Wire rope (1.3 cm dia) was then attached to the fish wheel at one end and to the anchor at the other end. Wood-pole or aluminum-plank spars were used to hold the bow of each fish wheel off the river bank or cliff, and two, propeller-driven, outboard motors mounted on transoms at the stern of the fish wheel pontoons were used to move each fish wheel to and from fishing sites. Once on site and anchored, fish wheels were re-positioned upriver and downriver by adjusting the bow anchor lines, and laterally by adjusting the stern and side anchor lines or repositioning the spar.

All fish wheels were operated 24 hours per day except when they were being re-positioned or repaired, or to avoid fish mortalities when catches became too great to allow continuous overnight fishing. Fish wheel speed (revolutions per minute, RPM) was measured one or more times each day by determining the time required for the fish wheel baskets to complete three complete revolutions, thus averaging the effects of temporary surges in water velocity. If fish wheel speed was recorded more than once in a day, the arithmetic mean of the measurements was calculated. Daily water levels (m) at both camps were measured from an aluminum staff gauge that was secured to the canyon wall near the fish wheels.

Fish wheel Catch and Effort

Two forms of fish wheel effort were calculated. First, daily fishing effort was expressed as the number of hours a fish wheel operated during a 24 h calendar day from midnight to midnight. Second, the fishing effort used to calculate catch per unit effort *(CPUE)* was expressed as the number of hours a fish wheel operated to obtain a given day's catch (CPUE effort). These two effort values were often not the same for a given day because the live tanks were not always emptied of fish at the exact same time each evening. So, while daily fishing effort could never be more than 24 h, CPUE effort could be greater than 24 h. To calculate CPUE (the number of fish caught per fish wheel hour), the total number of fish captured on a given calendar day (since the last sampling session on the previous day) was divided by the CPUE effort (number of hours the fish wheel operated since last sampling session on the previous day). For example, if fish were last sampled at 2200 hours on day t and then at 2000 hours on day t+1, then only 22 h of fishing effort (CPUE effort) was used to calculate *CPUE* for day t+1 (assuming uninterrupted fish wheel operation between the last sampling periods on day t and that on day t+1). However, the daily fishing effort for day t+1 would be 24 h because the fish wheel operated continuously for the entire calendar day. CPUE effort for day t+2 would exceed 24 h if the last sampling session for day $t+2$ was later than 2000 hours, the time of the last sampling session for day t+1.

Mark Application and Recovery

Two to four times per day, depending on catches, crews at Baird Canyon and Canyon Creek removed all fish from the live tanks of each fish wheel. All fish were identified to species and counted. All Chinook salmon were sexed, measured for fork length (FL), inspected for presence of an adipose fin (a missing adipose fin indicated a hatchery-produced Chinook salmon marked with a coded-wire-tag) and examined for marks, scars or bleeding. Salmon were transferred with a dip net from the live tanks to a V-shaped, water-filled, foam-lined trough (with a fixed measuring tape) for sampling. Water in the trough was changed repeatedly throughout each sampling session.

At Baird Canyon, all Chinook salmon greater than 500 mm FL and in good condition were marked (up to a maximum of 100 per day) with a 134.2 kHz, passive radio frequency identification (RFID) transponder (ENSID Technologies Ltd., Auckland, New Zealand). Each transponder was encapsulated on a T-bar style tag with two, 25 mm monofilament lines that terminated in perpendicular 9 mm anchor bars, which is referred to as a T-bar anchor-passive integrated transponder tag (TBA-PIT tag; Hallprint Pty Ltd., Adelaide South Australia). NVE's address and phone number were printed on a 45 mm piece of yellow PVC marker. Unique tag numbers were electronically encoded and read via a personal digital assistant (PDA; Aceeca Meazura) with an integrated RFID scanner (EditID). An external tag number was also printed on the tag in case the PIT tag was damaged or the PDA malfunctioned. The TBA-PIT tag was a new technology specially designed and constructed for this project. They were supplied in magazine clips of 20 tags each, and were applied to salmon using a hand held applicator gun with a 16 gauge needle. The tip of the needle was sunk into the musculature of the fish 1-2 cm ventral to the insertion of the dorsal fin between the third and fourth pterygiophores (the bones supporting the dorsal fin), to a depth of 1-2 cm, so that the tag anchors would lodge behind the pterygiophores within the dorsal musculature when ejected from the applicator gun. Each tagged Chinook salmon also received a secondary mark consisting of small hole punched in the right operculum, used to identify any Chinook salmon that had lost their TBA-PIT tag.

In addition to the sampling procedures described previously, all Chinook salmon caught in the Canyon Creek fish wheels were physically examined for a TBA-PIT tag or operculum punches. A PDA with a built in RFID scanner was used to record the unique identification number of each TBA-PIT tag. If the tag number could not be scanned into the PDA, technicians manually entered the externally printed TBA-PIT tag number into the PDA. All tags were then clipped in half, retaining the RFID component for future use, while leaving the remaining portion of the tag anchored in the salmon to provide a mark for Chinook salmon recaptured a second time. Since TBA-PIT tags were external and easily seen, and each Chinook salmon was handled by the crew, it is unlikely that any captured Chinook salmon that was previously marked escaped detection by the technicians. All Chinook salmon captured in the Canyon Creek fish wheels were also marked with a small hole punched in the left operculum, which allowed them to be identified in case they were captured again.

Inriver Abundance Estimates

Conditions for a Consistent Abundance Estimate

Two-sample mark-recapture methods were used to estimate the inriver abundance of adult Chinook salmon above the Baird Canyon fish wheels. This abundance estimate is potentially biased if any of the following five assumptions inherent to the mark-recapture model are violated (Ricker 1975; Seber 1982): (1) handling will not make fish more or less vulnerable to recapture than unhandled fish; (2) tagged fish do not lose their tags and there is no mortality of tagged fish between events; (3) marked fish will mix completely with unmarked fish across the river; (4) fish will have equal probabilities of being marked or equal probabilities of being recaptured regardless of size or sex; and (5) fish will have equal probabilities of being marked or equal probabilities of being recaptured, regardless of time.

Handling will not make fish more or less vulnerable to recapture than unhandled fish.

There was no explicit test for this assumption because we could not assess the behavior of Chinook salmon that were captured and handled or compare their behavior to that of Chinook salmon that had not been captured and handled. However, sampling sessions were frequent (two to four times per day) to ensure that fish were not retained in the live tanks for long periods of time. Also, escape panels were used to reduce fish densities in the live tanks by allowing Chinook salmon smaller than 500 mm FL as well as small individuals of other species to escape. Technicians were trained by experienced biologists on how to handle and sample Chinook salmon in order to reduce stress and injury, and any visibly stressed or injured fish were released without being marked. Additionally, the distance between the marking and recapture sites (91 km) was assumed to provide sufficient time for marked Chinook salmon to recover from handling effects that could cause "trap happiness" or "trap shyness". Finally, to examine the possibility that handling and marking Chinook salmon delayed their upriver migration, we collected information on the number of days at large for all marked Chinook salmon captured at Canyon Creek.

Tagged fish did not lose their tags, and there was no mortality of tagged fish between events.

The likelihood of lost marks was greatly reduced through the application of both a primary (TBA-PIT tag) and a secondary (operculum punch) mark on all Chinook salmon marked at Baird Canyon. All Chinook salmon captured at Canyon Creek that had either a TBA-PIT tag or just a right operculum punch were included in calculations of abundance. Chinook salmon captured at Canyon Creek with a secondary mark, but no primary mark, were also used to quantify TBA-PIT tag loss. Although not tested, there do not appear to be any factors that might lead us to think mortality between sampling events was unequal for marked and unmarked Chinook salmon. Finally, the effect on abundance estimates of immigration of unmarked Chinook salmon into and emigration of marked Chinook salmon out of the population between sampling events would be the same as that resulting from greater mortality of marked Chinook salmon (that is, abundance estimates would be biased upwards). However, immigration and emigration could not occur since there is no way for Chinook salmon to either enter or leave the mainstem Copper River between the marking and recovery sites. Even if Chinook salmon spawned in the mainstem between marking and recovery sites, which would be equivalent to mortality or emigration, the abundance estimate would be unbiased as long as the probability for this occurrence was the same for marked and unmarked Chinook salmon.

Marked fish will mix completely with unmarked fish across the river.

The opportunity for complete mixing of marked and unmarked Chinook salmon between sampling events seems to be enhanced by the highly braided nature of some sections of the Copper River between Baird Canyon and Canyon Creek. Results from previous years of this study have shown that recapture rates for Chinook salmon marked at Baird Canyon and recaptured at Canyon Creek were independent of the bank of capture. Furthermore, studies from

1999-2001 showed equal mixing of marked and unmarked Chinook salmon between the lower end of Wood Canyon and the Chitina Subdistrict subsistence fishery (Evenson and Wuttig 2000; Wuttig and Evenson 2001; Savereide and Evenson 2002), a much shorter distance than between the Baird Canyon and Canyon Creek fish wheels. Contingency tables and Chi-square tests could not be used to compare mark and recapture rates by bank of capture in 2010 for Chinook salmon because the recapture fish wheels at Canyon Creek were restricted to operation on the east bank due to river conditions.

Fish will have equal probabilities of being marked or equal probabilities of being recaptured regardless of size or sex.

We tried to distribute fishing effort between fish wheels and river banks (spatially) so that all Chinook salmon in the population would have equal probabilities of being marked or recaptured regardless of size or sex. The validity of this assumption was examined with Kolmogorov-Smirnov (K-S) two-sample tests (Zar 1984) to compare the cumulative length-frequency distributions of: (1) Chinook salmon marked during the first sampling event and those recaptured during the second event; and (2) Chinook salmon marked during the first sampling event and those examined during the second event (as presented in Bernard and Hansen 1992).

We could not test for sex selectivity because the determination of sex on live adult salmon is highly subjective at certain life stages and relies on personal interpretation of physical attributes by the research technicians. For example, fish sex as reported on tag harvest forms by voluntary fishery participants is often inconsistent with what is reported by research technicians at the time of tagging. Any efforts to compare the proportion of males to females between the capture and recovery fish wheels would be confounded by inaccurate recording of fish sex.

Fish will have equal probabilities of being marked or equal probabilities of being recaptured regardless of time.

To increase the potential for equal marking probability throughout the run, fishing effort at the Baird Canyon fish wheels was continuous throughout the study period apart from minor fish wheel stoppages for repairs and moves. Period-specific mark rates in the second sampling event were compared using contingency table analysis to determine whether Chinook salmon had equal probabilities of being recaptured regardless of when they were marked. Period-specific recapture rates in the second event were also compared using contingency table analysis to determine whether marked Chinook salmon had equal probabilities of being recaptured regardless of when they passed the recapture site. If both the mark and recapture rates varied among periods and a sufficient number of recaptures were available, a temporally stratified estimator was used to estimate abundance.

Abundance Estimate

One of two models was considered for calculating mark-recapture abundance estimates: the pooled Petersen estimator (PPE) with Chapman's correction (Seber 1982) or the stratified Petersen estimator that is referred to as the Darroch maximum likelihood estimator (MLE; Darroch 1961), in which capture probabilities vary. Schwarz and Taylor (1998) provide thorough descriptions of both models. The PPE pools all data from the sampling season to estimate abundance, whereas the MLE stratifies the data into groups with similar capture or movement probabilities to estimate abundance. The abundance estimate was calculated using SPAS software (Arnason, Kirby, Schwarz, and Irvine 1996).

RESULTS

Project Mobilization

Mobilization of the Baird Canyon camp began on 6 May. Six technicians, one project manager, one biologist, one Starband satellite internet system installation technician, and gear were flown to camp on several round-trip flights via helicopter (Robinson 44; Alpine Air, Cordova). Partially open water and ice were present throughout the Copper River from above Baird Canyon at the Bremner River confluence downstream to the Mile 27 and Mile 38 bridges. Miles Lake was ice locked and not navigable by boat until approximately 26 May. Snow cover was approximately 3.6 m deep upon arrival at camp and much of the equipment was buried but in good condition. Fish wheel 1 was placed into operation on 15 May, followed by fish wheel 2 on 28 May.

Mobilization of the Canyon Creek camp began on 9 May. Equipment, boats, and vehicles were moved from storage locations in Cordova to the camp site using trucks and jet boats. Most equipment was stored at the camp in cabins that were constructed on-site in the fall of 2009. This allowed a considerable reduction in mobilization effort as well as costs for transportation and local accommodation in Chitina during mobilization relative to previous years. Fish wheels 3 and 4 required substantial repairs. Due to regular wear-and-tear during the previous season, the baskets on fish wheel 3 had to be repaired and re-webbed. Fish wheel 4 required new bow decking and four new baskets. Fish wheel 4 was placed into operation on 17 May, followed by fish wheel 3 on 26 May.

Fish Wheel Operation and Catch

Fish Wheel Operation

Stage height of the Copper River at Baird Canyon varied by 4.5 m from 20 May to 5 July (Figure 4). At Canyon Creek, stage height varied by 1.68 m from 20 May to 15 July. Water levels rose slowly in late May, increased quickly in early June, and fluctuated throughout the remainder of the season. Stage height peaked at 3.0 m on 1 July at Baird Canyon and at 1.5 m 30 June at Canyon Creek. In 2010, daily stage height measurements of the Copper River at the Million Dollar Bridge were above historical mean values from late May to mid-June, but remained close to historical mean values for the remainder of the season (Figure 5).

Fish wheel 1 operated on the west bank of Baird Canyon for 1,030 h (84.4% of the total possible operating time) from 15 May to 5 July (Figure 6; Appendix A). Fish wheel 2 operated on the east bank of Baird Canyon for 835 h (99.6% of the total possible operating time) from 28 May to 2 July. Fish wheel speeds averaged 2.5 and 2.1 RPM for fish wheels 1 and 2, respectively (Figure 6; Appendix A).

At Canyon Creek, fish wheel 3 operated along the east bank of the Copper River, approximately 2.5 km downstream from the mouth of Canyon Creek, for 1,078 h (99.9% of the total possible operating time), from 26 May to 10 July (Figure 6; Appendix A). Fish wheel 4 operated primarily on the east bank, approximately 100 m downstream from the mouth of Canyon Creek, for 1,356 h (97.7% of the total possible operating time) from 17 May to 15 July. Fish wheel speeds averaged 2.2 and 3.8 RPM for fish wheels 3 and 4, respectively (Figure 6; Appendix A).

Fish wheel Catch

Of the 2,348 adult Chinook salmon captured at the Baird Canyon fish wheels, 1,551 were captured at fish wheel 1 and 797 at fish wheel 2 (Figure 7; Appendix B). Total daily catch peaked at 255 Chinook salmon on 3 June. Daily CPUE peaked at 22.8 and 5.6 Chinook salmon per hour at fish wheels 1 and 2, respectively (Figure 8; Appendix B). Four Dolly Varden *Salvelinus malma*, 603 adult sockeye salmon, 1 Pacific lamprey *Lampetra tridenta,* 8 whitefish *Coregonus spp.*, 1 salmon smolt *O. sp.*, and 1 sucker *Catostomus sp.*, were also captured and released.

Of the 917 Chinook salmon captured at the Canyon Creek fish wheels, i367 were captured at fish wheel 3 and 550 at fish wheel 4 (Figure 9; Appendix B). Daily catch peaked at 82 Chinook salmon on 12 June. Daily CPUE peaked at 1.08 and 2.99 Chinook salmon per hour at fish wheels 3 and 4, respectively (Figure 10; Appendix B). Six salmon smolts, 502 adult sockeye salmon, 32 whitefish, 8 suckers, and 2 steelhead *O. mykiss*, were also captured and released.

Mark Application and Recovery

Of the 2,348 Chinook salmon that were captured at the Baird Canyon fish wheels, 1,745 (74.3%) were marked with both a TBA-PIT tag and right operculum punch prior to being released (Figure 11; Appendix C). The number of Chinook salmon marked and released on a single day peaked at 100 on six days: 29 and 31 May; and 1, 3, 8, and 9 June. A total of 603 Chinook salmon were not marked: 365 were released voluntarily because the daily quota had been reached, 90 escaped prior to being sampled, 144 were visibly injured or stressed, 3 died prior to sampling, and 1 was released because it measured less than 500 mm FL.

A total of 917 Chinook salmon were examined for marks at the Canyon Creek fish wheels; while 10 Chinook salmon escaped prior to being thoroughly examined (Figure 12; Appendix C). Of those examined, 69 (7.5%) had been marked at Baird Canyon. The first recovery of marked Chinook salmon at Canyon Creek occurred on 30 May, and consisted of two individuals captured at fish wheel 1 and one marked on 23 and 26 May. The last recovery of marked Chinook salmon at Canyon Creek occurred on 15 July, and consisted of one individual captured and marked at fish wheel 1 on 21 June. The number of Chinook salmon examined for marks at Canyon Creek peaked at 82 on 12 June, and the number of recaptures peaked at 6 on that same day. The median travel time for Chinook salmon tagged at Baird Canyon to be recaptured at Canyon Creek was 9.1 d (range: 4.3-28.6 d; Figure 13).

Inriver Abundance Estimate

Conditions for a Consistent Estimator

We had no way to compare migratory behavior or mortality of marked and unmarked Chinook salmon to determine whether marking affected catchability or mortality. However, we did record the occurrence of multiple recaptures of marked Chinook salmon to examine the possibility of marking delaying migration or making marked fish more susceptible to capture. Of the 1,745 Chinook salmon marked and released at the Baird Canyon fish wheels, only 97 (5.6%) were subsequently captured in these fish wheels a second time, and 3 (0.2%) were captured a third time. Of these (n = 99; no date was recorded for one capture event), 54 (54.5%) were recaptured within 1 d and 88 (88.9%) were recaptured within 5 d (Figure 14). For one fish, the period between capture events was 26 d. Based on this information, we assumed that marking may not have appreciably delayed the migration of most marked Chinook salmon or made them more prone to capture in fish wheels.

Information collected during 2010 indicated that Chinook salmon did not lose their marks between sampling events. No Chinook salmon were captured at Canyon Creek with a right operculum punch and without a TBA-PIT tag.

We were unable to test the assumption that marked fish mixed completely with unmarked fish between sampling events. In prior years this was accomplished by examining the movement of marked Chinook salmon between river banks. In 2010, fish wheels 3 and 4 had to be operated on the east bank due to river conditions, so we were unable to examine movement between banks between Baird Canyon and Canyon Creek. However, since 2001, Chinook salmon in all years did appear to move equally between banks, which suggests that mixing of marked and unmarked fish occurs between sampling events.

Based on cumulative length-frequency distribution comparisons, it appeared that no size selectivity occurred during the second sampling event, although it did occur during the first sampling event. No significant difference was found between cumulative length-frequency distributions of Chinook salmon marked during the first sampling event and those recaptured during the second event (D_{max} = 0.072, P = 0.90; Figure 15). In contrast, a significant difference was found between cumulative length-frequency distributions of Chinook salmon marked during the first event and those examined for marks in the second event (D_{max} = 0.098, P = 0.00). Based on these results, no stratification by size was necessary to estimate abundance. All size classes appeared to be represented at both sample sites and thus were included to estimate abundance.

Daily capture statistics showed some variability in the mark and recapture rates over the study period (Figures 16 and 17). However, period-specific mark rates in the second sampling event were statistically similar (χ^2 = 2.3, df = 6, P = 0.89) which indicated that Chinook salmon had equal probabilities of being recaptured regardless of when they were marked (Table 1). Similarly, period-specific recapture rates in the second sampling event were not significantly different (χ^2 = 4.9, df = 5, P = 0.43) which indicated that marked Chinook salmon had equal probabilities of being recaptured regardless of when they passed the recapture site (Table 1). The results of these tests indicated that a PPE model was an appropriate way to estimate abundance.

Abundance Estimate

Using a PPE estimator, the number of Chinook salmon measuring 500 mm FL or greater that migrated upstream of Baird Canyon from 15 May to 5 July was 22,323 (SE = 2,492; CI = 17,438-27,207; Table 2).

Other TBA-PIT Tag Recoveries

Ninety-six Chinook salmon (5.5% of total marked) were reported harvested by the various Copper River fisheries (Table 3). Recoveries included: 5 in the sport fishery, 36 in the combined federal and state subsistence (primarily fish wheel) fisheries, 17 in the personal use dip net fishery, and 38 where the specific fishery was not reported.

DISCUSSION

Project Mobilization

In May 2010, river ice at Baird Canyon was similar to that experienced in previous years, but snow cover, which was just over 3.6 m deep was considerably more than that encountered in previous years. It took approximately 9 d from the time the Baird Canyon crew arrived at camp (6 May) to successfully deploy both fish wheels (15 May). This was the same time needed in 2005 and 2009 (9 d), but considerably faster than the time it took to mobilize in 2004 (21 d), 2006 (18 d), 2007 (16 d) and 2008 (13 d) when less extreme environmental conditions were encountered. Efficiency and refinement of mobilization procedures has expedited our fish wheel deployments. The first fish wheel was launched and began fishing on 13 May, followed by fish wheel 2 (28 May). Fish wheel 2 was delayed due to low river level and changing conditions at the fishing site.

As in previous years, the Canyon Creek fish wheels were stored intact at the camp site. Extensive repairs to both fish wheels were required prior to sampling. Between repairs, logistics of preparing fish wheels, and establishment of camp, it took approximately 8 d from the first day of mobilization on 9 May until the first wheel was actively fishing on 17 May. Camp preparation was delayed approximately 3 d due to the complete rebuilding of fish wheel 4 and the resulting need to haul equipment and materials to make those repairs. With the addition of three multi-use cabins at Canyon Creek, storage of equipment was done on site, which improved mobilization efforts overall. Also, due to the low river levels, fish wheels had to be moved over a longer distance for deployment, and a large volume of remaining shelf ice had to be broken down using hand tools to allow passage. This added at least 2 d to the mobilization effort. The timing and execution of mobilization at both camps was reasonable given the environmental conditions in early May, and we feel confident that the fish wheels began operating before the beginning of the Chinook salmon run since no catches were made until several days after fishing began.

Data Collection

In 2010, weatherproof PDA units with integrated RFID-PIT-tag scanners were used with updated software designed specifically for the needs of this project. This greatly reduced the amount of time expended due to equipment failures and lessened the chances of data loss or data-entry errors. However, some issues with the weatherproof PDA units persisted in 2010, which necessitated the use of hand-logging data on paper on several occasions in order to back-up the electronic data. These issues were partially attributed a faulty seal within some of the weatherproof PDA's, and minor bugs in the sampling software.

Fish wheel Operation and Catch

The first four commercial fishing openings (13, 17, 20, and 26 May) in the Copper River District, resulted in harvest of 9,353 Chinook salmon, which was well below the 10 year average of 32,825 and the smallest recorded in 40 years. The Miles Lake sonar indicated that few salmon were entering the Copper River, since only 46,283 fish were counted through 28 May versus an anticipated 110,091 fish. The poor commercial fishery performance and low salmon entry patterns resulted in the commercial fishery being closed until 7 June. Additionally, the commercial fishery was closed inside the barrier islands, as per State regulations in 5AAC24.350(1)(B), except for the first two openings to provide opportunities for Chinook salmon escapement into the Copper River. Despite the inside closures, the Chinook salmon escapement was poor. Potential factors contributing to ongoing low Chinook salmon escapements into the Copper River include a 100-year flood on the Copper River in 2006 that affected smolt migration and spawning habitat for the 2007 broodstock, the Pacific Decadal Oscillation shift away from favorable environmental conditions for Chinook salmon production, and Chinook salmon by-catch in the Bering Sea pollock fishery. The 2,348 Chinook salmon caught at Baird Canyon fish wheels in 2010 was the lowest total since 2003 and mirrored the low commercial fishery Chinook salmon harvest.

At the Canyon Creek fish wheels, Chinook salmon catches in 2010 (917 fish) were 63% lower than in 2009 (2,465 fish) and the lowest obtained since 2002. The substantial reduction in catches was mainly attributable to difficulties in finding a suitable fishing site for fish wheel 4, higher than average water levels from May to mid-June, and, conversely, lower than average water levels from mid-June through July. Due to the October 2006 100-year flood, depth and velocity conditions at several sites used previously for fish wheel 4 were unsuitable for use in 2010, making it necessary to find and use an entirely new site. At times the fish wheels were shut down and moved to more suitable locations. On 6 June, fish wheel 4 was relocated about 200 m downstream from the mouth of Canyon Creek. In addition to these factors, low catch rates were also likely due to low Chinook salmon abundance.

Abundance Estimate

Abundance estimates for Chinook salmon (22,323; CV = 11.2%) in 2010 appeared unbiased and exceeded the precision levels specified in the study objectives of estimates being within 25% of the true value 95% of the time. The spawning escapement goal set by the Board of Fisheries for the Copper River is 24,000 or more Chinook salmon. When the number of Chinook salmon harvested in the Glennallen Subdistrict (preliminary estimate = 2,320) and in the sport and personal use fishery (preliminary estimate = 2,500-3,000; M. Sommerville 2010a, pers. comm.) is subtracted from our abundance estimate, the 2010 spawning escapement was estimated to be about 17,003-17,500 Chinook salmon. This is well below the minimum escapement goal of 24,000 Chinook salmon. While some Chinook salmon were also taken in the Chitina Subdistrict dip net fishery, the harvest was assumed to be very small since this fishery was closed to Chinook salmon retention by emergency order beginning 15 June.

CONCLUSIONS

Despite the numerous and often significant challenges encountered during this study, it has continued to provide Chinook salmon abundance estimates that meet or exceed the project objective. Drainage-wide abundance estimates of Chinook salmon have been generated consistently and reliably for eight years, and the project has evolved into an important fishery management tool. This work has made NVE an integral part of Copper River salmon research and management, and has shown that agencies and organizations (e.g., USFWS, NVE, and ADF&G) can successfully work together to collect valuable data on Copper River salmon stocks. This project has demonstrated that fish wheels and mark-recapture methods can be used to estimate the inriver abundance of Chinook salmon on the Copper River and that this information is of great value in assessing management practices.

RECOMMENDATIONS

In light of the preceding discussion and the fact that this project has been funded through 2013, the following recommended were developed for the 2011 field season:

(1) Improve the inriver reporting of harvested marked and unmarked Chinook salmon within the Chitina and Glennallen subdistricts. Much public testimony provided to the Board of Fisheries, Federal Subsistence Board, and associated advisory bodies suggests that harvest estimates for the inriver fisheries of the Copper River are less than actual harvests. The effects of this problem on mark recoveries and total run estimates are not known. In 2008, NVE submitted a Monitoring Program project proposal to fund outreach efforts that would improve public awareness of the marking project in an attempt to increase the percentage of marked Chinook salmon reported to investigators. We would like to implement some of these ideas under the current budget framework.

(2) Operate fish wheels 1 and 2 at the same sites used in 2010. Fish wheels 3 and 4 at Canyon Creek are typically relocated throughout the season and from year to year to adapt to changing river conditions. River conditions in the Canyon Creek area have been more variable since the fall flood in 2006. Deploying a third fish wheel at Canyon Creek to improve recapture rates is a possibility, if additional suitable fishing sites can be found.

(3) In 2010, NVE attempted to operate Baird Camp with three technicians, which was considerably more challenging than expected and led to several potentially unsafe situations

and logistical difficulties in meeting project objectives. In 2011, four technicians should be hired to run the Baird Camp.

(4) Continue monitoring ice and snow conditions at Baird Canyon through April and early May in order to assess the best time, labor requirements, and transportation logistics to mobilize this camp. Plan on the Baird Canyon crew starting about 5 May and the Canyon Creek crew about 14 May. Baird Canyon should be mobilized in time to have the first fish wheel launched and fishing immediately following break-up and clearing of river ice above Miles Lake, and Canyon Creek should be mobilized in time to have the first fish wheel launched and fishing within 2 d of the first tagged Chinook salmon release.

(5) Continue to hire technicians locally as NVE employees to assist with fish wheel construction, transportation, installation, operation, inseason maintenance, fish sampling, and data collection. This has benefited both project operations as well as the local community.

ACKNOWLEDGMENTS

We would like to acknowledge the dedication and efforts of camp leads Danielle McPhee, and Julius Koenig as well as fisheries research technicians Joshua Rines, Joel Shute, Miranda Johnson and David Hippenhammer. Without their hard work, this project would not have been possible. Bruce Cain, Autumn Bryson, Mark King, Scott Madison, Erin Shew (VISTA), the 2010 trail crew, Megan Urton (Intern), and several locally hired temporary employees provided valuable project support. Tim Nelson installed Starband satellite internet communications. Lenny Peterson (Peterson Welding and Machine, Cordova) assisted with inseason repairs to fish wheels and equipment. Air support was provided by Alpine Aviation, Alaska Wilderness Air, and Cordova Air. David Hall (Hallprint Pty Ltd and ENSID Technologies Inc.) provided invaluable technical support in the continuing development and implementation of new TBA-PIT-tag technology. This project (FIS10-503) was funded through the Fisheries Resource Monitoring Program, administered by the U.S. Fish and Wildlife Service, Office of Subsistence Management. This project is a cooperative effort between the U.S. Fish and Wildlife Service, Native Village of Eyak, LGL Alaska Research Associates, Inc., and Alaska Department of Fish and Game. This annual report partially fulfills obligations for FWS Cooperative Agreement Number 70181AJ038.

LITERATURE CITED

ADF&G. 2010. Commercial fisheries news release. Retrieved on 24 September 2010 from the Alaska Department of Fish and Game, Commercial Fisheries Division webpage: http://csfish.adfg.state.ak.us/newsrelease/select.php?dist=CDV.

Arnason, A. N., C. W. Kirby, C. J. Schwarz, and J. R. Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapements and other populations. Canadian Technical Report of Fisheries and Aquatic Sciences 2106: vi + 37.

Bell, J., J. Botz, R. Brenner, G. Hollowell, and S. Moffitt. 2010. 2008 Prince William Sound area finfish management report. Alaska Department of Fish and Game, Fishery Management Report No. 10-45, Anchorage.

Bernard, D., and P. A. Hansen. 1992. Mark-recapture experiments to estimate the abundance of fish. Alaska Department of Fish and Game, Division of Sport Fish, Special Publication No. 92-4, Anchorage.

Brabets, T. P. 1997. Geomorphology of the lower Copper River, Alaska. United States Geological Survey, U.S. Geological Survey Professional Paper 1581, Denver.

Cappiello, T. A., and J. F. Bromaghin. 1997. Mark-recapture abundance estimates of fall-run chum salmon in the Upper Tanana River, Alaska, 1995. Alaska Fishery Research Bulletin 4(1): 12-35.

Darroch, J. N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48: 241-260.

Donaldson, I. J., and F. K. Cramer. 1971. Fishwheels of the Columbia. Binfords and Mort Publishers, Portland. 124 p.

Evenson, M. J., and J. W. Savereide. 1999. A historical summary of harvest, age composition, and escapement data for Copper River Chinook salmon, 1969-1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-27, Anchorage.

Federal Register. 2009. Subsistence management regulations for public lands in Alaska-2009-10 and 2010-11 Subsistence Taking of Fish Regulations. Federal Register 74 (59), Monday, March 30, 2009, Rules and Regulations. Retrieved on 1 January 2011 from the Federal Subsistence Management Program, US Fish and Wildlife Service, Office of Subsistence Management webpage: http://alaska.fws.gov/asm/pdf/fedreg/fr033009.pdf.

Evenson, M. J., and K. G. Wuttig. 2000. Inriver abundance, spawning distribution, and migratory timing of Copper River Chinook salmon in 1999. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 00-32, Anchorage.

Gordon, J. A., S. P. Klosiewski, T. J. Underwood, and R. J. Brown. 1998. Estimated abundance of adult fall chum salmon in the Upper Yukon River, Alaska, 1996. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report No. 45, Fairbanks.

Hollowell, G., and M. A. Sommerville. 2008. Management of salmon stocks in the Copper River, report to the Alaska Board of Fisheries: December 1-7, 2008, Cordova, Alaska. Alaska Department of Fish and Game, Divisions of Sport Fish and Commercial Fisheries, Special Publication No. 08-15.

Johnson, R. E., R. P. Marshall, and S. T. Elliot. 1992. Chilkat River Chinook salmon studies, 1991. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 92-49, Anchorage, AK.

Link, M. R., K. K. English, and R. C. Bocking. 1996. The 1992 fishwheel project on the Nass River and an evaluation of fishwheels as an inseason management and stock assessment tool for the Nass River. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2372: x + 82.

Link, M. R., and B. L. Nass. 1999. Estimated abundance of Chinook salmon returning to the Nass River, B.C., 1997. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2475: xi + 64.

Link, M. R., M. J. Nemeth, and R. Henrichs. 2001. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River. U.S. Fish and Wildlife Service, Office of Subsistence Management, Anchorage.

Meehan, W. R. 1961. The use of a fishwheel in salmon research and management. Transactions of the American Fisheries Society 90: 490-494.

Merritt, M. F., and K. Roberson. 1986. Migratory timing of upper Copper River sockeye salmon stocks and its implications for the regulation of the commercial fishery. North American Journal of Fisheries Management 6: 216-225.

Morstad, S., D. Sharp, J. Wilcock, T. Joyce, and J. Johnson. 1999. Prince William Sound management area 1998 annual finfish management report. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A99-20, Anchorage.

OSM. 2009. Priority information needs, federal subsistence fisheries, 2010 Fisheries Resource Monitoring Program. Office of Subsistence Management, Fisheries Information Services Division, U.S. Fish and Wildlife Service, Anchorage.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191. 382 p.

Savereide, J. W. 2005. Inriver abundance, spawning distribution and run timing of Copper River Chinook salmon, 2002-2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-50, Anchorage.

Savereide, J. W., and M. J. Evenson. 2002. Inriver abundance, spawning distribution, and migratory timing of Copper River Chinook salmon in 2001. Alaska Department of Fish and Game, Fishery Data Series No. 02-28, Anchorage.

Schwarz, C. J., and C. G. Taylor. 1998. Use of the stratified-Petersen estimator in fisheries management: estimating the number of pink salmon (*Oncorhynchus gorbuscha*) spawners in the Fraser River. Canadian Journal of Fisheries and Aquatic Sciences: 281-296.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, 2nd edition. Charles Griffin and Company, Ltd., London. 654 p.

Sharp, D., T. Joyce, J. Johnson, S. Moffitt, and M. Willette. 2000. Prince William Sound management area: 1999 annual finfish management report. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A00-32, Anchorage, AK.

Smith, J. J. 2004. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River, 2003 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 01-020), Anchorage, Alaska.

Smith, J. J., M. R. Link, and B. D. Cain. 2005. Development of a long-term monitoring project to estimate abundance of Chinook salmon in the Copper River, Alaska, 2001-2004. Alaska Fishery Research Bulletin 11(2): 118-134.

Smith, J. J., M. R. Link, and M. B. Lambert. 2003. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River, 2002 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 01-020), Anchorage, Alaska.

Smith, J. J., and K. van den Broek. 2005. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River, 2004 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 04-503), Anchorage, Alaska.

Smith, J. J., and K. van den Broek. 2006. Estimating Chinook salmon escapement on the Copper River, 2005 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 04-503), Anchorage, Alaska.

Smith, J. J., K. M. van den Broek, and G. Wade. 2007. Estimating Chinook salmon escapement on the Copper River, 2006 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 04-503), Anchorage, Alaska.

Sommerville, M. 2010a. Summary of king salmon harvests and upriver escapement in the Copper River 1990-2010 (pers. comm.) Alaska Department of Fish and Game, Division of Sport Fish.

Sommerville, M. 2010b. Summary data for the 2009 state of Alaska upper Copper and upper Copper and upper Susitna area subsistence, personal use, and sport fisheries. Alaska Department of Fish and Game, Division of Sport Fish.

Sturhahn, J. C., and D. A. Nagtegaal. 1999. Results of the Chinook assessment study conducted on the Klinaklini River during 1998. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2497: x + 18.

van den Broek, K. M., T. Haluska, and J. J. Smith. 2009. Estimating the inriver abundance of Copper River Chinook salmon, 2008 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 07-503), Anchorage, Alaska.

van den Broek, K. M., T. Haluska, and J. J. Smith. 2010. Estimating the inriver abundance of Copper River Chinook salmon, 2009 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 07-503), Anchorage, Alaska.

van den Broek, K. M., J. J. Smith, and G. Wade. 2008. Estimating the inriver abundance of Copper River Chinook and sockeye salmon, 2007 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 07-503), Anchorage, Alaska.

Wuttig, K. G., and M. J. Evenson. 2001. Inriver abundance, spawning distribution, and migratory timing of Copper River Chinook salmon in 2000. Alaska Department of Fish and Game, Fishery Data Series No. 01-22, Anchorage.

Zar, J. H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall, Inc., New Jersey. 718 p.

TABLES

Table 1. Capture history of Chinook salmon that were marked, examined, and recaptured at the Copper River fish wheels, 2010.

	Period of Recapture											
Period of Marking	5/26-6/1	6/2-6/8	6/9-6/15	6/16-6/22	6/23-6/29	6/30-7/6	7/7-7/15	7/14-7/15	Recaptured	Not Recaptured	Marked	Recapture Rate
5/17-5/23	1	1							**2**	**7**	9	0.222
5/24-5/30	3	5	3						**11**	**237**	248	0.044
5/31-6/6		8	11	4					**23**	**569**	592	0.039
6/7-6/13			6	6	2	3			**17**	**502**	519	0.033
6/14-6/20				1		3	2		**6**	**87**	93	0.065
6/21-6/27					1	1	1	1	**4**	**131**	135	0.030
6/28-7/4							3		**3**	**144**	147	0.020
7/5									**0**	**2**	2	0.000
Unknown						1	2		3			
Marked	**4**	**14**	**20**	**11**	**3**	**8**	**8**	**1**	69	1,676	1,745	0.040
Unmarked	**54**	**163**	**303**	**111**	**34**	**75**	**81**	**4**	825			
Examined	58	177	323	122	37	83	89	5	894			
Mark rate	0.069	0.079	0.062	0.090	0.081	0.096	0.090	0.200	0.077			

Note: Chi-square tests for heterogeneity were performed for cells with bold text. Cells with expected values less than 1.0 were pooled with adjacent cells.

Table 2. Estimated inriver abundance of Chinook salmon above Baird Canyon on the Copper River based on mark-recapture methods, 2003-2010.

	Period (m/d)		Length	Marked	Examined	Recaptures	Abundance	Standard
Year	From	To	(mm FL)	(M)	(C)	(R)	(N)	Error (SE)
2003	5/17	7/1	810-1,070	1,723	1,630	97	44,764	12,506
2004	5/22	6/22	> 600	2,477	3,101	185	40,564	4,650
2005	5/9	7/14	> 600	3,379	3,150	315	30,333	1,529
2006	5/21	7/31	> 500	4,035	5,224	377	67,789	4,779
2007	5/18	8/6	> 500	4,456	4,192	459	46,349	3,283
2008	5/19	8/4	> 500	3,931	3,509	342	41,343	2,166
2009	5/13	8/2	> 500	2,484	2,224	171	32,401	2,365
2010	5/15	7/5	>500	1,745	894	69	22,323	2,492

Table 3. Number of TBA-PIT tagged Chinook salmon reported harvested in the Copper River fisheries, 2010.

Recovery Location	Number of Tagged Chinook Salmon
Chitina Subdistrict	17
Glennallen Subdistrict	36
Sport Fishery	5
Unknown Location	38
Total Recovered	96
Total Tagged	1,745
Percent Recovered	5.5%

FIGURES

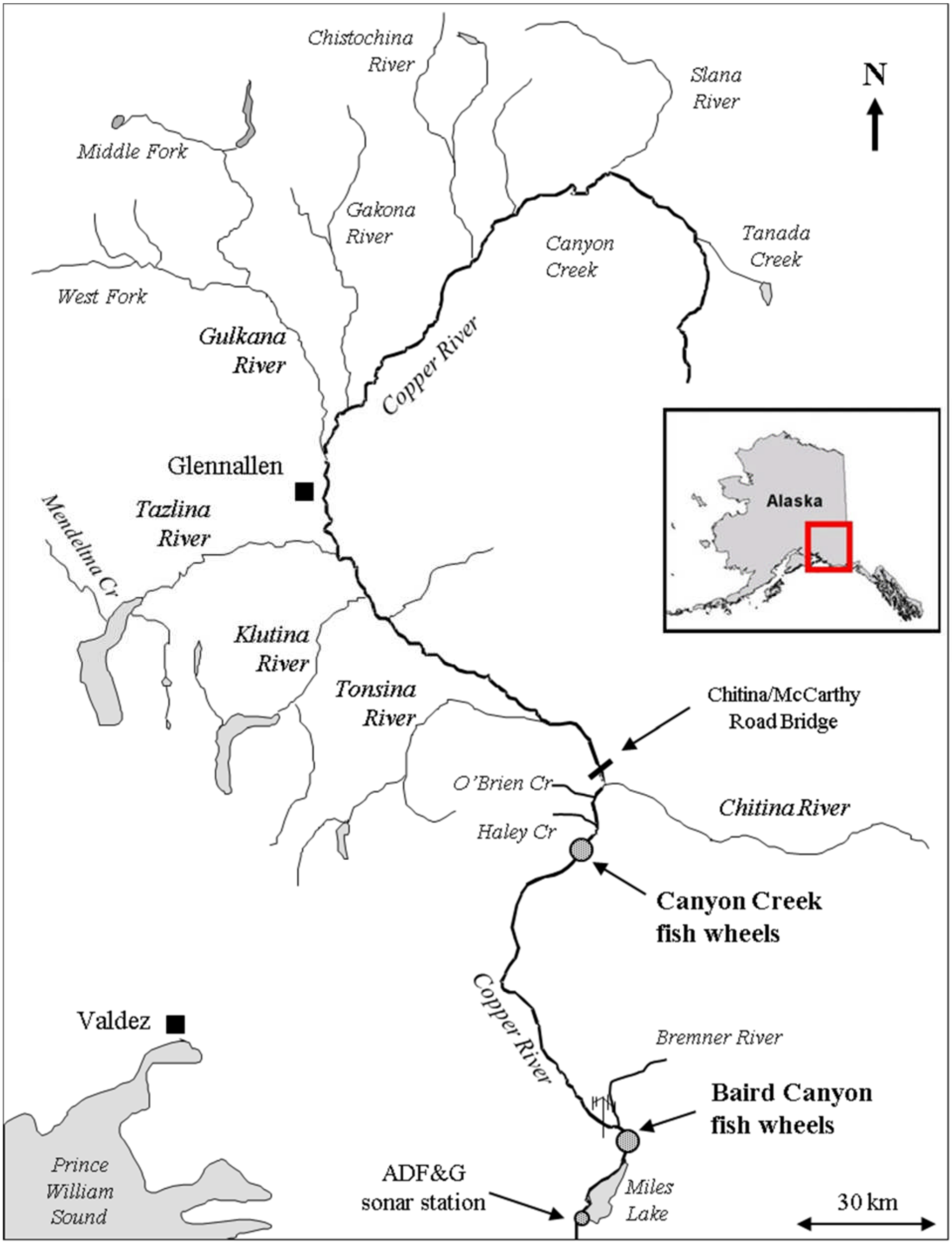

Figure 1. Map of the study area showing the location of the Baird Canyon and Canyon Creek fish wheels on the Copper River in Alaska, 2010.

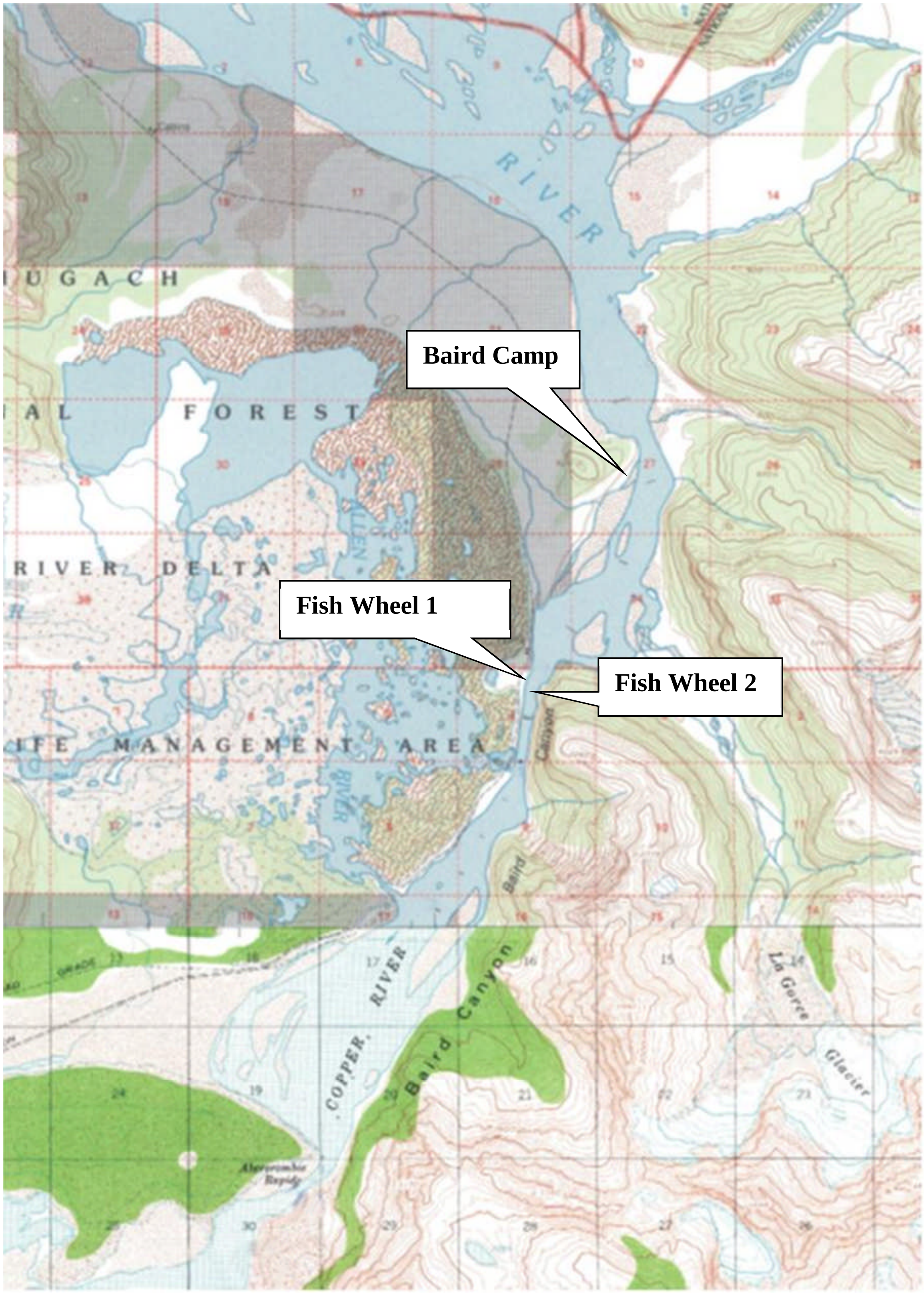

Figure 2. Map of Baird Canyon on the Copper River showing the location of the camp and fish wheel sites used in 2010.

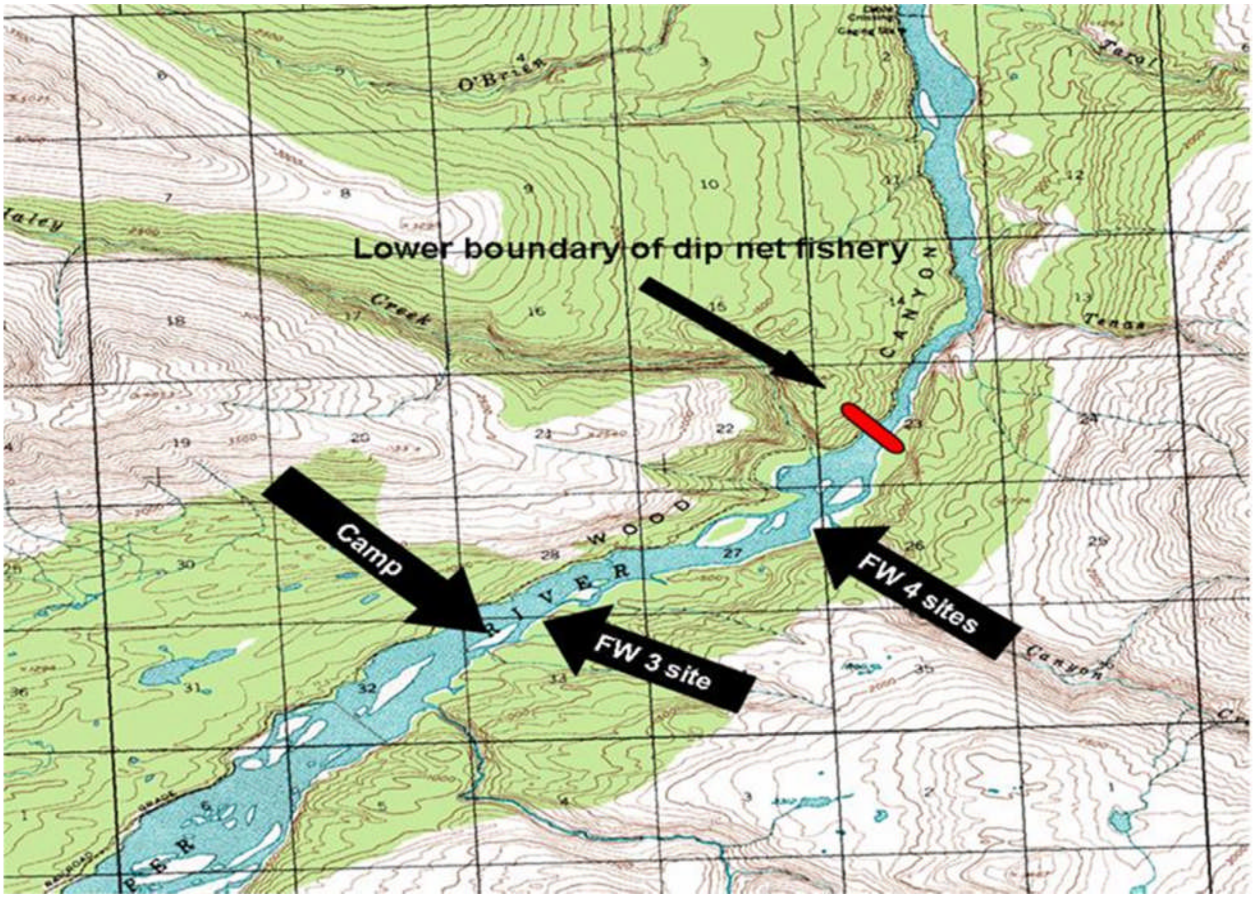

Figure 3. Map of Wood Canyon on the Copper River showing the location of the camp, boundaries of fish wheel sites used in 2010, and the lower boundary of the Chitina Subdistrict dip net fishery.

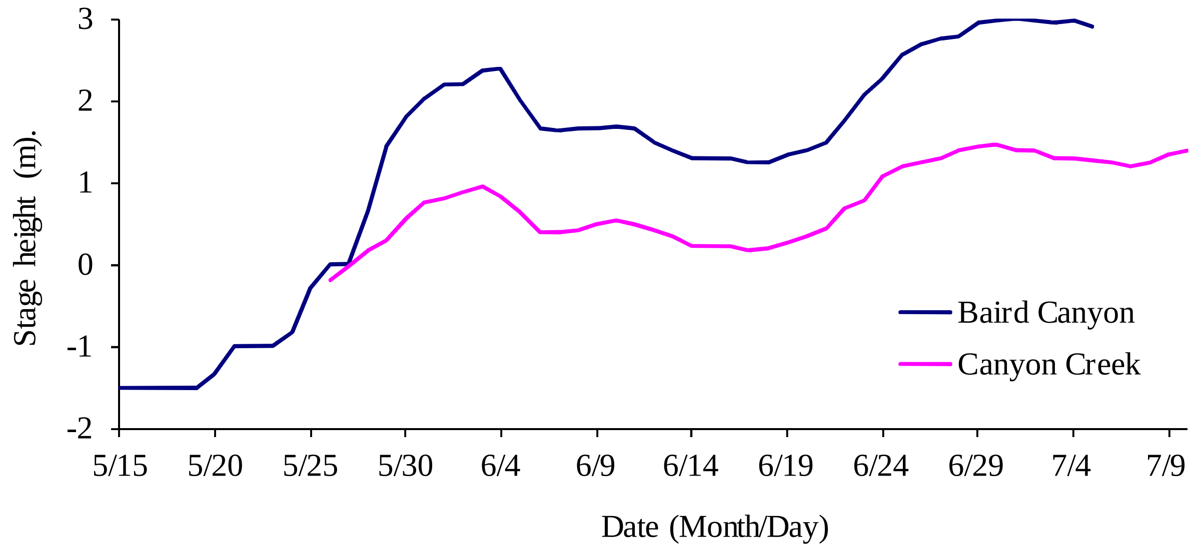

Figure 4. Stage height (m) of the Copper River near the Baird Canyon and Canyon Creek fish wheels, 19 May to 15 August 2010.

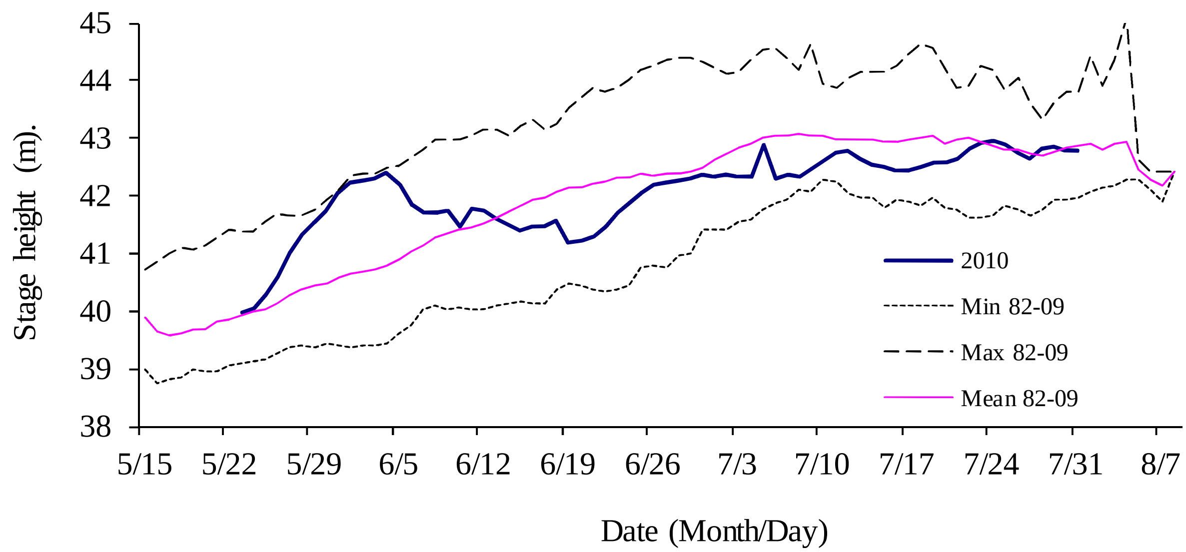

Figure 5. Stage height of the Copper River at the Million Dollar Bridge, 1982-2010.

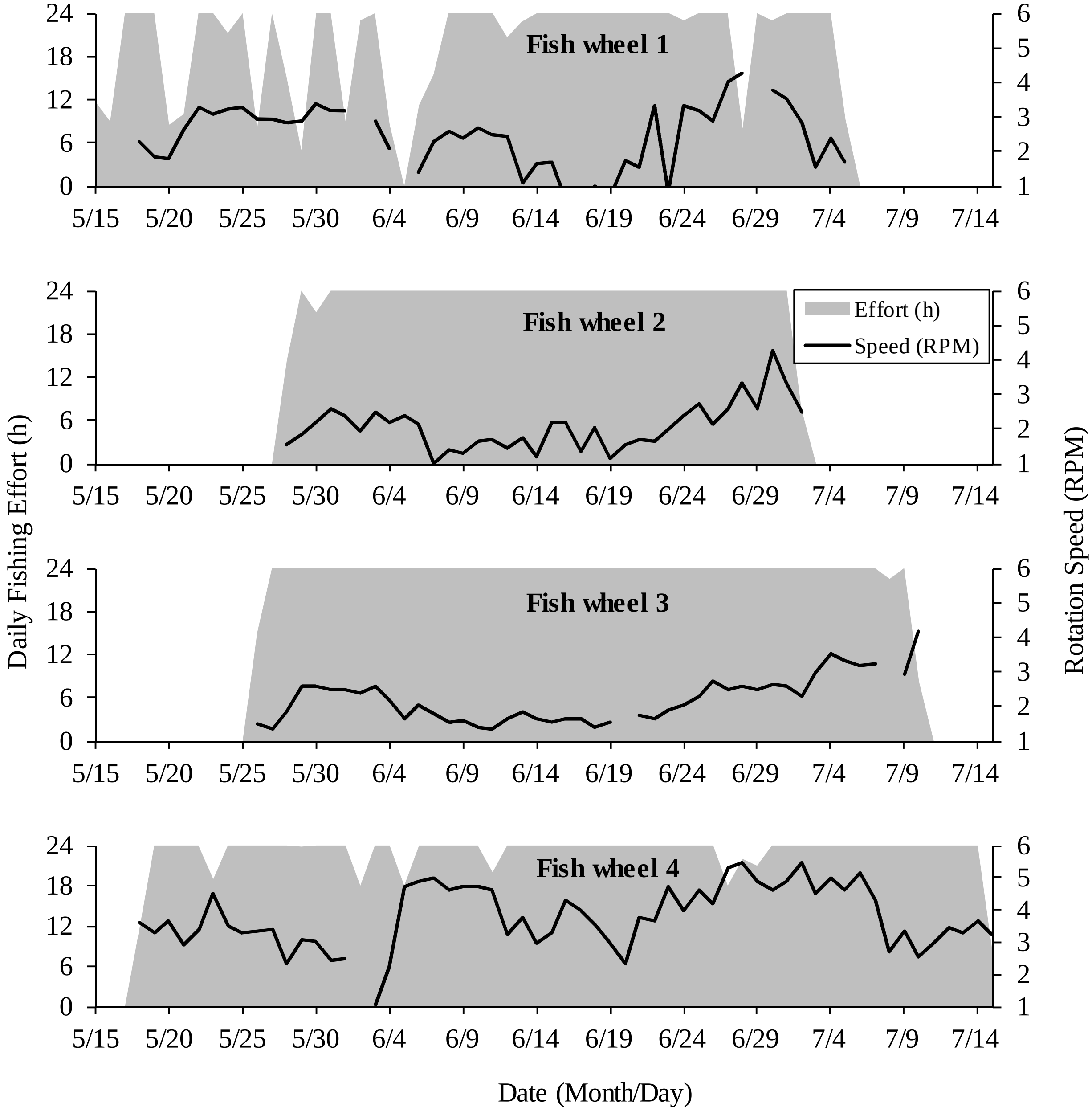

Figure 6. Daily fishing effort (h) and rotation speed (RPM) at the Baird Canyon fish wheels 1 and 2 and Canyon Creek fish wheels 3 and 4 on the Copper River, 2010.

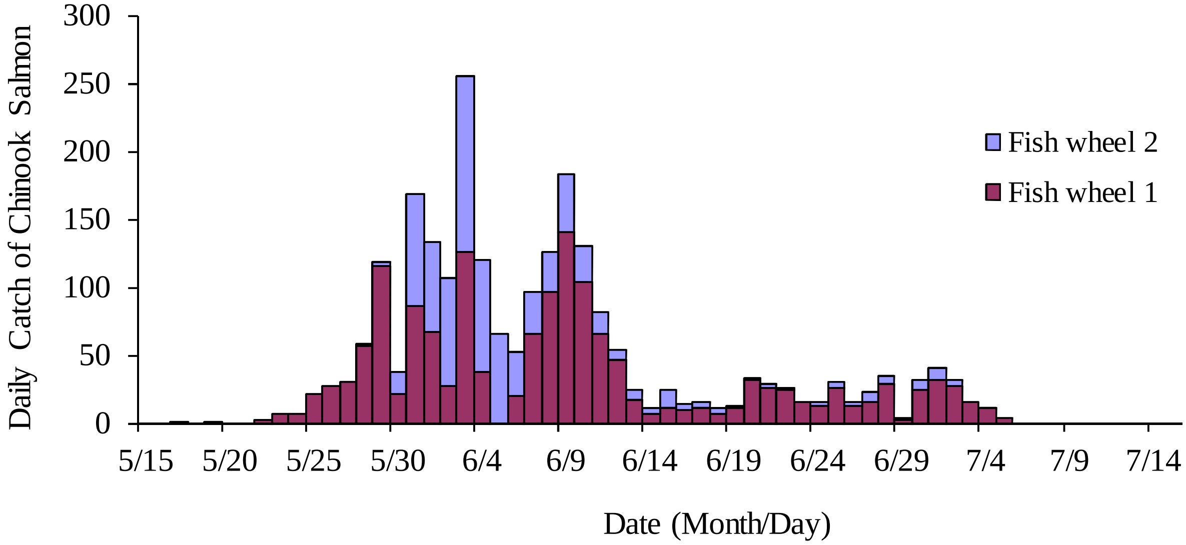

Figure 7. Daily catch of Chinook salmon at the Baird Canyon fish wheels on the Copper River, 2010.

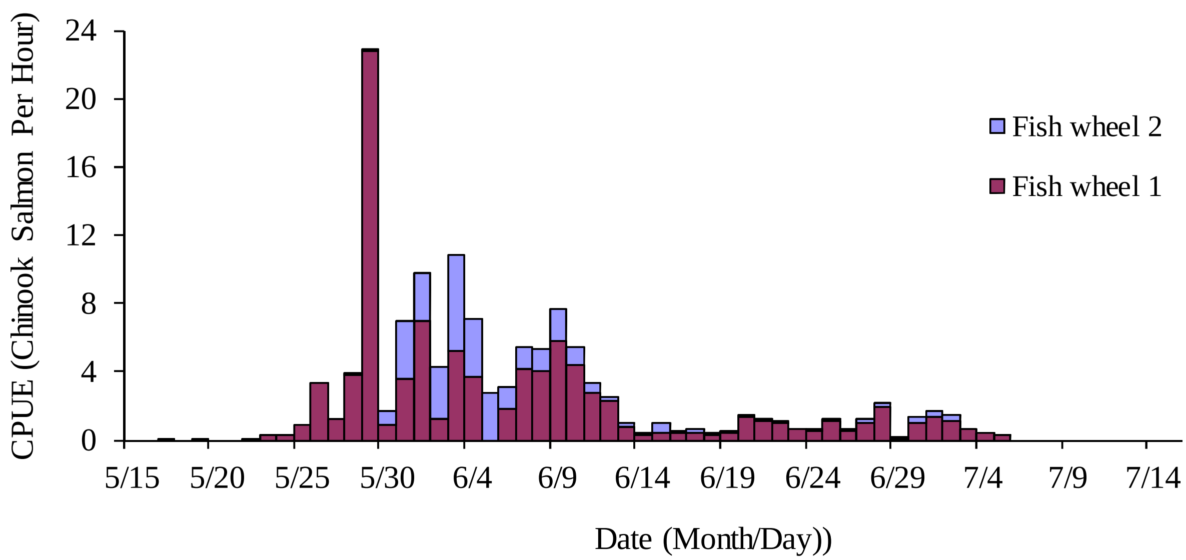

Figure 8. Catch per unit effort (CPUE, catch per fish wheel hour) for Chinook salmon at the Baird Canyon fish wheels on the Copper River, 2010.

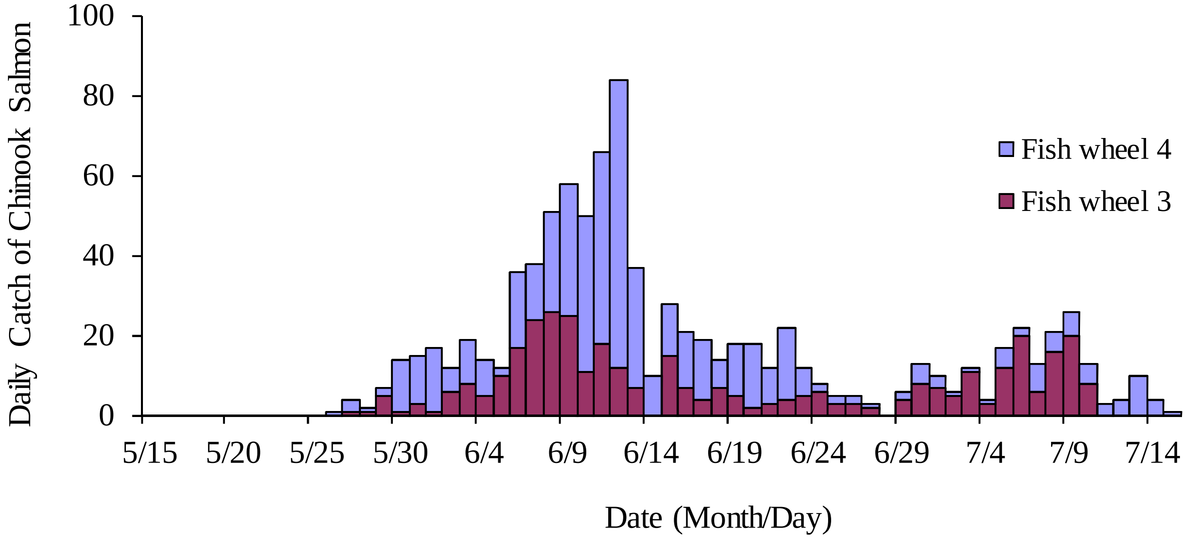

Figure 9. Daily catch of Chinook salmon at the Canyon Creek fish wheels on the Copper River, 2010.

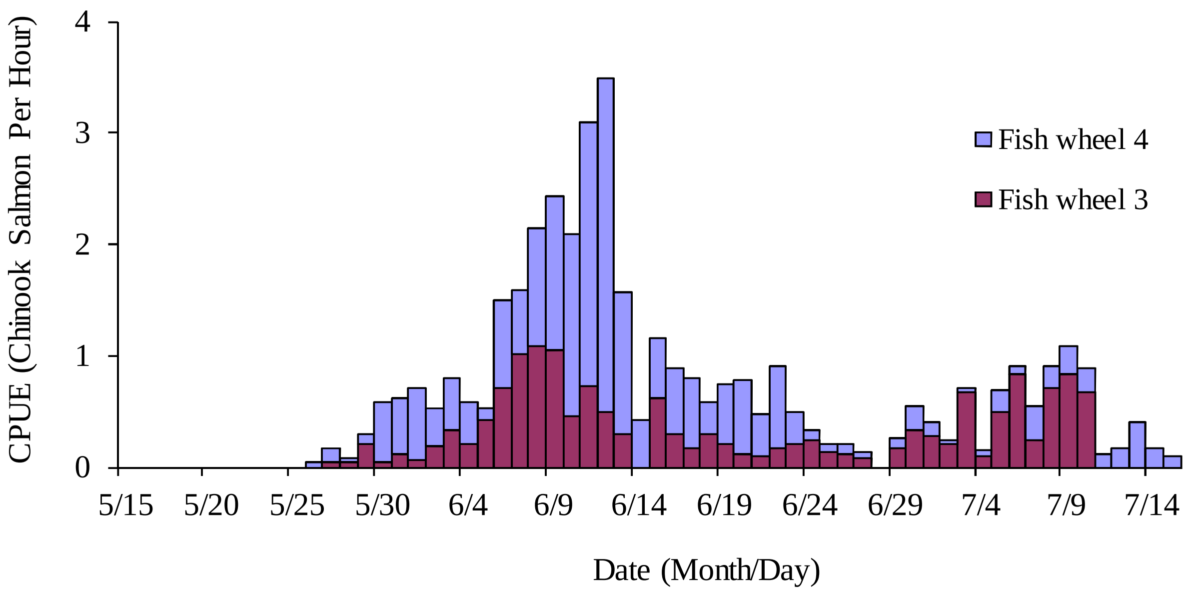

Figure 10. Catch per unit effort (CPUE, catch per fish wheel hour) for Chinook salmon at the Canyon Creek fish wheels on the Copper River, 2010.

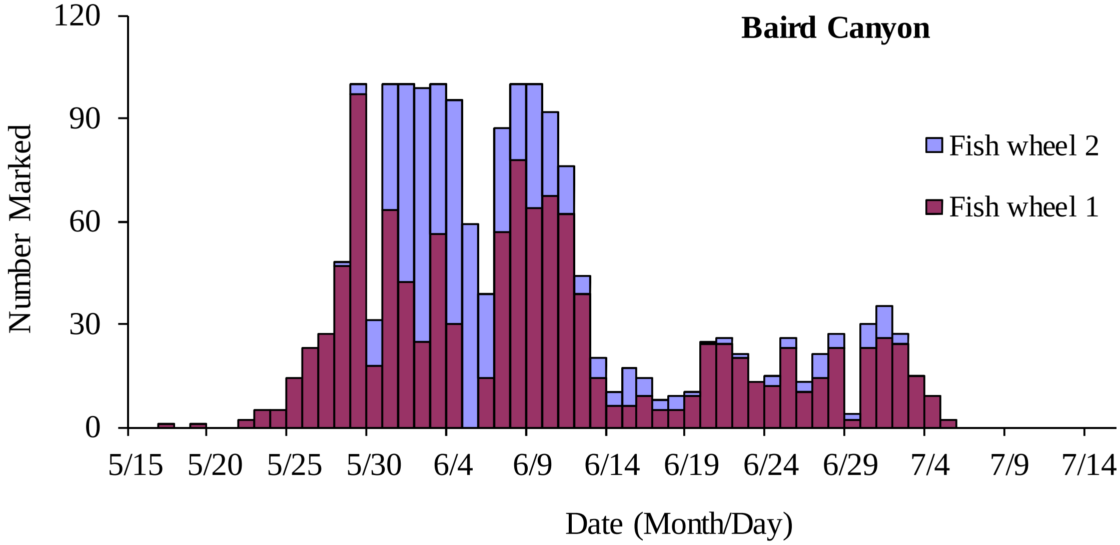

Figure 11. Number of Chinook salmon marked at the Baird Canyon fish wheels on the Copper River, 2010.

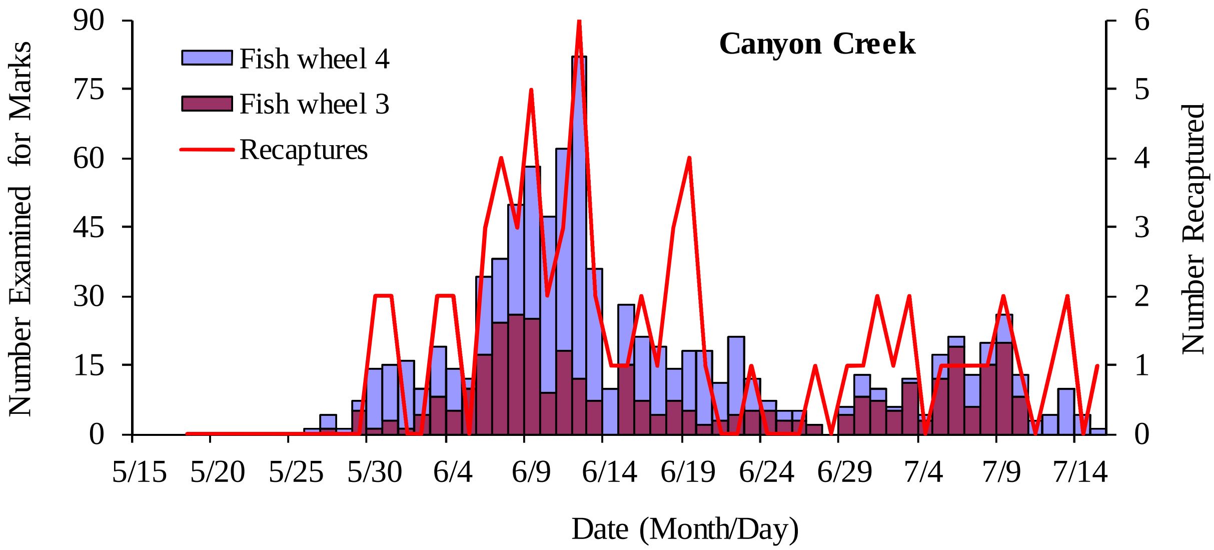

Figure 12. Number of Chinook salmon examined for marks and number of marked Chinook salmon recaptured at the Canyon Creek fish wheels on the Copper River, 2010.

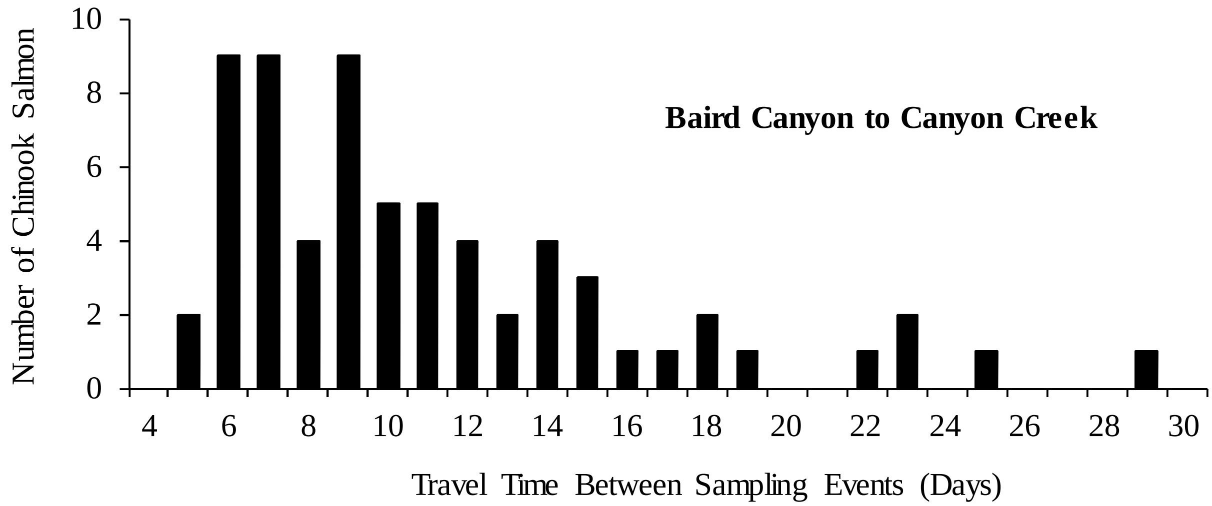

Figure 13. Number of days elapsed (travel time) between sampling events for Chinook salmon marked at the Baird Canyon fish wheels and recaptured at the Canyon Creek fish wheels, 2010.

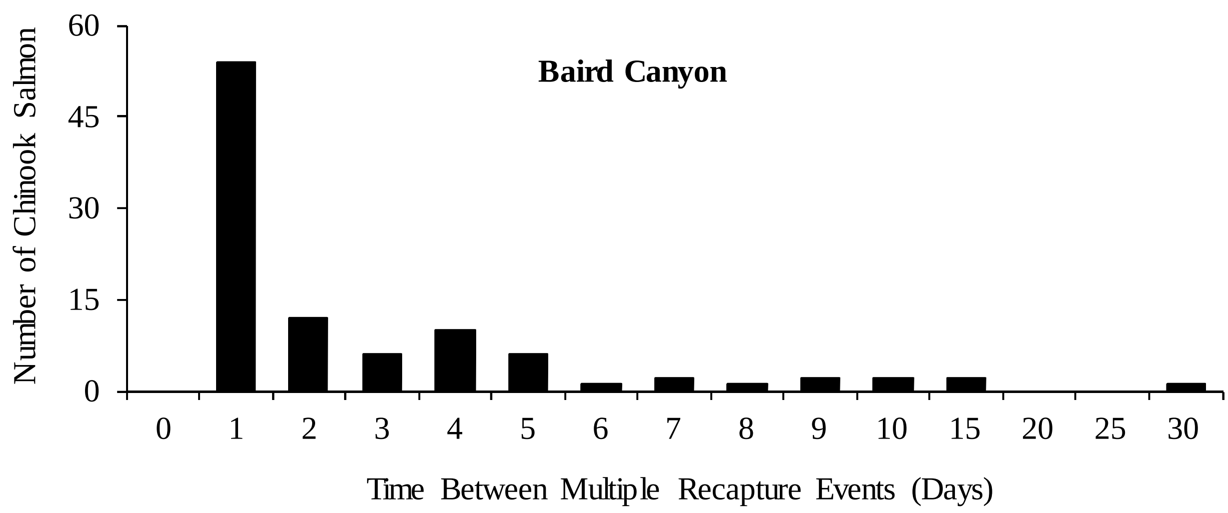

Figure 14. Number of days elapsed between recapture events for marked Chinook salmon recaptured more than once at the Baird Canyon fish wheels, 2010.

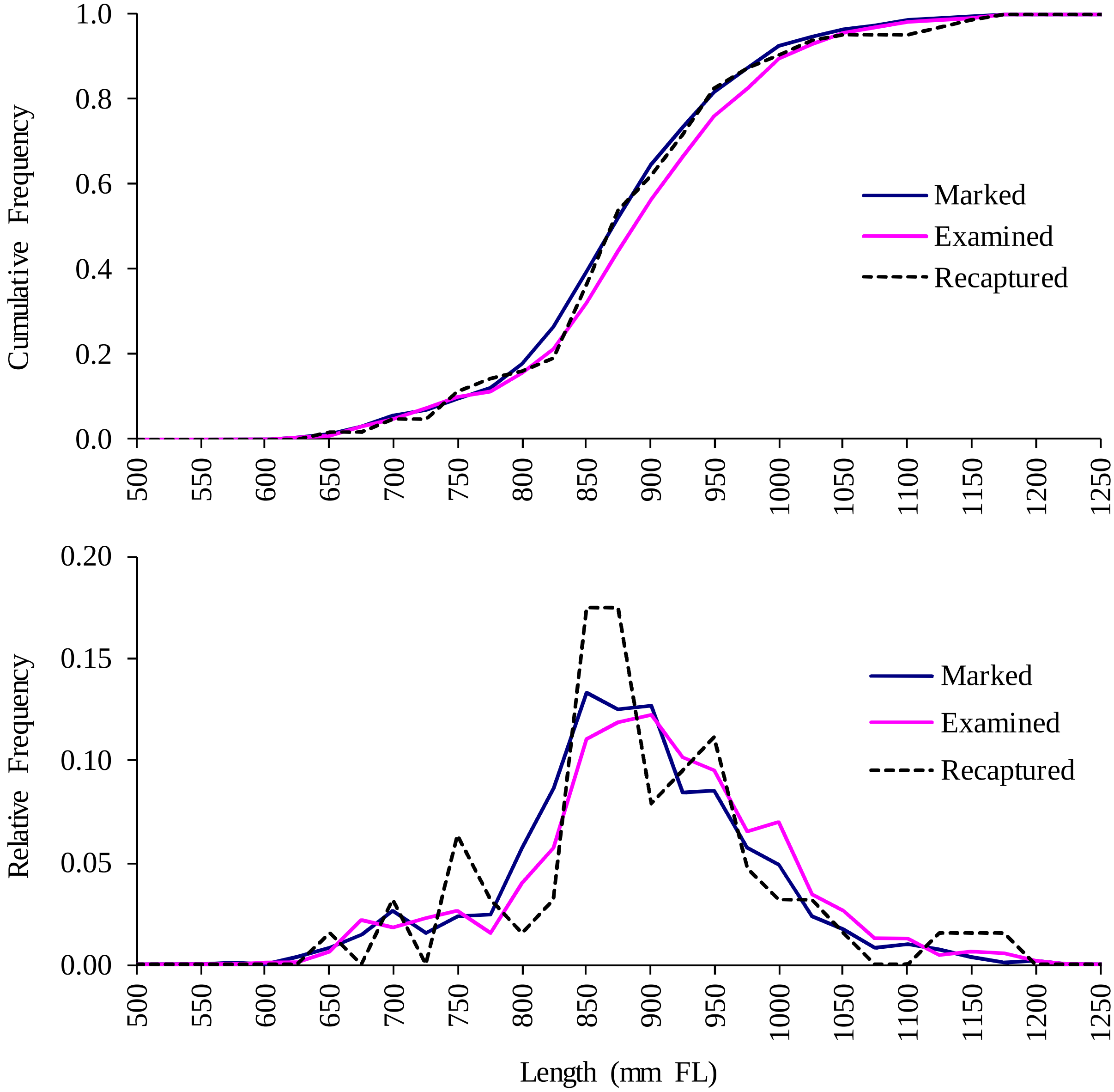

Figure 15. Relative (bottom) and cumulative (top) length-frequency distributions for Chinook salmon (≥ 500 mm FL) marked at Baird Canyon and examined and recaptured at Canyon Creek, 2010.

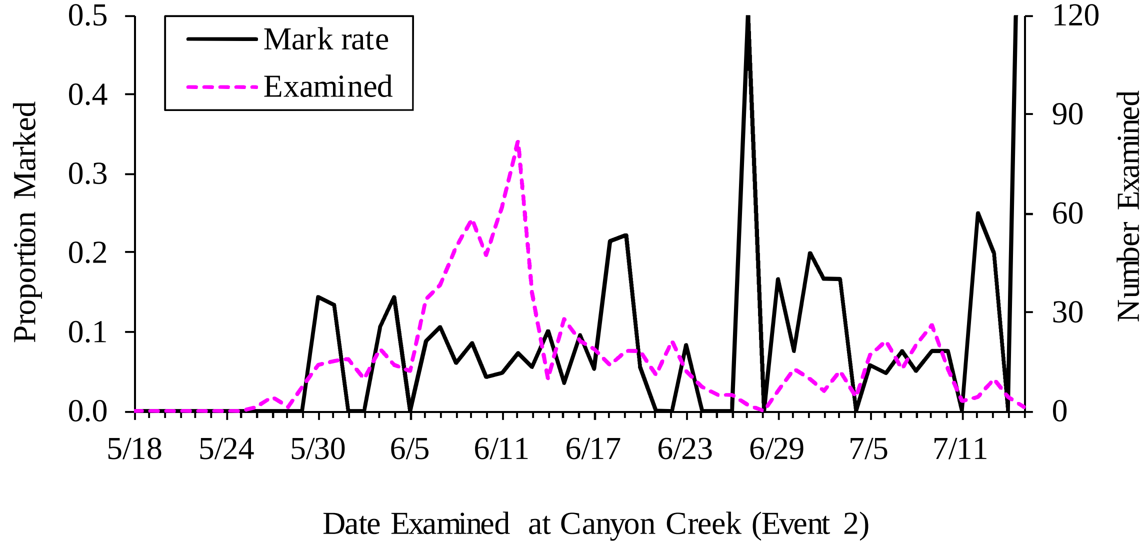

Figure 16. Daily proportion of Chinook salmon examined for marks at the Canyon Creek fish wheels that had been marked at the Baird Canyon fish wheels, 2010.

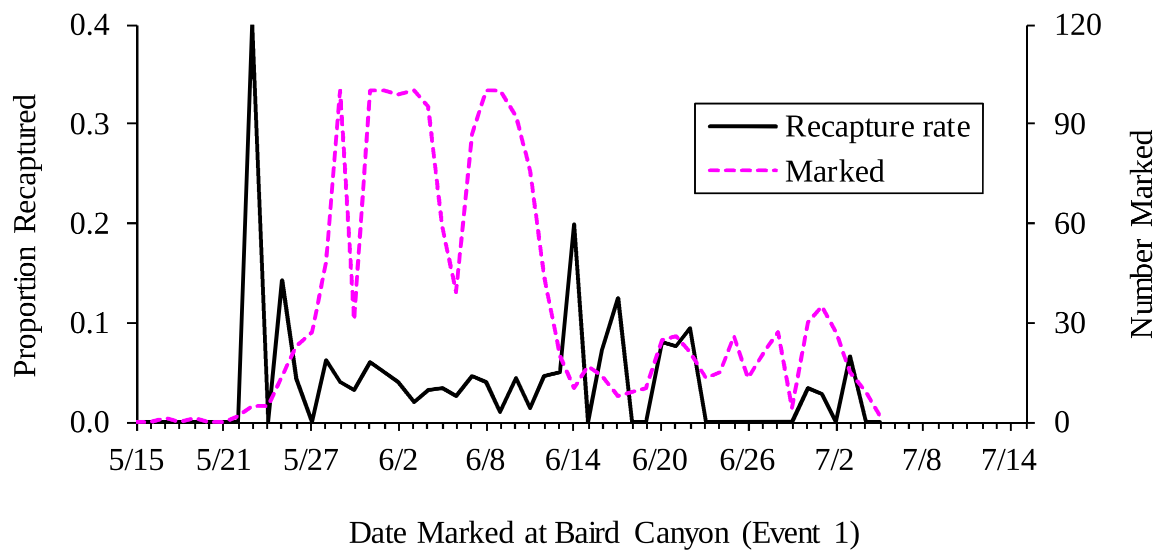

Figure 17. Daily proportion of Chinook salmon marked at the Baird Canyon fish wheels that were subsequently recaptured at the Canyon Creek fish wheels, 2010.

APPENDICES

Appendix A. Summary of daily fish wheel effort (h), effort used to calculate catch per unit effort (CPUE), and fish wheel speed (RPM) for the Copper River fish wheels, 2010.

	Baird Canyon						Canyon Creek					
	Fish Wheel 1			Fish Wheel 2			Fish Wheel 3			Fish Wheel 4		
Date	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM
15-May	11.7	9.4										
16-May	9.0	7.7	2.1									
17-May	24.0	24.5										
18-May	24.0	23.9	2.3							11.8	9.3	3.6
19-May	24.0	24.2	1.9							24.0	21.8	3.3
20-May	8.5	8.7	1.8							24.0	25.9	3.6
21-May	10.0	10.2	2.6							24.0	23.9	2.9
22-May	24.0	23.8	3.3							24.0	24.1	3.4
23-May	24.0	24.0	3.1							19.0	19.1	4.5
24-May	21.3	21.4	3.2							24.0	24.0	3.5
25-May	24.0	24.1	3.3							24.0	24.0	3.3
26-May	8.0	8.1	3.0				15.0	12.2	1.5	24.0	24.3	3.3
27-May	24.0	24.2	3.0				24.0	24.3	1.4	24.0	23.9	3.4
28-May	15.0	14.8	2.8	14.3	7.5	1.6	24.0	24.2	1.8	24.0	24.0	2.3
29-May	5.0	5.1	2.9	24.0	24.6	1.9	24.0	23.6	2.6	23.8	24.3	3.1
30-May	24.0	23.9	3.4	21.0	20.5	2.2	24.0	24.4	2.6	24.0	23.7	3.0
31-May	24.0	24.0	3.2	24.0	24.2	2.6	24.0	24.0	2.5	24.0	24.1	2.4
1-Jun	9.0	9.6	3.2	24.0	23.7	2.4	24.0	17.1	2.5	24.0	24.6	2.5
2-Jun	23.0	22.6		24.0	25.2	2.0	24.0	31.1	2.4	18.0	17.5	
3-Jun	24.0	24.5	2.9	24.0	22.9	2.5	24.0	23.9	2.6	24.0	23.8	1.1
4-Jun	8.5	10.5	2.1	24.0	23.9	2.2	24.0	24.3	2.2	24.0	24.0	2.3
5-Jun	0.0	0.0		24.0	23.8	2.4	24.0	23.7	1.7	18.0	18.1	4.7
6-Jun	11.3	11.4	1.4	24.0	24.3	2.1	24.0	24.1	2.0	24.0	24.0	4.9
7-Jun	15.5	15.8	2.3	24.0	24.3	1.0	24.0	23.5	1.8	24.0	24.4	5.0
8-Jun	24.0	23.9	2.6	24.0	23.9	1.4	24.0	24.0	1.6	24.0	23.8	4.6
9-Jun	24.0	24.2	2.4	24.0	23.5	1.3	24.0	23.9	1.6	24.0	24.0	4.7
10-Jun	24.0	23.9	2.7	24.0	23.9	1.7	24.0	23.9	1.4	24.0	23.9	4.7
11-Jun	24.0	23.9	2.5	24.0	24.5	1.7	24.0	24.9	1.4	20.0	20.2	4.6
12-Jun	20.7	20.4	2.4	24.0	23.9	1.5	24.0	24.4	1.6	24.0	24.1	3.2
13-Jun	22.8	22.8	1.1	24.0	23.6	1.7	24.0	23.3	1.9	24.0	23.6	3.8
14-Jun	24.0	24.0	1.7	24.0	24.1	1.2	24.0	23.5	1.6	24.0	24.0	3.0
15-Jun	24.0	24.0	1.7	24.0	23.8	2.2	24.0	24.5	1.5	24.0	24.0	3.3
16-Jun	24.0	24.0	0.6	24.0	24.1	2.2	24.0	23.5	1.6	24.0	24.1	4.3
17-Jun	24.0	24.0		24.0	24.2	1.3	24.0	23.9	1.6	24.0	23.8	4.0
18-Jun	24.0	24.1	1.0	24.0	23.5	2.0	24.0	24.3	1.4	24.0	23.9	3.5
19-Jun	24.0	24.2	0.7	24.0	24.1	1.2	24.0	24.3	1.5	24.0	24.2	3.0
20-Jun	24.0	23.8	1.7	24.0	24.2	1.5	24.0	16.7		24.0	24.0	2.3
21-Jun	24.0	24.0	1.6	24.0	24.2	1.7	24.0	30.8	1.8	24.0	23.9	3.8
22-Jun	24.0	24.3	3.3	24.0	24.1	1.6	24.0	24.0	1.6	24.0	24.1	3.7
23-Jun	24.0	23.9	0.8	24.0	23.9	2.0	24.0	24.3	1.9	24.0	24.2	4.7
24-Jun	23.0	22.8	3.3	24.0	24.0	2.4	24.0	24.3	2.0	24.0	23.7	4.0
25-Jun	24.0	24.3	3.2	24.0	24.3	2.7	24.0	23.4	2.3	24.0	24.1	4.6

Appendix A continued.

	Baird Canyon						Canyon Creek					
	Fish Wheel 1			Fish Wheel 2			Fish Wheel 3			Fish Wheel 4		
Date	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM
26-Jun	24.0	23.8	2.9	24.0	23.8	2.1	24.0	24.1	2.7	24.0	23.9	4.2
27-Jun	24.0	17.0	4.0	24.0	24.0	2.6	24.0	24.2	2.5	18.0	18.2	5.3
28-Jun	8.0	15.1	4.3	24.0	24.1	3.3	24.0	24.0	2.6	22.0	22.0	5.5
29-Jun	24.0	23.9		24.0	23.8	2.6	24.0	24.4	2.5	21.0	20.8	4.9
30-Jun	23.0	23.1	3.8	24.0	24.3	4.3	24.0	23.5	2.6	24.0	24.1	4.6
1-Jul	24.0	23.8	3.5	24.0	23.6	3.3	24.0	24.6	2.6	24.0	24.0	4.9
2-Jul	24.0	24.0	2.8	7.7	10.4	2.5	24.0	24.2	2.3	24.0	23.9	5.5
3-Jul	24.0	23.9	1.5				24.0	16.4	3.0	24.0	24.2	4.5
4-Jul	24.0	24.1	2.4				24.0	30.0	3.5	24.0	22.9	5.0
5-Jul	9.3	12.1	1.7				24.0	24.8	3.3	24.0	24.8	4.6
6-Jul							24.0	24.1	3.2	24.0	24.5	5.1
7-Jul							24.0	24.0	3.2	24.0	23.7	4.3
8-Jul							22.5	22.7		24.0	24.7	2.7
9-Jul							24.0	24.1	3.0	24.0	23.6	3.3
10-Jul							8.3	12.0	4.2	24.0	23.5	2.5
11-Jul										24.0	24.1	3.0
12-Jul										24.0	23.8	3.5
13-Jul										24.0	24.3	3.3
14-Jul										24.0	24.0	3.7
15-Jul										8.1	10.9	3.2
Effort (h)	1,030		2.5	835		2.1	1,078		2.2	1,356		3.8
% operational:												
	84.4%			99.6%			99.9%			97.7%		

Appendix B. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fish wheels, 2010.

	Baird Canyon						Canyon Creek					
	Fish Wheel 1			Fish Wheel 2			Fish Wheel 3			Fish Wheel 4		
Date	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE
15 May	0	0	0.0									
16 May	0	0	0.0									
17 May	1	1	0.0									
18 May	0	1	0.0							0	0	0.00
19 May	1	2	0.0							0	0	0.00
20 May	0	2	0.0							0	0	0.00
21 May	0	2	0.0							0	0	0.00
22 May	2	4	0.1							0	0	0.00
23 May	6	10	0.3							0	0	0.00
24 May	6	16	0.3							0	0	0.00
25 May	22	38	0.9							0	0	0.00
26 May	27	65	3.3				0	0	0.00	1	1	0.04
27 May	30	95	1.2				1	1	0.04	3	4	0.13
28 May	56	151	3.8	1	1	0.1	1	2	0.04	1	5	0.04
29 May	115	266	22.8	4	5	0.2	5	7	0.21	2	7	0.08
30 May	21	287	0.9	17	22	0.8	1	8	0.04	13	20	0.55
31 May	86	373	3.6	82	104	3.4	3	11	0.12	12	32	0.50
1 Jun	67	440	7.0	66	170	2.8	1	12	0.06	16	48	0.65
2 Jun	27	467	1.2	79	249	3.1	6	18	0.19	6	54	0.34
3 Jun	126	593	5.2	129	378	5.6	8	26	0.34	11	65	0.46
4 Jun	38	631	3.6	82	460	3.4	5	31	0.21	9	74	0.38
5 Jun	0	631		66	526	2.8	10	41	0.42	2	76	0.11
6 Jun	20	651	1.8	32	558	1.3	17	58	0.70	19	95	0.79
7 Jun	66	717	4.2	31	589	1.3	24	82	1.02	14	109	0.57
8 Jun	96	813	4.0	30	619	1.3	26	108	1.08	25	134	1.05
9 Jun	141	954	5.8	42	661	1.8	25	133	1.05	33	167	1.38
10 Jun	104	1,058	4.4	26	687	1.1	11	144	0.46	39	206	1.63
11 Jun	66	1,124	2.8	15	702	0.6	18	162	0.72	48	254	2.38
12 Jun	47	1,171	2.3	6	708	0.3	12	174	0.49	72	326	2.99
13 Jun	17	1,188	0.7	7	715	0.3	7	181	0.30	30	356	1.27
14 Jun	7	1,195	0.3	4	719	0.2	0	181	0.00	10	366	0.42
15 Jun	11	1,206	0.5	13	732	0.5	15	196	0.61	13	379	0.54
16 Jun	9	1,215	0.4	5	737	0.2	7	203	0.30	14	393	0.58
17 Jun	11	1,226	0.5	4	741	0.2	4	207	0.17	15	408	0.63
18 Jun	7	1,233	0.3	4	745	0.2	7	214	0.29	7	415	0.29
19 Jun	11	1,244	0.5	2	747	0.1	5	219	0.21	13	428	0.54
20 Jun	31	1,275	1.3	1	748	0.0	2	221	0.12	16	444	0.67
21 Jun	26	1,301	1.1	2	750	0.1	3	224	0.10	9	453	0.38
22 Jun	25	1,326	1.0	1	751	0.0	4	228	0.17	18	471	0.75
23 Jun	15	1,341	0.6	0	751	0.0	5	233	0.21	7	478	0.29
24 Jun	12	1,353	0.5	4	755	0.2	6	239	0.25	2	480	0.08
25 Jun	26	1,379	1.1	4	759	0.2	3	242	0.13	2	482	0.08
26 Jun	13	1,392	0.5	3	762	0.1	3	245	0.12	2	484	0.08
27 Jun	16	1,408	0.9	7	769	0.3	2	247	0.08	1	485	0.06

Appendix B continued.

	Baird Canyon						Canyon Creek					
	Fish Wheel 1			Fish Wheel 2			Fish Wheel 3			Fish Wheel 4		
Date	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE
28 Jun	29	1,437	1.9	5	774	0.2	0	247	0.00	0	485	0.00
29 Jun	2	1,439	0.1	2	776	0.1	4	251	0.16	2	487	0.10
30 Jun	24	1,463	1.0	7	783	0.3	8	259	0.34	5	492	0.21
1 Jul	31	1,494	1.3	10	793	0.4	7	266	0.28	3	495	0.12
2 Jul	27	1,521	1.1	4	797	0.4	5	271	0.21	1	496	0.04
3 Jul	16	1,537	0.7				11	282	0.67	1	497	0.04
4 Jul	11	1,548	0.5				3	285	0.10	1	498	0.04
5 Jul	3	1,551	0.2				12	297	0.48	5	503	0.20
6 Jul							20	317	0.83	2	505	0.08
7 Jul							6	323	0.25	7	512	0.30
8 Jul							16	339	0.71	5	517	0.20
9 Jul							20	359	0.83	6	523	0.25
10 Jul							8	367	0.67	5	528	0.21
11 Jul										3	531	0.12
12 Jul										4	535	0.17
13 Jul										10	545	0.41
14 Jul										4	549	0.17
15 Jul										1	550	0.09
Total	1,551			797			367			550		

Fish recaptured two or more times at the Baird Canyon or Canyon Creek fishwheels were not included in total catches.

Appendix C. Number of Chinook salmon marked, examined, and recaptured at the Baird Canyon and Canyon Creek fish wheels on the Copper River, 2010.

	Baird Canyon				Canyon Creek							
	Fish Wheel 1		Fish Wheel 2		Fish Wheel 3				Fish Wheel 4			
Date	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
15 May	0	0										
16 May	0	0										
17 May	1	1										
18 May	0	1							0	0	0	0
19 May	1	2							0	0	0	0
20 May	0	2							0	0	0	0
21 May	0	2							0	0	0	0
22 May	2	4							0	0	0	0
23 May	5	9							0	0	0	0
24 May	5	14							0	0	0	0
25 May	14	28							0	0	0	0
26 May	23	51			0	0	0	0	1	1	0	0
27 May	27	78			1	1	0	0	3	4	0	0
28 May	47	125	1	1	0	1	0	0	1	5	0	0
29 May	97	222	3	4	5	6	0	0	2	7	0	0
30 May	18	240	13	17	1	7	0	0	13	20	2	2
31 May	63	303	37	54	3	10	1	1	12	32	1	3
1 Jun	42	345	58	112	1	11	0	1	15	47	0	3
2 Jun	25	370	74	186	4	15	0	1	6	53	0	3
3 Jun	56	426	44	230	8	23	1	2	11	64	1	4
4 Jun	30	456	65	295	5	28	1	3	9	73	1	5
5 Jun	0	456	59	354	10	38	0	3	2	75	0	5
6 Jun	14	470	25	379	17	55	2	5	17	92	1	6
7 Jun	57	527	30	409	24	79	2	7	14	106	2	8
8 Jun	78	605	22	431	26	105	1	8	24	130	2	10
9 Jun	64	669	36	467	25	130	4	12	33	163	1	11
10 Jun	67	736	25	492	9	139	0	12	38	201	2	13
11 Jun	62	798	14	506	18	157	2	14	44	245	1	14
12 Jun	39	837	5	511	12	169	2	16	70	315	4	18
13 Jun	14	851	6	517	7	176	0	16	29	344	2	20
14 Jun	6	857	4	521	0	176	0	16	10	354	1	21
15 Jun	6	863	11	532	15	191	1	17	13	367	0	21
16 Jun	9	872	5	537	7	198	1	18	14	381	1	22
17 Jun	5	877	3	540	4	202	0	18	15	396	1	23
18 Jun	5	882	4	544	7	209	1	19	7	403	2	25
19 Jun	9	891	1	545	5	214	1	20	13	416	3	28
20 Jun	24	915	1	546	2	216	0	20	16	432	1	29
21 Jun	24	939	2	548	3	219	0	20	8	440	0	29
22 Jun	20	959	1	549	4	223	0	20	17	457	0	29
23 Jun	13	972	0	549	5	228	0	20	7	464	1	30
24 Jun	12	984	3	552	5	233	0	20	2	466	0	30
25 Jun	23	1,007	3	555	3	236	0	20	2	468	0	30
26 Jun	10	1,017	3	558	3	239	0	20	2	470	0	30
27 Jun	14	1,031	7	565	2	241	1	21	0	470	0	30

Appendix C continued.

	Baird Canyon				Canyon Creek							
	Fish Wheel 1		Fish Wheel 2		Fish Wheel 3				Fish Wheel 4			
Date	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
28 Jun	23	1,054	4	569	0	241	0	21	0	470	0	30
29 Jun	2	1,056	2	571	4	245	1	22	2	472	0	30
30 Jun	23	1,079	7	578	8	253	0	22	5	477	1	31
1 Jul	26	1,105	9	587	7	260	1	23	3	480	1	32
2 Jul	24	1,129	3	590	5	265	0	23	1	481	1	33
3 Jul	15	1,144			11	276	1	24	1	482	1	34
4 Jul	9	1,153			3	279	0	24	1	483	0	34
5 Jul	2	1,155			12	291	1	25	5	488	0	34
6 Jul					19	310	1	26	2	490	0	34
7 Jul					6	316	1	27	7	497	0	34
8 Jul					15	331	1	28	5	502	0	34
9 Jul					20	351	2	30	6	508	0	34
10 Jul					8	359	0	30	5	513	1	35
11 Jul									3	516	0	35
12 Jul									4	520	1	36
13 Jul									10	530	2	38
14 Jul									4	534	0	38
15 Jul									1	535	1	39
Total	1,155		590		359		30		535		39	