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Estimating the inriver abundance of Copper River Chinook salmon, 2008 annual report

Annual Report for Study 07-503

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ABSTRACT

The purpose of this project was to use fishwheels 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 2008 field season, the eighth year since the project's inception. The main objective in 2008 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 three live-capture fishwheels were operated at Baird Canyon for a total of 4,266 h from 19 May to 4 August. During this period, 4,807 adult Chinook salmon were marked. For the second sample event, up to two fishwheels were operated at Canyon Creek near the lower end of Wood Canyon for 3,966 h from 20 May to 19 August. A total of 3,952 Chinook salmon were examined, of which 342 were marked.

Using a temporally stratified Darroch estimator, the estimated abundance of Chinook salmon measuring 500 mm FL or greater that migrated upstream of Baird Canyon from 19 May to 19 August was 41,343 (SE = 2,166). The median travel time of Chinook salmon marked at Baird Canyon and recaptured at Canyon Creek (91 km upstream) was 10.9 d. Funding for this study by the Fisheries Resource Monitoring Program (FRMP) has been approved through 2009. This highly successful and long-term monitoring program has made the Native Village of Eyak (NVE) an integral part of Copper River salmon research.

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INTRODUCTION

The Copper River supports one of the largest Chinook *Oncorhynchus tshawytscha* and sockeye salmon *O. nerka* subsistence fisheries in Alaska. In addition, this resource is heavily utilized by commercial, sport, and personal-use fisheries. The majority of Copper River salmon are harvested in a commercial gillnet fishery from mid-May through August in the Copper River District (in and around the mouth of the Copper River). From 1998 to 2007, 1,344,291 sockeye, 43,059 Chinook, and 285,221 coho salmon were harvested in the Copper River District (Hollowell and Sommerville 2008). In 2008, an estimated 321,000 sockeye (the 4th smallest harvest since 1970) and 11,500 Chinook salmon were harvested in the Copper River District (ADF&G 2009). Personal-use and subsistence fisheries occur from mid-May through September between Haley Creek and the confluence of the Slana River. From 1998 to 2007, the average annual harvest of Chinook salmon was 3,274 fish in the personal-use fishery and 3,120 fish in the Glennallen Subsistence fishery (Hollowell and Sommerville 2008). Rod-and-reel sport fisheries harvest Chinook salmon in tributaries of the upper Copper River (mainly the Gulkana, Klutina, and Tonsina rivers). The sport fishery harvested 5,231 Chinook salmon on average from 1998 to 2007 (Hollowell and Sommerville 2008).

The 2009-2011 Federal Subsistence Fisheries Regulations (OSM 2009) identify two main areas in the Copper River drainage where subsistence fisheries take place: 1) Upper Copper River District (Chitina and Glennallen subdistricts), or all 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 waters of the Copper River and Tanada Creek between National Park Service regulatory markers. Salmon within these areas also have a Customary and Traditional Use determination for certain Alaskan residents (OSM 2009). In the Upper Copper River District, salmon may only be harvested using fishwheels, dip nets, and rod and reel. In the Batzulnetas area, salmon may be harvested using fishwheels, dip nets, rod and reel, and (in Tanada Creek only) fyke nets and spears. 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 numerous 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 using a sonar system at the outlet of Miles Lake. The escapement goal 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 717,799 salmon passed the Miles Lake sonar site between 16 May and 2 August 2008, which was 17% (102,800 fish) higher than the minimum anticipated count and 13% lower than the previous 5-y average (Lewis et al. 2008).

From 1999 to 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). Due to the project's high expense, biologists planned to terminate this telemetry-based, escapement-monitoring project after the 2001 season. The possible termination of the radio-tagging project created a need for the development of a long-term program to monitor Chinook salmon escapement in the Copper River. The Native Village of Eyak (NVE) began such a program in 2001, and since then has filled this critical data gap using fishwheels (Meehan 1961; Donaldson and Cramer 1971) and two-event mark-recapture techniques.

Fishwheels and mark-recapture techniques have been used to generate system-wide salmon escapement estimates on numerous large rivers (Meehan 1961; Donaldson and Cramer 1971; Johnson et al. 1992; Arnason et al. 1996; Link et al. 1996; Cappiello and Bromaghin 1997; Gordon et al. 1998; Link and Nass 1999; Sturhahn and Nagtegaal 1999). Feasibility and full-scale studies from 2001 to 2007 have shown that these methods are also suitable for use on the Copper River (Link et al. 2001; Smith et al. 2003; Smith 2004; Smith et al. 2005; Smith and van den Broek 2005, 2006; Smith et al. 2007; van den Broek et al. 2008).

This project addresses the highest ranked information need for Federal subsistence fisheries that was identified by the Fisheries Resource Monitoring Program (FRMP) in their 2007 request for proposals (OSM 2007). Specifically, this project will "estimate or index abundance of total run by species." This project was also integrated with another ongoing FRMP project: FIS08-501 – Estimating the abundance of Copper River sockeye salmon. This report was submitted as the annual report to U.S. Fish and Wildlife Service (USFWS), Office of Subsistence Management (OSM), Subsistence Fisheries Resource Monitoring Program for project number 07-503.

Objectives

The main objective of this study was to:

1. Estimate the annual, system-wide escapement of Chinook salmon to the Copper River using mark-recapture techniques such that the estimate was within 25% of the actual escapement 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 the majority of 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 cause the water to be unusually 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) offer the potential to capture substantial proportions of migrating Chinook salmon using fishwheels. Baird Canyon is the first major channel constriction on the Copper River upstream of Miles Lake that is suitable for operating the capture-tag fishwheels (Figure 2). The east bank of Baird Canyon is a steep, often sheer, rock wall that rises over 600 m 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, just below the mouth of Canyon Creek and the lower boundary of the Chitina Subdistrict dip net fishery, was considered a suitable location for operating the recapture fishwheels. 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 enter the river by early August (Merritt and Roberson 1986; Evenson and Savereide 1999; Morstad et al. 1999; Evenson and Wuttig 2000; Sharp et al. 2000). The majority 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. Ten full-time technicians, three full- and part-time interns, and one part-time field logistics coordinator were hired, including one returning technician from 2007, three Alaska Natives, and several rural Alaskan residents. Several other local residents were hired temporarily throughout the season during peak sampling periods, mobilization, and 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, Copper River salmon fisheries management overview, and basic outboard motor maintenance and troubleshooting. Inseason training focused on fishwheel operation, maintenance and safety, boat operation and maintenance, fish sampling, data entry in personal digital assistant (PDA) units, PDA passive integrated transponder (PIT) tag scanner, database management, and basic computer skills.

Permit Requirements

In order to access and operate both field camps and install the fishwheels on the Copper River (including anchoring them to 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. Permits were also acquired from ADF&G for fish collection and sampling. All permits were obtained prior to the start of the field season.

Fishwheel Design and Construction

Three tagging fishwheels (fishwheels 1, 2, and 5) were operated at Baird Canyon (rkm 66), and two recovery fishwheels (fishwheels 3 and 4) at Canyon Creek (rkm 157) in 2007. Two of the fishwheels at Baird Canyon (fishwheels 1 and 2) and one fishwheel at Canyon Creek (fishwheel 3) were large aluminum models built for fishing against deep canyon walls. These were made 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 were designed to fish up to about 3 m below the water surface and were lined with knotless nylon mesh (6.4 cm stretch). The baskets on fishwheel 3 were shorter than those on fishwheels 1 and 2 which allowed it to fish at 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.

The third fishwheel at Baird Canyon (fishwheel 5) was similar in design to fishwheel 4 that operated at Canyon Creek. These fishwheels were composed 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 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 fishwheels, each live tank was fitted with windows of extruded aluminum mesh and an escape panel.

Mobilizing the Field Camps

At Baird Canyon, a cabin that NVE built in the fall of 2001 served as the field camp again in 2008. The cabin was located on the west bank of the Copper River approximately 2 km upstream from the upper end of Baird Canyon (Figure 2), and was supplied by helicopter, boat, or plane from Cordova. The Canyon Creek camp was located on the east bank of the Copper River approximately 12 km downstream from Chitina (Figure 3). The upriver camp consisted of two Weatherport tents and individual canvas-walled tents for crew members, and it was supplied mainly by boat from Chitina. Mobilization at both camps was timed to ensure that the fishwheels were operational 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 and several handheld VHF radios, Iridium satellite telephones, and a Starband satellite internet system that provided continuous high-speed internet access. These systems were battery-powered (12 V) and charged by a combination of solar panels, wind turbines, and gas-powered generators. Each morning at a pre-arranged time, the camp lead from each camp was responsible for contacting the NVE office in Cordova via email to exchange information (e.g., provide daily fishwheel catches, place food and supply orders, arrange flights and crew changes). The majority of camp communications were conducted via the internet, with satellite phones reserved for emergencies and instances where internet was temporarily unavailable.

Fishwheel Operation and Catch

Fishwheel Operation

Suitable fishwheel sites were selected based on water depth, water velocity, accessibility, bankfull width, and protection from floating debris and rock fall. For the three large fishwheels 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 and force migrating fish to travel near shore and into the path of the fishwheels. Narrow, fast-flowing channels tend to concentrate migrating salmon close to shore and are thus preferred to wide, slow-flowing areas. The small, four-basket fishwheels could operate in slower water velocities and shallower depths than the large fishwheels. The basket assembly of fishwheels 4 and 5 could also be raised or lowered as water levels changed throughout the season.

The three large fishwheels used in 2008 were installed and operated similar to the methods used in 2007 (van den Broek et al. 2008). A rock drill was used to set steel anchor pins into the rock walls at the Baird Canyon and Canyon Creek fishwheel 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 the two smaller fishwheels in place when fishing along gravel bars, a boat anchor was buried 1.5 m deep on the river bank approximately 30 m upstream of the fishing site. Wire rope (1.3 cm dia) was then attached to the fishwheel at one end and to the anchor at the other end. Wood-pole or aluminum-plank spars were used to hold the bow of the fishwheels off the river bank or cliff. Two, propeller-driven, outboard motors were mounted on transoms at the stern of the fishwheel pontoons and were used to move the fishwheels between sites. Fishwheels were re-positioned upriver and downriver by adjusting the bow anchor lines, and laterally by adjusting the stern and side anchor lines.

The fishwheels were operated 24 hours per day except for stoppages when they were being re-positioned or repaired, or when catches were too high to fish them overnight. Fishwheel speed (revolutions per minute, RPM) was determined one or more times each day by measuring the time required for the fishwheel baskets to complete three revolutions, thus mitigating for the effects of temporary surges in water velocity. If fishwheel 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 fishwheels.

Fishwheel Catch and Effort

Two forms of fishwheel effort were calculated. First, *daily fishing effort* was computed as the number of hours that a fishwheel operated on a given calendar day from midnight to midnight. Second, *effort for calculating catch per unit effort (CPUE)* was computed as the number of hours that a fishwheel fished to obtain a given day's catch. 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 times each evening. For example, if fish were last sampled at 2200 hours on day *t* and last sampled on day *t*+1 at 2000 hours, then only 22 hours of fishing effort was used to obtain the *effort for calculating CPUE* on day *t*+1 (assuming uninterrupted fishwheel operation). However, in this example, the *daily fishing effort* on day *t*+1 would be 24 hours because the fishwheel operated continuously for the entire calendar day. *Effort for calculating CPUE* on day *t*+1 could also exceed 24 hours if the last sampling session on day *t* was earlier in the day than the last sampling session on day *t*+1. Additionally, daily effort for capture of sockeye salmon was distributed sporadically between different fishwheels and live tanks to ensure random sampling with minimal pressure on the fish. Therefore, effort for calculating CPUE for sockeye was generally considerably less than 24 hours for any fishwheel on any given day, even though actual daily fishing effort was 24 hours. To calculate CPUE (fish per fishwheel hour), the total number of fish captured on a given calendar day was divided by that day's effort for CPUE.

In order to reduce the potential for high densities and crowding of fish in the live tanks during periods when sockeye were not being sampled, escape panels were installed in the live tanks of all project fishwheels (see Photo 6 on p. 84 in Smith et al. 2003). 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).

Tag Application and Recovery

Two to four times per day, depending on catches, crews at Baird Canyon and Canyon Creek removed all fish in the live tanks of each fishwheel. All adult Chinook and sockeye salmon were counted. All Chinook salmon and a subsample of sockeye salmon were sexed, measured for fork length (FL), inspected for an adipose fin (a missing adipose fin indicated a coded-wire-tagged hatchery fish) 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. All other captured fish were identified to species, counted, and released.

At Baird Canyon, all Chinook salmon greater than 500 mm FL and in good condition were marked (up to a maximum of 125 per day) with a radio-frequency identification (RFID) transponder (ENSID Technologies, Inc, Auckland, New Zealand). These passive, 124.2 kHz transponders were encapsulated on a t-bar tag with two, 25-mm monofilament lines that terminated in 9-mm anchor bars (herein referred to as TBA-PIT tags). NVE's address and phone number were printed on a 45-mm piece of yellow PVC marker (Hallprint Pty Ltd, Adelaide South Australia). Unique tag numbers were electronically encoded and read via a PDA with integrated RFID scanner. The TBA-PIT tags were a new technology specially designed for this project. Tags were supplied in magazine clips of 20 tags each, and were applied to fish using a handheld applicator gun with 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 forth pterygiophores, 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. Chinook salmon also received a small hole punched in the right operculum, which was a secondary mark used to estimate tag loss.

In addition to the general sampling procedures described above (i.e., counting, recording length and sex, and examining for adipose fin and physical marks), all salmon caught at the Canyon Creek fishwheels were physically examined for a tag and scanned with a PDA with integrated RFID scanner to record the unique ID if a tag was observed. Since the TBA-PIT tags were external and easily seen, and each fish was handled by the crew, it is unlikely that a tagged fish was captured and not observed at the Canyon Creek fishwheels.

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 fishwheels. The abundance estimate is potentially biased if any of the assumptions inherent to the mark-recapture model are violated (Ricker 1975; Seber 1982).

Handling and tagging fish did not make them more or less vulnerable to recapture than untagged fish.

There was no explicit test for this assumption because the behavior of untagged fish could not be assessed. Sampling sessions were frequent (minimum of three times per day) to ensure that fish were not retained in the live tanks for long periods of time. Escape panels were used to reduce fish densities in the live tanks, particularly during periods of high sockeye salmon catches. Technicians were trained by experienced biologists on how to handle and sample fish in order to reduce the amount of stress on the fish. Visibly stressed or injured fish were not tagged. Also, the distance between the tag and recapture sites (91 km) was assumed sufficient enough to reduce the potential of handling-induced "trap happiness" or "trap shyness" in tagged fish.

Tagged fish did not lose their tags, and there was no mortality of tagged fish between the tagging and recovery sites.

Tag loss was tested through the application of a secondary mark (operculum punch) on all tagged Chinook salmon. Only Chinook salmon that received primary and secondary marks at Baird

Canyon, and fish that were examined for primary and secondary marks at Canyon Creek, were included in the calculations of abundance. The chance of a fish losing both marks between sampling events was assumed to be negligible. Fish captured at Canyon Creek with a secondary mark and no primary mark would be used to quantify tag loss. It was assumed that tag retention rates for sockeye salmon were the same as those for Chinook salmon. It was further assumed that natural mortality between sampling events was equal for tagged and untagged fish; thus the abundance estimates were germane to the tagging location at Baird Canyon. Also, since every Chinook salmon that was tagged had a secondary mark, and since every Chinook salmon was examined for both marks at Canyon Creek, it was unlikely that a tagged Chinook salmon was recaptured but not observed at Canyon Creek.

Tagged fish mixed completely with untagged fish between the sampling events.

The Copper River is highly braided in some sections between Baird Canyon and Canyon Creek, which reduced the chances that tagged and untagged fish remain unmixed between sample events. Results from previous years of this study have shown that recapture rates for fish tagged at Baird Canyon and recaptured at Canyon Creek were independent of the bank of capture (Smith et al. 2003). Furthermore, studies from 1999-2001 showed equal mixing of tagged and untagged Chinook salmon between the lower end of Wood Canyon and the CSS 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 fishwheels. Contingency table analyses were used to compare mark and recapture rates by bank of capture in 2008.

Fish had equal probabilities of being marked or equal probabilities of being recaptured regardless of size.

To test for size-selective sampling at the fishwheels, Kolmogorov-Smirnov (K-S) two-sample tests (Zar 1984) were used to compare the cumulative length-frequency distributions of: (1) a subsample of fish tagged during the first sampling event and a subsample of fish recaptured during the second event; and (2) a subsample of fish tagged during the first sampling event and a subsample of fish examined during the second event (as presented in Bernard and Hansen 1992).

Fish had equal probabilities of being marked regardless of time of capture.

Apart from minor fishwheel stoppages for repairs and moves, fishing effort at the Baird Canyon fishwheels was continuous throughout the study period for Chinook salmon. Fishing effort for sockeye salmon was based on periods when the escape panels were closed and was distributed between fishwheels and river banks (spatially) at consistent intervals (temporally) throughout each day to reduce the potential of bias being introduced into the experiment. Period-specific mark rates in the second sampling event were compared using contingency table analysis to determine whether this condition was met.

Marked fish had equal probabilities of being recaptured regardless of when they passed the recapture fishwheel.

Period-specific recapture rates in the second event were compared using contingency table analysis. If both the mark and recapture rates varied among periods and a sufficient number of recaptures were available, a temporally stratified estimator would be used.

Abundance Estimate

One of two models was used to provide mark-recapture estimates: the pooled Petersen estimator (PPE) with Chapman's correction (Seber 1982) or the partially stratified Petersen estimator (i.e., the Darroch model (Darroch 1961)). Schwarz and Taylor (1998) provide thorough descriptions of both models. The PPE pools all of the data from the entire sampling season to estimate abundance, whereas the Darroch model is used to stratify the data into groups with similar capture and/or movement probabilities (in this case temporally). The abundance estimate was calculated using the software SPAS (Arnason et al. 1996). Specifically, if a non-significant Chi-square test resulted from any of the three tests ($\alpha = 0.05$) shown in Table 1 then the PPE model was chosen.

Temporal strata were chosen via an iterative process of trying all possible cut-points along the daily transition matrix. The matrix was first stratified into two tagging and two recovery strata. All possible 2×2 stratifications were performed and for each the chi-square statistic from the equal movement test was recorded. Stratifications that rendered cells in the expected frequency table with a value less than 5 were dismissed. Of the remaining stratifications, the one that resulted in the greatest chi-square value was used to stratify the daily matrix. This approach divided the daily matrix into four cells that were the most different with respect to movement and/or capture probabilities, and therefore, the most homogenous within. Additional stratifications were performed on cells lying along the diagonal from top left to bottom right until there were too few recoveries to allow further stratification, or until the population estimate stabilized (i.e., additional stratifications caused little change in N). Schwarz and Taylor (1998) recommended the equal movement test for determining when to pool adjacent tagging strata; namely, low chi-square values indicate pooling is acceptable because of equality of movement across the strata. This concept was extended to allow objective determination of temporal strata and facilitate estimation from the Darroch maximum-likelihood (ML) model. Sometimes stratification schemes will not form a Darroch ML estimate, but this algorithm always seems to produce matrices that will (further investigation as to why is warranted).

RESULTS

Project Mobilization

Mobilization of the Baird Canyon camp began on 7 May. The project manager, a consultant, five technicians, a Starband technician, and gear were flown to camp on several round trip flights with an A-Star helicopter (Era Aviation). Apart from a 500-m long patch of open water near the cabin, the Copper River was frozen from Bremner River confluence downstream to the Mile 27 and Mile 38 bridges. Snow cover was approximately 3-m deep upon arrival at camp, and all equipment was buried but in good condition. The fishwheels were dug out and re-assembled. Fishwheel 1 began fishing at Baird Canyon on 19 May, followed by fishwheel 5 on 20 May, and fishwheel 2 on 30 May.

Mobilization of the Canyon Creek fishwheels began on 14 May. Equipment and boats were transported from storage locations in Cordova, Glennallen, and Gakona by vehicle to Chitina, and then to camp using jet boats. Fishwheels 3 and 4 required only minor repairs. Major build-up of shelf ice blocked the path of the fishwheels to the river, and required a full day of break-up using pick-axes and shovels. Low water levels prevented both fishwheels from starting the season in their usual fishing locations. Fishwheel 3 began fishing on 20 May and fishwheel 4 on 25 May.

Fishwheel Operation and Catch

Fishwheel Operation

Stage height of the Copper River at Baird Canyon varied by 4.9 m from 20 May to 4 August (Figure 4). At Canyon Creek, stage height varied by 5.3 m from 25 May to 21 August. Water levels rose slowly and fluctuated throughout the duration of the season. Stage height peaked on 18 July at both sites. In 2008, stage height of the Copper River at the Million Dollar Bridge tracked quite closely to the historical average for the entire season (Figure 5).

Fishwheel 1 operated on the west bank of Baird Canyon for 1,180 h (91.8% of the time) from 20 May to 12 July (Figure 6; Appendix A.1). Fishwheel 2 operated on the east bank of Baird Canyon for 1,277 h (99.1% of the time) from 30 May to 23 July. Fishwheel 5 operated on the west bank of the Copper River approximately 1.5 km upstream from Baird Canyon for 1,809 h (99.2% of the time) from 20 May to 4 August. Fishwheel speeds averaged 2.6, 1.7, and 2.9 RPM for fishwheels 1, 2, and 5, respectively (Figure 6; Appendix A.1).

At Canyon Creek, fishwheel 3 operated along the east bank of the Copper River approximately 2.5 km downstream from the mouth of Canyon Creek. From 21 May to 12 August, it operated for 1,973 h (98.2% of the time). Fishwheel 4 operated primarily on the east bank approximately 2.5 km downstream from the mouth of Canyon Creek, and fished for 1,993 h (98.3% of the time) from 26 May to 19 August. Fishwheel speeds averaged 2.5 and 4.6 RPM for fishwheels 3 and 4. Fishwheels 3 and 4 were moved inseason due to variable river levels and changes in bathymetry from previous years.

Fishwheel Catch

A total of 4,807 adult Chinook salmon were captured at the Baird Canyon fishwheels, of which 3,656 were captured at fishwheel 1, 875 at fishwheel 2, and 276 at fishwheel 5 (Figure 7; Appendix B.1). Total daily catch peaked at 231 Chinook salmon on 3 June. Daily CPUE peaked at 8.2, 2.7, and 0.9 Chinook salmon per hour for fishwheels 1, 2, and 5, respectively (Figure 8; Appendix B.1). Fifty coho salmon, 5 pink salmon *O. gorbuscha*, 3 steelhead trout *O. mykiss*, 127 Dolly Varden *Salvelinus malma*, 36 whitefish *Coregonus spp.*, 13 Pacific lamprey *Lampetra tridentata*, 34 sucker *Catostomus sp.*, 1 burbot *Lota lota*, 1 three spine stickleback *Gasterosteus* *aculeatus*, 1 beaver *Castor canadensis*, and 1 harbor seal *Phoca vitulina* were also captured and released.

A total of 3,592 Chinook salmon were captured at the Canyon Creek fishwheels, including 1,643 at fishwheel 3 and 1,949 at fishwheel 4 (Figure 9; Appendix B.1). Daily catch peaked at 207 Chinook salmon on 18 June. Daily CPUE peaked at 3.96 and 5.14 Chinook salmon per hour at fishwheels 3 and 4 (Figure 10; Appendix B.1). Twenty-six coho salmon, 11 steelhead trout, 63 Dolly Varden, 45 whitefish, 15 Pacific lamprey, 29 sucker, 1 burbot, 1 pink salmon, and 1 arctic grayling *Thymallus arcticus* were also captured and released.

Tag Application and Recovery

Of the 4,807 Chinook salmon captured at the Baird Canyon fishwheels, 3,931 fish (82%) were tagged and released (Figure 11; Appendix C.1). The number of tags applied in a single day peaked at 132 fish on 3 June. A total of 876 Chinook salmon were not tagged, including: 347 fish released voluntarily because the daily quota had been reached, 318 fish that escaped prior to being sampled, 141 fish that were visibly injured or stressed, 48 fish that measured less than 50 cm FL, and 22 mortalities.

A total of 3,509 Chinook salmon were examined for primary and secondary marks at the Canyon Creek fishwheels (Figure 12; Appendix C.1). Of those examined, 342 (8.7%) were recaptures, or fish that had been tagged at Baird Canyon. The first two tagged fish were captured at Canyon Creek on 27 May (one tagged on 26 May and two tagged on 28 May) and the last tagged fish was captured on 5 August (tagged on 12 June). The number of Chinook salmon examined for marks at Canyon Creek peaked at 202 fish on 18 June and the number of recaptures peaked at 19 fish on 17 and 21 June. The median travel time of Chinook salmon tagged at Baird Canyon and recaptured at Canyon Creek was 10.9 d (range: 3.6-33.2 d; Figure 13).

Inriver Abundance Estimate

Conditions for a Consistent Estimator

Handling and tagging procedures at Baird Canyon did not appear to significantly delay the migratory behavior of Chinook salmon. Of the 188 Chinook salmon captured twice at the Baird Canyon fishwheels, 85 fish (45.2%) were recaptured within 1 d of being tagged. The longest delay between captures was 18 d (Figure 14). It was assumed that these migratory delays had a negligible affect on the abundance estimate. Only one Chinook salmon was captured at Canyon Creek with a right operculum punch and no TBA-PIT tag, so tag loss between sampling events was negligible (0.29%; or 11.4 tags lost per every 3,931 Chinook tagged). It is possible that this recapture was one of the 10 Chinook salmon that received an operculum punch but no tag at Baird Canyon.

Tagged Chinook salmon appeared to move equally between banks. Recapture rates of Chinook salmon that were tagged on the west bank (7.9%) of the river at Baird Canyon were not significantly different than recapture rates of fish tagged on the east bank (9.1%; $\chi^2 = 1.3$, df = 1, P = 0.26; Table 2). A second test to assess the proportionality of movement across the river using Chinook salmon recaptures by bank of release and recovery showed no significant difference (χ^2 = 1.6, df = 1, P = 0.20; Table 3). Failure to reject these tests was justification for not stratifying by bank of capture. Mark rates of Chinook salmon inspected on the east bank (10.4%) at Canyon Creek were not significantly higher than mark rates of fish inspected on the west bank (9.2%; χ^2 = 1.3, df = 1, P = 0.26; Table 4).

Cumulative length-frequency distributions of Chinook salmon marked in the first event and fish recaptured in the second event were not significantly different (D_{max} = 0.07, P = 0.12; Figure 15). Cumulative length-frequency distributions of fish marked in the first event and fish examined for marks in the second event were also similar (D_{max} = 0.03, P = 0.10). No significant difference (D_{max} = 0.06, P = 0.21) was found between cumulative length-frequency distributions of fish examined and recaptured in the second event. Based on these results, there was no size selectivity during either event and no stratification by size was necessary to estimate abundance.

Mark rates varied over the study period indicating that the probability of a fish being marked at Baird Canyon was not independent of time of capture (Figure 16). Similarly, the proportion of fish tagged at Baird Canyon that were subsequently recaptured at Canyon Creek varied over time (Figure 17). These results indicated that a temporally stratified estimator was required to estimate abundance.

Abundance Estimate

Using a maximum likelihood Darroch estimator, estimated abundance of Chinook salmon measuring 500 mm FL or greater that migrated upstream of Baird Canyon from 20 May to 19 August was 41,343 (SE = 2,166; 95% CI = 37,098 – 45,588; Table 5). This estimate was based on 3,931 tagged fish available for recapture, 3,509 fish examined for marks, and 342 recaptures.

Other Tag Recoveries

A total of 156 tagged Chinook salmon (4.0% of tagged fish) were recovered throughout the watershed (Table 6). Of these, 70 were in the federal and state subsistence fisheries (primarily fishwheels), 34 were in the personal-use dip net fishery, 14 were in the sport fishery, and 38 were from unknown fisheries.

DISCUSSION

Project Mobilization

In 2008, river ice and snow cover in early May again delayed the deployment of the Baird Canyon fishwheels. It took approximately 13 d from the time the crew arrived at camp (7 May) until the successful deployment of two fishwheels (20 May). Low river levels prevented deployment of the third fishwheel (FW2) until 30 May, which was the latest date since project inception. The complete break-up of river ice happened on 18 May and the first fishwheel began fishing the next day.

As in previous years, the Canyon Creek fishwheels were stored intact at the camp site. Between repairs, modifications, and logistics of preparing the fishwheels and establishment of the camp, it took approximately 6 d from the first day of mobilization on 14 May until the first wheel was actively fishing on 20 May. The only major delay during mobilization was caused by the presence of large quantities of shelf ice at the fishwheel launching site, which had not been seen in years prior. This added 1 d to the mobilization time. There was no on-site storage at the Canyon Creek camp like there was at Baird Canyon, but all equipment was successfully moved from storage facilities in Cordova, Glennallen, and Gakona to the Canyon Creek camp in less than 3 d. The timing and execution of mobilization at both camps was suitable given the environmental conditions in early May. No early-run fish were missed by either site.

Data Collection

In 2007, technical difficulties occurred with PDA units and PIT-tag scanners, which were typically attributed to environmental factors such as water intrusion and cold temperatures. In 2008, weatherproof PDA units with integrated RFID-PIT-tag scanners were used. This reduced the amount of down time due to equipment failures and minimized the chances of data loss or data-entry errors. However, some problems with the PDA software persisted in 2008, which were partially attributed to increased sampling efficiency and being able to collect data more rapidly. This necessitated the use of hand-logging data on paper in order to back-up the electronic data.

Fishwheel Operation and Catch

Nine percent fewer Chinook salmon were caught at the Baird Canyon fishwheels in 2008 than in 2007; however, it was the second largest number of Chinook salmon caught since 2001 (Figure 18). At Canyon Creek, 25% fewer Chinook salmon were caught in 2008 compared to 2007. This decrease was mainly attributable to difficulties in finding a suitable fishing site for fishwheel 4. Changes in river depth and velocity that were caused by the flood event in October 2006 made the site used prior to 2007 unsuitable for fishwheel 4. Despite spending considerable time and effort in 2008 testing new sites for fishwheel 4, a sufficient number of Chinook salmon were captured during each sampling event to meet the study objectives.

During the first three 12-h openers (15, 19, and 22 May) in 2008, ADF&G anticipated that 19,279 Chinook salmon and 117,941 sockeye salmon would be harvested in the Copper River District. However, only 4,560 Chinook salmon and 69,522 sockeye salmon were harvested during these periods. As a result of low harvests and low inriver escapement (49,747 salmon counted at the Miles Lake sonar through 27 May), the commercial fishery was closed by emergency order (EO) for the duration of the second week. The 2008 closure during the second week was similar to the 2006 and 2007 seasons, which also saw an unusually late start of the run. These late runs combined with fishery closures appear to have contributed to increases in Chinook salmon catches at the fishwheels.

Abundance Estimate

The 2008 abundance estimate (41,343; CV = 5.2%) for Chinook salmon appeared unbiased and exceeded the precision levels specified in the study objectives. Given the high catch rates observed for Chinook salmon during both sampling events, it was relatively easy to capture a sufficient number of fish to satisfy the project requirements. The real challenge was trying to evenly distribute sampling effort over the entire run to avoid biasing the abundance estimates, running out of tags, or being left with extra tags at the end of the season.

In 2008, an estimated 2,580 Chinook salmon were harvested in the Glennallen Subdistrict and 4,300 in the sport fishery. Harvest data from the Chitina Subdistrict were not available when this report was being prepared; however, it can be assumed that harvest levels were similar to the 2001-2005 average of 2,331 Chinook salmon (Hollowell and Sommerville 2008). By subtracting the estimated 9,211 Chinook salmon harvested above Baird Canyon from the mark-recapture estimate, the 2008 spawning escapement was estimated to be 32,132 Chinook salmon. This was 34% higher than the spawning escapement goal of 24,000 or more spawners that was set by the Board of Fisheries.

CONCLUSIONS

Despite the numerous and often significant challenges encountered during this study, it has continued to meet or exceed all project objectives and expectations. Drainage-wide abundance estimates of Chinook salmon have been generated consistently and reliably for five years and the project has evolved into a long-term monitoring program. This work has made NVE an integral part of Copper River salmon research and management. In addition, this project has demonstrated that several agencies (e.g., USFWS, NVE, and ADF&G) can work cooperatively to collect valuable data on Copper River salmon stocks that can be used to assess current management practices. Given the success of the project, it appears that fishwheels and mark-recapture methods can be used to estimate the inriver abundance of salmon on the Copper River well into the future.

RECOMMENDATIONS

In light of the preceding discussion and the fact this project will be funded by the Federal Subsistence Board through 2009, the following are recommended for the 2009 field season:

(1) Redesign the Palm OS software used in data collection to reduce user errors. For example, simplifying the flow of the software and incorporating 'checks and balances' will ensure only relevant data is recorded and eliminate inconspicuous data entry. Along with new programming, the software developer should be available for immediate resolution of software issues as they occur in the field. Timely customer support is essential;

(2) Improve the inriver reporting of harvested tagged fish within the Chitina and Glennallen subdistricts. Recent research data and anecdotal information suggest that considerable unreported harvest is taking place in the inriver fisheries of the Copper River. Essentially, once the salmon pass the Miles Lake sonar, there is limited accountability of inriver harvests within the State and Federal subsistence, personal use, sport and guided sport fisheries throughout the Copper River drainage. The Native Village of Eyak submitted an unsuccessful pre-proposal to the U.S. Fish and Wildlife Service Office of Subsistence Management to improve public awareness of existing tagging studies and increase the

percentage of harvested tagged fish that are reported to project investigators. Attempts should be made to implement some of these ideas under the current budget framework;

(3) 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. Plan on the Baird Canyon crew starting around 5 May and the Canyon Creek crew around 12 May, with Baird Canyon mobilized in time to have the first fishwheel launched and fishing immediately following full break-up and clearing of river ice above Miles Lake, and Canyon Creek mobilized in time to have the first fishwheel launched and fishing within 2 d of the first tagged fish released;

(4) Operate fishwheels 1, 2, and 5 at the same sites used in 2008. Fishwheels 3 and 4 at Canyon Creek will need to be relocated as river conditions change. River conditions at the Canyon Creek location have been more variable since the 2006 Fall flooding event; and

(5) Continue to use the escape panels in each fishwheel with the openings set to a width of 6 cm except when closed to sample sockeye salmon.

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TABLES

Table 1. Three contingency-table tests used to determine whether the conditions necessary for a consistent pooled Petersen estimate were met, or whether a stratified Petersen estimator (Darroch model) was necessary to estimate abundance.

Mixing test:

Tagging stratum	Recovered	Not seen again
S1	$m_{2,S1,.}$	$n_1 - m_{2,S1,.}$
S2	$m_{2,S2,.}$	$n_1 - m_{2,S2,.}$
S3	$m_{2,S3,.}$	$n_1 - m_{2,S3,.}$
S4	$m_{2,S4,.}$	$n_1 - m_{2,S4,.}$

Equal proportions test:

	Recovery strata			
	R1	R2	R3	R4
Marked	$m_{2,.,R1}$	$m_{2,.,R2}$	$m_{2,.,R3}$	$m_{2,.,R4}$
Not marked	$u_{2,.,R1}$	$u_{2,.,R2}$	$u_{2,.,R3}$	$u_{2,.,R4}$

Equal movement test:

Tagging	Recovery strata				
stratum	R1	R2	R3	R4	Not seen again
S1	$m_{2,S1,R1}$	$m_{2,S1,R2}$	$m_{2,S1,R3}$	$m_{2,S1,R4}$	$n_1 - m_{2,S1,.}$
S2	$m_{2,S2,R1}$	$m_{2,S2,R2}$	$m_{2,S2,R3}$	$m_{2,S2,R4}$	$n_1 - m_{2,S2,.}$
S3	$m_{2,S3,R1}$	$m_{2,S3,R2}$	$m_{2,S3,R3}$	$m_{2,S3,R4}$	$n_1 - m_{2,S3,.}$
S4	$m_{2,S4,R1}$	$m_{2,S4,R2}$	$m_{2,S4,R3}$	$m_{2,S4,R4}$	$n_1 - m_{2,S4,.}$

Table 2. Number of Chinook salmon recaptured, by bank of release, and the results of a test to compare recapture rates of fish marked on the east and west banks of the Copper River, 2008.

Bank of Release	Recaptured	Not Recaptured	Tagged	Recapture Rate
West (FW1&5)	251	2,945	3,196	0.079
East (FW2)	67	668	735	0.091
Total	318	3,613	3,931	0.081

Chi-square = 1.28 df = 1 p-value = 0.258

Excludes 24 recaptures with unknown release locations

Table 3. Number of Chinook salmon recaptured, by bank of release and bank of recovery, and the results of a test to compare for equal movement across the river, 2008.

	Bank of Recovery		
Bank of Release	West	East	Recaptured
West (FW1&5)	124	127	251
East (FW2)	39	28	67
Total	163	155	318

Chi-square = 1.64 df = 1 p-value = 0.2

Excludes 24 recaptures with unknown release locations

Table 4. Number of Chinook salmon marked, by bank of recovery, and the results of a test to compare mark rates of fish recovered on the east and west banks of the Copper River, 2008.

Recovery Location	Marked	Not marked	Total Examined	Mark Rate
West (FW4)	177	1,740	1,917	0.092
East (FW3)	165	1,427	1,592	0.104
Total	342	3,167	3,509	0.097

Chi-square = 1.27 df = 1 p-value = 0.261

Table 5. Annual inriver abundance of Chinook salmon above Baird Canyon on the Copper River, 2003-2008.

	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

Table 6. Number of tagged Chinook salmon recovered from various locations throughout the Copper River drainage, 2008.

	Recovery Category				
Recovery Location	Personal Use	Subsistence	Unreported	Total	Percent
Chitina Subdistrict	25			25	16.0%
Glennallen Subdistrict	2	70	4	76	48.7%
Unknown Subdistrict	7		34	41	26.3%
Sport Fishery				14	9.0%
Total	34	70	38	156	

FIGURES

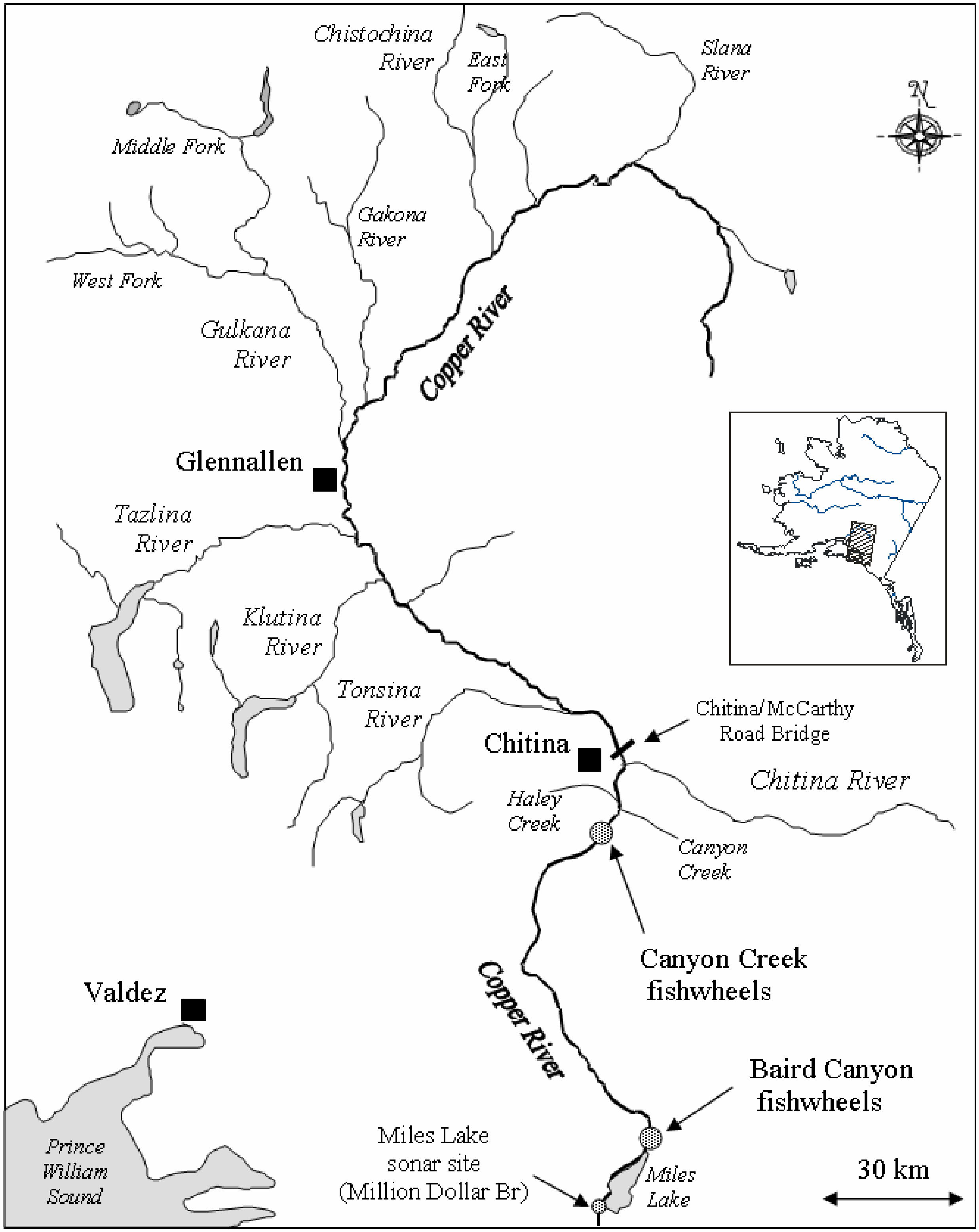

Figure 1. Map of the study area showing the location of the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2008.

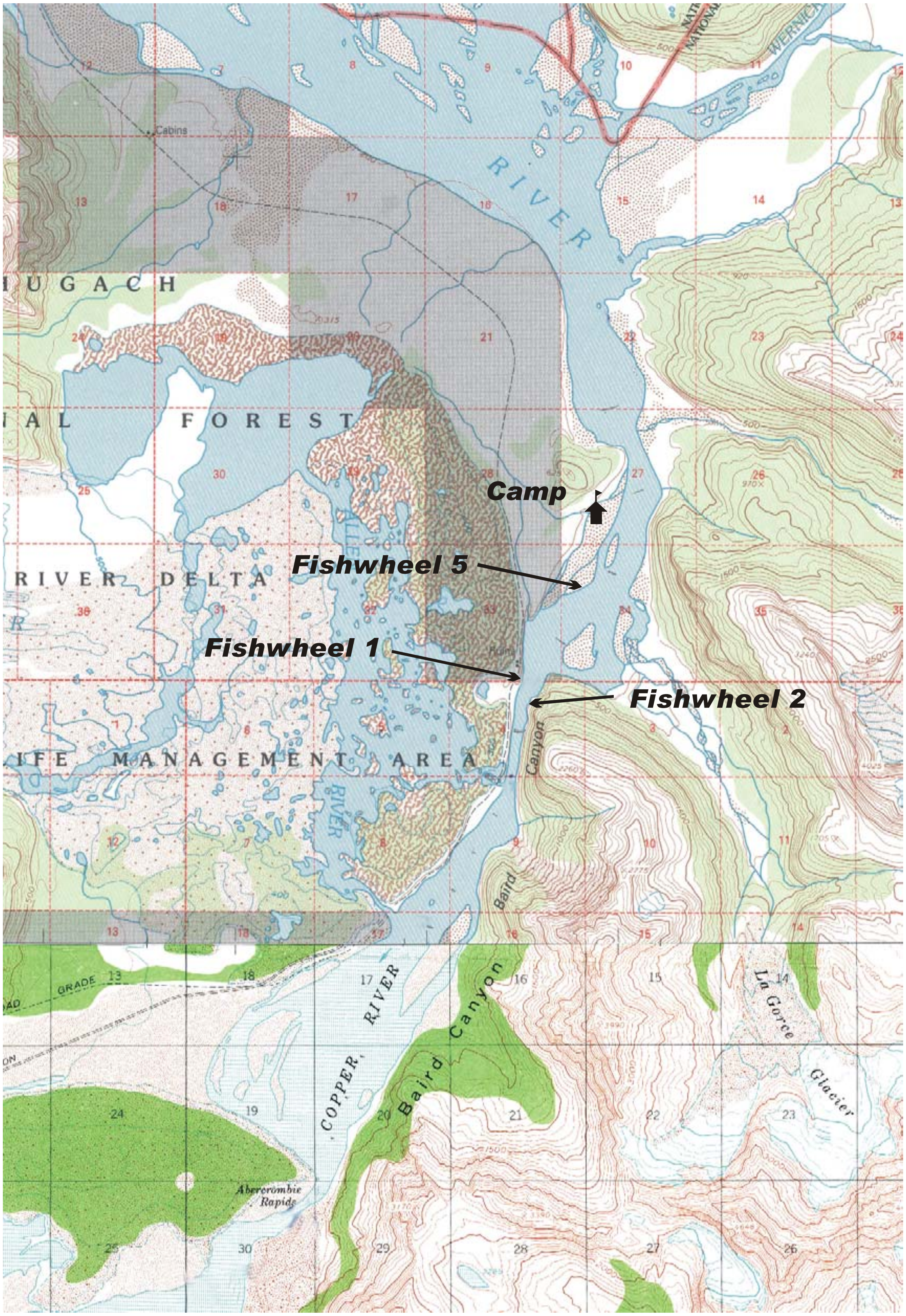

Figure 2. Map of Baird Canyon on the Copper River showing the location of the camp and fishwheel sites that were used in 2008.

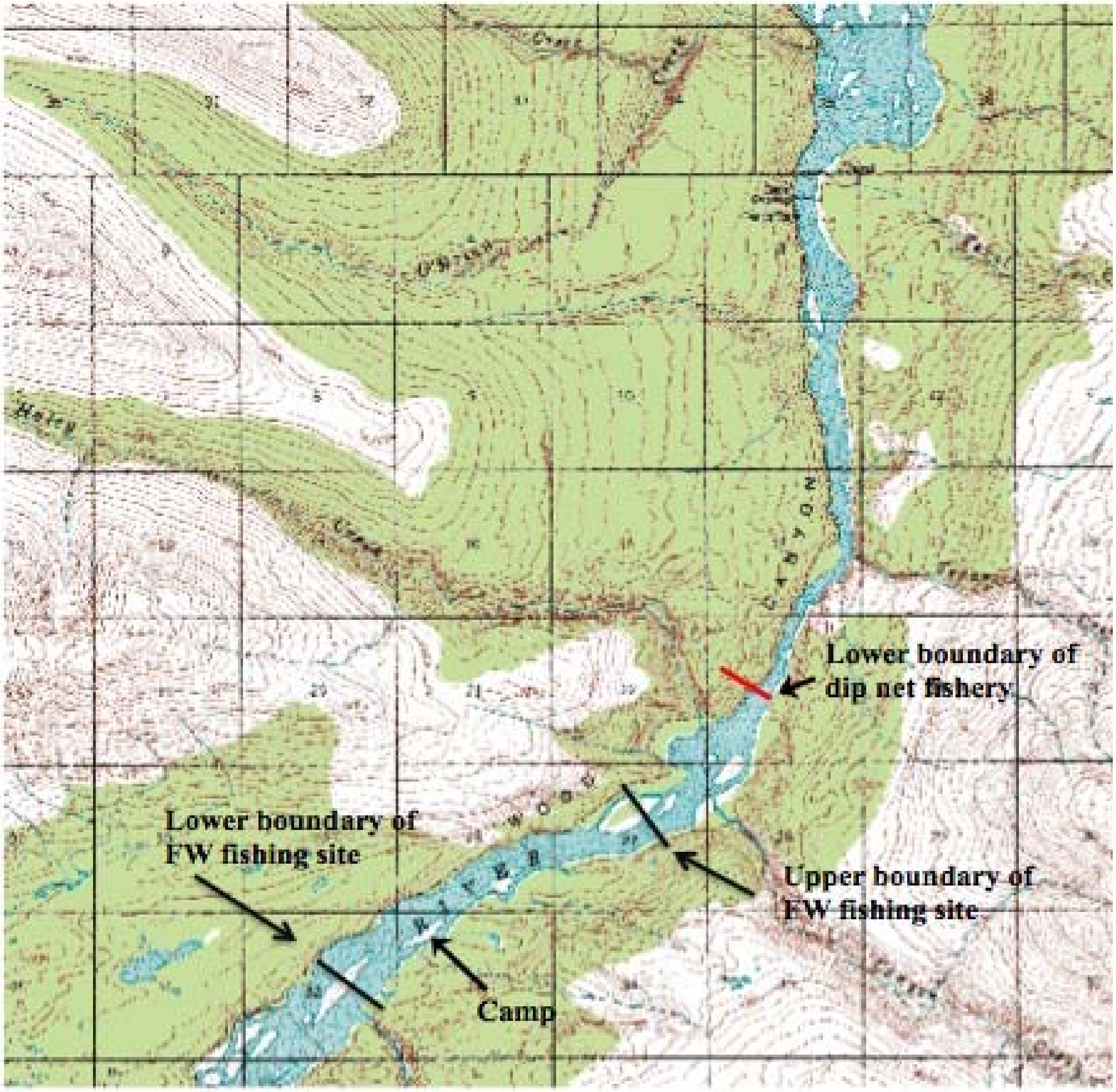

Figure 3. Map of Wood Canyon on the Copper River showing the location of the Canyon Creek camp and fishwheel sites that were used in 2008, and the lower boundary of the Chitina Subdistrict dip net fishery.

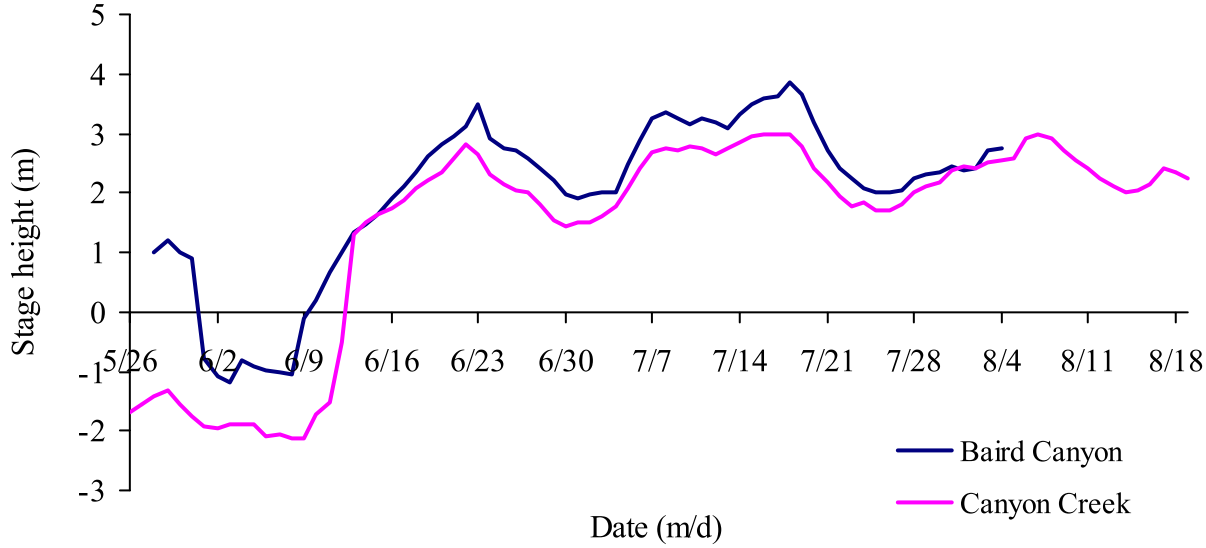

Figure 4. Stage height of the Copper River near the Baird Canyon and Canyon Creek fishwheels, 26 May to 19 August 2008.

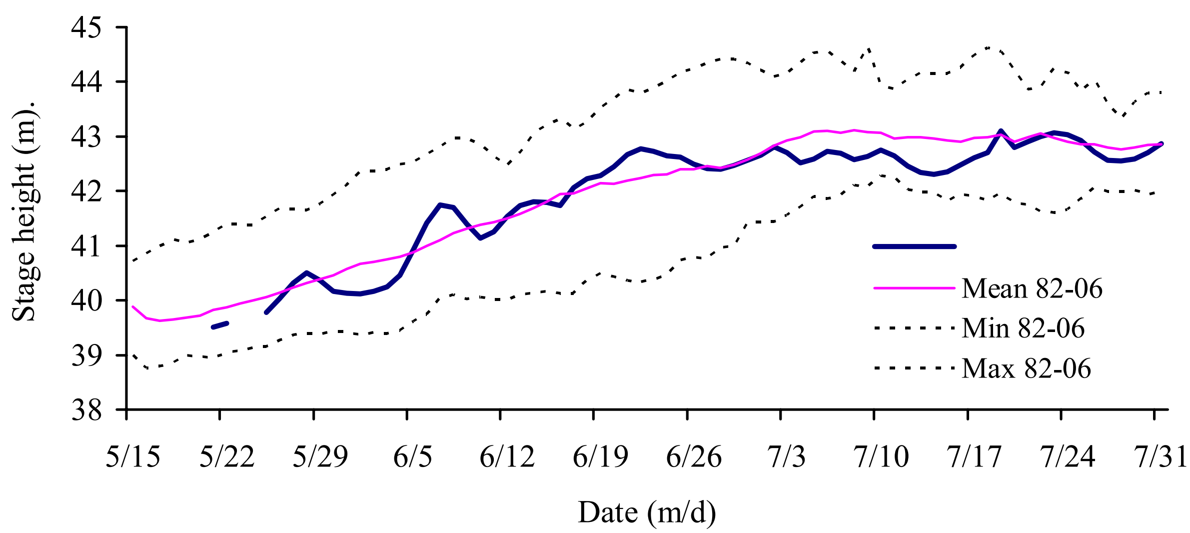

Figure 5. Stage height of the Copper River at the Million Dollar Bridge, 1982-2008.

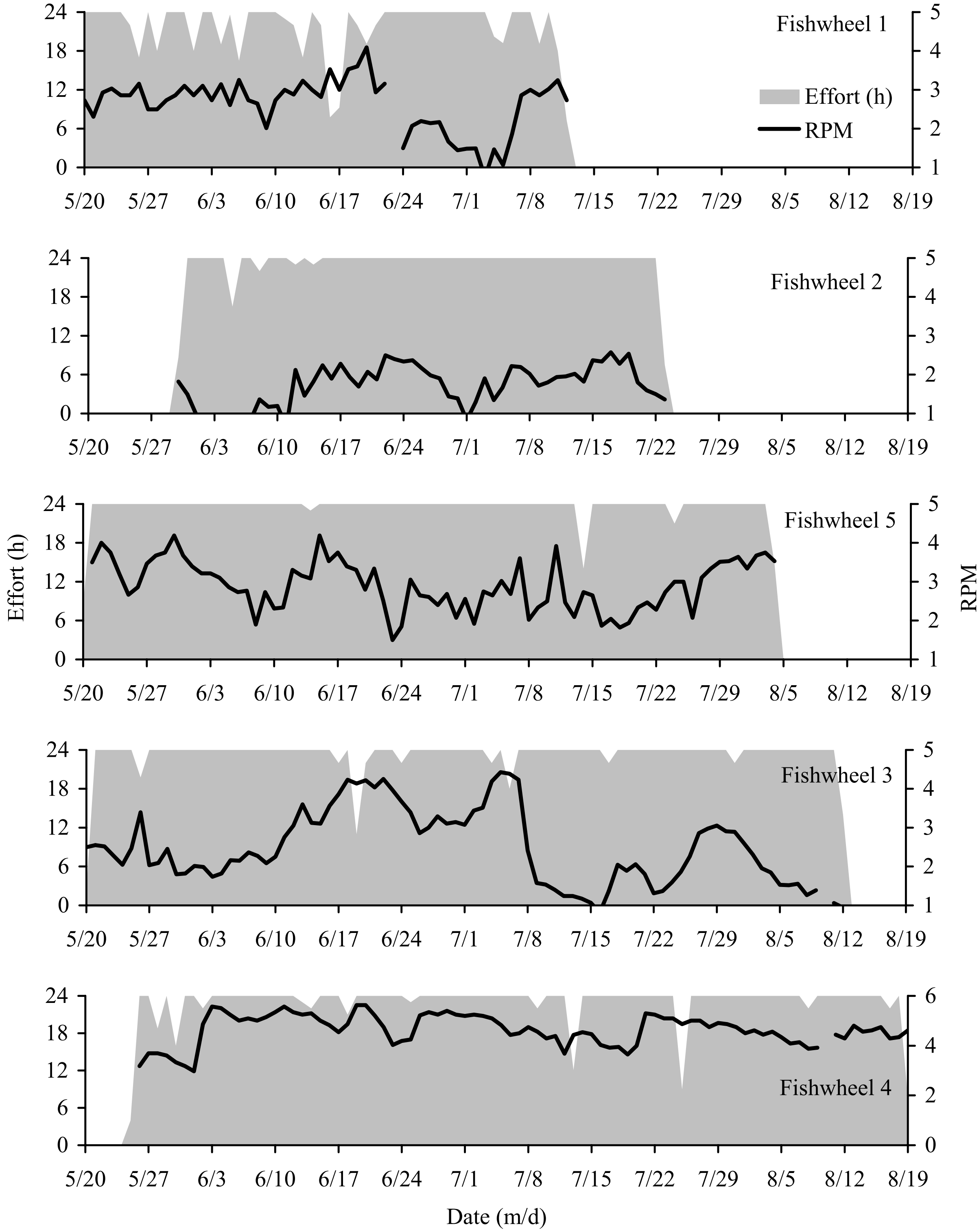

Figure 6. Fishwheel effort (h) and speed (RPM) at the Baird Canyon (fw 1, 2, and 5) and Canyon Creek (fw 3 and 4) fishwheels on the Copper River, 2008.

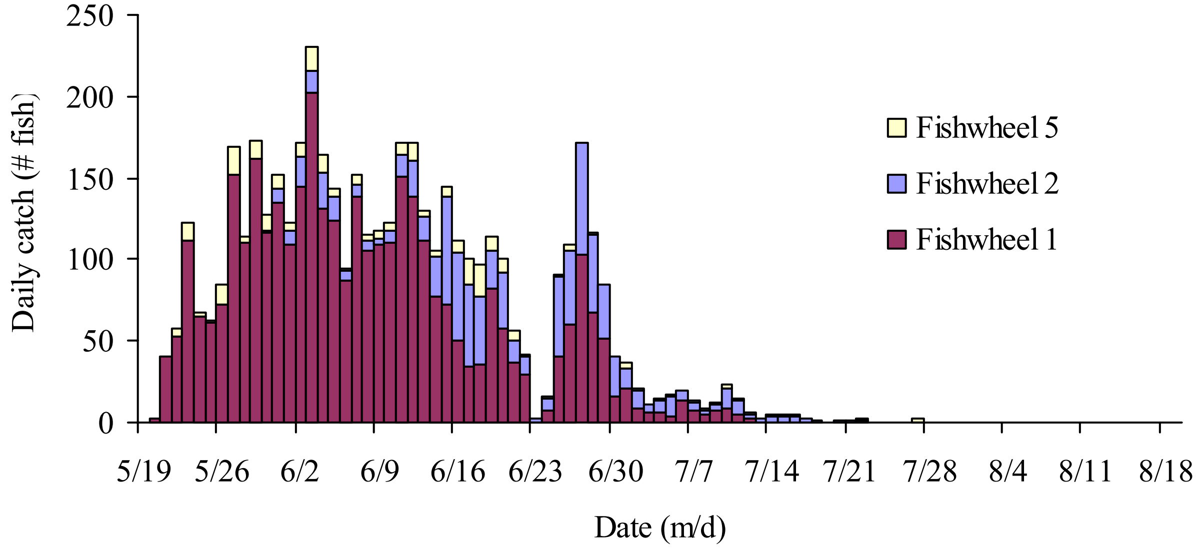

Figure 7. Daily catch of Chinook salmon at the Baird Canyon fishwheels on the Copper River, 2008.

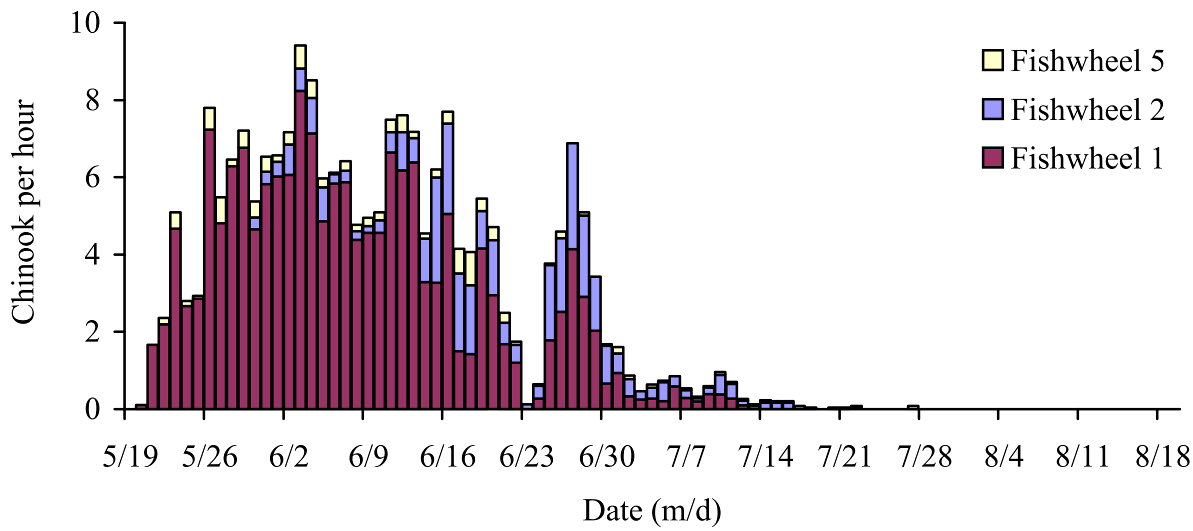

Figure 8. Catch per unit effort (fish per fishwheel hour) for Chinook salmon at the Baird Canyon fishwheels on the Copper River, 2008.

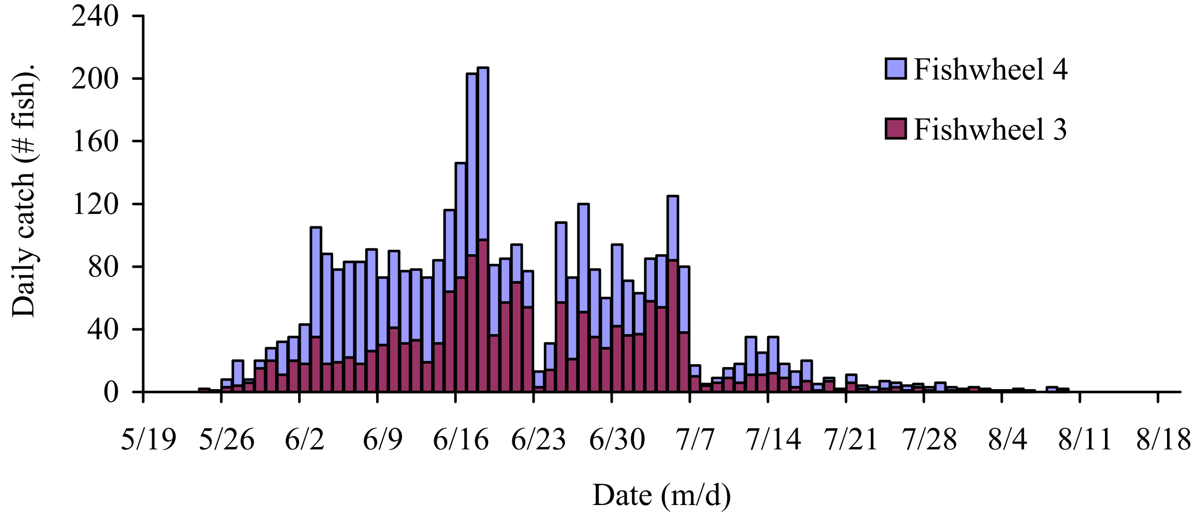

Figure 9. Daily catch of Chinook salmon at the Canyon Creek fishwheels on the Copper River, 2008.

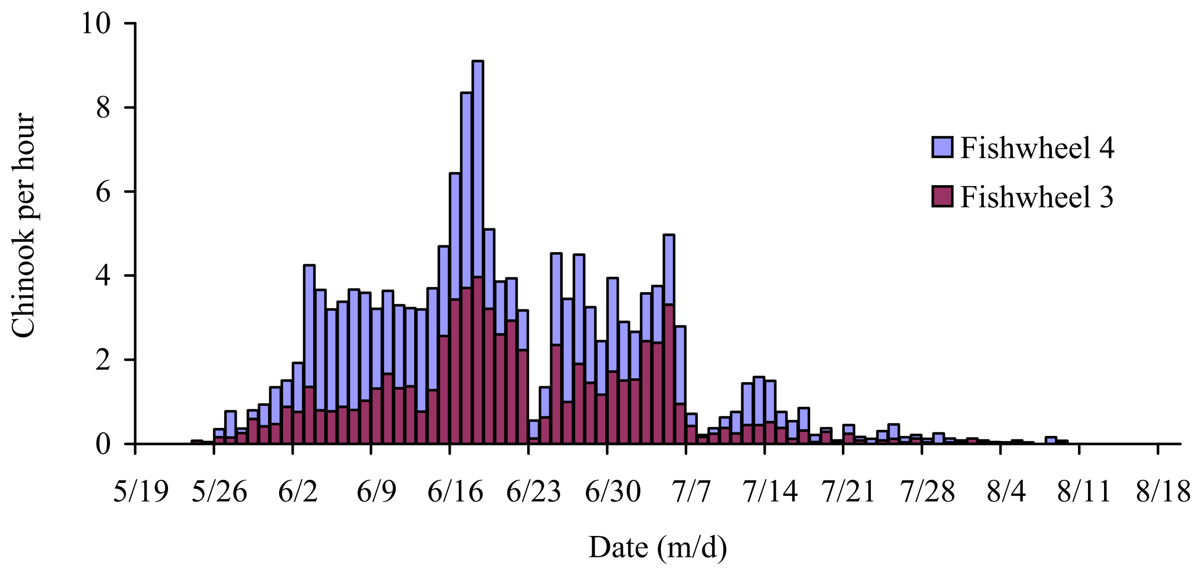

Figure 10. Catch per unit effort (fish per fishwheel hour) for Chinook salmon at the Canyon Creek fishwheels on the Copper River, 2008.

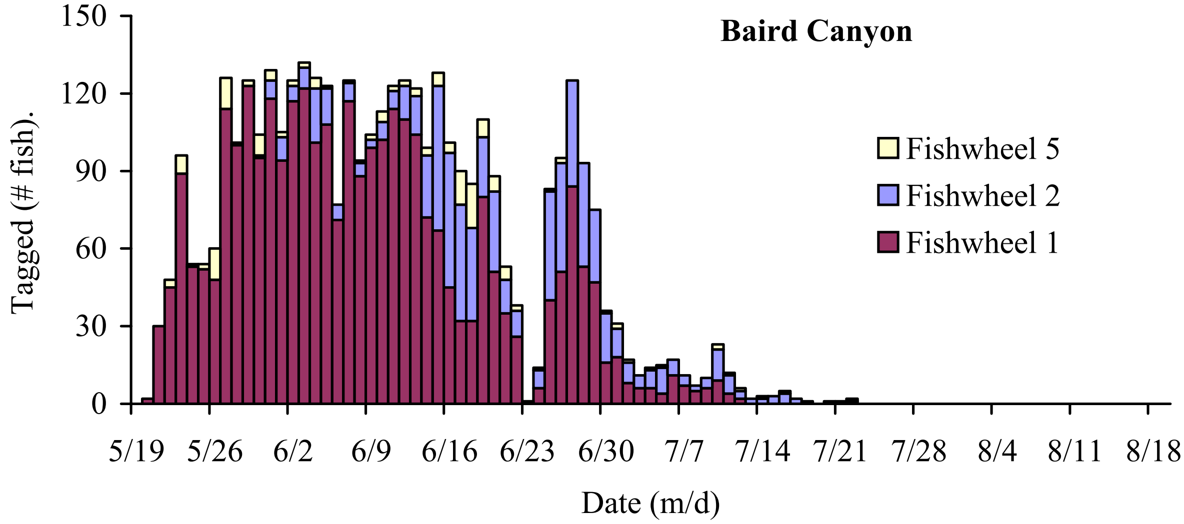

Figure 11. Number of Chinook salmon tagged at the Baird Canyon fishwheels on the Copper River, 2008.

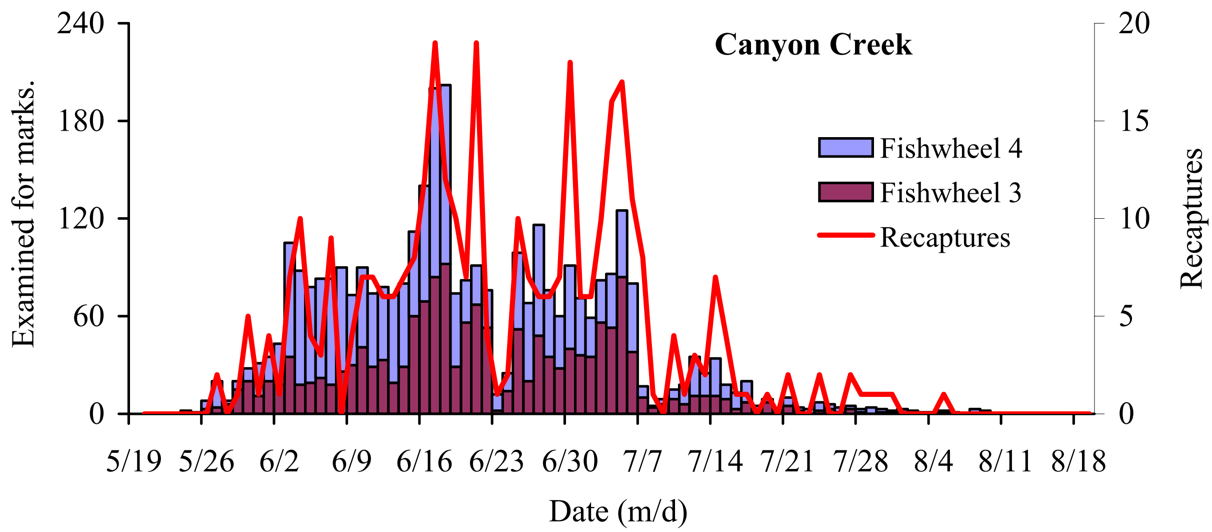

Figure 12. Number of Chinook salmon examined and recaptured at the Canyon Creek fishwheels on the Copper River, 2008.

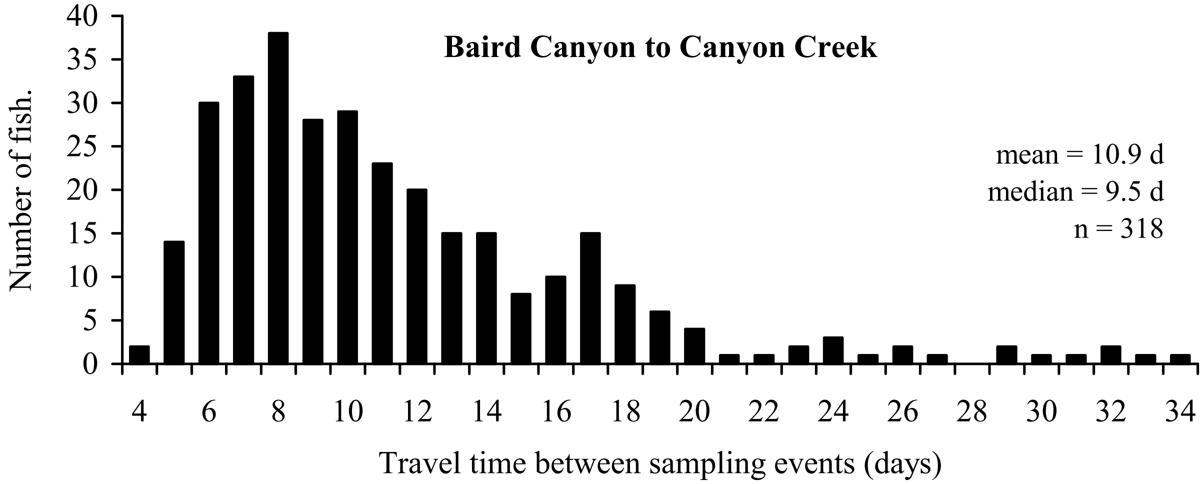

Figure 13. Travel time (days) of Chinook salmon tagged at the Baird Canyon fishwheels and recaptured at the Canyon Creek fishwheels, 2008.

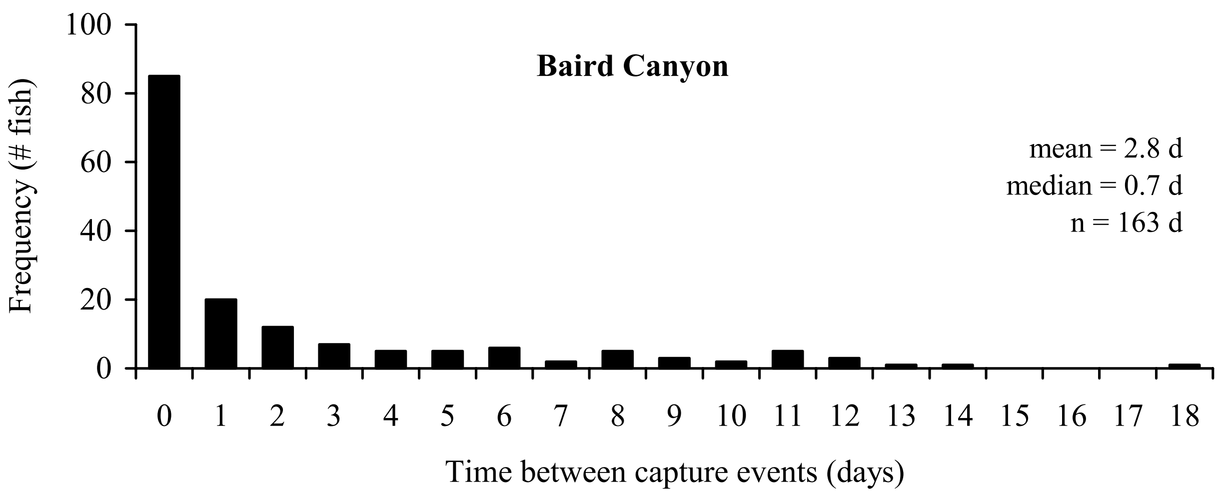

Figure 14. Migratory delay (days) for Chinook salmon captured more than once at the Baird Canyon fishwheels, 2008.

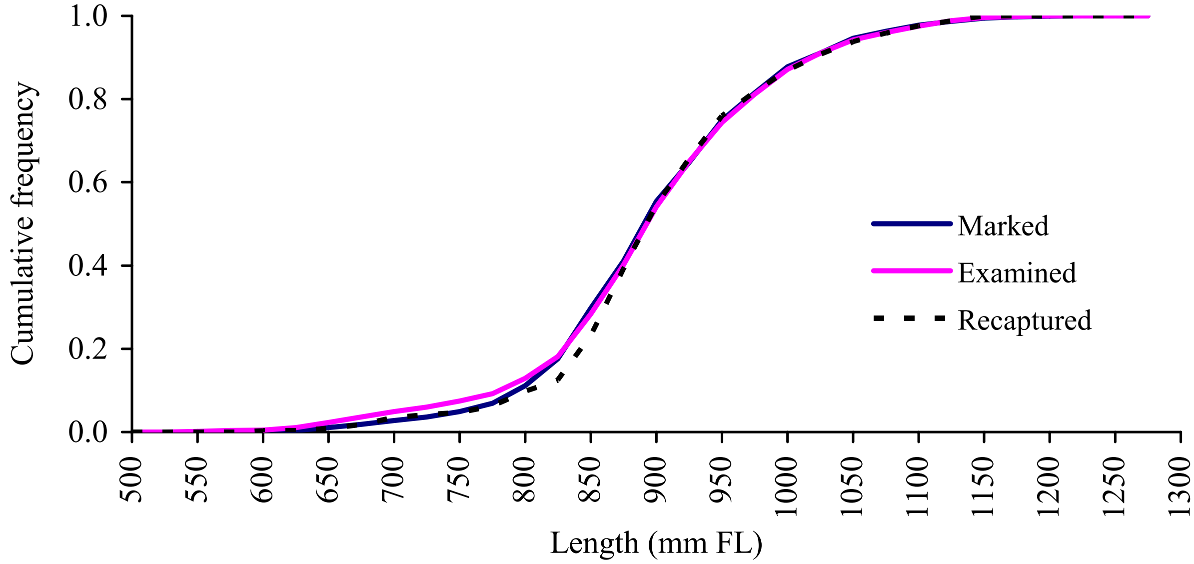

Figure 15. Cumulative length-frequency distributions for Chinook salmon (≥ 500 mm FL) marked at Baird Canyon and examined and recaptured at Canyon Creek, 2008.

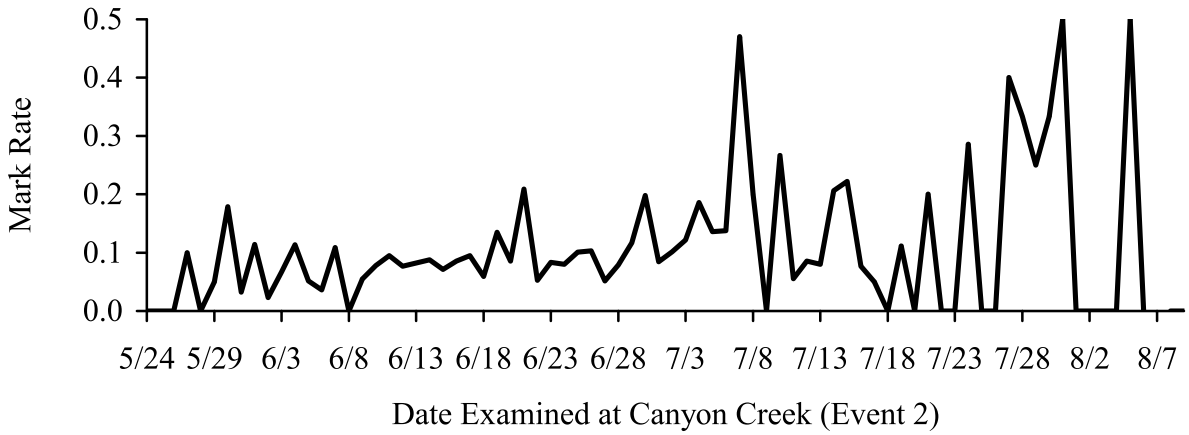

Figure 16. Daily proportion of Chinook salmon examined for marks at the Canyon Creek fishwheels that were recaptures (or fish that were tagged at Baird Canyon), 2008.

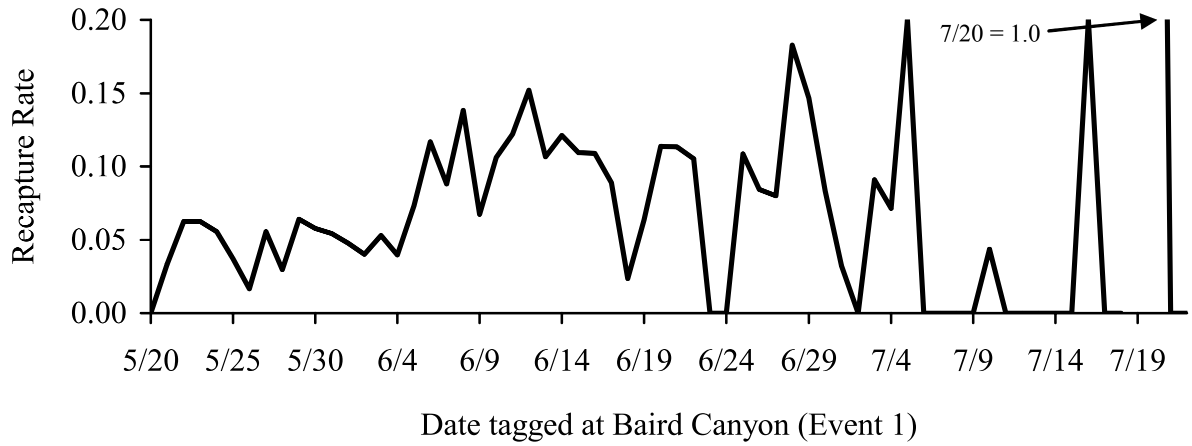

Figure 17. Daily proportion of fish tagged at the Baird Canyon fishwheels that were subsequently recaptured at the Canyon Creek fishwheels, 2008.

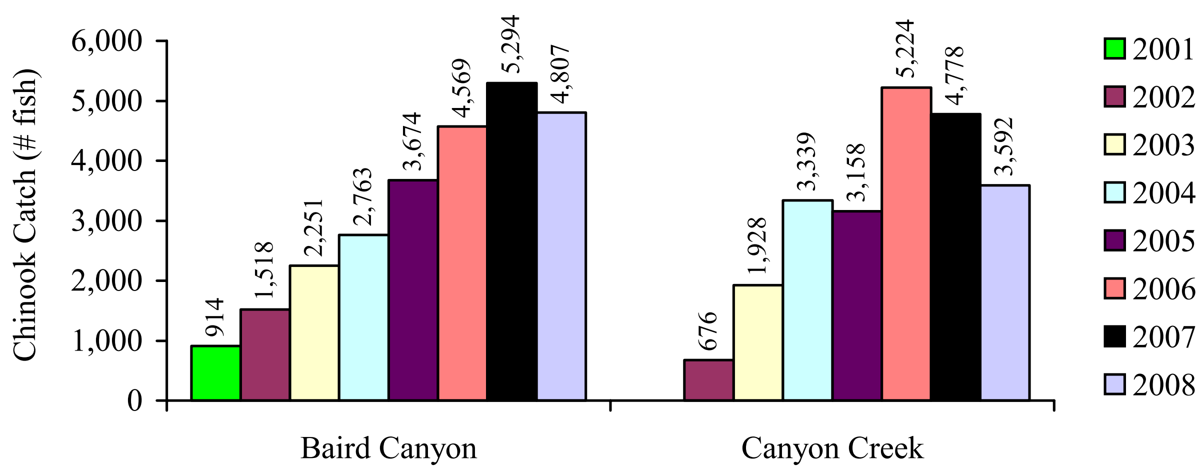

Figure 18. Number of Chinook salmon caught at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2001-2008.

APPENDICES

Appendix A.1. Summary of daily fishwheel effort (h), effort used to calculate catch per unit effort (CPUE), and fishwheel speed (RPM) for the Copper River fishwheels, 2008.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 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	Total effort (h)	CPUE effort (h)	RPM
19-May	5.7														
20-May	24.0	27.0	2.7				8.5			2.3	0.0	2.5			
21-May	24.0	24.6	2.3				24.0	28.8	3.5	24.0	22.6	2.5			
22-May	24.0	24.1	2.9				24.0	24.4	4.0	24.0	24.7	2.5			
23-May	24.0	24.0	3.0				24.0	23.7	3.8	24.0	23.8	2.3			
24-May	24.0	24.4	2.9				24.0	23.4	3.2	24.0	27.1	2.0			
25-May	22.0	21.4	2.9				24.0	24.7	2.7	24.0	22.7	2.5			
26-May	17.0	10.0	3.2				24.0	23.3	2.9	19.8	19.2	3.4	24.0	25.5	3.2
27-May	24.0	31.6	2.5				24.0	25.4	3.5	24.0	25.9	2.0	24.0	25.8	3.7
28-May	18.0	17.5	2.5				24.0	23.5	3.7	24.0	23.4	2.1	18.8	17.9	3.7
29-May	24.0	24.0	2.7				24.0	24.3	3.8	24.0	25.2	2.5	24.0	24.8	3.6
30-May	24.0	25.0	2.9	8.7	6.4	1.8	24.0	24.6	4.2	24.0	47.4	1.8	16.0	15.5	3.3
31-May	24.0	23.2	3.1	24.0	24.8	1.5	24.0	23.6	3.7	24.0	23.4	1.8	24.0	23.9	3.2
1-Jun	18.0	18.1	2.9	24.0	24.0	1.0	24.0	24.0	3.4	24.0	22.6	2.0	24.0	24.0	3.0
2-Jun	24.0	23.8	3.1	24.0	24.2	0.6	24.0	24.6	3.2	24.0	23.6	2.0	22.0	21.4	4.9
3-Jun	24.0	24.5	2.7	24.0	23.9	0.9	24.0	23.7	3.2	24.0	25.8	1.7	24.0	24.3	5.6
4-Jun	19.0	18.4	3.1	24.0	23.9	0.7	24.0	24.2	3.1	24.0	22.5	1.8	24.0	24.5	5.5
5-Jun	23.6	25.5	2.6	16.5	16.0	0.8	24.0	21.6	2.9	24.0	24.6	2.2	24.0	24.3	5.2
6-Jun	16.5	14.9	3.3	24.0	24.3	0.7	24.0	25.7	2.7	24.0	25.0	2.2	24.0	24.4	5.0
7-Jun	24.0	23.7	2.7	24.0	24.0	0.8	24.0	24.2	2.8	24.0	22.3	2.4	24.0	22.7	5.1
8-Jun	24.0	24.2	2.6	22.0	22.3	1.4	24.0	24.2	1.9	24.0	25.3	2.3	24.0	25.4	5.0
9-Jun	24.0	23.9	2.0	24.0	22.8	1.2	24.0	23.0	2.7	24.0	22.8	2.1	24.0	22.7	5.1
10-Jun	24.0	24.1	2.7	24.0	24.8	1.2	24.0	24.5	2.3	24.0	24.6	2.3	24.0	24.8	5.3
11-Jun	23.0	22.7	3.0	24.0	24.7	0.7	24.0	24.5	2.3	24.0	23.5	2.8	24.0	23.3	5.6
12-Jun	22.0	22.3	2.9	23.0	23.3	2.1	24.0	24.8	3.3	24.0	24.1	3.1	24.0	24.2	5.3
13-Jun	17.0	17.4	3.2	24.0	24.1	1.5	24.0	23.4	3.2	24.0	24.6	3.6	23.0	22.3	5.2
14-Jun	24.0	23.4	3.0	23.0	22.2	1.8	23.0	23.0	3.1	24.0	24.2	3.1	22.0	21.9	5.3
15-Jun	22.0	22.0	2.8	24.0	24.6	2.2	24.0	24.2	4.2	24.0	25.0	3.1	24.0	24.4	5.0
16-Jun	7.8	9.9	3.5	24.0	23.0	1.9	24.0	23.0	3.5	24.0	21.3	3.6	24.0	24.3	4.8
17-Jun	9.3	22.8	3.0	24.0	24.8	2.3	24.0	25.0	3.8	22.0	23.5	3.9	24.0	25.0	4.5

Appendix A.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 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	Total effort (h)	CPUE effort (h)	RPM
18-Jun	24.0	25.3	3.5	24.0	23.0	1.9	24.0	23.1	3.4	24.0	24.5	4.2	21.0	21.4	4.9
19-Jun	22.0	19.8	3.6	24.0	24.8	1.7	24.0	24.5	3.3	11.0	11.2	4.1	24.0	23.8	5.6
20-Jun	19.1	19.7	4.1	24.0	23.9	2.1	24.0	23.8	2.8	22.0	21.9	4.2	24.0	22.3	5.6
21-Jun	22.0	22.0	2.9	24.0	23.6	1.9	24.0	23.5	3.3	24.0	23.9	4.0	24.0	24.0	5.2
22-Jun	24.0	24.1	3.2	24.0	23.9	2.5	24.0	23.9	2.5	24.0	24.2	4.3	24.0	24.3	4.7
23-Jun	24.0	23.5	0.0	24.0	23.6	2.4	24.0	23.6	1.5	24.0	23.1	4.0	24.0	23.4	4.0
24-Jun	24.0	25.6	1.5	24.0	24.2	2.3	24.0	24.2	1.8	22.0	22.2	3.7	24.0	23.8	4.2
25-Jun	24.0	23.1	2.1	24.0	25.1	2.4	24.0	25.2	3.1	24.0	24.3	3.4	23.0	23.4	4.3
26-Jun	24.0	23.9	2.2	24.0	23.6	2.2	24.0	23.4	2.6	24.0	21.0	2.9	24.0	21.3	5.2
27-Jun	24.0	24.9	2.1	24.0	25.2	2.0	24.0	22.9	2.6	24.0	26.8	3.0	24.0	26.6	5.3
28-Jun	24.0	23.1	2.2	24.0	22.8	1.9	24.0	24.1	2.4	24.0	24.1	3.3	24.0	24.0	5.2
29-Jun	24.0	25.1	1.7	24.0	23.7	1.4	24.0	25.0	2.7	24.0	24.0	3.1	24.0	25.0	5.4
30-Jun	24.0	24.3	1.4	24.0	24.5	1.4	24.0	22.5	2.1	24.0	24.5	3.1	24.0	23.4	5.2
1-Jul	24.0	22.5	1.5	24.0	23.7	0.8	24.0	24.7	2.6	24.0	24.0	3.1	24.0	25.1	5.2
2-Jul	24.0	24.3	1.5	24.0	24.4	1.3	24.0	23.6	1.9	24.0	24.2	3.4	24.0	22.9	5.2
3-Jul	24.0	23.8	0.8	24.0	23.6	1.9	24.0	25.1	2.7	24.0	23.7	3.5	24.0	23.8	5.2
4-Jul	20.2	22.1	1.5	24.0	24.9	1.3	24.0	23.3	2.6	22.0	22.5	4.2	24.0	24.4	5.1
5-Jul	19.2	19.5	1.1	24.0	24.3	1.7	24.0	24.3	3.0	24.0	25.4	4.4	24.0	24.8	4.8
6-Jul	24.0	22.3	1.9	24.0	22.2	2.2	24.0	24.8	2.7	18.0	40.1	4.4	24.0	22.8	4.4
7-Jul	24.0	24.4	2.9	24.0	24.4	2.2	24.0	23.9	3.6	24.0	23.6	4.2	24.0	23.9	4.5
8-Jul	24.0	24.8	3.0	24.0	24.1	2.0	24.0	23.7	2.0	24.0	23.6	2.4	24.0	23.7	4.7
9-Jul	19.1	18.0	2.9	24.0	24.8	1.7	24.0	23.4	2.3	24.0	24.9	1.6	22.0	22.9	4.6
10-Jul	24.0	23.5	3.0	24.0	23.9	1.8	24.0	25.6	2.5	24.0	23.8	1.5	24.0	23.7	4.3
11-Jul	18.0	18.3	3.2	24.0	23.6	1.9	24.0	22.2	3.9	24.0	23.6	1.4	24.0	23.7	4.4
12-Jul	7.3	20.0	2.7	24.0	23.8	2.0	24.0	23.9	2.5	24.0	24.5	1.2	24.0	24.3	3.7
13-Jul				24.0	23.5	2.0	24.0	24.4	2.1	24.0	24.5	1.2	12.1	12.3	4.4
14-Jul				24.0	24.8	1.8	14.0	13.8	2.7	24.0	23.1	1.2	24.0	23.5	4.5
15-Jul				24.0	23.7	2.4	24.0	23.9	2.6	24.0	23.6	1.1	24.0	23.7	4.5
16-Jul				24.0	23.8	2.3	24.0	23.9	1.9	24.0	24.2	0.8	24.0	24.2	4.0
17-Jul				24.0	23.7	2.6	24.0	24.3	2.0	22.0	22.1	1.4	24.0	24.1	3.9

Appendix A.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 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	Total effort (h)	CPUE effort (h)	RPM
18-Jul				24.0	24.1	2.3	24.0	23.6	1.8	24.0	23.7	2.0	24.0	23.7	3.9
19-Jul				24.0	24.2	2.5	24.0	23.9	1.9	24.0	24.4	1.9	24.0	24.2	3.6
20-Jul				24.0	23.9	1.8	24.0	24.1	2.3	24.0	24.2	2.1	24.0	24.0	4.0
21-Jul				24.0	24.1	1.6	24.0	24.1	2.5	24.0	24.4	1.8	24.0	24.8	5.3
22-Jul				24.0	24.0	1.5	24.0	24.0	2.3	24.0	23.5	1.3	24.0	23.3	5.2
23-Jul				7.5	9.5	1.4	24.0	24.1	2.7	24.0	24.4	1.4	24.0	24.4	5.1
24-Jul							21.0	21.1	3.0	24.0	23.3	1.6	24.0	23.2	5.1
25-Jul							24.0	24.5	3.0	24.0	24.3	1.9	9.0	8.8	4.9
26-Jul							24.0	23.5	2.1	24.0	24.2	2.3	24.0	24.8	5.0
27-Jul							24.0	24.3	3.1	24.0	23.2	2.9	24.0	23.2	5.0
28-Jul							24.0	23.8	3.3	24.0	25.1	3.0	24.0	25.2	4.7
29-Jul							24.0	23.7	3.5	24.0	23.0	3.1	24.0	23.9	4.9
30-Jul							24.0	24.2	3.5	24.0	24.4	2.9	24.0	23.6	4.9
31-Jul							24.0	24.1	3.6	22.0	22.1	2.9	24.0	24.1	4.7
1-Aug							24.0	23.7	3.3	24.0	23.8	2.6	24.0	23.7	4.5
2-Aug							24.0	24.0	3.7	24.0	24.0	2.3	24.0	23.9	4.6
3-Aug							24.0	24.2	3.8	24.0	23.5	2.0	24.0	23.6	4.4
4-Aug							14.7	17.2	3.5	24.0	25.5	1.8	24.0	25.5	4.6
5-Aug										24.0	22.9	1.5	24.0	23.0	4.3
6-Aug										24.0	24.0	1.5	24.0	23.7	4.1
7-Aug										24.0	24.3	1.6	24.0	24.8	4.1
8-Aug										24.0	20.4	1.3	22.0	18.4	3.9
9-Aug										24.0	27.4	1.4	24.0	27.1	3.9
10-Aug										24.0	23.7	0.0	24.0	23.5	0.0
11-Aug										24.0	24.5	1.1	24.0	24.6	4.4
12-Aug										14.0	16.3	0.9	24.0	24.5	4.3
13-Aug													24.0	23.5	4.8
14-Aug													24.0	23.7	4.6
15-Aug													24.0	23.6	4.6
16-Aug													24.0	24.4	4.7

Appendix A.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 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	Total effort (h)	CPUE effort (h)	RPM
17-Aug													22.0	22.6	4.3
18-Aug													24.0	23.4	4.3
19-Aug													7.7	10.9	4.6
Effort (h)	1,180		2.6	1,277		1.7	1,809		2.9	1,973		2.5	1,993		4.6
Percent operational:															
	91.8%			99.1%			99.2%			98.2%			98.3%		

Appendix B.1. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fishwheels, 2008.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 4		
Date	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE
19 May	0	0													
20 May	3	3	0.1				0	0		0	0		0		
21 May	41	44	1.7				0	0	0.0	0	0	0.00	0		
22 May	53	97	2.2				4	4	0.2	0	0	0.00	0		
23 May	112	209	4.7				10	14	0.4	0	0	0.00	0		
24 May	65	274	2.7				3	17	0.1	2	2	0.07	0		
25 May	61	335	2.9				2	19	0.1	1	3	0.04	0	0	
26 May	72	407	7.2				13	32	0.6	3	6	0.16	5	5	0.20
27 May	152	559	4.8				17	49	0.7	4	10	0.15	16	21	0.62
28 May	110	669	6.3				4	53	0.2	6	16	0.26	2	23	0.11
29 May	162	831	6.8				11	64	0.5	15	31	0.60	5	28	0.20
30 May	116	947	4.6	2	2	0.3	10	74	0.4	20	51	0.42	8	36	0.52
31 May	135	1,082	5.8	8	10	0.3	9	83	0.4	11	62	0.47	21	57	0.88
1 Jun	109	1,191	6.0	9	19	0.4	4	87	0.2	20	82	0.88	15	72	0.62
2 Jun	144	1,335	6.1	19	38	0.8	8	95	0.3	18	100	0.76	25	97	1.17
3 Jun	202	1,537	8.2	14	52	0.6	14	109	0.6	35	135	1.36	70	167	2.89
4 Jun	131	1,668	7.1	22	74	0.9	11	120	0.5	18	153	0.80	70	237	2.86
5 Jun	124	1,792	4.9	14	88	0.9	5	125	0.2	19	172	0.77	59	296	2.42
6 Jun	87	1,879	5.8	6	94	0.2	1	126	0.0	22	194	0.88	61	357	2.50
7 Jun	139	2,018	5.9	7	101	0.3	6	132	0.2	18	212	0.81	65	422	2.86
8 Jun	106	2,124	4.4	5	106	0.2	4	136	0.2	26	238	1.03	65	487	2.56
9 Jun	109	2,233	4.6	4	110	0.2	5	141	0.2	30	268	1.31	43	530	1.89
10 Jun	110	2,343	4.6	8	118	0.3	5	146	0.2	41	309	1.67	49	579	1.98
11 Jun	151	2,494	6.6	13	131	0.5	8	154	0.3	31	340	1.32	46	625	1.97
12 Jun	138	2,632	6.2	23	154	1.0	11	165	0.4	33	373	1.37	45	670	1.86
13 Jun	111	2,743	6.4	15	169	0.6	4	169	0.2	19	392	0.77	54	724	2.42
14 Jun	77	2,820	3.3	25	194	1.1	3	172	0.1	31	423	1.28	53	777	2.42
15 Jun	72	2,892	3.3	67	261	2.7	5	177	0.2	64	487	2.56	52	829	2.13
16 Jun	50	2,942	5.1	54	315	2.3	7	184	0.3	73	560	3.43	73	902	3.00
17 Jun	34	2,976	1.5	50	365	2.0	16	200	0.6	87	647	3.71	116	1,018	4.64
18 Jun	36	3,012	1.4	41	406	1.8	20	220	0.9	97	744	3.96	110	1,128	5.14
19 Jun	82	3,094	4.2	24	430	1.0	8	228	0.3	36	780	3.21	45	1,173	1.89

Appendix B.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 4		
Date	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE
20 Jun	58	3,152	2.9	34	464	1.4	8	236	0.3	57	837	2.60	28	1,201	1.26
21 Jun	37	3,189	1.7	13	477	0.6	6	242	0.3	70	907	2.93	24	1,225	1.00
22 Jun	29	3,218	1.2	11	488	0.5	2	244	0.1	54	961	2.23	23	1,248	0.95
23 Jun	0	3,218	0.0	3	491	0.1	0	244	0.0	3	964	0.13	10	1,258	0.43
24 Jun	7	3,225	0.3	8	499	0.3	1	245	0.0	14	978	0.63	17	1,275	0.71
25 Jun	41	3,266	1.8	49	548	1.9	1	246	0.0	57	1,035	2.35	51	1,326	2.18
26 Jun	60	3,326	2.5	45	593	1.9	4	250	0.2	21	1,056	1.00	52	1,378	2.45
27 Jun	103	3,429	4.1	69	662	2.7	0	250	0.0	51	1,107	1.90	69	1,447	2.59
28 Jun	67	3,496	2.9	48	710	2.1	2	252	0.1	35	1,142	1.45	43	1,490	1.80
29 Jun	51	3,547	2.0	33	743	1.4	0	252	0.0	28	1,170	1.17	32	1,522	1.28
30 Jun	16	3,563	0.7	24	767	1.0	1	253	0.0	42	1,212	1.72	52	1,574	2.23
1 Jul	21	3,584	0.9	12	779	0.5	4	257	0.2	36	1,248	1.50	35	1,609	1.40
2 Jul	8	3,592	0.3	11	790	0.5	2	259	0.1	37	1,285	1.53	26	1,635	1.13
3 Jul	6	3,598	0.3	5	795	0.2	0	259	0.0	58	1,343	2.44	27	1,662	1.14
4 Jul	6	3,604	0.3	7	802	0.3	2	261	0.1	54	1,397	2.40	33	1,695	1.35
5 Jul	4	3,608	0.2	12	814	0.5	1	262	0.0	84	1,481	3.31	41	1,736	1.66
6 Jul	13	3,621	0.6	6	820	0.3	0	262	0.0	38	1,519	0.95	42	1,778	1.84
7 Jul	7	3,628	0.3	5	825	0.2	1	263	0.0	10	1,529	0.42	7	1,785	0.29
8 Jul	5	3,633	0.2	2	827	0.1	1	264	0.0	4	1,533	0.17	1	1,786	0.04
9 Jul	7	3,640	0.4	4	831	0.2	1	265	0.0	6	1,539	0.24	3	1,789	0.13
10 Jul	9	3,649	0.4	12	843	0.5	2	267	0.1	9	1,548	0.38	6	1,795	0.25
11 Jul	5	3,654	0.3	9	852	0.4	1	268	0.0	6	1,554	0.25	12	1,807	0.51
12 Jul	2	3,656	0.1	3	855	0.1	1	269	0.0	11	1,565	0.45	24	1,831	0.99
13 Jul				2	857	0.1	1	270	0.0	11	1,576	0.45	14	1,845	1.14
14 Jul				4	861	0.2	1	271	0.1	12	1,588	0.52	23	1,868	0.98
15 Jul				4	865	0.2	1	272	0.0	9	1,597	0.38	9	1,877	0.38
16 Jul				4	869	0.2	1	273	0.0	3	1,600	0.12	10	1,887	0.41
17 Jul				2	871	0.1	0	273	0.0	7	1,607	0.32	13	1,900	0.54
18 Jul				1	872	0.0	0	273	0.0	1	1,608	0.04	4	1,904	0.17
19 Jul				0	872	0.0	0	273	0.0	7	1,615	0.29	2	1,906	0.08
20 Jul				1	873	0.0	0	273	0.0	1	1,616	0.04	1	1,907	0.04
21 Jul				1	874	0.0	0	273	0.0	6	1,622	0.25	5	1,912	0.20

Appendix B.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 4		
Date	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE	Catch	Cum.	CPUE
22 Jul				1	875	0.0	1	274	0.0	2	1,624	0.09	2	1,914	0.09
23 Jul				0	875	0.0	0	274	0.0	0	1,624	0.00	3	1,917	0.12
24 Jul							0	274	0.0	2	1,626	0.09	5	1,922	0.22
25 Jul							0	274	0.0	3	1,629	0.12	3	1,925	0.34
26 Jul							0	274	0.0	1	1,630	0.04	3	1,928	0.12
27 Jul							2	276	0.1	3	1,633	0.13	2	1,930	0.09
28 Jul							0	276	0.0	1	1,634	0.04	2	1,932	0.08
29 Jul							0	276	0.0	0	1,634	0.00	6	1,938	0.25
30 Jul							0	276	0.0	1	1,635	0.04	2	1,940	0.08
31 Jul							0	276	0.0	1	1,636	0.05	1	1,941	0.04
1 Aug							0	276	0.0	3	1,639	0.13	0	1,941	0.00
2 Aug							0	276	0.0	1	1,640	0.04	1	1,942	0.04
3 Aug							0	276	0.0	0	1,640	0.00	1	1,943	0.04
4 Aug							0	276	0.0	0	1,640	0.00	1	1,944	0.04
5 Aug										1	1,641	0.04	1	1,945	0.04
6 Aug										1	1,642	0.04	0	1,945	0.00
7 Aug										0	1,642	0.00	0	1,945	0.00
8 Aug										0	1,642	0.00	3	1,948	0.16
9 Aug										1	1,643	0.04	1	1,949	0.04
10 Aug										0	1,643	0.00	0	1,949	0.00
11 Aug										0	1,643	0.00	0	1,949	0.00
12 Aug										0	1,643	0.00	0	1,949	0.00
13 Aug													0	1,949	0.00
14 Aug													0	1,949	0.00
15 Aug													0	1,949	0.00
16 Aug													0	1,949	0.00
17 Aug													0	1,949	0.00
18 Aug													0	1,949	0.00
19 Aug													0	1,949	0.00
Total	3,656			875			276			1,643			1,949		

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

Appendix C.1. Number of Chinook salmon tagged at the Baird Canyon fishwheels and examined/recaptured at the Canyon Creek fishwheels, 2008.

	Baird Canyon						Canyon Creek							
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3				Fishwheel 4			
Date	Tags	Cum	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
19 May	0	0												
20 May	2	2			0	0	0	0	0	0				
21 May	30	32			0	0	0	0	0	0				
22 May	45	77			3	3	0	0	0	0				
23 May	89	166			7	10		0	0	0				
24 May	53	219			1	11	2	2	0	0				
25 May	52	271			2	13	1	3	0	0	0	0	0	0
26 May	48	319			12	25	3	6	0	0	5	5	0	0
27 May	114	433			12	37	4	10	1	1	16	21	1	1
28 May	100	533			1	38	6	16	0	1	2	23	0	1
29 May	123	656			2	40	15	31	1	2	5	28	0	1
30 May	95	751	1	1	8	48	20	51	5	7	8	36	0	1
31 May	118	869	7	8	4	52	11	62	0	7	20	56	1	2
1 Jun	94	963	9	17	2	54	20	82	2	9	15	71	2	4
2 Jun	117	1,080	6	23	2	56	18	100	1	10	25	96	0	4
3 Jun	122	1,202	8	31	2	58	35	135	1	11	70	166	6	10
4 Jun	101	1,303	21	52	4	62	18	153	0	11	70	236	10	20
5 Jun	108	1,411	14	66	1	63	19	172	2	13	59	295	2	22
6 Jun	71	1,482	6	72	0	63	22	194	2	15	61	356	1	23
7 Jun	117	1,599	7	79	1	64	18	212	2	17	65	421	7	30
8 Jun	88	1,687	5	84	1	65	26	238	0	17	64	485	0	30
9 Jun	99	1,786	3	87	2	67	30	268	1	18	43	528	3	33
10 Jun	102	1,888	7	94	4	71	41	309	5	23	49	577	2	35
11 Jun	114	2,002	7	101	2	73	29	338	1	24	45	622	6	41
12 Jun	110	2,112	13	114	2	75	33	371	2	26	45	667	4	45
13 Jun	104	2,216	15	129	3	78	19	390	1	27	54	721	5	50
14 Jun	72	2,288	24	153	3	81	29	419	3	30	51	772	4	54
15 Jun	67	2,355	56	209	5	86	60	479	8	38	52	824	0	54
16 Jun	45	2,400	52	261	4	90	69	548	5	43	71	895	7	61
17 Jun	32	2,432	45	306	13	103	84	632	8	51	116	1,011	11	72
18 Jun	32	2,464	36	342	17	120	92	724	7	58	110	1,121	5	77

Appendix C.1 continued.

	Baird Canyon						Canyon Creek							
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3				Fishwheel 4			
Date	Tags	Cum	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
19 Jun	80	2,544	23	365	7	127	29	753	5	63	45	1,166	5	82
20 Jun	51	2,595	31	396	6	133	56	809	5	68	26	1,192	2	84
21 Jun	35	2,630	13	409	5	138	67	876	12	80	24	1,216	7	91
22 Jun	26	2,656	10	419	2	140	53	929	3	83	23	1,239	1	92
23 Jun	0	2,656	1	420	0	140	2	931	0	83	10	1,249	1	93
24 Jun	6	2,662	7	427	1	141	14	945	0	83	11	1,260	2	95
25 Jun	40	2,702	42	469	1	142	52	997	6	89	47	1,307	4	99
26 Jun	51	2,753	42	511	2	144	20	1,017	1	90	48	1,355	6	105
27 Jun	84	2,837	41	552	0	144	48	1,065	4	94	68	1,423	2	107
28 Jun	53	2,890	40	592	0	144	35	1,100	2	96	41	1,464	4	111
29 Jun	47	2,937	28	620	0	144	28	1,128	4	100	32	1,496	3	114
30 Jun	16	2,953	19	639	1	145	40	1,168	8	108	51	1,547	10	124
1 Jul	18	2,971	11	650	2	147	36	1,204	1	109	35	1,582	5	129
2 Jul	8	2,979	8	658	1	148	35	1,239	3	112	24	1,606	3	132
3 Jul	6	2,985	5	663	0	148	56	1,295	7	119	26	1,632	3	135
4 Jul	6	2,991	7	670	1	149	53	1,348	7	126	33	1,665	9	144
5 Jul	4	2,995	10	680	1	150	84	1,432	10	136	41	1,706	7	151
6 Jul	11	3,006	6	686	0	150	38	1,470	7	143	42	1,748	4	155
7 Jul	7	3,013	4	690	0	150	10	1,480	5	148	7	1,755	3	158
8 Jul	5	3,018	2	692	0	150	4	1,484	1	149	1	1,756	0	158
9 Jul	6	3,024	4	696	0	150	6	1,490	0	149	3	1,759	0	158
10 Jul	9	3,033	12	708	2	152	9	1,499	2	151	6	1,765	2	160
11 Jul	4	3,037	7	715	1	153	6	1,505	0	151	12	1,777	1	161
12 Jul	2	3,039	3	718	1	154	11	1,516	2	153	24	1,801	1	162
13 Jul			2	720	0	154	11	1,527	1	154	14	1,815	1	163
14 Jul			2	722	1	155	11	1,538	2	156	23	1,838	5	168
15 Jul			3	725	0	155	9	1,547	1	157	9	1,847	3	171
16 Jul			4	729	1	156	3	1,550	0	157	10	1,857	1	172
17 Jul			2	731	0	156	7	1,557	0	157	13	1,870	1	173
18 Jul			1	732	0	156	1	1,558	0	157	4	1,874	0	173
19 Jul			0	732	0	156	7	1,565	1	158	2	1,876	0	173
20 Jul			1	733	0	156	1	1,566	0	158	1	1,877	0	173

Appendix C.1 continued.

	Baird Canyon						Canyon Creek							
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3				Fishwheel 4			
Date	Tags	Cum	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
21 Jul			1	734	0	156	5	1,571	2	160	5	1,882	0	173
22 Jul			1	735	1	157	2	1,573	0	160	2	1,884	0	173
23 Jul			0	735	0	157	0	1,573	0	160	3	1,887	0	173
24 Jul					0	157	2	1,575	1	161	5	1,892	1	174
25 Jul					0	157	3	1,578	0	161	3	1,895	0	174
26 Jul					0	157	1	1,579	0	161	3	1,898	0	174
27 Jul					0	157	3	1,582	2	163	2	1,900	0	174
28 Jul					0	157	1	1,583	0	163	2	1,902	1	175
29 Jul					0	157	0	1,583	0	163	4	1,906	1	176
30 Jul					0	157	1	1,584	0	163	2	1,908	1	177
31 Jul					0	157	1	1,585	1	164	1	1,909	0	177
1 Aug					0	157	3	1,588	0	164	0	1,909	0	177
2 Aug					0	157	1	1,589	0	164	1	1,910	0	177
3 Aug					0	157	0	1,589	0	164	1	1,911	0	177
4 Aug					0	157	0	1,589	0	164	1	1,912	0	177
5 Aug							1	1,590	1	165	1	1,913	0	177
6 Aug							1	1,591	0	165	0	1,913	0	177
7 Aug							0	1,591	0	165	0	1,913	0	177
8 Aug							0	1,591	0	165	3	1,916	0	177
9 Aug							1	1,592	0	165	1	1,917	0	177
10 Aug							0	1,592	0	165	0	1,917	0	177
11 Aug							0	1,592	0	165	0	1,917	0	177
12 Aug							0	1,592	0	165	0	1,917	0	177
13 Aug											0	1,917	0	177
14 Aug											0	1,917	0	177
15 Aug											0	1,917	0	177
16 Aug											0	1,917	0	177
17 Aug											0	1,917	0	177
18 Aug											0	1,917	0	177
19 Aug											0	1,917	0	177
Total	3,039		735		157		1,592		165		1,917		177	