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Estimating Chinook salmon escapement on the Copper River, 2006 annual report

Annual Report for Study 04-503

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ANNUAL REPORT SUMMARY PAGE

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EXECUTIVE SUMMARY

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 2006 field season, the sixth year since the project's inception. Objectives for 2006 were to: (1) estimate the annual, system-wide escapement of Chinook salmon to the Copper River using mark-recapture methods, such that the estimate was within 25% of the actual escapement 95% of the time; (2) develop a long-term monitoring program operated by the Native Village of Eyak (NVE). For the first sample event, three live-capture fishwheels were operated at Baird Canyon for 4,219 h from 21 May to 31 July. During this period, 4,569 adult Chinook salmon were captured and 4,035 fish were marked. For the second sample event, two fishwheels were operated at Canyon Creek near the lower end of Wood Canyon for 3,696 h from 23 May to 14 August. A total of 5,224 Chinook salmon were examined for marks, of which 377 were recaptures. Using a temporally stratified Darroch estimator, estimated abundance of Chinook salmon measuring 500 mm FL or greater that migrated upstream of Baird Canyon from 21 May to 31 July was 67,789 (SE = 4,779). The median travel time of fish marked at Baird Canyon and recaptured at Canyon Creek (~91 km upstream) was 13.2 d. With funding currently approved through 2009, this project has evolved into a successful and potentially long-term monitoring program that has made NVE an integral part of Copper River salmon research.

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INTRODUCTION

The Copper River supports one of the largest Chinook salmon *Oncorhynchus tshawytscha* subsistence fisheries in Alaska. The importance of Copper River Chinook salmon to subsistence and other users has focused attention on the paucity of information about escapement levels and distribution among tributaries. Despite the importance of this fishery, managers have found it difficult to obtain annual estimates of Chinook salmon escapement to the drainage. Many stakeholders believe that escapement indices generated by conventional methods (aerial surveys, sonar and weirs on selected systems) have not adequately assessed the abundance of Copper River Chinook salmon stocks.

From 1999-2004, the Alaska Department of Fish and Game (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 use of fishwheels (Meehan 1961; Donaldson and Cramer 1971) and mark-recapture techniques can often be an effective method for estimating Chinook salmon escapement. This technique has 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), and after five consecutive years of feasibility testing and full-scale operation, has proven extremely suitable for use on the Copper River (Link et al. 2001; Smith et al. 2003). The purpose of this study was to continue using fishwheels and two-sample mark-recapture methods for long-term monitoring of Chinook salmon *Oncorhynchus tshawytscha* escapement on the Copper River.

Objectives

The objectives for this three-year study were to:

(1) Estimate the annual, system-wide escapement of Chinook salmon to the Copper River using mark-recapture methods such that the estimate is within 25% of the actual escapement 95% of the time; and
(2) Develop a long-term monitoring program operated by the Native Village of Eyak (NVE).

In 2006, three tagging fishwheels were operated at Baird Canyon approximately 66 km (41 mi) upstream of where the Copper River enters the Gulf of Alaska. In addition, two recovery fishwheels were operated near Wood Canyon (river km, rkm 157) approximately 12 km downstream from Chitina, Alaska. This report documents the methods, results, and conclusions from the 2006 field season.

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 (Fig. 1). Between the ocean and Miles Lake (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 (Fig. 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 (Fig. 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 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 *O. nerka* 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). Since 1978, ADF&G has operated a sonar system to count salmon at the outlet of Miles Lake. An estimated 854,268 salmon passed the Miles Lake sonar site in 2005 (ADF&G 2007b).

The Copper River supports important fisheries for Chinook salmon. The majority of Chinook salmon are caught in an ocean commercial gill net fishery that operates from mid-May to the end of July in the Copper River District near the mouth of the Copper River. Inriver personal use and subsistence fisheries occur from early June through September between Haley Creek and the

confluence of the Slana River on the upper Copper River. Rod-and-reel sport fisheries target Chinook salmon in tributaries of the upper Copper River (primarily Gulkana, Klutina, and Tonsina rivers). In 2006, an estimated 29,951 Chinook salmon were harvested in the Copper River District commercial fishery (ADF&G 2007a), 2,675 fish were harvested in the Chitina Subdistrict (preliminary), and 3,181 fish were harvested in the Glennallen Subdistrict (M. Somerville, ADF&G, Cordova, personal communication). Chinook salmon harvests in the inriver sport fishery were not available at the time this report was finalized; however, harvests averaged 4,646 fish annually from 2001 to 2005.

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. Seven full-time technicians were hired, including three returning technicians from 2004 and one returning from 2003. Several other technicians 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 PDA's, PIT tag scanner and other equipment operation, 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) operated at Baird Canyon, and two recovery fishwheels (fishwheels 3 and 4) at Canyon Creek in 2006. Two of the fishwheels at Baird Canyon (fishwheels 1 and 2) and 1 fishwheel at Canyon Creek (fishwheel 3) were large aluminum models intended 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, and an escape panel fitted to the stern of each tank to prevent overcrowding of smaller sockeye salmon and undersized king salmon.

The third fishwheel at Baird Canyon 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 in 2006. The cabin is located on the west bank of the Copper River approximately 2 km upstream from the upper end of Baird Canyon (Fig. 2), and was supplied by 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 (Fig. 3). The upriver camp consisted of two Weatherport tents and small sleeping 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 Chinook 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 (McLean, VA) that provided continuous high-speed internet access. These systems were powered/charged by an array of 6-V batteries (wired to provide 12-V power) that were charged by solar panels, wind turbines and a gas-powered generator. Every morning at a prearranged time, one crew member 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). A majority of camp communications were conducted via the internet, with satellite phones reserved for emergencies and instances where internet was temporarily unavailable. The crew was 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 tag updates to ADF&G biologists and fishery managers.

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 two large fishwheels used on this project, water depths greater than 3 m and velocities ranging from 0.5-1.5 m/s (1.6-4.9 ft/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 2004 were installed and operated similar to the methods used in previous years (Link et al. 2001; Smith et al. 2003; Smith 2004; Smith et al. 2005; Smith and van den Broek 2005, 2006). 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 fishwheels in place when fishing against gravel banks, 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. 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. 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. 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, 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 to 7.5 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). The escape panels on the Baird Canyon fishwheels were closed intermittently on pre-arranged intervals to allow retention of sockeye salmon for radiotelemetry (FIS05-501) and mark-recapture (FIS06-502) studies; however, this did not interfere with the capture or sampling of Chinook salmon for this study.

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 salmon were counted, sexed, measured for length, inspected for an adipose fin (a missing adipose fin indicated a coded-wire-tagged, or CWT hatchery fish) and examined for marks, scars or bleeding. Fork lengths, measured from the tip of the nose to the fork of the tail, were collected in 2006. Chinook 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, Chinook salmon greater than 500 mm FL and in good condition were marked with a uniquely coded green spaghetti tag (Floy Tag and Manufacturing Co., Inc., Seattle, WA). The tags were constructed of a 5-cm section of Floy tubing shrunk onto a 38-cm piece of 80-lb monofilament fishing line. Using a 10-cm hypodermic needle (16 gauge), the monofilament was sewn through the musculature of the fish 1-2 cm ventral to the insertion of the dorsal fin between the third and fourth fin rays from the posterior of the dorsal fin. The tag was secured by crimping (1.3 mm crimps) the monofilament line. All Chinook salmon also received a uniquely encoded, passive integrated transponder (PIT) tag that was injected into the body cavity using a syringe. The PIT tag acted as a secondary mark, as well as lending validation to the PIT tagging methodology being trialed on the sockeye mark-recapture study (FIS 06-502).

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 Chinook salmon caught at the Canyon Creek fishwheels were physically examined for a spaghetti tag and automatically scanned for a PIT tag. If a fish was marked, the spaghetti-tag number was recorded. Fork-lengths were only taken on fish captured from 31 May to 7 June.

Inriver Abundance Estimate

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. These abundance estimates are potentially biased if any of the assumptions inherent to the mark-recapture model are violated (Ricker 1975; Seber 1982). The following assumptions are relevant to this study and are similar to those examined by ADF&G in recent Chinook salmon radiotelemetry studies on the Copper River (Evenson and Wuttig 2000; Wuttig and Evenson 2001; Savereide and Evenson 2002; Savereide 2003).

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 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 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.

This assumption was not able to be tested in 2006 because of the discontinuation of the operculum punch as a secondary mark, and the lack of real-time data collection from the secondary PIT-tag mark. In previous years, only Chinook salmon that received both a primary and secondary mark at Baird Canyon were included in the calculations of abundance, so the chance of a fish losing both marks between sampling events was assumed to be negligible. Similarly, only fish that were examined for both marks at Canyon Creek were included in the analysis. In four years of utilizing secondary marks in this fashion, there was not a single observed incident of spaghetti-tag loss. Therefore, tag loss was assumed to be negligible.

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.

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. Weekly mark rates in the second 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.

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

Abundance Estimate

A temporally stratified Darroch estimator was used to estimate abundance above Baird Canyon. The computer program SPAS (Arnason et al. 1996) was used to calculate the abundance estimate and standard error.

RESULTS

Project Mobilization

Mobilization of the Baird Canyon camp began on 6 May (Photo 1). Eight people and gear were flown to camp on 8 round trips via a Cessna 206 (Cordova Air) on floats. Apart from a 500-m long patch of open water near the cabin, the Copper River was frozen from above Baird Canyon at the Bremner River confluence, downstream to the Mile 27 and Mile 38 Bridges. Snow cover was approximately 2-m deep upon arrival. Equipment did not incur any damage over winter, but considerable labor was required to clear snow and re-assemble fishwheel baskets. The first fishwheel (fw 5) began fishing at Baird Canyon on 21 May.

Mobilization of the Canyon Creek fishwheels began on 17 May. Equipment and vehicles were moved from storage locations in Cordova, Glennallen, and Gakona to the camp site using trucks and jet boats. The fishwheels required only minor repairs and the first one began fishing on 23 May.

Fishwheel Operation and Catch

Fishwheel Operation

Copper River stage height at Baird Canyon varied by 6.9 m from 21 May to 31 July (Fig. 4). At Canyon Creek, water levels varied by 3.3 m from 23 May to 14 August (Fig. 4). Water levels increased dramatically over three periods (21-28 May, 9-18 June, and 28 June to 8 July) and peaked on 15 July at Baird Canyon. In 2006, the stage height of the Copper River at the Million Dollar Bridge exceeded the 1982 to 2005 average from 24 May to 8 June, 11-23 June, and 7-17 July (Fig. 5).

Fishwheel 1 operated on the east bank of Baird Canyon for 1,448 h (96.3% of the time) from 22 May to 23 July (Fig. 6; Appendix A.1). Fishwheel 2 operated on the west bank of Baird Canyon for 1,107 h (94.0% of the time) from 23 May to 11 July. Fishwheel 5 operated on the west bank of the Copper River approximately 1.5 km upstream from Baird Canyon for 1,665 h (98.4% of the time). Fishwheel speeds averaged 1.8, 2.7, and 2.3 rpm for fishwheels 1, 2, and 5, respectively (Fig. 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 29 May to 14 August, it operated for 1,803 h (98.1% of the time; Fig. 6, Appendix A.1). Fishwheel 4 operated on the west bank and fished for 1,894 h (95.5% of the time) from 23 May to 14 August. Fishwheel speeds averaged 2.1 and 5.2 rpm for fishwheels 3 and 4, respectively (Fig. 6; Appendix A.1).

Fishwheel Catch

A total of 4,569 adult Chinook salmon were captured at the Baird Canyon fishwheels (Fig. 7; Appendix A.2). Fishwheels 1 captured 1,715 Chinook salmon from 27 May to 23 July, fishwheel 2 captured 2,653 Chinook salmon from 25 May to 11 June, and fishwheel 5 captured 201 Chinook salmon from 24 May to 15 July. Total daily catch peaked at 445 Chinook salmon on 31 May. Daily CPUE peaked at 6.2, 12.1, and 1.5 fish per hour for fishwheels 1, 2, and 5, respectively (Fig. 9; Appendix A.2). One coho salmon *O. kisutch*, 4 steelhead salmon *O. mykiss*, 11 Dolly Varden *Salvelinus malma*, 2 whitefish *Coregonus spp.*, 3 Pacific lamprey *Lampetra tridentata*, 4 sucker *Catostomus sp.*, and 1 beaver *Castor Canadensis* were also captured and released.

A total of 5,224 Chinook salmon were captured at the Canyon Creek fishwheels (Fig. 8; Appendix A.2). Fishwheel 3 captured 1,485 Chinook salmon from 19 May to 9 August and fishwheel 4 captured 3,739 Chinook salmon from 31 May to 10 August. Daily catch peaked at 438 Chinook salmon on 8 June. Daily CPUE peaked at 4.4 and 18.7 Chinook salmon per hour at fishwheels 3 and 4, respectively (Fig. 10; Appendix A.2).

The number of sockeye salmon captured, sampled, and released at the Baird Canyon and Canyon Creek fishwheels is documented in two separate reports for projects FIS05-501 and FIS06-502.

Tag Application and Recovery

Of the 4,569 Chinook salmon measuring 500 mm FL or greater that were captured at the Baird Canyon fishwheels, 4,035 fish (88.3%) were tagged and released (Fig. 11; Appendix A.3). The number of marks applied on a single day peaked at 353 fish on 31 May. On 31 May, 68 captured Chinook salmon were released untagged because a sufficient number of fish had already been tagged that day. The remaining untagged fish were released because they escaped prior to being sampled, were visibly injured or stressed (132 fish), mortalities (10 fish), or measured less than 500 mm FL (13 fish).

A total of 5,244 Chinook salmon were examined for primary and secondary marks at the Canyon Creek fishwheels (Fig. 11; Appendix A.3). Of those examined, 377 (7.2%) were recaptures, or fish that were marked at the Baird Canyon fishwheels. The first marked fish was captured at Canyon Creek on 31 May (tagged on 26 May), while the last marked fish was captured on 6 August (tagged on 24 June). The number of fish examined for marks at Canyon Creek peaked at 438 fish on 8 June and the number of recaptures peaked at 21 fish on 30 June. The median travel time of Chinook salmon tagged at Baird Canyon and recaptured at Canyon Creek was 13.2 d (range: 4.5–43.1 d; Fig. 12).

In addition, 385 Chinook salmon (9.5% of fish tagged) were reported harvested by various inriver fisheries, including: 1 in the commercial gill net fishery, 184 in the personal use dip net fishery, 115 in the subsistence fishwheel fishery, 45 in the sport fishery, and 40 where the specific fishery was not reported.

Inriver Abundance Estimate

Conditions for a Consistent Estimator

The probability of capture for fish at Canyon Creek appeared to be unaffected by the handling and tagging procedures at Baird Canyon. The tag number of marked fish released and later recaptured at the Baird Canyon fishwheels was recorded and used to calculate migratory delay. Of the 196 fish captured twice, 112 fish (57%) were recaptured within 1 d of being tagged, and the longest delay between captures was 20 d (Fig. 13). We assumed that these migratory delays had no affect on the abundance estimate. Tag loss and natural mortality were assumed to be negligible between the sampling events. No fish were captured at Canyon Creek with a PIT tag and no spaghetti tag, so it was assumed that no fish shed their primary mark.

Tagged fish appeared to move equally between banks. The recapture rate of fish tagged and released on the west bank of the river was not significantly different than the recapture rate of fish tagged on the east bank ($\chi^2 = 0.54$, df = 1, P = 0.463; Table 1). Cumulative length-frequency distributions of fish marked in the first event and fish recaptured in the second event were not significantly different ($D_{max} = 0.030$, P = 0.919, Fig. 14). In contrast, the cumulative length-frequency distributions of fish marked in the first event and fish examined for marks in the second event were significantly different ($D_{max} = 0.136$, P = 0.00). Based on these results, there was no size selectivity during the second event but there was during the first event, and no stratification by size was necessary to estimate abundance.

Capture statistics were summarized by period of marking and recapture over the study period (Table 2). The probability of a fish being marked at Baird Canyon was not independent of time of capture. Mark rates were significantly different over the study period (χ^2 = 193, df = 5, P = 0.000) and varied from 0.024 to 0.279. Similarly, recapture rates were significantly different over the study period (χ^2 = 25, df = 1, P = 0.00) and they ranged from 0.067 from 24 May to 6 June to 0.113 from 7 June to 23 July. These results indicated that a temporally stratified estimator was required to estimate abundance.

Abundance Estimate

Using SPAS and the Darroch moment estimator, estimated abundance of Chinook salmon measuring 600 mm FL or greater that migrated upstream of Baird Canyon from 21 May to 31 July was 67,789 (SE = 4,780). This estimate was based on 4,035 tagged fish available for recapture, 5,224 fish examined for tags, and 377 recaptures.

DISCUSSION

Project Mobilization

In 2006, river ice and snow cover in early May delayed the deployment of the Baird Canyon fishwheels. It took approximately 18 d from the time the crew arrived at camp (6 May) until the successful deployment of all three fishwheels (23 May). This was considerably longer than in 2005 (9 d), and similar to the time it took to mobilize in 2004 (21 d) when similar environmental conditions were encountered. The complete break-up of river ice on 21 May was the latest date seen since project inception. As in 2005, successful mobilization in 2006 was attributed to several factors, including:

(1) Efficient organization and equipment storage during demobilization in 2005;
(2) There was no significant damage to any equipment over the winter;
(3) An experienced crew was used during mobilization which expedited fishwheel assembly and reduced the amount of crew training required;
(4) The availability of a cabin stocked with the majority of supplies needed for mobilization; and
(5) The sites for all fishwheels had been used before and required little effort to prepare.

As in 2005, the Canyon Creek fishwheels were stored intact at the camp site and there was no need for major repairs or modification prior to sampling. 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 2 d. The timing and execution of mobilization at both camps was suitable given the environmental conditions in early May.

Fishwheel Operation and Catch

Catches of Chinook salmon at the Baird Canyon fishwheels have increased each year since the project's inception. These increases are largely attributable to increases in fishing effort, experience with existing fishwheel sites, and the ability to effectively operate fishwheels during a wide range of water levels. Catches of Chinook salmon were 24% greater in 2006 (4,569 fish) than catches in 2005 (3,674 fish). The significant increase in 2006 catches was primarily due to the unusually late timing of the start of the Chinook run, which resulted in a commercial fishery management decision to close the commercial fishery by EO during the second statistical week of the season, following historically low catches and feared run failure during the first statistical week of the season. This complete closure resulted in a larger than usual pulse of fish entering the river unhindered during the closure. Record counts up to 5 times greater than usual were also observed at the Miles Lake sonar station following this period. Ideal climatic and water-level conditions throughout most of the run also contributed to increased catches. Similarly at Canyon Creek, Chinook salmon catches in 2006 (5,224 fish) were 65% higher than catches in 2005 (3,158 fish).

Abundance Estimate

A continuing challenge of this project is to catch sufficient numbers of Chinook salmon during each sampling event from an expected abundance of 40,000 fish that migrated over a two-month period through widely fluctuating water conditions. In 2006, the number of Chinook salmon marked at Baird Canyon (4,035 fish) and examined for marks at Canyon Creek (5,224 fish) exceeded the target levels. In addition, the number of tagged fish recaptured at Canyon Creek (377 fish) was sufficient to develop an unbiased and very precise abundance estimate (coefficient of variation measured at 7% of the estimate). The escapement goal set by the Board of Fisheries for Chinook salmon on the Copper River is 24,000 or more spawners. If we subtract from our abundance estimate (67,789 fish) the number of Chinook salmon harvested in the Chitina and Glennallen subdistricts (5,856 fish), and assume that the number of Chinook salmon harvested in the sport fishery was similar to the 2001-2005 average (4,646 fish), then the 2006 spawning escapement is estimated to be 57,287 fish. The 2006 inriver abundance estimate was the highest observed since the project's inception (Table 3), and the estimated spawning escapement was 138% higher than the escapement goal.

CONCLUSIONS

This year (2006) was the final year of the current funding cycle (FY04-06) to operate a long-term Chinook salmon escapement monitoring project on the Copper River. 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 have been generated consistently and reliably for four years, and the project has evolved into a long-term monitoring program that has made NVE an integral part of Copper River salmon research. 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 will 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 Chinook 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 2007 field season:

(1) Continue to follow and refine the demobilization procedures that have been developed since the project's inception, particularly in light of damages incurred during post-season flooding event in October 2006;
(2) Continue monitoring ice and snow conditions at Baird Canyon in early May in order to assess the best time to mobilize; plan on the Baird Canyon crew starting around 5 May and the Canyon Creek crew around 12 May;
(3) Operate the Baird Canyon and Canyon Creek fishwheels at the same sites used in 2006; and
(4) Continue to use the escape panels in each fishwheel with the openings set to a width of 6.0 cm, except when closed for sockeye salmon sampling requirements.

ACKNOWLEDGMENTS

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This project (FIS04-503) was approved by the Federal Subsistence Board, managed by the U.S. Fish and Wildlife Service, Office of Subsistence Management, and funded by the USFS. This project was a cooperative effort between the USFS, NVE, LGL, and ADF&G, and this annual report partially fulfills contract obligations for USFS Contract #53-0109-2-00591.

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FIGURES

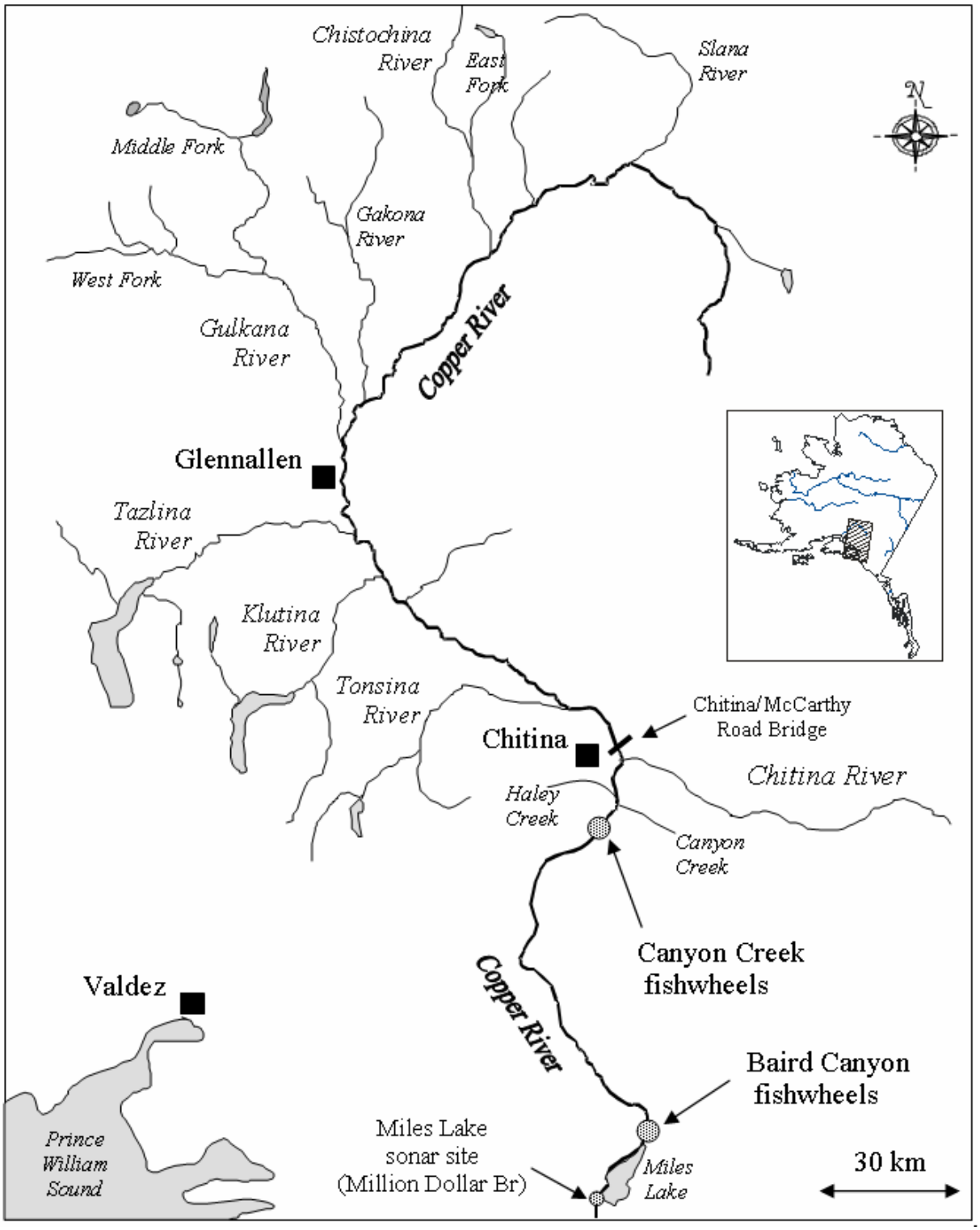

Figure 1. Map of the study area showing the location of the Baird Canyon and Canyon Creek fishwheels on the Copper River in Alaska, 2006.

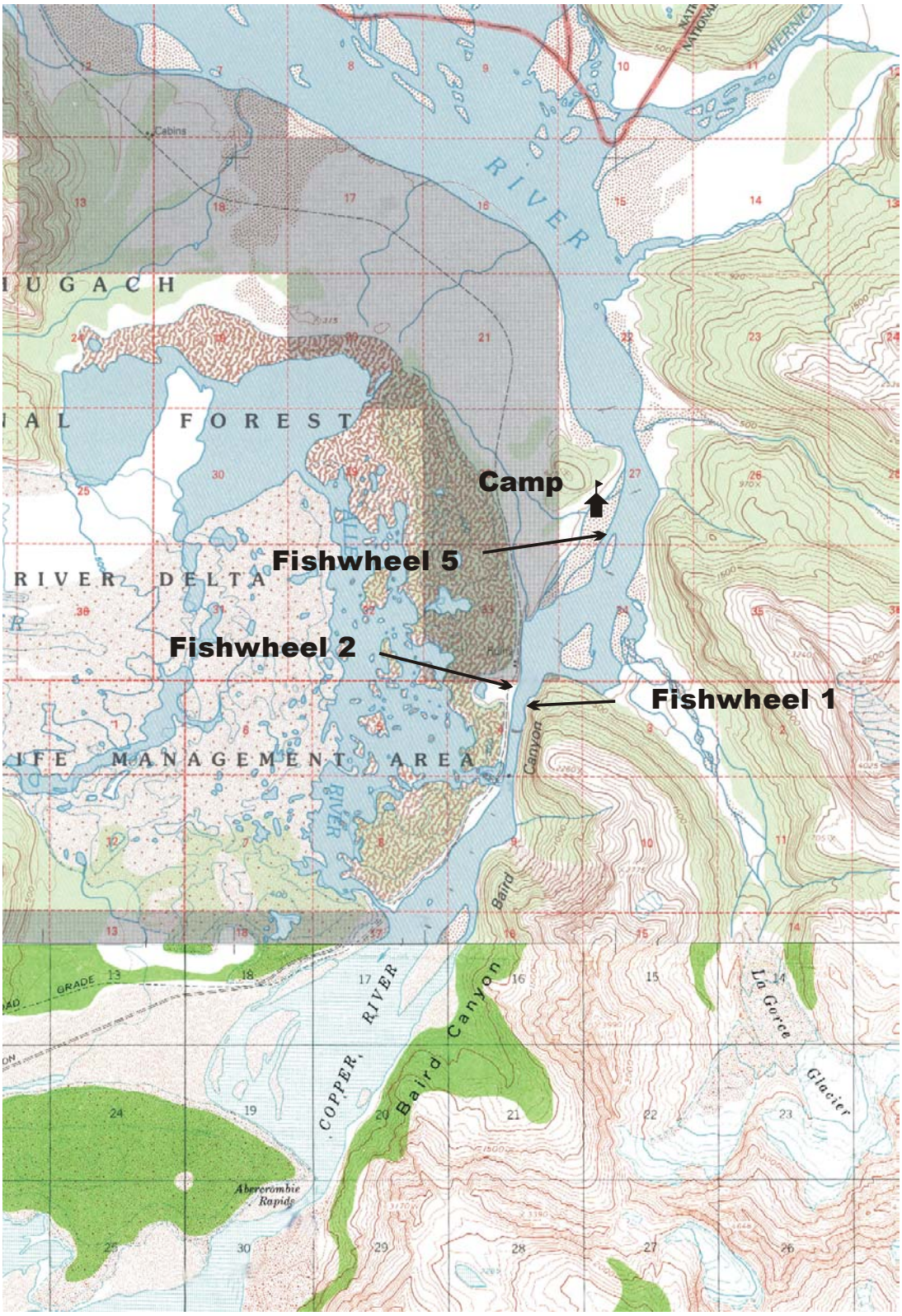

Figure 2. Map of Baird Canyon on the Copper River showing the location of the camp and fishwheel sites that were used in 2006.

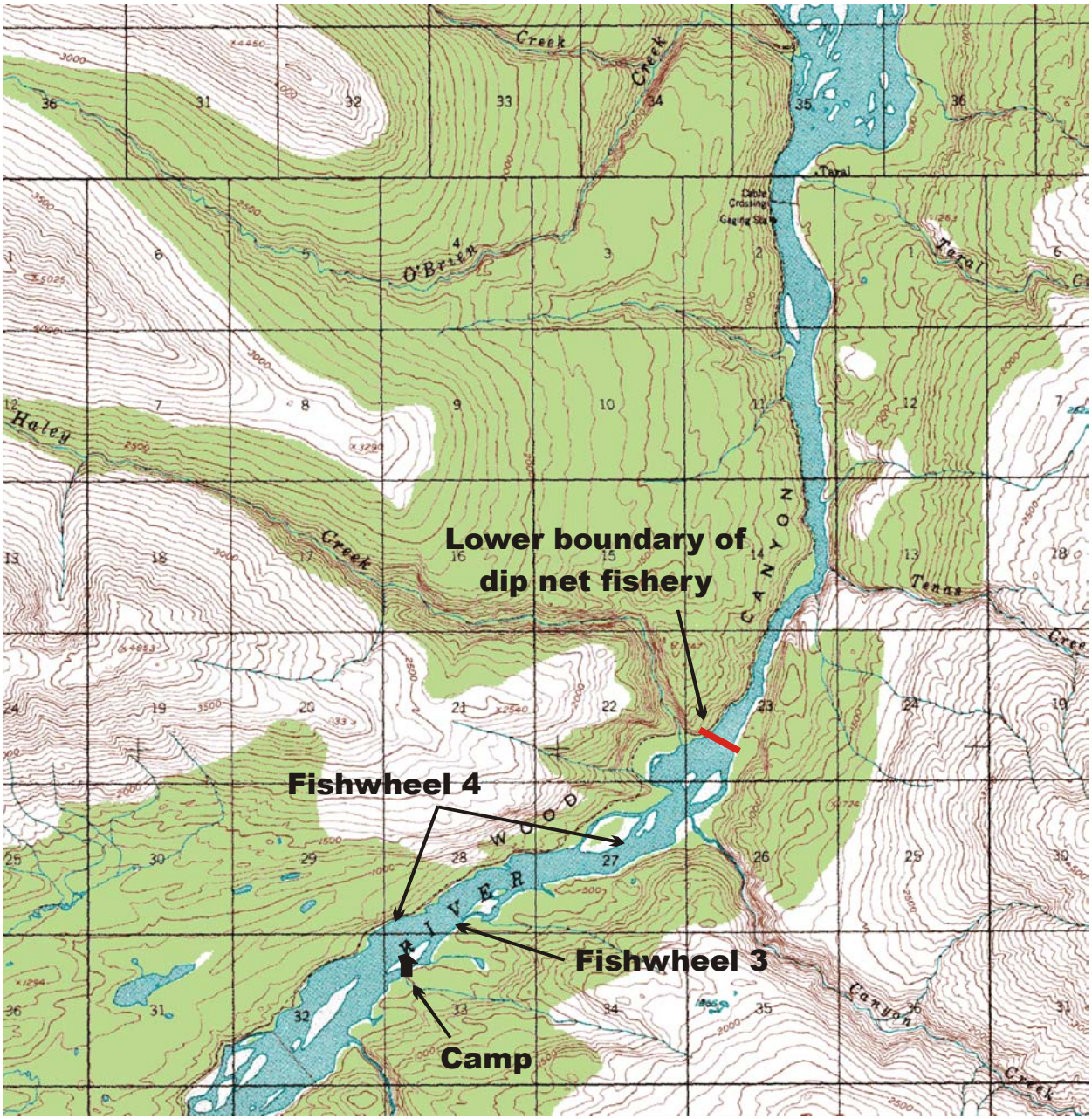

Figure 3. Map of Wood Canyon on the Copper River showing the location of the camp, fishwheel sites that were used in 2006, and the lower boundary of the Chitina Subdistrict dip net (CSDN) fishery.

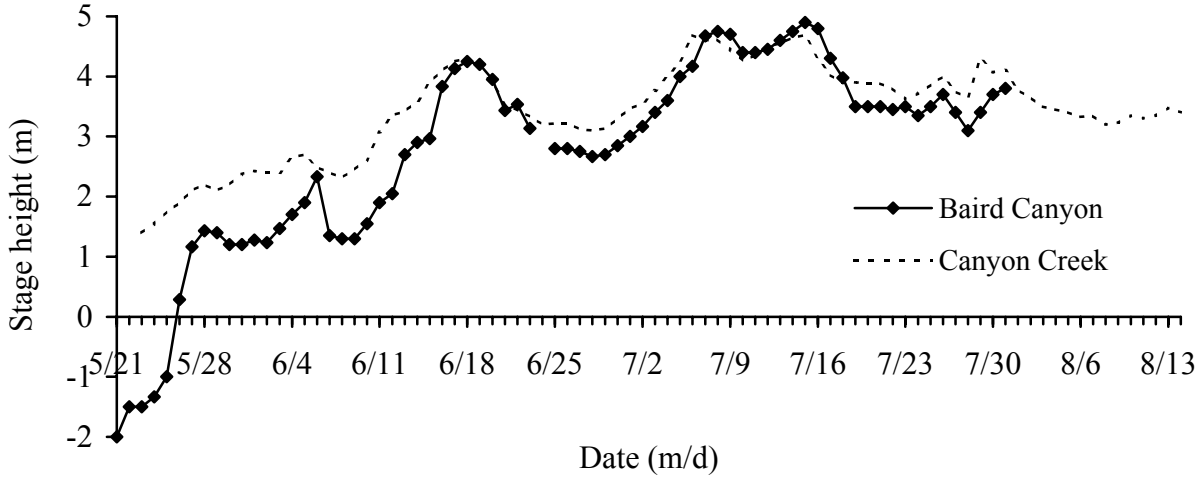

Figure 4. Average daily water level of the Copper River near the Baird Canyon and Canyon Creek fishwheels, 2006.

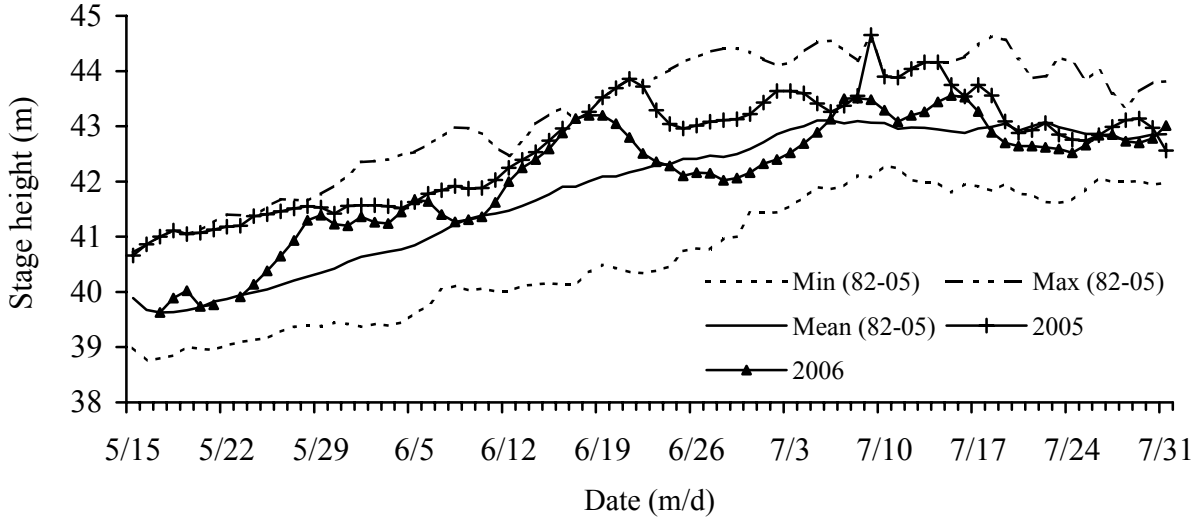

Figure 5. Stage height of the Copper River at the Million Dollar Bridge, 1982 to 2006.

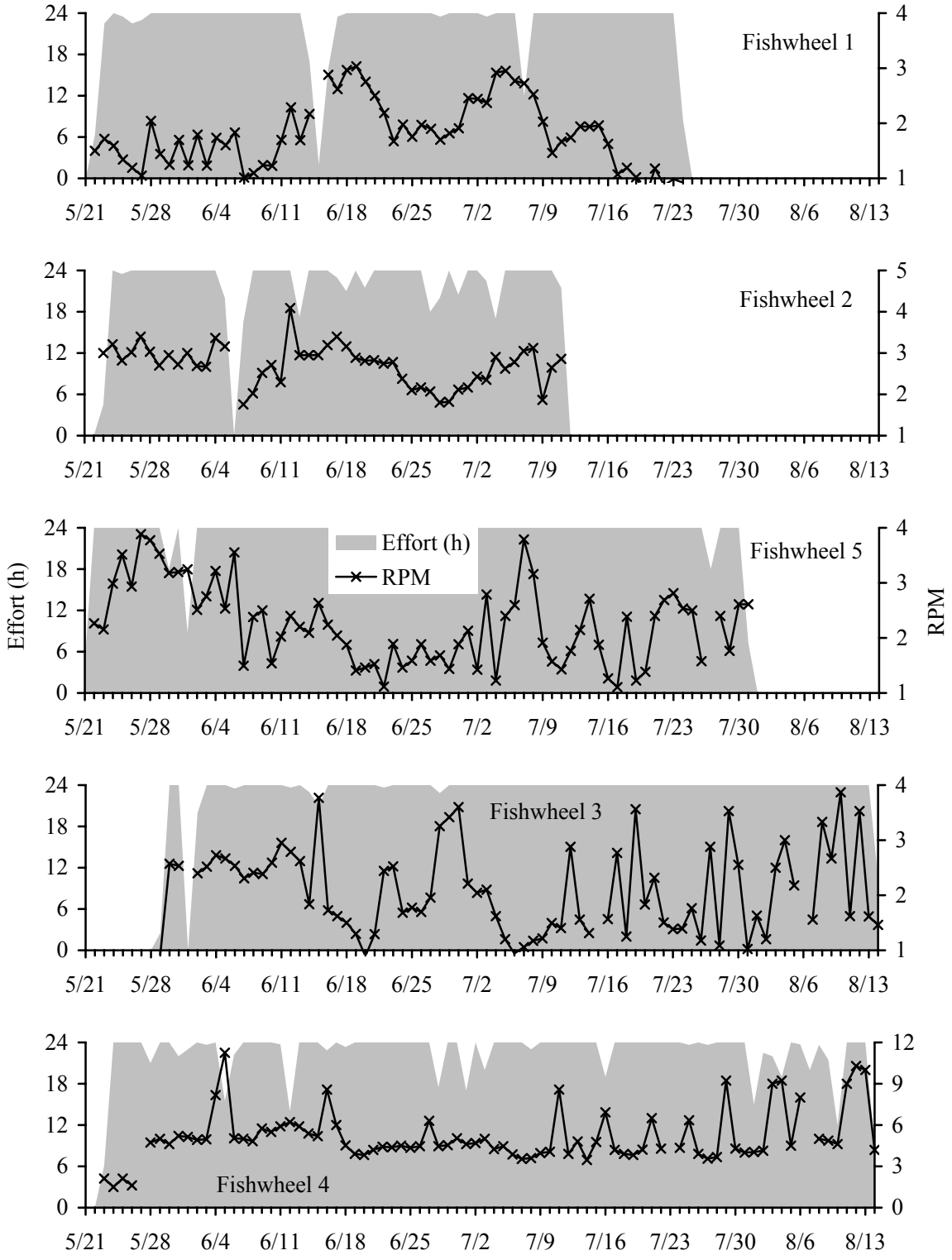

Figure 6. Fishwheel effort (h) and speed (rpm) at the Baird Canyon (fw 1, 2, and 5) and Canyon Creek (fw 3 and 4) fishwheels on the Copper River, 2006.

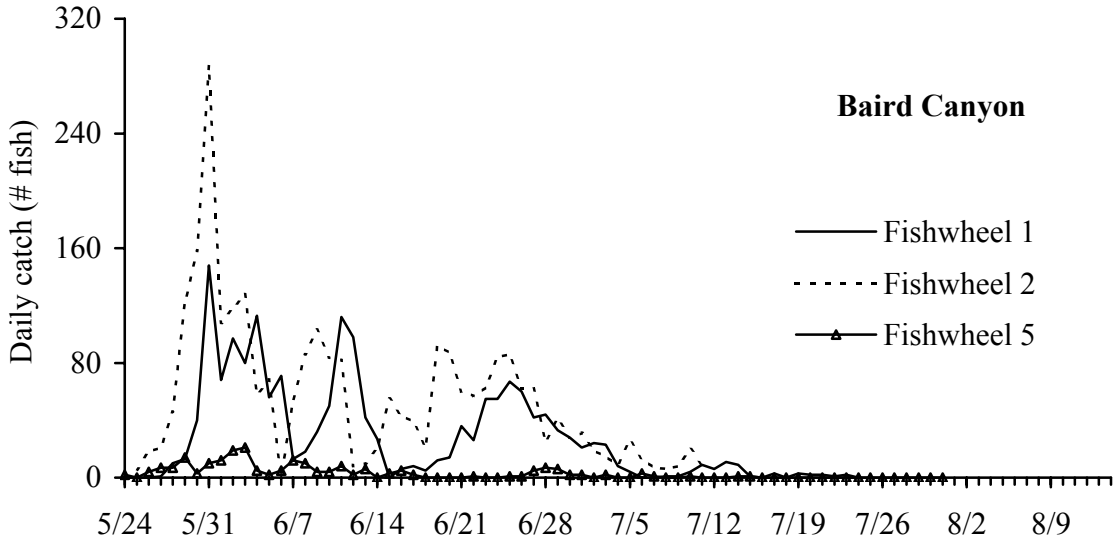

Figure 7. Daily catch of Chinook salmon at the Baird Canyon fishwheels on the Copper River, 2006.

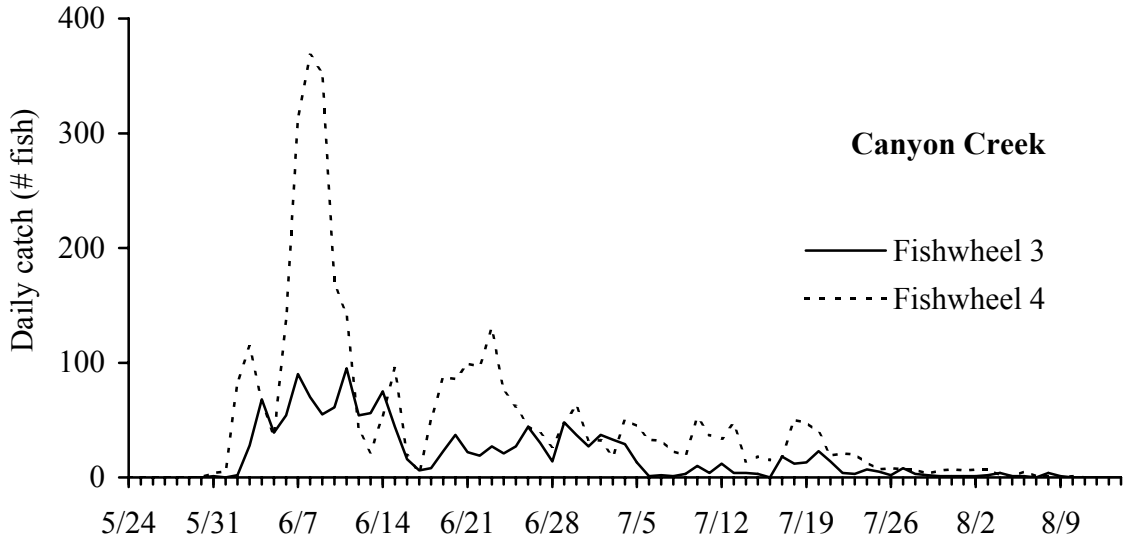

Figure 8. Daily catch of Chinook salmon at the Canyon Creek fishwheels on the Copper River, 2006.

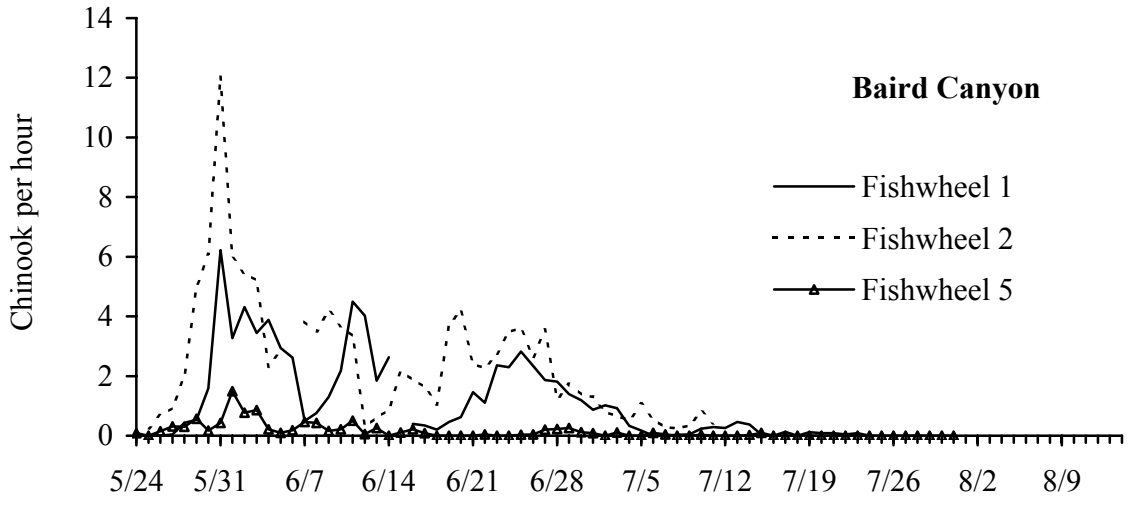

Figure 9. Catch per unit effort (fish per fishwheel hour) for Chinook salmon at the Baird Canyon fishwheels on the Copper River, 2006.

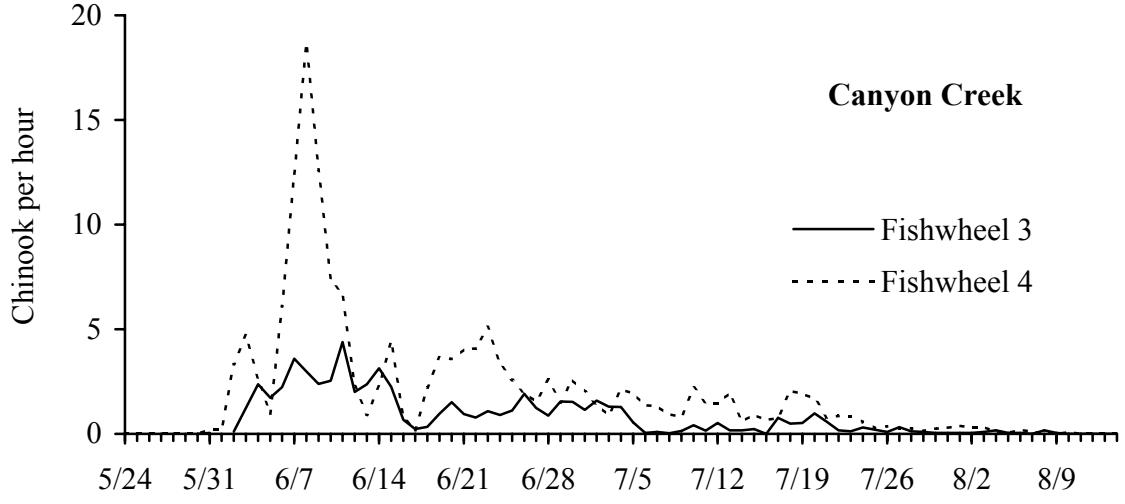

Figure 10. Catch per unit effort (fish per fishwheel hour) for Chinook salmon atthe Canyon Creek fishwheels on the Copper River, 2006.

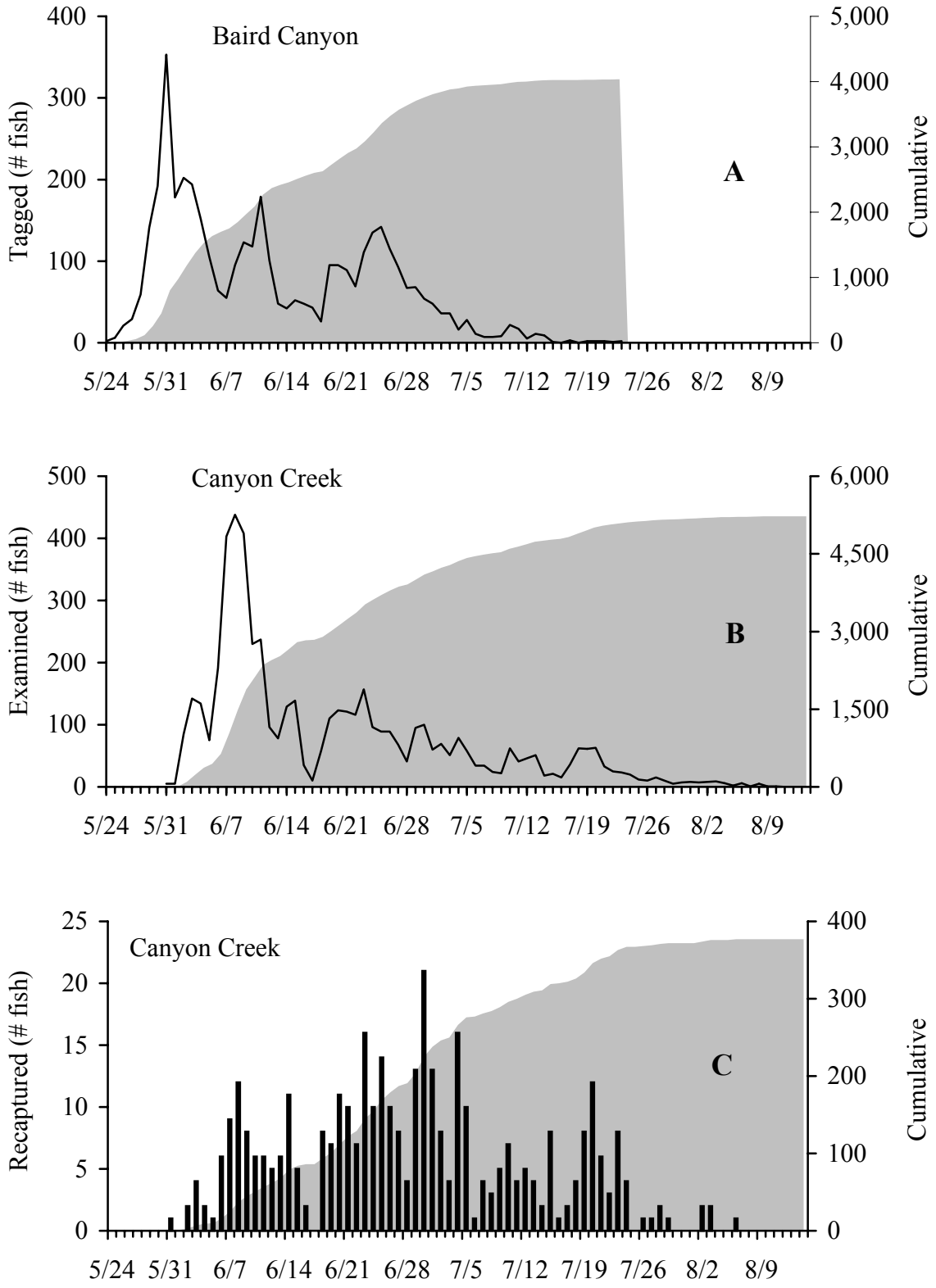

Figure 11. Number of Chinook salmon tagged (panel A), examined (panel B), and recaptured (panel C) at the Copper River fishwheels, 2006.

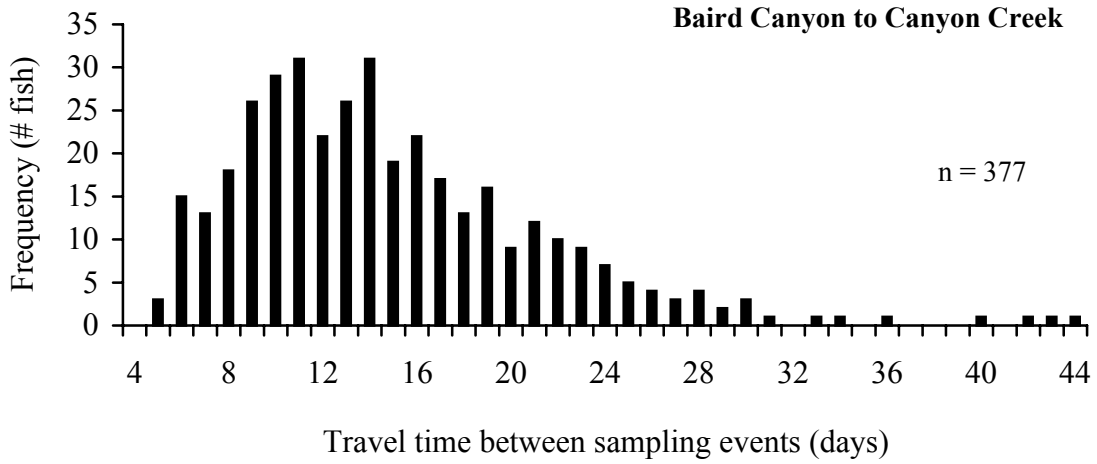

Figure 12. Travel time (days) of Chinook salmon that were tagged at the Baird Canyon fishwheels and recaptured at the Canyon Creek fishwheels, 2006.

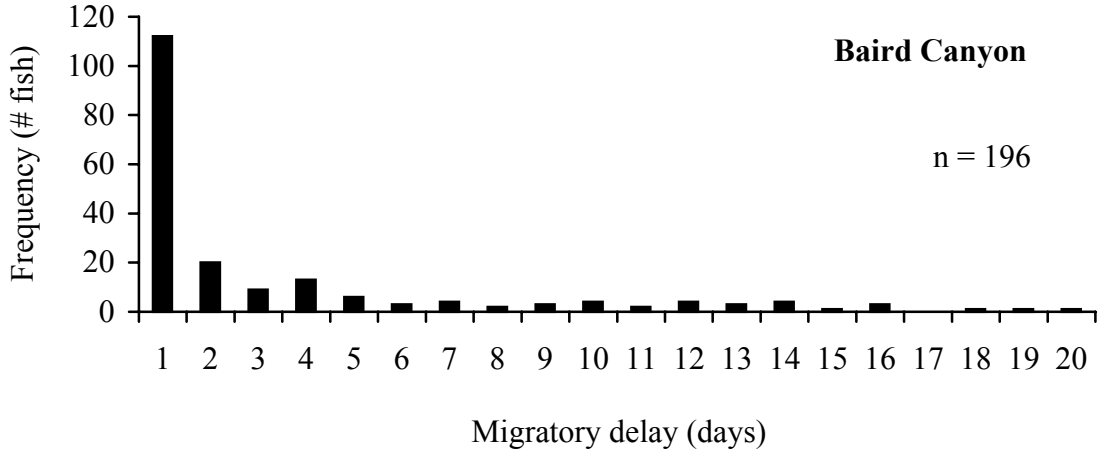

Figure 13. Migratory delay (days) for Chinook salmon captured more than once at the Baird Canyon fishwheels, 2006.

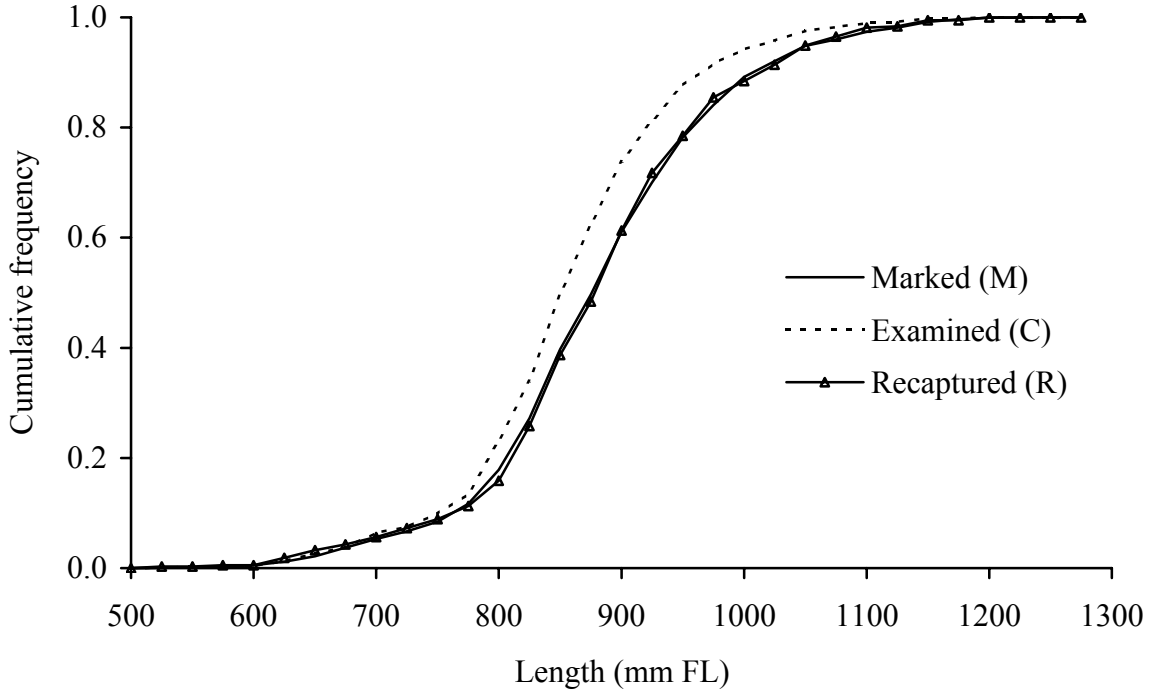

Figure 14. Cumulative length-frequency distributions for Chinook salmon (≥ 600 mm FL) marked at Baird Canyon and examined and recaptured at Canyon Creek, 2006.

TABLES

Table 1. 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, 2006.

Bank of Release	Recaptured	Not recaptured	Total	Recapture Rate
West	234	2,226	2,460	0.095
East	139	1,436	1,575	0.088
Total	373	3,662	4,035	0.092

Chi-square = 0.54, df = 1, p-value = 0.463

Table 2. Capture history of Chinook salmon that were tagged, examined, and recaptured at the Copper River fishwheels, 2006.

Period of marking	Period of recapture 5/31-6/11	6/12-6/29	6/30-7/17	7/18-7/22	7/23-7/24	7/25-8/14	Recaptured	Not recaptured	Marks	Recapture rate
5/24-6/6	57	55	1	0	0	0	**113**	**1585**	1698	0.067
6/7-7/23	0	92	117	33	12	10	**264**	**2073**	2337	0.113
Recaps	**57**	**147**	**118**	**33**	**12**	**10**	377	3658	4035	0.093
Unmarked	**2296**	**1503**	**703**	**211**	**31**	**103**	4847	$\chi^2 = 25.01$, df = 1, P = 0.000		
Examined	2353	1650	821	244	43	113	5224			
Mark rate	0.024	0.089	0.144	0.135	0.279	0.088	0.072	$\chi^2 = 193.1$, df = 5, P = 0.000		

Bold text indicates data used for chi-square tests. A 2 row x 4 column matrix and the Darroch moment estimator in SPAS were used to estimate abundance (recapture strata from 18 July to 14 August were pooled).

Table 3. Estimated inriver abundance of Chinook salmon above Baird Canyon on the Copper River, 2003-2006.

Year	Period (m/d) From	Period (m/d) To	Length (mm FL)	Marked (M)	Examined (C)	Recaptures (R)	Abundance (N)	Standard 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

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, 2006.

	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
21-May							4.5	3.2							
22-May	6.3	4.1	1.5				24.0	23.0	2.3						
23-May	22.5	22.0	1.7	4.5	2.0	3.0	24.0	24.0	2.2				6.1	0.0	2.1
24-May	24.0	23.9	1.6	24.0	24.0	3.2	24.0	24.2	3.0				24.0	26.0	1.5
25-May	23.5	23.6	1.3	23.5	23.6	2.8	24.0	24.1	3.5				24.0	24.2	2.1
26-May	22.5	24.4	1.2	24.0	26.4	3.0	24.0	26.4	2.9				24.0	25.6	1.6
27-May	23.0	22.0	1.0	24.0	22.8	3.4	24.0	22.9	3.9				24.0	24.2	
28-May	24.0	23.0	2.0	24.0	23.2	3.0	24.0	23.1	3.8				21.0	22.2	4.7
29-May	24.0	24.3	1.4	24.0	24.5	2.7	24.0	24.5	3.5	2.5	0.0	0.9	24.0	22.4	5.0
30-May	24.0	25.1	1.2	24.0	25.9	3.0	18.0	17.3	3.2	24.0	24.0	2.6	24.0	24.1	4.6
31-May	24.0	23.8	1.7	24.0	23.8	2.7	24.0	23.3	3.2	24.0	22.6	2.5	22.0	20.2	5.2
1-Jun	24.0	20.8	1.2	24.0	18.1	3.0	8.8	8.0	3.2	0.0	0.0		23.0	25.1	5.1
2-Jun	24.0	22.5	1.8	24.0	21.8	2.7	24.0	24.7	2.5	20.0	19.8	2.4	24.0	25.0	4.9
3-Jun	24.0	23.3	1.2	24.0	24.6	2.7	24.0	24.4	2.8	24.0	22.6	2.5	23.7	24.2	5.0
4-Jun	24.0	29.1	1.7	24.0	25.1	3.4	24.0	23.5	3.2	24.0	28.6	2.7	24.0	24.9	8.2
5-Jun	24.0	19.1	1.6	20.0	24.0	3.2	24.0	21.1	2.5	24.0	22.5	2.7	15.5	38.1	11.3
6-Jun	24.0	27.2	1.8	0.0	0.0		24.0	27.5	3.6	23.5	24.1	2.5	22.3	22.5	5.0
7-Jun	24.0	26.1	1.0	16.5	14.1	1.8	24.0	25.7	1.5	24.0	25.0	2.3	24.0	25.2	5.0
8-Jun	24.0	23.8	1.1	24.0	24.5	2.0	24.0	23.4	2.4	24.0	23.4	2.4	24.0	19.7	4.8
9-Jun	24.0	24.6	1.2	24.0	24.6	2.5	24.0	24.4	2.5	24.0	23.1	2.4	24.0	28.0	5.7
10-Jun	24.0	22.9	1.2	24.0	22.8	2.7	24.0	18.3	1.5	24.0	24.1	2.6	24.0	22.9	5.5
11-Jun	24.0	24.9	1.7	24.0	24.5	2.3	24.0	16.0	2.0	24.0	21.7	3.0	23.8	21.4	5.9
12-Jun	24.0	24.4	2.3	24.0	24.5	4.1	24.0	36.2	2.4	23.7	27.0	2.8	14.0	18.0	6.2
13-Jun	24.0	22.7	1.7	17.3	16.4	3.0	24.0	23.7	2.2	24.0	23.7	2.6	24.0	24.5	5.9
14-Jun	17.0	10.3	2.2	24.0	23.2	3.0	24.0	23.1	2.1	23.0	24.0	1.8	24.0	23.8	5.4
15-Jun	2.0	0.0		24.0	25.7	3.0	24.0	26.9	2.6	21.0	19.5	3.8	24.0	21.5	5.2
16-Jun	16.0	15.3	2.9	24.0	23.0	3.2	24.0	23.0	2.2	24.0	23.9	1.7	22.8	23.9	8.6
17-Jun	23.5	23.3	2.6	23.0	23.7	3.4	24.0	24.3	2.0	24.0	25.6	1.6	24.0	25.5	6.0
18-Jun	24.0	24.5	3.0	21.0	20.0	3.2	24.0	20.7	1.9	24.0	23.7	1.5	23.3	22.7	4.5
19-Jun	24.0	25.9	3.0	24.0	24.8	2.9	24.0	28.7	1.4	24.0	23.8	1.3	24.0	23.8	3.9
20-Jun	24.0	22.6	2.8	21.5	20.6	2.8	24.0	22.6	1.5	24.0	24.4	0.9	24.0	24.0	3.8

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, 2006.

	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
21-Jun	24.0	24.7	2.5	24.0	25.0	2.8	24.0	24.7	1.5	24.0	23.3	1.3	24.0	24.5	4.2
22-Jun	24.0	23.6	2.2	24.0	25.2	2.7	24.0	24.3	1.1	23.7	24.4	2.4	24.0	23.8	4.4
23-Jun	24.0	23.3	1.7	24.0	23.0	2.8	24.0	23.2	1.9	24.0	24.8	2.5	24.0	25.5	4.4
24-Jun	24.0	24.0	2.0	24.0	24.2	2.4	24.0	11.2	1.5	24.0	23.1	1.7	24.0	22.4	4.5
25-Jun	24.0	23.7	1.8	24.0	23.8	2.1	24.0	30.6	1.6	24.0	24.3	1.8	24.0	24.2	4.4
26-Jun	24.0	25.7	2.0	24.0	23.7	2.2	24.0	23.5	1.9	24.0	23.1	1.7	24.0	23.3	4.5
27-Jun	24.0	22.6	1.9	18.0	17.5	2.1	24.0	24.1	1.6	24.0	24.3	2.0	24.0	24.3	6.3
28-Jun	23.5	24.3	1.7	20.0	20.4	1.8	24.0	30.8	1.7	22.8	16.0	3.3	17.5	10.6	4.5
29-Jun	24.0	23.6	1.8	24.0	23.7	1.8	24.0	23.4	1.4	24.0	31.1	3.4	24.0	31.2	4.5
30-Jun	24.0	23.5	1.9	20.5	20.3	2.1	24.0	17.7	1.9	24.0	24.1	3.6	24.0	24.4	5.0
1-Jul	24.0	24.3	2.5	24.0	24.0	2.2	24.0	23.5	2.1	24.0	23.6	2.2	17.0	16.3	4.6
2-Jul	24.0	23.4	2.4	24.0	23.9	2.4	24.0	30.1	1.4	24.0	23.2	2.0	24.0	23.3	4.7
3-Jul	23.5	24.9	2.4	22.5	22.7	2.4	24.0	19.0	2.8	24.0	25.5	2.1	20.0	20.4	5.0
4-Jul	24.0	24.1	2.9	17.0	17.3	2.9	24.0	24.1	1.2	24.0	22.5	1.6	24.0	23.7	4.3
5-Jul	24.0	23.6	3.0	24.0	24.5	2.6	24.0	22.6	2.4	24.0	23.4	1.2	24.0	23.2	4.5
6-Jul	24.0	9.9	2.8	24.0	23.4	2.8	24.0	30.6	2.6	24.0	24.0	0.9	24.0	24.0	3.9
7-Jul	12.0	18.6	2.7	24.0	25.0	3.1	24.0	23.6	3.8	24.0	23.3	1.1	24.0	24.4	3.5
8-Jul	24.0	31.0	2.5	24.0	23.0	3.1	24.0	11.0	3.2	24.0	26.2	1.2	23.0	24.4	3.6
9-Jul	24.0	23.6	2.0	24.0	23.9	1.9	24.0	31.1	1.9	24.0	22.6	1.2	24.0	23.3	4.0
10-Jul	24.0	17.3	1.5	24.0	24.4	2.6	24.0	29.9	1.6	24.0	24.5	1.5	24.0	23.7	4.1
11-Jul	24.0	31.2	1.7	21.5	21.4	2.9	24.0	11.9	1.4	24.0	25.0	1.4	24.0	24.9	8.6
12-Jul	24.0	23.3	1.7				24.0	36.5	1.8	24.0	23.2	2.9	24.0	23.3	3.9
13-Jul	24.0	24.1	1.9				24.0	10.8	2.1	24.0	24.1	1.6	24.0	24.0	4.8
14-Jul	24.0	24.3	1.9				24.0	37.5	2.7	24.0	23.2	1.3	24.0	23.4	3.5
15-Jul	24.0	24.6	2.0				24.0	10.4	1.9	24.0	13.2		24.0	19.7	4.8
16-Jul	24.0	23.5	1.6				24.0	30.5	1.3	24.0	34.4	1.6	19.0	22.8	6.9
17-Jul	24.0	24.0	1.1				24.0	17.3	1.1	24.0	23.7	2.8	24.0	23.6	4.2
18-Jul	24.0	23.6	1.2				24.0	30.4	2.4	24.0	24.4	1.3	24.0	24.4	3.9
19-Jul	24.0	24.5	1.0				24.0	24.3	1.2	24.0	25.2	3.6	24.0	25.0	3.8
20-Jul	24.0	23.4	0.7				24.0	30.7	1.4	24.0	23.4	1.8	24.0	23.8	4.2
21-Jul	24.0	24.4	1.2				24.0	12.0	2.4	24.0	24.0	2.3	24.0	23.9	6.5

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, 2006.

	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
22-Jul	24.0	23.5	0.9				24.0	29.3	2.7	24.0	24.5	1.5	24.0	24.5	4.3
23-Jul	24.0	24.4	1.0				24.0	18.8	2.8	24.0	23.7	1.4	24.0	23.9	
24-Jul	8.5	11.1	0.9				24.0	30.6	2.5	24.0	23.0	1.4	24.0	22.7	4.4
25-Jul							24.0	28.7	2.5	24.0	25.4	1.8	23.7	25.5	6.4
26-Jul							24.0	19.1	1.6	24.0	22.4	1.2	24.0	21.8	3.9
27-Jul							18.0	21.5		24.0	25.5	2.9	23.7	25.3	3.6
28-Jul							24.0	22.5	2.4	24.0	24.2	1.1	24.0	25.0	3.7
29-Jul							24.0	20.4	1.8	24.0	23.4	3.5	24.0	22.5	9.2
30-Jul							24.0	26.8	2.6	24.0	24.4	2.6	24.0	24.8	4.3
31-Jul							7.3	7.3	2.6	24.0	23.1	1.0	24.0	23.6	4.0
1-Aug										24.0	24.3	1.6	15.0	15.5	4.0
2-Aug										24.0	24.4	1.2	22.5	22.0	4.1
3-Aug										24.0	23.8	2.5	22.0	21.8	9.0
4-Aug										24.0	23.9	3.0	19.0	18.9	9.2
5-Aug										24.0	23.3	2.2	24.0	19.2	4.5
6-Aug										24.0	24.4		23.8	28.2	8.0
7-Aug										24.0	24.8	1.6	20.0	9.9	
8-Aug										24.0	23.4	3.3	23.7	33.9	5.0
9-Aug										24.0	24.1	2.7	21.5	21.3	4.9
10-Aug										24.0	24.1	3.9	12.0	12.3	4.6
11-Aug										24.0	23.4	1.6	24.0	23.5	9.0
12-Aug										24.0	24.6	3.5	24.0	24.3	10.3
13-Aug										24.0	23.8	1.6	24.0	23.9	10.0
14-Aug										10.5	12.7	1.5	9.0	11.3	4.2
Effort (h)	1,448		1.8	1,107		2.7	1,665		2.3	1,803		2.1	1,894		5.2
Effort (d)	60.3			46.1			69.4			75.1			78.9		
Percent operational:	96.3%			94.0%			98.4%			98.1%			95.5%		

Appendix A.2. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fishwheels, 2006.

	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
21 May							0	0	0.00						
22 May							0	0	0.00						
23 May	0	0	0.00	0	0	0.00	0	0	0.00				0	0	
24 May	0	0	0.00	0	0	0.00	2	2	0.08				0	0	0.00
25 May	0	0	0.00	6	6	0.25	0	2	0.00				0	0	0.00
26 May	0	0	0.00	18	24	0.68	4	6	0.15				0	0	0.00
27 May	1	1	0.05	21	45	0.92	7	13	0.31				0	0	0.00
28 May	10	11	0.43	46	91	1.99	7	20	0.30				0	0	0.00
29 May	13	24	0.53	122	213	4.97	14	34	0.57	0	0		0	0	0.00
30 May	40	64	1.59	158	371	6.09	3	37	0.17	0	0	0.00	0	0	0.00
31 May	148	212	6.22	287	658	12.05	10	47	0.43	1	1	0.04	4	4	0.20
1 Jun	68	280	3.27	108	766	5.97	12	59	1.49	0	1		5	9	0.20
2 Jun	97	377	4.31	118	884	5.43	19	78	0.77	2	3	0.10	83	92	3.32
3 Jun	80	457	3.44	128	1,012	5.20	21	99	0.86	28	31	1.24	114	206	4.71
4 Jun	113	570	3.89	58	1,070	2.31	5	104	0.21	68	99	2.37	66	272	2.65
5 Jun	56	626	2.94	68	1,138	2.84	2	106	0.09	39	138	1.73	36	308	0.94
6 Jun	71	697	2.62	0	1,138		5	111	0.18	54	192	2.24	137	445	6.10
7 Jun	13	710	0.50	54	1,192	3.83	12	123	0.47	90	282	3.60	313	758	12.40
8 Jun	18	728	0.76	86	1,278	3.51	10	133	0.43	70	352	2.99	368	1,126	18.65
9 Jun	32	760	1.30	103	1,381	4.19	4	137	0.16	55	407	2.38	353	1,479	12.63
10 Jun	50	810	2.18	84	1,465	3.68	4	141	0.22	61	468	2.53	169	1,648	7.40
11 Jun	112	922	4.49	82	1,547	3.35	8	149	0.50	95	563	4.38	142	1,790	6.64
12 Jun	98	1,020	4.02	8	1,555	0.33	2	151	0.06	54	617	2.00	42	1,832	2.33
13 Jun	42	1,062	1.85	10	1,565	0.61	6	157	0.25	56	673	2.37	22	1,854	0.90
14 Jun	27	1,089	2.63	20	1,585	0.86	0	157	0.00	75	748	3.13	54	1,908	2.27
15 Jun	0	1,089		55	1,640	2.14	3	160	0.11	44	792	2.25	95	2,003	4.42
16 Jun	6	1,095	0.39	43	1,683	1.87	5	165	0.22	16	808	0.67	19	2,022	0.79
17 Jun	8	1,103	0.34	39	1,722	1.65	2	167	0.08	6	814	0.23	4	2,026	0.16
18 Jun	5	1,108	0.20	21	1,743	1.05	0	167	0.00	8	822	0.34	50	2,076	2.20
19 Jun	12	1,120	0.46	92	1,835	3.70	0	167	0.00	23	845	0.97	87	2,163	3.66
20 Jun	14	1,134	0.62	87	1,922	4.22	0	167	0.00	37	882	1.52	86	2,249	3.58
21 Jun	36	1,170	1.46	60	1,982	2.40	0	167	0.00	22	904	0.94	99	2,348	4.04

Appendix A.2. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fishwheels, 2006.

	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 Jun	26	1,196	1.10	57	2,039	2.26	1	168	0.04	19	923	0.78	97	2,445	4.08
23 Jun	55	1,251	2.36	63	2,102	2.74	0	168	0.00	27	950	1.09	130	2,575	5.09
24 Jun	55	1,306	2.29	84	2,186	3.48	0	168	0.00	21	971	0.91	75	2,650	3.35
25 Jun	67	1,373	2.82	86	2,272	3.61	1	169	0.03	27	998	1.11	62	2,712	2.56
26 Jun	60	1,433	2.34	62	2,334	2.62	1	170	0.04	44	1,042	1.91	45	2,757	1.94
27 Jun	42	1,475	1.86	62	2,396	3.55	5	175	0.21	30	1,072	1.23	38	2,795	1.56
28 Jun	44	1,519	1.81	25	2,421	1.23	7	182	0.23	14	1,086	0.87	27	2,822	2.55
29 Jun	33	1,552	1.40	41	2,462	1.73	6	188	0.26	48	1,134	1.54	47	2,869	1.51
30 Jun	28	1,580	1.19	28	2,490	1.38	2	190	0.11	37	1,171	1.53	63	2,932	2.58
1 Jul	21	1,601	0.86	31	2,521	1.29	2	192	0.09	27	1,198	1.14	33	2,965	2.02
2 Jul	24	1,625	1.02	19	2,540	0.80	0	192	0.00	37	1,235	1.59	32	2,997	1.37
3 Jul	23	1,648	0.92	15	2,555	0.66	2	194	0.11	33	1,268	1.30	18	3,015	0.88
4 Jul	8	1,656	0.33	9	2,564	0.52	0	194	0.00	29	1,297	1.29	50	3,065	2.11
5 Jul	4	1,660	0.17	26	2,590	1.06	0	194	0.00	13	1,310	0.55	45	3,110	1.94
6 Jul	0	1,660	0.00	13	2,603	0.56	3	197	0.10	1	1,311	0.04	33	3,143	1.38
7 Jul	0	1,660	0.00	7	2,610	0.28	1	198	0.04	2	1,313	0.09	32	3,175	1.31
8 Jul	1	1,661	0.03	6	2,616	0.26	0	198	0.00	1	1,314	0.04	23	3,198	0.94
9 Jul	1	1,662	0.04	8	2,624	0.33	0	198	0.00	3	1,317	0.13	19	3,217	0.82
10 Jul	4	1,666	0.23	20	2,644	0.82	1	199	0.03	10	1,327	0.41	52	3,269	2.20
11 Jul	9	1,675	0.29	9	2,653	0.42	0	199	0.00	4	1,331	0.16	37	3,306	1.48
12 Jul	6	1,681	0.26				0	199	0.00	12	1,343	0.52	34	3,340	1.46
13 Jul	11	1,692	0.46				0	199	0.00	4	1,347	0.17	47	3,387	1.96
14 Jul	9	1,701	0.37				1	200	0.03	4	1,351	0.17	14	3,401	0.60
15 Jul	1	1,702	0.04				1	201	0.10	3	1,354	0.23	18	3,419	0.92
16 Jul	0	1,702	0.00				0	201	0.00	0	1,354	0.00	15	3,434	0.66
17 Jul	3	1,705	0.12				0	201	0.00	18	1,372	0.76	18	3,452	0.76
18 Jul	0	1,705	0.00				0	201	0.00	12	1,384	0.49	50	3,502	2.05
19 Jul	3	1,708	0.12				0	201	0.00	13	1,397	0.52	48	3,550	1.92
20 Jul	2	1,710	0.09				0	201	0.00	23	1,420	0.98	40	3,590	1.68
21 Jul	2	1,712	0.08				0	201	0.00	14	1,434	0.58	19	3,609	0.79
22 Jul	1	1,713	0.04				0	201	0.00	4	1,438	0.16	21	3,630	0.86
23 Jul	2	1,715	0.08				0	201	0.00	3	1,441	0.13	20	3,650	0.84

Appendix A.2. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fishwheels, 2006.

	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
24 Jul	0	1,715	0.00				0	201	0.00	7	1,448	0.31	13	3,663	0.57
25 Jul							0	201	0.00	5	1,453	0.20	7	3,670	0.27
26 Jul							0	201	0.00	2	1,455	0.09	8	3,678	0.37
27 Jul							0	201	0.00	8	1,463	0.31	7	3,685	0.28
28 Jul							0	201	0.00	3	1,466	0.12	7	3,692	0.28
29 Jul							0	201	0.00	2	1,468	0.09	3	3,695	0.13
30 Jul							0	201	0.00	1	1,469	0.04	6	3,701	0.24
31 Jul							0	201	0.00	1	1,470	0.04	7	3,708	0.30
1 Aug										1	1,471	0.04	6	3,714	0.39
2 Aug										1	1,472	0.04	7	3,721	0.32
3 Aug										2	1,474	0.08	7	3,728	0.32
4 Aug										4	1,478	0.17	2	3,730	0.11
5 Aug										1	1,479	0.04	1	3,731	0.05
6 Aug										1	1,480	0.04	5	3,736	0.18
7 Aug										0	1,480	0.00	1	3,737	0.10
8 Aug										4	1,484	0.17	1	3,738	0.03
9 Aug										1	1,485	0.04	0	3,738	0.00
10 Aug										0	1,485	0.00	1	3,739	0.08
11 Aug										0	1,485	0.00	0	3,739	0.00
12 Aug										0	1,485	0.00	0	3,739	0.00
13 Aug										0	1,485	0.00	0	3,739	0.00
14 Aug										0	1,485	0.00	0	3,739	0.00
Total	1,715			2,653			201			1,485			3,739		

Appendix A.3. Number of Chinook salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2006.

	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
24 May	0	0	0	0	2	2								
25 May	0	0	6	6	0	2								
26 May	0	0	17	23	4	6								
27 May	1	1	21	44	7	13								
28 May	10	11	43	87	6	19								
29 May	13	24	114	201	14	33								
30 May	39	63	151	352	2	35								
31 May	138	201	206	558	9	44	1	1	1	1	4	4	0	0
1 Jun	66	267	100	658	12	56	0	1	0	1	5	9	0	0
2 Jun	91	358	111	769	0	56	2	3	0	1	83	92	2	2
3 Jun	73	431	121	890	0	56	28	31	0	1	114	206	4	6
4 Jun	100	531	52	942	0	56	68	99	1	2	66	272	1	7
5 Jun	45	576	60	1,002	0	56	39	138	1	3	36	308	0	7
6 Jun	64	640	0	1,002	0	56	54	192	0	3	137	445	6	13
7 Jun	10	650	45	1,047	0	56	90	282	3	6	313	758	6	19
8 Jun	16	666	79	1,126	0	56	70	352	7	13	368	1,126	5	24
9 Jun	27	693	96	1,222	0	56	55	407	1	14	353	1,479	7	31
10 Jun	41	734	77	1,299	0	56	61	468	1	15	169	1,648	5	36
11 Jun	104	838	75	1,374	0	56	95	563	3	18	142	1,790	3	39
12 Jun	93	931	8	1,382	0	56	54	617	5	23	42	1,832	0	39
13 Jun	39	970	9	1,391	0	56	56	673	5	28	22	1,854	1	40
14 Jun	26	996	16	1,407	0	56	75	748	5	33	54	1,908	6	46
15 Jun	0	996	52	1,459	0	56	44	792	0	33	95	2,003	5	51
16 Jun	6	1,002	42	1,501	0	56	16	808	2	35	19	2,022	0	51
17 Jun	6	1,008	37	1,538	0	56	6	814	0	35	4	2,026	0	51
18 Jun	5	1,013	21	1,559	0	56	8	822	1	36	50	2,076	7	58
19 Jun	9	1,022	86	1,645	0	56	23	845	1	37	87	2,163	6	64
20 Jun	13	1,035	82	1,727	0	56	37	882	4	41	86	2,249	7	71
21 Jun	32	1,067	57	1,784	0	56	22	904	1	42	99	2,348	9	80
22 Jun	24	1,091	45	1,829	0	56	19	923	1	43	97	2,445	6	86
23 Jun	48	1,139	63	1,892	0	56	27	950	5	48	130	2,575	11	97

Appendix A.3. Number of Chinook salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2006.

	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
24 Jun	54	1,193	81	1,973	0	56	21	971	3	51	75	2,650	7	104
25 Jun	63	1,256	79	2,052	0	56	27	998	8	59	62	2,712	6	110
26 Jun	56	1,312	59	2,111	0	56	44	1,042	4	63	45	2,757	6	116
27 Jun	39	1,351	54	2,165	0	56	30	1,072	3	66	38	2,795	5	121
28 Jun	43	1,394	24	2,189	0	56	14	1,086	2	68	27	2,822	2	123
29 Jun	30	1,424	38	2,227	0	56	48	1,134	7	75	47	2,869	6	129
30 Jun	27	1,451	27	2,254	0	56	37	1,171	8	83	63	2,932	13	142
1 Jul	19	1,470	29	2,283	0	56	27	1,198	6	89	33	2,965	7	149
2 Jul	20	1,490	16	2,299	0	56	37	1,235	2	91	32	2,997	6	155
3 Jul	21	1,511	15	2,314	0	56	33	1,268	3	94	18	3,015	1	156
4 Jul	7	1,518	9	2,323	0	56	29	1,297	2	96	50	3,065	14	170
5 Jul	4	1,522	24	2,347	0	56	13	1,310	1	97	45	3,110	9	179
6 Jul	0	1,522	11	2,358	0	56	1	1,311	0	97	33	3,143	1	180
7 Jul	0	1,522	7	2,365	0	56	2	1,313	0	97	32	3,175	4	184
8 Jul	1	1,523	6	2,371	0	56	1	1,314	0	97	23	3,198	3	187
9 Jul	1	1,524	7	2,378	0	56	3	1,317	0	97	19	3,217	5	192
10 Jul	4	1,528	18	2,396	0	56	10	1,327	0	97	52	3,269	7	199
11 Jul	9	1,537	8	2,404	0	56	4	1,331	0	97	37	3,306	4	203
12 Jul	5	1,542	0	2,404	0	56	12	1,343	1	98	34	3,340	4	207
13 Jul	11	1,553	0	2,404	0	56	4	1,347	1	99	47	3,387	3	210
14 Jul	9	1,562	0	2,404	0	56	4	1,351	0	99	14	3,401	2	212
15 Jul	1	1,563	0	2,404	0	56	3	1,354	1	100	18	3,419	7	219
16 Jul	0	1,563	0	2,404	0	56	0	1,354	0	100	15	3,434	1	220
17 Jul	3	1,566	0	2,404	0	56	18	1,372	2	102	18	3,452	0	220
18 Jul	0	1,566	0	2,404	0	56	12	1,384	2	104	50	3,502	2	222
19 Jul	2	1,568	0	2,404	0	56	13	1,397	2	106	48	3,550	6	228
20 Jul	2	1,570	0	2,404	0	56	23	1,420	9	115	40	3,590	3	231
21 Jul	2	1,572	0	2,404	0	56	14	1,434	3	118	19	3,609	3	234
22 Jul	1	1,573	0	2,404	0	56	4	1,438	0	118	21	3,630	3	237
23 Jul	2	1,575	0	2,404	0	56	3	1,441	1	119	20	3,650	7	244
24 Jul							7	1,448	2	121	13	3,663	2	246

Appendix A.3. Number of Chinook salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2006.

	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
25 Jul							5	1,453	0	121	7	3,670	0	246
26 Jul							2	1,455	0	121	8	3,678	1	247
27 Jul							8	1,463	0	121	7	3,685	1	248
28 Jul							3	1,466	0	121	7	3,692	2	250
29 Jul							2	1,468	1	122	3	3,695	0	250
30 Jul							1	1,469	0	122	6	3,701	0	250
31 Jul							1	1,470	0	122	7	3,708	0	250
1 Aug							1	1,471	0	122	6	3,714	0	250
2 Aug							1	1,472	0	122	7	3,721	2	252
3 Aug							2	1,474	0	122	7	3,728	2	254
4 Aug							4	1,478	0	122	2	3,730	0	254
5 Aug							1	1,479	0	122	1	3,731	0	254
6 Aug							1	1,480	0	122	5	3,736	1	255
7 Aug							0	1,480	0	122	1	3,737	0	255
8 Aug							4	1,484	0	122	1	3,738	0	255
9 Aug							1	1,485	0	122	0	3,738	0	255
10 Aug							0	1,485	0	122	1	3,739	0	255
11 Aug							0	1,485	0	122	0	3,739	0	255
12 Aug							0	1,485	0	122	0	3,739	0	255
13 Aug							0	1,485	0	122	0	3,739	0	255
14 Aug							0	1,485	0	122	0	3,739	0	255
Total	1,575		2,404		56		1,485		122		3,739		255	

PHOTO PLATES

Photo 1. Aerial view of the Baird Canyon cabin and two fishwheel assemblies covered in snow on 7 April 2006, a month before the crew arrived to begin mobilization.

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