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Estimating the inriver abundance of Copper River Chinook and sockeye salmon, 2007 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, and short-term monitoring of sockeye salmon *O. nerka* escapement on the Copper River. This report summarizes results from the 2007 field season, the seventh year since the project's inception. Objectives for 2007 were to: 1) estimate the inriver abundance of Chinook and sockeye salmon returning to the Copper River such that the estimates were within 25% of the true escapements 95% of the time; and 2) continue a long-term monitoring program operated by the Native Village of Eyak (NVE). For the first sample event, up to three live-capture fishwheels were operated at Baird Canyon for a total of 4,495 h from 18 May to 6 August. During this period, 4,456 adult Chinook salmon and 11,027 adult sockeye 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 3,717 h from 28 May to 19 August. A total of 4,192 Chinook salmon and 56,551 sockeye salmon were examined for marks. Of these, 459 Chinook salmon and 521 sockeye salmon 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 18 May to 6 August was 46,349 (SE = 3,283). Using a similar estimator, estimated abundance of sockeye salmon that migrated upstream of Baird Canyon from 18 May to 6 August was 1,290,591 (SE = 92,590). The median travel time of fish marked at Baird Canyon and recaptured at Canyon Creek (91 km upstream) was 12.2 d for Chinook and 9.5 d for sockeye salmon. Funding through the Fisheries Resource Monitoring Program (FRMP) for the Chinook and sockeye salmon mark-recapture studies has been approved through 2009. These highly successful and long-term monitoring programs have made 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 to the large subsistence harvest, this resource is heavily utilized by commercial, sport and personal use fisheries. The majority of Copper River salmon are harvested in an ocean commercial gillnet fishery from mid May through August in the Copper River District (in and around the mouth of the Copper River). In 2006, an estimated 1,462,451 sockeye salmon were harvested in the Copper River District, the fifth largest harvest on record (ADF&G 2007a). From 1996 to 2005, annual harvests in the Copper River District averaged 1,416,518 fish (Ashe et al. 2005; ADF&G 2007a). Personal use and subsistence fisheries occur from mid May through September between Haley Creek and the confluence of the Slana River. Rod-and-reel sport fisheries harvest Chinook and sockeye salmon in tributaries of the upper Copper River (mainly the Gulkana, Klutina, and Tonsina rivers).

Despite the value of these fisheries, Alaska Department of Fish and Game (ADF&G) managers have found it difficult to obtain annual estimates of Chinook salmon escapement to the drainage and largely focus management efforts on sockeye salmon. The ADF&G monitors salmon escapement to the Copper River primarily using acoustic methods which are incapable of species apportionment. 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 salmon stocks.

The 2005-2006 Federal Subsistence Fisheries Regulations (OSM 2005) identified two main areas in the Copper River drainage where subsistence fisheries for sockeye salmon 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 2005). 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 fyke nets and spears (in Tanada Creek only). The fishing season for both areas typically runs from mid May to the end of September. ADF&G manages the commercial fishery to achieve an inriver salmon escapement goal, which is monitored at the Miles Lake sonar site, that includes a sustainable escapement goal of 300,000 to 500,000 wild sockeye salmon; a goal of 17,500 other salmon species to account for Chinook and other salmon passing the site; annually determined allocations for inriver subsistence, personal use, and sport harvest based on recent harvest levels; and annually determined allocations for hatchery broodstock and surplus based on forecasted returns.

Management of Copper River sockeye 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. Recently, counted returns of sockeye salmon to several tributaries of the upper

Copper River basin (e.g., Gulkana Hatchery, Tanada Creek weir) have been lower than expected given the acoustic-based estimates of abundance obtained from the Miles Lake sonar site. Personal testimony by many upriver residents at 2005 Board of Fisheries hearings also indicated an overall failure of adequate viable spawners to reach headwaters. In 2001, the Native Village of Eyak (NVE) and various other groups expressed concerns over an apparent decline in salmon returns to tributaries of the upper Copper River (B. Cain, NVE, Cordova, pers. comm.). For example, the Gulkana Hatchery was not able to meet sockeye salmon brood requirements from Paxson Lake in 2000 and 2001, and hatchery staff observed low returns for seven Gulkana River stocks that they had worked with for over 20 years. Sockeye salmon counts at the Tanada Creek weir from 2001 to 2003 (range: 1,649-5,856) were also well below the counts in 1997 (27,521) and 1998 (28,992). In contrast, no declines in total inriver salmon returns were detected at the Miles Lake sonar site. Therefore, factors that contributed to declines of sockeye salmon in upper river tributaries were likely occurring above the Miles Lake sonar site.

ADF&G uses a combination of fishery performance statistics and estimates of sockeye entering the river to make decisions on whether and for how long to open the weekly fishery. Past attempts to assess and enumerate Copper River sockeye salmon have been met with limited success. From 1960-1964, 9,143 salmon (mostly sockeye) were tagged in the Copper River District and recovered in commercial and subsistence fisheries and on the spawning grounds; however, no results from these studies could be found (ADF&G 1962; Willette 2000). From 1966-1968, fishwheels were used to capture and tag sockeye salmon downstream of Wood Canyon as part of a mark-recapture study (Larson 1967; Larson and Fridgen 1968; Greenough 1971); and abundance estimates were generated for each of these three years. Other tagging studies were conducted in the early 1970s but did not generate abundance estimates (Fridgen and Roberson 1971; Roberson and Fridgen 1972; Roberson 1974; Roberson and Fridgen 1974). From 1969-1972, prior to establishing the Miles Lake sonar site, acoustic systems were operated at three different sites (Wood Canyon, Klutina River, Gulkana River) in the Copper River drainage in an attempt to assess sockeye salmon abundance (Roberson and Fridgen 1974). After 1974, sockeye enumeration efforts shifted from mark-recapture studies to weirs and aerial surveys (Willette 2000). Estimates of fish escaping the commercial fishery have been made using sonar counts at a site near the outlet of Miles Lake. In addition, a test fishing project at Flag Point Channel in the lower Copper River has been used to index salmon abundance from 2001-2006 (Link et al. 2001a; Lambert et al. 2003; Degan et al. 2004; Mueller and Degan 2005; Degan et al. 2006; van den Broek and Degan 2007). The information provided from this project was taken into consideration by fishery managers who make decisions regarding commercial openings.

Several concerns have been raised by stakeholder groups with respect to the acoustic counts generated by ADF&G at Miles Lake. First, only the near-shore areas are ensonified with the acoustic system, so any fish migrating offshore and outside of the ensonified area would not be counted. Second, the sonar system is not species-specific, and thus can not distinguish between co-mingled sockeye, Chinook and coho salmon *O. kisutch*. As a result, the sonar counts provide an index of overall salmon abundance. Third, the management system and management plans for Copper River sockeye salmon were established using a Bendix sonar (used since 1978); however, ADF&G has recently upgraded the south-bank site at Miles Lake with a newer and much different acoustic system (DIDSON, or dual-frequency identification sonar). And lastly,

estimates from the DIDSON system (or the older Bendix system) have never been independently validated on the Copper River by such means as a mark-recapture study.

Several studies have been conducted on the Copper River and elsewhere that relate to these stakeholder concerns. In 2003 and 2004, ADF&G collected paired counts for the Bendix and DIDSON systems along the south bank of the Copper River at Miles Lake and found that the estimates from the two systems were not significantly different in either year (S. Maxwell, ADF&G, pers. comm.). Studies on other river systems have shown comparable counts from Bendix and DIDSON systems (Maxwell and Gove 2004, 2007; Holmes et al. 2006). Field tests conducted by ADF&G on the Copper River at Miles Lake have also shown that fish counts drop to zero well within the end range of either acoustic system. In addition, cross-river surveys using a mobile DIDSON system found no evidence of fish migrating upstream in the middle of the Copper River (and outside the range of the shore-based systems; S. Maxwell, pers. comm.).

From 1999-2004, ADF&G conducted radiotelemetry studies to derive the first system-wide estimates of Chinook salmon escapement to the Copper River (Evenson and Wuttig 2000; Wuttig and Evenson 2001; Savereide and Evenson 2002). 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.

The use of 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 2006 have shown that these methods are also suitable for use on the Copper River (Link et al. 2001b; Smith et al. 2003; Smith 2004; Smith et al. 2005; Smith and van den Broek 2005, 2006; Smith et al. 2007).

The Chinook salmon abundance estimates are part of a continuing long-term monitoring program initiated in 2001. The sockeye salmon abundance estimates are intended to be a short-term 2-3 year snapshot used to compare a statistically defensible species apportioned estimate to salmon counts provided by the Miles Lake sonar site. It is important to note that this project is not intended to replace or become redundant with the existing Miles Lake sonar site. Instead, the project will provide fishery managers with additional information that can be used to better manage the fishery and ensure that an adequate number of fish make it upriver for subsistence harvests and spawning requirements. In addition, abundance estimates from this study may be used to generate more reliable run timing and distribution information for a concurrent radiotelemetry study (FIS05-501).

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 2005). Specifically, this project will "estimate or index abundance of total run

by species." This project was also integrated with another ongoing FRMP project: FIS05-501 – Spawning distribution and run timing 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

Specific objectives for this study were:

1. To estimate the inriver abundance of sockeye salmon returning to the Copper River in 2007 such that the estimate is within 25% of the true value 95% of the time; and
2. To continue a long-term monitoring program operated by the Native Village of Eyak, estimating the annual, system-wide escapement of Chinook salmon to the Copper River using mark-recapture techniques such that the estimate is 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 (1,970 ft) above the river. The west bank slopes more moderately to a maximum height of 20 m above the river, is densely wooded, and has a substrate ranging from sand to boulders. The land beyond the west bank is primarily a wetland area that drains the Allen Glacier to the west. The north branch of the Allen River enters on the west bank and is the only major tributary entering Baird Canyon.

Wood Canyon is the second major channel constriction on the Copper River upstream of Miles Lake and is located approximately 91 km upstream of Baird Canyon (Figure 3). The lower end of Wood Canyon, below the mouth of Canyon Creek and the lower boundary of the Chitina

Subdistrict dip net fishery, was 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). 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, 961,712 in 2006, and 926,438 in 2007 (ADF&G 2007b).

In 2007, an estimated 38,342 Chinook and 1,878,442 sockeye salmon were harvested in the Copper River District PWS commercial drift gillnet fishery; 2,448 Chinook and 115,669 sockeye salmon were harvested in the Chitina Subdistrict Personal Use fishery (preliminary based on 54% permit return); and 3,660 Chinook and 69,890 sockeye salmon were harvested in the Glennallen Subdistrict (preliminary based on 55% permit return)(Somerville 2007). 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. Ten full-time technicians and one part-time field logistics coordinator were hired, including one returning technician from 2006, one Alaska Native, and three rural Alaska 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 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) 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 2007. 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, wooden shower stall and individual 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 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 by an array of 6-V batteries (wired to provide 12-V power) at Baird Canyon and 12-V batteries at Canyon Creek. These arrays were charged by a combination of solar panels, wind turbines and a gas-powered generator (for backup only). Each morning at a pre-arranged time, the 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. 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 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 2007 were installed and operated similar to the methods used in previous years (Link et al. 2001b; Smith et al. 2003; Smith 2004; Smith and van den Broek 2005, 2006; Smith et al. 2007). 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. Opening or closing of escapement panels was used to regulate capture of sockeye or smaller sized Chinook salmon, limiting fish retention to only those times when they were required for sampling to avoid overcrowding of the live tanks. 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 150 per day) with a 134.2 kHz, passive RFID transponder (ENSID Technologies, Inc, Auckland, New Zealand). The transponder was encapsulated on a t-bar style tag with two, 25 mm monofilament lines that terminated in perpendicular 9 mm anchor bars (herein referred to as a TBA-PIT tag). 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 the passive transponder (Photo 1). The TBA-PIT tags were a new technology specially designed and constructed for these projects. Tags were supplied in magazine clips of 20 tags each, and were applied to fish using a hand held applicator gun with 16 gauge needle (Avery Dennison; Photo 2). 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 acted as a secondary mark for quantification of primary tag loss, if any.

A portion of sockeye salmon captured each day received a gastrically implanted radio transmitter and a uniquely numbered, external t-bar tag as part of a separate study (Wade et al. 2008). Radio-tagged sockeye salmon were included in the marked sample for estimating abundance. The remaining sockeye salmon, up to a maximum of 1.2% of the previous day's Miles Lake sonar count, received the same TBA-PIT tag applied to Chinook salmon, but did not receive a secondary mark.

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 racket-style RFID antenna 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 and sockeye 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).

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.

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 tables and Chi-square tests were used to compare mark and recapture rates by bank of capture in 2007 for Chinook and sockeye salmon.

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

A temporally stratified Darroch estimator was used to estimate abundance for Chinook and sockeye salmon above Baird Canyon. The computer program SPAS (Arnason et al. 1996) was used to calculate the estimates and their standard errors. Initially, data were pooled into strata based on where major breaks occurred in the daily mark and recapture rates over the season. Chi-square tests were then used to compare mark and recapture rates of adjacent strata; and homogeneous strata were pooled. If SPAS failed to generate an estimate using the strata produced by this process, then one or more heterogeneous strata would be pooled. If necessary, different combinations would be compared in SPAS to determine how sensitive the abundance estimate was to strata poolings.

RESULTS

Project Mobilization

Mobilization of the Baird Canyon camp began on 7 May (Photo 3). Five technicians, one project manager, one project consultant, one Starband installation technician, and gear were flown to camp on 12 round trip flights with a Robinson 44 helicopter (Alpine Air). 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 3-m deep upon arrival. Equipment had incurred some damage over the winter as a result of a 100-year flooding event in October 2006. The flood had moved the tethered fishwheels 10 m north of the original storage location and out of line with the river, so in addition to removing snow from the fishwheels, a wide channel had to be cleared in the snow so that the fishwheels could be turned sideways prior to being winched down to the river. Additionally, the plywood slides for the baskets, which had been stored on the ground between the fishwheel pontoons, had been crushed by the moving fishwheels. Minor repairs to the cabin were also necessary and some camp supplies were lost in the flood. Fishwheel 1 began fishing at Baird Canyon on 18 May, followed by fishwheels 2 and 5 on 21 May.

Mobilization of the Canyon Creek fishwheels began on 17 May. Equipment, boats, and vehicles were moved from storage locations in Cordova, Glennallen, and Gakona to the camp site using trucks and jet boats. Fishwheels 3 and 4 required substantial repairs. Due to regular wear-and-tear during the previous two seasons, the baskets on fishwheel 3 had to be repaired and re-

webbed. Fishwheel 4 required a new starboard axle brace. The plywood slides in the baskets of fishwheel 4 had to be modified so that fish would drop into both live tanks (the slides were modified in 2006 to direct all fish into the port tank). Fishwheel 3 began fishing on 24 May followed by fishwheel 4 on 28 May.

Fishwheel Operation and Catch

Fishwheel Operation

Stage height of the Copper River at Baird Canyon varied by 5.3 m from 19 May to 6 August (Figure 4). At Canyon Creek, stage height varied by 3.2 m from 29 May to 19 August. Water levels rose slowly and steadily through the duration of the season without any dramatic peaks or troughs. Stage height peaked on 23 July at both sites. In 2007, stage height of the Copper River at the Million Dollar Bridge tracked the average stage height from 1982 to 2006 quite closely for the entire season (Figure 5).

Fishwheel 1 operated on the west bank of Baird Canyon for 1,148 h (81.5% of the time) from 18 May to 16 July (Figure 6; Appendix A). Fishwheel 2 operated on the east bank of Baird Canyon for 1,522 h (98.6% of the time) from 21 May to 24 July. Fishwheel 5 operated on the west bank of the Copper River approximately 1.5 km upstream from Baird Canyon for 1,825 h (99.6% of the time) from 21 May to 6 August. Fishwheel speeds averaged 2.3, 1.9, and 3.1 RPM for fishwheels 1, 2, and 5, respectively (Figure 6; Appendix A).

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 28 May to 10 August, it operated for 1,776 h (99.7% of the time; Figure 6; Appendix A). Fishwheel 4 operated on the west bank approximately 1.5 km downstream from the mouth of Canyon Creek, and fished for 1,941 h (98.6% of the time) from 29 May to 19 August. Fishwheel speeds averaged 1.4 and 3.9 RPM for fishwheels 3 and 4 (Figure 6; Appendix A).

Fishwheel Catch

A total of 5,294 adult Chinook salmon were captured at the Baird Canyon fishwheels: 2,870 at fishwheel 1, 1,938 at fishwheel 2, and 486 at fishwheel 5 (Figure 7; Appendix B). Total daily catch peaked at 283 Chinook salmon on 1 June. Daily CPUE peaked at 21.6, 4.5, and 1.6 Chinook salmon per hour for fishwheels 1, 2, and 5, respectively (Figure 8; Appendix B). Twenty-five coho salmon, 1 pink salmon *O. gorbuscha*, 2 steelhead trout *O. mykiss*, 151 Dolly Varden *Salvelinus malma*, 16 whitefish *Coregonus spp.*, 17 Pacific lamprey *Lampetra tridentata*, and 8 sucker *Catostomus sp.* were also captured and released.

A total of 4,778 Chinook salmon were captured at the Canyon Creek fishwheels, including 3,379 at fishwheel 3 and 1,398 at fishwheel 4 (Figure 9; Appendix B). Daily catch peaked at 205 Chinook salmon on 28 June. Daily CPUE peaked at 7.1 and 4.6 Chinook salmon per hour at fishwheels 3 and 4 (Figure 10; Appendix B). Four coho salmon, 1 steelhead trout, 20 Dolly Varden, 6 whitefish, 3 Pacific lamprey, 7 sucker, and 1 arctic grayling *Thymallus arcticus* were also captured and released.

A total of 19,888 adult sockeye salmon were captured at the Baird Canyon fishwheels: 402 at fishwheel 1, 7,424 at fishwheel 2, and 12,062 at fishwheel 5 (Figure 11; Appendix C). Total daily catch peaked at 692 sockeye salmon on 31 May. These catch data do not reflect the total number of sockeye salmon actually caught by the fishwheels, but only those that were retained in live tanks when the escape panels were closed. Fish found in the live tanks during periods when escape panels were open were not counted. Daily CPUE peaked at 24.1 (7 June) and 21.5 (6 June) sockeye salmon per hour in the starboard live tanks of fishwheels 2 and 5, respectively (Figure 12; Appendix C).

A total of 56,636 sockeye salmon were captured at the Canyon Creek fishwheels, including 25,622 at fishwheel 3 and 31,014 at fishwheel 4 (Figure 13; Appendix C). Daily catch peaked at 1,949 sockeye salmon on 17 June. Similar to Baird Canyon, these catch data reflect only sockeye salmon captured and retained during periods when escape panels were closed. Catch per unit effort for sockeye salmon was not calculated for the Canyon Creek fishwheels.

Tag Application and Recovery

Of the 5,294 Chinook salmon that were captured at the Baird Canyon fishwheels, 4,456 fish (84.2%) were tagged and released (Figure 14; Appendix C). The number of tags applied on a single day peaked at 159 fish on 31 May. A total of 838 Chinook salmon were not tagged, including: 505 fish released voluntarily because the daily quota had been reached, 206 fish that escaped prior to being sampled, 91 fish that were visibly injured or stressed, 19 fish that measured less than 500 mm FL, and 17 mortalities.

A total of 4,192 Chinook salmon were examined for primary and secondary marks at the Canyon Creek fishwheels (Figure 15; Appendix D). Of those examined, 459 (10.9%) were recaptures, or fish that had been tagged at Baird Canyon. The first two tagged fish were captured at Canyon Creek on 1 June (one tagged on 26 May and two tagged on 28 May) and the last tagged fish was captured on 3 August (tagged on 12 June). The number of Chinook salmon examined for marks at Canyon Creek peaked at 179 fish on 4 June and the number of recaptures peaked at 27 fish on 27 and 28 June. The median travel time of Chinook salmon tagged at Baird Canyon and recaptured at Canyon Creek was 12.2 d (range: 3.6-56.7 d; Figure 16).

Of the 19,888 sockeye salmon that were captured at the Baird Canyon fishwheels, 11,027 fish (55.4%) were tagged and released (Figure 17; Appendix E). This included 553 radio-tagged fish and 10,474 TBA-PIT-tagged fish. Apart from a few days early and late in the season when catches were low, 1.0-1.2% of the previous day's counts at Miles Lake were tagged at Baird Canyon (Figure 17). The number of tags applied on a single day peaked at 438 on 3 June. The majority of sockeye salmon that were released untagged were done so because the daily tagging quota had been met.

A total of 56,551 sockeye salmon were examined for primary and secondary marks at the Canyon Creek fishwheels (Figure 18; Appendix E). Of those examined, 521 (0.9%) were recaptures, or fish that had been marked at Baird Canyon. The first recaptures at Canyon Creek were on 30 May (one tagged on 24 May and one on an unknown date) while the last recapture was on 19 August (tagged on 28 July). The number of sockeye examined for marks at Canyon Creek peaked at 1,942 fish on 7 June and the number of recaptures peaked at 19 fish on 4 June.

The median travel time of sockeye salmon tagged at Baird Canyon and recaptured at Canyon Creek was 9.5 d (range: 3.6-30.6 d; Figure 19).

Inriver Abundance Estimate

Conditions for a Consistent Estimator

Chinook Salmon: Handling and tagging procedures at Baird Canyon did not appear to significantly delay the migratory behavior of Chinook salmon. Of the 286 Chinook salmon captured twice at the Baird Canyon fishwheels, 155 fish (54.2%) were recaptured within 1 d of being tagged. The longest delay between captures was 32.8 d (Figure 20). It was assumed that these migratory delays had a negligible affect on the abundance estimate. No Chinook salmon were captured at Canyon Creek with an operculum punch and no TBA-PIT tag, so it was assumed that no fish shed their primary mark between sampling events.

Tagged Chinook salmon appeared to move equally between banks. Recapture rates of Chinook salmon that were tagged on the west bank (9.6%) of the river at Baird Canyon were not significantly different than recapture rates of fish tagged on the east bank (11.2%; $\chi^2 = 2.96$, df = 1, P = 0.085; Table 1). A second test to assess the proportionality of movement across the river using Chinook salmon recaptures by bank of release and bank of recovery showed no significant difference ($\chi^2 = 0.01$, df = 1, P = 0.928; Table 2). Failure to reject these tests was justification for not stratifying by bank of capture. In contrast, mark rates of Chinook salmon inspected on the east bank (12.9%) at Canyon Creek were significantly higher than mark rates of fish inspected on the west bank (7.6%; $\chi^2 = 28.0$, df = 1, P = 0.000; Table 3).

Cumulative length-frequency distributions of Chinook salmon marked in the first event and fish recaptured in the second event were significantly different ($D_{max} = 0.102$, P = 0.000; Figure 21). Similarly, cumulative length-frequency distributions of fish marked in the first event and fish examined for marks in the second event were significantly different ($D_{max} = 0.062$, P = 0.000). No significant difference ($D_{max} = 0.040$, P = 0.527) 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 the first event but there was during the second 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 4). 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 ($\chi^2 = 174.7$, df = 4, P = 0.000) and varied from 0.043 to 0.288. Similarly, recapture rates were significantly different over the study period ($\chi^2 = 71.3$, df = 5, P = 0.000) and ranged from 0.048 to 0.156. These results indicated that a temporally stratified estimator was required to estimate abundance.

Sockeye Salmon: Of the 161 sockeye salmon captured twice at the Baird Canyon fishwheels, 136 fish (84.5%) were recaptured within 1 d of being tagged (Figure 22). The longest delay between capture events was 5.1 d. Similar to Chinook salmon, sockeye salmon appeared to move equally between banks. Recapture rates of sockeye salmon that were tagged on the west bank (4.5%) of the river at Baird Canyon were not significantly different than recapture rates of fish tagged on the east bank (4.3%; $\chi^2 = 0.34$, df = 1, P = 0.561; Table 5). A second test to assess

equal movement across the river using sockeye salmon recaptures by bank of release and bank of recovery showed no significant difference ($\chi^2 = 0.43$, df = 1, P = 0.511; Table 6). Mark rates of sockeye salmon inspected on the east bank (1.0%) at Canyon Creek were significantly higher than mark rates of fish inspected on the west bank (0.8%; $\chi^2 = 6.76$, df = 1, P = 0.009; Table 7).

Cumulative length-frequency distributions of sockeye salmon marked in the first event and fish recaptured in the second event were significantly different ($D_{max} = 0.072$, P = 0.023; Figure 23). Similarly, cumulative length-frequency distributions of fish marked in the first event and fish examined for marks in the second event were significantly different ($D_{max} = 0.088$, P = 0.000). No significant difference ($D_{max} = 0.047$, P = 0.298) was found between cumulative length-frequency distributions of fish examined and recaptured in the second event. Thus, no size selectivity was detected during the first event but there was size selectivity during the second event, and no stratification by size was necessary to estimate abundance.

The probability of a fish being marked at Baird Canyon was not independent of time of capture. Period-specific mark rates were significantly different over the study period ($\chi^2 = 35.0$, df = 5, P = 0.000) and varied from 0.007 to 0.016 (Table 8). Similarly, recapture rates varied significantly ($\chi^2 = 41.2$, df = 4, P = 0.000) and ranged from 0.016 to 0.059. 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 18 May to 6 August was 46,349 (SE = 3,283; 95% CI = 39,914 - 52,784; Table 9). This estimate was based on 4,456 tagged fish available for recapture, 4,192 fish examined for marks, and 459 recaptures.

Using the same estimator, estimated abundance of sockeye salmon that migrated upstream of Baird Canyon from 18 May to 6 August was 1,290,591 (SE = 92,590; 95% CI = 1,109,115 - 1,472,067). This estimate was based on 11,027 tagged fish available for recapture, 56,557 fish examined for marks, and 521 recaptures.

Other Tag Recoveries

Reported Inriver Harvests

A total of 309 Chinook salmon (6.9% of total tagged), 1,012 sockeye salmon (9.2% of total tagged), and 12 fish with unrecognized tag numbers (i.e., the tag number was not recorded at Baird Canyon) were reported harvested by the various Copper River fisheries (Table 10). Nearly twice as many radio-tagged sockeye salmon (15.7%) were reported harvested compared to PIT-tagged sockeye salmon (8.8%). Recoveries included: 43 Chinook and 61 sockeye in the sport fishery, 134 Chinook and 367 sockeye in the combined federal and state subsistence (primarily fishwheel) fisheries, 115 Chinook and 524 sockeye in the personal use dip net fishery, 4 Chinook and 2 sockeye in the Prince William Sound commercial drift gillnet fishery, 1 Chinook which was found dead on the spawning grounds, 12 Chinook and 57 sockeye where the specific fishery was not reported, and 1 sockeye captured by beach seine by ADF&G research biologists near Clear Creek on the lower Copper River.

Mark rates of sockeye salmon inspected at two spawning areas were lower than those observed at the Canyon Creek fishwheels. Of the 7,728 sockeye salmon examined for marks at the Long Lake weir in 2007, 64 (0.8%) fish were marked (Figure 24). During broodstock collection in the Gulkana River drainage, hatchery personnel inspected 21,682 sockeye salmon for marks of which 133 (0.6%) fish were marked (Figure 25).

DISCUSSION

Project Mobilization

In 2007, river ice and snow cover in early May delayed the deployment of the Baird Canyon fishwheels. It took approximately 16 d from the time the crew arrived at camp (7 May) until the successful deployment of all three fishwheels (22 May). This was considerably longer than in 2005 (9 d), and similar to the time it took to mobilize in 2004 (21 d) and 2006 (18 d) when similar environmental conditions were encountered. The complete break-up of river ice happened on 17 May, and the first fishwheel was launched and began fishing by the next day. Successful mobilization in 2007 was attributed to several factors, including:

(1) Efficient organization and equipment storage during demobilization in 2006;
(2) There was significant damage to fishwheel baskets and equipment over the winter as a result of October 2006 floods, but all damage was documented prior to first snow, and crews were well prepared with manpower and materials to excavate damaged equipment and facilitate rapid repairs;
(3) A large and 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 previous years, the Canyon Creek fishwheels were stored intact at the camp site. Major repairs and modifications to both wheels were required prior to sampling. Additionally, some bank erosion to the fishwheel launching bank steepened the initial drop from the storage location to the river bank, and created a shallow sandbar for approximately 10 m extending from the waters edge into the river. Both of these factors dramatically increased the time required to mobilize and launch the fishwheels. Between repairs, modifications, and logistics of preparing the fishwheels and establishment of the camp, it took approximately 19 d from the first day of mobilization on 16 May until both wheels were actively fishing on 29 May. 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.

Fishwheel Operation and Catch

Catches of Chinook salmon at the Baird Canyon fishwheels have increased each year since the project's inception. These increases were largely attributable to increases in fishing effort, experience using existing fishwheel sites, and the ability to effectively operate fishwheels during a wide range of water levels. The number of Chinook salmon marked was 10% greater in 2007 (4,456 fish) than in 2006 (4,035 fish). As in 2006, the increase in 2007 catches was primarily due to the unusually late timing of the start of the Chinook salmon run, which led to a closure of the commercial fishery by EO during the second week of the season. Historically low catches were observed during the first week of the season. This closure resulted in a larger than usual pulse of fish entering the river. Record salmon counts up to five times greater than usual were also observed at the Miles Lake sonar site following this period. Ideal climatic and water-level conditions throughout most of the run also contributed to increased catches.

At Canyon Creek, Chinook salmon catches in 2007 (4,191 fish) were 20% lower than in 2006 (5,224 fish). This reduction in catches was mainly attributable to difficulties in finding a suitable fishing site for fishwheel 4. Due to the October 2006 flood, depth and velocity conditions at the site used in previous years made it unsuitable. Much of the season was spent with fishwheel 4 propped very far out from the bank in order to reach deeper water and swifter current, and with the baskets not lowered fully. Regardless of these problems, a sufficient number of Chinook and sockeye salmon were captured during each sampling event for the purposes of this study.

Tag Application and Recovery

The 2006 season provided a learning experience for project managers in what would be needed to effectively mark and examine the quantity of sockeye salmon required to enumerate an estimated run of one million fish. Initial trials using traditional spaghetti tags failed because of the amount of fish handling and crew labor required to apply tags, high percentage of data entry errors from manually entering tag numbers, and inability to automate the methodology due to difficulties identifying tagged fish or distinguishing tag colors on video screens. Later trials using glass-encapsulated PIT tags that were injected into the body cavity also failed for a variety of reasons, including: the high proportion of fish visibly injured, an inability to quantify tag loss, unreliable recovery rates from automated readers, loss and mixing up of tags in the field due to their small size, data entry errors, and other technical difficulties with the recovery system.

The single greatest factor in determining the success of the 2007 season, particularly the sockeye component, was the development of a new tagging technology. Fish were able to be tagged rapidly with minimal handling, data could be entered automatically with little risk of error, and the recovery effort was simplified because tagged fish could be easily spotted in the dip net and thus not all fish had to be transferred to a sampling trough for inspection. Minor technical difficulties arose with the PDA's and PIT-tag scanners, which were typically caused from exposure to water or from software and hardware issues on the camp computers. These problems can be reduced or eliminated in the future by upgrading some of the electronic equipment.

Abundance Estimate

Abundance estimates for Chinook (46,349; CV = 7.1%) and sockeye salmon (1,290,591; CV = 7.2%) in 2007 appeared unbiased and exceeded the precision levels specified in the study objectives. Given the high catch rates observed for both species 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. This was particularly challenging because of the use of escape panels which precluded accurately counting daily catch at the fishwheels. For sockeye salmon, the subsampling strategy of tagging 1.0-1.2% of the previous day's Miles Lake sonar counts appeared to work well (Figure 17). The fishwheel crew knew their daily tagging quota ahead of time and was able to evenly distribute tags across different sampling sessions, fishwheels, and live tanks. This strategy also reduced the amount of time the escape panels were closed and thus reduced the risk of overcrowding in the live tanks. Relatively minor adjustments were made in season to account for uncertainties in forecasted run strength and the removal of one of the tagging fishwheels part way through the season. Miles Lake sonar counts were the only measure of salmon abundance available in season to base the tagging effort at Baird Canyon.

The sockeye salmon mark-recapture estimate was 39% (364,153 fish) greater than the 2007 Miles Lake sonar count of 926,438 salmon. If the estimated number of Chinook salmon that migrated above Baird Canyon (46,349) was subtracted from the Miles Lake sonar count, then the sockeye salmon mark-recapture estimate was 47% greater than the sonar count. A large proportion of the difference between the mark-recapture estimate and Miles Lake count was attributed to the first week of June when high abundances of sockeye salmon were passing through the study area. Recapture rates were relatively low for fish tagged at Baird Canyon from 2-5 June (0.009-0.028) and mark rates were also relatively low for fish examined at Canyon Creek from 5-18 June (0.004-0.013). As a result, 27% (349,084 fish) of the mark-recapture estimate was derived from fish tagged in the 2-5 June tagging stratum. In comparison, only 14% (127,888 fish) of the total Miles Lake sonar count occurred from 1-4 June (which assumes a 1-d travel time between the sonar site and Baird Canyon).

The number of tagged fish available for recovery at Canyon Creek was not adjusted to account for potential handling or tag-induced mortality. Results from the 2007 radiotelemetry study showed that 5.1% (28 out of 553) of radio-tagged sockeye salmon released were either never detected after release (11 fish) or failed to migrate upstream of the tagging site (17 fish). If a similar "drop-out" rate was assumed for TBA-PIT tagged fish and the total number of tagged fish available for recovery was adjusted accordingly, then the mark-recapture abundance estimate decreased to 1,226,061 fish. It is unlikely that the drop-out rate for TBA-PIT tagged fish was as high as that for radio-tagged fish because the latter are more insulted during sampling and would have a higher probability of handling and tag-induced mortality.

The spawning escapement goal set by the Board of Fisheries for salmon on the Copper River is 24,000 or more Chinook and 300,000-500,000 sockeye salmon. If we subtract from our abundance estimate (46,349) the number of Chinook salmon harvested in the Chitina and Glennallen subdistricts (preliminary estimate is 6,108 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 2007 spawning escapement is estimated to be around 35,000 Chinook salmon. If we subtract from our abundance estimate (1,290,591) the number of sockeye salmon harvested in the inriver fisheries (preliminary estimate 115,669 fish), and assume that the number of sockeye salmon harvested in the sport fishery was similar to the 2001-2005 average (7,527 fish; Hollowell 2007), then the 2007 spawning escapement was estimated to be 1,275,537 fish.

CONCLUSIONS

This year (2007) was the first year of a new funding cycle (FY07-09) which combined the long-term Chinook salmon escapement monitoring program with a new study to estimate sockeye salmon escapement abundance. Funding has been approved to continue the sockeye escapement study in 2008 and 2009 through a different program (FIS 08-501). 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 2008 field season:

(1) Purchase more robust and weatherproof sampling equipment, particularly hand-held PDA's. Preferably, the PDA's would have integrated 134.2 kHz RFID scanners or include more robust external scanners with wireless connectivity or fewer connectors and cables. Reducing the number of electrical connections and power requirements on the fishwheels will improve data quality and reduce the amount of down time;
(2) Refine the demobilization procedures that have been developed since the project's inception, particularly in light of the damage incurred during the flooding event in October 2006. For example, an additional anchor point should be added at the streamside of the fishwheels to prevent lateral movement in the event of a flood. Loose equipment should also be secured.
(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, 3, and 5 at the same sites used in 2007. Fishwheel 4 at Canyon Creek should be relocated to a more suitable site if bank conditions have not improved over the winter; and

(5) Continue to use the escape panels in each fishwheel with the openings set to a width of 6.0 cm except when closed to sample sockeye salmon.

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FIGURES

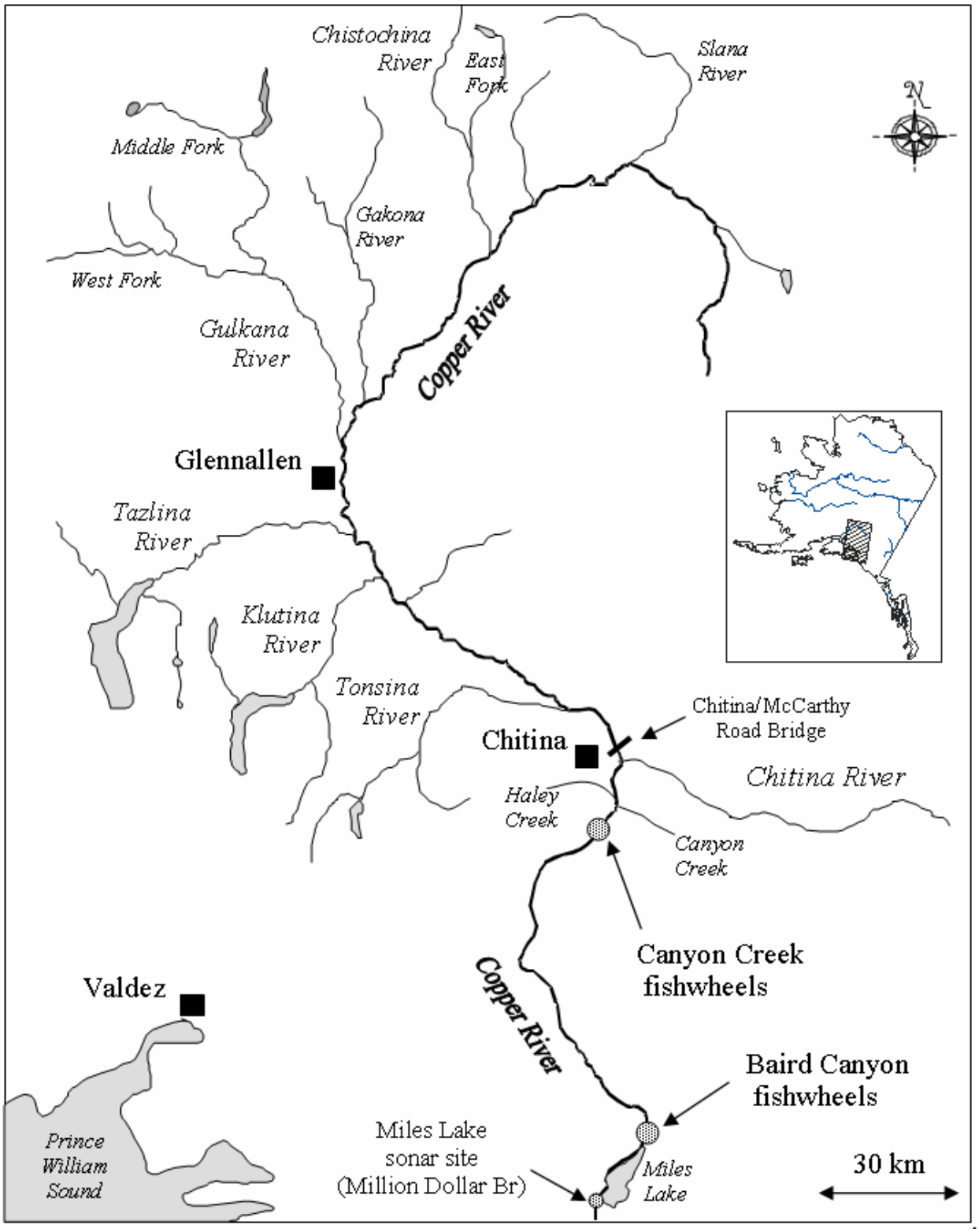

Figure 1. Map of the study area showing the location of the Baird Canyon and Canyon Creek fishwheels on the Copper River in Alaska, 2007.

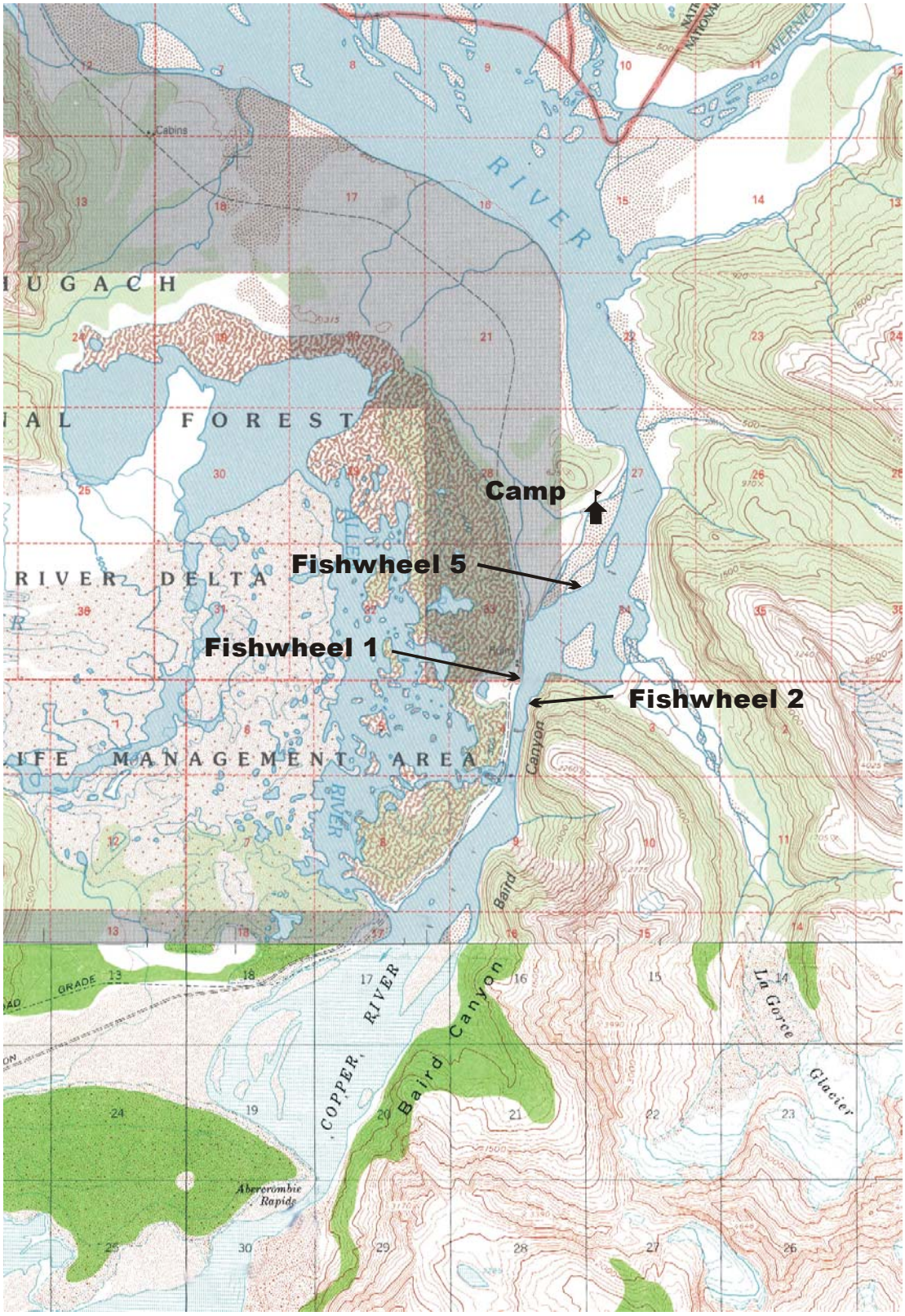

Figure 2. Map of Baird Canyon on the Copper River showing the location of the camp and fishwheel sites that were used in 2007.

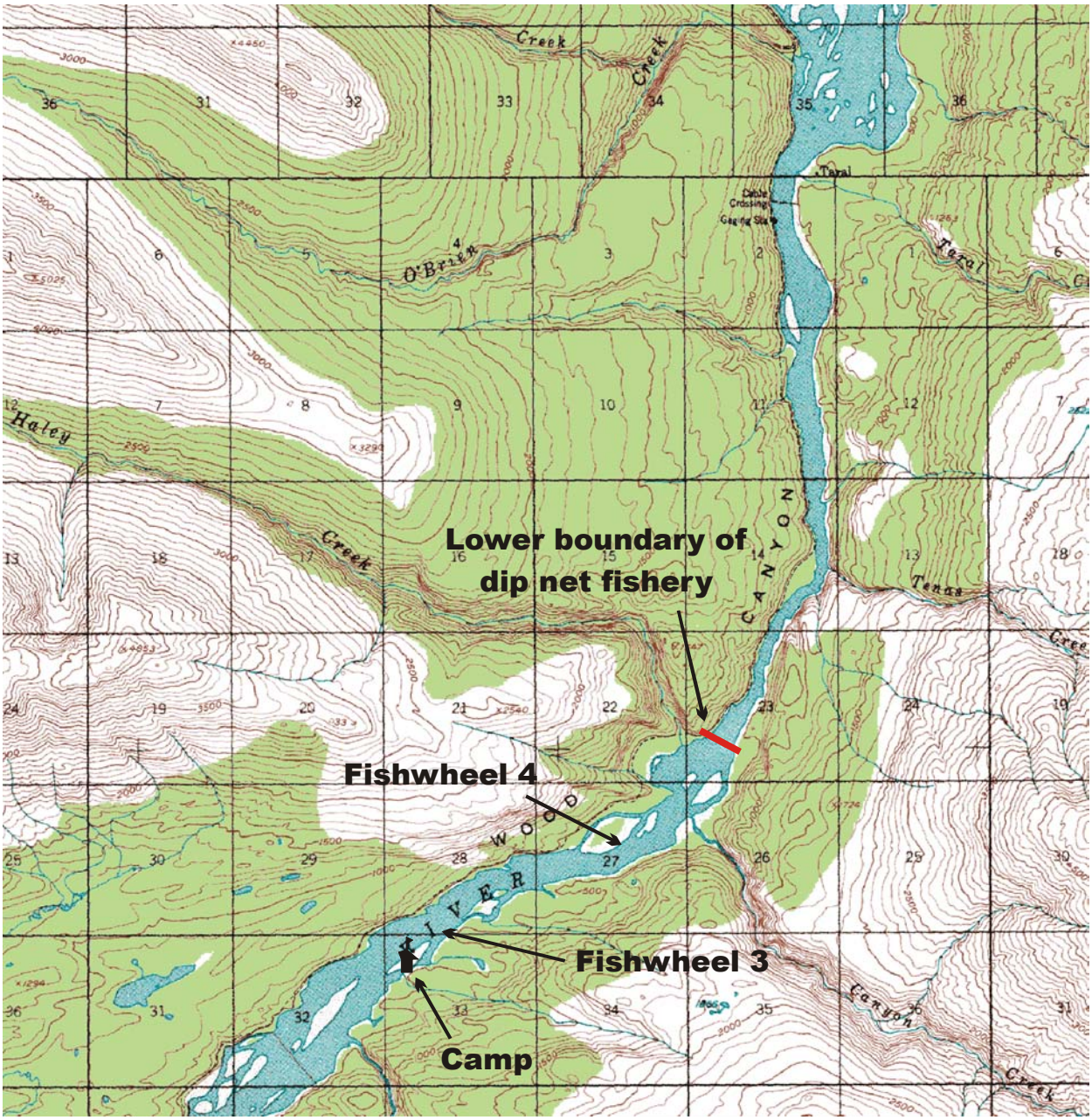

Figure 3. Map of Wood Canyon on the Copper River showing the location of the camp, fishwheel sites that were used in 2007, and the lower boundary of the Chitina Subdistrict dip net fishery.

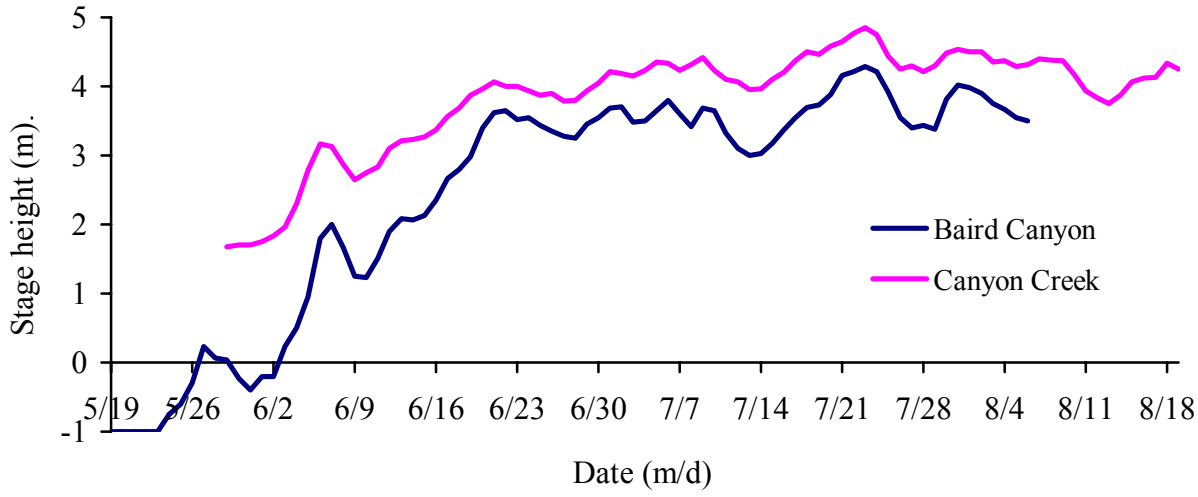

Figure 4. Stage height of the Copper River near the Baird Canyon and Canyon Creek fishwheels, 19 May to 19 August 2007.

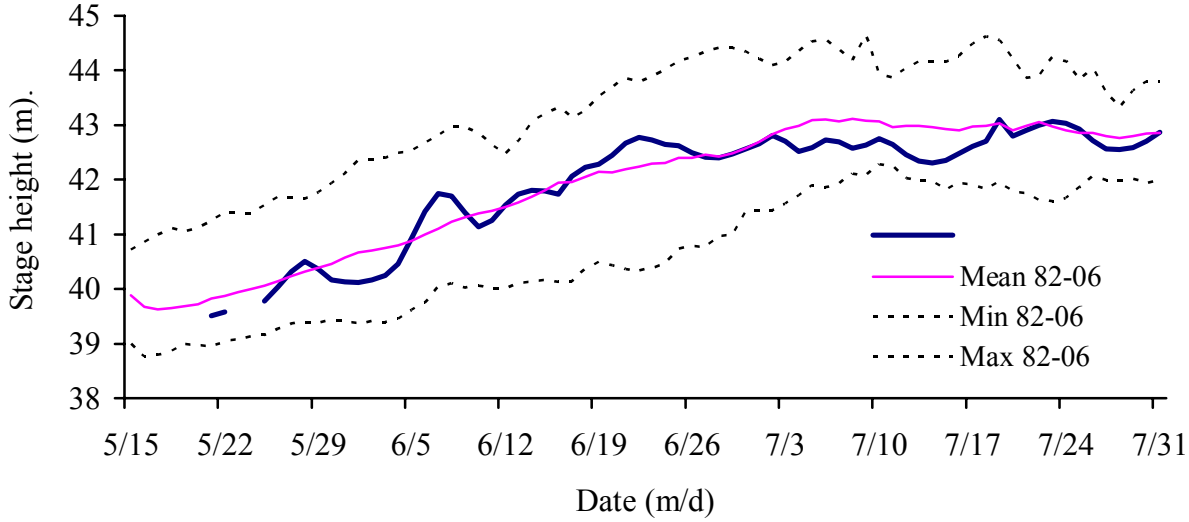

Figure 5. Stage height of the Copper River at the Million Dollar Bridge, 1982-2007.

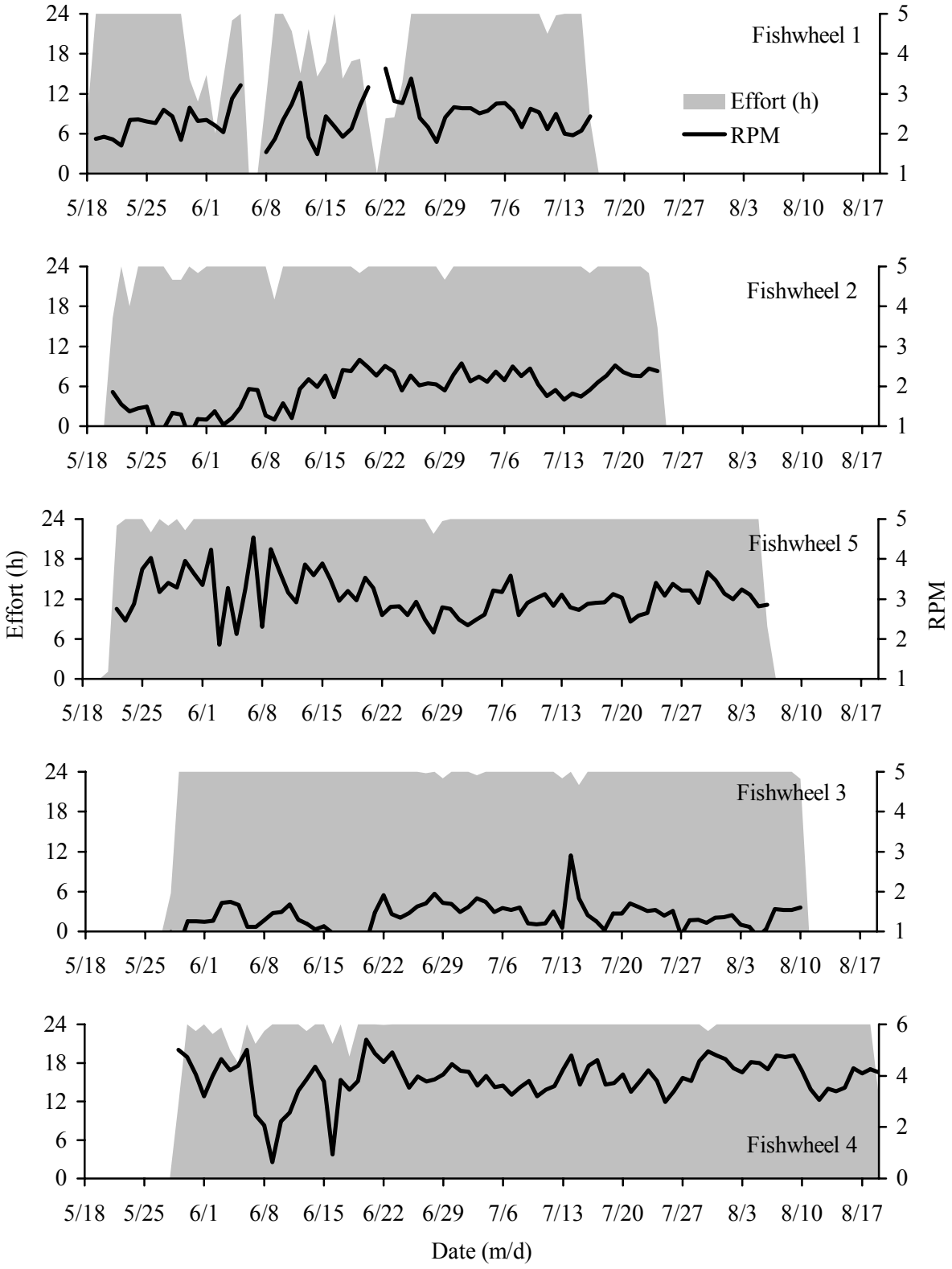

Figure 6. Fishwheel effort (h) and speed (RPM) at the Baird Canyon (fw 1, 2, and 5) and Canyon Creek (fw 3 and 4) fishwheels on the Copper River, 2007.

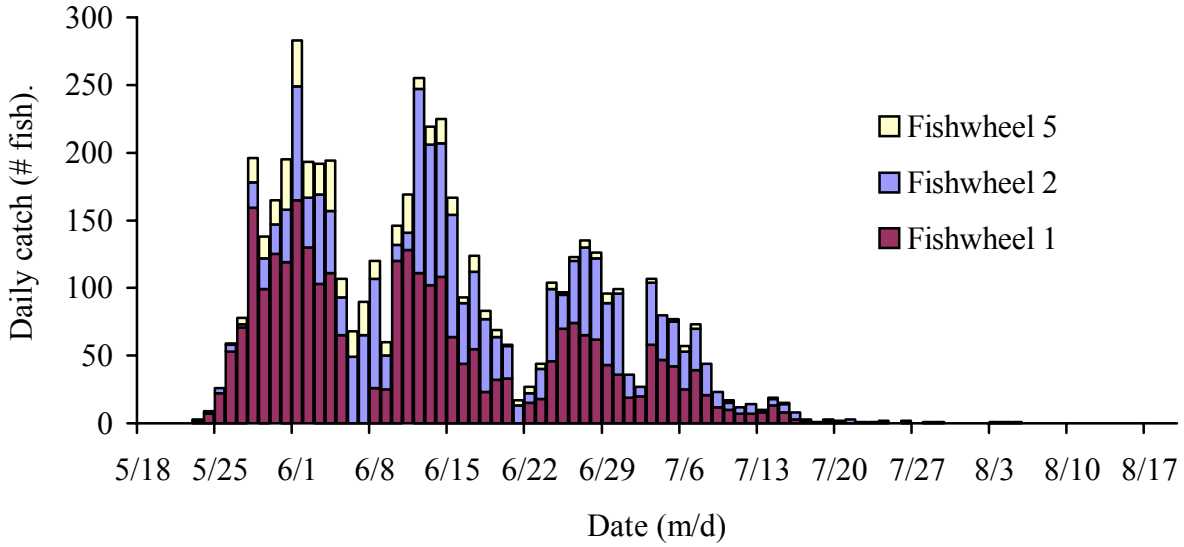

Figure 7. Daily catch of Chinook salmon at the Baird Canyon fishwheels on the Copper River, 2007.

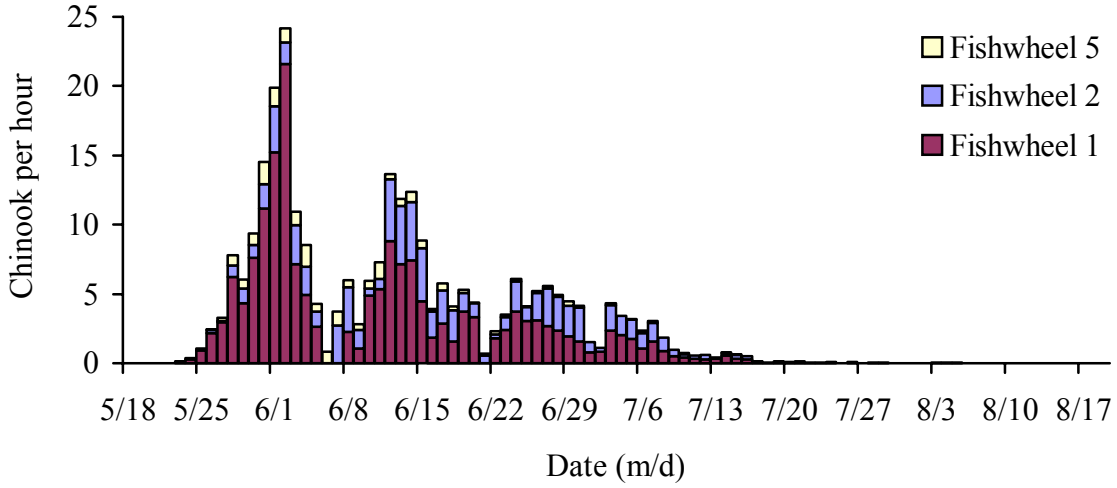

Figure 8. Catch per unit effort (fish per fishwheel hour) for Chinook salmon at the Baird Canyon fishwheels on the Copper River, 2007.

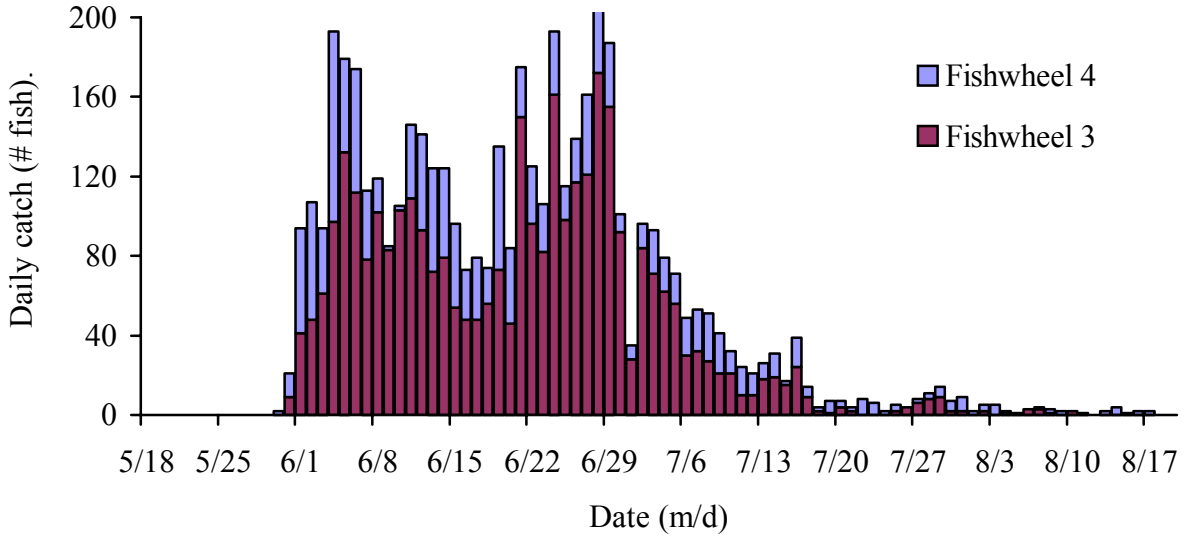

Figure 9. Daily catch of Chinook salmon at the Canyon Creek fishwheels on the Copper River, 2007.

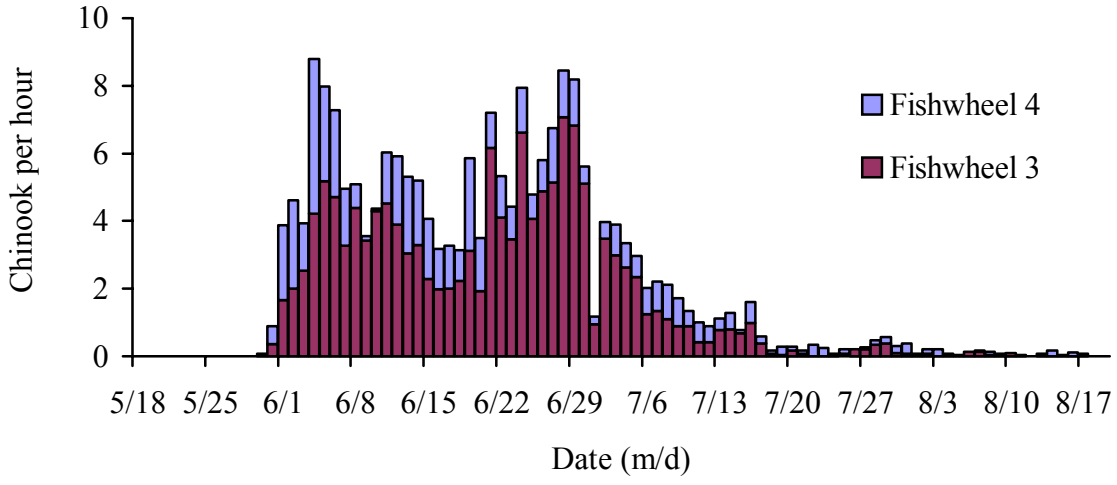

Figure 10. Catch per unit effort (fish per fishwheel hour) for Chinook salmon at the Canyon Creek fishwheels on the Copper River, 2007.

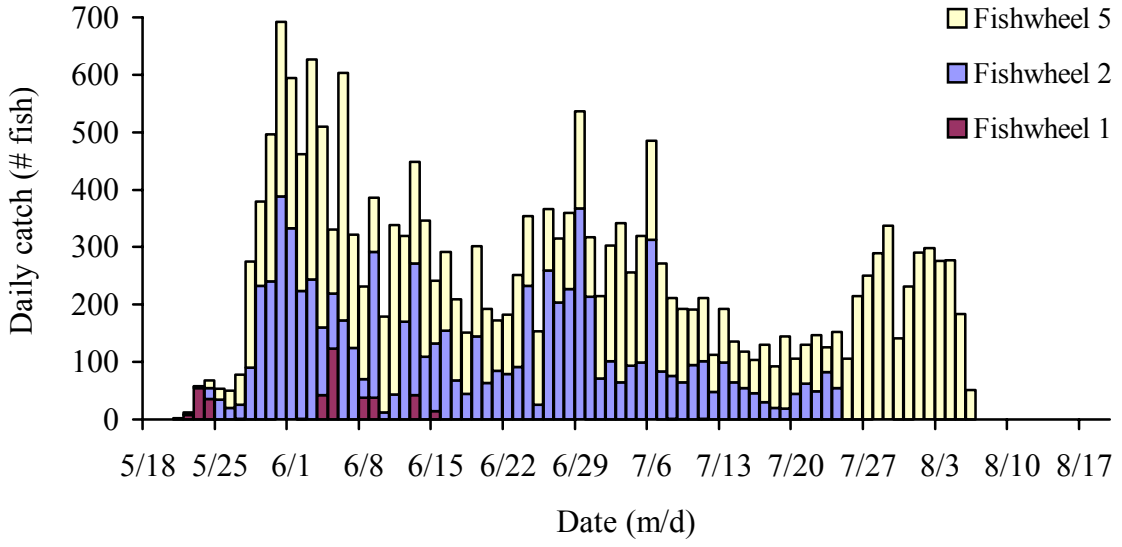

Figure 11. Daily catch of sockeye salmon at the Baird Canyon fishwheels on the Copper River, 2007. These catch data do not reflect the total number of sockeye salmon actually caught by the fishwheels, but only those that were retained in live tanks when the escape panels were closed.

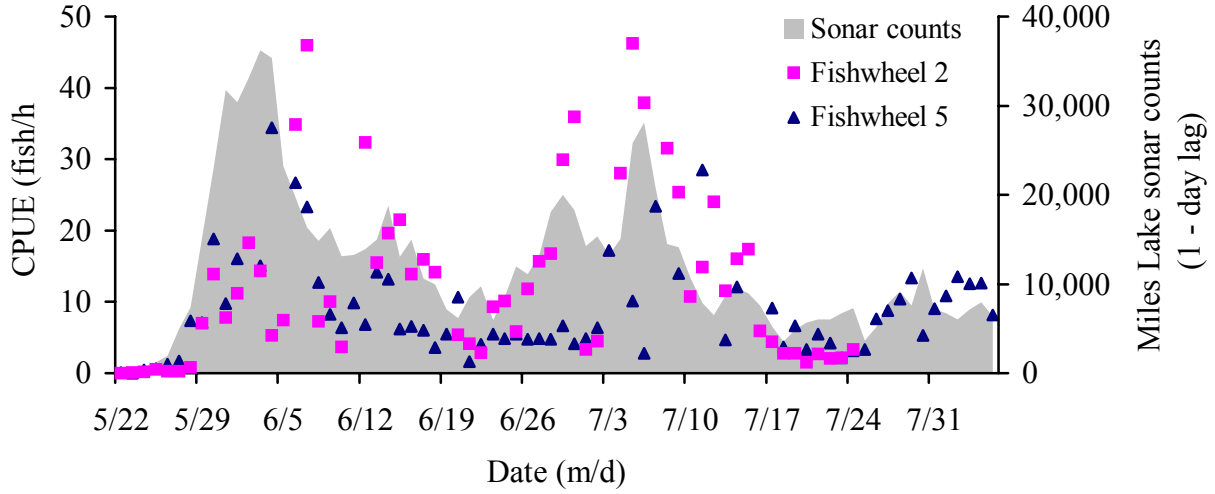

Figure 12. Catch per unit effort (fish per fishwheel hour) for sockeye salmon in the starboard live tanks of fishwheels 2 and 5 at Baird Canyon on the Copper River, 2007. Only sockeye salmon captured during periods when the escape panels were closed were used to generate this figure. Salmon counts at the Miles Lake sonar site were included for comparison.

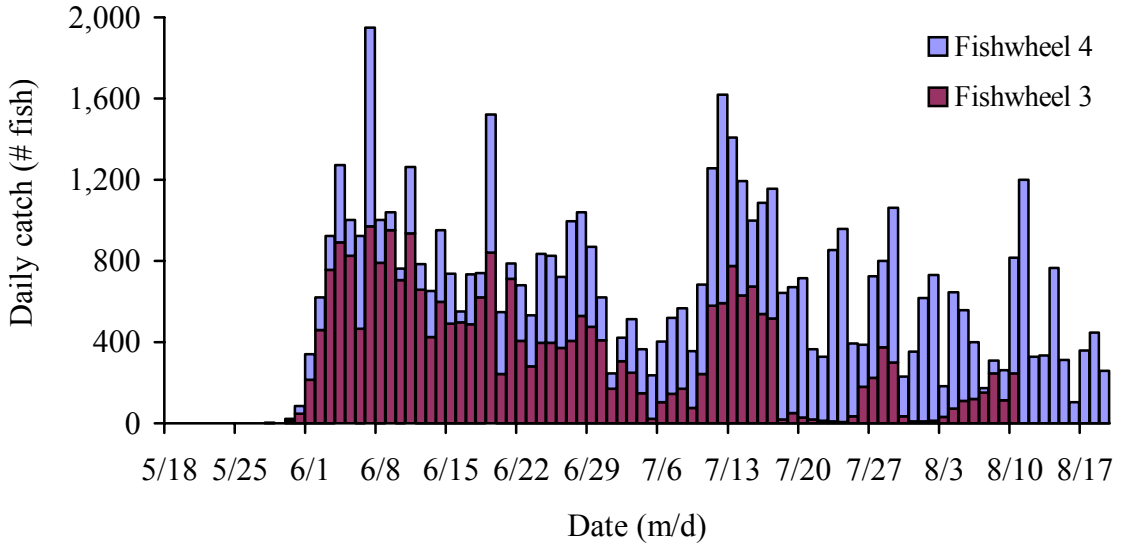

Figure 13. Daily catch of sockeye salmon at the Canyon Creek fishwheels on the Copper River, 2007.

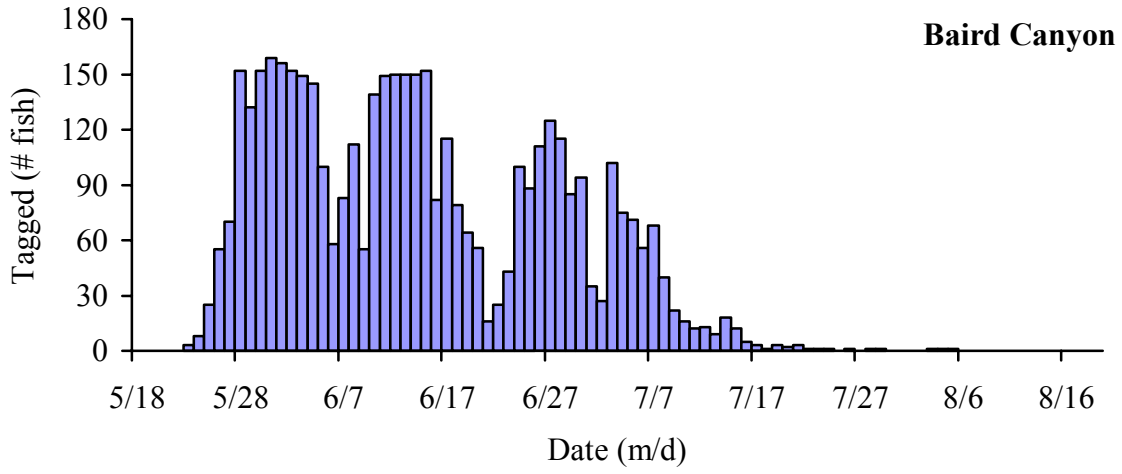

Figure 14. Number of Chinook salmon tagged at the Baird Canyon fishwheels on the Copper River, 2007.

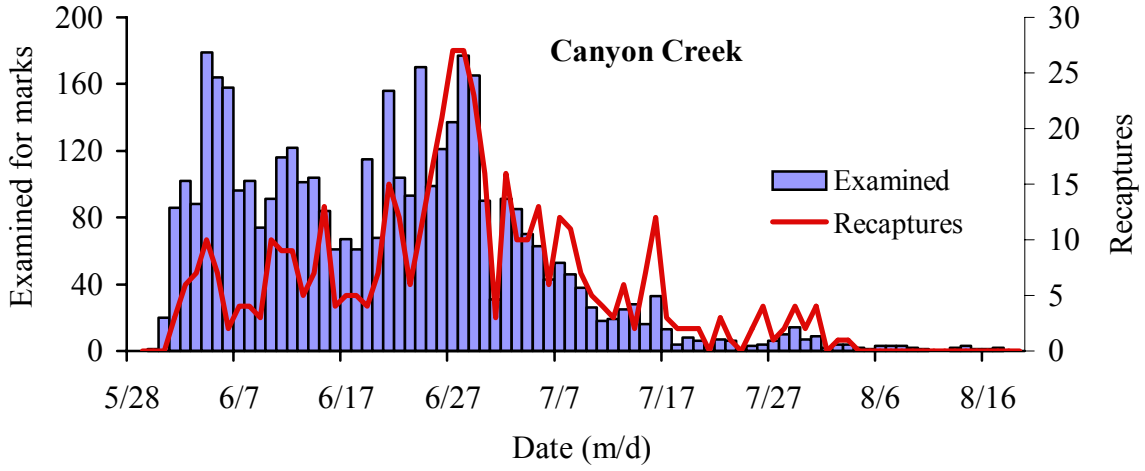

Figure 15. Number of Chinook salmon examined and recaptured at the Canyon Creek fishwheels on the Copper River, 2007.

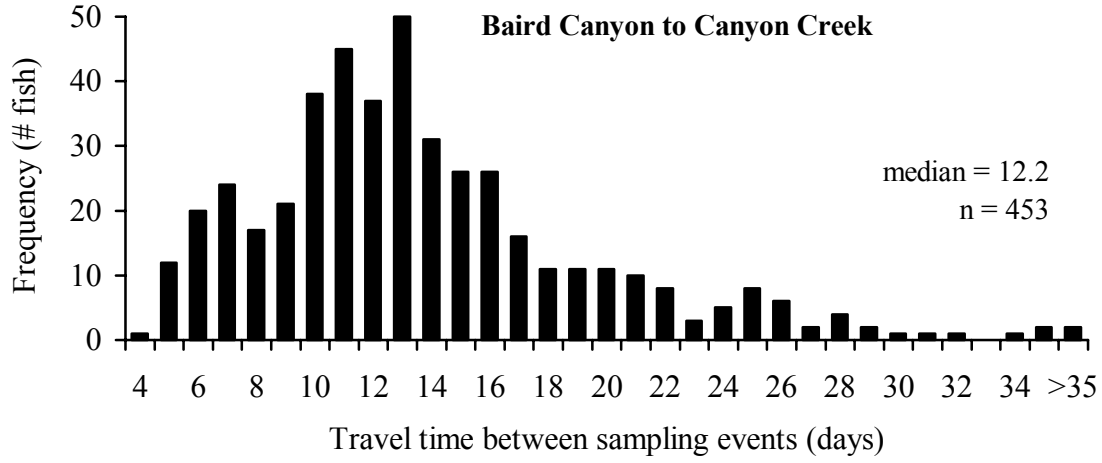

Figure 16. Travel time (days) of Chinook salmon tagged at the Baird Canyon fishwheels and recaptured at the Canyon Creek fishwheels, 2007.

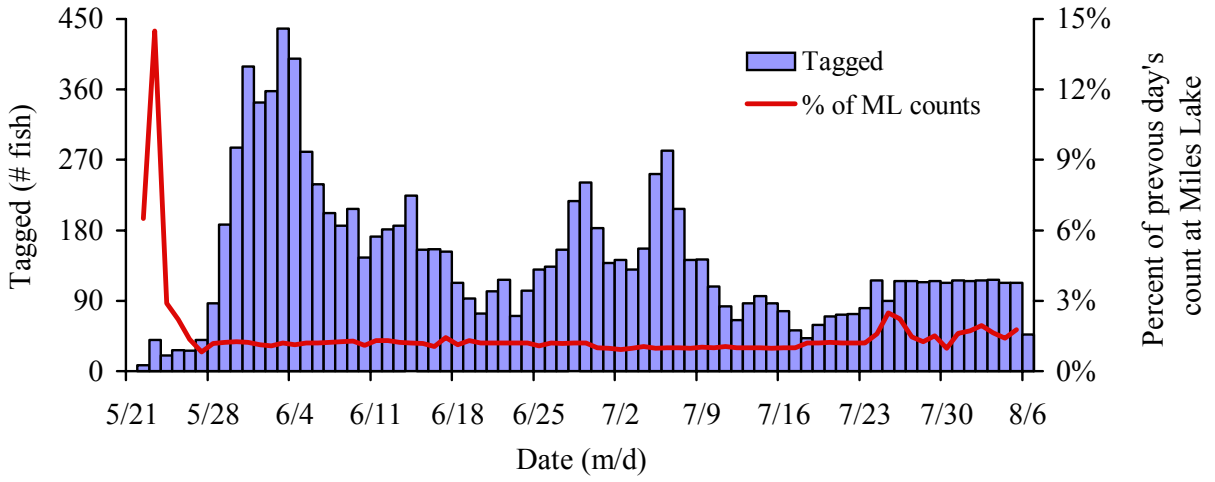

Figure 17. Number of sockeye salmon tagged at the Baird Canyon fishwheels and the proportion of sockeye salmon tagged relative to the previous day's count at the Miles Lake sonar site.

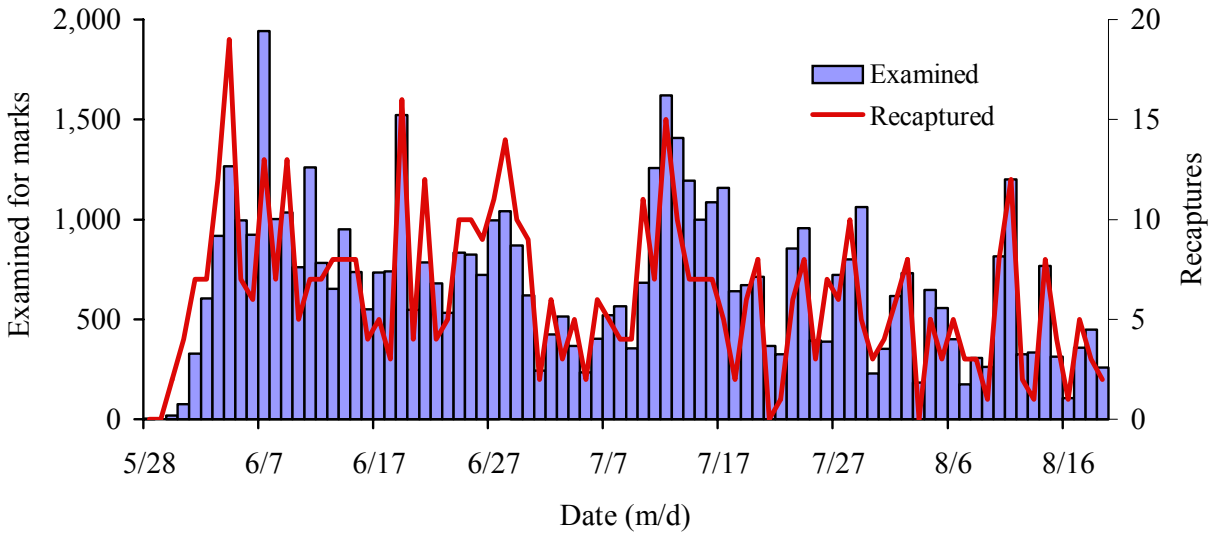

Figure 18. Number of sockeye salmon examined for marks and recaptured at the Canyon Creek fishwheels on the Copper River, 2007.

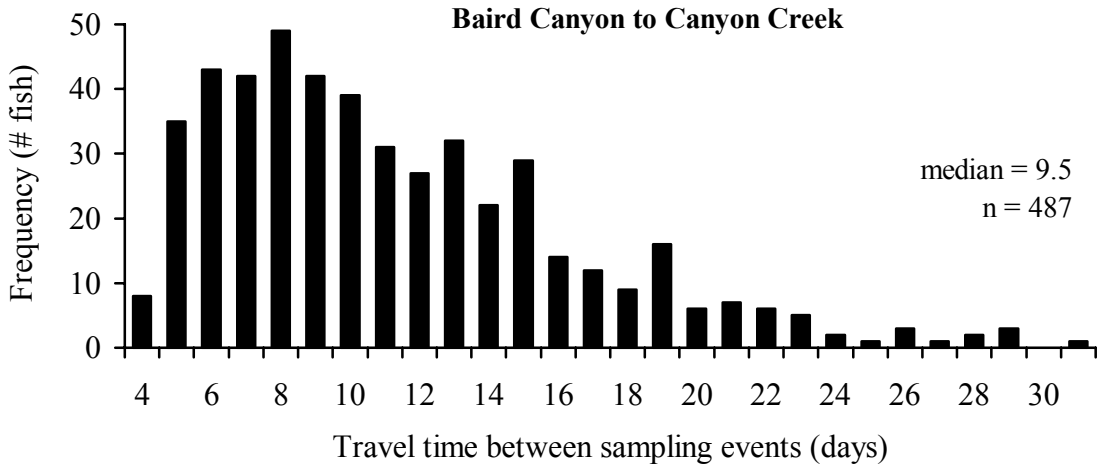

Figure 19. Travel time (days) of sockeye salmon tagged at the Baird Canyon fishwheels and recaptured at the Canyon Creek fishwheels, 2007.

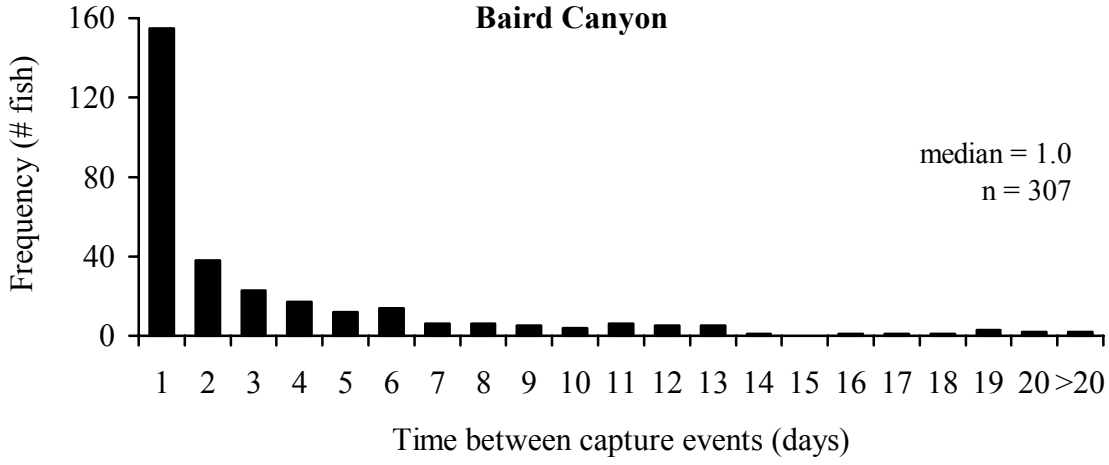

Figure 20. Time (days) between capture events for Chinook salmon captured more than once at the Baird Canyon fishwheels, 2007.

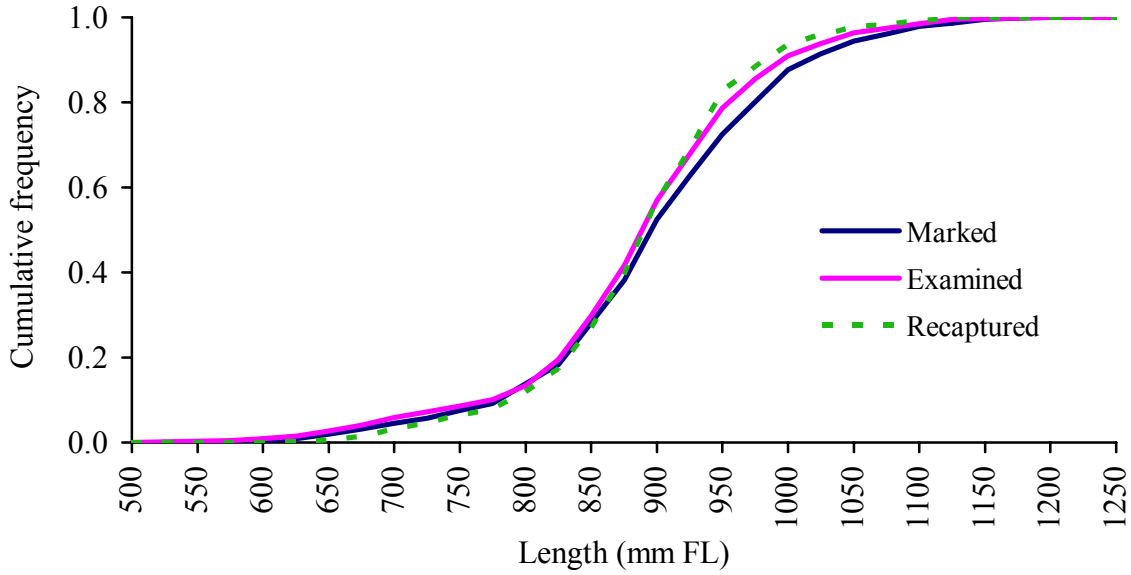

Figure 21. Cumulative length-frequency distributions for Chinook salmon (≥ 500 mm FL) marked at Baird Canyon and examined and recaptured at Canyon Creek, 2007.

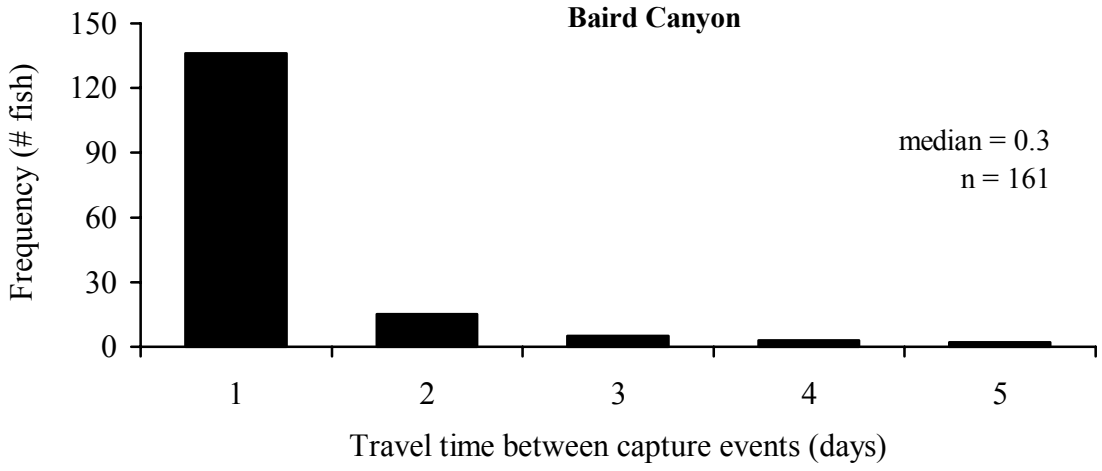

Figure 22. Time (days) between capture events for sockeye salmon captured more than once at the Baird Canyon fishwheels, 2007.

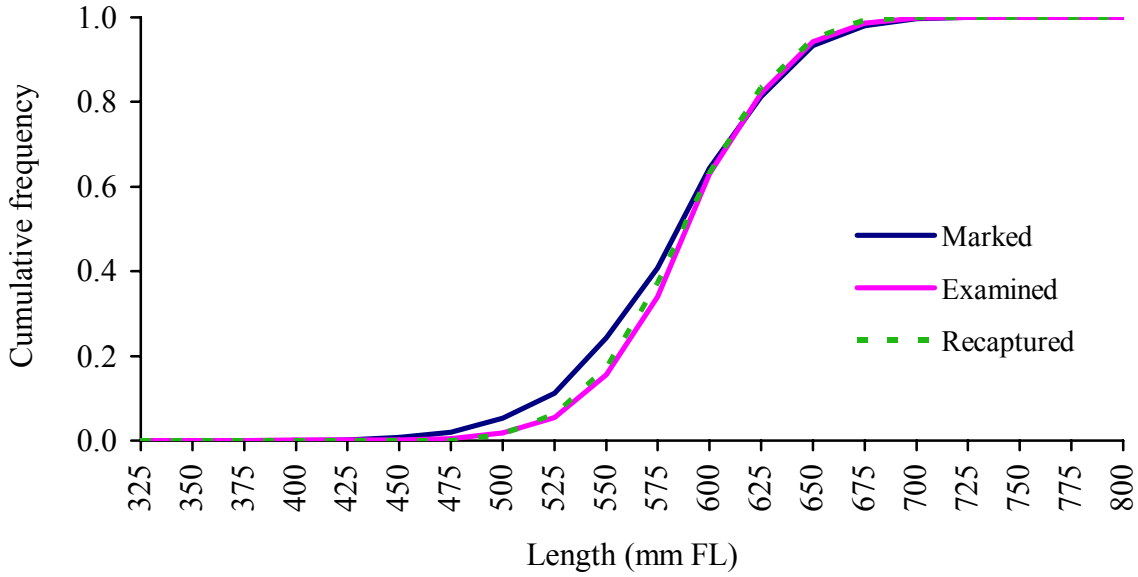

Figure 23. Cumulative length-frequency distributions for sockeye salmon marked at Baird Canyon and examined and recaptured at Canyon Creek, 2007.

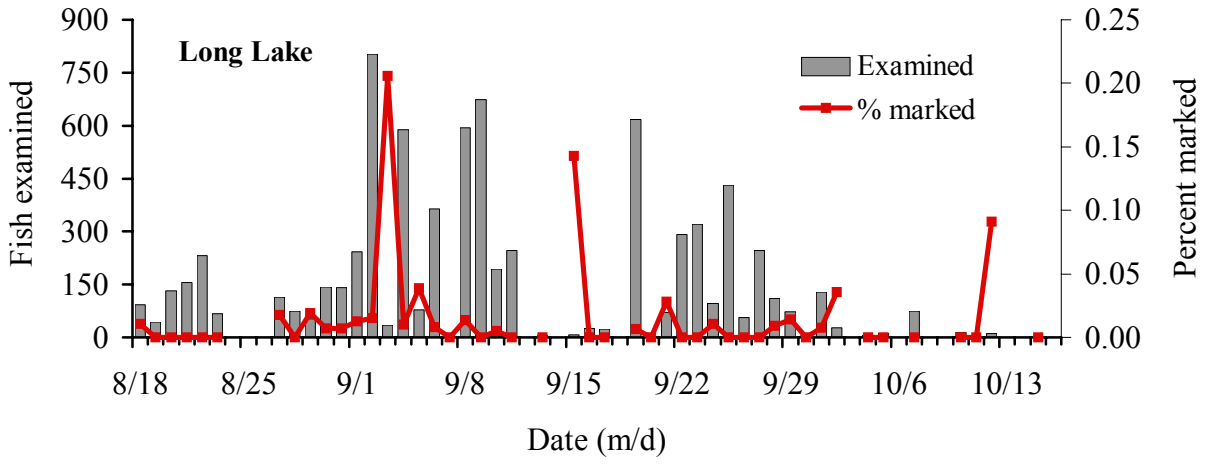

Figure 24. Number of sockeye salmon examined for marks and the proportion marked during operations at the Long Lake weir, 2007.

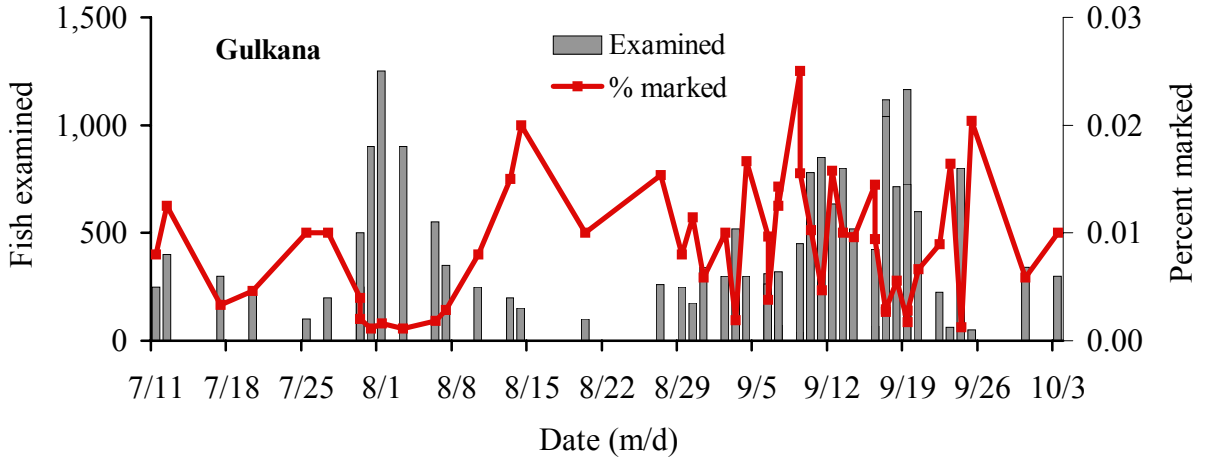

Figure 25. Number of sockeye salmon examined for marks, and the proportion marked, during brood stock collection in the Gulkana River drainage by Gulkana Hatchery personnel, 2007.

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, 2007.

Bank of Release	Recaptured [a]	Not Recaptured	Tagged	Recapture Rate
West (FW1&5)	274	2,585	2,859	0.096
East (FW2)	179	1,418	1,597	0.112
Total	453	4,003	4,456	0.102

Chi-square = 2.96 df = 1 p-value = 0.085

[a] Excludes 6 recaptures where the bank of tagging was unknown.

Table 2. 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, 2007.

	Bank of Recovery		
Bank of Release	West	East	Recaptured
West	73	201	274
East	47	132	179
Total	120	333	453

Chi-square = 0.01 df = 1 p-value = 0.928

[a] Excludes 6 recaptures where the bank of tagging was unknown.

Table 3. 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, 2007.

Recovery Location	Marked	Not marked	Total Examined	Mark Rate
West (FW4)	120	1,449	1,569	0.076
East (FW3)	339	2,284	2,623	0.129
Total	459	3,733	4,192	0.109

Chi-square = 28.03 df = 1 p-value = 0.000

Table 4. Capture history of Chinook salmon that were tagged, examined, and recaptured at the Copper River fishwheels, 2007. Bold text indicates the data used for the Chi-square tests.

Period of marking	Period of recapture 5/30-6/9	6/10-6/24	6/25-7/4	7/5-7/14	7/15-8/17	Recaptured	Not recaptured	Marks	Recapture rate
5/23-6/4	46	49	4	0	1	**100**	**1,258**	1,358	0.074
6/5-6/11	0	49	27	5	1	**82**	**614**	696	0.118
6/12-6/23	0	22	126	17	4	**169**	**913**	1,082	0.156
6/24-6/30	0	0	10	43	17	**70**	**648**	718	0.097
7/1-7/9	0	0	0	3	21	**24**	**472**	496	0.048
7/10-8/6	0	0	0	0	8	**8**	**98**	106	0.075
Unknown	0	2	2	1	1	6			
Recaps	**46**	**122**	**169**	**69**	**53**	459	4,003	4,456	0.103
Unmarked	**1,023**	**1,391**	**897**	**290**	**131**	3,732	$\chi^2 = 71.3, df = 5, P = 0.000$		
Examined	1,069	1,513	1,066	359	184	4,191			
Mark rate	0.043	0.081	0.159	0.192	0.288	0.110	$\chi^2 = 174.7, df = 4, P = 0.000$		

Table 5. Number of sockeye 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, 2007.

Release location	Recaptured[a]	Not recaptured	Total released	Recapture Rate
West (FW1&5)	316	6,688	7,004	0.045
East (FW2)	172	3,851	4,023	0.043
Total	488	10,539	11,027	0.044

Chi-square = 0.34, df = 1, P = 0.561

Excludes 33 recaptures with unknown release locations.

Table 6. Number of sockeye salmon recaptured, by bank of release and bank of recovery, and the results of a test to compare for equal movement across the river, 2007.

	Bank of Recovery		
Bank of Release	West	East	Recaptured
West	150	166	316
East	87	85	172
Total	237	251	488

Chi-square = 0.43 df = 1 p-value = 0.511

Excludes 33 recaptures with unknown release locations.

Table 7. Number of sockeye 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, 2007.

Recovery location	Marked	Not marked	Total examined	Mark rate
West (FW4)	256	30,723	30,979	0.008
East (FW3)	265	25,307	25,572	0.010
Total	521	56,030	56,551	0.009

Chi-square = 6.76, df = 1, P = 0.009

Table 8. Capture history of sockeye salmon that were tagged, examined, and recaptured at the Copper River fishwheels, 2007. Bold text indicates data used for chi-square tests.

	Period of recapture									
Period of marking	5/28-6/4	6/5-6/18	6/19-7/10	7/11-7/25	7/26-8/6	8/7-8/19	Recaptured	Not recaptured	Marks applied	Recapture rate
5/22-6/1	46	39	1				**86**	**1,367**	1,453	0.059
6/2-6/5		29	2				**31**	**1,444**	1,475	0.021
6/6-7/12		32	154	74	23		**283**	**5,505**	5,788	0.049
7/13-7/31				7	34	37	**78**	**1,612**	1,690	0.046
8/1-8/6						10	**10**	**611**	621	0.016
Unknown	5	1	5	11	5	6	33			
Recaps	**51**	**101**	**162**	**92**	**62**	**53**	521	10,539	11,027	*0.047*
Unmarked	**3,160**	**12,962**	**14,119**	**13,553**	**6,625**	**5,611**	56,030	*$\chi 2 = 41.2, df = 4, P = 0.000$*		
Examined	3,211	13,063	14,281	13,645	6,687	5,664	56,551			
Mark rate	0.016	0.008	0.011	0.007	0.009	0.009	*0.009*	*$\chi 2 = 35.0, df = 5, P = 0.000$*		

Bold text indicates data used for the Chi-square tests.

Table 9. Estimated inriver abundance of Chinook salmon above Baird Canyon on the Copper River, 2003-2007.

	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	4,191	458	46,399	3,391

Table 10. Number of tagged Chinook and sockeye salmon recovered, by location and tag type, 2007.

Recovery	Chinook	Sockeye			Unknown
Location	PIT	PIT	Radio	Total	PIT
ADF&G Research	0	1	0	1	
Commercial gillnet	4	2	0	2	
Chitina Subdistrict	115	492	32	524	
Glennallen Subdistrict	134	335	32	367	
Sport fishery	43	55	6	61	
Found on ground	1	0	0	0	
Unknown location	12	40	17	57	
Total	309	925	87	1,012	12
Tagged	4,456	10,474	553	11,027	
% recovered	6.9%	8.8%	15.7%	9.2%	

APPENDICES

Appendix A. Summary of daily fishwheel effort (h), effort used to calculate catch per unit effort (CPUE), and fishwheel speed (RPM) for the Copper River fishwheels, 2007.

	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-May	8.1														
19-May	24.0	29.5	1.9												
20-May	24.0	24.2	1.9												
21-May	24.0	24.2	1.9	16.3	14.3	1.9	1.1	0.0							
22-May	24.0	23.8	1.7	24.0	23.8	1.6	23.0	22.5	2.7						
23-May	24.0	24.0	2.3	18.0	17.9	1.4	24.0	23.9	2.5						
24-May	24.0	23.7	2.4	24.0	23.8	1.4	24.0	23.5	2.9						
25-May	24.0	24.0	2.3	24.0	24.0	1.5	24.0	24.0	3.8						
26-May	24.0	24.3	2.3	24.0	24.4	0.9	22.0	26.4	4.0						
27-May	24.0	23.9	2.6	24.0	23.8	0.9	24.0	22.9	3.2						
28-May	24.0	25.6	2.4	22.0	22.7	1.3	23.0	24.3	3.4	5.8	4.8	1.0			
29-May	24.0	22.8	1.8	22.0	22.4	1.3	24.0	23.9	3.3	24.0	21.7	0.6	11.6	8.3	5.0
30-May	14.2	16.5	2.6	24.0	23.5	0.7	22.3	21.9	4.0	24.0	25.9	1.3	24.0	25.6	4.7
31-May	10.8	10.7	2.3	23.0	22.2	1.2	24.0	23.4	3.6	24.0	24.5	1.3	23.0	23.4	4.1
1-Jun	14.8	10.8	2.3	24.0	25.4	1.2	24.0	25.0	3.4	24.0	24.5	1.2	24.0	24.0	3.2
2-Jun	6.1	6.0	2.2	24.0	24.3	1.4	24.0	25.2	4.2	24.0	24.0	1.3	22.5	22.6	4.0
3-Jun	14.3	14.4	2.0	24.0	23.7	1.0	24.0	23.0	1.9	24.0	24.1	1.7	23.5	23.5	4.7
4-Jun	23.0	22.4	2.9	24.0	22.9	1.2	24.0	23.6	3.3	24.0	23.0	1.7	20.0	21.1	4.2
5-Jun	24.0	24.7	3.2	24.0	25.3	1.5	24.0	24.5	2.1	24.0	25.5	1.7	18.0	16.8	4.4
6-Jun	0.0	0.0	0.0	24.0	23.0	1.9	24.0	23.0	3.3	24.0	23.8	1.1	24.0	24.1	5.0
7-Jun	0.0	0.0	0.0	24.0	23.9	1.9	24.0	24.2	4.5	24.0	23.8	1.1	21.0	20.8	2.5
8-Jun	11.5	11.5	1.5	24.0	25.1	1.3	24.0	24.7	2.3	24.0	23.3	1.3	23.0	23.9	2.1
9-Jun	24.0	23.5	1.9	19.0	18.6	1.2	24.0	23.7	4.3	24.0	24.2	1.5	24.0	15.8	0.6
10-Jun	24.0	24.6	2.3	24.0	24.2	1.6	24.0	24.5	3.7	24.0	24.0	1.5	24.0	32.4	2.2
11-Jun	21.4	24.0	2.7	24.0	17.3	1.2	24.0	23.7	3.2	24.0	24.1	1.7	24.0	24.4	2.6
12-Jun	15.0	12.6	3.3	24.0	30.4	1.9	24.0	23.5	2.9	24.0	23.9	1.3	24.0	23.7	3.4
13-Jun	21.7	14.3	1.9	24.0	24.8	2.2	24.0	24.9	3.9	24.0	23.7	1.2	23.0	22.9	3.9
14-Jun	14.6	14.6	1.5	24.0	23.6	2.0	24.0	23.5	3.6	24.0	24.0	1.1	24.0	23.7	4.4
15-Jun	16.8	14.3	2.4	24.0	23.6	2.3	24.0	24.2	3.9	24.0	23.7	1.1	24.0	23.6	3.8
16-Jun	24.0	24.0	2.2	24.0	23.8	1.7	24.0	23.2	3.5	24.0	24.1	1.0	21.0	21.1	0.9
17-Jun	14.3	19.2	1.9	24.0	23.7	2.4	24.0	24.3	3.0	24.0	24.1	0.9	24.0	24.3	3.8

Appendix A. Summary of daily fishwheel effort (h), effort used to calculate catch per unit effort (CPUE), and fishwheel speed (RPM) for the Copper River fishwheels, 2007.

	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	16.8	14.6	2.1	24.0	24.0	2.4	24.0	24.0	3.2	24.0	25.2	0.8	19.0	19.7	3.5
19-Jun	17.3	8.5	2.7	23.0	23.8	2.7	24.0	24.2	3.0	24.0	23.4	0.8	24.0	22.5	3.8
20-Jun	8.0	10.0	3.2	24.0	23.0	2.5	24.0	23.1	3.5	24.0	24.0	0.7	24.0	24.1	5.4
21-Jun	0.0	0.0	0.0	24.0	24.5	2.3	24.0	24.4	3.3	24.0	24.3	1.5	24.0	24.1	4.9
22-Jun	8.3	8.4	3.6	24.0	23.6	2.5	24.0	23.6	2.6	24.0	23.4	1.9	23.9	23.7	4.5
23-Jun	8.5	7.5	2.8	24.0	24.1	2.4	24.0	23.3	2.8	24.0	23.7	1.4	24.0	24.7	4.9
24-Jun	13.8	12.4	2.8	24.0	24.3	1.9	24.0	25.7	2.8	24.0	24.3	1.4	24.0	24.4	4.3
25-Jun	24.0	23.1	3.4	24.0	24.8	2.3	24.0	24.4	2.6	24.0	24.2	1.5	24.0	23.2	3.5
26-Jun	24.0	23.8	2.4	24.0	23.6	2.0	24.0	23.5	2.9	24.0	24.0	1.6	24.0	23.9	4.0
27-Jun	24.0	24.1	2.2	24.0	24.2	2.1	24.0	24.0	2.5	23.8	23.5	1.7	24.0	25.0	3.8
28-Jun	24.0	26.3	1.8	24.0	24.7	2.0	21.8	30.4	2.2	24.0	24.3	1.9	24.0	24.0	3.9
29-Jun	24.0	22.2	2.4	22.0	20.6	1.9	23.7	22.4	2.8	23.0	22.7	1.7	24.0	23.7	4.1
30-Jun	24.0	23.2	2.7	24.0	24.4	2.3	24.0	23.9	2.8	24.0	18.0	1.7	24.0	17.9	4.4
1-Jul	24.0	23.7	2.6	24.0	23.3	2.6	24.0	23.3	2.5	24.0	29.7	1.5	24.0	29.6	4.2
2-Jul	24.0	24.6	2.6	24.0	23.9	2.1	24.0	24.2	2.3	24.0	24.1	1.6	24.0	24.1	4.2
3-Jul	24.0	24.8	2.5	24.0	24.5	2.2	24.0	24.5	2.5	23.5	23.8	1.8	24.0	24.4	3.6
4-Jul	24.0	23.1	2.6	24.0	24.1	2.1	24.0	23.6	2.6	24.0	23.6	1.7	24.0	23.5	4.0
5-Jul	24.0	24.0	2.8	24.0	24.0	2.4	24.0	24.3	3.2	24.0	24.0	1.5	24.0	24.0	3.6
6-Jul	24.0	24.0	2.8	24.0	24.9	2.2	24.0	23.6	3.2	24.0	24.1	1.6	24.0	24.2	3.6
7-Jul	24.0	24.8	2.6	24.0	23.0	2.5	24.0	24.3	3.6	24.0	23.9	1.5	24.0	23.8	3.3
8-Jul	24.0	23.7	2.2	24.0	23.6	2.3	24.0	23.8	2.6	24.0	24.5	1.6	24.0	23.6	3.6
9-Jul	24.0	24.1	2.6	24.0	24.3	2.4	24.0	24.2	2.9	24.0	23.8	1.2	24.0	23.9	3.8
10-Jul	24.0	23.7	2.5	24.0	23.6	2.0	24.0	23.6	3.0	24.0	23.7	1.2	24.0	24.4	3.2
11-Jul	21.0	20.9	2.1	24.0	24.5	1.8	24.0	24.4	3.1	24.0	24.1	1.2	24.0	24.3	3.5
12-Jul	23.8	24.0	2.5	24.0	23.7	1.9	24.0	23.5	2.8	24.0	23.8	1.5	24.0	23.8	3.6
13-Jul	24.0	24.0	2.0	24.0	24.0	1.7	24.0	24.4	3.1	23.0	23.1	1.1	24.0	23.9	4.3
14-Jul	24.0	24.1	2.0	24.0	24.0	1.8	24.0	23.8	2.8	24.0	24.2	2.9	24.0	24.3	4.8
15-Jul	24.0	23.5	2.1	24.0	23.9	1.7	24.0	23.9	2.7	22.0	22.0	1.8	24.0	23.8	3.6
16-Jul	8.0	10.8	2.4	23.0	23.6	1.9	24.0	24.2	2.9	24.0	24.2	1.4	24.0	24.3	4.4
17-Jul				24.0	23.6	2.1	24.0	23.2	2.9	24.0	23.6	1.3	24.0	23.6	4.6
18-Jul				24.0	23.7	2.3	24.0	24.1	2.9	24.0	24.3	1.0	24.0	23.7	3.6

Appendix A. Summary of daily fishwheel effort (h), effort used to calculate catch per unit effort (CPUE), and fishwheel speed (RPM) for the Copper River fishwheels, 2007.

	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-Jul				24.0	24.2	2.5	24.0	24.4	3.1	24.0	24.2	1.5	24.0	24.0	3.7
20-Jul				24.0	23.9	2.4	24.0	24.2	3.0	24.0	24.4	1.5	24.0	25.3	4.1
21-Jul				24.0	24.0	2.3	24.0	23.7	2.4	24.0	23.6	1.7	24.0	22.8	3.4
22-Jul				24.0	24.0	2.3	24.0	23.9	2.6	24.0	23.9	1.6	24.0	24.0	3.8
23-Jul				23.0	23.6	2.4	24.0	24.6	2.6	24.0	23.9	1.5	24.0	23.9	4.2
24-Jul				14.8	17.0	2.4	24.0	23.3	3.4	24.0	24.0	1.5	24.0	24.0	3.8
25-Jul							24.0	24.2	3.1	24.0	24.2	1.4	24.0	24.0	3.0
26-Jul							24.0	23.9	3.4	24.0	18.9	1.5	24.0	18.4	3.4
27-Jul							24.0	24.9	3.2	24.0	29.6	0.9	24.0	30.1	3.9
28-Jul							24.0	23.8	3.2	24.0	23.6	1.3	24.0	23.5	3.8
29-Jul							24.0	23.9	2.9	24.0	24.4	1.3	24.0	24.4	4.6
30-Jul							24.0	23.6	3.7	24.0	23.5	1.2	23.0	22.6	5.0
31-Jul							24.0	24.1	3.5	24.0	24.3	1.4	24.0	24.3	4.8
1-Aug							24.0	24.1	3.1	24.0	23.9	1.4	24.0	23.9	4.7
2-Aug							24.0	24.4	3.0	24.0	24.4	1.4	24.0	24.4	4.3
3-Aug							24.0	23.8	3.2	24.0	23.6	1.2	24.0	23.5	4.1
4-Aug							24.0	23.6	3.1	24.0	24.2	1.1	24.0	24.2	4.5
5-Aug							24.0	24.1	2.8	24.0	23.9	0.9	24.0	23.9	4.5
6-Aug							7.9	10.2	2.9	24.0	23.9	1.1	24.0	23.9	4.3
7-Aug										24.0	24.0	1.6	24.0	24.0	4.8
8-Aug										24.0	24.0	1.5	24.0	24.6	4.7
9-Aug										24.0	24.0	1.5	24.0	23.5	4.8
10-Aug										22.9	23.3	1.6	24.0	24.3	4.2
11-Aug													24.0	23.9	3.5
12-Aug													24.0	23.5	3.1
13-Aug													24.0	24.2	3.5
14-Aug													24.0	24.0	3.4
15-Aug													24.0	23.3	3.5
16-Aug													24.0	19.1	4.3
17-Aug													24.0	29.0	4.1
18-Aug													24.0	24.1	4.3

Appendix A. Summary of daily fishwheel effort (h), effort used to calculate catch per unit effort (CPUE), and fishwheel speed (RPM) for the Copper River fishwheels, 2007.

	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-Aug													12.7	15.0	4.1
Effort (h)	1,148		2.3	1,522		1.9	1,825		3.1	1,776		1.4	1,941		3.9
Effort (d)	47.8			63.4			76.0			74.0			80.9		
Percent operational:	81.5%			98.6%			99.6%			99.7%			98.6%		

Appendix B. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fishwheels, 2007.

	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
18 May	0	0													
19 May	0	0	0.0												
20 May	0	0	0.0												
21 May	0	0	0.0	0	0	0.0									
22 May	0	0	0.0	0	0	0.0	0	0	0.0						
23 May	2	2	0.1	1	1	0.1	0	0	0.0						
24 May	7	9	0.3	2	3	0.1	0	0	0.0						
25 May	22	31	0.9	4	7	0.2	0	0	0.0						
26 May	53	84	2.2	5	12	0.2	1	1	0.0						
27 May	71	155	3.0	2	14	0.1	5	6	0.2						
28 May	159	314	6.2	19	33	0.8	18	24	0.7	0	0				
29 May	99	413	4.4	23	56	1.0	16	40	0.7	0	0	0.00	0	0	
30 May	125	538	7.6	22	78	0.9	18	58	0.8	0	0	0.00	2	2	0.08
31 May	119	657	11.2	39	117	1.8	37	95	1.6	9	9	0.37	12	14	0.51
1 Jun	165	822	15.2	84	201	3.3	34	129	1.4	41	50	1.67	53	67	2.21
2 Jun	130	952	21.6	37	238	1.5	26	155	1.0	48	98	2.00	59	126	2.61
3 Jun	103	1,055	7.2	66	304	2.8	23	178	1.0	61	159	2.53	33	159	1.41
4 Jun	111	1,166	5.0	46	350	2.0	37	215	1.6	97	256	4.22	96	255	4.56
5 Jun	65	1,231	2.6	28	378	1.1	14	229	0.6	132	388	5.17	47	302	2.80
6 Jun	0	1,231		49	427		19	248	0.8	112	500	4.71	62	364	2.58
7 Jun	0	1,231		65	492	2.7	25	273	1.0	78	578	3.27	35	399	1.68
8 Jun	26	1,257	2.3	81	573	3.2	13	286	0.5	102	680	4.38	17	416	0.71
9 Jun	25	1,282	1.1	25	598	1.3	10	296	0.4	83	763	3.43	2	418	0.13
10 Jun	120	1,402	4.9	12	610	0.5	14	310	0.6	103	866	4.30	2	420	0.06
11 Jun	128	1,530	5.3	13	623	0.8	28	338	1.2	109	975	4.52	37	457	1.52
12 Jun	111	1,641	8.8	136	759	4.5	8	346	0.3	93	1,068	3.89	48	505	2.03
13 Jun	102	1,743	7.2	104	863	4.2	13	359	0.5	72	1,140	3.04	52	557	2.27
14 Jun	108	1,851	7.4	99	962	4.2	18	377	0.8	79	1,219	3.30	45	602	1.90
15 Jun	64	1,915	4.5	90	1,052	3.8	13	390	0.5	54	1,273	2.28	42	644	1.78
16 Jun	44	1,959	1.8	45	1,097	1.9	4	394	0.2	48	1,321	1.99	25	669	1.19
17 Jun	55	2,014	2.9	57	1,154	2.4	12	406	0.5	48	1,369	1.99	31	700	1.27
18 Jun	23	2,037	1.6	54	1,208	2.3	6	412	0.3	56	1,425	2.23	18	718	0.92

Appendix B. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fishwheels, 2007.

	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 Jun	32	2,069	3.8	32	1,240	1.3	5	417	0.2	73	1,498	3.12	62	780	2.75
20 Jun	33	2,102	3.3	24	1,264	1.0	1	418	0.0	46	1,544	1.92	38	818	1.58
21 Jun	0	2,102		13	1,277	0.5	4	422	0.2	150	1,694	6.16	25	843	1.04
22 Jun	15	2,117	1.8	7	1,284	0.3	5	427	0.2	96	1,790	4.10	29	872	1.23
23 Jun	18	2,135	2.4	22	1,306	0.9	4	431	0.2	82	1,872	3.46	24	896	0.97
24 Jun	46	2,181	3.7	53	1,359	2.2	5	436	0.2	161	2,033	6.63	32	928	1.31
25 Jun	70	2,251	3.0	25	1,384	1.0	2	438	0.1	98	2,131	4.06	17	945	0.73
26 Jun	74	2,325	3.1	46	1,430	2.0	3	441	0.1	117	2,248	4.88	22	967	0.92
27 Jun	65	2,390	2.7	65	1,495	2.7	5	446	0.2	121	2,369	5.14	40	1,007	1.60
28 Jun	62	2,452	2.4	60	1,555	2.4	4	450	0.1	172	2,541	7.08	33	1,040	1.37
29 Jun	43	2,495	1.9	46	1,601	2.2	7	457	0.3	155	2,696	6.83	32	1,072	1.35
30 Jun	36	2,531	1.6	60	1,661	2.5	3	460	0.1	92	2,788	5.11	9	1,081	0.50
1 Jul	19	2,550	0.8	17	1,678	0.7	0	460	0.0	28	2,816	0.94	7	1,088	0.24
2 Jul	20	2,570	0.8	7	1,685	0.3	0	460	0.0	84	2,900	3.48	12	1,100	0.50
3 Jul	58	2,628	2.3	46	1,731	1.9	3	463	0.1	71	2,971	2.99	22	1,122	0.90
4 Jul	47	2,675	2.0	33	1,764	1.4	0	463	0.0	62	3,033	2.63	17	1,139	0.72
5 Jul	42	2,717	1.7	33	1,797	1.4	2	465	0.1	56	3,089	2.33	15	1,154	0.63
6 Jul	25	2,742	1.0	28	1,825	1.1	4	469	0.2	30	3,119	1.25	19	1,173	0.78
7 Jul	39	2,781	1.6	31	1,856	1.3	3	472	0.1	32	3,151	1.34	21	1,194	0.88
8 Jul	21	2,802	0.9	23	1,879	1.0	0	472	0.0	27	3,178	1.10	24	1,218	1.02
9 Jul	12	2,814	0.5	11	1,890	0.5	0	472	0.0	21	3,199	0.88	20	1,238	0.84
10 Jul	10	2,824	0.4	5	1,895	0.2	2	474	0.1	21	3,220	0.89	11	1,249	0.45
11 Jul	7	2,831	0.3	5	1,900	0.2	0	474	0.0	10	3,230	0.42	14	1,263	0.58
12 Jul	7	2,838	0.3	7	1,907	0.3	0	474	0.0	10	3,240	0.42	11	1,274	0.46
13 Jul	8	2,846	0.3	2	1,909	0.1	0	474	0.0	18	3,258	0.78	8	1,282	0.33
14 Jul	13	2,859	0.5	5	1,914	0.2	1	475	0.0	19	3,277	0.79	12	1,294	0.49
15 Jul	8	2,867	0.3	6	1,920	0.3	1	476	0.0	15	3,292	0.68	2	1,296	0.08
16 Jul	3	2,870	0.3	5	1,925	0.2	0	476	0.0	24	3,316	0.99	15	1,311	0.62
17 Jul				2	1,927	0.1	1	477	0.0	9	3,325	0.38	5	1,316	0.21
18 Jul				1	1,928	0.0	0	477	0.0	2	3,327	0.08	2	1,318	0.08
19 Jul				2	1,930	0.1	1	478	0.0	1	3,328	0.04	6	1,324	0.25
20 Jul				2	1,932	0.1	0	478	0.0	4	3,332	0.16	3	1,327	0.12

Appendix B. Total catch and catch per unit effort (fish per hour) for Chinook salmon at the Copper River fishwheels, 2007.

	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 Jul				3	1,935	0.1	0	478	0.0	2	3,334	0.08	2	1,329	0.09
22 Jul				1	1,936	0.0	0	478	0.0	0	3,334	0.00	8	1,337	0.33
23 Jul				1	1,937	0.0	0	478	0.0	0	3,334	0.00	6	1,343	0.25
24 Jul				1	1,938	0.1	1	479	0.0	0	3,334	0.00	2	1,345	0.08
25 Jul							0	479	0.0	2	3,336	0.08	3	1,348	0.12
26 Jul							2	481	0.1	4	3,340	0.21	0	1,348	0.00
27 Jul							0	481	0.0	6	3,346	0.20	2	1,350	0.07
28 Jul							1	482	0.0	8	3,354	0.34	3	1,353	0.13
29 Jul							1	483	0.0	9	3,363	0.37	5	1,358	0.21
30 Jul							0	483	0.0	2	3,365	0.09	5	1,363	0.22
31 Jul							0	483	0.0	2	3,367	0.08	7	1,370	0.29
1 Aug							0	483	0.0	0	3,367	0.00	2	1,372	0.08
2 Aug							0	483	0.0	2	3,369	0.08	3	1,375	0.12
3 Aug							1	484	0.0	0	3,369	0.00	5	1,380	0.21
4 Aug							1	485	0.0	1	3,370	0.04	1	1,381	0.04
5 Aug							1	486	0.0	1	3,371	0.04	0	1,381	0.00
6 Aug							0	486	0.0	3	3,374	0.13	0	1,381	0.00
7 Aug										3	3,377	0.12	1	1,382	0.04
8 Aug										1	3,378	0.04	2	1,384	0.08
9 Aug										0	3,378	0.00	2	1,386	0.09
10 Aug										2	3,380	0.09	0	1,386	0.00
11 Aug													1	1,387	0.04
12 Aug													0	1,387	0.00
13 Aug													2	1,389	0.08
14 Aug													4	1,393	0.17
15 Aug													1	1,394	0.04
16 Aug													2	1,396	0.10
17 Aug													2	1,398	0.07
18 Aug													0	1,398	0.00
19 Aug													0	1,398	0.00
Total	2,870			1,938			486			3,380			1,398		

Appendix C. Total catch and catch per unit effort (fish per hour) for sockeye salmon at the Copper River fishwheels, 2007.

	Baird Canyon								Canyon Creek			
	Fishwheel 1		Fishwheel 2			Fishwheel 5			Fishwheel 3		Fishwheel 4	
Date	Catch	Cum.	Catch	Cum.	CPUE[a]	Catch	Cum.	CPUE[a]	Catch	Cum.	Catch	Cum.
18 May	0	0										
19 May	0	0										
20 May	0	0										
21 May	2	2	0	0		0	0					
22 May	8	10	1	1	0.0	3	3	0.1				
23 May	54	64	3	4	0.1	1	4	0.0				
24 May	36	100	18	22	0.2	14	18	0.5				
25 May	0	100	35	57	0.5	18	36	0.6				
26 May	0	100	20	77	0.2	30	66	1.3				
27 May	1	101	25	102	0.3	52	118	1.7				
28 May	0	101	90	192	0.8	185	303	7.3	2	2		
29 May	0	101	233	425	7.0	146	449	7.0	1	3	0	0
30 May	0	101	240	665	13.9	256	705	18.8	9	12	12	12
31 May	0	101	388	1,053	7.8	304	1,009	9.7	46	58	38	50
1 Jun	0	101	333	1,386	11.2	261	1,270	16.0	214	272	126	176
2 Jun	1	102	223	1,609	18.3	238	1,508		461	733	161	337
3 Jun	0	102	244	1,853	14.3	382	1,890	15.0	757	1,490	167	504
4 Jun	42	144	118	1,971	5.3	350	2,240	34.4	891	2,381	382	886
5 Jun	123	267	96	2,067	7.5	111	2,351		826	3,207	177	1,063
6 Jun	0	267	172	2,239	34.8	431	2,782	26.7	465	3,672	459	1,522
7 Jun	0	267	125	2,364	46.0	197	2,979	23.3	969	4,641	980	2,502
8 Jun	38	305	32	2,396	7.3	162	3,141	12.8	789	5,430	214	2,716
9 Jun	38	343	254	2,650	10.0	94	3,235	8.2	952	6,382	86	2,802
10 Jun	0	343	12	2,662	3.7	167	3,402	6.3	707	7,089	56	2,858
11 Jun	0	343	43	2,705		295	3,697	9.8	937	8,026	326	3,184
12 Jun	0	343	170	2,875	32.4	149	3,846	6.8	657	8,683	128	3,312
13 Jun	42	385	230	3,105	15.5	176	4,022	14.1	426	9,109	226	3,538
14 Jun	0	385	109	3,214	19.6	237	4,259	13.1	600	9,709	350	3,888
15 Jun	15	400	117	3,331	21.5	110	4,369	6.2	491	10,200	245	4,133
16 Jun	0	400	155	3,486	13.9	137	4,506	6.6	497	10,697	54	4,187
17 Jun	0	400	68	3,554	16.0	141	4,647	6.0	487	11,184	247	4,434
18 Jun	0	400	45	3,599	14.1	106	4,753	3.6	620	11,804	120	4,554
19 Jun	0	400	145	3,744		157	4,910	5.5	841	12,645	681	5,235

Appendix C. Total catch and catch per unit effort (fish per hour) for sockeye salmon at the Copper River fishwheels, 2007.

	Baird Canyon								Canyon Creek			
	Fishwheel 1		Fishwheel 2			Fishwheel 5			Fishwheel 3		Fishwheel 4	
Date	Catch	Cum.	Catch	Cum.	CPUE[a]	Catch	Cum.	CPUE[a]	Catch	Cum.	Catch	Cum.
20 Jun	0	400	63	3,807	5.4	129	5,039	10.6	241	12,886	307	5,542
21 Jun	0	400	85	3,892	4.1	87	5,126	1.6	711	13,597	76	5,618
22 Jun	0	400	79	3,971	2.8	103	5,229	4.0	407	14,004	274	5,892
23 Jun	0	400	91	4,062	9.3	161	5,390	5.5	281	14,285	250	6,142
24 Jun	0	400	233	4,295	10.2	121	5,511	4.9	397	14,682	437	6,579
25 Jun	0	400	26	4,321	5.8	128	5,639	5.4	398	15,080	427	7,006
26 Jun	0	400	259	4,580	11.8	107	5,746	4.7	371	15,451	351	7,357
27 Jun	0	400	204	4,784	15.7	111	5,857	4.8	406	15,857	588	7,945
28 Jun	0	400	227	5,011	16.8	133	5,990	4.8	528	16,385	512	8,457
29 Jun	0	400	367	5,378	29.9	169	6,159	6.6	477	16,862	393	8,850
30 Jun	0	400	214	5,592	35.9	103	6,262	4.1	411	17,273	208	9,058
1 Jul	0	400	71	5,663	3.3	144	6,406	4.8	169	17,442	76	9,134
2 Jul	0	400	101	5,764	4.4	202	6,608	6.3	306	17,748	117	9,251
3 Jul	0	400	65	5,829		277	6,885	17.2	249	17,997	265	9,516
4 Jul	0	400	93	5,922	28.0	163	7,048		149	18,146	217	9,733
5 Jul	0	400	99	6,021	46.2	220	7,268	10.1	23	18,169	213	9,946
6 Jul	0	400	313	6,334	37.9	172	7,440	2.8	105	18,274	297	10,243
7 Jul	0	400	83	6,417		189	7,629	23.4	145	18,419	374	10,617
8 Jul	1	401	75	6,492	31.6	136	7,765		169	18,588	397	11,014
9 Jul	0	401	65	6,557	25.4	127	7,892	14.0	75	18,663	280	11,294
10 Jul	0	401	95	6,652	10.8	96	7,988		243	18,906	440	11,734
11 Jul	1	402	100	6,752	14.9	111	8,099	28.5	578	19,484	678	12,412
12 Jul	0	402	48	6,800	24.0	64	8,163		591	20,075	1,029	13,441
13 Jul	0	402	99	6,899	11.6	93	8,256	4.6	775	20,850	634	14,075
14 Jul	0	402	64	6,963	16.0	72	8,328	12.1	631	21,481	563	14,638
15 Jul	0	402	54	7,017	17.4	64	8,392		675	22,156	322	14,960
16 Jul	0	402	46	7,063	5.9	57	8,449		539	22,695	547	15,507
17 Jul			30	7,093	4.4	100	8,549	9.2	517	23,212	640	16,147
18 Jul			20	7,113	2.8	72	8,621	3.6	19	23,231	623	16,770
19 Jul			19	7,132	2.7	126	8,747	6.6	50	23,281	622	17,392
20 Jul			44	7,176	1.5	62	8,809	3.3	29	23,310	685	18,077
21 Jul			62	7,238	2.7	68	8,877	5.5	18	23,328	348	18,425
22 Jul			49	7,287	2.0	98	8,975	4.2	12	23,340	314	18,739

Appendix C. Total catch and catch per unit effort (fish per hour) for sockeye salmon at the Copper River fishwheels, 2007.

	Baird Canyon								Canyon Creek			
	Fishwheel 1		Fishwheel 2			Fishwheel 5			Fishwheel 3		Fishwheel 4	
Date	Catch	Cum.	Catch	Cum.	CPUE[a]	Catch	Cum.	CPUE[a]	Catch	Cum.	Catch	Cum.
23 Jul			82	7,369	2.1	44	9,019	2.1	9	23,349	845	19,584
24 Jul			55	7,424	3.3	97	9,116	3.1	5	23,354	952	20,536
25 Jul						106	9,222	3.3	36	23,390	359	20,895
26 Jul						215	9,437	7.6	180	23,570	208	21,103
27 Jul						250	9,687	8.8	225	23,795	498	21,601
28 Jul						289	9,976	10.4	374	24,169	426	22,027
29 Jul						337	10,313	13.4	300	24,469	761	22,788
30 Jul						141	10,454	5.3	36	24,505	194	22,982
31 Jul						231	10,685	9.0	8	24,513	345	23,327
1 Aug						291	10,976	10.9	8	24,521	608	23,935
2 Aug						298	11,274	13.5	14	24,535	717	24,652
3 Aug						276	11,550	12.6	31	24,566	152	24,804
4 Aug						277	11,827	12.6	72	24,638	574	25,378
5 Aug						184	12,011	8.2	110	24,748	446	25,824
6 Aug						51	12,062	5.4	119	24,867	281	26,105
7 Aug									150	25,017	24	26,129
8 Aug									246	25,263	62	26,191
9 Aug									113	25,376	149	26,340
10 Aug									246	25,622	569	26,909
11 Aug											1,199	28,108
12 Aug											326	28,434
13 Aug											333	28,767
14 Aug											766	29,533
15 Aug											313	29,846
16 Aug											105	29,951
17 Aug											358	30,309
18 Aug											447	30,756
19 Aug											258	31,014
Total	402		7,424			12,062			25,622		31,014	

Fish captured two or more times at the Baird Canyon and Canyon Creek fishwheels were not included in total catches.
Catch data does not include fish captured at the fishwheels during periods when the escape panels were open.

[a] CPUE based on catches in the starboard live tanks of fishwheels 2 and 5 when the escape panels were closed.

Appendix D. Number of Chinook salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2007.

	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	0	0												
21 May	0	0	0	0										
22 May	0	0	0	0	0	0								
23 May	2	2	1	1	0	0								
24 May	7	9	1	2	0	0								
25 May	21	30	4	6	0	0								
26 May	50	80	4	10	1	1								
27 May	65	145	2	12	3	4								
28 May	123	268	17	29	12	16	0	0	0	0				
29 May	96	364	21	50	15	31	0	0	0	0	0	0	0	0
30 May	120	484	17	67	15	46	0	0	0	0	1	0	0	0
31 May	115	599	34	101	10	56	9	9	0	0	11	11	0	0
1 Jun	103	702	20	121	33	89	36	45	2	2	50	61	1	1
2 Jun	101	803	34	155	17	106	43	88	4	6	59	120	2	3
3 Jun	89	892	48	203	12	118	52	140	4	10	36	156	3	6
4 Jun	74	966	40	243	31	149	82	222	7	17	97	253	3	9
5 Jun	61	1,027	27	270	12	161	112	334	7	24	52	305	0	9
6 Jun	0	1,027	41	311	17	178	102	436	2	26	56	361	0	9
7 Jun	0	1,027	62	373	21	199	61	497	3	29	35	396	1	10
8 Jun	25	1,052	74	447	13	212	84	581	4	33	18	414	0	10
9 Jun	24	1,076	22	469	9	221	69	650	3	36	5	419	0	10
10 Jun	116	1,192	12	481	11	232	79	729	10	46	12	431	0	10
11 Jun	124	1,316	11	492	14	246	76	805	8	54	40	471	1	11
12 Jun	74	1,390	72	564	4	250	71	876	6	60	51	522	3	14
13 Jun	73	1,463	66	630	11	261	56	932	4	64	45	567	1	15
14 Jun	73	1,536	64	694	13	274	62	994	7	71	42	609	0	15
15 Jun	56	1,592	85	779	11	285	42	1,036	6	77	42	651	7	22
16 Jun	41	1,633	39	818	2	287	39	1,075	1	78	22	673	3	25
17 Jun	51	1,684	54	872	10	297	34	1,109	3	81	33	706	2	27
18 Jun	23	1,707	50	922	6	303	39	1,148	4	85	22	728	1	28
19 Jun	30	1,737	30	952	4	307	57	1,205	3	88	58	786	1	29

Appendix D. Number of Chinook salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2007.

	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
20 Jun	31	1,768	24	976	1	308	36	1,241	2	90	32	818	5	34
21 Jun	0	1,768	13	989	3	311	121	1,362	13	103	35	853	2	36
22 Jun	15	1,783	5	994	5	316	72	1,434	9	112	32	885	3	39
23 Jun	18	1,801	21	1,015	4	320	69	1,503	4	116	24	909	2	41
24 Jun	44	1,845	51	1,066	5	325	131	1,634	10	126	39	948	1	42
25 Jun	67	1,912	20	1,086	1	326	72	1,706	12	138	27	975	4	46
26 Jun	70	1,982	39	1,125	2	328	83	1,789	18	156	38	1,013	3	49
27 Jun	61	2,043	60	1,185	4	332	79	1,868	24	180	58	1,071	3	52
28 Jun	60	2,103	53	1,238	2	334	124	1,992	22	202	53	1,124	5	57
29 Jun	41	2,144	40	1,278	4	338	117	2,109	22	224	48	1,172	1	58
30 Jun	35	2,179	57	1,335	2	340	65	2,174	16	240	25	1,197	0	58
1 Jul	19	2,198	16	1,351	0	340	21	2,195	3	243	10	1,207	0	58
2 Jul	20	2,218	7	1,358	0	340	65	2,260	14	257	26	1,233	2	60
3 Jul	55	2,273	45	1,403	2	342	59	2,319	7	264	26	1,259	3	63
4 Jul	44	2,317	31	1,434	0	342	48	2,367	7	271	22	1,281	3	66
5 Jul	39	2,356	30	1,464	2	344	42	2,409	10	281	21	1,302	3	69
6 Jul	25	2,381	27	1,491	4	348	25	2,434	4	285	18	1,320	2	71
7 Jul	36	2,417	29	1,520	3	351	28	2,462	5	290	25	1,345	7	78
8 Jul	19	2,436	21	1,541	0	351	22	2,484	4	294	24	1,369	7	85
9 Jul	12	2,448	10	1,551	0	351	19	2,503	2	296	19	1,388	5	90
10 Jul	10	2,458	5	1,556	1	352	16	2,519	1	297	10	1,398	4	94
11 Jul	7	2,465	5	1,561	0	352	5	2,524	3	300	13	1,411	1	95
12 Jul	6	2,471	7	1,568	0	352	6	2,530	3	303	13	1,424	0	95
13 Jul	7	2,478	2	1,570	0	352	13	2,543	4	307	12	1,436	2	97
14 Jul	12	2,490	5	1,575	1	353	16	2,559	1	308	12	1,448	1	98
15 Jul	6	2,496	6	1,581	0	353	7	2,566	7	315	9	1,457	0	98
16 Jul	2	2,498	3	1,584	0	353	14	2,580	6	321	19	1,476	6	104
17 Jul	0	2,498	2	1,586	1	354	6	2,586	3	324	7	1,483	0	104
18 Jul	0	2,498	1	1,587	0	354	1	2,587	1	325	3	1,486	1	105
19 Jul	0	2,498	2	1,589	1	355	1	2,588	1	326	7	1,493	1	106
20 Jul	0	2,498	2	1,591	0	355	3	2,591	0	326	3	1,496	2	108
21 Jul			3	1,594	0	355	2	2,593	0	326	1	1,497	0	108

Appendix D. Number of Chinook salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2007.

	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
22 Jul			1	1,595	0	355	0	2,593	0	326	7	1,504	3	111
23 Jul			1	1,596	0	355	0	2,593	0	326	6	1,510	1	112
24 Jul			1	1,597	0	355	0	2,593	0	326	1	1,511	0	112
25 Jul					0	355	0	2,593	1	327	3	1,514	1	113
26 Jul					1	356	0	2,593	4	331	4	1,518	0	113
27 Jul					0	356	4	2,597	1	332	2	1,520	0	113
28 Jul					1	357	7	2,604	1	333	3	1,523	1	114
29 Jul					1	358	7	2,611	3	336	7	1,530	1	115
30 Jul					0	358	1	2,612	1	337	6	1,536	1	116
31 Jul					0	358	0	2,612	2	339	9	1,545	2	118
1 Aug					0	358	0	2,612	0	339	2	1,547	0	118
2 Aug					0	358	2	2,614	0	339	2	1,549	1	119
3 Aug					1	359	0	2,614	0	339	4	1,553	1	120
4 Aug					1	360	1	2,615	0	339	1	1,554	0	120
5 Aug					1	361	1	2,616	0	339	0	1,554	0	120
6 Aug					0	361	3	2,619	0	339	0	1,554	0	120
7 Aug							2	2,621	0	339	1	1,555	0	120
8 Aug							1	2,622	0	339	2	1,557	0	120
9 Aug							0	2,622	0	339	2	1,559	0	120
10 Aug							1	2,623	0	339	0	1,559	0	120
11 Aug											0	1,559	0	120
12 Aug											0	1,559	0	120
13 Aug											2	1,561	0	120
14 Aug											3	1,564	0	120
15 Aug											1	1,565	0	120
16 Aug											1	1,566	0	120
17 Aug											2	1,568	0	120
18 Aug											0	1,568	0	120
19 Aug											0	1,568	0	120
Total	2,498		1,597		361		2,623		339		1,569		120	

Appendix E. Number of sockeye salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2007.

	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	0	0												
21 May	0	0	0	0										
22 May	6	6	0	0	2	2								
23 May	38	44	2	2	0	2								
24 May	10	54	10	12	0	2								
25 May	0	54	13	25	14	16								
26 May	0	54	14	39	12	28								
27 May	0	54	20	59	20	48								
28 May	0	54	53	112	34	82	2	2	0	0				
29 May	0	54	92	204	95	177	1	3	0	0	0	0	0	0
30 May	0	54	172	376	114	291	7	10	1	1	11	11	1	1
31 May	0	54	154	530	235	526	42	52	2	3	34	45	2	3
1 Jun	0	54	188	718	155	681	205	257	5	8	122	167	2	5
2 Jun	0	54	171	889	187	868	451	708	5	13	154	321	2	7
3 Jun	0	54	174	1,063	264	1,132	755	1,463	10	23	162	483	2	9
4 Jun	26	80	108	1,171	265	1,397	884	2,347	11	34	381	864	8	17
5 Jun	118	198	93	1,264	69	1,466	824	3,171	5	39	172	1,036	2	19
6 Jun	0	198	105	1,369	134	1,600	465	3,636	3	42	458	1,494	3	22
7 Jun	0	198	59	1,428	143	1,743	966	4,602	10	52	976	2,470	3	25
8 Jun	34	232	28	1,456	124	1,867	788	5,390	5	57	214	2,684	2	27
9 Jun	28	260	140	1,596	39	1,906	950	6,340	13	70	86	2,770	0	27
10 Jun	0	260	12	1,608	133	2,039	705	7,045	4	74	56	2,826	1	28
11 Jun	0	260	42	1,650	130	2,169	935	7,980	7	81	326	3,152	0	28
12 Jun	0	260	105	1,755	76	2,245	654	8,634	6	87	127	3,279	1	29
13 Jun	0	260	110	1,865	76	2,321	426	9,060	6	93	226	3,505	2	31
14 Jun	0	260	97	1,962	127	2,448	600	9,660	8	101	350	3,855	0	31
15 Jun	15	275	71	2,033	69	2,517	491	10,151	3	104	245	4,100	5	36
16 Jun	0	275	90	2,123	66	2,583	496	10,647	3	107	53	4,153	1	37
17 Jun	0	275	61	2,184	92	2,675	487	11,134	5	112	247	4,400	0	37
18 Jun	0	275	28	2,212	85	2,760	620	11,754	2	114	120	4,520	1	38
19 Jun	0	275	32	2,244	61	2,821	841	12,595	8	122	681	5,201	8	46

Appendix E. Number of sockeye salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2007.

	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
20 Jun	0	275	31	2,275	43	2,864	241	12,836	3	125	307	5,508	1	47
21 Jun	0	275	58	2,333	44	2,908	711	13,547	12	137	75	5,583	0	47
22 Jun	0	275	50	2,383	67	2,975	407	13,954	3	140	274	5,857	1	48
23 Jun	0	275	33	2,416	38	3,013	281	14,235	2	142	250	6,107	3	51
24 Jun	0	275	53	2,469	50	3,063	397	14,632	6	148	437	6,544	4	55
25 Jun	0	275	26	2,495	104	3,167	398	15,030	6	154	427	6,971	4	59
26 Jun	0	275	68	2,563	66	3,233	371	15,401	9	163	351	7,322	0	59
27 Jun	0	275	75	2,638	80	3,313	406	15,807	6	169	588	7,910	5	64
28 Jun	0	275	126	2,764	91	3,404	528	16,335	6	175	512	8,422	8	72
29 Jun	0	275	121	2,885	120	3,524	477	16,812	7	182	393	8,815	3	75
30 Jun	0	275	105	2,990	78	3,602	411	17,223	7	189	208	9,023	2	77
1 Jul	0	275	45	3,035	93	3,695	169	17,392	1	190	76	9,099	1	78
2 Jul	0	275	68	3,103	74	3,769	306	17,698	6	196	117	9,216	0	78
3 Jul	0	275	22	3,125	108	3,877	249	17,947	1	197	265	9,481	2	80
4 Jul	0	275	55	3,180	102	3,979	149	18,096	2	199	217	9,698	3	83
5 Jul	0	275	83	3,263	169	4,148	23	18,119	0	199	213	9,911	2	85
6 Jul	0	275	117	3,380	165	4,313	105	18,224	4	203	297	10,208	2	87
7 Jul	0	275	52	3,432	155	4,468	145	18,369	1	204	374	10,582	4	91
8 Jul	0	275	45	3,477	97	4,565	169	18,538	1	205	397	10,979	3	94
9 Jul	0	275	46	3,523	97	4,662	75	18,613	1	206	280	11,259	3	97
10 Jul	0	275	39	3,562	69	4,731	243	18,856	5	211	440	11,699	6	103
11 Jul	0	275	27	3,589	56	4,787	578	19,434	2	213	678	12,377	5	108
12 Jul	0	275	15	3,604	50	4,837	591	20,025	2	215	1,029	13,406	13	121
13 Jul	0	275	40	3,644	47	4,884	775	20,800	7	222	634	14,040	3	124
14 Jul	0	275	37	3,681	59	4,943	631	21,431	6	228	563	14,603	1	125
15 Jul	0	275	36	3,717	51	4,994	675	22,106	5	233	322	14,925	2	127
16 Jul	0	275	45	3,762	32	5,026	539	22,645	3	236	547	15,472	4	131
17 Jul	0	275	14	3,776	38	5,064	517	23,162	3	239	640	16,112	2	133
18 Jul	0	275	17	3,793	25	5,089	19	23,181	0	239	623	16,735	2	135
19 Jul	0	275	18	3,811	41	5,130	50	23,231	0	239	622	17,357	6	141
20 Jul	0	275	36	3,847	34	5,164	29	23,260	0	239	685	18,042	8	149
21 Jul			36	3,883	36	5,200	18	23,278	0	239	348	18,390	0	149

Appendix E. Number of sockeye salmon tagged, examined, and recaptured at the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2007.

	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
22 Jul			34	3,917	39	5,239	12	23,290	0	239	314	18,704	1	150
23 Jul			65	3,982	16	5,255	9	23,299	0	239	845	19,549	6	156
24 Jul			41	4,023	75	5,330	5	23,304	0	239	952	20,501	8	164
25 Jul					90	5,420	36	23,340	0	239	359	20,860	3	167
26 Jul					115	5,535	180	23,520	4	243	208	21,068	3	170
27 Jul					115	5,650	225	23,745	2	245	498	21,566	4	174
28 Jul					114	5,764	374	24,119	5	250	426	21,992	5	179
29 Jul					115	5,879	300	24,419	0	250	761	22,753	5	184
30 Jul					113	5,992	36	24,455	0	250	194	22,947	3	187
31 Jul					116	6,108	8	24,463	0	250	345	23,292	4	191
1 Aug					115	6,223	8	24,471	0	250	608	23,900	6	197
2 Aug					116	6,339	14	24,485	0	250	717	24,617	8	205
3 Aug					117	6,456	31	24,516	0	250	152	24,769	0	205
4 Aug					113	6,569	72	24,588	1	251	574	25,343	4	209
5 Aug					113	6,682	110	24,698	1	252	446	25,789	2	211
6 Aug					47	6,729	119	24,817	2	254	281	26,070	3	214
7 Aug							150	24,967	3	257	24	26,094	0	214
8 Aug							246	25,213	3	260	62	26,156	0	214
9 Aug							113	25,326	1	261	149	26,305	0	214
10 Aug							246	25,572	4	265	569	26,874	4	218
11 Aug											1,199	28,073	12	230
12 Aug											326	28,399	2	232
13 Aug											333	28,732	1	233
14 Aug											766	29,498	8	241
15 Aug											313	29,811	4	245
16 Aug											105	29,916	1	246
17 Aug											358	30,274	5	251
18 Aug											447	30,721	3	254
19 Aug											258	30,979	2	256
Total	275		4,023		6,729		25,572		265		30,979		256	

PHOTO PLATES

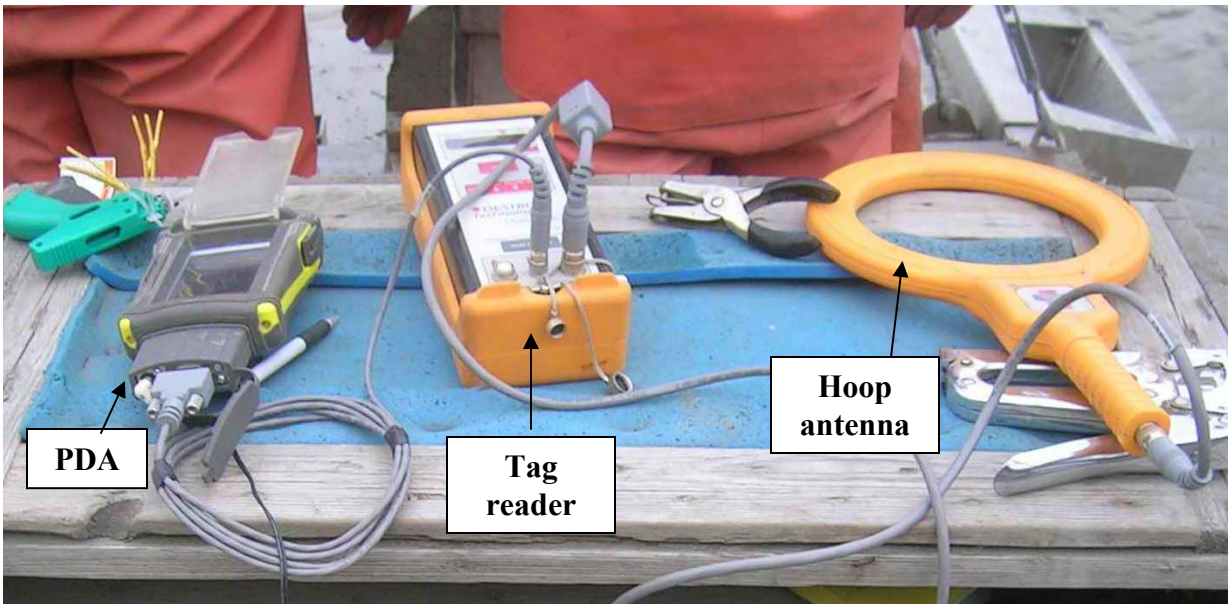

Photo 1. Photo of the PDA, tag reader, and hoop antenna used to automatically read and record the TBA-PIT tags applied to Chinook and sockeye salmon at the Baird Canyon fishwheels on the Copper River, 2007.

Photo 2. Photo of a TBA-PIT tag being inserted into the dorsal musculature of a Chinook salmon at Baird Canyon on the Copper River, 2007.

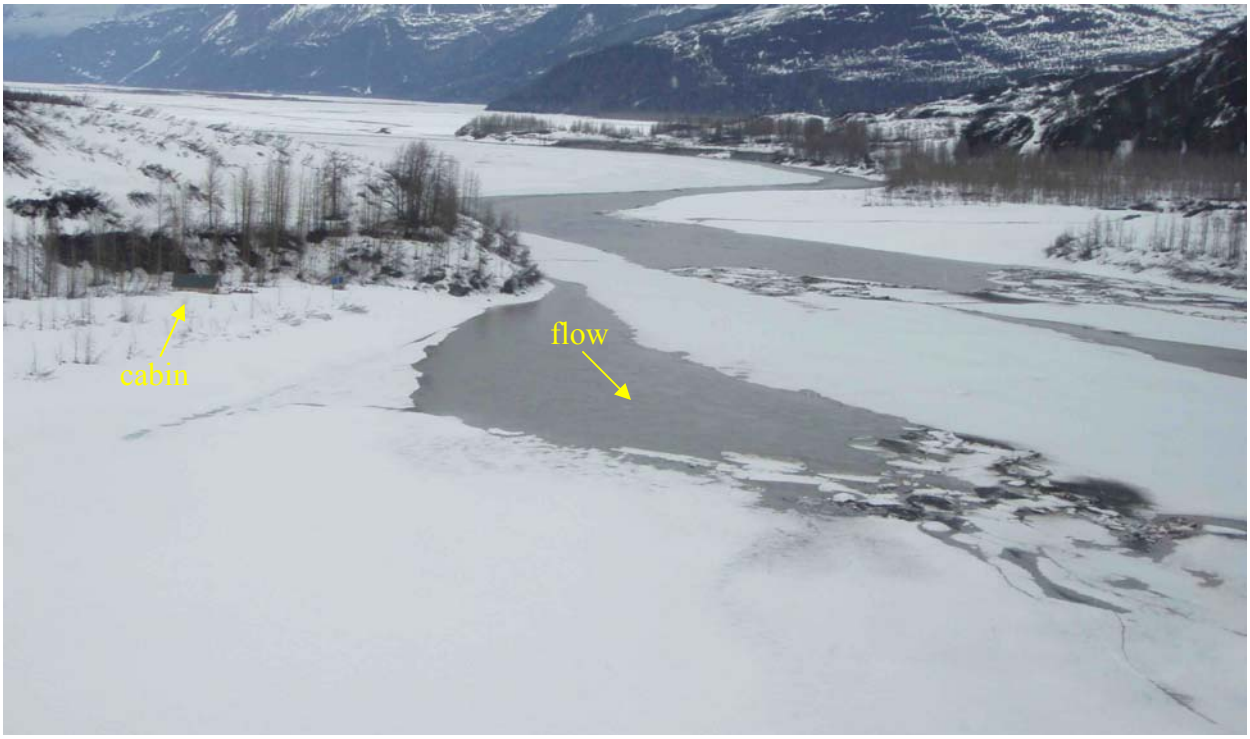

Photo 3. Aerial photograph of the Copper River (looking upstream) and Baird Canyon cabin on the first day of project mobilization, 7 May 2007.