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Estimating the inriver abundance of Copper River sockeye salmon, 2009 annual report

Annual Report for Study 08-501

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ABSTRACT

The purpose of this project was to use fishwheels and two-sample mark-recapture methods to monitor sockeye salmon *Oncorhynchus nerka* escapement on the Copper River. This report summarizes results from the 2009 field season. The main objective in 2009 was to estimate the inriver abundance of sockeye salmon returning to the Copper River such that the estimate was within 25% of the true escapements 95% of the time. For the first sample event, up to three live-capture fishwheels were operated at Baird Canyon for a total of 3,490 h from 13 May to 2 August. During this period, 8,898 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 3,569 h from 19 May to 15 August. A total of 38,115 sockeye salmon were examined for marks, of which 472 were recaptures. Using a temporally stratified Darroch estimator, the estimated abundance of sockeye salmon that migrated upstream of Baird Canyon was 751,133 (SE = 36,623). The median travel time of sockeye salmon marked at Baird Canyon and recaptured at Canyon Creek (91 km upstream) was 9.5 d. This was the final year of this project, which was funded by the Fisheries Resource Monitoring Program (FRMP). This project was one component of a long-term monitoring program operated by the Native Village of Eyak.

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INTRODUCTION

The Copper River supports one of the largest Chinook *Oncorhynchus tshawytscha* and sockeye salmon *O. nerka* subsistence fisheries in Alaska. In addition, this resource is heavily utilized by commercial, sport, and personal-use fisheries. The majority of Copper River salmon are harvested in a commercial gillnet fishery from mid-May through August in the Copper River District (in and around the mouth of the Copper River). The 2009 sockeye salmon harvest of 896,469 fish was below the previous 10-year harvest average of 1,242,000 fish (ADF&G 2010). From 1998 to 2007, 1,344,291 sockeye, 43,059 Chinook, and 285,221 coho *O. kisutch* salmon were harvested annually in the Copper River District (Hollowell and Sommerville 2008). In 2008, an estimated 321,000 sockeye salmon (the 4th smallest harvest since 1970) and 11,500 Chinook salmon were harvested in the Copper River District (ADF&G 2009). Personal-use and subsistence fisheries occur from mid-May through September between Haley Creek and the confluence of the Slana River. From 1998 to 2007, the average annual harvest of sockeye salmon was 115,486 fish in the personal-use fishery and 77,603 fish in the Glennallen Subdistrict subsistence fisheries (Hollowell and Sommerville 2008). Rod-and-reel sport fisheries harvest sockeye salmon in tributaries of the upper Copper River (mainly the Gulkana, Klutina, and Tonsina rivers). The upriver sport fishery harvested 10,986 sockeye salmon on average from 1999 to 2008 (Sommerville 2010).

The 2009-2011 Federal Subsistence Fisheries Regulations identify two main areas in the Copper River drainage where subsistence fisheries take place: 1) Upper Copper River District (Chitina and Glennallen subdistricts), or all waters of the mainstem Copper River from the mouth of the Slana River downstream to an east-west line crossing the Copper River approximately 200 yards upstream of Haley Creek; and 2) Batzulnetas area, or waters of the Copper River and Tanada Creek between National Park Service regulatory markers. Salmon within these areas also have a Customary and Traditional Use determination for certain Alaskan residents. In the Upper Copper River District, salmon may only be harvested using fishwheels, dip nets, and rod and reel. In the Batzulnetas area, salmon may be harvested using fishwheels, dip nets, rod and reel, and (in Tanada Creek only) fyke nets and spears. The fishing season for both areas typically runs from mid-May to the end of September.

Management of Copper River salmon is complex due to inter-annual variation in the size and timing of stocks, fisheries that target a mixture of stocks and difficulties in estimating abundance due to the physical characteristics of the drainage. This is further confounded by the interplay of numerous Federal and State government agencies in the management of this gauntlet of fisheries. The Alaska Department of Fish and Game (ADF&G) manages the commercial fishery to achieve an inriver salmon escapement goal which is monitored using a sonar system at the outlet of Miles Lake. The escapement goal includes a sustainable escapement goal of 300,000 to 500,000 wild sockeye salmon; a goal of 17,500 other salmon species to account for Chinook and other salmon passing the site; annually determined allocations for inriver subsistence, personal-use, and sport harvest based on recent harvest levels; and annually determined allocations for hatchery broodstock and surplus based on forecasted returns. An estimated 709,748 salmon passed the Miles Lake sonar site between 18 May and 1 August 2009, which was 23.4% (134,907 fish) higher than the minimum anticipated count of 574,841 fish (ADF&G 2009).

ADF&G uses a combination of fishery-performance statistics and estimates of sockeye salmon 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 salmon have been met with limited success. From 1960 to 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 to 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 in each of the 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 to 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 salmon enumeration efforts shifted from mark-recapture studies to using weirs and aerial surveys (Willette 2000). Estimates of fish escaping the commercial fishery have been made using sonar counts at the outlet of Miles Lake. In addition, a test-fishing project at Flag Point Channel in the lower Copper River was used to index salmon abundance from 2001 to 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 considered by fishery managers that make decisions regarding commercial openings.

In 2009, Tanada Creek weir counted 38,208 sockeye, which was a record high. The Long Lake weir also had a high return with 5,008 sockeye (McCormick 2009). 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. Sockeye salmon counts at the Tanada Creek weir from 2001 to 2008 (range: 1,649-17,120) were considerably lower than the counts in 1997 (27,521) and 1998 (28,992). Additionally, 555 sockeye salmon were counted at the Long Lake weir in 2008 (through 20 September), which was the lowest count observed 35 years (McCormick 2008). No declines in total inriver salmon returns were detected at the Miles Lake sonar site. Despite the high returns in 2009, upper Copper River sockeye returns remain a concern of upriver user groups. During the 2010 statewide Board of Fisheries meeting, upriver tribes expressed concern over the size and quality of the salmon migrating upriver over the last 3-5 years. Personal testimony by many upriver residents at 2008 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, personal communication). 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. Furthermore, the Gulkana Hatchery was expected to contribute 150,300 sockeye salmon to the 2008 commercial harvest but only contributed 59,900 sockeye salmon.

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 cannot distinguish between co-mingled sockeye, Chinook, and coho salmon. 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). Lastly, prior to 2007, estimates from the DIDSON (or the older Bendix) 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, personal communication). 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, personal communication).

In 2005, NVE initiated a feasibility study to determine whether Copper River sockeye salmon escapements could be monitored using fishwheels and mark-recapture methods (van den Broek and Smith 2006). These methods 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 on sockeye and Chinook salmon from 2001 to 2007 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; van den Broek et al. 2008).

This project addresses the highest ranked information need for Federal subsistence fisheries that was identified by the Fisheries Resource Monitoring Program (FRMP) in their 2008 request for proposals. Specifically, this project will conduct "research to improve and verify estimates of inriver returns for Copper River sockeye salmon," and "estimate or index abundance of total run by species." It is important to note that this project was 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. This project was integrated with another ongoing FRMP project: FIS07-503 – Estimating the abundance of Copper River Chinook 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 08-501.

Objectives

The main objective of this project was:

1. To estimate the annual inriver abundance of sockeye salmon returning to the Copper River in 2009 such that the estimates were within 25% of the true values 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 salmon using fishwheels. Baird Canyon is the first major channel constriction on the Copper River upstream of Miles Lake that is suitable for operating the capture-tag fishwheels (Figure 2). The east bank of Baird Canyon is a steep, often sheer, rock wall that rises over 600 m above the river. The west bank slopes more moderately to a maximum height of 20 m above the river, is densely wooded, and has a substrate ranging from sand to boulders. The land beyond the west bank is primarily a wetland area that drains the Allen Glacier to the west. The north branch of the Allen River enters on the west bank and is the only major tributary entering Baird Canyon. Wood Canyon is the second major channel constriction on the Copper River upstream of Miles Lake and is located approximately 91 km upstream of Baird Canyon (Figure 3). The lower end of Wood Canyon, just below the mouth of Canyon Creek and the lower boundary of the Chitina Subdistrict dip net fishery, was considered a suitable location for operating the recapture fishwheels. The west bank in this area consists mostly of steep rock walls, whereas the east bank is a mix of sand bars, rock outcroppings, and rock walls.

Chinook and sockeye salmon begin to enter the Copper River in early to mid-May, as rising temperatures and water flush the ice from the river. Nearly all Chinook and sockeye salmon enter the river by early August (Merritt and Roberson 1986; Evenson and Savereide 1999; Morstad et al. 1999; Evenson and Wuttig 2000; Sharp et al. 2000). Major sockeye salmon spawning tributaries include the Chitina, Tonsina, Klutina, Tazlina, and Gulkana rivers (Smith et al. 2006; Wade et al. 2007, 2008).

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. Eight full-time technicians were hired, including three returning technicians and one intern, who was a rural Alaskan native from 2008. Several other local residents were hired temporarily throughout the season during peak sampling periods, mobilization, and de-mobilization. Preseason training consisted of an overview of the project and NVE policies, first aid/CPR certification, shotgun maintenance, and safety training including bear safety videos, Copper River salmon fisheries management overview, and basic outboard motor maintenance and troubleshooting. Inseason training focused on fishwheel operation, maintenance and safety, boat operation and maintenance, fish sampling, data entry in personal digital assistant (PDA) units, PDA passive integrated transponder (PIT) tag scanner, database management, and basic computer skills.

Permit Requirements

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

Fishwheel Design and Construction

Three tagging fishwheels (fishwheels 1, 2, and 5) were operated at Baird Canyon (rkm 66), and two recovery fishwheels (fishwheels 3 and 4) at Canyon Creek (rkm 157) in 2009. 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. Fishwheels 1 and 2 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). Fishwheel 3 was designed similar to fishwheels 1 and 2 except the baskets were shorter, which allowed it to fish at shallower depths present in the Canyon Creek area. 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 and four bunkhouses (built by NVE in the summer of 2008) served as the field camp in 2009. The camp 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, which was located on the east bank of the Copper River approximately 12 km downstream from Chitina (Figure 3), consisted of two Weatherport tents and individual wall tents for crew members. The upriver camp 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

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 2009 were installed and operated similar to the methods used in 2008 (van den Broek et al. 2009). 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. Daily fishing effort was computed as the number of hours that a fishwheel operated on a given calendar day from midnight to midnight. 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.

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. 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. Fish 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 troughs was changed repeatedly throughout each sampling session. All fish species were counted prior to release.

At Baird Canyon, sockeye salmon that were in good condition were marked with a radio-frequency identification (RFID) transponder (ENSID Technologies, Inc, Auckland, New

Zealand). These passive, 134.2 kHz FDX transponders were encapsulated on a t-bar tag with two, 25-mm monofilament lines that terminated in 9-mm anchor bars (herein referred to as TBA-PIT tags). NVE's address and phone number were printed on a 45-mm piece of yellow PVC marker (Hallprint Pty Ltd, Adelaide South Australia). Unique tag numbers were electronically encoded and read via a PDA with integrated RFID scanner. The TBA-PIT tags were a new technology specially designed for this project. Tags were supplied in magazine clips of 20 tags each, and were applied to fish using a handheld applicator gun with 16-gauge needle. The tip of the needle was sunk into the musculature of the fish 1-2 cm ventral to the insertion of the dorsal fin between the third and forth pterygiophores, to a depth of 1-2 cm, so that the tag anchors would lodge behind the pterygiophores within the dorsal musculature when ejected from the applicator gun.

The portion of each day's fishwheel catch that received a tag was based on the number of salmon counted at the Miles Lake sonar site the previous day. A portion of sockeye salmon captured each day also received a gastrically implanted radio transmitter and a uniquely numbered, external t-bar tag as part of a separate study. Radio-tagged sockeye salmon were included in the marked sample for estimating abundance.

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 sockeye salmon caught at the Canyon Creek fishwheels were physically examined for a tag and scanned with a PDA with integrated RFID scanner to record the unique ID if a tag was observed. Since the TBA-PIT tags were external and easily seen, and each fish was handled by the crew, it is unlikely that a tagged fish was captured and not observed at the Canyon Creek fishwheels.

Inriver Abundance Estimates

Conditions for a Consistent Abundance Estimate

Two-sample mark-recapture methods were used to estimate the inriver abundance of adult sockeye salmon above the Baird Canyon fishwheels. The abundance estimate is potentially biased if any of the assumptions inherent to the mark-recapture model are violated (Ricker 1975; Seber 1982).

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

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

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

Tag loss on sockeye salmon was tested indirectly through the application of a secondary mark (operculum punch) on tagged Chinook salmon as part of a separate study. Tag loss would be estimated from the proportion of Chinook salmon captured at Canyon Creek with a secondary mark and no primary mark. 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 table analyses were used to compare mark and recapture rates by bank of capture in 2008.

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

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

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

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

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

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

Abundance Estimate

One of two models was used to provide mark-recapture estimates: the pooled Petersen estimator (PPE) with Chapman's correction (Seber 1982) or the partially stratified Petersen estimator (i.e., the Darroch model (Darroch 1961)). Schwarz and Taylor (1998) provide thorough descriptions of both models. The PPE pools all of the data from the entire sampling season to estimate abundance, whereas the Darroch model is used to stratify the data into groups with similar capture and/or movement probabilities (in this case temporally). The abundance estimate was calculated using the software SPAS (Arnason et al. 1996).

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

RESULTS

Project Mobilization

Mobilization of the Baird Canyon camp began on 6 May. Six technicians, one project manager, one biologist, one Starband installation technician, and gear were flown to camp on several round-trip flights via helicopter (A-Star, Era Helicopters, Valdez AK). Open water and some ice were present throughout the Copper River from above Baird Canyon at the Bremner River confluence downstream to the Mile 27 and Mile 38 bridges. Miles Lake was ice locked and not navigable by boat until approximately 12 May. Snow cover was approximately 1.5-m deep upon arrival at camp and much of the equipment was partially buried but in good condition. Fishwheel 1 began fishing at Baird Canyon on 13 May, followed by fishwheel 5 on 15 May and fishwheel 2 on 25 May.

Mobilization of the Canyon Creek camp began on 15 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 season, the baskets on fishwheel 3 had to be repaired and re-webbed. Fishwheel 4 required new bow decking and basket repair. Fishwheel 4 began fishing on 18 May followed by fishwheel 3 on 20 May.

Fishwheel Operation and Catch

Fishwheel Operation

Stage height of the Copper River at Baird Canyon varied by 6.3 m from 13 May to 2 August (Figure 4). At Canyon Creek, stage height varied by 4.5 m from 18 May to 15 August. Water levels rose slowly in late May, increased quickly in early June, and fluctuated throughout the remainder of the season. Stage height peaked on 31 July at both sites. In 2009, stage height of the Copper River at the Million Dollar Bridge was above the historical average from late May to mid-June, dropped below average from late June to early July, and was above average again in mid- and late-July (Figure 5).

Fishwheel 1 operated on the west bank of Baird Canyon for 1,275 h (75.3% of the time) from 13 May to 28 July (Figure 6; Appendix A.1). Fishwheel 2 operated on the east bank of Baird Canyon for 1,131 h (98.4% of the time) from 25 May to 2 August. Fishwheel 5 operated on the west bank of the Copper River approximately 1.5 km upstream from Baird Canyon for 1,084 h (99.1% of the time) from 15 May to 3 July. Fishwheel speeds averaged 2.3, 1.8, and 2.9 RPM for fishwheels 1, 2, and 5, respectively (Figure 6; Appendix A.1).

At Canyon Creek, fishwheel 3 operated along the east bank of the Copper River approximately 2.5 km downstream from the mouth of Canyon Creek. From 20 May to 15 August, it operated for 1,962 h (94.5% of the time). Fishwheel 4 operated primarily on the west bank approximately 1.5 km downstream from the mouth of Canyon Creek, and fished for 1,607 h (94.8% of the time) from 18 May to 29 July. Fishwheel 4 also operated approximately 0.75 km upstream from the mouth of Canyon Creek on the east bank from 29 May to 6 June until water levels dropped. Fishwheel speeds averaged 1.8 and 3.9 RPM for fishwheels 3 and 4, respectively.

Fishwheel Catch

A total of 17,723 adult sockeye salmon were captured at the Baird Canyon fishwheels: 2,016 at fishwheel 1, 11,008 at fishwheel 2, and 4,699 at fishwheel 5 (Figure 7; Appendix B.1). Total daily catch peaked at 496 sockeye salmon on 20 June. These catches do not reflect the total number of sockeye salmon actually caught by the fishwheels, but only those fish 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. Thirty-four salmon smolts, 1 pink salmon *O. gorbuscha*, 1 steelhead trout *O. mykiss*, 79 Dolly Varden *Salvelinus malma*, 30 whitefish *Coregonus spp.*, 20 Pacific lamprey *Lampetra tridentata*, 17 sucker *Catostomus sp.*, and 1 burbot *Lota lota*, were also captured and released.

A total of 38,119 sockeye salmon were captured at the Canyon Creek fishwheels, including 16,376 at fishwheel 3 and 21,743 at fishwheel 4 (Figure 8; Appendix B.1). Daily catch peaked at 1,714 sockeye salmon on 16 June. Similar to Baird Canyon, these catch data reflect only sockeye salmon captured and retained during periods when escape panels were closed. Four coho salmon, 4 steelhead trout, 18 Dolly Varden, 118 whitefish, 30 Pacific lamprey, 79 sucker, 58 salmon smolt, and 8 arctic grayling *Thymallus arcticus* were also captured and released.

Tag Application and Recovery

Of the 17,723 sockeye salmon that were captured at the Baird Canyon fishwheels, 8,898 fish (50.2%) were tagged and released (Figure 9; Appendix C.1). This included 536 radio-tagged fish and 8,362 TBA-PIT-tagged fish. The number of tags applied on a single day peaked at 237 on 27 May. Daily tag quota at Baird Canyon was set at 1.19% of the previous day's salmon count at the Miles Lake sonar site. The majority of sockeye salmon that were released untagged were done so because the daily tagging quota had been met.

A total of 38,115 sockeye salmon were examined for primary and secondary marks at the Canyon Creek fishwheels (Figure 10; Appendix C.1). Of those examined, 472 (1.2%) were recaptures, or fish that had been marked at Baird Canyon. The first recaptures were caught at Canyon Creek on 23 May (tagged 18, 19, and 20 May) and the last recaptures were caught on 14 August (tagged 31 July and 1 August). The number of sockeye examined for marks at Canyon Creek peaked at 1,714 fish on 16 June and the number of recaptures peaked at 24 fish on 16 June. The median travel time of sockeye salmon tagged at Baird Canyon and recaptured at Canyon Creek was 9.5 d (range: 3.0-37.3 d; Figure 11).

Inriver Abundance Estimate

Conditions for a Consistent Estimator

Handling and tagging procedures at Baird Canyon did not appear to significantly delay the migratory behavior of sockeye salmon. Of the 119 sockeye salmon captured twice at the Baird Canyon fishwheels, 86 fish (72.3%) were recaptured within 1 d of being tagged (Figure 12). The longest delay between capture events was 11.3 d.

Recapture rates of sockeye salmon that were tagged on the west bank (5.0%) of the river at Baird Canyon were not significantly different than recapture rates of fish tagged on the east bank (5.1%; $\chi^2 = 0.03$, df = 1, P = 0.857; Table 1). 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 ($\chi^2 = 2.41$, df = 1, P = 0.12; Table 2). In each of these tests, 18 recaptures with unknown release locations were excluded. Mark rates of sockeye salmon inspected on the west bank (1.4%) at Canyon Creek were not significantly different than mark rates of fish inspected on the east bank (1.2%; $\chi^2 = 0.13$, df = 1, P = 072.; Table 3).

Cumulative length-frequency distributions of sockeye salmon marked in the first event and recaptured in the second event were not significantly different ($D_{max} = 0.056$, P = 0.26; Figure 13). In contrast, cumulative length-frequency distributions of fish marked in the first event and fish examined for marks in the second event were significantly different ($D_{max} = 0.59$, P = 0.00). No significant difference ($D_{max}= 0.036$, P = 0.78) was found between cumulative length-frequency distributions of fish examined and recaptured in the second event. Based on these results, there was no size selectivity during either event and no stratification by size was necessary to estimate abundance.

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 as indicated by significantly different mark rates between periods of recapture ($\chi^2 = 13.9$, df = 1, P = 0.00; Figure 14). Similarly, recapture rates were significantly different between periods of marking ($\chi^2 = 30.3$, df = 1, P = 0.00; Figure 15). These results indicated that a temporally stratified estimator was required to estimate abundance.

Abundance Estimate

Using a maximum likelihood Darroch estimator, the estimated abundance of sockeye salmon that migrated upstream of Baird Canyon from 13 May to 2 August was 729,510 (SE = 34,190; 95% CI = 662,497-796,523). This estimate was based on 8,898 tagged fish available for recapture, 38,115 fish examined for marks, and 472 recaptures.

Other Tag Recoveries

A total of 1,051 sockeye salmon (11.1% of total tagged) were recovered from various locations (Table 5). Of these, 677 (7.6% of total tagged) fish were reported harvested, including: 262 in the federal and state subsistence fisheries (primarily fishwheels), 226 in the personal-use dip net fisheries, 27 (26 retained and 1 released) in the inriver sport fishery, 160 in unspecified inriver fisheries, and 2 in the commercial gillnet fishery. Additional tag recoveries included: 309 during the Crosswind Lake broodstock collection, 60 during the Gulkana broodstock collection, 3 found on the ground, and 2 recovered by ADF&G in various spawning tributaries during genetic sampling studies. There were also 28 tag recoveries for which the species was not reported. The median travel time for sockeye salmon tagged at Baird Canyon and recovered during broodstock collection at the Gulkana Hatchery was 55 d (range: 18-82 d; Figure 16).

DISCUSSION

Project Mobilization

In 2009, river ice was minimal as compared to previous years and snow cover was just over 1 m deep, which was considerably less compared to the previous two seasons. It took approximately 9 d from the time the crew arrived at camp (6 May) until the successful deployment of all three fishwheels (15 May). This was comparable to 2005 (9 d), and considerably faster than the time it took to mobilize in 2004 (21 d), 2006 (18 d), 2007 (16 d) and 2008 (13 d) when similar environmental conditions were encountered. The first fishwheel was launched and began fishing on 13 May, followed by fishwheel 5 (15 May) and fishwheel 2 (25 May). Fishwheel 5 needed extensive repairs to the basket assembly that delayed deployment, and fishwheel 2 was delayed due to low river levels and changing conditions at the fishing site.

As in previous years, the Canyon Creek fishwheels were stored intact at the camp site. Routine repairs to both fishwheels were required prior to sampling. Between repairs, logistics of preparing fishwheels, and the establishment of camp, it took approximately 5 d from the first day of mobilization on 15 May until the first wheel was actively fishing on 20 May. Camp preparation was delayed approximately 1 d due to improper storage of tents and tools from the previous season. The tents had extensive mold growth that required cleaning and the tool storage Weatherport was damaged during the winter and subsequently disorganized. Also, due to the low river levels, fishwheels had to be moved over a longer distance for deployment. This added at least 1 d to the mobilization effort. The timing and execution of mobilization at both camps was suitable given the environmental conditions in early May. No early run fish were missed by either site.

Data Collection

In 2009, weatherproof PDA units with integrated RFID-PIT-tag scanners were used with new software designed specifically for the needs of this project. This significantly reduced the amount of down time due to equipment failures and minimized the chances of data loss or data-entry errors. However, some issues with the weatherproof PDA units persisted in 2009, which were partially attributed to increased sampling efficiency, being able to collect data more rapidly, and a faulty seal within some of the weatherproof PDA's. This necessitated the use of hand-logging data on paper in order to back-up the electronic data.

Fishwheel Operation and Catch

Through the first four openers (14, 18, 25, and 28 May) in the Copper River District, harvest of sockeye salmon was the 10th largest since 1980, and harvest of Chinook salmon was the smallest since 1980. The Miles Lake sonar through 29 May had counted 144,104 fish versus an anticipated 112,084 fish, resulting in the fishery opening 1 June for 36 h, 8 June for 12 h and subsequently closed until 17 June when it opened for 12 h. Conversely, during the previous three seasons (2006-08) the commercial fishery was closed by emergency order (EO) for portions of the fishing season from 14 May to 17 June.

At Canyon Creek, sockeye salmon catches in 2009 (38,115 fish) were 24% lower than in 2008 (50,305 fish). The reduction in catches was mainly attributable to difficulties in finding a

suitable fishing site for fishwheel 4 and persistent high water. Due to the October 2006 flood, depth and velocity conditions at the fishwheel 4 site used in previous years made it unsuitable. Much of the season was spent relocating and adjusting fishwheel 4 in order to keep it safe and fishing properly in an attempt to maximize catches. Persistent high water from 8-13 June and 4 July to 10 August also affected fishing effort. At times the fishwheels had to be shut down to reposition them into more fishable locations. On the evening of 29 July, fishwheel 4 broke loose from its anchor and was swept down river. It was subsequently shut down for the remainder of the season due to extensive damage. The early shut down of fishwheel 4 had an obvious impact on the overall catch of sockeye. Despite these challenges, a sufficient number of sockeye were caught to meet the study objectives.

Abundance Estimate

The 2009 abundance estimate for sockeye salmon (729,510; CV = 4.7%) appeared unbiased and exceeded the precision levels specified in the study objectives. The mark-recapture estimate was 2.8% (19,762 fish) greater than the 2009 Miles Lake sonar count of 709,748 salmon. If the estimated number of Chinook salmon that migrated above Baird Canyon (32,401) was subtracted from the Miles Lake sonar count, then the sockeye mark-recapture estimate was 7.7% (52,163 fish) greater than the adjusted sonar count. The 2009 inriver goal for salmon passing the Miles Lake sonar was set at 592,051 to 792,051 fish.

The number of tagged sockeye salmon released at Baird Canyon that were available for recovery at Canyon Creek was not adjusted to account for potential handling or tag-induced mortality. A radiotelemetry study conducted in 2009 showed that 5.4% (29 out of 536) of radio-tagged sockeye salmon released at the Baird Canyon fishwheels were either never detected after release or failed to migrate upstream of the tagging site (G. Wade, LGL, Anchorage; personal communication). If a similar "drop-out" rate occurred in TBA-PIT-tagged fish, and the total number of tagged fish available for recovery was adjusted accordingly, then the 2009 mark-recapture abundance estimate decreased to 690,117 fish, which is only 1.9% more than the 2009 Miles Lake sonar count (less the Chinook estimate). 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 be expected to have a higher rate of handling or tag-induced mortality.

Given the high catch rates observed for sockeye salmon during both sampling events, it was relatively easy to capture a sufficient number of fish to satisfy the project requirements. The real challenge was trying to evenly distribute sampling effort over the entire run to avoid biasing the abundance estimates, running out of tags, or being left with extra tags at the end of the season. This was particularly challenging because of the use of escape panels, which precluded accurately counting daily fishwheel catches. Miles Lake sonar counts were the only measure of salmon abundance available to determine tagging rates at Baird Canyon, and this method seemed to work well. The tagging crew knew the 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 the forecasted run strength.

From 1998 to 2008, an estimated 193,917 sockeye salmon were harvested annually in fisheries upstream of Baird Canyon (Sommerville 2009). If similar harvest levels were assumed to have occurred in 2009 (2009 data was not available at the time of reporting), then the spawning escapement of sockeye salmon was 535,593 fish (729,510 minus 193,917). This level of escapement exceeds the sustainable escapement goal of 300,000 to 500,000 spawners in the Upper Copper.

CONCLUSIONS

Despite the numerous and often significant challenges encountered during this study, the main project objective was achieved. For the second consecutive year, a consistent and reliable abundance estimate for Copper River sockeye salmon was estimated. This work has helped to make 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.

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TABLES

Table 1. 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, 2009.

Bank of Release	Recaptured	Not Recaptured	Tagged	Recapture Rate
West (FW1&5)	168	3,160	3,328	0.050
East (FW2)	286	5,284	5,570	0.051
Total	454	8,444	8,898	0.051

Chi-square = 0.03 df = 1 p-value = 0.857

Excludes 18 recaptures with unknown release locations

Table 2. 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, 2009.

	Bank of Recovery		
Bank of Release	West	East	Recaptured
West (FW1&5)	7	161	168
East (FW2)	5	281	286
Total	12	442	454

Chi-square = 2.41 df = 1 p-value = 0.121

Excludes 18 recaptures with unknown release locations.

Table 3. 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, 2009.

Recovery Location	Marked	Not marked	Total Examined	Mark Rate
West	12	867	879	0.014
East	458	36,778	37,236	0.012
Total	470	37,645	38,115	0.012

Chi-square = 0.13 df = 1 p-value = 0.72

Table 4. Capture history of sockeye salmon that were tagged, examined, and recaptured at the Copper River fishwheels, 2009. Bold text indicates the data used for the Chi-square tests.

Period of marking	Period of recapture 5/20-6/25	6/26-8/15	Recaptured	Not recaptured	Marks	Recapture rate
5/15-6/18	272	4	**276**	**3833**	4,109	0.067
6/19-8/2	6	190	**196**	**4593**	4,789	0.041
Recaps	**278**	**194**	472	8,426	8,898	0.053
Unmarked	**18,916**	**18,727**	37,643			
Examined	19,194	18,921	38,115			
Mark rate	0.014	0.010	0.012			

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

Table 5. Number of tagged sockeye salmon recovered, by location and tag type, 2009.

Recovery Location	Tag Type TBA-PIT	Radio	Total	Percent of Recoveries	Percent of Tags Applied
ADF&G research	2	0	2	0.2	0.0
Commercial gillnet	2	0	2	0.2	0.0
Chitina Subdistrict	204	22	226	21.5	2.4
Glennallen Subdistrict	228	34	262	24.9	2.8
Sport fishery	26	1	27	2.6	0.3
Gulkana Hatchery Broodstock	55	5	60	5.7	0.6
Crosswind Lake Broodstock	309	0	309	29.4	3.3
Found on ground	0	3	3	0.3	0.0
Unknown location	136	24	160	15.2	1.7
Total	962	89	1,051	100.0	11.1
Tags Applied at Baird Canyon	8,898	536	9,434		
% recovered	10.8%	16.6%	11.1%		

An additional 28 tags were recovered for which the species was not reported.

FIGURES

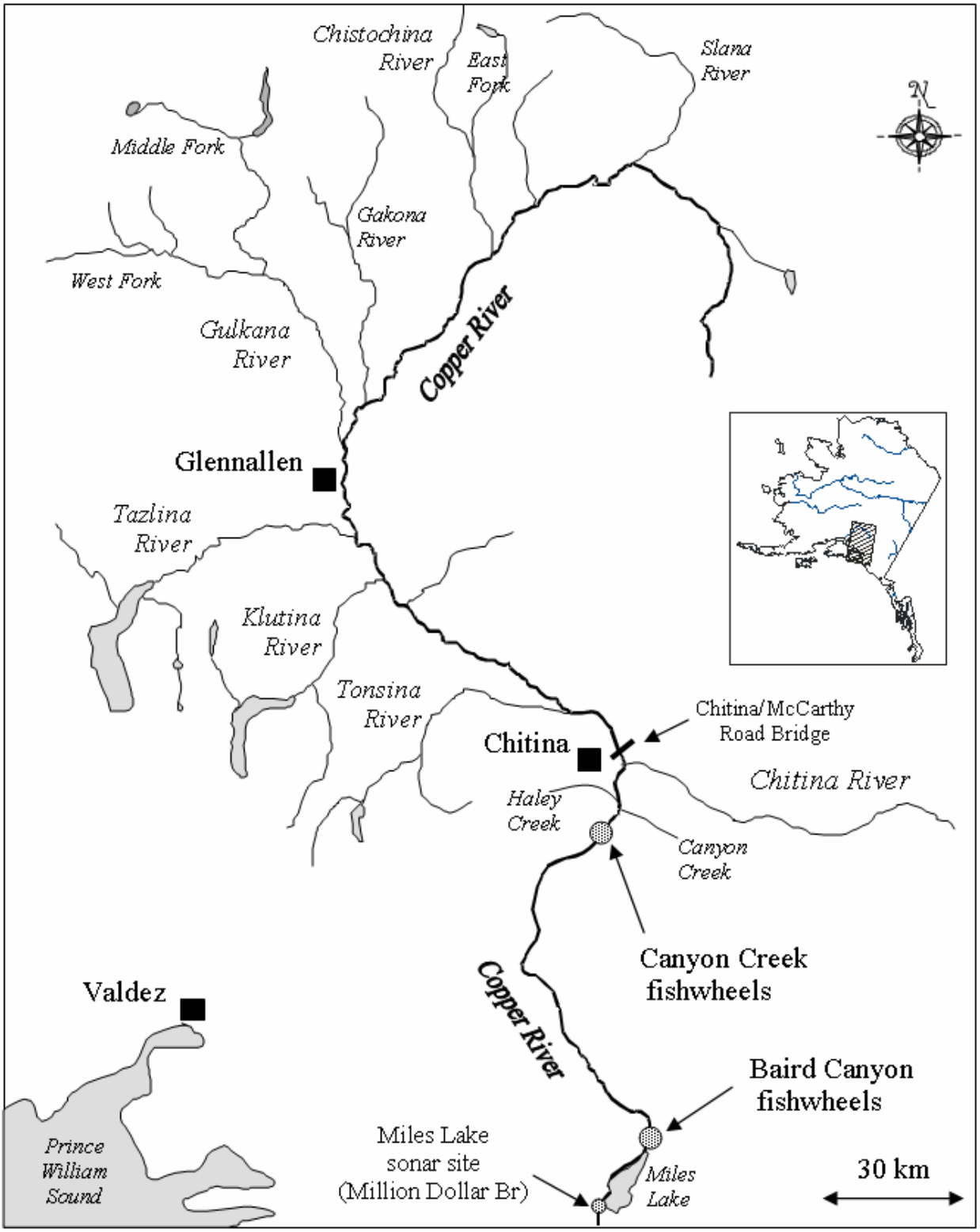

Figure 1. Map of the study area showing the location of the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2009.

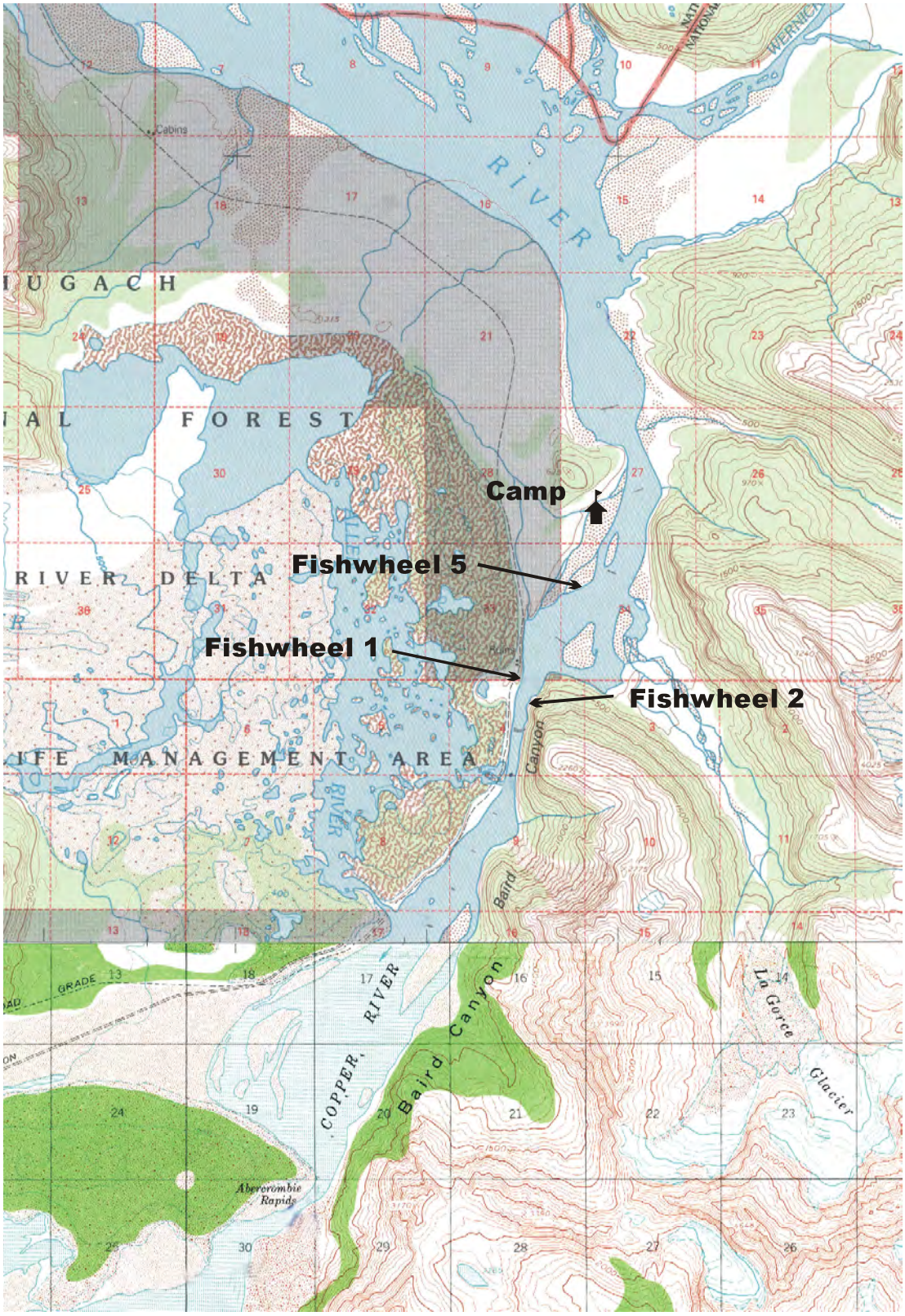

Figure 2. Map of Baird Canyon on the Copper River showing the location of the camp and fishwheel sites that were used in 2009.

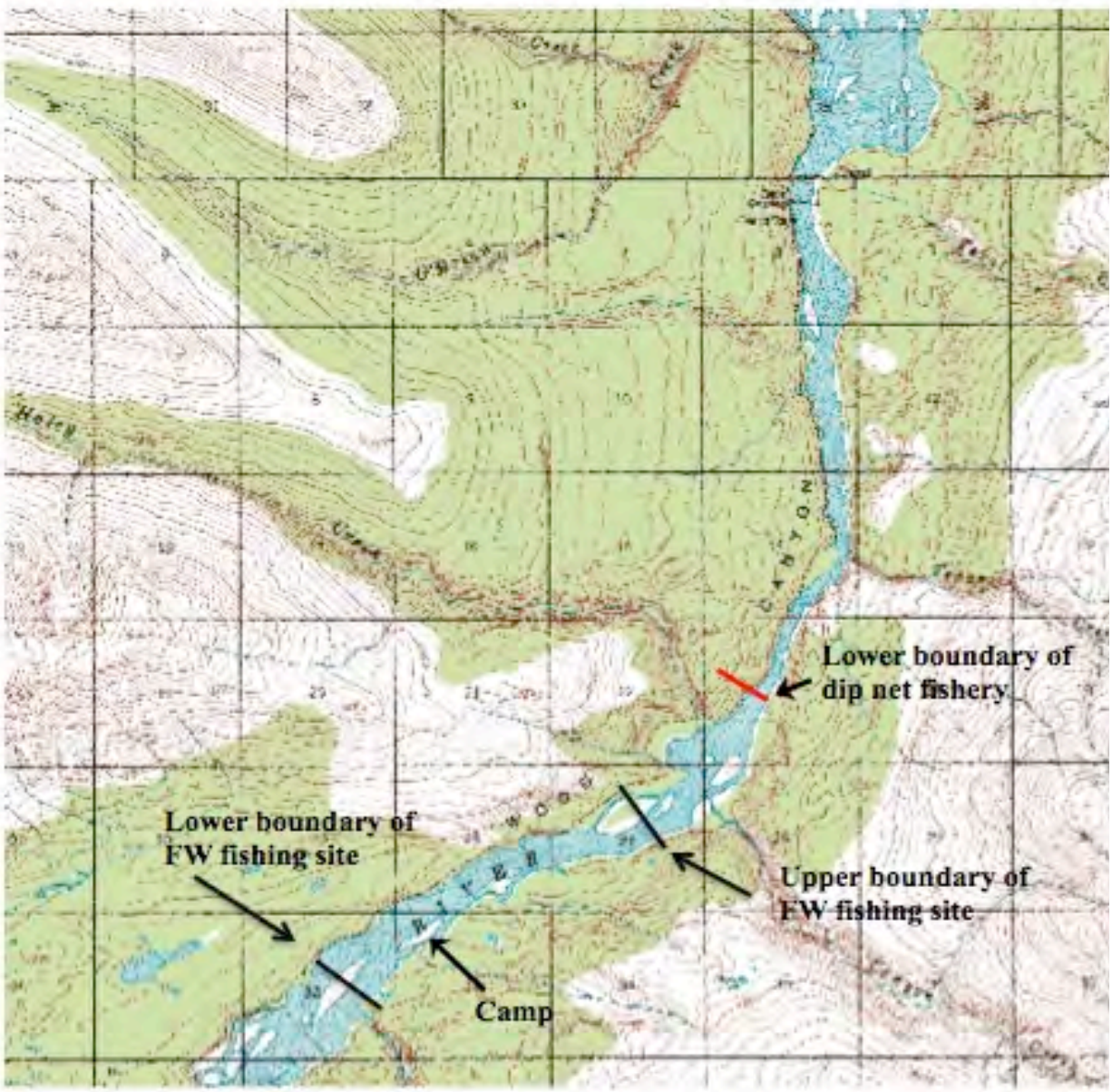

Figure 3. Map of Wood Canyon on the Copper River showing the location of the Canyon Creek camp and fishwheel sites that were used in 2009, and the lower boundary of the Chitina Subdistrict dip net fishery.

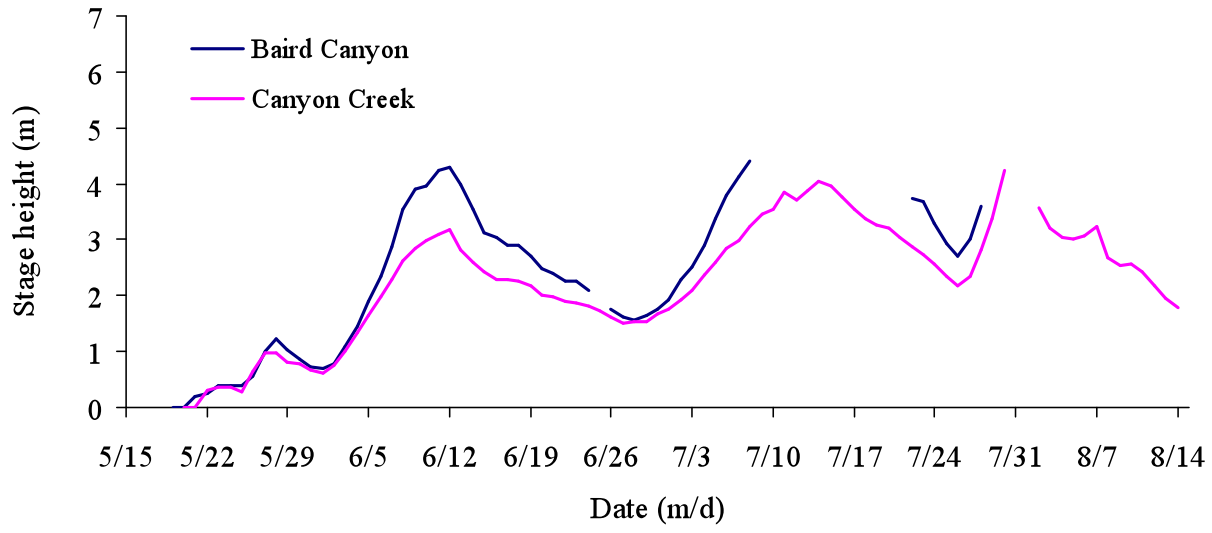

Figure 4. Stage height of the Copper River near the Baird Canyon and Canyon Creek fishwheels, 19 May to 14 August 2009.

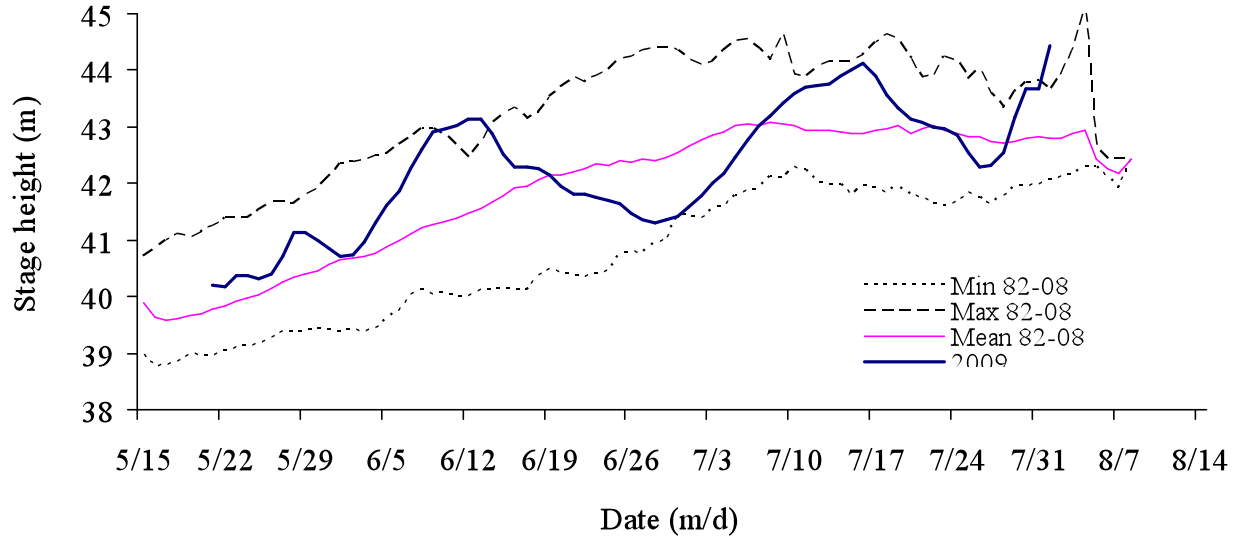

Figure 5. Stage height of the Copper River at the Million Dollar Bridge, 1982-2009.

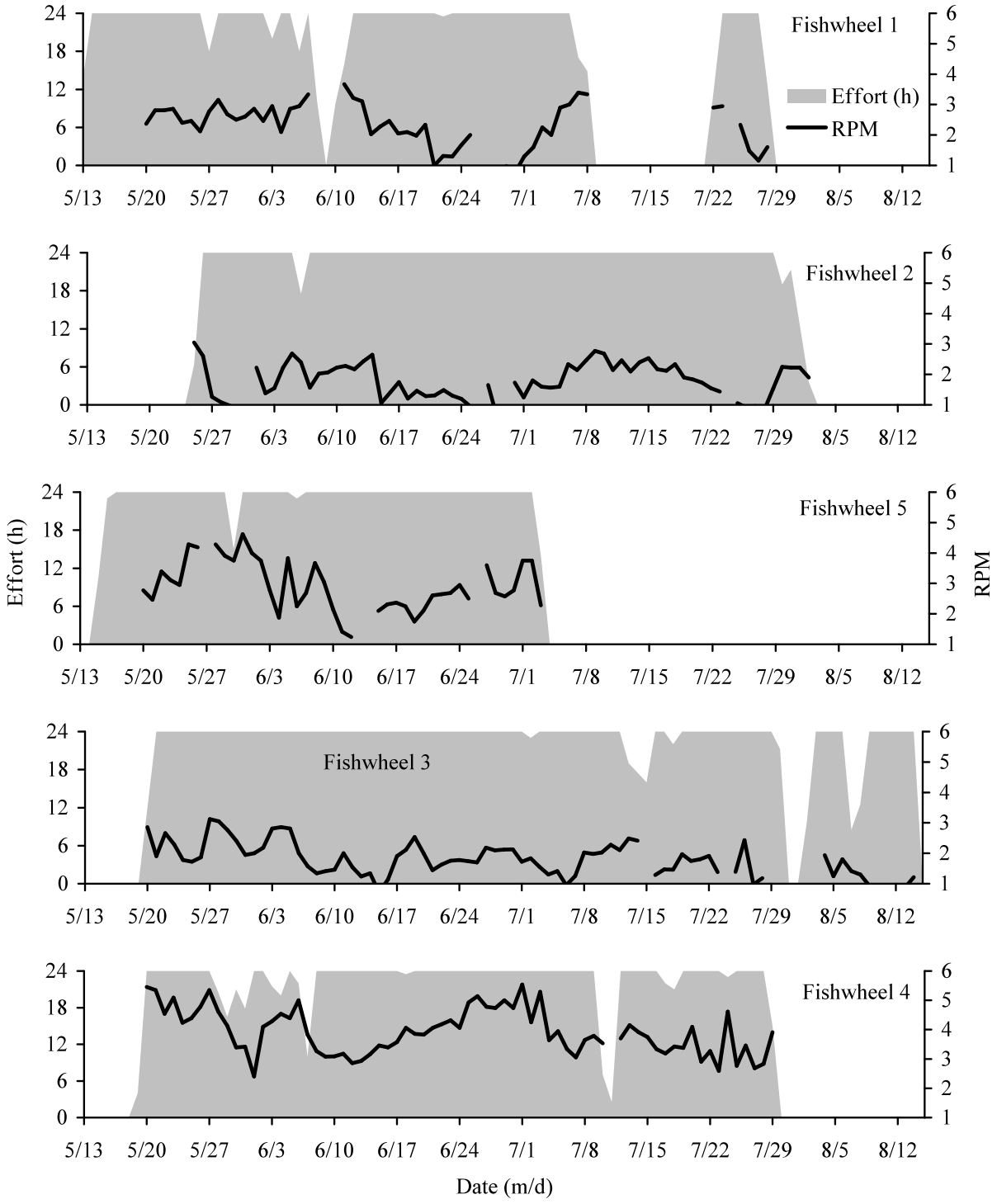

Figure 6. Fishwheel effort (h) and speed (RPM) at the Baird Canyon (fw 1, 2, and 5) and Canyon Creek (fw 3 and 4) fishwheels on the Copper River, 2009.

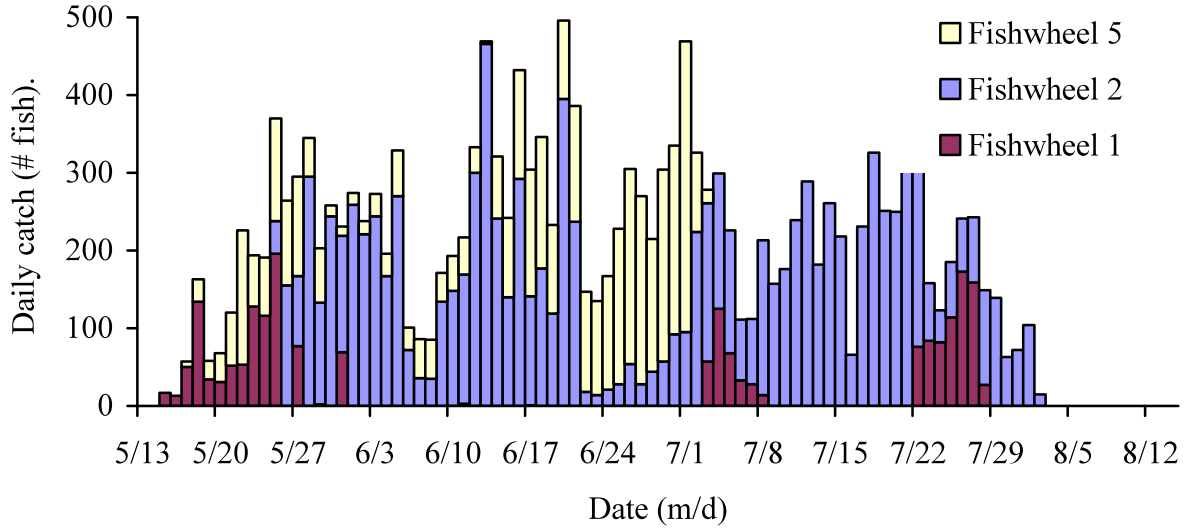

Figure 7. Daily catch of sockeye salmon at the Baird Canyon fishwheels on the Copper River, 2009. These catch data do not reflect the total number of sockeye salmon actually caught by the fishwheels, but only those that were retained in live tanks when the escape panels were closed.

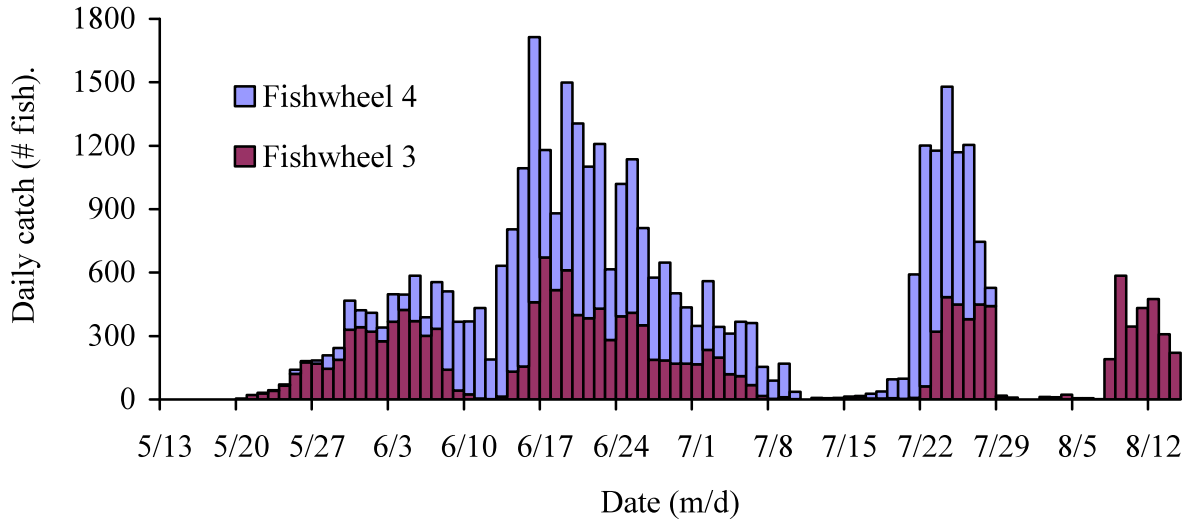

Figure 8. Daily catch of sockeye salmon at the Canyon Creek fishwheels on the Copper River, 2009.

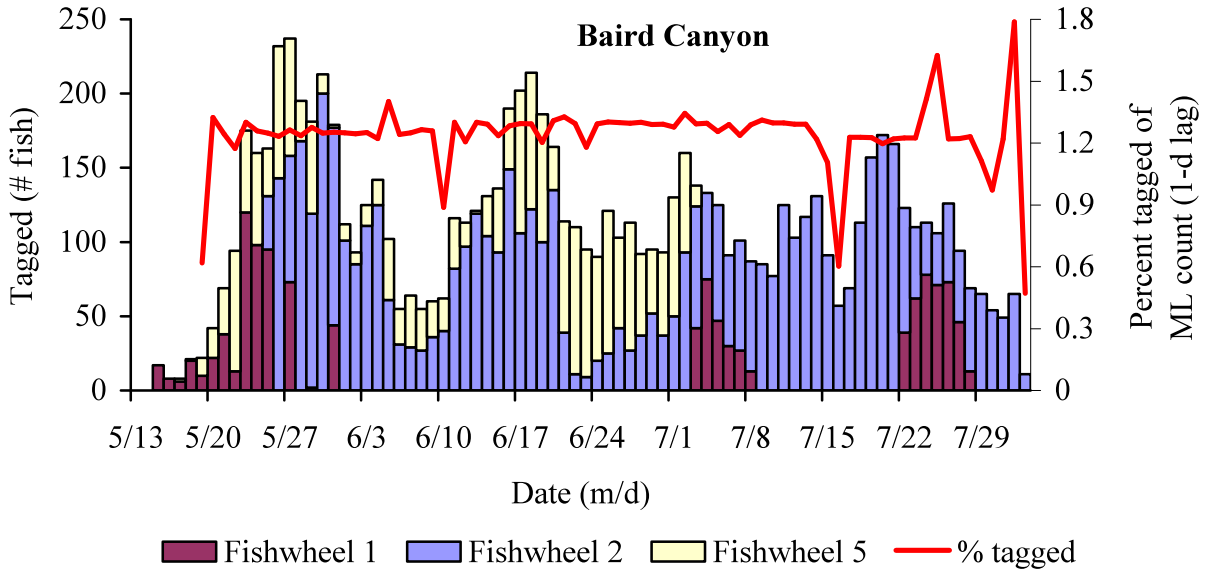

Figure 9. Number of sockeye salmon tagged at the Baird Canyon fishwheels and the proportion of sockeye salmon tagged relative to the previous day's count at the Miles Lake sonar site.

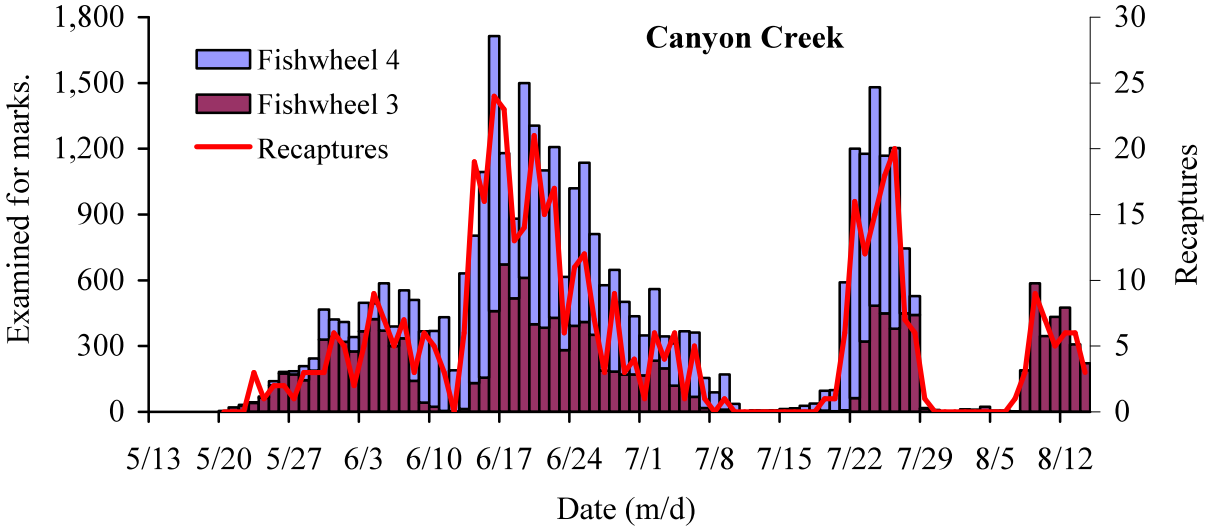

Figure 10. Number of sockeye salmon examined for marks and recaptured at the Canyon Creek fishwheels on the Copper River, 2009.

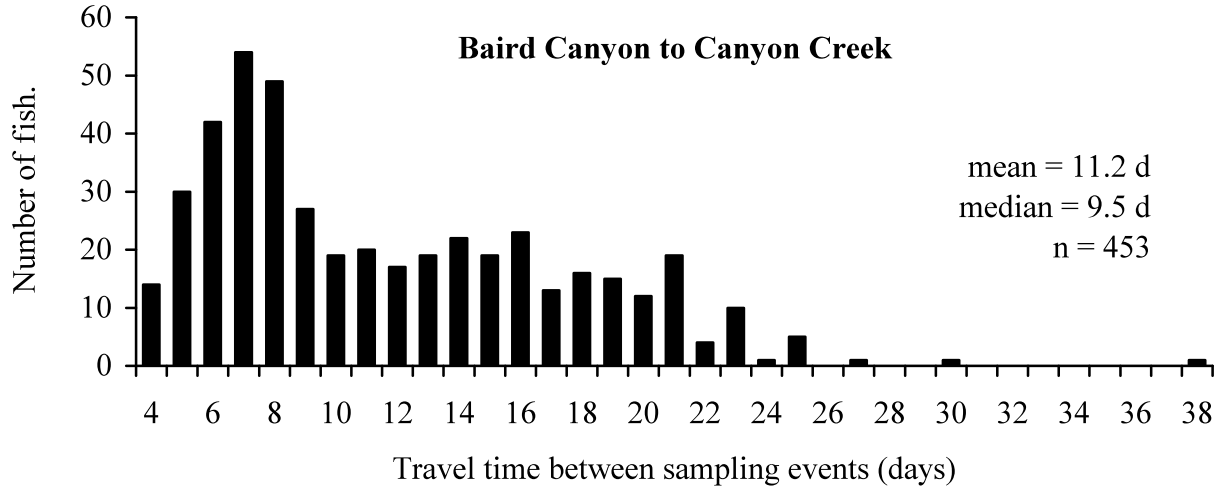

Figure 11. Travel time (days) of sockeye salmon tagged at the Baird Canyon fishwheels and recaptured at the Canyon Creek fishwheels, 2009.

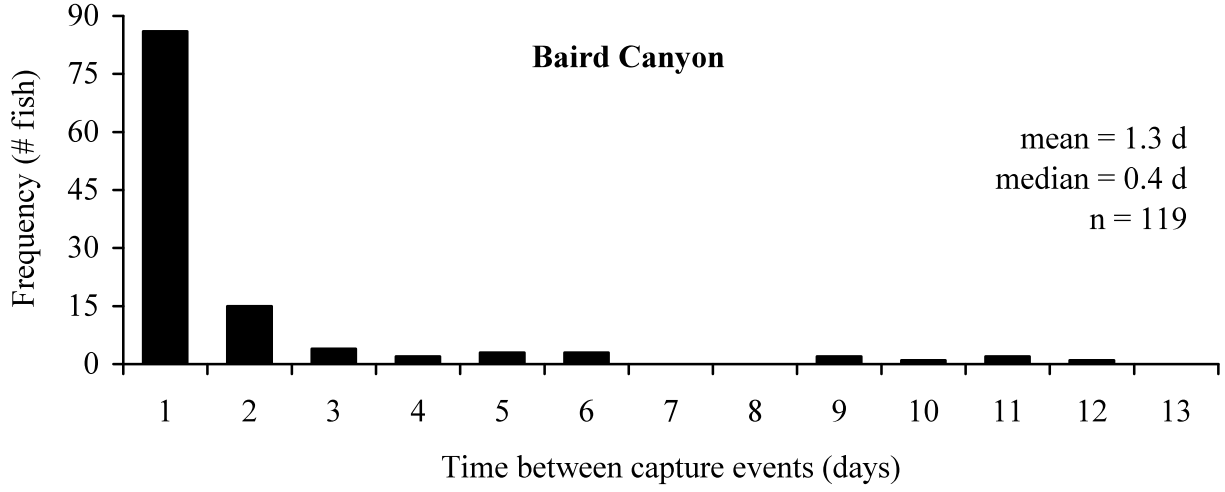

Figure 12. Migratory delay (days) for sockeye salmon captured more than once at the Baird Canyon fishwheels, 2009.

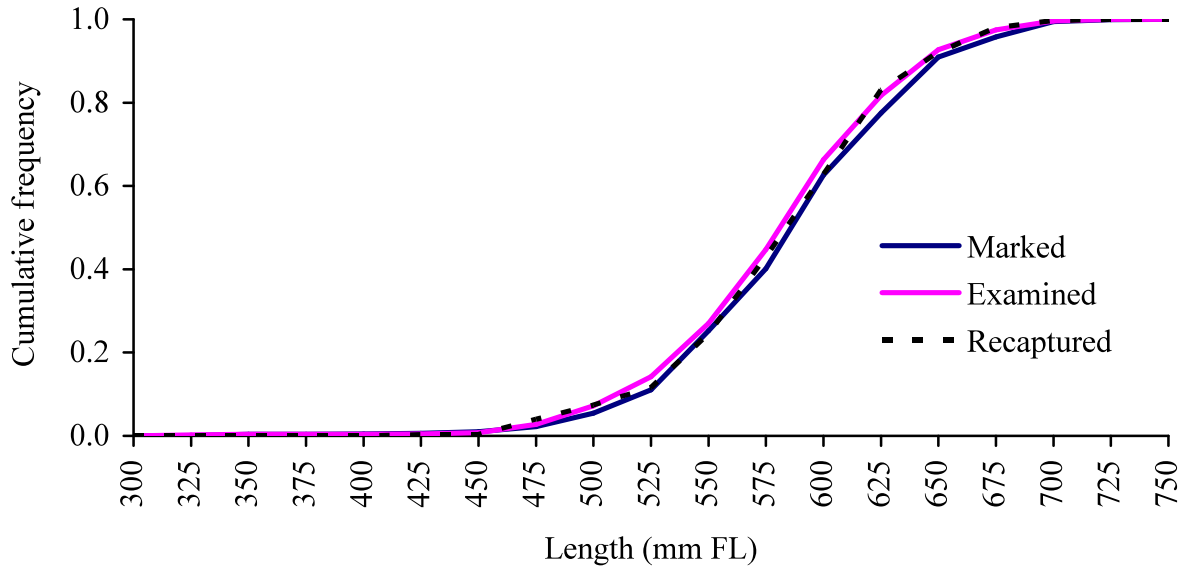

Figure 13. Cumulative length-frequency distributions for sockeye salmon marked at Baird Canyon and examined and recaptured at Canyon Creek, 2009.

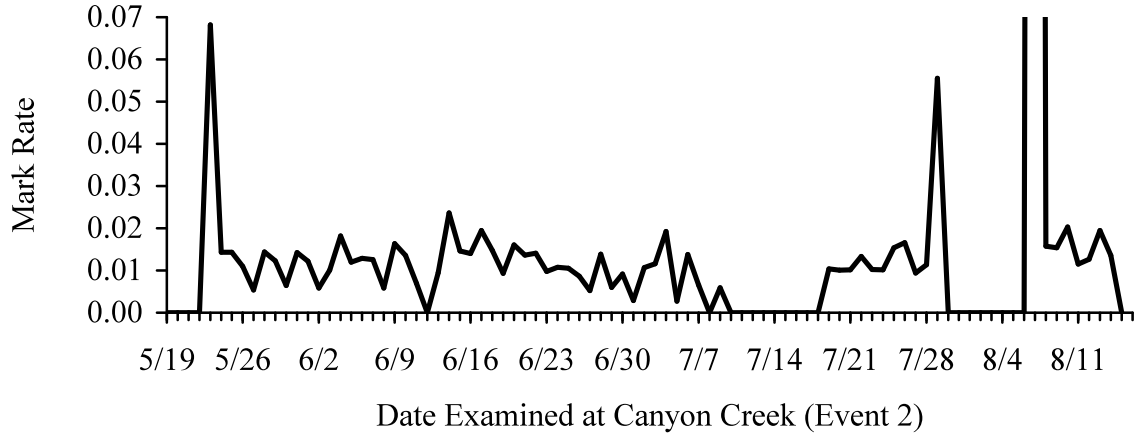

Figure 14. Daily proportion of sockeye salmon examined at the Canyon Creek fishwheels that were marked (mark rate), 2009.

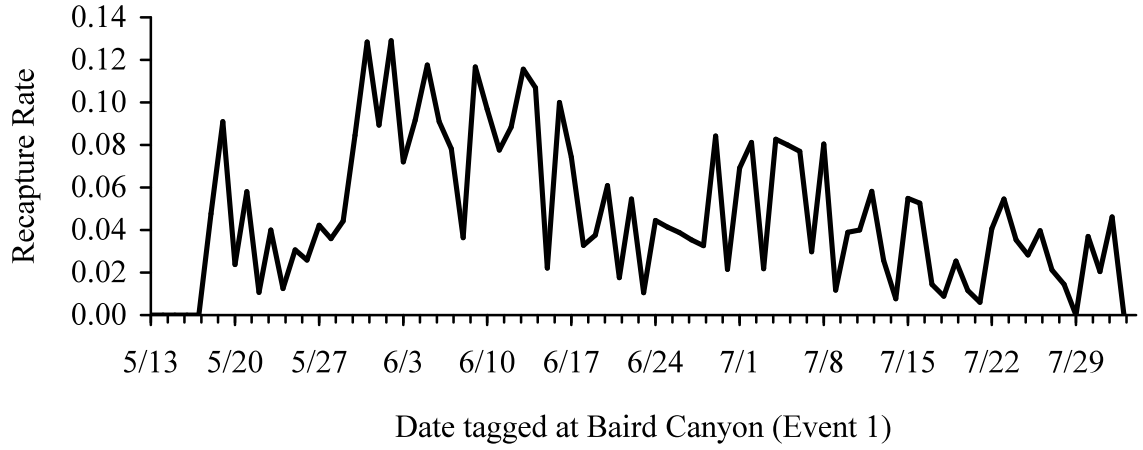

Figure 15. Daily proportion of sockeye salmon tagged at the Baird Canyon fishwheels that were subsequently recaptured at the Canyon Creek fishwheels (recapture rate), 2009.

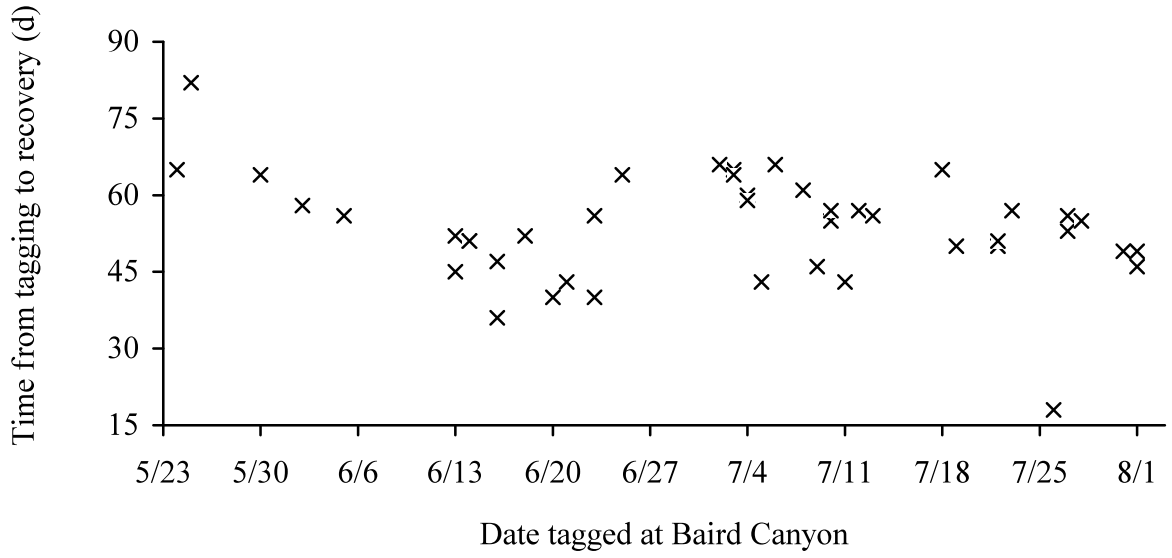

Figure 16. Travel time for sockeye salmon tagged at Baird Canyon and recovered by Gulkana Hatchery staff during broodstock collection, 2009.

APPENDICES

Appendix A.1. Summary of daily fishwheel effort (h), effort used to calculate catch per unit effort (CPUE), and fishwheel speed (RPM) for the Copper River fishwheels, 2009.

	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
13-May	13.8														
14-May	24.0	25.8													
15-May	24.0	24.0					10.4								
16-May	24.0	24.0					23.0	26.4							
17-May	24.0	33.8					24.0	29.0							
18-May	24.0	23.7					24.0	23.8							
19-May	24.0	24.3					24.0	23.5							
20-May	24.0	24.0	2.4				24.0	24.7	2.8	12.0	9.5	0.0	24.0	25.7	0.0
21-May	24.0	24.2	2.8				24.0	23.7	2.5	24.0	24.9	1.9	24.0	23.9	5.3
22-May	24.0	23.3	2.8				24.0	24.4	3.4	24.0	23.9	2.7	24.0	24.4	4.5
23-May	24.0	25.1	2.9				24.0	24.7	3.1	24.0	23.7	2.3	24.0	24.3	5.1
24-May	24.0	23.2	2.4				24.0	23.6	3.0	24.0	23.7	1.8	24.0	23.8	4.2
25-May	24.0	24.6	2.5	24.0	4.1	3.1	24.0	24.2	4.3	24.0	23.6	1.7	24.0	23.6	4.4
26-May	24.0	23.1	2.1	24.0	24.0	2.6	24.0	23.4	4.2	24.0	24.2	1.9	24.0	24.2	4.8
27-May	18.0	19.3	2.8	18.0	24.1	1.3	24.0	25.1		24.0	24.2	3.1	24.0	24.2	5.3
28-May	24.0	23.7	3.2	24.0	23.9	1.1	24.0	23.5	4.3	24.0	23.9	3.1	20.5	20.6	4.6
29-May	24.0	24.4	2.7	24.0	24.5	1.0	24.0	22.8	3.9	24.0	23.7	2.8	16.5	16.8	4.1
30-May	24.0	23.7	2.5	24.0	23.7	0.6	15.0	16.5	3.8	24.0	24.2	2.4	21.0	20.5	3.4
31-May	24.0	24.3	2.6	24.0	23.9		24.0	24.1	4.6	24.0	24.1	1.9	17.9	18.0	3.4
1-Jun	24.0	23.0	2.9	24.0	23.5	2.2	24.0	23.0	4.0	24.0	24.1	2.0	24.0	24.1	2.4
2-Jun	24.0	24.4	2.5	24.0	24.3	1.4	24.0	24.4	3.8	24.0	23.7	2.2	24.0	23.9	4.1
3-Jun	20.0	20.6	3.0	20.0	24.3	1.6	24.0	24.6	2.8	24.0	24.1	2.8	21.5	21.9	4.3
4-Jun	24.0	23.3	2.1	24.0	24.7	2.2	24.0	24.1	1.9	24.0	24.0	2.9	20.0	19.7	4.5
5-Jun	24.0	24.5	2.9	24.0	22.9	2.7	24.0	22.4	3.8	24.0	23.7	2.8	24.0	23.5	4.4
6-Jun	18.0	17.4	3.0	18.0	18.2	2.4	23.0	23.2	2.3	24.0	24.0	2.0	22.0	24.4	5.0
7-Jun	24.0	23.9	3.3	24.0	23.7	1.6	24.0	23.8	2.7	24.0	24.3	1.6	10.0	8.2	3.8
8-Jun	10.0	9.4		10.0	24.1	2.0	24.0	25.1	3.7	24.0	24.0	1.3	24.0	24.0	3.3
9-Jun	0.0	0.0		0.0	23.8	2.1	24.0	23.0	3.1	24.0	25.5	1.4	24.0	24.6	3.1
10-Jun	9.7	8.0		9.7	24.3	2.2	24.0	24.4	2.1	24.0	22.3	1.5	24.0	23.3	3.1
11-Jun	16.0	16.3	3.7	16.0	24.2	2.3	24.0	23.9	1.4	24.0	23.7	2.0	24.0	23.7	3.2

Appendix A.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 4		
Date	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM
12-Jun	24.0	22.8	3.2	24.0	24.1	2.2	24.0	24.9	1.2	24.0	24.0	1.5	24.0	23.8	2.9
13-Jun	24.0	25.0	3.1	24.0	23.9	2.4	24.0	22.9		24.0	24.8	1.2	24.0	24.2	2.9
14-Jun	24.0	23.0	2.0	24.0	24.3	2.6	24.0	25.6		24.0	23.6	1.3	24.0	24.5	3.2
15-Jun	24.0	24.8	2.3	24.0	22.7	1.1	24.0	22.2	2.1	24.0	24.8	0.7	24.0	25.0	3.5
16-Jun	24.0	23.1	2.5	24.0	23.9	1.4	24.0	24.6	2.3	24.0	25.7	1.1	24.0	23.8	3.4
17-Jun	24.0	25.5	2.0	24.0	25.4	1.7	24.0	25.7	2.4	24.0	22.5	1.9	24.0	23.9	3.6
18-Jun	24.0	23.6	2.1	24.0	23.6	1.2	24.0	23.8	2.3	24.0	24.4	2.1	23.5	22.5	4.1
19-Jun	24.0	23.6	2.0	24.0	23.6	1.5	24.0	23.4	1.7	24.0	23.7	2.5	24.0	24.1	3.9
20-Jun	24.0	24.4	2.3	24.0	24.6	1.3	24.0	24.3	2.1	24.0	24.8	2.0	24.0	24.3	3.8
21-Jun	24.0	23.2	1.0	24.0	23.9	1.3	24.0	23.4	2.6	24.0	23.4	1.4	24.0	23.4	4.1
22-Jun	23.5	24.2	1.3	23.5	25.0	1.5	24.0	23.8	2.6	24.0	24.1	1.6	24.0	24.3	4.2
23-Jun	24.0	24.0	1.3	24.0	23.5	1.3	24.0	23.9	2.7	24.0	23.3	1.8	24.0	23.5	4.3
24-Jun	24.0	24.1	1.7	24.0	23.2	1.2	24.0	24.5	3.0	24.0	24.6	1.8	24.0	24.3	4.1
25-Jun	24.0	23.6	2.0	24.0	23.9	1.0	24.0	23.7	2.5	24.0	23.9	1.7	24.0	24.0	4.9
26-Jun	24.0	23.7		24.0	23.8		24.0	24.2		24.0	24.5	1.7	24.0	23.9	5.1
27-Jun	24.0	24.0	0.9	24.0	24.0	1.7	24.0	24.0	3.6	24.0	23.0	2.2	24.0	23.8	4.8
28-Jun	24.0	23.7		24.0	23.8	0.6	24.0	23.7	2.7	24.0	24.3	2.1	24.0	24.2	4.7
29-Jun	24.0	24.2	1.0	24.0	24.0		24.0	24.2	2.6	24.0	24.1	2.1	24.0	24.3	5.0
30-Jun	24.0	24.4	0.8	24.0	24.5	1.7	24.0	23.6	2.8	24.0	23.6	2.1	24.0	23.5	4.7
1-Jul	24.0	24.2	1.3	24.0	24.1	1.3	24.0	24.0	3.8	24.0	23.8	1.7	24.0	23.9	5.5
2-Jul	24.0	23.8	1.6	24.0	23.8	1.8	24.0	23.6	3.8	23.0	23.5	1.8	24.0	24.3	4.3
3-Jul	24.0	23.6	2.3	24.0	24.1	1.6	14.0	17.1	2.3	24.0	23.6	1.6	24.0	23.7	5.3
4-Jul	24.0	23.9	2.0	24.0	23.9	1.6				24.0	24.8	1.3	24.0	24.8	3.6
5-Jul	24.0	24.2	2.9	24.0	24.2	1.6				24.0	23.4	1.4	24.0	23.4	3.9
6-Jul	24.0	23.7	3.0	24.0	23.6	2.3				24.0	23.8	1.0	24.0	23.9	3.3
7-Jul	17.0	17.3	3.4	17.0	24.5	2.1				24.0	24.7	1.3	24.0	24.6	3.1
8-Jul	14.9	17.4	3.3	14.9	24.0	2.5				24.0	23.1	2.0	24.0	23.4	3.6
9-Jul	0.0	0.0		0.0	24.0	2.8				24.0	24.2	2.0	24.0	24.2	3.8
10-Jul	0.0	0.0		0.0	23.6	2.7				24.0	9.9	2.0	7.0	9.9	3.5
11-Jul	0.0	0.0		0.0	25.0	2.1				24.0	31.2	2.3	2.6	0.0	

Appendix A.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 4		
Date	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM
12-Jul	0.0	0.0		0.0	23.2	2.5				24.0	30.6	2.1	24.0	23.7	3.7
13-Jul	0.0	0.0		0.0	23.3	2.1				19.0	19.0	2.5	24.0	23.9	4.2
14-Jul	0.0	0.0		0.0	24.8	2.4				17.5	17.3	2.4	24.0	24.0	3.9
15-Jul	0.0	0.0		0.0	23.7	2.5				16.0	16.3		24.0	24.2	3.8
16-Jul	0.0	0.0		0.0	24.2	2.2				24.0	23.7	1.3	24.0	23.8	3.3
17-Jul	0.0	0.0		0.0	24.0	2.1				24.0	24.3	1.5	22.0	22.3	3.2
18-Jul	0.0	0.0		0.0	24.1	2.3				22.0	21.9	1.5	21.0	21.0	3.4
19-Jul	0.0	0.0		0.0	24.2	1.9				24.0	24.4	2.0	24.0	24.0	3.4
20-Jul	0.0	0.0		0.0	23.9	1.8				24.0	23.8	1.7	24.0	23.9	4.1
21-Jul	0.0	0.0		0.0	24.0	1.7				24.0	23.9	1.8	24.0	24.4	2.9
22-Jul	11.3	8.9	2.9	11.3	24.2	1.6				24.0	24.7	1.9	24.0	24.8	3.3
23-Jul	24.0	24.4	3.0	24.0	23.7	1.4				24.0	23.8	1.4	24.0	22.9	2.6
24-Jul	24.0	23.9		24.0	23.9					24.0	25.4		23.0	24.3	4.6
25-Jul	24.0	24.1	2.3	24.0	24.1	1.1				24.0	22.9	1.4	24.0	23.1	2.8
26-Jul	24.0	24.2	1.5	24.0	23.9	0.9				24.0	23.9	2.4	24.0	23.8	3.5
27-Jul	24.0	23.5	1.2	24.0	24.0	1.0				24.0	24.0	1.0	24.0	24.0	2.7
28-Jul	12.7	15.0	1.6	12.7	23.9	0.8				24.0	23.6	1.2	24.0	23.7	2.8
29-Jul				0.0	24.5	1.5				24.0	17.1		15.0	17.9	3.9
30-Jul				0.0	18.8	2.3				21.3	30.8				
31-Jul				0.0	23.7	2.2				0.0	0.0				
1-Aug				0.0	12.5	2.2				0.0	0.0				
2-Aug				0.0	3.6	1.9				9.8	6.7				
3-Aug										24.0	22.9				
4-Aug										24.0	25.4	1.9			
5-Aug										24.0	24.0	1.3			
6-Aug										24.0	23.9	1.8			
7-Aug										8.5	11.4	1.4			
8-Aug										12.5	10.7	1.3			
9-Aug										24.0	23.2	0.9			
10-Aug										24.0	24.0	0.8			

Appendix A.1 continued.

	Baird Canyon									Canyon Creek					
	Fishwheel 1			Fishwheel 2			Fishwheel 5			Fishwheel 3			Fishwheel 4		
Date	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM	Total effort (h)	CPUE effort (h)	RPM
11-Aug										24.0	24.1	0.8			
12-Aug										24.0	25.9	0.6			
13-Aug										24.0	20.9	0.9			
14-Aug										24.0	19.3	1.2			
Effort (h)	1,275		2.3	1,131		1.8	1,084		2.9	1,962		1.8	1,607		3.9
Percent operational:	75.3%			98.4%			99.1%			94.5%			94.8%		

Appendix B.1. Number of sockeye salmon caught at the Copper River fishwheels, 2009.

	Baird Canyon						Canyon Creek			
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3		Fishwheel 4	
Date	Catch	Cum.	Catch	Cum.	Catch	Cum.	Catch	Cum.	Catch	Cum.
13 May	0	0								
14 May	0	0								
15 May	17	17			0	0				
16 May	13	30			0	0				
17 May	50	80			7	7				
18 May	134	214			29	36				
19 May	34	248			24	60				
20 May	31	279			37	97	5	5	0	0
21 May	52	331			68	165	21	26	0	0
22 May	53	384			173	338	28	54	4	4
23 May	128	512			66	404	41	95	3	7
24 May	116	628			75	479	65	160	6	13
25 May	196	824	42	42	132	611	121	281	19	32
26 May	0	824	155	197	109	720	175	456	7	39
27 May	77	901	90	287	128	848	170	626	15	54
28 May	0	901	295	582	50	898	145	771	63	117
29 May	2	903	131	713	70	968	188	959	56	173
30 May	0	903	244	957	14	982	329	1,288	138	311
31 May	69	972	150	1,107	12	994	342	1,630	80	391
1 Jun	0	972	259	1,366	15	1,009	320	1,950	90	481
2 Jun	0	972	221	1,587	17	1,026	275	2,225	66	547
3 Jun	0	972	244	1,831	29	1,055	368	2,593	130	677
4 Jun	0	972	167	1,998	29	1,084	423	3,016	73	750
5 Jun	0	972	270	2,268	59	1,143	371	3,387	215	965
6 Jun	0	972	72	2,340	29	1,172	301	3,688	88	1,053
7 Jun	0	972	36	2,376	50	1,222	335	4,023	220	1,273
8 Jun	0	972	35	2,411	50	1,272	141	4,164	370	1,643
9 Jun			134	2,545	37	1,309	42	4,206	325	1,968
10 Jun	0	972	148	2,693	45	1,354	24	4,230	345	2,313
11 Jun	3	975	166	2,859	48	1,402	5	4,235	427	2,740
12 Jun	0	975	300	3,159	33	1,435	1	4,236	188	2,928
13 Jun	0	975	466	3,625	3	1,438	13	4,249	619	3,547
14 Jun	0	975	241	3,866	80	1,518	131	4,380	673	4,220
15 Jun	0	975	140	4,006	102	1,620	156	4,536	938	5,158
16 Jun	0	975	292	4,298	140	1,760	460	4,996	1,254	6,412
17 Jun	1	976	140	4,438	163	1,923	672	5,668	508	6,920
18 Jun	0	976	177	4,615	169	2,092	518	6,186	363	7,283

Appendix B.1 continued.

	Baird Canyon						Canyon Creek			
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3		Fishwheel 4	
Date	Catch	Cum.	Catch	Cum.	Catch	Cum.	Catch	Cum.	Catch	Cum.
19 Jun	0	976	119	4,734	114	2,206	611	6,797	888	8,171
20 Jun	0	976	395	5,129	101	2,307	399	7,196	907	9,078
21 Jun	0	976	237	5,366	149	2,456	384	7,580	717	9,795
22 Jun	0	976	18	5,384	129	2,585	429	8,009	779	10,574
23 Jun	0	976	14	5,398	121	2,706	282	8,291	333	10,907
24 Jun	0	976	21	5,419	146	2,852	393	8,684	626	11,533
25 Jun	0	976	28	5,447	200	3,052	410	9,094	726	12,259
26 Jun	0	976	54	5,501	251	3,303	351	9,445	460	12,719
27 Jun	0	976	28	5,529	242	3,545	188	9,633	389	13,108
28 Jun	0	976	44	5,573	171	3,716	184	9,817	464	13,572
29 Jun	0	976	57	5,630	247	3,963	170	9,987	332	13,904
30 Jun	0	976	92	5,722	243	4,206	170	10,157	266	14,170
1 Jul	0	976	95	5,817	374	4,580	167	10,324	181	14,351
2 Jul	0	976	224	6,041	102	4,682	234	10,558	326	14,677
3 Jul	57	1,033	204	6,245	17	4,699	198	10,756	146	14,823
4 Jul	125	1,158	174	6,419			120	10,876	192	15,015
5 Jul	68	1,226	158	6,577			110	10,986	257	15,272
6 Jul	33	1,259	78	6,655			68	11,054	294	15,566
7 Jul	28	1,287	84	6,739			17	11,071	137	15,703
8 Jul	14	1,301	199	6,938			3	11,074	86	15,789
9 Jul			157	7,095			10	11,084	160	15,949
10 Jul			176	7,271			1	11,085	36	15,985
11 Jul			239	7,510			0	11,085	0	15,985
12 Jul			289	7,799			7	11,092	1	15,986
13 Jul			182	7,981			3	11,095	3	15,989
14 Jul			261	8,242			5	11,100	2	15,991
15 Jul			218	8,460			10	11,110	3	15,994
16 Jul			66	8,526			14	11,124	2	15,996
17 Jul			231	8,757			4	11,128	23	16,019
18 Jul			326	9,083			5	11,133	33	16,052
19 Jul			251	9,334			6	11,139	90	16,142
20 Jul			250	9,584			3	11,142	96	16,238
21 Jul			312	9,896			8	11,150	583	16,821
22 Jul	76	1,377	259	10,155			62	11,212	1,139	17,960
23 Jul	84	1,461	74	10,229			321	11,533	856	18,816
24 Jul	82	1,543	41	10,270			484	12,017	996	19,812
25 Jul	114	1,657	71	10,341			450	12,467	719	20,531

Appendix B.1 continued.

	Baird Canyon						Canyon Creek			
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3		Fishwheel 4	
Date	Catch	Cum.	Catch	Cum.	Catch	Cum.	Catch	Cum.	Catch	Cum.
26 Jul	173	1,830	68	10,409			379	12,846	825	21,356
27 Jul	159	1,989	84	10,493			449	13,295	297	21,653
28 Jul	27	2,016	122	10,615			442	13,737	86	21,739
29 Jul			139	10,754			14	13,751	4	21,743
30 Jul			63	10,817			9	13,760		
31 Jul			72	10,889			0	13,760		
1 Aug			104	10,993			0	13,760		
2 Aug			15	11,008			12	13,772		
3 Aug							10	13,782		
4 Aug							23	13,805		
5 Aug							6	13,811		
6 Aug							6	13,817		
7 Aug							1	13,818		
8 Aug							190	14,008		
9 Aug							586	14,594		
10 Aug							345	14,939		
11 Aug							433	15,372		
12 Aug							475	15,847		
13 Aug							308	16,155		
14 Aug							221	16,376		
Total	2,016		11,008		4,699		16,376		21,743	

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

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

	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
13 May	0	0												
14 May	0	0												
15 May	17	17			0	0								
16 May	8	25			0	0								
17 May	6	31			2	2								
18 May	20	51			1	3								
19 May	10	61			12	15								
20 May	22	83			20	35	5	5	0	0	0	0	0	0
21 May	38	121			31	66	20	25	0	0	0	0	0	0
22 May	13	134			81	147	28	53	0	0	4	4	0	0
23 May	120	254			55	202	41	94	2	2	3	7	1	1
24 May	98	352			62	264	64	158	0	2	6	13	1	2
25 May	95	447	36	36	32	296	121	279	2	4	19	32	0	2
26 May	0	447	143	179	89	385	175	454	2	6	7	39	0	2
27 May	73	520	85	264	79	464	170	624	1	7	15	54	0	2
28 May	0	520	168	432	27	491	145	769	1	8	63	117	2	4
29 May	2	522	117	549	62	553	188	957	3	11	56	173	0	4
30 May	0	522	200	749	13	566	329	1,286	1	12	138	311	2	6
31 May	44	566	133	882	2	568	342	1,628	4	16	80	391	2	8
1 Jun	0	566	101	983	11	579	320	1,948	3	19	90	481	2	10
2 Jun	0	566	85	1,068	8	587	275	2,223	2	21	66	547	0	10
3 Jun	0	566	111	1,179	14	601	368	2,591	4	25	130	677	1	11
4 Jun	0	566	125	1,304	17	618	423	3,014	7	32	72	749	2	13
5 Jun	0	566	61	1,365	41	659	371	3,385	5	37	215	964	2	15
6 Jun	0	566	31	1,396	24	683	301	3,686	4	41	88	1,052	1	16
7 Jun	0	566	29	1,425	35	718	335	4,021	1	42	220	1,272	6	22
8 Jun	0	566	27	1,452	28	746	141	4,162	1	43	370	1,642	2	24
9 Jun	0	566	36	1,488	24	770	42	4,204	1	44	325	1,967	5	29
10 Jun	0	566	40	1,528	22	792	24	4,228	0	44	345	2,312	5	34
11 Jun	0	566	82	1,610	34	826	5	4,233	0	44	427	2,739	3	37
12 Jun	0	566	97	1,707	16	842	1	4,234	0	44	188	2,927	0	37

Appendix C.1 continued.

	Baird Canyon						Canyon Creek							
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3				Fishwheel 4			
Date	Tags	Cum	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
13 Jun	0	566	119	1,826	2	844	13	4,247	0	44	619	3,546	6	43
14 Jun	0	566	104	1,930	27	871	131	4,378	2	46	673	4,219	17	60
15 Jun	0	566	93	2,023	43	914	156	4,534	3	49	938	5,157	13	73
16 Jun	0	566	149	2,172	41	955	460	4,994	4	53	1,254	6,411	20	93
17 Jun	0	566	106	2,278	96	1,051	672	5,666	12	65	508	6,919	11	104
18 Jun	0	566	122	2,400	92	1,143	518	6,184	7	72	363	7,282	6	110
19 Jun	0	566	100	2,500	86	1,229	611	6,795	5	77	888	8,170	9	119
20 Jun	0	566	135	2,635	29	1,258	399	7,194	4	81	906	9,076	17	136
21 Jun	0	566	39	2,674	75	1,333	384	7,578	6	87	717	9,793	9	145
22 Jun	0	566	11	2,685	99	1,432	429	8,007	6	93	779	10,572	11	156
23 Jun	0	566	9	2,694	86	1,518	282	8,289	1	94	333	10,905	5	161
24 Jun	0	566	20	2,714	70	1,588	393	8,682	2	96	626	11,531	9	170
25 Jun	0	566	25	2,739	96	1,684	410	9,092	4	100	726	12,257	8	178
26 Jun	0	566	42	2,781	61	1,745	351	9,443	3	103	460	12,717	4	182
27 Jun	0	566	27	2,808	86	1,831	188	9,631	1	104	389	13,106	2	184
28 Jun	0	566	37	2,845	55	1,886	184	9,815	1	105	464	13,570	8	192
29 Jun	0	566	52	2,897	43	1,929	170	9,985	1	106	332	13,902	2	194
30 Jun	0	566	37	2,934	56	1,985	170	10,155	2	108	266	14,168	2	196
1 Jul	0	566	50	2,984	80	2,065	167	10,322	0	108	181	14,349	1	197
2 Jul	0	566	93	3,077	67	2,132	234	10,556	3	111	326	14,675	3	200
3 Jul	42	608	82	3,159	14	2,146	198	10,754	3	114	146	14,821	1	201
4 Jul	75	683	58	3,217			120	10,874	1	115	192	15,013	5	206
5 Jul	47	730	78	3,295			110	10,984	0	115	257	15,270	1	207
6 Jul	30	760	61	3,356			68	11,052	1	116	294	15,564	4	211
7 Jul	27	787	74	3,430			17	11,069	1	117	137	15,701	0	211
8 Jul	13	800	74	3,504			3	11,072	0	117	86	15,787	0	211
9 Jul	0	800	85	3,589			10	11,082	0	117	160	15,947	1	212
10 Jul	0	800	77	3,666			1	11,083	0	117	36	15,983	0	212
11 Jul	0	800	125	3,791			0	11,083	0	117	0	15,983	0	212
12 Jul	0	800	103	3,894			7	11,090	0	117	1	15,984	0	212
13 Jul	0	800	117	4,011			3	11,093	0	117	3	15,987	0	212

Appendix C.1 continued.

	Baird Canyon						Canyon Creek							
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3				Fishwheel 4			
Date	Tags	Cum	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
14 Jul	0	800	131	4,142			5	11,098	0	117	2	15,989	0	212
15 Jul	0	800	91	4,233			10	11,108	0	117	3	15,992	0	212
16 Jul	0	800	57	4,290			14	11,122	0	117	2	15,994	0	212
17 Jul	0	800	69	4,359			4	11,126	0	117	23	16,017	0	212
18 Jul	0	800	113	4,472			5	11,131	0	117	33	16,050	0	212
19 Jul	0	800	157	4,629			6	11,137	0	117	90	16,140	1	213
20 Jul	0	800	172	4,801			3	11,140	0	117	96	16,236	1	214
21 Jul	0	800	166	4,967			8	11,148	0	117	583	16,819	6	220
22 Jul	39	839	84	5,051			62	11,210	0	117	1,139	17,958	16	236
23 Jul	62	901	48	5,099			321	11,531	2	119	856	18,814	10	246
24 Jul	78	979	35	5,134			484	12,015	7	126	996	19,810	8	254
25 Jul	71	1,050	35	5,169			450	12,465	5	131	719	20,529	13	267
26 Jul	73	1,123	53	5,222			379	12,844	7	138	825	21,354	13	280
27 Jul	46	1,169	48	5,270			449	13,293	3	141	297	21,651	4	284
28 Jul	13	1,182	56	5,326			442	13,735	3	144	86	21,737	3	287
29 Jul			65	5,391			14	13,749	1	145	4	21,741	0	287
30 Jul			54	5,445			9	13,758	0	145				
31 Jul			49	5,494			0	13,758	0	145				
1 Aug			65	5,559			0	13,758	0	145				
2 Aug			11	5,570			12	13,770	0	145				
3 Aug							10	13,780	0	145				
4 Aug							23	13,803	0	145				
5 Aug							6	13,809	0	145				
6 Aug							6	13,815	0	145				
7 Aug							1	13,816	1	146				
8 Aug							190	14,006	3	149				
9 Aug							586	14,592	9	158				
10 Aug							345	14,937	7	165				
11 Aug							433	15,370	5	170				
12 Aug							475	15,845	6	176				
13 Aug							308	16,153	6	182				

Appendix C.1 continued.

	Baird Canyon						Canyon Creek							
	Fishwheel 1		Fishwheel 2		Fishwheel 5		Fishwheel 3				Fishwheel 4			
Date	Tags	Cum	Tags	Cum	Tags	Cum	Exam	Cum	Recap	Cum	Exam	Cum	Recap	Cum
14 Aug							221	16,374	3	185				
15 Aug														
Total	1,182		5,570		2,146		16,374		185		21,741		287	

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