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

Annual Report for Studies 08-501

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

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

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

and

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

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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 sockeye salmon *O. nerka* escapement on the Copper River. This report summarizes results from the 2008 field season. The main objective in 2008 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 4,266 h from 19 May to 4 August. During this period, 11,282 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 3,966 h from 20 May to 19 August. A total of 50,293 sockeye salmon were examined for marks, of which 838 were recaptures. Using a temporally stratified Darroch estimator, the estimated abundance of sockeye salmon that migrated upstream of Baird Canyon was 739,883 (SE = 32,962). The median travel time of sockeye salmon marked at Baird Canyon and recaptured at Canyon Creek (91 km upstream) was 11.2 d. Funding through the Fisheries Resource Monitoring Program (FRMP) for this project has been approved through 2009. This project was one component of a long-term monitoring program operated by the Native Village of Eyak (NVE).



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# INTRODUCTION

The Copper River supports one of the largest Chinook *Oncorhynchus tshawytscha* and sockeye salmon *O. nerka* subsistence fisheries in Alaska. In addition, this resource is heavily utilized by commercial, sport, and personal-use fisheries. The majority of Copper River salmon are harvested in a commercial gillnet fishery from mid-May through August in the Copper River District (in and around the mouth of the Copper River). From 1998 to 2007, 1,344,291 sockeye, 43,059 Chinook, and 285,221 coho salmon were harvested in the Copper River District (Hollowell and Sommerville 2008). In 2008, an estimated 321,000 sockeye (the 4$^{th}$ 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 upiver sport fishery harvested 10,961 sockeye salmon on average from 1998 to 2007 (Hollowell and Sommerville 2008).

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

Management of Copper River salmon is complex due to inter-annual variation in the size and timing of stocks, fisheries that target a mixture of stocks and difficulties in estimating abundance due to the physical characteristics of the drainage. This is further confounded by the interplay of numerous Federal and State government agencies in the management of this gauntlet of fisheries. The Alaska Department of Fish and Game (ADF&G) manages the commercial fishery to achieve an inriver salmon escapement goal which is monitored using a sonar system at the outlet of Miles Lake. The escapement goal includes a sustainable escapement goal of 300,000 to 500,000 wild sockeye salmon; a goal of 17,500 other salmon species to account for Chinook and other salmon passing the site; annually determined allocations for inriver subsistence, personal-use, and sport harvest based on recent harvest levels; and annually determined allocations for hatchery broodstock and surplus based on forecasted returns. An estimated 717,799 salmon passed the Miles Lake sonar site between 16 May and 2 August 2008, which was 17% (102,800 fish) higher than the minimum anticipated count and 13% lower than the previous 5-y average (Lewis et al. 2008).

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.

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. 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). In contrast, no declines in total inriver salmon returns were detected at the Miles Lake sonar site. 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, 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. Furthermore, the Gulkana Hatchery was expected to contribute 168,000 sockeye salmon to the 2008 commercial harvest but only contributed 21,700 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 *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, 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, 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.).

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 2008 and 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. Ten full-time technicians, three full- and part-time interns, and one part-time field logistics coordinator were hired, including one returning technician from 2007, three Alaska Natives, and several rural Alaskan residents. Several other local residents were hired temporarily throughout the season during peak sampling periods, mobilization, and de-mobilization. Preseason training consisted of an overview of the project and NVE policies, first aid/CPR certification, shotgun maintenance, and safety training including bear safety videos, Copper River salmon fisheries management overview, and basic outboard motor maintenance and troubleshooting. Inseason training focused on fishwheel operation, maintenance and safety, boat operation and maintenance, fish sampling, data entry in personal digital assistant (PDA) units, PDA passive integrated transponder (PIT) tag scanner, database management, and basic computer skills.

### *Permit Requirements*

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

### *Fishwheel Design and Construction*

Three tagging fishwheels (fishwheels 1, 2, and 5) were operated at Baird Canyon (rkm 66), and two recovery fishwheels (fishwheels 3 and 4) at Canyon Creek (rkm 157) in 2007. Two of the fishwheels at Baird Canyon (fishwheels 1 and 2) and one fishwheel at Canyon Creek (fishwheel 3) were large aluminum models built for fishing against deep canyon walls. These were made of two, welded aluminum pontoons (11.6 m long x 0.9 m wide x 0.5 m deep), a 3.7 m long axle, three baskets (3.0 x 3.0 m x 2.1 m), and a tower (6.1 m high) and boom (4.9 m long) assembly that was used to raise and lower the axle. The baskets were designed to fish up to about 3 m below the water surface and were lined with knotless nylon mesh (6.4 cm stretch). The baskets on fishwheel 3 were shorter than those on fishwheels 1 and 2 which allowed it to fish at shallower depths. An aluminum tank (4.3 m long x 1.5 m deep x 0.6 m wide) for holding captured fish was fitted inside each pontoon. The bottom of each live tank was fitted with windows of extruded aluminum mesh to allow for ample water circulation.

The third fishwheel at Baird Canyon (fishwheel 5) was similar in design to fishwheel 4 that operated at Canyon Creek. These fishwheels were composed of two aluminum pontoons (11.6 m long x 0.6 m wide x 0.5 m deep), four lumber and spruce pole baskets (2 m long x 1.8 m wide x 0.8 m deep), and a tower assembly designed to raise and lower the axle. The baskets were lined with knotless nylon mesh (6.4 cm stretch). As with the other fishwheels, each live tank was fitted with windows of extruded aluminum mesh and an escape panel.

### *Mobilizing the Field Camps*

At Baird Canyon, a cabin that NVE built in the fall of 2001 served as the field camp again in 2008. The cabin was located on the west bank of the Copper River approximately 2 km upstream from the upper end of Baird Canyon (Figure 2), and was supplied by helicopter, boat, or plane from Cordova. The Canyon Creek camp was located on the east bank of the Copper River approximately 12 km downstream from Chitina (Figure 3). The upriver camp consisted of two Weatherport tents and individual canvas-walled tents for crew members, and it was supplied mainly by boat from Chitina. Mobilization at both camps was timed to ensure that the fishwheels were operational as soon as the river ice cleared and the first salmon began migrating past each location.

### *Camp Communication*

The field crews followed a specific communication protocol to ensure that the camps were operated as safely and efficiently as possible. Each camp was equipped with a base-station VHF and several handheld VHF radios, Iridium satellite telephones, and a Starband satellite internet system that provided continuous high-speed internet access. These systems were battery-powered (12 V) and charged by a combination of solar panels, wind turbines, and gas-powered generators. Each morning at a pre-arranged time, the camp lead from each camp was responsible for contacting the NVE office in Cordova via email to exchange information (e.g., provide daily fishwheel catches, place food and supply orders, arrange flights and crew changes). The majority of camp communications were conducted via the internet, with satellite phones reserved for emergencies and instances where internet was temporarily unavailable.

## Fishwheel Operation and Catch

Suitable fishwheel sites were selected based on water depth, water velocity, accessibility, bankfull width, and protection from floating debris and rock fall. For the three large fishwheels used on this project, water depths greater than 3 m and velocities ranging from 0.5-1.5 m/s were needed to rotate the baskets at optimal speeds and force migrating fish to travel near shore and into the path of the fishwheels. Narrow, fast-flowing channels tend to concentrate migrating salmon close to shore and are thus preferred to wide, slow-flowing areas. The small, four-basket fishwheels could operate in slower water velocities and shallower depths than the large fishwheels. The basket assembly of fishwheels 4 and 5 could also be raised or lowered as water levels changed throughout the season.

The three large fishwheels used in 2008 were installed and operated similar to the methods used in 2007 (van den Broek et al. 2008). A rock drill was used to set steel anchor pins into the rock walls at the Baird Canyon and Canyon Creek fishwheel sites. Anchor lines attached to these pins

consisted of galvanized wire rope (1.3 cm dia) and polypropylene rope (1.9 cm dia). To hold the two smaller fishwheels in place when fishing along gravel bars, a boat anchor was buried 1.5 m deep on the river bank approximately 30 m upstream of the fishing site. Wire rope (1.3 cm dia) was then attached to the fishwheel at one end and to the anchor at the other end. Wood-pole or aluminum-plank spars were used to hold the bow of the fishwheels off the river bank or cliff. Two, propeller-driven, outboard motors were mounted on transoms at the stern of the fishwheel pontoons and were used to move the fishwheels between sites. Fishwheels were re-positioned upriver and downriver by adjusting the bow anchor lines, and laterally by adjusting the stern and side anchor lines.

The fishwheels were operated 24 hours per day except for stoppages when they were being re-positioned or repaired, or when catches were too high to fish them overnight. 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, 124.2 kHz transponders were encapsulated on a t-bar tag with two, 25-mm monofilament lines that terminated in 9-mm anchor bars (herein referred to as TBA-PIT tags). NVE's address and phone number were printed on a 45-mm piece of yellow PVC marker (Hallprint Pty Ltd, Adelaide South Australia). Unique tag numbers were electronically encoded

and read via a PDA with integrated RFID scanner. The TBA-PIT tags were a new technology specially designed for this project. Tags were supplied in magazine clips of 20 tags each, and were applied to fish using a handheld applicator gun with 16-gauge needle. The tip of the needle was sunk into the musculature of the fish 1-2 cm ventral to the insertion of the dorsal fin between the third and forth pterygiophores, to a depth of 1-2 cm, so that the tag anchors would lodge behind the pterygiophores within the dorsal musculature when ejected from the applicator gun.

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). Specifically, if a non-significant Chi-square test resulted from any of the three tests ($\alpha = 0.05$) shown in Table 1 then the PPE model was chosen.

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

## RESULTS

### Project Mobilization

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

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

## Fishwheel Operation and Catch

### *Fishwheel Operation*

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

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

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

### *Fishwheel Catch*

A total of 25,237 adult sockeye salmon were captured at the Baird Canyon fishwheels: 303 at fishwheel 1, 11,923 at fishwheel 2, and 13,011 at fishwheel 5 (Figure 7; Appendix B.1). Total daily catch peaked at 1,308 sockeye salmon on 5 July. 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. Fifty coho salmon, 5 pink salmon *O. gorbuscha*, 3 steelhead trout *O. mykiss*, 127 Dolly Varden *Salvelinus malma*, 36 whitefish *Coregonus spp.*, 13 Pacific lamprey *Lampetra tridentata*, 34 sucker *Catostomus sp.*, 1 burbot *Lota lota*, 1 three spine stickleback *Gasterosteus aculeatus*, 1 beaver *Castor canadensis*, and 1 harbor seal *Phoca vitulina* were also captured and released.

A total of 50,305 sockeye salmon were captured at the Canyon Creek fishwheels, including 24,647at fishwheel 3 and 25,658 at fishwheel 4 (Figure 8; Appendix B.1). Daily catch peaked at 1,329 sockeye salmon on 19 July. Similar to Baird Canyon, these catch data reflect only sockeye salmon captured and retained during periods when escape panels were closed. Twenty-six coho salmon, 11 steelhead trout, 63 Dolly Varden, 45 whitefish, 15 Pacific lamprey, 29 sucker, 1 burbot, 1 pink salmon, and 1 arctic grayling *Thymallus arcticus* were also captured and released.

## Tag Application and Recovery

Of the 25,237 sockeye salmon that were captured at the Baird Canyon fishwheels, 11,282 fish (44.7%) were tagged and released (Figure 9; Appendix C.1). This included 503 radio-tagged fish and 10,779 TBA-PIT-tagged fish. The number of tags applied on a single day peaked at 438 on 5-6 July. Initially, the daily tag quota at Baird Canyon was set at 1.20% of the previous day's salmon count at the Miles Lake sonar site. On 16 June, due to a weaker than anticipated run, the daily tag quota was increased to 2.09% of the previous day's salmon counts at the Miles Lake sonar site. From 17 July onwards, the number of sockeye salmon tagged each day was capped at 90 fish. The majority of sockeye salmon that were released untagged were done so because the daily tagging quota had been met.

A total of 50,293 sockeye salmon were examined for primary and secondary marks at the Canyon Creek fishwheels (Figure 10; Appendix C.1). Of those examined, 838 (1.7%) were recaptures, or fish that had been marked at Baird Canyon. The first recapture was caught at Canyon Creek on 27 May (tagged 22 May) and the last recapture was caught on 15 August (tagged 26 July). The number of sockeye examined for marks at Canyon Creek peaked at 1,329 fish on 19 July and the number of recaptures peaked at 31 fish on 26 June. The median travel time of sockeye salmon tagged at Baird Canyon and recaptured at Canyon Creek was 11.0 d (range: 3.2-56.4 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 Chinook salmon. Of the 220 sockeye salmon captured twice at the Baird Canyon fishwheels, 171 fish (77.7%) were recaptured within 1 d of being tagged (Figure 12). The longest delay between capture events was 36.3 d. Only one Chinook salmon was captured at Canyon Creek with a right operculum punch and no TBA-PIT tag, so tag loss between sampling events was negligible (0.29%; or 11.4 tags lost per every 3,931 Chinook tagged). It is possible that this recapture was one of the 10 Chinook salmon that received an operculum punch but no tag at Baird Canyon.

Recapture rates of sockeye salmon that were tagged on the west bank (6.4%) of the river at Baird Canyon were significantly different than recapture rates of fish tagged on the east bank (7.6%; $\chi^2 = 6.2$, df = 1, P = 0.01; Table 2). 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 ($\chi^2 = 1.2$, df = 1, P = 0.28; Table 3). In each of these tests, 48 recaptures with unknown release locations were excluded. Mark rates of sockeye salmon inspected on the east bank (1.6%) at Canyon Creek were not significantly different than mark rates of fish inspected on the west bank (1.7%; $\chi^2 = 0.8$, df = 1, P = 0.38; Table 4).

Cumulative length-frequency distributions of sockeye salmon marked in the first event and recaptured in the second event were not significantly different ($D_{max} = 0.032$, P = 0.92; 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 ($D_{max} = 0.13$, P = 0.00).

A significant difference ($D_{max}$= 012, P = 0.00) was also 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.

Mark rates varied over the study period indicating that the probability of a fish being marked at Baird Canyon was not independent of time of capture (Figure 14). Similarly, the proportion of fish tagged at Baird Canyon that were subsequently recaptured at Canyon Creek varied over time (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 20 May to 19 August was 739,883 (SE = 32,962; 95% CI = 675,278 – 804,489). This estimate was based on 11,282 tagged fish available for recapture, 50,293 fish examined for marks, and 838 recaptures.

## Other Tag Recoveries

A total of 441 sockeye salmon (3.9% of total tagged) were reported harvested at various inriver locations (Table 5). Of these, 109 were in the federal and state subsistence fisheries (primarily fishwheels), 108 were in the personal-use dip net fisheries, 11 were in the sport fishery, 195 were from unknown fisheries, and 18 were recovered by ADF&G from various spawning tributaries. An additional 436 tagged sockeye salmon were recovered by Gulkana Hatchery staff during broodstock collection (Figure 16).

# DISCUSSION

## Project Mobilization

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

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

than 3 d. The timing and execution of mobilization at both camps was suitable given the environmental conditions in early May. No early-run fish were missed by either site.

**Data Collection**

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

**Fishwheel Operation and Catch**

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

Relative to 2007, 2.3% more sockeye salmon were tagged at Baird Canyon and 11.1% fewer sockeye salmon were examined for marks at Canyon Creek in 2008. The reduction in fish examined at Canyon Creek was mainly attributable to difficulties in finding a suitable fishing site for fishwheel 4. Changes in river depth and velocity that were caused by the flood event in October 2006 made the site used prior to 2007 unsuitable for fishwheel 4. Despite spending considerable time and effort in 2008 testing new sites for fishwheel 4, a sufficient number of sockeye salmon were captured during each sampling event to meet the study objectives.

**Abundance Estimate**

The 2008 abundance estimate for sockeye salmon (739,883; CV = 4.5%) appeared unbiased and exceeded the precision levels specified in the study objectives. The mark-recapture estimate was 3.1% (22,084 fish) greater than the 2008 Miles Lake sonar count of 717,799 salmon. If the estimated number of Chinook salmon that migrated above Baird Canyon (41,343) was subtracted from the Miles Lake sonar count, then the sockeye mark-recapture estimate was 9.4% (64,327 fish) greater than the sonar count. The 2008 inriver goal for salmon passing the Miles Lake sonar was set at 614,606 to 814,606.

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 2008 showed that 3.9% (20 out of 508) 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; pers. comm.). 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 2008 mark-recapture abundance estimate decreases to 711,028, which is only 5.1% more than the 2008 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 2007, an estimated 205,184 sockeye salmon were harvested in fisheries upstream of Baird Canyon (Hollowell and Sommerville 2008). If it is assumed that harvests in 2008 were similar (2008 data was not available at the time of reporting), then the spawning escapement of sockeye salmon was 534,649 (739,883 minus 205,184). This level of escapement exceeds the sustainable escapement goal of 300,000-500,000 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.

## RECOMMENDATIONS

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

1. Redesign our Palm OS software used in data collection to reduce user errors. For example, simplifying the flow of the software and incorporating 'checks and balances' will ensure only relevant data is recorded and eliminate inconspicuous data entry. Along with new programming, the software developer should be available for immediate resolution of software issues as they occur in the field. Timely customer support is essential;
2. Improve the inriver reporting of harvested tagged fish within the Chitina and Glennallen subdistricts. Recent research data and anecdotal information suggest that considerable unreported harvest is taking place in the inriver fisheries of the Copper River. Essentially, once the salmon pass the Miles Lake sonar, there is limited accountability of inriver harvests within the State and Federal subsistence, personal use, sport and guided sport fisheries throughout the Copper River drainage. The Native Village of Eyak submitted an unsuccessful pre-proposal to the U.S. Fish and Wildlife Service Office of Subsistence Management to improve public awareness of existing tagging studies and increase the percentage of harvested tagged fish that are reported to project investigators. Attempts should be made to implement some of these ideas under the current budget framework;
3. Continue monitoring ice and snow conditions at Baird Canyon through April and early May in order to assess the best time, labor requirements, and transportation logistics to mobilize. Plan on the Baird Canyon crew starting around 5 May and the Canyon Creek crew around 12 May, with Baird Canyon mobilized in time to have the first fishwheel launched and fishing immediately following full break-up and clearing of river ice above Miles Lake, and Canyon Creek mobilized in time to have the first fishwheel launched and fishing within 2 d of the first tagged fish released;
4. Operate fishwheels 1, 2, and 5 at the same sites used in 2008. Fishwheels 3 and 4 at Canyon Creek will need to be relocated as river conditions change. River conditions at the Canyon Creek location have been more variable since the 2006 Fall flooding event; and
5. Continue to use the escape panels in each fishwheel with the openings set to a width of 6 cm except when closed to sample sockeye salmon.

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**TABLES**

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

Mixing test:

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

Equal proportions test:

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

Equal movement test:

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

Table 2. Number of 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, 2008.

| Bank of Release | Recaptured | Not Recaptured | Tagged | Recapture Rate |
|---|---|---|---|---|
| West (FW1&5) | 380 | 5,528 | 5,908 | 0.064 |
| East (FW2) | 410 | 4,964 | 5,374 | 0.076 |
| Total | 790 | 10,492 | 11,282 | 0.070 |

Chi-square = 6.2, df = 1, p-value = 0.013

Excludes 48 recaptures with unknown release locations.

Table 3. 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, 2008.

| | Bank of Recovery | | |
|---|---|---|---|
| Bank of Release | West | East | Recaptured |
| West (FW1&5) | 193 | 187 | 380 |
| East (FW2) | 224 | 186 | 410 |
| Total | 417 | 373 | 790 |

Chi-square = 1.17, df = 1, p-value = 0.279

Excludes 48 recaptures with unknown release locations.

Table 4. 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, 2008.

| Recovery Location | Marked | Not marked | Total Examined | Mark Rate |
|---|---|---|---|---|
| West (FW4) | 440 | 25,207 | 25,647 | 0.017 |
| East (FW3) | 398 | 24,248 | 24,646 | 0.016 |
| Total | 838 | 49,455 | 50,293 | 0.017 |

Chi-square = 0.78, df = 1, p-value = 0.378

Table 5. Number of tagged sockeye salmon recovered, by location and tag type, 2008.

| | Recovery Category | | | | |
|---|---|---|---|---|---|
| Recovery Location | Personal Use | Subsistence | Unreported | Total | Percent |
| Chitina Subdistrict | 95 | | 1 | 96 | 21.8% |
| Glennallen Subdistrict | | 109 | 32 | 141 | 32.0% |
| Unknown Subdistrict | 13 | | 162 | 175 | 39.7% |
| Sport Fishery | | | | 11 | 2.5% |
| ADF&G Research | | | | 18 | 4.1% |
| Total | 108 | 109 | 195 | 441 | |

**FIGURES**

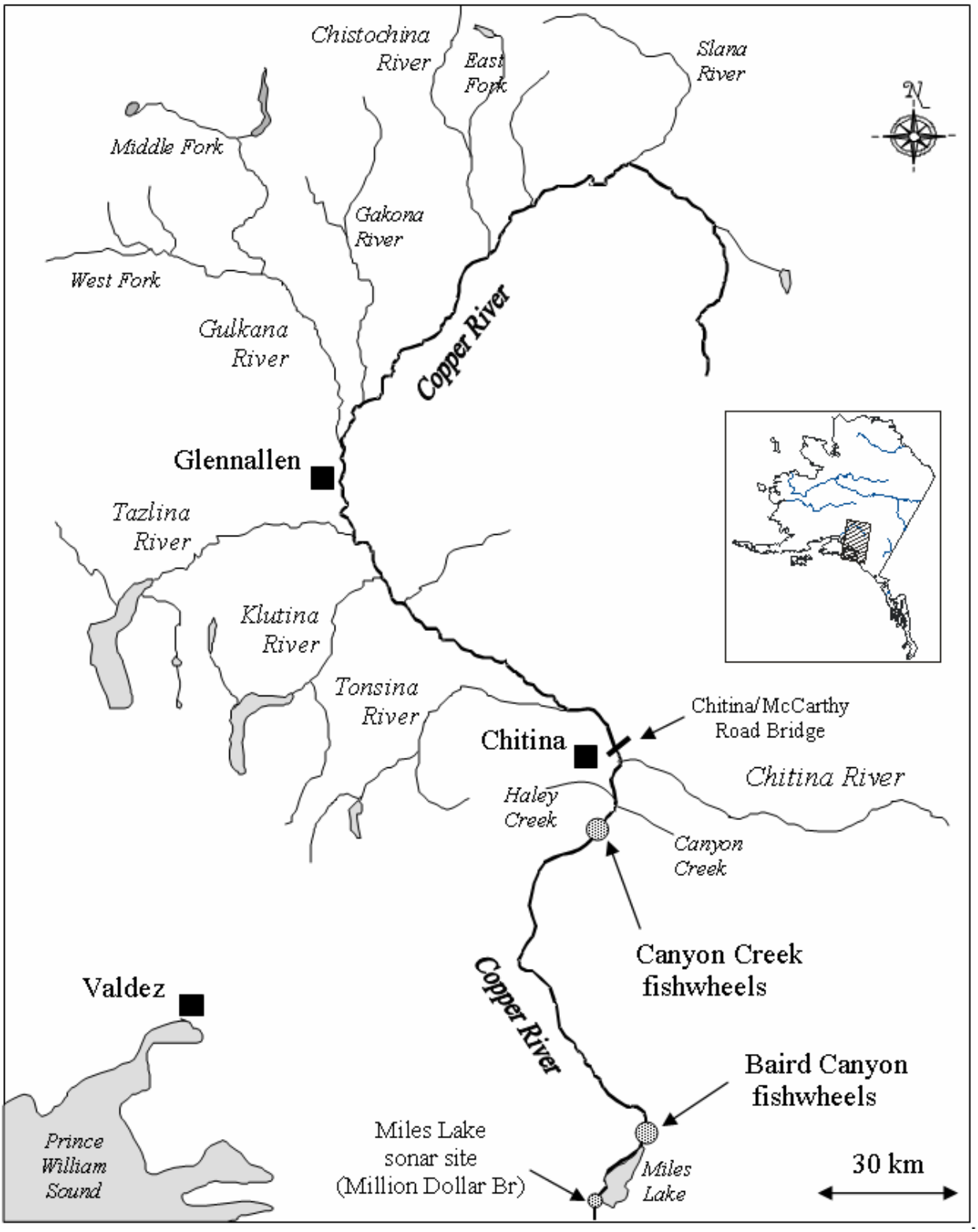


Figure 1. Map of the study area showing the location of the Baird Canyon and Canyon Creek fishwheels on the Copper River, 2008.

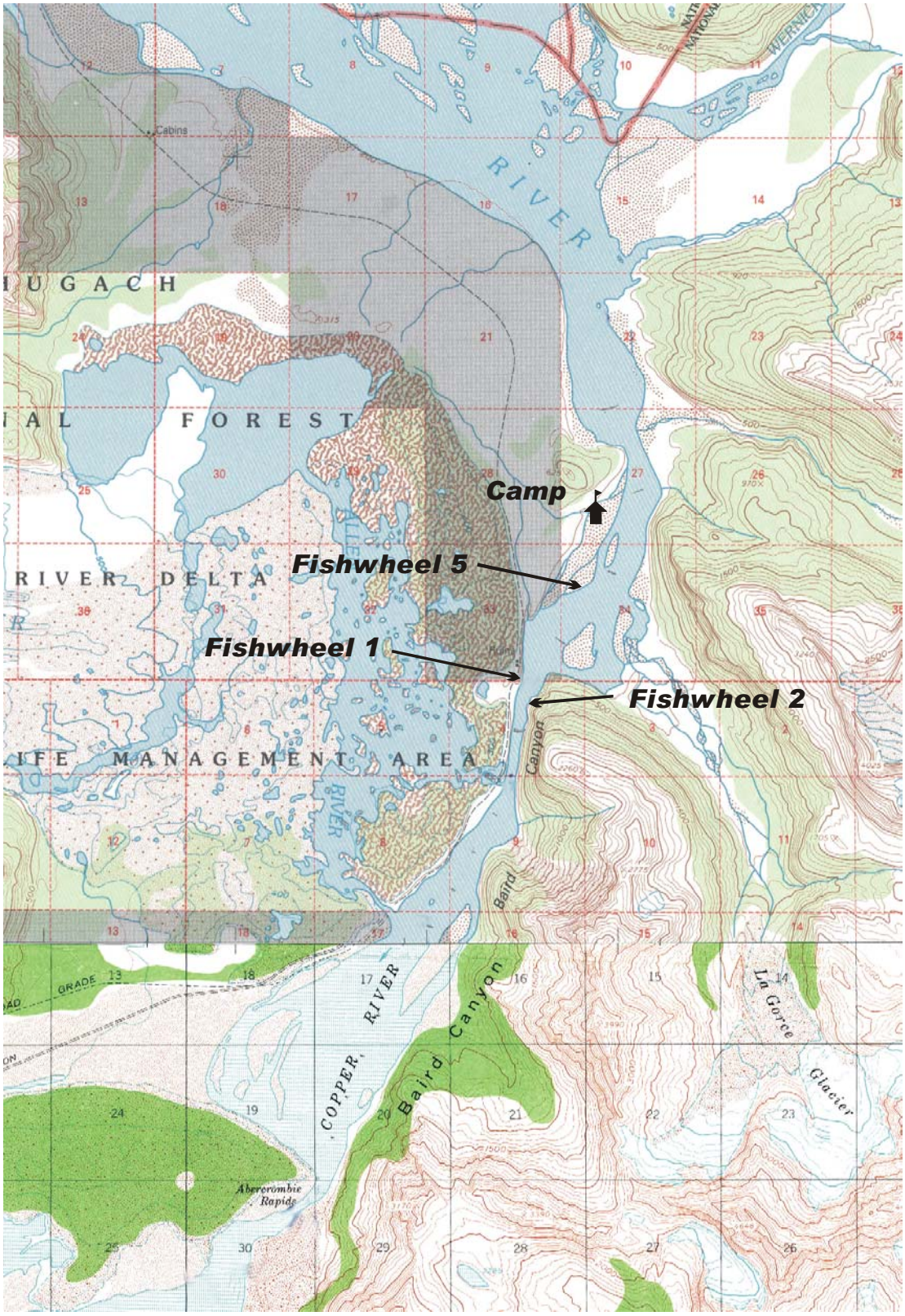


Figure 2. Map of Baird Canyon on the Copper River showing the location of the camp and fishwheel sites that were used in 2008.

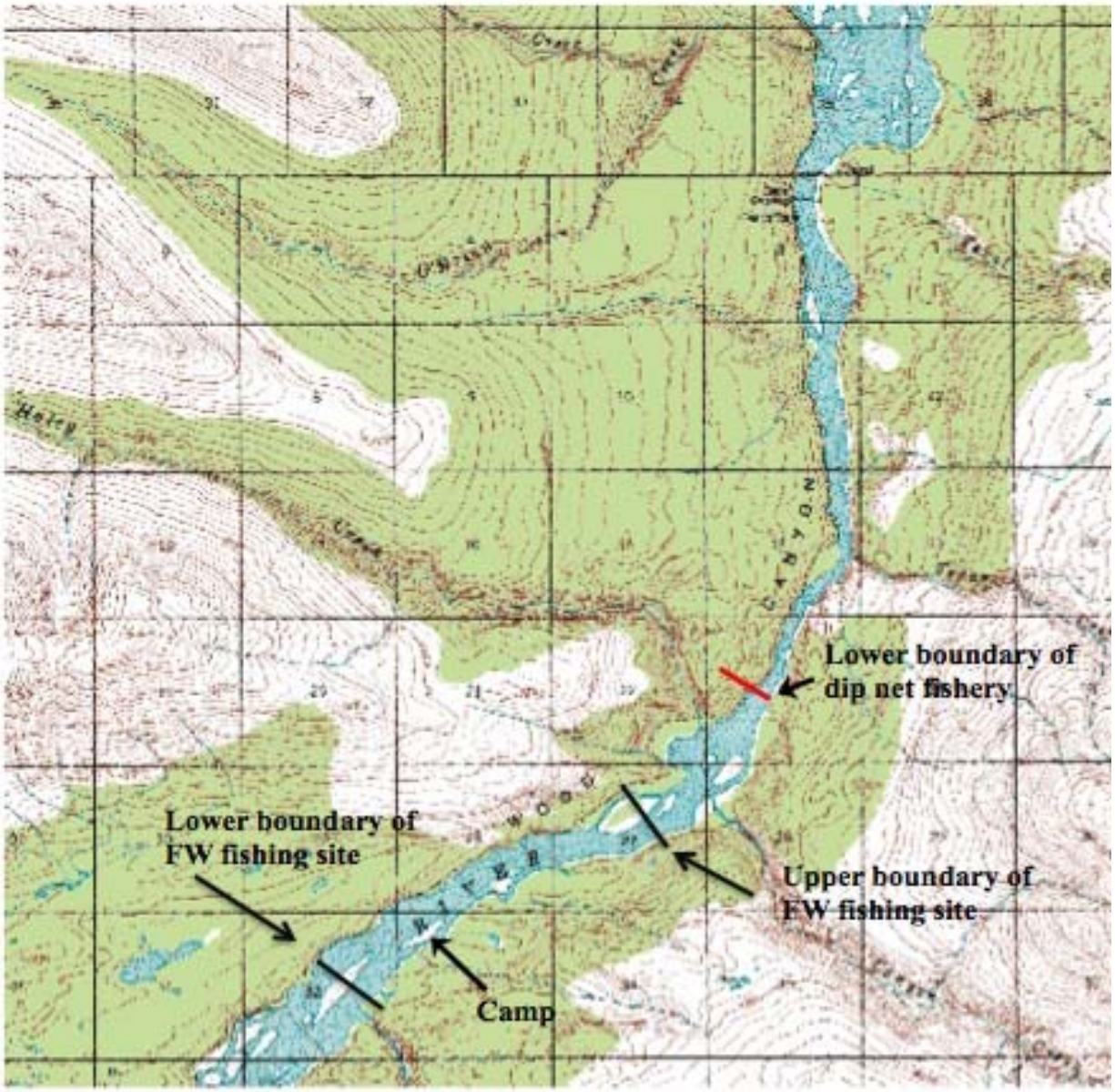


Figure 3. Map of Wood Canyon on the Copper River showing the location of the Canyon Creek camp and fishwheel sites that were used in 2008, and the lower boundary of the Chitina Subdistrict dip net fishery.

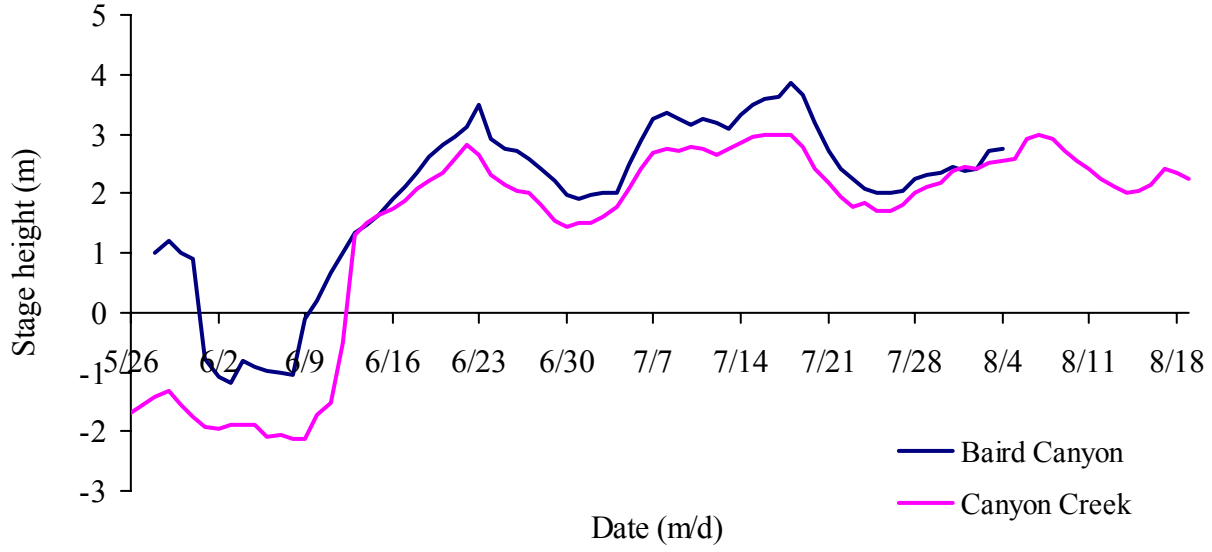


Figure 4. Stage height of the Copper River near the Baird Canyon and Canyon Creek fishwheels, 26 May to 19 August 2008.

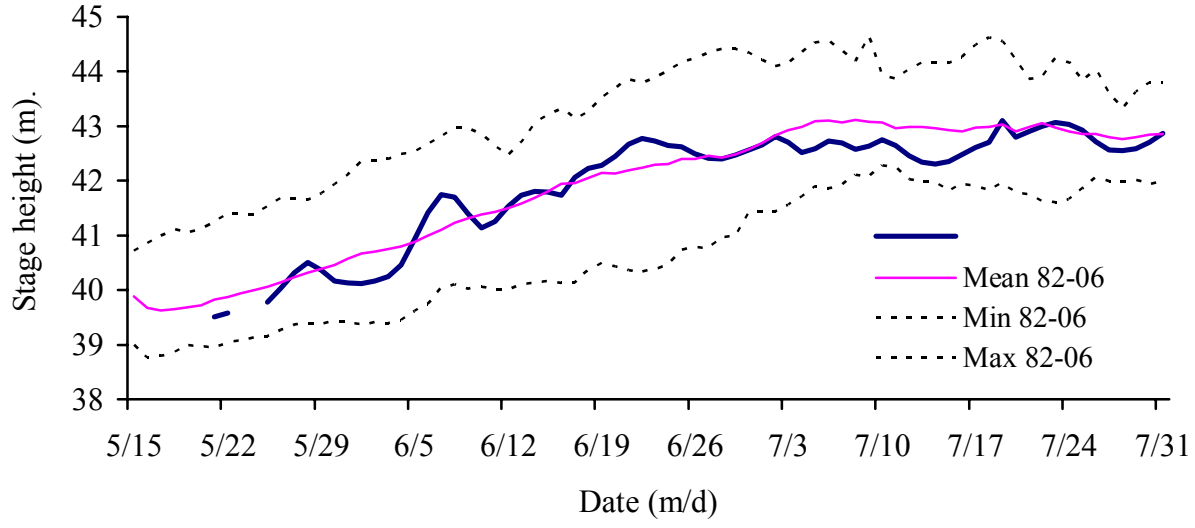


Figure 5. Stage height of the Copper River at the Million Dollar Bridge, 1982-2008.

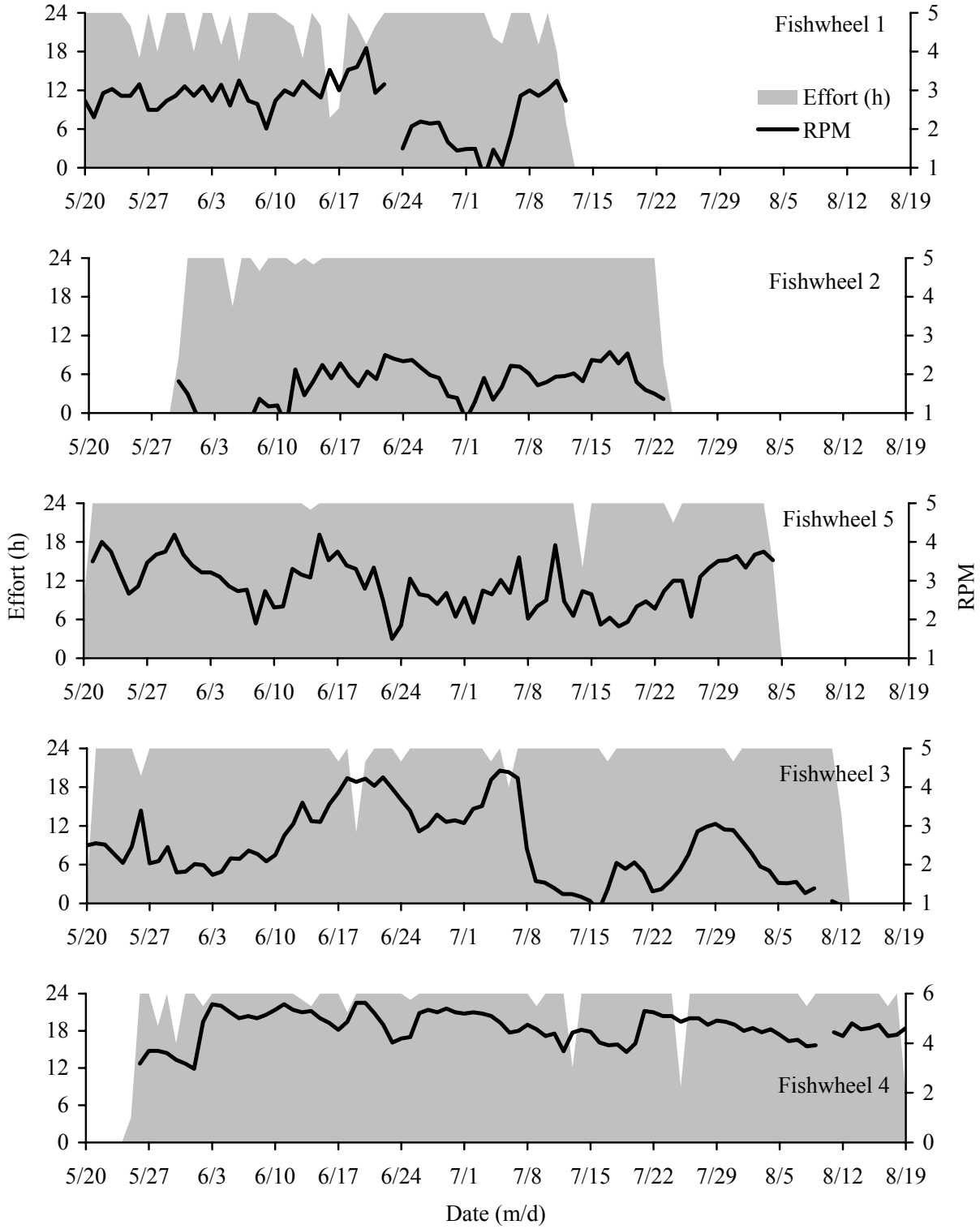


Figure 6. Fishwheel effort (h) and speed (RPM) at the Baird Canyon (fw 1, 2, and 5) and Canyon Creek (fw 3 and 4) fishwheels on the Copper River, 2008.

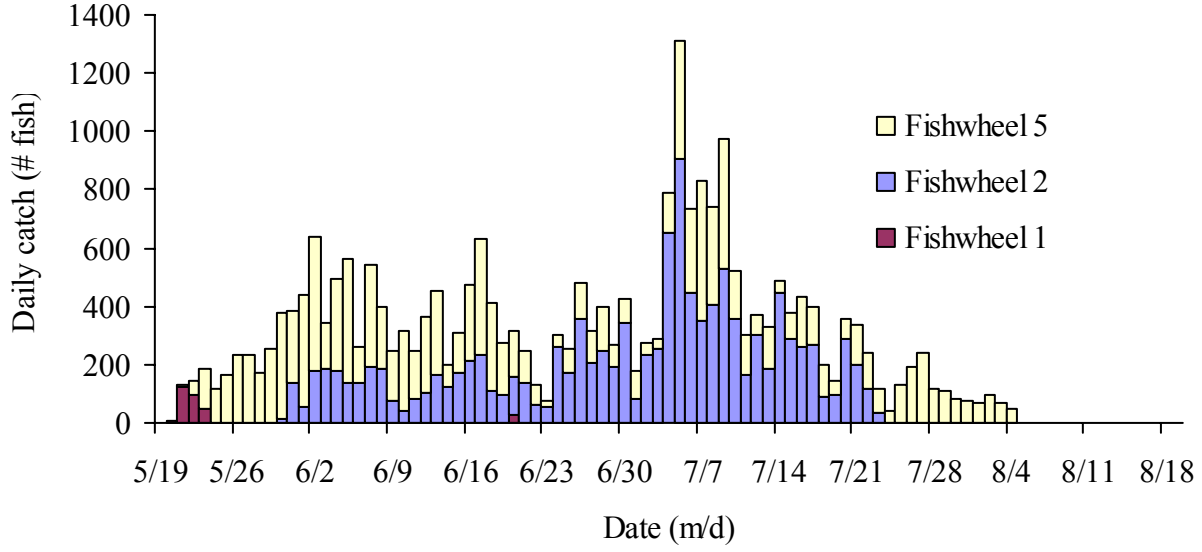


Figure 7. Daily catch of sockeye salmon at the Baird Canyon fishwheels on the Copper River, 2008. These catch data do not reflect the total number of sockeye salmon actually caught by the fishwheels, but only those that were retained in live tanks when the escape panels were closed.

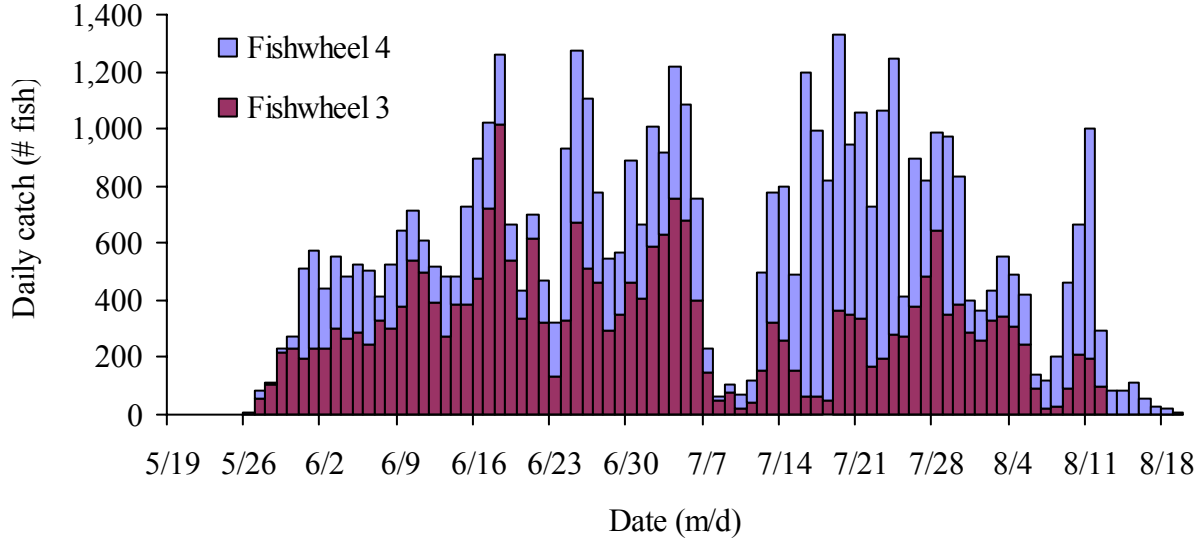


Figure 8. Daily catch of sockeye salmon at the Canyon Creek fishwheels on the Copper River, 2008.

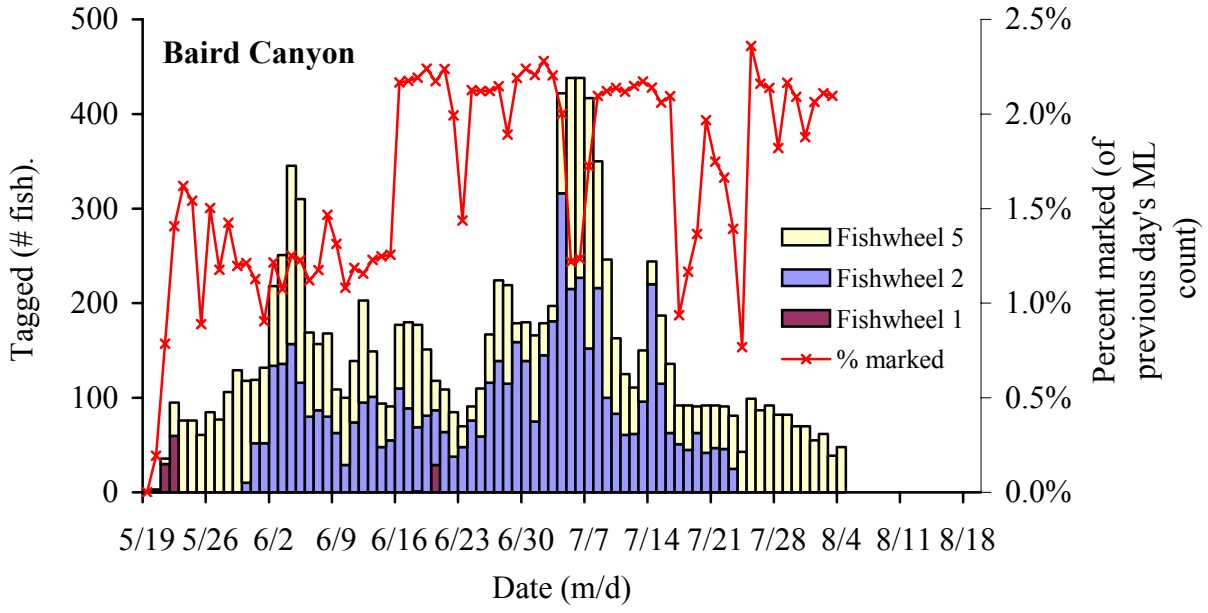


Figure 9. Number of sockeye salmon tagged at the Baird Canyon fishwheels and the proportion of sockeye salmon tagged relative to the previous day's count at the Miles Lake sonar site.

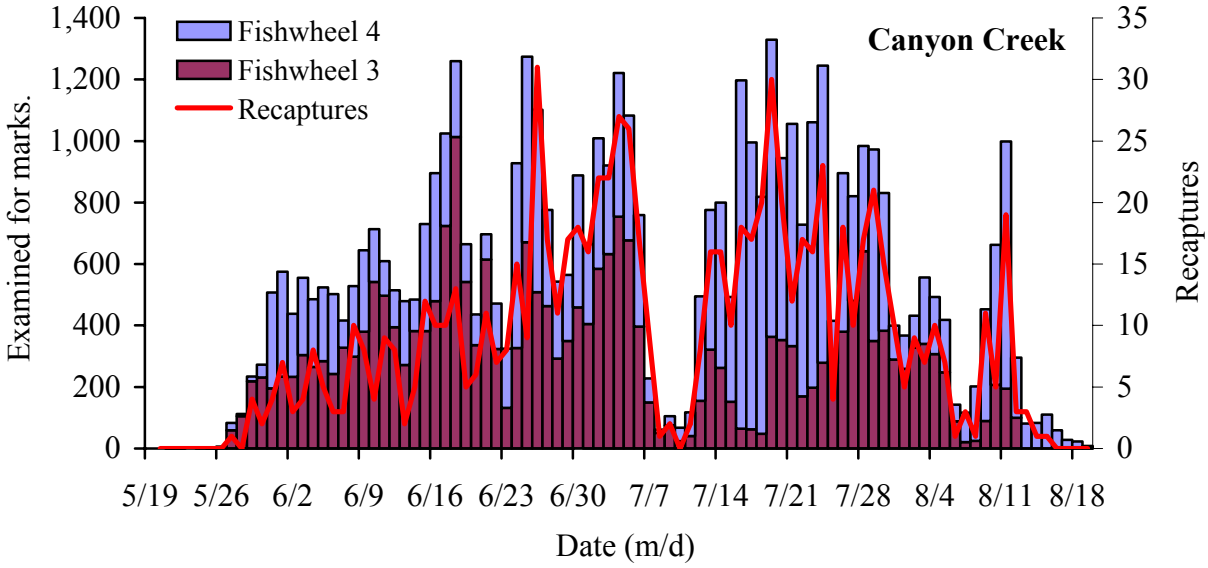


Figure 10. Number of sockeye salmon examined for marks and recaptured at the Canyon Creek fishwheels on the Copper River, 2008.

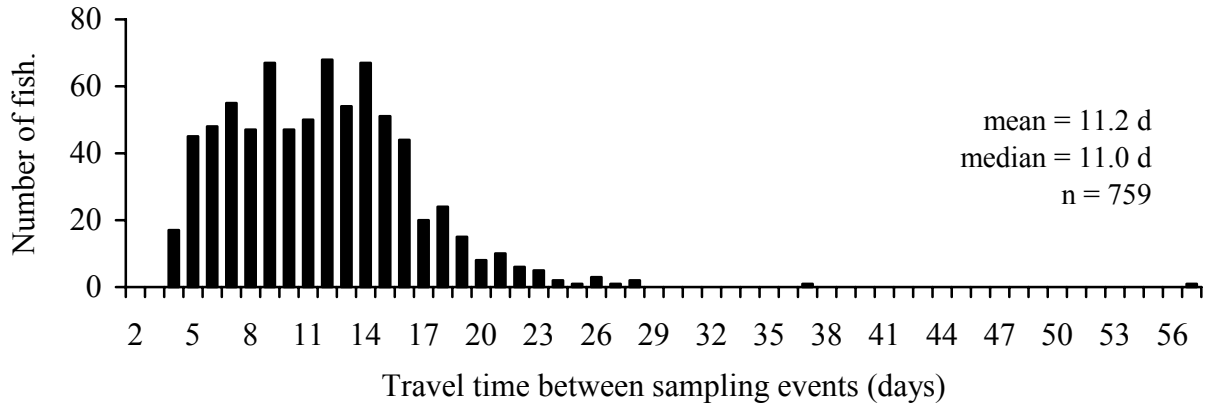


Figure 11. Travel time (days) of sockeye salmon tagged at the Baird Canyon fishwheels and recaptured at the Canyon Creek fishwheels, 2008.

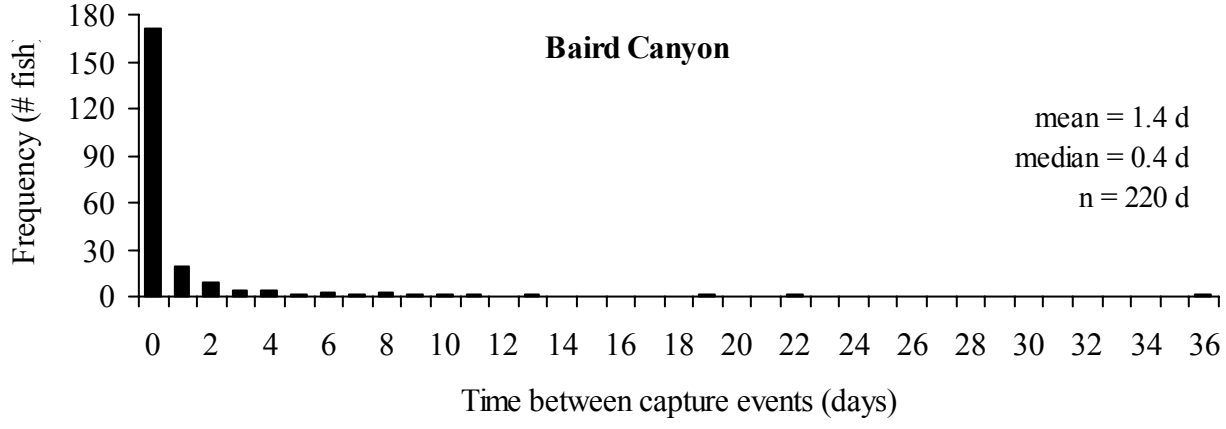


Figure 12. Migratory delay (days) for sockeye salmon captured more than once at the Baird Canyon fishwheels, 2008. Note that unlike Chinook, most sockeye were marked at FW5 and thus they were generally recaptured at FW5.

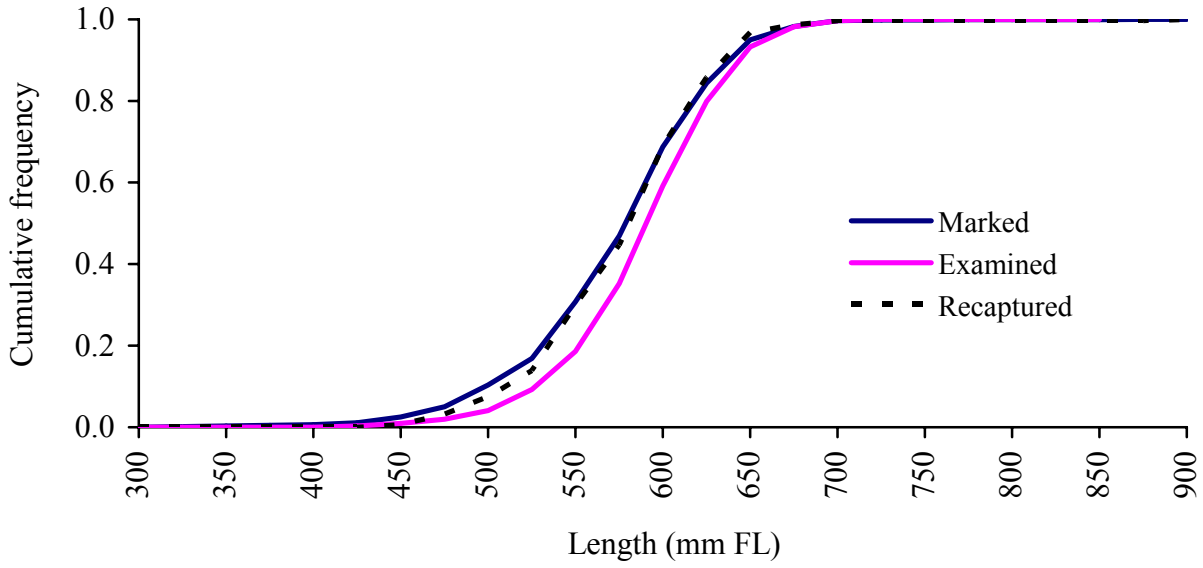


Figure 13. Cumulative length-frequency distributions for sockeye salmon marked at Baird Canyon and examined and recaptured at Canyon Creek, 2008.

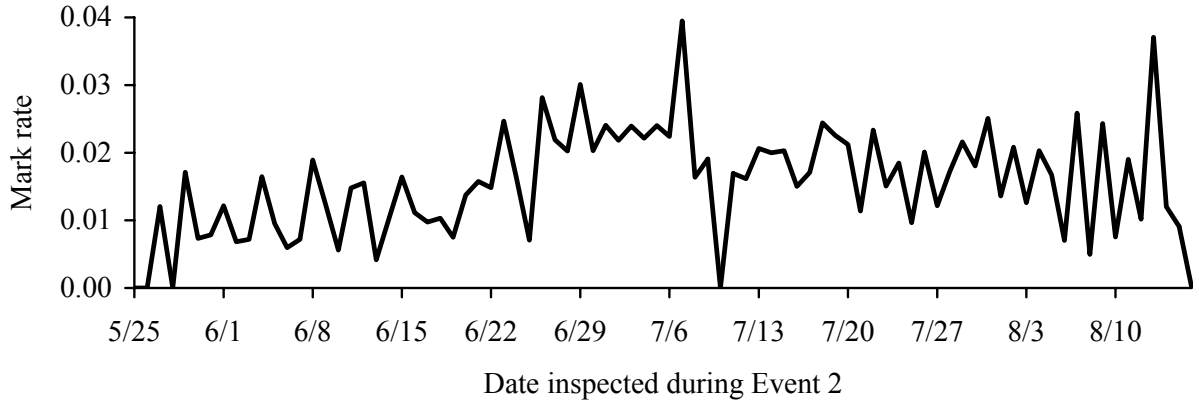


Figure 14. Daily proportion of sockeye salmon examined at the Canyon Creek fishwheels that were marked (mark rate), 2008.

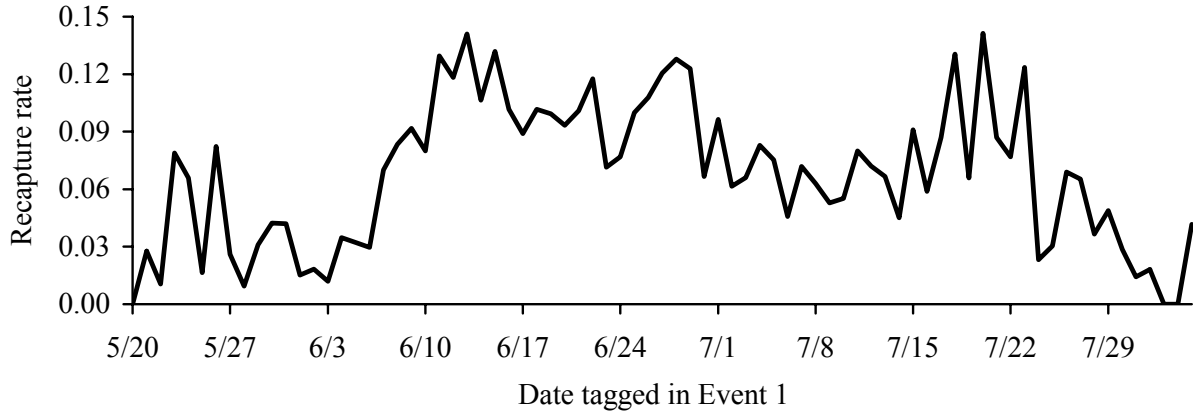


Figure 15. Daily proportion of sockeye salmon tagged at the Baird Canyon fishwheels that were subsequently recaptured at the Canyon Creek fishwheels (recapture rate), 2008.

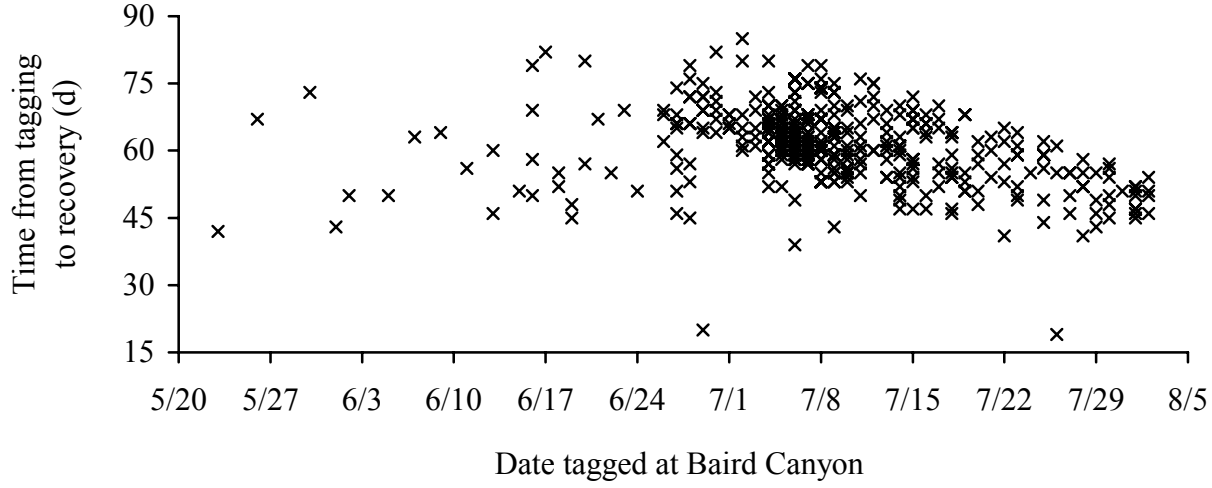


Figure 16. Travel time for sockeye salmon tagged at Baird Canyon and recovered by Gulkana Hatchery staff during broodstock collection, 2008.

# APPENDICES

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

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

Appendix A.1 continued.

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

Appendix A.1 continued.

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

Appendix A.1 continued.

| | Baird Canyon | | | | | | | | | Canyon Creek | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fishwheel 1 | | | Fishwheel 2 | | | Fishwheel 5 | | | Fishwheel 3 | | | Fishwheel 4 | | |
| Date | Total effort (h) | CPUE effort (h) | RPM | Total effort (h) | CPUE effort (h) | RPM | Total effort (h) | CPUE effort (h) | RPM | Total effort (h) | CPUE effort (h) | RPM | Total effort (h) | CPUE effort (h) | RPM |
| 17-Aug | | | | | | | | | | | | | 22.0 | 22.6 | 4.3 |
| 18-Aug | | | | | | | | | | | | | 24.0 | 23.4 | 4.3 |
| 19-Aug | | | | | | | | | | | | | 7.7 | 10.9 | 4.6 |
| Effort (h) | 1,180 | | 2.6 | 1,277 | | 1.7 | 1,809 | | 2.9 | 1,973 | | 2.5 | 1,993 | | 4.6 |
| Percent operational: | 91.8% | | | 99.1% | | | 99.2% | | | 98.2% | | | 98.3% | | |

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

| | 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 May | 0 | 0 | | | | | | | | |
| 20 May | 4 | 4 | | | 0 | 0 | 0 | 0 | | |
| 21 May | 121 | 125 | | | 7 | 7 | 1 | 1 | | |
| 22 May | 97 | 222 | | | 46 | 53 | 1 | 2 | | |
| 23 May | 50 | 272 | | | 133 | 186 | 0 | 2 | | |
| 24 May | 0 | 272 | | | 119 | 305 | 3 | 5 | | |
| 25 May | 0 | 272 | | | 165 | 470 | 1 | 6 | 0 | 0 |
| 26 May | 0 | 272 | | | 233 | 703 | 3 | 9 | 3 | 3 |
| 27 May | 0 | 272 | | | 235 | 938 | 59 | 68 | 24 | 27 |
| 28 May | 0 | 272 | | | 174 | 1,112 | 105 | 173 | 7 | 34 |
| 29 May | 0 | 272 | | | 255 | 1,367 | 218 | 391 | 16 | 50 |
| 30 May | 0 | 272 | 11 | 11 | 368 | 1,735 | 231 | 622 | 41 | 91 |
| 31 May | 0 | 272 | 135 | 146 | 251 | 1,986 | 196 | 818 | 312 | 403 |
| 1 Jun | 0 | 272 | 57 | 203 | 385 | 2,371 | 234 | 1,052 | 341 | 744 |
| 2 Jun | 0 | 272 | 178 | 381 | 459 | 2,830 | 233 | 1,285 | 205 | 949 |
| 3 Jun | 0 | 272 | 182 | 563 | 159 | 2,989 | 304 | 1,589 | 251 | 1,200 |
| 4 Jun | 0 | 272 | 178 | 741 | 319 | 3,308 | 265 | 1,854 | 221 | 1,421 |
| 5 Jun | 1 | 273 | 135 | 876 | 424 | 3,732 | 284 | 2,138 | 240 | 1,661 |
| 6 Jun | 0 | 273 | 134 | 1,010 | 130 | 3,862 | 242 | 2,380 | 260 | 1,921 |
| 7 Jun | 0 | 273 | 191 | 1,201 | 351 | 4,213 | 328 | 2,708 | 88 | 2,009 |
| 8 Jun | 0 | 273 | 188 | 1,389 | 212 | 4,425 | 299 | 3,007 | 229 | 2,238 |
| 9 Jun | 0 | 273 | 73 | 1,462 | 175 | 4,600 | 380 | 3,387 | 265 | 2,503 |
| 10 Jun | 0 | 273 | 41 | 1,503 | 273 | 4,873 | 542 | 3,929 | 172 | 2,675 |
| 11 Jun | 0 | 273 | 84 | 1,587 | 160 | 5,033 | 497 | 4,426 | 112 | 2,787 |
| 12 Jun | 0 | 273 | 106 | 1,693 | 258 | 5,291 | 394 | 4,820 | 121 | 2,908 |
| 13 Jun | 0 | 273 | 165 | 1,858 | 287 | 5,578 | 271 | 5,091 | 209 | 3,117 |
| 14 Jun | 0 | 273 | 124 | 1,982 | 77 | 5,655 | 382 | 5,473 | 103 | 3,220 |
| 15 Jun | 0 | 273 | 172 | 2,154 | 136 | 5,791 | 382 | 5,855 | 348 | 3,568 |
| 16 Jun | 0 | 273 | 211 | 2,365 | 262 | 6,053 | 479 | 6,334 | 417 | 3,985 |
| 17 Jun | 0 | 273 | 234 | 2,599 | 400 | 6,453 | 724 | 7,058 | 300 | 4,285 |
| 18 Jun | 1 | 274 | 109 | 2,708 | 304 | 6,757 | 1013 | 8,071 | 247 | 4,532 |
| 19 Jun | 0 | 274 | 93 | 2,801 | 183 | 6,940 | 542 | 8,613 | 123 | 4,655 |

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. |
| 20 Jun | 29 | 303 | 128 | 2,929 | 158 | 7,098 | 336 | 8,949 | 100 | 4,755 |
| 21 Jun | 0 | 303 | 137 | 3,066 | 107 | 7,205 | 615 | 9,564 | 82 | 4,837 |
| 22 Jun | 0 | 303 | 59 | 3,125 | 69 | 7,274 | 323 | 9,887 | 148 | 4,985 |
| 23 Jun | 0 | 303 | 52 | 3,177 | 26 | 7,300 | 132 | 10,019 | 192 | 5,177 |
| 24 Jun | 0 | 303 | 264 | 3,441 | 40 | 7,340 | 327 | 10,346 | 601 | 5,778 |
| 25 Jun | 0 | 303 | 174 | 3,615 | 79 | 7,419 | 671 | 11,017 | 603 | 6,381 |
| 26 Jun | 0 | 303 | 355 | 3,970 | 127 | 7,546 | 510 | 11,527 | 593 | 6,974 |
| 27 Jun | 0 | 303 | 207 | 4,177 | 110 | 7,656 | 463 | 11,990 | 313 | 7,287 |
| 28 Jun | 0 | 303 | 246 | 4,423 | 152 | 7,808 | 292 | 12,282 | 251 | 7,538 |
| 29 Jun | 0 | 303 | 189 | 4,612 | 77 | 7,885 | 349 | 12,631 | 216 | 7,754 |
| 30 Jun | 0 | 303 | 346 | 4,958 | 77 | 7,962 | 459 | 13,090 | 431 | 8,185 |
| 1 Jul | 0 | 303 | 81 | 5,039 | 99 | 8,061 | 405 | 13,495 | 260 | 8,445 |
| 2 Jul | 0 | 303 | 236 | 5,275 | 39 | 8,100 | 585 | 14,080 | 424 | 8,869 |
| 3 Jul | 0 | 303 | 252 | 5,527 | 37 | 8,137 | 632 | 14,712 | 288 | 9,157 |
| 4 Jul | 0 | 303 | 653 | 6,180 | 133 | 8,270 | 754 | 15,466 | 467 | 9,624 |
| 5 Jul | 0 | 303 | 909 | 7,089 | 399 | 8,669 | 677 | 16,143 | 406 | 10,030 |
| 6 Jul | 0 | 303 | 444 | 7,533 | 292 | 8,961 | 396 | 16,539 | 363 | 10,393 |
| 7 Jul | 0 | 303 | 352 | 7,885 | 478 | 9,439 | 150 | 16,689 | 78 | 10,471 |
| 8 Jul | 0 | 303 | 408 | 8,293 | 332 | 9,771 | 51 | 16,740 | 10 | 10,481 |
| 9 Jul | 0 | 303 | 529 | 8,822 | 443 | 10,214 | 75 | 16,815 | 30 | 10,511 |
| 10 Jul | 0 | 303 | 358 | 9,180 | 167 | 10,381 | 24 | 16,839 | 44 | 10,555 |
| 11 Jul | 0 | 303 | 165 | 9,345 | 140 | 10,521 | 41 | 16,880 | 78 | 10,633 |
| 12 Jul | 0 | 303 | 302 | 9,647 | 66 | 10,587 | 155 | 17,035 | 340 | 10,973 |
| 13 Jul | | | 185 | 9,832 | 143 | 10,730 | 321 | 17,356 | 455 | 11,428 |
| 14 Jul | | | 449 | 10,281 | 35 | 10,765 | 262 | 17,618 | 538 | 11,966 |
| 15 Jul | | | 290 | 10,571 | 89 | 10,854 | 152 | 17,770 | 341 | 12,307 |
| 16 Jul | | | 258 | 10,829 | 176 | 11,030 | 65 | 17,835 | 1132 | 13,439 |
| 17 Jul | | | 271 | 11,100 | 127 | 11,157 | 62 | 17,897 | 933 | 14,372 |
| 18 Jul | | | 89 | 11,189 | 111 | 11,268 | 48 | 17,945 | 771 | 15,143 |
| 19 Jul | | | 96 | 11,285 | 51 | 11,319 | 363 | 18,308 | 966 | 16,109 |
| 20 Jul | | | 285 | 11,570 | 72 | 11,391 | 353 | 18,661 | 591 | 16,700 |
| 21 Jul | | | 201 | 11,771 | 137 | 11,528 | 333 | 18,994 | 723 | 17,423 |

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. |
| 22 Jul | | | 120 | 11,891 | 117 | 11,645 | 170 | 19,164 | 558 | 17,981 |
| 23 Jul | | | 32 | 11,923 | 87 | 11,732 | 198 | 19,362 | 863 | 18,844 |
| 24 Jul | | | | | 43 | 11,775 | 279 | 19,641 | 966 | 19,810 |
| 25 Jul | | | | | 127 | 11,902 | 276 | 19,917 | 139 | 19,949 |
| 26 Jul | | | | | 195 | 12,097 | 380 | 20,297 | 516 | 20,465 |
| 27 Jul | | | | | 243 | 12,340 | 481 | 20,778 | 340 | 20,805 |
| 28 Jul | | | | | 115 | 12,455 | 642 | 21,420 | 342 | 21,147 |
| 29 Jul | | | | | 109 | 12,564 | 349 | 21,769 | 624 | 21,771 |
| 30 Jul | | | | | 85 | 12,649 | 383 | 22,152 | 448 | 22,219 |
| 31 Jul | | | | | 76 | 12,725 | 289 | 22,441 | 110 | 22,329 |
| 1 Aug | | | | | 70 | 12,795 | 259 | 22,700 | 108 | 22,437 |
| 2 Aug | | | | | 99 | 12,894 | 328 | 23,028 | 104 | 22,541 |
| 3 Aug | | | | | 67 | 12,961 | 340 | 23,368 | 216 | 22,757 |
| 4 Aug | | | | | 50 | 13,011 | 307 | 23,675 | 186 | 22,943 |
| 5 Aug | | | | | | | 248 | 23,923 | 170 | 23,113 |
| 6 Aug | | | | | | | 88 | 24,011 | 54 | 23,167 |
| 7 Aug | | | | | | | 21 | 24,032 | 95 | 23,262 |
| 8 Aug | | | | | | | 25 | 24,057 | 177 | 23,439 |
| 9 Aug | | | | | | | 89 | 24,146 | 371 | 23,810 |
| 10 Aug | | | | | | | 207 | 24,353 | 456 | 24,266 |
| 11 Aug | | | | | | | 194 | 24,547 | 805 | 25,071 |
| 12 Aug | | | | | | | 100 | 24,647 | 195 | 25,266 |
| 13 Aug | | | | | | | | | 81 | 25,347 |
| 14 Aug | | | | | | | | | 83 | 25,430 |
| 15 Aug | | | | | | | | | 110 | 25,540 |
| 16 Aug | | | | | | | | | 59 | 25,599 |
| 17 Aug | | | | | | | | | 28 | 25,627 |
| 18 Aug | | | | | | | | | 23 | 25,650 |
| 19 Aug | | | | | | | | | 8 | 25,658 |
| Total | 303 | | 11,923 | | 13,011 | | 24,647 | | 25,658 | |

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

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

| | Baird Canyon | | | | | | Canyon Creek | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fishwheel 1 | | Fishwheel 2 | | Fishwheel 5 | | Fishwheel 3 | | | | Fishwheel 4 | | | |
| Date | Tags | Cum | Tags | Cum | Tags | Cum | Exam | Cum | Recap | Cum | Exam | Cum | Recap | Cum |
| 19 May | 0 | 0 | | | | | | | | | | | | |
| 20 May | 3 | 3 | | | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 21 May | 30 | 33 | | | 6 | 6 | 1 | 1 | 0 | 0 | | | | |
| 22 May | 60 | 93 | | | 35 | 41 | 1 | 2 | 0 | 0 | | | | |
| 23 May | 0 | 93 | | | 76 | 117 | 0 | 2 | 0 | 0 | | | | |
| 24 May | 0 | 93 | | | 76 | 193 | 3 | 5 | 0 | 0 | | | | |
| 25 May | 0 | 93 | | | 61 | 254 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 May | 0 | 93 | | | 85 | 339 | 3 | 9 | 0 | 0 | 3 | 3 | 0 | 0 |
| 27 May | 0 | 93 | | | 77 | 416 | 59 | 68 | 0 | 0 | 24 | 27 | 1 | 1 |
| 28 May | 0 | 93 | | | 106 | 522 | 105 | 173 | 0 | 0 | 7 | 34 | 0 | 1 |
| 29 May | 0 | 93 | | | 129 | 651 | 218 | 391 | 3 | 3 | 16 | 50 | 1 | 2 |
| 30 May | 0 | 93 | 10 | 10 | 108 | 759 | 231 | 622 | 2 | 5 | 41 | 91 | 0 | 2 |
| 31 May | 0 | 93 | 52 | 62 | 67 | 826 | 196 | 818 | 2 | 7 | 312 | 403 | 2 | 4 |
| 1 Jun | 0 | 93 | 52 | 114 | 80 | 906 | 234 | 1,052 | 1 | 8 | 341 | 744 | 6 | 10 |
| 2 Jun | 0 | 93 | 134 | 248 | 84 | 990 | 233 | 1,285 | 2 | 10 | 205 | 949 | 1 | 11 |
| 3 Jun | 0 | 93 | 136 | 384 | 115 | 1105 | 304 | 1,589 | 4 | 14 | 251 | 1,200 | 0 | 11 |
| 4 Jun | 0 | 93 | 157 | 541 | 188 | 1293 | 265 | 1,854 | 6 | 20 | 221 | 1,421 | 2 | 13 |
| 5 Jun | 0 | 93 | 116 | 657 | 194 | 1487 | 284 | 2,138 | 4 | 24 | 240 | 1,661 | 1 | 14 |
| 6 Jun | 0 | 93 | 80 | 737 | 89 | 1576 | 242 | 2,380 | 0 | 24 | 260 | 1,921 | 3 | 17 |
| 7 Jun | 0 | 93 | 87 | 824 | 70 | 1646 | 328 | 2,708 | 2 | 26 | 88 | 2,009 | 1 | 18 |
| 8 Jun | 0 | 93 | 80 | 904 | 88 | 1734 | 299 | 3,007 | 7 | 33 | 229 | 2,238 | 3 | 21 |
| 9 Jun | 0 | 93 | 63 | 967 | 46 | 1780 | 380 | 3,387 | 3 | 36 | 265 | 2,503 | 5 | 26 |
| 10 Jun | 0 | 93 | 29 | 996 | 71 | 1851 | 542 | 3,929 | 2 | 38 | 172 | 2,675 | 2 | 28 |
| 11 Jun | 0 | 93 | 74 | 1,070 | 65 | 1916 | 497 | 4,426 | 8 | 46 | 112 | 2,787 | 1 | 29 |
| 12 Jun | 0 | 93 | 95 | 1,165 | 108 | 2024 | 394 | 4,820 | 7 | 53 | 121 | 2,908 | 1 | 30 |
| 13 Jun | 0 | 93 | 101 | 1,266 | 48 | 2072 | 271 | 5,091 | 0 | 53 | 209 | 3,117 | 2 | 32 |
| 14 Jun | 0 | 93 | 48 | 1,314 | 46 | 2118 | 382 | 5,473 | 4 | 57 | 103 | 3,220 | 1 | 33 |
| 15 Jun | 0 | 93 | 55 | 1,369 | 36 | 2154 | 382 | 5,855 | 5 | 62 | 348 | 3,568 | 7 | 40 |
| 16 Jun | 0 | 93 | 110 | 1,479 | 67 | 2221 | 479 | 6,334 | 3 | 65 | 417 | 3,985 | 7 | 47 |
| 17 Jun | 0 | 93 | 89 | 1,568 | 91 | 2312 | 724 | 7,058 | 8 | 73 | 300 | 4,285 | 2 | 49 |
| 18 Jun | 1 | 94 | 68 | 1,636 | 108 | 2420 | 1013 | 8,071 | 9 | 82 | 247 | 4,532 | 4 | 53 |

Appendix C.1 continued.

| | Baird Canyon | | | | | | Canyon Creek | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fishwheel 1 | | Fishwheel 2 | | Fishwheel 5 | | Fishwheel 3 | | | | Fishwheel 4 | | | |
| Date | Tags | Cum | Tags | Cum | Tags | Cum | Exam | Cum | Recap | Cum | Exam | Cum | Recap | Cum |
| 19 Jun | 0 | 94 | 81 | 1,717 | 70 | 2490 | 542 | 8,613 | 4 | 86 | 123 | 4,655 | 1 | 54 |
| 20 Jun | 29 | 123 | 58 | 1,775 | 31 | 2521 | 336 | 8,949 | 5 | 91 | 100 | 4,755 | 1 | 55 |
| 21 Jun | 0 | 123 | 64 | 1,839 | 45 | 2566 | 615 | 9,564 | 9 | 100 | 82 | 4,837 | 2 | 57 |
| 22 Jun | 0 | 123 | 38 | 1,877 | 47 | 2613 | 323 | 9,887 | 4 | 104 | 148 | 4,985 | 3 | 60 |
| 23 Jun | 0 | 123 | 48 | 1,925 | 22 | 2635 | 132 | 10,019 | 2 | 106 | 192 | 5,177 | 6 | 66 |
| 24 Jun | 0 | 123 | 76 | 2,001 | 15 | 2650 | 327 | 10,346 | 6 | 112 | 601 | 5,778 | 9 | 75 |
| 25 Jun | 0 | 123 | 59 | 2,060 | 51 | 2701 | 671 | 11,017 | 6 | 118 | 603 | 6,381 | 3 | 78 |
| 26 Jun | 0 | 123 | 116 | 2,176 | 51 | 2752 | 509 | 11,526 | 13 | 131 | 593 | 6,974 | 18 | 96 |
| 27 Jun | 0 | 123 | 139 | 2,315 | 85 | 2837 | 463 | 11,989 | 11 | 142 | 313 | 7,287 | 6 | 102 |
| 28 Jun | 0 | 123 | 115 | 2,430 | 104 | 2941 | 292 | 12,281 | 6 | 148 | 251 | 7,538 | 5 | 107 |
| 29 Jun | 0 | 123 | 159 | 2,589 | 20 | 2961 | 349 | 12,630 | 6 | 154 | 216 | 7,754 | 11 | 118 |
| 30 Jun | 0 | 123 | 139 | 2,728 | 41 | 3002 | 459 | 13,089 | 10 | 164 | 429 | 8,183 | 8 | 126 |
| 1 Jul | 0 | 123 | 75 | 2,803 | 91 | 3093 | 405 | 13,494 | 10 | 174 | 260 | 8,443 | 6 | 132 |
| 2 Jul | 0 | 123 | 145 | 2,948 | 34 | 3127 | 585 | 14,079 | 13 | 187 | 424 | 8,867 | 9 | 141 |
| 3 Jul | 0 | 123 | 181 | 3,129 | 16 | 3143 | 632 | 14,711 | 15 | 202 | 288 | 9,155 | 7 | 148 |
| 4 Jul | 0 | 123 | 316 | 3,445 | 106 | 3249 | 754 | 15,465 | 16 | 218 | 467 | 9,622 | 11 | 159 |
| 5 Jul | 0 | 123 | 215 | 3,660 | 223 | 3472 | 677 | 16,142 | 16 | 234 | 406 | 10,028 | 10 | 169 |
| 6 Jul | 0 | 123 | 227 | 3,887 | 211 | 3683 | 396 | 16,538 | 14 | 248 | 363 | 10,391 | 3 | 172 |
| 7 Jul | 0 | 123 | 152 | 4,039 | 265 | 3948 | 150 | 16,688 | 8 | 256 | 78 | 10,469 | 1 | 173 |
| 8 Jul | 0 | 123 | 216 | 4,255 | 134 | 4082 | 51 | 16,739 | 0 | 256 | 10 | 10,479 | 1 | 174 |
| 9 Jul | 0 | 123 | 100 | 4,355 | 146 | 4228 | 75 | 16,814 | 2 | 258 | 30 | 10,509 | 0 | 174 |
| 10 Jul | 0 | 123 | 83 | 4,438 | 80 | 4308 | 24 | 16,838 | 0 | 258 | 44 | 10,553 | 0 | 174 |
| 11 Jul | 0 | 123 | 61 | 4,499 | 64 | 4372 | 41 | 16,879 | 1 | 259 | 77 | 10,630 | 1 | 175 |
| 12 Jul | 0 | 123 | 62 | 4,561 | 49 | 4421 | 155 | 17,034 | 3 | 262 | 340 | 10,970 | 5 | 180 |
| 13 Jul | | | 96 | 4,657 | 54 | 4475 | 321 | 17,355 | 9 | 271 | 455 | 11,425 | 7 | 187 |
| 14 Jul | | | 220 | 4,877 | 24 | 4499 | 262 | 17,617 | 4 | 275 | 538 | 11,963 | 12 | 199 |
| 15 Jul | | | 115 | 4,992 | 72 | 4571 | 152 | 17,769 | 4 | 279 | 341 | 12,304 | 6 | 205 |
| 16 Jul | | | 63 | 5,055 | 73 | 4644 | 65 | 17,834 | 1 | 280 | 1,132 | 13,436 | 17 | 222 |
| 17 Jul | | | 51 | 5,106 | 41 | 4685 | 62 | 17,896 | 2 | 282 | 933 | 14,369 | 15 | 237 |
| 18 Jul | | | 45 | 5,151 | 47 | 4732 | 48 | 17,944 | 1 | 283 | 771 | 15,140 | 19 | 256 |
| 19 Jul | | | 63 | 5,214 | 28 | 4760 | 363 | 18,307 | 8 | 291 | 966 | 16,106 | 22 | 278 |

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 |
| 20 Jul | | | 42 | 5,256 | 50 | 4810 | 353 | 18,660 | 8 | 299 | 591 | 16,697 | 12 | 290 |
| 21 Jul | | | 47 | 5,303 | 45 | 4855 | 333 | 18,993 | 2 | 301 | 723 | 17,420 | 10 | 300 |
| 22 Jul | | | 46 | 5,349 | 45 | 4900 | 170 | 19,163 | 3 | 304 | 558 | 17,978 | 14 | 314 |
| 23 Jul | | | 25 | 5,374 | 56 | 4956 | 198 | 19,361 | 5 | 309 | 863 | 18,841 | 11 | 325 |
| 24 Jul | | | | | 43 | 4999 | 279 | 19,640 | 6 | 315 | 966 | 19,807 | 17 | 342 |
| 25 Jul | | | | | 99 | 5098 | 276 | 19,916 | 2 | 317 | 139 | 19,946 | 2 | 344 |
| 26 Jul | | | | | 87 | 5185 | 380 | 20,296 | 7 | 324 | 516 | 20,462 | 11 | 355 |
| 27 Jul | | | | | 92 | 5277 | 481 | 20,777 | 6 | 330 | 340 | 20,802 | 4 | 359 |
| 28 Jul | | | | | 82 | 5359 | 642 | 21,419 | 10 | 340 | 342 | 21,144 | 7 | 366 |
| 29 Jul | | | | | 82 | 5441 | 349 | 21,768 | 9 | 349 | 624 | 21,768 | 12 | 378 |
| 30 Jul | | | | | 70 | 5511 | 383 | 22,151 | 5 | 354 | 448 | 22,216 | 10 | 388 |
| 31 Jul | | | | | 70 | 5581 | 289 | 22,440 | 8 | 362 | 110 | 22,326 | 2 | 390 |
| 1 Aug | | | | | 55 | 5636 | 259 | 22,699 | 2 | 364 | 108 | 22,434 | 3 | 393 |
| 2 Aug | | | | | 62 | 5698 | 328 | 23,027 | 8 | 372 | 104 | 22,538 | 1 | 394 |
| 3 Aug | | | | | 39 | 5737 | 340 | 23,367 | 5 | 377 | 216 | 22,754 | 2 | 396 |
| 4 Aug | | | | | 48 | 5785 | 307 | 23,674 | 7 | 384 | 186 | 22,940 | 3 | 399 |
| 5 Aug | | | | | | | 248 | 23,922 | 4 | 388 | 170 | 23,110 | 3 | 402 |
| 6 Aug | | | | | | | 88 | 24,010 | 0 | 388 | 54 | 23,164 | 1 | 403 |
| 7 Aug | | | | | | | 21 | 24,031 | 0 | 388 | 95 | 23,259 | 3 | 406 |
| 8 Aug | | | | | | | 25 | 24,056 | 0 | 388 | 177 | 23,436 | 1 | 407 |
| 9 Aug | | | | | | | 89 | 24,145 | 4 | 392 | 363 | 23,799 | 7 | 414 |
| 10 Aug | | | | | | | 207 | 24,352 | 1 | 393 | 456 | 24,255 | 4 | 418 |
| 11 Aug | | | | | | | 194 | 24,546 | 3 | 396 | 805 | 25,060 | 16 | 434 |
| 12 Aug | | | | | | | 100 | 24,646 | 2 | 398 | 195 | 25,255 | 1 | 435 |
| 13 Aug | | | | | | | | | | | 81 | 25,336 | 3 | 438 |
| 14 Aug | | | | | | | | | | | 83 | 25,419 | 1 | 439 |
| 15 Aug | | | | | | | | | | | 110 | 25,529 | 1 | 440 |
| 16 Aug | | | | | | | | | | | 59 | 25,588 | 0 | 440 |
| 17 Aug | | | | | | | | | | | 28 | 25,616 | 0 | 440 |
| 18 Aug | | | | | | | | | | | 23 | 25,639 | 0 | 440 |
| 19 Aug | | | | | | | | | | | 8 | 25,647 | 0 | 440 |
| Total | 123 | | 5,374 | | 5,785 | | 24,646 | | 398 | | 25,647 | | 440 | |

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