Movement and abundance of freshwater fish in the Chuit River, Alaska, May through July, 2009

Annual Report

Prepared for

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April, 2010

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Executive Summary

Coho salmon (*Oncorhynchus kisutch*) smolts were monitored at three locations in the Chuit River watershed in Southcentral Alaska in 2009. This study was the second of four years of smolt abundance estimates designed to serve as a pre-mine development dataset that can assist in detecting and measuring potential effects of mine development on coho salmon in the Chuit River watershed, particularly Stream 2003. In addition to the abundance estimates, data were collected on other fish species, environmental conditions, and biological characteristics to help evaluate trends over time and/or among locations.

In 2009, fish were monitored from mid May through early August in streams 2003 and 2004 (18 and 31 river km, 11.2 and 19.3 miles, from the mouth, respectively), and from mid May through mid August in the mainstem Chuit River (4 km, 2.5 miles, from the river mouth). Smolt weirs and underwater video imagery were used to monitor fish emigrating from streams 2003 and 2004, and rotary screw traps (RSTs) were used to monitor fish in the Chuit River. Gear types, locations, and methods were consistent with those used in the 2008 field season, although the sampling season ended six weeks earlier in 2009 following completion of the coho salmon smolt run.

Coho salmon smolts emigrated from mid May through early July, with a peak in mid June. A total of 6,141 coho salmon smolts were enumerated in Stream 2003 and 7,477 from Stream 2004 (inclusive of video counts). The watershed-wide estimate was 44,794 smolts (SE 2,401). By comparison, total smolt estimates in 2008 were 7,790 and 4,941 from streams 2003 and 2004, respectively, with a watershed-wide estimate of 37,424 (SE 2,116). Juvenile coho salmon were the most abundant species captured in the tributary streams in the 2008 and 2009 field seasons.

The number of juvenile Chinook salmon (*O. tshawytscha*) captured watershed-wide increased from 2008 to 2009. Only pre-smolt (age-0 fish) Chinook salmon were captured in the tributary streams, whereas Chinook salmon smolts (age-1) and pre-smolts were captured in the Chuit River. A watershed-wide, mark-recapture estimate of Chinook salmon smolt abundance was not calculated because smolts were not caught at the tributary release locations (weirs). It appears plausible that some juvenile Chinook salmon hatch in the tributary streams, migrate out of the streams as age-0 fish, and then overwinter in the Chuit River before migrating to sea as age-1 smolts.

Warmer temperatures in 2009, coupled with a lower snowpack than in 2008, resulted in an earlier freshet that peaked in early May and declined to baseflow levels by early June. The coho salmon smolt run started approximately three weeks earlier in 2009 than in 2008, likely due to these changes in water flow and temperature. Other differences in the fish community from 2008 to 2009 were the increase in the number of Chinook salmon pre-smolts, minor changes in the community composition of non-target fish species, and the documentation in 2009 of Pacific lamprey (*Lampetra tridentata*) and threespine stickleback (*Gasterosteus aculeatus*) in the tributary streams which were not caught in 2008.

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1.0 Introduction

1.1 Regulatory Background

The Chuit River watershed, on the west side of Upper Cook Inlet in Southcentral Alaska, contains extensive coal deposits. This area has been under consideration for development since the 1960s. The impacts of this development on the environment will be assessed in accordance with federal and state regulations. At the federal level, the National Environmental Policy Act (NEPA) requires environmental data to be collected to develop an Environmental Impact Statement (EIS) for the proposed development area. An original EIS was completed for the Chuitna Coal Project in 1990, and is scheduled to be updated with a Supplemental EIS (SEIS) in 2011, using additional data collected between 2005 and 2008. At the state level, the Alaska Surface Coal Mining Control and Reclamation Act (ASCMCRA) requires additional environmental information for mine permitting, including information about salmon resources in the local area.

Per the ASCMCRA permitting requirements, salmon populations are to be monitored before and during mine development, with an emphasis on those areas within the watershed that will be directly affected by mining activity. The pre-development phase will occur over four seasons, with the first full year of abundance data collected in 2008. The 2008 data is the primary salmon dataset to be collected for the SEIS (Nemeth et al. 2009). Pre-development salmon monitoring continued in 2009, and requires two additional years of monitoring prior to mine development.

1.2 Objectives in 2009

The primary goal in 2009 was to continue the pre-development monitoring of smolt production in the impact and control streams that began in 2008. Additionally, we conducted a smolt abundance estimate for the entire Chuit River watershed as a follow up to the baseline monitoring conducted for the SEIS in 2008 (Nemeth et al. 2009). The specific objectives in 2009 were to:

1. Estimate the number of coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawytscha*) salmon smolts emigrating from streams 2003 and 2004;
2. Monitor fish community assemblages and environmental conditions to assist in understanding variability observed in the smolt production between the streams or among years; and
3. Estimate the number of coho salmon smolts produced in Stream 2003 relative to the entire Chuit River watershed (as an additional year of baseline information).

1.3 Study Background

Coho salmon smolts were selected as the indicator population due to their prominence in the Chuit River watershed, and because the smolt life stage is a key link between freshwater habitat conditions and future adult abundance. Coho salmon accounted for

over 99% of the salmon smolts emigrating from Stream 2003 in the 2008 sampling season (Nemeth et al. 2009). Coho salmon spend a relatively long time maturing in freshwater (generally two years in Southcentral Alaska); therefore, the quantity and quality of freshwater habitat can have a relatively strong influence on the number of smolts that migrate to the ocean (Nickelson 1998). The abundance of coho salmon smolts is known to strongly influence the number of adult salmon that return to spawn a year later (Bradford et al. 1997; Shaul et al. 2007). Altogether, this means that the number of adult salmon returning to a system is a function, at least in part, of the quantity and quality of habitat available for rearing juveniles (Bocking and Peacock 2005). For the Chuit River, the effects of development on habitat are most likely to manifest as changes in smolt abundance, which in turn would be an indicator of potential changes to the adult population.

The effects of mining operations on coho salmon smolt abundance will be assessed using a before-after control-impact (BACI) study design (Green 1979). Smolt abundance will be simultaneously monitored in streams 2003 and 2004, before and after mining operations begin. Streams 2003 and 2004 are relatively similar in size and physical setting, are adjacent in the watershed, and subject to similar environmental conditions (summarized in Nemeth et al. 2009). Mining development is expected to impact Stream 2003. Stream 2004 is not slated for any near-term mining development within its watershed and will be monitored as a control stream to allow for a paired BACI study. Concurrent monitoring of the control and impact streams will allow for comparisons that can isolate changes observed in the impacted stream due to the effects of mining.

A number of factors will influence the power of the BACI test to detect changes (Murphy and Myors 1998). The ability to detect changes in smolt abundance in Stream 2003 will be a function of the number of years of monitoring before and after development, the size of any effect, and the natural variability in annual smolt abundance. The study design allows for a comparison of smolt abundances in Stream 2003 before and after any impacts to the watershed, as well as for comparisons of the ratio of the number of smolts in streams 2003 and 2004, prior to any potential impacts to stream 2004. A similar study successfully identified multiple effects of habitat alteration on juvenile coho salmon in two Oregon coastal streams, where four years of monitoring data were collected before and after habitat modification (Solazzi et al. 2000). The use of ratios increases the tolerance of the analysis to interannual variability because any trends in population size that occur during the pre-treatment period are similar between the control and impact streams (e.g., populations are not increasing in one stream while declining in another). Comparisons of smolt abundance between streams and among years must account for attributes such as fish run timing, age, and body size, which may assist in explaining any temporal or spatial differences.

2.0 Study Area

2.1 Chuit River Watershed

The Chuit River watershed is a 4th-order river (Strahler 1957) that drains into the western shoreline of Upper Cook Inlet, 67 km (42 mi) southwest of the city of Anchorage and 3 km (2 mi) north of the Village of Tyonek, in Southcentral Alaska (Figure 1). The watershed flows southeast and drains an area approximately 38,850 hectares (96,000 acres). The watershed is in lowlands with elevations generally below 305 m (1,000 ft). It is bordered to the west by the Tordrillo Mountains, part of the Alaska Range (RTI 2007). The Chuit River watershed is unglaciated and consists of seven main subdrainages. In general, tributaries begin to freeze in late October and ice break-up occurs in late April. By early May, streams are mostly ice free (RTI 2007). Two of the lower tributaries that enter from the north (streams 2003 and 2004) are relatively similar in size (Table 1), and are the study streams described in this report (Figure 1).

Stream 2003 is a 2nd-order stream draining 3,693 hectares (9,126 acres), is approximately 5 m (16.4 ft) wide, and enters the Chuit River approximately 18 km (11.2 mi) upstream from Cook Inlet. The mean annual discharge of Stream 2003 is 0.96 m^3/s (33.90 ft^3/s) and the stream is 30 km (18.6 mi) long (Table 1; RTI 2007). The sampling site on this tributary was 1.9 km (1.2 mi) upstream from the confluence with the Chuit River (Figure 2), at an elevation of 104.9 m (344 ft) above sea level. The proposed coal mine development lies within this watershed.

Stream 2004 is a 3rd-order stream draining 3,845 hectares (9,501 acres), is approximately 5 m (16.4 ft) wide, and enters the Chuit River 30.8 km (19.1 mi) upstream from the ocean. The mean annual discharge of Stream 2004 is 0.93 m^3/s (32.84 ft^3/s) and the stream is 33 km (20.5 mi) long (Table 1; RTI 2007). The sampling site on this tributary was 1.7 km (1.1 mi) upstream from the confluence with the Chuit River (Figure 2), at an elevation of 194.8 m (639 ft) above sea level. The upper reaches of Stream 2004 lie within the boundaries of the proposed coal mine.

Both streams have numerous fish-bearing side tributaries. In Stream 2003, the weir was installed downstream of these side tributaries, thereby capturing all fish migrating from the watershed into the Chuit River. In Stream 2004, one side tributary enters downstream of the weir. This side tributary, known as Stream 200401, was sampled separately and the results added to those from the overall watershed in Stream 2004.

Stream 200401 is a 2nd-order stream that enters Stream 2004 approximately 0.5 km (0.3 mi) upstream from the confluence with the Chuit River, and 1.2 km (0.7 mi) below the sampling site in Stream 2004 (Figure 2). The confluence of the two streams is about 189.9 m (623 ft) above sea level.

2.2 Climate and Weather

The study area lies in a transitional zone between maritime and continental climate zones (RTI 2007), which are noted for mild winters, cool summers, and moderate precipitation.

For the 30-year period from 1971 to 2000, the average annual air temperature was 2.2 °C (35.9 °F) at the nearby community of Beluga. The average monthly air temperatures during the summer months were 12.3 °C (54.1°F) in June, 14.4 °C (57.9 °F) in July, and 13.2 °C (55.9 °F) in August. The average monthly air temperatures during the winter months were −5.4 °C (22.2 °F) in November, −8.6 °C (16.5 °F) in December, −9.4 °C (15.1 °F) in January, and −7.3 °C (18.8 °F) in February (ACRC 2008).

In summer, prevailing winds are from the south and southwest, and daylight peaks at 19.5 hours. In winter, prevailing winds are from the north-northwest to north-northeast (McVehil-Monnett 2006), and daylight drops to a low of 5.5 hours. A weather monitoring station has operated near Stream 2004 from early 2006 (McVehil-Monnett 2006) until December 2009.

2.3 Hydrology

The Chuit River has an estimated mean annual discharge of 10.1 m^3/s (354.9 ft^3/s) and is approximately 103 km (64 mi) long (Table 1; RTI 2007). Water levels peak in mid to late May from snowmelt and again from September through October from increased precipitation (Figure 3). The Chuit River watershed is typically covered with snow from October or November through late May. Average annual precipitation in the Village of Beluga (1971−2000) was approximately 66 cm (26 in) with average annual snowfall of 206 cm (81 in; ACRC 2008). Average annual precipitation at the mine site is in the range of 44 to 47 inches per year (unpublished data Tetra Tech, Juneau, Alaska, 2010).

Flood events have been thought to impact salmonid habitat in the Chuit River watershed in recent years, including events that occurred since the time of the original baseline work conducted in the early 1980s. One major flood event was in 1986, two years after the original baseline study was completed. The flood occurred over a three-day period in early October, resulting from unusually high levels of rainfall (Lamke and Bigelow 1988). During the flood, peak discharge for the Chuit River ranged from 566 to 1,416 m^3/s (20,000 to 50,000 ft^3/s), and roughly 85 to 198 m^3/s (3,000 to 7,000 ft^3/s) in the lower reaches of Stream 2003. Average discharges during the month of October usually range from about 7.1 to 17 m^3/s (250 to 600 ft^3/s) in the Chuit River, and 0.6 to 2.5 m^3/s (20 to 90 ft^3/s) in lower areas of Stream 2003 (ERT 1987).

The 1986 flood changed channel depths, reduced substrate size, caused bank erosion and slope failures, accumulated debris in streams, and formed new channels. Impacts on salmon habitat differed depending on species, life stage, and the location within the watershed. In general, effects on available habitat for juvenile salmonids were minimal (ERT 1987). Adult salmon spawning habitat was reduced in many areas and increased in a few other areas. Without any additional flood events, these areas were expected to return to their pre-flood condition within two to five years (ERT 1987). Other major floods occurred in Southcentral Alaska in 1995 and 2006 (RTI 2007). The size and effects of these floods on the Chuit River watershed have not been reported.

2.4 Fish

The Chuit River watershed provides habitat for anadromous and resident fish species, including juvenile and adult salmonids. Seven species of salmonids are found within the drainage: rainbow trout (*O. mykiss*), Dolly Varden (*Salvelinus malma*), and all five species of pacific salmon native to Alaska (coho, Chinook, pink [*O. gorbuscha*], chum [*O. keta*], and sockeye [*O. nerka*] salmon; EPA 1990). Other resident fish species include coastrange sculpin (*Cottus aleuticus*), slimy sculpin (*C. cognatus*), Pacific lamprey (*Lampetra tridentata*), Arctic lamprey (*L. camtschatica*), ninespine stickleback (*Pungitius pungitius*), and threespine stickleback (*Gasterosteus aculeatus*).

Salmon migrate up Cook Inlet and enter the Chuit River watershed to spawn. Beginning in mid June, Chinook salmon enter the Chuit River and migrate upstream; spawning occurs in early July through mid August. Coho salmon enter the Chuit River and begin their upstream migration in late July and spawn from late August through October (EPA 1990). Fishery managers with the Alaska Department of Fish and Game (ADF&G) use the Chuit River as an index of the run strength of Chinook salmon returning to Upper Cook Inlet (Fox and Shields 2005).

2.5 Vegetation and Geology

The study area within the Chuit River watershed is dominated by mixed woodland habitat, composed of spruce (white, *Picea glauca*, or black, *P. mariana*) and paper birch, *Betula papyrifera*. Shrub vegetation is dominated by alder species and account for a large portion of the canopy cover (HDR 2006). The watershed contains numerous bogs, ponds, and small lakes; most ponds and lakes eventually become muskegs (EPA 1990). Riparian vegetation is mostly alder (*Alnus*), willow (*Salix*), and various grass species. Vegetation overhanging stream banks provides cover for both resident and anadromous fish species (Oasis 2006).

The study area is characterized by morainal topography (EPA 1990) and composed of Tertiary sedimentary rock (RTI 2007). Over time, streams have carved out the underlying sedimentary rock to form valleys (EPA 1990). A steep-sloped valley occurs in the study area from the Chuit River mouth to the confluence with Stream 2004 (Oasis 2006). Tributaries and floodplains within the Chuit River watershed are composed of alluvium deposits. Well-sorted sand and gravel are deposited in stream channels, and fine-grained sediments, such as silt and sand, occur as overbank or floodplain deposits (RTI 2007). Alluvium deposits generally range from 3 to 12 m (10 to 30 ft) in depth (EPA 1990).

3.0 Methods

3.1 Fish Capture and Sampling

Movement of fish was monitored for three locations at five sites in the Chuit River watershed, largely using the same gear types, locations, and design as reported in 2008

(Nemeth et al. 2009). Sampling gear was operated continuously for the duration of the sampling season.

3.1.1 Monitoring in tributaries

In streams 2003 and 2004, downstream fish movements were monitored with smolt weirs that covered 100% of the stream width. The weirs were designed with a breach to allow for upstream fish movements, and underwater video cameras were used to record the number of fish moving upstream or downstream through the breach.

Weirs were constructed from panels built of aluminum tubing and covered in plastic mesh (Vexar®). Different combinations of mesh size (0.64 to 2.5 cm, 0.25 to 1.0 in) and panel heights (0.3 to 1.2 m, 1 to 4 ft) were used to maximize the release of water through the weir and at the same time prevent small fish (<50 mm) from passing through the weir panels. Modified dump panels were strategically placed to allow water spillover during high water events and to reduce stress on the weir. The weirs were supported using landscape fabric, sandbags, rebar, and steel pipe, and then secured to the shoreline using ropes.

The weirs were designed to divert downstream migrating fish into a holding box for sampling. Weirs were arranged in a "V" formation with panels leading to a pipe that ran to an aluminum holding box set in the stream (Photos 1 through 3). Fish moving down the pipe collected in this box, where they remained until sampled. Holding boxes were L-shaped with baffles to minimize water velocity and compartments to minimize turbulence and size induced predation. Sampling protocol is discussed in detail in Section 3.1.3.

Streams 2003 and 2004 have numerous side tributaries entering above the weirs. In Stream 2004 one side tributary, Stream 200401, enters downstream of the weir. Therefore a fyke net was placed in Stream 200401 to monitor downstream fish movement (Photo 4). A fyke net is a passive sampling device used to capture live fish and hold them with minimal injury or mortality until sampled. The fyke net was supported by a 1.7 x 1.8 m (5.6 x 5.9 ft) stainless steel frame faced with 0.32 x 0.64 cm (0.13 x 0.25 in) knotless netting deployed with 25 m (82 ft) long wings of 0.64 to 0.97 cm (0.25 to 0.38 in) mesh. A funnel led from the center of the frame into a cod end, where the fish were collected after passing through a series of constrictions designed to prevent fish from escaping.

The times when sampling equipment was not fishing, usually due to maintenance, heavy debris loads, or hydrological conditions, were considered downtime. Downtime was calculated by adding the total numbers of hours each gear type was not fishing at each site.

<u>Video system design, configuration, and operation</u>
A video system was installed at each weir to record fish moving upstream and downstream through the intentional breach in the weir. The breach allowed upstream movement of fish past the weir, but also allowed fish to avoid the pipe that led to the

holding box (described above). Fish using the breach were not captured and handled, but were identified and counted using the video system.

The video system consisted of a 0.5 x 0.5 x 0.9 m (1.5 x 1.5 x 3 ft) fish passage chute, a camera view window, and camera housing (Photo 5). Custom built underwater lights were installed in the chute to provide night-time illumination and enhance day-time imagery. All components and specifications were the same as in 2008 (Nemeth et al. 2009), except that in 2009 wooden spacers were installed in the video chutes to confine fish to the cameras' field of view. To aid in post-season video processing, wooden fish silhouettes were placed in the chute at varying distances from the camera to mimic the magnification and serve as a reference for video reviewers. These silhouettes were of the four main size classes (50, 90, 100, and 200 mm).

Video systems were operated seven days a week, 24 hours a day through early August. Daily maintenance and system checks included charging battery banks, cleaning chute walls, camera lenses, and camera view window, checking the DVR hard drives for data storage capacity, and reviewing samples of video from the previous 24 hours.

Video data were recorded using the same specifications as in 2008 (Nemeth et al. 2009). Twice daily the video system was checked to ensure it was working properly. During each check up to 20 motion-detection events and one hour of video were reviewed to track adult and juvenile fish movement. Recorded video was stored on hard drives, which were removed for analysis and replaced approximately every 15 days.

<u>Species identification and length classification</u>
Biologists were trained in the identification of fish species before compiling video data. Video images were identified to species or fish group, and then further placed into size classes meant to represent the life stages of interest for key species (e.g., smolts vs. pre-smolts for juvenile coho salmon).

Identified fish were assigned to size classes based on species or fish group. Juvenile coho salmon were placed into one of the following size classes: <50 mm, 50–89 mm, and ≥90 mm based on coho salmon size-at-age classes from 2008 (Nemeth et al. 2009). Size classes for Chinook salmon observed traveling through the video chute were partitioned in the same manner as the coho salmon because coho salmon were the dominant species in the watershed and few Chinook salmon were captured in the tributaries in 2008 (Nemeth et al. 2009). Rainbow trout and Dolly Varden were placed into the following size classes: <100 mm, 100–200 mm, 200–400 mm, and >400 mm. Chinook salmon were designated as "jacks" if they were less than 450 mm in length. All other adult salmon were identified to species but were not assigned to size classes. During video review, the photographs of the wooden fish silhouettes in the chute were displayed on a 2nd computer monitor to provide a visual reference for placement of fish into size classes.

Low light and high water turbidity sometimes reduced the ability of biologist to identify salmonid fish to species. In such cases, salmonids were apportioned to a species using the species composition and length classes of identified juvenile salmonids captured at the weir that day. Rainbow trout and Dolly Varden that were ≥90 mm in length were

easily identified in all water conditions; therefore the species of unidentified salmonids in this size category were estimated based entirely on the proportion of coho and Chinook salmon caught in the live boxes each day.

Video data processing and fish passage estimates

Hard drives from video cameras in the weirs were reviewed both in the field and in Anchorage. Video data were viewed using a DVR unit attached to a 48.3 cm (19 in) monitor (Triview model TLM-1903). Fish passage through the video system was estimated using hourly counts. Time-lapse clips were reviewed at 4x to 8x speed. Each time a fish was detected, the image was replayed until the fish was identified to species or fish group and a size class and direction of movement were assigned (upstream, downstream, or double-back).

Fish passage through the video system was estimated in two ways. Fish counts were primarily estimated by subsampling the first 15 minutes of each hour, and then extrapolating this count to generate an estimate for the entire hour. On rare occasions, full-hour counts were used when visibility in the video chute was poor due to turbidity or low lighting. Video footage was reviewed during the hours the video chute was open to fish passage was not reviewed when the video chute passage was blocked or closed. For full hour counts the number of fish observed was the total count of fish movement for that hour. Total daily counts were made by combining 24 hourly counts. A daily net movement of fish was calculated by subtracting the number of fish moving upstream from the number of fish traveling downstream.

Data from reviewed video were entered into a Microsoft® Access database. Queried data were exported from Access to Microsoft® Excel which was used to calculate hourly and daily fish passage through the video chute.

3.1.2 Monitoring in the mainstem Chuit River

Two rotary screw traps (RSTs) were located in the mainstem Chuit River roughly 1 km (0.6 mi) apart, and 3.5 to 4.0 km (2.1 to 2.6 mi) upstream from the mouth. The RSTs were manufactured by EG Solutions of Corvallis, Oregon (http://home.teleport.com/~egs), and consisted of a drum resting between two pontoons. Water entering the drum mouth caused the drum to turn. Fish swept into the trap were then funneled down into a holding box at the downstream end of the RST. Fish were removed from the holding box and sampled up to twice per day (Photo 6). The RSTs fished in the main current, at a target speed of six to eight revolutions per minute, and were repositioned in the current over the course of the season to fish effectively as water levels changed. Traps were fished alongside the bank, and tethered to trees onshore with an anchor system designed to keep the drum mouth facing perpendicular to the current (Photo 7).

In the mainstem Chuit River, a fyke net was fished concurrently with the upstream RST (RST1; Photo 8). The design and operation of this fyke net was the same as the one used in Stream 200401 (Section 3.1.1), and was used as ancillary gear to identify any differences in fish size selectivity among gear types.

3.1.3 Fish capture and handling

Sample sites in the tributaries and Chuit River were generally checked twice daily, but more frequently during times of high water or heavy debris loads. All fish captured were identified to species and counted. Species identifications were made using several fish guides and keys, notably those by Phillips (1977), Pollard et al. (1997), Morrow (1980), and Mecklenburg et al. (2002).

Random subsamples for length and weight measurements were taken twice daily from all species caught. All fish were transferred to one container and then randomly selected by sweeping a hand net (in varying directions and water depths) through the fish and transported to a separate container. All fish randomly selected were then measured for length and/or weight and sampled for scale analysis.

Length measurements were taken from a target sampling size of 60 coho and Chinook salmon per day, 30 other salmonids (primarily rainbow trout and Dolly Varden) per day, and 20 of each other species per day; the actual sampling size varied based on the catch on a given day. Species with forked tails (salmonids) were measured to fork length (FL); species with rounded or truncate tails were measured to total length (TL). Adult salmon were measured from mid eye to fork of tail (MEF). All lengths were recorded to the nearest millimeter.

Weights were taken once per week for each species of fish based on a pre-established catch calendar. Weight measurements were taken from up to 30 of each salmonid species and up to 20 of each other species per week. The actual sampling size varied depending on the catch on a given day. In addition, weights were taken from all fish from which scale samples were taken. Weights were recorded to the nearest 0.1 grams.

Scales were taken from randomly selected juvenile coho and Chinook salmon to refine the classifications for which combinations of age, length, and run timing should be considered smolts. Scale samples were also taken from randomly selected rainbow trout and Dolly Varden (≥60 mm). Coho and Chinook salmon scales were obtained weekly for six size classes of fish (10 fish per size class), and once per week from rainbow trout and Dolly Varden. Scales were taken from the preferred location, posterior to the dorsal fin, above the lateral line, following methods of Jearld (1983), and archived on gum cards. Length and weight measurements were taken on all fish that were scaled.

Fish sampled for length, weight, or scales (age) were anesthetized in a 9:1 solution of ethanol mixed with clove oil, diluted in water. Sampled fish were released back into the stream once they were vigorous and moved under their own power. Fish that were simply identified to species, counted, and marked were not anesthetized unless needed (e.g., could not be handled without anesthesia). Any sampling mortalities were noted and quantified.

3.1.4 Data management

All data were recorded on standard datasheets developed for the project. After each sampling event, datasheets were reviewed for completeness and accuracy by a second person not involved in the recording of the data, and then entered into an online database managed by Axiom Consulting and Design (Anchorage, AK; www.axiomalaska.com). Database entries were then checked against the field datasheets to ensure accuracy. Digital copies of the original datasheets were maintained on the LGL server as a backup. Data were organized and summarized using Microsoft® Access and Microsoft® Excel.

3.2 Coho and Chinook Salmon Smolt Abundance

3.2.1 Tributaries

Coho and Chinook salmon smolt abundances for streams 2003 and 2004 were calculated by adding weir catches and video counts, using size breaks determined (*a posteriori)* from age and length analysis. The number of coho and Chinook salmon smolts in each weir sample was estimated by multiplying the percentage of smolts in the random subsample by the total catch of coho and Chinook salmon in the entire sample. Fyke net catches at Stream 200401 were processed in the same manner as the weir catches, and smolts from this stream were added to the total from the Stream 2004 watershed.

Any periods of extensive downtime or weir damage were interpolated to determine the number coho salmon that were not counted during that period. Interpolations were based upon a regression of catches at the affected weir from the days adjacent to the missing interval. However, if the unaffected weir (on the other stream) had highly variable catches during this same interval (such as a pulse of fish moving downstream), then a second interpolation method was utilized. This second method examined the correlation between catches at both weirs for the days adjacent to the missing interval, after correcting for any lag in catches between weirs. If catches were strongly correlated between sites, then the counts at the unaffected weir were used to estimate the counts at the affected weir during the time interval.

Marked smolts (see section 3.2.2 for marking information) recaptured in the weir holding box were included in the daily weir smolt count. These recaptured smolts were recorded as smolts moving upstream through the video chute and traveling downstream into the weir livebox. The inclusion of recaptured smolts in the count the second time they were caught gave them a net value of one smolt moving downstream.

3.2.2 Coho and Chinook salmon smolt population estimates

Two-sample mark-recapture methods (Seber 1982) were used to estimate the abundance of coho and Chinook salmon smolts in the Chuit River. For the first sample event, smolts were marked and released at the weirs in streams 2003 and 2004. For the second sample event, smolts were captured and inspected for marks at the RSTs located in the Chuit River approximately 15.8 to 29.1 km (9.8 to 18.1 mi) downstream of the tagging sites.

The abundance estimates for the Chuit River were a function of the number of marked fish released, and the ratio of marked to unmarked fish sampled at the RST locations.

Smolt classification

Salmon smolts are by definition migrating out of the river to sea and are therefore susceptible to being recaptured downstream from a marking location. Smolts and pre-smolts co-occur in streams, requiring a careful classification of catches to determine a population estimate limited exclusively to smolts. During smoltification a series of physiological, behavioral, and morphological changes occur for fish to adapt from a life in freshwater to a life at sea (Wedemeyer 1996). As smoltification begins, fish develop a silvery appearance, with the parr marks (dark vertical lines on their body) becoming less prominent (Eales 1969) and their bodies becoming more streamlined. All juvenile coho and Chinook salmon captured in the Chuit River were examined for a silvery condition indicative of smoltification. Smoltification status was combined with length and age information from the sampling events to generate classification of size groups by date range that were likely to be smolts. Coho salmon in Alaska often migrate to sea at age-2 (Quinn 2005; Nemeth et al. 2009) and stream-type Chinook salmon migrate to sea at age-1 (Quinn 2005). Population estimates were calculated for coho and Chinook salmon identified as likely smolts.

Marking

Juvenile coho salmon ≥80 mm and Chinook salmon ≥65 mm, (hereafter referred to as smolts) captured at the weirs were marked with either a pelvic fin clip or temporary caudal fin mark. The size breaks were chosen for each species based upon length-age distribution patterns observed in 2008 (Nemeth et al. 2009). Mark types differed by location, with smolts from Stream 2003 receiving caudal fin marks and smolts from Stream 2004 receiving pelvic fin clips. The marks were alternated, either upper or lower for the caudal fin, or left or right for the pelvic fin, every 10 days allowing for temporal stratification during data analyses. The duration of the stratifications was based upon the greatest amount of time it took marked fish to travel between the marking locations and the recapture locations in 2008 (Nemeth et al. 2009).

The number of marked and unmarked smolts captured and the mark types were recorded at each sampling event. Any marked recaptures were measured for fork length to the nearest millimeter. All smolts captured at RST1 received a second identifying temporary mark on their upper and lower caudal fin. Fish captured at RST2 were sampled as noted above, but received no further marks and were simply released downstream.

Mark-recapture model selection and assumptions

Mark-recapture model selection was dependent on tests of equal probability of the recapture of marked fish through time. The first model considered was a pooled Petersen estimate (PPE) with Chapman's modification (Seber 1982), which was used if recapture probabilities in the RSTs were equal among time strata. If recapture probabilities were not equal through time, a Darroch model (Darroch 1961) was used. In either case, fish were stratified into size classes *post hoc* based on minimum and maximum lengths common to each site (i.e., the population analysis only pertains to the smallest and largest

sizes of fish recaptured). Notation for variables in the mark-recapture models were as follows:

n_1 = marks released
n_2 = fish examined for marks
m_2 = recaptures in the second sample (n_2)
u_2 = number of fish without tags in the second sample (n_2)
p_1 = probability of capture at time 1 = m_2/n_2
p_2 = probability of capture at time 2 = m_2/n_1
$\hat{N}$ = population abundance estimate

The PPE with Chapman's bias correction (Seber 1982) was calculated as

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \qquad (1)$$

The following assumptions must be met for this estimate to be unbiased (Seber 1982):

1. Closed population (i.e., no mortality or recruitment);
2. The probability of capture was constant across all individuals at the time of marking (constant p_1);
3. Marking did not affect catchability;
4. Marked fish mixed uniformly with unmarked fish before the recapture event, or the probability of capture was constant across all individuals at the time of recapture (constant p_2);
5. Tags were not lost; and
6. All tags were recognized and reported.

Assumption 1: closed population
Weirs were not placed on all of the tributaries that feed the Chuit River, and smolts outmigrating from tributaries without weirs had no chance of being marked. Fish migrating from outside of the marking pool had the same effect on the population estimate as would recruitment, rendering the estimate germane to the recapture site (the Chuit River) and not to the mark sites (streams 2003 and 2004).

We assumed no mortality due to the marking process and no appreciable natural mortality between the marking and recapture sites. Smolt from the tributary streams migrated past the mainstem sampling locations in less than a week's time (Nemeth et al. 2009) during a life history stage when mortality is relatively low; thus, the potential for natural mortality between the weirs and the RSTs was small. Mortality due to marking was assumed negligible because fish were marked quickly and with a minimal amount of handling (approximately five seconds per fish to identify to species and mark), and were released directly from the holding box into the stream. On the Nome River, the same

investigators detected minimal latent mortality in coho salmon after tagging with coded wire tags, a more invasive process than the one used on the Chuit River (Williams et al. 2009).

Average travel time from the weirs to the RSTs was computed to help assess evidence of injury manifested in the form of unusually slow migration time. Travel time from the marking to recovery sites was modeled as a Poisson distribution, which is typically used for count type data and can be described with one parameter. The lag time (i.e., the one parameter = the expected value from the Poisson distribution) between the number of fish released and the number recaptured at the RSTs, as well as the recapture rate were adjusted (parameterized) to minimize the sum of square differences between the number of recoveries observed and the number predicted based on the Poisson travel time model. Travel time information was used to corroborate the use of 10 day temporal stratifications; travel times consistently greater than 10 days would require alternative stratifications to be performed. Travel time was also used as indicators of any evidence for sub lethal effects from marking and handling.

Assumption 2: probability of marking was constant
Because weirs were placed on a subset of streams, the probability of capture at the marking site (p_1) was not constant across all migrating smolt in the Chuit River (smolts from tributaries without weirs had no chance of being marked). If smolt from tributaries without weirs migrated at different times during the season then uniform mixing was unlikely.

Assumption 3: equal catchability for marked and unmarked fish
Validating this assumption was not possible, but we considered it unlikely that marking affected catchability at the recapture site because: 1) the marks and fish handling were chosen based in large part on strategies that would minimize effects on fish, and 2) the use of different gear types at the mark and recapture sites would eliminate any learned aversion to the gear by marked fish. Note that if fish from tributaries without weirs experienced different capture rates at the downstream site (p_2) than fish from tributaries with weirs, the effect would be the same as violating Assumption 4 because nearly all fish from tributaries with weirs were marked.

Assumption 4: probability of capture was constant or uniform mixing (or both)
Fluctuating water levels throughout the study period would likely change the capture efficiencies of the RSTs at the recovery site, and p_2 would not be constant for all individuals. Any observed changes in capture probabilities, as well as lack of mixing, through time were addressed by way of partial stratification.

Likewise, differences in capture probabilities across body sizes were corrected with size-stratified estimates. Rotary screw traps can be size selective, so we anticipated p_2 might be a function of fish size. The KS two-sample test (Conover 1971) was used to detect if size selective sampling occurred during the second sampling event. The cumulative length frequency distribution of all fish marked during the first event (n_1) was compared to that of marked fish recaptured during the second event (m_2). If the length distributions

were significantly different (*D* statistic: the maximum absolute difference between the cumulative distributions), then we used the size grouping corresponding to the *D* statistic as the limit for stratification. That is, separate abundance estimates were developed for all fish smaller than or equal to the limit and fish greater than the limit. Using the location of the *D* statistic as the limit ensures that the differences between two strata with respect to p_2 were maximized, and in so doing homogeneity of p_2 within each size stratum was also achieved.

Assumption 5: tags were not lost and marked fish survived to the recapture site
There was little chance of marked fish becoming unmarked between the marking and recapture sites. The evaluation of marked fish travel times from the weir sites to the RSTs was used to determine if there was enough time between sites for regeneration to occur, thereby causing a loss of marks. Travel time of marked fish between sites was estimated to help assess whether fish had a relatively long or short exposure to natural mortality from sources such as predation. Fish marking and handling procedures were designed to be less invasive than other marking studies that have caused little short-term mortality.

Assumption 6: tags were recognized and reported
All fish captured in the RSTs were handled and inspected individually to keep the probability of missing marks to a minimum. Furthermore, the number of fish handled during individual site visits was generally low and the marks were easily recognized.

Model selection
Models were fit using the software Stratified Population Analysis System (SPAS) (Arnason et al. 1996) and thorough descriptions of both models are provided by Schwarz and Taylor (1998). If Assumption 4 was met then the PPE was chosen, and all data throughout the season was pooled. If Assumption 4 was not met, then the Darroch model was used to partially stratify the data into groups with similar capture probabilities (in this case temporally).

Initial temporal strata were preset based on the dates fin clips were altered; however, further pooling to improve model fit occurred when recapture matrices were uploaded into SPAS. Any pooling of rows was guided by similar p_1 values estimated for each cell, and columns were pooled based on similar p_2 values across cells. The only pooling requirement was that the matrix either be square (number of tagging strata = number of recovery strata) or the number of tagging strata be greater than recovery strata in order for the estimate to be applicable to the recapture site (Schwarz and Taylor 1998). If a non-significant Chi-square test resulted for any of the following three tests ($\alpha = 0.05$), then the PPE model was chosen.

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	$m_{2,S4,R1}$	$m_{2,S4,R2}$	$m_{2,S4,R3}$	$m_{2,S4,R4}$	$n_1 - m_{2,S4,.}$

3.3 Movement, Abundance, and Biological Characteristics of Fish in Streams 2003 and 2004

3.3.1 Length groupings

Select fish species captured in the weirs and fyke net were categorized into size classes meant to represent life stages of interest (e.g., smolts vs. pre-smolts for juvenile coho salmon). Size class stratifications for coho salmon were based upon age and length data used to categorize size groupings roughly analogous to age-0, age-1, and age-2 fish. Juvenile Chinook salmon were similarly analyzed for size stratification. Rainbow trout, Dolly Varden, and Arctic lamprey were placed into the following two size classes: <200 mm (juvenile) and ≥200 mm (adult) based on estimated maturity at length.

3.3.2 Catch per unit effort

Catch per unit effort (CPUE) was calculated for standardized comparisons of different locations and at different times (days, months, or years). Fishing effort at each sampling location was recorded as the amount of time that passed between sampling events less any downtime due to gear modifications or damage. Hours when the weirs or RSTs were not fishing (due to maintenance, the RST drum being raised due to low water, or high water events) were subtracted from the fishing effort. CPUE was calculated as the catch divided by the amount of fishing effort, reported in days.

Daily CPUE was computed for two size classes for four species of fish, no size stratification was used for Chinook salmon. Water temperatures and discharge were

compared to the CPUEs and described for each species. These five species and size classes were:

1. Coho salmon – pre-smolt <90 mm and smolts ≥90 mm.
2. Chinook salmon – all sizes.
3. Dolly Varden – juveniles <200 mm and adults ≥200 mm.
4. Rainbow trout – juveniles <200 mm and adults ≥200 mm.
5. Lamprey – juveniles <200 mm and adults ≥200 mm.

3.3.3 Community composition

Species diversity was calculated for each site (combined for the two RSTs), using species richness (*r*), Shannon-Wiener's index of diversity (*H'*), and Pielou's (1966) evenness index (*J'*). Species diversity was calculated as:

$$H' = [-P_i*(\ln P_i)],$$

Where P_i is the proportion of species ($_i$) in the community, and ln (P_i) is the natural log of that proportion (Elliott and Hewitt 1997).

Species evenness was calculated as:

$$J' = H'/H'_{max},$$

where *H'* is the Shannon-Wiener index, and H'_{max} (the maximum diversity) = ln (*r*), and *r* = the total number of species (Elliott and Hewitt 1997).

3.4 Environmental Sampling

3.4.1 Water temperature and depth – LGL Alaska

Stream temperatures were collected near each of the sampling sites with remote loggers programmed to record water temperature every 15 minutes (model TempProV2, manufactured by Onset Computer Corporation, Bourne, MA). In this report, temperatures are reported as daily averages. Stream temperatures were also recorded during fish sampling events with a hand-held bulb thermometer, as a backup to the data loggers.

Depth was recorded at each of the sample sites during each sampling event, as a backup in case discharge data was not available for this report. Temperature data was also collected from Stream 2002 at the same location sampled in 2008 (Nemeth et al. 2009) to maintain a dataset for future comparison.
A staff gauge at a fixed location in the stream was used for consistency in measurement. Depth data was standardized (Neter et al. 1993) for comparison across all sampling locations. Z-score standardization gives the values a mean of zero and variance of one.

3.4.2 Water temperatures and discharge – RTI

Temperature data were collected at numerous places in the watershed as part of separate hydrological monitoring project conducted by Riverside Technologies, Inc. (Ft. Collins, CO), including both study tributaries and in the mainstem Chuit River (RTI 2007). Gauging stations were visited monthly by RTI personnel and stream temperatures were measured to check instrument calibration (RTI 2007). Temperature data were collected using Campbell Scientific CR10 data loggers.

Discharge data were collected using Marsh-McBirney current meters to measure stream velocities. Water depth and mean velocities were measured at subsections of the stream using the midsection method. The mean stream velocities and the cross-sectional areas of each subsection were multiplied and then added together to calculate stream discharge. A full description of the hydrology methods is found in the hydrology baseline report by RTI (2007).

Where available, the more continuous temperature and discharge data from RTI will supersede data collected by LGL Alaska throughout this report.

3.4.3 Precipitation – McVehil-Monnett

Precipitation data were collected by McVehil-Monnett from a weather gauging station near Stream 2004 within the mining area. The station was located roughly 2 km (1.2 mi) upstream from the confluence with the Chuit River (McVehil-Monnett 2006).

4.0 Results

4.1 Sampling Effort

4.1.1 Tributaries

The weir in Stream 2003 was in place from May 11 through August 6, for a total operational time of 87 days (Table 2; Photos 1 and 2). The weir in Stream 2004 was in place from May 21 through August 6, for a total operational time of 78 days (Table 2; Photo 3). The fyke net in Stream 200401 operated for 72 of 74 days possible from May 25 through August 6 (Table 2; Photo 4).

Repairs, minor modifications, and adjustments to the weir were needed to adapt to varying hydrological conditions. Modifications were predominantly made to increase flow into the livebox due to low water levels (Photo 2). However, the Stream 2003 weir had a 15 cm (6 in) hole in a panel from June 7 until June 10, necessitating an interpolation of the number of coho salmon that passed through the hole on those dates.

4.1.2 Chuit River

RST1 was installed on May 21 and fished every day through August 11, 83 days in total. The fyke net placed downstream of RST1 was installed on June 21 and fished through July 26, 35 days of a possible 36 days (Table 2; Photo 8).

RST2 began fishing on May 12 and fished through August 11 (Photo 7). RST2 fished every day, 92 days in total (Table 2). Both RSTs were adjusted throughout the season as water levels fluctuated to capture more of the thalweg. Downtime was minimal in 2009; the RSTs fished nearly continuously, with only minor stoppages from debris jams, gear malfunctions, or to adjust trap placement (Figure 4).

4.2 Coho and Chinook Salmon Smolt Abundance

4.2.1 Tributaries

In total, 28,511 juvenile coho salmon and 1,165 juvenile Chinook salmon were captured moving downstream in streams 2003 and 2004 combined (all gear types; Table 3). A total of 4,760 coho salmon smolts were captured in Stream 2003 and 6,892 coho salmon smolts were captured in Stream 2004 (Table 4).

Catches of coho salmon smolts were highly correlated between the weirs in 2009. The highest correlation was with a lag of 0 day (Pearson correlation coefficient = 0.854), meaning that the best description of run timing, between the streams, was one where fish were following the same pattern on the same day in the two streams. During the interval from June 7 to June 10, catches at Stream 2004 spiked. Based on same-day correlations from Stream 2004 to Stream 2003, we estimated that 995 coho salmon smolts would have emigrated from Stream 2003 during this time, and the counts were adjusted to reflect this. This adjustment resulted in a total estimate of 5,945 smolts emigrating from Stream 2003. Similarly, interpolation from within Stream 2003 (based on adjacent dates) would have yielded similar results (5,752 smolts).

Video footage was reviewed from May through July 15 based on the run timing of salmon smolts captured at the weirs. Four different species (Dolly Varden, rainbow trout, coho salmon, and Chinook salmon) and two groups not identified to species (sculpin and lamprey) were observed traveling through the video chute in both streams. Many fish in the video chute were identified to species, including juvenile coho and Chinook salmon (Appendices A through D). Unidentifiable salmonids were apportioned by size class and the daily proportion of salmon species caught in the live box (Appendices E and F).

An estimated 196 coho salmon smolts moved downstream through the video chute in Stream 2003 and 585 coho salmon smolts in Stream 2004 (Table 4; Figures 5 and 6). The majority of coho salmon smolts were detected in June as stream discharge decreased and water temperatures increased (Figures 7 and 8).

After combining weir and video data, and interpolation counts, a total of 6,141 coho smolts emigrated from Stream 2003 and 7,477 coho smolts emigrated from Stream 2004 (Table 4).

4.2.2 Chuit River

In total 11,298 coho salmon, ≥90 mm in length, were marked at the weirs in streams 2003 and 2004. Marked fish were released in nine different temporal strata, starting on May 12 and ending August 6. In total, 1,385 coho salmon ≥90 mm in length were examined for marks at the RSTs; of these fish, 343 were recaptures of fish marked upstream (Table 5). Estimated travel time from the two study streams to the RSTs (14 km [8.7 mi] from Stream 2003, 26 km [16.2 mi] from Stream 2004) was two to nine days for most marked fish. Fish from Stream 2004 generally took a day or two longer to travel to the recapture site than fish from Stream 2003 (Figure 9).

Based upon silvery appearance, run timing, length, and age, the coho salmon smolt abundance was calculated for fish ≥90 mm, migrating from May 12 to July 15. The largest recaptured smolt was 145 mm in length; therefore the abundance estimate is only inclusive of smolts between 90 and 145 mm in length. There was no significant difference in size between coho salmon released at the weirs and recaptured at the RSTs (KS test; P-value = 0.115; Figure 10). After the data were truncated to reflect size and time adjustments, a total of 11,298 marked fish were released, over seven temporal strata. A total of 1,728 fish were examined for marks, of which 343 were recaptures. Diagnostic tests of the data in SPAS resulted in p-values <0.01, necessitating the use of the Darroch model to estimate population abundance. Partial pooling of the data resulted in three marking strata and two recovery strata (Table 5), with a resultant population estimate of 44,794 (SE = 2,401) coho salmon smolts (Table 6).

Juvenile Chinook salmon were caught in greater numbers in 2009 than in 2008 at all sampling sites (Table 7). In total, 308 Chinook salmon ≥65 mm in length were marked in Stream 2003 and 527 were marked in Stream 2004. These fish were released in nine different temporal strata, starting on May 12 and ending on August 6. An abundance estimate was not calculated for Chinook salmon smolts because scale-based age analysis identified Chinook salmon in the tributary streams to be age-0. Because age-0 Chinook salmon may not outmigrate, mark-recapture assumptions (equal probability of recapture) would be violated, thereby yielding a biased population estimate.

4.3 Movement, Abundance, and Biological Characteristics of Fish

4.3.1 Fish abundance and species composition

In total, 54,730 fish, representing thirteen different species and two groups not identified to species (sculpin, lamprey), were captured traveling downstream. The majority of the fish, 59%, were caught in the tributary streams and 41% were caught in the mainstem Chuit River (Table 3). Juvenile coho salmon dominated the catch composition in the tributary streams (Table 7), whereas juvenile Chinook salmon were the predominant species caught in the mainstem Chuit (Table 7).

Juvenile coho and Chinook salmon, Arctic lamprey, coastrange sculpin, Dolly Varden, juvenile lamprey, Pacific lamprey, adult pink salmon, rainbow trout, slimy sculpin, and sculpin *spp*. were caught in both tributary streams. Additionally, one adult Chinook salmon and one adult lamprey were caught in Stream 2003. One adult sockeye salmon was caught in Stream 2004 and one juvenile salmonid was not identified to species. Streams 2003 and 2004 had identical species richness, although species diversity and evenness were higher in Stream 2004 (Table 8).

Fish from six species and one genus group (sculpin) were caught in Stream 200401, the tributary entering Stream 2004. Relative to streams 2003 and 2004, Stream 200401 had higher species diversity and evenness, but lower species richness (Table 8).

All of the species or fish groups caught in the Chuit River were also captured in at least one of the tributaries. Juvenile chum salmon, sockeye salmon, pink salmon, and ninespine stickleback were also caught in the RSTs. Juvenile coho and Chinook salmon were the most prevalent species in RST catches. Chinook salmon were caught in greater numbers in the Chuit River than in both study tributaries, composing 49% of the RST catch compared to 2 to 7% of the weir catches. Overall, more Chinook salmon were captured in 2009, at all sampling sites, than in 2008 (Table 7).

Species richness, evenness, and diversity were greatest in the Chuit River, (Table 8). When all gear types were combined, overall species richness in the Chuit River drainage was 13 species and had an overall diversity (H') of 1.01 (Table 8).

4.3.2 Run timing and biological characteristics of juvenile coho and Chinook salmon

<u>Coho salmon</u>

The CPUE of juvenile coho salmon smolts (≥90 mm; Photo 9) peaked in mid June in streams 2003 and 2004, concurrent with decreased water discharge and increased water temperatures (Figures 7 and 8). After mid June, the catch was composed of younger, smaller coho salmon that gradually increased in size throughout the remainder of the season (Figure 11). Coho salmon captured in late May through early July were predominately ≥90 mm in length and almost entirely age-2. After mid July, coho salmon were primarily <90 mm in length and were age-1 or age-0 (Figure 12). The highest CPUE of pre-smolt coho salmon (<90 mm) was on July 26 in both tributary streams. Late-season catch per unit effort for juvenile coho salmon tended to increase with discharge levels following rain events (Figure 7); rain events were minimal in 2009 as compared to 2008.

In the tributary streams there was a relatively distinct separation of size classes, reflecting three different age classes. Catches of the largest size class (age-2+ smolts) decreased over time, and had ended by approximately July 15. Following this time period, catches of age-1 and age-0 fish increased. Trends in the mainstem Chuit River were similar. Although age-2 fish were seen through August 6, age-0 and age-1 fish comprised the majority of coho salmon caught after July 15.

In a reversal from catches in 2008, Stream 2003 had a greater number of pre-smolt coho salmon (<90 mm) than Stream 2004. Few coho salmon pre-smolts were captured from May through mid June and the CPUE for pre-smolts in Stream 2003 peaked in late July at 2,066 fish/day (Figure 12). In total, 16,716 coho salmon (smolts and pre-smolts) were captured moving downstream in Stream 2003 (Table 7).

The first coho salmon pre-smolt was captured on Stream 2004 as soon as the weir was installed, on May 22, and pre-smolts were captured almost daily through mid July. The greatest numbers of pre-smolts were captured in late July through early August with a peak CPUE on July 26 of 758.8 fish/day (Figure 12). In total, 10,226 juvenile coho salmon were caught moving downstream in Stream 2004 (Table 7).

Juvenile coho salmon represented 72% of the catch in Stream 200401. Few juvenile coho salmon smolts were captured however; coho salmon pre-smolts were consistently caught throughout the season. The CPUE of coho salmon pre-smolts peaked in late July at 463.7 fish/day. In total, 1,569 juvenile coho salmon were caught in Stream 200401 (Table 7).

The majority of coho salmon ≥90 mm were caught in the Chuit River in late May through mid July with the highest CPUE of 41.6 fish/day on June 8. Most of the juvenile coho salmon pre-smolts were caught in late July through early August. CPUE peaked for juvenile coho salmon pre-smolts on July 31 at 369.4 fish/day (Figure 12). In total, 6,776 juvenile coho salmon were captured at the RSTs in the Chuit River (Table 7).

The mean length of juvenile coho salmon was 79 mm (ranging from 29 to 235 mm). The mean weight was 8.9 g (ranging from 0.2–126.7 g; Table 9).

<u>Chinook salmon</u>

Chinook salmon juveniles were caught at all sites, but predominately in the Chuit River. In total, 11,750 juvenile Chinook salmon were caught in the Chuit River drainage (Table 3). Juvenile Chinook salmon were 49% of the catch in the Chuit River and 2 to 7% of the weir catches in the tributaries (Table 7).

Juvenile Chinook salmon were captured in streams 2003 and 2004 primarily in July. Almost all of the Chinook salmon captured in the tributaries were age-0 and not observed to be smolting. CPUE for age-0 Chinook salmon peaked in Stream 2004 on July 8 (110.1 fish/day) and in Stream 2003 on July 7 (43.8 fish/day; Figure 13).

Juvenile Chinook salmon were captured throughout the course of the season in the Chuit River. Early in the season these fish were generally age-1 (smolts) and accounted for the bulk of the catch. A second group of smaller fish (age-0 pre-smolts) were captured throughout the entire season. Overall, the majority of the age-0 Chinook salmon were captured in July in the Chuit River (Figure 13). CPUE for juvenile Chinook salmon peaked at 731.7 fish/day on July 23.

In the Chuit River, the CPUE for juvenile Chinook salmon increased as water levels decreased and temperatures increased. In the tributaries, the CPUE increased when water levels were low and water temperatures were relatively stable (Figures 14 and 15).

Most of the Chinook captured in the Chuit River drainage were 50 to 89 mm in length (Figure 16). The mean length of juvenile Chinook salmon was 66 mm (31–110 mm). The mean weight was 3.6 g (0.3–31 g; Table 9).

4.3.3 Run timing and biological characteristics of species or fish groups (non-coho or Chinook salmon)

Dolly Varden

In total, 751 Dolly Varden were caught from all of the sampling sites, representing 1% of fish captured in Stream 2003, 2% in Stream 2004, and 1% in the Chuit River (Table 7).

Few (12%) of the Dolly Varden captured in 2009 were >200 mm and most of these were caught from late July through early August. Dolly Varden CPUE peaked at 10.2 fish/day on July 22 in the Chuit River, 2.0 fish/day on August 2 in Stream 2004, and 4.0 fish/day on August 4 in Stream 2003 (Figure 17).

The majority of Dolly Varden ≤200 mm were captured earlier in the season, from mid May through mid June. Dolly Varden were caught at lower numbers from mid June through August. CPUE for Dolly Varden ≤200 mm peaked in Stream 200401 at 23.6 fish/day on June 1 and in Stream 2003 at 18.1 fish/day on May 18. CPUE peaked at 16.2 fish/day on May 31 in Stream 2004 and 5.2 fish/day on May 21 in the Chuit River.

Mean length of Dolly Varden was 127 mm (21–356 mm). Mean weight was 36.8 g (0.1–201.5 g; Table 9).

Rainbow trout

Rainbow trout were captured in the study tributaries and in the Chuit River throughout the season. In total, 1,245 rainbow trout were caught at all sampling sites combined. Rainbow trout represented 2% of catch on the Chuit River, 3% in Stream 2004, and 0% in Stream 2003. In 2008 the largest proportion of rainbow trout were caught at the fyke net in Stream 200401. Rainbow trout represented 16% of the total catch at Stream 200401 in 2009, a significant change from 2008 when rainbow trout were 55% of the catch (Table 7).

Very few (6%) of the rainbow trout captured were greater than 200 mm in length. CPUE for rainbow trout ≥200 mm peaked at 2.0 fish/day on May 18 in Stream 2003 and 2.1 fish/day on May 30 and August 6 in Stream 2004. In Stream 200401 the CPUE peaked on May 30 at 6.3 fish/day, and on July 15 at 1.5 fish/day in the Chuit River. CPUE of rainbow trout <200 mm was highest in Stream 200401 at 70.0 fish/day on July 20. Both study streams peaked on July 26 at 26.8 fish/day in Stream 2004 and 4.8 fish/day in Stream 2003. The CPUE of rainbow trout <200 mm was 14.0 fish/day in the Chuit River on July 15 (Figure 18).

The mean length of rainbow trout was 96 mm (21–432 mm). The mean weight was 28.5 g (0.3–622.0 g; Table 9).

Lamprey *spp.*

Adult Arctic lamprey (Photo 10) and Pacific lamprey (Photo 11) were caught in both tributary streams and in the mainstem Chuit River; no lamprey were captured in Stream 200401 (Table 3). Adult Arctic lamprey represented 1% of the fish caught in Stream 2003, 1% in the Chuit River, and 0.3% in Stream 2004 (Table 7). More Arctic lamprey were captured in 2009 than in 2008. A few Pacific lamprey were captured in the study tributaries in 2009 though none were captured in 2008.

Most Arctic lamprey were captured in streams 2003 and 2004 in late May through mid June. CPUE of Arctic lamprey ≥200 mm was highest in Stream 2003 peaking on May 26 at 2.4 fish/day. The CPUE for Arctic lamprey <200 mm was also highest in Stream 2003; the CPUE peaked at 28.6 fish/day on May 27 (Figure 19). Arctic lamprey were also captured throughout the season in the Chuit River but at much lower numbers than in the tributaries.

The mean length for Arctic lamprey was 147 mm (107–457 mm) and 450 mm (172–550 mm) for Pacific lamprey. The mean weight for Arctic lamprey was 6.0 g (1.6–29.3 g) and 6.8 g for Pacific lamprey; only one Pacific lamprey was weighed (Table 9).

Lamprey that had not yet undergone metamorphosis were classified as Ammocoetes, which is the larval life stage of lamprey. Ammocoetes were not differentiated to species, although they were presumed to be either Pacific or Arctic lamprey, based on adult lamprey captures. Ammocoetes represented 1% of fish caught in Stream 2003, 2% in Stream 2004, and 4% of the catch in the Chuit River (Table 7). Most of the ammocoetes were caught in mid May through early June and mid July through early August (Figure 20). Ammocoetes captured in the tributaries were generally longer than 100 mm in length and the mean length for the entire watershed was 110 mm (25–177 mm). The mean weight for all ammocoetes captured was 0.6 g (0.2–1.0 g; Table 9).

Threespine stickleback

Threespine sticklebacks were caught in Stream 2003, Stream 200401, and the Chuit River. Most of the 2,226 sticklebacks were captured in the Chuit River and four were caught in the study tributaries. In contrast, 57 threespine sticklebacks were caught in 2008, all of which were from the mainstem river (Table 7).

Threespine sticklebacks were captured from May through August. Two different life stages were represented in the fish catch. Those that appeared to be juveniles (not exhibiting physical characteristics of sexual maturity) were <65 mm (Figure 21). Those exhibiting characteristics of sexual maturity were often larger (≥65 mm). Males were identified by their conspicuous red chins and their bluish tinged backs. Females remained the less conspicuous gray color but their bodies were more shiny and bulky in appearance (Tinbergen 1952). The mean length of threespine stickleback was 56 mm (15–89 mm) and the mean weight was 3.1 g (0.1–6.1 g; Table 9).

4.3.4 Differences in fish species composition among sites and years

In 2009, more coho salmon smolts were counted in Stream 2004 than Stream 2003. This was a reversal from the prior year. However, the abundance estimate of the total contribution of coho salmon from the two tributaries to the entire Chuit River drainage in 2009 was similar to that estimated in 2008 (Table 4).

Another difference between 2008 and 2009 was the aforementioned increase in the number of juvenile Chinook salmon captured at all sites. In total, 41 juvenile Chinook salmon were captured in the study tributaries in 2008 compared to 1,165 Chinook salmon in 2009. Also, Chinook salmon dominated the catch in the mainstem Chuit River in 2009 representing 47% of the catch; in 2008 Chinook salmon were 20% of the catch (Table 7).

In 2009, two additional species were present in the tributary streams that had not been documented in 2008. Threespine stickleback were caught in streams 2003 and 200401 but not in Stream 2004. No threespine sticklebacks were caught in the study tributaries the previous year. Also, a few thousand more threespine sticklebacks were captured in the mainstem river in 2009 than in 2008. Pacific lamprey were also captured in both study tributaries in 2009 and were not captured in either of these streams in 2008. In total, 27 lamprey were captured in Stream 2004 in 2008 and 245 lamprey in 2009.

4.4 Environmental Sampling

4.4.1 Ice and snow out

Ice began to melt from streams 2003 and 2004 by mid to late April. Streams 2003 and 2004 were mostly ice free by early May and mid May (respectively) though snow and ice at these times had melted from the lower reaches of the streams, but were still extensive in the upper reaches. The snow was completely melted from both sampling sites by late May to early June.

The Chuit River was relatively ice free in early May, although some ice was still flowing downstream from the tributaries. The snowpack near the sampling sites was completely melted by mid May.

4.4.2 Water temperature

Water temperatures from the RTI gauging stations show similar trends among the tributary streams. Stream temperatures were coolest in May, with average daily temperatures ranging from 0.1 to 8.7 °C (31.8 to 47.6 °F). Stream temperatures gradually increased through June, and then peaked on July 8, with an average daily temperature of 15.3 °C (59.5 °F) in Stream 2002, 14.0 °C (57.2 °F) in Stream 2003, and 13.1 °C (55.6 °F) in Stream 2004. Water temperatures gradually decreased thereafter (Figure 22). Overall, water temperatures were slightly warmer in Stream 2002 compared to Stream 2003; Stream 2003 was slightly warmer than Stream 2004.

Water temperatures were a few degrees cooler in 2009 than in 2008 and followed a similar seasonal trend in 2008, with low temperatures in May that gradually increased in June and peaked in early July (Figure 22). Water temperatures then gradually decreased throughout the remainder of the season.

4.4.3 Discharge

As the snowpack melted in the spring there was an associated rise in discharge in the tributaries and in the mainstem Chuit River. Water levels were measured at the sampling sites using an instream staff gauge and at gauging stations located at the mouths of the tributaries and in the mainstem river. Discharge was highest in early May followed by a general decline through the rest of the season (RTI, unpublished data). Water levels remained low and relatively constant for the duration of the season. Discharge increased slightly in late July in response to increased precipitation (Figure 23). Water levels were higher initially in Stream 2003 than in streams 2002 and 2004, although the general water level trend was similar among streams. Following the peak discharge in mid May, base water levels remained higher in streams 2002 and 2004 than in Stream 2003 for the duration of the season. The Chuit River discharge followed a pattern similar to that observed in the tributaries with the highest levels in May, declining through June and base flow in July. The precipitation event in late July and early August (Figure 23) was more evident in the mainstem than in the tributaries.

The study tributaries had similar discharge patterns between 2008 and 2009, although water levels were typically higher in 2008. Water discharge was highest in May in both years, although it peaked earlier in 2009 than in 2008. Water levels in 2009 dropped early in May and much faster compared to 2008, when water levels did not peak until mid May and then gradually decreased (i.e., a short, fast break-up in 2009 as compared to a slower, more gradual break-up in 2008). In 2009, water discharge was low and fairly constant from mid June through mid July. In 2008, water discharge was decreased through most of June (Figure 23). Discharge increased in late July following precipitation events in both years. Fewer rain events occurred in 2009 than in 2008.

After precipitation events, stream discharge and turbidity increased then subsided within hours or days. During high water events, Stream 2003 peaked quickly, but then subsided quickly. The spikes in streams 2002 and 2004 were moderate compared to Stream 2003; peak levels were generally not as high but did remain higher for longer. Discharge in the Chuit River was influenced by the tributaries rising and falling after precipitation events in the tributaries. Water turbidity increased with discharge.

4.4.4 Precipitation

Precipitation occurred on few occasions throughout the season with the most rainfall in mid to late July (Figure 24).

Within the study area persistent rainfall led to increases in discharge deemed “high-water events”, loosely defined as a period of elevated water discharge that could negatively impact the ability for the sampling gear to function properly. Few high water events

occurred during the 2009 sampling season. In 2008, it was during these high water events that sampling equipment effectiveness was reduced and in some cases halted altogether. Modifications were incorporated into the weir panel designs in 2009 to increase equipment effectiveness during such events.

5.0 Discussion

5.1 Coho and Chinook Salmon Smolt Abundance in Streams 2003 and 2004

5.1.1 Number of coho salmon smolt produced in the tributaries

The most important objective of monitoring, *to generate a second consecutive year of coho salmon smolt estimates from streams 2003 and 2004*, was successfully met in 2009. Low catch rates at the start and end of the season indicate that sampling efforts covered the entire outmigration for each stream. Although the 2009 emigration began two to three weeks earlier than in 2008, we were able to capture the entirety of the run because the cues that appear to stimulate the onset of the smolt run (decreasing water levels and an associated rise in water temperature) gave us ample notice to allow us to install and operate the smolt weirs.

The second year of monitoring was important in that it provided an initial view of interannual variation in smolt abundances within the watershed. The annual mean and the variation around it are important statistics for detecting change between the pre- and post-development periods, and the reason for multi-year monitoring is to better understand this mean and variation. Studies of coho salmon smolts with similar life histories (i.e., two years in fresh water) elsewhere have shown an approximate fourfold difference in annual smolt abundance within a system over a four-year length of time (Lafferty et al. 2007; Massengill 2008; Williams et al. 2009). The first year of interannual variation on the Chuit River was well within this range, with percent changes of 19% for Stream 2003 (a decrease from 7,433 to 6,141 smolts), 41% for Stream 2004 (an increase from 4,941 to 7,477), and 18% for the entire Chuit River watershed (an increase from 37,424 to 44,794 smolts; Table 4). The next two annual smolt abundance estimates will provide important insight into the range of variability. These ranges should be lower than the expected variation in adult returns, as they exclude factors outside the Chuit drainage that can have a strong influence on adult population size (e.g., marine survival).

The separation of coho salmon smolts from pre-smolts in 2009 was clearly defined and similar to the 2008 division. The smolt run began in late May, ended by early to mid July, and was composed almost entirely of age-2 coho salmon. Following the smolt run, fewer age-1 fish were observed at the weirs than in 2008, perhaps because of the lower water levels in 2009. In 2008, rain fell intermittently throughout July and age-1 pre-smolts were active in the stream while age-0 pre-smolts (newly hatched fry) became active in the stream later, in August and September. In 2009, less rain fell in July and sampling ended by early August. The clear separation between smolts and pre-smolts

each year allowed for identification of the end of the smolt run and therefore the ability to estimate total smolt numbers.

The filmed activity pattern of fish utilizing the breaches was used to help determine whether a given fish should be considered to have emigrated from the system, or to have potentially moved back upstream at a later time. In 2009, the pattern was distinct; fish filmed earlier in the season (during the smolt run) were primarily the size of smolts, almost always moving downstream, and had relatively few immediate double-back events. Later in July, the movement was bi-directional with more associated double-back events. Fish that were pre-smolts were more likely to be making shorter distance movements associated with local-scale habitat changes than with larger scale emigrations from the system. Based on these patterns, smolt-sized fish counted using video in June were added to the counts recorded in the livebox, increasing the total smolt estimate by 4% for Stream 2003 and 8% for Stream 2004. It appeared that pre-smolts detected later in the season were milling, and it is possible that some of these fish could have been counted multiple times in the video chute. This milling behavior is not unexpected for this life stage, and since length and appearance were used to determine the smolt group, had no effect on the smolt abundance estimates.

Relatively low and stable water levels in combination with improvements made to the weir designs reduced weir downtime and associated uncounted fish in 2009. The greatest source of uncertainty in the counts came during the three days in early June on Stream 2003, when the weir had the 15 cm (6 in) hole in a panel. Both approaches to estimate the missed fish during this time (interpolation from the weir counts before and after those dates within Stream 2003; correlation with counts at Weir 2004 on those dates) yielded similar estimates. Given the strong same-day correlations between catches on streams 2003 and 2004 in 2009, we felt the between stream comparison method likely provided the best estimate because it could account for trend changes that occurred within the three-day window. In total, the differences had a minimal effect on the overall change in smolt abundance from 2008 to 2009, or on the ratio of counts from Stream 2003 to Stream 2004.

5.1.2 Number of Chinook salmon smolts produced in the tributaries

Relative to coho salmon, Chinook salmon are known to have a greater tendency to use larger or mainstem river habitat for rearing (Healey 1991), and there were clearly more juvenile Chinook salmon detected in the mainstem Chuit River than in the tributaries in both 2008 and 2009. Fewer Chinook salmon were captured in the tributary streams in 2008 and 2009 than anticipated, even taking into account the habitat use discrepancies noted above. The number of juvenile age-0 Chinook salmon observed did increase in 2009, which may be associated with the adult returns to the tributary streams in 2008 (Nemeth et al. 2009). No similar counts of adult returns were available for 2007; therefore, reasons for the additional catches of juvenile Chinook salmon in 2009 cannot be adequately explained in relation to juvenile catches in 2008. If the 2009 catches were more indicative of juvenile Chinook salmon abundances and life history characteristics then it is plausible that pre-smolts leave the tributaries before their first winter and migrate from the mainstem Chuit River as smolt the following spring.

5.2 Differences in Conditions and Overall Fish Communities Between Streams and Years

Secondary information collected was helpful for describing the smolt run and examining differences between years or streams. The age and length subsampling of coho salmon revealed similar breaks in size and run timing in 2008 and 2009. The water temperature and depth data provide an impetus for the earlier smolt migration in 2009 than in 2008. On the Nome River, coho salmon smolt migration appears to begin when daily water temperatures reach 2 °C to 4 °C (35.6 °F to 39.2 °F), which is coincident with falling water levels after ice breakup (Williams et al. 2009). Run timing in 2009 was consistent with the timing noted by Massengill (2008) in a study of coho salmon smolts on the Kenai Peninsula in Southcentral Alaska. Snowpack and April air temperatures should be monitored in future sampling years to provide an estimate of the likely start date of the smolt run.

The primary goal of the 2009 monitoring season was to gather data on smolt abundance and emigration, resulting in a need to sample only through the end of the smolt run in 2009 (approximately July 15, although sampling was extended into August to be sure). Differences in fish community composition data from 2008 to 2009 were likely due to the different durations of sampling seasons (ending in early August in 2009, as opposed to late September in 2008), and to the dryer, warmer mid-summer stream conditions in 2009. There were fewer precipitation events in July of 2009 than 2008, which may have delayed the activity of small fish redistributing within the system. In 2008, mid-summer precipitation events were associated with increased catches of small salmonids. In 2008, catches of age-1 coho salmon peaked in mid July (Stream 2003) to late July (Stream 2004), with many of the catches on Stream 2004 continuing into late August (Nemeth et al. 2009). In 2009, catches of these fish peaked two weeks later in Stream 2003, and were just beginning to be caught in Stream 2004. The most likely explanation for the reduced catches of age-1 coho salmon in Stream 2004 was that fish activity (and thus catches at the weirs) was delayed by low water. Similarly there were decreased catches of age-0 coho salmon fry in both streams. The low water level in 2009 does not explain the decreased catch of rainbow trout fry in Stream 2004 from 2008 to 2009. In 2008, fry catch peaked in late July, but had been caught in low numbers well before then. In 2009, they were almost entirely absent from both Stream 2004 and its tributary (Stream 200401), a difference that seems unlikely to be due entirely to precipitation differences.

5.3 Watershed-wide Abundance of Coho and Chinook Salmon Smolts

5.3.1 Coho salmon population estimate

In 2008, the operation of the RSTs helped establish that coho salmon <90 mm were less likely to be captured downstream (than fish ≥90 mm), and unlikely to be smolts, or to contribute many fish to the smolt run. In 2009, we continued to mark coho salmon down to 80 mm in length to account for possible annual variation in smolt length, but again saw downstream recapture difference in fish larger and smaller than 90 mm. This difference in recapture rates suggests that fish <90 mm were not as likely to be smolts, and thus more likely to hold in the Chuit River without migrating downstream, to the recapture

sites. They were not considered to be smolts and thus not included in the watershed-wide abundance estimate in 2009. In each year, nearly all coho salmon smolts included in the estimates were from 90 to 120 mm with some variation in the upper and lower size ranges (80–161 mm fish in 2008, 90–145 mm fish in 2009).

The validity of the study design with respect to the recognized assumptions for mark-recapture studies was discussed in detail in the report from 2008 (see Nemeth et al. 2009). The mark-recapture assumptions were dealt with in a similar manner in 2009 (see Section 3.2.2 for mark-recapture assumptions). As such, Assumptions 1, 5, and 6 were deemed unlikely to be violated. Regarding Assumption 1, we know the population is not closed, but we account for this by making the estimate germane to the recapture site (e.g., for the whole watershed) instead of the mark site. The possibility of handling-induced mortality during the marking process was negligible, given the low mortality rates for coho salmon smolts handled on other studies with more invasive marking techniques (e.g. coded wire tagging; Williams et al. 2009). Travel times of marked fish from the tributaries to the lower river was relatively fast, which gave some assurance that marking did not cause the sort of injuries that could contribute to marking-induced mortality, or be lost. Non-reporting was unlikely to have introduced appreciable bias because each fish at the recapture site was carefully scrutinized for marks. The Darroch model and length stratifications were utilized to address Assumptions 2, 3, and 4; however, if fish from tributaries with and without weirs experience different catchability rates, then a bias of unknown magnitude and direction could exist.

As in 2008, the RSTs in the mainstem Chuit River were operated past the end of the smolt runs in streams 2003 and 2004. The extended operation of the RSTs was to account for the travel time of smolts from these streams, and to account for smolts from other tributary streams migrating later. In watersheds the size of the Chuit River, it is likely that smolts migrate from tributaries at different times due to differences in snowmelt, temperature, and other biotic and abiotic conditions. Varying run timing patterns, by tributary, means that the date of ocean entry likely varies among smolts from different parts of the watershed.

5.3.2 Chinook salmon population estimate

As noted earlier, a watershed-wide Chinook salmon smolt abundance estimate was not calculated because fish marked in the tributaries were found to be pre-smolts, and thus uncertain to be moving downstream past the RSTs. Catch data supports the identification of these fish as pre-smolts, for example, age-0 Chinook salmon initially captured and marked in Stream 2003, were recaptured in Stream 2004 and vice versa.

Additionally, age-1 Chinook salmon smolts were captured at the RST in early June, which is consistent with smolt emigration timing (from mid June through mid July) elsewhere in Southcentral Alaska (Bendock 1996). The age-0 Chinook salmon in the tributaries upstream were caught later, in early to mid July, after the end of the smolt run in the lower mainstem river.

6.0 Conclusion

The second of four years of coho salmon smolt annual abundance estimates was successfully completed for the pre-development period in two tributaries in the Chuit River drainage. The dataset is intended to detect the potential effects of mine development upon fish species, with an emphasis on coho salmon smolts in Stream 2003 in future years. Coho salmon smolts sampled in 2009 had similar age structure and size to those in 2008, and some minor differences in run timing (earlier in 2009) and abundance (increase in Stream 2004, decrease in Stream 2003). The variation in annual abundance will be one of the main aspects of the study for the four-year pre-development period; at this time, the variation is within the range observed in other coho salmon smolt populations in the region. No major changes to the sampling strategy are recommended for 2010 (the next anticipated monitoring season).

Juvenile Chinook salmon that hatch in streams 2003 and 2004 appear to migrate from the tributaries in the summer as pre-smolts, overwinter elsewhere in the system, and then migrate to sea the following spring as age-1 smolts. As in 2008, no Chinook salmon smolts were detected emigrating from the tributaries in 2009.

Additionally, a second year's watershed-wide population estimate for coho salmon smolts was calculated. The 2009 population estimate was a 20% increase from the 2008 estimate, which is well within the interannual range of variability expected from a coho salmon population. Although Chinook salmon smolts were captured in the lower mainstem river in 2009, no watershed-wide population was estimated due to a lack of smolts in the upstream tributaries.

Peripheral information was collected for other fish species and environmental conditions to help understand results and trends over time. The change in water level and water temperature in May of 2009 (relative to May of 2008) likely explains the earlier emigration of coho salmon smolts in 2009. No other major differences in environmental conditions or fish community were observed that seemed likely to affect coho salmon smolt counts in 2009. The decrease in the number of age-1 (pre-smolt) coho salmon in streams 2003 and 2004, relative to the catches in 2008 could have implications for the smolt run in 2010, although this decrease may be more a reflection of environmental conditions than fish abundance.

Overall, the study met the intended objectives and provides data for the second of the four year pre-development period planned for the BACI design. Continued monitoring in future years will establish a clearer picture of the variability between the tributaries while providing the pre-development dataset needed to evaluate the potential impacts of mining development within the Chuit River drainage.

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Table 1. Summary statistics for the Chuit River and the study subdrainages. Historical flow data are from RTI (2007).

	Chuit River[1]	Stream 2003[2]	Stream 2004[3]
Watershed area (km^2)	341.1	37.0	38.3
Stream order[4]	4	2	3
Length (km)	103	30	33
Mean flow (m^3/s)			
April	8.7	1.2	0.5
May	30.0	3.0	4.1
June	20.1	0.9	0.9
July	5.1	0.3	0.3
August	7.5	0.6	0.8
September	15.9	1.7	2.5
Mean annual	10.1	1.0	0.9

[1]Data from Station C230, 6.4 river km downstream of Stream 2003, from 1989 to 2006

[2]Data from Station C180, at confluence with Chuit River, from 1988 through 2006

[3]Data from Station C110, at confluence with Chuit River, 2006

[4]From Strahler (1957)

Table 2. Locations, operating dates, and days sampled at each sampling site in the Chuit River watershed, May through September, 2008 and May through August, 2009. The fyke net coordinates are for the sampling sites used in 2009 (WGS84 datum).

	2008			2009				
Location and gear type	Dates of operation	Days available	Days sampled	Dates of operation	Days available	Days sampled	Latitude	Longitude
Stream 2003								
Weir	May 4 - Sep 30	150	147	May 11 - Aug 6	87	87	61.12908	151.32979
Stream 2004								
Weir	Jun 8 - Sep 30	115	96	May 21 - Aug 6	78	78	61.15707	151.44278
Stream 200401								
Fyke net	Jun 29 - Sep 3	65	65	May 25 - Aug 6	74	72	61.15189	151.44930
Chuit River								
Rotary screw trap (RST1)	May 12 - Sep 13	125	123	May 21 - Aug 11	83	83	61.02100	151.19380
Rotary screw trap (RST2)	May 14 - Sep 3	113	111	May 12 - Aug 11	92	92	61.10178	151.18011
Fyke net	May 26 - Jun 6 & Jul 2 - 17	28	28	Jun 21 - Jul 26	36	35	61.10091	151.19289

Table 3. The number of fish caught moving downstream by species, location, and gear type in the Chuit River drainage, May through August, 2009. Weir = smolt weir, Fyke = fyke net, RST = rotary screw trap. Not all gear types were used at all locations. The fyke net listed under Stream 2004 was in side tributary 200401. (a) = adult, (j) = juvenile.

		Stream 2003	Stream 2004			Chuit River				
Species	Scientific name	Weir	Weir	Fyke	Total	RST1	RST2	Fyke	Total	Total
Ammocoetes	*Lampetra spp.*	118	204		204	206	740	32	978	1,300
Arctic lamprey	*Lampetra camtschatica*	172	41		41	44	82	6	132	345
Chinook salmon (a)	*Oncorhynchus tshawytscha*	1					2		2	3
Chinook salmon (j)	*Oncorhynchus tshawytscha*	335	823	7	830	3,886	6,306	393	10,585	11,750
Chum salmon (j)	*Oncorhynchus keta*					39	30	2	71	71
Coastrange sculpin	*Cottus aleuticus*	16	77	41	118			3	3	137
Coho salmon (j)	*Oncorhynchus kisutch*	16,716	10,226	1,569	11,795	3,265	3,511	112	6,888	35,399
Dolly Varden	*Salvelinus malma*	235	222	150	372	54	89	1	144	751
Lamprey *spp.* (a)	*Petromyzontidae spp.*	1								1
Ninespine stickleback	*Pungitius pungitius*					40	62		102	102
Pacific lamprey	*Lampetra tridentata*	4	3		3	1		2	3	10
Pink salmon (a)	*Oncorhynchus gorbuscha*	7	8		8	5	7	1	13	28
Pink salmon (j)	*Oncorhynchus gorbuscha*					354	145	2	501	501
Rainbow trout	*Oncorhynchus mykiss*	66	397	349	746	211	211	11	433	1,245
Sculpin *spp.*	*Cottidae spp.*	206	114	61	175	178	211	45	434	815
Slimy sculpin	*Cottus cognatus*	5	8		8		1	1	2	15
Sockeye salmon (a)	*Oncorhynchus nerka*		1		1					1
Sockeye salmon (j)	*Oncorhynchus nerka*					6	14		20	20
Threespine stickleback	*Gasterosteus aculeatus*	3		1	1	1,074	1,096	52	2,222	2,226
Unidentified			1		1	6	3		9	10
Total		17,885	12,125	2,178	14,303	9,369	12,510	663	22,542	54,730

Table 4. The number of coho salmon smolts emigrating from study tributaries in the Chuit River watershed in 2008 and 2009. Data from the Stream 200401 fyke net are included.

Catch	Stream 2003[a]	Stream 2004[b]	Total
2008			
Weir	7,037	4,085	11,122
Video	396	856	1,252
Total	7,433	4,941	12,374
2009			
Weir[c]	5,945	6,892	12,837
Video	196	585	781
Total	6,141	7,477	13,618

[a]2008: May 27 through July 19

2009: May 11 through July 15

[b]2008: June 8 through July 19

2009: May 22 through July 15

[c]Includes interpolated 995 fish for Stream 2003

Table 5. The number of marked coho salmon released and recaptured in the Chuit River in 2009, organized by time strata. Release strata were pooled into two groups (periods 1–3, 4–7). Recapture strata were pooled into two groups (periods 1–4, 5–6). The abundance was estimated for coho salmon 90 to 145 mm in lenth, captured through July 15.

Release strata	Release dates	Release (*n1*)	Recovery strata 1	2	3	4	5	6	7	Total	Recapture % (*p1*)
1	May 13–19	1	0	0						0	0
2	May 20–30	196		1	12					13	6.6
3	May 31–June 9	2,348			36	33				69	2.9
4	June 10–19	6,711				121	70			191	2.8
5	June 20–29	1,932					60	6		66	3.4
6	June 30–July 9	104						2	1	3	2.9
7	July 10–15	6							1	1	17.6
	Total	11,298	0	1	48	154	130	8	2	343	
	Number examined (*n2*)		7	119	515	356	326	51	11		1,385
	Proportion with marks (*p2*)		0.0	0.8	9.3	43.2	39.9	15.6	18.2		24.8

Table 6. Coho salmon smolt abundance estimates for the Chuit River watershed in 2008 and 2009.

Year and length group	Estimate method	N	SE	95% CI Lower	95% CI Upper
2009					
90–145 mm	Darroch	44,794	2,401	40,088	49,500
2008					
80–161 mm	Darroch + Petersen[1]	37,424	2,116	33,276	41,572

[1]Petersen used only for fish 80–90 mm in length, then added to Darroch estimate used for fish 90-161 mm (Nemeth et al. 2009).

Table 7. Catch (total number of individuals and percent by species) of fish traveling downstream in the Chuit River drainage, according to location and sampling year. Data were from May through September, 2008 and May through August, 2009. Only sampling locations that were operational in both years are shown. Data does not include the Chuit River fyke net. (a) = adult, (j) = juvenile.

	Stream 2003				Stream 2004				Stream 200401				Chuit River			
	Catch		%		Catch		%		Catch		%		Catch		%	
Species	'08	'09	'08	'09	'08	'09	'08	'09	'08	'09	'08	'09	'08	'09	'08	'09
Ammocoetes	65	118	0	1	20	204	0	2					672	946	5	5
Arctic lamprey	226	172	1	1	7	41	0	0					242	126	2	1
Chinook salmon (a)	7	1	0	0	20		0						3	2	0	0
Chinook salmon (j)	11	335	0	2	26	823	0	7	4	7	0	0	2,953	10,192	21	49
Chum salmon (j)					1		0						5	69	0	0
Coastrange sculpin	7	16	0	0	62	77	0	1	49	41	1	2	321		2	
Coho salmon (a)	4		0		1		0						4		0	
Coho salmon (j)	18,698	16,716	98	94	22,682	10,226	98	86	2,212	1,569	43	72	9,388	6,776	68	32
Dolly Varden	124	235	1	1	137	222	1	2	16	150	0	7	106	143	1	1
Lamprey *spp.* (a)	6	1	0	0												
Ninespine stickleback													17	102	0	0
Pacific lamprey		4		0		3		0					2	1	0	0
Pink salmon (a)	3	7	0	0		8		0					18	12	0	0
Pink salmon (j)													128	499	1	2
Rainbow trout	37	66	0	0	210	397	1	3	2,783	349	55	16	494	422	4	2
Sculpin *spp.*	11	206	0	1	5	114	0	1	4	61	0	3	8	389	0	2
Slimy sculpin	16	5	0	0	26	8	0	0	25		0		110	1	1	0
Sockeye salmon (a)					1	1	0	0					1		0	
Sockeye salmon (j)					1		0						15	20	0	0
Threespine stickleback		3		0						1		0	57	2,170	0	10
Unidentified	1		0			1		0					4	9	0	0
Total	19,151	17,767	100	100	23,179	11,921	100	100	5,093	2,178	100	100	13,876	20,933	100	100

Table 8. Fish species richness, diversity, and evenness from all sampling sites in the Chuit River watershed, May through September, 2008 and May through August, 2009.

	S		H'		H'max		J'	
Sampling location	'08	'09	'08	'09	'08	'09	'08	'09
Stream 2003	8	10	0.14	0.26	2.08	2.30	0.07	0.11
Stream 2004	9	10	0.14	0.56	2.20	2.30	0.06	0.25
Stream 200401	6	6	0.79	0.81	1.79	1.79	0.44	0.45
Chuit River	13	13	1.04	1.24	2.56	2.56	0.41	0.48
All locations combined	13	13	0.43	1.01	2.56	2.56	0.17	0.39

Note: S = Species richness; H' = Shannon's index of diversity; H'max = maximum diversity; J' = Pielou's estimate of species evenness (Elliott and Hewitt 1997; Pielou 1966).

Table 9. Mean length and weight for all fish species sampled from the Chuit River watershed, from May through August, 2009. Species with forked tails (salmonids) were measured to fork length; species with rounded or truncate tails (all other species) were measured to total length. All gear types and sites are combined. (a) = adult, (j) = juvenile

	Length (mm)					Weight (g)				
Species	Mean	Min	Max	SD	n	Mean	Min	Max	SD	n
Ammocoetes	110	25	177	33.1	1,107	2.4	0.1	7.7	1.6	218
Arctic lamprey	147	107	457	39.0	343	6.0	1.6	29.3	6.0	46
Chinook salmon (a)	505	410	600	134.4	2	-	-	-	-	-
Chinook salmon (j)	66	31	110	12.9	5,206	3.6	0.3	13.8	2.0	1,342
Chum salmon (j)	48	33	64	7.4	71	1.1	0.5	1.9	0.5	9
Coastrange sculpin	62	40	105	11.6	134	2.6	1.1	6.4	1.6	18
Coho salmon (j)	79	29	235	30.4	11,148	8.9	0.2	126.7	8.0	2,717
Dolly Varden	127	21	356	55.2	733	36.8	0.1	201.5	40.0	249
Ninespine stickleback	42	26	88	7.1	99	0.6	0.2	1.0	0.2	30
Pacific lamprey	450	172	550	110.0	10	6.8	6.8	6.8	0.0	1
Pink salmon (a)	451	325	622	72.8	17	-	-	-	-	-
Pink salmon (j)	36	30	79	4.1	437	0.3	0.2	0.5	0.1	21
Rainbow trout	96	21	432	66.2	1,195	28.5	0.3	622.0	48.9	240
Sculpin *spp.*	62	18	157	12.6	795	3.1	0.4	15.5	2.5	131
Slimy sculpin	61	45	70	7.4	15	2.0	0.9	2.6	0.7	5
Sockeye salmon (a)	476	476	476	0.0	1	-	-	-	-	-
Sockeye salmon (j)	46	33	97	14.2	20	1.0	0.3	1.7	0.7	4
Threespine stickleback	56	15	89	26.8	1,296	3.1	0.1	6.1	2.0	152
Unidentified	41	30	49	8.3	6	0.7	0.7	0.7	0.0	1

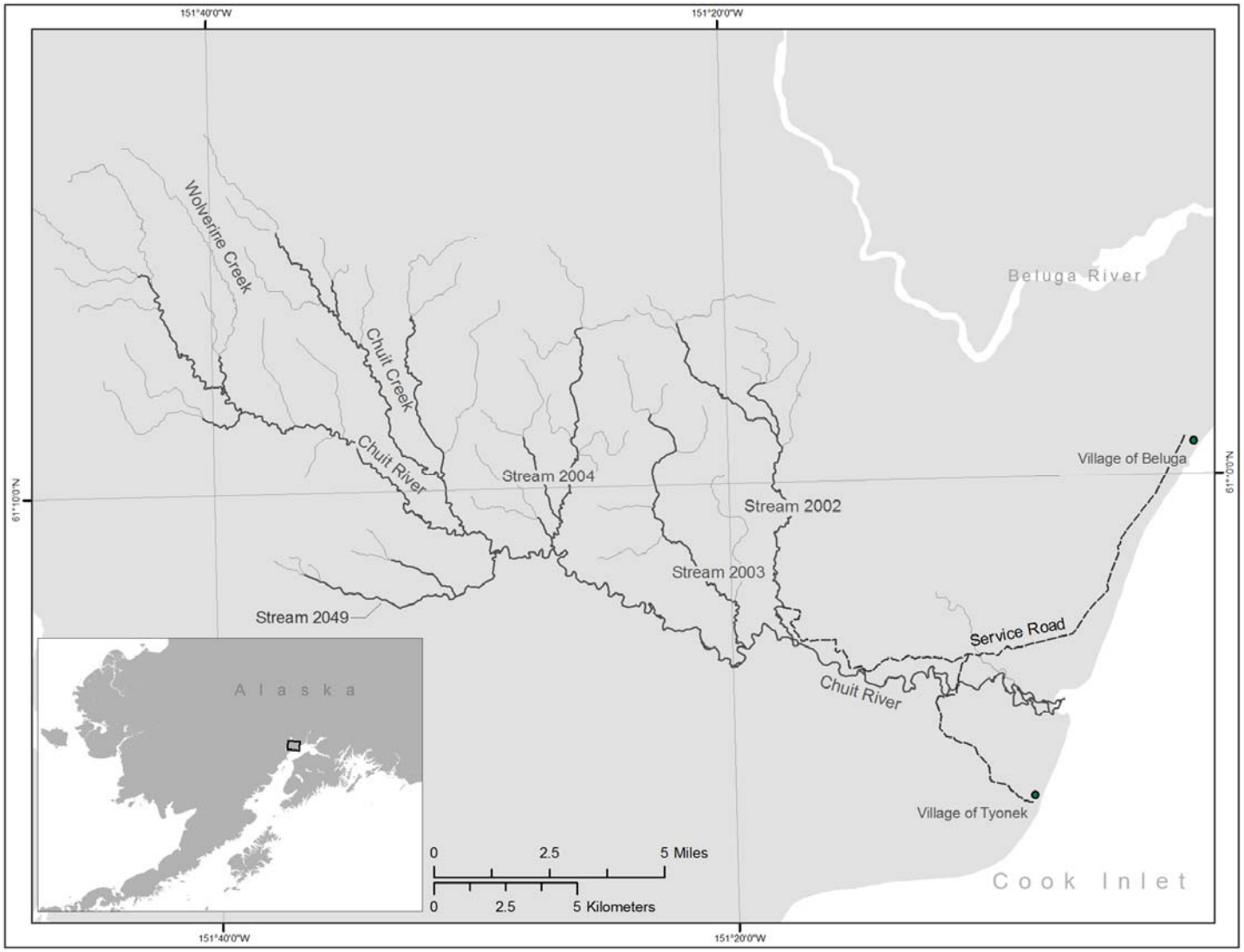

Figure 1. Map of the Chuit River drainage, showing the study tributaries in relation to the surrounding area.

Figure 2. Location of fish sampling sites in the Chuit River drainage.

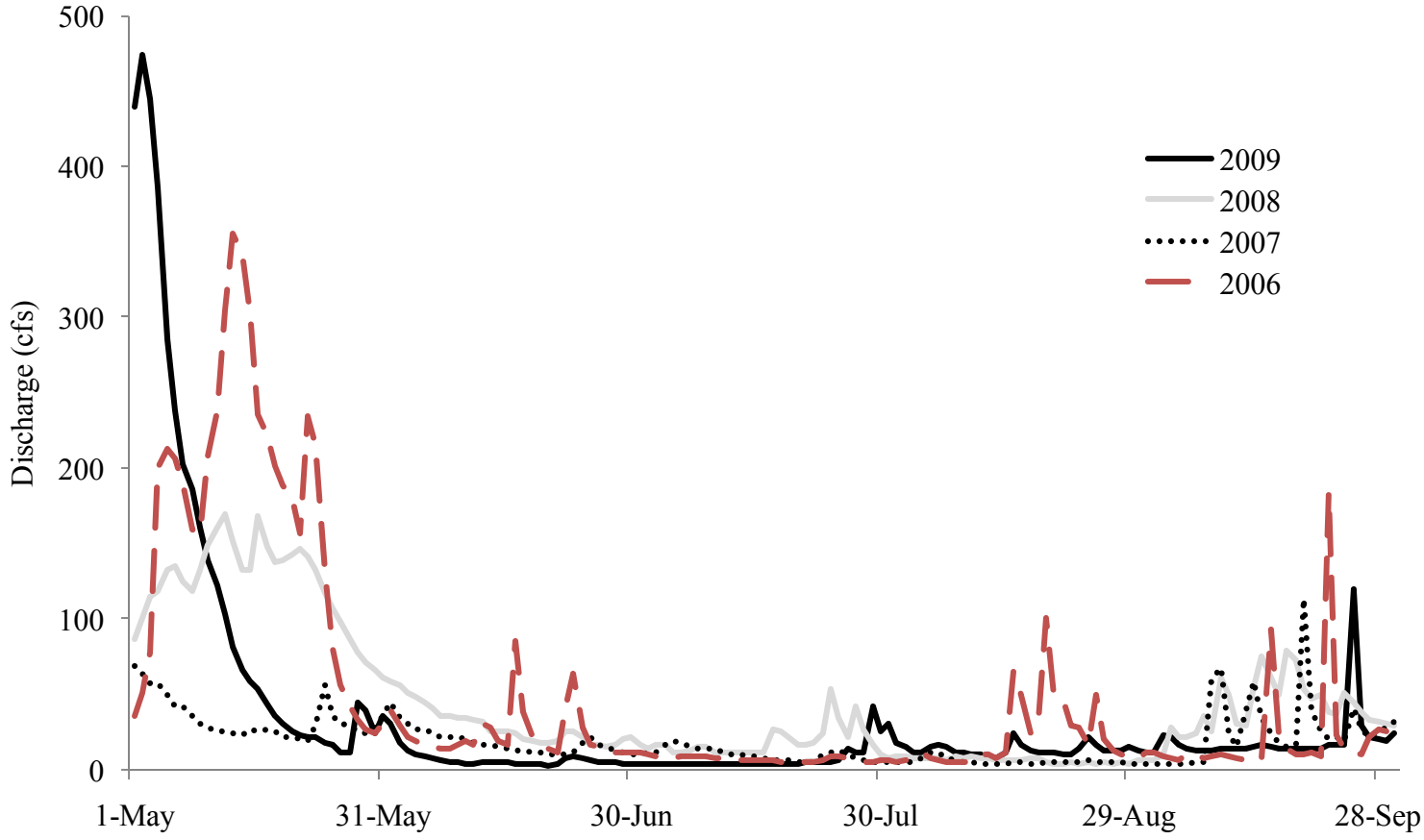

Figure 3. Mean daily discharge for Stream 2003 from May through September, 2006 through 2009. Data are from RTI (Fort Collins, CO) maintained station C180 and are in cubic feet per second (cfs).

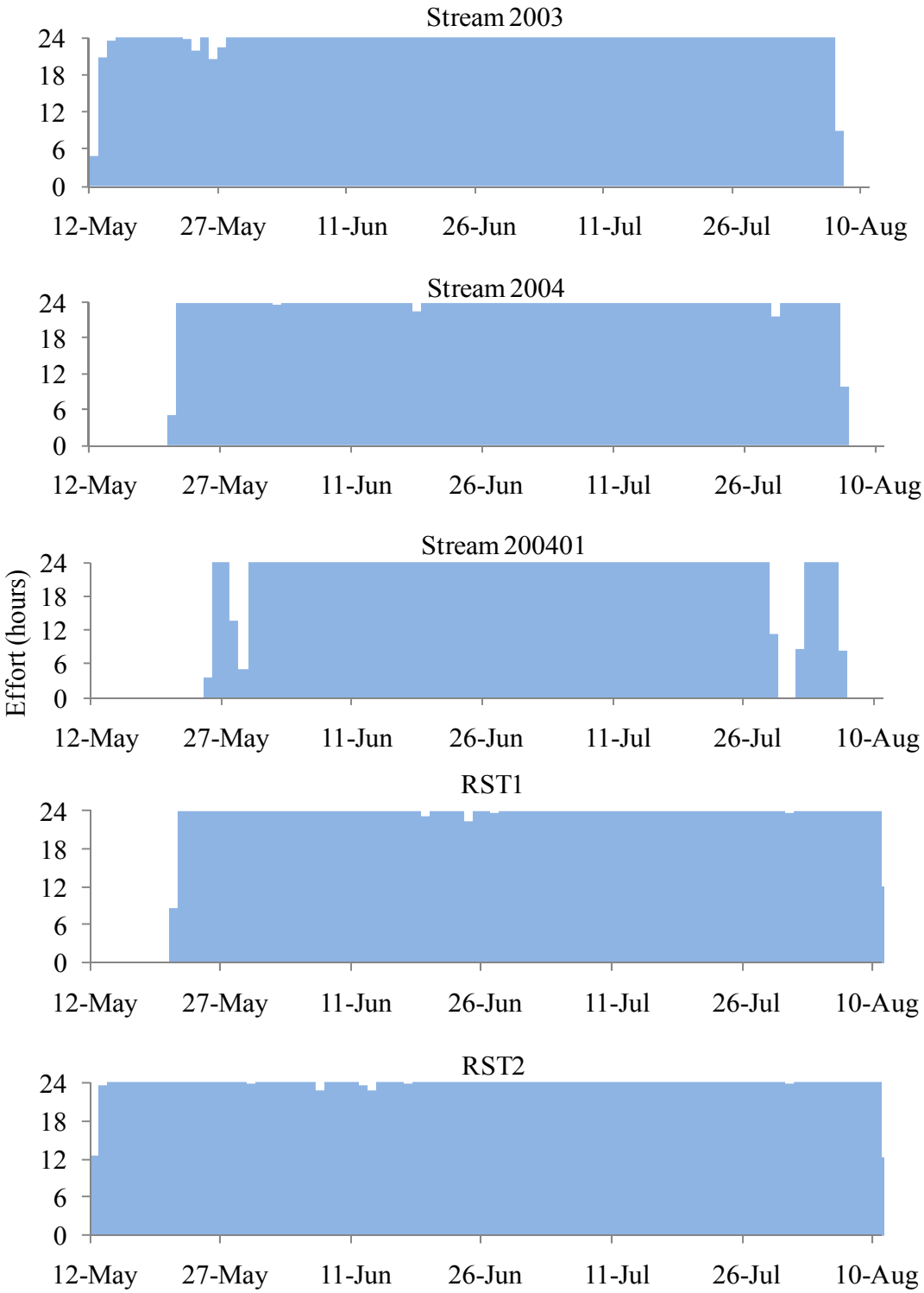

Figure 4. Sampling gear effort in hours per day by sampling site, from May through August, 2009. Sampling effort includes main gear types, but not ancillary gear. Stream 200401 is included as one of the main sites because it enters below the weir in Stream 2004.

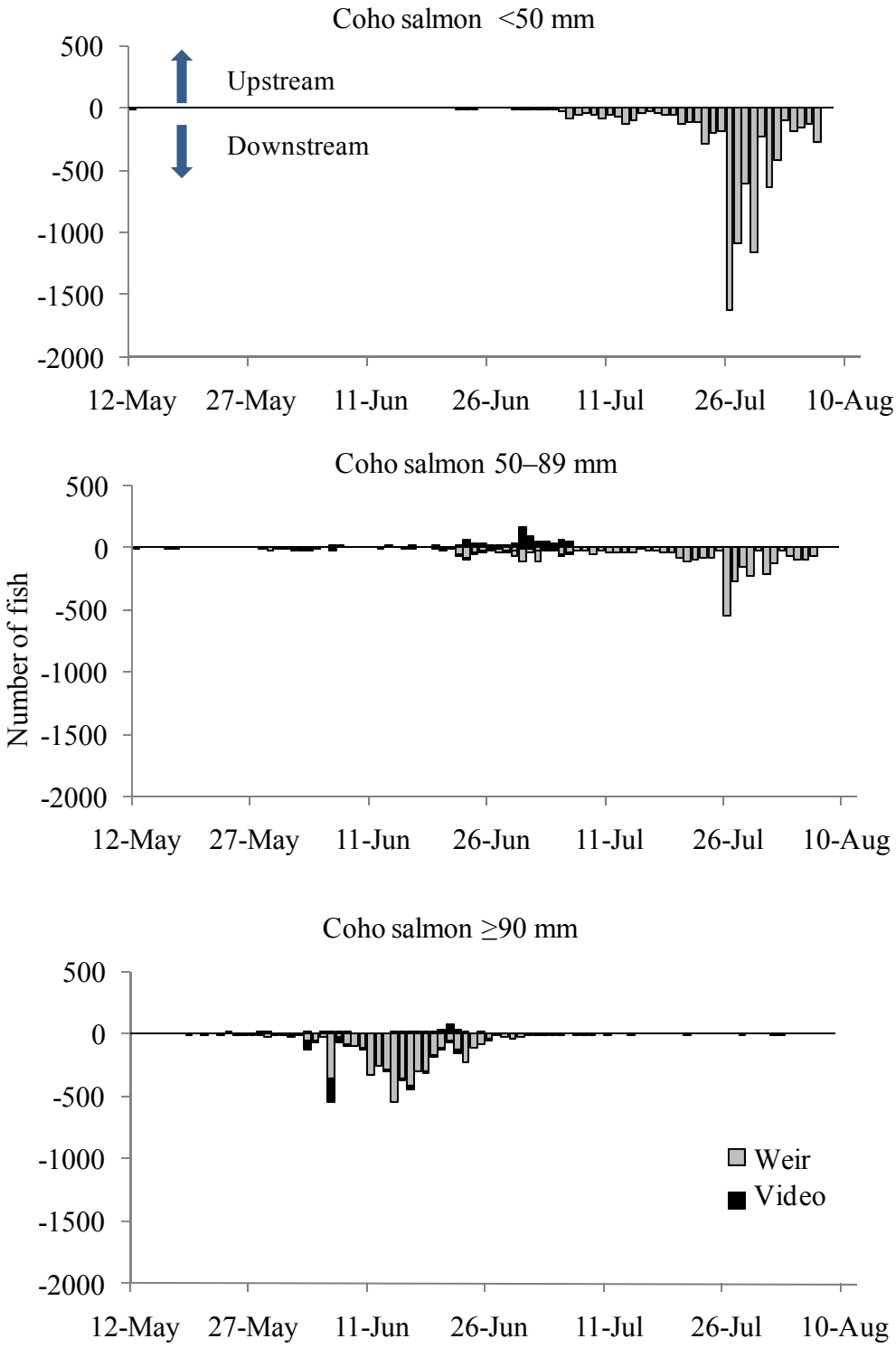

Figure 5. The daily movement of juvenile coho salmon in Stream 2003, May through August, 2009. Video counts are expanded from subsamples for coho salmon from May through July 15. Negative bars represent downstream movement of fish.

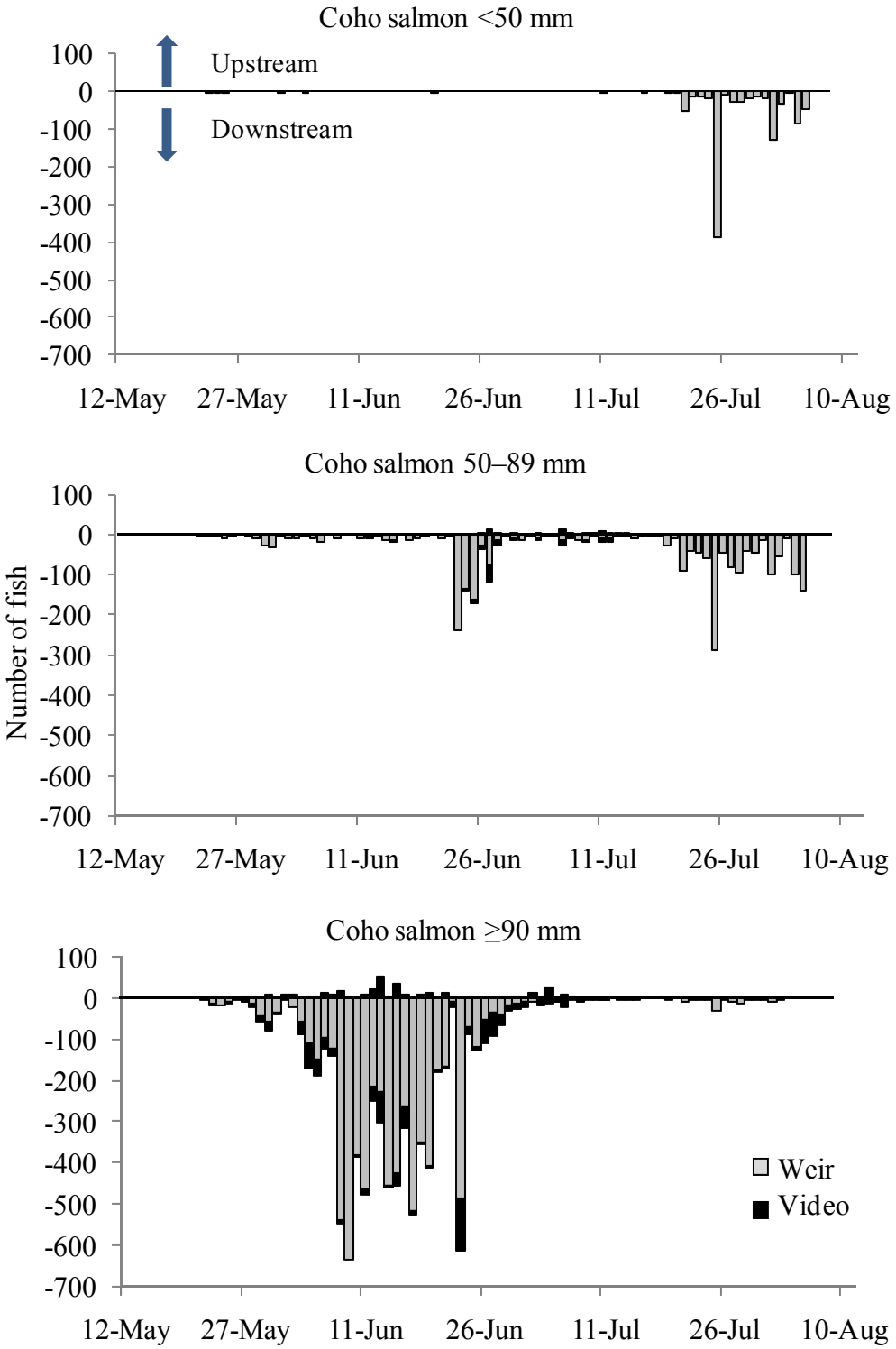

Figure 6. The daily movement of juvenile coho salmon in Stream 2004, May through August, 2009. Video counts are the total expanded number of coho salmon from May through July 15. Negative bars represent downstream movement of fish.

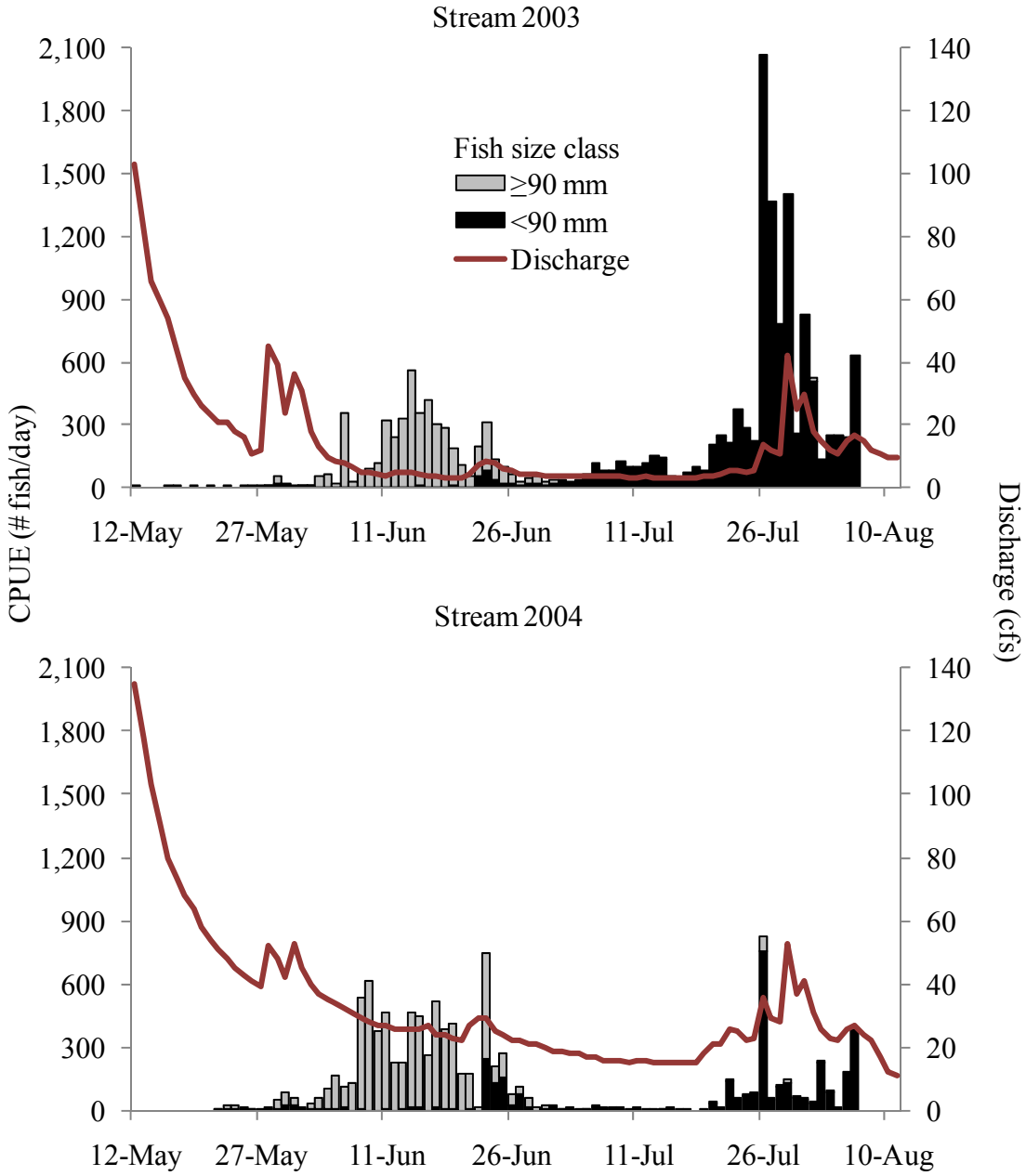

Figure 7. Catch per unit effort (CPUE) and mean daily discharge (cfs) for two size classes of juvenile coho salmon in the study tributaries, May through August, 2009. Fish ≥90 mm were considered smolts; fish <90 mm were considered pre-smolts. Discharge data from RTI (Fort Collins, CO).

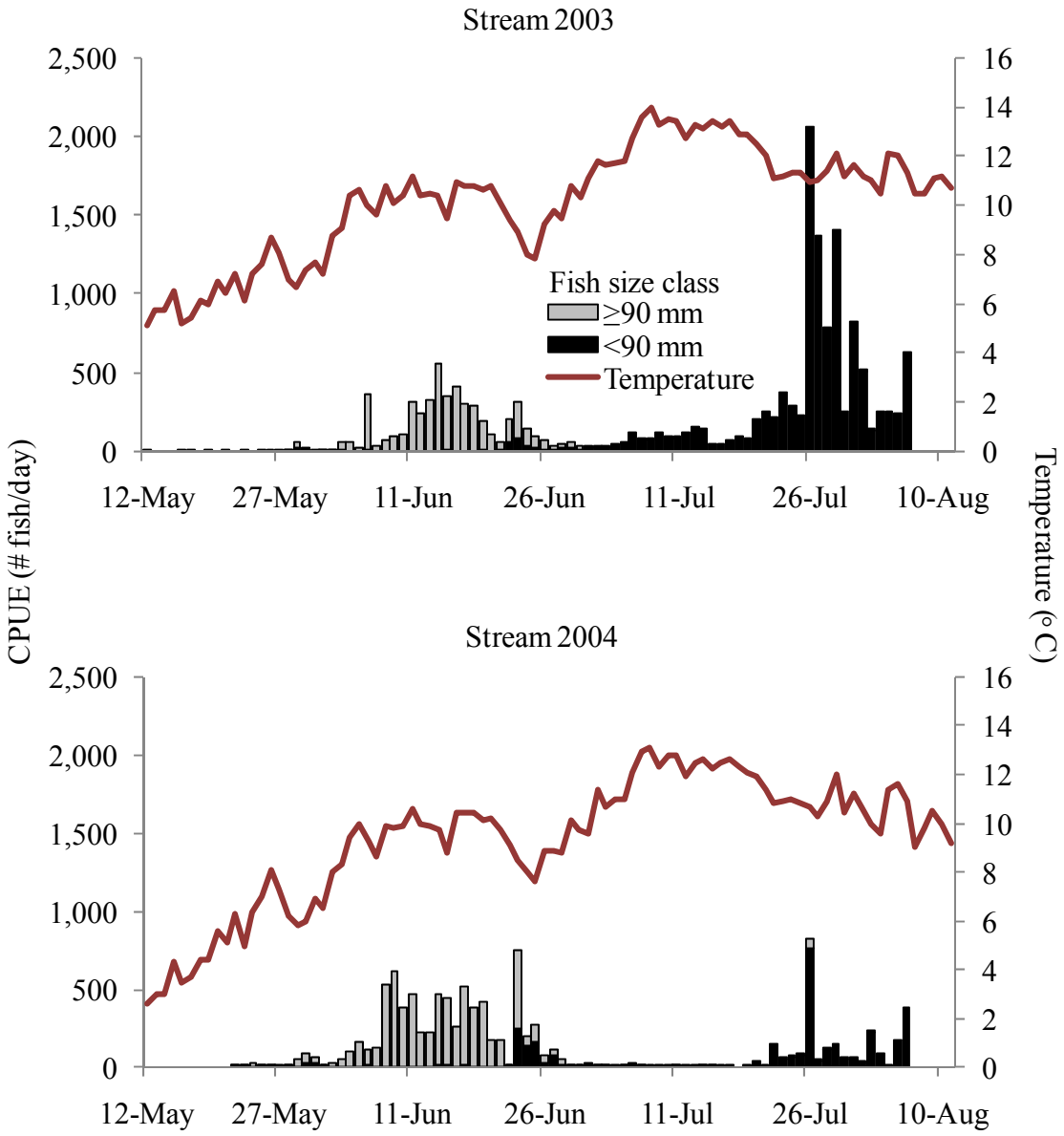

Figure 8. Catch per unit effort (CPUE) and mean daily water temperature for two size classes of juvenile coho salmon in the study tributaries, May through August, 2009. Fish ≥90 mm were considered smolts; fish <90 mm were considered pre smolts. Water temperature data were from RTI (Fort Collins, CO).

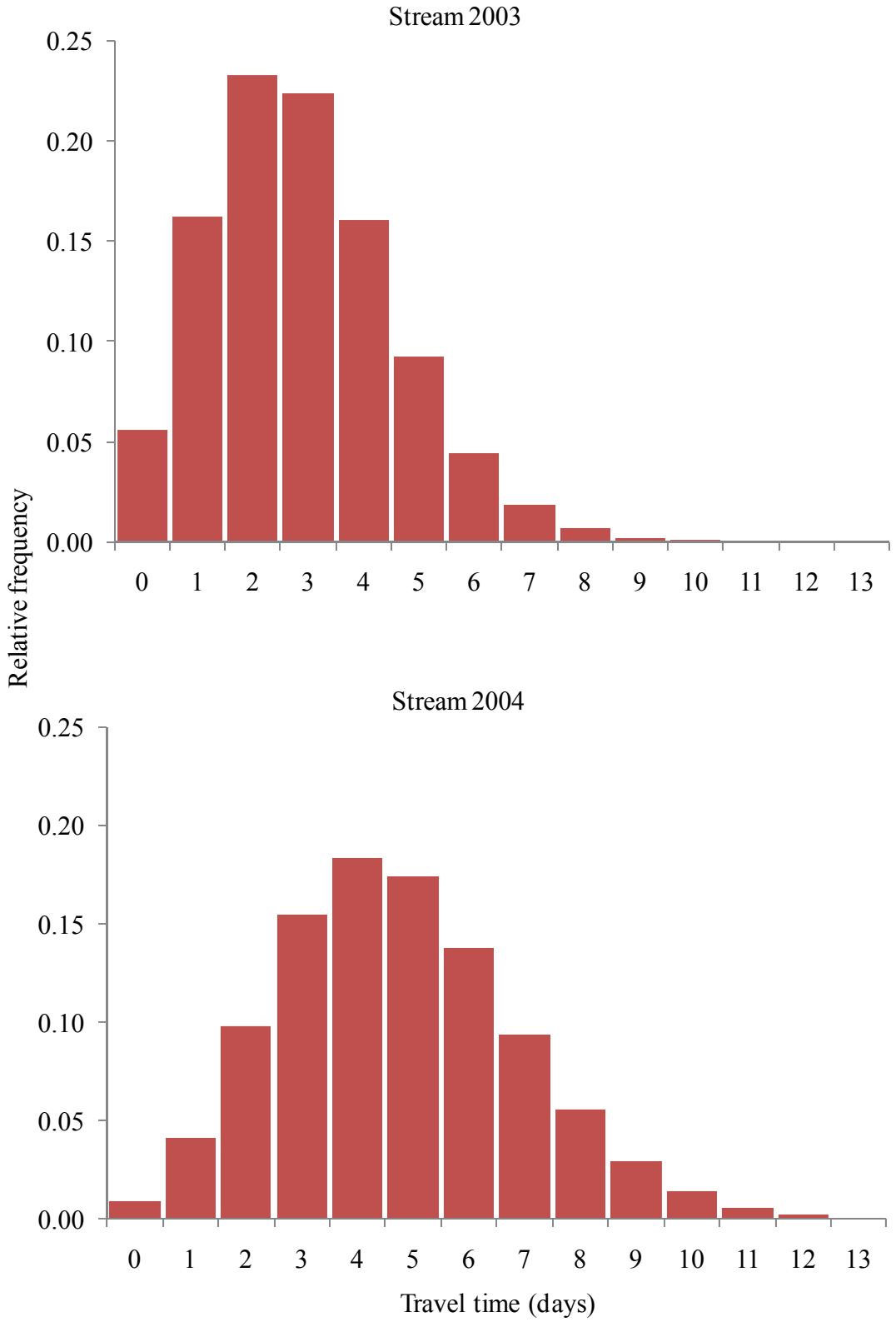

Figure 9. Estimated travel time of marked juvenile coho salmon moving from weirs in the tributary streams to the RSTs in the mainstem Chuit River. Travel time was modeled with a Poisson distribution based upon a constant rate of travel.

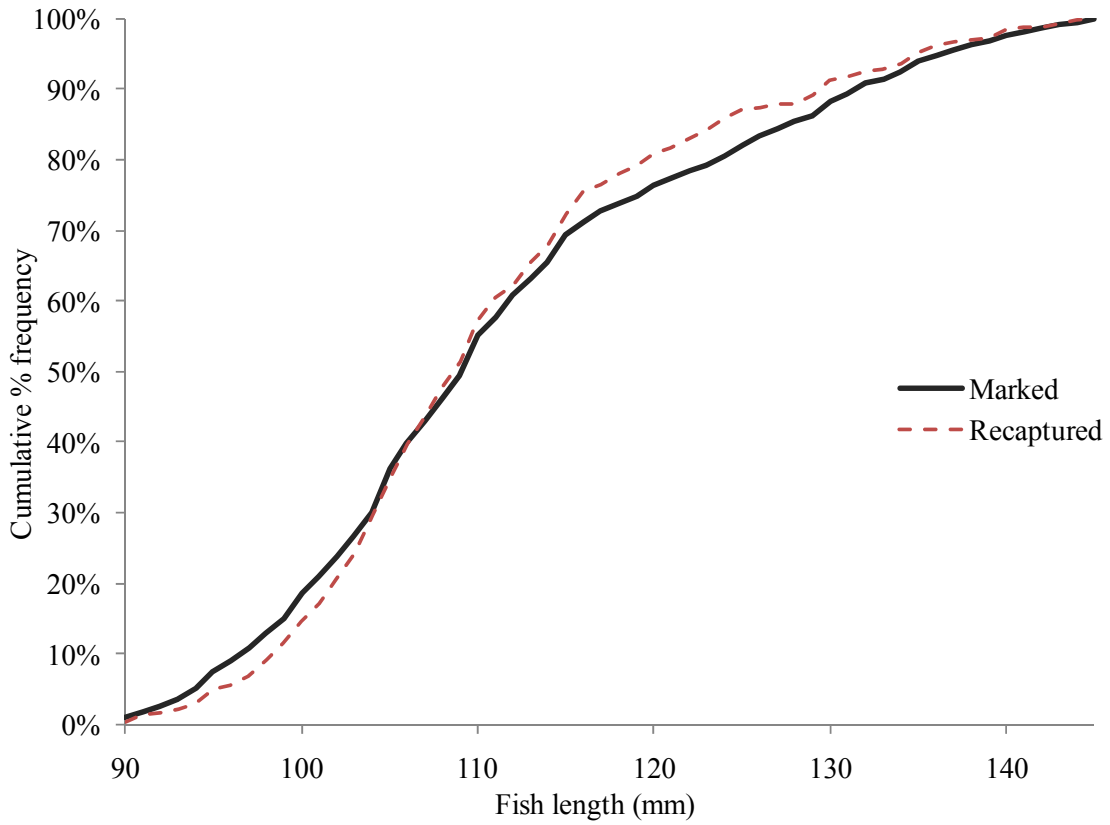

Figure 10. Cumulative % frequency distribution of lengths of juvenile coho salmon marked at the weirs and recaptured at the rotary screw traps (RSTs) in the Chuit River, 2009. A Kolmogorov-Smirnov test did not detect any significant differences in length between the release and recapture groups.

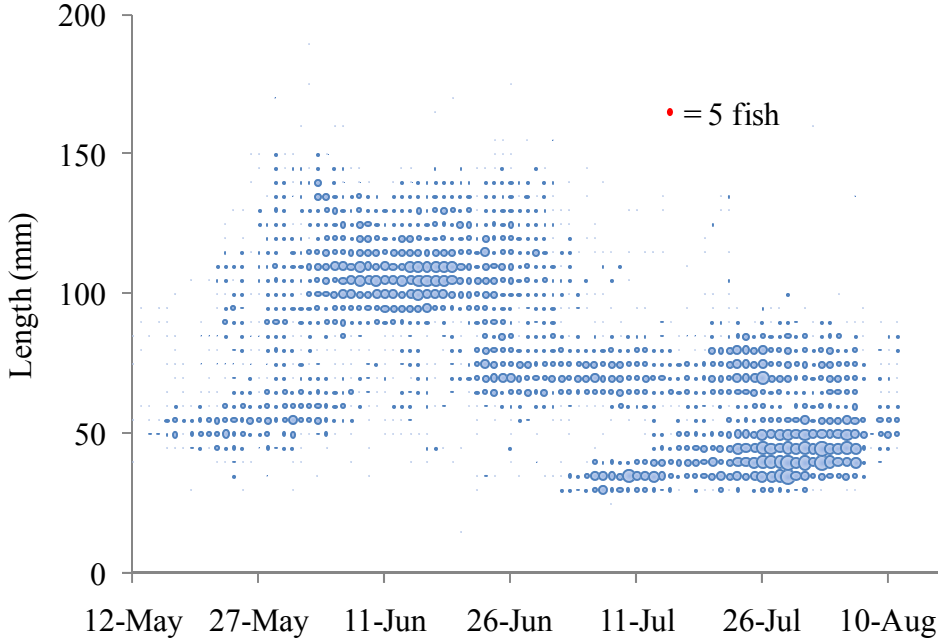

Figure 11. Lengths of juvenile coho salmon in the Chuit River watershed, by date of capture, from May through August, 2009. The size of the bubbles corresponds to the number of fish randomly measured in 5 mm length groupings (5 fish reference bubble). A maximum of 65 coho salmon were measured on July 29 and August 2 from the 40 mm size class. Data are from all gear types and sampling locations combined.

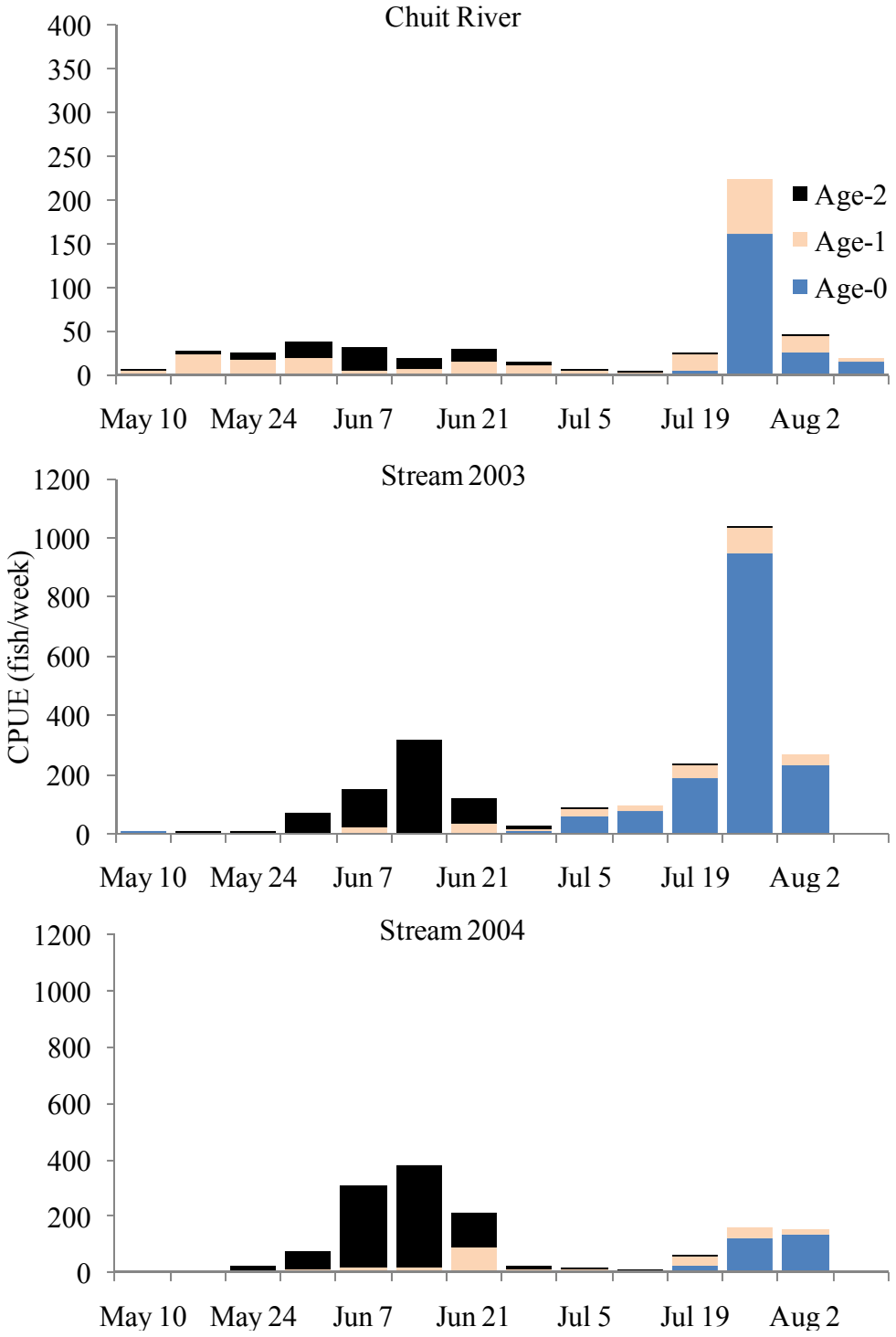

Figure 12. Juvenile coho salmon catch per unit of effort (CPUE) by location, and age from May through August, 2009. Only primary gear types are presented for a given location. Note the different y-axis, video data is not included.

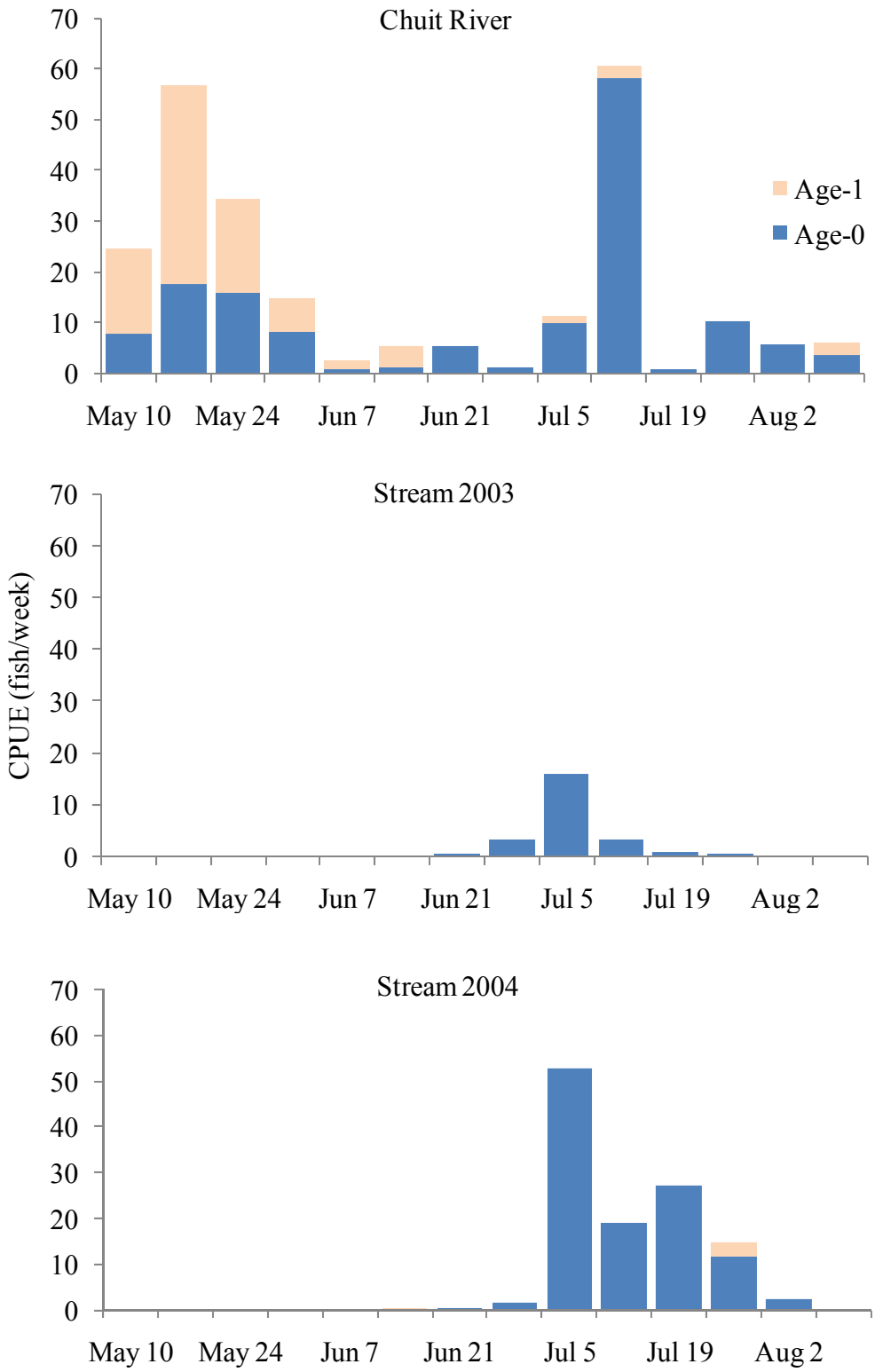

Figure 13. Juvenile Chinook salmon catch per unit of effort (CPUE) by location, and age from May through August, 2009. Only primary gear types are presented for a given location. Video data is not included.

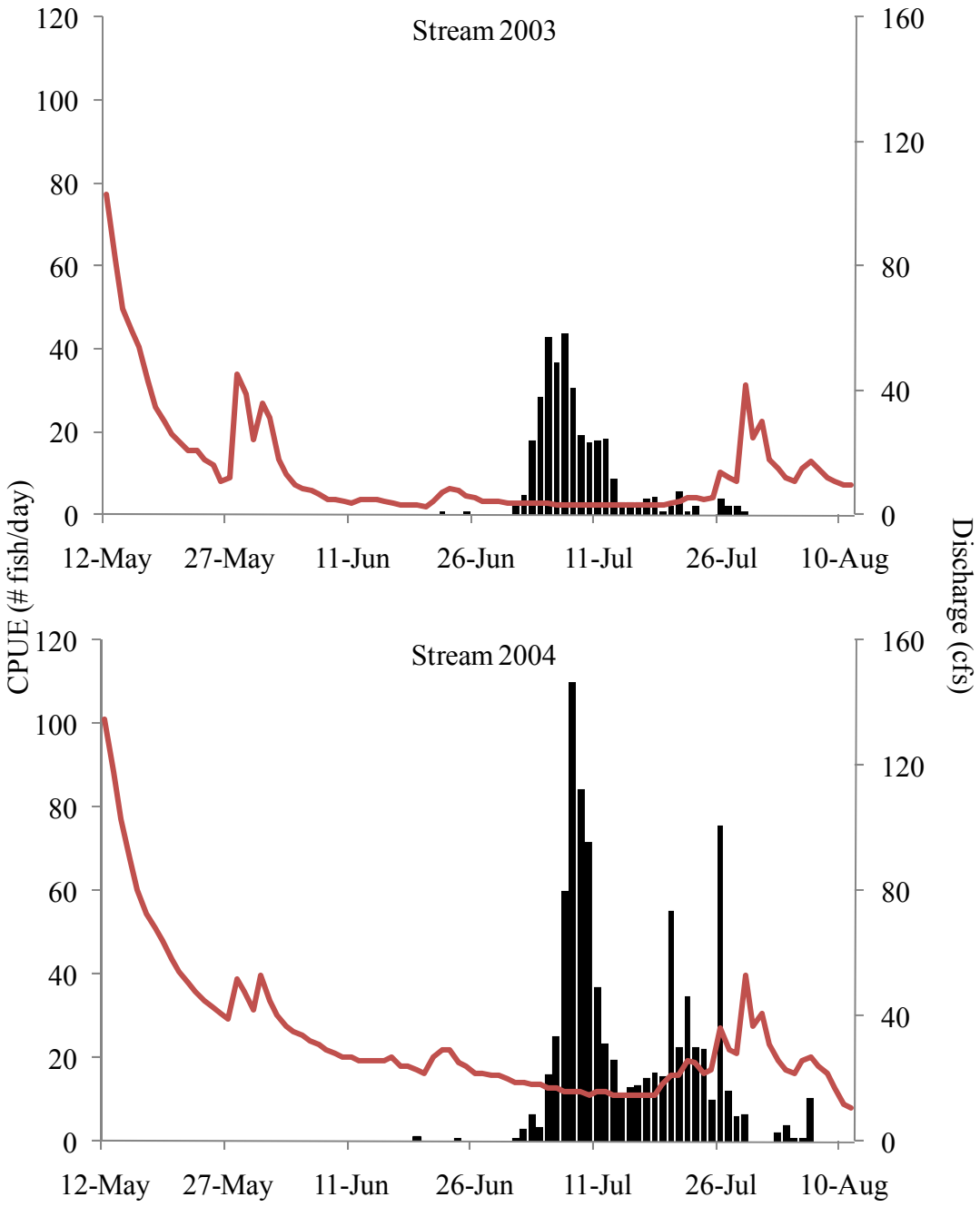

Figure 14. Catch per unit effort (CPUE) of juvenile Chinook salmon and mean daily water discharge (cfs) in the study tributaries, May through August, 2009. Discharge data are from RTI (Fort Collins, CO).

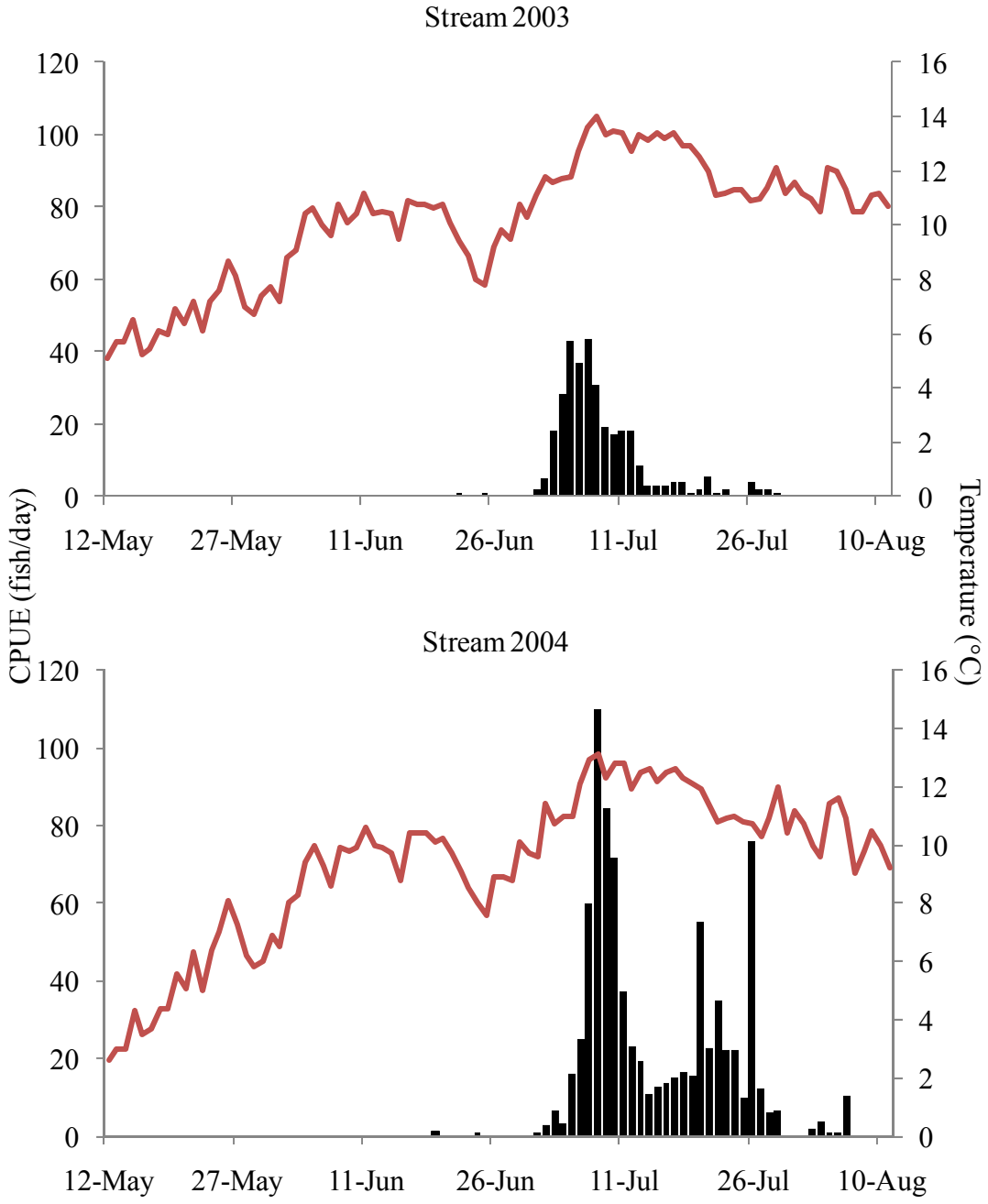

Figure 15. Catch per unit effort (CPUE) of juvenile Chinook salmon and mean daily water temperatures in the study tributaries, May through August, 2009. Water temperature data are from RTI (Fort Collins, CO).

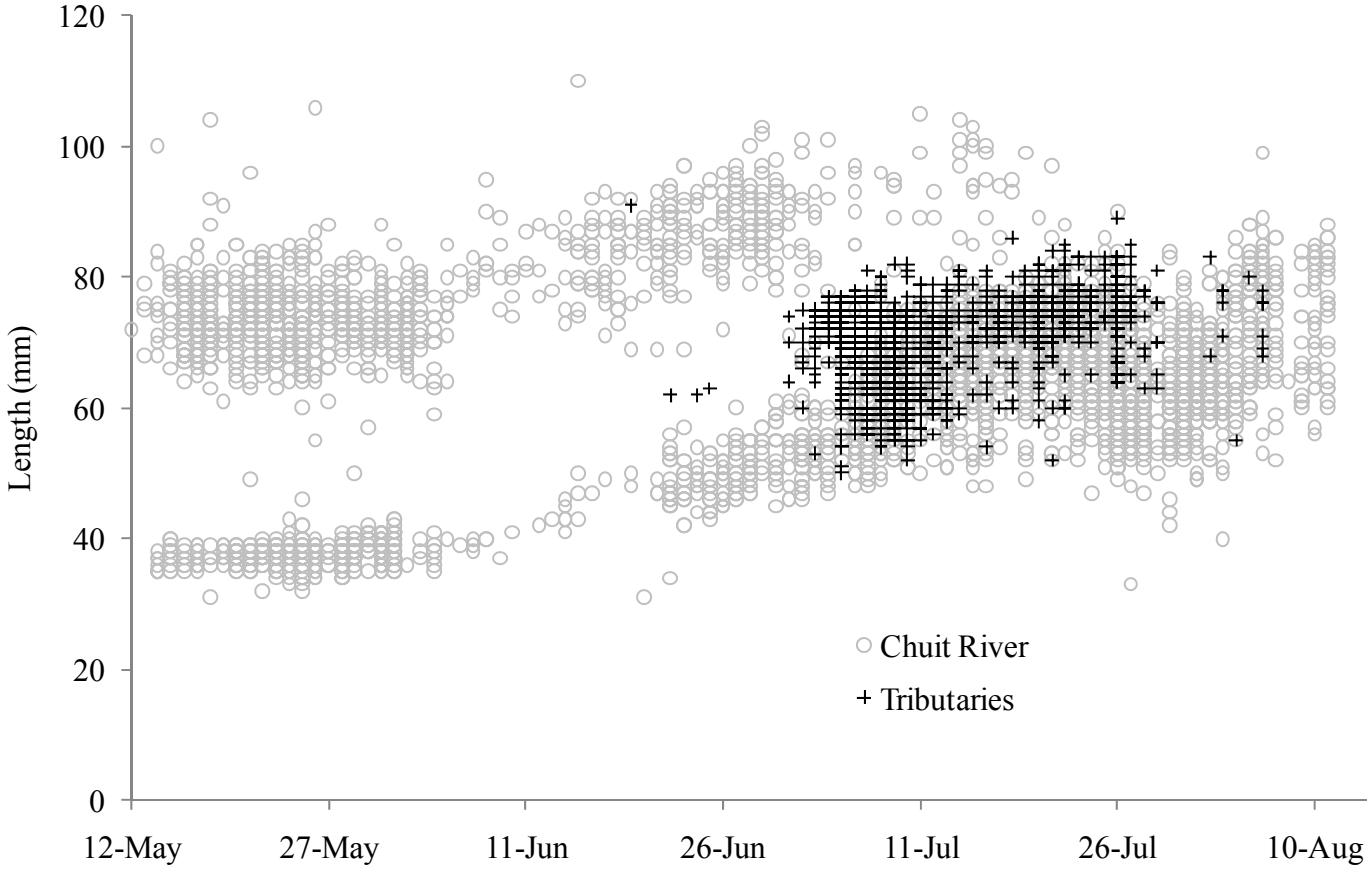

Figure 16. Juvenile Chinook salmon length by date measured from catches in the Chuit River watershed, May through August, 2009. Data are from all gear types.

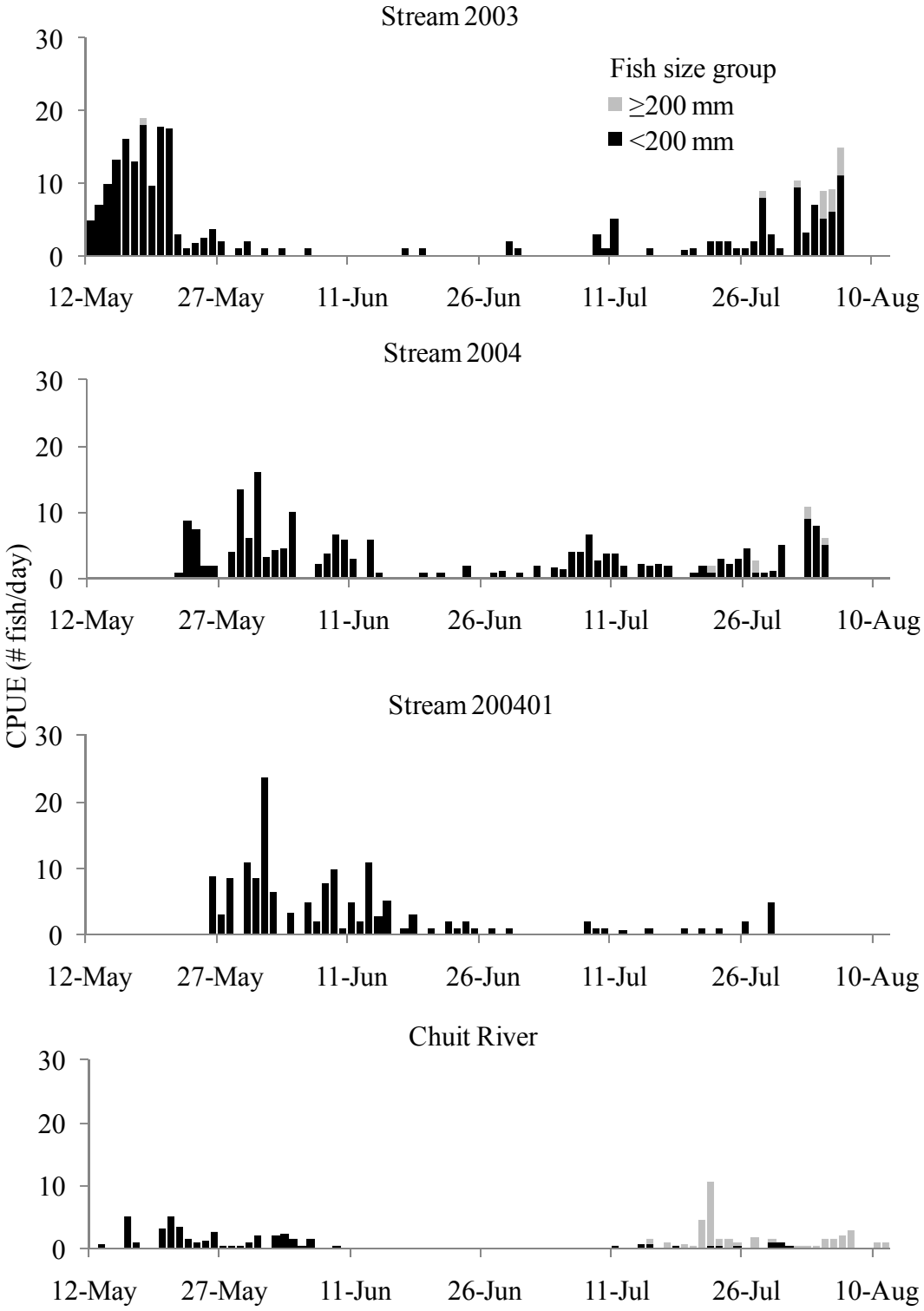

Figure 17. Dolly Varden catch per unit effort (CPUE) by location and size group, May through August, 2009. Data are only from primary gear types for a given location. Video data not included.

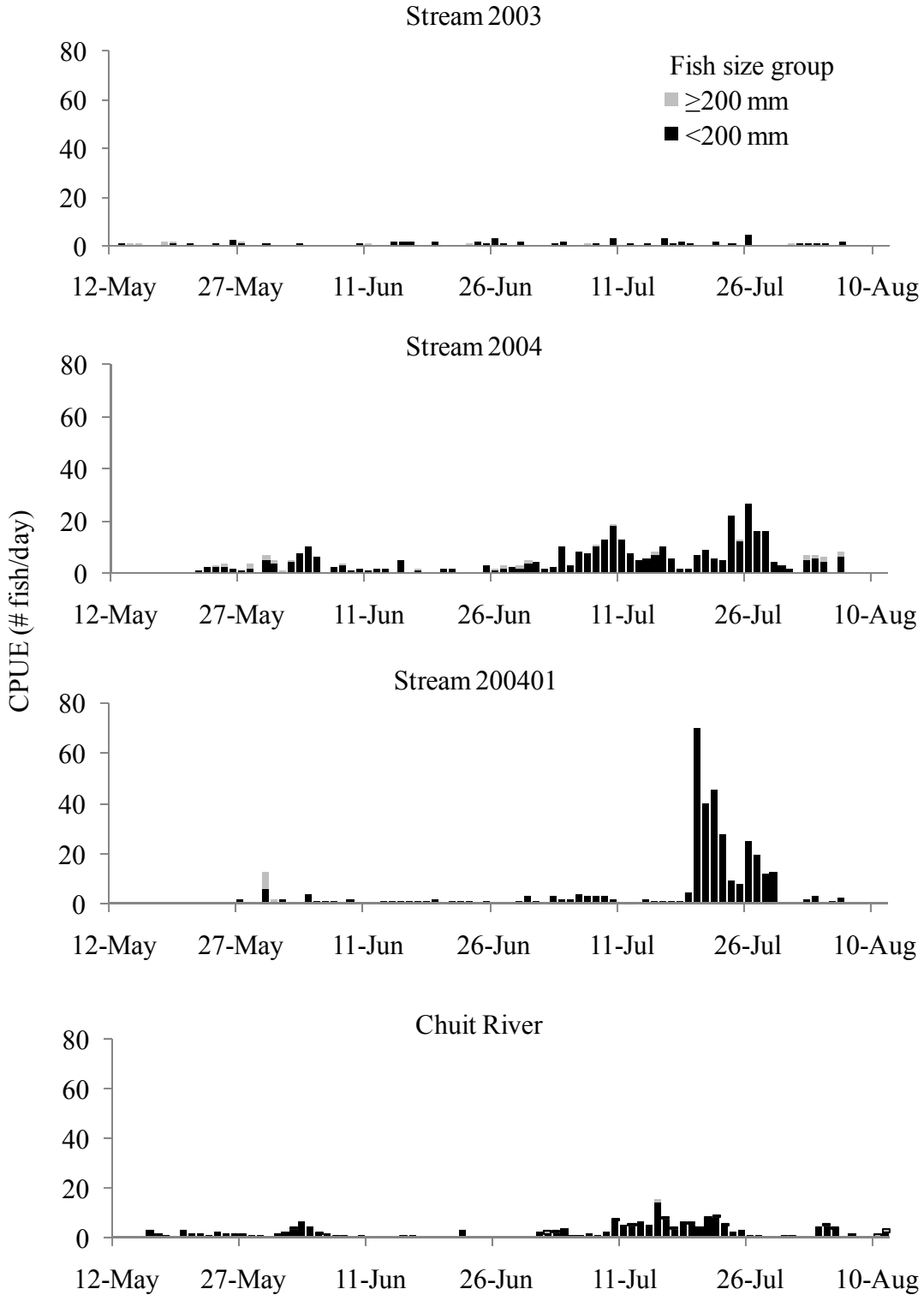

Figure 18. Rainbow trout catch per unit effort (CPUE) by location and size group, May through August, 2009. Data are only for primary gear types for a given location. Video data not included.

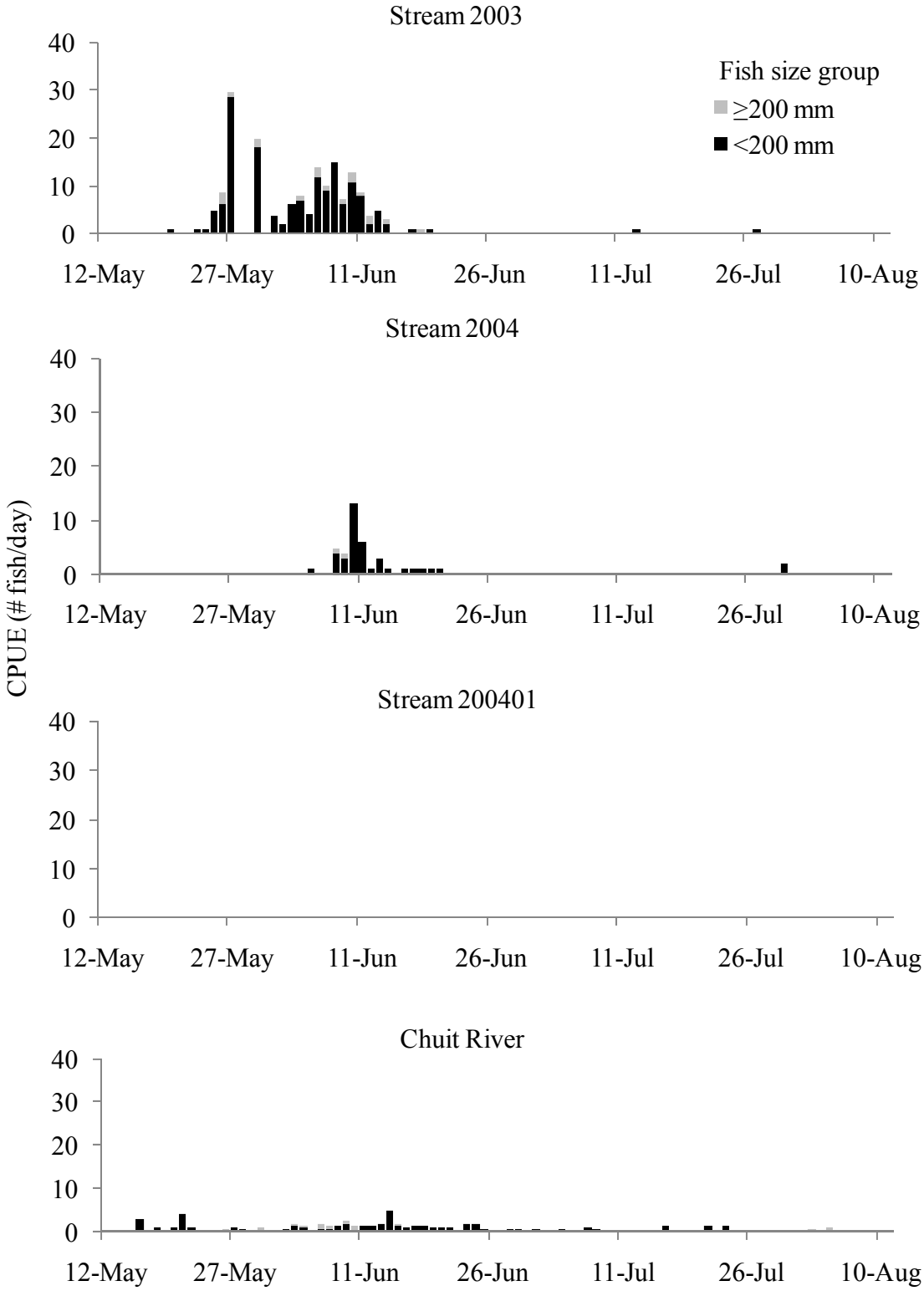

Figure 19. Arctic lamprey catch per unit effort (CPUE) by location and size group, May through August, 2009. Data are only for primary gear types for a given location. Video data not included.

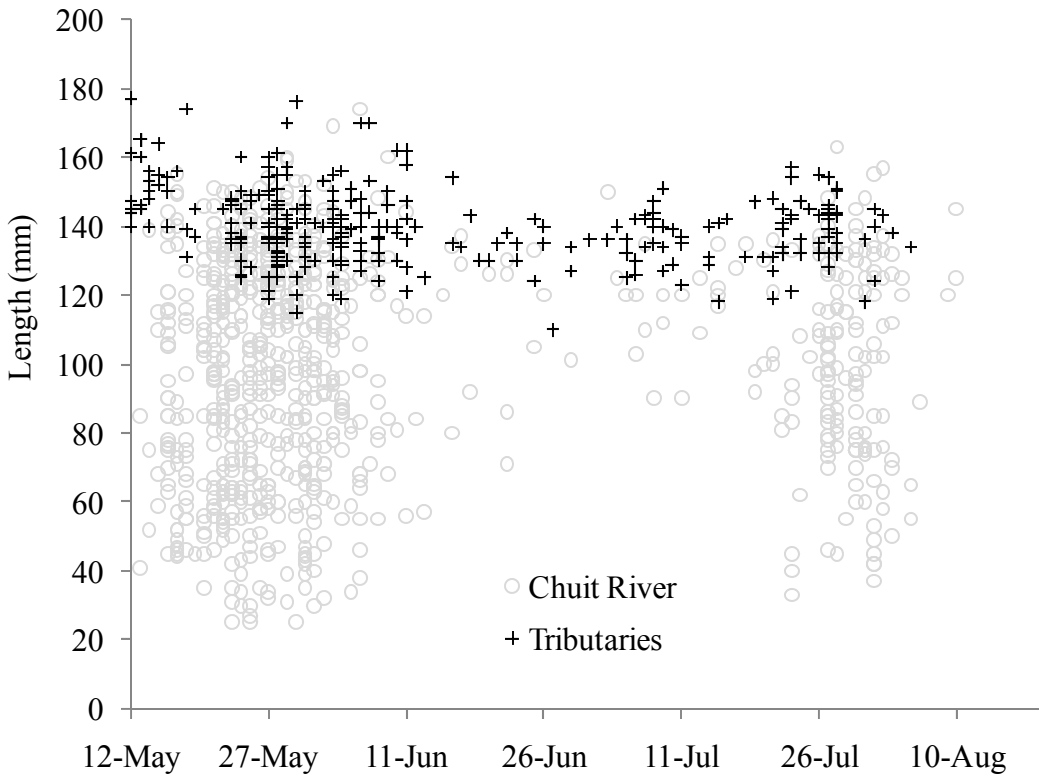

Figure 20. Ammocoetes length by date observed in the Chuit River watershed, May through August, 2009. Data are from all gear types combined.

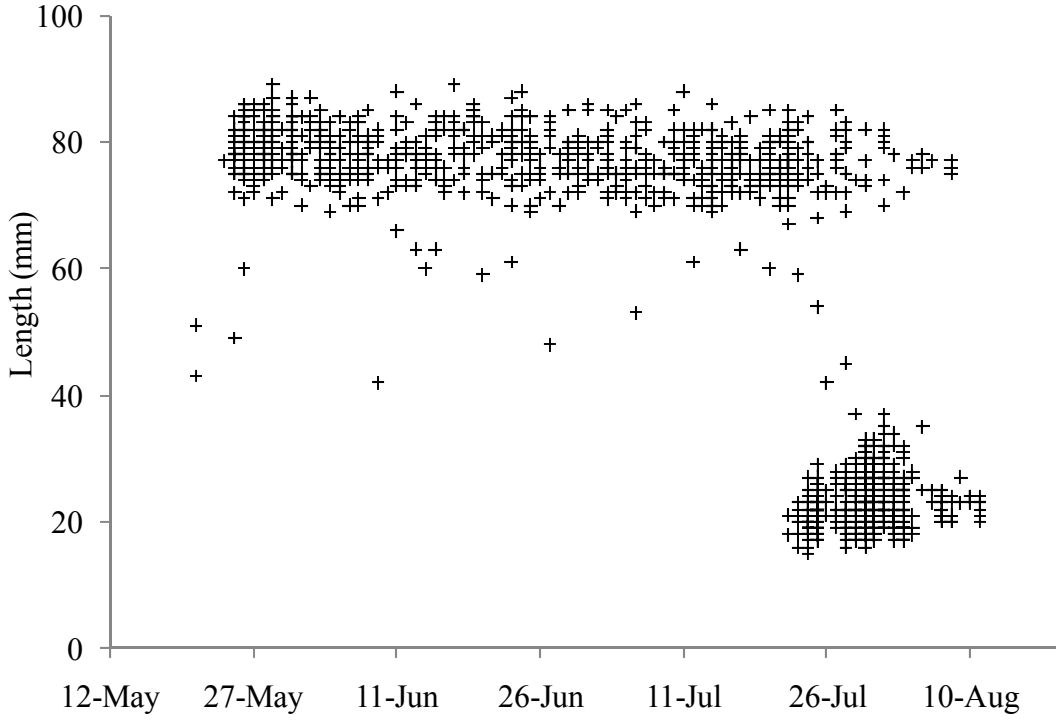

Figure 21. Threespine stickleback length by date observed in the Chuit River watershed, May through August, 2009. Data are from all gear types combined.

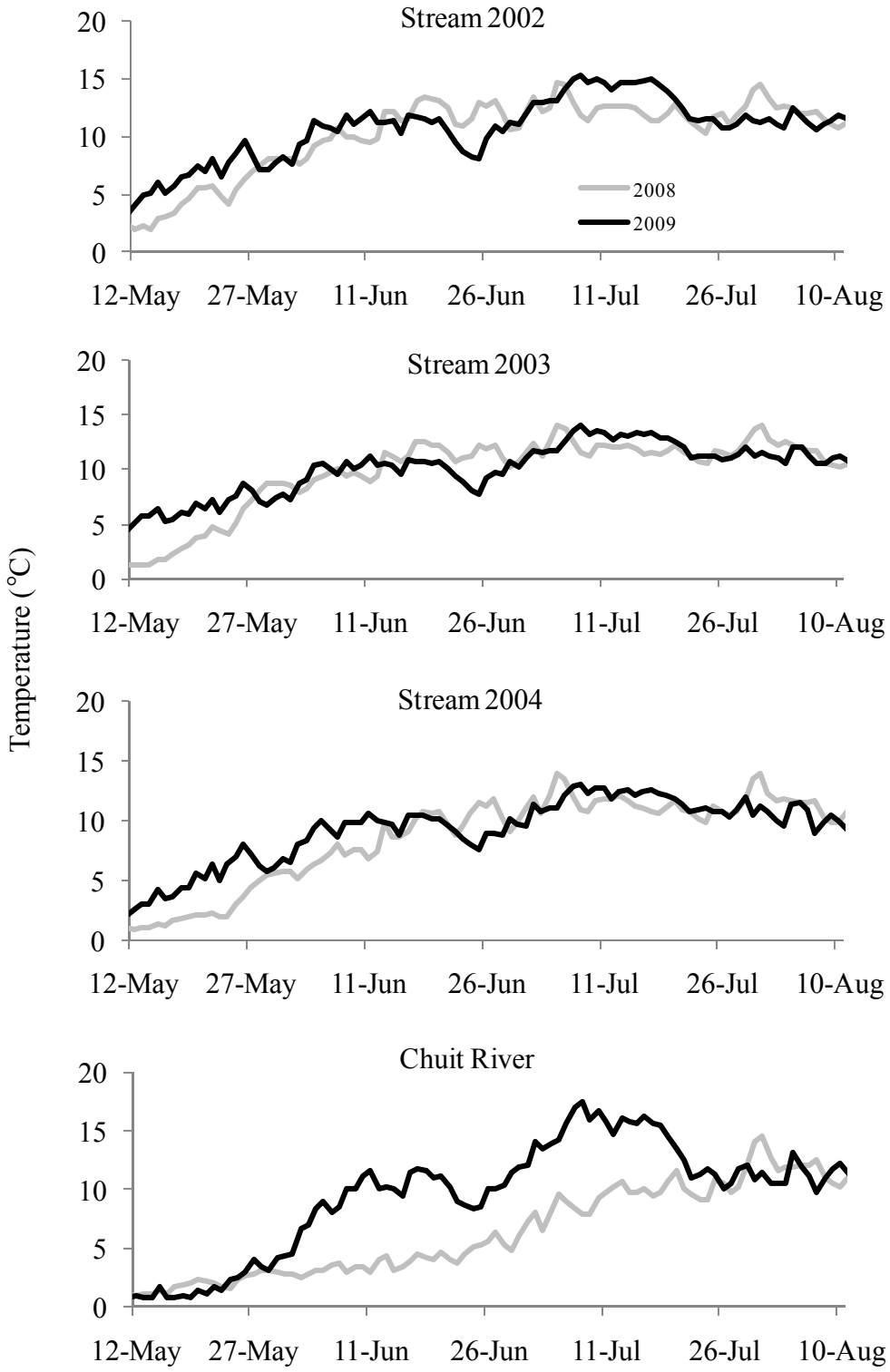

Figure 22. Mean daily water temperatures from streams 2002, 2003, and 2004 and the mainstem Chuit River from May through August, 2008 and 2009. Data provided by RTI (Fort Collins, CO).

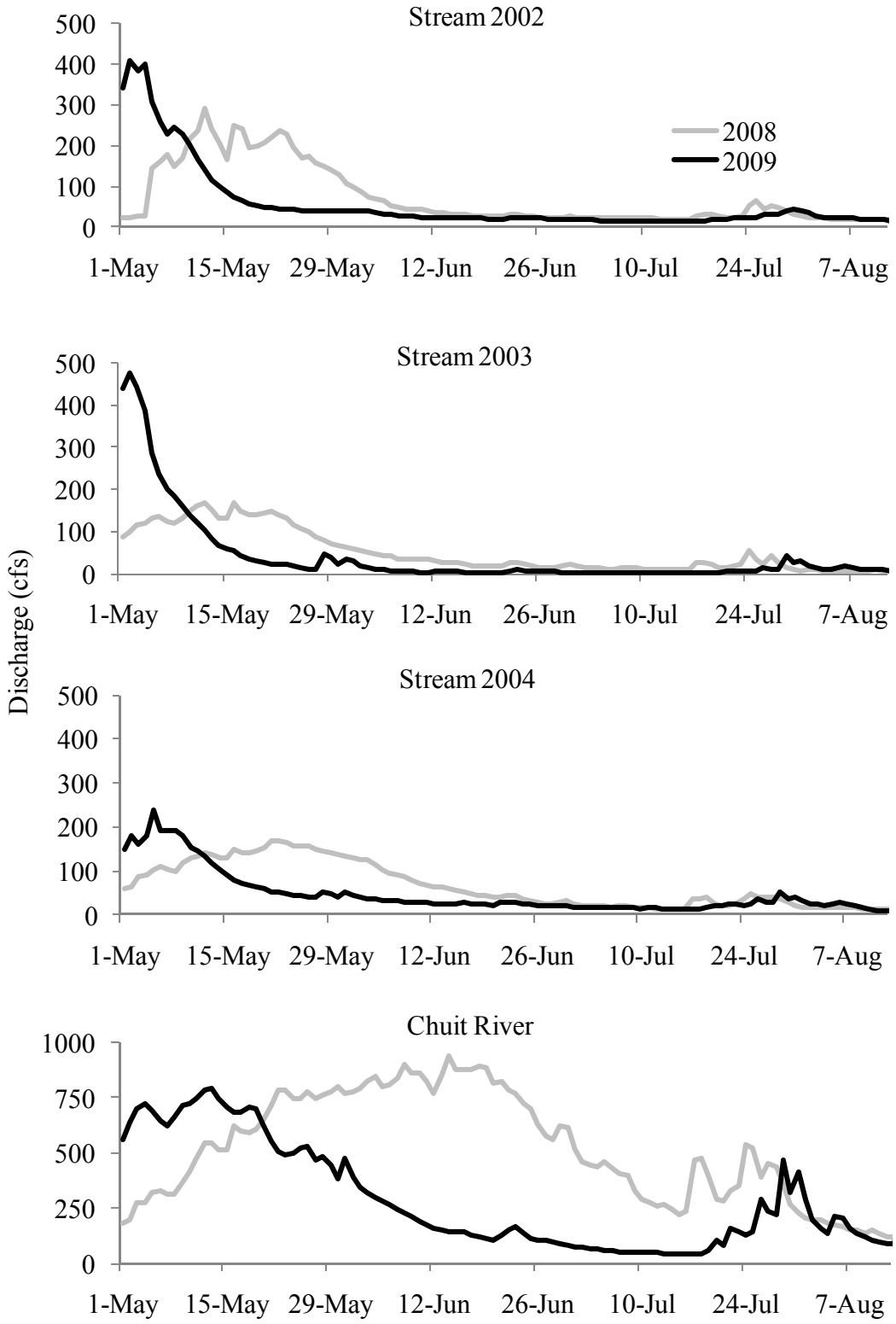

Figure 23. Mean daily water discharge from streams 2002, 2003, and 2004 and the mainstem Chuit River from May through August, 2008 and 2009. Data are in cubic feet per Second (cfs) and preliminary data are provided by RTI (Fort Collins, CO). Note the differing y-axes.

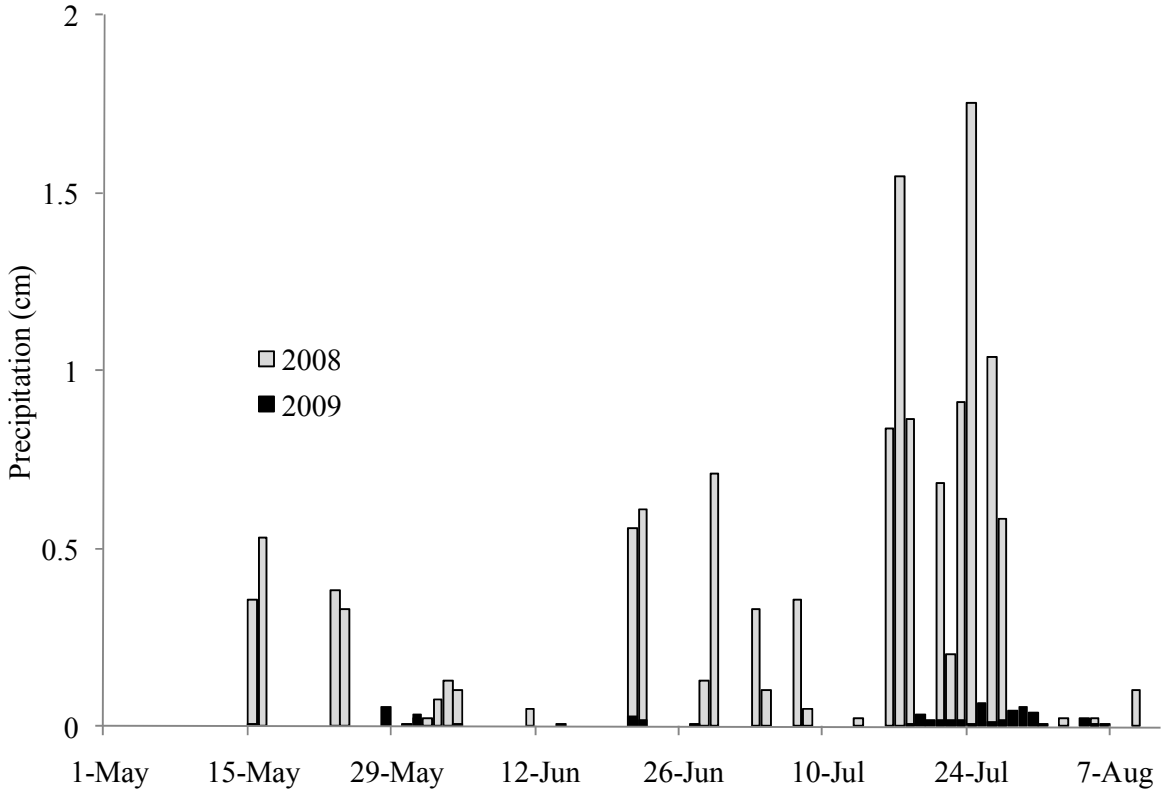

Figure 24. Daily precipitation (cm) from a gauge within the Stream 2004 watershed, May through August, 2008 and 2009. Precipitation data are from McVehil-Monnett (unpublished).

Photo 1. The weir in Stream 2003, May 12, 2009. The photo shows the "V" orientation with stream flow from the bottom of the image to the top.

Photo 2. The weir in Stream 2003 after some modifications, June 11, 2009. Photo is looking downstream.

Photo 3. The weir in Stream 2004, May 28, 2009. Water is flowing from the bottom of the image to the top.

Photo 4. The fyke net in Stream 200401 (tributary to Stream 2004), June 1, 2009. Photo is looking downstream. Fish passage upstream is through the small gap between the left side of the fyke net and the sandbags.

Photo 5. The underwater video chute and camera housing at the weir in Stream 2004, June 1, 2009. The top of the photo is downstream.

Photo 6. Fish sampling at the upstream rotary screw trap (RST1) in the Chuit River, May 23, 2009. Water is flowing from right to left.

Photo 7. The downstream rotary screw trap (RST2) in the Chuit River, July 17, 2009. Photo is looking downstream. A mesh wing was added upstream of the RST to provide additional coverage during low water levels.

Photo 8. A fyke net in the Chuit River, July 23, 2009. Mesh wings were added to both sides of the fyke net, providing coverage of half of the stream. Water is flowing from right to left.

Photo 9. Juvenile coho salmon of varying sizes captured in Stream 2004, July 22, 2009. The largest fish is representative of coho ≥90 mm in length.

Photo 10. Arctic lamprey captured in Stream 2004, June 2, 2009.

Photo 11. Pacific lamprey captured in Stream 2004, June 9, 2009.

Appendix A. The total number of identified juvenile coho salmon by size and direction of travel through the video chute in Stream 2003, from May 13 through July 15, 2009. Counts are from a combination of full hourly counts, partial counts, and 15 minute subsamples. The video chute was closed for repair and modification beginning June 11 and ending June 20.

	Coho ≥90 mm			Coho 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
13-May-09	0	0	0	0	0	0
14-May-09	0	0	0	0	0	0
15-May-09	0	0	0	0	0	0
16-May-09	0	0	0	0	0	0
17-May-09	0	0	0	0	0	0
18-May-09	0	0	0	0	0	0
19-May-09	0	0	0	0	0	0
20-May-09	0	0	0	0	0	0
21-May-09	0	0	0	0	0	0
22-May-09	0	0	0	0	0	0
23-May-09	0	0	0	0	0	0
24-May-09	0	0	1	0	0	0
25-May-09	0	0	0	0	0	0
26-May-09	1	0	2	0	0	0
27-May-09	0	0	0	0	0	0
28-May-09	0	0	0	0	0	0
29-May-09	0	0	0	0	0	0
30-May-09	0	0	0	0	0	0
31-May-09	0	0	0	0	0	0
01-Jun-09	0	0	0	0	0	0
02-Jun-09	0	0	0	0	0	0
03-Jun-09	0	0	0	2	0	2
04-Jun-09	16	1	8	3	0	1
05-Jun-09	0	0	2	0	0	0
06-Jun-09	0	1	0	0	0	0
07-Jun-09	46	1	1	1	4	2
08-Jun-09	9	1	1	0	1	0
09-Jun-09	0	3	4	0	0	0
10-Jun-09	0	0	0	0	0	0
11-Jun-09	1	0	0	0	0	0
12-Jun-09	-	-	-	-	-	-
13-Jun-09	-	-	-	-	-	-
14-Jun-09	-	-	-	-	-	-
15-Jun-09	-	-	-	-	-	-

Appendix A-Continued. Total number of identified juvenile coho salmon by size and direction moving through the video chute in Stream 2003.

	Coho ≥90 mm			Coho 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
16-Jun-09	-	-	-	-	-	-
17-Jun-09	-	-	-	-	-	-
18-Jun-09	-	-	-	-	-	-
19-Jun-09	-	-	-	-	-	-
20-Jun-09	0	0	0	0	0	0
21-Jun-09	0	0	0	0	0	0
22-Jun-09	0	0	0	0	0	0
23-Jun-09	0	1	1	0	0	0
24-Jun-09	1	2	10	0	0	2
25-Jun-09	7	2	8	0	0	0
26-Jun-09	0	2	3	0	0	0
27-Jun-09	1	3	18	0	0	0
28-Jun-09	1	1	1	0	0	0
29-Jun-09	0	0	0	0	0	0
30-Jun-09	0	7	4	0	0	0
01-Jul-09	2	2	12	1	0	0
02-Jul-09	0	0	1	0	2	2
03-Jul-09	0	0	0	0	0	0
04-Jul-09	0	0	0	0	0	0
05-Jul-09	0	0	0	0	0	0
06-Jul-09	0	0	0	0	0	0
07-Jul-09	0	0	0	1	1	7
08-Jul-09	0	0	0	0	0	0
09-Jul-09	0	0	0	0	0	0
10-Jul-09	0	0	0	0	0	0
11-Jul-09	0	0	0	0	0	0
12-Jul-09	0	0	0	0	0	0
13-Jul-09	0	0	0	0	0	0
14-Jul-09	0	0	0	0	0	0
15-Jul-09	0	0	0	0	0	0
Total	85	27	77	8	8	16

Appendix B. The total number of identified juvenile coho salmon by size and direction of travel through the video chute in Stream 2004, from May 22 through July 15, 2009. Counts are from a combination of full hourly counts, partial counts, and 15 minute subsamples. The video chute was closed for repair and modifications on July 15.

	Coho ≥90 mm			Coho 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
22-May-09	0	0	0	0	0	0
23-May-09	1	0	0	0	0	0
24-May-09	0	0	0	0	0	0
25-May-09	1	0	0	0	0	0
26-May-09	0	0	0	0	0	0
27-May-09	2	1	0	0	0	0
28-May-09	2	1	0	0	0	0
29-May-09	3	0	0	0	0	0
30-May-09	4	1	0	0	0	0
31-May-09	1	0	0	0	0	0
01-Jun-09	0	1	0	0	0	0
02-Jun-09	0	2	0	0	0	0
03-Jun-09	8	0	2	0	0	0
04-Jun-09	14	1	2	0	0	0
05-Jun-09	10	1	1	0	0	0
06-Jun-09	7	2	1	0	0	0
07-Jun-09	1	1	0	0	0	0
08-Jun-09	2	4	5	0	0	0
09-Jun-09	0	1	3	0	0	0
10-Jun-09	1	0	1	0	0	0
11-Jun-09	3	2	1	0	0	0
12-Jun-09	7	5	4	0	0	0
13-Jun-09	18	11	7	0	0	0
14-Jun-09	0	1	4	0	0	0
15-Jun-09	5	6	20	0	0	0
16-Jun-09	8	0	5	0	0	0
17-Jun-09	0	0	0	0	0	0
18-Jun-09	1	1	0	0	0	0
19-Jun-09	1	2	0	0	0	0
20-Jun-09	0	0	1	0	0	0
21-Jun-09	1	2	0	0	0	0
22-Jun-09	3	0	1	0	0	0
23-Jun-09	14	0	7	0	0	0
24-Jun-09	0	0	0	0	0	0

Appendix B-Continued. Total number of identified juvenile coho salmon by size and direction moving through the video chute in Stream 2004.

	Coho ≥90 mm			Coho 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
25-Jun-09	1	0	1	0	0	4
26-Jun-09	6	0	0	1	0	1
27-Jun-09	4	0	0	2	1	0
28-Jun-09	2	0	0	0	0	0
29-Jun-09	0	0	0	1	0	0
30-Jun-09	0	0	1	0	0	0
01-Jul-09	0	0	0	0	0	0
02-Jul-09	0	1	0	0	0	0
03-Jul-09	0	0	0	0	0	0
04-Jul-09	0	0	0	0	0	0
05-Jul-09	0	0	0	0	0	0
06-Jul-09	0	0	0	0	0	0
07-Jul-09	0	0	0	0	0	0
08-Jul-09	0	0	0	0	0	0
09-Jul-09	0	0	0	0	0	0
10-Jul-09	0	0	0	0	0	0
11-Jul-09	0	0	0	1	1	0
12-Jul-09	0	0	0	0	0	0
13-Jul-09	0	0	0	0	0	0
14-Jul-09	0	0	0	0	0	1
15-Jul-09	-	-	-	-	-	-
Total	131	47	67	5	2	6

Appendix C. The total number of identified juvenile Chinook salmon by size and direction of travel through the video chute in Stream 2003, from May 13 through July 15, 2009. Counts are from a combination of full hourly counts, partial counts, and 15 minute subsamples. The video chute was closed for repair and modification beginning June 11 and ending June 20.

	Chinook ≥90 mm			Chinook 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
13-May-09	0	0	0	0	0	0
14-May-09	0	0	0	0	0	0
15-May-09	0	0	0	0	0	0
16-May-09	0	0	0	0	0	0
17-May-09	0	0	0	0	0	0
18-May-09	0	0	0	0	0	0
19-May-09	0	0	0	0	0	0
20-May-09	0	0	0	0	0	0
21-May-09	0	0	0	0	0	0
22-May-09	0	0	0	0	0	0
23-May-09	0	0	0	0	0	0
24-May-09	0	0	0	0	0	0
25-May-09	0	0	0	0	0	0
26-May-09	0	0	0	0	0	0
27-May-09	0	0	0	0	0	0
28-May-09	0	0	0	0	0	0
29-May-09	0	0	0	0	0	0
30-May-09	0	0	0	0	0	0
31-May-09	0	0	0	0	0	0
01-Jun-09	0	0	0	0	0	0
02-Jun-09	0	0	0	0	0	0
03-Jun-09	0	0	0	0	0	0
04-Jun-09	0	0	0	0	0	0
05-Jun-09	0	0	0	0	0	0
06-Jun-09	0	0	0	0	0	0
07-Jun-09	0	0	0	0	0	0
08-Jun-09	0	0	0	0	0	0
09-Jun-09	0	0	0	0	0	0
10-Jun-09	0	0	0	0	0	0
11-Jun-09	0	0	0	0	0	0
12-Jun-09	-	-	-	-	-	-
13-Jun-09	-	-	-	-	-	-
14-Jun-09	-	-	-	-	-	-
15-Jun-09	-	-	-	-	-	-

Appendix C-Continued. Total number of identified juvenile Chinook salmon by size and direction moving through the video chute in Stream 2003.

	Chinook ≥90 mm			Chinook 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
16-Jun-09	-	-	-	-	-	-
17-Jun-09	-	-	-	-	-	-
18-Jun-09	-	-	-	-	-	-
19-Jun-09	-	-	-	-	-	-
20-Jun-09	0	0	0	0	0	0
21-Jun-09	0	0	0	0	0	0
22-Jun-09	0	0	0	0	0	0
23-Jun-09	0	0	0	0	0	0
24-Jun-09	0	0	0	0	0	0
25-Jun-09	0	0	0	0	0	0
26-Jun-09	0	0	0	0	0	0
27-Jun-09	0	0	0	0	0	0
28-Jun-09	0	0	0	0	0	0
29-Jun-09	0	1	0	0	0	0
30-Jun-09	0	0	0	0	0	0
01-Jul-09	0	0	0	0	0	0
02-Jul-09	0	0	0	0	0	0
03-Jul-09	0	0	0	0	0	0
04-Jul-09	0	0	0	0	0	0
05-Jul-09	0	0	0	0	0	0
06-Jul-09	0	0	0	0	0	0
07-Jul-09	0	0	0	0	0	0
08-Jul-09	0	0	0	0	0	0
09-Jul-09	0	0	0	0	0	0
10-Jul-09	0	0	0	0	0	0
11-Jul-09	0	0	0	0	0	0
12-Jul-09	0	0	0	0	0	0
13-Jul-09	0	0	0	0	0	0
14-Jul-09	0	0	0	0	0	0
15-Jul-09	0	0	0	0	0	0
Total	0	1	0	0	0	0

Appendix D. The total number of identified juvenile Chinook salmon by size and direction of travel through the video chute in Stream 2004, from May 22 through July 15, 2009. Counts are from a combination of full hourly counts, partial counts, and 15 minute subsamples. The video chute was closed for repair and modifications on July 15.

	Chinook ≥90 mm			Chinook 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
22-May-09	0	0	0	0	0	0
23-May-09	0	0	0	0	0	0
24-May-09	0	0	0	0	0	0
25-May-09	0	0	0	0	0	0
26-May-09	0	0	0	0	0	0
27-May-09	0	0	0	0	0	0
28-May-09	0	0	0	0	0	0
29-May-09	0	0	0	0	0	0
30-May-09	0	0	0	0	0	0
31-May-09	0	0	0	0	0	0
01-Jun-09	0	0	0	0	0	0
02-Jun-09	0	0	0	0	0	0
03-Jun-09	0	0	0	0	0	0
04-Jun-09	0	0	0	0	0	0
05-Jun-09	0	0	0	0	0	0
06-Jun-09	0	0	0	0	0	0
07-Jun-09	0	0	0	0	0	0
08-Jun-09	0	0	0	0	0	0
09-Jun-09	0	0	0	0	0	0
10-Jun-09	0	0	0	0	0	0
11-Jun-09	0	0	0	0	0	0
12-Jun-09	0	0	0	0	0	0
13-Jun-09	0	0	0	0	0	0
14-Jun-09	0	0	0	0	0	0
15-Jun-09	0	0	0	0	0	0
16-Jun-09	0	0	0	0	0	0
17-Jun-09	0	0	0	0	0	0
18-Jun-09	0	0	0	0	0	0
19-Jun-09	0	0	0	0	0	0
20-Jun-09	0	0	0	0	0	0
21-Jun-09	0	0	0	0	0	0
22-Jun-09	0	0	0	0	0	0
23-Jun-09	0	0	0	0	0	0
24-Jun-09	0	0	0	2	0	1

Appendix D-Continued. Total number of identified juvenile Chinook salmon by size and direction moving through the video chute in Stream 2004.

	Chinook ≥90 mm			Chinook 50-89 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate
25-Jun-09	0	0	0	0	0	0
26-Jun-09	0	0	0	0	0	0
27-Jun-09	0	0	0	0	0	1
28-Jun-09	0	0	0	0	0	0
29-Jun-09	0	0	0	0	0	0
30-Jun-09	0	0	0	0	0	0
01-Jul-09	0	0	0	0	0	0
02-Jul-09	0	0	0	0	0	0
03-Jul-09	0	0	0	0	0	0
04-Jul-09	0	0	0	0	0	0
05-Jul-09	0	0	0	0	0	0
06-Jul-09	0	0	0	0	0	0
07-Jul-09	0	0	0	0	0	0
08-Jul-09	0	0	0	0	0	0
09-Jul-09	0	0	0	0	0	0
10-Jul-09	0	0	0	0	0	0
11-Jul-09	0	0	0	0	0	0
12-Jul-09	0	0	0	0	0	0
13-Jul-09	0	0	0	0	0	0
14-Jul-09	0	0	0	0	0	0
15-Jul-09	-	-	-	-	-	-
Total	0	0	0	2	0	2

Appendix E. The total number of unidentified juvenile salmonids by size and direction of travel through the video chute in Stream 2003, from May 13 through July 15, 2009. Species identification was later assigned based on size classes and the proportion of coho salmon, Chinook salmon, rainbow trout, and Dolly Varden caught in the livebox each day. Counts are from a combination of full hourly counts, partial counts, and 15 minute subsamples. The video chute was closed for repair and modification beginning June 11 and ending June 20.

	Salmonids ≥90 mm			Salmonids 50-89 mm			Salmonids <50 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate	Down	Up	Indeterminate
13-May-09	0	0	0	0	0	0	0	0	0
14-May-09	0	0	0	0	0	0	0	0	0
15-May-09	0	0	0	0	0	0	0	0	0
16-May-09	0	0	0	0	0	0	0	0	0
17-May-09	0	0	0	0	0	0	0	0	0
18-May-09	0	0	0	0	0	0	0	0	0
19-May-09	0	0	0	0	0	0	0	0	0
20-May-09	0	0	0	0	0	0	0	0	0
21-May-09	0	0	0	0	0	0	0	0	0
22-May-09	0	0	0	1	0	0	0	0	0
23-May-09	0	0	0	0	0	0	0	0	0
24-May-09	0	0	1	0	0	0	0	0	0
25-May-09	0	1	0	0	1	0	0	0	0
26-May-09	2	0	0	0	0	0	0	0	0
27-May-09	0	0	0	0	0	0	0	0	0
28-May-09	0	0	0	0	0	0	0	0	0
29-May-09	0	1	1	0	0	0	0	0	0
30-May-09	0	1	0	0	0	1	0	0	1
31-May-09	0	0	0	0	0	0	0	0	0
01-Jun-09	2	0	0	0	0	0	0	0	0
02-Jun-09	4	0	2	1	0	3	0	0	0
03-Jun-09	0	0	0	0	0	2	0	0	0
04-Jun-09	1	0	0	1	0	1	0	0	0
05-Jun-09	2	0	0	2	0	0	0	0	0
06-Jun-09	0	0	0	0	0	0	0	0	0
07-Jun-09	0	0	0	0	0	0	0	0	0
08-Jun-09	0	0	0	0	0	0	0	0	0
09-Jun-09	1	0	0	0	0	0	0	0	0
10-Jun-09	0	0	0	0	0	0	0	0	0
11-Jun-09	0	0	0	0	0	0	0	0	0
12-Jun-09	-	-	-	-	-	-	-	-	-
13-Jun-09	-	-	-	-	-	-	-	-	-

Appendix E-Continued. Total number of unidentified juvenile salmonids by size and direction moving through the video chute in Stream 2003.

	Salmonids ≥90 mm			Salmonids 50-89 mm			Salmonids <50 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate	Down	Up	Indeterminate
14-Jun-09	-	-	-	-	-	-	-	-	-
15-Jun-09	-	-	-	-	-	-	-	-	-
16-Jun-09	-	-	-	-	-	-	-	-	-
17-Jun-09	-	-	-	-	-	-	-	-	-
18-Jun-09	-	-	-	-	-	-	-	-	-
19-Jun-09	-	-	-	-	-	-	-	-	-
20-Jun-09	0	0	0	0	0	0	0	0	0
21-Jun-09	0	0	0	0	0	0	0	0	0
22-Jun-09	1	0	1	0	1	0	0	0	0
23-Jun-09	0	0	0	0	0	0	0	0	0
24-Jun-09	0	1	0	0	0	1	0	0	0
25-Jun-09	0	0	0	0	1	1	0	0	0
26-Jun-09	0	0	0	0	0	0	0	0	0
27-Jun-09	0	0	0	0	0	0	0	0	0
28-Jun-09	0	0	0	0	1	0	0	0	0
29-Jun-09	5	7	9	1	0	1	0	0	0
30-Jun-09	4	11	6	0	0	0	0	0	0
01-Jul-09	4	7	6	2	6	7	0	0	0
02-Jul-09	0	1	1	4	18	16	0	0	0
03-Jul-09	0	0	0	3	21	10	0	0	0
04-Jul-09	0	6	2	3	19	13	0	1	2
05-Jul-09	1	0	0	5	11	32	0	0	0
06-Jul-09	1	0	0	10	4	45	1	0	0
07-Jul-09	0	0	1	17	12	98	0	0	1
08-Jul-09	0	0	0	26	20	114	0	0	0
09-Jul-09	0	0	0	34	59	129	0	1	2
10-Jul-09	1	0	0	10	46	94	0	0	0
11-Jul-09	0	0	0	35	18	80	0	0	0
12-Jul-09	0	0	0	1	18	2	0	1	0
13-Jul-09	0	0	0	4	11	2	0	0	0
14-Jul-09	0	0	0	6	17	0	13	2	0
15-Jul-09	0	2	0	2	18	8	4	2	0
Total	29	38	30	168	302	660	18	7	6

Appendix F. The total number of unidentified juvenile salmonids by size and direction of travel through the video chute in Stream 2004, from May 22 through July 15, 2009. Species identification was later assigned based on size classes and the proportion of coho salmon, Chinook salmon, rainbow trout, and Dolly Varden caught in the livebox each day. Counts are from a combination of full hourly counts, partial counts, and 15 minute subsamples. The video chute was closed for repair and modifications on July 15.

	Salmonids ≥90 mm			Salmonids 50-89 mm			Salmonids <50 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate	Down	Up	Indeterminate
22-May-09	0	0	0	0	0	0	0	0	0
23-May-09	0	0	0	0	0	0	0	0	0
24-May-09	0	0	0	0	0	0	0	0	0
25-May-09	0	0	0	0	0	0	0	0	0
26-May-09	0	0	0	0	0	0	0	0	0
27-May-09	0	0	0	0	0	0	0	0	0
28-May-09	0	0	1	0	0	0	0	0	0
29-May-09	0	0	0	0	0	0	0	0	0
30-May-09	2	1	0	0	0	0	0	0	0
31-May-09	0	0	0	0	0	0	0	0	0
01-Jun-09	0	1	0	0	0	0	0	0	0
02-Jun-09	0	0	0	0	0	0	0	0	0
03-Jun-09	0	0	0	0	0	0	0	0	0
04-Jun-09	1	0	1	0	0	0	0	0	0
05-Jun-09	0	0	1	0	0	0	0	0	0
06-Jun-09	0	1	0	0	0	0	0	0	0
07-Jun-09	3	1	1	0	0	0	0	0	0
08-Jun-09	0	0	0	0	0	0	0	0	0
09-Jun-09	0	0	0	0	0	0	0	0	0
10-Jun-09	0	0	0	0	0	0	0	0	0
11-Jun-09	0	0	0	0	0	0	0	0	0
12-Jun-09	2	0	2	1	0	0	0	0	0
13-Jun-09	0	2	0	0	0	0	0	0	0
14-Jun-09	1	0	3	0	0	0	0	0	0
15-Jun-09	2	3	16	1	0	0	0	0	0
16-Jun-09	5	2	1	1	0	0	0	0	0
17-Jun-09	2	0	2	0	0	0	0	0	0
18-Jun-09	0	1	2	0	0	0	0	0	0
19-Jun-09	0	1	7	0	0	0	0	0	0
20-Jun-09	1	0	0	0	0	0	0	0	0
21-Jun-09	0	1	1	0	0	0	0	0	0
22-Jun-09	0	0	0	0	0	0	0	0	0
23-Jun-09	18	0	1	0	0	0	0	0	0

Appendix F-Continued. Total number of unidentified juvenile salmonids by size and direction moving through the video chute in Stream 2004.

	Salmonids ≥90 mm			Salmonids 50-89 mm			Salmonids <50 mm		
Date	Down	Up	Indeterminate	Down	Up	Indeterminate	Down	Up	Indeterminate
24-Jun-09	4	0	0	1	0	1	0	0	0
25-Jun-09	1	0	0	2	0	6	0	0	0
26-Jun-09	8	0	0	1	1	1	0	0	0
27-Jun-09	10	0	2	8	2	4	0	0	0
28-Jun-09	4	1	2	3	1	3	0	0	0
29-Jun-09	4	1	2	0	0	4	0	0	0
30-Jun-09	3	1	1	1	1	1	0	0	0
01-Jul-09	4	0	0	0	0	0	0	0	0
02-Jul-09	0	2	1	0	0	0	0	0	0
03-Jul-09	3	1	3	1	1	2	0	0	0
04-Jul-09	3	7	5	0	0	5	0	0	0
05-Jul-09	1	0	2	0	0	3	0	0	0
06-Jul-09	5	2	1	7	8	4	1	0	0
07-Jul-09	0	1	0	3	3	5	0	0	0
08-Jul-09	2	0	1	0	0	5	0	0	0
09-Jul-09	1	0	2	7	1	7	0	0	0
10-Jul-09	1	0	3	1	9	5	0	0	0
11-Jul-09	1	0	1	6	5	8	0	0	0
12-Jul-09	0	0	0	8	5	4	0	0	0
13-Jul-09	1	0	0	3	5	6	0	0	0
14-Jul-09	0	0	1	2	5	19	0	0	0
15-Jul-09	-	-	-	-	-	-	-	-	-
Total	93	30	66	57	47	93	1	0	0