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Distribution of Resident Dolly Varden in Power Creek, Cordova, 2005-2007

by Scott H. Maclean
and Michael J. Daigneault

Power Creek Dam and Water Intake
Photograph by Scott H. Maclean

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Division of Habitat

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By

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Executive Summary

We sampled Dolly Varden in Power Creek above the Power Creek Hydroelectric Facility to document the distribution of Dolly Varden and investigate the possible effects of the design and operation of the water intake on resident Dolly Varden. Seven sampling events were conducted during the summer and fall, 2005-2007. A total of 1,615 Dolly Varden were captured throughout the course of this study; most were captured in the early sampling periods (July/August) and in the upper reaches of the study area. More suitable habitat for Dolly Varden appears to exist in these upstream reaches. The Power Creek resident Dolly Varden population exhibits characteristics similar to other isolated, resident Dolly Varden populations in terms of length frequency, small size at maturity, and localized movements. Few Dolly Varden (2.5% of the total catch) were captured in the vicinity of the water intake and diversion dam. Although Dolly Varden entrainment in the water intake could not be investigated in this study, the limited Dolly Varden use of this area suggests that operation of the facility's water intake may only affect a small portion of the population.

Introduction

The Power Creek hydroelectric project is owned and operated by the Cordova Electric Cooperative (CEC) and consists of five primary components: a diversion dam and intake structure located at Power Creek stream mile 3.3, a tunnel and pipeline conduit conveying water about 5,900 ft, a powerhouse at stream mile 2.2 with an installed capacity of about 6 megawatts, a 7.2 mile buried transmission line, and about 2.5 miles of access roads (Figure 1). Construction began in 1998 and operation began in October 2001. The project is a "run of the river" design (i.e., minimal water storage capacity). The project diversion dam and intake is located about half a mile upstream of Ohman Falls, which is a barrier to upstream fish migration. The dam consists of concrete abutments with a 50 ft. by 8 ft. inflatable bladder that can impound a forebay of about 0.07 hectares (Figure 2). The surface water level and forebay depth are controlled by the inflation or deflation of the bladder as power demand and streamflow fluctuate. Streamflow that is greater than project capacity or power generation needs spills over the diversion dam. There is a minimum 5 cubic feet per second (cfs) instream flow requirement immediately downstream of the diversion dam. The water intake is located immediately upstream of the diversion dam on the north abutment and contains vertical trash rack bars of 1.5-inch spacing and a sediment retention wall to prevent bedload intake (Figure 3). The dam bladder is periodically deflated to allow streamflows to flush any sediment accumulation immediately upstream of the dam and maintain downstream sediment transport. Operational flushing event frequency depends on streamflow and may occur daily during high flow periods or up to three months may pass during low flow periods (Clay Koplin, CEC, personal communication). After conveyance to the powerhouse (Figure 4), water is returned to Power Creek via an open channel tailrace about 60 ft long, 30 ft wide, and 5 ft deep (Figure 5).

The University of Alaska, Anchorage, conducted Power Creek fish investigations in 1995 and 1996 (Kelly 1995, Kelly and Major 1997). Sampling effort focused on Power Creek below Ohman Falls; coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*O. nerka*), and Dolly Varden (*Salvelinus malma*) were captured throughout the study reach. Concurrent with the 1996 investigations, Kelly and Major (1997) reported the capture of

23 small (59-98 mm) Dolly Varden over a mile upstream of Ohman Falls by Oregon State University researchers.

During 2001-2003, Sea-Run Fisheries (2004) conducted fish monitoring in Power Creek above Ohman Falls to determine the distribution of resident Dolly Varden near the diversion dam and water intake and to evaluate potential impacts of the hydroelectric project intake on Dolly Varden. The specific objectives of the study were to determine: 1) relative abundance of fish in the vicinity of the intake area compared to upstream habitat; 2) if Dolly Varden in the intake area were subject to injury or mortality as a result of project operations. Minnow traps were fished for 38 days over 9 sample events. Except for one trap located upstream about 0.4 miles, traps were fished in the vicinity of the diversion dam and water intake, both upstream and downstream. A total of 101 fish were captured in the intake area, of which 49 were recaptures; catch per unit effort (CPUE) ranged from 0.001 to 0.02 fish per trap hour. A total of 252 fish were captured at the upstream site, with 74 recaptures; CPUE ranged from 0 to 0.47 fish per trap hour. Attempts were made to observe fish presence and behavior in the immediate vicinity of the water intake. Fish were not observed during efforts of fish screening (58 hours total) or underwater video (4 hours) at the intake structure. This study concluded that fish use the diversion dam area but at lower relative abundance to the upstream site, likely because of the moderately steep (8%) gradient, coarse gravels and boulders, high water velocities, and long distances to peripheral habitats.

Currens et al. (2003) made various comparisons of coastal cutthroat trout and Dolly Varden populations throughout Prince William Sound. While this work focused on understanding similarities and differences among populations and species for the purpose of identifying appropriate recovery strategies after the Exxon Valdez oil spill, the results of this work indicate that Dolly Varden in Power Creek above Ohman Falls are a genetically isolated population. Power and Hawkins creek Dolly Varden populations above fish passage barriers were the most distinct populations in Prince William Sound based on allozyme and microsatellite DNA data analysis. Further, the different analyses indicated significant genetic differences between Dolly Varden in Power Creek above and below the barrier at Ohman Falls.

As a condition of the Federal Energy Regulatory Commission license, CEC was required to annually conduct fish, wildlife, and water quality monitoring studies for a period of eight years following the start of project operations. These studies are documented in a series of reports produced by Sea-Run Fisheries (2003a, 2003b, 2006a, 2006b, 2007, 2008, 2009, and 2010). Average daily streamflow measured at the former United States Geological Survey stream gage on Power Creek (#15216000) typically ranged from less than 100 cfs during winter low flow to about 1,500 cfs during summer and fall flows. However, flow in Power Creek can be extremely variable, with rapid, intense spikes in flow. For example, two significant flood events were recorded in 2006: one on August 20 with a peak discharge of 4,500 cfs and another on October 10 with a peak discharge greater than 8,000 cfs. In both events, flows subsided quickly after peak discharge and the floodplain and channels in the upper Power Creek valley returned to stable conditions. Water temperatures in Power Creek measured from 2002 through 2009 in the vicinity of the diversion dam ranged from about 0-8 °C. High water temperature (6-8 °C) typically occurred in late July or early August. The timing of lower water temperature (0-3 °C) was more variable, occurring for about a one or two month period any time between November and April for the years recorded.

Despite efforts of the studies described above, the isolated resident Dolly Varden population in Power Creek upstream of the hydropower facility remains understudied. The purpose of this study was to document the distribution of the resident Dolly Varden population in Power Creek above the hydroelectric facility's diversion dam to assess possible effects of the design and operation of the Power Creek Hydroelectric Facility. In particular, this study was intended to evaluate project compliance with fish habitat permit stipulations to determine if resident Dolly Varden are negatively affected by the design and operation of the project's diversion dam and water intake. Further, data gathered in this study may be useful to ADF&G in reviewing and monitoring other resource development projects that could potentially affect resident populations of Dolly Varden.

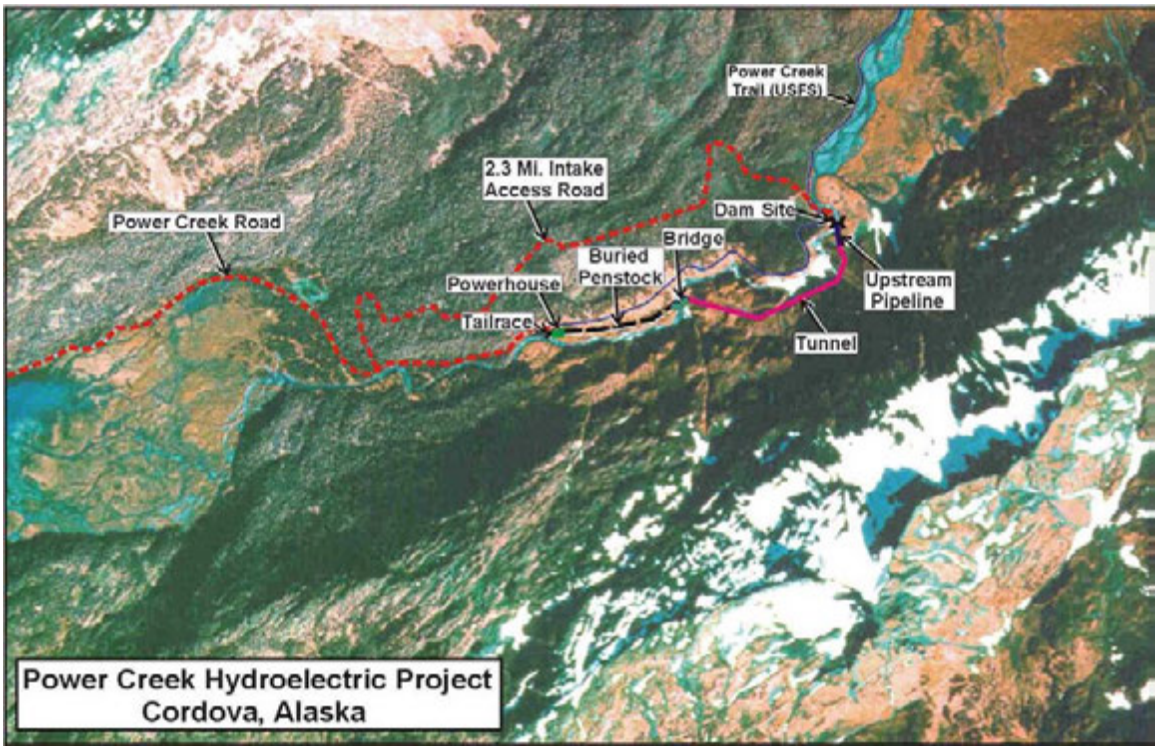

Figure 1. Power Creek Hydroelectric Project components.

Figure 2. Power Creek Hydroelectric Project diversion dam, intake structure, and forebay.

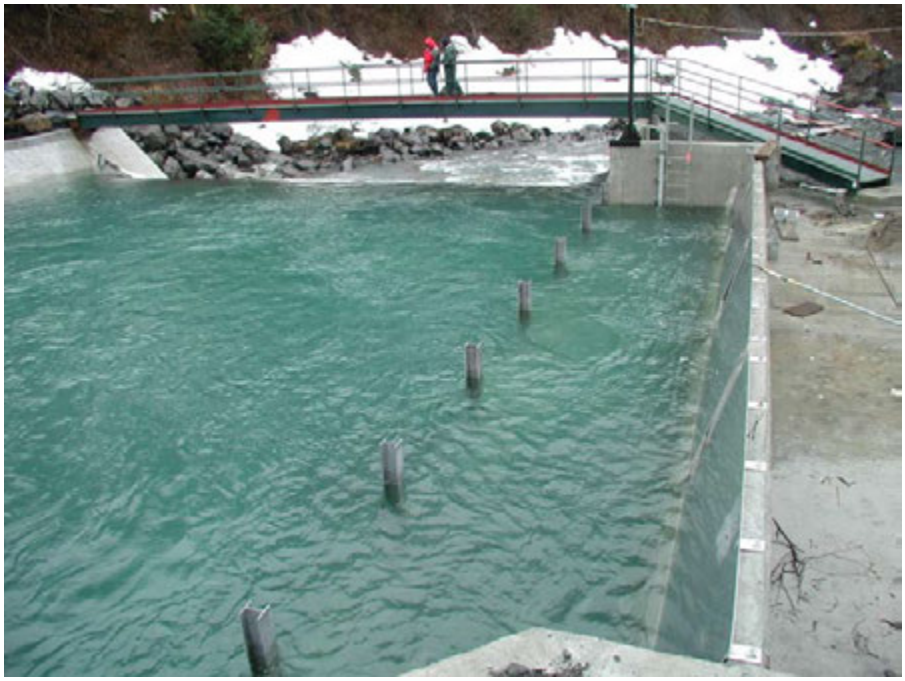

Figure 3. Power Creek Hydroelectric Project intake structure.

Figure 4. Power Creek Hydroelectric Project power house.

Figure 5. Power Creek Hydroelectric Project open water tailrace.

Methods

Study Area

The study area is located on Power Creek, a glacially influenced tributary to Eyak Lake northeast of Cordova, Alaska. About 12.8 river kilometers of resident fish habitat exist upstream of Ohman Falls. Power Creek flows through an alluvial valley of glacial deposition with braided channels at the top of the study area and becomes confined and steeper within 1.6 km of Ohman Falls. The study area included four sampling sites upstream of the project diversion dam and within 3.2 km of Ohman Falls (Figure 6). Site 1 was located immediately upstream of the diversion dam extending about 150 m upstream. Site 2 and 3 were located 465 – 815 m and 1,540 – 1,890 m upstream of the diversion dam and contained access to beaver ponds. Site 4 was the farthest upstream of the diversion dam between 2,620 – 2,970 m.

Fish Sampling

Seven fish sampling events occurred from 2005-2007: August, September, and October 2005; July and October, 2006; and August and October, 2007. The goal was to sample 3

times each year, but various factors (e.g., floods) precluded a consistent sampling schedule. Ten baited minnow traps were deployed at each site, five traps on each bank. The minnow traps were 22.8 cm in diameter and constructed of 0.6 cm mesh. Each trap was baited using equal amounts of fresh or frozen salmon roe disinfected in a betadyne solution and packaged in Whirl-Paks. To stabilize the minnow traps, a rock was placed inside each during deployment. Except for some locations where water depth became too shallow with varying flows, minnow traps were deployed in the same locations during each sampling event.

Traps were recovered 24 hours later and fish were anesthetized with Alka-Seltzer (half tablet per liter of water), measured to the nearest millimeter (fork length), marked with a fin clip, and released at the point of capture. To monitor movement patterns, fish were marked with four distinct fin clips (i.e., Site 1 – lower caudal lobe, Site 2 – upper caudal lobe, Site 3 – left pelvic fin, and Site 4 – right pelvic clip; Figure 7).

Figure 6. Study area in upper Power Creek above Ohman Falls. Four sites were sampled upstream of the diversion dam.

Figure 7. Dolly Varden with a left pelvic fin clip.

Results

Dolly Varden Catch and Metrics

Dolly Varden were the only fish captured in the study area. In general, catches were highest earlier in the season and at the uppermost sites (i.e., Sites 3 and 4; Table 1; Figure 8, Figure 9, and Figure 10). Catch per unit of effort (number of fish per trap hour) ranged from 0.00 to 1.48 (Table 2). Similar to catch, CPUE was highest early in the season and at the upstream sites.

Table 1. Dolly Varden catch, by year, month, and site.

	2005			2006		2007		
Site No.	Aug	Sept	Oct	July	Oct	Aug	Oct	Totals
1	10	9	1	9	5	6	0	40
2	60	43	25	40	23	55	14	260
3	156	117	85	102	140	64	21	685
4	356	68	21	56	13	92	24	630
Totals	582	237	132	207	181	217	59	1,615

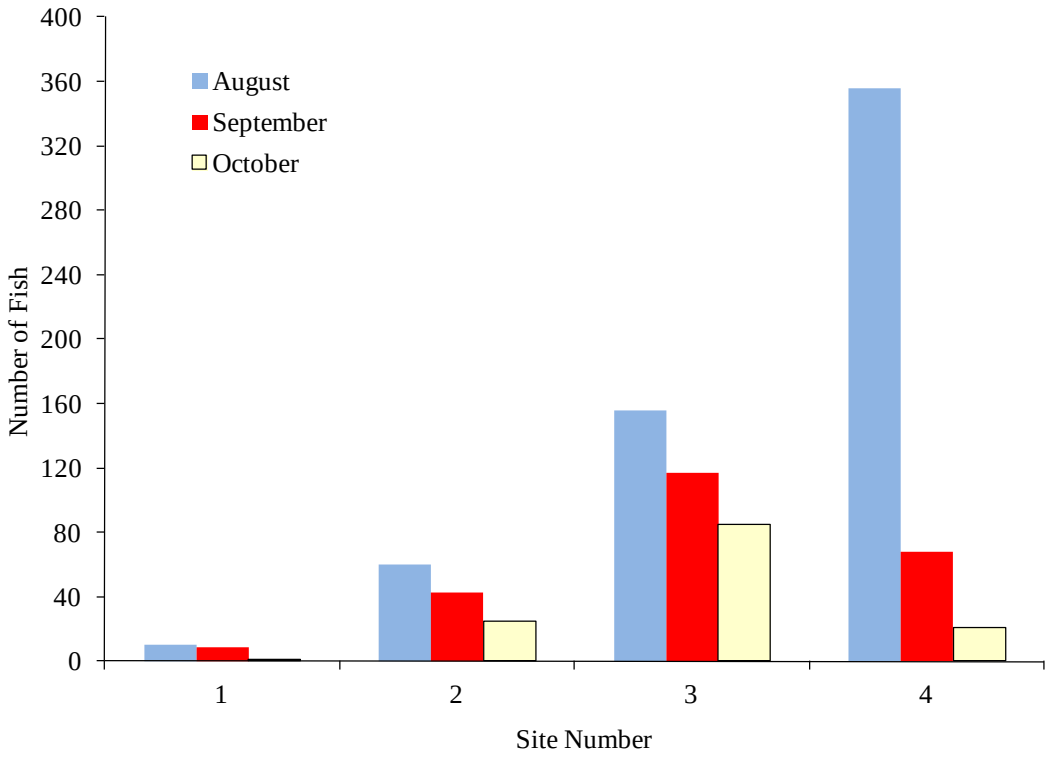

Figure 8. Dolly Varden catch by month and site, 2005.

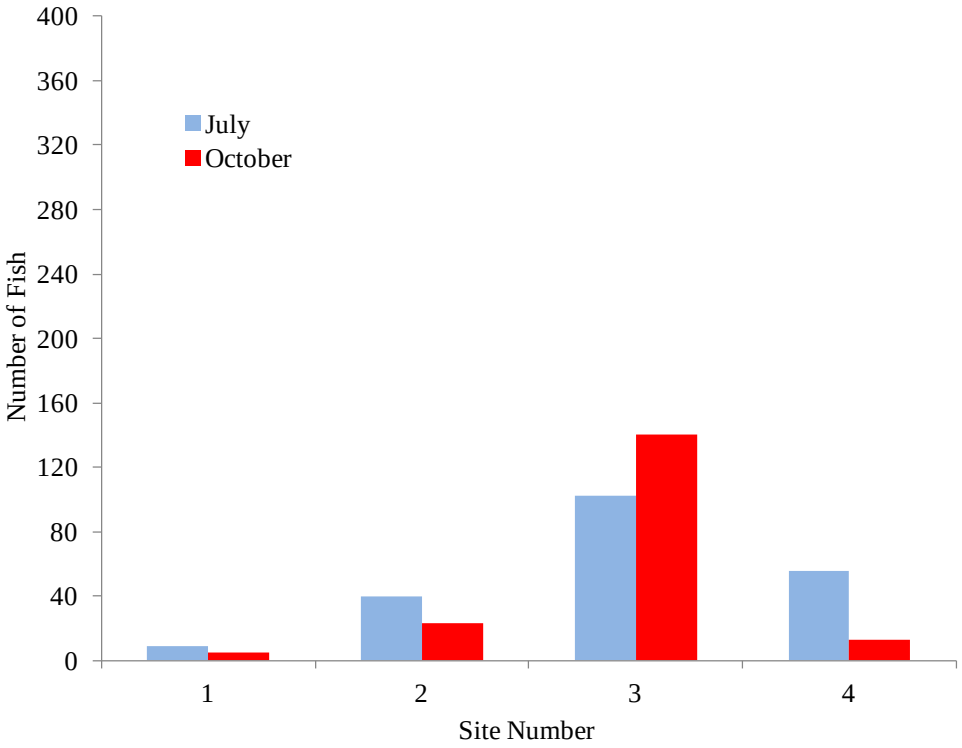

Figure 9. Dolly Varden catch by month and site, 2006.

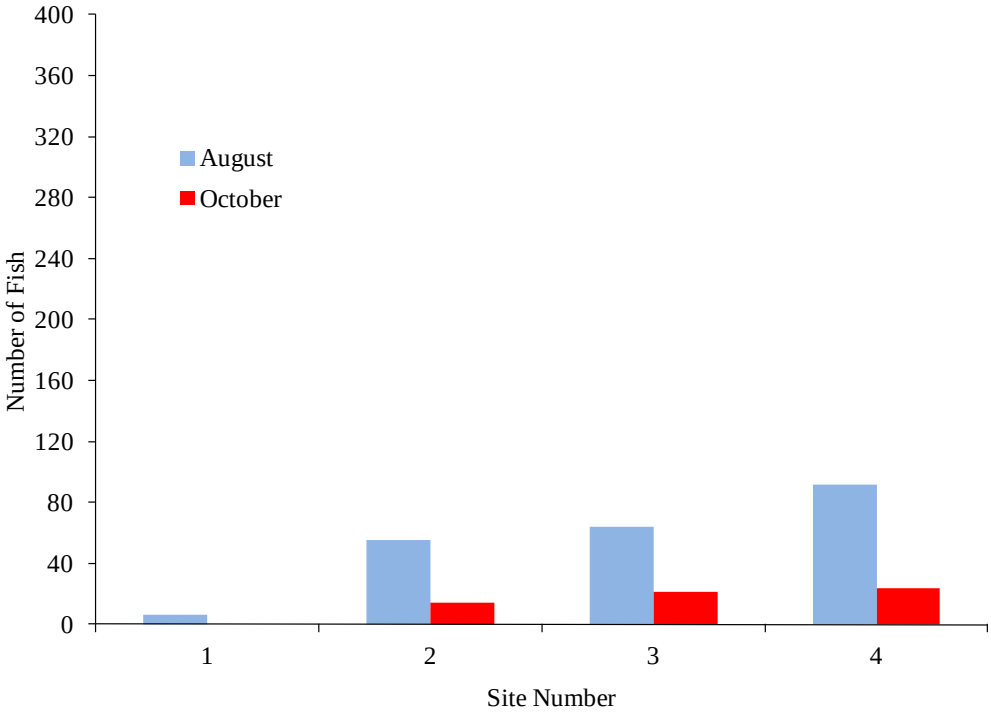

Figure 10. Dolly Varden catch by month and site, 2007.

Table 2. Dolly Varden CPUE, by year, month, and site.

	2005			2006		2007		
Site No.	Aug	Sept	Oct	July	Oct	Aug	Oct	Totals
1	0.04	0.04	0.00	0.04	0.02	0.03	0.00	0.02
2	0.25	0.18	0.10	0.17	0.10	0.23	0.06	0.15
3	0.65	0.49	0.35	0.43	0.58	0.27	0.09	0.41
4	1.48	0.28	0.09	0.23	0.05	0.38	0.10	0.38
Totals	0.61	0.25	0.14	0.22	0.19	0.23	0.06	

Length Frequency Distribution

Dolly Varden lengths ranged from 34 to 175mm, with most fish between 60 and 100mm (Figure 11, Figure 12, and Figure 13). In each year, mean length in the study area decreased over time; larger fish appeared less abundant in the October sampling event (Figure 11, Figure 12, and Figure 13). Month-specific (August and October) length frequency distributions were similar among years (using the July 28 sample in 2006 as a surrogate for August). The August and October mean lengths were also similar among years (August: $F=7.55$, $p=0.0006$; October: $F=8.59$, $p=0.0002$). The mean length of Dolly Varden was highest in the lower portions of the study area (Sites 1 and 2) relative to the upper parts of the study area (Sites 3 and 4; Figure 14); however, this result may be a function of sample size.

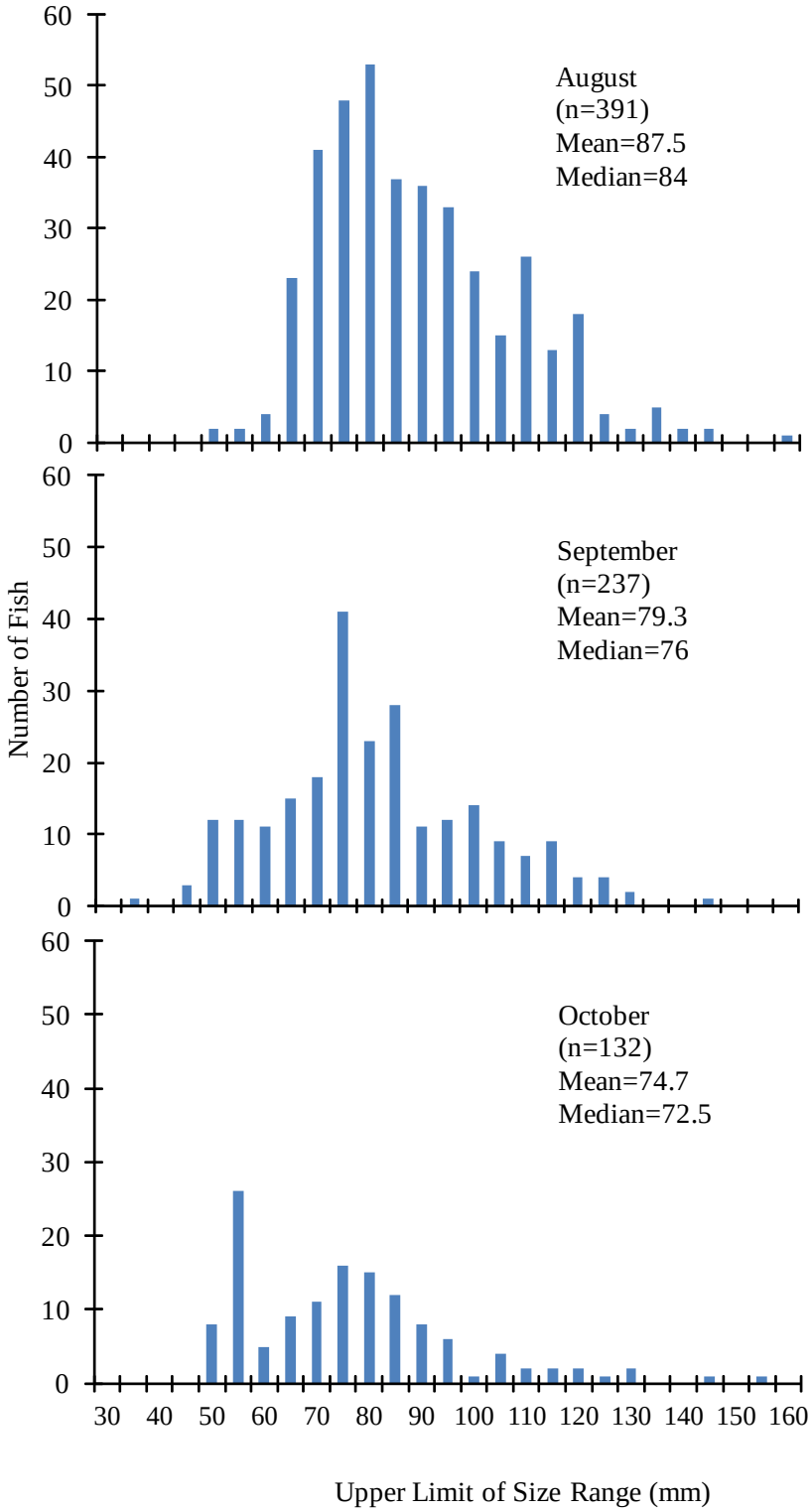

Figure 11. Dolly Varden length frequency distribution, by month, 2005.

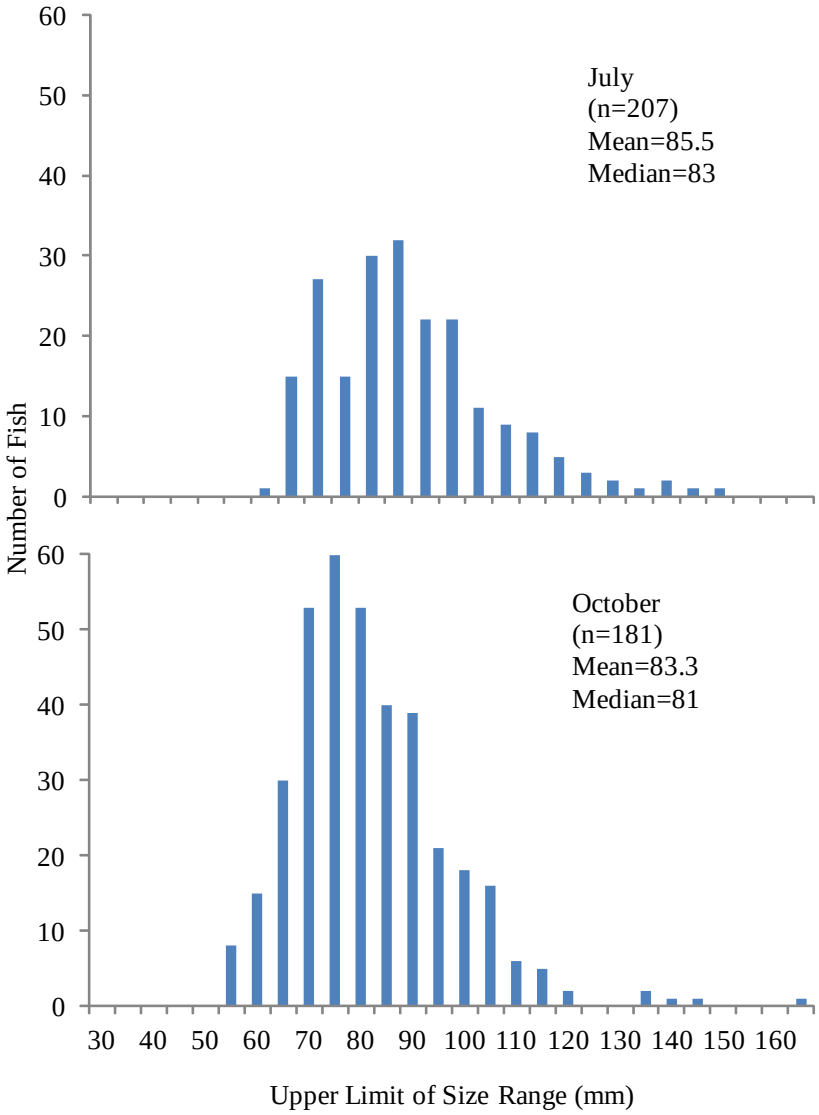

Figure 12. Dolly Varden length frequency distribution, by month, 2006.

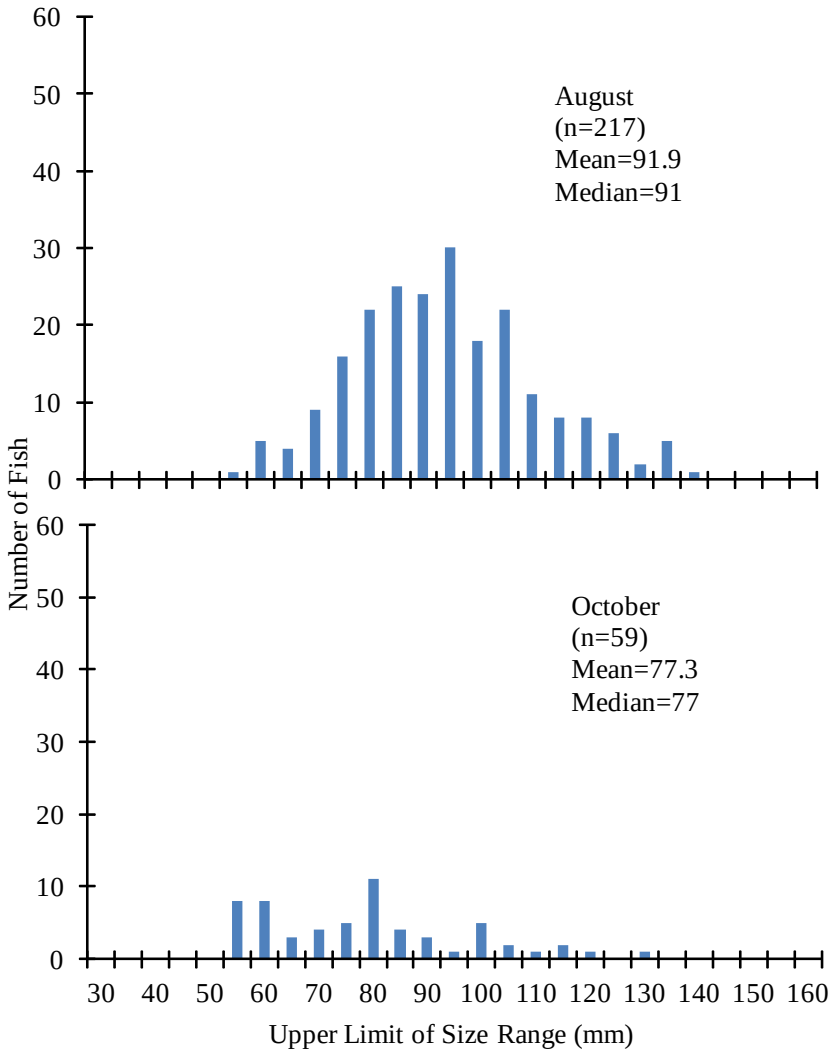

Figure 13. Dolly Varden length frequency distribution, by month, 2007.

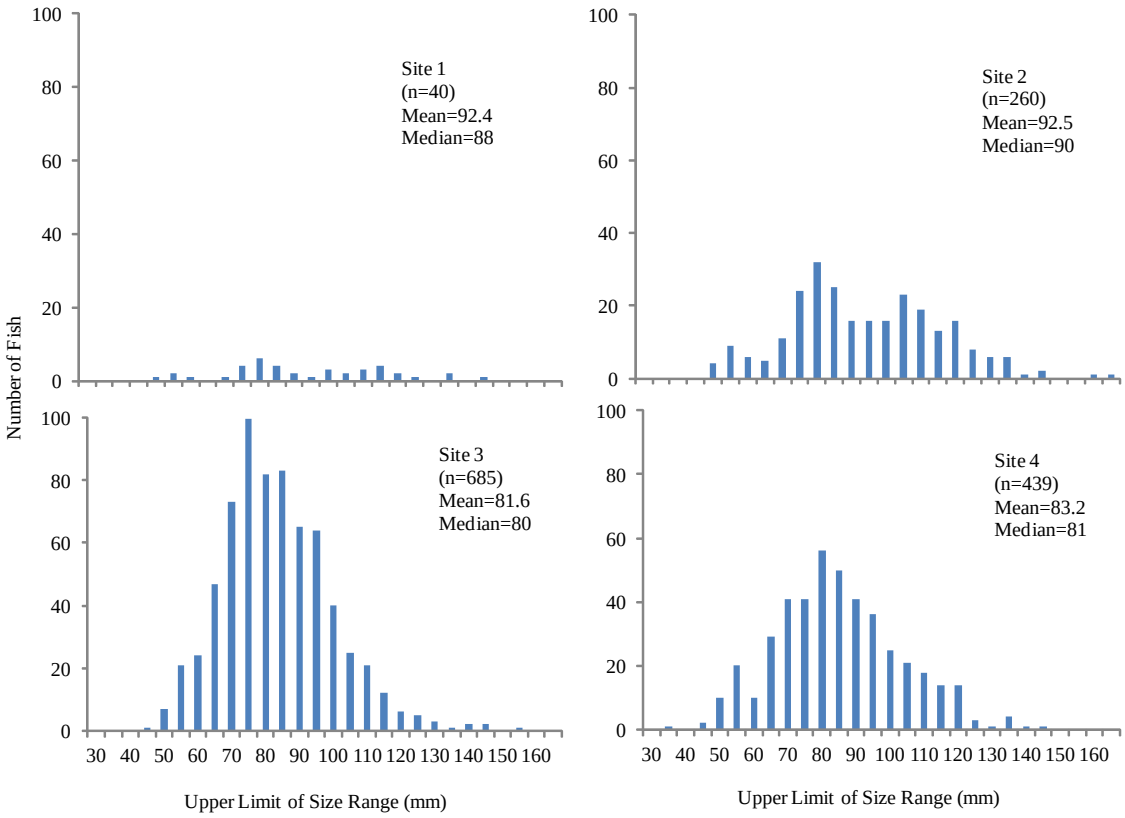

Figure 14. Dolly Varden length frequency distribution, by site.

Dolly Varden Movements

A total of 1,424 Dolly Varden were marked with a fin clip; 25 Dolly Varden were recaptured (2%). Most recaptured fish were found at their site of original capture (Table 3). Fish marked at Sites 1 or 2 were recaptured at the same location. Fish marked at Sites 3 and 4 were recaptured at both sites.

Table 3. Comparison of Dolly Varden capture and recapture sites, all years.

Capture Site No.	Recapture Site 1	2	3	4
1	2	0	0	0
2	0	5	0	0
3	0	0	12	2
4	0	0	1	3

Dolly Varden Sexual Maturity

We observed a difference in the coloration of the fins and spots between fish smaller and larger than about 90 mm. A white anterior ray of the pelvic fin of large fish was often followed by dark fin rays compared to semi-transparent or faint orange fins on the smaller fish. White spots were noted on the sides of larger fish compared to large parr marks and less prominent spotting on smaller fish. To examine sexual maturity, one female (94 mm) was sacrificed and found to be near spawning condition on October 11, 2005.

Figure 15. Female Dolly Varden (94mm) in near spawning condition on October 11.

Discussion

The objectives of this study were to document the distribution of the resident Dolly Varden population in upper Power Creek and to determine if resident Dolly Varden were negatively affected by the design and operation of the project's diversion dam and water intake. Objective 2 of the study was not accomplished and would require more detailed observations at the water intake during various flow and operational conditions as well as a means to estimate intake entrainment, either into the bypass providing the 5 cfs instream flow requirement or the water that enters the pipeline and eventually passes through the turbines.

Catch data suggest that few Dolly Varden use the area in the immediate vicinity of the diversion dam and water intake. Sea-Run Fisheries (2004) field observations indicate this reach of Power Creek is marginal habitat for Dolly Varden (i.e., moderately steep gradient (8%), coarse gravels and boulders, high water velocities, and long distances to peripheral habitats). Sea-run Fisheries (2004) CPUE estimates were lowest in the immediate vicinity of the intake and higher at their upstream sampling location; these sampling locations were similar to the Site 1 and Site 2 sampling locations in our study. We estimated similar Dolly Varden CPUE in these areas (Table 2). CPUE was highest at the uppermost sampling locations (Sites 3 and 4; Table 2), even in October when bigger fish were largely absent from the catch data. The progressive increase in CPUE is consistent with the general observation that there appears to be more available Dolly Varden habitat as you progress upstream in the upper Power Creek valley.

Population characteristics of Power Creek Dolly Varden above the hydroelectric diversion dam (and previously isolated by Ohman Falls) are similar to other stream-dwelling resident Dolly Varden populations above a barrier to upstream fish migration. Resident char length and body size are smaller than anadromous forms (Blackett 1973, Maekawa and Nakano 2002). Power Creek Dolly Varden lengths were similar to those recorded for other resident char populations (Figure 11, Figure 12, and Figure 13; Gregory 1988, Flory 1999, Flory 2000, Leder 2001, Bryant and Lukey 2004, Hastings 2005). The largest Dolly Varden captured in Power Creek was 175 mm; others have captured resident Dolly Varden >200 mm (Blackett 1973, Gregory 1988, Hastings 2005).

However, we suspect the apparent smaller size of Power Creek Dolly Varden is a result of sampling gear bias and sampling area, rather than an actual difference in lengths; additional information would be required to test this hypothesis. Stream-dwelling resident chars typically reach sexual maturity at a smaller size and younger age than either anadromous or lake-dwelling resident chars. Many anadromous Dolly Varden in Southeast Alaska matured at age 5 (Heiser 1965, Blackett 1973, Kruger 1981); reported lengths indicate these fish were about 300 mm. Similarly, McPhail and Murray (1979) reported that Dolly Varden residing in Upper Arrow Lake for most of their adult life migrated into the spawning tributary Mackenzie Creek at age 4 and 5. For stream-dwelling resident char populations, Gregory (1988) reported Tiekel River (Southcentral Alaska) Dolly Varden spawning as early as age 2 and Morita and Morita (2002) reported white-spotted charr (*S. leucomaenis*) in the Hitozuminai River (Hokkaido) spawning at age 1+, while Blackett (1973) reported Falls Creek (Southeast Alaska) Dolly Varden spawning at age 3. Length at spawning for these resident char studies ranged from 130 to 220 mm; the single Power Creek Dolly Varden sacrificed and determined to be near spawning condition was 94 mm (Figure 15).

During the summer months, Power Creek Dolly Varden appear to exhibit considerable site fidelity as evidenced by few fish recaptured in a different location than the original point of capture (Table 3). This fidelity appears to exist both within and between years. The only movement of fish documented was between the two upper sampling sites. The lack of Power Creek Dolly Varden summer movement is consistent with resident salmonid populations elsewhere. Bryant and Lukey (2004) and Bryant et al. (2009) indicated that most recorded resident Dolly Varden movements were less than 100m and, in many cases, fish did not move more than 20m. This is consistent with Northcote (1992) who reviewed various studies of resident salmonid movements and found that few moved distances greater than 300m.

The limited movement of Power Creek Dolly Varden during the summer months also suggests a strong resilience to flood events. Two significant flood events occurred during 2006: 4,500 cfs on August 20 and greater than 8,000 cfs on October 10. If significant redistribution of fish resulted from these flood events, we would have expected to see evidence of that redistribution during the October 24, 2006, sampling effort, yet did not.

The upper Power Creek floodplain appears to have sufficient space to allow Dolly Varden to laterally disperse during flood events, and then resume their position in habitats occupied prior to flooding when flood waters subside.

Based on length frequency distributions (Figure 11, Figure 12, and Figure 13), there appears to be a decrease of larger fish in the Power Creek October samples. This suggests a possible Dolly Varden spawning migration to Power Creek habitats above the study area. While more information would be required to verify this theory, the idea is consistent with observations elsewhere (Bryant and Lukey 2004, Bryant et al. 2009). Further, a possible spawning migration during this time of year correlates with declining water temperatures (Sea-Run Fisheries 2003a, 2006a, 2007, 2008, 2009, 2010); more data are needed to determine if this observation is coincidental or if declining temperatures trigger upstream movement to likely spawning areas.

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