COEUR ALASKA KENSINGTON PROJECT

Threespine stickleback in Upper Slate Lake

USFS Annual Report 2010

TSF Ecological Monitoring:

Upper Slate Dolly Varden

January 2011
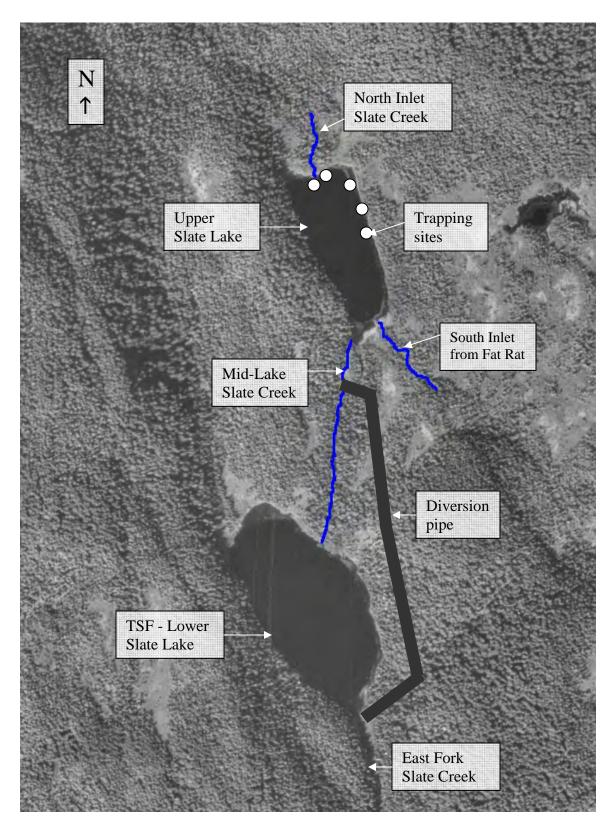
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1.0 Introduction

This report describes monitoring conducted during 2010 in accordance with the Ecological Monitoring Plan for the TSF (Tailings Storage Facility). The diversion pipe at Mid-Lake Slate Creek was rebuilt in September 2009 and the creek diverted around the TSF, formerly known as Lower Slate Lake and now referred to as the Tailings Treatment Facility or TTF. Fish passage trials were conducted to determine whether fish could pass safely down the diversion pipe from Upper Slate Lake to Lower Slate Creek. Dolly Varden spawner surveys were also conducted in conjunction with a Masters student project to determine the current population size of Dolly Varden in Upper Slate Lake.

2.0 Fish Passage Trials

The Ecological Monitoring Plan for the TSF states "*Dolly Varden in Mid-Lake Slate Creek will be captured and released below the TSF dam from the beginning of construction of the TSF until confirmation that suitable conditions for Dolly Varden are present in the TSF.*" Mid-Lake Slate Creek (MLSC) originally ran from Upper Slate Lake (USL) to Lower Slate Lake (LSL). The creek began at elevation 226m at USL and dropped to 200m at LSL and was dominated by bedrock riffle and cascade habitat with few pools. The creek was 468m long prior to road construction in 2006, with a natural barrier to upstream fish migration at approximately 215m from LSL.

During the summer of 2006, preparation of the TSF involved diversion of MLSC around LSL to East Fork Slate Creek (Figure 1). The diversion was removed and the creek restored to allow downstream fish passage during September and October of 2008. In August 2009, the U.S. Army Corps of Engineers 404 permit was reinstated allowing use of Lower Slate Lake as a Tailings Treatment Facility and construction work continued once more. The diversion structure was rebuilt in September 2009 and the creek once again diverted around the lake prior to dam construction. In March 2010, a 0.1" mesh screen was installed on the intake to prevent fish passage until field trials demonstrated safe fish passage through the pipeline. A Parshall flume was added in July 2010 to measure flow in the pipe (Figure 2).

Figure 1: Upper Slate Aerial View. Mid-Lake Slate Creek is now diverted around the TSF through a pipe. Trapping sites shown for fish passage trials and spawning surveys.
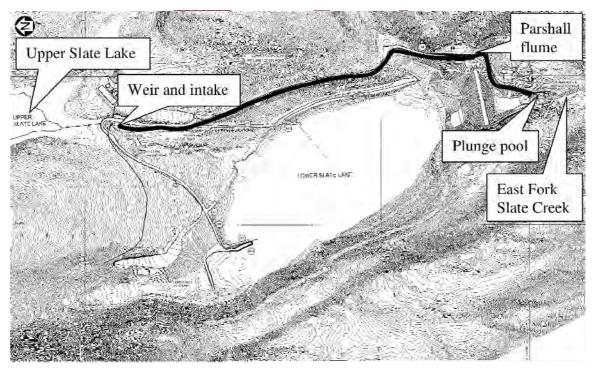
Figure 2: Diversion pipeline aerial representation.
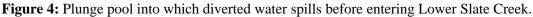

Figure 3: Concrete weir and intake structure.

2.1 Fish Trial Methods

The objective of the fish passage trials was to determine that the final diversion structure is suitable for downstream fish passage allowing fish to migrate from Upper Slate Lake to Lower Slate Creek and eliminating the need to transport fish by hand. Kate Kanouse of ADFG lead initial field trials in July 2010 to test fish passage down the diversion pipe. Three Dolly Varden captured in minnow traps in the TTF and 57 captured in Upper Slate Lake were released into the pipeline intake, downstream of the mesh screen, on July 7. Five minnow traps baited with salmon eggs were set in the plunge pool at the bottom end of the pipe (Figure 4) into which diverted water is released in an attempt to capture the 60 released fish after they had descended the pipe. A fyke net with live holding box was also placed in the outlet from the plunge pool to ensure fish could not pass further downstream. The traps were checked daily for ten days.

No fish were observed in the flume or plunge pool one hour after release. The floor of the concrete intake box was examined using an underwater camera, which revealed about twenty Dolly Varden still at the intake. A three inch gap was also discovered at the bottom of the mesh screen that could have allowed some fish to escape back upstream. Fourteen of these fish were recaptured at the intake and released again this time downstream from a 0.5" inch mesh screen. A further nine dollys and one stickleback were captured in Upper Slate Lake on July 8 and released in the flume rather than at the intake. This brought the total fish known to be in the pipeline to 24 (23 dollys plus 1 stickleback), although more as many as 40 could have passed down the pipe.

All recaptured fish were held in the live holding box for 24 hours for observation before being measured and examined for signs of injury. Uninjured fish were returned to Upper Slate Lake and any injured fish transported to ADFG in Juneau for further examination. More fish were captured in October after high rainfall increased flows down the pipeline. High flows lead to debris accumulation on the intake screen and water spilled over the concrete weir (Figure 3). ADFG requested the mesh screen be removed to prevent fish from entering the TTF. The lack of screen combined with high flows meant fish could pass down the pipeline and the opportunity was taken to examine passive fish movement down the pipeline. Five traps were set in the plunge pool from October 27 to November 3 when flows increased too much to continue trapping fish.

Figure 4: Plunge pool into which diverted water spills before entering Lower Slate Creek.

A snorkel survey was also conducted in the plunge pool on November 1 at 4:30pm to examine the pool for more fish that had not entered minnow traps.

2.2 Fish Passage Results

Twenty-seven Dolly Varden and two threespine stickleback were captured in the plunge pool at the lower end of the pipe in the days shortly following the release of fish at the intake (Table 1). Two fish showed external injuries and were transported to ADFG, Habitat division for further examination. The remaining 25 fish were returned to Upper Slate Lake. Flow in the pipe was estimated at 2.4 to 4.3 cfs during the first July trial. Liz Flory of Aquatic Science Inc. snorkeled the plunge pool on August 9, 2010 and observed 15-20 Dollys of various sizes swimming in the pool. It is likely that these were some of the fish released initially on July 7. There was no attempt made to capture these fish in August and high flows that damaged the pool liner likely flushed them further downstream. A further fifteen Dollys were captured between late October and mid November, bringing the final total to 42 Dollys captured in the plunge pool in 2010. Flow in the pipeline reached almost 14 cfs in October prior to trapping.

One fish captured in the plunge pool on October 28 had been tagged on the east shore of Upper Slate Lake on July 25 and one captured on November 11 was tagged on the north shore of the lake on July 27. All 15 fish captured in the fall were released to Lower Slate Creek. The lengths and date of capture of fish in the July trials are given in Table 1. Dollys released and recaptured in the plunge pool in July ranged from 60 to 240mm in length with the latter being one of two fish to suffer injury during descent (Table 1). Fish that were apparently washed down the pipe during high flows ranged from 134 to 188mm (Table 2). One fish was recovered dead from a trap after high flows washed traps out of the creek overnight. No fish, alive, injured or dead, were observed in the pool during the snorkel survey.

Species	Length (mm)	Date/Time Caught
Salvelinus malma	220	7/7/10 20:00
S. malma	190	7/9/10 9:30
S. malma	180	7/9/10 17:30
S. malma	140	7/9/10 17:30
S. malma	160	7/9/10 17:30
S. malma	160	7/9/10 17:30
S. malma	120	7/9/10 17:30
S. malma	*185	7/10/10 10:00
S. malma	80	7/10/10 10:00
S. malma	120	7/10/10 10:00
S. malma	180	7/10/10 17:25
S. malma	160	7/10/10 17:25
S. malma	140	7/10/10 17:25
S. malma	190	7/11/10 9:45
S. malma	200	7/11/10 9:45
S. malma	60	7/11/10 17:30
***G. aculeatus	80	7/11/10 17:30
S. malma	120	7/12/10 10:00
S. malma	120	7/12/10 10:00
***G. aculeatus	75	7/13/10 10:00
S. malma	**240	7/13/10 10:00
S. malma	185	7/13/10 10:00
S. malma	120	7/13/10 10:00
S. malma	80	7/13/10 16:45
S. malma	100	7/13/10 16:45
S. malma	120	7/14/10 10:30
S. malma	120	7/14/10 10:30
S. malma	180	7/15/10 17:45
S. malma	160	7/15/10 17:45

Table 1: Lengths of fish recaptured in plunge pool after release on July 7-8. *injured fish transported to ADFG Juneau; ***only one of these released at intake

Spawning color	Tag ID	Total Length (mm)	Weight (g)	Date Caught
orange belly, orange spots	none	172	31.9	10/28/10
pale orange spots	none	167	35	10/28/10
no spawning color	none	164	31	10/28/10
no spawning color	41471	167	31	10/28/10
no spawning color	none	134	15.7	10/29/10
no spawning color	none	169	31.1	10/29/10
orange spots, orange belly	none	188	42.8	11/1/10
no spawning color	59077	174	31.1	11/1/10
no spawning color	none	180	31.2	11/2/10
no spawning color	none	100	6.6	11/2/10
no spawning color - dead	none	188	47.9	11/3/10

Table 2: Lengths and weights of fish that passed down diversion pipe after fall rains.

2.3 Fish Passage Discussion

Two of the 42 Dolly Varden that passed down the flume had surface injuries (4.8%). It was concluded that they only suffered external abrasions rather than internal injury, which may have occurred when fish scraped the concrete floor of the flume at low flow (Kanouse 2010). None of the fish captured in the plunge pool that passed down the pipe at higher flows after the intake screen was removed, had any visible injuries. If fish were injured during downstream passage they might not be inclined to enter minnow traps, but snorkeling did not reveal any injured or dead fish in the bottom of the pool where they might end up, nor were any injured fish swept into the fyke net downstream.

Discharge down the pipe in spring is expected to range from 10-20 cfs, exceeding that at which fish passage trials were carried out. It is anticipated that further fish passage trials will be conducted during or immediately following high flow events to determine if further injuries to fish are possible at higher flows. The first section of the pipe decreases 18' in elevation over 3300 horizontal feet, while the succeeding section loses 70' elevation over 520 horizontal feet. There are also three horizontal bends in the pipe where fish may meet resistance at higher flows. Further testing should help determine whether fish may safely negotiate the turns and elevation drops at high flow, which is likely the time when most fish descend the pipe.

It was interesting to observe the time it took for some fish to pass down the pipe. The fish observed in the plunge pool on August 9 were likely some of the fish released on July 7 or 8 since fish were prevented from entering the intake after July 8 by the presence of a mesh screen. In the pre-construction stream, fish would likely take some time to pass from Upper Slate Lake to Lower Slate Lake and then on to Lower Slate Creek resting in pools on way, but once they enter the diversion pipe one would imagine a swift descent. Of course some fish may have traveled down to the plunge pool much earlier than August 9 and simply failed to enter a trap. It is likely that descent is rapid at high flow due to the lack of resting places, but this could also be true of Mid-Lake Slate Creek at high flow. In any case, fish will now enter Lower Slate Creek from Upper Slate Lake more rapidly since there is no opportunity to dwell in Lower Slate Lake. There could be more rapid addition to the lower creek population, but there should be no increased movement away from Upper Slate Lake that could impact the size of the population there.

3.0 Dolly Varden Population Estimate and Spawner Surveys

The population of Upper Slate Lake was estimated to be 1,378 Dolly Varden in 2003 (Kline 2003). A 2010 study aimed to estimate the size of current fish population in Upper Slate Lake and document fish movement through the Slate Creek system. This information will be useful to Coeur for rehabilitation purposes by helping understand how resident fish utilize available habitat. Additionally, tagging of fish in this study may lend insight to the spawning habits and locations of the lake resident Dolly Varden in future spawning studies.

3.1 Population estimate methods

A major assumption in the use of tags in mark-recapture population estimates is that fish retain their tags and each tagged fish is recognized upon recapture. Implanted, electronic PIT tags were chosen for this study due to their typically high retention and lack of adverse effects from abnormal behavior, predation or entanglement. They also allow individual fish to be recognized again allowing information to be collected on movement and growth over time (Guy et al 1996).

A preliminary tag retention study was conducted on July 14, 2010 to test the tolerance of fish to tagging and the ability to detect tags in all sizes of fish. Baited minnow traps were set on the east shore of Upper Slate Lake. 27 fish were tagged and held for 24 hours in the lake within a trap that had its entrances sealed with cable ties. After determining the retention of tags, ten minnow traps measuring 36" x 12" with 5" entrances, were baited with cured salmon eggs and soaked overnight around the perimeter of the lake on July 23-25 (Figure 5). Captured fish were anesthetized in a solution of MS222 (Tricane Methanesulphonate), measured to the nearest 1mm and weighed to the nearest 0.1g.

Fish were firstly scanned for presence of tags from previous studies. Only fish larger than 115mm with no previous tags were selected for tagging in 2010. These fish were implanted with one sterilized, pre-loaded PIT tag (Biomark model TX1411SST, 12.5mm x 2.07 mm, 134.2 kHz ISO tag with unique identification number). The tags were injected with a modified hypodermic syringe with removable 12-gauge needles (Biomark MK-25 Implant Gun). Fish were injected below the dorsal fin along the left side, and the injection hole sealed with SuperGlue© to prevent infection (Figure 6). Implanting PIT tags below the dorsal fin appears to have a higher tag retention rate in this species (Soiseth et al 2008). All needles and tags come pre-sterilized and sealed from the manufacturer. Implanted fish were scanned with a PIT tag reader and the last 5 digits of the unique PIT tag code recorded. The entire code was not recorded in order to prevent human error common when PIT tag codes are recorded manually (PIT Tag Marking Procedures Manual Version 2.0, 1999). After tagging and measuring is complete, fish were allowed to recover in freshwater by being housed in a dark-colored, aerated bucket until equilibrium was regained and opercula pumping steadily. Specimens were released away from trapping sites to facilitate mixing of marked and unmarked fish (Schneider 2000).

A second survey to recapture marked fish was conducted from July 27-29 using the same level of fishing effort as the first marking event. The tag code of any recaptured tagged fish was recorded along with the capture location. Fish continued to be implanted with tags to increase the chance of finding tagged fish in future studies. The data was used to calculate the size of the population.

Figure 5: Trapping sites used for mark-recapture population estimate.

Figure 6: Inserting a PIT tag into Dolly near dorsal fin.

3.2 Spawning survey methods

Potential Dolly Varden spawning habitat occurs mostly in North Inlet Slate Creek and along the eastern shore of Upper Slate Lake (Figure 1). Suitably sized gravel for spawning and flow from inlet streams is present in these areas. Annual spawner surveys were conducted in October and November 2010 as in previous years with fish scanned for tags to provide information on any movement towards spawning areas. Dark-colored tannin-stained water in Upper Slate Lake prevents direct observation of the lakebed along the shore, therefore minnow trapping was used to capture and examine fish for signs of spawning coloration and milt production. Surveys were conducted by setting minnow traps near likely spawning areas, namely gravel beds at the mouth of small streams running into the east and north shores of Upper Slate Lake (Figure 1). A new design of minnow trap was adopted in 2008. The traps are made of soft ¼ inch mesh with flat openings that allow large fish to enter, but prevent them escaping. Spawning coloration was also recorded for fish captured during population surveys in July.

Five traps baited with salmon eggs were set near potential spawning areas on October 25, 27, 30 and on November 1 and 15 and left to soak overnight. Captured fish were anesthetized in a solution of MS222 (Tricanemethane Sulphonate), weighed to the nearest 0.1g and their total length measured to the nearest 1mm. Fish were also examined for any spawning coloration or milt production (Figure 8). The fish were allowed to recover in a container of aerated stream water and released back into the habitat from which they captured.

In addition to minnow trapping, nighttime snorkel surveys were conducted at the end of October to look for spawning fish. One survey was conducted by a diver equipped with dry suit, snorkel and mask in the first 200m of the north inlet stream. Two divers then conducted a second survey along the northeast shore of Upper Slate Lake. Areas of suitable spawning gravel were examined for signs of spawning and any fish encountered were observed for spawning activity.

3.3 Upper Slate Lake Estimate

The number of Dolly Varden in Upper Slate Lake was estimated using the same modified Petersen equations (Seber 1982) used for in previous studies by Ed Kline (2001, 2003):

$$N = (n_1 + 1) (n_2 + 1) / (m_2 + 1)$$

$$V = ((n_1{}^2) (n_2 - m^2) / (m_2 + 1)^2 (m_2 + 2))^{0.5}$$

Where N = population estimate, V = variance of estimate, n_1 = number of fish tagged during initial surveys, July 14 to 25 (184 fish tagged), n_2 = total number of fish captured during second survey, July 27-29 (137 total fish captured), m_2 = number of tagged fish recaptured July 27-29 (27 fish).

Using these equations, the population of Upper Slate Lake was estimated as 945.6 fish with a standard deviation of 29.7 and 95% confidence interval of 58.2 fish. The smallest Dolly Varden found during population estimation was 84mm and 4g. The smallest fish tagged was 117mm in total length. The largest fish found during surveys was 262mm and 136g.

Figure 7: Length-frequency histograms for fish captured during estimate.

3.4 Spawning Survey Results

The lengths and weights of Dolly Varden captured in Upper Slate Lake are presented in Appendix 1. Lengths and weights were used to calculate Fulton's condition factor (K) using the equation given in Anderson & Neumann (1996):

$$K = W/L^3 \text{ x } 10,000$$

W = weight in g; L = total length in mm

Table 3 summarizes the minimum and maximum lengths and condition factors of all Dolly Varden captured between July 14 and November 16 compared to spawners. The size distribution of fish captured is displayed in histograms in Figure 9. Only seven fish of the 345 Dolly Varden captured in July showed any spawning color, while 115 of the 342 captured in fall had spawning sign. Spawning signs included bright orange belly, bright red to orange spots (Figure 8), and milt production. The percentage of spawners captured increased from 0 to 6% in July to 33% on October 26, to 44% on October 28 and 52% on November 1 declining again to 24% on November 16.

The smallest fish captured with spawning sign was 151mm and 25.4g and the largest was 274mm and 133.4g. This was the largest fish ever recorded in the lake. Milt was found in two fish examined on October 26 and one on October 28.

	All Fish						
Date	# Captured	% spawn	min length	max length	mean K	min k	max k
7/14/10	32	6.3	125	182	0.876	0.736	1.144
7/23/10	81	4.9	96	262	0.884	0.764	1.192
7/25/10	85	0.0	106	247	0.874	0.623	1.192
7/27/20	62	1.6	84	250	0.876	0.675	1.156
7/29/10	52	0.0	109	215	0.852	0.630	0.999
10/26/10	45	33.3	94	267	0.850	0.682	1.333
10/28/10	50	44.0	102	248	0.843	0.700	0.940
11/1/10	29	51.7	112	220	0.811	0.666	0.960
11/2/10	185	29.7	97	274	0.863	0.640	1.049
11/16/10	33	24.2	104	249	0.829	0.674	0.993
	Spawners						
Date	# Captured		min length	max length	mean K	min k	max k
7/14/10	2		168	180	0.849	0.809	0.888
7/23/10	4		169	225	0.862	0.804	0.918
7/25/10	0						
7/27/20	1		162	162	0.899	0.899	0.899
7/29/10	0						
10/26/10	15		151	267	0.846	0.736	1.102
10/28/10	22		157	248	0.825	0.750	0.868
11/1/10	15		162	220	0.794	0.666	0.932
11/2/10	55		150	274	0.778	0.640	0.946
11/16/10	8		169	249	0.797	0.721	0.878

Table 3: Summary statistics for all captured fish and spawners.

Tag Number	7/14-7/25				7/27-7/29				10/25-10/28				11/1-11/2			
	Site	mm	g	color	Site	mm	g	color	Site	mm	g	color	Site	mm	g	color
1082					3	167	31.7	none					3	165	na	spwn
1761					5	146	22.8	none					1	149	23.7	pale
2409					3	156	28.8	none					3	177	na	pale
4089					3	132	17.3	none					3	137	na	none
4687	3	159	28.7	none									3	170	na	none
5000	9	160	29.1	none	8											
5003	1	161	30.3	none					2	161	31.4	pale				
5087	1	187	47.2	spwn					2	187	47	spwn	2	190	46.7	spwn
6465					8	161	29.7	none					2	170	35.1	none
9246	6	169	34.5	spwn												
23752	1	142	24.1	none	1				2	143	22.7	none	3	146	na	none
31179									2	155	29.1	none	3	165	na	none
34165	1	160	28.7	none					2	159	26.3	none	1	162	26.4	none
34846					2	142	23.5	none					3	143	na	none
35398	1	154	28.5	none	1											
35683	1	179	42.1	spwn									2	178	34.9	spwn
38997	5	171	37	none	5											
39847	9				9											
41221	1	134	17.6	none									2	136	21.1	pale
41471	1	169	34.3	none	1				PP	167	31	none				
41639					8	172	39	none	2	174	37.5	pale	1			
41766					2	167	34.9	none	2	169	32.6	spwn	1	169	32	spwn
42641	7	249	122	none									1	250	122.8	spwn
42851					2	167	34.8	none					3	180	na	pale
43157	9	187	48	none					2	186	50.7	spwn	2	189	51.1	spwn
43221	5	134	17.6	none	5											
43659	3	186	51.5	none					1	205	63.8	none	3	206	na	none
44594					3	135	18.8	none	2	138	20.3	none	3	145	na	none
44765	10	151	24.6	none					1	152	25.7	none	1	152	25.3	pale
45095					5	212	69.7	none	2	219	80.3	none	1	220	75.3	spwn
45581									2	167	34.2	none	3	180	na	none
15598									2	248	106.4	spwn				
46088	6	170	35.5	none	5											
47026	1	157	26.9	none					2	158	27.2	none	1	160	27	none
48066									2	164	29.3	spwn				
48249	7	174	41.7	none	6											
49799					6	122	15.2	none	1	131	16.9	none				
50765					8	167	35.8	none	1	166	30.5	spwn	1	162	30.8	spwn
51706					1	155	26.6	none					3	155	na	none
52224					3	167	34.8	none					3	166	na	none
53121													3	250	na	spwn
54266					2	157	26.7	none	2	156	24.7	eggs?				
55462	5	196	59.9	none	7				1	193	50.2	spwn				
55475	10	172	35.6	none	1											
56227	3	225	82	none									3	225	na	spwn
56362	3	175	38.7	none									3	179	na	spwn
56477	9	165	35.5	none												
56870					5	147	22.7	none	2	154	24.9	none	1	150	22.8	pale
56876	3	225	87.5	spwn									3	240	na	spwn
57713	1	165	32.6	none					1	163	28.5	none				
57766					1	182	42.9	none	2	181	34.1	pale	2	179	32.4	spwn
58002									2	173	33.4	none	3	173	na	none
58015									2	165	31.7	spwn				
58032													3	135	na	none

Table 4: PIT tag data July-November 2010.

A summary of fish movements and spawning color documented over time of 110 recaptured tagged fish is given in Table 4. PIT tags allow individual fish to be recognized and the color change of 35 fish was observed between July and October/November. Some fish were observed to change from no visible spawning color in July to pale colored spots in October then more vibrant color by November. Only sites 1, 2 and 3 were trapped in fall since spawning sites were thought to occur nearby. Only small movements of fish towards these areas was observed in fall with the majority of fish recaptured at the site they were originally tagged.

Most migrations were short with fish moving between adjacent sites (eg. site 1 to site 2) although twelve fish moved to sites 1 and 2 from sites 5, 7, 8, 9 and 10 (Figure 5). No migrations were observed towards sites 1, 2 or 3 from site 6. If fish move around the perimeter of the lake rather than across the middle this would be the longest distance to travel. Thirty-seven Dollys were captured at site 3 where the greatest amount of spawning gravel was observed during snorkel surveys. Twenty of these fish were captured here in July while sixteen moved there from sites 1 or 2 and one fish migrated from site 9. Only one fish captured at site 3 in mid-November was found to have a PIT tag therefore it is unknown where the majority (32 fish) came from. The lake had around ½ inch of ice by this time.

Figure 8: Dolly Varden in spawning colors: red spots, bright orange belly.

Tag Number	7/14-7/25				7/27-7/29				10/25-10/28				11/1-11/2			
	Site	mm	g	color	Site	mm	g	color	Site	mm	g	color	Site	mm	g	color
58037									2	171	34.7	spwn				
58051									2	184	43.8	pale	2	183	42.5	none
58057									2	185	44.9	spwn				
58055									1	145	21.4	none	1	145	20.6	none
58062									2	157	28.2	pale	1	156	26.1	spwn
58063													2	210	61.5	spwn
58065									2	151	25.4	spwn				
58089									2	146	24.3	none	1	145	24.2	none
58092									2	167	33	none	1	165	30.3	pale
58295	10	173	41.1	none	3				2	172	37.9	pale				
58373					8	156	28.5	none					1	161	31.2	pale
58592													2	173	34.4	spwn
58593					2	171	38.2	spwn	2	171	35.2	spwn	2	170	33.4	spwn
58751	5	154	37.1	none									2	155	24.8	none
58871					3	149	24.2	none					3	149	na	none
59077					3	176	37.4	none					PP	174	31.1	none
59611									2	178	55.1	spwn				
60430					3	167	34.2	none					3	166	na	spwn
60752					3	146	24	none					3	153	na	none
63997					3	162	32.1	none	2	166	35	none	2	165	na	spwn
66277	5	186	48.4	none	5											
67062	3	179	39	none									3	180	na	none
67265					3	141	18.7	none					3	150	na	spwn
67269	10	162	28.5	none	8											
67469					2	157	29.6	none					3	155	na	spwn
67719	3	154	28.5	none	3								3	154	na	none
83493													3	155	na	spwn
75558									1	267	138	pale	1	274	133.4	spwn
83614					4	187	50.4	none					3	193	na	none
83860	3	207	70.6	none	3								2	206	67.5	spwn
84375	3	242	121	Kline					2	244	107.8	spwn				
85138	9	190	47.5	none	9											
85740									1	174	34.6	spwn	2	174	34.1	spwn
85862					3	190	55.4	none					3	192	na	spwn
86248	3	161	33.3	none	1				2	160	28.3	pale	2	160	27.8	spwn
86521	3	180	41.8	none									3	177	na	spwn
86676					3	181	38.1	none	2	176	33.2	pale	3	178	na	none
86733													3	210	na	spwn
86995					2	146	22	none					3	150	na	none
87205					1	147	22.6	none	2	153	25.4	spwn				
87594	3	203	56.9	spwn									3	203	na	spwn
87866	9	168	32	none					2	167	28.5	spwn				
87877					2	232	94.4	none					2	230	87.8	none
87936					1	169	33.6	none	1	169	30.8	spwn	2	185	33.7	spwn
88650	6	174	41.5	none	5											
88926	1	143	21.2	none									2	147	24	none
90267					1	166	30.9	none	2	167	30.8	pale	1	168	34.7	spwn
90980	10	158	27.1	none	1				2	159	27	spwn	2	158	27.1	spwn
93243	9	159	20.6	none	9								3	155	na	none
93308	1	209	69.1	none					2	216	72.3	spwn				
94088	1	152	24.5	none					2	157	27.2	pale	1	159	27.3	spwn
94874	1	164	30.1	none									1	170	34.4	spwn
97518	3	164	33.5	none									3	162	na	none
97657	7	182	44.1	spwn	7											
99050													3	178	na	spwn
99766	6	166	32.9	none	5											

Table 4 continued.

The sizes of recaptured fish were recorded making it possible to examine changes in length and weight over time, though it was apparent that some errors in measurement of 1-2mm and 1-2g likely occurred. Some fish appeared to grow in size between summer and fall rather than spawning since the fish that showed the greatest increases in length and weight had no spawning color by November (Table 4). The fish with tag #43659 was 20mm longer in November, but still had no spawning color. Similarly, #6465 was 9mm longer and 5.4g heavier in November, but also showed no spawning color. Some fish in spawning colors appeared to lose a little weight between summer and fall. The fish with tag number 58593 appeared to lose 5g between July and November.
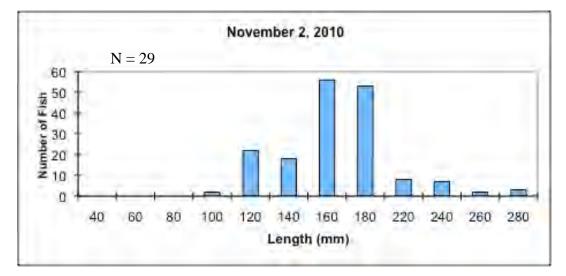
Figure 9: Length-Frequency Histograms of fish captured during spawning surveys.
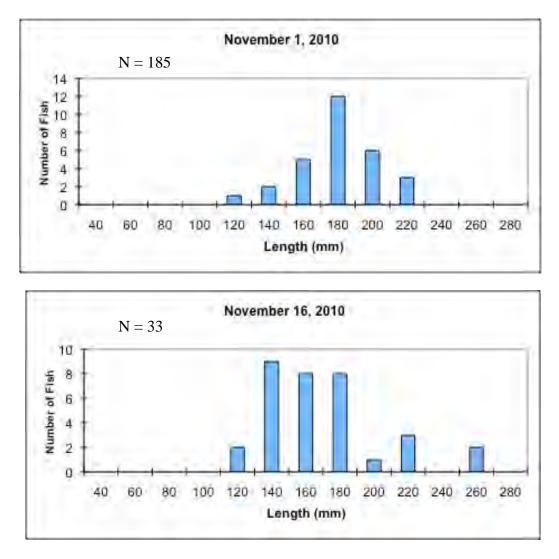
Figure 9: Length-Frequency Histograms continued.

The nighttime snorkel surveys of October 26 and 28 did not discover any spawning fish. The greatest amount of spawning gravel was observed around the inflow of the north inlet creek and a group of eight Dolly Varden was observed here. Twelve more dollys and several threespine stickleback were observed sitting by themselves as individual fish rather than as a group along the northeast shore of the lake. Only a few small dollys were observed in the north inlet with one larger dolly resting in a larger pool at 150m upstream from the lake. No spawning activity was observed during either survey.

3.5 Population estimate and spawning survey discussion

The population estimate made in 2010 was lower at 945 fish +/-58 than the estimate made in 2003 at 1378 fish +/- 300 fish. Given the lower confidence of the earlier estimate, the two estimates are fairly similar. There is likely natural variability in the population size from year to year as well as variability in the eagerness of fish to enter traps, which affects estimates made. The age of fish present in Upper Slate Lake has not been examined. Dolly Varden seldom live longer than 8-10 years, unless their diet includes kokanee (landlocked sockeye salmon) which can increase their lifespan to 19 years (Armstrong 1991). Van Alen (1983) reported Dolly Varden of 14 years in a Southeast Alaska lake where kokanee were present, but these were over 550mm in length whereas the largest fish found in Upper Slate Lake was 274mm. The presence of three-spine stickleback (*Gasterosteus aculeatus*) might increase Dolly Varden life span beyond 10 years, but no studies have been conducted to determine age. Two fish were captured in July 2010 that had been tagged in 2003 suggesting they were at least 10 years old since the smallest fish tagged in 2003 was likely already 3 years old.

The overall percentage (33.7%) of spawning fish captured in 2010 was the same as 2009 and greater than in 2008 (19.3%) or 2007 (12.2%). This is likely due to the sites now targeted for capturing spawners. The north end of the lake appears to yield more spawners than the south end presumably due to the proximity of spawning habitat at the north end. The marked increase in spawning fish found from July to October is in agreement with other studies that found Dolly Varden spawn in fall (Armstrong 1965, Armstrong & Morrow 1980, Blackett 1973, Heiser 1966).

There was some suggestion that spawning fish lost weight between summer and fall and this would likely be the case due to cessation of feeding during spawning. Eggs can also comprise a substantial amount of total body weight that is shed when eggs are deposited.   If it is assumed that fish with spawning coloration actually spawn, then a wide size range of fish are capable of spawning. The size of spawners did not appear to vary much over time. A large range in size of spawners was noted even in July when only 7 fish out of 345 fish showed spawning sign. The size range of Dolly Varden spawners was similar in 2010 (150-274mm) to previous years. Van Alen (1983) found evidence from the Indian Lake system in southeast Alaska that Dolly Varden males only

spawn every 2 years. This would explain why many fish are captured without showing any spawning colors, despite capturing fish of spawning size. Some fish of course are too young yet to spawn and around 60 of the 185 fish captured on Nov 2 (33%) were too small to be spawning. It will be interesting to see if any tagged fish that did not show signs of spawning in 2010 will show any sign in 2011. The fact that some fish that had no spawning colors showed some growth, while fish with spawning colors showed no growth or even slight weight loss suggests that energy may be put towards either spawning or growth, but seldom both at the same time. Reproduction likely consumes considerable energy that may temporarily prohibit any gains in body size.

Fish movement toward suspected spawning sites was not greatly apparent from the recapture of tagged fish, but a large proportion of the fish captured at site 3 in mid-November did not have tags suggesting they perhaps came from deeper water than was surveyed in July. Dollys may also move towards the north inlet to take advantage of greater dissolved oxygen here after the lake becomes iced over, as well as seeking suitable sites for spawning.

Summary

Fish passage trials showed that fish could pass down the diversion pipe mostly unscathed at low to moderate flows, but more trials are needed to show safe fish passage at higher flows, which is when most fish are likely to move down the pipe. Fifteen fish (two with tags from USL) came down the pipe in fall 2010.

A mark-recapture population estimate of Dolly varden in Upper Slate Lake found 945 fish (+/- 58). This was lower than the 2003 estimate of 1378 fish, but also more precise. Only a handful of fish showed any spawning color in July, but the presence of tags allowed observation of color change in individual fish in fall. Tagged fish showed limited movement towards the north tributary from the eastern shore where gravel appears most suitable for spawning, and a high proportion of untagged fish were captured there in mid-November. About 1/3 of fish captured were too small to spawn yet and of the remaining fish, about half showed spawning colors. This proportion appears similar to previous years.

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Appendix 1: Length, weight, condition and spawning color of Dolly Varden captured during 2010.

Upper Slate Lake	10/26/10		Dolly Varden					
Spawning Coloration	Tag number	New tag	Length (mm)	Fork Length	Weight (g)	K	mean	0.850
pink spots, no milt	75558	new	267	256	138	0.823	ST dev	0.104
none	43659	recap	205	195	63.8	0.860	n	45
none	57713	recap	163	157	28.5	0.736	95% CI	0.030
few red spots, milt	85740	recap	174	164	34.6	0.784	min k	0.682
few orange spots, female	87936	recap	169	160	30.8	0.752	max k	1.333
pale pink spots	87205	recap	154	146	25.4	0.816	# spawners	15
none	49799	recap	131	126	16.9	0.845	% spawners	33.3
red spots, no milt	5087	recap	187	170	47	0.957	min L	94
none	31179	new	155	155	29.1	0.781	max L	267
orange belly, no milt	86248	recap	160	152	28.3	0.806		
pale spots, no milt	90267	recap	167	157	30.8	0.796		
pale spots, no milt	5003	recap	161	153	31.4	0.877		
no color, swollen w/eggs?	54226	recap	156	149	24.7	0.747		
none	58005	new	137	129	18.3	0.852		
none	none	too small	111	105	9.8	0.847		
none	none	too small	94	87	6.3	0.957		
none	none	too small	111	105	9.1	0.786		
none	none	too small	104	100	8.2	0.820		
bright orange belly, milt	84375	recap	244	235	107.8	0.831		
pale orange spots	none	tag rejected	233	195	67.7	0.913		
none	39871	new	154	146	28.4	0.913		
none	58080	new	136	127	27.3	1.333		
orange spots	43157	recap	186	180	50.7	0.869		
red spots	58593	recap	171	162	33.8	0.795		
pale spots	57766	recap	181	171	34.1	0.682		
red spots	59611	new	178	171	55.1	1.102		
none	none	tag rejected	167	156	36	0.948		
none	49743	new	182	171	37.6	0.752		
red spots, no milt	41766	recap	169	160	32.6	0.796		
none	58021	new	143	136	20.1	0.799		
none	no number	new	164	147	30.2	0.951		
none	45581	new	167	157	34.2	0.884		
orange spots	90980	recap	159	149	27	0.816		
none	58092	new	167	157	33	0.853		
none	58029	new	164	154	32.1	0.879		
red spots	48066	new	164	153	29.3	0.818		
orange spots	87866	recap	167	157	28.5	0.736		
orange spots	58065	new	151	143	25.4	0.869		
orange spots	58037	new	171	162	34.7	0.816		
pale orange spots	45536	new	161	151	27.9	0.810		
pale orange spots	94088	recap	157	147	27.2	0.856		
none	58046	new	122	117	13.4	0.837		
none	none	tag rejected	119	113	12.5	0.866		
none	none	too small	101	96	7.8	0.882		
none	none	too small	113	107	9.7	0.792		

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Upper Slate Lake	10/28/10		Dolly Varden		Date:			
Spawning Coloration	Tag number	New tag	Length (mm)	Fork Length	Weight (g)	K	mean	0.843
vibrant red spots	50765	recap	166	156	30.5	0.803	ST dev	0.050
vibrant red spots	55462	recap	193	184	50.2	0.806	n	50
pale orange spots	58062	new	157	149	28.2	0.852	95% CI	0.014
pale orange spots	94088	recap	157	147	27.1	0.853	min k	0.700
pale pink spots	86248	recap	160	150	28	0.830	max k	0.940
pale orange spots	43157	recap	187	177	49.6	0.894	# spawr	22
none	none	no tag	126	117	14.5	0.905	% spaw	44.0
none	none	no tag	134	127	17	0.830	min L	
none	none	no tag	111	105	10.3	0.890	max L	
pale spots	87866	recap	166	156	30.6	0.806		
none	44765	recap	152	144	25.7	0.861		
pale orange spots	90980	recap	159	150	27.4	0.812		
none	58089	new	146	138	24.3	0.925		
none	58055	new	145	136	21.4	0.851		
pale orange spots	58063	new	207	196	64.7	0.859		
pale orange spots	41639	recap	174	164	37.5	0.850		
pale orange spots	none	tag rejected	187	175	47.8	0.892		
none	23752	recap	143	136	22.7	0.902		
none	none	tag rejected	142	135	19.1	0.776		
vibrant red spots, orange belly, milt	45598	new	248	233	106.4	0.841		
orange spots, no milt	93308	recap	216	205	72.3	0.839		
none	45095	recap	219	208	80.3	0.892		
none	63997	recap	166	155	35	0.940		
none	none	too small	121	114	13.2	0.891		
red spots, orange belly	58057	new	185	175	44.9	0.838		
none	47026	recap	158	149	27.2	0.822		
none	90267	recap	166	156	32.3	0.851		
orange spots, no milt	none	no tag	157	149	24.8	0.750		
none	45584	new	179	172	43	0.845		
red and orange spots, orange belly	58015	new	165	154	31.7	0.868		
red spots	58593	recap	171	162	35.2	0.828		
none	none	no tag	132	125	16.6	0.850		
none	none	no tag	133	126	18.2	0.910		
few pale orange spots	58051	new	184	176	43.8	0.803		
none	none	no tag	162	155	30.4	0.816		
two orange spots	58295	recap	172	164	37.9	0.859		
few pale orange spots	85740	recap	174	162	33.4	0.786		
none	54226	recap	156	147	24.2	0.762		
none	none	no tag	153	141	25	0.892		
pale spots	86676	recap	176	168	33.2	0.700		
none	58002	new	173	162	33.4	0.786		
none	44594	recap	138	131	20.3	0.903		
orange spots, no milt	87205	recap	153	145	25.4	0.833		
none	none	no tag	158	149	25.5	0.771		
none	none	no tag	102	98	8.3	0.882		
none	none	no tag	111	105	9.8	0.847		
none	none	no tag	114	108	11.4	0.905		
orange spots, no milt	none	no tag	179	170	41.4	0.843		
none	34165	recap	159	151	26.3	0.764		
none	56870	recap	154	145	24.9	0.817		

Plunge Pool	Spawning	Tag		Length (mm)	Weight (g)	k
28-Oct	orange belly	none		172	31.9	0.627
	pale orange spots	none		167	35	0.751
	eggs in belly	none		164	31	0.703
	none	41471	recap	167	31	0.666
29-Oct	none	none		134	15.7	0.653
	none	none		169	31.1	0.644
	none	none		167	35.5	0.762
	none	none		164	28	0.635
	orange spots	none		173	32.4	0.626
1-Nov	orange belly, orange spots	none		188	42.8	0.644
	none	59077	recap	174	31.1	0.590
18-Nov	none	none		134	14.9	0.619
	none	none		154	22.3	0.611
	red spots	none		165	29.6	0.659
	none	none		166	30.1	0.658

Upper Slate Lake	11/1/10			Dolly Varden					
Spawning Coloration	Tag number	New tag	Length	Fork Length	Weight (g)	K		mean	0.81081822
vibrant red spots, orange belly	none		220	210	70.8	0.764	ST dev	0.07710716
pale orange spots	none		185	175	44.6	0.832	n	29
none	none		133	125	17.2	0.881	95% CI	0.02806363
pale orange belly, orange spots	43157	recap	189	180	51.1	0.876	min k	0.66612245
some red spots	none		162	155	32.6	0.875	max k	0.96040055
red spots	50765	recap	162	156	30.8	0.811	# spawners	16
none	none		112	105	10.2	0.881	% spawners	55.1724138
orange spots	90267	recap	168	155	34.7	0.932	min L	
pale orange spots	58021	recap	141	135	19.5	0.793	max L	
none	34165	recap	162	153	26.4	0.737		
orange belly	none		189	176	45.3	0.831		
none	88926	recap	149	140	23.8	0.867		
pale orange spots	41221	recap	136	130	21.1	0.960		
red orange spots	87936	recap	185	175	35.7	0.666		
none	none		168	160	31.8	0.776		
orange spots, pale orange belly	none		165	158	32	0.811		
vibrant red spots, orange belly	58592	recap	173	163	34.4	0.794		
some orange spots	90980	recap	158	145	27.1	0.889		
orange spots	85740	recap	174	165	34.1	0.759		
pale orange belly, orange spots	57766	recap	179	171	33.4	0.668		
none	58051	recap	183	173	42.5	0.821		
none	47026	recap	160	155	26	0.698		
orange belly	86248	recap	172	162	28.8	0.677		
pale orange belly, orange spots	45095	recap	220	210	75.3	0.813		
orange spots	83860	recap	206	196	67.5	0.896		
red spots, orange belly	5087	recap	190	180	46.7	0.801		
pale orange belly, orange spots	63997	recap	165	159	34.8	0.866		
none	none		156	147	25.6	0.806		
red spots, orange belly	35683	recap	178	168	34.6	0.730		

Upper Slate Lake	11/18/10	Dolly Varden		Date:				
Spawning Coloration	Tag number	Length (mm)	fork Length	Weight (g)	K		mean	0.829
none	none	184	175	47.5	0.886	ST dev	0.076
orange spots	none	174	166	39.1	0.855	n	33
orange spots	none	209	199	61.2	0.777	95% CI	0.026
none	none	125	115	15.1	0.993	min k	0.674
none	none	124	114	14.6	0.985	max k	0.993
none	none	132	125	16.2	0.829	# spawner	8
orange spots	none	169	159	35.3	0.878	% spawne	24.2
none	none	139	129	20.1	0.936	min L	104
none	none	158	150	25.6	0.759	max L	249
none	none	133	125	17.1	0.876		
orange spots	none	206	195	62.4	0.842		
none	none	136	128	18.5	0.882		
none	none	158	150	29.3	0.868		
red on fins	none	178	169	37.5	0.777		
none	none	142	134	21.2	0.881		
none	none	164	155	31.5	0.846		
none	none	137	128	17.4	0.830		
none	none	113	105	8.5	0.734		
none	none	104	97	7.5	0.822		
none	none	180	172	38.1	0.749		
none	none	144	135	20.8	0.845		
none	none	162	154	31.3	0.857		
none	none	151	149	22.3	0.674		
none	none	122	114	13.3	0.898		
none	none	204	195	51.4	0.693		
none	none	154	145	24.2	0.794		
none	none	130	122	15.8	0.870		
vibrant red	53121	249	241	104.5	0.747		
vibrant red	none	249	239	106.3	0.779		
none	none	153	143	25.8	0.882		
red spots	none	169	161	30.1	0.721		
none	none	144	139	23	0.856		
none	none	167	158	29.5	0.748		

Upper Slate Lake	11/2/10	Dolly Varden		Date:				
Spawning Coloration	Tag number	Length (mm)	Fork length	Weight (g)	K	mean	0.80333672	
orange belly, red spots	none	230	220	68.2	0.640	ST dev	0.0764022	
orange belly, orange spots	42641	250	235	122.8	0.946	n	184	
pale orange spots	44765	152	145	22.8	0.748	95% CI	0.01103939	
pale orange spots	87936	170	160	32.3	0.789	min k	0.64049587	
pale orange spots	56870	150	145	22.8	0.748	max k	1.04897452	
none	none	157	150	24.2	0.717	# spawners	55	
none	none	155	149	24.8	0.750	% spawners	29.8913043	
none	58089	145	135	24.2	0.984	min L	97	
orange spots	83860	205	195	64.2	0.866	max L	274	
orange belly, orange spots	41639	185	175	37.3	0.696			
none	66440	160	151	28	0.813			
none	none	170	162	31.7	0.746			
none	none	102	97	7.7	0.844			
pale orange spots	none	140	124	20	1.049			
none	none	120	115	13.3	0.874			
none	none	119	113	11.4	0.790			
pale gold belly & spots	none	209	200	63.3	0.791			
red spots, orange belly	5087	190	181	46.2	0.779			
orange and red spots	94874	170	160	34.4	0.840			
orange spots	35683	178	169	34.9	0.723			
orange spots	none	178	170	36.8	0.749			
red spots, orange belly	85740	175	165	32.8	0.730			
none	none	150	141	22.4	0.799			
red spots, orange belly	41766	169	160	32	0.781			
none	none	156	149	23.9	0.723			
pale orange spots, some red	58062	156	150	26.1	0.773			
none	none	115	110	9.7	0.729			
none	none	160	150	28	0.830			
red spots, orange belly	75558	274	260	133.4	0.759			
none	58021	142	135	18.8	0.764			
none	47026	160	151	27	0.784			
none	88926	147	137	24	0.933			
red spots, orange belly	none	170	164	35.1	0.796			
none	58055	145	136	20.6	0.819			
slight orange belly	86248	160	154	25.6	0.701			
none	none	180	170	34.6	0.704			
orange belly, gold spots	none	188	180	42.4	0.727			
orange spots	90267	167	160	31.9	0.779			
orange belly, gold spots	94088	159	150	27.3	0.809			
pale gold belly & spots	1761	149	142	23.7	0.828			
none	none	109	104	8.3	0.738			
none	45095	220	210	75.5	0.815			
pale orange spots	58092	165	159	30.3	0.754			
few orange spots	58373	161	152	31.2	0.888			
orange spots, gold belly	57766	178	170	35.6	0.725			
none	memory full	168	160	30	0.732			
orange spots	memory full	165	155	28.1	0.755			
none	memory full	110	104	8.8	0.782			
pale orange spots	memory full	181	171	41.2	0.824			
some red spots	memory full	164	157	30.2	0.780			
none	memory full	131	125	17.3	0.886			
orange and red spots	memory full	158	150	29.1	0.862			
none	memory full	164	156	31.2	0.822			
few red spots	memory full	160	152	28.4	0.809			
none	memory full	115	110	12	0.902			
none	memory full	167	157	31.2	0.806			
orange and red spots	memory full	158	148	27	0.833			
red spots, orange belly	memory full	167	159	30.5	0.759			
none	memory full	120	115	12.8	0.842			
none	memory full	120	113	12.9	0.894			
none	memory full	120	114	13.5	0.911			
red spots, orange belly	58593	170	160	33.4	0.815			
pale gold belly & spots	none	190	180	53	0.909			
none	6465	170	163	35.1	0.810			
none	87877	230	220	87.8	0.825			
none	5003	160	152	31.4	0.894			
none	58751	155	145	24.8	0.813			
orange spots	58063	210	198	61.5	0.792			
orange spots	none	228		na				
none	none	163	155	na				
none	none	138		na				
none	none	118		na				
none	none	149		na				
orange and red spots	53121	250		na				
red spots, orange belly	none	240		na				
red spots, orange belly	56277	225		na				
none	43659	206		na				
red spots, orange belly	none	165		na				
none	none	145		na				
pale orange spots	42851	180		na				
none	58032	135		na				
none	none	129		na				
none	none	115		na				
none	none	142		na				
none	none	170		na				
none	58000	173		na				
orange and red spots	none	173		na				
none	none	142		na				
none	none	130		na				
orange spots, gold belly	86733	210		na				
pale orange spots	none	183		na				

Upper Slate Lake	11/02/10	Dolly Varden
Spawning Coloration	Tag number	Length (mm)
none	44594	145
pale orange spots	none	175
pale orange spots	none	144
none	none	125
none	none	163
none	31179	165
none	none	115
none	none	110
vibrant red spots &belly	none	227
vibrant red spots &belly	none	180
bright orange spots	none	166
none	none	165
pale gold belly & spots	83276	170
pale gold belly & spots	2409	177
orange spots	67265	150
none	none	150
none	none	124
none	none	97
vibrant red spots &belly	none	273
orange belly, orange spots	none	183
none	86676	178
none	none	129
orange spots	67469	155
none	none	165
orange spots	none	170
red spots, orange belly	none	173
orange spots	1082	165
orange spots, gold belly	56362	179
none	none	150
none	none	130
none	none	107
vibrant red spots &belly	56876	240
none	none	269
none	none	190
none	none	155
none	none	157
none	86995	150
none	none	110
vibrant red spots &belly	none	189
none	4687	170
none	83614	193
none	none	150
vibrant red spots &belly	85862	192
none	none	164
none	none	155
none	93243	155
none	51706	155
none	none	160
none	none	155
orange spots	86521	177
none	58871	149
none	none	136
none	4089	137
none	none	125
none	none	127
none	none	102
orange spots	none	160
none	none	170
red spots	none	179
none	none	147
none	none	123
none	none	185
none	none	146
orange spots	none	174
bright orange spots	none	220
none	67062	180
none	97518	162
none	67719	154
none	none	139
none	none	130
none	none	114
none	none	97
red spots, orange belly	none	185
none	none	145
orange and red spots	83493	155
orange and red spots	60430	160
none	none	167
none	none	152
none	23752	146
none	none	125
none	34846	143
none	none	104
none	none	110
none	none	158
none	none	120
none	45584	180
none	52224	166
none	60752	153
none	none	112
orange spots	99050	178
bright orange spots	87594	203
none	none	154
none	none	149