TECHNICAL REPORT NO. 08-04

FAIRBANKS CREEK MINE REHABILITATION PROJECT, ARCTIC GRAYLING POPULATION ASSESSMENT AND WATER QUALITY INVESTIGATIONS, 2007

by William Morris
Nancy Ihlenfeldt

Pond A, looking upstream. Photo by William Morris, ADNR OHMP

April 2008

Alaska Department of Natural Resources Office of Habitat Management and Permitting

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Acknowledgements

We thank Jim Thurman for his efforts to reclaim and improve fish habitat in this area of Fairbanks Creek. Jim has provided access to the area for our sampling, continues to support our efforts and continues to take great interest in the health of the Arctic grayling population in the reclaimed area. Jack Winters (Alaska Department of Natural Resources, Office of Habitat Management and Permitting) and Audra Brase (Alaska Department of Fish and Game, Sport Fish Division) provided review and comment on this summary report. Al Ott provided assistance during several field sampling events and provided comments on the report.

Introduction

In May 2006, a placer miner operating on Fairbanks Creek rerouted the creek to flow through a series of six ponds left behind from old mine cuts and settling ponds. The upstream-most three ponds were rehabilitated to improve the ponds for fish habitat (Figure 1). Fairbanks Creek is located approximately 30 miles north west of Fairbanks, Alaska and just west from the Fort Knox Gold Mine. The pond margins were voluntarily contoured and islands and littoral habitats were created to varying degrees in all ponds in late 2005. Some large woody debris were also added to the ponds during late fall 2006. Connection channels were constructed between the ponds and allowed to stabilize to the natural flow regime of the creek. Appendix A contains photographs of the ponds and connection channels in 2006 and 2007. The intention of this rehabilitation work was to provide enhanced habitat for the isolated population of Arctic grayling (*Thymallus arcticus*) residing within this reach of the creek. The Fairbanks Creek area has experienced extensive placer mining activity since the early 1900's and, at some point in the 1950's, a dredge left enough tailings in the Fairbanks Creek drainage to force the creek subsurface for about 3km before it reaches the remainder of the Chena River watershed (Ott and Townsend, 1996). Surface flow from upper Fairbanks Creek and its Arctic grayling population have been isolated from the Chena River drainage for at least 50 years. The population of Arctic grayling has survived even with minimal feeding habitat and very limited wintering habitat. This survival is likely due to their tendency to decrease the size of individuals within a population over time as food and space become limited.

In fall 2006, fyke nets were fished in the upper three ponds to evaluate the Arctic grayling population. Fish were also caught with seines in an isolated reach of stream destined to be filled in during mining, and relocated to the ponds. Most fish handled during this sampling event were marked with individually numbered Floy® T-bar anchor tags and released after measuring. These marked fish were considered our initial measurement of population structure as described in Morris and Ihlenfeldt (2006) as well as an initial mark with which to compute a preliminary abundance estimate during 2007. This report, the first in what is planned to be an annual series, summarizes Arctic grayling and water quality data collected during 2007 at the Fairbanks Creek Mine.

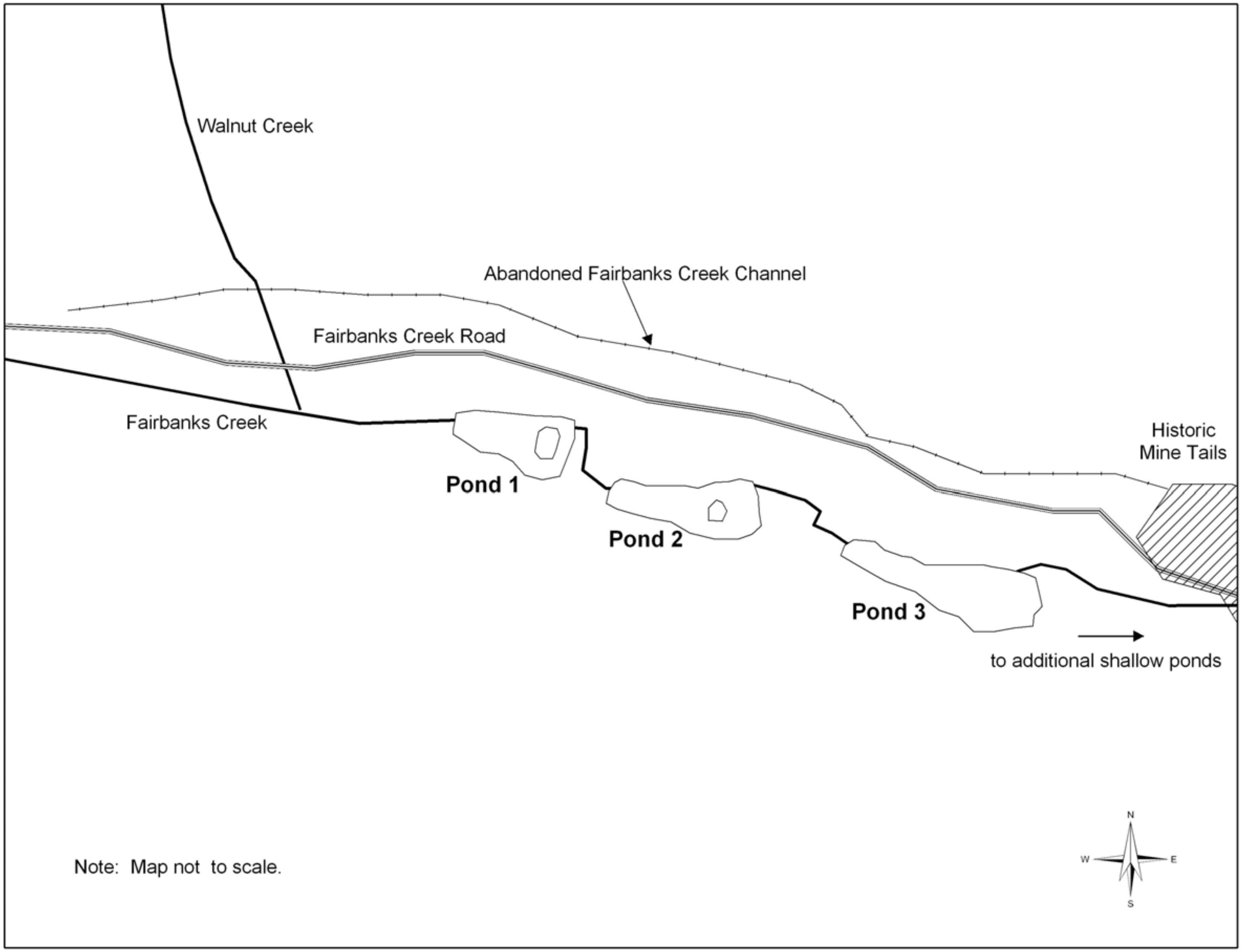

Figure 1. Map of project area.

Methods

Water Quality

In 2007, temperature (°C), dissolved oxygen concentration (mg/L), dissolved oxygen percent saturation, pH, specific conductance (*u* S/cm), oxidation reduction potential (mV), and depth (m) were measured at 0.5 meter intervals at Pond 1, Pond 2 and Pond 3. A Hydrolab® MiniSonde® 5 water quality multiprobe connected to a Surveyor® 4a water quality display/datalogging unit was used to collect and record all data.

On April 5, water quality data were collected at two of the three rehabilitated ponds within the Fairbanks Creek project area. Data were collected at one site each in ponds 1 and 2. Access to Pond 2 was limited while access to Pond 1 was good. Pond 3 was inaccessible and no water quality data were collected there.

On June 27, water quality data were collected at all three ponds. A canoe was used to access all sampling locations. Water quality data were collected at two sites in Pond 1, one site in Pond 2 and two sites in Pond 3.

Hobo® Water Temp Pro v2 temperature recorders were deployed in the inlet and outlet of Pond 1, the inlet of Pond 2 and the inlet of Pond 3 on May 10. The temperature loggers were configured to record water temperature once every 30 minutes. All data loggers were successfully retrieved on September 26.

Fish Sampling

In 2007, fyke nets were used to capture Arctic grayling in all three ponds between May 8 and May 25. Nets were set in two basic configurations but were always set associated with the inlet and outlet to each pond. One set type blocked the entire channel and was set to capture fish moving in one direction only, either moving upstream or moving downstream. The second configuration was set to capture fish as they were moving in either direction and also blocked the creek. Table 1 provides set details for each sample site. Nets were set on May 8 at the outlet to Pond 1; and the inlets to ponds 2 and 3. On May 16, a second net was added at the Pond 3 outlet. Second nets were also set on May 18 at the Pond 1 inlet, and on May 23 at the Pond 2 outlet. Nets were checked at intervals between 24 and 72 hours depending on observed catch rates and water temperatures. All fish captured were measured to the nearest millimeter fork length (FL), inspected for existing tags, and released. Tags on previously tagged fish were cleaned, read and recorded. Fish over 175 mm and not previously tagged were tagged with an individually numbered FLOY® T-bar anchor tag and released. All nets were checked and removed on May 25.

On June 27, the ponds and channels were visually inspected for the presence of Arctic grayling fry. In addition, hook and line sampling was attempted for a total of three hours; two hours at Pond 2 and one hour at Pond 1. Fish captured with angling techniques were measured to the nearest millimeter FL and inspected for an existing tag. Fish greater than 175 mm and not previously tagged were implemented with an individually numbered FLOY® T-bar anchor tag and released. Tags on previously marked fish were cleaned and the number recorded prior to release of the fish.

Fish captured in May were used to calculate a population estimate based on recaptures of fish from Fall 2006 as well as to compare the overall population structure between 2006 and 2007. Chapman’s modification of the Lincoln Peterson estimator was used. Fish captured in June, via angling, were not included in the mark recapture estimate. Data gathered from these fish were used solely to look at growth over the relatively short period between May and late June 2007.

Results

Water Quality

In April 2007, severe aufeis and overflow conditions were encountered and prevented safe access to Pond 3 (furthest downstream pond in the project), as the moat around the pond exceeded 2 feet deep (Morris and Ihlenfeldt 2007). Ice around the margins of the pond was grounded. Ice sagged into the pond approximately 2 feet; indicating the pond had continued to drain after freeze-up and had lost approximately 2 feet of water since the onset of winter (Photograph 1).

We could only access an area of Pond 2 that was approximately 2.25 meters deep because of overflow. Ice sagging, as observed at Pond 3, appeared less significant at Pond 2. At the sampling location for Pond 2, the ice thickness was between 24 and 30 inches and about 6 inches of overflow water was present above the ice (Photograph 2). Surface water influx into the sampling hole occurred throughout sampling. Pond 1 was fully accessible and little overflow had covered the pond (Photograph 3). Significant aufeis was present on the margins of the pond but surface flow was minimal. The pond was covered with approximately 42 inches of ice and the water surface was about 2 inches below the ice surface in the sampling hole, although approximately 1 inch of surface water was present on top of the ice. Surface water flow into the hole was minimal as most water was being contained in the snow. The site selected for water quality analysis at Pond 1 was 4 meters deep.

Water quality data collected at Pond 2 were probably influenced by the influx of surface water; however, when compared to data collected from Pond 1, it appears that the influence may have been minimal. Dissolved oxygen concentration remained above 7.00 mg/L at all depths sampled and all other parameters investigated were adequate for fish survival. Specific conductance values were relatively high for fresh surface water suggesting a strong ground water component to the system.

Water quality data collected at Pond 1 indicated that the pond provides viable fish overwintering habitat. Dissolved oxygen concentrations remained above 7.00 mg/L at all depths sampled. Specific conductance data suggested significant ground water input, similar to that observed in Pond 2. The temperature in a significant portion of the water column at Pond 1 was recorded at between 0.0 and -0.1^{o} C. However, the accuracy of the temperature probe used was +/- 0.1^{o} C so it is our interpretation that, while the water was indeed cold, it was slightly above freezing at all depths. All data collected at ponds 1 and 2 in April 2007 are summarized in Figure 2.

Photograph 1. Pond 3 had lost a minimum of 2 feet of water since freeze-up and was largely inundated with overflow water at the time of our attempt to conduct water quality sampling, April 5, 2007.

Photograph 2. Pond 2 was covered by approximately 6 inches of overflow water but was more accessible than Pond 3, April 5, 2007.

Photograph 3. Pond 1 was fully accessible and showed signs of significant aufeis production from the north facing slopes, April 5, 2007.

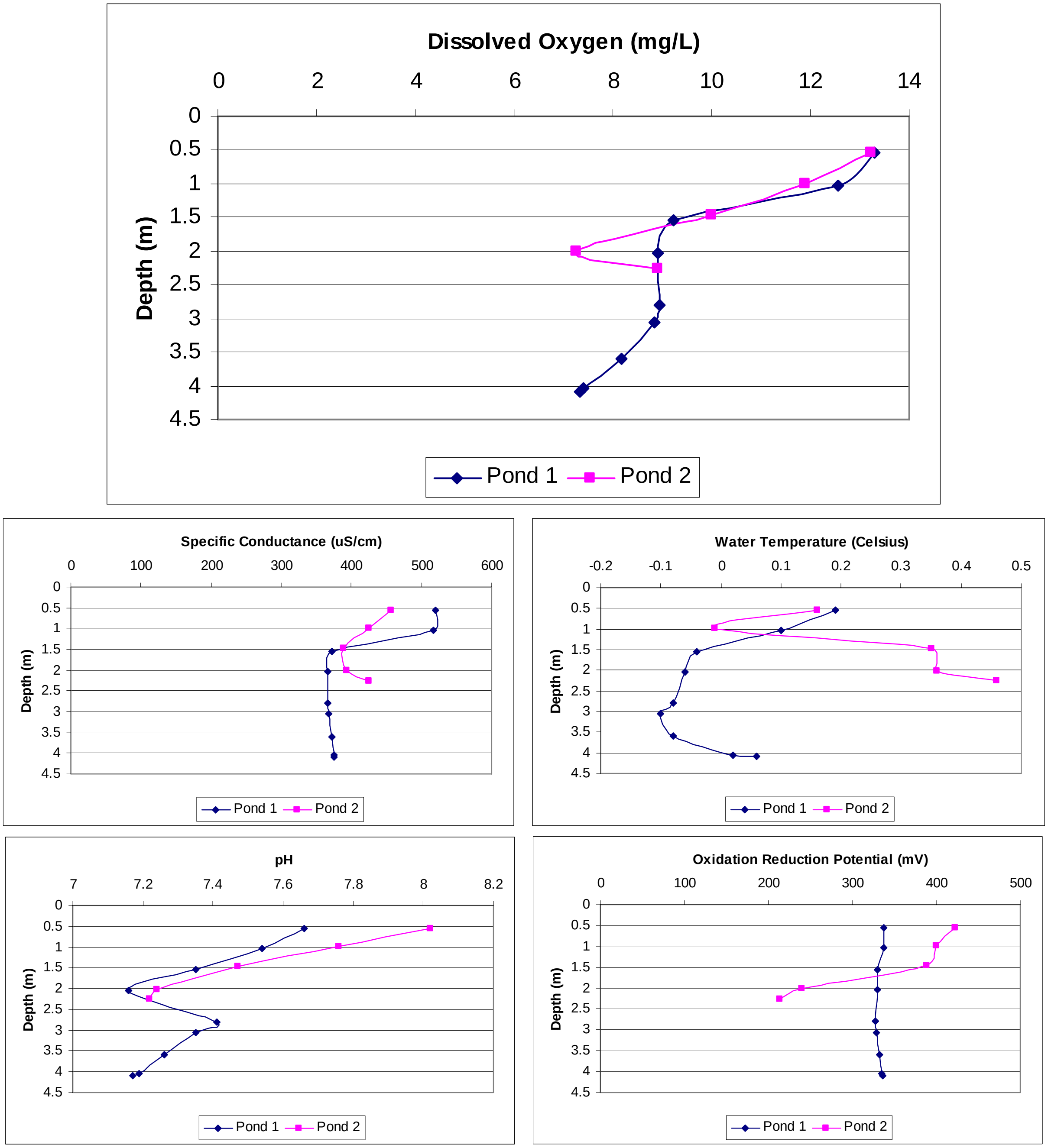

Figure 2. Summary of water quality data collected at all ponds, April 5, 2007, Fairbanks Creek Mine, Alaska.

On June 27, 2007 the sample sites were accessed with a canoe and water quality data were collected from near the deepest area of each of the three ponds within the project area. The weather was cool and raining at the onset of sampling (Pond 1) but became sunny and warm by the end of sampling (Pond 3).

Dissolved oxygen (DO) concentrations were near or above saturation at all ponds throughout the water column (Figure 3). As the afternoon progressed, DO concentrations continued to rise and by the time Pond 3 was sampled, the water column at the deepest location in the pond ranged from 101% to 110% saturated. We moved to a shallow area of Pond 3 and found that DO saturation was 106% at the surface and increased to approximately 120% saturated at 1 meter of depth, at the bottom. Algal masses on the benthos were observed actively giving off oxygen throughout the shallow area.

Pond 1 DO concentrations ranged from about 10.6 to 10.3 mg/L and were relatively uniform throughout the 4.5 m deep water column (Figure 3). Specific conductance was indicative of a predominantly surface water source and ranged from 226 to 214 µS/cm throughout the water column; considerably lower than recorded during April (Figure 2, Figure 3). Water temperatures ranged from about 11.2^{o} C to 10.2^{o} C and cooled slightly with increasing depth. pH was basic throughout the water column and ranged from 8.16 at the surface to 7.87 at the bottom. Figure 3 summarizes water quality data collected at the deepest site in all ponds.

Pond 2 DO concentrations ranged from 10.15 to 10.27 mg/L throughout the water column with no discernable pattern from the surface to the bottom at 2.26 m (Figure 3). Specific conductance was slightly lower throughout the water column than observed at Pond 1, and ranged from 213.1 to 214.3 µS/cm, with no discernable pattern with depth. Similar to results from Pond 1, specific conductance values were considerably lower in June at Pond 2 than under the ice in April (Figure 2, Figure 3). Water temperatures decreased with depth from a surface water high of 13.3^{o} C to a low of 11.6^{o} C at the bottom. The entire water column was basic with pH hovering around 8.00 for most of the water column.

Pond 3 DO concentrations were above saturation at all sample depths and ranged from 10.83 to 10.28 mg/L (Figure 3). The maximum depth was 2.44 m and no relationship between DO and depth was observed. Specific conductance was between 208.2 and 209.9 µS/cm throughout the water column and was the lowest of the three ponds. pH was basic, ranging from 8.17 at the surface to 8.05 at the bottom and was slightly higher by depth than in ponds 1 and 2. Water temperatures were the most variable at Pond 3 and ranged from 16.7^{o} C at the surface to 13.0^{o} C at the bottom.

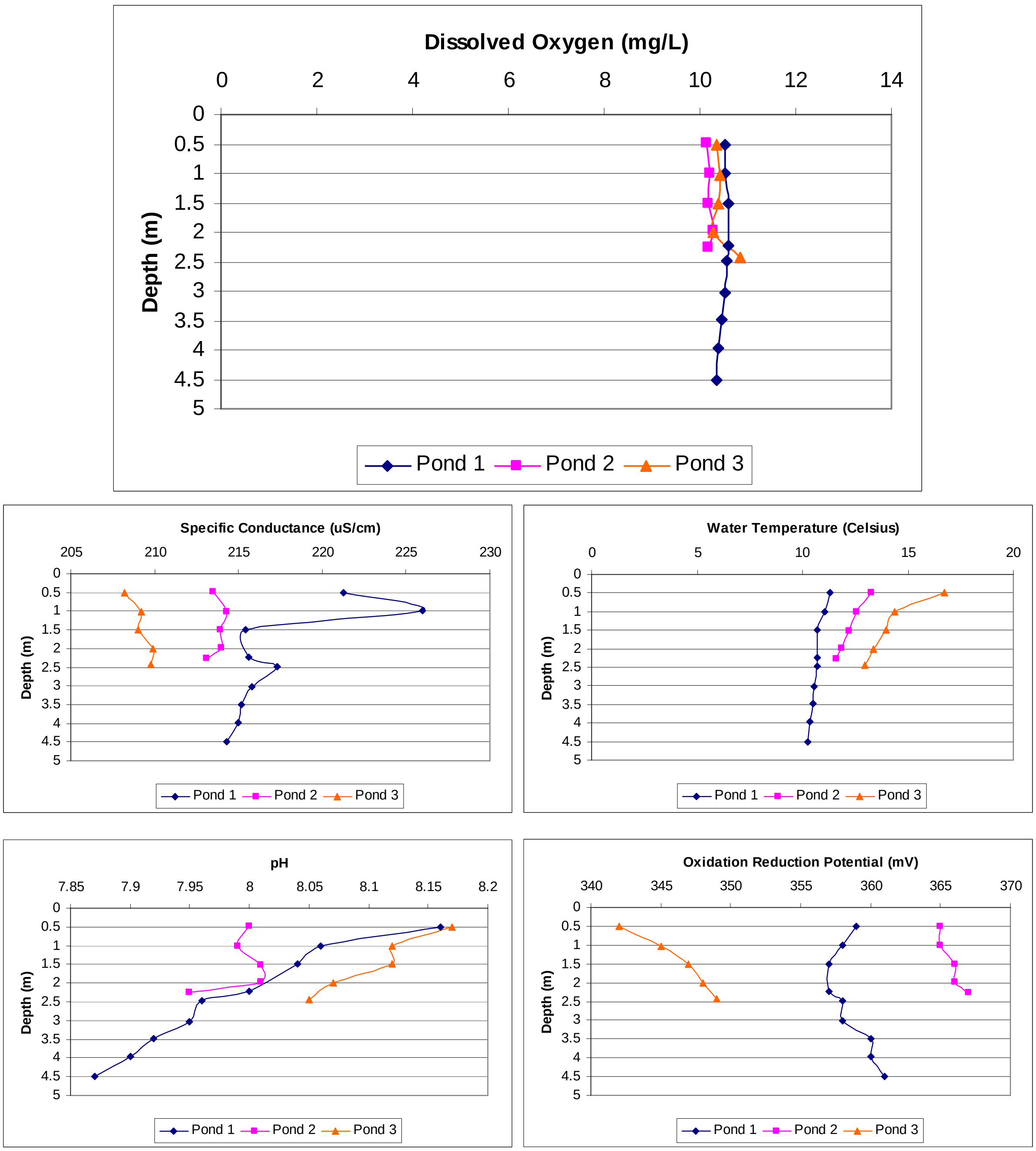

Figure 3. Summary of water quality data collected at all ponds, June 27, 2007, Fairbanks Creek Mine, Alaska.

Water temperatures recorded at ½ hour intervals during the period of fish sampling in May (May 10 through May 25,) differed among ponds and warmed as water moved downstream through each successive pond and channel (Figure 4). Water temperature at the inlet to Pond 1 was the lowest, averaging 2.4^o C (S.D. = 1.6) with a minimum temperature of 0.2^o C and a maximum of 6.1^o C. Water temperature increased slightly by the time it reached the outlet of the pond and averaged 2.9^o C (S.D. = 1.9) with a period minimum of 0.4^o C and a maximum of 7.8^o C. Water picked up additional heat as it passed through a rocky shallow channel to Pond 2 where the average water temperature was 3.3^o C (S.D. = 2.0) with a minimum of 0.4^o C and a period maximum of 8.2^o C at the inlet to Pond 2. The warmest water temperatures recorded were from the inlet to Pond 3 which had a period average water temperature of 4.4^o C (S.D. = 2.4) and a minimum temperature of 0.6^o C and a maximum temperature of 10.5^o C. Peak daily water temperatures first rose above 4.0^o C at the Pond 3 inlet on May 16 followed by the Pond 2 inlet on May 17; however, temperatures quickly dropped on May 17 at Pond 2. Water temperatures did not exceed 4.0^o C in Pond 1 until May 20 at the outlet and May 21 at the inlet, although the inlet peak was only slightly above 4.0^o C and for only about one hour (Figure 4). Water temperatures first exceeded 7.0^o C at Pond 3 on May 22, Pond 2 on May 23, Pond 1 at the outlet on May 26 and at the inlet on May 27.

The trend for increasing water temperature from the Pond 1 outlet to the Pond 3 inlet continued throughout the summer season (Figure 5). Summer (May 10 through September 26) water temperatures at the inlet to Pond 1 were the coolest (8.4^o C (S.D. = 3.2)) and gradually warmed with downstream flow to the outlet of Pond 1 (9.1^o C (S.D. = 3.6)), the Pond 2 inlet (9.3^o C (S.D. = 3.5)) and Pond 3 inlet (10.7^o C (S.D. = 4.0)) (Figure 5).

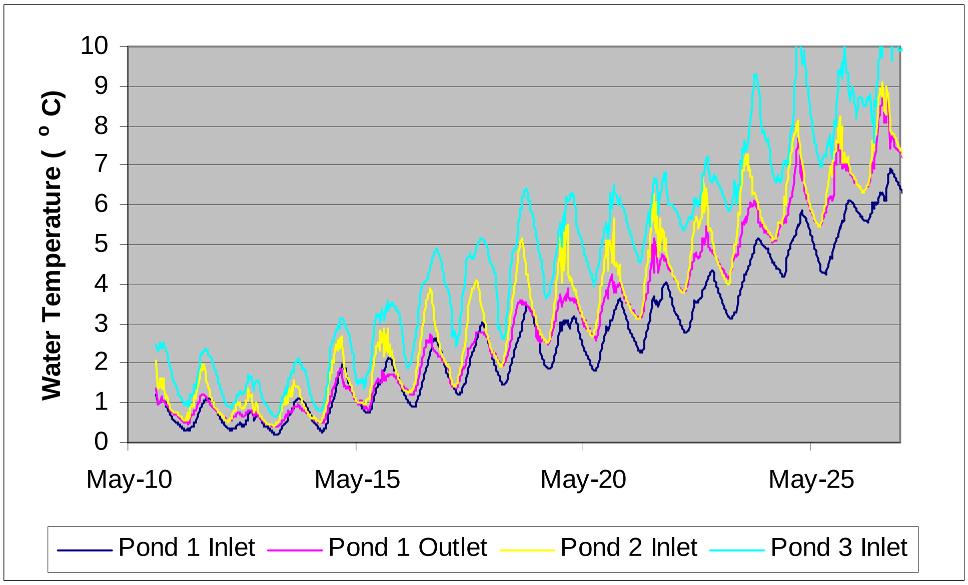

Figure 4. Water temperatures slowly increased over the fish sampling/ Arctic grayling spawning period in May 2007.

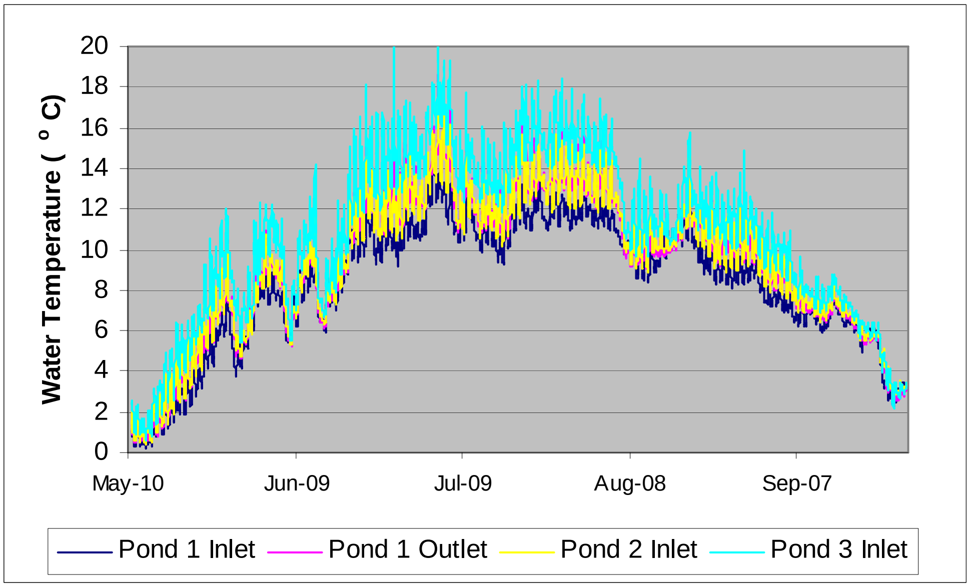

Figure 5. Summer water temperatures recorded from early-May to late-September at the rehabilitated ponds/channels at the Fairbanks Creek Mine, 2007.

Fish Sampling

Population Size and Structure

Between May 8 and May 25, 2007, six fyke nets were fished for a total combined effort of 1,652 hours of fishing. This effort yielded 1,010 Arctic grayling that were measured, inspected for tags or tagged, and released. Table 1 provides a breakdown of effort, capture, numbers of newly tagged fish and numbers of recaptured fish tagged in 2006. About 70% of fish captured in 2007 were too small to tag and, hence, would also have been too small to tag in 2006. In May 2007, 239 Arctic grayling over 175 mm were caught; of these fish, 195 received a numbered Floy® tag and 44 were recaptures that had been tagged in our initial sampling effort in September 2006. In September 2006, 97 individual Arctic grayling over 180 mm were tagged.

To estimate the population of Arctic grayling in the pond system at the start of the project in 2006, we adjusted our total number of Arctic grayling >175 mm caught in 2007 (239 fish) by disregarding fish tagged in 2007 that would have been too small to tag in 2006. We used the median observed annual growth rate (September 2006 – May 2007) of 3 mm for fish under 200 mm to estimate the minimum size of fish caught in 2007 to include in our estimate. As a result, 23 fish captured and tagged in 2007 were not included in the population estimate calculations.

Based on the initial mark of 97 fish larger than 180 mm in 2006, our total catch of 216 fish over 183 mm in 2007, of which 44 were recaptures; the 2006 population of Arctic grayling was estimated at 471 fish over 180 mm long (95% C.I. = 382 – 560 fish).

Table 1. May 2007 net site sampling history, set type and orientation, effort and catch for each pond. A summary of angling results from ponds 1 and 2 from June, 2007 is also provided.

Sample Site	Dates Fished	Set Type/ Fishing Direction	Effort Hours	Total Fish	New Tags (fish over 175 mm)	2006 Recaptures
Pond 1 Inlet	May 18 - May 25	block/upstream	168.5	160	21	4
Pond 1 Outlet	May 8 - May 25	partial block upstream/downstream	408.9	237	28	7
Pond 2 Inlet	May 8 - May 25	partial block on south inlet channel/ downstream	407.4	180	19	3
Pond 2 Outlet	May 23 - May 25	partial block upstream/downstream	45.9	123	15	2
Pond 3 Inlet	May 8 - May 25	partial block in north channel/ upstream	406.1	137	70	16
Pond 3 Outlet	May 16 - May 25	partial block/ upstream/downstream	215.3	173	42	12
Total			***1652.1***	***1010***	***195***	***44***
Pond 1	June 28	Angling	0.8	14	2	1
Pond 2	June 28	Angling	2.2	33	14	0

All Arctic grayling captured in May were assessed for sexual maturity and spawning condition. Males were most numerous in the mature population, with 97 mature males representing 61% of the catch and 62 mature females composing the remaining 39% of the catch. Mature males ranged from 187 to 296 mm long with mean length of 236 mm (N = 96, SE = 2.67) (Figure 6). Mature female Arctic grayling ranged from 175 to 292 mm long and had a mean length of 228 mm (N = 62, SE = 3.22) (Figure 6). The size distribution of mature males and females was not significantly different (Wilcoxon Rank Sum; W = 1.316, p = 0.1883) and the mean size between mature males and females was not significantly different (T (equal variance) = -1.76, DF = 157, p = 0.0799).

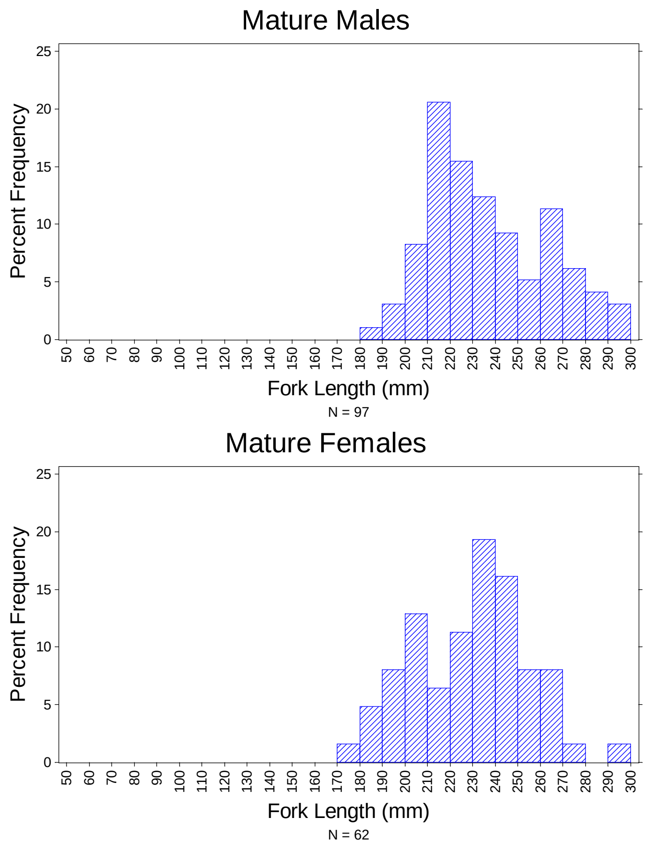

Figure 6. Length frequency distribution of mature male (top) and female (bottom) Arctic grayling in the rehabilitated ponds/channels of the Fairbanks Creek Mine, May 2007.

The length frequency distribution results for mature male and female Arctic grayling indicated that maturation for both sexes in this isolated population can occur at a relatively small size with some females and males smaller than 200 mm exhibiting characteristics of sexual maturity (ripe gametes)(Figure 6). However, for mature males, the most significant contribution in terms of numbers of fish is from the 210 to 225 mm size classes while for females, the 230 to 250 mm size classes contribute the most significant numbers of fish.

The proportion of mature fish present in each 20 mm size class illustrates that while some fish of extremely small size are sexually mature, the proportion is reasonably low (Figure 7). Only about 9% of fish in size classes between 170 and 190 mm are mature. However, maturity rates begin to rise dramatically between 190 and 210 mm with about 52% of fish captured showing evidence of maturity. Nearly 90% of fish captured between 210 to 230 mm were sexually mature and greater than 96% of all larger fish captured were sexually mature (Figure 7). If a 5 mm size class bracket is used, virtually all Arctic grayling over 220 mm were sexually mature.

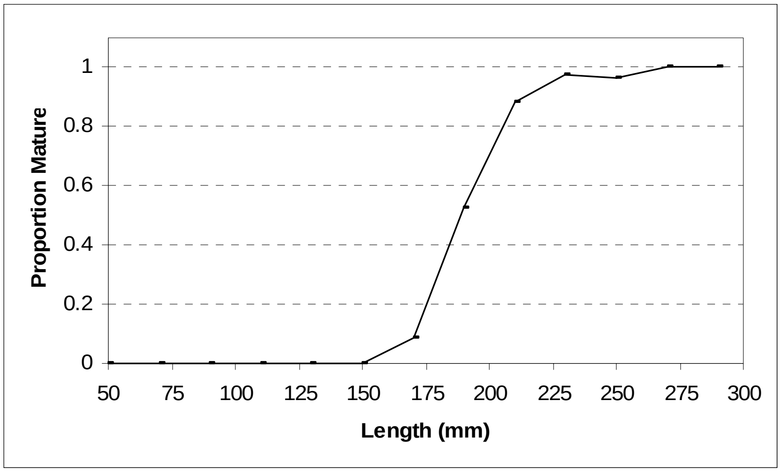

Figure 7. Proportion of mature fish, per 20 mm size class, as determined by visible sex products at the time of capture, May 2007.

The pond system Arctic grayling population structure was similar in May 2007 to that observed in September 2006 (Wilcoxon Rank Sum; W = 0.958, p = 0.3382); but clear differences exist between the fish found in the old/abandoned channel and those now using the new habitats (Figure 8, Figure 9). When compared to the length frequency distribution observed in the old channel that was rerouted through the ponds (Morris and Ihlenfeldt 2006), it appears that juvenile and age-0 cohorts in the ponds were already much more numerous in 2006 and remained much more numerous in 2007 than those observed in the abandoned channel (Figure 8, Figure 9).

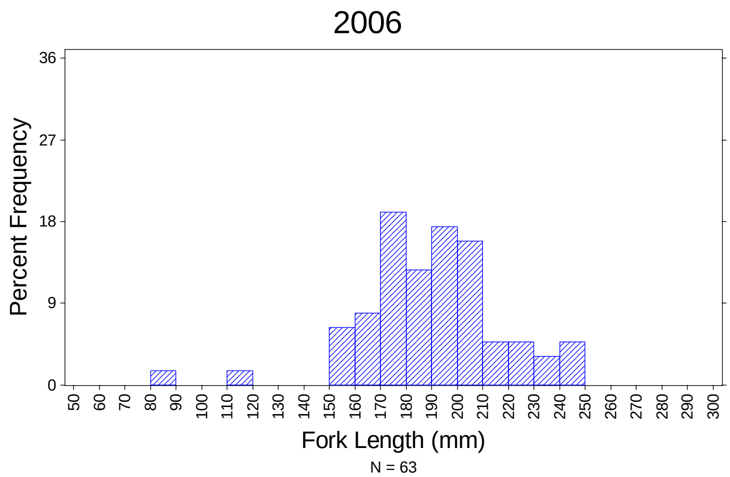

Figure 8. Length Frequency distribution of Arctic grayling captured in the abandoned Fairbanks Creek Channel, September 2006.

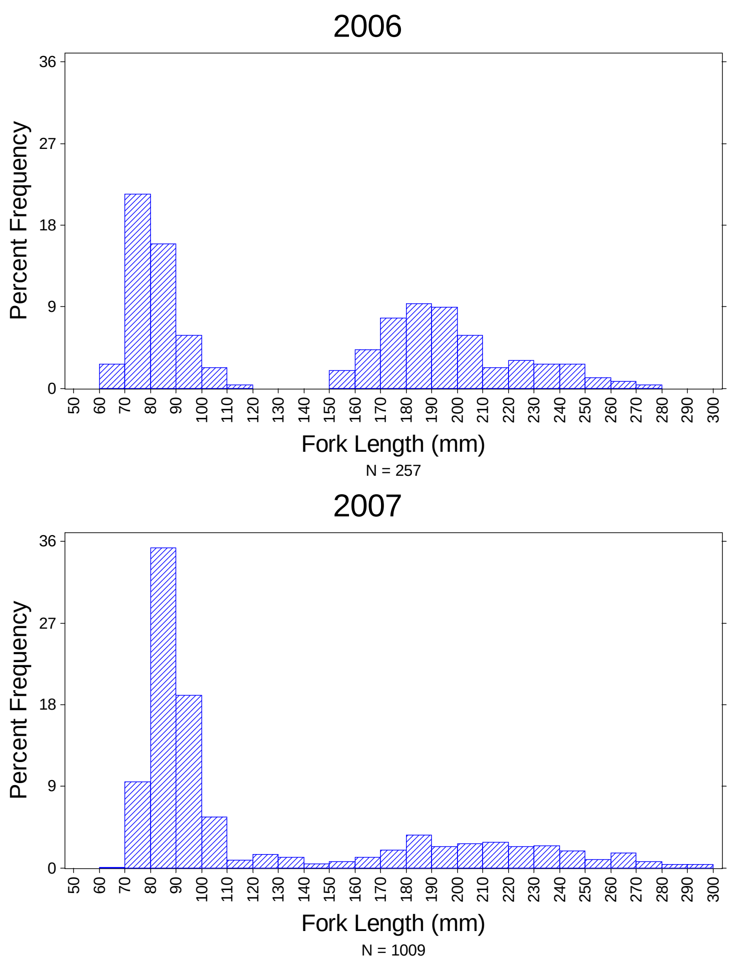

Figure 9. Length frequency distributions were similar in 2006 (top) and 2007 (bottom).

Based on 44 recaptured fish, Arctic grayling growth rates between September 1, 2006 and May 2007, ranged from 0 to 24 mm, but were generally low with a mean growth of 4.7 mm (SD = 4.96). However, growth between the May 2007 sampling period and the June 28, 2007 angling effort was considerably higher, averaging 20.7 mm (N = 31, SD = 8.87) but ranged from 0 to 37 mm. All recaptures exhibiting negative growth (growth within our measurement error) were assigned 0 mm of growth. Growth was standardized by time at large between observations for both periods and expressed as growth per day (Figure 10). Low growth over the winter period was similar for all size classes whereas growth was much higher during summer and was inversely related to fish length at first capture (Figure 10).

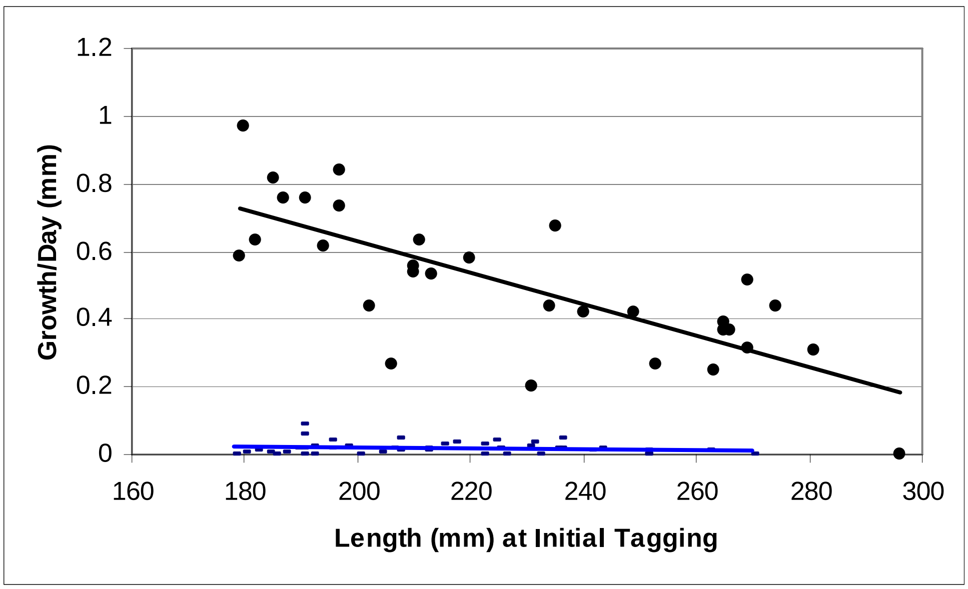

Figure 10. Arctic grayling winter (blue line) and summer growth rates (black line) in the rehabilitated ponds/channels of the Fairbanks Creek Mine.

Distribution in Pond System and Spawning

Larger mature Arctic grayling were most frequently captured in association with warmer water temperatures during May, although fish distribution throughout the ponds was likely changing to some degree throughout the sampling period. The size distribution of fish captured among the three ponds was significantly different (KW Statistic = 158.465, p = 0.0001) with the fish from Pond 3 tending towards a larger size while fish from ponds 1 and 2 were not distributed differently (Figure 11). The numbers of juvenile and age-1 fish captured from ponds 1 and 2 were so significantly different from the numbers of larger fish that any larger fish captured in those ponds were considered possible or probable outliers to the respective pond's dataset (Figure 11).

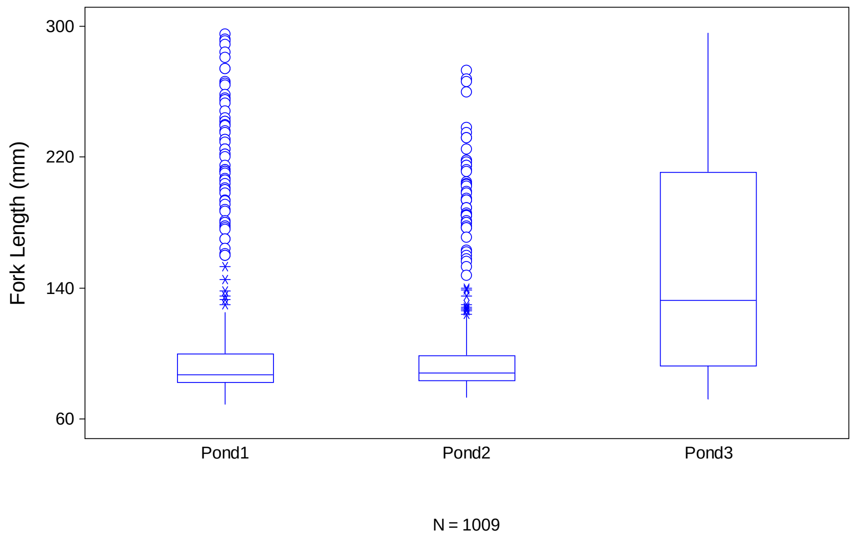

Figure 11. Box-whisker plot of fish length (mm) from each of the three pond sites. The center half of the data are represented by the box, the horizontal line is the median length in the data set and the tails represent the typical data range, ending at a data point. Fish with lengths more than 1.5 times greater than the middle half of the data set (the box) are likely outliers (*) while fish with lengths greater than 3 times the range of the box are probable outliers (O).

Out of 160 mature fish captured in May 2007, 60.6% were captured in Pond 3, most of which were associated with the inlet to the pond. Approximately 28.8% of mature fish were captured at Pond 1 while only about 10.6% of mature fish were captured in Pond 2. Mature fish numbers in the catch peaked on May 21 in both ponds 1 and 2. The adult catch dropped sharply by May 23 and continued to drop for Pond 3 on May 25 (Figure 12). By May 21, peak water temperatures in the inlet stream to Pond 3 had been above 4.0 ^{o}C for 5 consecutive days during which peaks were above 6.0 ^{o}C on three days (Figure 4). Water temperatures on the three days preceding the peak catch of adult Arctic grayling in Pond 3 remained above 4.0 ^{o}C for the majority of each day and peaked above 6.0 ^{o}C. Water temperatures on May 21 were above 4.0 ^{o}C for the entire day and peaked at nearly 7.0 ^{o}C. Rises in water temperature to peaks of 7.0 ^{o}C and higher have been linked with a rapid completion of spawning by Arctic grayling at the Fort Knox Mine (Ott and Morris 2000, 2001, 2002a, 2002b, 2003, 2005a, 2005b, 2006, 2007). The drop in catches immediately following the peak in temperature suggests that the majority of adults using Pond 3 channel habitats for spawning had completed spawning and had moved into either Pond 3 or upstream to ponds 2 and 1 where they were less susceptible to capture than when frequenting the narrow, easily blocked stream channels. Increased catches of adults on May 25 in ponds 1 and 2 probably are indicative of post-spawning fish moving upstream for recovery.

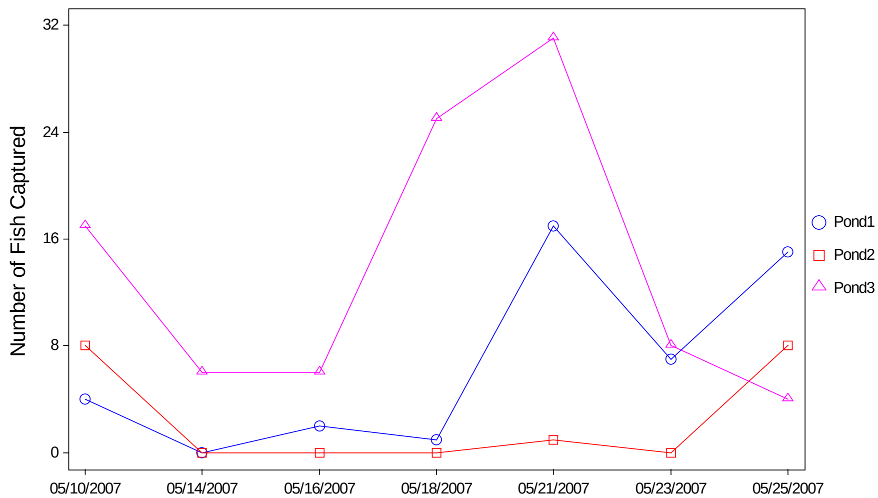

Figure 12. Number of mature Arctic grayling captured at each pond by sample date.

Most females captured between May 8 and May 16 were immature or non-ripe mature fish (green), with a low proportion of ripe females (Figure 13). On May 18, the proportion of ripe females increased to around 80% and remained at that level until May 25 when the number dropped slightly, coinciding with an increase in the proportion of spent females in the catch (Figure 13). Spent females were first caught on May 21 and numbers of spent females peaked on May 25 at about 40%. However, few spent females were ever captured, a result similar to that observed with post spawning females at the Fort Knox Mine where spent females move into pond habitats to recover after spawning and are not susceptible to capture in fyke nets (Ott and Morris 2000, 2001, 2002a, 2002b, 2003, 2005a, 2005b, 2006, 2007). Coupled with the observation of spent females beginning on May 21 and the sharp drop in adult catches at Pond 3 after May 21, it is likely that spawning in the pond system peaked between May 21 and May 23 and that most spawning occurred in association with Pond 3.

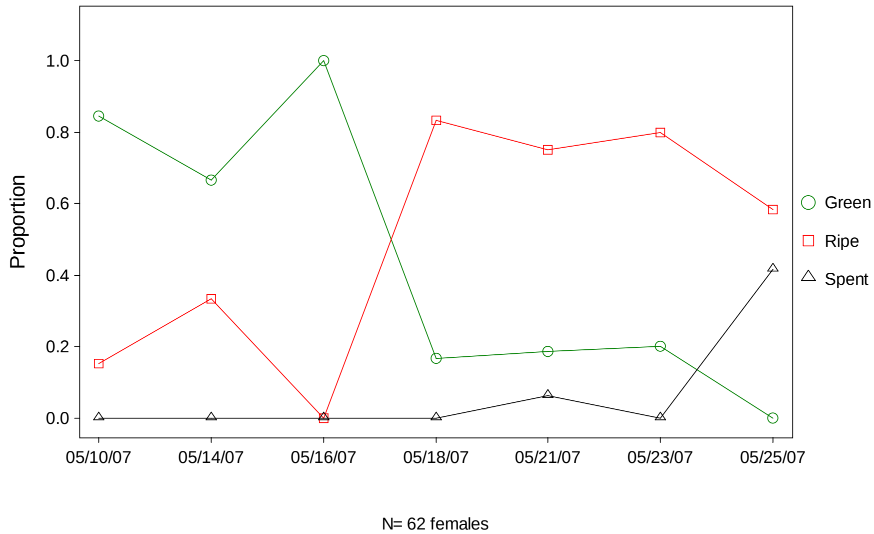

Figure 13. The spawning condition of mature females by date.

Visual searches for Arctic grayling fry were made on June 27 at all three ponds, including inlets and outlets. A few small schools of fry (about 15 to 20 mm long individuals) were observed in Pond 1. All fry observed were associated with the shallow, slow moving water surrounding a small island at the outlet. No fry were observed in or around the inlet channel. Similar to Pond 1, fry were observed only around the shallow outlet portion of Pond 2. However, many large schools of hundreds of fry were observed. Fry were observed in the largest numbers in Pond 3 and were associated with large woody debris placed in the pond for cover. Most fry were associated with the inlet area of the pond. The three lower, very shallow ponds downstream from Pond 3 were also inspected for fry but none were observed.

Discussion

The estimated population of Arctic grayling using the pond system by the end of 2006 was 470 fish over 180 mm. Many fry had already been produced during spring 2006 and were thriving in the pond system, a stark contrast to the fish residing in the adjacent and eventually abandoned stream channel. Late winter water quality data collected in spring 2007 suggests that, relative to the remainder of Fairbanks Creek, a large volume of fish wintering habitat is present in the three ponds. High numbers of 2006 marked fish recaptured in 2007 further suggests that the habitat provided for high winter survival during winter 2006/2007, although an estimate was not yet possible. High numbers of age-1 fish captured during 2007 are also consistent with this conclusion.

Arctic grayling adults appear able to successfully use the channel habitats constructed between the three ponds for spawning. Catches of adults in May, and the relative distribution of fry in June suggest that the channel that warmed the fastest in spring, the inlet to Pond 3, was used most heavily for spawning. Our lack of spawning observations in any channels during spring was an artifact of the lack of cover in the channels to hold fish during the day and the late evening timing of peak water temperatures. Osprey, ravens and mergansers were observed hunting the channels during spring.

Size of Arctic grayling fry captured in September 2006 (N=109, 63 to 100 mm, mean = 80 mm) indicate that juvenile growth is high and equal to the highest rates observed from some of the more productive wetland complexes at the Fort Knox Mine (Ott and Morris 2000, 2001, 2002a, 2002b, 2003, 2005a, 2005b, 2006, 2007). Achievement of a relatively large size during the first summer of life will increase the likelihood for winter and future survival. Additionally, fry immediately move into productive warm water habitat that coincidentally will provide good over wintering habitat, further increasing their chance for survival.

Provided the ponds and channels remain stable, this Arctic grayling population is likely to increase over time. The average size of fish within the population is also likely to increase to some extent with the increase in habitat volume and productivity as compared to the disturbed channel. Similarly, we expect to see the size of maturation begin to increase over time as growth rates increase. However, depending on survival and recruitment to the adult population, the maximum size of individuals may again become limited as competition for resources begins to increase over time.

We plan to continue monitoring this population to track changes in the population size and structure in response to the newly constructed habitat. Opportunities to investigate how habitat manipulations and rehabilitation techniques, used in heavily mined areas, affect fish populations over time in such a controlled environment are rare, and provide a unique opportunity to explore restoration techniques and their efficacies. We will also continue to monitor water quality conditions, focusing on late winter, to document any changes over time.

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APPENDIX A: Partial Photo-log, Fairbanks Creek Mine Rehabilitation, 2006 and 2007.

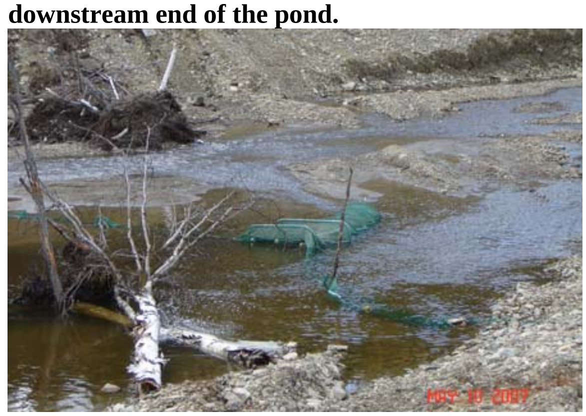
Photograph 4. View of the constructed outlet channel between Ponds 1 and 2, looking upstream into Pond 1, August 2006.

Photograph 5. View of the outlet and constructed island in Pond 1, May 2007.

Photograph 6. View of the Pond 1 outlet channel looking towards Pond 2, August 2006.

Photograph 7. View of Pond 1 looking at Fairbanks Creek flowing into the pond, August 2006.

Photograph 8. View of Pond 2 looking downstream from the inlet, May 2007. The constructed island in Pond 2 is visible at the downstream end of the pond.



Photograph 9. View of the Pond 3 inlet looking upstream, May 2007. Large woody debris placed in pond was used by adults and large numbers of fry during June 2007.