Technical Report No. 07-01

Arctic Grayling and Burbot Studies at the Fort Knox Mine, 2007

by Alvin G. Ott
and William A. Morris

Last Chance Creek (Aufeis 4 m Deep Covering Stream Channel), May 2007
Photograph by William A. Morris

December 2007

Alaska Department of Natural Resources
Office of Habitat Management and Permitting

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Acknowledgements

We thank Fairbanks Gold Mining Inc. (Larry Radford and Delbert Parr) for their continued support of our study to evaluate fisheries resources in the water supply reservoir, tributaries, and developed wetlands. We thank Nancy Ihlenfeldt and Laura Jacobs with the Alaska Department of Natural Resources (ADNR) for their assistance with fieldwork. Jack Winters (ADNR), Audra Brase (Alaska Department of Fish and Game), and Delbert Parr provided constructive review of our report.

Executive Summary

Water Quality

- Dissolved oxygen (DO) concentrations continued to be low in the Water Supply Reservoir (WSR) and decreased with depth in winter (page 11)
- DO concentrations in Pond F during late winter were less than 0.5 mg/L, winter fish survival unlikely (page 11)

Arctic Grayling

- Arctic grayling (*Thymallus arcticus*) present in the stilling basin include some recaptured fish originally marked in the WSR (pages 12 and 13)
- Reduced spawning success in the wetland complex in spring 2007 due to cold water temperatures (massive aufeis) and beaver dams that reduced riffle habitat (pages 16 and 17)
- Arctic grayling did not spawn successfully in Last Chance Creek due to cold water temperatures caused by massive aufeis (pages 17 and 18)
- The estimated Arctic grayling population in spring 2006 was 5,930, a reduction from the spring 2005 estimate of 7,926 fish >200 mm (page 18)
- Growth rates of Arctic grayling >200 mm based on marked and recaptured fish indicated growth in summer 2006 was comparable to the highest measured to date in 2001 (page 20)

Burbot

- Due to extremely low recaptures, the burbot (*Lota lota*) population for fish >200 mm could not be estimated for spring 2006, but based on previous population estimates and catch per unit of effort data the number of smaller burbot has decreased substantially since 1999 (pages 22 and 23)
- The estimated burbot population for fish >400 mm in spring 2006 was 128 – the number of large burbot has remained relatively stable for six years (page 23)
- Successful spawning of burbot in the WSR continued based on catches of small fish (page 23)
- The burbot population is characterized by a small number of large burbot at various sizes between 400 and 900 mm and an unknown, but low number of burbot <400 mm (page 23)

Introduction

Fairbanks Gold Mining Inc. (FGMI) began construction of the Fort Knox hard-rock gold mine in March 1995. The mine is located in the headwaters of the Fish Creek drainage about 25 km northeast of Fairbanks (Figure 1). The project includes an open-pit mine, mill, tailing impoundment, water supply reservoir (WSR), and related facilities. Construction of the WSR dam and spillway was complete by July 1996. In 2007, state and federal permits were issued for the construction, operation, and closure of a valley fill heap leach facility located in Walter Creek upstream of the tailing pond.

Rehabilitation, to the extent practicable, has been concurrent with mining activities and natural revegetation of disturbed habitats has been rapid. Wetland construction between the tailing dam and WSR began in summer 1998. A channel connecting wetlands along the south side of the valley was built in spring 1999. Civil work to mitigate aufeis in Last Chance Creek, occurred in fall 2001. Repair work on dikes separating Ponds D and E and the channel connecting the ponds was completed in summer 2002. Buell and Moody (2005) provided recommendations for additional work to enhance fish and wildlife habitats between the tailing dam and WSR. Some of their key recommendations are summarized below:

- Remove the culvert connecting the head of Pond C to the channel presently conveying high runoff (during breakup) on the north side of the road in the bottom of the Fish Creek valley to allow high runoff flows to remain in the north side drainage;
- Continue implementing wetland rehabilitation and restoration work in the Fish Creek valley between the tailing dam and WSR and continue to systematically document usage of wildlife and waterfowl until closure;
- Explore development of a "pilot" passive treatment constructed wetland for the purpose of removing arsenic, antimony, and any other "problem" elements from tailing seepage water that might reduce or eliminate long-term pump-back requirements;
- Start planning and designing future Fish Creek alignment from the tailing embankment to the small drainage on the north side of the Fish Creek valley bottom; and

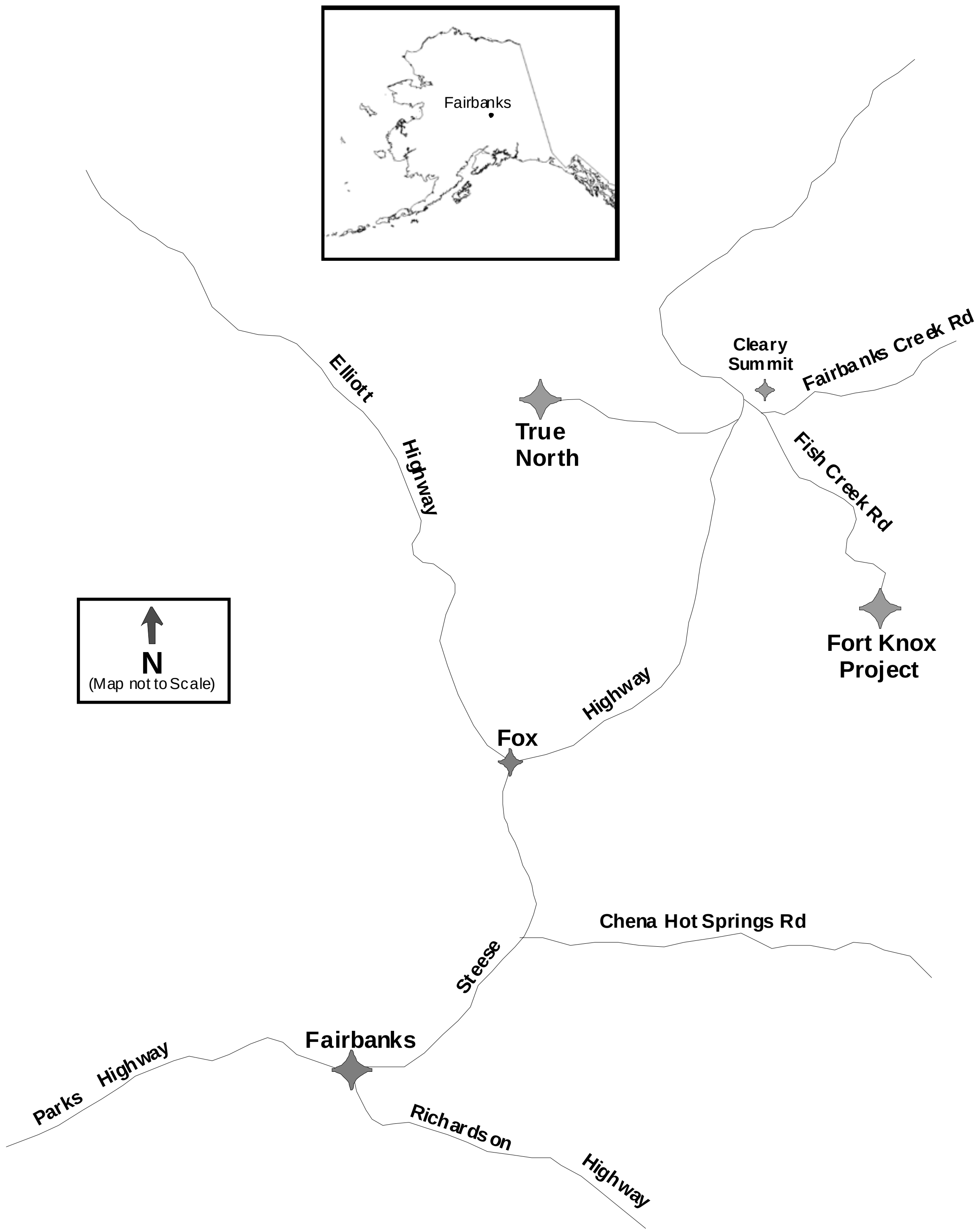

Figure 1. Fort Knox project location.

- Develop a detailed plan and implementation schedule for the conversion of the existing causeway across the WSR into re-vegetated islands to increase habitat diversity and improve water exchange/circulation.

In addition to enhancement projects recommended by Buell and Moody (2005), Office of Habitat Management and Permitting (OHMP) has continued to work with FGMI to identify civil work that could be done to improve aquatic habitats. A cooperative field visit with FGMI was conducted in the Last Chance Creek valley in summer 2007 to assess possible mitigative measures that might be taken to reduce aufeis. Work to remove beaver dams from the Ponds D, E, and F in the lower part of the developed wetlands also was recommended for the purpose of maintaining the most productive Arctic grayling (*Thymallus arcticus*) spawning and early life history rearing habitat in the WSR complex.

Fish research prior to construction of the Fort Knox mine and related facilities began in 1992 (Weber Scannell and Ott 1993, Weber Scannell and Ott 1994, Ott et al. 1995). Arctic grayling and burbot (*Lota lota*) populations were estimated to determine numbers of fish available to colonize the WSR. Following completion of the WSR dam, OHMP has continued to monitor Arctic grayling and burbot populations (Ott and Weber Scannell 1996, Ott and Townsend 1997, Ott and Weber Scannell 1998, Ott and Morris 1999, Ott and Morris 2000, Ott and Morris 2001, Ott and Morris 2002a, Ott and Morris 2002b, Ott and Morris 2003, Ott and Morris 2005a, Ott and Morris 2005b, Ott and Morris 2006). Viable, self-sustaining populations of both Arctic grayling and burbot exist in the WSR today. The Arctic grayling population was estimated at about 6,000 fish in spring 2006. From 1997 to 1999, the burbot population increased from 622 to 4,136 fish and then began to decrease. Presently, the burbot population is characterized as having a small number (100 to 150) of large fish (>400 mm long).

Water quality sampling in the WSR began in summer 1997 and has continued annually. Our report summarizes fish and water quality data collected during 2007 and discusses these findings in relation to previous work.

Methods

Sampling Sites

Multiple fyke net sampling sites in the WSR and developed wetlands, including Last Chance Creek, have been used to capture Arctic grayling (Figures 2 and 3). Changes in fyke net locations have been made to optimize catches and to account for water surface elevation changes in the WSR. In spring 2007, fyke nets were fished at two stations (#11 and #18; Figure 2). Hoop traps targeting burbot were set throughout the WSR in spring 2007.

Water Quality

Temperature (°C), dissolved oxygen (DO) concentration (mg/L), DO percent saturation (barometrically corrected), pH, specific conductance (*u* S/cm), and depth (m) were measured with a Hydrolab® Minisonde®5 water quality multiprobe connected to a Surveyor® 4 digital display unit. The multiprobe sensors were calibrated to suggested specifications prior to use. The LDO sensor was calibrated using a saturated air method. Conductivity, ORP, and pH sensors were calibrated with fresh standard solutions. Water quality measurements were made at the surface, at 1 m depth intervals, and near the bottom.

Fish

Fish sampling methods and gear included angling, visual observations, fyke nets, and hoop traps baited with whitefish (Figure 4). Prior to setting burbot hoop traps, DO profile data were collected at selected sites in the WSR to ensure adequate DO concentrations were present. In spring 2007, DO profiles were not collected, hence all traps were set in water less than 4 m deep where past water quality measurements have indicated adequate DO concentrations to ensure burbot survival. Burbot and Arctic grayling >200 mm were marked with a numbered Floy® T-bar internal anchor tag.

Arctic grayling and burbot abundance were estimated using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951). Variance was calculated as given by Seber (1982).

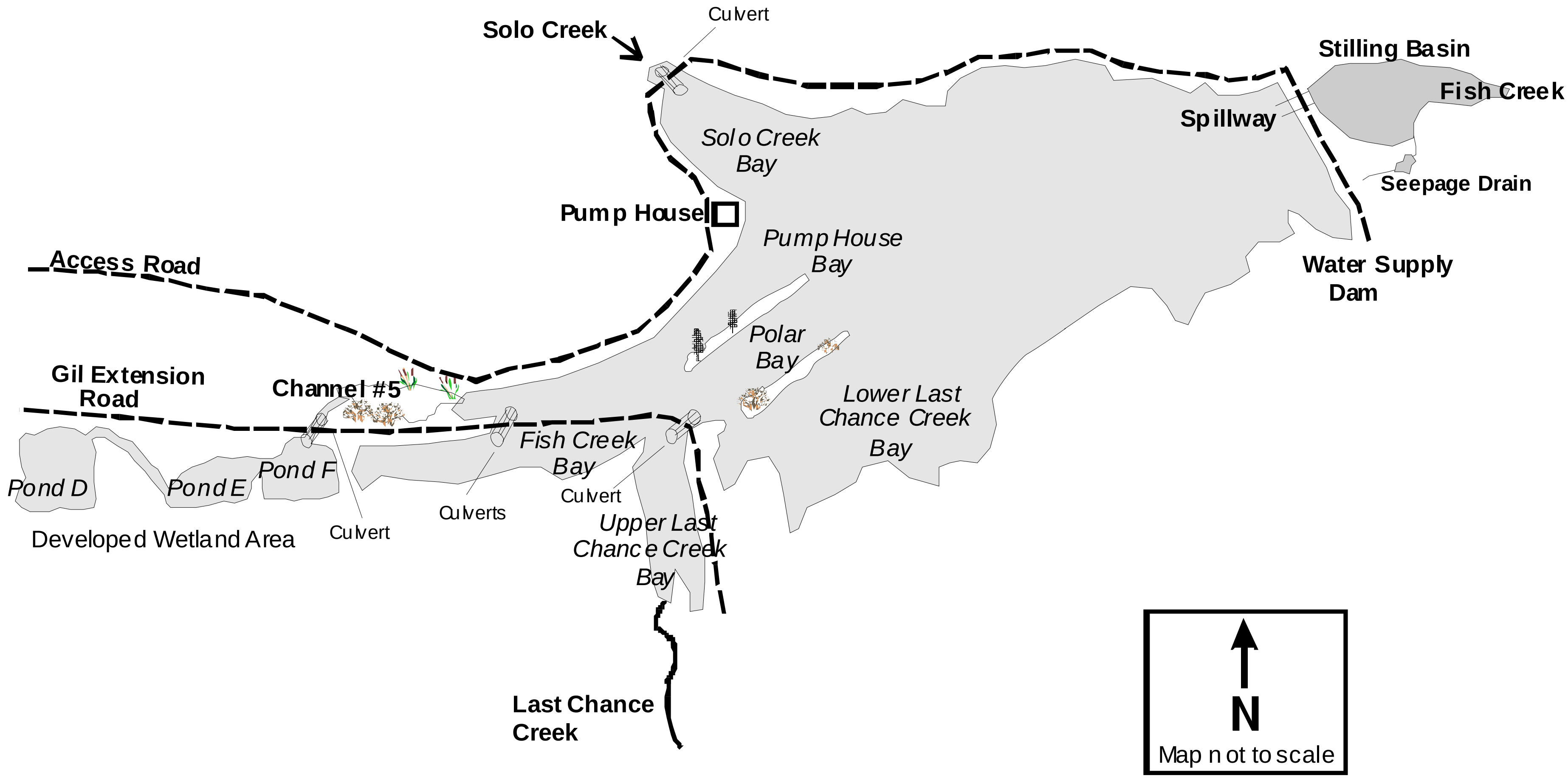

Figure 2. Sample areas in the Fort Knox WSR, stilling basin, and developed wetlands.

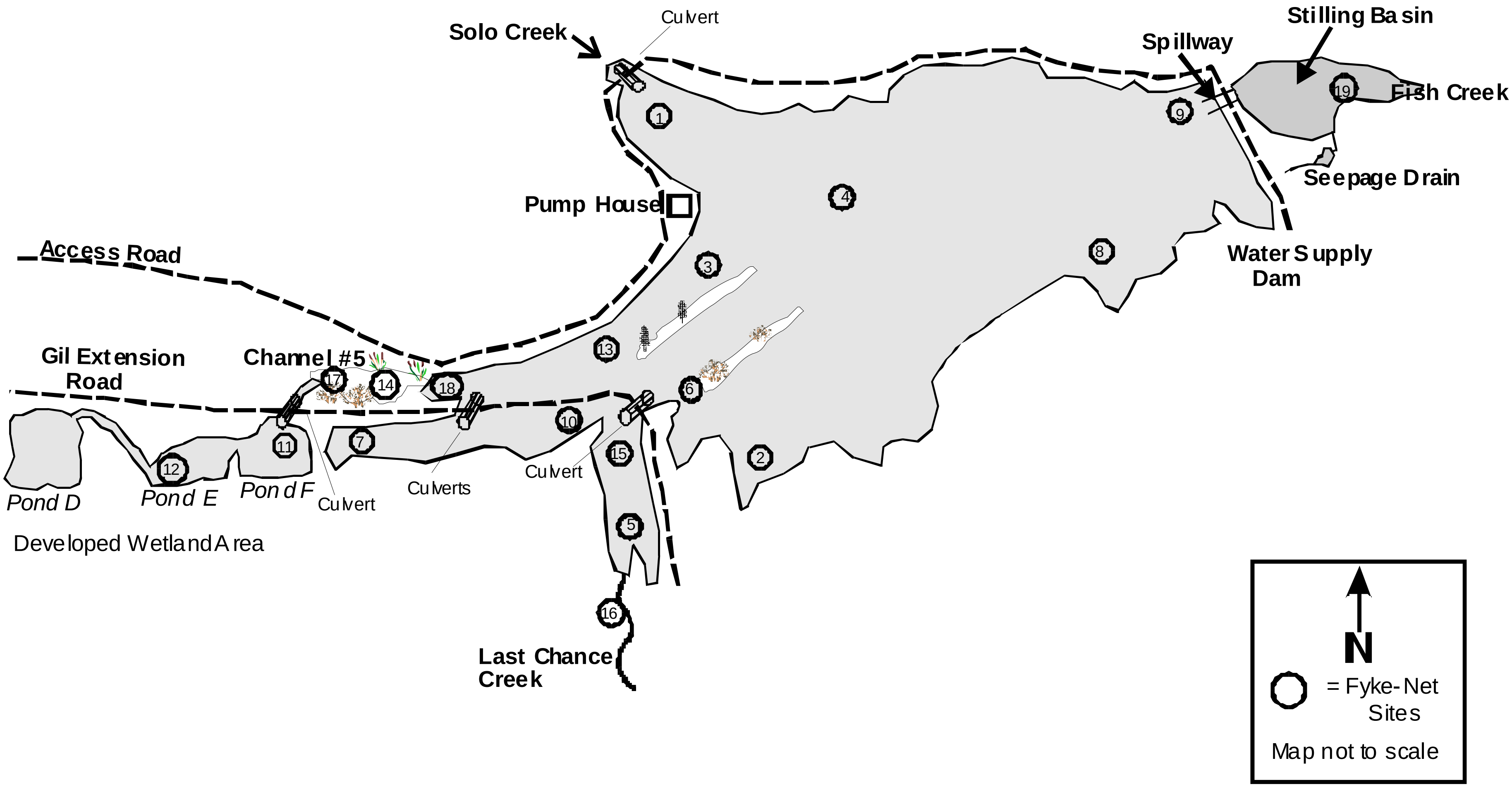

Figure 3. Fyke net sample sites in the Fort Knox WSR, stilling basin, and developed wetlands.

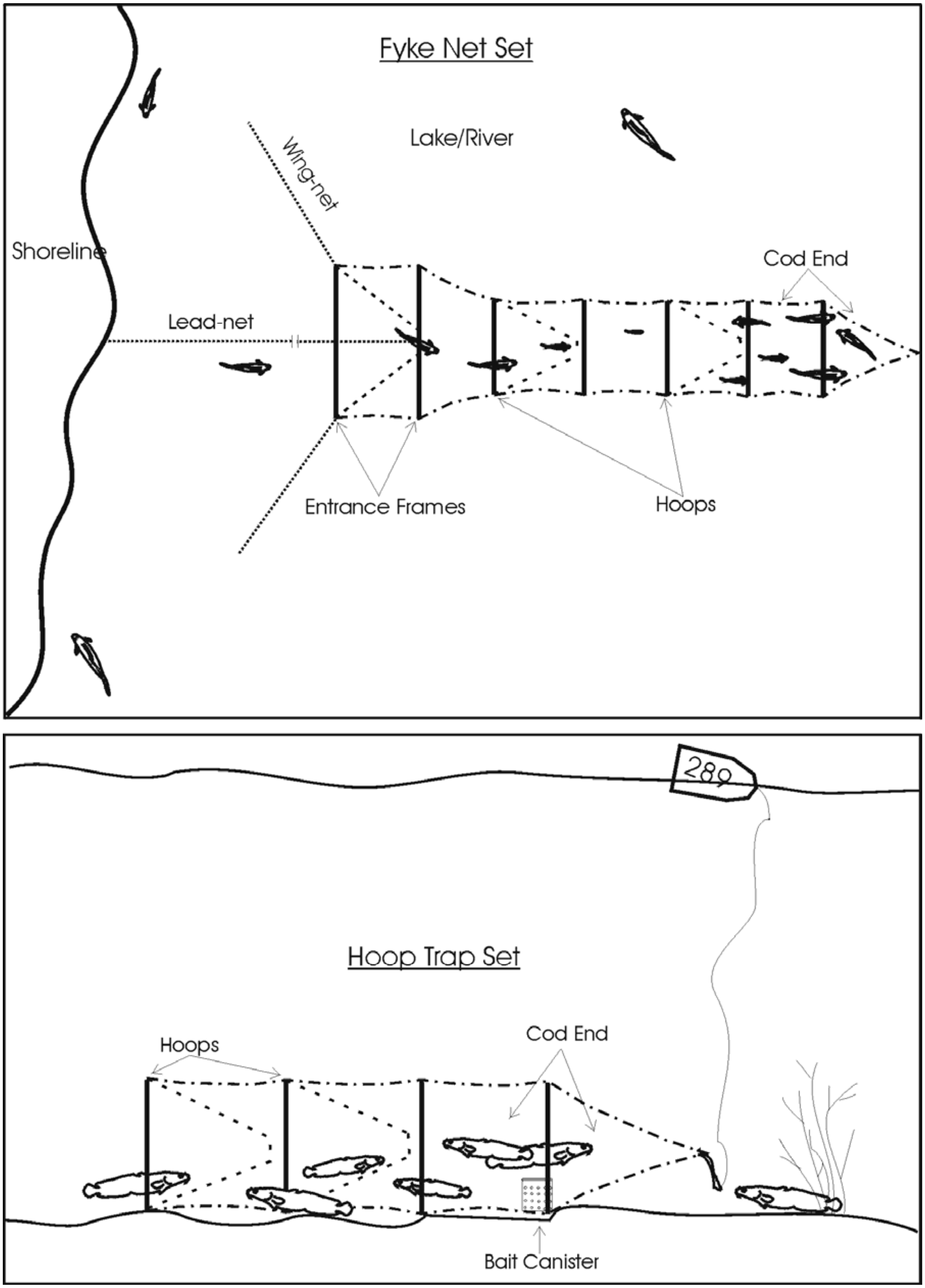

Figure 4. Diagram of fyke net and hoop trap sets.

Results and Discussion

Water Supply Reservoir, Water Quality

Five water quality sites located in the main portion of the WSR have been sampled annually since 1997 (Figure 5). Ponding of water for the WSR began in November 1995. Water surface elevation varied in 1996 and 1997 due to water use and winter seepage below the freshwater dam. The WSR reached the projected maximum water surface elevation of 1,021 feet on September 29, 1998, after a major rainfall event. When full, the WSR contains about 3,363 acre-feet (1.1 billion gallons) of water.

Water levels have remained fairly constant since 1998, except in winter 2000/2001 when about 1,464 acre-feet (477 million gallons) of water were pumped to the tailing pond (Table 1). In 2001, it took until mid-summer before the WSR recharged and water flowed over the spillway. Generally, there is a discharge from the WSR over the spillway throughout the year, including most of the winter.

Table 1. Winter water use from the WSR, 1997 to 2007.

Year	Acre-Feet of Water Removed
1997/1998	660
1998/1999	605
1999/2000	577
2000/2001	1,464
2001/2002	320
2002/2003	337
2003/2004	279
2004/2005	716
2005/2006	659
2006/2007	299

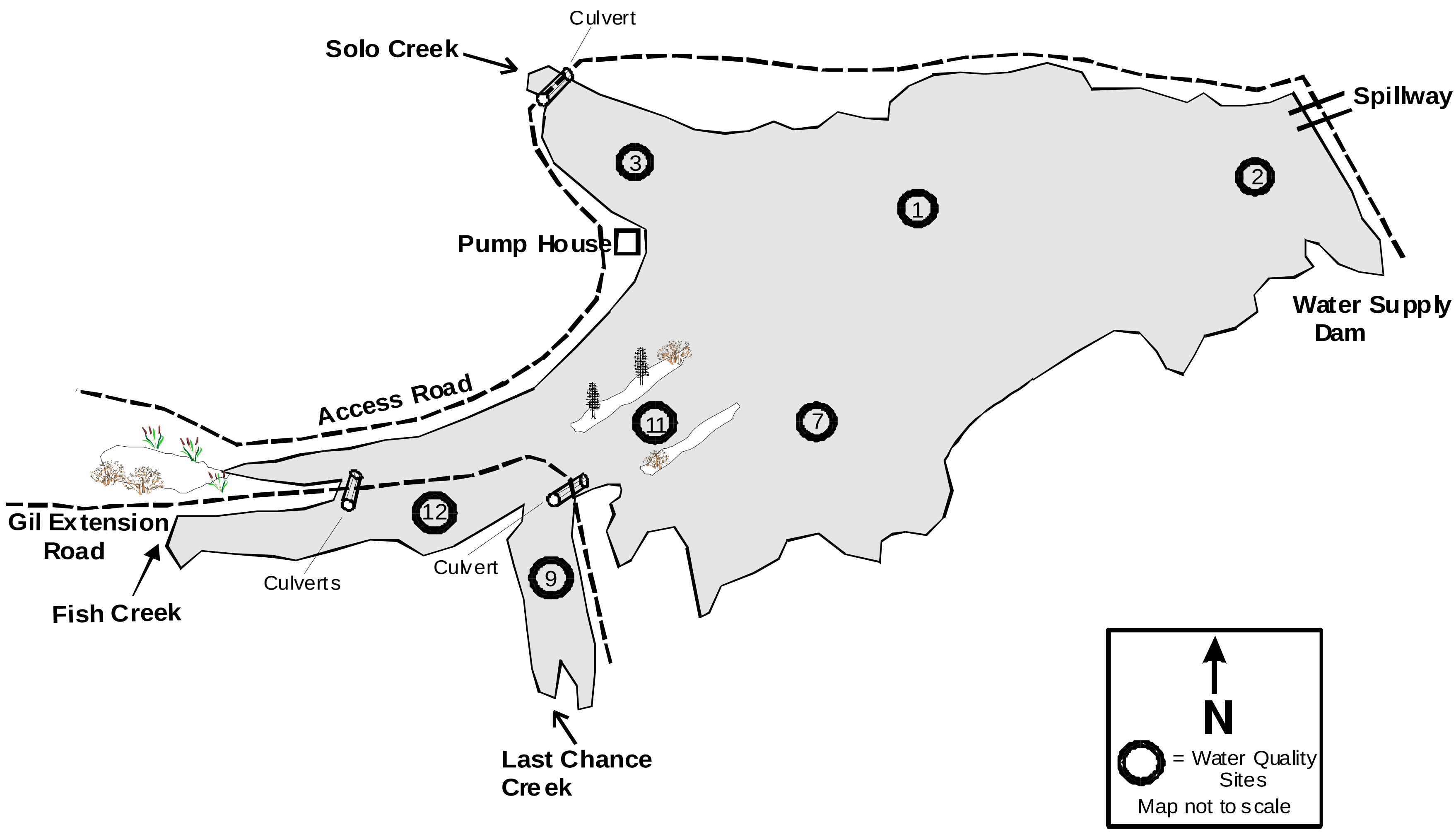

Figure 5. Water quality sample sites in the Fort Knox WSR.

Seepage flow downstream of the WSR is monitored continuously by FGMI. Seepage flow has remained fairly constant for the last nine years (Table 2).

Table 2. Seepage flow rates below the WSR dam.

Year	Rate of Flow (cfs)	Geometric Mean (cfs)
1999	1.16 to 1.82	1.47
2000	1.03 to 1.86	1.38
2001	1.03 to 1.78	1.31
2002	1.13 to 1.78	1.41
2003	1.13 to 1.78	1.36
2004	1.00 to 1.69	1.28
2005	0.97 to 2.35	1.49
2006	1.30 to 2.35	1.44
2007	1.13 to 1.78	1.32

In April 2007, winter water quality data were collected. DO concentrations were highest at the surface and decreased with depth (Figure 6). At Site #1, higher DO concentrations were seen in the upper 6 m of the water column. In all sample years except 2001, winter DO concentrations were depressed to less than 1 mg/L in the deeper water.

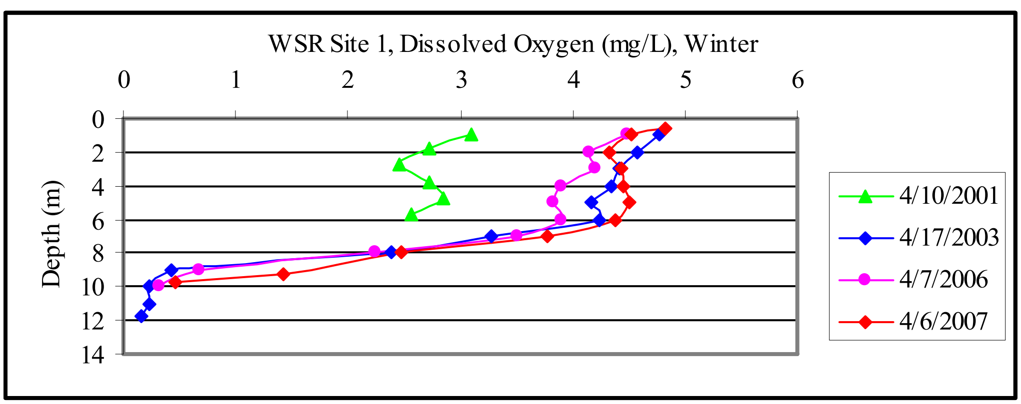

Figure 6. Winter DO concentrations at Site #1 (middle of WSR).

In the winter of 2000/2001, 477 million gallons of water were removed from the WSR. The water intake structure located on the bottom of the WSR likely removed water of the lowest quality, with respect to DO, present in the WSR.

Water at the three bay sites (Solo, Polar, and Last Chance), in 2007, had lower DO concentrations than the main body of the WSR (Figure 7). Low snow conditions seen throughout the interior in 2007 led to substantial aufeis formation in the area and may have reduced the flow of more highly oxygenated water from Solo and Last Chance creeks.

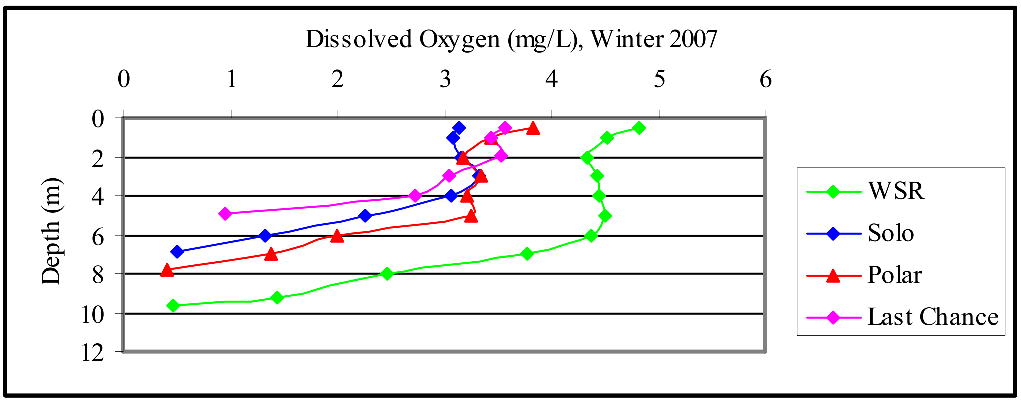

Figure 7. Winter DO concentrations at Site #1 (middle of WSR) and Solo, Polar, and Last Chance Bays.

DO concentrations in Pond F in the lower wetland complex were less than 0.5 mg/L at all depths including the samples taken at the water's surface and under direct influence of surface water flowing into the hole. Water from both sample sites produced a sulfur smelling odor, which is indicative of anoxic conditions. It is highly unlikely that any fish could have survived the winter in Pond F.

Stilling Basin, Arctic Grayling and Burbot

The stilling basin, located immediately downstream of the WSR spillway, is fed by groundwater, seepage flow, and surface flow (Figure 8). The narrow notch in the spillway was designed to accommodate surface water discharge from the WSR during winter without forming substantial aufeis. No aufeis formation in the spillway has been observed.

Figure 8. Spillway in Ft. Knox freshwater dam (August 2006).

In spring 2007, Arctic grayling were sampled in the stilling basin using angling as the capture method. Fish were concentrated where the seepage water drainage from the freshwater dam enters the stilling basin. Length-frequency distribution and assessment of condition (e.g., ripe, spent) indicated that most of the Arctic grayling caught in the stilling basin were immature (Figure 9).

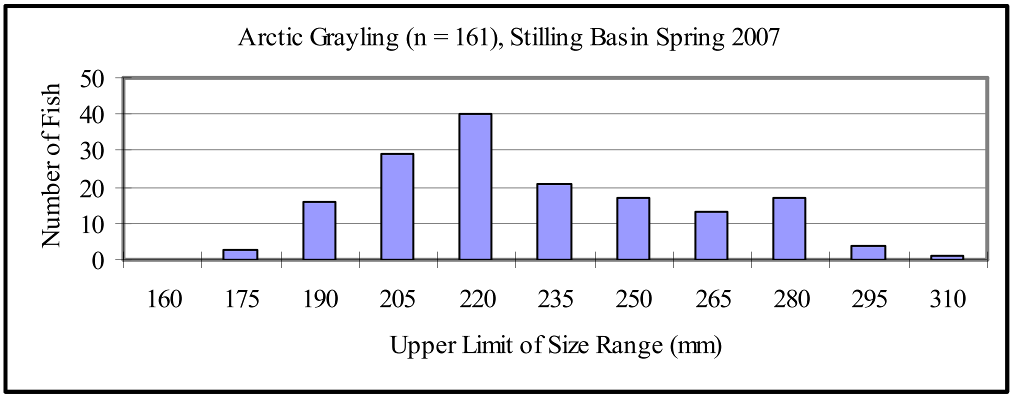

Figure 9. Length frequency distribution of Arctic grayling in the stilling basin.

Twelve Arctic grayling recaptured in the stilling basin were originally tagged in the WSR. Recaptured Arctic grayling had been tagged as long ago as 2002 and as recently as 2007.

Water Supply Reservoir, Arctic Grayling

Arctic grayling were found throughout the Fish Creek drainage prior to construction of the WSR. Fish were concentrated in flooded mine cuts in Last Chance Creek. The population appeared stunted: fish larger than 220 mm were rare; annual growth rate was 9 mm; and size at maturity was small (148 mm for males, 165 mm for females). Successful spawning was limited to inlets and outlets of the ponds. Flooding of the WSR eliminated all pond inlets and outlets.

Fish sampling from 1996 through 1998 in the WSR and Last Chance Creek found very few fry. In spring 1999, FGMI constructed an outlet channel (Channel #5) to connect the developed wetland complex with the WSR (Figure 2). Channel #5 bypassed water from the wetland complex that had previously flowed through a perched pipe and provided fish access to spawning and rearing habitat in the wetland complex (Figure 10).

Figure 10. Pond D in the wetland complex.

Arctic grayling have successfully spawned in the wetland complex every year since 1999 and have used most of the wetland complex in the majority of years. However, substantial aufeis and resultant cold water temperatures in the wetland complex did limit spawning to Channel #5 and Ponds E and F in 2002, 2006, and 2007. Since our field work began in 1992, only in 2004 and 2005 have Arctic grayling successfully spawned in Last Chance Creek.

Arctic Grayling Spawning Timing and Temperature

In 2007, fyke nets were fished only in the wetland complex. Last Chance Creek was inundated with aufeis, water temperatures remained cold, and there were no locations available to set a fyke net. Daily observations were made in Last Chance Creek and no fish were seen. Arctic grayling spawning was limited to Ponds E and F and in Channel #5 downstream of the ponds due to substantial aufeis in Pond D and upstream in Channel C (Figure 11).

Figure 11. Massive aufeis in Channel C in upper part of wetland complex.

In 2007, a fyke net was set in the Pond F outlet on April 26 and at the mouth of the wetland complex on April 27. Arctic grayling were captured beginning on April 30 until sampling was completed on May 21. Males dominated the catch early, with females entering the wetland complex later, and juveniles not showing up in large numbers until the end of the sampling period (Table 3). When sampling began, Ponds E and F were still 90% ice covered and Pond D and upstream were still inundated with aufeis. The first partially spent females were seen on May 4. Peak spawning in the wetland complex was judged to occur from May 16 to 18.

Table 3. Arctic grayling caught in fyke nets fished in the wetland complex in 2007.

Date	Immature	Males	Total Females	Spent[1] Females	Total Catch[2]
April 27	0	0	0	0	0
April 30	2	81	46	0	129
May 1	0	74	46	0	120
May 2	1	63	33	0	97
May 3	1	31	17	0	49
May 4	2	73	88	2	163
May 7	4	147	151	2	302
May 9	3	42	72	6	117
May 11	5	72	100	12	177
May 14	1	77	68	8	146
May 16	3	79	85	13	167
May 21	213	0	2	0	215

[1]Catch rates provide an indication for when spawning occurs, but spent females are difficult to catch at Ft. Knox after they spawn. Post-spawning females tend to stay in the ponds to feed before moving downstream to the WSR.

[2]Only one entry per fish is made; recaptures within the same sample event are not included.

On May 9, 53 Arctic grayling (35 females, 18 males) were captured by angling in the WSR near the mouth of the wetland complex. Seven of the females were spent. It appeared that some of the Arctic grayling that normally would have entered the wetland complex to spawn had probably spawned in the WSR near the mouth of the wetland complex where water temperatures were warmer. No Arctic grayling were observed in the open water channel between Ponds D and E. Peak water temperatures in Channel D are presented in Figure 12. The lack of spawning in Channel D appeared temperature related as water temperatures never warmed until after the majority of Arctic grayling had spawned in other downstream habitats.

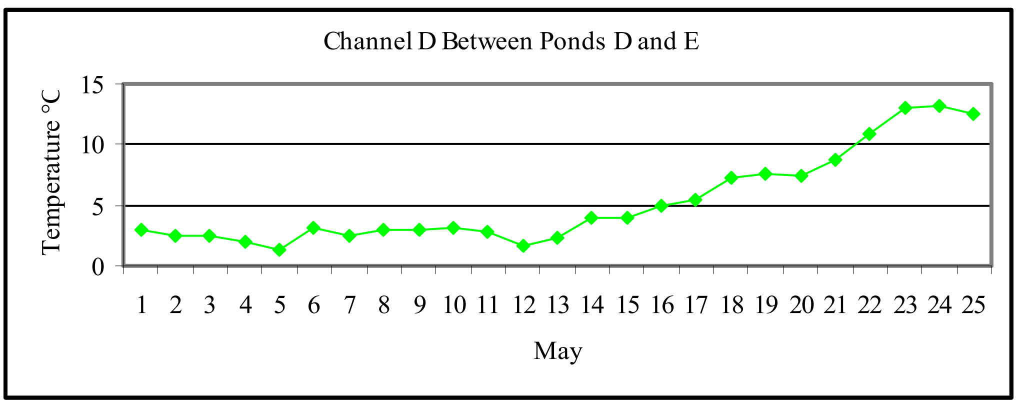

Figure 12. Peak daily water temperatures in Channel D.

Arctic Grayling Fry

Visual surveys of both the wetland complex and Last Chance Creek for Arctic grayling fry were conducted during late summer 2007. Arctic grayling fry were not seen in either area. Based on observations made during the spring spawning run of Arctic grayling, spawning did not occur in Last Chance Creek and fewer fish successfully spawned in the wetland complex than in previous years (1999 through 2006).

The lack of spawning success in Last Chance Creek was most likely due to cold water temperatures caused by aufeis. The reduced use of the wetland complex is attributed to habitat changes caused by a series of beaver dams that have converted riffle habitat to pools with a silt and debris substrate. There is very little riffle habitat available for Arctic grayling spawning and fish movement is limited in the wetland complex because of numerous beaver dams. Since the wetland complex is the primary spawning area for the Arctic grayling population in the WSR, recruitment to the population can be expected to decrease in the future, if beavers maintain their current level of occupancy in the valley.

Arctic Grayling Mark/Recapture, Population Estimate, and Growth

The abundance of Arctic grayling was estimated in the WSR using spring 2006 as the mark event and spring 2007 as the recapture event. In spring 2006, there were 1,146 marks when newly tagged and recaptured fish were combined. In spring 2007, 1,421 Arctic grayling >230 mm were captured, and of these, 274 were recaptures. The spring 2006 population estimate for Arctic grayling >200 mm long was 5,930 fish (95% CI 5,382 to 6,478) (Figure 13 and Appendix 1). This estimate represents a decrease from the number of fish estimated for spring 2005.

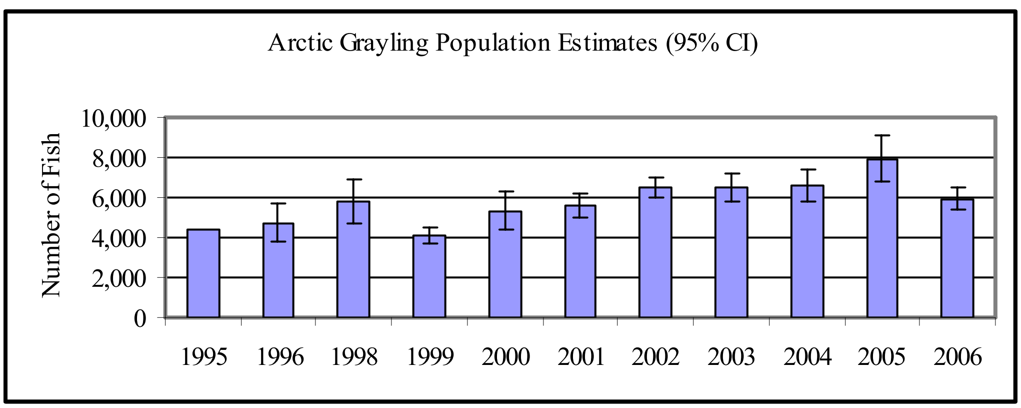

Figure 13. Estimates of the Arctic grayling population in the WSR.

For the 2006 estimated Arctic grayling population, length frequency distributions were compared for fish marked in spring 2006 with those recaptured in spring 2007 to eliminate those fish handled in 2007 that would have been too small (<200 mm) to mark in spring 2006 (Figures 14 and 15).

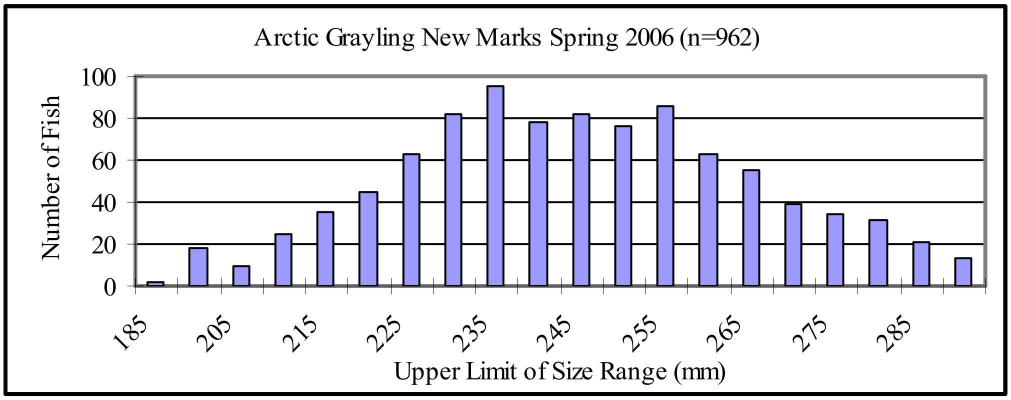

Figure 14. Length frequency distribution of Arctic grayling marked in spring 2006.

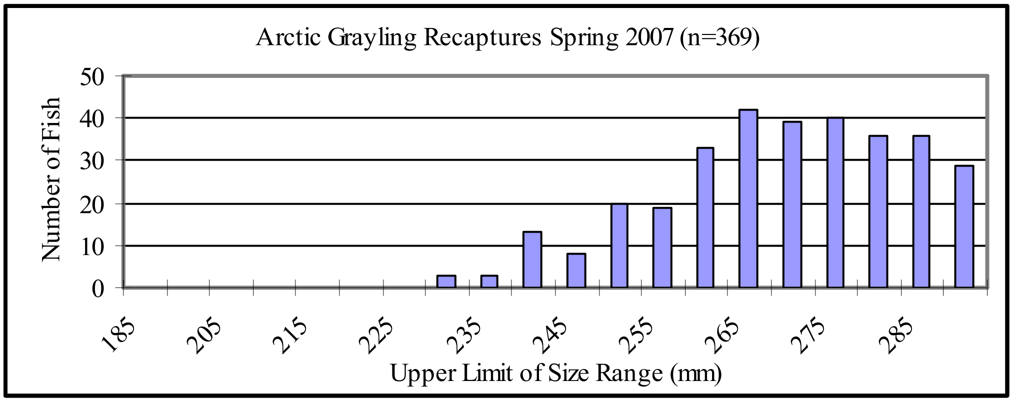

Figure 15. Length frequency distribution of Arctic grayling recaptures in spring 2007.

The comparisons of length frequency diagrams indicated that fish <230 mm in spring 2007 should not be included in the population estimate as they would have been too small in 2006 to mark. Using this approach, we reduced the number of fish seen in spring 2007 by 56 individuals.

Average growth prior to development of the WSR was 9 mm per year for Arctic grayling. Once the WSR was flooded, annual growth rates for all marked fish increased dramatically. Annual growth rates of marked fish by size class reached a peak in 2001, and then decreased each year through 2004 (Figure 16). Since 2004, growth rates of individual fish have increased, peaking in 2006 but still lower for most size groups of fish when compared with 2001.

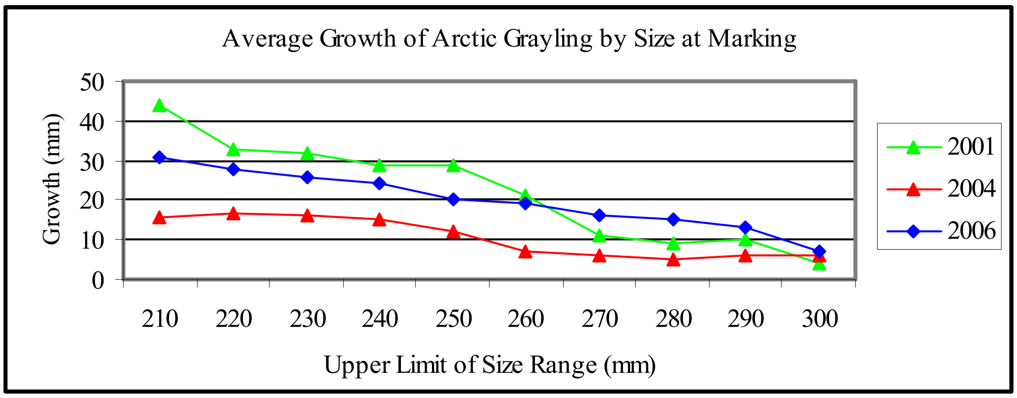

Figure 16. Annual growth (mm) for marked-recaptured Arctic grayling by size at marking.

The length frequency distribution for Arctic grayling collected in spring 2006 and spring 2007 are presented in Figures 17 and 18. Most of the small fish present in both sample years were caught at the end of the sampling period. Juveniles are likely underrepresented in these figures. All age classes were present in the catches and there continued to be evidence of successful recruitment. Somewhat different in 2007 was the low catch of fish between 190 and 220 mm; generally, catches in spring have included a large number of fish in this size range. Arctic grayling in this population may reach maturity at a larger size now than in the past and simply were not mixed with the spawning fish targeted in the recapture effort. By comparison, the apparent missing size class of fish from the WSR was the most common size class of fish captured by angling in the stilling basin in spring 2007, although the sample size was low.

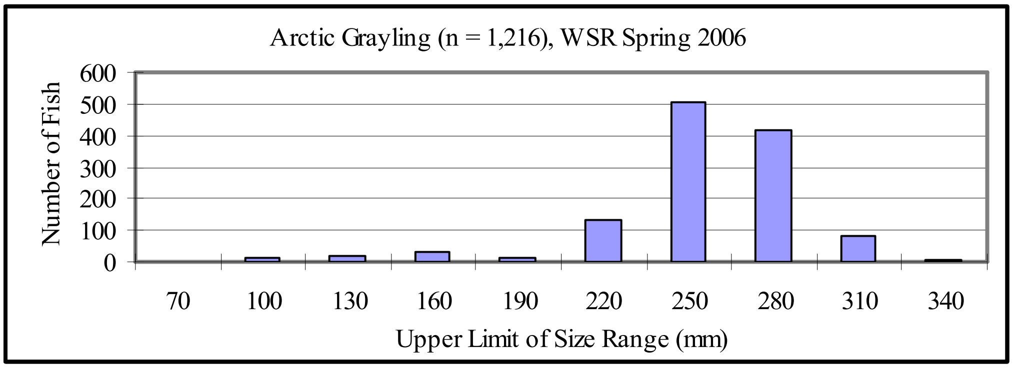

Figure 17. Length frequency distribution for Arctic grayling caught in spring 2006 with fyke nets and by angling. Most of the fish were caught with fyke nets.

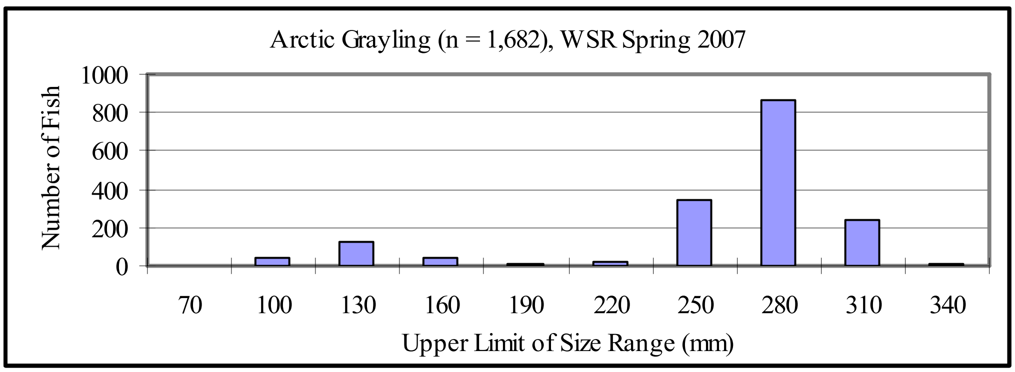

Figure 18. Length frequency distribution for Arctic grayling caught in spring 2007 with fyke nets and by angling. Most of the fish were caught with fyke nets.

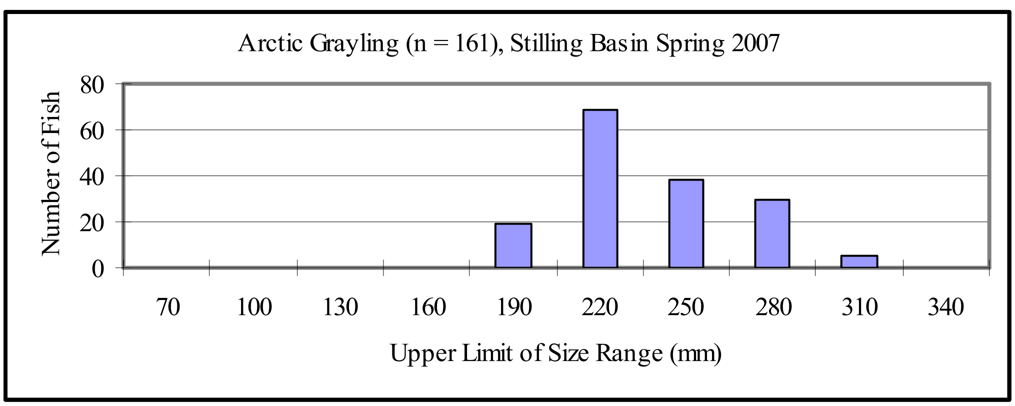

Figure 19. Length frequency distribution for Arctic grayling caught in spring 2007 by angling.

Water Supply Reservoir, Burbot

Burbot were found in Lower Last Chance Creek Pond and in Polar Ponds #1 and #2 prior to construction of the freshwater dam (Ott and Weber Scannell 1996). In May 1995, a mark/recapture experiment was conducted and the abundance of burbot between 150 and 331 mm long was estimated at 825 (Ott and Weber Scannell 1996).

Flooding of the WSR inundated areas where burbot were caught with fyke nets in Polar Ponds #1 and #2. A few small burbot also were caught in Last Chance Creek using electrofishing upstream of the area eventually flooded. After flooding of the WSR, the burbot population steadily increased and peaked in 1999 at 4,136 fish >200 mm. Since 1999, the number of burbot has steadily decreased with a slight increase in summer 2004. Our most recent estimate for burbot >200 mm was 944 fish in spring 2005 (95% CI, 572 to 1,316). Catch per unit of effort (burbot/day) tracked well with population estimates and the peak in 1999 (Figure 20).

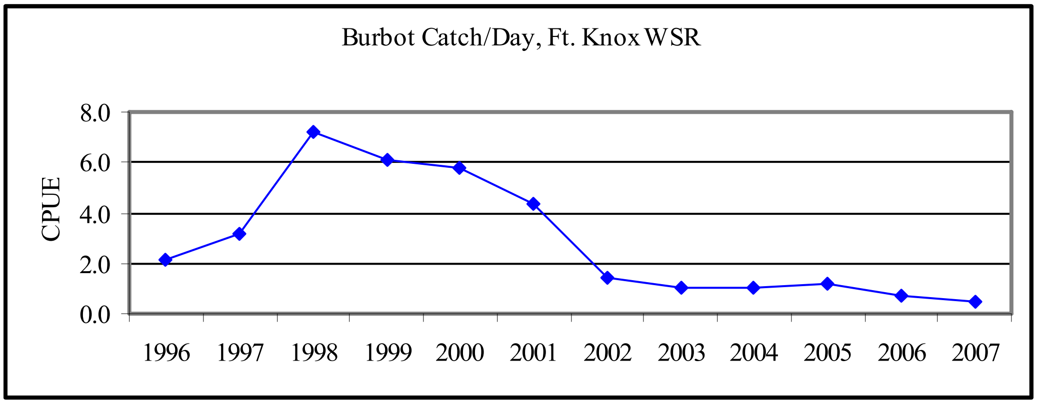

Figure 20. Catch per unit of effort (one day) in the Ft. Knox WSR.

Due to low numbers of recaptured fish <400 mm (4 fish), a spring 2006 estimate for the burbot population was not possible. However, the number of recaptured burbot >400 mm was sufficient and we were able to estimate the 2006 population of large burbot at 128 fish (95% CI, 82 to 173) (Figure 21, Appendix 2). The number of larger burbot in the Ft. Knox WSR has remained fairly stable for six years.

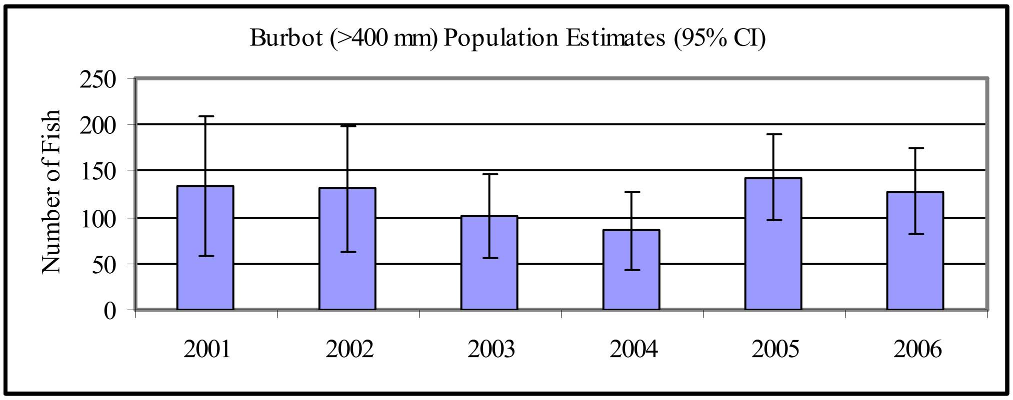

Figure 21. Estimates of the burbot population (>400 mm) in the WSR.

Small burbot were still present in hoop traps and fyke net catches in 2007. Based on the length frequency of burbot captured in 2007, it appears that successful spawning and recruitment continued in 2007 in the WSR (Figure 22 and Appendix 3).

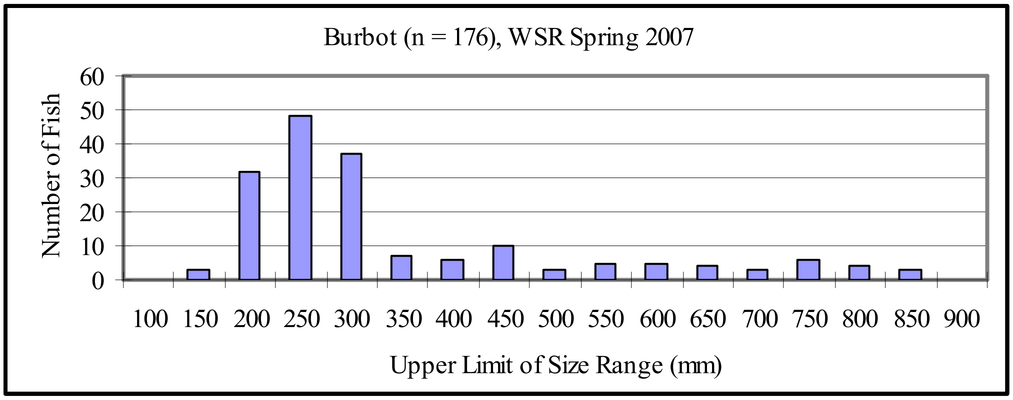

Figure 22. Length frequency distribution for burbot caught in spring 2007 with baited hoop traps.

One burbot recaptured in 2007 was first marked in spring 1995 prior to construction of the WSR. The fish was 218 mm when initially marked, and in 2007 the fish was 740 mm long. Capture history for this fish is presented in Table 4.

Table 4. Capture history for a burbot initially tagged on May 18, 1995.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1484	Gray	218	5/18/1995	Polar 2	5/20/1998	WSR	396
					6/5/1999	WSR	409
					6/10/2002	Upper WSR	460
					6/2/2003	WSR	540
					10/3/2003	WSR	560
					6/15/2007	WSR	740

Conclusion

Self-sustaining populations of Arctic grayling and burbot have been established in the Fort Knox WSR. The post-mining goal for the Arctic grayling population was set at 800 to 1,600 fish >200 mm prior to construction. Our spring 2006 estimated population for Arctic grayling >200 mm was 5,930 fish. A goal for the burbot population was not set prior to construction, but a self-sustaining population currently exists. Burbot numbers increased substantially after flooding of the WSR and peaked in 1999, but have declined since. The number of large burbot >400 mm in the WSR has been fairly stable since 2001.

OHMP plans to continue to work cooperatively with FGMI to gather data on fish resources and water quality in the WSR and to implement rehabilitation projects designed to increase fish and aquatic habitat values. Options under consideration include development of a second wetland complex along the north side of the Fish Creek valley, conversion of the existing Gil causeway into re-vegetated islands, civil work in Last Chance Creek to mitigate aufeis, rehabilitation of the road down the valley between the tailing dam and freshwater reservoir, explore construction of a passive treatment constructed wetland below the tailing dam, and removal of beaver dams to maintain Arctic grayling spawning habitat in the developed wetlands.

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Appendix 1. Arctic Grayling Population Estimates in the WSR

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
1995[1]	150	4,358	
1996[2]	150	4,748	3,824-5,672
1996[3]	150	3,475	2,552-4,398
1998[4]	200	5,800	4,705-6,895
1999[4]	200	4,123	3,698-4,548
2000[4]	200	5,326	4,400-6,253
2001[4]	200	5,623	5,030-6,217
2002[4]	200	6,503	6,001-7,005
2003[4]	200	6,495	5,760-7,231
2004[4]	200	6,614	5,808-7,420
2005[4]	200	7,926	6,759-9,094
2006[4]	200	5,930	5,382-6,478

[1]We used estimates from the ponds and creeks for the Arctic grayling population; a confidence interval was not applicable to the data set.
[2]The 1996 estimate was made with a capture and recapture event in summer 1996.
[3]Gear type for the population estimate was a boat-mounted electroshocker with both capture and recapture events in fall 1996.
[4]The 1998 through 2005 population estimates were made using a mark event in spring of the year of the estimate, but the recapture event was in spring of the following year.

Appendix 2. Burbot Population Estimates in the WSR

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
1995[1]	150	876	666-1,087
1997[2]	250	622	462-782
1998[2]	300	703	499-907
1998[3]	200	3,609	2,731-4,485
1999[3]	200	4,136	3,215-5,057
2000[3]	200	3,536	2,444-4,629
2001[4]	200	3,391	2,017-4,764
2001	400	134	58-210
2002[4]	200	1,763	1,045-2,480
2002	400	131	62-199
2003[4]	200	1,103	671-1,535
2003	400	102	57-147
2004[5]	200	2,100	1,242-2,957
2004	400	86	44-128
2005[5]	200	944	572-1,316
2005	400	143	96-191
2006[5]	200	-	-
2006	400	127	82-173

[1]We used fyke nets in the Polar Pond complex to make the 1995 population estimate.
[2]The 1997 and 1998 estimates were made with a capture and recapture event in May of the same year.
[3]The 1998, 1999, and 2000 population estimates were made using a mark event in spring with the recapture event occurring one year later in the spring.
[4]The 2001, 2002, and 2003 population estimates were made with capture and recapture events in the same year.
[5]The 2004, 2005, and 2006 population estimates were made using the previous year as the mark event with the recapture event occurring the following spring. No estimate was possible for burbot >200 mm in spring 2006.

Appendix 3. Burbot Catches in the WSR

Set Date	Gear Type	Number of Traps	Pull Date	Total Burbot	Catch/ Total Effort	Days Fished	Adjusted CPUE/Day
5/21/1996	Small Hoops	11	5/22/1996	36	3.3	1	3.3
5/21/1996	Large Hoops	4	5/22/1996	6	1.5	1	1.5
5/22/1996	Small Hoops	11	5/23/1996	19	1.7	1	1.7
5/22/1996	Large Hoops	4	5/23/1996	2	0.5	1	0.5
5/19/1997	Small Hoops	11	5/20/1997	58	5.3	1	5.3
5/19/1997	Large Hoops	13	5/20/1997	24	1.8	1	1.8
5/20/1997	Small Hoop	11	5/21/1997	61	5.5	1	5.5
5/20/1997	Large Hoops	17	5/21/1997	56	3.3	1	3.3
5/27/1997	Small Hoop	11	5/28/1997	45	4.1	1	4.1
5/27/1997	Large Hoops	19	5/28/1997	42	2.2	1	2.2
5/28/1997	Small Hoops	11	5/29/1997	32	2.9	1	2.9
5/28/1997	Large Hoops	20	5/29/1997	39	2.0	1	2.0
5/19/1998	Small Hoops	7	5/20/1998	87	12.4	1	12.4
5/20/1998	Small Hoops	9	5/21/1998	61	6.8	1	6.8
5/20/1998	Large Hoops	3	5/21/1998	20	6.7	1	6.7
5/21/1998	Small Hoops	9	5/22/1998	57	6.3	1	6.3
5/26/1998	Small Hoops	9	5/27/1998	61	6.8	1	6.8
5/27/1998	Small Hoops	9	5/28/1998	67	7.4	1	7.4
5/28/1998	Small Hoops	9	5/29/1998	44	4.9	1	4.9
6/2/1999	Small Hoops	17	6/3/1999	135	7.9	1	7.9
6/3/1999	Small Hoops	17	6/4/1999	124	7.3	1	7.3
6/4/1999	Small Hoops	17	6/5/1999	136	8.0	1	8.0
6/5/1999	Small Hoops	17	6/7/1999	142	8.4	2	4.2
6/7/1999	Small Hoops	17	6/8/1999	89	5.2	1	5.2
5/29/2000	Small Hoops	24	5/30/2000	191	8.0	1	8.0
5/30/2000	Small Hoops	24	5/31/2000	105	4.4	1	4.4
5/31/2000	Small Hoops	24	6/1/2000	122	5.1	1	5.1
6/5/2001	Small Hoops	30	6/6/2001	209	7.0	1	7.0
6/6/2001	Small Hoops	30	6/7/2001	76	2.5	1	2.5
6/26/2001	Small Hoops	30	6/27/2001	98	3.3	1	3.3
6/27/2001	Small Hoops	30	6/28/2001	140	4.7	1	4.7

Appendix 3. Burbot Catches in the WSR (concluded)

Set Date	Gear Type	Number of Traps	Pull Date	Total Burbot	Catch/ Total Effort	Days Fished	Adjusted CPUE/Day
6/1/2002	Small Hoops	30	6/3/2002	58	1.9	2	1.0
6/3/2002	Small Hoops	30	6/5/2002	58	1.9	2	1.0
6/5/2002	Small Hoops	30	6/6/2002	41	1.4	1	1.4
6/6/2002	Small Hoops	30	6/8/2002	118	3.9	2	2.0
6/8/2002	Small Hoops	30	6/10/2002	120	4.0	2	2.0
10/1/2002	Small Hoops	30	10/3/2002	69	2.3	2	1.2
5/28/2003	Small Hoops	30	5/29/2003	62	2.1	1	2.1
5/29/2003	Small Hoops	30	5/30/2003	34	1.1	1	1.1
5/30/2003	Small Hoops	30	6/2/2003	75	2.5	3	0.8
10/1/2003	Small Hoops	30	10/2/2003	50	1.7	1	1.7
10/2/2003	Small Hoops	30	10/3/2003	28	0.9	1	0.9
10/3/2003	Small Hoops	30	10/6/2003	36	1.2	3	0.4
10/6/2003	Small Hoops	5	10/8/2003	26	5.2	2	2.6
5/21/2004	Small Hoops	30	5/24/2004	115	3.8	3	1.3
5/24/2004	Small Hoops	30	5/28/2004	107	3.6	4	0.9
5/18/2005	Small Hoops	21	5/19/2005	33	1.6	1	1.6
5/19/2005	Small Hoops	27	5/20/2005	74	2.7	1	2.7
5/20/2005	Small Hoops	27	5/23/2005	73	2.7	3	0.9
5/23/2005	Small Hoops	27	5/26/2005	76	2.8	3	0.9
6/2/2006	Small Hoops	12	6/5/2006	34	2.8	3	0.9
6/5/2006	Small Hoops	12	6/6/2006	8	0.7	1	0.7
6/6/2006	Small Hoops	28	6/9/2006	53	1.9	3	0.6
6/6/2007	Small Hoops	14	6/8/2007	23	1.6	2	0.8
6/8/2007	Small Hoops	14	6/12/2007	26	1.9	4	0.5
6/12/2007	Small Hoops	30	6/15/2007	42	1.4	3	0.5
6/15/2007	Small Hoops	30	6/19/2007	44	1.5	4	0.4