A Transplant of Arctic Grayling to a Flooded Gravel Mine Site in the Kuparuk River Oilfield

by
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Executive Summary

Arctic grayling were captured at seven locations within the Sagavanirktok River drainage near Happy Valley Creek 21-25 June 1989. Two hundred ten arctic grayling, ranging in length from 176 to 399 mm, were transplanted to Kuparuk Mine Site B on 26-27 June 1989. Additional sampling is planned for 1990 and subsequent years to assess the success of this experimental fish transplant.

ARCO Alaska, Inc. completed a habitat enhancement project in May 1989 at Kuparuk Mine Site B that contained features that ADF&G believed would increase the long-term success of the arctic grayling transplant. A description of these features, their importance to the long-term success of the transplant, and their benefits to other fish and wildlife at the site is presented.

Sampling in the Kuparuk River downstream of the Spine Road crossing indicated that limited numbers of large arctic grayling use this area in mid July. Numbers of large arctic grayling were insufficient to conduct disease screening of arctic grayling in the Kuparuk River at this time.

INTRODUCTION

Since 1986, the Alaska Department of Fish and Game (ADF&G) has conducted limnological and fish sampling in selected flooded gravel mine sites in the Prudhoe Bay - Kuparuk oilfields to determine if these sites would provide suitable habitat for fish and wildlife. Sampling in 1986 and 1987 concentrated on the chemical and physical features of the sites (Hemming 1988). Sampling in 1988 focused on limnological sampling directed at identifying features of each site that could influence algal productivity and zooplankton densities. This sampling provided additional chemical and physical information, indications of productivity of the sites, and estimates of densities and species of zooplankton that could be used by fish for food (Hemming et al. 1989). With the results of these studies, ADF&G determined that Kuparuk Mine Site B, a flooded gravel mine site with limited potential for colonization by most freshwater fish, contained sufficient habitat to support a population of arctic grayling. As a result of these studies, ADF&G transplanted arctic grayling to this site in 1989.

There are two components to this technical report. The first component describes the capture and transplanting of Sagavanirktok River drainage arctic grayling to Kuparuk Mine Site B in June 1989. This section also describes site rehabilitation efforts conducted by the oil industry at Kuparuk Mine Site B and the potential benefits of these efforts to fish and wildlife at this site. The second component describes fish sampling in the Kuparuk River to obtain arctic grayling for disease screening so that this river system could be used as a source of arctic grayling for future transplants to mine sites within the oilfields.

ARCTIC GRAYLING TRANSPLANT

Introduction

Within the Prudhoe Bay-Kuparuk oilfields are several tundra streams that discharge directly to the Beaufort Sea, have limited populations of fish, and have limited potential for colonization by freshwater fish from distant streams. Brackish or marine conditions that exist in the nearshore Beaufort Sea usually provide a barrier to movements of freshwater fish, such as arctic grayling, beyond the mouths of streams and thereby limit colonization of distant streams by these salt-intolerant fish. These tundra streams also contain limited habitat suitable to fish for overwintering, as the streams are shallow and generally freeze to the bottom in winter. Two of these streams now connect with deep flooded gravel mine sites that provide conditions required to overwinter fish. Such conditions in these two stream systems provide an opportunity to determine if a common arctic freshwater fish, arctic grayling, that does not occur in these stream systems, can be introduced, survive, and reproduce in a mine site/stream system. With this opportunity, the Alaska Department of Fish and Game in June 1989 conducted an experimental introduction of arctic grayling into one tundra stream/mine site system, East Creek/Kuparuk Mine Site B.

The objective of the transplant was to establish a reproducing population of arctic grayling in East Creek/Kuparuk Mine Site B. Our goal was to obtain 200-500 large arctic grayling from the Sagavanirktok River drainage that could be transplanted to the mine site. Arctic grayling from the Sagavanirktok River drainage were screened for diseases, and approved for transplanting in Kuparuk Mine Site B in 1988 (Hemming et al. 1989). Hemming et al. (1989) collected arctic grayling for disease screening in the lower Sagavanirktok River drainage during mid-to-late summer and found too few for transplanting. The Happy Valley Creek area, about 130 km upstream in the Sagavanirktok River drainage, contains several streams with abundant large arctic grayling in early summer. Thus, we collected all fish from this area for transplanting to Kuparuk Mine Site B.

The following component describes the results of the arctic grayling capture and transplant and some initial observations on the success of the transplant. This component also describes the modifications made to the Kuparuk Mine Site B/East Creek system to enhance its ability to support fish and that may directly contribute to the success of the experimental transplant.

Methods

We attempted to capture arctic grayling at 10 locations near Happy Valley Creek 21-25 June 1989 (Figure 1). We captured arctic grayling at seven locations with several types of sampling equipment: fyke nets, seines, angling, and dip net. Limited sampling with a backpack electroshocker did not yield fish. Fyke nets were most effective at the mouths of tundra streams where stream velocities were low, and stream depth and width allowed adequate placement of the nets. One fyke net was also set in one pond of Goose Green Gulch, a former gravel mine site. We checked fyke nets daily for fish, and measured and released captured fish other than arctic grayling, and arctic grayling less than 176 mm.

We placed captured arctic grayling suitable for transplant in an insulated cooler and transported them from the capture site to a holding pen in lower Happy Valley Creek. When necessary, supplemental oxygen delivered through aquarium airstones kept the water in the cooler well oxygenated. Before placing the arctic grayling in the holding pen, we anesthesized the fish with MS 222 (tricane methane sulfonate), measured them to the nearest millimeter (fork length), and removed scales for age estimation. We also tagged the fish at the base of their dorsal fin with numbered yellow floy tags, that will allow monitoring of the growth of the fish. A 1.2 x 2.4 x 1.2 m covered net pen held the arctic grayling for up to 5 days before transport to Kuparuk Mine Site B.

We transported approximately 100 arctic grayling to Kuparuk Mine Site B on both 26 and 27 June 1989. Two 114 L plastic garbage containers lined with a large plastic bag containing about 95 L of water and a similarly lined 64 L insulated cooler containing about 50 L of water held the fish during transport. Plastic bags were tied to prevent loss of water and fish. Supplemental oxygen delivered through aquarium airstones during loading of the fish into the transport containers and the subsequent 3 hr drive to Kuparuk Mine Site B reduced the possibility of suffocation. We released the arctic grayling at the northeast section of Kuparuk Mine Site B upon arrival at the site.

We placed two fyke nets within Kuparuk Mine Site B on 23 and 24 August in part to determine if arctic grayling were still present in the site. On 5 October we again sampled for arctic grayling, on this occasion by angling.

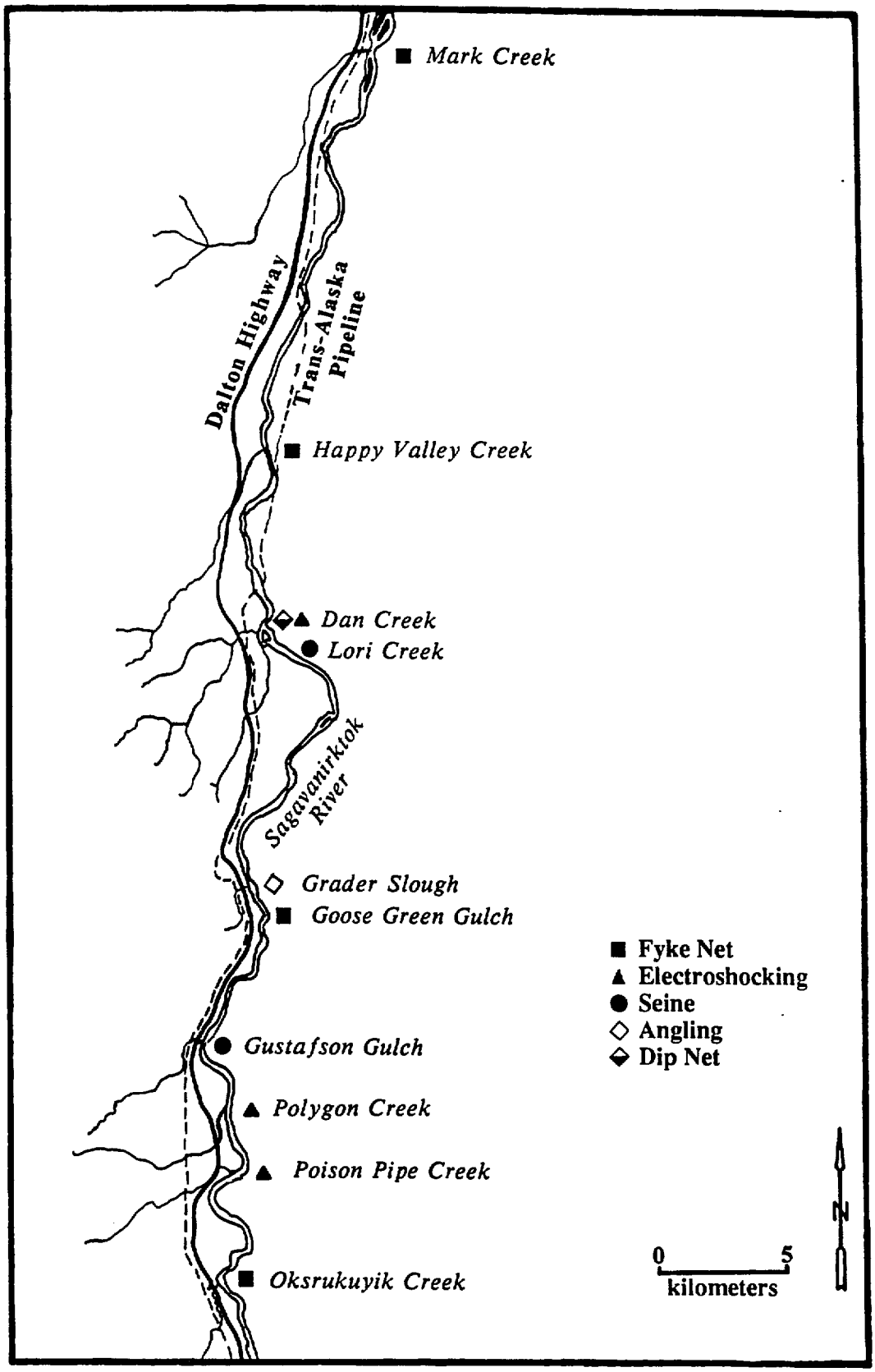

Figure 1. Capture locations and sampling techniques used to capture arctic grayling, June 1989.

Results

We placed 210 arctic grayling, ranging in length from 176 to 399 mm, in Kuparuk Mine Site B on 26 and 27 June 1989 (Appendix 1). The average size of the transplanted arctic grayling was 283 ± 52 mm (Table 1). All arctic grayling appeared healthy when released and several began feeding at the surface within minutes of their release. One arctic grayling swam out of Kuparuk Mine Site B and into East Creek immediately upstream of the Spine Road culverts within 15 min of its release.

Oil industry personnel caught and kept at least two arctic grayling (an unknown number were also caught and released) within the first few weeks after stocking (S. Bishop, Wildlife Biologist, ADF&G, Fairbanks, pers. comm.). Although the site was not closed to sport fishing following the transplant, ADF&G staff requested anglers to release all tagged arctic grayling that they caught. In August, ARCO Alaska, Inc. placed a sign describing the transplant project and requesting release of tagged arctic grayling at Kuparuk Mine Site B.

We caught two arctic grayling in fyke nets set in Kuparuk Mine Site B on 23 and 24 August. One arctic grayling did not have a numbered floy tag but had a wound at the base of its dorsal fin, suggesting this fish had lost its tag and was a transplanted fish. The other arctic grayling grew at an average rate of 0.23 mm/day over the 61 days between its initial and subsequent capture (Table 2).

ADF&G staff captured and released three arctic grayling in Kuparuk Mine Site B by angling on 5 October, including one previously captured in a fyke net on 23 August. Average rates of growth for these arctic grayling over a 102-105 day period ranged from 0.24 to 0.34 mm/day (Table 2).

Based on scale annuli, we estimated the ages of transplanted arctic grayling to range from 3 to 11 yrs (Table 3). The age-length relationship is highly correlated: age = 0.0383 (length [mm]) - 4.62; $r^2 = 0.84$. Estimated ages of the transplanted arctic grayling were similar to those estimated for arctic grayling obtained from the lower Sagavanirktok River in 1988 (Hemming et al. 1989).

Discussion

Before the introduction of arctic grayling into Kuparuk Mine Site B, ARCO Alaska, Inc. completed a habitat enhancement project that contained features ADF&G believed would

Table 1. Size category, number, and origin of arctic grayling transplanted to Kuparuk Mine Site B, June 1989, from the Sagavanirktok River drainage.

Capture Site (Capture Method)	Number of Arctic Grayling			Mean Length (mm) ± s.d.
	Total	<300 mm	≥300 mm	
Happy Valley Creek (fyke net)	52	26	26	281 ± 55
Dan Creek (dip net)	1	0	1	330
Mark Creek (2 fyke nets)	39	15	24	294 ± 60
Oksrukuyik Creek (fyke net)	12	6	6	283 ± 51
Grader Slough (angling)	7	5	2	258 ± 49
Gustafson Gulch (seine)	13	12	1	243 ± 45
Goose Green Gulch (fyke net)	86	44	42	288 ± 45
All Sites	210			283 ± 52

Table 2. Estimated growth rates of individual arctic grayling transplanted to Kuparuk Mine Site B, summer 1989.

Length (mm)		Estimated Growth (mm)	Days in Mine Site	Estimated Growth Rate (mm/day)
At Capture	At Recapture			
310*	324	14	61	0.23
310*	335	25	104	0.24
299	324	25	105	0.24
335	370	35	102	0.34

* same fish

Table 3. Age-length relationships for arctic grayling captured within the Sagavanirktok River drainage and later transplanted to Kuparuk Mine Site B, June 1989. Ages estimated from scale annuli; n = number of fish in sample; sd = standard deviation.

	Fork Length (mm)			
Age	n	Mean	Range	sd
3	28	200.8	176-246	16.2
4	29	228.8	180-292	25.2
5	21	262.7	225-298	18.3
6	28	291.0	254-324	18.9
7	23	315.9	281-334	14.1
8	30	321.3	287-353	14.5
9	18	334.8	299-376	20.4
10	4	344.2	316-368	21.7
11	6	365.8	356-399	16.4
TOTAL	187			

increase the long-term success of the arctic grayling transplant. The ADF&G had two objectives for the enhancement project: to connect the two separate basins with two channels to form one contiguous lake with an island; and to connect the mine site and East Creek with a permanent channel. ARCO Alaska, Inc. completed this enhancement project in May 1989. In addition, ARCO Alaska, Inc. previously removed fill and culverts from East Creek upstream of Kuparuk Mine Site B in late summer 1988.

ARCO Alaska, Inc. excavated three channels during the enhancement project (Figure 2). Two channels, approximately 15 m wide, 15 m long, and 1 m deep, cut through the ground separating the two basins of the mine site, create an island approximately 30 m x 15 m. A third channel, excavated between East Creek and the southwest corner of the southernmost basin is approximately 20 m wide, 25 m long, and 2 m deep. The excavated material was stockpiled next to existing overburden on the east side of the site, and on an existing overburden stockpile on the south side of the site.

The connections between the two basins and between the site and East Creek were deep enough to contain adequate amounts of water throughout the summer. Previously, the connection between East Creek and Kuparuk Mine Site B was marginal during periods of low flow. The new connection provided an adequate channel between the site and the creek, yet flow continued through the original stream channel that bordered the western edge of the site. There was some concern during the planning of this enhancement project that by constructing a deep connection between East Creek and Kuparuk Mine Site B, the creek would flow through the mine site, and exit at the site's northwest corner, thereby eliminating flow through a portion of the original stream channel. During our site visits, some of which were during periods of low stream flow, water continued to flow through the original channel.

The permanent connection of Kuparuk Mine Site B with East Creek provides several benefits to the site's fish and wildlife. The connection may now divert a significant portion of the spring runoff of East Creek through the site, promoting more rapid ice melt within Kuparuk Mine Site B. Rapid ice melt should provide areas of open water that may be used by surface feeding fish and by waterfowl. The tundra stream water also should be warmer at times during spring and summer than mine site water, and may serve to warm the lake. Water from East Creek also should bring additional nutrients to mine site waters, enhancing the productivity of the system. The permanent connection will enable arctic grayling to move freely out of the mine site to areas in the creek that may be suitable for feeding or spawning, and then into the mine site when the creek freezes.

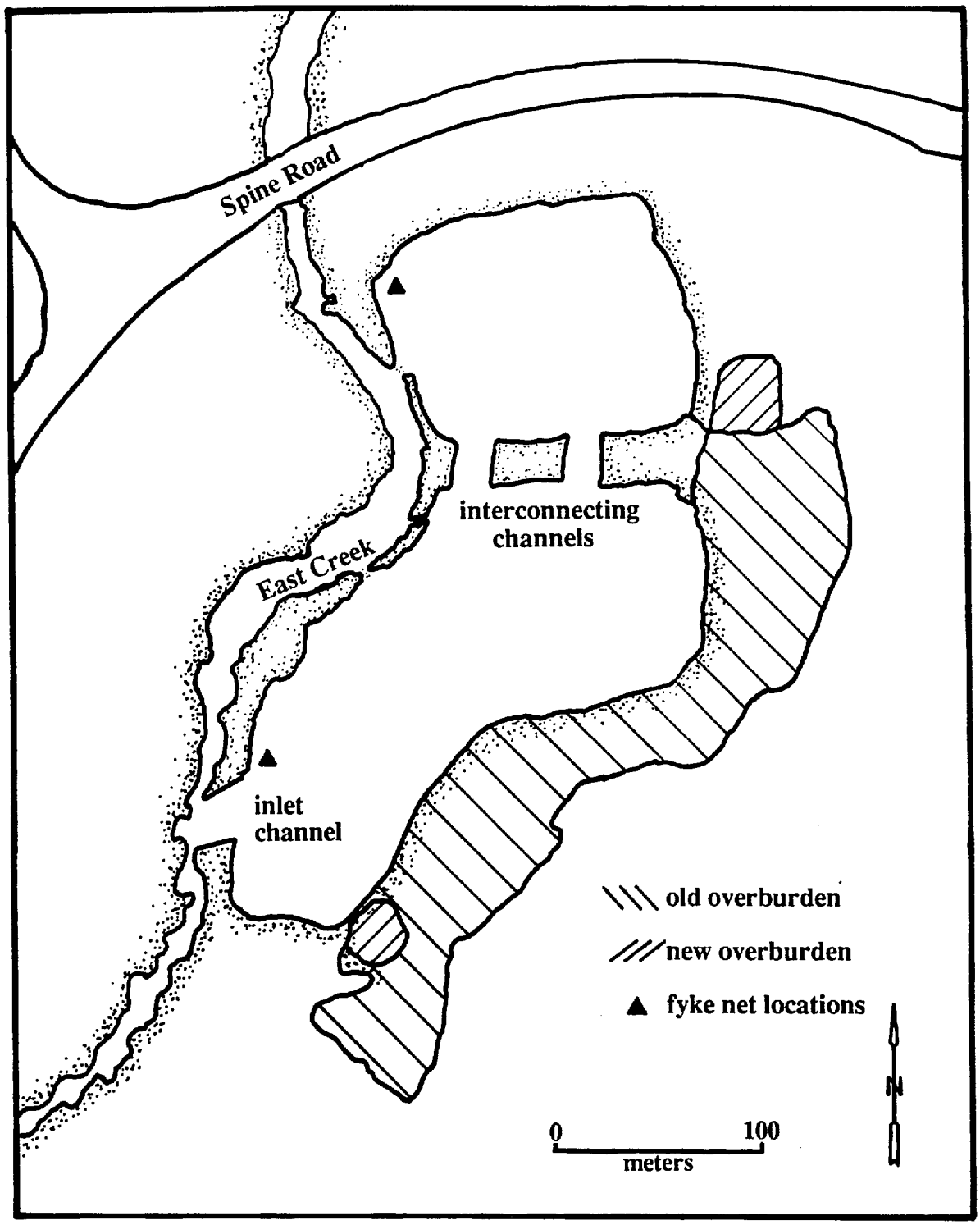

Figure 2. Kuparuk Mine Site B, depicting the locations of the inlet and interconnecting channels excavated in May 1989. Map drawn from July 1989 aerial photograph.

We selected several sites for capture of arctic grayling in the Happy Valley Creek area for three reasons: to collect the desired number of fish rapidly; to obtain fish from a variety of locations after they had spawned; and to minimize the potential of removing a significant portion of the adult population of a particular stream. Netting at the mouths of streams in late June increased the chances that some arctic grayling captured at a particular stream had spawned, or that the arctic grayling were from other systems and were using the stream mouths as feeding areas or as intermediate stops between other areas. McCart et al. (1972) reported that arctic grayling from Happy Valley Creek disperse to the Sagavanirktok River and other mountain streams after spawning. Craig and Poulin (1975) also noted similar patterns of movement by arctic grayling in Weir Creek in the Kavik River system (approximately 80 km northeast of Happy Valley). These studies also suggested that by mid-June, most arctic grayling have spawned in their tundra streams and have begun downstream movements. During our capture of arctic grayling, we noted no evidence of sex products from the fish we handled. Thus, the arctic grayling we removed from these systems probably spawned before their capture.

Forty-one percent (86) of the 210 transplanted arctic grayling were from Goose Green Gulch, a site that contains about 1.5 ha of ponds connected to the Sagavanirktok River. These fish were likely transients from another stream system as conditions in this site did not appear favorable for spawning by arctic grayling. Arctic grayling use several tundra streams that drain into the Sagavanirktok River and that are within several kilometers of Goose Green Gulch. Although possible, it is unlikely that all arctic grayling caught at Goose Green Gulch were from any particular one of these streams. It is more likely that these and other streams contributed individuals to this catch and that the removal of these 86 individuals did not affect any particular arctic grayling population severely.

We do not know the extent to which the transplanted arctic grayling used East Creek. At least one arctic grayling moved into the creek shortly after its release into Kuparuk Mine Site B. Water levels and wind produced conditions that made arctic grayling difficult to see in East Creek during our visits throughout the summer. Sampling with fyke nets in late August in Kuparuk Mine Site B yielded only two arctic grayling, suggesting that some arctic grayling may have been in the creek at this time. Conversely, arctic grayling may not have been captured at these net sites because only two nets fished for two days, or because arctic grayling may not have intercepted the nets.

The presence of arctic grayling in Kuparuk Mine Site B in early October suggests that some arctic grayling would overwinter within the mine site. We do not know whether

these fish spent the entire summer in Kuparuk Mine Site B or ventured into East Creek and returned after some undetermined period. Sampling in late winter or spring, preferably before the arctic grayling leave the site for the creek, will be required to assess overwinter survival of these fish.

Large numbers of ninespine stickleback in the Kuparuk Mine Site B/East Creek system may affect the success of the transplant of arctic grayling, through competition with fry and juvenile arctic grayling, should successful spawning by arctic grayling occur in this system. Our sampling in late August in Kuparuk Mine Site B produced overnight catches of an estimated 23,000-24,000 ninespine stickleback. Skaugstad (1989) noted poor growth of stocked arctic grayling fingerlings and little or no apparent survival of sac fry in interior Alaska ponds containing threespine stickleback. Whether competition occurs between ninespine stickleback and arctic grayling will depend upon the relative densities of each species, the microhabitats used by each species and their degree of overlap, the degree to which prey species overlap, and the availability of alternative prey. Potential predation by adult ninespine stickleback on arctic grayling sac fry also may adversely affect survival of arctic grayling fry.

A complete assessment of the success of the arctic grayling transplant experiment will require several years of continued sampling within the Kuparuk Mine Site B/East Creek system. Since arctic grayling within and near the Sagavanirktok River drainage mature between ages 4 and 8 (Craig and Poulin 1975, McCart et al. 1972), eight years may be required to determine if any progeny of the transplanted adults successfully spawns and continues to perpetuate arctic grayling within the Kuparuk Mine Site B/East Creek system. Sampling will be needed to detect the presence of fry and thus successful spawning by the stocked adults. Further sampling will be required to determine if any arctic grayling fry survive beyond initial hatching and contribute to the juvenile component of the population. Sampling also should reveal the relative survival of any progeny of the transplanted adults.

KUPARUK RIVER ARCTIC GRAYLING DISEASE SCREENING

Introduction

To comply with our Fish Transport Permit, we attempted to obtain 60 arctic grayling from the Kuparuk River for disease screening. Approval to use Kuparuk River arctic grayling would provide two benefits: an additional source of fish other than the Sagavanirktok River system, and a source of fish minutes from potential stocking locations as opposed to hours for some Sagavanirktok River sites.

Methods

During the period 19-21 July, we fished one fyke net in each of three locations in slack water channels of the Kuparuk River: 1.6, 2.4, and 4.8 km downstream of the Spine Road crossing. We fished one additional net at the mouth of Smith Creek, about 3.2 km downstream of the Spine Road crossing. We checked the nets daily and kept all arctic grayling greater than 170 mm in a 1.2 x 2.4 x 1.2 m net holding pen in Kuparuk Deadarm Reservoir 5. Each day we released all arctic grayling less than 170 mm and all other fish after measuring them to the nearest millimeter (fork length). After two days we ended sampling and returned all of the arctic grayling held in the holding pen at Kuparuk Deadarm Reservoir 5 to Smith Creek (all of the penned arctic grayling were from Smith Creek).

Results

Fyke nets set in slack water channels of the lower Kuparuk River captured 52 arctic grayling, 2 slimy sculpin, and 12 ninespine stickleback. These 66 fish were small, less than 130 mm in length (Appendix 3). The fyke net set at the mouth of Smith Creek for 2 days captured 4 ninespine stickleback, a 465 mm broad whitefish, and 26 arctic grayling from 79 to 434 mm long (Appendix 3).

Discussion

Catch rates of large arctic grayling in the lower Kuparuk River in late July precluded obtaining an adequate sample of arctic grayling for disease screening. At least 7 to 10 days would have been required to capture the 60 arctic grayling needed for disease screening. As Smith Creek was the only site that produced any arctic grayling suitable for screening, it is likely that all arctic grayling used for disease screening would have to

come from Smith Creek or other small tributaries to the Kuparuk River. The number of streams tributary to the Kuparuk River in the vicinity of the Spine Road crossing is small and removal of the number of arctic grayling necessary for disease screening or a transplant could have adverse effects on the populations of arctic grayling in these streams.

Our sampling indicates that there are insufficient large arctic grayling at catchable locations in the Kuparuk River in mid July to successfully conduct a transplant operation should this arctic grayling stock be approved for transplanting. Arctic grayling may be more numerous in the lower Kuparuk River in late August if this segment of the river is used by arctic grayling as an overwintering area. Additional sampling in late August may indicate that sufficient numbers of large arctic grayling are available for disease screening and transplanting immediately before freeze-up.

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Appendix 1. Length and estimated ages of arctic grayling captured within the Sagavanirktok River drainage and later transplanted to Kuparuk Mine Site B, June 1989.

Creek (Date of capture)	Length (mm)	Age (yr)	Tag #
Dan Creek (6/22/89)	330	9	002039
Goose Green Gulch (6/25/89)	183	3	002167
	189	3	002164
	193	3	002165
	194	4	002151
	198	3	002160
	203	3	002206
	206	3	002149
	212	3	002208
	215	3	002132
	216	3	002144
	219	4	002139
	227	4	002174
	229	4	002183
	230	4	002202
	235	4	002136
	246	3	002148
	246	4	002200
	251	4	002135
	253	5	002166
	259	4	002169
	260	5	002182
	262	4	002181
	264	5	002157
	265	5	002201
	269	6	002172
	271	5	002145
	273	-	002187
	276	5	002130
	277	5	002177
	277	3	002193
	281	5	002186
	282	6	002190
	283	5	002134
	284	6	002191
	286	6	002155
	289	6	002168
	289	5	002161
	290	6	002210
	290	6	002211
	292	4	002196
	295	7	002129
	295	-	002147
	296	8	002173

Appendix 1 continued.

Creek (Date of capture)	Length (mm)	Age (yr)	Tag #
Goose Green Gulch (6/25/89)	296	6	002204
	298	5	002128
	301	6	002158
	301	6	002162
	303	6	002171
	306	7	002207
	306	8	002209
	307	-	002203
	309	-	002137
	311	-	002143
	312	6	002152
	312	7	002175
	312	7	002176
	314	7	002199
	315	8	002146
	315	7	002192
	317	6	002126
	320	-	002178
	321	8	002154
	322	7	002197
	323	7	002159
	323	-	002170
	323	-	002188
	324	6	002127
	324	6	002184
	324	7	002195
	326	8	002131
	328	8	002205
	329	8	002138
	329	-	002156
	329	-	002179
	330	7	002153
	331	7	002163
	332	7	002141
	335	-	002194
	335	8	002198
	337	8	002150
	341	8	002185
	347	9	002125
	350	-	002180
	351	10	002133
	352	-	002140
	353	8	002142
	360	-	002189
Grader Slough (6/24/89)	216	3	002122
	227	4	002120
	229	-	002118

Appendix 1 continued.

Creek (Date of capture)	Length (mm)	Age (yr)	Tag #
Grader Slough (6/24/89)	285	6	002124
	291	7	002119
	313	8	002121
	342	10	002123
Gustafson Gulch (6/21/89)	176	3	002002
	225	4	002003
	232	4	002001
	274	-	002004
	313	-	002006
(6/23/89)	177	3	002088
	201	3	002090
	210	3	002096
	241	5	002089
	241	4	002098
	254	6	002087
	267	5	002091
	297	6	002097
Happy Valley Creek (6/22/89)	193	4	002002
	199	4	002029
	218	4	002012
	226	4	002017
	227	4	002008
	232	5	002022
	237	-	002033
	250	5	002016
	276	6	002038
	292	6	002027
	297	-	002023
	299	9	002032
	304	6	002018
	307	8	002014
	307	-	002024
	307	8	002037
	308	8	002015
	311	6	002009
	311	8	002034
	316	10	002019
	320	9	002007
	321	7	002010
	321	7	002013
	324	8	002028
	326	-	002036
	328	7	002021
	329	7	002020
	330	8	002039
	336	9	002030
	356	11	002031

Appendix 1 continued.

Creek (Date of capture)	Length (mm)	Age (yr)	Tag #
Happy Valley Creek (6/22/89)	358	11	002035
	359	11	002025
	368	10	002011
(6/23/89)	191	3	002081
	201	3	002080
	203	3	002075
	206	3	002082
	218	4	002079
	238	-	002085
	238	4	002088
	265	6	002076
	281	7	002077
	287	8	002072
	310	9	002073
	314	9	002074
	315	8	002078
	315	8	002086
	317	7	002083
	399	11	002084
(6/24/89)	185	3	002099
	188	3	002102
	194	3	002101
	257	5	002100
Mark Creek (6/23/89)	180	3	002048
	180	4	002051
	187	4	002058
	209	3	002056
	214	4	002043
	214	3	002054
	217	4	002052
	221	3	002065
	239	4	002050
	256	6	002044
	266	5	002060
	301	-	002045
	312	9	002069
	316	7	002046
	316	8	002070
	317	8	002063
	318	9	002064
	325	-	002068
	329	8	002061
	331	8	002062
	332	8	002071
	334	7	002066
	337	8	002059
	343	9	002049

Appendix 1 continued.

Creek (Date of capture)	Length (mm)	Age (yr)	Tag #
Mark Creek (6/23/89)	347	9	002055
	348	9	002057
	349	9	002067
	362	11	002053
	376	9	002047
(6/24/89)	212	3	002109
	232	4	002104
	260	5	002103
	266	6	002110
	329	8	002107
	330	9	002108
	330	9	002112
	355	9	002111
	362	-	002105
	363	9	002106
Oksrukuyik Creek (6/22/89)	225	5	002042
	296	7	002040
	310	6	002041
(6/23/89)	258	5	002093
	286	6	002092
	307	8	002094
	361	11	002095
(6/24/89)	176	3	002113
	244	5	002116
	278	6	002114
	315	7	002117
	338	8	002115

Appendix 2. Lengths of fish caught and released in Sagavanirktok River drainage streams, 21-25 June 1989.

	Length of Fish in Millimeters				
Species	Mark Creek	Happy Valley Creek	Gustafson Gulch	Oksrukuyik Creek	Goose Green Gulch
Arctic Grayling	54	59	115	65	66
	61	64	138	68	66
	64	64	148	71	68
	68	67	151	76	69
	68	68	-	146	70
	72	68	-	155	71
	72	69	-	-	72
	73	70	-	-	72
	77	71	-	-	73
	78	73	-	-	75
	79	73	-	-	75
	86	75	-	-	76*
	90	77	-	-	78
	91	77	-	-	79
	92	77	-	-	104
	95	78	-	-	109
	101	78	-	-	110
	103	79	-	-	113
	104	81*	-	-	115
	106	85	-	-	115
	110	106	-	-	128
	110	108	-	-	139
	112	110	-	-	144
	113	111	-	-	157
	115	112	-	-	158
	116	113	-	-	162
	119	113	-	-	163
	120	113	-	-	164
	122	115	-	-	165
	124	116	-	-	169
	128	117	-	-	176
	147	117	-	-	-
	150	118	-	-	-
	151	121	-	-	-
	155	124	-	-	-
	155	124	-	-	-
	155	124	-	-	-
	155	125	-	-	-
	157	125	-	-	-
	160	125	-	-	-
	163	126	-	-	-

Appendix 2 continued.

Species	Length of Fish in Millimeters				
	Mark Creek	Happy Valley Creek	Gustafson Gulch	Oksrukuyik Creek	Goose Green Gulch
Arctic Grayling	164	127	-	-	-
	167	132	-	-	-
	171	139	-	-	-
	182	141	-	-	-
	183	146	-	-	-
	191	152	-	-	-
	192	153	-	-	-
	193	153	-	-	-
	209	154	-	-	-
	218	155	-	-	-
	302	155	-	-	-
	-	156	-	-	-
	-	156	-	-	-
	-	157	-	-	-
	-	159	-	-	-
	-	159	-	-	-
	-	162	-	-	-
	-	163	-	-	-
	-	166	-	-	-
	-	166	-	-	-
	-	167	-	-	-
	-	170	-	-	-
	-	172	-	-	-
	-	300	-	-	-
	-	324*	-	-	-
	-	328	-	-	-
	-	347	-	-	-
Round Whitefish	153	268	-	328	332
	249	275	-	333	335
	249	284	-	345	-
	265	309	-	348	-
	272	312	-	-	-
	288	312	-	-	-
	293	329	-	-	-
	306	336	-	-	-
	306	345	-	-	-
	307	349	-	-	-
	314	-	-	-	-
	319	-	-	-	-
	320	-	-	-	-
	324	-	-	-	-
	334	-	-	-	-
	342	-	-	-	-
	347	-	-	-	-

Appendix 2 continued.

Species	Length of Fish in Millimeters				
	Mark Creek	Happy Valley Creek	Gustafson Gulch	Oksrukuyik Creek	Goose Green Gulch
Round Whitefish	368	-	-	-	-
	378	-	-	-	-
	378	-	-	-	-
Burbot	500	-	-	415	-
	550	-	-	430	-
	-	-	-	455	-
	-	-	-	455	-
	-	-	-	462	-
	-	-	-	484	-
	-	-	-	486	-
	-	-	-	493	-
	-	-	-	495	-
	-	-	-	500	-
	-	-	-	501	-
	-	-	-	502	-
	-	-	-	505	-
	-	-	-	510	-
	-	-	-	510	-
	-	-	-	510	-
	-	-	-	520	-
	-	-	-	520	-
	-	-	-	520	-
	-	-	-	520	-
	-	-	-	520	-
	-	-	-	525	-
	-	-	-	530	-
	-	-	-	540	-
	-	-	-	600	-
	-	-	-	600	-
	-	-	-	600	-
Dolly Varden	-	68	-	85	-
	-	70	-	118	-
	-	72	-	-	-
	-	75	-	-	-
	-	76	-	-	-
	-	77	-	-	-
	-	77	-	-	-
	-	96	-	-	-
	-	101	-	-	-
	-	102	-	-	-
	-	103	-	-	-
	-	105	-	-	-
	-	107	-	-	-

Appendix 2 continued.

	Length of Fish in Millimeters				
Species	Mark Creek	Happy Valley Creek	Gustafson Gulch	Oksrukuyik Creek	Goose Green Gulch
Dolly Varden	-	193	-	-	-
Ninespine Stickleback	-	-	-	-	72

* mortality

Mark Creek: netted 23-25 June
Happy Valley Creek: netted 22-25 June
Gustafson Gulch: netted 21, 23 June
Oksrukyik Creek: netted 22-25 June
Goose Green Gulch: netted 25 June

Appendix 3. Lengths of fish caught in fyke nets in the Kuparuk River and Smith Creek downstream of the Spine Road crossing, 20-21 July 1989.

	Length of Fish in Millimeters			
Species	Net 1	Net 2	Net 3	Net 4
Arctic Grayling	34	77	79*	40
	35	78	79	66
	35	80	82*	71
	37	82	85	72
	38	83	87	73
	79	86	88*	73
	79	87	116	74
	83	110	125	75
	84	119	127	76
	86	144	135	77
	87	-	137	77
	92	-	181	77
	113	-	183	78
	-	-	253	79
	-	-	262	80
	-	-	284	81
	-	-	287	81
	-	-	291	82
	-	-	292	82
	-	-	306	83
	-	-	309	84
	-	-	309	84
	-	-	338	85
	-	-	354	86
	-	-	373	87
	-	-	434	91
	-	-	-	102
	-	-	-	120
	-	-	-	125
Ninespine Stickleback	54	72	54*	43*
	-	-	66	47
	-	-	67	53
	-	-	72*	54
	-	-	-	58
	-	-	-	61
	-	-	-	63
	-	-	-	66
	-	-	-	67
	-	-	-	68

Appendix 3 continued.

	Length of Fish in Millimeters			
Species	Net 1	Net 2	Net 3	Net 4
Slimy Sculpin	76	-	-	56
Broad Whitefish	-	-	465	-

* fyke net mortality

Locations of nets:
Net 1 - 1.6 km downstream of the Spine Road crossing
Net 2 - 2.4 km downstream of the Spine Road crossing
Net 3 - mouth of Smith Creek, 3.2 km downstream of the Spine Road crossing
Net 4 - 4.8 km downstream of the Spine Road crossing