Limnological and Fisheries Investigations of Flooded North Slope Gravel Mine Sites, 1988

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Carl R. Hemming, Phyllis K. Weber, and Jack F. Winters

Technical Report No. 89-1

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Division of Habitat

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EXECUTIVE SUMMARY

Fishery and limnological investigations were conducted at five flooded gravel mine sites in the Prudhoe Bay - Kuparuk oilfields from May through August 1988. Our study included three components: chemical and biological limnology in four mine sites, an arctic grayling (*Thymallus arcticus*) population estimate in Sag Site C, and disease screening of arctic grayling in the Savavanirktok River.

The flooded gravel mine sites are cold monomictic lakes that either mix continuously during the ice-free season or form weak thermoclines. Dissolved oxygen concentrations were at or near saturation throughout the water column.

Primary production experiments with light/dark bottles did not have sufficient sensitivity to detect the low production rates found in most of the sites. Where production was detectable, it usually occurred in mine sites with extensive shallow water habitat.

Phytoplankton standing crop, estimated by measuring concentrations of chlorophyll-a, were low at all sites but comparable to concentrations reported by other researchers from northern latitude systems. It was interesting that lowest concentrations occurred in the mine site with greatest zooplankton densities. We speculate that grazing by zooplankton accounted for the low phytoplankton standing crop.

Zooplankton densities, estimated with vertical plankton tows, were highest in mine sites with extensive littoral habitat and virtually non-existent in mine sites where there is limited littoral habitat.

Arctic grayling in Sag Site C were marked by fin clips or tags in mid July and then recaptured in early August. A modified Peterson mark-recapture analysis was used for the population estimate, and produced an estimate of 229 arctic grayling larger than 80 mm within Sag Site C.

Arctic grayling were the most frequently captured species in Sag Site C. Of the 1636 fish captured (including recaptures), 605 fish were arctic grayling. Round whitefish (*Prosopium cylindraceum*) made up 30% of the catch, broad whitefish (*Coregonus nasus*) made up 8%, and Dolly Varden char (*Salvelinus malma*), burbot (*Lota lota*), slimy sculpin (*Cottus cognatus*), and ninespine stickleback (*Pungitius*

pungitius) each made up less than 1% of the total catch. Seventy seven percent of all fish were captured in a shallow water area of the mine site. Water temperatures in the shallow water area of the mine site were up to 8° C warmer than those found in the main body of the mine site in mid July and influenced the distribution of fish, particularly small fish. Catches of fish were more evenly distributed between the littoral habitat area and the main portion of the mine site in August, as the difference in water temperature between these areas was considerably less than that observed in July.

Arctic grayling from the Sagavanirktok River were collected and sampled for bacterial and viral diseases as part of the requirements for issuance of a fish transport permit to allow eventual transport of arctic grayling to flooded gravel mine sites. Sixty arctic grayling from the Sagavanirktok River in the vicinity of Prudhoe Bay were captured in fyke nets and gill nets, sacrificed, and screened for bacterial kidney disease, fish furunculosis, and infectious pancreatic necrosis. Analyses found no evidence of these diseases in the sacrificed arctic grayling, satisfying disease screening requirements for issuance of a fish transport permit. Sagavanirktok River arctic grayling may now be transported to flooded gravel mine sites within the Prudhoe Bay - Kuparuk oilfields.

Two previous attempts at introducing fish to barren lakes within the coastal plain of northern Alaska were unsuccessful. A history of these stocking attempts at Barrow and Prudhoe Bay is presented.

INTRODUCTION

Fish populations in the mid-Beaufort Coastal Plain region of northern Alaska are limited by the availability of overwintering habitat (Bendock 1977, Adams 1987). Most lakes and tundra streams in the region are unsuitable as year round fish habitat, because they contain insufficient quantities of under ice water, or because the water quality in winter is unsuitable. Flooded gravel mine sites created for oil development provide suitable overwintering habitat for several species of freshwater and anadromous fish because they retain large quantities of water with dissolved oxygen concentrations that are at or near saturation throughout the year. Previous sampling of the mine sites during the open water season indicated that the sites might also have sufficient primary and invertebrate productivity to sustain summer populations of fish; however, the productivity appeared to vary considerably among the mine sites (Hemming 1988).

Colonization of flooded gravel mine sites by fish is governed by the permanence of the connection to a stream: A permanent hydrological connection allows movement of fish into or out of the site throughout the open water season, whereas a temporary connection limits fish migration to periods of high water. The permanence of the connection will also determine the ability of fish to leave the mine site. Aquatic productivity of the mine site may play a primary role in determining growth and survival of fish during periods when sites are isolated from adjacent riverine habitats.

In 1988, the Alaska Department of Fish and Game conducted studies of selected gravel mine sites on the North Slope of Alaska to determine their relative productivity and the feasibility of establishing fish in sites that provide suitable habitat but where colonization by fish was unlikely to occur. Five flooded gravel mine sites were investigated: Sag Site C, Kuparuk Mine Sites B and D, and Kuparuk Deadarm Mine Site 6. Limited investigations were also conducted in Kuparuk Deadarm Mine Site 5.

Sag Site C is a 15.5 ha site located in the floodplain of the West Channel of the Sagavanirktok (Sag) River. This site is bounded on the south side by the Sag River causeway and to the north by the Sag River oil pipeline crossing. The mine site was flooded on June 8, 1986 when the perimeter berm on the west side of the site was breached, allowing Sag River flood water to enter the mine site. Habitat rehabilitation to establish littoral areas was conducted in Sag Site C in autumn 1987.

Kuparuk Mine Site B consists of two adjacent basins covering a total of 3.7 ha. The excavated area was flooded in 1978 and is connected to a tundra stream, known locally as "East Creek," that drains directly into the Beaufort Sea. Kuparuk Mine Site B contains ninespine stickleback (*Pungitius pungitius*) and broad whitefish (*Coregonus nasus*).

Kuparuk Mine Site D is the largest flooded mine site connected to a tundra stream, covering 15.6 ha adjacent to "Charlie Creek," a western tributary to the Ugnuravik River, itself a tundra stream. The Ugnuravik River is reported to contain ninespine stickleback only (Hemming 1988) and is not connected to a larger river system.

The Kuparuk Deadarm area is a former high-water channel on the east side of the Kuparuk River floodplain. The site consists of six connected flooded gravel mine sites covering 58.3 ha. The lower sites (5 & 6) were flooded by water backing up into the high-water channel from the East Channel of the Kuparuk River in 1986. Kuparuk Mine Sites 5 & 6 contain arctic cisco (*Coregonus autumnalis*) and arctic grayling (*Thymallus arcticus*) (Hemming 1988). More detailed descriptions of the mine sites investigated in this report are presented in Hemming (1988).

This annual progress report contains three studies: a limnological investigation to determine biological productivity and standing crop of each site, an arctic grayling population estimate including an evaluation of fish use of a habitat enhancement area, and an examination of arctic grayling for disease in preparation for experimental fish transplants. The physical and chemical features and fish species present in these sites have been documented in a report on the first two years of this project (Hemming 1988).

The limnological section includes temperature and dissolved oxygen measurements, estimates of rates of primary productivity, estimates of phytoplankton standing crop, and estimates of densities and species composition of zooplankton sampled at four flooded mine sites (Figure 1). Limited sampling was conducted in a fifth mine site. The limnological data provide the basis for comparing physical and chemical characteristics and biological productivity among the flooded mine sites.

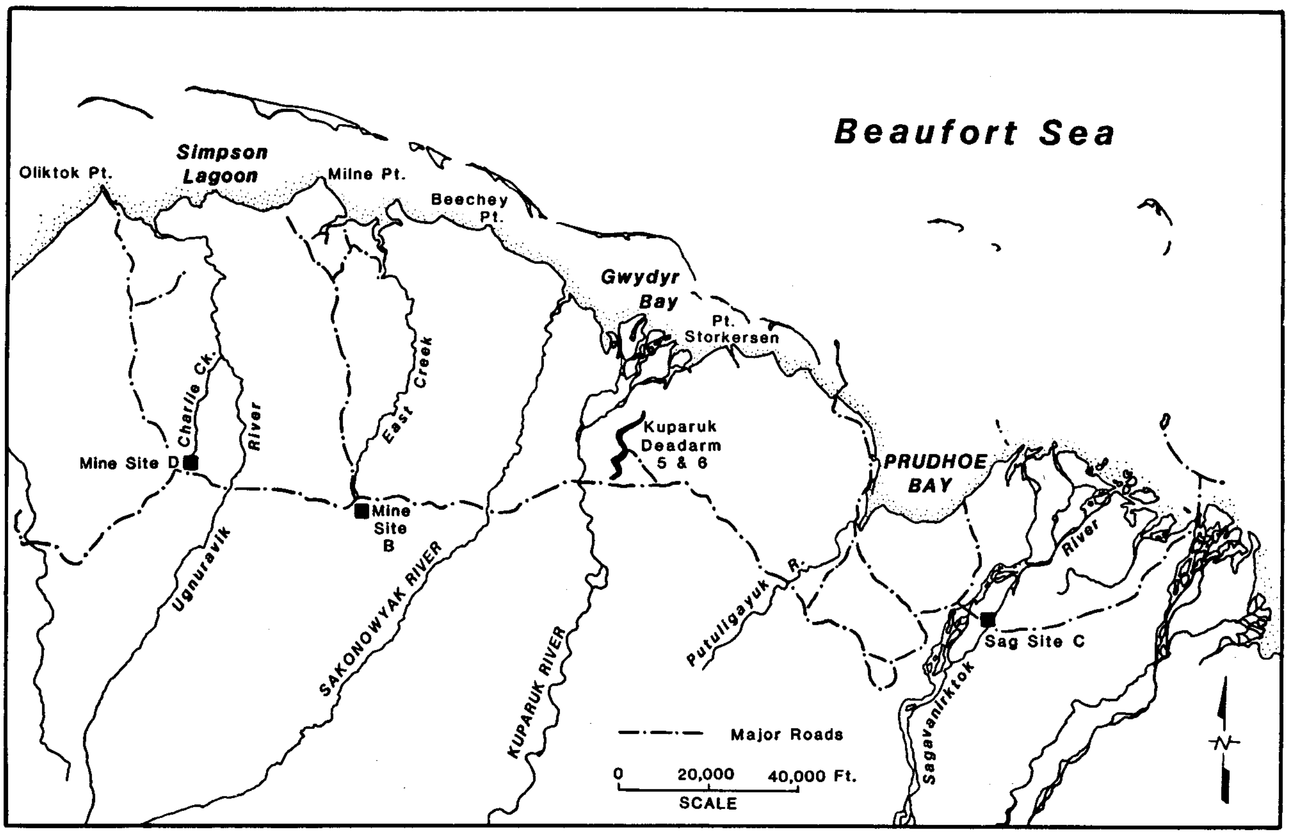

Figure 1. Map of the Prudhoe Bay - Kuparuk oilfields depicting the locations of flooded gravel mine sites sampled in 1988.

An arctic grayling population estimate was conducted in Sag Site C to provide information on the level of colonization that might be expected in a flooded mine site with a high water connection to a large river system and to assess the use of the recently rehabilitated section of Sag Site C. Previous sampling by gill nets (reported in Hemming 1988) documented the presence of fish in all of the mine sites investigated in the present study; however, the population levels were unknown. Sag Site C was selected for initial population estimates because previous sampling with gill nets showed that this site had the highest catch per unit effort.

An experimental introduction of arctic grayling to sites where colonization is likely to be limited is proposed. Fish will be transported from neighboring drainages into sites that are connected to riverine systems that may provide spawning habitat. Arctic grayling from the Sagavanirktok River were collected and screened for diseases to assure that the fish to be transplanted are disease free, thereby avoiding the introduction of diseases to other systems. Disease screening of these fish, and of future collections, will also provide information about the health of arctic grayling populations from sampled drainages where a disease history is not available. Additional information on the fish captured from the lower Sagavanirktok River during this project is presented in appendices.

This annual progress report provides technical background information used to develop specific recommendations for enhancing flooded gravel mine site habitat. Enhancement projects involve habitat manipulation by physically altering basin morphology or providing a mechanism for fish use through the construction or improvement of a hydrologic connection to an adjacent stream or river. An experimental arctic grayling transplant is proposed for sites where suitable habitat is present but where the adjacent riverine system has few fish.

LIMNOLOGICAL INVESTIGATIONS

INTRODUCTION

Since 1986, the Alaska Department of Fish and Game has conducted limnological sampling in selected flooded gravel mine sites on the North Slope to determine whether or not these sites would provide suitable habitat for fish and wildlife. Earlier investigations (reported in Hemming 1988) concentrated on chemical and physical features of the sites. An important finding was that these flooded mine sites retain dissolved oxygen concentrations that are at or near saturation throughout the year, thus providing potential overwintering habitat for fish. All of the mine sites investigated were adjacent to or connected to a riverine system; thus there were opportunities for fish to migrate into the sites during periods of high water. Sampling of the mine sites during summer 1987 (Hemming 1988) indicated that the sites might also have sufficient primary and invertebrate productivity to sustain summer rearing populations of fish; however, the productivity appeared to vary considerably among the mine sites.

The current study focuses on identifying particular features of each site that may influence algal productivity and zooplankton densities. Limnological sampling included four components: temperature and dissolved oxygen measurements, estimation of rates of primary productivity, estimation of phytoplankton standing crop, and estimation of densities and species composition of zooplankton. The first three components not only provide physical and chemical information, and indications of productivity of the sites, but they also give indirect evidence of the extent of nutrient availability to primary producers within the sites. Zooplankton analyses provide information on the availability and degree of complexity of food resources available to fish.

METHODS

In 1988, limnological sampling was conducted at four flooded mine sites: Kuparuk Mine Sites B and D, Kuparuk Deadarm Reservoir 6, and Sag Site C. Limited samples were collected from Kuparuk Deadarm Reservoir 5 in May. Sampling was conducted at Sag Site C on May 16-17, July 13-14, and August 25; at Kuparuk Deadarm Reservoir 6 on May 18, July 15-16, and August 25; at Kuparuk Mine Site B (a-side) on May 19, July 13-14, and August 24; and at Kuparuk Mine Site D on

May 19, July 16, and August 24. Kuparuk Mine Site B (b-side) and Kuparuk Deadarm Reservoir 5 were only sampled on May 19 and May 18, respectively.

Water samples were collected to determine chlorophyll concentrations with a vanDorn water sampling bottle. Depths sampled (site bathymetry permitting) were 2 (just below ice level), 5, 10, and 15 m in May, and 1, 2, 4, 6, 8, and 10 m in July and August. A sample was collected just above the site bottom at those sites less than 15 m deep in May and less than 10 m deep in July and August. Up to 3 L of water for each sample were filtered through a 0.3 *u*m Gelman A/E glass fiber filter using a Nalge hand vacuum pump. One sample was taken at each depth during May; three samples were taken at each depth in July and August. Saturated magnesium carbonate solution was added to the filter to prevent acidification of the chlorophyll. Each filter was labeled, placed in a plastic bag containing dessicant, and frozen pending analysis. Filters were ground in 90% aqueous acetone solution and allowed to extract for 2 hr. The samples were then centrifuged and the absorbance of the supernatant was determined on a spectrophotometer using a 4-cm cell, according to Wetzel and Likens (1979). Amounts of chlorophyll-a, -b, and -c were determined using a trichromatic method and corrected for turbidity, according to Strickland and Parsons (1968). The samples were acidified to correct for phaeophytin, using a monochromatic method (Wetzel and Likens 1979).

Zooplankton tows were conducted at each of the mine sites. A Wisconsin-type plankton net was lowered to the bottom and slowly hauled to the surface. Two plankton tows were conducted at each mine site in May, whereas five tows were conducted in July and August (except Kuparuk Deadarm 6 where 10 were conducted). Zooplankton were stored in 70% ethanol pending analysis. Larger zooplankton were identified to genus and counted. Numbers of larval or immature zooplankton too small to identify (<0.75 mm for *Daphnia* and <0.5 mm for copepods) were estimated for July and August samples, and because of low numbers, counted directly in May. Genera of immature copepods were not identified.

Temperature and dissolved oxygen measurements were taken at depth at each of the mine sites. Depths sampled were identical to those sampled for chlorophyll. Water samples at depth were obtained with a vanDorn water sampling bottle. In July and August, biochemical oxygen demand (BOD) bottles were filled for dissolved oxygen analysis by placing a tube from the vanDorn bottle into the bottom of the BOD bottle and overfilling it the equivalent of three times its volume. In May, air temperatures were too low to keep the tube from the vanDorn bottle from freezing, therefore samples were filled by immersing the entire BOD bottle, mouth up, into the vanDorn sampler and overfilling it. Water temperatures were measured in the vanDorn bottle with a hand-held thermometer or by a temperature probe on a dissolved oxygen meter (calibrated against a mercury thermometer) in May, and with a digital thermometer that was calibrated against hand-held mercury thermometers in July and August. Dissolved oxygen concentrations were measured by the azide modification of the Winkler procedure, using 300 mL samples and a digital titrator (hand-held buret). Kuparuk Deadarm Reservoir 5 and Kuparuk Mine Site B (b-side) were only sampled in May.

Estimates of primary productivity at flooded mine sites were made in July and August by measuring changes in dissolved oxygen concentrations within light and dark BOD bottles. Productivity measurements were made at Sag Site C, Kuparuk Mine Sites B and D, and Kuparuk Deadarm Reservoir 6 in July, and at Kuparuk Deadarm Reservoir 6 only in August. A device was fabricated from polyvinylchloride (PVC) pipe that held one dark and two light bottles horizontally for incubation at the depth from which the water was taken. Water collected with a vanDorn bottle from a given depth was used to fill the three BOD bottles. Bottles were suspended at the same depth from which the water was taken and incubated for 24 hr. Water was collected from and incubated from the following depths: 1, 2, 4, 6, 8, and 10 m. Kuparuk Deadarm Reservoir 6, however, because of its relatively shallow depth, allowed sampling only to 7 m. An additional series of bottles were placed in Kuparuk Deadarm Reservoir 6 at 1, 2, and 3 m (3 m was the maximum depth at this location). At all sites, one dark and two light bottles were set at each sampled depth. Initial dissolved oxygen concentrations and temperatures were measured for each sampled depth at the time the BOD bottles were filled. Dissolved oxygen was measured with the azide modification of the Winkler titration. After 24 hr, dissolved oxygen concentrations were measured in all BOD bottles using a dissolved oxygen meter calibrated with Winkler titration in July, and by Winkler titration in August.

RESULTS

Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen concentrations at depth for Prudhoe Bay and Kuparuk mine sites are presented in Appendix 1. In May, water temperatures were essentially isothermal at all sites and ranged from 0 to 1.7°C. Dissolved oxygen concentrations in May were at or near saturation for Sag Site C and Kuparuk Deadarm Reservoirs 5 and 6. Kuparuk Mine Sites B and D, however, had dissolved oxygen concentrations considerably lower than saturation. In Kuparuk Mine Site B, concentrations at depth ranged from 10.0 to 12.0 mg/L (a-side) and 8.2 to 9.5 mg/L (b-side), which correspond to concentrations 70 to 83% and 58 to 68% of saturation, respectively. Dissolved oxygen concentrations were even lower in Kuparuk Mine Site D, ranging from 6.4 to 10.1 mg/L (45 to 70% of saturation).

By the July sampling period, some sites began to show slight temperature stratification. Kuparuk Mine Site B, the smallest mine site sampled, had the strongest temperature stratification, with temperatures ranging from 12.2°C at a depth of 1 m to 3.9°C at a depth of 10 m. Kuparuk Deadarm Reservoir 6 was isothermal at 11°C to a depth of 3 m, but water temperature declined to 6.8°C at 6 m. Kuparuk Mine Site D, ice-free for 6 days at the time of sampling, showed a weak temperature stratification of approximately 2°C between the surface and a depth of 10 m. Sag Site C was isothermal at 3°C and was partially ice-covered at the time of sampling. Concentrations of dissolved oxygen were at or near saturation at all sampled depths at each site, except for the 10 m depth at Kuparuk Mine Site B where the dissolved oxygen concentration was 75% of saturation (10 mg/L).

By the August sampling period, water temperatures had declined at most sites and were isothermal at all sites. Water temperatures were approximately 7°C at Kuparuk Mine Sites B and D and Sag Site C, and near 5°C for the Kuparuk Deadarm Reservoir 6. Concentrations of dissolved oxygen were at or near saturation for all sites during the August sampling period.

Primary Productivity

Rates of primary productivity were extremely low in July and August in all reservoirs sampled (estimates were not made in Kuparuk Mine Site D in July, nor in Kuparuk Mine Sites B or D, and Sag Site C in August). Final concentrations of oxygen were lower than the initial concentrations in 10 of the 12 samples from Kuparuk Mine Site B, in 2 of the 12 samples from Sag Site C, in 4 of the 8 samples from Kuparuk Deadarm Reservoir 6 in July, and in 1 of the 10 samples from Kuparuk Deadarm Reservoir 6 in August. Of the 54 samples from all reservoirs, only 10 samples contained oxygen concentrations in the light bottles that were sufficient to estimate gross photosynthetic activity (Table 1). Dissolved oxygen concentrations increased by 0.3 mg/L O_2/24 hr in 9 of the 10 samples, and by 0.4 mg/L O_2/24 hr in one sample from Kuparuk Deadarm Reservoir 6. Although considered measurable, these concentrations are below the recommended amounts to achieve a statistical probability limit of 0.05 (Wetzel and Likens 1979) and should be viewed with caution. Of the samples with sufficient oxygen concentrations to estimate photosynthetic activity, all samples from Kuparuk Mine Site B and 5 of the 6 samples from Kuparuk Deadarm Reservoir 6 occurred in the top 2 m of water, whereas the sample from Sag Site C with sufficient oxygen concentrations to estimate photosynthetic activity occurred at 4 m.

Phytoplankton Standing Crop

Phytoplankton standing crop, estimated as concentration of chlorophyll-a, was low in all of the mine sites in May, July, and August (Table 2). Concentrations of chlorophyll-a were significantly different among the mine sites (Kruskall-Wallis one-way ANOVA, $p<0.05$), with the highest overall concentrations found in Kuparuk Mine Site D (average 2.10 μg/L) and the lowest in Kuparuk Deadarm Reservoir 6 (average 0.98 μg/L). Average concentrations in Kuparuk Mine Site B (1.88 μg/L) and Sag Site C (1.85 μg/L) were slightly lower (but not significantly, Kruskall-Wallis one-way ANOVA, $p> 0.05$) than those found in Kuparuk Mine Site D. Kuparuk Deadarm Reservoir 5 was sampled in May only; at that time chlorophyll-a concentrations were 1.66 μg/L Kuparuk Deadarm Reservoir 5 compared to 0.95 μg/L in Kuparuk Deadarm Reservoir 6.

In May, the highest concentrations were found in Kuparuk Mine Site D, where they ranged from 2.8 to 3.9 μg/L (Figure 2). Sag Site C, Kuparuk Mine Site B, and Kuparuk Deadarm Reservoir 6 all had low concentrations that were less than 1.5 μg/L at all of the depths measured. Concentrations of chlorophyll-a did not vary appreciably with depth in any of the four mine sites.

Table 1. Samples from North Slope flooded gravel mine sites with measurable amounts of photosynthetic activity, July and August 1988.

Area	Depth m	Gross Photosynthetic Activity mg O_2/L/24 hr
Kuparuk Deadarm 6	2	0.3
July	2	0.3
Kuparuk Deadarm 6	1	0.4
August	1	0.3
	2	0.3
	6	0.3
Kuparuk Mine Site B	1	0.3
July	2	0.3
	2	0.3
Sag Site C July	4	0.3

Table 2. Average concentrations of chlorophyll-a ($\mu g/L$) in five flooded gravel mine sites on the North Slope, Alaska. Numbers in parentheses are the number of samples.

	Mine Site				
	KDA 6	KDA 5	KMS B	KMS D	Sag C
May	0.95	1.66	0.85	3.35	0.72
	(2)	(4)	(3)	(4)	(4)
July	1.22		1.54	1.65	2.76
	(5)		(6)	(6)	(6)
August	0.79		2.75	1.72	1.79
	(6)		(6)	(6)	(6)
Average	0.98	--	1.89	2.10	1.85

Sites: KDA 6 = Kuparuk Deadarm Reservoir 6
KDA 5 = Kuparuk Deadarm Reservoir 5
KMS B = Kuparuk Mine Site B
KMS D = Kuparuk Mine Site D
Sag C = Sag Site C

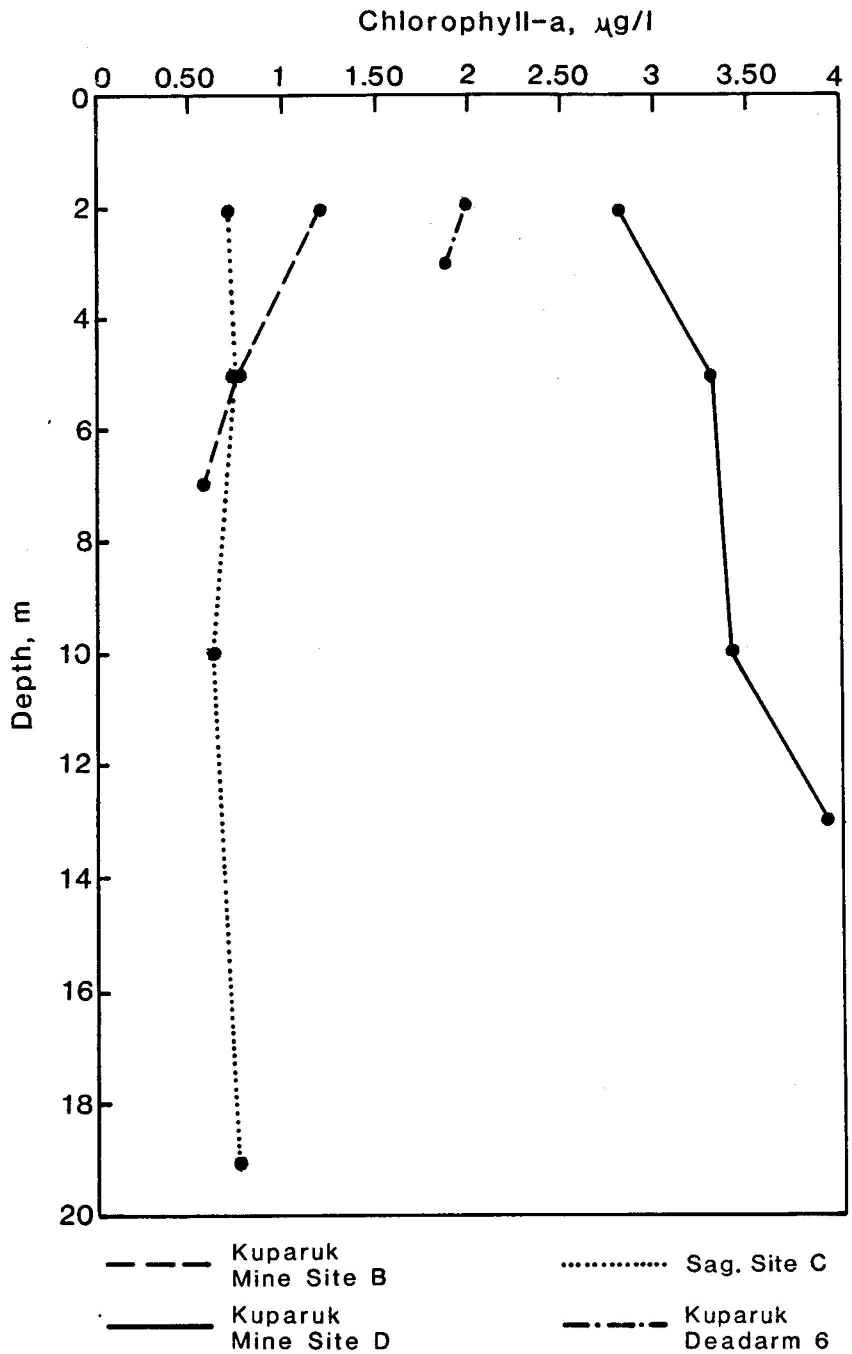

Figure 2. Concentrations of chlorophyll-a (ug/L) in five flooded gravel mine sites on the North Slope, Alaska. May 1988.

In July, the concentration of chlorophyll-a increased in Sag Site C and Kuparuk Mine Site B, but remained low in Kuparuk Deadarm Reservoir 6 (Figure 3). Concentrations in Kuparuk Mine Site D were lower in July than in May. Concentrations of chlorophyll-a did not vary appreciably with depth in any of the mine sites except Kuparuk Mine Site B. Algal standing crop in Kuparuk Mine Site B was highest at 1 and 2 m, where the concentrations of chlorophyll-a were 2.8 and 3.15 *u*g/L, respectively. Concentrations at 4 m and 6 m (in the area of the thermocline) were 1.04 *u*g/L and 1.5 *u*g/L, respectively (or about 33 to 50% of the concentrations found in the upper levels) and at 8 and 10 m, the concentrations were only 0.38 *u*g/L.

In August, chlorophyll-a concentrations were highest in Kuparuk Mine Site B (average of 2.75 *u*g/L), followed by Kuparuk Mine Site D (average of 1.72 *u*g/L) and Sag Site C (average of 1.7 *u*g/L) (Figure 4). Concentrations were lowest in Kuparuk Deadarm Reservoir 6 (average of 0.79 *u*g/L). Phytoplankton standing crop showed little variation with depth in the four mine sites sampled in August. No seasonal patterns in phytoplankton standing crop were evident from the samples.

Average concentrations of chlorophyll-b were low in all mine sites (Table 3) where they ranged from 0.14 *u*g/L in Sag Site C to 0.20 *u*g/L in Kuparuk Mine Site D. The ratio of chlorophyll-b to chlorophyll-a was correspondingly low, from 0.07 in Kuparuk Mine Site D to 0.16 in Kuparuk Deadarm Reservoir 6. Concentrations of chlorophyll-c (Table 3) ranged from an average of 0.67 *u*g/L in Kuparuk Deadarm Reservoir 6 to 1.03 *u*g/L in Kuparuk Mine Site B, while the ratio of chlorophyll-c to chlorophyll-a ranged from 0.41 in Kuparuk Mine Site D to 0.71 in Kuparuk Deadarm Reservoir 6.

Zooplankton

Numbers of zooplankton present in the flooded mine sites varied considerably among the May, July, and August sampling periods. In addition, the relative number of "immature" versus "adult" zooplankton varied among the sampling periods and mine sites.

In May, estimated densities of immature zooplankton (copepods and *Daphnia*) present in the sites were low, generally less than 1/L, with the exception of

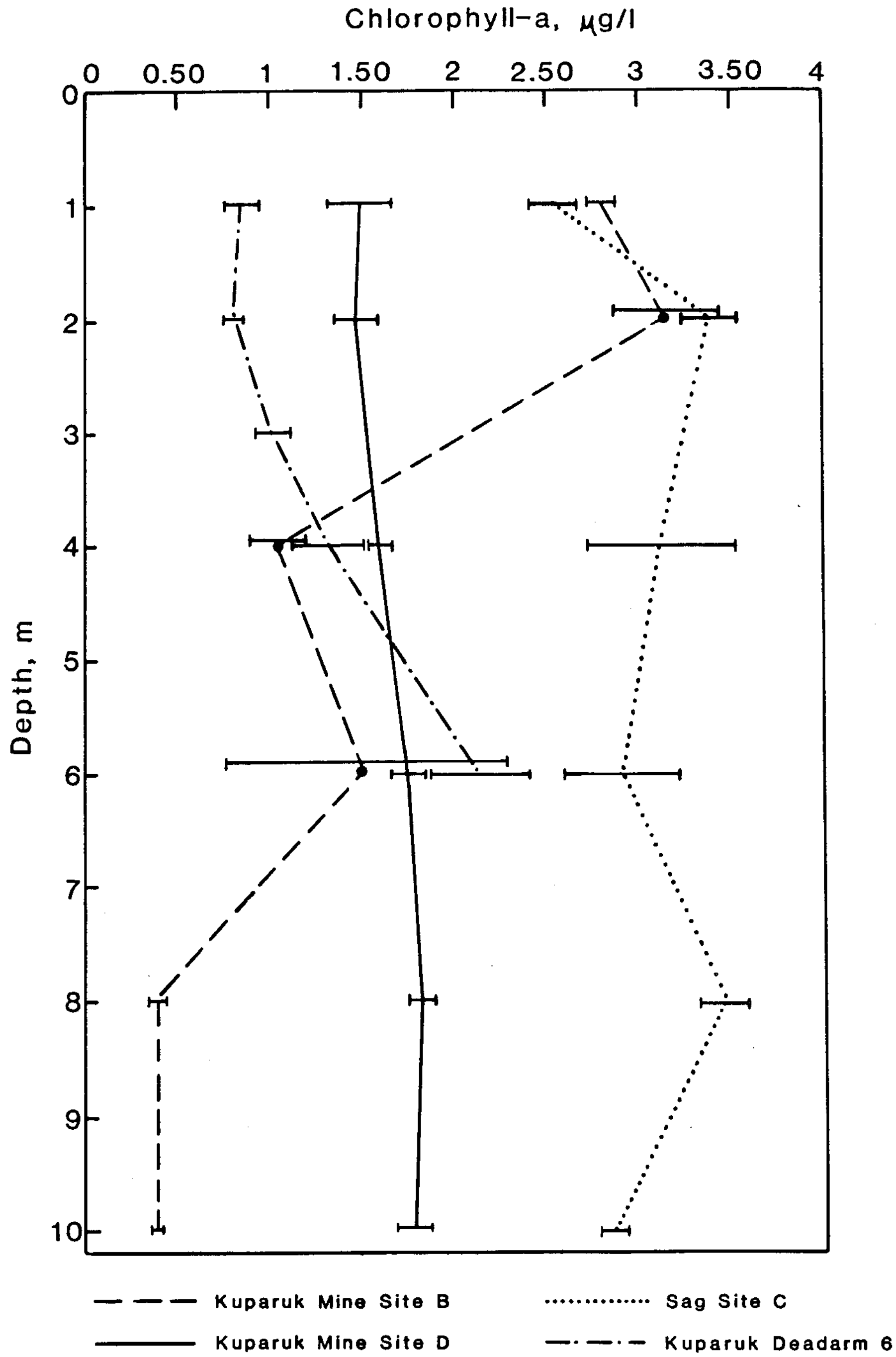

Figure 3. Concentrations of chlorophyll-a (µg/L) in four flooded gravel mine sites on the North Slope, Alaska. July 1988. The standard error bars for Mine Site B have been shifted slightly above the actual sampling depth to allow clear representation of standard error bars for all four gravel mine sites. The black dot on the line shows the actual depth at which sampling occurred.

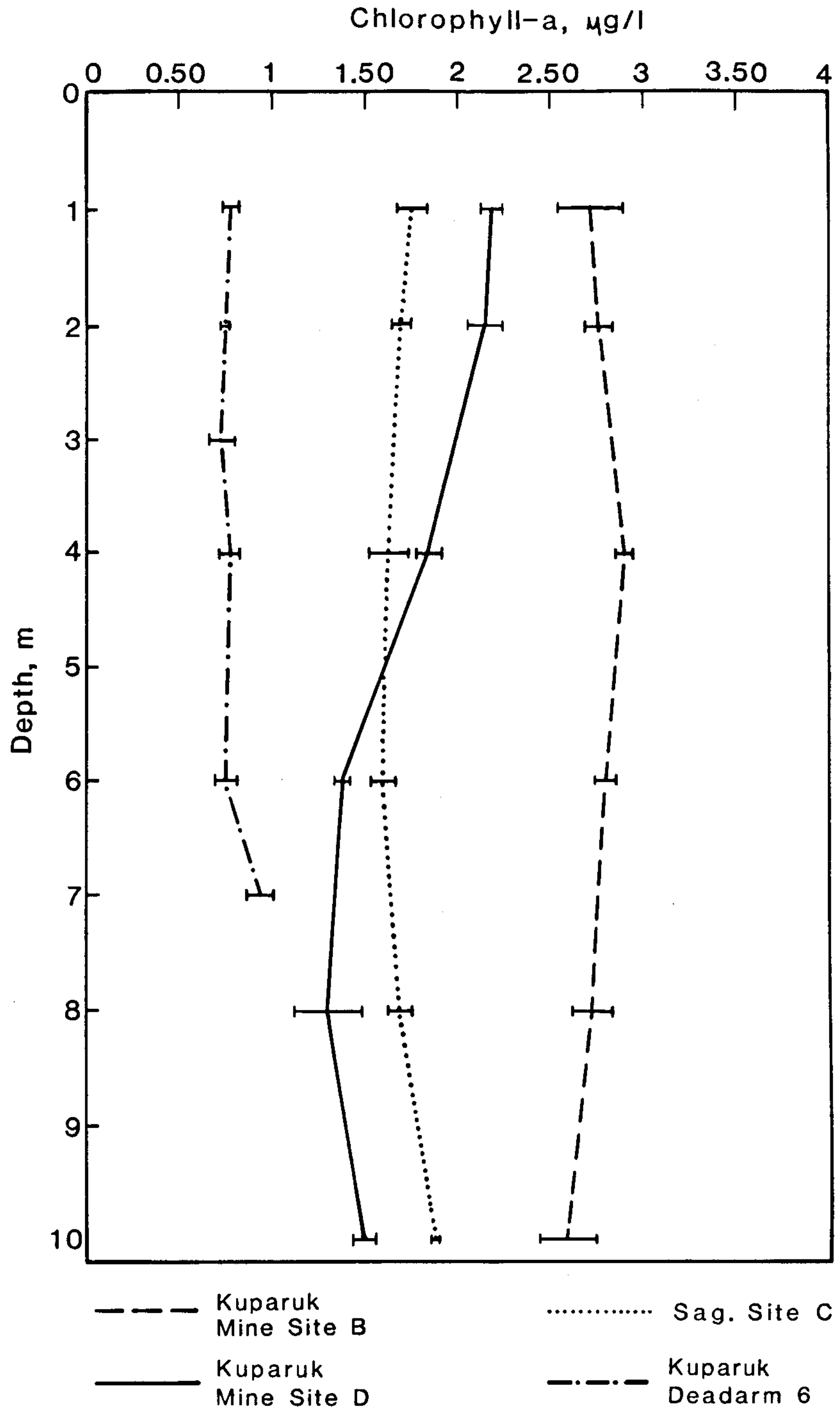

Figure 4. Concentrations of chlorophyll-a (µg/L) in four flooded gravel mine sites on the North Slope, Alaska. August 1988.

Table 3. Average concentrations of chlorophyll-b and c in flooded gravel mine sites on the North Slope. Data combined from May, July, and August 1988 sampling periods.

Site	Conc. Chlor-b ug/L	Ratio Chlor-b: Chlor-a	Conc. Chlor-c ug/L	Ratio Chlor-c: Chlor-a
Kuparuk Deadarm Reservoir 6	0.15	0.16	0.67	0.71
Kuparuk Mine Site B	0.15	0.11	1.03	0.59
Kuparuk Mine Site D	0.20	0.07	0.85	0.41
Sag Site C	0.14	0.13	0.83	0.62

Kuparuk Deadarm Reservoir 6, where the estimated density was in the range of 2-10/L (Table 4). No zooplankton were found in the samples collected from Sag Site C. No zooplankton collected in May at any of the sites were mature (Table 5).

In July, estimated densities of large zooplankton were highest in Kuparuk Deadarm Reservoir 6, in fact, in numbers two to three orders of magnitude above those recorded in the other sites (Table 5). The cladoceran *Daphnia* sp. and the copepod *Cyclops* sp. made up 71 and 26%, respectively, of the 532 large zooplankton collected in the samples at this site (Table 6). The samples from the other three sites had far fewer large zooplankton at this time than did Kuparuk Deadarm Reservoir 6. Kuparuk Mine Site B samples contained 26 large zooplankton (92% *Cyclops* sp. and 8% *Diaptomus* sp.), Kuparuk Mine Site D samples contained only 2 *Daphnia* sp. and 1 *Cyclops* sp., and Sag Site C samples contained only 1 unidentified organism.

The pattern of estimated densities of immature zooplankton present in the July mine site samples was similar to the pattern recorded for the large zooplankton (Tables 4 and 5). Immature zooplankton were most numerous in Kuparuk Deadarm Reservoir 6 and least abundant in Sag Site C. Estimated densities of immature zooplankton in Kuparuk Mine Site D were higher than those found in Kuparuk Mine Site B, but were less than those found in Kuparuk Deadarm Reservoir 6.

The highest estimated densities of large zooplankton observed in 1988 occurred in August, again at Kuparuk Deadarm Reservoir 6 (Table 5). Kuparuk Mine Site B had estimated densities approximately one half that of Kuparuk Deadarm Reservoir 6. Estimated densities of large zooplankton in Kuparuk Mine Site D and Sag Site C were equal and approximately two orders of magnitude less than that recorded for Kuparuk Deadarm Reservoir 6.

The most numerous of the large zooplankton collected during the August sampling interval were *Diaptomus* sp. (Table 6). These organisms contributed over 50% of the zooplankton collected in Kuparuk Deadarm Reservoir 6 and over 95% in Kuparuk Mine Site B. *Cyclops* sp. comprised over 30% of the total in Kuparuk Deadarm Reservoir 6, with the remainder at this and other sites contributed primarily by *Daphnia* sp. and *Heterocope septentrionalis*.

The estimated densities of immature zooplankton during August were highest in Kuparuk Mine Site D, an increase over that recorded for this site in July (Table 4).

Table 4. Estimated density of immature zooplankton (*Daphnia* < 0.75 mm; copepods < 0.5 mm) in flooded gravel mine sites, 1988.

	May		July		August	
Site	Density number/L*	n**	Density number/L	n	Density number/L	n
Kuparuk Deadarm Reservoir 6	2-10	2	26-50	10	11-25	10
Kuparuk Deadarm Reservoir 5	< 1	2	***		***	
Kuparuk Mine Site B (A side)	< 1	2	2-10	5	26-50	5
(B side)	< 1	2	***		***	
Kuparuk Mine Site D	< 1	2	11-25	4	50-75	5
Sag Site C	0	2	< 1	3	< 1	5

* density categories: < 1/L; 2-10/L; 11-25/L; 26-50/L; 50-75/L
** number of samples
*** not sampled

Table 5. Estimated densities of large (*Daphnia* > 0.75 mm; copepods > 0.5 mm) zooplankton in flooded gravel mine sites, 1988.

	May		July			August		
	Density		Density			Density		
Site	(number/L)	n**	(number/L)	sd*	n	(number/L)	sd	n
Kuparuk Deadarm Reservoir 6	0	2	3.5	2.80	10	4.9	2.16	10
Kuparuk Mine Site B	0	2	0.07	0.53	5	2.1	2.02	5
Kuparuk Mine Site D	0	2	0.005	0.01	4	0.05	0.04	5
Sag Site C	0	2	0.009	0.02	3	0.05	0.01	5

* standard deviation
** number of samples

Table 6. Number and percent of adult zooplankton by species present in flooded gravel mine sites, 1988.

	SPECIES									
	Diaptomus sp.		*Daphnia* sp.		*Cyclops* sp.		*Heterocope septentrionalis*		Unknown	
Site	Number	%	Number	%	Number	%	Number	%	Number	%
Kuparuk Deadarm Reservoir 6										
July	-	-	376	71	138	26	-	-	18	3
August	526	55	100	11	301	32	14	1	14	1
Kuparuk Mine Site B										
July	2	8	-	-	24	92	-	-	-	-
August	764	95	5	0.1	38	5	-	-	-	-
Kuparuk Mine Site D										
July	-	-	2	67	1	33	-	-	-	-
August	13	48	1	4	-	-	-	-	13	48
Sag Site C										
July	-	-	-	-	-	-	-	-	1	100
August	15	63	-	-	1	4	7	29	1	4

Estimated densities of immature zooplankton also increased in Kuparuk Mine Site B over that recorded at this site in July, whereas estimated densities decreased in Kuparuk Deadarm Reservoir 6. Again, few organisms were recorded for Sag Site C.

DISCUSSION

Physical Limnology of Reservoirs

The mine site reservoirs are basically cold, monomictic lakes that either mix continuously during the ice-free period or form weak thermoclines. Epilimnion depths in deep, northern latitude lakes are usually greater than for similar lakes at lower latitudes, which has been attributed to slower heating, frequent winds, lack of wind protection by trees or the landscape, and less intensive maximum solar radiation than at lower latitudes (Welch et al. 1987). Ice-out typically occurs in early- to mid-July, depending upon spring air temperatures and characteristics of the reservoirs. Ice-out occurred later on Sag Site C than on the other reservoirs. Slower thermal heating in Sag Site C may be because this reservoir lies closer to the coast and is more strongly influenced by coastal fog and the associated cooler microclimate.

Rapid cooling and prevalent winds in September probably prevent icing over until the entire water column of the reservoirs is below 1°C. Freezing of the surface appears to occur when the reservoirs are isothermal. The ice-rich soils that are prevalent on the North Slope, combined with the great depth of the reservoirs probably prevent heating of the benthos; therefore, there is relatively little heat contribution from the reservoir bottom to form an inverse thermocline in the winter. In addition, there is no solar input for a period of 2+ months when the sun sets in late November and rises again in early February. In January 1988, Sag Site C was essentially isothermal in the range of 0.2 to 1.2°C. Temperatures in February and April were similar at 0.9°C (Hemming 1988). (Few winter temperature data are available for the other reservoirs.) Convective mixing under the ice is probably responsible for the isothermal nature of the mine sites.

High oxygen concentrations throughout the year are probably attributable to frequent mixing in the summer and relatively low densities of biological organisms and low biochemical oxygen demands during the winter months. Primary productivity in the early spring may increase dissolved oxygen concentrations.

Primary Productivity

Phytoplankton production rates were near or below the detection limit in all samples. However, production rates did indicate that the four sampled mine sites can be ranked in order from highest to lowest productivity as (1) Kuparuk Deadarm Reservoir 6, (2) Kuparuk Mine Site B, and (3, tied) Kuparuk Mine Site D and Sag Site C.

The light-dark bottle method for measuring changes in dissolved oxygen concentrations was not sensitive enough to detect production rates in these cold-water, high latitude systems. In fact, 42 of the 52 samples contained higher concentrations of dissolved oxygen in the dark bottle than the light bottle at the end of the experiment. Dugdale and Wallace (1960) also reported lower concentrations of dissolved oxygen in light bottles than in the initial concentrations or concentrations in dark bottles from lakes in southcentral Alaska. They postulated that higher oxygen concentrations in dark than light bottles may be due to the dependence of respiration rates upon oxygen concentration. The lack of locally high oxygen tensions in dark bottles (hence low respiration rates) may result in negative calculated gross photosynthetic rates, especially at low rates of production. According to Dugdale and Wallace, Hutchinson (1957) also reported negative calculated values for gross primary productivity from Lake Quassaparig, Connecticut. Hutchinson suggests that a photokinetic effect on the zooplankton might be responsible for the oxygen depletion occurring in the light bottle.

Although gross primary productivity rates are undoubtedly low in all of the flooded mine sites sampled, the rates are probably detectable with a more sensitive technique, such as carbon-14 isotope. Future studies should incorporate a more sensitive method and investigate the possibility that heterotrophic production may be an important contribution to the food web of these systems.

Phytoplankton Standing Crop

Phytoplankton standing crop was low in the gravel mine sites; however, the average concentrations (0.8 to 2.8 $\mu g/L$) were comparable to or somewhat higher than those reported by Alexander et al. (1980) for tundra ponds near Barrow (0.1 to 1.2 ug/L) and in Ikroavik Lake (0.03 to 2.37 ug/L). In Peters and Schrader lakes, deep lakes in the Brooks Range, Hobbie (1959, cited in Alexander et al. 1980) found up to 1.6 ug chlorophyll-a/L during an under-ice bloom in May, but concentrations dropped to 0.8 ug/L during the open-water period. Concentrations in our study were generally highest under the ice (May) in Kuparuk Mine Site D and during ice-out (July) in Sag Site C. Alexander et al. (1980) reported that the chlorophyll content of Barrow area tundra ponds showed a rapid rise after spring melt, then fell to low values in mid-July, followed by a rise in August. Except for concentrations in Kuparuk Mine Site D, the flooded mine sites sampled in our study did not show a similar seasonal pattern. Unfortunately, we have only three samples from each mine site (May, July, and August) so annual cycles in phytoplankton populations are unknown and we may have missed sampling peak seasonal blooms. Overall, the low concentrations of chlorophyll-a indicate extremely small quantities of algae and ultra-oligotrophic systems.

Highest concentrations of chlorophyll-a in Kuparuk Deadarm Reservoir 6 were found on the bottom of the reservoir in July and averaged 2.12 ug/L. This pattern of concentration with depth is consistent with findings in 1987 when 18 ug/L chlorophyll-a were found near the water-sediment interface in Kuparuk Deadarm Reservoir 6 and an average of only 1.3 ug/L in the water column (Hemming 1988). Kuparuk Deadarm Reservoir 6 is the shallowest mine site of the study with an average depth of 2.5 m; most of the benthos is within the photic zone. Epipelic algae (algae living in the top 2 mm of sediments) are probably not significant in the other mine sites sampled because of their greater depth and lack of shallow littoral areas. The shallow littoral area created in Sag Site C in 1988 was not sampled for chlorophyll. Higher concentrations occurring near the sediment layer have also been reported by other researchers. For example, Kalff and Welch (1974) reported highest chlorophyll-a concentrations near the sediment layer in Charr Lake on Resolute Island. They estimated that 80% of the primary productivity, including mosses, occurred in the lake bottom. Alexander et al. (1980) also reported algal-rich sediments from shallow ponds (20 cm deep) in the Barrow area where algae in the sediments were about 60 times more abundant than planktonic algae. They postulated that the higher abundance of algae in the sediment layer was due to higher concentrations of nitrogen and phosphorous in the thick organic/soil layer at the bottom of the pond.

Alexander et al. (1980) describe possible factors limiting algal production and standing crop in tundra ponds as light, nutrients, and grazing. Light is probably limiting in the mine sites during spring, particularly in Kuparuk Mine Site B where snow cover was thickest and the lowest concentrations of chlorophyll-a occurred. The other three mine sites are more exposed to wind, had less snow cover, and had higher concentrations of chlorophyll-a. Light transmission through clear black ice is assumed to be the same as through pure water (Welch et al. 1987).

Nutrients undoubtedly limit algal production and standing crop in the mine sites; concentrations of nitrogen and phosphorus are below detection limits in all four mine sites (Hemming 1987, unpublished data). Grazing of phytoplankton by zooplankton or of epipelic algae by benthic organisms is probably a more important factor limiting algal standing crop in Kuparuk Deadarm Reservoir 6 than in the other three sites. Overall, Kuparuk Deadarm Reservoir 6 had the lowest concentrations of chlorophyll-a, while gross primary productivity rates were highest and zooplankton densities were about 10 times higher than in any of the other mine sites in July and about 2 times higher in August. Estimates suggest that on the order of 20% of the annual phytoplankton production in tundra ponds is lost to zooplankton grazing (Alexander et al. 1980).

Chlorophyll-b and -c were detected in all mine sites in May, July, and August. Chlorophyta and Euglenophyta, both of which contain chlorophyll-b, are known to occur in similar high-latitude lakes and ponds (Wright 1964, Alexander et al. 1980). Relative concentrations of chlorophyll-b were similar to those reported by Wright (1964) from small tundra lakes near Barrow. Although there may be other algal genera that contain chlorophyll-c, Cryptomonads have been identified by Wright (1964) and Alexander et al. (1980) as important components of algal communities in far northern lakes and ponds. Relative concentrations of chlorophyll-c in the flooded gravel mine sites were higher than those reported by Wright. We found concentrations of chlorophyll-c ranging from 41% to 71% of the chlorophyll-a concentrations, whereas Wright reported ratios of 1:3, or about 33%. Concentrations of chlorophylls a, b, and c were low in all mine sites, which is expected in high latitude, ultra-oligotrophic systems.

Zooplankton

The four sampled mine sites can be ranked using estimates of zooplankton abundance as an indicator of productivity. Based on this approach, Kuparuk Deadarm Reservoir 6 is the most productive site, followed by Kuparuk Mine Site B, Kuparuk Mine Site D, and Sag Site C. Hemming (1988) found a similar pattern of relative abundance of zooplankton at these four mine sites, and ranked them in a similar fashion.

Seasonal changes in the abundance of immature and adult zooplankton found in the mine sites reflect the life-cycle patterns of these organisms. The lack of any adult crustaceans in the May samples reflects the fact that these organisms overwinter as resting eggs, or in the case of cyclopoid copepods (*Cyclops*), as copepodids (preadults) (Hobbie 1973, 1984, Stross et al. 1980). However, zooplankton in deeper arctic lakes can overwinter as free-swimming forms (Hobbie 1973). Hobbie (1984) states that the copepodids mature and reproduce shortly after ice melts in June (studies discussed by Hobbie were primarily on small ponds near Barrow) and that the other copepods and cladocerans also hatch as the ice melts and then reproduce in mid-to-late July. The presence of adult zooplankton in July, particularly in Kuparuk Deadarm Reservoir 6 and Kuparuk Mine Site B, suggests that zooplankton in these sites are maintaining temporal patterns of reproduction and growth similar to that recorded in ponds at Barrow, even though the ice in these large sites is retained longer than that of shallow ponds.

In Kuparuk Mine Site D, numbers of immature zooplankton (which include what appeared to be overwintering eggs) increased substantially from mid-July to late August, and were the highest numbers observed in the four sites, all in the apparent absence of adult zooplankton. Very few adult zooplankton were observed in Kuparuk Mine Site D at any time, and numbers were substantially lower than those found at Kuparuk Deadarm Reservoir 6 or Kuparuk Mine Site B, sites that had lesser numbers of immature zooplankton in August than did Kuparuk Mine Site D. One possible explanation for the observed lack of adult zooplankton that could produce large numbers of immature zooplankton in Kuparuk Mine Site D is that the sampling locations may have been situated such that concentrations of adult zooplankton were missed. Hobbie (1984) reported that zooplankton are difficult to sample because they tend to form clumps. For example, large *Daphnia* often congregate along the margin of the pond away from the sun and in midsummer may even circle the pond over a 24 hr period. (It is unlikely, however, that a *Daphnia* could circumnavigate Kuparuk Mine site D in 24 hrs; such travel would encompass approximately 1.6 km of directed travel at the average rate of 1.1 m/min. Luecke and O'Brien [1983] reported a cruising velocity of 0.356 cm/sec for *Daphnia middendorffiana*.) Even though zooplankton samples were collected at five different sites in Kuparuk Mine Site D, if adult zooplankton were indeed congregating at specific locations within the site, it would be entirely possible to miss such congregations. Such a pattern of irregular distribution could also affect the accuracy of sampling at other sites and time periods.

A second possible explanation for the lack of adult zooplankton in Kuparuk Mine Site D in August is that these adult organisms may have died prior to the August sampling period. Zooplankton populations survive the winter as resting or resistant eggs or as copepodids on or in the bottom muds, and generally not as adults (Hobbie 1973). Zooplankton in Kuparuk Mine Site D may have completed the reproductive stage of their life cycle and subsequently were in the overwintering stage at the time of sampling in August. If such is the case, this scenario does not explain why zooplankton in Kuparuk Mine Site D are in the resting stage of their life cycle while those in other mine sites still had numerous individuals within the growth and reproductive stage of their life cycle.

Fish stomach samples reported by Hemming (1988) showed that fish in different reservoirs showed a dependence upon different food sources: arctic grayling in Sag Site C had fed almost entirely on terrestrial insects, broad whitefish and round whitefish (*Prosopium cylindraceum*) in Sag Site C fed primarily on midge (Diptera: Chironomidae) larvae. Broad whitefish from Kuparuk Mine Site B fed on caddisfly (Trichoptera: Limnophilidae) larvae and freshwater snails (Gastropoda). In comparison, arctic cisco from Kuparuk Deadarm Reservoir 6 fed on either *Daphnia* sp. or on one of three copepods: *Heterocope* sp., *Diaptomus* sp., or *Cyclops* sp.

The difference in food habits found among fish from these reservoirs reflects differences in physical characteristics of the mine sites, zooplankton densities, and algal production, as well as inherent differences in food habits of the different fish species.

Both primary productivity and zooplankton densities were highest in Kuparuk Deadarm Reservoir 6 (although algal standing crop was low). This reservoir has an extensive area of littoral habitat that contributes to the presence of relatively warm water at this site, as this site averages about 2.5 m in depth. Deeper areas provide overwintering habitat for fish.

Kuparuk Mine Site B, ranked second in terms of primary productivity and zooplankton densities, is older than the other sites, contains noticeable amounts of peat, and has some emergent vegetation. Fish stomach samples reported by Hemming (1988) indicate that the reservoir also supports a benthic invertebrate community. The shallow and deep water areas combined with areas of emergent and submergent vegetation provide the most diverse community types of any of the reservoirs sampled. A small, interconnecting tundra stream provides access for anadromous fish to the reservoir.

In contrast, Kuparuk Mine Site D and Sag Site C are relatively young, large, deep sites that have no emergent vegetation and little littoral habitat. Estimated primary productivity rates and zooplankton densities are lowest in these two mine sites. Kuparuk Mine Site D is attached to a tundra stream and has extensive overburden berms containing some organic material that erodes into the site in summer; these factors likely contribute to this site's apparent higher productivity than Sag Site C. Fish in Sag Site C appear to feed almost entirely on terrestrial insects and a limited benthic community. The littoral habitat created in 1988 may be sufficient to increase habitat diversity and eventually supply a zooplankton-terrestrial insect food base for fish. Because the benthos of the littoral zone is unconsolidated gravel, we do not expect a benthic invertebrate community similar to that found in Kuparuk Mine Site B to establish itself here in the near future.

ARCTIC GRAYLING POPULATION ESTIMATE
SAG SITE C

INTRODUCTION

Sag Site C was flooded in June 1986 when the perimeter berm of the 15.5 ha former gravel mine site was breached allowing Sagavanirktok River water to fill the excavated area. Information on the physical, chemical, and biological characteristics of the site were gathered during 1986 and 1987 and are presented in ADF&G Habitat Division Technical Report 88-1 (Hemming 1988). Gillnet sampling documented the presence of four species of fish: arctic grayling, Dolly Varden (*Salvelinus malma*), round whitefish, and broad whitefish. Arctic grayling were the most abundant fish captured during July and August. In the fall of 1987, a habitat enhancement project was completed at the site. This project involved removing a 183 m section of the gravel perimeter berm and excavating the gravel floodplain area outside of the berm 0.6 to 1.2 m below the water-surface elevation to create 2.0 ha of shallow-water littoral habitat.

This section of the progress report describes a mark-recapture estimate of arctic grayling abundance in Sag Site C and an evaluation of use of the shallow-water zone by fish.

METHODS

Fyke nets were used to capture fish for the mark-recapture experiment. The nets were 3.7 m in length with two 1.2 m entrance frames, 5 hoops, and a 1.8 m cod end. Net wings measuring 1.2 m by 7.6 m were attached to the first entrance frame. The netting material consisted of 4.8 mm square-measure, knotless nylon. The nets were set perpendicular to shore with a center lead connected to the first entrance frame to divert fish into the net. The length of the center lead depended on water depth and ice conditions at each net site, but did not exceed 15.2 m.

Up to four nets at a given time were fished during sampling in mid-July and early August 1988. Arctic grayling were initially tagged between July 9 and 16 and recaptured on August 4 and 5. The 18 day period between marking and recapturing allowed adequate mixing of fish and loss of temporary "trap behavior." The nets were fished at four locations: in the newly excavated shallow-water zone, off the access ramp, off the outlet channel, and at the southeast corner of the site

(Figure 5). These sites were the only areas where enough shallow water was available to deploy the nets.

Only arctic grayling over 80 mm fork length (FL) were marked. Fish greater than 200 mm were tagged beneath the central portion of the dorsal fin with Floy fine-fabric, internal-anchor tags, each identified by an individual number. Fish between 80 mm and 200 mm were marked by clipping a portion of the caudal fin. Fin-clipped fish were identified by trap location, with those initially captured in the shallow water zone receiving a top-caudal fin clip and those captured in the main portion of the site receiving a bottom-caudal fin clip.

Arctic grayling under 80 mm FL and other fish species captured were identified, counted, and released. Arctic grayling over 80 mm were measured to the nearest millimeter (FL), marked either by fin clip or Floy tag, and released during the first sampling period and examined for marks, measured, and released during the second period.

Surface water temperatures were measured at the trap locations with a hand-held mercury or an electronic digital thermometer.

The population estimate was calculated using Chapman's modification of the Peterson mark-recapture formula (Seber 1982):

$$N = \frac{(n_1 + 1)(n_2 + 1) - 1}{(m_2 + 1)}$$

where:

N = the estimated population size,
n_1 = the number of fish marked during the first sampling period,
n_2 = the total number of fish caught during the second sampling period,
and
m_2 = the number of marked fish recaptured.

The sampling variance of this estimate was calculated as:

$$V[N] = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)^2}$$

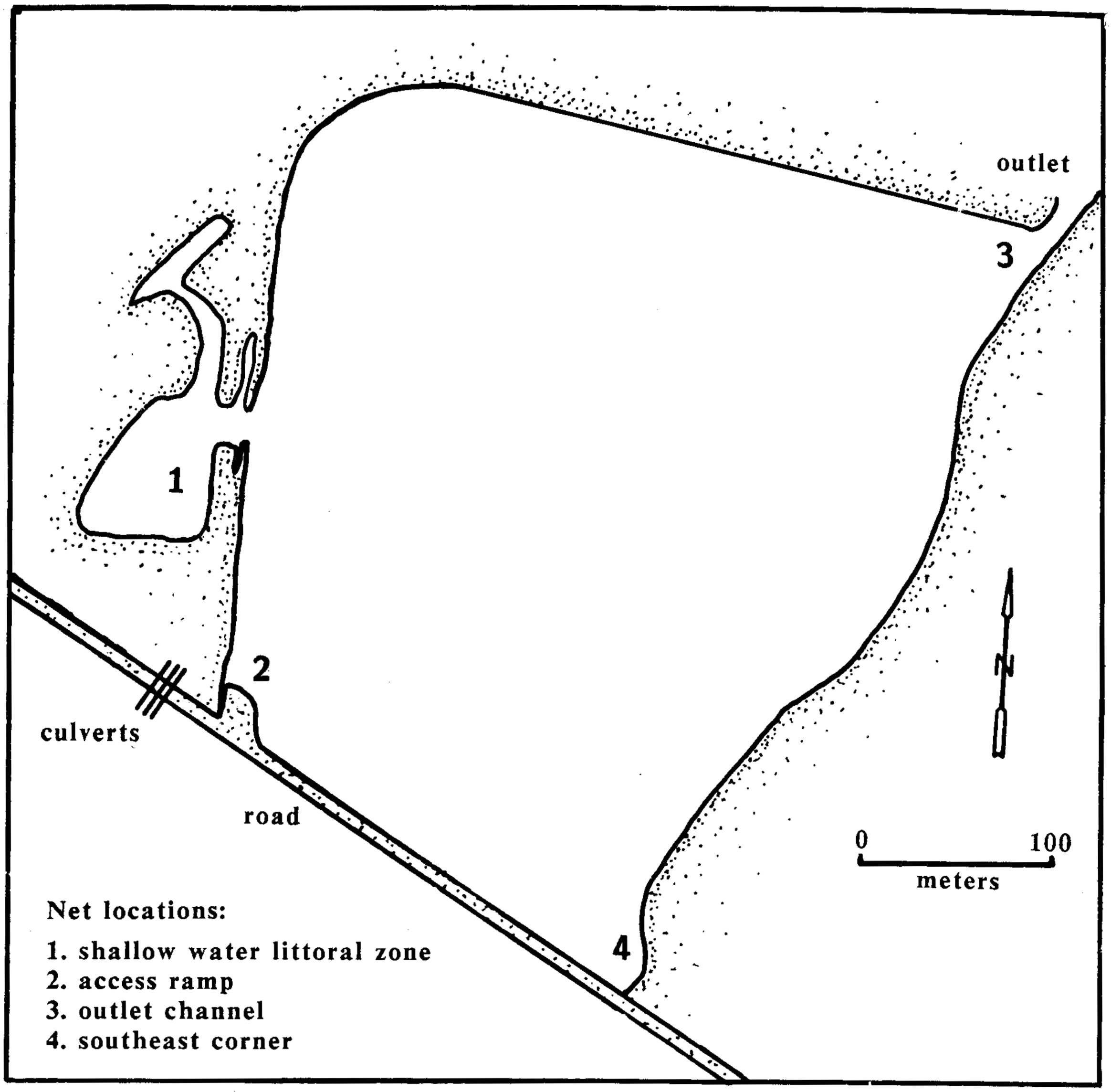

Figure 5. Locations of fyke nets for fish sampling in Sag Site C, July and August 1988.

RESULTS

Population Estimate

A total of 1,636 fish, including recaptures, was captured in Sag Site C. The fyke net catch included seven species: arctic grayling, round whitefish, broad whitefish, Dolly Varden, burbot (*Lota lota*), slimy sculpin (*Cottus cognatus*), and ninespine stickleback. Arctic grayling was the most frequently captured species representing 60% of the total catch, round whitefish was the second most frequently captured species representing 30% of the catch, 8% of the catch consisted of broad whitefish, and Dolly Varden, burbot, slimy sculpin, and ninespine stickleback each represented less than 1% of the total catch (Figure 6).

In July, 207 arctic grayling over 80 mm were marked. The size distribution of the marked grayling is presented in Figure 7. In August, 62 arctic grayling were captured, including 56 marked fish, producing a 90% rate of recapture.

The distributions of fork lengths of fish in the two sampling periods were tested using the Kolmogorov-Smirnov (KS) two-sample test. No significant differences between the distribution of lengths of marked fish and the distribution of lengths of recaptured fish (P = 0.22), or the distribution of lengths of fish captured during July and the total fish captured in August (P = 0.06) were found. Therefore, we concluded that there was no differential size selectivity in either sampling period.

To determine if marked fish mixed completely with the unmarked portion of the population, a chi-square contingency analysis was used to test the probability of capture in the two basins of the mine site. The site was divided into the shallow-water, littoral habitat area and the deep area (original mine site), and fish were marked and recaptured in each area. No difference between the probability of capture for fish marked in the shallow water area and for fish marked in the deep water area was detected ($X^2 = 1.59$, df = 2, p> 0.95). The catchability of fish in the two areas was also tested; fish were found to be equally vulnerable to capture from either area ($X^2 = 0.63$, df = 1, p> 0.95) during August.

The abundance of arctic grayling larger than 80 mm FL was calculated with the modified Peterson formula (Seber 1982). The estimated abundance of arctic

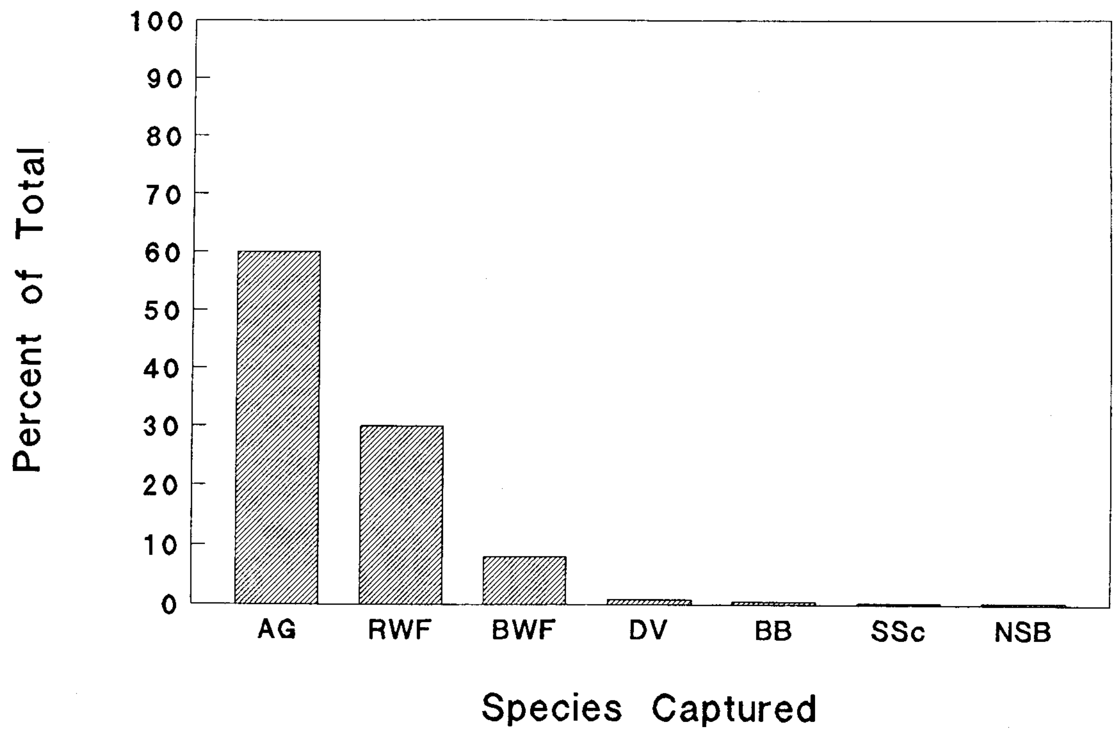

Figure 6. Proportions of each fish species captured, as percent of the total catch, from fyke nets in Sag Site C, 1988. n = 1636.

AG	=	arctic grayling	NSB	=	ninespine stickleback
BWF	=	broad whitefish	RWF	=	round whitefish
BB	=	burbot	SSc	=	slimy sculpin
DV	=	Dolly Varden			

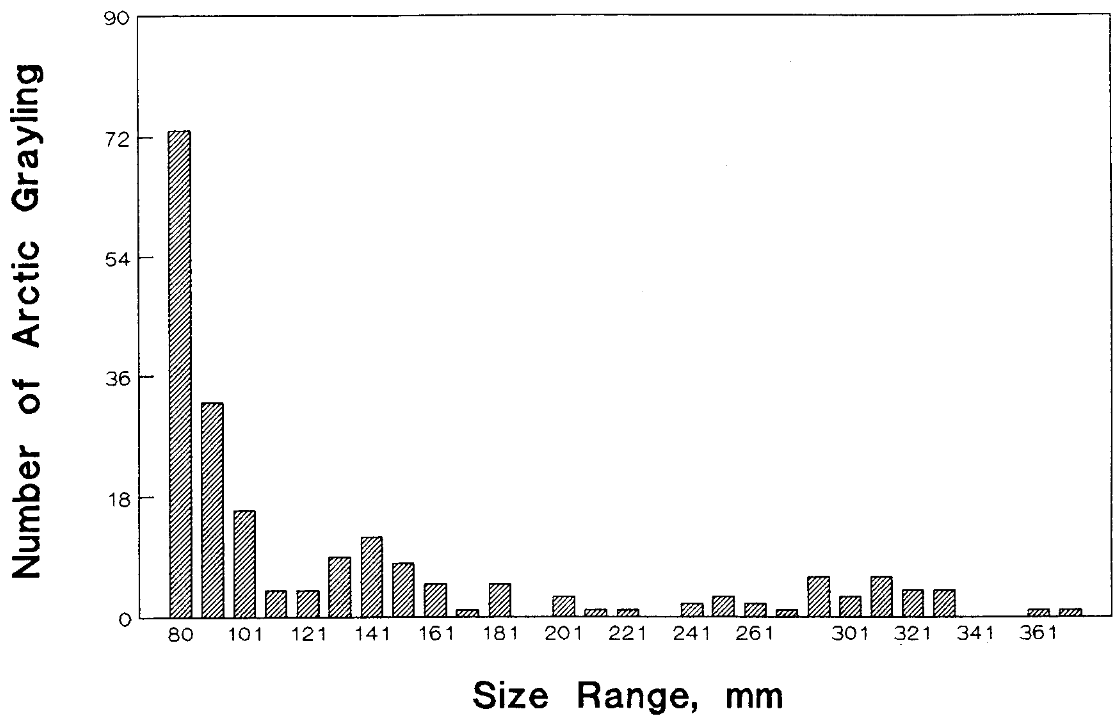

Figure 7. Size distribution of arctic grayling captured and marked in Sag Site C, July 1988. n = 207.

grayling in Sag Site C was 229 ± 16 (standard error = 8; 95% confidence interval). The estimated density of arctic grayling larger than 80 mm FL is 14.8 grayling per ha. Neither the inlet nor the outlet channels were connected to the Sagavanirktok River beteen July 9 and August 5, thus immigration or emigration are not factors affecting this estimate.

Use of the Enhancement Area by Fish

The net located in the shallow-water zone captured 1,259 fish including recaptures, and a total of six species during the two sampling periods. Seventy-seven percent of all captures occurred in the shallow-water zone. The catch per unit effort (CPUE) of 125.9 fish per net-day for the shallow-water site exceeded the CPUE for the other sites (Table 7). The shallow-water net was fished longer than the nets at other sites because the shallow water habitat was ice-free earlier, allowing early deployment of this net. The water temperatures in the shallow water habitat were up to 8^{o}C warmer than the remainder of the mine site during July (Figure 8). During August, water temperatures had risen in the main portion of the mine site while the water temperatures in the shallow water habitat had decreased. Approximately the same numbers of fish were caught in the shallow and deep water areas in August.

The shallow-water area was the only area fished from July 8 to 11 when ice conditions prevented net placement in the main portion of the mine site. During this time period, 496 fish were captured: 294 arctic grayling, 189 round whitefish, and 13 broad whitefish. The size composition of the arctic grayling captured in the shallow water habitat between July 8 and 11 is presented in Figure 9. The round whitefish captured during this time period ranged from 50 to 188 mm FL and averaged 66.9 mm (sd = 19.6 mm), and the broad whitefish ranged from 57 to 75 mm FL and averaged 66.4 mm (sd = 6.6 mm).

DISCUSSION

The density of arctic grayling in Sag Site C is low when compared to the densities of arctic grayling supported by gravel mine sites and ponds in interior Alaska. The ADF&G Sport Fish Division has stocked fingerling and sac-fry arctic grayling

Table 7. Number of fish captured, by species, and the catch per unit effort (CPUE) for four fyke nets in Sag Site C, 1988.

Date	Species	Net 1	Net 2	Net 3	Net 4
7/9-11/88	AG	294	***	***	***
	BWF	13			
	RWF	189			
	TOTAL	496			
7/12/88	DV	1	***	***	***
	AG	84			
	BWF	4			
	RWF	39			
	TOTAL	128			
7/13/88	DV	1	1	0	***
	AG	32	39	3	
	BWF	4	0	1	
	RWF	21	6	1	
	TOTAL	58	46	5	
7/14/88	AG	86	28	2	***
	BB	1	0	0	
	BWF	26	0	0	
	RWF	27	12	0	
	TOTAL	140	40	2	
7/15/88	DV	2	0	0	***
	AG	67	75	16	
	BB	1	0	2	
	BWF	31	3	0	
	RWF	39	43	6	
	TOTAL	140	121	24	
7/16/88	DV	0	2	0	***
	AG	145	26	11	
	BB	0	1	2	
	BWF	46	0	2	
	RWF	65	10	16	
	TOTAL	256	39	31	

Table 7, continued.

Date	Species	Net 1	Net 2	Net 3	Net 4
8/4/88	DV	0	2	0	***
	AG	11	13	6	
	BWF	1	0	0	
	RWF	4	0	0	
	SSC	0	2	0	
	TOTAL	16	17	6	
8/5/88	DV	0	1	0	0
	AG	18	25	7	5
	NSB	1	0	0	0
	RWF	6	5	1	1
	TOTAL	25	31	8	6
Total catch	DV	4	6	0	0
	AG	737	206	45	5
	BB	2	1	4	0
	BWF	125	3	4	0
	NSB	1	0	0	0
	RWF	390	76	24	1
	SSC	0	2	0	0
	TOTAL	1259	294	77	6
CPUE FISH/Net Day		125.9	49	12.8	6.0

***Fyke nets not fished on these dates.

AG = arctic grayling
BB = burbot
BWF = broad whitefish
DV = Dolly Varden
NSB = ninespine stickleback
RWF = round whitefish
SSC = slimy sculpin

Locations of fyke nets:
Net 1 - shallow water littoral zone
Net 2 - off access ramp
Net 3 - off outlet channel
Net 4 - southeast corner of mine site

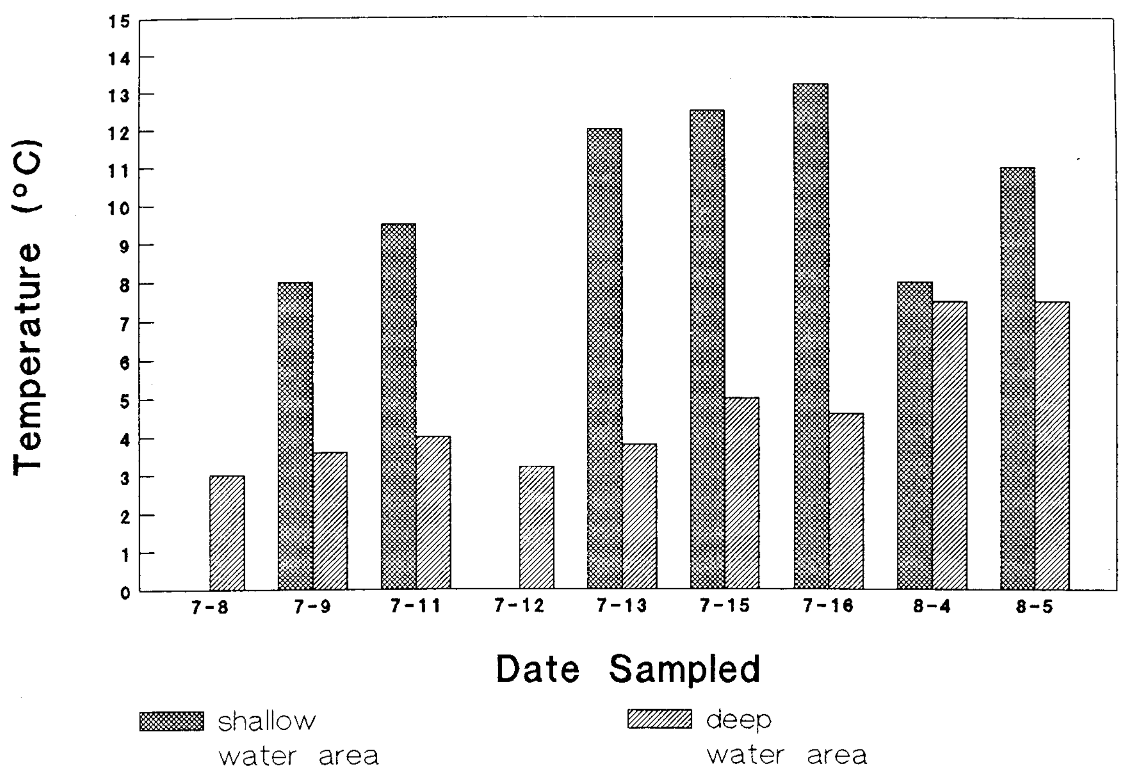

Figure 8. Water temperatures (°C) in shallow and deep water areas of Sag Site C, July and August 1988.

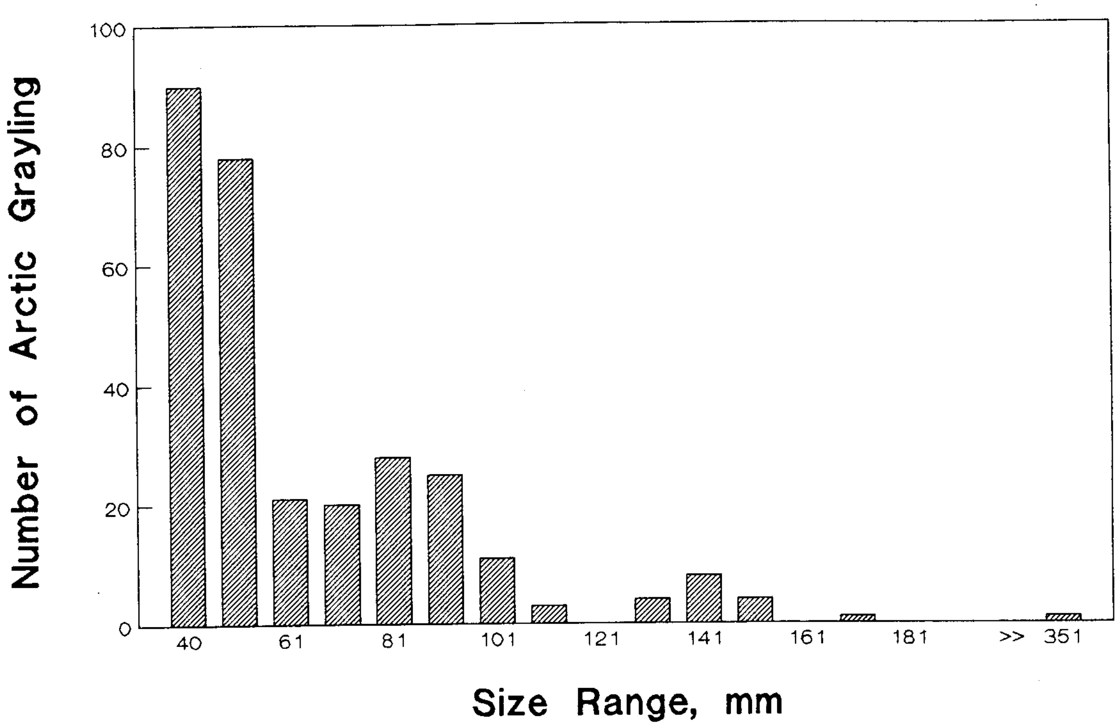

Figure 9. The size distribution of arctic grayling captured in the shallow water habitat of Sag Site C (Figure 5, net site 1) between July 8 and July 11, 1988. n = 294.

in numerous ponds and lakes (Doxey 1987). The stocking density generally used for development of sport fisheries has been 80 fingerling arctic grayling per ha. An evaluation of survival of grayling fingerlings from age of stocking to age 1 was calculated to be 0.33 in a 1.6 ha shallow (3.0 m depth) pond (Ridder 1987), or an average density of 26 fish per ha. In contrast, we estimated the arctic grayling density in Sag Site C was 14.8 fish per ha. The density of fish in Sag Site C may be more closely related to immigration during flooding of the site by the Sagavanirktok River than by other factors. The presence of other species of fish and the potential for interspecific competition, as well as high latitude conditions creating low site productivity, may limit population levels during periods when the site is isolated from the Sagavanirktok River.

The arctic grayling population in Sag Site C is dominated by the 40 to 50 mm size class and the 80 to 90 mm size class, which most likely represent age classes 1 and 2. It is possible that these juvenile fish colonized the site in 1987 when high water kept the site connected to the Sagavanirktok River for most of the open-water season or during the very brief period of high water in June 1988. Observations made in late summer failed to verify the presence of young-of-the-year arctic grayling. It is unlikely that spawning in the mine site accounts for the age 1 and age 2 arctic grayling.

The higher CPUE in the shallow water area suggested a preference by juvenile fish for this habitat type. The differences in the CPUE were greatest during the first sampling period as juvenile arctic grayling, round whitefish, and broad whitefish were captured most frequently in the shallow warm-water area. For example, 95% of the total broad whitefish were caught in the shallow-water site. During August after ice was off the mine site, catches were more evenly distributed between the littoral area and the main portion of the mine site. At this time, water temperatures were similar in the littoral area and the main portion of the site.

The enhancement project at Sag Site C was designed to provide an additional 2.0 ha of shallow water habitat, but only a portion of the excavated area was flooded in 1988, due to limited spring mflooding of the site. The flooded shallow water zone was estimated to be less than 1 ha in size. A 1 ha littoral zone expansion to this 15.5 ha lake represents less than 5% littoral habitat for the entire lake complex. Previous studies have recommended 25% littoral habitat for sites designed for fish (Joyce et al. 1980). The substantial use of this small area by juvenile fish in mid-July suggests a preference for shallow water habitat during July when the ice was melting.

No documentation of overwinter survival of fish in the gravel mine sites currently exists, although temperature and dissolved oxygen concentrations indicate high quality overwintering habitat is present. We recommend that future sampling address winter survival of arctic grayling.

ARCTIC GRAYLING DISEASE SCREENING
SAGAVANIRKTOK RIVER

INTRODUCTION

As part of the requirements for issuance of a fish transport permit to allow the transport of arctic grayling from the Sagavanirktok River to flooded gravel mine sites in the Prudhoe Bay - Kuparuk oilfields, 60 arctic grayling were collected and sacrificed to establish a disease history for this stock. The disease screening focused on three fish diseases: the bacterial diseases, fish furunculosis and bacterial kidney disease (BKD); and the viral disease, infectious pancreatic necrosis (IPN).

Fish furunculosis, a bacterial disease caused by the bacterium *Aeromonas salmonicida*, is a widespread disease that frequently occurs in salmonid fishes, and commonly occurs in Alaska salmonids. This disease is characterized by a number of symptoms that include, depending on the severity of the disease: massive bacteremia; lesions in muscle tissue that often contain blood, pus, and necrotized tissue; hemorrhagic spots in muscle; liquefactive necrosis of the kidneys and spleen; congestion of the posterior part of the intestine; bloody discharge from the vent; bleeding from the gills; hemorrhages and necrotic lesions at the base of pectoral and pelvic fins; and fraying of the fins (Snieszko and Bullock 1975). *A. salmonicida* can survive in water and sediment for days or weeks, but cannot reproduce indefinitely outside of fish. It is considered an obligate pathogen of fish, and diseased or carrier fish are sources and reservoirs of the bacteria. Transmission of *A. salmonicida* occurs through contaminated water, contact with diseased or carrier fish, or from contaminated eggs. Disinfectants and antimicrobial drugs can be used to prevent, control, and treat furunculosis.

Bacterial kidney disease (BKD), caused by the bacterium *Renibacterium salmoninarum*, is a systemic infection that often causes high mortality among wild and propagated salmonids. This disease is commonly found in Alaska salmonids (L. Wenderoff, Microbiologist, ADF&G, FRED Div., Anchorage, pers. comm.). BKD progresses slowly, is systemic, and may not show clinical signs until the disease is well established. Typical external characteristics of this disease include protrusion of the eyes, open lateral lesions, and small closed blebs containing blood cells, necrotized tissue, and large numbers of *R. salmoninarum* (Bullock 1980). Internally, the disease is characterized by swollen kidneys with white areas containing bacteria, cell debris, and leucocytes; hemorrhages in the body wall and testes; and necrotic areas within the kidneys, spleen and liver (Bullock 1980). In advanced cases, much kidney tissue is destroyed, affecting both excretory and hematopoietic functions. Transmission of the disease occurs from fish to fish through skin lesions, and with sex products. A 100% transmission has also been achieved by feeding infected viscera to fingerling salmon. Subclinically infected or carrier fish serve as a reservoir for infection.

Infectious pancreatic necrosis (IPN) is a viral infection of salmonid fishes causing high mortality in fry and fingerlings, and occasionally in larger fish. IPN has not been found in arctic grayling in Alaska (L. Wenderoff, pers. comm.). Symptoms of the disease include overall darkening, protruding eyes, abdominal distention, hemorrhages in ventral areas including bases of fins, multiple hemorrhages in the pyloric caecal area, pale liver and spleen, depressed hematocrit, and pronounced pancreatic necrosis (Wolf 1966). Behavioral abnormalities include weak respiration and lying on the bottom alternating with periods of whirling swimming (rotating about their long axis) when near death. IPN seldom kills all infected fish; some recover and attain functional sexual maturity. These recovered fish serve as carriers of the disease, shedding the virus in their feces, and thus transmitting the disease through flowing water. The virus is also transmitted in eggs and sperm.

METHODS

Up to 4 fyke nets and 4 gill nets were used to obtain 60 arctic grayling from the Sagavanirktok River during the period 28 July - 4 August 1988. Nets were set in slack-water areas in a 10.5 km stretch of river from about 1 km upstream of the Deadhorse airport to about 3 km downstream of the Sagavanirktok River bridge. Fyke nets were fished from 5-7 days and usually checked on a daily basis. Because arctic grayling greater than 150 mm in length were desired for disease screening, and catches of the desired size fish were usually small, arctic grayling were usually held in the fyke nets for several days before they were sacrificed to obtain sufficient numbers for sampling and shipment. Fish other than arctic grayling and arctic grayling less than 150 mm in length were released, generally on a daily basis.

Gill nets were fished from 1-2 days and live fish other than arctic grayling were released.

Sacrificed arctic grayling were measured and scales and otoliths were collected for age determination. Otoliths were immersed in Loess' solution and aged under a dissecting microscope. Scales were cleaned, pressed on to heated acetate sheets, and the impressions read on a microfiche reader. The arctic grayling were rinsed with Betadyne disinfectant and their spleen and kidneys were removed. The kidneys and spleens were placed in labeled plastic bags, packed in ice, and shipped to the Fish Pathology Section, FRED Division, ADF&G, Anchorage, for disease screening. Fluorescent antibody techniques were used to test for the presence of the bacterial diseases. Traditional viral assay was used to test for the presence of IPN virus.

RESULTS

Analyses of the arctic grayling tissue samples found no presence of fish furunculosis, kidney disease bacteria, or IPN virus (Appendix II), thus satisfying all requirements for implementation of the fish transport permit.

Of the 60 arctic grayling sacrificed for disease screening, 33 were female, 20 were male, and 7 were not sexed. Females ranged in fork length from 176 to 384 mm (mean = 302.3, sd = 48.8), males ranged in length from 181 to 378 mm (mean = 268.9, sd = 61.6), and the unsexed arctic grayling ranged in length from 159-310 mm (mean = 186.7, sd = 54.8) (Appendix III). Ages of the sacrificed arctic grayling ranged from 3 to 10 based on scales and from 3 to 12 based on otoliths (Table 8). For those fish that were aged by otoliths and by scales (n = 53), the mean otolith-based age was 1 yr greater than that determined from scales (7.1 vs 6.1 yrs). Scale-based ages were similar to those determined from otoliths through age 5, but generally were 1 yr less for fish aged 6-10. For fish aged 8-10 by scales, an underestimation of 1-4 years occurred from ages determined by otoliths. This observed difference between scale- and otolith-based ages is similar to that found in other studies of North Slope arctic grayling (Craig and Poulin 1975, McCart et al. 1972).

The total number and size of fish per species caught in the fyke nets and the number of fish caught in gill nets are listed in Appendices IV, V, and VI. Fish

Table 8. Age-length relationships for otolith- and scale-aged arctic grayling collected for disease screening 28 July - 4 August 1988 from the Sagavanirktok River near Prudhoe Bay. n = number of fish in sample; sd = standard deviation.

	Otolith aging Fork length (mm)				Scale aging Fork length (mm)			
Age	**n**	**Mean**	**Range**	**sd**	**n**	**Mean**	**Range**	**sd**
3	6	179.5	167-202	12.2	10	177.5	159-214	15.0
4	3	219.0	214-220	4.6	7	232.3	202-251	19.1
5	7	268.1	229-299	24.9	10	279.6	258-304	16.1
6	7	285.6	250-321	25.0	6	307.5	292-321	10.4
7	8	298.5	271-315	14.4	12	313.0	288-336	16.4
8	3	307.3	292-320	14.2	7	335.9	301-368	25.2
9	11	325.2	298-349	16.0	5	361.6	345-384	18.8
10	3	341.7	330-350	10.4	1	378.0		
12	5	375.2	366-384	7.8				
Total	53				58			

caught other than arctic grayling included round, broad, and humpback whitefish; Dolly Varden; and slimy sculpin.

DISCUSSION

Disease screening showed no evidence of diseases in arctic grayling in the Sagavanirktok River, thus enabling the use of a readily available source of arctic grayling for transplants to other sites within the Prudhoe Bay-Kuparuk oilfields. However, the sampling effort for the disease sample indicates that the numbers of arctic grayling that are accessible to capture by fyke nets in the lower Sagavanirktok River are low. Sampling suggests that in each of the fyke net-fishable slack-water areas, only a few arctic grayling are present, and that these fish are quickly captured. This necessitates either leaving a net at a site for extensive periods or moving the net to new or more productive sites. The number of fyke net-fishable sites in the Sagavanirktok River in the vicinity of Prudhoe Bay is limited in number and accessibility, although there are other potential sites inland of the Dalton Highway. More efficient capture sites may be found, particularly in early summer, in or near small tundra streams feeding the Sagavanirktok River, such as those found in the vicinity of and including Happy Valley Creek.

Tundra streams, such as Happy Valley Creek, Dan Creek, and others may provide an easily obtainable source of adult arctic grayling in the early summer as these fish descend these streams to larger rivers following spawning. After this postspawning downstream migration, few adult arctic grayling remain, although the system may prove to be important rearing habitat for juveniles (Craig and Poulin 1975, McCart et al. 1972). Craig and Poulin (1975) counted 13 adult arctic grayling (>300 mm) (0.29 adults/km) at a weir on Weir Creek, a stream about 45 km in length and a tributary of the Kavik River. Catches of juveniles (arctic grayling <300 mm, excluding fry) numbered 2,165 (0.47/km). McCart et al. (1972) tagged a total of 80 arctic grayling >200 mm in Happy Valley Creek in 1971, yielding an estimate of 0.43 fish/km for this creek. More adult arctic grayling were probably in these systems, as some individuals probably left the systems prior to establishment of the weirs or during upset periods. If the Weir Creek densities are applied to Happy Valley Creek, using a stream length of 34.4 km for Happy Valley

Creek, an estimated 10 adult arctic grayling and 1,643 juveniles should use this stream. Thus, because of the low numbers of adult arctic grayling present in these small streams, care must be taken to avoid removing excessive numbers of adult arctic grayling from any particular stream.

Two unsuccessful attempts at introducing fish to barren lakes have been conducted within the coastal plain of northern Alaska. In June 1981, 50,000 newly hatched arctic grayling fry were stocked in Isatkoak Lagoon at Barrow as part of an experimental stocking program to enhance recreational fishing opportunities for local residents (Bendock 1982). This impounded former salt water lagoon has been dredged to a maximum depth of 7.6 m, and the upper two (of three) impoundments serve as a municipal water supply. The arctic grayling fry from Clear Hatchery stock were stocked in the uppermost lagoon in June, a time when the lagoon was ice covered. Limited open water was present where tundra runoff had melted a small amount of ice. The fry were placed in this open water area and appeared to be in good condition when released (T. Bendock, Fishery Biologist, ADF&G, Sport Fish Division, Soldotna, pers. comm). Predation on the fry by gulls and terns was noted shortly after the fry were released. Sampling in August 1983 failed to capture any arctic grayling, and workers at the Barrow water facility had not observed any arctic grayling or arctic grayling-sized fish (Bendock and Burr 1984). Workers did observe a number of ninespine sticklebacks at the water intake in the upper lagoon. Bendock (pers. comm.) believed that this stocking occurred too early in the year for this location and that better survival may have occurred if the fish had been released when the lagoon was ice free. The lagoon has not been restocked since this apparent stocking failure. The North Slope Borough is currently developing plans to stock this reservoir with adult arctic grayling taken from local stocks (M. Philo, Research Biologist, North Slope Borough, Barrow, pers. comm.).

On 23 August 1977, 3,000 fingerling rainbow trout were stocked in Webster Reservoir (Unpubl. data files, ADF&G, Sport Fish Division, Fairbanks), a 12 ha tundra lake adjacent to the Sagavanirktok River floodplain that had been deepened and serves as a water supply reservoir for oilfield activities. In the summer of 1978 or 1979, gill nets were fished overnight in Webster Reservoir on several occasions; no rainbow trout were caught in these nets, suggesting that no trout survived (T. Bendock, pers. comm).

The current plan to introduce large juvenile and adult arctic grayling to systems lacking arctic grayling should prove to be more successful than the two previous attempts to stock lakes. The large fish are unlikely to be eaten by birds as would fry or fingerling fish. Abundant ninespine stickleback may provide a plentiful source of food for some large arctic grayling and access to streams may provide additional feeding habitat. Access to a stream system that will have higher water temperatures in the spring may provide conditions more suitable to spawning than in the mine site. Such factors may allow an arctic grayling population to become established in a system previously barren of a population of fish other than ninespine stickleback and broad whitefish.

CONCLUSIONS

Biological sampling conducted during summer 1988 indicated that the amount of littoral habitat present in a flooded gravel mine site strongly influences the productivity in that site. Highest rates of algal production and greatest zooplankton densities were found in mine sites with extensive littoral habitat (Table 9). Fish sampling at Sag Site C suggested a preference for shallow water habitats by juvenile fish during the ice-out period when this habitat is accessible to them. Results of this study suggest that enhancement of gravel mine sites for fish habitat should emphasize creation of additional littoral habitat to increase algal production, zooplankton densities, and use by fish.

Permanently connecting a mine site to a river will allow colonization of the mine site by fish and will provide the mine site-resident fish access to the river for rearing and potential spawning. A deep mine site connected to a river system may also increase the capacity of a system to overwinter fish. Sites with ephemeral connections will likely not provide conditions as beneficial to fish as will permanently connected sites if the mine sites do not provide habitat for spawning, rearing, and overwintering. At such temporarily connected sites, the productivity of the site, in terms of food available to fish, will be important to the survival of fish in the site until a river connection is reestablished and fish have the opportunity to leave the site.

Mine sites associated with small tundra streams and not connected to a major river with overwintering habitat have low fish species diversity (Table 9). An arctic grayling transplant is proposed to increase fish species diversity and use of available habitat. It is assumed that arctic grayling will use mine sites for overwintering and potentially, connected tundra streams for spawning. Rearing may occur in either the mine sites or the tundra streams. Large numbers of ninespine stickleback found in these sites may provide a readily available source of food for large juvenile and adult arctic grayling. Success with this arctic grayling transplant in a tundra stream/mine site setting will likely direct the design of future gravel mine sites toward the optimization of use by fish and other species.

Table 9. Summary of physical and biological characteristics at four flooded gravel mine sites.

	Kuparuk Deadarm 6	Kuparuk Mine Site B	Kuparuk Mine Site D	Sag Site C
size, ha	15.2	3.7	15.6	16.5
ave. depth, m	2.5	7.1	14.0	16.8
age, yrs	3	11	5	3
% littoral habitat	41	20	4	5
hydrologic connection	highwater	flooded wetland	permanent	highwater
river system	large river	small tundra	small tundra	large river
phytoplankton production ranking	1	2	3	4
zooplankton production ranking	1	2	3	4
thermal stratification	slight	yes	none	none
fish species	ACi AG NSB	BWF NSB	LCi NSB	AG BWF BB DV NSB RWF SSc

ACi = arctic cisco
AG = arctic grayling
BB = burbot
BWF = broad whitefish
DV = Dolly Varden
LCi = least cisco
NSB = ninespine stickleback
RWF = round whitefish
SSc = slimy sculpin

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APPENDIX I

Dissolved oxygen (D.O.) and temperature values for Prudhoe Bay-Kuparuk mine sites, 1988.*

Site	Depth m	May °C**	May D.O. mg/L	July °C	July D.O. mg/L	August °C	August D.O. mg/L
Kuparuk Deadarm							
Reservoir 6	1	-	-	11.9	13.5	5.0	11.7
(deep site)	2	-	-	11.6	11.9	5.4	10.9
	4	-	-	8.7	12.0	5.2	11.5
	6	-	-	6.8	12.3	5.4	10.8
	7	-	-	-	-	5.0	11.5
Kuparuk Deadarm							
Reservoir 6	1	-	-	11.6	11.0	5.7	11.7
(shallow site)	2	0.3	13.8	11.6	11.1	5.6	11.7
	3	0.0	13.9	11.7	11.3	5.6	11.7
Kuparuk Deadarm							
Reservoir 5	2	0.0	12.6	-	-	-	-
	5	0.0	14.6	-	-	-	-
	10	0.0	13.4	-	-	-	-
	12	0.0	13.6	-	-	-	-
Kuparuk Mine							
Site B	1	-	-	12.2	11.1	6.8	10.8
(A side)	2	0.3	10.4	10.8	11.2	7.1	10.7
	4	-	-	8.0	11.4	7.2	11.1
	5	0.6	12.0	-	-	-	-
	6	-	-	7.7	11.3	7.2	10.7
	7	0.9	10.0	-	-	-	-
	8	-	-	4.6	11.5	7.3	10.8
	9	-	-	-	-	7.0	10.1
	10	-	-	3.9	10.0	-	-
Kuparuk Mine							
Site B	2	1.1	9.5	-	-	-	-
(b side)	5	1.1	9.3	-	-	-	-
	7.5	1.1	8.2	-	-	-	-

APPENDIX I, continued

Site	Depth m	May °C**	May D.O. mg/L	July °C	July D.O. mg/L	August °C	August D.O. mg/L
Kuparuk Mine							
Site D	1	-	-	7.2	12.3	7.1	10.9
	2	1.1	7.1	7.1	12.3	7.1	11.2
	4	-	-	6.8	12.6	7.4	10.7
	5	1.1	10.1	-	-	-	-
	6	-	-	5.9	12.8	7.1	11.2
	8	-	-	5.3	12.6	7.2	11.0
	10	1.1	8.6	4.9	12.8	7.2	11.5
	13	1.1	6.4	-	-	-	-
Sag Site C							
	1	-	-	3.2	14.4	6.7	11.8
	2	1.7	13.6	3.4	13.8	6.8	11.5
	4	-	-	3.1	13.1	6.7	11.6
	5	1.1	13.5	-	-	-	-
	6	-	-	3.1	13.4	6.8	11.2
	8	-	-	3.1	12.9	6.9	11.3
	10	1.1	14.1	3.3	13.2	6.9	9.5
	13	1.1	13.8	-	-	-	-

* Sampling periods:
Kuparuk Deadarm Reservoir 6: May 18, July 15, August 22
Kuparuk Deadarm Reservoir 5: May 18
Kuparuk Mine Site B: May 19, July 13, August 24
Kuparuk Mine Site D: May 19, July 16, August 24
Sag Site C: May 17, July 13, August 25

** May temperature values converted from °F

APPENDIX II

Laboratory results of fish disease screening.

ALASKA DEPARTMENT OF FISH AND GAME
FISH PATHOLOGY SECTION, F.R.E.D. DIVISION
333 RASPBERRY ROAD, ANCHORAGE, AK 99518-1599
PHONE 267-2244

REPORT OF LABORATORY EXAMINATION

SAMPLE DATE: 7/31/88 ACCESSION NO: 89-0015 DATE SAMPLE RECEIVED: 8/2/88

CONTACT PERSON/FACILITY: Jack Winters, ADF&G, FRED-Fairbanks

LOT (YEAR, STOCK, SPECIES): Sagavanirktok River grayling

STAGE: Adult WILD: Yes

NUMBER IN SAMPLE: 60 SPECIMEN TYPE: Kidneys STATE: On ice

HISTORY/SIGNS:

REASON FOR SUBMISSION: To establish a disease history on this stock before it is transplanted into main site B, a part of East Creek. This sample was required as part of FTP # 88A-1029.

FINAL REPORT DATE: 9/9/88

CLINICAL FINDINGS:

FAT: 0/60 positive for both Renibacterium salmoninarum and Aeromonas salmonicida.

VIROLOGY: 0/60 positive for IPNV. Traditional assay was done using dilutions of 10^0, 10^{-1}, 10^{-2}, 10^{-3}. $CHSE_{214}$ cell lines at 13°C for 15 days. Blind-passed for an additional 14 days. Minimum level of detection: 100 infectious particles per pooled sample (5 fish/pool).

COMMENT: The disease history is complete.

FISH HEALTH INVESTIGATOR: L. Wenderoff

COPIES TO: 6.8.9, T. Meyers, R. Burkett, K. Pratt

APPENDIX III

Length, age, and sex of arctic grayling collected for disease screening in the Sagavanirktok River, 28 July - 4 August 1988.

Length mm	Scale age yrs	Otolith age yrs	Sex
159	3	--	--
160	--	--	--
165	--	--	--
165	3	--	--
167	3	3	--
172	3	3	M
176	3	3	F
177	3	3	F
181	3	--	M
181	3	--	--
183	3	3	M
202	4	3	M
214	3	4	M
220	4	4	M
223	4	4	M
229	4	5	F
250	4	6	F
251	4	5	F
251	4	--	F
258	5	5	M
265	5	6	F
266	5	5	M
270	5	6	F
271	5	7	M
279	5	5	M
288	7	7	M
289	5	6	F
290	7	7	F
292	6	8	F
295	5	5	M
298	7	9	F
299	5	5	M
300	6	6	F
301	8	9	F
302	7	7	F
304	5	6	M
305	7	7	F
307	6	7	M
310	7	8	F
310	6	7	--
315	6	7	F
319	7	9	F
320	8	8	M

APPENDIX III, continued

Length mm	Scale age yrs	Otolith age yrs	Sex
321	8	9	F
321	6	6	F
322	7	9	F
328	7	9	F
328	8	9	F
328	7	9	F
330	7	10	F
336	7	9	F
345	9	10	F
347	8	9	F
349	9	9	M
350	9	10	F
366	8	12	F
368	8	12	M
378	10	12	M
380	9	12	F
384	9	12	F

APPENDIX IV

Numbers of fish, by species, caught in fyke nets in the Sagavanirktok River, 28 July - 3 August 1988.

Net Site	Arctic Grayling	Round Whitefish	Broad Whitefish	Slimy Sculpin	Dolly Varden
July 28					
Net 1[1]	4	6	-	-	-
Net 2[2]	11	1	-	-	-
Net 3[3]	2	1	-	-	-
July 29					
Net 1	-	-	-	1	-
Net 2	5	3	-	1	-
Net 3	2	-	-	-	-
July 30					
Net 1	1	3	-	-	-
Net 2	3-5	-	-	-	-
Net 3	-	-	-	-	-
July 31					
Net 1	4	4	2	-	-
Net 2	5-7	5	-	-	1
Net 3	4	1	-	7	-
Net 4[4]	1	6-10	-	-	-
August 2[5]					
Net 1	-	-	-	-	-
Net 2	4	-	-	1	-
Net 3	15	11	-	2	-
Net 4	1	-	-	-	-
August 3					
Net 1	-	-	-	-	-
Net 2	1	-	-	-	-
Net 3	-	-	-	-	-
Net 4	-	-	-	-	-

1 = 1 km south of Deadhorse Airport
2 = due east of Deadhorse Airport
3 = 3 km upstream of Sagavanirktok River bridge
4 = at Sagavanirktok River bridge
5 = 2 day set

APPENDIX V

Numbers of fish, by species, caught in gill nets in the Sagavanirktok River, 3-4 August 1988.

Net Site	Arctic Grayling	Round Whitefish	Broad Whitefish	Dolly Varden	Humpback Whitefish
August 3					
Net 1[1]	9	1	-	-	-
August 4					
Net 1	-	2	2	1	-
Net 2[2]	8	2	8	-	-
Net 3[3]	1	-	6	1	-
Net 4[4]	1	1	12	1	1

1 = east bank, Sagavanirktok River bridge
2 = west bank, Sagavanirktok River bridge
3 = 3 km downstream of Sagavanirktok River bridge
4 = 3 km downstream of Sagavanirktok River bridge

APPENDIX VI

Lengths of fish, by species, caught in fyke nets in the Sagavanirktok River, 28 July - 3 August 1988. Where more than one fish was caught in a given size range, the number of fish is shown in parenthesis following the size range.

	Length of Fish in Millimeters			
Species	Net 1	Net 2	Net 3	Net 4
Arctic grayling	68	70*	61	-
7/28-31	74	71*	77	-
	80*	76*	113	-
	167	78*	148	-
	229	124	168	-
	233	148	250	-
	288	153	289	-
	305	158	340	-
	319	159	-	-
	-	160	-	-
	-	164	-	-
	-	165	-	-
	-	165	-	-
	-	168	-	-
	-	181	-	-
	-	181	-	-
	-	214	-	-
	-	251	-	-
	-	258	-	-
	-	270	-	-
	-	289	-	-
	-	295	-	-
	-	299	-	-
	-	304	-	-
	-	310	-	-
	-	322	-	-
	-	336	-	-
7/31-8/3	-	191*	60-80 (10)**	172
	-	202	176	-
	-	220	177	-
	-	279	183	-
	-	-	226	-
	-	-	307	-

APPENDIX VI (continued)

Species	Length of Fish in Millimeters			
	Net 1	Net 2	Net 3	Net 4
Round whitefish				
7/28-31	80-90 (6)**	74	407	-
	100 (3)	80-100 (3)	378	-
	70-80 (4)**	81	40-55 (20)	-
	-	82	80-90 (5)	-
	-	96	-	-
	-	114	-	-
	-	132	-	-
7/31-8/3	-	-	120 *	400-425 (2)
	-	-	60 (10)	-
Dolly Varden				
7/28-31	-	155	-	-
Broad whitefish				
7/28-31	425	-	-	-
	438	-	-	-
Slimy sculpin				
7/28-31	70 *	-	88	-
	-	-	84	-
	-	-	30-50 (5)**	-
7/31-8/3	-	-	50-70 (2)**	-

* fyke net mortality
** approximate numbers or lengths

Locations of nets:
- Net 1 - 1 km south of Deadhorse Airport
- Net 2 - due east of Deadhorse Airport
- Net 3 - 3 km upstream of Sagavanirktok River bridge
- Net 4 - at Sagavanirktok River bridge