Technical Report No. 01-05

Fish Habitats and Use in the Tanana River Floodplain near Big Delta, Alaska, 1999-2000

by James D. Durst

June 2001

Alaska Department of Fish and Game **Habitat and Restoration Division**

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ABSTRACT

The Alaska Department of Fish and Game, Habitat and Restoration Division, conducted a project to quantitatively evaluate differential use by fish of five water type habitats (clearwater, mixed clear/glacial, glacial, mixed humic/glacial, and humic-stained) in a 50-km reach of the Tanana River and its tributaries near Big Delta, Alaska. Six sampling periods were spread across the openwater seasons of two years: August and September, 1999, and May, June, July, and August, 2000. Baited minnow traps were set (n = 228) in all habitat types, and a beach seine was used (n = 85) to sample glacial and mixed clear/glacial habitats. A total of 1,301 fish were captured, identified to species, and measured. Ten species were represented: chinook, chum, and coho salmon, Arctic grayling, least cisco, round whitefish, lake chub, longnose sucker, burbot, and slimy sculpin. Water temperature, depth, velocity, turbidity, dissolved oxygen, conductance, and pH, and substrate physical characteristics were recorded at sampling locations during or immediately after seining or trap setting, and each site was photographically documented. Upland vegetation within 30 meters of the bank at each sample site was classified to level III of *The Alaska Vegetation Classification*. Minnow traps captured almost no freshwater-rearing salmon in turbid waters (the exceptions being coho in May). Chinook salmon juveniles were captured primarily in humic-stained habitat and to a lesser extent in clearwater habitat. Coho salmon were captured primarily in clearwater habitat, with some captures in humic-stained habitat. Coho salmon juveniles were captured by both traps and seine in the Tanana River in May, possibly as outmigrating smolt. Chum salmon fry were captured by seine in turbid glacial waters in May and June. These results agree with previous work in the Tanana River but contrast with the minnow trap captures of rearing chinook and coho salmon in turbid glacial waters in southeast Alaska. Beach seine hauls captured Arctic grayling (primarily subadults) in turbid glacial waters in all sample periods. Round whitefish were also captured by seine in all periods, although their use of glacial waters may decrease with increasing turbidity.

Fish use of sampled habitats, habitat characteristics, and habitat sensitivities (or lack thereof) to nonpoint source pollution from timber harvests were evaluated concurrent with the Region III Science/Technical Committee (STC) process. This interdisciplinary, multiagency evaluation included a review of pertinent literature on fish species, life stages, and habitats in relation to use of glacial streams, as well as fish sensitivity to land use practices and typical forestry management techniques. Recommendations developed by the STC were accepted by the Alaska Board of Forestry, and forwarded to a stakeholder Implementation Group (IG) that developed draft changes to statutes and regulations necessary to implement the recommendation to minimize effects on fish habitat and water quality during forestry activities such as timber harvest and access road construction. The IG's recommendations, also accepted by the Board, center around no-harvest buffers along essentially all water bodies that contain anadromous or high value resident fish. Buffer width, and whether or not a selective cut buffer is adjacent to the no-harvest buffer, varies by land ownership and water body type. Fieldwork continues to finalize harvest recommendations beside non-glacial waters <1m wide that contain high value resident fish only.

INTRODUCTION

The Tanana River supports a variety of fish species including Arctic lamprey[1]; least cisco; broad, humpback, and round whitefish; inconnu; chinook, chum, and coho salmon; Arctic grayling; northern pike; lake chub; longnose sucker; burbot; and slimy sculpin (Mecum 1984, Ott et al. 1998, Hemming and Morris 1999). An Alaska Department of Fish and Game (ADF&G) radio telemetry study of fall chum salmon spawning upstream of Fairbanks (Barton 1992) identified approximately 18 different spawning areas within the Tanana River floodplain (including the main channel) between upper Salchaket Slough and the Little Gerstle River, a river distance of about 220 km. Use of the Tanana River as overwintering habitat by adult fish has been documented during major studies on Arctic grayling (Clark and Ridder 1988), northern pike (Burkholder and Bernard 1994), and burbot (Evenson 1989), and local ADFG&G fish biologists believe that all species documented to occur in the river use it as overwintering habitat to some extent. Although studies have been done on large glacial rivers in southeast Alaska (Lorenz and Eiler 1989, Eiler et al. 1992, Jordan 1998), habitat selection by fish, particularly juveniles, is poorly understood in the Tanana and other turbid river systems of interior Alaska during the openwater period.

Water bodies connected to, or associated with, major glacial river systems (e.g., oxbow lakes, side channels, sloughs and backwaters) can have different physical and chemical properties and characteristics (collectively referred to in this report as "water quality") than the mainstem river. Water quality in connected water bodies can be strongly influenced by hyporheic flow, groundwater discharge, precipitation runoff, surface and wetland drainage (e.g., humic acids, nutrients, suspended solids, or dissolved solids), and by settling of suspended solids in quiescent water. The ADF&G conducted limited summer sampling of fish habitat use in the Tanana River near Fairbanks during the 1996 field season (Ott et al. 1998), followed by more intensive sampling near Fairbanks and Big Delta during the 1997 field season (Hemming and Morris 1999). Specific habitats identified as potentially used by fish in or adjacent to glacial systems include rocky substrates associated with rock bluffs, gravel bars, silt bars, tree root wads, backwaters, groundwater-discharge tributaries, humic-stained runoff and wetland drainages, and blackwater sloughs. In general, habitat preferences of fish species by life stage are best known in clearwater systems, moderately known for humic-stained systems, and poorly known for glacial systems.

The objectives of this project were to

- Identify fish species and life stages that use the specific habitats in, and connected to, the Tanana River in the Big Delta portion of the drainage during the openwater period;
- Identify physical and water quality characteristics associated with specific habitats in, and connected to, the Tanana River and identify the adjacent upland and wetland vegetation classes;
- Identify forest management practices that put sensitive habitats at risk; and
- Identify forest management practices necessary to protect sensitive fish species, life stages, and habitats where restrictive forest management practices are not required.

[1] Appendix A lists common and scientific names of all species noted in this report.

This study is one of three concurrent, complementary Tanana Basin projects with funding provided by the Alaska Department of Environmental Conservation through its nonpoint source pollution prevention program. For additional information, see the final reports for the Alaska Boreal Forest Council's upwelling delineation project (McCaffrey 2001), and the joint Tanana River erosion dynamics project by the Tanana Chiefs Conference and DNR Division of Forestry (Ott et al. 2001 and Worum et al. 2001).

ACKNOWLEDGEMENTS

Majority funding for this project was provided through the Alaska Department of Environmental Conservation Nonpoint Source Program, Community Water Quality RSAs to projects NP-00-R7 and NP-01-R7, Tanana Basin Fish Habitat Use. Match funding was provided by the ADF&G Habitat and Restoration Division.

This project would not have been possible without the fieldwork, gear preparation, boat dragging, and data entry contributions of Nancy Ihlenfeldt, Bruce McIntosh, Bill Morris, and Brendan Scanlon, and their efforts are gratefully acknowledged. ADF&G staff in Delta Junction shared their office and bunk facilities, and provided invaluable local knowledge. The Richardson Clearwater landowners greatly assisted with access to the lower portion of the study area through use of the Shaw Creek boat launch. Chris Stark performed the laboratory identification of voucher specimens and stomach contents. Bonnie Borba, Mike Doxey, Laura Jacobs, Bruce McIntosh, Bill Morris, Tom Paragi, and Fronty Parker provided edits and comments on draft versions of this report.

STUDY AREA

The Tanana River is a 700-km long river in interior Alaska. Glacial-melt runoff and associated sediment loads dominate the river's hydrology and channel morphology. The 114,740-km^2 Tanana Basin lies north of the Alaska Range and south of the Yukon-Tanana Uplands. A major transportation route, the Tanana River flows west from near the United States/Canada border, past Fairbanks, and into the Yukon River, contributing about one-fifth of the total Yukon River basin annual discharge (Brabets et al. 2000). The Tanana River's historic floodplain has numerous isolated masses of permafrost, and the adjacent uplands contain discontinuous permafrost. Like other subarctic glacial rivers, the Tanana River has two personas. During the openwater period (approximately May through mid-October), the Tanana is a high-energy, braided, silty river, with shifting bedload and a variable discharge driven by glacial meltwater and major rain events. During the frozen period (about November through mid-April), the Tanana is a moderate-energy, split-channel, clearwater river, with relatively stable bedload and a fairly stable discharge that at times is increased due to short thaw periods along its tributaries. Springs and upwelling flows can keep portions of the Tanana River (such as the reach at Big Delta) open year round. Localized but substantial bedload scour can occur under ice (scour depths of 3m or more have been documented), particularly if solid or frazil ice occludes a significant portion of the channel cross-sectional area. This project predominantly addresses fish habitat during the openwater period.

Tributaries to the Tanana River from the north drain the Yukon-Tanana Uplands, and are typically humic-stained runoff streams (such as the Chena, Salcha, and Goodpaster rivers and Shaw Creek). Tributaries from the south drain the north side of the glaciated Alaska Range and the extensive intervening glacial outwash plains. These tributaries are typically either glacial-fed streams (such as the Gerstle, Delta, and Nenana rivers), or clear groundwater streams (such as the Richardson Clearwater and Delta Clearwater rivers, and Blue Creek). Upwelling flows in the Tanana River floodplain are a complex mix of hyporheic flows, infiltration from perched wetlands and outwash gravels, and deep groundwater. The south bank of the Tanana River in the Big Delta area is characterized by numerous upwelling areas giving rise to clearwater creeks and rivers that run into the Tanana River, such as the Delta Clearwater and Richardson Clearwater rivers, and Providence Creek. Upwelling areas also exist in south bank side channels and within the mainstem of the Tanana River, including Bluff Cabin Slough, Cub Creek, and the Tanana River mainstem a short distance upstream of the Richardson Highway bridge. These slough and side channels often run clear in the spring and do not take on a glacial appearance until increased summer water levels in the Tanana River flood the sloughs, potentially offering additional habitat types for fish.

This study used the same 50-km stretch of Tanana River basin centered near Big Delta (N64°09', W145°50') as did the 1997 study of Hemming and Morris (1999). Sampling was done between the outlet of Clearwater Lake and the lower Richardson Clearwater River (Figure 1). Sample locations included a variety of mainstem and side channel Tanana River habitats and those of connected tributaries and wetlands. Sites were chosen based on water quality and substrate characteristics as a means to assess a variety of fish habitats.

Water body names in this report attempt to follow local use, and are the same as those used by Hemming and Morris (1999) with one exception. The clearwater stream Hemming and Morris called Clear Creek we reference as Providence Creek (after a local timber sale) in this report change to reduce confusion with other clearwater streams nearby. The humic-stained stream flowing to the Tanana River and containing the Thompson Lake outlet flow is called Indian Creek consistent with the U.S. Geological Survey 1:250,000 map, and should not be confused with the Indian Creek tributary of the Goodpaster River.

METHODS

This project expanded upon the work by ADF&G in 1997, with changes to the sample design to better accommodate the highly variable habitats found in the Big Delta area of the Tanana River basin. Hemming and Morris (1999) used fixed sample sites that sometimes had different water quality characteristics in different sampling periods (clear water one month, silt-laden water the next month). This project based site selection primarily on water quality at the time of sampling, so sites sampling the same habitat type (e.g., mixed clearwater/ glacial) could have differing physical locations over time. Field sampling occurred during six periods over most of the openwater season on the Tanana: 16-20 August (late summer)

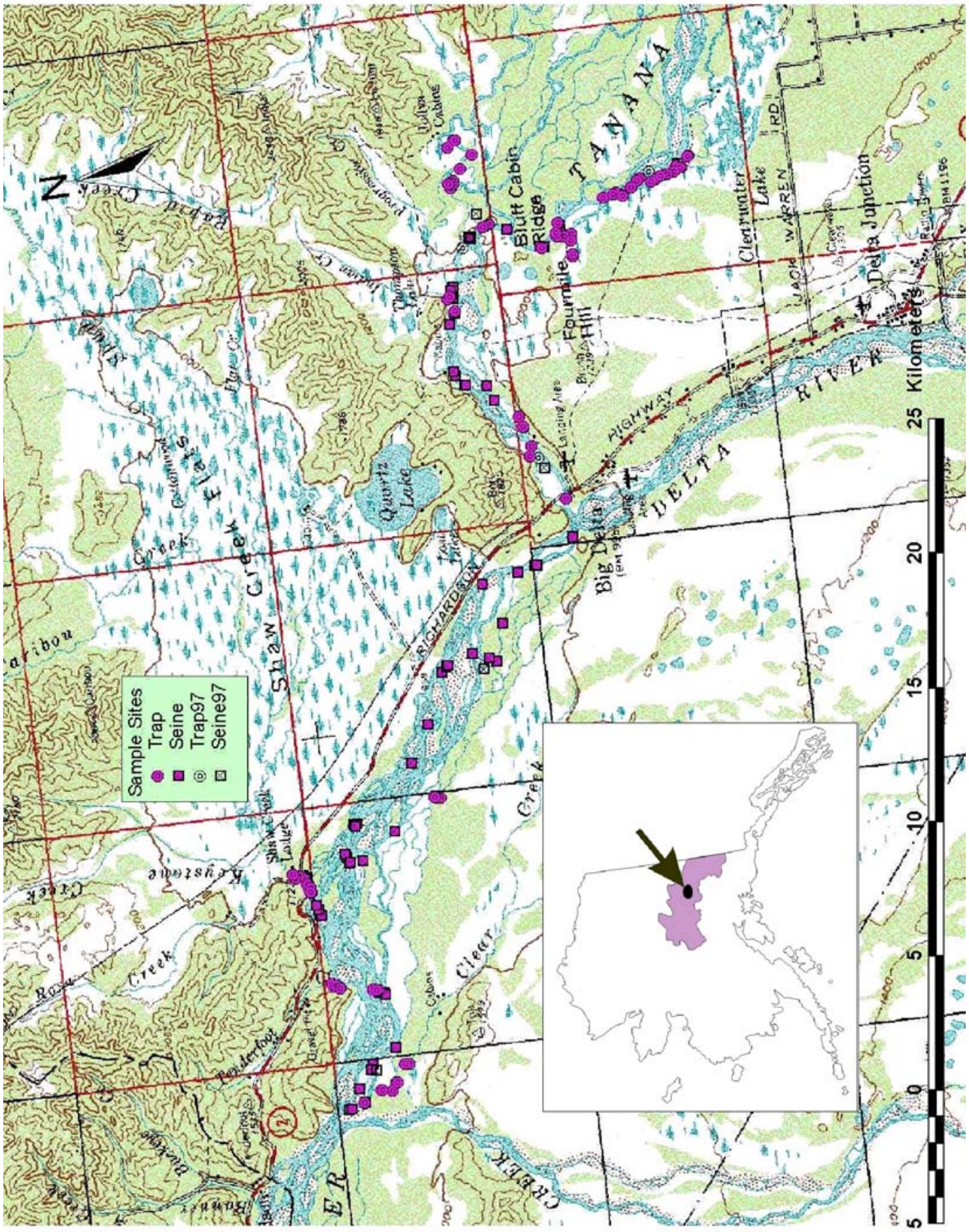

Figure 1. Project study area in interior Alaska, encompassing the Tanana River and its tributaries between Clearwater Lake outlet and the Richardson Clearwater River ("Clear Creek" on this USGS map base). Trap97 and Seine97 sites are from Hemming and Morris (1999). The Tanana River Basin is shaded area on the locator inset; the black oval gives location of the study area map.

and 20-27 September (fall) 1999; and 17-26 May (spring), 13-21 June (early summer), 17-25 July (mid-summer), and 16-23 August (late summer) 2000. An 18-foot long, flatbottom aluminum riverboat with a 90-horsepower outboard jet was used to access sample sites, allowing travel in shallow water.

The goal was to sample fish and water in each habitat type evenly during each of the six sampling sessions. Minnow traps were set at about seven sample sites in each of the five water types (clearwater, mixed clear and glacial waters, glacial, mixed humic and glacial waters, and humic-stained). Beach seine hauls were made at about five sites in each of three glacial water substrate types (gravel, mixed gravel and silt, and silt). The variability in water levels of the Tanana River changed the availability of habitats for sampling (both water and substrate types) between each sampling period for both minnow trap sets and beach seine hauls.

Water Quality and Habitat Characteristics

Water quality characteristics were measured at each trap as it was set, and in the middle of each area seined after seining was completed. Some locations were sampled during more than one period. Temperature, dissolved oxygen (DO), DO percent saturation (DO%), specific conductivity (conductance), and pH were measured using a Hydrolab Surveyor® 4 with a Minisonde® multiprobe. Water depth and average velocity were measured using a Global FP101 Flow Probe. A 500-ml grab sample of water was taken at each sample site and immediately analyzed for turbidity using a Hach® 2100P Portable Turbidimeter. In 2000, three 1000-ml grab samples of Tanana River mainstem water were taken each sample period and analyzed at a laboratory for total suspended sediments. All water quality sampling was done using standard methods, and standard reporting accuracy is used throughout this report (APHA 1992).

Substrate was qualitatively described and categorized at each sample site. Emergent and upland vegetation was classified to Level III of The Alaska Vegetation Classification (Viereck et al. 1992) along a visual transect perpendicular from water's edge to 30 m onshore of the sample site. Photographic documentation was made using a 35-mm camera, and color prints of each site at each sample event were cataloged for reference use. Global positioning satellite (GPS) location information was gathered using Garmin® GPS 40 and 12CX Personal Navigators™ with external antennas. Locations for sample sites and other features of interest are listed in Appendix B. All data were written onto "Rite-in-the-Rain"® paper forms in the field, then transcribed into computer spreadsheets at the office for review, summarization, and analyses. Appendix C contains a sample data form.

Fish Sampling and Observations

Minnow traps were used in all water type habitats. Unmodified Gee minnow traps were baited with preserved coho and chinook salmon roe held in perforated plastic bags, and placed in locations where fish were deemed most likely to be present and susceptible to capture. These were typically areas with relatively low velocity, cover when present in the vicinity, and least likely to be disturbed by wakes from passing boats. River rocks were sometimes placed in traps to anchor them in stronger current. Fishing time (approximately 24 hours) was recorded.

Beach seines were used to collect fish where current, depth, and substrate allowed. Their use was generally restricted to glacial waters (a few mixed clearwater/glacial sites were seined) because of the tendency observed in fish to flee visual disturbances such as the net and operators in clearwater and humic-stained habitats. A 9.1 m long, 1.2 m deep, 7 mm mesh nylon beach seine was pulled upstream, current permitting, primarily in debris-free areas with depths <1 m for a distance of 10-15 m, and then pulled shoreward. Hauls were pulled downstream on a few occasions where currents precluded upstream hauls. Bottom area swept by each haul was recorded.

Field species identification used a variety of keys, including McConnell and Snyder (1972), McPhail and Lindsey (1970), Morrow (1980), and Pollard et al. (1997). A measuring board was used to determine fork length (distance from tip of snout to fork of tail) to the nearest millimeter for each fish captured. Burbot and slimy sculpin were measured for total length due to tail shape. A few voucher specimens were retained and preserved by freezing for positive identification and examination of stomach contents. All fish not retained for identification or for collection of biological materials were released at or near point of capture. Fish capture and collection was done under authorization of ADF&G Scientific Collecting Permit No. 91-37. Ancillary observations of other fish species and life stages were noted.

Data Analyses

Data analyses were primarily performed with Statistix® 7.0 for Windows (Analytical Software 2000). A general analysis of variance procedure on habitat characteristics was used to explore whether the *a priori* water type designations were reflected in the field data (H_0: No differences in mean values for water quality characteristics between water types). The Tukey(-Kramer) method for all pairwise comparisons with unequal sample sizes was used to test for homogeneous means among water types within each period. Significance was specified at $\alpha = 0.05$ for all tests. Stepwise regression was used to evaluate the ability of habitat characteristics to explain total fish captures. To accommodate the logarithmic nature of pH, the values were converted to hydrogen ion concentrations (times 10^9) before calculation of means or hypothesis testing. Results were converted back to pH for presentation. Microsoft® Excel 97 used for additional summary statistics and graphics.

Habitat Sensitivity and Forest Practices

The objectives for this study included identifying forest management practices that put sensitive habitats at risk; and identifying forest management practices necessary to protect sensitive fish species, life stages, and habitats where restrictive forest management practices are not required. These objectives were accomplished in parallel with, and as part of, the Region III Science/Technical Committee (STC) process.

The Alaska Board of Forestry charged the STC to develop a draft stream classification system for Alaska forests north of the Alaska Range (includes the project area), review the available literature on sensitivities of streams and glacial rivers to land management activities (particularly forest practices), and recommend any changes needed to existing Alaska Forest Resources and Practices Act (FRPA) riparian management standards and practices to protect fish habitat and water quality. The STC had expertise including fish biology and habitats, forestry, hydrology, and soils, and consisted of scientists and experienced field staff from the state resource agencies, University of Alaska, U.S. Geological Survey, Tanana Chiefs Conference, and ABR Inc.

The FRPA and its implementing Regulations establish the current forest practices standards in Alaska for fish habitat and water quality. The FRPA identifies ten components of fish habitat that could be affected by forest practices: large woody debris[2] (LWD), stream bank stability, channel morphology, water temperatures, stream flows, water quality, adequate nutrient cycling, food sources, clean spawning gravels, and sunlight (AS 41.17.115). Habitat characteristic and fish capture data were evaluated for potential to affect, and sensitivity to changes in, these ten habitat components.

RESULTS

Water Quality and Habitat Characteristics

Water Habitat Types

Water quality measurements were made during 228 minnow trap sets (95 unique sites) and 85 beach seine hauls (61 unique sites), and one water-only sample (total 314 samples). A complete set of water quality measurements and notations on site physical characteristics were made at nearly all sites. Equipment failures resulted in 15 sample events not being measured for DO, DO%, conductance, or pH, and in two sample events not being measured for water velocity.

Substrate and velocity were variable from site to site in non-turbid water types (clearwater and humic-stained). In turbid water types (glacial, clear/glacial mixed, and humic/glacial mixed), the turbidity, velocity, and substrate characteristics were variable from place to place and time to time. This resulted in an extremely complex and patchy system of microhabitats available to fish.

Table 1 presents a summary of the water quality values measured, by water type, for all periods combined. Appendix D contains mean and range values of measured characteristics by water type and sampling period, and presents results of the Tukey's pairwise comparisons of water type mean values. The following paragraphs present general descriptions of each water type habitat. Comparisons are to the other water types sampled.

Clearwater: Characterized by moderated temperatures, moderate conductance, slightly basic pH, and extremely low turbidity. Clearwater habitats had the highest DO concentrations, and tended to be stable unless seasonally combined with glacial flow. Flows, temperature, and water quality tended to vary less than in the other habitat types. Sample sites were located in Clearwater Lake outlet, Bluff Cabin Creek, Blue Creek, Providence Creek, and the Richardson Clearwater River.

[2] Woody material that is at least 10 cm diameter and at least 3 m long.

Table 1. Summary ranges of water quality characteristic values measured at minnow trap and beach seine sites during 1999 and 2000 openwater sampling of five aquatic habitats in the Tanana River and associated tributaries.

Characteristic	Clearwater	Clear/Glacial	Glacial	Humic/Glacial	Humic-Stained
No. Samples	47	41	129	45	50
Depth (m)	0.3-1.2	0.2-1.5	0.1-1.1	0.2-1.2	0.2-1.4
Velocity (m/s)	0.00-0.50	0.00-1.15	0.00-2.10	0.00-0.70	0.00-0.85
Temp. (ºC)	3.2-14.2	3.9-14.4	3.6-20.3	3.9-15.4	0.3-14.9
DO (mg/L)	8.4-12.7	7.4-11.8	7.6-12.2	6.5-11.9	7.1-11.7
DO Sat. (%)	76-104	70-101	80-102	65-101	61-99
Conduct. (μS/cm)	236-271	208-1094	178-320	101-432	64-453
pH (units)	7.7-8.4	7.7-8.2	7.6-8.5	7.3-8.1	6.9-8.3
Turbidity (NTU)	0.35-16	10-950	55-2000	11-900	1.2-80

Clearwater/Glacial Mixed: Characterized by fairly intermediate temperatures, with conductance and pH more similar to clearwater than glacial waters, and intermediate turbidity. Mixed clearwater/glacial habitats were highly variable temporally, spatially, and in terms of water quality characteristics. Sample sites were located in Clearwater Lake outlet slough, lower Bluff Cabin Slough, Providence Creek slough, and the lower Richardson Clearwater River.

Glacial: Characterized by variable temperatures, with conductance generally lower and pH generally higher than in clearwater sites, and moderate to very high turbidity. Glacial habitats were moderately variable, with intermediate values for DO. They were more turbid and had higher average velocities than other habitats. Sample sites were located in the Tanana River mainstem, side channels, and sloughs, Cub Creek slough, Providence Creek slough, and Shaw Creek outlet channel.

Humic-Stained/Glacial Mixed: Characterized by variable temperatures, with intermediate conductance, pH, and turbidity values reflecting their mixed nature. Mixed humic/glacial habitats were extremely variable over time and place. Sample sites were located in the lower Goodpaster River and adjoining Tanana River mainstem, the lower portion of Indian Creek, the Shaw Creek outlet channel, and lower Tenderfoot Creek.

Humic-Stained: Characterized by highly variable temperatures, about half the conductance of clearwater and glacial water, high-neutral pH, low turbidity, and generally the lowest and most variable DO. Humic-stained habitats ranged from streams with low discharges such as Indian and Tenderfoot creeks to the high discharge Goodpaster River. Water levels in this habitat rose and fell in concert with rainfall events more than in other habitats. Sample sites were located in the benched wetlands northwest of Clearwater Lake, the Goodpaster River, and Indian, Shaw, and Tenderfoot creeks.

The following figures (2-6) show representative reaches of each water habitat type.

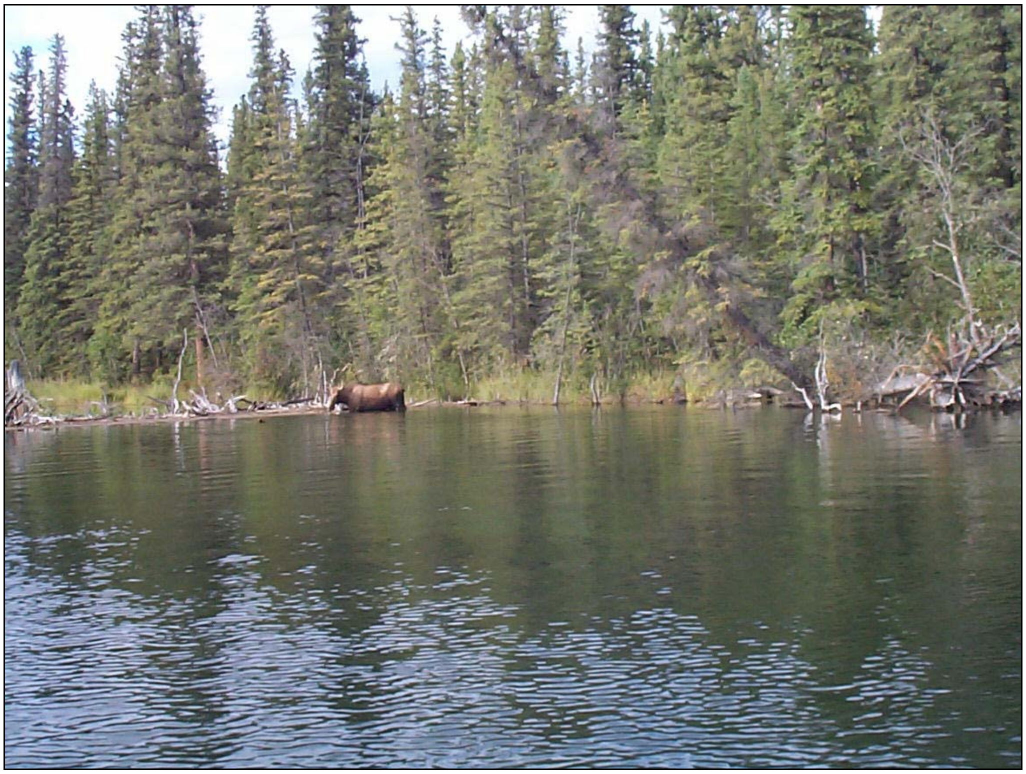

Figure 2. Clearwater habitat in Clearwater Lake outlet (20 Aug 99).

Figure 3. Mixed Clearwater/Glacial habitat trap site in Richardson Clearwater River (21 Aug 00).

Figure 4. Glacial habitat seine site in the Tanana River below Bluff Cabin (19 Aug 99).

Figure 5. Mixed Humic/Glacial habitat in lower Goodpaster River (20 Aug 99).

Figure 6. Humic-Stained habitat in Goodpaster River (20 Aug 99).

Upwelling Areas

The study area and adjoining portions of the Tanana River basin have a complex hydrology, characterized in places by actively upwelling waters (Anderson 1970, Wilcox 1980). The flow emerging at some of these upwelling areas has been called "true" groundwater—centuries- or millennia-old water that entered the ground on the footslopes of the Alaska Range, flowed through a massive bed of gravel and other glacially-deposited material, and is being forced back to the surface because of bedrock configuration. This groundwater tends to be mineralized (high conductance), and contains essentially no DO. In the winter, its relative warmth (often noted at 4-6ºC) compared to other winter flows may be a valuable thermal resource for incubating fish eggs such as those from fall chum salmon.

General evidence of groundwater upwelling was observed throughout the study area. Nearly all logjams examined in the study area contained from a few to many pieces of wood with orange stain, presumable from iron and other mineral oxides. This provides indirect evidence of widespread groundwater upwelling. In May 2000, we observed that the gravel on about one kilometer of main channel bank downstream of Peregrine Point was stained orange, adjacent to an area seen as orange-stained and open in aerial photos taken the previous winter as part of the Alaska Boreal Forest Council study (McCaffrey 2001).

We observed four gravel/silt bar sites within the active floodplain of the Tanana River that showed evidence of localized groundwater upwelling. The sites were downstream of the Goodpaster River and Indian Creek confluences, and midway between the Delta River and Shaw Creek. At three sites, features that seemed to be ordinary scour holes on first impression were found to be deeper, more conical than elongated, and without apparent nearby features that would have induced scour. Many had gravel bottoms, and about half of the holes were more than 1.5m deep. We took water quality measurements from several of the "sand blows" that were at least partially filled with water. These waters were variable in color and quality, presumably due to influx of Tanana River water and whether or not upwelling was actively occurring. The fourth site was a series of smaller conical holes (up to 1m deep) among LWD on a bar. These holes were filled with dark-stained water, and water quality was more different at this site from that of the Tanana River than at the other three sites. Compared to the adjacent Tanana River waters, the water in the features at each of the four sites was cooler, with a higher conductance, lower pH, and lower DO, and had a water surface elevation greater than the adjacent channel. Based on these observations, we conclude that these areas are evidence of active groundwater upwelling.

Besides groundwater, areas of upwelling can be attributed to hyporheic flows, a component of the complex flow of river waters moving into and out of the porous bed sediments (Winter et al. 1999). The braided nature of the Tanana River may enhance this flow, which has thermal and chemical characteristics (including DO) similar to those of the river source because the subsurface residence time is short.

The Tanana River basin also exhibits upwelling flows that appear to be relatively warm in the winter, chemically similar but not identical to that found in the river, and well oxygenated. These flows are valuable resources to fish, potentially providing habitat for egg incubation, rearing, and overwintering, and appear to be selected for as spawning sites by some species of fish (Barton 1992, Garrett et al. 1998). Compared to surface flows, these upwelling flows provide seasonally stable flow and temperature with abundant DO. In places, the flows appear to be sufficient to reduce infiltration of sediments from the water column (such as Bluff Cabin Creek). These upwelling flows, perhaps in concert with hyporheic and groundwater flows, provide the source for the numerous clearwater stream systems on the south side of the Tanana River, including the Delta Clearwater and Richardson Clearwater rivers, and Bluff Cabin, Blue, and Providence creeks.

During this study, upwelling flows of hyporheic and other oxygenated waters were directly observed in Clearwater Lake outlet, the Tanana River mainstem adjacent to the outlet's connecting channel, Bluff Cabin Creek, and Blue Creek. Indirect evidence of upwelling flows (weeping isolated banks, old sand boils, etc.) was observed in the south-bank Tanana River side channels downstream of the Providence Timber Sale area, about seven kilometers downstream of the Richardson Highway bridge.

Substrate

In the study area, the Tanana River is essentially a gravel-bedded river with some cobbles, overlain by a silt cap of varying thickness[3]. Most channel bottoms and lower bank sections are gravel or gravel overlain by silt, while exposed cutbanks tend to be pure silt. Mid-channel bars are gravelly or silty on their surface depending on river stage and velocity

[3] Material size classes follow the USDA (1993) scheme: clay <0.002 mm, silt 0.002-0.05 mm, sand 0.05-2 mm, pebbles 2-75 mm, cobbles 75-250 mm, stones 250-600 mm, boulders ≥600 mm.

during deposition, but all appear to have a gravel base. Floodplain materials have a very nonuniform particle size distribution, with little or no sand, fine pebbles, stones, or boulders.

Substrate type affects the production of fish prey items such as aquatic invertebrates. It also plays a major role in determining the structural features of fish habitat. Except in the immediate vicinity of LWD, silt substrate sites showed little or no evidence of variations in surface structure or irregular water velocities. Mixed gravel and silt sites had some areas of lower velocity and variability as evidenced by differential silt deposition and small-scale scouring. This was due to larger pebbles or cobbles that extended into the water column, providing roughness and disturbing smooth water flow. Sites with mixed substrate often had small pieces of woody debris that also afforded structure, and were occasionally influenced by LWD. Gravel sites had highly variable surfaces with numerous areas of lower velocity, small woody pieces, and LWD.

Because beach seine sites were chosen to sample substrate classes about evenly within glacially-influenced waters rather than proportionally to their presence, these sites do not provide direct information on the distribution of substrates within the project area. Substrate was related to water velocity at time of deposition. Gravel seine sites were usually near the thalweg, in stable, contained side channels, or in locations where water velocities were high enough to prevent settling of silt onto the gravelly stream bed. It was often difficult to find gravelly sites with velocities and depths that allowed for seining. Silt sites were usually found on the lee sides of channel bends, in highly braided areas, or in other locations where low water velocities allowed silt deposition onto the gravel base. Sites with a thin (10 cm or less) but contiguous silt layer over gravel were classified as silt sites because it is unlikely that fish would be able to discriminate between these and areas with a thicker silt layer. Many sites with thicker silt deposits were not consolidated, would not bear a human's weight, and could not be seined. Mixed gravel and silt sites were the most difficult to find and extremely localized, since they required water velocities that allowed silt to remain only in the interstitial spaces between gravel. Localized changes to substrate occur in areas where salmon spawn because redd construction resuspends finer sediments and "cleans" the gravel streambed.

Minnow trap sites were established in all water types without concern for substrate type, and therefore they provide information on substrates present in the low velocity sites that were used for trapping. Presumably, these would be the sites most available to fish, particularly juveniles. A preponderance (82-89%) of glacial and mixed water type sites, and about half of clear and humic sites, had a silt substrate (Figure 7). About two-fifths (37-42%) of clear and humic sites had mixed gravel and silt substrate. Clearwater habitat had almost half (3) of the relatively rare (n = 7) gravel-substrate trap sites sampled over all water types.

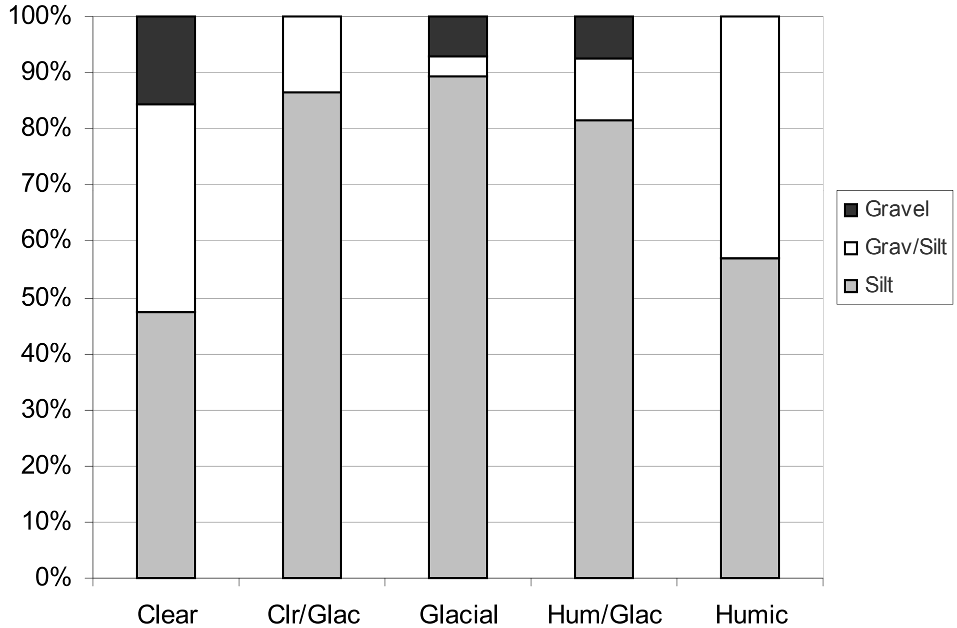

Figure 7. Substrate percent occurrence for all minnow trap sites by water type, Tanana River and tributaries.

Riparian Vegetation

In accordance with The Alaska Vegetation Classification (Viereck et al. 1992), areas with less than two percent vegetative cover were designated Barren. This generally occurred only when the sample site was adjacent to a gravel or silt bar. When differing classifications were evident within 30 m of the site (such as Wet Graminoid Herbaceous for the first 15 m from ordinary high water and Closed Needleleaf Forest from 15 m to 30 m from ordinary high water), both were noted in the field notes, but only the classification that would directly predominate fish habitat at the sample site was included in the summaries.

Vegetation at sites classified Forest was typically open or closed spruce stands. Although white spruce predominated, some stands were mixed white and black spruce while a few were completely black spruce. Most spruce-dominated Forest stands contained at least some balsam poplar or paper birch (quaking aspen was infrequently present), and scattered alder and willow were common mid-story plants. A few Forest stands were hardwoods (balsam poplar and paper birch) or mixed white spruce and hardwoods. Understory vegetation included grasses (reed-grass was common), prickly rose, horsetail, and other herbaceous species on drier sites. Bush cinquefoil, dwarf arctic birch, prickly rose, wild iris, willows, and ericaceous shrubs were common on wetter sites.

Scrub vegetation at sample sites was more often dominated by tall shrubs (balsam poplar, alder, willows) than low shrubs. Balsam poplar, alder, and willows in varying proportions were most common, with white spruce in the lower levels of some tall shrub-dominated Scrub stands. There was often no appreciable understory vegetation in these stands. Sample sites classified Herbaceous were usually low-lying areas dominated by grasses, horsetails, or sedges.

Minnow trap sites were located adjacent to a variety of vegetation types. About three-fifths of the clearwater, mixed clearwater/glacial, glacial, and humic-stained habitat trap sites were next to Forest (Figure 8). There were no Barren areas adjacent to clearwater trap sites, and no Scrub vegetation adjacent to humic trap sites. Seine sites were predominantly Barren silt and/or gravel bars, because of the relatively flat bed and bank structure needed for effective seining, although some were adjacent to Scrub vegetation. A summary table to Level III is presented in Appendix E.

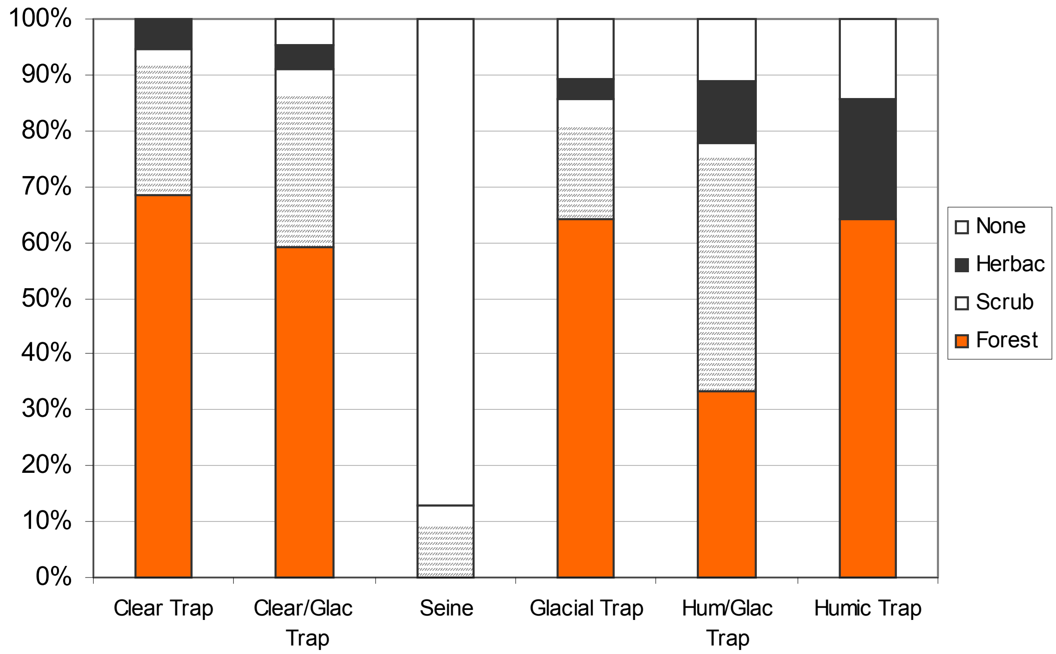

Figure 8. Viereck et al. (1992) Level I vegetation classification for streamside vegetation at baited minnow trap and beach seine sample sites in 1999 and 2000 along the Tanana River and tributaries.

Fish Presence and Habitat Associations

Approximately 1,300 fish were captured, identified to species, and measured. Ten species were identified: chinook, chum, and coho salmon, Arctic grayling, least cisco, round whitefish, lake chub, longnose sucker, burbot, and slimy sculpin.

Minnow Trap Captures

Baited minnow traps set in all habitat water types captured 393 fish of nine species (Table 2). Coho salmon in clearwater habitats were the dominant trap capture, followed by lake chub in mixed humic/glacial waters and slimy sculpin in clearwater habitat. Fish were captured with traps in glacial waters only during the sample periods with lower turbidity, September 1999 and May 2000.

Table 3 presents the frequency of occurrence of fish captures in traps, by species, for each habitat water type. This is consistent with the basic pattern shown in Table 2, except that juvenile chinook salmon join lake chub and slimy sculpin as subdominant catches after coho salmon.

Minnow traps can be used in all water types but are a selective gear type for both species and life stage. Negative data (no captures) for water types that were only trapped (not also sampled with seine) need to be evaluated with caution since they do not necessarily mean absence of fish. For example, during the May 2000 sampling period, no Arctic grayling were captured in minnow traps while 121 Arctic grayling were captured by beach seine hauls in glacial and clear/glacial mixed waters. Lake chub, round whitefish, and Arctic grayling were observed on occasion adjacent to minnow traps when none were captured by the traps.

Stepwise regression analysis was performed for total captures per trap, with unforced variables for water type, substrate type, and vegetation type (p to enter or exit = 0.05). Water type was the only variable to be entered into the model (p = 0.004). Once water type was in the model, substrate and vegetation types did not explain enough additional variation to be added. Although this is most useful as a screening rather than predictive analysis due to the categorical nature of the variables, it affirms the conceptual framework of using water types as a basis for defining habitats.

The most notable finding from minnow trap sampling is the nearly complete lack of captures in silty waters of salmon that rear in the study area. Chinook salmon juveniles were captured primarily in the humic-stained waters of the Goodpaster River, and to a lesser extent upstream in the clear backwaters of Bluff Cabin Creek. Coho salmon were captured primarily in the clearwater habitat of Clearwater Lake outlet. Some coho salmon captures were in other clearwater habitats and in the humic-stained habitats of Shaw Creek and the Goodpaster River. These results agree with previous work in the Tanana River (Mecum 1984, Ott et al. 1998, Hemming and Morris 1999) but are at odds with the minnow trap captures of both species in the glacial Taku, Stikine, and Bradfield (Jordan 1998) rivers in southeast Alaska.

Table 2. Fish capture **numbers** by species by water type for baited minnow **traps** in the Tanana River and tributaries. Cells marked "-" had no captures. Habitat water types: clear = clearwater, clrglac = mixed clearwater and glacial, glacial = glacial water, humglac = mixed humic-stained and glacial, humic = humic-stained runoff. Fish species: RWF = round whitefish, CH = chum salmon, KS = chinook salmon, CO = coho salmon, AG = Arctic grayling, LC = lake chub, LNS = longnose sucker, BB = burbot, CN = slimy sculpin.

Number of Traps	Period Habitat	RWF	CH	KS	CO	AG	LC	LNS	BB	CN	Total
	Aug-99										
6	clear	-	-	2	35	-	-	-	-	2	39
5	clrglac	-	-	-	-	-	-	1	-	-	1
5	glacial	-	-	-	-	-	-	-	-	-	0
5	humglac	-	-	-	-	-	-	2	-	-	2
6	humic	-	-	3	-	-	1	-	-	-	4
	Sep-99										
7	clear	-	-	-	1	-	-	-	1	2	4
5	clrglac	-	-	-	2	-	-	-	-	3	5
7	glacial	-	-	-	-	-	2	-	-	-	2
9	humglac	-	-	-	-	-	1	-	-	-	1
10	humic	1	-	1	-	-	1	1	-	5	9
	May-00										
7	clear	-	-	-	36	-	-	-	-	1	37
4	clrglac	-	-	-	16	-	-	-	-	-	16
8	glacial	-	-	-	6	-	1	-	1	1	9
7	humglac	-	-	-	2	-	15	-	-	-	17
9	humic	-	-	-	3	-	1	-	-	1	5
	Jun-00										
9	clear	-	-	-	5	-	-	-	-	9	14
7	clrglac	-	-	-	-	1	-	-	-	2	3
10	glacial	-	-	-	-	-	-	-	-	-	0
8	humglac	-	1	-	-	1	25	-	1	-	25
9	humic	-	-	1	2	-	-	-	-	1	4
	Jul-00										
9	clear	-	-	-	63	-	-	-	-	50	68
10	clrglac	-	-	-	-	-	-	-	-	1	1
8	glacial	-	-	-	-	-	-	-	-	-	0
9	humglac	-	-	-	-	-	1	-	-	1	2
8	humic	-	-	-	4	-	3	-	-	-	7
	Aug-00										
9	clear	-	-	-	102	-	-	1	-	5	108
8	clrglac	-	-	-	-	-	-	-	-	-	0
8	glacial	-	-	-	-	-	-	-	-	-	0
7	humglac	-	-	-	-	-	-	-	-	-	0
9	humic	-	-	4	1	-	-	-	-	2	7
	Combined										
47	clear	-	-	2	242	-	-	1	1	24	270
39	clrglac	-	-	-	18	1	-	1	-	6	26
46	glacial	-	-	-	6	-	3	-	1	1	11
45	humglac	-	1	-	2	1	42	2	1	1	50
51	humic	1	-	9	10	-	6	1	-	9	36
228	TOTAL	1	1	11	278	2	51	5	3	41	393

Table 3. Fish capture **percent frequency of occurrence** by species by water type for baited minnow **traps** in the Tanana River and tributaries. Cells marked "-" had no captures. Habitat water types: clear = clearwater, clrglac = mixed clearwater and glacial, glacial = glacial water, humglac = mixed humic-stained and glacial, humic = humic-stained runoff. Fish species: RWF = round whitefish, CH = chum salmon, KS = chinook salmon, CO = coho salmon, AG = Arctic grayling, LC = lake chub, LNS = longnose sucker, BB = burbot, CN = slimy sculpin.

Number	Period	Percent of Trap Sets with Fish Captures									
of Traps	Habitat	RWF	CH	KS	CO	AG	LC	LNS	BB	CN	All
	Aug-99										
6	clear	-	-	33	83	-	-	-	-	17	100
5	clrglac	-	-	-	-	-	-	20	-	-	20
5	glacial	-	-	-	-	-	-	-	-	-	0
5	humglac	-	-	-	-	-	-	20	-	-	20
6	humic	-	-	33	-	-	17	-	-	-	33
	Sep-99										
7	clear	-	-	-	14	-	-	-	14	29	43
5	clrglac	-	-	-	20	-	-	-	-	40	40
7	glacial	-	-	-	-	-	14	-	-	-	14
9	humglac	-	-	-	-	-	11	-	-	-	11
10	humic	10	-	10	-	-	10	10	-	20	60
	May-00										
7	clear	-	-	-	57	-	-	-	-	14	57
4	clrglac	-	-	-	50	-	-	-	-	-	50
8	glacial	-	-	-	38	-	13	-	13	13	50
7	humglac	-	-	-	29	-	14	-	-	-	43
9	humic	-	-	-	11	-	11	-	-	11	33
	Jun-00										
9	clear	-	-	-	33	-	-	-	-	44	66
7	clrglac	-	-	-	-	14	-	-	-	29	29
10	glacial	-	-	-	-	-	-	-	-	-	0
8	humglac	-	13	-	-	13	25	-	13	-	50
9	humic	-	-	11	11	-	-	-	-	11	22
	Jul-00										
9	clear	-	-	-	78	-	-	-	-	22	78
10	clrglac	-	-	-	-	-	-	-	-	10	10
8	glacial	-	-	-	-	-	-	-	-	-	0
9	humglac	-	-	-	-	-	11	-	-	11	11
8	humic	-	-	-	25	-	13	-	-	-	38
	Aug-00										
9	clear	-	-	-	78	-	-	11	-	33	89
8	clrglac	-	-	-	-	-	-	-	-	-	0
8	glacial	-	-	-	-	-	-	-	-	-	0
7	humglac	-	-	-	-	-	-	-	-	-	0
9	humic	-	-	22	11	-	-	-	-	22	33
	Combined										
47	clear	-	-	4	57	-	-	2	2	28	72
39	clrglac	-	-	-	8	3	-	3	-	13	21
46	glacial	-	-	-	16	-	9	-	4	4	24
45	humglac	-	2	-	4	2	7	2	2	2	22
51	humic	2	-	12	10	-	8	-	-	12	37
228	TOTAL	>0	>0	4	18	1	4	1	1	11	33

Beach Seine Captures

Beach seine hauls in glacial and mixed clearwater/glacial habitat water types captured 909 fish of nine species (Table 4). Round whitefish, Arctic grayling, lake chub, and longnose suckers were captured each sampling period. The capture of chum salmon in the Tanana River in May and June 2000 reflects the outmigration of fry. Arctic grayling were captured in seine hauls in all sampling periods and were primarily subadults. The large numbers captured in May 2000 may reflect movements to summer rearing and feeding waters from overwintering and spawning sites. Table 5 presents the information of Table 4 as percent frequency of occurrence of fish captures in seine hauls.

Seines are a nonselective gear type, but are most effective in waters where fish are not visually disturbed by the net or personnel during use. Capture rates can also be lowered by water body substrate characteristics (cobbles, sticks, slope breaks, etc.) that allow fish to escape under the net during seining.

Table 4. Fish capture **numbers** by species by water type for beach **seine** hauls in the Tanana River and tributaries. Cells marked "-" had no captures. Habitat water types: clrglac = mixed clearwater and glacial, glacial = glacial water; no hauls were made in clearwater, mixed humic-stained and glacial, or humic-stained runoff water types. Fish species: LCI = least cisco, RWF = round whitefish, CH = chum salmon, CO = coho salmon, AG = Arctic grayling, LC = lake chub, LNS = longnose sucker, BB = burbot, CN = slimy sculpin, Unk = escaped prior to identification.

Number of Sites	Period Habitat	LCI	RWF	CH	CO	AG	LC	LNS	BB	CN	Unk	Total
	Aug-99											
1	clrglac	-	-	-	-	-	-	4	5	-	-	9
8	glacial	-	11	-	-	3	52	16	-	15	-	97
	Sep-99											
14	glacial	-	57	-	-	18	9	37	-	3	-	124
	May-00											
1	clrglac	-	4	74	8	12	-	1	-	2	-	101
14	glacial	1	39	98	70	109	19	42	-	10	1	389
	Jun-00											
16	glacial	-	14	14	-	9	20	28	1	8	-	94
	Jul-00											
15	glacial	-	2	-	-	14	10	13	-	1	1	41
	Aug-00											
16	glacial	-	4	-	-	6	30	12	2	-	-	54
	Combined											
2	clrglac	-	4	74	8	12	4	6	-	2	-	110
83	glacial	1	127	112	70	159	140	148	3	37	2	799
85	TOTAL	1	131	186	78	171	144	154	3	39	2	909

Table 5. Fish capture **frequency of occurrence** by species by water type for beach **seine** hauls in the Tanana River and tributaries. Cells marked "-" had no captures. Habitat water types: clrglac = mixed clearwater and glacial, glacial = glacial water; no hauls were made in clearwater, mixed humic-stained and glacial, or humic-stained runoff water types. Fish species: LCI = least cisco, RWF = round whitefish, CH = chum salmon, CO = coho salmon, AG = Arctic grayling, LC = lake chub, LNS = longnose sucker, BB = burbot, CN = slimy sculpin, Unk = escaped prior to identification.

Number of Sites	Period Habitat	LCI	RWF	CH	CO	AG	LC	LNS	BB	CN	Unk	Total
	Aug-99											
1	clrglac	-	-	-	-	-	-	1	1	-	-	1
8	glacial	-	5	-	-	3	1	4	-	5	-	7
	Sep-99											
14	glacial	-	8	-	-	10	5	8	-	3	-	11
	May-00											
1	clrglac	-	1	1	1	1	-	1	-	1	-	1
14	glacial	1	7	10	13	6	2	7	-	3	1	14
	Jun-00											
16	glacial	-	4	9	-	1	6	7	1	5	-	15
	Jul-00											
15	glacial	-	2	-	-	4	4	3	-	1	1	9
	Aug-00											
16	glacial	-	4	-	-	3	9	5	2	-	-	12
	Combined											
2	clrglac	-	1	1	1	1	-	2	1	1	-	2
83	glacial	1	30	19	13	27	27	34	3	17	2	68
85	TOTAL	1	31	20	14	28	27	36	4	18	2	70

Species Accounts

The following paragraphs present observed habitat associations for anadromous species that do (coho salmon) and do not (chum salmon) rear in fresh water, and high value resident species that are (round whitefish) and are not (Arctic grayling) typically associated with rearing in silt-laden waters. For general information on life history, distribution, and taxonomy, the reader is referred to McPhail and Lindsey (1970), Morrow (1980), and ADF&G (various).

Coho salmon: Based on minnow trap data, rearing coho salmon are most abundant in clearwater habitats, with some use of humic-stained habitats and limited use of the mixes of these with glacial waters when the glacial water turbidity is relatively low (Figure 9). Juvenile coho salmon were captured in clearwater habitat with minnow traps during all sample periods. A few coho salmon were captured at humic sites in each sample period in 2000, and in all habitat types in May 2000. Seine data indicate a wider distribution. Fourteen of 15 beach seine hauls in the May 2000 period captured a total of 77 coho salmon juveniles (13 glacial and 1 clear/glacial water types). This was the only period in which coho salmon were captured with seines, and appears to represent the time of maximum habitat use by juvenile coho salmon.

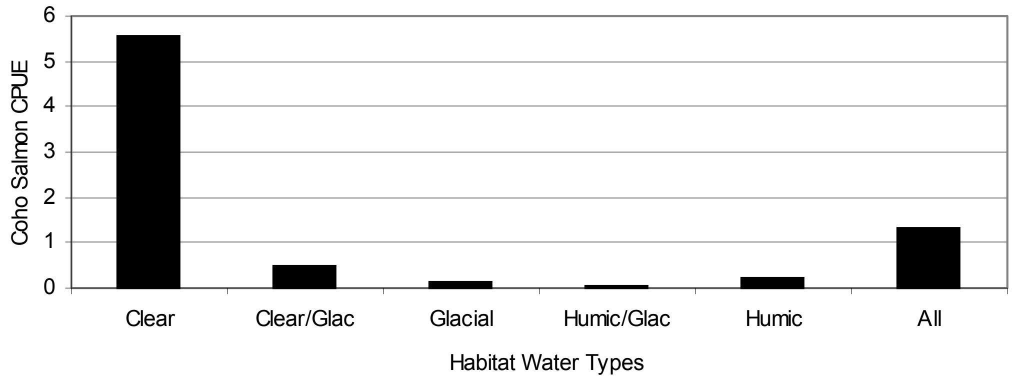

Figure 9. Coho salmon captures per unit effort (24-hr baited minnow trap set) for five water types in the Tanana River and tributaries in 1999 and 2000.

Length frequency plots (Figure 10) suggest that the coho salmon captured in August and September 1999 were mostly age 0 that were also captured as age-1 fish in May 2000. In June 2000, captures shifted to predominantly age-0 fish that had recently emerged. The age-1 cohort previously captured largely disappeared from the samples in and after June 2000, presumably because they moved to other rearing areas or smolted. Seines captured coho salmon only in May 2000. These fish had a very similar, but slightly larger, size distribution compared to coho salmon captured with minnow traps the same period. This information, combined with the May 2000 capture of coho salmon by minnow traps in all water types including glacial suggests that a major movement of juvenile coho salmon was underway, likely smolting.

Chum salmon: Chum salmon fry were captured in beach seine hauls in May 2000 and, in lesser numbers, June 2000. Seine hauls in both glacial and clear/glacial water types captured chum salmon, and one chum salmon fry was captured in a trap in clear/glacial water. No evidence was seen of chum salmon use of humic habitats. The small size of the chum salmon fry captured (Figure 11) means that their swimming power likely has minimal effect on where they are transported by the relatively strong current in glacial and mixed water types, and allows them to typically swim through the mesh of minnow traps. The generally smaller size and more immature body form of the chum salmon fry captured in June compared to those captured in May suggest that the fry captured in June were closer to their natal redds than those captured in May. We have no information on whether the captured fry were from summer or fall chum salmon stocks. In September 1999, adult (fall) chum salmon were seen in glacial and clear/glacial mixed habitats between Clearwater Lake outlet and Bluff Cabin Ridge, and in clearwater habitat in the lower portion of Bluff Cabin Creek.

Round whitefish: Beach seine data showed widespread use by round whitefish of glacial water types in all sample periods, although captures were lower with increased turbidity (Figure 12). Since turbidity has a distinct seasonal component, information taken more frequently on catch and turbidity (such as weekly rather than monthly samples as for this project) would be needed to separate the interaction effects of season and turbidity. Substrate type did not appear to be a factor in captures. One round whitefish was captured in a minnow trap in humic waters (Indian Creek). Adult round whitefish were observed in the Goodpaster River (humic) and in Clearwater Lake outlet (clear).

Arctic grayling: Beach seines captured Arctic grayling in glacial waters in all sample periods, and in clear/glacial mixed waters in May 2000. The two Arctic grayling captured by minnow traps were in mixed water types (one each in clear/glacial and humic/glacial) in June 2000. Most of the Arctic grayling captured were subadults (≤220 mm, Figure 13). Adult Arctic grayling were observed in the Goodpaster River (humic), and in Providence Creek (clearwater) upstream of where our traps were set. Arctic grayling did not appear to exhibit a consistent decreased presence in glacial waters when turbidity increased as did round whitefish, but rather appear to be present in all seasons with higher use in some months. Nine Arctic grayling (lengths 86-304 mm) and six round whitefish (lengths 82-216 mm) were captured in a single seine haul on 19 June 2000 in glacial waters (848 NTU) on the north bank of a Tanana River side channel immediately across from the mouth of Providence Creek. It is suspected that these subadult and adult fish were feeding in the clearwater-glacial interface, and using the glacial water for cover. Arctic grayling were captured at this site in July and August 2000 as well, suggesting that it provides an important habitat type that is quite limited in extent.

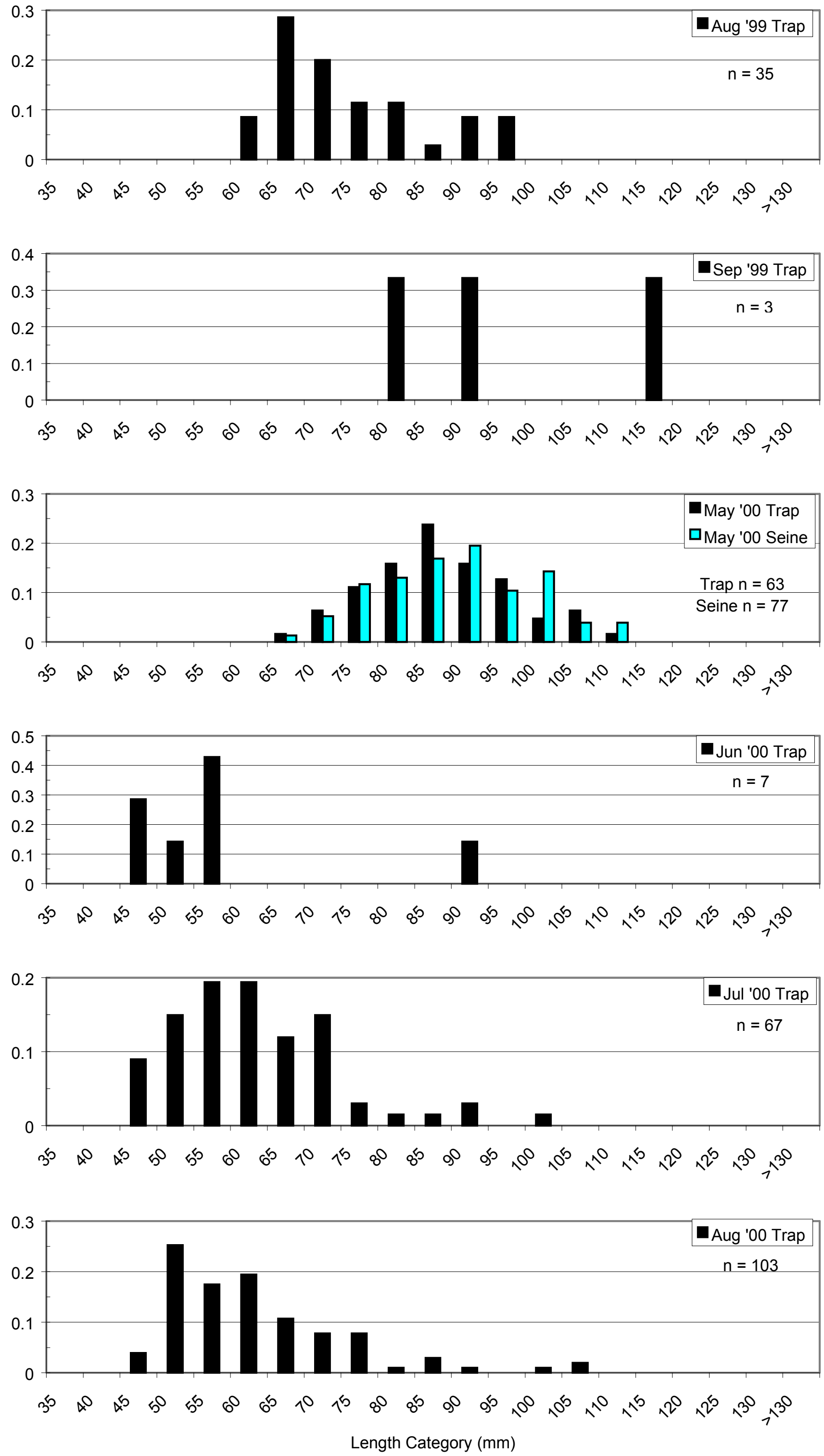

Figure 10. Length frequencies (proportion of catch) for coho salmon captured with baited minnow traps and beach seines, by sampling period, in 1999 and 2000 in the Tanana River and tributaries.

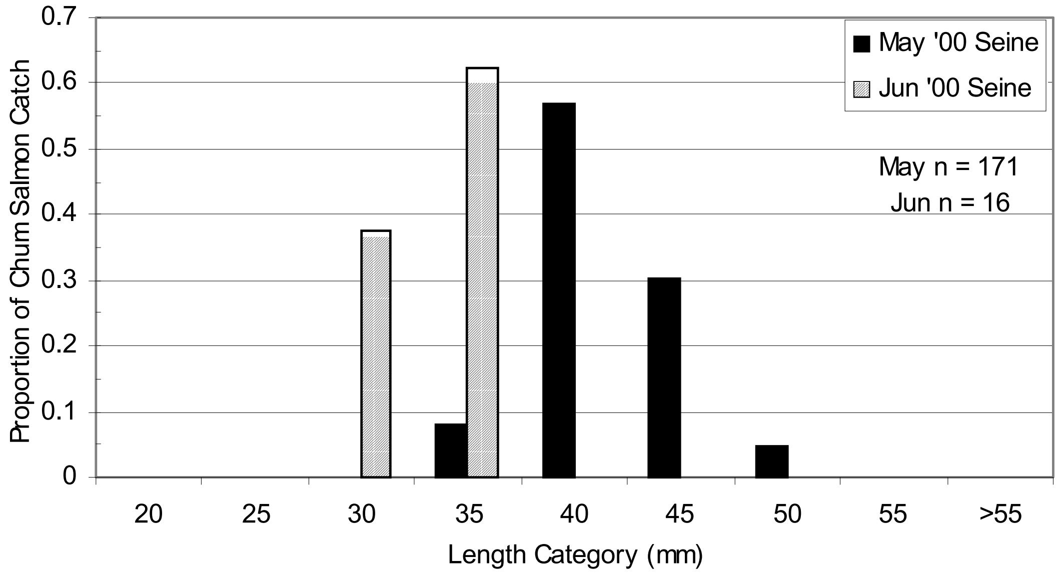

Figure 11. Length frequency of chum salmon captured in the Tanana River, 1999 and 2000.

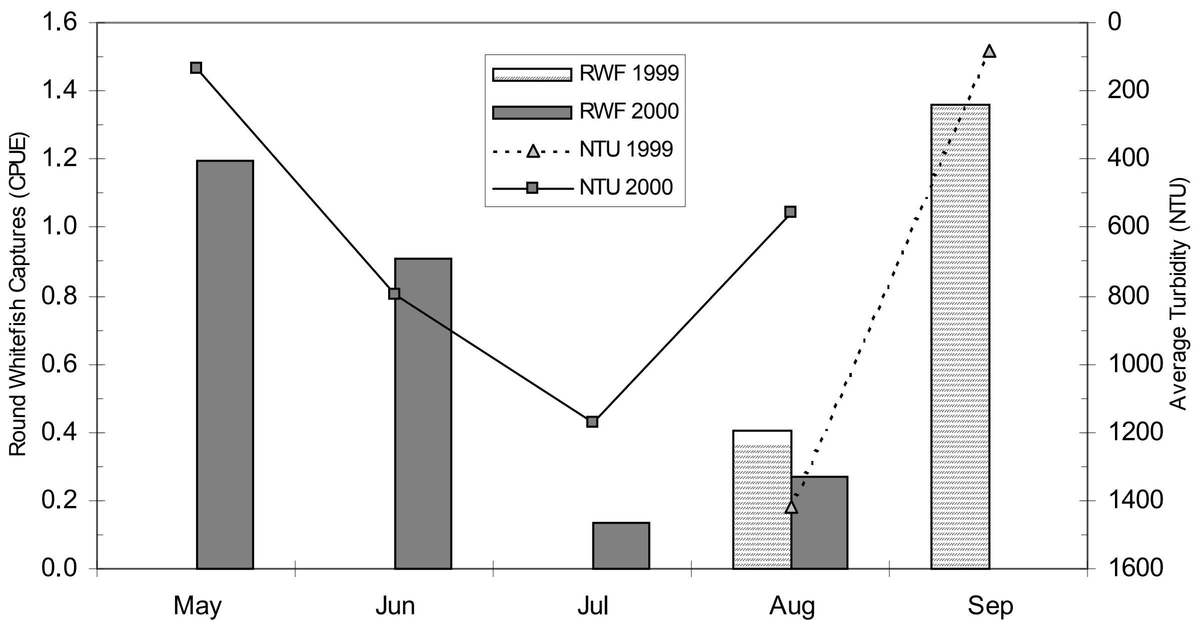

Figure 12. Beach seine catch per unit effort for round whitefish in the Tanana River compared to average turbidity at seine sites. Note that turbidity scale is reversed.

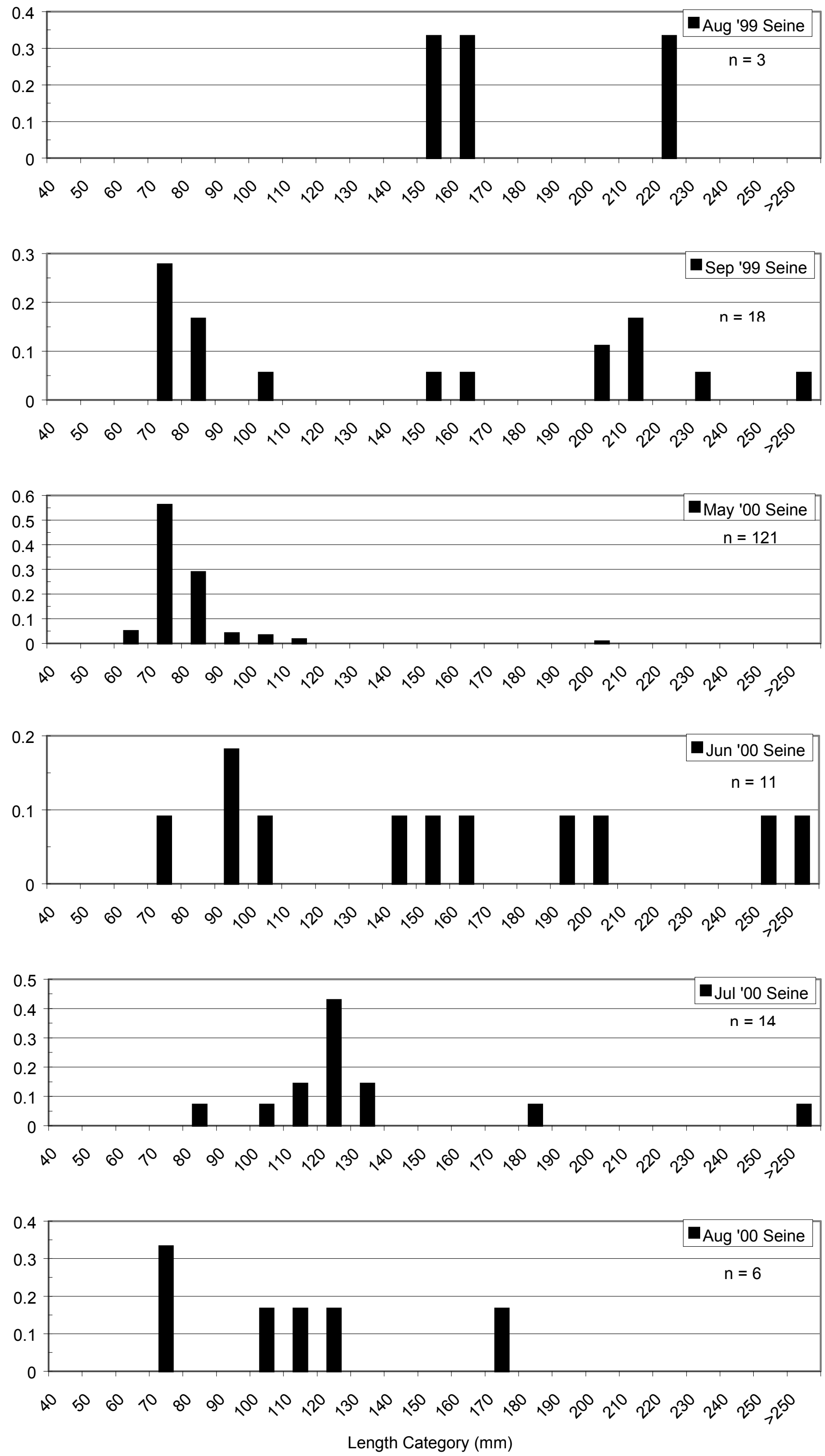

Figure 13. Length frequencies (proportion of catch) for Arctic grayling captured with beach seines, by sampling period, in 1999 and 2000 in the Tanana River.

Food Habits

Twelve fish (chinook, chum, and coho salmon) were collected and preserved by freezing, primarily for laboratory confirmation of field species identification. The stomachs of these fish were also examined to give some idea of prey items and evidence of feeding. Appendix F presents the complete results of the laboratory examination. Larval, emerging, and adult (black?) flies were the most common food items, followed by midge, stonefly, and mayfly larvae.

Habitat Sensitivity and Forest Practices

Between March 1999 and July 2000, STC members worked to develop a number of consensus points that met their charge from the Board of Forestry. A matrix of the ten FRPA components of fish habitat, and anticipated effects on those components from forest practices (Appendix G), was initially developed from expert knowledge, and then modified after the literature review. An annotated bibliography with section synopses was prepared (Freeman 2000). Sections in the bibliography on buffer function and design, LWD, winter fish use of glacial streams, and fish use of upwelling areas are incorporated into this report by reference. Other literature reviews relevant to the project area include Mecum (1984) and Ott et al. (1998) for fish use of glacial waters, Scannell (1988) and Lloyd (1985) for effects of turbidity on fish, and Magoun and Dean (2000) for an extensive review of floodplain forests along the Tanana River from a terrestrial perspective.

The Board of Forestry reviewed and concurred with the STC's recommendations. A Region III Implementation Group (IG) of stakeholders was formed to develop feasible riparian management standards that reflected the consensus points developed by the STC. The IG also operated by consensus, and consisted of representatives from the state resource agencies, private land owners, the timber and fishing industries, and citizen and environmental groups. The IG condensed the stream classification system from five types of water bodies containing anadromous or high value resident fish to three, and provided riparian standards for each. These consensus products are also incorporated into this report by reference. Appendix G contains a summary of the IG's recommendations. The Board of Forestry reviewed and concurred with the IG's recommendations, which were the bases for draft legislation currently before the Alaska Legislature for adoption. The entire STC and IG process was open to the public, and is documented in DNR (2001).

DISCUSSION

Fish captures with both minnow traps and beach seines show that many species of fish use the Tanana River during the openwater period when it is turbid. Some of this use is as a travel corridor, but fish presence was so widespread in both time and place that fish are likely rearing in these turbid waters as well. Stomachs of chum salmon fry captured in the Tanana River, including those fish that had just emerged, all contained food items apparently eaten in the very turbid waters because no fry were observed or captured in other water types. The widespread seine capture of Arctic grayling subadults (frequently but not always in the southern half of the active floodplain) also supports use of the Tanana River for rearing.

These fish species are sight feeders, so must be using other faculties to find prey items given the documented ability of turbidity to interfere with sight feeding (Scannell 1988). A more thorough examination of food habits would add much to our understanding of the fish resources in the study area.

Fish densities (numbers per given area) tended to be relatively low in turbid waters. However, the large area encompassed by the braided channel system of its active floodplain means that the abundance and biomass of fish present in the Tanana River during the openwater period are likely great. When taken together with the documented and suspected winter use of the Tanana River, the resulting picture is one of a diverse, productive aquatic system that functions out of sight of most human users.

Many "habitats" could not be sampled safely with the gear and access methods used in this study due to high velocities along cut banks; shallow water or indefinite channel bottoms (such as near mid-channel rootwads); unsuitable or unstable material (unconsolidated silts that either entrap workers, form debilitating rolls in seine hauls, or both); presence of underwater trees or brush; or small size. The size constraint relates to the patchiness of the complex system of water, vegetation, and substrate types found in the Tanana River active floodplain. The result is that small "flatwater" areas off the glacial mainstem, which may be highly productive especially for species such as lake chub and longnose suckers, were generally not sampled as part of this project. These areas and wetland complexes accessible to fish at high water levels may also be important as refugia during high water events. ADF&G staff have captured large burbot in the past with fyke nets set in side channels that are dry most of the year (M. R. Doxey, Alaska Department of Fish and Game Sport Fish Division, personal communication).

Fish species and life stages occupying the turbid summer waters of glacial rivers would seem less likely to be as sensitive to low-intensity nonpoint-source runoff from timber-harvest and road construction activities than are life stages strongly tied to clearwater and humic habitats in side channels, drainages, or wetlands. Those less sensitive fish could be sensitive during the winter clearwater period in the same channels.

The STC literature review (Freeman 2000), strongly suggests that LWD recruitment and retention plays both direct and indirect(but crucial) roles in large glacial rivers. The direct effects of LWD are bank armoring, velocity and water depth modification, and as a substrate for aquatic invertebrates. Indirect effects include modification of channel morphology (including occlusion of side channels) and bedload movement, and retention of the whole host of sediments moving downstream in an active channel. Wood is important at the site of introduction in the short-term, but most long-term effects occur at locations downstream. Log jams and other masses of wood (grounded or submerged) can almost serve as temporary bedrock for resisting a large river if securely anchored or interlaced. Land management and use activities that have the potential to affect LWD recruitment and retention rates have to be carefully considered.

Forest practices available for prevention of nonpoint-source pollution include buffer zones, restrictions on harvest season, procedures to reduce surface disturbance and bank instability associated with timber harvest and road construction, and care in siting and constructing winter road and ice bridges. These and other practices can be viewed as a tool bag to assist with prevention of nonpoint source pollution.

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APPENDIX A. COMMON AND SCIENTIFIC NAMES

Common and scientific names of plants, insects, and fish mentioned in the text.

PLANTS	
white spruce	*Picea glauca*
black spruce	*Picea mariana*
balsam poplar	*Populus balsamifera*
quaking aspen	*Populus tremuloides*
paper birch	*Betula papyrifera*
dwarf arctic birch	*Betula nana*
alder	*Alnus* spp.
willow	*Salix* spp.
bush cinquefoil	*Potentilla fruticosa*
prickly rose	*Rosa acicularis*
wild iris	*Iris setosa*
reed-grass	*Calamagrostis* spp.
sedge	*Carex* spp.
horsetail	*Equisetum* spp.
INSECTS	
mayflies	Ephemeroptera
stoneflies	Plecoptera
flies	Diptera
midges	Chironomidae
black flies	Simuliidae
FISH	
Arctic lamprey	*Lampetra japonica*
least cisco	*Coregonus sardinella*
broad whitefish	*Coregonus nasus*
humpback whitefish	*Coregonus pidschian*
round whitefish	*Prosopium cylindraceum*
inconnu (sheefish)	*Stenodus leucichthys*
chinook (king) salmon	*Oncorhynchus tshawytscha*
chum (dog) salmon	*Oncorhynchus keta*
coho (silver) salmon	*Oncorhynchus kisutch*
Arctic grayling	*Thymallus arcticus*
northern pike	*Esox lucius*
lake chub	*Couesius plumbeus*
longnose sucker	*Catostomus catostomus*
burbot	*Lota lota*
slimy sculpin	*Cottus cognatus*

APPENDIX B. GEOGRAPHIC POSITIONS OF SITES

Geographic position of sample and other sites. Map datum is North American 1927 - Alaska (NAD27). Includes minnow trap, beach seine, and other study locations, as well as sample sites used by Hemming and Morris (1999).

Name	Latitude	Longitude
Minnow Trap Sites		
Used by Hemming and Morris (1999)		
B97-01	64.1654	-145.8099
B97-02	64.1690	-145.7857
B97-03	64.1817	-145.6430
B97-04	64.1712	-145.6253
B97-05	64.1493	-145.6427
B97-06	64.1167	-145.6026
B97-07	64.1070	-145.5993
B97-08	64.1896	-145.9592
B97-09	64.2122	-146.0592
B97-10	64.2588	-146.1133
B97-11	64.2615	-146.1067
B97-12	64.2374	-146.2724
B97-13	64.2487	-146.2858
B97-14	64.1885	-145.6797
B97-15	64.2538	-146.1933
This project		
T99-01	64.1033	-145.5947
T99-02	64.1062	-145.6021
T99-03	64.1082	-145.6048
T99-04	64.1264	-145.6176
T99-05	64.1265	-145.6183
T99-06	64.1473	-145.6435
T99-07	64.1498	-145.6426
T99-08	64.1679	-145.8076
T99-09	64.1701	-145.7769
T99-10	64.1689	-145.7848
T99-11	64.1691	-145.7848
T99-12	64.1876	-145.6788
T99-13	64.1889	-145.6802
T99-14	64.1792	-145.5819
T99-15	64.1746	-145.5720
T99-16	64.1803	-145.5594
T99-16A	64.1797	-145.5594
T99-17	64.1826	-145.5647
T99-18	64.1577	-145.8433
T99-19	64.1821	-145.5904
T99-20	64.1821	-145.5929
T99-21	64.1832	-145.5922
T99-22	64.1838	-145.5924
T99-23	64.1454	-145.6472
T99-24	64.1453	-145.6577
T99-25	64.1118	-145.6062
T99-26	64.1108	-145.6057
T99-27	64.1129	-145.6066
T99-28	64.1499	-145.6399
T99-29	64.1721	-145.6272
T99-30	64.1732	-145.6280
T99-31	64.1742	-145.6288
T99-32	64.1877	-145.6791
T99-33	64.1879	-145.6791
T99-34	64.1870	-145.6902
T99-35	64.1669	-145.8003
T99-36	64.2600	-146.1082
T99-37	64.2617	-146.1063
T99-38	64.2629	-146.1077
T99-39	64.2634	-146.1043
T99-40	64.2595	-146.1099
T99-41	64.2591	-146.1125
T99-42	64.2590	-146.1138
T99-43	64.2582	-146.1164
T99-44	64.2584	-146.1196
T99-45	64.2322	-146.2596
T99-46	64.2338	-146.2594
T99-47	64.2369	-146.2727
T99-48	64.2487	-146.2851
T99-49	64.2403	-146.2019
T99-50	64.2403	-146.2010
T99-51	64.2404	-146.2006
T00-01	64.1055	-145.6021
T00-02	64.1029	-145.5941
T00-03	64.1031	-145.5947
T00-04	64.1201	-145.6065
T00-05	64.1284	-145.6155
T00-06	64.1210	-145.6082
T00-07	64.1232	-145.6126
T00-08	64.1329	-145.6179
T00-09	64.1491	-145.6326
T00-10	64.2589	-146.1130

Name	Latitude	Longitude
T00-11	64.2586	-146.1165
T00-12	64.2583	-146.1189
T00-13	64.2581	-146.1206
T00-14	64.2523	-146.1953
T00-15	64.2396	-146.2005
T00-16	64.2424	-146.2769
T00-17	64.1472	-145.6425
T00-18	64.1480	-145.6424
T00-19	64.1452	-145.6425
T00-20	64.1556	-145.6506
T00-21	64.2120	-146.0588
T00-22	64.2115	-146.0594
T00-23	64.2127	-146.0589
T00-24	64.2133	-146.0585
T00-25	64.2388	-146.2790
T00-26	64.2422	-146.2772
T00-27	64.2543	-146.1942

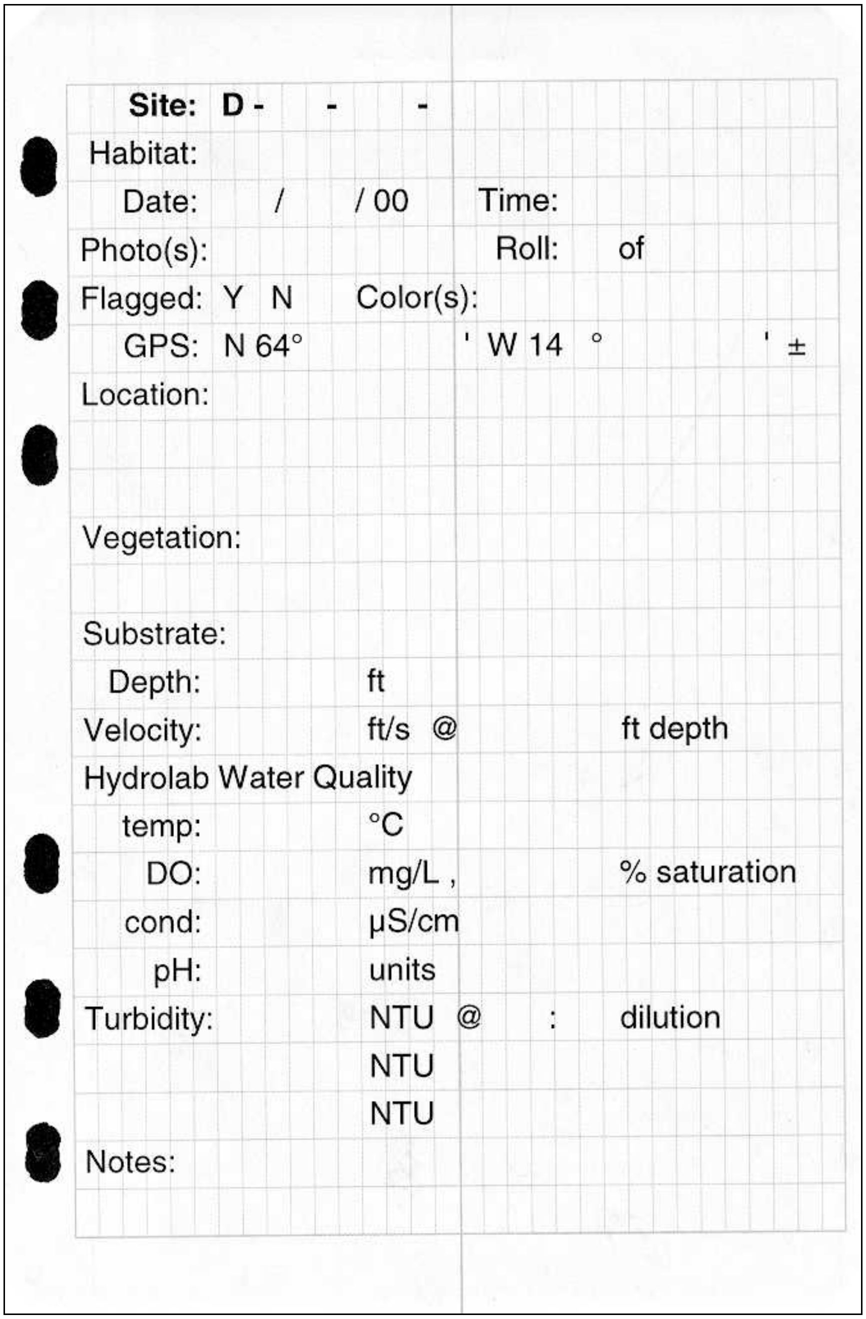
Name	Latitude	Longitude
T00-28	64.2548	-146.1916
T00-29	64.1294	-145.6160
T00-30	64.1454	-145.6601
T00-31	64.1832	-145.5961
T00-32	64.2539	-146.1936
T00-33	64.2538	-146.1936
T00-34	64.2537	-146.1940
T00-35	64.2335	-146.2594
T00-36	64.2414	-146.1995
T00-37	64.1147	-145.6087
T00-38	64.1164	-145.6103
T00-39	64.1072	-145.6004
T00-40	64.2534	-146.1937
T00-41	64.2536	-146.1932
T00-42	64.2522	-146.1962
T00-43	64.2591	-146.1096
T00-44	64.2597	-146.1095

Name	Latitude	Longitude
Beach Seine Sites		
Used by Hemming and Morris (1999)		
S97-01	64.1070	-145.5993
S97-02	64.1485	-145.6349
S97-03	64.1785	-145.6365
S97-04	64.1871	-145.6812
S97-05	64.1634	-145.8186
S97-06	64.1708	-145.8915
S97-07	64.1918	-145.9649
S97-08	64.2588	-146.1085
S97-09	64.2435	-146.2615
S97-10	64.2484	-146.2850
S97-11	64.1756	-145.6187
This project		
S99-01	64.1867	-145.7478
S99-02	64.1864	-145.7477
S99-04	64.1874	-145.6743
S99-05	64.1700	-145.8913
S99-06	64.1570	-145.8730
S99-07	64.1560	-145.6490
S99-08	64.1547	-145.6499
S99-09	64.1662	-145.6329
S99-10	64.1870	-145.6922
S99-11	64.1891	-145.6997
S99-12	64.1774	-145.7624
S99-13	64.1794	-145.7506
S99-14	64.1702	-145.8916
S99-15	64.1702	-145.8911
S99-16	64.1571	-145.8734
S99-17	64.2379	-146.2031
S99-18	64.2373	-146.2049
S99-19	64.2570	-146.1305
S99-20	64.1888	-145.9005
S99-21	64.1766	-145.8951
S00-22	64.2197	-146.0307
S00-23	64.2126	-146.0023
S00-24	64.2058	-145.9639
S00-25	64.2593	-146.1083
S00-26	64.2402	-146.0715
S00-27	64.2413	-146.0723

Name	Latitude	Longitude
S00-28	64.2409	-146.0733
S00-29	64.2449	-146.0965
S00-30	64.2453	-146.0942
S00-31	64.2442	-146.1015
S00-32	64.2439	-146.1005
S00-33	64.1892	-145.7398
S00-34	64.1896	-145.7363
S00-35	64.1872	-145.9607
S00-36	64.1897	-145.9570
S00-37	64.2042	-145.9595
S00-38	64.2042	-145.9601
S00-39	64.2124	-146.0577
S00-40	64.2128	-146.0579
S00-41	64.2397	-146.1008
S00-42	64.2444	-146.2569
S00-43	64.1869	-145.6728
S00-44	64.1837	-145.9321
S00-45	64.1949	-145.9523
S00-46	64.2539	-146.2900
S00-47	64.2531	-146.2894
S00-48	64.2499	-146.2745
S00-49	64.2450	-146.2608
S00-50	64.2362	-146.2462
S00-51	64.2562	-146.1381
S00-52	64.2557	-146.1386
S00-53	64.2280	-146.0813
S00-54	64.1485	-145.6389
S00-55	64.1785	-145.6349
S00-56	64.1790	-145.6348
S00-57	64.1868	-145.6801
S00-58	64.1866	-145.6721
S00-59	64.2035	-145.9591
S00-60	64.2561	-146.1343
S00-61	64.2125	-146.0579
Upwelling Features		
Craters1	64.2408	-146.0718
Craters2	64.1894	-145.7387
Craters3	64.1705	-145.6298
Teaholes	64.1778	-145.6336

APPENDIX C. SAMPLE DATA FORM

Forms used in the field were printed on loose-leaf Rite in the Rain® paper. The reverse side was used to record fish captures and lengths, sketch maps, and ancillary field observations.



Site: D - - -
Habitat:
Date: / / 00 Time:
Photo(s): Roll: of
Flagged: Y N Color(s):
GPS: N 64° ' W 14 ° ' ±
Location:

Vegetation:

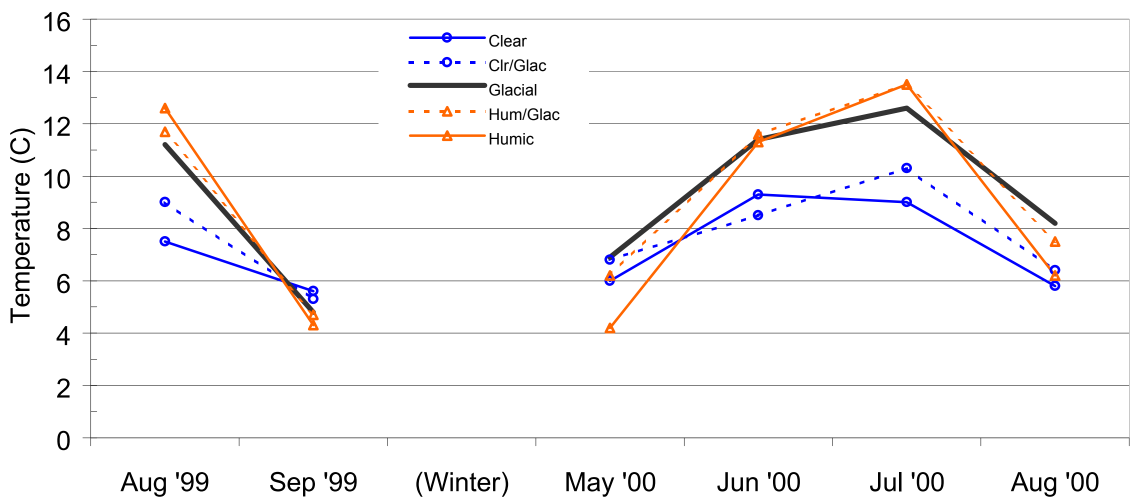
Substrate:
Depth: ft
Velocity: ft/s @ ft depth
Hydrolab Water Quality
temp: °C
DO: mg/L , % saturation
cond: µS/cm
pH: units
Turbidity: NTU @ : dilution
NTU
NTU
Notes:

APPENDIX D. WATER QUALITY DATA SUMMARIES

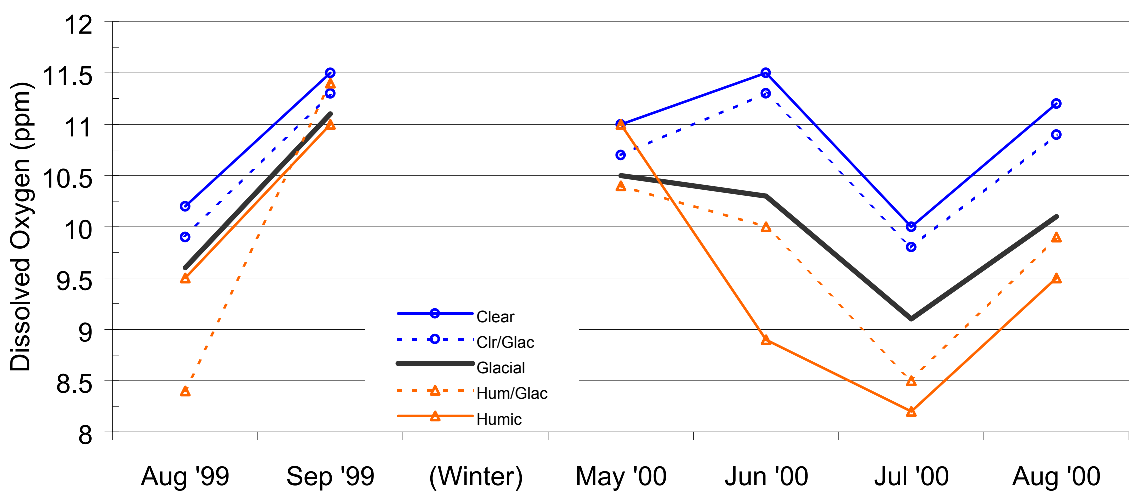
Table presents mean (and range) of measured characteristic values for sample sites on the Tanana River and adjacent tributaries, by sampling period and water type. Overall analysis of variance F-test values for treatment (water type) effects for each characteristic by period are given in same rows as period date. Rejection of H_0 – All of the means are equal: -- = p > 0.10, * = 0.10 ≤ p > 0.05, ** = p ≤ 0.05, *** = p ≤ 0.01. Figures following that table are based on mean values.

Water Type (n)	Velocity (m/s)	Temp (ºC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% sat)	Conduct (μS/cm)	pH (units)	Turbidity (NTU)
Aug 1999	***	***	*	--	**	***	***
clear	0.07	7.5	10.2	87	251	8.0	2.65
(6)	(0.00-0.29)	(4.6-9.9)	(9.6-11.1)	(76-96)	(236-266)	(7.9-8.3)	(0.58-10.57)
clear/glac	0.29	9.0	9.9	88	396	8.0	28.5
(6)	(0.00-1.17)	(8.1-12.0)	(7.4-11.0)	(70-95)	(242-1094)	(7.9-8.2)	(11.1-56.4)
glacial	0.91	11.2	9.6	89	219	8.2	1417
(13)	(0.00-2.11)	(8.8-20.3)	(7.6-11.1)	(83-98)	(193-320)	(8.2-8.5)	(330-1966)
hum/glac	0.13	11.7	8.4	79	128	7.6	155
(5)	(0.00-0.67)	(10.9-14.5)	(6.5-9.0)	(65-83)	(110-154)	(7.3-8.0)	(11-557)
humic	0.34	12.6	9.5	91	127	7.5	3.34
(6)	(0.00-0.83)	(12.1-14.1)	(7.1-10.4)	(70-99)	(101-220)	(6.9-8.3)	(1.94-5.16)
Sep 1999	*	--	--	--	***	***	***
clear	0.17	5.6	11.5	93	256	8.0	7.43
(7)	(0.00-0.49)	(3.2-10.6)	(10.1-12.7)	(87-100)	(236-262)	(7.7-8.3)	(2.32-15.53)
clear/glac	0.20	5.3	11.3	91	260	8.0	34.9
(5)	(0.09-0.40)	(3.9-7.3)	(10.9-11.6)	(90-93)	(246-272)	(7.9-8.2)	(14.9-71.6)
glacial	0.30	4.8	11.1	89	273	8.0	82.8
(21)	(0.00-0.65)	(3.6-7.1)	(10.3-12.2)	(82-96)	(254-282)	(7.9-8.2)	(56.9-121.3)
hum/glac	0.15	4.7	11.4	91	226	7.8	53.8
(9)	(0.00-0.35)	(3.9-5.9)	(9.9-11.9)	(80-98)	(164-263)	(7.8-7.9)	(29.3-80.8)
humic	0.17	4.3	11.0	88	137	7.4	4.21
(10)	(0.00-0.42)	(3.1-5.7)	(9.0-11.7)	(73-95)	(117-166)	(7.1-7.6)	(1.17-11.97)
May 2000	--	**	*	--	***	***	***
clear	0.24	6.0	11.0	91	268	8.1	1.45
(7)	(0.08-0.46)	(3.9-7.0)	(10.3-11.7)	(84-97)	(261-270)	(8.0-8.2)	(0.69-2.54)
clear/glac	0.14	6.8	10.7	90	255	8.1	46.2
(5)	(0.00-0.23)	(6.2-7.4)	(10.4-11.3)	(87-94)	(208-270)	(7.9-8.2)	(23.5-97.7)
glacial	0.26	6.9	10.5	88	216	7.9	133
(22)	(0.00-0.81)	(4.5-9.1)	(9.1-11.8)	(80-94)	(178-261)	(7.6-8.2)	(58.8-246)
hum/glac	0.11	6.2	10.4	86	149	7.6	80.7
(7)	(0.00-0.20)	(4.5-8.0)	(9.9-10.7)	(84-90)	(131-172)	(7.5-7.7)	(54.1-109)
humic	0.18	4.2	11.0	86	104	7.2	30.1
(9)	(0.00-0.37)	(0.3-7.7)	(10.3-11.6)	(76-97)	(71-183)	(6.9-7.6)	(3.41-80.1)

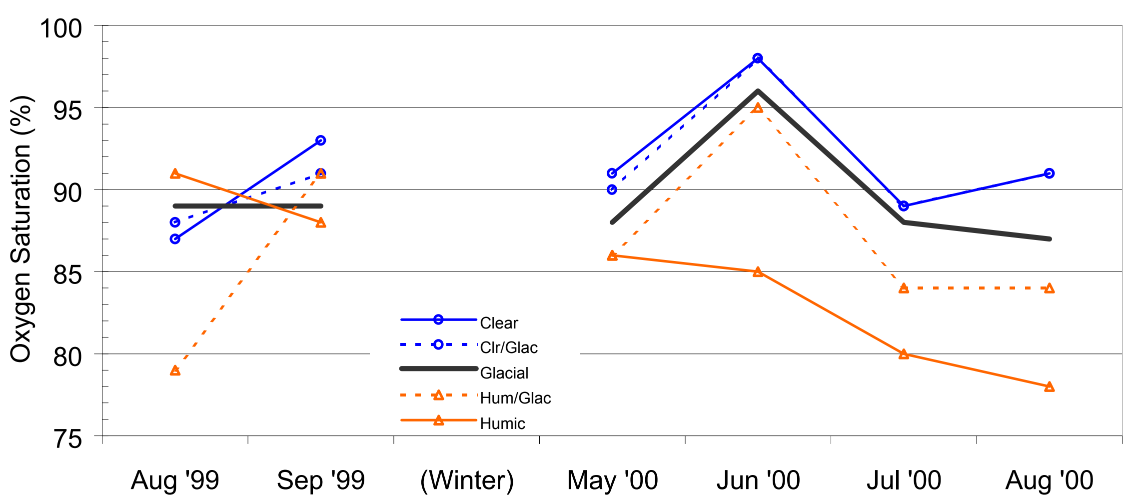
Water Type (n)	Velocity (m/s)	Temp (ºC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% sat)	Conduct (μS/cm)	pH (units)	Turbidity (NTU)
Jun 2000	***	***	***	***	--	***	***
clear	0.03	9.3	11.5†	98†	257†	8.2†	2.02
(9/5†)	(0.00-0.18)	(5.0-13.0)	(11.3-11.7)	(92-104)	(237-266)	(8.0-8.4)	(0.36-4.74)
clear/glac	0.12	8.5	11.3†	98†	244†	8.1†	223
(7/4†)	(0.00-0.25)	(5.6-10.0)	(10.7-11.8)	(96-101)	(223-257)	(8.0-8.2)	(60.9-547)
glacial	0.31	11.4	10.3†	96†	221†	8.1†	795
(26/21†)	(0.00-0.70)	(9.8-13.1)	(9.8-11.0)	(93-102)	(203-244)	(8.0-8.1)	(519-985)
hum/glac	0.05	11.6	10.0†	95†	226†	7.9†	226
(8/7†)	(0.00-0.20)	(10.1-15.4)	(9.6-10.5)	(92-101)	(116-432)	(7.6-8.1)	(116-432)
humic	0.02†	11.3	8.9‡	85‡	170‡	7.4‡	6.02
(9/8†/7‡)	(0.00-0.10)	(8.8-14.9)	(7.4-11.1)	(76-98)	(69-453)	(7.3-7.6)	(3.79-12.4)
Jul 2000	***	***	***	***	***	***	***
clear	0.00	9.0	10.0	89	258	8.0	1.14
(9)	(0.00-0.00)	(9.9-14.2)	(8.4-10.8)	(83-94)	(237-264)	(7.8-8.2)	(0.61-2.31)
clear/glac	0.11	10.3	9.8	89	246	8.0	379
(10)	(0.00-0.22)	(7.5-14.4)	(8.0-10.8)	(82-93)	(210-263)	(7.7-8.1)	(45.3-949)
glacial	0.40	12.6	9.1	88	207	8.1	1171
(23)	(0.08-0.98)	(10.7-13.9)	(8.7-9.8)	(85-91)	(201-213)	(8.0-8.2)	(975-1740)
hum/glac	0.11	13.5	8.5	84	179	7.9	571
(9)	(0.00-0.35)	(13.0-13.9)	(7.1-9.1)	(69-90)	(101-261)	(7.7-8.1)	(17.6-920)
humic	0.00†	13.5	8.2	80	125	7.6	3.39
(8/7†)	(0.00-0.00)	(12.7-14.9)	(7.1-9.5)	(68-95)	(99-152)	(7.4-7.9)	(1.43-5.16)
Aug 2000	***	***	***	***	***	***	***
clear	0.00	5.8	11.2	91	265	8.1	1.23
(9)	(0.00-0.00)	(3.9-7.1)	(10.4-12.1)	(83-102)	(245-271)	(7.8-8.3)	(0.47-2.60)
clear/glac	0.16	6.4	10.9	91	252	8.0	107
(8)	(0.07-0.45)	(4.9-7.6)	(10.2-11.8)	(86-99)	(231-268)	(7.9-8.1)	(10.4-304)
glacial	0.35†	8.2	10.1	87	218	8.0	559
(25/23†)	(0.07-0.95)	(7.1-9.4)	(9.6-11.1)	(84-93)	(179-244)	(7.8-8.0)	(292-920)
hum/glac	0.12	7.5	9.9	84	177	7.5	251
(7)	(0.00-0.27)	(6.7-8.6)	(9.4-10.5)	(79-89)	(114-281)	(7.3-7.9)	(91.0-422)
humic	0.10	6.2	9.5	78	97	7.0	17.5
(9)	(0.00-0.18)	(5.8-7.7)	(7.1-10.2)	(61-84)	(64-204)	(6.9-7.2)	(7.47-24.7)



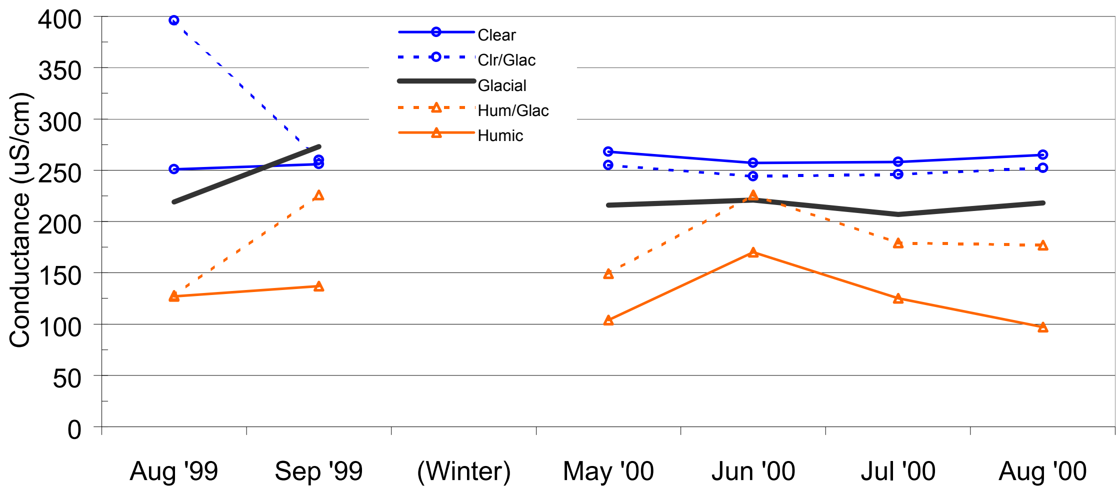
Temperature (C)
16
14
12
10
8
6
4
2
0
Clear
Clr/Glac
Glacial
Hum/Glac
Humic
Aug '99
Sep '99
(Winter)
May '00
Jun '00
Jul '00
Aug '00

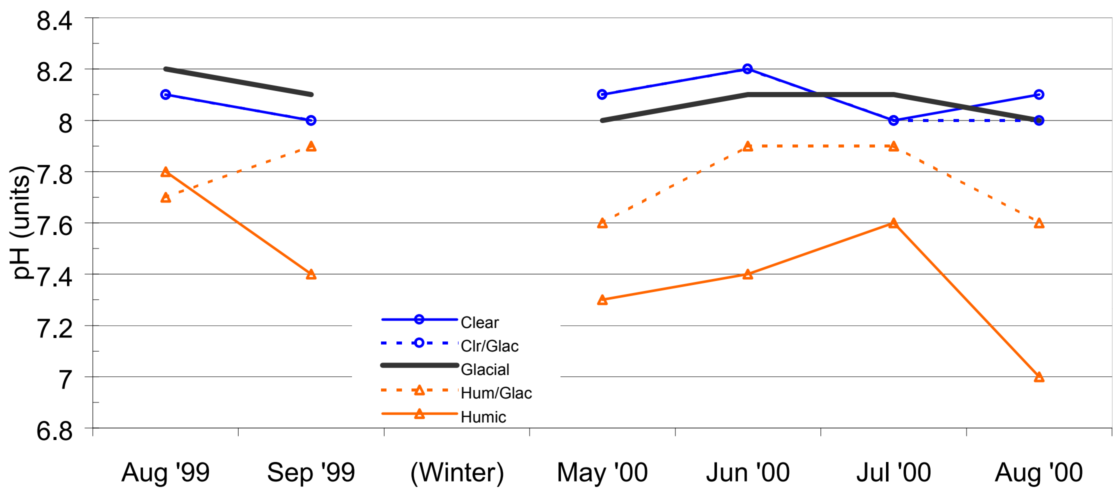


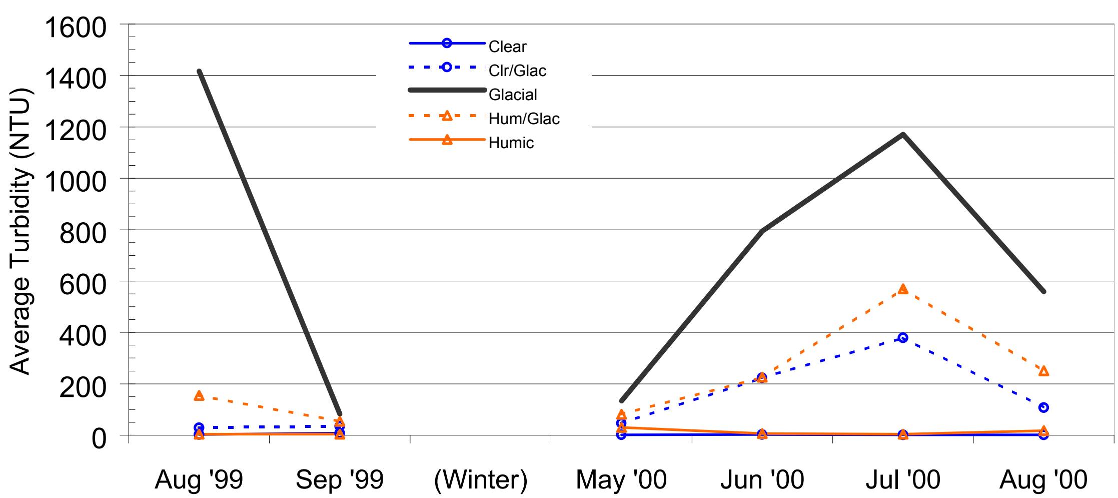
Dissolved Oxygen (ppm)
12
11.5
11
10.5
10
9.5
9
8.5
8
Clear
Clr/Glac
Glacial
Hum/Glac
Humic
Aug '99
Sep '99
(Winter)
May '00
Jun '00
Jul '00
Aug '00



Oxygen Saturation (%)
100
95
90
85
80
75
Clear
Clr/Glac
Glacial
Hum/Glac
Humic
Aug '99
Sep '99
(Winter)
May '00
Jun '00
Jul '00
Aug '00

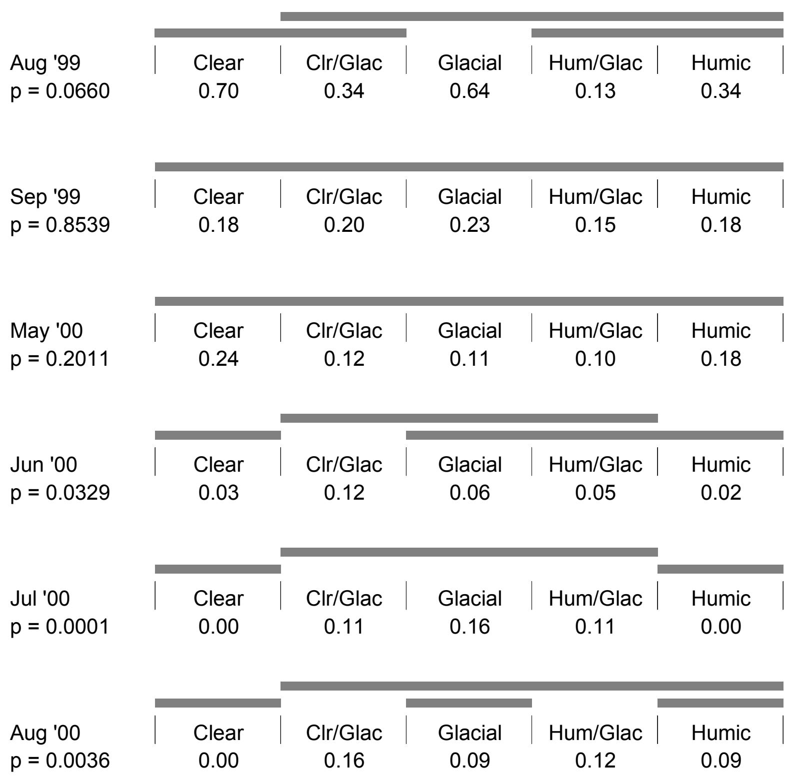

Conductance (uS/cm)
400
350
300
250
200
150
100
50
0
Clear
Clr/Glac
Glacial
Hum/Glac
Humic
Aug '99
Sep '99
(Winter)
May '00
Jun '00
Jul '00
Aug '00


pH (units)
8.4
8.2
8
7.8
7.6
7.4
7.2
7
6.8
Clear
Clr/Glac
Glacial
Hum/Glac
Humic
Aug '99
Sep '99
(Winter)
May '00
Jun '00
Jul '00
Aug '00


Average Turbidity (NTU)
1600
1400
1200
1000
800
600
400
200
0
Clear
Clr/Glac
Glacial
Hum/Glac
Humic
Aug '99
Sep '99
(Winter)
May '00
Jun '00
Jul '00
Aug '00

The following figures present overall analysis of variance F-test p values for each sample period (H_0: No differences between mean values for all water types). Horizontal bars at the same level connect water types for which the water type mean values (beneath water type) are not significantly different at $\alpha = 0.05$ using Tukey's HSD pairwise comparison of means, valid even if the overall F test does not reject H_0.

Like Mean Velocity (m/s) at Trap Sites Only, by Period



Like Mean Temperatures (C), by Period

	Clear	Clr/Glac	Glacial	Hum/Glac	Humic
Aug '99 p = 0.0014	7.5	9.0	11.2	11.7	12.6
Sep '99 p = 0.3616	5.6	5.3	4.8	4.7	4.3
May '00 p = 0.0252	6.0	6.8	6.9	6.2	4.2
Jun '00 p - 0.0008	9.3	8.5	11.4	11.6	11.3
Jul '00 p = 0.0000	9.0	10.3	12.6	13.5	13.4
Aug '00 p = 0.0000	5.8	6.4	8.2	7.5	6.3

Like Mean Dissolved Oxygen (ppm), by Period

	Clear	Clr/Glac	Glacial	Hum/Glac	Humic
Aug '99 p = 0.795	10.2	9.9	9.6	9.5	8.4
Sep '99 p = 0.4230	11.5	11.3	11.1	11.4	11.0
May '00 p = 0.0842	11.0	10.7	10.5	10.4	11.0
Jun '00 p = 0.0000	11.5	11.3	10.3	10.0	8.9
Jul '00 p = 0.0000	10.0	9.8	9.2	8.5	8.2
Aug '00 p = 0.0000	11.2	10.9	10.1	9.9	9.5

Like Mean Dissolved Oxygen Saturation (%), by Period

Period	Clear	Clr/Glac	Glacial	Hum/Glac	Humic
Aug '99 (p = 0.1286)	87	88	89	79	91
Sep '99 (p = 0.1242)	93	91	89	91	88
May '00 (p = 0.2322)	91	90	88	86	86
Jun '00 (p = 0.0000)	98	98	96	95	85
Jul '00 (p = 0.0033)	89	89	88	84	80
Aug '00 (p = 0.0000)	91	91	87	84	78

Like Mean Conductance (uS/cm), by Period

Period	Clear	Clr/Glac	Glacial	Hum/Glac	Humic
Aug '99 (p = 0.0162)	396	251	219	128	127
Sep '99 (p = 0.0000)	257	260	273	226	137
May '00 (p = 0.0000)	268	255	216	149	104
Jun '00 (p = 0.2008)	257	244	221	226	170
Jul '00 (p = 0.0000)	258	246	207	179	125
Aug '00 (p = 0.0000)	265	252	218	177	97

Like Mean pH (units), by Period
(means calculated using [H-] rather than units)

Period	Clear	Clr/Glac	Glacial	Hum/Glac	Humic
Aug '99 (p = 0.0553)	8.0	8.0	8.2	7.6	7.5
Sep '99 (p = 0.0000)	8.0	8.0	8.0	7.8	7.4
May '00 (p = 0.0000)	8.1	8.1	7.9	7.6	7.2
Jun '00 (p = 0.0000)	8.2	8.1	8.1	7.9	7.4
Jul '00 (p = 0.0000)	8.0	8.0	8.1	7.9	7.6
Aug '00 (p = 0.0000)	8.1	8.0	8.0	7.5	7.0

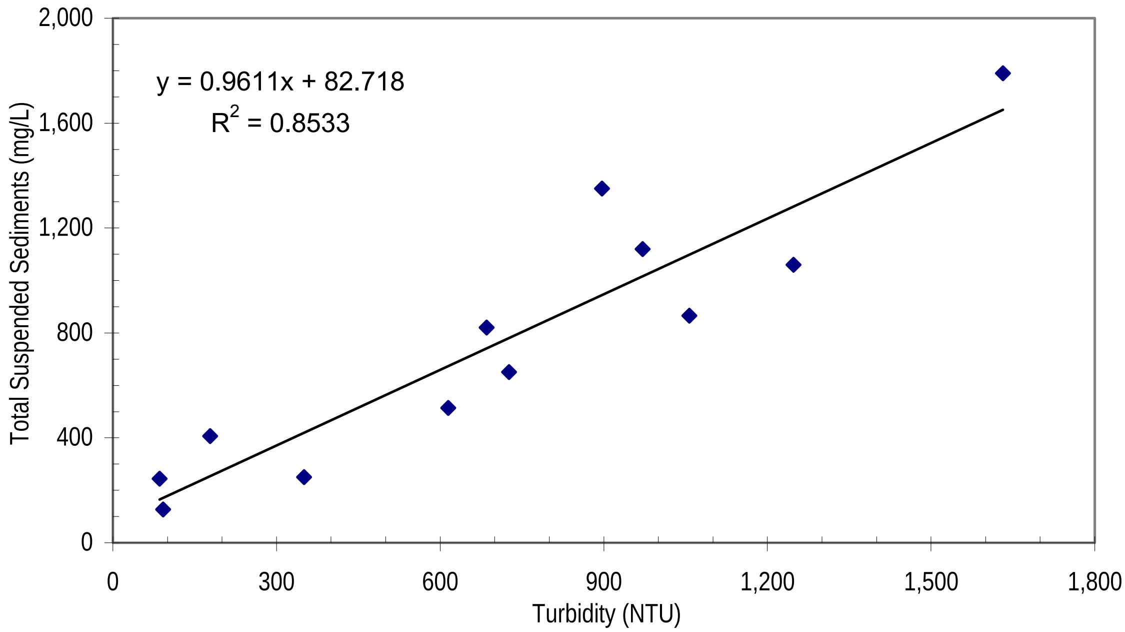
Like Mean Turbidity (NTU), by Period

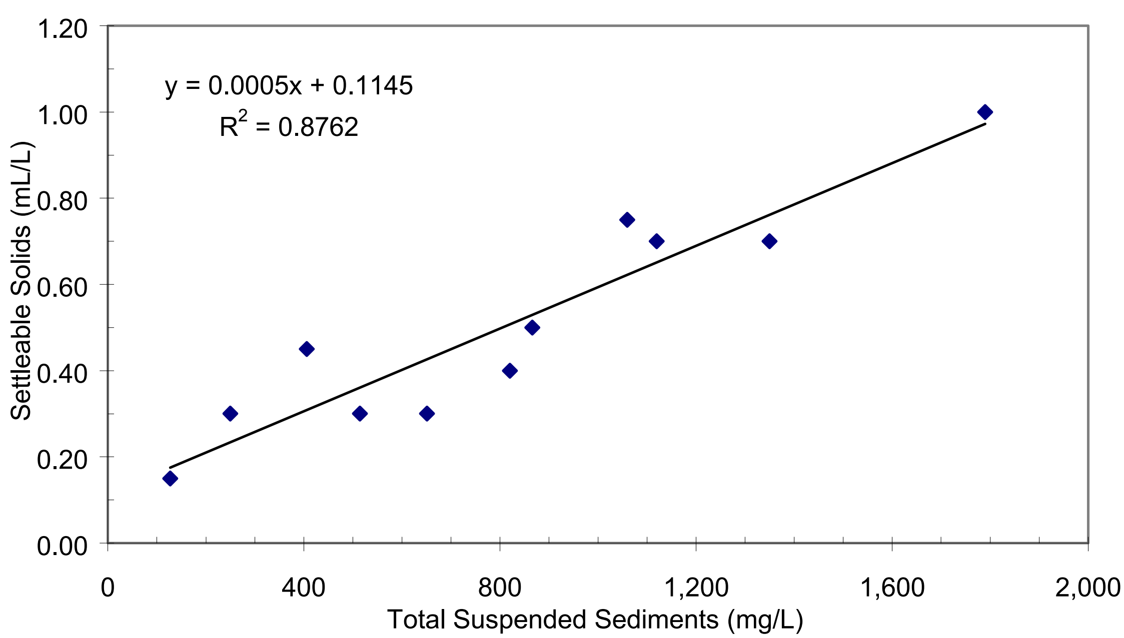
Period	Clear	Clr/Glac	Glacial	Hum/Glac	Humic
Aug '99 (p = 0.0000)	3	29	1417	155	3
Sep '99 (p = 0.0000)	7	35	83	54	4
May '00 (p = 0.0000)	1	46	133	81	30
Jun '00 (p = 0.0000)	2	224	796	402	6
Jul '00 (p = 0.0000)	1	379	1171	571	3
Aug '00 (p = 0.0000)	1	107	559	251	17

Like Mean Turbidity (NTU) at Trap Sites Only, by Period

	Clear	Clr/Glac	Glacial	Hum/Glac	Humic
Aug '99 (p = 0.0000)	3	31	1487	155	3
Sep '99 (p = 0.0000)	7	35	94	54	4
May '00 (p = 0.0000)	1	46	91	81	30
Jun '00 (p = 0.0000)	2	224	759	402	6
Jul '00 (p = 0.0000)	1	379	1328	571	3
Aug '00 (p = 0.0000)	1	107	519	251	17

Results of total suspended sediment (TSS) and settleable solids testing on twelve grab samples (three each during May, June, July, and August periods) from the main channel of the Tanana River during 2000. Settleable solids were determined by one-hour standard method using an Imhoff cone, TSS by laboratory analysis.





APPENDIX E. STEAMSIDE VEGETATION CLASSIFICATION

Summary of streamside vegetation types (to Viereck et al. [1992] Level III) for baited minnow trap and beach seine sample sites along the Tanana River and tributaries in 1999 and 2000. Number of sites is indicated before each type. Some sites were sampled more than once, but are presented in the table only once unless the habitat water type changed. In that case, the water level and streamside vegetation were often different enough to warrant inclusion as a different site.

Site Water Type		Alaska Vegetation Classification					
		Level I		Level II		Level III	
No.	Description	No.	Description	No.	Description	No.	Description
19	Clearwater	13	Forest	10	Needleleaf forest	3	Closed needleleaf forest
						5	Open needleleaf forest
						2	Needleleaf woodland
				1	Broadleaf forest	1	Closed broadleaf forest
				2	Mixed forest	2	Closed mixed forest
		5	Scrub	1	Dwarf tree scrub	1	Open dwarf tree scrub
				2	Tall scrub	1	Closed tall scrub
						1	Open tall scrub
				2	Low scrub	2	Open low scrub
		1	Herbaceous	1	Forb herbaceous	1	Wet forb herbaceous (emergent)
24	Clear/Glacial Mixed	13	Forest	11	Needleleaf forest	1	Closed needleleaf forest
						8	Open needleleaf forest
						2	Needleleaf woodland
				1	Broadleaf forest	1	Closed broadleaf forest
				1	Mixed forest	1	Open mixed forest
		8	Scrub	7	Tall scrub	2	Closed tall scrub
						5	Open tall scrub
				1	Low scrub	1	Open low scrub
		1	Herbaceous	1	Forb herbaceous	1	Wet forb herbaceous (emergent)
		2	Barren				
88	Glacial	18	Forest	14	Needleleaf forest	2	Closed needleleaf forest
						12	Open needleleaf forest
				2	Broadleaf forest	1	Closed broadleaf forest
						1	Open broadleaf forest
				2	Mixed forest	2	Closed mixed forest
		13	Scrub	1	Dwarf tree scrub	1	Dwarf tree scrub woodland
				10	Tall scrub	8	Closed tall scrub
						2	Open tall scrub
				2	Low scrub	2	Open low scrub
		1	Herbaceous	1	Graminoid herbaceous	1	Mesic graminoid herbaceous
		56	Barren				

Site Water Type		Alaska Vegetation Classification					
		Level I		Level II		Level III	
No.	Description	No.	Description	No.	Description	No.	Description
27	Humic/Glacial Mixed	9	Forest	5	Needleleaf forest	3	Closed needleleaf forest
						1	Open needleleaf forest
						1	Needleleaf woodland
				3	Broadleaf forest	1	Closed broadleaf forest
						2	Open broadleaf forest
				1	Mixed forest	1	Open mixed forest
		12	Scrub	1	Dwarf tree scrub	1	Dwarf tree scrub woodland
				2	Tall scrub	1	Closed tall scrub
						1	Open tall scrub
				9	Low scrub	1	Closed low scrub
						8	Open low scrub
		3	Herbaceous	2	Graminoid herbaceous	1	Mesic graminoid herbaceous
						1	Wet graminoid herbaceous (emergent)
				1	Forb herbaceous	1	Mesic forb herbaceous
		3	Barren				
14	Humic-stained	9	Forest	5	Needleleaf forest	1	Closed needleleaf forest
						1	Open needleleaf forest
						3	Needleleaf woodland
				1	Broadleaf forest	1	Open broadleaf forest
				3	Mixed forest	3	Open mixed forest
		3	Herbaceous	2	Graminoid herbaceous	1	Mesic graminoid herbaceous
						1	Wet graminoid herbaceous (emergent)
				1	Forb herbaceous	1	Wet forb herbaceous (emergent)
		2	Barren				

APPENDIX F. VOUCHER SPECIMENS AND STOMACHS DATA

Results of laboratory examination of frozen voucher specimens. Twelve fish from the Tanana River and tributaries were examined for confirmation of field species determination, and for identification of stomach contents. Stomach contents are presented in two tables, one by fish stomach and the other by taxon. In the by-fish table, prey items were larval unless otherwise noted. Field data are by James Durst and Bruce McIntosh; species identifications are based on external characteristics, primarily adipose fin and parr marks. Laboratory data are by Chris Stark; species identifications are based on internal characteristics, primarily pyloric caeca and gill rakers.

Taxon	Life Stage	Present in
INSECTA		
Ephemeroptera (mayflies)	larval	70-mm chinook
Plecoptera (stoneflies)	larval	69-mm coho
Diptera (flies)	emerger	30-mm chum
	emerger	32-mm chum
	emerger	33-mm chum
	emerger	86-mm coho
	adult	27-mm chum
	adult	42-mm coho
	adult	45-mm coho
	adult	53-mm coho
	adult	77-mm chinook
Chironomidae (midges)	larval	45-mm coho
	larval	53-mm coho
	larval	70-mm chinook
Simuliidae (black flies)		
	larval	30-mm chum
	larval	32-mm chum
	larval	33-mm chum
	larval	42-mm coho
	larval	45-mm coho
	larval	53-mm coho
	larval	69-mm coho
	larval	70-mm chinook
	larval	77-mm chinook

			Field Data		Laboratory Data		
Date	Site	Location	Species	FL mm	Species	FL mm	Stomach Contents
06/15/00	D-S-99-07	Tanana R	. . .	30	chum	30	Simuliidae, emerger Diptera
			. . .	32	chum	31	" "
			. . .	33	chum	33	" "
06/16/00	D-T-99-22	Goodpaster R	chinook	70	chinook	70	Simuliidae, Chironomidae, Ephemeroptera
06/18/00	D-S-00-38	Tanana R	unk larval fish	27	chum	25	adult Diptera
06/20/00	D-T-00-22	Providence/	coho	45	coho	46	ad Diptera, Chironomidae, Simuliidae
		Clear Cr	coho	53	coho	53	" " "
06/13/00	D-T-00-03	Clrwtr Lk outl	coho	42	coho	40	adult Diptera, Simuliidae
			coho	89	coho	90	empty
07/20/00	D-T-99-15	Goodpaster R	coho	69	coho	70	Plecoptera, Simuliidae
08/18/00	D-T-99-14	Goodpaster R	chinook	77	chinook	75	adult Diptera, Simuliidae
08/18/00	D-T-99-15	Goodpaster R	chinook?	86	coho	85	emerger Diptera

APPENDIX G. REGION III STC IMPORTANCE MATRIX AND IG RECOMMENDATIONS

Importance Matrix of Water Body Types and FRPA Habitat Components (version of 28 July 2000) as developed by the Region III Science/Technical Committee (STC). The STC was charged by the Alaska Board of Forestry to develop a water body classification scheme and associated riparian standards for protection of fish habitat and water quality during forest practices activities north of the Alaska Range.

Once the Board of Forestry had approved the STC's recommendations, the stakeholder Implementation Group (IG) developed a set of recommendations (8 November 2000) that were also approved by the Board and the basis for statutory and regulatory changes currently under consideration by the Alaska Legislature.

Region III Science/Technical Committee **07/28/00**

Importance Matrix of Water Body Types and FRPA Habitat Components

(Consensus point **C3am**)

Water Body Type	1. Large Woody Debris	2. Stream Bank Stability	3. Channel Morphology	4. Water Temperatures	5. Stream Flows	6. Water Quality	7. Adequate Nutrient Cycling	8. Food Sources	9. Clean Spawning Gravels	10. Sunlight	Comments
GLACIAL W/ ANADROMOUS OR HIGH VALUE RESIDENT FISH											
A. Glacial Waters -- Dynamic reaches or channels	**H** L-M	L L	M L-M	**H** L	**H** L*	**H** L	**H** L	**H** L	L L	L L	includes full-time sloughs such as Salchaket
H. Glacial Waters -- Stable reaches or channels	**H** M	**H** M-H	**H** M	**H** L	**H** L*	**H** L	**H** L	**H** L	L L	M* L	
F. Clear Upwellings in Glacial Streams	? M	L L	M? M	**H** L	**H** L*	**H** L	**H** L	**H** L	**H** M	L L	potential effects due to road crossings (ice bridges, scouring, etc.)
B. Sloughs or Oxbows Seasonally or Partly Connected to Glacial Waters	**H** M	**H** L	**H** L	**H** M	**H*** L-M	**H** M	**H** L	**H** L	**H*/L** L	**H** M*	photosynthesis is key; emergent veg'n very important
NON-GLACIAL W/ANADROMOUS OR HIGH VALUE RESIDENT FISH											
C. Non-glacial Clear Groundwater Streams (e.g., Richardson Clearw R)	**H** **H**	**H** **H**	**H** **M-H**	**H** L	**H** L-M	**H** L/M*	**H** L	**H** L	**H** **M-H**	**H** M*	gravel bed (as opposed to silt); veg'n does stabilize banks
D. Non-glacial Runoff/Tannic Streams (e.g., Chena R, Goldstream Cr)	**H** **H**	**H** **H**	**H** **M-H**	**H** L-M	**H** L-M	**H** M	**H** L	**H** **H**	**H*** **M-H**	**H*** L	veg'n does stabilize banks
I. Non-glacial--Dynamic reaches	**H** **M-H***	**H** **L-M**	**H** **M**	**H** L	**H** L*	**H** L-M	**H** L	**H** L-M	**H** L	**H** L	
H. Non-glacial sloughs and oxbows	**H** M	**H** M	**H** M	**H** M	**H** L-M	**H** M	**H** L	**H** M	**H** M	**H** **H**	
E. Lake and Wetland Connections to River Systems (e.g., Minto area)	**H** L	L M	**H** L	**H** L	**H** M*	**H** L	**H** L	**H** L	L L	**H** L	silty bottoms; emergent veg'n very important; road effect since low harvest
LAKES W/ ANADROMOUS OR HIGH VALUE RESIDENT FISH											
G. Lakes w/A5 Anadromous and High Value Resident Fish	L **H**	? L	**H** L	**H** L	**H*** L	**H** **M-H***	**H** **H**	**H** **H**	**H*** L*	**H** L	emergent veg'n very important; effects are due to closed, autotrophic system

CHART NOTES: Importance ranks: Upper rank is value to anadromous or high value resident fish habitat in this water body type => **H**

M <= lower rank likelihood of forest management activities influencing that value.

H = high; M = moderate or mixed; L = low; ? = Unknown or not well enough understood to rank.

Channel morphology was restricted to channel geometry (entrenchment, depth to width ratio, etc.).

Habitat components 1 and 4-8 were deemed most important. [most direct effect -jdd]

Water body type B is a subset of type A, and includes reaches that fish can access from the main river at least seasonally, and that mix with glacial water at least seasonally.

Concern rank: Combination of importance rank and likelihood of disturbance.

= **H** importance and **H** or **M-H** likelihood of management activities affecting

= **H** importance and M or L-M likelihood of management activities affecting

*CELL NOTES: for importance matrix cells flagged with an asterisk:

A5, F5, H5, I5 -- potential for impact low except for possible impacts from ice bridging.

B10, C10 – may increase productivity if sunlight increases

C8 – driven by primary production; highly productive streams, with large amounts of benthic algae since no scouring flows

C6, D6 – low likelihood for harvest, moderate for access roads

C9, D9 – freeze-down issues?

D5 – removing timber would likely increase snow load and runoff flows

E2 – moderate likelihood of impact from waterbody crossings

E5 – moderate likelihood of impact to winter flows and maintenance of fish passage

G6 – likelihood of impacts depends on size of water body

G6, G7, G8 – effects depend on extent of harvesting in watershed

G9 – if cleared large areas off for staging or access due to freeze-down in shallow areas

H6 – due to ice bridges

H7 – flow driven

H9 – due to lack of flushing ability

I1 -- potential for impact varies depending on size of river

SUMMARY OF REGION III FRPA RECOMMENDATIONS FROM IMPLEMENTATION GROUP (IG-C22)

November 8, 2000

Background. The Region III FRPA Implementation Group met in October and November to

- figure out how to implement the recommendations from the Science & Technical Committee in a feasible manner, and
- draft changes to the Forest Resources and Practices Act and regulations to put the recommendations into effect.

The group included representatives of the resource agencies, the timber and fishing industry, and other groups affected by the forest practices decisions. A list of Implementation Group members is attached.

Recommendations.

Riparian Buffers		
Waterbody type	**Public land**	**Private land**
Type III-A: All backwater sloughs, non-glacial anadromous fish water bodies, and non-glacial high-value resident fish water bodies >3 feet wide at OHWM	▪ 100-foot no-cut riparian zone, except that between 66 feet and 100 feet harvest may occur where consistent with maintenance of important fish and wildlife habitat. ▪ Decisions to harvest within the 66 to 100-foot zone will be made by DNR with the concurrence of ADF&G.	▪ 66-foot no-cut riparian zone.
Type III-B: All other glacial anadromous waters and glacial high value resident fish water bodies	▪ 100-foot riparian zone ▪ 50-foot no-cut zone adjacent to waterbody ▪ 50-foot variable retention zone where up to 50% of the white spruce ≥9 inches dbh may be harvested without requiring a variation.	▪ 66-foot riparian zone ▪ 33-foot no-cut zone adjacent to waterbody ▪ 33-foot variable retention zone where up to 50% of the white spruce ≥9" dbh may be harvested without requiring a variation.
Type III-C: Non-glacial high-value resident fish waters ≤3 feet wide at OHWM	▪ 100-foot riparian zone within which harvesting may occur but must be consistent with maintenance of important fish and wildlife habitat **Note:** These are typically upland streams for which little information is available. DNR and ADF&G will examine this stream type in the field in the summer of 2001 to determine the presence of high value resident fish, overlap with commercial harvest areas, and needs for fish habitat protection. The agencies will then review findings with an STC/IG.	▪ 100-foot riparian zone within which harvesting must be located and designed primarily to protect fish habitat and surface water quality. (status quo) ▪ See note under public land re field checks

Other issues	
Definitions	Added statutory definitions for ▪ glacial water body ▪ non-glacial water body ▪ Type III-A, III-B, and III-C Revise regulator definitions for ▪ "commercial forest operation" and "commercial timber harvest" in Region III from 10 MBF to 30 MBF to allow continued small-scale harvest along rivers in remote areas without requiring DPO ▪ "lake or pond" in Region III to include lakes with high value resident fish that don't have an inlet or outlet "permanent road or crossing structure" and "temporary road or crossing structure" to set the break at 5 years and eliminate the gap between the definitions of permanent and temporary crossings. This affects only the sizing of culverts. Consider moving the definition of regions from the regulations to the statute to simplify and clarify the description of regions in the Act.
Consistency	Several sections updated to make references to the riparian standards consistent with the recommended buffers: AS 41.17.950 Definition of riparian area for Region III 11 AAC 95.260 Riparian standards 11 AAC 95.265 Classification of surface water bodies
Guidelines for variable retention area in buffers on glacial water bodies	Add to 11 AAC 95.275 Uses Within a Riparian Area ▪ emphasize retention of trees with wildlife habitat benefits ▪ retention trees must be well-dispersed throughout the variable retention area in type III-B buffers. ▪ allow felling from variable retention area into no-cut buffer when necessary to minimize damage to residuals ▪ allow tops to be left within no-cut buffer if treated to minimize risk of insect infestation ▪ require high- and low-marking of all harvest trees within variable retention area
Slope stability standards	Delete slope stability standards for Region III in 11 AAC 95.280

Winter roads	Add water bars to the list of practices that may be used to prevent erosion on winter roads (11 AAC 95.290(g)
Snow bridges and ice crossings	▪ Change "organic debris" to "organic mat" in the regulation on snow ramps and ice bridges to be consistent with definitions ▪ Require review of likely impacts of ice bridges on fish habitat when natural ice thickness will be augmented; factors to be considered are freezedown, bed scouring, volume of aquatic habitat, and stream flow patterns.

<u>Implementation Group members</u>
Marty Welbourn Freeman, DNR co-chair
Jim Ferguson, ADF&G co-chair
Fred Dean, Boreal Forest Council
Jim Durst, ADF&G Habitat & Restoration
Bill Fliris/Jill Klein, Yukon River Drainage Fisheries Assn.
Chris Foley, DEC Air & Water Quality
Nancy Fresco, Northern Alaska Environmental Center
Doug Hanson, Tanana Chiefs Conference
Gary Lee, Doyon, Ltd.
Chris Maisch, DNR Division of Forestry
Jack Phelps, Alaska Forest Association
Chris Stark, Alaska Biological Research
Bob Zachel, Alaska Birch Works