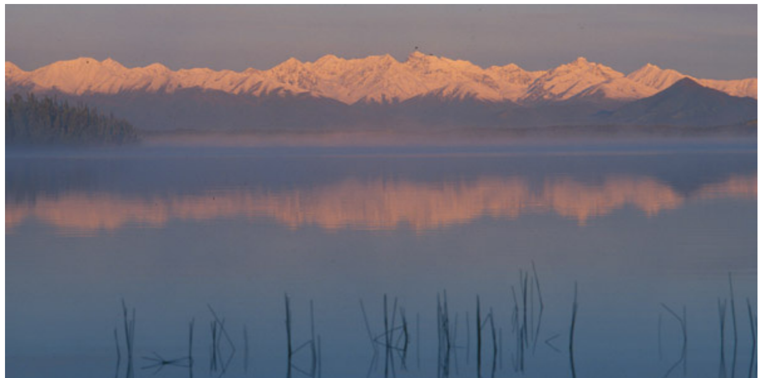
U.S. Fish & Wildlife Service

Metals in Water, Sediment, and Fish of Tetlin National Wildlife Refuge, Alaska, 1987-1992



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Acknowledgments

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Introduction

The Tetlin National Wildlife Refuge (Tetlin NWR) encompasses 924,000 acres of federal, selected and conveyed lands (Fig. 1). It is bordered on the north by the Alaska Highway, on the east by the Canadian border, on the south by the Wrangell-St. Elias National Park and Preserve (Wrangell - St. Elias NPP), and on the west by the Tetlin Reserve (previously known as the Tetlin Indian Reservation). Identified special values of the Tetlin NWR include the sand dunes of the Tanana Valley, the subsistence way of life for residents of the area, wetland habitats for waterfowl and other bird species, fish and wildlife resources, cultural resources, and opportunities for public education about natural and cultural resources afforded by the proximity of the Alaska Highway. The Refuge landscape consists primarily of climax black spruce forest interspersed with thousands of wetlands and large areas of tussock peatland. These habitats support 13 fish, 192 bird, 44 mammal, and one amphibian species.

Congress established the Tetlin NWR in 1980 when it enacted the Alaska National Interest Lands Conservation Act (ANILCA). Refuge purposes defined within ANILCA include, "to conserve fish and wildlife populations and habitats in their natural diversity including, but not limited to, waterfowl, raptors and other migratory birds, furbearers, moose, caribou, salmon, and Dolly Varden," and "to ensure, to the maximum extent practicable...water quality and necessary water quantity within the refuge." This study addresses conservation of fish and wildlife habitat and water quality within the Refuge by establishing baseline data for, and examining potential mining impacts on, water quality and metals[1] concentrations in water, sediments, and fish tissue.

Biological Resources

Thirteen fish species have been documented on Tetlin NWR, and the Refuge has appropriate habitat for others (U.S. Fish and Wildlife Service 1990). Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. keta*), were reported by subsistence users to have been historically present on the refuge; however, no salmon are known to occur in Refuge waters today. Species of particular relevance to this study include: arctic grayling (*Thymallus arcticus*), northern pike (*Esox lucius*), humpback whitefish (*Coregonus pidschian*), burbot (*Lota lota*), and longnose sucker (*Catostomus catostomus*). Tetlin NWR contains important sport and subsistence fisheries for burbot, arctic grayling, northern pike, and several species of whitefish. Within the Yukon River drainage only six spawning areas have been identified for humpback whitefish and two of these are located on the Tetlin NWR. Additional information about the fish and fisheries of the Tetlin NWR is contained in the refuge's Fishery Management Plan (U.S. Fish and Wildlife Service 1990).

[1] In this report "metals" includes the metalloids antimony, arsenic, boron, and selenium.

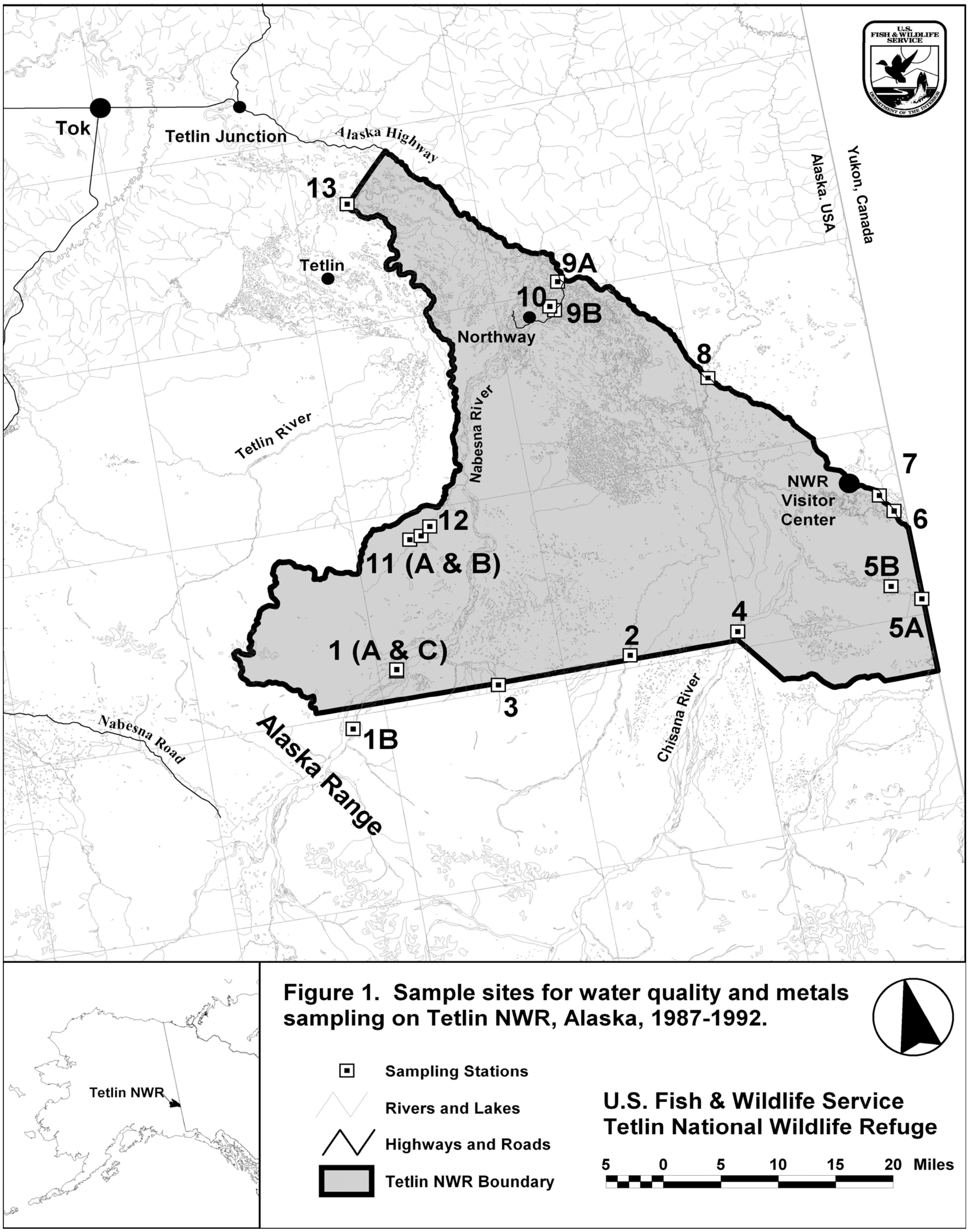

Figure 1. Sample sites for water quality and metals sampling on Tetlin NWR, Alaska, 1987-1992.

The rivers, adjoining lakes, and numerous connected wetlands provide habitat for one of the most dense and productive concentrations of nesting waterfowl in Alaska, with approximately 25,000 ducklings produced each year, including lesser scaup (*Aythya affinis*), American wigeon (*Anas americana*), green-winged teal (*Anas crecca*), bufflehead (*Bucephala albeola*), ring-necked duck (*Aythya collaris*), white-winged scoter (*Melanitta fusca*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), canvasback (*Aythya valisineria*), and common (*Bucephala clangula*) and Barrow's (*B. islandica*) goldeneye. Tetlin NWR supports an expanding population of trumpeter swans (*Cygnus buccinator*), a nationally significant species. On the major swan migration route, several thousand swans stage on the refuge each fall and the summer population exceeds 1,200. Thirty-two osprey (*Pandion haliaetus*), 64 bald eagle (*Haliaeetus leucocephalus*), and 13 peregrine falcon (*Falco peregrinus anatum*) pairs occupied nests on and adjacent to the refuge in 2003 (Timm et al. 2004), and the refuge is part of a major spring and fall migratory corridor for these and other raptors. Birds regularly found on the refuge but rare elsewhere in interior Alaska include the American coot (*Fulica americana*), sora (*Porzana carolina*), and blue-winged teal (*Anas discors*).

Other refuge resources include approximately 60 wolves (*Canis lupus*), 500 moose (*Alces alces*), more than 45,000 caribou (*Rangifer tarandus*) from three distinct herds, lynx (*Lynx canadensis*), grizzly bear (*Ursus arctos*), black bear (*Ursus americanus*), several species of furbearers (Mustelidae), and wood frogs (*Rana sylvatica*).

Water Resources

Water is an extremely important resource on the Tetlin NWR. Fish and wildlife production is greatest in the lowland complexes of ponds, marshes, and streams of the northern portion of the refuge. The rivers and major streams on and off the refuge influence water levels and nutrient richness in these wetland areas. Although most of the tributary streams have maximum discharge during spring run-off, the major glacial rivers experience maximum discharge in late summer when glacial melt is increased by high temperatures. Glacial rivers in the Tanana basin generally remain high through August due to rain and melting of glacial ice, with some flooding potential. Minimum discharges occur from mid to late winter when subsurface water from the major rivers provides the majority of flow. Many of the small tributary streams are completely frozen at this time. In summer, both the Chisana and the Nabesna drainages carry large loads of sediment (up to 2000 mg/L). In winter the streams are relatively clear of glacial sediment. There are few known pollution sources on the refuge and most river waters contain natural minerals in moderate amounts (total dissolved solids of 75-200 mg/L). The Chisana and Nabesna rivers have fairly hard water, normal pH, relatively high levels of calcium and magnesium, and some waters have a high iron content (0.71 mg/L in one lake in the northwest corner of the refuge) (U.S. Fish and Wildlife Service 1990).

This study focused on Tetlin NWR's three primary watersheds, the Nabesna, Chisana, and Tanana rivers, and their major tributaries. The Nabesna River watershed includes regions flowing into the Nabesna River, Cheslina River, and Lick and Alder creeks. The Nabesna River is a large glacial stream (watershed over 5,500 km^2) originating from the Nabesna Glacier in the Wrangell Mountains. The stream has a 0.8% gradient from its origin in the Wrangell-St.Elias NPP for a distance of about 33 km to the refuge's southern boundary, and a 0.16% gradient from the refuge boundary to Northway. Water is turbid in spring, summer, and fall but clears in winter. The Cheslina River originates in the Mentasta Mountains in the sourthwest corner of the refuge, and meanders northeast to join the Nabesna River midway between the refuge boundary and Northway.

The Chisana River watershed includes those regions flowing into the Chisana River and Desper, Gardiner, Mirror, Moose, Scottie, Stuver, Yellow Water, and Wellesley creeks. These creeks originate from off-refuge watersheds located in Canada (Mirror, Scottie, Yellow Water), on state and private lands north of the Alaska Highway (Gardiner, Desper), on federal lands south of the refuge within Wrangell - St. Elias NPP (Stuver), or within the refuge (Moose). The Chisana River originates at the base of the Chisana Glacier in the Nutzotin Mountains and flows northeast about 64 km through the Wrangell - St. Elias NPP to the refuge boundary. The river flows another 81 km toward Northway where it joins the Nabesna to form the Tanana River. The river substrate within the refuge is variable with sand, gravel, and cobble in riffle areas and sand-silt in pool areas. Stream banks are unstable with riparian vegetation of poplar or aspen (*Populus* spp.), spruce (*Picea* spp.), birch (*Betula* spp.), willow (*Salix* spp.) and alder (*Alnus* spp.). Large slip areas, with mature trees in various stages of inundation, are quite common. The Chisana is highly turbid during the open water season but clears during the winter.

Gardiner Creek is a spring-bog stream draining an area of over 777 km^2 northeast of the Alaska Highway. Riparian vegetation is primarily spruce, birch, and aspen. The stream substrate is composed of silt and sand but also has riffle areas of gravel and cobble. This creek has organically stained water, 6.6-7.5 pH, open-water conductivity of 40-93 µmhos/cm in winter, and dissolved oxygen (DO) near saturation during open water.

Desper Creek is a spring-bog stream originating east of the Alaska Highway at Island Lake. It flows into Scottie Creek about 6.5 km below the highway. Spruce, birch, alder, and willow grow at the top of steep stream banks and there is an abundance of aquatic vegetation. A culvert crossing the Alaskan Highway restricts fish upstream movement during low flows. The stream has a width of 5-10 m, humic-stained water, 6.5-7.0 pH, 75 µmhos/cm conductivity and DO at saturation during open water. During winter, it freezes to the bottom or has shallow, anoxic, water under the ice.

Scottie Creek is a low gradient, spring-bog creek originating in a lake area northeast of the Alaska Highway. It flows through a portion of Canada and re-enters the United States about 32 km south of the source lake. The stream channel is 15-20 m wide and 1.2-3.0 m deep with streamside vegetation of spruce, alder, and willow, and a mud substrate. Water quality during the open water period is excellent, indicated by 6.8-7.0 pH, 60 (open water) to 130 (winter) µmhos/cm conductivity and DO near saturation (open water) to < 2 ppm (winter).

Yellow Water Creek is a small side tributary of Scottie Creek approximately 16 km north of the refuge boundary. In 1987, an active placer mining operation immediately across the Yukon/Alaska border discharged effluent directly into the stream. Turbidity was pronounced during this operation and sedimentation occurred in several lakes immediately downstream. This mine was still in operation in 2000. Yellow Water Creek drains into the refuge via Scottie Creek.

Mirror Creek is a clear spring stream that originates in Canada and flows almost due west 19 km through the southern portion of the refuge to the Chisana River. The stream averages 10.6 m wide with variable depth (0.6- 3.6 m) and a sand and gravel substrate. Streamside vegetation is spruce, willow, and alder. The stream has clear water, 7.5-8.0 pH, 170 to 250 µmhos/cm conductivity, and 6-8 ppm DO.

Moose Creek is a spring-bog stream originating in the Black Hills and flows northeast to the Chisana River roughly 5 km above the Tanana confluence. The stream averages 10-20 m width and 0.5-1.0 m depth, with a mud substrate. Streamside vegetation is spruce, alder, willow, cottonwood (*Populus* spp.), sedge (*Carex* spp.), and horsetail (*Equisetum* spp.) with rooted aquatics of bur-reed (*Sparganium* spp.), pond weed (*Potamogeton* spp.), and water milfoil (*Myriophyllum* spp.). Floating duckweed (*Lemna minor*) is also present on many sections of the stream. During summer months, the water is tannin-stained with 8.5-9.0 pH, 150-195 µmhos/cm conductivity, and 4-9 ppm surface DO.

The upper Tanana River watershed is made up of regions flowing into the Tanana River, Bitters Creek, Beaver Creek, and the Kalutna River. The Tanana River originates at the confluence of the Chisana and Nabesna rivers; its aquatic habitats, fish, sediments, and water quality are similar to those rivers.

Threats to Refuge Resources

Section 304(g)(2E) of ANILCA mandates identification and description of problems that may adversely affect refuge fishery resources and wildlife populations. On the Tetlin NWR, potential problems include development of extensive inholdings and adjacent private lands, and mining to extract abundant mineral resources existing both within the refuge and on adjacent lands (U.S. Fish and Wildlife Service 1987). In particular, placer gold or other types of mining on inholdings, or across the international or refuge borders, could affect water quality, fish and wildlife populations and their habitats within the refuge.

Placer mining for gold and other heavy metals grew dramatically in Alaska since the early 1970's when Federal restrictions on gold prices were lifted. As of 2004, there were no active mining claims on Tetlin NWR, but mining prospects on allotments within and near the refuge boundaries are currently being investigated. There are no large metal mines currently operating in the Yukon Territories, Canada (http://mmsd1.mms.nrcan.gc.ca/mmsd/producers/default_e.asp, accessed 6 June 2005), but a large-scale hydraulic mine on a tributary of Scottie Creek, one of the most productive drainages for waterfowl breeding on the Refuge, was active as late as 2000 (B. Johnson, pers. comm.). Several mining operations also exist in the Chisana River and Scottie Creek drainages bordering the refuge. There are three active placer mines in Wrangell-Saint Elias NPP that could potentially affect Tetlin NWR; Bonanza Creek, the Nabesna River, and the White River. Future placer mining is expected in the mineral-rich Nutzotin and Mentasta mountains along the southwestern and southern boundaries of the refuge, and near the village of Northway, as the economy, regulations, or extraction processes change. In particular, the Road Metal prospect near Northway has considerable development potential (http://wwwdggs.dnr.state.ak.us/scan1/ic/text/IC48.PDF, accessed 6 June 2005).

Placer operations destroy river habitats by the direct removal or relocation of substrate, downstream deposition of sediment loads, and mobilization of toxic metals. Large amounts of overburden are removed in the placer mining process to extract gold from ancient alluvia; this often disturbs active stream beds. Placer mining can also cause channelization, changing pool-and-riffle reaches into long, straight chutes of water unsuitable for spawning habitat. Such physical changes can cause even an uncontaminated stream to be relatively sterile. Unless it is treated ("recycled"), water used to sort the gold from the lighter materials and other uncontrolled surface and groundwater discharges at the mine site result in sediment-rich effluent. Sediment-rich mine effluent, transported in suspension and as bedload, causes highly turbid water and blankets the stream bottom with a layer of fines unsuitable for benthic aquatic life and fish spawning (Bjerklie and LaPerriere 1985; Wagener and LaPerriere 1985; LaPerriere et al. 1985; Van Nieuwenhyse and LaPerriere 1986; Lloyd 1987; Lloyd et al. 1987). In addition, mining activities may mobilize toxic metals such as arsenic, cadmium, copper, lead, mercury, and zinc, thus making them more available for biological uptake (LaPerriere et al. 1985). Studies typically show higher total and dissolved metal concentrations in water from non-rehabilitated or actively mined watersheds compared to unmined, with copper, zinc, lead and arsenic commonly found in association with placer mining (Madison 1981, LaPerriere et al. 1985) in interior Alaska. Other toxic metals that may be mobilized by placer mining include mercury, antimony, aluminum, cadmium, chromium, iron, manganese, nickel, selenium, and silver.

Plant, invertebrate, and fish abundance and productivity decline in streams with placer impacts (Cordone and Kelley 1961; Wagener and LaPerriere 1985; Van Nieuwenhyse and LaPerriere 1986; Lloyd et al. 1987). Many metals, especially copper, zinc, and mercury, are more bioavailable in waters with low alkalinity and low hardness, such as those on the Tetlin NWR. Copper and zinc in water and sediment may concentrate in fish and can result in increased susceptibility to disease (U.S. Environmental Protection Agency 1985a). Arctic grayling in mined streams exhibited higher metal concentrations and greater propensity for liver and cellular abnormalities compared to fish from control streams (West 1982; West and Deschu 1984). Copper-containing water from mined streams was acutely toxic to early life stages of fish, with arctic grayling from Alaska being more sensitive than Montana arctic grayling or other species tested (Buhl and Hamilton 1990). Mercury, absorbed through the gills and skin into the bloodstream, concentrates in the muscles for long-term storage (U.S. Environmental Protection Agency 1985b), and can affect spawning success and therefore productivity. Mercury at high concentrations in fish tissue is also a potential concern for human consumers, especially subsistence users in Alaska who eat large amounts of fish.

Study Objectives

In response to historic and proposed mining activities, this study was initiated to establish baseline water quality and heavy metal concentrations in water, sediments, and fish from drainages with mining potential or history in Tetlin NWR

The study objectives were to: 1) Establish permanent monitoring sites, in historic or proposed mined and reference drainages, on the major streams and rivers of the Tetlin NWR and determine baseline water quality and trace metal concentrations in water, sediment, and fish at these sites; and 2) Evaluate the effects of metal concentrations for each site, based on mining status and underlying geology as indexed by source (glacial or clear water), on Refuge resources including fish, invertebrates, and their habitats.

Methods

Study Area

The study area included numerous drainages within Tetlin NWR, located in eastern Alaska (Fig. 1). Sample sites are described in Table 1.

Table 1. Sample site descriptions for water, sediment, and fish collections for metals analysis in Tetlin National Wildlife Refuge, Alaska, 1987-92. All reasonable efforts were made to return to sites in subsequent years; sites were moved only when necessary due to flooding, debris, river channel changes, or lack of suitable helicopter landing sites.

Site Name (Number)	Year	Description
Nabesna River (1)	1987	On the south Refuge boundary, east side of main channel immediately upstream of high cliff face in T. 9 N, R. 16 E, Sec. 20, NE 1/4, Copper River Meridian (CRM), 62° 32' 53"N, 142° 26' 58" W
	1989	East side of east channel, approximately 0.6 km west of Jimmy Brown Lake in T. 8 N, R. 15 E, Sec. 10, SE 1/4, CRM, 62° 29' 00"N, 142° 35' 42"W
	1992	South end of small island in main channel, approx. 0.5 km north of 1987 site in T. 9 N, R. 16 E, Sec. 17, SE 1/4, CRM, 62° 33' 00"N, 142° 26' 54" W (GPS)
Stuver Creek (2)	1987 1989 1992	On the south Refuge boundary, east bank directly across from the mouth of Ellis Creek in T. 9 N, R. 19 E, Sec. 34, SE 1/4, CRM, 62° 30' 58"N, 141° 49' 07" W (GPS)

Site Name (Number)	Year	Description
Chisana River (4)	1987 1989 1992	On the south Refuge boundary, west bank directly opposite Hill 2290 in T. 9 N, R. 21E, Sec. 32, NW 1/4, CRM, 62°31'20"N, 141° 30' 48" W (GPS)
Mirror Creek (5)	1987 1988	On the Canadian border, south bank immediately below large tributary stream in T. 9 N, R. 23 E, Sec. 36, NE 1/4, CRM, 62° 31' 11"N, 141° 00' 12" W
	1989 1992	T. 9 N, R. 23 E, Sec. 22, SW 1/4, CRM, 62° 32' 36"N, 141° 04' 42" W.
Scottie Creek (6)	1987 1989 1992	On the north bank about 200 yards downstream from the Alaska Highway Bridge in, T. 10 N, R. 23 E, Sec. 24, NW 1/4, CRM, 62° 38' 21"N, 141° 01' 45" W
Desper Creek (7)	1987 1989 1992	On the Alaska highway at boat ramp on south bank of creek immediately below the highway in T. 10 N, R. 23 E, Sec. 11, SW 1/4, CRM, 62° 39' 45"N, 141° 03' 36" W
Gardiner Creek (8)	1987 1989 1992	On the Alaska highway immediately below wayside pullout on east bank of creek, south of the highway in T. 12 N, R. 21 E, Sec. 3, NW 1/4, CRM, 62° 51' 15"N, 141° 27' 29" W
Moose Creek (9)	1987 1989	On the south bank about 50 yards upstream from the confluence with Chisana River in T. 14 N, R. 19 E, Sec. 9, NE 1/4, CRM, 63° 00' 44"N, 141° 48' 57" W
	1992	Three miles upstream from the confluence of the Chisana River, about 1/4 mile upstream of Fish Camp Creek in T. 14 N, R. 19 E, Sec. 20, SE 1/4, CRM, 62° 58' 36"N, 141° 50' 18" W
Yellow Water Creek (10)	1988 1992	On the north bank of Swamp Creek right at the junction with Yellow Water Creek in T. 14 N, R. 23 E, Sec. 23, SW 1/4, CRM, 62° 58' 58"N, 141° 50' 59" W (GPS)
S. Cheslina River (11)	1987 1992	On the west bank immediately upstream at junction with Wolf Den Creek in T. 11 N, R. 16 E, Sec. 23, SE 1/4, CRM, 62° 42' 52"N, 142° 20' 56" W (GPS)
	1989	On the south bank, in T. 11 N, R. 16 E, Sec. 24, SE 1/4, CRM, 62° 43' 00"N, 142° 19' 00" W

Site Name (Number)	Year	Description
N. Cheslina River (12)	1987 1989 1992	On the west bank approximately one half mile below the cabins at the mouth of Fern Creek overflow near the site where a hillside comes close to the west bank in T. 11 N, R. 17 E, Sec. 19, NE 1/4, CRM, 62° 43' 37"N, 142° 17' 18" W (GPS)
Tanana River (13)	1987 1989 1992	On the south bank immediately upstream of the junction with the Kalutna River in T. 16 N, R. 16 E, Sec. 22, NE 1/4, CRM, 63° 09' 33"N, 142° 21' 02" W (GPS)

Sample Collection

Not all sample matrices were collected at all sites in all years (Table 2). Water samples were collected for analysis of water quality variables for most sites in most years (1987-1989, 1992). Sediment and water samples were collected for metals analysis for most sites in all study years. Fish tissue samples for metals analysis were collected when and where fish could be caught.

Table 2. Sites (numbers referenced in Table 1) for baseline water quality and contaminant data collection in Tetlin National Wildlife Refuge, Alaska, 1987-92. Not all data were collected at all sites in all years.

		Metals in Water				
Year	Water Quality	Total	Total Recoverable	Dissolved	Metals in Sediment	Metals in Fish
1987	1-9, 11-13	1-9, 11-13	1	9, 11	13	1, 6-9, 13
1988	5, 10	10	10	10	10	5
1989	1-9, 11-13	1-9, 11-13	none	1	9, 11	6-9, 13
1992	1-13	1-8, 10-13	1-8, 10-13	1-8, 10-14	1-13	5-9, 13

Water Quality: Water quality data were collected during one or more sample periods in September, 1987 and 1989, May 1988, and August, 1992. Triplicate 500 mL grab samples were collected from just below the surface in 1987, 1988, 1989 (except 1 L samples for total settleable solids), and 1992 (except 1 L samples for total suspended and total settleable solids). Bottles were completely filled to minimize gaseous exchange. Each bottle was labeled immediately prior to collection and placed in a cooler with ice or snow for transport to a field laboratory for analysis.

In all years, pH, total alkalinity, total hardness, conductivity, turbidity, suspended solids, and settleable solids were measured, plus DO in 1988. Water pH was measured with either a VWR portable digital pH meter (1987 - 1989) or a Hach One digital pH meter (1992), both equipped with a combination electrode and automatic temperature compensation. Prior to each measurement series, two-buffer calibrations were performed using buffers that bracketed the sample pH. Hardness and alkalinity were determined with a Hach digital titrator and Hach standards. Conductivity was measured with a Hach DREL/5 conductivity meter with automatic temperature compensation to 25°C, calibrated prior to each measurement series with Hach standards.

Turbidity was measured using a Hach Portable Turbidity Meter Model 16800, calibrated with Gelex secondary standards for 1, 10, and 100 nephelometric turbidity units (NTU). Total suspended solids (TSS) samples were sent to a commercial laboratory (Northern Testing Laboratories, Fairbanks, AK). Total settleable solids were measured using the Imhoff Cone Method for 1 L samples (APHA et al. 1989). If settleable solids did not exceed 0.1 mL/L, "trace" or <0.3 was recorded.

<u>Metals in Water:</u> Surface grab samples were collected in triplicate (except for 1989 with one bottle per site, except site 6 where samples were collected in triplicate) just below the water surface in 250 ml or 500 ml (1992) precleaned bottles. Bottles were completely filled to minimize gaseous exchange. Each bottle was labeled immediately prior to collection and placed in a cooler with ice or snow for transport to a field laboratory for preparation for total, recoverable, and dissolved metals analysis.

Dissolved metals samples were filtered in the field laboratory using 0.8-μm prefilters and 0.45 μm cellulose acetate syringe filters with Luerlock fittings (approximately 250 ml). Samples for total metals, total recoverable metals, and dissolved metals analysis were acidified in the field to a pH <2 with 1-2 mL concentrated pure nitric acid (HNO_3) (Ultrix). In 1987 and 1989 replicate water samples for total metals and total recoverable metals were collected at each site in a single previously unused 500-mL acid-precleaned high-density polyethylene bottles (I-Chem) and split in the laboratory; in 1988 all replicates were collected and remained in separate bottles. In 1988, dissolved metals samples (n=3) could not be filtered in the field due to excessive suspended solids, so were allowed to settle for 72 hours, filtered as above (final volume approximately 120 mL), then acidified.

Total metals were analyzed after a vigorous acid digestion and included all metal molecules in the sample; recoverable metals were analyzed after a weak acid digestion and included free and particulate-bound but not silicate-bound molecules, and dissolved metals were analyzed on an unacidified but filtered sample. All three analyses were done because of their usefulness in a variety of toxicity comparisons; for example, dissolved metals represent only completely bioavailable metals.

<u>Sediment:</u> Three samples were collected from shore at each site, except in 1989 only one sample was collected at sites 1-5 and 7-13. Samples were collected in areas of fine silt with a stainless steel strainer, mixed in a plastic bucket, and placed in acid cleaned 500 mL I-Chem polyethylene bottles with teflon-lined lids. Sample bottles were labeled immediately prior to collection,

placed in a cooler with ice or snow for transport, and stored frozen.

<u>Fish:</u> Fish were collected by angling or experimental monofilament gillnet (mesh sizes varied from 1/4 inch to 1-1/2 inch) depending on the site and stream conditions. Target fish species included Arctic grayling and northern pike; however, humpback whitefish, burbot, and longnose sucker were also caught and analyzed. Fish were stripped from the net or taken from the line and placed in plastic garbage bags; then individually wrapped in plastic bags or plastic wrap. Fish samples were weighed (g), and total and fork lengths measured (mm). Liver, kidney, and muscle samples were extracted with stainless steel instruments from fish longer than approximately 400 mm; smaller fish were bagged and analyzed as whole samples. Tissues were extracted either in the laboratory in (1987, 1988) or in the field (1989, 1992). Sample bottles were labeled immediately prior to collection, placed in a cooler with ice or snow for transport, and stored frozen.

All samples were shipped from the field in coolers filled with ice or snow. Sediments and fish tissues were frozen as soon as possible, stored frozen, and shipped to the analytical laboratory via overnight mail on blue or dry ice. A “catalog” or list of samples was prepared and approved prior to sample shipment. This contained a regional identifier for the sample batch, study objectives, instructions to the laboratory on analyses requested and detection limits, and a tabulated summary for each sample including species, tissue type, collection location, collection date, weight, and other variables.

Chemical Analysis

Except where noted, aluminum (Al), antimony (Sb), arsenic (As), boron (B), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), selenium (Se), silver (Ag), tin (Sn), strontium (Sr), thallium (Tl), vanadium (V) and zinc (Zn) were analyzed. Mercury was analyzed by cold vapor atomic absorption (AA) spectrometry. Arsenic and Se in water were analyzed by graphite furnace AA and by hydride generation/graphite furnace AA in sediments and tissue. All other metals were analyzed by inductively coupled plasma (ICP) spectrometry. Three different laboratories were used over the four sampling years because of differing availability (although use of different laboratories would no longer be tolerated because of the high probability of data quality differences).

<u>1987 and 1992</u>: Metals in water, sediments, and fish were analyzed by Environmental Trace Substances Research Center, University of Missouri (Columbia, MO). Sediment samples were mixed and large fish tissue samples were ground in a meat grinder. Sample aliquots were weighed, freeze-dried (Labcono Freeze Dryer 8), weighed and further homogenized (Spex Industries, Inc. Model 8000 mixer/mill with tungsten-carbide vial and balls), then slowly acid-digested in 100 mL glass beakers with sub-boiled nitric (HNO_3), perchloric ($HClO_4$), and hydrochloric (HCl) acids. Analysis instruments and methods included: Graphite furnace AA (either a Perkin-Elmer Model 3030B with HGA-500 graphite furnace or a Perkin-Elmer Model

5100 Seeman with HGA-600 graphite furnace); hydride generation/graphic furnace AA (Perkin-Elmer MHS-1 hydride generation accessory mounted on either a Perkin-Elmer 603 AA or 3030(B) AA); cold vapor AA (Perkin-Elmer Model 403 AA); and ICP (Jarrell-Ash Model 1100) according to Standard Methods (APHA et al. 1989).

1988: Metals in water, sediments, and fish were analyzed by Versar, Inc. (Springfield, VA). Arsenic and selenium in water, and in tissue and sediments were analyzed by AA following Kopp and McKee (1983) and Krynitsky (1987), respectively. For tissues, mercury digestion and analysis followed the wet ash mercury procedure used by Patuxent Analytical Control Facility in 1988[2]; for water and sediments, mercury analysis used cold vapor AA. The graphite furnace AA digestates were analyzed using a Zeeman background correction. ICP analysis for all other samples followed Mavrodineanu (1977) or Kopp and McKee (1983).

1989: Metals in water, sediments, and fish were analyzed by Hazleton Laboratories America, Inc. (Madison, WI). Arsenic and selenium was determined by graphite furnace AA, with tissue samples digested with nitric acid in a microwave digester and sediment and water samples digested with nitric acid and hydrogen peroxide. Prior to cold vapor AA (with a MHS-20 hydride generation unit) for mercury analysis, water samples were digested with sulphuric acid, potassium permanganate, and potassium persulfate, and tissue and sediment samples were digested with a mixture of sulfuric and nitric acid and reduced with sodium borohydride. Analysis for all other elements was by ICP spectroscopy after nitric acid digestion, reduction, and filtration.

Quality Assurance/Quality Control (QA/QC): Laboratory quality assurance/quality control (QA/QC) procedures included duplicate (split) samples, spiked samples, standard reference materials (SRMs), and blanks. Data were considered acceptable if they had relative percent difference (RPD) of duplicate analyses $\leq$20%, spike recovery of 80 - 120%, SRM within $\pm$20% of the certified mean, and mean blank $\leq$15% of the mean duplicate value or < the Limit of Detection (LOD). Analyte/matrix combinations that did not pass these QA/QC criteria, or that were deemed unsound by the reporting laboratory, were not presented, summarized, or used.

Data Analysis

Discrepancies among catalogs from different laboratories required resolution prior to presenting or analyzing data. First, detection limits often varied among years, so upon combination any data less than highest reasonable detection limit were considered non-detections. Second, total recoverable metals concentrations (from filtered water) were sometimes greater than total metals concentrations (from unfiltered samples); the same was true for dissolved and total recoverable concentrations. These were resolved by a case-by-case evaluation and removal of the affected data. Third, not every matrix was sampled at each site every year, and many data did not meet QA/QC criteria. This resulted in many data gaps and inadequate data for statistical comparisons

2 No reference for this procedure was found.

between mined and unmined drainages, so these comparisons had to be made graphically. However, statistical comparisons could be made between glacial (Nabesna River, Chisana River, Moose Creek, and Tanana River) and clearwater (Stuver Creek, Alder Creek, Mirror Creek, Scottie Creek, Desper Creek, Gardiner Creek, Yellow Water Creek, S. Cheslina River, and N. Cheslina River) streams, since even normal sediment loading can affect both water quality and metals concentrations. For these comparisons, Multivariate Analysis of Variance (MANOVA) tested differences in metals detected in 100% of samples, using a backwards stepwise model resulting in the most parsimonious significant model. In this analysis, individual metals are determined to be significantly different between groups if they are included in a significant multivariate model (Wilks' lambda multivariate statistic $P < 0.05$) and have a univariate P (from the F statistic) < 0.15. Non-parametric Kruskal-Wallis rank sum testing was used for metals detected less frequently but in at least 50% of samples, with alpha = 0.05. Concentrations of the more toxic metals were also compared to water quality standards and toxicity thresholds.

Results and Discussion

Glacial and Clearwater Streams

There were significant differences in metal concentrations between glacial and clear streams in abiotic matrices. In sediments ($P = 0.034$), Cr, Cu, and Mg were all greater in glacial streams (univariate $P = 0.101$, 0.019, and 0.125, respectively), and Zn was lower (univariate $P = 0.026$). Arsenic, Ba, Sr, and V were also greater in sediments from glacial streams, although the differences were not significant in the multivariate model (all univariate $P > 0.15$). In water, total Fe, Mg, and Sr concentrations were greater in glacial streams, significantly so for Fe and Mg ($P = 0.009$; univariate $P = 0.001$, 0.007, 0.447, respectively). Although not detected in all water samples, total Ba, Mn, and Zn were also significantly greater in glacial streams ($P = 0.025$, <0.001, and <0.001, respectively). Significant differences between glacial and clearwater streams indicate that future sampling needs to take the stream type into account when designing new studies or comparing new data to the baseline data presented here.

However, northern pike (the only fish species with enough samples to compare statistically) from glacial streams did not have different metal concentrations compared to those from clear streams (liver, $P = 0.397$; muscle, $P = 0.444$). Northern pike are considered resident, but migrate on an annual basis between deep overwintering areas and shallow spring spawning areas, which can be quite distant (Morrow 1980). With the notable exception of mercury, most metals do not biomagnify (concentrate up the food chain).

Mined and Unmined Drainages

A statistical comparison of metals in mined compared to unmined drainages was not feasible, because of the unbalanced experimental design (n=2 mined drainages, Scottie and Yellow Water Creeks, and n=11 mined drainages), poor data quality, and lack of data on underlying geology in each drainage. Graphical comparison between mined and unmined drainages showed no consistent pattern, except that Ba, Mn, and Cr appeared substantially greater in sediments from the mined sites (Fig. 2). Of the metals previously associated with interior Alaska placer mining (Cu, Zn, Pb, and As; Madison 1981, LaPerriere et al. 1985), Zn and As concentrations appeared slightly greater in sediments from mined sites, Cu concentrations appeared lower (Fig. 2), and Pb was not measured or detected in enough samples to make a comparison. In water, total Fe concentrations appeared greater in mined compared to unmined sites (although with high variability), but total Sr and B concentrations appeared lower (Fig. 3). Few conclusions can be drawn from these data regarding the effects of mining on metals concentrations in sediment and water metals concentrations at the time these samples were taken. However, these data still serve as useful baseline data for Scottie Creek and Yellow Water Creek for assessment of future mining impacts.

Effect Levels in Water

Measurements at some sites exceeded 2003 Alaska Water Quality Criteria (WQC) for protection of aquatic life.[3] Comparisons are not exact because WQC are based on multiple measurements over a short time (days), compared with the sampling over years in this study. Further, the WQC themselves are often not specific to Alaska , a region with highly mineralized soils and therefore relatively high "background" concentrations of minerals in water, to which invertebrate communities may be adapted (Oswood et al. 1990). Some WQC also require additional parameters for interpretation, such as hardness and ammonia (NH_3). Nevertheless, they provide an estimate of the potential toxicity of waters to aquatic life, especially if measured concentrations greatly exceed the WQC.

Arsenic (As), Cr, Ni, and Se did not exceed their WQC. Aluminun (Al), Cd, and Zn WQC were exceeded by some samples, especially the highly turbid glacial sites on the Nabesna, Chisana, and Tanana rivers for all of the contaminants for most years (Table 3). The Hg WQC was exceeded at most sites (Table 3).

3 Aquatic Life Freshwater Acute Criteria, from Alaska Water Quality Standards, 18 AAC 70.020(b), are based on a one-hour average of total recoverable metals. Criteria are hardness-dependent for cadmium, copper, lead, and zinc.

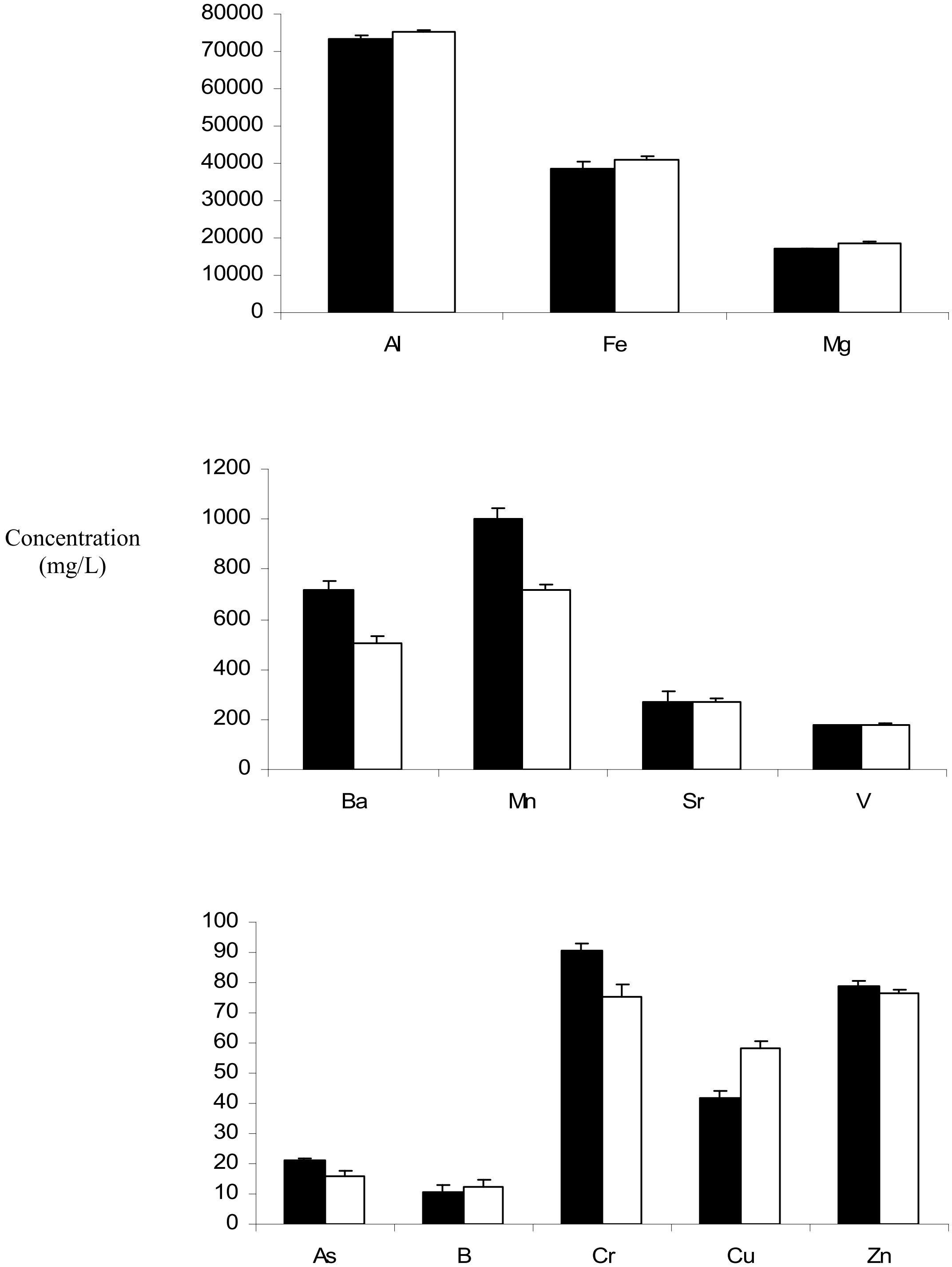

Fig. 2. Mean (+ SE) metals concentrations in sediments from streams with a history of mining (■, n=2) compared to those without (□, n=11) in Tetlin National Wildlife Refuge, Alaska, 1987-92.

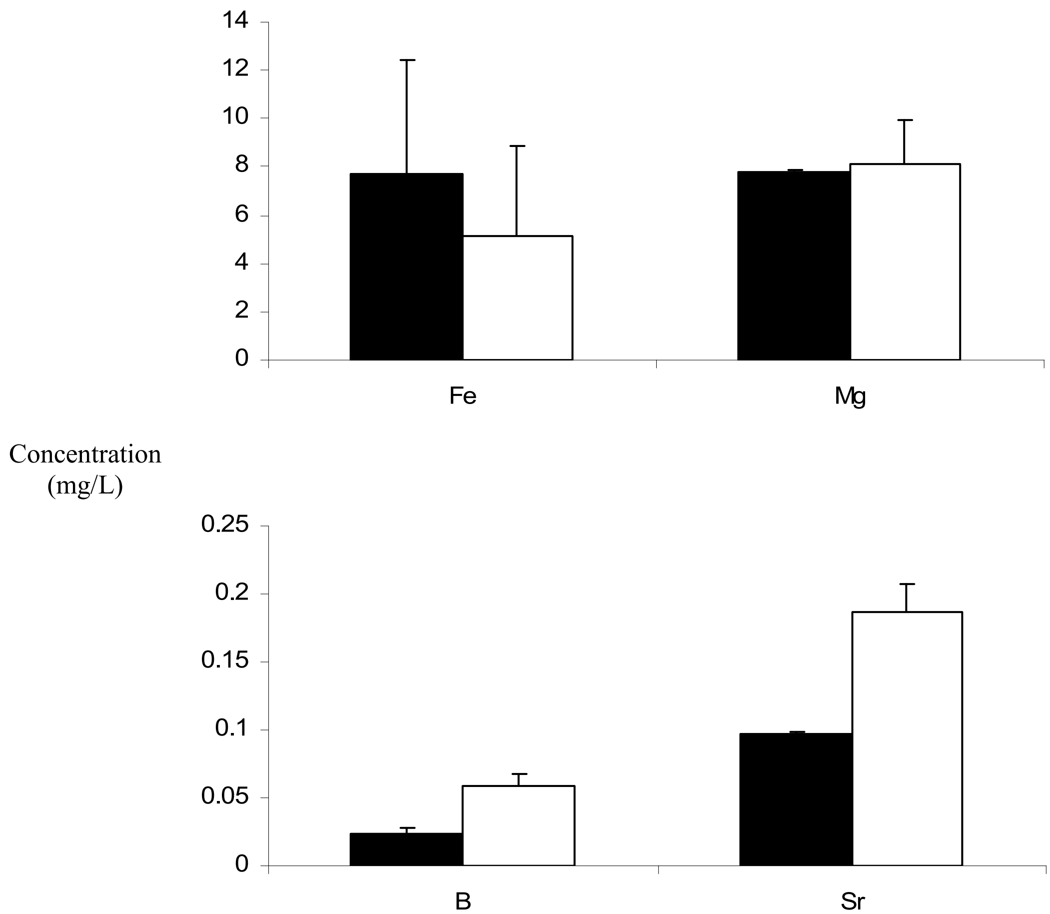

Fig. 3. Mean (+ SE) metals concentrations in water from streams with a history of mining (■, n=2) compared to those without (□, n=11) in Tetlin National Wildlife Refuge, Alaska, 1987-92.

Table 3. Streams in which dissolved aluminum (Al), cadmium (Cd), mercury (Hg), and zinc (Zn) in water exceeded 2003 Alaska Water Quality Aquatic Life Freshwater Acute Criteria, Tetlin National Wildlife Refuge, Alaska, 1988-92.

Site	Al	Cd	Hg	Zn
Glacial streams				
Nabesna River	X	X	X	X
Chisana River	X	X	X	X
Tanana River	X	X	X	X
Moose Creek		X	X	
Clear streams				
Stuver Creek	X		X	
Yellow Water Creek	X		X	
Scottie Creek		X	X	
All other sites			X	

Effect Levels in Sediments

Sediment standards for the protection of aquatic life have not been promulgated for the state of Alaska. However, sediment data can be compared to Screening Quick Reference Tables (SQuiRTs), thresholds developed by the National Oceanic and Atmospheric Administration (NOAA). These are probabilistic toxicity estimates based on large compilations of published effect data on microorganisms and benthic communities. The threshold should be interpreted with some caution in Alaska because benthic biota may be adapted to mineralized soils. Nevertheless, SQuiRT thresholds are useful, especially if measured concentrations are much greater. Threshold levels of greatest concern are upper effects thresholds (UET), followed by probable effects level (PEL), then threshold effects level (TEL) for most organisms and specifically *Hyallela azteca* (TEL-HA). Specific thresholds and caveats for their use are available online (http://response.restoration.noaa.gov/cpr/sediment/sediment.html, accessed 6 June 2005).

Metal concentrations often exceeded the SQuiRTs, in both glacial and clear streams, although the greatest exceedances were in glacial streams for Ba and Cr (Table 4). Individual sites may also have had exceedances for metals that were not detected in every sample (and are therefore not reported in this general discussion). While these comparisons are not precise, the overall pattern indicates that streams on Tetlin NWR drain highly mineralized watersheds. While background metal concentrations on Tetlin NWR may be considered toxic to some biota, there may also be some degree of adaptation to the high metals for others (e.g. Oswood et al. 1990).

Table 4. Stream types, thresholds, and metals with concentrations in exceedance in streams on Tetlin National Wildlife Refuge, Alaska, 1987-92.

Stream Type	Greatest SQuiRT[1] Level Exceeded	Metal
Glacial	Background	As, Fe, Mn, V, Zn
	Threshold Effects Level – *H. azteca*	Al, Sr
	Threshold Effects Level	Cu
	Upper Effect Threshold	Ba, Cr
Clear	Background	As, Ba, Fe, Mn, V, Zn
	Threshold Effects Level – *H. azteca*	Al, Sr
	Threshold Effects Level	Cr, Cu

[1] Screening Quick Reference Tables (SQuiRTs), thresholds developed by the National Oceanic and Atmospheric Administration (NOAA); see explanation in text. Thresholds have not been developed for B and Mg.

Effect Levels in Fish

Most metals in fish were at relatively low concentrations, including mercury concentrations, which were all below those that caused mortality or behavioral changes in a variety of adult fish species, including salmonids and northern pike (at 3-20 ppm wet weight; various refs. cited in Wiener and Spry 1996). Very few fish samples exceeded the Food and Drug Administration (FDA) action level of 1 ppm wet weight for methyl-mercury in edible tissues. However, these data are now more than a decade old. As with other arctic organisms, mercury may have increased during the intervening years and should be measured again, especially in northern pike, before current conclusions regarding effects can be made.

Conclusions

This study established water quality and metals concentrations in water, sediments, and fish, for glacial and clearwater streams within Tetlin NWR. The study sites, all on the major drainages of Tetlin NWR, have been established for use in future monitoring, although erosion and channel changes may necessitate slight changes in location. Future sampling may be conducted to determine impacts of development or other phenomena that introduce pollution to the Refuge, such as atmospheric deposition of mercury. While there weren’t enough data to test whether differences existed between mined and unmined drainages, and consequently the effects of placer mining, others evaluations were made. In particular, some metals in water and sediments, especially in glacial streams, exceeded toxicity thresholds (with the caveat that native aquatic biota may be adapted to highly mineralized Alaskan waters). Additionally, if active mining were to occur in the Scottie Creek or Yellow Water Creek drainages, these are useful pre-impact baseline data (especially if combined with more recent pre-impact sampling to account for atmospheric deposition since 1992).

Mercury in fish is of particular concern. It is toxic to organisms at many trophic levels, including fish and their consumers. In the years since these data were collected, mercury has emerged as one of the few persistent contaminants that is increasing, rather than decreasing, in arctic biota, and is of special concern in species used for subsistence. While the measured concentrations in fish in this study were low, these data cannot be used to illustrate current conditions. Queries regarding the effects of mercury on fish populations and their suitability as subsistence foods should be answered with current data, which would account for potential increases over time.

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Appendix A. Quality assurance/quality control (QA/QC) evaluation for metal analyses in sediments, water, and fish from Tetlin National Wildlife Refuge, AK, 1987-92.

Table A-1. Quality assurance/quality control (QA/QC) evaluation for metals in sediments from Tetlin National Wildlife Refuge, AK, 1987-92. For each year and analyte, the lower limit of detection (LOD) (ppm, dw) is given if QA/QC criteria were met; the highest of these was used as the overall LOD for that analyte and matrix. Other entries include: Not analyzed (NA); rejection due to poor duplicate precision (DUP); rejection due to poor standard reference material recovery (SRM); rejection due to poor spike recovery (SPIKE); and rejection by analytical laboratory due to methodological problems (LAB).

Analyte	1987	1988	1989	1992
Aluminum (Al)	SRM	50.0	SRM	10.0
Antimony (Sb)	NA	LAB	13.4	NA
Arsenic (As)	1.00	SRM	0.27	SRM
Boron (B)	SPIKE	NA	6.72	NA
Barium (Ba)	0.10	0.50	SRM	0.40
Beryllium (Be)	0.10	0.10	0.67	0.40
Cadmium (Cd)	0.80	SRM	0.67	0.80
Chromium (Cr)	2.00	1.00	SRM	4.00
Copper (Cu)	0.40	0.50	3.36	0.80
Iron (Fe)	40.0	10.0	13.4	6.00
Mercury (Hg)	0.02	0.10	0.067	0.01
Magnesium (Mg)	4.00	20.0	SRM	0.50
Manganese (Mn)	0.90	0.50	1.69	0.80
Molybdenum (Mo)	4.00	1.00	6.72	4.00
Nickel (Ni)	2.00	2.00	DUP	4.00
Lead (Pb)	5.00	5.00	4.03	20.0
Selenium (Se)	SRM	SRM	0.27	0.10
Silver (Ag)	2.00	1.00	6.72	NA
Strontium (Sr)	0.10	NA	1.34	0.40
Tin (Sn)	NA	10.0	6.72	NA
Thallium (Tl)	8.00	SRM	NA	NA
Vanadium (V)	0.40	1.00	SRM	1.00
Zinc (Zn)	SPIKE	1.00	2.69	0.80

Table A-2. Quality assurance/quality control (QA/QC) evaluation for total metals in water from Tetlin National Wildlife Refuge, AK, 1987-92. For each year and analyte, the lower limit of detection (LOD) (ppm, dw) is given if QA/QC criteria were met; the highest of these was used as the overall LOD for that analyte and matrix. Other entries include: Not analyzed (NA); rejection due to poor duplicate precision (DUP); rejection due to poor standard reference material recovery (SRM); rejection due to poor spike recovery (SPIKE); and rejection by analytical laboratory due to methodological problems (LAB).

Analyte	1987	1988	1989	1992
Aluminum (Al)	0.0004	SRM	0.05	NA
Antimony (Sb)	NA	NA	0.05	NA
Arsenic (As)	0.002	0.003	0.001	NA
Boron (B)	NA	NA	0.025	NA
Barium (Ba)	NA	NA	0.025	NA
Beryllium (Be)	SRM	DUP	0.003	NA
Cadmium (Cd)	0.0004	DUP	0.003	NA
Chromium (Cr)	0.001	0.015	0.005	NA
Copper (Cu)	0.0003	0.015	0.013	NA
Iron (Fe)	SRM	0.15	0.05	NA
Mercury (Hg)	NA	NA	0.0004	NA
Magnesium (Mg)	NA	NA	0.5	NA
Manganese (Mn)	0.0004	SRM	0.006	NA
Molybdenum (Mo)	NA	NA	0.025	NA
Nickel (Ni)	0.001	0.01	0.02	NA
Lead (Pb)	0.006	0.015	0.015	NA
Selenium (Se)	0.002	0.0025	0.001	NA
Silver (Ag)	NA	NA	0.025	NA
Strontium (Sr)	NA	NA	0.005	NA
Tin (Sn)	NA	0.03	0.025	NA
Thallium (Tl)	0.006	0.05	0.1	NA
VaNAdium (V)	NA	NA	0.025	NA
Zinc (Zn)	0.0004	0.03	SPIKE	NA

Table A-3. Quality assurance/quality control (QA/QC) evaluation for recoverable metals in water from Tetlin National Wildlife Refuge, AK, 1987-92. For each year and analyte, the lower limit of detection (LOD) (ppm, dw) is given if QA/QC criteria were met; the highest of these was used as the overall LOD for that analyte and matrix. Other entries include: Not analyzed (NA); rejection due to poor duplicate precision (DUP); rejection due to poor standard reference material recovery (SRM); rejection due to poor spike recovery (SPIKE); and rejection by analytical laboratory due to methodological problems (LAB).

Analyte	1987	1988	1989	1992
Aluminum (Al)	0.004	SRM	NA	0.03
Antimony (Sb)	NA	NA	NA	NA
Arsenic (As)	0.002	SPIKE	NA	0.0005
Boron (B)	NA	NA	NA	SRM
Barium (Ba)	NA	NA	NA	0.001
Beryllium (Be)	SRM	SRM	NA	0.0001
Cadmium (Cd)	0.0004	0.001	NA	0.0003
Chromium (Cr)	0.001	0.015	NA	SRM
Copper (Cu)	0.0003	SRM	NA	0.002
Iron (Fe)	0.001	SRM	NA	0.01
Mercury (Hg)	0.0003	0.0002	NA	0.003
Magnesium (Mg)	NA	NA	NA	0.003
Manganese (Mn)	0.0004	SRM	NA	0.002
Molybdenum (Mo)	NA	NA	NA	0.01
Nickel (Ni)	RECOV > TOTAL[A]	0.01	NA	0.002
Lead (Pb)	0.006	DUPS, SRM	NA	0.004
Selenium (Se)	0.002	0.0025	NA	0.001
Silver (Ag)	NA	NA	NA	NA
Strontium (Sr)	NA	NA	NA	0.001
Tin (Sn)	NA	0.030	NA	NA
Thallium (Tl)	0.006	0.05	NA	NA
Vanadium (V)	NA	NA	NA	DUPS
Zinc (Zn)	RECOV > TOTAL	0.03	NA	0.002

[A] Recoverable values in water greater than total values in water.

Table A-4. Quality assurance/quality control (QA/QC) evaluation for dissolved metals in water from Tetlin National Wildlife Refuge, AK, 1987-92. For each year and analyte, the lower limit of detection (LOD) (ppm, dw) is given if QA/QC criteria were met; the highest of these was used as the overall LOD for that analyte and matrix. Other entries include: Not analyzed (NA); rejection due to poor duplicate precision (DUP); rejection due to poor standard reference material recovery (SRM); rejection due to poor spike recovery (SPIKE); and rejection by analytical laboratory due to methodological problems (LAB).

Analyte	1987	1988	1989	1992
Aluminum (Al)	0.007	DUPS, SRM	0.05	0.03
Antimony (Sb)	NA	NA	0.05	NA
Arsenic (As)	0.002	0.003	0.001	0.0003
Boron (B)	NA	NA	DISS > TOTAL	SRM
Barium (Ba)	NA	NA	0.025	DISS > RECOV[B]
Beryllium (Be)	SRM	SRM	0.003	0.001
Cadmium (Cd)	0.0003	0.001	0.003	0.0002
Chromium (Cr)	0.002	0.015	0.005	0.002
Copper (Cu)	0.0004	0.015	0.013	DISS > RECOV
Iron (Fe)	DUPS	DUPS		0.03
Mercury (Hg)	0.005	0.0002	0.0004	0.0003
Magnesium (Mg)	NA	NA	0.5	DISS > RECOV
Manganese (Mn)	DUPS	0.01	0.006	0.01
Molybdenum (Mo)	NA	NA	0.025	0.01
Nickel (Ni)	0.0003	0.01	0.02	0.001
Lead (Pb)	DISS > TOTAL[A]	0.015	0.015	DISS > RECOV
Selenium (Se)	0.002	0.0025	0.001	0.0005
Silver (Ag)	NA	NA	0.025	NA
Strontium (Sr)	NA	NA	0.005	DISS > RECOV
Tin (Sn)	NA	0.03	0.025	NA
Thallium (Tl)	0.01	0.05	0.10	NA
Vanadium (V)	NA	NA	0.025	0.003
Zinc (Zn)	DUPS	SRM	SPIKE	0.003

[A] Dissolved values in water greater than total values in water.
[B] Dissolved values in water greater than recoverable values in water.

Table A-5. Quality assurance/quality control (QA/QC) evaluation for metals in fish tissues (whole fish, muscle and liver) from Tetlin National Wildlife Refuge, AK, 1987-92. For each year and analyte, the lower limit of detection (LOD) (ppm, dw) is given if QA/QC criteria were met; the highest of these was used as the overall LOD for that analyte and matrix. Other entries include: Not analyzed (NA); rejection due to poor duplicate precision (DUP); rejection due to poor standard reference material recovery (SRM); rejection due to poor spike recovery (SPIKE); and rejection by analytical laboratory due to methodological problems (LAB).

Analyte	1987	1988	1989	1992
Aluminum (Al)	5.00	DUP	9.09	SRM
Antimony (Sb)	NA	LAB	9.09	NA
Arsenic (As)	0.20	SRM	0.70	0.40
Boron (B)	6.00	NA	4.55	4.00
Barium (Ba)	0.20	0.50	4.55	0.20
Beryllium (Be)	0.20	0.20	0.45	0.06
Cadmium (Cd)	0.80	0.50	0.45	0.10
Chromium (Cr)	5.00	2.00	0.91	1.00
Copper (Cu)	0.30	1.00	2.27	0.40
Iron (Fe)	2.00	DUP	9.09	2.00
Mercury (Hg)	0.08	0.10	0.14	0.05
Magnesium (Mg)	5.00	2.00	90.9	0.10
Manganese (Mn)	0.30	1.00	1.14	0.40
Molybdenum (Mo)	2.00	1.00	4.55	2.00
Nickel (Ni)	4.00	2.00	3.64	0.80
Lead (Pb)	7.00	4.00	2.73	2.00
Selenium (Se)	0.20	SRM	0.55	0.40
Silver (Ag)	3.00	LAB	4.55	NA
Strontium (Sr)	0.20	NA	4.55	0.20
Tin (Sn)	NA	LAB	4.55	NA
Thallium (Tl)	7.00	10.0	18.2	NA
Vanadium (V)	0.50	1.00	4.55	0.60
Zinc (Zn)	1.00	1.00	1.82	0.40

Appendix B, Table B-1. Summary statistics for metal concentrations (ppm, dw) in sediment collected from Tetlin National Wildlife Refuge, AK, 1987-1992. Shown are number of samples per site (N) that met QA/QC criteria, and summary statistics. When a portion of the data were below the detection limit, the minimum is given as "nd" (non-detect), and the median was calculated rather than the mean and standard deviation (SD). No statistics were calculated when all data were below the detection limit. Antimony, molybdenum, silver, and thallium are not included as they were detected in few or no samples.

Site	Statistic	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg
Nabesna River	N	3	4	1	6	7	7	6	7	7	7
	Minimum	79600	3.0	7.92	104	nd	nd	11	38	15978	nd
	Maximum	81100	22.2		583	2.2		77	84	41200	
	Median	80800	3.3		362	1.7		45	52	22400	
	Mean	80500	7.9		352			45	62	28668	
	SD	794	9.5		250			33	20	10922	
Stuver Creek	N	3	4	1	6	7	7	6	7	7	7
	Minimum	75700	6.7	11.37	72	nd	nd	35	48	39610	nd
	Maximum	77100	33.5		637	5.5	1.0	67	68	42900	
	Median	76700	7.4		355	2.1	0.8	50	61	41600	
	Mean	76500	13.7		355			50	60	41330	
	SD	721	13.2		292			16	7	1089	
Alder Creek	N	3	4	1	6	7	7	6	7	7	7
	Minimum	74300	4.7	nd	92	nd	nd	27	45	28429	nd
	Maximum	79400	26.7		611	2.5		87	95	54800	
	Median	76700	9.9		333	2.0		51	78	39200	
	Mean	76800	12.8		336			55	73	40976	
	SD	2551	9.9		257			29	17	10162	
Chisana River	N	3	4	1	6	7	7	6	7	7	7
	Minimum	70400	5.2	9.40	156	nd	nd	25	58	27100	nd
	Maximum	71000	26.1		567	4.4		160	95	52200	
	Median	71000	5.4		380	2.2		81	73	31600	
	Mean	70800	10.5		373			86	77	38700	
	SD	346	10.4		210			64	15	11458	

Appendix B, Table B-1. Metals in sediments (cont.).

Site	Statistic	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg
Mirror Creek	N	3	4	1	6	7	7	6	7	7	7
	Minimum	71900	14.9	38.66	175	nd	nd	56	40	33300	nd
	Maximum	74600	27.2		657	4.5	2.0	97	82	43000	0.11
	Median	73400	19.2		419	2.0	0.8	81	63	37400	0.08
	Mean	73300	20.1		418			79	65	38373	
	SD	1353	5.2		245			19	14	3828	
Scottie Creek	N	3	6	3	6	9	9	6	9	9	9
	Minimum	70100	4.0	7.04	177	nd	nd	33	24	25891	nd
	Maximum	71500	22.4	12.98	588	4.3		98	50	39700	
	Median	71200	12.7	12.44	396	1.9		64	32	30700	
	Mean	70933	12.9	10.82	388			64	36	32396	
	SD	737	9.1	3.28	217			33	10	5663	
Desper Creek	N	3	4	1	6	7	7	6	7	7	7
	Minimum	69300	4.2	9.81	118	nd	nd	29	nd	23011	nd
	Maximum	70000	14.5		551	2.0		100	58	43300	
	Median	69900	9.6		348	0.7		66	43	30300	
	Mean	69733	9.5		339			65		34402	
	SD	379	4.4		225			38		8384	
Gardiner Creek	N	3	4	1	6	7	7	6	7	7	7
	Minimum	74800	4.1	nd	126	nd	nd	21	14	23597	nd
	Maximum	76500	18.4		746	3.1		73	37	38200	
	Median	75800	10.1		404	1.7		39	16	32600	
	Mean	75700	10.7		417			44	23	32685	
	SD	854	7.1		299			24	10	5639	
Moose Creek	N	3	4	1	6	7	7	6	7	7	7
	Minimum	72700	8.1	12.66	194	nd	nd	32	52	35100	nd
	Maximum	77900	38.3		663	4.5		87	78	56200	0.07
	Median	76700	8.3		361	1.6		41	71	37300	0.05
	Mean	75767	15.8		401			49	67	39593	
	SD	2723	15.0		222			20	11	7441	

Appendix B, Table B-1. Metals in sediments (cont.).

Site	Statistic	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg
S. Cheslina River	N	3	4	1	6	7	7	6	7	7	7
	Minimum	75200	7.6	13.17	93	nd	nd	43	40	42297	nd
	Maximum	76800	28.7		788	5.0		77	69	44900	0.15
	Median	75600	8.4		402	2.2		58	47	43900	0.06
	Mean	75867	13.3		426			59	54	43671	
	SD	833	10.3		360			16	11	885	
N. Cheslina River	N	3	4	1	6	7	7	6	7	7	7
	Minimum	70800	7.1	8.95	76	nd	nd	39	43	40500	nd
	Maximum	76400	29.8		819	5.3	0.9	79	66	47225	0.07
	Median	75300	8.0		413	2.2	0.8	55	51	43500	0.05
	Mean	74167	13.2		418			58	54	43718	
	SD	2967	11.1		362			18	9	1968	
Tanana River	N	3	4	1	6	7	7	6	7	7	7
	Minimum	75400	3.7	10.85	136	nd	nd	21	40	24500	nd
	Maximum	76900	22.6		555	3.8		120	81	46500	
	Median	75600	4.4		354	1.9		64	61	29200	
	Mean	75967	8.8		348			68	61	35285	
	SD	814	9.2		216			47	15	9439	
Yellow Water Creek	N	3	no data	no data	3	3	3	3	3	3	6
	Minimum	73900			716	2	nd	83	41	42100	nd
	Maximum	75700			823	2		100	46	45100	
	Median	74500			808	2		84	46	44400	
	Mean	74700			782	2		89	44	43867	
	SD	917			58	0		10	3	1570	

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Sn	V	Zn
Nabesna River	N	6	7	6	7	4	7	1	6	4
	Minimum	7670	373	nd	nd	nd	55	nd	48	38.6
	Maximum	21700	866	24	20	0.7	457		173	79.6
	Median	14940	449	13	12	0.3	132		111	77.2
	Mean	14775	599				247		111	68.1
	SD	6953	237				192		60	19.7

Appendix B, Table B-1. Metals in sediments (cont.).

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Sn	V	Zn
Stuver Creek	N	6	7	6	7	4	7	1	6	4
	Minimum	17300	633	nd	nd	nd	129	nd	63	83.3
	Maximum	22200	734	31	20	0.3	339		197	92.1
	Median	19600	700	16	7	0.2	175		134	88.3
	Mean	19667	694				231		133	88.0
	SD	2221	40				96		66	3.7
Alder Creek	N	6	7	6	7	4	7	1	6	4
	Minimum	11500	512	nd	nd	nd	124	nd	76	52.4
	Maximum	28400	1070	27	20		654		286	79.0
	Median	17450	621	13	6		168		158	72.8
	Mean	19000	748				356		173	69.2
	SD	7726	248				267		96	12.0
Chisana River	N	6	7	6	7	4	7	1	6	4
	Minimum	12000	460	nd	nd	nd	78	nd	74	57.7
	Maximum	23900	942	39	20	0.3	297		274	75.0
	Median	17600	525	19	10	0.2	105		177	73.0
	Mean	17750	673				178		174	69.7
	SD	5804	227				110		102	8.1
Mirror Creek	N	6	7	6	7	4	7	1	6	4
	Minimum	11100	433	nd	nd	nd	43	nd	75	83.5
	Maximum	18800	826	35	120		298		204	92.5
	Median	15000	586	18	10		96		141	89.9
	Mean	15117	624				168		139	89.0
	SD	3737	171				114		68	4.4
Scottie Creek	N	6	9	6	9	6	9	3	6	6
	Minimum	8730	594	nd	nd	nd	51	nd	79	68.5
	Maximum	16600	1150	26	20	0.3	334		170	85.3
	Median	12465	1070	15	7	0.3	86		125	78.5
	Mean	12577	936				156		125	77.9
	SD	4155	228				130		48	7.9

Appendix B, Table B-1. Metals in sediments (cont.).

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Sn	V	Zn
Desper Creek	N	6	7	6	7	4	7	1	6	4
	Minimum	7380	290	nd	nd	nd	44	nd	79	72.3
	Maximum	18500	683	24	20	0.4	321		206	85.3
	Median	13045	467	13	10	0.3	77		142	82.0
	Mean	13102	505				174		143	80.4
	SD	5533	166				134		67	5.7
Gardiner Creek	N	6	7	6	7	4	7	1	6	4
	Minimum	7410	260	nd	nd	nd	32	nd	61	48.4
	Maximum	16100	670	19	20		356		163	80.8
	Median	10415	420	11	7		83		101	71.2
	Mean	11222	457				184		108	67.9
	SD	4065	153				154		47	15.7
Moose Creek	N	6	7	6	7	4	7	1	6	4
	Minimum	14300	636	nd	nd	nd	88	nd	89	60.0
	Maximum	25800	984	48	20	0.4	393		270	87.3
	Median	16050	720	23	9	0.2	118		114	64.5
	Mean	17417	746				223		140	69.1
	SD	4216	113				148		71	12.4
S. Cheslina River	N	6	7	6	7	4	7	1	6	4
	Minimum	15100	633	nd	nd	nd	57	nd	95	75.4
	Maximum	19400	826	36	20	0.5	320		204	89.3
	Median	17350	717	20	8	0.3	87		152	84.3
	Mean	17300	731				180		151	83.3
	SD	1942	73				126		58	5.9
N. Cheslina River	N	6	7	6	7	4	7	1	6	4
	Minimum	14700	664	nd	nd	nd	51	nd	75	82.4
	Maximum	19000	828	37	20	0.5	324		203	89.4
	Median	17250	735	19	7	0.3	98		150	85.3
	Mean	17150	749				175		145	85.6
	SD	1896	64				130		61	3.1

Appendix B, Table B-1. Metals in sediments (cont.).

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Sn	V	Zn
Tanana River	N	6	7	6	7	4	7	1	6	4
	Minimum	9970	406	nd	nd	nd	90	nd	74	61.3
	Maximum	23600	900	34	20	0.5	395		218	76.0
	Median	16850	643	17	6	0.2	130		147	72.5
	Mean	16778	671				226		148	70.6
	SD	6676	212				151		69	6.4
Yellow Water Creek	N	3	3	3	3	3	3	no data	3	3
	Minimum	16700	899	nd	20	nd	346		168	76.0
	Maximum	18000	1080		30		366		189	82.9
	Median	17100	1020		20		355		173	79.2
	Mean	17267	1000		23		356		177	79.4
	SD	666	92		6		10		11	3.5

Appendix C. Summary statistics for metal concentrations in water collected from Tetlin National Wildlife Refuge, AK, 1987-92. Shown are number of samples per site (N) that met QA/QC criteria, and summary statistics. When a portion of the data were below the detection limit, the minimum is given as "nd" (non-detect), and the median was calculated rather than the mean and standard deviation (SD). No statistics were calculated when all data were below the detection limit.

Table C-1. Summary statistics for total metal concentrations (mg/L) in water collected from Tetlin National Wildlife Refuge, AK, 1987-1992. Antimony, beryllium, mercury, molybdenum, silver, thallium, and tin were detected in few or no samples. No samples were collected from Yellow Water Creek.

Site	Statistic	Al	Sb	As	B	Ba	Cd	Cr	Cu
Nabesna River	N	4	1	4	1	1	4	4	4
	Minimum	6.45	nd	Nd	0.109	0.056	nd	0.009	0.024
	Maximum	25.90		0.005				0.028	0.031
	Median	24.95		0.002				0.027	0.029
	Mean	20.56						0.023	0.028
	SD	9.42						0.009	0.003
Stuver Creek	N	4	1	4	1	1	4	4	4
	Minimum	0.09	nd	Nd	0.055	0.028	nd	nd	nd
	Maximum	2.07		0.003				0.007	
	Median	0.13		0.002				0.006	
	Mean	0.61							
	SD	0.98							
Alder Creek	N	4	1	4	1	1	4	4	4
	Minimum	0.02	nd	Nd	0.027	nd	nd	nd	nd
	Maximum	0.60		0.003				0.008	
	Median	0.04		0.002				0.005	
	Mean								
	SD								
Chisana River	N	4	1	4	1	1	4	4	4
	Minimum	18.70	nd	0.005	0.190	0.482	nd	0.034	0.041
	Maximum	62.10		0.051			0.025	0.095	0.200
	Median	18.90		0.006			0.000	0.035	0.041
	Mean	29.65		0.017				0.050	0.081
	SD	21.63		0.023				0.030	0.079

Appendix C, Table C-1. Total metals in water (cont.).

Site	Statistic	Al	Sb	As	B	Ba	Cd	Cr	Cu
Mirror Creek	N	4	1	4	1	1	4	4	4
	Minimum	0.02	nd	Nd	0.092	0.027	nd	nd	nd
	Maximum	0.20		0.002				0.006	
	Median	0.03		0.002				0.006	
	Mean								
	SD								
Scottie Creek	N	6	3	6	3	3	6	6	6
	Minimum	0.02	nd	Nd	nd	nd	nd	nd	nd
	Maximum	0.50		0.003	0.030	0.027	0.008	0.008	
	Median	0.07		0.002	0.025	0.025	0.005	0.005	
	Mean								
	SD								
Desper Creek	N	4	1	4	1	1	4	4	4
	Minimum	0.02	nd	Nd	nd	nd	nd	nd	nd
	Maximum	0.07		0.002				0.006	0.022
	Median	0.04		0.002				0.005	0.001
	Mean								
	SD								
Gardiner Creek	N	4	1	4	1	1	4	4	4
	Minimum	0.02	nd	Nd	nd	nd	nd	nd	nd
	Maximum	0.10		0.002				0.006	
	Median	0.02		0.002				0.003	
	Mean								
	SD								
Moose Creek	N	4	1	4	1	1	4	4	4
	Minimum	0.04	nd	Nd	0.030	0.101	nd	0.005	nd
	Maximum	7.12		0.008			0.008	0.011	
	Median	0.80		0.002			0.008	0.006	
	Mean							0.007	
	SD							0.003	

Appendix C, Table C-1. Total metals in water (cont.).

Site	Statistic	Al	Sb	As	B	Ba	Cd	Cr	Cu
S. Cheslina River	N	4	1	4	1	1	4	4	4
	Minimum	0.03	nd	Nd	nd	nd	nd	nd	nd
	Maximum	0.66						0.006	
	Median	0.04						0.004	
	Mean								
	SD								
N. Cheslina River	N	4	1	4	1	1	4	4	4
	Minimum	nd	nd	Nd	0.038	nd	nd	nd	nd
	Maximum								
	Median								
	Mean								
	SD								
Tanana River	N	4	1	4	1	1	4	4	4
	Minimum	8.60	nd	0.003	0.079	0.083	nd	0.012	nd
	Maximum	24.10		0.006				0.030	0.036
	Median	22.25		0.003				0.028	0.036
	Mean	19.30		0.004				0.025	
	SD	7.22		0.002				0.008	

Site	Statistic	Fe	Mg	Mn	Ni	Pb	Se	Sr	V	Zn
Nabesna River	N	1	1	4	4	4	4	1	1	3
	Minimum	6	9.20	0.109	nd	0.015	nd	0.119	nd	0.031
	Maximum			0.304	0.023	0.032	0.003			0.032
	Median			0.296	0.023	0.031	0.002			0.031
	Mean			0.251		0.027				0.031
	SD			0.095		0.008				0.001
Stuver Creek	N	1	1	4	4	4	4	1	1	3
	Minimum	2.81	5.40	nd	nd	0.019	0.002	0.408	nd	0.005
	Maximum			0.043		0.033	0.003			0.011
	Median			0.004		0.028	0.002			0.008
	Mean					0.027	0.002			0.008
	SD					0.006	0.001			0.003

Appendix C, Table C-1. Total metals in water (cont.).

Site	Statistic	Fe	Mg	Mn	Ni	Pb	Se	Sr	V	Zn
Alder Creek	N	1	1	4	4	4	4	1	1	3
	Minimum	0.76	3.10	nd	nd	nd	0.002	0.207	nd	0.003
	Maximum			0.011		0.029	0.003			0.007
	Median			0.001		0.026	0.002			0.004
	Mean						0.002			0.004
	SD						0.001			0.002
Chisana River	N	1	1	4	4	4	4	1	1	3
	Minimum	81.60	44.40	0.287	0.028	nd	0.002	0.322	0.241	0.036
	Maximum			1.260	0.130	0.032	0.003			0.038
	Median			0.290	0.028	0.029	0.002			0.037
	Mean			0.532	0.054		0.002			0.037
	SD			0.485	0.051		0.001			0.001
Mirror Creek	N	1	1	4	4	4	4	1	1	3
	Minimum	0.33	8.50	nd	nd	nd	0.002	0.194	nd	0.004
	Maximum			0.011		0.033	0.004			0.011
	Median			0.002		0.026	0.002			0.007
	Mean						0.003			0.007
	SD						0.001			0.004
Scottie Creek	N	3	3	6	4	6	6	3	3	3
	Minimum	0.71	7.85	0.026	nd	nd	nd	0.099	nd	0.058
	Maximum	0.73	8.00	0.056		0.130	0.003	0.103		0.067
	Median	0.71	7.90	0.042		0.073	0.002	0.099		0.064
	Mean	0.71	7.92	0.042				0.100		0.063
	SD	0.01	0.08	0.011				0.002		0.005
Desper Creek	N	1	1	4	4	4	4	1	1	3
	Minimum	0.37	8.05	0.028	nd	nd	nd	0.080	nd	nd
	Maximum			0.049		0.033	0.002			0.007
	Median			0.037		0.027	0.002			0.006
	Mean			0.037						
	SD			0.009						

Appendix C, Table C-1. Total metals in water (cont.).

Site	Statistic	Fe	Mg	Mn	Ni	Pb	Se	Sr	V	Zn
Gardiner Creek	N	1	1	4	4	4	4	1	1	3
	Minimum	1.91	5.00	0.027	nd	0.031	nd	0.063	nd	nd
	Maximum			0.037		0.033	0.002			
	Median			0.029		0.032	0.002			
	Mean			0.030		0.032				
	SD			0.005		0.001				
Moose Creek	N	1	1	4	4	4	4	1	1	3
	Minimum	8.31	11.60	0.055	nd	nd	nd	0.187	nd	0.048
	Maximum			0.150		0.130	0.002			0.050
	Median			0.069		0.120	0.002			0.048
	Mean			0.085						0.049
	SD			0.044						0.001
S. Cheslina River	N	1	1	4	4	4	4	1	1	3
	Minimum	0.06	5.90	nd	nd	nd	nd	0.236	nd	nd
	Maximum			0.014		0.031	0.003			
	Median			0.004		0.027	0.002			
	Mean									
	SD									
N. Cheslina River	N	1	1	4	4	4	4	1	1	3
	Minimum	0.07	5.70	nd	nd	nd	nd	0.235	nd	nd
	Maximum					0.029	0.002			
	Median					0.029	0.002			
	Mean									
	SD									
Tanana River	N	1	1	4	4	4	4	1	1	3
	Minimum	8.77	11.10	0.027	nd	nd	nd	0.182	nd	0.025
	Maximum			0.301	0.024	0.035	0.002			0.028
	Median			0.221	0.022	0.030	0.002			0.027
	Mean			0.193						0.027
	SD			0.126						0.002

Table C-2. Summary statistics for dissolved metal concentrations (mg/L) in water collected from Tetlin National Wildlife Refuge, AK, 1987-1992. No data were available for boron. Antimony, beryllium, copper, mercury, molybdenum, nickel, lead, silver, thallium, tin, and vanadium were detected in few or no samples.

Site	Statistic	Al	As	Ba	Cd	Cr	Fe	Mg	Mn	Se	Sr	Zn
Nabesna River	N	7	7	1	7	7	4	1	4	7	1	3
	Minimum	nd	nd	nd	nd	nd	0.05	6.30	0.020	nd	0.094	nd
	Maximum	0.61				0.0070	0.36		0.035			0.004
	Median	0.10				0.0040	0.07		0.025			0.004
	Mean						0.14		0.026			
	SD						0.15		0.008			
Stuver Creek	N	7	7	1	7	7	4	1	4	7	1	3
	Minimum	nd	nd	nd	nd	nd	0.05	4.05	nd	0.001	0.388	nd
	Maximum	0.06				0.0060	0.10			0.002		0.004
	Median	0.05				0.0050	0.06			0.002		0.004
	Mean						0.07					
	SD						0.02					
Alder Creek	N	7	7	1	7	7	4	1	4	7	1	3
	Minimum	nd	nd	nd	nd	nd	nd	2.65	nd	nd	0.199	nd
	Maximum					0.0110						0.009
	Median					0.0050						0.004
	Mean											
	SD											
Chisana River	N	7	7	1	7	7	4	1	4	7	1	3
	Minimum	0.06	nd	0.034	nd	nd	nd	4.95	nd	nd	0.125	nd
	Maximum	0.33				0.0090	0.39		0.010			0.009
	Median	0.11				0.0060	0.04		0.010			0.004
	Mean	0.15										
	SD	0.10										
Mirror Creek	N	7	7	1	7	6	4	1	4	7	1	3
	Minimum	nd	nd	0.026	nd	nd	0.06	8.10	nd	nd	0.183	0.007
	Maximum						0.08		0.020			0.009
	Median						0.08		0.010			0.007
	Mean						0.07					0.008
	SD						0.01					0.001

Appendix C, Table C-2. Dissolved metals in water (cont.).

Site	Statistic	Al	As	Ba	Cd	Cr	Fe	Mg	Mn	Se	Sr	Zn
Scottie Creek	N	8	7	3	8	8	5	3	5	8	3	2
	Minimum	nd	nd	nd	nd	nd	0.56	7.50	0.039	nd	0.092	nd
	Maximum	0.16	0.003	0.027	0.0080	0.0050	0.60	7.75	0.051		0.098	0.004
	Median	0.05	0.002	0.025	0.0030	0.0040	0.59	7.55	0.046		0.094	
	Mean						0.58	7.60	0.045		0.095	
	SD						0.02	0.13	0.006		0.003	
Desper Creek	N	7	7	1	7	6	4	1	4	7	1	3
	Minimum	nd	nd	nd	nd	nd	0.24	7.40	nd	nd	0.074	nd
	Maximum	0.07					0.37		0.023			
	Median	0.05					0.36		0.015			
	Mean						0.33					
	SD						0.06					
Gardiner Creek	N	7	7	1	7	6	4	1	4	7	1	3
	Minimum	nd	nd	nd	nd	nd	0.59	4.55	0.020	nd	0.061	nd
	Maximum	0.17	0.003				1.58		0.036			
	Median	0.05	0.001				0.61		0.025			
	Mean						0.85		0.026			
	SD						0.49		0.008			
Moose Creek	N	4	4	1	4	4	1	1	1	4	1	no data
	Minimum	nd	nd	0.039	nd	nd	0.15	6.05	0.019	0.002	0.151	
	Maximum	0.11				0.0080	0.15			0.002		
	Median	0.02				0.0040	0.15			0.002		
	Mean						0.15					
	SD						.					
S. Cheslina River	N	6	5	1	6	6	3	1	3	6	1	2
	Minimum	nd	nd	nd	nd	nd	nd	5.35	nd	nd	0.236	0.008
	Maximum	0.05				0.0050						0.017
	Median	0.02				0.0040						
	Mean											
	SD											

Appendix C, Table C-2. Dissolved metals in water (cont.).

Site	Statistic	Al	As	Ba	Cd	Cr	Fe	Mg	Mn	Se	Sr	Zn
N. Cheslina River	N	6	6	1	6	6	3	1	3	6	no data	2
	Minimum	nd	nd	nd	nd	nd	nd	5.35	nd	0.001		0.008
	Maximum									0.002		0.017
	Median									0.002		
	Mean											
	SD											
Tanana River	N	6	6	1	6	6	3	1	3	6	1	2
	Minimum	0.07	nd	nd	nd	nd	nd	6.75	nd	nd	0.144	nd
	Maximum	0.23				0.0650	0.15					0.004
	Median	0.15				0.0060	0.04					
	Mean	0.14										
	SD	0.06										
Yellow Water Creek	N	4	4	no data	4	4	4	no data	4	4	no data	4
	Minimum	nd	nd		nd	nd	0.25		0.051	nd		0.004
	Maximum	0.15	0.004				0.76		0.130			0.009
	Median	0.07	0.003				0.53		0.108			0.008
	Mean						0.52		0.099			0.007
	SD						0.25		0.038			0.002

Table C-3. Summary statistics for recoverable metal concentrations (mg/L) in water collected from Tetlin National Wildlife Refuge, AK, 1987-1992. No data were available for antimony, boron, silver, tin, and vanadium. Mercury, molybdenum, and thallium were detected in few or no samples.

Site	Statistic	Al	As	Ba	Be	Cd	Cr	Cu	Fe
Nabesna River	N	6	6	3	3	6	3	6	6
	Minimum	24.3	nd	0.264	0.0010	nd	0.025	0.029	16.8
	Maximum	38.8	0.0043	0.272	0.0011	0.0013	0.025	0.084	31.4
	Median	31.0	0.0034	0.272	0.0010	0.0008	0.025	0.055	23.5
	Mean	31.4		0.269	0.0010		0.025	0.056	23.9
	SD	7.4		0.005	0.0001		0.000	0.029	7.6
Stuver Creek	N	6	6	3	3	6	3	6	6
	Minimum	0.1	nd	0.038	0.0001	nd	0.005	nd	0.2
	Maximum	3.4		0.041	0.0001		0.007	0.011	3.5
	Median	1.6		0.040	0.0001		0.006	0.005	1.7
	Mean	1.7		0.040	0.0001		0.006		1.7
	SD	1.7		0.002	0.0000		0.001		1.7
Alder Creek	N	6	6	3	3	6	3	6	6
	Minimum	nd	nd	0.015	nd	nd	0.003	nd	nd
	Maximum	0.03		0.015			0.005	0.004	0.1
	Median	0.03		0.015			0.004	0.002	0.0
	Mean			0.015			0.004		
	SD			0.000			0.001		
Chisana River	N	6	6	3	3	6	3	6	6
	Minimum	18.4	nd	0.463	0.0015	nd	0.031	0.041	17.2
	Maximum	66.0	0.0110	0.544	0.0019	0.0033	0.032	0.268	69.3
	Median	36.7	0.0054	0.533	0.0018	0.0015	0.031	0.134	37.2
	Mean	40.0		0.513	0.0017		0.031	0.147	40.9
	SD	23.9		0.044	0.0002		0.001	0.118	26.2
Mirror Creek	N	6	6	3	3	6	3	6	6
	Minimum	nd	nd	0.026	nd	nd	0.004	nd	nd
	Maximum	0.3	0.0020	0.027			0.005	0.009	0.4
	Median	0.1	0.0020	0.027			0.005	0.004	0.2
	Mean			0.027			0.005		
	SD			0.001			0.000		

Appendix C, Table C-3. Recoverable metals in water (cont.).

Site	Statistic	Al	As	Ba	Be	Cd	Cr	Cu	Fe
Scottie Creek	N	6	6	3	3	6	3	6	6
	Minimum	nd	nd	0.021	nd	nd	0.004	nd	1.0
	Maximum	0.5		0.022		0.0078	0.006	0.007	1.7
	Median	0.4		0.021		0.0039	0.004	0.004	1.1
	Mean			0.021			0.004		1.2
	SD			0.001			0.001		0.3
Desper Creek	N	6	6	3	3	6	3	6	6
	Minimum	nd	nd	0.008	nd	nd	0.002	nd	0.4
	Maximum	0.2		0.009			0.005	0.006	0.5
	Median	0.0		0.009			0.004	0.003	0.4
	Mean			0.008			0.004		0.4
	SD			0.001			0.001		0.0
Gardiner Creek	N	6	6	3	3	6	3	6	6
	Minimum	nd	nd	0.014	nd	nd	0.003	0.002	0.8
	Maximum	0.4		0.019	0.0001		0.003	0.006	1.4
	Median	0.1		0.017	0.0001		0.003	0.004	1.2
	Mean			0.017			0.003	0.004	1.2
	SD			0.003			0.000	0.002	0.3
Moose Creek	N	6	6	3	3	6	3	6	6
	Minimum	0.1	nd	0.023	nd	nd	0.004	0.002	0.8
	Maximum	1.4	0.0031	0.025		0.0080	0.006	0.008	1.9
	Median	0.2	0.0021	0.024		0.0042	0.005	0.006	0.8
	Mean	0.4		0.024			0.005	0.005	1.0
	SD	0.5		0.001			0.001	0.002	0.4
S. Cheslina River	N	6	6	3	3	6	3	6	6
	Minimum	nd	nd	0.012	nd	nd	0.003	nd	0.0
	Maximum	0.6		0.013			0.006	0.007	0.9
	Median	0.1		0.013			0.004	0.004	0.1
	Mean			0.013			0.004		0.2
	SD			0.001			0.002		0.3

Appendix C, Table C-3. Recoverable metals in water (cont.).

Site	Statistic	Al	As	Ba	Be	Cd	Cr	Cu	Fe
N. Cheslina River	N	6	6	3	3	6	3	6	6
	Minimum	nd	nd	0.014	nd	nd	0.003	nd	0.0
	Maximum	0.2		0.015			0.003	0.006	0.2
	Median	0.1		0.014			0.003	0.003	0.1
	Mean			0.014			0.003		0.1
	SD			0.001			0.000		0.1
Tanana River	N	6	6	3	3	6	3	6	6
	Minimum	22.8	0.0030	0.220	0.0008	nd	0.024	0.034	15.8
	Maximum	35.6	0.0056	0.265	0.0010	0.0011	0.027	0.082	31.4
	Median	25.9	0.0040	0.235	0.0009	0.0006	0.026	0.056	20.4
	Mean	27.2	0.0042	0.240	0.0009		0.026	0.056	21.9
	SD	5.1	0.0009	0.023	0.0001		0.002	0.022	6.4
Yellow Water Creek	N	3	3	3	3	no data	no data	3	3
	Minimum	1.7	0.0062	0.062	nd			0.011	2.9
	Maximum	3.8	0.0140	0.072	0.0001			0.012	5.0
	Median	3.7	0.0130	0.071	0.0001			0.011	4.9
	Mean	3.1	0.0111	0.068				0.011	4.2
	SD	1.2	0.0042	0.006				0.001	1.2

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Zn
Nabesna River	N	3	6	3	6	6	3	3
	Minimum	18.4	0.276	0.037	nd	nd	0.251	0.070
	Maximum	19.3	0.657	0.040	0.036		0.260	0.120
	Median	18.9	0.457	0.038	0.032		0.259	0.078
	Mean	18.9	0.463	0.038			0.257	0.089
	SD	0.5	0.196	0.002			0.005	0.027
Stuver Creek	N	3	6	3	6	6	3	3
	Minimum	5.2	0.003	0.002	nd	nd	0.399	0.009
	Maximum	5.7	0.057	0.003	0.032	0.003	0.439	0.029
	Median	5.4	0.028	0.002	0.028	0.002	0.416	0.026
	Mean	5.4	0.029	0.002			0.418	0.021
	SD	0.3	0.027	0.001			0.020	0.011

Appendix C, Table C-3. Recoverable metals in water (cont.).

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Zn
Alder Creek	N	3	6	3	6	6	3	3
	Minimum	2.9	nd	nd	0.022	nd	0.225	0.008
	Maximum	3.0			0.027	0.003	0.235	0.010
	Median	3.0			0.025	0.002	0.231	0.008
	Mean	3.0			0.025		0.230	0.009
	SD	0.1			0.002		0.005	0.001
Chisana River	N	3	6	3	6	6	3	3
	Minimum	36.8	0.271	0.099	nd	nd	0.330	0.130
	Maximum	43.5	1.460	0.120	0.041	0.003	0.386	0.170
	Median	43.4	0.762	0.120	0.030	0.002	0.385	0.160
	Mean	41.2	0.831	0.113			0.367	0.153
	SD	3.8	0.617	0.012			0.032	0.021
Mirror Creek	N	3	6	3	6	6	3	3
	Minimum	7.7	0.001	nd	0.021	nd	0.190	0.010
	Maximum	7.9	0.019		0.030	0.003	0.194	0.012
	Median	7.7	0.010		0.025	0.002	0.191	0.010
	Mean	7.8			0.026		0.192	0.011
	SD	0.1			0.004		0.002	0.001
Scottie Creek	N	3	6	3	6	6	3	3
	Minimum	3.7	0.029	nd	nd	nd	0.048	0.002
	Maximum	3.8	0.060	0.002	0.130		0.050	0.004
	Median	3.7	0.057	0.002	0.067		0.048	0.004
	Mean	3.7	0.048				0.049	0.003
	SD	0.1	0.015				0.001	0.001
Desper Creek	N	3	6	3	6	6	3	3
	Minimum	3.8	0.012	nd	nd	nd	0.043	nd
	Maximum	4.3	0.046	0.004	0.032		0.049	0.006
	Median	4.2	0.021	0.002	0.017		0.048	0.003
	Mean	4.1	0.026				0.047	
	SD	0.3	0.015				0.003	

Appendix C, Table C-3. Recoverable metals in water (cont.).

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Zn
Gardiner Creek	N	3	6	3	6	6	3	3
	Minimum	2.3	0.021	nd	nd	nd	0.032	nd
	Maximum	2.9	0.031	0.002	0.034	0.003	0.040	0.006
	Median	2.7	0.028	0.002	0.018	0.002	0.038	0.002
	Mean	2.6	0.027				0.037	
	SD	0.3	0.003				0.004	
Moose Creek	N	3	6	3	6	6	3	3
	Minimum	8.2	0.058	nd	nd	nd	0.133	nd
	Maximum	8.4	0.085		0.140		0.137	
	Median	8.3	0.062		0.067		0.135	
	Mean	8.3	0.066				0.135	
	SD	0.1	0.010				0.002	
S. Cheslina River	N	3	6	3	6	6	3	3
	Minimum	6.5	nd	nd	0.022	nd	0.280	0.003
	Maximum	6.6	0.016	0.002	0.032		0.285	0.030
	Median	6.6	0.003	0.002	0.029		0.284	0.007
	Mean	6.6			0.028		0.283	0.013
	SD	0.1			0.004		0.003	0.015
N. Cheslina River	N	3	6	3	6	6	3	3
	Minimum	6.1	nd	nd	0.024	nd	0.259	0.003
	Maximum	6.2	0.009		0.029	0.002	0.263	0.012
	Median	6.1	0.005		0.027	0.002	0.261	0.007
	Mean	6.1			0.027		0.261	0.007
	SD	0.1			0.003		0.002	0.005
Tanana River	N	3	6	3	6	6	3	3
	Minimum	15.8	0.267	0.031	0.027	nd	0.224	0.053
	Maximum	18.4	0.572	0.036	0.039		0.260	0.100
	Median	17.3	0.377	0.033	0.033		0.241	0.063
	Mean	17.2	0.399	0.033	0.033		0.242	0.072
	SD	1.3	0.140	0.003	0.004		0.018	0.025

Appendix C, Table C-3. Recoverable metals in water (cont.).

Site	Statistic	Mg	Mn	Ni	Pb	Se	Sr	Zn
Yellow Water Creek	N	3	3	3	3	3	3	3
	Minimum	8.8	0.180	0.002	0.031	nd	0.127	0.007
	Maximum	8.8	0.190	0.004	0.032		0.128	0.013
	Median	8.8	0.190	0.003	0.032		0.128	0.010
	Mean	8.8	0.187	0.003	0.032		0.128	0.010
	SD	0.0	0.006	0.001	0.001		0.001	0.003

Appendix D: Summary statistics for metal concentrations in fish collected from Tetlin National Wildlife Refuge, AK, 1987-92. Shown are number of samples per site (N) that met QA/QC criteria, and site summary statistics. When a portion of the data were below the detection limit, the minimum is given as "nd" (non-detect), and the median was calculated rather than the mean and standard deviation (SD). No statistics were calculated when all data were below the detection limit.

Table D-1. Summary statistics for metal concentrations (ppm, dw) in whole fish collected in Tetlin National Wildlife Refuge, 1987-92. Beryllium, boron, cadmium, chromium, nickel, lead, and silver were detected in few or no samples.

Site	Species	Statistic	Al	Sb	As	Ba	Cu	Fe	Hg	Mg
Nabesna River	Arctic Grayling	N	1	no data	1	1	1	1	1	1
		Minimum	25.0		nd	nd	2.60	78	0.140	1390
		Maximum								
		Median								
		Mean								
		SD								
Mirror Creek	Arctic Grayling	N	no data	no data	no data	1	1	no data	1	1
		Minimum				5.00	2.50		nd	1210
		Maximum								
		Median								
		Mean								
		SD								
Gardiner Creek	Arctic Grayling	N	3	3	3	3	3	3	3	3
		Minimum	10.0	nd	nd	2.85	2.21	60	nd	1271
		Maximum	26.8			6.83	2.82	87	0.180	1356
		Median	16.3			4.14	2.47	65	0.162	1275
		Mean	17.7				2.50	71		1301
		SD	8.5				0.31	15		48
Desper Creek	Northern Pike	N	10	5	10	10	10	10	10	10
		Minimum	11.0	nd	0.30	2.80	2.69	75	nd	1301
		Maximum	46.2		1.41	8.70	6.20	210	0.290	1550
		Median	24.1		0.46	6.68	3.43	96	0.120	1391
		Mean	27.7				3.91	106		1398
		SD	10.5				1.17	40		69

Appendix D, Table D-1. Metals in whole fish (cont.).

Site	Species	Statistic	Al	Sb	As	Ba	Cu	Fe	Hg	Mg
Gardiner Creek	Northern Pike	N	no data	no data	2	2	2	2	2	2
		Minimum			nd	4.60	2.80	78	nd	1310
		Maximum			0.70	5.90	6.50	140		1450
		Median								
		Mean								
		SD								
Moose Creek	Northern Pike	N	1	1	2	2	2	2	2	2
		Minimum	37.6	nd	nd	6.50	5.70	67	0.150	1398
		Maximum				10.90	6.60	198	0.498	1410
		Median								
		Mean								
		SD								
Gardiner Creek	Longnose Sucker	N	no data	no data	1	1	1	1	1	1
		Minimum			nd	8.30	4.90	357	nd	1310
		Maximum				8.30	4.90	357		1310
		Median								
		Mean								
		SD								
Nabesna River	Arctic Grayling	N	1	1	1	1	1	no data	1	1
		Minimum	8.3	nd	5.60	30.8	nd		nd	102
		Maximum								
		Median								
		Mean								
		SD								
Mirror Creek	Arctic Grayling	N	1	1	no data	no data	1	no data	1	1
		Minimum	29.0	nd			nd		nd	67
		Maximum								
		Median								
		Mean								
		SD								

Appendix D, Table D-1. Metals in whole fish (cont.).

Site	Species	Statistic	Al	Sb	As	Ba	Cu	Fe	Hg	Mg
Gardiner Creek	Arctic Grayling	N	3	3	3	3	3	3	3	3
		Minimum	15.1	nd	0.98	34.2	nd	nd	nd	50
		Maximum	58.5		1.13	52.5				86
		Median	15.2		1.07	37.9				57
		Mean	29.6		1.06	41.5				64
		SD	25.0		0.08	9.6				19
Desper Creek	Northern Pike	N	10	10	10	10	10	5	10	10
		Minimum	8.2	nd	nd	23.0	nd	nd	nd	137
		Maximum	31.6	8.68		58.2		20.3		173
		Median	12.4	1.65		40.0		9.2		153
		Mean	15.9			40.2				155
		SD	7.9			10.6				12
Gardiner Creek	Northern Pike	N	2	2	2	2	no data	no data	2	2
		Minimum	39.3	nd	0.67	33.9			5.5	133
		Maximum	74.0		0.72	36.7			18.0	172
		Median								
		Mean								
		SD								
Moose Creek	Northern Pike	N	2	2	2	2	1	1	2	2
		Minimum	29.1	nd	nd	38.3	nd	24.2	nd	179
		Maximum	57.6	3.53	2.44	53.4			8.0	194
		Median								
		Mean								
		SD								
Gardiner Creek	Longnose Sucker	N	1	1	1	1	no data	no data	1	1
		Minimum	57.9	nd	0.85	45.0			nd	68
		Maximum	57.9		0.85	45.0				68
		Median								
		Mean								
		SD								

Table D-2. Summary statistics for metal concentrations (ppm, dw) in fish muscle collected in Tetlin National Wildlife Refuge, 1987-92. Antimony, boron, beryllium, lead and silver were detected in few or no samples.

Site	Species	Statistic	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Mg
Scottie Creek	Humpback Whitefish	N	10	10	10	10	10	10	10	10	10
		Minimum	3.0	nd	nd	nd	nd	nd	13	0.380	807
		Maximum	23.8				5.00	9.60	71	1.100	1357
		Median	5.5				2.12	1.86	31	0.766	1146
		Mean							32	0.747	1104
		SD							16	0.229	181
Tanana River	Humpback Whitefish	N	5	5	5	5	5	5	5	5	5
		Minimum	nd	nd	nd	nd	nd	nd	32	0.420	994
		Maximum						3.10	61	0.660	1140
		Median						2.30	51	0.560	1030
		Mean							49	0.542	1059
		SD							11	0.087	63
Mirror Creek	Arctic Grayling	N	no data	2	6	6	6	6	2	6	6
		Minimum		nd	nd	nd	nd	nd	nd	0.240	nd
		Maximum						4.60	111	0.530	1210
		Median						1.95		0.405	919
		Mean								0.383	
		SD								0.124	
Gardiner Creek	Arctic Grayling	N	7	7	7	7	7	7	7	7	7
		Minimum	nd	nd	nd	nd	nd	nd	nd	0.340	1110
		Maximum						3.61	58	0.899	1274
		Median						2.50	38	0.500	1150
		Mean								0.574	1173
		SD								0.214	65

Appendix D, Table D-2. Metals in fish muscle (cont.).

Site	Species	Statistic	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Mg
Desper Creek	Northern Pike	N	no data	5	5	5	5	5	5	5	5
		Minimum		nd	nd	nd	nd	nd	25	0.280	1470
		Maximum		0.70				10.00	57	1.300	1530
		Median		0.40				2.20	30	0.521	1510
		Mean							35	0.613	1504
		SD							13	0.408	24
Gardiner Creek	Northern Pike	N	no data	2	2	2	2	2	2	2	2
		Minimum		nd	nd	nd	nd	nd	17	0.606	1210
		Maximum							53	1.200	1450
		Median									
		Mean									
		SD									
Moose Creek	Northern Pike	N	5	8	8	8	8	8	8	8	8
		Minimum	nd	nd	nd	nd	nd	nd	12	0.333	1338
		Maximum		1.03	7.14			5.78	65	0.836	1508
		Median		0.75	1.70			2.42	22	0.479	1410
		Mean							34	0.517	1415
		SD							21	0.162	57
Tanana River	Burbot	N	5	10	10	10	10	10	10	10	10
		Minimum	nd	nd	nd	nd	nd	nd	nd	0.310	1119
		Maximum	43.7	0.94				3.83	102	1.300	1318
		Median	11.9	0.65				2.05	38	0.693	1239
		Mean								0.734	1221
		SD								0.340	66
Scottie Creek	Longnose Sucker	N	no data	3	3	3	3	3	3	3	3
		Minimum		nd	nd	nd	nd	nd	49	1.100	1290
		Maximum						2.60	65	1.500	1360
		Median						2.00	56	1.450	1350
		Mean							57	1.350	1333
		SD							8	0.218	38

Appendix D, Table D-2. Metals in fish muscle (cont.).

Site	Species	Statistic	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Mg
Moose Creek	Longnose Sucker	N	no data	1	1	1	1	1	1	1	1
		Minimum		nd	nd	nd	nd	nd	115	0.620	1410
		Maximum									
		Median									
		Mean									
		SD									
Scottie Creek	Humpback Whitefish	N	10	10	10	10	10	10	5	10	10
		Minimum	nd	nd	nd	nd	nd	nd	16.1	nd	12.1
		Maximum	2.00		4.00	2.05	11.70		25.3		31.0
		Median	1.10		2.58	0.44	1.69		19.9		16.0
		Mean							19.9		17.5
		SD							3.9		5.2
Tanana River	Humpback Whitefish	N	5	5	5	5	5	5	no data	5	5
		Minimum	nd	nd	nd	0.71	nd	nd		nd	27.0
		Maximum	1.20			4.90	8.70				34.0
		Median	1.00			0.94	2.80				31.0
		Mean				2.30					30.6
		SD				1.99					2.7
Mirror Creek	Arctic Grayling	N	6	6	6	2	2	4	no data	6	6
		Minimum	nd	nd	nd	nd	nd	nd		nd	nd
		Maximum	2.20			0.68					38.5
		Median	1.70								30.6
		Mean									
		SD									
Gardiner Creek	Arctic Grayling	N	7	7	7	7	7	7	2	7	7
		Minimum	1.56	nd	nd	nd	nd	nd	17.1	nd	15.2
		Maximum	3.30			2.90			21.4		22.0
		Median	1.90			1.10					17.9
		Mean	2.19								18.3
		SD	0.63								2.5

Appendix D, Table D-2. Metals in fish muscle (cont.).

Site	Species	Statistic	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Mg
Desper Creek	Northern Pike	N	5	5	5	5	5	no data	no data	5	5
		Minimum	1.90	nd	nd	nd	nd			nd	17.0
		Maximum	3.70								27.2
		Median	2.40								18.0
		Mean	2.48								20.0
		SD	0.72								4.1
Gardiner Creek	Northern Pike	N	2	2	2	2	2	no data	no data	2	2
		Minimum	1.50	nd	nd	1.20	nd			nd	13.0
		Maximum	1.50			2.70					19.0
		Median									
		Mean									
		SD									
Moose Creek	Northern Pike	N	8	8	8	8	8	5	4	8	8
		Minimum	1.60	nd	nd	nd	nd	nd	21.9	nd	16.0
		Maximum	7.46			2.76	22.10		25.8	8.70	61.0
		Median	3.25			1.37	4.64		23.7	2.41	27.9
		Mean	3.72						23.7		31.1
		SD	1.90						2.0		15.2
Tanana River	Burbot	N	10	10	10	10	10	5	5	10	10
		Minimum	nd	nd	nd	nd	nd	nd	12.2	nd	16.0
		Maximum	1.78		5.10	2.30			23.5	16.00	36.8
		Median	1.50		2.06	1.47			19.7	2.57	18.1
		Mean							18.5		20.4
		SD							4.5		6.2
Scottie Creek	Longnose Sucker	N	3	3	3	3	3	no data	no data	3	3
		Minimum	1.50	nd	nd	nd	nd			nd	15.0
		Maximum	3.20		8.00	0.88				23.00	19.0
		Median	2.00		0.20	0.62				0.30	15.0
		Mean	2.23								16.3
		SD	0.87								2.3

Appendix D, Table D-2. Metals in fish muscle (cont.).

Site	Species	Statistic	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Mg
Moose Creek	Longnose Sucker	N	1	1	1	1	1	no data	no data	1	1
		Minimum	2.10	nd	nd	1.00	nd			nd	18.0
		Maximum									
		Median									
		Mean									
		SD									

Table D-3. Summary statistics for metal concentrations (ppm, dw) in fish livers collected in Tetlin National Wildlife Refuge, 1987-92. Boron, barium, beryllium, chromium, nickel, lead, silver, and thallium were detected in few or no samples.

Site	Species	Statistic	Al	Sb	As	Cd	Cu	Fe	Hg	Mg
Scottie Creek	Humpback Whitefish	N	10	5	10	10	10	10	10	10
		Minimum	3.0	nd	0.20	nd	11.0	167	0.571	457
		Maximum	26.5		0.82		99.6	890	1.900	1090
		Median	7.2		0.38		44.1	393	1.313	782
		Mean					47.9	406	1.295	796
		SD					29.5	223	0.448	194
Tanana River	Humpback Whitefish	N	5	no data	5	5	5	5	5	5
		Minimum	nd		nd	nd	13.0	184	0.670	744
		Maximum	17.0				68.5	639	1.040	919
		Median	11.0				24.5	396	0.935	752
		Mean					34.7	419	0.879	786
		SD					22.1	168	0.161	75
Mirror Creek	Arctic Grayling	N	no data	no data	2	2	2	2	6	2
		Minimum			nd	nd	7.6	594	0.190	nd
		Maximum					9.5	871	0.590	666
		Median							0.305	
		Mean							0.327	
		SD							0.147	
Gardiner Creek	Arctic Grayling	N	7	2	6	7	7	7	2	7
		Minimum	nd	nd	nd	nd	6.7	321	0.630	559
		Maximum	16.0			1.22	11.5	631	0.719	1040
		Median	11.2			0.8	9.7	488	0.675	877
		Mean					9.5	469	0.675	845
		SD					1.7	127	0.063	161
Desper Creek	Northern Pike	N	no data	no data	5	5	5	5	5	5
		Minimum			nd	nd	15.0	264	0.160	478
		Maximum			0.70		598.0	796	0.620	659
		Median			0.40		29.0	465	0.190	528
		Mean					145.7	500	0.266	559
		SD					253.6	192	0.199	72

Appendix D, Table D-3. Metals in fish liver (cont.).

Site	Species	Statistic	Al	Sb	As	Cd	Cu	Fe	Hg	Mg
Gardiner Creek	Northern Pike	N	no data	no data	2	2	2	2	2	2
		Minimum			nd	nd	19.0	146	0.160	319
		Maximum					25.0	184	0.320	475
		Median								
		Mean								
		SD								
Moose Creek	Northern Pike	N	5	4	7	8	8	8	7	8
		Minimum	nd	nd	nd	nd	9.9	89	nd	359
		Maximum	11.8		0.89		189.6	4527	0.74	826
		Median	10.4		0.5		39.7	356	0.12	676
		Mean					64.5	1081		593
		SD					62.2	1517		181
Tanana River	Burbot	N	5	5	10	10	10	10	10	10
		Minimum	nd	nd	nd	nd	7.3	30	nd	161
		Maximum	71.5		7.40	0.92	108.0	539	0.470	707
		Median	7.5		1.10	0.19	33.7	98	0.132	289
		Mean					41.2	163		320
		SD					30.2	151		159
Scottie Creek	Longnose Sucker	N	no data	no data	3	3	3	3	3	3
		Minimum			nd	nd	13.0	180	0.320	610
		Maximum			1.00	0.92	20.3	539	0.370	717
		Median			0.60	0.40	16.0	309	0.340	708
		Mean					16.4	343	0.343	678
		SD					3.7	182	0.025	59
Moose Creek	Longnose Sucker	N	no data	no data	1	1	1	1	1	1
		Minimum			nd	nd	13.0	205	0.170	609
		Maximum								
		Median								
		Mean								
		SD								

Appendix D, Table D-3. Metals in fish liver (cont.).

Site	Species	Statistic	Mn	Mo	Se	Sr	Sn	V	Zn
Scottie Creek	Humpback Whitefish	N	10	10	10	10	5	10	10
		Minimum	3.8	nd	1.79	nd	nd	nd	93.4
		Maximum	10.6		8.22		12.6		168.0
		Median	4.6		3.10		11.0		149.0
		Mean	5.9		3.52				135.6
		SD	2.3		1.78				28.8
Tanana River	Humpback Whitefish	N	5	5	5	5	no data	5	5
		Minimum	4.4	nd	2.60	nd		nd	115.0
		Maximum	6.2		11.00				223.0
		Median	4.9		3.50				211.0
		Mean	5.2		6.26				180.6
		SD	0.7		4.34				51.0
Mirror Creek	Arctic Grayling	N	2	2	2	2	no data	2	2
		Minimum	6.9	nd	4.90	nd		nd	84.1
		Maximum	7.2		28.00				89.0
		Median							
		Mean							
		SD							
Gardiner Creek	Arctic Grayling	N	7	7	6	7	2	7	7
		Minimum	5.4	nd	2.70	nd	nd	nd	81.5
		Maximum	47.1		15.00	6.20	15.9		103.0
		Median	14.0		4.10	1.30			95.5
		Mean	16.9		5.73				92.3
		SD	14.2		4.63				8.5
Desper Creek	Northern Pike	N	5	5	5	5	no data	5	5
		Minimum	3.9	nd	1.70	nd		nd	119.0
		Maximum	5.1		7.40			5.20	333.0
		Median	4.0		2.30				142.0
		Mean	4.3		3.20				174.4
		SD	0.5		2.37				89.5

Appendix D, Table D-3. Metals in fish liver (cont.).

Site	Species	Statistic	Mn	Mo	Se	Sr	Sn	V	Zn
Gardiner Creek	Northern Pike	N	2	2	2	2	no data	2	2
		Minimum	1.7	nd	3.50	nd		nd	58.4
		Maximum	3.3		6.60				61.3
		Median							
		Mean							
		SD							
Moose Creek	Northern Pike	N	8	8	7	8	4	8	8
		Minimum	1.9	nd	2.1	nd	nd	nd	79.3
		Maximum	5.3		13.6		14.3	6.55	277.7
		Median	4.1		4.2		4.3	2.16	166.6
		Mean	3.7		5.8				163.5
		SD	1.4		4.1				72.7
Tanana River	Burbot	N	10	10	10	10	5	10	10
		Minimum	nd	nd	0.78	nd	6.5	nd	36.4
		Maximum	4.3		7.50		17.4		190.0
		Median	1.8		1.75		9.7		64.0
		Mean			2.69		10.9		79.0
		SD			2.26		4.1		46.0
Scottie Creek	Longnose Sucker	N	3	3	3	3	no data	3	3
		Minimum	5.9	nd	2.70	nd		nd	65.3
		Maximum	11.0		3.00				77.0
		Median	8.1		2.90				75.9
		Mean	8.3		2.87				72.7
		SD	2.6		0.15				6.5
Moose Creek	Longnose Sucker	N	1	1	1	1	no data	1	1
		Minimum	5.2	nd	3.20	nd		nd	66.7
		Maximum							
		Median							
		Mean							
		SD							