Characterization of the juvenile fish community in the middle Tanana River near Nenana, AK

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Introduction:

Background

Feasibility and development projects for hydrokinetic devices, which utilize kinetic energy from water to turn a turbine to generate electricity, are being conducted for some rural communities in Alaska to reduce some of the energy demand on diesel generators (Seitz et al. 2011). One of these proposed projects is located in Nenana, AK on the Tanana River where a bottom-mounted turbine will be positioned in the deepest, fastest section of the river (Seitz et al. 2011).

Impacts of hydrokinetic turbines on fishes are poorly understood, especially in large, glacially-influenced systems like the Tanana River (Seitz et al. 2011). To assess the potential impacts of the turbines placed in turbid glacial river systems such as the Tanana River, baseline information about the fish community and its potential overlap with hydrokinetic devices must be examined. To accomplish this, it is necessary to understand the species composition of the fish community and their spatial and temporal patterns of distribution in the river channel.

In this document, we describe a study conducted during the ice-free season in 2011 that examined the spatial and temporal distribution of down-migrating juvenile fishes in the Tanana River.

Tanana River fishes

Adult salmon – Seventeen fish species have been described in the Tanana River, of which three are Pacific salmon species including Chinook salmon (*Oncorhynchus tshawytscha*), two distinct runs of chum salmon (*O. keta*) and coho salmon (*O. kisutch*) (Seitz et al. 2011). These three species of Pacific salmon are very important to commercial and subsistence fisheries (Seitz et al. 2011) and adult ecology of these species is relatively well-described throughout their range.

The range of Chinook salmon extends from Point Hope, AK, south to the Ventura River in southern California. Upstream run timing of adults to spawning grounds is often variable by stock and geographic location (Morrow 1980). Towards the southern end of their range in the Columbia and Fraser Rivers, there are distinct spring and fall runs (Morrow 1980) while further north in the Yukon River there is just one run entering the river in late-May through mid-June where upstream migrations can be 3,000 km (Kocan et al. 2004). Run-timing for adult Chinook salmon in the Tanana River at Nenana, AK occurs July through mid-August (Seitz et al. 2011). In the Tanana River drainage, the Chena and Salcha rivers support the largest Chinook salmon populations (Brase 2009).

The range of coho salmon extends from Point Hope, AK, south to Monterey Bay, California. Adult upstream run timing to spawning grounds occurs in December and January in the southern part of their range, and occurs progressively earlier with increasing latitude (Morrow 1980). Adult coho salmon enter the mouth of the Yukon River in early-August and upstream run timing in the Tanana River at Nenana, AK occurs mid-August to October (Borba 2007). In the Tanana River drainage, they spawn in spring fed tributaries on the south side of the drainage (Parker

2009). One of these spring fed tributaries is the Delta Clearwater River, which supports the largest population of coho salmon in the Yukon River drainage (Parker 2009).

The range of chum salmon extends from the Arctic, south to the Sacramento River in California (Morrow 1980). In most locations, there is a single chum salmon run; however, in the Yukon River and some of its tributaries such as the Tanana River, genetically distinct summer and fall runs occur (Morrow 1980; Gordon et al. 1998). Summer chum salmon enter the mouth of the Yukon River in mid-June through mid-July and upstream run timing in the Tanana River at Nenana, AK occurs July through mid-August (Cappielo and Bromaghin 1997; Borba 2007). Summer chum salmon spawn mainly in runoff tributaries (Flannery et al. 2007) and are generally found in the lower 800 rkm of the Yukon River. Fall chum salmon enter the mouth of the Yukon River in July through early September (Underwood et al. 2007) and occur in the Tanana River at Nenana mid-August through October (Crane and Dunbar 2009; Seitz et al. 2011). Fall chum salmon are larger than summer chum salmon, mainly spawn in spring fed tributaries and are found throughout the Yukon River drainage from the Tanana River to the Yukon River headwaters (Flannery et al. 2007).

Juvenile salmon – While many studies focus on the ecology of adult salmon, much less effort has been dedicated to understanding the ecology of juvenile salmon. Juvenile Chinook salmon are exclusively stream-type in the Tanana River (Seitz et al. 2011). In the Chena and Salcha rivers, two major spawning tributaries in the Tanana River drainage, a majority of Chinook salmon reside in freshwater for one year, sometimes up to two years, before migrating to the ocean (Evenson 2002). Incline plane traps and screw traps operated in the Chena River in the mid-1990's documented the timing of smolt outmigration to be in early-May to mid-June (Lambert 1998; Peterson 1997). Sampling on the river margins of the Tanana River mainstem has resulted in minimal catches of Chinook salmon smolts, which suggests they may be using the mid-channel for down-migration (Seitz et al. 2011).

Like juvenile Chinook salmon, most juvenile coho salmon often reside in freshwater for at least one year before migrating to the ocean (Morrow 1980). In the Tanana River drainage, a majority of coho salmon reside in freshwater for two years (Pearse 1974), but freshwater residency can range from one to three years (Parker 1991; Raymond 1986). Peak outmigration for coho salmon smolts from the Delta Clearwater River occurs in late-April through early-May (Parker 1991) while sampling in the margins of the Tanana River mainstem documented peak outmigration of juvenile coho salmon in mid-May (Hemming and Morris 1999).

In contrast to coho salmon and stream-type Chinook salmon, chum salmon migrate almost immediately to the ocean as age-0 smolts after emergence from the gravel without spending rearing time in freshwater (Bradford et al. 2008). Chum salmon were documented down-migrating from the Delta River, a major tributary and spawning location for fall chum salmon in the Tanana River drainage, beginning early-April (Buklis and Barton 1984). Peaks in outmigration have been documented throughout the Tanana River drainage, typically occurring in May and June (Hemming and Morris 1999; Durst 2001; Francisco 1977), but varies between years based on timing of peak flows (Buklis and Barton 1984). It is likely chum salmon reside in their natal streams until the first high water event, at which time they begin their outmigration (Buklis and Barton 1984).

Other fishes – Five coregonine species have been documented in the Tanana River including inconnu (*Stenodus leucichthys*), round whitefish (*Prosopium cylindraceum*), humpback whitefish (*Coregonus pidschian*), least cisco (*C. sardinella*), and broad whitefish (*C. nasus*) (Brown et al. 2007; Seitz et al. 2011). Coregonine fishes can exhibit a wide variety of life-history traits including both freshwater resident and anadromous behavior (Brown et al. 2007). It is thought that adult coregonines typically make upriver migrations in the summer and early fall to deposit eggs in the gravel bottoms of lakes and clear streams in late fall (Alt 1994). In the Tanana River, whitefishes concentrate in the mainstem and lakes in the fall, both of which are thought to be spawning areas (Seitz et al. 2011). After incubating until spring, the eggs hatch and the fry emerge from the gravel. Age-0 coregonines then migrate to down-river feeding and rearing locations where they remain until reaching sexual maturity (Seitz et al. 2011), but timing of this down-migration has not been documented in the Tanana River.

Arctic grayling occur throughout the tributaries of the Tanana Rivers and often display extensive migrations between spawning, overwintering and feeding areas, depending on age and time of year (West et al. 1992; Seitz et al. 2011). In the Yukon River basin, including the Tanana River, Arctic grayling spawn in tributaries in the spring soon after ice-out and then migrate to summer feeding areas which may involve down-migration of adults in the mainstem of the Tanana River (Seitz et al. 2011). Juvenile Arctic grayling are known to follow the adults during their migration to and from spawning locations, which probably serves as mechanism for imprinting on migration routes (Seitz et al. 2011). During the summer months, juveniles tend to inhabit lower ends of clearwater tributaries while larger adults inhabit the headwaters (Seitz et al. 2011). Migration timing and habitat utilization of the Tanana River mainstem by juvenile Arctic grayling has not been documented.

In addition to salmonids, a variety of freshwater resident species occur in the Tanana River. Burbot (*Lota lota*) are a benthic, piscivorous fish whose distribution ranges widely across Alaska, where they occur in a variety of lakes and rivers in the Tanana River drainage (McPhail and Paragamian 2000). It is thought that in large, glacial rivers, burbot migrate and spawn in the main river channel during winter and are mainly sedentary during the remainder of the year (Breeser et al. 1988). Northern pike (*Esox lucius*) are a top level predator and are typically found in slow moving water with aquatic vegetation (Muhlfeld et al. 2008), as found in Minto Flats in the Tanana River drainage. Radio tagged northern pike in Minto Flats showed extensive seasonal movements, some of which overwintered in the Tanana River mainstem (Burkholder and Bernard 1994). Migration timing and habitat utilization of the Tanana River mainstem by juvenile burbot and northern pike has not been documented.

Lake chub (*Cousius plumbeus)*, longnose sucker (*Catostomus catostomus)*, and slimy sculpin (*Cottus cognatus)* are widely abundant resident species in the Tanana River and are important forage species for other fishes, as well as birds and mammals (Seitz et al. 2011). River margin sampling studies using minnow traps, seines, and electroshocking in the Tanana River have consistently found these three species to be the most common fishes (Mecum 1984; Ott et al. 1998). Both lake chubs and longnose suckers make migrations up small streams to spawn in the spring (Scott and Crossman 1973). In contrast to lake chubs and longnose suckers, it is thought

that sculpins do not undertake migrations as it is a relatively poor swimming fish (Mansfield 2004a).

Lampreys (*Lampetra* spp.) are a group of jawless fishes that exhibit both anadromous and freshwater life-history forms in Alaska (Mansfield 2004b). Lampreys typically spawn in the spring in stream headwaters (Mansfield 2004b). One to two weeks after spawning, the eggs hatch into a larval form called ammocoetes which burrow in soft substrates and filter feed for three to seven years (Mansfield 2004b). After the ammocoete stage, they metamorphose into adults and the anadromous form migrates to the ocean to feed for up to two years (Mansfield 2004b). Migration timing and habitat utilization of the Tanana River mainstem by lamprey ammocoetes has not been documented.

Objectives

Although previous studies have described the juvenile fish community in the river margins in a few locations along the Tanana River (Mecum 1984; Ott et al 1998; Hemming and Morris 1999), there have not been any studies conducted that sampled juvenile fishes in the middle of the river channel, nor has there been a comprehensive study conducted in the Tanana River at Nenana describing the temporal and spatial patterns in down-migration of juvenile fishes. Because down-migrating juvenile fishes are small and relatively weak swimmers, they may use the highest velocity area of the river channel to conserve energy during down-migration. This is exactly the location where hydrokinetic devices are typically deployed; therefore, it is imperative to study river channel and habitat use by these fishes. The potential impacts of a hydrokinetic device will likely be relatively small if down-migrating juvenile fishes mostly use river margins rather than the middle of the channel. Conversely, potential impacts may be more substantial if juvenile fishes are utilizing the middle of the river as a down-migration corridor as they may pass through the turbine. Therefore, the goal of this study was to provide baseline information about habitat utilization by fishes in the mainstem of the Tanana River before deployment of a hydrokinetic turbine. To achieve this goal, two objectives were accomplished:

1. Characterize the juvenile fish community, including species composition, relative abundance and age, in the mainstem of the Tanana River near Nenana, AK

2. Characterize the spatial and temporal patterns of downstream juvenile fish migration and determine environmental correlates to migration

To accomplish these objectives, we aimed to sample juvenile fishes in the mid-channel and river margins of the Tanana River near Nenana, AK, during the majority of the ice-free season of 2011. In addition to fish sampling, a suite of environmental variables was collected throughout the sampling season.

Methods:

2011 Nenana Sampling

Study area – The Tanana River is the largest tributary to the Yukon River with the drainage covering approximately 115,250 km^2. It flows 1,000 km from its headwaters to the confluence of the Yukon River (Borba 2007) and Nenana, AK, is located approximately 260 km upstream of this confluence (Seitz et al. 2011). The Tanana River is glacially influenced and has high glacial sediment load during the summer months (Durst 2001).

Fish sampling – Fish sampling was conducted in the vicinity of Nenana, AK, in two distinct river habitats: the river margins and the mid-channel. River margin sampling was accomplished using fyke nets with 4'x4' frames and dual 30' wings (Figure 1) at one location on each river bank (Figure 2). To modify our gear to fish in the strong current of the Tanana River without allowing fish to bypass the net, 15' of heavy duty chain was attached to the lead line of each wing to keep the lead line on the river bottom. Additionally, buoys were attached to the float line on the offshore wing to keep the float line near the river surface. These modifications reduced the chance of fish swimming above or below the wings of the fyke net. The near-shore wing was attached to a piece of iron rebar that was driven into the riverbed, and the far wing was attached to a 30 lb. anchor placed on the riverbed. At the downstream end of the fyke net was a live box that provided the captured fish refuge from the strong currents of the river. Fyke net sampling began on 12 May and continued through 28 August 2011, the target duration was 30 minutes per set and the target number of sets per day was six.

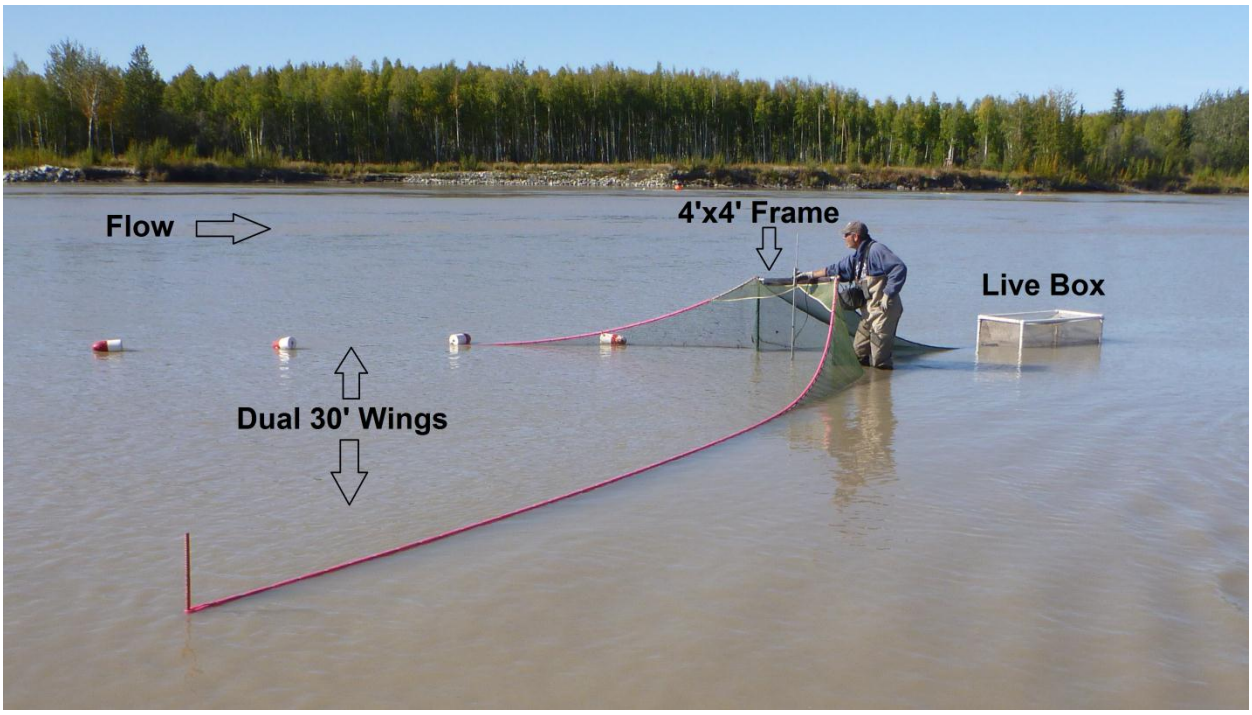

Figure 1. Fyke net set on river margin of Tanana River at Nenana, AK.

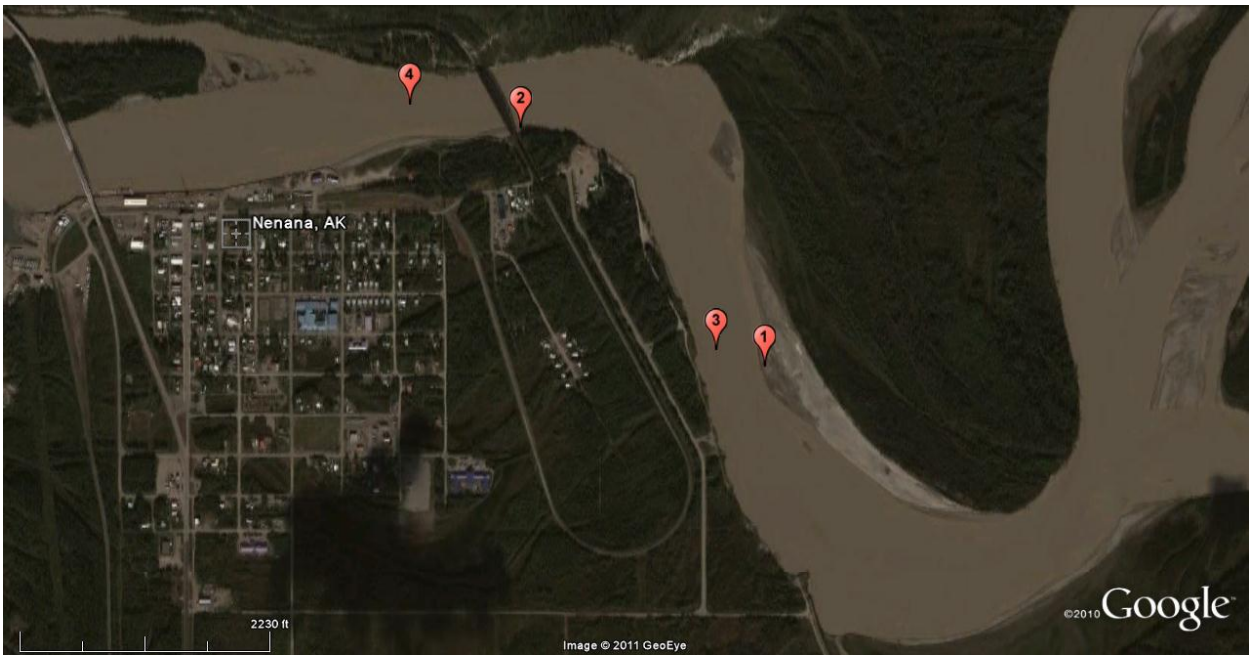

Figure 2. River margin sampling sites (1 and 2) and mid-channel sampling sites (3 and 4) in the Tanana River at Nenana, AK.

Mid-channel sampling was accomplished using two pieces of equipment, an incline plane trap and a modified frame trawl. The incline plane trap was attached to a mooring buoy, in the deepest, fastest portion of the river (Figure 3) in two primary mid-channel locations (Figure 2). The inclined plane trap consisted of two major sections: the trap and the live box (Todd 1994). The trap's front opening was 42" high by 60" wide and the overall length of the trap was 96". When the inclined plane screen trap was lowered into the current, the top 42" of the water column was strained through screens in the opening of the trap and downstream migrants were swept up the screen incline and deposited into a protected, solid-sided and floored live box at the back of the apparatus. The back of the live box contained a sliding door to quickly release captured fish and to facilitate cleaning. Sampling with the incline plane trap began 20 May and continued through 18 August 2011. The target sampling duration was one hour per set and the target number of sets per day was three. When not in use, the incline plane trap was pulled to the river margins to prevent damage from river debris.

Figure 3. Incline plane trap used for sampling the top 42” of the mid-channel of the Tanana River at Nenana, AK.

The second mid-channel sampling method was a modified frame trawl which was deployed off of a pontoon barge moored in the mid-channel (Figure 4) at sampling site 4 (Figure 2). Our method is a modified version of a similar configuration that was used in the Hanford Reach of the Columbia River (Figure 5; Dauble et al. 1989). The frame trawl was outfitted with a steel “live-box” cod-end equipped with a Parker Protection Cone (PPC) designed to deflect the strong water current from entering the live box and to reduce hydrodynamic force on the net. The cod-end was removable to facilitate fish sorting on the pontoon barge.

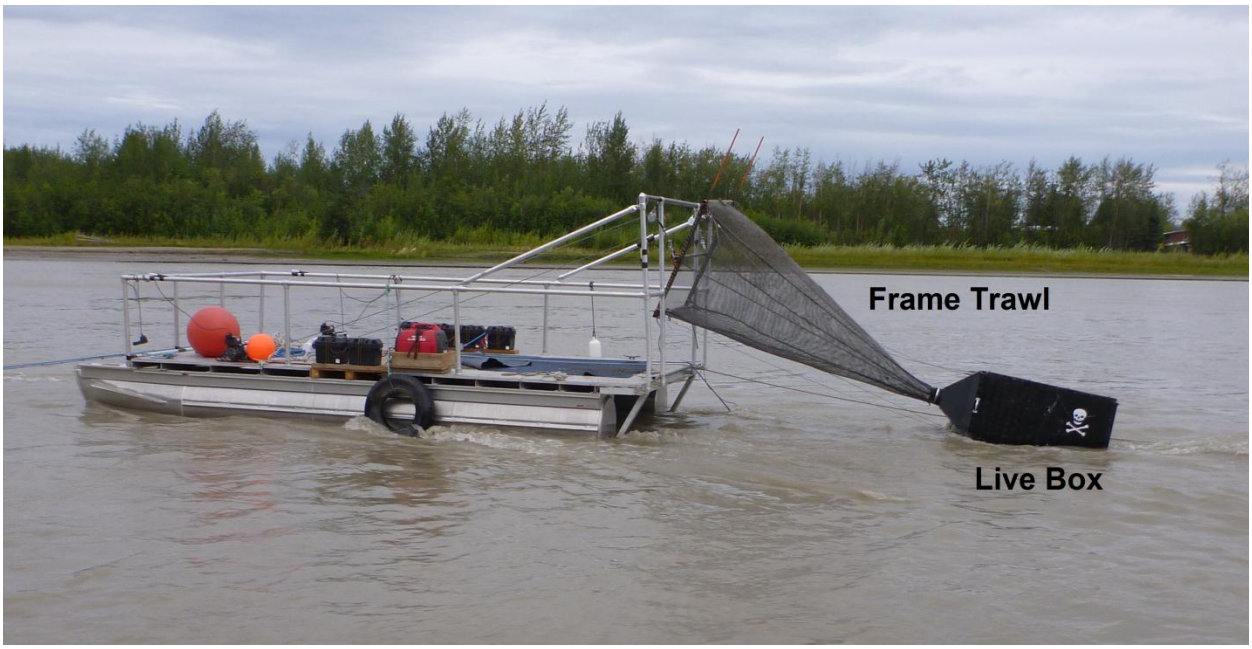

Figure 4. Pontoon barge with frame trawl used for sampling the entire water column in the mid-channel of the Tanana River at Nenana, AK.

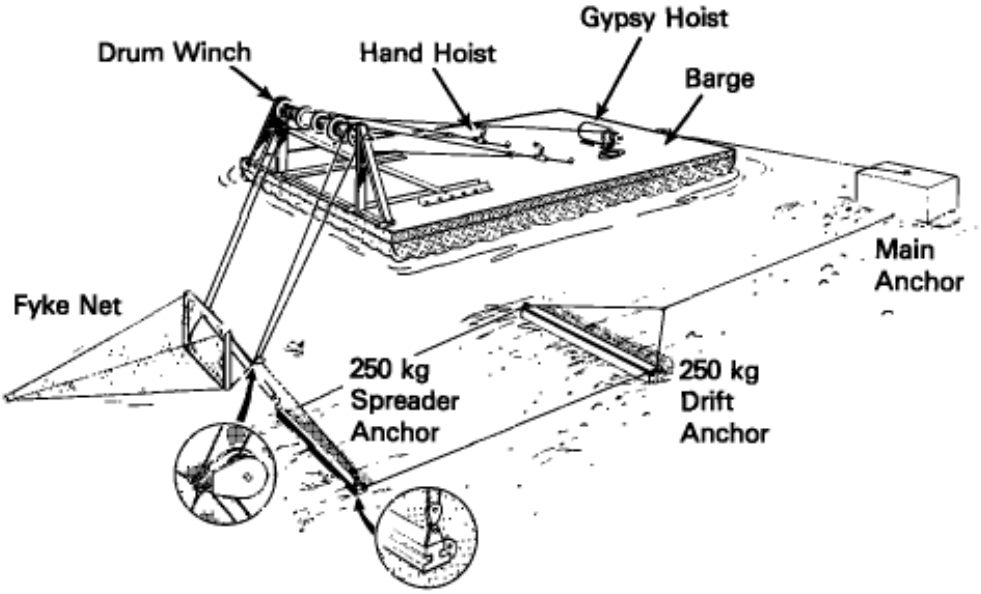

Figure 5. Modified frame trawl net deployed from a mid-channel sampling platform (figure from Dauble et al. 1989).

For deploying the frame trawl, we utilized a 300 lb. I-beam anchor (spreader anchor; Figure 5) positioned directly underneath the pontoon barge. In the center of the I-beam anchor was a swivel pulley through which a 200 ft. section of rope was fixed. For each frame trawl deployment, we attached one end of the rope to the frame trawl and the other end to a capstan

winch on the pontoon barge. By pulling this rope with the capstan winch, the frame trawl was pulled down towards the pulley on the I-beam spreader anchor. Concurrently, two 8,000 lb. winch cables which were attached directly to the frame trawl for retrieval purposes, were deployed (Figure 6). With this configuration of cables, ropes and winches, this system was capable of sampling the entire water column from the surface of the river to the bottom substrate (Figure 7). It was determined that the sampling net was on the river bottom when both winch lines were slack and all tension was on the rope fixed through the spreader anchor pulley. For retrieval, the two winches pulled in the frame trawl while the rope was slowly released from the capstan winch through the pulley on the spreader anchor. Sampling with the frame trawl began 18 August and continued through 24 August 2011. The target duration was ten minutes per set and target number of sets per day was three. After each set, the rope was detached from the frame trawl and capstan winch, each end of the rope fixed with a buoy, and both buoys were released into the river. When not in use, the pontoon barge was pulled to the river margins to prevent damage from river debris.

Margin and mid-channel sampling was conducted six days per week and starting times were randomly stratified over a 24 hr period. Fyke nets sets at both river margin locations immediately followed one another, and when the incline plane trap was in operation, this sampling was conducted concurrent to both fyke net sets. Frame trawl sampling was sporadic and opportunistic, therefore did not follow a regular pattern. Sampling was not conducted on Mondays, during which time supplies were obtained and maintenance was conducted.

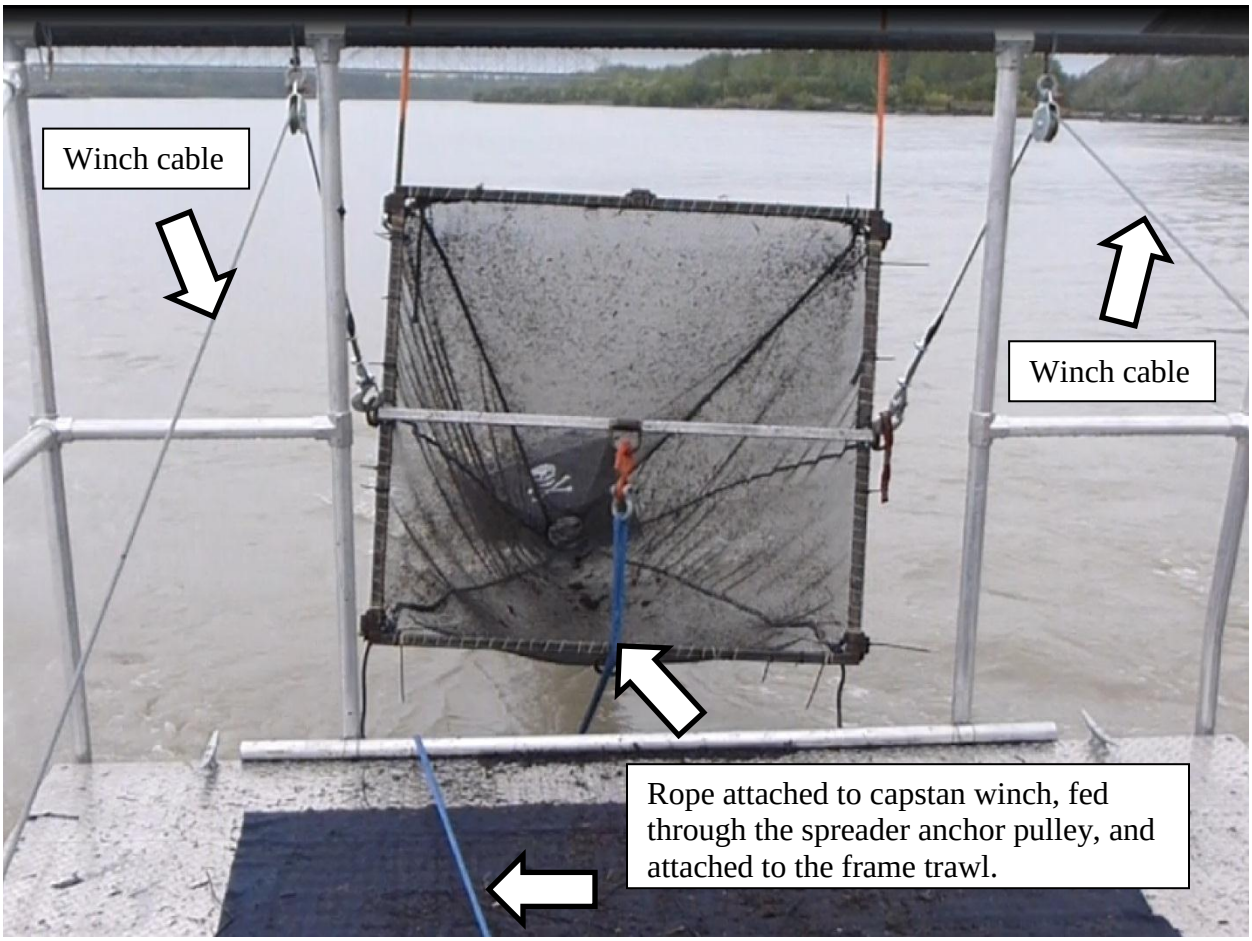

Figure 6. Frame trawl pre-deployment behind the pontoon barge in the mid-channel of the Tanana River at Nenana, AK.

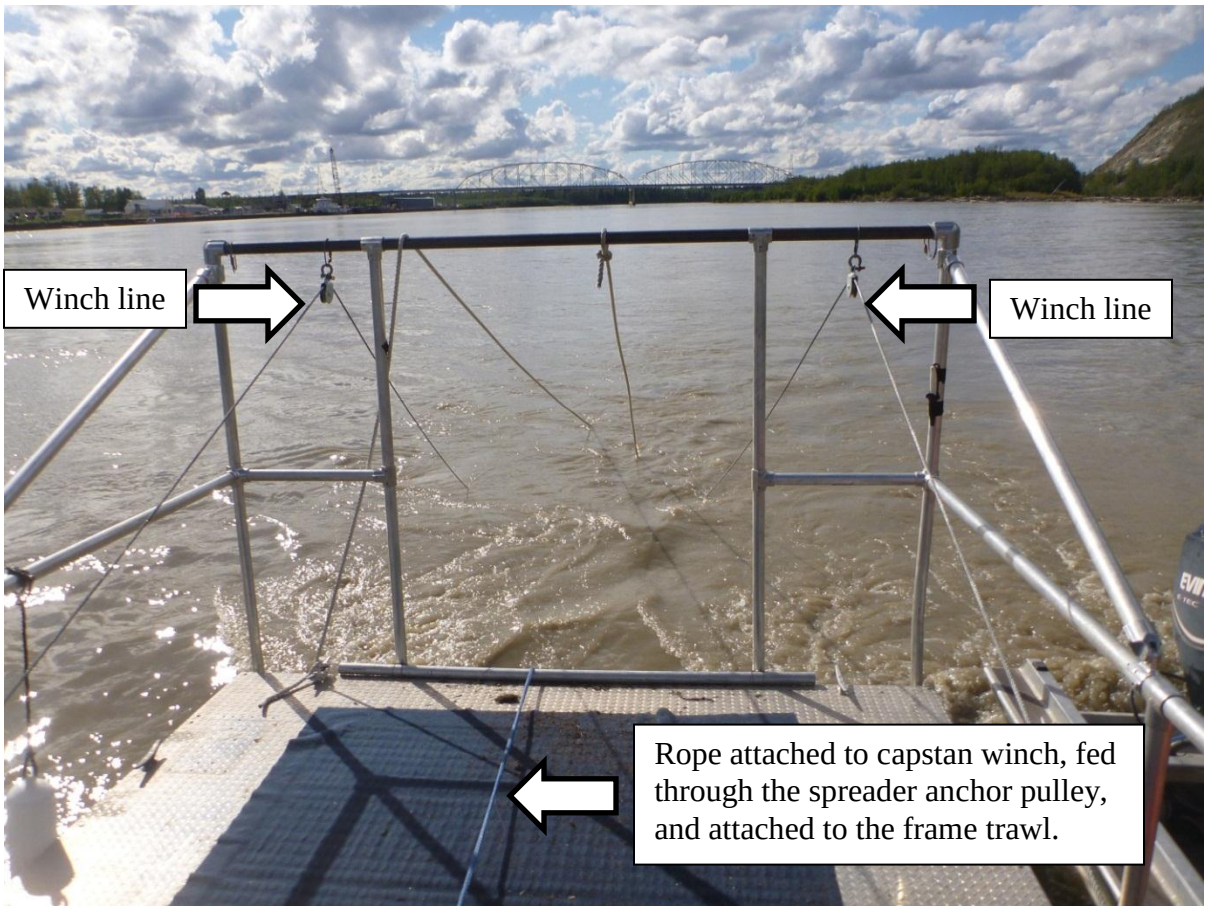

Figure 7. Frame trawl deployed from the pontoon barge sampling the bottom of the water column in the mid-channel of the Tanana River at Nenana, AK.

All captured fish were identified to the lowest taxonomic level, measured for fork length and released alive, except for two voucher specimens of a few species that were retained. Additionally, 46 Arctic lamprey and 2 Alaskan brook lamprey were transported live to an aquarium at the University of Alaska Fairbanks, under Permit Number SF2011-181 (P.I. Michael Harris). Because of difficulty in identifying different species of juvenile whitefishes and distinguishing between Chinook and coho salmon smolts, all were grouped into a general whitefishes or a Chinook/coho salmon category. All catch data was converted into catch-per-unit-effort (CPUE), expressed as the number of fish captured per m^3 of water filtered by the sampling devices. For graphical purposes, CPUE was square root transformed to down-weight large CPUE values which may mask smaller, but potentially significant peaks in CPUE. Additionally, when overall mean CPUE was calculated for each species, it was multiplied by 1,000 to reduce excessive decimal places as values were extremely small.

Environmental variables – During each sampling event, we measured water temperature and determined the Parker Index, which was a visual count of the number of individual Surface Hydrokinetic Interference Debris (SHID) floating by in a five minute period. SHID was classified in one of three categories based on size: Type 1 – debris that is small enough to pick up; Type 2 – debris that is too large to pick up, but too small to ride as a raft; and Type 3 – debris that is large enough for one person to ride down the river. All SHID captured in the sampling

gear was placed on a 1-m^2 white board and photographed. Additionally for each fyke net set, water velocity at the net opening, depth of net and distance of net and wings from shore were measured. For each incline plane trap and frame trawl set, water velocity 0.64 m beneath the surface was measured in front of the sampling device. Turbidity was measured daily in the middle of the river channel using a Secchi disk and river discharge data were obtained from the US Geological Survey gauging station in Nenana (http://waterdata.usgs.gov/ak/nwis/uv?site_no=15515500).

Results

Fyke net sampling

A total of 384 fyke net sets was made from 12 May to 28 August 2011 (4.2/day ± 1.7 [mean ± 1 SD], range 1–7) with an evenly stratified sampling schedule over a 24 hr. time period (Figure 8). The duration of each fyke net set (30 ± 3 minutes, range 24–60 min) was fairly consistent.

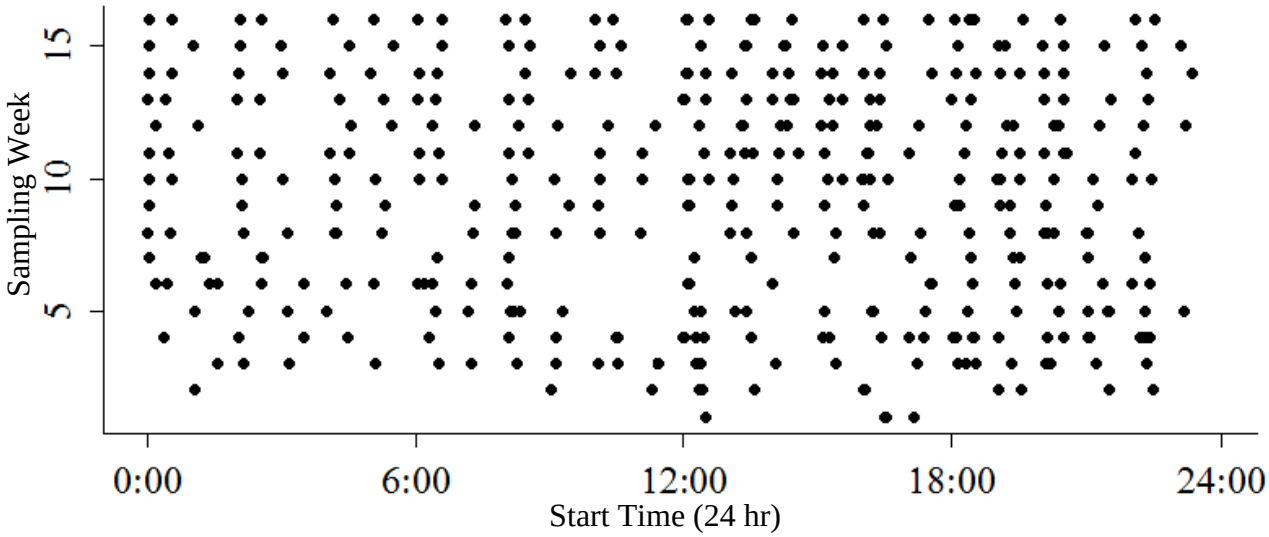

Figure 8. Start time for each fyke net set by sampling week.

Abundance and CPUE – A total of 4,136 fishes was captured in the river margins which included 22 Chinook/coho salmon, 775 chum salmon, 1,589 whitefishes, 31 Arctic grayling, 1,000 longnose suckers, 4 slimy sculpin, 131 Arctic lamprey, 2 Alaskan brook lamprey, 559 lake chub, 22 burbot and 1 northern pike (Table 1).

Table 1. Total catch, mean length (mm) ± 1 SD (range) and mean CPUE ± 1 SD (#fish/m^3 x 1000) for each fish species captured in the river margins of the Tanana River at Nenana, AK.

Fish species	Total	Mean length (mm) ± 1 SD (range)	Mean CPUE ± 1SD
Chinook/Coho salmon	22	68.3 ± 11.3 (35–81)	0.03 ± 0.20
Chum salmon	775	36.2 ± 2.5 (27–48)	1.07 ± 3.01
Whitefishes	1589	40.6 ± 29.5 (21–510)	4.15 ± 14.12
Arctic grayling	31	70.8 ± 37.6 (37–201)	0.06 ± 0.24
Longnose sucker	1000	65.6 ± 52.0 (22–460)	1.49 ± 3.85
Slimy sculpin	4	55.5 ± 15.6 (40–81)	0.006 ± 0.06
Arctic lamprey	131	117.6 ± 33.4 (42–350)	0.18 ± 0.54
Alaskan brook lamprey	2	132.5 ± 7.5 (125–140)	0.002 ± 0.04
Lake chub	559	53.0 ± 17.6 (24–152)	1.04 ± 2.35
Burbot	22	301.9 ± 99.9 (60–450)	0.07 ± 0.41
Northern pike	1	600	0.001 ± 0.03

Down-migration timing – Several species of fish displayed one or several peaks in down-migration abundance. Juvenile chum salmon were captured from our first day of sampling until early-July, with a majority of the catches occurring in May (Figure 9). Whitefishes showed the largest peak in CPUE in mid/late-June, after which they were captured less frequently (Figure 9). Longnose suckers were captured from the first through the last day of sampling with a large peak in CPUE in early-June (Figure 9). Lake chubs were also captured from the first through the last day of sampling with a large peak in CPUE in mid-May (Figure 9). In contrast to the previously described species, the remaining species did not display temporal trends in CPUE as their frequency of occurrence was too small to elucidate migration patterns (Figure 9). Additionally, diel patterns based on CPUE for each fyke net setting was not evident in the species captured (Figure 10).

Trends in size – Burbot (301.9 mm ± 99.9 (1 SD)), Arctic lamprey (117.6 mm ± 33.4 (1 SD)) and Alaskan brook lamprey (132.5 mm ± 7.5 (1 SD)) had the largest mean lengths while chum salmon (excluding two adults) (36.2 mm ± 2.5 (1 SD)) and whitefishes (40.6 mm ± 29.5 (1 SD)) had the smallest mean lengths (Table 1 and Figure 11). Other captured fishes included Chinook/coho salmon (68.3 mm ± 11.3 (1 SD)), Arctic grayling (70.8 mm ± 37.6 (1 SD)), longnose sucker (65.6 mm ± 52.0 (1 SD)), slimy sculpin (55.5 mm ± 15.6 (1 SD)), lake chub (53.0 mm ± 17.6 (1 SD)) and one northern pike (600 mm) (Table 1). Aside from burbot and lamprey, most of the fish captured were less than 100 mm FL (Figure 11). Of all of the captured species, only whitefishes showed a growth trend over the sampling season. The weekly mean lengths of juvenile whitefishes beginning in week four, increased from 31.3 mm ± 25.7 (1 SD) to 92.3 mm ± 53.8 (1 SD) ($p<0.0001$) by the end of the sampling season (Figure 12). For the remainder of the species, the weekly mean lengths did not significantly increase ($p >0.05$) as the summer progressed (Figure 12).

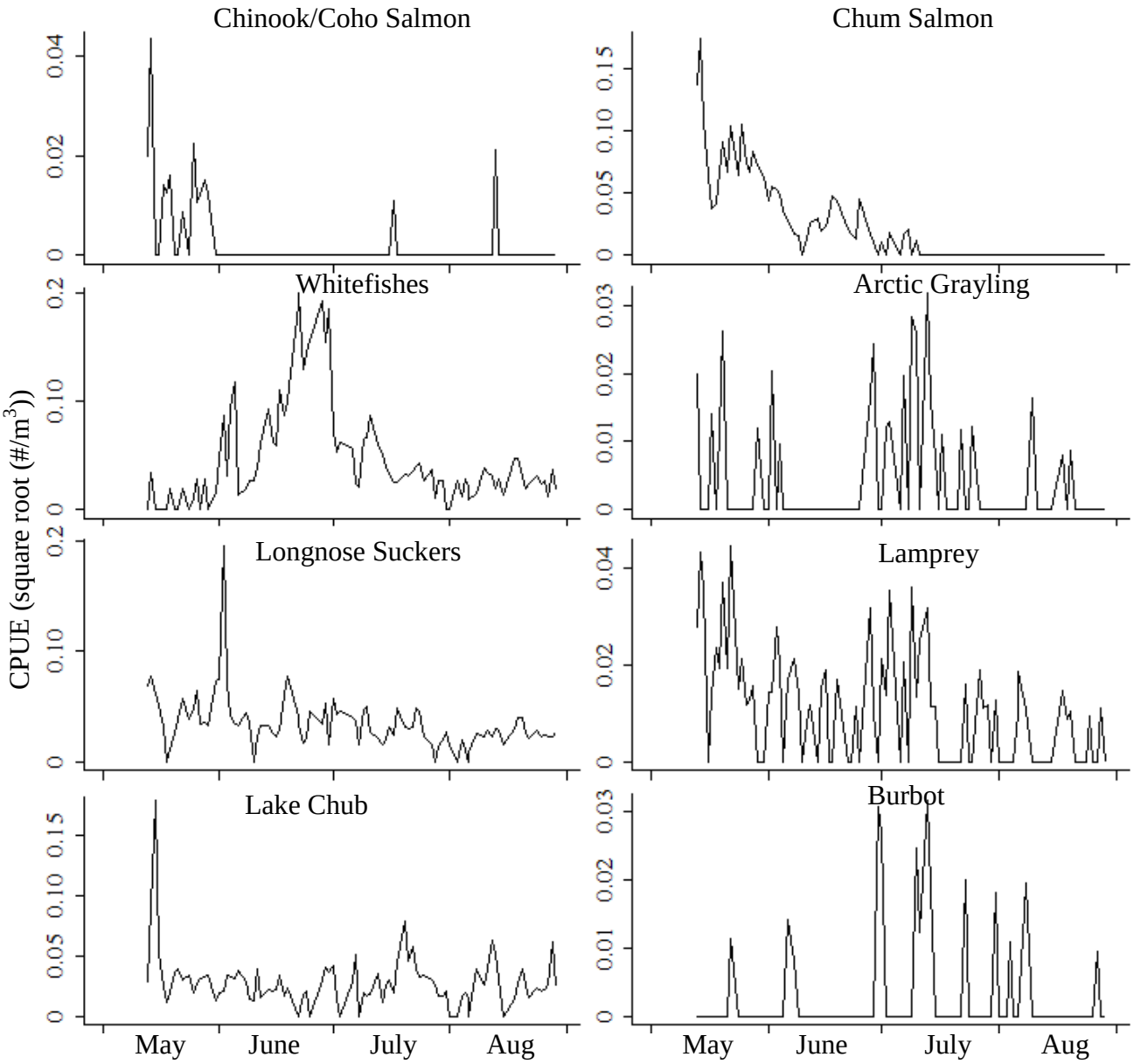

Figure 9. Daily mean CPUE (square root (#fish/m^3)) of eight commonly captured species in the river margins of the Tanana River at Nenana, AK. Note that the scales of the vertical axes are not identical.

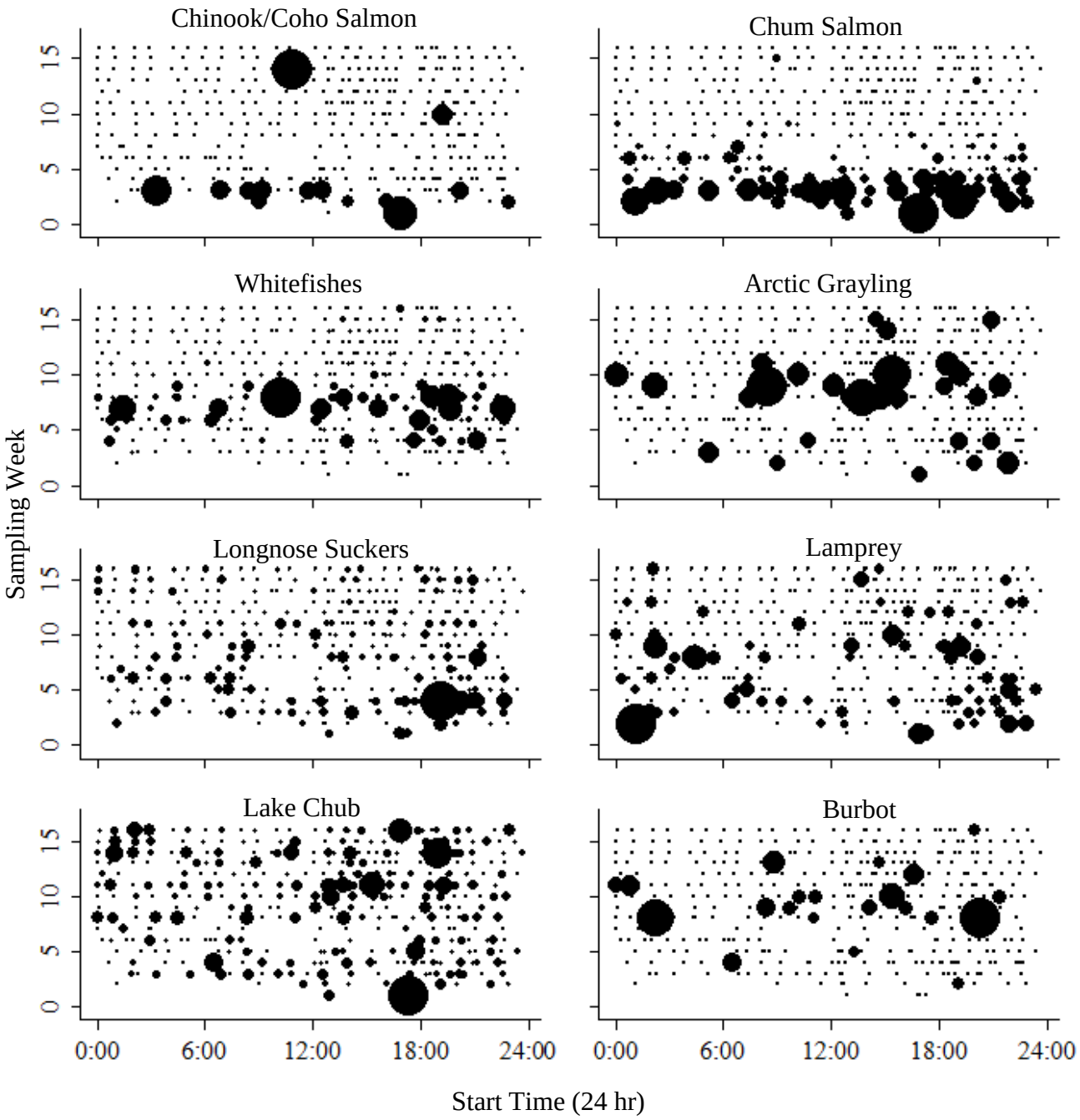

Figure 10. Relative CPUE (square root (#fish/m^3)) of eight commonly captured species for each fyke net set in the river margins of the Tanana River at Nenana, AK. Each circle represents a fyke net set. The smallest circles represent zero catches while larger circles represent larger CPUE.

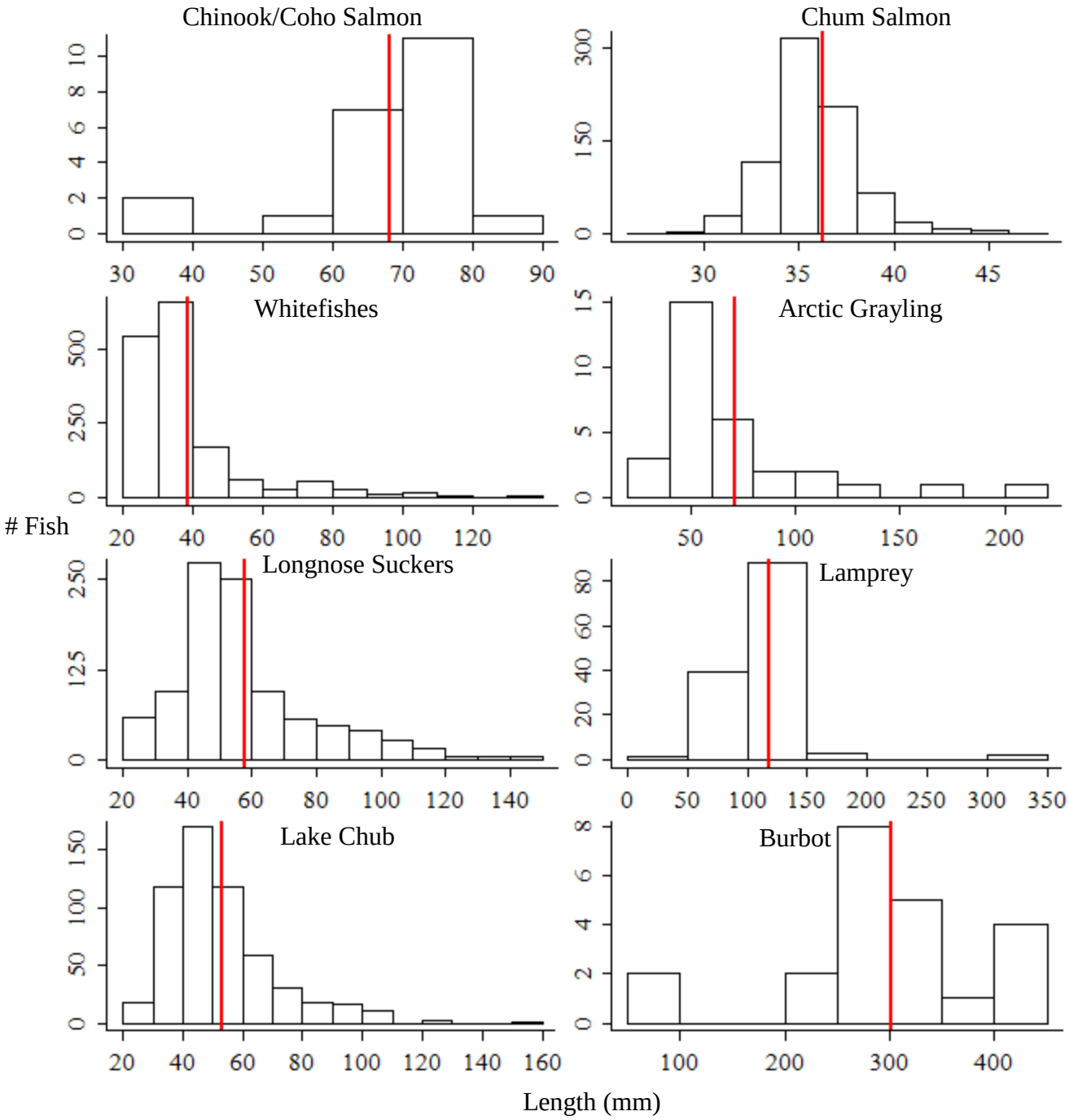

Figure 11. Length-frequency distributions with mean length (red line) of eight commonly captured species in the river margins of the Tanana River at Nenana, AK. Note that the scales of the horizontal and vertical axes are not identical. Whitefishes and longnose suckers ≥150 mm were considered outliers so only lengths <150 mm are included to highlight length frequencies of juveniles.

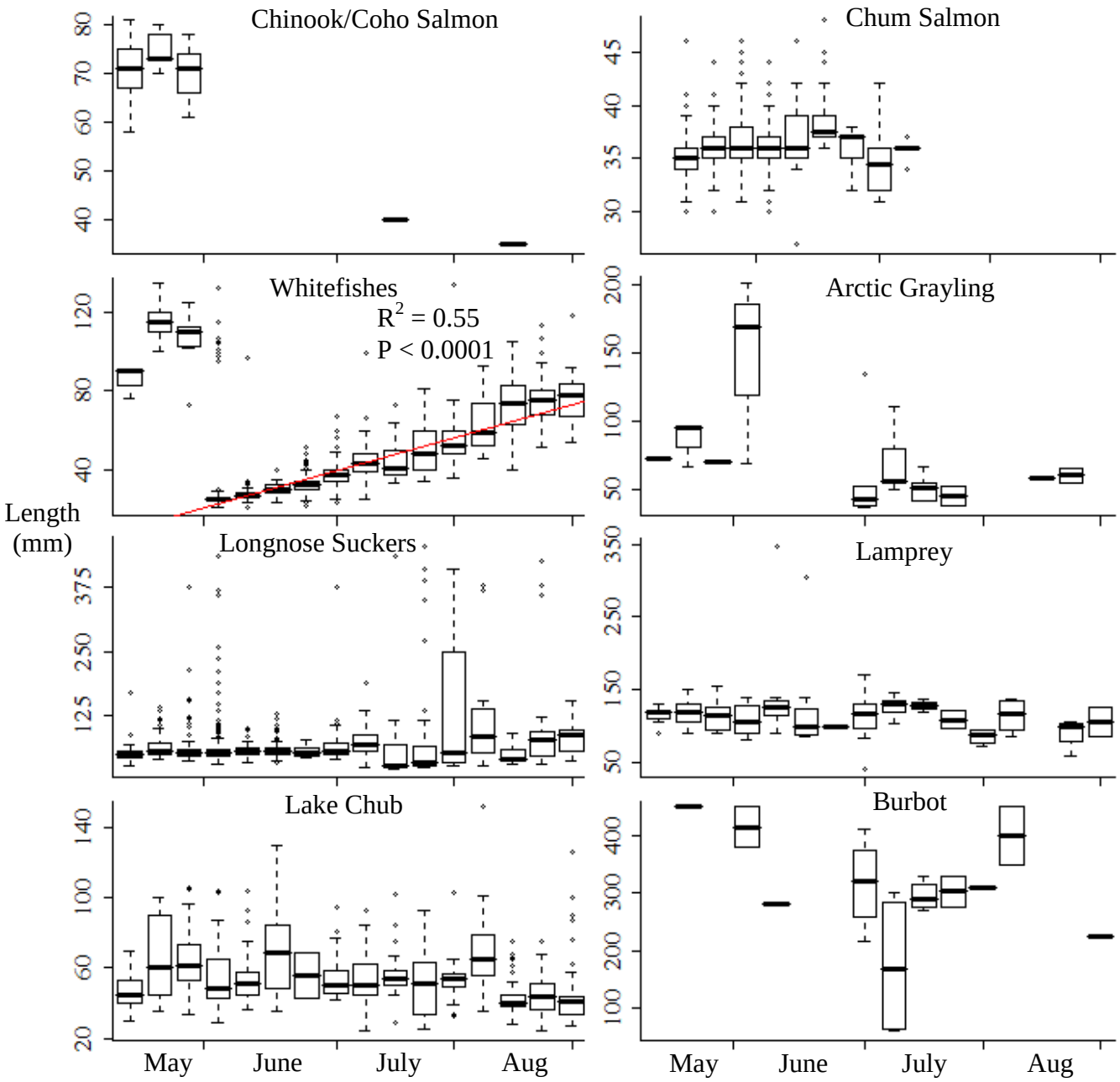

Figure 12. Weekly length box-plots of eight commonly captured species in the river margins of the Tanana River at Nenana, AK. The dimensions of the boxes represent the 25th and 75th percentiles, the lines within the boxes the medians, and the error bars the 10th and 90th percentiles. Individual points represent outliers. Note that the scales of the vertical axes are not identical. Whitefishes ≥ 150 were considered outliers so only lengths <150 mm are included to highlight the length trend from week four to week sixteen.

Incline plane trap sampling

A total of 73 incline plane trap sets was made from 20 May to 18 August 2011 (2/day ± 0.7, range 1–3) with a nearly evenly stratified sampling schedule over a 24 hr time period (Figure 13). Because of several major repairs that were required on the incline plane trap, it was out of commission from late-June through late-July (Figure 13). Sampling was conducted strictly at location 3 until 13 August, at which time sampling was conducted strictly at location 4 (Figure 2). The duration of each incline plane trap set (63 ± 23 minutes, range 20–160 min) varied depending on duration of concurrently set fyke nets.

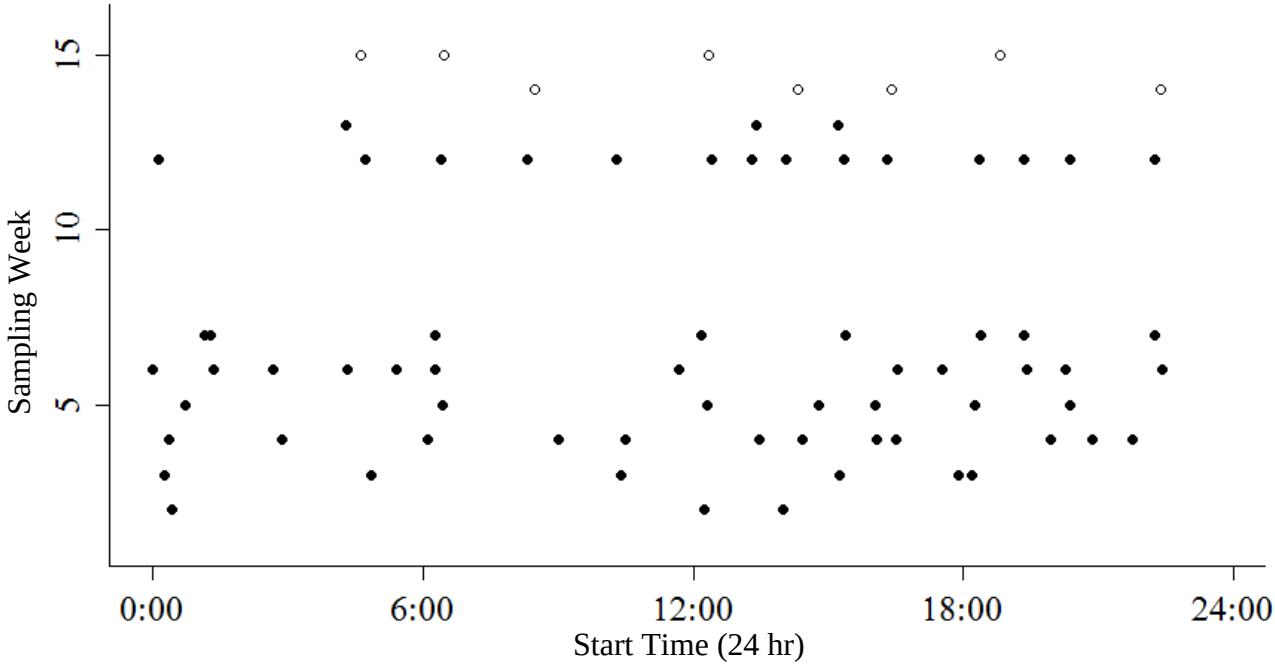

Figure 13. Start time for each incline plane trap set by sampling week at location 3 (solid) and location 4 (open).

Abundance and CPUE – A total of 583 fishes was captured in the surface of the mid-channel which included 330 Chinook/coho salmon, 239 chum salmon, 10 whitefishes, 3 Arctic lamprey, and 1 burbot (Table 2).

Table 2. Total catch, mean length (mm) ± 1 SD (range) and mean CPUE ± 1 SD (#fish/m^3 x 1000) for each fish species captured in the surface of the mid-channel in the Tanana River at Nenana, AK.

Fish species	Total	Mean length (mm) ± 1 SD (range)	Mean CPUE ± 1 SD
Chinook/Coho salmon	330	80.7 ± 9.3 (61–114)	0.53 ± 0.78
Chum salmon	239	41.7 ± 5.0 (32–54)	0.40 ± 0.62
Whitefishes	10	29.7 ± 4.8 (23–35)	0.02 ± 0.08
Arctic lamprey	3	297.3 ± 96.5 (162–380)	0.003 ± 0.02
Burbot	1	155	0.01 ± 0.01

Down-migration timing – Both Chinook/coho salmon and chum salmon showed peaks in CPUE in late-May and mid-June (Figure 14). After repairs were completed in late-July, no more Chinook/coho salmon or chum salmon were captured in the mid-channel. In contrast to Chinook/coho salmon and chum salmon, the other species captured in the mid-channel did not display temporal trends in CPUE as their frequency of occurrence was too small to elucidate migration patterns. Additionally, diel patterns based on CPUE for each incline plane trap setting were not evident in Chinook/coho salmon or chum salmon (Figure 15).

Trends in size – Chinook/coho salmon (80.7 mm ± 9.3 (1 SD)) had a relatively large mean length compared to chum salmon (41.7 mm ± 5.0 (1 SD)) (Table 2 and Figure 16). Other captured fishes include whitefishes (29.7 mm ± 4.8 (1 SD)), Arctic lamprey (two of which were adults) (297.3 mm ± 96.5 (1 SD)) and one burbot (155 mm). Neither Chinook/coho salmon nor chum salmon showed trends in growth during the six weeks in which they were captured (Figure 17). For the remainder of the species, the weekly mean lengths did not significantly increase as their frequency of occurrence was too small to elucidate trends in size.

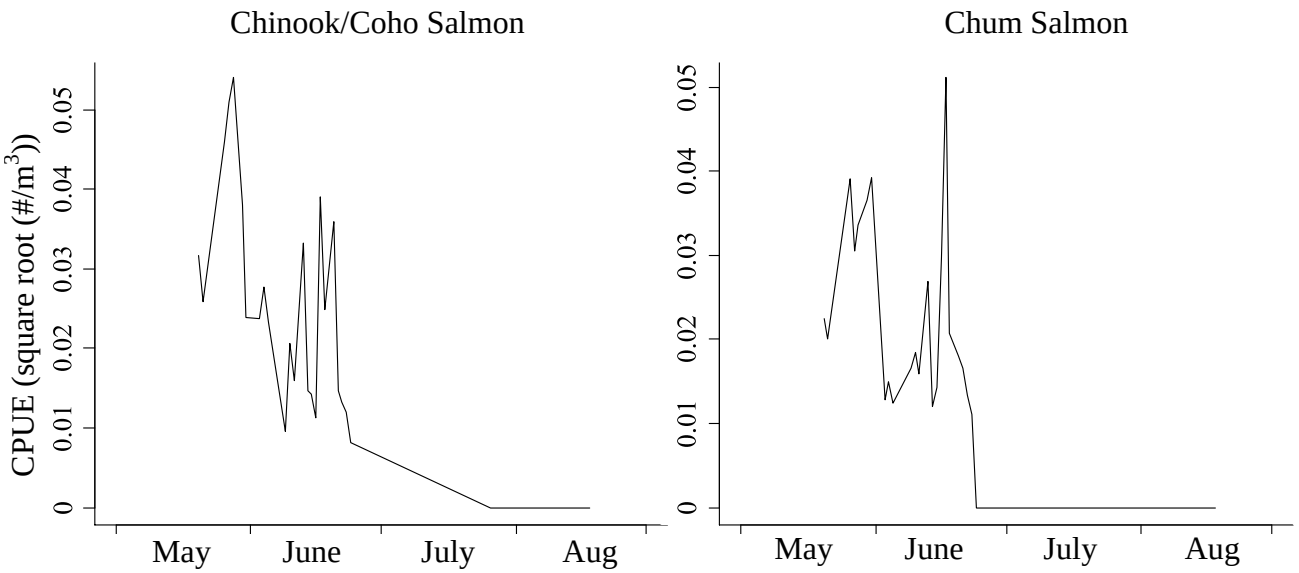

Figure 14. Daily mean CPUE (square root (#fish/m^3)) of two commonly captured species in the surface of the mid-channel of the Tanana River at Nenana, AK. Note that the scales of the vertical axes are not identical.

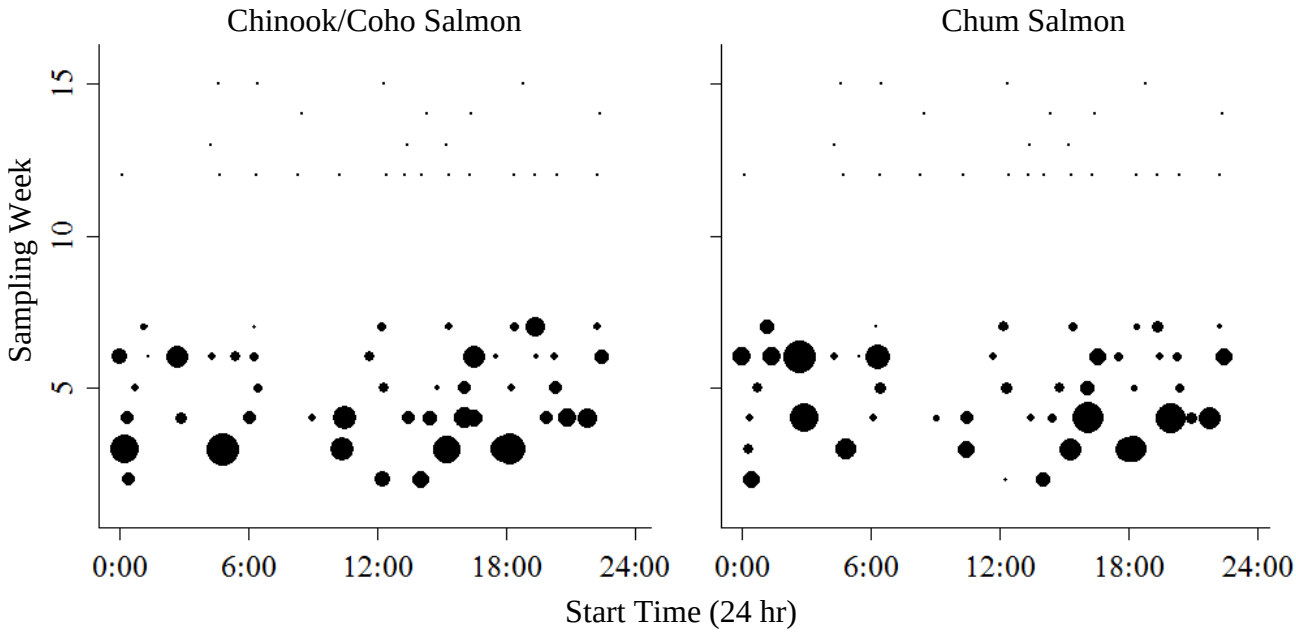

Figure 15. Relative CPUE (square root (#fish/m^3)) of two commonly captured species in the surface of the mid-channel of the Tanana River at Nenana, AK. Each circle represents an incline plane trap set. The smallest circles represent zero catches while larger circles represent larger CPUE.

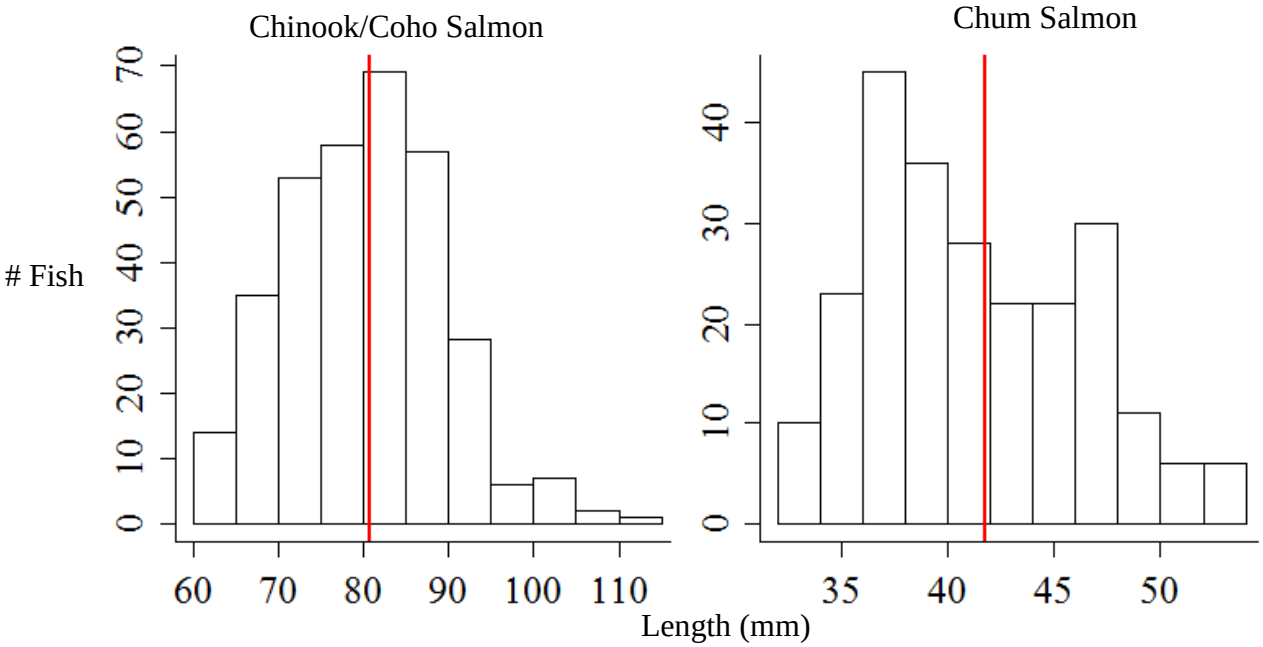

Figure 16. Length-frequency distributions with mean length (red line) of two commonly captured species in the surface of the mid-channel of the Tanana River at Nenana, AK. Note that the scales of the horizontal and vertical axes are not identical.

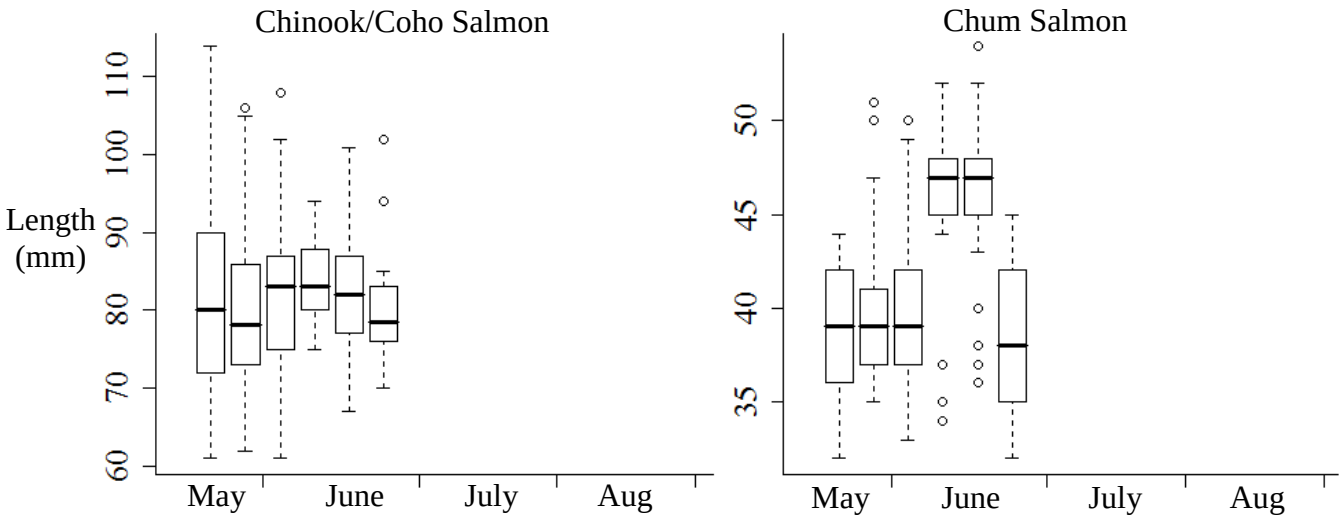

Figure 17. Weekly length box-plots of two commonly captured species in the surface of the mid-channel of the Tanana River at Nenana, AK. The dimensions of the boxes represent the 25th and 75th percentiles, the lines within the boxes the medians, and the error bars the 10th and 90th percentiles. Individual points represent outliers. Note that the scales of the vertical axes are not identical.

Frame trawl sampling

A total of six frame trawl sets was made from 18 August to 24 August 2011. The duration of each frame trawl set averaged 11 ± 2 minutes (1 SD) and ranged from 10 to 15 minutes at location 4 (Figure 2). Sets were either made in the top or bottom of the water column (Table 3) and were short in duration because of the large amounts of small debris that clogged the throat of the frame trawl net (Figure 18).

Table 3. Number of frame trawl sets per depth of water column.

Water column depth	Top	Middle	Bottom
Number of sets	2	0	4

Figure 18. Small debris captured in the frame trawl net during a 10 minute set at the bottom of the water column in the Tanana River at Nenana, AK.

Environmental Variables

Turbidity was relativity high when measurements began on 12 May 2011. Turbidity immediately began decreasing until late-May, at which time it quickly increased and remained relativity turbid throughout the remainder of the sampling period (Figure 19). Mean daily water temperatures ranged from 5.2 to 16.8°C with a mean of 13.7°C ± 1.7 (1 SD). Water temperature showed an increasing trend until late-May, fluctuated between 13°C and 16°C until late-July, then began decreasing (Figure 19). Discharge of the Tanana River exhibited an increasing trend until it peaked in early-July, then a slight decreasing trend through the end of the sampling period (Figure 19). The daily mean of the Parker Index exhibited distinct peaks throughout the summer (Figure 19). Occasionally during heavy debris events, it became too difficult to count all SHID so a maximum value of 100 was given for the index. Type 1 SHID accounted for 98% of the Parker Index while type 2 and 3 SHID accounted for 1.7% and 0.3% of the Parker Index.

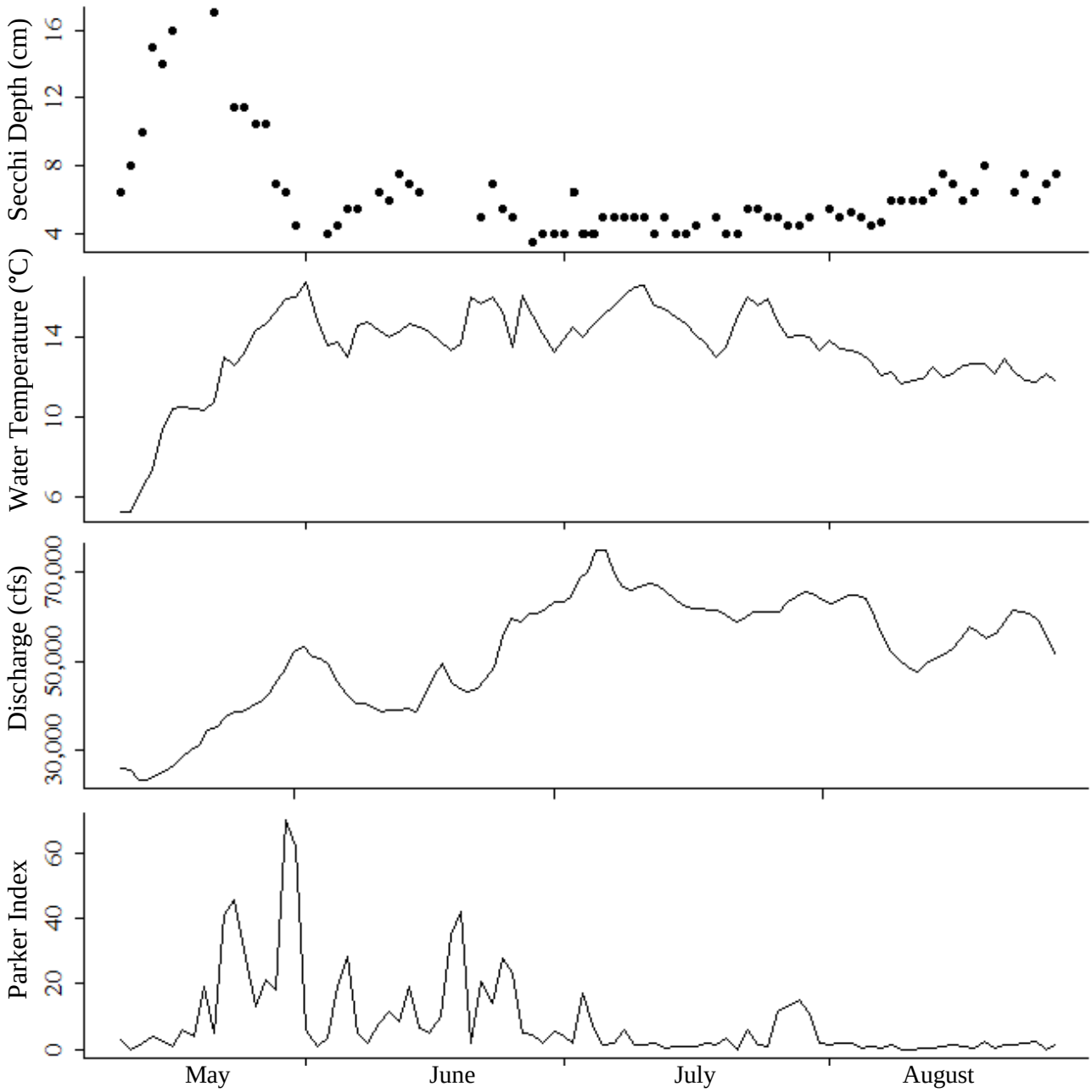

Figure 19. Secchi depth (cm), daily average of water temperature (°C), discharge (cfs) and Parker Index of the Tanana River at Nenana, AK.

Discussion

We effectively sampled the river margins with fyke nets and the surface of the mid-channel with an incline plane trap throughout the sampling period, thus describing the juvenile fish community and characterizing spatial and temporal migration patterns of juvenile fishes in the Tanana River at Nenana, AK. Additionally, we modified an existing method for sampling the bottom of the water column in large glacially influenced rivers in Alaska.

Species composition, abundance and spatial migration patterns

In the current study, catches were dominated by whitefishes, longnose suckers, chum salmon and lake chubs in the river margins and Chinook/coho salmon and chum salmon in the surface of the mid-channel. Based on fish size and time of capture, a majority of the Chinook/coho salmon we captured in the river margins and mid-channel were age-1+ smolts migrating to the ocean. The only exception was two age-0 Chinook/coho salmon fry captured in July and August in the river margins, possibly moving to non-natal streams to overwinter, though this behavior has yet to be documented in the Tanana River (personal comm. Dave Daum). Catches of Chinook/coho salmon peaked in late-May and mid-June in the mid-channel. While the mid-channel was not sampled for one month beginning late-June, it is likely that the down-migration of Chinook/coho salmon smolts during this time was decreasing based on a decreasing trend in catches in June and lack of catches when mid-channel sampling continued in late-July. A similar pattern was observed in the Yukon River, at Dawson, YT, where the down-migration of age-1+ Chinook salmon smolts was near completion by late-June (Bradford et al. 2008).

Because chum salmon do not rear and feed in freshwater, but rather migrate straight to the ocean after emergence, all of the chum salmon we captured in the river margins and mid-channel were age-0 smolts migrating to the ocean. The only exception was two spawned out adult females captured in the fyke nets in August. Catches of chum salmon peaked in late-May and mid-June in the mid-channel. Like the down-migrating Chinook/coho salmon smolts, it is likely the chum salmon smolt down-migration was decreasing in the mid-channel after sampling ceased in late-June. This hypothesis is based on the decreasing trend of catches of chum salmon in the river margins during this time and lack of catches in the mid-channel when sampling re-commenced in late-July. A similar pattern was observed in the Yukon River near Dawson, YT, where the down-migration chum salmon peaked once in early June and was completed by early July (Bradford et al. 2008).

Catches of whitefishes were rare during the first three weeks of sampling, at which time the weekly mean length was relatively large. These were likely sub-adult and adult whitefishes moving to summer feeding areas. Beginning early-June, catches began increasing and peaked in mid/late-June. At this time, the weekly mean length decreased as smaller whitefishes began appearing in our catches. These relatively small fish were likely age-0 hatched earlier the same year, most moving to feeding and rearing locations (Seitz et al. 2011).

Based on a previous general age classification of juvenile fishes in the Tanana River drainage (Mecum 1984), it is likely that a large portion of both lake chubs and longnose suckers were age-1 fishes. However, based on the fact that there no statistically significant trends in size during the sampling season for either species, it is likely we captured a variety of age classes in the Tanana River margins throughout the open water season. Catch rates of lake chubs exhibited one large peak in mid-May while longnose suckers showed one large peak in early-June. The peak of longnose suckers in early-June also corresponded to the first peak in river discharge, but the peak of lake chubs in mid-May does not appear to visually correspond with environmental variables. Aside from the peaks, catches of both species were relatively consistent throughout the sampling season, similar to previous studies that have found that these two species to be the most common in the Tanana River drainage (Mecum 1984; Ott et al. 1998).

In addition to lake chubs and longnose suckers, the remaining species including Arctic grayling, Arctic lamprey, slimy sculpin and burbot, did not show any peaks in down-migration or significant trends in length during the sampling season. This likely because our sample size was too small to detect any relationships.

Some species' CPUE varied by an order of magnitude between the river margins and mid-channel. For example, whitefishes and lamprey mid-channel surface catches were very small, whereas catches of the whitefishes and lamprey in the margins were substantially larger. In contrast, Chinook/coho salmon catches in the river margins were relatively small and substantially larger in the mid-channel. The river margin and mid-channel sampling locations in this study were in close spatial proximity to each other and samples were collected during the same time, leaving gear selectivity (fyke nets vs. incline plane trap) or migration location preference (river margin vs. mid-channel) by juvenile fishes as possible explanations for this variation in species abundance between sampling locations. While gear selectivity may be possible, we believe that it is unlikely that it accounts for a large proportion of the differences in mid-channel surface and river margin catches because the mesh size openings of the fyke net were approximately the same size as the perforations in the incline plane.

Alternatively, we believe that fishes are actively selecting specific areas within the river channel, based on microhabitat characteristics, such as water velocity, bathymetry and depth. Salmonids of different species and ages have been shown to down-migrate in different areas within the river channel in other large rivers, such as the Columbia River (Dauble et al. 1989). In the Hanford Reach of the Columbia river, age-0 wild Chinook salmon, of which over 80% were ≤ 45 mm fork length, utilized river margins for down-migration whereas age-0 hatchery Chinook salmon, which were >80 mm fork length, utilized the mid-channel, from the surface to the bottom, for down-migration (Dauble et al. 1989). Age-1 Chinook salmon and sockeye salmon (*Oncorhynchus nerka*) smolts utilized the deepest part of the river and were not captured near the river margins (Dauble et al. 1989). Similar patterns were seen in juvenile steelhead, ranging from 165 mm to 241 mm fork length, which were not captured on the shoreline, but mostly in the mid-channel at mid-depth and at the bottom (Dauble et al. 1989).

In this study, diel patterns of down-migration were not evident. Generally, down-migrating salmonid smolts exhibit nocturnal behavior in low turbidity systems and less distinct diel patterns in turbid systems (Gregory and Levings 1998). One hypothesis for this pattern is that smolts migrate during times of decreased visibility to minimize the chance of predation by piscivorous fish (Gregory and Levings 1998). Therefore, in low turbidity environments where visibility is relatively good, smolts generally down-migrate at night to reduce the chance of visual detection by predators. In contrast, in high turbidity environments, such as the Tanana River, visibility is low, regardless of time of day, thus down-migration occurs at all times of the day (Gregory and Levings 1998), such as seen in this study.

Factors other than turbidity may be correlated to diel down-migration timing. For example, in the Taku River, AK, a highly turbid river, coho salmon and chum salmon exhibited significant peaks in down-migration timing during night (Meehan and Siniff 1962). In the Taku River, smolts down-migrating to the ocean have a relatively short distance to travel, therefore may be

afforded greater selectivity in their migration timing. In contrast, down-migration distance for smolts in the Tanana River is relatively long, which may require daytime travel to reach the ocean in time for the period of high marine productivity and thus increased feeding opportunities.

Methodology developments

In addition to describing juvenile fish down-migration patterns in this study, we modified an existing method for sampling the bottom of the water column in large rivers, previously used only once in the Columbia River, for use in large glacially influenced rivers (Dauble et al. 1989). However, sampling with this new method was limited to a few days in August because delayed shipping of the pontoon barge, which required extensive modifications upon arrival, and delayed anchor installation. Once sampling with the frame trawl commenced in August, it was short-lived due to the spreader anchor pulley becoming seized, most likely due to being clogged by heavy silt and substantial mulch-like debris on the bottom of the river. Additionally, the Tanana River has a moving bedload, which could have easily buried our entire spreader anchor and pulley. Without a working pulley on the bottom of the river, we were not able to pull the frame trawl to the bottom of the river. Even though sampling was minimal, we gained valuable information about improving this sampling methodology. One potential future improvement is not utilizing a pulley, thus removing our dependence on a mechanical device in the harsh environment of the river bottom. Rather, by utilizing a fixed line attached to an anchor, we will be able to drop the sampling net to the river bottom and sample this habitat.

Future Analysis

All of these data will be further analyzed by Mr. Parker Bradley who is a MS student in Fisheries at the University of Alaska Fairbanks School of Fish and Ocean Sciences. The goal of the analysis is to describe the juvenile fish community in Tanana River and its temporal and spatial migration patterns, while examining possible effects of environmental factors. To accomplish this, a variety of statistical methods will be used.

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