Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Study of Fish Distribution and Abundance in the Upper Susitna River (Study 9.5)

Evaluation of 2014 Study Modifications in the Black River Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants, Inc.

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
CPUE	Catch per unit effort
CW	Channel width
FDA UP	Study of Fish Distribution and Abundance in the Upper Susitna River
FERC	Federal Eneregy Regulatory Commission
GRTS	Generalized random tessellation stratified sampling
IP	Implementation Plan
ISR	Initial Study Report
km	Kilometer
km^2	Square kilometers
m	Meter
MC	Main Channel
Mi	Mile
mi^2	Square miles
OC	Off-Channel
OCH	Off-Channel Habitat
PRM	Project river mile
RSP	Revised Study Plan
SE	Standard Error
SPD	Study Plan Determination
SR	Species richness
TSR	True species richness

1. INTRODUCTION

In 2013, AEA's study teams conducted the first year of data collection for the Fish Distribution and Abundance in the Upper Susitna River Study (Study 9.5). Objective 1 of the Study of Fish Distribution and Abundance in the Upper Susitna River was to describe the seasonal distribution, relative abundance (as determined by catch per unit effort [CPUE], fish density, and counts), and fish-habitat associations of resident fishes, juvenile anadromous salmonids, and the freshwater life stages of non-salmon anadromous species (RSP Section 9.5.1; AEA 2012). Sampling in 2013 was effective at documenting fish distribution (Task A). Relative abundance estimates were effectively generated for all sampled habitats (Task B). However, analysis of habitat associations (Task C) was limited by the low number of off-channel habitats in the mainstem Susitna River and the low number of rare habitat types in Upper River tributaries.

Modifications to the Study Plan were presented in Part C, Section 7 of the Initial Study Report (ISR) filed with FERC June 3, 2014 (AEA 2014a). AEA implemented the following proposed modifications in 2014 to gather additional information; to meet study plan objectives; and better inform the second study year. This technical memorandum describes how the modifications to the Study of Fish Distribution and Abundance in the Upper Susitna River (Study 9.5) outlined in the ISR were applied to the Black River during the 2014 study year.

In response to the October 2014 ISR meetings, AEA informed the licensing participants that AEA would be filing this TM with the Commission ahead of the January 2015 ISR meetings.

2. SAMPLING DECISION: INCREASED SAMPLING EFFORT IN SELECT UPPER RIVER TRIBUTARIES

2.1. Sampling in 2013

The April 2013 FERC Study Plan Determination (SPD) recommended scaling sampling in proportion to stream size (FERC 2013, p. B-124). To achieve a spatially-balanced and random sample of fish habitats within Upper River tributaries, the length of the tributaries were divided into sampling panels that were 200, 400, or 800 m long, depending on the tributary drainage area, and the required percentage of stream length was sampled using a generalized random tessellation stratified (GRTS) sampling methodology. The original sampling plan (ISR 9.5 Section 4.1.2.1) was to survey the GRTS panel for mesohabitat types, and to select one unit of each mesohabitat type and sample 40 m (131 ft) of each selected unit. The FERC SPD recommended all the classified mesohabitat units be sampled. However, logistical constraints in 2013 required sub-sampling 100 m (328 ft)-long units within GRTS panels. Specifically, within a selected GRTS panel, fish sampling occurred in either a complete mesohabitat unit or up to 00 m (656328 ft) per mesohabitat for each mesohabitat type present (ISR 9.5 Section 7.1.2.4).

2.2. Measures of Sampling Sufficiency

Post-season analysis indicated that the 2013 tributary sampling program was effective at documenting the fish species present within Upper River tributaries. The analysis consisted of

comparing the total number of species found in a tributary, referred as observed species richness (SR), and an estimate of true species richness (TSR) in a tributary (Cochran 1977).

However, as indicated in Section 7.1.2.4 of Study 9.5 Initial Study Report (AEA 2014b), the 2013 sub-sampling may have been inconsistent with the intent of the April 2013 FERC SPD, with smaller basins receiving proportionally more effort, and larger basins receiving proportionally less. In addition, a post-2013 field season review of the remote video within each GRTS panel indicated that there were some habitat types that were under-represented in 2013 fish sampling and the fish-habitat association analysis likely would benefit from additional replicates.

Sampling sufficiency for characterizing fish distribution is often evaluated in relation to channel width (Paller 1995, Patton et al. 2000, Hughes et al. 2002, Maret and Ott 2003, Reynolds et al. 2003, Kirsch et al. 2014). Fish sampling and habitat surveys completed in 2013 provided channel width information that was not available to incorporate into the Implementation Plan (AEA 2013). The AEA study team reviewed the 2013 sampling effort in the context of field measurements of channel width to prioritize additional sampling. Kirsch et al. (2014) recommended sampling lengths of 40 wetted channel widths for wadeable streams, 120 channel widths for nonwadeable streams in basins with a watershed area of 100-300 km^2 (38.6 – 115.8 mi^2), and more than 140 channel widths in nonwadeable streams in larger drainage basins.

2.3. Increased Sampling Effort

AEA proposed to apply the recommendation from Kirsch et al. 2014 for determining the length of Upper River tributaries to sample during the next year of sampling as described in Upper River technical memorandum filed September 17, 2014 (R2 Resource Consultants 2014). The stream-specific sample length changes for all Upper River tributary waters were presented in the September 2014 technical memorandum and are included in Table 2.3-1 for ease of access.

AEA proposed to maintain the spatial configuration of the original GRTS panel sampling and apportioned the additional sampling length within the existing panels by selecting the number of fully-sampled panels necessary to achieve the sampling length target as described in ISR Section 9.5.7.1.2.4. However, in the Black River the total length of main channel habitat within GRTS panels selected for sampling in 2013 was short target sampling lengths, so two more panels were added to the 2014 fish surveys.

2.4. Implementation of Increased Tributary Sampling Effort in 2014

As described in ISR Section 9.5.7.1.2.4, AEA implemented the recommended increase in sampling in the Black River in 2014. The proposed increase in sampling length for the Black River was more than triple the effort expended in 2013 (Table 2.4-1). In 2013, the 100 m (328 ft) sub-sampling approach occurred in six GRTS panels (Panels 1, 2, 4, 6, 7, 9) and resulted in sampling of 11 mesohabitat units within 1,050 m (0.65 mi) of sample unit length (Table 2.4-2). In 2014, sampling the full length of all available main channel mesohabitats and 20x wetted-widths of off-channel habitats present within in the same six panels resulted in 19 mesohabitat units for a total length of 2,724 m (1.69 mi) sampled (Table 2.4-2). In order to achieve the target length of 3,178 m (1.97 mi) of recommended sampling (Table 2.3-1), two additional 400 m

panels were added using the GRTS methodology (Panels 3 and 5). These eight panels also included 402 m of off-channel habitats so the total effort in 2014 completed surveys in 28 mesohabitat units for a total of 3,619 m (2.25 mi).

3. RESULTS OF COMPARISON OF SAMPLING PROTOCOLS IN THE BLACK RIVER

The 2014 sampling was conducted so as to first replicate the 2013 survey length and then extend the sampling to the full targeted sample length. Breaking the data in this way facilitated comparison between the subsample and full sample approaches and avoided concerns about interannual variability of data that could result from comparing 2013 and 2014 data sets. For the remainder of the memorandum, the replicated data set is referred to as the 2014 subsample while the data collected from the fully expanded effort is referred to as the 'full sample'. The purpose of such a comparison was to determine if completing the full sampling approach improved AEA's ability to meet study objectives. The evaluation that follows is based on various species metrics including fish distribution, species richness, relative abundance, and fish-habitat associations.

3.1. Fish Distribution

Five fish species were identified in the Black River system during the full 2014 sampling effort: Arctic grayling (Thymallus arcticus), burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), sculpin (Cottid sp.), and round whitefish (*Prosopium cylindraceum*) (Table 3.1-1). These species represent resident salmonid or non-salmonid functional groups and all were observed previously in the Black River. Notably absent in 2014, were anadromous juvenile Chinook salmon (*Oncorhynchus tshawytscha*), observed in Black River during subsampling in 2013.

In replicating the 2013 survey effort, the 2014 subsample resulted in the collection of three of the five species documented: Arctic grayling, burbot, and sculpin. Longnose sucker and round whitefish were found in the extended survey length in low numbers; only1 longnose sucker and 5 whitefish were observed out of 3,193 total fish observations (Table 3.1-1). Due to their relative rarity in the Black River habitats, the subsampling approach was insufficient to reliably detect these species.

3.1.1. Species Richness

The observed species richness (SR), or the total number of species found in the Black River in 2014, and an estimate of true species richness (TSR) following the concepts of Cochran (1977) were used as measures of sampling sufficiency, indicative of the success of the full and subsampling approaches in detecting species' presence. The SR and TSR values, and when these metrics were first achieved within the GRTS panel matrix, are shown in Table 3.1-2 and depicted in Figure 3.1-1. As discussed above, the observed SR from the full sample was five species collected from eight GRTS panels. The five species were detected within the first two GRTS panels. The estimated TSR for the Black River was 5.6 species. The subsample returned only three species from six GRTS panels and all three were detected in the first site. The SR and TSR

were both calculated at 3.0 fish for the subsampling effort. These calculations highlight the limitations of this analysis when all species are either very common (observed at all six sites) or very rare (never observed).

3.2. Relative Fish Abundance

Fish counts across all sites, mesohabitats, sampling methods, and seasons are shown in Table 3.1-1 for the full and subsamples. Sculpin dominated the catches followed by Arctic grayling, and burbot using both the full and sub-sampling methods. Since the full sample effort totaled 3.4 times the stream distance of the subsampling (3,619/1,050m = 3.4x), it was expected that the numeric factor between fish counts of fish from the two approaches should be in the range of 3.4x (or conversely, the subsample ran slightly less than 30 percent of the full sample). As expected, the count expansion factors for Arctic grayling, burbot, and sculpin ranged between 2.7 and 3.9x (Table 3.1-1). This finding suggests the subsampling approach provided consistent information compared to the full sampling regarding the most abundant species.

3.2.1. CPUE

Fish abundance information can be somewhat biased as a function of sampling gear type and the level of effort expended during the surveys. For this reason fish counts are often reported in terms of relative fish abundance and the counts are normalized with respect to effort. For comparative purposes, catch per unit of effort (CPUE) was calculated for the most frequently used sampling technique performed during the 2014 surveys, backpack electrofishing.

Analyses were conducted for the three species most often observed, with several lifestage groupings:

- Arctic grayling juveniles, subadult/adults, and total of all lifestages,
- Burbot juveniles, subadults/adults, and total of all lifestages, and
- Sculpin total of all lifestages.

CPUE was estimated as catch per hour of shocking time for each species/lifestage combination within each mesohabitat unit sampled using backpack electrofishing. Mesohabitats were the primary mesohabitat sampling units and were sampled as clusters defined by GRTS panels. Average CPUE and the associated standard error (SE) for each mesohabitat type was estimated using a combined ratio estimate (Cocharn 1977). Calculations were performed with package *survey* (Lumley 2004, Lumley 2014) in the statistical software *R* (version 3.1.1; R Core Team 2014).

CPUE for backpack electrofishing results by mesohabitat type and sampling events (seasons) are shown in Tables 3.2-1 through 3.2-7. The mean, standard error, and number of replicate mesohabitat units sampled for the full and subsampling approaches are shown in each of the tables. Boxplots comparing the subsample and the full sample CPUE results for the three species and three sampling events, early summer, late summer, and fall are presented by habitat type and life history stage in Figures 3.2-1 to 3.2-7.

3.2.1.1. Arctic Grayling

The CPUE for juvenile Arctic grayling ranged between 0 and 10 fish/hr during the full sample survey depending on habitat type. The same metric for the subsample ranged from 0 to 11 fish/hr. The CPUE results were nearly identical for all habitat types and all seasons during the full and subsample surveys (Table 3.2-1, Figure 3.2-1). The standard errors were generally lower for the full sample, as expected due to increased sampling. This finding suggests that the main benefit for an expanded sampling effort for juvenile Arctic grayling in terms of relative abundance was an increase in precision.

Given the lower abundances of subadult and adult life stages, it appears the grayling capture rate was slightly greater in the full sample compared to the subsample for boulder riffle, rapid, and upland slough habitats (Table 3.2-2, Figure 3.2-2). A small improvement in accuracy of relative abundance for the full sample was apparent for subadult/adult Arctic grayling.

The total CPUE for all Arctic grayling, regardless of life history stage, indicated similar findings as for the juvenile grayling. Since juveniles comprise at least 63 percent of this total, and since the added benefit ascribed to the subadult/adult class was small, the full sampling effort did not provide considerable improvement in CPUE accuracy for this species compared to what could be determined from the subsample (Table 3.2-3, Figure 3.2-3). However, there were improvements in precision of the estimates, which can be helpful in comparing abundance among habitats.

3.2.1.2. Burbot

The CPUE for juvenile burbot ranged between 0 and 4 fish/hr during the full sample survey and from 0 to 8 fish/hr for the subsample. The mean CPUE results differed between the full and subsampling surveys (Table 3.2-4, Figure 3.2-4). This finding suggests there may have been added benefit in accuracy as well as precision (reduced SE estimates) for the full sample effort for juvenile burbot.

There were no adult and very few subadult burbot captured during 2014 by any of the sampling approaches. Given the rare occurrences of this life history stage, it appears the burbot capture rate was slightly greater during the full sample compared to the subsample for boulder riffle, and rapid habitats (Table 3.2-5; Figure 3.2-5). A small added benefit for the full sample effort was apparent for subadult burbot.

The total CPUE for all burbot, regardless of life history stage, indicated similar findings as the juvenile burbot. Small gains in accuracy and precision during the full sample were observed, particularly in riffle habitats and in the rapid habitat that was not sampled in the subsample approach (Table 3.2-6, Figure 3.2-6).

3.2.1.3. Sculpin

Sculpin were the most abundant species observed during the surveys. Given the small overall size of the sculpin, the total of all life histories was evaluated for this species.

The mean CPUE for sculpin ranged between 23 and 82 fish/hr during the full sample survey and from 37 to 91 fish/hr for the subsample. In some habitats, the CPUE data show large differences

in mean estimates between the full and subsample methods, but the mean estimates using the full sample methodology were not always higher or lower (Table 3.2-7, Figure 3.2-7). Thus, the subsample did not result in consistently biased estimates of average CPUE. Precision, however, was substantially better (lower SE) with the full compared to the subsampling approach, with a few exceptions. In these few cases when the subsampling method offered lower standard errors than the full survey, the sample size was very small and likely resulted in an underestimate in the overall variability in CPUE. The full sample resulted in more realistic variability measurements and better precision in estimating CPUE for sculping. This finding suggests that the only added benefit for an expanded sampling effort for sculpin is in small increases in estimating error.

3.3. Fish-Habitat Associations

For consistency with the ISR (AEA 2014), this section documents the total observations (counts) of fish species and life history types among mesohabitats during the 2014 sub- and full sampling. The total observations of fish species in the Black River system by season and macrohabitat type are presented in Table 3.3-1. When these count data are reviewed simultaneously with the increased sampling of mesohabitats depicted in Tables 3.2-1 and 3.2-2 (taken from R2 Resource Consulants 2014), it is clear that the 2014 sampling effort resulted in increased replicates of fish counts across habitats, including rarer habitats. This increased replication will better support a full evaluation of fish-habitat association for the USR once the study modification is implemented in Upper River tributaries during the next year of study.

In addition, some general observations based on fish counts by habitat, including seasonal shifts in habitat associations as fish grew and matured and as water temperature declined are presented below.

- Highest counts of Arctic grayling, sculpin, and burbot were in boulder riffle habitat, followed closely by counts in run/glide habitat
- Arctic grayling counts lowest in upland slough habitat
- Overall trend for Arctic grayling, sculpin, and burbot was for reduced counts from summer to fall
- Patterns in habitat associations were similar across life stages for Arctic grayling
- Sculpin found in all habitat types sampled
- Round whitefish and longnose sucker were rare in all Black River mesohabitats

4. DISCUSSION

This technical memorandum was prepared to assess whether additional sampling effort improved AEA's ability to meet study objectives including fish distribution, relative abundance, or habitat associations in the Black River. The subsampling approach performed adequately where species and habitats were abundant. The expanded, full sampling approach provided the greatest return with respect to rare habitats and rare species and, thus, confirms the adequacy of the ISR proposed modification. Thus, AEA recommends continuing future surveys using the full sampling approach. After successfully implementing the full sampling approach in the Black River, AEA recommends adopting the tributary sampling modifications and targets from the Initial Study Report 7.1.2.4, as summarized in Section 2.3 above.

In applying this modified approach, the sampling length in all but one tributary would be maintained or increased beyond that accomplished in 2013 (R2 Resource Consultants 2014). The sample length for each tributary will be developed for the length of main-channel to be sampled and will be accomplished by sampling the fewest number of GRTS panels possible to accommodate the target length. The use of the GRTS panel process for selection will ensure that survey sites are spatially balanced throughout the mainstem. In addition, because the target lengths are based on main channel panels, the length of off-channel habitat surveyed will be in addition to the length of sample targets, as was evident for the Black River in 2014. As the application of this modification in the Black River has shown, this modified approach will allow for inclusion of additional mesohabitat replicates and will improve AEA's ability to discuss fish use of habitats for rare species and habitats in Upper River tributaries.

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6. TABLES

Table 2.3-1. 2013-2014 tributary sampling summary and proposed future Upper River tributary sampling length targets.

GRTS Sampled Tributaries	Drainage Basin Area (km^2)	Chinook salmon presence	GRTS Sampling Unit Size (m)	Number of GRTS Population Sample Units	Number of 2013 Sample Sites	Number of mesohabitats sampled 2013	Meters Sampled 2013	% Sampled 2013	Number of mesohabitats sampled 2014	Meters sampled 2014	Average Wetted width (m)	Channel Widths Sampled 2013	Kirsch et al. 2014 target (CW)	Kirsch et al. 2014 target (m)	Kirsch et al. 2014 target (%)	Proposed Change (m)
Oshetna River (PRM 235.1)	1424.5	yes	800	52	13	28	2,604	6%	--	--	36	73	140	5,026	12%	2,422
Black River	NA	no	400	24	6	11	1,050	11%	28	3619	23	46	140	3,178	33%	2,128
Goose Creek (PRM 232.8)	269.1	no	200	81	20	38	3,107	19%	--	--	14	219	120	1,704	11%	-1,403
Kosina Creek (PRM 209.1)	1036.5	yes	800	24	6	10	1,000	5%	--	--	32	31	120	4,522	24%	3,522
Tsisi Creek	NA	no	400	23	6	10	980	11%	--	--	14	69	140	1,988	22%	1,008
Watana Creek (PRM 196.9)	452.7	yes	400	60	15	30	2,561	11%	--	--	11	231	140	1,554	6%	--
Watana Creek Tributary	NA	no	200	67	13	18	1,459	11%	--	--	10	154	140	1,330	10%	--
Unnamed Tributary (PRM 194.8)	321.2	no	400	32	2	4	300	2%	--	--	3	88	140	476	4%	176
GRTS Total	--	--	--	454	81	149	13,061	8%	--	--	--	--		19,778	12%	7,853
Direct sample Tributaries																
Jay Creek (PRM 211)	160.1	no	NA	--	NA	8	324	--			14	--	--	--	--	--
Unnamed Tributary (PRM 206.3)	<80.3	no	NA	--	NA	--	--	--	3	263	6.9	--	--	--	--	Direct
Unnamed Tributary (PRM 204.5)	<80.3	no	NA	--	NA	--	--	--	2	330	4.5	--	--	--	--	Direct
Unnamed Tributary (PRM 197.7)	<80.3	no	NA	--	NA	--	--	--	5	358	7.1	--	--	--	--	Direct
Deadman Creek (PRM 189.4)	453.5	no	NA	--	NA	--	--	--	5	357	28.4	--	--	--	--	--
Direct Sample Total	--	--	--	--	--	8	324	--	15	1,308	--	--	--	--	--	--

Table 2.4-1. Black River sample unit length (meters) by tributary channel /macrohabitat and mesohabitat type for GRTS sampling approach 2013 and 2014.

	Trib Hab Type	Single Channel				Split Channel					Complex Channel					Off-Channel Habitat					
	Trib MC/OC HabType	Main Channel				Primary			Secondary		Primary		Secondary	Tertiary		Tributary		Upland Slough			
Year	Mesohabitat	Boulder riffle	Rapid	Run/Glide	Single Total	Boulder riffle	Riffle	Run/Glide	Run/Glide	Split Total	Boulder riffle	Run/Glide	Riffle		Complex Total	Run/Glide	Boulder Riffle	Pool	Run/Glide	OCH Total	Grand Total
2013	Black River: Panel 01			100	100													100		100	200
	Black River: Panel 02											100	100		200				100	100	300
	Black River: Panel 04	100			100																100
	Black River: Panel 06					100		100	50	250											250
	Black River: Panel 07	100			100																100
	Black River: Panel 09	100			100																100
2013 Total		300	-	100	400	100	-	100	50	250	-	100	100	-	200	-	-	100	100	200	1,050
2014	Black River: Panel 01	104		296	400													127		127	527
	Black River: Panel 02						100	245		345			55		55				140	140	540
	Black River: Panel 03	43	282	75	400											51	44			95	495
	Black River: Panel 04		90		90			310		310									40	40	440
	Black River: Panel 05										400				400						400
	Black River: Panel 06	150		100	250	100				100		50			50						400
	Black River: Panel 07	210	190		400				17	17											417
	Black River: Panel 09	280			280						120				120						400
2014 Total		787	562	471	1,820	100	100	555	17	772	520	50	55	-	625	51	44	127	180	402	3,619

Table 2.4-2. Black River mesohabitat unit count (number of replicate mesohabitat units) by tributary macrohabitat and mesohabitat type for GRTS sampling approach 2013 and 2014.

	Tributary Habitat Type	Single Channel				Split Channel					Complex Channel					Off-Channel Habitat					
	Trib MC/OC HabType	Main Channel				Primary			Secondary		Primary		Secondary	Tertiary		Tributary		Upland Slough			
Year	Mesohabitat	Boulder riffle	Rapid	Run/Glide	Single Total	Boulder riffle	Riffle	Run/Glide	Run/Glide	Split Total	Boulder riffle	Run/Glide	Riffle		Complex Total	Run/Glide	Boulder Riffle	Pool	Run/Glide	OCH Total	Grand Total
2013	Black River: Panel 01			1	1													1		1	2
	Black River: Panel 02											1	1		2				1	1	3
	Black River: Panel 04	1			1																1
	Black River: Panel 06					1		1	1	3											3
	Black River: Panel 07	1			1																1
	Black River: Panel 09	1			1																1
	2013 Total	3	-	1	4	1	-	1	1	3	-	1	1	-	2	-	-	1	1	2	11
2014	Black River: Panel 01	1		1	2													1		1	3
	Black River: Panel 02						1	1		2			1		1				1	1	4
	Black River: Panel 03	1	2	2	5											2	1			3	8
	Black River: Panel 04		1		1			1		1									1	1	3
	Black River: Panel 05										1				1						1
	Black River: Panel 06	1		1	2	1				1		1			1						4
	Black River: Panel 07	1	1		2				1	1											3
	Black River: Panel 09	1			1						1				1						2
	2014 Total	5	4	4	13	1	1	2	1	5	2	1	1	-	4	2	1	1	2	6	28

Table 3.1-1. Total observations of fish species in the Black River by habitat category using full and subsampling approaches during 2014.

Habitat Category	2014 Full Sample[a]					2014 Subsample[a]				
	Burbot	Arctic Grayling	Longnose Sucker	Sculpin Sp.	Round Whitefish[b]	Burbot	Arctic Grayling	Longnose Sucker	Sculpin Sp.	Round Whitefish[b]
Black River Mainstem	101	422	0	2,147	5	37	122	0	736	0
Unnamed Tributary	3	52	0	206	0	NS	NS	NS	NS	NS
Upland Slough	9	10	1	237	0	5	2	0	207	0
Total Observations	113	484	1	2,590	5	42	124	0	943	0
Factor (Full/ subsample)	2.7	3.9	-	2.7	-	0.37	0.26	-	0.36	-

[a] Counts from all sampling methods
[b] Whitefish total includes unidentified species
NS = Not surveyed during 2014 under the subsampling approach
0 = Surveyed in 2014 without any recorded fish observations by any of the collection methods

Table 3.1-2. Summary of sampling sufficiency measures for the Black River in 2013 and 2014.

Upper River Tributary	Number of Sample Sites	SR[a]	Site when SR first observed	TSR_{H-T}[b]	Site when TSR_{H-T} -1 first observed	TSR_{H-T} minus SR	Percent of TSR observed
Black River Subsample 2013	6	6	3	6.6	3	0.6	91%
Black River Subsample 2014	6	3	1	3.0	1	0.0	100%
Black River Full Sample 2014	8	5	2	5.6	2	0.6	89%

[a] Observed species richness - the total number of species found in a tributary
[b] Horvitz-Thompson estimate (Cochran 1977) of the true species richness in a tributary

Table 3.2-1. Summary of juvenile Arctic grayling CPUE for backpack electrofishing in fish/hour by habitat type in the Black River for three sampling periods in 2014.

		Arctic Grayling Juveniles					
		2014 Full Sample			2014 Subsample		
		Number of Units[1]	Mean	SE	Number of Units[1]	Mean	SE
Boulder Riffle	Early Summer	12	5.9	1.3	4	5.0	2.9
	Late Summer	11	9.9	1.9	4	11.0	0.4
	Fall	14	5.2	1.2	4	3.8	1.2
Run/Glide	Early Summer	9	9.1	3.0	4	7.6	3.2
	Late Summer	11	4.9	1.1	6	5.9	2.9
	Fall	9	3.4	1.1	4	5.1	1.7
Rapids	Early Summer	4	6.6	2.9	0	n/a	n/a
	Late Summer	4	1.4	1.7	0	n/a	n/a
	Fall	2	7.8	1.1	0	n/a	n/a
Riffles	Early Summer	2	2.3	n/a	1	4.6	n/a
	Late Summer	1	0.0	n/a	0	n/a	n/a
	Fall	2	9.3	n/a	1	7.0	n/a
Upland Sloughs (Pools + Run/Glide)	Early Summer	5	0.7	0.5	2	0.0	n/a
	Late Summer	4	0.0	0.0	2	0.0	n/a
	Fall	4	1.4	0.9	2	2.9	2.5

[1]Replicate mesohabitat units

Table 3.2-2. Summary of subadult/adult Arctic grayling CPUE for backpack electrofishing in fish/hour by habitat type in the Black River for three sampling periods in 2014.

		Arctic Grayling Subadults/Adults					
		2014 Full Sample			2014 Subsample		
		Number of Units[1]	Mean	SE	Number of Units[1]	Mean	SE
Boulder Riffle	Early Summer	12	1.6	0.84	4	0.4	0.36
	Late Summer	11	1.0	0.38	4	0.0	n/a
	Fall	14	0.6	0.23	4	0.6	0.50
Run/Glide	Early Summer	9	1.1	0.51	4	1.8	0.63
	Late Summer	11	0.0	n/a	6	0.0	n/a
	Fall	9	0.4	0.30	4	0.0	n/a
Rapids	Early Summer	4	5.2	2.00	0	n/a	n/a
	Late Summer	4	0.0	n/a	0	n/a	n/a
	Fall	2	0.0	n/a	0	n/a	n/a
Riffles	Early Summer	2	0.7	n/a	1	0.0	n/a
	Late Summer	1	0.0	n/a	0	n/a	n/a
	Fall	2	0.0	n/a	1	0.0	n/a
Upland Sloughs (Pools + Run/Glide)	Early Summer	5	0.7	0.54	2	0.0	n/a
	Late Summer	4	0.0	n/a	2	0.0	n/a
	Fall	4	0.0	n/a	2	0.0	n/a

[1]Replicate mesohabitat units

Table 3.2-3. Summary of total Arctic grayling CPUE for backpack electrofishing in fish/hour by habitat type in the Black River for three sampling periods in 2014.

		Arctic Grayling Total					
		2014 Full Sample			2014 Subsample		
		Number of Units[1]	Mean	SE	Number of Units[1]	Mean	SE
Boulder Riffle	Early Summer	12	7.5	1.7	4	5.4	3.0
	Late Summer	11	11.0	1.8	4	11.0	0.4
	Fall	14	5.8	1.3	4	4.4	1.4
Run/Glide	Early Summer	9	10.0	2.9	4	9.4	3.1
	Late Summer	11	4.9	1.1	6	5.9	2.9
	Fall	9	3.8	1.3	4	5.1	1.7
Rapids	Early Summer	4	12.0	3.7	0	n/a	n/a
	Late Summer	4	1.4	1.7	0	n/a	n/a
	Fall	2	7.8	1.1	0	n/a	n/a
Riffles	Early Summer	2	3.0	n/a	1	4.6	n/a
	Late Summer	1	0.0	n/a	0	n/a	n/a
	Fall	2	9.3	n/a	1	7.0	n/a
Upland Sloughs (Pools + Run/Glide)	Early Summer	5	1.5	1.1	2	0.0	n/a
	Late Summer	4	0.0	n/a	2	0.0	n/a
	Fall	4	1.4	0.9	2	2.9	2.5

[1]Replicate mesohabitat units

Table 3.2-4. Summary of juvenile burbot CPUE for backpack electrofishing in fish/hour by habitat type in the Black River for three sampling periods in 2014.

		Burbot Juveniles					
		2014 Full Sample			2014 Subsample		
		Number of Units[1]	Mean	SE	Number of Units[1]	Mean	SE
Boulder Riffle	Early Summer	12	2.1	0.52	4	2.9	1.0
	Late Summer	11	4.3	1.20	4	8.3	2.7
	Fall	14	1.2	0.29	4	2.4	0.7
Run/Glide	Early Summer	9	2.4	0.92	4	3.0	2.0
	Late Summer	11	0.7	0.35	6	0.4	0.2
	Fall	9	0.0	n/a	4	0.0	n/a
Rapids	Early Summer	4	4.4	3.30	0	n/a	n/a
	Late Summer	4	1.4	1.70	0	n/a	n/a
	Fall	2	0.0	n/a	0	n/a	n/a
Riffles	Early Summer	2	0.7	n/a	1	0.0	n/a
	Late Summer	1	3.3	n/a	0	n/a	n/a
	Fall	2	0.0	n/a	1	0.0	n/a
Upland Sloughs (Pools + Run/Glide)	Early Summer	5	0.9	0.69	2	2.3	2.0
	Late Summer	4	0.0	n/a	2	0.0	n/a
	Fall	4	1.1	0.99	2	2.1	1.9

[1]Replicate mesohabitat units

Table 3.2-5. Summary of subadult/adult burbot CPUE for backpack electrofishing in fish/hour by habitat type in the Black River for three sampling periods in 2014.

		Burbot Subadults/adults[1]					
		2014 Full Sample			2014 Subsample		
		Number of Units[1]	Mean	SE	Number of Units[2]	Mean	SE
Boulder Riffle	Early Summer	12	0.4	0.32	4	0.0	n/a
	Late Summer	11	0.1	0.08	4	0.0	n/a
	Fall	14	0.0	n/a	4	0.0	n/a
Run/Glide	Early Summer	9	0.0	n/a	4	0.0	n/a
	Late Summer	11	0.0	n/a	6	0.0	n/a
	Fall	9	0.0	n/a	4	0.0	n/a
Rapids	Early Summer	4	1.1	0.66	0	n/a	n/a
	Late Summer	4	0.0	n/a	0	n/a	n/a
	Fall	2	0.0	n/a	0	n/a	n/a
Riffles	Early Summer	2	0.0	n/a	1	0.0	n/a
	Late Summer	1	0.0	n/a	0	n/a	n/a
	Fall	2	0.0	n/a	1	0.0	n/a
Upland Sloughs (Pools + Run/Glide)	Early Summer	5	0.0	n/a	2	0.0	n/a
	Late Summer	4	0.0	n/a	2	0.0	n/a
	Fall	4	0.0	n/a	2	0.0	n/a

[1] No adult burbot were collected. [2]Replicate mesohabitat units

Table 3.2-6. Summary of total burbot CPUE for backpack electrofishing in fish/hour by habitat type in the Black River for three sampling periods in 2014.

		Burbot Total					
		2014 Full Sample			2014 Subsample		
		Number of Units[1]	Mean	SE	Number of Units[1]	Mean	SE
Boulder Riffle	Early Summer	12	3.0	0.96	4	2.9	1.0
	Late Summer	11	4.5	1.10	4	8.3	2.7
	Fall	14	1.2	0.29	4	2.4	0.8
Run/Glide	Early Summer	9	2.4	0.92	4	3.0	2.0
	Late Summer	11	0.7	0.35	6	0.4	0.2
	Fall	9	0.0	n/a	4	0,0	n/a
Rapids	Early Summer	4	6.6	2.70	0	n/a	n/a
	Late Summer	4	1.4	1.70	0	n/a	n/a
	Fall	2	0.0	n/a	0	n/a	n/a
Riffles	Early Summer	2	0.7	n/a	1	0.0	n/a
	Late Summer	1	3.3	n/a	0	n/a	n/a
	Fall	2	0.0	n/a	1	0.0	n/a
Upland Sloughs (Pools + Run/Glide)	Early Summer	5	0.9	0.69	2	2.3	2.0
	Late Summer	4	0.0	n/a	2	0.0	0.0
	Fall	4	1.1	0.99	2	2.1	1.9

[1]Replicate mesohabitat units

Table 3.2-7. Summary of total sculpin CPUE for backpack electrofishing in fish/hour by habitat type in the Black River for three sampling periods in 2014.

		Sculpin Total					
		2014 Full Sample			2014 Subsample		
		Number of Units[1]	Mean	SE	Number of Units[1]	Mean	SE
Boulder Riffle	Early Summer	12	68	11	4	39	5.3
	Late Summer	11	53	9.9	4	77	12
	Fall	14	30	5.3	4	37	6.8
Run/Glide	Early Summer	9	69	9.1	4	91	11
	Late Summer	11	82	15	6	75	15
	Fall	9	51	9.0	4	68	20
Rapids	Early Summer	4	46	12	0	n/a	n/a
	Late Summer	4	77	1.9	0	n/a	n/a
	Fall	2	43	15	0	n/a	n/a
Riffles	Early Summer	2	52	n/a	1	54	n/a
	Late Summer	1	23	n/a	0	n/a	n/a
	Fall	2	47	n/a	1	52	n/a
Upland Sloughs (Pools + Run/Glide)	Early Summer	5	35	11	2	63	26
	Late Summer	4	35	19	2	70	24
	Fall	4	45	15	2	91	5.5

[1]Replicate mesohabitat units

Table 3.3-1. Total observations of fish species in the Black River by season and mesohabitat type using full and subsampling approaches during 2014.

		Full 2014 Sampling Approach[a]							2014 Subsampling Approach[a]						
		Burbot		Arctic Grayling		Longnose Sucker	Sculpin Sp.	Round Whitefish[b]	Burbot		Arctic Grayling		Longnose Sucker	Sculpin Sp.	Round Whitefish[b]
Mesohabitat Type	StudyPeriod	Juvenile	All Life Stages	Juvenile	All Life Stages	All Life Stages	All Life Stages	All Life Stages	Juvenile	All Life Stages	Juvenile	All Life Stages	All Life Stages	All Life Stages	All Life Stages
Black River Mainstem															
Boulder Riffle	Early Summer	15	27	66	112	0	504	4	6	11	16	21	0	116	0
	Late Summer	19	22	62	92	0	331	0	9	9	17	22	0	120	0
	Fall	11	14	40	58	0	273	0	4	5	7	11	0	67	0
Rapid	Early Summer	5	9	10	26	0	65	0	NS	NS	NS	NS	NS	NS	NS
	Late Summer	4	4	3	6	0	101	0	NS	NS	NS	NS	NS	NS	NS
	Fall	0	0	6	7	0	35	0	NS	NS	NS	NS	NS	NS	NS
Riffle	Early Summer	2	3	3	5	0	96	1	1	2	3	3	0	48	0
	Late Summer	2	2	0	0	0	11	0	NS	NS	NS	NS	NS	NS	NS
	Fall	0	0	4	8	0	29	0	0	0	2	6	0	20	0
Run/Glide	Early Summer	12	13	26	39	0	239	0	6	7	18	23	0	141	0
	Late Summer	6	6	40	50	0	305	0	3	3	19	28	0	142	0
	Fall	1	1	14	19	0	158	0	0	0	8	8	0	82	0
Unnamed Tributary															
Boulder Riffle	Early Summer	2	2	4	5	0	7	0	NS	NS	NS	NS	NS	NS	NS
	Fall	0	0	3	5	0	2	0	NS	NS	NS	NS	NS	NS	NS
Riffle	Late Summer	0	0	3	3	0	8	0	NS	NS	NS	NS	NS	NS	NS
	Fall	0	0	0	0	0	4	0	NS	NS	NS	NS	NS	NS	NS
Run/Glide	Early Summer	1	1	11	32	0	2	0	NS	NS	NS	NS	NS	NS	NS
	Late Summer	0	0	0	0	0	24	0	NS	NS	NS	NS	NS	NS	NS
	Fall	0	0	6	7	0	159	0	NS	NS	NS	NS	NS	NS	NS
Upland Slough															
Pool	Early Summer	3	4	1	3	1	62	0	2	2	0	0	0	44	0
	Late Summer	0	0	3	4	0	3	0	NS	NS	NS	NS	NS	NS	NS
	Fall	1	2	0	1	0	1	0	NS	NS	NS	NS	NS	NS	NS
Run/Glide	Early Summer	1	1	0	1	0	45	0	1	1	0	1	0	39	0
	Late Summer	1	1	0	0	0	68	0	1	1	0	0	0	68	0
	Fall	1	1	1	1	0	58	0	1	1	1	1	0	56	0

[a] Counts from all sampling methods
[b] Whitefish total includes unidentified species
NS = Not surveyed during 2014 under the subsampling approach
0 = Surveyed in 2014 without any recorded fish observations by any of the collection methods

7. FIGURES

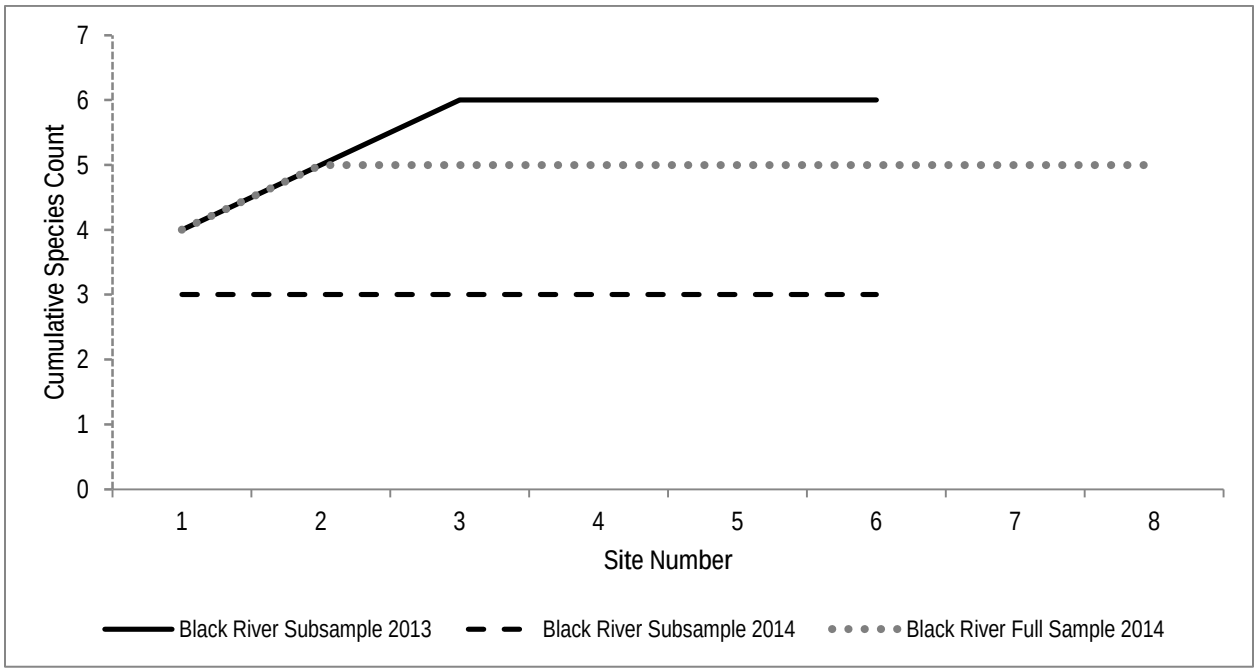

Figure 3.1-1. Species accumulation curves from the Black River GRTS sampling sites during full and subsampling in 2014. Note: The species accumulation curve generated during subsampling in 2013 is provided for reference.

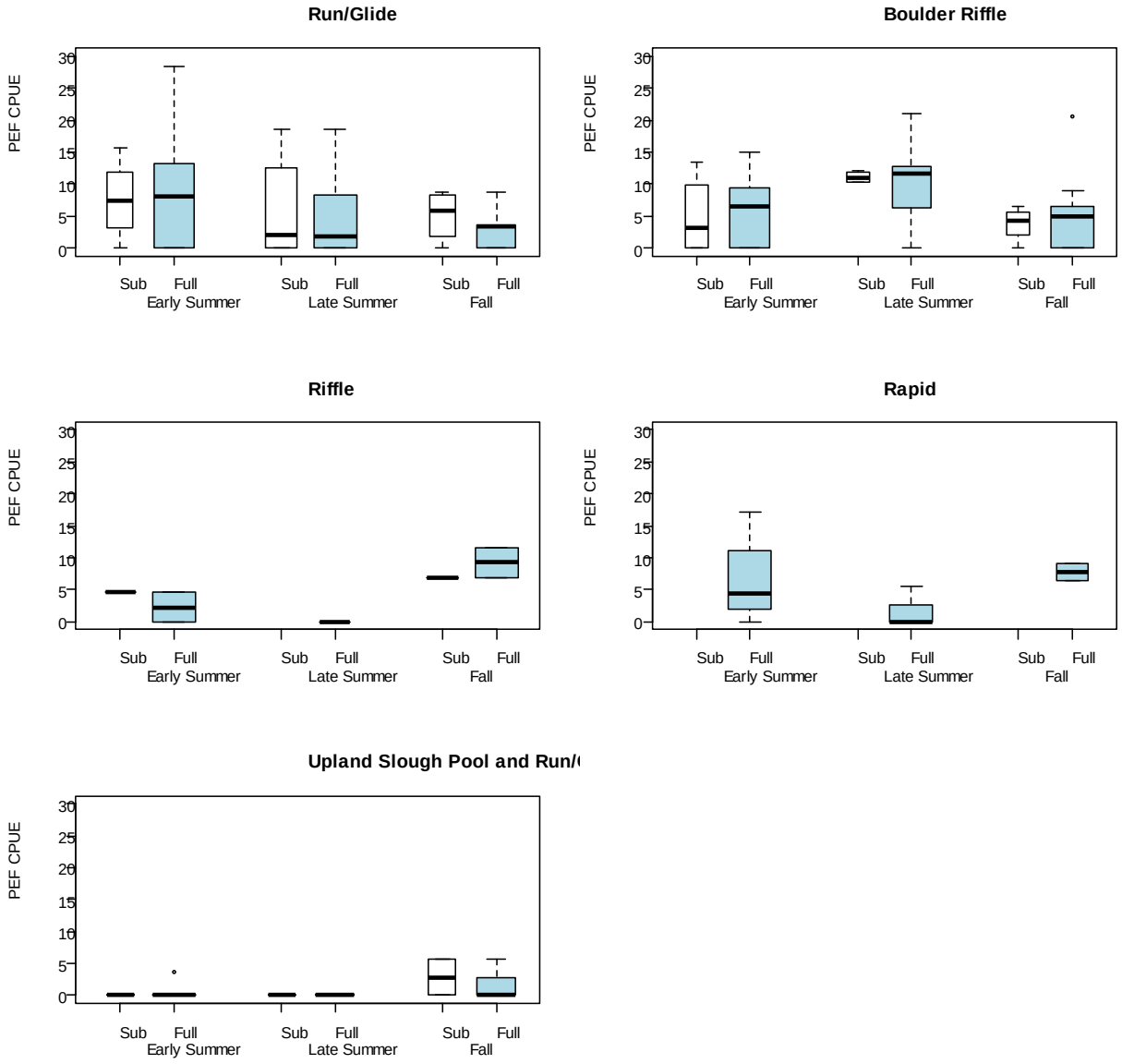

Figure 3.2-1. Boxplots comparing 2014 subsampling to 2014 full sample in the Black River based on CPUE for backpack electrofishing in fish/hour for juvenile Arctic grayling during three sampling events. The boxes represent the interquartile range (i.e., 1st to 3rd quartile of data), the black line in the box is the median. The whiskers extend to the full range of the data unless one or more data points are extreme, in which case these points are plotted separately as small circles. Box width is proportional to sample size.

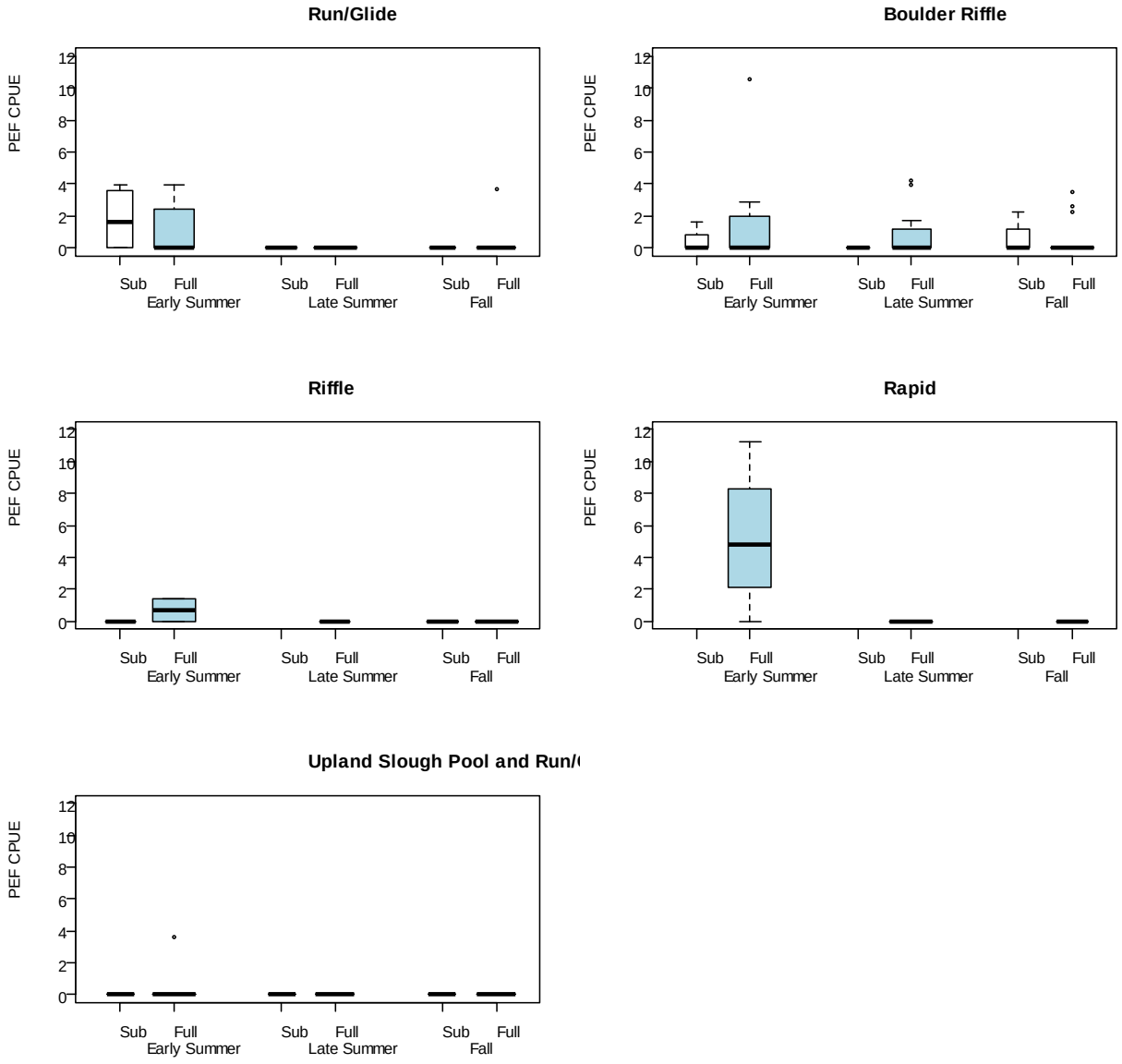

Figure 3.2-2. Boxplots comparing 2014 subsampling to 2014 full sample in the Black River based on CPUE for backpack electrofishing in fish/hour for subadult/adult Arctic grayling during three sampling events. The boxes represent the interquartile range (i.e., 1st to 3rd quartile of data), the black line in the box is the median. The whiskers extend to the full range of the data unless one or more data points are extreme, in which case these points are plotted separately as small circles. Box width is proportional to sample size.

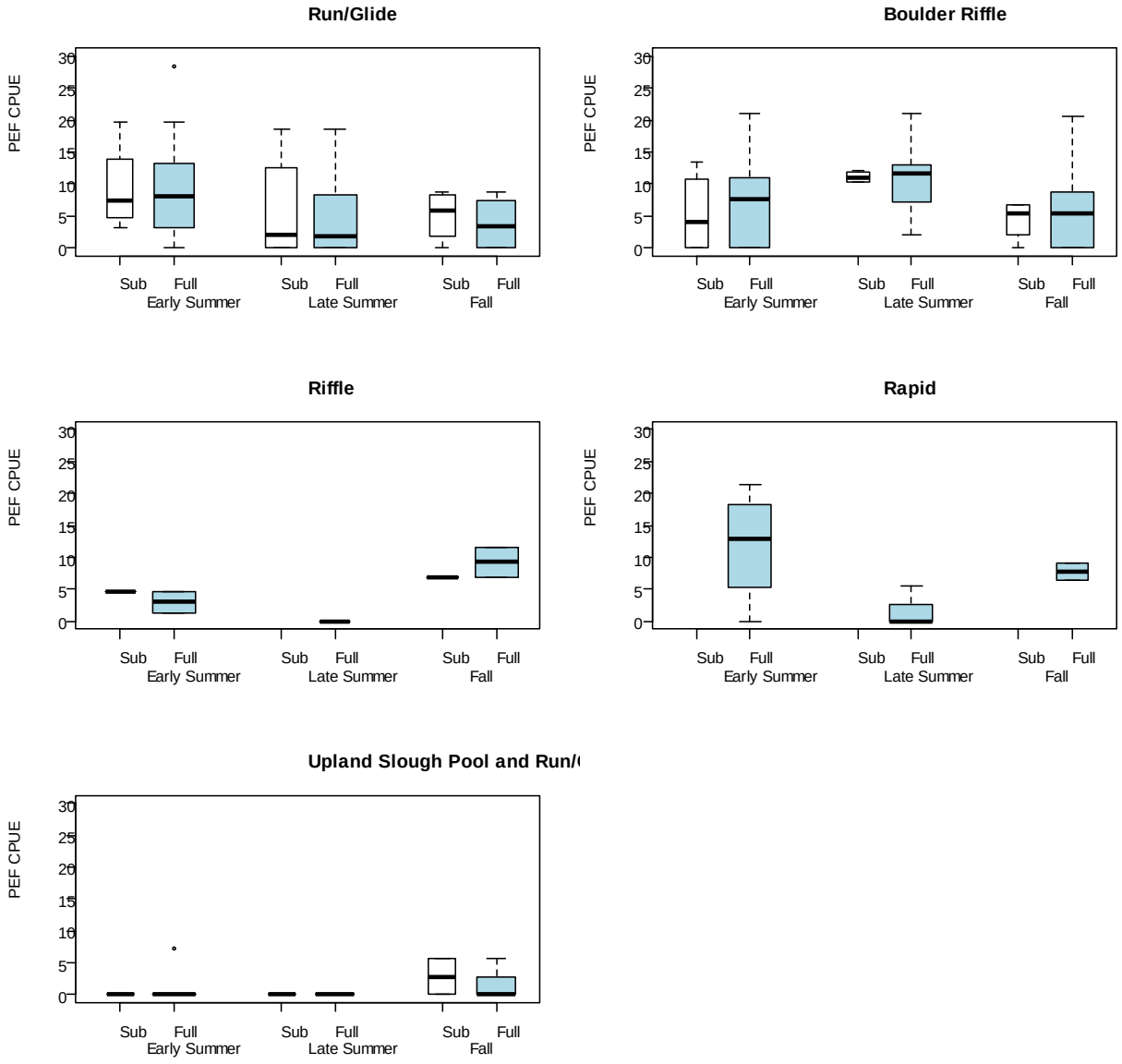

Figure 3.2-3. Boxplots comparing 2014 subsampling to 2014 full sample in the Black River based on CPUE for backpack electrofishing in fish/hour for total Arctic grayling during three sampling events. The boxes represent the interquartile range (i.e., 1st to 3rd quartile of data), the black line in the box is the median. The whiskers extend to the full range of the data unless one or more data points are extreme, in which case these points are plotted separately as small circles. Box width is proportional to sample size.

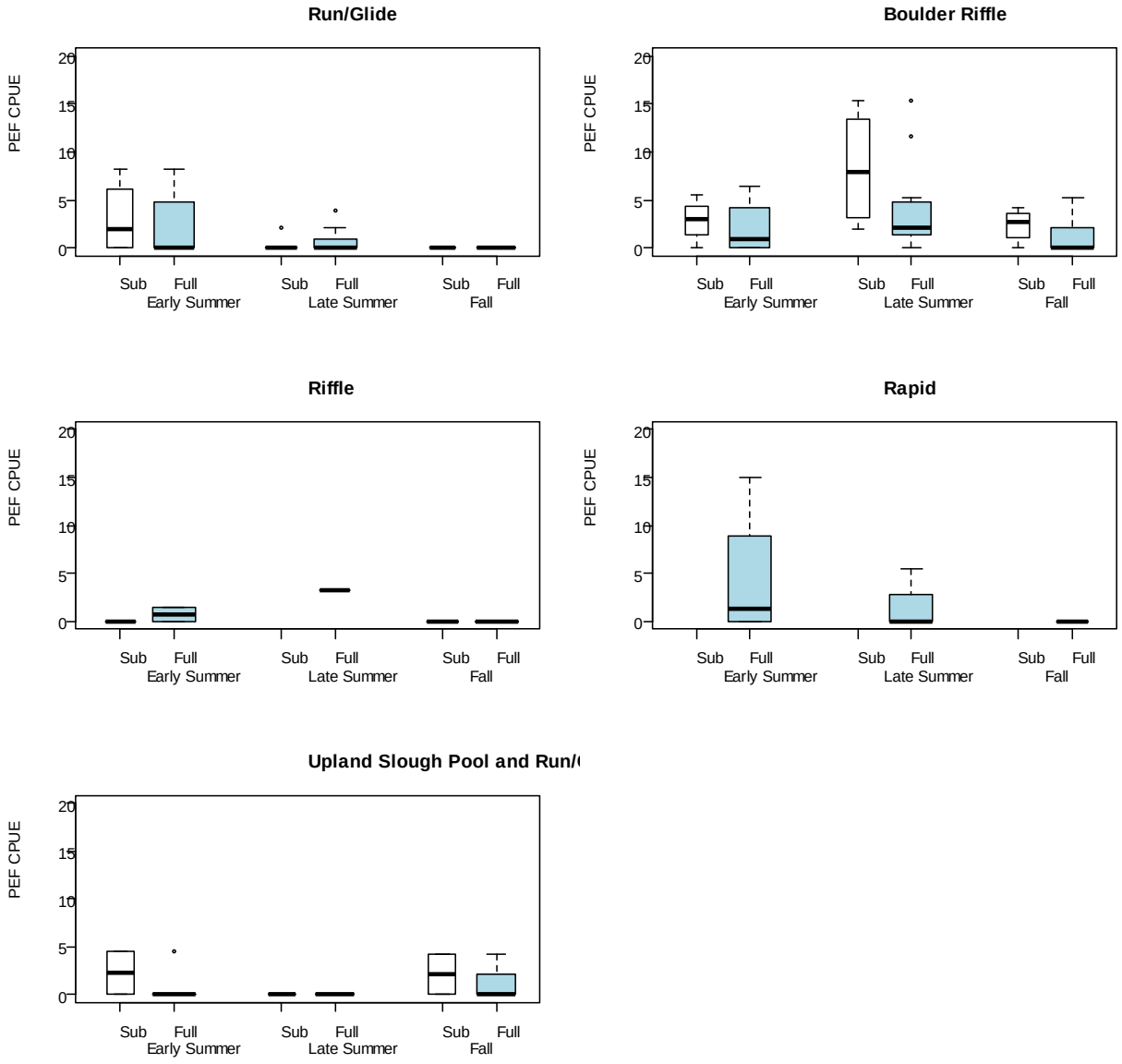

Figure 3.2-4. Boxplots comparing 2014 subsampling to 2014 full sample in the Black River based on CPUE for backpack electrofishing in fish/hour for juvenile burbot during three sampling events. The boxes represent the interquartile range (i.e., 1st to 3rd quartile of data), the black line in the box is the median. The whiskers extend to the full range of the data unless one or more data points are extreme, in which case these points are plotted separately as small circles. Box width is proportional to sample size.

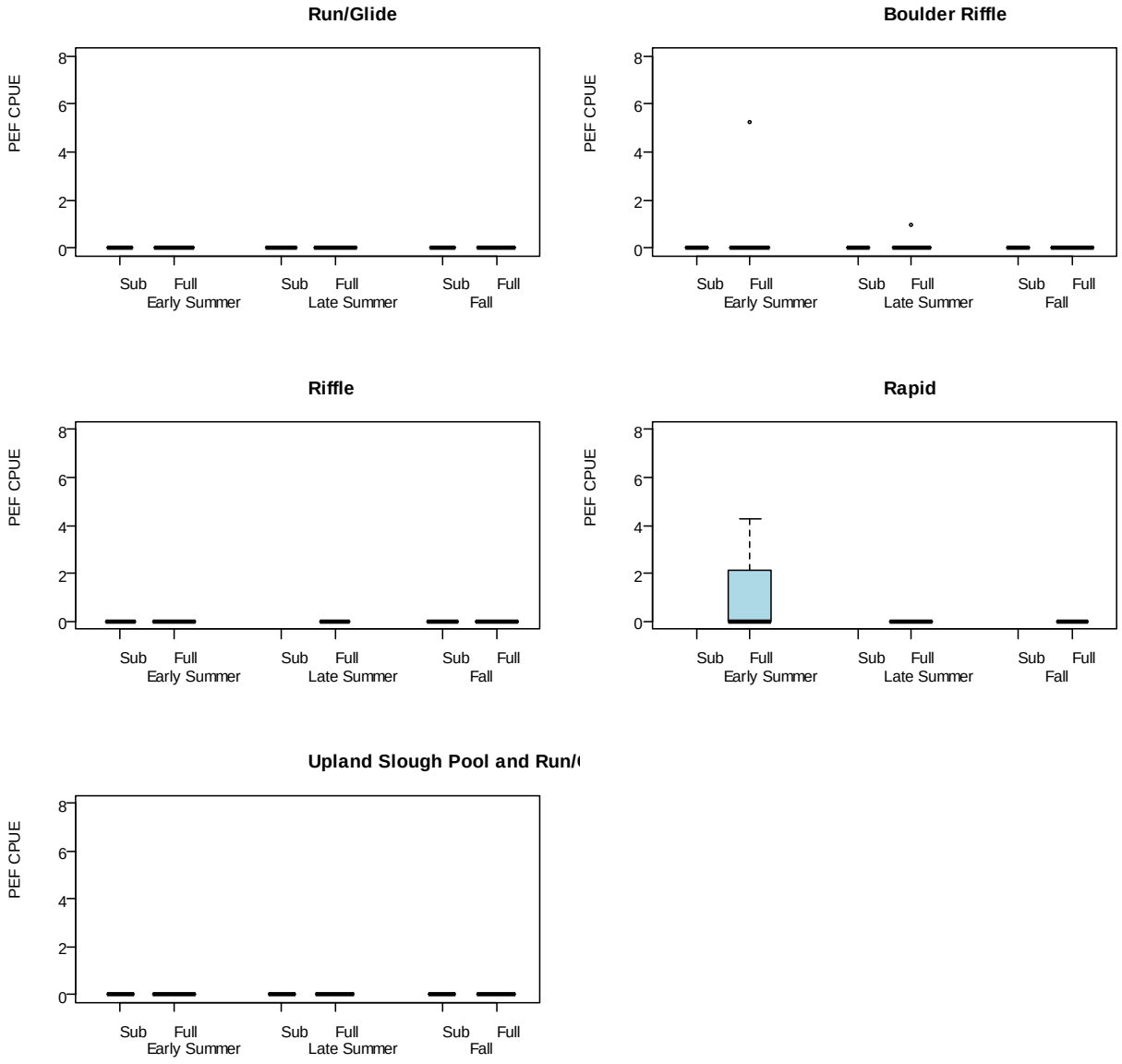

Figure 3.2-5. Boxplots comparing 2014 subsampling to 2014 full sample in the Black River based on CPUE for backpack electrofishing in fish/hour for subadult/adult burbot during three sampling events. The boxes represent the interquartile range (i.e., 1st to 3rd quartile of data), the black line in the box is the median. The whiskers extend to the full range of the data unless one or more data points are extreme, in which case these points are plotted separately as small circles. Box width is proportional to sample size.

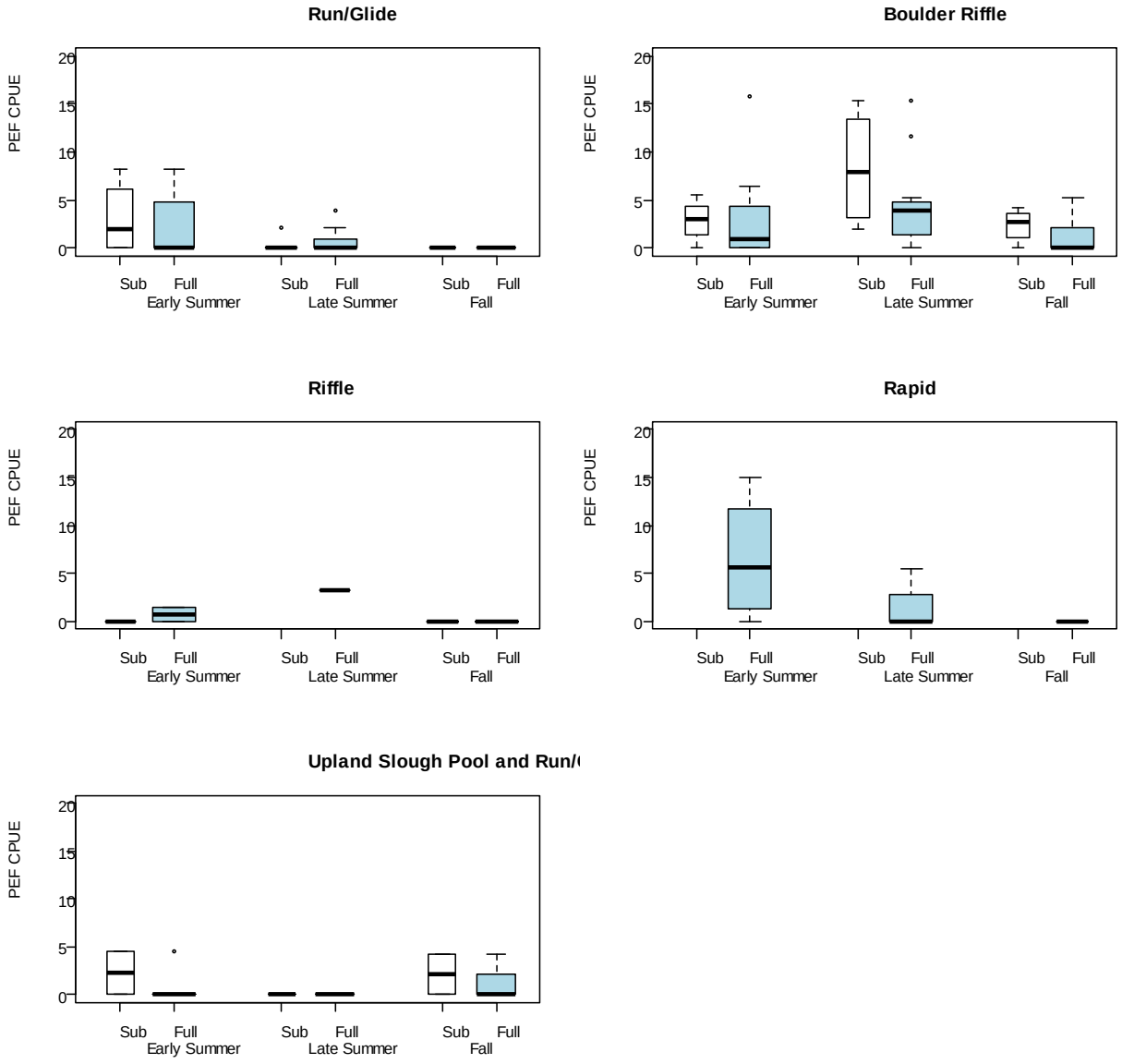

Figure 3.2-6. Boxplots comparing 2014 subsampling to 2014 full sample in the Black River based on CPUE for backpack electrofishing in fish/hour for total burbot during three sampling events. The boxes represent the interquartile range (i.e., 1st to 3rd quartile of data), the black line in the box is the median. The whiskers extend to the full range of the data unless one or more data points are extreme, in which case these points are plotted separately as small circles. Box width is proportional to sample size.

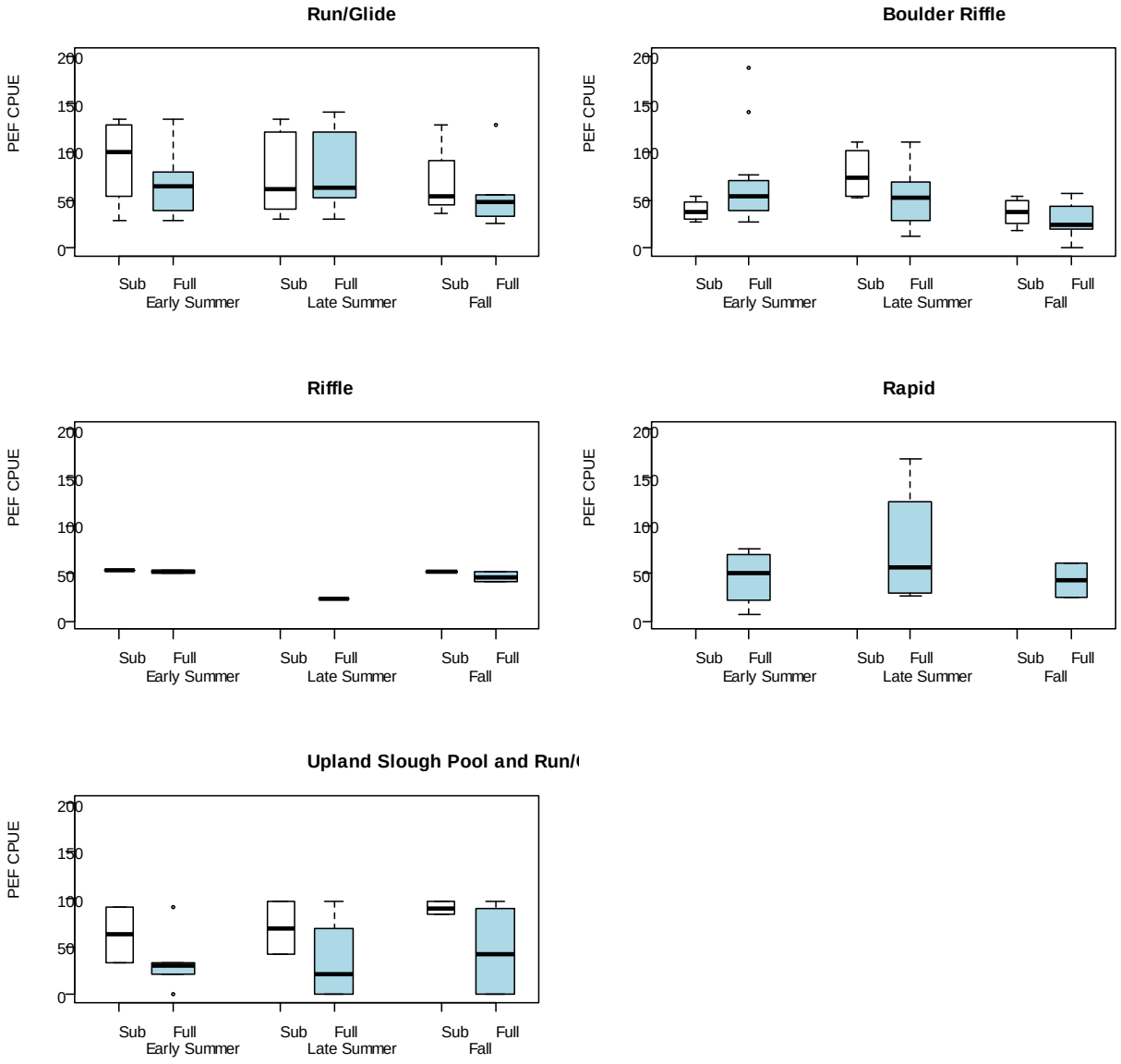

Figure 3.2-7. Boxplots comparing 2014 subsampling to 2014 full sample in the Black River based on CPUE for backpack electrofishing in fish/hour for total sculpin during three sampling events. The boxes represent the interquartile range (i.e., 1st to 3rd quartile of data), the black line in the box is the median. The whiskers extend to the full range of the data unless one or more data points are extreme, in which case these points are plotted separately as small circles. Box width is proportional to sample size.