Susitna-Watana Hydroelectric Project

(FERC No. 14241)

Fish Distribution and Abundance Studies

Study Plan Sections 9.5 and 9.6

Development of Relative Abundance and Fish Habitat Use Indices – 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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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
AWC	Anadromous Waters Catalog
backwater	Found along channel margins and generally within the influence of the active main channel with no independent source of inflow. Water is not clear. A backwater will be mapped as if it were a separate mesohabitat type.
beaver complex	Complex ponded water body created by beaver dams. A beaver dam will be mapped as if it were a separate mesohabitat type.
boulder riffle	Same flow and gradient as Riffle but with numerous boulders that can create sub-unit sized pools or pock water created by scour.
Cascade	A fast water habitat with turbulent flow; many hydraulic jumps, strong chutes, and eddies and between 30 80 percent white water. High gradient; usually greater than 4 percent slope. Much of the exposed substrate composed of boulders organized into clusters, partial bars, or step-pool sequences. 1
clearwater plume	Discharge from a tributary that forms a pronounced area of clearwater, in contrast to the turbid water of th main channel, along the main channel shoreline. The length, breadth, and depth of the clearwater plume depend on the relative discharge between the tributary and the main channel, relative turbidity, and on mixing conditions along the shoreline. A clearwater plume will be mapped as if it were a separate mesohabitat type.
CPUE	catch per unit effort
CAI	Combined Abundance Index
CW	channel width
delta log normal distribution	a statistical probability distribution that is a variant of the lognormal distribution, commonly used when dat are skewed and contain a relatively large number of zeros …
FA	Focus Area; sections of river delineated for intensive investigation by multiple disciplines as part of the AEA study program
Family	one of the eight taxonomic ranks of animals; located between order and genus
FDA	Study of Fish Distribution and Abundance
FUHI	Fish Use Habitat Index
gear event	Application of a single gear within a sampling event. May be applied at the meso- or macrohabitat level
Genus	one of the eight taxonomic ranks of animals; located between family and species
GND	Drift gill net
GRTS	generalized random tessellation stratified sampling
IBI	Index of Biotic Integrity
IBW	Index of Well-Being
log transformation	Transformation is the replacement of a variable by a function of that variable, in this case, replacing a variable x with the logarithm of x.
IP	Implementation Plan
ISR	Initial Study Report
km	kilometer
m	meter

Abbreviation	Definition
macrohabitat	a discrete area of stream defined by connectedness to the main channel and flow; macrohabitat types include: main channel, side channel, side slough, upland slough, tributary lower reach, tributary mouth, clearwater plume, backwater, additional open water
main channel	For habitat classification system: a single dominant main channel. Also, the primary downstream segmen of a river, as contrasted to its tributaries.
mesohabitat	a discrete area of stream exhibiting relatively similar characteristics of depth, velocity, slope, substrate, cover, and variances thereof; mesohabitat types include: pool, run/glide, riffle, boulder riffle, cascade, rapid,
MINB	baited minnow trap
MR 1 through 7	Middle River geomorphic reaches 1 through 7
NFA	Non-focus area; referring to data collected outside of focus areas
off-channel	Habitat within those bodies of water adjacent to the main channel that have surface water connections to the main river at higher discharge levels.
PEF	Backpack electrofishing
Pool	A slow water habitat with a flat surface slope and low water velocity that is deeper than the average channel depth. Substrate is highly variable.
PRM	Project river mile
RAI	Relative Abundance Index
RI	Species/lifestage richness Index
Riffle	A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section. Low gradient; usually 0.5-2.0 percent slope, rarely u to 6 percent.
run/glide	A habitat area with minimal surface turbulence with generally uniform depth that is greater than the maximum substrate size. Velocities are on border of fast and slow water. Gradients are approximately 0 to less than 2 percent. Generally deeper than riffles with few major flow obstructions and low habitat complexity.
RSP	Revised Study Plan
sampling event	seasonal visit to a sampling unit
sampling season	season e.g., FDA-1 (early summer), FDA-2 (summer), or FDA-3 (fall)
sampling unit	sampling target selected using either GRTS or transects or as a mesohabitat within a macrohabitat selected using either GRTS or transects
SEN	Seining
side channel	Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well-defined secondary (overflow) channels, or in poorly-defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.
side slough	Off-channel habitat characterization of an Overflow channel contained in the floodplain, but disconnected from the main channel. Has clear water.
SIRA	Species/lifestage-specific index of relative abundance
SNK	Snorkeling
SPD	Study Plan Determination
special habitat feature	habitat types that overlap with macrohabitat and mesohabitat categories and are treated as both in fish-habitat analyses including: backwater, clearwater plume, and beaver complex

Abbreviation	Definition
species/lifestage richness	a metric that describes the number of different fish species and lifestages present, calculated as a sum of all species plus the total number of life stages for each species present in catch
tributary lower reach	the lower reach of the tributary that will be influenced by the Project's zone of hydrologic influence
tributary mouth	the delta portion of the tributary downstream of the tributary lower reach and upstream of the clearwater plume, a mainstem macrohabitat type
upland slough	Off-channel habitat characterization feature that is similar to a side slough, but contains a vegetated bar a the head that is rarely overtopped by mainstem flow. Has clear water.
UR	Upper River, the Susitna River upstream of the proposed Watana Dam site

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed with the Federal Energy Regulatory Commission (FERC) its Revised Study Plan (RSP), which included 58 individual study plans (AEA 2012). Included within the RSP was the Study of Fish Distribution and Abundance in the Upper Susitna River (FDAUP), Section 9.5, and the Study of Fish Distribution and Abundance in the Middle and Lower Susitna River (FDAML), Section 9.6. Following the filing of the RSP, AEA held stakeholder meetings and filed detailed study methodology in an Implementation Plan (AEA 2013) for Studies 9.5 and 9.6, collectively referred to as Fish Distribution and Abundance (FDA). The FDA Implementation Plan was filed on March 1, 2013 in accordance with Commission-approved schedule. On April 1, 2013, FERC-approved the Revised Study Plans (FERC 2013) for the FDA studies with staff-recommended modifications.

The overarching goal of the FDA studies is to characterize the current distributions, relative abundances, run timings, and life histories of all resident and non-salmon anadromous species encountered as well as freshwater rearing life stages of anadromous salmonids (fry and juveniles) in the Upper, and Middle/Lower Susitna River. Adult salmon species are addressed in the Salmon Escapement Study (Section 9.7). Data collected as part of this study will be used to provide a baseline characterization of fish assemblages in the Susitna River, to identify and evaluate potential Project-induced effects on fish assemblages, and inform development of any necessary protection, mitigation, and enhancement measures. The FDA studies are designed to provide baseline biological information regarding periodicity and habitat suitability for the Instream Flow Modeling Study (see Section 8.5). Results of this study will include key life history information about fish species in the Susitna River, which will provide inputs for the Study of Fish Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Section 9.12) and the Study of Fish Passage Feasibility at Watana Dam (Section 9.11).

Detailed information describing the data collection and preliminary results for the relative abundance and fish-habitat association components of FDA was provided in the Initial Study Report (ISR) for Studies 9.5 and 9.6 Part A, Sections 4.1.2, 4.2, 4.4.2, 4.4.3, 5.1.2, 5.1.3, 6 (AEA 2014C, AEA 2014d) and most recently in Study 9.5 and 9.6 *2014-2015 Study Implementation Reports* (SIR), Section 4.2 (9.5 & 9.6), 4.3 (9.5 & 9.6), 4.1.1 (9.5), 4.1.2 (9.6), 5.1.1 (9.5) and 5.1.2 (9.6) (AEA 2015a & AEA 2015b). The analytical methods and preliminary results to date have focused on reporting and updating the fish distribution data as well as the fish catch and gear-specific CPUE estimates by habitat type. To date, the presentation of preliminary results has been limited by an approach for combining CPUE across gears.

This TM (a supplement to Study 9.5 and 9.6 *2014-2015 Study Implementation Report* (November 9, 2015) and filed with FERC as Attachment 7 to *Response of the Alaska Energy Authority to Comments on the Initial Study Report*) furthers the summary and analysis of relative abundance and CPUE data collected in 2013 and 2014 by providing and testing a method for combining gear-specific CPUE. In addition, example analyses of results from field surveys are presented to demonstrate the utility of the method for future baseline characterization and impact analyses of fish assemblages. This TM is pertinent to both studies, the Study of Fish Distribution and Abundance in the Upper Susitna River (9.5) and the Study of Fish Distribution and Abundance in the Middle and Lower Susitna River (9.6).

In 2013 and 2014, AEA completed the first year of data collection for the Study of Fish Distribution and Abundance in the Upper River (Study 9.5) and Middle/Lower Susitna River (Study 9.6). This technical memorandum provides preliminary methods and results related to Objective 1, specifically describing the relative abundance and fish-habitat associations of resident fishes, juvenile anadromous salmonids, and the freshwater life stages of non-salmon anadromous species.

The Susitna River is a large and complex river aquatic ecosystem. The river morphology varies across its 300-mile length with stream channels that range from 200-meter wide, low gradient, single channels to highly braided island complexes and tributary inputs that range from large rivers, to steep cascading tributaries, to 20-meter-wide meandering sloughs. Habitats are diverse within these channels (Figure 1-1), including everything from pools to cascades; some are turbid due to glacial till while others run clear due to groundwater influences. To help describe this complex riverscape, AEA has created an aquatic habitat classification system for both mainstem and tributary waterbodies that is hierarchical with mesohabitats (e.g., pools, riffles, and glides) nested within macrohabitats (e.g., sloughs, side channels). The fish assemblage is also diverse with at least 22 fish species documented in the study area, including fish of various sizes and life stages that exhibit several different life history strategies, feeding habits, diel behaviors, swimming abilities, physical tolerances, and migration patterns.

Given the Susitna River system's complexity, AEA's goal for the Fish, Distribution and Abundance (FDA) studies was to characterize the fish assemblage in a comprehensive manner across the riverscape, including habitats that do and do not support fishes. This goal required a multi-species, multi-habitat sampling approach. No single gear or technique was appropriate for effectively sampling all of the fish species and lifestages potentially present in all habitat types within the river. Furthermore, the effectiveness of fish sampling gear was variable both in time and space and was influenced by physiochemical site parameters that are dynamic in nature (turbidity, velocity, depth, substrate, conductivity, instream cover), as well as target fish behavior (diet for baited techniques, activity periods, microhabitat preferences, and migration patterns). Other constraints, such as access and permit restrictions affected when, where, and how sampling techniques were applied.

While sampling with a single gear in all habitat types would have simplified logistics and mathematical calculations of fish abundance, it would have imposed an unacceptable risk of not accurately characterizing all the fish species and life stages present due to gear-specific capture efficiency and size selectivity biases. For example, adult burbot would not likely be captured by minnow traps due to size, and electrofishing is not an effective method in water with low visibility. Thus, to properly address the study goal and objectives, which necessitated fish collection across diverse habitats and multiple seasons while targeting a wide variety of life stages and species that inhabit different areas of the water column, a standardized approach for selecting and deploying multiple gear types was implemented (AEA 2013; R2 Resource Consultants, Inc. 2014).

Although sampling fishes with multiple gear types strengthens our ability to characterize the fish assemblages present, the need to combine numbers of fish caught with different methods complicates the development of metrics to describe fish abundance and fish-habitat associations. To overcome the complication and describe the seasonal fish use of macro- and mesohabitat throughout the river's geomorphic reaches and tributaries, AEA developed methods for standardizing and combining gear-specific CPUEs for each species/lifestage to create species/lifestage-specific indices of relative abundance (SIRAs) that are comparable across habitats and species. In addition to help qualify the value of habitat to fishes, AEA has created an index of fish use that moves beyond the relative abundance of individual species/life stages to characterize overall fish use of habitats. As this memorandum describes, AEA's Fish Use Habitat Index (FUHI) incorporates the overall relative abundance of fish species groups and fish species richness within each habitat type. The FUHI is used to characterize and compare the relative importance of diverse habitats to fishes throughout the large and complex riverscape of the study area and across sampling seasons.

2. METHODS

2.1. Sampling Design and Quality Control of Effort Metrics

A complex survey design has been used to satisfy multiple objectives for Fish Distribution and Abundance studies in the large and diverse Susitna River system, as described in the Final Susitna River Fish Distribution and Abundance Implementation Plan (Sections 5.2-5.4, AEA 2013). The sampling units were mesohabitats, but sample selection was conducted at the macrohabitat and special habitat feature level. This two-stage sampling was necessary because the habitat mapping that was available for study design was not implemented to the mesohabitat level throughout the river, and because the location, type, and size of mesohabitat units change with varying flows. Sampling was conducted during three sampling seasons: early summer, late summer and fall. The timing of seasonal sampling in 2013 and 2014 (AEA 2014a, 2014b; R2 Resource Consultants 2015a, 2015b) and the associated flow and water temperatures are presented in Figure 2.1-1.

In the Lower River, mainstem river transects were selected using systematic random sampling. All mesohabitats within each macrohabitat type that intersected each transect were sampled (Table 2.1-1). Less common off-channel habitats also were included in sampling by selecting habitats within a buffer area surrounding each transect. The same sampling approach was used in the Upper River in 2013; however, in the Upper River only a few off-channel habitats were found for sampling (AEA 2013). For this reason, in 2014 additional Upper River off-channel habitats were randomly selected from line mapping using a generalized random tessellation stratified sampling (GRTS) approach (R2 Resource Consultants 2015a).

In the Middle River, a population of segmented macrohabitat units was obtained from line mapping. These units were stratified by geomorphic reach and then by Focus Area and Non-Focus Area sections within each geomorphic reach. There was a higher density of sampling applied inside Focus Areas (with fewer macrohabitat segments in the population) as compared to Non-Focus Areas. Sampling unit selection at the macrohabitat and special habitat feature level then occurred using a GRTS approach. This site selection process can be described as a stratified multi-stage or cluster sampling design, which requires weighting by stratum population sizes when estimating averages. Given this design, care must be taken to properly estimate ratios such as CPUE when combining individual samples.

In the Upper River, thirteen tributary streams were selected for sampling based on: Alaska's anadromous water's catalog (AWC) listings, drainage basin, historical sampling efforts, and the potential for impact or inundation from the proposed Project. These tributaries were evaluated for general accessibility based on existing information and eight were deemed at least partially accessible and suitable for statistical sampling. Due to challenges of acquiring complete remote imagery coverage, the tributary habitat characterization included habitat unit frequency rather than the complete habitat mapping that was conducted in the mainstem. Therefore, the sampling design used the lengths of the accessible portions of these eight tributaries up to the 3,000-ft (914 m) elevation contour and divided them into units of equal length, creating GRTS panels for sample site selection. The GRTS sampling method was used to randomly select GRTS panels for sampling among the population of panels within each tributary. Within each selected GRTS panel, one unit of each available mesohabitat type (Table 2.1-2) was randomly selected for fish sampling. In 2013, sampling unit lengths were either the complete mesohabitat unit length or 200 m (656 ft) per mesohabitat type per site, whichever was shorter. In 2014, 400 m (1,312 ft) GRTS panels were classified to mesohabitat type and sampled in their entirety (R2 Resource Consultants 2015a).

Access was severely limited on the remaining five Upper River tributaries, so the GRTS sampling design could not be applied to those streams. Instead, they were sampled using a non-random direct sampling approach. Data from these five direct-sample tributaries were not included in generation of the SIRA and FUHI indices presented herein.

The SIRA and FUHI analyses included data from systematic transect sampling and GRTS sampling units. In the mainstem of the Lower Susitna River, a total of 44 macrohabitat locations were sampled along 10 transects (Table 4.1-4 in AEA 2013). In the mainstem of the Middle Susitna River, a total of 182 macrohabitats were sampled in six geomorphic reaches; seven macrohabitats were re-sampled in 2014 (Table 4.1-3 in R2 Resource Consultants 2014). In the mainstem of the Upper Susitna River, a total of 55 macrohabitats were sampled along transects and in GRTS sampling units; five of which were re-sampled in 2014 (Table 4.1.4 in AEA 2014b and Table 4.1-4 in R2 Resource Consultants 2015a). In Upper River tributaries, a total of 83 GRTS panels were sampled; six units were re-sampled in 2014 (Table 4.1.2 in AEA 2014b and Table 4.1-4 in R2 Resource Consultants 2015a). Summing across the three sampling seasons, the total number of macrohabitat samples used in this Fish Use Habitat Index is 1,128 (Table 2.1-3; Table A1). The total number of mesohabitat samples identified within these macrohabitats was 1,576 (Table 2.1-4; Table A2).

Following the gear selection protocol for fish abundance sampling (R2 Resource Consultants 2014), the appropriate use and application of gears varied by macrohabitat and mesohabitat type (Tables 2.1-1 and 2.1-2). For example, snorkeling was applied most frequently in run/glide and pool mesohabitats in tributaries and sloughs where visibility was sufficient. Some gear types were rarely applied; therefore, data collected with those gear were not conducive to standardization across habitats and the catch data from these gear types were not used in generating the SIRAs and FUHIs. Specifically, techniques used in fewer than fifty sampling events (trotline and fixed gillnet) were excluded from analysis. Nine gear types were included in the FUHI analysis: angling, backpack electrofishing, boat electrofishing, drift gillnetting, fyke netting, hoop trapping, minnow trapping, seining, and snorkeling. Effort and catch data for each gear-specific sampling event (gear event) were reviewed prior to analysis. Records missing documentation of effort, those with insufficient effort applied (e.g., sampling suspended due to observing an adult salmon shortly after beginning boat electrofishing, as per permit stipulations) or those suspected to have errors in the recorded effort values (e.g., unusually high intensity sampling for the size of the site) were excluded from the analysis (Table 2.1-5). After quality control of gear events and summing across sampling seasons, the total number of gear events at the macrohabitat level used in this Fish Use Habitat Index was 3,021 (Table 2.1-3; Table A1). The total number of mesohabitat gear events used in the Fish Use Habitat Index was 4,002 (Table 2.1-4; Table A2).

A total of 46,804 fish were caught or observed in gear events incorporated into the Fish Use Habitat Index (Table 2.1-6). Examination of the catch data for various gears demonstrates biases (size selectivity, feeding habits, etc.) and illustrates the need for a combined gear approach for understanding habitat associations. For example, minnow trapping was very effective at catching juvenile salmon but was not effective for adult trout or grayling, and therefore would not have been an effective tool for understanding habitat associations for those species (Table 2.1-6).

2.2. Analytical Methods

The following sections describe the background for the decision to create the FUHI for habitat and seasonal comparisons (Section 2.2.1), followed by the four steps used to estimate the relative abundance (Sections 2.2.2 to 2.2.5) and species/life stage richness metrics (Section 2.2.6) that are combined into the FUHI index (Section 2.2.7).

2.2.1. Background

To draw conclusions about relative fish assemblages across Susitna River habitat types and in different reaches of the river, either a statistically valid population estimate or a corresponding index of total fish abundance for each habitat type is needed. Studies with this objective often use a single gear type across multiple habitats and reaches and assume that the gear type has similar efficiency in each habitat type and reach for all target species. However, there was no single gear type that could have been used effectively and efficiently in all habitats of the Susitna River. To meet the objectives of this study and document the diverse assemblage of species and life stages potentially present, it was necessary to apply multiple gear types in every type of fish habitat encountered. As a result, the data consist of a set of non-additive gear-specific abundances. For example, the same fish that was observed in the initial snorkeling at a site could have also been caught during electrofishing. This complicated the generation of habitat-specific abundance estimates and the comparison of fish abundances among habitats and across seasons.

Evaluating fish-habitat associations with a multiple-gear data set could be approached in multiple ways. For any given species, or group of species, AEA considered the following options:

1. Calculate CPUE for each gear type separately and conduct multiple single-gear comparisons for habitats where each gear was used;
2. Use presence/absence rather than abundance across all gear types to draw conclusions on general use; or

3. Develop a combined CPUE index that provides for a relative comparison of CPUE across habitats with all catch methods combined.

Calculating gear-specific CPUE (Option 1) was straightforward, was used as a preliminary step in the analysis of 2013 data (9.5 ISR Section 5.1.2 and 9.6 ISR Section 5.1.2), and was incorporated into the FUHI presented herein. This option provides good information on gear efficiency and selectivity but results in large numbers of discrete gear and species-specific CPUEs that make habitat-level patterns difficult to detect. Furthermore, it is difficult to synthesize the information across all habitat types and seasons because the sample sizes for gear applications were highly variable due to changing conditions. For example, seining was done in different types of habitats than boat electrofishing, and snorkeling might only be possible to apply at some sites in some seasons depending on changing flow and/or turbidity levels.

Option 2, using presence/absence data across all gear types to draw conclusions (e.g., Longnose Sucker were caught in 88 percent of sampled pools in side sloughs) also is a simple, straightforward way to characterize fish use of habitats. This was reported for 2013 data in 9.5 and 9.6 ISRs (Section 5.1.3 in both ISRs), and is related to the species richness values that are included in the FUHI. However, relying on this analysis alone limits inference to one dimension, presence. It does not allow us to characterize relative abundance, such as differentiating between a pool that was occupied by 1,000 Longnose Sucker and a riffle where 2 Longnose Sucker were caught. Also, this approach is subject to large bias in interpretation when unequal effort across habitat types and reaches occurs. For example, if the analysis shows that Longnose Sucker were captured more frequently in pools than in riffles, this result could be due to that the difference in sampling effort if considerably more sampling effort was expended in pools. Catch-per-unit-effort better facilitates comparisons across habitats when effort is unequal.

Developing a combined-gear CPUE (Option 3) was necessary to allow for meaningful relative abundance comparisons across habitat types, among different areas of the river, and across seasons. There are several ways that fish scientists have combined fish count data across gears to make comparisons. The study team reviewed these approaches before deciding upon the metric best suited for the Susitna River data set.

One possibility for combining relative abundance across habitats or studies with different methods would be to group counts of fish into categories (e.g., dominant, common, rare) to discuss relative abundance in qualitative terms. Some authors have simply added CPUE across gear methods when the type of effort was comparable between the two methods (e.g., counts per length of stream) and when several assumptions could reasonably be made (Quist et al. 2006; Pugha and Schramm 1998; Jackson and Harvey 1997; Tremain and Adams 1995; Weaver et al. 1993). However, in cases where the type and amount of sampling effort applied across the compared units differs substantially, method-specific CPUE is needed to standardize counts prior to any combinations. The complexity of the Susitna River system and the variable pattern of gear type usage in different and similar habitats do not equate to a simple combination process.

Statistical modeling or multivariate analyses also have been used to analyze data collected using multiple gears. For example, Feyrer and Healey (2002) included CPUE from multiple gears in a comprehensive multivariate analysis studying the effects of gear type and environmental variables on fish assemblage structure. Also, as summarized by Hinton and Maunder (2003), standardization of CPUE using generalized linear models is common in stock assessment efforts.

These statistical modeling methods require sufficient replication of a consistent set of gear types in similar habitats to develop defensible co-varying relationships. Because of the difficulties in using the same gears in all habitats and in all events, these methods cannot be applied in a robust manner to the Susitna River FDA dataset.

To remove systematic differences in abundance estimates related to varying gear efficiencies (sometimes referred to as “gear effects”), other authors have standardized the CPUE to the mean and standard deviation for each gear type. This standardization yields CPUE values of comparable scales (de Lafontaine et al. 2010; Chick and Pegg 1998) before summing across gear types. This was the general process adopted by AEA’s study team in developing the FUHI.

2.2.1.1. Developing the SIRA and the FUHI

The SIRA is a species/life stage-specific index that combines CPUE estimates from data collected using different gear types into an index of relative abundance by habitat type.

The FUHI integrates the following six individual components into one metric to describe overall fish use by habitat type:

1. Total species/life stage richness (number of species/life stages found);

2. Relative abundance of juvenile commercial fishery species;

3 – 5. Relative abundance of non-commercial fishery species (species with only sport, personal use, and subsistence fisheries) for adult (3), juvenile or adult (4), and juvenile (5) life stages;

6. Relative abundance of non-harvest fish species for all life stages.

The process for generating the SIRA and the FUHI is the same for the first three steps described below. The only difference is that the data used for these calculations is limited to one species or life stage of interest for the SIRA, while data on multiple species and life stages are included for the fish harvest groups when calculating the FUHI. Calculations for the SIRA stop with Step 3 while the additional calculations are used for the FUHI to combine across fish groups and incorporate species richness into the index.

All fish species collected during FDA sampling were categorized into one of three harvest species groups (Table 2.2-1). The commercial harvest group consisted of the five species of anadromous salmon present in the basin. The non-commercial harvest group included Arctic Char, Arctic Grayling, Rainbow Trout, Round Whitefish, Humpback Whitefish, Northern Pike, and Burbot. Species within this group can have anadromous life history types, but no evidence was available to confirm that this life history pattern was exhibited in the Susitna River basin. The non-harvest group included the smaller-bodied fishes that are numerically abundant like sculpin and stickleback as well as other non-harvested species including Longnose Sucker, Arctic Lamprey, and Bering Cisco. Captured fish with undetermined genus or species identifications could not be placed into a group and, thus, were not used in estimating relative abundance. Alaska Blackfish, Eulachon, and Pacific Lamprey were not collected during 2013 and 2014 FDA sampling and therefore were not included in the FUHI (Table 2.2-1). Life stages were used to further delineate groupings for commercial and non-commercial harvest groups because juveniles were discernable from, and often use different habitats than, adult stages. All life stages were combined for the non-harvest group as this group was numerically dominated by sculpin and stickleback and life stages for these species were not readily discernable in the field (Table 2.2-1).

Consistent with the habitat classification schemes, FUHI scores were generated for the Upper, Middle, and Lower River mainstem and Upper River tributary habitats. FUHI scores are relative to all other habitat types within these combined river segments. In general, the FUHI score will vary with richness and overall fish abundance and will identify habitat types that have high versus low fish use for future assessment of potential Project effects to fish habitats. At this time, the species groupings selected for the FUHI were based on current fishery classifications; any habitat evaluation would be relative to these groups. However, it is important to note that the FUHI methodology is flexible in that different combinations of species groups or habitat classifications could be developed to address specific questions regarding fish use of habitat.

2.2.2. SIRA and FUHI Step 1: Calculate gear specific CPUE for each species/life stage or fish group in each stratum

Two levels of habitat comparisons are desired for Susitna River fish-habitat analysis, comparisons across macrohabitat types and comparisons across mesohabitat types within macrohabitat types. For macrohabitat comparisons, catch and effort data for each gear type within each macrohabitat unit were summed across mesohabitat units (Table A1). Then average CPUE for each macrohabitat type within each habitat stratum (i.e., across habitat units) was estimated using (total catch)/(total effort) for the stratum. For mesohabitat comparisons, the mesohabitat units are not summed within each macrohabitat unit; the average CPUE for each mesohabitat type within each macrohabitat type is estimated separately (Table A2). The following steps for generating a fish group-specific CPUE by gear type were identical for both macrohabitat and mesohabitat calculations.

Catch data obtained from using five different gear types were developed into distinct metrics to describe the effort applied by sampling. The following method and effort metrics were combined into the CPUE:

- Baited Minnow Traps (MINB): Catch/(# traps x m sampled) (i.e., catch/trap/m),
- Backpack Electrofishing (PEF), Boat Electrofishing (BEF): Catch/Minutes of Pulse Time,
- Snorkeling (SNK), Seining (SEN), Drift gill-nets (GND): Catch/100m^{2,}
- Angling: Catch/Minutes Sampled,
- Fyke Nets and Hoop Traps (all one-night duration): Catch/Net (Trap).

For the Middle River GRTS design, sampling strata were based on the seasonal period (Early Summer, Late Summer, and Fall), geomorphic reach, Focus Area (FA)/Non Focus Area (NFA) group, and macrohabitat type. The Upper and Lower River mainstem sampling and Upper River tributary designs were simpler, and did not include geomorphic reaches or Focus Areas. For these initial SIRA and FUHI analyses, one level of stratification, the FA and NFA samples, was combined to facilitate comparing fish use across habitats in the Middle River. Another level of post-sampling combination was necessary because special mesohabitats (Clearwater Plumes and Backwaters) were sampled as though they were macrohabitats, but were summarized in their correct mesohabitat level for this analysis. It is worth noting, that inherent to these analyses is the potential to combine other strata in various ways to increase sample sizes to make more general conclusions or address specific questions. For example, different stratification would allow evaluation of effort in backwaters within side sloughs and upland sloughs, or in main channel habitats above versus below Devils Canyon. The level of stratification chosen should be consistent with the questions the data are being used to address.

For stratified sampling, CPUE statistics were combined across strata based on estimated population sizes. Thus, for a combined stratified ratio estimate, AEA used the stratified total catch estimate divided by the stratified total effort estimate.

For combined FA and NFA CPUE, the ratio estimate was therefore:

$$CPUE = \frac{N_{FA} * \overline{C_{FA}} + N_{NFA} * \overline{C_{NFA}}}{N_{FA} * \overline{E_{FA}} + N_{NFA} * \overline{E_{NFA}}},$$

where

N_{FA} is the estimated number of habitat units in Focus Areas for this stratum,

N_{NFA} is the estimated number of habitat units in Non-Focus Areas for this stratum,

$\overline{C_{FA}}$ is the average catch in FA habitat units,

$\overline{C_{NFA}}$ is the average catch in NFA habitat units,

$\overline{E_{FA}}$ is the average effort in FA habitat units, and

$\overline{E_{NFA}}$ is the average effort in NFA habitat units.

An estimate of the population size of habitat units is needed for each macrohabitat type in each stratum (reach/FA group) to compute these estimates. The habitat population size estimates were based on the original line mapping sample size for macrohabitat units, but were adjusted upward if more macrohabitat units were sampled than were originally mapped.

The package "survey" (Lumley 2004, 2014; see functions *svydesign*, *svyby*, *svyratio*) in R statistical software (R Core Team 2014) was used for all CPUE estimates. This program provided a fast reliable way to estimate the gear-specific CPUE for any given species/life stage or fish group. The function also provided proper estimates for any combined strata, which can be complicated for complex surveys with small sample sizes. If the weighting is not done properly, the estimates will be biased.

2.2.3. SIRA/FUHI Step 2: Calculate Standardized Gear-Specific CPUE Indices for each Species/Life Stage or Fish Group

In this step, AEA standardized the CPUE for individual gear types so that they are comparable across gear types. Standardized data indicate the direction (sign) and scaled distance (number of standard deviations) of each observation relative to the mean. The CPUE distributions tend to be skewed with moderate to high levels of zero CPUE results (no fish collected even with effort applied). When a distribution is skewed, however, the simple arithmetic average of the observations and the usual standard deviation estimates are biased estimates of distributional parameters. For example, two sets of data might be similar except one has two extremely large observations, resulting in a much higher (biased) standard deviation. Dividing by that standard deviation would reduce the numbers in the second data set so that they appear to have much lower results than the first data set. Standardizing in this case can result in skewed standardized results that are difficult to correctly interpret. Log-transforming a skewed dataset prior to standardizing can alleviate this issue (de Lafontaine et al. 2010); however, the presence of zeros is a nuisance to this transformation and researchers regularly add a small constant (typically = 1) to all observations prior to log-transformation. This process is flawed, as the number of zero results has a large impact on the mean and variance estimates, and results will differ if the value summed to this distribution is, for example, 0.5 rather than 1. AEA selected a more robust standardization process based on the assumption of a zero-modified or delta lognormal distribution (e.g., Johnson et al. 1999) for average strata CPUE for each gear type. The non-zero portion of a delta lognormal distribution is lognormally distributed, and an extra parameter describes the probability of a zero value (estimated by the proportion of the data that are zeroes).

Based on the delta lognormal probability distribution assumption, the non-zero average strata CPUE for each gear type were natural log-transformed and scaled using the sample mean and standard deviation, then back-transformed to the original scale:

$$\left\{ \begin{array}{c} CPUE'_g = exp\left[\frac{\ln(CPUE_g) - \overline{\ln(CPUE_g)}}{s_{\ln(CPUE_g)}}\right] \; for \; CPUE_g > 0; \\ \\ CPUE'_g = 0 \; for \; CPUE_g = 0 \end{array} \right\}$$

Where

$\ln(CPUE_g)$ is the natural log-transformed CPUE for gear type g in a given stratum,

$CPUE'_g$ is the standardized CPUE estimate for gear type *g* in a given stratum,

$\overline{\ln(CPUE_g)}$ is the average or mean of the log-transformed CPUE for gear type *g* across strata, and

$s_{\ln(CPUE_g)}$ is the sample standard deviation of log-transfomred CPUE for gear type g across strata.

This transformation maintains the position of the zeroes in the distribution, while scaling the remaining values to facilitate summation across gears. The standardized average CPUE for each individual stratum are all positive, with the following interpretation:

- Stratum was sampled, but no fish observed: $CPUE_g^{'} = 0$
- Stratum has average CPUE less than the median CPUE for the gear type across all sampled strata in the Susitna River: $0 < CPUE_g^{'} < 1$
- Stratum has average CPUE greater than the median CPUE for the gear type across all sampled strata in the Susitna River: $CPUE_g^{'} > 1$

Note that the distribution of standardized CPUE remains skewed, habitats with very high observed CPUE will maintain that position in the distribution. But the high CPUE for each gear type is now on a comparable scale so the CPUE can be compared and combined across gears.

2.2.4. SIRA/FUHI Step 3: Calculating Combined-Gear Relative Abundance Indices by Species/Life Stage or Fish Group

The next step was to create the relative abundance index ($CPUE'$) for a species/lifestage or fish group by combining the standardized gear-type CPUE indices across gear types. To accomplish this, it may appear logical to consider summing abundance metrics; however, the standardized values are no longer fish abundances, but rather indices, marking the location of the stratum in the distribution of abundances for each gear. Also, the number of gear types varied among strata (Tables A1 and A2), so a weighted average of these indices provided a better comparison than a sum.

A simple average of the CPUE indices across gear types would give equal weighting to gear types that were used (at all) in the stratum (example of stratum: FDA-1 MR-6 side channel pools), regardless of the number of uses. For example, if seining was used six times in this stratum, and backpack electrofishing was used only once, the backpack electrofishing relative abundance would be given equal weight to the seining relative abundance. A more appropriate weighting was used here, with weighting based on the number of uses of each gear method in each habitat type (stratum):

$$CPUE' = \frac{\sum_{g=1}^{9} w_g CPUE_g'}{\sum_{g=1}^{9} w_g},$$

where

$CPUE'$ is the relative abundance index for a given habitat stratum,

$CPUE_g'$ is the standardized relative abundance for gear type g in the habitat stratum, and

w_g is the number of habitat units in the stratum sampled using gear type g.

Counts of gear applications by stratum are presented in tables A1 and A2. This weighted average gives the more frequently used gear types more weight in determining the overall status of the stratum, based on the idea that there is more information in that sample (less likely to be an outlier, for example). Because different gear types were used in different habitat types or under different flow conditions, there were some strata that have no observations for a given gear type. Using the weighted average method, these missing gear types received a weight of 0 and essentially did not impact the combined gear relative abundance result.

For a species/life stage, SIRA = $CPUE'$, and the calculations are completed. For the FUHI, RAI = $CPUE'$, and there are three more steps as described below.

2.2.5. FUHI Step 4: Developing a Combined Abundance Index

The relative abundance indices were developed as presented in Steps 2-4 for each of five fish groups:

commercial harvest juveniles,

non-commercial harvest adults,

non-commercial harvest juvenile/adults,

non-commercial harvest juveniles,

non-harvest species.

For incorporation into the FUHI, a combined abundance index (CAI) was generated as the weighted average of all fish group relative abundance indices in each stratum. To reflect the economic and cultural importance of commercial harvest species in this general index, AEA weighted the commercial harvest juvenile life stage CPUE by 4 and the other four groups were equally weighted by 1:

$$CAI = \frac{1}{8}(4 * RAI_{chjuv} + RAI_{nchadt} + RAI_{nchja} + RAI_{nchjuv} + RAI_{nh}),$$

where

RAI_{chjuv} is the relative abundance index for commercial harvest juvenile species,

RAI_{nchadt} is the relative abundance index for non-commercial harvest adult species,

RAI_{nchja} is the relative abundance index for non-commercial harvest juvenile/adult species,

RAI_{nchjuv} is the relative abundance index for non-commercial harvest juvenile species, and

RAI_{nh} is the relative abundance index for non-harvest species.

2.2.6. FUHI Step 5: Species and Life Stage Richness

Measures of habitat-specific relative abundance and species richness are two means of describing habitat quality. Biodiversity, residence time, growth, condition factor, reproduction, survival, and production are other commonly used measures. Habitats that support a high amount of biodiversity are often considered to be of higher quality. At the species level, biodiversity may include: taxonomic richness, habitat and guild groupings, life forms, and life stages. Other bioassessment metrics including the IBW, Index of Well-Being (Gammon 1976; Hughes and Gammon 1987) and the IBI, Index of Biotic Integrity (Karr et al. 1986) have integrated estimates of both abundance and taxonomic richness to evaluate habitat quality. For development of the FUHI, biodiversity was represented by a species and life stage richness metric that AEA calculated by summing the number of distinct species and life stages present in a sample.

Richness was calculated by the total observed counts of species and life stages summed for all gears at the mesohabitat and macrohabitat levels. Life stages included juvenile (all individuals sexually immature), juvenile or adult (mixture of immature and mature individuals), and adult (all individuals mature; Table 2.2-2). For juvenile Pacific salmon, the juvenile category was further sub-divided into fry, parr, and smolt (Table 2.2-2). To maximize richness values, AEA incorporated species and life stage counts for fishes identified to the family or genus level when these observations represented a unique occurrence of a fish group and/or if one or multiple life stage categories were present. The criteria directing counts for non-specific identification are presented in Table 2.2-2. The life stage "carcass" was not used in species/life stage counts since it could not be applied to a habitat with certainty (e.g., it could have floated downstream from a glide and been sampled in a riffle).

The richness counts for each macrohabitat unit or each mesohabitat unit were averaged within strata and summarized using the same methods applied to CPUE for individual gear types. The combined Focus Area and Non-Focus Area strata richness index (RI) within a middle river geomorphic reach stratum (e.g., Early Summer side channel pools) is:

$$Richness = \frac{N_{FA} * \overline{RI_{FA}} + N_{NFA} * \overline{RI_{NFA}}}{N_{FA} + N_{NFA}},$$

where

N_{FA} is the estimated number of habitat units in Focus Areas for this stratum,

N_{NFA} is the estimated number of habitat units in Non-Focus Areas for this stratum,

$\overline{RI_{FA}}$ is the average richness count in FA habitat units, and

$\overline{RI_{NFA}}$ is the average richness count in NFA habitat units.

The average RI for each habitat type was then scaled by dividing out the standard deviation of the distribution of species/life stage richness for the entire Susitna River:

$$RI' = \frac{Richness}{s_{Richness}},$$

where

Richness is the average RI for the given stratum, and

$s_{Richness}$ is the sample standard deviation of richness indices across all strata.

This scaled RI has similar scale to CAI previously calculated.

2.2.7. FUHI Step 6: Generate a Combined Fish Use Habitat Index (FUHI)

The development of indices of both relative abundance (CPUE) and species/life stage richness has been described in previous sections. To generate a FUHI for each macro- and mesohabitat type, the CAI index and the RI were averaged with equal weighting:

$$FUHI = \frac{1}{2}(CAI + RI').$$

The final result was a FUHI index for each habitat stratum that integrated fish abundance and richness across all gear types.

2.3. SIRA and FUHI Comparisons

In this TM, AEA presents example SIRA and FUHI results graphically and in tabular form to compare fish use among habitats and to investigate seasonal and longitudinal trends.

As an example SIRA analysis for Arctic Grayling in Upper and Middle River macro- and mesohabitat associations is presented below. To evaluate habitat associations in terms of both macrohabitat and mesohabitat types, SIRA were calculated for three Arctic Grayling life stages: juvenile, juvenile-or-adult, and adult; although, only juvenile results are presented herein. For habitat associations, only locations selected through randomized design (mainstem GRTS, tributary GRTS, and mainstem transect) were included. Arctic Grayling are found in all three river segments and SIRA scores from each segment can be compared. To describe relative abundance at the mesohabitat level, scores for mesohabitat sampling units within mainstem GRTS, tributary GRTS, mainstem transect and direct sample tributaries were compared to identify locations of high abundance.

An example FUHI analysis is presented at the macrohabitat level. In addition to the macrohabitat comparisons, several high-use macrohabitat types are further investigated at the mesohabitat level graphically with FUHI.

For both the SIRA and FUHI analyses, graphs show the ranges and distributions of index scores for each habitat stratum. Scores of 0.0 indicate that the sampling unit was sampled but no individuals were observed. For the SIRA, index scores >1.0 indicate that relative abundance in that sampling unit was greater than the median. Absolute "cutoff" values of FUHI are avoided, as the index is an average of multiple abundance indices and a richness index. Thus, for the FUHI, the interpretation is made only in relative terms. Individual strata with very high scores, and habitat types, seasons, or geomorphic reaches with consistently high index scores are noted. Median index scores across habitat strata are used to summarize groups of strata.

Data are available in tabular format at: http://gis.suhydro.org/SIR/09-Fish_and_Aquatics/9.6-Fish_Dist_and_Abund_Mid_Lower_Susitna/ and http://gis.suhydro.org/suwareports/SIR/09-Fish_and_Aquatics/9.5-Fish_Dist_and_Abund_Upper_Susitna/.

2.4. Simulations to Evaluate Fish Group Relative Abundance Indices

Step 3 of the FUHI calculations results in a fish group-specific relative abundance index (RAI). The RAI is the functional equivalent of the SIRA for fish groups and identifies habitats with the highest fish group abundance, as part of the FUHI. Given the importance of these estimators to the overall characterization of habitats and habitat patterns, AEA conducted simulation study to evaluate the RAI. This simulation study is intended to:

1. Verify that this estimator is able to accurately portray existing patterns in fish relative abundance,
2. Verify that it does not indicate extraneous patterns, and
3. Evaluate threshold values for determining habitats that are highly used.

Observed catch and effort data were used to develop statistical populations that could be defined as low, moderate, or high abundance populations, then known preference patterns were imposed. The RAI index was calculated for sample simulations from these known preference patterns, then the accuracy of the RAI index over 1,000 simulations was examined. The simulation study methods and results are provided in detail in Appendix A.

3. RESULTS

3.1. Species/lifestage-specific Index of Relative Abundance

To illustrate the utility of the SIRA for comparing the relative abundance of a fish species across the riverscape, AEA presents results for juvenile Artic Grayling in the Upper and Middle River.

3.1.1. Juvenile Arctic Grayling Relative Abundance

Juvenile Artic Grayling were present in 601 of the 1,737 sampling events used to evaluate relative abundance. The SIRA scores where Arctic Grayling were observed ranged from 0.03 to 21.7, with most of the high and moderate scores occurring in Upper River tributaries. The median SIRA score where juvenile Arctic Grayling were observed was 0.43. The majority of sampling events documenting juvenile Arctic Grayling were in the Susitna River (42%), Goose Creek (16%), Black River (16%), Watana Creek Basin (10%), and Kosina Creek (8%). In Upper River tributaries, SIRA scores ranged from 0.03 to 21.7. The two highest-scoring sampling units in the Upper River, as well as 9 of the top 20 highest-scoring units were located in Goose Creek (PRM 232.8), where 97 sampling units stretching from the mouth to the upper reaches had scores ranging from low to high. The highest score (21.7) was located in a riffle habitat unit near Goose Creek TRM 8.7 during the early summer. Moderate to high SIRA scores at this location occurred throughout the sampling season, where late summer and fall scores were 1.9 and 4.5, respectively. The second area of high relative abundance occurred within two adjacent boulder riffles near TRM 1.4 in Goose Creek. In one riffle high SIRA scores in summer 19.6 (early summer), 7.1 (late summer) tapered off to 0.62 in fall. In the second riffle, scores were comparatively less but still above median values with SIRA values of 3.4 and 2.6 in early and late summer, respectively.

Variable SIRA scores were observed throughout both Watana Creek (PRM 196.9) and an unnamed Watana Creek Tributary. In Watana Creek, the highest abundance occurred in a riffle habitat unit (TRM 2.9) where scores ranged from 0.3 to 7.0 across seasons. In an adjacent run/glide unit, scores ranged from 0.8 to 2.9. In both sampling units, the highest scores occurred in the fall and the lowest occurred in the late summer; both units were located within the proposed minimum pool elevation of Watana Reservoir. In the unnamed Watana Creek Tributary, 14 of the 35 sampling units where juvenile Arctic Grayling were present had scores greater than 1.0. The highest abundance was observed within adjacent run/glide and boulder riffle habitat units located 1.3 miles from the confluence with Watana Creek. Scores in the run/glide unit were 2.6, 5.2, and 5.4, while the boulder riffle unit had scores of 1.2, 1.8, and 3.2, respectively, in early summer, late summer, and fall. Between TRM 2.0 and 5.0 of the unnamed Watana Creek Tributary, scores ranged from 0.3 to 2.3 for run/glide, riffle, and rapid habitat units.

Throughout the Black River, a tributary of the Oshetna River (PRM 235.1), juvenile Arctic Grayling SIRA scores were variable. Only 2 of the top 20 scores were in the Black River, both of which occurred during early summer within adjacent run/glide and boulder riffle habitat in the upper reaches. In the run/glide habitat, scores ranged from 0.06 to 7.5 across all seasons and only the early summer sampling period had an abundance score greater than 1. In the boulder riffle habitat unit, scores ranged from 0.2 to 5.1 across all sampling seasons and again, scores greater than 1 were associated only with early summer sampling period.

In the Middle River, juvenile Arctic Grayling occurred primarily in main channel, side channel, and side slough habitats. In the Middle River, 19 relative abundance scores were greater than 2.0, and 4 were in the top 20 highest scores observed in all river segments. A majority (n=91) of the 150 Middle River sampling units with juvenile Arctic Grayling were located upstream of Devils Canyon. The highest score (11.7) was located at the mouth of a side slough (PRM 182.7) during fall. However, juveniles were also widely found above Devils Canyon in side sloughs and tributary mouths located within or near FA-173 (PRM 173.6-175.4), where 6 of 26 observations had abundance scores greater than 2.0; the highest abundance score occurred in a run/glide habitat located in a side slough (PRM 174.2). At this location, scores were 1.3, 3.6, and 8.9 during the fall, late summer, and early summer sampling seasons, respectively. Within an adjacent riffle habitat unit, scores ranged between 0.6 and 1.0 during all three sampling seasons. Just 0.3 miles downstream near the mouth of the side slough and within clearwater plume habitat of Unnamed Tributary 173.5, scores of 0.09, 2.1, and 2.6 were observed during the fall, late summer, and early summer sampling season, respectively. In addition, scores of 1.1 and 3.3 occurred in a riffle habitat unit near the mouth of Unnamed Tributary 173.5 in the late summer and early summer sampling season. In a nearby side slough (PRM 175), scores ranged from 0.9 to 4.0 in backwater habitat during the late and early summer sampling periods. Juvenile Arctic Grayling were observed in low abundance throughout Tsusena Creek (PRM 184.6) with the exception of higher scores near the mouth in clearwater plume habitat (3.7 score in late summer) and in run/glide habitat (1.5 in fall).

Below Devils Canyon, scores ranged from 0.04 to 11.7 across 59 sampling units. The greatest abundance of juvenile Arctic Grayling sampled in the Middle River, were located at the mouths of Slough 17 (PRM 142.3) and Indian River (PRM 142.1). In a backwater unit at the mouth of Slough 17, SIRA scores were 2.3 and 4.0 during the early and later summer sampling seasons. Just downstream of Slough 17, in the mouth and lower reaches of Indian River, scores ranged from 0.2 to 2.37, where 8 of the 9 observations occurred during the early summer sampling period. In addition, high SIRA scores were observed in a main channel riffle across from the mouth Portage Creek (PRM 152.3) and a pool habitat unit at the mouth of Whisker Creek (PRM 105.1). At the main channel riffle, scores were 3.6 and 1.8 during the late summer and fall sampling seasons. The pool abundance score recorded at the mouth of Whiskers Creek was 4.0 during the fall season.

3.1.2. Juvenile Arctic Grayling Macrohabitat Associations

Within the Upper River tributary GRTS sites, juvenile Arctic Grayling SIRA scores were moderate or high in every sampled tributary during at least one season (Figure 3.1-1). The highest scores were in main channel habitat in Goose Creek (4.1 score) and Watana Creek Tributary (3.2 score) during early summer. In both main channel and off-channel areas, SIRA scores typically decreased from early summer to fall. The one exception was Kosina Creek main channel habitat, where juvenile Arctic Grayling SIRA scores increased noticeably as the open-water season progressed. Watana Creek and its tributary were the only streams in which juvenile Arctic Grayling were not found in off-channel habitat surveys.

In the Upper River mainstem, SIRA scores were low to moderate in every macrohabitat type sampled (Figure 3.1-2). The highest of these was in backwater (1.7) and tributary mouth (1.3) habitat during early summer and side channel habitat during fall (1.4). SIRA values were highest during early summer in side slough, backwater, clearwater plume, and tributary mouth habitat. In contrast, scores were highest during fall in main channel, side channel, and upland slough habitat.

In the Middle River, juvenile Arctic Grayling were documented in at least one reach/season in every macrohabitat type sampled (Figure 3.1.2). High SIRA scores were calculated for tributary lower reach in MR-8 during fall (4.1 score) and in side slough in MR-2 during fall (3.5 score) and early summer (2.8 score). Low to moderate scores were detected in all other habitat types sampled except for upland sloughs, where scores were all <0.1. Within a given reach, SIRA scores for backwater, clearwater plume, and tributary mouth habitat were generally highest during early summer. In contrast, main channel, side channel, side slough, and tributary lower reach scores were typically highest during fall.

In summary, juvenile Arctic Grayling were found in a wide variety of habitat types, particularly in the Middle River. Seasonal changes in relative abundance indices suggest many juvenile Arctic Grayling may shift to habitats associated with main channel features (i.e., main channel or side channel), as the open-water season progresses. However, continued detection in a wide range of habitats during early fall suggests that such movements may occur later in the season or may not be ubiquitous for all juvenile grayling.

3.1.3. Juvenile Arctic Grayling Mesohabitat Associations

Within main channel habitat in Upper River tributaries, juvenile Arctic Grayling were found in all mesohabitats sampled (Table 3.1-1). In many tributaries, the SIRA values in boulder riffle, riffle, run/glide, and pool habitat were moderate to high; whereas scores were generally lower in backwater and rapid habitat. Off-channel habitat in tributaries was limited to the Oshetna and Black rivers and Tsisi Creek. Sampling occurred in percolation channels where low to moderate SIRA for juvenile grayling was documented.

In the Upper River mainstem, juvenile grayling SIRA values were low to moderate for all sampled mesohabitat types with the exception of boulder riffle, and clearwater plume (Table 3.1-2). The highest scores in the mainstem were detected in main channel riffle during fall (2.2 score), side slough backwater during early summer (score 1.9), and side channel pool during late summer (1.9 score).

In the Middle River, juvenile Arctic Grayling had high SIRA scores in run/glide, riffle, and pool habitat (Table 3.1-2). Moderate scores were detected in backwater, boulder riffle, and clearwater plume habitat in at least one reach/season. Overall, the three highest relative abundance scores were detected in main channel riffle during late summer (5.4 score in MR-5), side slough run/glide during early summer (5.0 score in MR-2), and tributary lower reach pool in fall (3.2 score in MR-8).

In summary, juvenile Arctic Grayling were documented using a wide variety of mesohabitat types in each river segment and relative abundance scores varied considerably across reaches/segments, seasons, and macrohabitat types. Nonetheless, run/glide and riffle were the two habitat types with relative abundance scores most frequently greater than other habitat types.

3.2. FUHI Development

To illustrate the components and demonstrate the flexibility of the FUHI, AEA selected example results at the macrohabitat level by season in the Upper River mainstem and Middle River geomorphic reaches. First, AEA demonstrates the steps used to generate metrics calculated for the commercial harvest juvenile group (Section 3.2). Second, AEA generates FUHI scores for the mainstem Upper River, Upper River tributaries, the Middle River, and the Lower River using macrohabitats within geomorphic reaches as the level of stratification (Section 3.3). Third, AEA focuses on three high-use macrohabitat types: Upper River tributary main channel habitats, Middle River side sloughs, and Middle River tributary lower reaches, and uses FUHI scores to compare the use of mesohabitats within these macrohabitat types (Section 3.4).

3.2.1. Example of Fish Use Habitat Index (FUHI) Calculation

Herein AEA walks through the steps required to take fish species/life stage counts that are generated from sampling with multiple gear types in diverse habitats within a reach and combines the data across gears to generate an index of fish habitat use that is statistically valid and rigorous for comparing the data across space and time. This example begins with illustrating the steps (1 through 4) used to generate the CAI for one fish group, the commercial harvest juvenile group. In steps 5 and 6, the example proceeds with development of a FUHI that is inclusive of all fish groups in the defined strata.

3.2.2. Calculating the Combined Abundance Index for Commercial Harvest Juveniles

Step 1 of this example calculation entailed calculating the commercial harvest juvenile gear-specific CPUEs within strata in the mainstem Upper River and Middle River by calculating total catch by gear type of the four species/lifestages in the commercial harvest group and dividing by total effort applied by gear. These commercial harvest CPUE values were then standardized across the sampling strata (Step 2), in this case for the entire Upper Middle mainstem and Middle River, into a CPUE index by gear type. In Step 3, the standardized CPUEs were combined across gears using a weighted average to account for differing gear sample sizes in some habitat types. The result is a commercial harvest species/life stage-specific abundance index for each macrohabitat stratum in the mainstem Upper River and the Middle River. As an example, the relative abundance indices by macrohabitat are plotted for the juvenile commercial harvest fish in Figure 3.2-1. Evident in Figure 3.2-1 is a high relative abundance in tributary mouth and tributary lower reaches in several Middle River reaches and a noticeably low relative abundance in main channel and side channel habitats.

Step 4 of FUHI combines the five fish group CPUEs into one CAI for each macrohabitat stratum (Figure 3.2-2). These CAI results are used to compare relative abundance across the strata. The CAI is a relatively high in MR-5 tributary mouths, is moderate in tributary lower reaches, side sloughs, upland sloughs, and MR-6 tributary mouths, and is low in main channel, side channel macrohabitats and in the UR, MR-1, and MR-2 and in some clearwater plumes (Figure 3.1-2). The relative importance of upland sloughs in MR-6, MR-7, and MR-8 and side sloughs in the UR and MR-2 show a marked increased with the CAI (Figure 3.2-3) as compared to the commercial harvest juveniles abundance index (Figure 3.2-1). Upland slough macrohabitats in the UR and MR-2 have extremely low fish abundance for both the juvenile commercial harvest group and all groups combined (Figure 3.2-1 and Figure 3.2-2). In respect to seasonal trends, there was a slight increase in combined group abundance in main channel habitat from early summer to late summer to fall, a decrease in abundance in tributary lower reaches in MR-5 and MR-6 from early to late summer, and an increase in tributary lower reaches in MR-7 and MR-8 from early to late summer (Figure 3.2-2).

3.2.3. Species and Life Stage Richness

Fish species and life stage richness is the complementary piece to the CAI in building the FUHI and was assessed by calculating a standardized RI for each habitat (Step 5), the number of species and life stages divided by the standard deviation of richness for the strata. The RI was overall less variable among macrohabitats than the CAI (Figure 3.2-3). Richness was noticeably higher in side slough and tributary lower reach habitats in MR-8 than in other habitats or reaches (Figure 3.2-3). For many habitats including main channel, side, channel, side slough, backwater, and clearwater plumes, the RI above Devils Canyon in the UR, MR-1 and MR-2 was similar to downstream reaches. Tributary mouth habitats, which had some of the highest abundance values, had relatively low richness among the Upper River mainstem and most Middle River habitat types.

3.2.4. FUHI

The final step to creating the example FUHI, Step 6, is to average the CAI value (Figure 3.2-2) and RI scores (Figure 3.2-3) for each stratum. The FUHI scores for macrohabitats in the Upper River mainstem and Middle River reaches are discussed below in Section 3.3.

3.2.4.1. Correlation of Richness Index and Combined Abundance Index

Prior to completing the FUHI, AEA examined the relatedness of the two metrics to evaluate the utility of combining these scores for an index that would accurately describe the use of habitats by fishes. Graphical comparison of the RI and CAI revealed little correlation between the two measures of fish use at either the macrohabitat or mesohabitat scale (Figure 3.2-4). Although low abundance necessarily limits species/life stage richness at the macrohabitat scale, the sampling events with the highest RI values had intermediate values of the combined relative abundance index. Conversely, the sites with the highest values of combined relative abundance had relatively low values for the species/life stage RI. AEA determined that given this apparent low level of relatedness, it was appropriate and would be beneficial to combine both indices to thoroughly describe the use of macro- and mesohabitats by fish species.

3.3. FUHI Results at Macrohabitat scale

Fish Use Habitat Index scores were generated for the macrohabitat strata in the Upper River (Figures 3.3-1 and 3.3-2), Middle River (Figure 3.3-2) and Lower River (Figure 3.3-3). Because of the non-random sampling design FUHI scores were generated separately for Upper River tributaries. Scores for mainstem Upper River were developed consistent with the Middle River habitats and thus are presented and discussed together. FUHI scores were generated within each geomorphic reach for macrohabitat and special mesohabitat types.

3.3.1. Fish Use of Macrohabitats

Across all macrohabitats, the seasonal FUHI scores ranged from a minimum of 0 in backwaters, tributary mouths and upland sloughs to a maximum of 4.3 in tributary lower reaches (MR-8; Figures 3.3-1 and 3.3-2). These extreme values were all associated with habitats with a single sampling unit for a given season and geomorphic reach. This is a phenomenon that was repeated in FUHI results. Because of the high variation in species richness and abundance for similar habitat types across the landscape, when these metrics are averaged to generate a FUHI based on multiple units of the same type the resulting FUHI score is moderated. To demonstrate this effect, the range of FUHI scores for sampling habitats with more than one sampling unit was between 0.2 for upland sloughs in MR-2 in early summer and 3.0 for tributary lower reaches in MR-6 in early summer.

3.3.1.1. Upper River

FUHI scores in Upper River tributary main channel habitats ranged from 0.7 to 2.0; while scores in off-channel habitat ranged from 0.25 to 1.1 (Figure 3.3-1). The highest score of 2.0 came from the main channel of Unnamed Tributary 194.8 in early summer, where both RI and CAI were relatively high (Figure 3.3-4).

In the Upper River mainstem, side channel, side slough and backwater habitats had higher FUHI scores (1.2 – 1.8) for two out of three seasons that were consistent with species richness (Figure 3.2-3). Scores for upland sloughs (0.3 – 0.4) and tributary mouths (0.4 – 0.7) were more moderate. FUHI scores in tributary mouths were consistent with low RI values; while, the upland slough habitat had low FUHI, CAI and RI values (Figure 3.3-5).

3.3.1.2. Middle River

In the Middle River, the macrohabitat with the highest FUHI scores was tributary lower reach downstream from Devils Canyon and scores ranged from 1.1 to 4.3 (Figure 3.3-2). These high scores were consistent with high RI values within tributaries in MR-8 and a combination of moderate to high CAI and RI values within tributaries in other geomorphic reaches downstream of the canyon (Figure 3.3-6). Tributary mouth habitats FUHI scores were moderate compared to lower tributary reaches, except for tributary mouth habitat in MR-5 that had similar or higher FUHI scores in tributary mouths than tributary lower reaches (Figure 3.3-2). The pattern for MR-5 was also reflected by high CAI (Figure 3.3-7) whereas the higher values of tributary lower reaches had similarly high RI in MR-6, MR-7 and MR-8 (Figure 3.3-6).

Most of the other main channel and off channel macrohabitats in the Middle River had similar moderate to low FUHI scores (medians 0.4 – 1.7) with the exception of side slough habitat in MR-8 that had a FUHI greater than 2 in all three events (Figure 3.3-2). The higher side slough FUHI was similar to relatively high RI in MR-8 side sloughs (Figure 3.3-7).

3.3.2. Seasonal Patterns

No overall seasonal trends were evident for the FUHI values for the Upper and Middle River macrohabitats (Figure 3.3-2). However, there were several seasonal trends evident for specific habitats, such as a decrease in backwater use from late-summer to fall and a decrease in clearwater plume use from early- to late-summer. Within other macrohabitats seasonal trends varied by geomorphic reach. For example while the FUHI for tributary mouth habitat decreased from early summer to fall in the Upper River and MR-2, an increase was evident for MR-5.

3.3.2.1. Upper River

In the Upper River small seasonal decreases in FUHI from late summer to fall were evident for tributary mouths and backwaters. The decrease in tributary mouths was also reflected in CAI while in backwaters a similar decrease was evident in both CAI and RI (Figures 3.3-7 and 3.3-8). Within the main channel, other macrohabitats were relatively consistent across seasonal sampling events. Seasonal patterns were more variable among Upper River tributaries; FUHI scores were highest in early summer in six out of eight tributaries (Figure 3.3-1).

3.3.2.2. Middle River

In the Middle River, FUHI scores were generally similar among seasons with a few exceptions. FUHI scores in backwater habitats dropped in the fall (median 1.6 to 1); the decrease was driven by a drop in RI values (median 2.5 to 1.4) while CAI was relatively constant (median 0.7 to 0.6; Figure 3.3-8). Similarly, in MR-5 and MR-6, FUHI scores for tributary lower reaches and clearwater plumes dropped in the fall, with corresponding decreases in both diversity and abundance indices (Figures 3.3-6 and 3.3-10). The decreasing FUHI scores in tributary lower reaches were matched by a slight increase in FUHI scores in main channel habitats (medians 0.8 to 1.7 in MR-5 and 0.5 to 0.9 in MR-6).

3.3.2.3. Lower River

Seasonal patterns in FUHI varied by macrohabitat (Figure 3.3-3). Four out of six macrohabitats with samples in all three sampling periods had the highest FUHI scores in late summer and the lowest FUHI score in the fall. One apparent decrease was in backwater FUHI scores from early summer to fall and was driven by a single high score (3.3) from an early summer sampling; this habitat was not present at subsequent samples (the number of units pooled by macrohabitat type are presented in (Appendix B, Table B1). Patterns of species/lifestage richness and relative abundance were not consistent across macrohabitats.

3.3.3. Longitudinal Patterns

Broadly speaking, median FUHI scores were highest in the Lower River (median 1.3 [ranging between 1.0 and 3.3]), intermediate in the Middle River (median 1.1[ranging between 0.0 and 4.3])), and lowest in the Upper River (median 1.0 [ranging between 0.2 and 2])). This trend was consistent during each seasonal sampling event, but strongest in late summer and weakest in the fall. Tributary habitats showed the same pattern among river segments as mainstem habitats. Notably, the FUHI for Upper River mainstem habitats were only slightly lower than in the Middle River (Figure 3.3-2) despite lower CAI and moderate RI, except in upland sloughs, where both RI (0.6) and CAI (0.1) were low (Figures 3.2-2 and 3.2-3).

FUHI scores for upland slough habitats in the Upper River and the Middle River above Devils Canyon (0.2 – 0.4) were lower than in the Middle River below Devils Canyon (1.3 – 1.6) or the Lower River (2.1; Figures 3.3-2 and 3.3-3). This was not true for side sloughs which were remarkably similar among river segments (1.37 - 1.40). Within the Middle River, geomorphic reach MR-8 had the highest FUHI scores for both tributary lower reaches and side sloughs (Figure 3.3-2). This high tributary score was an artifact of a single sampling unit (Appendix B, Table B1); whereas, the high MR-8 side slough score was based on more than one habitat unit and was consistent with high RI (3.5; Figure 3.3-9).

3.4. FUHI Results at the Mesohabitat Scale in High Use Macrohabitats

Because fish may utilize different mesohabitat types in different macrohabitats, the FUHI index was estimated at the meso- within macrohabitat level. The range of FUHI values is different for the meso- level, and for this exercise was calculated separately, so comparisons across habitat levels (macro to meso) are not appropriate. Using these results, however, one can focus in on the most utilized macrohabitat types within reaches, and within these strata look for mesohabitat associations. For the purposes of demonstrating FUHI usage, AEA has selected three high use macrohabitats from different river segments (Upper River main channel, Middle River tributary lower reach, and Middle River side slough) and presents results of mesohabitat associations within these macrohabitats below

3.4.1. Upper River Tributary Main Channel Habitats

3.4.1.1. Habitat Associations

Overall, mesohabitats in the Black River main channel habitats had similar FUHI scores, relative abundances were generally low, the highest being run/glide habitat in early summer, and FUHI scores were consistent with relatively high species/life stage richness (Figures 3.4-1 through 3.4-3). FUHI scores ranged from 0.7 (rapid) to 1.6 (backwater) in the five main channel mesohabitat types present. The high backwater FUHI score in early summer was similar to high RI (Figure 3.4-3) but represented on single sampling unit (Appendix B, Table B2).

In Goose Creek, four mesohabitat types were present; FUHI scores for pool and riffle habitats were higher than run/glide and boulder riffle habitats within all seasons (Figure 3.4-1). Riffle habitat in the early summer had the highest FUHI score (1.6) and was consistent with high CAI. (Figure 3.4-2).

Of the three mesohabitat types present in Kosina Creek, boulder riffles had the highest FUHI score in two of the three seasons, a pattern also reflected in RI values. In the fall, run/glide habitat showed the highest FUHI, again similar to RI (Figure 3.4-3).

The Oshetna River had five main channel mesohabitats present. Similar to Kosina Creek, boulder riffle habitat was consistently one of the highest FUHI scores across seasons (Figure 3.4-1) and was consistent with RI (Figure 3.4-3); however, this FUHI was based on a single boulder riffle unit (Appendix B, Table B2). Pool habitats, rare in Upper River tributaries, had low FUHI scores in the Oshetna River, with very low CAI and average RI (Figures 3.4-2 and 3.4-3).

In Tsisi Creek, FUHI was relatively uniform across the three mesohabitat types sampled. Scores among mesohabitats were higher in the early summer (1.3-1.4) as compared to the late summer and fall (Figure 3.4-1). CAI values were below average in each mesohabitat, but RI values were consistent with other tributaries (Figures 3.4-2 and 3.4-3).

Unnamed Tributary 194.8 contained the highest macrohabitat FUHI score in the Upper River (Section 3.3.1.1). It also contained the highest mesohabitat FUHI score in the Upper River, with a score of 2.0 in run/glide habitat in early summer (Figure 3.4-1). This high run/glide FUHI score was reflected in moderate to high RI but CAI (Figure 3.4-2) scores were more moderate (Figure 3.4-3). It is important to note that this high score reflects sampling from a single run/glide unit in Unnamed Tributary 194.8.

Of the five mesohabitats present in Watana Creek, boulder riffle had the highest FUHI in each season (Figure 3.4-1). This pattern was consistent with high RI in boulder riffle habitat (Figure 3.4-3). A FUHI score of 0 for the single beaver pond in Watana Creek reflects that sampling was conducted but no fish were captured or observed.

Run/glide habitat had the highest FUHI score in Watana Creek and was consistently the highest scored habitat in each season (Figure 3.4-1). It is interesting to note that this FUHI score was similar to high CAI (Figure 3.4-2) and RI (Figure 3.3-3). Conversely, rapid habitat had high RI values in late summer to fall (1.7-2.1), but low CAI values (0.1-0.4) and moderate FUHI scores.

3.4.1.2. Season

Seasonal patterns were evident for Upper River tributary FUHIs. Seven out of eight of the tributaries exhibited overall higher mesohabitat FUHIs in early summer (median 1.2) with scores decreasing in late summer (median 1.0) and again in fall (median 0.86) as water levels dropped (Figure 3.3-1). The seasonal decline was consistent with decreases in CAI and RI in tributaries such as Goose Creek, Watana Creek, and Unnamed Tributary 194.8 (Figures 3.4-2 and 3.4-3). This trend was also evident for RI in the Black and Oshetna River and for CAI in Watana Creek Tributary. The one exception to this seasonal trend was Kosina Creek where average FUHI scores increased steadily from 0.6 in early summer to 1.2 in fall (Figure 3.4-1). Within Kosina Creek, FUHI scores for run/glide and riffle increased from early summer (0.4 and 0.4 respectively) through fall (1.1 and 1.4 respectively) while boulder riffle remained consistent (1.1) among seasons (Figure 3.4-1).

3.4.2. Middle River Tributary Lower Reaches

3.4.2.1. Habitat Associations

Although every sampled tributary lower reach within each geomorphic reach and seasonal strata had fish present, the relative abundance of these fishes as reflected in FUHI scores for this mesohabitat was highly variable ranging from 0.1 to 4.7 (Figure 3.4-4). In MR-2 and MR-5, rapid habitat had the highest overall FUHI scores (1.3 and 2.5) and was consistently the highest in both reaches across seasons (Figure 3.4-4), a trend that was not evident CAI (Figure 3.4-5) but was evident in RI (Figure 3.4-6). In MR-6, MR-7, and MR-8, slower water habitat (pool and run/glide), generally scored higher than riffles and boulder riffles with the exception of MR-6 pool habitat in fall (Figure 3.4-4). Patterns of FUHI in pool mesohabitats were similar to patterns evident in CAI and RI within MR-6, MR-7 and MR-8 pools (Figure 3.4-6). Cascades, when present, had FUHI scores similar to other mesohabitat types with the same geomorphic reach (Figure 3.4-4).

3.4.2.2. Season

There was no overall seasonal trend evident in mesohabitat use of tributary lower reaches. While fish use of some mesohabitats declined from early summer to fall (rapid, boulder riffle), others increased in some reaches and decreased in others (riffle, run/glide) and some showed a third pattern with FUHI scores peaking in late summer (pools).

3.4.3. Middle River Side Sloughs

3.4.3.1. Habitat Associations

FUHI scores for mesohabitats in Middle River side sloughs ranged from 0 to 2.7 and were less variable across geomorphic reaches than the scores for lower tributary reaches discussed in Section 3.4.2 (Figure 3.4-7). The highest FUHI score was in MR-8 run/glide mesohabitat (2.7) followed by backwater in MR-2 (2.3). FUHI scores for run/glide were generally the highest or second highest scored mesohabitat in each reach and season. In contrast, riffle habitat had low to moderate FUHIs, with a score of 0 for MR-6 side slough riffles. Patterns in MR-2 FUHI scores were more similar to RI than CAI for clearwater plume, backwater, pool and riffle habitats

(Figures 3.4-8, 3.4-9). In MR-5, mesohabitat FUHI was low and run/glide habitat scored higher (1.3-1.6) than pool habitat. In MR-6, beaver complex, pool and run/glide habitats had similar moderate FUHI scores (0.9-1.6) while riffles and backwaters had lower score (Figure 3.4-7). This pattern was more similar to the pattern seen in RI than CAI for these habitats. In MR-7, run/glide habitat had high FUHI scores in early summer and fall (1.5-1.6). In MR-8, run/glide habitat had very high scores in all seasons (2-2.7) and pools were high in early summer (2), a pattern matching that of RI (Figure 3.4-9) more than CAI (Figure 3.4-8).

3.4.3.2. Season

No overall seasonal trends in FUHI scores were evident but some mesohabitat- and reach-specific patterns were observed. Many mesohabitats types had similar FUHI scores across seasons. For example, run/glide habitat had among the highest scores in each reach and had consistent scores among seasons except for in MR-7 and MR-2 during late summer when the run/glide FUHI dipped (Figure 3.4-7). FUHI scores for pools dropped over the course of seasonal sampling in MR-2 and MR-8 but not in MR-6 and MR-7. Backwater habitats in MR-2 had high seasonal scores, but were only present in early and late summer when Susitna River flows were higher (Figure 3.4-7).

3.5. Simulations to Evaluate the Relative Abundance Index

Full results from the simulation study are provided in Appendix A. The important results from the simulation study were:

- The RAI generally performed well in the detection of imposed high and low use habitats. A threshold level of 2.0 was found to result in better detection of high use habitats than a threshold of 2.7, without increasing error rates.
- In some cases, there was a fairly high percentage of simulations (e.g., 25%) from individual moderate abundance populations that had low sample RAI values, indicating that only consistent and repeated low results should be interpreted as low use of habitat.
- Small sample sizes, particularly habitat strata with only one habitat unit, yielded inconsistent results.
- Indications of low preference from single season samples when there was no underlying population pattern had fairly high (up to 22%) occurrence, but this was reduced to less than 2 percent when interpretation was limited to average response over three seasons.

Overall, the simulations showed that the index performs as expected, and is a good predictor of the most-used fish habitats, especially when viewed in a context of consistent results.

4. DISCUSSION

AEA's study team has developed statistical metrics of relative abundance using combined gear-specific CPUE data and has presented examples herein to demonstrate the utility of these metrics for characterizing and comparing relative abundance and fish-habitat associations across habitats. The SIRA metric is specific to fish species and/or lifestages, consistent with the way data were collected during 2013 and 2014 field studies, and provides information on relative abundance and habitat associations for each species/lifestage. The FUHI was developed using a fish guild concept and provides information on the use of habitat types by the Susitna River fish assemblage. These metrics are flexible and can be generated as desired within the different strata inherent to the study design (e.g. river segments, geomorphic reaches, within and outside of Focus Areas) or to answer specific questions about the relative abundance of fishes within macro- and meso- habitats across the riverscape and throughout time. The simulation study conducted on the RAI is applicable to both the SIRA and the FUHI and demonstrated that this metric can accurately depict fish abundance. Increased sample sizes that would occur during future study implementation and use of different thresholds to differentiate low, moderate, and high abundance levels should further improve the FUHI’s ability to depict patterns in fish use of habitats.

Patterns in Arctic Grayling relative abundance and habitat association were evident from SIRA results. There was high relative abundance of Arctic Grayling in Upper River tributaries in early summer with the highest abundance documented in Goose Creek. The abundance in most tributary habitats with moderate to high abundance decreased from early summer to fall, while seasonal trends in habitats with low to moderate abundance varied and were habitat specific. In the Middle River, grayling were documented with varying abundance in main channel, side channel and side slough habitat. The highest Arctic Grayling relative abundance in the Middle River was documented in slough and main channel habitats, with a high abundance in MR-8 tributary lower reach habitat in fall.

Some trends were also evident for Artic Grayling relative abundance based on SIRA values in meso-habitats. In the Upper River tributaries with high abundance, the highest relative abundance was in main-channel riffle habitat. Other high abundance meso-habitats in the Upper River were riffle and run-glide in side channels, and riffle and rapid in tributary mouths. The highest Arctic Grayling relative abundance in the Middle River was in run/glide within a side slough and riffle within main channel; although, backwater and clearwater plume habitats within side sloughs also had high abundance. In general, mesohabitats with moderate to high relative abundances were more common in geomorphic reaches MR-1 and MR-2 as compared to MR-5, MR-6, MR-7 and MR-8; although the highest abundance for Arctic Grayling in the Middle River mesohabitat was main channel riffle habitat in MR-5.

The FUHI results also indicated some general patterns after one year of sampling. There were generally higher FUHI scores in habitats downstream of Devils Canyon than in habitat upstream. In Upper River tributaries, main channel macrohabitats had more fish use than off-channel habitat. The Middle River tributary lower reach habitat, especially in MR-8, had the highest fish use of all macrohabitats sampled. Seasonal changes were evident for fish use of Middle and Lower River backwaters and clearwater plume habitat. Macrohabitats with noticeably high FUHI scores (2-4) were tributary lower reaches in MR-5, MR-7, and MR-8, tributary mouths in MR-5, side sloughs in MR-8, and Lower River backwater habitats. No habitats in the Upper River had FUHI scores above 2. Mesohabitat FUHI score in Upper River tributaries shows fish use of riffles and boulder riffles was similar to other slower water habitats. There also appeared to be a generally decreasing seasonal trend for fish use of tributary mesohabitats for some, but not all, tributaries. The FUHI scores for high use Middle River macrohabitats showed generally high use of slow water mesohabitats as compared to fast water riffles.

Understanding how different fish species and lifestages use habitats both independently and as an assemblage is important for making sound management decisions that potentially affect aquatic habitats. Unfortunately, many fishing gears are selective and only catch a portion of the fish that reside within the sampled habitat. Specific gear efficiency can be affected by many factors, including gear selectivity (size and feeding habits), fish behavior, technique of gear deployment (user knowledge and skill), and environmental factors (water clarity, conductivity, snags, substrate, etc.). Many other fish studies have focused on a particular target species life stage or habitat of interest, and could therefore sample relatively small areas using one or two gear types together to compare their relative efficiencies (Poos et al. 2007; Poesch 2014). However, for this study of the Susitna River system, multiple gear types were necessary to effectively sample and characterize the relative abundance of a diverse fish assemblage among very different aquatic habitats. Using multiple gears reduces the selectivity or gear bias introduced by using any one gear and increases the likelihood of detecting rare species (Poos et al. 2007). Instead of comparing efficiencies across nine different gear types, the combined group relative abundance index portion of the FUHI, the CAI, includes the standardization and combining of catch-per-unit-effort from multiple gears. This step of the FUHI approach was valuable unto itself for understanding species-specific relative abundance, in particular when making inferences across habitat types that cannot be sampled effectively with the same suite of gear types as demonstrated by SIRA results.

While both the SIRA and the FUHI are novel metrics, the concept of combining metrics (e.g. catch, abundance, biomass, species richness, trophic structure, presence of sensitive species) is not new. Various customized bioassessment indices based on the Index of Well Being (Gammon 1976) and the Index of Biotic Integrity (Karr 1986) are commonly applied by natural resource agencies to compare fish and invertebrate populations at the longitudinal, reach, or basin scale to inform management decisions (Barbour et al 1999; Keller et al. 2012; Leader 2001; Linam et al. 2002; Proulx and Drake 2009). Ecologists have also long recognized the importance of species richness and diversity for maintaining ecosystem health and productivity (Simpson 1949) and have developed other indices to describe these patterns including functional diversity indices (Petchy and Gaton 2006; Schleuter et al. 2010). For the example FUHI presented here, relative abundance and species/life stage richness (scaled) were combined with equal weighting; but, alternative weighting scenarios could be considered before using this index during impact analysis.

This report describes the development of the SIRA for individual species and lifestages and FUHI using fish grouped by fisheries value to score the overall importance or value of habitats. As shown by the preliminary results presented for Arctic Grayling, the SIRA can be used to evaluate species-specific relative abundance across gear types for common species and life stages with sufficient samples sizes (gear events with catch) for standardization. In the FUHI example presented herein, fish were grouped based on value to local fisheries; however, the FUHI and its components can also be modified to evaluate the habitat associations for any specific grouping of fishes provided samples sizes are large enough for meaningful standardization of relative abundance. For example, the CAI could be used to identify habitats utilized by juvenile salmonids of the size vulnerable to stranding. Juvenile salmonids < 50 mm in length are particularly vulnerable to stranding because they are relatively poor swimmers and settle along shallow margins of rivers and often occupy interstitial spaces in rock and cobble substrates (Hunter 1992). A combined relative abundance index could be developed specifically for sizes and species of juvenile salmonids of interest. Other examples include selecting different groups of species such as functional groups, (e.g. fall spawners or mainstem spawners) to look at seasonal habitat utilization.

The purpose of the results presented in Section 3 was to introduce the development of the SIRA and FUHI tools, to look broadly at patterns of relative and fish-habitat associations evident from the baseline data collected to date, and to demonstrate the utility of these tools at describing fish relative abundance and habitat use consistent with the objectives presented in the FERC-approved Study Plan for studies 9.5 and 9.6. The results demonstrate AEA's ability to fully characterize both species and life-stage-specific relative abundance by habitat as well as the overall fish assemblages associated with the diverse and dynamic habitats throughout the Susitna River. The simulations presented in Appendix A demonstrate the success of these tools at identifying known patterns that exist within datasets. The simulation also provides insight into how AEA can refine the tool to increase our ability to detect patterns in fish abundance and habitat use once data collection is complete. The FUHI is comprehensive and synthesizes information from thousands of fish surveys. Once data collection is complete, precision estimates of FUHI scores can be developed and presented. This will allow for more robust comparisons and the detection of statistical differences between various levels of relative abundance and fish use including macrohabitats, Middle River geomorphic reaches, and seasons.

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6. TABLES

Table 2.1-1. Nested and tiered habitat mapping units and categories for macrohabitats and mainstem channel mesohabitats used in the FUHI.

Level	Unit	Grouping	Category	FUHI Comment
1	Major Hydrologic Segment	Segments	Upper, Middle, Lower River	*FDA Upper River Study Area* – PRM –187.1 – 235.1 *FDA Middle River Study Area* - PRM –102.4 – 187.1 *FDA Lower River Study Area* – PRM 32.3 – 102.4
2	Geomorphic Reach	Upper River Segment	6 reaches	Upper River Reaches in study area (UR-3 – UR-6) combined for FUHI
		Middle River Segment	8 reaches	6 Reaches (MR-1,2,5,6,7,8) sampled inside and outside of Focus Areas & included in FUHI at the reach level
		Lower River Segment[1]	6 reaches	Lower River Reaches in study area (LR-1 – LR-4) combined for FUHI
3	Macrohabitat	Main Channel Habitat	Single Main Channel	These categories were combined into “Main Channel” for FUHI in UR & MR Segments. Placed into “Combined Main Channel” in LR segment
			Split Main Channel	
			Multiple Split Main Channel	
			Side Channel	Side Channels analyzed separately for UR and MR Segments, added to “Combined Main Channel” in LR segment
			Side Channel Complex	These macrohabitats, unique to the Lower River study area were added to “Combined Main Channel” in LR segment
			Bar Island Complex	
			Tributary Mouth	Main Channel category for all segments
		Off-Channel Habitat	Side Slough	Side Sloughs with and without beaver complexes combined for FUHI
			Side Slough Beaver Complex^	
			Upland Slough	Upland Sloughs with and without beaver complexes combined for FUHI
			Upland Slough Beaver Complex^	
		Tributary Habitat	Single Channel	Tributary channel types in the UR segment were combined for FUHI (Main Channel); off-channel features were added to the macrohabitat level (Tributary Off-Channel). In the MR and LR segments, tributary sampling units immediately upstream of the confluence with the Susitna River were labeled “Tributary Lower Reach”
			Split Channel	
			Channel complex	
		Special Habitat Features	Clearwater Plume^	These special Habitat Features were included in the FUHI at the macrohabitat and mesohabitat level
			Backwater^	

Level	Unit	Grouping	Category	FUHI Comment
4	Mesohabitat	Fast water	Cascade	Cascade added to mainstem habitat classification for tributary mouths only
			Rapid	Used as a mesohabitat type
			Riffle	Used as a mesohabitat type
			Run/Glide	Used as a mesohabitat type
		Slow Water	Pool	Used as a mesohabitat types
			Pool Subtypes: Straight Scour, Plunge, Lateral Scour, Backwater and Isolated	Pool subtypes were not used in FUHI
		Special Habitat Feature	Clearwater Plume	These special Habitat Features were included in the FUHI at the macrohabitat and mesohabitat level
			Backwater	
			Beaver Complex	Used as a mesohabitat type
		Tributary Mesohabitat	Multiple Types	Tributary mesohabitats were typed using the classification system described in Table 2.1-2

Table 2.1-2. Nested and tiered habitat mapping units and hydraulic categories used for tributary mesohabitats and FUHI analysis.

Macrohabitat (# of channels)	Grouping	Mesohabitat Type	FUHI Comment
Single channel, Split channel, and Complex channel types were Combined into “Tributary Main Channel” for FUHI	Fast Water	Falls	No falls were sampled in 2013-2014
		Cascade	Used as a mesohabitat
		Chute	No chutes were sampled in 2013-2014
		Rapid	Used as a mesohabitat
		Boulder Riffle	Used as a mesohabitat
		Riffle	Used as a mesohabitat
		Run/Glide	Used as a mesohabitat
	Slow Water	Pool	Used as a mesohabitat; Pool subtypes were not used in FUHI
		Beaver Pond	Used as a mesohabitat
		Alcove	Alcoves sampled were combined with backwaters
		Backwater	Added ad a tributary mesohabitat type
Off-channel	Off-channel	Percolation channel	Used as a mesohabitat
		Tributary	Tributary of a tributary added as an off-channel mesohabitat type

Table 2.1-3. Gear events by macrohabitat and special habitat type used in FUHI, 2013-2014.

Macrohabitat Types & Special Habitat Features	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events	Number of Sample Events
Main Channel (Combined)	4	177	175	49	8	73	93	86		665	232
Side Channel		81	16	4	12	7	51	31	4	206	85
Additional Open Water						1	9	2	2	14	9
Side Slough	4	93	3		10	2	94	26	51	283	125
Upland Slough	12	79	3		35	6	119	36	70	360	137
Tributary Mouth	14	46			3		46	6	32	147	59
Clearwater Plume*	35	52	9	2	11	6	41	18	35	209	79
Backwater*	8	16	4		16	2	25	12	4	87	35
Tributary Main Channel	156	309	2	1	44	19	258	9	157	955	328
Tributary Off-Channel	13	39			4		29		10	95	39
Total Gear Events	246	892	212	56	143	116	765	226	365	3,021	1,128

*Special habitat features included in FUHI at mesohabitat and macrohabitat levels

Table 2.1-4. Gear events by mesohabitat and special habitat type used in FUHI, 2013-2014.

Mesohabitat Type	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events	Total Sample Events
Backwater^	8	19	4		20	2	29	12	7	101	39
Beaver Complex~	11	34			15	3	71	19	32	185	75
Boulder Riffle	90	184			29	14	131	1	63	512	190
Cascade		33			2		25		21	81	34
Clearwater Plume^	38	54	9	2	11	6	42	22	38	222	82
Pool	14	146	9		24	13	152	44	102	504	209
Rapid	15	33			5	7	23		20	103	39
Riffle	46	238	7	1	12	6	170	24	102	606	261
Run/Glide	97	451	184	56	54	85	329	134	165	1,555	589
Tributary Beaver Pond*		4					5		2	11	6
Tributary Percolation Channel*	12	36			1		27		10	86	36
Tributary to Tributary*	4	11			4		6		11	36	12
Total Gear Events	335	1,243	213	59	177	136	1,010	256	573	4,002	1,572

^ Special habitat features included in FUHI at mesohabitat and macrohabitat levels
~Special habitat feature included in FUHI at mesohabitat level
* Apply to tributary mesohabitats only

Table 2.1-5. Quality control criteria for records included in FUHI by gear type, 2013-2014.

Gear	Metric Used for FUHI	Minimum Criteria	Maximum Criteria	Records Used (meso)
Angle	Catch/Minutes of Angling Time	Duration recorded and ≥ 5 minutes	≤ 240 minutes	335
Backpack E-fisher	Catch/Minutes of Pulse Time	Pulse Time recorded and ≥ 0.5 minutes	≤ 80 minutes	1,243
Boat E-fisher	Catch/Minutes of Pulse Time	Pulse Time recorded and ≥ 1 minute	≤ 29 minutes	213
Drift Gillnet	Catch/Area (100m^2)	Sample area recorded and ≥ 285 m^2	Sample area ≤ 18000 m^2	59
Fyke Net	Catch/Net (overnight soak)	Duration recorded and overnight soak ≥ 770 minutes	≤ 1563 minutes soak duration, < 2 nights	177
Hoop Trap	Catch/Trap (overnight soak)	Duration recorded and overnight soak ≥ 937 minutes	≤ 1553 minutes soak duration, < 2 nights	136
Minnow Trap	Catch/Trap/m sample length	Duration recorded and overnight soak ≥ 776 minutes	≤ 1855 minutes soak duration, < 2 nights	1,010
Seine	Catch/Area (100m^2)	Sample area recorded	sample area estimate ≤ 120% meso area estimate	256
Snorkel	Observations/Area (100m^2)	Sample area recorded	sample area estimate ≤ 120% meso area estimate, sample length estimate ≤ 120% of meso length	573

Table 2.1-6. Total numbers of fish caught or observed by FUHI group and gear type, 2013-2014.

FUHI Group	Life stage	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel Observation	Total Catch/Observation
Commercial Harvest	Juvenile (Fry, Parr. Smolt)	36	1,313	11	0	2,300	146	3,289	2,542	2,497	12,134
Commercial Harvest	Adult^	54	0	1	5	44	53	0	113	4,410	4,680
Sport, Personal Use, Subsistence	Juvenile	64	2,122	94	0	663	58	351	797	1,910	6,059
Sport, Personal Use, Subsistence	Juvenile or Adult	206	425	250	1	183	94	68	71	979	2,277
Sport, Personal Use, Subsistence	Adult	87	29	69	0	19	16	1	11	205	437
Non-Harvest	All Combined	0	10,059	106	0	2,934	775	9,339	1,898	786	25,897
Total Catch/Observation		447	13,948	531	6	6,143	1,142	13,048	5,432	10,787	51,484
Total Gear Events (Macrohabitat Level)		246	892	212	56	143	116	765	226	365	3,021
Total Gear Events (Mesohabitat Level)		335	1,243	213	59	177	136	1,010	256	573	4,002

^ Commercial harvest adults were not targeted as part of study and not included in relative abundance portion of FUHI but are included in richness counts

Table 2.2-1. Species groupings and life stages used for relative abundance metrics.

Group	Common Name	Latin Name	Distribution	Life stages Used for Relative Abundance		
Commercial Fisheries (AEA 2012)						
Commercial Harvest	Chinook Salmon	*Oncorhynchus tshawytscha*	Lower, Middle, Upper	Juvenile (fry, parr, smolt, and unspecified juveniles)		
	Chum Salmon	*Oncorhynchus keta*	Lower, Middle			
	Coho Salmon	*Oncorhynchus kisutch*	Lower, Middle			
	Pink Salmon	*Oncorhynchus gorbuscha*	Lower, Middle			
	Sockeye Salmon	*Oncorhynchus nerka*	Lower, Middle			
	Pacific salmon, unspecified	*Oncorhynchus sp.*				
Sport, Personal Use, and Subsistence Fisheries (AEA 2012)				Juvenile	Juvenile/Adult	Adult
Sport, Personal Use, and Subsistence	Arctic Grayling	*Thymallus arcitcus*	Lower, Middle, Upper	<125 mm	125-219 mm	>219 mm
	Burbot	*Lota lota*	Lower, Middle, Upper	<280 mm	280-498 mm	>498 mm
	Dolly Varden	*Salvelinus malma*	Lower, Middle, Upper	<83 mm	≥ 83 mm	
	Lake Trout	*Salvelinus namaycush*	Upper	<300 mm	300-430 mm	>430 mm
	Northern Pike	*Esox lucius*	Lower	<330 mm	330-448 mm	>448 mm
	Rainbow Trout	*Oncorhynchus mykiss*	Lower, Middle	<200 mm	200-325mm	>325 mm
	Whitefish, Humpback	*Coregonus pidschian*	Lower, Middle, Upper	<280 mm	280-363 mm	>363 mm
	Whitefish, Round	*Prosopium cylindraceum*	Lower, Middle, Upper	<199 mm	199-318 mm	>318 mm
	Whitefish, unspecified			<199 mm	199-363 mm	>363 mm
Not Considered of Fishery Value in Study Area (AEA 2012)						
Non-Harvest	Arctic Lamprey	*Lethenteron japonicum*	Lower, Middle	All Life Stages Combined		
	Bering Cisco	*Coregonus laurettae*	Lower, Middle			
	Longnose Sucker	*Catostomus catostomus*	Lower, Middle, Upper			
	Slimy Sculpin	*Cottus cognatus*	Lower, Middle, Upper			
	Stickleback, Ninespine	*Pungitius pungitius*	Lower, Middle			
	Stickleback, Threespine	*Gasterosteus aculeatus*	Lower, Middle			
	Lamprey, unspecified					
	Sculpin, unspecified	*Cottus sp.*				
	Stickleback, unspecified					
Not Used in Relative Abundance Metrics						
Multiple groups	Fish, species unspecified Salmonid, unspecified			Species Not Used in Analysis		
Non-Harvest	Alaska Blackfish	*Dallia pectoralis*	Unknown	Species Not Used in Analysis: not documented during 2013-14 Fish Distribution and Abundance Studies (9.5 & 9.6)		
Commercial Harvest	Eulachon	*Thaleichthys pacificus*	Lower			
Non-Harvest	Pacific Lamprey	*Lampetra tridentata*	Unknown			

Table 2.2-2. Species and life stages used for richness counts.

Common Name	Latin Name	Distribution	Life stages Used for Richness Index		
			Juvenile	Juvenile/Adult	Adult
Chinook Salmon	*Oncorhynchus tshawytscha*	Lower, Middle, Upper	Fry, Parr, Smolt (Juvenile), Adult (Jack)		
Chum Salmon	*Oncorhynchus keta*	Lower, Middle			
Coho Salmon	*Oncorhynchus kisutch*	Lower, Middle			
Pink Salmon	*Oncorhynchus gorbuscha*	Lower, Middle			
Sockeye Salmon	*Oncorhynchus nerka*	Lower, Middle			
Pacific salmon, unspecified*	*Oncorhynchus sp.*				
Arctic Grayling	*Thymallus arcitcus*	Lower, Middle, Upper	<125 mm	125-219 mm	>219 mm
Dolly Varden	*Salvelinus malma*	Lower, Middle, Upper	<83 mm	≥ 83 mm	
Lake Trout	*Salvelinus namaycush*	Upper	<300 mm	300-430 mm	>430 mm
Rainbow Trout	*Oncorhynchus mykiss*	Lower, Middle	<200 mm	200-325mm	>325 mm
Bering Cisco	*Coregonus laurettae*	Lower, Middle	Only adults present		
Whitefish, Humpback	*Coregonus pidschian*	Lower, Middle, Upper	<280 mm	280-363 mm	>363 mm
Whitefish, Round	*Prosopium cylindraceum*	Lower, Middle, Upper	<199 mm	199-318 mm	>318 mm
Whitefish, unspecified*			<199 mm	199-363 mm	>363 mm
Salmonid, unspecified*			Life stages not assigned		
Arctic Lamprey	*Lethenteron japonicum*	Lower, Middle	<125	125-219	>219
Lamprey, unspecified*			<125	125-219	>219
Burbot	*Lota lota*	Lower, Middle, Upper	<280 mm	280-498 mm	>498 mm
Longnose Sucker	*Catostomus catostomus*	Lower, Middle, Upper	<188	188-348	>348
Northern Pike	*Esox lucius*	Lower	<330 mm	330-448 mm	>448 mm
Slimy Sculpin	*Cottus cognatus*	Lower, Middle, Upper	<51	51-68	>68
Sculpin, unspecified*	*Cottus sp.*		<51	51-68	>68
Stickleback, Ninespine	*Pungitius pungitius*	Lower, Middle	<40	40-70	>70
Stickleback, Threespine	*Gasterosteus aculeatus*	Lower, Middle	<40	40-70	>70
Stickleback, unspecified*			<40	40-70	>70
Fish, species unspecified*			Life stages not assigned		
Alaska Blackfish	*Dallia pectoralis*	Unknown	Species not used in divesity counts: not documented during 2013-14 FDA studies (9.5 & 9.6)		
Eulachon	*Thaleichthys pacificus*	Lower			
Pacific Lamprey	*Lampetra tridentata*	Unknown			

*Mutually exclusive group, count only used for broad taxonomic levels if there was no overlap with specific species member and lifestage

Table 3.1-1. Juvenile Arctic Grayling Species/lifestage-specific Index of Relative Abundance (SIRA) values for mesohabitats by stream, macrohabitat type, and season in Upper River tributaries based on GRTS sampling, 2013-2014. SIRA scores >0 are indicated for low (bold; ≤0.37), moderate (gray shading; 0.38-2.70), and high (black shading/white font; >2.70) values.

Stream	Macrohabitat	Study Period	Backwater	Beaver Pond	Boulder Riffle	Percolation Channel	Pool	Rapid	Riffle	Run/Glide	Tributary
Black River	Main Channel	FDA 1 - Early Summer	0.12		0.46			0.43	0.15	0.98	
		FDA 2 - Late Summer	0.45		0.49			0.12	0.00	0.61	
		FDA 3 - Fall	0.00		0.29			0.38	0.47	0.27	
	Off-Channel	FDA 1 - Early Summer				0.08					0.60
		FDA 2 - Late Summer				0.00					0.94
		FDA 3 - Fall				0.12					0.61
Goose Creek	Main Channel	FDA 1 - Early Summer			2.74		1.59		12.24	2.60	
		FDA 2 - Late Summer			1.81		1.63		2.49	1.29	
		FDA 3 - Fall			1.38		1.92		1.64	0.64	
Kosina Creek	Main Channel	FDA 1 - Early Summer			0.39				0.00	0.49	
		FDA 2 - Late Summer			1.05				0.00	0.00	
		FDA 3 - Fall			1.84				0.00	1.81	
Oshetna River	Main Channel	FDA 1 - Early Summer			1.09		0.50	0.00	1.41	0.47	
		FDA 2 - Late Summer			0.37		2.13	0.00	0.47	0.08	
		FDA 3 - Fall			0.21		0.00	0.00	1.18	0.52	
	Off-Channel	FDA 1 - Early Summer				0.00					
		FDA 2 - Late Summer				0.68					
		FDA 3 - Fall				0.50					
Tsisi Creek	Main Channel	FDA 1 - Early Summer			1.48				1.65	0.58	
		FDA 2 - Late Summer			0.23				0.35	0.37	
		FDA 3 - Fall			0.98				0.45	0.00	
	Off-Channel	FDA 1 - Early Summer				0.94					
		FDA 2 - Late Summer				1.19					
		FDA 3 - Fall				1.02					
Unnamed 194.8	Main Channel	FDA 1 - Early Summer					0.00		0.00	0.67	
		FDA 2 - Late Summer					0.00		0.00	0.00	
		FDA 3 - Fall					0.00		0.00	0.00	
Watana Creek	Main Channel	FDA 1 - Early Summer		0.00	1.61		0.39		0.39	1.21	
		FDA 2 - Late Summer		0.00	0.83		0.38		0.17	1.04	
		FDA 3 - Fall		0.00	0.37		0.00		1.71	1.10	
	Off-Channel	FDA 1 - Early Summer		0.00		0.00					
		FDA 2 - Late Summer		0.00		0.00					
		FDA 3 - Fall		0.00		0.00					
Watana Creek Tributary	Main Channel	FDA 1 - Early Summer			2.32				1.74	4.43	
		FDA 2 - Late Summer			1.93			0.81	1.46	2.35	
		FDA 3 - Fall			3.03			0.53	0.96	3.34	
	Off-Channel	FDA 1 - Early Summer				0.00					
		FDA 2 - Late Summer				0.00					
		FDA 3 - Fall				0.00					

Table 3.1-2. Juvenile Arctic Grayling Species/lifestage-specific Index of Relative Abundance (SIRA) values for mesohabitats by Upper and Middle River geomorphic reach, macrohabitat type, and season, 2013-2014. SIRA scores >0 are indicated for low (bold; ≤0.37), moderate (gray shading; 0.38-2.70), and high (black shading/white font; >2.70) values.

Reach	Macrohabitat	Study Period	Backwater	Beaver Complex	Boulder Riffle	Cascade	Clearwater Plume	Pool	Rapid	Riffle	Run/Glide
UR	Main Channel	FDA 1 - Early Summer					0.46			0.29	0.27
		FDA 2 - Late Summer					0.30			0.00	0.26
		FDA 3 - Fall					0.12			2.16	0.97
	Side Channel	FDA 1 - Early Summer	1.20					0.86		1.01	0.42
		FDA 2 - Late Summer	0.17					1.93		0.45	1.23
		FDA 3 - Fall	0.95					0.55		0.64	1.58
	Side Slough	FDA 1 - Early Summer	1.93					0.40		0.72	0.41
		FDA 2 - Late Summer	0.21					0.00		0.86	0.55
		FDA 3 - Fall						0.72		0.00	0.00
	Tributary Mouth	FDA 1 - Early Summer				0.00			1.02	1.85	
		FDA 2 - Late Summer				0.00			0.00	0.15	
		FDA 3 - Fall			0.00	0.00			0.22	0.00	
	Upland Slough	FDA 1 - Early Summer						0.00			0.32
		FDA 2 - Late Summer						0.06			0.27
		FDA 3 - Fall						0.17			0.88
MR-1	Main Channel	FDA 1 - Early Summer									0.05
		FDA 2 - Late Summer									0.63
		FDA 3 - Fall									0.97
	Side Channel	FDA 1 - Early Summer								0.00	0.33
		FDA 2 - Late Summer								1.15	1.30
		FDA 3 - Fall								1.57	1.45
MR-2	Main Channel	FDA 1 - Early Summer					0.26				0.40
		FDA 2 - Late Summer					0.83				1.03
		FDA 3 - Fall					0.29				0.60
	Side Channel	FDA 1 - Early Summer								0.00	0.33
		FDA 2 - Late Summer								0.73	0.47
		FDA 3 - Fall						0.00			2.36
	Side Slough	FDA 1 - Early Summer	2.52				2.63	1.40			5.01
		FDA 2 - Late Summer	1.09				2.00	0.39		0.36	2.04
		FDA 3 - Fall					0.13	0.00			2.73
	Trib Lower Reach	FDA 1 - Early Summer				0.00			0.10	0.00	
		FDA 2 - Late Summer			0.00	0.00			0.00	0.19	0.00
		FDA 3 - Fall				0.00		0.00	0.11	0.09	0.00
	Tributary Mouth	FDA 1 - Early Summer				0.00				1.75	
		FDA 2 - Late Summer				0.00				0.82	
		FDA 3 - Fall				0.00				0.00	
	Upland Slough	FDA 1 - Early Summer						0.00			0.00
		FDA 2 - Late Summer		0.00				0.00			0.00
		FDA 3 - Fall									0.00

Reach	Macrohabitat	Study Period	Backwater	Beaver Complex	Boulder Riffle	Cascade	Clearwater Plume	Pool	Rapid	Riffle	Run/Glide
MR-5	Main Channel	FDA 1 - Early Summer					0.00			0.00	0.00
		FDA 2 - Late Summer					0.00			5.35	0.00
		FDA 3 - Fall					0.00			2.83	0.03
	Side Slough	FDA 1 - Early Summer									0.00
		FDA 2 - Late Summer									0.51
		FDA 3 - Fall						0.00			0.00
	Trib Lower Reach	FDA 1 - Early Summer							0.12		
		FDA 2 - Late Summer							0.00		0.00
		FDA 3 - Fall							0.00		0.00
	Tributary Mouth	FDA 1 - Early Summer				0.00		0.00	0.00	0.00	0.00
		FDA 2 - Late Summer				0.00		0.00	0.00	0.00	0.00
		FDA 3 - Fall				0.00		0.00	0.00	0.00	
MR-6	Main Channel	FDA 1 - Early Summer					0.57			0.00	0.00
		FDA 2 - Late Summer					0.11			0.27	0.04
		FDA 3 - Fall					0.00			0.64	0.13
	Side Channel	FDA 1 - Early Summer						0.00		0.00	0.09
		FDA 2 - Late Summer					0.00	0.30		0.00	0.05
		FDA 3 - Fall	0.00				0.00	0.25		0.00	0.00
	Side Slough	FDA 1 - Early Summer	0.00	0.00				0.11		0.00	0.06
		FDA 2 - Late Summer	0.00	0.00				0.00		0.00	0.00
		FDA 3 - Fall		0.00				0.79		0.00	0.00
	Trib Lower Reach	FDA 1 - Early Summer			0.17			0.31		0.00	0.33
		FDA 2 - Late Summer			0.00					0.00	0.00
		FDA 3 - Fall			0.96	0.00		0.00		0.00	0.00
	Tributary Mouth	FDA 1 - Early Summer						0.00		1.42	2.62
		FDA 2 - Late Summer						0.00		0.00	0.00
		FDA 3 - Fall						0.00	0.00	0.29	0.00
	Upland Slough	FDA 1 - Early Summer	0.85	0.00				0.04			0.00
		FDA 2 - Late Summer	0.43	0.00				0.00			0.00
		FDA 3 - Fall		0.00				0.00			0.00

Reach	Macrohabitat	Study Period	Backwater	Beaver Complex	Boulder Riffle	Cascade	Clearwater Plume	Pool	Rapid	Riffle	Run/Glide
MR-7	Main Channel	FDA 1 - Early Summer					0.00			0.00	0.00
		FDA 2 - Late Summer					0.00			0.44	0.00
		FDA 3 - Fall					0.00				0.01
	Side Channel	FDA 1 - Early Summer						0.00		0.00	0.00
		FDA 2 - Late Summer								0.00	0.00
		FDA 3 - Fall						0.00		0.00	0.00
	Side Slough	FDA 1 - Early Summer		0.00				0.00			0.00
		FDA 2 - Late Summer	0.27	0.00				0.13		0.00	0.00
		FDA 3 - Fall	0.00	0.00				0.00			0.00
	Trib Lower Reach	FDA 1 - Early Summer						0.00		0.00	0.00
		FDA 2 - Late Summer						0.00		0.00	0.00
		FDA 3 - Fall				0.00		0.00		0.00	0.00
	Tributary Mouth	FDA 1 - Early Summer								0.00	
		FDA 2 - Late Summer				0.00				0.00	
		FDA 3 - Fall								0.00	
	Upland Slough	FDA 1 - Early Summer	0.00	0.00				0.00			0.55
		FDA 2 - Late Summer	0.00	0.00				0.00			0.00
		FDA 3 - Fall	0.00	0.00				0.00			0.00
MR-8	Main Channel	FDA 1 - Early Summer									0.00
		FDA 2 - Late Summer									0.00
		FDA 3 – Fall									0.10
	Side Channel	FDA 1 - Early Summer						0.00			0.00
		FDA 2 - Late Summer						0.00		0.20	0.00
		FDA 3 – Fall						0.00		0.65	0.00
	Side Slough	FDA 1 - Early Summer						0.18		0.00	0.18
		FDA 2 - Late Summer						0.35		0.00	0.08
		FDA 3 – Fall						0.17		1.38	0.62
	Trib Lower Reach	FDA 1 - Early Summer						0.00		0.00	0.00
		FDA 2 - Late Summer						0.00		0.00	0.20
		FDA 3 – Fall						3.19		0.00	
	Upland Slough	FDA 1 - Early Summer	0.00	0.00				0.00			0.00
		FDA 2 - Late Summer	0.00					0.00			0.00
		FDA 3 – Fall	0.00	0.00				0.00			0.03

7. FIGURES

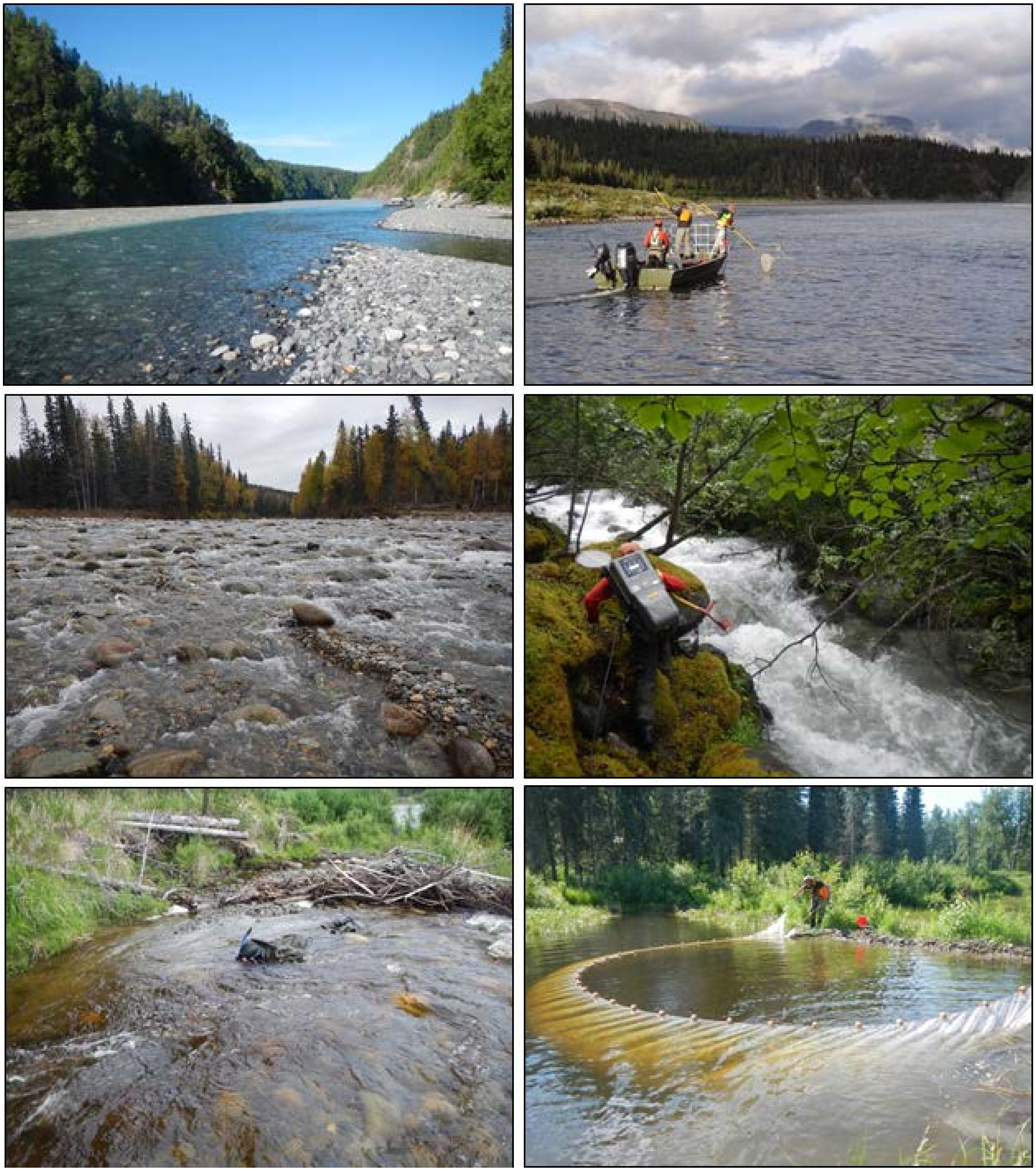


Figure 1-1. Examples of various habitat types encountered in the Susitna-Watana Fish Distribution and Abundance study area.

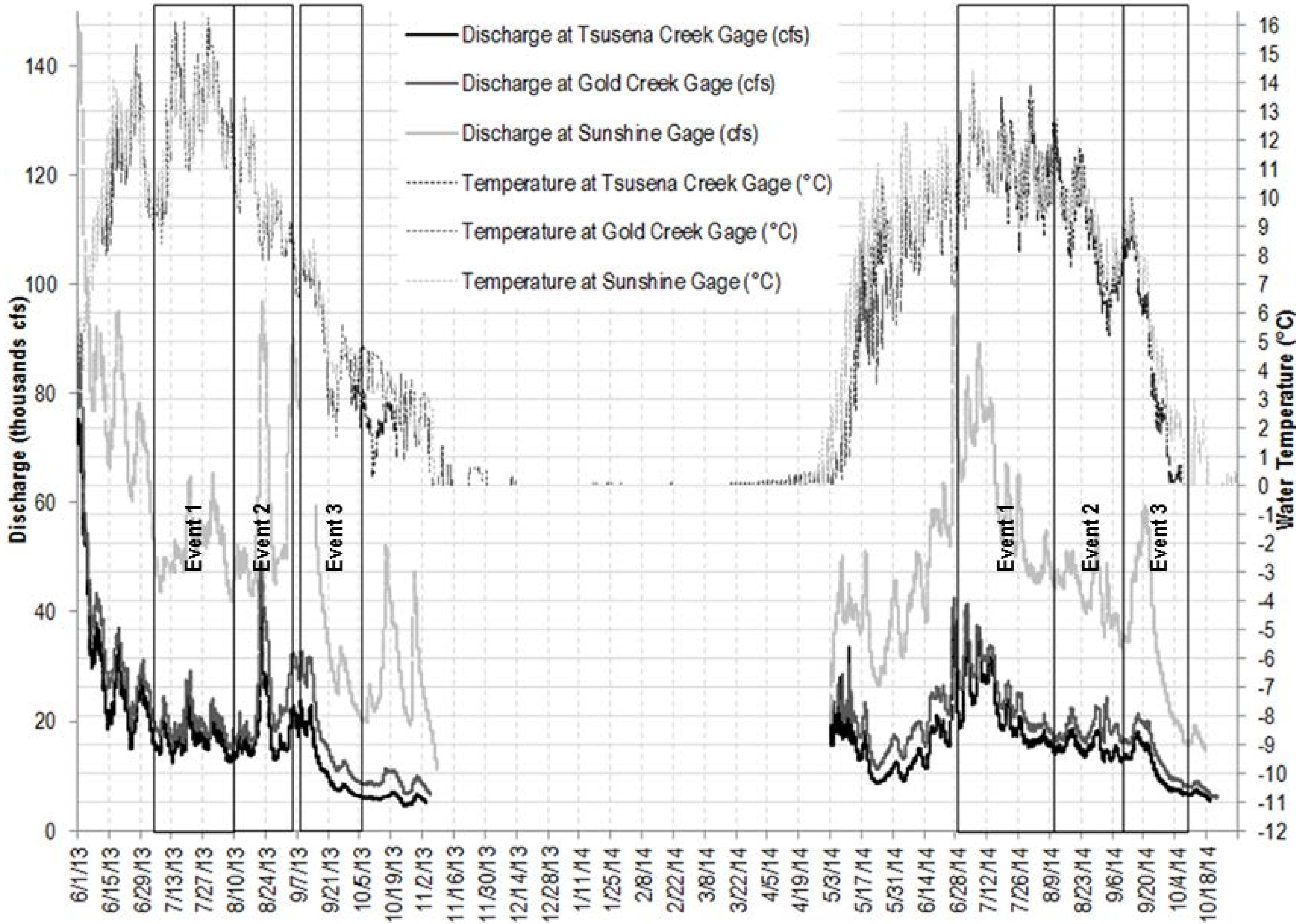


Figure 2.1-1. Susitna River discharge and temperature at Tsusena (PRM 184), Gold Creek (PRM 140), and Sunshine (PRM 30) during seasonal sampling events, 2013-2014.

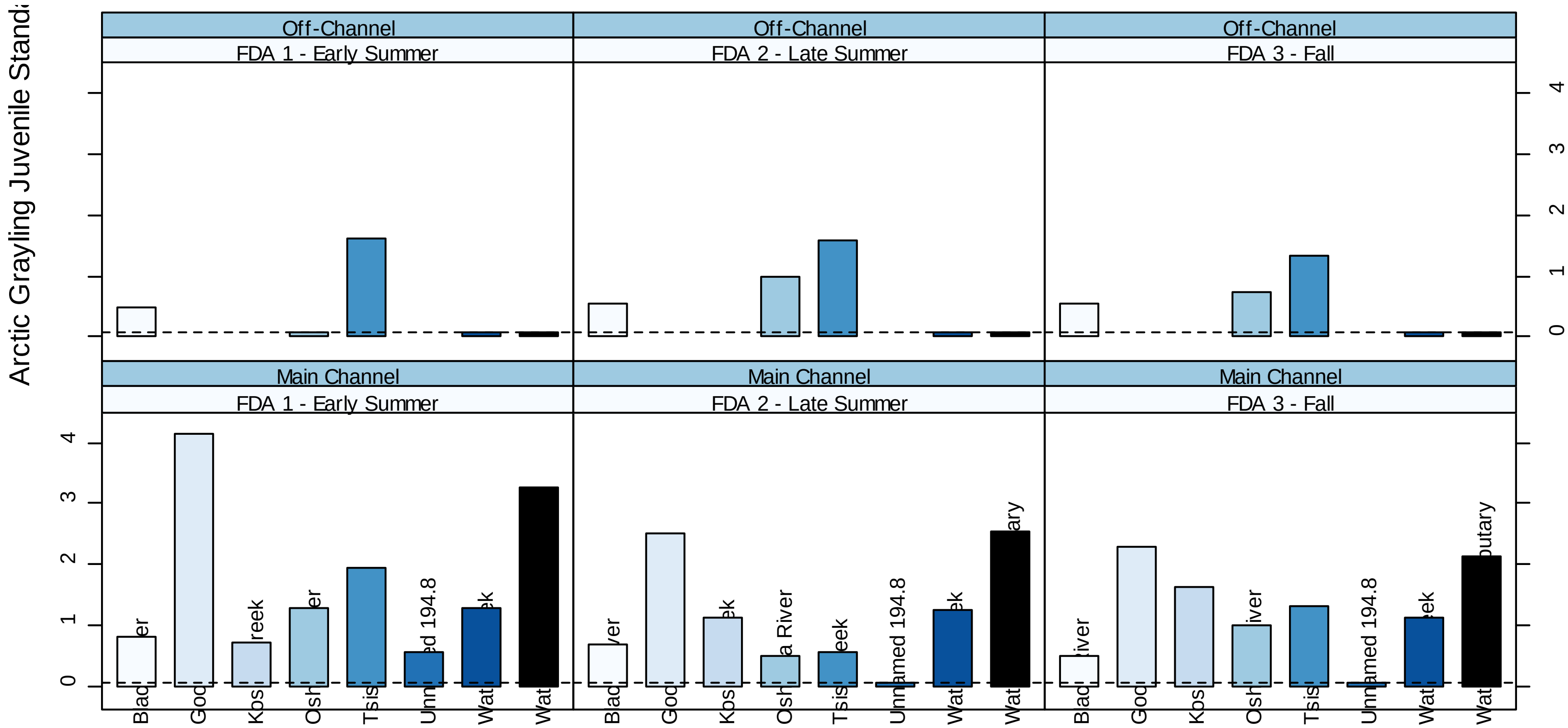


Figure 3.1-1. Relative abundance index (across gear types) for juvenile Arctic Grayling by season, reach, and macrohabitat types in Upper River tributaries, 2013-2014. Note: Bars below the dashed horizontal line indicate effort was applied but no fish were captured (relative abundance score of 0). No bar indicates the habitat stratum was not sampled.

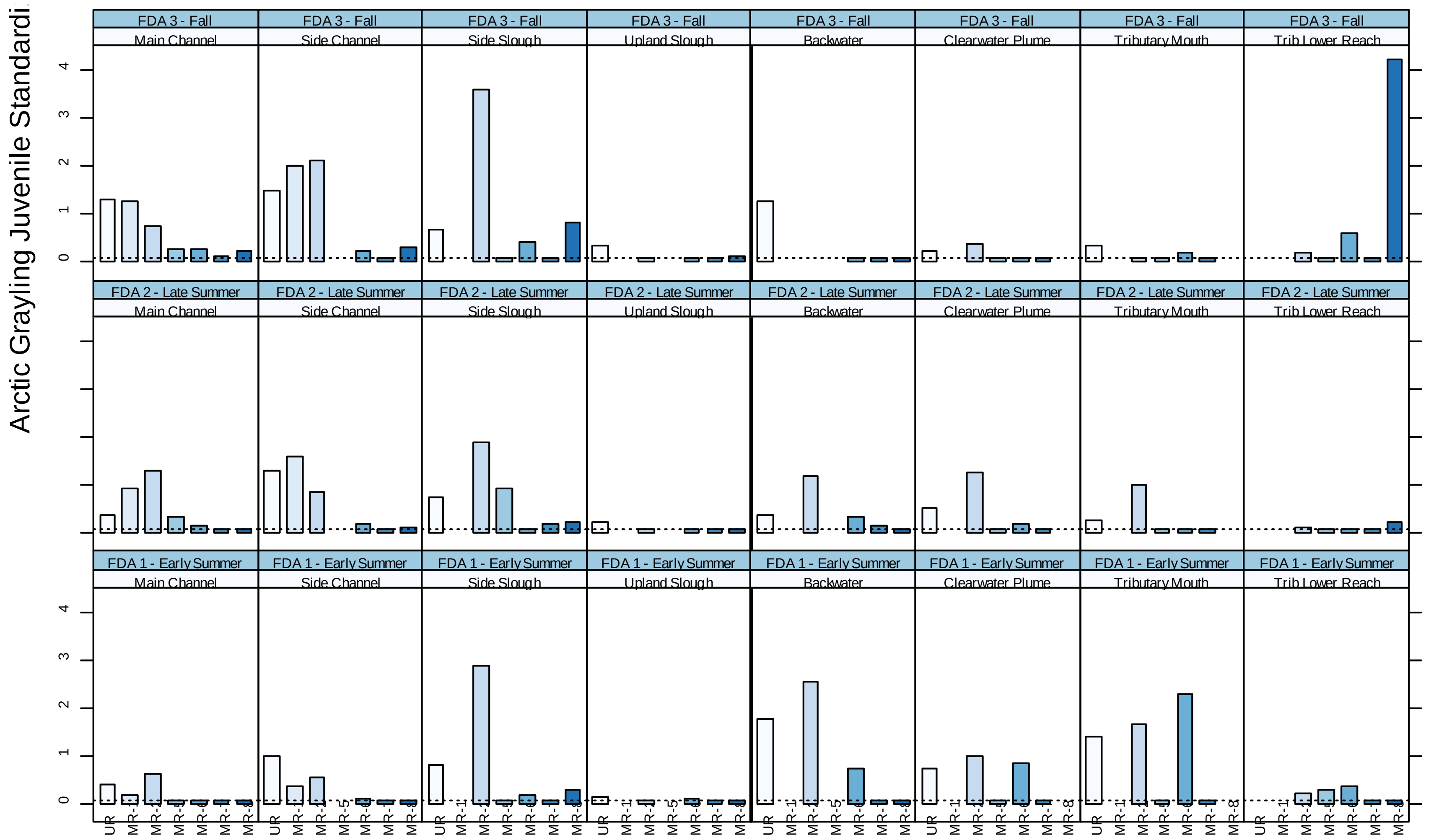


Figure 3.1-2. Relative abundance index (across gear types) for juvenile Arctic Grayling by season, reach, and macrohabitat types for UR and MR geomorphic reaches of the Susitna River, 2013-2014. Note: Bars below the dashed horizontal line indicate effort was applied but no fish were captured (relative abundance score of 0). No bar indicates the habitat stratum was not sampled.

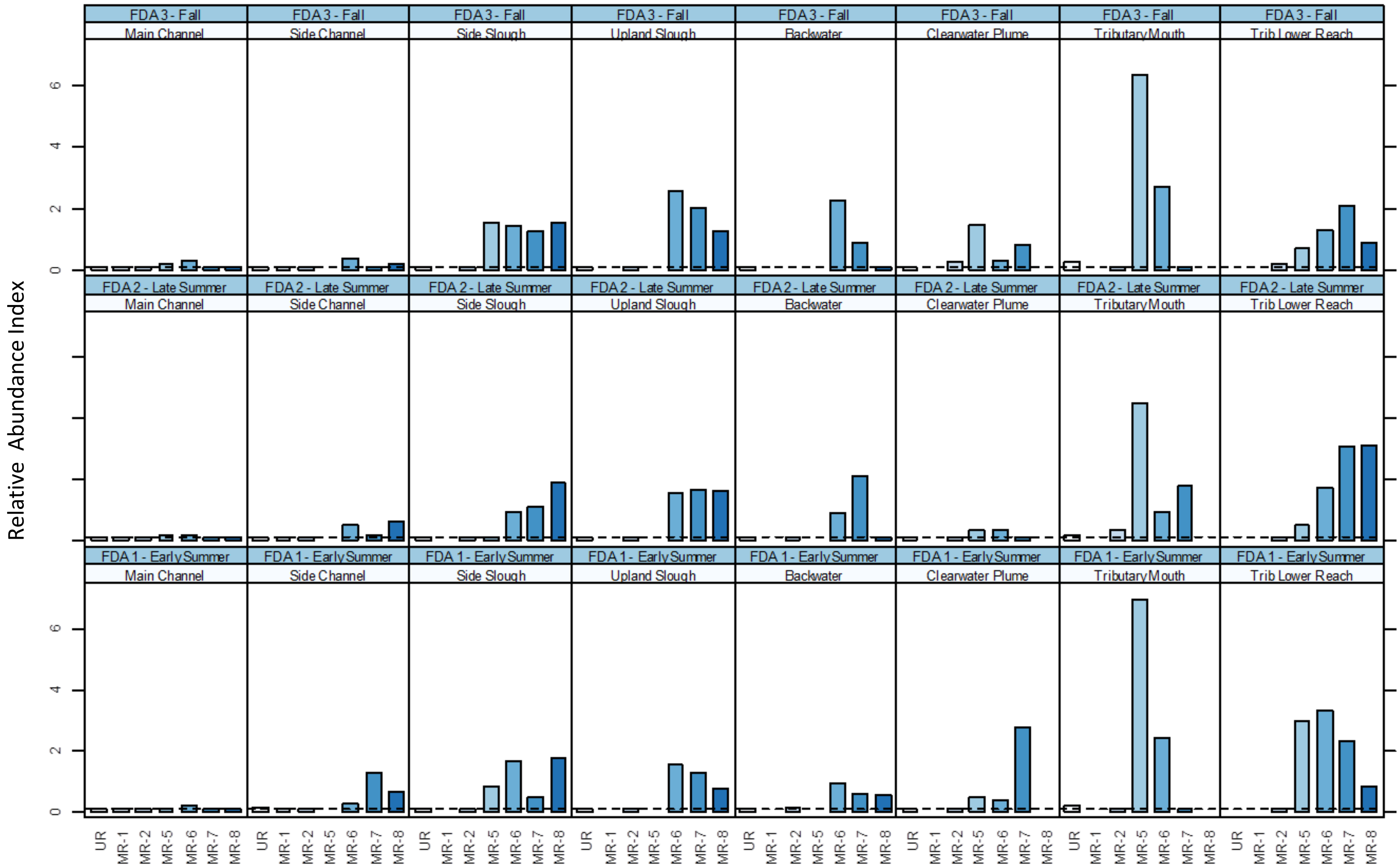


Figure 3.2-1. Commercial harvest juvenile relative abundance index for each macrohabitat type sampled within UR and MR geomorphic reaches and across 2013/2014 sampling seasons. Note: Bars below the dashed horizontal line indicate effort was applied but no fish were captured (relative abundance score of 0). No bar indicates the habitat stratum was not sampled.

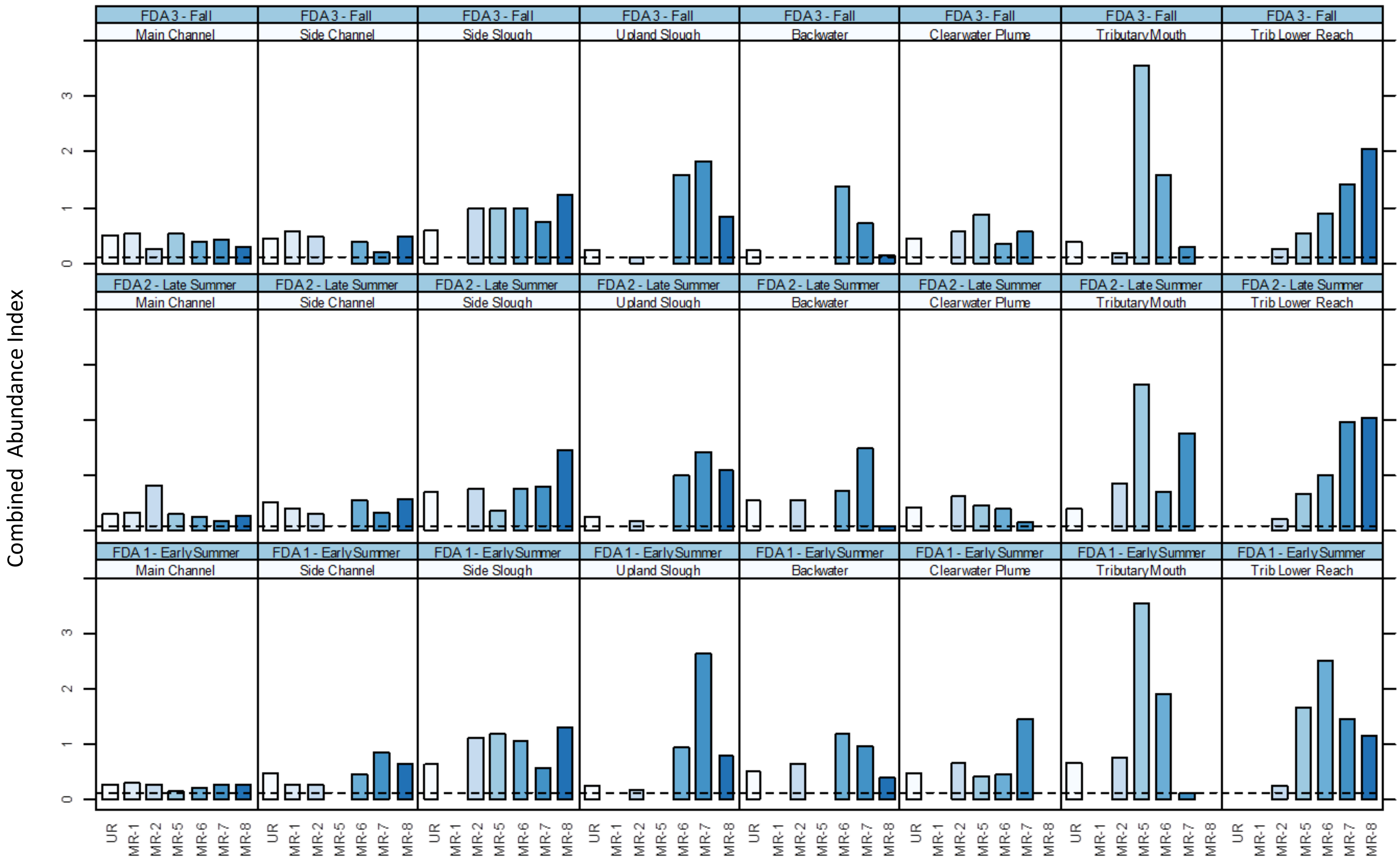


Figure 3.2-2. Combined abundance index (CAI) for each macrohabitat type sampled within UR and MR geomorphic reaches and across 2013/2014 sampling seasons. Note: Bars below the dashed horizontal line indicate effort was applied but no fish were captured (CAI score of 0). No bar indicates the habitat stratum was not sampled.

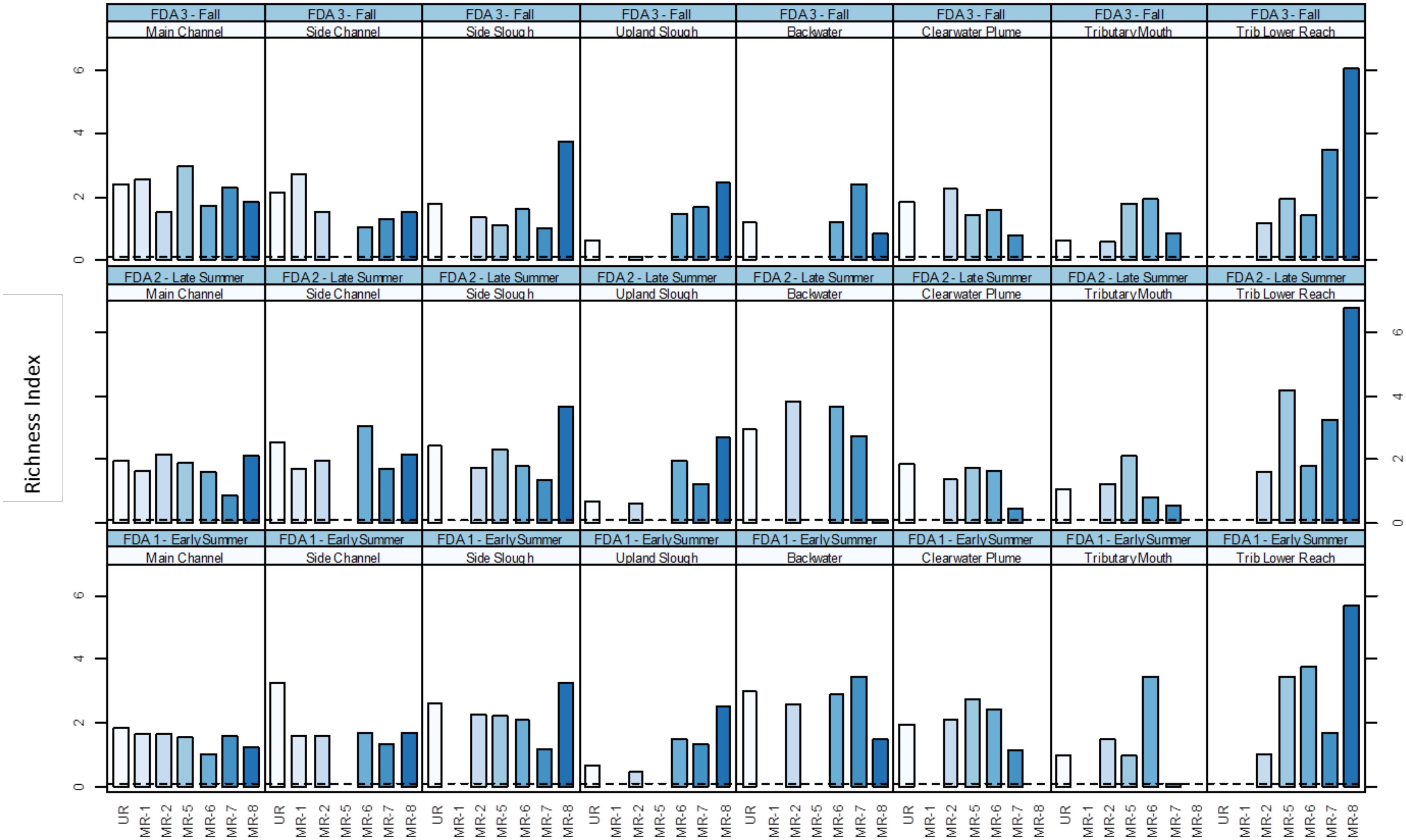
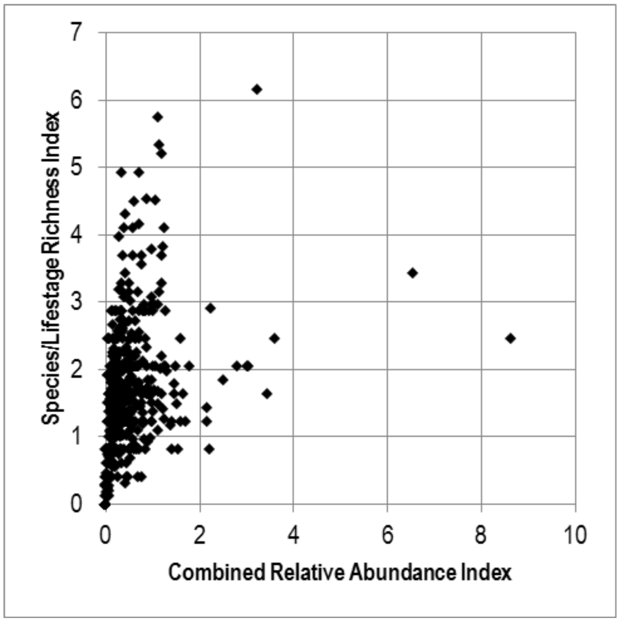


Figure 3.2-3. Richness index (RI) for each macrohabitat type sampled within UR and MR geomorphic reaches and across 2013/2014 sampling seasons. Note: Bars below the dashed horizontal line indicate effort was applied but no fish were captured (RI score of 0). No bar indicates the habitat stratum was not sampled.

a)



b)

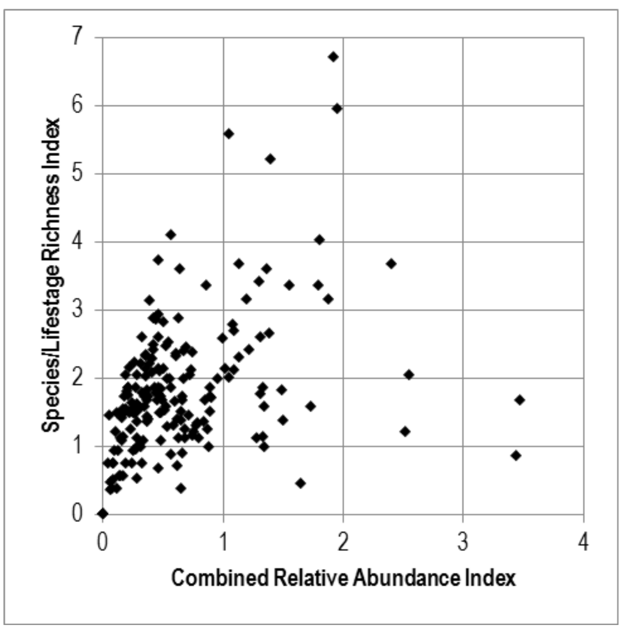


Figure 3.2-4. Scatter plots of a) macrohabitat Richness Index (RI) versus Combined Abundance Index (CAI; R^2 =0.15) and b) mesohabitat RI versus CAI (R^2 =0.10).

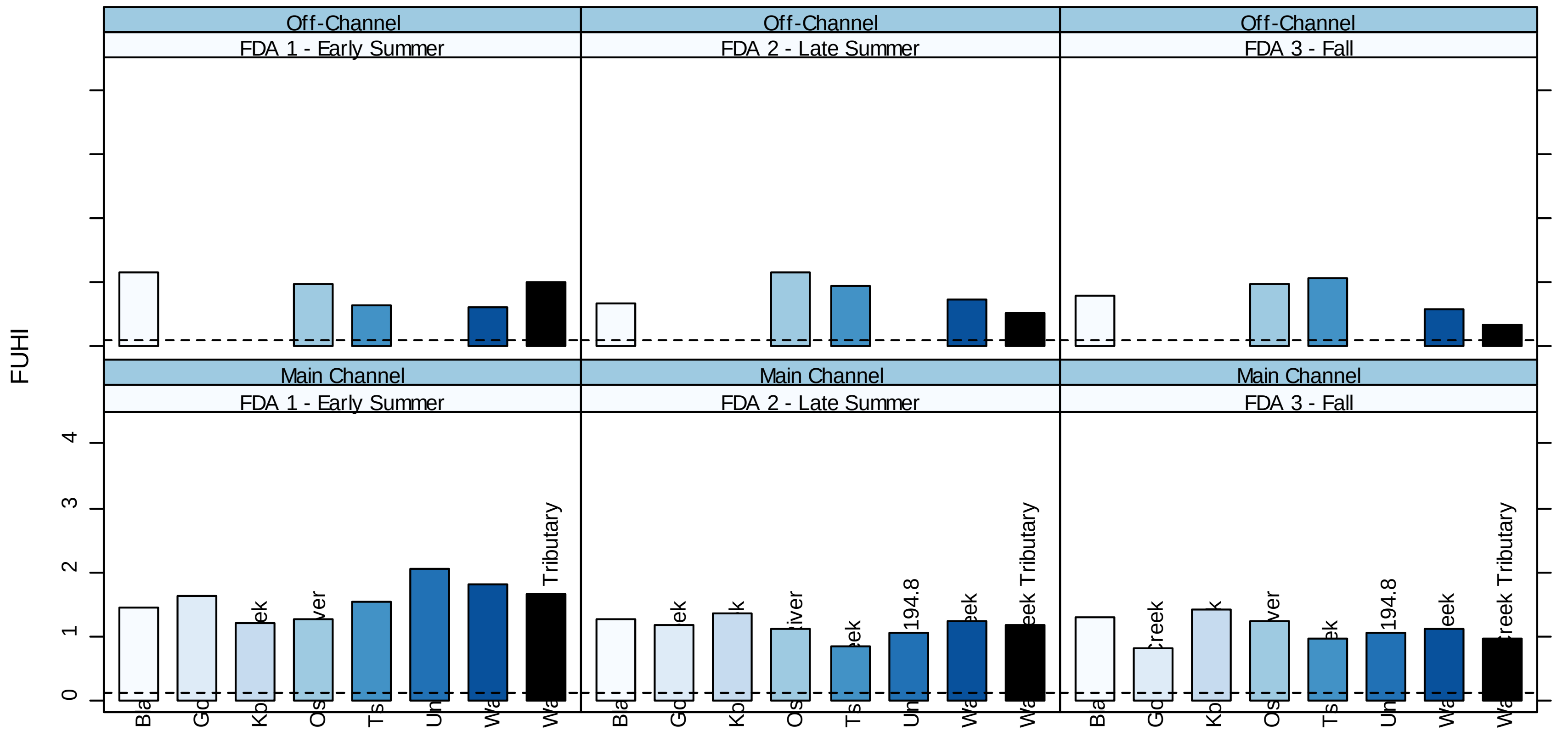


Figure 3.3-1. Fish use habitat index (FUHI) for each macrohabitat type sampled in UR tributaries, plotted by tributary and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI score is 0. No bar indicates the habitat stratum was not sampled.

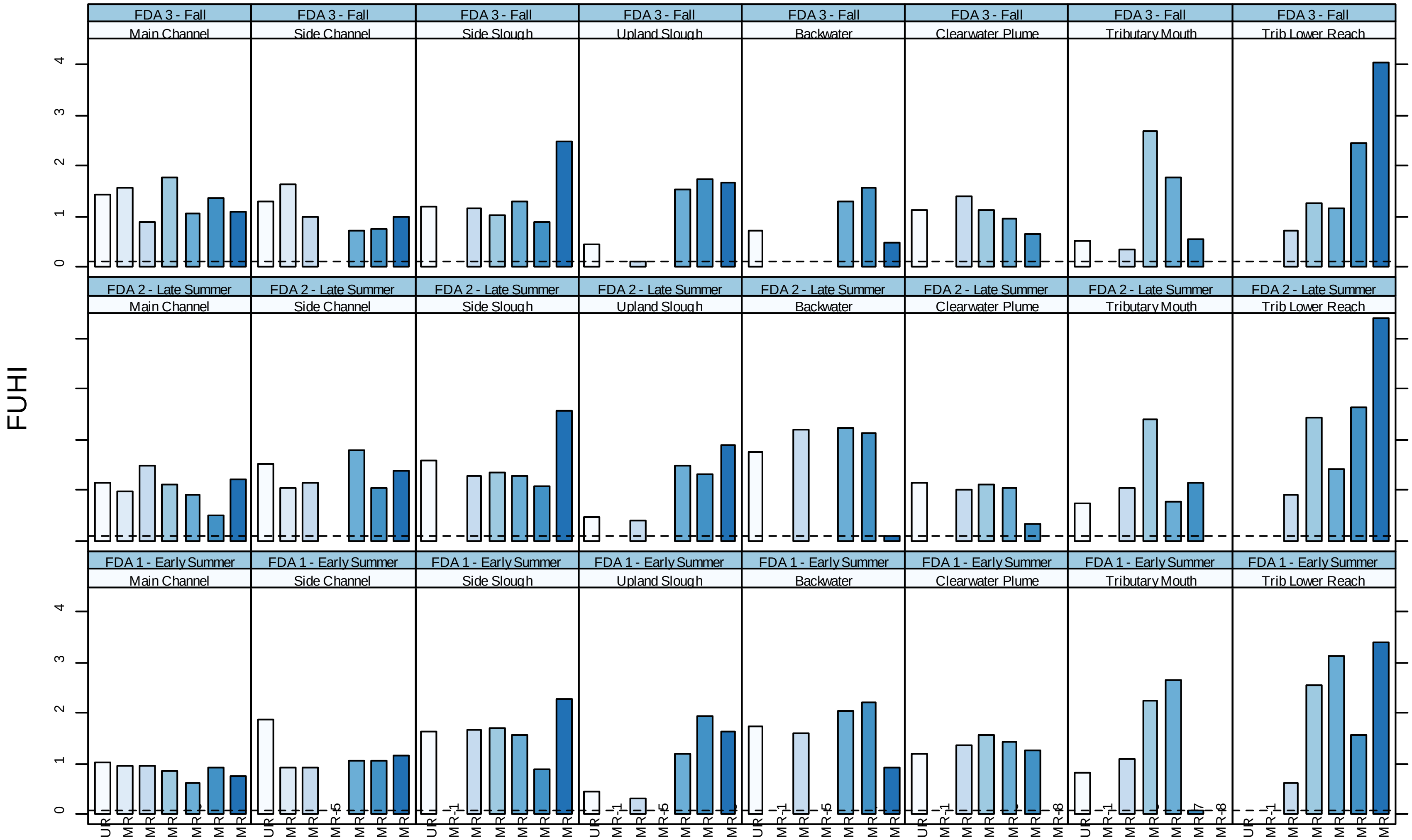


Figure 3.3-2. Fish use habitat index (FUHI) scores for each macrohabitat type sampled in Upper River (UR) and Middle River (MR) mainstem plotted by geomorphic reaches and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI score is 0. No bar indicates the habitat stratum was not sampled.

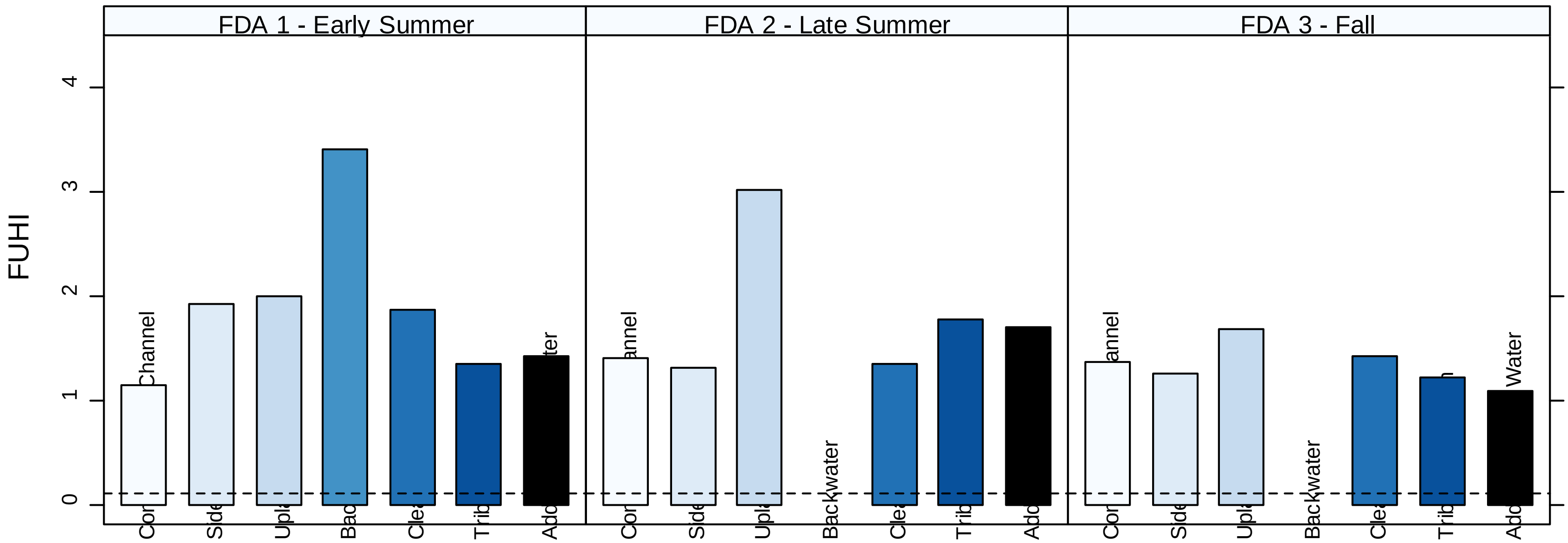


Figure 3.3-3. Fish use habitat index (FUHI) scores for each macrohabitat type sampled in the Lower River (LR) mainstem plotted by geomorphic reaches and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI score is 0. No bar indicates the habitat stratum was not sampled.

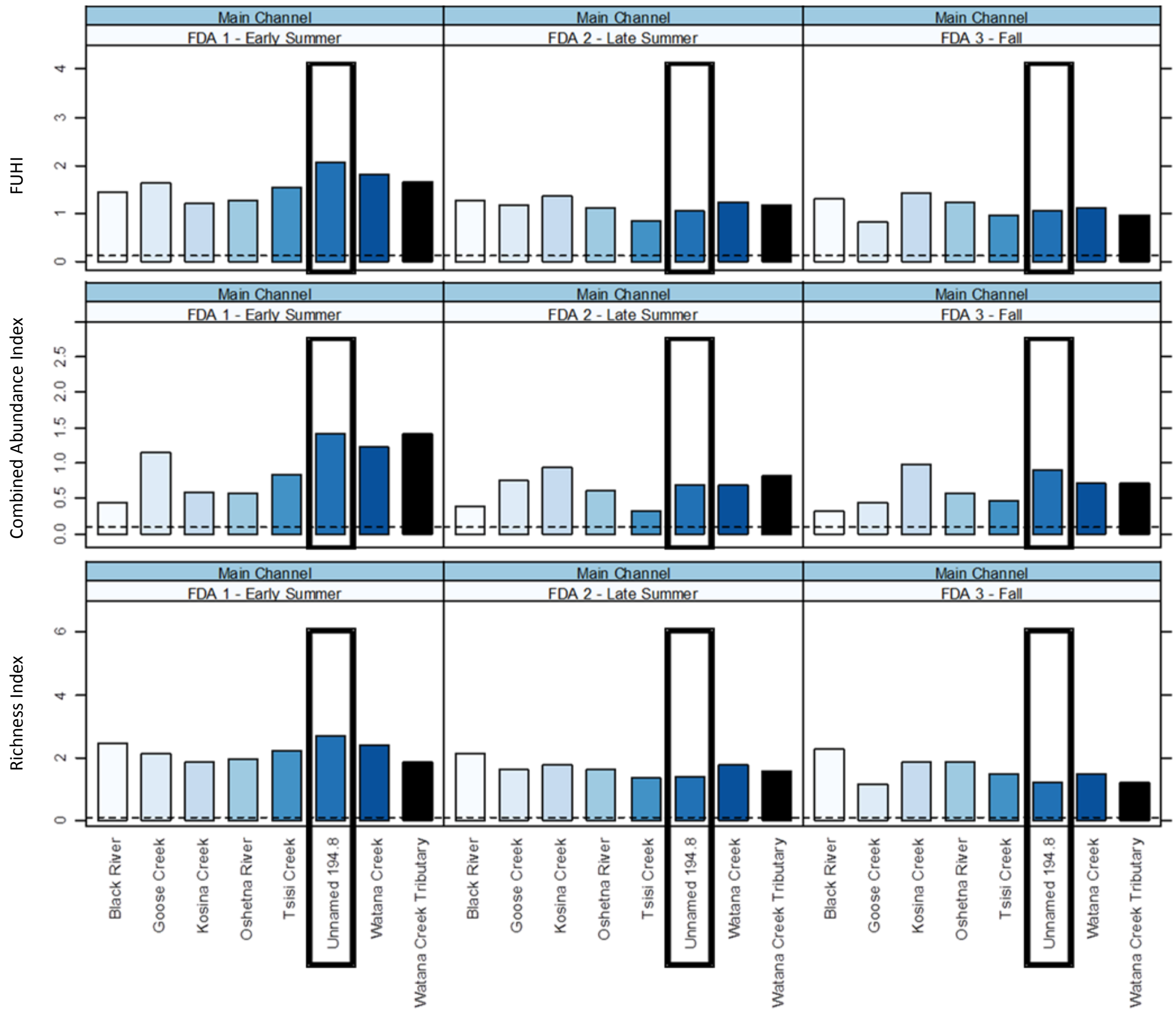


Figure 3.3-4. Fish use habitat index (FUHI), combined abundance index (CAI) and richness index (RI) for main channel macrohabitat in Upper River tributaries. Highlight designates values for Unnamed Tributary 194.8 (black boxes). Note: Bars below the dashed horizontal line indicate effort was applied but FUHI score is 0. No bar indicates the habitat stratum was not sampled.

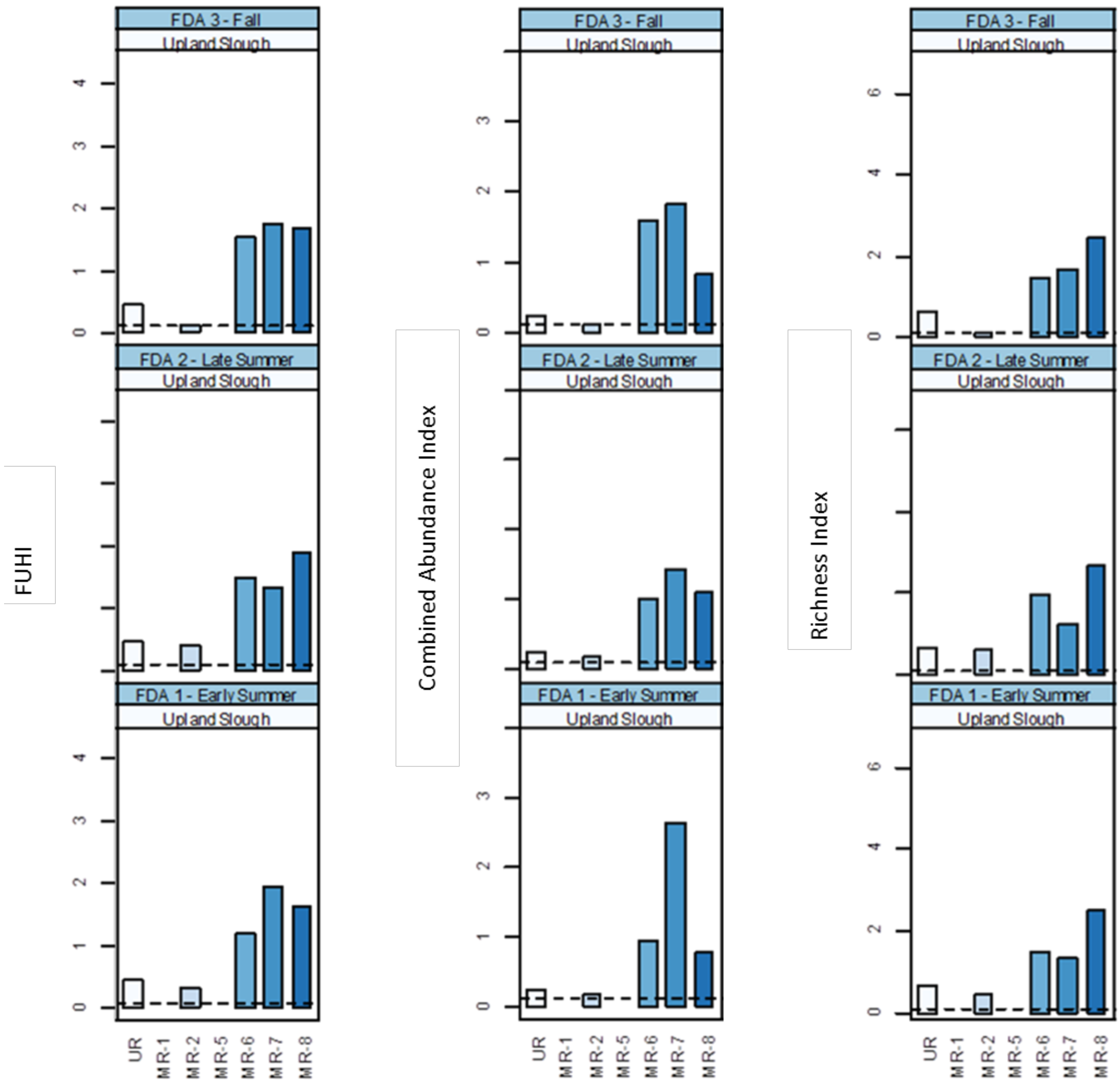


Figure 3.3-5. Fish use habitat index (FUHI), combined abundance index (CAI), and richness index (RI) for UR and MR mainstem upland sloughs by geomorphic reach and 2013/2014sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI, RI, of CAI value is 0. No bar indicates the habitat stratum was not sampled.

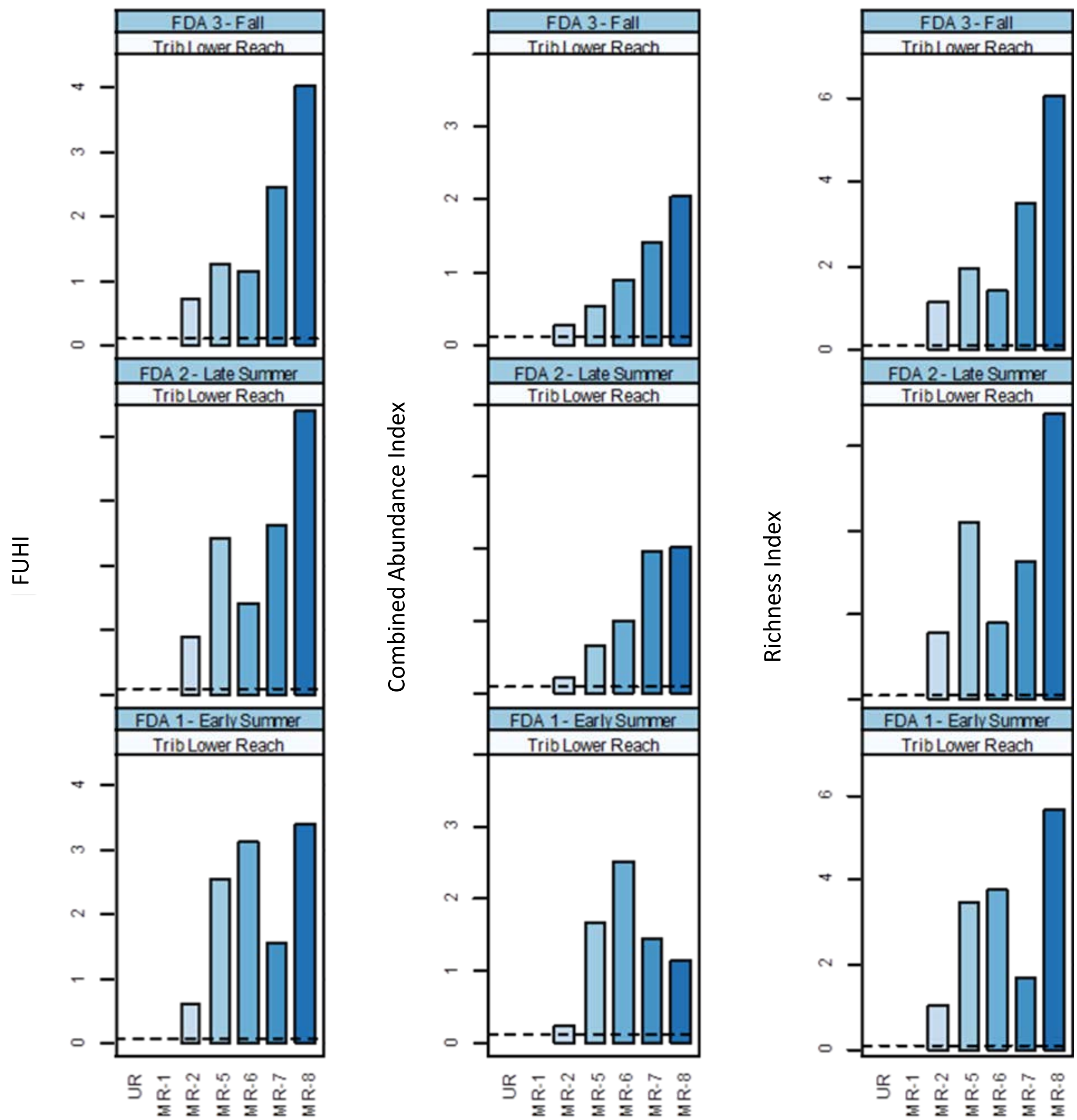


Figure 3.3-6. Fish use habitat index (FUHI), richness index (RI) and combined abundance index (CAI) for UR and MR tributary lower reach habitat by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI, RI, of CAI value is 0. No bar indicates the habitat stratum was not sampled.

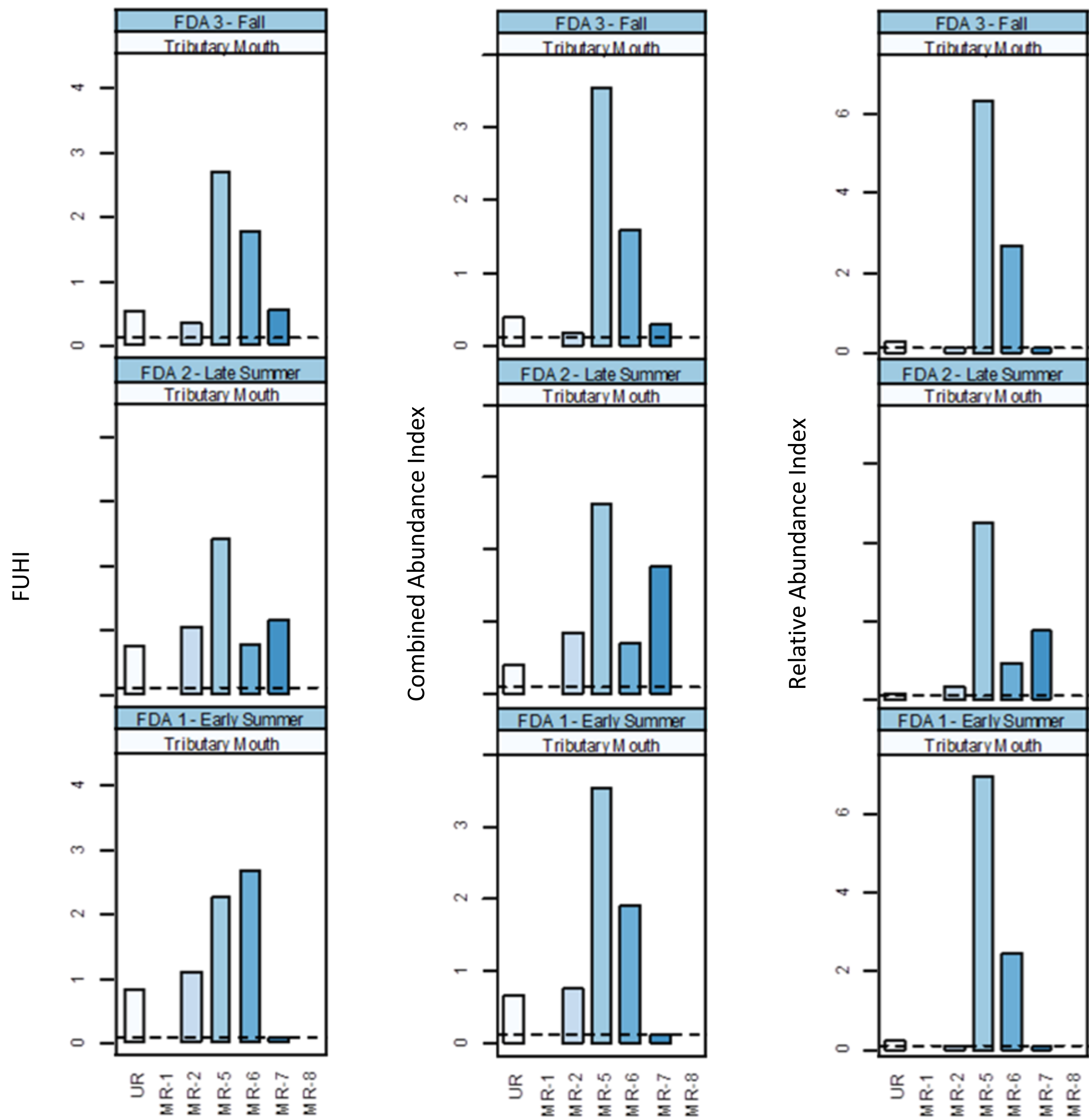


Figure 3.3-7. Fish use habitat index (FUHI), combined abundance index (CAI), and juvenile commercial fishery group relative abundance index (RAI) for UR and MR tributary mouth habitat by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI, CAI, or RAI value is 0. No bar indicates the habitat stratum was not sampled.

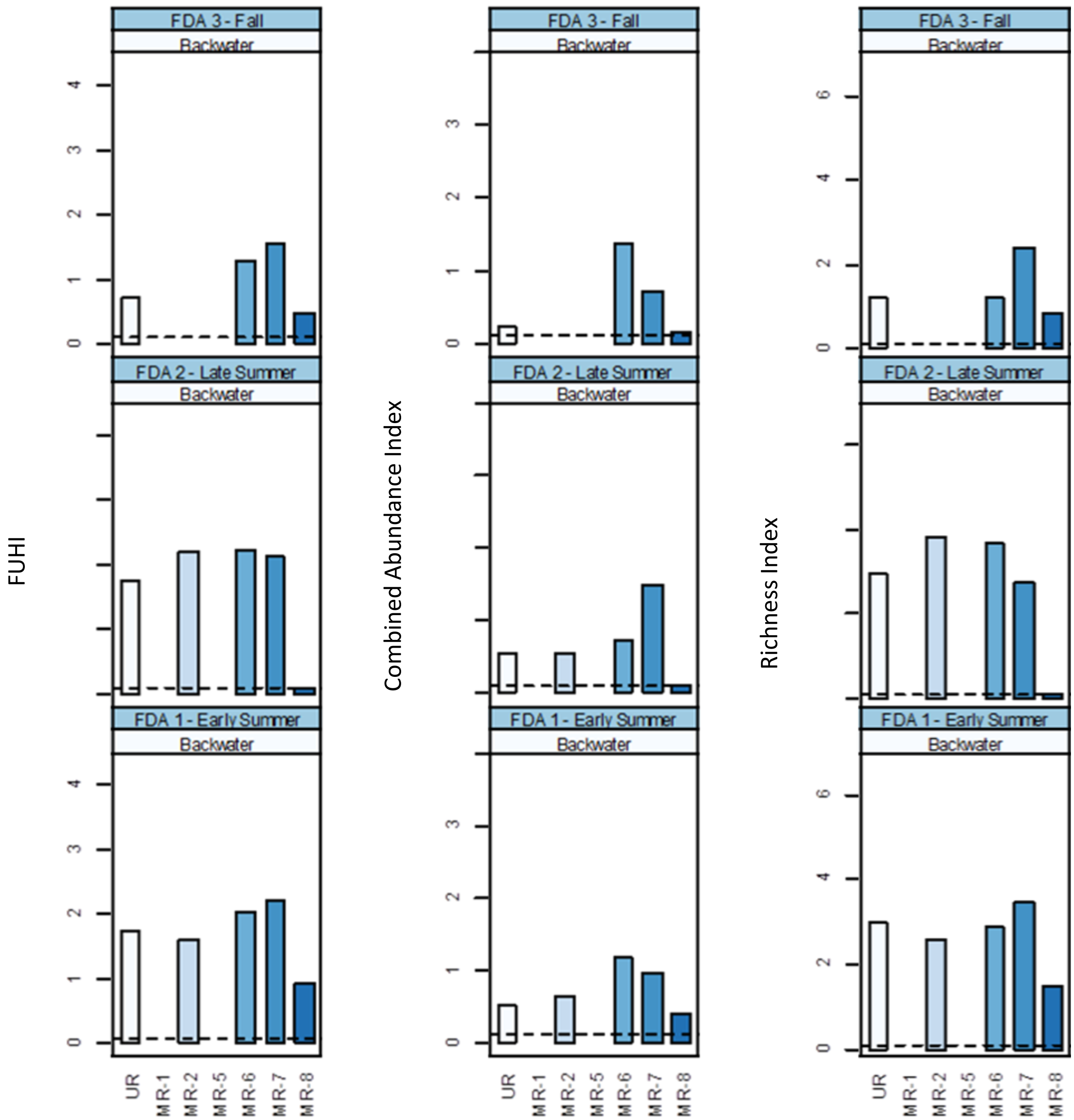


Figure 3.3-8. Fish use habitat index (FUHI), richness index (RI) and combined abundance index (CAI) for UR and MR mainstem backwater habitat by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI, RI, of CAI value is 0. No bar indicates the habitat stratum was not sampled.

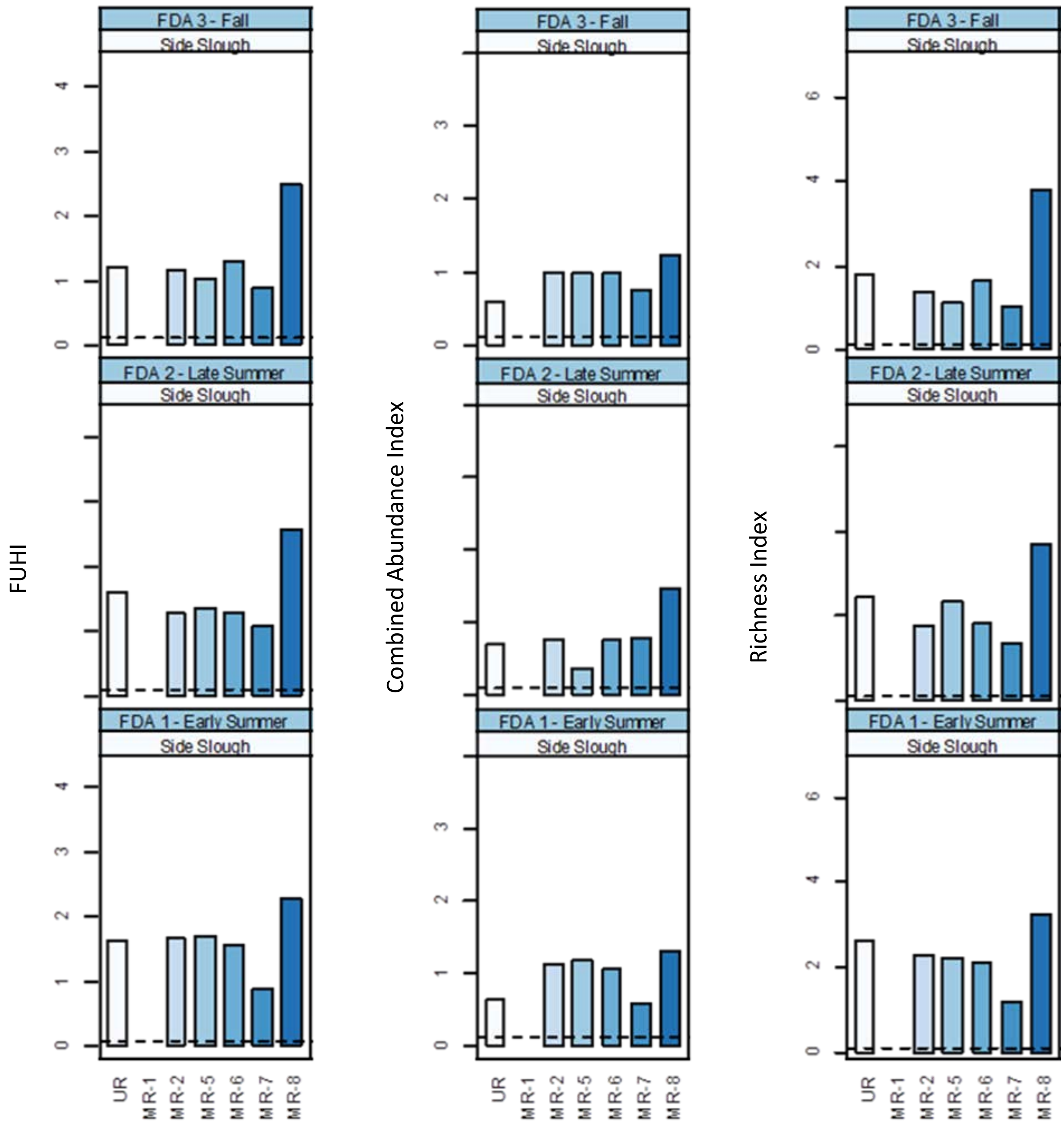


Figure 3.3-9. Fish use habitat index (FUHI), richness index (RI) and combined abundance index (CAI) for UR and MR mainstem side sloughs by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI, RI, of CAI value is 0. No bar indicates the habitat stratum was not sampled.

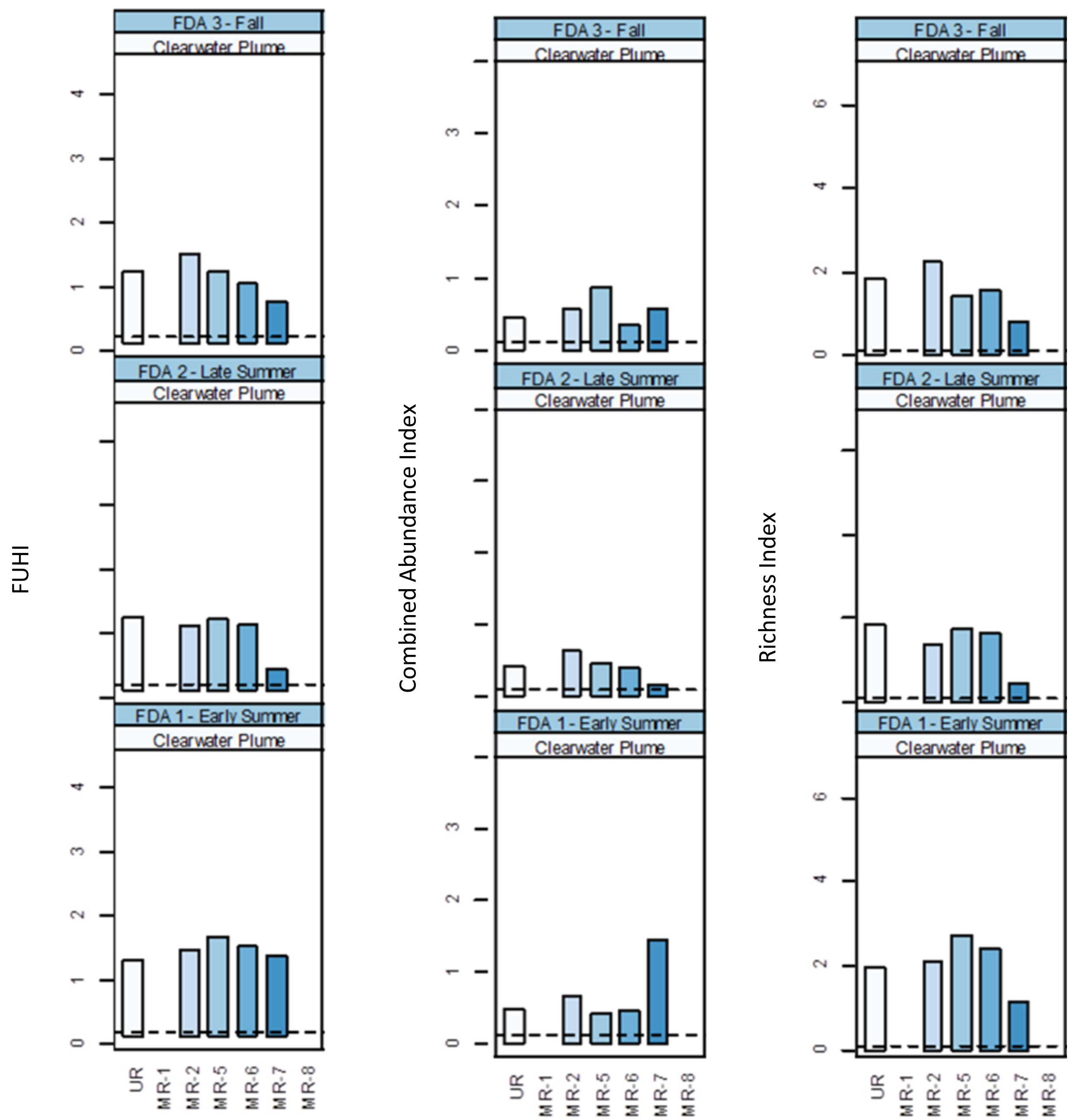


Figure 3.3-10. Fish use habitat index (FUHI), richness index (RI) and combined abundance index (CAI) for UR and MR mainstem clearwater plume habitat by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI, RI, of CAI value is 0. No bar indicates the habitat stratum was not sampled.

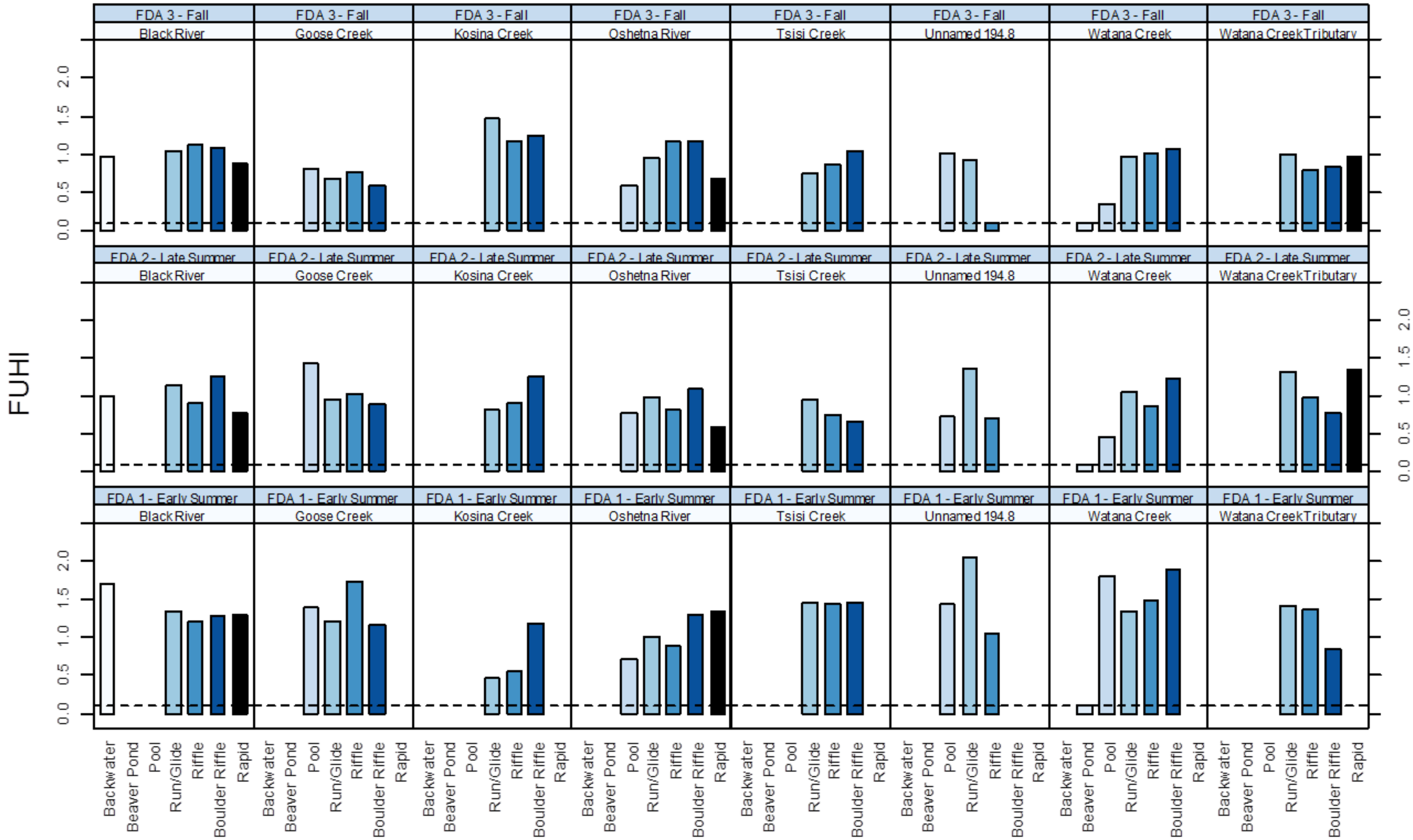


Figure 3.4-1. Fish use habitat index (FUHI) for mesohabitats sampled within UR tributary main channel habitat, plotted by tributary and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI, score is 0. No bar indicates the habitat stratum was not sampled.

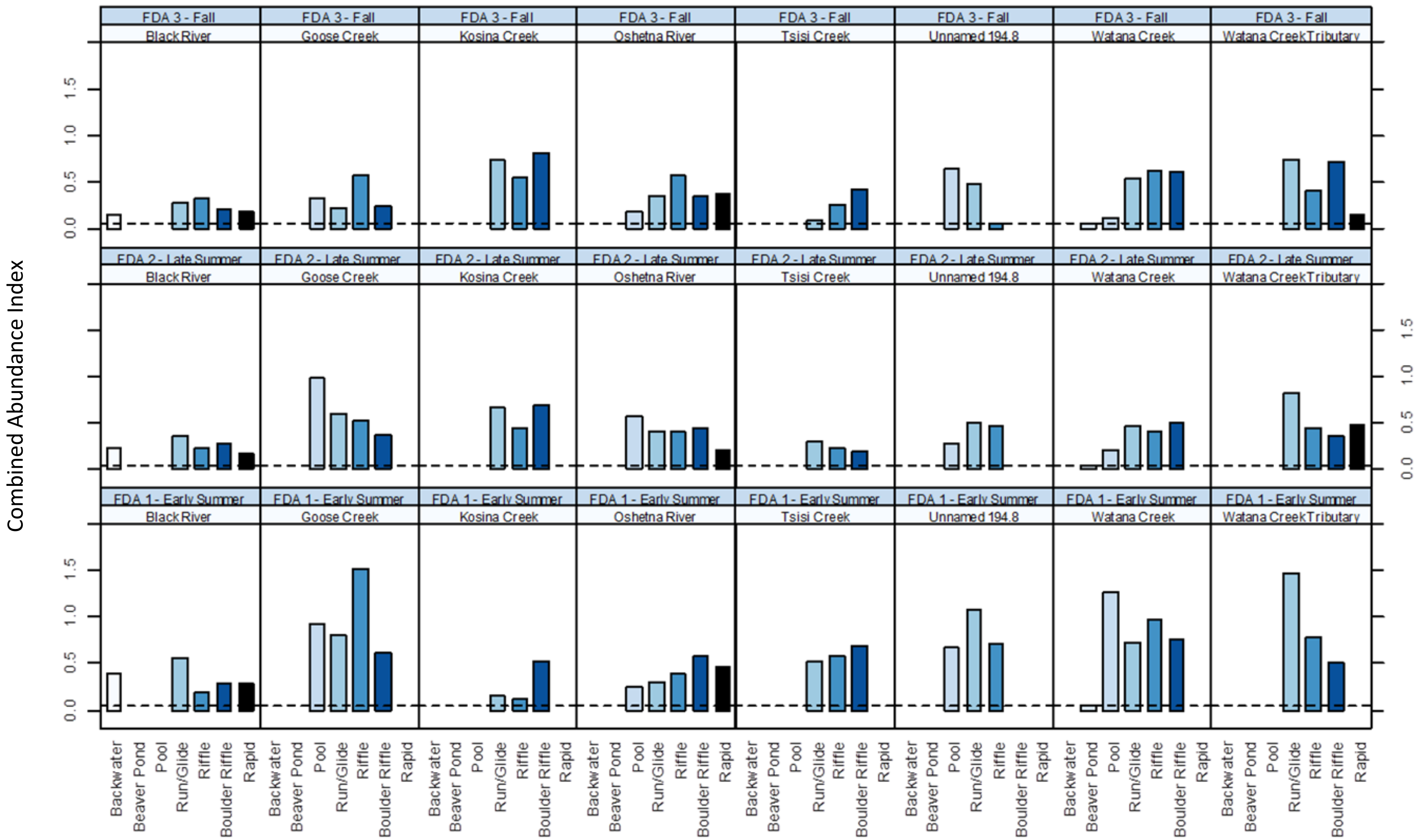


Figure 3.4-2. Combined abundance index (CAI) for mesohabitats sampled within UR tributary main channel habitat, plotted by tributary and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but CAI value is 0. No bar indicates the habitat stratum was not sampled.

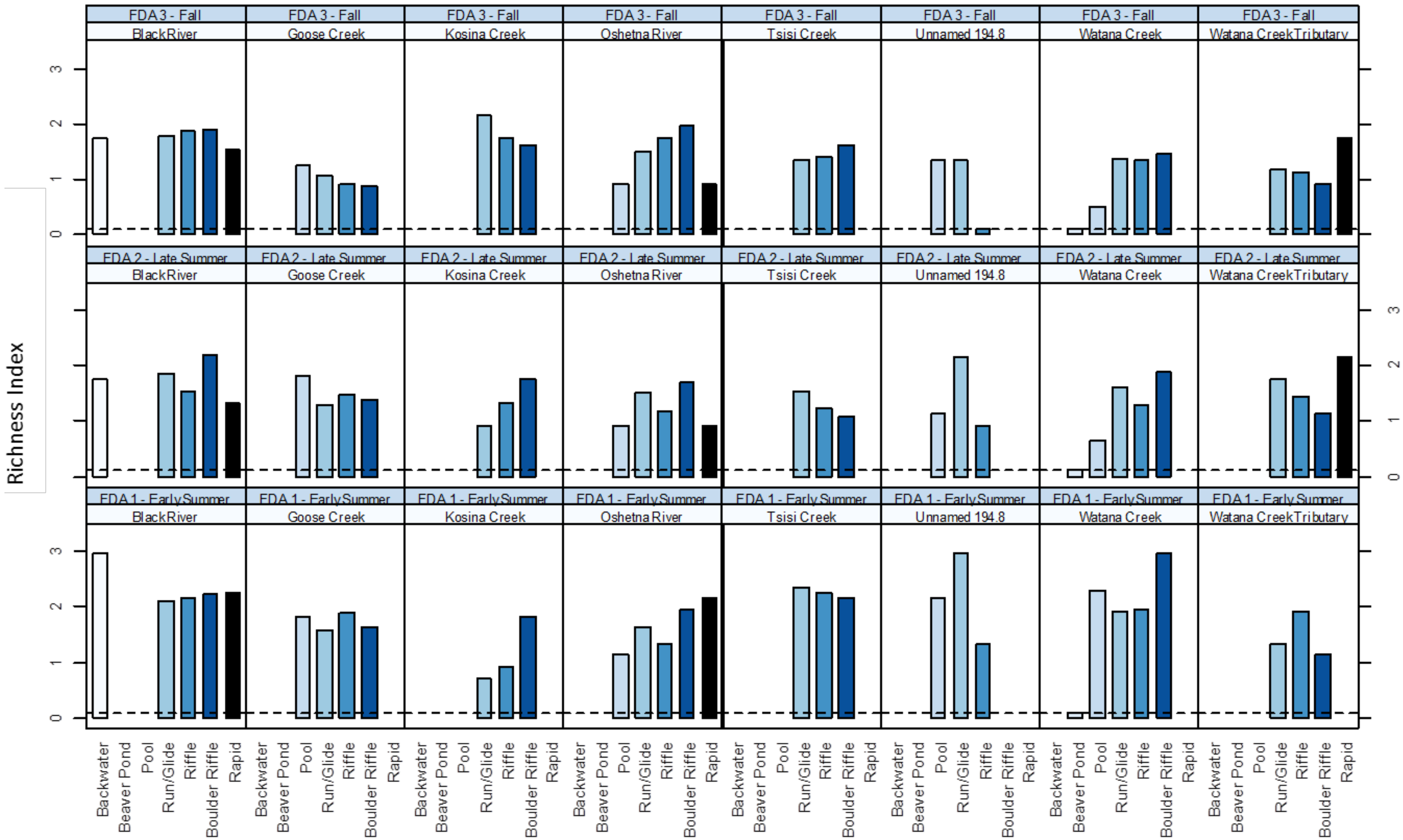


Figure 3.4-3. Richness index (RI) for mesohabitats sampled within UR tributary main channel habitat, plotted by tributary and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but RI value is 0. No bar indicates the habitat stratum was not sampled.

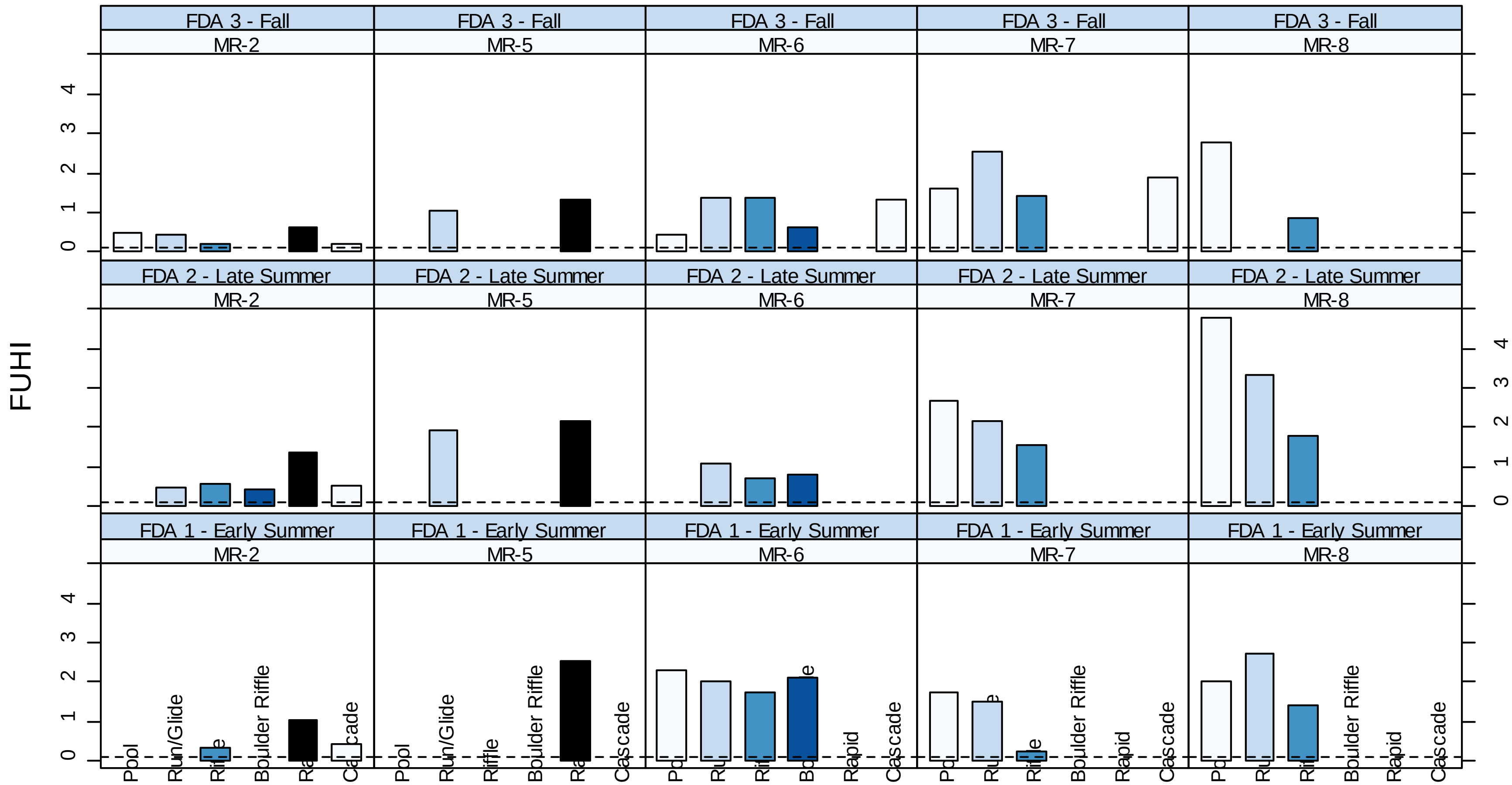


Figure 3.4-4. Fish use habitat index (FUHI) for mesohabitats sampled within MR tributary lower reaches, plotted by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI score is 0. No bar indicates the habitat stratum was not sampled.

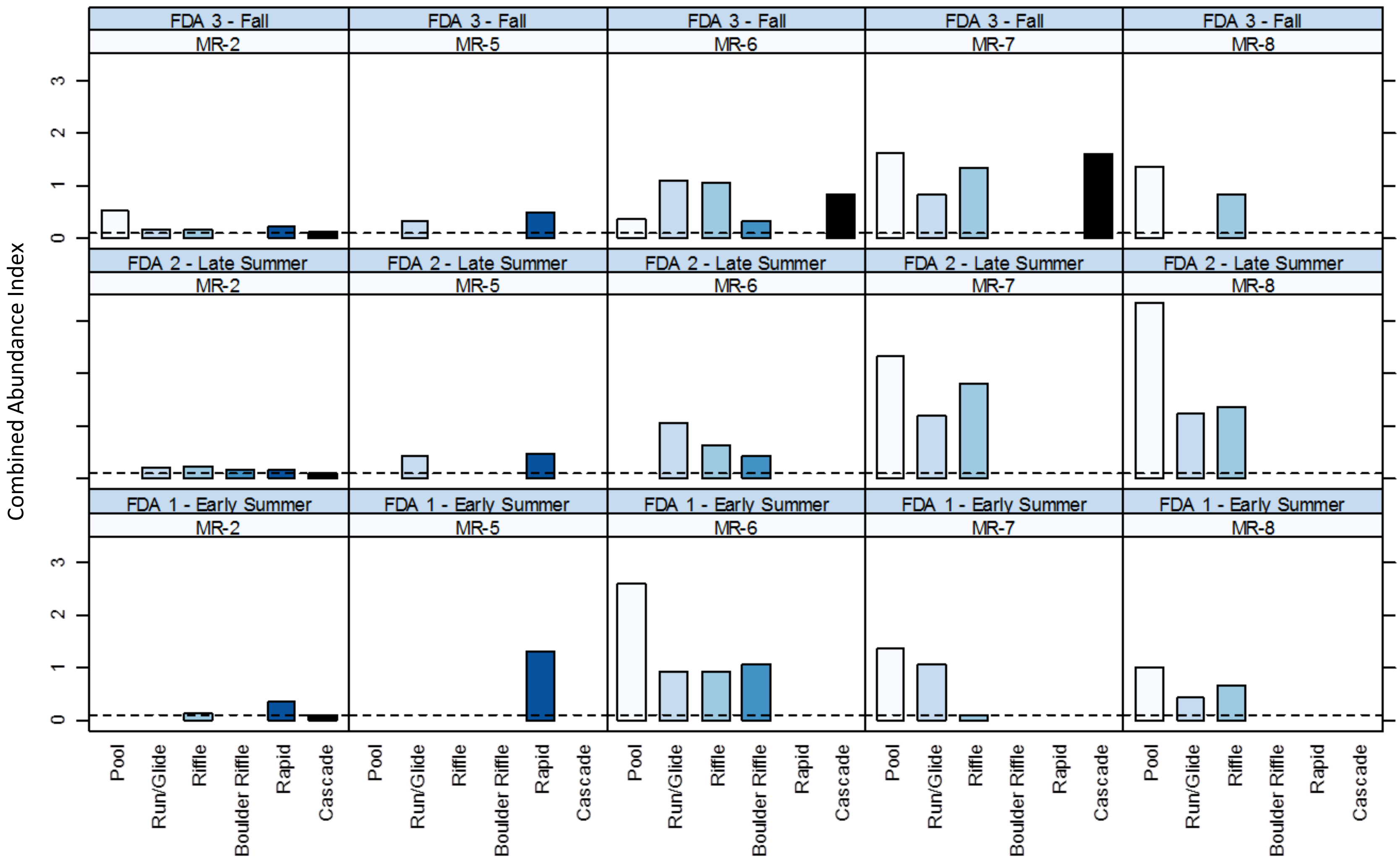


Figure 3.4-5. Combined abundance index (CAI) for mesohabitats sampled within MR tributary lower reaches, plotted by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but CAI value is 0. No bar indicates the habitat stratum was not sampled.

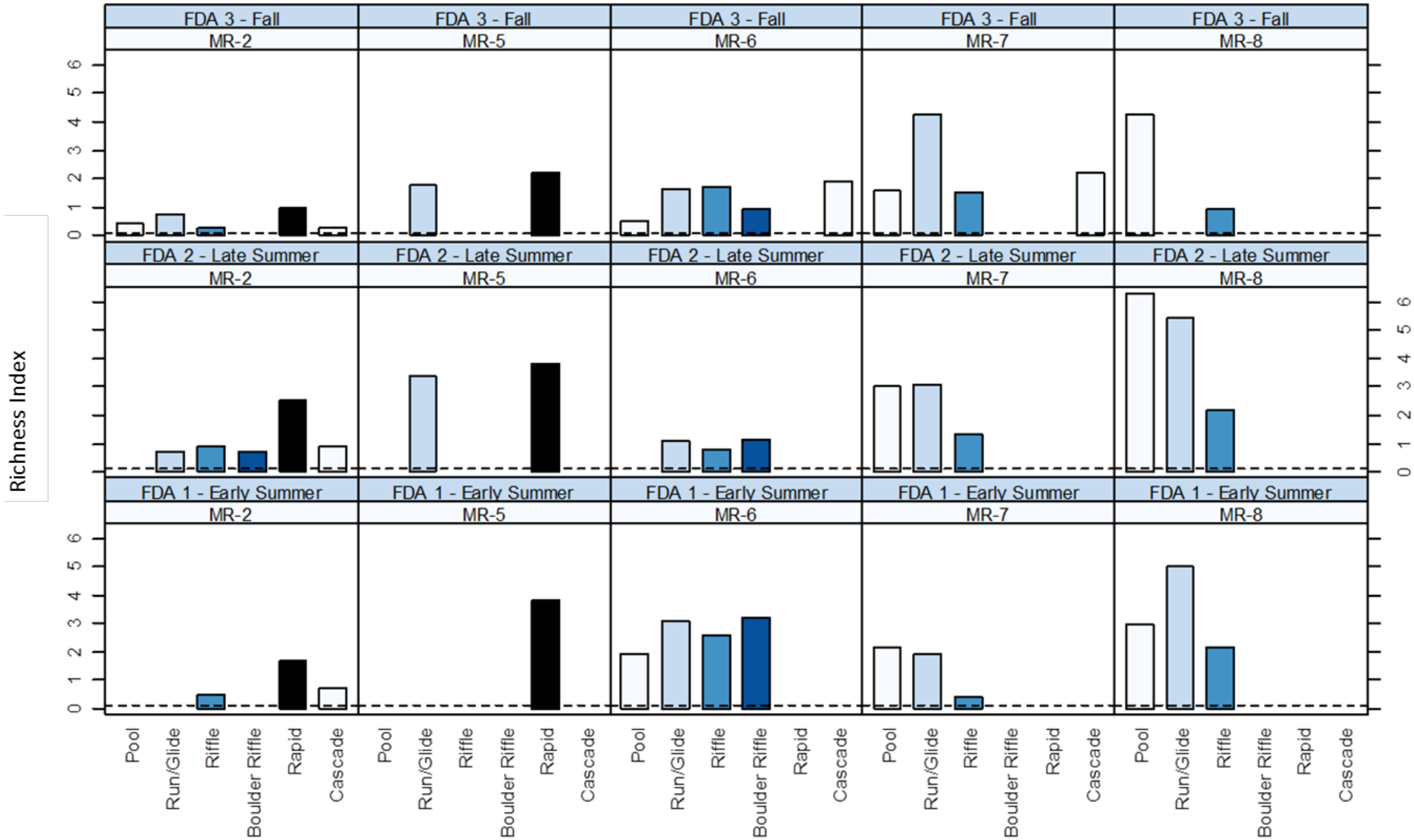


Figure 3.4-6. Richness index (RI) for mesohabitats sampled within MR tributary lower reaches, plotted by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but RI value is 0. No bar indicates the habitat stratum was not sampled.

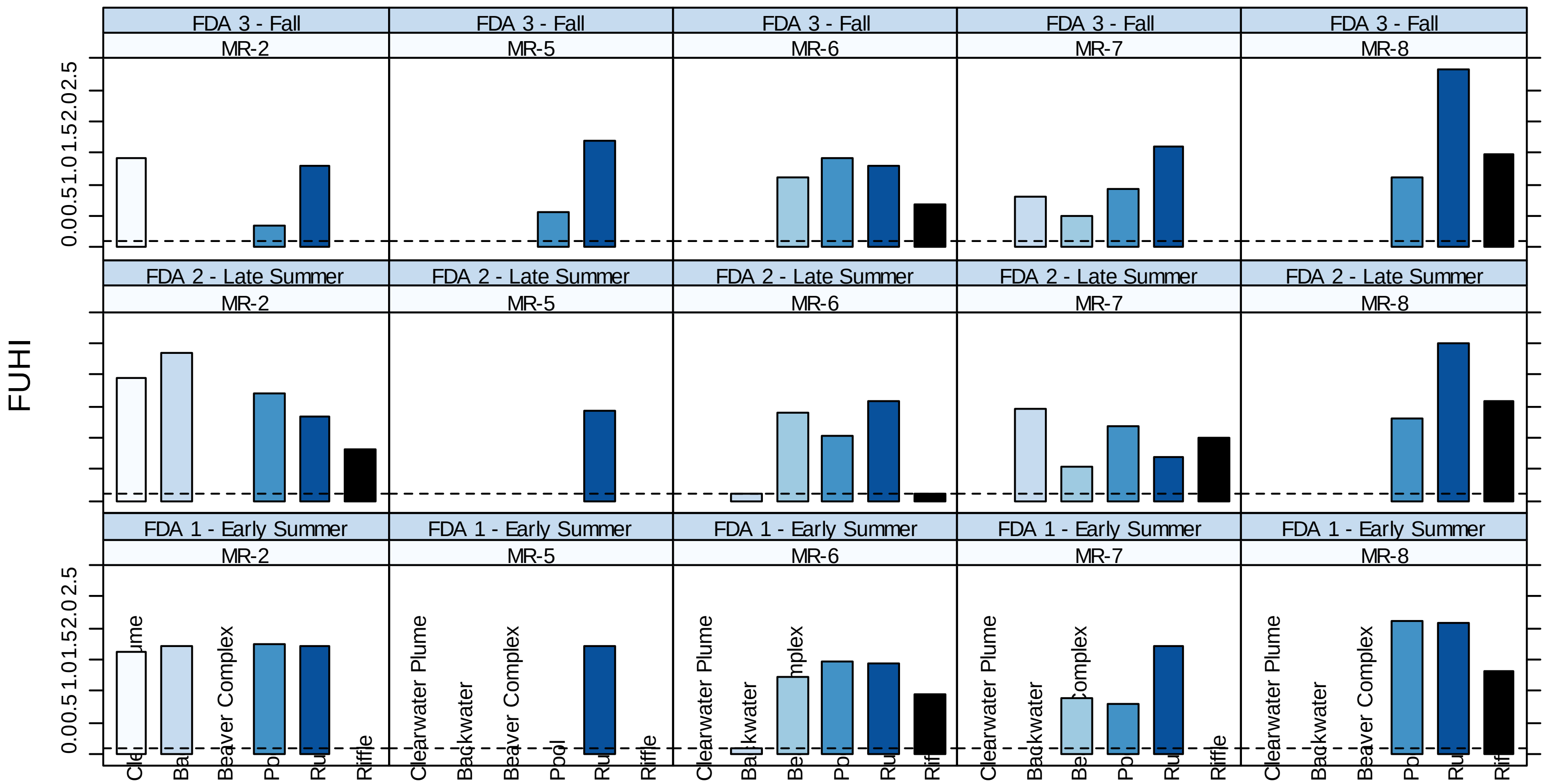


Figure 3.4-7. Fish use habitat index (FUHI) for mesohabitats sampled within MR side sloughs, plotted by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but FUHI score is 0. No bar indicates the habitat stratum was not sampled.

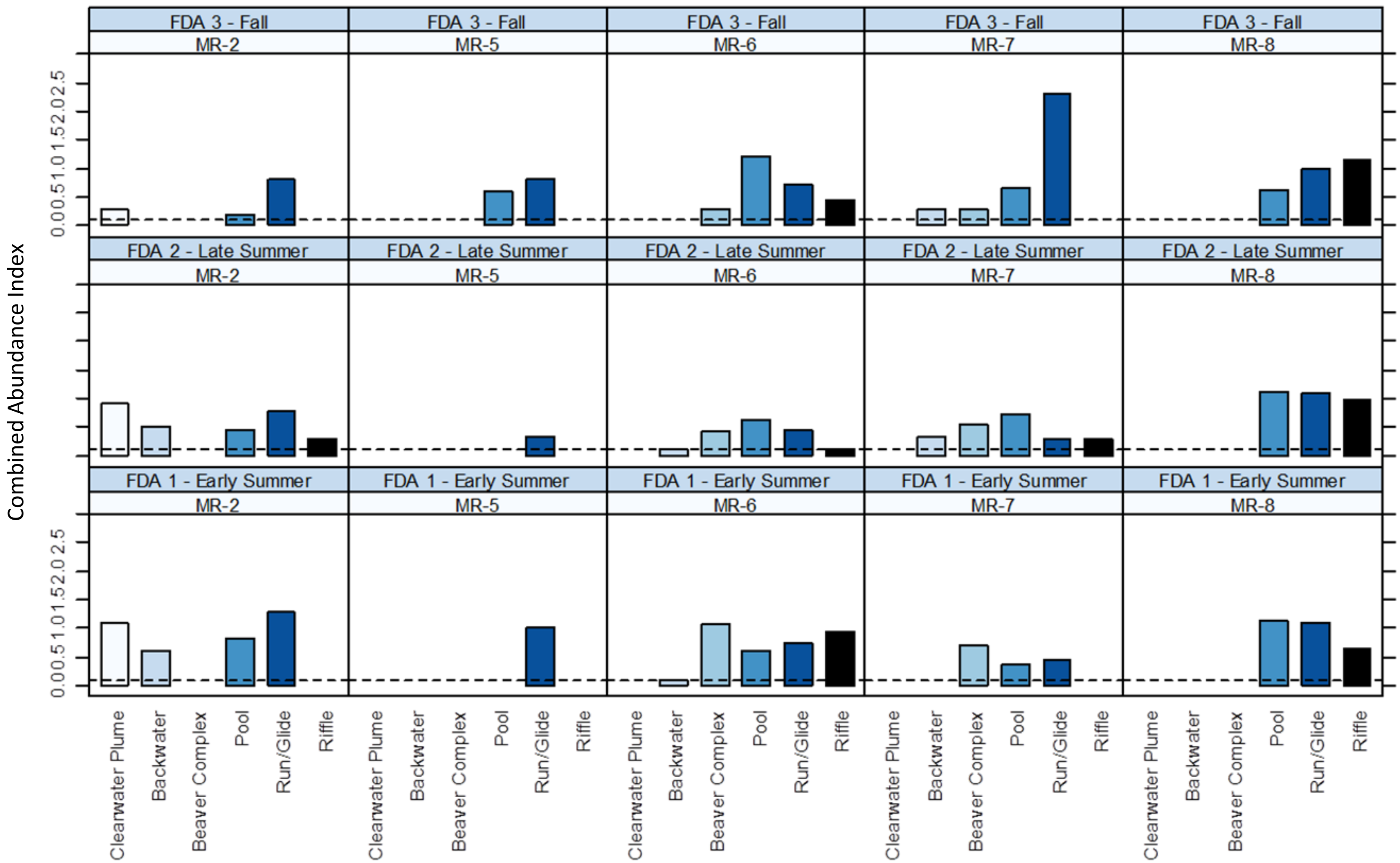


Figure 3.4-8. Combined abundance index (CAI) for mesohabitats sampled within MR side sloughs, plotted by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but CAI value is 0. No bar indicates the habitat stratum was not sampled.

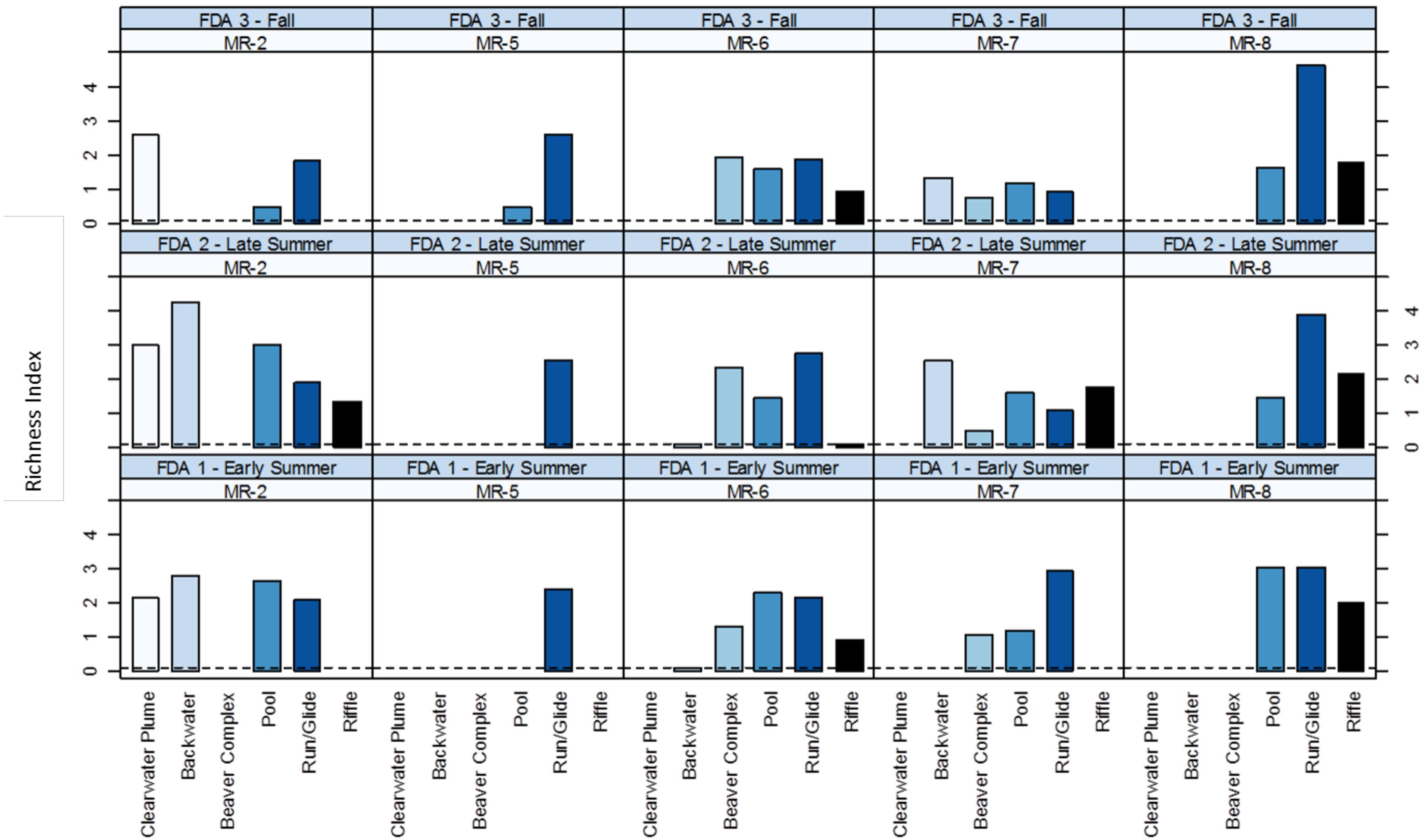


Figure 3.4-9. Richness index (RI) for mesohabitats sampled within MR side sloughs, plotted by geomorphic reach and 2013/2014 sampling season. Note: Bars below the dashed horizontal line indicate effort was applied but RI value is 0. No bar indicates the habitat stratum was not sampled.

APPENDIX A: SIMULATION STUDY TO EVALUATE RELATIVE ABUNDANCE INDICES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The relative abundance index (RAI) has been developed to identify the most highly used habitats, as well as those rarely used, both by individual species and by groups of species as part of the FUHI index in this document. The index is formed by standardizing catch per unit effort (CPUE) for each gear type, then averaging across gear types (weighting by gear use). This simulation study is intended to:

1. Verify that this estimator is able to accurately portray existing patterns in fish relative abundance;
2. Verify that it does not indicate extraneous patterns;
3. Evaluate threshold values for determining habitats that are highly used.

2. METHODS

The simulations were based on imposing a known habitat preference pattern using statistical population parameters for CPUE, and then statistically sampling from the populations and recording how often selected samples resulted in correct interpretations of the imposed pattern. The following population preference patterns were used:

1. Consistent macrohabitat preference for Tributary Mouth (TM) habitats, with Side Channel (SC) habitats uncommonly used;
2. Longitudinal pattern increasing in a downstream direction
    a. Minimum and maximum observed distributions across macrohabitats and reaches used as extremes (Figures A2-1 to A2-3 Solid lines), and
    b. Exponential trend in overall mean through the observed moderate CPUE level (Figures A2-1 to A2-3 dashed lines; mean doubles in each succeeding reach).
3. No difference among habitats or reaches (all locations have moderate CPUE)

AEA selected four macrohabitat types on which to base simulations: side channel (SC), side slough (SS), upland slough (US), and tributary mouth (TM), and three gear types: baited minnow traps (MINB; Catch/trap/m), backpack electrofishing (PEF; Catch/minute pulse time), and snorkeling (SNK; Catch/100m2). Six geomorphic reaches were assumed. No seasonal patterns were imposed, so the seasons were treated as replicate samples from the same imposed preference pattern.

Two longitudinal trends were used because the trend from the lowest to highest observed (solid lines in Figures A2-1 to A2-3) may be most realistic for this system, while the exponential trend represents a trend that may be easier to detect because of the consistent increase, but is a smaller overall change.

The sections below define the assumptions and methods for the simulation study, including how the underlying CPUE statistical populations were determined, the magnitude of differences in preference, how relative gear efficiencies were taken into account, what sample sizes were used for each habitat strata, and how the simulated RAI were evaluated.

2.1. Defining Statistical Populations for CPUE

The first step in a simulation study is developing the characteristics and parameters of the known populations from which simulations will be drawn. For this study, parameters of zero-modified lognormal distributions for CPUE were needed at low, moderate, and high fish abundance levels for multiple gear types. Because CPUE distributional parameters are likely to be somewhat specific to a river system, and also to a species or species group (based on spatial patchiness and overall abundance), AEA used CPUE levels calculated from Susitna River field observations to develop the statistical population parameters used for these simulations.

To develop a range of realistic CPUE statistical population parameters, AEA used total catch and total effort field observations within macrohabitat units for three fish groups: commercial harvest juvenile species (CHJUV), non-harvest fish (NHTOT), and other harvest juvenile species (OHJUV). For each species group and gear type, the CPUE estimates for habitat units within each habitat type/reach/season combination (maximum 6x4x3=72 groups) were treated as though they came from a common distribution (i.e., they were samples from the unknown population CPUE for that habitat type in that reach in that season), and then used to estimate three parameters for zero-modified lognormal distributions: the percent of units with CPUE zero (PZERO), the mean of non-zero CPUE (NZMEAN), and the coefficient of variation (standard deviation/mean) of non-zero CPUE (NZCV). Four example stratum/season units used for estimating CHJUV distributions for PEF CPUE are displayed in Table A2.1-1. The first combination, TM in MR-5 in Late Summer sampling, has only two habitat units sampled; but, there was very high abundance in one of the units. Fall sampling of SC in MR-6 had much lower CPUE, and the other two groups had a more mid-range CPUE. This summary was done for all groups that had sampling in TM habitat using PEF (51 out of 72 possible combinations), and PZERO and NZMEAN population parameters for a moderate abundance level were defined based on groups that were on or near the median overall mean. The selected moderate CPUE population parameters for CHJUV PEF CPUE were PZERO = 75 percent and NZMEAN = 0.7 (overall mean = 0.18; Table A2.1-2). Other mean levels (from “very low” to “very high”) were selected in a similar way to form a natural trend. The NZCV parameter could only be estimated for groups with multiple units with detected fish. If there were a linear increase in standard deviation with the mean, the CV should be roughly constant. Thus, for the simulations, AEA used the average observed CV across the habitat/reach/season groups, rather than estimating different CVs for all groups (Table A2.1-2).

This process was repeated for each species group and gear type and the resulting sets of observed distributions were used to put realistic boundaries on what “high”, “moderate”, and “low” relative abundance for the gear type and species would look like in terms of observed distributions of CPUEs. Specifically, the distribution with the median nonzero overall mean CPUE was used for the moderate CPUE level, and therefore the basis of “no trend” simulations and the MidHigh level for any added preference patterns by habitat or reach (Tables A2.1-2 – A2.1-4). The distribution with the highest overall mean CPUE was used for high relative abundance, and the distribution with the lowest (non-zero) overall mean CPUE was used for low (nonzero) relative abundance.

2.2. Framework and Sample Sizes for Simulations

Within each sampling event or season, there were 6 reaches and 4 habitat types with multiple habitat units sampled within. Six macrohabitat/reach combinations were never sampled (e.g., no upland slough habitat in MR-1), so there was a total of 18 macro/reach combinations for which CPUE distributions were estimated for each species group and gear type. For SNK sampling, there was only 17, because MR-1 Side Channels were never sampled using SNK.

The simulations reflected the imbalance in sample sizes among reaches and habitat types to closely mimic the natural setting for the analysis. The sample sizes for simulated samples by reach and habitat type were based on the observed sample sizes in the 2013-2014 FDA sampling (maximum across seasons; Table A2.2-1).

Gear selection for each simulated macrohabitat sample was a multinomial random variable based on the proportional use of gears for that macro/reach combination in the 2013-2014 sampling. For example, MR-1 Side Channels were always PEF sampled, and were also MINB sampled 44 percent of the time (Table A2.2-1). Thus, when this macrohabitat/reach is sampled via simulation, the sample will have a MINB CPUE value in approximately 44 percent of the simulations, and it will always have a PEF CPUE, and never a SNK CPUE.

2.3. Evaluation of Simulation Samples

The simulations were based on imposing a known habitat preference pattern using population parameters, and then sampling from these known populations (three seasonal samples) and recording whether or not the overall sample would result in correct interpretation of the preference pattern.

The set of simulated CPUEs (18 macrohabitat/reach combinations x 3 seasons = set of 54 simulations) for each gear type was standardized and combined following the methods for the RAI as described in Sections 2.2.3 and 2.2.4 of the main body of report. For the exponential longitudinal trend simulations, a second standardization method was also applied for comparison. For this alternative method, the skewness in the data was ignored, and a basic standardization was used, whereby the data were centered (by subtracting the mean) and scaled by dividing by the standard deviation.

In this report, RAI and overall FUHI scores are discussed in relative terms, i.e., the range or median of values for a particular habitat type across reaches is discussed, and the overall results are examined for consistent patterns. RAI values for individual species >2.7 were considered high, values <0.37 were considered low, and other values, especially those near 1 were considered moderate habitat use values. These threshold values were based on back-transformation from natural log distribution, which was used for CPUE scaling for a single gear type. Specifically, because the data were standardized, the non-zero mean of the standardized data in log-scale would be zero, and one standard deviation above the mean would be 1, and one standard deviation below the mean would be -1. Exponentiation converts these values to 1 (e^0), 2.7 (e^1), and 0.37 (e^{-1}). The back-transformed data are then averaged across gears, however, so the average would only be above 2.7 if it was consistently above 2.7 for all gears, or if it was very high for at least one gear type. Thus, the threshold values are "conservative", in that they are unlikely to result in false positive determinations of highly used habitats.

AEA applied the 0.37 and 2.7 threshold values to the 1000 simulations in each group to determine what percent of the simulated samples would result in a correct interpretation of imposed population gradients. Other thresholds were also evaluated, to aid in determining whether the approach used was reasonable, or whether other thresholds would provide more accurate interpretations. For the compared second standardization method, where no transformation is used, AEA used the (-1, 0, 1) thresholds in untransformed space in a similar way.

False positive results are simulations that had a RAI less than the low abundance threshold (e.g., 0.37) or greater than the high abundance threshold (e.g., 2.7) when the imposed population parameters were for a moderate abundance level. False negative results are simulations that had a RAI in the moderate range (e.g., within the 0.37-2.7 range) when they were drawn from a defined low or high CPUE population. Some errors are to be expected, but a false positive error rate greater than 10 percent might be of concern. Higher false negative error rates (the inverse of statistical power) are sometimes tolerated (i.e., 20 percent false negative error rate is 80 percent statistical power).

3. RESULTS

Results for simulations with consistently high CPUE for Tributary Mouth habitat and consistently low CPUE for Side Channels are displayed in Table A3-1. Side Channels are properly identified as low use habitats (combined gear index less than 0.37) 100 percent of the time for all species. However, for each species there are some habitats that have high percentages of "false positive" (i.e., >10 percent error rate) low CPUE categorizations for sloughs. In addition, tributary mouth habitat was consistently above the median-based level (index >1) for all but MR-7, which had only one sampled unit. However, the "false negative" error rate at the 2.7 threshold is relatively high. This may be due in part to the low sample sizes for TMs in most reaches (note that the error rate is zero for MR-6, which has the highest sample size). A secondary reason may be that the 2.7 threshold is too conservative. For comparison, AEA also provides results for a lower threshold level of 2 for the RAI, which increases the statistical power for detecting this high habitat use without causing false positives for high abundance.

Results for simulations with an added longitudinal trend from minimum observed in MR-1 to maximum observed in MR-8 are displayed in Table A3-2. The longitudinal trend can be seen in the spread of numbers across threshold values in the table, with higher percent results moving to the right. MR-1 and MR-2 are consistently correctly identified as low use habitat. With the 2.7 threshold, MR-8 is identified as high use habitat in the majority of cases, but a reduced threshold of 2 provides more consistent "true positives" without increasing the false positive rate.

The RAI simulated results for the exponential longitudinal trend had similar general results (Table A3-3) to the extreme longitudinal trend (Table A3-2).

When the standardization technique with no transformation is applied (Table A3-4), these results are also similar, with one notable exception. With this standardization method, the extreme low abundance estimates are not identified at the -1 threshold value.

A summary of the simulation results with no preference pattern (i.e., all habitat types in all reaches had a moderate CPUE level) are displayed in Table A3-5. The error rate for (falsely) identifying at least one low habitat in 3 seasonal samples across 18 habitat/reach combinations appears to be relatively high – from 9 to 22 percent. For false "high" determinations, the rate is 6-9 percent. This means that if there are three seasonal samples in 18 habitat types with these sample sizes, and all habitats have moderate fish use (i.e., no patterns), it is quite possible that at least one RAI will be below 0.37 and at least one will be above 2.7. However, it is very unlikely that a habitat type would be consistently <0.37 or >2.7 across all seasons if there are no true underlying pattern – the probability of this type of false positive is estimated to be 0 to 1.5 percent.

4. DISCUSSION

This limited simulation study was intended to:

1. Verify that the RAI estimator is able to accurately portray existing patterns in fish relative abundance,
2. Verify that the RAI estimator does not indicate extraneous patterns, and
3. Evaluate RAI threshold values for determining habitats that are highly used.

The RAI generally performed well in detection of the most extreme high and low use habitats. Low and moderate population levels of habitat use never had RAI results >2.7 and very rarely had RAI results > 2.0 (overwhelmingly zero, but 2%, 5%, 6%, and 26% in 4 species/habitat groups within single simulated preference patterns; Tables A3-1 to A3-3). High population levels were correctly identified at the 2.7 level in most cases (median of 27 species/habitat simulations sample size >1 unit is 73%), but power to detect the high population levels was much better using a threshold of 2.0 (median of 27 species/habitat simulations with sample size > 1 unit is 100 percent).

Moderate population levels of habitat use had single season results <0.37 (i.e., false positive errors in low habitat use direction) in some habitats in relatively high proportion of the simulations (Tables A 3-1 to A3-3, orange highlighted cells). An important conclusion is that zero or low abundance results should only be relied upon when there is a clear consistent pattern among multiple seasons or grouped habitats. This is reasonable due to well documented challenges of detecting very low numbers of fish sampling.

The habitat with only one macrohabitat unit was very inconsistent, revealing that results for very small sample sizes should not be relied upon. Rather, habitat strata with low numbers of sampled units should be combined with similar habitats either within or across geomorphic reaches to make more general conclusions.

The no-pattern simulations further enforce the concept that the results are more reliable if interpreted in context of consistency. For example, consistent high results across three seasons, or for a habitat type in most or all reaches are much more reliable. This is partially due to the fact that the index is created to always have a spread from high to low values, without necessarily having an independent measure of what high or low abundance would be (i.e., it is relative to other habitats).

An alternative standardization scheme that would be a bit simpler to apply performed similarly except that it had a high false negative rate for the lowest abundance sites (Table A3-4). That is, low abundance habitats were rarely detected.

Overall, AEA finds the index performs as expected, and viewed in a context of consistent results, should be a good predictor of the most-used fish habitats. In terms of a threshold for indication of high-use habitats, the simulation results indicate that a threshold of 2.7 may be too conservative and result in missing high-use habitats. The findings suggest that a threshold of 2 would reduce the occurrence of false negatives for high-use habitats without increasing false positive error rates.

A second year of data collection will yield more confidence in these results in several ways. The standardization process will be made over a larger sample of habitat/season/year strata, which will provide a greater range of results from which to estimate population parameters like mean and standard deviation. The standardization process will naturally account for differences in overall abundance among years because of the standardization process. Consistency in results such as slow/fast habitats and longitudinal patterns among years will give more credence to patterns observed in one year of data.

5. TABLES

Table A2.1-1. Example of four habitat strata CPUE estimates for CHJUV using PEF sampling.

Season:	FDA 2 – Late Summer	FDA 3 – Fall	FDA 3 – Fall	FDA 3 – Fall
Reach:	MR-5	MR-6	MR-6	MR-6
Macrohabitat Type:	TM	SS	US	SC
CPUE for Macrohabitat Units:	0	0	0	0
	6.1	0	0	0
		0.39	0	0
		1.2	0	0
		1.8	0.083	0.081
			0.15	0.26
			0.42	
			0.53	
			1.6	
MEAN	3.0	0.69	0.30	0.057
PZERO	50%	40%	44%	67%
NZMEAN	6.1	1.1	0.55	0.17
NZCV	NA	0.63	1.1	0.75

Table A2.1-2. Statistical parameters used for zero-modified lognormal distributions of average macrohabitat CPUE for MINB sampling for three species groups.

Species Group	NonZero CV	CPUE Level	Natural Trend			Exponential Trend		
			Overall Mean	Proportion Zero	NonZero Mean	Overall Mean	Proportion Zero	NonZero Mean
CHJUV	1	VeryLow	0	1	NA	0	1	NA
CHJUV	1	Low	0.009	0.70	0.03	0.030	0.50	0.060
CHJUV	1	MidLow	0.045	0.70	0.15	0.060	0.45	0.11
CHJUV	1	MidHigh	0.12	0.40	0.2	0.12	0.40	0.20
CHJUV	1	High	0.24	0.20	0.3	0.24	0.35	0.37
CHJUV	1	VeryHigh	1	0	1	0.48	0.30	0.69
NHTOT	1	VeryLow	0	1	NA	0	1	NA
NHTOT	1	Low	0.0004	0.90	0.0040	0.0088	0.60	0.022
NHTOT	1	MidLow	0.01	0.50	0.020	0.018	0.55	0.039
NHTOT	1	MidHigh	0.035	0.50	0.070	0.035	0.50	0.070
NHTOT	1	High	0.134	0.33	0.20	0.070	0.45	0.13
NHTOT	1	VeryHigh	1.8	0.10	2.0	0.14	0.40	0.23
OHJUV	0.9	VeryLow	0	1	NA	0	1	NA
OHJUV	0.9	Low	0.0003	0.85	0.0020	0.0020	0.70	0.0067
OHJUV	0.9	MidLow	0.003	0.70	0.010	0.0040	0.65	0.011
OHJUV	0.9	MidHigh	0.008	0.60	0.020	0.0080	0.60	0.020
OHJUV	0.9	High	0.04	0.60	0.10	0.016	0.55	0.036
OHJUV	0.9	VeryHigh	0.48	0.60	1.2	0.032	0.50	0.064

Table A2.1-3. Statistical parameters used for zero-modified lognormal distributions of average macrohabitat CPUE for PEF sampling for three species groups.

Species Group	NonZero CV	CPUE Level	Natural Trend			Exponential Trend		
			Overall Mean	Proportion Zero	NonZero Mean	Overall Mean	Proportion Zero	NonZero Mean
CHJUV	0.7	VeryLow	0	1	NA	0	1	NA
CHJUV	0.7	Low	0.0075	0.75	0.030	0.044	0.85	0.29
CHJUV	0.7	MidLow	0.10	0.75	0.40	0.088	0.80	0.44
CHJUV	0.7	MidHigh	0.18	0.75	0.70	0.18	0.75	0.70
CHJUV	0.7	High	1.2	0.60	3.0	0.35	0.70	1.2
CHJUV	0.7	VeryHigh	2.5	0.50	5.0	0.70	0.65	2.0
NHTOT	0.7	VeryLow	0	1	NA	0	1	NA
NHTOT	0.7	Low	0.006	0.85	0.04	0.16	0.30	0.23
NHTOT	0.7	MidLow	0.35	0.50	0.70	0.32	0.25	0.43
NHTOT	0.7	MidHigh	0.64	0.20	0.80	0.64	0.20	0.80
NHTOT	0.7	High	1.2	0.20	1.5	1.3	0.15	1.5
NHTOT	0.7	VeryHigh	3.6	0.10	4.0	2.6	0.10	2.8
OHJUV	0.6	VeryLow	0	1	NA	0	1	NA
OHJUV	0.6	Low	0.0045	0.85	0.03	0.020	0.70	0.067
OHJUV	0.6	MidLow	0.035	0.65	0.10	0.040	0.65	0.11
OHJUV	0.6	MidHigh	0.080	0.60	0.20	0.080	0.60	0.20
OHJUV	0.6	High	0.15	0.25	0.20	0.16	0.55	0.36
OHJUV	0.6	VeryHigh	0.85	0.15	1.0	0.32	0.50	0.64

Table A2.1-4. Statistical parameters used for zero-modified lognormal distributions of average macrohabitat CPUE for SNK sampling for three species groups.

Species Group	NonZero CV	CPUE Level	Natural Trend			Exponential Trend		
			Overall Mean	Proportion Zero	NonZero Mean	Overall Mean	Proportion Zero	NonZero Mean
CHJUV	1	VeryLow	0	1	NA	0	1	NA
CHJUV	1	Low	0.014	0.65	0.040	0.56	0.65	1.6
CHJUV	1	MidLow	0.52	0.60	1.3	1.1	0.60	2.8
CHJUV	1	MidHigh	2.3	0.55	5.0	2.3	0.55	5.0
CHJUV	1	High	4.4	0.45	8.0	4.5	0.50	9.0
CHJUV	1	VeryHigh	24	0.45	44	9.0	0.45	16
NHTOT	1	VeryLow	0	1	NA	0	1	NA
NHTOT	1	Low	0.0060	0.70	0.020	0.060	0.70	0.20
NHTOT	1	MidLow	0.080	0.60	0.20	0.12	0.65	0.34
NHTOT	1	MidHigh	0.24	0.60	0.60	0.24	0.60	0.60
NHTOT	1	High	0.80	0.50	1.6	0.48	0.55	1.1
NHTOT	1	VeryHigh	4.0	0.50	8.0	0.96	0.50	1.9
OHJUV	1.2	VeryLow	0	1	NA	0	1	NA
OHJUV	1.2	Low	0.0045	0.85	0.030	0.30	0.80	1.5
OHJUV	1.2	MidLow	0.015	0.70	0.050	0.60	0.75	2.4
OHJUV	1.2	MidHigh	1.2	0.70	4.0	1.2	0.70	4.0
OHJUV	1.2	High	3.2	0.20	4.0	2.4	0.65	6.9
OHJUV	1.2	VeryHigh	8.0	0	8.0	4.8	0.60	12

Table A2.2-1. Sample size and gear use proportions for each macrohabitat type within each reach.

Reach	MacroHabitat Type	Single Event Sample Size	Proportion of Samples Using Gear Types						
			All	MINB Only	PEF Only	SNK Only	MINB + PEF	MINB + SNK	PEF + SNK
MR-1	Side Channel	3	0	0	0.56	0	0.44	0	0
MR-2	Side Channel	3	0.11	0	0.22	0.11	0.56	0	0
MR-2	Side Slough	7	0.48	0	0.19	0	0.33	0	0
MR-2	Tributary Mouth	3	0.38	0	0.08	0	0.46	0	0.08
MR-2	Upland Slough	7	0.71	0	0.07	0	0.07	0	0.14
MR-5	Side Slough	4	0	0.09	0.55	0	0.36	0	0
MR-5	Tributary Mouth	2	0.17	0	0.33	0	0.17	0	0.33
MR-6	Side Channel	6	0	0.11	0.17	0	0.61	0	0.11
MR-6	Side Slough	9	0.23	0.04	0.08	0	0.12	0.42	0.12
MR-6	Tributary Mouth	5	0.23	0.08	0	0	0.23	0.31	0.15
MR-6	Upland Slough	12	0.17	0.2	0	0	0.37	0.26	0
MR-7	Side Channel	4	0	0	0.5	0	0.50	0	0
MR-7	Side Slough	8	0	0.30	0.09	0	0.61	0	0
MR-7	Tributary Mouth	1	0	0.25	0	0	0.50	0.25	0
MR-7	Upland Slough	13	0.14	0.11	0.08	0.03	0.33	0.33	0
MR-8	Side Channel	5	0	0.07	0.47	0	0.47	0	0
MR-8	Side Slough	7	0.15	0	0.15	0	0.25	0.3	0.15
MR-8	Upland Slough	6	0	0.06	0.06	0.06	0.39	0.44	0

Table A3-1. Percent of 1,000 simulated combined gear average CPUE in three seasons (total 3,000) that fell into the displayed threshold categories for simulations with no fish use in Side Channels, and high fish use in Tributary Mouths. Cells highlighted in orange indicate higher than expected "false positive" low CPUE indications, and cells highlighted in green indicate lower than expected high CPUE indications (i.e., high false negative rates).

Reach	MacroHabitat Type	Sample Size in Each of Three Events	CHJUV					NHTOT					OHJUV				
			<0.37	<1	>1	>2	>2.7	<0.37	<1	>1	>2	>2.7	<0.37	<1	>1	>2	>2.7
MR-1	Side Channel	3	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-2	Side Channel	3	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-6	Side Channel	6	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-7	Side Channel	4	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-8	Side Channel	5	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-2	Side Slough	7	0	100	0	0	0	0	100	0	0	0	33	100	0	0	0
MR-5	Side Slough	4	0	95	5	0	0	21	100	0	0	0	0	67	33	0	0
MR-6	Side Slough	9	5	100	0	0	0	0	100	0	0	0	2	100	0	0	0
MR-7	Side Slough	8	24	67	33	0	0	33	100	0	0	0	33	100	0	0	0
MR-8	Side Slough	7	0	98	2	0	0	16	100	0	0	0	42	94	6	0	0
MR-2	Upland Slough	7	0	100	0	0	0	0	100	0	0	0	0	100	0	0	0
MR-6	Upland Slough	12	24	87	13	0	0	0	73	27	0	0	0	100	0	0	0
MR-7	Upland Slough	13	2	100	0	0	0	0	100	0	0	0	26	100	0	0	0
MR-8	Upland Slough	6	7	82	18	0	0	0	100	0	0	0	0	93	7	0	0
MR-2	Trib Mouth	3	0	0	100	97	72	0	0	100	100	100	0	0	100	100	73
MR-5	Trib Mouth	2	4	4	96	67	48	0	0	100	93	69	0	0	100	75	44
MR-6	Trib Mouth	5	0	0	100	100	100	0	0	100	100	100	0	0	100	100	100
MR-7	Trib Mouth	1	0	58	42	33	16	0	0	100	100	58	74	74	26	0	0

Table A3-2. Percent of 1,000 simulated combined gear average CPUE in three seasons (3,000 total simulations) that fell into the displayed threshold categories for simulations with increasing gradient from no fish in MR-1 to highest levels in MR-8. Cells highlighted in orange indicate higher than expected "false positive" low CPUE indications, and cells highlighted in green indicate lower than expected high CPUE indications.

Reach	MacroHabitat Type	Sample Size in Each of Three Events	CHJUV					NHTOT					OHJUV				
			<0.37	<1	>1	>2	>2.7	<0.37	<1	>1	>2	>2.7	<0.37	<1	>1	>2	>2.7
MR-1	Side Channel	3	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-2	Side Channel	3	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-2	Side Slough	7	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-2	Trib Mouth	3	89	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-2	Upland Slough	7	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-5	Side Slough	4	36	100	0	0	0	10	100	0	0	0	68	100	0	0	0
MR-5	Trib Mouth	2	70	100	0	0	0	33	73	27	0	0	44	100	0	0	0
MR-6	Side Channel	6	0	67	33	0	0	0	65	35	0	0	2	94	6	0	0
MR-6	Side Slough	9	0	47	53	0	0	0	84	16	0	0	0	69	31	0	0
MR-6	Trib Mouth	5	0	44	56	0	0	0	100	0	0	0	0	100	0	0	0
MR-6	Upland Slough	12	0	33	67	0	0	0	100	0	0	0	0	100	0	0	0
MR-7	Side Channel	4	0	0	100	25	2	0	0	100	0	0	0	75	25	0	0
MR-7	Side Slough	8	0	0	100	3	0	0	0	100	0	0	0	0	100	33	0
MR-7	Trib Mouth	1	25	49	51	8	0	25	33	67	8	0	0	17	83	8	8
MR-7	Upland Slough	13	0	0	100	44	0	0	0	100	0	0	0	0	100	0	0
MR-8	Side Channel	5	0	0	100	100	100	0	0	100	100	94	0	0	100	99	48
MR-8	Side Slough	7	0	0	100	100	99	0	0	100	100	100	0	0	100	100	75
MR-8	Upland Slough	6	0	0	100	100	64	0	0	100	99	77	0	0	100	67	66

Table A3-3. Percent of 1,000 simulated combined gear average CPUE in three seasons (3,000 total simulations) that fell into the displayed threshold categories for simulations with exponential increasing gradient from no fish in MR-1 to MR-8. Cells highlighted in orange indicate higher than expected false low CPUE indications, and cells highlighted in green indicate lower than expected high CPUE indications.

Reach	MacroHabitat Type	Sample Size in Each of Three Events	CHJUV					NHTOT					OHJUV				
			<0.37	<1	>1	>2	>2.7	<0.37	<1	>1	>2	>2.7	<0.37	<1	>1	>2	>2.7
MR-1	Side Channel	3	100	100	0	0	0	100	100	0	0	0	100	100	0	0	0
MR-2	Side Channel	3	38	100	0	0	0	76	100	0	0	0	68	100	0	0	0
MR-2	Side Slough	7	67	100	0	0	0	67	100	0	0	0	75	100	0	0	0
MR-2	Trib Mouth	3	46	100	0	0	0	97	100	0	0	0	66	100	0	0	0
MR-2	Upland Slough	7	67	100	0	0	0	75	100	0	0	0	68	100	0	0	0
MR-5	Side Slough	4	100	100	0	0	0	61	100	0	0	0	33	65	35	5	0
MR-5	Trib Mouth	2	66	99	1	0	0	85	100	0	0	0	39	100	0	0	0
MR-6	Side Channel	6	0	100	0	0	0	0	35	65	26	0	17	40	60	0	0
MR-6	Side Slough	9	3	66	34	6	0	0	100	0	0	0	0	98	2	0	0
MR-6	Trib Mouth	5	0	42	58	2	0	2	100	0	0	0	37	100	0	0	0
MR-6	Upland Slough	12	0	100	0	0	0	0	3	97	0	0	0	100	0	0	0
MR-7	Side Channel	4	2	13	87	33	33	0	2	98	31	31	0	0	100	100	90
MR-7	Side Slough	8	8	61	39	0	0	0	0	100	29	0	0	32	68	0	0
MR-7	Trib Mouth	1	16	40	60	25	0	33	83	17	0	0	100	100	0	0	0
MR-7	Upland Slough	13	0	2	98	33	0	0	0	100	68	0	0	0	100	67	10
MR-8	Side Channel	5	0	0	100	94	49	0	0	100	100	99	0	0	100	100	59
MR-8	Side Slough	7	0	3	97	67	64	0	0	100	100	95	0	0	100	85	33
MR-8	Upland Slough	6	0	0	100	100	99	0	1	99	70	63	0	0	100	95	46

Table A3-4. Percent of 1,000 simulated average CPUE with alternative standardization in three seasons that fell into the displayed threshold categories for simulations with exponential increasing gradient from no fish in MR-1 to MR-8. Cells highlighted in orange indicate higher than expected false low CPUE indications, and cells highlighted in green indicate lower than expected high CPUE indications.

Reach	MacroHabitat Type	Sample Size in Each of Three Events	CHJUV				NHTOT				OHJUV			
			< -1	<0	>0	>1	< -1	<0	>0	>1	< -1	<0	>0	>1
MR-1	Side Channel	3	0	100	0	0	18	100	0	0	0	100	0	0
MR-2	Side Channel	3	0	100	0	0	0	100	0	0	0	100	0	0
MR-2	Side Slough	7	0	100	0	0	0	100	0	0	0	100	0	0
MR-2	Trib Mouth	3	0	100	0	0	0	100	0	0	0	100	0	0
MR-2	Upland Slough	7	0	100	0	0	0	100	0	0	0	100	0	0
MR-5	Side Slough	4	0	100	0	0	0	100	0	0	0	67	33	0
MR-5	Trib Mouth	2	0	100	0	0	0	100	0	0	0	100	0	0
MR-6	Side Channel	6	0	100	0	0	0	67	33	0	0	78	22	0
MR-6	Side Slough	9	0	68	32	0	0	100	0	0	0	100	0	0
MR-6	Trib Mouth	5	0	69	31	0	0	100	0	0	0	100	0	0
MR-6	Upland Slough	12	0	100	0	0	0	98	2	0	0	100	0	0
MR-7	Side Channel	4	0	11	89	33	0	67	33	11	0	0	100	90
MR-7	Side Slough	8	0	67	33	0	0	33	67	0	0	67	33	0
MR-7	Trib Mouth	1	0	31	69	17	0	67	33	0	0	100	0	0
MR-7	Upland Slough	13	0	66	34	0	0	0	100	0	0	0	100	18
MR-8	Side Channel	5	0	0	100	67	0	0	100	73	0	0	100	66
MR-8	Side Slough	7	0	9	91	62	0	0	100	79	0	0	100	33
MR-8	Upland Slough	6	0	0	100	100	0	5	95	40	0	0	100	56

Table A3-5. Percentages of false positive (low and high) habitats identified in simulations

	CHJUV	NHTOT	OHJUV
Average % of seasonal habitat estimates <0.37	18%	9%	22%
Average % of habitat estimates <0.37 in all 3 seasons	0.017%	0%	1.5%
Average % of seasonal habitat estimates >2.7	9%	6%	8%
Average % of habitat estimates >2.7 in all 3 seasons	1.4%[a]	0%	0%

6. FIGURES

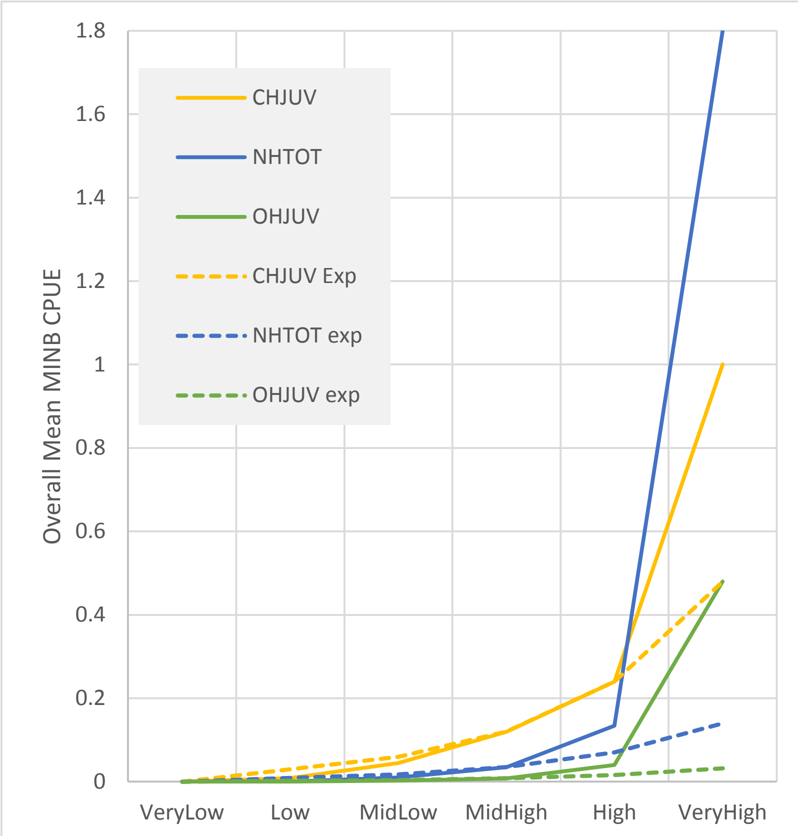


Figure A2-1. Imposed trends for MINB simulations for three species groups. Solid lines are based on quartiles of observed mean CPUE levels. Dashed lines are exponential trends through the "MidHigh" level.

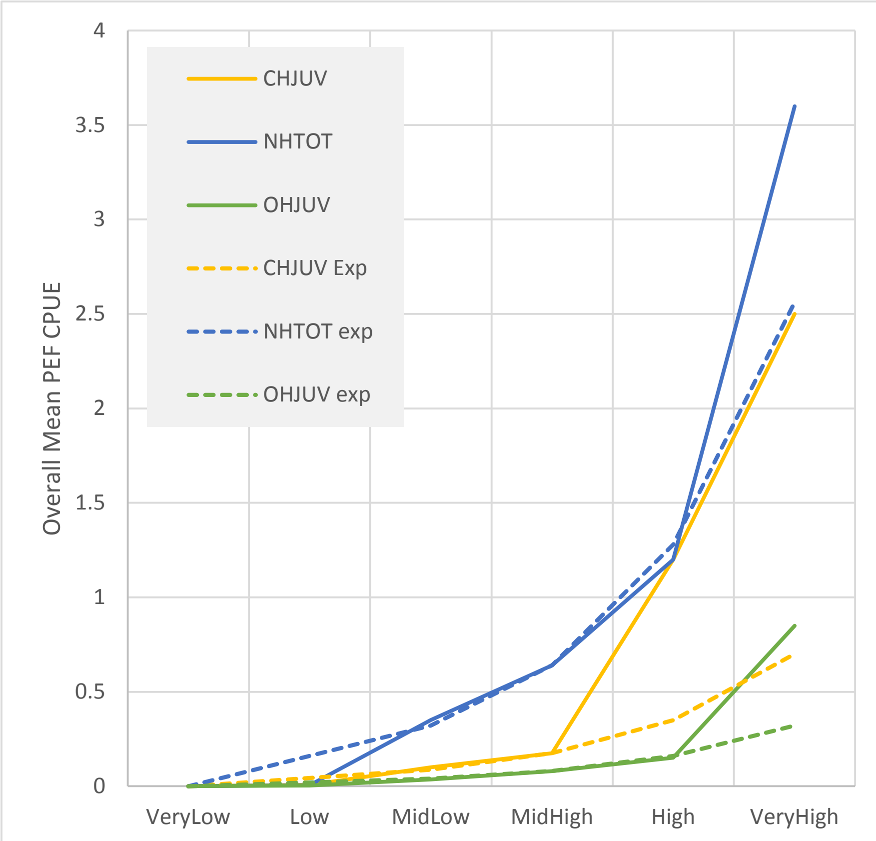


Figure A2-2. Imposed trends for PEF simulations for three species groups. Solid lines are based on quartiles of observed mean CPUE levels. Dashed lines are exponential trends through the "MidHigh" level.

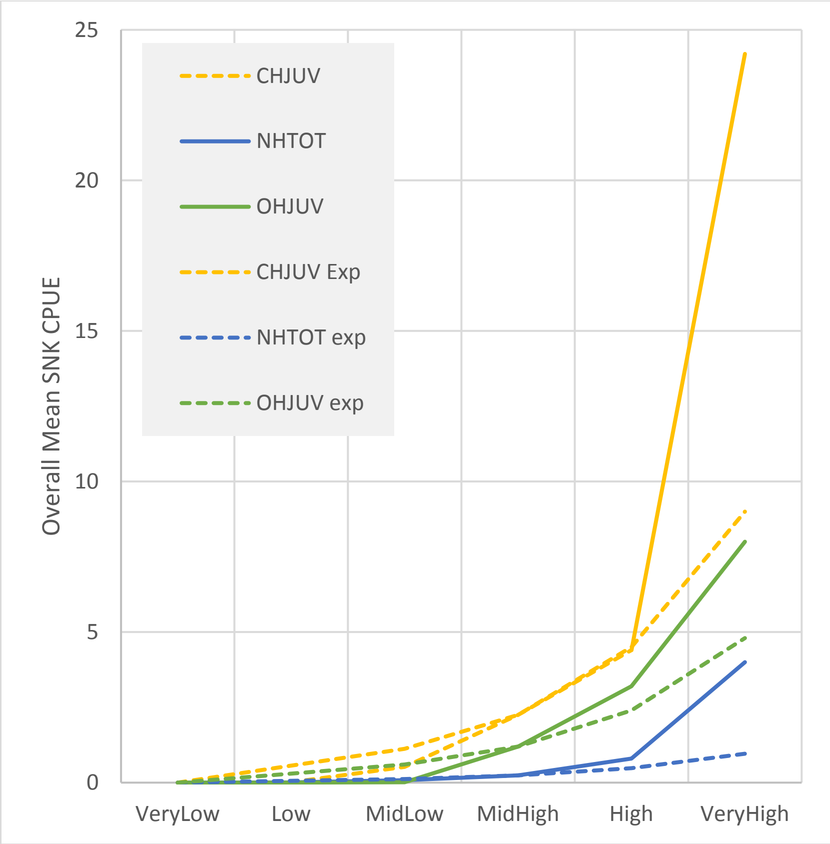


Figure A2-3. Imposed trends for SNK simulations for three species groups. Solid lines are based on quartiles of observed mean CPUE levels. Dashed lines are exponential trends through the "MidHigh" level.

APPENDIX B: GEAR EVENT TABLES

LIST OF TABLES

Table B1. Macrohabitat and special mesohabitat sampling units and gear events used in Fish Use Habitat Index (FUHI), 2013-2014 (Page 1 of 10).

Reach	Stream Name	Macrohabitat & Special Mesohabitat Type	Season	Number of Macro Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
LR	Susitna	Additional Open Water	FDA 1	3							3	1	1	5
LR	Susitna	Additional Open Water	FDA 2	3							3	1	1	5
LR	Susitna	Additional Open Water	FDA 3	3						1	3			4
LR	Susitna	Backwater	FDA 1	1		1					1			2
LR	Susitna	Clearwater Plume	FDA 1	4	3	2		1				3	1	10
LR	Susitna	Clearwater Plume	FDA 2	4	1	1		1		3	1	2	1	10
LR	Susitna	Clearwater Plume	FDA 3	4	2	1				3	2	3	1	12
LR	Susitna	Combined Main Channel	FDA 1	23	3	12	8	6		2	6	17		54
LR	Susitna	Combined Main Channel	FDA 2	22		13	11	8		13	5	13		63
LR	Susitna	Combined Main Channel	FDA 3	23		15	10	5		13	5	15		63
LR	Susitna	Side Slough	FDA 1	2		2					1	1	2	6
LR	Susitna	Side Slough	FDA 2	2		1					1	2	2	6
LR	Susitna	Side Slough	FDA 3	2						1	2	1		4
LR	Susitna	Trib Lower Reach	FDA 1	5	1	2			1		3	1	3	11
LR	Susitna	Trib Lower Reach	FDA 2	5	4	1	1		1	1	4		3	15
LR	Susitna	Trib Lower Reach	FDA 3	5	2		1	1		3	3	1	1	12
LR	Susitna	Upland Slough	FDA 1	4		3					4		1	8
LR	Susitna	Upland Slough	FDA 2	5	1	2			1	3	5	1		13
LR	Susitna	Upland Slough	FDA 3	5	1	3			2		3	2	1	12
MR-1	Susitna	Main Channel	FDA 1	6		6	5			2	2	1		16
MR-1	Susitna	Main Channel	FDA 2	6		6	6	2			2			16
MR-1	Susitna	Main Channel	FDA 3	6		6	4			3	2			15
MR-1	Susitna	Side Channel	FDA 1	3		3					2	2		7
MR-1	Susitna	Side Channel	FDA 2	3		3		1				1		5
MR-1	Susitna	Side Channel	FDA 3	3		3	1			2	2	1		9
MR-2	Susitna	Backwater	FDA 1	2	1	1			1		2		1	6
MR-2	Susitna	Backwater	FDA 2	1					1		1	1		3
MR-2	Susitna	Clearwater Plume	FDA 1	5	2	4	2		1		3	1	3	16
MR-2	Susitna	Clearwater Plume	FDA 2	5	2	4	2				3	1	3	15
MR-2	Susitna	Clearwater Plume	FDA 3	5	2	4	3		1		3		1	14
MR-2	Susitna	Main Channel	FDA 1	6		5	5	1		3	2			16

Reach	Stream Name	Macrohabitat & Special Mesohabitat Type	Season	Number of Macro Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-2	Susitna	Main Channel	FDA 2	6		5	6	4		2	2			19
MR-2	Susitna	Main Channel	FDA 3	6		2	6	3		3	2			16
MR-2	Susitna	Side Channel	FDA 1	3		3	1				2		1	7
MR-2	Susitna	Side Channel	FDA 2	3		3					3			6
MR-2	Susitna	Side Channel	FDA 3	3		2	1				1		1	5
MR-2	Susitna	Side Slough	FDA 1	7		6					6	1	4	17
MR-2	Susitna	Side Slough	FDA 2	8		8					6		3	17
MR-2	Susitna	Side Slough	FDA 3	8		8					6		3	17
MR-2	Susitna	Trib Lower Reach	FDA 1	4		4			2		4		2	12
MR-2	Susitna	Trib Lower Reach	FDA 2	4		4			2		3		4	13
MR-2	Susitna	Trib Lower Reach	FDA 3	4		4					4		4	12
MR-2	Susitna	Tributary Mouth	FDA 1	4		3					4		2	9
MR-2	Susitna	Tributary Mouth	FDA 2	5		5					5		3	13
MR-2	Susitna	Tributary Mouth	FDA 3	4		4					2		1	7
MR-2	Susitna	Upland Slough	FDA 1	7		7			3	1	5	1	6	23
MR-2	Susitna	Upland Slough	FDA 2	6		6			1		6		6	19
MR-2	Susitna	Upland Slough	FDA 3	1		1								1
MR-5	Susitna	Clearwater Plume	FDA 1	1	1				1				1	3
MR-5	Susitna	Clearwater Plume	FDA 2	2	1	1					1	1	2	6
MR-5	Susitna	Clearwater Plume	FDA 3	2	1	2			1					4
MR-5	Susitna	Main Channel	FDA 1	5		5	3	2		2		1		13
MR-5	Susitna	Main Channel	FDA 2	5	1	4	5	2		2	3			17
MR-5	Susitna	Main Channel	FDA 3	5		4	5	2		1	3			15
MR-5	Susitna	Side Slough	FDA 1	3		3								3
MR-5	Susitna	Side Slough	FDA 2	3		3					2			5
MR-5	Susitna	Side Slough	FDA 3	3		2					2			4
MR-5	Susitna	Trib Lower Reach	FDA 1	1		1					1			2
MR-5	Susitna	Trib Lower Reach	FDA 2	1	1						1		1	3
MR-5	Susitna	Trib Lower Reach	FDA 3	1	1	1							1	3
MR-5	Susitna	Tributary Mouth	FDA 1	2		2						1	1	4
MR-5	Susitna	Tributary Mouth	FDA 2	2	1	2					1	1	2	7
MR-5	Susitna	Tributary Mouth	FDA 3	2	1	2					1			4
MR-6	Susitna	Backwater	FDA 1	4		2	1				2	2	1	8

Reach	Stream Name	Macrohabitat & Special Mesohabitat Type	Season	Number of Macro Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-6	Susitna	Backwater	FDA 2	4		2			2		4	2		10
MR-6	Susitna	Backwater	FDA 3	1			1				1			2
MR-6	Susitna	Clearwater Plume	FDA 1	3	3	2						1	1	7
MR-6	Susitna	Clearwater Plume	FDA 2	5	3	2					3	2	3	13
MR-6	Susitna	Clearwater Plume	FDA 3	4	3	3					3		1	10
MR-6	Susitna	Main Channel	FDA 1	7		3	4			3	1	4		15
MR-6	Susitna	Main Channel	FDA 2	7		4	7	1		3	4	5		24
MR-6	Susitna	Main Channel	FDA 3	7		4	7			3	4	6		24
MR-6	Susitna	Side Channel	FDA 1	6		6			3		3	3	1	16
MR-6	Susitna	Side Channel	FDA 2	6		4			3		6	4		17
MR-6	Susitna	Side Channel	FDA 3	6		6			1		4	2	1	14
MR-6	Susitna	Side Slough	FDA 1	9		6			2		5	3	7	23
MR-6	Susitna	Side Slough	FDA 2	9		3			2		8	4	6	23
MR-6	Susitna	Side Slough	FDA 3	9		5				1	8	2	7	23
MR-6	Susitna	Trib Lower Reach	FDA 1	3	2	2					3	1	3	11
MR-6	Susitna	Trib Lower Reach	FDA 2	4	2	3			1		4		4	14
MR-6	Susitna	Trib Lower Reach	FDA 3	5	2	4			1		4		1	12
MR-6	Susitna	Tributary Mouth	FDA 1	2	1	2					1	1	2	7
MR-6	Susitna	Tributary Mouth	FDA 2	5	3	1			1		5	2	4	16
MR-6	Susitna	Tributary Mouth	FDA 3	7	4	5			1		6	1	3	20
MR-6	Susitna	Upland Slough	FDA 1	11	1	6			3		10	3	6	29
MR-6	Susitna	Upland Slough	FDA 2	12	2	4			1		12	6	8	33
MR-6	Susitna	Upland Slough	FDA 3	13	1	9			3		13	1	1	28
MR-7	Susitna	Backwater	FDA 1	2	1		1		1		1	1		5
MR-7	Susitna	Backwater	FDA 2	4	1	2			1		3	2		9
MR-7	Susitna	Backwater	FDA 3	4	1	1			2		3	1		8
MR-7	Susitna	Clearwater Plume	FDA 1	2	1						1		1	3
MR-7	Susitna	Clearwater Plume	FDA 2	3	1	2					1	1	2	7
MR-7	Susitna	Clearwater Plume	FDA 3	3	1	1					2	1	2	7
MR-7	Susitna	Main Channel	FDA 1	6		5	3	3	1	3	1	3		19
MR-7	Susitna	Main Channel	FDA 2	5		4	5	3		3	2	4		21
MR-7	Susitna	Main Channel	FDA 3	6		5	6			3	3	1		18
MR-7	Susitna	Side Channel	FDA 1	4		4					1	1		6

Reach	Stream Name	Macrohabitat & Special Mesohabitat Type	Season	Number of Macro Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-7	Susitna	Side Channel	FDA 2	4		4					3	1		8
MR-7	Susitna	Side Channel	FDA 3	4		4					2	1		7
MR-7	Susitna	Side Slough	FDA 1	8		6					7	2		15
MR-7	Susitna	Side Slough	FDA 2	8	2	5					8			15
MR-7	Susitna	Side Slough	FDA 3	8	2	5					6			13
MR-7	Susitna	Trib Lower Reach	FDA 1	5	1	3					4	1	1	10
MR-7	Susitna	Trib Lower Reach	FDA 2	5	1	5			1		5		3	15
MR-7	Susitna	Trib Lower Reach	FDA 3	6	2	6			1		5	1	1	16
MR-7	Susitna	Tributary Mouth	FDA 1	1							1			1
MR-7	Susitna	Tributary Mouth	FDA 2	2	1						2		1	4
MR-7	Susitna	Tributary Mouth	FDA 3	1	1						1			2
MR-7	Susitna	Upland Slough	FDA 1	13	2	6			3		12	4	7	34
MR-7	Susitna	Upland Slough	FDA 2	12	2	6			2	1	10	3	7	31
MR-7	Susitna	Upland Slough	FDA 3	12	2	7			2		11	3	4	29
MR-8	Susitna	Backwater	FDA 1	2	1					1			1	3
MR-8	Susitna	Backwater	FDA 2	1	1						1			2
MR-8	Susitna	Backwater	FDA 3	1	1						1			2
MR-8	Susitna	Main Channel	FDA 1	6		5	5	3		3	1	2		19
MR-8	Susitna	Main Channel	FDA 2	6		4	6	3		3	1	1		18
MR-8	Susitna	Main Channel	FDA 3	6		5	5			3	2	4		19
MR-8	Susitna	Side Channel	FDA 1	5		5	2	1		1		2		11
MR-8	Susitna	Side Channel	FDA 2	5		4	2			1	4	2		13
MR-8	Susitna	Side Channel	FDA 3	5		5	3				4	2		14
MR-8	Susitna	Side Slough	FDA 1	7		6					1	3	4	14
MR-8	Susitna	Side Slough	FDA 2	7		5			2		6	2	4	19
MR-8	Susitna	Side Slough	FDA 3	7		4			3		7	3	4	21
MR-8	Susitna	Trib Lower Reach	FDA 1	1		1				1			1	3
MR-8	Susitna	Trib Lower Reach	FDA 2	1						1	1		1	3
MR-8	Susitna	Trib Lower Reach	FDA 3	1					1		1		1	3
MR-8	Susitna	Upland Slough	FDA 1	6		3	1		1		4	3	3	15
MR-8	Susitna	Upland Slough	FDA 2	6		3	1		1		6	3	3	17
MR-8	Susitna	Upland Slough	FDA 3	6		2	1		1		6	3	3	16
UR	Susitna	Backwater	FDA 1	4	1	3			4	1	1	2	1	13

Reach	Stream Name	Macrohabitat & Special Mesohabitat Type	Season	Number of Macro Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR	Susitna	Backwater	FDA 2	3		3	1		3		3	1		11
UR	Susitna	Backwater	FDA 3	1		1			1		1			3
UR	Susitna	Clearwater Plume	FDA 1	10	3	9			3		6	1	6	28
UR	Susitna	Clearwater Plume	FDA 2	9	3	7	1		3		6	1	4	25
UR	Susitna	Clearwater Plume	FDA 3	8	2	7	1		1		6		2	19
UR	Susitna	Main Channel	FDA 1	19		18	18	1	2		13	5		57
UR	Susitna	Main Channel	FDA 2	19		18	17		2		13	2		52
UR	Susitna	Main Channel	FDA 3	19		19	18		3		14	2		56
UR	Susitna	Side Channel	FDA 1	7		7	2	2	2	3	3	4		23
UR	Susitna	Side Channel	FDA 2	8		8	2		1		4	3		18
UR	Susitna	Side Channel	FDA 3	7		7	2		2		7	2		20
UR	Susitna	Side Slough	FDA 1	5		5	1				4	2	2	14
UR	Susitna	Side Slough	FDA 2	6		6	1		1		4		2	14
UR	Susitna	Side Slough	FDA 3	4		4	1				4		1	10
UR	Susitna	Tributary Mouth	FDA 1	8	1	6			1		4		6	18
UR	Susitna	Tributary Mouth	FDA 2	7	1	7					7		5	20
UR	Susitna	Tributary Mouth	FDA 3	7		7					6		2	15
UR	Susitna	Upland Slough	FDA 1	6		2			5	1	2	2	5	17
UR	Susitna	Upland Slough	FDA 2	6		5			2		4	1	6	18
UR	Susitna	Upland Slough	FDA 3	6		4			4		6		3	17
UR-TRIB	Black River	Trib Main Channel	FDA 1	14	8	15			10	7	11		2	53
UR-TRIB	Black River	Trib Main Channel	FDA 2	14	9	14			9	3	14		1	50
UR-TRIB	Black River	Trib Main Channel	FDA 3	14	12	14			9	3	12		1	51
UR-TRIB	Black River	Trib Off-Channel	FDA 1	6	2	6			2		4		2	16
UR-TRIB	Black River	Trib Off-Channel	FDA 2	6	2	6			1		6		3	18
UR-TRIB	Black River	Trib Off-Channel	FDA 3	6	3	6			1		5		3	18
UR-TRIB	Goose Creek	Trib Main Channel	FDA 1	20	12	20			2		2		12	48
UR-TRIB	Goose Creek	Trib Main Channel	FDA 2	20	13	20					20		12	65
UR-TRIB	Goose Creek	Trib Main Channel	FDA 3	20	11	20					18		10	59
UR-TRIB	Kosina Creek	Trib Main Channel	FDA 1	6	3	6			1		1		4	15
UR-TRIB	Kosina Creek	Trib Main Channel	FDA 2	6	2	6					6		4	18
UR-TRIB	Kosina Creek	Trib Main Channel	FDA 3	6	2	6					5		4	17
UR-TRIB	Oshetna River	Trib Main Channel	FDA 1	13	12	13					4	3		32

Reach	Stream Name	Macrohabitat & Special Mesohabitat Type	Season	Number of Macro Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR-TRIB	Oshetna River	Trib Main Channel	FDA 2	13	12	13					8			33
UR-TRIB	Oshetna River	Trib Main Channel	FDA 3	13	13	13					7			33
UR-TRIB	Oshetna River	Trib Off-Channel	FDA 1	2	2	2					1			5
UR-TRIB	Oshetna River	Trib Off-Channel	FDA 2	2	2	2					1			5
UR-TRIB	Oshetna River	Trib Off-Channel	FDA 3	2	2	2					2			6
UR-TRIB	Tsisi Creek	Trib Main Channel	FDA 1	6	1	6			1		6		6	20
UR-TRIB	Tsisi Creek	Trib Main Channel	FDA 2	6	1	6					6		4	17
UR-TRIB	Tsisi Creek	Trib Main Channel	FDA 3	6		6					6		6	18
UR-TRIB	Tsisi Creek	Trib Off-Channel	FDA 1	1		1					1		1	3
UR-TRIB	Tsisi Creek	Trib Off-Channel	FDA 2	1		1					1			2
UR-TRIB	Tsisi Creek	Trib Off-Channel	FDA 3	1		1					1		1	3
UR-TRIB	Unnamed 194.8	Trib Main Channel	FDA 1	2		2					2		2	6
UR-TRIB	Unnamed 194.8	Trib Main Channel	FDA 2	2		2					2		2	6
UR-TRIB	Unnamed 194.8	Trib Main Channel	FDA 3	2		2					2			4
UR-TRIB	Watana Creek	Main Channel	FDA 1	15	5	15					12	1	12	45
UR-TRIB	Watana Creek	Main Channel	FDA 2	15	6	15					14		10	45
UR-TRIB	Watana Creek	Main Channel	FDA 3	15	5	15					12		9	41
UR-TRIB	Watana Creek	Trib Off-Channel	FDA 1	3		3					1			4
UR-TRIB	Watana Creek	Trib Off-Channel	FDA 2	3		3					2			5
UR-TRIB	Watana Creek	Trib Off-Channel	FDA 3	3		3					1			4
UR-TRIB	Watana Creek Tributary	Trib Main Channel	FDA 1	13	2	13			1		12		9	37
UR-TRIB	Watana Creek Tributary	Trib Main Channel	FDA 2	13	5	13					13		6	37
UR-TRIB	Watana Creek Tributary	Trib Main Channel	FDA 3	13	3	13					13		6	35
UR-TRIB	Watana Creek Tributary	Trib Off-Channel	FDA 1	1		1					1			2
UR-TRIB	Watana Creek Tributary	Trib Off-Channel	FDA 2	1		1					1			2
UR-TRIB	Watana Creek Tributary	Trib Off-Channel	FDA 3	1		1					1			2
Grand Total				1,128	246	892	212	56	143	116	765	226	365	3,021

Table B2. Mesohabitat sampling units and gear events used in Fish Use Habitat Index (FUHI), 2013-2014 (Page 1 of 21).

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
LR	Susitna	Additional Open Water	Beaver Complex	FDA 3	1							1			1
LR	Susitna	Additional Open Water	Pool	FDA 1	3							3	1	1	5
LR	Susitna	Additional Open Water	Pool	FDA 2	3							3	1	1	5
LR	Susitna	Additional Open Water	Pool	FDA 3	2						1	2			3
LR	Susitna	Combined Main Channel	Clearwater Plume	FDA 1	3	3	1		1				2	1	8
LR	Susitna	Combined Main Channel	Clearwater Plume	FDA 2	3	1	1		1		2	1	1	1	8
LR	Susitna	Combined Main Channel	Clearwater Plume	FDA 3	3	2	1				2	1	2	1	9
LR	Susitna	Combined Main Channel	Pool	FDA 1	2		2					1	2		5
LR	Susitna	Combined Main Channel	Pool	FDA 2	3		3				1	3	2		9
LR	Susitna	Combined Main Channel	Pool	FDA 3	3		3				2	2	1		8
LR	Susitna	Combined Main Channel	Riffle	FDA 1	3	1	2	1					3		7
LR	Susitna	Combined Main Channel	Riffle	FDA 2	1		1						1		2
LR	Susitna	Combined Main Channel	Riffle	FDA 3	2		1				2	1	2		6
LR	Susitna	Combined Main Channel	Run/Glide	FDA 1	18	2	8	6	7		2	4	12		41
LR	Susitna	Combined Main Channel	Run/Glide	FDA 2	18		9	11	8		12	2	10		52
LR	Susitna	Combined Main Channel	Run/Glide	FDA 3	18		11	10	6		9	2	12		50
LR	Susitna	Side Slough	Clearwater Plume	FDA 1	1		1						1		2
LR	Susitna	Side Slough	Clearwater Plume	FDA 2	1						1		1		2
LR	Susitna	Side Slough	Clearwater Plume	FDA 3	1						1	1	1		3
LR	Susitna	Side Slough	Pool	FDA 1	1		1					1		1	3

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
LR	Susitna	Side Slough	Pool	FDA 2	2		1					1	2	2	6
LR	Susitna	Side Slough	Pool	FDA 3	2						1	2	1		4
LR	Susitna	Side Slough	Run/Glide	FDA 1	1		1						1	1	3
LR	Susitna	Trib Lower Reach	Pool	FDA 1	1		1								1
LR	Susitna	Trib Lower Reach	Pool	FDA 2	2	2		1			1	2			6
LR	Susitna	Trib Lower Reach	Riffle	FDA 1	1							1	1	1	3
LR	Susitna	Trib Lower Reach	Run/Glide	FDA 1	3	1	1			1		2		2	7
LR	Susitna	Trib Lower Reach	Run/Glide	FDA 2	3	2	1			1		2		3	9
LR	Susitna	Trib Lower Reach	Run/Glide	FDA 3	5	2		1	1		3	3	1	1	12
LR	Susitna	Upland Slough	Backwater	FDA 1	1		1					1			2
LR	Susitna	Upland Slough	Beaver Complex	FDA 1	1		1					1			2
LR	Susitna	Upland Slough	Beaver Complex	FDA 2	1		1				1	1			3
LR	Susitna	Upland Slough	Pool	FDA 2	1		1					1			2
LR	Susitna	Upland Slough	Run/Glide	FDA 1	3	1	2					3		1	7
LR	Susitna	Upland Slough	Run/Glide	FDA 2	3	1				1	2	3	1		8
LR	Susitna	Upland Slough	Run/Glide	FDA 3	5	1	3			2		3	2	1	12
MR-1	Susitna	Main Channel	Run/Glide	FDA 1	6		6	5			2	2	1		16
MR-1	Susitna	Main Channel	Run/Glide	FDA 2	6		6	6	2			2			16
MR-1	Susitna	Main Channel	Run/Glide	FDA 3	6		6	4			3	2			15
MR-1	Susitna	Side Channel	Riffle	FDA 1	1		1						1		2
MR-1	Susitna	Side Channel	Riffle	FDA 2	1		1								1
MR-1	Susitna	Side Channel	Riffle	FDA 3	2		2	1				2			5
MR-1	Susitna	Side Channel	Run/Glide	FDA 1	3		3	1				2	2		8
MR-1	Susitna	Side Channel	Run/Glide	FDA 2	3		3		1				1		5
MR-1	Susitna	Side Channel	Run/Glide	FDA 3	2		2				2	1	1		6
MR-2	Susitna	Main Channel	Clearwater Plume	FDA 1	4	1	4	2		1		2		2	12
MR-2	Susitna	Main Channel	Clearwater Plume	FDA 2	4	1	4	2				2		2	11
MR-2	Susitna	Main Channel	Clearwater Plume	FDA 3	4	1	4	3				2			10
MR-2	Susitna	Main Channel	Run/Glide	FDA 1	6		5	5	1		3	2			16
MR-2	Susitna	Main Channel	Run/Glide	FDA 2	6		5	6	4		2	2			19
MR-2	Susitna	Main Channel	Run/Glide	FDA 3	6		2	6	3		3	2			16
MR-2	Susitna	Side Channel	Pool	FDA 3	1									1	1
MR-2	Susitna	Side Channel	Riffle	FDA 1	1		1								1

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-2	Susitna	Side Channel	Riffle	FDA 2	1		1					1			2
MR-2	Susitna	Side Channel	Run/Glide	FDA 1	2		2	1				2		1	6
MR-2	Susitna	Side Channel	Run/Glide	FDA 2	2		2					2			4
MR-2	Susitna	Side Channel	Run/Glide	FDA 3	2		2	1				1			4
MR-2	Susitna	Side Slough	Backwater	FDA 1	2	1	1			1		2		1	6
MR-2	Susitna	Side Slough	Backwater	FDA 2	1					1		1	1		3
MR-2	Susitna	Side Slough	Clearwater Plume	FDA 1	1	1						1	1	1	4
MR-2	Susitna	Side Slough	Clearwater Plume	FDA 2	1	1						1	1	1	4
MR-2	Susitna	Side Slough	Clearwater Plume	FDA 3	1	1				1		1		1	4
MR-2	Susitna	Side Slough	Pool	FDA 1	5		5					5		4	14
MR-2	Susitna	Side Slough	Pool	FDA 2	1		1					1		1	3
MR-2	Susitna	Side Slough	Pool	FDA 3	2		2					1			3
MR-2	Susitna	Side Slough	Riffle	FDA 2	1		1					1			2
MR-2	Susitna	Side Slough	Run/Glide	FDA 1	2		2					1	1		4
MR-2	Susitna	Side Slough	Run/Glide	FDA 2	6		6					4	1	2	13
MR-2	Susitna	Side Slough	Run/Glide	FDA 3	6		6					5		3	14
MR-2	Susitna	Trib Lower Reach	Boulder Riffle	FDA 2	2		2			1		1		2	6
MR-2	Susitna	Trib Lower Reach	Cascade	FDA 1	2		2			1		2		1	6
MR-2	Susitna	Trib Lower Reach	Cascade	FDA 2	1		1					1		1	3
MR-2	Susitna	Trib Lower Reach	Cascade	FDA 3	3		3					3		3	9
MR-2	Susitna	Trib Lower Reach	Pool	FDA 3	2		2					2		2	6
MR-2	Susitna	Trib Lower Reach	Rapid	FDA 1	2		2			1		1		1	5
MR-2	Susitna	Trib Lower Reach	Rapid	FDA 2	1		1			1				1	3
MR-2	Susitna	Trib Lower Reach	Rapid	FDA 3	4		4					4		4	12
MR-2	Susitna	Trib Lower Reach	Riffle	FDA 1	1		1					1		1	3
MR-2	Susitna	Trib Lower Reach	Riffle	FDA 2	2		2					1		2	5
MR-2	Susitna	Trib Lower Reach	Riffle	FDA 3	4		4					4		4	12
MR-2	Susitna	Trib Lower Reach	Run/Glide	FDA 2	2		2			1				2	5
MR-2	Susitna	Trib Lower Reach	Run/Glide	FDA 3	2		2					2		2	6
MR-2	Susitna	Tributary Mouth	Cascade	FDA 1	3		3					3		3	9
MR-2	Susitna	Tributary Mouth	Cascade	FDA 2	3		3					2		3	8
MR-2	Susitna	Tributary Mouth	Cascade	FDA 3	2		2					1		1	4
MR-2	Susitna	Tributary Mouth	Riffle	FDA 1	5		5					4		3	12

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-2	Susitna	Tributary Mouth	Riffle	FDA 2	6		6					6		4	16
MR-2	Susitna	Tributary Mouth	Riffle	FDA 3	2		2					1			3
MR-2	Susitna	Upland Slough	Beaver Complex	FDA 2	1		1					1		1	3
MR-2	Susitna	Upland Slough	Pool	FDA 1	3		3			2	1	1	1	2	10
MR-2	Susitna	Upland Slough	Pool	FDA 2	5		5			1		4		5	15
MR-2	Susitna	Upland Slough	Run/Glide	FDA 1	6		5			1		5		6	17
MR-2	Susitna	Upland Slough	Run/Glide	FDA 2	2		2					2		1	5
MR-2	Susitna	Upland Slough	Run/Glide	FDA 3	1		1								1
MR-5	Susitna	Main Channel	Clearwater Plume	FDA 1	1	1				1				1	3
MR-5	Susitna	Main Channel	Clearwater Plume	FDA 2	4	2	1					2	2	4	11
MR-5	Susitna	Main Channel	Clearwater Plume	FDA 3	2	1	2			1					4
MR-5	Susitna	Main Channel	Riffle	FDA 1	1		1								1
MR-5	Susitna	Main Channel	Riffle	FDA 2	1		1								1
MR-5	Susitna	Main Channel	Riffle	FDA 3	1		1								1
MR-5	Susitna	Main Channel	Run/Glide	FDA 1	6		4	3	2		2		1		12
MR-5	Susitna	Main Channel	Run/Glide	FDA 2	5	1	3	5	2		2	3			16
MR-5	Susitna	Main Channel	Run/Glide	FDA 3	5		4	5	2		1	3			15
MR-5	Susitna	Side Slough	Pool	FDA 3	2		1					1			2
MR-5	Susitna	Side Slough	Run/Glide	FDA 1	3		3								3
MR-5	Susitna	Side Slough	Run/Glide	FDA 2	3		3					2			5
MR-5	Susitna	Side Slough	Run/Glide	FDA 3	1		1					1			2
MR-5	Susitna	Trib Lower Reach	Rapid	FDA 1	1		1					1		1	3
MR-5	Susitna	Trib Lower Reach	Rapid	FDA 2	1	1						1		1	3
MR-5	Susitna	Trib Lower Reach	Rapid	FDA 3	1	1	1							1	3
MR-5	Susitna	Trib Lower Reach	Run/Glide	FDA 2	1	1						1		1	3
MR-5	Susitna	Trib Lower Reach	Run/Glide	FDA 3	1	1	1							1	3
MR-5	Susitna	Tributary Mouth	Cascade	FDA 1	2		2								2
MR-5	Susitna	Tributary Mouth	Cascade	FDA 2	1		1							1	2
MR-5	Susitna	Tributary Mouth	Cascade	FDA 3	1		1								1
MR-5	Susitna	Tributary Mouth	Pool	FDA 1	1								1	1	2
MR-5	Susitna	Tributary Mouth	Pool	FDA 2	1		1					1		1	3
MR-5	Susitna	Tributary Mouth	Pool	FDA 3	1		1					1			2
MR-5	Susitna	Tributary Mouth	Rapid	FDA 1	1		1							1	2

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-5	Susitna	Tributary Mouth	Rapid	FDA 2	1	1						1		1	3
MR-5	Susitna	Tributary Mouth	Rapid	FDA 3	1	1	1					1			3
MR-5	Susitna	Tributary Mouth	Riffle	FDA 1	1		1							1	2
MR-5	Susitna	Tributary Mouth	Riffle	FDA 2	1							1		1	2
MR-5	Susitna	Tributary Mouth	Riffle	FDA 3	1		1					1			2
MR-5	Susitna	Tributary Mouth	Run/Glide	FDA 1	2		2							2	4
MR-5	Susitna	Tributary Mouth	Run/Glide	FDA 2	1							1	1	1	3
MR-6	Susitna	Main Channel	Clearwater Plume	FDA 1	3	3	2						1	1	7
MR-6	Susitna	Main Channel	Clearwater Plume	FDA 2	3	3	1					2	1	1	8
MR-6	Susitna	Main Channel	Clearwater Plume	FDA 3	3	3	2					2	1	1	9
MR-6	Susitna	Main Channel	Riffle	FDA 1	1		1								1
MR-6	Susitna	Main Channel	Riffle	FDA 2	2		2						1		3
MR-6	Susitna	Main Channel	Riffle	FDA 3	1		1								1
MR-6	Susitna	Main Channel	Run/Glide	FDA 1	7		3	4	1		3	1	5		17
MR-6	Susitna	Main Channel	Run/Glide	FDA 2	7		4	7	1		3	4	5		24
MR-6	Susitna	Main Channel	Run/Glide	FDA 3	7		4	7			3	4	6		24
MR-6	Susitna	Side Channel	Backwater	FDA 3	1			1				1			2
MR-6	Susitna	Side Channel	Clearwater Plume	FDA 2	2	1	1					1	1	2	6
MR-6	Susitna	Side Channel	Clearwater Plume	FDA 3	1		1					1			2
MR-6	Susitna	Side Channel	Pool	FDA 1	3		2					1	1	1	5
MR-6	Susitna	Side Channel	Pool	FDA 2	4		1					4	3		8
MR-6	Susitna	Side Channel	Pool	FDA 3	3		3					2			5
MR-6	Susitna	Side Channel	Riffle	FDA 1	4		4			1		1	2		8
MR-6	Susitna	Side Channel	Riffle	FDA 2	4		4			1		2	2		9
MR-6	Susitna	Side Channel	Riffle	FDA 3	1		1								1
MR-6	Susitna	Side Channel	Run/Glide	FDA 1	4		3			2		1	3		9
MR-6	Susitna	Side Channel	Run/Glide	FDA 2	5		1			2		5	5		13
MR-6	Susitna	Side Channel	Run/Glide	FDA 3	4		4			1		2	2	1	10
MR-6	Susitna	Side Slough	Backwater	FDA 1	1		1					1			2
MR-6	Susitna	Side Slough	Backwater	FDA 2	1		1					1			2
MR-6	Susitna	Side Slough	Beaver Complex	FDA 1	3					1		3	1	3	8
MR-6	Susitna	Side Slough	Beaver Complex	FDA 2	2							2	2	1	5
MR-6	Susitna	Side Slough	Beaver Complex	FDA 3	2		1				1	2	1	2	7

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-6	Susitna	Side Slough	Pool	FDA 1	5		3			1		3	1	3	11
MR-6	Susitna	Side Slough	Pool	FDA 2	5		2			1		4	2	4	13
MR-6	Susitna	Side Slough	Pool	FDA 3	4		2					3		3	8
MR-6	Susitna	Side Slough	Riffle	FDA 1	1		1							1	2
MR-6	Susitna	Side Slough	Riffle	FDA 2	1							1			1
MR-6	Susitna	Side Slough	Riffle	FDA 3	2							2		2	4
MR-6	Susitna	Side Slough	Run/Glide	FDA 1	4		4						1	4	9
MR-6	Susitna	Side Slough	Run/Glide	FDA 2	3		1			1		3		2	7
MR-6	Susitna	Side Slough	Run/Glide	FDA 3	5		3					5	1	4	13
MR-6	Susitna	Trib Lower Reach	Boulder Riffle	FDA 1	2	1	1					2		2	6
MR-6	Susitna	Trib Lower Reach	Boulder Riffle	FDA 2	4	3	1					4		4	12
MR-6	Susitna	Trib Lower Reach	Boulder Riffle	FDA 3	2	1	1					1			3
MR-6	Susitna	Trib Lower Reach	Cascade	FDA 3	4		4			1		4			9
MR-6	Susitna	Trib Lower Reach	Pool	FDA 1	4		1					3	1	4	9
MR-6	Susitna	Trib Lower Reach	Pool	FDA 3	1	1						1		1	3
MR-6	Susitna	Trib Lower Reach	Riffle	FDA 1	2	1						1		2	4
MR-6	Susitna	Trib Lower Reach	Riffle	FDA 2	4	1	2					3		4	10
MR-6	Susitna	Trib Lower Reach	Riffle	FDA 3	4	1	3					3			7
MR-6	Susitna	Trib Lower Reach	Run/Glide	FDA 1	5	3	2					4		5	14
MR-6	Susitna	Trib Lower Reach	Run/Glide	FDA 2	4	2	1			1		4		4	12
MR-6	Susitna	Trib Lower Reach	Run/Glide	FDA 3	4		3					2		2	7
MR-6	Susitna	Tributary Mouth	Pool	FDA 1	1								1	1	2
MR-6	Susitna	Tributary Mouth	Pool	FDA 2	1					1		1		1	3
MR-6	Susitna	Tributary Mouth	Pool	FDA 3	1		1			1		1			3
MR-6	Susitna	Tributary Mouth	Rapid	FDA 3	1	1						1			2
MR-6	Susitna	Tributary Mouth	Riffle	FDA 1	5	1	2					1		4	8
MR-6	Susitna	Tributary Mouth	Riffle	FDA 2	4	1	1					4	1	4	11
MR-6	Susitna	Tributary Mouth	Riffle	FDA 3	3		3					2		2	7
MR-6	Susitna	Tributary Mouth	Run/Glide	FDA 1	1									1	1
MR-6	Susitna	Tributary Mouth	Run/Glide	FDA 2	5	2						5	1	3	11
MR-6	Susitna	Tributary Mouth	Run/Glide	FDA 3	7	3	5					7	1	5	21
MR-6	Susitna	Upland Slough	Backwater	FDA 1	3		1	1				1	2	1	6
MR-6	Susitna	Upland Slough	Backwater	FDA 2	3		1			2		3	2		8

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-6	Susitna	Upland Slough	Beaver Complex	FDA 1	9		5			3		8	2	3	21
MR-6	Susitna	Upland Slough	Beaver Complex	FDA 2	11	2	3			1		11	6	6	29
MR-6	Susitna	Upland Slough	Beaver Complex	FDA 3	10		8			3		10	1	2	24
MR-6	Susitna	Upland Slough	Pool	FDA 1	2		1					2	1	2	6
MR-6	Susitna	Upland Slough	Pool	FDA 2	2		1					2	1	2	6
MR-6	Susitna	Upland Slough	Pool	FDA 3	2		1					2			3
MR-6	Susitna	Upland Slough	Run/Glide	FDA 1	1	1						1		1	3
MR-6	Susitna	Upland Slough	Run/Glide	FDA 2	1	1						1		1	3
MR-6	Susitna	Upland Slough	Run/Glide	FDA 3	2	1	1					2			4
MR-7	Susitna	Main Channel	Clearwater Plume	FDA 1	2	1						1	1	1	4
MR-7	Susitna	Main Channel	Clearwater Plume	FDA 2	3	1	2					1	1	2	7
MR-7	Susitna	Main Channel	Clearwater Plume	FDA 3	3	1	1					2	1	2	7
MR-7	Susitna	Main Channel	Riffle	FDA 1	2		2		1	1			1		5
MR-7	Susitna	Main Channel	Riffle	FDA 2	2		2						1		3
MR-7	Susitna	Main Channel	Run/Glide	FDA 1	6		5	3	2		3	1	2		16
MR-7	Susitna	Main Channel	Run/Glide	FDA 2	5		3	5	3		3	2	3		19
MR-7	Susitna	Main Channel	Run/Glide	FDA 3	6		5	6			3	3	1		18
MR-7	Susitna	Side Channel	Pool	FDA 1	1		1						1		2
MR-7	Susitna	Side Channel	Pool	FDA 3	1		1						1		2
MR-7	Susitna	Side Channel	Riffle	FDA 1	1		1								1
MR-7	Susitna	Side Channel	Riffle	FDA 2	2		2					2			4
MR-7	Susitna	Side Channel	Riffle	FDA 3	1		1					1			2
MR-7	Susitna	Side Channel	Run/Glide	FDA 1	2		2					1			3
MR-7	Susitna	Side Channel	Run/Glide	FDA 2	3		3					2	1		6
MR-7	Susitna	Side Channel	Run/Glide	FDA 3	2		2					1			3
MR-7	Susitna	Side Slough	Backwater	FDA 2	1		1					1	1		3
MR-7	Susitna	Side Slough	Backwater	FDA 3	1		1						1		2
MR-7	Susitna	Side Slough	Beaver Complex	FDA 1	3		1					3			4
MR-7	Susitna	Side Slough	Beaver Complex	FDA 2	3	2	1					3			6
MR-7	Susitna	Side Slough	Beaver Complex	FDA 3	2	1	1					1			3
MR-7	Susitna	Side Slough	Pool	FDA 1	4		4					3	1		8
MR-7	Susitna	Side Slough	Pool	FDA 2	3		3					3			6
MR-7	Susitna	Side Slough	Pool	FDA 3	4		4					4			8

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-7	Susitna	Side Slough	Riffle	FDA 2	1		1								1
MR-7	Susitna	Side Slough	Run/Glide	FDA 1	1		1					1	1		3
MR-7	Susitna	Side Slough	Run/Glide	FDA 2	3		2					3			5
MR-7	Susitna	Side Slough	Run/Glide	FDA 3	1							1			1
MR-7	Susitna	Trib Lower Reach	Cascade	FDA 3	1		1					1			2
MR-7	Susitna	Trib Lower Reach	Pool	FDA 1	1							1	1	1	3
MR-7	Susitna	Trib Lower Reach	Pool	FDA 2	5		5			1		4		5	15
MR-7	Susitna	Trib Lower Reach	Pool	FDA 3	3	1	1			1		3	1	1	8
MR-7	Susitna	Trib Lower Reach	Riffle	FDA 1	2		1					1			2
MR-7	Susitna	Trib Lower Reach	Riffle	FDA 2	6		6					6		6	18
MR-7	Susitna	Trib Lower Reach	Riffle	FDA 3	4		4					3			7
MR-7	Susitna	Trib Lower Reach	Run/Glide	FDA 1	4	1	2					3			6
MR-7	Susitna	Trib Lower Reach	Run/Glide	FDA 2	6	1	6			1		5		4	17
MR-7	Susitna	Trib Lower Reach	Run/Glide	FDA 3	3	1	3			1		3		1	9
MR-7	Susitna	Tributary Mouth	Cascade	FDA 2	1							1		1	2
MR-7	Susitna	Tributary Mouth	Riffle	FDA 1	1							1			1
MR-7	Susitna	Tributary Mouth	Riffle	FDA 2	1	1	1					1			3
MR-7	Susitna	Tributary Mouth	Riffle	FDA 3	1	1	1					1			3
MR-7	Susitna	Upland Slough	Backwater	FDA 1	2	1		1		1		1	1		5
MR-7	Susitna	Upland Slough	Backwater	FDA 2	3	1	1			1		2	1		6
MR-7	Susitna	Upland Slough	Backwater	FDA 3	3	1				2		3			6
MR-7	Susitna	Upland Slough	Beaver Complex	FDA 1	7	2	3			3		7	1	4	20
MR-7	Susitna	Upland Slough	Beaver Complex	FDA 2	8	2	3			2	1	7	2	5	22
MR-7	Susitna	Upland Slough	Beaver Complex	FDA 3	9	2	5			2		9	3	3	24
MR-7	Susitna	Upland Slough	Pool	FDA 1	3		3					2		1	6
MR-7	Susitna	Upland Slough	Pool	FDA 2	3		3					2		1	6
MR-7	Susitna	Upland Slough	Pool	FDA 3	3		3					2		1	6
MR-7	Susitna	Upland Slough	Run/Glide	FDA 1	3							3	3	2	8
MR-7	Susitna	Upland Slough	Run/Glide	FDA 2	2							2	2	2	6
MR-7	Susitna	Upland Slough	Run/Glide	FDA 3	1		1					1		1	3
MR-8	Susitna	Main Channel	Run/Glide	FDA 1	6		5	5	3		3	1	2		19
MR-8	Susitna	Main Channel	Run/Glide	FDA 2	6		4	6	3		3	1	2		19
MR-8	Susitna	Main Channel	Run/Glide	FDA 3	6		5	5			3	2	4		19

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-8	Susitna	Side Channel	Pool	FDA 1	3		3				1		1		5
MR-8	Susitna	Side Channel	Pool	FDA 2	3		2	1			1	3	1		8
MR-8	Susitna	Side Channel	Pool	FDA 3	2		2	1				2			5
MR-8	Susitna	Side Channel	Riffle	FDA 2	1		1					1	1		3
MR-8	Susitna	Side Channel	Riffle	FDA 3	1		1	1					1		3
MR-8	Susitna	Side Channel	Run/Glide	FDA 1	2		2	2	1				1		6
MR-8	Susitna	Side Channel	Run/Glide	FDA 2	2		2	1				1	1		5
MR-8	Susitna	Side Channel	Run/Glide	FDA 3	3		3	1				3	1		8
MR-8	Susitna	Side Slough	Pool	FDA 1	4		3						1	1	5
MR-8	Susitna	Side Slough	Pool	FDA 2	3		3					2			5
MR-8	Susitna	Side Slough	Pool	FDA 3	5		2			1		5	3	3	14
MR-8	Susitna	Side Slough	Riffle	FDA 1	3		3							3	6
MR-8	Susitna	Side Slough	Riffle	FDA 2	2		2					1		2	5
MR-8	Susitna	Side Slough	Riffle	FDA 3	2		1					1		2	4
MR-8	Susitna	Side Slough	Run/Glide	FDA 1	5		4					1	2	5	12
MR-8	Susitna	Side Slough	Run/Glide	FDA 2	6					2		6	3	6	17
MR-8	Susitna	Side Slough	Run/Glide	FDA 3	5		1			2		5	3	4	15
MR-8	Susitna	Trib Lower Reach	Pool	FDA 1	1						1			1	2
MR-8	Susitna	Trib Lower Reach	Pool	FDA 2	1						1	1		1	3
MR-8	Susitna	Trib Lower Reach	Pool	FDA 3	2					1		2		2	5
MR-8	Susitna	Trib Lower Reach	Riffle	FDA 1	1		1							1	2
MR-8	Susitna	Trib Lower Reach	Riffle	FDA 2	1							1		1	2
MR-8	Susitna	Trib Lower Reach	Riffle	FDA 3	1							1		1	2
MR-8	Susitna	Trib Lower Reach	Run/Glide	FDA 1	1									1	1
MR-8	Susitna	Trib Lower Reach	Run/Glide	FDA 2	1							1		1	2
MR-8	Susitna	Upland Slough	Backwater	FDA 1	2	1					1			1	3
MR-8	Susitna	Upland Slough	Backwater	FDA 2	1	1						1			2
MR-8	Susitna	Upland Slough	Backwater	FDA 3	1	1						1			2
MR-8	Susitna	Upland Slough	Beaver Complex	FDA 1	1									1	1
MR-8	Susitna	Upland Slough	Beaver Complex	FDA 3	1							1		1	2
MR-8	Susitna	Upland Slough	Pool	FDA 1	2		2	1		1		2			6
MR-8	Susitna	Upland Slough	Pool	FDA 2	3		2	1		1		3		1	8
MR-8	Susitna	Upland Slough	Pool	FDA 3	2		1	1		1		2			5

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
MR-8	Susitna	Upland Slough	Run/Glide	FDA 1	4		1					2	3	3	9
MR-8	Susitna	Upland Slough	Run/Glide	FDA 2	5		1					5	4	4	14
MR-8	Susitna	Upland Slough	Run/Glide	FDA 3	5		1					5	3	4	13
UR	Susitna	Main Channel	Clearwater Plume	FDA 1	11	4	10			3		6	1	7	31
UR	Susitna	Main Channel	Clearwater Plume	FDA 2	9	3	8	1		3		6	2	4	27
UR	Susitna	Main Channel	Clearwater Plume	FDA 3	8	2	7	1		1		6		2	19
UR	Susitna	Main Channel	Riffle	FDA 1	2		2	2		1		1			6
UR	Susitna	Main Channel	Riffle	FDA 2	1		1	1				1			3
UR	Susitna	Main Channel	Riffle	FDA 3	1		1	1				1			3
UR	Susitna	Main Channel	Run/Glide	FDA 1	17		16	16	1	1		12	5		51
UR	Susitna	Main Channel	Run/Glide	FDA 2	18		18	17		2		12	2		51
UR	Susitna	Main Channel	Run/Glide	FDA 3	18		18	17		3		13	2		53
UR	Susitna	Side Channel	Backwater	FDA 1	1		1			1	1	1			4
UR	Susitna	Side Channel	Backwater	FDA 2	1		1			1		1			3
UR	Susitna	Side Channel	Backwater	FDA 3	1		1			1		1			3
UR	Susitna	Side Channel	Pool	FDA 1	1		1					1	1		3
UR	Susitna	Side Channel	Pool	FDA 2	1		1						1		2
UR	Susitna	Side Channel	Pool	FDA 3	1		1					1	1		3
UR	Susitna	Side Channel	Riffle	FDA 1	4		4			2	2	2	1		11
UR	Susitna	Side Channel	Riffle	FDA 2	4		4			1		2	1		8
UR	Susitna	Side Channel	Riffle	FDA 3	2		2			1		2	1		6
UR	Susitna	Side Channel	Run/Glide	FDA 1	2		2	2	2		1		2		9
UR	Susitna	Side Channel	Run/Glide	FDA 2	3		3	2				2	1		8
UR	Susitna	Side Channel	Run/Glide	FDA 3	4		4	2		1		4			11
UR	Susitna	Side Slough	Backwater	FDA 1	3	1	3			3			2	1	10
UR	Susitna	Side Slough	Backwater	FDA 2	3		3	1		3		3	1		11
UR	Susitna	Side Slough	Pool	FDA 1	1		1	1				1			3
UR	Susitna	Side Slough	Pool	FDA 2	1		1	1				1			3
UR	Susitna	Side Slough	Pool	FDA 3	2		2	1				2			5
UR	Susitna	Side Slough	Riffle	FDA 1	3		3					2	1	1	7
UR	Susitna	Side Slough	Riffle	FDA 2	1		1							1	2
UR	Susitna	Side Slough	Riffle	FDA 3	1		1							1	2
UR	Susitna	Side Slough	Run/Glide	FDA 1	3		3					2	1	2	8

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR	Susitna	Side Slough	Run/Glide	FDA 2	6		6			1		3		3	13
UR	Susitna	Side Slough	Run/Glide	FDA 3	3		3					3		2	8
UR	Susitna	Tributary Mouth	Boulder Riffle	FDA 3	1		1					1			2
UR	Susitna	Tributary Mouth	Cascade	FDA 1	5		5					4		4	13
UR	Susitna	Tributary Mouth	Cascade	FDA 2	2		2					2		1	5
UR	Susitna	Tributary Mouth	Cascade	FDA 3	3		3					1		2	6
UR	Susitna	Tributary Mouth	Rapid	FDA 1	5	1	3			1		2		5	12
UR	Susitna	Tributary Mouth	Rapid	FDA 2	1	1	1					1		1	4
UR	Susitna	Tributary Mouth	Rapid	FDA 3	3		3					3		1	7
UR	Susitna	Tributary Mouth	Riffle	FDA 1	1		1								1
UR	Susitna	Tributary Mouth	Riffle	FDA 2	7		7					7		6	20
UR	Susitna	Tributary Mouth	Riffle	FDA 3	2		2					2			4
UR	Susitna	Upland Slough	Pool	FDA 1	7		1			4	2	2	5	6	20
UR	Susitna	Upland Slough	Pool	FDA 2	5		4			2		3	1	5	15
UR	Susitna	Upland Slough	Pool	FDA 3	5		3			4		5		3	15
UR	Susitna	Upland Slough	Run/Glide	FDA 1	1		1			1				1	3
UR	Susitna	Upland Slough	Run/Glide	FDA 2	1		1					1		1	3
UR	Susitna	Upland Slough	Run/Glide	FDA 3	1		1					1			2
UR-Trib	Black River	Main Channel	Backwater	FDA 1	1		1			1		1		1	4
UR-Trib	Black River	Main Channel	Backwater	FDA 2	1					1		1		1	3
UR-Trib	Black River	Main Channel	Backwater	FDA 3	1					1		1		1	3
UR-Trib	Black River	Main Channel	Boulder Riffle	FDA 1	16	5	16			7	8	10			46
UR-Trib	Black River	Main Channel	Boulder Riffle	FDA 2	15	6	15			9	2	14			46
UR-Trib	Black River	Main Channel	Boulder Riffle	FDA 3	18	14	18			9	4	12			57
UR-Trib	Black River	Main Channel	Rapid	FDA 1	4	2	4			1	3	2			12
UR-Trib	Black River	Main Channel	Rapid	FDA 2	4	2	3				3	1			9
UR-Trib	Black River	Main Channel	Rapid	FDA 3	2		2			1	1	1			5
UR-Trib	Black River	Main Channel	Riffle	FDA 1	3	1	3			2	2	1			9
UR-Trib	Black River	Main Channel	Riffle	FDA 2	2	1	2			1		2			6
UR-Trib	Black River	Main Channel	Riffle	FDA 3	3	1	3			1		3			8
UR-Trib	Black River	Main Channel	Run/Glide	FDA 1	14	4	14			6	7	7		1	39
UR-Trib	Black River	Main Channel	Run/Glide	FDA 2	16	9	15			9	1	9			43
UR-Trib	Black River	Main Channel	Run/Glide	FDA 3	13	11	13			8	1	6			39

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR-Trib	Black River	Off-Channel	Percolation Channel	FDA 1	6	2	6			1		4		1	14
UR-Trib	Black River	Off-Channel	Percolation Channel	FDA 2	6	2	6					6		3	17
UR-Trib	Black River	Off-Channel	Percolation Channel	FDA 3	6	2	6					6		3	17
UR-Trib	Black River	Off-Channel	Tributary	FDA 1	4		4			2		2		4	12
UR-Trib	Black River	Off-Channel	Tributary	FDA 2	4		3			1		4		3	11
UR-Trib	Black River	Off-Channel	Tributary	FDA 3	4	4	4			1				4	13
UR-Trib	Goose Creek	Main Channel	Boulder Riffle	FDA 1	22	10	22			1		2		9	44
UR-Trib	Goose Creek	Main Channel	Boulder Riffle	FDA 2	21	11	21					21		8	61
UR-Trib	Goose Creek	Main Channel	Boulder Riffle	FDA 3	21	11	21					19		8	59
UR-Trib	Goose Creek	Main Channel	Pool	FDA 1	6	2	6							6	14
UR-Trib	Goose Creek	Main Channel	Pool	FDA 2	5	1	5					5		4	15
UR-Trib	Goose Creek	Main Channel	Pool	FDA 3	5	2	5					5		2	14
UR-Trib	Goose Creek	Main Channel	Riffle	FDA 1	3	1	3					1		1	6
UR-Trib	Goose Creek	Main Channel	Riffle	FDA 2	3	2	3					2			7
UR-Trib	Goose Creek	Main Channel	Riffle	FDA 3	4	1	4					4		1	10
UR-Trib	Goose Creek	Main Channel	Run/Glide	FDA 1	9	1	8			1				7	17
UR-Trib	Goose Creek	Main Channel	Run/Glide	FDA 2	9	1	9					8		6	24
UR-Trib	Goose Creek	Main Channel	Run/Glide	FDA 3	8	1	8					6		6	21
UR-Trib	Kosina Creek	Main Channel	Boulder Riffle	FDA 1	6		6			1		2		5	14
UR-Trib	Kosina Creek	Main Channel	Boulder Riffle	FDA 2	6		6					6		6	18
UR-Trib	Kosina Creek	Main Channel	Boulder Riffle	FDA 3	6		6					4		4	14
UR-Trib	Kosina Creek	Main Channel	Riffle	FDA 1	2	2	2								4
UR-Trib	Kosina Creek	Main Channel	Riffle	FDA 2	2	2	2					2			6
UR-Trib	Kosina Creek	Main Channel	Riffle	FDA 3	2	2	2					2			6
UR-Trib	Kosina Creek	Main Channel	Run/Glide	FDA 1	2	2	1								3
UR-Trib	Kosina Creek	Main Channel	Run/Glide	FDA 2	2	1	2					2		1	6
UR-Trib	Kosina Creek	Main Channel	Run/Glide	FDA 3	3	1	3					1		2	7
UR-Trib	Oshetna River	Main Channel	Boulder Riffle	FDA 1	8	8	8					2	1		19
UR-Trib	Oshetna River	Main Channel	Boulder Riffle	FDA 2	8	8	8					5			21
UR-Trib	Oshetna River	Main Channel	Boulder Riffle	FDA 3	8	8	8					4			20

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR-Trib	Oshetna River	Main Channel	Pool	FDA 1	2		2						1		3
UR-Trib	Oshetna River	Main Channel	Pool	FDA 2	1		1								1
UR-Trib	Oshetna River	Main Channel	Pool	FDA 3	2		2					1			3
UR-Trib	Oshetna River	Main Channel	Rapid	FDA 1	1	1	1								2
UR-Trib	Oshetna River	Main Channel	Rapid	FDA 2	1	1	1								2
UR-Trib	Oshetna River	Main Channel	Rapid	FDA 3	1	1	1								2
UR-Trib	Oshetna River	Main Channel	Riffle	FDA 1	6	4	6					1	1		12
UR-Trib	Oshetna River	Main Channel	Riffle	FDA 2	5	4	5					3			12
UR-Trib	Oshetna River	Main Channel	Riffle	FDA 3	6	5	6					3			14
UR-Trib	Oshetna River	Main Channel	Run/Glide	FDA 1	8	8	8					1	1		18
UR-Trib	Oshetna River	Main Channel	Run/Glide	FDA 2	9	9	9					3			21
UR-Trib	Oshetna River	Main Channel	Run/Glide	FDA 3	8	8	8					1			17
UR-Trib	Oshetna River	Off-Channel	Percolation Channel	FDA 1	2	2	2					1			5
UR-Trib	Oshetna River	Off-Channel	Percolation Channel	FDA 2	2	2	2					1			5
UR-Trib	Oshetna River	Off-Channel	Percolation Channel	FDA 3	2	2	2					2			6
UR-Trib	Tsisi Creek	Main Channel	Boulder Riffle	FDA 1	3	1	3			1		2		3	10
UR-Trib	Tsisi Creek	Main Channel	Boulder Riffle	FDA 2	3		3					3		1	7
UR-Trib	Tsisi Creek	Main Channel	Boulder Riffle	FDA 3	3		3					3		3	9
UR-Trib	Tsisi Creek	Main Channel	Riffle	FDA 1	4		4					3		4	11
UR-Trib	Tsisi Creek	Main Channel	Riffle	FDA 2	4	1	4					4		3	12
UR-Trib	Tsisi Creek	Main Channel	Riffle	FDA 3	5		5					4		5	14
UR-Trib	Tsisi Creek	Main Channel	Run/Glide	FDA 1	2		2					2		2	6
UR-Trib	Tsisi Creek	Main Channel	Run/Glide	FDA 2	2	1	2					2		1	6
UR-Trib	Tsisi Creek	Main Channel	Run/Glide	FDA 3	1		1					1		1	3
UR-Trib	Tsisi Creek	Off-Channel	Percolation Channel	FDA 1	1		1					1		1	3
UR-Trib	Tsisi Creek	Off-Channel	Percolation Channel	FDA 2	1		1					1		1	3
UR-Trib	Tsisi Creek	Off-Channel	Percolation Channel	FDA 3	1		1					1		1	3

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR-Trib	Unnamed 194.8	Main Channel	Pool	FDA 1	2		2					2		2	6
UR-Trib	Unnamed 194.8	Main Channel	Pool	FDA 2	2		2					2		2	6
UR-Trib	Unnamed 194.8	Main Channel	Pool	FDA 3	2		2					2			4
UR-Trib	Unnamed 194.8	Main Channel	Riffle	FDA 1	1		1					1		1	3
UR-Trib	Unnamed 194.8	Main Channel	Riffle	FDA 2	1		1					1			2
UR-Trib	Unnamed 194.8	Main Channel	Riffle	FDA 3	1		1					1			2
UR-Trib	Unnamed 194.8	Main Channel	Run/Glide	FDA 1	1		1					1		1	3
UR-Trib	Unnamed 194.8	Main Channel	Run/Glide	FDA 2	1							1		1	2
UR-Trib	Unnamed 194.8	Main Channel	Run/Glide	FDA 3	1		1					1			2
UR-Trib	Watana Creek	Main Channel	Beaver Pond	FDA 1	1									1	1
UR-Trib	Watana Creek	Main Channel	Beaver Pond	FDA 2	1							1		1	2
UR-Trib	Watana Creek	Main Channel	Beaver Pond	FDA 3	1		1					1			2
UR-Trib	Watana Creek	Main Channel	Boulder Riffle	FDA 1	3	1	3					2		2	8
UR-Trib	Watana Creek	Main Channel	Boulder Riffle	FDA 2	3	1	3					3		2	9
UR-Trib	Watana Creek	Main Channel	Boulder Riffle	FDA 3	3	1	3					2		1	7
UR-Trib	Watana Creek	Main Channel	Pool	FDA 1	3	2	1					2		3	8
UR-Trib	Watana Creek	Main Channel	Pool	FDA 2	3	1	3					2		3	9
UR-Trib	Watana Creek	Main Channel	Pool	FDA 3	3	2	1					2		3	8
UR-Trib	Watana Creek	Main Channel	Riffle	FDA 1	10		10					5	1	3	19
UR-Trib	Watana Creek	Main Channel	Riffle	FDA 2	9	2	9					6		2	19
UR-Trib	Watana Creek	Main Channel	Riffle	FDA 3	9		9					4		4	17
UR-Trib	Watana Creek	Main Channel	Run/Glide	FDA 1	10	3	10					8		7	28
UR-Trib	Watana Creek	Main Channel	Run/Glide	FDA 2	11	6	11					10		6	33
UR-Trib	Watana Creek	Main Channel	Run/Glide	FDA 3	11	2	11					9		4	26

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR-Trib	Watana Creek	Off-Channel	Beaver Pond	FDA 1	1		1					1			2
UR-Trib	Watana Creek	Off-Channel	Beaver Pond	FDA 2	1		1					1			2
UR-Trib	Watana Creek	Off-Channel	Beaver Pond	FDA 3	1		1					1			2
UR-Trib	Watana Creek	Off-Channel	Percolation Channel	FDA 1	2		2								2
UR-Trib	Watana Creek	Off-Channel	Percolation Channel	FDA 2	2		2					1			3
UR-Trib	Watana Creek	Off-Channel	Percolation Channel	FDA 3	2		2								2
UR-Trib	Watana Creek Tributary	Main Channel	Boulder Riffle	FDA 1	2		2					2			4
UR-Trib	Watana Creek Tributary	Main Channel	Boulder Riffle	FDA 2	2		2					2		1	5
UR-Trib	Watana Creek Tributary	Main Channel	Boulder Riffle	FDA 3	2		1					2		2	5
UR-Trib	Watana Creek Tributary	Main Channel	Rapid	FDA 2	2	1	2					2		1	6
UR-Trib	Watana Creek Tributary	Main Channel	Rapid	FDA 3	1		1					1		1	3
UR-Trib	Watana Creek Tributary	Main Channel	Riffle	FDA 1	12	2	12					11		8	33
UR-Trib	Watana Creek Tributary	Main Channel	Riffle	FDA 2	10	4	10					10		4	28
UR-Trib	Watana Creek Tributary	Main Channel	Riffle	FDA 3	10	3	10					10		5	28
UR-Trib	Watana Creek Tributary	Main Channel	Run/Glide	FDA 1	3		3			1		2		3	9
UR-Trib	Watana Creek Tributary	Main Channel	Run/Glide	FDA 2	2		2					2		2	6
UR-Trib	Watana Creek Tributary	Main Channel	Run/Glide	FDA 3	3		3					3		3	9
UR-Trib	Watana Creek Tributary	Off-Channel	Percolation Channel	FDA 1	1		1					1			2

Reach	Stream Name	Macrohabitat	Mesohabitat	Sampling Period	Number of Meso Units	Angle	Backpack E-fisher	Boat E-fisher	Drift Gillnet	Fyke Net	Hoop Trap	Minnow Trap	Seine	Snorkel	Total Gear Events
UR-Trib	Watana Creek Tributary	Off-Channel	Percolation Channel	FDA 2	1		1					1			2
UR-Trib	Watana Creek Tributary	Off-Channel	Percolation Channel	FDA 3	1		1					1			2
Grand Total					1,572	335	1,243	213	59	177	136	1,010	256	573	4,002