FISH COMMUNITY MONITORING AND SAMPLING METHODOLOGY EVALUATION

Task 4 Report

Comparison of Methods Used to Sample the Middle Rio Grande Fish Community and the Endangered Rio Grande Silvery Minnow – Final Study Results

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Prepared for

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EXECUTIVE SUMMARY

This fish community monitoring and sampling methodology evaluation study was designed to identify, evaluate, and validate sampling gear types that may be used to monitor the Middle Rio Grande fish community. Particular emphasis is placed on estimating abundance and characterizing the length structure of the Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow) on floodplains and side channel habitats during spring runoff and in the main channel during pre-runoff and fall base flow periods in the Middle Rio Grande, New Mexico. The study was funded by the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) and coordinated by the U.S. Bureau of Reclamation with technical guidance from the Science Workgroup of the Collaborative Program.

Samples were collected from different habitats (i.e., main channel, floodplain, and side channel) and during different seasons (i.e., before spring runoff, during spring runoff, and during fall baseflow) in 2010, 2011, and 2012 to compare backpack electrofishing, beach seine, fyke net, and bag seine catches under different environmental conditions. Primary study objectives include using a paired gear approach to assess the relative efficiency of commonly used gear types in floodplain and main channel habitats for 1) monitoring the Middle Rio Grande fish community, 2) determining the silvery minnow population length structure, and 3) monitoring the relative abundance of silvery minnow. Results collected during the study indicate that the relative efficiency of gear types for sampling the Middle Rio Grande fish community and the silvery minnow varies among gear types depending on the parameter measured (e.g., species richness, detection, relative abundance, silvery minnow size), habitat sampled (i.e., floodplain, main channel), and time of year.

Beach seines were consistently the most effective method for estimating species richness from floodplain habitats. The effectiveness of the backpack electrofishing unit and the beach seine was similar for estimating species richness from main channel habitats, and both generally captured more species per sample than the bag seines or fyke nets. Relative efficiency of the fyke net and bag seine gears to measure species richness in the main channel was influenced by environmental constraints for deploying these gears.

Percent species composition of samples varied among gear types and between floodplain and side channel habitats sampled. Silvery minnow was the most common species collected with fyke nets and backpack electrofishing from floodplain and side channel habitats. In contrast, silvery minnow was the fourth and fifth most common species collected with beach seines from floodplain and side channel habitats. Percent similarity of species composition between gear types from floodplain and side channel habitats shows that species composition data collected with beach seines is unlike species composition data collected fyke nets and backpack electrofishing.

In main channel habitats, percent species composition of samples varied among gear types and between samples collected in October 2010, March 2011, October 2011, and March 2012. Red shiner (*Cyprinella lutrensis*) was the most common species collected from main channel habitats. The silvery minnow was commonly collected with backpack electrofishing, fyke nets, and the bag seine, but not with the beach seine. More fish were collected per main channel survey with

beach seines; however beach seine catches consisted almost entirely of red shiner during all four main channel surveys.

The number of silvery minnow collected from floodplain and side channel sites varied among samples collected with the backpack electrofishing unit, beach seines, and fyke nets during both years of sampling, despite standardizing the size and location of the sample area. Fyke nets collected the greatest number of silvery minnow per sample during both years of floodplain and side channel monitoring, while beach seines collected the fewest number of silvery minnow per sample.

When combining all the catch data, silvery minnow relative abundance was correlated among gears for floodplain and side channel samples but not for main channel samples. Fyke nets collected more fish per sample from floodplain and side channel habitats than beach seine and backpack electrofishing, suggesting the species is relatively more abundant in these habitats than would be indicated by backpack electrofishing and beach seines alone. This likely results from differences in capture efficiency among the tested gear types, which is influenced by a variety of physical, chemical, and biological factors. Silvery minnow relative abundance of main channel habitats were not correlated between any tested gear types or data standardizations, suggesting that main channel habitats of the Middle Rio Grande are highly variable within 1-km (0.6-mile) reaches used for this study. These variable results reinforce the need to understand factors that bias fish sample data and how fisheries indices vary among and between gear types for sampling the Middle Rio Grande fish community.

When sample sizes were sufficient, silvery minnow standard length differed among the tested gear types for floodplain and main channel habitats, with the largest silvery minnow being collected with fyke nets. Large numbers of silvery minnow collected from floodplain and side channel habitats during October 2010 enabled comparisons of length frequency among gears that were not possible with data from other sampling events. Large sample sizes provide better descriptions of length frequency that more closely match the actual size structure of a fish population. During October 2010, a large sample size of silvery minnow (electrofishing = 293, beach seines = 107, fyke nets = 444) was collected with all three gear types and the mean length of silvery minnow collected with fyke nets was larger than mean length of silvery minnow collected with the backpack electrofishing unit and beach seines. In addition, the relative proportion of fish larger than 62 mm was greater for silvery minnow collected with fyke nets (28%) than backpack electrofishing (14%) and beach seines (14%). Results from this year of sampling indicate fyke nets provide a different perspective regarding the proportion of the age 2 and older spawning silvery minnow than beach seines and backpack electrofishing and this gear type may be useful for describing the length structure of the silvery minnow population.

In summary, no one gear outperformed the others tested for all of the parameters compared. The sampling gear recommended depends on the sampling location and sampling objective.

Sampling on the floodplain is not currently recommended for monitoring trends in silvery minnow abundance because the proportion of the population that uses floodplain habitats is not known and the availability of floodplain habitats varies among years. Thus, it may be more desirable to catch as many silvery minnow as possible (e.g., to characterize population age structure) than to produce the lowest coefficient of variation among samples. Fyke nets and the backpack electrofishing unit were most cost effective at collecting silvery minnow from these off-channel habitats. Used together (i.e., data pooled for collections by both gears at a site) these gears would produce a less biased estimate of the population length structure than either used alone.

Monitoring silvery minnow relative abundance in the main channel is currently conducted by the Collaborative Program using beach seines. The species richness and silvery minnow catch per unit effort data collected by the backpack electrofishing unit in the main channel was comparable, so it is not recommended that sampling with the backpack electrofishing unit be used to supplement the existing beach seine sampling. Fyke nets are not effective for monitoring silvery minnow abundance in the main channel and are only recommended for use when larger numbers of silvery minnow need to be collected to characterize population length structure, health indices, and other measures of individual fish.

If the primary objective is compiling a species list, then it may be useful to supplement the current beach seine sampling with backpack electrofishing and bag seine samples. These gear types collected fish, particularly larger species that were missed by the beach seine.

The backpack electrofishing unit is recommended if one gear had to be selected to sample both floodplain/side channel and main channel habitats for silvery minnow. The cost of sampling with the backpack electrofishing unit is similar to that of sampling with the beach seine, but the backpack electrofishing unit appears to be more effective at capturing silvery minnow, especially in structurally complex habitats. The primary drawback of this method is the expense to purchase and maintain the sampling gear, and the increased potential for fish injury.

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1.0 INTRODUCTION

This fish community monitoring and sampling methodology evaluation study has been designed to identify, evaluate, and validate sampling gear types that may be used to monitor the Middle Rio Grande (MRG) fish community. Particular emphasis is placed on estimating relative abundance and characterizing the length structure of the Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow) on floodplains and side channel habitats during spring runoff and in the main channel during pre-runoff and fall base flow periods in the MRG, New Mexico (Figure 1) (Widmer et al. 2010a). The study is funded by Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) and coordinated by the U.S. Bureau of Reclamation with technical guidance from the Science Workgroup of the Collaborative Program.

Abundance of silvery minnow in the MRG has been consistently monitored using an index of abundance (catch per 100 m^2) for samples collected from several sites using beach seines several times per year (Dudley and Platania 2008). A review of published sampling gear evaluations ranks beach seines highest of all the gears reviewed for collection of small-bodied fishes based on the following criteria: 1) suitability for sampling silvery minnow adults, juveniles, larvae, and eggs; 2) suitability for sampling the fish community in a medium sandbed river; 3) logistical ease of use; 4) gear purchase cost; and 5) reliability for quantitative information (Burckhardt et al. 2010). However, power and trend analyses of existing monitoring data for silvery minnow in the MRG have indicated that low precision (i.e., high variability) in beach seine catch rates may obscure population trends at current sample sizes (Widmer et al. 2010b). Other gears, such as backpack electrofishing units and fyke nets, have also been used to collect silvery minnow in the MRG, although their application has usually been project-specific and less consistent over time (Widmer et al. 2010b). Differences in sampling times, frequency, and sampling periods have confounded comparisons of gear effectiveness (Widmer et al. 2010b), although the literature suggests that these gears can be effective for monitoring *Hybognathus* species (Burckhardt et al. 2010).

Gear validation is the process of evaluating the ability of a method to catch the fish that are present in the sampling area (Bonar et al. 2009). Paired gear comparisons characterize the proportion of the MRG fish community and the silvery minnow population that may be missed or underrepresented by one gear type but collected by a second gear type. A paired gear comparison with beach seines would enable MRG investigators to decide whether the additional information gained using supplemental gears is worth the cost and effort given their project goals. This study conducted paired gear comparisons using beach seines, backpack electrofishing units, fyke nets, and bag seines. Samples were collected from different habitats (i.e., floodplain and side channel and main channel) and during different seasons (i.e., spring and fall), and repeated for two years, so that the gears could be compared under different environmental conditions.

Primary study objectives include using a paired gear approach to assess the relative efficiency of commonly used gear types, in floodplain and main channel habitats, for 1) monitoring the MRG fish community, 2) determining the silvery minnow population length structure, 3) and monitoring the relative abundance of silvery minnow.

Figure 1. Reaches of the MRG in central New Mexico with sites used for long-term monitoring with beach seines (e.g., Dudley and Platania 2008).

2.0 METHODS

An overview of the study designs and sampling methods for each part of the study are described separately below. Details of the study design and its conception are provided in Widmer et al. (2010a).

2.1 FLOODPLAIN AND SIDE CHANNEL

2.1.1 SITE SELECTION

Floodplain and side channel areas were selected to sample during May and June 2010 and 2011 based on availability, which was determined by the magnitude and duration of spring runoff during each year. In 2010, two floodplain sites (Alameda and I-40) and one side channel site (Paseo del Norte) were sampled from May 31 to June 9 with backpack electrofishing units, beach seines, and fyke nets (Figure 2). In 2011, one floodplain site (Alameda) and two side channel sites (Paseo del Norte and I-40) were sampled with the same three gear types from May 10 to June 3.

Prior to sampling, a polygon was established at each sampling site that delineated the area to be sampled; the polygons ranged from 40 to 170 m^2 (430.5–1,830 square feet) in size depending on habitat characteristics. A Trimble GeoXH handheld global positioning unit (GPS) unit (Trimble Navigation Limited**,** Sunnyvale, California) with sub-foot accuracy was used to determine the area of the polygons at each site. At each site, three sampling locations were selected that represented available habitat. Sampling locations were spaced sufficiently so that each collection could be considered an independent sample. At each sampling location, a single fyke net was set at the upstream or downstream end of each polygon so that fish moving through the floodplain or side channel habitat could be intercepted. Appendix A contains maps of sites and sampling polygons during floodplain and side channel sampling in 2010 and 2011 (main channel maps are provided separately in Appendix B, along with photographs from all sites in Appendix C).

2.1.2 SAMPLING APPROACH

On each sampling date, a single gear type was used to collect fish from each sampling polygon at each site. Each sampling polygon was sampled with each gear type a minimum of three times.

Electrofishing samples were collected with a backpack electrofishing unit (LR-24, Smith Root, Inc., Vancouver, Washington) at each sampling polygon. Each electrofishing sample was collected by making one electrofishing pass over the entire polygon area and netting all fish detected. Electrofishing unit settings were standardized and maintained among polygons, and the number of seconds of electricity applied was recorded for each sample. For each sample, all fish were identified to species and counted. Standard length (mm) was recorded for silvery minnow. After processing, fish were released back to the polygon where they were captured. Electrofishing samples were collected on June 2, 5, and 9, 2010; May 12, 16, 19, and 25, 2011; and June 3, 2011.

Seine net samples were collected with a small beach seine (3.1 × 1.8 m [10 × 6 feet], with 3-mm [0.118-inch] mesh) at each sampling location. For a single sample, the entire polygon area was seined once; multiple individual seine hauls were required to cover the polygon area. All fish seined from the polygon were considered a single sample, regardless of the number of seine hauls. Collected fish were identified to species and counted after each seine haul. Standard length (mm) was recorded for silvery minnow. Fish were released back to the polygon where they were captured after the area was completely sampled. Seine samples were collected on May 30, 2010; June 3, 6, and 8, 2010; May 10, 13, 17, and 23, 2011; and June 1, 2011.

Fyke samples were collected with D-frame double-wing fyke nets (2.1 m length × 1.0 m width × 0.60 m height [6.9 × 3.3 × 2.0 feet]; wings 0.6 m height × 4.6 m length [2.0 × 15.1 feet]; 3.1-mm delta mesh, 5-cm-diameter [2-inch-diameter] throat) soaked for 3.5 to 4.75 hours at each sampling location. Depth (feet) and velocity (m/s) at the mouth of the fyke net were recorded for each sample at the beginning of the sampling process. For each sample, all fish were identified to species and counted. Standard length (mm) was recorded for silvery minnow. After processing, fish were released back to the polygon where they were captured. Fyke net samples were collected on June 1, 4, and 7, 2010; May 11, 14, 18, and 24, 2011; and June 2, 2011.

On each sampling date, water quality measurements were collected from each polygon prior to sampling. Water quality parameters were measured using a YSI 556 multi-parameter handheld meter (Yellow Springs Instruments, Yellow Springs, Ohio) and included temperature (°C), dissolved oxygen (mg/L and percentage), conductivity ($\mu S/cm^c$ [conductivity corrected to 25°C] and µS/cm [uncorrected]), salinity (parts per thousand), pH, and turbidity (Formazin turbidity units). Water depth (feet) and flow velocity (m/s) were measured using a U.S. Geological Survey (USGS) top-setting wading rod fitted with a Marsh-McBirney Flo-Mate portable flowmeter (Hach Company, Loveland, Colorado). Appendix D details water quality data taken from floodplain and side channel habitats.

Figure 2. Overview map of floodplain and side channel habitats.

2.2 Main Channel

2.2.1 Site Selection

Five representative 1-km (0.6-mile) sites were selected and sampled. One site from each of the major channel geomorphology types in the MRG (Massong et al. 2006)—moderate incision, low to moderate incision, no recent incision, high incision, and slightly aggrading. Sites were located (>2 km [1.2 mile]) away from existing long-term monitoring sites so that sampling would not affect the outcome of the ongoing monitoring program. Two sites were selected in the Albuquerque Reach (Site 1 - Calabacillas, Site 2 - La Orilla), two in the Isleta Reach (Site 3 - Bosque Farms, Site 4 - Veguita), and one in the San Acacia Reach (Site 5 - 380 Bridge) (Figure 3).

Each 1-km (0.6-mile) site was divided into three 300-m-long (984-foot-long) blocks with 50-m (164-foot) breaks between them. Each block was randomly assigned to sampling by 1) electrofishing, 2) beach seines and bag seine, or 3) fyke nets. Appendix B depicts sites, blocks, gear assignments, and sample areas for main channel surveys conducted during October 2010, March 2011, October 2011, and March 2012.

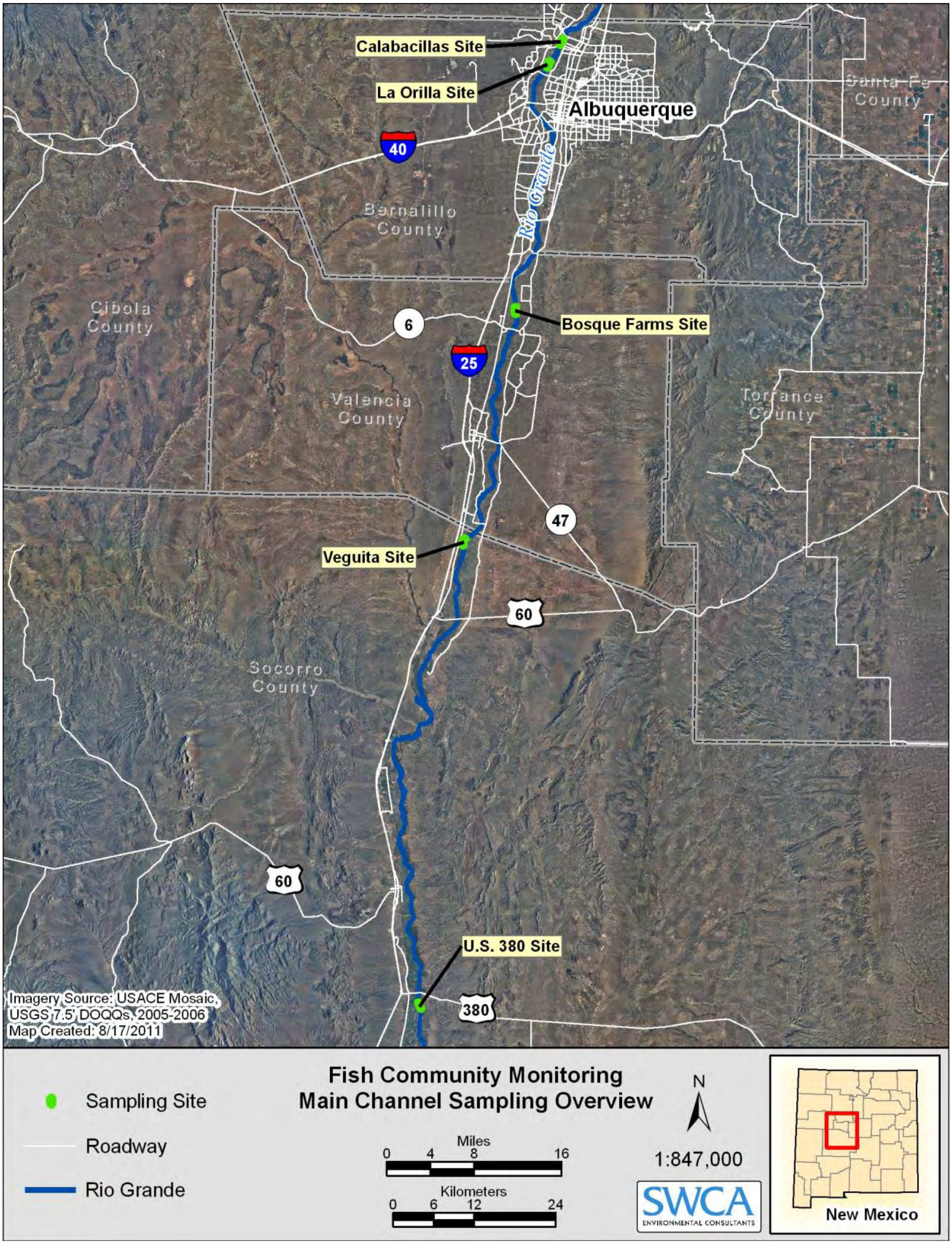

Figure 3. Overview map of main channel sites sampled.

2.2.2 SAMPLING APPROACH

On each sampling date, main channel mesohabitats within the electrofishing and beach seine blocks were sampled in proportion to their occurrence. Each mesohabitat type was sampled at least once. Mesohabitats were visually identified according to definitions adopted from Armantrout (1998) and currently used by the U.S. Fish and Wildlife Service (Remshardt 2008). A handheld Trimble GeoXH GPS unit (Trimble Navigation Limited, Sunnyvale, California) with sub-foot accuracy was used to determine the area of each mesohabitat sampled (m^2). Depth (feet) and velocity (m/s) were recorded from the center of each sampled mesohabitat. Main channel sampling was conducted on October 4, 6, 7, and 8, 2011; March 1, 2, 3, 4, and 11, 2011; October 17, 18, 19, 20, and 21, 2011; and March 5, 6, 7, and 12, 2012.

Electrofishing samples were collected with a backpack electrofishing unit (LR-24, Smith Root, Inc., Vancouver, Washington) from 10 distinct mesohabitats from within the electrofishing block at each main channel site on each sampling date. Each electrofishing sample was collected by making one pass over the entire mesohabitat area and netting all fish detected. Electrofishing was typically conducted from downstream to upstream, but occasionally laterally or from upstream to downstream depending on the characteristics of the sampled mesohabitat. Electrofishing unit settings were standardized and maintained among sampled mesohabitats, and the number of seconds of electricity applied was recorded for each sample. For each mesohabitat sample, all fish were identified to species and counted. Standard length (mm) was recorded for silvery minnow. After processing, fish were released back to the mesohabitat where they were captured.

Seine net samples were collected with a small beach seine (3.1 × 1.8 m [10 × 6 feet] with 3-mm [0.118-inch] mesh) from a maximum of 20 distinct mesohabitats from within the seine block at each main channel site on each sampling date. Seining was typically conducted from upstream to downstream, but occasionally in a lateral direction depending on the characteristics of the sampled mesohabitat. A single seine haul was collected from each sampled mesohabitat and all fish seined from each mesohabitat were considered a single sample. Collected fish were identified to species and counted after each seine haul. Standard length (mm) was recorded for silvery minnow. Fish were released back to the mesohabitat where they were captured after each seine haul.

Fyke net samples were collected with two D-frame double-wing fyke nets (2.1 m length × 1.0 m width × 0.60 m height [6.9 × 3.3 × 2.0 feet]; wings 0.6 m height × 4.6 m length [2.0 × 15.1 feet]; 3.1-mm delta mesh, 5-cm-diameter [2-inch-diameter] throat) and two single-wing rectangular fyke nets (4.0 m length × 0.5 m width × 0.5 m height [13.1 × 1.6 × 1.6 feet]; wings 0.5 m height × 4.0 m length [1.6 × 13.1 feet]; 5-mm delta mesh, 5-cm-diameter [2-inch-diamter] throat) soaked for 3.3 to 5.8 hours. Fyke net samples were collected from within the fyke net block at each main channel site on each sampling date. Fyke nets were set where conditions were conducive to sampling with this gear type such as backwaters, side channels, pools, or other low velocity habitats. A schematic and description of each fyke net location and mesohabitat type was recorded. Depth (feet) and velocity (m/s) at the mouth of the fyke net were recorded for each sample at the beginning of the sampling process. For each sample, all fish were identified to species and counted. Standard length (mm) was recorded for silvery minnow. After processing, fish were released back to the area where they were captured.

A large bag seine (e.g., 15.24 ×1.8 m [50 × 6 feet] with mesh approximately 5 mm) was fished in mesohabitats that were free of woody debris and had a bank-attached bar with sufficient area for landing the net. One end of the bag seine was anchored on shore. The net was extended out and upstream along the bank and then swiftly pulled through the water in a 180 degree arc back to the bank. The lead line of the seine was pulled in slowly, maintaining contact with the stream bottom so that the fish concentrated in the bag of the seine. For each sample, all fish were identified to species and counted. Standard length (mm) was recorded for silvery minnow. After processing, fish were released back to the area where they were captured. The bag seine was not one of the primary gears compared in this study, but is included as an experimental gear. Samples were collected with this gear in the seine net or fyke net sampling block after the conclusion of sampling with the primary gear (i.e., seine net, fyke net, or backpack electrofishing).

Additional experimental sampling was conducted by electrofishing in a downstream direction into a beach seine held in place by two crew members with a backpack electrofishing unit during March 2011 at Site 5 (380 Bridge). Ten mesohabitats were sampled using this approach.

On each sampling date, water quality measurements were collected from the electrofishing block prior to and after sampling at each main channel site. Water quality parameters were measured using a YSI 556 multi-parameter handheld meter (Yellow Springs Instruments, Yellow Springs, Ohio), and included temperature (°C), dissolved oxygen (mg/L and percentage), conductivity ($\mu S/cm^c$ [conductivity corrected to 25°C] and µS/cm [uncorrected]), salinity (parts per thousand), pH, and turbidity (Formazin turbidity units). Water depth (feet) and flow velocity (m/s) were measured using a USGS top-setting wading rod fitted with a Marsh-McBirney Flo-Mate portable flowmeter (Hach Company, Loveland, Colorado). Appendix D details water quality data taken from main channel habitats.

2.3 Data Analysis

The project database submitted with this report contains raw fisheries data collected from floodplain and side habitats from which all the following analysis were conducted.

2.3.1 Floodplain and Side Channel Fish Community Composition and Species Detection

The number of fish collected from floodplain and side channel habitats was summarized by species, and percent species composition was calculated for all collections combined and individually for each gear type. Percent similarity was calculated from species composition data to compare fish community data between gear types (Kwak and Peterson 2007). Percent species composition was conducted separately for May and June 2010 and May and June 2011 floodplain and side channel data sets.

Mean numbers of sampling locations where a fish species was captured were compared among the three gear types (electrofishing, beach seine, and fyke nets) with a Kruskal-Wallis one-way analysis of variance (ANOVA) (Zar 1999). Species detection was conducted for both years of sampling combined and for each year separately (May and June 2010 and May and June 2011).

2.3.2 FLOODPLAIN AND SIDE CHANNEL SPECIES RICHNESS

The number of species collected from floodplain and side channel habitats during each sampling occasion was compared across gear types with a Kruskal-Wallis one-way ANOVA (Zar 1999). If significant differences were detected among the three methods, then a Wilcoxon rank sum test was used to compare mean differences between each of the three gear types (Zar 1999). Statistical significance (P <0.05) of multiple comparisons was adjusted with the standard Bonferroni correction (P = 0.05/n). Species richness was analyzed combined and separately for May and June 2010 and May and June 2011 floodplain and side channel collections.

2.3.3 FLOODPLAIN AND SIDE CHANNEL SILVERY MINNOW RELATIVE ABUNDANCE

The number of silvery minnow caught on each sampling occasion from floodplain and side channel sites was compared across gear types with a Kruskal-Wallis one-way ANOVA (Zar 1999). If significant differences were detected among the three methods (electrofishing, beach seine, and fyke nets), then a Wilcoxon rank sum test was used to compare mean differences between each of the three gear types (Zar 1999). Statistical significance (P <0.05) of multiple comparisons was adjusted with the standard Bonferroni correction (P = 0.05/n). The numbers of silvery minnow collected on each sampling occasion were analyzed separately for May and June 2010 and May and June 2011 collections.

The catch of silvery minnow was standardized for each gear type so that comparisons of relative abundance indices derived from each gear type could be compared. Seine sample catch per unit effort (CPUE) was calculated as fish per 100 m^2 seined (fish/100 m^2) and as fish per seine haul (fish/haul). Electrofishing CPUE was calculated as fish collected per minute of electricity applied (fish/minute) and as fish per 100 m^2 sampled (fish/100 m^2). Fyke net sample CPUE was calculated as fish collected per hour of soak time (fish/hour) (Quinn and Deriso 1999; Hubert and Fabrizio 2007).

Mean values of CPUE indices at each sampling location were calculated and compared between gear types using linear regression and non-parametric Spearman rank correlation coefficients (Zar 1999). A high coefficient of determination (R^2) or a high Spearman's Rho (R_s) indicated that CPUE indices were closely related and provided a similar assessment of relative abundance for silvery minnow among sites. CPUE comparisons were conducted for May and June 2010 and May and June 2011 collections combined.

2.3.4 FLOODPLAIN AND SIDE CHANNEL SILVERY MINNOW SIZE

Standard length of silvery minnow was compared among gear types using a Kruskal-Wallis ANOVA (Zar 1999). If significant differences were detected among the three methods, then a Wilcoxon rank sum test was used to compare mean differences between each of the three gear types (Zar 1999). Statistical significance (P <0.05) of multiple comparisons was adjusted with the standard Bonferroni correction (P = 0.05/n). Standard length was analyzed separately for May and June 2010 and May and June 2011 samples.

To discern age groups ($\geq$1 and $\geq$2), the length frequency of all collected silvery minnow was analyzed with Bhattacharya's method (Bhattacharya 1967) and refined age separation was analyzed with NORMSEP, a maximum likelihood estimate that separates normally distributed components of length-frequency samples given approximate mean lengths. Bhattacharya's method and NORMSEP were run in the program FiSAT (Food and Agriculture Organization of the United Nations 2000). The length at which the tails of the normal length distributions crossed was used as the cut-off between groups. The percentage of all silvery minnow collected with each gear for each group was calculated and compared among the gear types to assess relative efficiency of age group estimation among gear types.

2.3.5 MAIN CHANNEL FISH COMMUNITY COMPOSITION AND SPECIES DETECTION

The number of fish collected was summarized by species, and percent species composition was calculated for all collections combined and individually for each gear type used (electrofishing, beach seine, fyke net, and bag seine). Percent similarity was calculated from species composition data to compare fish community data between gear types (Kwak and Peterson 2007). Percent species composition was calculated separately for October 2010, March 2011, October 2011, and March 2012 surveys.

Species detection was tested by comparing numbers of sites where a fish species was captured with each of the three gear types (electrofishing, beach seine, and fyke nets) with a Kruskal-Wallis one-way ANOVA (Zar 1999). If significant differences were detected among the three methods, then a Wilcoxon rank sum test was used to compare mean differences between each of the three gear types (Zar 1999). Statistical significance (P <0.05) of multiple comparisons was adjusted with the standard Bonferroni correction (P = 0.05/n). Too few samples were collected with the bag seine for a valid comparison with other gears. Data collected with beach seines and backpack electrofishing from main channel Site 5 (380 Bridge) during March 2011 were not included in the analysis because fyke nets were not used at that site. Species detection was conducted for all four main channel surveys combined and separately for each survey (May and June 2010 and May and June 2011).

2.3.6 MAIN CHANNEL SPECIES RICHNESS

The number of species collected from main channel habitats during each sampling occasion was compared across gear type with a Kruskal-Wallis one-way ANOVA (Zar 1999). If significant differences were detected among the four methods (electrofishing, beach seine, fyke net, and bag seine), then a Wilcoxon rank sum test was used to compare mean differences between each of the three gear types (Zar 1999). Statistical significance (P <0.05) of multiple comparisons was adjusted with the standard Bonferroni correction (P = 0.05/n). Species richness was analyzed combined for all main channel surveys and separately for October 2010, March 2011, October 2011, and March 2012 main channel surveys.

2.3.7 MAIN CHANNEL SILVERY MINNOW RELATIVE ABUNDANCE

The number of silvery minnow caught per mesohabitat sample from main channel sites was compared across gear types with a Kruskal-Wallis one-way ANOVA (Zar 1999). If significant differences were detected among the four methods (electrofishing, beach seine, fyke net, and bag seine), then a Wilcoxon rank sum test was used to compare mean differences between each of the four gear types (Zar 1999). Statistical significance (P <0.05) of multiple comparisons was adjusted with the standard Bonferroni correction (P = 0.05/n). The numbers of silvery minnow collected per sample were analyzed separately for October 2010, March 2011, October 2011, and March 2012 collections.

The catch of silvery minnow was standardized for each gear type so that relative abundance indices derived from each gear type could be compared. Beach and bag seine sample CPUE was calculated as fish per 100 m^2 seined (fish/100 m^2) and as fish per seine haul (fish/haul). Electrofishing CPUE was calculated as fish collected per minute of electricity applied (fish/minute) and as fish per 100 m^2 sampled (fish/100 m^2). Fyke net sample CPUE was calculated as fish collected per hour of soak time (fish/hour) (Quinn and Deriso 1999; Hubert and Fabrizio 2007).

Mean values of CPUE indices at each sampling location were calculated and compared between gear types using linear regression and non-parametric Spearman rank correlation coefficients (Zar 1999). A high coefficient of determination (R^2) or a high Spearman's Rho (R_s) indicated that CPUE indices were closely related and provided a similar assessment of relative abundance for silvery minnow among sites. CPUE comparisons were conducted for October 2010, March 2011, October 2011, and March 2012 collections combined.

2.3.8 MAIN CHANNEL SILVERY MINNOW SIZE

Standard length of silvery minnow was compared across gear types using a Kruskal-Wallis one-way ANOVA (Zar 1999). If significant differences were detected among the four methods (electrofishing, beach seine, fyke net, and bag seine), then a Wilcoxon rank sum test was used to compare mean differences between each of the three gear types (Zar 1999). Statistical significance (P <0.05) of multiple comparisons was adjusted with the standard Bonferroni correction (P = 0.05/n). Standard length was analyzed separately for October 2010, March 2011, October 2011, and March 2012 collections.

2.3.9 POWER ANALYSIS OF SAMPLING DATA

Power analysis was used to evaluate the precision of the data collected by SWCA in 2010 and 2011 for determining necessary sample sizes using different gear types to detect changes in CPUE of silvery minnow. The Resampling Stats program (Blank et al. 2001) was used to randomly resample the data for different size samples. This resampling routine randomly selected data from the original sample set, with replacement, and gave each sample 1/n probability of being selected each time. This technique is called bootstrapping and effectively normalizes the data. Resampling Stats version 4.0 was also used to perform 1,000 simulations (i.e., iterations) on each constructed data set (i.e., Monte Carlo simulations) for a reasonable array of prospective sample sizes for floodplain/side channel monitoring in the spring (i.e., 10, 20, 30, 40, 60, 80, 100, 150, and 200) and main channel monitoring at low flows in the spring and fall (i.e., 10, 20, 30, 40, 60, 80, 100, 150, 200, 300, 400, and 600). Mean, coefficient of variation (CV), and upper and lower 95% confidence intervals (C.I.) were recorded for the 1,000 simulations for each sample size and plotted to illustrate 1) change in upper and lower 95% confidence bounds, 2) change in CV, and 3) percent detectable change.

Samples collected from all sites were pooled for the analysis to increase sample size. Thus, the interpretation of sample sizes to achieve metrics of comparison should be interpreted as the number of samples collected from all sites combined. A single sample from a floodplain/side channel habitat consisted of all the data collected from one of the predefined polygons. In contrast, a single sample from the main channel consisted of the data collected from a single mesohabitat unit (for the beach seine and the backpack electrofishing unit), a single four-hour set (for fyke nets), or a single haul through multiple mesohabitats (for bag seine).

Results for each year, sampling occasion, and gear were plotted (Appendices E–J). Metrics used to compare the effectiveness of gear types were the number of samples required to achieve a CV of 0.2 and the number of samples required to detect a 50% change in the mean catch rate among samples. Tabular summaries were created of these metrics to address three primary questions:

1. Is it more effective to standardize backpack electrofishing data CPUE by time or by area?
2. Which gear type is most effective for monitoring silvery minnow CPUE in floodplain and side channel habitats?
3. Which gear type is most effective for monitoring silvery minnow CPUE in the main channel (spring and fall low flow periods)?

A gear type was considered most "effective" if it required the fewest number of samples to achieve the comparison metric thresholds. Because the different gear types require differing amounts of time, equipment, and staff effort to collect a single sample, these particular comparisons may not always identify the most efficient gear type from an effort perspective. The effort per sample is compared in the next section.

2.3.10 COMPARISON OF SAMPLING EFFORT AMONG GEARS

Comparisons of effort required in this study to deploy each gear in floodplain and side channel habitats and in main channel habitats were conducted to help identify the most efficient gear type for monitoring silvery minnow CPUE. Comparisons were made of type of data collected, number of sites sampled, number of sampling locations, size of sampling location, crew size required to use the gear, time required to sample, equipment required, and the field measurements collected.

3.0 RESULTS

3.1 FLOODPLAIN AND SIDE CHANNEL FISH COMMUNITY COMPOSITION AND SPECIES DETECTION

Overall, 2,364 fish from 13 species were collected during sampling of floodplain and side channel sites during May and June 2010. Adult silvery minnow was the most commonly collected species. Red shiner (*Cyprinella lutrensis*), common carp (*Cyprinus carpio*), and white sucker (*Catostomus commersonii*) were also common in collections, although many individuals of these species were young-of-year fish (Table 1). All other species or groups constituted less than 10% of the combined catch. Among gear types, more fish were collected with beach seines (1,210) and fyke nets (624) than with backpack electrofishing (525), and percent composition of the most common species varied among gear types during May and June 2010. Adult silvery minnow comprised the majority of the fyke net (71%) and backpack electrofishing (56%) catch, while red shiner was the most common species collected with beach seines (36%). Common carp and white sucker comprised 43% and 30% of the beach seine and backpack electrofishing catch, respectively, but only comprised 9% of the fyke net catch. Although red shiner was the most common species collected with beach seines, it was the second and fourth most common species collected with fyke nets and backpack electrofishing, respectively.

During May and June 2011, fish totaling 1,299 from 14 species were collected during sampling of floodplain and side channel sites. White sucker was the most commonly collected species. Unknown larval fish, red shiner, silvery minnow, and flathead chub (*Platygobio gracilis*) were also common in collections (see Table 1). All other species or groups comprised less than 10% of the combined catch. Among gear types, more fish were collected with beach seines (869) and fyke nets (281) than with backpack electrofishing (149), and species composition of the catch varied among gear types. Adult silvery minnow comprised the majority of the fyke net (56%) and backpack electrofishing (41%) catch, while unknown larval fish and white sucker were the most common species collected with beach seines, comprising 35% and 32% of the beach seine catch, respectively. Unknown larval fish and white suckers only comprised 3% and 12% of the backpack electrofishing catch, and 1% and 6% of the total fyke net catch, respectively.

Percent similarity between gear types was greater during 2010 than during 2011. Overall fyke net and backpack electrofishing species composition was similar during both years, with 74% and 67% similarity for 2010 and 2011, respectively (Table 2). Conversely, beach seine species composition was dissimilar to fyke net and backpack electrofishing species composition during both years. Beach seine species composition was 51% similar to backpack electrofishing during October 2010 and less than 40% similar to all other electrofishing and fyke net species compositions (see Table 2).

Species detection did not differ among gear types for both surveys combined (Table 3; Kruskal-Wallis one-way ANOVA, $P = 0.15$) or for surveys conducted during May and June 2010 (Kruskal-Wallis one-way ANOVA, $P = 0.51$) and May and June 2011 (Kruskal-Wallis one-way ANOVA, $P = 0.21$). Overall, species detection tended to be highest at a site when sampled with a beach seine and backpack electrofisher, and lowest for a site when sampled with fyke nets (Table 3).

Table 1. Total Number and Percent Composition of the Catch for Each Species Collected from Floodplain and Side Channel Sites Using a Backpack Electrofishing Unit, Beach Seine, and Fyke Nets during May and June 2010 and 2011

Common Name	Scientific Name	Overall		Electrofishing Unit		Beach Seine		Fyke Net	
		2010 Total (%)	2011 Total (%)	2010 Total (%)	2011 Total (%)	2010 Total (%)	2011 Total (%)	2010 Total (%)	2011 Total (%)
Red shiner	*Cyprinella lutrensis*	554 (23.43)	250 (19.25)	28 (5.33)	11 (7.38)	431 (35.62)	187 (21.52)	95 (15.10)	52 (18.51)
Common carp	*Cyprinus carpio*	387 (16.37)	56 (4.31)	80 (15.24)	6 (4.03)	273 (22.56)	19 (2.19)	34 (5.41)	31 (11.03)
Rio Grande silvery minnow	*Hybognathus amarus*	848 (35.87)	230 (17.71)	293 (55.81)	61 (40.94)	108 (8.93)	13 (1.50)	447 (71.07)	156 (55.52)
Fathead minnow	*Pimephales promelas*	44 (1.86)	17 (1.31)	17 (3.24)	11 (7.38)	15 (1.24)	1 (0.12)	12 (1.91)	5 (1.78)
Flathead chub	*Platygobio gracilis*	38 (1.61)	95 (7.31)	4 (0.76)	27 (18.12)	21 (1.74)	52 (5.98)	13 (2.07)	16 (5.69)
Longnose dace	*Rhinichthys cataractae*	0 (0.00)	1 (0.08)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.12)	0 (0.00)	0 (0.00)
River carpsucker	*Carpiodes carpio*	0 (0.00)	3 (0.23)	0 (0.00)	2 (1.34)	0 (0.00)	1 (0.12)	0 (0.00)	0 (0.00)
White sucker	*Catostomus commersonii*	355 (15.02)	314 (24.17)	79 (15.05)	18 (12.08)	252 (20.83)	279 (32.11)	24 (3.82)	17 (6.05)
Yellow bullhead catfish	*Ameiurus natalis*	1 (0.04)	2 (0.15)	0 (0.00)	2 (1.34)	0 (0.00)	0 (0.00)	1 (0.16)	0 (0.00)
Channel catfish	*Ictalurus punctatus*	1 (0.04)	3 (0.23)	0 (0.00)	2 (1.34)	1 (0.08)	1 (0.12)	0 (0.00)	0 (0.00)
Rainbow trout	*Oncorhynchus mykiss*	0 (0.00)	1 (0.08)	0 (0.00)	1 (0.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Western mosquitofish	*Gambusia affinis*	6 (0.25)	7 (0.54)	1 (0.19)	1 (0.67)	4 (0.33)	5 (0.58)	1 (0.16)	1 (0.36)
White bass	*Morone chrysops*	3 (0.13)	0 (0.00)	2 (0.38)	0 (0.00)	1 (0.08)	0 (0.00)	0 (0.00)	0 (0.00)
Green sunfish	*Lepomis cyanellus*	9 (0.38)	4 (0.31)	2 (0.38)	2 (1.34)	5 (0.41)	1 (0.12)	2 (0.32)	1 (0.36)
Largemouth bass	*Micropterus salmoides*	0 (0.00)	3 (0.23)	0 (0.00)	1 (0.67)	0 (0.00)	2 (0.23)	0 (0.00)	0 (0.00)
White crappie	*Pomoxis annularis*	2 (0.08)	0 (0.00)	1 (0.19)	0 (0.00)	1 (0.08)	0 (0.00)	0 (0.00)	0 (0.00)
Yellow perch	*Perca flavescens*	16 (0.68)	0 (0.00)	1 (0.19)	0 (0.00)	15 (1.24)	0 (0.00)	0 (0.00)	0 (0.00)
Unknown larval fish		100 (4.23)	313 (24.10)	17 (3.24)	4 (2.68)	83 (6.86)	307 (35.33)	0 (0.00)	2 (0.71)
Total		**2,364 (100.00)**	**1,299 (100.00)**	**525 (100.00)**	**149 (100.00)**	**1,210 (100.00)**	**869 (100.00)**	**629 (100.00)**	**281 (100.00)**

Note: Percentages may not sum exactly due to rounding.

Table 2. Percent Similarity of Species Composition Data Collected from Floodplain and Side Channel Sites during June and May 2010 and June and May 2011

Comparison	2010 Percent	2011 Percent
Electrofishing vs. beach seine	51%	33%
Electrofishing vs. fyke net	74%	67%
Beach seine vs. fyke net	37%	35%

Table 3. Numbers of Floodplain and Side Channel Sampling Polygons (9 total) for the Backpack Electrofishing Unit, Beach Seine, and Fyke Nets in May and June 2010 and May and June 2011

Common Name	Electrofishing Unit		Beach Seine		Fyke Net	
	2010	2011	2010	2011	2010	2011
Yellow bullhead catfish	0	1	0	0	1	0
River carpsucker	–	2	–	1	–	0
White sucker	9	5	9	8	4	4
Red shiner	6	6	8	8	7	4
Common carp	9	5	8	4	4	3
Western mosquitofish	1	1	2	2	1	1
Rio Grande silvery minnow	9	5	8	6	8	4
Channel catfish	0	2	1	1	0	0
Green sunfish	2	2	1	1	2	1
Largemouth bass	–	1	–	2	–	0
White bass	1	–	1	–	0	–
Rainbow trout	–	1	–	0	–	0
Yellow perch	1	–	4	–	0	–
Fathead minnow	7	4	3	1	3	3
Flathead chub	2	7	5	8	4	5
White crappie	1	–	1	–	0	–
Longnose dace	–	0	–	1	–	0
Mean	**3.69**	**3.00**	**3.92**	**3.07**	**2.62**	**1.79**
Standard error	**1.23**	**0.60**	**1.10**	**0.83**	**0.90**	**0.52**

Note: – indicates the species was not collected by any gear type during that survey.

3.1.1 FLOODPLAIN AND SIDE CHANNEL SPECIES RICHNESS

The number of species collected at a sample polygon during each sampling occasion during May and June 2010 varied by gear type (Table 4; Kruskal-Wallis ANOVA, P = 0.02). Beach seine samples generally documented the highest species richness. On average, backpack electrofishing detected 92% of the species detected at a site with a beach seine, and fyke nets detected 73%. Mean number of species detected at a sample location with beach seines (mean = 3.83 species) was significantly greater than the number detected with fyke nets (mean = 2.78 species; Wilcoxon rank sum test, P = 0.03), but neither detected significantly different numbers of species compared to backpack electrofishing (mean = 3.54 species; $P \geq 0.05$).

The number of species collected at a sampling polygon during each sampling occasion during May and June 2011 also varied by gear type (see Table 4; Kruskal-Wallis ANOVA, $P \leq 0.001$). Beach seine samples generally documented the highest species richness. On average, backpack electrofishing detected 77% of the species detected at a site with a beach seine, and fyke nets detected 45%. Mean number of species detected at a sample location with beach seines (mean = 2.1 species) and backpack electrofishing (mean = 1.6) was significantly greater than the number detected with fyke nets (mean = 0.9 species; Wilcoxon rank sum test, both $P \leq 0.01$). No difference was found between mean number of species detected with beach seines and backpack electrofishing.

Species richness also differed among gear types for both surveys combined (see Table 4; Kruskal-Wallis ANOVA, $P \leq 0.001$). The overall mean number of species detected at a sample location with beach seines (mean = 2.9 species) and backpack electrofishing (mean = 2.3) was significantly greater than the number detected with fyke nets (mean = 1.7 species; Wilcoxon rank sum test, both $P \leq 0.01$). No difference was found between mean number of species detected with beach seines and backpack electrofishing for both data sets combined.

Table 4. Mean Number of Species Captured at Each Polygon during Each Sampling Occasion with the Backpack Electrofishing Unit, Beach Seine, and Fyke Nets, from Floodplain and Side Channel Habitats during May and June 2010 and May and June 2011.

Statistic	Electrofishing Unit			Beach Seine			Fyke Net		
	May–June 2010	May–June 2011	Overall Summary	May–June 2010	May–June 2011	Overall Summary	May–June 2010	May–June 2011	Overall Summary
Sample size	26	45	71	36	45	81	27	45	72
Mean	3.54	1.64	2.34	3.83	2.13	2.89	2.78	0.98	1.65
Standard error	0.26	0.17	0.18	0.26	0.16	0.17	0.30	0.15	0.18

3.1.2 FLOODPLAIN AND SIDE CHANNEL SILVERY MINNOW RELATIVE ABUNDANCE

During May and June 2010, the number of silvery minnow captured at a polygon during each sampling occasion varied among gear types (Table 5; Kruskal-Wallis ANOVA, $P \leq 0.001$). The number of silvery minnow captured on a sampling occasion with fyke nets (mean = 16.56 fish) and electrofishing unit (mean = 11.27 fish) did not differ significantly (Wilcoxon rank sum test $P = 0.31$), but both gears captured more silvery minnow than beach seines (mean = 3.0 fish; $P \leq 0.05$). On average, fyke nets collected 1.5 and 5.5 times as many silvery minnow as the backpack electrofishing unit and beach seine, respectively.

The number of silvery minnows captured at a polygon during each sampling occasion was not different among gear types during May and June 2011 (see Table 5; Kruskal-Wallis ANOVA, $P = 0.13$). Despite the lack of statistical significance, the number of silvery minnow captured on a sampling occasion was greater with fyke nets (mean = 3.47 fish) than electrofishing (mean = 1.36 fish) or beach seines (mean = 0.31 fish). On average, fyke nets collected 2.6 and 11.2 times as many silvery minnow as the backpack electrofisher and beach seine, respectively.

Table 5. Mean Number of Silvery Minnow Captured at Each Sampling Polygon during Each Sampling Occasion with the Backpack Electrofishing Unit, Beach Seine, and Fyke Nets, from Floodplain and Side Channel Habitats during May and June 2010 and May and June 2011.

Statistic	Electrofishing Unit		Beach Seine		Fyke Net	
	2010	2011	2010	2011	2010	2011
Sample size	26	45	36	45	27	45
Total captured	293	61	108	14	447	156
Mean	11.27	1.36	3.00	0.31	16.56	3.47
Standard error	3.11	0.45	0.67	0.09	3.05	1.07

When combining all of the CPUE data for floodplain and side channel sampling, silvery minnow relative abundance indices were significantly correlated between all three gear types (Table 6; Appendix K). Only one contrast was not significant and this was between fyke net (fish/hour) and electrofishing (fish/100 m^2). Linear regression and non-parametric rank correlation coefficients (Spearman's Rho [R_s]) indicate that beach seines and backpack electrofishing approximately tracked the same silvery minnow relative abundance for floodplain and side channel survey areas. Although fyke net indices of silvery minnow relative abundance were significantly correlated with those calculated for beach seines and backpack electrofishing, coefficients of determination (R^2) and rank correlation coefficients (Spearman's Rho [R_s]) were lower for all contrasts than they were between beach seine and backpack electrofishing contrasts. This indicates that fyke net indices of silvery minnow relative abundance provide a different picture of relative abundance for the species than the other two gear types. Since fyke nets collected more fish per sample during both years of sampling, this increased variability likely results from environmental conditions that affected fyke net catches differentially than beach seine and backpack electrofishing catches such as low water clarity, the presence of large woody debris, and/or increased presence of rooted vegetation at floodplain sites.

Table 6. Correlation between Silvery Minnow Relative Abundance Indices Calculated for Floodplain and Side Channel Samples Collected during May and June 2010 and May and June 2011

Contrast	Regression (*P*)	R^2	Rank Correlation (*P*)	R_s
Fyke (fish/hour) (y) vs. electrofishing (fish/min) (x)	0.04	0.23	0.01	0.56
Fyke (fish/hour) (y) vs. beach Seine (fish/haul) (x)	0.005	0.40	<0.001	0.72
Fyke (fish/hour) (y) vs. electrofishing (fish/100 m^2) (x)	0.07	0.19	0.01	0.57
Fyke (fish/hour) (y) vs. beach Seine (fish/100 m^2) (x)	0.009	0.36	<0.001	0.72
Electrofishing (fish/min) (y) vs. beach Seine (fish/haul) (x)	<0.00001	0.89	<0.001	0.72
Electrofishing (fish/min) (y) vs. beach Seine (fish/100 m^2) (x)	<0.00001	0.91	0.001	0.71
Beach Seine (fish/haul) (y) vs. electrofishing (fish/100 m^2) (x)	<0.00001	0.84	<0.001	0.74
Electrofishing (fish/100 m^2) (y) vs. beach Seine (fish/100 m^2) (x)	<0.00001	0.89	<0.001	0.73

3.1.3 FLOODPLAIN AND SIDE CHANNEL SILVERY MINNOW SIZE

The size of silvery minnow collected from floodplain and side channel habitats varied significantly gear types during May and June 2010 (Kruskal-Wallis ANOVA, $P \leq 0.001$). Fish collected with fyke nets were significantly larger than those collected with backpack electrofishing units and beach seines (Table 7; Wilcoxon rank sum test, $P < 0.001$). No statistical size difference was found between silvery minnow collected by backpack electrofishing and beach seines (Wilcoxon rank sum test, $P = 1.00$). Examination of silvery minnow length frequency from May and June 2010 indicates two distinct modes with a substantial amount of overlap between them (Figure 4). The second length mode was more pronounced for silvery minnow collected with fyke nets than for backpack electrofishing and beach seines. Decomposition of the length distributions resulted in a size cutoff of 62 mm standard length between age 1 and 2 silvery minnow in May. We use the standard fisheries convention of advancing a fish's age by one year on January 1 each year; thus, a fish born anytime in 2009 would be age 1 in 2010. Using 62 mm as the minimum length at age 2, 86% and 14% of silvery minnow collected with the backpack electrofishing unit and beach seine were ages 1 and 2+, while 72% and 28% of silvery minnow collected with fyke nets were ages 1 and 2+, respectively.

During May and June 2011, the size of silvery minnow collected from floodplain and side channel habitats did not vary among gear types (Kruskal-Wallis ANOVA, $P = 0.08$). Although not significant, fish collected with fyke nets (mean = 72) were larger than those collected with backpack electrofishing (mean = 67) and beach seines (mean = 66) (see Table 7). Examination of silvery minnow length frequency from May and June 2011 indicates one distinct mode with some size observations occurring well to the left and right sides of the distribution (Figure 5). Using the minimum length at age 2 (62 mm) derived from length frequency data collected during 2010, the majority of silvery minnow collected during May and June 2011 were age 2 (93%), while a few were age 1 (7%).

Table 7. Size Summary Statistics for Silvery Minnow Collected with Backpack Electrofishing, Beach Seines, and Fyke Nets from Floodplain and Side Channel Habitats during May and June 2010 and May and June 2011

Statistic	Electrofishing Unit		Beach Seine		Fyke Net	
	2010	2011	2010	2011	2010	2011
Sample size	293	61	107	18	444	154
Range	40	30	42	37	44	45
Mean	53	67	52	66	57	72
Standard error	0.45	0.77	0.79	2.54	0.43	0.54

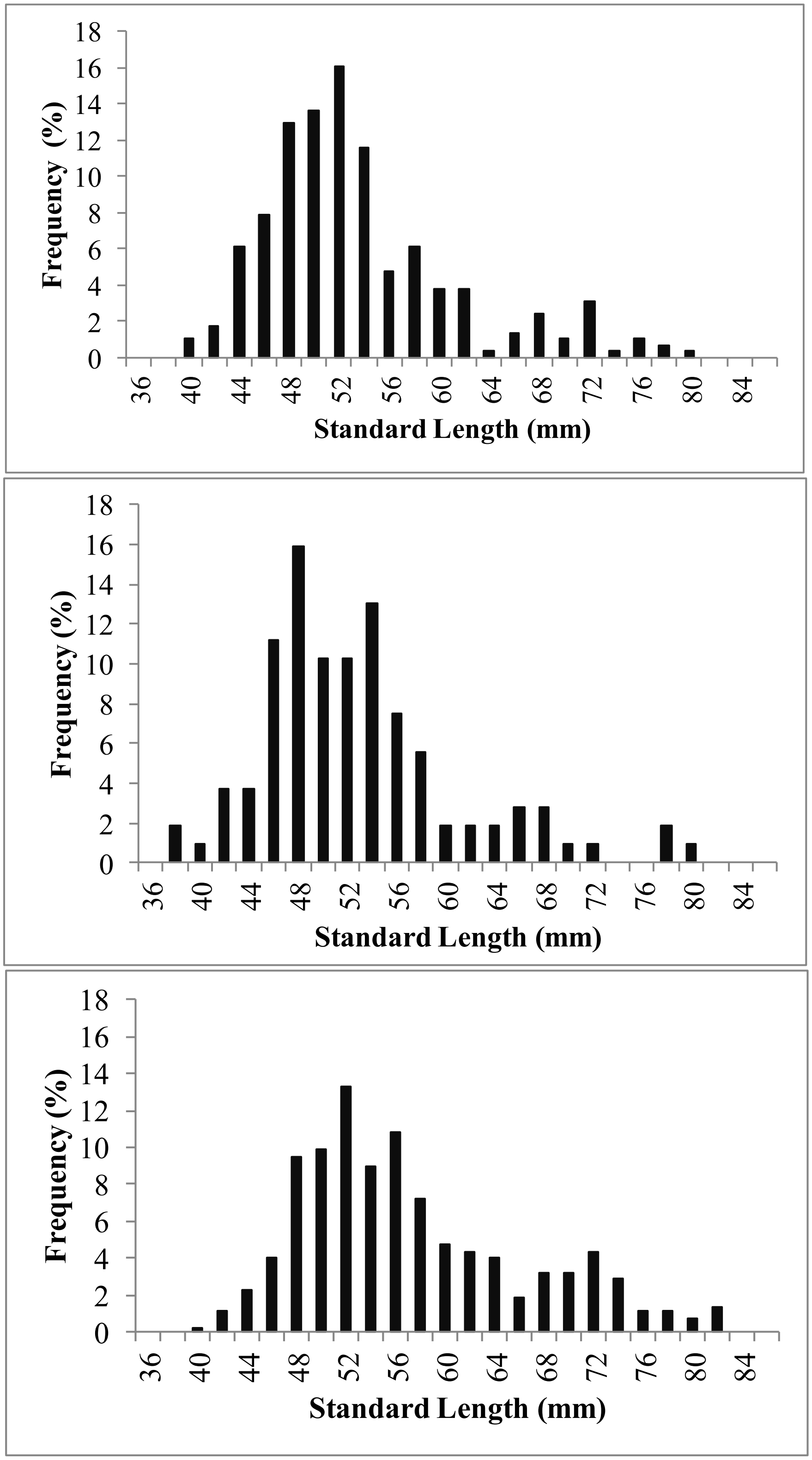

Figure 4. Length frequency of silvery minnow collected with backpack electrofishing (top), beach seine (middle), and fyke nets (bottom) during May and June 2010

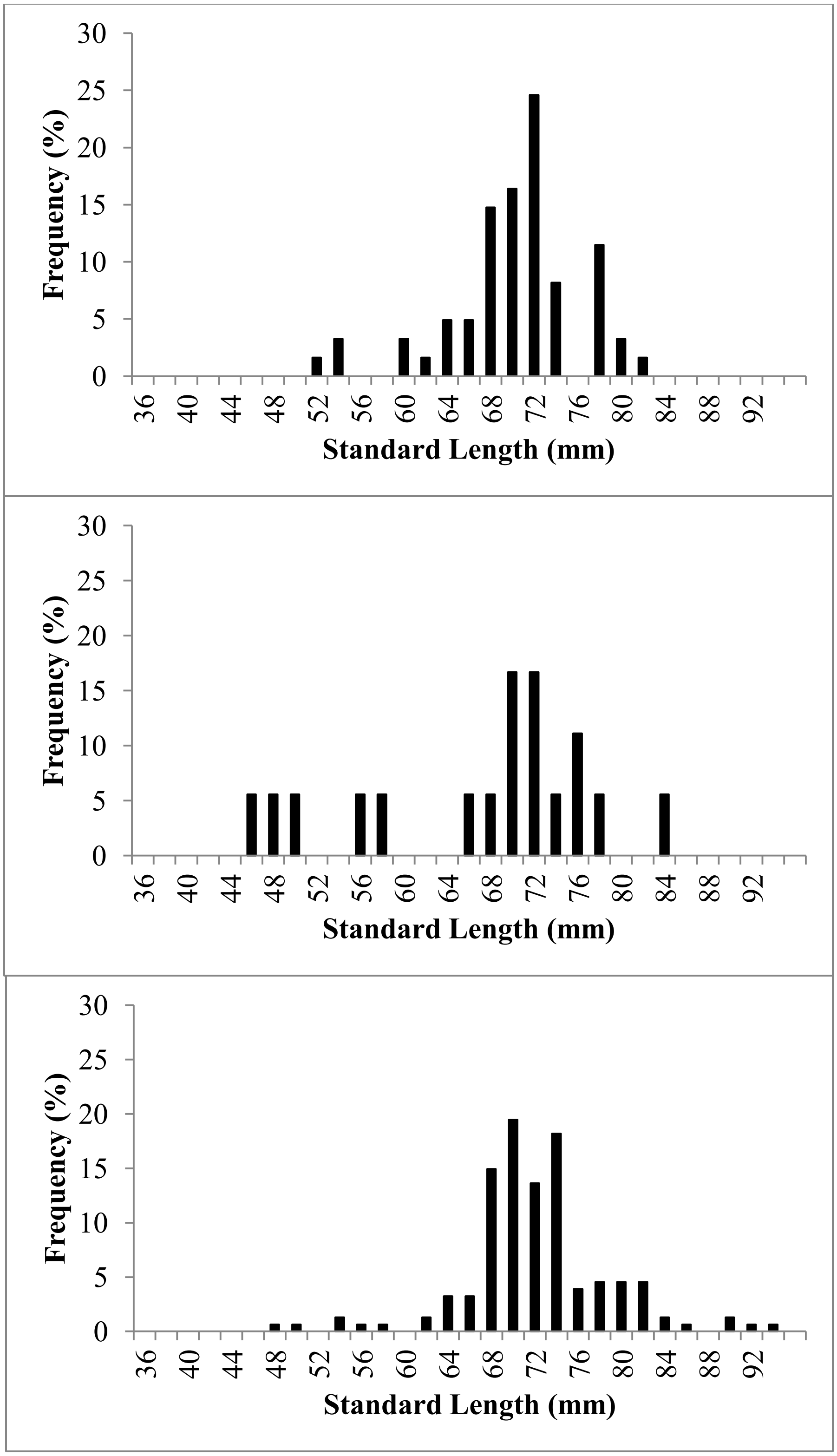

Figure 5. Length frequency of silvery minnow collected with backpack electrofishing (top), beach seine (middle), and fyke nets (bottom) from floodplain and side channel habitats during May and June 2011.

3.1.4 MAIN CHANNEL FISH COMMUNITY COMPOSITION AND SPECIES DETECTION

In October 2010 fish totaling 2,296 from 15 species were collected during sampling of main channel habitats (i.e., all blocks and sites combined). Red shiner and western mosquitofish (*Gambusia affinis*) were the most commonly collected species. Flathead chub, channel catfish (*Ictalurus punctatus*), and silvery minnow were also common in collections (Table 8). All other species or groups comprised less than 10% of the combined catch. The number of fish collected was higher with the beach seine (1,582) than with the backpack electrofishing unit (328), fyke net (226), and the bag seine (160). Unlike the samples collected in the floodplain and side channel habitats, the number of samples per block and the total area sampled per block in the main channel varied with each gear type; thus, total numbers of fish collected may not be an indicator of gear effectiveness. Percent composition of the catch for the most common species varied among gear types during October 2010. Red shiner was the most common species collected with the beach seine (72% of the catch), the backpack electrofishing unit (36%), and the bag seine (40%), while channel catfish was the most commonly collected species with a fyke net (54%). Silvery minnow was commonly collected with the backpack electrofishing unit (22% of the catch), the bag seine (28%), and the fyke net (12%) but not with the beach seine (1%). Flathead chub was also common in the bag seine (19%), backpack electrofishing unit (16%), and beach seine (7%) collections. No flathead chub were collected with the fyke net.

During March 2011, 2,083 fish from 10 species were collected during sampling of main channel habitats. Red shiner and flathead chub were the most commonly collected species. Western mosquitofish and silvery minnow were also common in collections, comprising 5% and 4% of the combined catch, respectively. All other species or groups comprised less than 10% of the combined catch (see Table 8). The number of fish collected was higher with the beach seine (1,669) than with the backpack electrofishing unit (265), bag seine (101), and fyke net (46). Percent composition of the catch for the most common species varied little among gear types during March 2010. Red shiner was the most common species collected with all four gear types. Silvery minnow were commonly collected with the three principal gear types (backpack electrofishing unit, beach seine, and fyke net) but not with the bag seine. Only two fish (both silvery minnow) were collected from Site 5 (380 Bridge) with the electrofishing and beach seine combination.

In October 2011, fish totaling 5,022 from 12 species were collected during sampling of main channel habitats (i.e., all blocks and sites combined). Red shiner and western mosquitofish were the most commonly collected species. Fathead minnow (*Pimephales promelas*) were also common in collections (see Table 8). All other species or groups comprised less than 10% of the combined catch. The number of fish collected was higher with the beach seine (3,810) than with the backpack electrofishing unit (690), fyke net (342), and bag seine (180). Percent composition of the catch for the most common species varied little among gear types during October 2011. Red shiner was the most common species collected with the beach seine (93% of the catch), fyke net (91%), backpack electrofishing (71%), and bag seine (57%). Silvery minnow was commonly collected with the backpack electrofishing unit (9% of the catch) and the bag seine (9%), but not with the fyke net (2%) or beach seine (0.42%) during October 2011.

Fish totaling 2,534 from 10 species were collected during sampling of main channel habitats (i.e., all blocks and sites combined) in March 2012. Red shiner and silvery minnow were the most commonly collected species. River carpsucker (*Carpiodes carpio*) and common carp were also common in collections (see Table 8). All other species or groups comprised less than 10% of the combined catch. The number of fish collected was higher with the beach seine (2,059) than with the backpack electrofishing unit (322), fyke net (107), and bag seine (46). Percent composition of the catch for the most common species varied among gear types during March 2012. Red shiner was the most common species collected with all the gear types (range 61%–91% of the catch) except for with fyke nets where silvery minnow (73%) was the most commonly collected species.

Percent similarity of species composition data from main channel habitats was similar among gear types and surveys (Table 9). The lowest similarity between gear types occurred in March 2012 and October 2010 when species composition data between fyke nets and beach seines was 27% and 36% similar, respectively. Conversely, species composition was almost identical between fyke nets and beach seines during October 2011 (96%).

Species detection differed among gear types for all main channel surveys combined (Table 10; Kruskal-Wallis one-way ANOVA, $P < 0.0001$) but did not differ for surveys conducted in October 2010, March 2011, and October 2011 (Kruskal-Wallis one-way ANOVA, $P > 0.05$). During March 2012 species detection differed among gear types (Kruskal-Wallis one-way ANOVA, $P = 0.03$); however, pairwise comparisons did not indicate differences between gear types for this survey.

For all main channel surveys combined, pairwise comparisons indicate that beach seines and backpack electrofishing detected fish at a greater rate than fyke nets (Wilcoxon rank sum test, $P < 0.001$). No differences in species detection were found between beach seines and backpack electrofishing (Wilcoxon rank sum test, $P > 0.05$). On average beach seines and backpack electrofishing detected a species at 2.2 sites while fyke nets detected a species at 1.0 sites.

Table 8. Total Number and Percent (%) of Each Species Collected from Main Channel Sites with Backpack Electrofishing, Beach Seines, Fyke Nets, and Bag Seines during October 2010, March 2011, October 2011, and March 2012

Common Name (Scientific Name)	Overall Total (%)				Electrofishing Unit Total (%)				Beach Seine Total (%)				Fyke Net Total (%)				Bag Seine Total (%)			
	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012
Gizzard shad (*Dorosoma cepedianum*)	1 (0.04)	0 (0.00)	0 (0.00)	1 (0.04)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.06)	0 (0.00)	0 (0.00)	1 (0.05)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Red shiner	1,393 (60.67)	1,646 (79.02)	4,437 (88.35)	2,127 (83.94)	117 (35.67)	179 (67.55)	491 (71.16)	196 (60.87)	1,139 (72.00)	1,364 (81.73)	3,531 (92.68)	1,871 (90.87)	74 (32.74)	25 (54.35)	312 (91.23)	28 (26.17)	63 (39.38)	78 (77.23)	103 (57.22)	32 (69.57)
Common carp	14 (0.61)	1 (0.05)	62 (1.23)	65 (2.57)	13 (3.96)	0 (0.00)	52 (7.54)	3 (0.93)	0 (0.00)	1 (0.06)	6 (0.16)	62 (3.01)	1 (0.44)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	4 (2.22)	0 (0.00)
Rio Grande silvery minnow	160 (6.97)	78 (3.74)*	99 (1.97)	196 (7.73)	73 (22.26)	20 (7.55)	61 (8.84)	96 (29.81)	17 (1.07)	45 (2.70)	16 (0.42)	12 (0.58)	26 (11.50)	10 (21.74)	6 (1.75)	78 (72.90)	44 (27.50)	1 (0.99)	16 (8.89)	10 (21.74)
Fathead minnow	35 (1.52)	12 (0.58)	113 (2.25)	22 (0.87)	19 (5.79)	6 (2.26)	48 (6.96)	5 (1.55)	11 (0.70)	4 (0.24)	41 (1.08)	15 (0.73)	1 (0.44)	2 (4.35)	4 (1.17)	1 (0.93)	4 (2.50)	0 (0.00)	20 (11.11)	1 (2.17)
Flathead chub	197 (8.58)	215 (10.32)	72 (1.43)	22 (0.87)	51 (15.55)	47 (17.74)	1 (0.14)	6 (1.86)	116 (7.33)	152 (9.11)	67 (1.76)	13 (0.63)	0 (0.00)	7 (15.22)	0 (0.00)	0 (0.00)	30 (18.75)	9 (8.91)	4 (2.22)	3 (6.52)
Longnose dace	4 (0.17)	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.61)	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.13)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
River carpsucker	16 (0.70)	14 (0.67)	66 (1.31)	76 (3.00)	3 (0.91)	1 (0.38)	6 (0.87)	3 (0.93)	9 (0.57)	3 (0.18)	33 (0.87)	73 (3.55)	1 (0.44)	0 (0.00)	1 (0.29)	0 (0.00)	3 (1.88)	10 (9.90)	26 (14.44)	0 (0.00)
White sucker	0 (0.00)	0 (0.00)	1 (0.02)	2 (0.08)	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.62)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.56)	0 (0.00)
Yellow bullhead catfish	7 (0.30)	0 (0.00)	2 (0.04)	0 (0.00)	7 (2.13)	0 (0.00)	2 (0.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Channel catfish	172 (7.49)	10 (0.48)	23 (0.46)	8 (0.32)	18 (5.49)	5 (1.89)	7 (1.01)	1 (0.31)	18 (1.14)	2 (0.12)	10 (0.26)	7 (0.34)	122 (53.98)	0 (0.00)	2 (0.58)	0 (0.00)	14 (8.75)	3 (2.97)	4 (2.22)	0 (0.00)
Western mosquitofish	290 (12.63)	105 (5.04)	145 (2.89)	15 (0.59)	23 (7.01)	7 (2.64)	20 (2.90)	10 (3.11)	266 (16.81)	97 (5.81)	106 (2.78)	5 (0.24)	0 (0.00)	1 (2.17)	17 (4.97)	0 (0.00)	1 (0.63)	0 (0.00)	2 (1.11)	0 (0.00)
White bass	3 (0.13)	1 (0.05)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.06)	1 (0.06)	0 (0.00)	0 (0.00)	1 (0.44)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.63)	0 (0.00)	0 (0.00)	0 (0.00)
Green sunfish	1 (0.04)	1 (0.05)	1 (0.02)	0 (0.00)	1 (0.30)	0 (0.00)	1 (0.14)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (2.17)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Largemouth bass	0 (0.00)	0 (0.00)	1 (0.02)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.14)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Walleye (*Sander vitreus*)	1 (0.04)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.30)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Unknown larvae	2 (0.09)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.13)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Total	**2,296 (100.00)**	**2,083 (100.00)**	**5,022 (100.00)**	**2,534 (100.00)**	**328 (100.00)**	**265 (100.00)**	**690 (100.00)**	**322 (100.00)**	**1,582 (100.00)**	**1,669 (100.00)**	**3,810 (100.00)**	**2,059 (100.00)**	**226 (100.00)**	**46 (100.00)**	**342 (100.00)**	**107 (100.00)**	**160 (100.00)**	**101 (100.00)**	**180 (100.00)**	**46 (100.00)**

Note: Percentages may not sum exactly due to rounding.

Table 9. Percent Similarity of Species Composition Data Collected from Main Channel Habitats during October 2010, March 2011, October 2011, and March 2012

	October 2010	March 2011	October 2011	March 2012
Electrofishing vs. beach seine	54	83	77	65
Electrofishing vs. fyke net	51	82	78	57
Electrofishing vs. bag seine	83	80	81	86
Beach seine vs. fyke net	36	69	96	27
Beach seine vs. bag seine	51	87	63	72
Fyke net vs. bag seine	54	64	62	49

Table 10. Numbers of Main Channel Sites in Which Each Species Was Captured with Backpack Electrofishing, Beach Seines, and Fyke Nets during October 2010 (4 sites total), March 2011 (4 sites total), October 2011 (5 sites total), and March 2012 (4 sites total)

Common Name	Electrofishing Unit				Beach Seine				Fyke Net			
	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012
Yellow bullhead catfish	4	–	2	–	0	–	2	–	0	–	0	–
River carpsucker	2	1	2	2	3	3	2	2	1	0	1	0
White sucker	–	–	–	1	–	–	–	0	–	–	–	0
Red shiner	4	4	4	4	4	4	5	4	3	3	4	3
Common carp	2	0	3	2	0	1	2	2	1	0	0	0
Gizzard shard	0	–	–	0	1	–	–	1	0	–	–	0
Western mosquitofish	3	2	4	1	4	3	5	3	0	1	2	0
Rio Grande silvery minnow	3	3	4	4	3	4	4	2	3	2	3	3
Channel catfish	4	2	3	1	3	1	3	2	4	0	1	0
Green sunfish	1	0	1	–	0	0	0	–	0	1	0	–
Largemouth bass	–	–	1	–	–	–	0	–	–	–	0	–
White bass	0	0	–	–	1	1	–	–	1	0	–	–
Fathead minnow	4	3	3	3	4	1	4	3	1	1	2	1
Flathead chub	3	3	1	2	3	4	4	2	0	2	0	0
Longnose dace	1	–	–	–	1	–	–	–	0	–	–	–
Walleye	1	–	–	–	0	–	–	–	0	–	–	–
Mean	**2.29**	**1.80**	**2.67**	**2.0**	**1.93**	**2.20**	**2.67**	**2.10**	**1.00**	**1.00**	**1.42**	**0.70**
Standard error	**0.40**	**0.47**	**0.36**	**0.40**	**0.44**	**0.49**	**0.54**	**0.33**	**0.36**	**0.33**	**0.45**	**0.38**

Note: – indicates the species was not collected by any gear type during that survey.

3.1.5 MAIN CHANNEL SPECIES RICHNESS

The number of species collected per site from main channel habitats differed among gear types for all surveys combined and during October 2010 and March 2012 (Table 11; Kruskal-Wallis ANOVA, $P < 0.05$). Species richness did not differ among gear types during March or October 2011 (Kruskal-Wallis ANOVA, $P > 0.05$). For all surveys combined, the number of species collected per site from main channel habitats was highest for the beach seine (5.7 species/site) and the backpack electrofisher (5.5 species/site). The lowest number of species collected per main channels site was with the fyke net (2.6 species/site), while bag seine collections were intermediate of all gear types (4.0 species/site). Pairwise Wilcoxon rank sum comparisons indicate that differences in species richness among gear types exist between beach seines and fyke nets ($P = 0.0003$), and electrofishing and fyke nets ($P = 0.009$). No other pairwise comparisons indicated differences in species richness between gear types.

Table 11. Mean Number of Species Captured at Each Site during Main Channel Sampling with a Backpack Electrofishing Unit, Beach Seine, Fyke Net, and Bag Seine during October 2010

Statistic	Electrofishing Unit					Beach Seine					Fyke Net					Bag Seine				
	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Overall Summary	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Overall Summary	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Overall Summary	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Overall Summary
Sample size	4	5	5	4	18	4	5	5	4	18	4	4	5	4	17	3	4	3	3	13
Mean	8.00	3.80	5.60	5.00	5.50	6.75	5.00	5.80	5.25	5.67	3.50	2.50	2.60	1.75	2.59	6.00	1.75	6.00	3.00	4.00
Standard error	0.40	0.97	1.63	0.71	0.63	0.95	0.84	0.49	0.95	0.40	1.04	0.96	0.75	0.48	0.40	1.00	0.48	0.00	0.58	0.61

3.1.6 MAIN CHANNEL SILVERY MINNOW RELATIVE ABUNDANCE

During October 2010, October 2011, and March 2012 the mean number of silvery minnow captured per sample from main channel habitats varied among gear types (Table 12; Kruskal-Wallis ANOVA, $P \leq 0.005$). On average the number of silvery minnow captured with the bag seine and electrofishing was greater than the number collected per sample with the beach seine (Wilcoxon rank sum test both $P \leq 0.05$). No other differences were detected between gear types and no difference was found among gear types for the number of silvery minnow collected per mesohabitat during March 2011 (Kruskal-Wallis ANOVA, $P = 0.34$).

When combining all of the CPUE data for main channel sampling, silvery minnow relative abundance indices were not significantly correlated between the four gear types tested in main channel habitats (Table 13). Although one contrast was significant between fyke net (fish/hour) and electrofishing (fish/100 m^2) for the non-parametric rank correlation coefficient, linear regression of the same indices did not indicate a correlation between the two (see Table 13).

Table 12. Mean Number of Silvery Minnow Captured per Sample with the Backpack Electrofishing Unit, Beach Seine, Fyke Net, and Bag Seine from Main Channel Habitats during October 2010, March 2011, October 2011, and March 2012

Statistic	Electrofishing Unit				Beach Seine				Fyke Net				Bag Seine			
	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012
Sample size	39	50	51	40	66	100	91	72	16	16	20	16	9	14	9	10
Total captured	73	20	61	96	17	45	16	12	26	10	6	78	44	1	16	10
Mean	1.9	0.40	1.20	2.40	0.26	0.45	0.18	0.17	1.6	0.63	0.30	4.88	4.9	0.07	1.78	1.00
Standard error	0.59	0.19	0.52	1.51	0.09	0.24	0.05	0.07	0.94	0.31	0.18	4.22	1.82	0.07	1.06	0.33

Table 13. Correlation between Silvery Minnow Relative Abundance Indices Calculated for Main Channel Samples Collected during October 2010, March 2011, October 2011, and March 2012

Contrast	Regression (P)	R^2	Rank Correlation (P)	R_s
Electrofishing (fish/100 m^2)(y) vs. bag seine (fish/100 m^2) (x)	0.99	-0.000016	0.11	0.46
Beach seine (fish/100 m^2) (y) vs. bag seine (fish/100 m^2) (x)	0.52	0.037	0.19	-0.38
Electrofishing (fish/100 m^2) (y) vs. beach seine (fish/100 m^2) (x)	0.46	0.033	0.45	0.18
Fyke net (fish/hour) (y) vs. bag seine (fish/100 m^2) (x)	0.64	0.02	0.96	0.014
Fyke net (fish/hour) (y) vs. beach seine (fish/100 m^2) (x)	0.48	0.034	0.2	0.32
Fyke net (fish/hour) (y) vs. electrofishing (fish/100 m^2) (x)	0.93	0.0004	0.05	0.49
Electrofishing (fish/min) (y) vs. bag seine (fish/haul) (x)	0.87	0.0025	0.29	0.32
Electrofishing (fish/min) (y) vs. beach seine (fish/haul) (x)	0.64	0.013	0.34	0.23
Electrofishing (fish/min) (y) vs. fyke net (fish/hour) (x)	0.88	0.0014	0.11	0.4
Fyke net (fish/hour) (y) vs. beach seine (fish/haul) (x)	0.33	0.06	0.2	0.33
Fyke net (fish/hour) (y) vs. bag seine (fish/haul) (x)	0.77	0.008	0.72	-0.11
Beach seine (fish/haul) (y) vs. bag seine (fish/haul) (x)	0.76	0.008	0.72	-0.11
Beach seine (fish/haul) (y) vs. electrofishing (fish/100 m^2) (x)	0.52	0.025	0.4	0.21
Bag seine (fish/haul) (y) vs. electrofishing (fish/100 m^2) (x)	0.96	0.00018	0.22	0.36
Beach seine (fish/haul) (y) vs. bag seine (fish/100 m^2) (x)	0.64	0.019	0.61	-0.16
Bag seine (fish/haul) (y) vs. Beach seine (fish/100 m^2) (x)	0.39	0.067	0.22	-0.37

3.1.7 MAIN CHANNEL SILVERY MINNOW SIZE

The size of silvery minnow collected from main channel habitats was not different across tested gear types during October 2010, October 2011, or March 2011 (Table 14; Kruskal-Wallis ANOVA, all $P > 0.10$). Examination of silvery minnow length frequency from October 2010 indicates two distinct modes for silvery minnow collected with the backpack electrofishing unit but not the other gear types (Figure 6). Sample sizes of silvery minnow collected during October 2010, October 2011, and March 2011 are insufficient to adequately determine age from length frequency alone (Figure 7 and Figure 8).

The size of silvery minnow collected from main channel habitats during March 2012 was different among gear types (Kruskal-Wallis ANOVA, $P < 0.0001$) (see Table 14, Figure 9). Pairwise comparisons indicate that differences were between fyke nets (mean = 53 mm) and backpack electrofishing (mean = 50 mm) (Wilcoxon rank sum test, $P = 0.0012$); however, this difference was only 3 mm and is of little biological significance. No other differences were found between gear types.

Table 14. Size Summary Statistics for Silvery Minnow Collected from Main Channel Habitats with Backpack Electrofishing, Beach Seines, Fyke Nets, and Bag Seines during October 2010, March 2011, October 2012, and March 2012

Statistic	Electrofishing Unit				Beach Seine				Fyke Net				Bag Seine			
	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012	Oct 2010	Mar 2011	Oct 2011	Mar 2012
Sample size	17	26	61	95	73	45	16	11	26	10	6	78	44	1	16	10
Range	26	21	41	54	30	29	39	13	38	30	11	36	34	-	21	20
Mean	65	59	49	50	63	57	46	50	64	61	46	53	64	70	44	53
Standard error	1.91	1.24	0.97	0.69	1.01	1.00	2.68	1.20	1.69	3.11	1.83	0.59	1.10	NA	1.67	1.94

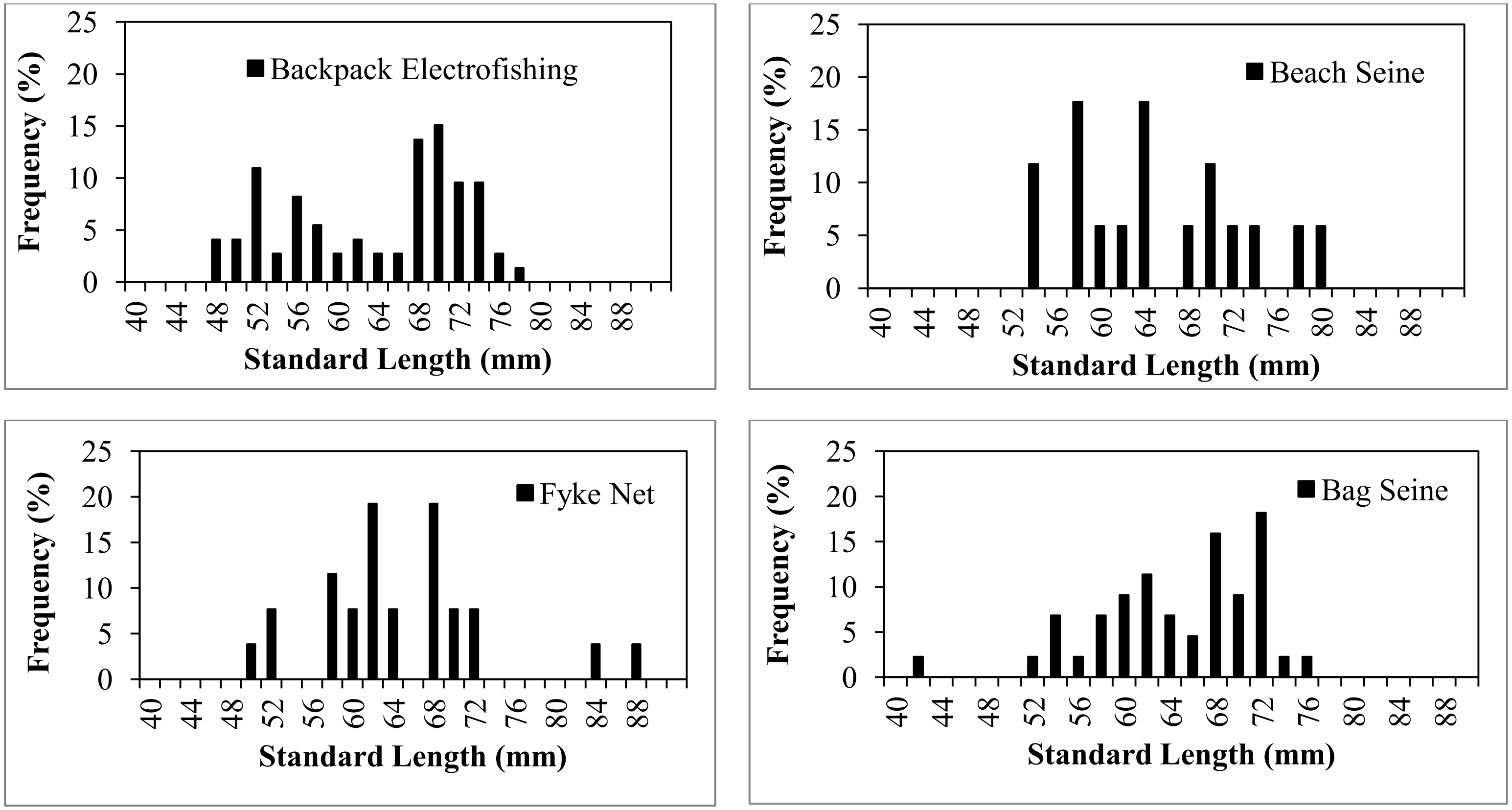

Figure 6. Length frequency of silvery minnow collected with backpack electrofishing, beach seines, fyke nets, and the bag seine from main channel habitats during October 2010.

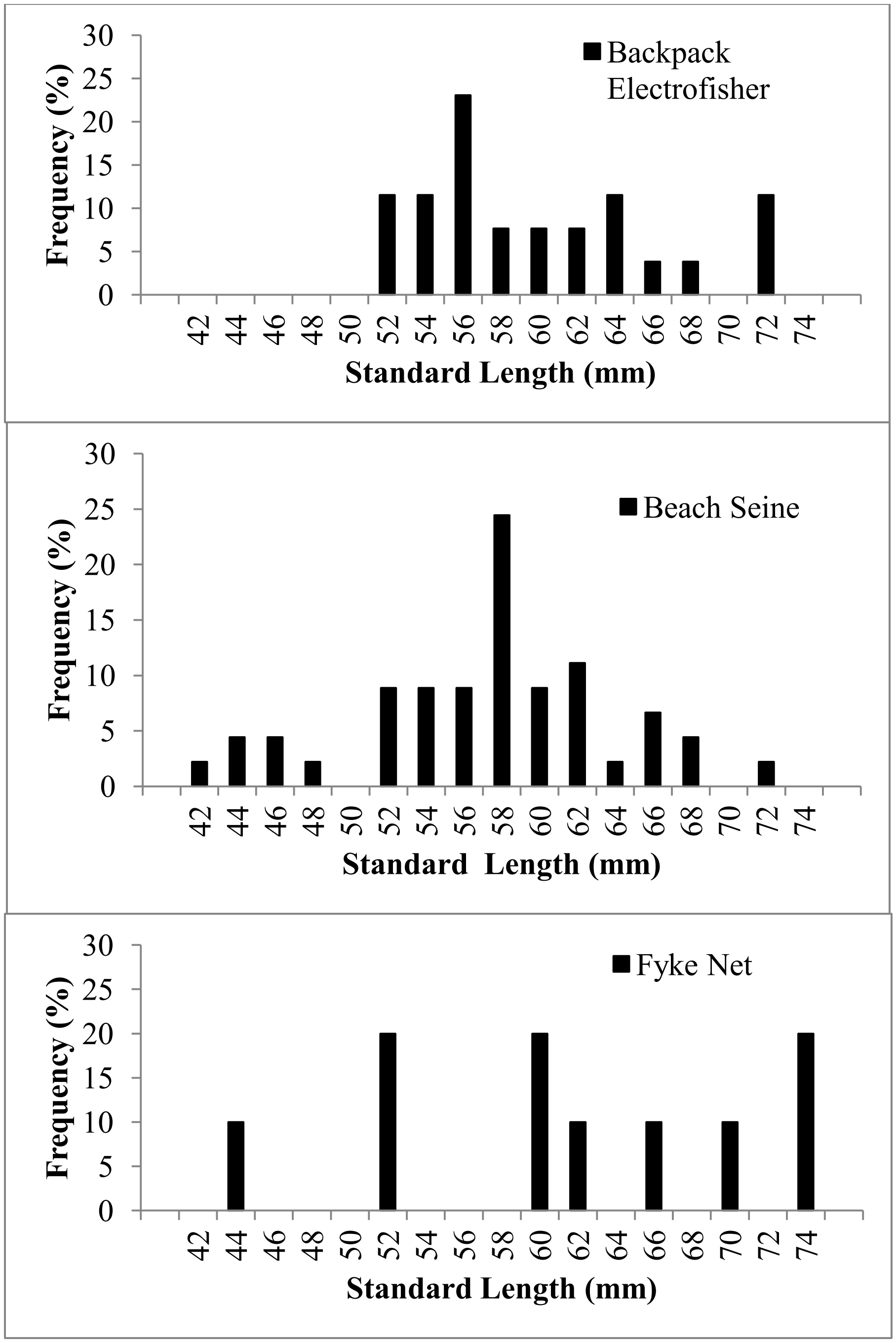

Figure 7. Length frequency of silvery minnow collected with the backpack electrofishing unit (top), beach seine (middle), and fyke nets (bottom) from main channel habitats during March 2011.

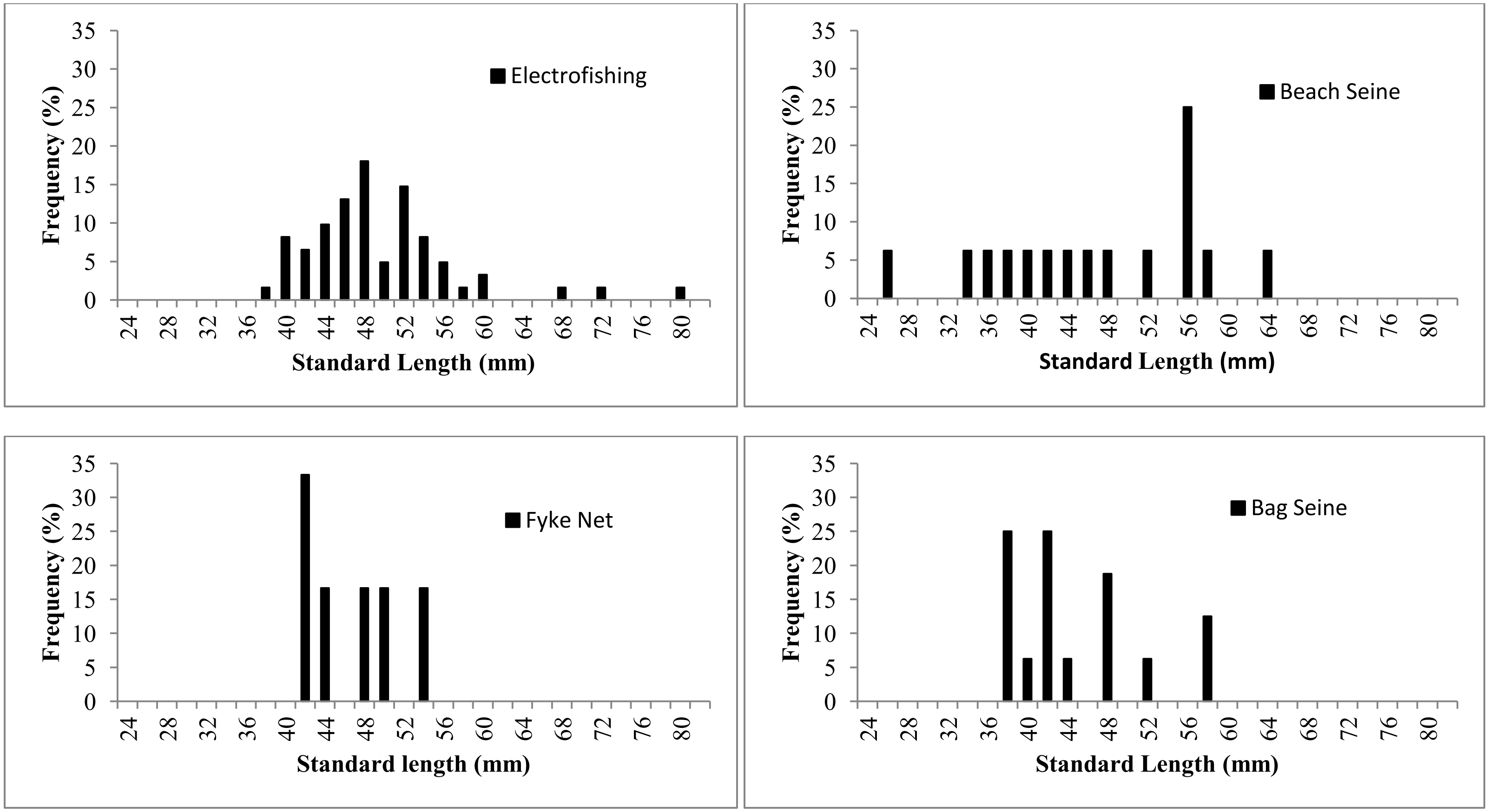

Figure 8. Length frequency of silvery minnow collected with backpack electrofishing, beach seines, fyke nets, and the bag seine from main channel habitats during October 2011.

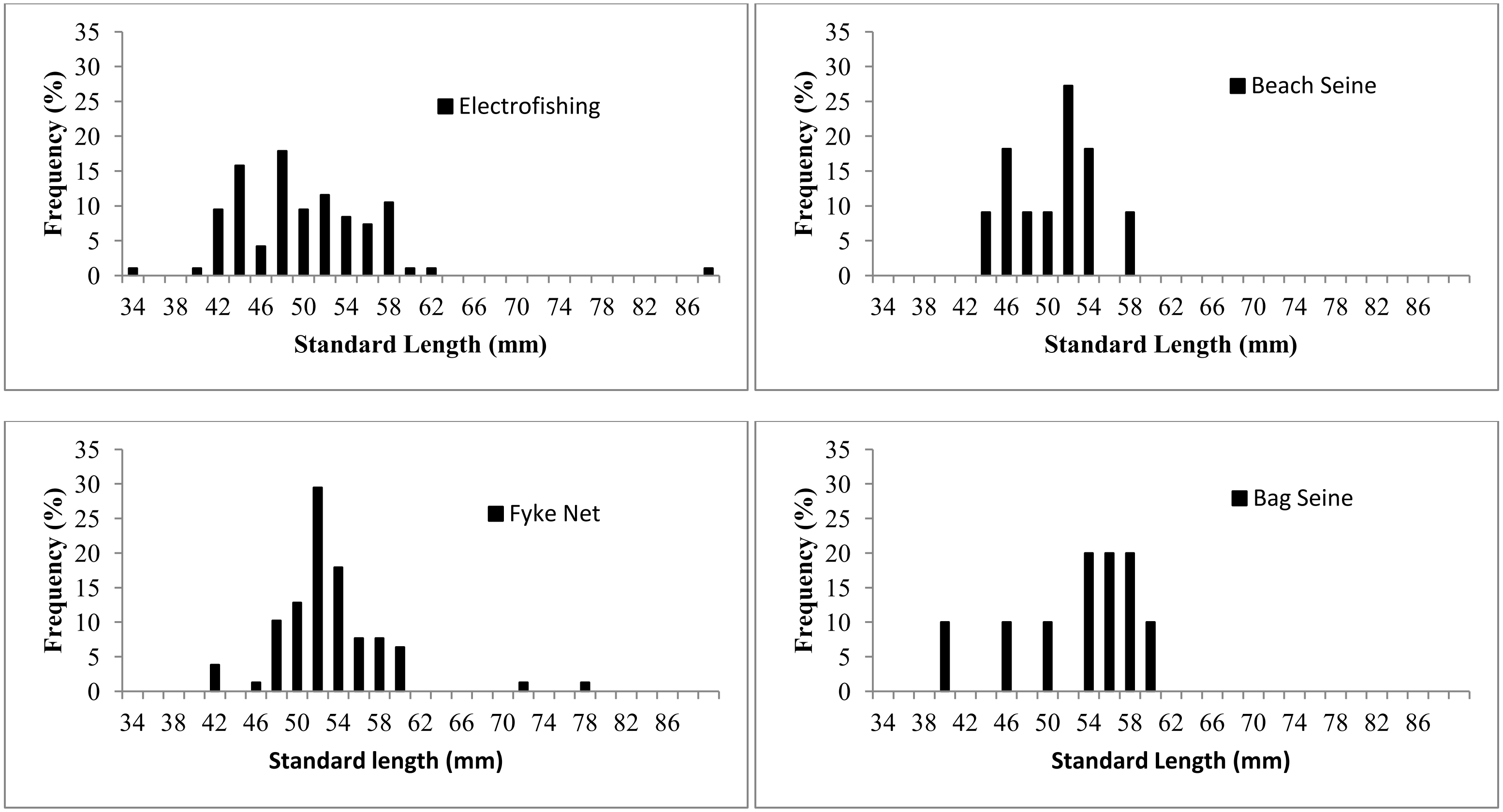

Figure 9. Length frequency of silvery minnow collected with backpack electrofishing, beach seines, fyke nets, and the bag seine from main channel habitats during March 2012.

3.1.8 POWER ANALYSIS OF SAMPLING DATA

The power analysis results are organized by the primary questions identified in the methods section for these analyses. The full power analysis results are provided in graphical format in Appendices E through J.

QUESTION 1: IS IT MORE EFFECTIVE TO STANDARDIZE BACKPACK ELECTROFISHING DATA CPUE BY TIME OR BY AREA?

The most effective means of standardization depended on the habitat being sampled in 2010 and 2011 (Table 15). Standardization of the main channel samples by seconds of electricity applied produced less variable (and thus more powerful) results. Conversely, samples collected from floodplain and side channel habitats that were standardized by area sampled produced slightly less variable results. The conflicting results may stem from differences in the way the area was standardized in the floodplain and side channel samples and the main channel samples. Samples collected from the floodplain and side channel were confined by predefined sampling polygons with known areas. Samples collected from the main channel were collected from a distinct mesohabitat unit, and the area sampled was estimated afterwards. In the main channel, time was likely a more precise measurement of effort than area sampled.

Table 15. The Number of Electrofishing Samples Needed to Achieve a CV of 0.2 in Silvery Minnow CPUE and the Detectable Change in Silvery Minnow CPUE with 100 Samples Compared across Sampling Occasions and between Catch Rate Data Standardized by Area and by Time

Sampling Location and Occasion	Approximate Number of Electrofishing Samples Needed to Achieve CV of 0.2		% of Change in Catch Rate Detectable with 100 Electrofishing Samples	
	Area Sampled (100 m^2)	Time Sampled (seconds)	Area Sampled (100 m^2)	Time Sampled (seconds)
Floodplain/ Side channel 2010	50	70	58%	66%
Floodplain/ Side channel 2011	100	125	78%	87%
Main channel fall 2010	110	100	87%	77%
Main channel spring 2011	400	200	156%	104%

QUESTION 2: WHICH GEAR TYPE IS MOST EFFECTIVE FOR MONITORING SILVERY MINNOW CPUE IN FLOODPLAIN AND SIDE CHANNEL HABITATS?

In 2010, fyke nets and beach seines produced the least variable results (i.e., had the lowest CV) and were most sensitive to change (Table 16). In 2011, a smaller percentage of the samples contained silvery minnow, so the variability among samples and the number of samples substantially increased for all gear types. The performance of all gear types was similarly poor in 2011; the number of samples required to detect a 50% change in the population was over 200, regardless of gear type (Figure **10**).

Table 16. The Number of Samples Needed to Achieve a CV of 0.2 and to Detect a 50% Change in Silvery Minnow CPUE in the Main Channel Compared across Gear Types for the Fall 2010 and Spring 2011 Sampling Occasions

Gear Type	Approximate Number of Samples Required to Achieve a CV of 0.20		Approximate Number of Samples Required to Detect a 50% Change in Mean CPUE	
	2010	2011	2010	2011
Backpack electrofishing (silvery minnow per 100 m^2 sampled)	50	100	130	>200 (58% change detectable at 200 samples)
Backpack electrofishing (silvery minnow per seconds of electricity applied)	70	125	160	>200 (61% change detectable at 200 samples)
Beach seine (silvery minnow per 100 m^2 sampled)	45	100	95	>200 (54% change detectable at 200 samples)
Fyke net (silvery minnow per fyke net hour)	18	110	60	>200 (60% change detectable at 200 samples)

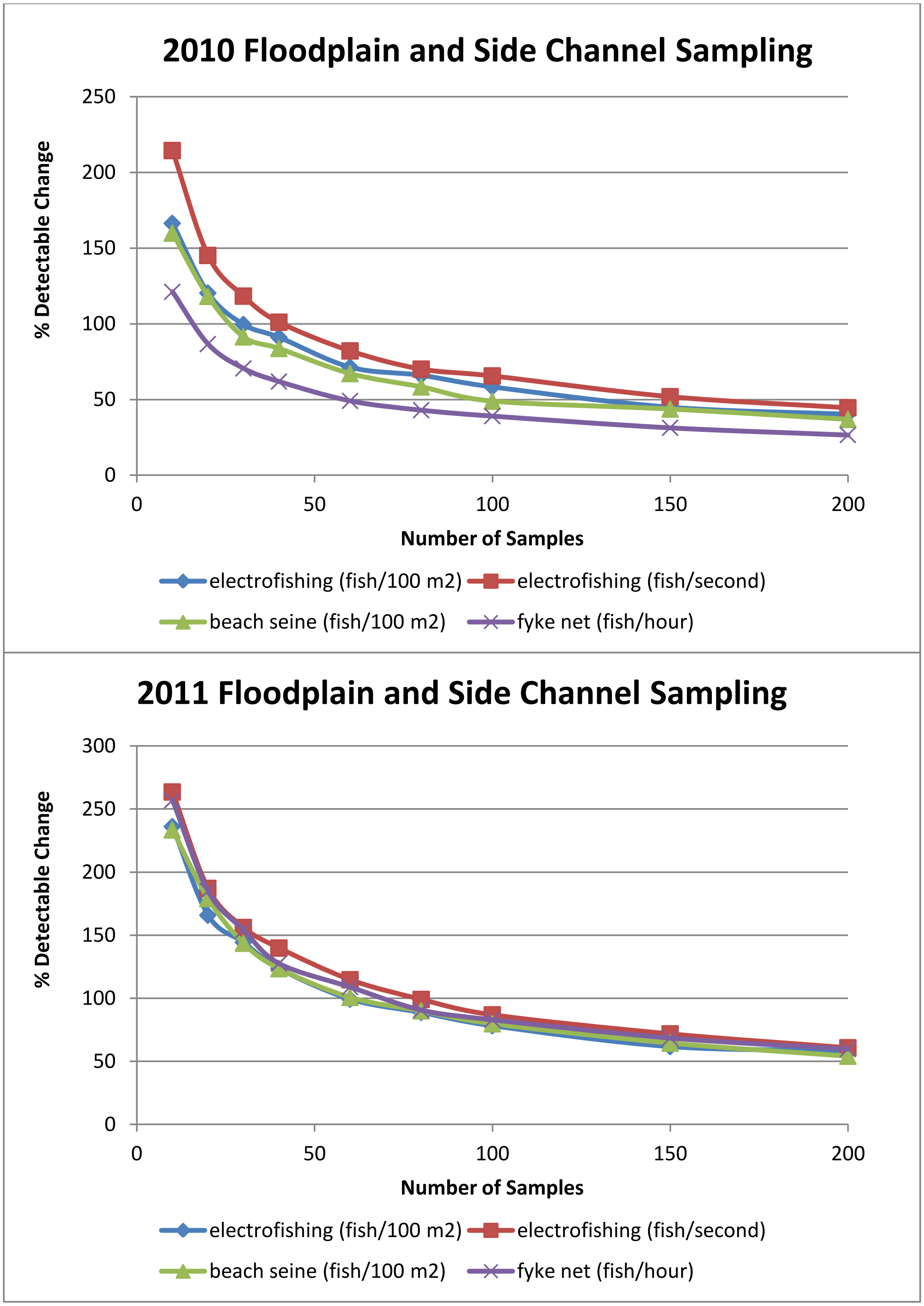

Figure 10. Percent detectable change in capture rate with sample size based on samples collected with a beach seine from predefined sampling areas (polygons) in floodplain and side channel habitat in 2010 and 2011 for backpack electrofishing, beach seines and fyke nets.

QUESTION 3: WHICH GEAR TYPE IS MOST EFFECTIVE FOR MONITORING SILVERY MINNOW CPUE IN THE MAIN CHANNEL (SPRING AND FALL LOW FLOW PERIODS)?

The results of the power analysis suggest that the backpack electrofishing unit may be the most effective gear type for monitoring silvery minnow catch rates in the main channel (Table 17). Although the bag seine produced less variable catch rates than the backpack electrofishing unit in 2010, this result was based on relatively few samples and this gear type performed relatively poorly in 2011 (Figure **11**). The fyke net was the most consistent gear, with similar variation and power to detect change between years. In 2011, the fyke net was the top performing gear (based on comparison of number of samples), but was less effective than the backpack electrofishing unit and bag seine in 2010. The beach seine had the worst performance of the four gear types in both fall 2010 and spring 2011 with regard to catch rate variability and power to detect changes in silvery minnow catch rate. This can be attributed to the high percentage of beach seine samples that contain no silvery minnow.

Table 17. The Number of Samples Needed to Achieve a CV of 0.2 and to Detect a 50% Change in Silvery Minnow CPUE in the Main Channel Compared across Gear Types for the Fall 2010 and Spring 2011 Sampling Occasions

Gear Type	Approximate Number of Samples Required to Achieve a CV of 0.20		Approximate Number of Samples Required to Detect a 50% Change in Mean CPUE	
	Fall 2010	Spring 2011	Fall 2010	Spring 2011
Backpack electrofishing (silvery minnow per 100 m^2 sampled)	110	400	275	>600 (63% change detectable at 600 samples)
Backpack electrofishing (silvery minnow per seconds of electricity applied)	100	200	270	450
Beach seine (silvery minnow per 100 m^2 sampled)	225	600	550	>600 (81% change detectable at 600 samples)
Fyke net (silvery minnow per fyke net hour)	120	100	280	250
Bag seine (silvery minnow per 100 m^2 sampled)	26	330	65	>600 (60% change detectable at 600 samples)

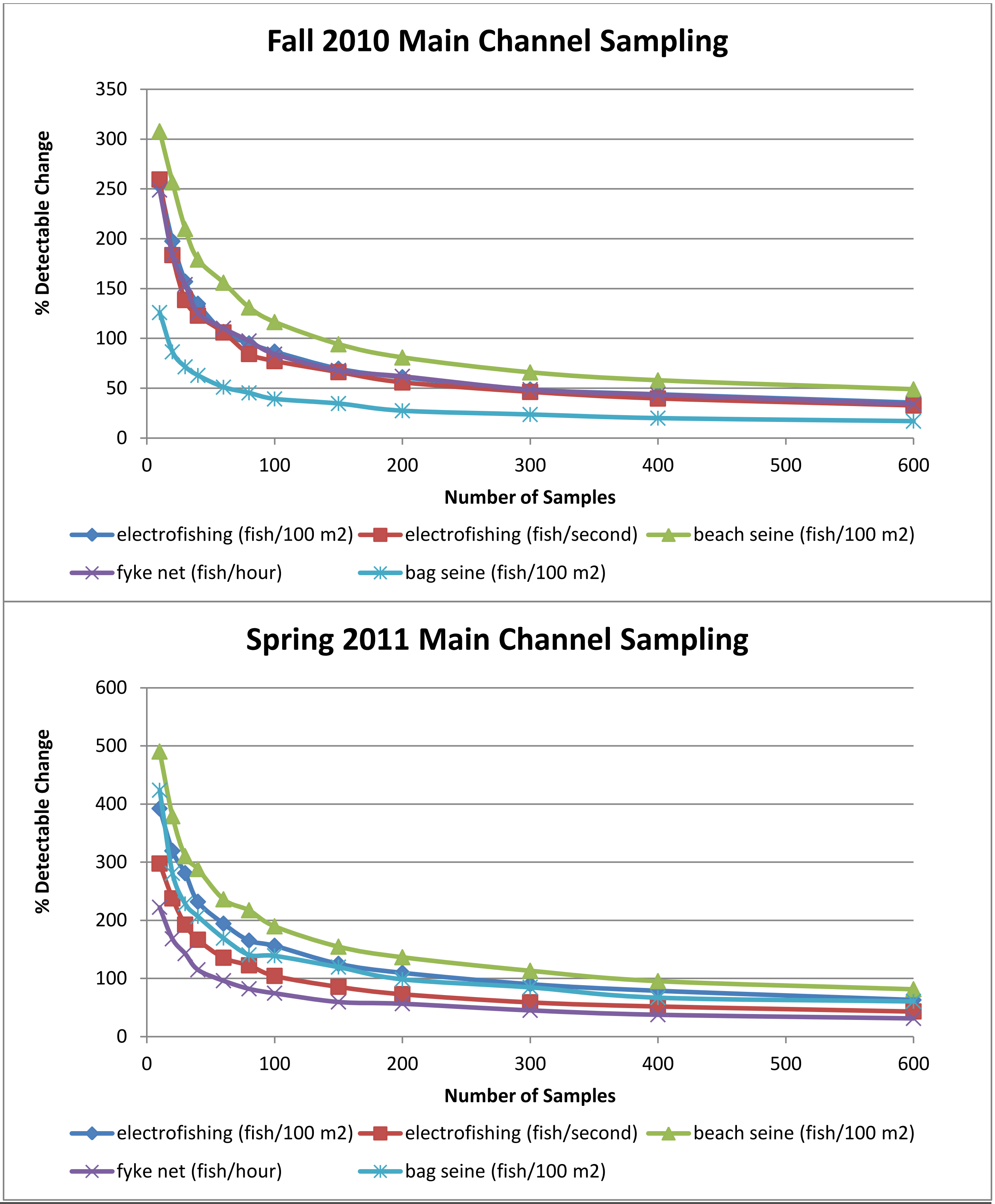

Figure 11. **Percent detectable change in capture rate with sample size based on samples collected with a beach seine from main channel mesohabitats in October 2010 and March 2011 for backpack electrofishing, beach seines, fyke nets, and the bag seine.**

3.1.9 COMPARISON OF SAMPLING COST AMONG GEARS

The effort and equipment required during this study to conduct floodplain and side channel monitoring is displayed in Table 18. All three gear types were used within the same fixed sampling polygons and required the same crew size. The same number of personnel hours was required to collect data using the backpack electrofishing unit and beach seine. Fyke nets required a greater number of personnel hours because each net soaked for four hours. However, the fyke nets were deployed relatively quickly and staff could set nets at multiple sites before returning to the first site to pull the nets, potentially reducing the mean time per sample. Overall, one floodplain and side channel site could be monitored using the three gear types within eight hours with a crew of three biologists.

The effort and equipment required during this study to conduct main channel monitoring is displayed in Table 19. All four gear types were used at the same five sites. At each site, one gear was used in each 300-m-long (984-m-long) sampling block, for a total of three blocks at each site. The number of samples collected per block varied by gear type, with the most samples being collected by beach seining and the fewest being collected with the bag seine. Beach seines required the least amount of time per sample, collecting twice as many samples as were collected with the backpack electrofishing unit in the same amount of time. Fyke nets required one fewer crew member, but a slightly longer time to sample because of the time required to soak the net. The bag seine needed the largest crew to deploy and required almost twice as much time per sample as the beach seine. Overall, the main channel monitoring was conducted using the four gear types within 10 hours with a crew of six biologists.

For monitoring both habitat types (i.e., floodplain and side channel, and main channel), backpack electrofishing is the most expensive gear to use because of the up-front cost of the equipment. Fyke nets are the second most expensive gear because multiple nets must be purchased, and they are more expensive cumulatively than beach and bag seines. Fyke nets required the largest quantity of equipment to deploy because of the number of nets set and the number of t-posts required to set each net.

Table 18. Comparison of Effort Required by Each Gear for Current Floodplain and Side Channel Sampling Design

	Backpack Electrofishing	Beach Seine	Fyke Nets
Number of sites	3		
Number of sampling locations per site (area of sampling location)	3 fixed polygons (40–170 m^2)		
Samples per polygon	1	1	1
Crew size	3		
Time to sample a polygon	2 hours	2 hours	2 hours[1]
Large equipment	Backpack electrofishing unit Batteries for electrofishing unit Dip nets Buckets	Beach seine Buckets	3 t-posts (9 total for the 3 polygons at the site) 1 fyke net (3 total for the 3 polygons at the site) Buckets
Field measurements	Species of fish Number of each species Standard length of silvery minnow Reproductive condition of silvery minnow Seconds of electricity applied Area of subreach Water quality Water depth and flow	Species of fish Number of each species Standard length of silvery minnow Reproductive condition of silvery minnow Area of subreach Water quality Water depth and flow	Species of fish Number of each species Standard length of silvery minnow Reproductive condition of silvery minnow Total time net was set Area of subreach Water quality Water depth and flow

[1] Hands-on time. Total time required to sample a site was eight hours for three nets at three polygons with a four-hour soak time.

Table 19. Comparison of Effort Required by Each Gear for Current Main Channel Sampling Design

	Backpack Electrofishing	Beach Seine	Fyke Nets	Bag Seine
Number of sites	5			
Number of sampling locations per site (size of sampling location)	3 blocks (300 m long)			
Samples per block	10 mesohabitat samples per block	20 mesohabitat samples per block	4 sets per block	3 hauls through multiple mesohabitats
Crew size per block[1]	4	4	3	6
Time to sample a block[2]	3.5 hours	3.5 hours	4 hours[3]	1 hour
Large equipment	Backpack electrofishing unit Batteries for electrofishing unit Dip nets Buckets	Beach seine Buckets	12 t-posts (3 per net) 4 fyke nets Buckets	Bag seine Buckets
Field measurements	Species of fish Number of each species Standard length of silvery minnow Seconds of electricity applied Area of subreach Water quality Water depth and flow	Species of fish Number of each species per seine haul Standard length of silvery minnow Total number of seine hauls Area of subreach Water depth and flow	Species of fish Number of each species per seine haul Standard length of silvery minnow Total time net was set Area of subreach Water depth and flow	Species of fish Number of each species per seine haul Standard length of silvery minnow Total number of seine hauls Area of subreach Water depth and flow

[1]Crew size used per site (i.e., all 3 blocks) was 6.
[2]Total time required to sample a site with all four gears was 10 hours for a crew of 6.
[3] Fyke net personnel hours includes the soak time.

4.0 DISCUSSION

Samples of the MRG fish community collected with a beach seine, backpack electrofishing unit, fyke nets, and bag seine in a paired-gear design yielded results that were consistent among gear types for some of the measured parameters and inconsistent for others.

4.1 PERCENT SPECIES COMPOSITION

Percent species composition of samples varied among gear types, between habitat types (floodplain/side channel or main channel), and among years (2010–2012). The results of the gear comparisons are summarized in Table 20.

In floodplain and side channel habitats, silvery minnow was the most common species collected by fyke nets and by backpack electrofishing unit in 2010 and 2011. Although beach seines collected a greatest numbers of fish overall, they collected fewer silvery minnow than the other gear types tested in the same sampling areas (silvery minnow was the fourth and fifth most common species collected with beach seines in 2010 and 2011, respectively). The relatively poor overall performance of beach seine nets for collecting silvery minnows in floodplain and side channel habitats may be because the efficiency of the beach seine declines with increased structural habitat complexity (Hayes et al. 1996; Mecado-Silva and Escandon-Sandoval 2008). Spring discharge during May and June 2010 inundated areas of heavily vegetated floodplain, while spring discharge during May and June 2011 was not of sufficient magnitude to inundate the same types of areas. Of the three floodplain and side channel sites sampled during May and June 2011, only the Alameda site could be considered to have high structural complexity. There were 204 silvery minnows collected from floodplain and side channel habitats at the Alameda site during 2011. The majority were collected with fyke nets (154) and backpack electrofishing (40). Only nine silvery minnow were collected with a beach seine. The relative performance of the beach seine for silvery minnow collection was improved at the less structurally complex sites in May and June 2011. Silvery minnow were only collected from one other site with fyke nets, while they were collected from all three sites (Alameda, Paseo del Norte, and I-40) with the backpack electrofishing unit and beach seine.

In main channel habitats, percent species composition of samples was similar for beach seines and the backpack electrofishing unit; overall the catch was dominated by red shiner. The fyke net catch was dominated by channel catfish in 2010 and red shiner in 2011. This gear type appears to have less influence on the percent species composition of the catch in the main channel than in the floodplain and side channel habitats.

4.2 SPECIES DETECTION AND SPECIES RICHNESS

Beach seines and backpack electrofishing units consistently detected common species at most sites, including species that were often missed by fyke nets. Backpack electrofishing also picked up larger-bodied piscivorous species that were missed by beach seines, such as rainbow trout (*Oncorhynchus mykiss*) and walleye (*Sander vitreus*). Although not included in the detection analysis, the bag seine detected species that the other three gear types missed. For example, bag seine was the only gear to detect silvery minnow and adult river carpsucker from main channel Site 1: Calabacillas during October 2010 and March 2011. Bag seines may be valuable for determining silvery minnow presence during times when the population is low or for species richness monitoring.

In floodplain and side channel habitats, beach seines and backpack electrofishing units consistently estimated higher species richness than fyke nets (see Table 20). Seine nets have proven effective for estimating fish species richness in shallow homogenous offshore waters of large rivers (Lapointe et al. 2006), but less effective than fyke nets when sampling complex shoreline habitats containing a substantial amount of woody debris (Clark et al. 2007). Fewer fish were caught per backpack electrofishing sample than beach seine sample for the same sample area, although both gears produced similar estimates of species richness. The fyke nets collected fewer species, because the gear selects for mobile fish species, especially those that tend to follow shorelines (Hubert 1996). Fyke nets are not as effective for collecting top water species such as western mosquitofish (Clark et al. 2007) as the other gear types tested. Furthermore, the mini fyke nets used for this study were biased against collecting larger fish because the net throats were narrow (5 cm). These behavioral and physical constraints contributed to the low species richness estimated by fyke nets in this study.

In the main channel, beach seines and backpack electrofishing units performed similarly to estimate species richness. Both captured significantly more species per sample than fyke nets, due in part to the physical and behavioral constraints of fyke nets described above, and in part due to the sampling protocol. Samples were collected from all available mesohabitat types with the beach seine and the backpack electrofishing unit. Fyke nets sampled fewer mesohabitat types, being set at fixed locations in habitats that were conducive to sampling with this gear type. The distribution of fish within rivers and streams is associated with structural characteristics of the physical environment that varies among species and age groups at both large and small spatial scales (Schlosser 1991). Therefore, greater species richness per sample collected with the backpack electrofishing unit and beach seine is expected because the entire spectrum of available mesohabitats was sampled with these gear types.

Table 20. Summary of Gear Comparison Outcomes by Habitat Type and Sampling Event

Metric or Measure Compared	Floodplain/Side Channel			Main Channel				
	May/June 2010	May/June 2011	Both Surveys Combined	October 2010	March 2011	October 2011	March 2012	All Four Main Channel Surveys Combined
Fish community composition	Differed among gear types. Adult silvery minnow dominated fyke net and backpack electrofishing unit catch. Red shiner dominated beach seine catch.	Differed among gear types. Adult silvery minnow dominated fyke net and backpack electrofishing unit catch. White suckers and unknown larval fish dominated beach seine catch.	N/A	Differed among gear types. Red shiner dominated beach seine and backpack electrofishing unit catch. Channel catfish dominated fyke net catch.	Similar among all gear types. Red shiner dominated catch.	Similar among all gear types. Red shiner dominated catch.	Differed among gear types. Silvery minnow common in for fyke net (73%), backpack electrofishing unit (30%), and bag seine (22%) catches. Red shiner dominated beach seine catch (91%).	N/A
Species detection	No statistically significant difference. Beach seine and backpack electrofishing unit performed better than fyke nets.	No statistically significant difference. Beach seine and backpack electrofishing unit performed better than fyke nets.	No statistically significant difference. Beach seine and backpack electrofishing unit performed better than fyke nets.	No statistically significant difference. Beach seine and backpack electrofishing unit performed better than fyke nets.	No statistically significant difference. Beach seine and backpack electrofishing unit performed better than fyke nets.	No statistically significant difference (although close, $P = 0.07$). Beach seine and backpack electrofishing unit performed better than fyke net.	Beach seine and backpack electrofishing unit performed significantly better than fyke net.	Beach seine and backpack electrofishing unit performed significantly better than fyke nets.
Species richness	Differed among gear types. Beach seines collected significantly higher species richness than fyke nets.	Differed among gear types. Beach seines and backpack electrofishing unit collected significantly higher species richness than fyke nets.	Differed among gear types. Beach seines and backpack electrofishing unit collected significantly higher species richness than fyke nets.	No statistically significant differences among gear types. Backpack electrofishing unit and beach seines detected highest numbers of species on average.	No statistically significant differences among gear types. Backpack electrofishing unit and beach seines detected highest numbers of species on average.	No statistically significant difference (although close, $P = 0.09$). Beach seine and backpack electrofishing unit performed better than fyke net.	Beach seine and backpack electrofishing unit performed significantly better than fyke net.	Beach seine and backpack electrofishing unit performed significantly better than fyke nets.
Silvery minnow relative abundance (CPUE)	Varied significantly among gear types. Silvery minnow CPUE by fyke net and electrofishing unit was significantly higher than by beach seine. Notable that fyke net collected 1.5 and 5.5 times as many silvery minnow as the backpack electrofishing unit and beach seine, respectively.	No statistically significant difference among gear types. Notable that fyke net collected 2.6 and 11.2 times as many silvery minnows as backpack electrofishing unit and beach seine, respectively.	N/A	No statistically significant differences among primary gear types (comparison of silvery minnow per sample). Backpack electrofishing unit collected 7 times more silvery minnow per sample than beach seine, on average.	No statistically significant differences among gear types (comparison of silvery minnow per sample). Comparable numbers of silvery minnow collected per sample between the electrofishing unit and beach seine.	Statistically significant differences among gear types (comparison of silvery minnow per sample). Backpack electrofishing and bag seine both collected significantly more silvery minnow than the beach seine.	Statistically significant differences among gear types (comparison of silvery minnow per sample). Backpack electrofishing and bag seine both collected significantly more silvery minnow than the beach seine.	N/A
Silvery minnow length structure	Varied significantly among gear types. Fyke nets collected more large silvery minnows than collected with backpack electrofishing unit or beach seine, but missed the smallest silvery minnow.	No statistically significant difference among gear types (although close, $P = 0.08$). Silvery minnows collected with fyke nets were larger on average than other gear types. Beach seines and fyke nets collected the smallest silvery minnow.	N/A	No statistically significant difference among gear types. Distinct length modes only detected in fish collected with the backpack electrofishing unit. Too few collected to determine age from length frequency.	No statistically significant difference among gear types. The largest range of sizes was collected with the fyke nets (largest and smallest silvery minnows). Too few were collected to determine age from length frequency.	No difference in size detected. Sample size of silvery minnow was small.	Fyke nets collected significantly larger (3mm difference) silvery minnow than the backpack electrofishing unit. Sample sizes from bag seine and beach seine were too small for statistical comparison.	N/A

4.3 SILVERY MINNOW CPUE

In floodplain and side channel habitats, the number of silvery minnow collected varied among samples collected with the backpack electrofishing unit, beach seine, and fyke nets during both years of sampling, despite standardizing the size and location of the sample area of these samples. However, more silvery minnow were consistently collected with the fyke nets and the backpack electrofishing unit than with the beach seine (Table 20). When catch data were pooled over both years of floodplain and side channel sampling, indices of silvery minnow CPUE were consistently correlated between gear types. Correlation coefficients were consistently higher for beach seine and backpack electrofishing indices than for any comparison made between these gear types and fyke nets. Fyke nets collected more fish per sample than beach seine and backpack electrofishing, indicating the species is relatively more plentiful than is indicated by these gear types. This is an artifact of differences in capture efficiency among the three gear types. Capture efficiency is influenced by a variety of physical, chemical, and biological factors (Peterson and Paukert 2009), which varied among sites and between years at a single site (e.g., different levels of vegetation inundation in 2010 and 2011). Factors such as predation, soak time, and fish density can all affect fyke net catches (Breen et al. 2006). Other factors such as habitat complexity can affect beach seine (Hayes et al. 1996; Mecado-Silva and Escandon-Sandoval 2008) and electrofishing (Peterson et al. 2004) capture efficiency.

In main channel habitats, the number of silvery minnow collected per sample (area not standardized) with beach seines, the backpack electrofishing unit, bag seines, and fyke nets varied among tested gear types and survey periods. Bag seine collections collected the greatest number of silvery minnows per sample (i.e., per haul or set) than other gears in October 2010 and fyke nets collected the greatest during March 2011. When silvery minnow CPUE is standardized by area sampled, beach seine and backpack electrofishing unit collected comparable numbers of silvery minnow. Beach seine and backpack electrofishing unit indicated greater silvery minnow CPUE, on average, in March than October.

Catch rate of silvery minnow is roughly correlated among gears for large differences in silvery minnow density, regardless of how CPUE is calculated (i.e., area, time, or number of samples). However, this correlation among gear CPUE measures breaks down when changes in silvery minnow density are small. Correlation among gear CPUE measures is also poor when silvery minnow density is low, resulting in large numbers of samples containing no silvery minnow. When pooled among main channel survey events to increase sample size, there were no significant correlations in CPUE between any two of the gear types tested. These variable results reinforce the need to understand factors that bias fish sample data (Peterson and Paukert 2009) and how fisheries indices vary among and between gear types for sampling the MRG fish community.

4.4 SILVERY MINNOW SIZE

Silvery minnow standard length distribution differed among the tested gear types for floodplain/side channel collections and in the main channel in March 2012. Large numbers of silvery minnow collected from floodplain and side channel habitats during May and June 2010 and from main channel habitats in March 2012 enabled comparisons of length frequency among gears that were not possible with data from other sampling events (see Table 20). Large sample sizes provide better descriptions of length frequency that more closely match the actual size structure of a fish population (Neumann and Allen 2007). These comparisons indicated that fyke nets collected significantly larger silvery minnows on average than the other gear types tested. Although the length range was similar among all gears (i.e., they all detected small fish and large fish), a higher proportion of the fyke net catch consisted of fish greater than 60 mm in length.

Silvery minnow are known to be formidable swimmers whose swimming ability increases with size (Bestgen et al. 2010). This increased swimming ability makes silvery minnow less vulnerable to the beach seine and backpack electrofishing unit (i.e., more likely to evade the gear). Fyke nets are effective for silvery minnow capture because the wings of the net passively intercept moving schools of silvery minnow and channel them into the trap net. It is possible that smaller, less active fish would be less likely to encounter the fyke net, resulting in a catch that under represents small fish. Conversely, catches with the beach seine and backpack electrofishing unit may under represent large fish. It is likely that larger silvery minnow would be better at evading the beach seine or backpack electrofishing unit, swimming away from an area as they are approached with the active capture gear. The larger fish would likely be better able to escape, decreasing the proportion of the catch comprising large fish from these active gear types.

4.5 POWER ANALYSIS

For all gears used and habitats sampled for silvery minnow, power analysis of the survey data indicates that the ability of any of the three principal gear types to detect change in the population is very limited when relative abundance for the species is low. A simple way to increase the precision of a CPUE index is to compare the performance of the same data standardized two separate ways. Electrofishing data overall were less variable when standardized by time than by area. Consequently, power analyses indicated that electrofishing data standardized by time were more appropriate for monitoring as smaller changes in relative abundance could be detected.

Fyke nets produced the least variable silvery minnow catch rates (i.e., had the lowest coefficient of variation among samples) and were most sensitive to change for sampling floodplain and side channel habitats in 2010. All gears performed similarly in 2011. The ability to detect change in silvery minnow CPUE was notably lower for samples collected during May and June 2011 than those collected during May and June 2010 because a smaller percentage of the samples contained silvery minnow. For all three gear types, greater than 200 samples (pooled across all sites) were necessary to detect a 50% change in CPUE. Given the relative rarity of floodplain and side channel habitats, it may not be possible to collect more than 200 samples in the study reach, limiting the utility of floodplain/side channel monitoring especially in lower water years.

Backpack electrofishing samples (standardized by seconds of electricity) had a lower CV than beach seine samples (standardized by area) and fyke nets (standardized by soak time) for monitoring main channel habitats for silvery minnow CPUE. Beach seines produced the most variable CPUE of all the gear types tested, requiring more than 600 samples to detect 81% change in the silvery minnow population from main channel habitats during March 2011. Backpack electrofishing provides the most consistent and precise estimates of main channel silvery minnow CPUE of all the gear types tested.

4.6 COMPARISON OF SAMPLING COST AMONG GEARS

Aside from the cost of purchasing and maintaining sampling gear, two main variables contribute to the cost of sampling: the number of samples needed and the cost to collect each sample. Sampling costs, measured in field crew hours, are estimated for floodplain and side channel habitats (Table 21) and main channel habitats (Table 22) based on the results of the power analyses (i.e., number of samples to achieve a CV of 0.20 in silvery minnow CPUE) and the crew effort recorded for this study.

Effort to collect samples from fixed area polygons in floodplain and side channel habitats was identical among gear types, so the cost to sample was directly proportional to the number of samples required. In 2010, sampling with fyke nets provided the best value; fyke nets required less than half of the field crew hours required by the other gears tested. However, in 2011, costs were similar for all gears.

In the main channel, the cost to collect mesohabitat samples varied among gear types as did the number of samples required to achieve a CV of 0.20. Because beach seine catches are more variable than backpack electrofishing catches, two to three times as many beach seine samples are required than backpack electrofishing samples to achieve the same CV. However, given that the cost (in field crew hours) of collecting a beach seine sample is estimated to be half of that to collect a backpack electrofishing sample, the overall sampling costs are comparable between the two gears. Considering the cost of purchasing and maintaining electrofishing units, beach seines may be the most cost-effective gear type to sample the main channel.

Table 21. Comparison of Cost in Field Crew Hours to Collect Samples to Achieve a CV of 0.20 in Silvery Minnow CPUE in Floodplain and Side Channel Habitats with Different Gears

Gear Type	Approximate Number of Samples Required to Achieve a CV of 0.20		Crew Size and Sample Time	Crew Hours per Sample	Approximate Cost to Achieve a CV of 0.20 in Field Crew Hours	
	2010	2011			2010	2011
Backpack electrofishing (silvery minnow per 100 m^2 sampled)	50	100	3 people collected 3 samples (polygons with set area) in 2 hours	(3*2)/3 = 2 crew hours per sample	100	200
Backpack electrofishing (silvery minnow per seconds of electricity applied)	70	125	3 people collected 3 samples (polygons with set area) in 2 hours	(3*2)/3 = 2 crew hours per sample	140	250
Beach seine (silvery minnow per 100 m^2 sampled)	45	100	3 people collected 3 samples (polygons with set area) in 2 hours	(3*2)/3 = 2 crew hours per sample	90	200
Fyke net (silvery minnow per fyke net hour)	18	110	3 people collected 3 samples (polygons with set area) in 2 hours	(3*2)/3 = 2 crew hours per sample	36	220

Table 22. Comparison of Cost in Field Crew Hours to Collect Samples to Achieve a CV of 0.20 in Silvery Minnow CPUE in the Main Channel with Different Gears

Gear Type	Approximate Number of Samples Required to Achieve a CV of 0.20		Crew Size and Sample time	Cost	Approximate Cost to Achieve a CV of 0.20 in Field Crew Hours	
	Fall 2010	Spring 2011			Fall 2010	Spring 2011
Backpack electrofishing (silvery minnow per 100 m^2 sampled)	110	400	4 people collected 10 samples in 3.5 hours	(4*3.5)/10 = 1.4 crew hours per sample	154	560
Backpack electrofishing (silvery minnow per seconds of electricity applied)	100	200	4 people collected 10 samples in 3.5 hours	(4*3.5)/10 = 1.4 crew hours per sample	140	280
Beach seine (silvery minnow per 100 m^2 sampled)	225	600	4 people collected 20 samples in 3.5 hours	(4*3.5)/10 = 0.7 crew hours per sample	158	420
Fyke net (silvery minnow per fyke net hour)	120	100	3 people collected 4 samples in 4 hours	(3*4)/4 = 3 crew hours per sample	360	300
Bag seine (silvery minnow per 100 m^2 sampled)	26	330	6 people collected 3 samples in 1 hour	(6*1)/3 = 2 crew hours per sample	52	660

5.0 SUMMARY AND CONCLUSIONS

The relative efficiency of gear types for sampling the MRG fish community and the silvery minnow varies among gear types depending on the parameter measured (e.g., species richness, detection, relative abundance, silvery minnow size), habitat sampled (e.g., floodplain, main channel), and time of year. Major findings for measured parameters relative to gear types are summarized below:

- At low silvery minnow densities all the gear types tested had high CV regardless of the habitat sampled. This high variability contributed to the low correlation among gear type CPUE measurements for silvery minnow. Stronger correlations may be revealed with a larger data set.

- Beach seines generally detected the greatest number of species at a site, but did not perform significantly better at estimating species richness than the backpack electrofishing unit.

- Fyke nets outperformed all gear types for collecting silvery minnow from floodplain and side channel habitats during 2010, but not during 2011. This gear type can produce fairly precise data but only for off-channel and low velocity habitats.

- Backpack electrofishing outperformed other gear types for sampling main channel habitats for silvery minnow (numbers of silvery minnow collected per area sampled and lower variability in CPUE standardized by seconds of electricity).

- A larger percentage of fyke net catches comprise large silvery minnow than beach seine or backpack electrofishing catches. Supplemental fyke net sampling could be used to help better describe the length structure of the silvery minnow population.

- Bag seines sometimes detected species that other gear types missed and could be used to supplement ongoing population monitoring.

No one gear outperformed the others tested for all of the parameters compared. The sampling gear recommended depends on the sampling location and sampling objective.

Sampling on the floodplain is not currently recommended for monitoring trends in silvery minnow abundance because floodplain habitats are not always available depending on spring runoff discharge. Sampling of these habitats may be desirable for characterizing the population age structure. Fyke nets and the backpack electrofishing unit were most cost effective at collecting silvery minnow from these off-channel habitats. Used together (i.e., data pooled for collections by both gears at a site) these gears would produce a less biased estimate of the population length structure than either used alone.

Monitoring silvery minnow relative abundance in the main channel is currently conducted by the Collaborative Program using beach seines. The species richness and silvery minnow CPUE data collected by the backpack electrofishing unit in the main channel were comparable, so it is not recommended that sampling with the backpack electrofishing unit be used to supplement the existing beach seine sampling. Fyke nets are not effective for monitoring silvery minnow abundance in the main channel and are only recommended for use when larger numbers of silvery minnow need to be collected to characterize population length structure, health indices, and other measures of individual fish.

If the primary objective is compiling a species list, then it may be useful to supplement the current beach seine sampling with backpack electrofishing and bag seine samples. These gear types collected fish, particularly larger species that were missed by the beach seine.

The backpack electrofishing unit is recommended if one gear had to be selected to sample both floodplain/side channel and main channel habitats for silvery minnow. The cost of sampling with the backpack electrofishing unit is similar to that of sampling with the beach seine, but the backpack electrofishing unit appears to be more effective at capturing silvery minnow, especially in structurally complex habitats. The primary drawback of this method is the expense to purchase and maintain the sampling gear.

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APPENDIX A
MAPS OF FLOODPLAIN AND SIDE CHANNEL SITES AND SAMPLING POLYGONS

Figure A.1. Paseo del Norte floodplain and side channel site sampling locations with delineated polygon areas and fyke net placement, May and June 2010. Open area of fyke net triangle depicts fyke wings and sampling direction.

Figure A.2. Paseo Del Norte floodplain and side channel site sampling locations with delineated polygon areas and fyke net placement, May and June 2011. Open area of fyke net triangle depicts fyke wings and sampling direction.

Figure A.3. I-40 site floodplain and side channel sampling locations with delineated polygon areas and fyke net placement, May and June 2010. Open area of fyke net triangle depicts fyke wings and sampling direction.

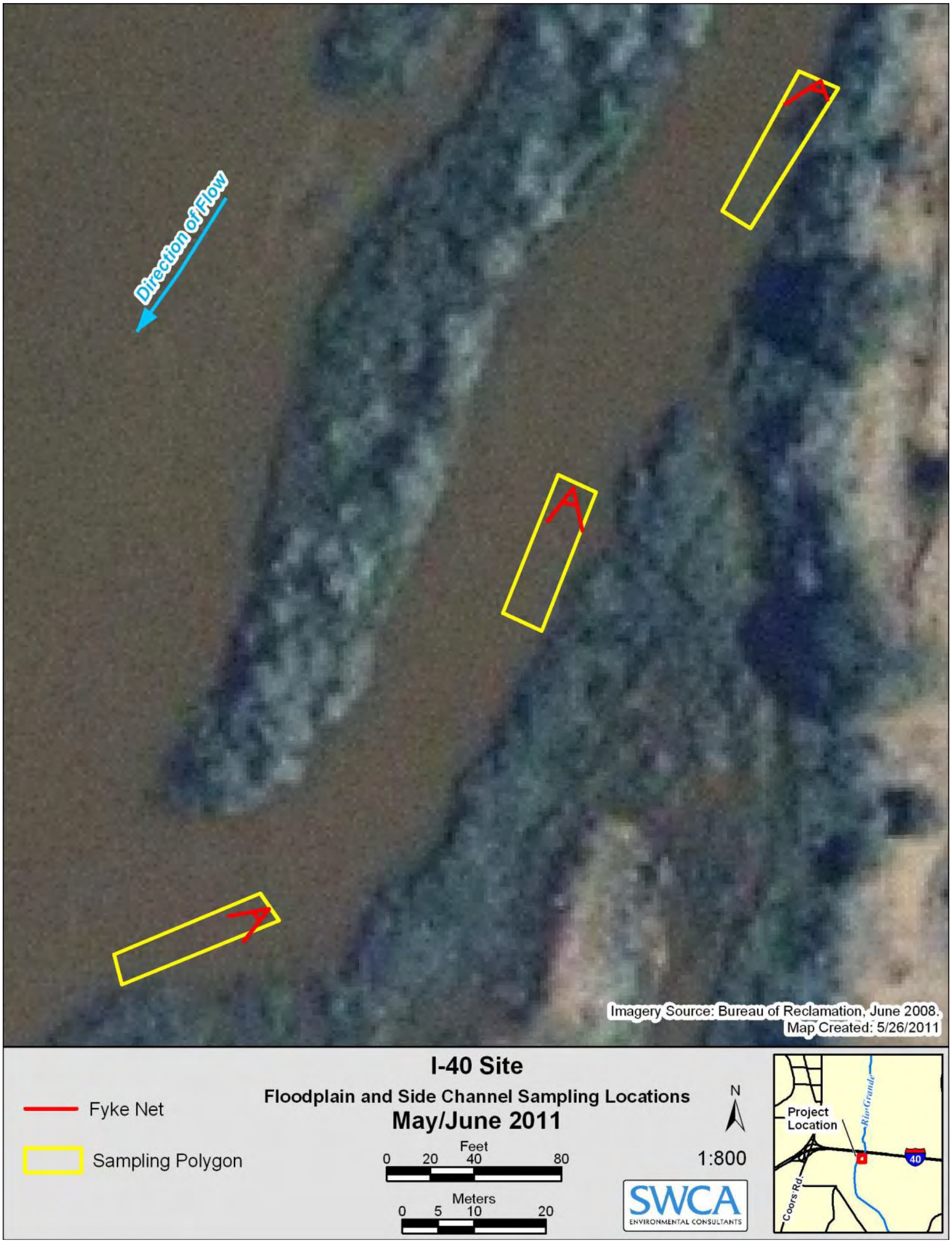

Figure A.4. I-40 site floodplain and side channel sampling locations with delineated polygon areas and fyke net placement, May and June 2011. Open area of fyke net triangle depicts fyke wings and sampling direction.

Figure A.5. Alameda site floodplain and side channel sampling locations with delineated polygon areas and fyke net placement, May and June 2010. Open area of fyke net triangle depicts fyke wings and sampling direction.

Figure A.6. Alameda site floodplain and side channel sampling locations with delineated polygon areas and fyke net placement, May and June 2011. Open area of fyke net triangle depicts fyke wings and sampling direction.

APPENDIX B
MAPS OF MAIN CHANNEL SITE GEAR BLOCKS AND SAMPLE LOCATIONS

Figure B.1. Map of La Orilla site main channel depicting gear blocks and mesohabitat sample locations, October 2010.

Figure B.2. Map of La Orilla site main channel depicting gear blocks and mesohabitat sample locations, March 2011.

Figure B.3. Map of La Orilla site main channel depicting gear blocks and mesohabitat sample locations, October 2011.

Figure B.4. Map of La Orilla site main channel depicting gear blocks and mesohabitat sample locations, March 2012.

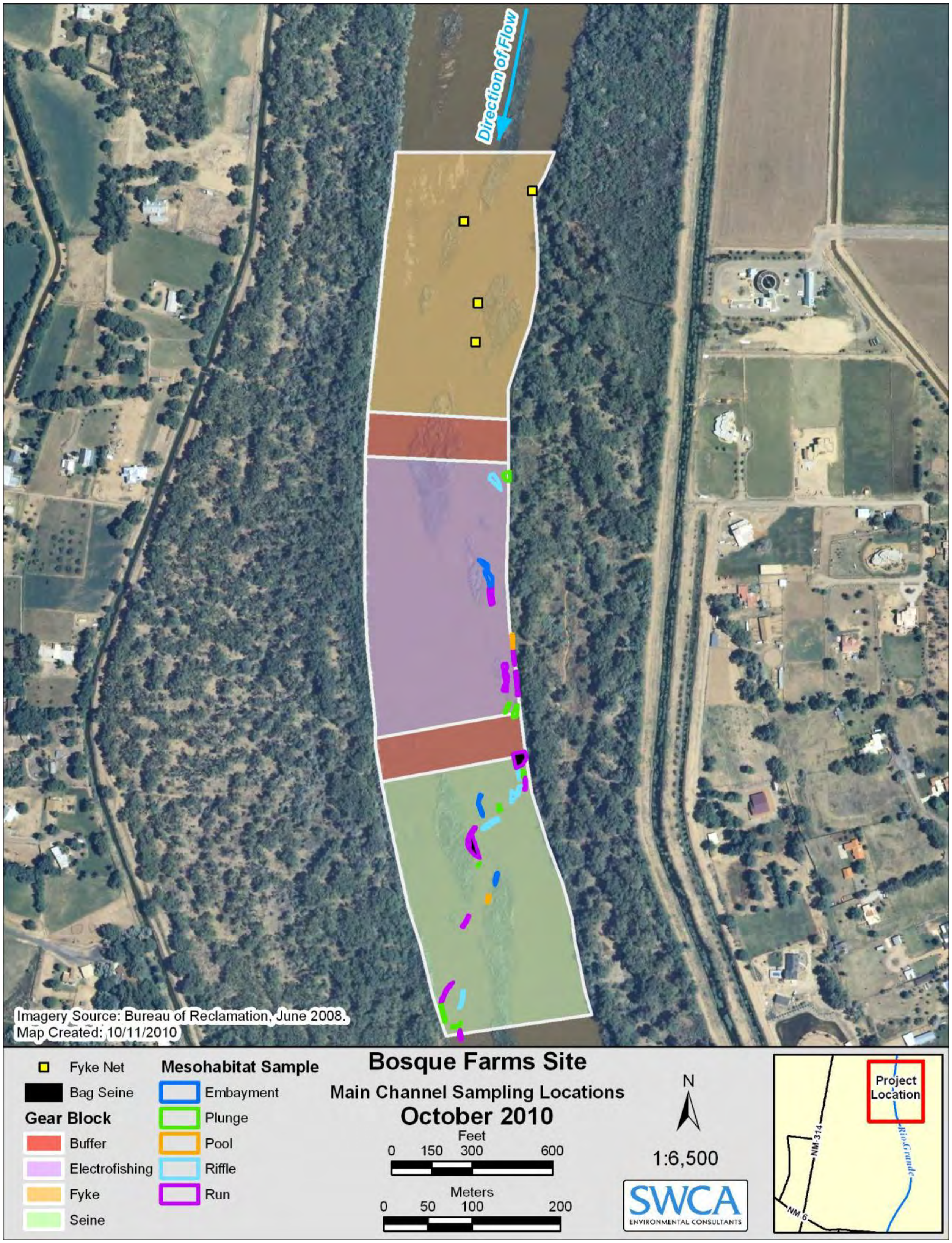

Figure B.5. Map of Bosque Farms site main channel depicting gear blocks and mesohabitat sample locations, October 2010.

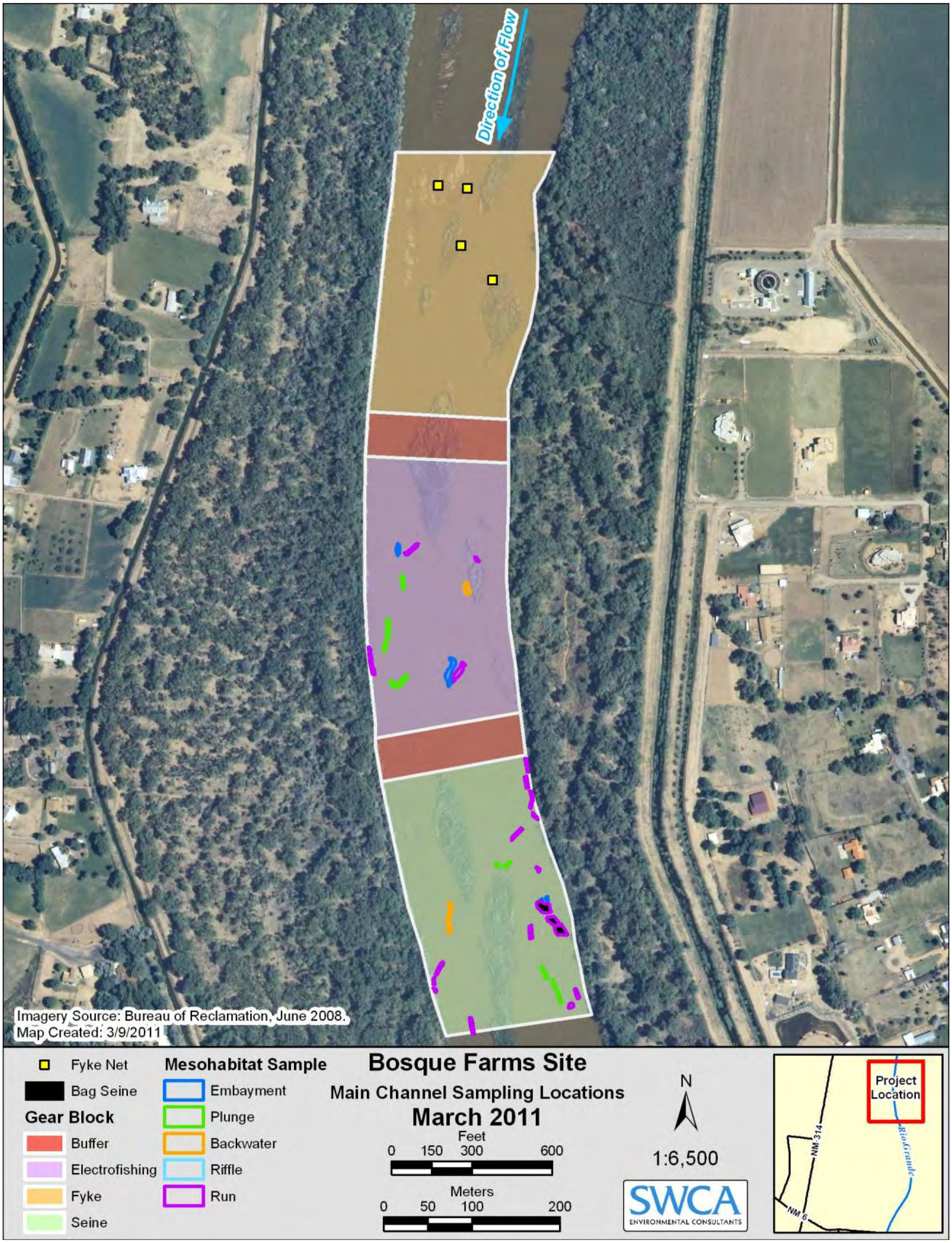

Figure B.6. Map of Bosque Farms site main channel depicting gear blocks and mesohabitat sample locations, March 2011.

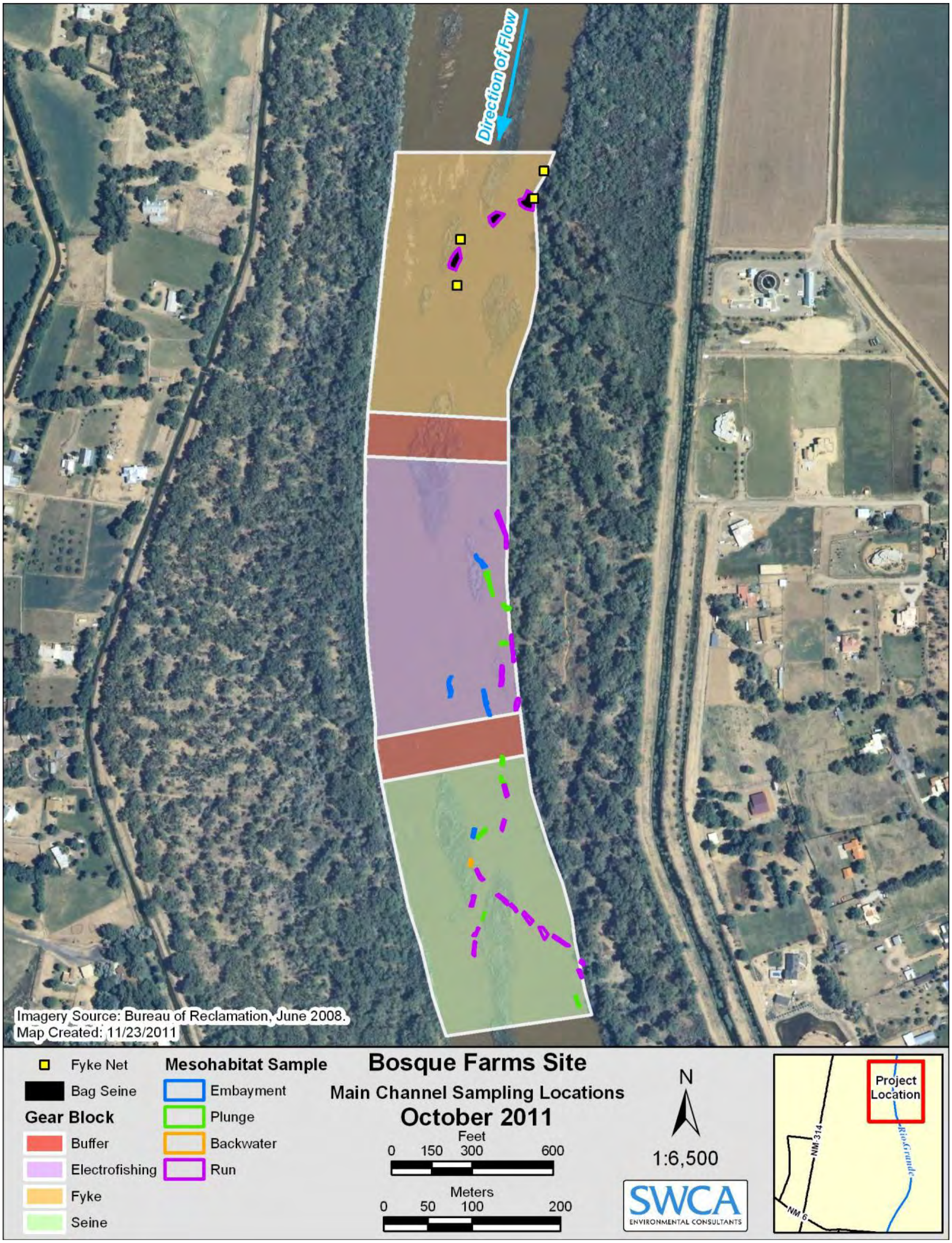

Figure B.7. Map of Bosque Farms site main channel depicting gear blocks and mesohabitat sample locations, October 2011.

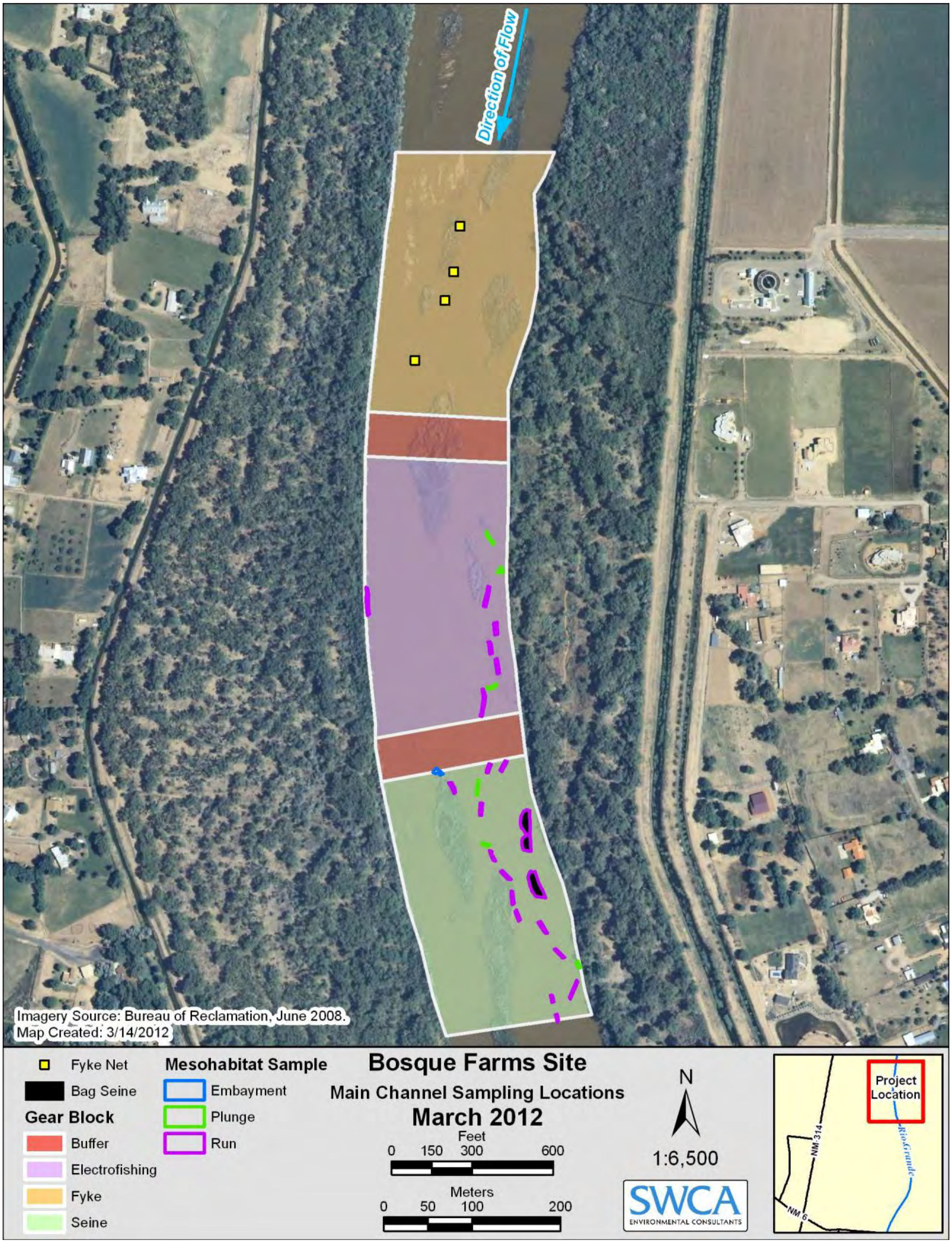

Figure B.8. Map of Bosque Farms site main channel depicting gear blocks and mesohabitat sample locations, March 2012.

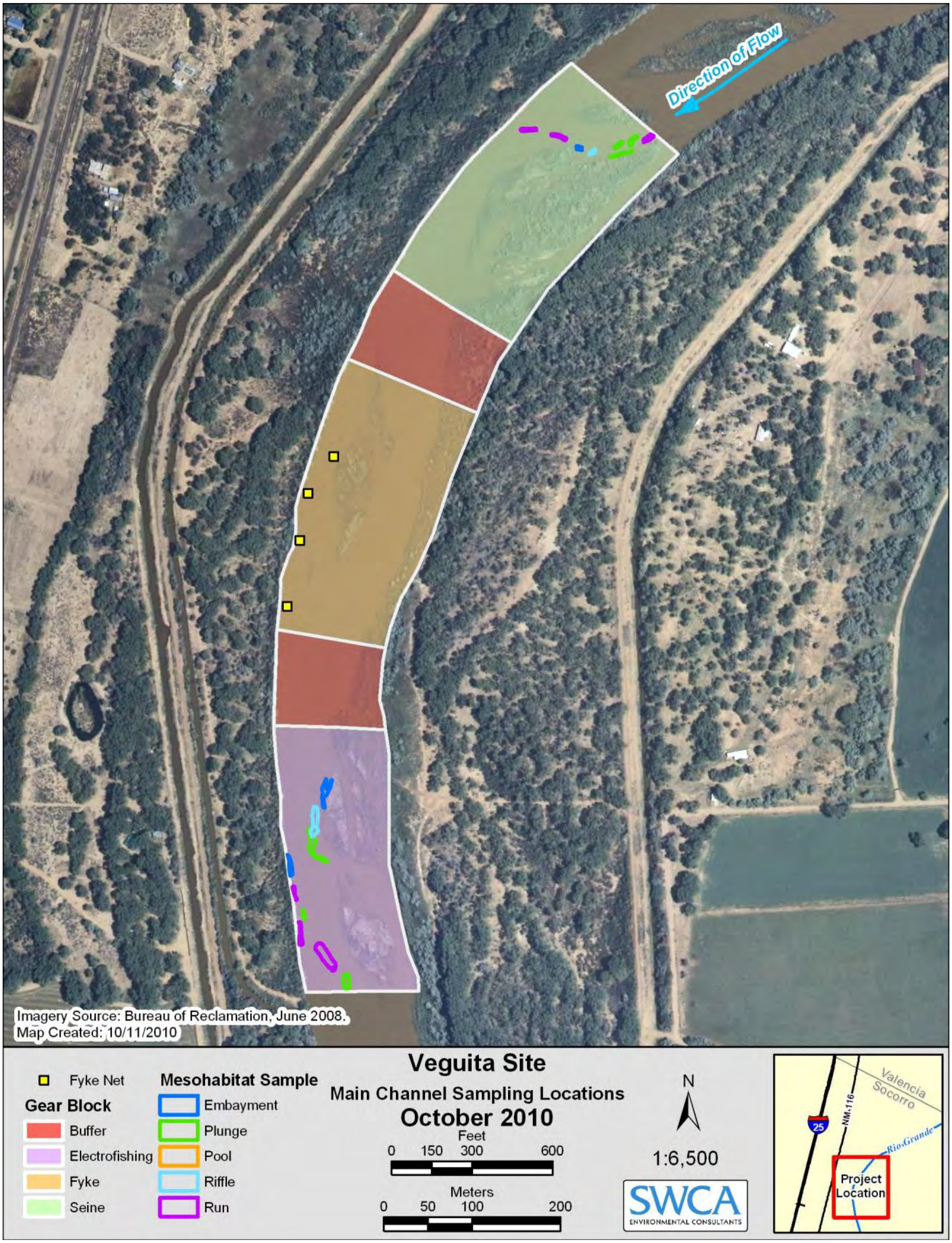

Figure B.9. Map of Veguita site main channel depicting gear blocks and mesohabitat sample locations, October 2010.

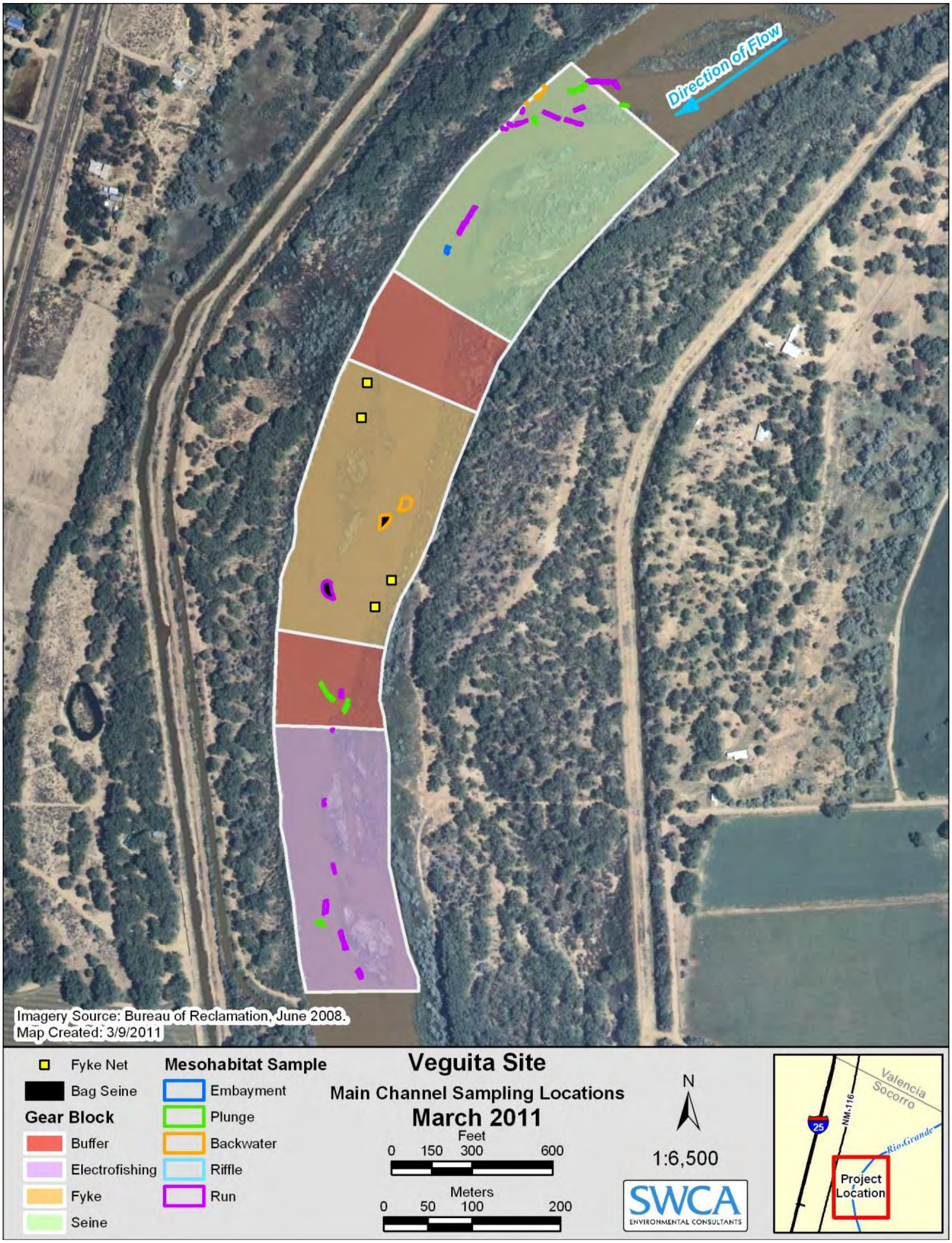

Figure B.10. Map of Veguita site main channel depicting gear blocks and mesohabitat sample locations, March 2011.

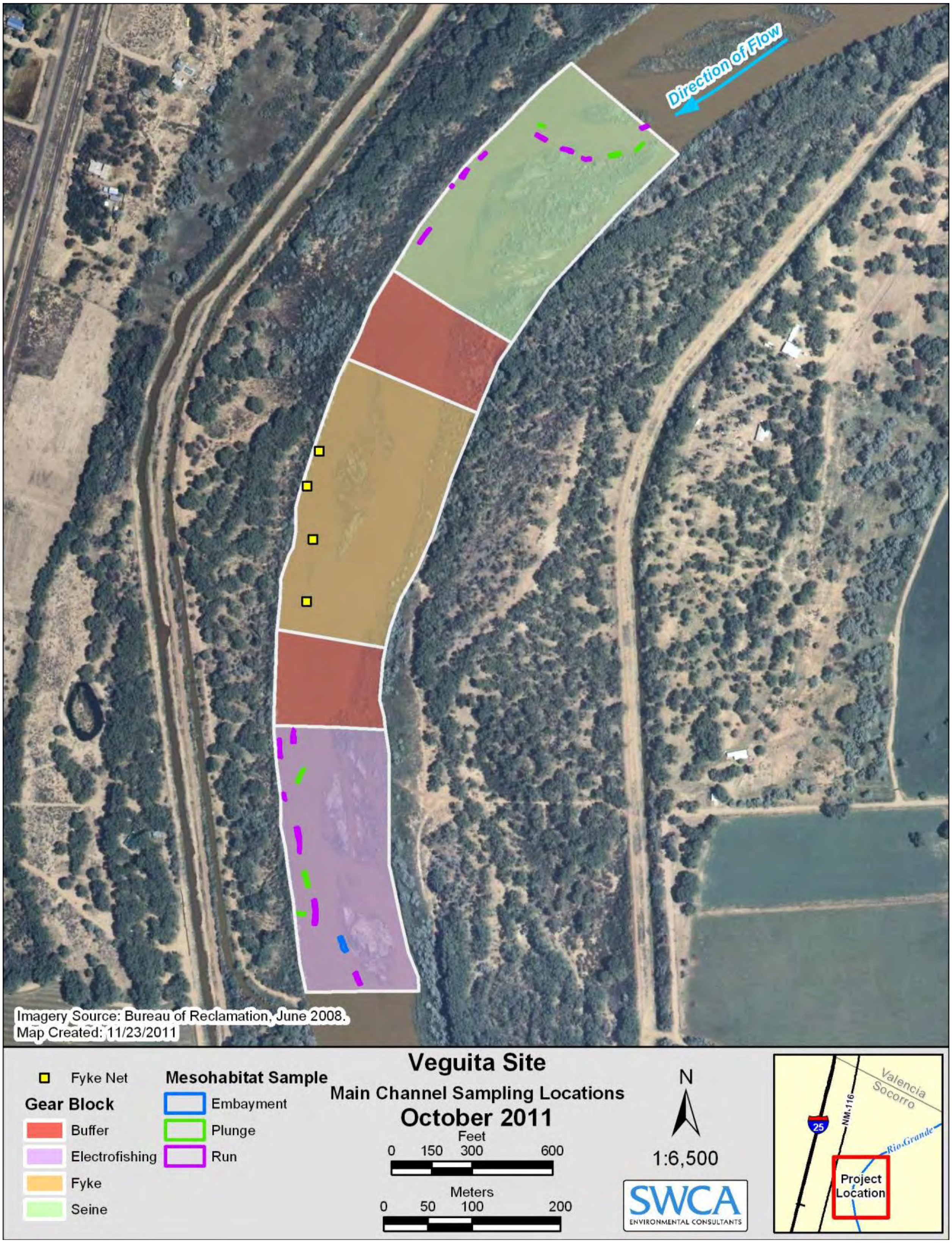

Figure B.11. Map of Veguita site main channel depicting gear blocks and mesohabitat sample locations, October 2011.

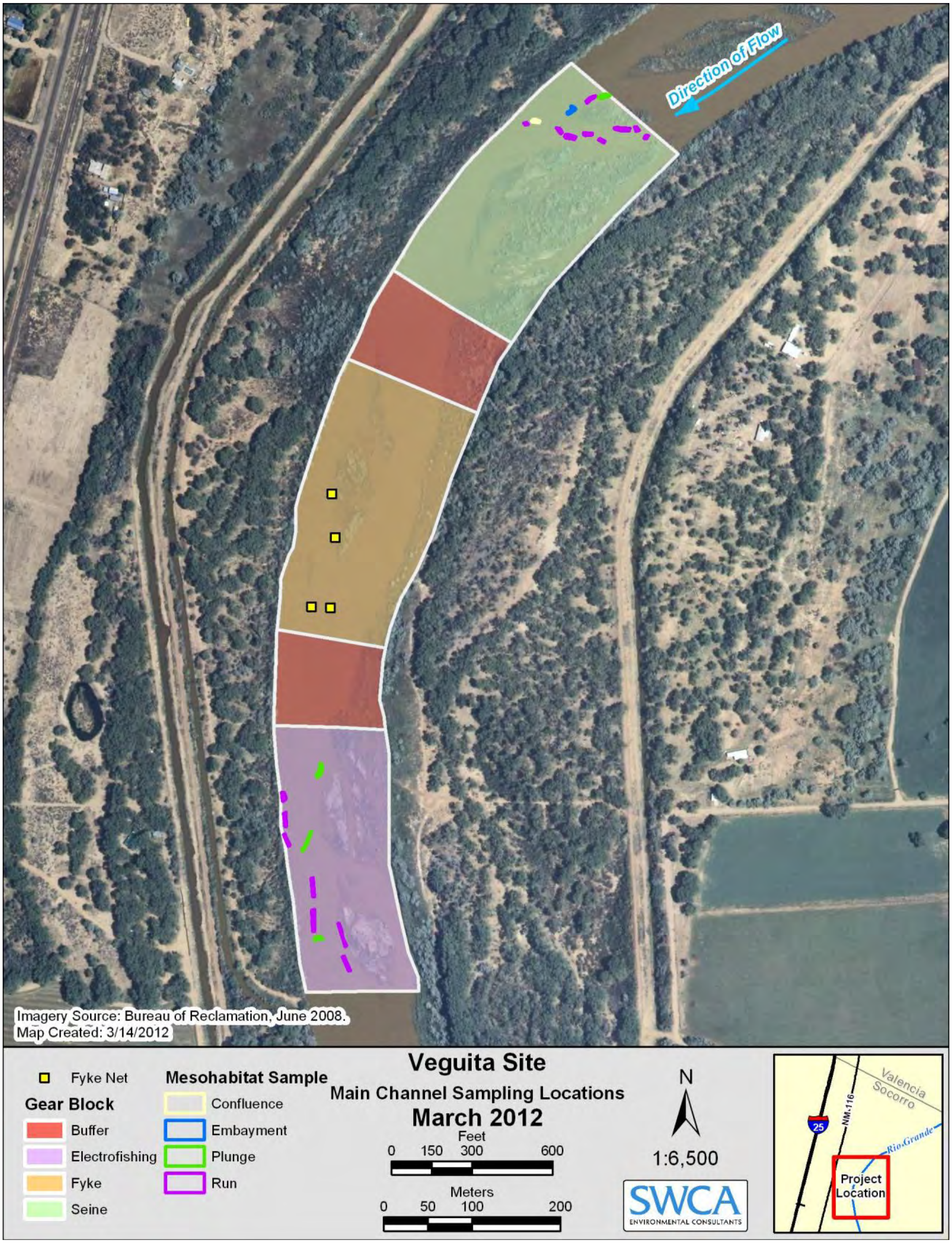

Figure B.12. Map of Veguita site main channel depicting gear blocks and mesohabitat sample locations, March 2012.

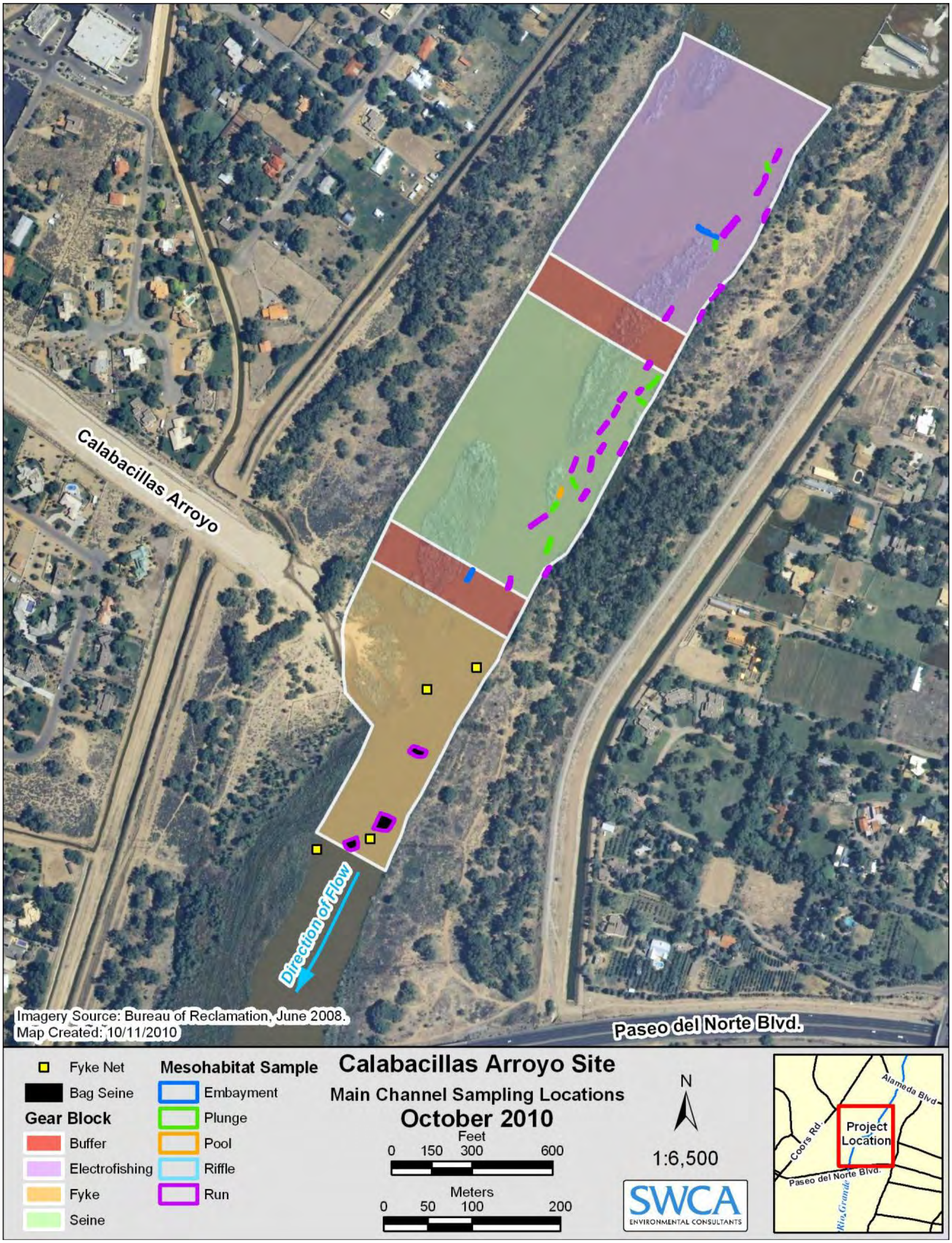

Figure B.13. Map of Calabacillas site main channel depicting gear blocks and mesohabitat sample locations, October 2010.

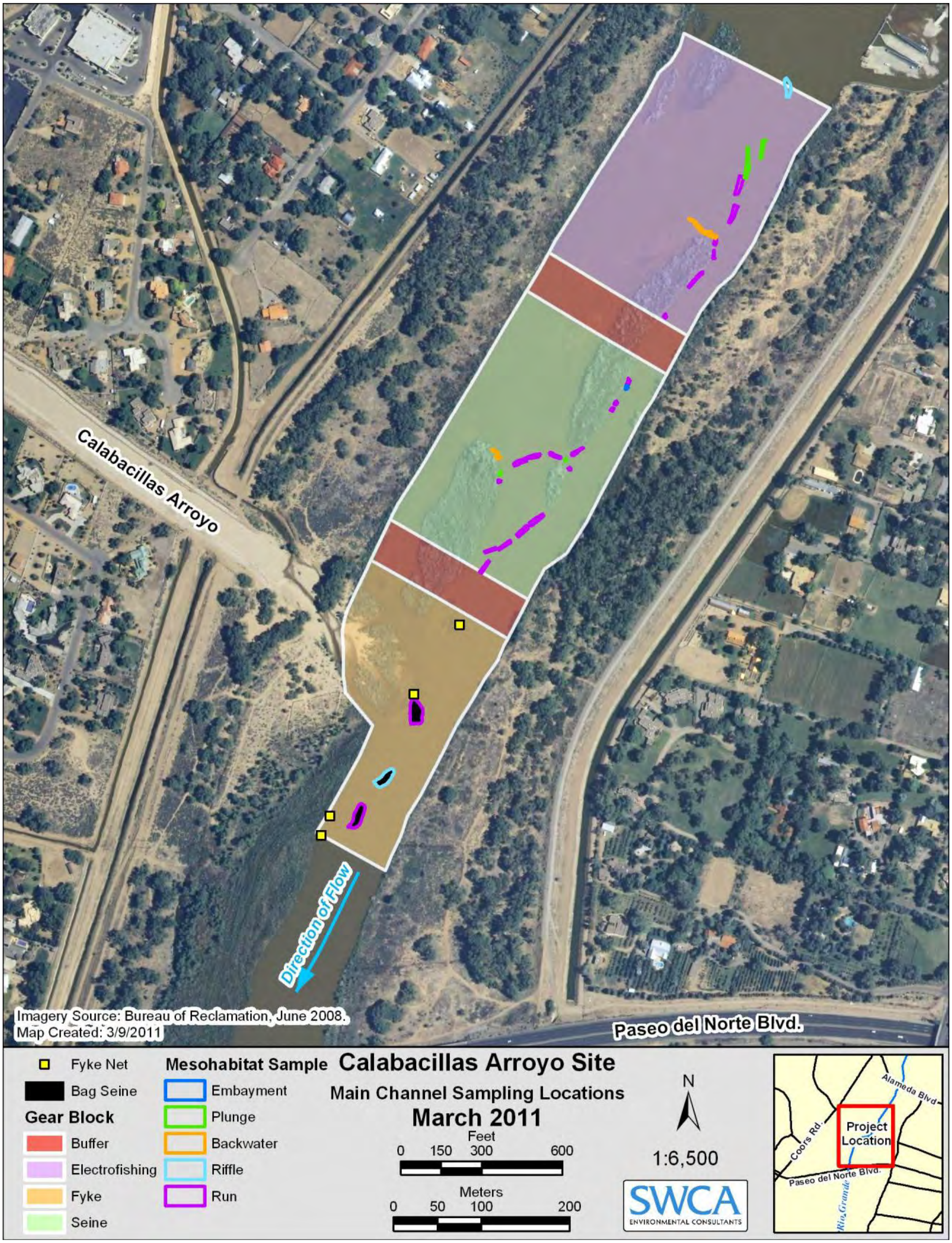

Figure B.14. Map of Calabacillas site main channel depicting gear blocks and mesohabitat sample locations, March 2011.

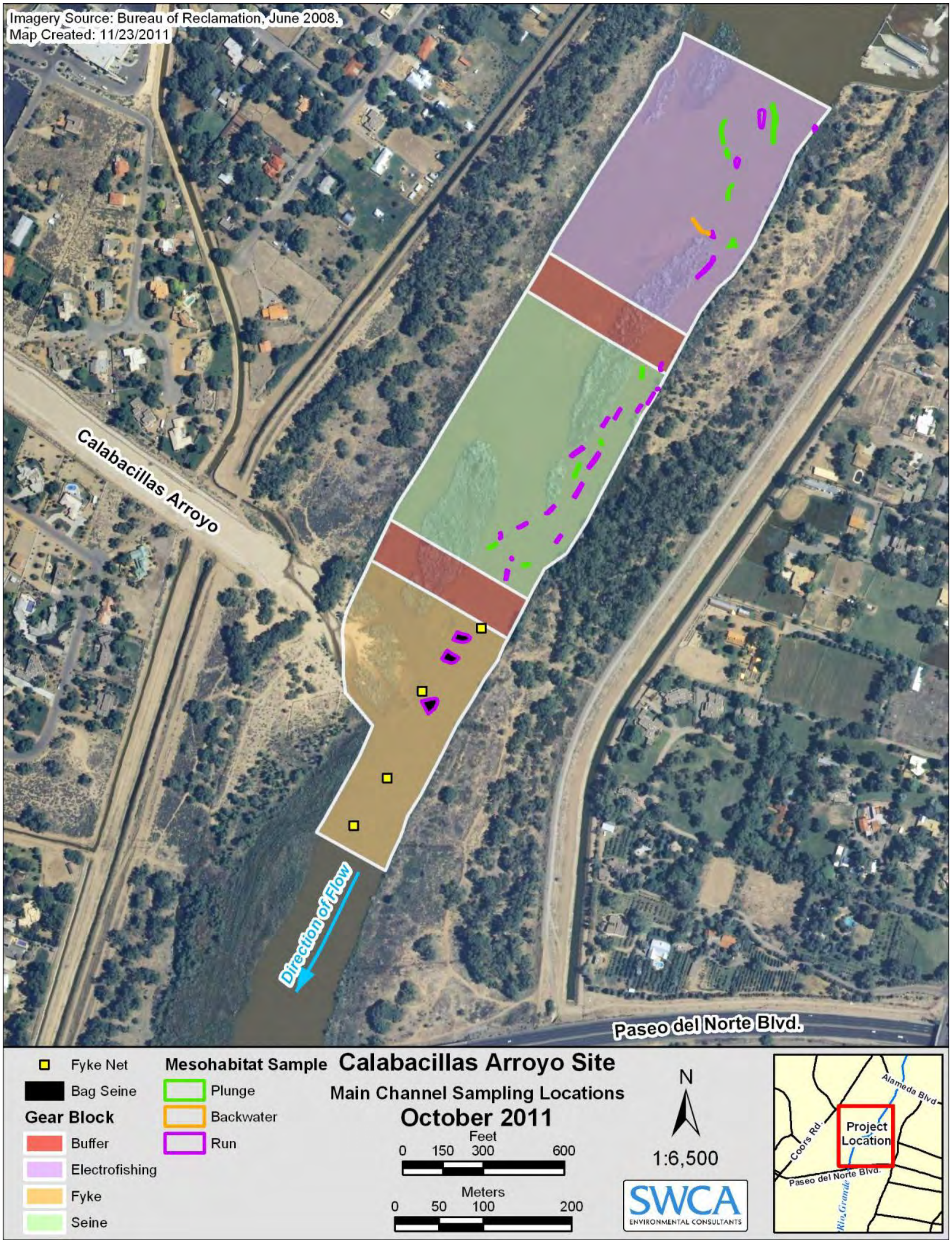

Figure B.15. Map of Calabacillas site main channel depicting gear blocks and mesohabitat sample locations, October 2011.

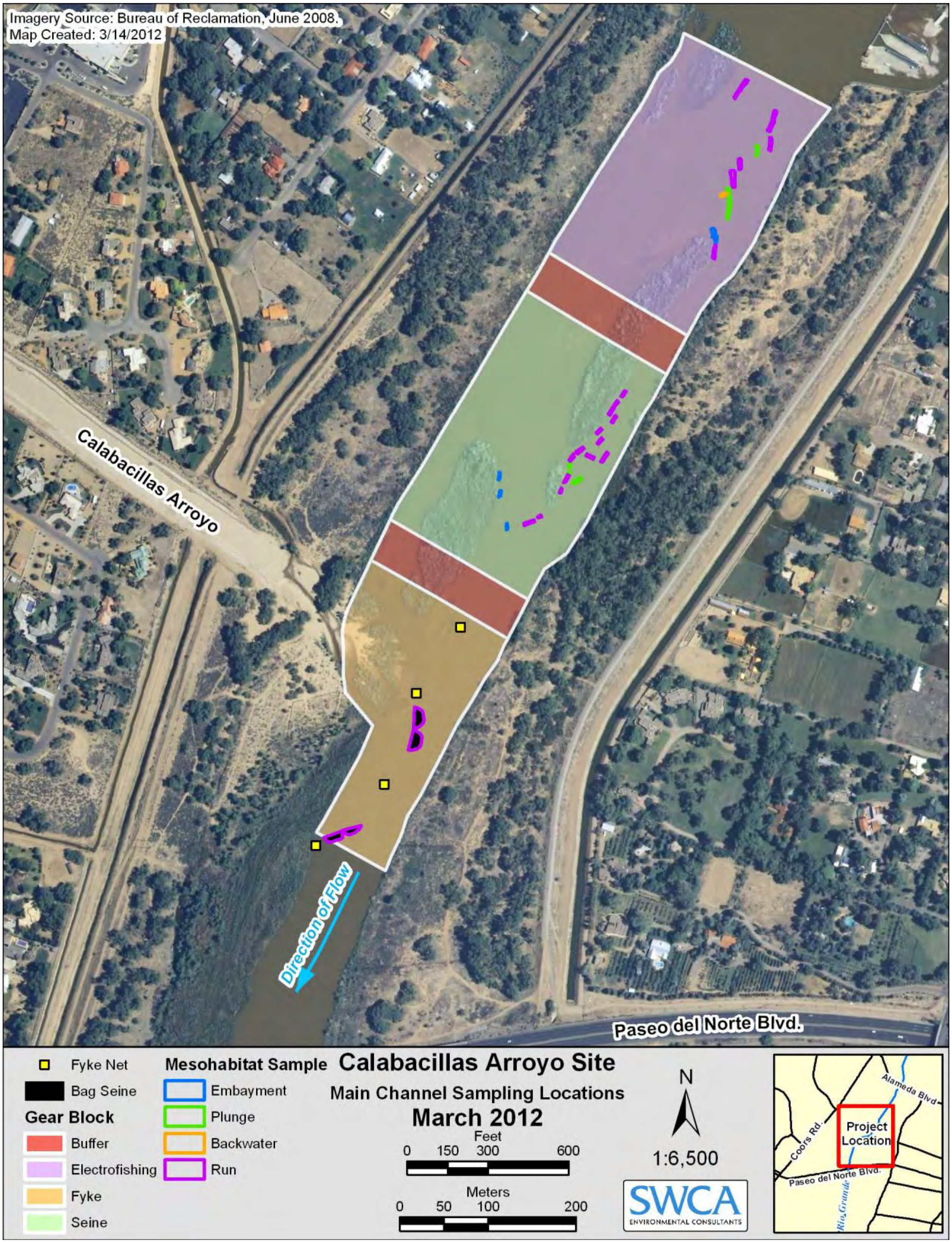

Figure B.16. Map of Calabacillas site main channel depicting gear blocks and mesohabitat sample locations, March 2012.

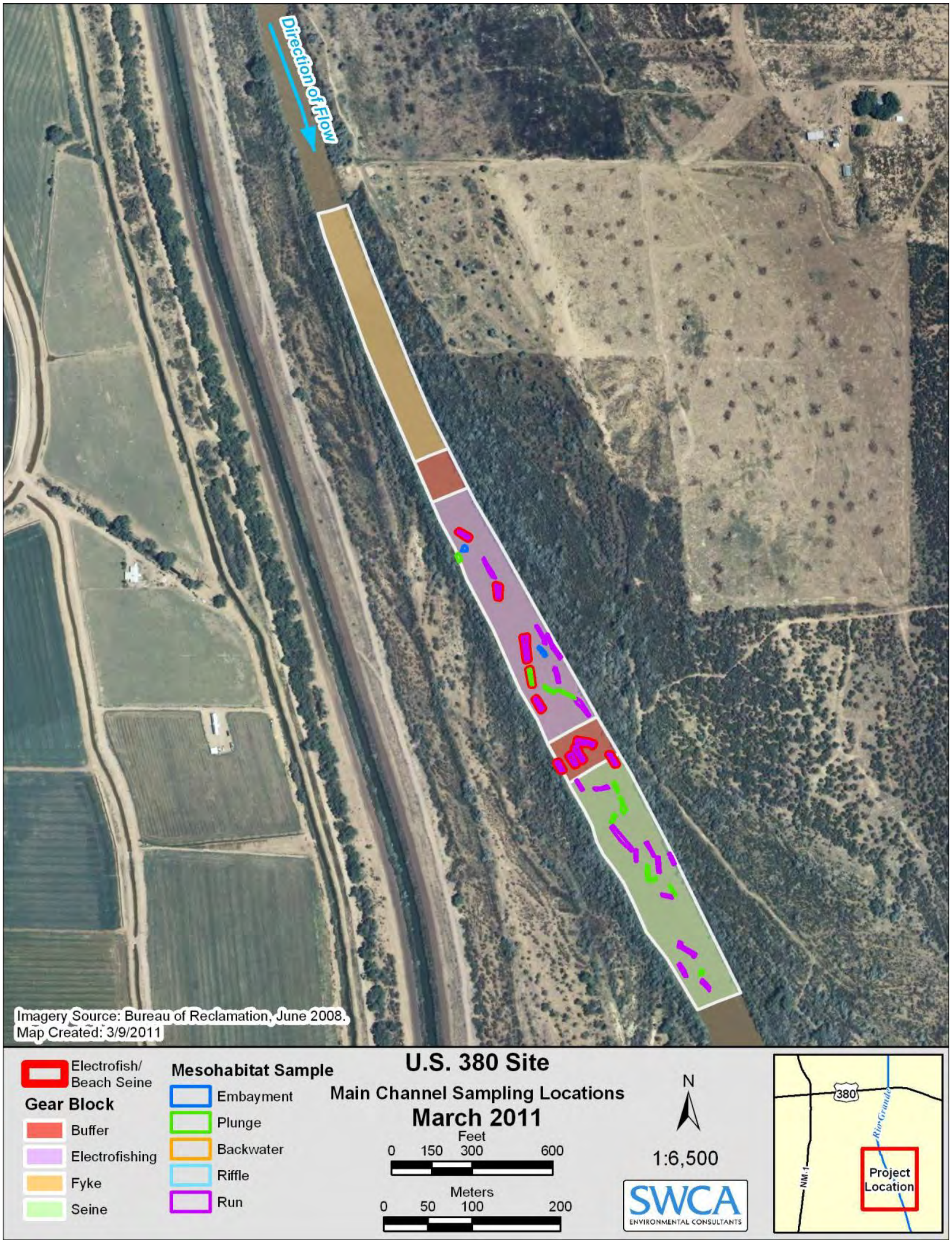

Figure B.17. Map of 380 Bridge site main channel depicting gear blocks and mesohabitat sample locations, March 2011.

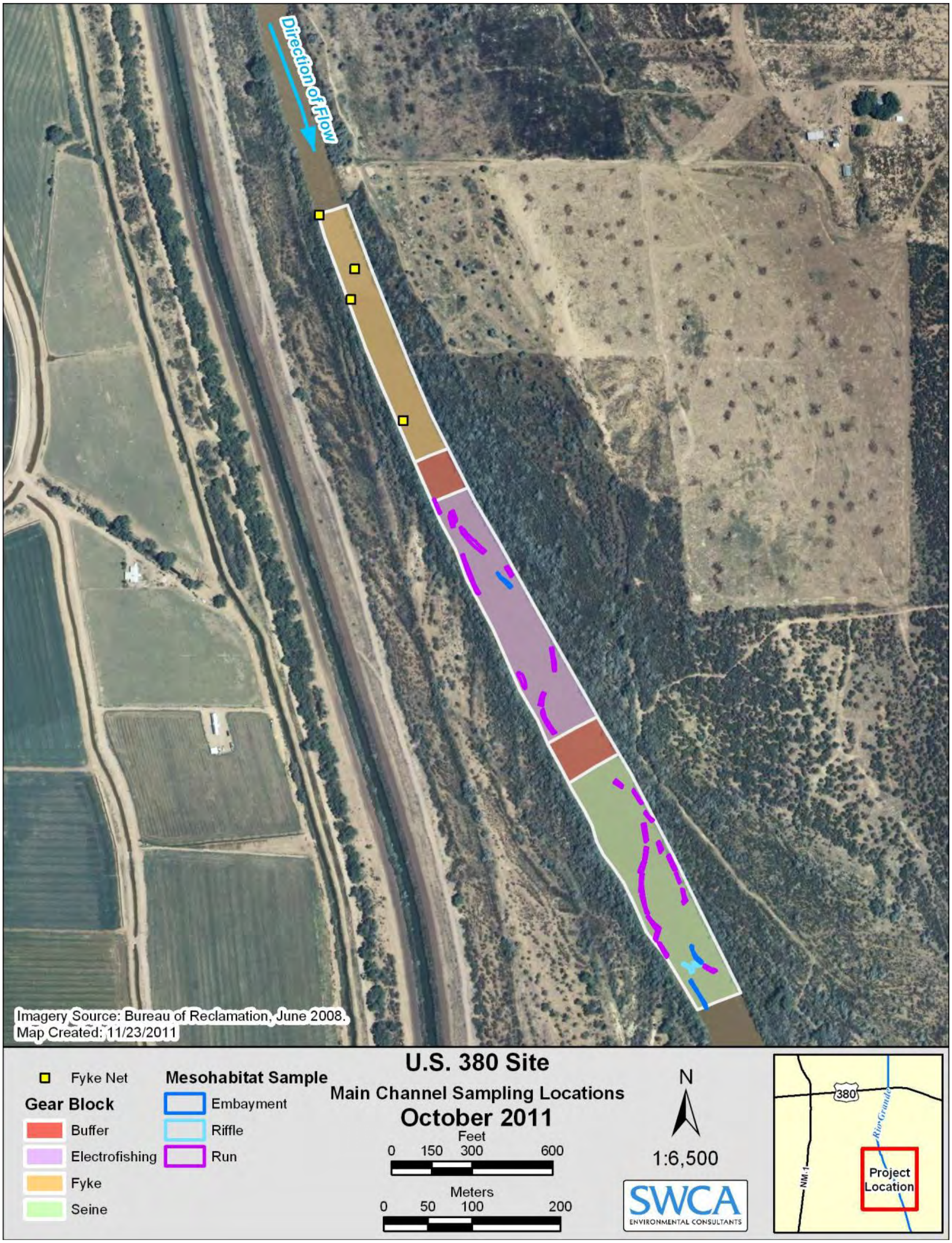

Figure B.18. Map of 380 Bridge site main channel depicting gear blocks and mesohabitat sample locations, October 2011.

APPENDIX C
PHOTOGRAPHS

Figure C.1. Facing west at a fyke net location, Alameda site, Polygon 1, on June 7, 2010.

Figure C.2. Facing northwest at crew seining Alameda site, Polygon 2, on June 8, 2010.

Figure C.3. Facing south at a fyke net positioned upstream at Alameda site, Polygon 3, on June 1, 2010.

Figure C.4. Electrofishing sampling at Alameda site, Polygon 3, on June 2, 2010.

Figure C.5. Facing west at a fyke net located in Paseo del Norte site, Polygon 2 (in foreground), and another fyke net located in Paseo del Norte site, Polygon 1 (in background), on June 7, 2010.

Figure C.6. Crew sampling with a beach seine at Paseo del Norte site, Polygon 1, on June 8, 2010.

Figure C.7. Facing north at Paseo del Norte site, Polygon 3, on June 6, 2010.

Figure C.8. Facing northwest at Paseo del Norte site, Polygon 1, on June 8, 2010.

Figure C.9. Facing west towards the main channel confluence at I-40 site, Polygon 2, on May 28, 2010.

Figure C.10. Facing northeast at a crew setting a fyke net at I-40 site, Polygon 3, on June 1, 2010.

Figure C.11. Seine sampling (facing north) at Alameda site, Polygon 3, on May 17, 2011.

Figure C.12. Facing south as a crew sets a fyke net Alameda site, Polygon 2, on May 15, 2011.

Figure C.13. Facing upstream at Alameda site, Polygon 1, on May 14, 2011.

Figure C.14. An adult 69-mm standard length silvery minnow caught while seining on May 17, 2011, at Alameda site, Polygon 1.

Figure C.15. Facing south at Paseo del Norte site, Polygon 2, on May 11, 2011.

Figure C.16. Facing southeast at Paseo del Norte site, Polygon 3, on May 9, 2011.

Figure C.17. Facing northwest at Paseo del Norte site, Polygon 1, on May 18, 2011.

Figure C.18. Facing southwest at I-40 site, Polygon 1, on June 2, 2011.

Figure C.19. Facing southwest at I-40 site, Polygon 2, on June 1, 2011.

Figure C.20. Facing southwest at I-40 site, Polygon 3, on June 2, 2011.

Figure C.21. Gravid 80-mm standard length silvery minnow was caught with a beach seine at I-40 site, Polygon 1, on June 1, 2011.

Figure C.22. One of three fyke nets positioned in the main river channel at the Calabacillas site on October 8, 2010.

Figure C.23. Electrofishing sampling (facing north) at the Calabacillas site on October 8, 2010.

Figure C.24. Seine sampling (facing south) at the Calabacillas site on October 8, 2010.

Figure C.25. Bag seine sampling (facing east) at the Calabacillas site on October 8, 2010.

Figure C.26. Single-wing fyke net (facing south) setup at the La Orilla site on October 7, 2010.

Figure C.27. Electrofish sampling (facing northeast) at the La Orilla site on October 7, 2010.

Figure C.28. Seine sampling (facing southwest) at the La Orilla site on October 7, 2010.

Figure C.29. Facing east at a double-wing fyke net at the Bosque Farms site on October 6, 2010.

Figure C.30. Facing southeast at crew electrofish sampling at Bosque Farms site on October 6, 2010.

Figure C.31. Seine sampling (facing west) at Bosque Farms site on October 6, 2010.

Figure C.32. Facing northwest at a bag seine location, Bosque Farms site, on October 6, 2010.

Figure C.33. Facing southwest at a seine sampling location, Veguita site, on October 4, 2010.

Figure C.34. Seine sampling at Calabacillas site on March 4, 2011.

Figure C.35. Crew conducting bag seine sampling at the Calabacillas site on March 4, 2011.

Figure C.36. Facing southwest at a fyke net location, La Orilla site, on March 1, 2011.

Figure C.37. Crew electrofishing (facing northwest) at La Orilla site on March 1, 2011.

Figure C.38. Facing east at a seine sampling location at the La Orilla site on March 1, 2011.

Figure C.39. Double-wing fyke net facing downstream at Bosque Farms site on March 2, 2011.

Figure C.40. Electrofish sampling at the Bosque Farms site on March 2, 2011.

Figure C.41. Adult 63-mm standard length silvery minnow caught at the La Orilla site on March 2, 2011.

Figure C.42. Facing east at crew seine sampling at Bosque Farms on March 2, 2011.

Figure C.43. Double-wing fyke net location, Veguita site, on March 3, 2011.

Figure C.44. Electrofishing (facing northwest) at the Veguita site on March 3, 2011.

Figure C.45. Gravid 66-mm standard length silvery minnow caught at the Veguita site on March 3, 2011.

Figure C.46. Facing northeast at the electrofish sampling location at the 380 Bridge site on March 11, 2011.

Figure C.47. Adult 54-mm standard length silvery minnow caught at the 380 Bridge site on March 11, 2011.

APPENDIX D
WATER QUALITY DATA

Table D.1. Water Quality Data Collected from Floodplain and Side Channel Sites, 2010 and 2011

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm[c])	Turbidity
Alameda	5/30/2010	1	8:15	1.00	0.00	15.10	4.34	43.30	7.82	0.12	253	205	82.00
Alameda	5/30/2010	2	8:11	0.70	0.01	14.59	3.98	39.10	7.41	0.12	256	205	111.00
Alameda	5/30/2010	3	8:00	1.40	0.00	15.21	3.81	38.00	7.74	0.12	260	211	99.00
Alameda	6/1/2010	1	7:45	1.10	0.01	15.97	5.70	58.70	8.13	0.11	199	241	ND
Alameda	6/1/2010	2	7:40	1.00	0.02	15.95	5.65	57.70	8.10	0.12	201	243	ND
Alameda	6/1/2010	3	7:30	1.80	0.02	16.09	4.86	49.50	8.06	0.12	204	245	ND
Alameda	6/2/2010	1	7:35	1.20	0.01	16.34	8.37	85.90	8.22	0.11	201	242	54.00
Alameda	6/2/2010	2	7:37	1.10	0.02	16.24	7.89	80.70	8.18	0.11	200	241	52.00
Alameda	6/2/2010	3	7:30	1.90	0.05	16.37	8.11	82.80	8.03	0.12	202	242	62.00
Alameda	6/3/2010	1	8:10	1.00	0.16	15.84	7.53	76.50	8.16	0.11	222	184	45.80
Alameda	6/3/2010	2	8:06	0.90	0.22	15.90	7.24	73.40	8.11	0.11	223	184	43.80
Alameda	6/3/2010	3	8:01	1.70	0.20	16.02	7.06	71.80	8.04	0.11	225	187	60.00
Alameda	6/4/2010	1	8:00	0.90	0.03	16.37	6.69	69.00	8.31	0.11	232	194	68.00
Alameda	6/4/2010	2	7:50	0.90	0.02	16.57	6.47	66.10	8.23	0.11	232	194	42.88
Alameda	6/4/2010	3	7:45	1.60	0.03	16.82	6.57	67.90	7.90	0.11	231	195	74.00
Alameda	6/5/2010	1	11:25	0.80	0.08	19.73	7.96	87.40	8.54	0.11	211	235	39.27
Alameda	6/5/2010	2	11:15	0.90	0.07	18.48	7.50	81.00	8.35	0.11	206	235	59.00
Alameda	6/5/2010	3	11:12	1.65	0.02	19.17	7.24	78.20	8.48	0.11	211	237	43.17
Alameda	6/6/2010	1	10:23	1.00	-0.01	19.23	8.13	8.13	8.41	0.11	207	233	29.53
Alameda	6/6/2010	2	10:18	0.08	-0.01	18.50	7.42	78.90	8.22	0.11	204	232	32.54
Alameda	6/6/2010	3	10:13	1.60	0.01	18.87	7.07	77.20	8.25	0.11	206	322	38.91
Alameda	6/7/2010	1	7:36	1.10	-0.02	19.22	6.44	69.80	8.24	0.11	209	235	131.00
Alameda	6/7/2010	2	7:32	1.10	0.01	19.40	6.03	65.80	8.14	0.11	211	236	72.00
Alameda	6/7/2010	3	7:24	1.70	0.04	19.57	6.22	67.90	8.00	0.11	211	235	61.00
Alameda	6/8/2010	1	7:43	0.90	0.02	18.07	5.50	58.40	8.01	0.12	225	260	77.00
Alameda	6/8/2010	2	7:40	0.60	0.01	18.34	4.22	45.00	7.89	0.13	230	263	130.00
Alameda	6/8/2010	3	7:34	1.30	0.01	18.64	4.54	48.90	7.83	0.13	231	263	167.00
Alameda	6/9/2010	1	11:15	0.60	-0.02	21.33	3.46	38.50	8.05	0.14	271	292	99.00
Alameda	6/9/2010	2	11:10	0.90	0.00	19.98	3.25	36.50	7.99	0.14	265	293	116.00

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm[c])	Turbidity
Alameda	6/9/2010	3	11:05	1.25	-0.01	20.60	4.37	48.30	8.09	0.13	257	280	106.00
Alameda	5/10/2011	1	8:15	1.10	0.00	11.43	6.91	63.40	7.44	0.17	260	351	44.26
Alameda	5/10/2011	2	8:54	0.80	0.00	11.82	5.84	54.40	7.90	0.17	269	360	79.00
Alameda	5/10/2011	3	9:45	0.90	0.00	12.03	4.80	45.50	7.88	0.17	271	361	101.00
Alameda	5/11/2011	1	8:07	1.20	0.00	10.69	6.04	54.60	ND	0.17	255	351	37.95
Alameda	5/11/2011	2	8:15	1.00	0.00	11.20	4.81	44.10	ND	0.17	261	354	58.00
Alameda	5/11/2011	3	8:15	0.90	0.01	10.94	4.44	40.20	ND	0.17	259	354	81.00
Alameda	5/12/2011	1	8:15	1.20	0.00	10.62	7.14	64.40	7.98	0.16	248	342	29.88
Alameda	5/12/2011	2	8:22	1.10	0.01	10.73	6.18	56.00	7.99	0.16	247	340	48.04
Alameda	5/12/2011	3	8:25	0.60	0.01	10.54	5.71	51.20	7.95	0.17	248	343	71.00
Alameda	5/13/2011	1	8:19	1.20	0.00	12.18	6.67	62.90	7.92	0.16	258	342	39.17
Alameda	5/13/2011	2	8:41	1.00	0.00	12.16	5.04	47.50	7.84	0.17	259	343	82.00
Alameda	5/13/2011	3	9:04	0.50	0.00	11.89	4.43	41.10	7.76	0.17	258	345	88.00
Alameda	5/14/2011	1	7:52	1.25	0.01	13.98	6.20	60.30	8.22	0.16	266	338	45.15
Alameda	5/14/2011	2	8:00	1.13	0.02	14.34	4.27	41.90	7.95	0.17	275	345	91.00
Alameda	5/14/2011	3	8:07	1.13	0.03	13.98	4.10	40.10	7.85	0.17	272	345	89.00
Alameda	5/16/2011	1	8:20	1.30	0.02	14.24	8.56	83.30	8.13	1.60	267	336	49.43
Alameda	5/16/2011	2	8:30	0.70	0.01	15.13	6.14	61.20	7.94	0.16	276	340	44.88
Alameda	5/16/2011	3	8:35	0.60	0.00	15.13	5.86	58.80	7.89	0.16	276	339	54.00
Alameda	5/17/2011	1	7:59	1.30	0.01	14.05	5.61	54.50	8.03	0.16	264	333	86.00
Alameda	5/17/2011	2	9:19	1.30	0.01	14.77	3.04	30.20	7.81	0.16	276	343	71.00
Alameda	5/17/2011	3	9:30	1.20	0.01	14.63	3.14	31.20	7.83	0.16	274	342	62.00
Alameda	5/18/2011	1	7:50	1.30	0.02	13.28	5.24	50.30	8.23	0.16	262	337	131.00
Alameda	5/18/2011	2	7:54	0.70	0.01	14.16	3.64	35.40	8.17	0.16	268	339	100.00
Alameda	5/18/2011	3	7:58	1.12	0.02	13.73	3.26	31.70	8.01	0.16	267	343	84.00
Alameda	5/19/2011	1	8:43	1.30	0.01	12.48	6.14	5.60	8.25	0.16	255	335	48.61
Alameda	5/19/2011	2	8:48	1.20	0.01	12.37	4.09	38.50	8.11	0.16	258	340	76.00
Alameda	5/19/2011	3	8:50	1.00	0.00	12.23	4.34	40.40	8.03	0.16	258	341	88.00
Alameda	5/23/2011	1	8:36	1.40	0.00	14.75	5.23	53.70	8.42	0.16	261	324	107.00
Alameda	5/23/2011	2	9:15	1.30	0.01	14.65	4.17	42.00	8.06	0.16	268	334	62.00

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm[c])	Turbidity
Alameda	5/23/2011	3	9:41	1.17	0.00	14.67	3.98	39.10	7.91	0.16	268	335	77.00
Alameda	5/24/2011	1	8:02	1.40	0.00	14.18	6.00	58.50	8.09	0.16	261	329	112.00
Alameda	5/24/2011	2	8:16	1.30	0.00	14.77	4.26	41.90	8.09	0.16	272	338	96.00
Alameda	5/24/2011	3	8:22	1.30	0.00	14.38	4.60	45.00	7.98	0.16	269	337	86.00
Alameda	5/25/2011	1	9:03	1.90	0.00	12.77	5.65	53.20	8.49	0.16	251	328	93.00
Alameda	5/25/2011	2	9:09	1.20	0.00	12.83	3.86	36.50	8.11	0.16	262	342	112.00
Alameda	5/25/2011	3	9:15	1.10	0.00	12.82	3.94	37.50	8.08	0.16	262	341	104.00
Alameda	6/1/2011	1	9:13	1.60	0.01	17.29	5.58	58.50	8.29	0.15	269	316	129.00
Alameda	6/1/2011	2	10:00	1.50	0.00	16.83	4.32	44.70	7.98	0.16	276	325	116.00
Alameda	6/1/2011	3	10:36	1.50	0.00	16.97	3.81	39.50	7.73	0.16	276	327	84.00
Alameda	6/2/2011	1	7:59	1.60	0.02	17.40	5.46	57.10	8.03	0.15	271	317	73.00
Alameda	6/2/2011	2	8:20	1.50	0.02	17.78	3.69	39.00	7.94	0.16	279	324	91.00
Alameda	6/2/2011	3	8:30	1.50	0.02	18.00	3.25	34.20	7.83	0.16	281	325	98.00
Alameda	6/3/2011	1	9:30	1.70	0.00	15.91	7.12	71.90	8.31	0.15	316	261	47.74
Alameda	6/3/2011	2	9:38	1.30	0.00	15.49	6.43	64.20	8.06	0.15	318	260	64.00
Alameda	6/3/2011	3	9:45	1.00	0.00	15.68	5.29	53.20	8.00	0.15	263	320	86.00
Paseo del Norte	5/30/2010	1	9:50	1.00	0.08	18.14	5.13	54.50	8.38	0.12	252	219	140.00
Paseo del Norte	5/30/2010	2	9:45	0.65	0.02	18.17	5.29	56.30	8.39	0.12	252	219	93.00
Paseo del Norte	5/30/2010	3	10:30	0.65	0.02	17.94	5.25	55.60	8.27	0.12	252	218	88.00
Paseo del Norte	6/1/2010	1	8:10	1.70	0.05	16.87	5.98	62.20	8.27	0.11	241	204	ND
Paseo del Norte	6/1/2010	2	8:15	1.20	0.09	16.76	5.75	59.30	8.29	0.11	241	203	ND
Paseo del Norte	6/1/2010	3	8:25	1.30	0.17	16.67	5.42	56.00	8.27	0.12	242	204	ND
Paseo del Norte	6/2/2010	1	11:25	1.40	0.07	18.26	9.31	99.10	8.31	0.12	211	242	53.00
Paseo del Norte	6/2/2010	2	11:20	1.10	0.10	18.22	9.92	105.80	8.35	0.11	208	239	53.00
Paseo del Norte	6/2/2010	3	12:10	1.30	0.14	18.52	9.93	106.30	8.31	0.12	216	247	55.00
Paseo del Norte	6/3/2010	1	9:29	1.50	0.20	18.17	8.48	89.80	8.37	0.11	230	199	71.00
Paseo del Norte	6/3/2010	2	9:32	1.10	0.18	17.92	8.38	89.10	8.38	0.11	225	195	50.00

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm^c)	Turbidity
Paseo del Norte	6/3/2010	3	10:07	1.20	0.21	17.75	8.56	90.10	8.28	0.11	230	199	51.00
Paseo del Norte	6/4/2010	1	8:35	1.60	0.04	18.09	7.91	84.20	8.48	0.11	232	201	56.00
Paseo del Norte	6/4/2010	2	8:30	0.95	0.02	17.99	7.57	80.50	8.52	0.11	232	201	48.61
Paseo del Norte	6/4/2010	3	8:45	1.00	0.09	17.87	7.89	83.90	8.45	0.11	233	201	47.88
Paseo del Norte	6/5/2010	1	9:35	1.60	0.03	19.80	8.13	89.40	8.39	0.11	207	230	41.06
Paseo del Norte	6/5/2010	2	9:40	0.60	0.03	19.77	7.35	79.80	8.35	0.11	208	231	40.95
Paseo del Norte	6/5/2010	3	10:20	1.05	0.07	19.43	8.07	87.70	8.55	0.11	208	233	53.00
Paseo del Norte	6/6/2010	1	12:00	1.30	0.04	22.78	7.91	92.30	8.51	0.11	224	234	37.95
Paseo del Norte	6/6/2010	2	11:52	0.90	0.01	22.33	8.31	95.60	8.45	0.11	222	234	39.56
Paseo del Norte	6/6/2010	3	12:40	0.80	0.08	21.72	8.27	94.20	8.35	0.11	222	236	43.38
Paseo del Norte	6/7/2010	1	8:15	1.50	0.03	19.60	7.68	83.90	8.23	0.11	210	234	106.00
Paseo del Norte	6/7/2010	2	8:21	0.90	0.08	19.58	7.27	79.50	8.34	0.11	211	235	2.50
Paseo del Norte	6/7/2010	3	8:31	1.20	0.11	19.34	7.91	86.00	8.29	0.11	212	237	271.00
Paseo del Norte	6/8/2010	1	9:28	1.30	0.02	19.42	6.55	71.10	8.43	0.12	231	258	64.00
Paseo del Norte	6/8/2010	2	9:21	1.00	0.01	19.29	7.02	76.20	8.38	0.12	231	260	97.00
Paseo del Norte	6/8/2010	3	10:04	0.80	0.00	20.53	7.37	81.80	8.57	0.12	237	259	79.00
Paseo del Norte	6/9/2010	1	9:45	1.00	0.04	21.92	7.25	80.80	8.49	0.12	238	252	51.00
Paseo del Norte	6/9/2010	2	9:50	0.10	-0.04	22.60	7.15	81.70	8.47	0.13	260	271	90.00
Paseo del Norte	5/10/2011	1	11:25	1.00	0.40	15.84	8.84	89.40	ND	0.16	272	329	47.07
Paseo del Norte	5/10/2011	2	12:22	0.50	0.35	17.01	9.13	95.10	ND	0.16	279	329	41.24
Paseo del Norte	5/10/2011	3	11:56	1.50	0.46	16.50	9.04	92.80	8.50	0.16	276	329	47.33
Paseo del Norte	5/11/2011	1	8:55	0.70	0.41	12.82	8.29	78.50	ND	0.16	255	333	49.09
Paseo del Norte	5/11/2011	2	9:15	0.50	0.23	12.98	7.74	73.50	ND	0.16	256	332	47.62

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm[c])	Turbidity
Paseo del Norte	5/11/2011	3	9:05	1.70	0.47	12.87	7.91	75.00	ND	0.16	255	332	53.00
Paseo del Norte	5/12/2011	1	10:30	0.90	0.37	14.16	8.36	81.60	8.25	0.16	259	327	48.45
Paseo del Norte	5/12/2011	2	11:10	0.60	0.38	15.10	8.14	81.10	8.41	0.16	264	326	43.32
Paseo del Norte	5/12/2011	3	10:50	1.60	0.38	14.58	8.26	81.40	8.31	0.16	262	326	47.03
Paseo del Norte	5/13/2011	1	10:00	0.80	0.45	15.28	8.42	84.20	8.37	0.16	264	324	43.37
Paseo del Norte	5/13/2011	2	10:50	0.60	0.45	16.33	8.41	86.20	8.44	0.15	269	323	47.74
Paseo del Norte	5/13/2011	3	10:26	1.60	0.42	15.74	8.46	85.50	8.39	0.16	269	323	48.93
Paseo del Norte	5/14/2011	1	8:42	1.00	0.40	15.57	7.97	80.00	8.35	0.15	265	323	48.21
Paseo del Norte	5/14/2011	2	8:52	1.90	0.55	15.56	7.88	79.00	8.38	0.15	265	323	48.72
Paseo del Norte	5/14/2011	3	8:59	0.65	0.45	15.72	7.84	79.00	8.39	0.15	265	322	51.00
Paseo del Norte	5/16/2011	1	10:20	1.05	0.36	16.85	11.61	119.90	18.35	0.15	269	318	40.13
Paseo del Norte	5/16/2011	2	10:53	0.58	0.42	17.06	10.76	112.90	8.52	0.15	273	318	40.73
Paseo del Norte	5/16/2011	3	10:45	2.23	0.46	17.26	10.75	112.00	8.44	0.15	271	318	36.85
Paseo del Norte	5/17/2011	1	10:40	1.00	0.34	15.43	8.08	81.20	8.47	0.15	258	315	40.91
Paseo del Norte	5/17/2011	2	11:34	0.60	0.48	16.35	8.11	83.10	8.58	0.15	263	315	48.89
Paseo del Norte	5/17/2011	3	11:07	2.23	0.40	16.07	8.12	82.60	8.56	0.15	262	316	36.23
Paseo del Norte	5/18/2011	1	8:37	0.97	0.36	14.49	8.28	81.60	8.33	0.16	258	323	42.19
Paseo del Norte	5/18/2011	2	8:45	0.55	0.26	14.71	8.24	81.40	8.42	0.15	259	322	37.43
Paseo del Norte	5/18/2011	3	8:45	2.10	0.42	14.53	8.18	80.40	8.40	0.16	258	323	35.08
Paseo del Norte	5/19/2011	1	10:40	1.00	0.36	14.18	8.34	81.20	8.49	0.15	252	317	31.77
Paseo del Norte	5/19/2011	2	11:10	0.50	0.34	14.59	8.52	84.00	8.60	0.15	254	317	30.20
Paseo del Norte	5/19/2011	3	10:55	2.20	0.35	14.47	8.43	82.80	8.56	0.15	253	317	32.08
Paseo del Norte	5/23/2011	1	10:50	0.95	0.45	17.89	7.83	82.70	8.49	0.15	266	308	40.96

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm[c])	Turbidity
Paseo del Norte	5/23/2011	2	11:35	0.70	0.38	18.89	8.03	86.40	8.64	0.15	274	310	36.28
Paseo del Norte	5/23/2011	3	11:17	1.60	0.42	18.44	8.01	85.40	8.60	0.15	271	309	40.22
Paseo del Norte	5/24/2011	1	9:00	1.10	0.56	15.75	8.83	89.10	8.48	0.15	256	311	43.60
Paseo del Norte	5/24/2011	2	9:12	0.70	0.39	15.60	8.89	89.40	8.56	0.15	256	312	42.68
Paseo del Norte	5/24/2011	3	9:08	1.60	0.48	15.67	8.89	89.50	8.55	0.15	253	308	44.36
Paseo del Norte	5/25/2011	1	10:57	1.00	0.60	16.29	8.45	86.30	8.49	0.15	259	310	55.00
Paseo del Norte	5/25/2011	2	11:40	0.50	0.35	17.23	8.50	88.70	8.55	0.15	266	312	51.00
Paseo del Norte	5/25/2011	3	11:23	1.60	0.45	16.94	8.44	87.30	8.52	0.15	263	311	61.00
Paseo del Norte	6/1/2011	1	11:22	1.50	0.39	19.79	7.68	83.80	8.40	0.15	278	309	52.00
Paseo del Norte	6/1/2011	2	12:27	0.70	0.35	20.51	7.75	86.40	8.47	0.15	284	311	63.00
Paseo del Norte	6/1/2011	3	11:38	2.40	0.42	20.33	7.62	84.20	8.44	0.15	283	310	62.00
Paseo del Norte	6/2/2011	1	9:30	1.50	0.46	18.20	8.04	85.00	8.35	0.15	267	307	54.00
Paseo del Norte	6/2/2011	2	9:56	0.70	0.48	18.55	8.11	86.70	8.41	0.15	220	308	60.00
Paseo del Norte	6/2/2011	3	9:40	2.20	0.50	18.49	8.10	86.50	8.42	0.15	220	308	60.00
Paseo del Norte	6/3/2011	1	11:00	1.00	0.35	18.03	8.59	90.80	8.32	0.15	270	311	90.00
Paseo del Norte	6/3/2011	2	11:58	1.10	0.43	18.60	8.41	89.90	8.27	0.15	274	312	92.00
Paseo del Norte	6/3/2011	3	11:25	2.30	0.55	18.42	8.39	89.40	8.27	0.15	273	312	96.00
I-40	5/30/2010	1	13:30	0.90	0.14	19.77	5.02	55.00	8.28	0.12	253	228	104.00
I-40	5/30/2010	2	12:45	1.40	0.06	20.74	5.21	58.20	8.44	0.12	253	233	95.00
I-40	5/30/2010	3	12:15	1.50	0.01	18.71	3.91	42.00	8.14	0.12	258	227	100.00
I-40	6/1/2010	1	9:40	1.20	0.21	17.55	5.80	61.00	8.34	0.12	209	243	ND
I-40	6/1/2010	2	9:25	1.80	0.12	17.64	5.83	61.30	8.35	0.12	209	243	ND
I-40	6/1/2010	3	9:15	1.90	0.01	16.80	5.16	53.40	8.21	0.12	208	247	ND
I-40	6/2/2010	1	14:45	1.10	0.23	19.59	9.47	103.20	8.20	0.12	223	249	56.00
I-40	6/2/2010	2	14:10	1.70	0.12	20.16	9.87	108.80	8.39	0.12	225	248	55.00

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm[c])	Turbidity
I-40	6/2/2010	3	13:40	1.80	0.00	23.02	10.15	118.80	8.37	0.12	241	251	49.90
I-40	6/3/2010	1	12:11	1.10	0.29	19.26	8.52	92.60	8.40	0.11	237	211	52.00
I-40	6/3/2010	2	11:49	1.50	0.17	19.97	9.47	104.20	8.61	0.11	235	213	50.00
I-40	6/3/2010	3	11:30	1.80	0.05	17.84	7.45	78.40	8.27	0.11	236	203	57.00
I-40	6/4/2010	1	9:55	0.95	0.07	18.63	7.63	82.30	8.49	0.11	236	207	52.00
I-40	6/4/2010	2	9:50	1.10	0.06	18.85	9.08	97.90	8.72	0.11	236	208	47.96
I-40	6/4/2010	3	9:35	2.90	0.03	18.58	6.83	72.50	8.37	0.11	238	209	101.00
I-40	6/5/2010	1	8:25	0.90	0.09	18.70	7.55	81.00	8.35	0.11	203	231	48.64
I-40	6/5/2010	2	8:00	1.45	0.05	18.70	8.00	86.30	8.50	0.11	203	231	44.75
I-40	6/5/2010	3	7:29	1.65	0.01	18.50	6.83	71.20	8.55	0.11	204	233	107.00
I-40	6/6/2010	1	9:04	0.90	0.07	19.71	8.04	88.20	8.36	0.11	209	232	45.08
I-40	6/6/2010	2	8:35	1.30	0.04	19.85	8.59	93.50	8.52	0.11	209	232	37.87
I-40	6/6/2010	3	7:49	1.50	0.01	19.33	6.49	70.80	8.12	0.11	207	232	42.87
I-40	6/7/2010	1	9:37	1.10	0.12	20.36	7.59	84.30	8.40	0.11	216	237	41.11
I-40	6/7/2010	2	9:39	1.50	0.05	20.75	7.93	89.10	8.70	0.11	218	238	40.23
I-40	6/7/2010	3	9:25	1.70	-0.02	20.64	7.44	82.70	8.46	0.11	217	237	39.40
I-40	6/8/2010	1	12:35	0.80	0.04	21.60	7.46	58.30	8.50	0.13	257	275	81.00
I-40	6/8/2010	2	12:00	1.30	0.03	22.67	9.20	106.90	8.82	0.13	263	275	88.00
I-40	6/8/2010	3	11:22	1.40	0.02	21.61	6.30	70.70	8.36	0.13	283	361	83.00
I-40	6/9/2010	1	8:40	0.45	0.00	19.50	6.70	74.30	8.39	0.12	223	249	51.00
I-40	6/9/2010	2	8:15	1.00	-0.03	18.56	4.37	47.00	8.07	0.12	225	257	119.00
I-40	6/9/2010	3	7:35	1.20	-0.01	19.38	4.50	48.10	8.34	0.13	253	284	89.00
I-40	5/10/2011	1	2:45	0.70	0.39	19.56	8.46	92.10	11.78	0.16	305	341	54.00
I-40	5/10/2011	2	2:30	0.80	0.34	19.64	8.80	96.40	ND	0.16	303	338	62.00
I-40	5/10/2011	3	2:12	1.10	0.38	19.48	8.43	91.90	8.36	0.16	303	339	63.00
I-40	5/11/2011	1	10:05	0.60	0.34	12.50	7.96	74.80	ND	0.17	263	346	60.00
I-40	5/11/2011	2	10:00	0.70	0.33	12.48	8.11	76.20	ND	0.17	264	347	53.00
I-40	5/11/2011	3	9:55	1.10	0.39	12.51	8.54	80.30	ND	0.17	263	346	53.00
I-40	5/12/2011	1	12:43	0.75	0.35	16.54	7.87	80.70	8.27	0.16	273	325	62.00
I-40	5/12/2011	2	12:30	0.80	0.30	16.33	7.89	80.50	8.24	0.16	278	333	61.00

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm^c)	Turbidity
I-40	5/12/2011	3	12:15	1.10	0.50	16.07	8.05	81.90	8.32	0.16	278	335	49.32
I-40	5/13/2011	1	1:20	0.70	0.41	19.72	7.79	85.60	8.32	0.16	299	332	53.00
I-40	5/13/2011	2	1:00	0.70	0.42	19.33	8.00	87.20	8.29	0.16	295	331	63.00
I-40	5/13/2011	3	12:30	1.00	0.44	18.70	8.12	87.30	8.30	0.16	293	333	60.00
I-40	5/14/2011	1	9:50	0.95	0.42	15.25	8.33	83.30	8.34	0.16	271	333	61.00
I-40	5/14/2011	2	9:56	0.70	0.42	15.34	8.03	80.30	8.26	0.16	272	333	61.00
I-40	5/14/2011	3	10:01	0.68	0.33	15.42	8.00	79.90	8.27	0.16	272	333	60.00
I-40	5/16/2011	1	1:12	0.70	0.35	20.11	10.45	115.60	8.38	0.16	295	325	48.89
I-40	5/16/2011	2	12:55	0.70	0.33	19.82	10.35	113.50	8.36	0.15	278	309	53.00
I-40	5/16/2011	3	12:38	0.90	0.14	19.51	10.56	115.00	8.31	0.16	292	326	51.00
I-40	5/17/2011	1	2:02	0.70	0.35	18.93	7.81	83.00	8.44	0.15	284	322	51.00
I-40	5/17/2011	2	1:42	0.60	0.31	18.64	7.80	83.70	8.39	0.15	283	323	54.00
I-40	5/17/2011	3	1:25	0.75	0.09	18.31	7.87	83.70	8.38	0.15	282	323	45.06
I-40	5/18/2011	1	10:11	0.62	0.32	15.15	8.22	82.00	8.39	0.16	273	336	52.00
I-40	5/18/2011	2	10:04	0.60	0.37	15.05	8.23	81.70	8.34	0.16	271	335	46.75
I-40	5/18/2011	3	9:55	1.04	0.41	14.74	8.39	82.90	8.44	0.16	271	336	43.13
I-40	5/19/2011	1	12:59	0.60	0.33	14.86	8.23	81.70	8.42	0.16	262	324	41.30
I-40	5/19/2011	2	12:45	0.60	0.32	14.74	8.24	81.40	8.41	0.15	257	319	45.63
I-40	5/19/2011	3	12:31	1.00	0.40	14.60	8.27	82.40	8.45	0.16	261	326	39.65
I-40	5/23/2011	1	2:26	0.80	0.33	22.20	7.41	85.10	8.41	0.15	297	314	55.00
I-40	5/23/2011	2	2:08	0.80	0.40	21.96	7.54	86.30	8.42	0.15	298	316	49.87
I-40	5/23/2011	3	13:54	1.13	0.45	21.92	7.72	88.30	8.39	0.15	296	315	52.00
I-40	5/24/2011	1	9:55	1.10	0.47	15.19	9.14	91.10	8.41	0.16	266	327	59.00
I-40	5/24/2011	2	10:00	0.80	0.34	15.24	8.97	89.60	8.40	0.16	265	326	52.00
I-40	5/24/2011	3	10:05	0.80	0.34	15.80	8.95	89.10	8.36	0.16	265	326	57.00
I-40	5/25/2011	1	12:55	1.00	0.55	18.84	8.49	91.40	8.43	0.15	281	318	62.00
I-40	5/25/2011	2	1:05	0.90	0.36	19.13	8.23	89.10	8.38	0.15	280	316	64.00
I-40	5/25/2011	3	1:30	0.70	0.34	19.41	8.10	88.10	8.40	0.15	280	314	63.00
I-40	6/1/2011	1	14:39	1.00	0.44	22.45	7.13	81.90	8.34	0.15	296	312	72.00
I-40	6/1/2011	2	14:20	1.10	0.54	22.54	7.14	82.70	8.36	0.15	298	313	77.00

Site	Date	Sample Polygon	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cm[c])	Turbidity
I-40	6/1/2011	3	14:07	0.80	0.55	22.94	7.26	84.10	8.35	0.15	298	312	76.00
I-40	6/2/2011	1	10:51	1.40	0.56	19.70	8.12	88.30	8.39	0.15	279	313	74.00
I-40	6/2/2011	2	10:58	1.70	0.55	19.35	8.04	87.90	8.37	0.15	280	313	70.00
I-40	6/2/2011	3	11:09	1.10	0.39	19.44	7.98	87.00	8.36	0.15	281	314	69.00
I-40	6/3/2011	1	13:35	2.00	0.41	20.86	8.23	92.10	8.24	0.15	314	289	118.00
I-40	6/3/2011	2	13:14	1.60	0.56	20.68	8.05	89.80	8.23	0.15	289	315	127.00
I-40	6/3/2011	3	13:00	2.00	0.62	20.86	8.23	92.10	8.24	0.15	314	289	118.00

ND = no data.

Table D.2. Water Quality Data Collected from Main Channel Sites, 2010–2012

Site	Date	Sample Block	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cmc)	Turbidity
Calabacillas	10/8/2010	Electrofishing	8:45	1.30	0.33	15.48	7.94	79.70	8.66	0.13	217	266	91.00
Calabacillas	10/8/2010	Electrofishing	10:29	0.80	0.54	16.96	8.03	83.20	8.68	0.12	214	252	80.00
Calabacillas	3/4/2011	Electrofishing	8:12	2.50	0.64	6.83	9.99	82.00	8.33	0.16	336	219	49.14
Calabacillas	3/4/2011	Electrofishing	13:05	2.50	0.83	11.54	9.67	88.90	8.45	0.16	333	248	46.93
Calabacillas	10/21/2011	Electrofishing	9:22	2.60	0.85	10.74	9.13	82.40	8.55	0.17	350	254	69.00
Calabacillas	10/21/2011	Electrofishing	11:05	0.60	0.33	12.88	9.09	86.10	8.48	0.14	294	226	79.00
Calabacillas	3/7/2012	Electrofishing	10:30	1.90	0.69	8.00	8.60	72.90	8.47	0.16	338	228	77.00
Calabacillas	3/7/2012	Electrofishing	12:20	1.90	0.71	10.50	8.41	75.60	8.70	0.16	330	239	94.00
La Orilla	10/7/2010	Electrofishing	8:41	0.70	0.12	15.23	14.10	140.90	8.45	0.14	235	289	138.00
La Orilla	10/7/2010	Electrofishing	10:49	1.00	0.12	18.78	14.18	152.40	8.64	0.13	243	276	116.00
La Orilla	3/1/2011	Electrofishing	8:49	1.10	0.60	4.02	10.37	88.70	8.79	0.16	339	203	57.00
La Orilla	3/1/2011	Electrofishing	13:41	1.60	0.52	10.48	10.91	83.70	8.84	0.16	324	235	34.37
La Orilla	10/20/2011	Electrofishing	9:09	0.70	0.40	10.39	8.81	79.00	8.61	0.17	356	256	93.00
La Orilla	3/5/2012	Electrofishing	9:53	0.70	0.41	5.92	11.12	89.50	8.42	0.17	346	220	72.00
La Orilla	3/5/2012	Electrofishing	14:06	1.10	0.56	12.93	9.87	93.80	8.31	0.16	341	263	78.00
Bosque Farms	10/6/2010	Electrofishing	8:45	0.60	0.15	13.47	8.39	80.60	8.32	0.20	323	414	439.00
Bosque Farms	10/6/2010	Electrofishing	14:50	0.40	0.45	24.13	7.41	88.30	8.41	0.22	443	450	431.00
Bosque Farms	3/2/2011	Electrofishing	9:13	1.20	0.54	7.34	9.98	82.90	8.10	0.21	428	284	53.00
Bosque Farms	3/2/2011	Electrofishing	13:24	1.50	0.71	11.88	9.64	89.30	8.15	0.21	428	321	55.00
Bosque Farms	10/18/2011	Electrofishing	10:09	0.40	0.32	12.01	8.91	82.90	8.42	0.24	490	368	71.00
Bosque Farms	10/18/2011	Electrofishing	14:38	0.40	0.10	22.20	7.28	83.30	8.40	0.25	597	496	95.00
Bosque Farms	3/6/2012	Electrofishing	8:57	0.80	0.31	9.40	9.26	81.00	8.43	0.21	435	305	67.00
Bosque Farms	3/6/2012	Electrofishing	11:47	1.00	0.35	10.62	9.37	84.40	8.30	0.21	428	311	70.00
Veguita	10/4/2010	Electrofishing	11:52	0.50	0.33	21.35	20.51	237.30	7.43	0.24	465	500	127.00
Veguita	10/4/2010	Electrofishing	16:21	0.50	0.48	25.59	18.91	231.80	9.54	0.24	498	492	278.00
Veguita	3/3/2011	Electrofishing	9:06	2.70	0.73	10.91	9.19	88.30	8.22	0.22	456	333	84.00

Site	Date	Sample Block	Time	Depth (feet)	Flow (m/s)	Water Temp (°C)	D.O. (mg/L)	D.O. (%)	pH	Salinity (ppt)	Conductivity (µs/cm)	Conductivity (µs/cmc)	Turbidity
Veguita	3/3/2011	Electrofishing	13:49	1.30	0.60	13.38	9.33	89.50	8.21	0.21	445	347	84.00
Veguita	10/19/2011	Electrofishing	10:04	1.00	0.24	13.04	10.18	96.80	8.50	0.27	563	435	150.00
Veguita	10/19/2011	Electrofishing	12:22	0.40	0.27	16.15	9.80	99.80	8.36	0.29	585	486	94.00
Veguita	3/12/2012	Electrofishing	11:00	0.40	0.52	8.72	10.37	89.20	8.64	0.22	447	308	89.00
Veguita	3/12/2012	Electrofishing	14:00	1.70	0.68	11.29	10.41	95.20	8.36	0.21	439	324	79.00
380 Bridge	2/28/2011	Electrofishing	11:34	2.00	0.51	6.53	12.16	99.40	8.72	0.26	537	347	209.00
380 Bridge	3/11/2011	Fyke	8:57	1.65	0.51	9.12	9.76	84.70	8.35	0.23	483	337	158.00
380 Bridge	3/11/2011	Fyke	13:00	2.00	0.62	13.30	9.65	92.50	8.33	0.24	489	380	168.00
380 Bridge	10/17/2011	Electrofishing	10:34	0.60	0.30	13.66	9.52	92.00	8.03	0.32	660	517	1000.00
380 Bridge	10/17/2011	Electrofishing	14:05	1.20	0.54	19.13	8.63	93.70	8.28	0.33	667	591	1000.00

APPENDIX E
POWER ANALYSIS RESULTS FOR FLOODPLAIN AND SIDE CHANNEL SAMPLING IN 2010 AND 2011 USING AREA TO STANDARDIZE EFFORT

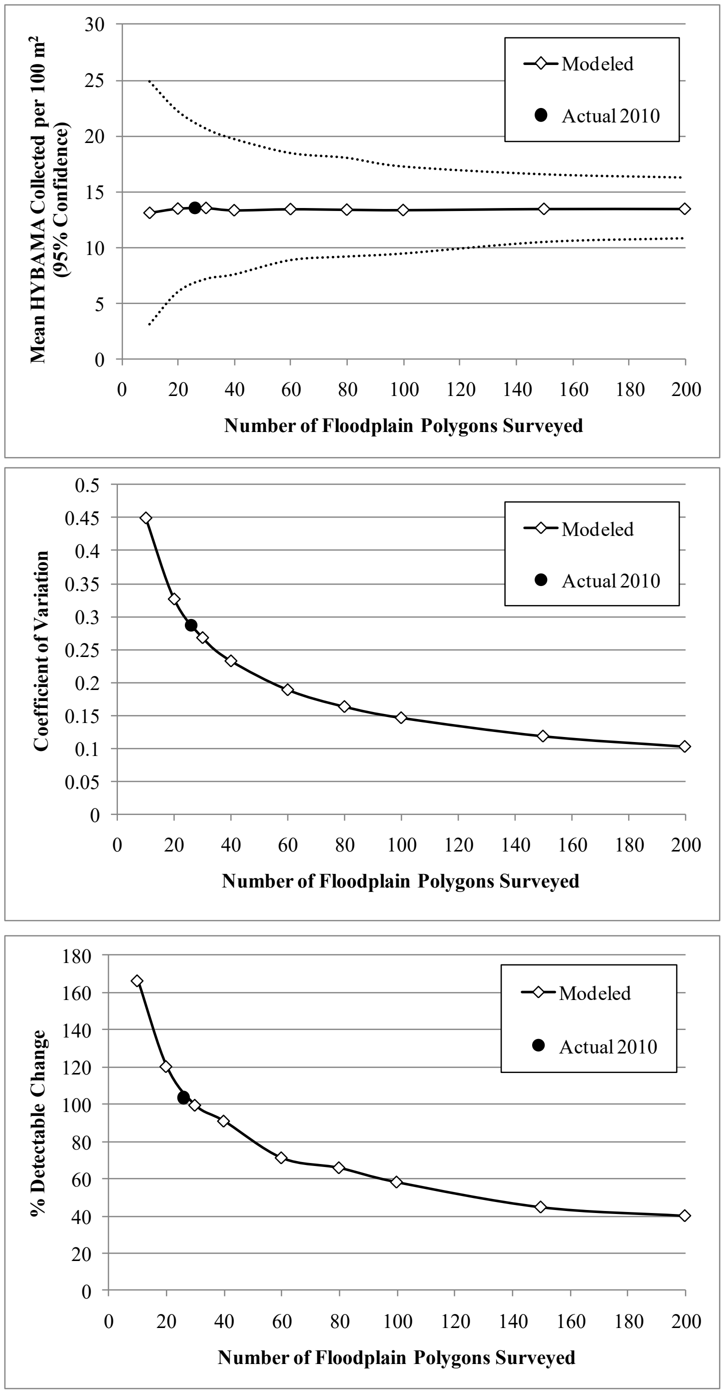

Figure E.1. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from predefined sampling areas (polygons) in floodplain and side channel habitat in 2010.

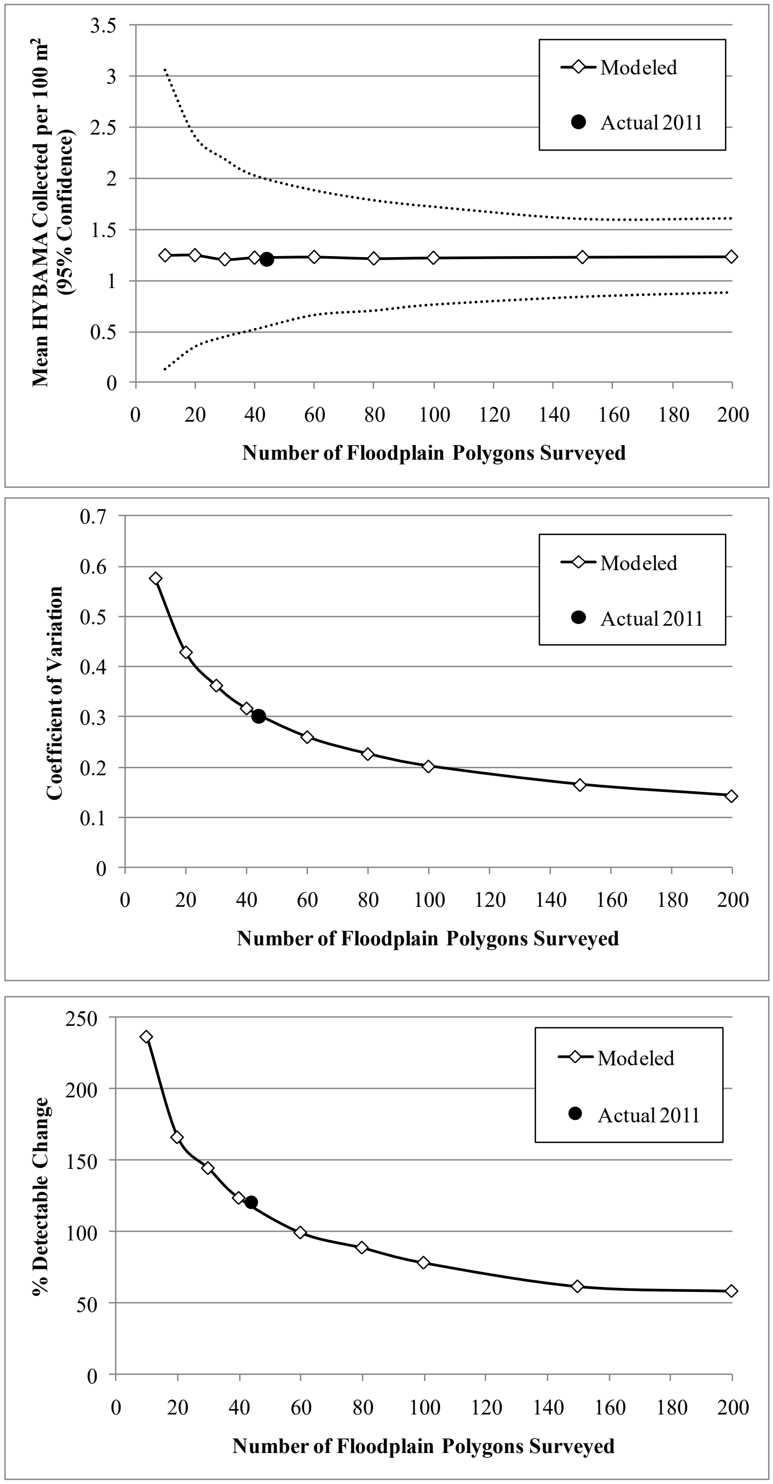

Figure E.2. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from predefined sampling areas (polygons) in floodplain and side channel habitat in 2011.

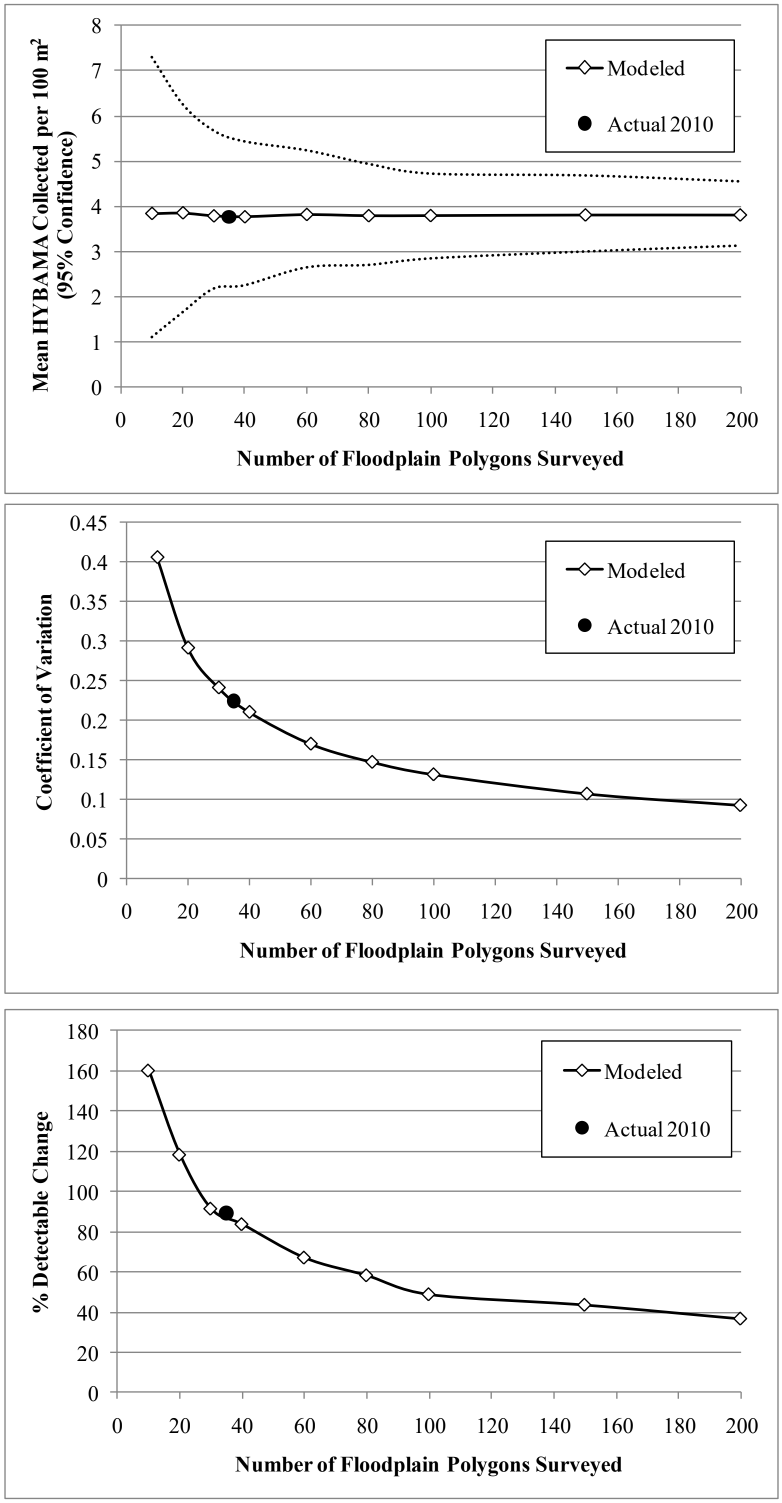

Figure E.3. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a beach seine from predefined sampling areas (polygons) in floodplain and side channel habitat in 2010.

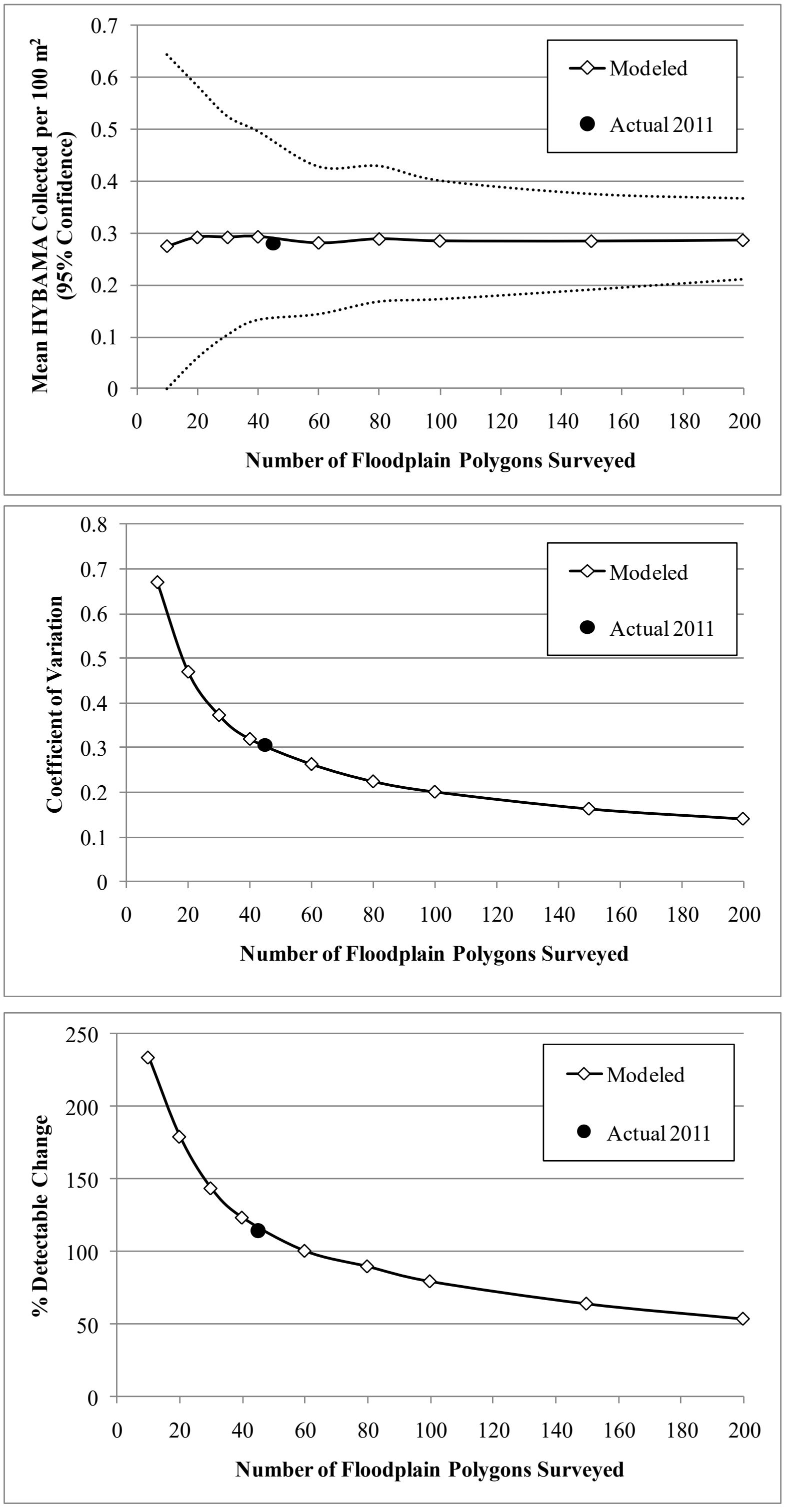

Figure E.4. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a beach seine from predefined sampling areas (polygons) in floodplain and side channel habitat in 2011.

APPENDIX F
POWER ANALYSIS RESULTS FOR FLOODPLAIN AND SIDE CHANNEL SAMPLING IN 2010 AND 2011 USING SAMPLING TIME TO STANDARDIZE EFFORT

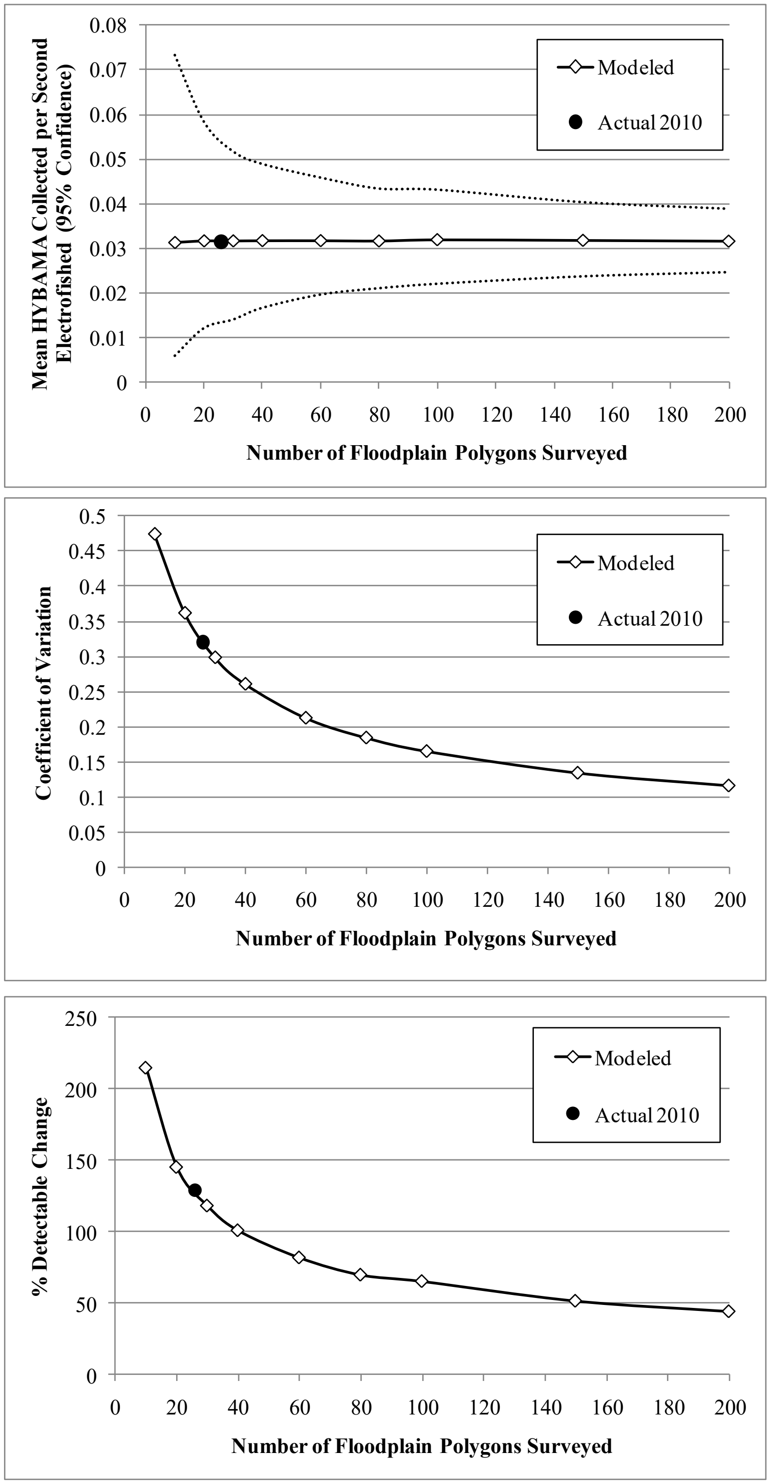

Figure F.1. The modeled change in the mean number of silvery minnow (HYBAMA) collected per time sampled (fish per seconds of electricity; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from predefined sampling areas (polygons) in floodplain and side channel habitat in 2010.

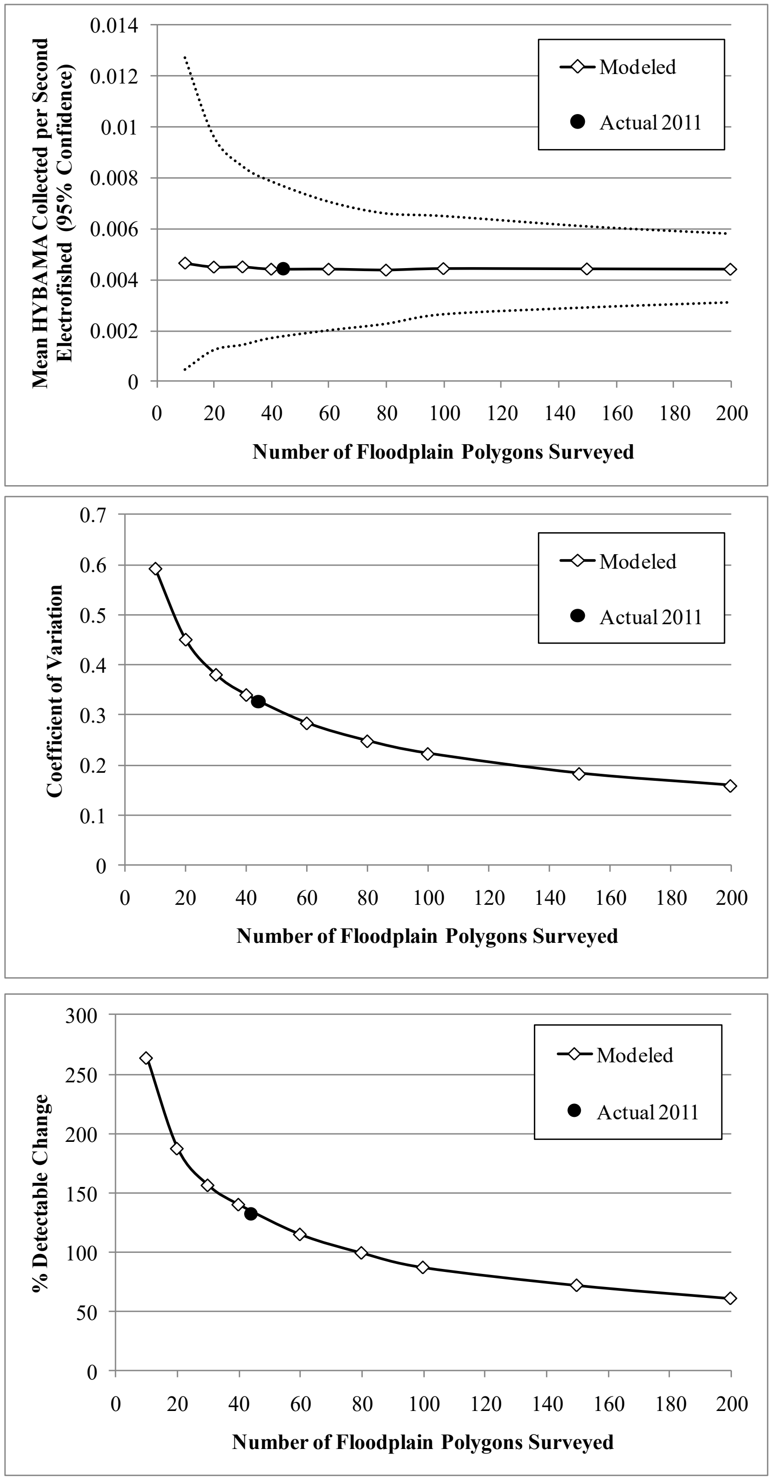

Figure F.2. The modeled change in the mean number of silvery minnow (HYBAMA) collected per time sampled (fish per seconds of electricity; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from predefined sampling areas (polygons) in floodplain and side channel habitat in 2011.

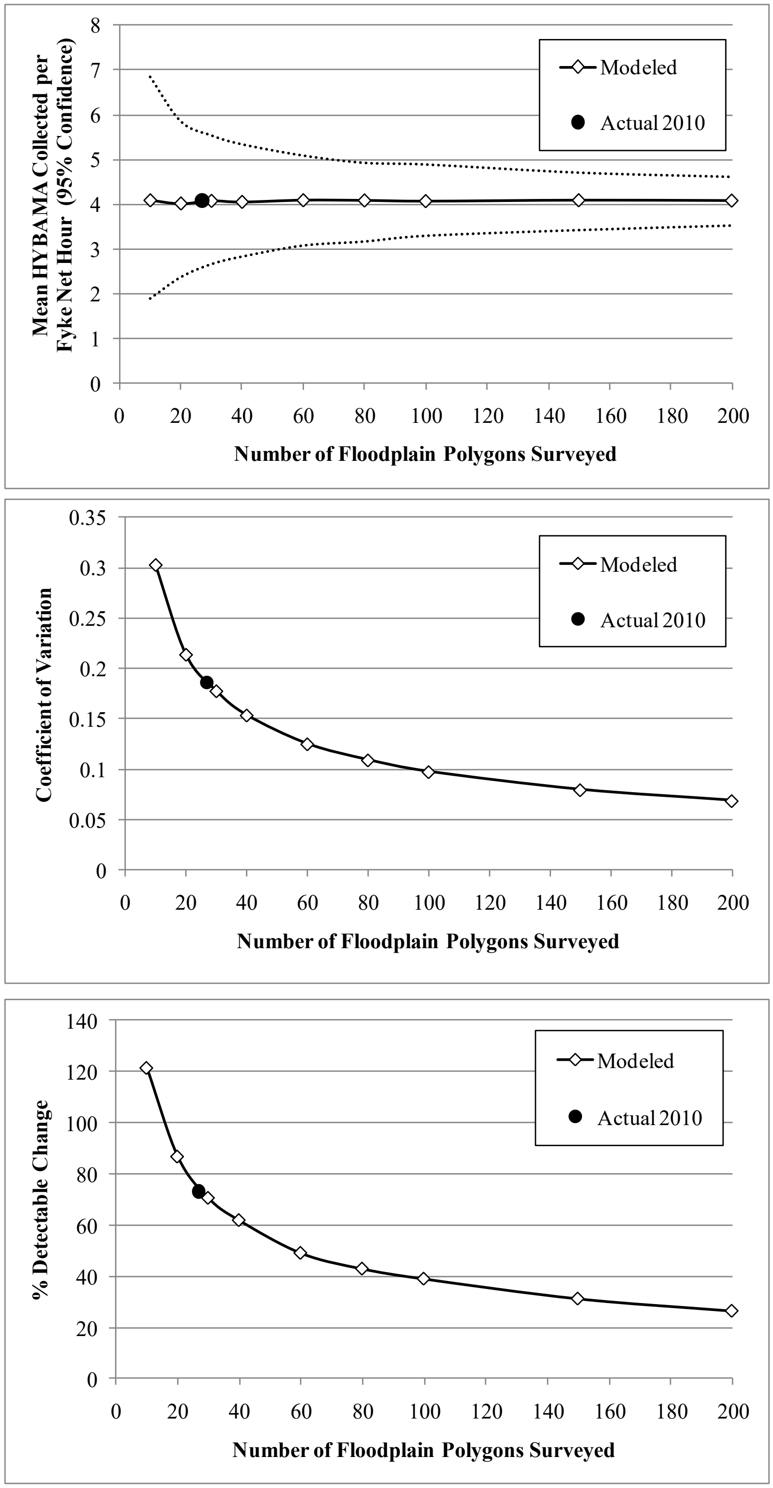

Figure F.3. The modeled change in the mean number of silvery minnow (HYBAMA) collected per time sampled (fish per fyke net hour; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a fyke net from predefined sampling areas (polygons) in floodplain and side channel habitat in 2010.

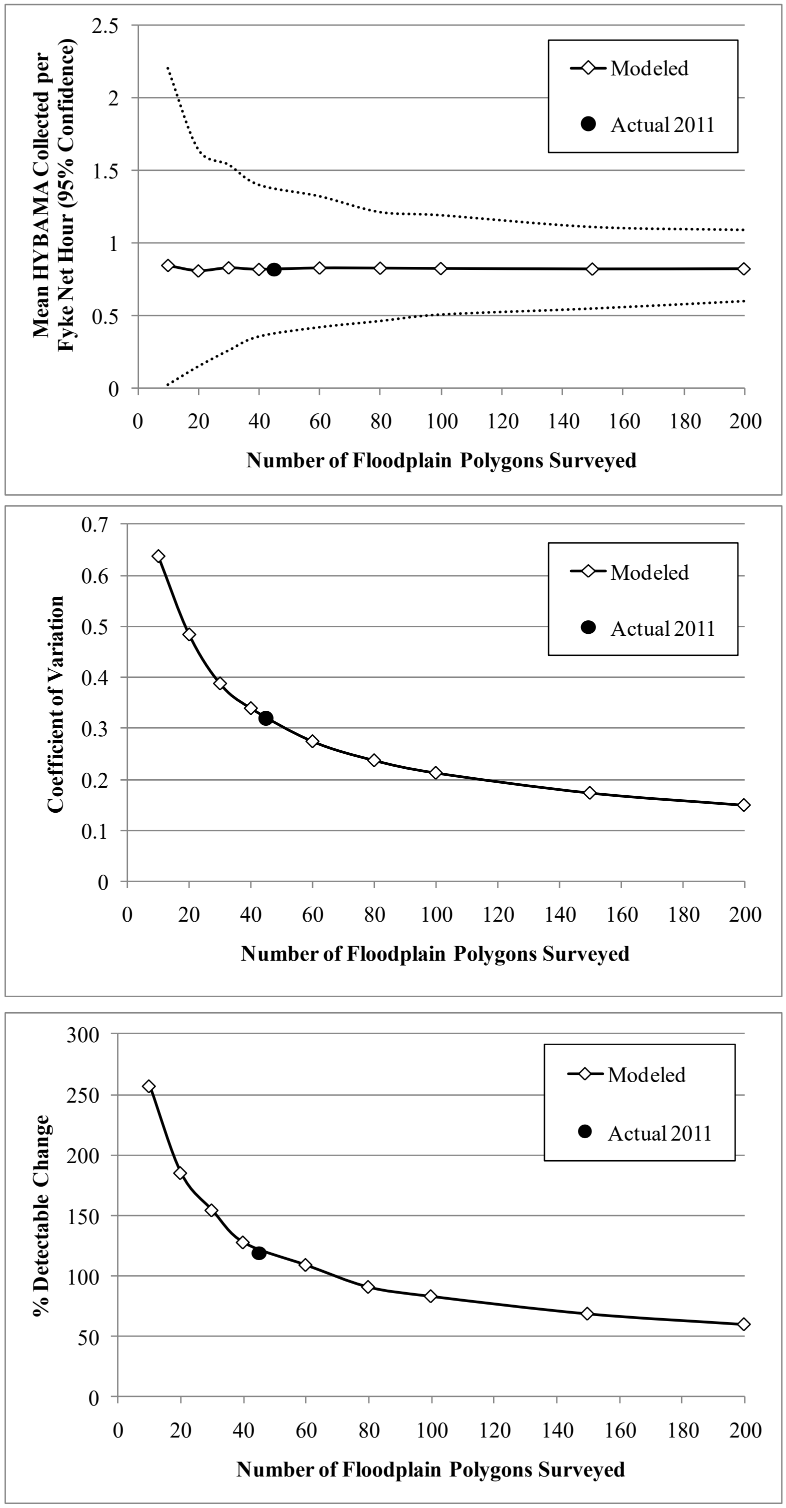

Figure F.4. The modeled change in the mean number of silvery minnow (HYBAMA) collected per time sampled (fish per fyke net hour; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a fyke net from predefined sampling areas (polygons) in floodplain and side channel habitat in 2011.

APPENDIX G
POWER ANALYSIS RESULTS FOR MAIN CHANNEL SAMPLING IN FALL 2010 USING AREA TO STANDARDIZE EFFORT

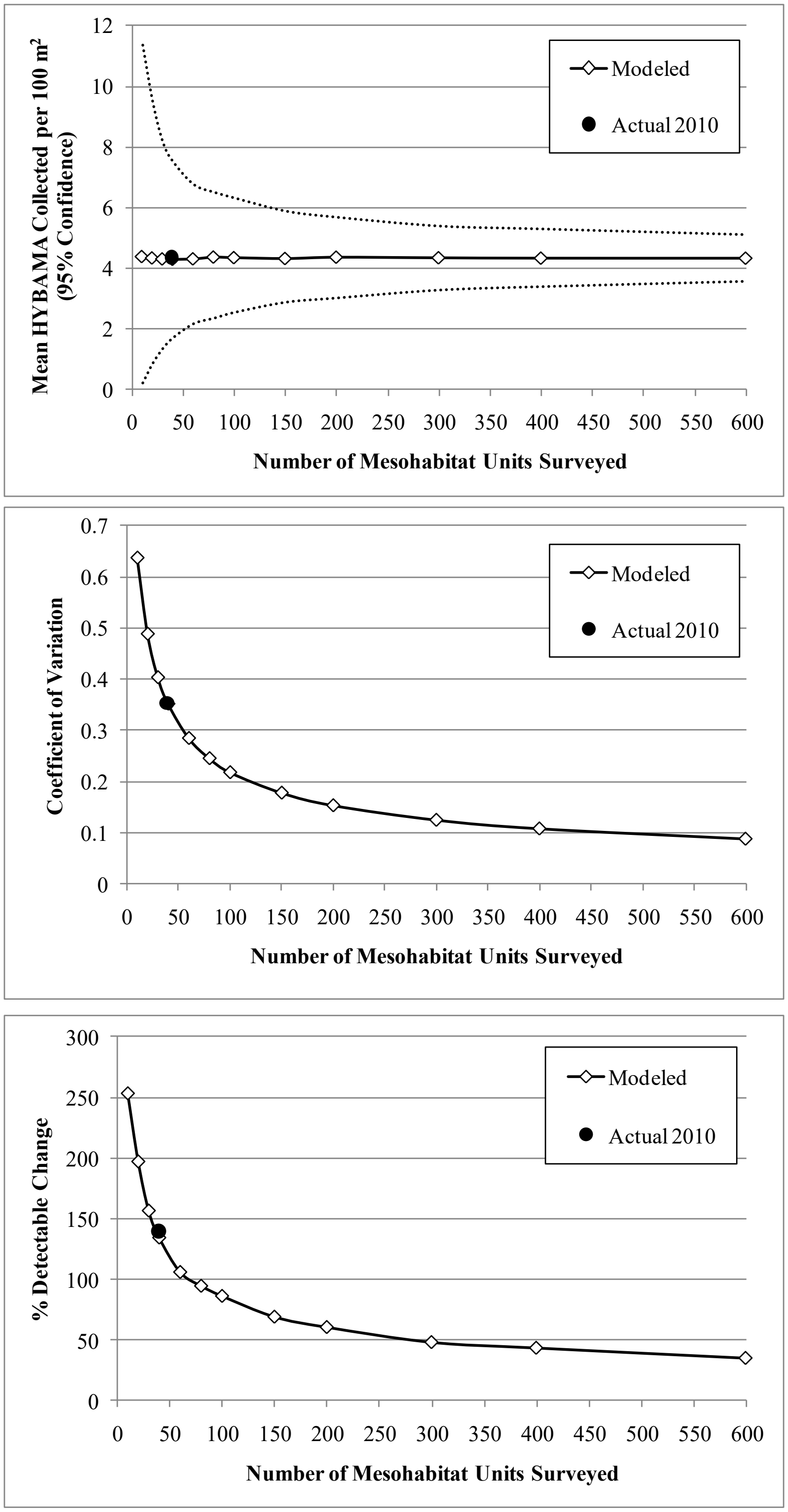

Figure G.1. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from individual mesohabitat units in the main channel in the fall of 2010.

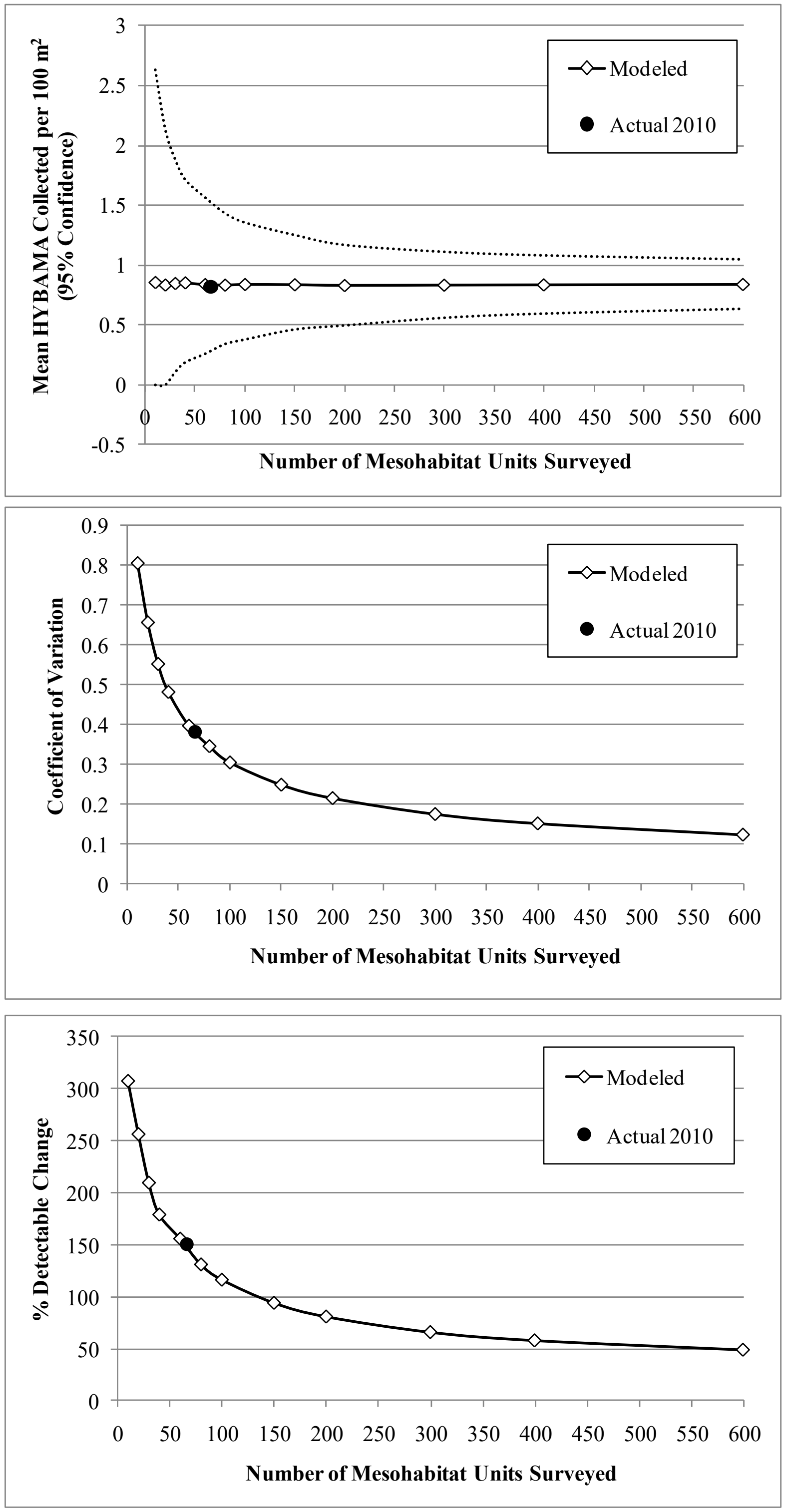

Figure G.2. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a beach seine from individual mesohabitat units in the main channel in the fall of 2010.

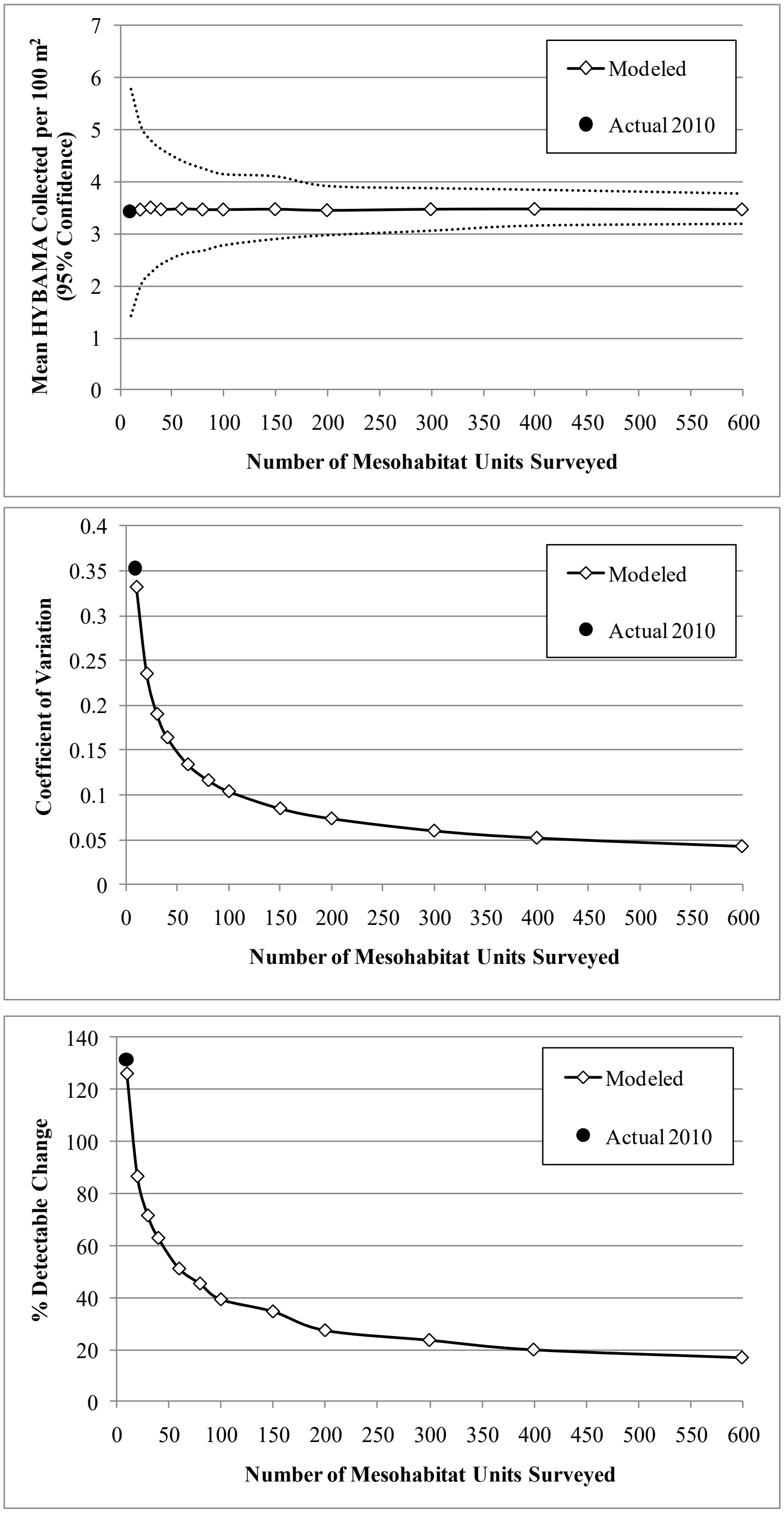

Figure G.3. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a bag seine over multiple mesohabitats in the main channel in the fall of 2010.

APPENDIX H
POWER ANALYSIS RESULTS FOR MAIN CHANNEL SAMPLING IN FALL 2010 USING TIME TO STANDARDIZE EFFORT

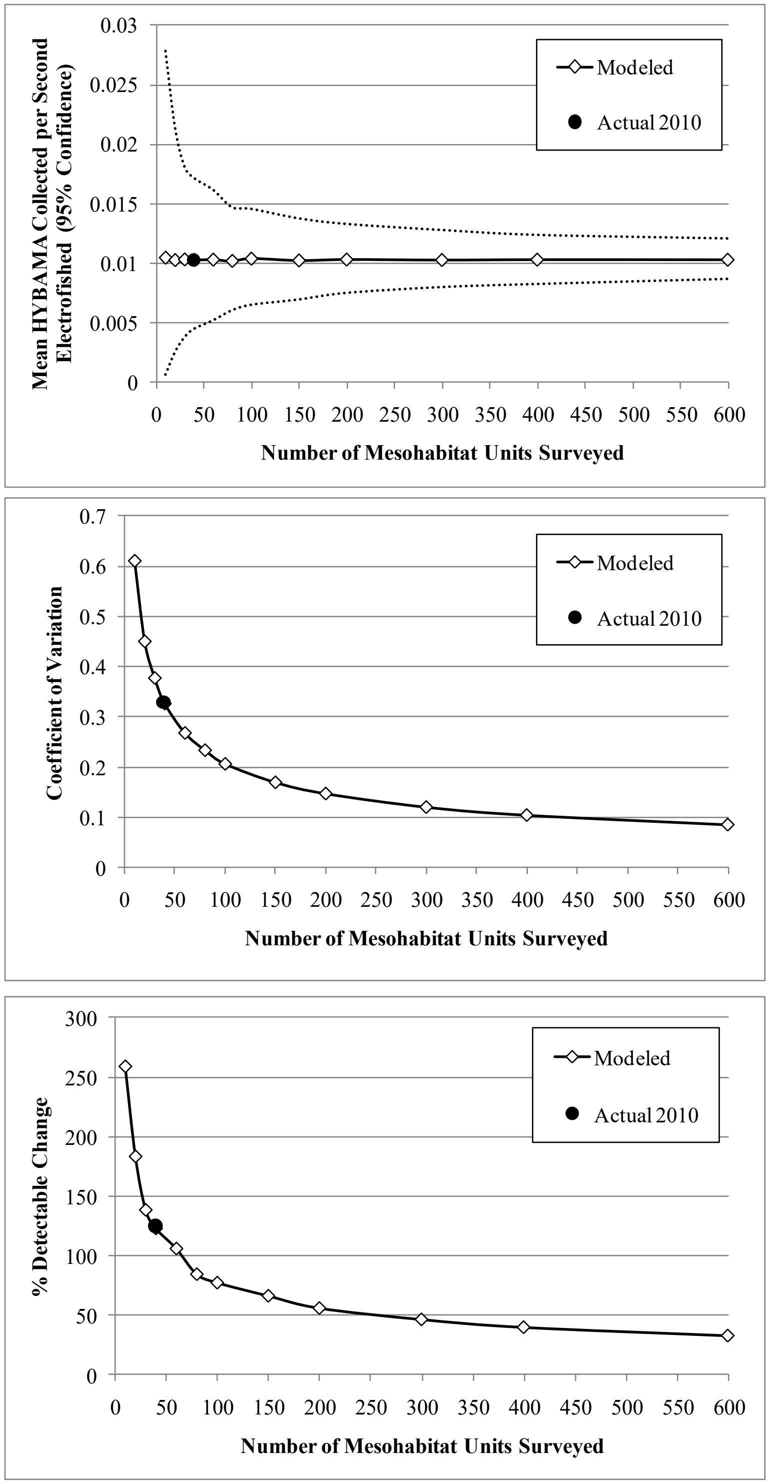

Figure H.1. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish per seconds of electricity; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from individual mesohabitat units in the main channel in the fall of 2010.

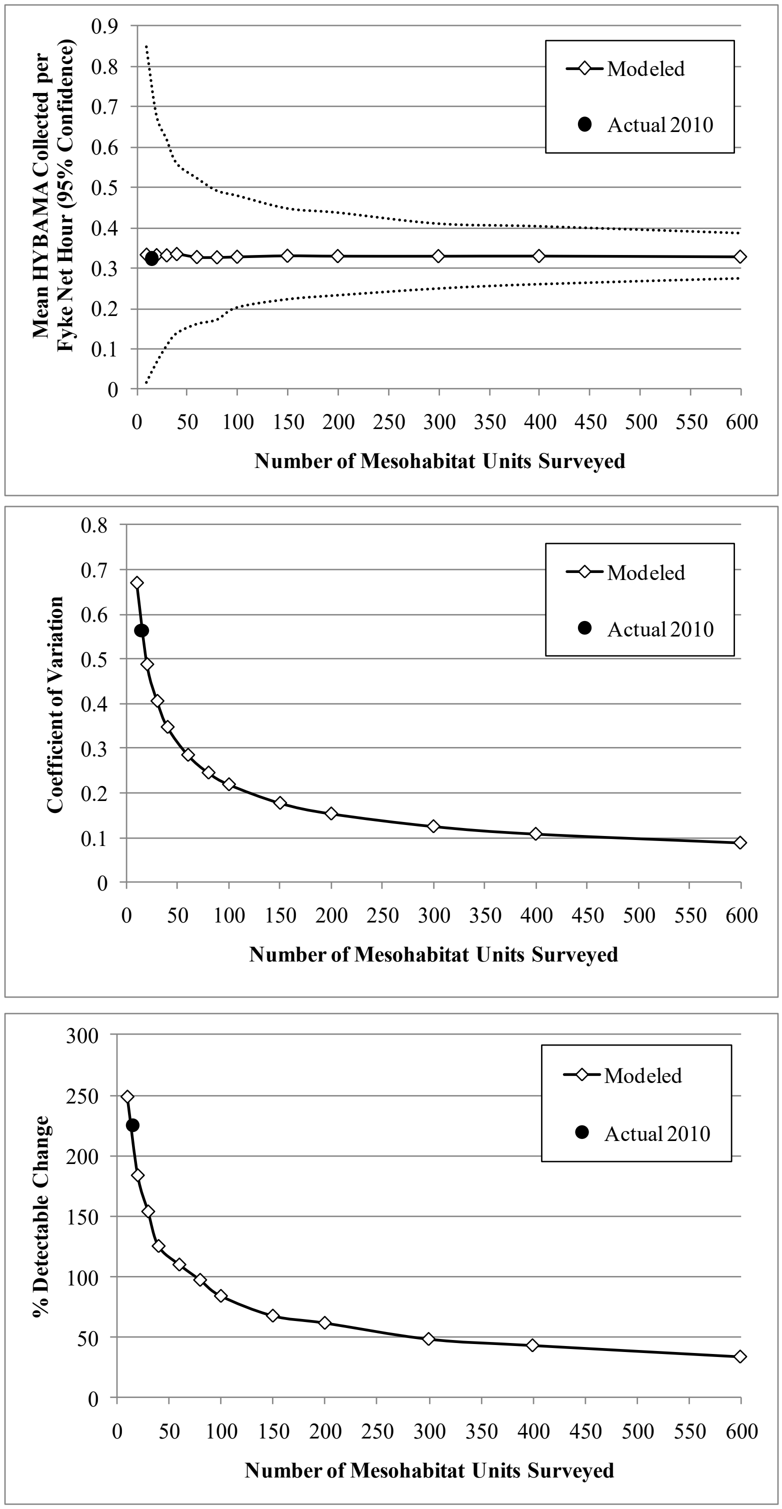

Figure H.2. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish per fyke net hours; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a fyke net from individual mesohabitat units in the main channel in the fall of 2010.

APPENDIX I
POWER ANALYSIS RESULTS FOR MAIN CHANNEL SAMPLING IN SPRING 2011 USING AREA TO STANDARDIZE EFFORT

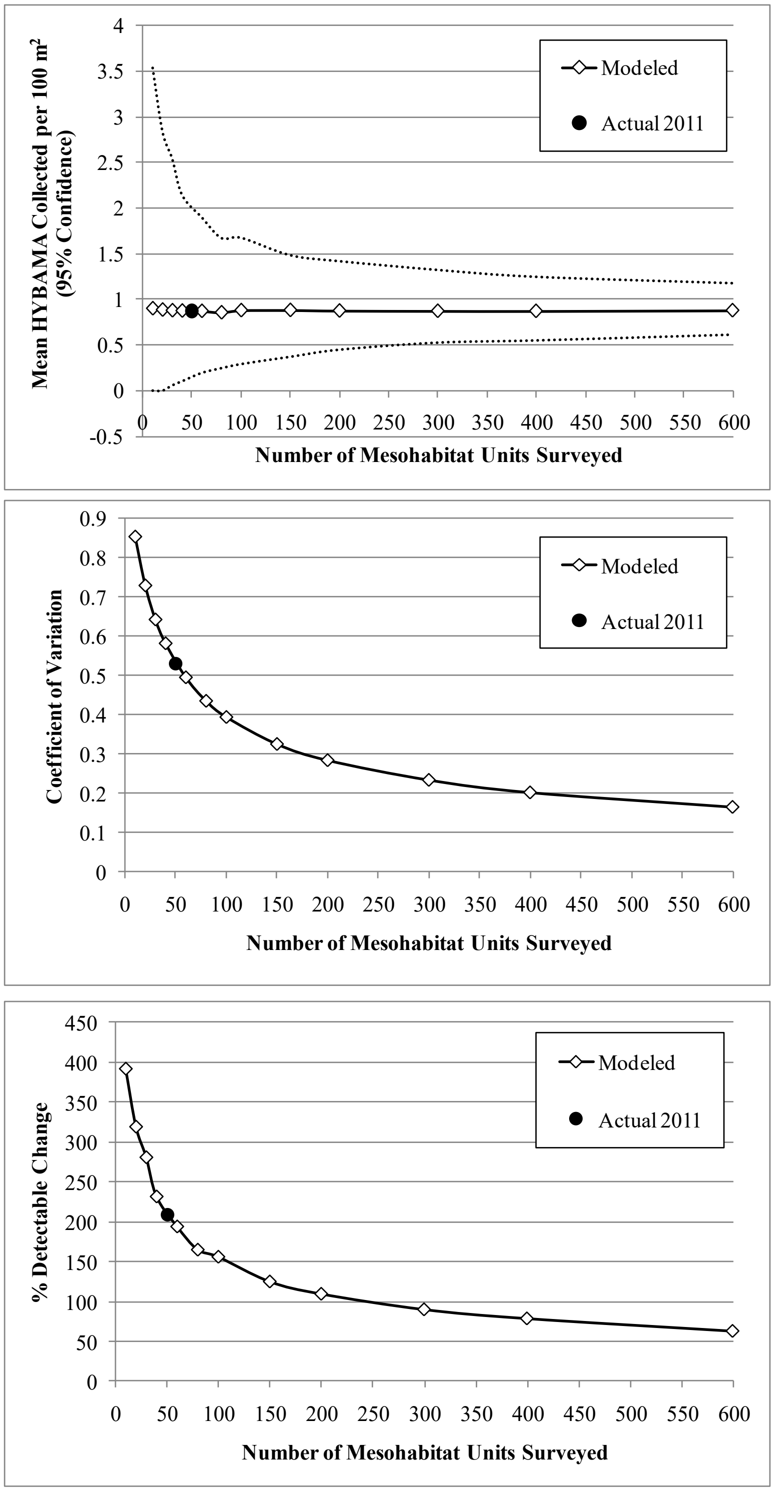

Figure I.1. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from individual mesohabitat units in the main channel in the spring of 2011.

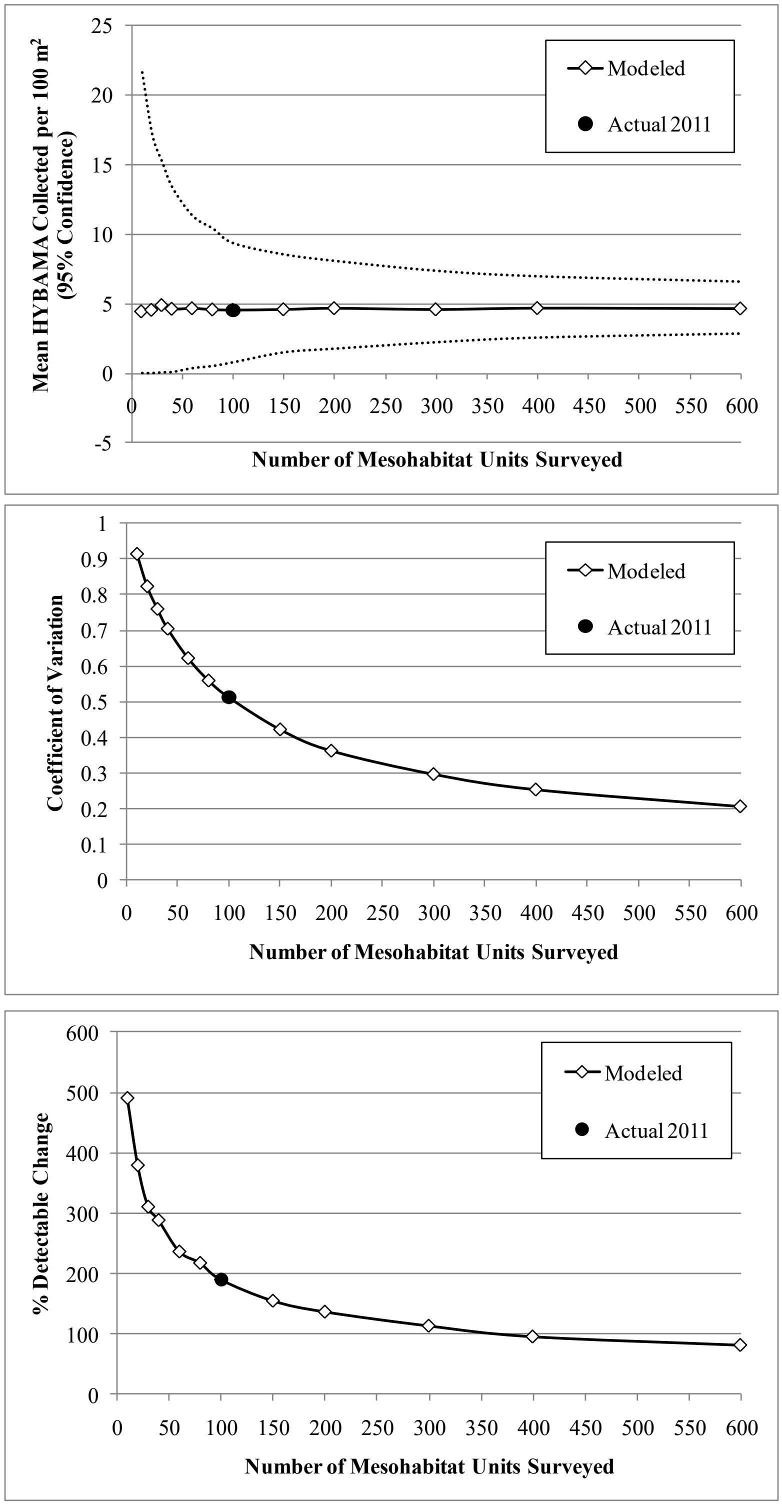

Figure I.2. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a beach seine from individual mesohabitat units in the main channel in the spring of 2011.

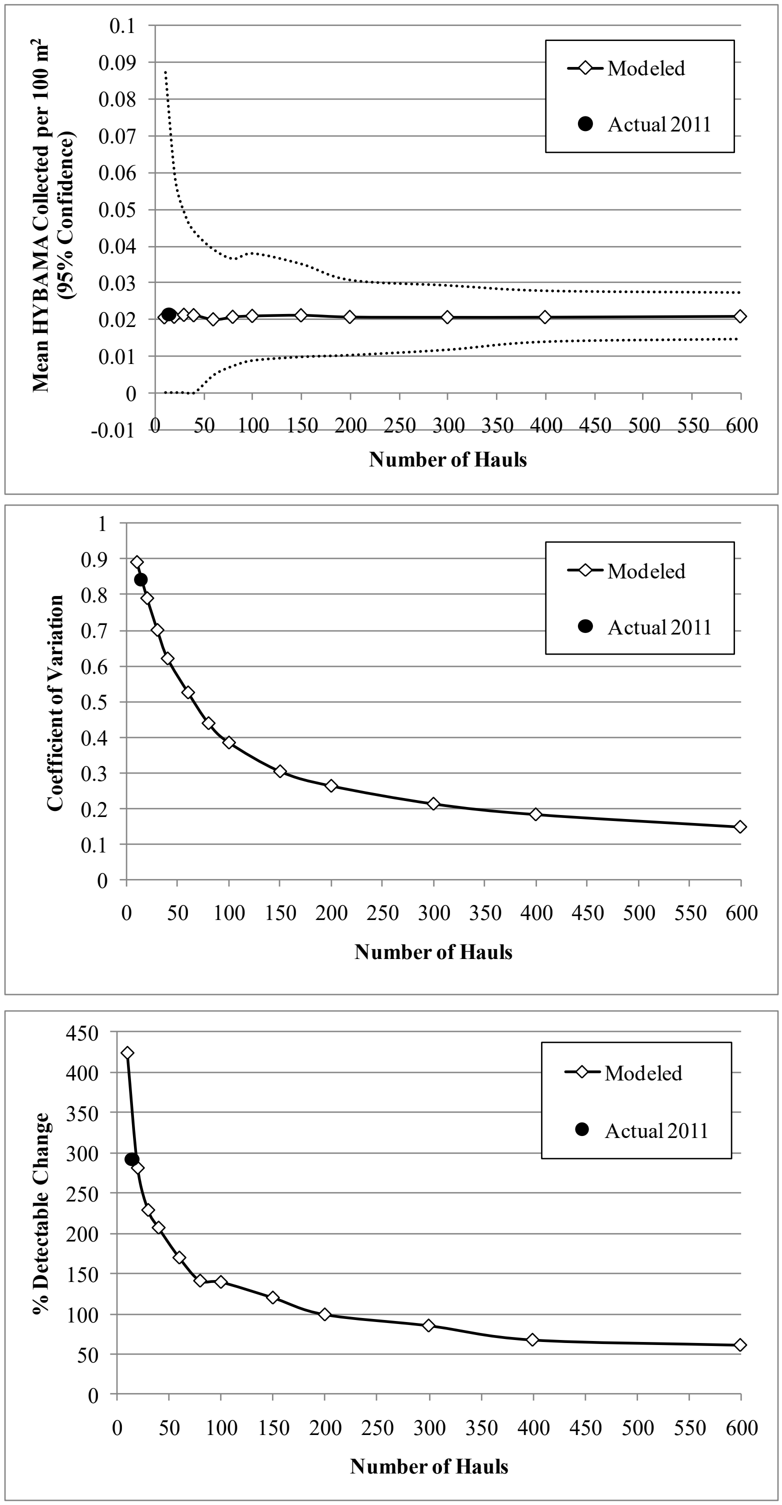

Figure I.3. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish/100 m^2; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a bag seine over multiple mesohabitats in the main channel in the spring of 2011.

APPENDIX J
POWER ANALYSIS RESULTS FOR MAIN CHANNEL SAMPLING IN SPRING 2011 USING TIME TO STANDARDIZE EFFORT

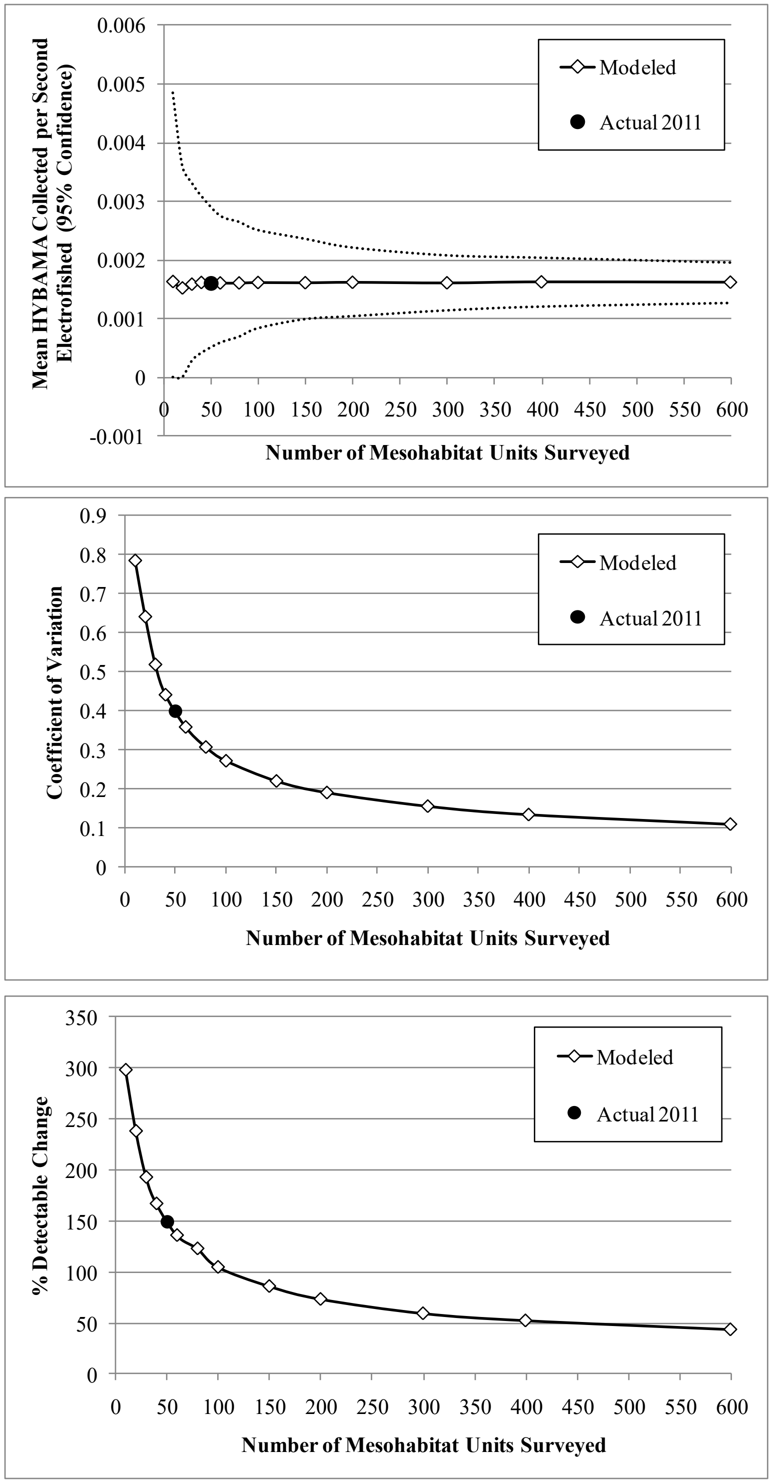

Figure J.1. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish per seconds of electricity; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a backpack electrofishing unit from individual mesohabitat units in the main channel in the spring of 2011.

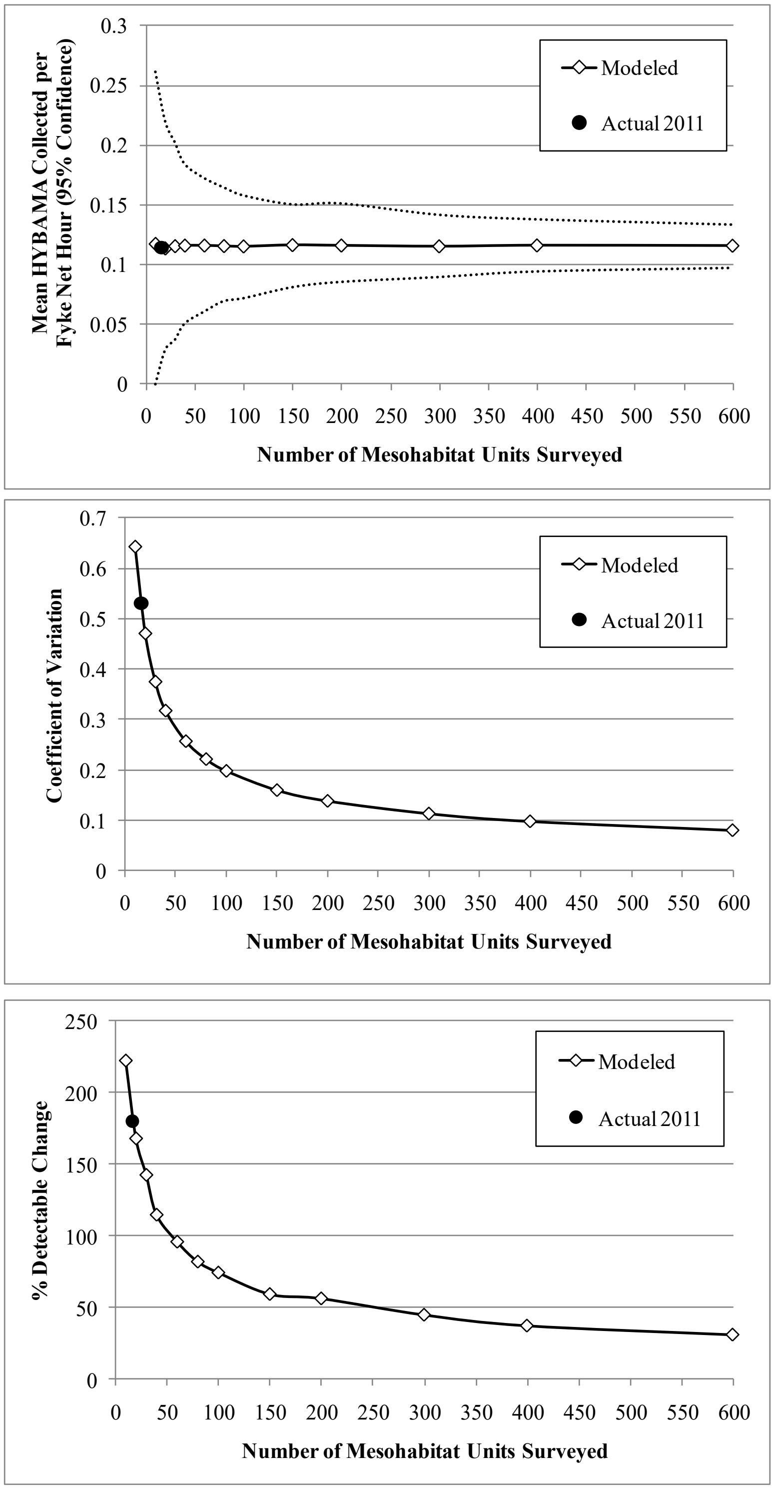

Figure J.2. The modeled change in the mean number of silvery minnow (HYBAMA) collected per area sampled (fish per fyke net hour; top), the CV of capture rate (middle), and the detectable change in capture rate (bottom) with sample size based on samples collected with a fyke net from individual mesohabitat units in the main channel in the spring of 2011.

APPENDIX K
FLOODPLAIN AND SIDE CHANNEL RELATIVE ABUNDANCE REGRESSION

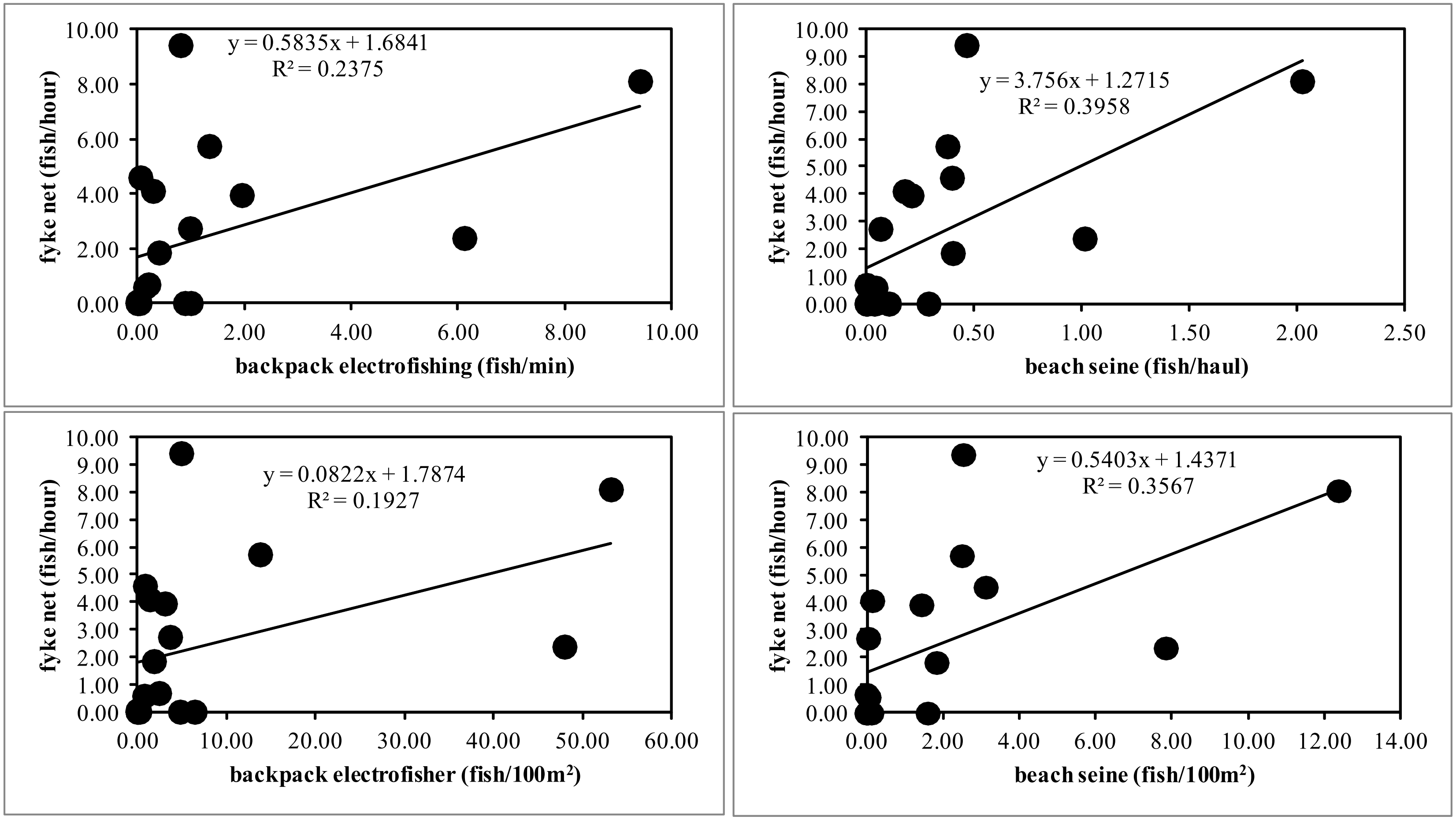

Figure K.1. Correlation between silvery minnow relative abundance indices calculated for floodplain and side channel fyke net, beach seine, and backpack electrofishing collected during May and June 2010 and May and June 2011.

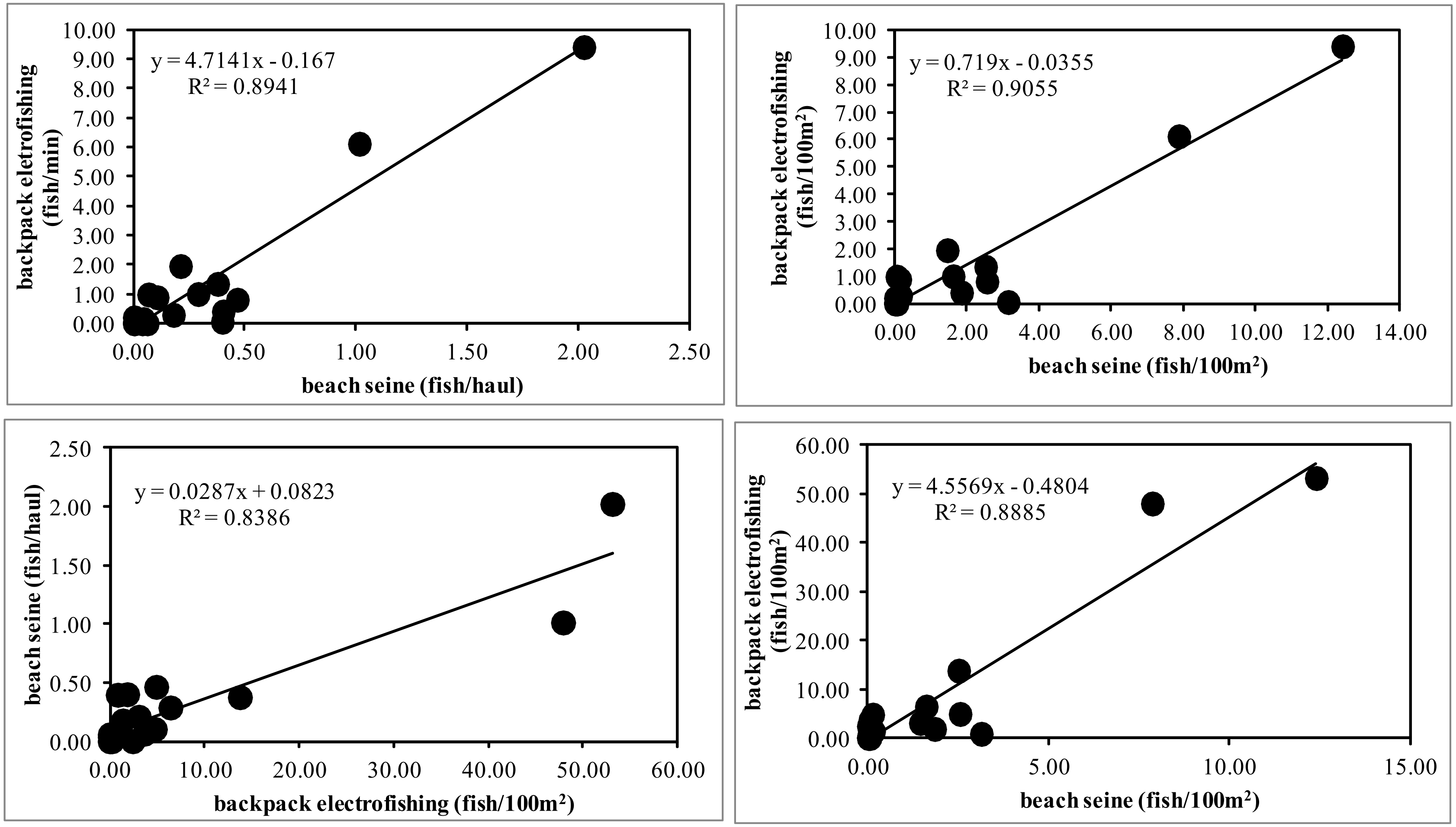

Figure K.2. Correlation between silvery minnow relative abundance indices calculated for floodplain and side channel fyke net, beach seine, and backpack electrofishing collected during May and June 2010 and May and June 2011.