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Fish Community Monitoring and Fish Sampling Methodology Evaluation Final Report

Task 1 Report - Assessment of Current Techniques to Sample the Fish Assemblages of the Middle Rio Grande

Prepared for

U.S. Bureau of Reclamation, Albuquerque Area Office

Prepared by

SWCA Environmental Consultants

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Fish Community Monitoring and Fish Sampling Methodology Evaluation

Final Report

Task 1 Report
Assessment of Current Techniques to Sample the Fish Assemblages of the Middle Rio Grande

U.S. Bureau of Reclamation Contract No. 09-SP-40-8309

Prepared for

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PREFACE

This assessment report is being submitted to the U.S. Bureau of Reclamation, Albuquerque Area Office, in partial fulfillment of Contract No. 09-SP-40-8309. The report is the first task of a project to evaluate fish sampling techniques in the Middle Rio Grande and develop and implement a study design to monitor the fish assemblages. In this report, we identify and assess the gears and methods currently used in the system. For the assessment, we received a total of 37 datasets from four groups involved in research and monitoring in the Middle Rio Grande. We remain sensitive to the use of other investigators' data for the assessment, and we have tried throughout the project to preserve the originality and integrity of those datasets. We used only the data received in their original formats, although it became necessary to sort and partition the data, as necessary, for various analyses. In the analyses for the project, we focused on documentation of sampling gears and methods, as well as evaluation of efforts and statistical powers associated with each dataset. Although the number of potential analyses for any given set of data is large, our analyses were guided by the stated objectives of the study under which the data were collected and by the goals and objectives of this project. This assessment report is not intended to be a description of the demography or biology of fish species in the Middle Rio Grande, although describing some demographic parameters was necessary for a full evaluation of the utility of certain datasets. Most analyses were conducted for data within a dataset or for a group of similar datasets; however, we also conducted analyses across datasets to perform the comparisons and assessments necessary to fulfill the objectives of the project.

ACKNOWLEDGEMENTS

We thank the groups and principal investigators responsible for the collection of the data included in the datasets provided to us for analysis, including the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, American Southwest Ichthyological Researchers, and SWCA Environmental Consultants (SWCA). Mr. Jericho Lewis serves as Contract Officer and Ms. Jeanne Dye serves as Contract Officer Technical Representative for the U.S. Bureau of Reclamation, and we appreciate the collaboration and coordination they have provided for this project. We also acknowledge Mr. Joseph Fluder, Office Principal for the Albuquerque Office of SWCA, and Dr. Steven W. Carothers for their continued guidance and support on this project.

EXECUTIVE SUMMARY

Altogether, 37 datasets were evaluated to assess the current techniques used to sample the fish assemblages of the Middle Rio Grande, including the endangered Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow). The purpose of the assessment was to 1) document sampling gears and methods for fish escapement and catchability, 2) document the sampling effort for sampling gears and methods, and 3) document the statistical power of sampling gears and methods. Sampling gears and methods were evaluated to determine the most effective technique(s) for population monitoring and estimation, recruitment and survival, Population Viability Analysis modeling, evaluation of habitat restoration, and adaptive management. The four principal sampling techniques evaluated were seining, electrofishing, fyke or fyke netting, and egg sampling.

Quantitative fish sampling has been conducted in the Middle Rio Grande since 1993. Most data received were through 2008, although some datasets included data for 2009. The longest running datasets were associated with seining used primarily to monitor the silvery minnow. Evaluation of habitat restoration projects, principally in floodplain habitats, produced datasets from fyke nets and seines, sometimes collected simultaneously, as well as egg collections. Fish community surveys have been conducted with raft and all-terrain vehicle electrofishing since 2001 and constitute the only ongoing dataset of information for fish assemblages from the array of main channel mesohabitats. Fish rescue data for the silvery minnow have been collected annually since 2001 as the total numbers of silvery minnow salvaged and translocated. A variety of egg collections have been made, although much of these data were not available electronically. Egg monitoring data have been collected annually since 2004, although data after 2006 were not available.

A total of 36 species of fish was captured with three of the four principal gear types from 1993 through 2008. Seines, electrofishing, and fyke nets captured 35, 26, and 20 species, respectively, and the proportions of species caught by gear type were markedly different. The types and proportions of species caught with different gear types is fundamental to understanding the gears and sampling designs necessary to monitor target fish species, as well as fish assemblages. Although these fish totals represent sampling from a variety of habitats and environmental conditions, it is important to note these differences. Largest numbers of fish by species caught with these principal gear types were red shiner (*Cyprinella lutrensis*) with seines (45%) and silvery minnow with electrofishing (38%) and fyke nets (72%).

The precision of each dataset or group of datasets was evaluated with standard statistical metrics, including 95% confidence intervals and coefficient of variation, as well as percent of detectable change. We found with the use of power analysis and trend analysis that the precision of all datasets could be improved with increased sample size, as well as with greater partitioning of sample collection through sample techniques designed to reduce statistical variability. We direct readers of this report to the summary of the findings of this assessment in Section 5.0. The information assimilated from this assessment will be used in collaboration with the U.S. Bureau of Reclamation and the Science Workgroup of the Middle Rio Grande Endangered Species Collaborative Program in the design and implementation of a study to sample various aspects of the fish community in the Middle Rio Grande.

1.0 INTRODUCTION

This assessment report evaluates the current gear types and methods used to sample the fish assemblage of the Middle Rio Grande, including the endangered Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow). This report is the first phase of a larger project to assess sampling techniques and develop and implement a study design that may be used to sample various aspects of the fish community. The document includes an assessment of seining, electrofishing, fyke or fyke netting, and egg sampling by habitat from population estimation, community monitoring, nursery habitat evaluation, and habitat restoration studies. The value of this document is as a reference for the evaluation of datasets that establishes the foundation for development of the study design. The project is being conducted for the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) and is coordinated by the U.S. Bureau of Reclamation (Reclamation), with technical guidance from the Science Workgroup of the Collaborative Program.

1.1 GOALS

The overall goals of the project are listed below, and this assessment report addresses the first of these four goals. The remainder of the goals will be addressed in future reports described in the Project Overview (Section 1.3) below.

1. Use existing literature to evaluate current fish sampling techniques on the Rio Grande and other large rivers for small-bodied fish as appropriate.
2. Develop a study design to evaluate gear and sampling techniques for overall catchability of silvery minnow and other small riverine fishes on the Rio Grande.
3. Conduct the study developed with Science Workgroup input to evaluate the selected sampling techniques.
4. Evaluate sampling gears and techniques for population monitoring and estimation and recruitment based on the study design. Evaluate sampling intensity, crew size, and statistical power for sampling gears and methods.

1.2 OBJECTIVES

The following are the objectives of the first goal of this project. These objectives are intended to document and evaluate the different techniques used for sampling the Rio Grande fish assemblages:

1. Document sampling gears and methods for fish escapement and catchability.
2. Document sampling effort for sampling gears and methods.
3. Document statistical power of sampling gears and methods.

The above objectives have been designed to identify and evaluate the following elements:

1. Sampling gears and methods for Rio Grande fish surveys.
2. Sampling techniques for representative sampling of silvery minnow size range.

3. Sampling techniques for silvery minnow population monitoring and estimation, recruitment and survival, Population Viability Analysis (PVA) modeling, evaluation of habitat restoration, and adaptive management.

1.3 PROJECT OVERVIEW

The following describes the overall tasks of this project and the deliverables:

1. Assessment Report—This assessment report documents and evaluates the various fish sampling methodologies and gears being used presently in the Middle Rio Grande. Other methodologies/gears being used outside this basin are being evaluated and will be reported in a separate report. All methodologies that may be suitable for use with the silvery minnow should be considered by the Science Workgroup in the development of the study design. This report will be reviewed by Reclamation and the Science Workgroup, and feedback will be provided to SWCA Environmental Consultants (SWCA) for development of the study design.
2. Study Design—The study design will be developed based on feedback to the assessment report to accurately and precisely assess spring brood stock, summer recruitment, and fall abundance of silvery minnow, as well as estimates of precision, accuracy, logistics, and costs for various levels of sample effort.
3. Implementation of the Study Design—SWCA will implement the approved study design during spring, summer, and fall 2010. Implementation will evaluate sampling techniques (i.e., seining, electrofishing, fyke and fyke netting, and electrofishing) by habitat and incorporate the use of one or more of these techniques, as well as other techniques that have proven effective in other rivers.
4. Draft Technical Report—A draft technical report will be submitted to Reclamation and the Science Workgroup following execution of the study design. The report will rank gears and methods by habitat type for population monitoring and estimation and will document sampling intensity, crew size, and statistical power for sampling gears and methods evaluated.
5. Final Report—The final report will include a synthesis and overview of the assessment report and the results of the study design. All data assimilated for the project will be submitted to Reclamation and the Science Workgroup, including a table of habitat and water quality data collected concurrently with the fish sampling data.

1.4 PROJECT AREA

The Middle Rio Grande for the purpose of the Collaborative Program is defined as the area of the Rio Grande watershed, including the Rio Chama and all tributaries from the Colorado/New Mexico state line downstream to the headwaters of Elephant Butte Reservoir (4,450 feet above mean sea level, the elevation of the spillway crest of Elephant Butte Dam) (Figure 1.1). This area contains several river reaches of similar hydrology and environmental conditions. For the purpose of this project, the majority of datasets acquired were from the Albuquerque, Isleta, and San Acacia reaches of the Middle Rio Grande.

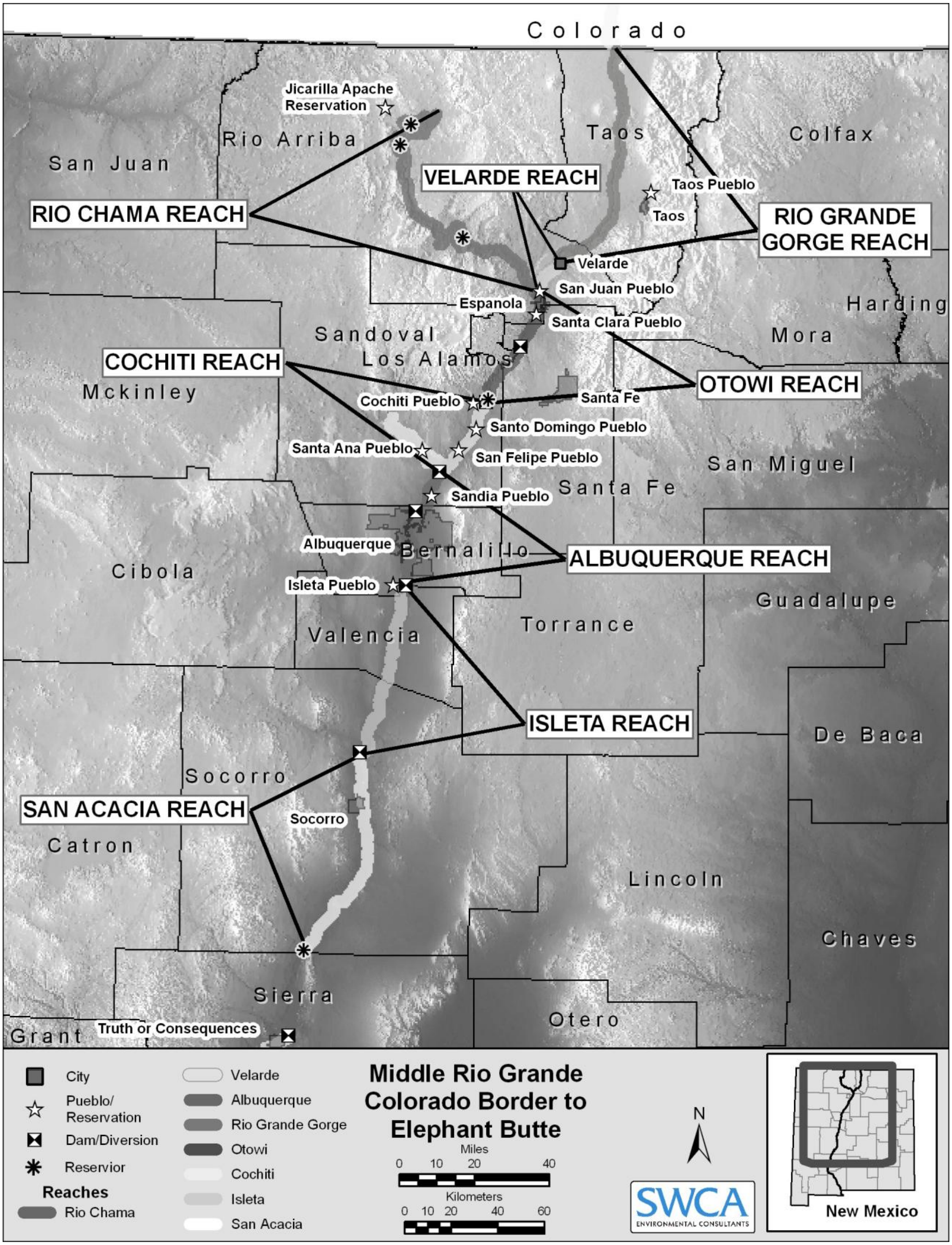


Figure 1.1. Middle Rio Grande, showing river reaches and other features.

2.0 METHODS

2.1 ASSIMILATION AND ORGANIZATION OF DATASETS

The datasets for the project were procured primarily from Reclamation in either Microsoft Excel or Access format. Additional datasets were procured from SWCA. Each dataset was identified with a four-letter acronym at the beginning of the file name to identify the agency or group responsible for collecting the data. A standardized database with common formats and data codes was not developed, nor was a linked database established. Each dataset was analyzed from its original format following partitioning for the appropriate analyses. All datasets were assimilated into a folder that will be provided to Reclamation and the Science Workgroup at the end of the project and will be compatible with ongoing database management objectives of the Collaborative Program.

2.2 ANALYTICAL METHODS

Each dataset was evaluated primarily for the stated objectives behind the study design, as described by the principal investigator(s) in associated scopes of work or progress reports. Additional analyses were completed, where possible, that further addressed the goals and objectives of the project. The number of possible analyses for a given dataset was large, but we did not try to perform all possible analyses—only those that addressed the purpose and need of the project. We analyzed datasets to identify major sources of variability, but did not attempt to tease out all sources of variability because many datasets lacked measures of associated variables or sample sizes were insufficient for comprehensive analyses. The following are specific analytical techniques that were applied to the various datasets, either individually or to compare with other datasets.

2.2.1 DESCRIPTIVE STATISTICS

Summary descriptive statistics were used that provided sample size (N), arithmetic mean, upper and lower 95% confidence intervals (95% C.I.), variance, standard deviation, standard error of the mean, coefficient of variation (CV; standard error/mean), minimum and maximum values, and a Shapiro-Wilk normality test (Sokal and Rohlf 1987). Tables of descriptive statistics are included in this report to provide a characterization of the statistical properties of certain datasets.

2.2.2 COMPARISON OF MEANS

Comparisons were made within and among datasets for means of certain parameters, such as fish length and catch rates. Data were first sorted and tested for distributional characteristics with the Shapiro-Wilk normality test. Data found to be normally distributed ($p < 0.05$) were treated with parametric statistics, including t-tests and analysis of variance (ANOVA). Data found to be non-normally distributed were evaluated with non-parametric statistical analyses, such as Kruskal-Wallis one-way ANOVA for means comparisons (Zar 1999). A Tukey-type non-parametric multiple comparisons test for unequal sample sizes was used for post-hoc pairwise comparisons at a specified rejection level for type I error (alpha [α] = 0.05). Catch rate data were also normalized with resampling and bootstrapping procedures to estimate data precision using parametric methods. Data were analyzed with *Systat 12* (Systat Software, Inc., Chicago, Illinois) and *Statistix 9* analytical software (Analytical Software, Tallahassee, Florida).

2.2.3 POWER ANALYSIS

Power analysis was used to evaluate the precision of existing data for determining necessary sample size, including catch per unit effort (CPUE), species diversity indices, and species richness. 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* was also used to perform 1,000 simulations (i.e., iterations) on each constructed dataset (i.e., Monte Carlo simulations) for a reasonable array of prospective sample sizes (e.g., 20, 50, 75, 100, 125, 150, 175, and 200). Mean, CV, and upper and lower 95% 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.

2.2.4 TREND ANALYSIS

Trend analysis was performed using the program *Trends* (Gerrodette 1987) to analyze the data for detecting significant trends in CPUE for a period of time (e.g., 10 years). *Trends* implements the concept of power analysis for detecting trends in abundance using linear regression and is used to evaluate the precision of the data in detecting rates of change in CPUE for the period of study. *Trends* also calculates number of sampling occasions, sample precision, and detectable rate of change in CPUE. The program allows the user to input and change four variables, and it automatically computes the remaining fifth. The variables include 1) minimum number of sample occasions, i.e., years; 2) rate of change by specified time step; 3) CV; 4) significance level (α = probability of a type I error), and 5) power (1–beta [$1-\beta$], β = probability of a type II error). The standard alpha level for analyses was $\alpha \leq 0.05$, and the beta level was $\beta \geq 0.80$ (Cohen 1988).

3.0 DATASETS EVALUATED FOR THIS PROJECT

3.1 LIST OF DATASETS EVALUATED

Altogether, 37 datasets were provided and evaluated for this project (Table 3.1 and Table 3.2). The data contained in the datasets were collected and/or assimilated by Reclamation, the U.S. Fish and Wildlife Service (USFWS), American Southwest Ichthyological Researchers (ASIR), and SWCA.

Each of the 37 datasets evaluated contained data collected with one or more gear types or techniques (see Table 3.1). The four principal gears used were seines, electrofishing, fyke or fyke nets, and egg collectors. Other gears included minnow traps, dip nets, and kick screens, but the numbers of samples collected with these were too small for evaluation. Most of these gears were employed with the same sampling technique, although some were different for study design purposes or habitats sampled.

Table 3.1. Numbers of Datasets with Data from the Four Principal Sampling Gears

Gear	Number of Datasets*
Seines	21
Electrofishing	10
Fyke or Fyke Nets	9
Egg Collectors	10

*Some data sets contain data collected with multiple gear types.

3.2 SAMPLING TECHNIQUES

3.2.1 SEINES

A variety of seine sizes were used to sample fishes in the Middle Rio Grande. The standard seine dimensions were 3.1 m long and 1.8 m deep with 5-mm mesh (10 × 6 feet, 3/16-inch mesh). Each seine was hauled by two people, and the area covered by the haul was recorded for computation of CPUE as numbers of fish per 100 m^2. Seine hauls were taken within a specific mesohabitat type (e.g., run, riffle, pool) or across several mesohabitat types. Mesohabitat types were often not recorded for seine hauls in the datasets received. A standard protocol for estimating fish density was a computation of CPUE from the total numbers of fish caught and the total area seined by a number of hauls at a particular site (e.g., 10–15). Given this technique, estimates of precision (i.e., variability of mean CPUE) were based on mean estimates among sample sites, rather than within sample sites.

3.2.2 ELECTROFISHING

Three fundamental variations of electrofishing were used to sample fishes in the Middle Rio Grande: 1) a 220-v electrofishing system on a whitewater raft for the main channel, 2) a 220-v electrofishing system on an all-terrain vehicle (ATV) during low-flow conditions, and 3) a 110-v backpack electrofishing system for small, enclosed habitats. Electrofishing was used primarily to survey the fish community of the Middle Rio Grande with a metric of abundance that was numbers of fish captured per hour of electrofishing.

3.2.3 FYKE NETS

Fyke nets were generally used in floodplains to sample absence or presence of target fish species, as well as densities of fishes. These nets were sometimes used to document movements of fish to and from floodplains. Each fyke net was rectangular, 0.5 m × 0.5 m with 6.4-mm mesh (1.6 × 1.6 feet, ¼-inch mesh), and was secured to the substrate with fence posts. Some fyke nets were baited with a nylon mesh bag of timothy hay placed in the cod end of the fyke net.

3.2.4 EGG COLLECTORS

Two techniques were used to collect silvery minnow eggs in the Middle Rio Grande. The most common was the Moore egg collector (MEC). MECs were generally set at river depths where workers could access them by wading into the river and comfortably monitor the collectors while standing in the river. Egg collectors were set for short time periods to minimize clogging from river debris, and the duration set was generally recorded to compute number of eggs collected per hour. The second technique was a drift net commonly used to sample macroinvertebrates in the water column. These drift nets were set at about the same depths as the MECs, and volume of water filtered was recorded to compute number of eggs collected per cubic meter of water filtered. The MECs were designed and implemented for catching drifting eggs because they allow for the efficient, quantitative, and nondestructive collection of large numbers of semi-buoyant fish eggs without a large accumulation of debris (Altenbach et al. 2000).

Table 3.2. Datasets Included in Fish Community Monitoring and Fish Sampling Methodology Evaluation

No.	File Name[1] (Type, Size)	Principal Data	Purpose or Objectives	Sampling Technique
1	ASIR-AllRGSMLengths_Raw.xls (Excel, 665 kb)	38,707 silvery minnow lengths by seining for 1993–1997, 1999, 2007, most months	Annual monitoring of silvery minnow	Seine
2	ASIR-RGSM_Pop_mon_Query_ PVAgoodman.xls (Excel, 1,514 kb)	13,791 records with numbers of all species by seining for 1993–1997, 1999, 2007, most months	Annual monitoring of fish community	Seine
3	USFWS-05.+rgsmMonitoringData _Dec2007+for+Goodman.xls	17,465 records with number of all species by seining for 2002–2007	Evaluate survival and movement of stocked silvery minnow	Seine
4	SWCA- SWCA-LosLunas_ MainChannel_Seine_2009.mdb (Access, 1,304 kb)	1,672 records with numbers of all species with various gears in floodplains for 2009	Evaluate Los Lunas habitat restoration	Seine, dip net, fyke net, MEC
5	SWCA-13199 Nurs Hab Data.xls (Excel, 3,061 kb)	12,531 silvery minnow lengths by gear type, plus other species in floodplains in 2008	Evaluate habitat restoration	Fyke net, seine
6	SWCA-BOR_Floodplain_08_ MDH.mdb (Access, 1,032 kb)	187 records of fish community data; occurrence of silvery minnow eggs, larvae, adults in floodplains in 2008	Evaluate habitat restoration	Fyke net, kick net, seine
7	SWCA-Embayment Monitoring Database 2006.xls (Excel, 133 kb)	358 records of fish catches in 2006	Monitor movement between main channel and floodplains	Fyke nets (baited and unbaited)
8	SWCA-ISC_HR_Monitor_08_ and_09.mdb (Access, 2,564 kb)	439 records in 2009	Evaluate habitat restoration	Fyke net, seine
9	SWCA-Los_Lunas_Floodplain_ 2008.mdb (Access, 2,180 kb)	2,752 records of fish catches with different gears in 2008; 1,614 silvery minnow lengths by gear	Evaluate Los Lunas habitat restoration	Fyke net, seine
10	SWCA-Los Lunas_FloodPlain_ 2009.mdb (Access, 3,666 kb)	144 records of fish community data in 2009	Evaluate Los Lunas habitat restoration	Fyke net, seine
11	SWCA-LosLunas_MainChannel_ Seine_2009.mdb (Access, 1,304 kb)	61 records of fish catches with different gears in 2008; 264 silvery minnow lengths by gear	Evaluate Los Lunas habitat restoration	Fyke net, seine
12	SWCA-LWD queries.xls (Excel, 200 kb)	272 records of fish catches in 2005, 2006	Evaluate use of woody debris emplacements by fish	Backpack electrofishing, seine
13	SWCA-LWD_species_log_electric_ database.xls (Excel, 39 kb)	~120 records of fish captures in 2005 and 2006	Evaluate use by silvery minnow of woody debris emplacements	Backpack electrofishing, seine
14	SWCA-RGSM_Data_by Site_Update.xls (Excel, 501 kb)	Mesohabitat associations	Mesohabitat associations	Seine

Table 3.2. Datasets Included in Fish Community Monitoring and Fish Sampling Methodology Evaluation, continued

No.	File Name[1] (Type, Size)	Principal Data	Purpose or Objectives	Sampling Technique
15	USBR-BOR Data_2.mdb (Access, 11,329 kb)	200 records of fish catches with different gears in 2008; 1,226 silvery minnow lengths	Fish community surveys	Raft electrofishing
16	USBR-fish_collection-2001.xls (Excel , 631 kb)	Occurrence and distribution of fish in Middle Rio Grande	Fish community surveys	Raft electrofishing
17	USBR-fish_collection-2002.xls (Excel , 356 kb)	Occurrence and distribution of fish in Middle Rio Grande	Fish community surveys	Raft electrofishing
18	USBR-fish_collection-2003.xls (Excel , 340 kb)	Occurrence and distribution of fish in Middle Rio Grande	Fish community surveys; evaluate habitat where silvery minnow eggs are found	Raft electrofishing, ATV electrofishing
19	USBR-fish_collection-2004.xls (Excel , 555 kb)	Occurrence and distribution of fish in Middle Rio Grande	Fish community surveys	Raft electrofishing, ATV electrofishing, seine, minnow trap, MEC
20	USBR-fish_collection-2005.xls (Excel , 1,246 kb)	Occurrence and distribution of fish in Middle Rio Grande	Fish community surveys	Raft electrofishing, ATV electrofishing, seine
21	USBR-fish_collection-2006.xls (Excel , 518 kb)	Occurrence and distribution of fish in Middle Rio Grande	Fish community surveys	Raft electrofishing, ATV electrofishing, kick screen
22	USBR-fish_collection-2007.xls (Excel , 1,213 kb)	Occurrence and distribution of fish in Middle Rio Grande	Fish community surveys	Raft electrofishing, ATV electrofishing, kick screen
23	USFWS- USFWS-RGSM_Rescue _06.xls (Access, 1,296 kb)	60 records with numbers of silvery minnow salvaged in 2006	Salvage silvery minnow during drying	Seine
24	USFWS-2004 Rescue.xls (Excel , 24 kb)	75 records with numbers of silvery minnow salvaged in 2004	Salvage silvery minnow during drying	Seine
25	USFWS-BOR_Exp_Act_DB_ 2007.mdb (Access, 1,638 kb)	Numbers of silvery minnow salvaged in 2007	Salvage silvery minnow during drying	Seine
26	USFWS-RGSM_Rescue_05.xls (Access, 1,056 kb)	75 records with numbers of silvery minnow salvaged in 2005	Salvage silvery minnow during drying	Seine
27	USFWS-RGSM-salvage_2001.xls (Excel, 1,600 kb)	32 records with numbers of silvery minnow salvaged in 2001	Salvage silvery minnow during drying	Seine
28	SWCA-Eggs_total.xls (Excel, 785 kb)	340 records of egg catches in 2007	Determine presence of silvery minnow eggs	Kick net, seine
29	SWCA-AWcomment_Vertical_ Drift_Data_0607 SB.xls; See also: Final Vertical_Drift_Data.xls (Excel, 307 kb)	55 records with gellan beads in river channel	Evaluate uniform dispersal of artificial beads	Drift net, MEC
30	ASIR-RGSM Egg Data for Friday, 13 June 2008.xls (Excel, 17 kb)	44 records with egg collection data in 2008 from Albuquerque, Sevilleta, Upper Coral sites	Estimate numbers of silvery minnow eggs in drift	MEC

Table 3.2. Datasets Included in Fish Community Monitoring and Fish Sampling Methodology Evaluation, continued

No.	File Name[1] (Type, Size)	Principal Data	Purpose or Objectives	Sampling Technique
31	SWCA-Lateral comparison.xls (Excel , 221 kb)	1,000 records with gellan beads from different banks of river channel	Evaluate uniform dispersal of artificial beads	MEC
32	SWCA-Los Lunas Egg_Monitor_ 09.mdb (Access, 824 kb)	15 records with egg counts	Silvery minnow spawning periodicity and indices of reproductive effort	MEC
33	SWCA-NMISC Habitat Rest Egg_Monitor_08-09.mdb (Access, 1,000 kb)	138 records with egg counts in 2008, 2009	Estimate silvery minnow eggs in drift	MEC
34	SWCA-NMISC_Nursery_ Habitat.mdb (Access, 5,888 kb)	375 records of fish catches with different gears in 2008; 229 silvery minnow lengths	Evaluate occurrence of silvery minnow in floodplains	MEC, fyke net, kick net, seines
35	USFWS – Egg_Monitor_04.mdb (Access, 1,044 kb)	Silvery minnow spawning periodicity and indices of reproductive effort in main channel, 2004	Silvery minnow spawning periodicity and indices of reproductive effort, 2004	MEC
36	USFWS – Egg_Monitor_05.mdb (Access, 1,004 kb)	Silvery minnow spawning periodicity and indices of reproductive effort in main channel, 2005	Silvery minnow spawning periodicity and indices of reproductive effort, 2005	MEC
37	USFWS – Egg_Monitor_06.mdb (Access, 1,1116 kb)	Silvery minnow spawning periodicity and indices of reproductive effort in main channel, 2006	Silvery minnow spawning periodicity and indices of reproductive effort, 2006	MEC

Note: Datasets analyzed as a group are indicated by alternate shaded or unshaded cells.
[1]ASIR = American Southwest Ichthyological Researchers
SWCA = SWCA Environmental Consultants
USBR = U.S. Bureau of Reclamation
USFWS = U.S. Fish and Wildlife Service

4.0 RESULTS OF ANALYSES

4.1 OVERVIEW OF DATASETS

To introduce the datasets analyzed, we present an overview of the numbers of samples by year for each group of datasets identified and described in Table 3.2 (Table 4.1). The principal gear types displayed are seines, electrofishing, fyke nets, and egg collectors. Small numbers of minnow traps, dip nets, and kick screens were also included in some datasets, but the numbers of samples with these gears were too small to evaluate. Most datasets received were for data collected through 2008, although some 2009 sample counts are provided. The longest running datasets were those associated with seine samples in the main channel since 1993 (Datasets 1–2). Evaluation of survival, retention, and temporal and spatial movements of stocked silvery minnow produced a dataset with seining data within various mesohabitat types (Dataset 3). Evaluation of habitat restoration projects, principally in floodplain habitats, produced datasets with fyke nets and seines sometimes collected simultaneously, as well as egg collections (Datasets 4–14). Fish community surveys have been conducted with raft and ATV electrofishing since 2001 and constitute the only ongoing dataset of information for fish assemblages from mesohabitats of the main channel (Datasets 15–22). Fish rescue data for silvery minnow have been collected annually since 2001 as the total numbers of fish salvaged and translocated (Datasets 23–27). A variety of egg collections have been made, although much of these data were not available electronically (Datasets 28–34), and the egg monitoring data of the USFWS were collected annually from 2004 through 2006 (Datasets 35–37).

A further perspective of fish sampling gears is provided through a list of fish species collected by gear in the Middle Rio Grande starting in 1993. A total of 36 species of fish was captured with three of the four principal gear types (Table 4.2). Seines, electrofishing, and fyke or fyke nets captured 35, 26, and 20 species, respectively, and the proportions of species caught by gear type were markedly different (Figure 4.1). The types and proportions of species caught with different gear types is fundamental to understanding the gears and sampling designs necessary to monitor target fish species, as well as fish assemblages. Although these fish totals represent sampling from a variety of habitats and environmental conditions, it is important to note these differences. The suite of species captured with each gear type was similar, but the proportions differed markedly. The largest numbers of fish by species were red shiner (*Cyprinella lutrensis*) with seines (45%) and silvery minnow with electrofishing (38%) and fyke nets (72%).

Table 4.1. Numbers of Samples by Year Contained in Groups of Datasets Identified and Described in Table 3-2

Gear	1993	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Totals
Datasets: 1–2 (ASIR Seine Monitoring[a])																	
Seines	60	60	59	61	57	88	90	116	239	228	234	240	218	180	177	NA	2,107
Electrofishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Fyke Nets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Egg Collectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Dataset: 3 (USFWS Augmentation Monitoring[b])																	
Seines	0	0	0	0	0	0	0	0	1,538	2,518	2,937	4,376	3,888	2,208	0	0	17,465
Datasets: 4–14 (SWCA Habitat Restoration[a])																	
Seines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	0	37
Electrofishing	0	0	0	0	0	0	0	0	0	0	0	41	0	0	19	0	60
Fyke Nets	0	0	0	0	0	0	0	0	0	0	0	0	280	36	80	56	452
Egg Collectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Datasets: 15–22 (Reclamation Fish Community Surveys[a])																	
Seines	0	0	0	0	0	0	0	0	20	10	10	1	3	44	0	NA	88
Electrofishing	0	0	0	0	0	0	0	4	4	9	11	12	6	12	0	NA	58
Fyke Nets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Egg Collectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Datasets: 23–27 (USFWS Fish Rescue)																	
Seines	0	0	0	0	0	0	0	32	0	0	63	NA	NA	NA	0	NA	95
Electrofishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Fyke Nets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Egg Collectors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA	0
Datasets: 28–34 (ASIR and SWCA Egg Collections)																	
Seines	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	33
Electrofishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fyke Nets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egg Collectors	0	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	138	15	153
Datasets: 34–37 (USFWS Egg Monitoring)																	
Seines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrofishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fyke Nets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egg Collectors	0	0	0	0	0	0	0	0	0	0	169	58	169	NA	NA	NA	396

Note: A zero (0) in a cell means that samples were not collected in that year; NA means that samples were collected but were not made available. [a]Seine monitoring sample sizes are number of sites visited and not number of seine hauls collected. [b]USFWS augmentation monitoring sample sizes are number of seine hauls.

Table 4.2. Total Numbers and Percentages of Fish Species Caught with the Principal Gear Types in the Middle Rio Grande

Species	Code	Seines[1]		Electrofishing[2]		Fyke Nets[3]	
		Totals	Percent	Totals	Percent	Totals	Percent
Ameiurus melas	AMEMEL	132	0.01	11	0.11	16	0.04
Ameiurus natalis	AMENAT	1,387	0.16	7	0.07	9	0.02
Ameiurus nebulosus	AMENEB	0	0.00	1	0.01	0	0.00
Campostoma anomalum	CAMANO	1	<0.01	0	0.00	0	0.00
Carpiodes carpio	CARCAR	30,579	3.46	991	10.10	78	0.21
Catostomus commersonii	CATCOM	54,540	6.17	924	9.42	251	0.68
Cyprinella lutrensis	CYPLUT	397,344	44.94	641	6.53	3,737	10.16
Cyprinus carpio	CYPCAR	16,105	1.82	1,331	13.57	3,975	10.81
Dorosoma cepedianum	DORCEP	2,393	0.27	3	0.03	0	0.00
Dorosoma petenense	DORPET	112	0.01	0	0.00	0	0.00
Gambusia affinis	GAMAFF	98,570	11.15	71	0.72	1,202	3.27
Gila pandora	GILPAN	3	0.00	0	0.00	0	0.00
Hybognathus amarus	HYBAMA	159,557	18.05	3,764	38.37	26,621	72.37
Ictalurus furcatus	ICTFUR	6	<0.01	0	0.00	0	0.00
Ictalurus punctatus	ICTPUN	20,097	2.27	846	8.62	54	0.15
Ictiobus bubalus	ICTBUB	290	0.03	124	1.26	0	0.00
Lepomis cyanellus	LEPCYA	71	0.01	5	0.05	24	0.07
Lepomis macrochirus	LEPMAC	259	0.03	3	0.03	9	0.02
Lepomis megalotis	LEPMEG	1	<0.01	0	0.00	0	0.00
Micropterus dolomieu	MICDOL	1	<0.01	21	0.21	1	0.00
Micropterus punctulatus	MICPUN	18	<0.01	0	0.00	0	0.00
Micropterus salmoides	MICSAL	398	0.05	19	0.19	4	0.01
Morone chrysops	MORCHR	545	0.06	55	0.56	0	0.00
Notemigonus crysoleucas	NOTCRY	2	<0.01	0	0.00	0	0.00
Oncorhynchus mykiss	ONCMYK	5	<0.01	14	0.14	0	0.00
Perca flavescens	PERFLA	189	0.02	2	0.02	1	<0.01
Percina macrolepida	PERMAC	2	<0.01	0	0.00	0	0.00
Pimephales promelas	PIMPRO	66,452	7.52	247	2.52	688	1.87
Pimephales vigilax	PIMVIG	79	0.01	0	0.00	0	0.00
Platygobio gracilis	PLAGRA	25,356	2.87	512	5.22	91	0.25
Pomoxis annularis	POMANN	567	0.06	1	0.01	15	0.04
Pomoxis nigromaculatus	POMNIG	19	<0.01	0	0.00	1	0.00
Pylodictis olivaris	PYLOLI	24	<0.01	1	0.01	0	0.00
Rhinichthys cataractae	RHICAT	9,013	1.02	164	1.67	5	0.01
Salmo trutta	SALTRU	6	0.00	50	0.51	0	0.00
Sander vitreus	SANVIT	78	0.01	2	0.02	1	<0.01
Totals		**884,199**	**100**	**9,810**	**100**	**36,783**	**100**
Numbers of Species Caught		**36**		**26**		**20**	

Notes: The six most abundant species for each gear are highlighted in gray. Percentages may not sum exactly due to rounding.
[1]Data from Datasets 1–3.
[2]Data from Datasets 15–22.
[3]Data from Datasets 4–14.

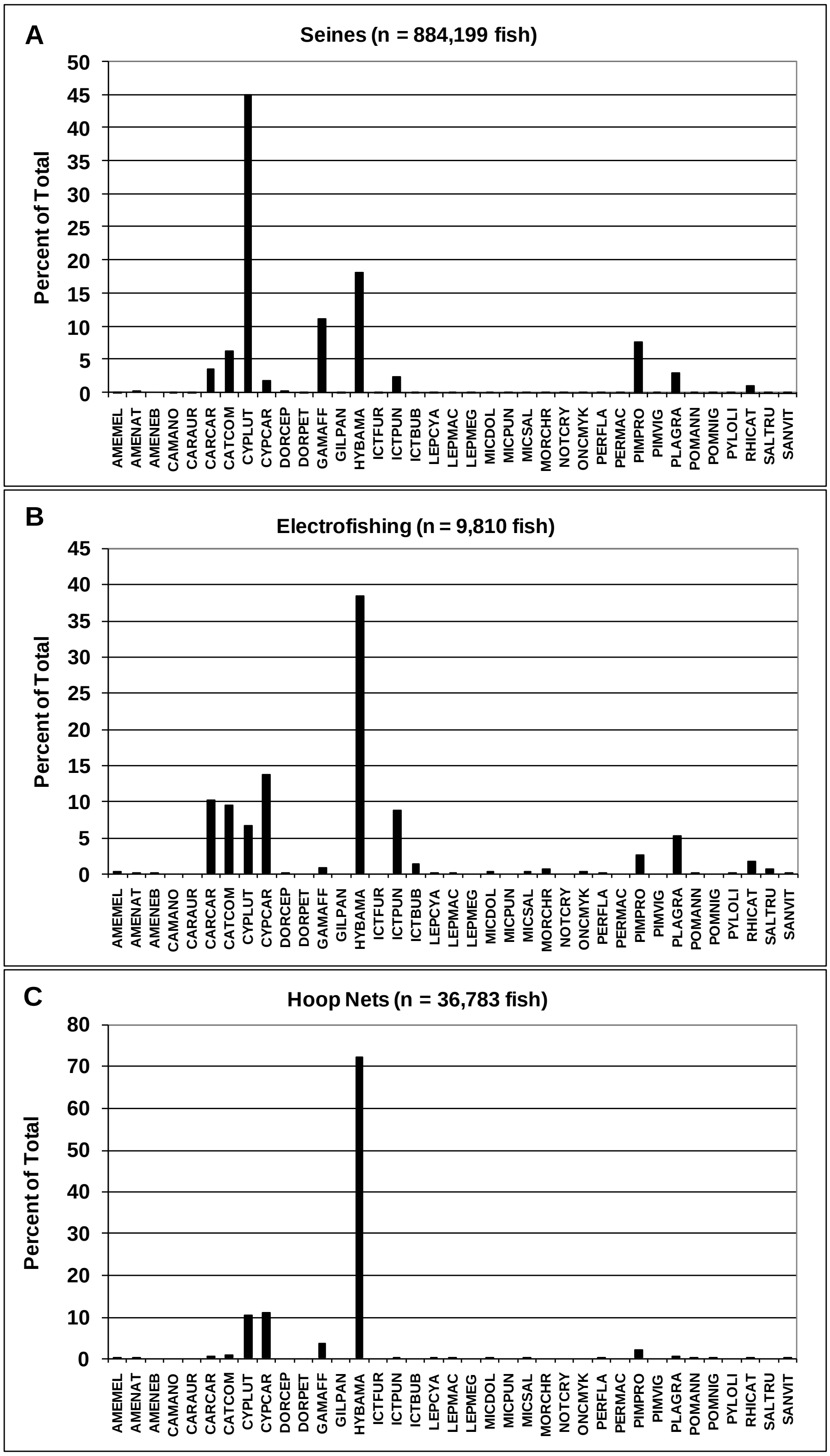


Figure 4.1. Percentage of total numbers of fish caught by species with three principal gear types: (A) seines, (B) electrofishing, and (C) fyke nets in the Middle Rio Grande. See Table 4.2 for species codes.

The following is a description of the analyses performed for each dataset or group of datasets identified in Table 3.2. Consistent with objectives 1 through 3 (see Section 1.2), documentation of sampling gears and methods, sampling effort for gears and methods, and statistical power of sampling gears and methods are described for each dataset. Also, relevant reports associated with each dataset are identified and provided in the Literature Cited section of this document, as well as descriptions of the study objectives that guided collection of the respective datasets. Figures and tables showing detailed analyses are provided in Appendices A and B.

4.2 DATASETS 1 AND 2

1. ASIR-AllRGSMLengths_Raw.xls
2. ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls

4.2.1 RELEVANT REPORTS

Platania (1993, 1995), Platania and Dudley (1997, 2001, 2003), Dudley and Platania (2000, 2001, 2002, 2003, 2007, 2008), Dudley et al. (2003, 2004, 2005, 2006)

4.2.2 STUDY OBJECTIVES

- Monitor the long- and short-term trends in the abundance and status of silvery minnow at numerous sites throughout the Middle Rio Grande (1993–1997 and 1999–2008).
- Examine seasonal and spatial differences in population structure and abundance of native and non-native Middle Rio Grande fishes.

4.2.3 DOCUMENTATION OF SAMPLING GEARS AND METHODS

Fish were collected by rapidly drawing a two-person seine, measuring 3.1 × 1.8 m (10 × 6 feet) with small mesh (ca. 5 mm [3/16 inch]), through up to 20 discrete mesohabitats (usually <15 m [49.2 feet]). Each mesohabitat type (e.g., main channel run, backwaters, etc.) was sampled at least once, and the remaining samples were taken in the dominant shoreline run habitats. Mesohabitats with similar conditions (i.e., not exceeding reasonable depths/velocities for efficient seining) were sampled to ensure relatively static capture efficiencies regardless of flows. During spring and summer, a 1.0 × 1.0–m (3.3 × 3.3–foot), fine-mesh (ca. 1.5 mm [0.06 inch]) seine was used to selectively sample shallow low-velocity habitats for larval fish. CPUE was calculated for each species and each collection as the number of individuals collected per 100 m^2 (surface area) of water sampled. Effort was calculated by multiplying the seine width during sampling (regular = 2.5 m [8.2 feet], larval = 0.25 m [0.82 foot]) by the length of the seine haul. Samples from isolated pools were not included in analyses because densities in these confined habitats were artificially elevated (Dudley and Platania 2008). Mean CPUE was computed for each site from the pool of fish captured by species from all seine hauls (~10) on a single trip divided by the total area seined for all seine hauls at the same site. For the purposes of this analysis, the composite of all the seine hauls at a site was considered a single sample. Data collected in October of each year were used to monitor silvery minnow, and data for the remainder of the year provided insight into the fish community year-round.

4.2.4 SAMPLING EFFORT FOR GEARS AND METHODS

Samples by Year and Reach—The numbers of year-round samples (i.e., pool of seine hauls from a given site per year) increased from about 20 to a maximum of about 60 to 100 samples per year in each of the three reaches (Albuquerque, Isleta, and San Acacia) during 2002 through 2006 (Figure 4.2). The total numbers of samples declined to a maximum of about 50 to 80 in 2007 and 2008. The largest numbers of samples were consistently taken in the San Acacia Reach, whereas the lowest numbers were taken from the Isleta Reach prior to 2001 and from the Albuquerque Reach thereafter. The average area seined per sample, although expected to be about the same over time, changed from about 250 m^2 (2,690 square feet) to about 650 m^2 (7,000 square feet). Accordingly, the total area seined also increased dramatically after 2001 with the greatest numbers of samples in the San Acacia Reach. Annual CPUE monitoring of silvery minnow is based on only the samples collected in October.

If it is assumed that the numbers of samples collected in a given reach is a function of reach length and area, we can evaluate the proportional distribution of samples by reach. At base flow of 100 to 500 cubic feet per second (cfs) in October, the Albuquerque, Isleta, and San Acacia reaches comprise about 28%, 33%, and 39% of total river area, respectively. For the period 2002 to 2006, the proportions of average numbers of samples taken in the three respective reaches were 26%, 30%, and 44% (Table 4.3). From this comparison, it is surmised that sampling was distributed approximately according to reach area, with only about 9% and 7% undersampling for the Albuquerque and Isleta reaches, respectively, and about 12% oversampling of the San Acacia Reach.

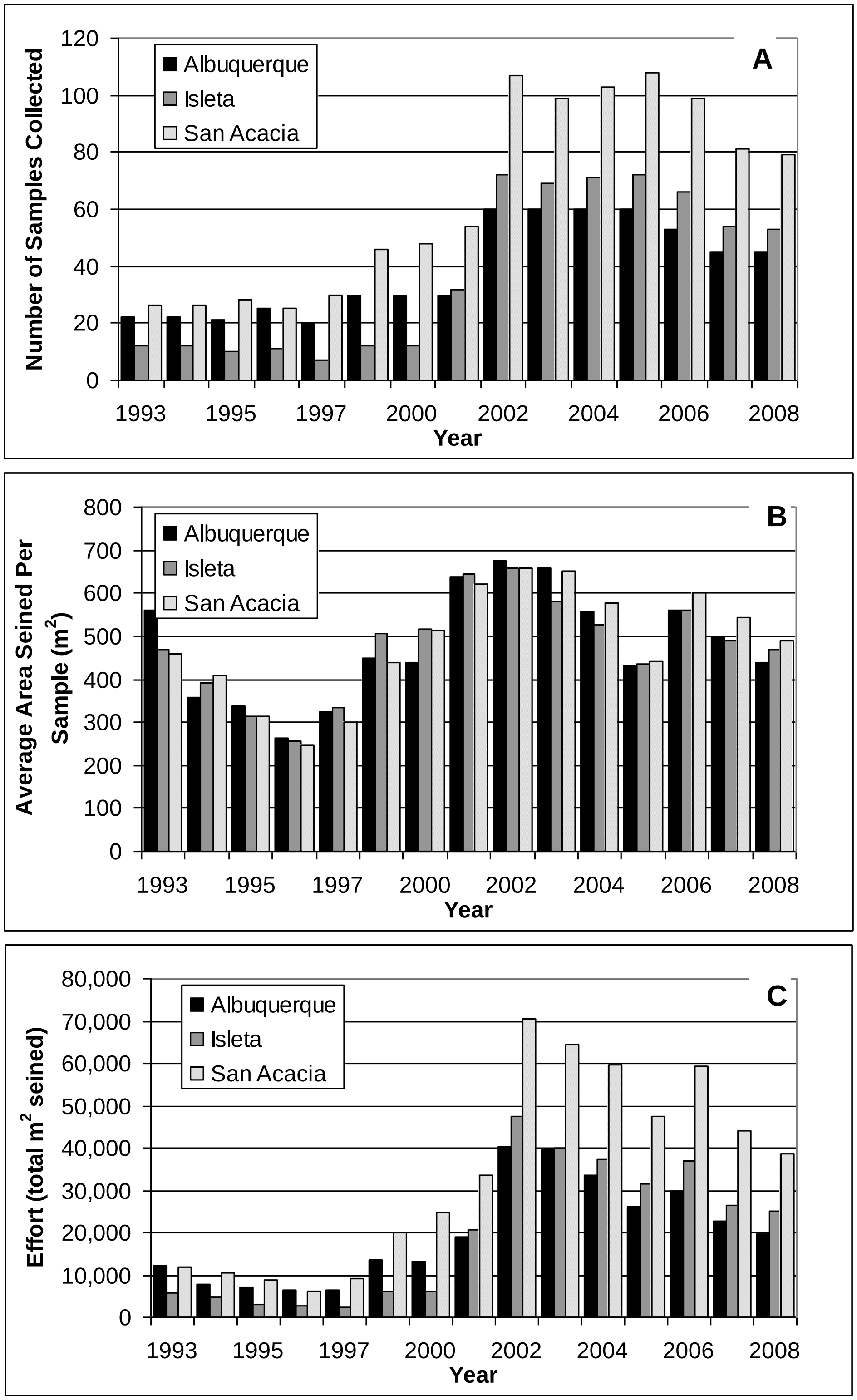


Figure 4.2. (A) Number of seine samples collected, (B) average area seined per sample, and (C) total square meters seined by reach and year. Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

Table 4.3. Comparison of Approximate Reach Length with Total Numbers of Seine Samples, 2002–2006

Reach	Reach Attributes				Sample Attributes (2002–2006)		
	Length (m)	Average Width (m)	Area (m^2)	Percentage of Total Area	Average Number of Samples	Percentage of Total Samples	Ratio of Samples to Area
Albuquerque	65,000	182	11,830,000	28%	59	26%	0.91
Isleta	85,500	161	13,765,500	33%	70	30%	0.93
San Acacia	92,000	182	16,744,000	39%	103	44%	1.12
Totals	**242,500**	**175**	**42,339,500**	**100%**	**232**	**100%**	**1.00**

Reach lengths and areas from Miller (2008).
Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

Samples by Month and Year—The total numbers of seine samples from 1993 to 2008 in the Albuquerque, Isleta, and San Acacia reaches were 583, 565, and 959, respectively (Table 4.4, Figure 4.3). Over the 16 years of sampling, the proportion of samples ranged from 3% to 13% per month for any given reach. The majority of samples were taken in February, August, and October. When evaluated for precision with mean CPUE and CV, the months with highest precision for all three reaches were February through April and August through October. Although monitoring takes place over nine months of the year, October is the month used for annual catch rate indices of silvery minnow (Figure 4.4). Observed variability is an important consideration in development of a study design that will yield the best data precision possible.

Table 4.4. Comparison of Seine Samples by Month and Years with Proportions of Samples and Mean CPUE and Variability for Silvery Minnow, 1993–2008

Reach and Metric	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Albuquerque													
No. Samples	19	71	36	50	54	47	60	63	40	74	20	49	583
Percent of Total	3%	12%	6%	9%	9%	8%	10%	11%	7%	13%	3%	8%	100%
Mean CPUE	2.51	3.03	1.79	0.96	23.5	22.07	14.9	10.48	6.55	4.26	8.46	3.91	––
CV	0.72	0.30	0.34	0.29	0.89	0.49	0.37	0.24	0.28	0.25	0.49	0.39	––
Isleta													
No. Samples	30	59	34	51	45	59	50	55	40	66	24	52	565
Percent of Total	5%	10%	6%	9%	8%	10%	9%	10%	7%	12%	4%	9%	100%
Mean CPUE	15.4	2.49	1.63	0.60	2.11	34.27	36.8	11.83	11.34	10.32	11.26	12.79	–
CV	0.88	0.34	0.49	0.32	0.28	0.34	0.32	0.29	0.48	0.38	0.39	0.50	–
San Acacia													
No. Samples	45	111	57	80	92	83	86	99	64	118	36	88	959
Percent of Total	5%	12%	6%	8%	10%	9%	9%	10%	7%	12%	4%	9%	100%
Mean CPUE	6.88	13.7	4.94	4.15	34.3	15.34	115	40.18	7.72	19.04	12.78	8.82	–
CV	1.57	1.27	3.12	5.71	0.16	0.96	0.04	0.18	2.10	0.82	0.45	2.36	–

Note: Percentages may not sum exactly due to rounding.
Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

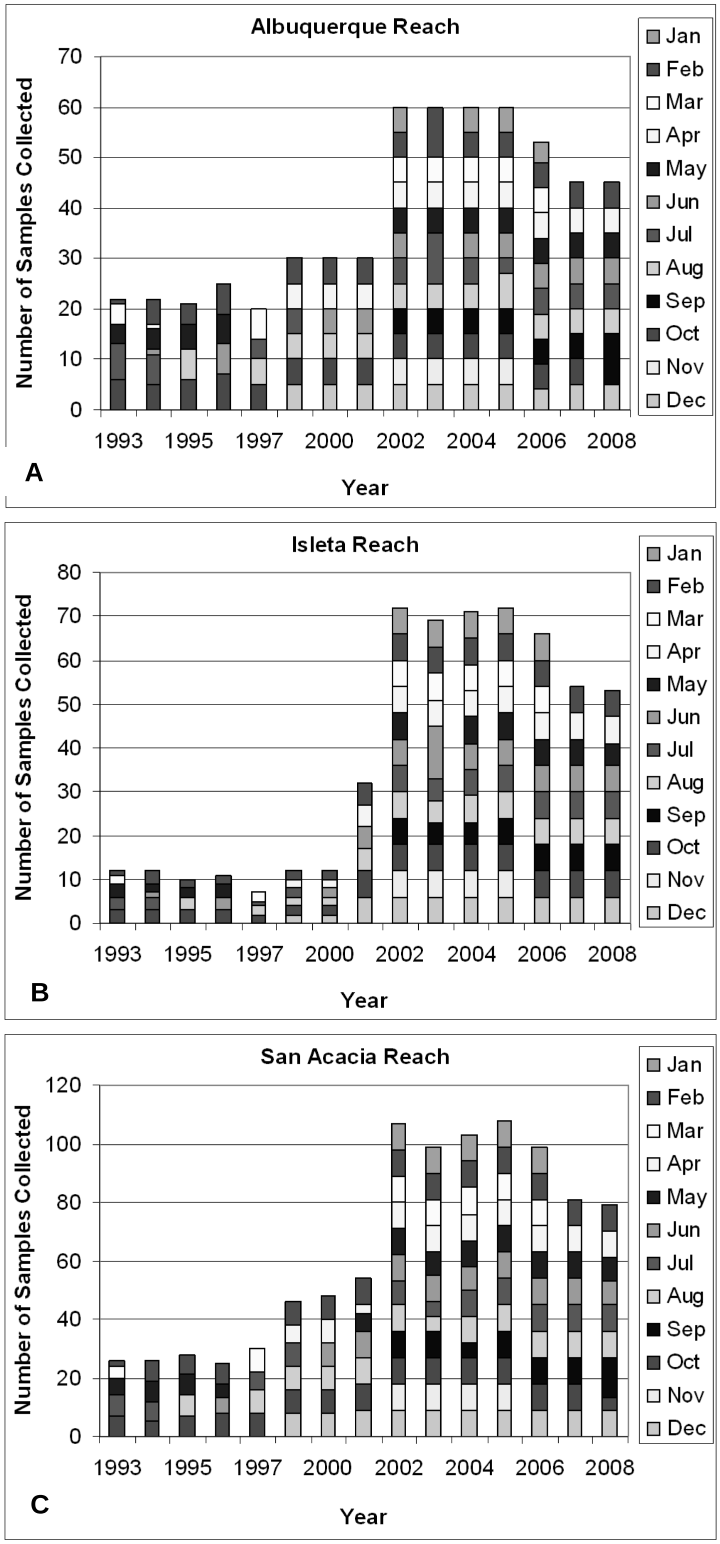


Figure 4.3. (A) Number of seine samples collected by month and year for the Albuquerque Reach, (B) Isleta Reach, and (C) San Acacia Reach. Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

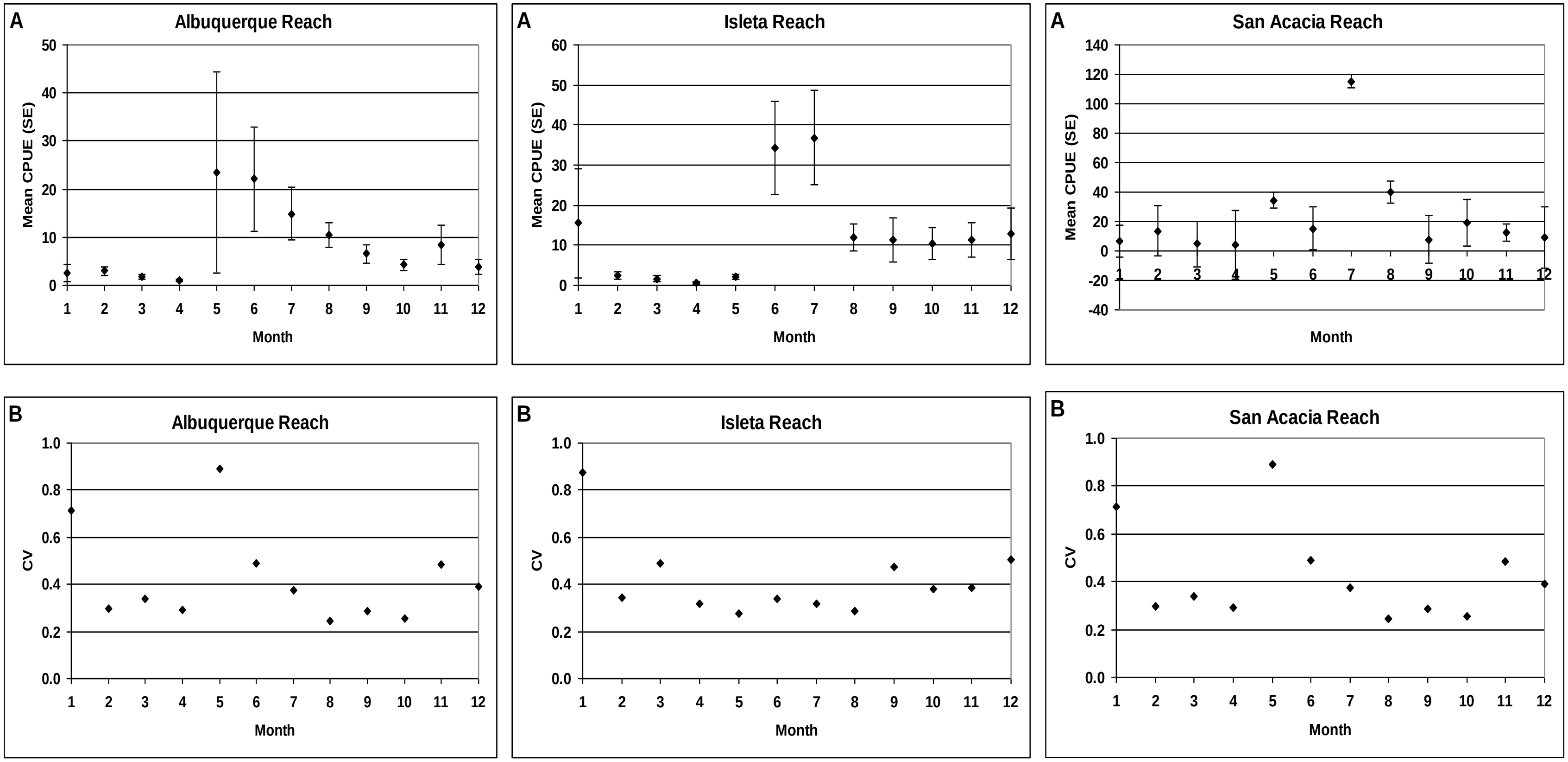


Figure 4.4. **Mean monthly CPUE (A row) and CV (B row) for silvery minnow for all years and seine samples for 1993–2008. Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.**

4.2.5 Statistical Power of Sampling Gears and Methods

Descriptive Statistics—Descriptive statistics by reach and year for all samples for seine CPUE of silvery minnow are presented in Table 4.5. This table characterizes the fundamental statistical properties of this dataset and lays the groundwork for the types of analyses that are possible with these data, as well as to provide an initial assessment of data precision.

Numbers of samples, mean CPUE, and 95% C.I. are presented and further described in other sections of this analysis. A prominent feature of these data is the lack of normality (i.e., individual observations are not normally distributed around the mean), as indicated by low Shapiro-Wilk statistics and p-values ≤ 0.05 (i.e., distribution is significantly different from a normal distribution). Non-normally distributed data require non-parametric statistics.

Mean Catch Rates—Mean annual CPUE and 95% C.I. for the silvery minnow by reach from 1993 to 2008 are presented in Figure 4.5. Mean catch rates of silvery minnow were compared among years to identify statistically significant differences using non-parametric Kruskal-Wallis one-way ANOVA (Table A.1–Table A.4 in Appendix A). One or more highly significant differences were detected among years within each reach and in all reaches combined. Tukey-type non-parametric multiple comparisons tests showed that catch rates for silvery minnow declined and subsequently recovered over the 1993 to 2008 time period. Catch rates of silvery minnow were significantly lower from 1999 to 2003 in the Albuquerque Reach, 1999 to 2004 in the Isleta Reach, 2002 to 2004 in the San Acacia Reach, and 2000 to 2004 for all reaches combined. These non-parametric rank analyses examined relative catch rate among years but do not quantify the magnitude of changes in catch rate. Because this assessment deals with properties of gears and methods and not with interpretation of population patterns, an in-depth interpretation of differences in annual mean CPUE is not pursued.

Table 4.5. Descriptive Statistics by Reach and Year for All Samples for Seine CPUE of Silvery Minnow

Statistic	1993	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Albuquerque															
Number of Samples	22	22	21	25	20	30	30	30	60	60	60	60	53	45	45
Arithmetic Mean	6.75	24.09	11.80	48.52	5.82	0.21	0.02	1.35	0.33	0.60	7.14	21.75	1.28	17.29	5.26
Standard Error	2.72	14.38	5.96	44.98	1.47	0.10	0.01	0.95	0.11	0.20	2.07	8.41	0.26	3.74	1.09
Lower 95% C.I.	1.10	-5.81	-0.63	-44.32	2.74	0.01	-0.01	-0.60	0.11	0.20	3.00	4.92	0.76	9.75	3.06
Upper 95% C.I.	12.39	53.99	24.23	141.36	8.90	0.42	0.04	3.30	0.56	1.01	11.27	38.59	1.79	24.84	7.45
CV	0.40	0.60	0.51	0.93	0.25	0.48	0.50	0.70	0.33	0.33	0.29	0.39	0.20	0.22	0.21
Shapiro-Wilk Statistic	0.60	0.37	0.50	0.22	0.83	0.46	0.28	0.27	0.42	0.44	0.52	0.32	0.70	0.72	0.73
Shapiro-Wilk *p*-value	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Isleta															
Number of Samples	12	12	10	11	7	12	12	32	72	69	71	72	66	54	53
Arithmetic Mean	6.58	19.03	21.81	2.74	4.33	1.40	0.06	3.17	0.96	0.18	1.68	55.85	10.65	18.61	13.99
Standard Error	4.66	16.57	12.76	1.18	2.00	0.87	0.04	1.36	0.24	0.07	0.47	12.63	6.25	3.56	4.19
Lower 95% C.I.	-3.68	-17.43	-7.06	0.10	-0.56	-0.51	-0.03	0.40	0.47	0.03	0.73	30.67	-1.83	11.47	5.59
Upper 95% C.I.	16.84	55.50	50.68	5.38	9.22	3.30	0.16	5.94	1.44	0.33	2.62	81.03	23.13	25.74	22.39
CV	0.71	0.87	0.59	0.43	0.46	0.62	0.67	0.43	0.25	0.39	0.28	0.23	0.59	0.19	0.30
Shapiro-Wilk Statistic	0.45	0.37	0.61	0.75	0.81	0.54	0.48	0.44	0.50	0.30	0.47	0.58	0.18	0.73	0.44
Shapiro-Wilk *p*-value	<0.001	<0.001	<0.001	0.002	0.046	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
San Acacia															
Number of Samples	26	26	28	25	30	46	48	54	107	99	103	108	99	81	79
Arithmetic Mean	213.91	93.81	118.42	157.39	19.43	41.72	4.56	7.72	3.74	0.15	1.04	28.82	10.94	4.74	15.58
Standard Error	107.66	47.38	61.86	105.44	3.84	17.59	0.85	2.16	1.80	0.04	0.35	8.40	2.38	1.16	2.34
Lower 95% C.I.	-7.83	-3.77	-8.52	-60.22	11.58	6.30	2.85	3.39	0.18	0.08	0.34	12.17	6.23	2.43	10.92
Upper 95% C.I.	435.65	191.38	245.35	375.01	27.27	77.15	6.26	12.05	7.31	0.23	1.74	45.48	15.66	7.05	20.24
CV	0.50	0.51	0.52	0.67	0.20	0.42	0.19	0.28	0.48	0.27	0.34	0.29	0.22	0.24	0.15
Shapiro-Wilk Statistic	0.44	0.45	0.36	0.31	0.80	0.32	0.69	0.53	0.18	0.43	0.32	0.34	0.48	0.47	0.73
Shapiro-Wilk *p*-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

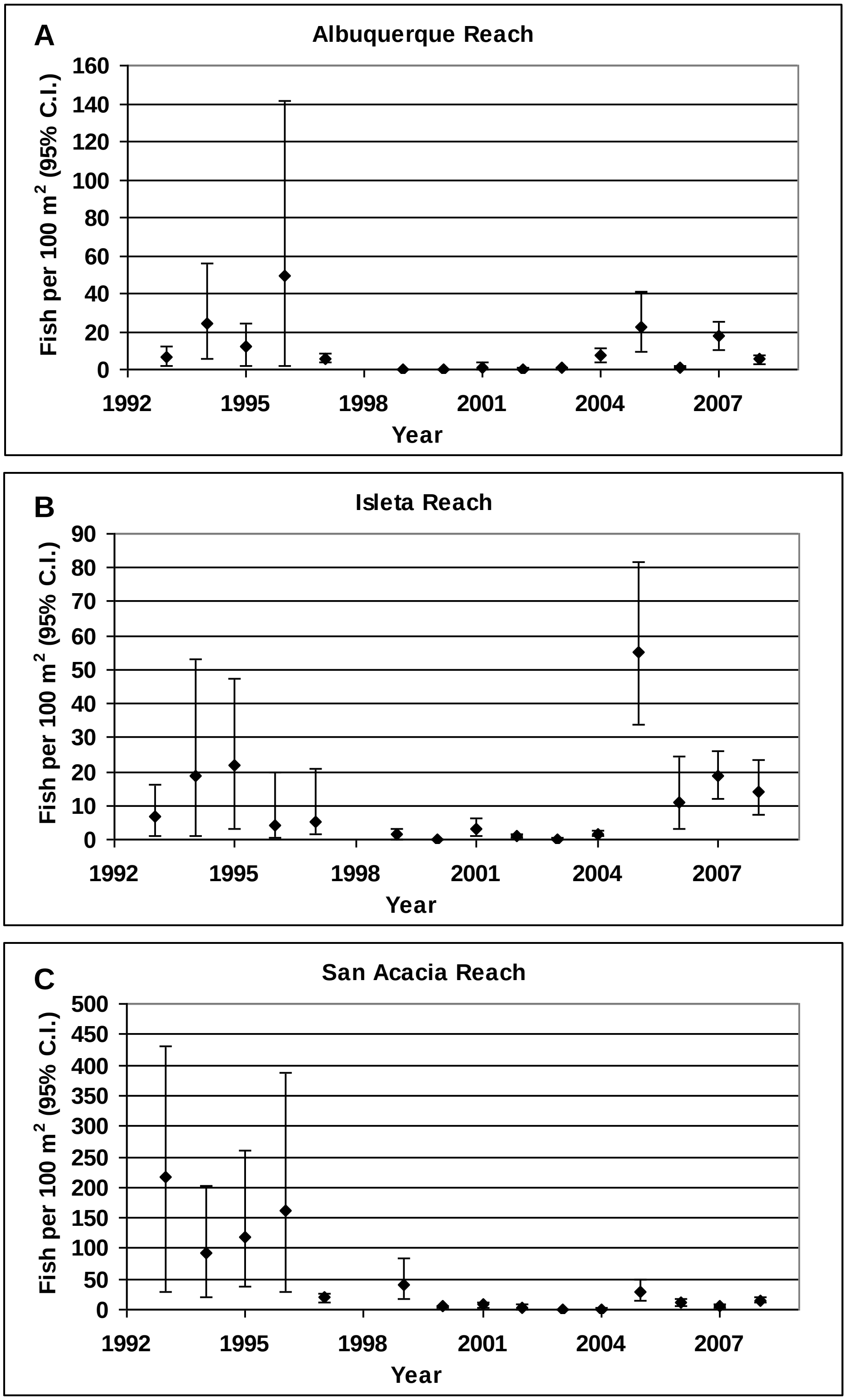


Figure 4.5. Mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) in (A) the Albuquerque Reach (N = 583), (B) the Isleta Reach (N = 565), and (C) the San Acacia Reach (N = 959), 1993–1997 and 1999–2008. Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

<u>Effect of Sample Size on Precision</u>—The effect of seine sample size (i.e., number of composite seine samples) on mean CPUE and 95% C.I., CV, and percent detectable change was evaluated with bootstrapping (resampling from original sample set and 1,000 iterations for each of various sample sizes) for the three reaches for 1993 to 1997, 1999, and 2001 to 2007. When all samples for a year were considered, the necessary samples to improve precision to an acceptable level for monitoring were considerably larger than actual sample size. For all reaches, more than 300 samples would be necessary to achieve an arbitrarily selected set of criteria, i.e., 95% C.I. ≤ 20% of the mean, CV ≤ 0.10, and ≤ 35% detectable change in mean CPUE (Figure 4.6 and Figure 4.7). The maximum number of samples taken varied from 99 to 108 between 2002 and 2006 in the San Acacia Reach; only 79 samples were collected in 2008, the most recent recorded year of sample collections. When evaluated on an annual basis, effect of samples size on percent detectable change and CV for mean CPUE is evident in Figure 4.8 to Figure 4.10. Bootstrap simulations show that increasing sample size improves percent detectable change and CV, but the number of samples necessary for acceptable precision far exceeds 100.

When only the October samples were considered (used for annual monitoring of silvery minnow), the precision was considerably better despite a smaller sample size (Figure A.1–Figure A.13 in Appendix A). For the Albuquerque Reach, between 188 and 280 samples would be needed to achieve the precision for 95% C.I., CV, and detectable change described above (see Table 4.5). Samples needed for the stated precision would be about 140 to 175 in the Isleta Reach and about 150 to 175 in the San Acacia Reach.

The number of samples collected for the standardized monitoring protocol in October was five to nine per year in each reach (Table 4.6). From our analysis, it appears that the number of samples would have to be increased dramatically in order to improve precision to an acceptable scientific level. However, it should be noted that a "sample" used in this analysis was not an individual seine haul, but rather a pool of about 10 seine hauls at each of five to nine sites; hence, a total of about 50 to 90 seine hauls was actually taken, but the area seined and the numbers of fish from each haul were not recorded individually. A measure of variability at the individual seine haul level should be a better measure of precision for this sampling strategy than for a pool of seine hauls.

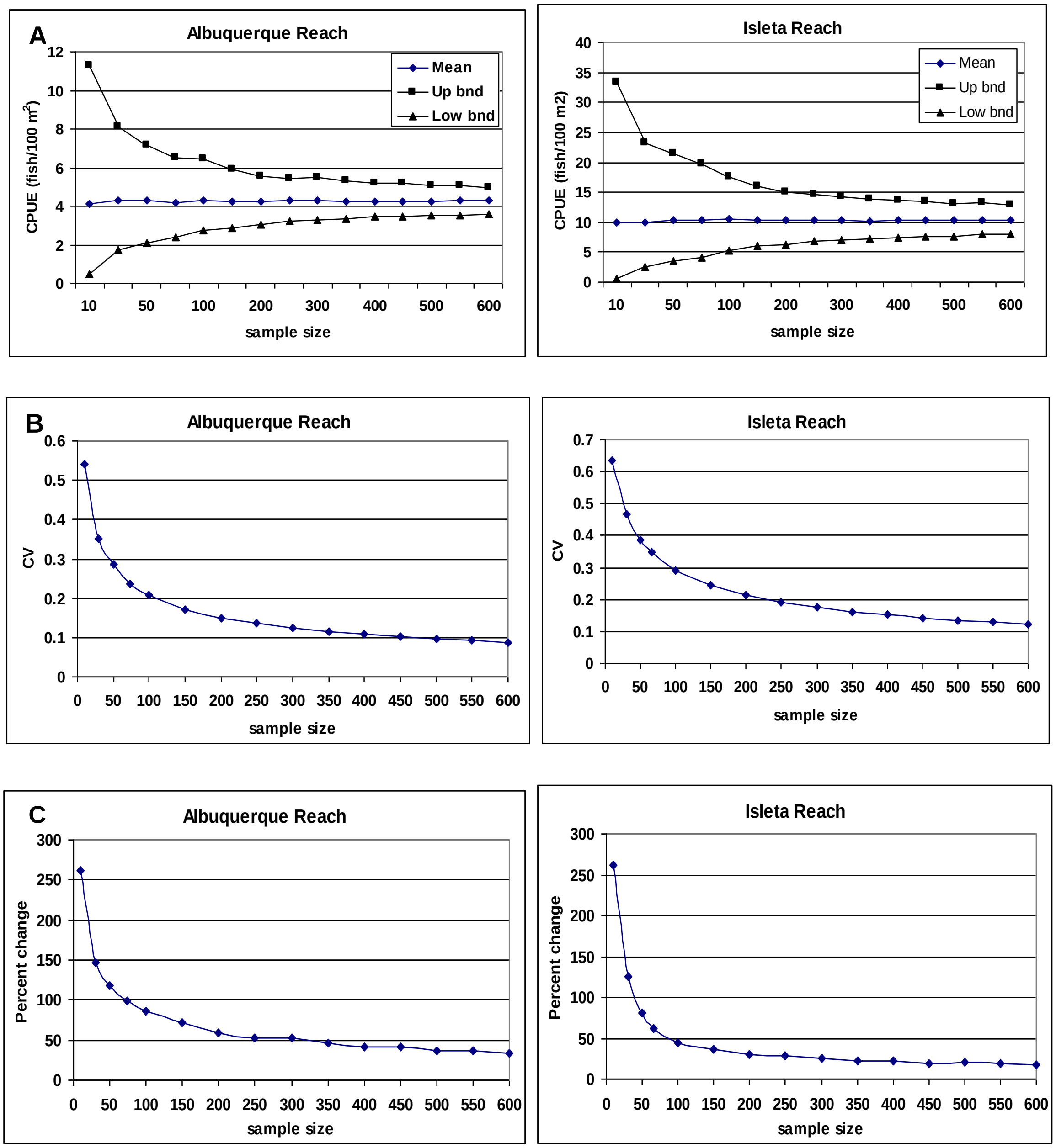


Figure 4.6. The effect of seine sample size for all samples on (A) mean CPUE and 95% C.I., (B) CV, and (C) percent detectable change by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach and the Isleta Reach, 1993–1997 and 1999–2008.

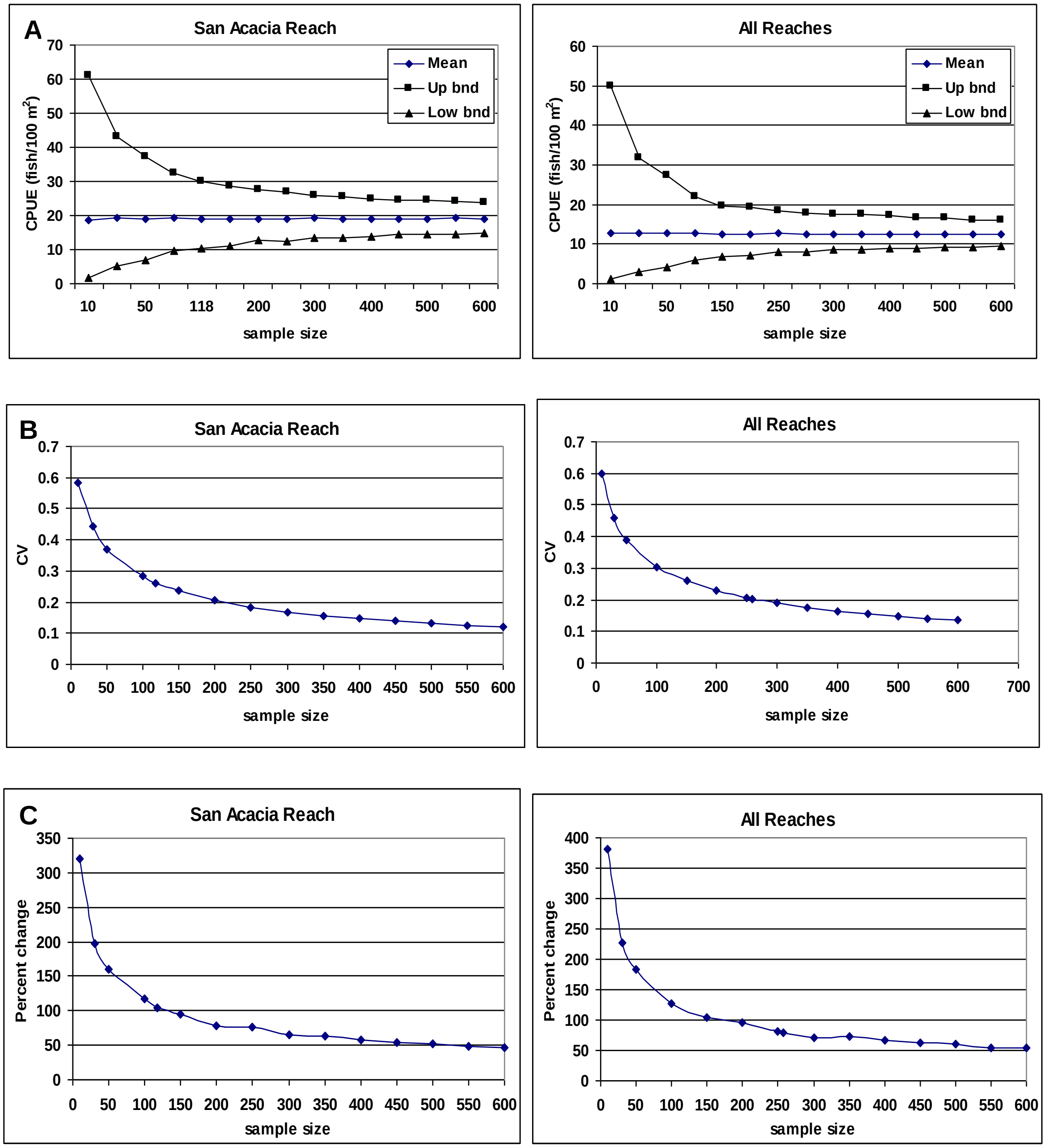


Figure 4.7. The effect of seine sample size for all samples on (A) mean CPUE and 95% C.I., (B) CV, and (C) percent detectable change by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach and for all reaches, 1993–1997 and 1999–2007.

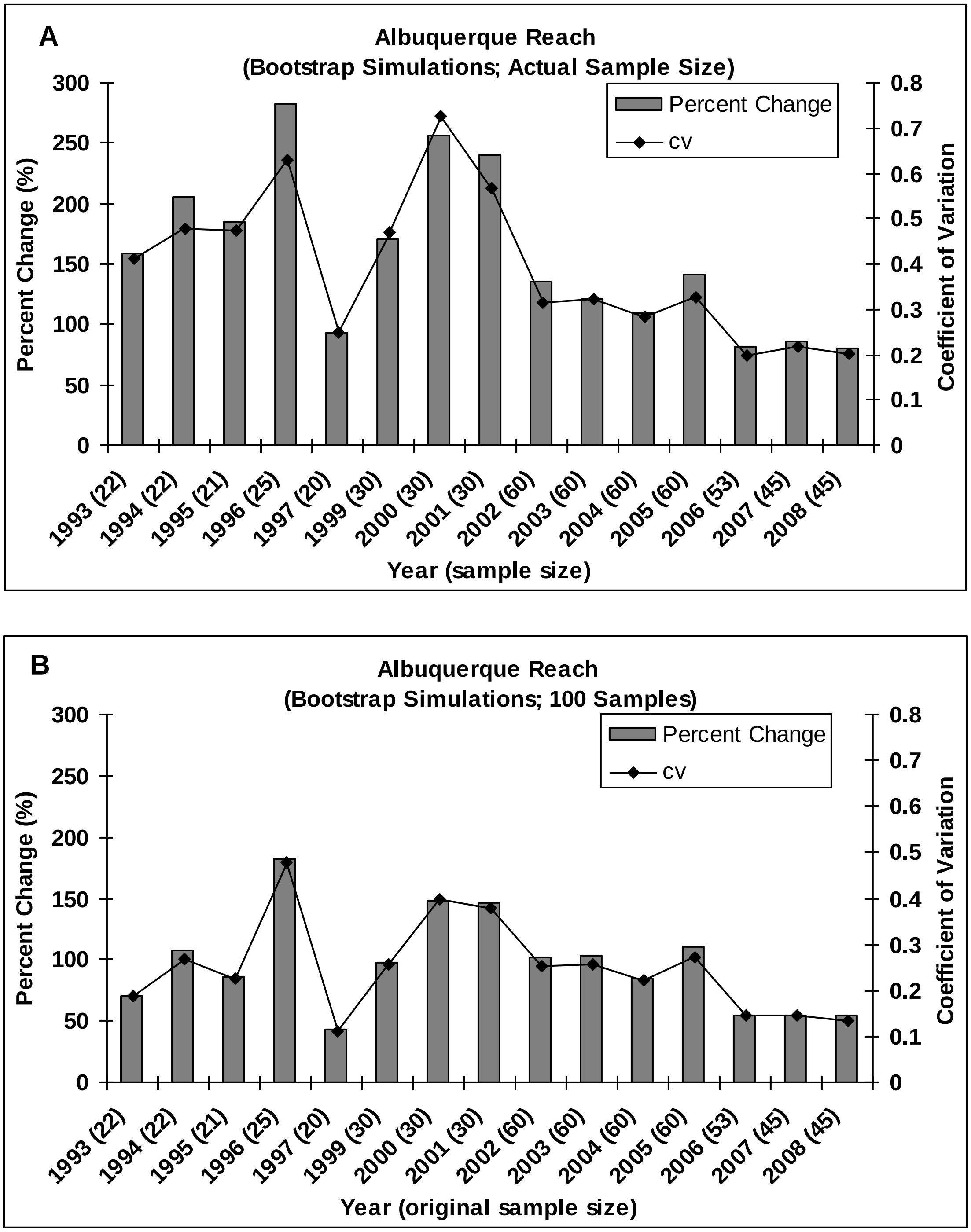


Figure 4.8. Percent detectable change for all samples by year and CV for (A) mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples in the Albuquerque Reach, 1993–1997 and 1999–2008.

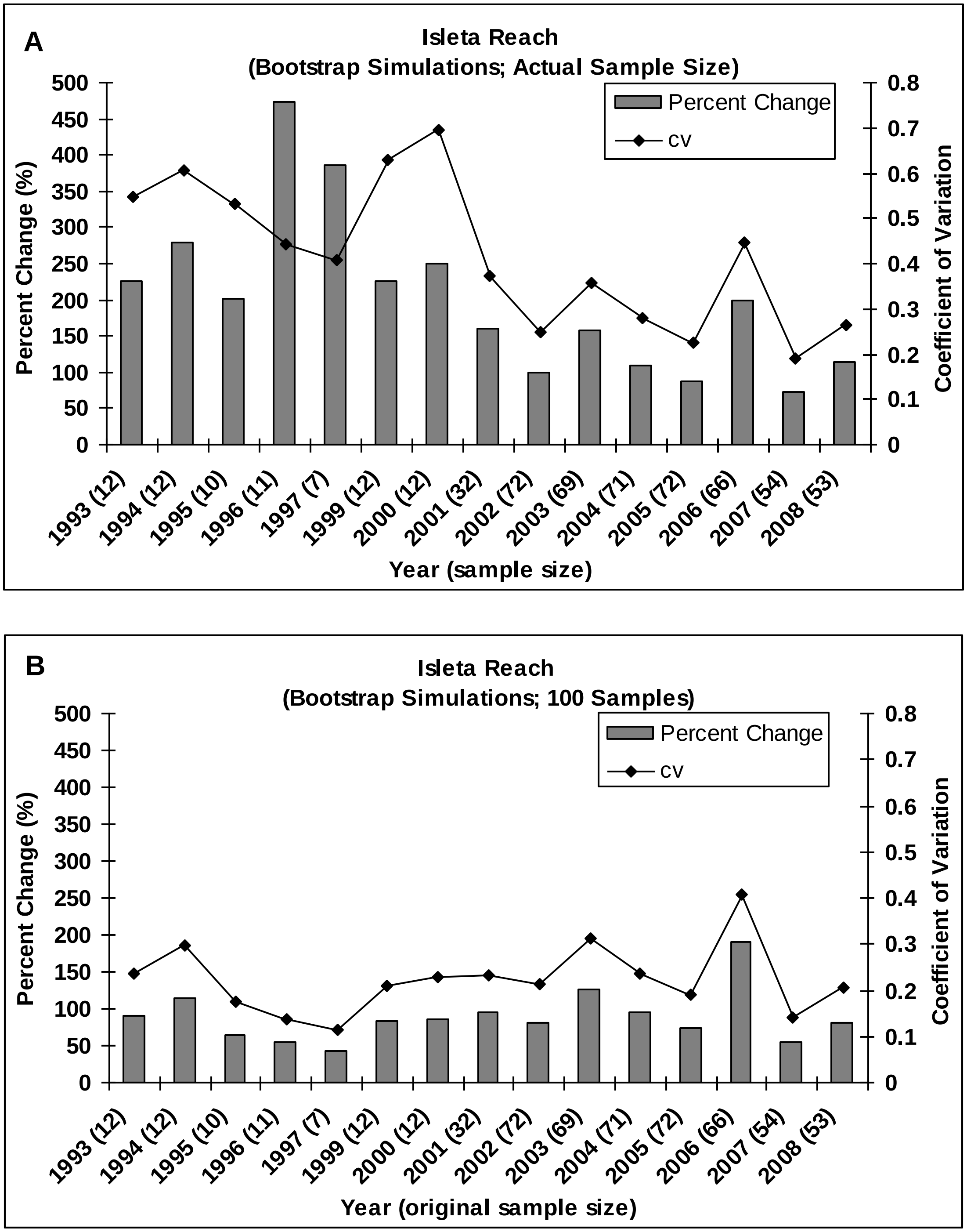
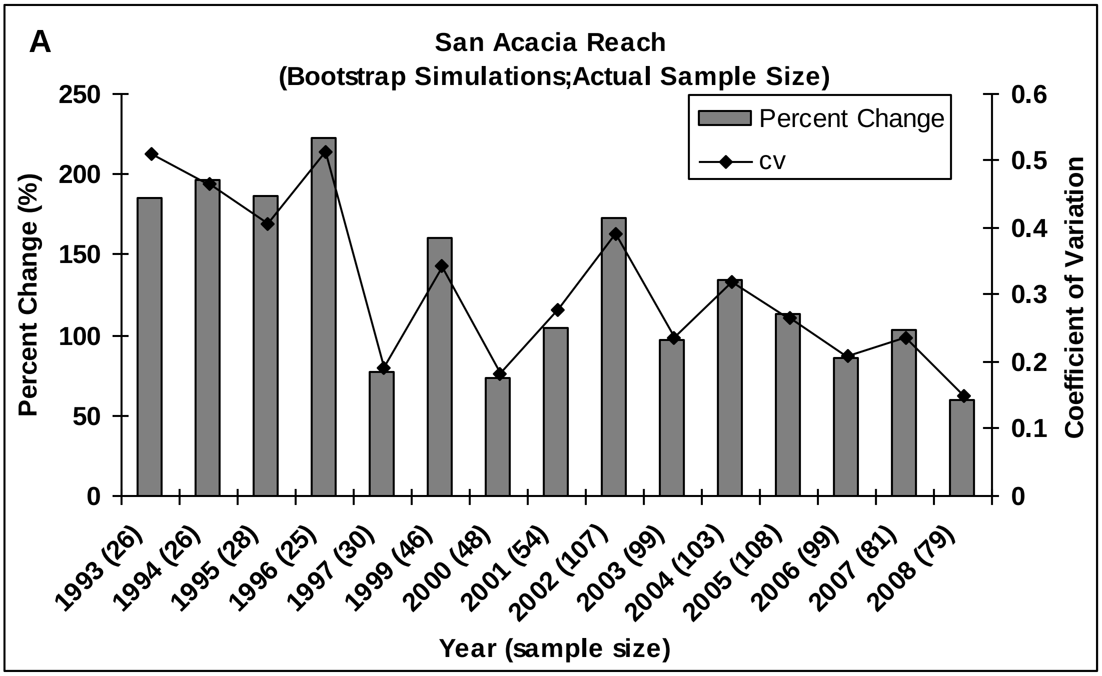


Figure 4.9. Percent detectable change for all samples by year and CV for (A) mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples in the Isleta Reach, 1993–1997 and 1999–2008.



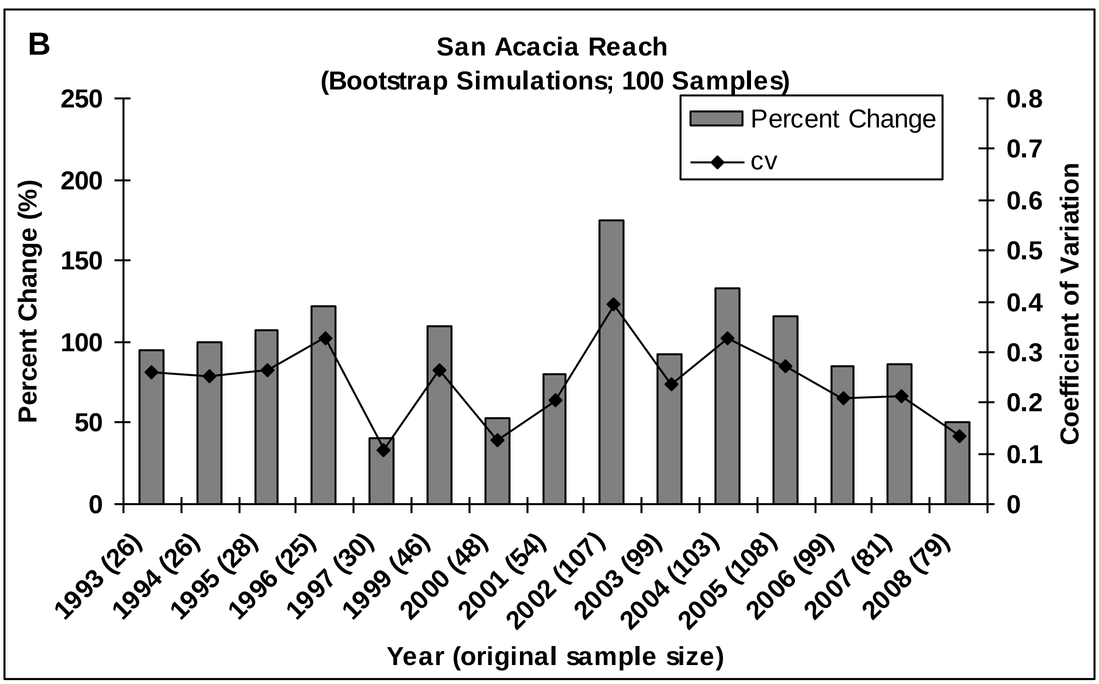


Figure 4.10. Percent detectable change for all samples by year and CV for (A) mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples in the San Acacia Reach, 1993–1997 and 1999–2008.

Table 4.6. Numbers of Seine Samples Necessary to Meet Three Criteria for Each Reach

Year	Sample Size	Mean CPUE	Number of Samples		
			95% CI = 20%	CV = 0.10	35% Change
Albuquerque					
1993	6	10	90	90	125
1994	5	7	60	75	80
1995	6	1	125	75	80
1996	7	0.29	425	430	625
1997	5	8	60	60	75
1999	5	0.47	425	410	525
2001	5	0.09	420	410	425
2002	5	0.26	140	160	210
2003	5	0.04	325	400	475
2004	5	2	140	140	175
2005	5	6	125	125	160
2006	5	3	70	75	80
2007	5	23	75	75	115
Means	–	–	191	194	242
Isleta					
1993	3	2	40	20	40
1994	3	2	175	125	160
1995	3	25	75	80	125
1996	3	0.3	60	50	75
1997	2	5	40	75	80
1999	2	0.5	75	110	125
2000	2	0	–	–	–
2001	6	0.6	20	260	325
2002	6	0.02	600	500	650
2004	6	0.04	575	500	650
2005	6	0.2	275	325	375
2006	6	78	90	75	125
2007	6	0.6	75	75	80
2008	6	14	75	80	115
Means	–	–	157	164	212
San Acacia					
1993	7	18	100	125	125
1994	5	123	150	200	220
1995	7	49	100	100	125
1996	8	70	300	250	325
1997	8	20	75	100	120
1999	8	11	75	75	110
2000	8	0.8	75	100	120
2001	9	1.4	75	50	75
2002	9	0.02	550	650	750
2004	9	0.72	425	425	525
2005	9	28	75	75	120
2006	9	1.4	75	120	125
2007	9	1.8	125	150	175
2008	4	13	50	60	75
Means	–	–	161	177	213

Note: Data based on bootstrap simulations of sample size from October; 95% CI = 20% of mean, CV = 0.10, 35% change in mean CPUE is detectable. Table represents a summary of Figures A.1–Figure A.43.

Trend Analysis—Trend analysis was performed on the seining data to determine 1) the probability of detecting different levels of change in mean annual CPUE and 2) the number of years necessary to detect a change in mean annual CPUE of different levels. The analysis used data from all seine samples for the original samples and bootstrapped for 100 samples, as well as the original October samples and the October samples bootstrapped for 100 samples (Table 4.7–Table 4.12, Figure 4.6–Figure 4.11). Trend analysis with all seine samples showed that for a 10-year period, the probability of detecting a trend in CPUE of 50% or less is unreliably low for all three reaches (i.e., < 0.79; $\alpha = 0.21$; top parts of Table 4.7, Table 4.9, and Table 4.11; top parts of Figure 4.11, Figure 4.13, and Figure 4.15). Of the 15 years of data, the minimum number of years for detecting a trend in CPUE of 50% was 13 years (i.e., $\alpha = 0.05$).

Trend analysis with October samples showed that for a 10-year period, the probability of detecting a trend in CPUE of 50% or less was similarly low for all three reaches (i.e., < 0.63; $\alpha = 0.34$; top parts of Table 4.8, Table 4.10, and Table 4.12; top parts of Figure 4.12, Figure 4.14, Figure 4.16). Of the 15 years of data, the minimum number of years for detecting a trend in CPUE of 50% was 12 years (i.e., $\alpha = 0.05$).

When all samples were bootstrapped to 100 samples, the level of detectability improved considerably. Analysis of all seine samples showed that for a 10-year period, the probability of detecting a trend in CPUE of 50% or less was as high as 98% for all three reaches (i.e., < 0.98; $\alpha = 0.02$; bottom parts of Table 4.7, Table 4.9, and Table 4.11; bottom parts of Figure 4.11, Figure 4.13, and Figure 4.15). Of the 15 years of data, the minimum number of years for detecting a trend in CPUE of 50% was five years (i.e., $\alpha = 0.05$).

An even greater level of detectability was revealed when the October samples were bootstrapped to 100 samples. Analysis of the October seine samples showed that for a 10-year period, the probability of detecting a trend in CPUE of 50% or less was as high as 100% and frequently above 95% for all three reaches (i.e., $= 1.00$; $\alpha < 0.001$; bottom parts of Table 4.8, Table 4.10, and Table 4.12; bottom parts of Figure 4.12, Figure 4.14, Figure 4.16). Of the 15 years of data, the minimum number of years for detecting a trend in CPUE of 50% was four years and frequently less than five (i.e., $\alpha = 0.05$).

Table 4.7. Summary of Trend Analysis Based on All Seine Monitoring Samples and All Samples Bootstrapped to 100 Samples for the Albuquerque Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
All Samples						
1993	22	0.4103	0.31	502%	NC	38
1994	22	0.4765	0.28	1,256%	NC	50
1995	21	0.4757	0.28	1,236%	NC	51
1996	25	0.6304	0.24	NC	NC	NC
1997	20	0.2493	0.56	138%	38	15
1999	30	0.4692	0.28	1,095%	NC	50
2000	30	0.7256	0.23	NC	NC	NC
2001	30	0.5656	0.25	NC	NC	NC
2002	60	0.3159	0.41	224%	60	22
2003	60	0.3218	0.40	235%	NC	24
2004	60	0.2842	0.47	178%	49	19
2005	60	0.3275	0.39	245%	NC	24
2006	53	0.1994	0.73	95%	25	10
2007	45	0.2157	0.67	108%	29	12
2008	45	0.2018	0.72	97%	24	10
All Samples Bootstrapped to 100 Samples						
1993	100	0.1856	0.78	86%	21	8
1994	100	0.2687	0.50	159%	44	17
1995	100	0.2270	0.63	117%	32	12
1996	100	0.4773	0.28	1,276%	NC	50
1997	100	0.1104	0.97	43%	8	5
1999	100	0.2548	0.54	144%	39	15
2000	100	0.3974	0.32	442%	NC	35
2001	100	0.3792	0.34	373%	NC	33
2002	100	0.2525	0.55	141%	39	15
2003	100	0.2546	0.54	144%	40	15
2004	100	0.2221	0.64	113%	30	12
2005	100	0.2726	0.49	163%	45	17
2006	100	0.1454	0.90	61%	13	7
2007	100	0.1444	0.90	60%	13	7
2008	100	0.1358	0.93	56%	12	6

Note: A 100% change is equal to a doubling in CPUE for the specified time period; e.g., for the 1993 dataset, a CV of 0.41 is the precision to detect a doubling of CPUE in 38 years. NC = not possible to calculate.

Table 4.8. Summary of Trend Analysis Based on October Seine Monitoring Samples and October Samples Bootstrapped to 100 Samples for the Albuquerque Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
October Samples						
1993	6	0.4450	0.29	754%	NC	44
1994	5	0.4406	0.30	712%	NC	43
1995	6	0.2978	0.44	196%	54	20
1996	7	0.7671	0.23	NC	NC	NC
1997	5	0.2906	0.45	186%	52	19
1999	5	0.8336	0.22	NC	NC	NC
2000	5	–	–	–	–	–
2001	5	0.8288	0.23	NC	NC	NC
2002	5	0.5627	0.25	NC	NC	NC
2003	5	0.8284	0.22	NC	NC	NC
2004	5	0.5153	0.27	4,539%	NC	NC
2005	5	0.4047	0.32	475%	NC	37
2006	5	0.3368	0.38	263%	NC	25
2007	5	0.3636	0.35	327%	NC	31
2008	0	–	–	–	–	–
October Samples Bootstrapped to 100 Samples						
1993	100	0.0523	1.00	18%	5	4
1994	100	0.1117	0.97	43%	9	5
1995	100	0.0961	0.99	36%	7	5
1996	100	0.0777	1.00	28%	6	4
1997	100	0.0866	1.00	32%	7	5
1999	100	0.1012	0.98	38%	7	5
2000	–	–	–	–	–	–
2001	100	0.1649	0.85	72%	17	7
2002	100	0.2294	0.62	120%	33	12
2003	100	0.2299	0.62	120%	32	13
2004	100	0.1773	0.8	80%	20	9
2005	100	0.0909	1.00	34%	7	5
2006	100	0.0877	1.00	20%	7	4
2007	100	0.0985	0.99	37%	7	5
2008	–	–	–	–	–	–

Note: A 100% change is equal to a doubling in CPUE for the specified time period; e.g., for the 1993 dataset, a CV of 0.445 is the precision to detect a doubling of CPUE in 44 years. NC = not possible to calculate.

Table 4.9. Summary of Trend Analysis Based on All Seine Monitoring Samples and All Samples Bootstrapped to 100 Samples for the Isleta Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years(1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
All Samples						
1993	12	0.5473	0.26	NC	NC	NC
1994	12	0.6043	0.25	NC	NC	NC
1995	10	0.5302	0.26	NC	NC	NC
1996	11	0.4410	0.30	716%	NC	44
1997	7	0.4066	0.31	484%	NC	37
1999	12	0.6292	0.24	NC	NC	NC
2000	12	0.6934	0.23	NC	NC	NC
2001	32	0.3712	0.34	348%	NC	31
2002	72	0.2468	0.56	136%	37	14
2003	69	0.3570	0.36	309%	NC	29
2004	71	0.2809	0.48	174%	48	19
2005	72	0.2245	0.64	115%	31	12
2006	66	0.4461	0.29	766%	NC	45
2007	54	0.1900	0.76	89%	22	9
2008	53	0.2632	0.52	153%	42	16
All Samples Bootstrapped to 100 Samples						
1993	100	0.2371	0.59	126%	34	13
1994	100	0.2967	0.44	195%	54	19
1995	100	0.1765	0.81	80%	19	9
1996	100	0.1371	0.92	56%	12	6
1997	100	0.1135	0.97	44%	8	5
1999	100	0.2099	0.69	103%	27	11
2000	100	0.2282	0.62	118%	33	12
2001	100	0.2305	0.62	120%	33	13
2002	100	0.2122	0.68	105%	28	12
2003	100	0.3139	0.41	221%	NC	23
2004	100	0.2363	0.60	126%	34	13
2005	100	0.1899	0.76	89%	23	9
2006	100	0.4081	0.31	491%	NC	37
2007	100	0.1398	0.92	58%	13	6
2008	100	0.2038	0.71	99%	26	10

A 100% change is equal to a doubling in CPUE for the specified time period; e.g., for the 2002 dataset, a CV of 0.25 is the precision to detect a doubling of CPUE in 14 years. NC = not possible to calculate.

Table 4.10. Summary of Trend Analysis Based on October Seine Monitoring Samples and October Samples Bootstrapped to 100 Samples for the Isleta Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
October Samples						
1993	3	0.2307	0.62	121%	32	13
1994	3	0.6575	0.24	NC	NC	NC
1995	3	0.4868	0.28	1,573%	NC	53
1996	3	0.5088	0.27	3,208%	NC	NC
1997	2	0.4224	0.30	572%	NC	40
1999	2	0.6583	0.24	NC	NC	NC
2000	2	0.0000	–	–	–	–
2001	6	0.6543	0.24	NC	NC	NC
2002	6	0.8425	0.22	NC	NC	NC
2003	6	0.8524	0.22	NC	NC	NC
2004	6	0.7147	0.23	NC	NC	NC
2005	6	0.3207	0.40	233%	NC	24
2006	6	0.3689	0.44	341%	NC	30
2007	6	0.3800	0.33	376%	NC	33
2008	6	0.2260	0.63	117%	30	12
October Samples Bootstrapped to 100 Samples						
1993	100	0.0985	0.99	37%	7	5
1994	100	0.0838	1.00	31%	6	4
1995	100	0.0821	1.00	30%	6	4
1996	100	0.2144	0.67	107%	28	12
1997	100	0.0709	1.00	25%	5	4
1999	100	0.2029	0.71	98%	26	10
2000	–	–	–	–	–	–
2001	100	0.2045	0.71	99%	26	11
2002	100	0.1263	0.95	51%	11	6
2003	100	0.2037	0.71	99%	25	10
2004	100	0.1209	0.96	48%	10	6
2005	100	0.1113	0.97	43%	9	5
2006	100	0.0838	1.00	31%	6	4
2007	100	0.0948	0.99	36%	7	5
2008	–	0.0534	1.00	19%	4	4

A 100% change is equal to a doubling in CPUE for the specified time period; e.g., for the 1993 dataset, a CV of 0.23 is the precision to detect a doubling of CPUE in 13 years. NC = not possible to calculate.

Table 4.11. Summary of Trend Analysis Based on All Seine Monitoring Samples and All Samples Bootstrapped to 100 Samples for the San Acacia Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
All Samples						
1993	26	0.5098	0.27	3,361%	NC	NC
1994	26	0.4653	0.28	1,023%	NC	48
1995	28	0.4071	0.31	486%	NC	37
1996	25	0.5131	0.27	3,984%	NC	NC
1997	30	0.1916	0.75	90%	23	10
1999	46	0.3445	0.37	279%	NC	27
2000	48	0.1812	0.79	83%	20	9
2001	54	0.2768	0.48	169%	46	17
2002	107	0.3924	0.32	421%	NC	34
2003	99	0.2373	0.59	127%	33	13
2004	103	0.3205	0.40	232%	NC	24
2005	108	0.2665	0.51	156%	42	17
2006	99	0.2104	0.69	104%	28	11
2007	81	0.2349	0.60	124%	33	13
2008	79	0.1485	0.90	53%	13	7
All Samples Bootstrapped to 100 Samples						
1993	100	0.2585	0.53	148%	40	16
1994	100	0.2520	0.55	141%	38	15
1995	100	0.2633	0.52	153%	43	16
1996	100	0.3256	0.39	241%	NC	24
1997	100	0.1061	0.98	41%	9	5
1999	100	0.2632	0.52	153%	42	16
2000	100	0.1268	0.95	51%	11	6
2001	100	0.2048	0.71	99%	26	11
2002	100	0.3956	0.32	434%	NC	34
2003	100	0.2362	0.60	126%	33	13
2004	100	0.3269	0.39	244%	NC	24
2005	100	0.2722	0.50	163%	45	16
2006	100	0.2097	0.69	103%	27	11
2007	100	0.2139	0.67	107%	28	12
2008	100	0.1326	0.93	54%	12	6

A 100% change is equal to a doubling in CPUE for the specified time period; e.g., for the 2002 dataset, a CV of 0.39 is the precision to detect a doubling of CPUE in 34 years. NC = not possible to calculate.

Table 4.12. Summary of Trend Analysis Based on October Seine Monitoring Samples and October Samples Bootstrapped to 100 Samples for the San Acacia Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
October Samples						
1993	7	0.3410	0.37	272%	NC	27
1994	5	0.5817	0.25	NC	NC	NC
1995	7	0.4098	0.31	500%	NC	38
1996	8	0.5292	0.26	32,272%	NC	NC
1997	8	0.3307	0.39	251%	NC	25
1999	8	0.3273	0.39	245%	NC	24
2000	8	0.3372	0.38	264	NC	26
2001	9	0.2340	0.60	124%	33	13
2002	9	0.8397	0.22	NC	NC	NC
2003	9	–	–	–	–	–
2004	9	0.6510	0.24	NC	NC	NC
2005	9	0.3036	0.43	205%	56	21
2006	9	0.3397	0.38	269%	NC	27
2007	9	0.4012	0.32	458%	NC	37
2008	4	0.3630	0.35	325	NC	29
October Samples Bootstrapped to 100 Samples						
1993	100	0.1093	0.97	42%	9	5
1994	100	0.1398	0.92	58%	13	6
1995	100	0.1030	0.98	39%	8	5
1996	100	0.1596	0.86	69%	16	7
1997	100	0.0939	0.99	35%	7	5
1999	100	0.0931	0.99	35%	7	5
2000	100	0.0939	0.99	35%	7	5
2001	100	0.0730	1.00	26%	5	4
2002	100	0.2946	0.45	192%	52	20
2003	100	–	–	–	–	–
2004	100	0.2052	0.70	100%	26	11
2005	100	0.0903	1.00	34%	7	5
2006	100	0.1051	0.98	60%	8	5
2007	100	0.1215	0.96	48%	10	6
2008	100	0.0781	1.00	28%	6	4

A 100% change is equal to a doubling in CPUE for the specified time period; e.g., for the 1993 dataset, a CV of 0.34 is the precision to detect a doubling of CPUE in 27 years. NC = not possible to calculate.

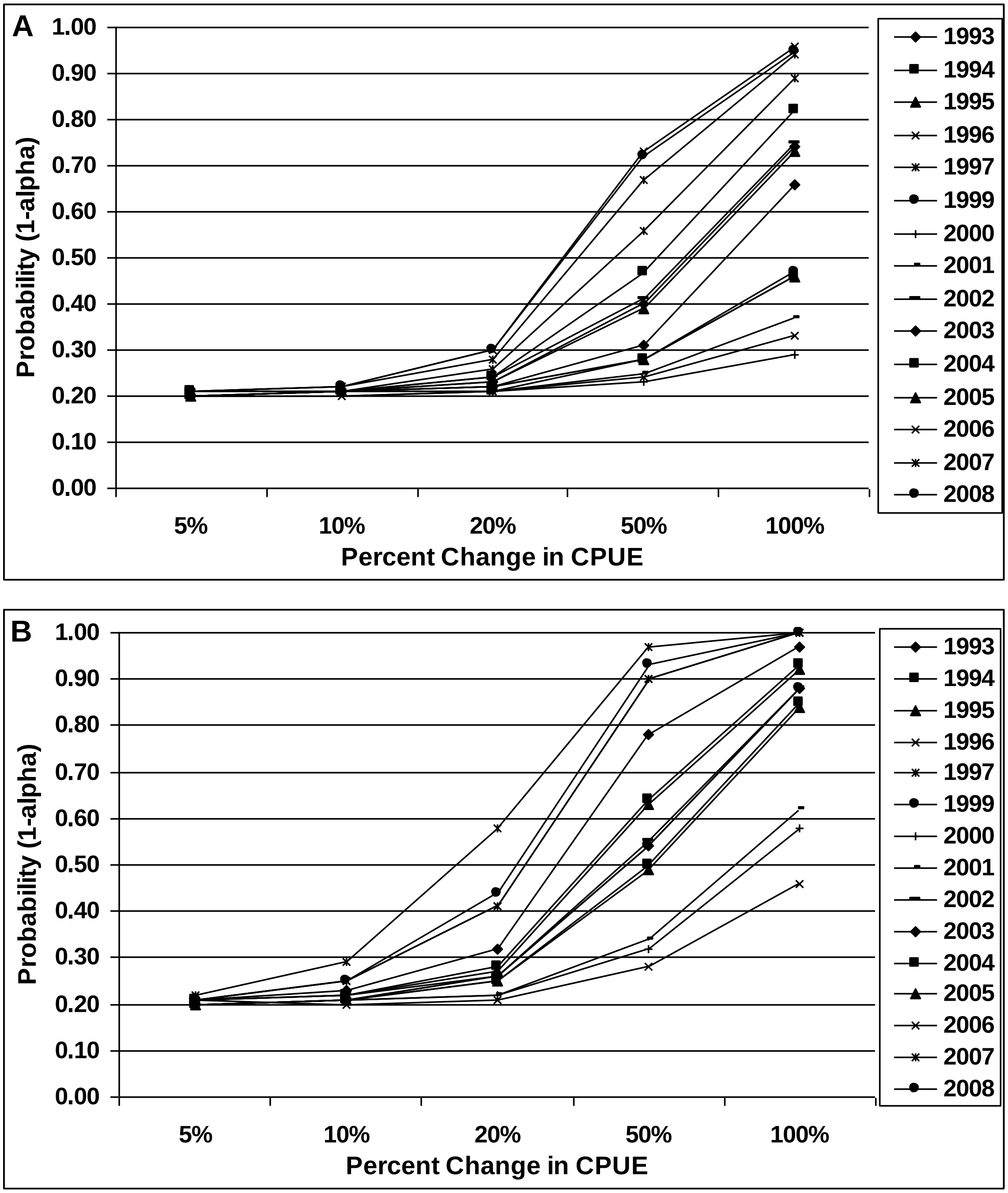


Figure 4.11. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all seine monitoring samples and (B) all samples bootstrapped to 100 samples in the Albuquerque Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE.

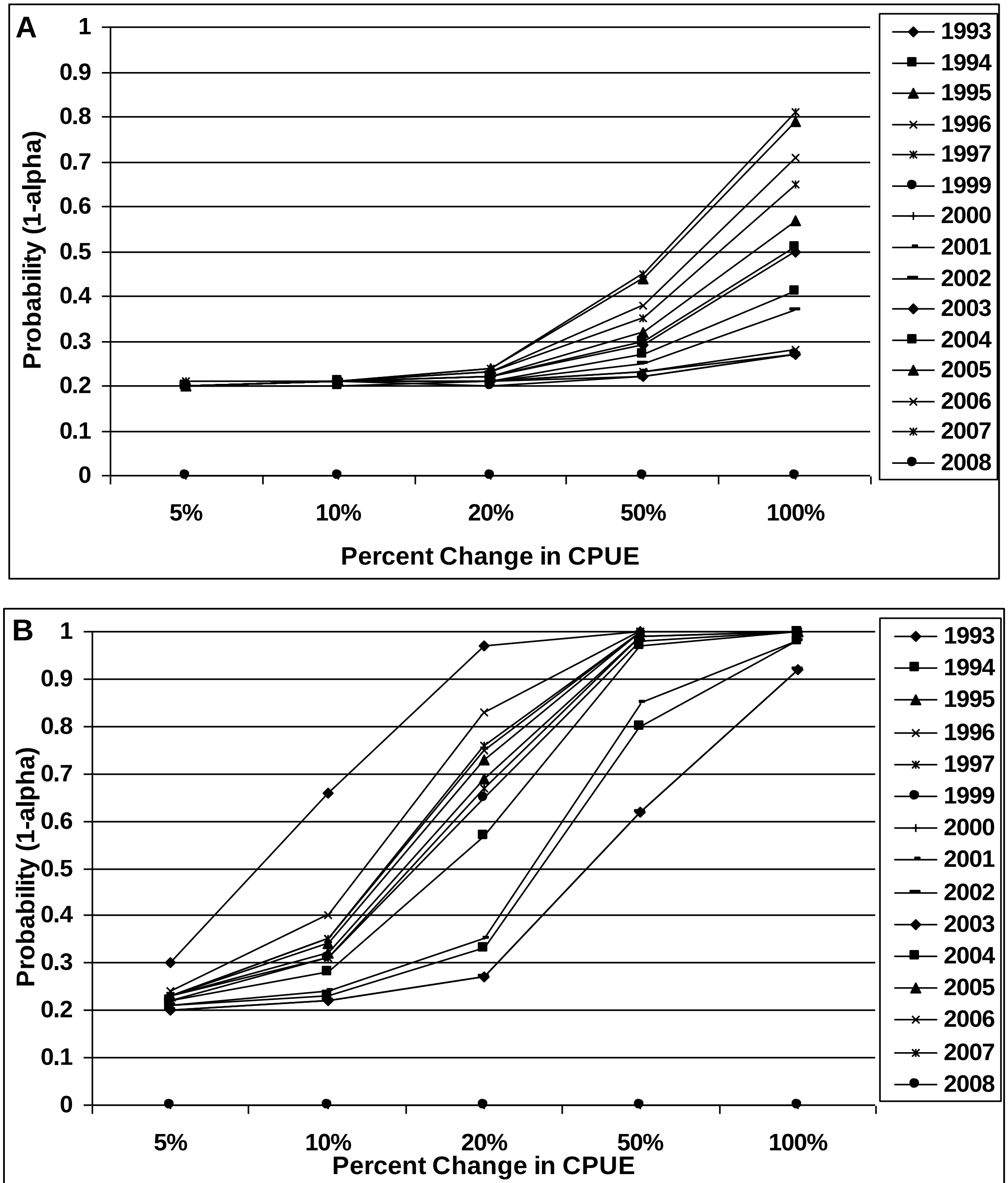
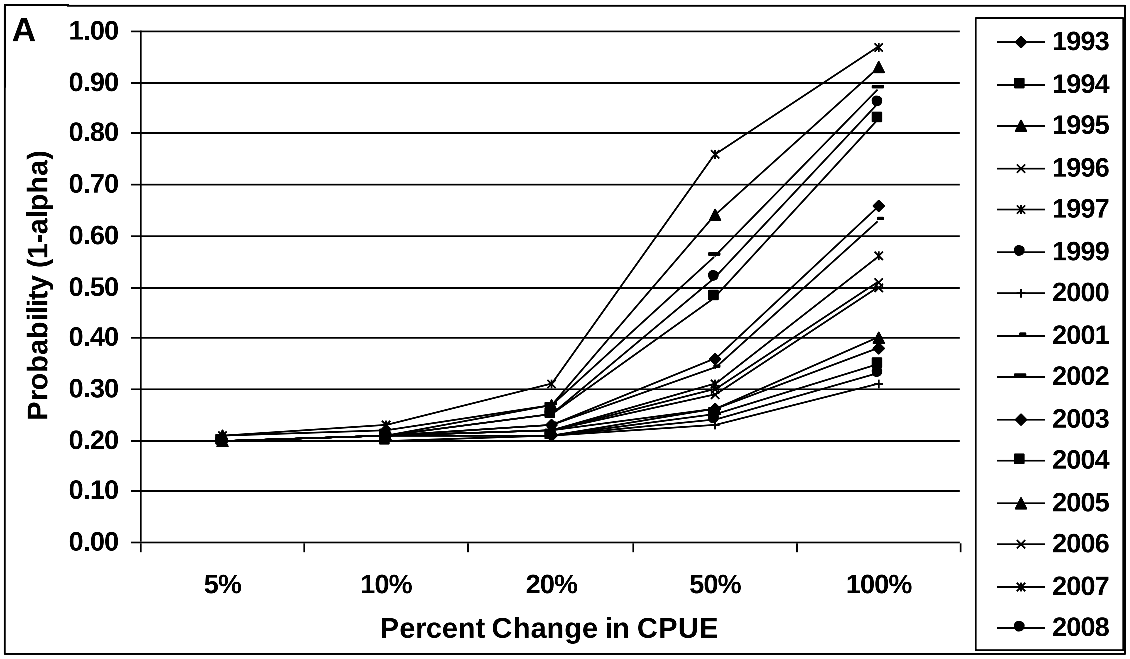


Figure 4.12. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of minnow for (A) all October seine monitoring samples and (B) October bootstrapped to 100 samples in the Albuquerque Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE.



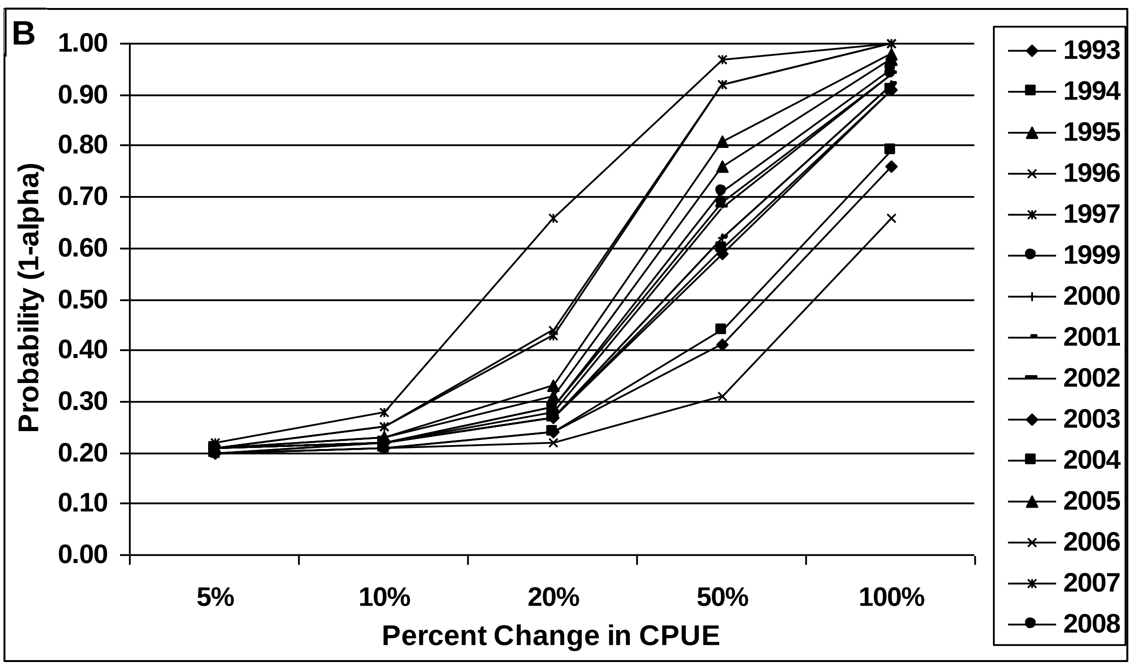


Figure 4.13. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all seine monitoring samples and (B) all samples bootstrapped to 100 samples in the Isleta Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE.

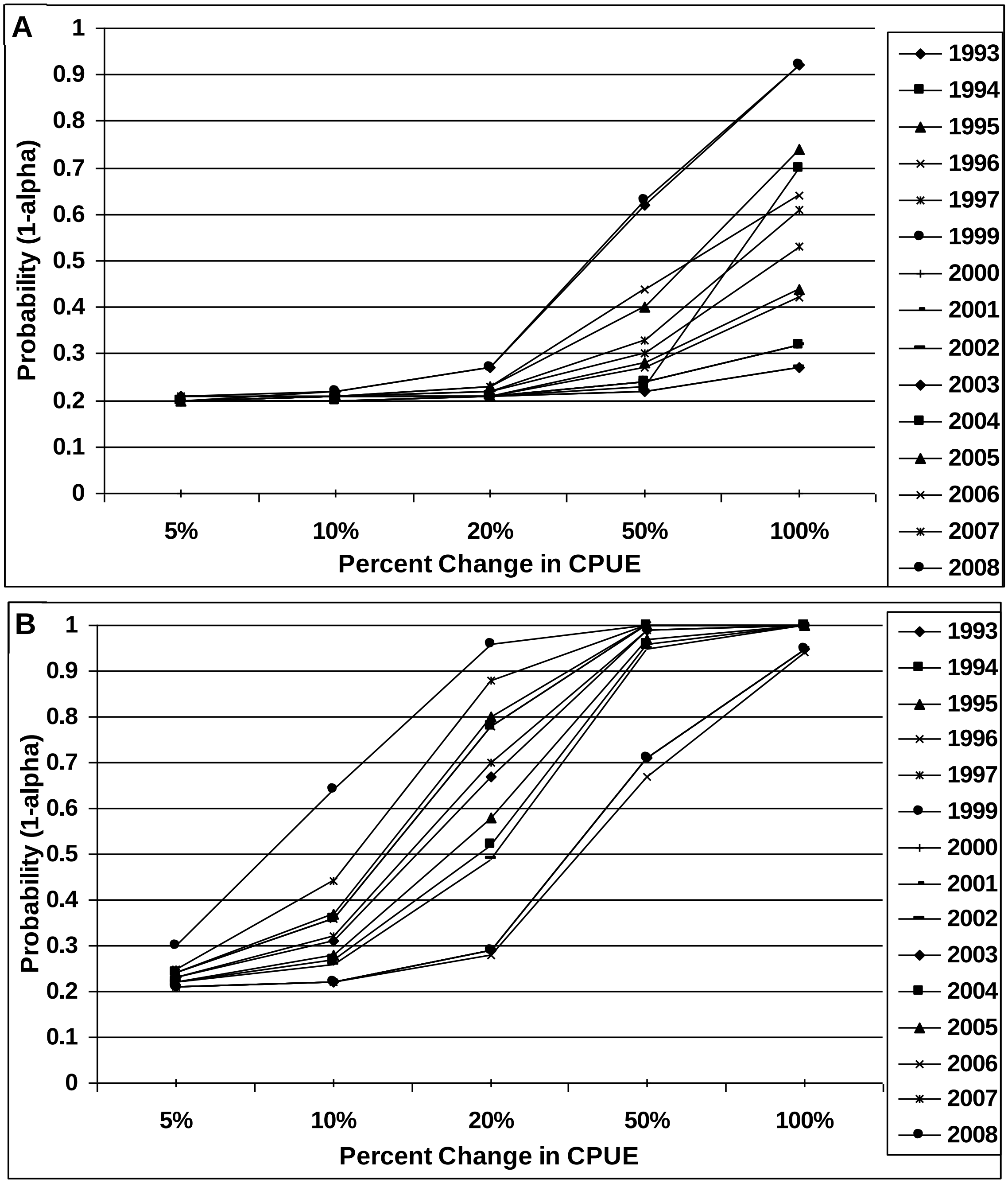


Figure 4.14. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all October seine monitoring samples and (B) October bootstrapped to 100 samples in the Isleta Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE.

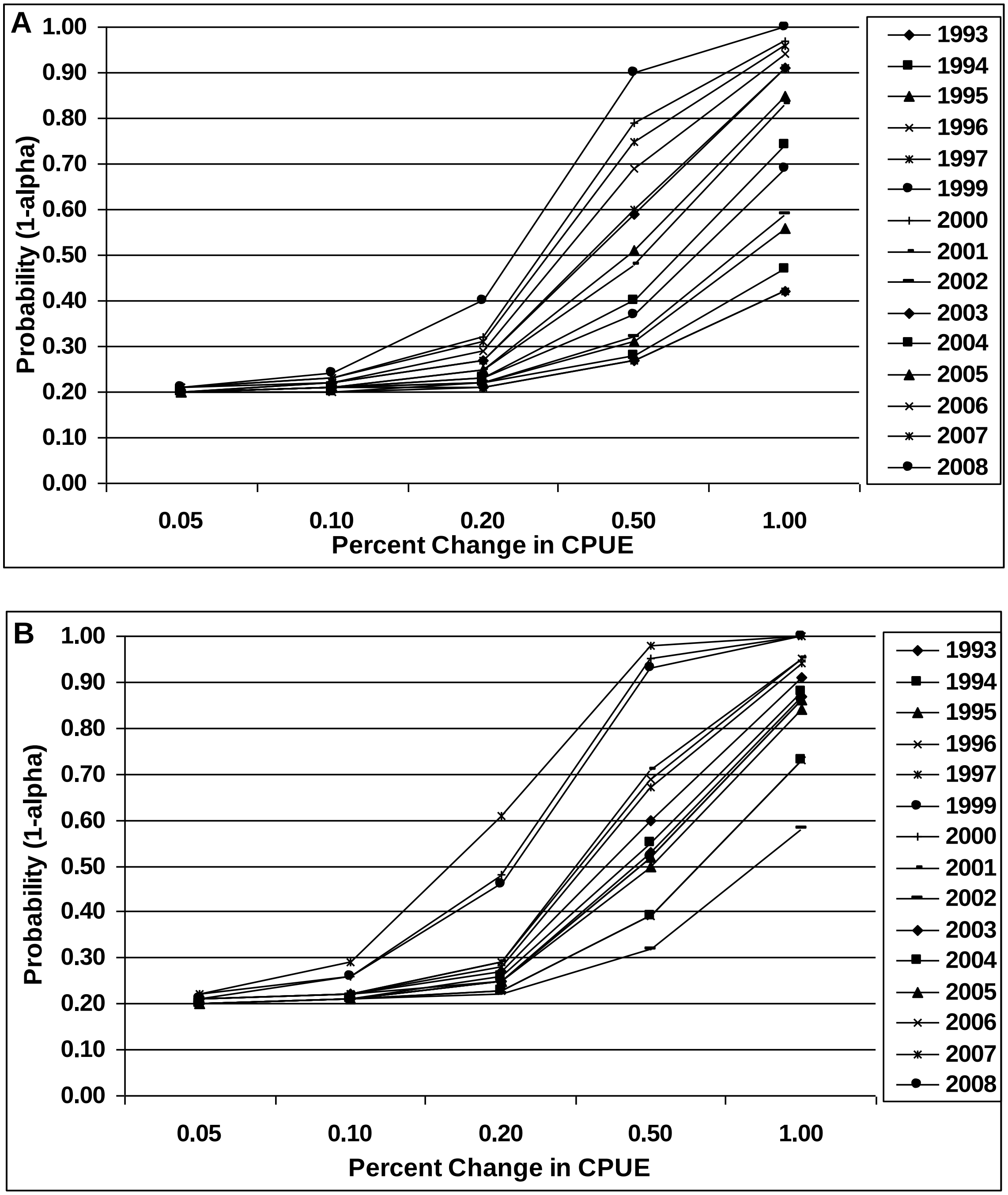


Figure 4.15. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all seine monitoring samples and (B) all samples bootstrapped to 100 samples in the San Acacia Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE.

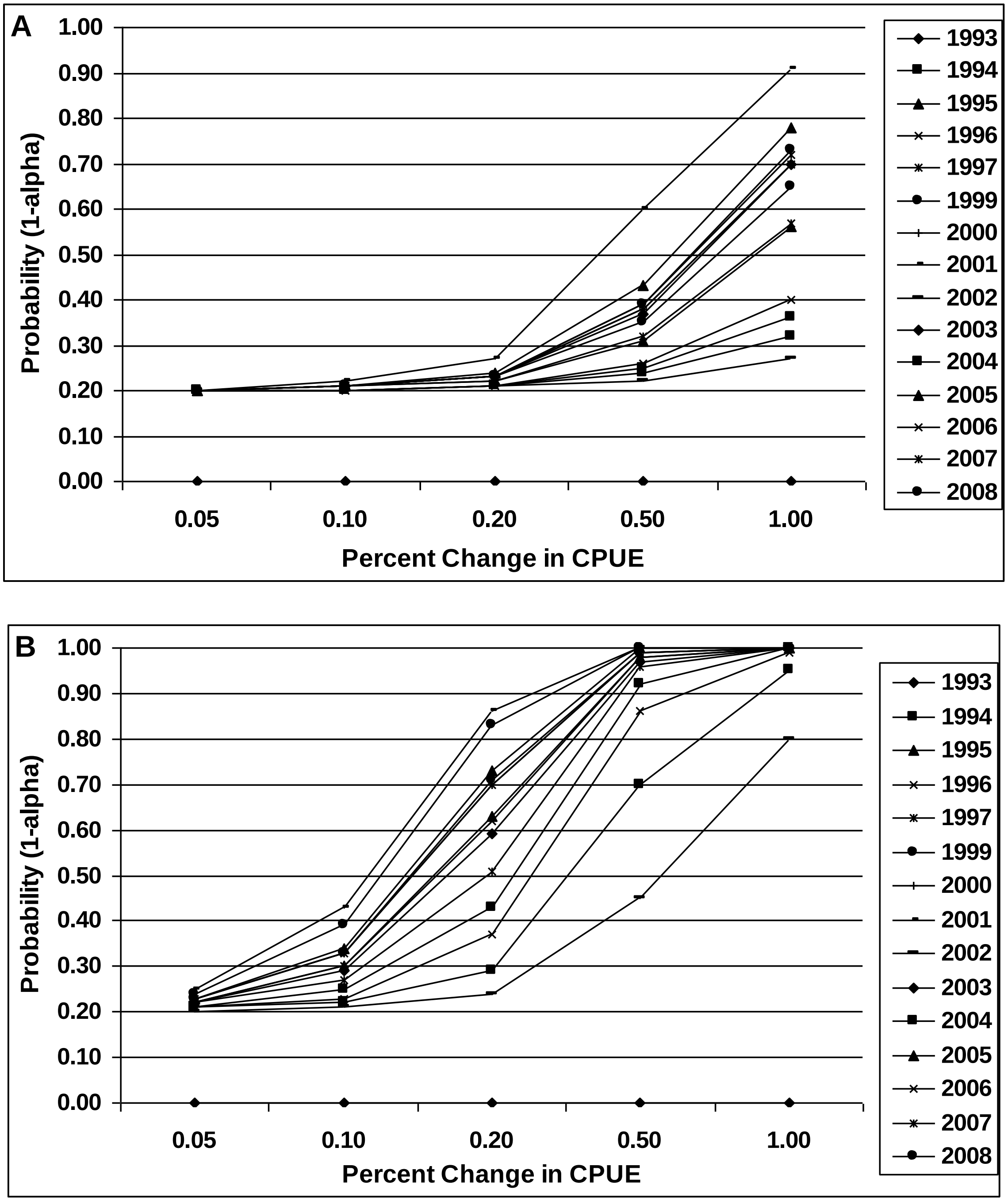


Figure 4.16. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all October seine monitoring samples and (B) October bootstrapped to 100 samples in the San Acacia Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE.

4.3 DATASET 3

3. USFWS-05.+rgsmMonitoringData_Dec2007+forGoodman.xls.

4.3.1 RELEVANT REPORTS

Remshardt (2008)

4.3.2 STUDY OBJECTIVES

- Determine temporal and spatial upstream and downstream movement of stocked silvery minnow within and among reaches.
- Identify and characterize river reaches where retention and survival of stocked silvery minnow are maximized.
- Provide guidance for augmentation activities to maximize survival of silvery minnow

4.3.3 DOCUMENTATION OF SAMPLING GEARS AND METHODS

Surveys were conducted post stocking in one-month intervals to determine survival, growth, and movement. Stocked fish were marked using visible implant elastomer tags. Samples were collected at a total of 23 sites, although not every site was sampled in each month or year. Fish were collected by drawing a two-person seine, measuring 3.0 × 1.8 m (10 × 6 feet) with small mesh (ca. 3 mm [1/8 inch]), through a minimum of 30 discrete mesohabitats at each site. Each mesohabitat type (e.g., main channel run, backwaters, etc.) was sampled at least once. CPUE was calculated for each species and each seine haul as the number of individuals collected per 100 m^2 (surface area) of water sampled. Effort was calculated by multiplying the seine width during sampling (2.5 m [8.2 feet]) by the length of the seine haul, which was measured to the nearest 0.1 m (0.3 foot). For the purposes of this analysis, a sample was defined as a single seine haul. Standard length of marked and unmarked silvery minnow were collected on each trip. Standard lengths were compared over time using the Peterson method of length-frequency analysis to assign age groups (Isaac 1990; DeVries and Frie 1996) and regression to estimate growth. Tag recaptures were used to document movement upstream and downstream in miles.

4.3.4 SAMPLING EFFORT FOR GEARS AND METHODS

<u>Samples by Year and Reach</u>—Sample density and sampling effort was greatest in the Albuquerque Reach in all years 2002 to 2007 (Figure 4.17). A total of 12,700 samples was collected in the Albuquerque Reach during this period. The Isleta and San Acacia reaches were sampled four and two out of the six years, respectively; there were 4,505 samples collected in the Isleta Reach and 260 samples collected in the San Acacia Reach. The average area sampled per seine haul was relatively constant from 2002 to 2005, and increased by 25% to 50% in 2006 and 2007. Samples were consistently collected each month in each year, except 2002 (Figure 4.18).

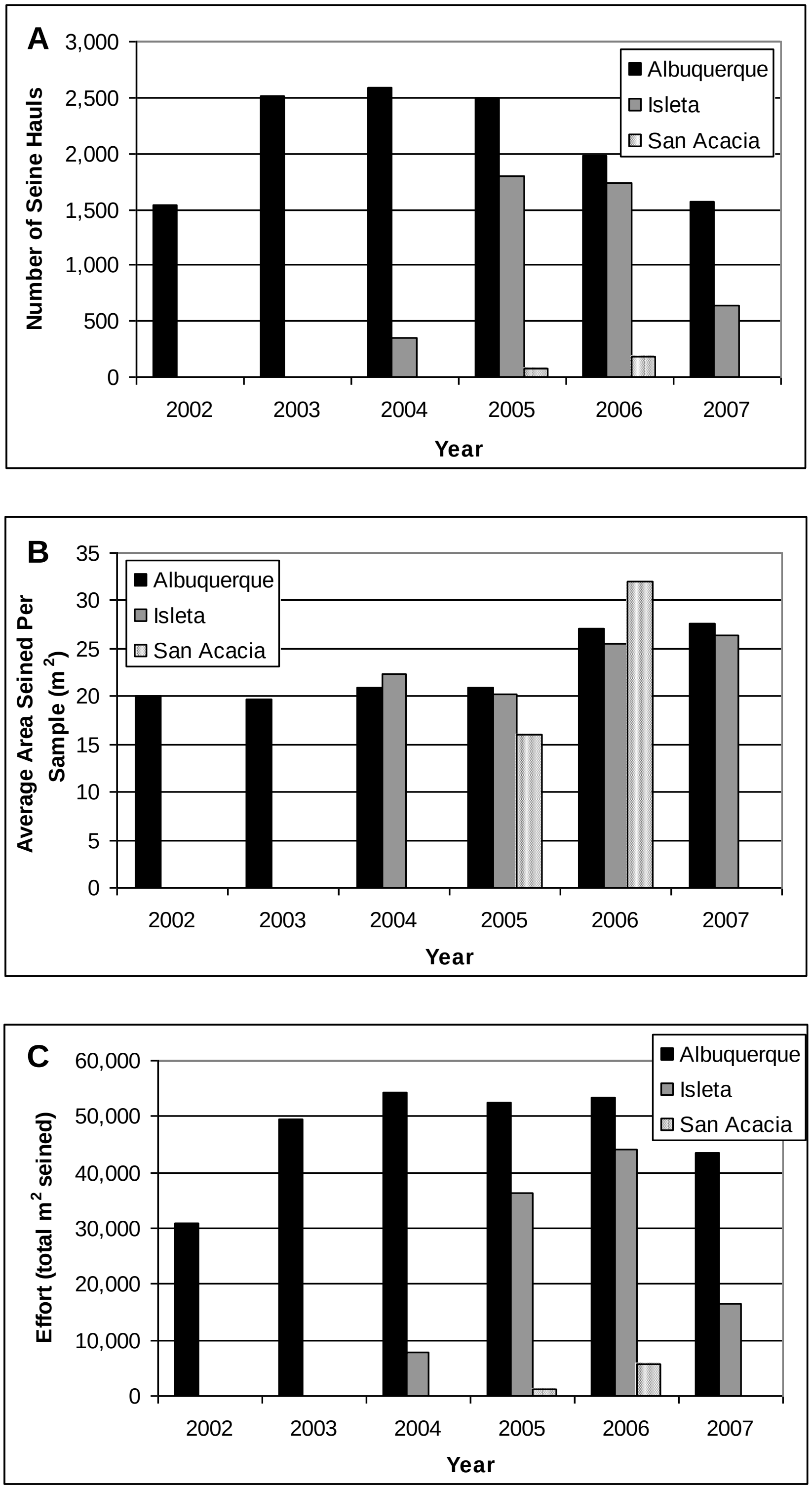


Figure 4.17. (A) Number of seine samples collected, (B) average area seined per sample, and (C) total square meters seined by reach and year. Dataset: USFWS-05.+rgsmMonitoringData_Dec2007+forGoodman.xls.

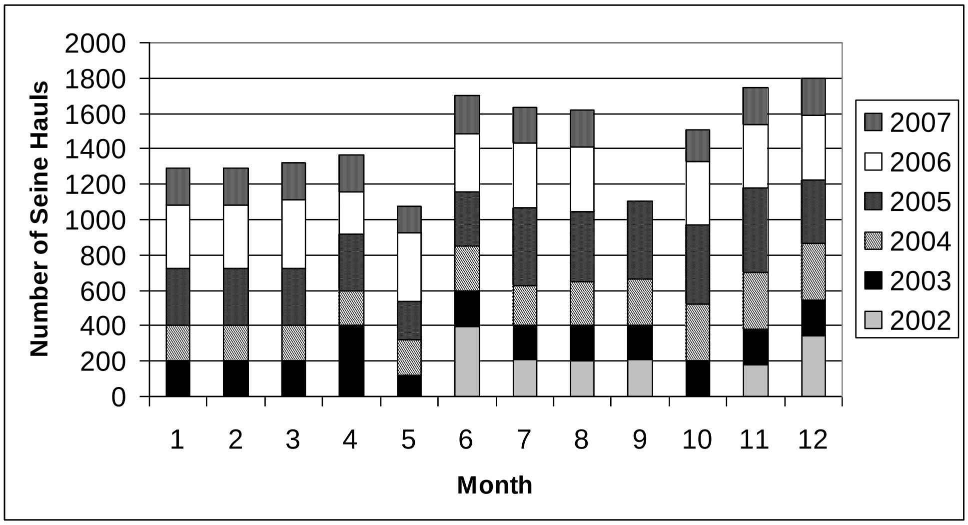


Figure 4.18. Cumulative number of seine hauls collected by the USFWS by month, 2002–2007. Dataset: USFWS-05.+rgsmMonitoringData_ Dec2007+ forGoodman.xls.

<u>Samples by Habitat, Month, and Year</u>—The majority of samples were collected in runs (52%–65%), followed by pools (12%–23%), embayments (8%–11%), and backwaters (6%–7%) (Figure 4.19, Table 4.13). As described by Dudley and Platania (2008), isolated pools may have contained artificially high densities of silvery minnow. Isolated pools and backwaters produced the highest silvery minnow CPUE indices in all three reaches.

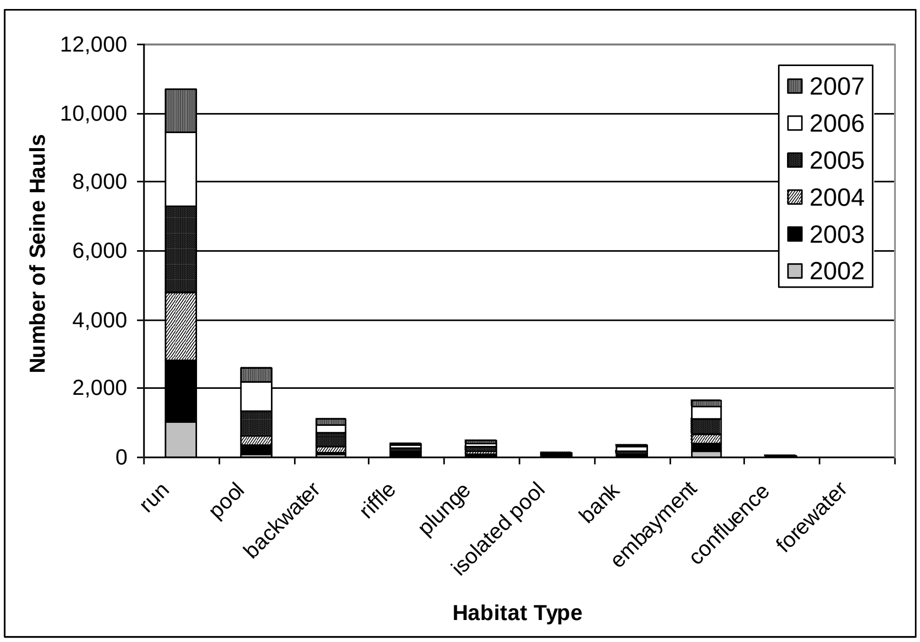


Figure 4.19. Cumulative number of seine hauls collected by the USFWS by habitat type, 2002–2007. Dataset: USFWS-05.+rgsmMonitoringData_Dec2007 +forGoodman.xls.

Table 4.13. Comparison of Seine Samples by Habitat and Reach with Proportions of Samples and Mean CPUE and Standard Error for Silvery Minnow, 2002–2007

Reach and Metric	Habitat Types											
	Run	Pool	Backwater	Riffle	Plunge	Isolated Pool	Bank	Embayment	Confluence	Forewater	Undefined	Total
Albuquerque												
No. Samples	8,241	1,530	761	370	323	65	244	1,131	25	1	9	12,700
Percent of Total	65%	12%	6%	3%	3%	1%	2%	9%	0%	0%	0%	100%
Mean CPUE	3.97	14.52	89.07	2.43	10.40	312.12	3.94	16.66	0.74	0.00	10.19	13.16
Standard Error	0.54	2.87	19.43	0.61	5.65	276.25	1.65	2.75	0.56	NC	10.19	1.93
Isleta												
No. Samples	2,324	1,007	321	41	171	47	97	496	1	0	0	4,505
Percent of Total	52%	22%	7%	1%	4%	1%	2%	11%	0%	0%	0%	100%
Mean CPUE	25.98	46.43	180.14	37.82	62.08	532.80	4.01	64.39	666.67	0.00	0.00	52.20
Standard Error	7.17	9.16	62.77	28.24	36.76	209.31	1.22	19.34	NC	NC	NC	7.07
San Acacia												
No. Samples	147	61	16	5	5	0	4	22	0	0	0	260
Percent of Total	57%	23%	6%	2%	2%	0%	2%	8%	0%	0%	0%	100%
Mean CPUE	5.73	26.09	150.81	0.00	12.32	0.00	2.91	127.48	0.00	0.00	29.71	0.00
Standard Error	1.93	19.44	75.12	0.00	10.62	NC	2.04	78.34	NC	NC	NC	9.59

Note: Percentages may not sum exactly due to rounding.
NC = Not Calculated; Dataset: USFWS-05.+rgsmMonitoringData_Dec2007+forGoodman.xls.

4.3.5 STATISTICAL POWER OF SAMPLING GEARS AND METHODS

Descriptive Statistics—Descriptive statistics by reach and year for all samples for seine CPUE of silvery minnow are presented in Table 4.14. This table characterizes the fundamental statistical properties of this dataset and lays the groundwork for the types of analyses that are possible with these data, as well as to provide an initial assessment of data precision.

Numbers of samples, mean CPUE, and 95% C.I. are presented and further described in other sections of this analysis. A prominent feature of these data is the lack of normality (i.e., individual observations are not normally distributed around the mean), as indicated by low Shapiro-Wilk statistics and p-values ≤ 0.05 (i.e., distribution is significantly different from a normal distribution). Non-normally distributed data require non-parametric statistics.

Mean Catch Rate by Year—Mean annual CPUE and 95% C.I. for the silvery minnow by reach from 2002 to 2007 are presented in Figure 4.20. Catch rate of silvery minnow was highest in 2005 and 2007.

Mean Catch Rate by Habitat—The highest catch rate of age-0 silvery minnow occurred in pools and backwaters (Figure 4.21, top), while the highest catch rates for age-1 and age-2 silvery minnow occurred in backwater and plunge habitats (Figure 4.21, bottom). While catch rates appear to vary somewhat among months and among age groups, slow-water habitat types had the highest catch rate for both age-0 and age-1+ silvery minnow year-round (Kruskal-Wallis one-way ANOVA $p = <0.0001$; Table 4.15 and Table 4.16). For most months, habitats with the highest catch rates were backwaters, pools, and isolated pools.

Pairwise comparisons reveal that CPUE did not differ between backwater, pool, and isolated pool habitats (Table 4.17). Significant differences were predominantly found between slow and faster water mesohabitats, such as riffle and isolated pool and run and pool habitats. Small sample sizes for confluence and forewater habitats precluded meaningful comparisons to other habitat types.

Because this assessment deals with properties of gears and methods and not with interpretation of habitat use patterns, an in-depth interpretation of differences in mean CPUE by habitat is not pursued.

Table 4.14. Descriptive Statistics by Reach and Year for All Samples for Seine CPUE (fish/100 m^2) of Silvery Minnow

Statistic	2002	2003	2004	2005	2006	2007
Albuquerque						
Number of Samples	1,538	2,518	2,592	2,502	1,975	1,575
Arithmetic Mean	0.16	2.46	7.26	34.27	6.91	26.99
Standard Error	0.05	1.40	1.78	7.84	1.69	8.22
Lower 95% C.I.	0.06	-0.29	3.77	18.90	3.59	10.88
Upper 95% C.I.	0.27	5.21	10.76	49.65	10.23	43.11
CV	0.33	0.57	0.25	0.23	0.25	0.30
Shapiro-Wilk Statistic	0.05	0.01	0.05	0.05	0.06	0.05
Shapiro-Wilk *p*-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Isleta						
Number of Samples	0	0	345	1,794	1,733	633
Arithmetic Mean	NC	NC	8.17	81.06	31.87	50.08
Standard Error	NC	NC	2.60	13.41	10.82	14.12
Lower 95% C.I.	NC	NC	3.06	54.75	10.65	22.37
Upper 95% C.I.	NC	NC	13.28	107.36	53.09	77.80
CV	NC	NC	0.32	0.17	0.34	0.28
Shapiro-Wilk Statistic	NC	NC	0.15	0.11	0.04	0.11
Shapiro-Wilk *p*-value	NC	NC	<0.001	<0.001	<0.001	<0.001
San Acacia						
Number of Samples	0	0	NC	80	180	0
Arithmetic Mean	NC	NC	0.00	94.46	0.93	NC
Standard Error	NC	NC	0.00	30.05	0.31	NC
Lower 95% C.I.	NC	NC	0.00	34.65	0.32	NC
Upper 95% C.I.	NC	NC	0.00	154.26	1.54	NC
CV	NC	NC	NC	0.32	0.33	NC
Shapiro-Wilk Statistic	NC	NC	NC	0.39	0.23	NC
Shapiro-Wilk *p*-value	NC	NC	NC	<0.001	<0.001	NC

NC = Not Calculated; Dataset: USFWS-05.+rgsmMonitoringData_Dec2007+forGoodman.xls.

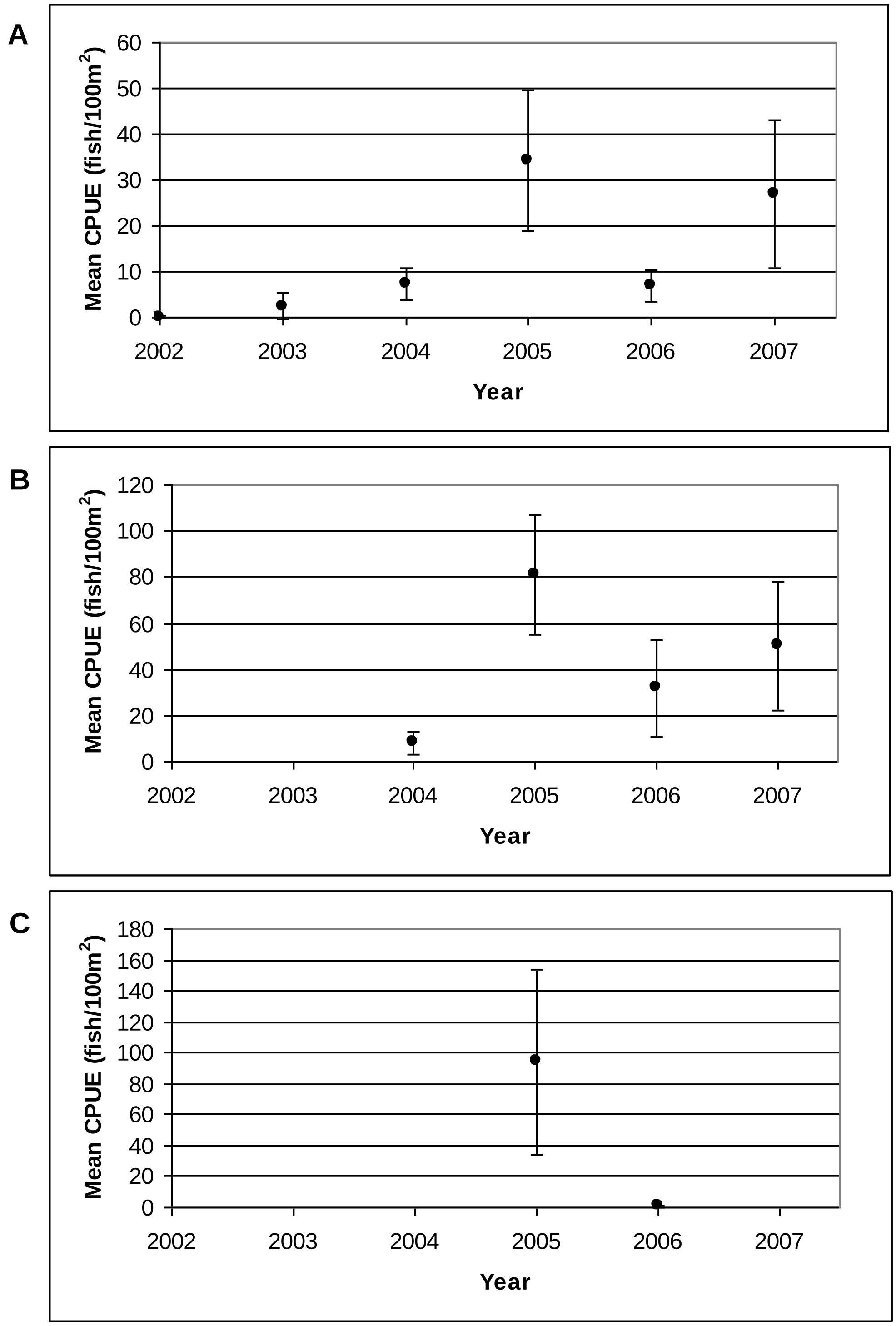
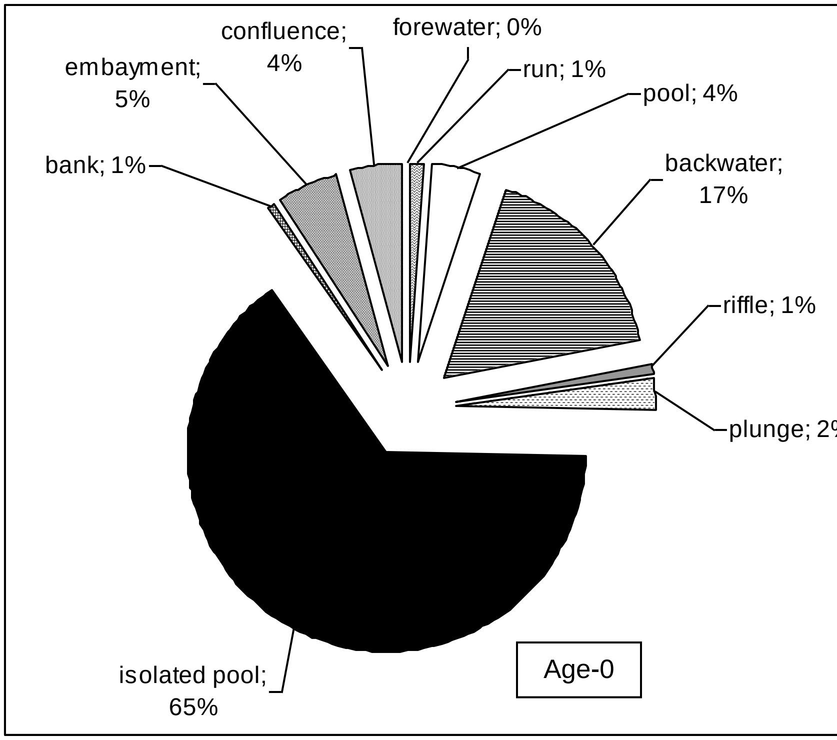


Figure 4.20. Mean CPUE of silvery minnow seine monitoring data in (A) the Albuquerque Reach (N = 12,700), (B) the Isleta Reach (N = 4,505), and (C) the San Acacia Reach (N = 260), 2002–2007. Dataset: USFWS-05.+rgsmMonitoringData_ Dec2007+forGoodman.xls.



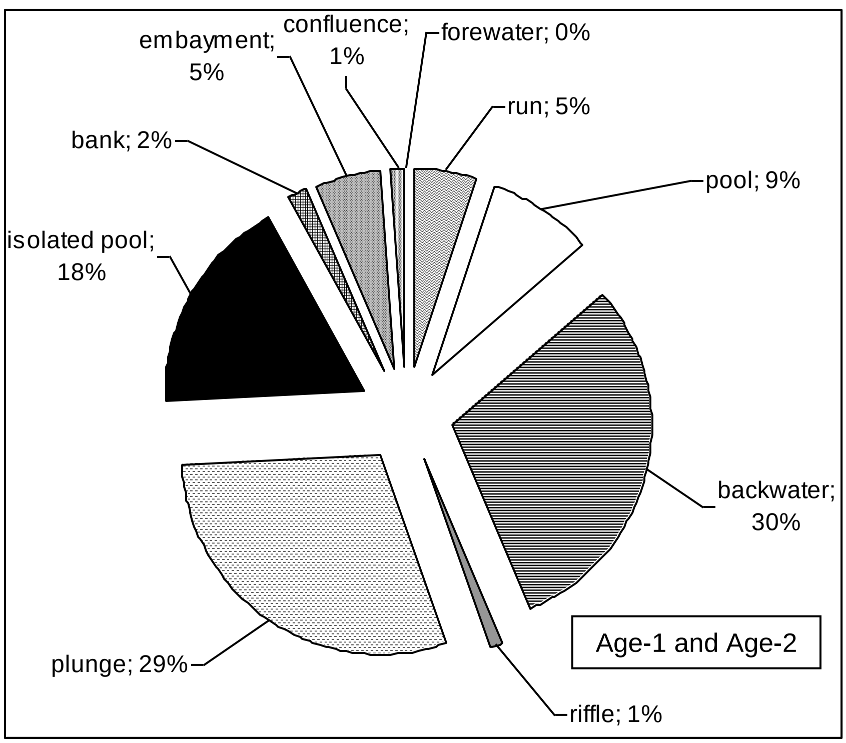


Figure 4.21. Percentage of the young-of-year (top) and adult (bottom) silvery minnow catch (CPUE) by habitat type in samples. Dataset: USFWS-05.+rgsmMonitoringData_ Dec2007+forGoodman.xls.

Table 4.15. Relative Abundance of Age-0 Silvery Minnow by Habitat Type for Each Month Based on Mean CPUE for All Sites from Data collected 2002–2007

Habitat Type	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Run	4.36%	0.80%	1.08%	100.00%	NC	1.00%	1.43%	4.73%	2.81%	0.76%	1.82%	0.03%
Pool	4.32%	26.95%	87.47%	0.00%	NC	9.26%	5.55%	9.62%	7.81%	0.79%	5.54%	0.10%
Backwater	84.35%	72.00%	7.18%	0.00%	NC	69.20%	19.53%	34.42%	39.72%	9.84%	73.13%	2.01%
Riffle	1.77%	0.00%	0.00%	0.00%	NC	1.68%	1.46%	3.06%	2.25%	0.77%	0.48%	0.00%
Plunge	0.39%	0.00%	2.51%	0.00%	NC	2.15%	5.56%	2.39%	3.67%	0.52%	0.39%	0.03%
Isolated Pool	0.00%	0.00%	0.00%	0.00%	NC	4.29%	58.31%	37.09%	25.03%	19.72%	0.00%	97.48%
Bank	0.00%	0.19%	0.38%	0.00%	NC	0.96%	0.88%	1.57%	0.27%	0.31%	1.11%	0.10%
Embayment	4.80%	0.07%	1.40%	0.00%	NC	11.46%	7.28%	7.12%	18.44%	2.77%	17.52%	0.21%
Confluence	0.00%	0.00%	0.00%	0.00%	NC	0.00%	0.00%	0.00%	0.00%	64.53%	0.00%	0.04%
Forewater	0.00%	0.00%	0.00%	0.00%	NC	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Totals	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**NC**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Note: Percentages may not sum exactly due to rounding. Habitat types containing more than 10% of the catch in a month are shaded.
NC is not collected. Dataset: USFWS-05.+rgsmMonitoringData_Dec2007+forGoodman.xls.

Table 4.16. Relative Abundance of Age-1 and Age-2 Silvery Minnow by Habitat Type for Each Month Based on Mean CPUE for All Sites from Data Collected 2002–2007

Habitat Type	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Run	2.72%	10.81%	1.48%	4.29%	4.11%	9.92%	6.62%	0.95%	24.02%	6.01%	4.60%	0.17%
Pool	0.22%	7.61%	3.88%	8.31%	48.51%	25.03%	20.75%	9.60%	9.89%	14.07%	14.13%	0.38%
Backwater	29.01%	39.21%	80.21%	14.38%	8.03%	13.26%	21.02%	19.96%	0.00%	50.80%	47.84%	2.71%
Riffle	0.00%	0.00%	1.75%	0.00%	8.72%	22.95%	11.65%	6.65%	0.00%	0.00%	0.00%	0.00%
Plunge	0.00%	2.43%	2.69%	63.39%	6.17%	5.45%	18.41%	7.78%	0.00%	18.01%	0.00%	0.00%
Isolated Pool	53.30%	0.00%	3.82%	7.85%	0.00%	0.00%	0.00%	2.99%	0.00%	0.00%	0.00%	96.32%
Bank	0.22%	2.15%	2.18%	0.23%	2.10%	2.41%	4.14%	40.78%	0.00%	0.00%	15.83%	0.00%
Embayment	14.54%	6.34%	3.98%	1.54%	22.35%	20.98%	17.42%	11.30%	66.09%	11.10%	17.60%	0.41%
Confluence	0.00%	31.44%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Forewater	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Totals	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Note: Percentages may not sum exactly due to rounding. Habitat types containing more than 10% of the catch in a month are shaded.
Dataset: USFWS- 05.+rgsmMonitoringData_Dec2007+forGoodman.xls.

Table 4.17. Mann-Whitney Test Pairwise Comparisons of Silvery Minnow CPUE between Sampled Mesohabitat Types from Data Collected 2002–2007

Mesohabitat	Run	Pool	Backwater	Riffle	Plunge	Isolated Pool	Bank	Embayment
Pool	<0.001	–	–	–	–	–	–	–
Backwater	<0.001	1.000	–	–	–	–	–	–
Riffle	1.000	1.000	0.744	–	–	–	–	–
Plunge	1.000	0.399	0.048	1.000	–	–	–	–
Isolated Pool	<0.0001	0.103	1.000	0.003	0.001	–	–	–
Bank	1.000	1.000	0.640	1.000	1.000	0.005	–	–
Embayment	<0.001	1.000	1.00	0.932	0.060	0.117	0.660	–
Confluence	1.000	1.000	1.00	1.000	1.000	1.000	1.000	1.000

Note: p-values are Bonferroni adjusted. Significant differences (α = 0.05) are shaded.
Dataset: USFWS-05.+rgsmMonitoringData_Dec2007+forGoodman.xls.

Effect of Sample Size on Precision—The effect of sample size on mean CPUE and 95% C.I., CV, and percent detectable change was evaluated with bootstrapping (resampling from original sample set and 1,000 iterations for each of various sample sizes) for the three reaches for available sampling data between 2002 and 2007. Even though this dataset was not collected for the purpose of population monitoring, this analysis was conducted to permit comparisons between precision of CPUE data that were composite for a site (i.e., Datasets 1 and 2) and precision of CPUE data that were recorded separately from each distinct mesohabitat sampled (Dataset 3). For the purpose of these analyses, every sample (i.e., individual seine haul) was assumed to be independent.

If these data were used to track population size through time, greater sample sizes would be required to an acceptable level of precision. For the Albuquerque and Isleta reaches, more than 5,000 samples (individual seine hauls) would be necessary to achieve an arbitrarily selected set of criteria, i.e., 95% C.I. ≤ 20% of the mean, CV ≤ 0.10, and ≤ 35% detectable change in mean CPUE (Figure 4.22). For the San Acacia Reach, more that 4,000 samples would be necessary to achieve those same criteria (Figure 4.23). In the Albuquerque Reach, between 1,538 and 2,592 samples were collected between 2002 and 2007. In the Isleta Reach, 345 to 1,794 samples were collected; between 80 and 180 samples were collected in the San Acacia Reach.

When evaluated on an annual basis, effect of samples size on percent detectable change and CV for mean CPUE is evident in Figure 4.24 to Figure 4.26. Bootstrap simulations show that increasing sample size improves percent detectable change and CV, but the number of samples necessary for acceptable precision in the Albuquerque and Isleta reaches exceeds 8,000 (Table 4.18; Figure B.1–Figure B.12 in Appendix B). In the San Acacia Reach, approximately 1,500 samples would be necessary for the same precision (see Table 4.18; Figure B.1–Figure B.12 in Appendix B). However, these numbers should be interpreted cautiously because these data were not collected for the purpose of abundance monitoring.

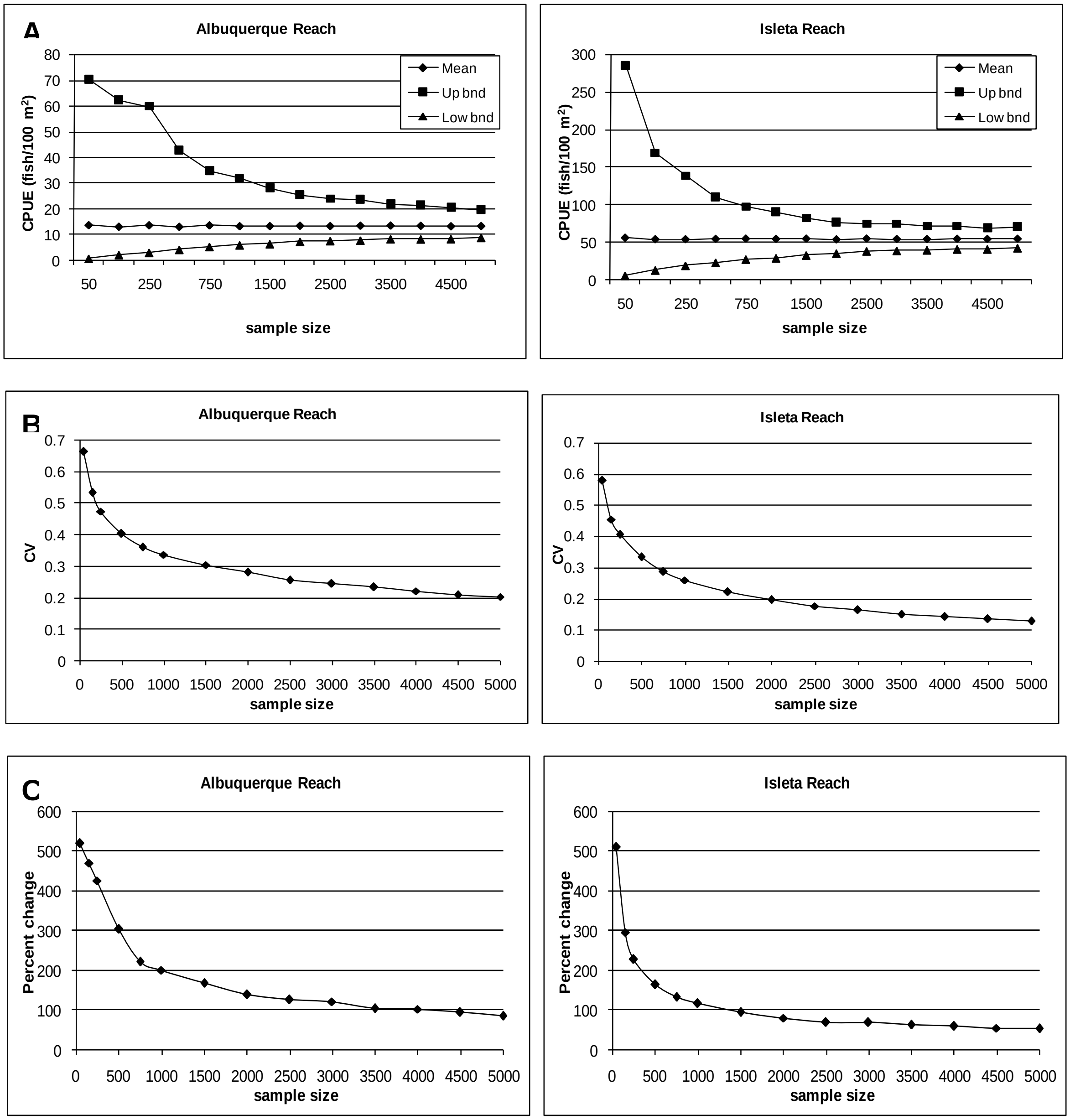


Figure 4.22. The effect of seine sample size for all samples on (A) mean CPUE and 95% C.I., (B) CV, and (C) percent detectable change by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach (2002–2007) and the Isleta Reach (2004–2007). Dataset: USFWS-05.+rgsmMonitoringData_Dec2007 +forGoodman.xls.

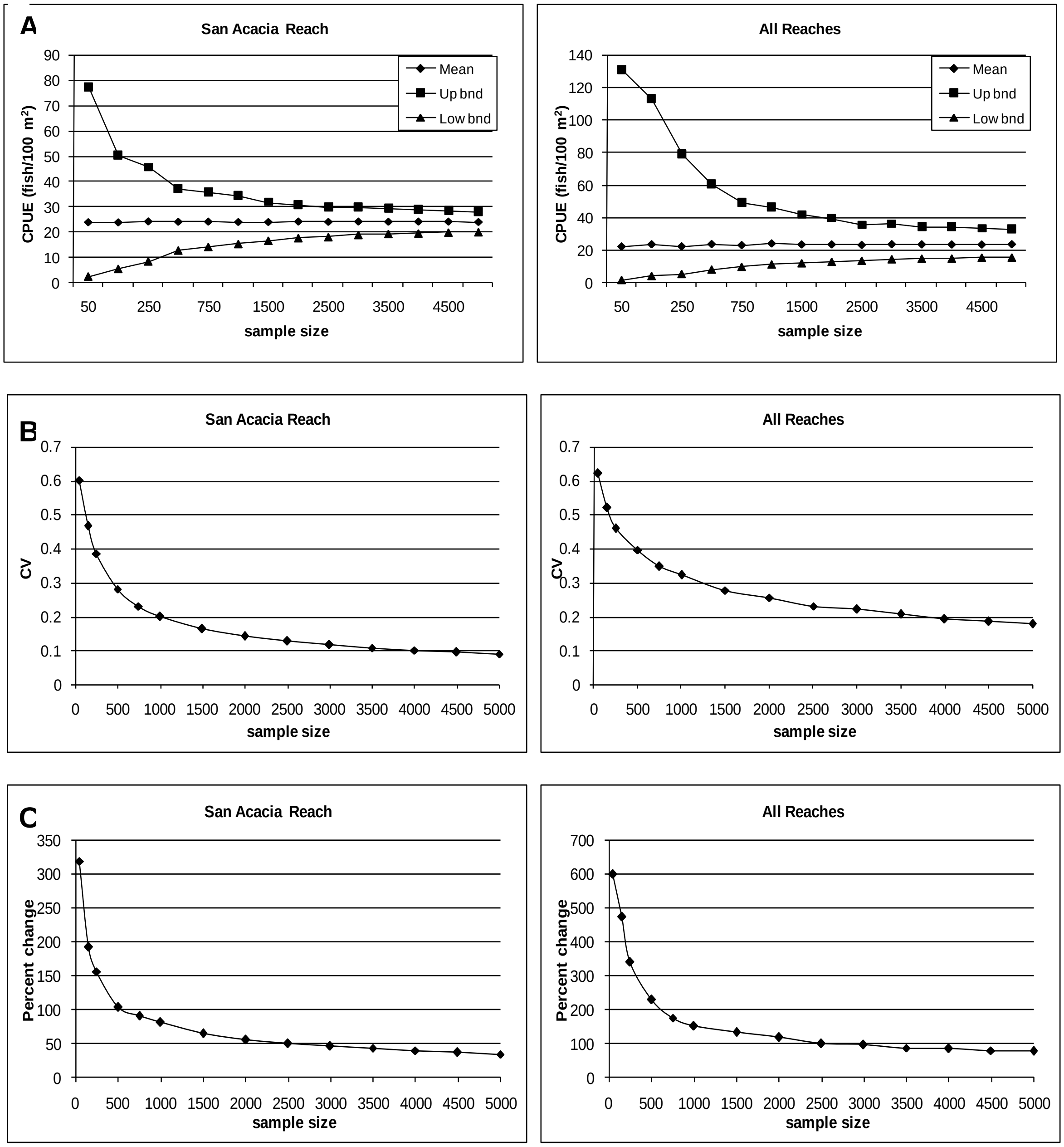


Figure 4.23. The effect of seine sample size for all samples on (A) mean CPUE and 95% C.I., (B) CV, and (C) percent detectable change by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach (2005–2006) and for all reaches (2002–2007). Dataset: USFWS-05.+rgsmMonitoringData_Dec2007 +forGoodman.xls.

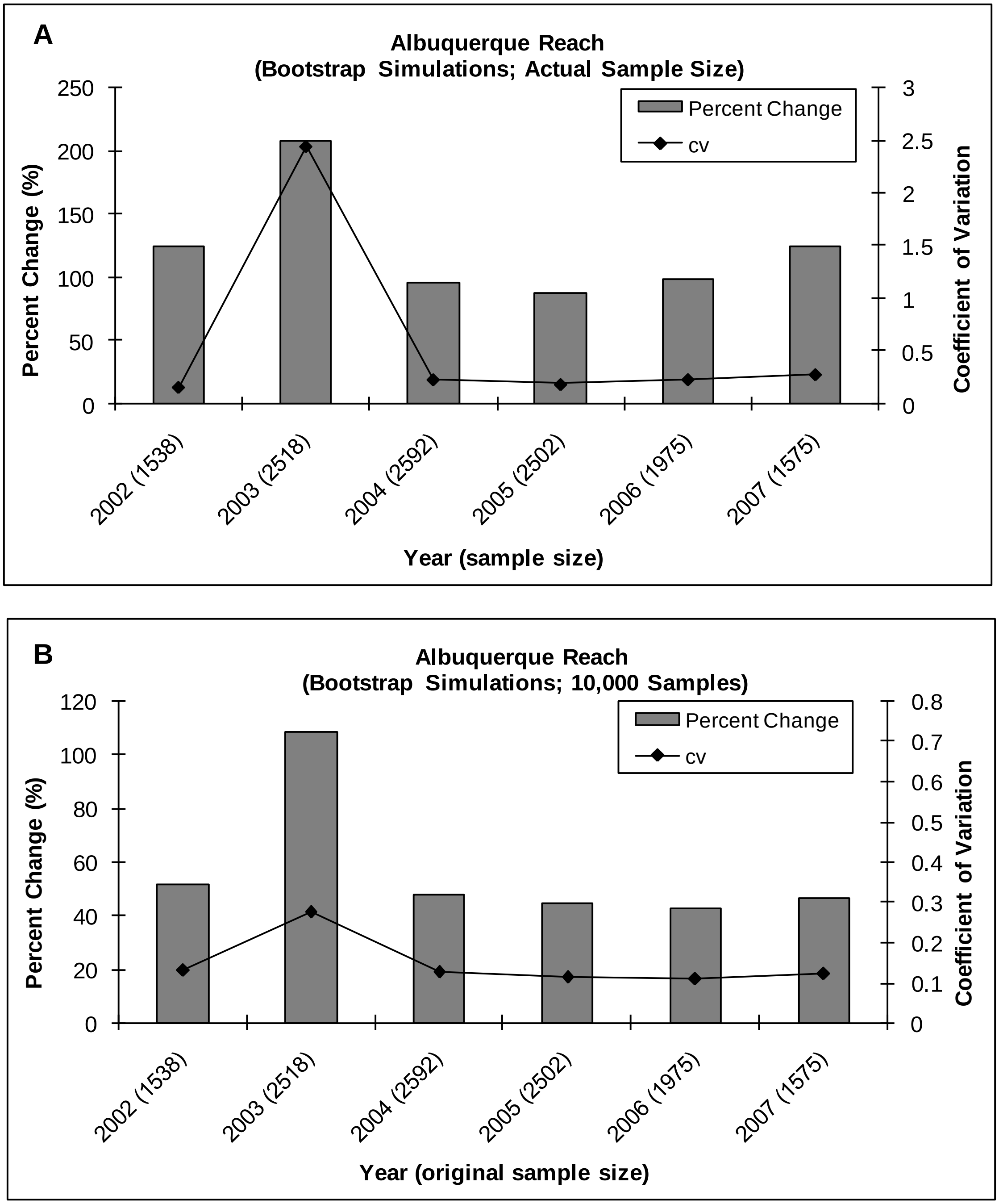
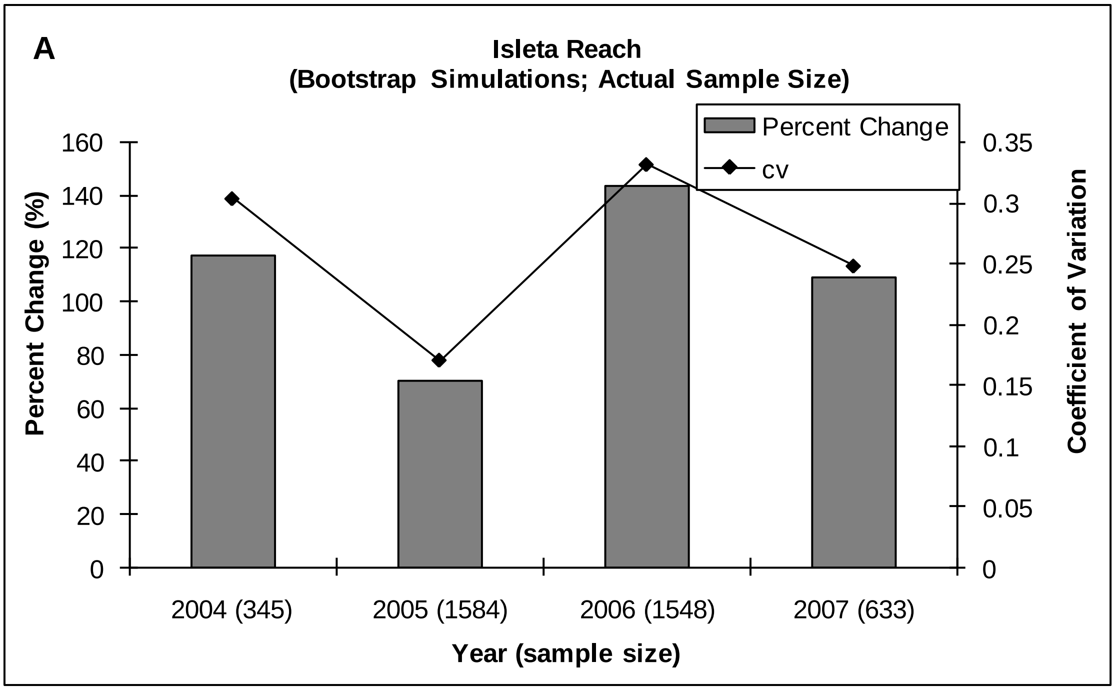


Figure 4.24. Percent detectable change for all samples by year and CV for (A) mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 10,000 samples in the Albuquerque Reach, 2002–2007. Dataset: USFWS-05.+rgsmMonitoringData_Dec2007+forGoodman.xls.



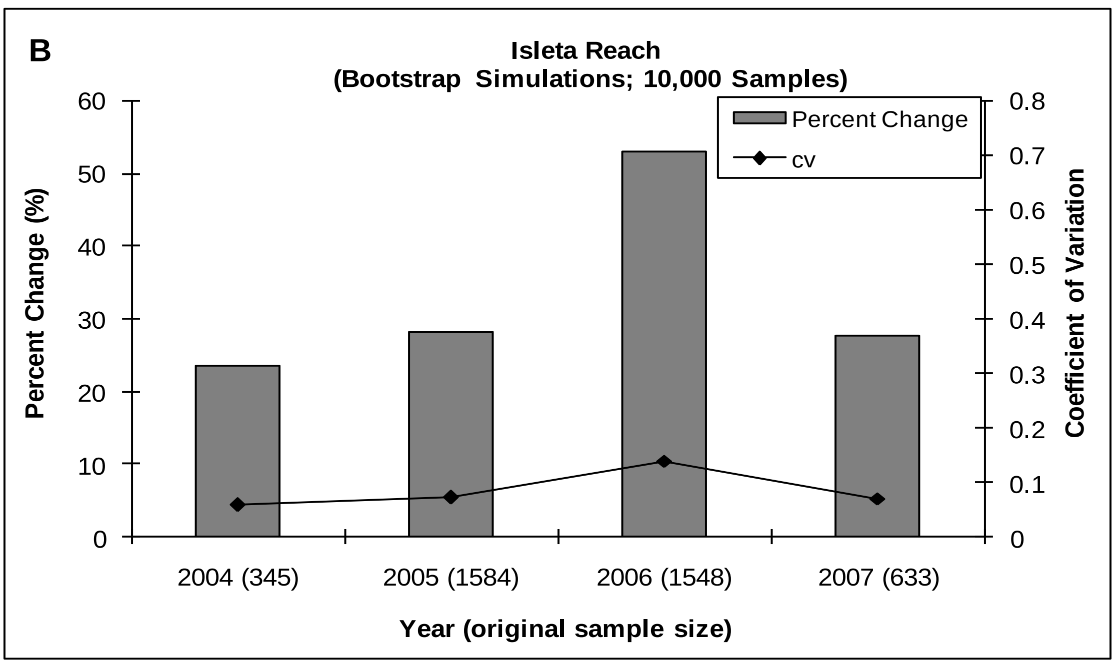


Figure 4.25. Percent detectable change for all samples by year and CV for (A) mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 10,000 samples in the Isleta Reach, 2004–2007. Dataset: USFWS-05.+rgsmMonitoringData_Dec2007 +forGoodman.xls.

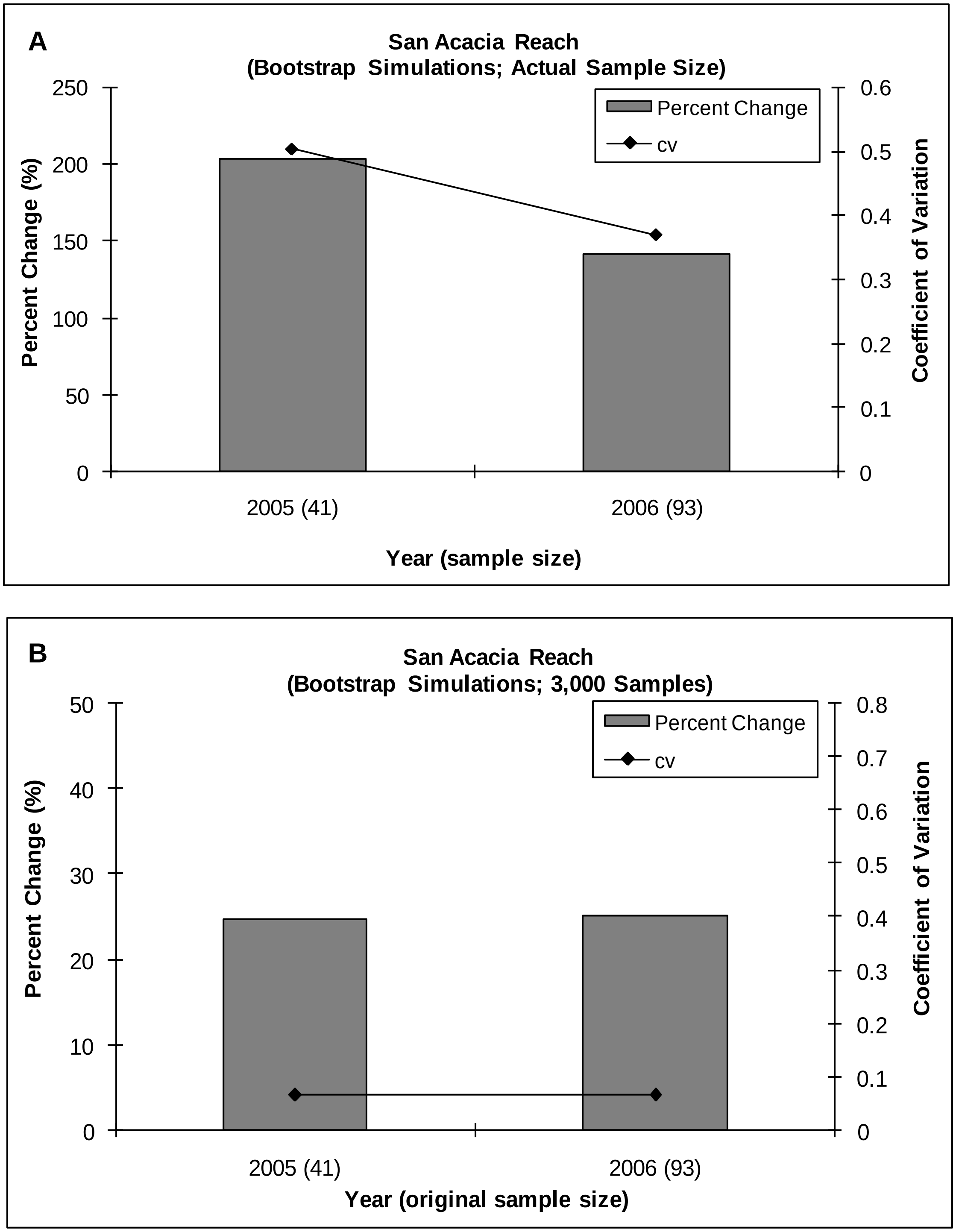


Figure 4.26. Percent detectable change for all samples by year and CV for (A) mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 3,000 samples in the San Acacia Reach, 2005–2006. Dataset: USFWS-05.+rgsmMonitoringData_Dec2007 +forGoodman.xls.

Table 4.18. Numbers of Seine Samples Necessary to Meet Three Criteria for Each Reach

Year	Sample Size	Mean CPUE	Number of Samples		
			95% CI = 20%	CV = 0.10	35% Change
Albuquerque					
2002	1,538	0.16	15,000	15,000	20,000
2003	2,518	2.46	>20,000	>20,000	>20,000
2004	2,592	7.26	15,000	15,000	17,000
2005	2,502	34.27	15,000	10,000	17,000
2006	1,975	6.91	12,500	10,000	12,500
2007	1,575	26.99	15,000	12,500	17,000
Means	–	–	15,417	8,917	17,250
Isleta					
2004	345	8.17	2,750	3,000	4,000
2005	1,794	81.06	7,500	5,000	4,500
2006	1,733	31.87	20,000	17,500	17,500
2007	633	50.08	4,500	4,500	6,000
Means	–	–	8,688	7,500	8,000
San Acacia					
2005	80	94.46	1,300	1,300	900
2006	180	0.93	1,300	1,250	1,500
Means	–	–	1,300	1,275	1,200

Note: Data based on bootstrap simulations of sample size by year; 95% CI = 20% of mean, CV = 0.10, 35% change in mean CPUE is detectable. Table represents a summary of Figure B.1–Figure B.12 in Appendix B.

4.4 DATASETS 4 TO 14

4. SWCA-SWCA-LosLunas_MainChannel_Seine_2009.mdb
5. SWCA-13199 Nurs Hab Data.xls
6. SWCA-BOR_Floodplain_08_MDH.mdb
7. SWCA-Embayment Monitoring Database 2006.xls
8. SWCA-ISC_HR_Monitor_08_and_09.mdb
9. SWCA-Los_Lunas_Floodplain_2008.mdb
10. SWCA-Los Lunas_FloodPlain_2009.mdb
11. SWCA-LosLunas_MainChannel_Seine_2009.mdb
12. SWCA-LWD queries.xls
13. SWCA-LWD_species_log_electric_database.xls
14. SWCA-RGSM_Data_by Site_Update.xls

4.4.1 RELEVANT REPORTS

Fluder and Hayes (2005), Fluder et al. (2008), Hatch and Gonzales (2008, 2009), Gonzales and Hatch (2009)

4.4.2 STUDY OBJECTIVES

- Evaluate silvery minnow use of habitat restoration sites.
- Describe movement of silvery minnow to and from floodplains.

4.4.3 STATISTICAL POWER OF SAMPLING GEARS AND METHODS

Effect of Mesohabitat—The effect of mesohabitats on numbers of fish caught by species and capture rates of silvery minnow was evaluated for seining data. A total of 1,672 fish, representing 10 species, was collected in main channel surveys with seines (Table 4.19). Red shiner and silvery minnow were the most abundant species, comprising 67% and 15% of the total catch, respectively. Western mosquitofish (*Gambusia affinis*) and fathead minnow (*Pimephales promelas*) comprised 8% and 6%, respectively, and common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), flathead chub (*Platygobio gracilis*), river carpsucker (*Carpiodes carpio*), white crappie (*Pomoxis annularis*), and yellow perch (*Perca flavescens*) each comprised less than 1% of the total catch.

During main channel surveys, a total area of 17,681 m^2 (190,317 square feet) was sampled from accessible mesohabitats (Table 4.20). Shallow runs/riffles, main channel runs, eddies, and backwaters were the most abundant mesohabitats with 38%, 26%, 20%, and 15%, respectively, of total area. Pools represented only 2% of the area.

A total of 259 silvery minnow was collected from main channel habitats (see Table 4.20). Of this total, 170 (65%) were collected on November 21, 2008, and the majority were found in eddy habitats. Silvery minnow CPUE did not differ among sampling dates (Kruskal-Wallis one-way ANOVA; p = 0.7346) but did differ among main channel, shallow run/riffle, and eddy mesohabitats (Kruskal-Wallis one-way ANOVA; p = 0.008). Mean silvery minnow CPUE ranged from 0.87 to 45.3 fish/100 m^2 among sampling dates and 0.31 to 36.09 fish/100 m^2 among mesohabitat types. The highest single-day CPUE values were in eddy (168.5 fish/100 m^2), pool (11.03 fish/100 m^2), and backwater (10.07 fish/100 m^2) habitats, while the lowest CPUE values were observed in main channel run habitats (0.00 fish/100 m^2) on November 21, 2008.

A chi-square test of homogeneity and independence compared silvery minnow CPUE with percent area of mesohabitat type (Table 4.21). The overall chi-square of 66.36 and $p < 0.001$ (degrees of freedom = 4) shows a positive association between CPUE and mesohabitat types.

Table 4.19. Fish Species Collected from the Main Channel with Seines in 2009

Common Name	Scientific Name	Number Sampled	Percent Composition
Red shiner	*Cyprinella lutrensis*	1,120	66.99
Rio Grande silvery minnow	*Hybognathus amarus*	259	15.49
Western mosquitofish	*Gambusia affinis*	139	8.31
Fathead minnow	*Pimephales promelas*	106	6.34
Common carp	*Cyprinus carpio*	16	0.96
Channel catfish	*Ictalurus punctatus*	13	0.78
Flathead chub	*Platygobio gracilis*	9	0.54
River carpsucker	*Carpiodes carpio*	8	0.48
White crappie	*Pomoxis annularis*	1	0.06
Yellow perch	*Perca flavescens*	1	0.06
	Totals	1,672	100.00

Note: Percentages may not sum exactly due to rounding.
Dataset: SWCA-LosLunas_MainChannel_Seine_2009.mdb.

Table 4.20. Numbers of Silvery Minnow and CPUE (fish/100 m^2) and Area Seined (m^2) by Mesohabitat and Date during Main Channel Seine Surveys

Date	Backwater	Eddy	Main Channel Run	Pool	Shallow Run/Riffle	Total
Numbers of Silvery Minnow						
10/31/08	37	3	1	NA	2	43
11/21/08	NA	156	2	8	4	170
12/19/08	NA	1	0	NA	9	10
1/27/09	NA	2	1	NA	9	12
2/19/09	NA	9	2	NA	13	24
Total	37	171	6	8	37	259
CPUE of Silvery Minnow						
10/31/08	10.07	1.82	0.16	NA	0.55	3.15
11/21/08	NA	168.65	0.53	11.03	1.00	45.30
12/19/08	NA	0.93	0.00	NA	2.48	1.14
1/27/09	NA	0.89	0.35	NA	1.36	0.87
2/19/09	NA	8.18	0.50	NA	1.32	3.33
Mean	10.07	36.09	0.31	11.03	1.34	10.76
Standard Error	NA	33.17	0.10	NA	0.32	8.65
Area of Mesohabitat						
10/31/08	2,573	990	2,470	NA	1,450	7,483
11/21/08	NA	555	750	363	1,600	3,268
12/19/08	NA	860	313	NA	363	1,535
1/27/09	NA	900	575	NA	1,325	2,800
2/19/09	NA	220	400	NA	1,975	2,595
Total	2,573	3,525	4,508	363	6,713	17,681
Percent	14.55	19.94	25.50	2.05	38.00	100

NA = Not Applicable.
Dataset: SWCA-LosLunas_MainChannel_Seine_2009.mdb.

Table 4.21. Chi-square Test of Homogeneity and Independence for Comparison of Silvery Minnow CPUE and Percent Area of Mesohabitat

Statistic	Backwater	Eddy	Main Channel Run	Pool	Shallow Run/Riffle
Mean CPUE	10.07	36.09	0.31	11.03	1.34
Chi-square Expected	8.92	20.45	9.29	4.83	14.50
Cell Chi-square	0.13	11.83	9.29	7.87	12.57
Percent Mesohabitat	14.55	19.94	25.50	2.05	38.00
Chi-Square Expected	15.08	34.55	15.71	8.17	24.50
Cell Chi-square	0.08	7.00	5.50	4.66	7.44

Overall chi-square = 66.36, $p < 0.001$, degrees of freedom = 4.
Dataset: SWCA-LosLunas_MainChannel_Seine_2009.mdb.

Effect of Gear Type on Capture Efficiency—Capture efficiency was compared for seines and fyke nets to evaluate which gear type sampled silvery minnow most effectively. A simple approach is to compare indices calculated from data collected using two different gear types at approximately the same time and location so they can be assumed to be sampling the same fish population and assemblage (Peterson and Paukert 2009). During floodplain monitoring seine hauls were collected from the Los Lunas habitat restoration site concurrent with fyke net samples. Indices of abundance for each sample date and gear type (i.e., fish/m^2 for seines and fish/hour with fyke nets) were calculated and compared. Linear regression of the two indices of silvery minnow abundance indicates a general agreement in absolute trends of daily fluctuations in abundance (Figure 4.27). Despite the general daily agreement, average rate of silvery minnow catch in fyke nets was 70 times higher than catch rate with seines. The calculated fishing power coefficient indicates that the fyke net CPUE index (silvery minnow/hour) was on average 9.0 times higher (standard error = 1.5) than comparable seine CPUE (silvery minnow/100 m^2) values.

The noted disparity in sampling efficiency between fyke nets and seining is probably a consequence of the heightened existence of hazards in floodplain habitats, such as uneven ground, emergent plants, and organic debris. Relative to seining, fyke nets are less affected by these limitations because they operate passively. However, fyke nets and other sampling methods have their own set of limitations that govern their utility in gathering samples that would allow researchers/managers to discriminate among competing hypotheses about system behavior.

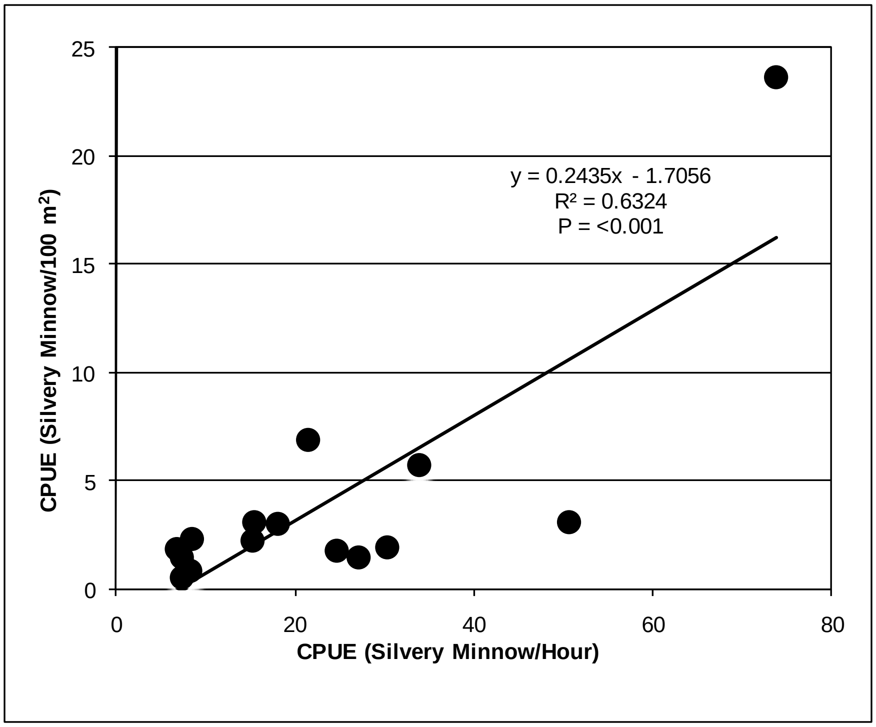


Figure 4.27. Relationship between indices of abundance for fyke nets (silvery minnow/hour) and seines (silvery minnow/100 m²) during floodplain monitoring at Los Lunas, 2008. Dataset: SWCA-Los_Lunas_Floodplain_ 2008.mdb.

4.5 DATASETS 15 TO 22

15. USBR-BOR Data_2.mdb
16. USBR-fish_collection-2001.xls
17. USBR-fish_collection-2002.xls
18. USBR-fish_collection-2003.xls
19. USBR-fish_collection-2004.xls
20. USBR-fish_collection-2005.xls
21. USBR-fish_collection-2006.xls
22. USBR-fish_collection-2007.xls

4.5.1 RELEVANT REPORTS

Porter and Massong (2003, 2004), Porter and Dean (2004, 2005, 2006, 2007), Porter et al. (2004)

4.5.2 STUDY OBJECTIVES

- Conduct fish community surveys on the Rio Grande to document trends in fish community structure, evaluate the effects of river maintenance and water operations, and perform other project-related commitments.

4.5.3 DOCUMENTATION OF SAMPLING GEARS AND METHODS

Surveys were conducted by Reclamation biologists within three study reaches of the Middle Rio Grande and portions of the Low Flow Conveyance Channel (LFCC). Within each reach, a varying number of electrofishing passes were conducted at sites selected from previous studies and new sites where monitoring was required. Surveys included a range of habitat types, including natural (defined as not altered), backwater, riprap, and jetty areas. A Smith-Root backpack electrofisher was used for fish surveys in the LFCC. A Smith-Root 1.5-kV pulsed-DC electrofishing system was used to sample designated passes along the study reaches. The electrofishing unit was mounted on a raft with two sphere anodes and adjusted to produce 2.0 to 3.5 amps at 30 pulses per second for sampling in reaches with flows of 400 cfs. Water conductance varied from 300 to 600 mS/cm upstream to downstream. Sampling effort was measured as seconds of electricity applied. For the purposes of this analysis, a single sample was defined as a single continuous electrofishing run at a site. Sampling effort (i.e., seconds electrofished) varied among samples, so catch rate was standardized as fish collected per minutes or per hour of electricity. The Smith-Root pulsed-DC electrofishing system was also mounted on an Argo ATV replacing the spherical anodes with a pair of wands with anode fykes. The ATV facilitated sampling in 100- to 200-cfs flows where the river channel was wider with shallow water (mean depth < 0.5 m [1.2 feet]). Two technicians walked beside the ATV, sweeping the water area with the wands. Two additional technicians netted the electro-anesthetized fish.

4.5.4 SAMPLING EFFORT FOR GEARS AND METHODS

The numbers of samples with an associated measure of effort (electrofishing seconds) increased from about 20 per year to 74 per year in the Albuquerque, Isleta, and San Acacia reaches combined, with the largest numbers of samples collected in the Albuquerque Reach in 2005 and 2007 (Figure 4.28). Additional samples were collected in the Cochiti Reach. Approximately equal amounts of effort were applied in the Albuquerque and San Acacia reaches over time, roughly double that applied in the Isleta Reach. The average time electrofished per sample was relatively consistent over time (5–10 minutes), except for 2003, which had longer sample times (approximately 20 minutes). Accordingly, the total sampling effort per reach tracks closely with the number of samples collected in each reach. This analysis shows that the numbers of electrofishing samples by year were generally not evenly distributed among reaches.

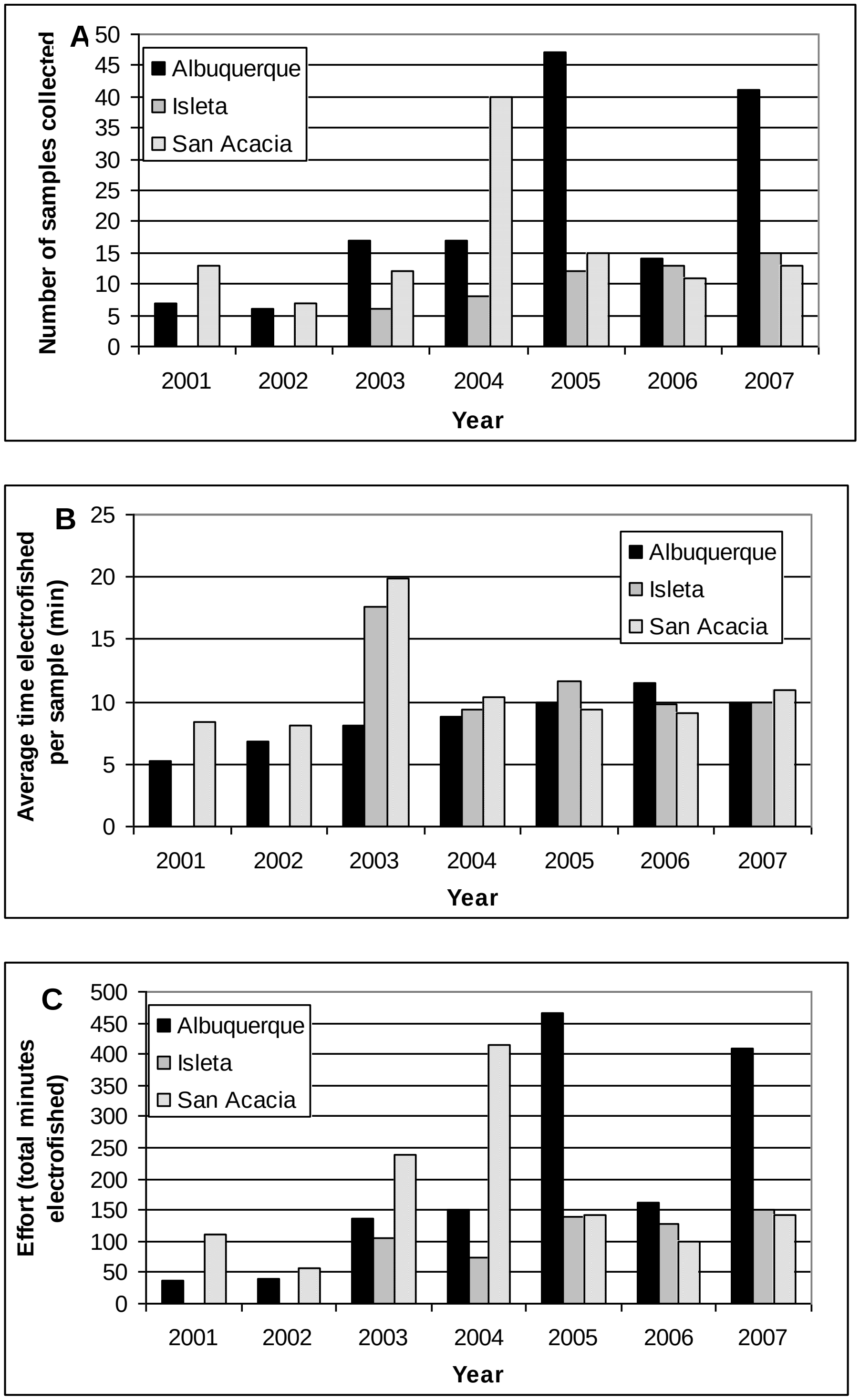


Figure 4.28. (A) Number of electrofishing samples collected, (B) average time electrofished per sample, and (C) total time electrofished by reach and year for samples where effort was recorded.

4.5.5 STATISTICAL POWER OF SAMPLING GEARS AND METHODS

CPUE—Twenty-six fish species were reported with electrofishing during 2001 to 2007 in the Cochiti, Albuquerque, Isleta, and San Acacia reaches (Table 4.22). The six most abundant species were silvery minnow, common carp, channel catfish, river carpsucker, white sucker (*Catostomus commersonii*), and red shiner. These species comprised 89% of the total mean catch rate for all species in all years, and the remaining 20 species comprised 11% of total mean catch rate (Figure 4.29). Although the precision of mean CPUE for these data is low, the data reveal patterns that may be improved with sample size.

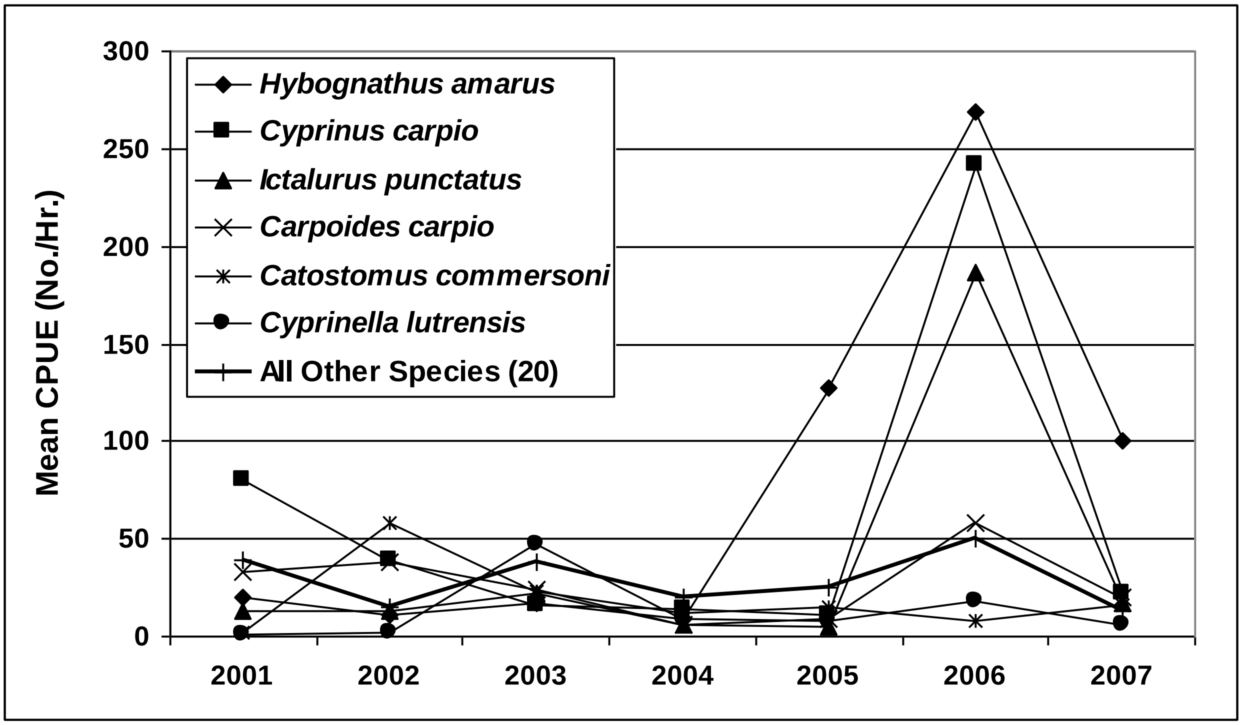


Figure 4.29. Mean CPUE by year for the six most common species captured with electrofishing and for the 20 other species from the Middle Rio Grande. Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Table 4.22. Mean CPUE (fish/hour) by Species for All Electrofishing Samples (grouped by site) from the Middle Rio Grande

Species	2001		2002		2003		2004		2005		2006		2007	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Ameiurus melas	0.00	0.00	0.26	0.55	1.53	4.05	0.00	0.00	0.00	0.00	1.43	3.68	0.14	0.33
Ameiurus natalis	0.00	0.00	0.00	0.00	0.25	0.59	0.04	0.15	0.06	0.22	0.00	0.00	0.13	0.31
Ameiurus nebulosus	0.00	0.00	0.26	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carpiodes carpio	33.02	20.95	38.02	37.74	24.08	32.33	5.92	9.12	9.23	11.40	58.49	74.37	20.06	28.40
Catostomus commersonii	2.00	3.41	57.80	64.81	23.23	44.57	12.47	27.87	14.93	22.43	7.61	12.89	15.97	23.41
Cyprinella lutrensis	1.45	1.26	1.63	2.22	47.04	68.65	8.85	15.77	7.72	11.46	18.49	40.04	5.97	12.72
Cyprinus carpio	80.25	127.60	38.85	7.17	16.31	15.68	14.09	20.38	11.20	6.97	242.14	157.84	21.78	18.40
Dorosoma cepedianum	0.30	0.62	0.00	0.00	0.13	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gambusia affinis	0.40	0.85	0.00	0.00	5.67	7.47	0.19	0.48	2.64	6.40	2.89	7.43	0.24	0.66
Hybognathus amarus	19.64	23.96	11.24	21.58	17.55	49.25	9.40	22.31	127.84	225.78	268.76	352.00	100.68	164.61
Ictalurus punctatus	13.31	8.06	13.13	11.44	22.47	36.33	5.56	7.99	4.99	6.75	186.66	117.32	17.43	13.82
Ictiobus bubalus	25.70	48.66	2.36	4.96	1.54	3.64	0.64	1.15	0.29	0.81	7.59	7.88	0.10	0.25
Lepomis cyanellus	0.00	0.00	0.00	0.00	0.56	1.75	0.16	0.55	0.00	0.00	0.00	0.00	0.00	0.00
Lepomis macrochirus	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.65	0.10	0.35	0.00	0.00	0.00	0.00
Micropterus dolomieu	0.00	0.00	0.30	0.63	0.71	1.58	0.75	2.60	0.58	1.51	0.00	0.00	0.00	0.00
Micropterus salmoides	0.00	0.00	1.95	4.09	0.24	0.74	0.00	0.00	0.78	1.82	0.00	0.00	0.10	0.25
Morone chrysops	0.84	1.18	0.00	0.00	0.59	1.86	0.28	0.98	1.33	2.89	12.41	17.70	1.82	4.37
Oncorhynchus mykiss	0.00	0.00	0.28	0.58	0.00	0.00	0.00	0.00	0.63	1.46	0.00	0.00	0.36	0.90
Perca flavescens	0.00	0.00	0.28	0.58	0.00	0.00	0.00	0.00	0.10	0.35	0.00	0.00	0.00	0.00
Pimephales promelas	1.10	1.59	0.53	1.10	9.35	19.18	0.97	2.60	5.92	8.00	12.86	29.22	2.31	4.49
Platygobio gracilis	10.04	14.91	2.06	1.73	9.19	15.71	10.98	21.23	9.26	12.19	5.38	7.28	6.25	9.28
Pomoxis annularis	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Pylodictis olivaris	0.40	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rhinichthys cataractae	0.00	0.00	1.87	2.99	6.99	10.89	4.31	11.61	3.23	6.82	5.08	9.88	1.11	4.03
Salmo trutta	0.00	0.00	5.39	10.55	1.18	2.70	1.18	2.84	0.58	1.42	1.30	3.34	0.11	0.40
Sander vitreus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.25	1.30	3.34	0.00	0.00

Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Effect of Sample Size on CPUE Precision—The effect of electrofishing sample size on mean CPUE and 95% C.I., CV, and percent detectable change was evaluated with bootstrapping for the Albuquerque, Isleta, and San Acacia reaches for 2003 to 2007. Samples without a record of seconds electrofished were omitted from this analysis. When all samples for a year were considered, the necessary samples to improve precision to an acceptable level for monitoring were considerably larger than actual sample size. For all three reaches, more than 400 samples would be necessary to achieve 95% C.I. <20% of the mean, CV <0.10, and <35% detectable change in mean CPUE (Figure 4.30 and Figure 4.31). The maximum number of samples collected was 47 in the Albuquerque Reach in 2005. When evaluated on an annual basis, the effect of sample size on percent detectable change and CV for mean CPUE is evident in Figure 4.32 to Figure 4.34. Bootstrap simulations show that increasing sample size improves detectable change and CV, but the number of samples necessary for precision exceeds 100 in most cases. Table 4.23 summarizes the number of electrofishing samples that would be required to achieve the three arbitrarily selected sampling precision criteria.

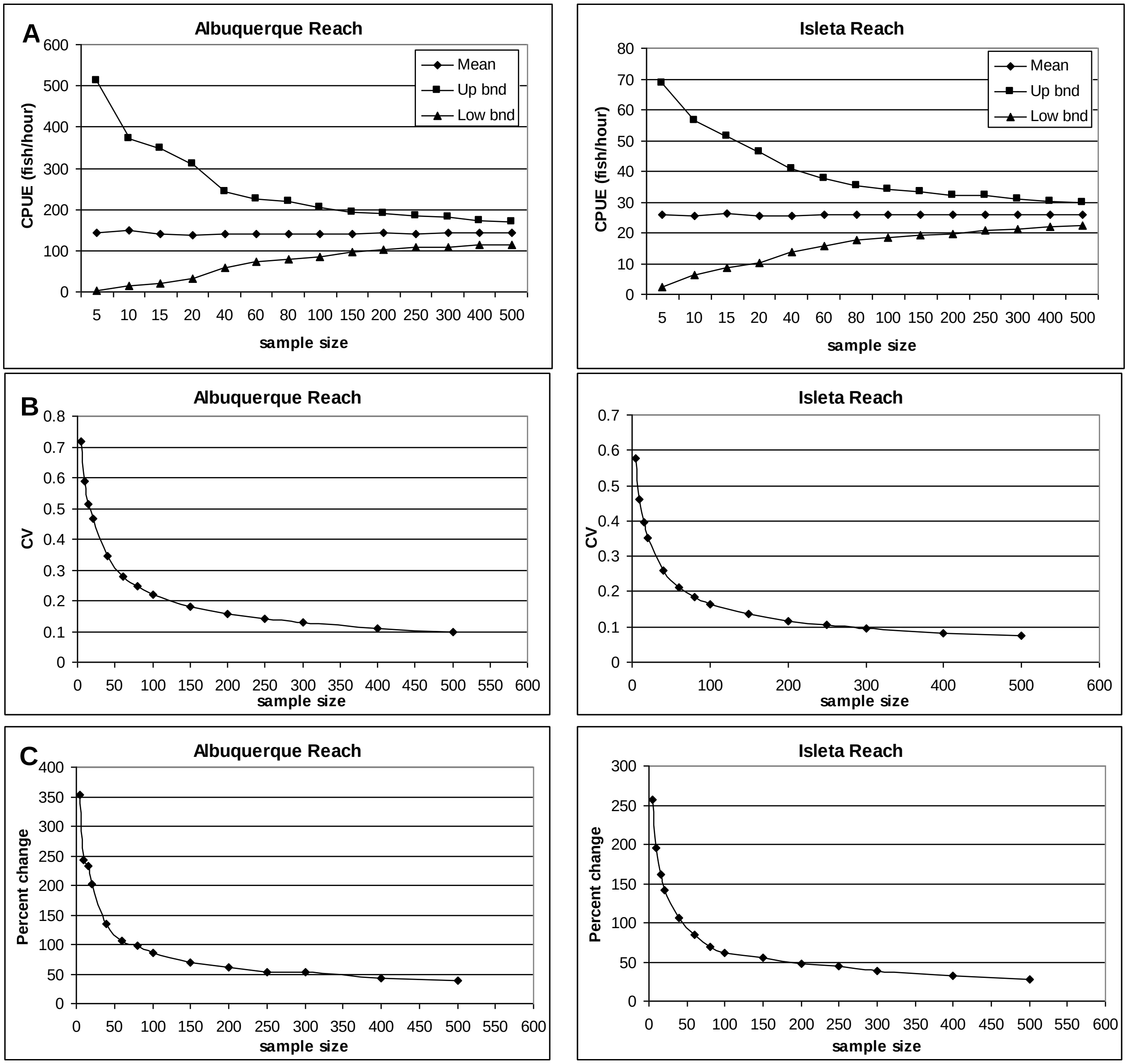


Figure 4.30. The effect of electrofishing sample size for all samples on (A) mean CPUE and 95% C.I., (B) CV, and (C) percent detectable change by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach and the Isleta Reach, 2003–2007. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

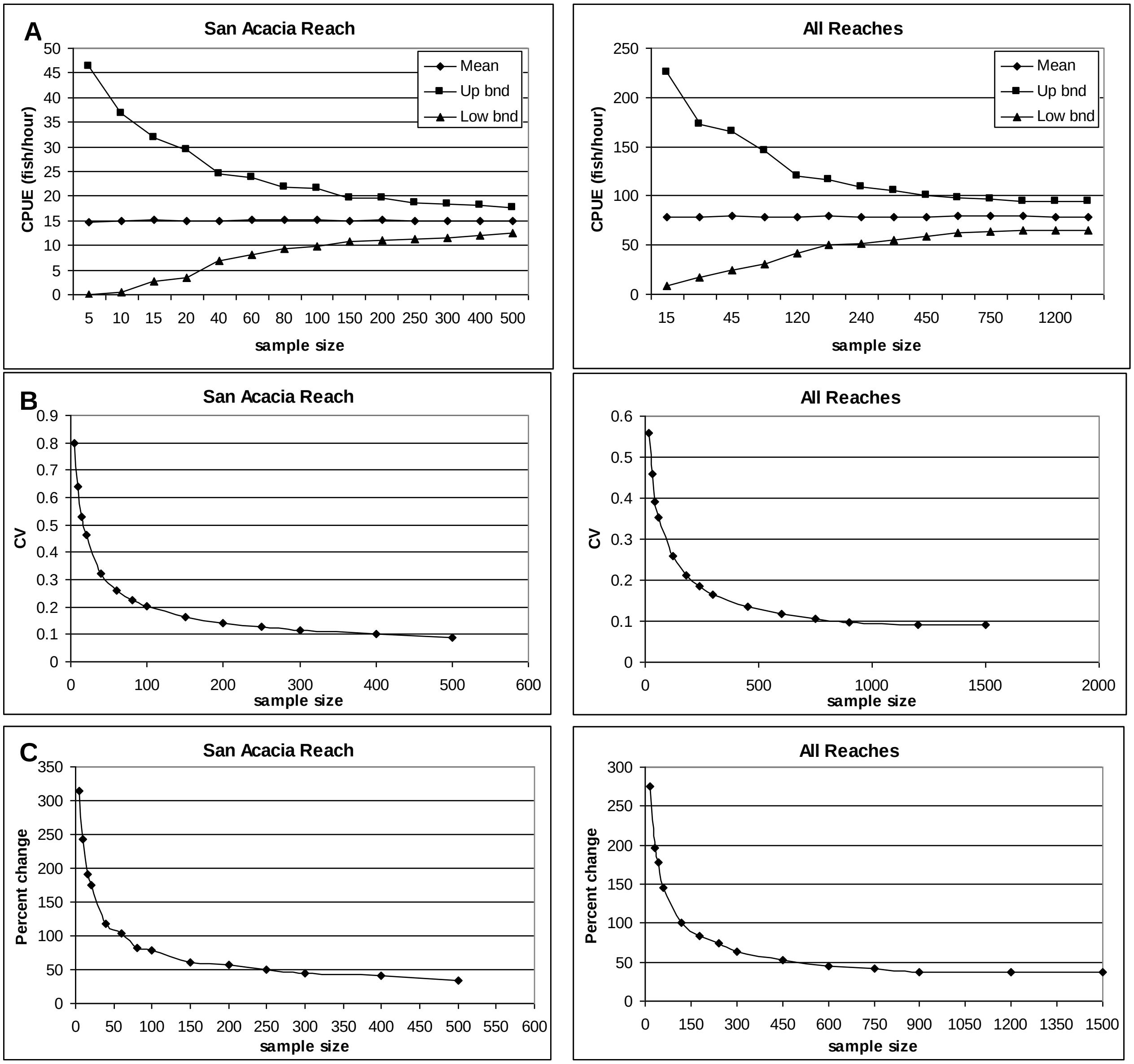


Figure 4.31. The effect of electrofishing sample size for all samples on (A) mean CPUE and 95% C.I., (B) CV, and (C) percent detectable change by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach and for all three reaches combined, 2003–2007.

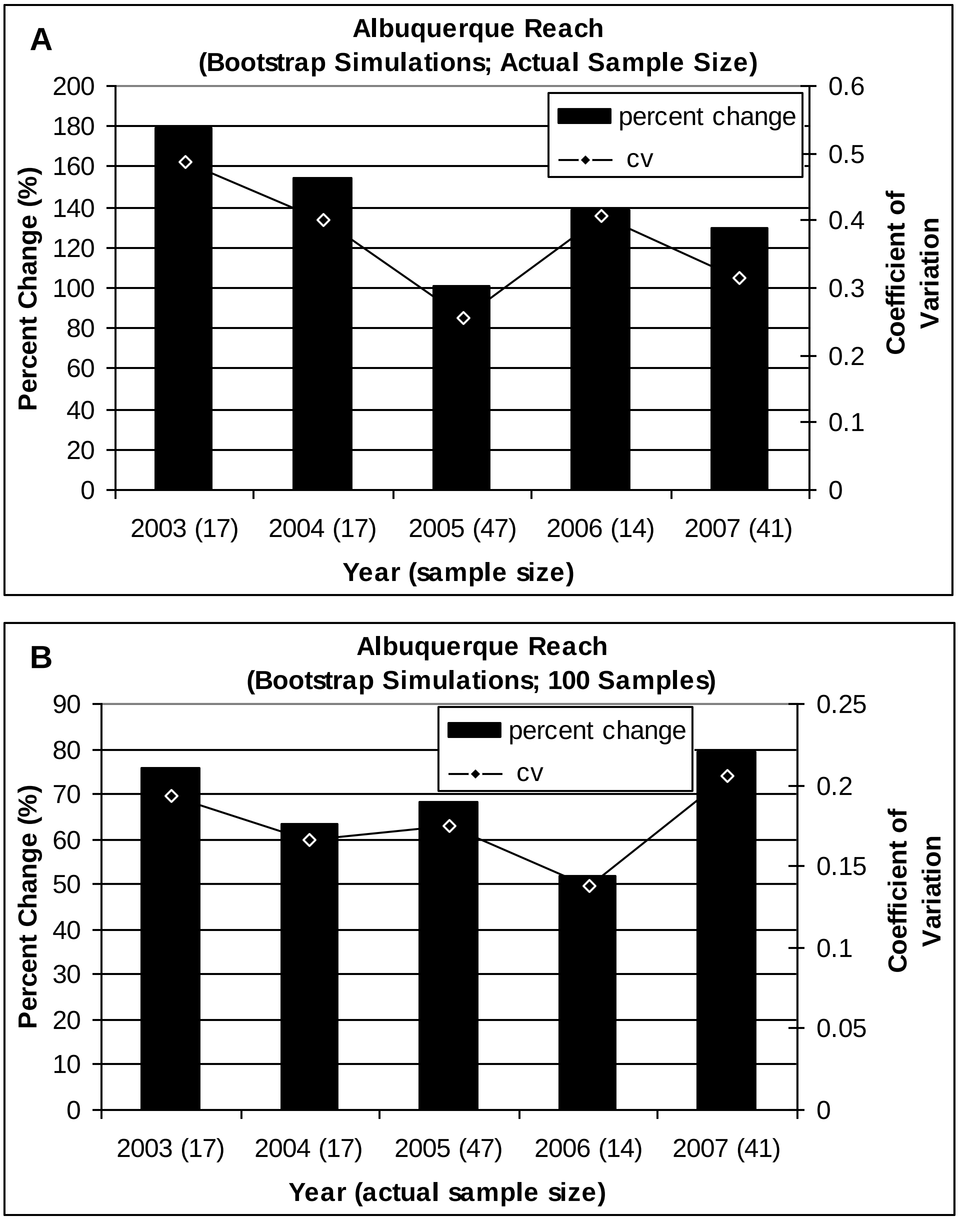


Figure 4.32. Percent detectable change for (A) all samples by year and CV for mean CPUE of silvery minnow electrofishing data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples for the Albuquerque Reach, 2003–2007. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

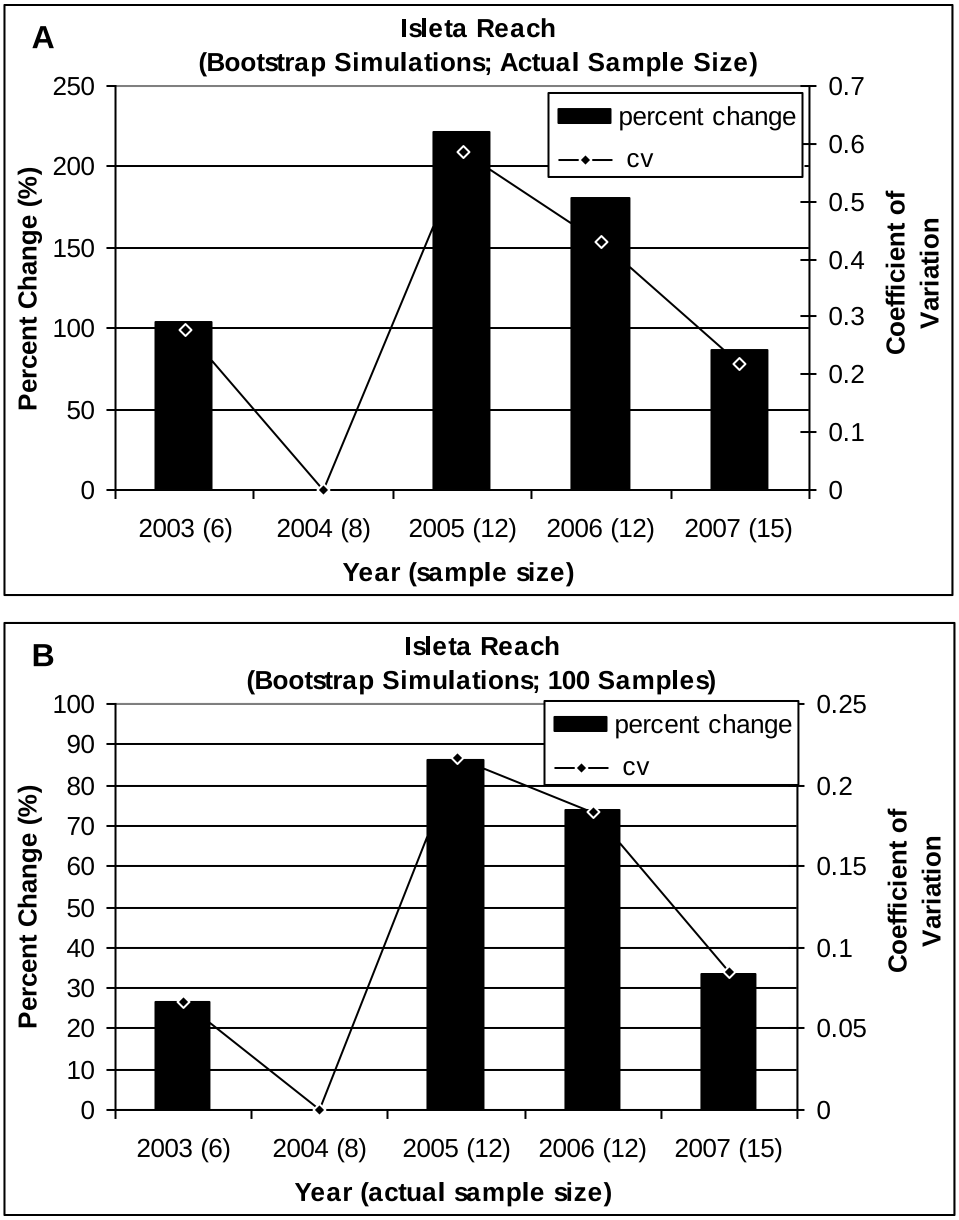


Figure 4.33. Percent detectable change for (A) all samples by year and CV for mean CPUE of silvery minnow electrofishing data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples for the Isleta Reach, 2003–2007. No silvery minnow were collected in 2004. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

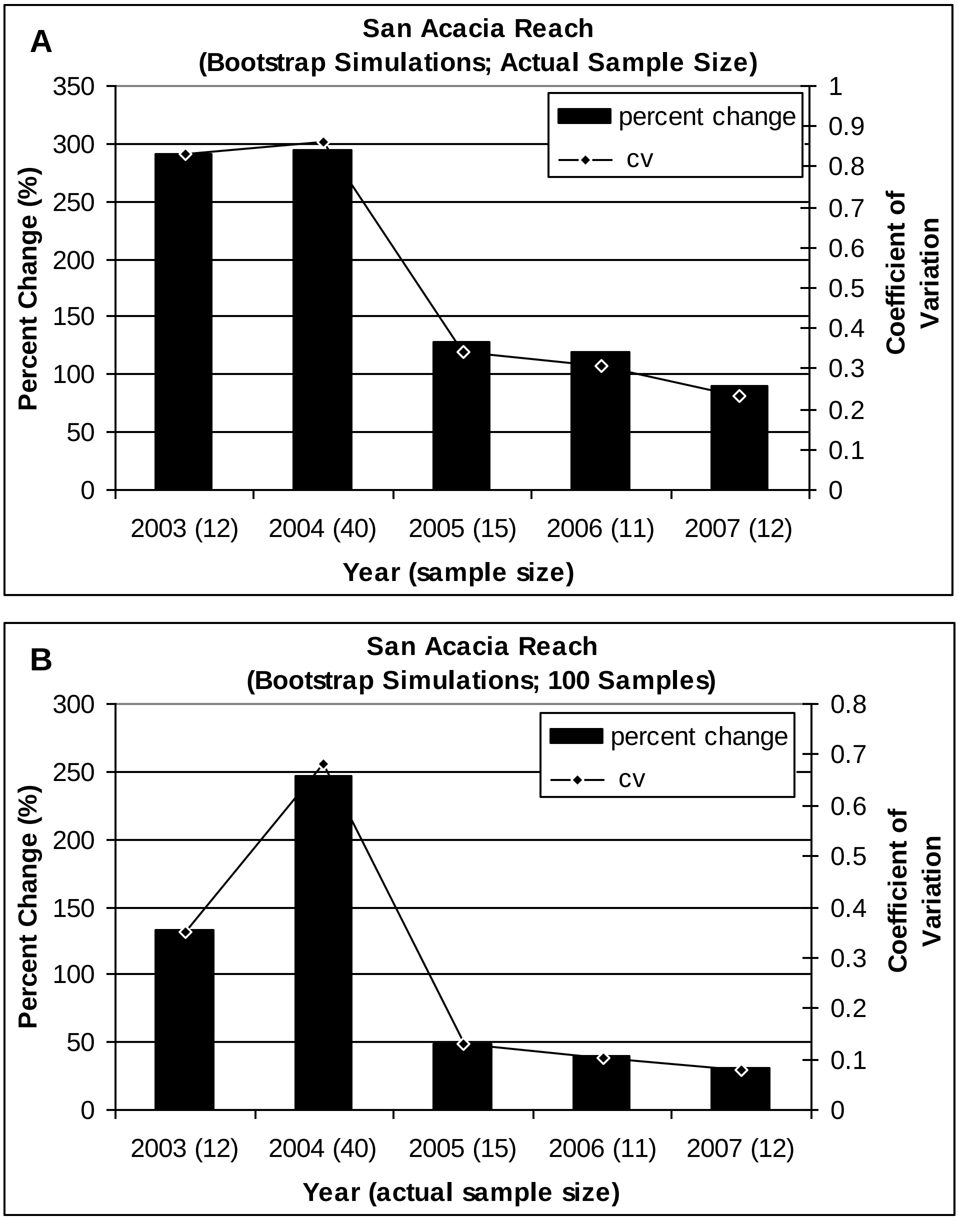


Figure 4.34. Percent detectable change for (A) all samples by year and CV for mean CPUE of silvery minnow electrofishing data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples for the San Acacia Reach, 2003–2007. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Table 4.23. Numbers of Electrofishing Samples Necessary to Meet Three Criteria for Each Reach, Based on Bootstrap Simulations of Sample

Year	Actual No. of Samples	Mean CPUE	Number of Samples		
			95% CI = 20%	CV = 0.10	35% Change
Albuquerque					
2003	17	0.505	350	350	425
2004	17	1.319	250	275	350
2005	47	3.554	300	300	350
2006	14	0.036	200	175	225
2007	41	3.071	475	425	525
Means	–	–	315	305	375
Isleta					
2003	6	0.204	50	45	55
2004	8	0	–	–	–
2005	12	0.311	525	450	550
2006	12	0.529	350	350	400
2007	15	0.762	70	70	90
Means	–	–	249	229	274
San Acacia					
2003	12	0.003	20	600	1600
2004	40	0.002	40	700	1200
2005	15	0.322	175	175	175
2006	11	0.730	125	125	125
2007	12	0.797	75	60	70
Means	–	–	87	332	634

Note: 95% CI = 20% of mean, CV = 0.10, 35% change in mean CPUE is detectable. The table represents a summary of Figure C.1–C.13 in Appendix C. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Trend Analysis—Trend analysis was performed on the electrofishing data to determine 1) the probability of detecting different levels of change in mean annual CPUE and 2) the number of years necessary to detect a change in mean annual CPUE of different levels. The analysis used data from all electrofishing samples with recorded effort for the original samples and bootstrapped for 100 samples (Table 4.24–Table 4.26, Figure 4.35–Figure 4.37). Trend analysis with all electrofishing samples showed that for a 10-year period, the probability of detecting a trend in CPUE of 50% or less is unreliably low for all three reaches (i.e., < 0.66; $\alpha=0.34$; top parts of Table 4.24, Table 4.25, and Table 4.26; top parts of Figure 4.35, Figure 4.36, and Figure 4.37). Of the five years of data, the minimum number of years for detecting a trend in CPUE of 50% was 29 years (i.e., $\alpha=0.05$).

When the samples were bootstrapped to 100 samples (i.e., 100 independent electrofishing runs), the level of detectability improved considerably. Analysis of all electrofishing samples showed that for a 10-year period, the probability of detecting a trend in CPUE of 50% or more was as high as 100% for all three reaches (i.e., < 1.00; $\alpha<0.01$; bottom parts of Table 4.24, Table 4.25, and Table 4.26; bottom parts of Figure 4.35, Figure 4.36, and Figure 4.37). Of the five years of data, the minimum number of years for detecting a trend in CPUE of 50% was five years (i.e., $\alpha=0.05$).

Table 4.24. Summary of Trend Analysis Based on All Electrofishing Samples and All Samples Bootstrapped to 100 Samples for the Albuquerque Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
All Samples						
2003	17	0.4875	0.28	285%	NC	53
2004	17	0.4020	0.32	462%	NC	36
2005	47	0.2544	0.54	143%	40	15
2006	14	0.4069	0.31	485%	NC	37
2007	41	0.3147	0.41	222%	59	23
All Samples Bootstrapped to 100 Samples						
2003	100	0.1932	0.75	91%	23	10
2004	100	0.1658	0.84	73%	17	7
2005	100	0.1747	0.81	78%	19	9
2006	100	0.1375	0.92	56%	12	6
2007	100	0.2059	0.70	100%	26	11

Note: A 100% change is equal to a doubling in CPUE for the specified time period. NC = not possible to calculate. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Table 4.25. Summary of Trend Analysis Based on All Electrofishing Samples and All Samples Bootstrapped to 100 Samples for the Isleta Reach

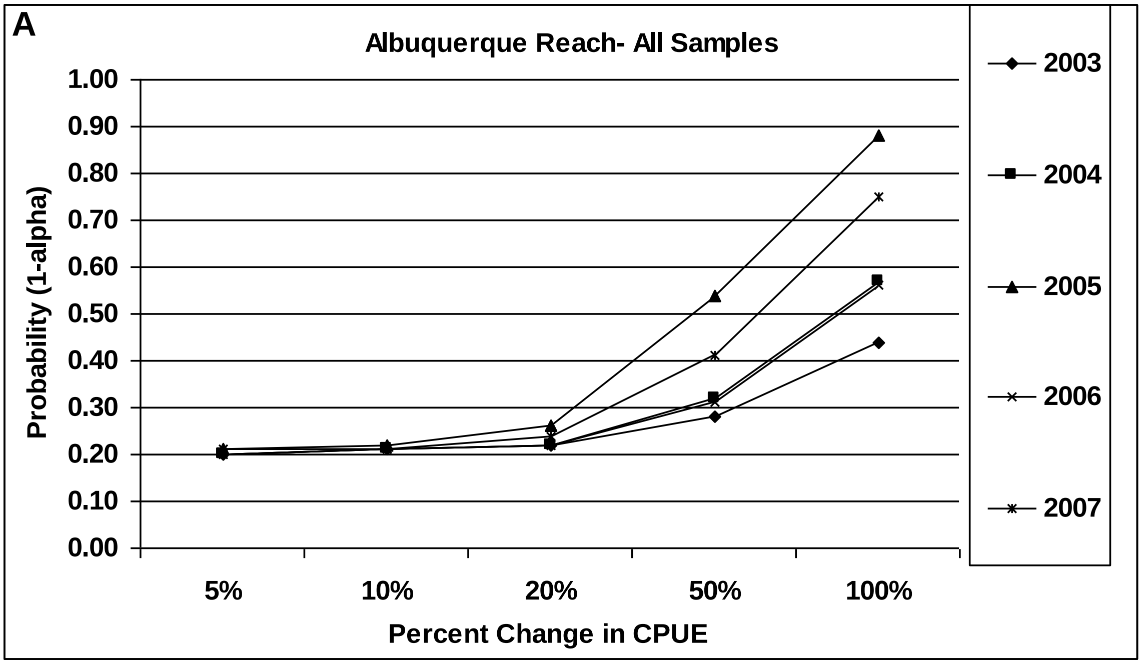
Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
All Samples						
2003	6	0.2788	0.48	171%	47	18
2004	8	0.0000	–	–	–	–
2005	12	0.5867	0.25	NC	NC	NC
2006	12	0.4303	0.30	627%	NC	41
2007	15	0.2179	0.66	110%	29	12
All Samples Bootstrapped to 100 Samples						
2003	100	0.0664	1.00	24%	5	4
2004	100	0.0000	–	–	–	–
2005	100	0.2169	0.66	109%	30	12
2006	100	0.1836	0.78	84%	21	9
2007	100	0.0846	1.00	31%	6	4

Note: A 100% change is equal to a doubling in CPUE for the specified time period. NC = not possible to calculate. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Table 4.26. Summary of Trend Analysis Based on All Electrofishing Samples and All Samples Bootstrapped to 100 Samples for the San Acacia Reach

Year	Sample Size	CV	Probability of Detecting a 50% Change in CPUE over 10 Years (1-α; β=0.20)	Min. Detectable Rate of Change in CPUE over 10 Years (α=0.05; β=0.20)	Years to Detect a Trend in CPUE (α=0.05; β=0.20)	
					50%	100%
All Samples						
2003	12	0.8339	0.22	NC	NC	NC
2004	40	0.8591	0.22	NC	NC	NC
2005	15	0.3405	0.38	271%	NC	25
2006	11	0.3054	0.43	208%	57	21
2007	12	0.2317	0.61	122%	32	13
All Samples Bootstrapped to 100 Samples						
2003	100	0.3522	0.36	297%	NC	28
2004	100	0.6808	0.24	NC	NC	NC
2005	100	0.1283	0.94	52%	11	6
2006	100	0.1025	0.98	39%	8	5
2007	100	0.0778	1.00	28%	6	4

Note: A 100% change is equal to a doubling in CPUE for the specified time period. NC = not possible to calculate. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.



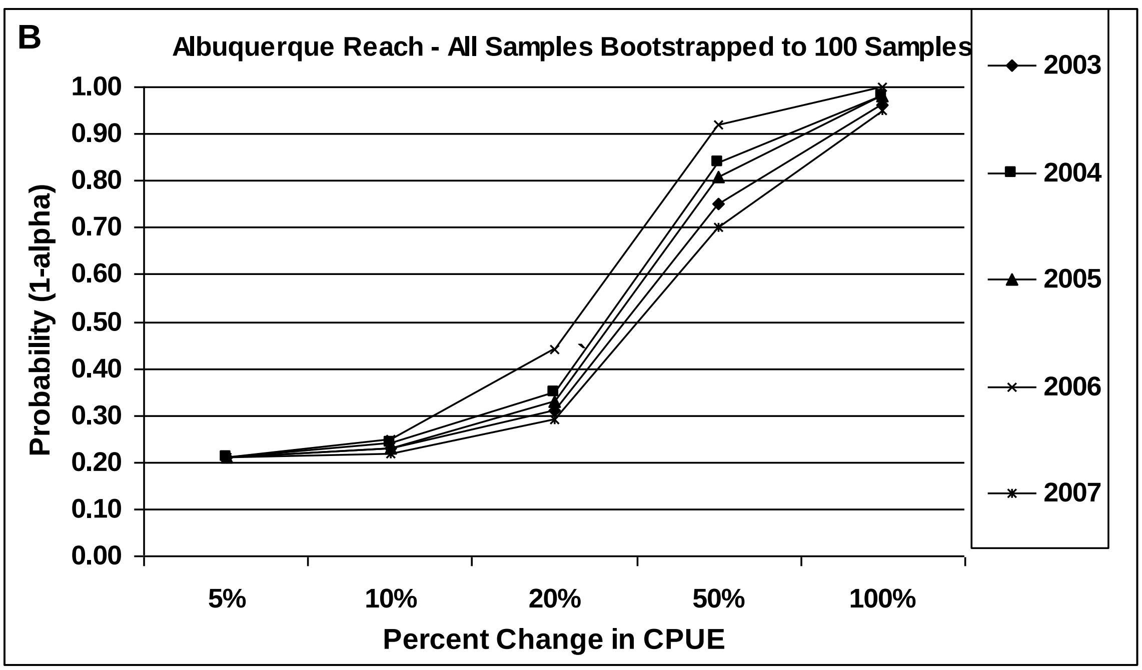


Figure 4.35. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all electrofishing samples and (B) all samples bootstrapped to 100 samples in the Albuquerque Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

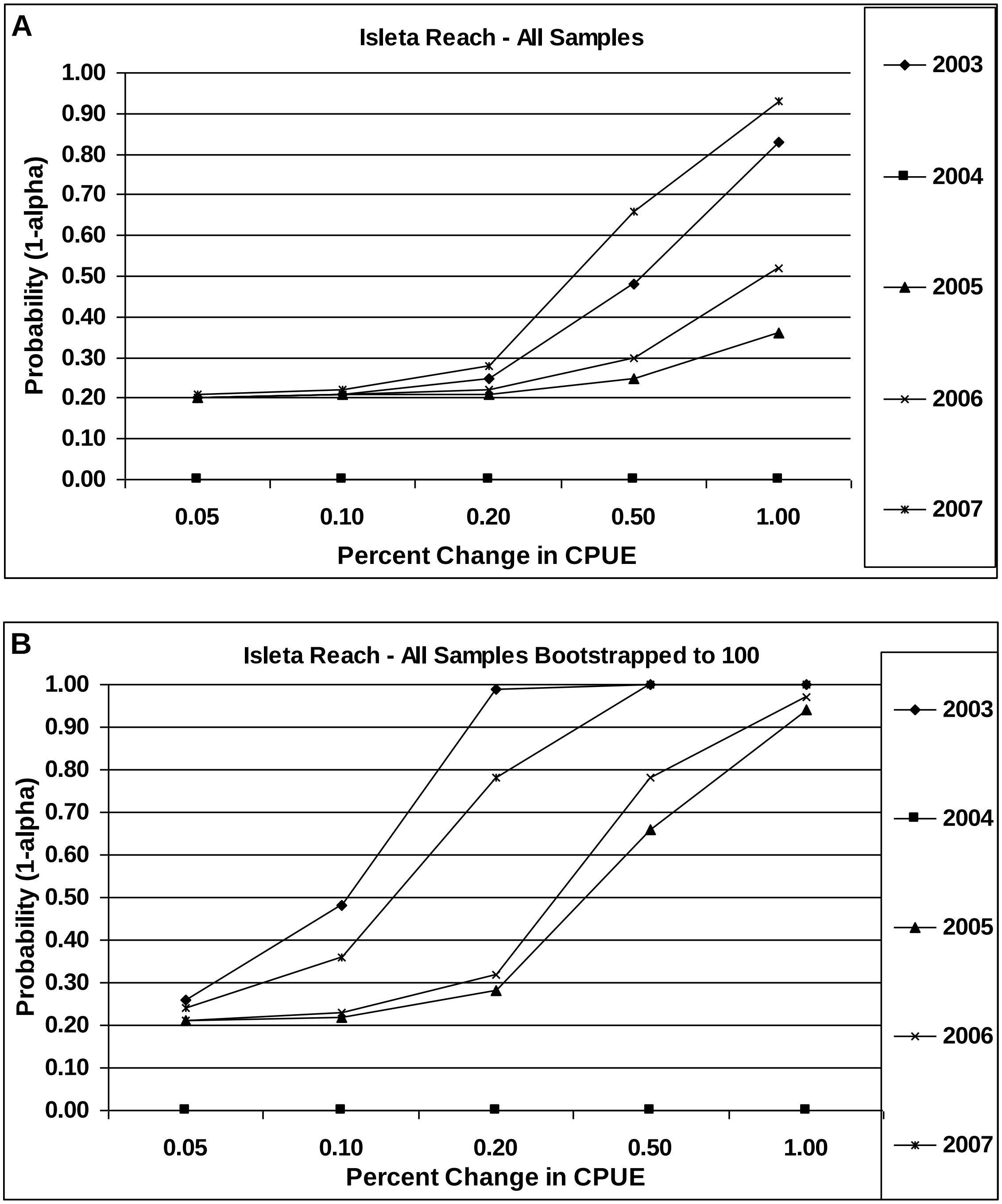
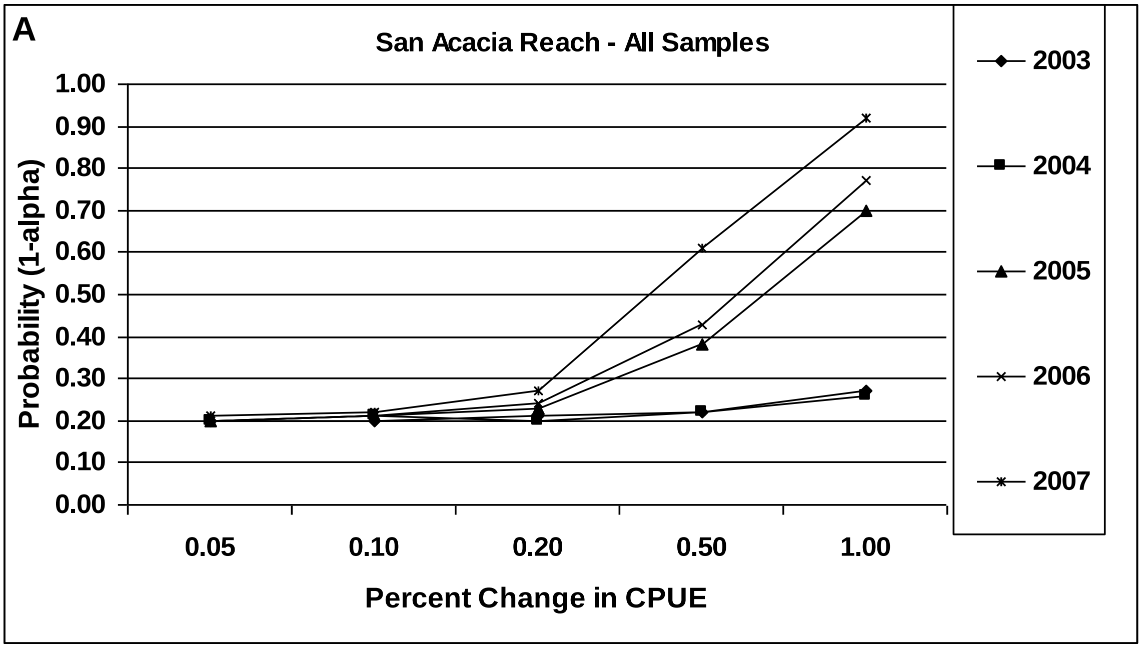


Figure 4.36. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all electrofishing samples and (B) all samples bootstrapped to 100 samples in the Isleta Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.



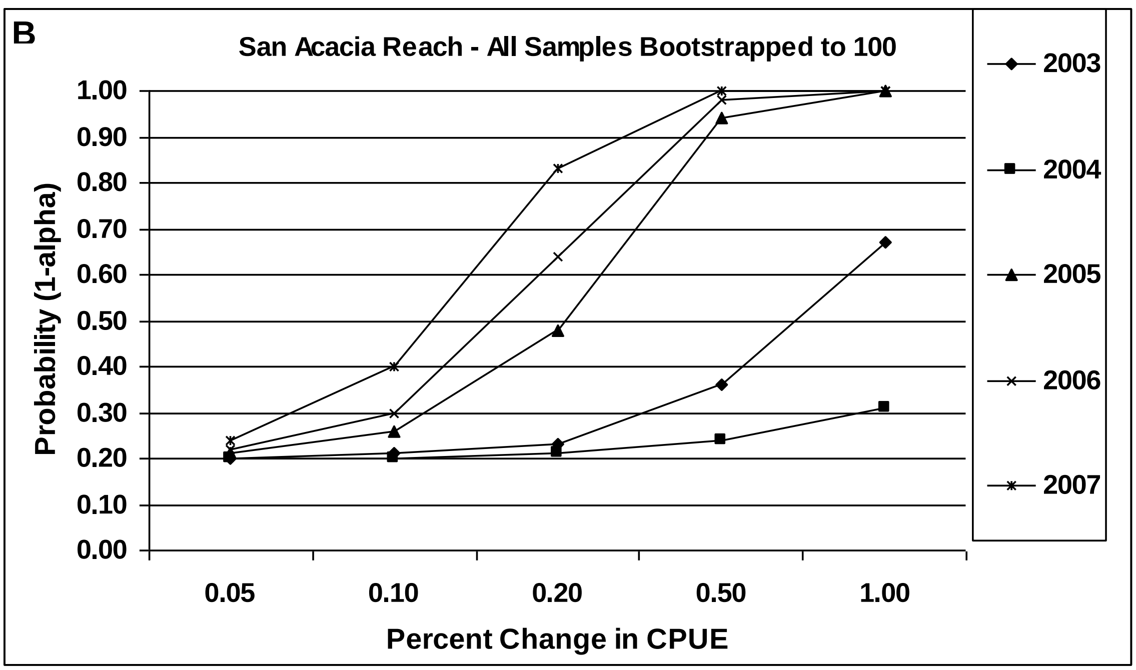


Figure 4.37. Probability of detecting a 5%, 10%, 20%, 50%, or 100% change in trend of CPUE of silvery minnow for (A) all electrofishing samples and (B) all samples bootstrapped to 100 samples in the San Acacia Reach over a 10-year period. Probability is determined by using the CV computed from simulations for each year and a power level (1–β) of 0.80. A 100% change represents a doubling of CPUE. Datasets: USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Shannon-Wiener Diversity Index—In order to evaluate these data at the fish community level, the Shannon-Wiener diversity index (used by the collector of these data) was used (Table 4.27, Figure 4.38). This index performs well in evaluation of fish species and their abundances, including rare species (Kwak and Peterson 2007). The diversity scores increase as number of species increases (i.e., species richness) and as the proportional abundance of species becomes even. The Shannon-Wiener diversity index (H) measured by electrofishing in the Albuquerque, Isleta, and San Acacia reaches was relatively low, not exceeding a score of 2 (see Figure 4.38). This is consistent with the low species richness at a site and uneven species relative abundance reported in Table 4.27.

Table 4.27. Summary Statistics for Site-specific Shannon-Wiener Diversity Indices in the Albuquerque, Isleta, and San Acacia Reaches Calculated from Reclamation Electrofishing Data, 2001–2007

Statistic	2001	2002	2003	2004	2005	2006	2007
Albuquerque							
Number of Samples	13	6	18	19	47	42	41
Arithmetic Mean	0.90	0.96	0.82	1.13	1.10	0.94	1.08
Standard Deviation	0.27	0.34	0.85	0.53	0.53	0.35	0.33
Standard Error	0.07	0.14	0.20	0.12	0.08	0.05	0.05
Lower 95% C.I.	0.74	0.60	0.39	0.88	0.94	0.83	0.97
Upper 95% C.I.	1.06	1.32	1.24	1.39	1.25	1.05	1.18
CV	0.08	0.15	0.25	0.11	0.07	0.06	0.05
Shapiro-Wilk Statistic	0.9808	0.9020	0.7304	0.8777	0.9704	0.9549	0.9706
Shapiro-Wilk *p*-value	0.9831	0.3862	0.0002	0.0196	0.2733	0.0965	0.3611
Isleta							
Number of Samples	0	0	6	17	12	21	15
Arithmetic Mean	–	–	1.57	0.38	0.78	0.97	1.23
Standard Deviation	–	–	0.26	0.43	0.46	0.51	0.38
Standard Error	–	–	0.11	0.11	0.13	0.11	0.10
Lower 95% C.I.	–	–	1.29	0.15	0.49	0.74	1.02
Upper 95% C.I.	–	–	1.84	0.60	1.07	1.20	1.44
CV	–	–	0.07	0.28	0.17	0.11	0.08
Shapiro-Wilk Statistic	–	–	0.7943	0.7686	0.8398	0.8404	0.8690
Shapiro-Wilk *p*-value	–	–	0.0522	0.0008	0.0275	0.0029	0.0326
San Acacia							
Number of Samples	21	7	12	32	15	12	14
Arithmetic Mean	1.08	1.38	1.04	0.25	0.99	0.81	1.03
Standard Deviation	0.47	0.27	0.35	0.35	0.51	0.46	0.45
Standard Error	0.10	0.10	0.10	0.06	0.13	0.13	0.12
Lower 95% C.I.	0.87	1.13	0.81	0.13	0.71	0.52	0.77
Upper 95% C.I.	1.30	1.63	1.26	0.38	1.28	1.10	1.29
CV	0.10	0.07	0.10	0.24	0.13	0.16	0.12
Shapiro-Wilk Statistic	0.9168	0.8607	0.9225	0.7293	0.9236	0.9009	0.8871
Shapiro-Wilk *p*-value	0.0748	0.1537	0.3071	0.0000	0.2182	0.1632	0.0734

Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls

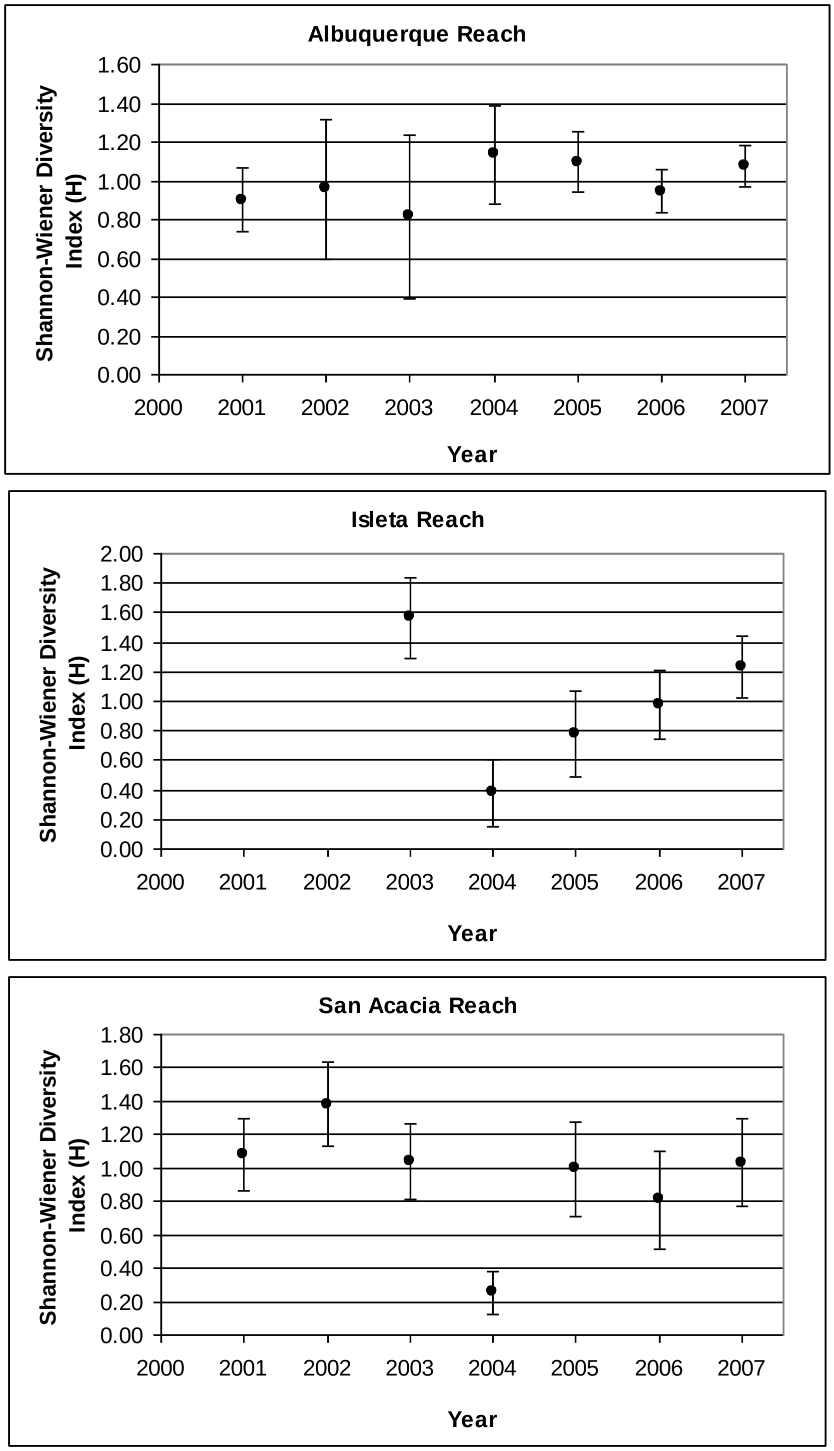


Figure 4.38. Mean Shannon-Wiener diversity index and 95% C.I. for sites sampled by electrofishing in the Albuquerque, Isleta, and San Acacia reaches by year. Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls

Effect of Sample Size on Shannon-Wiener Diversity Index—The effect of electrofishing sample size on cumulative Shannon-Wiener diversity index and 95% C.I. and percent detectable change was evaluated with bootstrapping for the Albuquerque, Isleta, and San Acacia reaches for 2003 to 2007. Unlike the site-specific Shannon-Wiener indices calculated in Table 4.27 and Figure 4.38 above, this analysis of sample size calculated a cumulative index from all samples in a reach. Thus, an additional sample could increase the index score if it documents a new species for the reach, even if the sample itself does not contain high species richness. Also, all samples were included in the analysis, not just those with sampling effort recorded.

When all samples for a year were considered, current sample sizes provided a reasonable level of precision for the Shannon-Wiener diversity index. For all three reaches, the cumulative diversity index value increased slightly as additional samples were added. For the species vulnerable to capture by electrofishing, most were detected in fewer than 10 samples. For the Isleta and San Acacia reaches, approximately 10 samples would be necessary to achieve 95% C.I. <20% of the mean and <35% detectable change in mean CPUE (Figure 4.39 and Figure 4.40). Variability in the Shannon-Wiener diversity index was higher in the Albuquerque Reach, partially due to a high number of samples with zero fish captured. Based on the data from 2003 through 2007, approximately 75 samples would be necessary to achieve 95% C.I. <20% of the mean and <35% detectable change in mean CPUE in this reach (see Figure 4.42).

When evaluated on an annual basis, the effect of sample size on percent detectable change for cumulative Shannon-Wiener diversity index is evident in Figure 4.41 to Figure 4.43. Bootstrap simulations show that increasing sample size improves detectable change on average from <60% (current sample sizes) to <20% (100 samples).

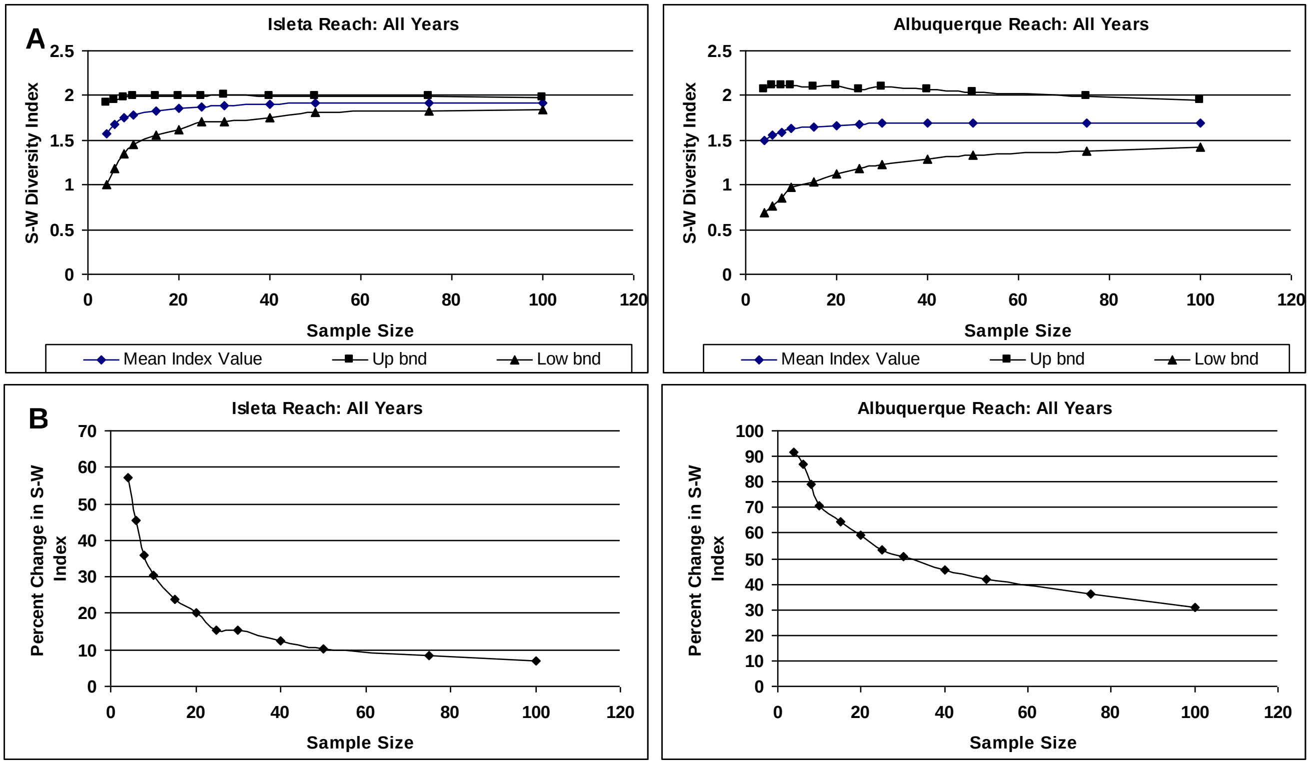


Figure 4.39. The effect of electrofishing sample size for (A) all samples on cumulative Shannon-Wiener (S-W) diversity indices and 95% C.I. and (B) percent detectable change by bootstrapping (1,000 iterations of actual sample size) in the Albuquerque and Isleta reaches, 2001–2007. Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls

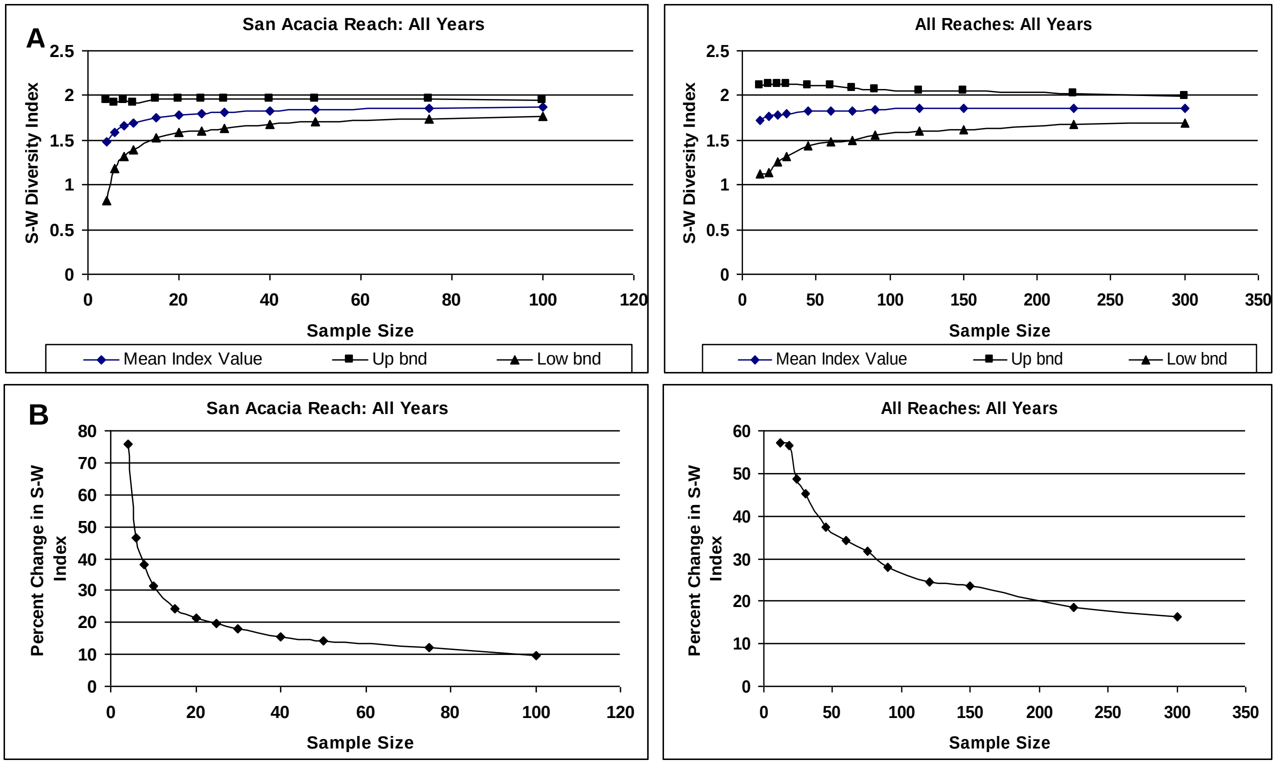


Figure 4.40. The effect of electrofishing sample size for (A) all samples on cumulative Shannon-Wiener (S-W) diversity indices and 95% C.I. and (B) percent detectable change by bootstrapping (1,000 iterations of actual sample size) in the San Acacia Reach and all reaches combined, 2001–2007. Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls

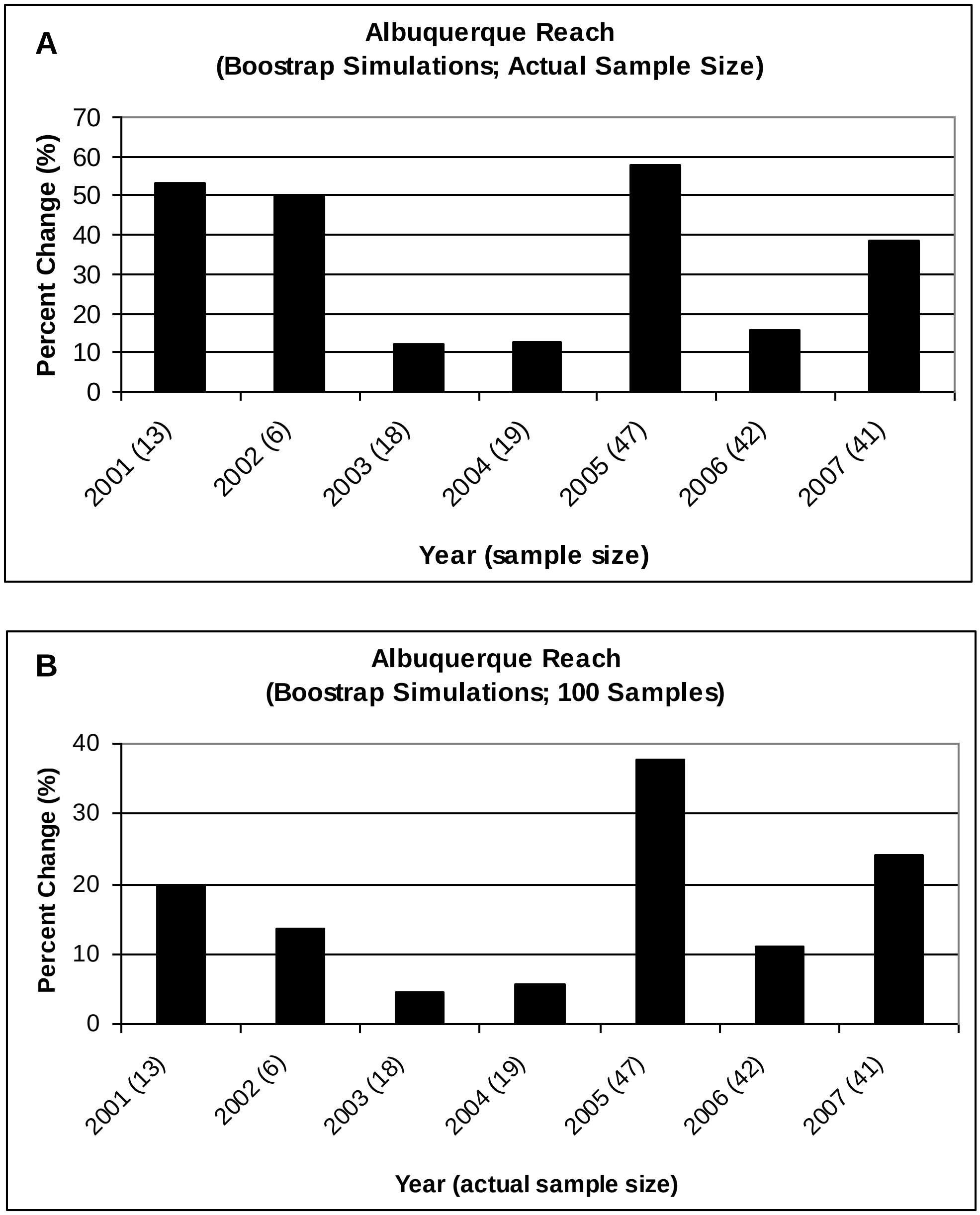


Figure 4.41. Percent detectable change for (A) all samples by year for cumulative Shannon-Wiener diversity index of electrofishing data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples for the Albuquerque Reach, 2001–2007. Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls

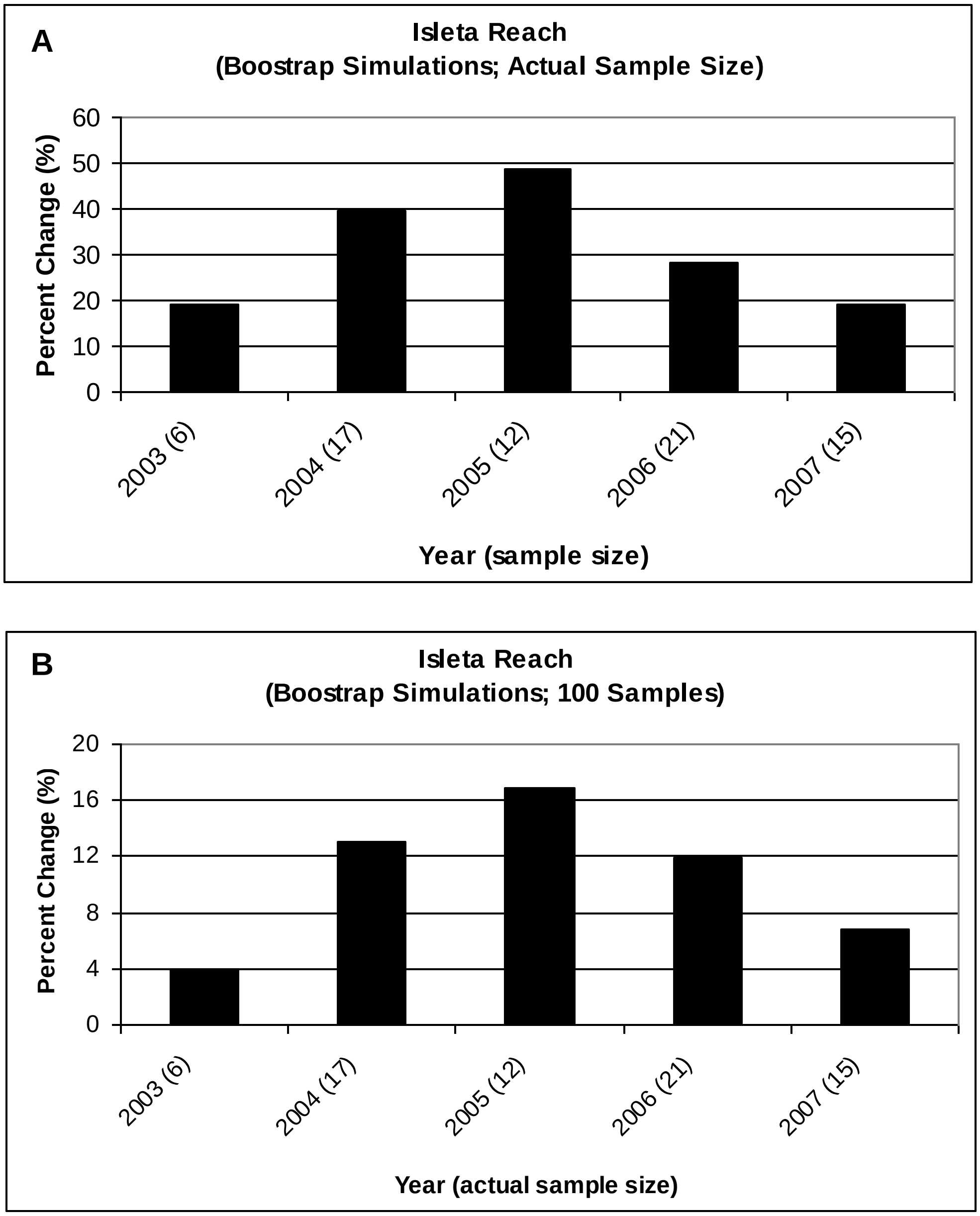


Figure 4.42. Percent detectable change for (A) all samples by year for cumulative Shannon-Wiener diversity index of electrofishing data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples for the Isleta Reach, 2003–2007. Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls

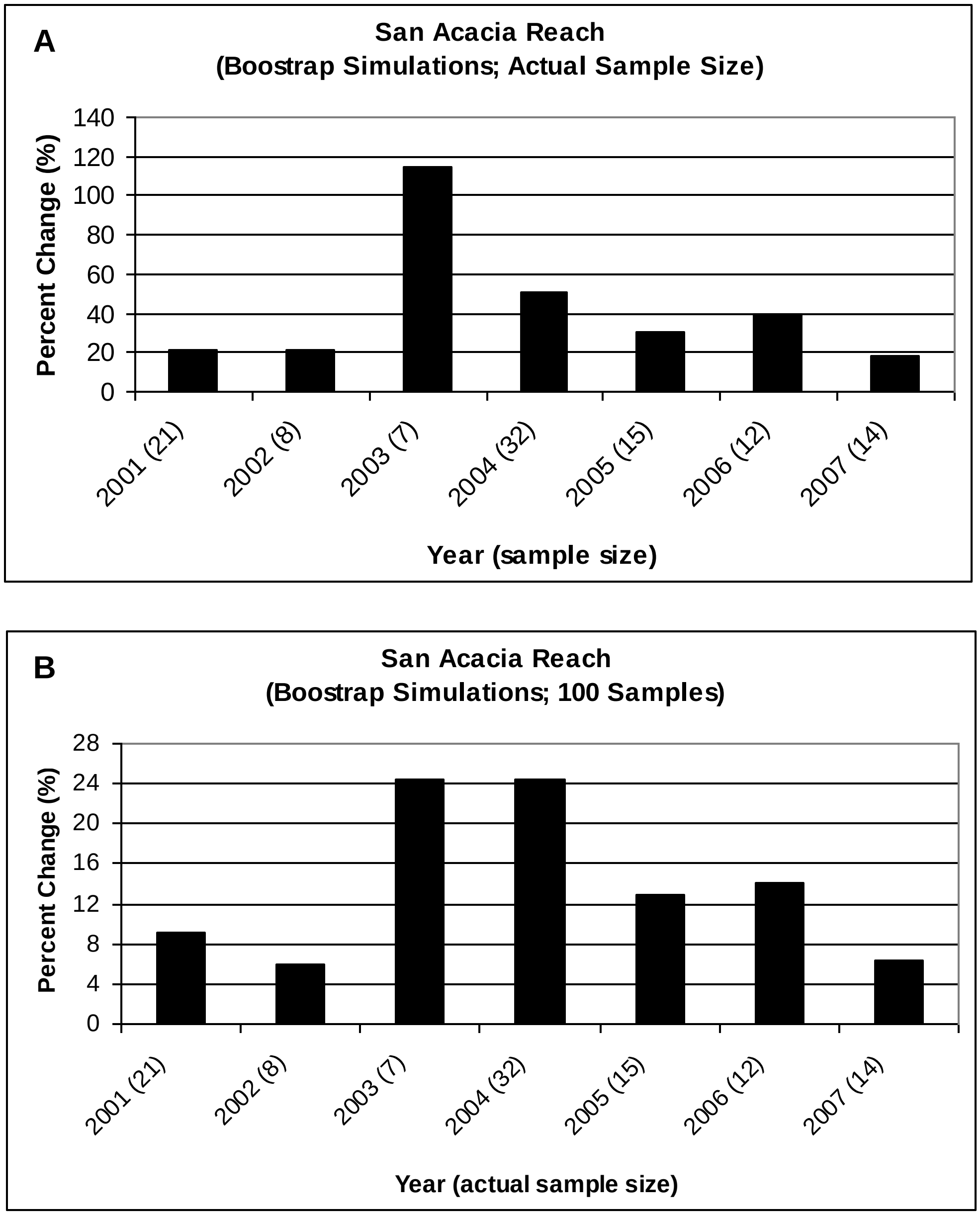


Figure 4.43. Percent detectable change for (A) all samples by year for cumulative Shannon-Wiener diversity index of electrofishing data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size and (B) expanded to 100 samples for the San Acacia Reach, 2001–2007. Datasets: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls

4.6 DATASETS 23 TO 27

23. USFWS-USFWS-RGSM_Rescue_06.xls
24. USFWS-2004 Rescue.xls
25. USFWS-BOR_Exp_Act_DB_2007.mdb
26. USFWS-RGSM_Rescue_05.xls
27. USFWS-RGSM-salvage_2001.xls

4.6.1 RELEVANT REPORTS

Smith (2001), Smith and Munoz (2002), Smith and Basham (2003), USFWS (2004, 2005a, 2006, 2007)

4.6.2 STUDY OBJECTIVES

- Salvage silvery minnow from drying reaches of the Middle Rio Grande for translocation to flowing reaches upstream, as part of the March 17, 2003, Biological Opinion (amended August 15, 2005; USFWS 2005b) that established the annual incidental take limit for the silvery minnow.

4.6.3 DOCUMENTATION OF SAMPLING GEARS AND METHODS

Using seines of various sizes, fish were collected from pools that formed as flow in the Middle Rio Grande became discontinuous. All captured fish were identified to species, and silvery minnow were quickly culled from the collections. Captured silvery minnow were placed in 19-L (5-gallon) buckets filled with river water and subsequently transferred to ice chests or plastic bags for hauling to a release site. The fish were transported as quickly as possible to the Isleta and Albuquerque reaches where they were released to the river.

4.6.4 SAMPLING EFFORT FOR GEARS AND METHODS

Data contained in these datasets were generally numbers of silvery minnow salvaged from drying reaches of the Middle Rio Grande and transported to flowing reaches upstream (Table 4.28). Because of the urgency for salvaging these fish and their already stressed condition, lengths of fish were generally not taken, nor were measures of sampling effort recorded, e.g., area seined for CPUE computation. Hence, the data contained in these datasets have limited use, except perhaps to estimate survival rates with known age-at-length information.

Table 4.28. The Number of Rescued Silvery Minnow Captured in Drying Pools of the Middle Rio Grande and Translocated to the Isleta and Albuquerque Reaches

Year	Number Rescued
2001	240
2002	3,662
2003	713
2004	12,865
2005	626,444
2006	66,965
2007	13,953
2008	0
2009	15,190

4.7 DATASETS 28 TO 34

28. SWCA-Eggs_total.xls
29. SWCA-AWcomment_Vertical_Drift_Data_0607 SB.xls; see also: Final Vertical_Drift_Data.xls
30. ASIR-RGSM Egg Data for Friday, 13 June 2008.xls
31. SWCA-Lateral comparison.xls
32. SWCA-Los Lunas Egg_Monitor_09.mdb
33. SWCA-NMISC Habitat Rest Egg_Monitor_08-09.mdb
34. SWCA-NMISC_Nursery_Habitat.mdb

4.7.1 RELEVANT REPORTS

Hatch and Gonzales (2008), Widmer et al. (2008), Gonzales and Hatch (2009)

4.7.2 STUDY OBJECTIVES

- Determine densities of silvery minnow eggs in drift.
- Evaluate MECs and drift nets for estimating density of silvery minnow eggs in drift.
- Determine the presence of silvery minnow eggs at habitat restoration sites.

4.7.3 DOCUMENTATION OF SAMPLING GEARS AND METHODS

Sampling gears and methods varied for collection of these data, depending on study design and study purpose and goals. The MECs were generally set in a standard manner as previously described in Section 3.2.4. Some of the datasets included in this group compared MECs with drift nets set to collect bottom and top drift for colored gellan beads as a surrogate to silvery minnow eggs. Other datasets evaluated collection of MECs in various mesohabitats and river locations. Silvery minnow eggs were also collected with D-frame kick nets and seines from flooded habitat restoration sites during spring runoff in 2007 to 2009.

4.7.4 SAMPLING EFFORT FOR GEARS AND METHODS

Data contained in these datasets are generally numbers of silvery minnow eggs collected from main channel habitats with MECs and from transects of known length within flooded habitat restoration sites with kick nets (Table 4.29). Data collected with MECs (although not reported for all datasets) include sample time and flow of water through the MEC. MEC data were standardized by volume of water filtered and expressed as eggs/hour, egg/m^3, or eggs/100 m^3. Kick net data were expressed as the number of eggs collected or eggs/transect length. Because of the variable format and purpose of the datasets (see Table 4.29), only datasets 28 and 30 were used in the methods analysis below.

Table 4.29. Summary of Data Type and Effort Reported in Datasets 28–34

Data set	Year	Gear Type	Number of Silvery Minnow Eggs Collected	Effort	Comment
28	2007	Seine and kick nets	663 collected with seines; 1,321 with kick nets	579 seine samples; 1,628 kick net samples	Insufficient information for data standardization
29	2007	MECs and drift nets	0	242 individual 15-minute MEC samples; 110 individual 5-minute drift net samples	Data were collected as part of an experiment intended to evaluate the uniform dispersal of artificial beads and contain sufficient information to standardize by egg/hour, eggs/m^3, and eggs/100 m^3
30	2008	MECs	2,105	128 samples	Insufficient information for data standardization
31	2007	MECs	0	972 individual 15-minute MEC samples	Data were collected as part of an experiment intended to evaluate the uniform dispersal of artificial beads and contain sufficient information to standardize by egg/hour, eggs/m^3, and eggs/100 m^3
32	2009	MECs	3	15 individual MEC samples ranging from 15–60 minutes	Data contain sufficient information to standardize by egg/hour, eggs/m^3, and eggs/100 m^3
33	2008–2009	MECs	123	142 individual MEC samples ranging from 15–240 minutes	Data contain sufficient information to standardize by egg/hour, eggs/m^3, and eggs/100 m^3
34	2008–2009	Kick nets	363	926 individual kick net samples	Data contain sufficient information to standardize by egg/transect or egg/length sampled

4.7.5 STATISTICAL POWER OF SAMPLING GEARS AND METHODS

Gear Efficiency and Equal Mixing—MECs have become the standard gear for sampling and estimating the density of drifting silvery minnow eggs in the Middle Rio Grande. Parameter estimates of silvery minnow egg density (eggs/m^3 or eggs /100 m^3) as indices of reproductive effort assume that the eggs were equally distributed within the water column. This assumption and sampling efficiency of MECs relative to drift nets was tested and the results are described below.

An estimated 7.9 million artificial eggs (gellan beads) were released into the thalweg below Angostura Diversion Dam and collected 51.34 km (31.90 miles) downstream at the South Diversion Channel (SDC) during June 25 to 27, 2007. Two types of bead collectors were used simultaneously: MECs (N = 4) and drift nets (N = 2). Two MECs were set off the left bank and two off the right bank. The drift nets were mounted one directly over the other off the right bank. The purpose of these data was to evaluate distribution of beads in the channel (vertical and lateral).

The four MECs collected 15-minute samples continuously for 48 hours after the arrival of the first bead. The two drift nets (0.115-m^2 opening) collected samples for 5 minutes of every 15-minute sampling period for 13.75 hours of the 48-hour study period. Water velocity was measured in the mouth of each collector with a FloMate portable water velocity meter (Marsh-McBirney, Inc.) once per sample. Bead density was calculated from the number of beads collected and the volume of water filtered in each sample.

During periods of simultaneous bead collection, the drift nets collected a higher number of beads per cubic meter of water filtered (mean 2.93, standard deviation 0.07) than the MECs (mean 1.29, standard deviation 0.46) (Mann-Whitney U-test, U = 2,075, two-sided $p < 0.001$ (Figure 4.44). A Wilcoxon signed rank test on the paired untransformed lateral comparison MEC data revealed no significant difference in bead density between left and right river banks over the duration of the experiment (Z = -1.568, two-sided $p = 0.117$) (Figure 4.45). In addition, there was no significant difference between the drift net at the surface of the water column and the drift net at the bottom of the water column (Wilcoxon signed rank test, df = 28, Z = -0.541, two-sided $p = 0.589$). Assuming the drifting particles were not negatively buoyant, samples collected by MECs at the water's surface should adequately represent drifting silvery minnow eggs in the channel.

The higher rate of bead collection by the drift nets may be an artifact of changing water filtration rates throughout the sampling period. The screens of the MECs were cleared frequently throughout the 15-minute sample period, maintaining a relatively constant filtration rate. By contrast, drift nets could effectively be sampled for only about five minutes because of debris accumulation, so the rate of filtration decreased throughout the sample period. If water velocity was measured after debris began to accumulate, the average water filtration rate would be underestimated and the bead collection rate overestimated.

The MECs are considered a more reliable device for quantitatively collecting beads and silvery minnow eggs than drift nets because of the MEC's relatively consistent filtration rate (Altenbach et al. 2000). It is possible to mount a flow meter in the mouth of a MEC or drift net to measure the total flow through the collector (e.g., General Oceanics Model 2030, General Oceanics, Inc., Miami, Florida); however, researchers have found these flow meters to be unreliable due to frequent propeller jamming, which results in lost measurements. Measurement of water velocity using the FloMate velocity meter was more reliable, but it is unclear which method provides the most accurate estimates of the amount of water filtered.

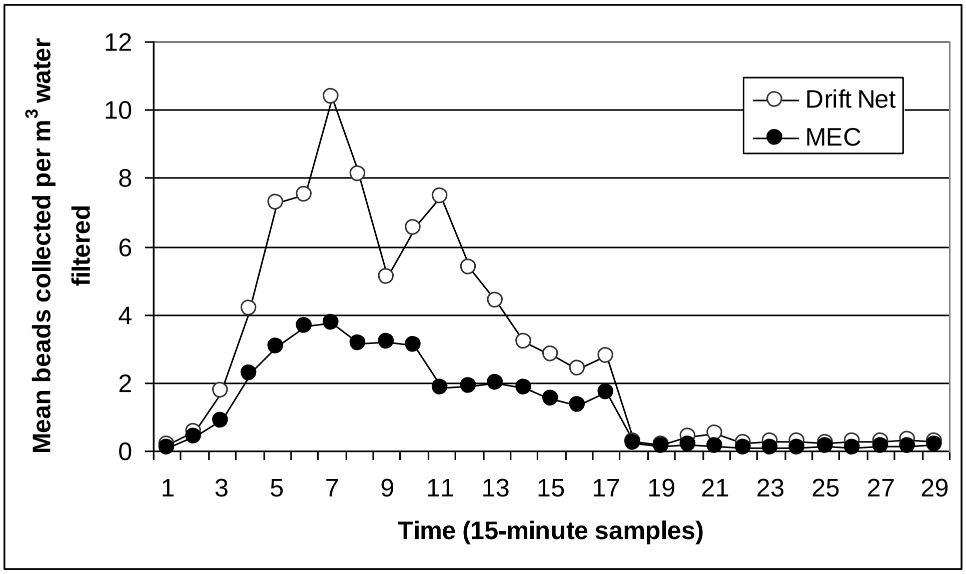


Figure 4.44. Comparison of mean bead capture rate between drift nets and MECs simultaneously sampling the main channel of the Rio Grande at the SDC. Dataset: SWCA-AWcomment_Vertical_Drift_Data_0607 SB.xls.

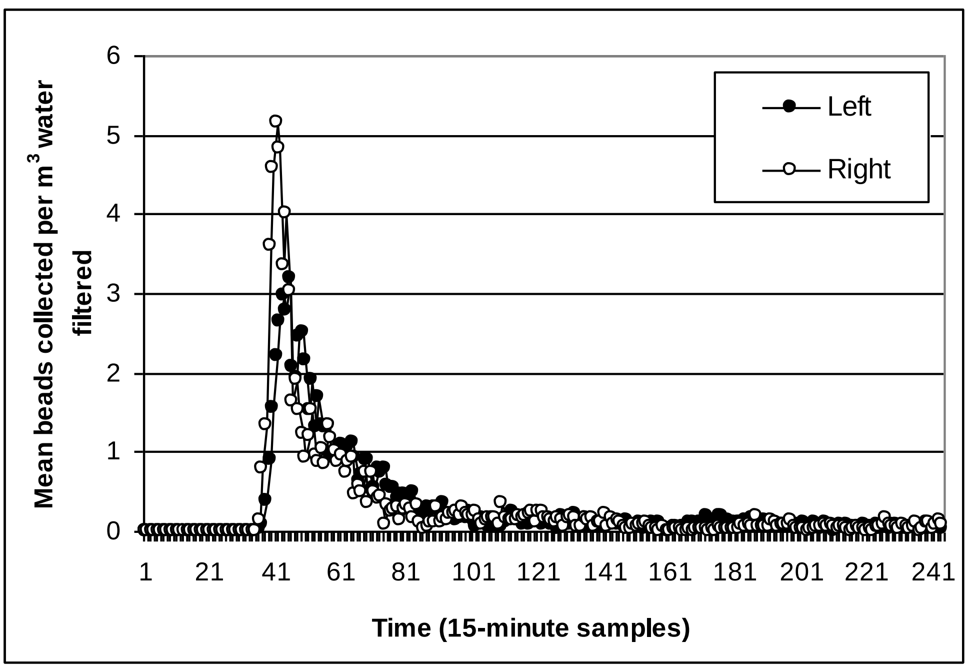


Figure 4.45. A comparison of pairs of MECs simultaneously sampling near the right and left banks of the Rio Grande at the SDC. Dataset: SWCA-Lateral comparison.xls.

4.8 DATASETS 35 TO 37

35. USFWS – Egg_Monitor_04.mdb
36. USFWS – Egg_Monitor_05.mdb
37. USFWS – Egg_Monitor_06.mdb

4.8.1 RELEVANT REPORTS

USFWS (2004, 2005a, 2006)

4.8.2 STUDY OBJECTIVES

- Document the periodicity of silvery minnow spawning and develop an index expressive of reproductive effort based on rates of capture of downstream-drifting eggs.

4.8.3 DOCUMENTATION OF SAMPLING GEARS AND METHODS

Drifting eggs and larvae were collected with MECs, which were placed in the river current at depths that could be accessed by wading. Flow meters were usually attached to each MEC that measured water velocity over time for calculation of water volume filtered and eggs/m^3 of water.

4.8.4 STATISTICAL POWER OF SAMPLING GEARS AND METHODS

Probability of Egg Captures—Given the inconsistent and irregular pattern of capturing silvery minnow eggs with MECs, a probability density function was developed to help predict the effort necessary (as one-hour samples) to capture (detect) eggs in the river. Index values of the number of silvery minnow eggs in the downstream drift (i.e., CPUE) for 2004 to 2006 were highly variable, i.e., CV > 0.20. The average probability of detecting an egg in a one-hour sample trial was 0.41. Given the average density of eggs in the drift over the three years of data examined, 50 one-hour sample trials are necessary to achieve a probability of 1.0 of detecting at least one egg (Figure 4.46). This minimal level of sampling was necessary on average over the three years of data examined to declare that it was improbable that no eggs existed in the drift with zero observed successes.

Figure 4.46. Count-specific and exceedance probabilities (binomial) of collecting silvery minnow eggs in MECs, given 50 hourly sample trials and a probability of success of 0.41, i.e., the sample effort required to achieve a probability of 1.0 of observing one or more eggs with the given probability of detection. Datasets: USFWS – Egg_Monitor_04.mdb, USFWS – Egg_Monitor_05.mdb, USFWS – Egg_Monitor_06.mdb.

Considering the probability function described above, it appears that there were numerous past sampling efforts for drifting silvery minnow eggs in which the level of effort was insufficient to declare that it was improbable that no eggs existed when the observed number of successes (i.e., eggs) was zero. This compromises the strength of statistical inferences because of the insufficient sampling results in datasets characterized by a large number of zeros, hence an inability to normalize the data through transformation.

Information regarding the level of variability in egg CPUE can be used to estimate the required sample size at some level of significance (e.g., $\alpha = 0.05$). For example, assuming that future sampling efforts produce results with similar variability between sampling units, a sample of 7,808 would be required to detect a difference between sampling means of 50 eggs (i.e., approximately 20% of mean) with a power (β) of 0.80 at $\alpha = 0.05$.

Relationship of Egg Density to Flow—Reach-specific paired observations of silvery minnow egg CPUE and flow were examined from 2004 to 2006—a sequence of years representing contrasting spring hydrologic regimes (Figure 4.47). Weekly averages were restricted to weeks 20 through 26, nominally from the first full week of May and extending through the last full week of June. Linear regression and correlation analysis was employed to explore how rates of capture of downstream-drifting eggs in MECs varied with flow. Linear regression is typically used in biology to describe the relationship between a predictor and independent variable. Correlation determines if two datasets are dependent on each other. A negative Spearman rank-order correlation (-0.609) and *p*-value of 0.002 for silvery minnow egg CPUE indicate that egg CPUE tends to decrease as flow increases up to 3,110 cfs. In contrast, silvery minnow egg CPUE was low but relatively constant over a wide range of flows over 3,109 cfs. The coefficient of determination (r^2) for the regression line that was fitted to paired values of egg CPUE at flows less than 3,110 cfs was only 0.1872, which indicates that only about 19% of the variation in egg CPUE was associated with differences in flow. This low value suggests that factors in addition to silvery minnow spawning and flow were accountable for rates of egg drift. This possibility can be explored in the future by means of multiple regression in instances when more than one predictor variable is recorded for incorporation in the analysis.

It has been suggested that the negative correlation of egg CPUE with increases in flow is a simple consequence of dilution. To test this hypothesis, values of egg CPUE were standardized to a common value for flow to see how regression and correlation values would be affected. Although the scale of egg CPUE changed with standardization to flow (10,000 cfs), basic fidelity of the pattern of the standardized regression to that of the original graph was maintained. The coefficient of determination actually decreased, while the Spearman rank-order correlation (-0.648) and *p*-value (0.001) suggest a marginally stronger dependency between datasets. Variation of observed egg CPUE as a dilution function of flow cannot be unequivocally demonstrated with the datasets examined.

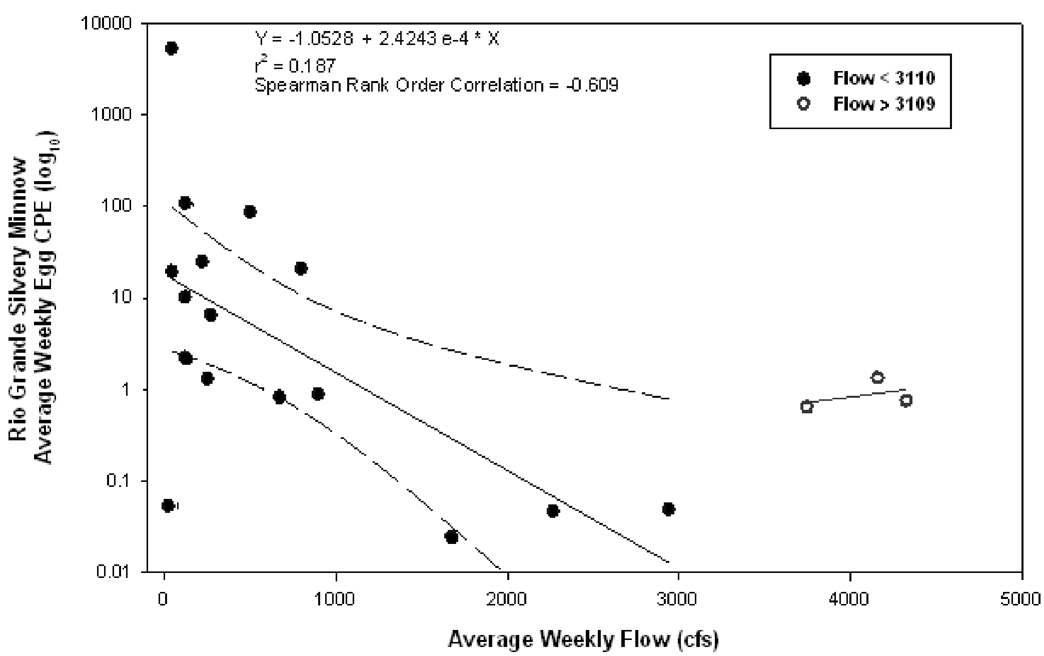


Figure 4.47. Average weekly CPUE of silvery minnow eggs (eggs per trap hour) as a function of average weekly flow of less than 3,110 cfs (filled circles) and greater than 3,109 cfs (open circles). Dashed 95% confidence bands border the solid regression line for egg CPUE.

Egg Density as a Predictor of Year-class Strength—The rate of silvery minnow eggs observed in an MEC sampler may be interpreted as a predictor of year-class strength. We tested the validity of this assumption by blocking the data to eliminate systematic variation caused by confounding effects from environmental conditions that are not specific to the effects in question. Data from sample sites were blocked to exclude sites subject to extreme environmentally driven fluctuations in population growth rate. Also, samples were excluded based on insufficient sampling effort necessary to achieve a probability of 1.0 of detecting at least one egg (see Figure 4.46).

Using this dataset, the log-log regression of October post-larval silvery minnow CPUE on silvery minnow egg CPUE during the previous spring (weeks 20–26) indicates that MEC CPUE of drifting silvery minnow eggs is negatively correlated with year-class strength (Figure 4.48), which is the opposite of what has commonly been presumed. These results indicate that MEC CPUE of drifting silvery minnow eggs is a poor index of anticipated year-class strength. Further research may be warranted and beneficial to better understand this apparent relationship.

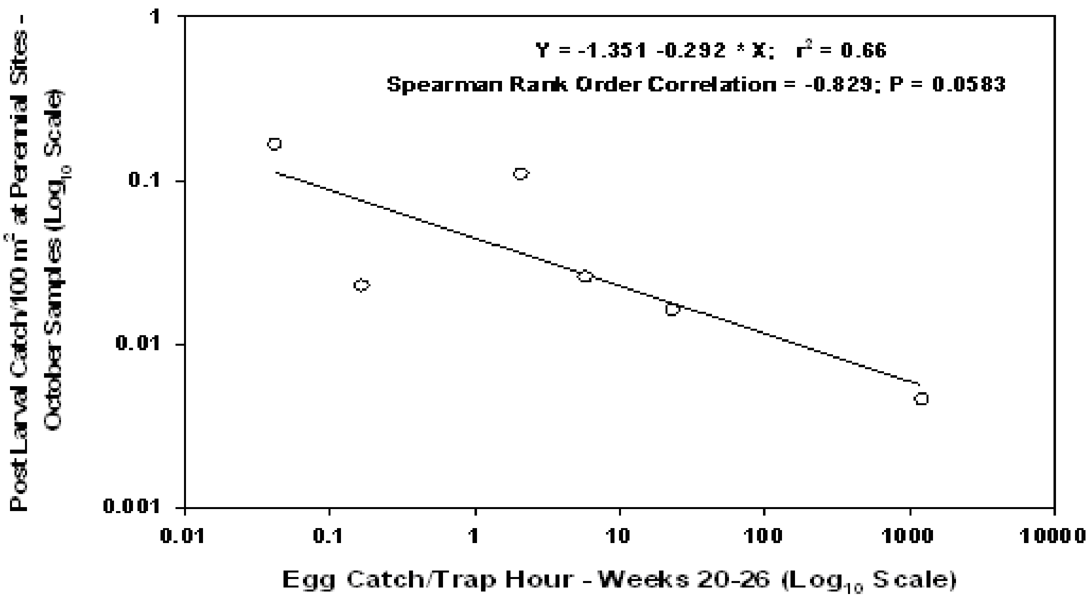


Figure 4.48. The log-log regression of October post-larval CPUE for silvery minnow on egg CPUE during the previous spring (weeks 20–26).

4.9 ANALYSES ACROSS DATASETS

4.9.1 FISH SIZE SELECTION BY GEAR TYPES

Pool of All Samples—Lengths of all silvery minnow captured with seines, electrofishing, and fyke nets were compared to determine if these gears selected different size fish, i.e., gear selectivity. Mean standard lengths of fish captured with seines (32.4 mm), electrofishing (40.0 mm), and fyke nets (52.8 mm) were significantly different among all comparisons (Tukey HSD pairwise comparison all *P* < 0.001) (Table 4.30). Fyke nets captured the largest fish (22–92 mm), compared to electrofishing (19–89 mm) and seine nets (5–87 mm) (Figure 4.49).

Table 4.30. Average Sizes and Ranges of Standard Lengths of Silvery Minnow Captured with Seines, Electrofishing, and Fyke Nets

Gear	Sample Size	Mean Standard Length (mm) ± 95% C.I.	Range in Standard Length (mm)
Seines	29,580	32.4 ± 0.1	5–87
Electrofishing	3,850	40.0 ± 0.4	19–89
Fyke Nets	6,898	52.8 ± 0.1	22–92

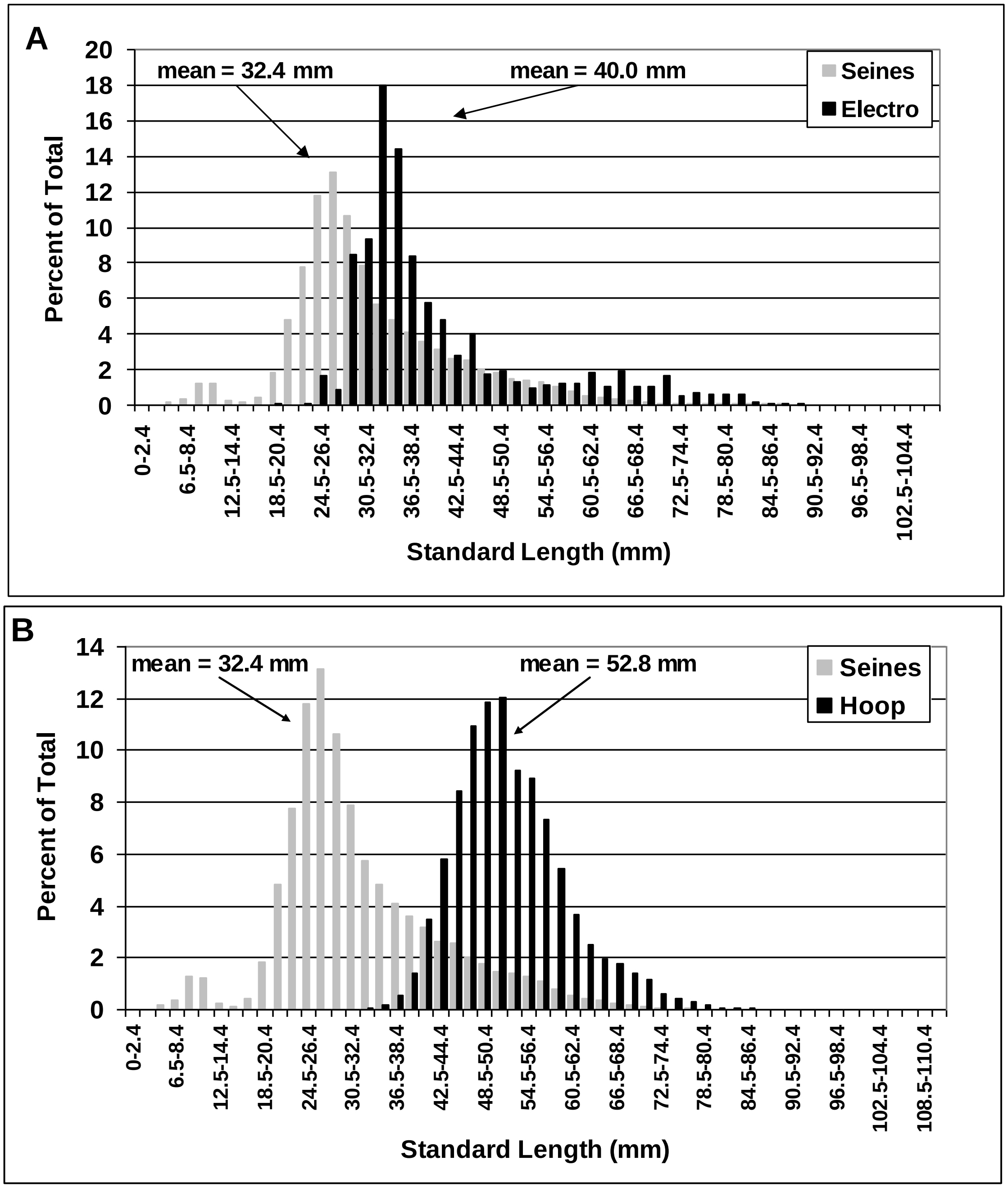


Figure 4.49. Percentage of silvery minnow in 2-mm standard length intervals captured with (A) seines and electrofishing and with (B) seines and fyke nets. Datasets: Seines: ASIR-AllRGSMLengths_Raw.xls; Electrofishing: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls; Fyke nets: SWCA-BOR_Floodplain_08_MDH.mdb, SWCA-NMISC_Nursery_Habitat.mdb.

Datasets were incomplete with regard to environmental, sampling, and resource variability, and it is not possible to discern the reasons for this size selectivity. The most reasonable cause can be attributed to gear type, technique, and habitat sampled; seining and electrofishing are active gears used in a variety of habitats, and fyke nets are passive gears usually set in floodplains. The most commonly used seines with 5-mm (3/16-inch) mesh can capture small silvery minnow in their first month of life, but may not effectively capture the faster swimming larger fish. Although the mesh size of fyke nets was 6.4 mm (¼ inch), this passive gear allows fishes of all sizes to swim into the net. Size of fish caught with electrofishing was probably determined by the interaction of an unknown mesh size for capture nets and the numbers and behavior of the netters. The variables that drive gear selectivity are numerous, but if samples are taken year-around and from a similar array of habitat types and flows, it appears that no single gear type in use captures the full range of sizes of silvery minnow available in the river.

Pool of All August Seine and Electrofishing Samples—To reduce the effect of season on lengths of silvery minnow captured with different gears, we compared captures for the same months. Lengths of all silvery minnow captured with seines and electrofishing during August were compared to determine if these gears selected different size fish, i.e., gear selectivity. Mean standard lengths of fish captured with seines (30.09 mm) and electrofishing (34.78 mm) were significantly different between the gear types (two sample t-test $p < 0.001$) (Table 4.31). Seines captured significantly smaller fish and a greater size range (15–87 mm) compared to those captured with electrofishing (19–87 mm) (Figure 4.50).

Table 4.31. Average Sizes and Ranges of Standard Lengths of Silvery Minnow Captured during August with Seines and Electrofishing

Gear	Sample Size	Mean Standard Length (mm) ± 95% C.I.	Range in Standard Length (mm)
Seines	7,169	30.09 ± 0.2	15–87
Electrofishing	2,859	34.78 ± 0.2	19–87

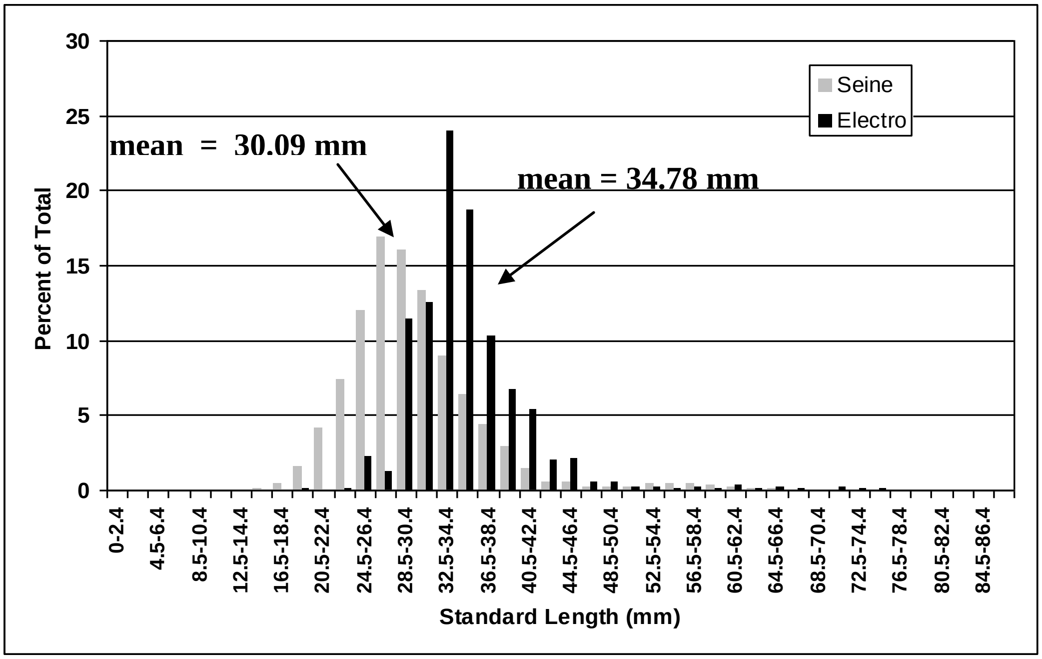


Figure 4.50. Percentage of silvery minnow in 2-mm standard length intervals captured with seines and electrofishing during August. Datasets: Seines: ASIR-AllRGSMLengths_Raw.xls; Electrofishing: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls.

Albuquerque Reach August 2007 Seine and Electrofishing Samples—To reduce the effect of reach on lengths of silvery minnow captured with different gears, lengths of all silvery minnow captured in the Albuquerque Reach during August 2007 with seines and electrofishing were compared to determine if these gears selected different size fish. Mean standard lengths of fish captured with seines (27.93 mm) and electrofishing (33.79 mm) were significantly different (two sample t-test $p < 0.001$) (Table 4.32). Seines captured significantly smaller fish (18–45 mm) compared to those captured with electrofishing (20–87 mm) (Figure 4.51).

Table 4.32. Average Sizes and Ranges of Standard Lengths of Silvery Minnow Captured from the Albuquerque Reach during August 2007 with Seines and Electrofishing

Gear	Sample Size	Mean Standard Length (mm) ± 95% C.I.	Range in Standard Length (mm)
Seines	598	27.93 ± 0.3	18–45
Electrofishing	1,226	33.79 ± 0.3	20–87

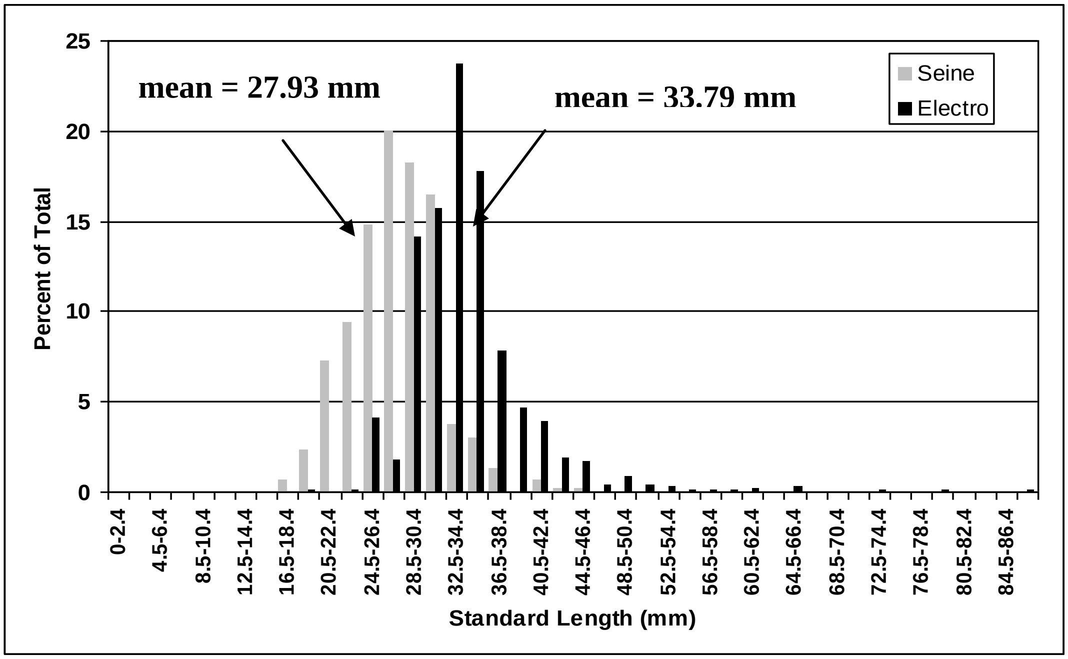


Figure 4.51. Percentage of silvery minnow in 2-mm standard length intervals captured with seines and electrofishing from the Albuquerque Reach during August 2007. Datasets: Seines: ASIR-AllRGSMLengths_Raw.xls; Electrofishing: USBR-fish_collection-2007.xls.

Pool of May and June Seine and Fyke Net Samples—Lengths of all adult silvery minnow (young-of-year excluded) captured during May and June with seines and fyke nets were compared to determine if these gears selected different size fish. Mean standard lengths of fish captured with seines (50.21 mm) and fyke nets (53.5 mm) were significantly different (two sample t-test $p < 0.0001$) (Table 4.33). Seines captured significantly smaller fish (28–75 mm) compared to those captured with fyke nets (32–94 mm) (Figure 4.52).

Table 4.33. Average Sizes and Ranges of Standard Lengths of Silvery Minnow Captured from the Albuquerque Reach during May and June with Seines and Fyke nets.

Gear	Sample Size	Mean Standard Length (mm) ± 95% C.I.	Range in Standard Length (mm)
Seines	1,100	50.21 ± 0.4	28–75
Fyke Nets	11,327	53.50 ± 0.1	32–94

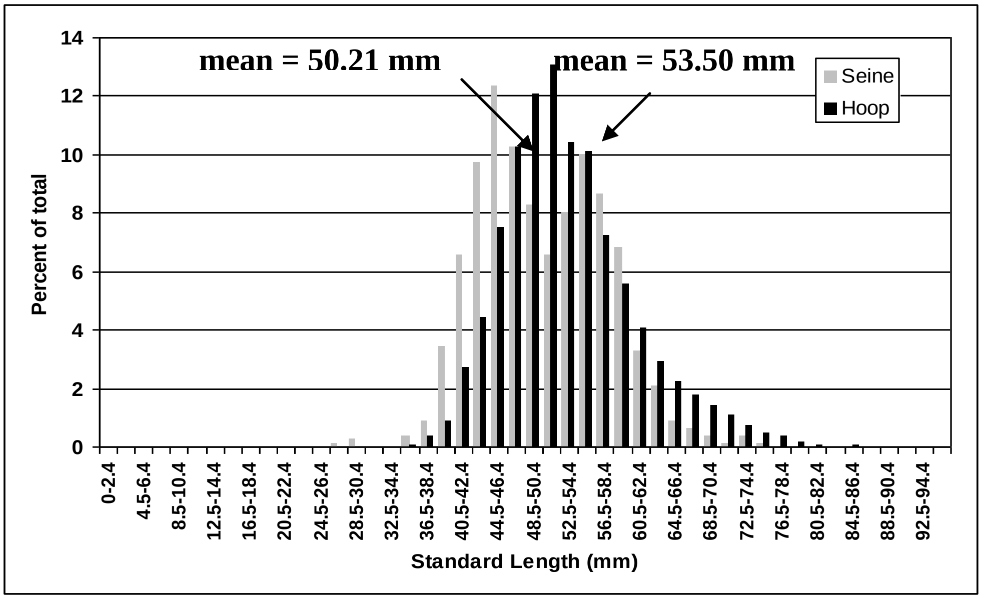


Figure 4.52. Percentage of silvery minnow in 2-mm standard length intervals captured with seines and fyke nets during May and June 2007. Datasets: Seines: ASIR-AllRGSMLengths_Raw.xls; Fyke nets: SWCA-BOR_Floodplain_08_MDH.mdb, SWCA-NMISC_Nursery_Habitat.mdb.

4.9.2 Effect of Reach on Species Richness

Indices of fish community composition and fish species richness can be derived from a number of sample methods and sample gear types currently employed in the Middle Rio Grande. Although species composition is known to increase with distance downstream (Sublette et al. 1990; Oberdorff et al. 1995; Matthews 1998), seine and electrofishing samples indicate the opposite pattern (Figure 4.53). Estimates of species richness actually decrease by reach with increasing distance downstream.

Historically, the richness of the probable native fish fauna of the Rio Grande in New Mexico was a predictable function of basin size (Hatch et al., in prep.). As such, that relationship can provide a basis for the measure of change in a fish community over time that is indicative of environmental stress. It is well known that environmental stressors can lead to alterations in fish community richness (e.g., Bayley and Li 1996).

The contemporary reach-specific median counts of species from seine samples are consistently small relative to the larger assemblage of species known from each reach. Figure 4.54 indicates a positive correlation of seine sample effort and the cumulative number of species sampled. On average, species richness is substantially underrepresented with sample efforts less than 700 m^2, whereas diminished addition of previously unsampled species occurs with sample efforts in excess of 800 m^2. However, for most datasets examined, it is impossible to determine how well a species richness estimate measured true species richness in a community. Site-specific habitat heterogeneity and the relative abundance (numeric evenness) of each species will invariably result in unique sampling curves.

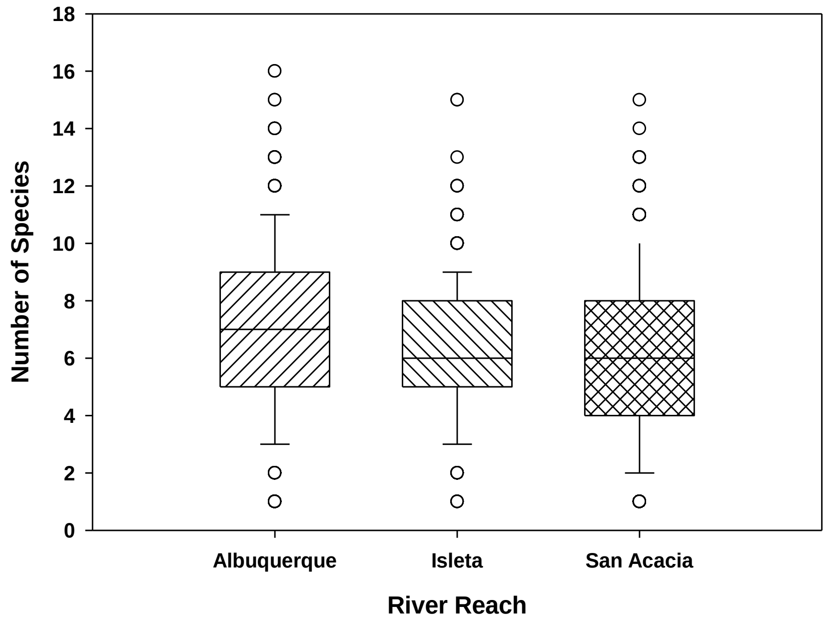


Figure 4.53. Species richness for main channel seine samples over the period of 1993–1997 and 1999–2008. The bottom and top boundaries of each box indicate the 25th and 75th percentiles, and the error bars below and above the box indicate the 10th and 90th percentiles, respectively. The circle symbols represent outlying points. Dataset: ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

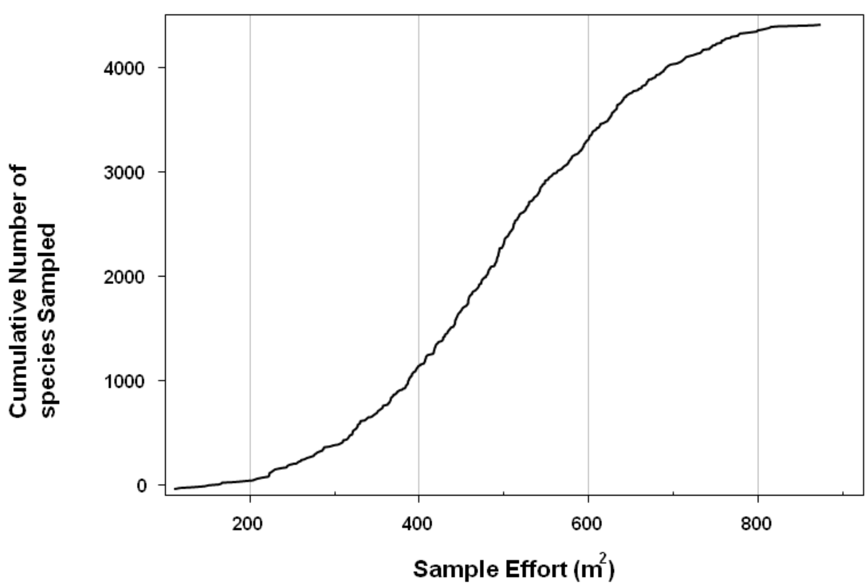


Figure 4.54. Species richness as a function of sample effort for main channel seine samples from the Albuquerque Reach over the period of 1993–1997 and 1999–2008.

4.9.3 EFFECT OF GEAR TYPE AND SAMPLE EFFORT ON SPECIES RICHNESS

Comparisons were made between estimates of species richness (i.e., species counts) obtained from different sample gear types. A log-linear function was used to predict sample sizes necessary for capturing the total numbers of species documented for the Middle Rio Grande. The log-linear function is non-asymptotic and best describes the pattern of species accumulation with sequential samples (Kwak and Peterson 2007). Altogether, 36 species of fish were reported by the various studies (see Table 4.2). Species accumulation curves for sequential fish samples collected with seines in 1993, electrofishing during 2001 to 2007, and fyke nets in 2008 revealed a dramatic difference in the predicted number of samples needed to capture all 36 species (Figure 4.55). Estimated numbers of samples to capture all 36 species with seines, electrofishing, and fyke nets were approximately 740, 2,350, and 12,250, respectively, although sample size to capture 75% of species (26) was considerably less at 110, 325, and 1,025, respectively.

Estimates of species richness appear to decrease by reach in a downstream direction. Although the median number of species detected in the Albuquerque and Isleta reaches was about the same (7), the majority of sampling efforts resulted in a range of species detected from the Albuquerque Reach (5–10) that was greater than in the Isleta Reach (5–8). For the most downstream San Acacia Reach, the median number of species detected (6) was lower. There are likely biological reasons for this longitudinal phenomenon and not necessarily gear bias.

An examination of species richness and diversity of the various gear types used to sample fish in the Middle Rio Grande is important in understanding which gear or gears are best suited for characterizing the fish assemblages of this river system. Equally important is an understanding of the variation in species richness among reaches of the Middle Rio Grande.

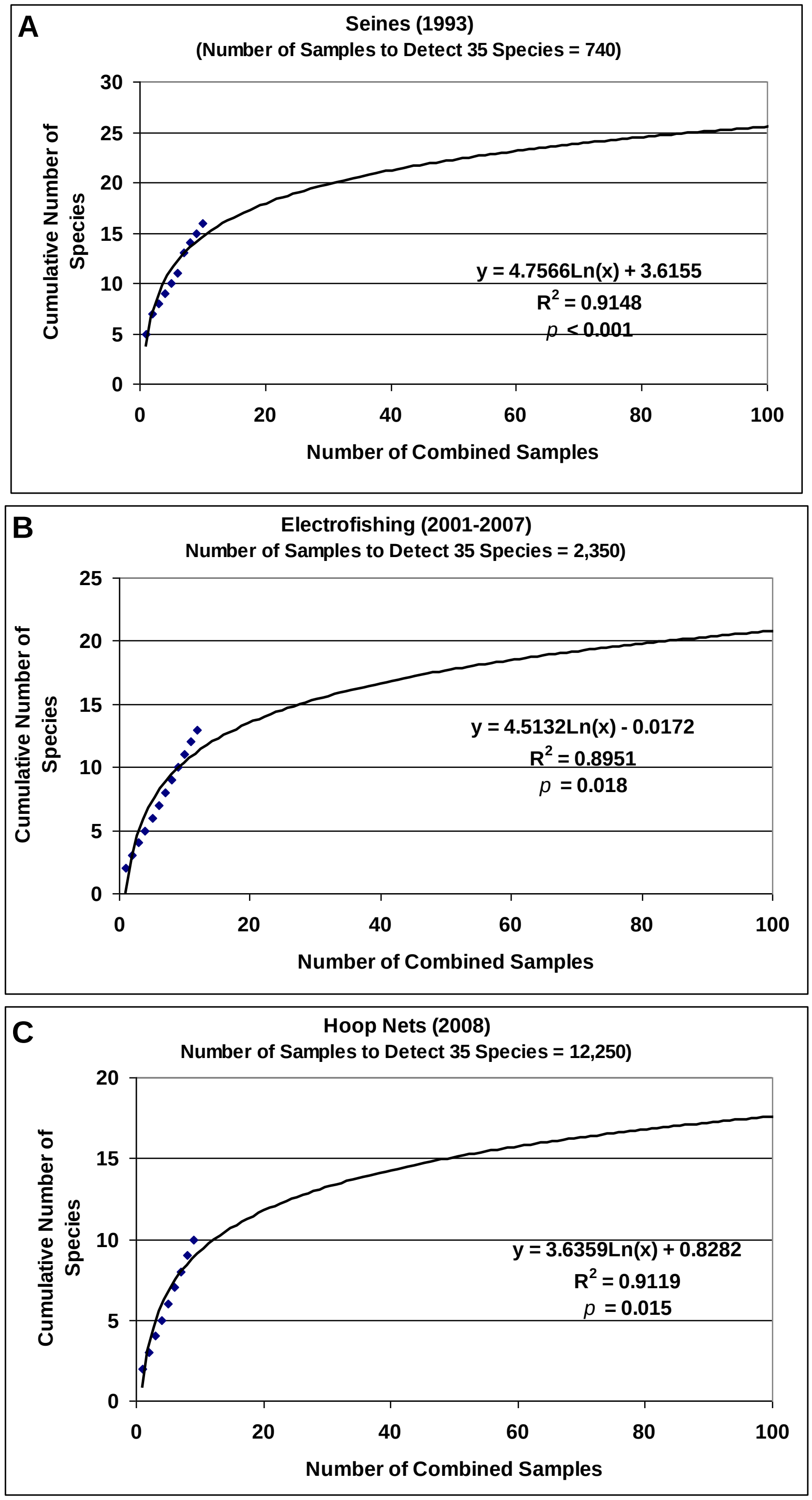


Figure 4.55. Species accumulation curves for sequential fish samples collected with (A) seines in 1993, (B) electrofishing during 2001–2007, and (C) fyke nets in 2008. A total of fish species was captured altogether with all gears.

4.9.4 EFFECT OF RIVER FLOW ON ESTIMATED SPECIES RICHNESS

Linear regression and correlation analysis was employed to compare statistical properties of species richness estimates obtained from electrofishing and seine samples, in reach-specific main channel habitats, and over a broad range of flows (cfs). Analysis is restricted to the Albuquerque and Isleta reaches where the effects of water discharge on estimates of species richness can be investigated due to highly variable hydrological conditions that coincide with fish collections. This analysis was not conducted for the San Acacia Reach because flow did not exceeded 500 cfs on dates of seine sampling (1993–1997 and 1999–2008).

Seining—Species richness was estimated with seine data for the Albuquerque and Isleta reaches over flow ranges of 117 to 5,630 and 21 to 1,650 cfs, respectively (Figure 4.56). Normality (Shapiro-Wilk) and constant variance tests failed for the bivariate plot of species richness estimates from seine samples and flow within the Albuquerque Reach, but were accepted for datasets from the Isleta Reach. Although no significant relationship was found between species richness estimates from seine samples and flow within the Albuquerque Reach ($p > 0.050$), a significant negative correlation (Spearman rank-order correlation = -0.247, $p = 0.008$) existed for the Isleta Reach. These findings show that flow may affect the number of species that can be detected with seining.

Electrofishing—Species richness was estimated with electrofishing data for the Albuquerque and Isleta reaches over flow ranges of 117 to 5,630 and 21 to 1,650 cfs, respectively (Figure 4.57). Normality (Shapiro-Wilk) and constant variance tests were accepted for datasets from both reaches. Although no significant relationship was found between species richness estimates from electrofishing samples and flow within either the Albuquerque or Isleta reach ($p > 0.050$), a significant negative correlation (Spearman rank-order correlation = -0.243; $p = 0.005$) was found for the relationship of species counts to flow. These findings show that flow is a variable that affects the numbers of species that can be detected with electrofishing.

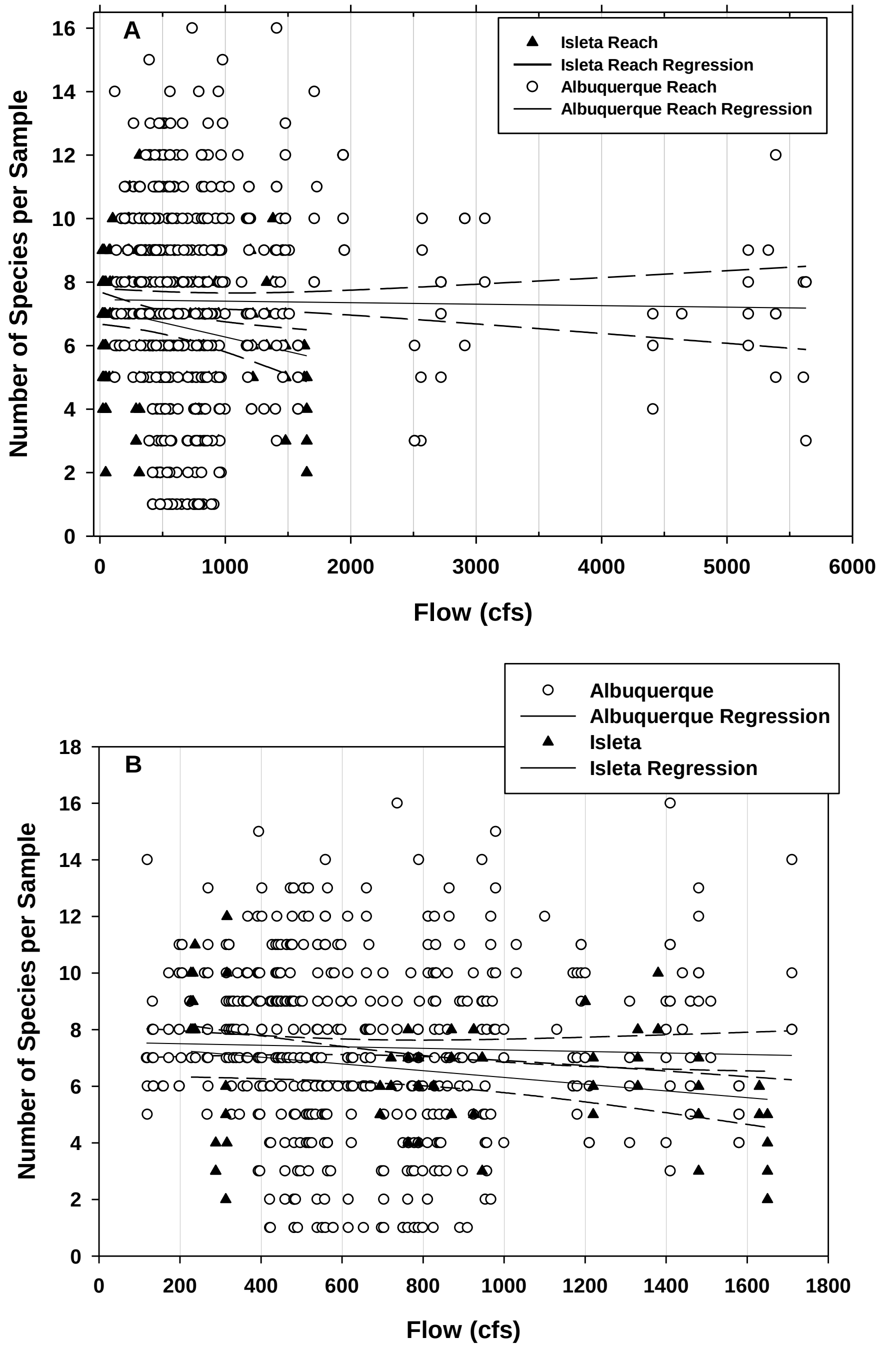


Figure 4.56. Variation in the number of species sampled with seines in main channel habitats of the (A) Albuquerque and Isleta reaches over the entire realized range of flow over which sampling was conducted and (B) over a constrained range of flow (117–1,710 cfs) that matches the more constrained range of flow in which electrofishing sampling was conducted (see Figure 4.57). Analysis was restricted to datasets with common data values for river reach, year, and month for the period from 1993–2008. Dataset: ASIR-AllRGSMLengths_Raw.xls.

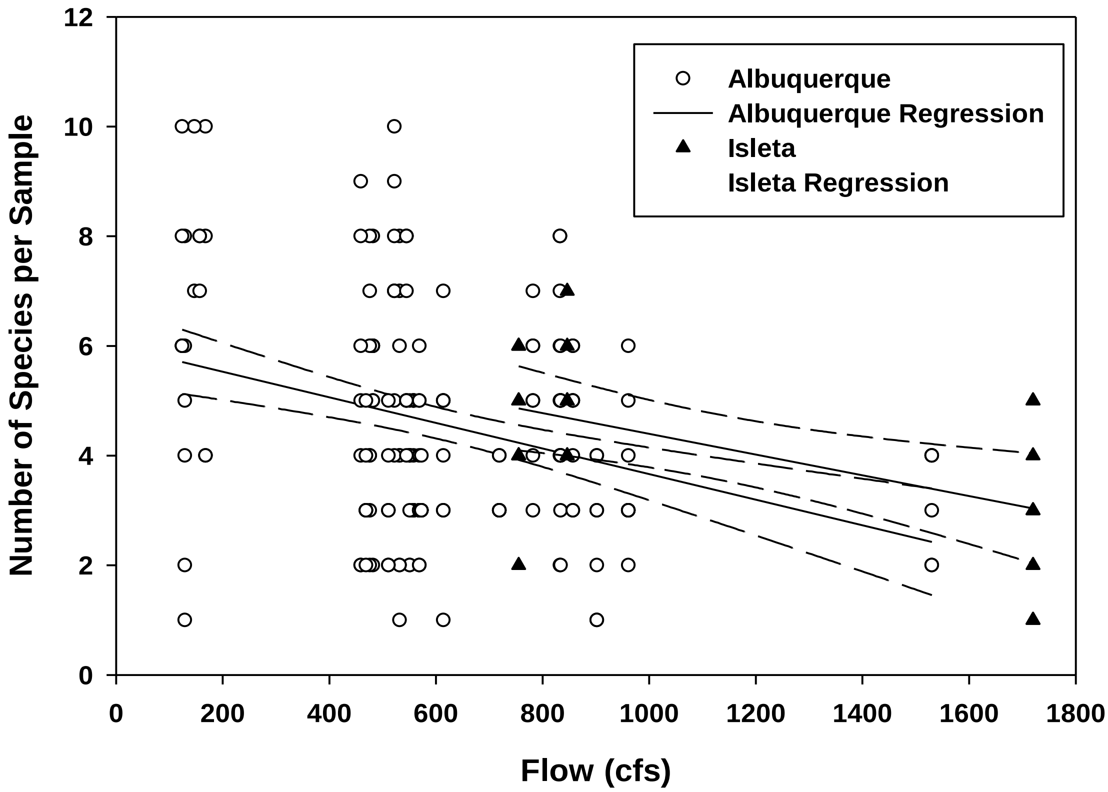


Figure 4.57. Variation in the number of species sampled with electrofishing in main channel habitats of the Albuquerque and Isleta reaches over the entire realized range of flow over which sampling was conducted (117–1,710 cfs). Analysis was restricted to datasets with common data values for river reach, year, and month for the period March 1, 2001–August 23, 2007. Dataset: SWCA-Los_Lunas_Floodplain_2008.mdb.

5.0 FINDINGS

The objectives of this assessment report were designed to identify and evaluate the following elements:

4. Sampling gears and methods for Rio Grande fish surveys.
5. Sampling techniques for representative sampling of silvery minnow size range.
6. Sampling techniques for silvery minnow population monitoring and estimation, recruitment and survival, PVA modeling, evaluation of habitat restoration, and adaptive management.

The following is a summary of the findings of this assessment for each of the above elements.

5.1 IDENTIFICATION AND EVALUATION OF SAMPLING GEARS AND METHODS FOR RIO GRANDE FISH SURVEYS

Four principal gear types have been used to sample the fish community of the Middle Rio Grande: seines, electrofishing, fyke nets, and egg collectors. Minnow traps, dip nets, and kick screens have also been used, but the numbers of sample are too small for evaluation. Average number of sites sampled per day was greatest for electrofishing surveys and lowest for fyke net surveys (Table 5.1). The average number of fish captured on each sampling date was greatest for seines and lowest for electrofishing while fyke net surveys have resulted in an intermediate number of fish collected on each sample day. Number of samples (i.e., sites) required to obtain a CV of 0.25 is higher for seines than electrofishing. A power analysis has not been completed for fyke net samples, so this information is unavailable for this gear type. Of 36 fish species reported altogether, seines, electrofishing, and fyke nets captured 35, 26, and 20 species, respectively (see Table 5.1). The proportions of species caught by gear type are markedly different. Red shiner was most commonly collected with seines, while the silvery minnow was most commonly collected with electrofishing and fyke nets. The probability of collecting silvery minnow may have been higher for electrofishing and hoop nets because these gears targeted the low-velocity habitats where silvery minnow density appears to be highest. Also, the sizes of silvery minnow caught with the three gear types differed significantly, with hoop nets and electrofishing detecting larger fish than was detected using seines alone. These analyses indicate that more than one gear type is necessary to fully monitor the silvery minnow, as well as the fish assemblages of the Middle Rio Grande.

Small-mesh beach seines (3.1 m × 1.8 m [10 × 6–foot], 5-mm [3/16-inch] mesh) have been used to monitor the silvery minnow since 1993 with mean annual CPUE estimates as numbers of fish per 100 m^2. This is the longest-running fisheries dataset for the Middle Rio Grande and provides an index to species abundance and patterns of abundance. The mean annual estimates are based on pools of about 10 seine hauls at each of about 20 fixed sites per year during October. Statistical analysis and bootstrapping show that precision of mean CPUE can be improved with increased sample size, possibly by tabulating individual seine hauls rather than pooling all hauls at a given site. Additional seine samples have been collected approximately monthly since 1993 that can help to assess and monitor fish community richness and diversity. The precision of seine samples taken year-around is lower than that for samples taken in October, but as with October samples, data precision can be improved substantially with increased sample size.

Stocked silvery minnow have been monitored since 2002 with small-mesh beach seines to determine temporal and spatial upstream and downstream movement within and among reaches. Primarily these surveys are intended to provide guidance for augmentation activities to maximize survival of silvery minnow. Data recorded for these surveys includes number of fish species collected by seine haul and mesohabitat type for each survey site. Statistical analysis and bootstrapping showed that precision of mean CPUE can be improved with increased number of seine hauls. This dataset could be explored further to determine the optimal allocation of sampling effort among mesohabitats at each site.

Fish community surveys have been conducted with raft and ATV electrofishing since 2001 and constitute the only ongoing dataset of information for fish assemblages from throughout mesohabitats of the main channel. The variability of these data is high, but power analysis indicates that precision can be increased substantially with greater sample size. These data can be used to derive community-based species diversity indices, such as Shannon-Wiener.

Recent projects to restore fisheries and riparian habitat in the Middle Rio Grande elevate the importance of appropriate fish sampling to monitor fish response to these and other management actions. Evaluation of fish populations associated with floodplain restoration and habitat enhancement with large woody debris has been conducted since 2005. These evaluations have employed a variety of sampling gears, including seines, fyke nets, and electrofishing. As with the other datasets, the precision of these data is low; however, mean size of silvery minnow captured with fyke nets from floodplain habitats is larger than mean size of silvery minnow captured with beach seines.

Fish rescue data for silvery minnow have been collected annually since 2001 as the total numbers of fish salvaged and translocated. These data usually do not include fish lengths or measures of effort, and their utility is limited to numbers of fish salvaged and/or lost for years of river drying. Age-specific reduction in numbers across year classes may be useful for estimates of survival. Monitoring of silvery minnow eggs in river drift has been conducted annually since 2004. These data may have utility and importance when reconciling successful from failed hatches of silvery minnow through analysis of length data for determination of hatching dates.

Table 5.1. Gear Comparison Table for the Three Major Gear Types Used to Sample the Middle Rio Grande Fish Community

Gear	Average Number of Sites Sampled/ Day	Average Number of Fish Captured/Day	Number of Samples to Obtain CV 0.25	Top 5 Species Captured	Number of Species Collected	Silvery Minnow Length Range (mm)
Seines	4	1,378	450	1. Red shiner 2. Silvery minnow 3. Western mosquito fish 4. Fathead minnow 5. White sucker	35	5–87
Electrofishing	7	157	120	1. Silvery minnow 2. Common carp 3. River carpsucker 4. White sucker 5. Channel catfish	26	19–89
Fyke Nets	3	677[a] 148[b]	NA	1. Silvery minnow 2. Common carp 3. Red shiner 4. Western mosquito fish 5. Fathead minnow	20	22–92

[a] 24-hour fyke net soak time. [b] 3- to 5-hour fyke net soak time. Dataset: ASIR-AllRGSMLengths_Raw.xls; RGSM_Pop_mon_Query_PVAgoodman.xls; Electrofishing: USBR-fish_collection-2001.xls, USBR-fish_collection-2002.xls, USBR-fish_collection-2003.xls, USBR-fish_collection-2004.xls, USBR-fish_collection-2005.xls, USBR-fish_collection-2006.xls, USBR-fish_collection-2007.xls; Fyke nets: SWCA-NMISC_Nursery_Habitat.mdb.

5.2 Identification and Evaluation of Sampling Techniques for Representative Sampling of Silvery Minnow Size Range

An important finding of this assessment is that mean lengths of silvery minnow caught with seines, electrofishing, and fyke nets were significantly different. Average size was smallest for fish collected with seines, and the largest for fish collected with fyke nets; average size of fish caught with electrofishing were intermediate. Where possible, all sampling efforts should record standard length data from a full representation of sizes of silvery minnow. This size information is important for understanding gear selectivity and size and age structure of the populations. Use of modal progression analysis is a promising tool for estimating and evaluating age, growth, and survival of fish from lengths taken at regular monthly intervals.

5.3 Identification and Evaluation of Sampling Techniques for Silvery Minnow Population Monitoring and Estimation, Recruitment and Survival, PVA Modeling, Habitat Restoration, and Adaptive Management

5.3.1 Population Monitoring

Monitoring of the silvery minnow is currently conducted under a fixed block design in which sampling is completed annually in October at fixed locations within each of three reaches. Precision of these data is low (CV > 0.25), but our analyses show that increasing sample size to 100 to 150 samples could markedly improve precision. This may be accomplished by recording individual seine samples instead of pooling all samples at a given site. Analyses of these data show an approximately proportional distribution of samples by reach and river length, and the least variability in mean CPUE in early spring and fall months, including October, which is the month of monitoring.

The electrofishing survey data have also revealed valuable inferences into the possible development of a monitoring program for the fish community with electrofishing. Although the current dataset is imprecise, our analyses show that increased sample size could markedly improve precision. The Shannon-Wiener diversity index is highly sensitive to sample size, and the precision of this community index can also be markedly improved with increased sample size.

5.3.2 Population Estimation

Data for estimating population size of silvery minnow were not received for this assessment. Two methods of population estimation are most commonly applied and could be used in the Middle Rio Grande. The mark-recapture method requires marking individuals released into the wild population to provide a proportion of marked to unmarked fish through subsequent capture efforts. The second method is based on a depletion effect of subsequent removals of fish from an enclosed area, which was implemented for the silvery minnow in the Middle Rio Grande in 2006, 2007, and 2008 (Dudley et al. 2007, 2008, 2009). Evaluating population estimation requires analyses of original capture data in order to examine capture probabilities from subsequent removal efforts.

5.3.3 Recruitment and Survival

Data structured to specifically estimate recruitment and survival of fish were not received for this assessment. Monthly length measurements of silvery minnow and differences in numbers of fish salvaged by year class may be used to estimate these demographic parameters. Additional work to age silvery minnow from hard structures is ongoing and will be helpful to reconcile the age structure of the population and age-specific growth rates. When the age structure of the population is known, modal progression may be used to provide estimates of growth and survival. Mark-recapture estimates of survival have been done from hatchery silvery minnow released to the wild in their first year of life, but these data were not provided for this assessment.

5.3.4 PVA Modeling

A PVA for the silvery minnow is ongoing. This process has used much of the data collected for the silvery minnow in the Middle Rio Grande, as well as from hatchery-reared fish. The fundamental demographic parameters necessary for this modeling process are age structure, survival by age group, fecundity or maternity, movement, dispersal of eggs and larvae, and the relationship of various life stages to river flow and habitat. Definitive determination of population age structure and survival and recruitment have been largely lacking for the silvery minnow, and the PVA process has had to use deductive estimates or opinions of professional biologists. Study designs tailored to estimating fish abundance should include collection schemes for deriving estimates of survival and recruitment, as well as age structure.

5.3.5 Habitat Restoration

The Collaborative Program has invested a great deal into restoration of habitat in the Middle Rio Grande to benefit the aquatic and riparian ecosystem, including the silvery minnow. Some data collected since 2005 have begun to provide insight into the types of sampling designs, gears, and techniques most suitable for a reliable evaluation of habitat restoration or other management actions. The current habitat restoration evaluations have incorporated at least three different gear types in paired sampling arrays that enable direct comparisons of gear selectivity and efficiency. This dataset is currently not large or extensive, and fish responses may not yet be manifested. Ongoing data collection and evaluation will be necessary to better evaluate this aspect of data collection in the Middle Rio Grande.

5.3.6 Adaptive Management

Adaptive management is the cornerstone of any research and monitoring program, whereby information gleaned from these efforts is used to inform decisions to modify, revise, or reform activities, as well as management decisions. A reliable, precise, and accurate monitoring program that is scientifically founded is necessary for the principles of adaptive management to work. An important element of the adaptive management process is the need for corroboration among researchers and managers, in which managers establish criteria for precision. The need for researchers to know from managers the level of detection necessary for a change in the target resources is rarely sufficiently emphasized. Yet, in order for adaptive management to work, managers need to fully understand resource responses and the consequences of their actions. As part of the process of study design development, Reclamation and the Science Workgroup will be asked to help develop a set of criteria that expresses the desired level of precision and sensitivity desired and expected by managers and decision-makers for the various target resources of the Middle Rio Grande.

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APPENDIX A
TABLES AND FIGURES SHOWING DETAILED ANALYSES OF DATASETS 1 AND 2: (1) ASIR-ALLRGSMLENGTHS_RAW.XLS, (2) ASIR-RGSM_POP_MON_QUERY_PVAGOODMAN.XLS

Table A.1. Non-parametric Multiple Comparisons Test (Q) of Null Hypothesis (H_0) That Mean CPUE of Silvery Minnow Is Not Significantly Different among Years in the Albuquerque Reach Using the Seine Data

Q	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1993	1.78	0.49	0.23	1.12	3.46	4.32	2.56	3.29	3.07	0.56	1.99	0.85	1.73	0.95
1994		1.27	1.61	0.62	5.37	6.23	4.48	5.44	5.23	2.71	0.16	2.97	0.33	1.11
1995			0.28	0.62	3.94	4.79	3.06	3.82	3.61	1.14	1.37	1.42	1.14	0.37
1996				0.93	3.83	4.72	2.90	3.72	3.50	0.86	1.81	1.17	1.54	0.73
1997					4.56	5.40	3.69	4.51	4.30	1.87	0.59	2.14	0.40	0.36
1999						0.94	0.97	0.68	0.92	3.72	6.56	3.30	6.03	5.17
2000							1.91	1.76	2.00	4.80	7.65	4.36	7.06	6.20
2001								0.44	0.21	2.60	5.44	2.20	4.97	4.10
2002									0.29	3.73	7.21	3.20	6.44	5.41
2003										29.77	6.92	2.92	6.17	5.14
2004											3.48	0.41	2.99	1.96
2005												3.78	0.23	1.27
2006													3.29	2.29
2007														0.97

Unshaded cells indicate that mean CPUE was not significantly different between years (accept H_0). Shaded cells indicate that mean CPUE was significantly different between years (reject H_0, critical value Q = 3.494; $p<0.05$). Q-values were derived with Kruskal-Wallis test and Tukey-type multiple comparisons.

Table A.2. Non-parametric Multiple Comparisons Test (Q) of Null Hypothesis (H_0) That Mean CPUE of Silvery Minnow Is Not Significantly Different among Years in the Isleta Reach Using the Seine Data

Q	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1993	0.64	1.85	0.06	0.56	1.37	2.44	0.24	1.13	2.81	1.41	2.29	1.23	2.23	2.39
1994		1.24	0.69	0.01	2.01	3.08	1.02	1.97	3.65	2.25	1.45	0.40	1.41	1.57
1995			1.87	1.07	3.15	4.18	2.41	3.39	4.94	3.65	0.24	1.20	0.23	0.08
1996				0.60	1.27	2.32	0.16	1.01	2.63	1.28	2.28	1.27	2.23	2.39
1997					1.73	2.65	0.83	1.56	2.89	1.78	1.13	0.30	1.11	1.24
1999						1.07	1.41	0.66	1.03	0.37	4.07	3.01	3.98	4.14
2000							2.70	2.06	0.37	1.78	5.48	4.40	5.35	5.50
2001								1.27	3.73	1.68	3.74	2.18	3.56	3.78
2002									3.13	0.53	6.39	4.33	5.91	6.17
2003										27.10	9.45	7.35	8.76	9.00
2004											6.90	4.84	6.38	6.64
2005												1.91	0.00	0.29
2006													1.77	2.05
2007														0.27

Unshaded cells indicate that mean CPUE was not significantly different between years (accept H0). Shaded cells indicate that mean CPUE was significantly different between years (reject H0, critical value Q = 3.494; $p<0.05$). Q-values were derived with Kruskal-Wallis test and Tukey-type multiple comparisons.

Table A.3. Non-parametric Multiple Comparisons Test (Q) of Null Hypothesis (H_0) That Mean CPUE of Silvery Minnow Is Not Significantly Different among Years in the San Acacia Reach Using the Seine Data

Q	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1993	0.48	1.14	0.78	0.54	0.77	1.99	2.61	5.15	7.96	7.25	2.60	2.03	3.30	0.85
1994		1.63	1.26	1.04	1.31	1.44	2.05	4.54	7.35	6.64	1.99	1.42	2.70	0.26
1995			0.33	0.63	0.51	3.34	4.01	6.77	9.65	8.93	4.15	3.54	4.81	2.29
1996				0.27	0.12	2.85	3.48	6.05	8.81	8.12	3.55	2.97	4.20	1.79
1997					0.19	2.70	3.37	6.15	9.11	8.37	3.46	2.84	4.15	1.57
1999						3.26	4.04	7.46	10.89	10.04	4.30	3.56	5.05	2.05
2000							0.70	3.69	7.22	6.34	0.49	0.21	1.42	1.60
2001								3.02	6.69	5.77	0.32	1.04	0.69	2.44
2002									4.50	3.37	4.09	4.87	2.60	6.29
2003										38.34	8.52	9.20	6.75	10.35
2004											7.43	8.14	5.71	9.36
2005												0.88	1.19	2.54
2006													1.98	1.69
2007														3.48

Unshaded cells indicate that mean CPUE was not significantly different between years (accept H0). Shaded cells indicate that mean CPUE was significantly different between years (reject H0, critical value Q = 3.494; p<0.05). Q-values were derived with Kruskal-Wallis test and Tukey-type multiple comparisons.

Table A.4. Non-parametric Multiple Comparisons Test (Q) of Null Hypothesis (H_0) That Mean CPUE of Silvery Minnow Is Not Significantly Different among Years in the Combined Albuquerque, Isleta, and San Acacia Reaches Using the Seine Data

Q	1994	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1993	1.06	1.94	0.49	1.69	1.27	3.92	2.83	5.49	8.44	6.00	0.65	0.89	0.17	1.36
1994		0.89	0.58	0.64	2.42	5.08	4.05	6.83	9.77	7.34	0.69	2.21	1.13	0.06
1995			1.47	0.24	3.38	6.03	5.05	7.90	10.83	8.41	1.81	3.31	2.21	1.02
1996				1.22	1.80	4.47	3.41	6.14	9.11	6.66	0.04	1.50	0.43	0.77
1997					3.09	5.70	4.72	7.50	10.38	8.00	1.48	2.97	1.89	0.72
1999						2.94	1.69	4.66	8.07	5.25	2.45	0.65	1.82	3.18
2000							1.44	1.13	4.59	1.74	6.04	4.18	5.25	6.61
2001								3.02	6.79	3.68	4.82	2.79	4.00	5.47
2002									4.67	0.83	9.70	7.08	8.29	10.04
2003										55.52	14.26	11.56	12.54	14.25
2004											10.48	7.86	9.02	10.76
2005												2.39	0.70	1.10
2006													1.53	3.28
2007														1.68

Unshaded cells indicate that mean CPUE was not significantly different between years (accept H0). Shaded cells indicate that mean CPUE was significantly different between years (reject H0, critical value Q = 3.494; p<0.05). Q-values were derived with Kruskal-Wallis test and Tukey-type multiple comparisons.

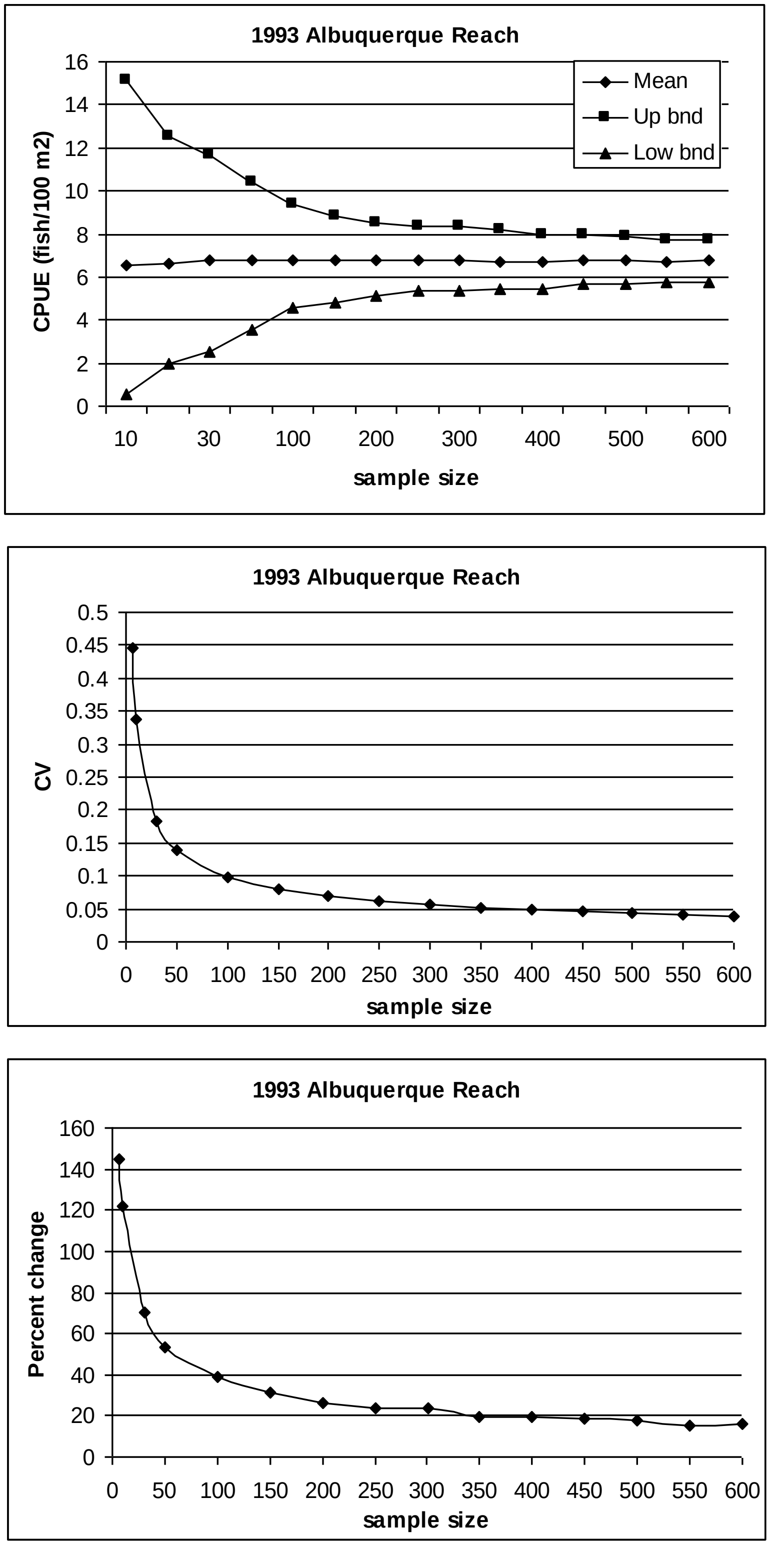


Figure A.1. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 1993.

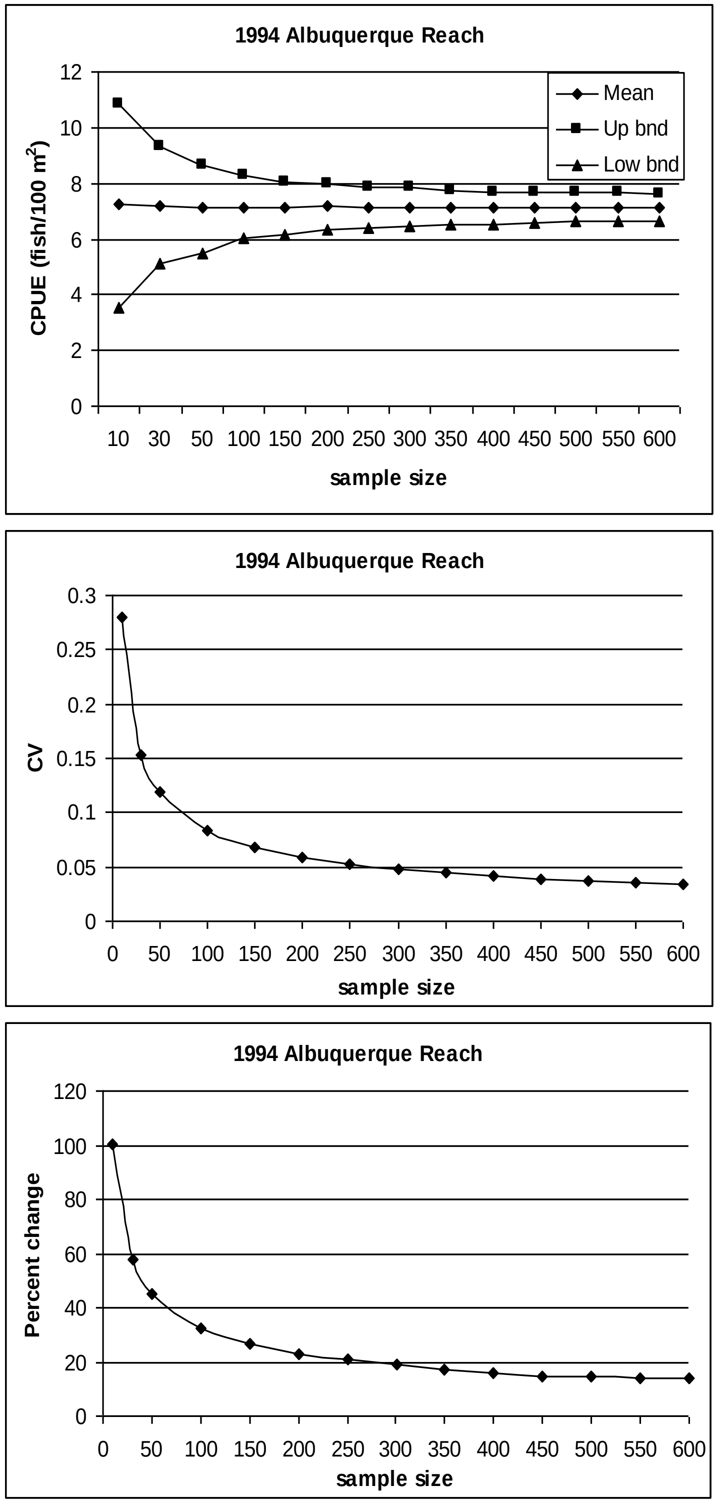


Figure A.2. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 1994.

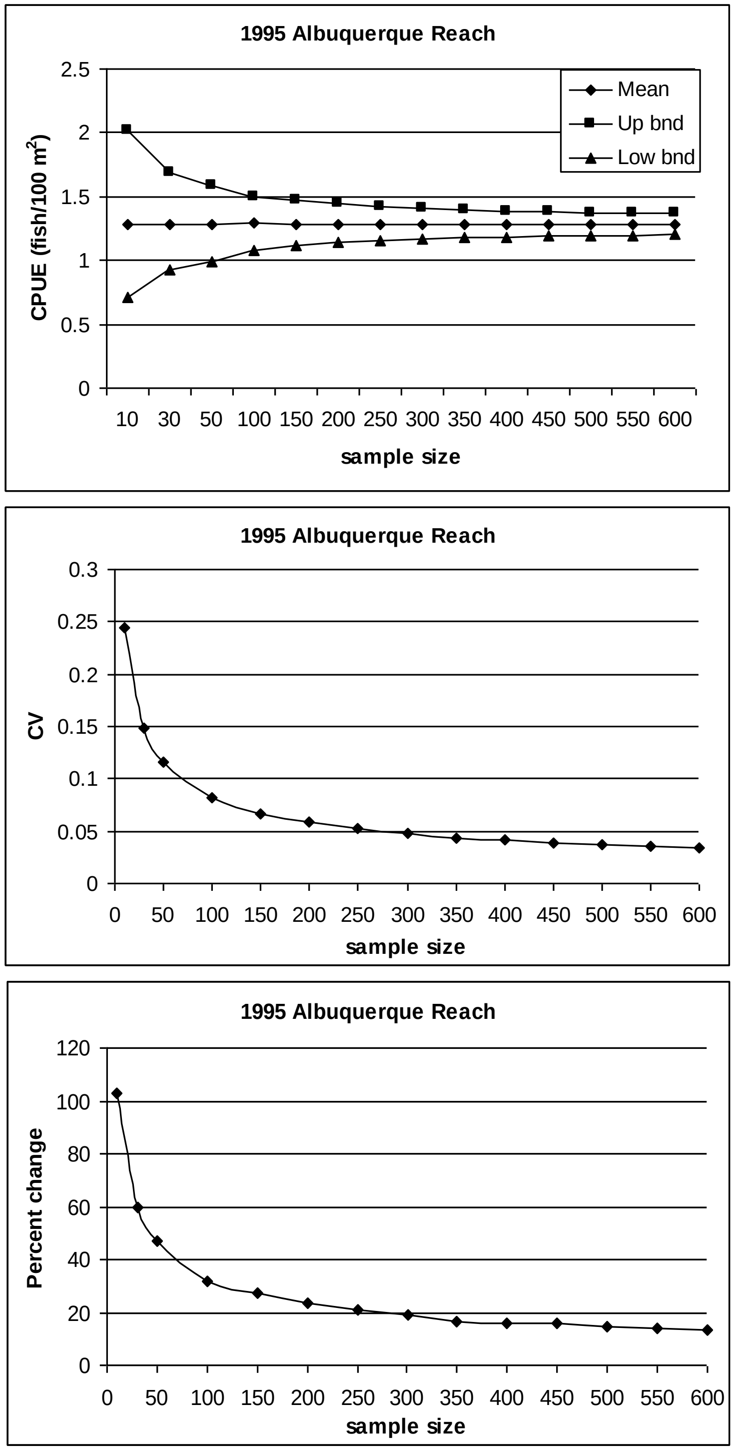


Figure A.3. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 1995.

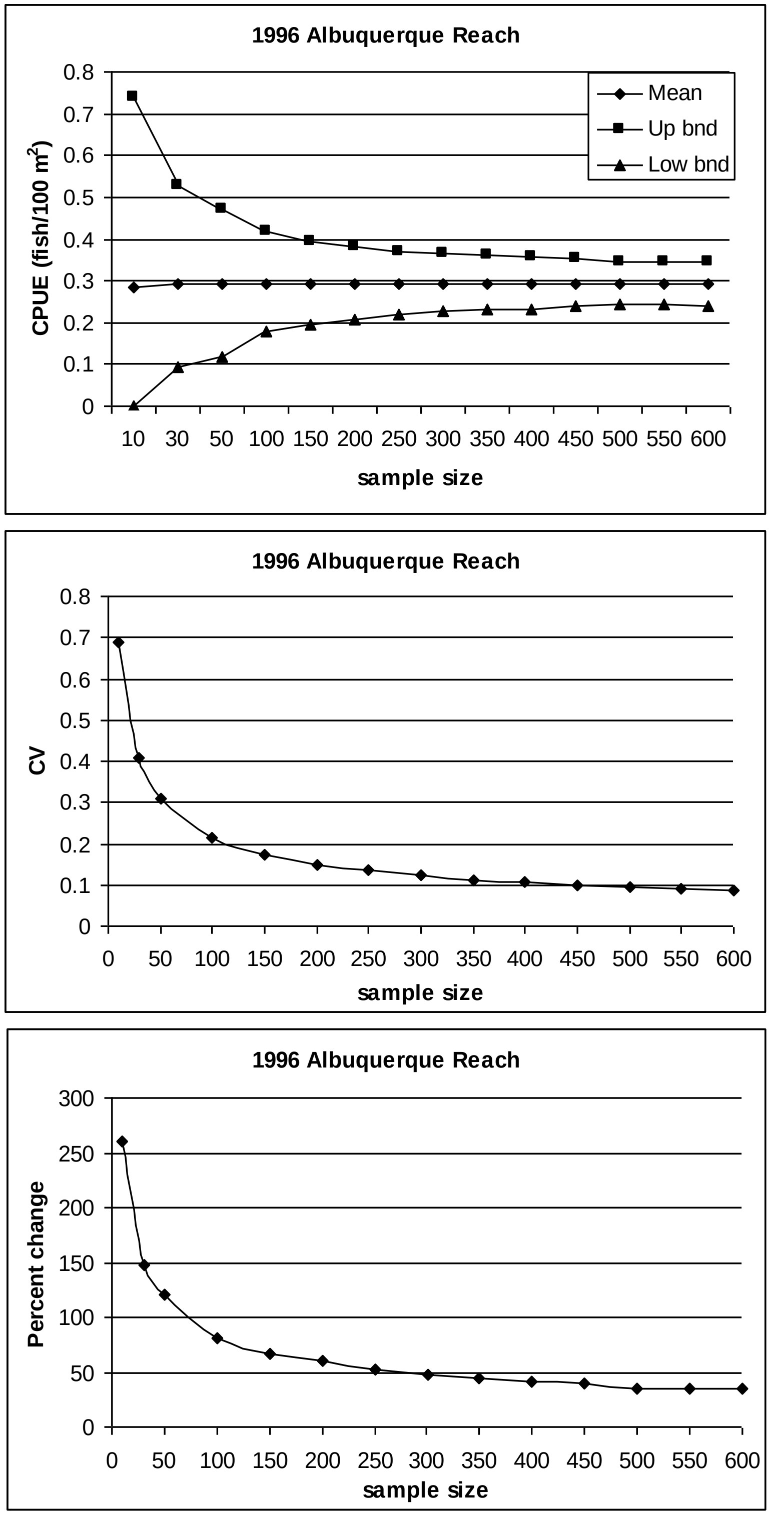


Figure A.4. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 1996.

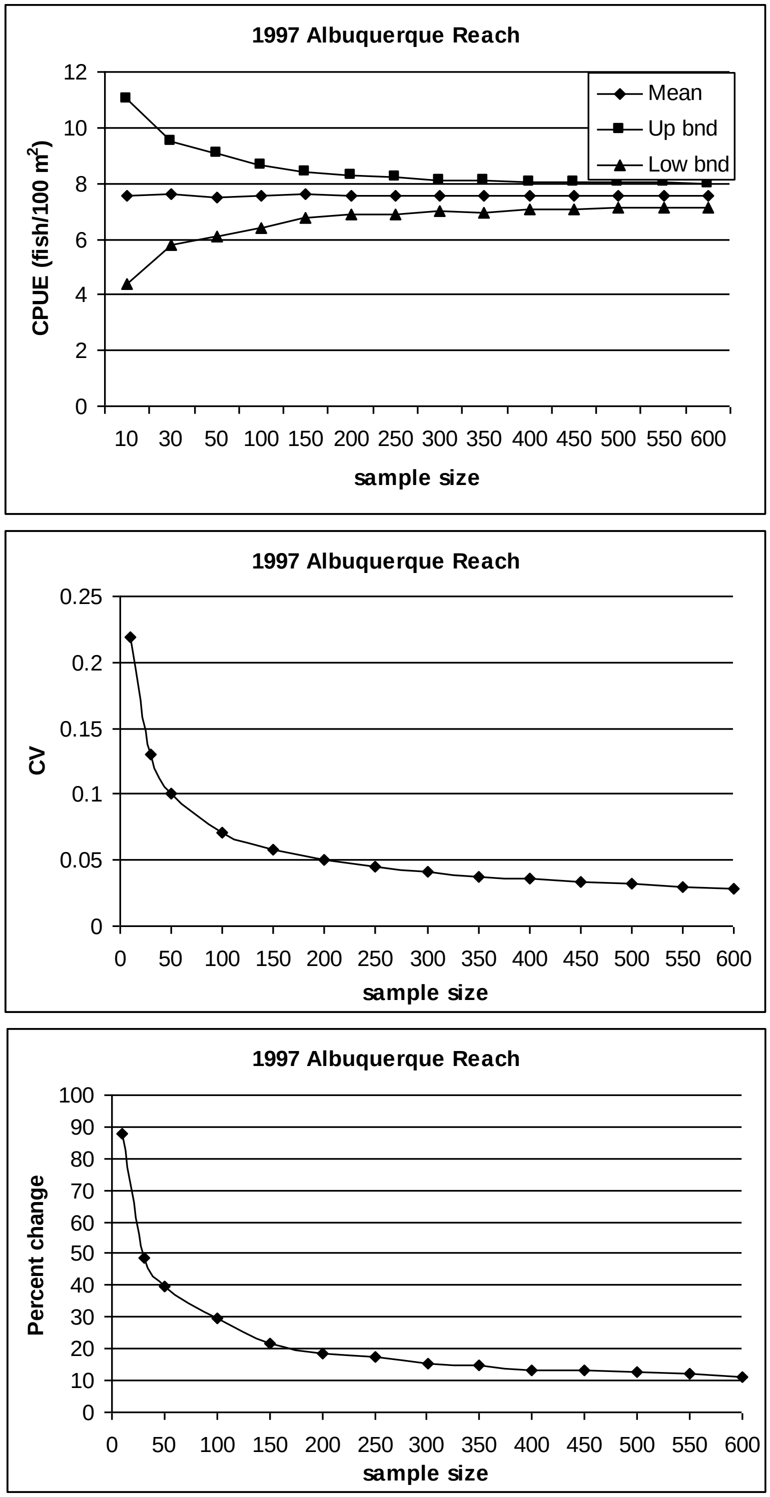


Figure A.5. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 1997.

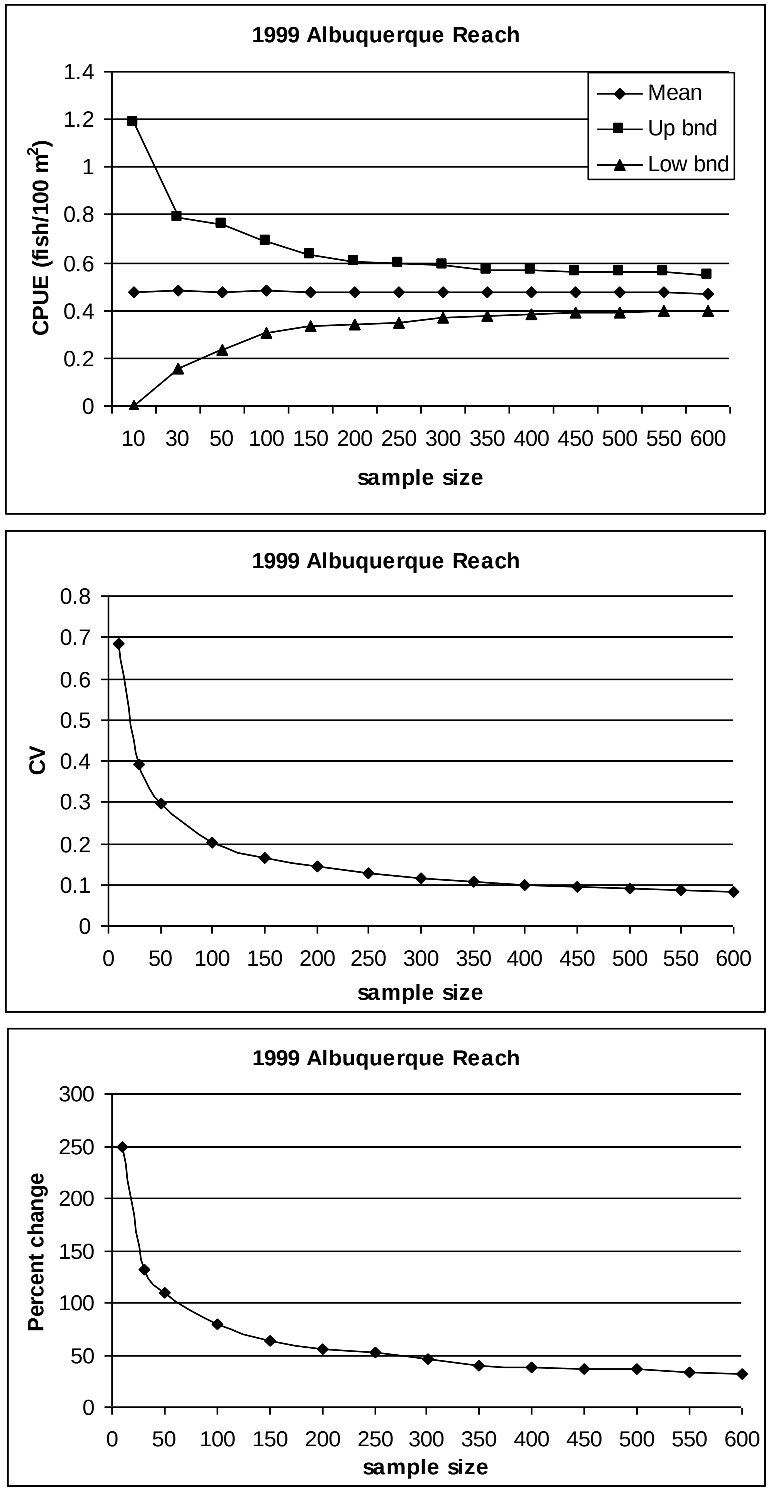


Figure A.6. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 1999.

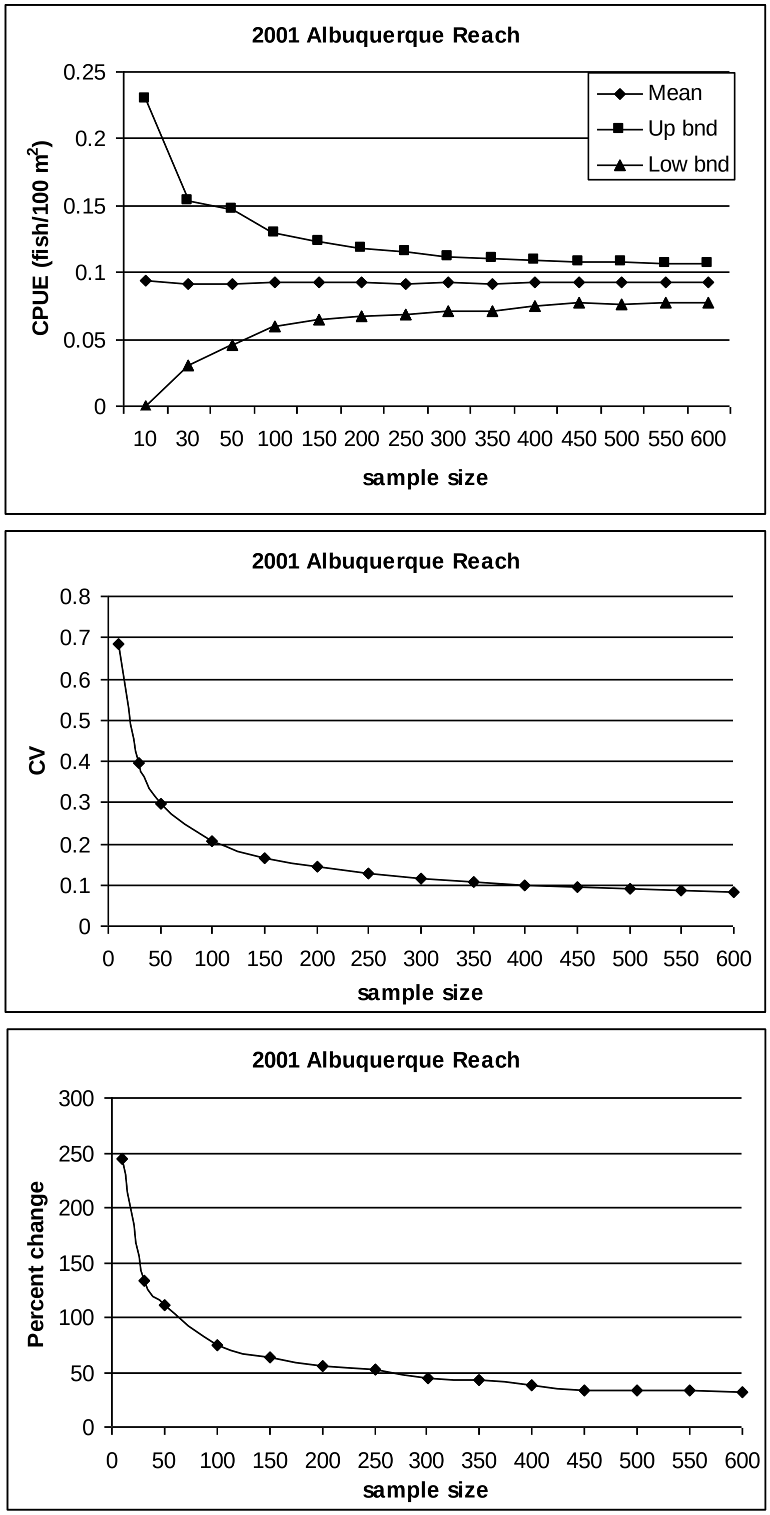


Figure A.7. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2001.

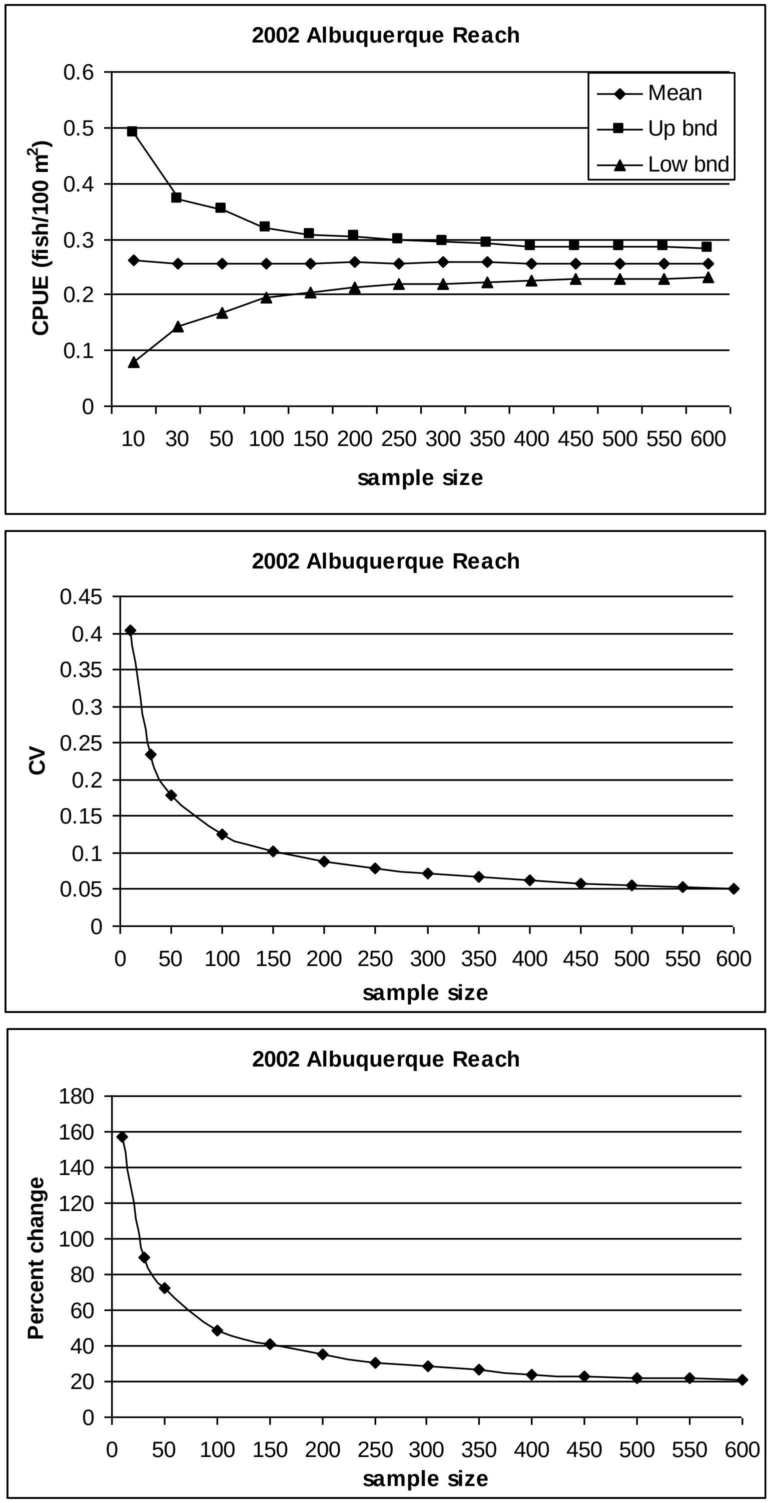


Figure A.8. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2002.

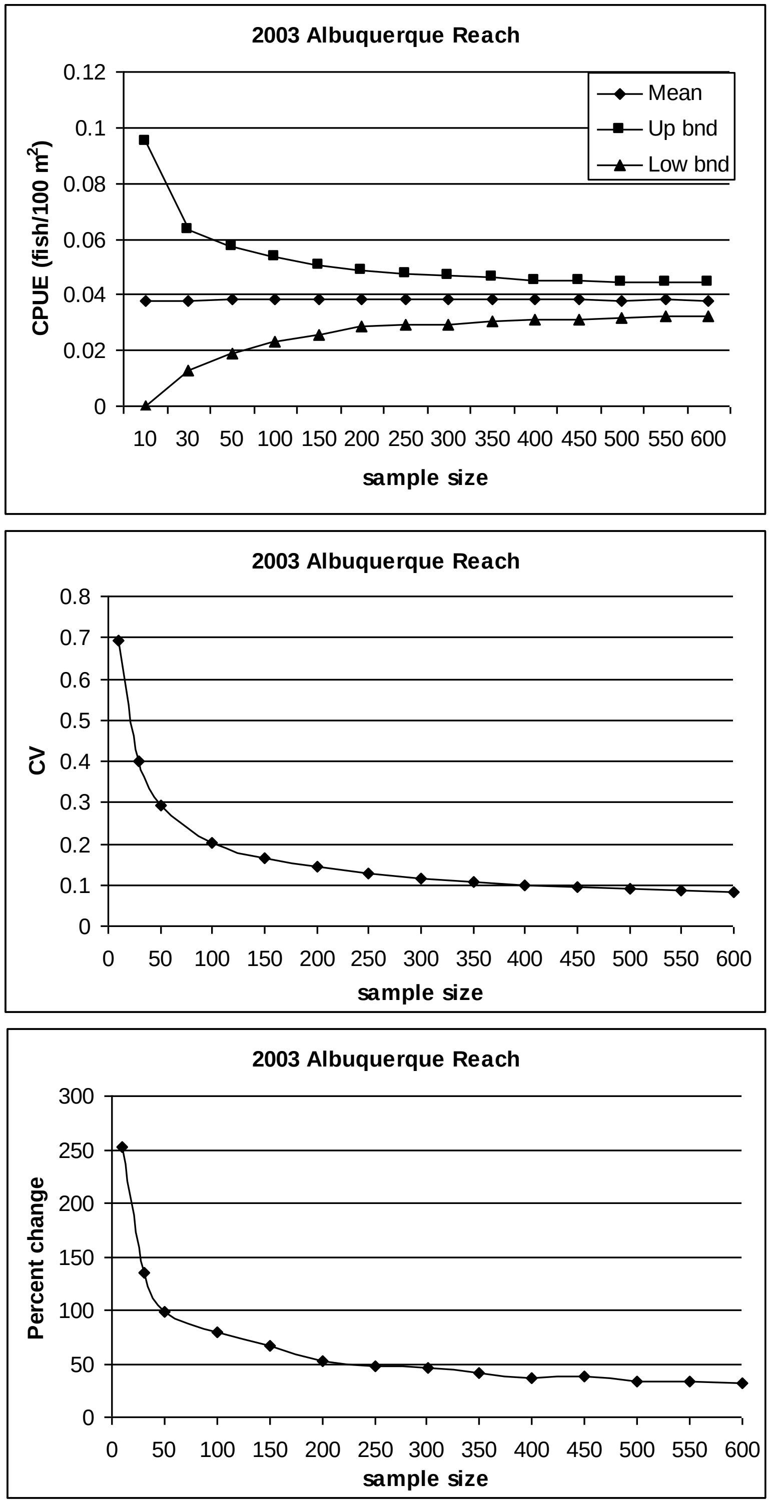


Figure A.9. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2003.

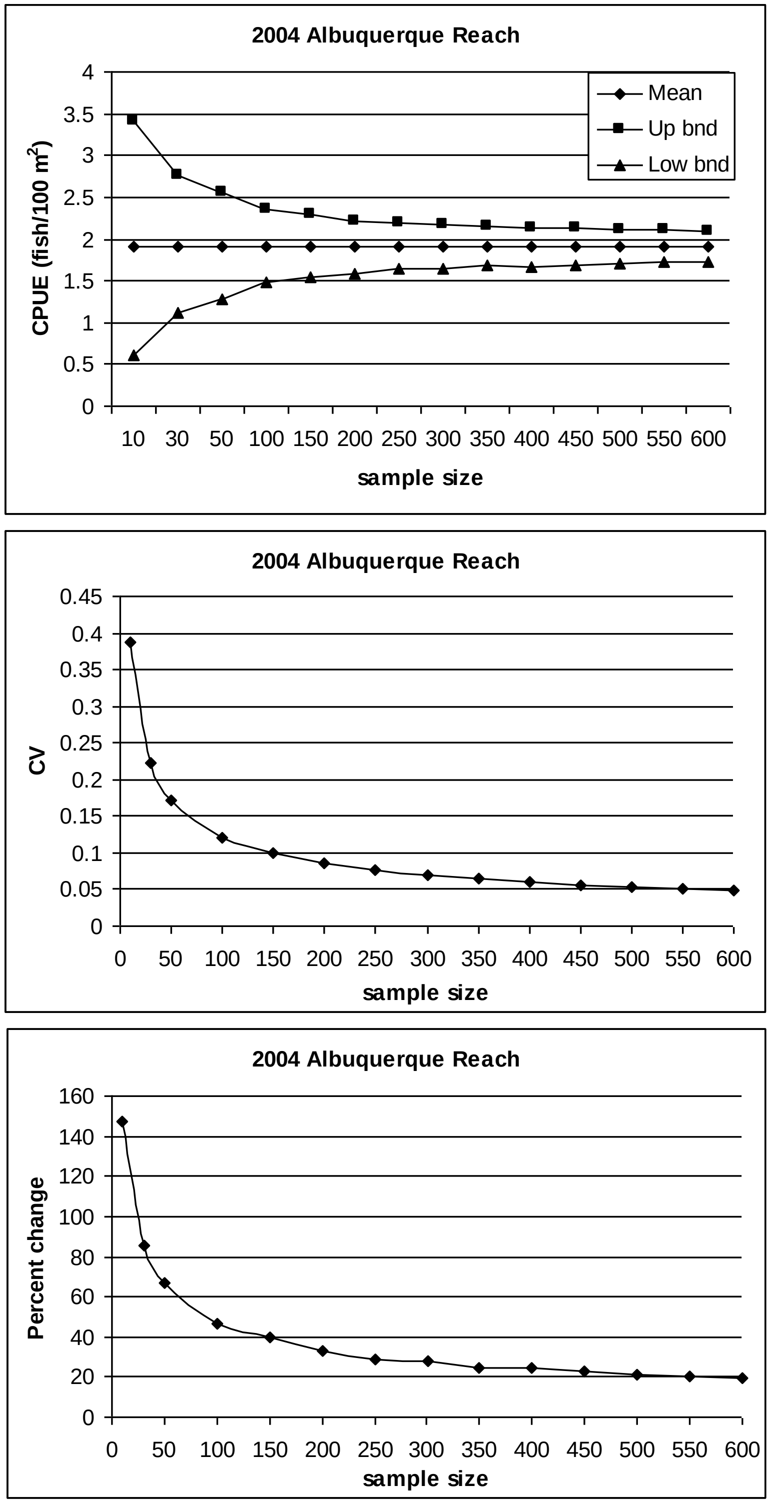


Figure A.10. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2004.

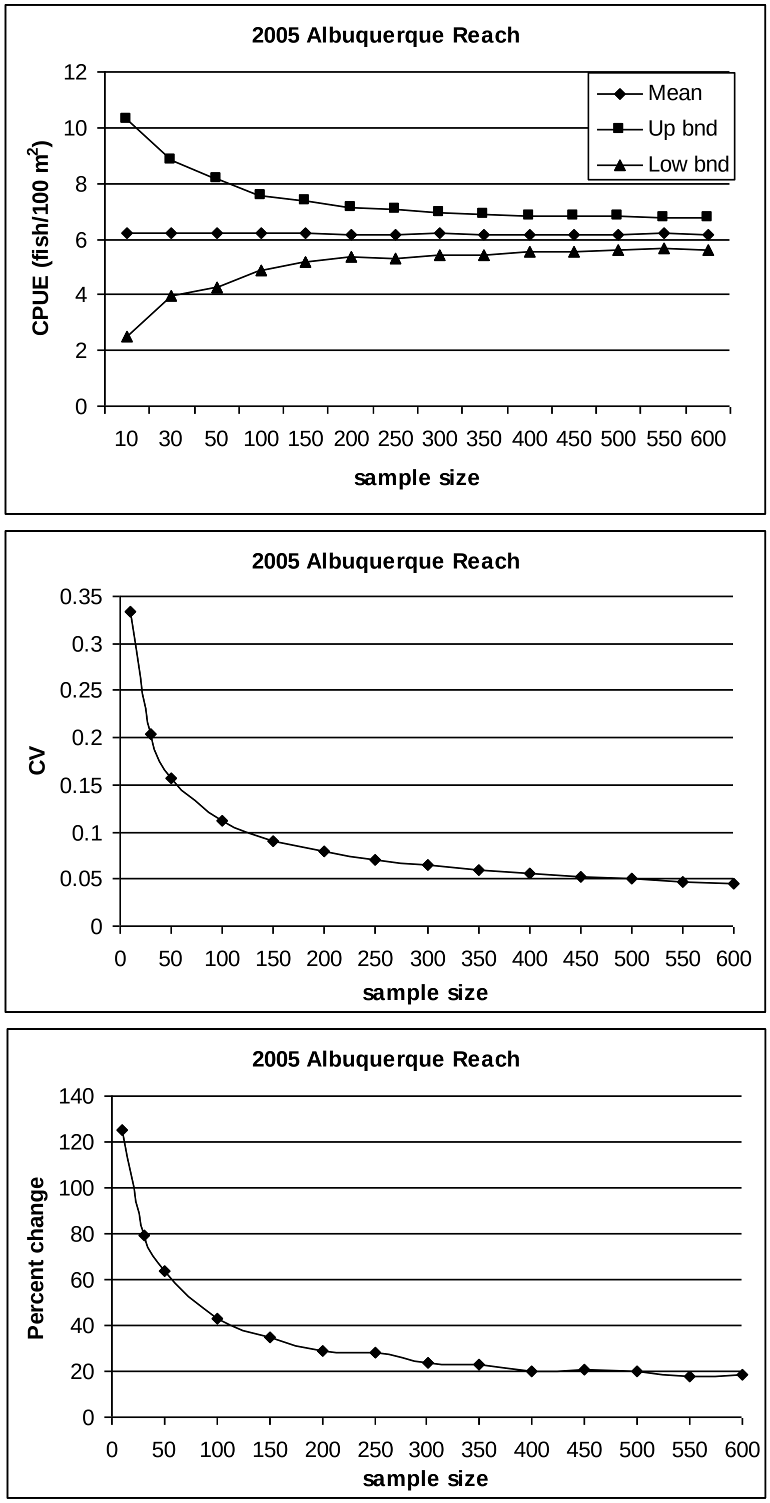


Figure A.11. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2005.

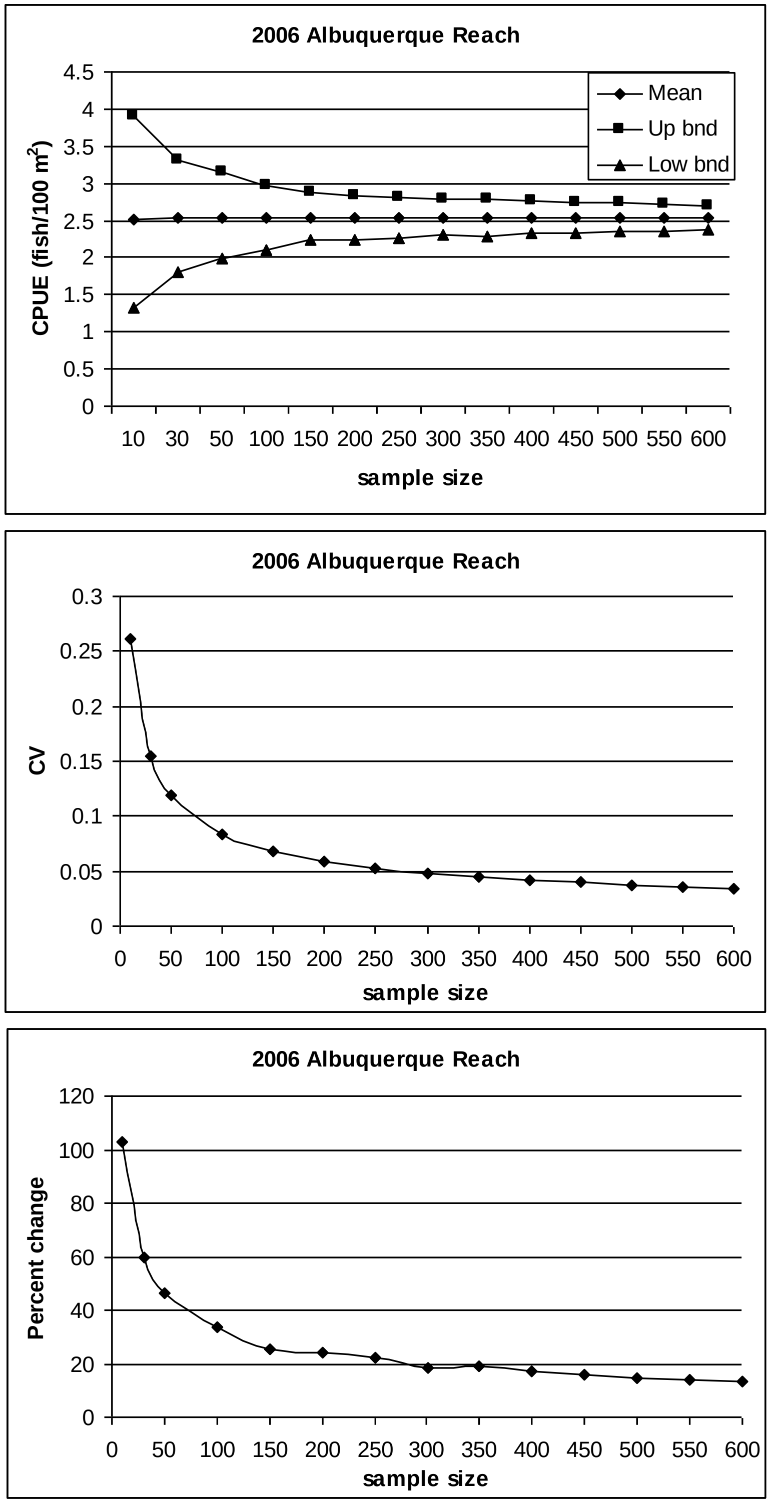


Figure A.12. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2006.

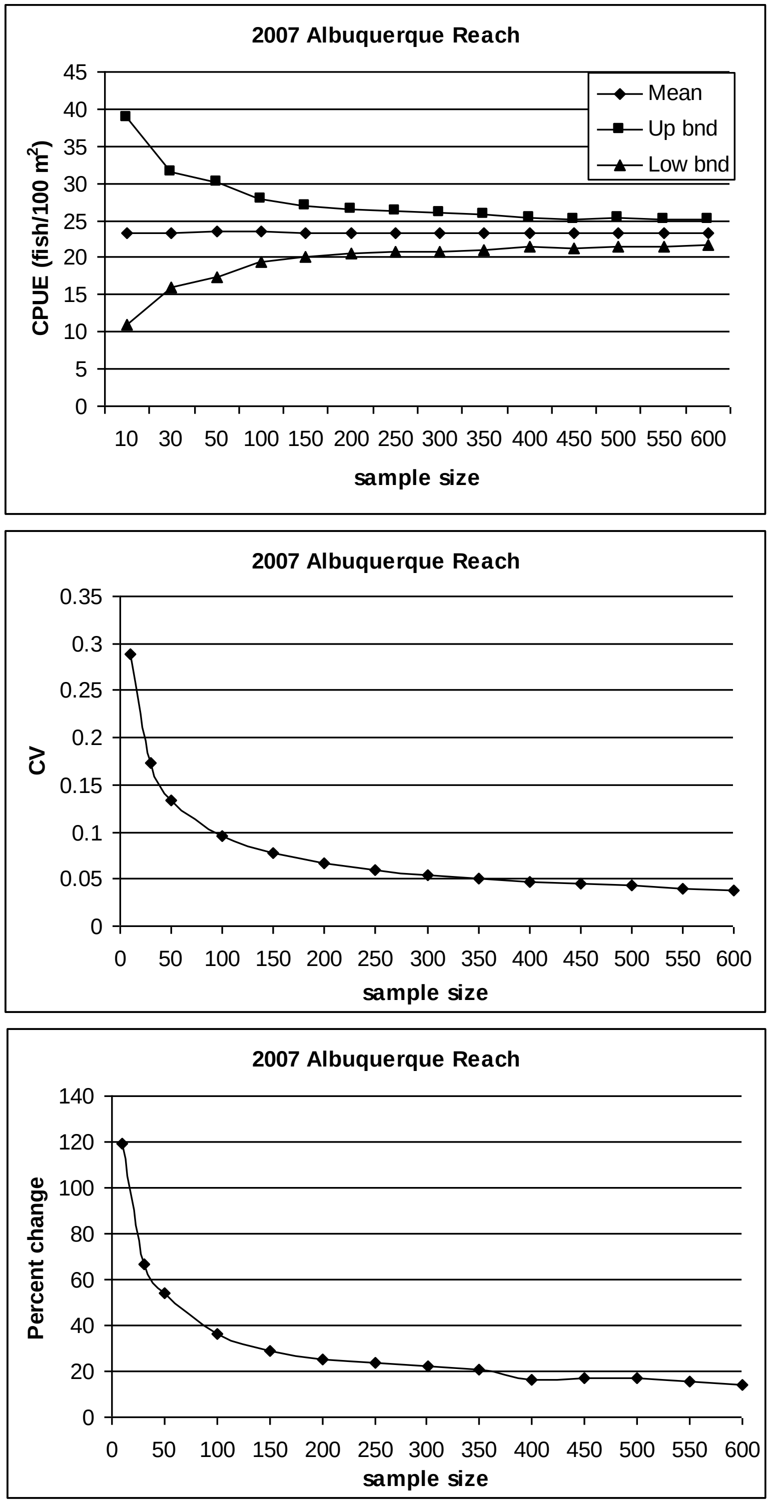
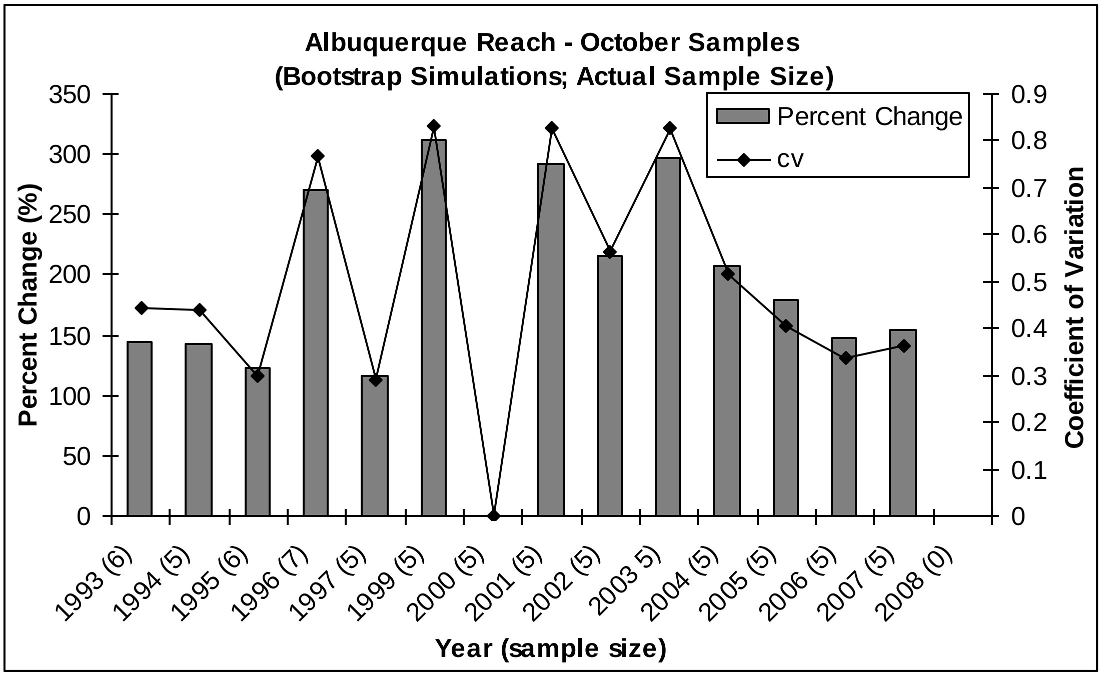


Figure A.13. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2007.



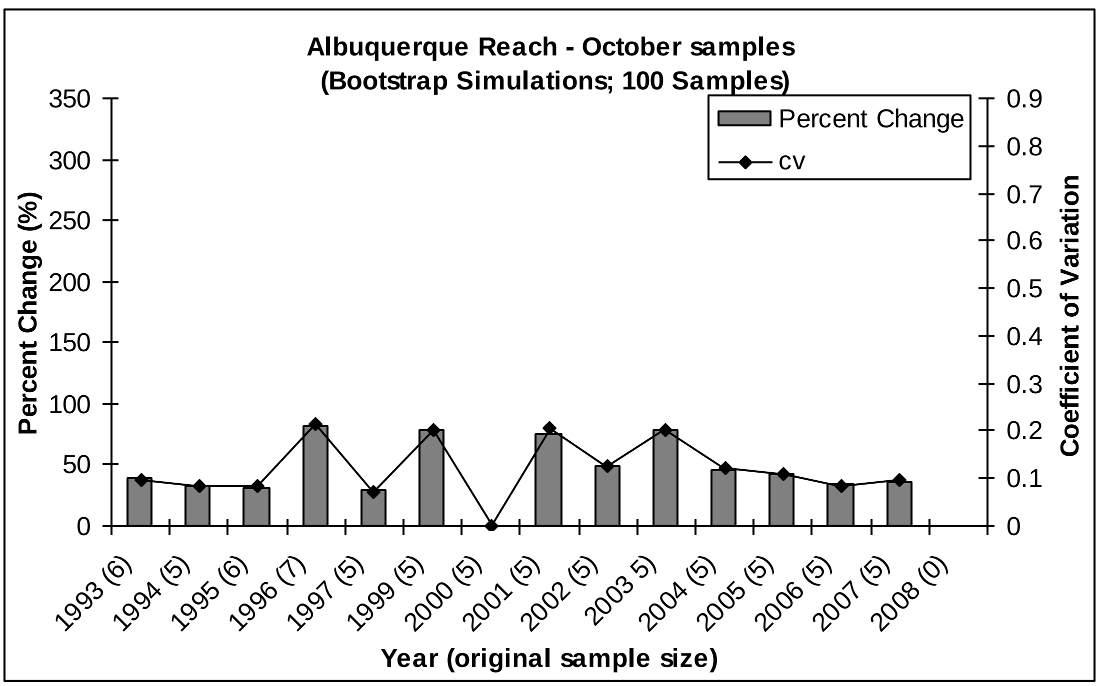


Figure A.14. Percent detectable change for October samples by year and CV for mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size (top) and expanded to 100 samples (bottom) in the Albuquerque Reach, 1993–1997 and 1999–2008. Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_ PVAgoodman.xls.

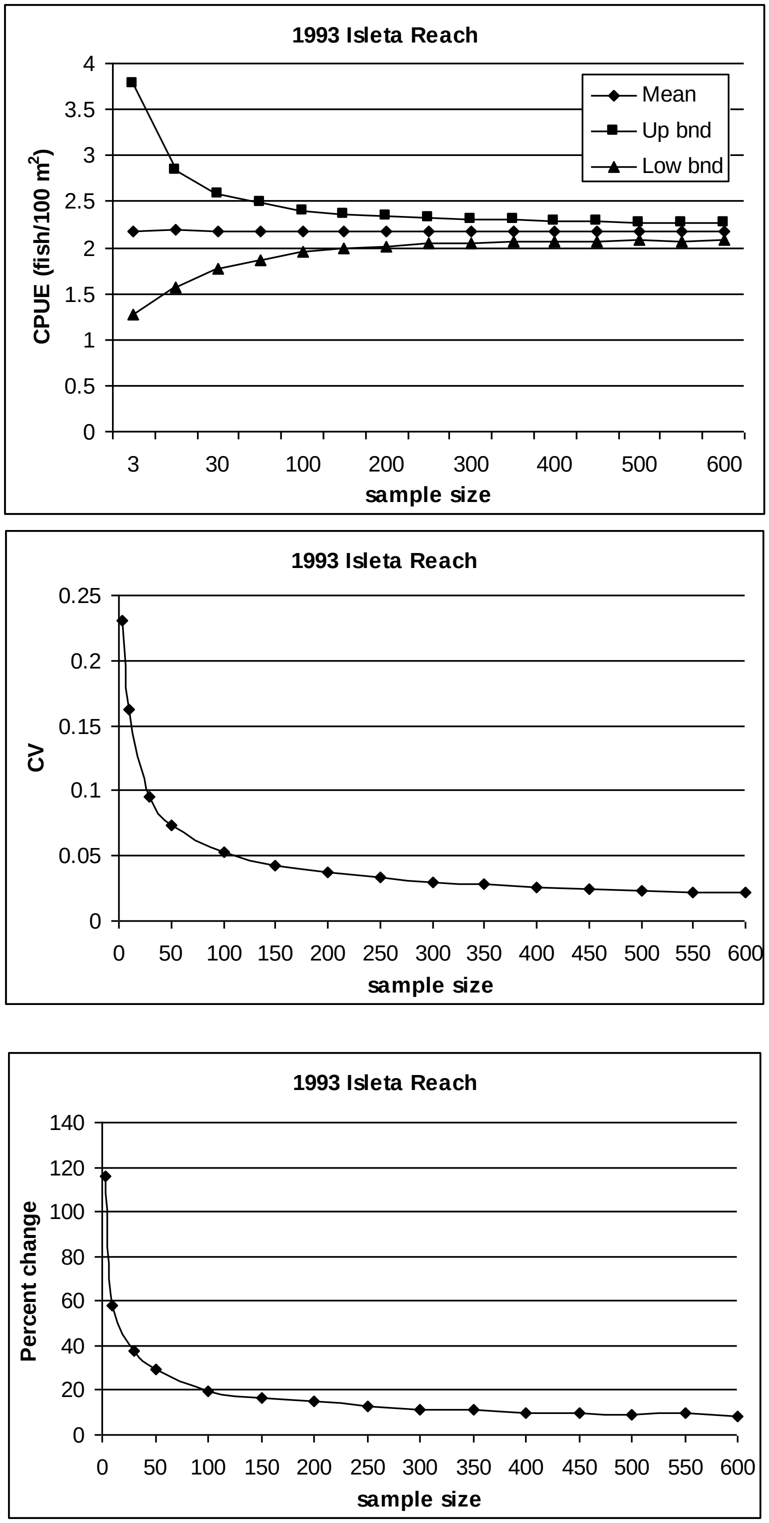


Figure A.15. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 1993.

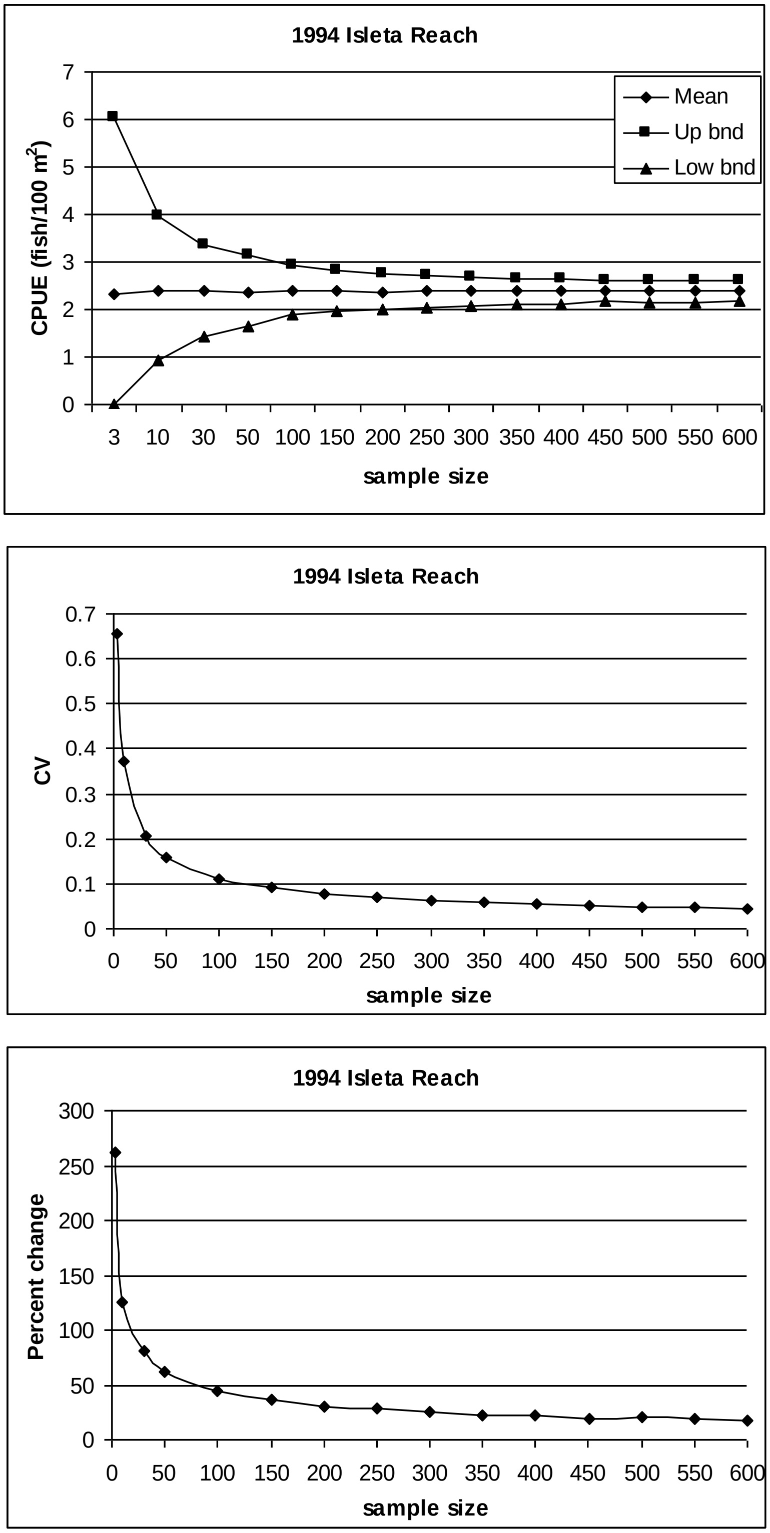


Figure A.16. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 1994.

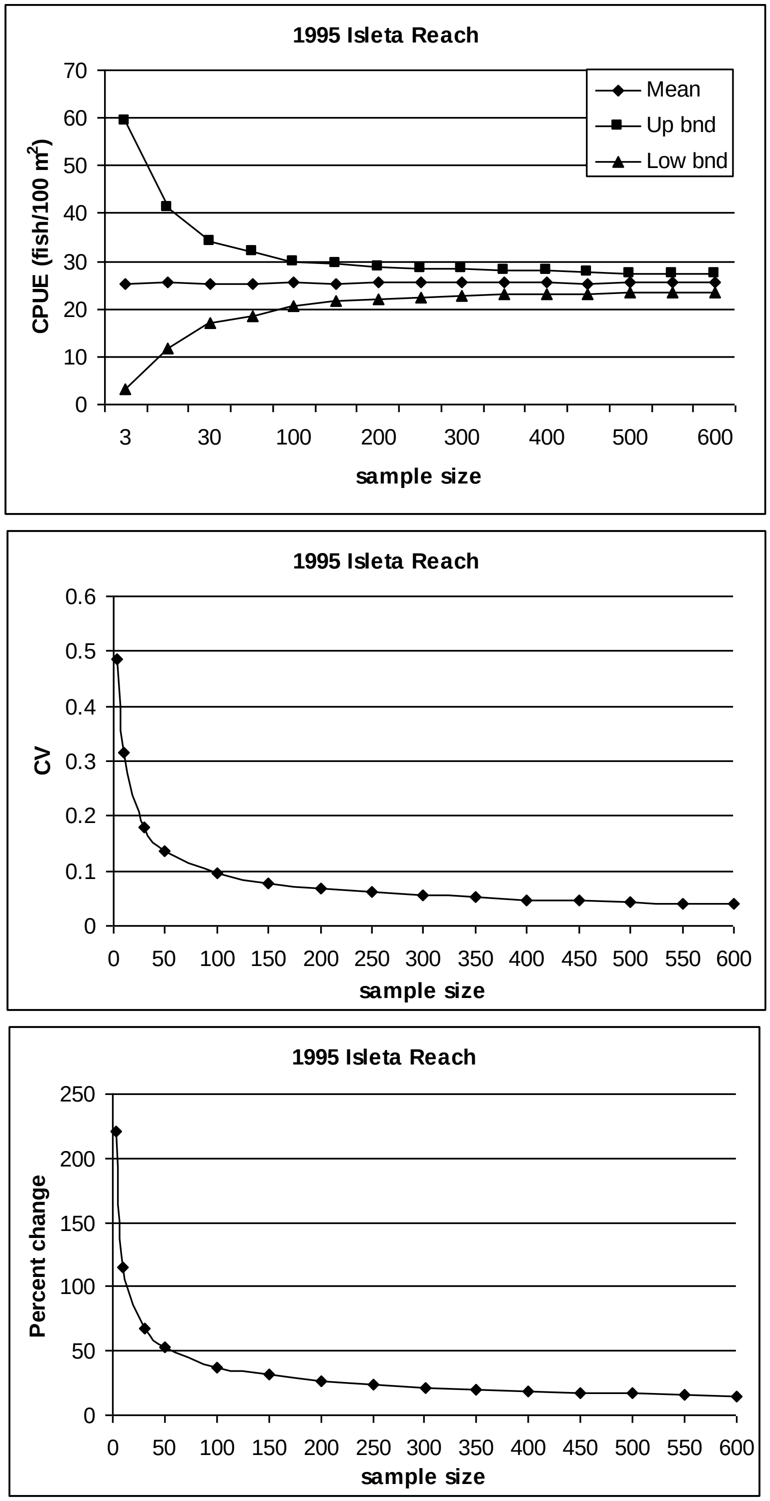


Figure A.17. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 1995.

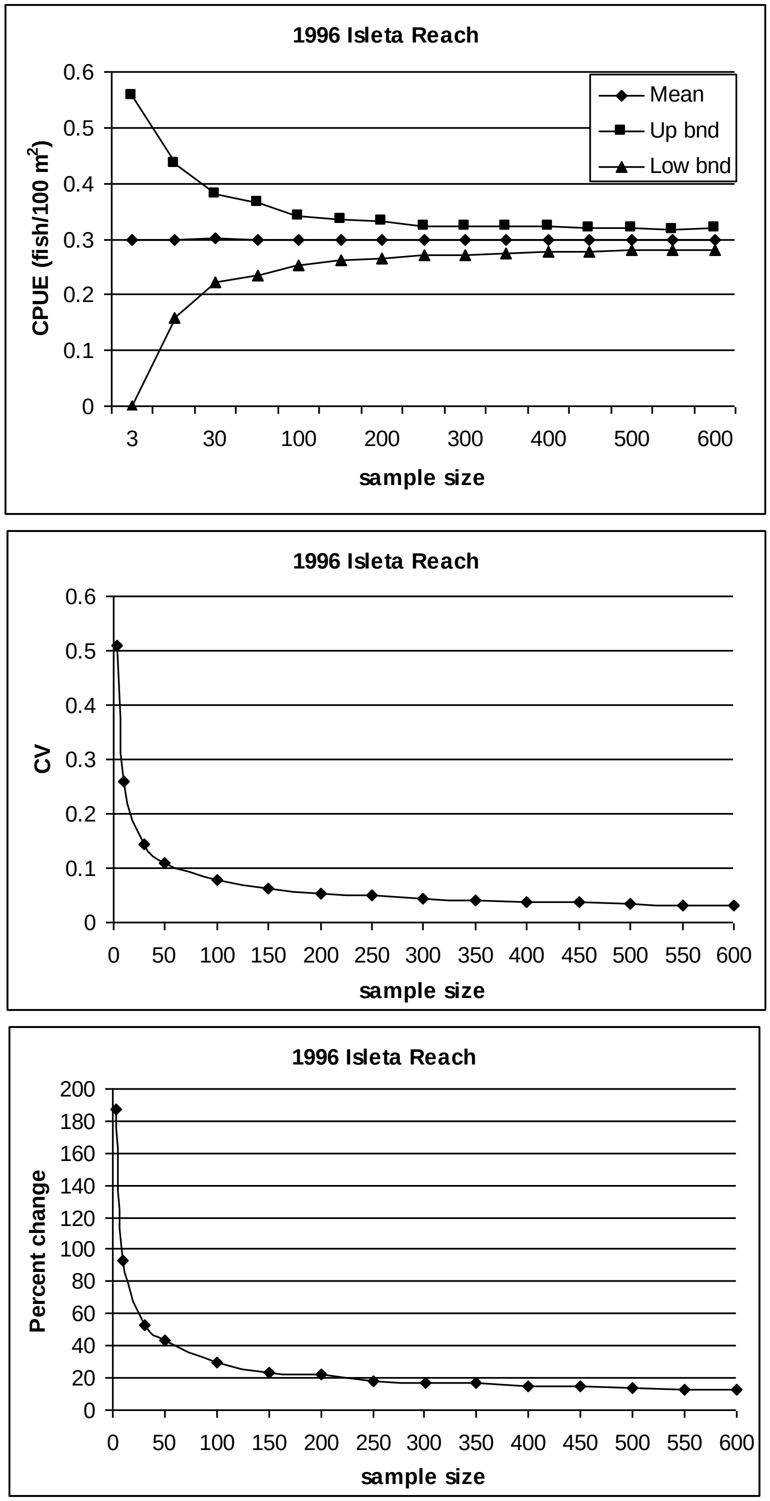


Figure A.18. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 1996.

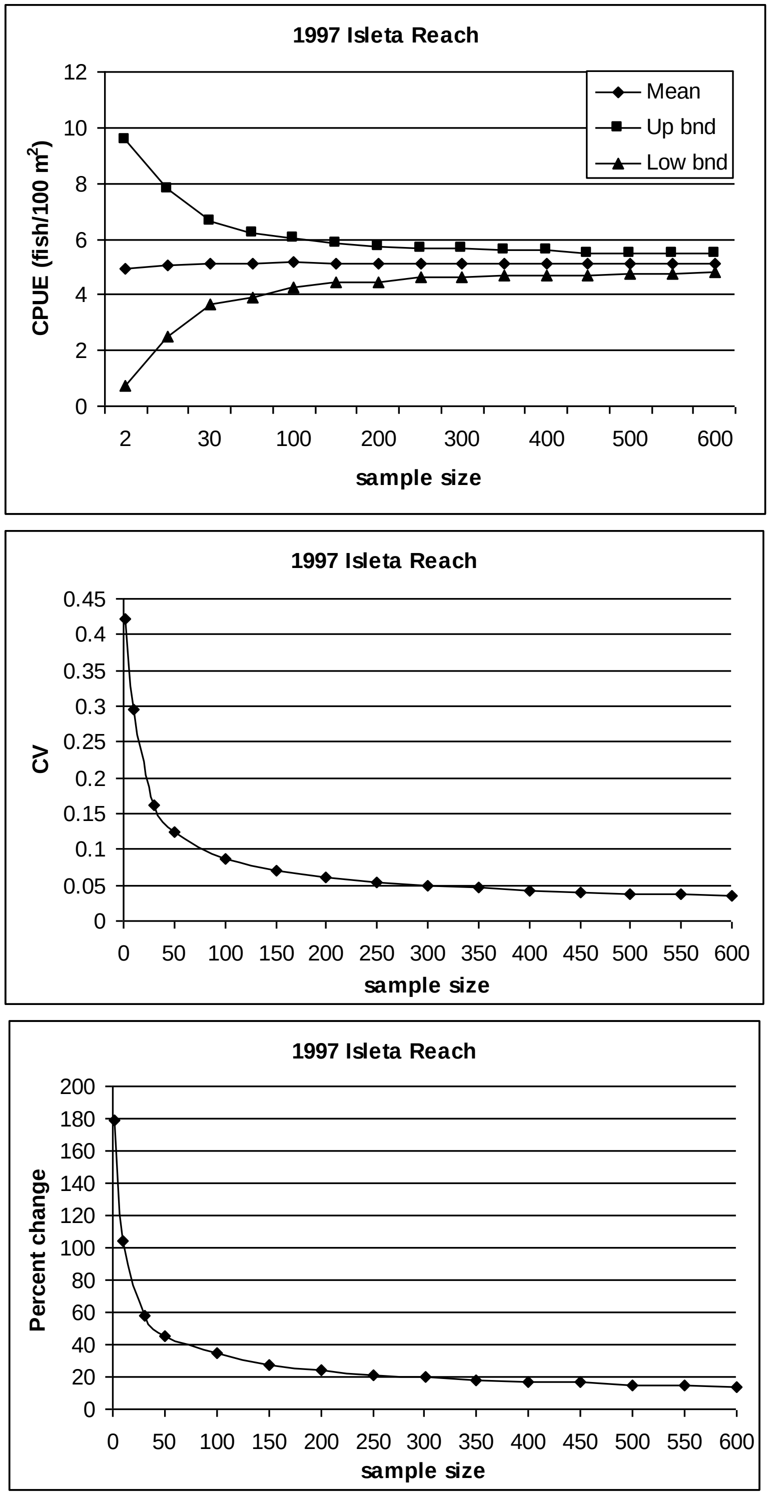


Figure A.19. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 1997.

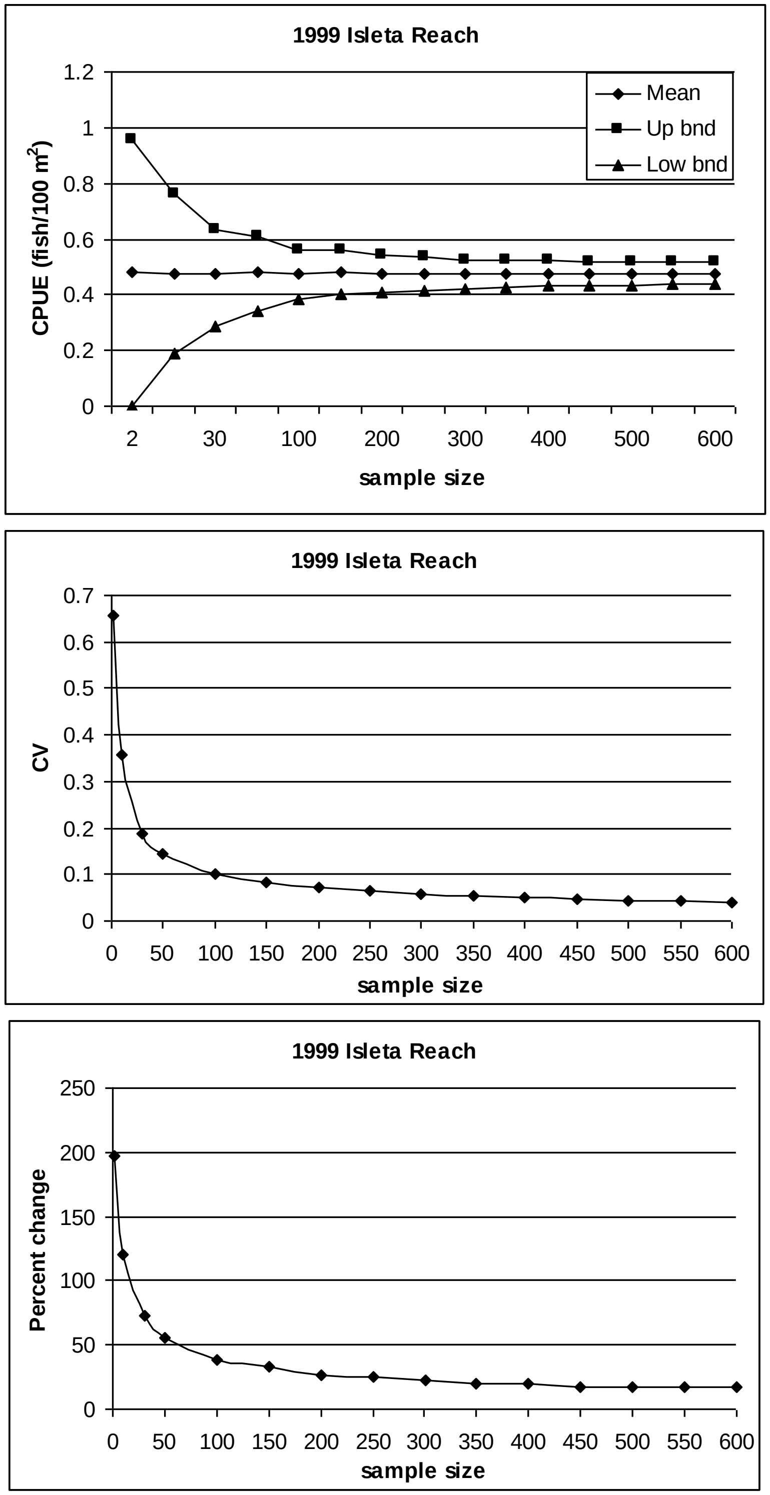


Figure A.20. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 1999.

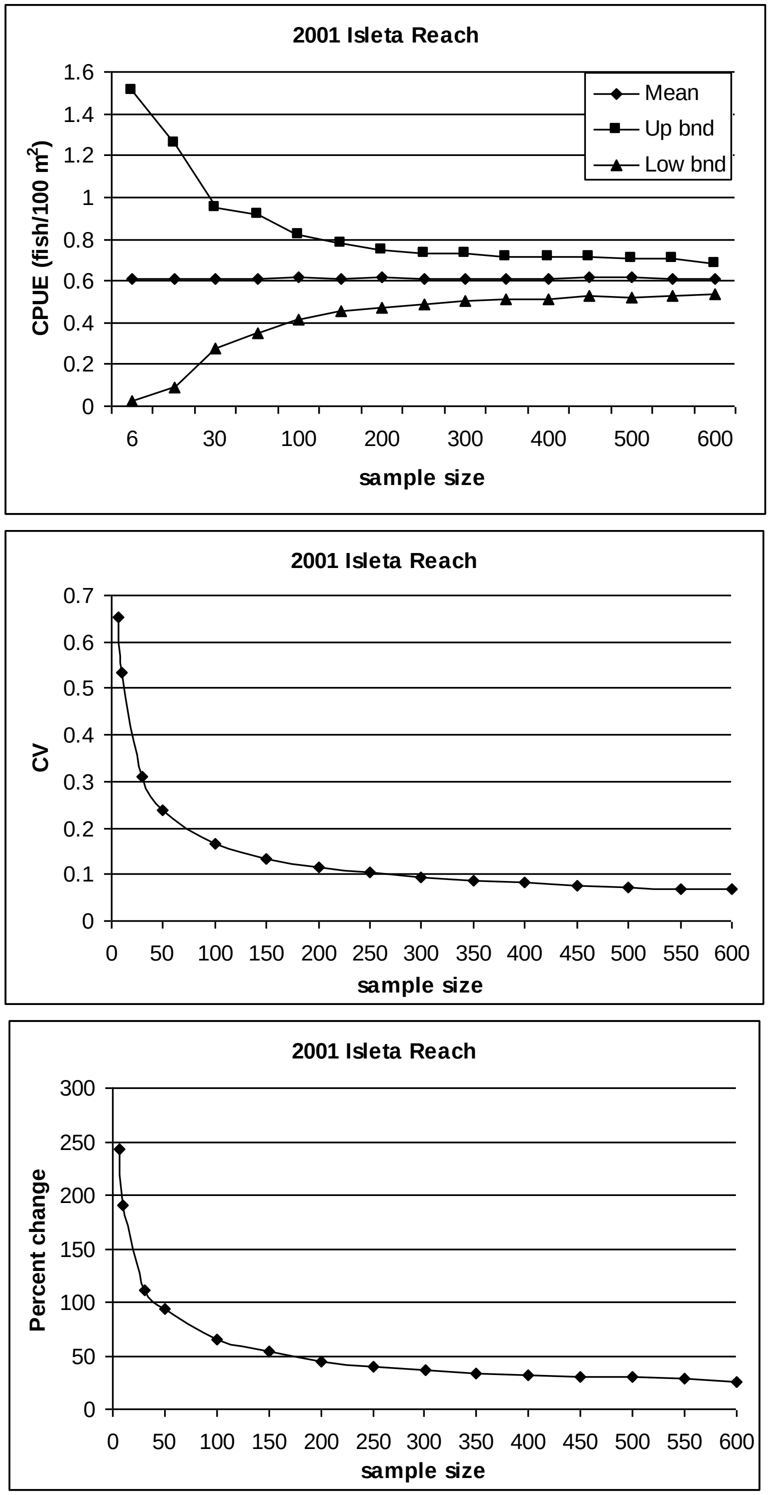


Figure A.21. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2001.

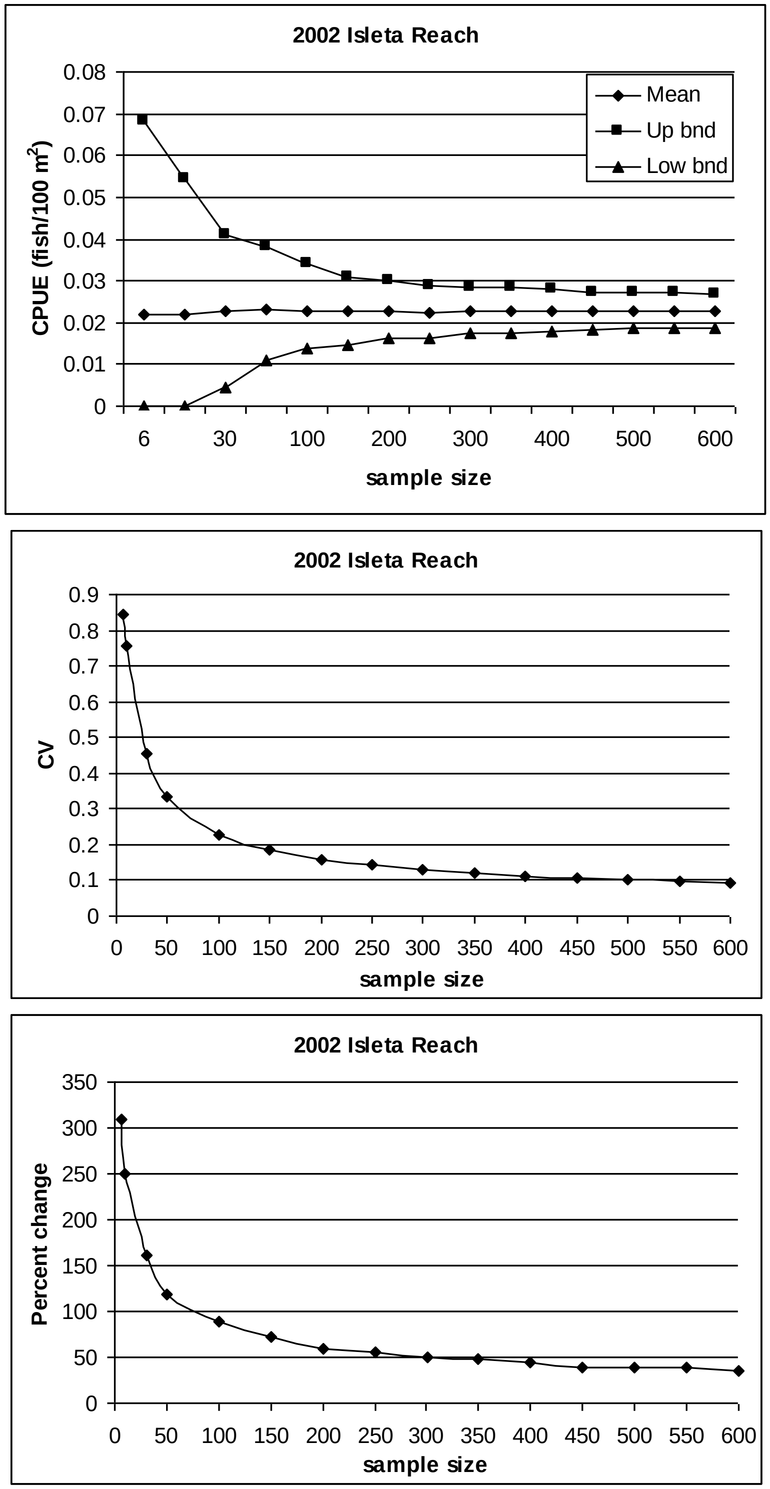


Figure A.22. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2002.

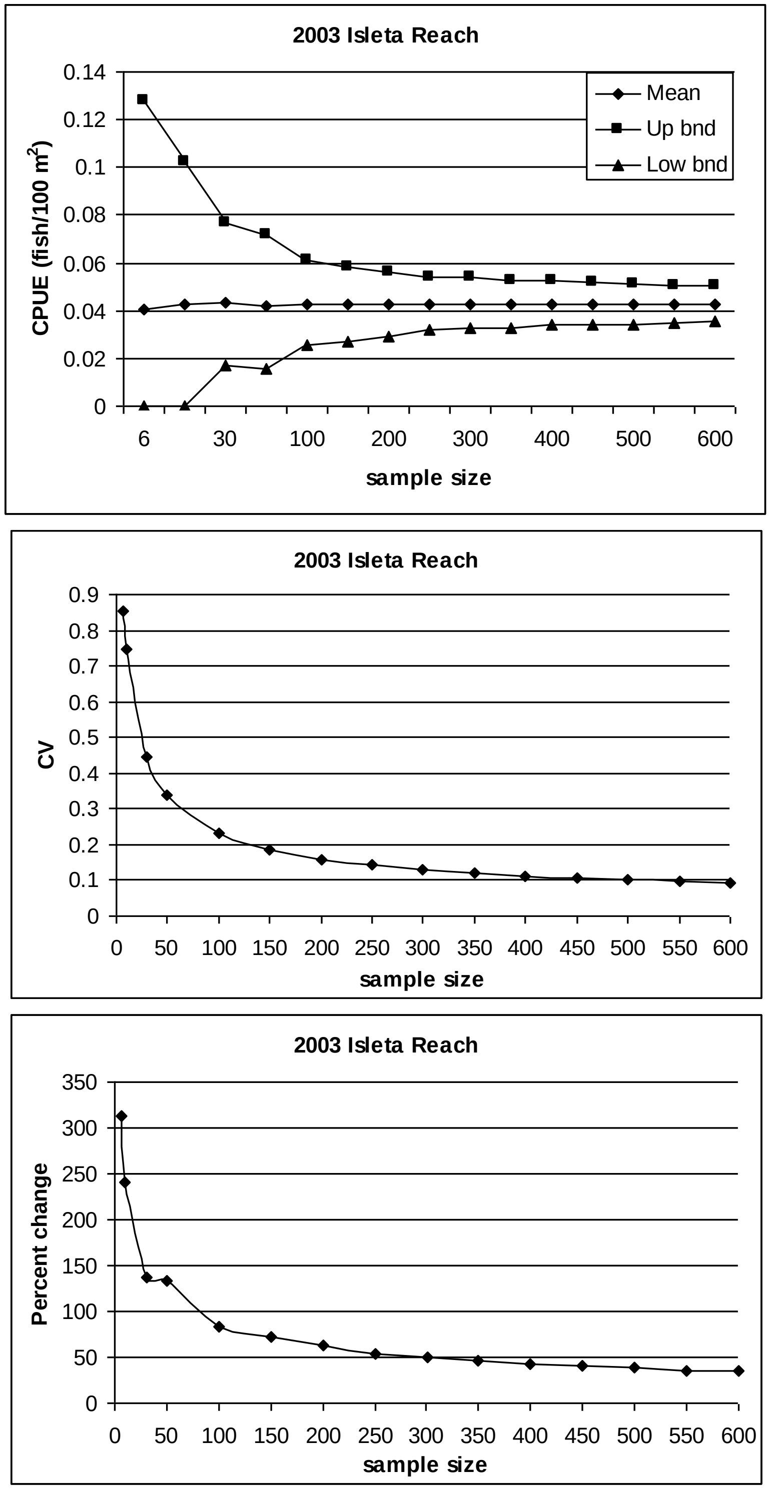


Figure A.23. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2003.

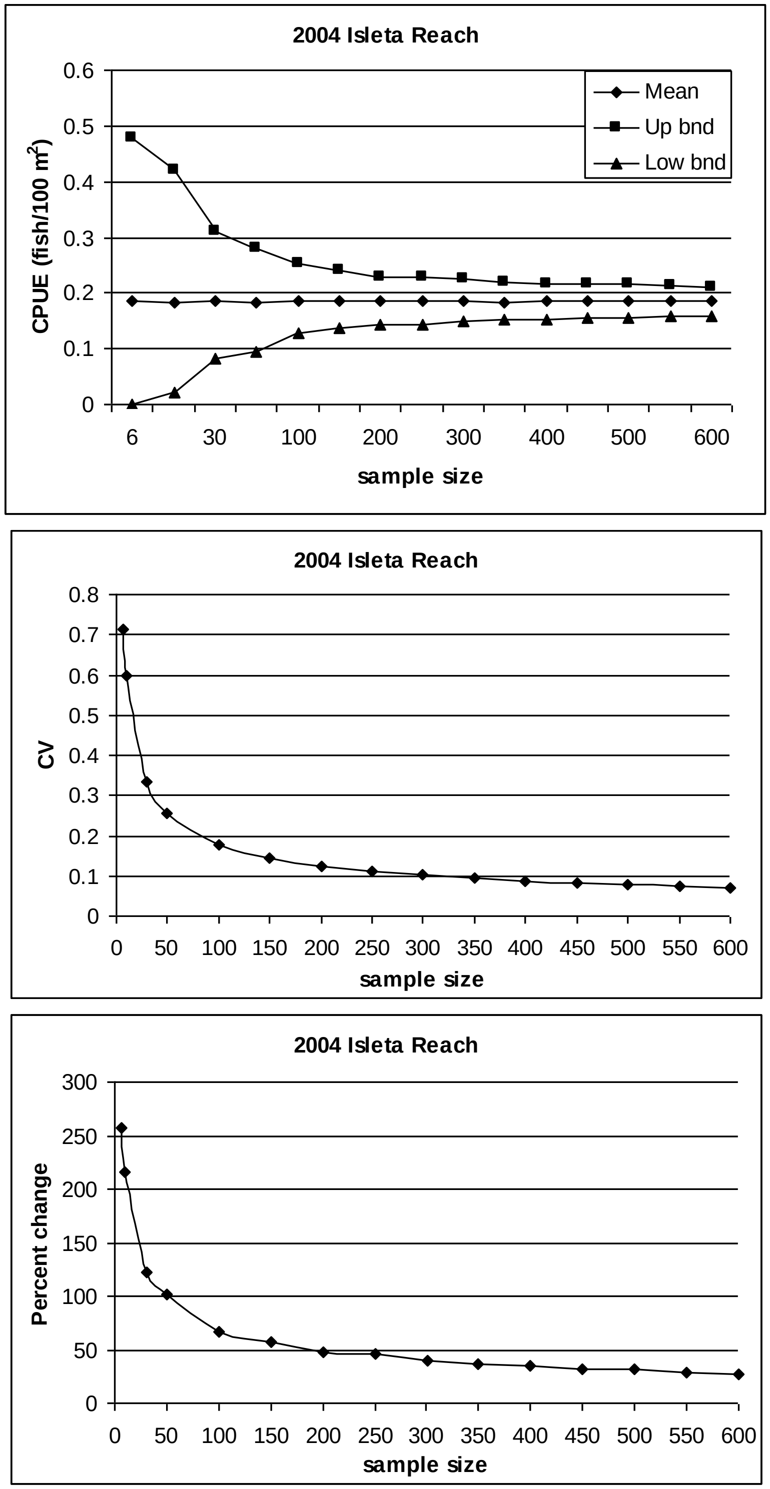


Figure A.24. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2004.

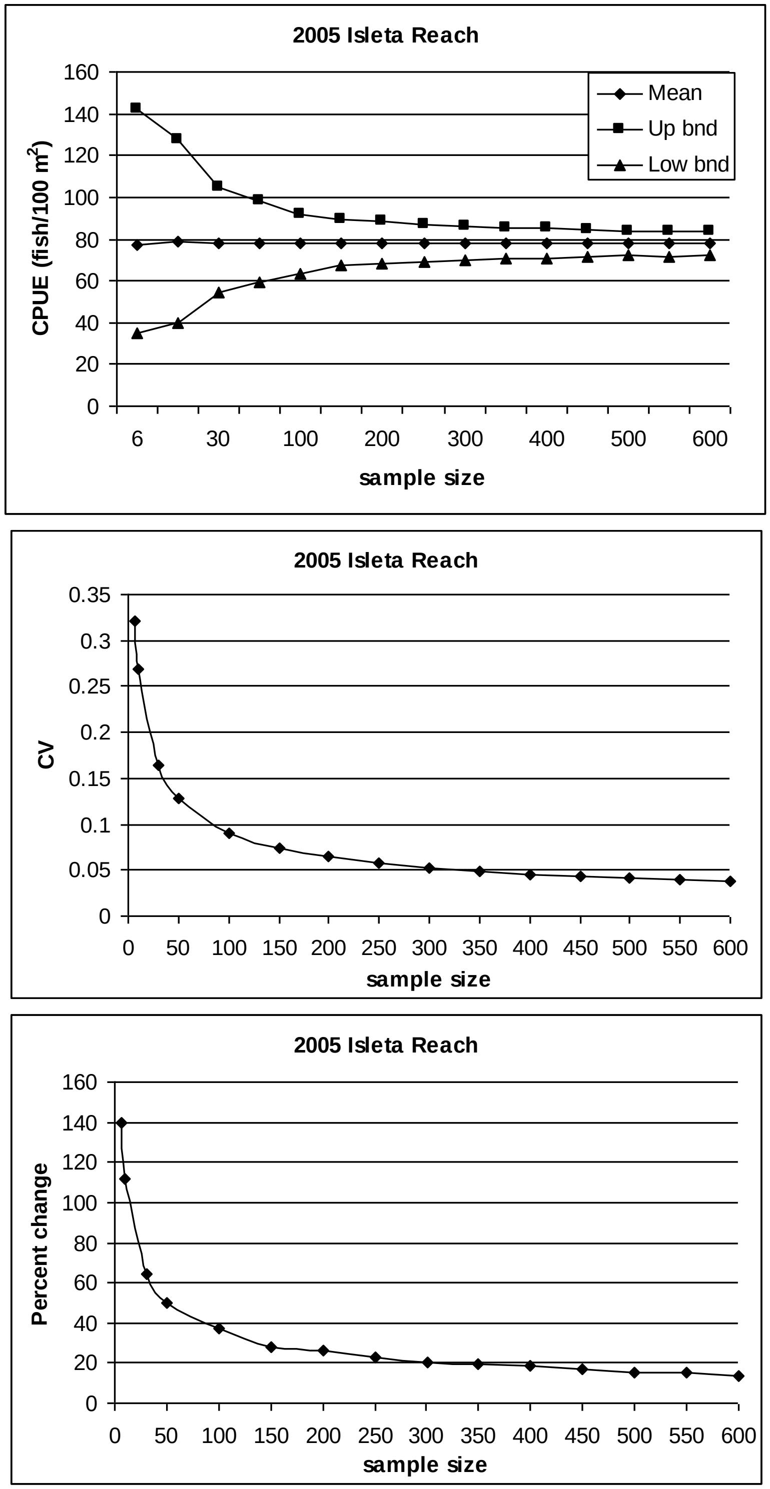


Figure A.25. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2005.

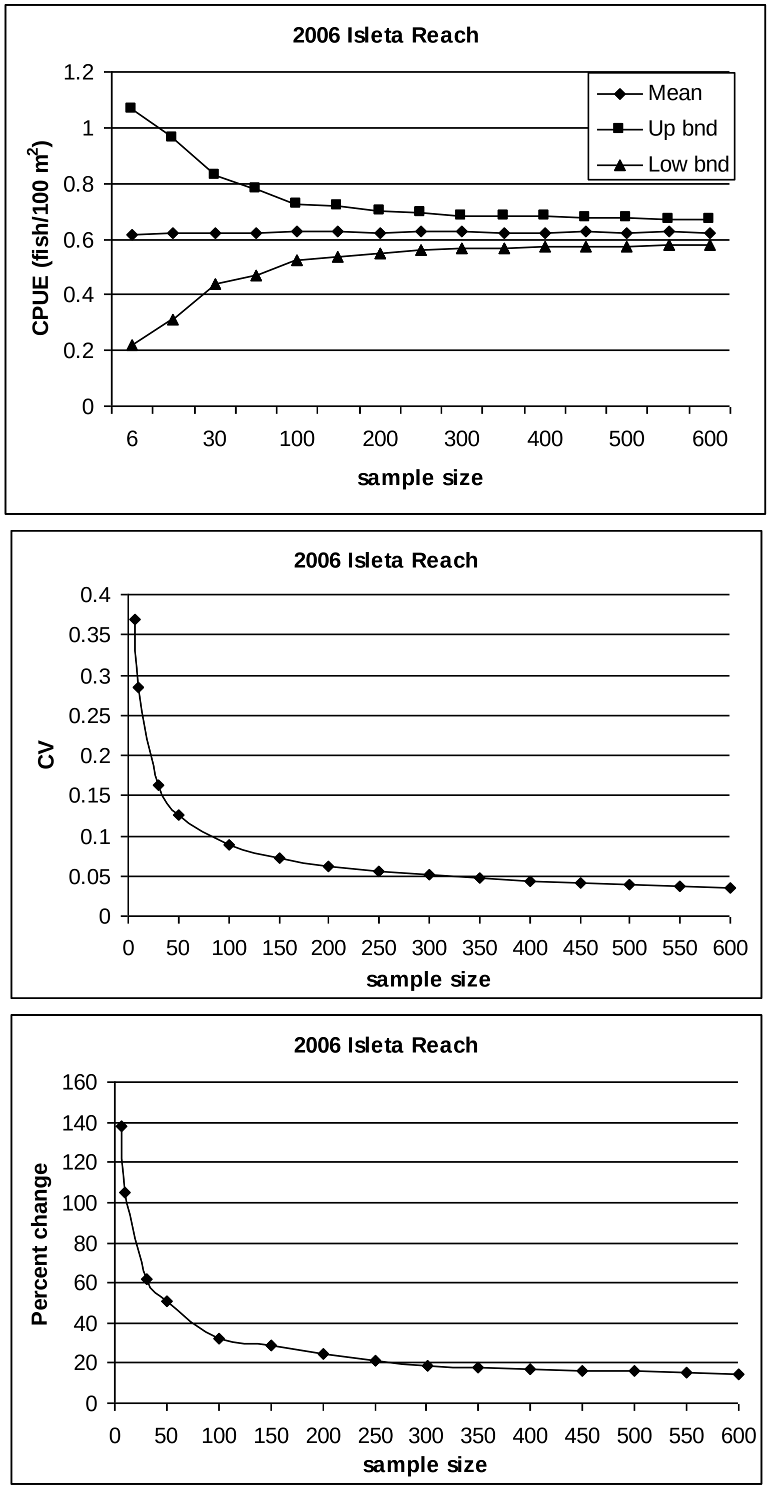
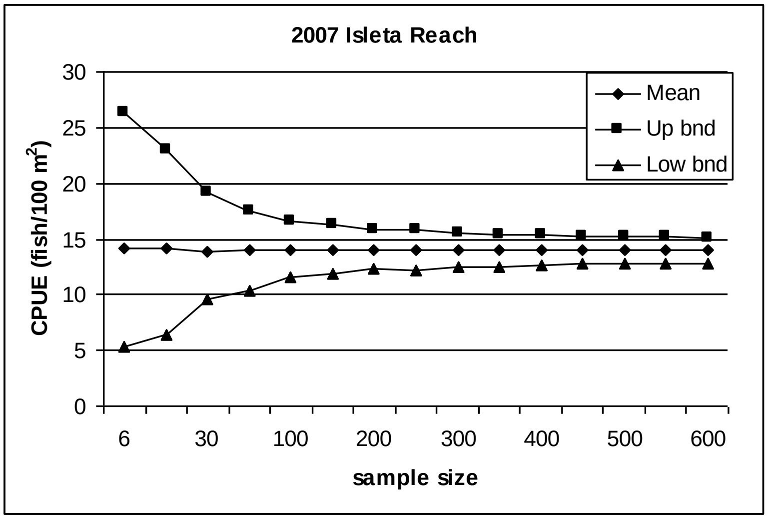
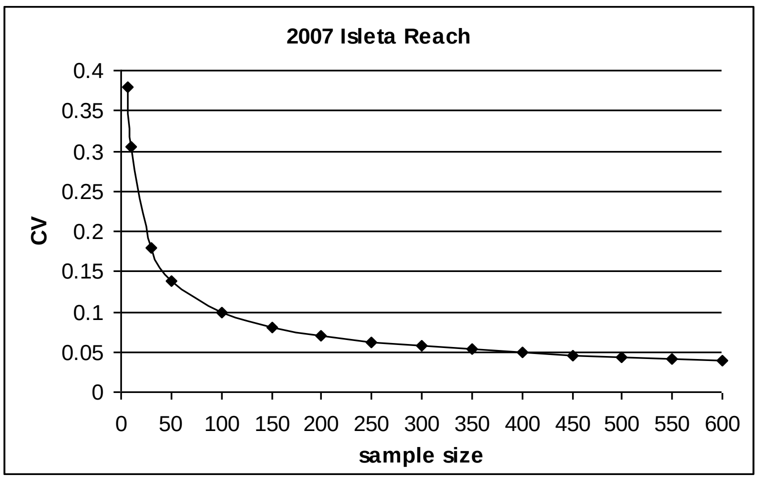


Figure A.26. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2006.





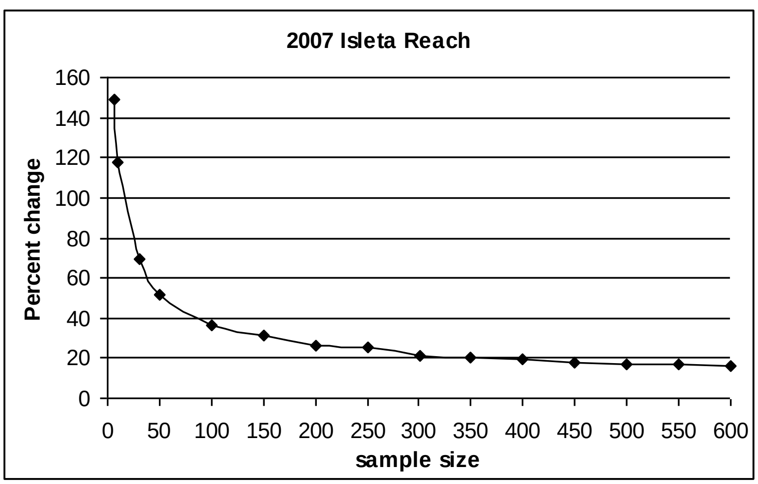


Figure A.27. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2007.

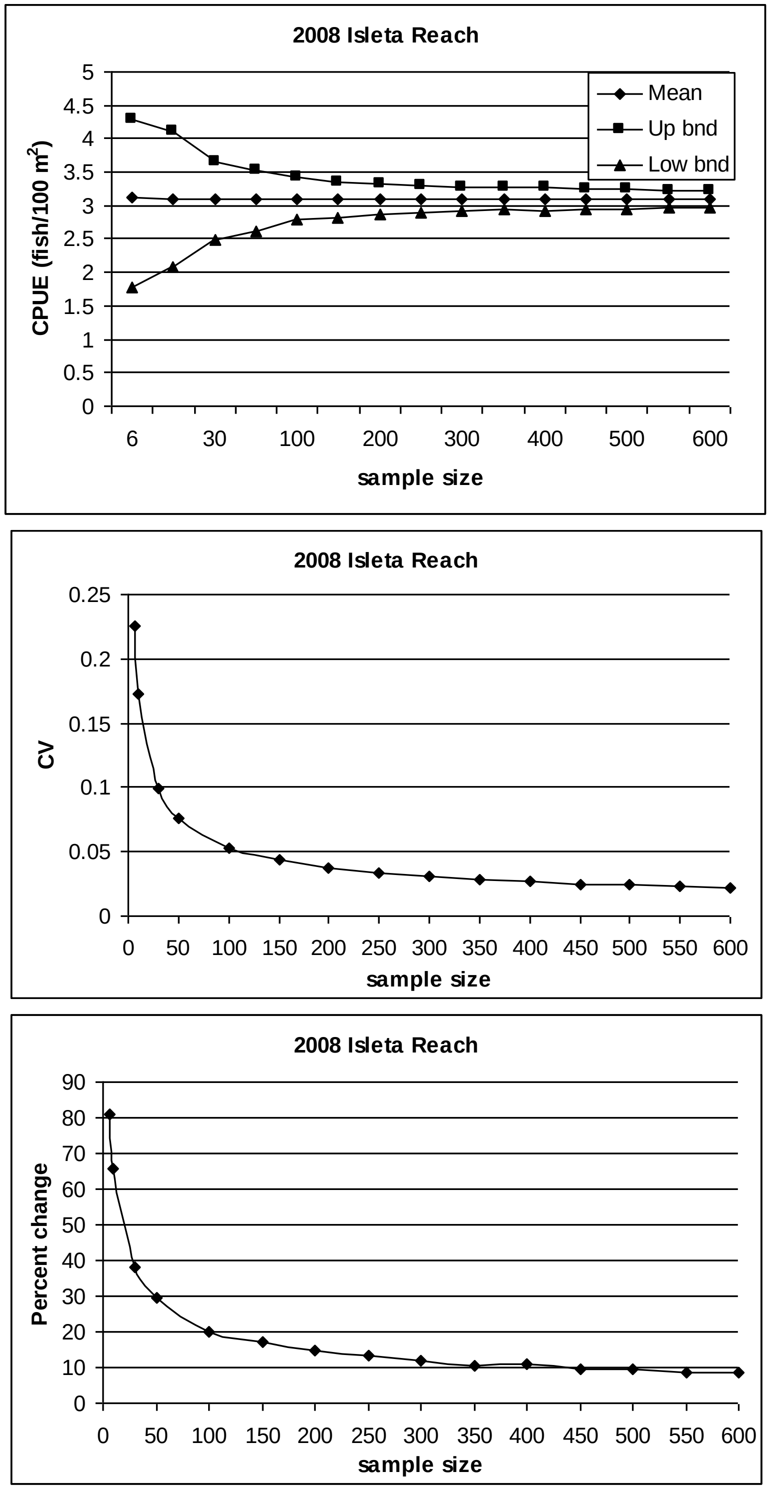
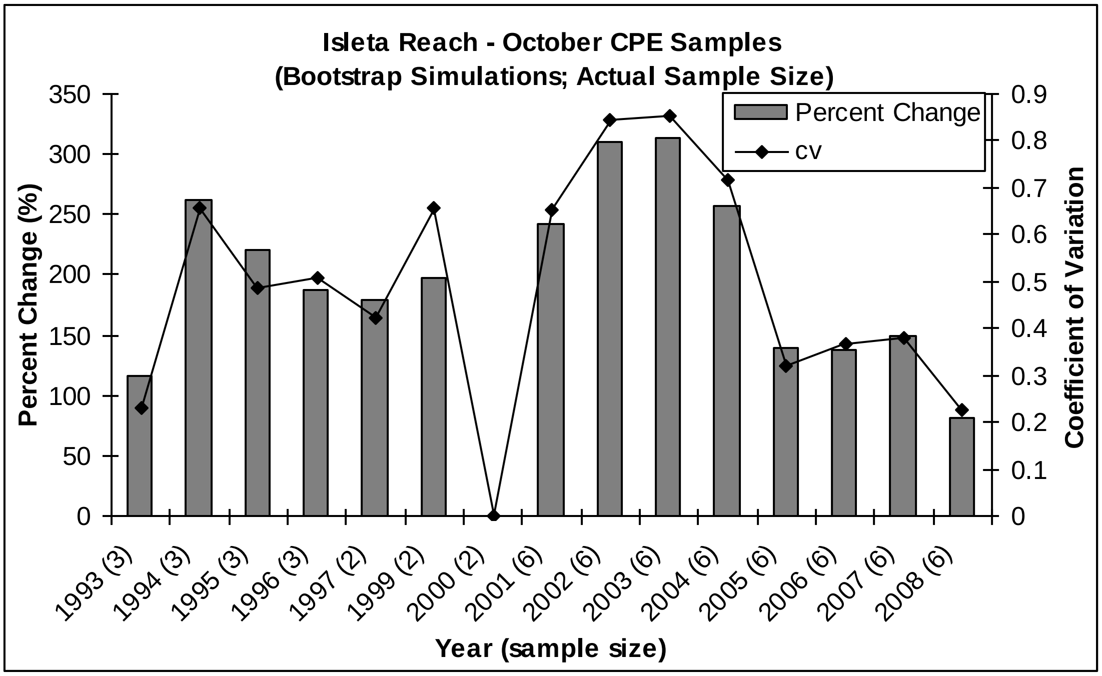


Figure A.28. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2008.



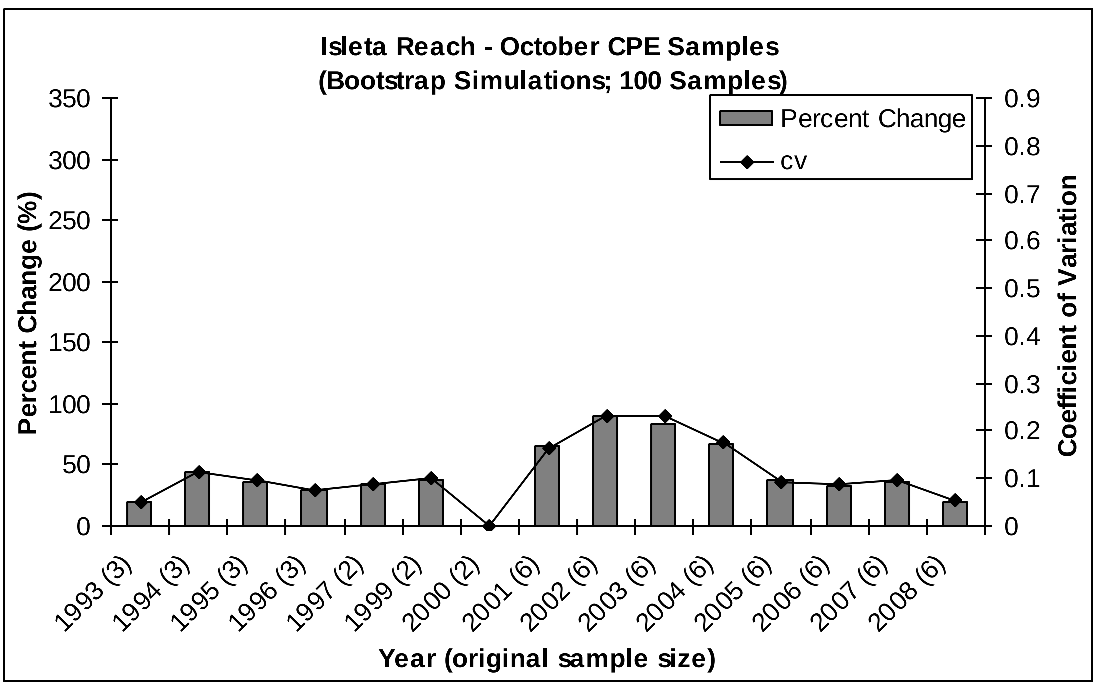


Figure A.29. Percent detectable change for October samples by year and CV for mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size (top) and expanded to 100 samples (bottom) in the Isleta Reach, 1993–1997 and 1999–2008. Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_PVAgoodman.xls.

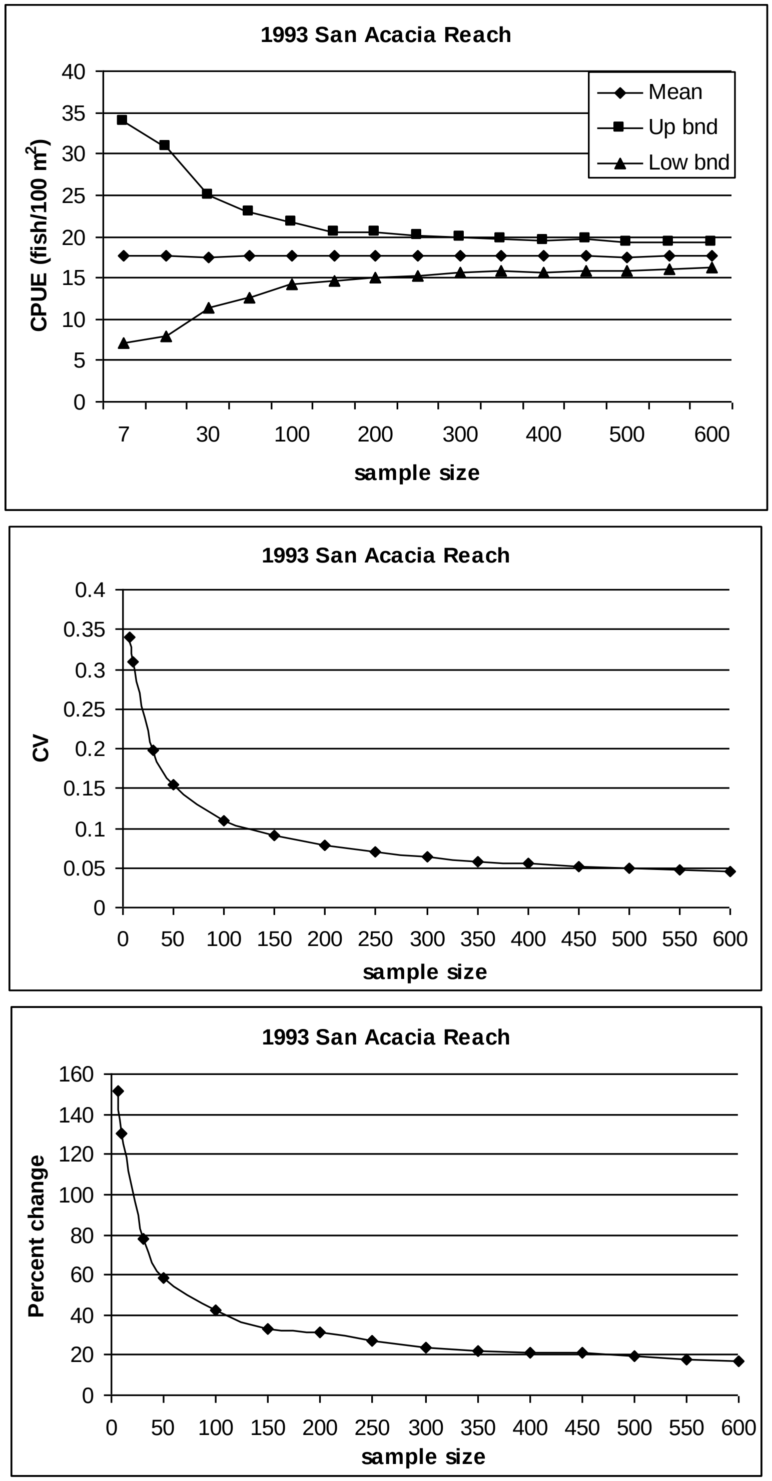


Figure A.30. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 1993.

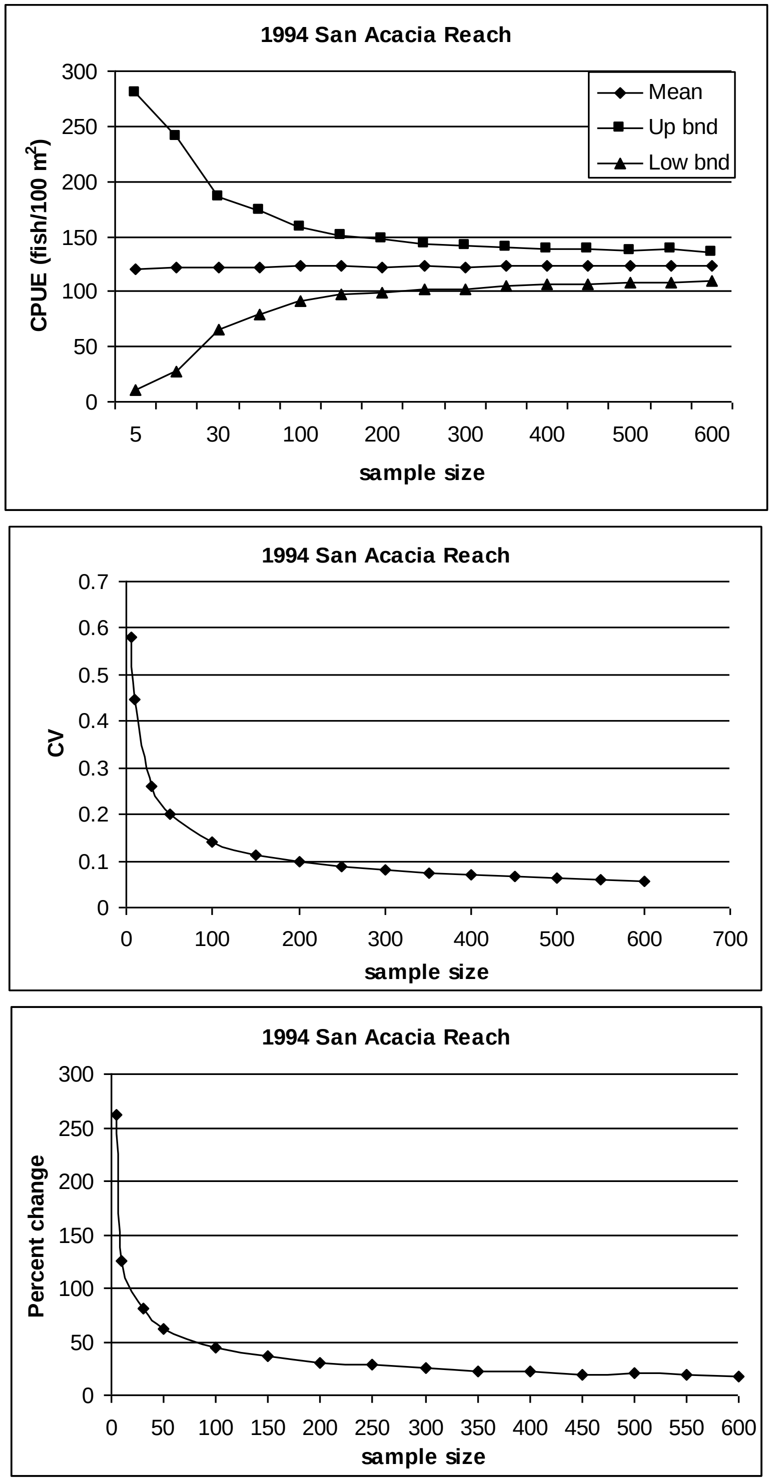


Figure A.31. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 1994.

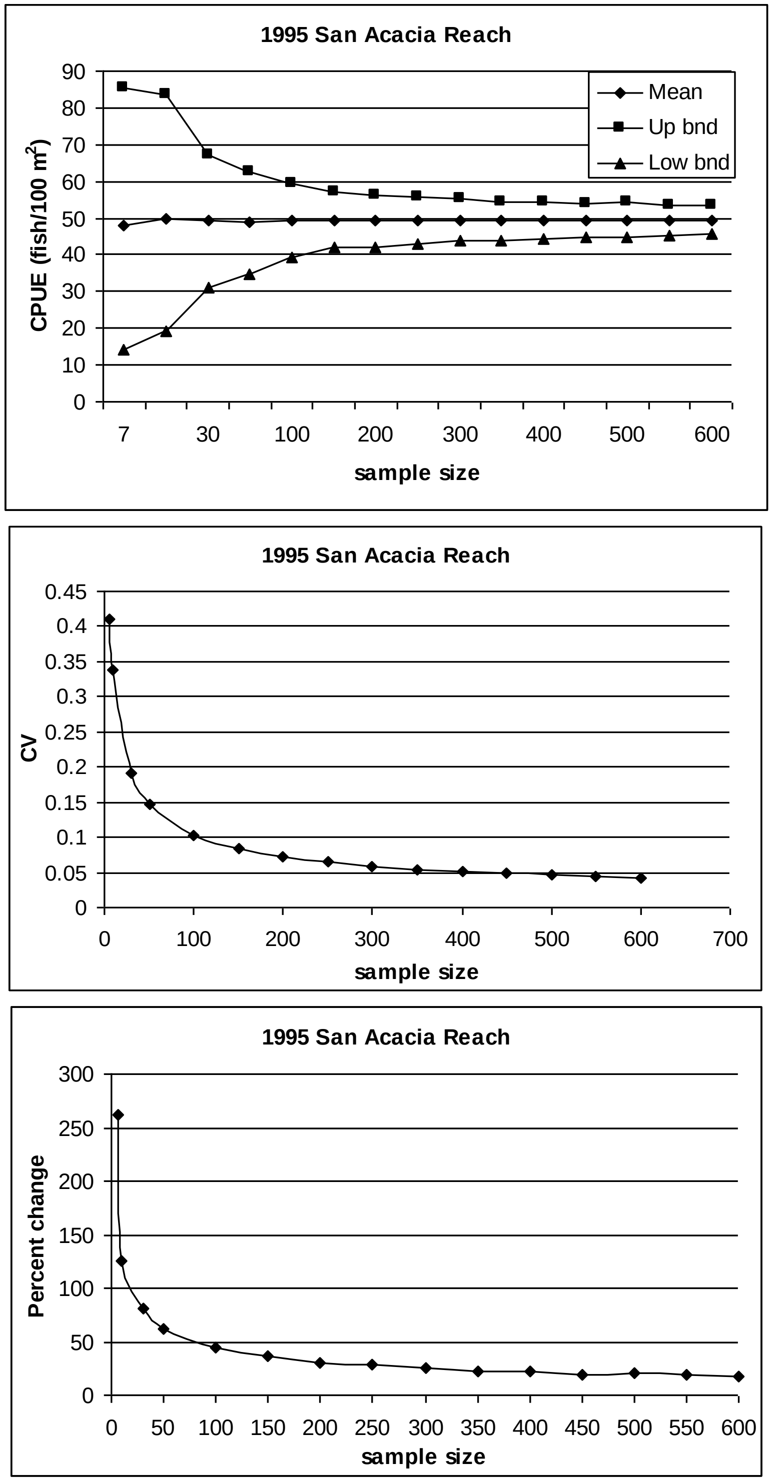


Figure A.32. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 1995.

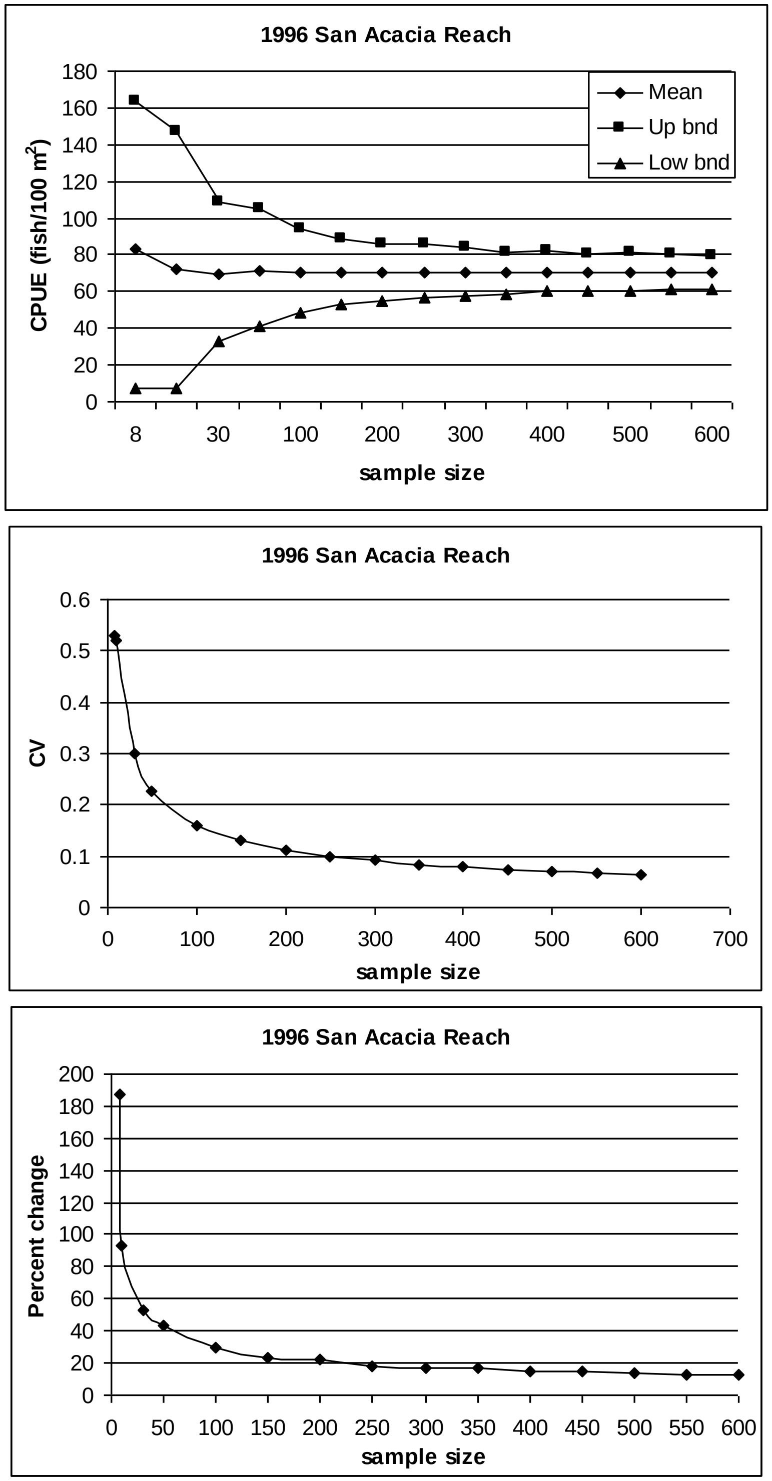


Figure A.33. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 1996.

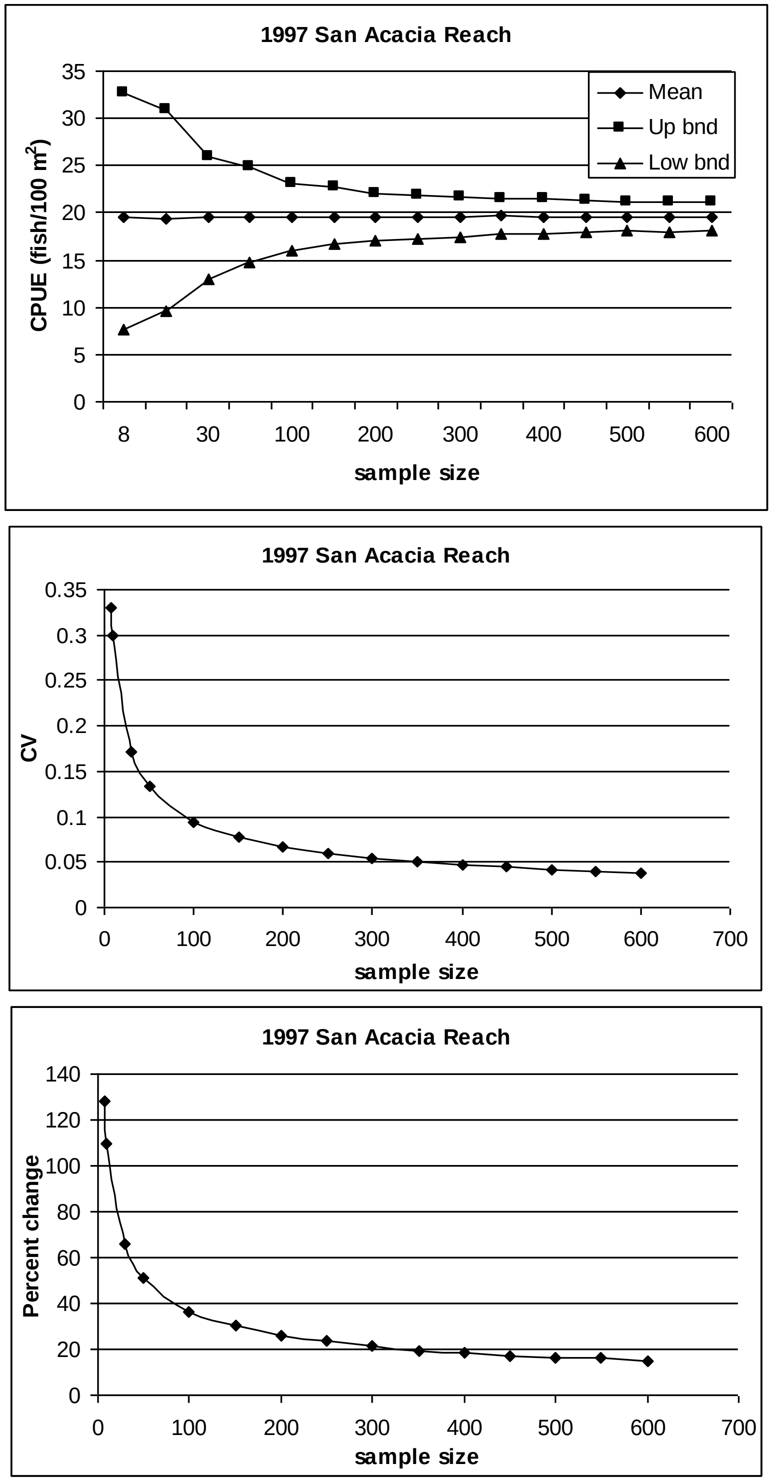


Figure A.34. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 1997.

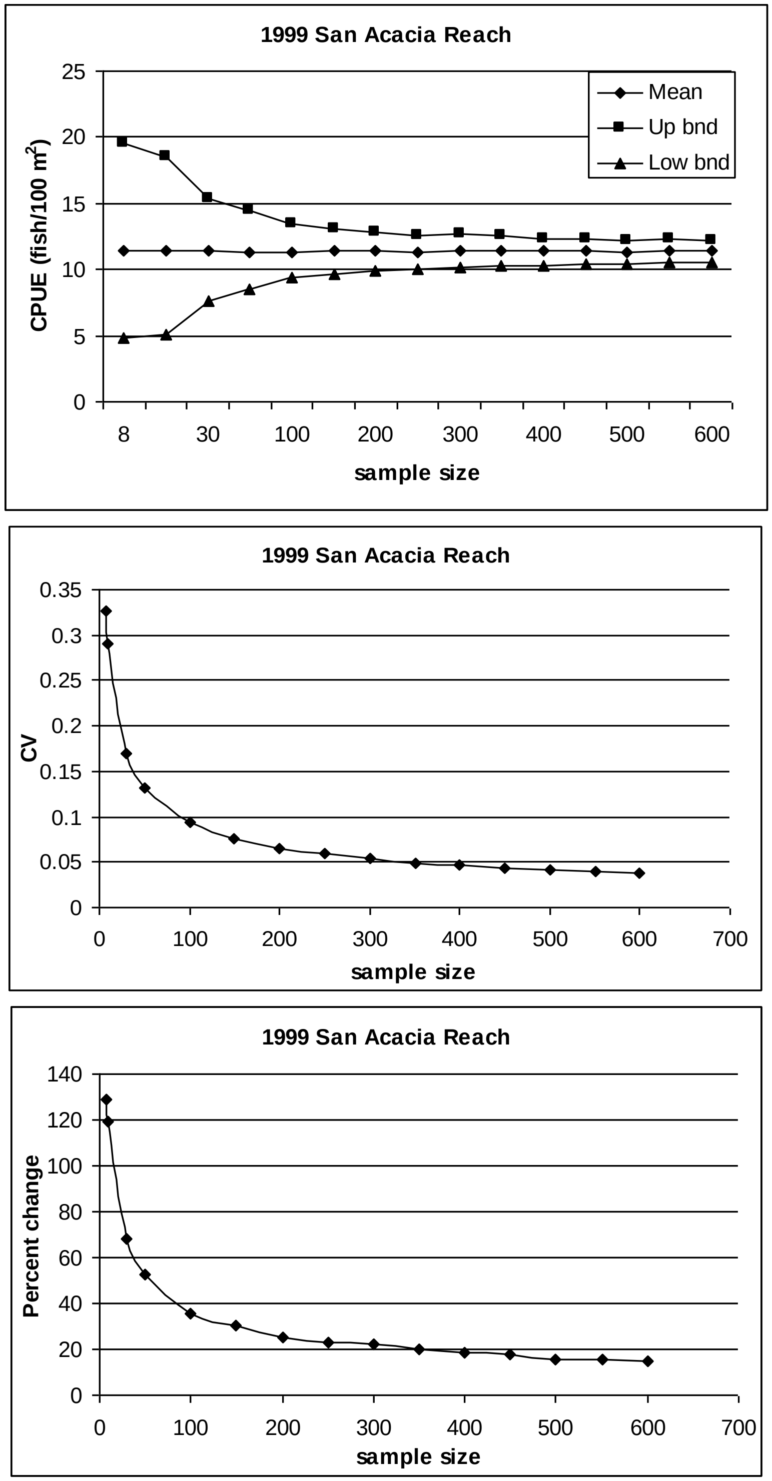


Figure A.35. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 1999.

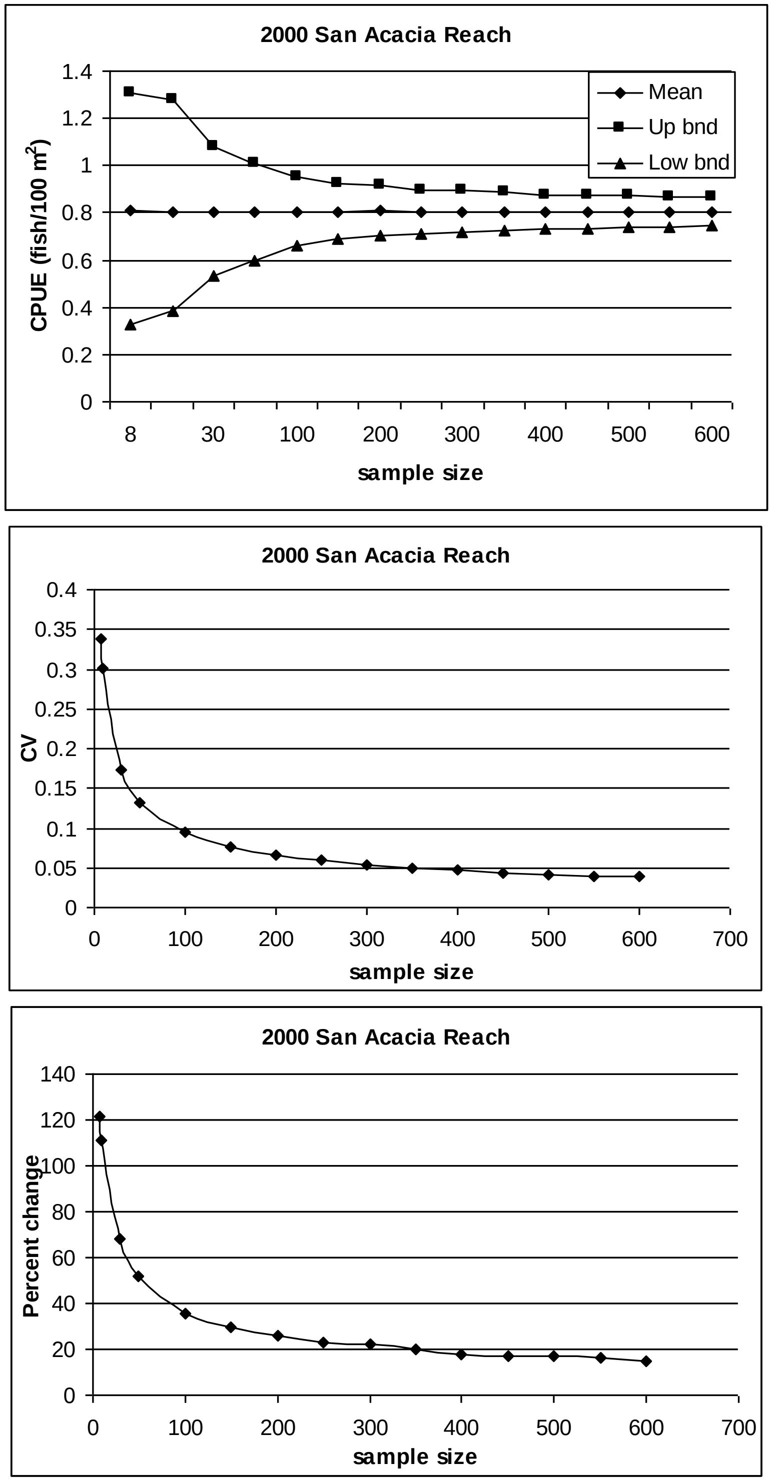


Figure A.36. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2000.

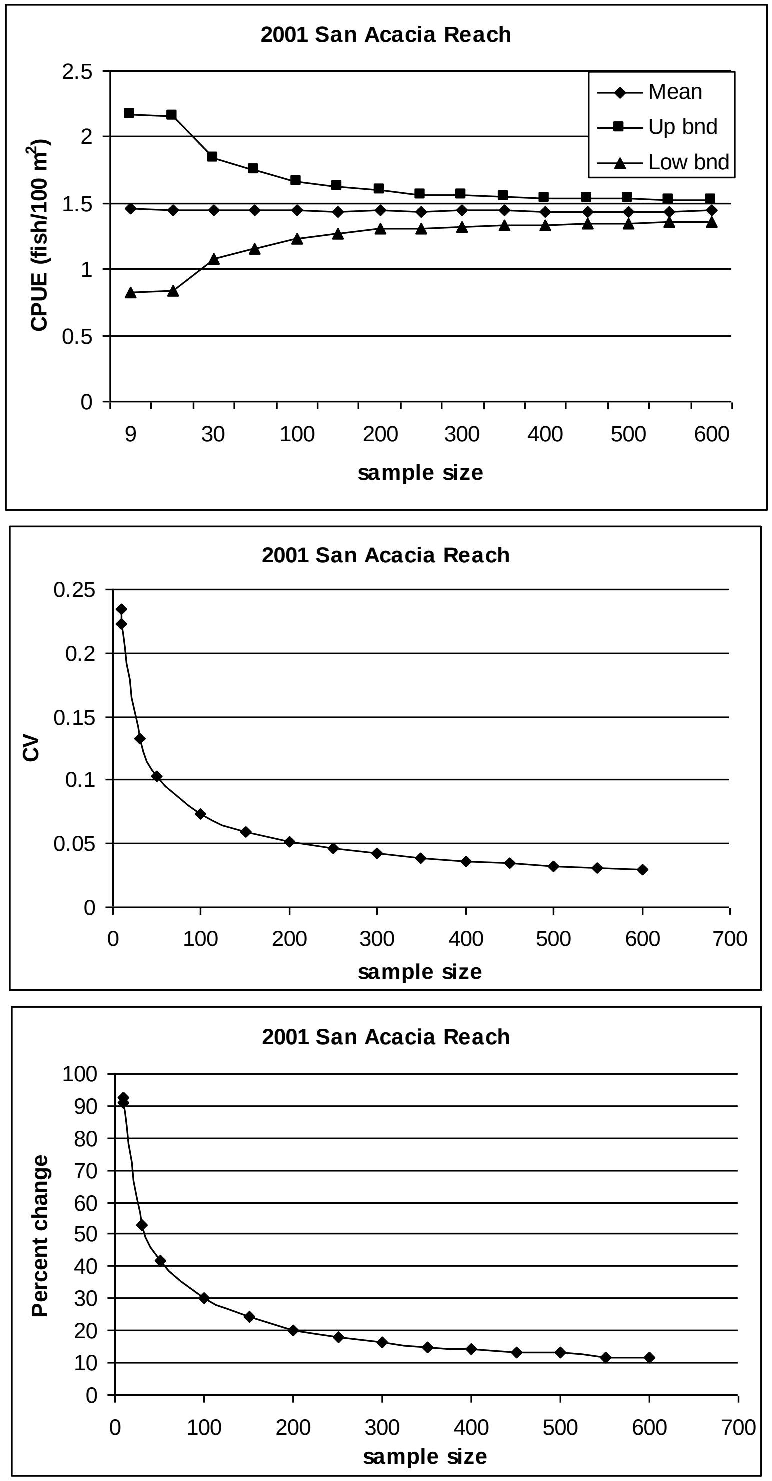


Figure A.37. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2001.

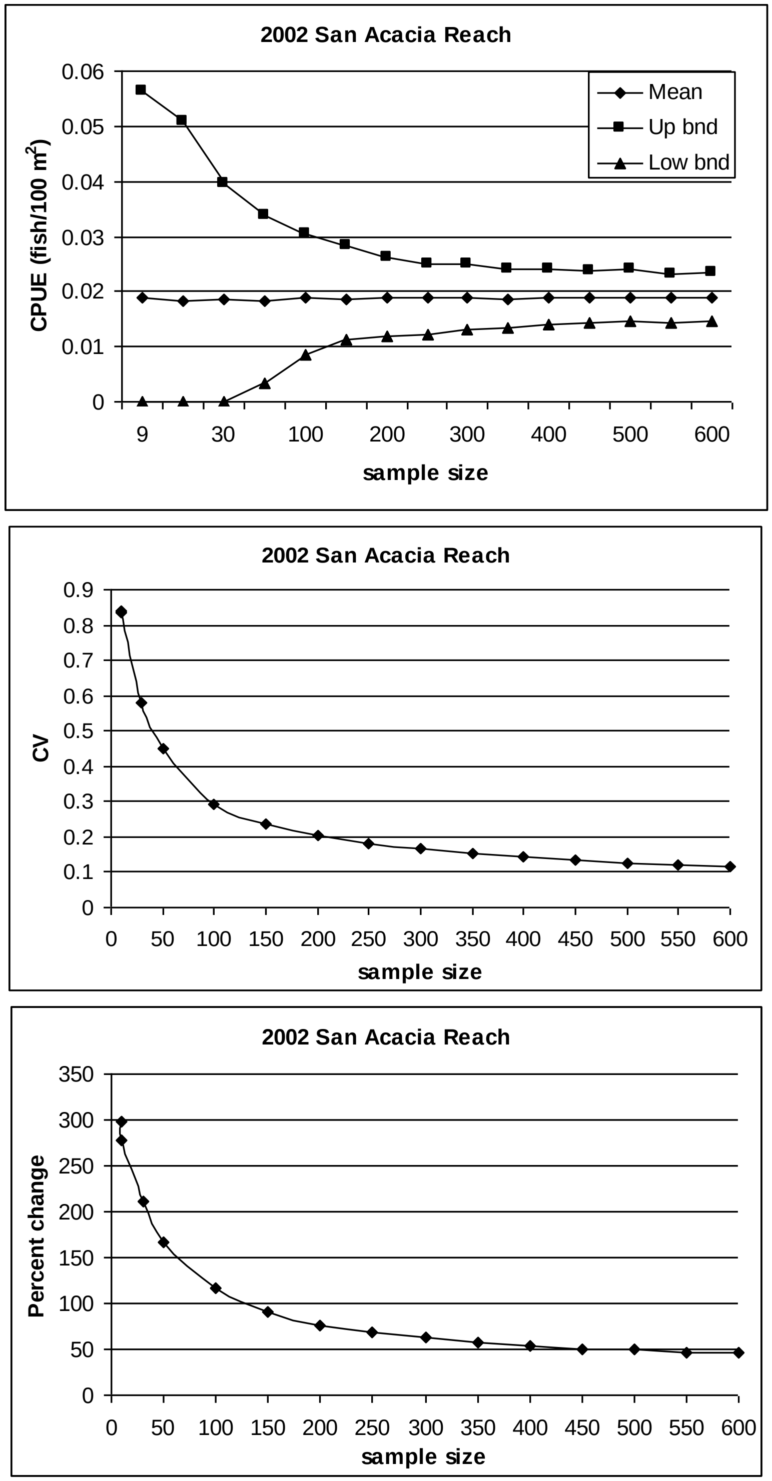


Figure A.38. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2002.

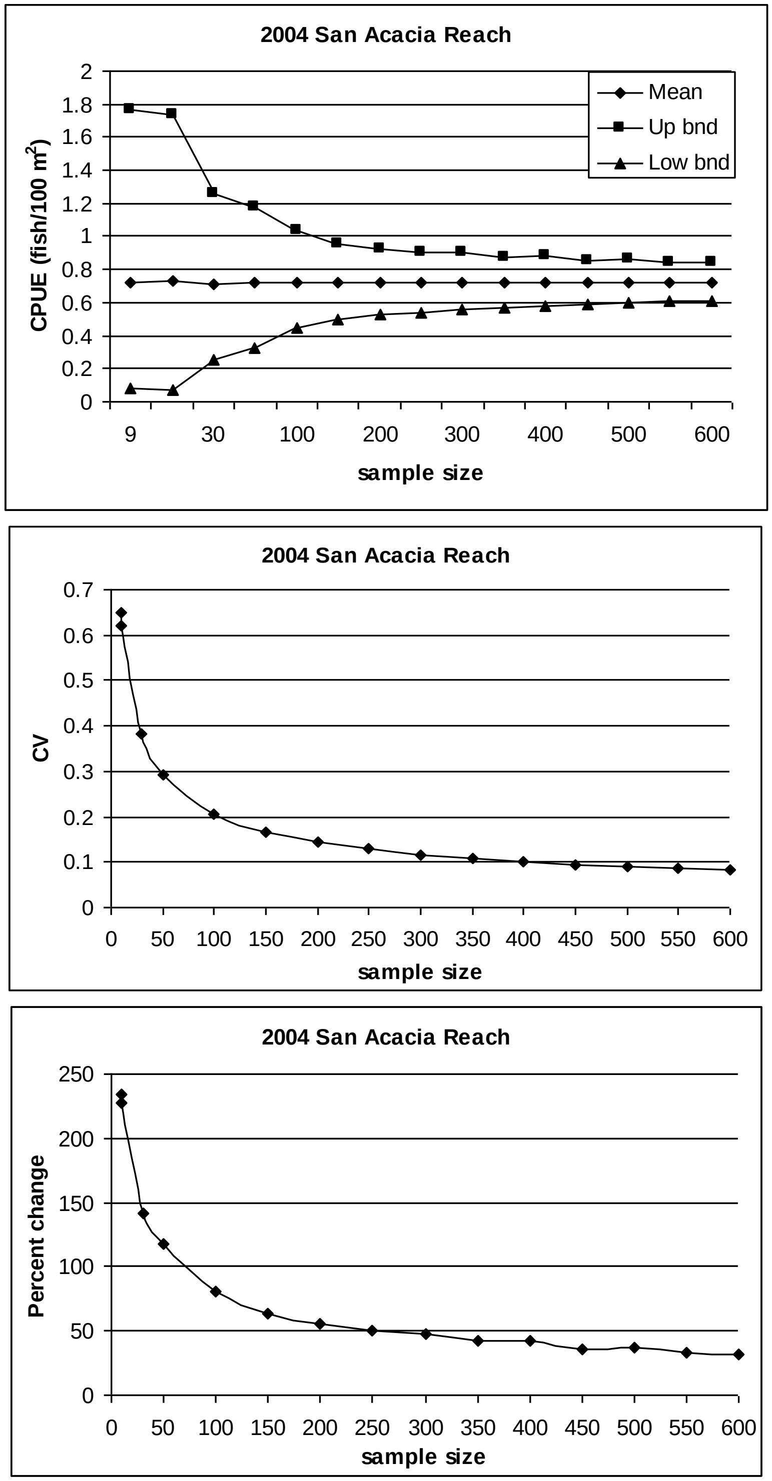


Figure A.39. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2004.

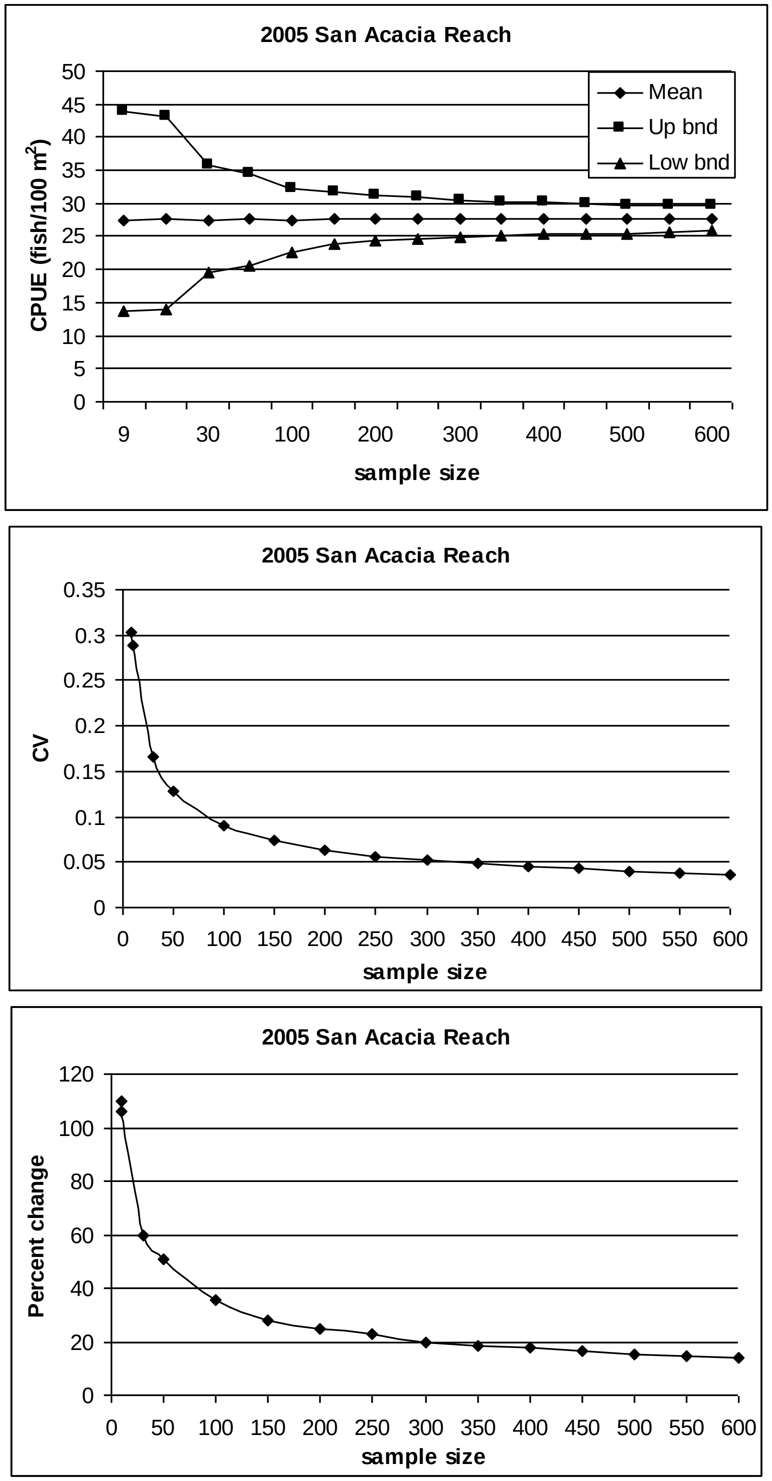


Figure A.40. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2005.

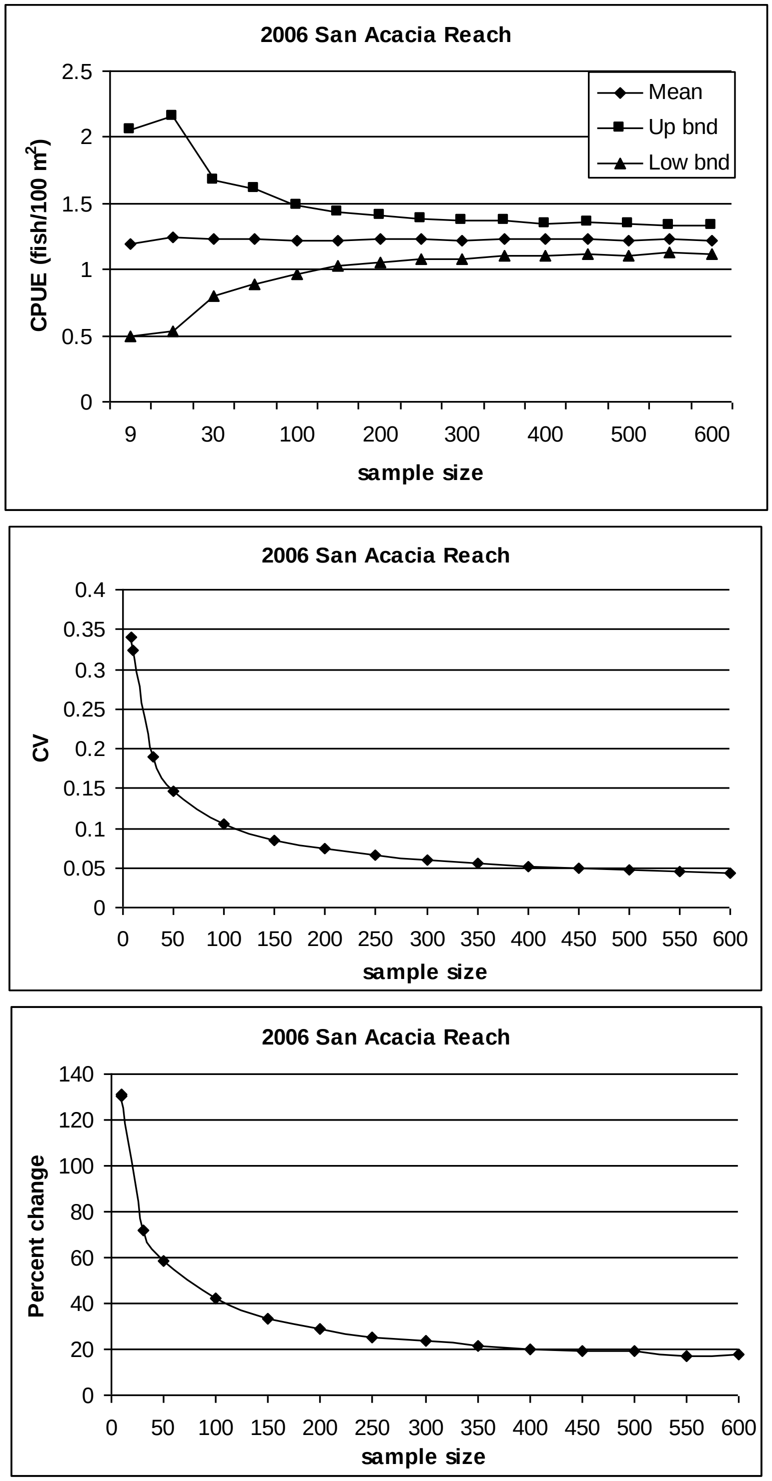


Figure A.41. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2006.

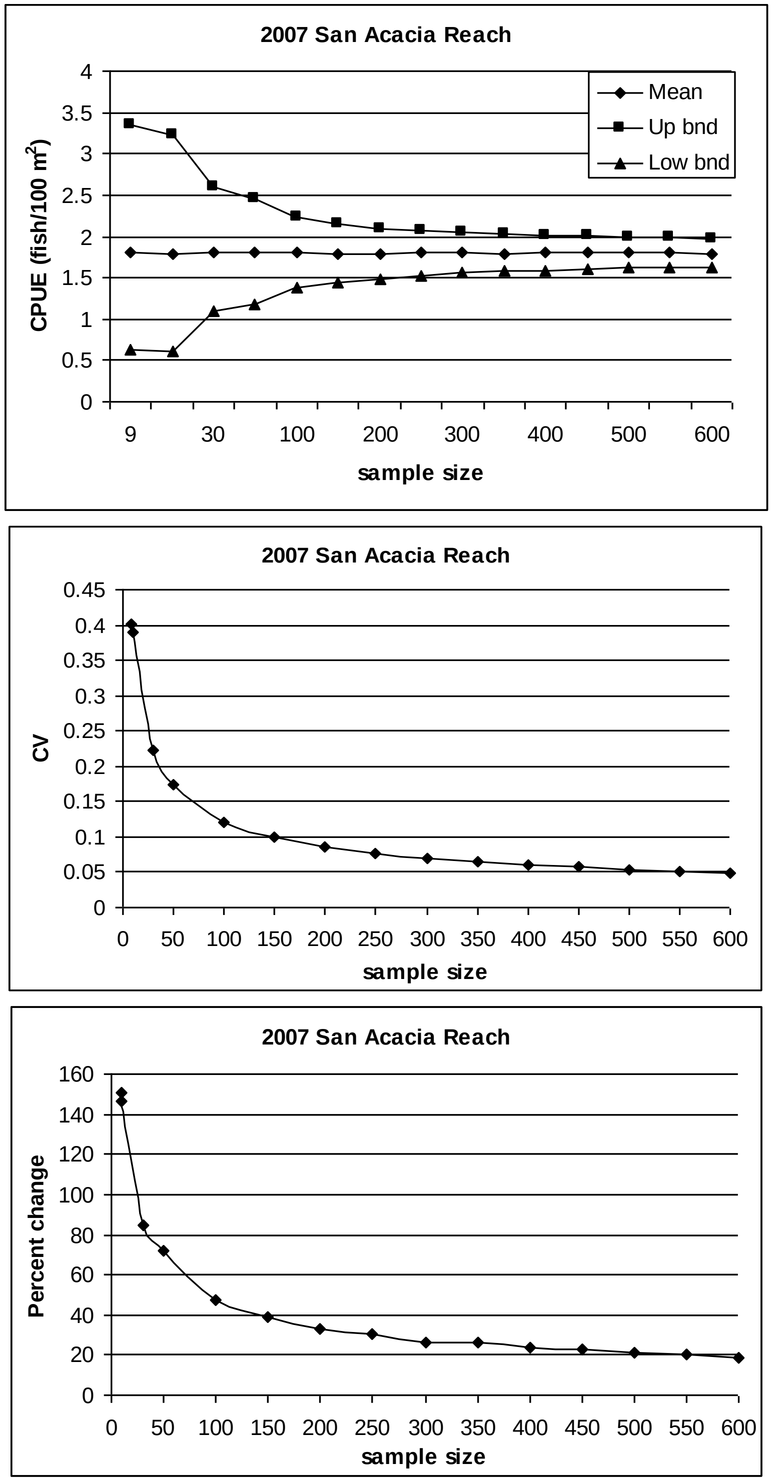
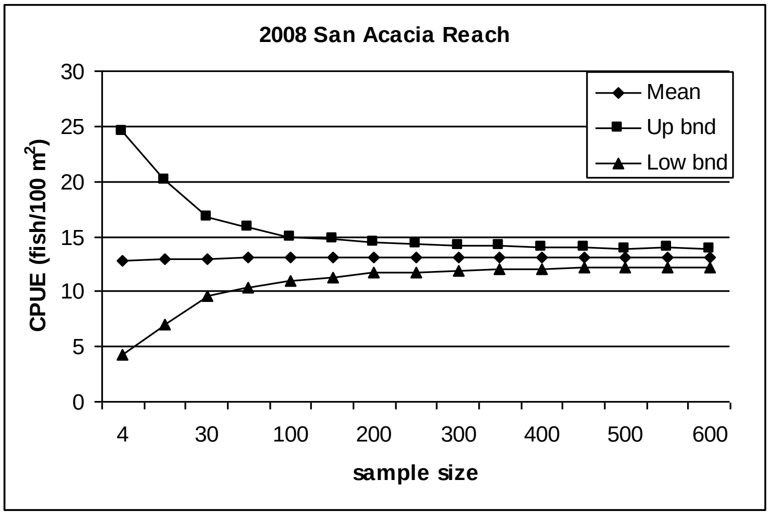
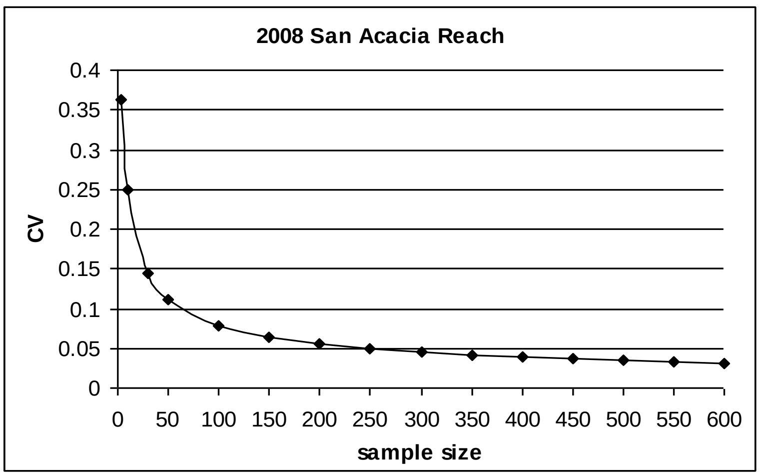


Figure A.42. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2007.





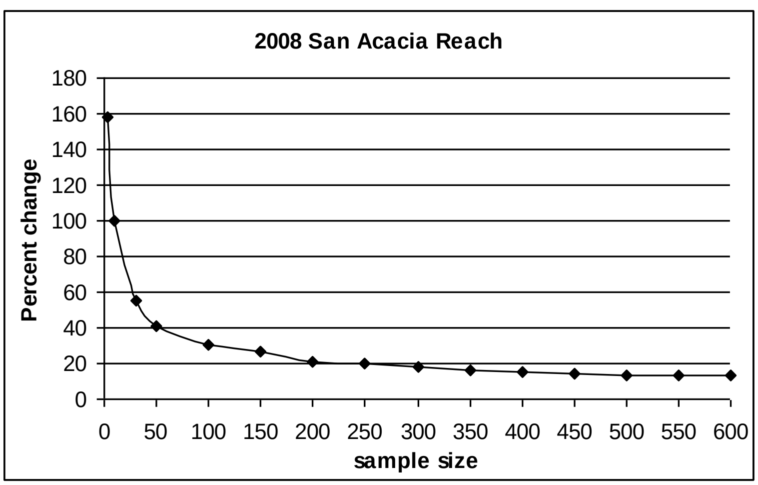


Figure A.43. The effect of seine sample size in October on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2008.

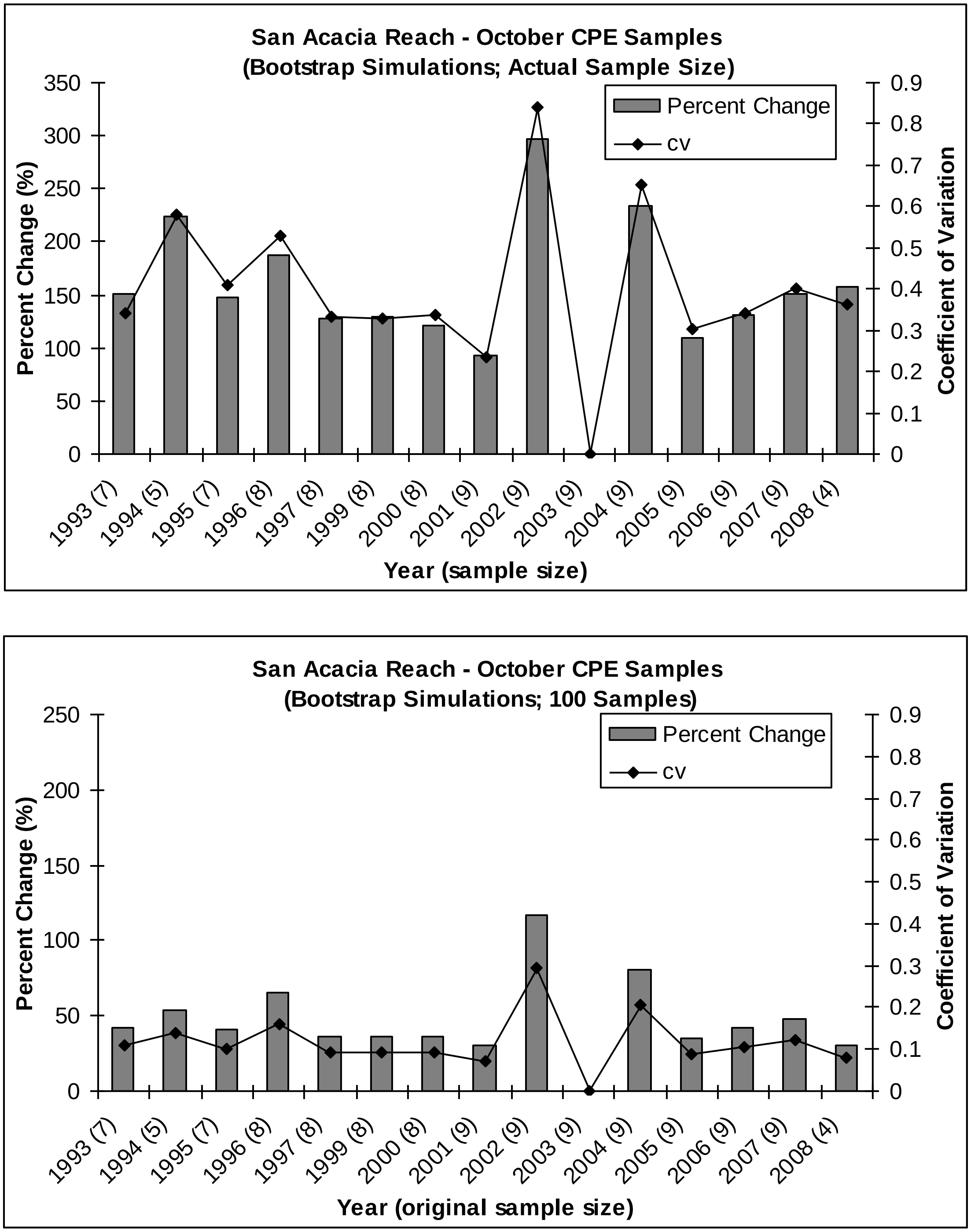


Figure A.44. Percent detectable change for October samples by year and CV for mean CPUE of silvery minnow seine monitoring data normalized by bootstrapping (1,000 iterations of actual sample size) with actual sample size (top) and expanded to 100 samples (bottom) in the San Acacia Reach, 1993–1997 and 1999–2008. Datasets: ASIR-AllRGSMLengths_Raw.xls, ASIR-RGSM_Pop_mon_Query_ PVAgoodman.xls.

APPENDIX B
TABLES AND FIGURES SHOWING DETAILED ANALYSES OF DATASETS 3:
05.+RGSMMONITORINGDATA_DEC2007+FOR+GOODMAN.XLS

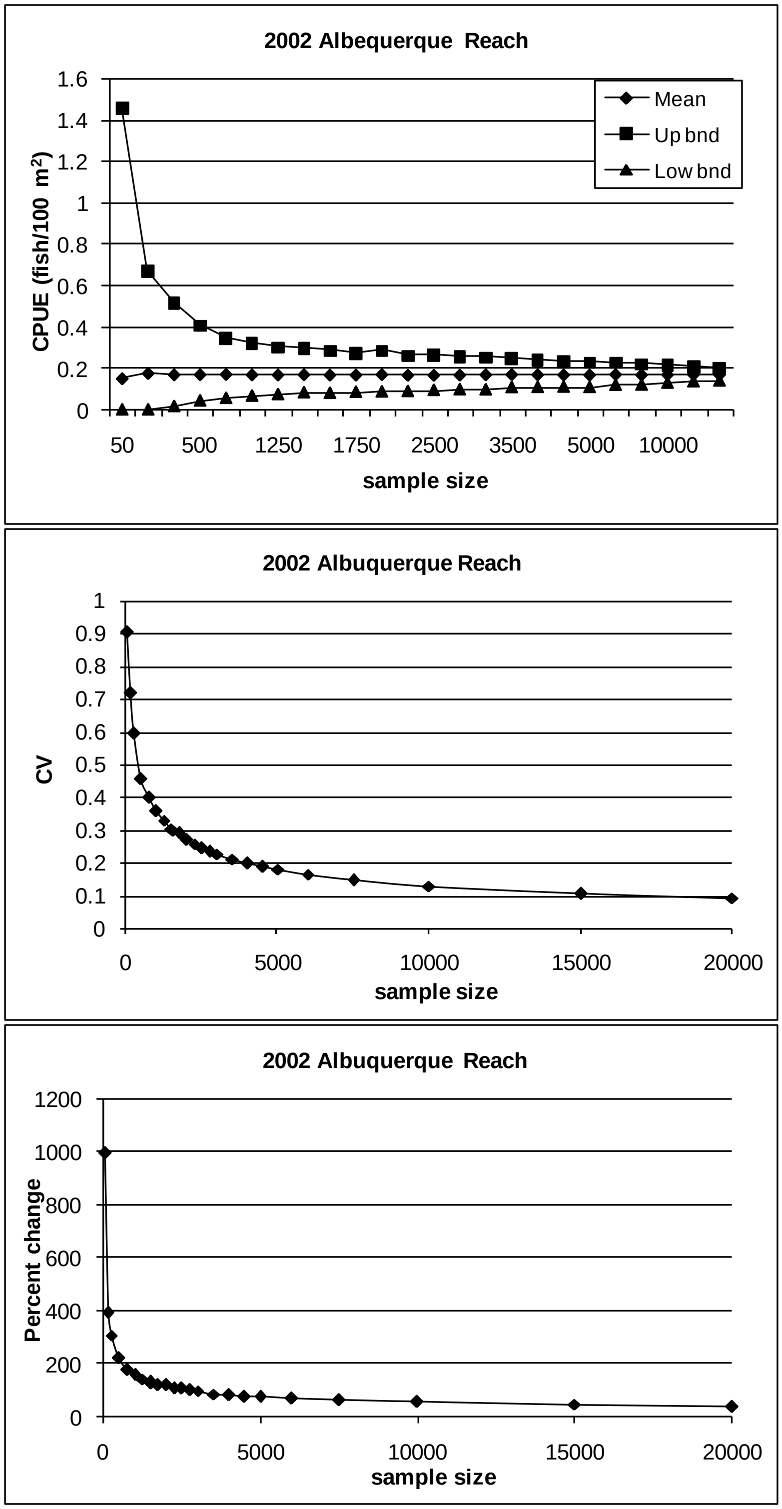


Figure B.1. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2002.

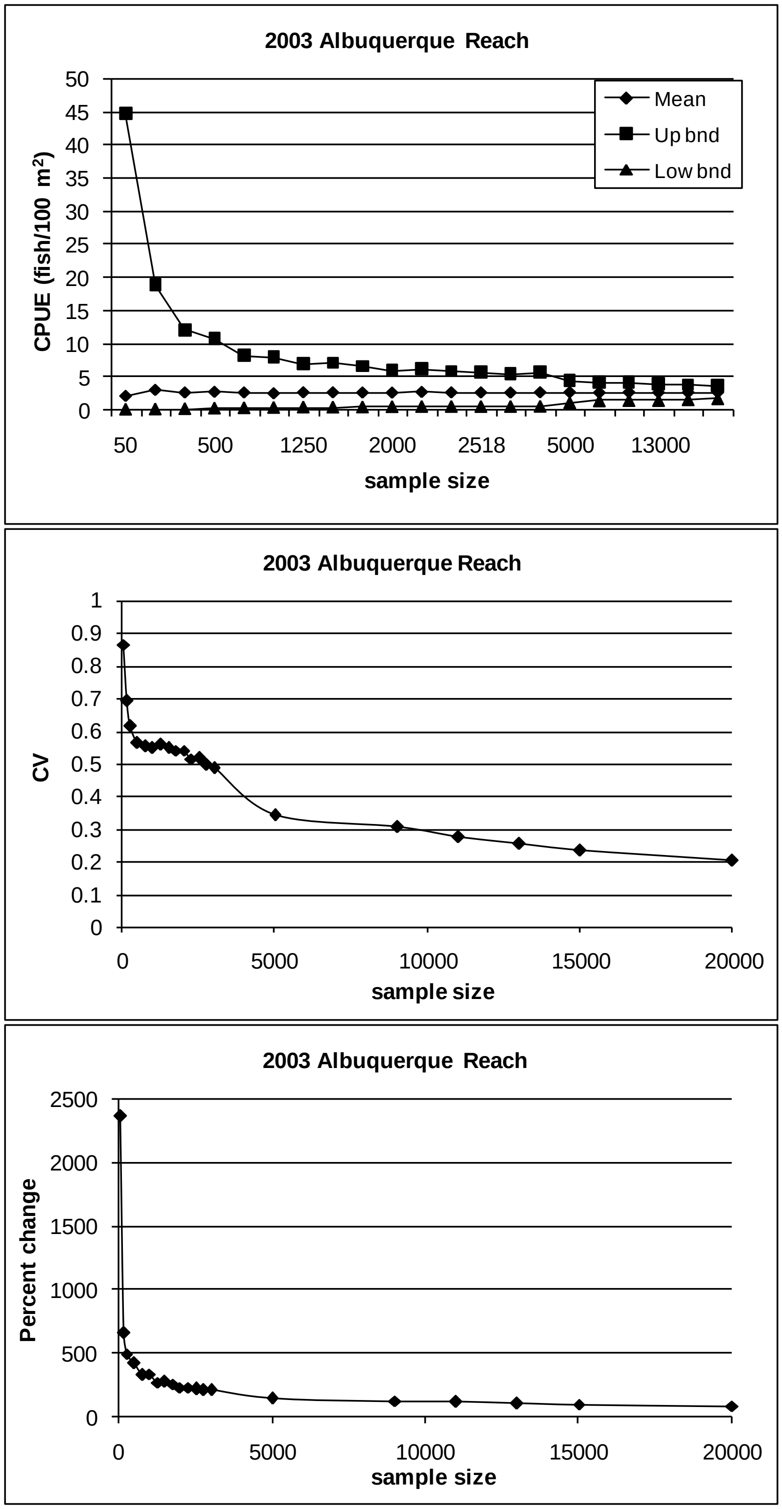


Figure B.2. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2003.

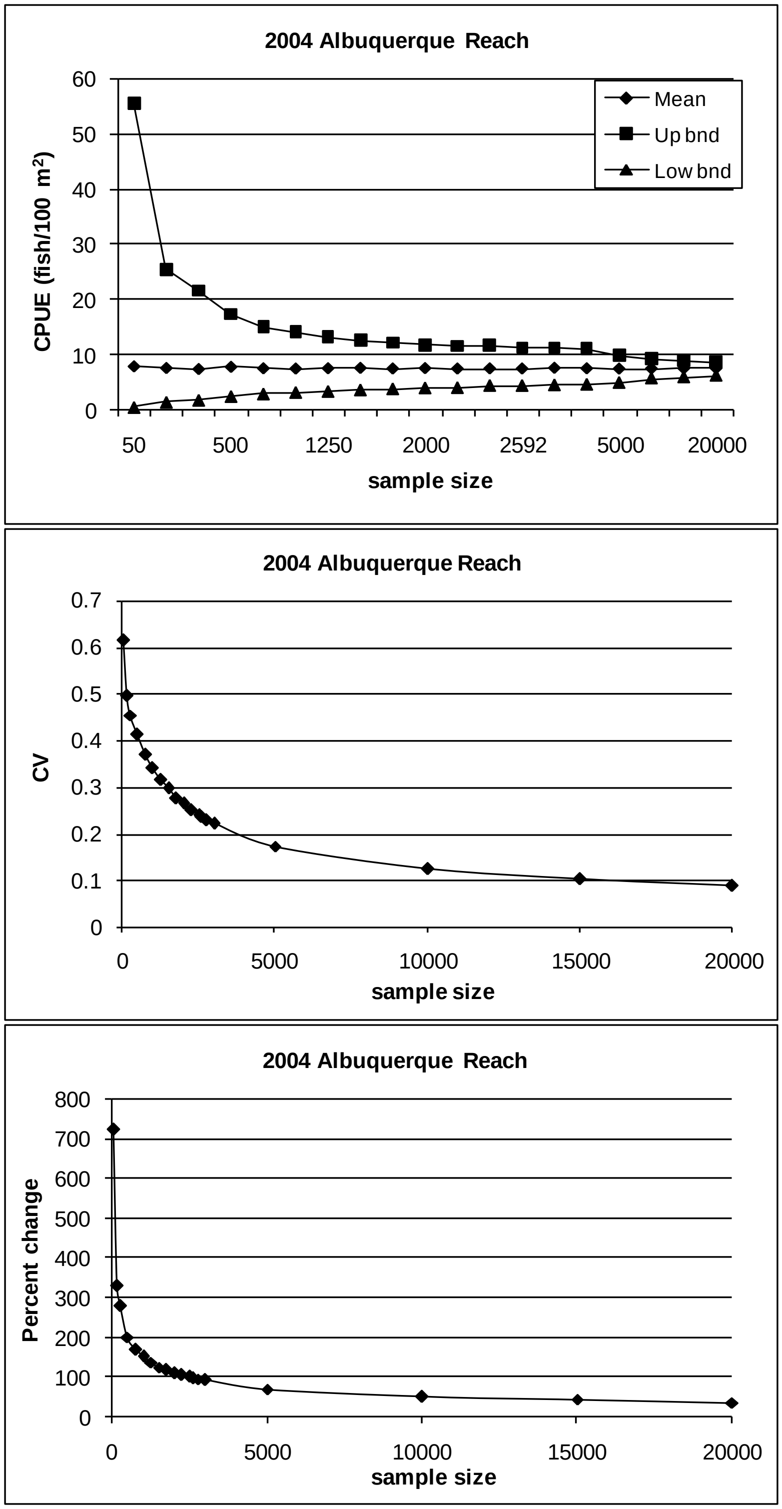


Figure B.3. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2004.

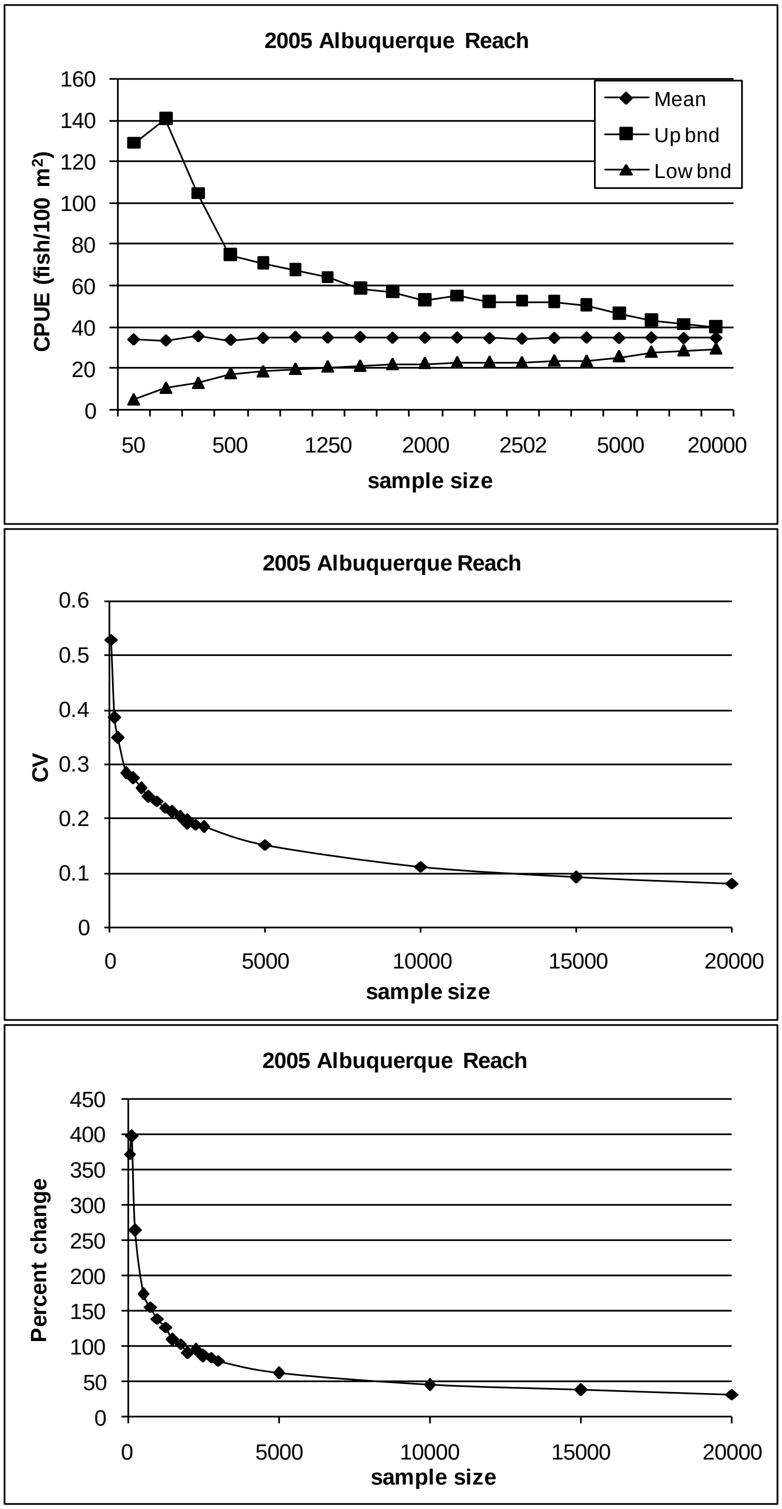


Figure B.4. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2005.

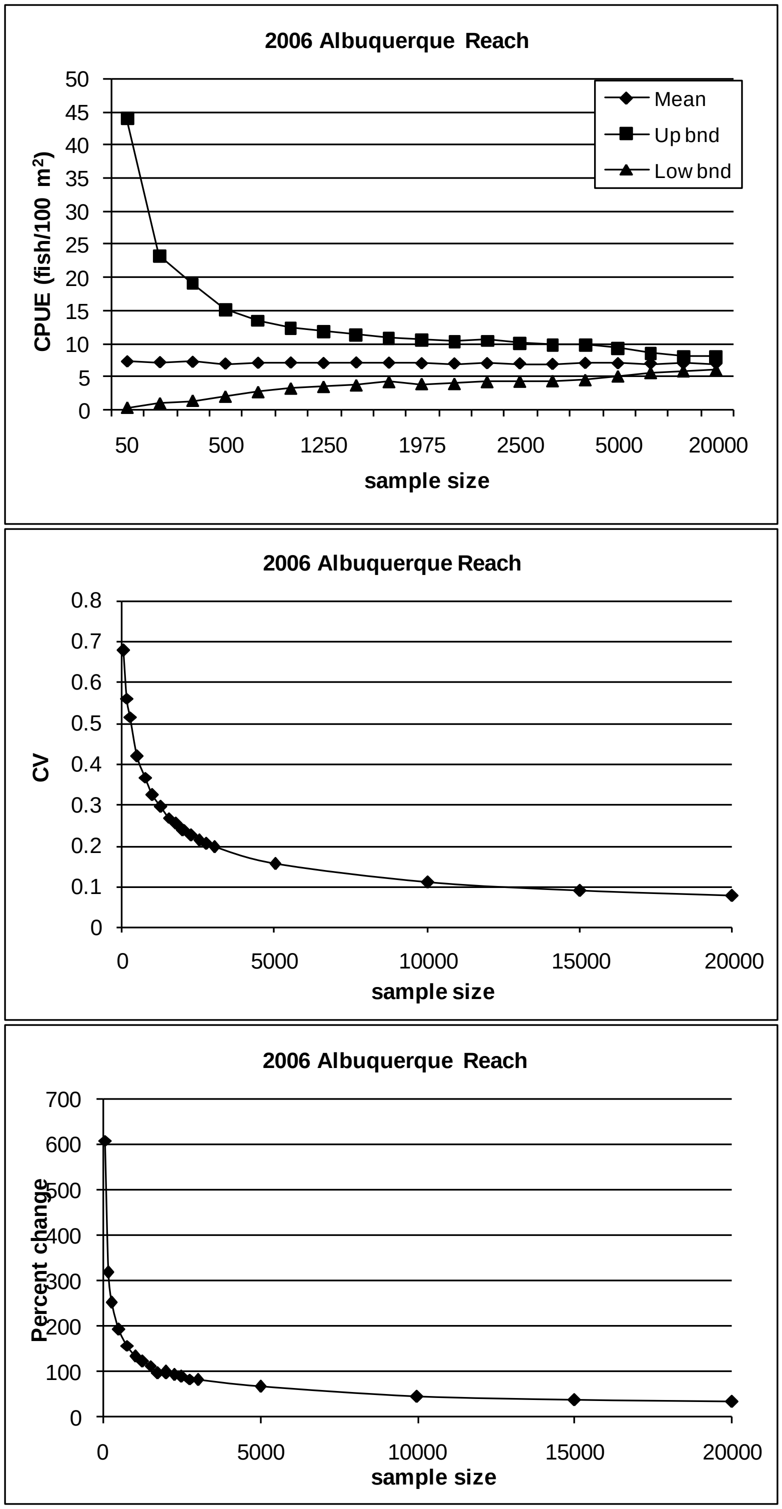


Figure B.5. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2006.

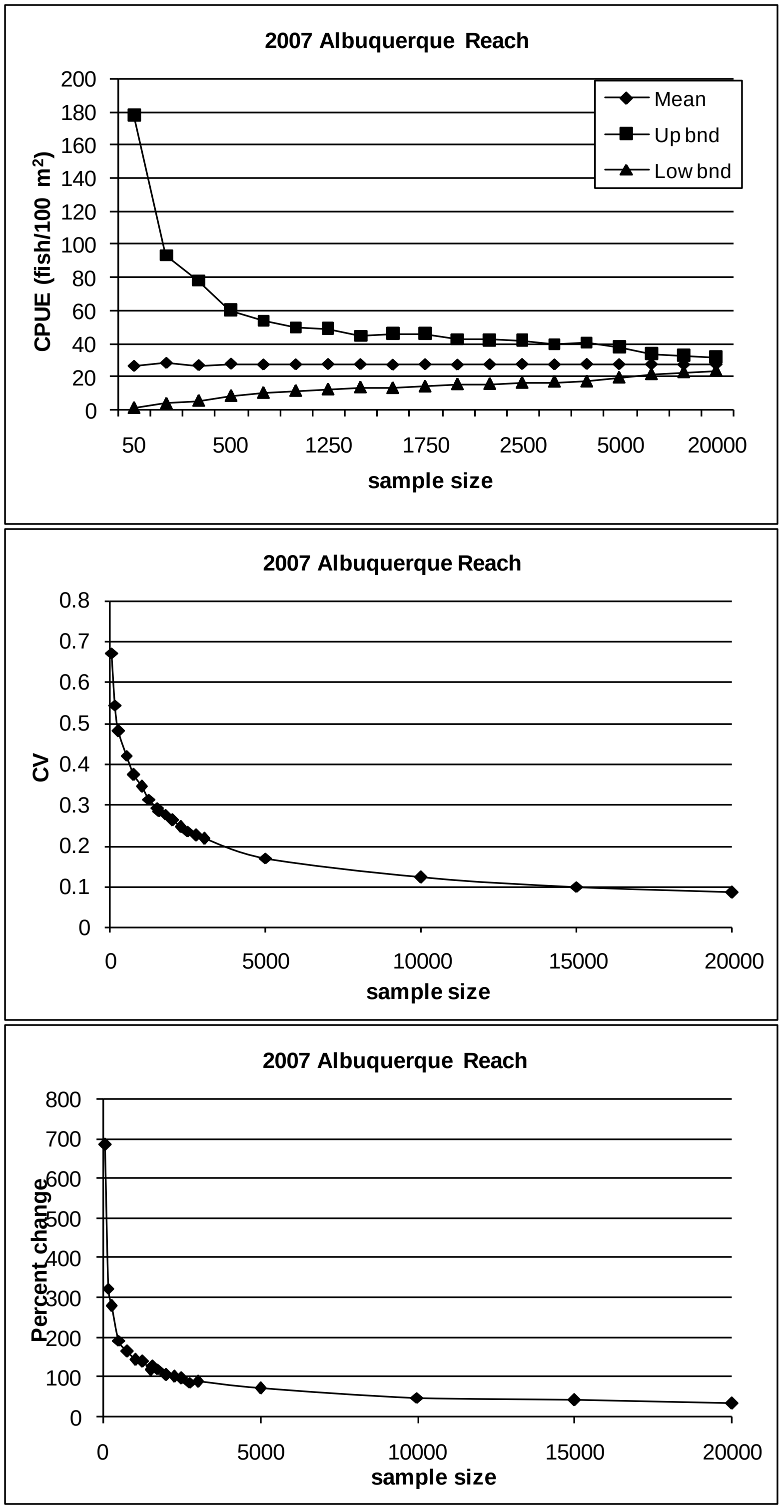


Figure B.6. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2007.

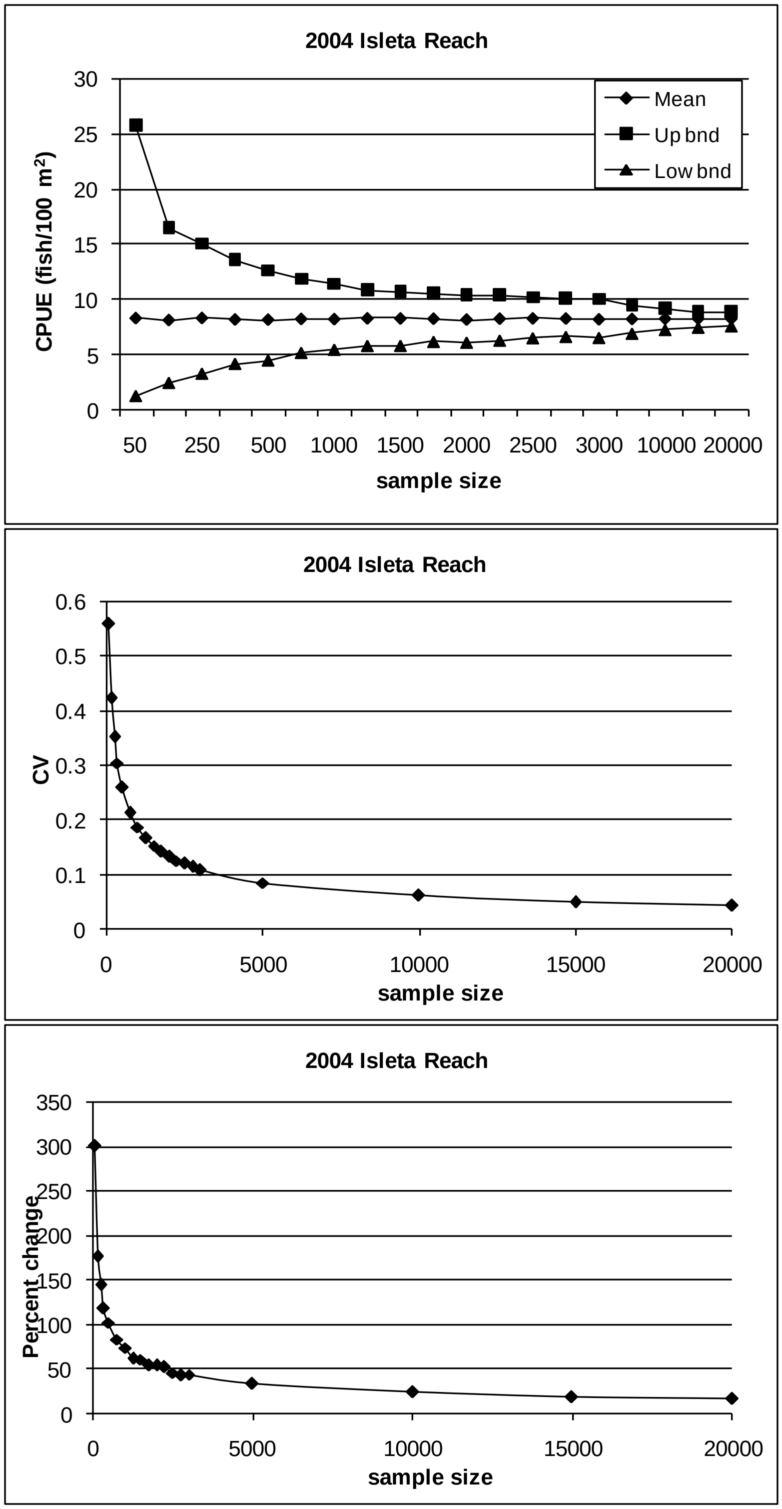


Figure B.7. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2004.

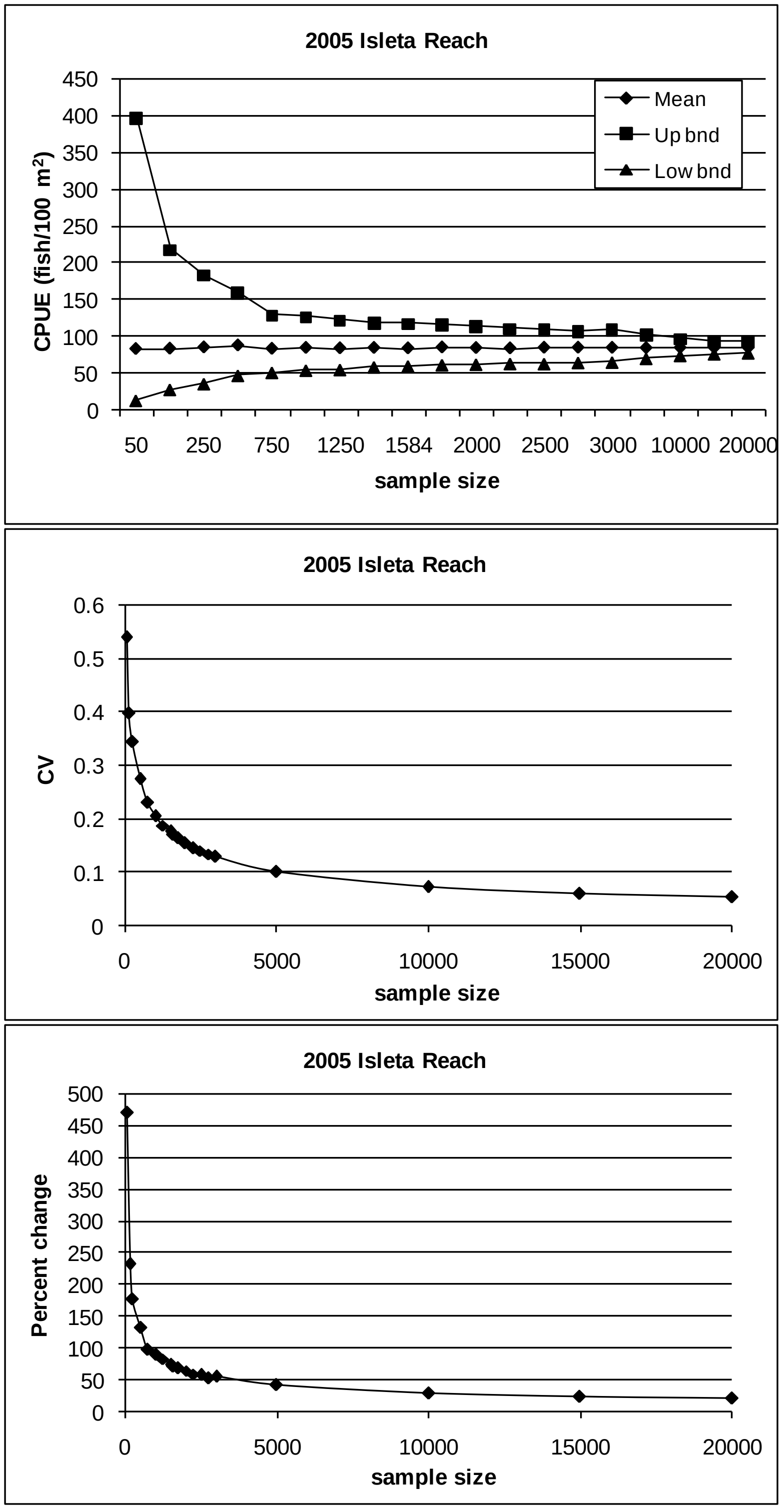


Figure B.8. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2005.

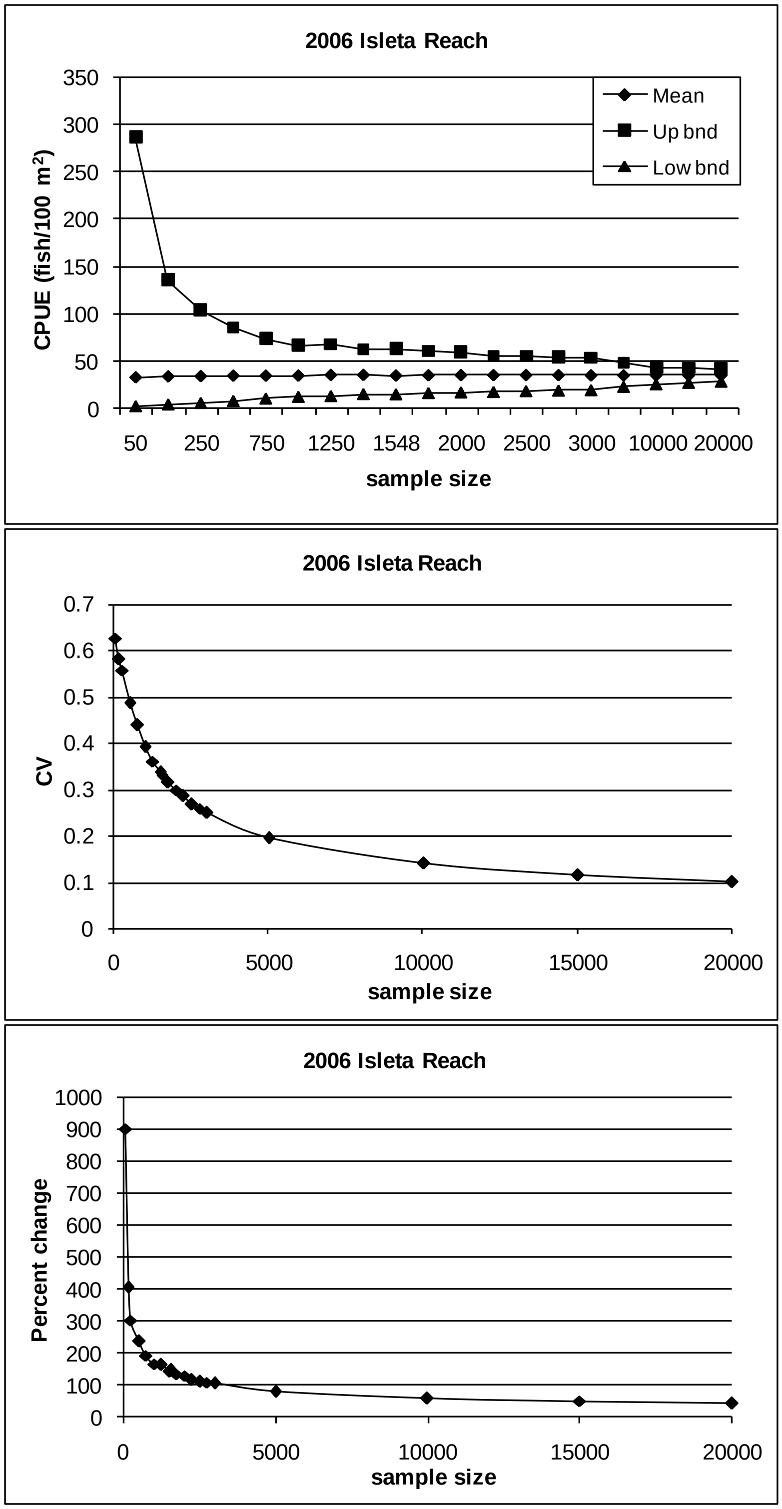


Figure B.9. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2006.

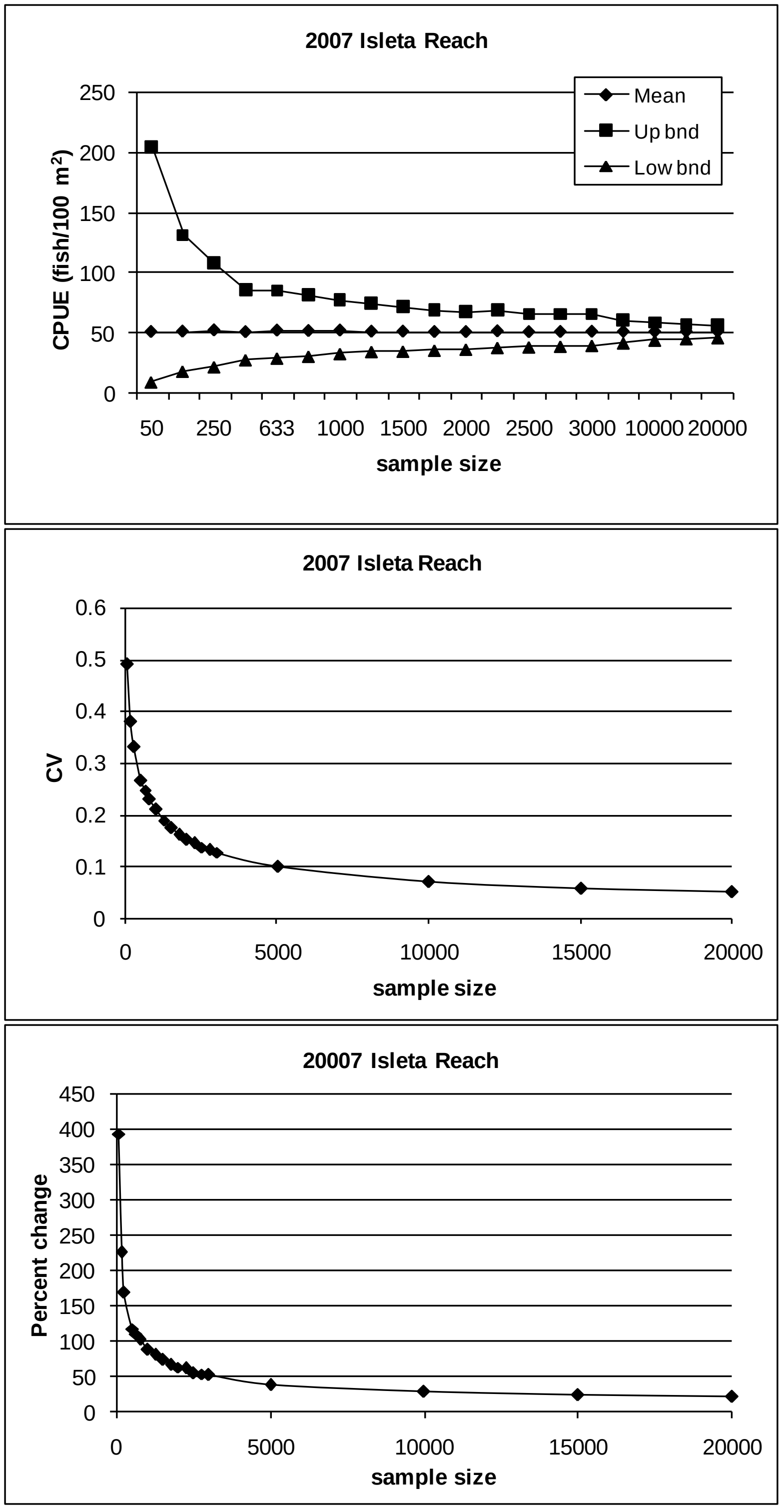


Figure B.10. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2007.

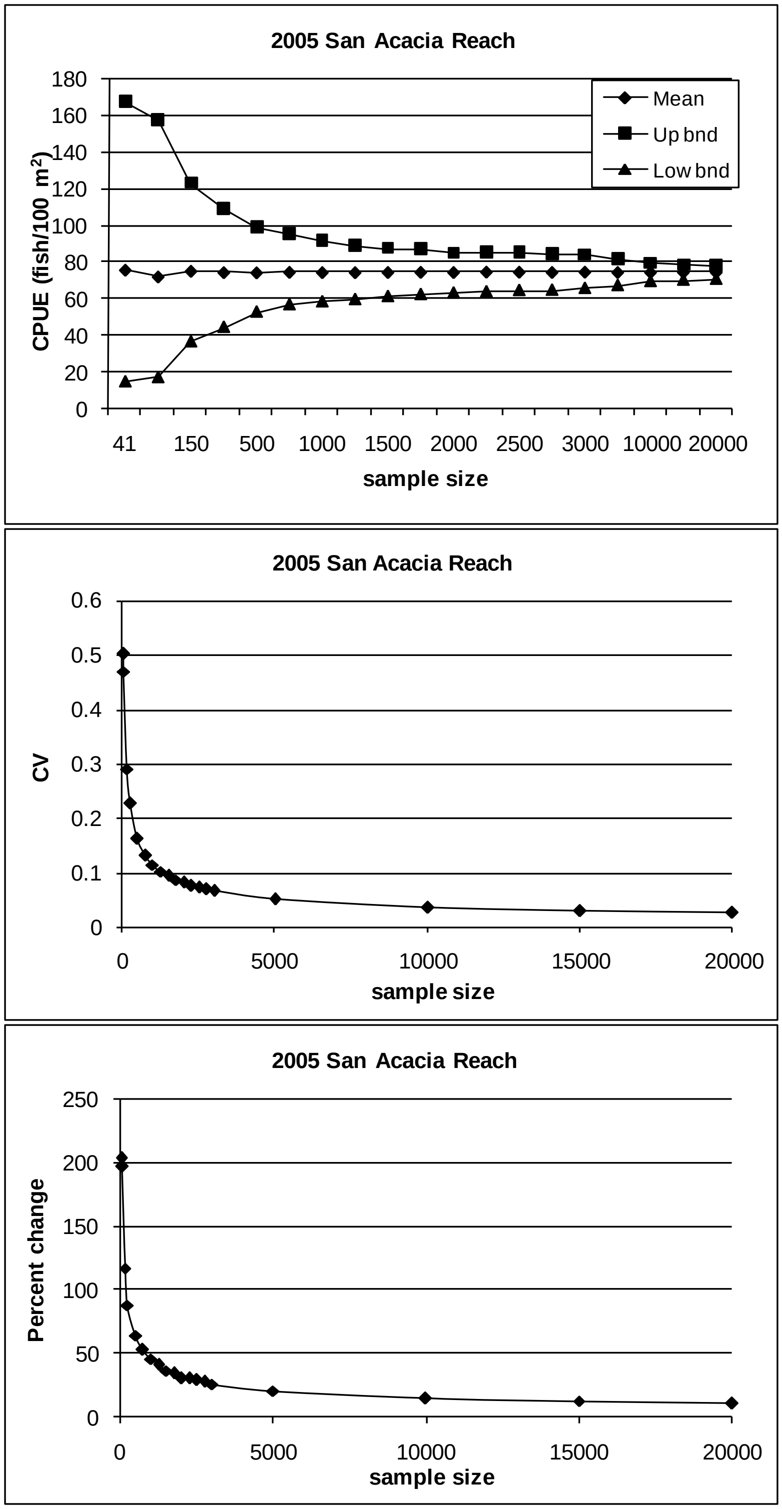


Figure B.11. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2005.

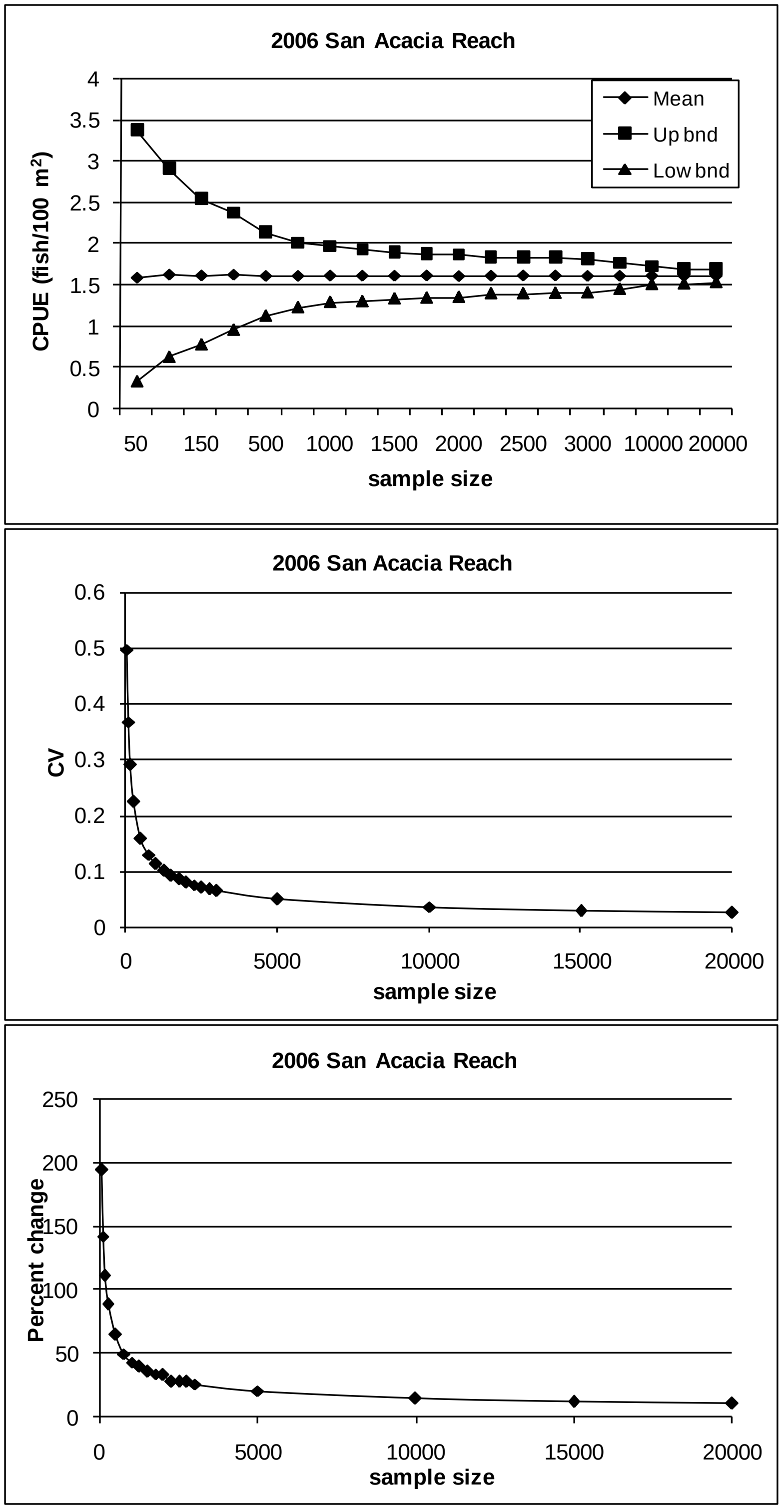


Figure B.12. The effect of seine sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2006.

APPENDIX C
FIGURES SHOWING DETAILED ANALYSES OF DATASETS 18 TO 22: (18) USBR-FISH_COLLECTION-2003.XLS, (19) USBR-FISH_COLLECTION-2004.XLS, (20) USBR-FISH_COLLECTION-2005.XLS, (21) USBR-FISH_COLLECTION-2006.XLS, (22) USBR-FISH_COLLECTION-2007.XLS.

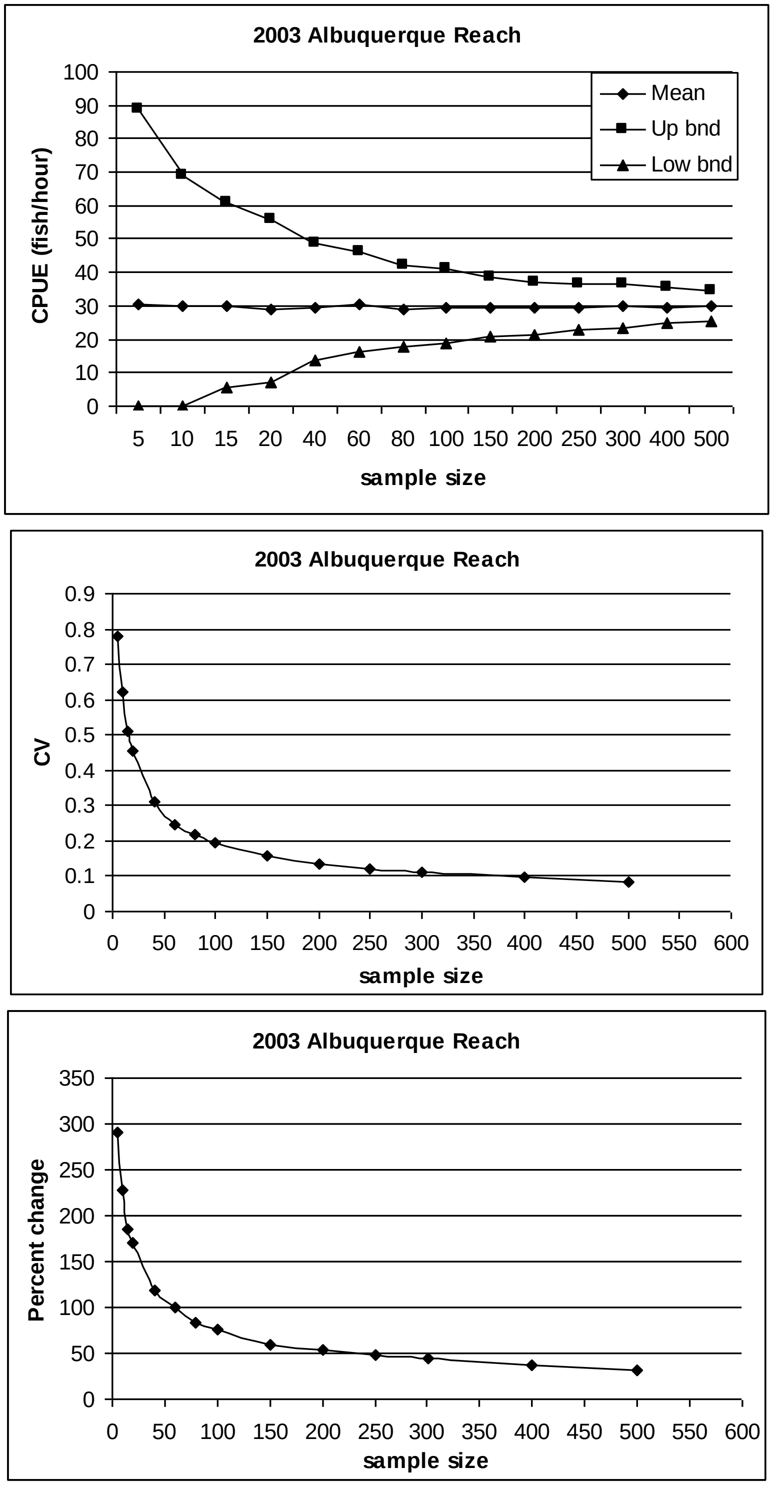


Figure C.1. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2003. Dataset: USBR-fish_collection-2003.xls.

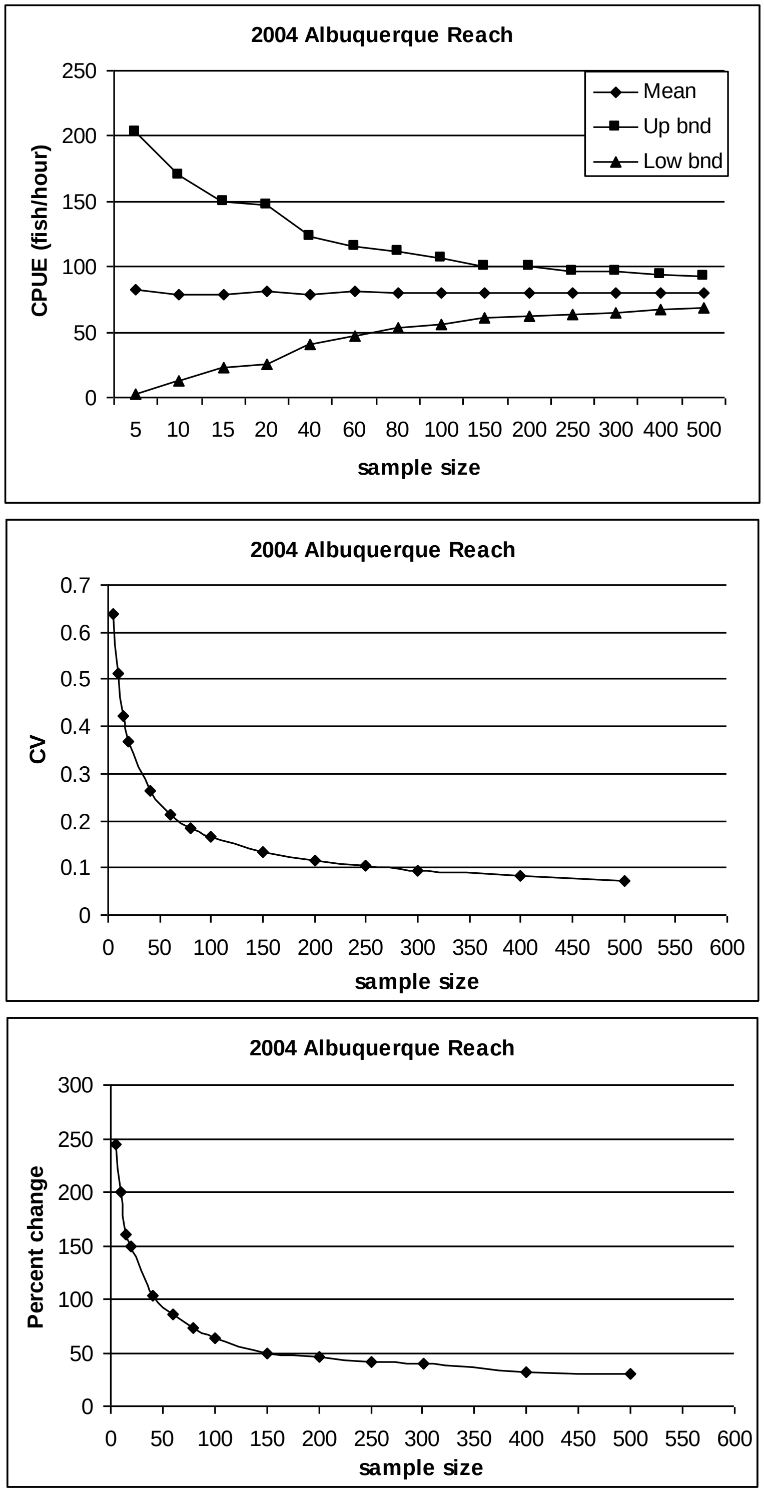


Figure C.2. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2004. Dataset: USBR-fish_collection-2004.xls.

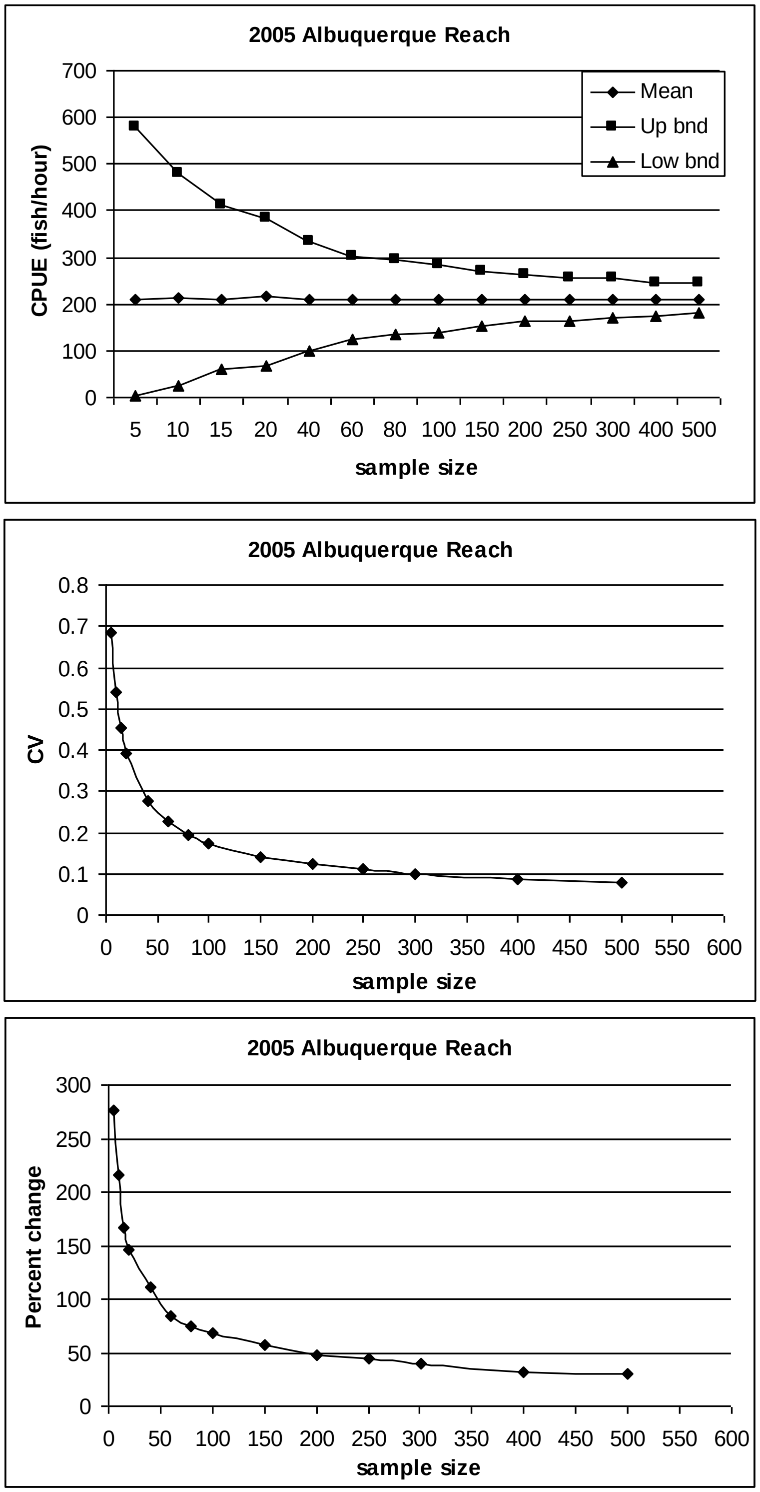


Figure C.3. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2005. Dataset: USBR-fish_collection-2005.xls.

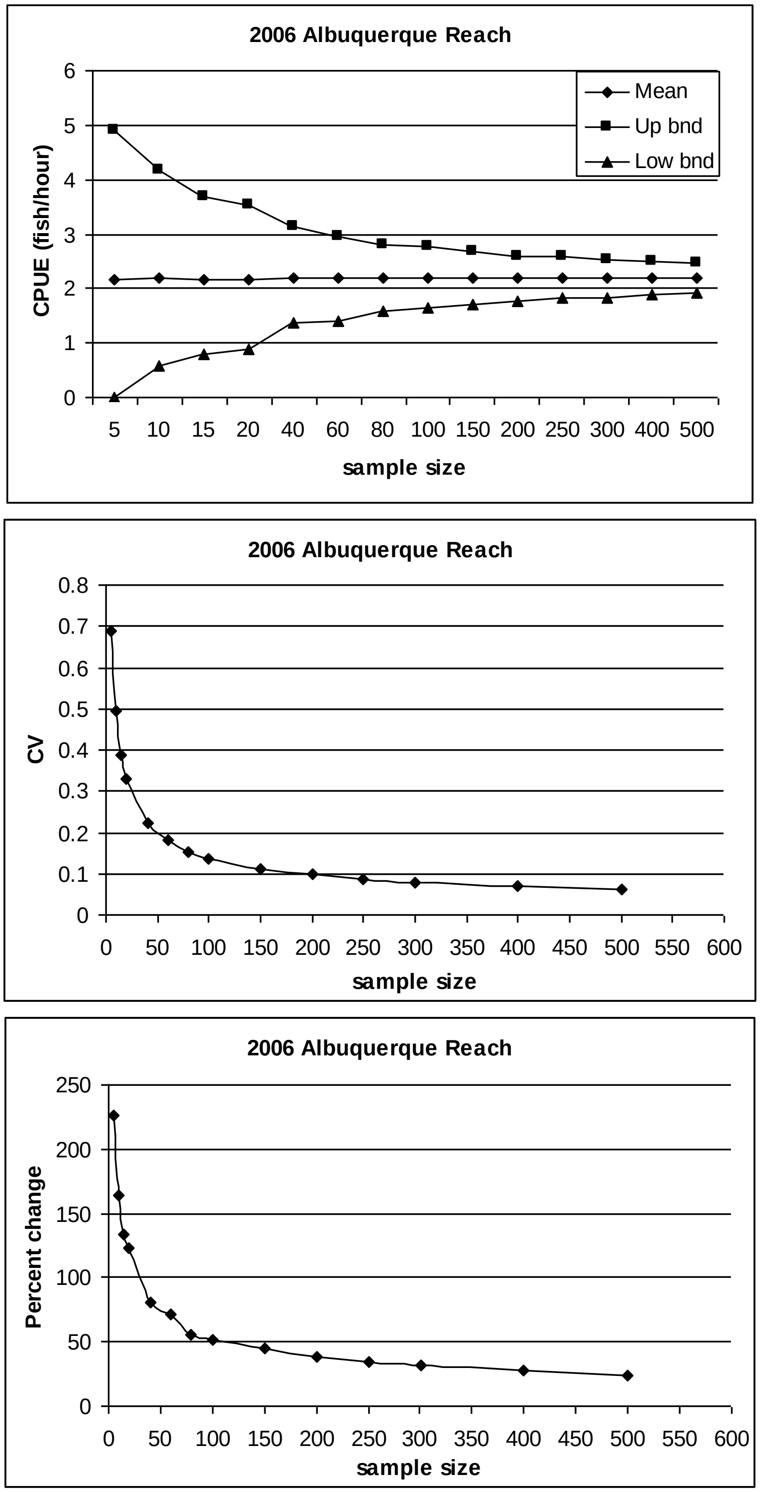


Figure C.3. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2006. Dataset: USBR-fish_collection-2006.xls.

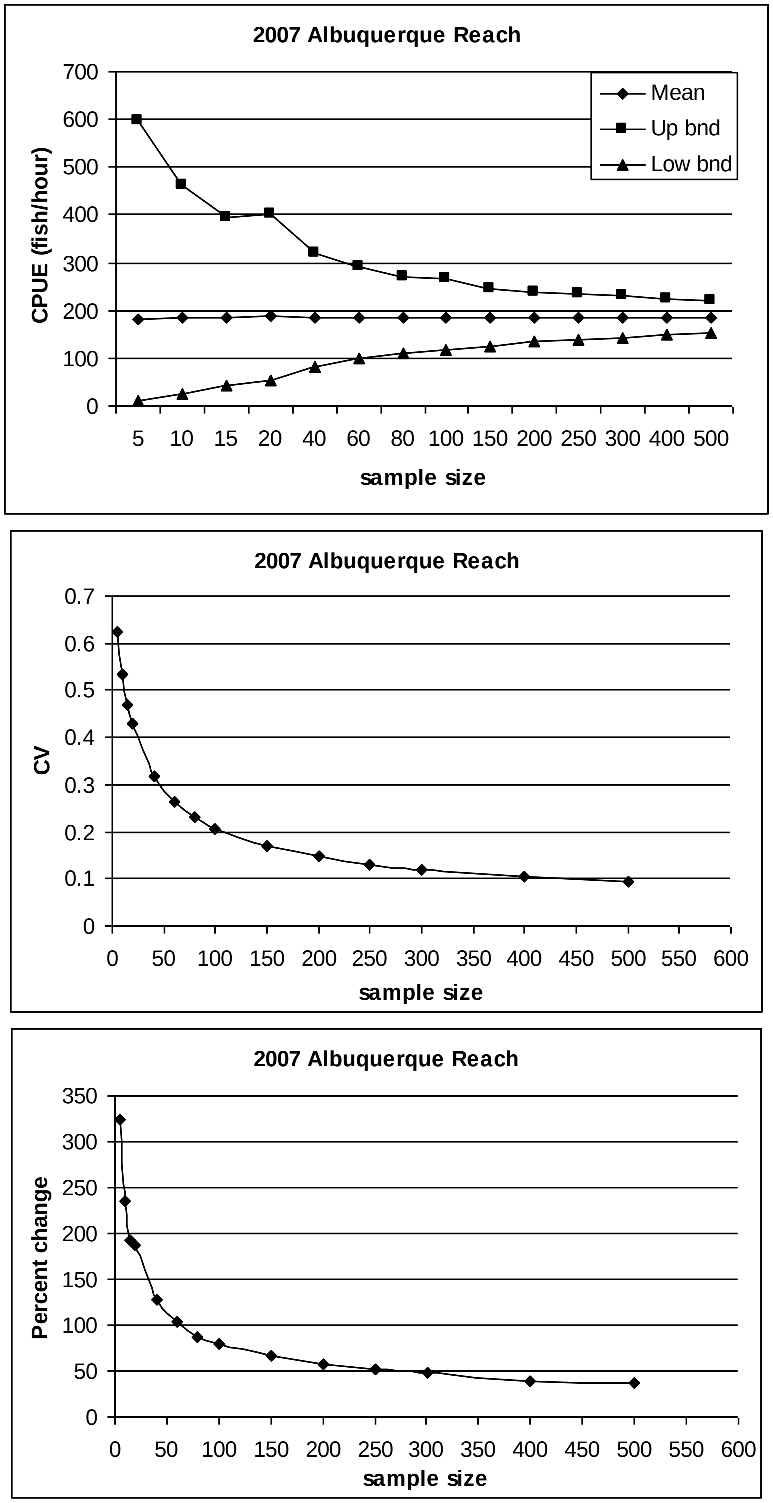


Figure C.4. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Albuquerque Reach in 2007. Dataset: USBR-fish_collection-2007.xls.

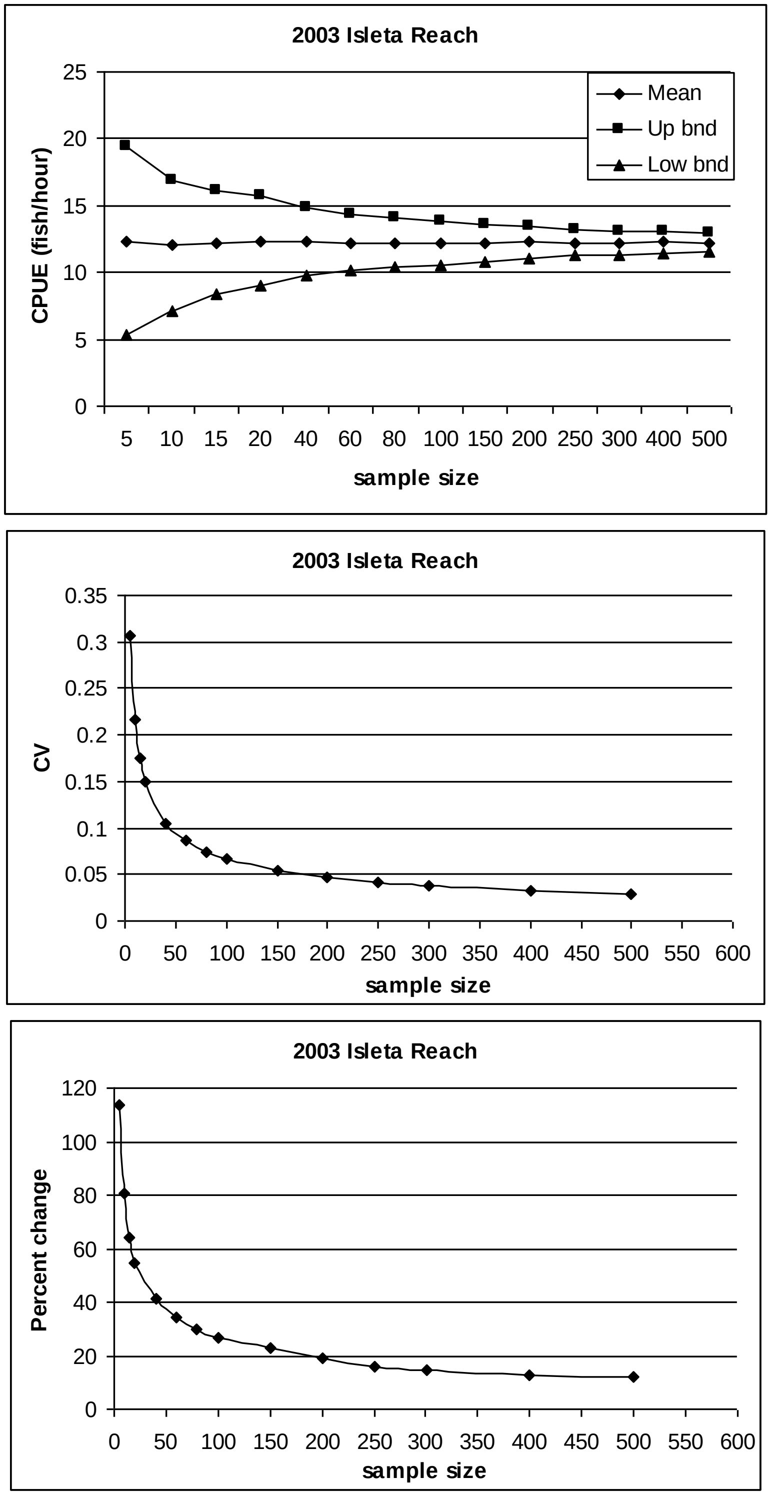


Figure C.5. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2003. Dataset: USBR-fish_collection-2003.xls.

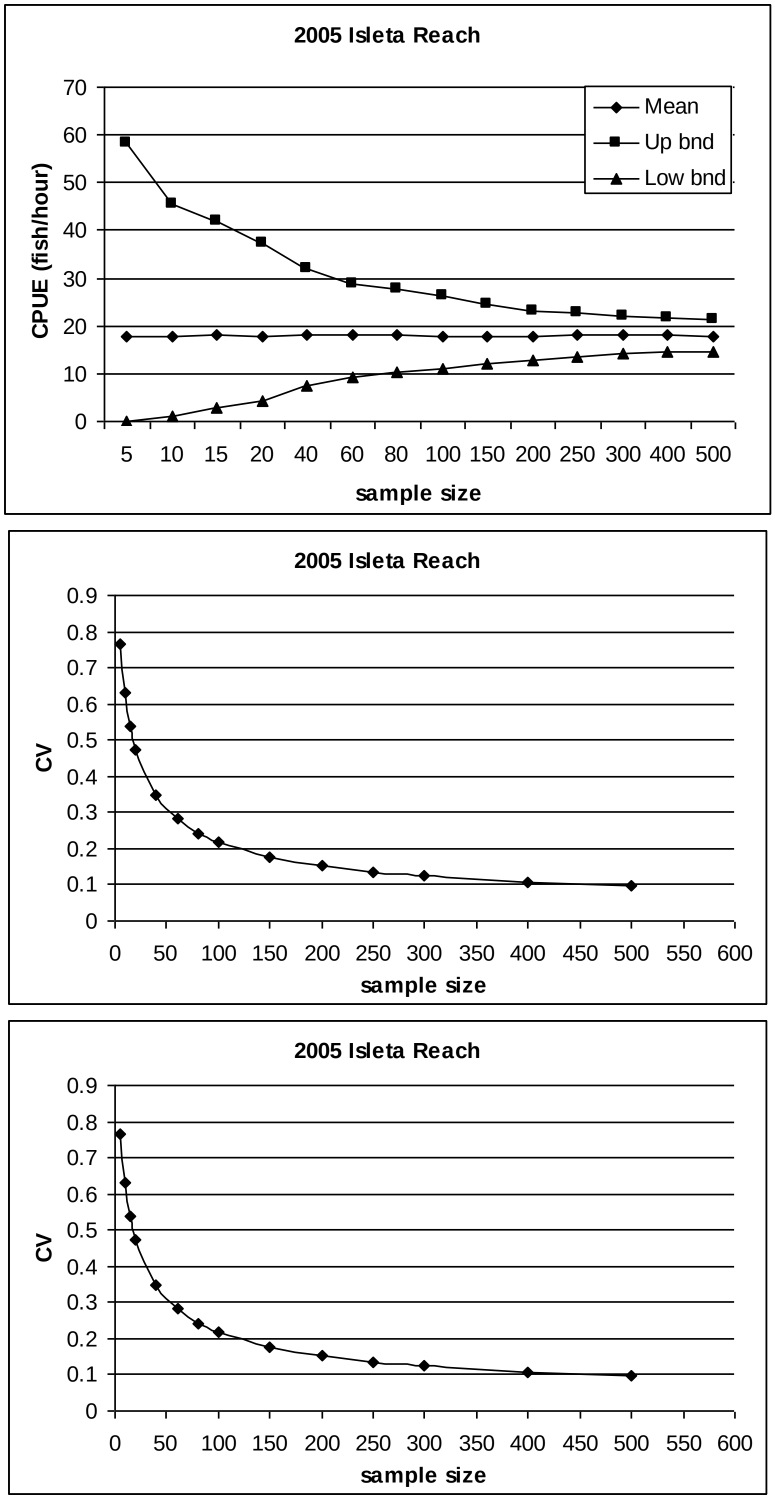


Figure C.6. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2005. Dataset: USBR-fish_collection-2005.xls.

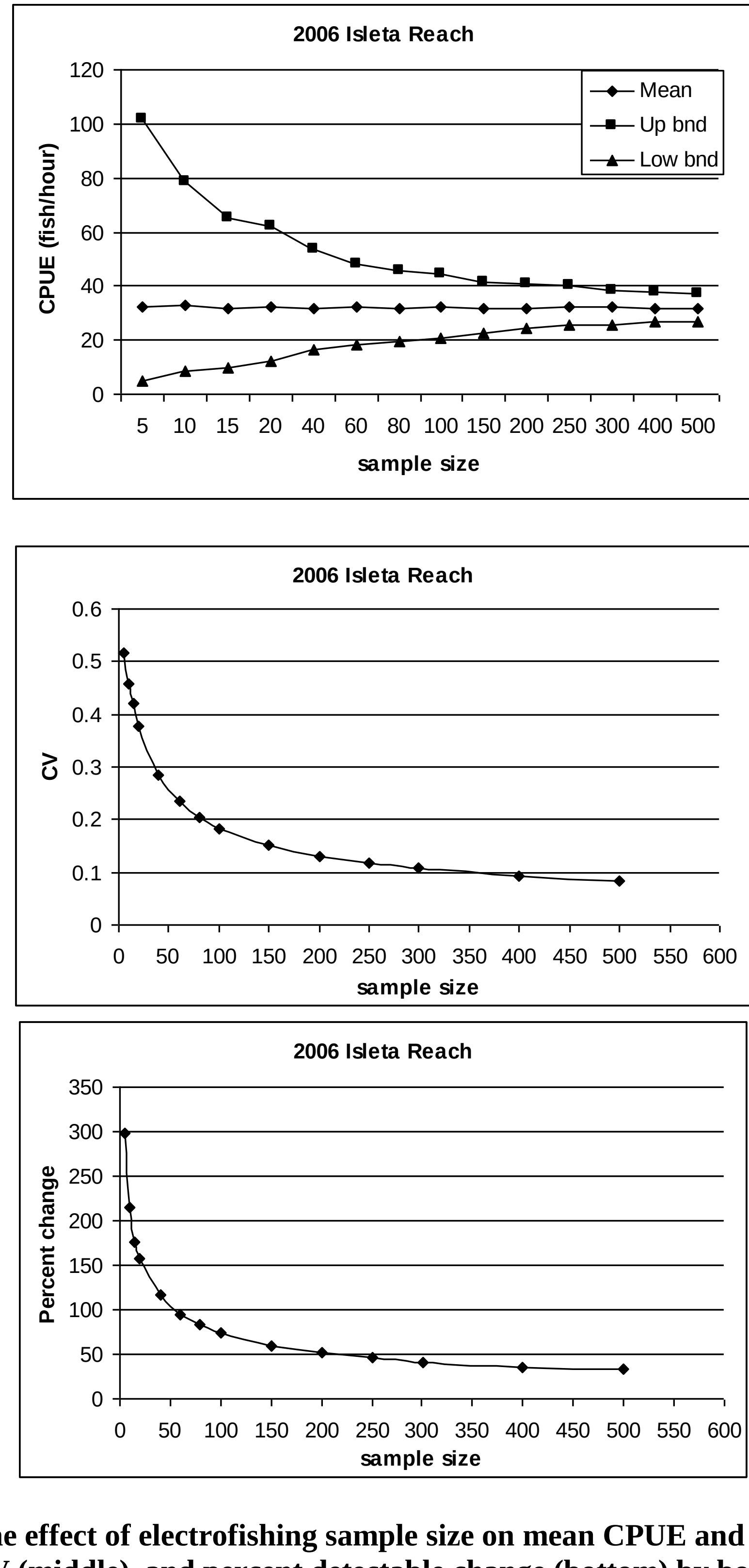


Figure C.7. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2006. Dataset: USBR-fish_collection-2006.xls.

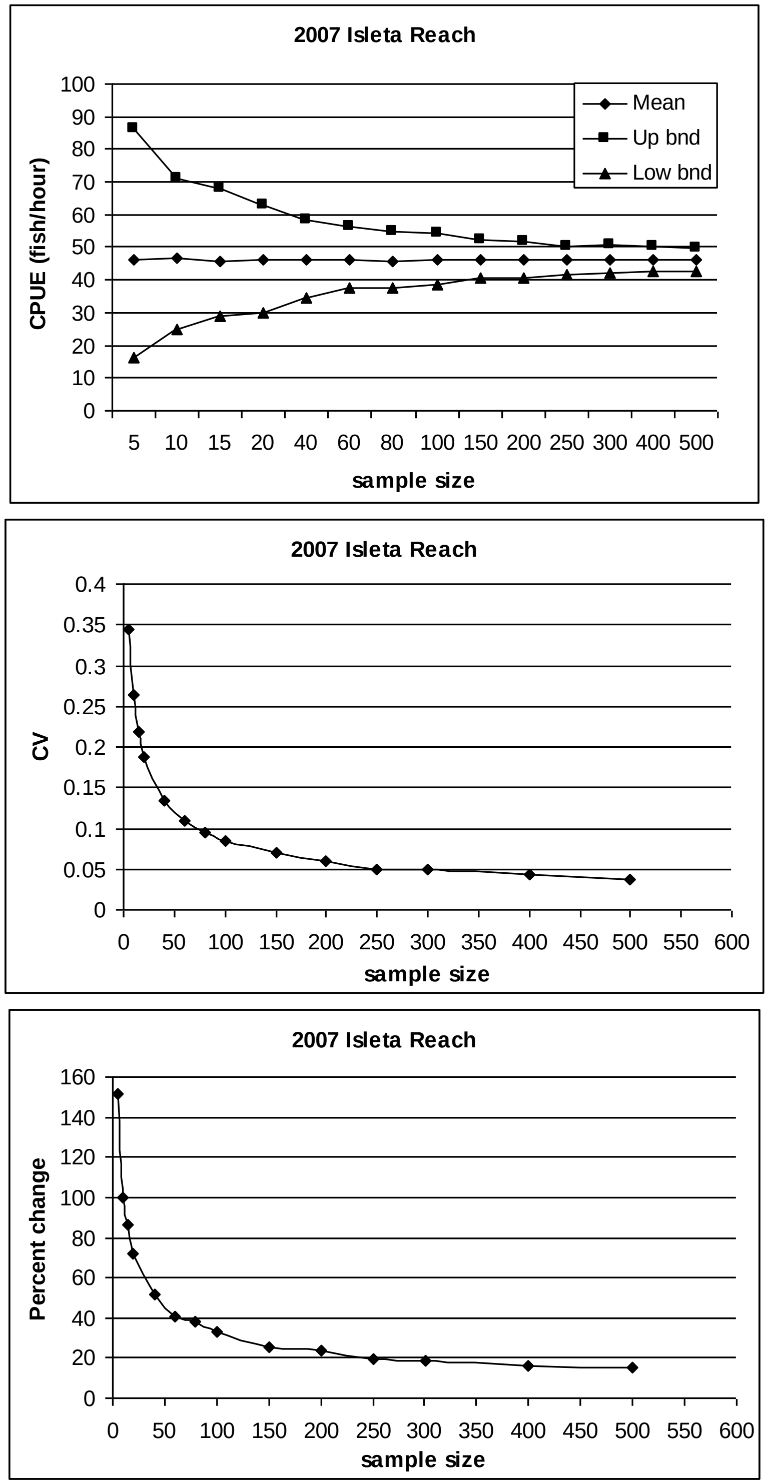


Figure C.8. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the Isleta Reach in 2007. Dataset: USBR-fish_collection-2007.xls.

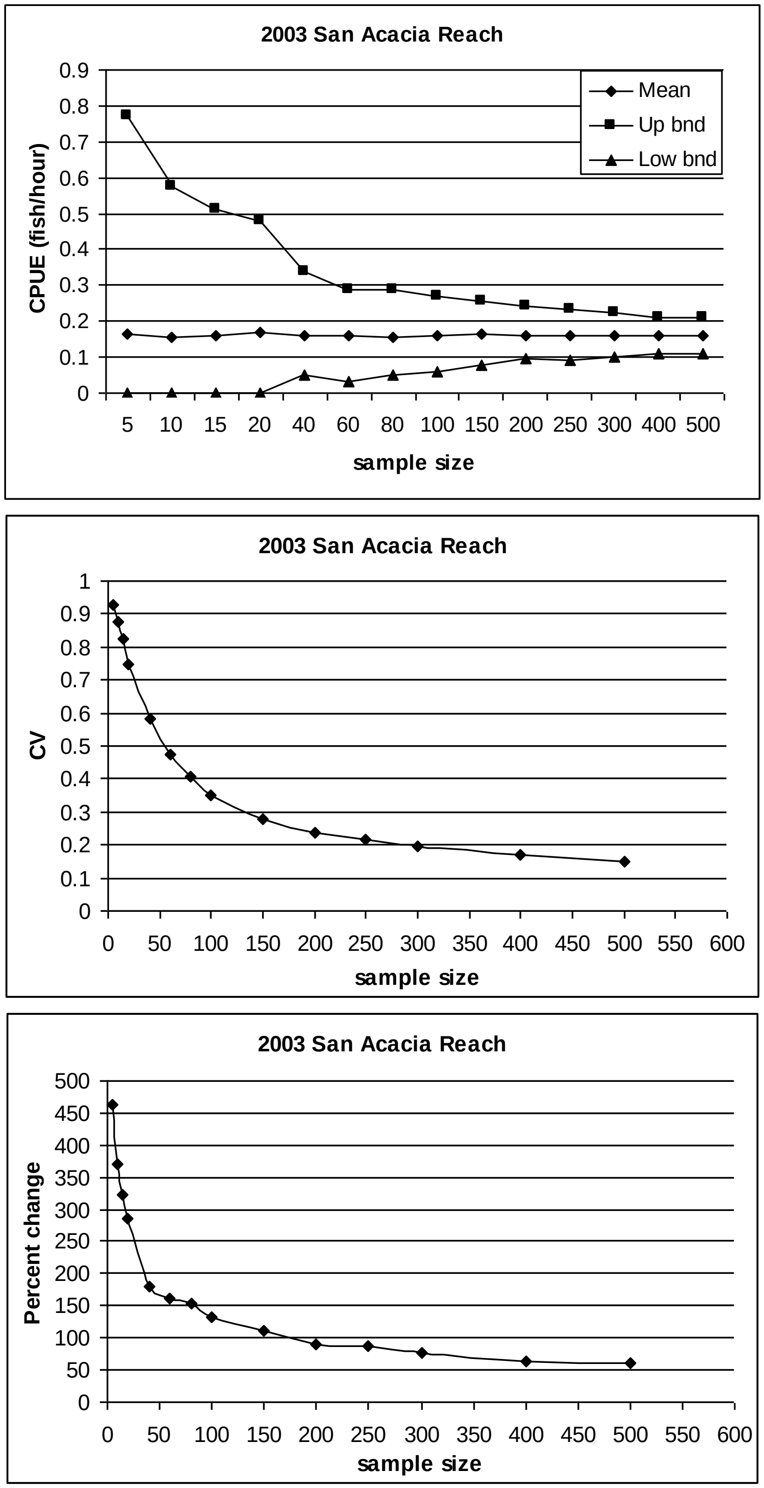


Figure C.9. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2003. Dataset: USBR-fish_collection-2003.xls.

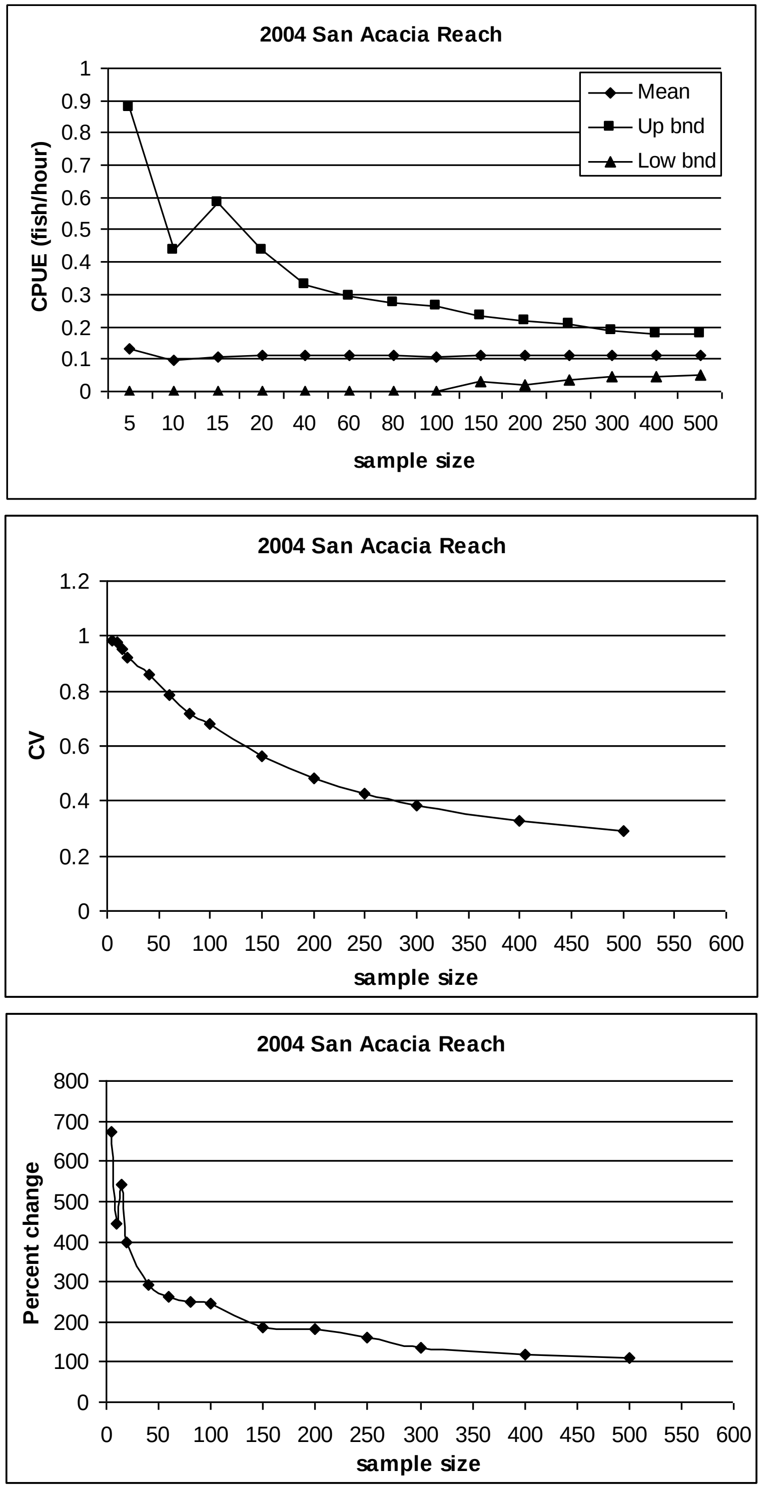


Figure C.10. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2004. Dataset: USBR-fish_collection-2004.xls.

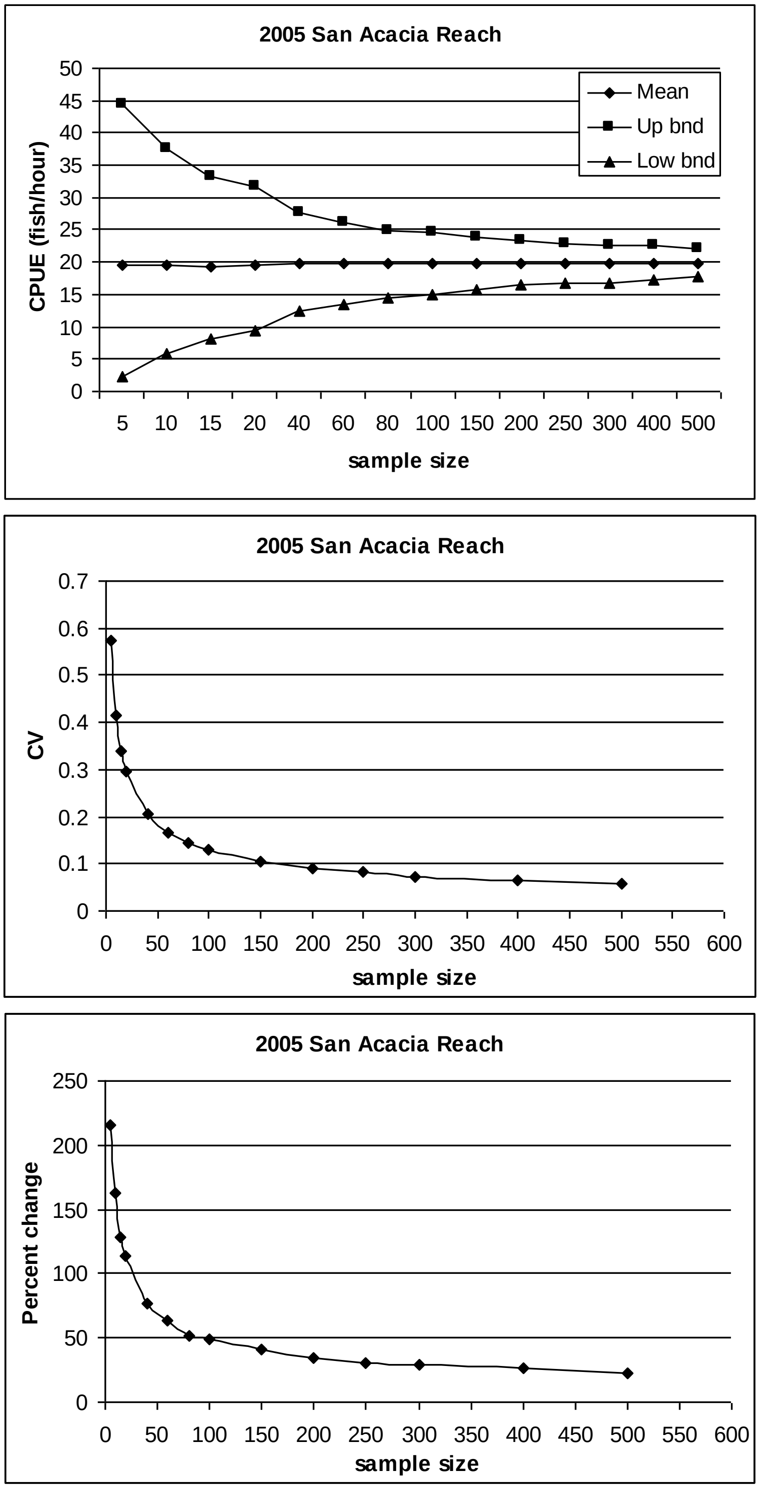


Figure C.11. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2005. Dataset: USBR-fish_collection-2005.xls.

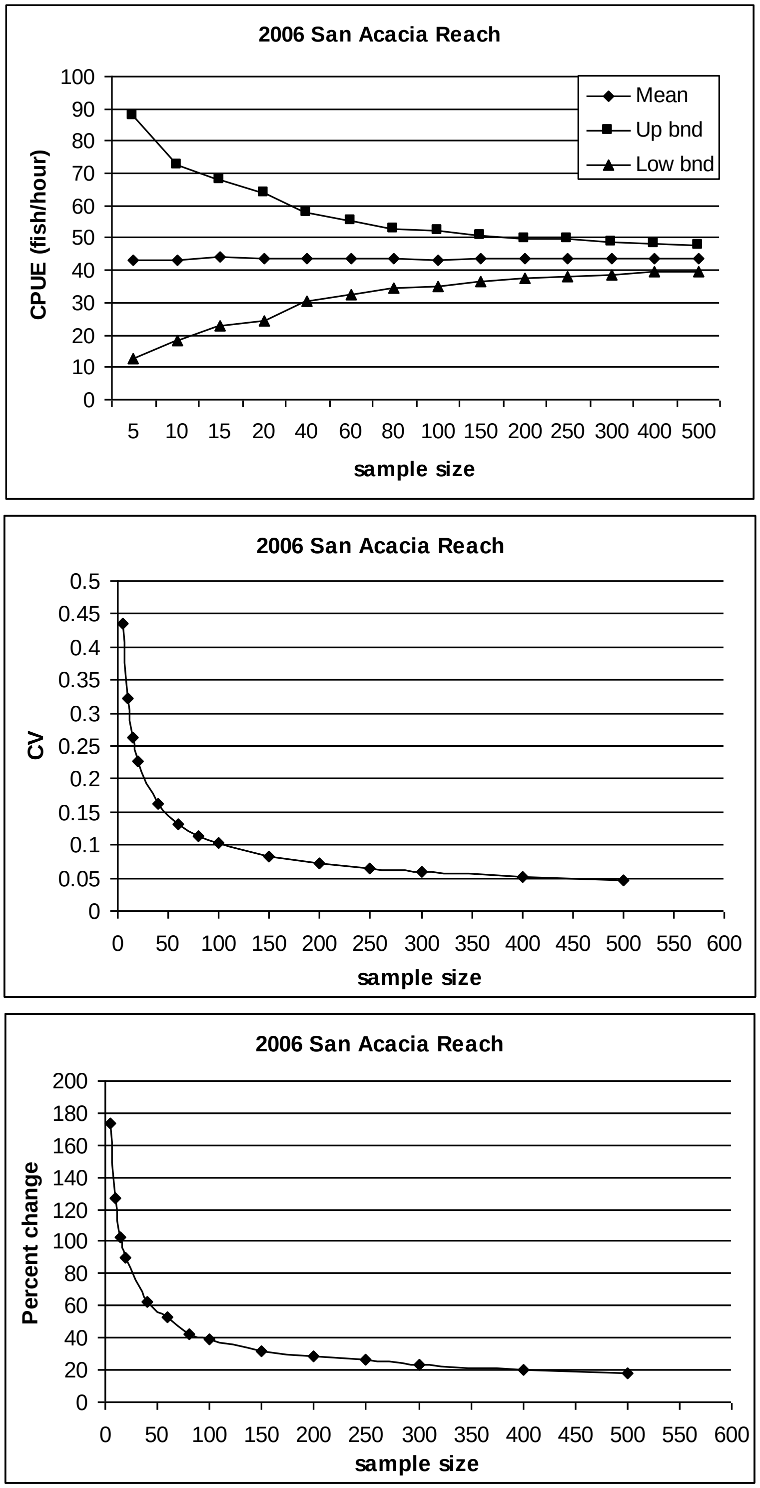


Figure C.12. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2006. Dataset: USBR-fish_collection-2006.xls.

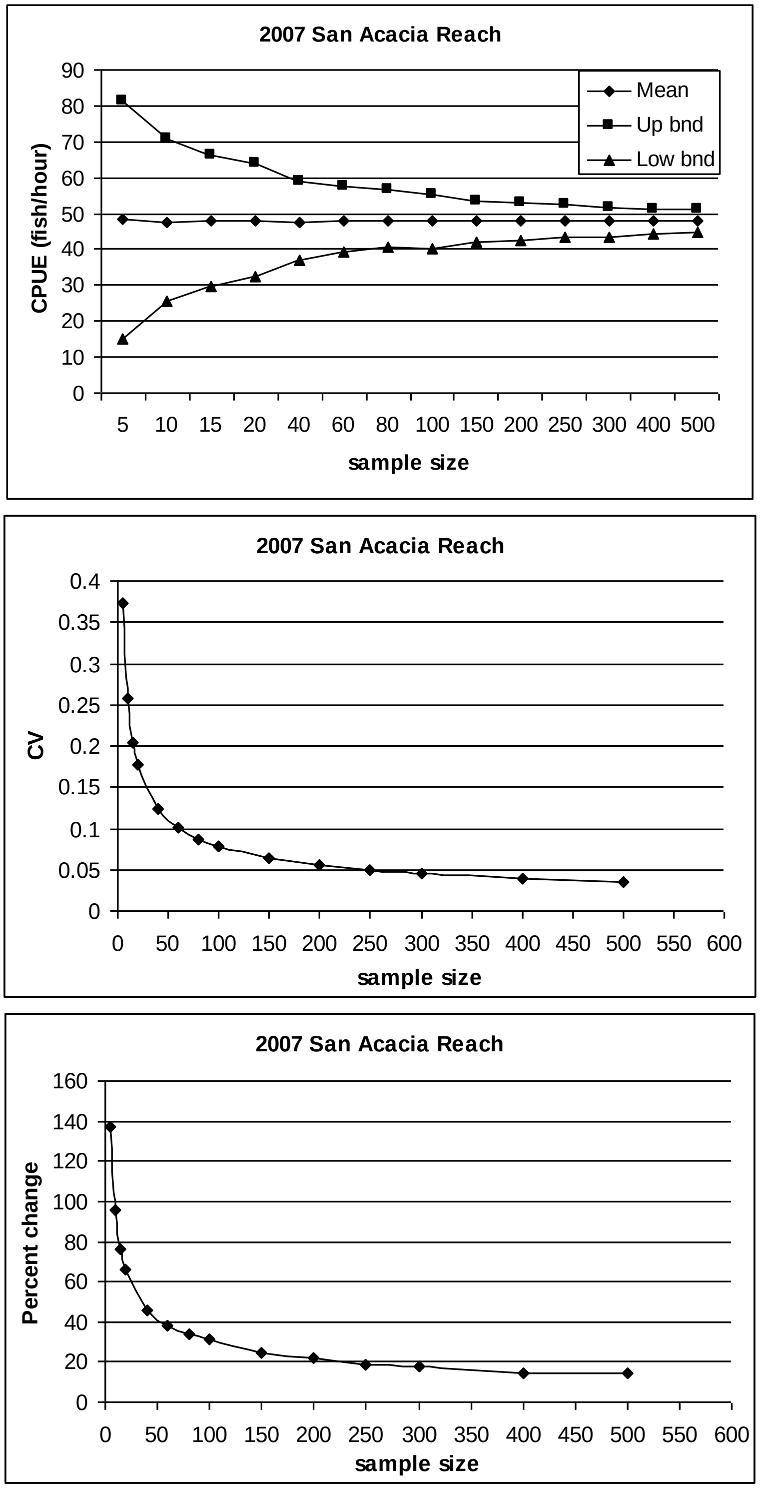


Figure C.13. The effect of electrofishing sample size on mean CPUE and 95% C.I. (top), CV (middle), and percent detectable change (bottom) by bootstrapping (1,000 iterations of actual sample size) for silvery minnow in the San Acacia Reach in 2007. Dataset: USBR-fish_collection-2007.xls.