CENTRAL ARIZONA PROJECT FISH MONITORING

FINAL REPORT

ANALYSIS OF FISH POPULATION MONITORING DATA FOR SELECTED WATERS OF THE GILA RIVER BASIN, ARIZONA, FOR THE FIVE-YEAR PERIOD 2005-2009

By

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Introduction

The Central Arizona Project (CAP) Canal and infrastructure were constructed by U.S. Bureau of Reclamation (Reclamation) to deliver Colorado River water from Lake Havasu to users in the Gila River basin of central Arizona. The canal and its interconnected channels represent a potential conduit for distribution within the system of nonindigenous fishes and other biota, and from the source to a suite of downstream sites. Because of this potential a U.S. Fish and Wildlife Service biological opinion (USFWS 1994) determined that the project would jeopardize four federally listed native fishes: loach minnow *Tiaroga cobitis*, spikedace *Meda fulgida*, razorback sucker *Xyrauchen texanus*, and Gila topminnow *Poeciliopsis occidentalis*, and adversely impact critical habitat of the first three species. A reasonable and prudent alternative of the biological opinion directed Reclamation to develop a long-term monitoring program for the CAP and interconnected regional canals, plus selected stream reaches in Arizona. The fundamental purpose of such monitoring is two-fold, to detect (1) new species and (2) long-term trends in the fish community relative to distribution and assemblage structure.

Standardized monitoring of fish communities in canals and streams began in 1995 under the auspices of a detailed plan (Clarkson 1996). The plan identifies six watercourses to be sampled: (1) the CAP aqueduct, (2) Salt River Project (SRP) canals, (3) Florence-Casa Grande (FCG) Canal, (4) Salt River between Stuart Mountain and Granite Reef dams, (5) Gila River between Coolidge and Ashurst-Hayden dams, and (6) perennial reaches of San Pedro River north of the U.S. and Mexico international boundary, and a seventh water, lower Cienega Creek, was added to the program in 2007 (see Reclamation 2006). Multiple reaches and stations within reaches are further defined within each stream. The plan specifies annual sampling and identifies parameters to be measured, repeatable methods, a standardized database, statistical methods for data analysis, and a schedule for data analysis and review. Procedural field manuals are appended to the plan.

Several investigators have discussed or attempted to evaluate the ability of the CAP monitoring plan to detect changes in fish community composition (Wilson 1996, Abarca and Allison 2000, Allison 2000). These assessments determined that only large-scale changes in community structure (species abundances) would be detected using the established protocol. This primarily was due to rarity of many species and extreme variability in catch data for others. Other factors include the broad geographical scope of the program, which makes it unrealistic to perform sampling adequate to produce the data required to detect statistical changes. Allison (2000: 12) concluded that trends of only two of 17 species examined, Sonora sucker *Catostomus insignis* and red shiner *Cyprinella lutrensis*, could be adequately

described from data acquired to that time under the standardized monitoring. Detection of new species would be serendipitous if rare, with the likelihood of an encounter increasing with increasing abundance and/or expanding spatial distribution.

This report documents fish distributions and assemblage structure using data derived from the CAP standardized monitoring program for the five-year period 2005 to 2009, as provided by Reclamation. The futility of formal statistical analysis of data for individual species has been documented in our previous report (Marsh and Kesner 2004). Therefore the data were not subjected to a statistical significance test. Instead, data are graphically presented in ways that allow the visual representation of trends in species composition for all streams and reaches.

Methods

Sampling Reaches and Stations. Reclamation designated sample reaches and sample stations on major Gila River basin streams and canals (see Clarkson 1996 for complete descriptions, coordinate locations, and maps). One-to-four, fixed sample reaches were designated on three natural streams (Gila, Salt and San Pedro rivers) and four artificial watercourses (CAP, FGC, and SRP Arizona [North] and South canals). Stream reaches were stratified to reflect variation in geomorphology (gradient and channel confinement) and/or hydrology (distribution of perennial surface flows), while canal reaches were based on locations of electrical fish barriers (all canals except CAP, which lacks such a structure) and established geopolitical divisions.

Stream reaches on San Pedro River were (1) Hereford to Fairbank, (2) Cascabel to Redington, (3) Aravaipa Creek to Gila River; on Gila River were (1) Coolidge Dam to Needles Eye, (2) Little Ash Creek to Hayden, (3) Hayden to Mineral Creek, and (4) Mineral Creek to Ashurst-Hayden Diversion Dam; and on Salt River was Stewart Mountain Dam to Granite Reef Diversion Dam. A single reach of Cienega Creek (the downstream-most perennial reach upstream of Pantano Wash) was added in 2007 (Reclamation 2006). Canal reaches on CAP Canal were (1) Hayden Rhodes Aqueduct, (2) Fannin-McFarland Aqueduct, and (3) Tucson Aqueduct; on FGC Canal were (1) Ashurst-Hayden Diversion Dam to China Wash electrical fish barrier and (2) electric fish barrier to Pima Lateral Feeder Canal; on SRP Arizona Canal were (1) Granite Reef Diversion Dam to electrical fish barrier and (2) electric fish barrier to Indian Bend Wash; and on SRP South Canal were (1) Granite Reef Diversion Dam to electrical fish barrier and (2) electrical fish barrier to terminus.

Two (Cienega Creek) or three (all others), fixed sample stations (upstream, middle, and downstream) were designated within each stream reach (but not always available to sample) and on the FGC Canal. Fixed sample stations on the CAP Canal were immediately upstream and in the forebays of pumping plants at Bouse, Little Harquahala, and Hassayampa (Hayden Rhodes Aqueduct), Salt-Gila (Fannin-McFarland Aqueduct), and Brady, Red Rock and San Xavier (Tucson Aqueduct). Fixed stations were not designated on the SRP Arizona or South canals, where each reach was considered a station. However, the same sites have been sampled consistently since initiation of the monitoring program.

Fish Collection Methods. A suite of standard collection techniques was available to sample fishes in behalf of the CAP Monitoring Program, and these were applied as appropriate to the variety of habitats and situations represented by the various stream and canal reaches and stations (see Clarkson 1996). Backpack electrofishing was the standard for most stream sites, augmented by opportunistic seining. Deeper stream habitats were sampled with entrapment or entanglement gears, or by boat or barge-mounted electrofishers. CAP Canal reaches were sampled primarily with boat electrofishing, entanglement and entrapment devices (trammel and hoop nets, minnow traps), and angling (multiple-hook trot lines, rod and reel). FCG and SRP Arizona and South canals typically were sampled during drawdown periods when backpack electroshocker, seines, and dip nets were effective in shallow water. Deeper water was sampled with trammel or hoop nets at selected locations in all canals, and with boat-mounted electrofishing in accessible portions of the SRP Arizona and South canals.

All data were recorded on standardized datasheets and entered into Key Entry III software that requires each datasheet to be entered twice as a validation tool to minimize mistakes. All species were coded using a 4-letter abbreviation for the species scientific name (Table 1). The data were imported into a Microsoft® Office Access 2003 database.

Stream Data. Each record in the comprehensive raw database file provided by Reclamation included an individual species catch (number) for a period of sampling. Station samples for each species were totaled so as to represent the complete sampling for that station for a given species and year. Not all stations were sampled every year (Table 2), and data that were from non-quantitative samples or from gear other than electrofishing were not included in the analysis because this lack of methodological standardization could misrepresent species composition for a given reach and year. Data were restricted to backpack electrofishing for the San Pedro and Gila rivers, and to boat or backpack electrofishing for the Salt River. This resulted in a total of 93 station samples from 2005 to 2009 (Table

3). Combining these station samples into their associated reaches resulted in seven out of 45 reach samples (8 reaches and 5 years of data) having no station samples, and leaving 38 reach-year combinations to analyze (Tables 4-7). The upstream reach of the Gila River was not sampled for the entire period due to permitting issues. All other reaches had at least three years of data from at least one station.

Canal Data. As for streams above, each record for canals in the database file provided by Reclamation included an individual species catch (number) for a period of sampling. Station samples for each species in each reach were totalled so as to represent the complete sampling for that reach for a given species and year. Not all stations were sampled every year on each canal: the upstream reach on the CAP Canal was not sampled in 2005 and 2008 and the SRP-South Canal below the fish barrier was not sampled in 2009 (Table 8). The comprehensive annual survey report in 2006 lacked monitoring data for the CAP reaches 2 and 3 (Marsh and Kesner 2007), this data was recently added to the database and is included in all tables and figures. A corrected species catch table for all stations sampled in 2006 is provided in Appendix A.

All collection records except visual counts were used for the CAP, SRP-South, SRP-North and FCG canal data analyses (Tables 9-12). All records from the CAP were quantitative, and collections above the electric fish barriers on the SRP-South and SRP-North canals are quantitative and near complete samples; data elsewhere are qualitative and opportunistic.

Data Analysis. To analyze the emergence (first detection) of new species, presence or absence of species for all reaches from streams and canals was determined using all available data (quantitative or qualitative) from three five-year time periods; 1995-1999, 1995-2004, and 2005-2009. The data were then tabulated for each reach and system and the apparent emergence of a species within the system and geographical domain of the reaches in the sampling protocol was verified by review of survey reports from 1970 to 1995 (see Clarkson 1996).

We used Pearson's correlation coefficient (Sokal and Rohlf 1995) to examine the relationship between electrofishing effort and catch for pooled-reach stream samples from Gila, Salt, and San Pedro rivers. To analyze trends in species composition stacked bar graphs of species relative abundance for reaches and streams were developed across the five year study period. Each species captured at least once within

the last five years of sampling was given a unique color which was used consistently among all streams (Table 13).

Results and Discussion

New Species Records. There were four species captured during the 2005-2009 sampling years that had previously gone unsampled by the monitoring program since collections began in 1995 (Tables 14-17 and 19-22), and three that were new to the sampled reaches since 1970 (Clarkson 1996). Goldfish was captured for the first time in the downstream reach of the San Pedro River in 2005 and the upstream reach in 2006, and the presence of flathead catfish in the downstream reach of the San Pedro was confirmed in 2006 (questionable status in Clarkson 1996). Pacu was encountered for the first time in the middle reach of the CAP canal (Salt-Gila pumping station) in 2006 and black bullhead was encountered below the electrical fish barrier on the FCG canal for the first time in 2007. This is in addition to 29 species new to the specific reaches collected during routine monitoring from 1995 to 2004 (Marsh and Kesner 2006).

In addition to new records, the fifteen-year monitoring program has documented the disappearance of all native fish species from collections in the Gila River and one native species in the Salt River (Tables 14 and 15). Longfin dace, desert sucker, and Sonora sucker were encountered in every year from 1995 to 1999 and captured at least once in all reaches sampled in the same time period. In 2000-2004 only Sonora sucker was encountered in two sampling years and once in 2006. The other two species have not been encountered in 10 years. In the Salt River, roundtail chub were not encountered in SY 2005-2009 although it was encountered in the two previous five year periods. Roundtail chub is still encountered in small numbers downstream in the SRP canals fed by Salt River, so it undoubtedly yet occurs in the Salt and/or Verde rivers immediately upstream.

Stream Data. Correlation between catch and effort was weak for all streams (Figures 1-5). Total annual electrofishing effort in each stream varied little among the five years, which contributed to weak correlations (Figure 1). A slightly positive correlation between total catch and effort was evident for the Gila and Salt rivers, the two streams with the largest variation in effort (Figure 1). For the Gila River, average catch and effort (per reach) were also consistent (Figure 3). On the Salt River, average effort declined every year from 2005 to 2008, yet the largest average catch was recorded in 2007, more than double the average for any other year (Figure 4). Average effort on the San Pedro River was nearly uniform for all five years but average catch differed by an order of magnitude (Figure 2), and average

catch in Cienega Creek increased over the three years of sampling although average effort remained the same or slightly declined (Figure 5). The general lack of correlation between catch and effort for the sampled streams is likely due to the inconsistencies among years in discharge, stations sampled, and gears deployed.

An additional factor on the Salt River was presence in 2008 and 2009 of an active bald eagle *Haliaeetus leucocephalus* nest with juveniles in proximity to station 2 (Goldfield Administrative Site), which precluded access to that location regardless of flow conditions.

Twenty-two fish taxa were encountered in samples among the four streams sampled (Table 14-17). Fourteen taxa were taken from San Pedro River, 12 from Gila River, 16 from Salt River and three from Cienega Creek. Six taxa are native in the Gila River basin, longfin dace, Gila chub, roundtail chub, Sonora sucker, desert sucker and Gila topminnow; the remaining species are introduced from Africa, Asia, and eastern and northwestern United States. Although there was much variation among streams, reaches, and stations, native longfin dace overall was the most abundant species, followed by nonnative red shiner and mosquitofish (Table 18). These same three species were the most abundant ones during the prior five-year period, although their relative rankings were different (i.e., red shiner, mosquitofish, and longfin dace; Marsh and Kesner 2006).

San Pedro River---Six of fourteen species collected in the San Pedro River were found in all five sample years, two in four years, four in two years and two in one year alone (Table 14). Four of the fourteen species were taken from all three reaches, five were in two reaches, and five were from one reach. There was much variation in abundance among years, but longfin dace was the most abundant taxon in all five years from quantitative electrofishing samples (Table 4). Mosquitofish, black bullhead, desert sucker, fathead minnow, green sunfish, common carp and red shiner were captured in most years, while other taxa were sporadic in occurrence.

Overall species composition in the San Pedro River changed little over the course of the five year period (Figure 6). Relative abundance of longfin increased in 2007-2008 at the primary expense of black bullhead. Other nonnatives including channel catfish, flathead catfish, yellow bullhead, mosquitofish, and green sunfish, which increased in relative proportion in 2006, also declined in 2007. Catch totals were relatively low in 2005 and 2006 largely due to low numbers of longfin dace in the catch (Table 4). As noted below for the Gila River, stream drying may be responsible in part for this result, but unlike the Gila River below Coolidge Dam, the San Pedro River also is subject to episodic flooding that may affect

fishes. For example, maximum mean daily flows near Tombstone for the years 2005-2009 were 1820, 3840, 1560, 974 and 63 cfs, respectively, punctuated each year by periods of zero discharge at the same location.

In the upstream reach of the San Pedro relative abundance of longfin dace rebounded in 2007 from a decreasing trend in 2005-2006, while nonnative black bullhead, mosquitofish, fathead minnow and green sunfish relative abundance appear cyclical (Figure 7). Longfin dace made up the entire collection of fish for the middle reach in 2005 and 2009 and predominated throughout the five year period (Figure 8), but nonnative black bullhead, mosquitofish, green sunfish, and largemouth bass were captured at least once in the intervening years (2006-2008). This general pattern of relative abundance in the middle reach has changed little since monitoring began (Marsh and Kesner 2004, 2006). The capture of a few nonnative red shiner in 2005 and a few nonnative black bullhead, channel catfish, flathead catfish, yellow bullhead and green sunfish in 2006 made up the entirety of the catch in the downstream reach (Figure 9). In 2007 the catch was completely different with relatively larger catch of 125 fish made up entirely of longfin dace. Large numbers of longfin dace continued to predominate in 2008 and 2009.

Gila River---Six of twelve species collected in the Gila River were found in all five sample years, two in three years and four in only one year (Table 15). Eight of twelve taxa were taken from all three reaches sampled and four were in one reach. There was substantial variation in abundance among years. From quantitative electrofishing samples, red shiner was the most abundant species in three of five years, and mosquitofish predominated in the other two (Table 5). Mosquitofish or red shiner was the second most abundant species in years they did not predominate, a pattern which is remarkably similar to the previous five year period (Marsh and Kesner 2006). Channel catfish, common carp and flathead catfish were captured in all years, and yellow bullhead and green sunfish were encountered most years. The remaining species generally were sporadic in occurrence and few in number.

Overall, relative abundance from Gila River collections appears to have shifted from red shiner dominance to mosquitofish dominance during the five year sampling period (Figure 10). However, a cyclical pattern of dominance between these two species was evident in the previous five year sampling period (Marsh and Kesner 2006), and so the shift in abundance during the current five year sampling may not persist. Yellow bullhead, channel catfish, and flathead catfish continue to vary in relative importance year to year. A similar shift in relative abundance occurred in the upper middle reach of the Gila River with a decrease in red shiner and a subsequent increase in mosquitofish (Figure 11).

Relative abundance was inconsistent for most species in the Gila River lower middle reach (Figure 12). The five year period is bookended by years of mosquitofish dominance (2005 and 2009). Catfishes dominated in 2006 and 2007 with yellow bullhead making up the majority of the catch in 2006 and channel catfish dominating in 2007. In 2008 catfishes, common carp, and mosquitofish each made up a sizable portion (greater than 15%) of the catch. The downstream reach also had inconsistent relative abundances of common species (Figure 13). Yellow bullhead dominated the catch in 2005 and 2006, while red shiner increased in relative abundance from 2005 to 2007. Red shiner dominated the sample in 2007, but disappeared the following year (2008) when the sample was dominated by channel catfish. The catch was dominated by mosquitofish in 2009, although it was uncommon to rare in the previous four years.

Salt River---Three of sixteen species collected in the Salt River were found in all five sample years, one was found in four years, one in three years, five in two years and six were taken only in one year each (Table 16). There were no assemblage comparisons among reaches because there was only one reach. Total catch from quantitative electrofishing samples generally was small (Table 6), likely a reflection of the gears deployed in this stream, which favored capture of large-bodied fishes (Table 2). Desert sucker was the most abundant taxon overall, but predominated in only one year (2007 with 256 individuals captured), and was captured in only two sample years total. Largemouth bass was captured every year and predominated in the four other years. At least one yellow bullhead was encountered every sample year, while Sonora sucker, bluegill and rainbow trout were encountered in most years. Other species were sporadic in occurrence and generally were uncommon-to-rare.

In the single Salt River reach largemouth bass dominated in 2008-2009, desert sucker dominated in 2007, and 2005-2006 was a mix of species (Figure 14). The species composition is undoubtedly affected by variations in discharge across samples, which stations were sampled, and which gears were deployed (see above). The short-lived dominance of desert sucker was due to an uncharacteristically large number of desert sucker in the sample from a single eddying pool at the Blue Point Ranger Station (station 3-1-2).

Cienega Creek---Two of three species encountered in Cienega creek were captured all three years sampling was conducted (Table 17). The single reach in Cienega Creek has a consistent species composition of native longfin dace dominance and Gila topminnow presence (Table 7, Figure 15) with one Gila chub captured in a qualitative sample in 2009.

Canal Data. *CAP Canal*---Seven of thirteen species (excluding undetermined sunfish) encountered in the CAP Canal were found in all years, one species was found in four years, one species was found in three years, one was found in two years, and three were found only once (Table 9). Seven of the thirteen species were taken from all three reaches, two were in two reaches, and four were from one reach each. The most abundant taxon was redear sunfish followed respectively by largemouth bass, grass carp, channel catfish, common carp, bluegill and striped bass. Other species were uncommon to rare.

The CAP Canal overall was consistently diverse with a large proportion of sunfishes (mostly redear sunfish with some bluegill and occasional green sunfish), a usually somewhat smaller proportion of largemouth bass, striped bass, channel catfish, grass carp and common carp, and occasional increases in red shiner and black bullhead (Figure 16). Other species such as threadfin shad and smallmouth bass make occasional appearances.

Sunfishes played a smaller role in species composition for the upstream CAP reach while grass carp and common carp dominated two of the three years for which sampling was conducted (Figure 17). For the middle reach on the CAP Canal the dominant species captured shifted among channel catfish, red shiner, and striped bass during the five year sampling period (Figure 18). Red shiner made up a significant portion of the catch in 2005, 2007 and 2008 but was absent in catches from 2006 when channel catfish dominated the catch and in 2009 when striped bass made up over 75% of the catch. The downstream reach on the CAP Canal was dominated by sunfishes and largemouth bass (Figure 19).

SRPs Canal---Nine of 21 species encountered (excluding undetermined cichlid) in the SRP South Canal were found in all years sampled, two were found in four years, three species were found in three years, three species were found in two years, and four species were found only once each (Table 10). A majority of species (11) was found both above and below the electric fish barrier. Seven taxa, threadfin shad, common carp, goldfish, yellow bullhead, rainbow trout, smallmouth bass and blue tilapia were only in the reach above the barrier, while three others, grass carp, bigmouth buffalo and striped bass were found only below the barrier. Red shiner was the most abundant taxon, followed respectively by Sonora sucker, channel catfish, flathead catfish, common carp, largemouth bass, undetermined cichlid, blue tilapia, grass carp, desert sucker, bluegill, rainbow trout, roundtail chub, green sunfish, mosquitofish, redbelly tilapia, striped bass, yellow bullhead, goldfish, smallmouth bass, threadfin shad and bigmouth buffalo (one each).

Channel catfish, red shiner, and Sonora sucker co-dominated the catch in the SRPs Canal during 2005-2009 (Figure 20). Above the barrier, a similar dominance of channel catfish and Sonora sucker is evident with undetermined cichlids, common carp and red shiner making up significant proportions in 2005, 2007 and 2009 respectively (Figure 21). Below the barrier, relative abundance of red shiner dominated the catch in three of the four years sampled (2006-2008, Figure 22). In 2005, grass carp, red shiner, Sonora sucker, channel catfish and largemouth bass all made significant (greater than 10%) contributions to the catch.

SRPn Canal---Six of 21 species encountered (excluding undetermined or hybrid sunfishes and undetermined cichlids) in the SRPn Canal were found in all years, three species were found in four years, five species were found in three years, one species was found in two years, and six species were found only once each (Table 11). Seven species were found both above and below the electric fish barrier. Ten fishes, threadfin shad, common carp, goldfish, roundtail chub, desert sucker, yellow bullhead, black crappie, smallmouth bass, yellow bass and blue tilapia were only in the reach above the barrier and four others, grass carp, mosquitofish, green sunfish and redear sunfish were found only below the barrier. Mosquitofish were observed above the barrier in most years although none were captured. Channel catfish was the most abundant taxon, followed respectively by Sonora sucker, flathead catfish, common carp, largemouth bass, red shiner, mosquitofish, bluegill, rainbow trout, grass carp, blue tilapia, yellow bullhead, desert sucker, green sunfish, roundtail chub, threadfin shad, black crappie, redear sunfish, yellow bass, smallmouth bass, and one goldfish.

Similar to SRPs Canal, no trends were evident in the species composition of the SRPn Canal catch (Figure 23). Channel and flathead catfishes and Sonora sucker were predominant in one or more years and common carp and red shiner made up significant proportions of the catch in 2007 and 2009, respectively. The above-barrier composition is similar except for a lack of red shiner in 2009, replaced by a dominance of Sonora sucker (Figure 24). The below-barrier sample is similar in overall composition, but a change from bluegill and largemouth bass dominance in 2005 and 2006 to a dominance of red shiner, Sonora sucker and mosquitofish by 2009 is evident (Figure 25).

FCG Canal---Two of nine species encountered in the FGC Canal were found in all years, two species were found in four years, three species were found in three years, one species was found in two years, and one species was found only once (Table 12). A single specimen of black bullhead was collected only below the barrier in 2007; all other species were collected above and below the fish barrier. The two

most abundant species, channel catfish and red shiner (in order of abundance), were collected in all years. Other species collected in order of abundance were yellow bullhead, mosquitofish, threadfin shad, common carp, flathead catfish, green sunfish and black bullhead.

Overall in the FCG canal, the four most abundant species channel catfish, red shiner, yellow bullhead and mosquitofish fluctuated in abundance from year to year but together made up the vast majority of the catch every year (Figure 26). This was evident above and below the barrier although common carp made a more significant contribution in the above barrier sample in 2006 (Figures 27 and 28).

Conclusion and Recommendations

Twenty native and more than 30 non-native warmwater fishes are recorded from the Gila River basin (Minckley and Marsh 2009). Among native kinds, a dozen are state or federally listed as threatened or endangered, natural populations of five species are extirpated, and one is extinct (Desert Fishes Team 2003, 2004). The Gila River Basin fish monitoring program has detected the presence of 32 species that had gone unreported since 1970 within the reaches sampled prior to the start of the monitoring program (Marsh and Kesner 2006 & this report), and has documented the decline and potential disappearance of native species from sampled reaches of the Gila River. From this perspective the program can be considered successful. Other species, undetected and undocumented, also may be present, but if so they are so rare or distributed in such a manner as to avoid detection by the current protocol. It is unreasonable to expect the program to be 100% accurate in assessing species presence.

Although formal statistical models were not utilized for this report, the decline and current absence of the four native species formerly common in samples from the Gila River is indicative of the current state of native fishes in the basin. Native fishes continue to lose ground to nonnative fishes wherever the two kinds co-occur (Desert Fishes Team 2003, 2004). Because the nonnative species persist where these losses have occurred, we indict the presence of nonnative fishes as the most likely reason these four native species appear to have been locally extirpated.

We make the following recommendation to improve implementation of the CAP fish monitoring program: Species composition data within a reach can be strongly affected by the number and location of stations sampled, and apparent trends in composition may arise if stations sampled vary from year to year when actual composition within the reaches may not have changed. Therefore, wherever possible,

stations that are consistently problematic because of access or other issues (for example, the upper two Salt River stations) should be moved to new locations where annual sample acquisition is better assured. In addition, sample gear biases and temporal changes in site conditions also affect sampling accuracy, and thus consideration of station or even reach-wide sampling results as indicative of real conditions may be problematic. Given these constraints, presence/absence of new or previously abundant species may be the best indication of change within a reach or stream.

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Table 1. Common and scientific names and four-letter species codes of fishes and other aquatic vertebrates encountered during routine monitoring of waters in the Gila River basin, Arizona. Native taxa are indicated by an asterisk (*).

Common Name	Species Name	Species Code
Threadfin shad	*Dorosoma petenense*	DOPE
Bigmouth buffalo	*Ictiobus cyprinella*	ICCY
Black buffalo	*Ictiobus niger*	ICNI
Common carp	*Cyprinus carpio*	CYCA
Fathead minnow	*Pimephales promelas*	PIPR
Gila chub*	*Gila intermedia*	GIIN
Goldfish	*Carassius auratus*	CAAU
Grass carp	*Ctenopharyngodon idella*	CTID
Loach minnow*	*Tiaroga cobitis*	TICO
Longfin dace*	*Agosia chrysogaster*	AGCH
Red shiner	*Cyprinella lutrensis*	CYLU
Roundtail chub*	*Gila robusta*	GIRO
Speckled dace*	*Rhinichthys osculus*	RHOS
Desert sucker*	*Pantosteus clarki*	PACL
Hybrid sucker*	*Pantosteus X Catostomus*	HYBR
Sonora sucker*	*Catostomus insignis*	CAIN
Pacu	*Colossoma sp*	COLO
Black bullhead	*Ameiurus melas*	AMME
Channel catfish	*Ictalurus punctatus*	ICPU
Flathead catfish	*Pylodictis olivaris*	PYOL
Yellow bullhead	*Ameiurus natalis*	AMNA
Rainbow trout	*Oncorhynchus mykiss*	ONMY
Gila topminnow*	*Poeciliopsis occidentalis*	POOC
Mosquitofish	*Gambusia affinis*	GAAF
Sailfin molly	*Poecilia latipinna*	POLA
Striped bass	*Morone saxatilis*	MOSA
White bass	*Morone chrysops*	MOCH
Yellow bass	*Morone mississippiensis*	MOMI
Black crappie	*Pomoxis nigromaculatus*	PONI
Bluegill	*Lepomis macrochirus*	LEMA
Green sunfish	*Lepomis cyanellus*	LECY
Largemouth bass	*Micropterus salmoides*	MISA
Redear sunfish	*Lepomis microlophus*	LEMI
Smallmouth bass	*Micropterus dolomieui*	MIDO
Undetermined or hybrid sunfish	*Lepomis ?*	LEPO
Walleye	*Sander vitreus (Stizostedion vitreum)*	STVI
Walleye	*Sander vitreus (Stizostedion vitreum)*	SAVI
Yellow perch	*Perca flavescens*	PEFL
Blue tilapia	*Oreochromis aureus (Tilapia aurea)*	TIAU
Blue tilapia	*Oreochromis aureus (Tilapia aurea)*	ORAU
Mozambique tilapia	*Oreochromis mossambicus (Tilapia mossambica)*	TIMO
Mozambique tilapia	*Oreochromis mossambicus (Tilapia mossambica)*	ORMO
Redbelly tilapia	*Tilapia zilli*	TIZI
Undetermined cichlid	*Tilapia ?*	TILA

Table 1. Continued.

Common Name	Species Name	Species Code
American bullfrog	*Lithobates catesbeianus (Rana catesbeiana)*	RACA
American bullfrog	*Lithobates catesbeianus (Rana catesbeiana)*	LICA
Lowland leopard frog*	*Lithobates yavapaiensis (Rana yavapaiensis)*	RAYA
Lowland leopard frog*	*Lithobates yavapaiensis (Rana yavapaiensis)*	LIYA
No fish caught	*No fish caught*	0000
Sonora mud turtle*	*Kinosternon sonoriense*	KISO
Spiny softshell turtle	*Apalone spinifera (Trionyx spinifera)*	TRSP
Spiny softshell turtle	*Apalone spinifera (Trionyx spinifera)*	APSP
Undetermined frog	*Lithobates ? (Rana ?)*	LITH
Undetermined frog	*Lithobates ? (Rana ?)*	RANA
Unknown fish species	*Unknown fish species*	FISH
Unknown species	*Unknown species*	UNKN

Table 2. Sampling equipment used in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona, for sample years (SY) 2005 through 2009. Gear codes, by category are Entrapment/Entanglement: trammel net (T); Seining: straight seine (SS), dip net (D); Electrofishing: backpack shocker (Bp), boat shocker (Ef).

		Station 1		Station 2		Station 3	
Reach	SY	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative
San Pedro River							
Upstream (1)	2005	SS	Bp	-	Bp	-	Bp
	2006	Bp	Bp	-	Bp	-	Bp
	2007	-	Bp	-	Bp	-	Bp
	2008	-	Bp	-	Bp	-	Bp
	2009	-	Bp	-	Bp	-	Bp
Middle (2)	2005	-	Bp	-	-	Bp	Bp
	2006	Bp	Bp	-	-	Bp, SS	Bp
	2007	-	Bp	-	-	-	Bp
	2008	DS	-	-	-	-	Bp
	2009	DS	-	-	-	-	Bp
Downstream (3)	2005	-	SS	-	SS	-	Bp
	2006	Bp	Bp, SS	-	Bp	-	Bp, SS
	2007	Bp	Bp	Bp	Bp	-	Bp
	2008	-	Bp	-	Bp	-	Bp
	2009	-	Bp	-	Bp	-	DS
Gila River							
Upstream (1)	2005	-	-	-	-	-	-
	2006	-	-	-	-	-	-
	2007	-	-	-	-	-	-
	2008	-	-	-	-	-	-
	2009	-	-	-	-	-	-
Upper Middle (2)	2005	-	Bp	-	Bp	-	Bp
	2006	-	Bp,T	-	Bp	-	Bp,T
	2007	-	Bp	-	Bp	-	Bp
	2008	-	Bp,T	-	Bp	-	Bp
	2009	-	Bp,T	-	Bp	-	Bp
Lower Middle (3)	2005	DS	-	-	Bp	-	Bp
	2006	Bp	Bp	-	Bp	-	Bp
	2007	D	-	-	Bp	-	Bp
	2008	-	Bp	-	Bp	-	Bp
	2009	-	D	-	Bp	-	Bp
Downstream (4)	2005	-	-	-	Bp	-	Bp
	2006	-	Bp,T	Bp	Bp	-	Bp
	2007	-	Bp	-	Bp	-	Bp
	2008	-	Bp	-	Bp	-	Bp
	2009	-	Bp	-	Bp	Bp	Bp
Salt River							
Downstream (1)	2005	-	Ef	-	Ef	-	Ef
	2006	-	Bp, T	-	Bp, T	-	Ef, T
	2007	-	Bp, SS, T	-	Bp, T	-	Ef, T
	2008	-	-	-	-	-	Ef, T
	2009	-	-	-	-	-	Ef, T
Cienega Creek							
Downstream (1)	2005	-	-	-	-	-	-
	2006	-	-	-	-	-	-
	2007	SS	Bp	SS	Bp	-	-
	2008	-	Bp	-	Bp	-	-
	2009	SS	Bp, SS	-	Bp	-	-

Table 3. Available station data for detecting trends in fish species as part of a long-term monitoring plan for selected waters of the Gila River basin, Arizona; sample years 2005 through 2009.

Stations Sampled

	San Pedro River			Gila River				Salt River	Cienega Creek
Year	Upstream	Middle	Downstream	Upstream	Upper Middle	Lower Middle	Downstream	Single Reach	Single Reach
2005	1,2,3	1,3	1(ne),2(ne),3	none	1,2,3	2,3	2,3	1,2,3	none
2006	1,2,3	1,3	1,2,3	none	1,2,3	1,2,3	1,2,3	1,2,3	none
2007	1,2,3	1,3	1,2,3	none	1,2,3	1(nq),2,3	1,2,3	1,2,3	1,2
2008	1,2,3	3	1,2,3	none	1,2,3	1,2,3	1,2,3	3	1,2
2009	1,2,3	3	1,2	none	1,2,3	1(ne),2,3	1,2,3	3	1,2

nq = nonquantitative sample

ne = nonelectrofishing sample

# of Stations for Analysis

	San Pedro River			Gila River				Salt River	Cienega Creek
Year	Upstream	Middle	Downstream	Upstream	Upper Middle	Lower Middle	Downstream	Single Reach	Single Reach
2005	3	2	1	0	3	2	2	3	0
2006	3	2	3	0	3	3	3	3	0
2007	3	2	3	0	3	2	3	3	2
2008	3	1	3	0	3	3	3	1	2
2009	3	1	2	0	3	2	3	1	2

Table 4. Total numbers of fishes captured in the San Pedro River during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears. Reaches are labelled as upstream, middle, and downstream to indicate relative position upstream to downstream. Reaches that were not sampled or non-quantitatively sampled are excluded from this table. Fish species native to the basin are denoted by an asterisk (*).

	Upstream Reach					Middle Reach					Downstream Reach					
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sum**
Common carp	7	1	2	1	19											30
Fathead minnow	2	5		9	64				3							83
Goldfish		1														1
Longfin dace*	14	1	47	57	459	15	33	442	232	113			125	126	41	1705
Red shiner					19						4			2		25
Desert sucker*	3	1	13	17	52											86
Black bullhead	23	22	29	16	27		1	2	12			2		1		135
Channel catfish					5							8				13
Flathead catfish												5				5
Yellow bullhead												4		1		5
Mosquitofish		9	6	4	463			2								484
Green sunfish	3	3	8	1	8		1	4				2				30
Largemouth bass			4		7			4								15
Totals	52	43	109	105	1123	15	35	454	247	113	4	21	125	130	41	2617

Table 5. Total numbers of fishes captured in the Gila River during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears. Reaches are labelled as upper middle, lower middle, and downstream to indicate relative position upstream to downstream, the upstream reach was not sampled. Fish species native to the basin are denoted by an asterisk (*).

	Upper Middle Reach					Lower Middle Reach					Downstream Reach					
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sum**
Threadfin shad					1										12	13
Common carp	4	15	10	11	7		2	2	12				2		1	66
Red shiner	284	304	144	58	76	2	1	17	1	1	8	23	202		1	1122
Desert sucker*		1														1
Channel catfish	1	36	24	59	16		10	38	8	6	10	1	26	22	3	260
Flathead catfish	2	2	2	1	8		2	1	3				4	2	6	33
Yellow bullhead		1				23	33				49	30	10			146
Mosquitofish	36	46	60	117	159	75		4	5	29			5		47	583
Black crappie					1											1
Bluegill	3															3
Green sunfish	13	19	11	5		3	3				2					56
Largemouth bass	2	1		4												7
Totals	345	425	251	255	268	103	51	62	29	36	69	54	249	24	70	2291

Table 6. Total numbers of fishes captured in the Salt River during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears. A single downstream reach was sampled. Fish species native to the basin are denoted by an asterisk (*).

Species	2005	2006	2007	2008	2009	Sum
Common carp	18	1				19
Longfin dace*		11	9			20
Red shiner			6			6
Desert sucker*		19	256			275
Sonora sucker*	32	6	15		1	54
Black bullhead		7				7
Flathead catfish	2					2
Yellow bullhead	16	2	3	1	1	23
Rainbow trout		1	2	6		9
Mosquitofish	1		11			12
Sailfin molly			6			6
Bluegill	9	11	1		4	25
Green sunfish	2				2	4
Largemouth bass	63	25	28	22	69	207
Totals	143	83	337	29	77	669

Table 7. Total numbers of fishes captured in Cienega Creek during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2007 through 2009 (sampling began on Cienega Creek in 2007; NS indicates no sample). Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears. A single downstream reach was sampled. Fish species native to the basin are denoted by an asterisk (*).

Species	2005	2006	2007	2008	2009	Sum
Longfin dace*			501	591	882	1974
Gila topminnow*			11	96	58	165
Totals	NS	NS	512	687	940	2139

Table 8. Sampling equipment used in behalf of a long-term monitoring plan for fish populations in selected canals, for sample years (SY) 2005 through 2009. Gear codes, by category are Entrapment/Entanglement: trammel net (T), minnow trap (M); Seining: straight seine (SS), bag seine (BS), dip net (D); Electrofishing: backpack shocker (Bp), boat shocker (Ef); Angling: trot line (TL).

		Reach 1		Reach 2		Reach 3	
	SY	Qualitative	Quantitative	Qualitative	Quantitative	Qualitative	Quantitative
CAP Canal							
	2005				Ef, M, T, TL		Ef, M, T, TL
	2006		Ef, M, T, TL		Ef, M, T, TL		Ef, M, T, TL
	2007		Ef, M, T, TL		Ef, M, T, TL		Ef, M, T, TL
	2008				Ef, M, T, TL		Ef, M, T, TL
	2009		Ef, M, T, TL		Ef, M, T, TL		Ef, M, T, TL
SRP South Canal							
	2005		BS	BS, D, G, T			
	2006		BS	BS, D, SS, T			
	2007		BS	BS, D, SS			
	2008		BS	D, SS			
	2009	SS	BS				
SRP North Canal							
	2005		BS	Ef, M			
	2006		BS	Ef			
	2007		BS	Ef, T			
	2008		BS	Ef, T			
	2009		BS, SS	Ef, EXPG, T			
FCG Canal							
	2005	Bp, SS		Bp, D, SS			
	2006	Bp, SS		Bp, D, SS			
	2007	Bp, SS		Bp, SS			
	2008	Bp, SS		Bp, D, SS			
	2009	Bp		Bp, D, SS			

Table 9. Total numbers of fishes captured in the CAP Canal during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009. Totals include young of year and adult individuals captured in quantitative samples (NS indicates no sample). The upstream reach includes all pumping stations upstream of the Phoenix, AZ area, the middle reach is for the Salt-Gila pumping plant, and the downstream reach includes pumping stations downstream of the Phoenix area. Fish species native to the basin are denoted by an asterisk (*).

	Upstream Reach					Middle Reach					Downstream Reach					
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sum**
Threadfin shad											1					1
Common carp		23	24		11	3		1		1	5	6	10	25	15	124
Red shiner						12		3	10		1	1	1			28
Grass carp		34	2		17	6	3	8	12	2	12	8	10	8	11	133
Black bullhead											7		1			8
Channel catfish		11	11		8	8	22	10	3	1	4	15	29	3	6	131
Bluegill		1	4					2			27	23	53	1	10	121
Green sunfish					3											3
Largemouth bass		20	11		7	5	8				24	31	51	10	57	224
Smallmouth bass			1			2				1						4
Undetermined or hybrid sunfish		7	11			1						2	1			22
Redear sunfish			1								28	20	205	49	89	392
Striped bass		18	20		9	6	11	7	10	16	4	9	1		7	118
Pacu							1									1
Totals	NS	114	85	NS	55	43	45	31	35	21	113	115	362	96	195	1310

Table 10. Total numbers of fishes captured in the SRPs Canal during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009. Totals include young of year and adult individuals captured (NS indicates no sample). The above barrier reach includes all sampling upstream of the electrical fish barrier and the below barrier reach includes all sampling downstream. Fish species native to the basin are denoted by an asterisk (*).

	Above Barrier					Below Barrier					
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sum**
Threadfin shad		1									1
Common carp	30	45	71	19	23						188
Goldfish			2	1							3
Red shiner		2	2	4	158	65	99	853	34		1217
Grass carp						54	1	1			56
Roundtail chub*	6	1	4	10	3	3					27
Bigmouth buffalo						1					1
Desert sucker*	3	18	12	10	1	9	1				54
Sonora sucker*	59	90	83	67	199	77	8	76			659
Channel catfish	56	180	40	97	60	105	36	73	8		655
Flathead catfish	42	41	12	74	9	17	5	1	5		206
Yellow bullhead		1		4							5
Rainbow trout		26	7	1	6						40
Mosquitofish					1	1	2	9	5		18
Bluegill	6	2	14			10		1	12		45
Green sunfish			10					9			19
Largemouth bass	10	3	20	31	32	60	1	4	5		166
Smallmouth bass	2										2
Striped bass						6		1			7
Undetermined cichlid	96										96
Redbelly tilapia		5	1			2					8
Blue tilapia			47	11	2						60
Totals	310	415	325	329	494	410	153	1028	69	NS	3533

Table 11. Total numbers of fishes captured in the SRPn Canal during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009. Totals include young of year and adult individuals captured. The above barrier reach includes all sampling upstream of the electrical fish barrier and the below barrier reach includes all sampling downstream. Fish species native to the basin are denoted by an asterisk (*).

	Above Barrier					Below Barrier					
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sum**
Threadfin shad			3								3
Common carp	17	17	195	15	3						247
Goldfish				1							1
Red shiner	1							2		232	235
Grass carp								3	7	38	48
Roundtail chub*			2	1	2						5
Desert sucker*	2	5	4	2							13
Sonora sucker*	40	27	74	35	56	2	24	32	14	158	462
Channel catfish	156	815	69	217	41	3	2	1	31	3	1338
Flathead catfish	139	55	10	141	6	1					352
Yellow bullhead			3	12							15
Rainbow trout		24	40	13			2				79
Mosquitofish							3	10	33	103	149
Black crappie				3							3
Bluegill	1	5	2		8	35	2	21	16		90
Green sunfish						7	2		1	1	11
Largemouth bass	47	12	26	36	32	34	32	9	4	6	238
Smallmouth bass	2										2
Undetermined or hybrid sunfish							2				2
Redear sunfish								3			3
Yellow bass	2										2
Undetermined cichlid	17										17
Blue tilapia			3	11	3						17
Totals	424	960	431	487	151	82	69	81	106	541	3332

Table 12. Total numbers of fishes captured in the FCG Canal during sampling in behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009. Totals include young of year and adult individuals captured. The above barrier reach includes all sampling upstream of the electrical fish barrier and the below barrier reach includes all sampling downstream. Fish species native to the basin are denoted by an asterisk (*).

	Above Barrier					Below Barrier					
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sum**
Threadfin shad					51			1		75	127
Common carp	6	15				8	3			2	34
Red shiner	116	3	65	3	2	174	38	22	12	13	448
Black bullhead								1			1
Channel catfish	218	7	28	76	1	3	22	6	79	70	510
Flathead catfish		1		4	1		2		1	4	13
Yellow bullhead	226	21	11	1		3	12	35	2		311
Mosquitofish	13		43	1	86	38		65	15	1	262
Green sunfish	5	1				3	1	2			12
Totals	584	48	147	85	141	229	78	132	109	165	1718

Table 13. Fish species encountered from 2005 to 2009 during routine sampling on behalf of long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona and their associated colors as used in species composition bar graphs in figures 6 to 28. The color scheme in RGB (Red, Green, Blue) values is provided so that the reader can recreate the actual colors with their own software.

	Color scheme			
Common name	**R**	**G**	**B**	**swatch**
Undetermined cichlid	171	193	255	
Redbelly tilapia	85	51	204	
Mozambique tilapia	0	0	153	
Blue tilapia	51	102	204	
Yellow perch	255	255	0	
Walleye	204	255	51	
Undetermined or hybrid sunfish	51	102	153	
Smallmouth bass	1	255	231	
Redear sunfish	0	153	153	
Largemouth bass	0	102	102	
Green sunfish	0	153	0	
Bluegill	0	0	255	
Black crappie	0	204	255	
Yellow bass	204	204	255	
White bass	204	153	255	
Striped bass	191	61	150	
Sailfin molly	121	123	23	
Mosquitofish	182	150	132	
Gila topminnow*	119	139	99	
Rainbow trout	255	179	179	
Yellow bullhead	234	234	234	
Flathead catfish	178	178	178	
Channel catfish	128	128	128	
Black bullhead	0	0	0	
Pacu	102	0	51	
Sonora sucker*	128	128	0	
Hybrid sucker*	153	102	51	
Desert sucker*	102	51	0	
Roundtail chub*	190	94	100	
Red shiner	208	0	0	
Longfin dace*	161	132	81	
Grass carp	230	227	164	
Goldfish	245	235	103	
Gila chub*	200	95	84	
Fathead minnow	255	153	51	
Common carp	214	158	46	
Bigmouth buffalo	255	99	88	
Threadfin shad	255	255	255	

Table 14. Fish species presence (+) or absence (-) from fifteen years of collections on the San Pedro River in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. Species occurrences among reaches are denoted along the diagonal from upstream (top left) to downstream (bottom right). All collection records were used regardless of method. Shading indicates the species is a new record for the system since collections began in 1995.

Species	95-99	00-04	05	06	07	08	09
Common carp	- - +	+ - +	+ - -	+ - -	+ - -	+ - -	+ - -
Fathead minnow	+ + +	+ + +	+ - -	+ - -	- - -	+ + -	+ - -
Goldfish	- - -	- - -	- - +	+ - -	- - -	- - -	- - -
Longfin dace*	+ + +	+ + +	+ + +	+ + -	+ + +	+ + +	+ + +
Red shiner	- - +	- - +	- - +	- - +	- - -	- - +	+ - -
Desert sucker*	+ + +	+ - +	+ - -	+ - -	+ - -	+ - -	+ - -
Hybrid sucker*	- - +	- - -	- - -	- - -	- - -	- - -	- - -
Sonora sucker*	- - +	- - -	- - -	- - +	- - -	- - -	- - -
Black bullhead	+ + -	+ + +	+ + +	+ + +	+ + +	+ + +	+ - -
Channel catfish	- - +	- - -	- - -	- - +	- - -	- - -	+ - -
Flathead catfish	- - -	- - -	- - -	- - +	- - -	- - -	- - -
Yellow bullhead	+ + +	+ - +	- - -	- - +	- - -	- - +	- - -
Mosquitofish	+ + +	+ + +	- + +	+ - -	+ + -	+ - -	+ - -
Bluegill	+ - -	- - -	- - -	- - -	- - -	- - -	- - -
Green sunfish	+ + +	+ + +	+ - -	+ + +	+ + -	+ - -	+ - -
Largemouth bass	+ - -	+ - -	- - -	- - -	+ + -	- - -	+ - -

Table 15. Fish species presence (+) or absence (-) from fifteen years of collections on the Gila River in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. Species occurrences amongst reaches are denoted along the diagonal from upstream (top left) to downstream (bottom right). All collection records were used regardless of method. Shading indicates the species is a new record for the system since collections began in 1995.

Species	**95-99**	**00-04**	**05**	**06**	**07**	**08**	**09**
Threadfin shad	+ + +	- - -	- - -	- - -	- - -	- - -	+ + +
Common carp	+ + +	+ + +	+ - -	+ + -	+ + +	+ + -	+ - +
Fathead minnow	- + -	+ + -	- - -	- - -	- - -	- - -	- - -
Longfin dace*	+ + +	+ + -	- - -	- - -	- - -	- - -	- - -
Red shiner	+ + +	+ + +	+ + +	+ + +	+ + +	+ -	+ + +
Desert sucker*	+ + +	- - -	- - -	+ - -	- - -	- - -	- - -
Hybrid sucker*	- - +	- - -	- - -	- - -	- - -	- - -	- - -
Sonora sucker*	+ + +	+ + +	- - -	- - -	- - -	- - -	- - -
Black bullhead	+ - -	- - +	- - -	- - -	- - -	- - -	- - -
Channel catfish	+ + +	+ + +	+ - +	+ + +	+ + +	+ + +	+ + +
Flathead catfish	+ + -	+ - -	+ - -	+ + -	+ + +	+ + +	+ + +
Yellow bullhead	+ + +	+ + +	- + +	+ + +	- - +	- - -	- - -
Mosquitofish	+ + +	+ + +	+ + -	+ - -	+ + +	+ + -	+ + +
Black crappie	+ - -	- - -	- - -	- - -	- - -	- - -	+ - -
Bluegill	+ + -	+ + -	+ - -	- - -	- - -	- - -	- - -
Green sunfish	+ + +	+ + +	+ + +	+ + +	+ - -	+ - -	- + -
Largemouth bass	+ + -	+ + -	+ - -	+ - -	- - -	+ - -	- - -

Table 16. Fish species presence (+) or absence (-) from fifteen years of collections on the Salt River in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. All collection records were used regardless of method. Shading indicates the species is a new record for the system since collections began in 1995.

Species	95-99	00-04	05	06	07	08	09
Threadfin shad	-	+	-	-	-	-	-
Common carp	+	+	+	+	-	-	-
Longfin dace*	-	+	-	+	+	-	-
Red shiner	-	+	-	-	+	-	-
Roundtail chub*	+	+	-	-	-	-	-
Desert sucker*	+	+	-	+	+	-	-
Hybrid sucker*	+	+	-	-	-	-	-
Sonora sucker*	+	+	+	+	+	+	+
Black bullhead	-	-	-	+	-	-	-
Channel catfish	+	+	-	-	-	-	-
Flathead catfish	+	+	+	-	-	-	-
Yellow bullhead	+	+	+	+	+	+	+
Rainbow trout	+	+	-	+	+	+	-
Mosquitofish	+	+	+	-	+	-	-
Sailfin molly	+	+	-	-	+	-	-
Yellow bass	+	+	-	-	-	-	-
Black crappie	+	+	-	-	+	-	-
Bluegill	+	+	+	+	+	-	+
Green sunfish	+	+	+	-	-	-	+
Largemouth bass	+	+	+	+	+	+	+
Redear sunfish	+	+	-	-	-	-	-
Smallmouth bass	+	+	-	-	-	-	-
Undetermined or hybrid sunfish	+	+	-	-	-	-	-
Walleye	+	-	-	-	-	-	-
Blue tilapia	+	-	-	-	-	-	+
Redbelly tilapia	+	-	-	-	-	-	-
Undetermined cichlid	+	+	-	-	-	-	-

Table 17. Fish species presence (+) or absence (-) from three years of collections on Cienega Creek in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. Species occurrences amongst reaches are denoted along the diagonal from upstream (top left) to downstream (bottom right). All collection records were used regardless of method. Shading indicates the species is a new record for the system.

Species	07	08	09
Gila chub*	-	-	+
Longfin dace*	+	+	+
Gila topminnow*	+	+	+

Table 18. Total numbers of fishes captured in four sampled streams on behalf a long-term monitoring plan for fish populations in Gila River basin, Arizona, during sample years 2005 through 2009.). Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

	San Pedro River					Gila River					Salt River					Cienega Creek					
Species	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**2005**	**2006**	**2007**	**2008**	**2009**	**Sum**
Threadfin shad										13											13
Common carp	7	1	2	1	19	4	17	14	23	8	18	1									115
Fathead minnow	2	5		12	64																83
Goldfish		1																			1
Longfin dace*	29	34	614	415	613							11	9					501	591	882	3699
Red shiner	4			2	19	294	328	363	59	78			6								1153
Desert sucker*	3	1	13	17	52		1					19	256								362
Sonora sucker*											32	6	15		1						54
Black bullhead	23	25	31	29	27							7									142
Channel catfish		8			5	11	47	88	89	25											273
Flathead catfish		5				2	4	7	6	14	2										40
Yellow bullhead		4		1		72	64	10			16	2	3	1	1						174
Rainbow trout												1	2	6							9
Gila topminnow*																		11	96	58	165
Mosquitofish		9	8	4	463	111	46	69	122	235	1		11								1079
Sailfin molly													6								6
Black crappie										1											1
Bluegill						3					9	11	1		4						28
Green sunfish	3	6	12	1	8	18	22	11	5		2				2						90
Largemouth bass			8		7	2	1		4		63	25	28	22	69						229
Totals	71	99	688	482	1277	517	530	562	308	374	143	83	337	29	77			512	687	940	7716

Table 19. Fish species presence (+) or absence (-) from fifteen years of collections on the CAP Canal in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. Species occurrences amongst reaches are denoted along the diagonal from upstream (top left) to downstream (bottom right). All collection records were used regardless of method. Shading indicates the species is a new record for the system since collections began in 1995.

Species	95-99	00-04	05	06	07	08	09
Threadfin shad	+ - +	+ + +	- - +	- - -	- - -	- - -	- - -
Common carp	+ + +	+ + +	- + +	+ - +	+ + +	- - +	+ + +
Goldfish	- - +	- - +	- - -	- - -	- - -	- - -	- - -
Grass carp	+ + +	+ + +	- + +	+ + +	+ + +	- + +	+ + +
Red shiner	+ + +	+ + +	- + +	- - +	- + +	- + -	- - -
Pacu	- - -	- - -	- - -	- + -	- - -	- - -	- - -
Black bullhead	- - +	- - +	- - +	- - -	- - +	- - -	- - -
Channel catfish	+ + +	+ + +	- + +	+ + +	+ + +	- + +	+ + +
Flathead catfish	- - -	+ - +	- - -	- - -	- - -	- - -	- - -
Yellow bullhead	- - +	- - +	- - -	- - -	- - -	- - -	- - -
Striped bass	+ + +	+ + +	- + +	+ + +	+ + +	- + -	+ + +
White bass	- + +	- - -	- - -	- - -	- - -	- - -	- - -
Bluegill	+ + +	+ + +	- - +	+ - +	+ + +	- - +	- - +
Green sunfish	+ - +	+ - +	- - -	- - -	- - -	- - -	+ - -
Largemouth bass	+ + +	+ + +	- + +	+ + +	+ - +	- - +	+ - +
Redear sunfish	+ - +	+ + +	- - +	- - +	+ - +	- - +	- - +
Smallmouth bass	- - -	+ - -	- + -	- - -	+ - -	- - -	- + -
Undetermined or hybrid sunfish	+ - +	+ - +	- + -	+ - +	+ - +	- - -	- - -

Table 20. Fish species presence (+) or absence (-) from fifteen years of collections on the SRPs Canal in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. Species occurrences amongst reaches are denoted along the diagonal from upstream (top left) to downstream (bottom right). All collection records were used regardless of method. Shading indicates the species is a new record for the system since collections began in 1995.

Species	**95-99**	**00-04**	**05**	**06**	**07**	**08**	**09**
Threadfin shad	+ +	- +	- -	+ -	- -	- -	- -
Bigmouth buffalo	- -	- -	- +	- -	- -	- -	- -
Common carp	+ +	+ +	+ -	+ -	+ -	+ +	+ -
Goldfish	- -	- +	- -	- -	+ -	+ +	- -
Grass carp	+ +	+ +	- +	- +	- +	- +	- -
Longfin dace*	- +	- -	- -	- -	- -	- -	- -
Red shiner	+ +	+ +	- +	+ +	+ +	+ +	+ -
Roundtail chub*	+ +	+ +	+ +	+ -	+ -	+ -	+ -
Desert sucker*	+ +	+ +	+ +	+ +	+ -	+ -	+ -
Sonora sucker*	+ +	+ +	+ +	+ +	+ +	+ +	+ -
Channel catfish	+ +	+ +	+ +	+ +	+ +	+ +	+ -
Flathead catfish	+ +	+ +	+ +	+ +	+ +	+ +	+ -
Yellow bullhead	- +	- +	- -	+ -	- -	+ -	- -
Rainbow trout	+ +	+ -	- -	+ -	+ -	+ -	+ -
Mosquitofish	- +	- +	- +	- +	- +	- +	+ -
Striped bass	- +	- +	- +	- -	- +	- -	- -
Yellow bass	+ -	- +	- -	- -	- -	- -	- -
Black crappie	- +	+ -	- -	- -	- -	- -	- -
Bluegill	+ +	+ +	+ +	+ -	+ +	- +	- -
Green sunfish	- +	+ +	- -	- -	+ +	- -	- -
Largemouth bass	+ +	+ +	+ +	+ +	+ +	+ +	+ -
Smallmouth bass	+ +	+ +	+ -	- -	- -	- -	- -
Undetermined or hybrid sunfish	+ -	- -	- -	- -	- -	- -	- -
Walleye	+ +	+ -	- -	- -	- -	- -	- -
Blue tilapia	+ +	- +	- -	- -	+ -	+ -	+ -
Mozambique tilapia	- -	- +	- -	- -	- -	- -	- -
Redbelly tilapia	- +	- -	- +	+ -	+ -	- -	- -
Undetermined cichlid	+ +	+ +	+ -	- -	- -	- +	- -

Table 21. Fish species presence (+) or absence (-) from fifteen years of collections on the SRPn Canal in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. Species occurrences amongst reaches are denoted along the diagonal from upstream (top left) to downstream (bottom right). All collection records were used regardless of method. Shading indicates the species is a new record for the system since collections began in 1995.

Species	**95-99**	**00-04**	**05**	**06**	**07**	**08**	**09**
Threadfin shad	+ +	+ +	- -	- -	+ -	- -	- -
Bigmouth buffalo	+ -	+ -	- -	- -	- -	- -	- -
Common carp	+ +	+ +	+ -	+ -	+ -	+ -	+ -
Goldfish	- +	- -	- -	- -	- -	+ -	- -
Grass carp	+ +	+ +	- -	- -	- +	- +	- +
Longfin dace*	- +	- -	- -	- -	- -	- -	- -
Red shiner	+ +	- +	+ -	- -	- +	- -	- +
Roundtail chub*	+ +	+ +	- -	- -	+ -	+ -	+ -
Desert sucker*	+ +	+ +	+ -	+ -	+ -	+ -	- -
Hybrid sucker*	- -	- +	- -	- -	- -	- -	- -
Sonora sucker*	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Channel catfish	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Flathead catfish	+ +	+ +	+ +	+ -	+ -	+ -	+ -
Yellow bullhead	- -	+ -	- -	- -	+ -	+ -	- -
Rainbow trout	+ +	+ +	- -	+ +	+ -	+ -	- -
Mosquitofish	- +	- +	- -	- +	- +	- +	- +
Yellow bass	+ +	+ +	+ -	- -	- -	- -	- -
Black crappie	+ +	+ -	- -	- -	- -	+ -	- -
Bluegill	+ +	+ +	+ +	+ +	+ +	- +	+ -
Green sunfish	+ +	+ +	- +	- +	- -	- +	- +
Largemouth bass	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Redear sunfish	- +	- -	- -	- -	- +	- -	- -
Smallmouth bass	+ -	+ -	+ -	- -	- -	- -	- -
Undetermined or hybrid sunfish	+ -	- -	- -	- +	- -	- -	- -
Walleye	+ -	+ -	- -	- -	- -	- -	- -
Yellow perch	- -	+ -	- -	- -	- -	- -	- -
Blue tilapia	+ +	- -	- -	- -	+ -	+ -	+ -
Redbelly tilapia	+ +	- -	- -	- -	- -	- -	- -
Undetermined cichlid	+ +	+ +	+ -	- -	- -	- -	- -

Table 22. Fish species presence (+) or absence (-) from fifteen years of collections on the FCG Canal in behalf of a long-term monitoring plan for fish populations in selected waters of the Gila River basin, Arizona. Species occurrences amongst reaches are denoted along the diagonal from upstream (top left) to downstream (bottom right). All collection records were used regardless of method. Shading indicates the species is a new record for the system since collections began in 1995.

Species	**95-99**	**00-04**	**05**	**06**	**07**	**08**	**09**
Threadfin shad	+ +	+ +	- -	- -	- +	- -	+ +
Common carp	+ +	+ +	+ +	+ +	- -	- -	- +
Fathead minnow	+ +	- -	- -	- -	- -	- -	- -
Longfin dace*	+ +	- +	- -	- -	- -	- -	- -
Red shiner	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Desert sucker*	+ +	- -	- -	- -	- -	- -	- -
Sonora sucker*	+ +	+ -	- -	- -	- -	- -	- -
Black bullhead	- -	- -	- -	- -	- +	- -	- -
Channel catfish	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Flathead catfish	- -	+ -	- -	+ +	- -	+ +	+ +
Yellow bullhead	+ +	+ +	+ +	+ +	+ +	+ +	- -
Mosquitofish	+ +	+ +	+ +	- -	+ +	+ +	+ +
Bluegill	- +	+ +	- -	- -	- -	- -	- -
Green sunfish	- +	+ +	+ +	+ +	- +	- -	- -
Largemouth bass	- -	- +	- -	- -	- -	- -	- -

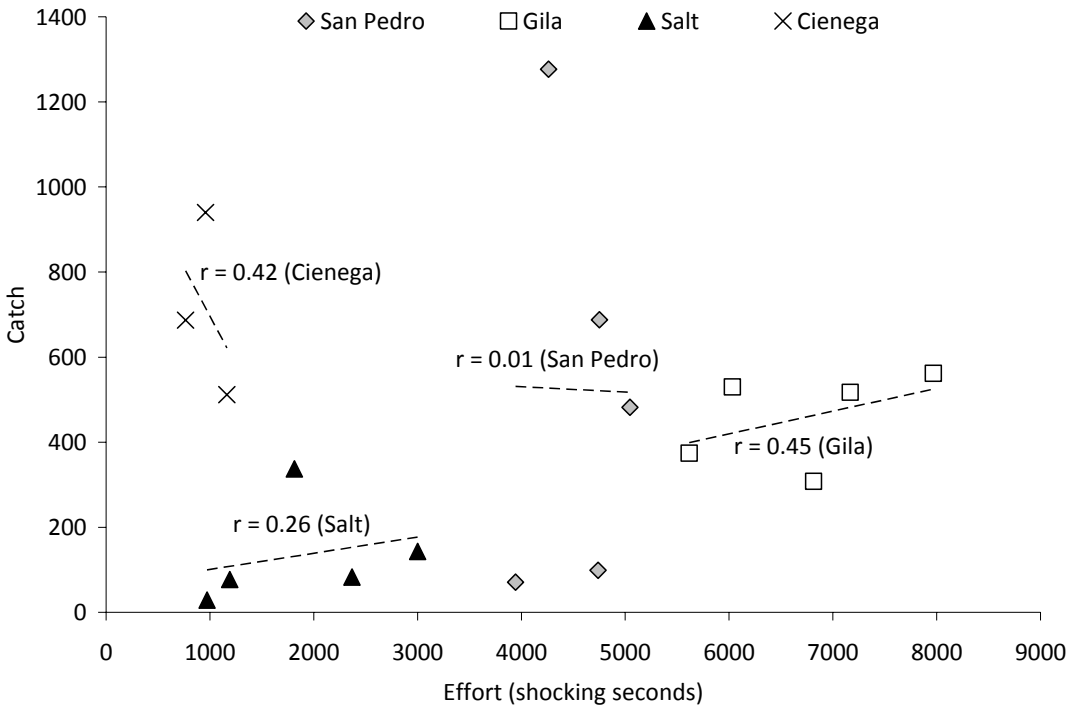

Figure 1. The correlation of catch and effort calculated by summing electrofishing catch and effort for each sample year and river system. Effort is backpack electrofishing seconds for San Pedro and Gila rivers and Cienega Creek, and boat or backpack electrofishing seconds for Salt River. Catch includes young of year and adult individuals captured during quantitative sampling using electrofishing gears.

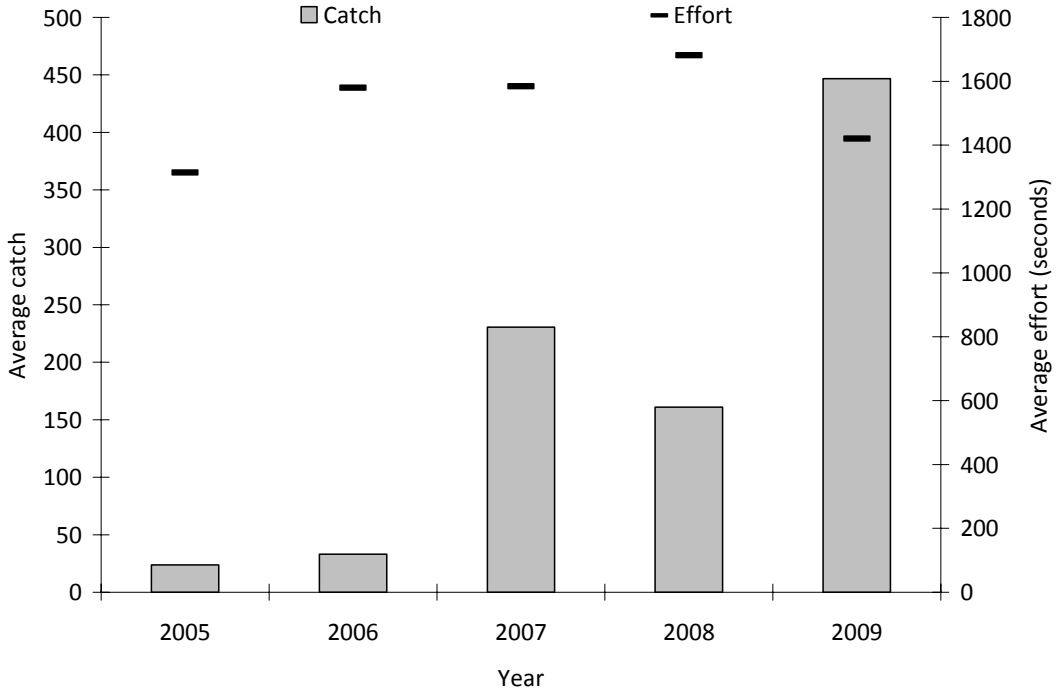

Figure 2. The average catch and effort among reaches for San Pedro River, sample years 2005 to 2009. Effort is backpack electrofishing seconds and catch includes young of year and adult individuals captured during quantitative sampling using electrofishing gears.

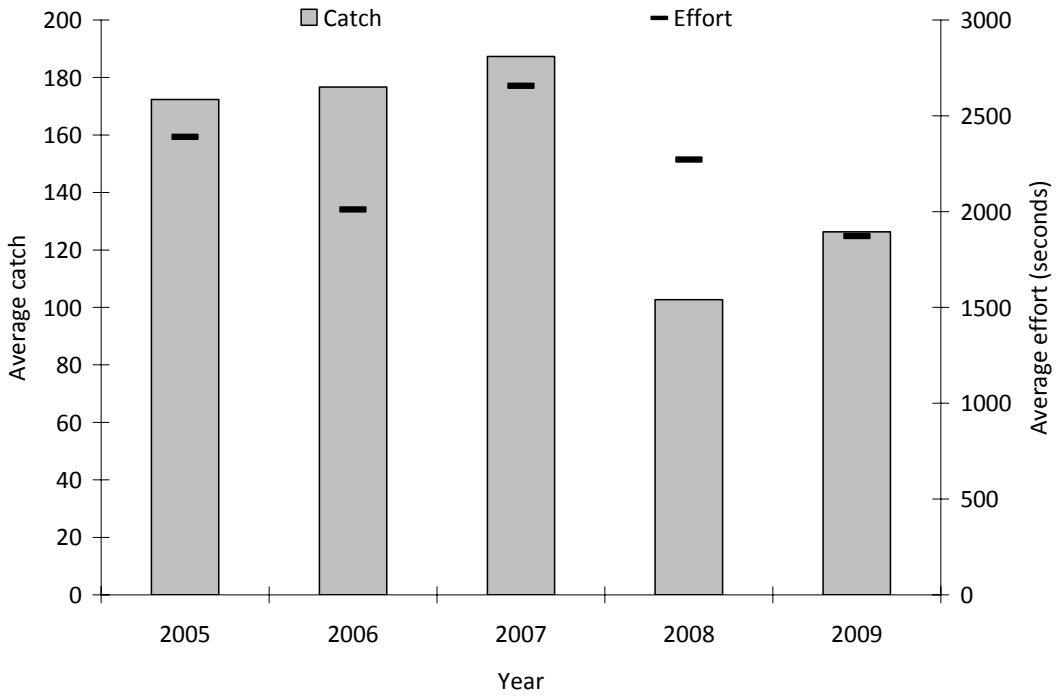

Figure 3. The average across reaches of catch and effort for Gila River, sample years 2005 to 2009. Effort is backpack electrofishing seconds and catch includes young of year and adult individuals captured during quantitative sampling using electrofishing gears.

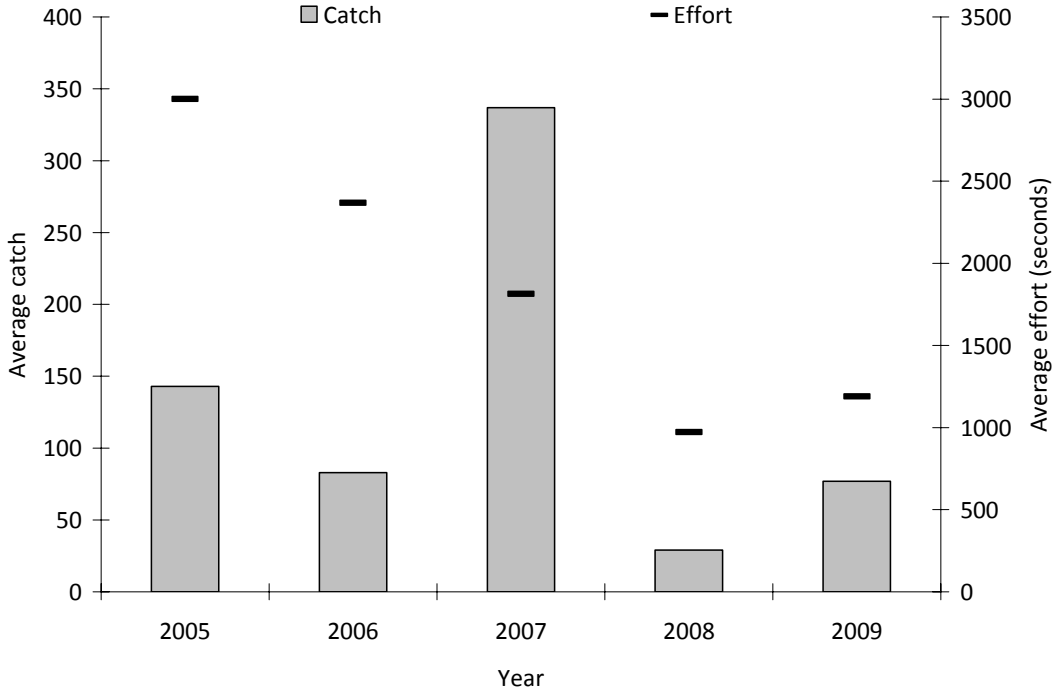

Figure 4. The average across reaches of catch and effort for Salt River, sample years 2005 to 2009. Effort is boat and backpack electrofishing seconds and catch includes young of year and adult individuals captured during quantitative sampling using electrofishing gears.

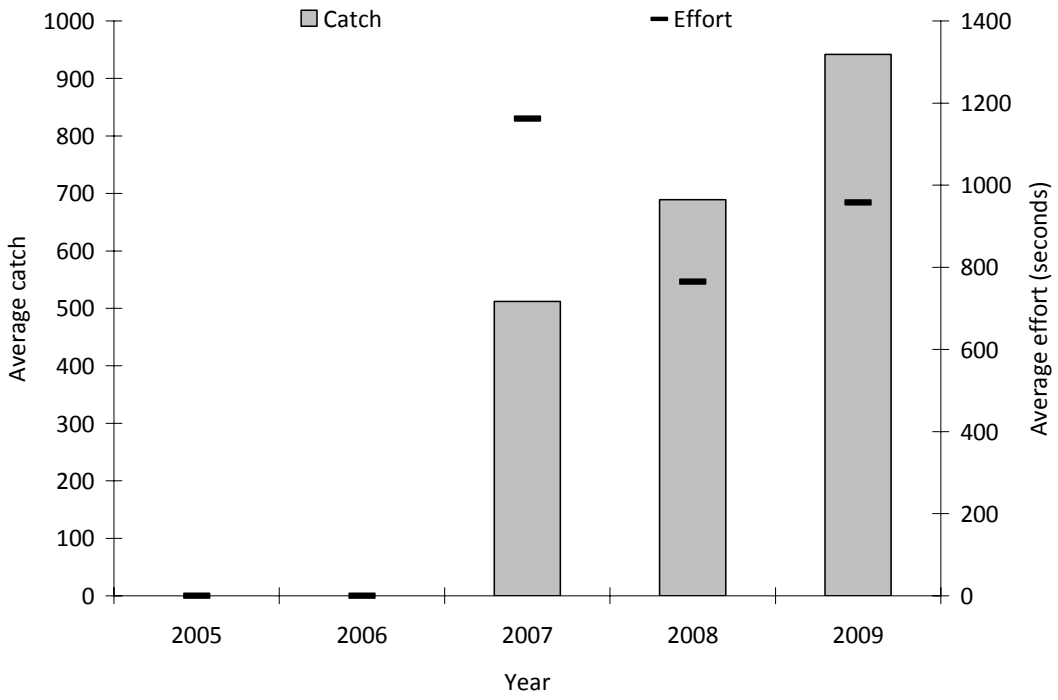

Figure 5. The average across reaches of catch and effort for Cienega Creek, sample years 2005 to 2009. Effort is backpack electrofishing seconds and catch includes young of year and adult individuals captured during quantitative sampling using electrofishing gears. Cienega Creek sampling began in 2007.

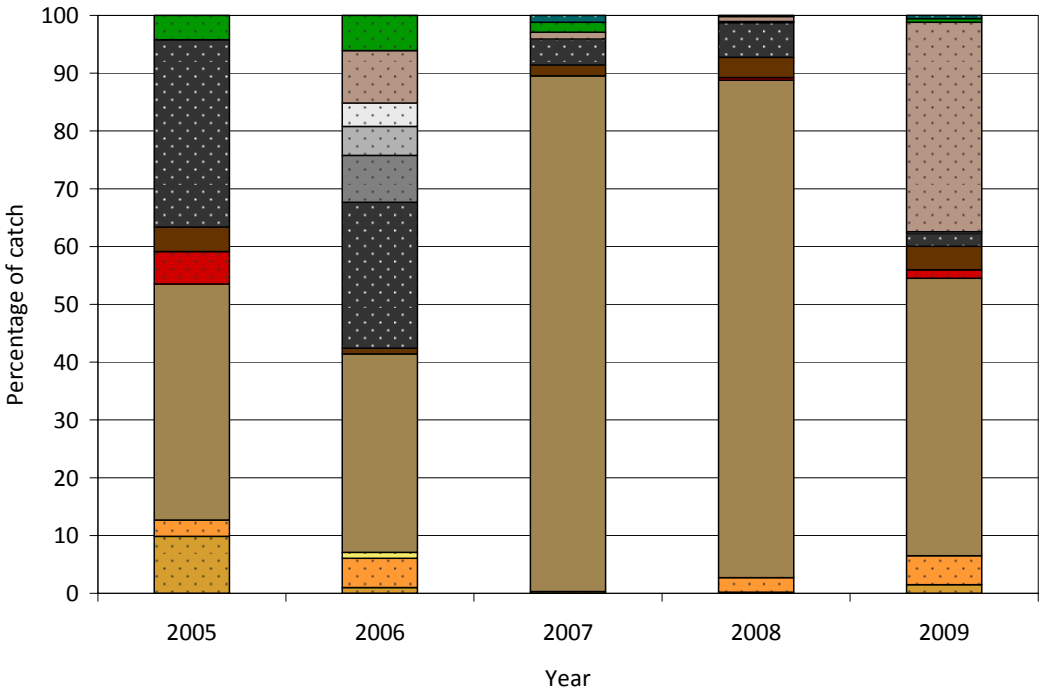

Figure 6. Relative abundance of fishes captured in San Pedro River during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears. See Table 13 for color legend, nonnative species are stippled.

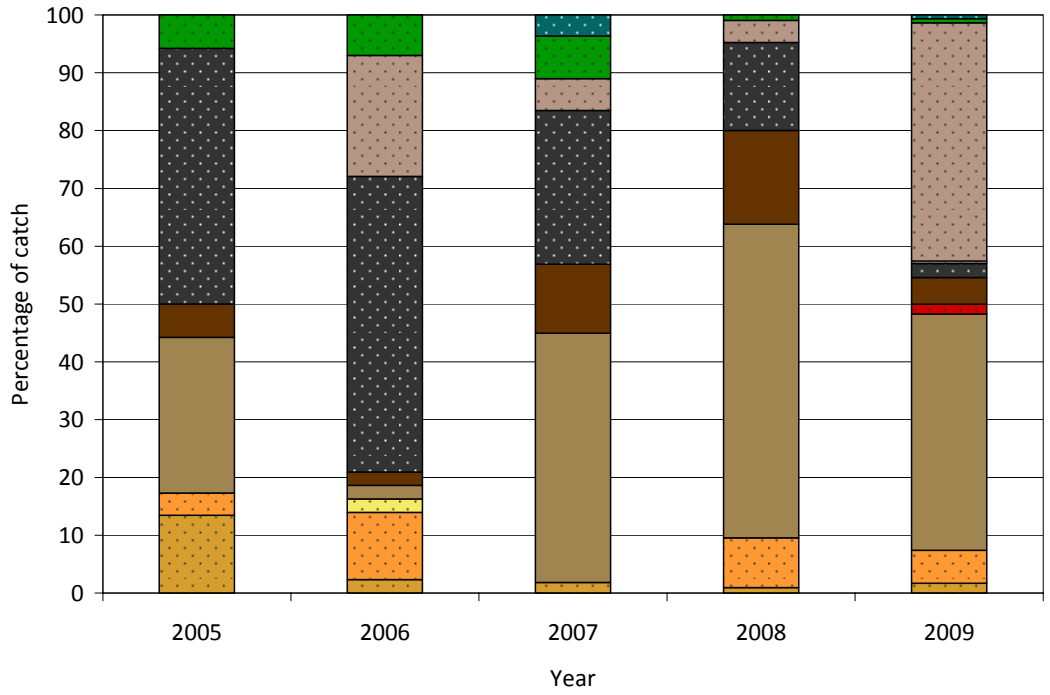

Figure 7. Relative abundance of fishes captured in San Pedro River upstream reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

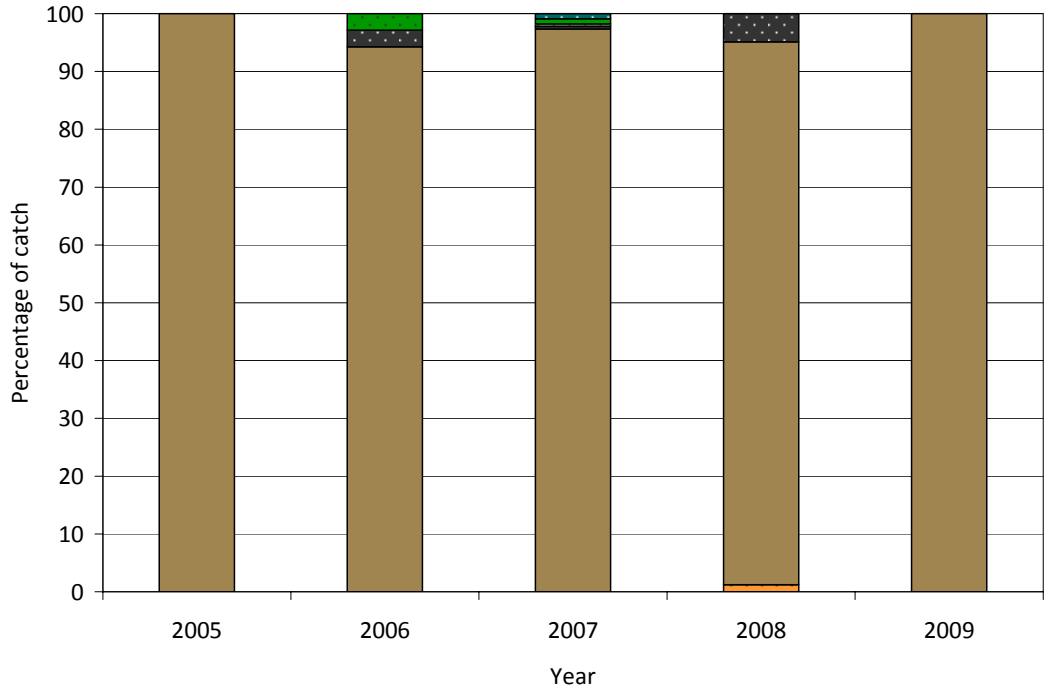

Figure 8. Relative abundance of fishes captured in San Pedro River middle reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

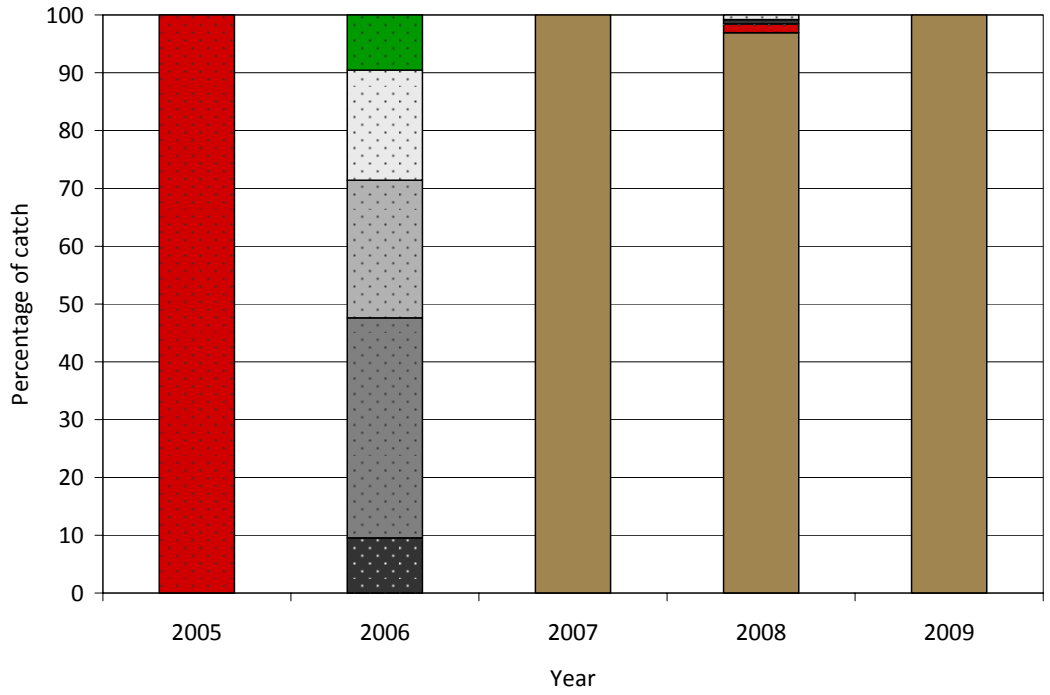

Figure 9. Relative abundance of fishes captured in San Pedro River downstream reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

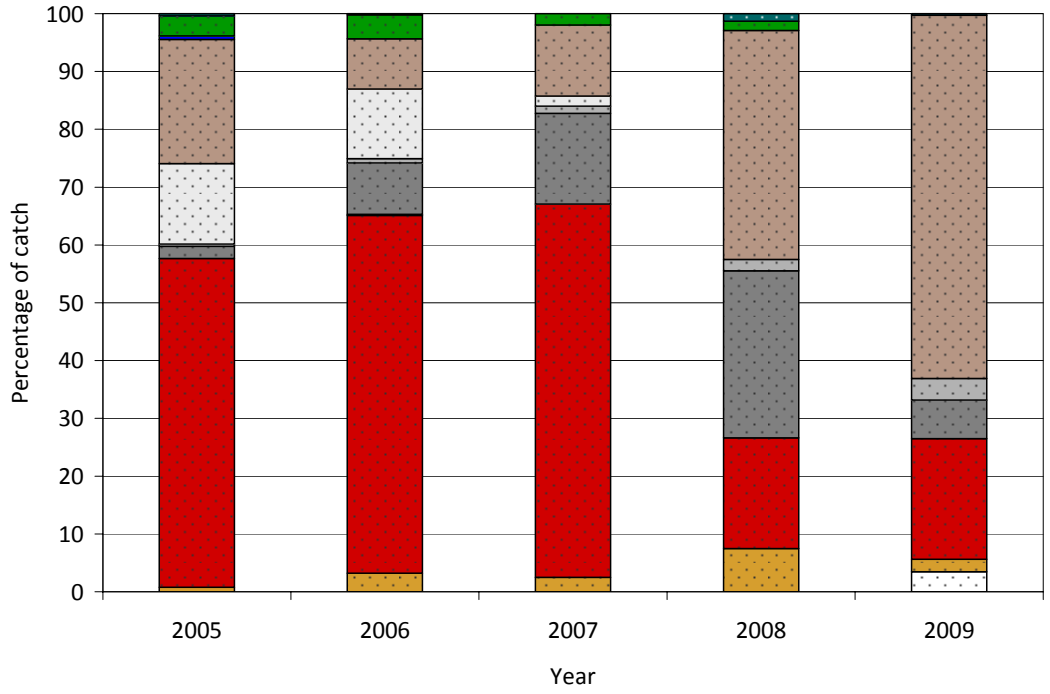

Figure 10. Relative abundance of fishes captured in the Gila River during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

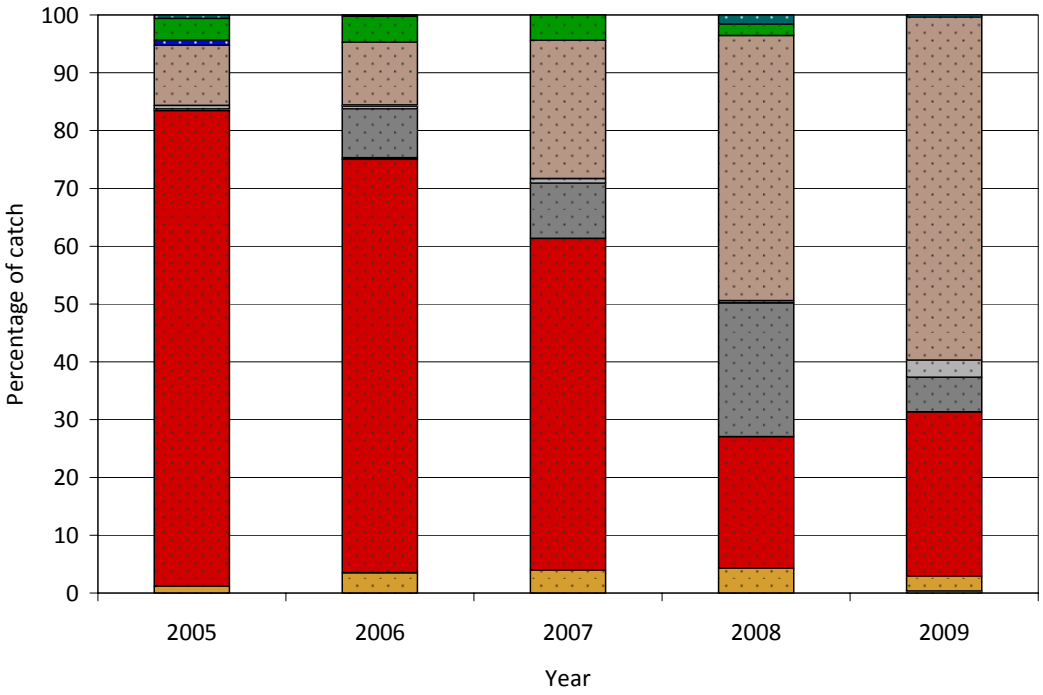

Figure 11. Relative abundance of fishes captured in Gila River upper middle reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

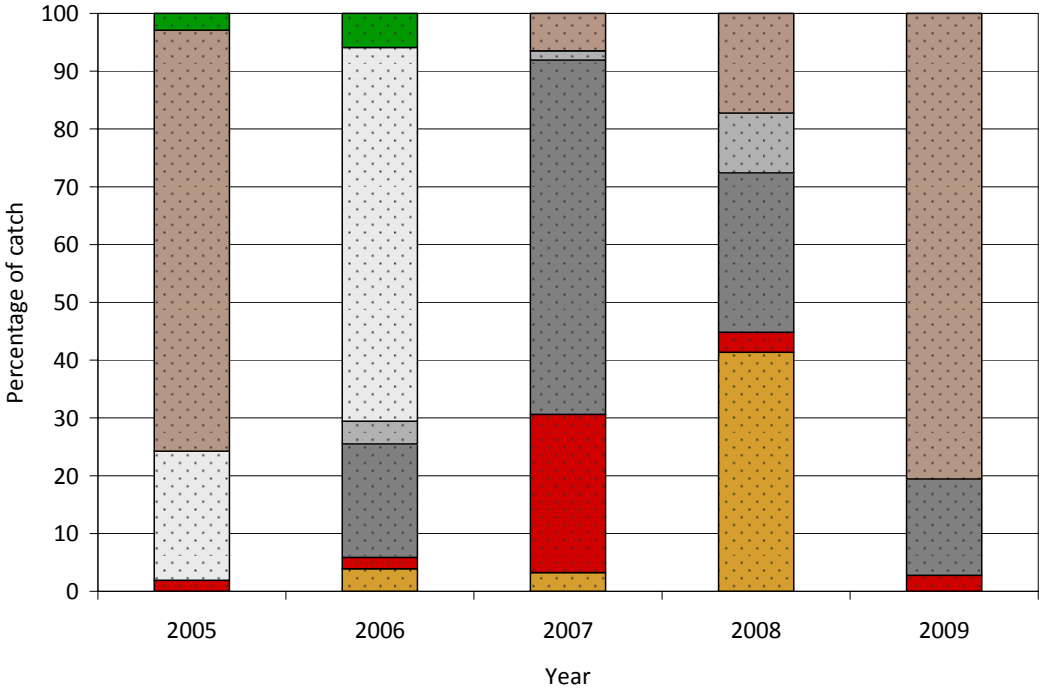

Figure 12. Relative abundance of fishes captured in Gila River lower middle reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

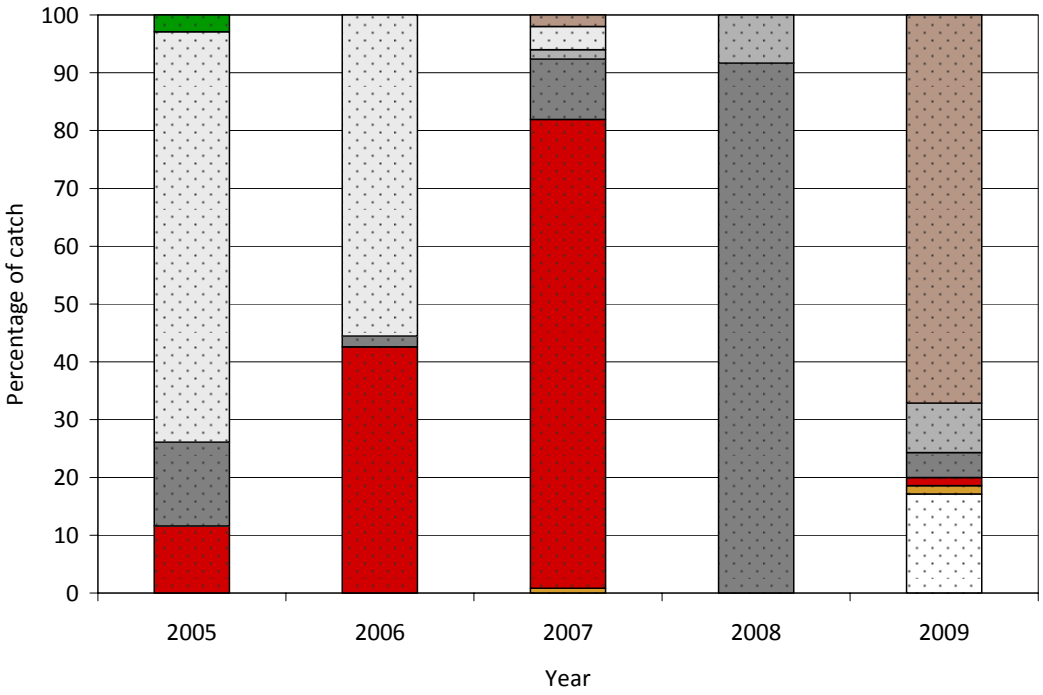

Figure 13. Relative abundance of fishes captured in Gila River downstream reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

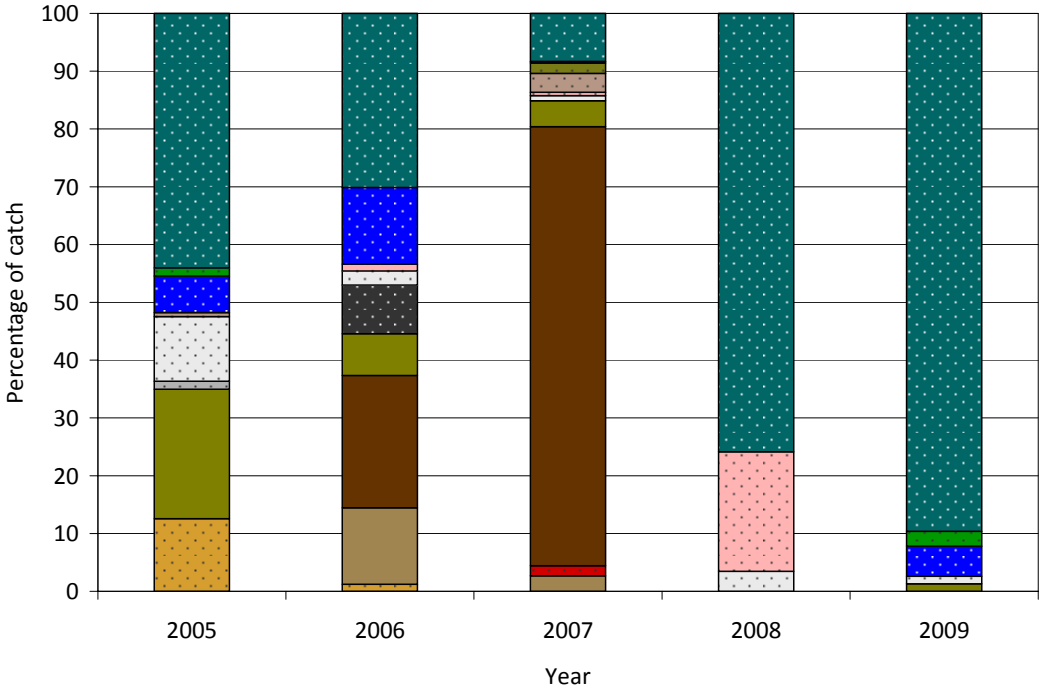

Figure 14. Relative abundance of fishes captured in the Salt River during sample years 2005 through 2009. Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

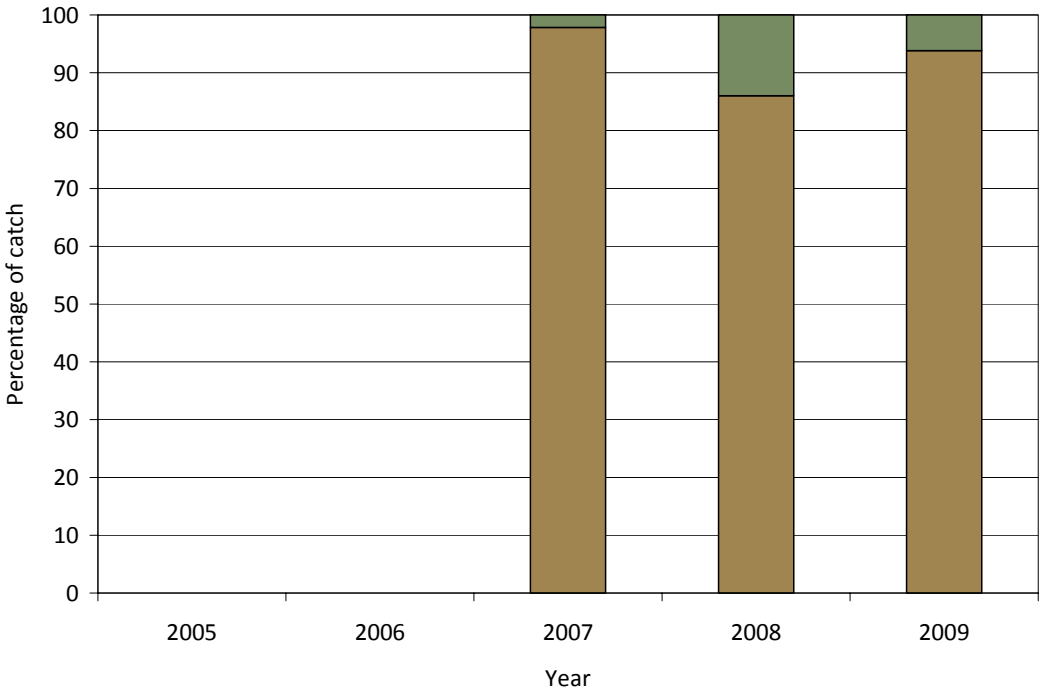

Figure 15. Relative abundance of fishes captured in Cienega Creek during sample years 2005 through 2009 (collections began in 2007). Totals include young of year and adult individuals captured during quantitative sampling using electrofishing gears.

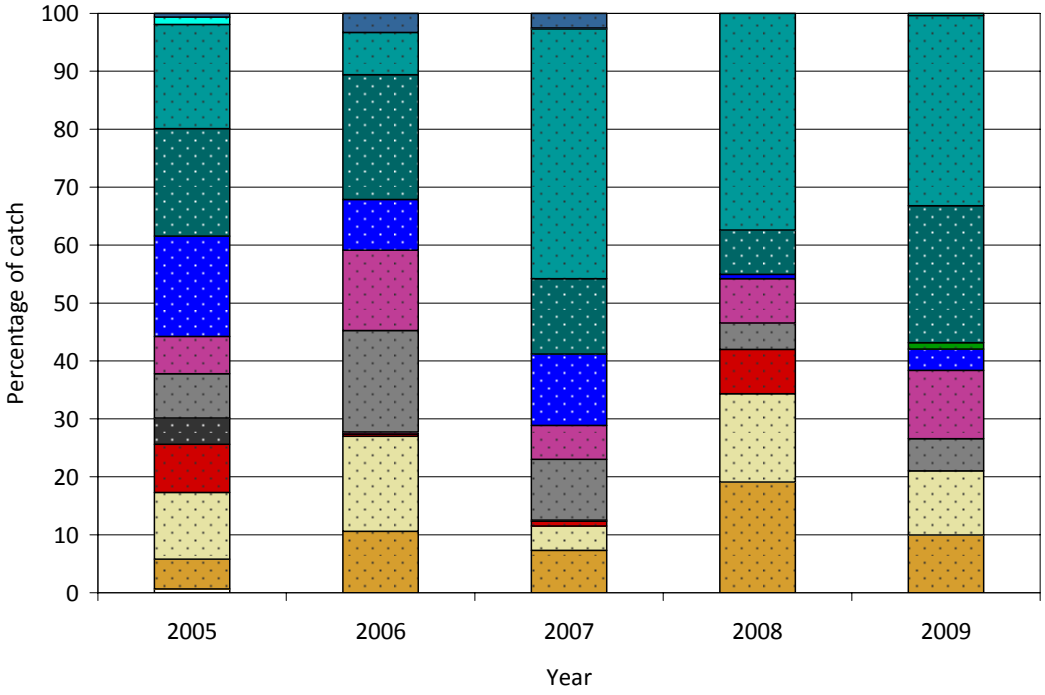

Figure 16. Relative abundance of fishes captured in the CAP Canal during sample years 2005 through 2009. Totals include young of year and adult individuals captured in quantitative samples.

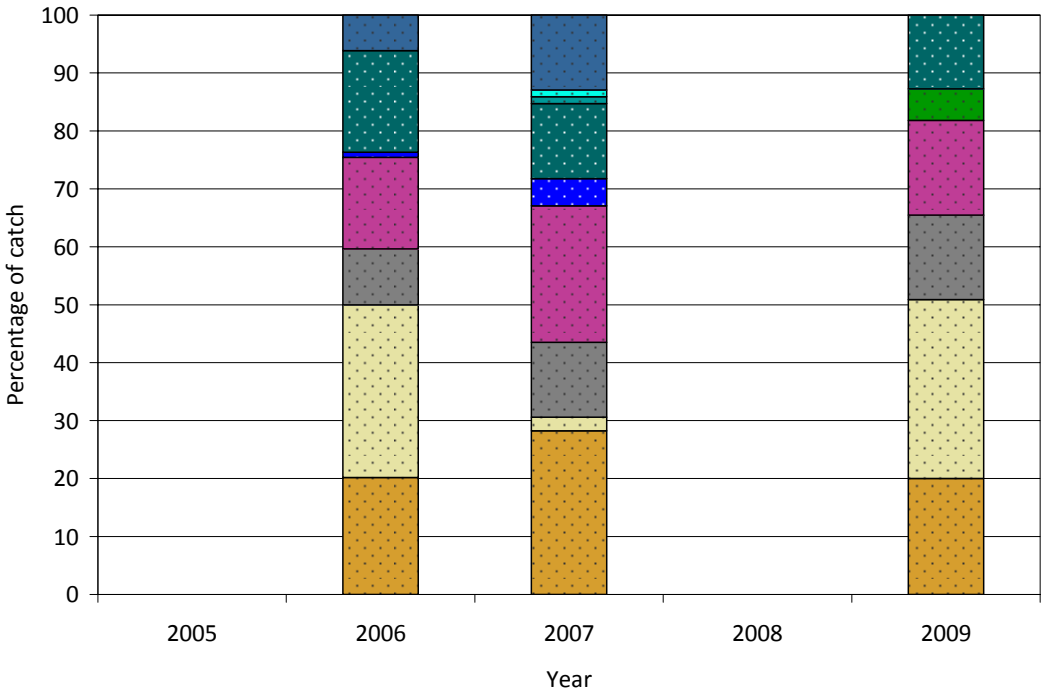

Figure 17. Relative abundance of fishes captured in the CAP Canal upstream reach during sample years 2005 through 2009 (no collections were made in 2005 and 2008). Totals include young of year and adult individuals captured in quantitative samples.

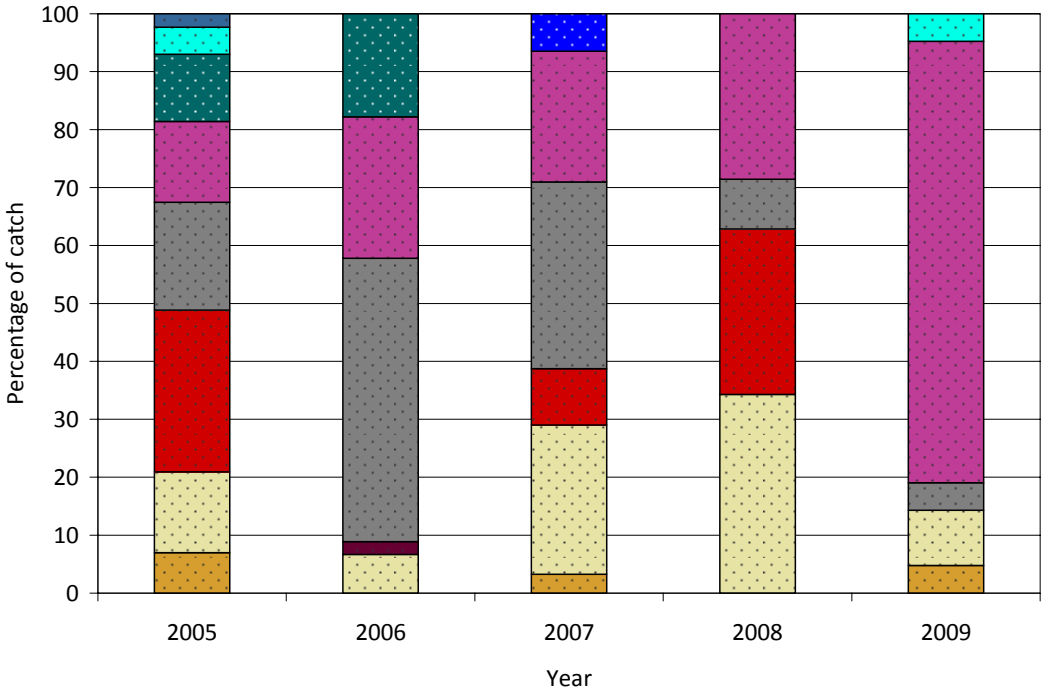

Figure 18. Relative abundance of fishes captured in the CAP Canal middle reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured in quantitative samples.

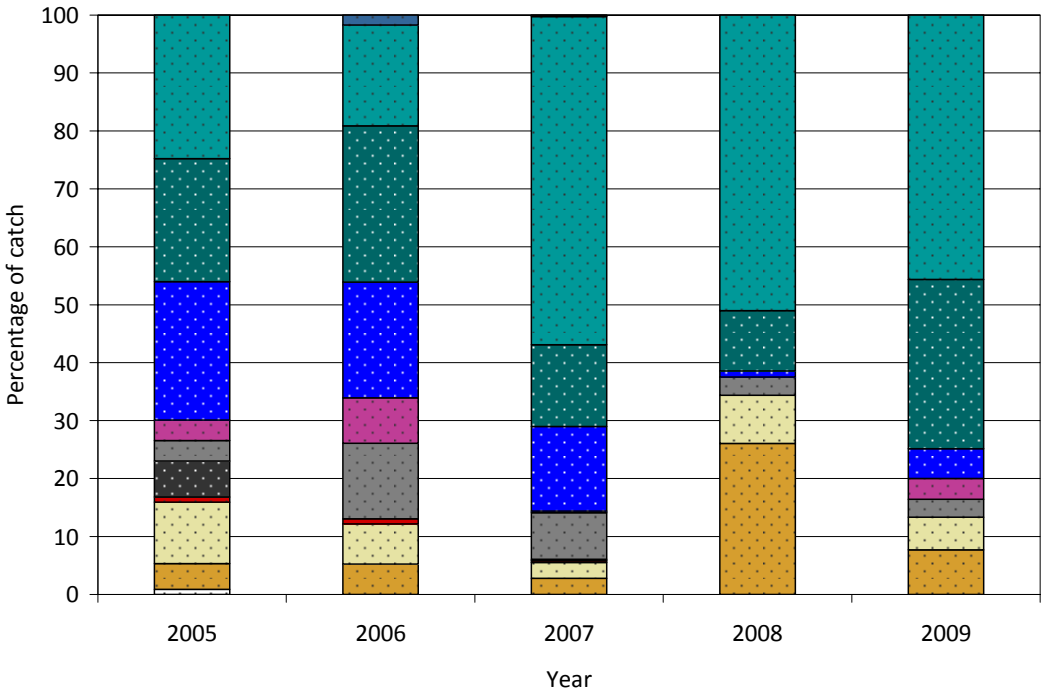

Figure 19. Relative abundance of fishes captured in the CAP Canal downstream reach during sample years 2005 through 2009. Totals include young of year and adult individuals captured in quantitative samples.

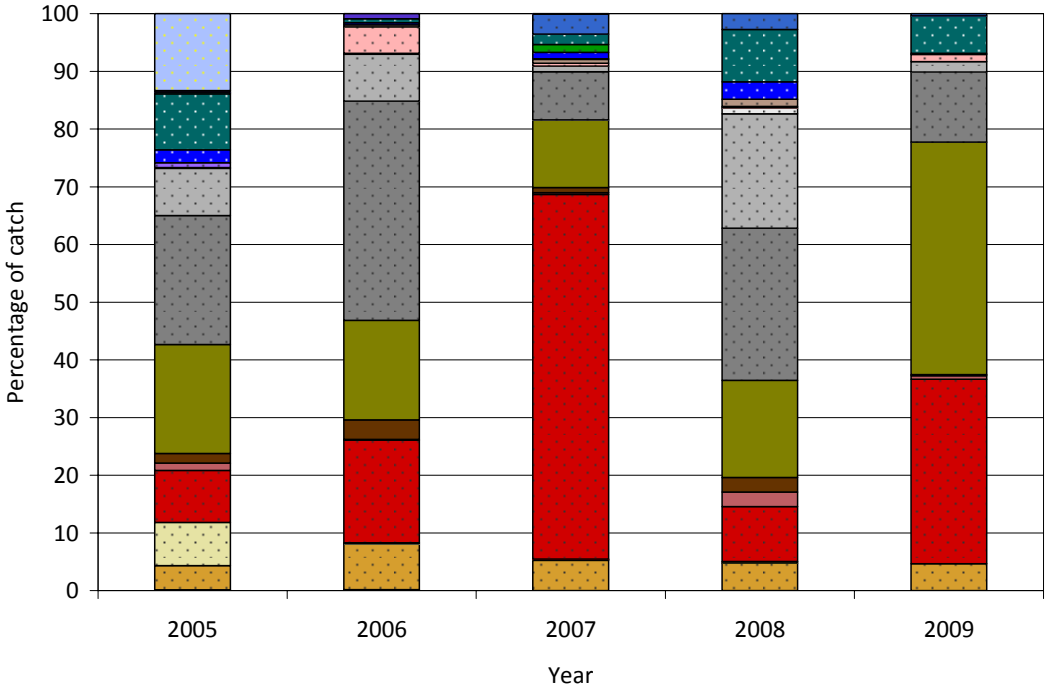

Figure 20. Relative abundance of fishes captured in SRPs Canal during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

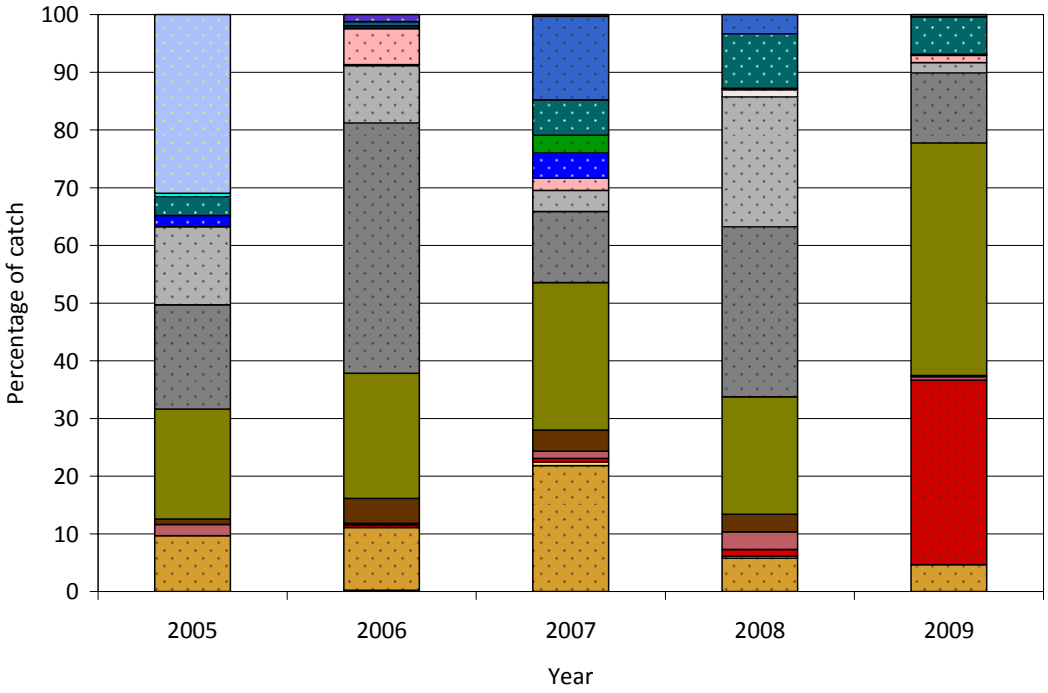

Figure 21. Relative abundance of fishes captured in SRPs Canal above the electrical fish barrier during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

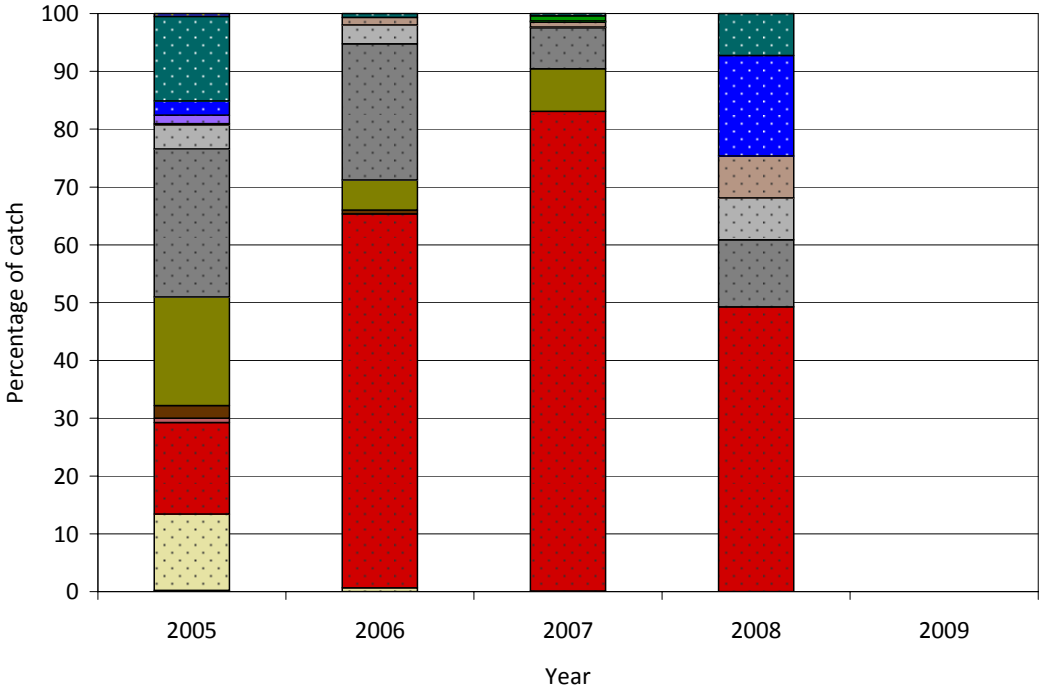

Figure 22. Relative abundance of fishes captured in SRPs Canal below the electrical fish barrier during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

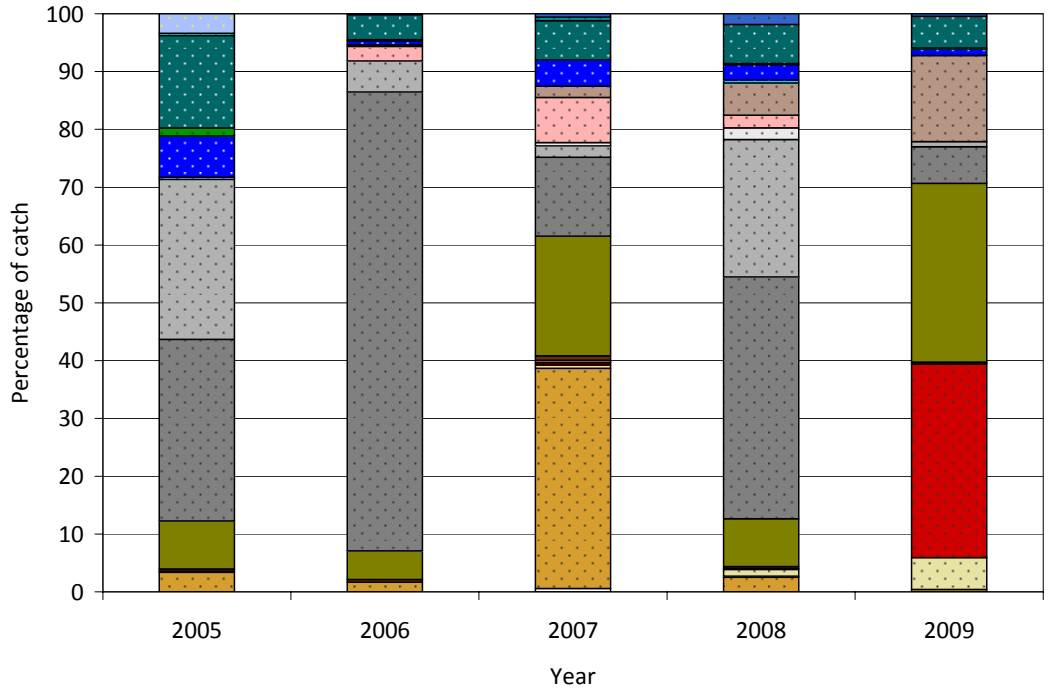

Figure 23. Relative abundance of fishes captured in SRPn Canal during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

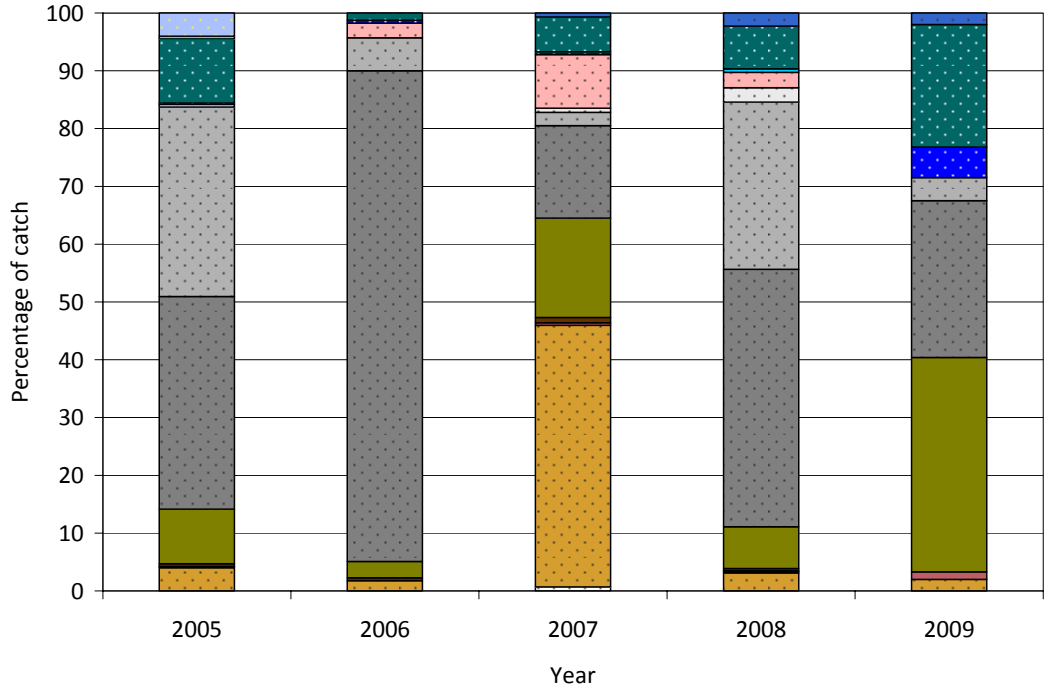

Figure 24. Relative abundance of fishes captured in SRPn Canal above the electrical fish barrier during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

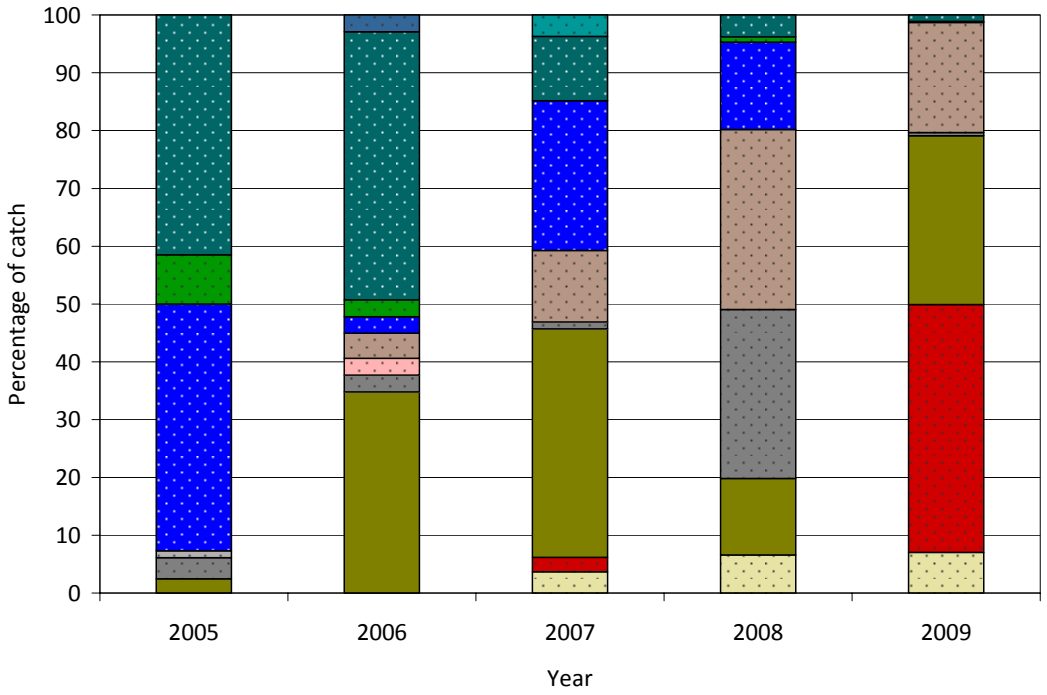

Figure 25. Relative abundance of fishes captured in SRPn Canal below the electrical fish barrier during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

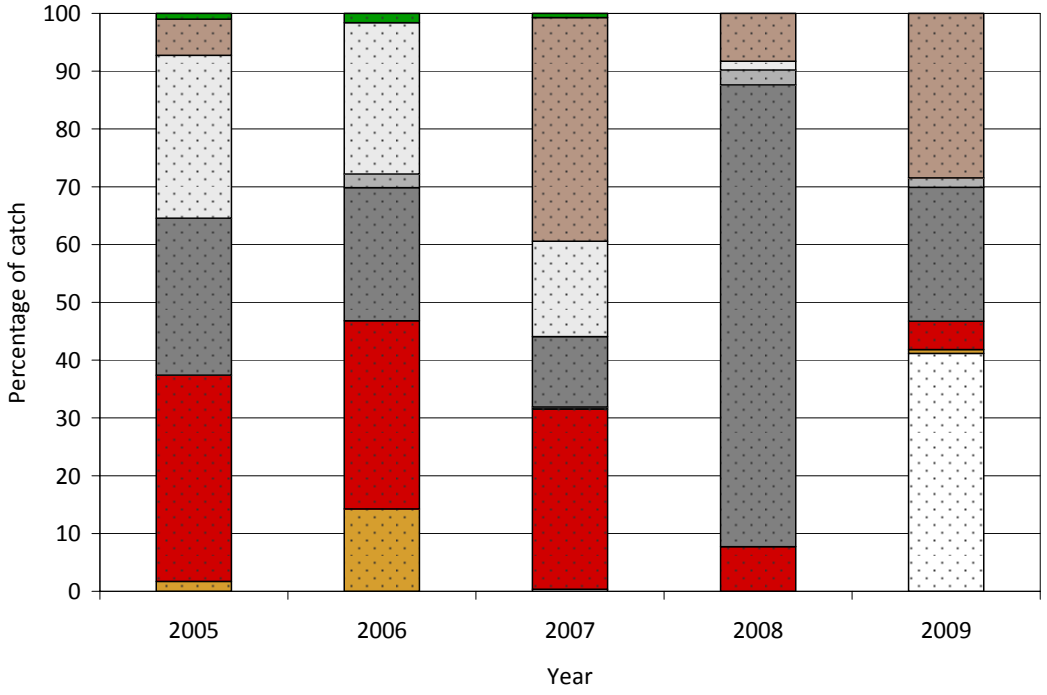

Figure 26. Relative abundance of fishes captured in FCG Canal during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

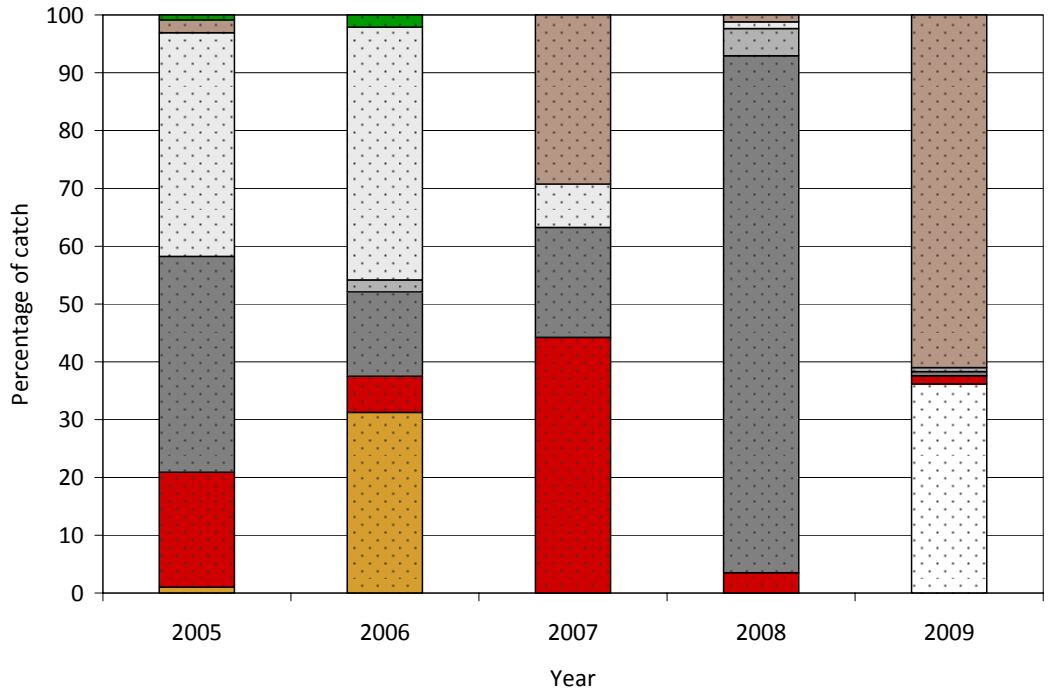

Figure 27. Relative abundance of fishes captured in FCG Canal above the electrical fish barrier during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

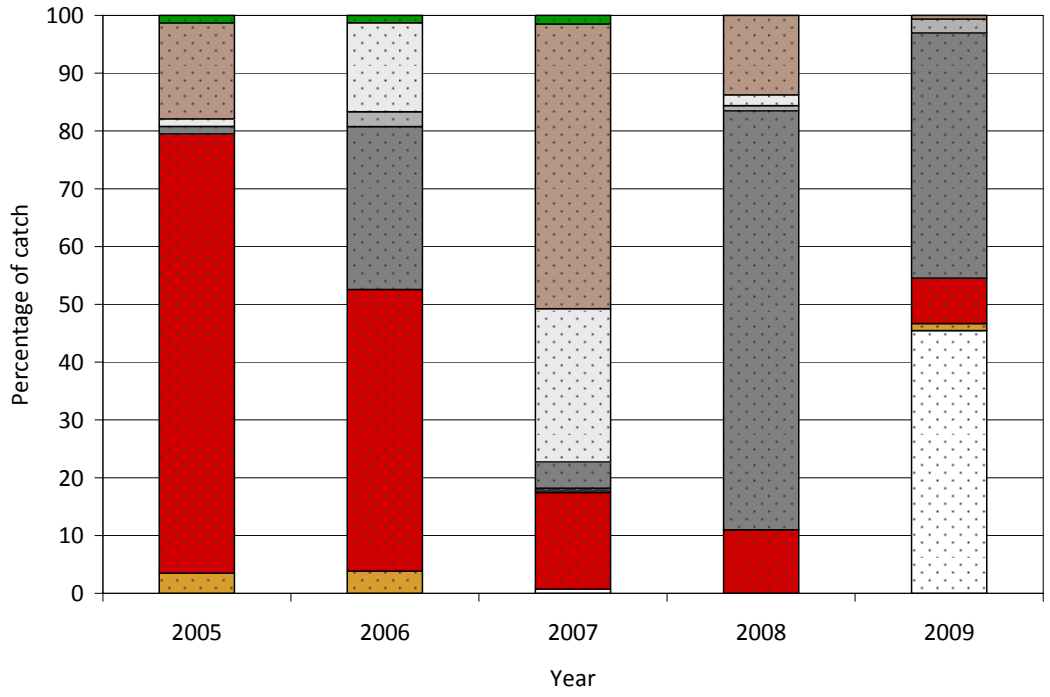

Figure 28. Relative abundance of fishes captured in FCG Canal below the electrical fish barrier during sample years 2005 through 2009. Totals include all young of year and adult individuals captured regardless of method.

Appendix A. Corrected total catch data for the CAP canal for SY 2006. The previous annual report stated no sampling was conducted below reach 1, which was incorrect (Marsh and Kesner 2007). These data are provided below.

Species	Age	4-1-1	4-1-2	4-1-3	Reach Sum	4-2-1	Reach Sum	4-3-1	4-3-2	4-3-3	Reach Sum	Totals
Common carp	1	0	1	22	23	0	0	3	3	0	6	29
Grass carp	1	0	4	30	34	3	3	0	5	3	8	45
Red shiner		0	0	0	0	0	0	1	0	0	1	1
Pacu	1	0	0	0	0	1	1	0	0	0	0	1
Channel catfish	1	2	2	7	11	22	22	1	0	14	15	48
Striped bass	0	0	0	0	0	0	0	2	5	0	7	7
	1	10	1	7	18	11	11	1	1	0	2	31
Bluegill	1	1	0	0	1	0	0	2	9	12	23	24
Largemouth bass	0	0	0	0	0	0	0	0	0	5	5	5
	1	7	6	7	20	8	8	2	6	18	26	54
Redear sunfish	1	0	0	0	0	0	0	0	1	19	20	20
Undetermined or hybrid sunfish	0	2	5	0	7	0	0	0	0	2	2	9
Totals		22	19	73	114	45	45	12	30	73	115	274